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ELECTRONIC FUEL INJECTION (SFI-MA) STRATEGY BOOK

STRATEGY LEVEL "GUFB"
NOTE: OVER 16K; REQUIRES 2732 CHIPS

FOR USE WITH EEC-IV MODULES: SFI-MA1, SFI-MA2 AND SFI-MA3

COMMENTS OR QUESTIONS SHOULD BE DIRECTED TO PAUL BALTUSIS ON EXTENSION 72583.

THE PROCEDURE FOR OBTAINING COPIES OF THIS BOOK OR ANY OTHER AVAILABLE "GU" DOCUMENTATION IS EXPLAINED ON THE NEXT PAGE.

PAUL BALTUSIS
POWERTRAIN STRATEGY SECTION
CONTROL SYSTEMS DEPT
POWERTRAIN ELECTRONICS
DEVELOPMENT DEPARTMENT - PTOPE

DECEMBER 7, 1987

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**********************************************************
NOTE: A NEW MODULE (PROCESSOR) #XF-252812 IS REQUIRED TO RUN
     THIS AND ALL SUCCEEDING VERSIONS OF THIS STRATEGY.
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ALL CURRENT STRATEGY DOCUMENTATION IS STORED ON THE VAX COMPUTER CLUSTER. DOCUMENTATION CAN BE OBTAINED BY LOGGING INTO A VAX COMPUTER (I.E. SYS2) AND ISSUING ONE OR MORE OF THE FOLLOWING VAX/DCL COMMANDS. GENERALLY, THREE TYPES OF DOCUMENTATION ARE AVAILABLE:

1. UPDATE PACKAGES - CHANGE BARS AT THE LEFT MARGIN ARE USED TO INDICATE WHERE CHANGES IN TEXT HAVE OCCURRED SINCE THE PREVIOUS LEVEL. SOME OF THESE CHANGES MAY SIMPLY BE ENHANCEMENTS OR CORRECTIONS TO THE TEXT OF THE PREVIOUS LEVEL AND MAY BE UNRELATED TO THE STRATEGY LEVEL CHANGE. THIS FILE CAN BE USED AS A QUICK REFERENCE TO SHOW THE CHANGES WHICH HAVE BEEN MADE FOR THIS RELEASE. AT THIS TIME THE VIP SECTION IS NOT INCLUDED IN THE UPDATE PACKAGE. THE FILE NAME FORMAT IS GU**UP.MEM, WHERE ** IS THE DESIRED NEW STRATEGY LEVEL.

2. PRELIMINARY VERSION - THE FILE FORMAT IS GU**EX.MEM, WHERE ** IS THE DESIRED STRATEGY LEVEL. IF THIS FILE EXISTS, THEN APPROVED DOCUMENTATION IS NOT AVAILBALE AT THIS TIME. WHEN THE FINAL VERSION IS APPROVED, IT WILL REPLACE THE PRELIMINARY VERSION ON THE SYSTEM AS A COMPLETE BOOK.

3. COMPLETE BOOKS - THE FILE NAME FORMAT IS GU**.MEM, WHERE ** IS THE DESIRED STRATEGY LEVEL. CHANGES IN TEXT WHICH HAVE OCCURRED SINCE THE PREVIOUS LEVEL BOOK WILL BE INDICATED WITH CHANGE BARS. AT THIS TIME THE VIP SECTION WILL NOT CONTAIN CHANGE BARS. THE INDEX CONTAINS AN ENTRY, "CHANGED PAGES," WHICH LISTS ALL PAGES CONTAINING CHANGES.

THE FOLLOWING VAX/DCL COMMANDS MAY BE HELPFUL IN WORKING WITH STRATEGY BOOK DOCUMENTATION:TO DETERMINE IF A SPECIFIC STRATEGY BOOK IS AVAILABLE, TYPE:

DIR STRATEGY:GU**.MEM
DIR STRATEGY:GU**UP.MEM

TO OBTAIN A LINE PRINTER COPY OF A GIVEN DOCUMENT, TYPE:

PRINT/NOFEED STRATEGY:GU**.MEM   where ** = the desired strategy level

TO OBTAIN A XEROX COPY OF A GIVEN DOCUMENT, TYPE:

XEROX STRATEGY:GU**.MEM/DEST=EEE/NAME=name/COPIES=no/PMODE=P

where: ** = the desired strategy level
name = your user name
no = desired number of copies (i.e. 1)

TO DETERMINE TARGETING OF EMR'S FOR FUTURE RELEASES, TYPE:

DISEMR

TO DETERMINE THE STATUS OF STRATEGY BOOK DOCUMENTATION, TYPE:

@STRATEGY:BOOKSTATUS

TABLE OF CONTENTS

CHAPTER 1

STRATEGY EVOLUTION

STRATEGY EVOLUTION

SOURCE FILE EMR NO.	EVOLUTION FILE	DESCRIPTION/REMARKS
GUFA	GUFB	(12/7/87)
9-423		Add a proportional control term to DEBYMA.
GUF1	GUFA	(3/11/87)
8-300		Add minimum Daspot Clip when vehicle is moving to prevent declutch stalls.
8-301		ISC - Apply FN880(CTNTMR) only when CTNFLG = 1.
GUF0	GUF1	(2/6/87)
8-234C		Revise Mass Air Flow Sensor FMEM logic.
8V-285B		VIP - Revise implementation, documentation, and logic relating to BP sensor FMEM.
8V-285C		VIP - Clarify documentation. Including all cases of BP sensor faults for clearing BAPCNT and setting MINTIM2 to clock value.
8V-287		VIP - Revise FMEM logic setting KAM indicating MAFS failure during forced stall.
9-089		S/W - Correct error in Thermactor Bypass Logic.
9-091		S/W - Correct error in INJECTOR_UPDATE_REQUEST routine.
9-097		S/W - Run ARCHI filter during Mass Air Meter FMEM.
9-100		VIP - Eliminate stalling after running VIP.
GUE0	GUF0	(12/22/86)
7-442		Revise EOS.014 module for documentation only to create EOS.V01 module.
7-442A		Cancel EMR 7-442.
8-064G		Documents the module and CPU pin number for the FPM for model years 1988 and 1989.
8-092I		S/W - In the MFLOW module, clear FFMTMR after it is used for UROLAV_TC.
8V-285		VIP - Add BP FMEM.
8V-285A		VIP - Add BPSSW, add FMEM documentation.
9-054		Move filter on Air Charge (manifold filling) to foreground.
9-054A		Revise manifold filtering logic to be compatible with FMEM.
9-069		Add function FN884 for ISC Crank.
9-072		S/W - Modify VSBAR calculation.

GUD0	GUE0	(11/26/86)
7-566A		Clarify, revise, thrift original strategy logic.
8-033		Add Heated Windshield Strategy.
8-033A		Implement 8-034A,B,C in GX.
8-034A		Add DNDSUP = 0 to Heated Windshield logic.
8-034B		Define range, resolution, etc for ACRT and HWPPM.
8-034C		Redefine HWPPM.
8-135		Add MU type Speed Limiting.
8-135B		Revise strategy logic and documentation relative to Speed Limiting.
8-135C		Clarify that FN179A applies to WOT spark, as well as Part Throttle Spark.
8-159		Improve Cruise control command switch Debounce filter.
8-167		Revise Decel Fuel Shutoff Logic.
8V-173A		VIP - Correct VIP error causing false continuous error codes 41 and 91.
8-201		S/W - Set a flag for faster determination of PHEHP.
8-229		S/W - Use a common routine to do clip for DP and 'DP.
8-236		S/W - Restructure foreground Spark code to use common subroutines.
8-237A		S/W - Process HIG_PIP_MISC code in PIP input routine, instead of as a trigger.
8-271		Compute new air charge correction for leakage and add in foreground.
8-271A		Revise logic so that the AIR37 clip includes all sources of air.
8-280		S/W - Correct FN1355 table lookup error affecting GUA0 through GUD0.
9-012		Implement Adaptive Fuel KAM initialization as a subroutine.
9-012A		Add KWUCTR register to Adaptive Table validation.
9-021		Delete DAC register to display EFTR and support code.
9-023		ISC thrift - Delete IPSBFG register and TP decision branch.
9-024		S/W - Eliminate 2 unnecessary jumps in FRGRND_FUEL_CALC module.
9-031		Reinit RATCH to RATCHIV during TP failure.
9-035		Revise convention for table labels in FCA.
9-041		Complete 8-138. (Delete CRKFLG logic from CRKTMR and allow free-run).
9-044		S/W - Process LOAD_OUTPUT directly in OUTPUT_CMD_EDGE instead of using call.
9-045		Revise PIP_DATA routines for byte and chrono efficiency.
9-046		Modify Decel Fuel Shutoff Logic to add Cal Switch to use it at Part Throttle for enrichment via FN374(N).
0-003		Implement EXP-147 and EXP-147A into main stratvine (Spark angle pulsewidth transfer function change for CT20).

0-003A			Revise transfer function for SAPW, change clips on SAPW.
GUC1	GUD0		(11/12/86)
7-573C			Revise FCA for FN824 to say "N_BYTE" instead of "BYTERPM", revise strategy book.
7-579A			S/W - Revise foreground control of fuel pulses to support Bank-to-Bank EFI.
7-688			Revise strategy book to specify requirements for FN1327.
8-032A			H/W - Remove 2nd output for ACL put in by 8-032.
8V-064E			VIP - Correct interference between normal and VIP fuel pump control.
8V-064F			VIP - Use VIP_FP_OVERRIDE instead of corrupting TSLPIP.
8V-188A			VIP - Correct error in VIP fault filter relating to Threshold Level Flag.
8-234			Add FMEM strategy for Mass Air meter.
8-234A			Revise logic, include base values.
8-234B			Add Cranking check to FMEM logic of 8-234A.
8-240			S/W - Revise range of parameters EDNHYS and SPUCLP.
8-261			Delete NOPS from start of O.I. #1 module.
8-263			Document how the PIP noise filter works.
8-264			S/W - Thrift code in Fuel service routine.
GUC0	GUC1		(11/5/86)
8-266			S/W - Correct problem in ISC related to adding 7V-709 in GUB0.
8-267			S/W - Correct problem related to FN1035 (ARCHOR) lookup.
GUB0	GUC0	(Merged with GUAC)	(10/23/86)
8-061A			Add new row to Adaptive Fuel table exclusively for Idle.
8-107			Use relative LOAD (PERLOAD) instead of absolute LOAD.
8-107A			Use LOAD for EGR (Delete APECHG, APEBAR, APELOAD) etc. Add ability to disable PERLOAD usage.
8-107B			FN035 to be function of N, Not N_BYTE.
8-136			Add Lugging Mode. Thrift Open Loop Fuel.
8-136A			Use DNDSUP instead of NDSFLG in "C" calculation logic.
8-189			Use special temperature Normalizing function for FN1861.
8-223			Revise documentation in CRANK/UNDERSPEED/RUN logic (N < NSTALL).
9-007			Revise and thrift Foreground/Background.

9-033	Revise Vector lower limit for parameter XFREPT.
GUA0 GUB0	(10/17/86)
7V-025	VIP - Implement the MIL logic using a single timer.
7-209	VIP - New Continuous EGO test for MIL.
7-209B	VIP - Do EGO Test after a certain number of TP transitions rather than time at Part Throttle.
7-209C	VIP - Ensure against false codes 41 and 91 if EGO Test is bypassed.
7-225E	VIP - Add TFMFLG and MFMFLG before performing Continuous VSS Test.
7-479	VIP - Modify entry to EGR tests for compatibility with 3-state PFEHP.
7-482	VIP - VIP Test power steering pressure switch.
7-552	VIP - Ensure proper VIP entry even if FMEM is in effect on ITP.
7-560	VIP - Short index external RAM locations.
7V-593D	VIP - Modify VIP code for a 13 byte thrift.
7V-593F	VIP - Cancel 7V-593 through 7V-593E.
7V-643	VIP - Add initialization of LAMBSE to VRLAM2 at beginning of KOER goose Test.
7V-650	VIP - Put OCCDT4 and OCCDT7 in individual strategy OCCDT calibration files.
7-681	VIP - Improve accuracy and resolution of dither Purge Duty Cycle and frequency.
7V-706	VIP - Correct VIP so that if EGO Test fails, THERMACTOR and Fuel Tests are bypassed.
7V-709	VIP - Revise ISC Strategy to make VIP ISC calibration independent from the normal engine ISC calibration.
7V-709A	VIP - FN820A is MU only; GU uses FN820B.
7V-709B	VIP - Use parameter name V820A in GU to replace FN820B (for file commonality).
7V-709C	VIP - Substitute 1.0 for FN824 when VIP running flag = 1.
8V-056	VIP - Remove all previous EMR history from VIP source files.
8V-064A	VIP - Incorporate new continuous fuel pump circuit test.
8V-064C	VIP - Revise VIP documentation of names, etc.
8-092D	Correct errors relating to Manifold Filling Filter.
8-092E	VIP - Do time based VIP filter constant routines for VIP filter constants.
8-092F	Correct register clobbered by rolling average routine relating to EGR.
8V-101	VIP - Add MAF sensor test to VIP.
8V-111	VIP - Gives blanket authority to fix documentation in VIP files without any further EMRs.
8-115	VIP - Delete Cal. parameter VSPCLP and delete setting ADVLIM = 0 from Self-Test.

8V-121		VIP - Expand allowable error codes from 32 to 'N'.
8V-125		VIP - Expand the meaning of goose flag to allow output of one digit codes up to 90.
8V-127		VIP - Quit displaying service code 16 for engine-running EGO test failure.
8V-139		VIP - Revise type checks to allow ease of changing between MTXSW and TRTYPE.
8V-162		VIP - Thrift PSPS Input Test in running VIP.
8V-162A		VIP - Correct Software to bypass VIP KOER Brake Input Test if BIHP not 1.
8V-173		VIP - Control EMR for GU VIP; Basic idea is to use MU VIP 53A as a base for GU VIP.
8V-174		VIP - Do not enter, or remain in, KOEO VIP if underspeed or run mode.
8V-174A		VIP - Do not do cruise control static test if in underspeed mode.
8V-188		VIP - Recode Continuous VIP fault filter to allow up to 8 bytes of error codes.
8V-190		VIP - Assign 2 bytes of RAM to FMEM monitor.
8V-206		VIP - Change flag VPFESEL to PHEHP_FLG.
8V-215		VIP - Change position of Continuous code 67 to a unique slot.
8-216		Move ROM_TO from 9FFE to calid location ^200A.
8-216A		Add dummy parameter to tweak ROM_TO if needed.
8-216C		Documentation for ROM_TO code.
8V-232		VIP - Don't force Closed Throttle mode when doing engine running Self-Test.
9V-004		VIP - Revise SCVNT and SCVAC VIP parameters (OCCDT1 & OCCDT2) to OCCDTA & OCCDTB.
GUAB	GUAC	(10/14/86)
8-248		S/W - Revise the KAMRFn determination in Adaptive Fuel.
GUAA	GUAB	(10/7/86)
8-061A		Add new row to Adaptive Fuel table exclusively for Idle.
8-092D		Correct errors relating to Manifold Filling Filter.
8-092F		Correct register clobbered by rolling average routine relating to EGR.
8-107		Use relative LOAD (PERLOAD) instead of absolute LOAD.
8-107A		Use LOAD for EGR (Delete APECHG, APEBAR, APELOAD) etc. Add ability to disable PERLOAD usage.
8-107B		FN035 to be function of N, Not N_BYTE.
8-136		Add Lugging Mode. Thrift Open Loop Fuel.
8-136A		Use DNDSUP instead of NDSFLG in "C" calculation logic.
8-189		Use special temperature Normalizing function for FN1861.

8-223		Revise documentation in CRANK/UNDERSPEED/RUN logic (N < NSTALL).
GUA0	GUAA	(9/25/86)
9-007		Revise and thrift Foreground/Background
8-092D		S/W - Correct errors relating to Manifold Filling filter in GUA0.
GXZ0	GUA0	(9/15/86)
7-379		S/W filter of digital inputs.
7-379A		Implement 7-379 in MU, GX, 9X, etc.
7-386B		S/W - Revise parameter MIKE100 and verify that paths do not exceed this time.
7-386D		S/W - Do 7-386B for MU & GU, except set MIKE100 to 66 clock ticks.
7-573B		ISC - Add Neutral/Drive Idle Speed gains and spark feedback.
7-651C		Cancel 7-651. 7-651A, 7-651B for GX. Do thrift part of 7-651A.
8-046		S/W - Utilize common byte count allocation technique.
8-047		Start ECT averaging for TCSTRT calculation at TKON2.
8-047A		Revise logic to re-compute TCSTRT after a stall.
8-047C		Cancel 8-047B. Clarify that TCSTRT isn't part of Inferred BP.
8-047D		Ensure that PIP counter control logic is coded as previously specified.
8-053		Allow 'on the boundary' range checks to be good sensor values for FMEM as well as VIP.
8-089		Make BIAS, Peak-to-Peask amplitude and TAU tables of speed/load.
8-089B		Change the X input of 1343,1351,1352,1353, 1354,1355 from FN070/3 to FN039.
8-089C		Create dedicated register for BIAS, correct documentation.
8-092		Rework rolling average subroutine to give truer time constants.
8-092A		Make manifold filling filter constant truly time (BG loop variant).
8-092B		Amend 8-092A. Respecify manifold filling time constants.
8-092C		Reverse filter increment/decrement logic.
8-092G		Documentation changes for 8-092, to agree with the code.
8-138		Thrifts in ISC and CRKTMR.
8-180		Delete AXOD.
8-182A		Delete FN's 088 and 089, which are no longer needed.
8-182B		Delete FN's 1330 and 1341.
8-211		S/W - Delete code from cal-console call that reads alternate calibrations.
8-211A		S/W - Thrift console routine.
9-003		Replace 7 hardware switches with TRLOAD and

			TSTRAT.
9-003A			Revise for compatibility with multiplexed NDS/ACC.
9-003B			Correct ISC documentation relating to 9-003.
GXY1	GXZ0	(8/4/86)	
6-391			Clip DELOPT to 922 counts after it is filtered.
6-391A			Implement EMR 6-391.
6-410A			Implement EMR-410 - Initialize TBART to same value as RATCH initialization.
7-429B			Revise Spark equation to be like MU.
7-457			Delete entire EGO aging strategy.
7-521			Revise cruise control; delete Fav speed, delete variable freq duty cycle.
7-521A			VSC - Byte thrift - Delete VSCPUL.
7-634			Major ISC revisions (7-634,B,C cancelled by 8-137).
7-634B			Clarify start up hicam DSDRPM direction to agree with other recent EMR's.
7-634C			Cleanup documentation, delete TGFLG, thrift N/D desired RPM and DESMAF logic.
7-656			Use fixed INJDLY for Idle instead of table value.
7-659			S/W - Byte thrift to speed up foreground execution time.
7-667			Do not do decel fuel shut off if any FMEM flag is set.
7-669			Correct non-recognition of "Drive" on a neutral to fourth transition.
7-669A			Delete EMR 7-669; N/D logic is not required.
7-670			Use 3-state hardware present switch (0=null, 1=VSS only, 2=VSS+Cruise).
7-670B			Revise original EMR. (originally issued as 7-670A).
7-670C			Revise 7-670A.
8-035			Install signed spark table as FN(ECT,MAP).
8-048			Add vehicle speed to logic inputs for decel fuel shutoff.
8-048A			Respecify parameters. Specify correct existing DFSO logic.
8-105A			S/W - Implement 8-105 - byte thrift.
8-137			Delete 7-634,A,B,C,D. Revise/simplify ISC.
8-137A			Cleanup EMR for ISC changes; define A3CTMR.
8-154			Make parameters IXFRPR and XFREPT signed.
8-161			Thrift PPCTR logic in Decel Fuel Shutoff.
8-182			Make range of CIDRSW 0 to 1.
GXY0	GXY1	(7/2/86)	
7-666			Init SPKMUL to 0.99. If any FMEM failure, set SPKMUL to 0.99.
8-134			Delete TKTMR from timer list.
8-140			Correct resolution problem with foreground fuel (FUEL_C and FORFUL1,2)
8-140A			Clarify that 8-140 was partially required

		by strategy resolution misspec.
8-141		Cancel EMR's not required for GX: 6-291, 7-092, 7-259, 7-388, 7-417, 7-441, 7-441A, 8-080, 8-080A, 8-080B, 8-103.
GXX1	GXY0	(6/13/86)
7-199		Inititalize FAM filter to (N*ENGCYL*ARCHG).
7-653		Include hysteresis on DELRAT to exit FAM; Add clip on (AMPEM-EM) on entry to FAM.
7-694		Implement 'DNAC' addition.
8-032		Implement Ride Control Strategy.
8-050		Add Upstream Air flag in Thermactor Air Strategy for use with ECAD.
8-050A		ECAD revisions.
8-050B		ECAD revisions.
8-050C		ECAD - Respecify and correct calibration constant values.
8-077		Byte thrift - Eliminate alternate calibrations.
8-090		Move the ATOD routine ahead of the Throttle Mode select routine.
GXX0	GXX1	(5/19/86)
8-074		S/W - FUEL - Correct usage of ML3W instruction.
8-079		S/W - FUEL - Output Routine - Injector firing during CRANK fix.
GXW0	GXX0	(5/8/86)
7-455		FUEL - Foreground Fuel Calculation.
7-455A		FUEL - Foreground Fuel Calculation cleanup.
7-671		S/W - Delete the KEYOFF flag and the code that references it.
8-023		Air Meter Correction Table.
8-029		Delete INJDLY2, Rename INJDLY1 to INJDLY.
8-030		Raw Air Charge Calculation time reduction.
GXV0	GXW0	(4/25/86)
6-607A		S/W - Correct CTNTMR logic; clip to (NIOLD + NIHYS).
7-384		S/W - Add new engr. console call.
7-432		S/W - Automatic generation of MROM identifier.
7-453		Purge output frequency should be 10 Hz.
7-453A		Delete EVRPM and EVRPMH.
7-575		Revise High Speed Fan Logic.
7-575A		EMR - 575, use LOAD instead of MAPPA.
7-588		Make DASPOT a function of DSTPR - (RATCH + DELHYS).
7-614		Disable Transient Fuel if in DFSO (and fuel

		is shut off).
7-614A		Delete SW_TFI from Transient Fuel.
7-633		S/W - Neutral Idle Injector Delay.
7-636		If in ISC Failure Mode Strategy, set DSDRPM to FMMDSD.
7-677		Documentation - ISC/FAM - BGCNT docu.
7-681		S/W - Purge Duty Cycle in Foreground.
8-026		Expand MFA table.
8-027		Delete Synchronous Sampling of the EPT sensor.
GXU1	GXV0	(2/24/86)
7-494	Dillon	S/W - Include overflow check in Fuel Pulsewidth equation.
7-525	Zaghati	Add Closed Throttle check to DFSO; Add 2 breakpoints to FN131.
7-574	Baltusis	Add C/L Fuel delay after DFSO.
7-590	Baltusis	S/W - Execute AEFUEL right after TAR calculation in Convert Routine.
8-018	Ward	Incorporate the Manifold Filling Model.
8-018A	Ward	Name & range changes - Manifold Filling.
GXU0	GXU1	(2/4/86)
7-580	Hughes	S/W - Insure ACITMR cleared for all cases of ACIFLG clear.
7-586	Hughes	S/W - Correct O/L Lambse.
7-587	Meshkinnafas	S/W - Correct repeaters error.
7-589	Meshkinnafas	S/W - Fix for EFTR calc.
GXT0	GXU0	(1/23/86)
6-589C	Hughes	Correct Software Rel. to ATMR3.
7-411	Allen	Dual MKAY.
7-411A	Allen	SIGKAY/MKAY fix.
7-421	Zaghati	Eliminate Upstream air on WOT after a certain time from start.
7-486	Ward	Rearrange MCAL Region assignments.
7-486A	Ward	Put parameters from MISC module in Region 1.
7-486B	Meshkinnafas	Change Region assignments for GX.
7-449A	Hughes	S/W - Set base value of MHPFD to 0.24.
7-541	Meshkinnafas	S/W - Save FN311 & FN212A in RAM.
7-560	Meshkinnafas	S/W - Short Index External RAM automatically.
7-577	Ward	S/W - Correct temp. register usage in DFSO.
0-002	Allen	CID-VRS added to CID-HALL.
GXS0	GXT0	

(1/8/86)

6-469	Pearson	S/W - Reprioritize Repeaters.
6-469A	Pearson	Cancel EMR 6-469.
6-705	Zaghati	Allow air on heavy crowds only until engine stabilizes.
6-705A	Ward	Implement 6-705 in GX.
7-094E	Ward	S/W - Invert THS3/2.
7-172B	Chupa	S/W - Eliminate redundant operation, SAFTOT is done in Foreground.
7-197B	Ward	Revise Adaptive Fuel Default logic.
7-373	Baltusis	Add a percentage deadband around equilibrium fuel to turn off transient fuel.
7-387	Baltusis	Delete FN824(N); Add FN824A(DSDRPM-N).
7-402	Baltusis	Reorder code to check unique NDSFLG condition first.
7-402A	Baltusis	Revise logic so that reordering code isn't needed, dont implement 7-402.
7-403	Baltusis	Use 100% ISC Duty Cycle in Crank Mode even if FMEM flag is set.
7-413	Ward	I/M test changes.
7-413B	Ward	Change +FN180(CTNTMR) to -FN180(CTNTMR).
7-413C	Ward	Delete HPTPMR timer.
7-414	Zaghati	Include HSPFLG in Dump Air logic; include W.O.T. in O/C Fuel Logic.
7-414A	Ward	Clarify 7-414 for GX.
7-426	Ward	Change all references of OCPSSW to THRMHP.
7-427	Baltusis	Add a third position to PFEHP; If PFEHP = 2, disable EGR strategy.
7-427A	Baltusis	Set EM = 0 & EGRACT = 0 when no EGR control is required.
7-428	Zaghati	Initialize TPBAR to RATIV.
7-435	Baltusis	Delete DASMAX dashpot clip, replace with a function of RPM.
7-435A	Baltusis	Add Vector clip to FN882, maximum clip of 2.0.
7-437	Baltusis	Correct Transient Fuel "M" logic.
7-444	Ward	Allow torque truncation spark if N > TTNOV * VSBAR without executing AXOD code.
7-466	Huck	Revise code to clip all negative DELPR results to 0.
7-466A	Huck	Ignore code revisions in 7-466, implement revisions in 7-466A.
7-474	Liller	S/W - Modify the MAF repeaters module.
7-475	Mingo	S/W - Prevent inhibition of high speed outputs due to large carousel count.
7-524	McIntee	S/W - Clip injector beta to < 1.75.
7-530	Liller	S/W - Separate Injdly register for each bank.
8-016	Ward	Allow clutch input to be selectable for DFSO logic & for ISC logic.
8-017	Ward	Change base values of MAFK1 to 1.00 & MAFK2 to 0.00.
8-020	Liller	S/W - DOL code revisions.

GXR0	GXS0	(10/31/85)
7-371	McIntee	S/W - Move the external Ram ares designated as Keep Alive Memory to ^700 - ^7FF.
7-422	Mazzara	S/W - FCA changes for SWDV testing.
7-449	Mazzara	S/W - Set base value of MHPFD to .24.
0-001	Allen	Provide support for High Data Rate Electronic Spark System for CT-20 design contest.
0-001A	Allen	Revise Spark Angle Pulse Width equation and correct limits for SAPW.
GXQ0	GXR0	(10/4/85)
6-517C	Harris	VIP - Correct Type_check error.
6-517D	Rachedi	VIP - Revise Cylinder Balance Test.
6-517E	Harris	VIP - Revise calibration constant values.
6-519A	Sass	VIP - Add MTXSW criteria to Self-Test.
6-549	Yagley	S/W - Set PTPFLG = 1, if PIP interrupt occurs.
6-677	Rachedi	VIP - ISC Duty Cycle.
7-025	Neubacher	VIP - FMEM & MIL v36.
7-025A	Mingo	VIP - Implement MIL using a single timer.
7-025B	Hughes	VIP - Apply 7-025 to 9X & GX Versions.
7-028	Neubacher	VIP - Include a bulb check with MIL.
7-028A	Mingo	VIP - Cancel bulb test when disableEOLT has been set.
7-029B	Ward	Set EGRACT to 0 when EGR is disabled.
7-087	Sass	VIP - New filter for ISC.
7-105	Sass	VIP - Use KIHP & GOOSW.
7-230	Mingo	VIP - Rewrite error codes & STO output for byte efficiency.
7-236	Pearson	S/W - Transfer between VAX/DEC-20.
7-243	Yagley	Use VSBAR to enter RPM Control.
7-245	Yagley	Use VSBAR to enter MFA Mode.
7-257	Sass	VIP - Protect against STI noise.
7-257A	Schumaker	VIP - Include 9X in EMR 7-257.
7-257B	Sass	VIP Documentation clarification of 7-257 & 7-257A.
7-261A	Harris	Clip KWUCTR to 255 in Warm_up logic.
7-286	Neubacher	VIP - Add MIL documentation.
7-286A	Neubacher	VIP - Revise MIL documentation.
7-305	Rachedi	VIP - Fix error code 33 at ALT.
7-305A	Mingo	VIP - Do not implement 7-305A for GX.
7-352A	Baltusis	Include GX in 7-352, Correct PE calculation.
7-378	Liller	S/W - TTBAR filter does not work if PFEHP = 1.
GXP0	GXQ0	
6-499A	Yagley	Clarify TIPFLG & CTFLG logic.
6-585	Zagheti	Bypass Knock Control Strategy.
6-585A	McIntee	Revise Knock detention logic.

6-585B	Baltusis	Add KIHP switch to bypass knock.
7-195	Yagley	Rename DISFLG to CIDHP.
7-198C	Dillon	Revise APT determination code.
7-238	Mazzara	S/W - Remove VERID.
7-255	Mortimer	S/W - Protect SPKAD register from noise.
7-261	Baltusis	Two Speed Adaptive Fuel Learning.
7-347	McIntee	S/W - Avoid ML3W instruction.
8-007	Hardy	S/W - Change CCDFLG to CCDSW in CCD logic.
GXO0	GXP0	
6-531	McIntee	S/W - Add overflow check in EGR Control algorithm.
6-724	Chupa	S/W - FKINJD effectiveness improvement.
7-094	Yagley	Implement AXOD strategy.
7-094A	Yagley	Revise LAMMUL logic for AXOD.
7-094C	Yagley	Revise AXOD.
7-094D	Ward	Add RATIV & NPSSW.
7-191A	Baltusis	Revise definitions in AXOD.
7-192	Yagley	Revise AXOD & Idle Speed.
7-194	Yagley	Define brake input logic.
7-206	Yagley	Add Torque Truncation Spark Retard.
7-215	Yagley	Revise Tip-in logic.
7-241	Baltusis	AXOD 3-4 upshift delay time.
7-246	Chupa	S/W - Proper update of SPKAD index register.
7-268	Baltusis	Revise scaling of TTNOV.
7-319	Dewey	S/W - Fix to BAPXFR.
8-010	Meshkinnafas	S/W - Correct scaling error in EGRDC calculation.
8-010A	Meshkinnafas	S/W - Overflow check in EGRDC calc.
8-011	Chupa	S/W - RPM Vector clip to 7600 RPM.
GXN0	GXO0	
6-431	Hardy	Delete IDMAX from Getfile.
7-117	Baltusis	Add FN306.
7-137A	Yagley	Support 3.8L FWD programs with EDF.
7-147	Yagley	Smooth trasition to MFA.
7-172	Baltusis	DAC total spark advance.
7-172A	Yagley	Revise range of SAFTOT.
7-174	Baltusis	Revise IPSIBR update logic.
7-197	Baltusis	Revise use idle adaptive cells.
7-197A	Taylor	Add Else condition to logic.
7-198	Baltusis	Remove LAMBSE reset from ISC.
7-198A	Baltusis	Set ISLAST before DSDRPM.
7-226	Dewey	Revise Mode select logic.
GXM0	GXN0	
7-090	Yagley	Add integrated VSC.
7-090A	Yagley	Revise VSC (include Hardware present sw).
7-09A	Yagley	Do VSC only if VSCHP = 1.

7-137	Yagley	Add 2-speed EDF.
7-140	Yagley	Revise VSC.
7-140B	Yagley	Use Rising edge of VS Sensor input.
7-140C	Maurer	Calculate speed after 2nd MPH transition.
7-251		S/W - Delete PIP_OK logic.
GXL0	GXM0	
6-642	Baltusis	Add Logic Switch to force NDSFLG.
6-670	Yagley	Revise DASHPOT preposition.
6-674	Yagley	Ensure Time delay in shutting off A/C.
6-675	Yagley	AETAR added.
6-678	Baltusis	Add conditions to clear latch.
6-689	Chupa	Correct underflow for tip-in.
6-689A	Chupa	Do 6-689.
7-089	Yagley	Do NOT open EGR unless DESEM>MINDES+DESHY.
7-089A	Yagley	Set CONPR = EPTBAR, if disabled or too low.
7-229	Meshkinafas	Save PE value.
GXK0	GXL0	
6-336	Pearson	Move calibration parameters.
6-425	Chupa	Correct Software error Re: Filter constant for NDBAR.
6-428	Pearson/Geer	Make (CHECKSUM) Uncommon.
6-574	McIntee	Revise injector output algorithm.
6-574A	McIntee	Change logcation of label Injector 400.
6-608	Hughes	Correct minor issue in throttle mode.
6-679	Yagley	Revise Region assignments to fit in memory.
6-709	Yagley	Reduce ambiguity of document and S/W.
6-700	Rein	Check all timect subroutine calls.
7-076	Yagley	Convert GX Stratvine to multi-cal.
7-168	Chupa	Move BP to external RAM.
7-179	Yagley	Assign Parameters to Regions.
7-202	Liller	Revise Non-signature mode to avoid two injectors firing on same PIP.
GXJ0	GXK0	
6-231	Heikkila	WCOTMR changed to ACWTMR.
6-240	Heikkila	Define WCOTMR where (TP-RATCH) is negative.
6-393	Yagley	Revise DOL ALGORITHM.
6-393A	McIntee/Yagley	Improve and simplify DOL algorithm.
6-434	Chupa	Revise/Clarify LAMBSE reset Logic.
6-486	Zaghati	Ramp decel fuel "SHUTOFF".
6-486A	Yagley	Define "DMIN"
6-486B	Zaghati	Allow decel S/O at commencement of decel.
6-547	McIntee	Fix Transient error in DOL calculation.
6-619	Yagley	Change Range - FN1124 TO 0-31.75.
6-620	Zaghati	Filter INJDLY before use in foreground.
6-645	McIntee	Eliminate extraneous type checks.
6-690	Chupa	Correction to clip logic - LAMSE2.
6-694	Chupa	Clip FN374 to min, not maximum.
7-010C	Armitage	Information EMR relating to FAM Logic.
7-103	Yagley	Incorporate FMEM strategy.

7-104	Yagley	Delete FN348A--Use FN348.
7-107	McIntee	Remove Asynchronous AE.
7-116	Yagley	Commonize low speed output EVR.
7-129	Yagley	Revise Closed Loop Fuel/Adaptive learning.
7-136	Yagley	Replace IDLTMR/CTNTMR with EXTMR.
7-143	Chupa	Free up unused RAM.
7-145	Yagley	Decrease EGR if in MFA MODE.
7-150	Velting	Store PHFDLT instead of DT12S/2 into HFDLTA.
7-156	Yagley	Provide Rich Open Loop LAMBSE.
GXI0	GXJ0	
6-140	Chupa	Modify Self-Test to avoid undesirable PW modifiers.
6-140A	Mortimer	Revision to 6-140.
6-140B	Chupa	Revision to 6-140.
6-432	Baltusis	Revise desired RPM and desired airflow calculations.
6-432A	Baltusis	Revise original ISC EMR.
6-432B	Baltusis	Correct ISFLAG logic.
6-432C	Baltusis	Change NDADLT to NDDELT.
6-495	Zaghati	Increase Repetition of FN367.
6-496	Zaghati	Increase Range of FN367.
6-545	Ratkowski	Eliminate use of ML3W.
6-583	Zaghati	Add Unique Spark adder in Neutral.
6-584	Zaghati	Unique Injection timing - Neutral.
6-588	Yagley	Open Loop Tip-in Retard permitted.
6-589	Baltusis	Revise DESMAF calculation.
6-589A	Baltusis	Rename FN018B to FN018 (ATMR3).
6-590	Baltusis	100% duty cycle to ISC actuator.
6-590A	Baltusis	Modify Reinit during Running.
6-590C	Yagley	First-RPM/STALLN Compare to set REFLG.
6-598	Zaghati	New timer to delay Rich Open Loop.
6-602	Yagley	Increase range of CTATMR.
6-610	Yagley	EGR disabled, set EM=0 if in RPM ISC control or FMEM extant.
6-635	Yagley	Revise Anticipatory FAM.
6-664	Chupa	Correct Canister Purge problem.
7-083	Yagley	Add Open Loop ability during Crowds.
7-114	Yagley	3 PIP intervals that limit RPM.
7-114A	Yagley	Shorten MINPIP to MNPIP.
7-120	Chupa	Change FN652A to Cal-Par.
7-131	Chupa	Change FN036 to Cal-Par.
GXH0	GXI0	
6-144A	Ward	Correct EPTZER input to EPTBAR.
6-615	Yagley	Delete ACCFLG = 1 in Closed Throttle.
6-646	Chupa	Define BG_Timer as Byte.
7-029A	Yagley	Define FKEACT.
7-054	Armitage	I/O definition to support 3.0L.
7-054A	Yagley	Clarify A/C-NDS input handling.
7-078	Yagley	Add inlet air control.
7-102	Dewey	Add Thermactor Option.

8-002	Allen	Add option to use distributorless Ignition, instead of Sig. PIP.
8-002A	Allen	Delete all ref. to SIGDC, if DISFLG = 1, then SIGPIP = 1.
GXG0	GXH0	
$5E-190	Sass	VIP - Word/byte efficiency.
$5E-190A	Sass	VIP - Thrift word/byte.
$5E-203	Sass	VIP - Insure ISC Precondition.
6-125	Davison	VIP - Add single EGO self-test.
6-125A	Davison	VIP - Revise 6-125.
6-133A	Davison	VIP - Show new Stereo-EGO terms.
6-148C	Rachedi	VIP - Upgrade PFE/EVR Self-Test.
6-152	Davison	VIP - Add Crossed-EGO check.
6-157	Davison	VIP - Add manufacturing test.
6-157A	Rachedi	VIP - Checksum to include 32K ROM.
6-157B	Rachedi	VIP - Commonize Veh and EED test.
6-157C	Rachedi	VIP - Instruction for STO "off"
6-224	Mingo	VIP - Revise Knock Window Routine.
6-229	Sweppy	VIP - Use FMEM.
6-245	Rachedi	VIP - Delete Transmission test, Add 6-246.
6-246	Krzyske	VIP - Revise Knock Test.
6-263	Mingo	VIP - Revision to implement 6-162.
6-270	Krzyske	VIP - Add Keypower circuit test.
6-275	Krzyske	VIP - Actuate EDF/HEDF outputs.
6-297	Sass	VIP - Re-enter KODO Self-test.
6-301	Sass	VIP - Revise KAMREF reference.
6-327	Sass	VIP - Obviate interference between STO/KTS.
6-331	Tedesco	VIP - Avoid Transient Fuel when in Self-Test.
6-347	Rachedi	VIP - New Fuel test for 2-EGO sys.
6-347A	Krzyske	VIP - Save Test time.
6-348	Rachedi	VIP - Add Air test for 2-EGO sys.
6-387	Krzyske	VIP - Documentation revision only.
6-388	Rachedi	VIP - Improved PIP and IDM Test.
6-388A	Rachedi	VIP - Revise PIP test.
6-388B	Harris	VIP - Revise PIP->IDM test logic.
6-388C	Rachedi	VIP - Revise PIP-IDM test.
6-388D	Rachedi	VIP - Correct continuous PIP/IDM.
6-400	Sass	VIP - Accomodate various air flows.
6-400B	Baltusis	VIP - Bypass 98% Duty Cycle clip.
6-400C	Mingo	VIP - Byte thrift, revise FLRNFG.
6-438	Girdis	VIP - Revise macros, ROM 1 and 2.
6-452	Krzyske	VIP - Delete ECT rationality.
6-460	Krzyske	VIP - Verify continuous codes-KAM.
6-460A	Neubacher	VIP - delete 3U strat. from 6-640.
6-463	Schumaker	VIP - 11 Byte thrift.
6-475	Rachedi	VIP - Revise SW documentation only.
6-476	Rachedi	VIP - Revise SW documentation only.
6-483	Krzyske	VIP - Resolve Multi-cal conflicts.
6-500	Mingo	VIP - EOL RAM test revision.

6-501	Mingo	VIP - Revise output circuit check.
6-501A	Mingo	VIP - Revise 6-501.
6-501B	Mingo	VIP - Revise Output circuit check.
6-517	Rachedi	VIP - New cylinder balance test.
6-517A	Rachedi	VIP - Revises 6-517.
6-517B	Rachedi	VIP - Avoid engine stall.
6-518	Mingo	VIP - Prevent false indications.
6-536	Mingo	VIP - Revise EVR Output circuit ck.
6-573	Rachedi	VIP - Calib. Capability for PSPS.
6-573A	Rachedi	VIP - Supercedes 6-573.
6-586	Sass	VIP - Extend KAM extension.
6-586A	Rachedi	VIP - Revise 6-586.
6-595	Rachedi	VIP - Commonize Goose.
6-599A	Krzyske	VIP - Prevent false error code 74.
6-599B	Krzyske	VIP - maintain flag naming con.
6-599C	Baltusis	VIP - BIHP specification.
6-612	Mingo	VIP - Revise Goose.
6-621	Pearson	VIP - Adjust MAPCNT.
6-627	Mingo	VIP - Create Mask of output state.
6-632	Krzyske	VIP - Code 33 revision.
6-646	Chupa	VIP - Define BG_Timer as Byte.
7-019A	Rachedi	VIP - Add PFE EGR test; delete AM1 and AM2; revise MAP sensor name.
7-073	Yagley	Rename EGRSW->PFEHP.
GXF0	GXG0	
6-419	Allen	Revise Signature PIP.
6-419A	Allen	Revise Switching in Spark logic between Single and Double Edge.
6-419C	Salamon	Use Tick values for SPKSWH/SPKSWL.
6-548	Allen	Revise Signature PIP.
7-052	Allen	Implement 6-419, 6-419A, 6-419C at same time as 6-548.
7-070	Liller	Revision to Injector pulse S/W.
7-071	Liller	Revise cranking fuel pulse S/W.
SCM-008	Gaynier	Eliminate use of nested "get files" in software routines.
GXE0	GXF0	
6-577	Liller	Revise PIP input processing mod.
6-597	McIntee	Revise Transient fuel.
6-601	Liller	Fix Injector Sync. Routine.
7-033	Allen	Add computer controlled dwell for Distributorless Ignition System.
7-033A	Allen	Revise 7-033.
7-033B	Allen	Make CCDFLG calibratible.
7-033C	Velting/Allen	Final revision/Documentation.
GXD0	GXE0	

6-414	Yagley	Revise TIP-in Retard.
6-414A	Yagley	Load hysteresis in CTFLAG.
6-455	Zaghati	Bypass MFA at altitude.
6-456	Zaghati	Time delay before upstream air in Decel. Delete unused timers.
6-456A	Yagley	Define HMCTM.
6-470A	Baltusis	Revise IVPWR to IIVPWR.
6-481	Yagley	Insert SIL Chapter.
6-499	Yagley	Revise Retard logic, clarify flags: TIPFLG and CTFLAG.
6-506	Yagley	Turn off fuel as RPM limiter.
6-508	Yagley	Delete ACDFLG, use ACCFLG.
6-541	Yagley	Revise Retard logic.
6-587	Liller	Add 3 levels to foreground.
7-055	Liller	Fix overflow in aircharge calc.
7-056	Liller	Correct Transient Fuel S/W.
SCM-006	Gaynier	V29, KAM_Qualify.
GXC0	GXD0	
6-164	Yagley	A/C status logic revision.
6-164A	Yagley	Further A/C status revision.
6-241	Armitage	ISC revisions.
6-278	Armitage	Add RPM Adder vs Act.
6-312	Zaghati/Armitage	Revise ISC Mode Select.
6-338	Bosley	ISCFLG redefined, SW.
6-377	Zaghati	VBAT Cal-Console Displayable.
6-389	Girdis	ISCDTY from Byte to Word.
6-441	Brelian	Remove All TSAD Strategy.
7-039	Liller	Remove Map usage from Sonic EGR.
7-040	Armitage	Add 6-164, 6-241, 6-441.
7-042	Liller	Correct Fuel sequencing.
GXB0	GXC0	
6-145	Hoen	Add Stereo EGO Adaptive Fuel Control re: open/closed loop.
6-145A	Yagley	Include Table, Row 7 Adaptive Fuel.
6-145B	Yagley	Revise Adaptive Documentation to match Code.
6-189	Baltusis	Revise Adaptive Fuel Learning Relating to ACT.
6-189B	Baltusis	Revise AFACT1/AFACT2 in Adaptive.
6-277	Zaghati	Lambda Resets/Jumpback only in Closed Loop.
6-311	Yagley	New DAC Register FAMREG.
6-324C	Yagley	If ISCKAM pass ISKSUM test, set ISKSUM = Sum of ISCKAM.
6-325	Yagley	Qualify EPTZER as KAM Parameter.
6-346	Hughes	Correct Stereo-Adaptive Code.
6-365	Jones	3-Byte Test to go in ROM.
6-367	Chupa	Correct Stereo Adaptive load of BIASCT.
6-375	Ward	Add enable interrupt to balance disable interrupt in CRANK.

6-394	McIntee	Move ECTCNT to External RAM.
6-405	Hardy	Delete header module from FCA.
6-433	Yagley	Canceled after execution of LAMBSE=LAMBSE-LMPJMP.
6-433A	Yagley	Cancel 6-433 - NO problem.
7-029	Yagley	Revised PFE Strategy.
7-032	Armitage	Use BIASCT instead of ASYBCT.
7-034	Armitage	Delete NDCT/NDLAM. Add FN371.
7-034A	Armitage	Modify Minimum Range for LAMMUL and FN371.
7-036	Liller	Remove Bad instruction clearing Simultaneous Flag too low RPM.
GXA0	GXB0	
6-033A	Yagley	Change EVR frequency.
6-204	Yagley	Add PFE EGR Control.
6-204A	Yagley	Use FN239 with Pressure/EGR Input, depending on EGRSW.
6-218	Yagley	Delete references to Non-existent flags.
6-324	Yagley	Add checksum to KAM qualification test during powerup.
6-324B	Yagley	Do not check KAM_ERROR flag during powerup KAM qualification.
6-380	Yagley	Do not reinitialize ISCKAM during KAM qualification.
SCM-001	Gaynier	Common Filter constant.
7-026	Gaynier	Change FKECT1 to FKECT.
MXG0	MXG3 GXA0	
5E-082	McLean	Supplement Dual-edge Spark Routine.
5E-082A	McLean	Delete Registers DIFF0 and DIFF1.
5E-187A	McLean	Delete Signat, MHPFD to .99.
5-306	Allen/McIntee	Correct value of ticks.
6-118	McLean	Improve Dynamic spark accuracy.
6-133	Gaynier	Remove reference to Left/Right with regard to Stereo EGO.
6-158	Baltusis	Withhold knock windows for WINCLD PIP Periods.
6-158A	Velting	Simplify and improve 6-158.
6-166	Yagley	Replace single injector slope with Dual slope and Fox Function.
6-184	Mazzara/McIntee	Remove PSTRUC counter.
6-195	Pearson	Ensure at least 10 usec wait.
NONE	Rutz	Commonize scheduler with CH.
6-217	Ratkowski	Confirm Calls to IN22 < .992 only, occur.
6-224	Mingo	Fix Single Knock Module EOS.
6-224A	Mingo	Correct Implementation of 6-224.
6-249	McIntee	Clear Simultaneous flag if PIP period indicates > 1953 RPM.
6-272	Velting	Revise Knock strategy to correct

		Knock window.
6-295	Zaghati	Make Individual cylinder Knock spark cal console.
6-341	Chupa	Correct Scaling in return of feedback bias from FN312A. Correct KAMREF.
6-343	McIntee	Correct software problemm in Transient Fuel.
6-344	Hughes	Correct Software problem for A/C Cutout.
6-363	Liller	Correct scaling error dual slope.
7-005	Gaynier/Armitage	Revise Fuel Control.
7-005A	""	Clarify APELOAD normalizing to be FN071A.
7-005B	""	Clarify/correct 7-005/7-005A.
7-005C	""	Modify cranking fuel logic to reference BP instead of MAP.
7-005D	""	Clarify intent of 7-005A re: FN071 and FN071A.
7-005E	""	Modify range/resolution specification for FN071 and FN071A.
7-006	Gaynier/Armitage	Revise spark control.
7-007	Gaynier	Define Knock Strategy (MAPPA v LOAD)
7-009	Gaynier	Revise Thermactor Strategy.
7-010	Gaynier	Revise Idle Speed Strategy.
7-010A	Armitage	Define Calibration parameters LOWLOD/ACLOD.
7-010B	Armitage	Define new FN820B,delete FN820A.
7-012	Gaynier	Control Supercharger Bypass.
7-014	Gaynier	Revise Timer control.
7-013	Gaynier/Armitage	Add/revise System Equations for Air and EGR Mass Flow rates.
7-013A	""	Replace Aircharge, new range for EM.
7-013B	""	Define AELOAD
7-013C	""	Modify Range/Resolution for EM/FN037.
7-017	Armitage	Revise Sonic EGR Control.
7-020	Armitage	Apply 6-166 to GX.
7-022	Armitage	Delete overdrive Strategy, delete THERMACTOR Pump Clutch.
7-024	Armitage	TAR conversion in software.

CHAPTER 2

SYMBOLOGY

INPUTS

The inputs to most logical operations will be conditional statements of the form:

X > Y

where, X is a variable (RAM), and Y is a calibration constant, fox function or table look-up, or a mathematical expression. In some cases, Y may also represent a variable.

Typically, six types of conditional statements will appear in the strategy logic diagrams. They are; X>Y, X<Y, X>OR=Y, X<OR=Y, X=Y, and XNOT=Y.

SYMBOL	MEANING
=	EQUAL TO
NOT=	NOT EQUAL TO
>	GREATER THAN
>OR=	GREATER THAN OR EQUAL TO
<	LESS THAN
<OR=	LESS THAN OR EQUAL TO

It should be noted that when the expression X>Y or X<Y is encountered, the conditional statement can be calibrated such that it will never be true, and the appropriate strategy action will never take place. For example, if the variable X has a range of 0 to 255, and the calibration constant in the logical statement, X>Y, is selected to be 255, the statement will always be false. This provides a means for calibrating out certain strategy functions.

When any conditional statement is true, the INPUT STATE to the logical operation is said to be 'TRUE', and is assigned a value of '1'. When the statement is false, the INPUT STATE is 'FALSE', and is assigned a value of '0'.

LOGICAL OPERATIONS

Two logical operations are used, the 'AND' gate and the 'OR' gate. An 'AND' gate is represented by the following symbol:

```
A ----|
      | AND--------| C
B ----|
```

where A and B are INPUT STATES and C is defined as the OUTPUT STATE of the logical 'AND' operation. The value of the OUTPUT STATE is a function of the INPUT STATES as shown in the following truth table:

AND GATE

INPUT STATE A	INPUT STATE B	OUTPUT STATE C
0	0	0
0	1	0
1	0	0
1	1	1

Likewise, the 'OR' gate is represented by:

```
A ----|
      | OR--------| C
B ----|
```

And the OUTPUT STATE for various INPUT STATES is given by the 'OR' truth table:

OR GATE

INPUT STATE A	INPUT STATE B	OUTPUT STATE C
0	0	0
0	1	1
1	0	1
1	1	1

OUTPUTS

The output of all logical operations results in one of two possible paths:

1) The output is an input to another logical operation.

```
A ----|
      | AND--- C ---|
B ----|             | OR--------| E
D ------------------|
```

In this case, OUTPUT STATE C is an input to an 'OR' gate. It should be treated like any other conditional statement when determining the value of the final OUTPUT STATE E.

2) ACTION is taken based upon the OUTPUT STATE.

```
A ----|
      | AND--- C ---| ENERGIZE OUTPUT
B ----|             |
                    | --- ELSE ---
                    |
                    | DE-ENERGIZE OUTPUT
```

The ACTION described in the action box is taken when OUTPUT STATE C is 'true'. If an ALTERNATE ACTION is required when OUTPUT STATE C is 'false', the alternate action is described below an ELSE statement in the action box. If no alternate action is required, no ELSE statement will appear.

Multiple "ELSE/ACTION" blocks can appear in a logic diagram in which three or more alternate actions are possible. Consider the following example:

```
A ----|
      | AND--- C ---| ACTION #1
B ----|             |
                    |
                    | --- ELSE ---
                    |
D ----|             |
      | AND--- F ---| ACTION #2
E ----|             |
                    |
                    | --- ELSE ---
                    |
                    |
                    | ACTION #3
```

The procedure is:

1. Test for ACTION #1. If "C" is true, perform ACTION #1.
2. Otherwise, test for ACTION #2. If "F" is true, perform ACTION #2.
3. Otherwise, perform ACTION #3.

Notes about multiple "ELSE/ACTION" logic:

1. When logic has multiple "ELSE/ACTION" blocks, only one action block can be performed during a program pass. Priority is always top down. In the example, if "C" and "F" are simultaneously true, "C" takes precedence and ACTION #1 is performed.

2. If the final "ELSE/ACTION" block does not have logic as input pointing to it (as in the example), the final action block is performed when no preceeding action block is true. Action is always performed during each program pass with this type of logic.

3. If the final "ELSE/ACTION" block has logic as input pointing to it, the final action block is performed only when no preceeding action block is true and when its input logic is true. Action is not always performed during each program pass with this type of logic.

HYSTERESIS

Hysteresis in a strategy is a situation in which the logic used to make an output true is different from the logic used to make the output false. An example use would be to prevent on/off cycling of an output because of jitter in an input parameter.

Hysteresis is represented in strategy logic diagrams using the following "flip-flop" notation:

```
A ----| S   Q --------| C
      |
B ----| C
```

The actual conditional statements and direction of hysteresis will depend upon the specific application in each strategy module. The action of this hysteresis notation is given by the following truth table:

HYSTERESIS FLIP-FLOP

S(SET) A	C(CLEAR) B	Q-OUTPUT C
0	0	no change
0	1	0
1	0	1
1	1	1

The action of the flip-flop can be described as follows. When the "A" (set)input is true, regardless of the "B" (clear) input level, the flip-flop sets and the "C" output is true. When the "B" input is true and the "A" input is false, the flip-flop clears and the "C" output is false. When "A" and "B" are both false, the "C" output remains unchanged.

ADVICE:

1. Since the intent of a flip-flop is to provide hysteresis, the state of a flip-flop must be remembered from pass to pass. The output is usually defined as a flag.

2. All flip-flops must be serviced every pass through the program, even though some flip-flops are shown in portions of logic that may not execute each pass. The normal practice is to lump and service the flip-flops together at the beginning of a routine. This guarantees that all flip-flop outputs will reflect the correct state based on current input conditions. Then, when logic refers to a flip-flop, the logic only needs to look at the flag which represents the state of the flip-flop.

3. Clear (0) is the default initial value of the output flag for a flip-flop. The strategy specification must explicitly state if the initial value should be set (1).

4. The set input always takes precedence over the clear input. When both are true, the flip-flop output should set. In some instances, the software practice has been to perform the clear logic first, followed by the set logic. The procedure may initially clear the flag and then reverse the decision later. This practice could cause problems if the flip-flop output flag is tested during an EOS interrupt because the EOS can catch the flag in the wrong state.

    The flip-flop procedure should always be:

```
IF set condition met
     THEN set flip-flop output flag
ELSE
     IF clear condition met
          THEN clear flip-flop output flag
     ENDIF
ENDIF
```

CHAPTER 3

EEC OVERVIEW

ELECTRONIC ENGINE CONTROL SYSTEM OVERVIEW

The Electronic Engine Control system is intended to provide a more optimum engine control strategy than is possible through a strictly mechanical system. This is accomplished by using a microprocessor which interprets input data from a number of engine parameter sensors, and based on a control strategy in the microprocessor's program chips, generates output control signals to a number of actuators.

The control strategy is divided into two segments, an engine control strategy, and self test diagnostics. The diagnostics will be discussed in another section. The engine control strategy is segmented into three principal modes:

-CRANK
-UNDERSPEED
-RUN

The strategy description and the entrance and exit conditions for CRANK/UNDERSPEED/RUN are shown on the following pages. RUN is of particular interest because it contains the control logic for most engine operating regions. The RUN strategy is further broken down into three modes to facilitate optimum control. Based primarily on throttle position, they are:

-CLOSED THROTTLE
-PART THROTTLE
-WIDE OPEN THROTTLE

The specific entrance and exit conditions for these modes are described in the throttle mode selection section.

AIR MANAGEMENT 1 (AM1) (SFI-MA2)

This Software output controls (via software) a Thermactor Air Bypass (TAB) valve; via a vacuum solenoid. When AM1 is OFF, the air is bypassed (dumped to the atmosphere). When AM1 is ON air is routed to an up/down-stream valve.

AIR MANAGEMENT 2 (AM2) (SFI-MA2)

This Software output controls a vacuum solenoid which controls the secondary air system to a catalyst via an up/down-stream divertor valve (TAD); but this output only controls if AM1 output is ON.

CANISTER PURGE (CANP)

This software controls a solenoid which purges fuel vapor from a carbon canister. The carbon canister collects fuel vapor when the engine is off.

DATA OUTPUT LINK (DOL)

This software generates a digital signal to one of the Economy Display Subsystems: Tripminder, Fuel Economy Meter Clock, etcetera). This displays such information as current Miles per Gallon to the driver.

ELECTRO-DRIVE FAN (EDF) (SFI-MA3)

The Software Output provides a signal for the AC/Electro-drive Fan Controller to control the Electro drive engine cooling fan.

ELECTRONIC VACUUM REGULATOR (EVR)

This software output controls a solenoid which varies the vacuum to the EGR valve via a varying frequency and/or duty cycle pulse train to the regulator. The Actuator contains a clamping diode which eliminates the need for a diode in the control module.

FUEL PUMP (FP)

The software for the Fuel Pump controls a relay which provides power to operate the electric fuel pump.

HIGH SPEED ELECTRO-DRIVE FAN (HEDF) (SFI-MA3)

This software output provides a signal for the AC/Electro-Drive fan which, in turn, increases the speed of a two-speed electro-drive fan when required via a normally open relay or an integrated relay controller module.

IAC (SFI-MA3)

The Inlet Air Control opens a valve (upstream of the intake manifold) which increases the engine airflow. The Engine strategy uses this valve to increase the horsepower at high RPM.

INJECTORS

The Sequential Fuel Injection system uses one output driver per injector (as compared to the EFI systems which have two or more injectors controlled by each driver). The SFI system provides more precise timing and duration of

the fuel injection. As most EFI systems, SFI uses High Resistance (16 Ohms) high pressure (39 psi) injectors.

IDLE SPEED CONTROL - BYPASS AIR - CONSTANT CURRENT (ISC-BPA)

The EEC controls a linear actuator which varies air intake (from 0 to maximum) through a bypass valve in the throttle body. The software outputs a duty-cycled pulse train which is coverted into a constant current. This output is cycled at a frequency of 160 Hz.

LOCK-UP SOLENOID (LUS) (SFI-MA3)

This software output controls the lock-up of the AXOD transmission convertor via a solenoid.

SUPERCHARGER BOOST SOLENOID (SBS) (SFI-MA1)

This software output provides a signal to the supercharger boost solenoid. The signal can be used in a linear manner (varying frequency and duty cycle) to control the position of the supercharger boost bypass valve. While the system is in HLOS, the Boost Solenoid is in the OFF (de-activated) condition.

SPEED CONTROL VACUUM (SCVAC) (SFI-MA3)

This software controls a normally-closed solenoid which applies a vacuum to the Speed Control Servo. If the SCVNT valve is closed, the state of the SCVAC controls the position of the Speed Control Servo.

SPEED CONTROL VENT (SCVNT)

This software controls a normally open solenoid which traps (closes) or vents (opens) a vacuum to the speed ControlServo.

SHIFT INDICATOR LIGHT (SIL) (SFI-MA1)

This output is used to drive a lamp on the instrument panel to signal the driver to shift gears (manual transmission only) at an optimum point determined by the strategy.

SPARK OUTPUT (SPOUT)

The Spark software generates an ignition control signal capable of driving the Thick Film Ignition Module (TFI). The driver is a tri-state device (High, low, open) which interfaces with the TFI-IV module (This Module can accomodate a 250 Hz/sec acceleration). The spout signal is referenced to the PIP signal. Its timing is controlled by the SAF calculation. If the EEC is in LOS mode, the TFI module causes the spark timing to be equal to 10 deg BTC (same as PIP).

WIDE OPEN THROTTLE AIR CONDITION CUTOFF (WAC)

This output is used to temporarily disable or turn off the air-conditioning by activating a normally closed relay.

The remainder of this document describes the normal engine control strategy (RUN) for the various outputs, including fuel, spark, EGR, thermactor air, and idle speed control (ISC).

CHAPTER 4

CRANK/UNDERSPEED/RUN MODE SELECTION STRATEGY

OVERVIEW

The EEC IV strategy operation is divided into three distinct strategy segments. They are:

1) CRANK
2) UNDERSPEED
3) RUN

The CRANK mode is entered after a power-up initialization or after an engine stall. CRANK employs a special strategy to aid engine starting. When the CRANK logic first becomes false, the UNDERSPEED mode is entered. The UNDERSPEED mode employs a special spark and fuel strategy in place of the normal engine control strategy (RUN). After start, the RUN mode is entered and the normal engine control strategy is executed. If the engine stumbles during RUN mode, the UNDERSPEED mode can again be entered to help recover from the stumble and prevent a stall.

The specific strategies are:

CRANK STRATEGY

Fuel	Fire all injector ports simultaneously every CRKPIP PIPS. See the Fuel strategy.
Spark Advance	10 degrees BTDC (on PIP signal)
Thermactor Air	bypass
EGR	disabled
Purge	disabled
ISC	FN884(TCSTRT)
Data Output Link	execute strategy
A/C Clutch	disabled
S.I.L.	disabled
Thermactor Pump Clutch	disabled

UNDERSPEED STRATEGY

Fuel	Fire all injector ports in the same manner as in the RUN mode. The multiplier FN387 is included in the pulsewidth equation. See the Fuel strategy.
Spark Advance	10 degrees BTDC (on PIP signal)

Other outputs are the same as the RUN mode.

RUN STRATEGY

The normal engine control strategy is described in the remainder of this book.

DEFINITIONS

INPUTS

Registers:

- ECTCNT = Number of times ECT sensor input was read.

- N = Engine RPM.
- PIPCNT = Number of PIPs which have occurred.
- STALLN = Stall RPM: If the first RPM calculated is greater than this value, assume there was a reinit, RPM.
- TSLPIP = Time since last PIP.

Bit Flags:

- CRKFLG = Engine Mode Flag. (1 = Crank Mode; 0 NOT= Crank Mode)

Calibration Constants:

- CRKPIP = Number of PIPs between injector outputs during Crank.
- FN387 = Fuelpw Multiplier versus ECT - Input = ECT, Output = Multiplier.
- FN884(TCSTRT) = ISC Duty Cycle in Crank, deg.
- NCNT = Minimum number of PIP necessary to exit CRANK Mode.
- NRUN = Minimum Engine Speed to exit CRANK Mode.
- NSTALL = Engine Stall speed to re-enter CRANK Mode.
- UNRPM = Underspeed Engine Speed, RPM.
- UNRPMH = Hysteresis term for UNDERSPEED Mode.

OUTPUTS

Registers:

- N = See inputs above.

Bit Flags:

- CRKFLG = See inputs above.
- FIRST_PIP = Indicates that first PIP has been received.
- UNDSP = Run/Underspeed Flag. (1 = Underspeed (or CRANK), 0 = Run)

CRANK/UNDERSPEED/RUN MODE SELECTION - GUF0

The Crank Flag is set by the PIP Counter and ECT Counter Control logic which is described in SYSTEMS EQUATIONS CHAPTER.

PROCESS

```
CRKFLG = 1 -------------------|
 (CRANK mode)                 |
                              |AND -------------| CRANK mode
N <OR= NRUN --------|         |                 | CRKFLG = 1
                    |         |                 | UNDSP = 1
ECTCNT < 8 ---------|OR ------|                 |
                    |                           | --- ELSE ---
PIPCNT < NCNT ------|                           |
                                                | A stall has occured
                                                |
CRKFLG = 0 -------------------|                 | CRKFLG = 1
 (RUN or UNDERSPEED mode)     |                 | UNDSP = 1
                              |AND -------------| ECTCNT = 0
N < NSTALL -------------------|                 |
                                                |
                                                | --- ELSE ---
                                                |
CRKFLG = 1 ---------|                           |
                    |OR ------|S Q -------------| UNDERSPEED mode
N < UNRPM ----------|         |                 | CRKFLG = 0
                              |                 | UNDSP = 1
N > UNRPM + UNRPMH -----------|C                |
                                                |
                                                |
                                                | --- ELSE ---
                                                |
                                                | RUN mode
                                                | CRKFLG = 0
                                                | UNDSP = 0
```

ENGINE RUNNING REINIT STRATEGY

The reinit strategy attempts to differentiate an engine running reinit from a normal start engine runup. After a reinit, a "first RPM" is calculated from the first two PIP rising-edges. If the calculated RPM is greater than idle RPM, then a reinit is assumed.

```
TSLPIP >or= 800 msec ---------------------| Set N = 0
                                          | Set FIRST_PIP = 0
```

CHAPTER 5

THROTTLE MODE SELECTION STRATEGY

THROTTLE MODE SELECTION STRATEGY

OVERVIEW

The throttle mode scheduler is used to determine what engine operating region is currently extant. The variable APT (At Part Throttle flag) is used to indicate throttle mode and is assigned the following values:

Throttle Mode	APT
CLOSED THROTTLE	-1
PART THROTTLE	0
WIDE OPEN THROTTLE	1

The value of APT is determined by the logic shown on the following page. Briefly, throttle angle breakpoints, in terms of counts, are used to define the CLOSED/PART_THROTTLE and PART/WIDE_OPEN_THROTTLE transitions. Hysteresis is incorporated in both breakpoints to prevent jitter between modes.

The variable RATCH is the output of a ratchet algorithm which continuously seeks the minimum throttle angle corresponding to a CLOSED THROTTLE position. This alleviates the necessity to set the throttle position sensor at an absolute position and compensates for system changes and differences between vehicles. The ratchet algorithm uses filtered throttle position for the determination of RATCH.

A more detailed explanation of the throttle position ratchets and throttle position filter is contained in the SYSTEM EQUATIONS section.

DEFINITIONS

INPUTS

Registers:

- APT = Status of Part Throttle. (Set = -1 = Closed Throttle) (Set = 1 = Wide Open Throttle) (Set = 0 = Part Throttle)
- RATCH = Closed throttle.
- TP = Position of Throttle.

Bit Flag:

- CRKFLG = Flag indicating engine mode; 1 = Crank.

Calibration Constants:

- DELTA = CT/PT Breakpoint value above RATCH.
- HYST2 = Hysteresis term to enter WOT mode.
- THBP2 = PT/WOT Breakpoint value above RATCH.

OUTPUTS

Registers:

- APT = See inputs above.

Bit Flags:

- CTPTFG = Closed throttle to PT/WOT transition flag.
- PTSCR = Part throttle mode since exiting CRANK Flag.

THROTTLE MODE SELECTION LOGIC

The logic described below considers the current position of the throttle and compares its value to the RATCH, Closed Throttle, plus the change in throttle position from the last setting. If both flip-flops in the logic clear, then Part Throttle is set.

PROCESS

```
TP <OR= RATCH + DELTA ---------------|S  Q -| Closed Throttle mode
                                     |      | APT = -1
TP <OR=  RATCH + DELTA + HYST2 ------|C     |
                                            | --- ELSE ---
                                            |
                                            |
TP > (RATCH+THBP2+HYST2) -|S  Q ------------| Wide Open Throttle
                          |                 | mode
TP <OR= (RATCH + THBP2) --|C                | APT = 1
                                            |
                                            | --- ELSE ---
                                            |
                                            | Part Throttle Mode

                                            | APT = 0
```

NOTE: PTSCR is initialized to 0.

```
previous APT = -1 ------------|
                              |
current APT NOT= -1 ----------|AND ---------| Set CTPTFG = 1
                              |             | Closed Throttle to
CRKFLG = 1 -------------------|             | Part Throttle transition
                                            |
                                            | --- ELSE ---
previous APT = -1 ------------|             |
                              |             |
current APT NOT= -1 ----------|AND ---------| Set CTPTFG = 1
                              |             | Closed Throttle to
CRKFLG = 0 -------------------|             | Part Throttle transition
                                            | Set PTSCR = 1
                                            |
                                            | --- ELSE ---
                                            |
                                            | Set CTPTFG = 0
```

CHAPTER 6

FUEL CONTROL STRATEGY

EEC-IV FUEL CONTROL STRATEGY OVERVIEW

DEFINITIONS

INPUTS

Registers:

- AMPEM = Air mass flow plus EGR mass flow.

- CLFLG = Register that is used solely to indicate fuel mode. (1 = Closed Loop, 0 = Open Loop)

- EFTR = Transient Fuel Compensation fuel flow, lb/sec.

- EM = EGR mass flow.

- FM = Fuel mass flow.

- LAMBSE1 and LAMBSE2 = Desired equivalence ratios.

Calibration Constants:

- ENGCYL = Number of cylinders per engine revolution (NUMCYL/2); or number of PIPs per engine revolution.

- FN1327 = Fuel pulsewidth register map; used to determine which fuel register is used.
Output = Fuel Register-left offset.
X-input = Injector Output Number
Y-input = Null.

- LAMMAX = Maximum LAMBSE Clip when in Closed Loop.

- LAMMIN = Minimum LAMBSE clip when in Closed Loop.

- NUMCYL = Number of cylinders in the engine.

- NUMEGO = Calibration switch indicating number of Ego Sensors. 1=mono; 2=stereo.

OUTPUTS

Registers:

- AEFUEL = Acceleration enrichment desired fuel flow rate (lb/min).
- AM = Air mass flow.
- BASEFF1 = EGO-1 base fuel flow in Lb/Min.
- BASEFF2 = EGO-2 base fuel flow in Lb/Min.
- BASEFFT = Total base fuel flow in Lb/Min.
- CLFLG = Register that is used solely to indicate fuel mode. (1 = Closed Loop, 0 = Open Loop)
- DSLMBS1 = Rescaled LAMBSE1 used for DAC'ing stereo EGO.
- DSLMBS2 = Rescaled LAMBSE2 used for DAC'ing mono EGO.
- EFTRFF = Equilibrium fuel transfer rate for transient fuel compensation (lb/min).
- FM = Fuel mass flow.
- LAMBDA = Air/fuel equivalence ratio.

SEQUENTIAL ELECTRONIC FUEL INJECTION (SEFI)

The A/F ratio control actuators consist of injectors whose fuel metering function is affected by energizing and de-energizing the injector solenoids.

Each injector has a metering needle or pintle which opens or closes the injector nozzle to release fuel.

A high pressure fuel pump delivers fuel to the injectors at approximately 42 PSI.

Based upon the calculated air mass value, the software calculates the injector pulsewidths required to give the desired A/F ratio.

The desired A/F ratio for all operating conditions is determined by the A/F strategy and calibration.

The strategy is designed to handle any reasonable injector configuration and firing patterns.
Example configurations are:

1. 1 or 2 output CFI
2. 1 or 2 output bank EFI
3. 4, 6 or 8 output Sequential EFI

The strategy can run on 4, 6 or 8-cylinder engines. The calibration parameters ENGCYL and NUMCYL control the engine type. The user must set both parameters for the strategy to work correctly.

On SEFI applications, each cylinder has an injector located in the intake port near the intake valve. The injectors are individually fired in an order that matches the firing order of the engine. The injector output numbers correspond to engine cylinder numbers. This allows for consistent nomenclature for the module pinouts and the wiring harness. Under normal engine running, each injection is timed to occur at an optimum point in the intake event. Injector timing is determined by strategy and calibration.

Timed sequential fuel injection requires a signature PIP distributor. The signature PIP allows the computer to identify cylinder #1. The PIP signal for cylinder #1 has a unique duty cycle, that is smaller than the normal 50% duty cycle. The computer recognizes the signature PIP to synchronize the fuel injections.

STEREO EGO FUEL SYSTEM CONFIGURATION

The following Side 1 and Side 2 designations are used.

```
|                                                       |
|                                                       |
|                                                       |
|       EGO SENSOR ----- E     E ----- EGO SENSOR       |
|       EGO-1                             EGO-2         |
|       HEGO-1                            HEGO-2        |
|                                                       |
|                                                       |
|                                                       |
|                        -------                        |
|                       | I   I |                       |
| SIDE 1 INJECTORS -->  | I   I |  <-- SIDE 2 INJECTORS|
|                       | I   I |                       |
|                    #1 | I   I |                       |
|                        -------                        |
|                                                       |
|                                                       |
|                                                       |
|                                                       |
|                                                       |
\_______________________________________________________/
```

FRONT OF VEHICLE
(TOP VIEW)

NUMEGO

A calibration switch exists which is used to tell the computer how many EGO sensors are present. If NUMEGO = 1, the system is treated as a mono EGO sensor system and all fuel pulsewidths are calculated from the single EGO sensor (treated as EGO-1). If NUMEGO = 2: Fuel pulsewidths for the EGO-2 injectors are calculated from EGO-2 sensor information; Fuel pulsewidths for the EGO-1 injectors are calculated from EGO-1 sensor information. FN1327 links the injector outputs to the appropriate EGO sensor.

***** NOTE *****

Lambdas are used for all A/F calibration parameters.

Lambda is defined as:

AM/(14.64*FM) = (AMPEM - EM)/(14.64*FM)

LAMBDA CLIPS

LAMBSE1 and LAMBSE2 (the desired equivalence ratios) are clipped as shown below:

```
CLOSED LOOP FUEL CONTROL -------------| CLIP LAMBSE1 AND
                                      | LAMBSE2 BETWEEN
                                      | LAMMIN AND LAMMAX
                                      |
                                      | --- ELSE ---
                                      |
                                      | CLIP LAMBSE1 AND
                                      | LAMBSE2 BETWEEN
                                      | 0.0000305 AND
                                      | 1.9999695
```

****

SPECIAL DAC REGISTERS

Special registers have been added to assist in calibration development by increasing the resolution of key parameters for display purposes.

DSLMBS1 and DSLMBS2 are calculated as shown:

DSLMBS1 = LAMBSE1 - 1.0

DSLMBS2 = LAMBSE2 - 1.0

Because DSLMBS1 and DSLMBS2 are signed word quantities, a value of zero will be output as 5 volts.

CLFLG is the Closed Loop flag (if set to 1, fuel mode is closed loop).

All fuel flow registers have Lb/Min units for easy display and comparisons. They are: BASEFF1 (EGO-1 base fuel flow), BASEFF2 (EGO-2 base fuel flow), BASEFFT (total base fuel flow), AEFUEL (acceleration enrichment desired fuel flow rate) and EFTRFF (equilibrium fuel transfer rate for transient fuel compensation); all units are lb/min.

FUEL CONTROL STRATEGY is divided into 2 mutually exclusive modes:

OPEN LOOP
CLOSED LOOP

OPEN LOOP MODE

During open loop operation, the computer calculates the injector fuel pulsewidths required to provide a pre-determined A/F ratio or lambda value. The desired lambda values (LAMBSE1, LAMBSE2) can vary with engine operating conditions and are calibration-dependent. During open loop, LAMBSE1 equals LAMBSE2.

CLOSED LOOP MODE

During closed loop operation, the computer ramps the desired lambda values (LAMBSE1, LAMBSE2) in a limit cycle manner about stoichiometry. Using the EGO (Exhaust Gas Oxygen) sensor, the computer increases or decreases lambda at a calculated rate of change. The rate at which lambda changes is calibration dependent. For Stereo EGO operation, LAMBSE1 and LAMBSE2 vary independently using EGO-1 and EGO-2 sensors. For Mono EGO operation, LAMBSE1 equals LAMBSE2.

DEFINITIONS
INPUTS
Registers:

- ATMR1 = Time since start (time since exiting crank mode), sec.

- ATMR2 = Time since ECT became greater than TEMPFB, sec.

- CTNTMR = Closed throttle neutral timer.

- EGOSSS = EGO switches since start.

- HLTMR = High Load Timer, sec.

- LOAD = Universal Load parameter, unitless.
  = Aircharge normalized to Sea Level.

- NACTMR = Time not at Closed throttle, sec.

- PERLOAD = Percent of Peak LOAD at any altitude, unitless.

- PPCTR = PIP counter for Fuel Ramp, unitless.

- TCSTRT = Temperature of ECT at Cold Startup, deg F.

Bit Flags:

- CHKAIR = Thermactor Status flag.

- HSPFLG = High Speed Mode Flag; 1 = High speed alternate Fuel/Spark.

- MFAFLG = Managed Fuel/Air State flag.

- NDSFLG = Flag = 0 if transmission in neutral; = 1 if in gear.

- WMEGOL = WRMEGO was 1 at least once.

- WRMEGO = EGO sensor should be warm flag.

Calibration Constants:

- CTHIGH = Hot Start Minimum Engine coolant Temperature, Deg F.
- CTLOW = Cold Start Maximum ECT, deg F.
- EGOCL1 = Number of EGO switches since start required to set WRMEGO = 1.
- FN320A(ECT) = Upper PERLOAD Limit for Closed Loop fuel control, unitless.

- HLCTM = Time delay before high load forced open loop, sec.
- HLODH = Hysteresis term for FN320A(ECT), unitless.
- LOLOD = Minimum LOAD to enter Closed Loop, unitless.
- LOLODH = Closed Loop Enable LOAD hysteresis.
- MFASW = Calibratible switch, which if set, indicates Managed Fuel Air logic is being used.
- NIOLD = Maximum time to allow closed loop fuel if in neutral at idle, secs.
- OPCLT1 = ATMR1 Closed Loop enable time delay for TCSTRT <or= CTLOW.
- OPCLT2 = ATMR1 Closed Loop enable time delay for CTLOW < TCSTRT < CTHIGH.
- OPCLT3 = ATMR1 Closed Loop Enable Time delay for TCSTRT >or= CTHIGH.
- OPCLT4 = ATMR2 Closed Loop enable time delay for TCSTRT <or= CTLOW.
- OPCLT5 = ATMR2 Closed Loop Enable Time Delay for CTLOW < TCSTRT < CTHIGH.
- PIPNUM = Number of steps to Ramp Fuel, unitless.
- THBP5 = Throttle breakpoint above RATCH for Open Loop Fuel, counts.

OUTPUTS

Registers:

- CLFLG = Register that is used solely to indicate fuel mode. 1 = Closed loop; 0 = Open loop
- EGOSSS = See Inputs above.

Bit Flags:

- NFLG = Neutral idle flag.
- OLFLG = Flag indicating Open loop if set (1); indicating Closed loop if cleared (0).
- WMEGOL = WRMEGO was 1 at least once.
- WRMEGO = EGO sensor should be warm flag.

PROCESS

```
APT = 0 -----------------|
                         |OR -------|
CTNTMR <OR= NIOLD -------|          |
                                    |
WRMEGO = 1 -------------------------|
 (SEE BELOW)                        |
                                    |
CHKAIR = 1 -------------------------|AND -----| CLOSED LOOP
 (USE INDEX)                        |         | CLEAR OLFLG = 0
                                    |         | SET CLFLG = 1
                                    |         |
PPCTR = PIPNUM ---------------------|         | --- ELSE ---
                                    |         |
                                    |         | OPEN LOOP
MFAFLG = 0 ---------------|         |         | SET OLFLG = 1
 (USE INDEX)              |         |         | CLEAR CLFLG = 0
                          |OR ------|
MFASW = 0 ----------------|         |
 (USE INDEX)                        |
                                    |
HSPFLG = 0 -------------------------|
 (NOT in High Speed Open Loop)      |
                                    |
LOAD > LOLOD ----------|S Q---------|
                       |            |
LOAD < LOLOD - LOLODH -|C           |
                                    |
HLTMR <OR= HLCTM -------------|     |
                              |OR --|
PERLOAD < FN320A(ECT) ---|S Q-|     |
                         |          |
PERLOAD > FN320A(ECT) ---|          |
          + HLODH                   |
                                    |
TP <OR= (RATCH + THBP5) -|S Q ------|
                         |          |
TP > (RATCH+THBP5+HYST2)-|          |
                                    |
LDFLG = 0 --------------------------|
 (NOT IN LUGGING MODE)
```

WRMEGO LOGIC

```
TCSTRT >OR= CTHIGH ------------|
                               |AND ---|
ATMR1 >OR= OPCLT3 -------------|       |
                                       |
CTLOW < TCSTRT < CTHIGH -------|       |
                               |AND ---|OR --|
ATMR1 >OR= OPCLT2 -----|       |       |     |
                       |AND ---|       |     |
ATMR2 >OR= OPCLT5 -----|               |     |
                                       |     |
TCSTRT <OR= CTLOW -------------|       |     |AND --| Set WRMEGO = 1
                               |AND ---|     |      | Set WMEGOL = 1
ATMR1 >OR= OPCLT1 -----|       |             |
                       |AND ---|             |
ATMR2 >OR= OPCLT4 -----|                     |
                                             |
EGOSSS >OR= EGOCL1 --------------------------|
```

EGOSSS LOGIC

```
EGO_SWITCH -------------------| INCREMENT EGOSSS (CLIP AT 255)
                              |
                              | --- ELSE ---
                              |
                              | FREEZE EGOSSS
```

NFLG LOGIC

```
APT = -1 (CLOSED THROTTLE) ----|
                               |AND ---| SET NFLG = 1
                               |       |
NDSFLG = 0 (NEUTRAL) ----------|       | --- ELSE ---
                                       |
                                       | SET NFLG = 0
```

DEFINITIONS

INPUTS

Registers:

- APT = At Part Throttle. -1 = Closed throttle; 0 = Part throttle; 1 = Wide Open throttle.
- ATMR1 = Time since start (time since exiting crank mode), sec.
- LAMBSE2 = Desired open loop (or closed loop) equivalence ratio for EGO-2 injectors. LAMBSE2 appears in the fuel pulsewidth equation for EGO-2.
- LAMMUL = Multiplier which is used to prevent cold-engine stalls following transmission engagement.
- MFAMUL = MFA table ramp-in Multiplier, unitless.
- MULTMR = Time since incrementing LAMMUL, sec.
- PERLOAD = Percent of peak LOAD at any altitude.
- TCSTRT = Temperature of ECT at Cold Start, deg F.

Bit Flags:

- DNDSUP = Drive Neutral select.
- HSPFLG = High speed mode flag; 1 = High Speed alternate fuel/spark.
- IDLFLG = Flag indicating transmission in Drive and at Idle.
- LDFLG = "Lugging" mode open loop flag.
- MFAFLG = Managed Fuel/Air State flag.
- NDSFLG = Flag = 0 if transmission in Neutral; = 1 if in gear.
- NEUFLG = N/D transition occurred.
- NFLG = Neutral Idle Flag.
- OLFLG = Flag indicating Open loop if set = 1; Closed loop if set = 0.
- WMEGOL = Flag set if WRMEGO set.
- WRMEGO = If set, EGO sensor should be warm and flag set to 1 if EGO sensor is switching; and reset to 0 if it has cooled down. Its state is controlled by the WRMEGO logic.

Calibration Constants:

- CTHIN = Maximum TCSTRT value to use NUMPR.
- CTLOW = Cold Start Maximum ECT, deg F.
- FN022B = Temperature normalizing function; used for table lookup.
  Input = FRCBFT *ACT + (1-FRCBFT) * ECT
  --OR--
  Input = FRCSFT * ACT + (1-FRCSFT) * ECT
- FN035(N) = Maximum LOAD at sea level (29.4 dry barometer, 100 deg. f) Input = N (RPM).
- FN072A = PERLOAD normalizing function; used for table lookup.
  Input = PERLOAD and Output = Normalized perload.
- FN082 = Load normalizing function; generates table entry point. Input = LOAD and Output = Normalized Load.
- FN083 = RPM normalizing function; generates table entry point. Input = N and Output = Normalized N.
- FN300 = Multiplier as a function of ACT, modifies FN1305.
- FN301 = Closed Throttle Open Loop Fuel Multiplier as a function of RPM.
- FN301N = Neutral Open Loop Fuel Multiplier as a function of engine speed N.
- FN303 = WOT Fuel Multiplier as a function of engine speed N.
- FN308 = Sea level fuel multiplier, RPM.
- FN309 = Altitude lugging fuel multiplier, RPM.
- FN311 = MFA altitude multiplier, unitless.
- FN371 = Initial LAMMUL as a function of ECT. This is a Fuel Multiplier to provide fuel compensation during Drive Engagement.
- FN393F = Time between Lammul decrements - forward gear.
- FN396A = High Speed Fuel enrichment, mph.
- FN1306 = Startup Open Loop Fuel table = a 10 x 8 table of lambda values as a function of [FRCSFT*ACT + (1 - FRCSFT)*ECT] and ATMR1. TABSFT is the Synonym for this Table.
- FN022B = Temperature normalizing function (X-input).
  FN018 = Time (ATMR1) normalizing function (Y-input).

- FN1307 = Base Open Loop Fuel table = a 10 x 8 table of lambda values as a function of [FRCBFT*ACT + (1 - FRCBFT)*ECT] and PERLOAD. TABBFT is the Synonym for this Table.

- FN022B = Temperature normalizing function (X-input).
  FN072A = PERLOAD normalizing function (Y-input).
- FN1328 = Manage Fuel Air Fuel Table, 10 x 8 table of multipliers
  as a function of engine speed N and LOAD.
- X-input = Normalizing function for N - FN070
  Y-input = Normalizing function for PERLOAD - FN072A
- FRCBFT = Act fraction for FN1305 lookup.
- FRCSFT = ACT fraction for FN1306 lookup.
- LDEL = Minimum ECT to enable Lugging Open Loop, deg.F.
- LDEM = Maximum ECT to enable Lugging Open Loop, deg.F.
- LDLTM = Minimum time in Lugging Mode (High MAP low RPM)
  before entering Lugging Open Loop, seconds.
- LDTM = Minimum time delay after start up to enable Lugging
  Open Loop, seconds.
- LDMH = Minimum PERLOAD to enable Lugging Open Loop (near W.O.T.).
- LDMHH = Hysteresis for LDMH.
- MFARMP = MFAMUL Ramp increment, unitless.
- MFASW = Calibratible switch which, if set, indicates
  Managed Fuel Air logic is being used.
- NUMPR = Open Loop Fuel multiplier.
- OLMCL = Open Loop Fuel Calibration multiplier.
- OLMTD1 = NUMPR Open Loop fuel multiplier time delay,
  sec.
- PRLDSW = Switch which determines the formula for computing PERLOAD.
  1 -> PERLOAD = LOAD
  0 -> PERLOAD = LOAD/PEAK_LOAD
- TRLOAD = Transmission Load switch.
  0 = Manual Transmission, no clutch or gerar switches,
  forced neutral state (NDSFLG = 0).
  1 = Manual Transmission, no clutch or gear switch.
  2 = Manual Transmission, one clutch or gear switch.
  3 = Manual Transmission, both clutch and gear switches.
  4 = Auto Transmission, non-electronic, neutral drive switch.
  5 = Auto Transmission, non-electronic, neutral pressure switch,
  (AXOD).
  6 = Auto Transmission, electronic, PRNDL sensor - park, reverse,
  neutral, overdrive, manual 1, manual 2.

OUTPUTS

Registers:

- LAMBSE1 = Desired open loop (or closed loop) equivalence ratio for EGO-1 injectors. LAMBSE1 appears in the fuel pulsewidth equation for EGO-1.

- LAMMUL = Multiplier which is used to prevent cold-engine stalls following transmission engagement.

- MFAMUL = MFA table ramp-in Multiplier, unitless.

- MULTMR = Time since incrementing LAMMUL, sec.

Bit Flags:

- LDFLG = "Lugging" mode open loop flag.

- NEUFLG = N/D transition occurred.

PARAGRAPH During Open Loop fuel Control, the desired equivalence ratios (LAMBSE1 and LAMBSE2) are basically calculated from two tables as modified for various engine conditions.

PROCESS

```
Open Loop fuel control ------| Set LAMBSE1 = LAMBSE2
                             |  = C * [(FN300*FN1307)
                             |    - FN1306] * LAMMUL * OLMCL

HSPFLG = 1 ------------------| LAMBSE1 = LAMBSE1 * FN396A
                             | LAMBSE2 = LAMBSE2 * FN396A
```

LAMMUL LOGIC

LAMMUL can either jump lean (ramp rich) or jump rich (ramp lean), depending upon whether neutral to drive transitions cause rich or lean errors.

RAMP BACK LOGIC

```
MULTMR >OR= FN393F -------|                  | (LAMMUL was RESET RICH)
 (In Forward)             |AND --------------| LAMMUL = LAMMUL
                          |                  |    + 0.0039
LAMMUL < 1.0  ------------|                  | MULTMR = 0
                                             |
                                             | Clip LAMMUL to
                                             | 1.0 as a maximum
                                             |
                                             | --- ELSE ---
                                             |
MULTMR >OR= FN393F -------|                  | (LAMMUL was RESET LEAN)
 (In Forward)             |AND --------------|
                          |                  | LAMMUL = LAMMUL
LAMMUL > 1.0  ------------|                  |    - 0.0039
                                             | MULTMR = 0
                                             |
                                             | Clip LAMMUL to
                                             | 1.0 as a minimum
                                             |
```

LAMMUL RESET LOGIC

```
TRLOAD <OR= 3 ------------|
 (Manual Transmission)    |                 | No LAMMUL RESET
                          |OR --------------| No change to LAMMUL
CLOSED LOOP --------------|                 | No change to NEUFLG
 (OLFLG = 0)                                |
                                            | --- ELSE ---
DNDSUP = 1 ---------------|                 |
 (Transmission in gear)   |                 | LAMMUL RESET
                          |AND -------------| LAMMUL = FN371
NEUFLG = 1 ---------------|                 | NEUFLG = 0
 (Transition from neutral)|                 |
                                            | --- ELSE ---
                                            |
DNDSUP = 0 ---------------------------------| NEUFLG = 1
 (Transmission in neutral)
```

NOTE: LAMMUL and FN371 have a range of 0 through 1.99.

'C' DEFINITION

```
LDFLG = 1 --------------------------| LUGGING MODE
                                    | 'C' = FN308 * FN212A
                                    |  + FN309 * FN129A
                                    |
DNDSUP = 1 (DRIVE) ----------|      | --- ELSE ---
                             |      |
APT = -1 (CLOSED THROTTLE) --|AND --| 'C' = FN301
                             |      |
WRMEGO = 0 ------------------|      |
                                    |
                                    | --- ELSE ---
                                    |
NFLG = 1 --------------------|      |
                             |      |
CTLOW < TCSTRT < CTHIN ------|AND --| 'C' = FN301N * NUMPR
                             |      |
ATMR1 < OLMTD1 --------------|      |
                                    |
                                    | --- ELSE ---
                                    |
MFAFLG = 1 ------------------|      |
                             |AND --| 'C' = 1 + (FN1328 *
MFASW = 1 -------------------|      |  FN311 * MFAMUL)
                                    |
                                    | --- ELSE ---
                                    |
NFLG = 1 ---------------------------| 'C' = FN301N
                                    |
                                    | --- ELSE ---
                                    |
APT = 1 (WIDE OPEN THROTTLE) -------| 'C' = FN303
                                    |
                                    | --- ELSE ---
                                    |
                                    | 'C' = 1
```

"LUGGING" OPEN LOOP FLAG

The strategy provides the capacity of Open Loop Fuel Control during "lugging" conditions (Part throttle, high Load, low RPM). The "lugging" Open Loop multiplier is adjusted for altitude much like Spark and EGR (by means of FN212A and FN129A).

CALIBRATION NOTES: LDMH and LDMHH should correspond to high loads (near WOT). LDLTM must be less than or equal to LUGTIM (since LUGTMR is clipped to LUGTIM).

The logic below sets LDFLG -- the flag which indicates whether lugging Open Loop is in process or not.

```
APT = 0 (PART THROTTLE) --------------|
                                      |
LDEL < ECT < LDEH --------------------|
                                      |
LUGTMR >OR= LDLTM --------------------|AND ---| LDFLG = 1
                                      |       |
PERLOAD >OR= LDMH + LDMHH -|S Q-------|       | --- ELSE ---
                           |          |       |
PERLOAD < LDMH ------------|C         |       | LDFLG = 0
                                      |
WMEGOL = 1 ---------------------------|
```

MFAMUL LOGIC

The MFAMUL ramps in the MFA tables (FN1328, FN1124 and FN1223). The fuel is systematically ramped lean with corresponding changes to Spark and EGR.

```
MFAFLG = 0 --------------------| MFAMUL = 0
                               |
                               | --- ELSE ---
                               |
                               | MFAMUL = MFAMUL
                               |  + MFARMP
                               | Clip MFAMUL to 1.0
                               |  as a maximum
```

CLOSED LOOP FUEL STRATEGY

STEREO EGO SYSTEMS

The following description applies to each side of an engine if operating in stereo EGO mode.

1. Independent closed loop ramp rates and jumpback (LAMBSE1 and LAMBSE2) amounts are calculated.

2. Calibration values for peak-to-peak amplitude, bias, and transport delay are common to both sides.

3. ANPIP, ENPIP, and LAMBSE calculations are unique to each side.

4. The injector pulsewidths, FUELPW1 and FUELPW2, are calculated from LAMBSE1 and LAMBSE2, respectively.

NOTE: If system uses only one EGO sensor, the strategy uses LAMBSE1 and FUELPW1 for the desired LAMBSE and fuel Pulsewidth. (Set NUMEGO = 1)

INTENT

The goals of the closed loop strategy are:

1. To add capability of introducing large amounts of Air/Fuel biasing (up to 45% expressed as ratio of bias to peak-to-peak amplitude).

2. To maximize the feedback limit cycle frequency for all bias values.

3. To adapt to EGO sensor slow down as the sensor ages (see Adaptive EGO Strategy).

4. To maintain a simple calibration procedure to describe the closed loop limit cycle.

APPROACH

The fuel flow is driven in a limit cycle manner about stoichiometry. Using the EGO (Exhaust Gas Oxygen) sensor, the computer increases or decreases the injector pulsewidths in a controlled manner. If the EGO reads rich, the pulsewidths will be decreased (made leaner) at a calculated rate. If the EGO reads lean, the pulsewidths will be increased (made richer) at a calculated rate.

When an EGO switch occurs, an instantaneous change (or "jumpback") is made in the air/fuel ratio back towards stoichiometry. The jump is made relative to the A/F ratio (lambda) value at the EGO switch.

The limit cycle can be biased to operate on the average richer (or leaner) of stoichiometry.

An example of the closed loop limit cycle is shown after the definitions section.

CLOSED LOOP FUEL STRATEGY

DEFINITIONS

INPUTS

Registers:

- ANPIP = Actual number of PIP signals since the last EGO switch; clipped to a maximum of 255; reset to zero when not in closed loop; reset to zero after the EGO switches and the jumpback distance is calculated.
- BIAS = Closed Loop biasing term = FN1353(N,LOAD), defined below.
- EGO = Exhaust Gas Oxygen Sensor. (GX has mono and stereo EGO capacity, EGO-1 and EGO-2 represent the EGO sensors in stereo mode; generic represent = EGO-n).
- ENPIP = Expected number of PIP signals between EGO switches; reset to 1 when not in closed loop.
- FUELPW1 = EGO-1 injector pulsewidths, clock ticks.
- FUELPW2 = EGO-2 injector pulsewidths, clock ticks.
- LAMBDA = Air/Fuel equivalency ratio.
- LAMBSE1 = Desired open loop (or closed loop) equivalence ratio for EGO-1 injectors. LAMBSE1 appears in the fuel pulsewidth equation for EGO-1.
- LAMBSE2 = Desired open loop (or closed loop) equivalence ratio for EGO-2 injectors. LAMBSE2 appears in the fuel pulsewidth equation for EGO-2.
- PIPRAT = Ratio of the actual number of PIP signals since the last EGO switch to the expected number of PIP signals between EGO switches; clipped to a maximum of 1.0.
- TSLAMU = Time since last LAMBDA update.

Bit Flags:

- LEGOFG1 = Lack of EGO-1 switching. (LEGOFG2 reflects state of EGO-2 switching).
- OLFLG = Flag indicating Open Loop if set (1); indicating Closed Loop if cleared (0).

Calibration Constants:

- ENGCYL = Number of PIPs per engine revolution; or Number of cylinders/2.
- FN339 = Closed Loop ramp rate Multiplier versus absolute value of BIAS/PTPAMP. Input = |BIAS/PTPAMP| and Output = Ramp rate multiplier.
- FN342 = Closed Loop Jumpback distance Multiplier versus |BIAS/PTPAMP|. (Toward BIAS) Input = |BIAS/PTPAMP| and Output Jumpback distance Multiplier.

- FN344 = Closed Loop Jumpback Distance Multiplier versus |BIAS/PTPAMP|. (Opposite BIAS) Input = |BIAS/PTPAMP| and Output = Jumpback distance multiplier.

- FN346 = Expected number of PIPs multiplier. Input = |BIAS/PTPAMP| and Output = Multiplier.

- FN1351(N,LOAD) = System transport lag time; time delay from when a fuel change is made until the EGO sensor indicates this change, units are REVs. X-input = FN039 - Normalized engine speed, RPM; Y-input = FN071 - Normalized engine load, LOAD; Output = Transport delay, REVs.

- FN1352(N,LOAD) = Closed Loop Peak-to-Peak amplitude, units are lambdas. X-input = FN039 - Normalized engine speed, RPM; Y-input = FN071 - Normalized engine load ,LOAD; Output = Peak-to-Peak amplitude, PTPAMP.

- FN1353(N,LOAD) = Amount of Bias from stoichiometry, X-input = FN039 - Normalized engine speed, RPM; Y-input = FN071 - Normalized engine load ,LOAD; Output = Bias from stoichiometry. (Store in register).

- LAMSW = Lambda reset switch.

- LMBJMP = Desired Rich correction.

- NUMEGO = Number of EGO sensors present; mono or stereo only.

- PTPAMP = Limit cycle peak-to-peak amplitude, FN1352(N,LOAD).

OUTPUTS

Registers:

- ANPIP = Actual number of PIP signals since the last EGO switch; clipped to a maximum of 255; reset to zero when not in closed loop; reset to zero after the EGO switches and the jumpback distance is calculated.
- BIAS = Value factored into the Jumpback and Ramping equations, its sign indicates direction of of these functions (as described in Closed Fuel Section).
- ENPIP = Expected number of PIP signals between EGO switches; reset to 1 when not in closed loop.
- LAMBSE1 = Desired open loop (or closed loop) equivalence ratio for EGO-1 injectors. LAMBSE1 appears in the fuel pulsewidth equation for EGO-1.
- LAMBSE2 = Desired open loop (or closed loop) equivalence ratio for EGO-2 injectors. LAMBSE2 appears in the fuel pulsewidth equation for EGO-2.

LIMIT CYCLE DESCRIPTION
(lean bias example)

```
- - - - - - - - - *
|               * *                                           *
|             *   *                                         *
|           *     *              LEAN                     *
|         *       *                                     *
|       *         *                                   *
|     *           *                                 *
|   *       |       *                             *
| *-  -  - --- -  -  -* -  -  -  -  -  -  -  -  *  -  - AVERAGE
|                       *                       *       A/F RATIO
|                         *                     *
| --------------------------*-------------------*----- STOICHIOMETRY
|           |                 *                 *
|           |                   *               *
|         BIAS                    *             *
|         TERM                      *           *
|                                     *         *
|                         RICH          *       *
|--PEAK TO PEAK                           *     *
|  AMPLITUDE                                *   *
|                                             * *
- - - - - - - - - - - - - - - - - - - - - - - - *
```

EGO SENSOR STATUS

```
RICH **************                             ********************
                  *                             *
                  *                             *
                  *                             *
LEAN              *******************************
```

INJECTOR PULSEWIDTH STATUS

```
ON **      ****     *****    ******   *******  *******    *****
    *      *  *     *   *    *    *   *     *  *     *    *   *
    *      *  *     *   *    *    *   *     *  *     *    *   *
    *      *  *     *   *    *    *   *     *  *     *    *   *
OFF ********  *******   ******    *****     ****     ******   ******
                  |                             |
<--DECREASING --->|<---------INCREASING ------->|<---DECREASING --->
   PULSEWIDTH     |          PULSEWIDTH         |    PULSEWIDTH
```

The bias term is used to make the limit cycle operate at an average A/F ratio rich or lean of stoichiometry. For zero bias, the average A/F ratio is stoichiometry.

Based on calibration information supplied by the user, the fuel pulsewidth ramp rates and jumpback distances are calculated automatically to produce the proper limit cycle.

The calibration items are: FN1351(N,LOAD), FN1352(N,LOAD), FN1353(N,LOAD).

***** Note *****

The direction of the bias is controlled by the sign of the bias value. If the bias term is negative, a rich bias is indicated. If the sign of the bias term is positive, a lean bias is indicated.

****

FN1352(N,LOAD) is also a calibration constant. System transport lag time; time delay from when a fuel change is made until the EGO sensor indicates this change; varies with engine speed, units are REVs.

****
***** WARNING *****
****

It is imperative that an accurate value for the system transport lag be entered. An incorrect value will result in greatly reduced catalyst efficiencies due to excessively fast or slow ramp rates, incorrect jumpback amounts, etc.

****
***** WARNING *****
****

Two methods of achieving the desired bias are employed.

1. Variable jumpback distance on one side of the limit cycle with symmetric pulsewidth ramp rates.

2. No jumpback on one side of the limit cycle with asymmetric pulsewidth ramp rates.

The logic used to achieve biasing depends on the absolute value of BIAS/PTPAMP (|BIAS/PTPAMP|): where;

BIAS = Amount of bias from stoichiometry, FN1353(N,LOAD)

PTPAMP = Limit cycle peak-to-peak amplitude, FN1352(N,LOAD)

Any calculated value of |B/P| exceeding 0.45 is clipped to 0.45. This is done to avoid extremely long limit cycle periods.

FOR NO BIAS |BIAS/PTPAMP| = 0

The limit cycle has full jumpback on both sides of stoichiometry and uses symmetric pulsewidth ramp rates.

FOR SMALL BIAS 0 < |BIAS/PTPAMP| <OR= 0.171573 (0.171573 = 3 - SQRT(8))

The limit cycle has a partial jumpback on one side of stoichiometry to achieve biasing and uses symmetric pulsewidth ramp rates.

FOR LARGE BIAS 0.171573 < |BIAS/PTPAMP| <OR= 0.45

The limit cycle has no jumpback on one side of stoichiometry and uses asymmetric pulsewidth ramp rates to achieve biasing.

Examples of biasing are shown on the next page.

CLOSED LOOP LIMIT CYCLE EXAMPLES
(not drawn to scale)

```
                      NO BIAS   | BIAS/PTPAMP | = 0
     *       *       *       *       *
    **      **      **      **      **
   * *     * *     * *     * *     * *     SYMMETRIC RAMP RATES
  *  *    *  *    *  *    *  *    *  *     FULL JUMPBACK IN
-----*---*---*---*---*---*---*---*---*---  BOTH DIRECTIONS
      *  *      *  *      *  *      *  *      *
       * *     * *     * *     * *     *
        **      **      **      **      *
         *       *       *       *       *

                 SMALL BIAS   | BIAS/PTPAMP | < 0.171573
     *          *          *          *
    **         **         **         **
   * *        * *        * *        * *         SYMMETRIC RAMP RATES
  *  *       *  *       *  *       *  *         PARTIAL JUMPBACK
-----*------*---*------*---*------*---*----     IN ONE DIRECTION
     *     *    *     *    *     *    *
      *   *      *   *      *   *      *   *
       * *        * *        * *        * *
        **         **         **         **
         *          *          *          *

                MODERATE BIAS   | BIAS/PTPAMP | = 0.171573
     *           *           *           *
    **          **          **          **
   * *         * *         * *         * *    SYMMETRIC RAMP RATES
  *  *        *  *        *  *        *  *    NO JUMPBACK
-----*-------*---*-------*---*-------*---*--  IN ONE DIRECTION
     *      *    *      *    *      *    *
     *     *     *     *     *     *     *
      *   *       *   *       *   *       *
       * *         * *         * *         *
        *           *           *

                 LARGE BIAS   | BIAS/PTPAMP | > 0.171573
     *                    *
   * *                  * *
 *   *                *   *                *   SYMMETRIC RAMP RATES
     *              *     *              *     NO JUMPBACK
-----*------------*-------*------------*-----  IN ONE DIRECTION
     *          *         *          *
     *        *           *        *
      *     *              *     *
       *  *                 *  *
        *                    *
```

Note: Limit cycle frequency decreases with increasing bias.

After an EGO switch, a finite amount of time (equal to the transport lag) should pass before the EGO can switch. Noise in the EGO system could be interpreted by the computer as EGO switches. These phantom switches could occur at a faster rate than dictated by the system transport lag time. Since the jumpback is made from the lambda when the EGO switches, phantom switches could make the jumpback go beyond the average Air/Fuel ratio. A high rate of phantom switches would create a high rate of jumps. A special feature of the closed loop strategy prevents this problem.

A full jumpback is done only if the proper transport lag time has elapsed. If not, the jumpback distance is reduced to match the reduction in transport lag time. The actual strategy uses PIP signal counts to control this feature.

The jumpback distance is multiplied by the ratio PIPRAT.

PIPRAT = Ratio of the actual number of PIP signals since the last EGO switch to the expected number of PIP signals between EGO switches; clipped to a maximum of 1.0. PIPRAT is a temporary register.

PIPRAT = ANPIP/ENPIP

ANPIP = Actual number of PIP signals since the last EGO switch; clipped to a maximum of 255; reset to zero when not in closed loop; reset to zero after the EGO switches and the jumpback distance is calculated.

ENPIP = Expected number of PIP signals between EGO switches; reset to 1 when not in closed loop.

The transport delay (FN1351) is entered as REVS. The strategy uses units of both seconds and PIPS. The transport delay in PIPS is:

TDPIP = FN1351(N,LOAD) * ENGCYL

Transport delay in seconds is:

TDSEC = FN1351(N,LOAD) * 60/N

TDPIP and TDSEC are temporary registers.

```
                                EGO-n SWITCH

BIAS >OR= 0 -----------|       | LAMBSEn = LAMBSEn + [PTPAMP
                       |AND ---|  + | BIAS |] * FN344
EGO-N SWITCH from Lean |       |  * PIPRATn
 to Rich --------------|       |
                               | ENPIPn = TDPIP
                               |
                               | ANPIPn = 0
                               |
                               | --- ELSE ---
BIAS >OR= 0 -----------|       |
                       |       |
EGO-n SWITCH from Rich |AND ---| LAMBSEn = LAMBSEn - PTPAMP *
 to Lean --------------|       |  FN342 * PIPRATn
                               |
                               | ENPIPn = TDPIP * FN346(|BIAS/PTPAMP|)
                               |
                               | ANPIPn = 0
                               |
                               | --- ELSE ---
BIAS < 0 --------------|       |
                       |AND ---| LAMBSEn = LAMBSEn +
EGO-n SWITCH from Lean |       |  PTPAMP * FN342 * PIPRATn
 to Rich --------------|       |
                               | ENPIPn = TDPIP * FN346(|BIAS/PTPAMP|)
                               |
                               | ANPIPn = 0
                               |
                               | --- ELSE ---
BIAS < 0 ---------------|      |
                        |AND --| LAMBSEn = LAMBSEn -[PTPAMP +
EGO-n SWITCH from Rich  |      |  | BIAS |]* FN344 * PIPRATn
 to Lean ---------------|      | ANPIPn = 0
                               | ENPIPn = TDPIP
```

RAMP-RATE CALCULATIONS BASED ON BIAS AND EGO STATE

EGO-n SENSOR HAS NOT SWITCHED

```
BIAS >OR= 0 ---------|       | LAMBSEn = LAMBSEn -
                     |AND --|
                     |       | (PTPAMP - |BIAS|)*(1-FN339)*TSLAMUn
EGO-n Lean ----------|       |  -------------------------
                             |          TDSEC
                             |
                             | --- ELSE ---
                             |
BIAS < 0 ------------|       | LAMBSEn = LAMBSEn -
                     |AND --|
                     |       | (PTPAMP - |BIAS|)*FN339*TSLAMUn
EGO-n Lean ----------|       |  ----------------------
                             |          TDSEC
                             |
                             | --- ELSE ---
                             |
BIAS >OR= 0 ---------|       | LAMBSEn = LAMBSEn +
                     |AND --|
                     |       | (PTPAMP - |BIAS|)*FN339*TSLAMUn
EGO-n Rich ----------|       |  ----------------------
                             |          TDSEC
                             |
                             | --- ELSE ---
                             |
BIAS < 0 ------------|       | LAMBSEn = LAMBSEn +
                     |AND --|
                     |       | (PTPAMP - |BIAS|)*(1-FN339)*TSLAMUn
EGO-n Rich ----------|       |  -------------------------
                             |          TDSEC
```

An EGO switch is defined as either:

1. The EGO sensor reads rich during the current background loop and it reads lean during the previous background loop.

2. The EGO sensor reads lean during the current background loop and it reads rich during the previous background loop.

CLOSED LOOP LAMBSE1 AND LAMBSE2 LOGIC

```
CLOSED LOOP --------------|      | MONO EGO OR STEREO
                          |AND --| EGO WITH LACK OF
LEGOFG1 = 1 ---------|    |      | EGO-2 SWITCHING.
 (see TIMER section) |    |      | USE EGO-1 SENSOR
                     |OR -|      | ONLY FOR CLOSED LOOP
NUMEGO = 1 ----------|           | CONTROL OF LAMBSE1 AND
 (MONO EGO)                      | SET LAMBSE2 = LAMBSE1
                                 |
                                 | --- ELSE ---
                                 |
                                 | STEREO EGO WITH LACK
                                 | OF EGO-1 SWITCHING.
CLOSED LOOP ---------------|     | USE EGO-2 SENSOR
                           |AND -| ONLY FOR CLOSED LOOP
LEGOFG1 = 1 ---------------|     | CONTROL OF LAMBSE2 AND
 (see TIMER section)             | SET LAMBSE1 = LAMBSE2
                                 |
                                 | --- ELSE ---
                                 |
CLOSED LOOP ---------------------| NORMAL STEREO EGO.
                                 | USE EGO-1 SENSOR
                                 | FOR CLOSED LOOP
                                 | CONTROL OF LAMBSE1
                                 |         AND
                                 | USE EGO-2 SENSOR
                                 | FOR CLOSED LOOP
                                 | CONTROL OF LAMBSE2
```

LAMBDA RESET LOGIC

LAMBSE is reset to 1.0 under the conditions listed below, provided it is in Closed Loop fuel control. LAMBSE is not reset in Open Loop Fuel Control because the value of LAMBSE is calculated using the Open Loop Fuel logic. LAMBSE is reset in Closed Loop as described below.

1) When entering or exiting the Filtered Idle Air Mass Regions (FAM);

2) When Changing load states within FAM; and/or

3) Any time a transition is made from Open Loop to Closed Loop Fuel control.

LAMBSE is always clipped to 1.0 as a maximum. The intent is to allow rich errors and to prevent lean errors, given that running rich does not cause any drivability concerns.

LAMBSE RESET - ENTERING/EXITING FAM REGION

```
REFFLG = 1 ----------------|       | Set JMPFLG = 1
                           |AND ---| Clip LAMBSE1 and LAMBSE2
JMPFLG = 0 ----------------|       |  to 1.0 as Maximum.
 (Entry into FAM Region)           |
                                   | --- ELSE ---
                                   |
REFFLG = 0 ----------------|       | Set JMPFLG = 0
                           |AND ---| Set LAMBSE1 = LAMBSE1
JMPFLG = 1 ----------------|       |  - LMBJMP
 (Exit from FAM Region)            | Set LAMBSE2 = LAMBSE2
                                   |  - LMBJMP
```

LAMBSE RESET - LOAD STATE CHANGE AT IDLE

```
APT = -1 ------------------|AND -----| Clip LAMBSE1 and LAMBSE2
 (Closed throttle)         |         |  to 1.0 as maximum.
                           |
ISFLAG NOT= ISLAST --------|
 (Load state change)
```

LAMBSE RESET - OPEN LOOP TO CLOSED LOOP TRANSITION

```
Previous OLFLG = 1 ---------|AND -----| Clip LAMBSE1 and LAMBSE2
 (Last state = Open Loop)   |         |  to 1.0 as Maximum.
                            |
Current OLFLG = 0 ----------|
 (Current state = Closed    |
  Loop)                     |
                            |
LAMSW = 1 ------------------|
```

ADAPTIVE FUEL CONTROL

BACKGROUND

Fuel injected systems may exhibit vehicle to vehicle steady state A/F ratio errors due to normal variability in fuel system components.

The adaptive fuel strategy attacks this problem by memorizing the characteristics of the individual fuel system being used. This memorized information is used to predict what the system will do based on past experience.

The ability to predict fuel system behavior improves both open loop and closed loop fuel control. As an example, the memorized information can be used on cold starts to achieve better open loop fuel contol before the EGO sensor reaches operating temperature.

The chief benefit of the adaptive fuel strategy will be to reduce the effects of product variability in the field.

The memorized or adaptive information is stored in table form in the Keep Alive Memory (KAM). KAM is continuously powered by the vehicle battery even when the vehicle is shut off. As a result, the table is not lost on vehicle shutdown.

ADAPTIVE EGO STRATEGY deleted (GXZ0)

DEFINITIONS - ADAPTIVE FUEL CONTROL

INPUTS
Registers:
- ACT = Air charge temperature, deg F.
- ADPTMR = Adaptive learning enable timer (see TIMER section).
- AEFUEL = Acceleration enrichment fuel flow (lb/min).
- BIAS = Closed loop biasing term = FN1353(N,LOAD).
- CHKSUM = KAM memory word which contains the sum of the LTMTB1 or LTMTB2 contents.
- COLTBU = A register which contains the column number of the Adaptive Learning Cell to be updated.
- EFTR = Transient fuel compensation fuel flow (lb/sec).
- EGO = Exhaust Gas Oxygen Sensor. (GX has mono and stereo EGO capacity, EGO-1 and EGO-2 represent the EGO sensors in stereo mode; generic represent = EGO-n).
- EGOCT1 = Number of EGO-1 switches since last Adaptive Fuel Update.
- EGOCT2 = Number of EGO-2 switches since last Adaptive Fuel Update.
- ISCFLG = ISC MODE Flag (1 = RPM CONTROL Mode).
- ISFLAG = Flag that indicates the degree of loading on the engine at Idle. See the ISC Chapter.
  0 = Drive
  1 = Drive + A/C (WAC Relay De-Energized)
  2 = Neutral
  3 = Neutral + A/C (WAC Relay De-Energized)
- KAM = Keep Alive Memory.
- KAMRF1/KAMRF2 = Adaptive Fuel strategy correction factor. It is composed of the value LTMTB1rc + .5.
- KWUCTR = KAM warm_up counter. Stores number of warm_ups in KAM. Reset to zero if KAM is corrupted. (battery disconnect, etc.)
- LAMBSE1 = Desired open loop (or closed loop) equivalence ratio for EGO-1 injectors. LAMBSE1 appears in the fuel pulsewidth equation for EGO-1.
- LAMBSE2 = Desired open loop (or closed loop) equivalence ratio for EGO-2 injectors. LAMBSE2 appears in the fuel pulsewidth equation for EGO-2.

- LEGOFG1 = Lack of EGO-1 switching.

- LEGOFG2 = Lack of EGO-2 switching.

- LPCT1L = Number of background loops that the LAMBSE1 was outside a deadband in the rich direction, with EGO-1 sensor reading lean.

- LPCT2L = Number of background loops that the LAMBSE2 was outside a deadband in the rich direction, with EGO-2 sensor reading lean.

- LPCT1R = Number of background loops that the LAMBSE1 was outside a deadband in the lean direction, with EGO-1 sensor reading rich.

- LPCT2R = Number of background loops that the LAMBSE2 was outside a deadband in the lean direction, with EGO-2 sensor reading rich.

- LSTCOL = Last normalized column value.

- LSTROW = Last normalized row value.

- LTMTB1rc = EGO-1 Adaptive Fuel cell which corresponds to
  r = Integer part of FN021 (LOAD) and
  c = Integer part of FN070 (N).

- LTMTB2rc = EGO-2 Adaptive Fuel cell which corresponds to
  r = Integer part of FN021 (LOAD) and
  c = Integer part of FN070 (N).

- N = Engine revolutions, RPM.
- NRMCES = Current normalized column number.
- NRMRLD = Current normalized row number.
- RANNUM = Random number adder.
- ROWTBU = Register which contains the row number of the Adaptive Fuel cell to be updated.
- TCSTRT = Temperature of ECT at cold start, deg. F

Bit Flags:

- AFMFLG = ACT Failure Mode (FMEM) flag.
- CFMFLG = ECT FMEM flag.
- EFMFLG = EGR FMEM flag.
- HCAMFG = Flag indicating state of Hi Cam.
- MFMFLG = MAP/MAF FMEM flag.

- REFFLG = Indication of Idle Air Flow (1 = Idle Air Flow).
- TFMFLG = TP FMEM flag.
- WARM_UP = Indicates engine warmup occured.

Calibration Constants:

- ADAPTM = Adaptive learning enable time delay (seconds).
- ADEFTR = Maximum transient fuel compensation fuel flow to allow adaptive learning (lb/sec).
- ADEGCT = EGO switch requirement to increment counters.
- AELIM = Maximum acceleration enrichment fuel flow to allow adaptive learning (lb/min).
- AFACT1 = Minimum ACT to Update Adaptive Fuel Table deg F.
- AFACT2 = Maximum ACT to update Adaptive Fuel Table, deg F.
- DELCOL = Calibration constant (normalized engine speed N) which provides the ability to lock out table updates under transient conditions; establishes an operating range (engine speed) within which the appropriate loop counter may be incremented.
- DELROW = Same function as DELCOL but for normalized load LOAD.
- DELAMB = Deadband (around LAMBSE1 = 1.0) within which loop counter values are not altered.
- FAEGCT = Fast Adaptive EGO count. Number of EGO switches required to permit adaptive learning when KWUCTR < KWUCNT. Should be set to 0 to permit fast adaptive learning for the first few warm_up cycles.
- FN021 = LOAD normalizing function for LTMTB1(LTMTB2) and FN1325. Input = Load and Output = Normalized Load.
- FN070 = N normalizing function.
- FN1325rc = LTMTB1 and LTMTB2 learning/use control table. X-input = FN070 - Normalized RPM. Y-input = FN021 - Normalized Load.
- HCAMSW = Calibratible switch which allows selection of when and which adaptive fuel cells are to be used.
- KWUCNT = Maximum mumber of warm_up cycles to use fast adaptive EGO count. It should be set to approx. 3 to 5 warm_ups.

- MAXADP = Maximum adaptive correction.
- MINADP = Minimum adaptive correction.
- NUMEGO = Switch indicating number of EGO sensors present; Select mono or stereo.
- RANMUL = Multiplier for Random number generation.
- VECT3 = Minimum coolant temperature (engine on), deg. F
- VECT5 = Starting coolant temperature for warm_up counter, deg. F

OUTPUTS

Registers:

- CHKSUM = KAM memory word which contains the sum of the LTMTB1 or LTMTB2 contents.
- COLTBU = A register which contains the column number of the Adaptive Learning Cell to be updated.
- EGOCT1 = Number of EGO-1 switches since last Adaptive Fuel Update.
- EGOCT2 = Number of EGO-2 switches since last Adaptive Fuel Update.
- KAMRF1/KAMRF2 = Adaptive Fuel strategy correction factor. It is composed of the value LTMTB1rc + .5.
- KWUCTR = KAM warm_up counter. Stores number of warm_ups in KAM. Reset to zero if KAM is corrupted. (battery disconnect, etc.)

- LPCT1L = Number of background loops that the LAMBSE1 was outside a deadband in the rich direction, with EGO-1 sensor reading lean.
- LPCT2L = Number of background loops that the LAMBSE2 was outside a deadband in the rich direction, with EGO-2 sensor reading lean.
- LPCT1R = Number of background loops that the LAMBSE1 was outside a deadband in the lean direction, with EGO-1 sensor reading rich.
- LPCT2R = Number of background loops that the LAMBSE2 was outside a deadband in the lean direction, with EGO-2 sensor reading rich.
- LSTCOL = Last normalized column value.
- LSTROW = Last normalized row value.

- LTMTB1rc = EGO-1 Adaptive Fuel cell which corresponds to
  r = Integer part of FN021 (LOAD) and
  c = Integer part of FN070 (N).

- LTMTB2rc = EGO-2 Adaptive Fuel cell which corresponds to
  r = Integer part of FN021 (LOAD) and
  c = Integer part of FN070 (N).

- NRMCES = Current normalized column number.

- NRMRLD = Current normalized row number.

- RANNUM = Random number adder.

- ROWTBU = Register which contains the row number of the
  Adaptive Fuel cell to be updated.

Bit Flags:

- WARM_UP = Indicates engine warmup occured.

ADAPTIVE FUEL TABLE

The adaptive fuel tables, LTMTB1 and LTMTB2, are 2-dimensional arrays of learned fuel system corrections. Ideally, if LAMBSE1 = 1.0, LAMBSE2 = 1.0 and data from a mature adaptive fuel table is used, a stoichiometric A/F ratio would result at whatever speed-load point adaptive learning had taken place.

Present table size is 8(rows) x 10(columns) or 80 cells for each Adaptive Fuel Table, plus depending on the strategy family, either 4 or 6 special idle adaptive cells. There will always be 86 total cells per table

The total learned fuel system correction for the EGO-1 side of the engine is called KAMRF1 where KAMRF1 = 0.5 + LTMTB1rc. The corresponding fuel correction for the EGO-2 side is called KAMRF2, where KAMRF2 = 0.5 + LTMTB2rc.

During adaptive learning, only the LTMTB1 and LTMTB2 cells are modified. Therefore, the ranges of each of the KAMRF1 and KAMRF2 multipliers (0.5 + 0.0) to (0.5 + 1.0) or 0.5 to 1.5.

The range of the LTMTB1 and LTMTB2 cells can be further restricted by use of the calibration parameter clips, MINADP and MAXADP.

The precise location where KAMRF1 and KAMRF2 are used is shown in the fuel pulsewidth equation.

If KAM fails the KAM validation test (described later), all LTMTB1 and LTMTB2 cells are initialized to 0.5 or 80 (HEX) resulting in a value of KAMRF1 = KAMRF2 = 0.5 + 0.5 = 1.0.

When allowed, updates to LTMTB1 and LTMTB2 are statistically distributed in the vicinity of the speed-load operating point, except in the case of the idle cells. Only the current idle cell is updated, no statistical distribution is done.

Data extracted from the table undergoes a 4-point linear interpolation. This is explained further under the FN1325 description. Note that the idle cells do not undergo four point interpolation. Only the current idle cell is used.

LTMTB1, LTMTB2 and FN1325 share the same normalizing functions. FN021 is the LOAD normalizing function. FN070 is the engine speed N normalizing function.

As an example of an adaptive fuel table, LTMTB1, is shown on the next page. EGO-2 Adaptive Fuel Table, LTMTB2, uses similar nomenclature.

ADAPTIVE FUEL TABLE (LTMTB1)

LTMTB1rc CELLS

(LTMTB2 has similar designation)

```
Special idle  ------>|80 81 82 83 84 85
adaptive cells       |
                7    |70 71 72 73 74 75 76 77 78 79
                     |
                6    |60 61 62 63 64 65 66 67 68 69
                     |
                5    |50 51 52 53 54 55 56 57 58 59
                     |
    FN021       4    |40 41 42 43 44 45 46 47 48 49
  NORMALIZED
    ENGINE      3    |30 31 32 33 34 35 36 37 38 39
    LOAD             |
   (LOAD)       2    |20 21 22 23 24 25 26 27 28 29
                     |
                1    |10 11 12 13 14 15 16 17 18 19
                     |
                0    |00 01 02 03 04 05 06 07 08 09
                     ------------------------------

                       0  1  2  3  4  5  6  7  8  9

                           FN070 NORMALIZED
                             ENGINE SPEED
                                 (N)
```

The special Adaptive Idle cells are not defined by FN021 or FN070; they are defined by the value of the ISFLAG. (See ISFLAG definition)

FN1325 DESCRIPTION

FN1325 is a 9(rows) x 10(columns) table containing 1 cell corresponding to each cell in the adaptive fuel table LTMTB1 or LTMTB2. (The 9th row is used to reference the idle cells and is not accessible from FN021 which only goes from 0 to 7).

The normalizing functions for FN1325, LTMTB1 and LTMTB2 are shared. FN021 is the LOAD normalizing function. FN070 is the engine speed N normalizing function.

FN1325 is designed to do the following:

1. Identify LTMTB1 and LTMTB2 cells where learning is allowed to occur.

   Learning is allowed in any LTMTB1 and LTMTB2 cells whose corresponding

   FN1325rc cell contains a value >OR= 0. Negative FN1325 cell values disallow learning in the corresponding LTMTB1 and LTMTB2 cell(s).

2. Define a high confidence speed-load region that can be referenced from any other speed-load point.

   This occurs whenever a negative value is entered into a FN1325 cell. The negative number serves as an offset to LTMTB100 and LTMTB200. If 1 of the 4 cells used by the 4-point linear interpolation LTMTB1 or LTMTB2 table lookup routine contained -42, the cell value used by the interpolation routine for the cell that contained the -42 would be the value found in the LTMTB1 or LTMTB2 cell located at the intersection of row 4 and column 2. In the extreme, if -42 was entered into every cell of FN1325rc except for the cell corresponding to LTMTB142 and LTMTB242, learning would be allowed only in cell LTMTB142 and LTMTB242 and the learned correction in LTMTB142 and LTMTB242 would be applied to all speed-load points for fuel calculations referencing EGO-1 (every cell referenced by the 4-point linear interpolation routine during the LTMTB1 table lookup would point to cell LTMTB142). This calibration for FN1325 is shown on the next page.

3. Specify the values of the Loop Counters (LPCT1L, LPCT1R, LPCT2L and LPCT2R) required to update an individual LTMTB1 or LTMTB2 cell(s).

   This is done by entering a value into FN1325 that is >OR= 0. The value entered represents 1/2 the required update value. A value of 20 entered would require (LPCT1R, LPCT1L, LPCT2L and LPCT2R) to be greater than 40 for an update to occur.

   NOTE: FN1325 controls the update rate and update area for both LTMTB1 and LTMTB2.

LTMTB1 AND LTMTB2 LEARNING/USE CONTROL TABLE FN1325

FN1325 CELLS

FN021 NORMALIZED ENGINE LOAD (LOAD)	0	1	2	3	4	5	6	7	8	9
Special idle adaptive cells ---->	-42	-42	-42	-42	-42	-42				
7	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
6	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
5	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
4	-42	-42	20	-42	-42	-42	-42	-42	-42	-42
3	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
2	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
1	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42
0	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42

FN070 NORMALIZED
ENGINE SPEED
(N)

LOOP COUNTER LOGIC FOR PACING ADAPTIVE LEARNING

```
AFMFLG = 1 ---------------------------|
                                      |
CFMFLG = 1 ---------------------------|
                                      |
MFMFLG = 1 ---------------------------|
                                      |
TFMFLG = 1 ---------------------------|OR --| Disable Adaptive Learning
                                      |     |
                                      |     | SET LPCT1R = 0
OPEN LOOP FUEL CONTROL ---------------|     | SET LPCT1L = 0
                                      |     | SET LPCT2R = 0
ADPTMR < ADAPTM ----------------------|     | SET LPCT2L = 0
                                      |     | EGOCT1 = 0
REFFLG = 1 -------------|             |     | EGOCT2 = 0
                        |AND ---------|     |
ISCFLG NOT= 1 ----------|                   | EXIT Adaptive Fuel
                                            |      Routine
                                            |
                                            | --- ELSE ---
REFFLG = 1 -------------|                   |
                        |AND ---------------| Special Idle Cells
ISCFLG = 1 -------------|                   |
                                            | SET NRMCES = ISFLAG
                                            | SET COLTBU = ISFLAG
                                            | SET NRMRLD = 8
                                            | SET ROWTBU = 8
                                            |
                                            | --- ELSE ---
                                            |
REFFLG = 0 ---------------------------------| Look up Normal Cell
                                            | coordinates
                                            |
                                            | RANNUM = RANNUM * RANMUL
                                            | NRMCES = NORM_N70
                                            | NRMRLD = NORM_MAPOPE21
                                            | ROWTBU = NRMRLD + 0.5 +
                                            | lower byte of RANNUM
                                            | COLTBU = NRMCES + 0.5 +
                                            | upper byte of RANNUM
                                            |
```

```
FN1325rc < 0 ---------------------|
                                  |
|NRMRLD - LSTROW| > DELROW -------|OR ------| Change Adpative Region
                                  |          |
|NRMCES - LSTCOL| > DELCOL -------|          | SET LSTROW = NRMRLD
                                             |  (Current Normalized
                                             |   Row number)
                                             | SET LSTCOL = NRMCES
                                             |  (Current Normalized
                                             |   Column number)
                                             | SET LPCT1R = 0
                                             | SET LPCT1L = 0
                                             | SET LPCT2R = 0
                                             | SET LPCT2L = 0
                                             | EGOCNT1 = 0; EGOCNT2 = 0
                                             | EXIT Adaptive Fuel
                                             | Routine
                                             |
                                             | --- ELSE ---
                                             |
SWTFLn = 1 ---------------------------------| Increment EGOCTn if EGOn
                                             | switched


AEFUEL > AELIM -------------------|          | Disable Adaptive Learning
                                  |          |
|EFTR| >OR= ADEFTR ---------------|OR ------| SET LPCT1R = 0
                                  |          | SET LPCT1L = 0
REFFLG = 0 -----------|           |          | SET LPCT2R = 0
                      |AND -------|          | SET LPCT2L = 0
ROWTBU = 8 -----------|           |          | EGOCT1 = 0; EGOCT2 = 0
                                  |          |
ACT <OR= AFACT1 ------------------|          | EXIT Adaptive Fuel
                                  |          |      Routine
ACT >OR= AFACT2 ------------------|
```

EGO-1 LOOP COUNTER UPDATE

(LPCT1L and LPCT1R)

```
EGOCT1 >OR= "A" -----------------|
                                 |
EGO-1 is RICH -------------------|AND --| Increment LPCT1R
                                 |      |
LAMBSE1 >OR= (1+ BIAS + DELAMB) -|      | --- ELSE ---
                                        |
EGO-1 is LEAN -------------------|      |
                                 |AND --| Increment LPCT1L
LAMBSE1 <OR= (1+BIAS - DELAMB) --|
                                 |
EGOCT1 >OR= "A" -----------------|
```

EGO-2 LOOP COUNTER UPDATE

(LPCT2L and LPCT2R)

```
EGOCT2 >OR= "A" ----------------|
                                |
EGO-2 is RICH ------------------|
                                |AND --| Increment LPCT2R
LAMBSE2 >OR= (1+BIAS + DELAMB) -|      |
                                       | --- ELSE ---
EGO-2 is LEAN ------------------|      |
                                |AND --| Increment LPCT2L
LAMBSE2 <OR= (1+BIAS - DELAMB) -|
                                |
EGOCT2 >OR= "A" ----------------|
```

Where: (See next page)

WARM_UP COUNTER LOGIC

```
WARM_UP = 0 -----------|
                       |
TCSTRT < VECT5 --------|
                       |AND ---| Set WARM_UP = 1
ECT > VECT3 -----------|       | Set KWUCTR = KWUCTR + 1
                       |       | Clip KWUCTR to 255
RUN MODE --------------|
```

Note: The above logic is actually done in Continuous Self Test.

```
KWUCTR < KWUCNT ---------------| "A" = FAEGCT
(First few warm_up cycles)     | (Use fast learning rate)
                               |
                               | --- ELSE ---
                               |
KWUCTR >OR= KWUCNT ------------| "A" = ADEGCT
                               | (Use normal learning rate)
```

INPUTS/OUTPUTS

KWUCTR = KAM warm_up counter. Stores number of warm_ups in KAM. Reset to zero if KAM is corrupted. (battery disconnect, etc.)

CALIBRATION CONSTANTS

FAEGCT = Fast Adaptive EGO count. Number of EGO switches required to permit adaptive learning when KWUCTR < KWUCNT. Should be set to 0 to permit fast adaptive learning for the first few warm_up cycles.

KWUCNT = Maximum mumber of warm_up cycles to use fast adaptive EGO count. It should be set to approx. 3 to 5 warm_ups.

ADAPTIVE LEARNING CONDITIONS FOR LTMTB1 (EGO-1) TABLE

LTMTB1 cells are updated when the following conditions are satisfied:

```
FN1325rc >OR= 0 ----------|
                          |
LPCT1R > 2*FN1325rc ------|AND -| LTMTB1rc = LTMTB1rc - 0.0039
                          |     |  (1 bit)
LTMTB1rc > MINADP --------|     |
                                | DECREMENT CHKSUM
                                | SET LPCT1R = 0
                                | SET EGOCT1  = 0
                                |
                                | --- ELSE ---
                                |
LPCT1L > 2*FN1325rc ------|     | LTMTB1rc = LTMTB1rc + 0.0039
                          |     |  (1 bit)
LTMTB1rc < MAXADP --------|AND -| INCREMENT CHKSUM
                          |     | SET LPCT1L = 0
FN1325rc >OR= 0 ----------|     | SET EGOCT1 = 0
```

ADAPTIVE LEARNING CONDITIONS FOR LTMTB2 (EGO-2) TABLE

```
FN1325rc >OR= 0 ----------|
                          |
LPCT2R > 2*FN1325rc ------|      | LTMTB2rc = LTMTB2rc - 0.0039
                          |AND -| DECREMENT CHKSUM
LTMTB2rc > MINADP --------|      | SET LPCT2R = 0
                                 | SET EGOCT2  = 0
                                 |
                                 | --- ELSE ---
                                 |
LPCT2L > FN1325rc --------|      | LTMTB2rc = LTMTB2rc + 0.0039
                          |AND -| INCREMENT CHKSUM
LTMTB2rc < MAXADP --------|      | SET LPCT2L = 0
                          |      | SET EGOCT2 = 0

FN1325rc >OR= 0 ----------|
```

LPCT2L and LPCT2R logic is shown in the Loop Counter update Section. NOTE that During Adaptive Learning r = ROWTBU and c = COLTBU.

The Adaptive Fuel Strategy statistically distributes the learned values to the four adjacent cells to a given speed load point by adding a random number to the normalized inputs. However, if the engine is operating in one of the Idle regions (Row 8, Columns 0 - 5), the software does not use the statistical distribution.

USE OF KAM ADAPTIVE FUEL DATA

The adaptive fuel table stored in KAM is used as a reference for both open and closed loop fuel control.

The adaptive fuel table is referenced as shown below.

```
CRKFLG = 1 ------------------|
 (CRANK Mode)                |
                             |OR --| KAMRF1 = 1.0
LEGOFG1 = 1 ---------|       |     | KAMRF2 = 1.0
                     |AND ---|     | Use no interpolation
LEGOFG2 = 1 ---------|             |
                                   | --- ELSE ---
REFFLG = 1 ----------|             |
 (In FAM)            |             |
                     |AND ---------| KAMRF1 = 0.5 + LTMTB1rc
HCAMFG = 0 -----|    |             | KAMRF2 = 0.5 + LTMTB2rc
 (no RPM adder) |OR -|             | r = 8, c = ISFLAG
                |                  | Use no interpolation
HCAMSW = 0 -----|                  |
 (ignore HCAMFG)                   | --- ELSE ---
                                   |
                                   | KAMRF1 = 0.5 + LTMTB1rc
                                   | KAMRF2 = 0.5 + LTMTB2rc
                                   | Use 4 point interpolation
```

HCAMSW is a calibration switch allowing the developer to select how the adaptive fuel idle cells are to be used. If HCAMSW is set to 0, the adaptive fuel idle cells are used as soon as the filtered air mass region is entered (REFFLG = 1). If HCAMSW is set to 1, the adaptive fuel idle cells are used only when in the filtered air mass region and no RPM adder above base idle is present (HCAMFG = 0). This includes FN825A, FN825B, FN26 and BZZRPM.

For purposes of interpolation, the LTMTBn 80 to LTMTBn 85 cells are not included. These cells should correspond to the special idle cells.

LACK OF EGO SWITCHING KAMRF

```
LEGOFG2 = 1 ---------|
                     |OR ----------| KAMRF2 = KAMRF1
NUMEGO = 1 ----------|             |
                                   | --- ELSE ---
                                   |
LEGOFG1 = 1 -----------------------| KAMRF1 = KAMRF2
```

Note: For purposes of Interpolation, the Idle Adaptive cells are treated as containing 0.5. These cells should correspond to Idle Mode.

The use of KAMRF1 and KAMRF2 is shown in the pulsewidth equation in the FUEL section.

ACCELERATION ENRICHMENT FUEL DESCRIPTION

In the RUN and UNDERSPEED modes, whenever the rate of change of throttle angle exceeds a minimum value, acceleration enrichment fuel is delivered until the manifold filling effect is completed (LOAD stops increasing). The fuel is delivered at a rate determined by AEFUEL.

AE fuel is delivered synchronous with the base fuel pulse. AEFUEL is added into the FUELPW calculation (See the FUELPW logic and equations). No separate AE pulses are delivered.

DEFINITIONS

- CRANK = Engine startup strategy.

- RUN = Normal engine control strategy, (used once engine has maintained a certain speed and does not stall).

- UNDERSPEED = Strategy to assist the transition from CRANK to RUN; it also is called whenever the engine stalls or stumbles.

INPUTS

Registers:

- AEFUEL = Rate of AE fuel delivery in LB/MIN.
- AELOAD = Filtered LOAD (defined in System Equations).
- LOAD = Normalized ARCHG divided by SARCHG.
- N = Engine speed (revs/min).
- NEW_AE = Handshaking flag between background and EOS.
- OLDTP = Previous TP sensor value, counts.
- TAR = Throttle Angle Rate of change, deg/sec.
- TP = Throttle position sensor.

Bit Flags:

- AEOFLG = Indicates whether the LOAD rate of change reflects the manifold filling effect. After the LOAD begins to increase, the AEOFLG is set to one to signal manifold filling effect.
- CRKFLG = Flag indicating engine mode; 1 = Crank.

Calibration Constants:

- AEACLD = Change in LOAD indicating that the Intake Manifold is filling, "Hg.
- AEM = A calibratible multiplier for AE fuel.
- AETAR = Calibratible minimum TAR, deg/sec.
- FN019B = Throttle angle rate normalizing function;

used to clip and scale for table look-up.
Input = throttle angle rate and Output =
Normalized throttle angle rate.

- FN020B = Temperature normalizing function; used to clip and scale for table look-up. Input = ECT and Output = Normalized Temperature.

- FN331B = A multiplier as a function of the present throttle angle minus the lowest measured throttle angle (TP - RATCH).

- FN378 = A multiplier as a function of BP. Input = BP and Output = Multiplier.

- FN1303 = Acceleration enrichment desired fuel flow table.
Output = AE desired fuel flow. TAE is its synonom.
X-input = Normalized throttle angle rate - FN019B
Y-input = Normalized ECT - FN020B

- FRCTAE = TAE ACT to ECT proportioning factor.

- TAE (FN1303) = An 8x7 table of fuel flow as a function of throttle angle rate of change (TAR) and temperature. The temperature input can be ECT or ACT as defined by the combination [FRCTAE*ACT +(1-FRCTAE)*ECT].
The normalizing function for TAR is FN019B. The normalizing function for the ECT/ACT temperature combination is FN020B.

- TPDLTA = Minimum TP change that indicates throttle plate travel.

OUTPUTS

Registers:

- AEFUEL = Rate of AE fuel delivery in LB/MIN.

- NEW_AE = Handshaking flag between background and EOS.

- OLDTP = Previous TP sensor value, counts.

- TAR = Throttle Angle Rate of change, deg/sec.

Bit Flags:

- AEOFLG = Indicates whether the LOAD rate of change reflects the manifold filling effect. After the LOAD begins to increase, the AEOFLG is set to one to signal manifold filling effect.

AEFUEL LOGIC

```
CRKFLG = 1 (CRANK) -------------|
                                |OR ---| AEFUEL = 0
TAR <OR= AETAR -----------------|      |
                                |      |
LOAD - AELOAD <OR= AEACLD -|    |      |
 (Manifold is full)        |    |      |
                           |AND-|      |
AEOFLG = 1 ----------------|           |
 (Manifold was/is filling)             |
                                       | --- ELSE ---
                                       |
         AEM*TAE*FN331B*FN378          |         AEM*TAE*FN331B*FN378
AEFUEL < ------------------------|OR --| AEFUEL = --------------------
               60                |     |                   60
                                 |     |
NEW_AE = 1 ----------------------|     | CLEAR NEW_AE = 0
```

TAE (8x7 table of fuel flow function) is used in the above logic diagram. The X and Y inputs to this table are TAR and Temperature. For throttle angle rates of change below that of the first column of the TAE Table (17 degrees/second), TAE is set to zero. For TAR values between AETAR and 17 deg/sec, AEFUEL should be constant (to avoid effects of TAR jitter.

NEW_AE = a handshaking flag between background and EOS. It is set in the FUEL_SERVICE routine (rising or falling edge of PIP) and indicates that current value of AEFUEL has been used. It is cleared by the background when the AEFUEL calculation is done. When set, the background allows AEFUEL to decrease if needed. This guarantees that AE will always be output for short tip-in's.

The AE fuel is turned off by setting TAR equal to zero, if the driver tips out (TP decreases). TP is saved as OLDTP to permit recognition of instantaneous accels or decels. TPDLTA must be set large enough to avoid treating A/D jitter as a decel condition.

```
OLDTP - TP > TPDLTA (DECEL) -------| Set TAR = 0
```

AEOFLG LOGIC

The AEOFLG indicates whether the LOAD rate of change indicates the occurrence of the manifold filling effect. The rate of change of LOAD represents the engine response to the driver demand command. There is a short delay between the TP change and the LOAD change. During this delay, the AEOFLG remains at zero. After the LOAD begins to increase, the AEOFLG is set to one to signal the occurrence of the manifold filling effect. After the manifold has filled (LOAD stops increasing), the software turns off the AE fuel regardless of the status of the TAR circuit.

```
TAR > AETAR ---------------|
                           |AND --|S  Q--| SET AEOFLG = 1
LOAD - AELOAD > AEACLD ----|      |      | (Manifold filling)
                                  |      | OLDTP = TP
                                  |      |
TAR = 0 --------------------------|C     | --- ELSE ---
                                         |
                                         | SET AEOFLG = 0
                                         | (Manifold not filling)
                                         | OLDTP = TP
```

TRANSIENT FUEL COMPENSATION STRATEGY

BACKGROUND

Transient Fuel is variously referred to as manifold wall wetting, puddling, filling, fuel film condensation/evaporation.

A liquid fuel film resides on the walls of the intake manifold. The film mass varies primarily with manifold absolute pressure and manifold wall temperature. During steady state conditions, the film mass is constant. The rates of condensation and evaporation on the manifold walls are equal. During transients, the film mass changes creating air/fuel ratio errors.

- During accelerations, the film mass increases. Fuel will condense faster on the manifold walls until equilibrium is reached. In an uncompensated system at stoichiometry, fuel is diverted from the cylinders, resulting in a momentary lean condition.

- During decelerations, the film mass decreases. Fuel will evaporate faster from the manifold walls until equilibrium is reached. In an uncompensated system at stoichiometry, fuel is added to the cylinders, resulting in a momentary rich condition.

The problem is magnified in closed loop fuel systems because the fuel control will incorrectly chase the transient air/fuel excursions.

INTENT

The Transient Fuel Compensation Strategy (TFC) augments the closed/open loop fuel control to keep cylinder events at the desired air/fuel ratio during all engine transients. The goals are:

- To eliminate lean air/fuel excursions during accelerations.

- To eliminate rich air/fuel excursions during decelerations.

APPROACH

. The computer adjusts fuel flow to match the transient fuel flow to or from the manifold fuel film.

```
COMPENSATED   CLOSED/OPEN LOOP   FILM MASS RATE OF CHANGE
 FUEL FLOW  =    FUEL FLOW     +   OR FUEL FLOW
 (ACTUAL)      (BASE STRATEGY)    (TFC STRATEGY)
```

. The film mass rate of change is proportional to the amount of fuel that must be added to or subtracted from the manifold film.

```
                                    /                     \
  FILM MASS           1            |  STEADY       ACTUAL  |
  RATE OF      = --------------- * |  STATE    -           |
  CHANGE          TIME CONSTANT    | FILM MASS   FILM MASS |
                                    \                     /
```

. The time constant and steady state film mass are calculated from APELOD and temperature variables and must be calibrated for different applications.

. The actual film mass is a time integration of the film mass rate of change.

```
                           /                            \
 ACTUAL      ACTUAL       | FILM MASS        TIME SINCE |
 FILM     =  FILM    +    | RATE OF     *      LAST     |
 MASS        MASS         | CHANGE             UPDATE   |
                           \                            /
```

TRANSIENT FUEL COMPENSATION STRATEGY

DEFINITIONS

- CRANK = Engine Starting Strategy.
- RUN = Normal engine control strategy.
- UNDERSPEED = Engine Strategy which makes the transition from CRANK to RUN mode; it also operates when the engine stalls or stumbles.

INPUTS

Registers:

- AISF = Actual Intake Surface Fuel.
- ATMR1 = Time since exiting Crank Mode, secs.
- DELTIM = Time since last AISF update.
- EFTR = Equilibrium Fuel Transfer Rate during the previous program pass.
- ISCFLG = ISC Mode Flag (1 = RPM Control Mode).

Bit Flags:

- CRKFLG = Flag indicating engine mode. Set to 1, if engine Cranking. Set to 0 for other modes.
- DFSFLG = Indicates Decel Fuel Shutoff.
- EFFLG1 = Equilibrium Fuel Flag. This flag controls the initialization of AISF.
- UNDSP = Flag set to 1 if engine in UNDERSPEED or CRANK mode, set to zero otherwise.

Calibration Constants:

- AISFM = Multiplier on AISF when in DFSO. Determines Fuel Puddle size upon re-entering normal fuel.
- ALPHA = A multiplier proportioning the dependency of ACT TO ECT.
- EFTC = Equilibrium fuel time constant.
  = TEFTC(FN1322) = An 10 X 8 table of equilibrium fuel transfer time constants as a function of:
  ALPHA * ACT + (1 - ALPHA)*ECT and APELOD.
- EISF = TEISF(FN1321) = An 10 X 8 table of fuel mass values as a function of:
  ALPHA*ACT + (1 - ALPHA)*ECT and APELOD.
- FN071 = Load Normalizing function; used for table lookup. Input = LOAD and Output = Normalized load.
- FN374 = Open Loop Fuel multiplier, RPM.
- FN1321 = Equilibrium Intake Surface Fuel Table. TEISF is the synonym for this Table.
  X-input = Normalized ALPHA * ACT + (1-ALPHA) * ECT = FN022A
  Y-input = Normalized Load = FN071.

- FN1322 = Equilibrium Fuel Transfer Constant. TEFTC is the synonym for this Table.
  X-input = Normalized ALPHA * ACT + (1-ALPHA) * ECT = FN022A
  Y-input = Normalized Load = FN071.

- KFT = Multiplier (can be used to disable transient fuel compensation by setting equal to zero).
- MEFTRA = Multiplier for accelerations.
- MEFTRD = Multiplier for decelerations.
- MTEFTC = Equilibrium Fuel transfer constant multiplier.
- MTEISF = Equilibrium intake surface fuel multiplier.
- TEISF = Load Normalizing function; used for table lookup. Input = LOAD and Output = Normalized load.
  X-input = Normalized ALPHA * ACT + (1-ALPHA) * ECT = FN022A
  Y-input = Normalized Load = FN071.
- TFCDED = Percentage deadband around Equilibrium Intake Surface Fuel to turn off transient fuel.

- TFCISW = Transient fuel compensation initialization switch.

- TFCTM = Time delay after start before enabling Transient Fuel compensation.

- TFSMN = Maximum RPM deadband above Idle RPM to disable Transient Fuel during Dashpot Mode, RPM.

OUTPUTS

Registers:

- AISF = Actual Intake Surface Fuel.

- AEFTRFF = The upper word of the sum of (AEFUEL/2) and (EFTRFF/2).

- EFTR = Equilibrium Fuel Transfer Rate during the previous program pass.

- EFTRFF = Transient fuel flow in LB/MIN.

- EFTRFFL = The lower word of the sum of (AEFUEL/2) and (EFTRFF/2).

Bit Flags:

- EFFLG1 = Equilibrium Fuel Flag. This flag controls the initialization of AISF.

TRANSIENT FUEL COMPENSATION STRATEGY CONTROL LOGIC

```
CRANK mode ---------------|
(CRKFLG = 1)              |
                          |
UNDERSPEED mode ----------|OR -----| DO NOT RUN TRANSIENT
(UNDSP = 1)               |        | FUEL COMPENSATION
                          |        | EFFLG1 = 0 (CLEAR)
ATMR1 < TFCTM ------------|        | EFTR = 0
                          |        |
                                   | --- ELSE ---
                                   |
EFFLG1 = 0 ---------------|        |
                          |        |
RUN mode -----------------|AND ----| DO NOT RUN TRANSIENT
(CRKFLG = 0, UNDSP = 0)   |        | FUEL COMPENSATION
                          |        | INITIALIZE
TFCISW = 1 ---------------|        | AISF = MTEISF
 (assume wet manifold              |       * FN1321(TEISF)
  at startup)                      | EFFLG1 = 1 (SET)
                                   |
                                   |
                                   | --- ELSE ---
                                   |
                                   |
EFFLG1 = 0 ---------------|        |
                          |        |
RUN mode -----------------|AND ----| DO NOT RUN TRANSIENT
                          |        | INITIALIZE
TFCISW = 0 ---------------|        | AISF = 0
 (assume dry manifold              | EFFLG1 = 1 (SET)
  at startup)                      |
                                   |
                                   | --- ELSE ---
RUN Mode -----------------|        |
                          |        |
DFSFLG = 1 ---------------|AND ----| DO NOT RUN TRANSIENT
 (in DFSO)                |        | FUEL COMPENSATION
                          |        | INITIALIZE AISF =
EFFLG1 = 1 ---------------|        | MTEISF*FN1321(TEISF) * AISFM
                                   | EFFLG1 = 1 (SET)
                                   | EFTR = 0
                                   |
                                   |
EFFLG1 = 1 ---------------|        |
                          |AND ----| RUN TRANSIENT
RUN mode -----------------|        | FUEL COMPENSATION
(CRKFLG = 0, UNDSP = 0)            | DO ACTUAL INTAKE SURFACE
                                   | FUEL CALCULATIONS
                                   | DO EQUILIBRIUM FUEL
                                   | TRANSFER CALCULATIONS
```

EQUILIBRIUM FUEL TRANSFER CALCULATIONS

These calculations are performed during each program pass (background loop) while transient fuel compensation is enabled. The general form of the rate calculation is:

EFTR = KFT * [(EISF * MTEISF - AISF)/(EFTC * MTEFTC)]

EISF and EFTC are defined as follows: (NOTE: EISF and EFTC may not be saved as dedicated registers. They appear here as an aid in showing the calculations.)

AISF -- Actual Intake Surface Fuel Calculation.

This calculation is performed during each program pass (background loop) while TFC is enabled. AISF is a time integration of the fuel flow to and from the manifold puddle.

AISF = AISF + (EFTR * DELTIM)

EFTR - TRANSIENT FUEL FLOW CALCULATION/MULTIPLIER

```
REFFLG = 1 -----------------------|
 (in FAM region)                  |
                                  |
ISCFLG > 0 -----------------------|
 (RPM control or lockout)         |
                                  |

ISCFLG = -1 -----------|          |
                       |AND -------|
N - DSDRPM < TFSMN ----|          |
 (low RPM decel)                  |
                                  |
MTEISF * FN1321 = AISF ------------|OR ----| EFTRFF = 0
 (values are equal or 0)          |       | (stop adding transient
                                  |       |  fuel to pulsewidth,
|(MTEISF * FN1321 - AISF)/        |       |  continue AISF update)
 (MTEISF * FN1321)| <OR= TFCDED ---|       |
 (percentage difference is small)         | --- ELSE ---
                                          |
MTEISF * FN1321 < AISF -------------------| EFTRFF=EFTR*60*MEFTRD
 (decrease puddle)                        | (use decel multiplier)
                                          |
                                          | --- ELSE ---
                                          |
                                          | EFTRFF=EFTR*60*MEFTRA
                                          | (use accel multiplier)
```

Determine total fuel requirements due to manifold filling (AEFUEL) and wall wetting (EFTRFF) and provide that value to the fuel pulsewidth equation. The value is divided by two assuming equal distribution between banks.

AEFTRFF,EFTRFFL = (AEFUEL/2) + (EFTRFF/2)

DECEL FUEL SHUT OFF STRATEGY

The Fuel Shutoff strategy is divided into two sub-strategies:

1) Decel Fuel Lean Out.

2) Manual Transmission Shift Fuel Lean Out.

The Decel Fuel Lean Out strategy reduces the fuel flow during specific load and RPM condition only during Closed Throttle Mode. The FUELPWs are multiplied by FN374 during a decel until the RPM is within the band created by [DSFRPM - DSFRPH] of the idle RPM range. Typically, FN374 is calibrated to provide a lean limit air/fuel ratio during the decel RPM range.

The Manual Transmission Shift Fuel Lean out strategy reduces (or eliminates) fuel flow at the beginning of the shift, until the RPM is within the band created by [SHFRPM - SHFHYS] of the idle speed (or until the transmission has been in Neutral for DSTM2 seconds. Typically, FN374 can be calibrated to zero during the range of shift RPMs.

DEFINITIONS

INPUTS

Registers:

- APT = If = -1, Closed Throttle.
- ATMR1 = Time since start, sec.
- CTTMR = Time since entering Closed throttle mode, secs. CTTMR is used to delay Decel Fuel Shutoff (DFSO).
- DLTMR = Decel fuel low load timer, sec.
- DSDRPM = Desired engine speed.
- ECT = Engine Coolant Temperature, deg F.
- LOAD = Normalized ARCHG divided by SARCHG.
- N = Engine speed, RPM.
- NACTMR = Not at Closed Throttle timer, sec.
- NDDTIM = Time since Transmission shift, sec. In the DFSO Strategy, this timer is used to delay Decel Fuel Shutoff if a vehicle with a manual transmission shifts into Neutral during the decel.
- PPCTR = PIP counter for Fuel Ramp, unitless.
- RATCH = Warm curb Idle Throttle Position, counts.
- TP = Throttle position, counts.
- VSBAR = Vehicle speed, MPH.

Bit Flags:

- AFMFLG = Flag indicating that ACT sensor is in/out of range.
- CFMFLG = Flag indicating that ECT sensor is in/out of range.
- DMFLG = Decel fuel low load timer enabled flag, 1 = Count up timer.
- EFMFLG = Flag indicating that EVP EGR sensor has failed.
- MFAFLG = Managed Fuel/Air state flag.
- MFMFLG = Flag indicating that MAF sensor has failed.
- NDSFLG = Neutral/Drive Flag, 1 = Drive.
- TFMFLG = Flag indicating that TP sensor has failed.

Calibration Constants:

- AGB = Decel fuel shutoff time delay, sec.
- CTDFSO = Minimum time delay after entering Closed Throttle to enable DFSO, sec.
- CTEDSO = Decel Fuel Shutoff time delay during extended decels. This time delay allows DFSO during extended decels (ie., down mountains), even if times at Part Throttle are very short (light Tip-ins), sec.
- DFLDH = Decel Fuel low load hysteresis.
- DFLDL = Decel Fuel low load shut off.
- DFLOD = Maximum load to enable decel Fuel Shut-off.
- DFLODH = Hysteresis for DFLOD.
- DFSECT = Minimum ECT to allow Decel Fuel Shutoff.
- DFSVS = Minimum VSBAR for Decel fuel shut off, mph.
- DFSVSH = Hysteresis for DFSVS.
- DLDFSO = Decel Fuel low load shut off time, sec.
- DMIN = Minimum FN379 clip during Fuel Ramp Back, unitless.
- DSFRPH = Hysteresis for DSFRPM, unitless.
- DSFRPM = Minimum RPM for Decel fuel shutoff, RPM.
- DSFTM = Minimum Time at Part Throttle (or WOT) to permit Decel Fuel Shutoff AFTER CTDFSO seconds, sec. This time requirement prevents decel fuel shutoff when parking the vehicle.
- DSTM1 = Maximum time that Decel Fuel Shutoff is enabled if decelerating in Neutral, sec.
- DSTM2 = Maximum time that DFSO logic is enabled during manual transmission shifts, secs.
- FN374 = Open Loop Fuel multiplier, RPM.
- PIPNUM = Number of PIPS to remain in Open Loop Fuel after DFSO. Prevents LAMBSE from ramping rich due to normal transport delay time. Set to 1 to calibrate out.
- PTDFSW = Part Throttle Decel Fuel shut off switch; 1 = Do Part Throttle DFSO, 0 = Do Closed Throttle DFSO.
- SHFHYS = Hysteresis term, rev/min. If the RPM drops this amount, the normal Fuel Strategy operates.
- SHFRPM = Minimum RPM at which DFSO logic is enabled, Rev/min. (This corresponds to the RPMs during the shift.)

TRLOAD = Transmission Load switch.
- 0 = Manual Transmission, no clutch or gerar switches, forced neutral state (NDSFLG = 0).
- 1 = Manual Transmission, no clutch or gear switch.
- 2 = Manual Transmission, one clutch or gear switch.
- 3 = Manual Transmission, both clutch and gear switches.
- 4 = Auto Transmission, non-electronic, neutral drive switch.
- 5 = Auto Transmission, non-electronic, neutral pressure switch, (AXOD).
- 6 = Auto Transmission, electronic, PRNDL sensor - park, reverse, neutral, overdrive, manual 1, manual 2.

OUTPUTS

Registers:

- DLTMR = Decel fuel low load timer, sec.
- PPCTR = PIP counter for Fuel Ramp, unitless.

Bit Flags:

- DFSFLG = Indicates DECEL Fuel shutoff.
- DMFLG = Decel fuel low load timer enabled flag, 1 = Count up timer.

DECEL FUEL SHUT OFF LOGIC

```
"A" ---------|
             |OR ------------------------------|
"B" ---------|                                 |
             |                                 |AND -| 'D'=FN374
"C" ---------|                                 |     | PPCTR = 1
                                               |     |
                                               |     |
N - DSDRPM > DSFRPM -------------|S Q----------|     |
                                 |             |     |
N - DSDRPM < DSFRPM - DSFRPH ----|C            |     |
 (DECEL RPM)                                   |     | --- ELSE ---
                                               |     |
                                               |     |
ATMR1 > AGB --------------------|              |     |
 (START UP DELAYS)              |OR -----------|     |
                                |              |     |
ECT >OR= DFSECT ----------------|              |     |
                                               |     |
MFAFLG = 0 ------------------------------------|     |
 (NOT MANAGED FUEL AIR)                        |     |
                                               |     | Driver wants
RUNNING = 0 -----------------------------------|     | to accelerate
 (NOT IN VIP)                                  |     | 'D' = 1.0
                                               |     | Increment PPCTR
AFMFLG = 0 ------------------------------------|     | once per PIP
                                               |     | period
CFMFLG = 0 ------------------------------------|     | Clip  PIPNUM
                                               |
TFMFLG = 0 ------------------------------------|
                                               |
EFMFLG = 0 ------------------------------------|
                                               |
MFMFLG = 0 ------------------------------------|
```

When fuel is shut off (FN374) a flag is set - DFSFLG to disable Transient fuel. See Transient Fuel Compensation Logic for details.

```
FN374 = 0 -----------------| DFSFLG = 1
                           |
                           | --- ELSE ---
                           |
                           | DFSFLG = 0
```

"A" LOGIC

```
 (Normal Decel)
LOAD < DFLOD ----------------------|S Q -------|
                                   |           |
LOAD > DFLOD + DFLODH -------------|C          |
                                               |
NDSFLG = 1 ---------|                          |
 (Trans. in gear)   |OR -----------|S Q -------|
                    |              |           |
TRLOAD < 2 ---------|              |           |
 (ignore N/D input)                |           |
                                   |           |
TRLOAD >OR= 4 ------|              |           |
                    |OR -|         |           |
NDDTIM >OR= DSTM1 --|    |         |           |
                         |AND------|C          |AND ----| "A"
NDSFLG = 0 --------------|                     |
                                               |
CTTMR > CTDFSO --------------------|           |
                                   |AND --|    |
APT = -1 --------------------------|      |    |
                                   |      |    |
CTTMR > CTEDSO ---------------|    |      |    |
 (LONG DECEL)                 |OR -|      |    |
                              |           |    |
NACTMR > DSFTM ----------|S Q-|           |    |
 (CRUISE)                |                |OR -|
                         |                |    |
0 < NACTMR <OR= DSFTM ---|C               |    |
 (SHORT TIP IN)                           |    |
                                          |    |
PTDFSW = 1 -------------------------------|    |
                                               |
VSBAR >OR= DFSVS --------|S Q -----------------|
                         |
VSBAR < DFSVS - DFSVSH --|C
```

"B" LOGIC

(MANUAL TRANSMISSION SHIFT)

```
APT = -1 ------------------------------|
 (Closed Throttle)                     |
                                       |

TRLOAD <OR= 3 -------------------------|
 (Manual trans.)                       |
                                       |
NDSFLG = 0 ----------------------------|
                                       |
NDDTIM < DSTM2 ------------------------|AND -| "B"
                                       |
N - DSDRPM > SHFRPM ---------------|S Q-|
                                   |
N - DSDRPM <OR= SHFRPM-SHFHYS -----|C
 (Short RPM)
```

"C" LOGIC

```
DMFLG = 1 -------------------|
 (Decel and Closed Throttle)  |AND ----| "C"
                             |
DLTMR < DLDFSO --------------|
 (Start of Decel)
```

CALIBRATION HINTS:

The use of Decel Fuel Shutoff can aggravate Clunk. Therefore, DFSO should occur only at low airflow (low MAP) in order to minimize the rate of change of Torque. CTDFSO can be used to delay DFSO.

FN374 should be calibrated to avoid lean misfires. Therefore, it should be either zero (Decel Fuel Shutoff) or greater than the lean limit (Decel Fuel Lean Out).

CTEDSO should be greater than CTDFSO to prevent DFSO after Tip-in, Tip-out.

For MANUAL TRANSMISSIONS: SHFRPM should be greater than DSFRPM.

BASE FUEL FLOW CALCULATIONS

OVERVIEW

Using the assumption of equal air flow (AM) between bank 1 and bank 2, a calculation can be made of the amount of fuel required by the engine to operate at stoichiometry.

DEFINITIONS

INPUTS

Registers:

- AM = Air mass flow for the engine (lb/min).
- ARCHG = Air charge inducted per intake stroke. Value is updated once per background loop at the time that AM is computed, (lb).
- KAMRFn = Fuel correction factor obtained from the adaptive fuel tables that use the EGO sensor(s) for input. KAMRFn = [0.5 + LTMTBn (r,c)] where:
  - c = column
  - n = bank number
  - r = row
- LAMBSEn = The stoichiometric equivalence value. (n=bank number).
- N = Engine speed in revolutions per minute.

Calibration Constants:

- ENGCYL = The number of cylinders in an engine revolution.

OUTPUTS

Registers:

- ARCHG_BG = Air charge inducted per intake stroke. Value is updated once per background loop at the time that base fuel flow is computed.

- BASEFFn = The fuel flow for bank (n). (lb/min).

The base fuel flow for each bank is:

$$BASEFF1 = \frac{0.5 * AM * KAMRF1}{14.64 * LAMBSE1}$$

$$BASEFF2 = \frac{0.5 * AM * KAMRF2}{14.64 * LAMBSE2}$$

where:

AM = ARCHG * N * ENGCYL

and:

ARCHG_BG = ARCHG after the calculation of BASEFF1 and BASEFF2.

BACKGROUND FUEL

OVERVIEW

The fuel pulsewidth for each bank of the engine is calculated during each pass through the background loop. This calculation consists of a base fuel calculation, BASEFFn, that is a determination of the amount of fuel the bank would need to remain at or near stoichiometry during steady state engine operation. Additionally, there is a need to modify this value with other values that reflect the fuel needs of the engine under non-steady conditions. Under all operating conditions except CRANK mode the fuel equation is:

FUELPWn = D * (BASEFFn + AEFTRFF) * PWCF + FN367

As one of the controlling elements, the speed limiter logic turns off the fuel when the engine speed becomes excessively high. This logic operates as an overspeed protection, like a software governor. This action reduces the power output of the engine and causes the speed to drop to a more reasonable level.

DEFINITIONS

INPUTS

Registers:

- AEFTRFF = The upper word of the sum of (AEFUEL/2) and (EFTRFF/2).
- AEFUEL = Rate of acceleration enrichment fuel delivery (lb/min).
- APT = At Part Throttle - indicates throttle mode; -1 = closed throttle, 0 = part throttle, and 1 = wide open throttle.
- BASEFFn = Base Fuel Flow associated with "n" EGO. (n = 1,2) (lb/min).
- BP = Barometric Pressure (inches of Mercury).
- CRKTMR = Timer indicating time in Crank mode.
- D = Deceleration Fuel Shutoff multiplier.
- ECT = Engine Coolant Temperature.
- EFTRFF = Equilibrium fuel transfer rate for transient fuel compensation (lb/min).
- EFTRFFL = The lower word of the sum of (AEFUEL/2) and (EFTRFF/2).
- N = Engine speed in revolution per minute.
- VBAT = Battery voltage inferred from IIVPWR, volts.

Bit Flags:

- BFULSW = Force Background Fuel Switch (1 = Do not calculate fuel pulseswidth in foreground at any time).
- CRKFLG = Engine mode flag. (1 = Crank Mode, 0 = Not in Crank Mode).
- FAM_FLG = Indicates that the engine is in the operating region where a filter is being applied to the air mass value to reduce fluctuations and that filtered value is to be used in the fuel pulsewidth as a replacement for AM.
- FOFFLG = Alternate injector fire enable flag; 1 = fire alternate injectors.
- HSPFLG = High speed mode flag; 1 = High speed alternate fuel/spark.
- IMFMFLG = Instantaneous mass air flow sensor FMEM flag.
- MFMFLG = Air Meter failure flag.
- NLMT_FLG = Engine Speed Limiter Flag - (1 = limit engine speed by turning off the fuel; 0 = normal engine speed).
- UNDSP = Run/Underspeed Engine Mode Flag. (1 = Underspeed/Crank, 0 = Run Mode).

Calibration Constants:

- AHISL = High fuel flow injector slope (lb/sec).
- ALOSL = Low fuel flow injector slope (lb/sec).
- ENGCYL = Number of cylinders per engine revolution.
- FN306(CRKTMR) = Cranking fuel pulsewidth as a function of time in crank.
- FN348(ECT) = Crank fuel pulsewidth as a function of ECT.
- FN367(VBAT) = Injector offset as a function of VBAT.
- FN387(ECT) = Fuel pulsewidth muliplier as a function of ECT.
- FN389(VBAT) = Dual slope injector breakpoint. Input = VBAT, volts and Output = lb/rev.
- INJOUT = Number of injectors fired by each output port.
- MTCF = Milliseconds to clock ticks conversion factor.
- NLMT = Overspeed RPM.
- NLMTH = Hysteresis for overspeed RPM.
- NUMOUT = Number of injector output ports.
- PIPOUT = Number of PIP's between injector outputs on each injector port.

OUTPUTS

Registers:

- BGFULn = Background Fuel Pulsewidth for bank "n" (n = 1,2).
- FFULCn = The value that is added in the foreground fuel pulsewidth.
- FFULMn = The value that is multiplied by the ratio of air charges in the foreground fuel pulsewidth equation for bank "n".
- FUELFLOWn = Desired fuel flow for the "n" bank (n = 1,2).
- LBMF_INJn = The pounds mass of fuel per injection that is calculated for summing to be sent out on the Data Output Link (DOL).
- PWCF = Computed value to convert amount of fuel for the engine to amount of fuel to be delivered by each injector.
- PWOFF = Injector pulsewidth offset (clock ticks).
- PWOFS = Injector pulsewidth offset (milliseconds).

Bit Flag:

- FFULFLG = Foreground Fuel Flag - (1 = compute fuel pulsewidth in foreground using latest integrated air charge, 0 = use background calculated fuel pulsewidth.

Calculate the value of the pulsewidth conversion factor (PWCF):

$$PWCF = \frac{1}{N * ENGCYL} * \frac{2 * PIPOUT}{NUMOUT * INJOUT}$$

Determine the value of the underspeed and deceleration fuel multipliers:

```
UNSPD = 1 -----| fuel_a = FN387(ECT) * D
               |
               | --- ELSE ---
               |
               | fuel_a = D
```

Determine the intersection point, in fuelflow, of the two slopes of the injector flow vs time transfer functions.

fuel_f = FN389(VBAT) * N / 2

NOTE: Lower case designators indicate temporary registers that are not accessible. (i.e. fuel_a)

Calculate the crank fuel and dechoke pulsewidth, and the underspeed/run fuel flow amounts:

```
CRKFLG = 1 ----|
               |AND ------------| BGFUL1 = BGFUL2 = 0
APT = 1 -------|                |
(Wide Open                      |
 Throttle)                      |
                                |
                                | --- ELSE ---
                                |
CRKFLG = 1 ---------------------| BGFUL1 = FN348 * (BP/29.875) *
                                |                  FN306(CRKTMR)
                                |
                                | BGFUL2 = BGFUL1
                                |
                                | --- ELSE ---
                                |
NLMT_FLG = 1 -------------------| BGFUL1 = 0
                                | BGFUL2 = 0
                                |
                                | --- ELSE ---
                                |
                                | FUELFLOW1 = fuel_a * (BASEFF1 + AEFTRFF)
                                |
                                | FUELFLOW2 = fuel_a * (BASEFF2 + AEFTRFF)
```

Determine on which slope the injector is operating and calculate the fuel pulsewidth (BGFULn) and foreground fuel intermediate values (FFULMn and FFULCn).

```
FUELFLOW1 <OR=
          fuel_f -| BGFUL1 = FUELFLOW1 / ALOSL * PWCF
                  |
                  | FFULM1 = fuel_a * BASEFF1 / ALOSL * PWCF
                  |
                  | FFULC1 = fuel_a * AEFTRFF / ALOSL * PWCF
                  |
                  | --- ELSE ---
                  |
                  |          { fuel_f   FUELFLOW1   fuel_f }
                  | BGFUL1 = { ------ + --------- - ------ } * PWCF
                  |          { ALOSL     AHISL      AHISL  }
                  |
                  | FFULM1 = (fuel_a * BASEFF1 / AHISL) * PWCF
                  |
                  |          {fuel_f   fuel_f  (fuel_a * AEFTRFF)}
                  | FFULC1 = {------ - ------ + ---------------- } * PWCF
                  |          {ALOSL    AHISL         AHISL       }


FUELFLOW2 <OR=
          fuel_f -| BGFUL2 = FUELFLOW2 / ALOSL * PWCF
                  |
                  | FFULM2 = fuel_a * BASEFF2 / ALOSL * PWCF
                  |
                  | FFULC2 = fuel_a * AEFTRFF / ALOSL * PWCF
                  |
                  | --- ELSE ---
                  |
                  |          { fuel_f   FUELFLOW2   fuel_f }
                  | BGFUL2 = { ------ + --------- - ------ } * PWCF
                  |          { ALOSL     AHISL       AHISL }
                  |

                  | FFULM2 = (fuel_a * BASEFF2 / AHISL) * PWCF
                  |
                  |          {fuel_f   fuel_f  (fuel_a * AEFTRFF)}
                  | FFULC2 = {------ - ------ + ---------------- } * PWCF
                  |          {ALOSL    AHISL         AHISL       }
```

Compute the pounds mass per injector for use by the Data Output Link (DOL):

```
CRKFLG = 1 ---------| LBMF_INJ1 = ALOSL * BGFUL1
                    | LBMF_INJ2 = ALOSL * BGFUL2
                    |
                    | --- ELSE ---
                    |
                    | LBMF_INJ1 = FUELFLOW1 * 2 / (ENGCYL * N)
                    | LBMF_INJ2 = FUELFLOW2 * 2 / (ENGCYL * N)
```

Determine the state of the flag which allows updates to fuel pulsewidth using the latest computed air charge in foreground:

```
BFULSW = 1 -----------------------|
                                  |
IMFMFLG = 1 ----------------------|
                                  |
MFMFLG = 1 -----------------------|
                                  |
CRKFLG = 1 -----------------------|
                                  |
FAM_FLG = 1 ----------------------|
                                  |OR ------| FFULFLG = 0
NLMT_FLG -------------------------|         |
                                  |         | --- ELSE ---
FOFFLG = 1 -----------------------|         |
                                  |         | FFULFLG = 1
HSPFLG = 1 -----------------------|
```

Calculate the injector pulsewidth offset:

PWOFF = PWOFS * MTCF = [FN367(VBAT)] * MTCF

FOREGROUND FUEL

OVERVIEW

This module is designed to calculate an updated fuel pulsewidth using the latest air charge value upon the completion of the air charge computation during the PIP interrupt. Included within this module is a a check for a 10% change in computed pulsewidth, a determination of whether to update the fuel pulsewidth, and a new request for a new computation of the injector timing.

DEFINITIONS

INPUTS

Registers:

- ARCHFG = The integrated value of air charge as computed at each PIP interrupt (lb).
- ARCHG_BG = The value of air charge that was used to compute the intermediate values for the foreground fuel calculation and additionally, the air charge value that is divided into the latest air charge to scale the new fuel pulsewidth (lb).
- BGFULn = The fuel pulsewidth that is calculated in background for each bank. (n = 1,2).
- DT12S = The period of time between two adjacent rising edges of PIP.
- FFULCn = The computed value that is added in the foreground fuel pulsewidth calculation.
- FFULMn = The computed value that is multiplied by the scaled value of ARCHI divided by ARCHG_BG in the foreground fuel pulsewidth calculation for each bank.
- PWOFF = The offset in the transfer function for injector fuel delivered versus time in clockticks.

Bit Flag:

- FFULFLG = Foreground Fuel Flag (1 = compute fuel pulsewidth in foreground using the latest integrated air charge, 0 = use background computed fuel pulsewidth).

Calibration Constants:

- PIPOUT = The number of PIP periods between the start of consecutive injections.

Constant:

- STCF = Seconds to clock ticks conversion factor.

OUTPUTS

Register:

- FUELPWn = The injector pulsewidth in clock ticks (n = 1,2).

Bit Flag:

- CHANGE_FUELPW = A flag that indicates that the desired pulsewidth for in-progress fuel injections needs to be modified because the latest calculated value for that injection has changed by more than 10 percent.

Following the completion of the ARCHFG calculation in foreground, determine if the foreground fuel flag (FFULFLG) is set, and if so, calculate the fuel pulsewidth at that time, otherwise use the background computed pulsewidth.

PROCESS

```
FFULFLG = 1 --------| fuelpw1 = [(FFULM1 * ARCHFG) / ARCHG_BG] + FFULC1
                    | fuelpw2 = [(FFULM2 * ARCHFG) / ARCHG_BG] + FFULC2
                    |
                    | --- ELSE ---
                    |
                    | fuelpw1 = BGFUL1
                    | fuelpw2 = BGFUL2
```

then convert into clockticks:

```
FUELPW1 (ticks) = fuelpw1 * STCF
FUELPW2 (ticks) = fuelpw2 * STCF
```

Determine if the fuel requested is greater than the amount that can be delivered when the injectors are on full time, and if so, clip the fuel pulsewidth to a full-on pulsewidth.

```
DT12S < 65536 ticks ------|
                          |AND ---| fgbeta = PIPOUT - 0.03125
(FUELPWn / DT12S)         |       | FUELPWn = fgbeta * DT12S
 >OR= PIPOUT -------------|       |
```

Determine if the latest pulsewidth calculated for each bank is a change of more than 10% from the previous pulsewidth for that bank. If so, set the flag CHANGE_FUELPW, which will cause any injection in progress for that bank to be altered to reflect the latest calculated pulsewidth.

```
  /                             \
 | |(new FUELPWn - old FUELPWn)| |
 | ----------------------------- | > 0.010 ----| CHANGE_FUELPW = 1
 |         old FUELPWn           |
  \                             /
```

DUAL SLOPE BREAKPOINT DETERMINATION

FN389 CALIBRATION

1. Plot fuel flow per pulsewidth as a function of Pulsewidth at various battery voltage. (see Fuel Mass versus Fuel Pulsewidth figure on next page)

2. Make a table of fuel flow breakpoints, at which the injector slope changes.

   NOTE: The breakpoint is the FUELFLOW -- not the pulsewidth.

3. Convert the breakpoints into FN389-y parameters.

```
FN389 y-value = BREAKPOINT * NUMOUT*INJOUT * ENGCYL
                             -------------
                                PIPOUT
```

The BREAKPOINT is equal to the fuel flow at which the injector slope changes for the corresponding battery voltage, lb/pulsewidth.

For example, the injectors used on a 5.0L engine have two slopes. These slopes intercept at 3.0 mg/pw at VBAT = 13.5V. Thus,

```
FN389 = 3.0     lb      8*1
        ----- * ----- * ------ * 4 = 2.64*10E-5 lb/rev.
        1000    454g      8
```

NOTE: FN367 breakpoints may require recalibration.

FUEL CONTROL STRATEGY - FUEL PULSEWIDTH - GXX0
PEDD-PTOPE, FoMoCo, PROPRIETARY & CONFIDENTIAL
FUEL MASS VERSUS FUEL PULSEWIDTH DIAGRAM

```
          |
          |
         6|
          |                                 AHISL-->  *
          |                                        .         .
          |                                     .          .
          |                                  .           .
       4.5|                               .             .
Fuel      |                              .            .
Mass      |                            .            .
          |                           .           .
Mg/Pulse  |                         .           .
         3|          FN389(VBAT1) .          .
          |                |     .         .
(f(x))    |                V  .         .
          |     ALOSL -->  *          .
          |              .          * <--FN389(VBAT2)
       1.5|            .          .
          |           .         .
          |          .        .
          |         .       .
          |        .       .
          |      .       .
         0 -----|------|-------------|------------|-----------|--
           .5   |     1.5           2.5          3.5         4.5
                |
                V
              FN367(VBAT1)      FUEL PULSEWIDTH (msec) (x)
```

SPEED LIMITER

The speed limiter logic protects vehicle function in three stages, depending upon the engine speed and vehicle speed (inferred from AM). These stages are shown below.

1) Stage One: Reduces the engine's power output in a gradual manner by enriching the fuel and retarding the spark (See Open Loop Fuel and Spark Strategies).

2) Stage Two: Further reduces the engine output by disabling the outputs to one-half of the injector ports. This action will occur only if the fuel and spark strategy in Stage One is ineffective.

3) Stage Three: Turns off the fuel if the engine RPM exceeds its "red-line" limit.

NOTE: NLM_SH should approximate the engine's "red line" limit.

DEFINITIONS

INPUTS

Registers:

- N = Engine RPM
- VSBAR = Filtered Vehicle Speed.

Bit Flag:

- FOFFLG = Alternate INJ fire enable flag.

Calibration Constants:

- HVS_CL = Disable Stage 1 Speed Limiter.
- HVS_SH = Enable Stage 1 Speed Limiter.
- VVS_CL = Disable Stage 2 Speed Limiter.
- VVS_SH = Enable Stage 2 Speed Limiter.
- NLM_SH = Overspeed RPM, sets stage 3 fuel limiter.
- NLM_CL = RPM to clear Stage 3 Fuel Limiter, RPM.
- VSTYPE = Vehicle speed sensor/Cruise control H/W present switch 0 = No integrated cruise control and no Vehicle Speed Sensor. 1 = Vehicle speed sensor present (VSS) 2 = Integrated cruise control and Vehicle Speed Sensor (VSS+VSC)

OUTPUTS

Bit Flags:

- FOFFLG = Alternate INJ fire enable flag.
- HSPFLG = High Speed Mode Flag, = 1 means High Speed Alt. Fuel/Spark Speed Limit.
- NLMT_FLG = Overspeed limiter flag, stage 3.

EXAMPLE OF SPEED LIMITER

NORMAL FUEL

```
       ----                              ----
      |    |                            |    |
INJ-1 |    |                            |    |
            -------------------------------      ---------------

            ----                              ----
           |    |                            |    |
           |    |                            |    |
INJ-5 -----      --------------------------------      ---------

                 ----                              ----
                |    |                            |    |
                |    |                            |    |
INJ-4 ----------      ---------------------------------      ----

                      ----
                     |    |
                     |    |
INJ-2 ---------------      --------------------------------------

 .                       .
 .                       .
 .                       .

                                       ----
                                      |    |
                                      |    |
INJ-8 --------------------------------      ----------------------
```

SPEED LIMITED FUEL

```
       ----                                 ----
      |    |                               |    |
INJ-1 |    |                               |    |
            -------------------------------      ---------------

INJ-5 ----------------------------------------------------------

                 ----                                   ----
                |    |                                 |    |
                |    |                                 |    |
INJ-4 ----------      ---------------------------------      ----

INJ-2 -----------------------------------------------------------

 .                       .
 .                       .
 .                       .

                                  ----
                                 |    |
                                 |    |
INJ-7 ---------------------------      --------------------------

INJ-8 -----------------------------------------------------------
```

FUEL STRATEGY - SPEED LIMITER - GUE0
PEDD-PTOPE, FoMoCo, PROPRIETARY & CONFIDENTIAL
ALTERNATE FUEL/SPARK LOGIC AND
ALTERNATE INJECTOR FIRING LOGIC
(Vehicle Overspeed Protection)

```
N > NLM_SH --------------------|S   Q ---------| STAGE 3
                               |               | Set NLMT_FLG
N < NLM_CL --------------------|C


VSTYPE = 0 ------------------------------------| HSPFLG = 0
 (No VSS sensor)                               | FOFFLG = 0
                                               |
                                               | --- ELSE ---
                                               |
VSBAR > VVS_SH -----------|S  Q ---------------| STAGE 2
 (Very High Speed)        |                    | Fire Alternate
                          |                    | Injectors using
VSBAR < VVS_CL -----------|C                   | Normal Fuel strategy
                                               | FOFFLG = 1
                                               |
                                               | --- ELSE ---
                                               |
VSBAR > HVS_SH -----|                          |
 (High Speed)       |OR --|S  Q ---------------| STAGE 1
                    |     |                    | Do Fuel Enrichment
FOFFLG = 1 ---------|     |                    | and Spark Retard
                          |                    | HSPFLG = 1
VSBAR < HVS_CL -----------|C                   | FOFFLG = 0
                                               |
                                               | --- ELSE ---
                                               |
                                               | HSPFLG = 0
```

BACKGROUND CALCULATION
INJECTOR TIMING

Injector timing is the delay before each injector output is fired. The delay is taken from TDC of the reference PIP signal for each injector output. The units for injector timing are absolute engine crank degrees. The range is 0 degrees TDC to 720 degrees ATDC with 4 degree resolution.

Either edge (on or off) of the injector pulse can be timed. The calibration switch INJREF defines the reference edge for injector timing.

INJREF = 0, Use start of fuel pulse.
INJREF = 1, Use end of fuel pulse.

Regardless of which edge is used, the injector delay is used only to start a fuel pulse. Once started, pulsewidth accuracy has top priority.
When the system is not in sync (SYNFLG = 0), the injector timing is coincident with the relevant PIP signal. The injector outputs are fired in sequence after receiving the rising edge of the reference PIP signals. Actual timing will be the result of the random link between signature PIP (cylinder #1) and #1 injector output.

When the system is in sync (SYNFLG = 1), injector timing is calculated from the following equation:

```
FUEL_IN_SYNC = 0 --------------| Signature PIP is recognized
                               |  but fuel timing has not
                               |  yet SYNC'ed. INJDLY is set
                               |  by the EOS
                               |
DNDSUP = 0 -----------|        | --- ELSE ---
                      |        |
CINTSW = 1 -----------|AND ----| Neutral Timing
                      |        | INJDLY =
"A" ------------------|        |  UROLAV (CINTV,TCINJD)
                               |
                               | --- ELSE ---
IDLFLG = 1 -----------|        |
                      |AND ----| Idle Timing (in drive)
CIDRSW = 1 -----------|        | INJDLY =
                               |  UROLAV (MIDTV,TCINJD)
                               |
                               | --- ELSE ---
                               |
MFAFLG = 1 --------------------| MFA Mode Injector Timing
                               | INJDLY =
                               |  UROLAV (MINTV,TCINJD)
                               |
                               | --- ELSE ---
                               |
                               | temp = IDKMUL * FN1315 + IDKADD
                               | INJDLY = UROLAV (temp,TCINJD)
```

STARTUP_DELAY LOGIC FOR FIXED IDLE INJECTOR TIMING

```
TCSTRT >OR= CTHIGH -------------|
                                |AND --|
ATMR1 >OR= NITMR3 --------------|      |
                                       |
CTLOW < TCSTRT < CTHIGH --------|      |
                                |AND --|OR --| "A"
ATMR1 >OR= NITMR2 ------|       |      |
                        |AND ---|      |
ATMR2 >OR= NITMR5 ------|              |
                                       |
TCSTRT <OR= CTLOW --------------|      |
                                |AND --|
ATMR1 >OR= NITMR1 ------|       |
                        |AND ---|
ATMR2 >OR= NITMR4 ------|
```

FOREGROUND INJECTOR TIMING

OVERVIEW

Each time a new fuel pulse start time is calculated and the delay from the current PIP edge is between 0.5 and 1.5 PIP periods, a request for a new delay calculation is requested.

DEFINITIONS

INPUTS

Registers:

- INJDLY = Delay in degrees from the reference PIP to the referenced edge in the fuel pulse.

- TOTAL_DELAYn = Delay in percent of PIP period from the reference PIP to the starting edge of the fuel pulse.

Calibration Constants:

- DEGPIP = Engine degrees per PIP period.

- INJREF = Indicates which edge of the fuel pulse is the reference edge for fuel timing, INJDLY. (0 = start edge).

- NUMCYL = Number of cylinders in the engine.

OUTPUTS

Register:

- TOTAL_DELAYn = Same as above.

NOTES:

1. The change in injector timing between consecutive injector firings is limited to a maximum of 45 degrees. This has the effect of walking the injector timing for large timing changes.

2. The final value of injector delay is limited to the range 0 degrees to 720 degrees. Intermediate calculations and results are maintained in an unlimited fashion.

3. The user must set DEGPIP to match his engine. DEGPIP is the number of engine crank degrees per PIP interval. (90 for 8-cylinder, 120 for 6-cylinder, 180 for 4-cylinder)

DEFINITIONS

- RUN = Engine strategy designed to operate normal engine running.

INPUTS

Registers:

- ACT = Air Charge Temperature, deg F.
- ATMR1 = Time since exiting crank mode, sec.
- ATMR2 = Time since engine coolant temperature became greater than TEMPFB, sec.
- CID = Camshaft Cylinder Number 1 identification sensor.
- ECT = Engine Coolant Temperature, deg F.
- HFDLTA = Latest elapsed time from PIP_UP_EDGE to PIP_DOWN_EDGE, clock ticks.
- INJDLY = Injector delay in degrees.
- LOAD = Normalized ARCHG divided by SARCHG.
- N = Engine speed, RPM.
- PIP = Profile Ignition Pickup (RPM sensor)
- SYNCTR = Counter which counts PIP signals until its value is equal to NUMCYL (Number of cylinders). SYNCTR is initialized to 0.
- TCSTRT = Temperature of engine coolant (ECT) at initial startup, deg F.

Bit Flags:

- FUEL_IN_SYNC = Fuel synchronized with PIP.
- IDLFLG = Flag indicating transmission in Drive and at Idle.
- MFAFLG = Managed Fuel Air State flag.
- NDSFLG = Neutral/Drive flag 1 = Drive.
- NEW_IDELAY = Flag controlled by EOS. If set (1) this flag triggers injector delay calculation in the background loop; if clear (0), no injector delay calculation is done.
- SIGPIP = Flag which is set if Signature PIP has occurred; Flag which is cleared if Signature PIP has not. This flag is initialized to 0.
- UNDSP = Run/Underspeed flag. (1 = Underspeed (or CRANK), 0 = RUN).

- WMEGOL = Flag set if WRMEGO set.

Calibration Constants:

- CIDRSW = Calibration switch to enable Special Fuel Timing at Idle, unitless. If set to 1, Enable; 0, Disable.
- CINTSW = Cal Switch to enable special fuel timing in Neutral, unitless.
- CINTV = Injector Timing Value in Neutral, deg.
- CTHIGH = Coolant temperature at Hot start, deg F.
- CTLOW = Coolant temperature at Cold start, deg F.
- DEGPIP = Engine degrees per PIP period, deg. (90 deg = 8 cyl;120 deg = 6; 180 = 4 cyl)
- ENGCYL = Number of PIPs per engine revolution. 2,3 & 4 for 4,5, & 6 respectively.
- FKINJD = Filter constant for INJDLY, (NOTE: This filter may require treating INJDLY as a word during the actual filtering), unitless.
- 070 = Normalizing function for engine speed N as X-input to FN1315.
- FN082 = Load normalizing function; generates table entry point. Input = LOAD and Output = Normalized Load.
- FN083 = RPM Normalizing function; generates table entry point. Input = N and Output = Normalized N.
- FN085 = Normalizing function for LOAD as Y-input to FN1315.
- FN131 = Wide Open Throttle base spark advance versus engine speed to provide base WOT Spark advance. Input = Engine speed, RPM and Output = spark advance.
- FN1315 = An 10x8 table which gives injector delay as

a function of engine speed and load.
X-input = FN070 - Normalized Engine Speed (N).
Y-input = FN085 - Normalized Load.

- HP_CID = A flag indicating cylinder # Identification Hardware is present.
- HP_CIDSEL = A flag indicating type of hardware present, 0 = Hall Effect; 1 = VRS.
- IDKADD = Injector delay timing adder.
- IDKMUL = Injector delay timing multiplier.
- INJREF = Reference edge for injector timing:
  0 = indicates the start of the fuel pulse.
  1 = indicates the end of the fuel pulse.

- MHPFD = Signature PIP difference check value.

- MIDTV = Injector timing value for Idle in Drive, deg. Range of 0 to 720.

- MINTV = Injector Timing value for Lean Cruise Mode, Deg. (Enabled by MFAFLG) Range of 0 to 720.

- NITMR1 = ATMR1 timed delay to enter Closed Loop fuel after Cold start, sec. Range of 0-255 sec., accuracy 1 sec.

- NITMR2 = ATMR1 timed delay to enter Closed Loop fuel after Medium start, sec. Range of 0-255 sec., accuracy 1 sec.

- NITMR3 = ATMR1 timed delay to enter Closed Loop fuel after Hot start, sec. Range of 0 to 255 sec., accuracy 1 sec.

- NITMR4 = ATMR2 timed delay to enter Closed Loop fuel after Cold start, sec. Range of 0 to 255 sec., accuracy 1 sec.

- NITMR5 = ATMR2 timed delay to enter Closed Loop fuel after Medium start, sec. Range of 0 to 255 sec., accuracy 1 sec.

- NUMCYL = Number of cylinders.

- PIPOUT = Number of PIPs between injector outputs on each injector port.

OUTPUTS

Registers:

- HFDLTA = Latest elapsed time from PIP_UP_EDGE to PIP_DOWN_EDGE, clock ticks.
- INJDLY = Injector delay in degrees.
- SYNCTR = Counter which counts PIP signals until its value is equal to NUMCYL (Number of cylinders). SYNCTR is initialized to 0.

Bit Flags:

- FUEL_IN_SYNC = Fuel synchronized with PIP.
- SYNC_UP_FUEL = Fuel synchronization request.
- SIGPIP = Flag which is set if Signature PIP has occurred; Flag which is cleared if Signature PIP has not. This flag is initialized to 0.
- SYNFLG = Flag indicating whether AE fuel is synchronous (set = 1) or asynchronous (set = 0). Initialized to 0.

INJECTOR TIMING EXAMPLES

INJDLY = 400 DEGREES

ENGINE CYCLE

```
   TDC            BDC            TDC             BDC


    |              |              |               |                |
    |              |              |               |                |
    |<----POWER--->|<---EXHAUST-->|<---INTAKE---->|<-COMPRESSION-->|
    |     STROKE   |    STROKE    |    STROKE     |  STROKE        |
    |              |              |               |                |
   360            540            720             180             360

    | 1ST PIP

PIP SIGNAL

    | #1 PIP
    |
   ****  *****    *****  *****   *****   *****   *****   *****    **
   *  *  *   *    *   *  *   *   *   *   *   *   *   *   *   *    *
   *  *  *   *    *   *  *   *   *   *   *   *   *   *   *   *    *
   *  *  *   *    *   *  *   *   *   *   *   *   *   *   *   *    *
  **  ****   ******   ****   *****   *****   *****   *****   ******
    |    |        |      |       |       |       |
    0   80       170    260     350     440     530
   TDC                                 |
    |                                  |
    |<--------- INJDLY = 400 --------->|
    |                                  |
    |ON       INJECTOR  1         ******
    |                             *    *
    |                             *    *
    |OFF             INJREF = 1   *    *
***********************************    *******************************
    |                                  |
    |         INJECTOR  1              |
    |         INJREF = 0               ******
    |                                  *    *
    |                                  *    *
    |                                  *    *
****************************************    **************************
```

INJECTOR SYNCHRONIZATION

There are two possible mechanisms for recognition of cylinder number one for purposes of fuel synchronization: Signature PIP or Camshaft I.D. The Signature PIP is a narrow pulsewidth from the Hall Effect Sensor on the Distributor. The CID is a signal timed to the number-one cylinder cam. CID is designed for use with distributorless Ignition Systems.

A. CID EDGE PROCESSING
(HP_CID = 1)

HP_CID is the flag set by the calibrator to indicate which kind of fuel synchronization system is being used. If HP_CID is set to 1, CID hardware is present and SIGPIP will ALWAYS be set to zero. If HP_CID is set to 0, then Signature PIP logic is utilized.

When HP_CID is set to 1 then the HP_CIDSEL is the flag set by the calibrator to indicate which kind of CID hardware is present, Hall Effect sensing or Variable Reluctance sensing (Hall = 0 and VRS = 1).

B. SIGNATURE PIP DETECTION

This portion of the strategy is only activated if the HP_CID is set equal to 0. The system is allowed to synchronize during RUN MODE only. (The SYNFLG is cleared during CRANK or UNDERSPEED.)

Note: MHPFD is a calibration constant which is dependent only on the number of cylinders and the Signature PIP Duty Cycle. The user must calibrate MHPFD to the appropriate value, as shown in the table below.

CYLINDERS	SIGNATURE DUTY CYCLE	MHPFD
8	=OR< 35 percent	.20
6	=OR< 30 percent	.24
4	=OR< 30 percent	.29

NOTE: If Signature PIP Distributor is NOT present, then MHPFD = .99.

INJECTOR OUTPUT CONTROL PHILOSOPHY

1. The injector pulse start should be based on pulsewidth and timing values calculated from the most recent input data (PIP, LOAD, lambda, etc.).

2. The injector timing value is used only to start the injector pulse, regardless of which edge is used as the reference.

3. Pulsewidth accuracy has top priority after an injector pulse is started.

4. If possible, the pulsewidth should be updated while in progress to take advantage of the most recent input data. That is, the injector pulse can end early or extend later as conditions change.

5. Each time a fuel PW is outputted or corrected, the Data Output Link Fuel Summation, FUEL_SUM is updated. FUEL_SUM = FUEL_SUM + LBMF_INJn (N=1, if FUELPW1 is outputted; n=2 if FUELPW2 is outputted.)

INJECTOR OUTPUT CONTROL

DEFINITIONS

REGISTERS/FLAGS:

- CRANK = Strategy for Start up mode of engine.
- CRKFLG = Flag indicating status of engine mode. (Set to 1, when in Crank)
- FGFFLG = Toggle flag for alternate Injector Firing, = 1 No firing on this injector.
- FOFFLG = Alternate Injector Firing enable flag.
- FUELPW1/FUELPW2 = EGO-1 (or EGO-2) injector pulse- width, clock ticks.
- PWOFF = Injector pulsewidth offset (clock ticks).
- RUN = Normal engine operation strategy.
- SYNFLG = Flag indicating synchronous fuel, if set = 1; asynchronous if set = 0. It is initialized to 0.
- UNDERSPEED = Strategy used to make the transition between CRANK and RUN. It is also used when the engine stalls or stumbles.

CALIBRATION CONSTANTS:

- CRKPIP = Number of PIP periods per Injector(s) firing(s). (NOTE: Must be INTEGER value.)
- EDSEL = Switch for selective Crank Fuel Timing at Falling- Edge of PIP.
- ENGCYL = Number of PIPs per engine revolution, or Number of cylinders/2.
- FN1327 = Fuel pulsewidth register map, used to determine which fuel register is used. Output = Fuel Register-left offset. X-input = Injector output number. Y-input = Null.
- FN1329 = Injector firing order used for correcting Inj_Fank to correct the firing order. Output = fuel injector to be fired. X-input = INJ_BANK Y-input = Null
- NUMEGO = Number of EGO sensors present; mono or stereo.
- NUMOUT = Number of injector output ports.
- OUTINJ = Calibration switch to select between sequential and simultaneous injections (OUTINJ = 1 for sequential, OUTINJ = 2 for simultaneous).
- PIPOUT = Number of PIPs between injector outputs on each injector port.

INJECTOR OUTPUT CONTROL

```
CRKFLG = 1 ----|
(CRANK)        |
               |AND --| WOT CRANK DE-CHOKE FUNCTION
FUELPW1 = 0 ---|      | .No injector output.
                      |
                      | --- ELSE ---
                      |
CRKFLG = 1 ---|       | NORMAL CRANK - Falling Edge Timing
(CRANK)       |AND ---| .Fire NUMOUT injector outputs every CRKPIP
EDSEL = 0 ----|       |  number of PIP's, upon receiving the falling
                      |  edge of the proper PIP signal.
                      | .Outputs included are INJ-1 thru INJ-NUMOUT.
                      | .FN1327 governs the use of FUELPW1 or FUELPW2
                      |  as the injector pulsewidth.
                      | .The injector offset PWOFF is included in
                      |  the actual injector pulse output.
                      | .Add FUELPWn to FUEL_SUM; increment
                      |    PULSCT
                      |
                      | --- ELSE ---
                      |
CRKFLG = 1 -----------| NORMAL CRANK - Rising Edge Timing
                      | .Fire NUMOUT injector outputs every CRKPIP
                      |  number of PIP's, upon receiving the rising
                      |  edge of the proper PIP signal.
                      | .Outputs included are INJ-1 thru INJ-NUMOUT.
                      | .FN1327 governs the use of FUELPW1 or FUELPW2
                      |  as the injector pulsewidth.
                      | .The injector offset PWOFF is included in
                      |  the actual injector pulse output.
                      | .Add FUELPWn to FUEL_SUM; increment
                      |    PULSCT
                      |
                      | --- ELSE ---
                      |
                      |     ...continued next page...
```

```
                        |
                        |    ...continued from previous page...
                        |
                        | RUN OR UNDERSPEED, NOT IN SYNC
                        | .Fire the appropriate injector outputs upon
                        |  receiving the rising edge of the proper PIP
                        |  signal. Injector timing is random.
                        | .If OUTINJ = 1, the outputs are fired
SYNFLG = 0 -----------|  sequentially. If OUTINJ = 2, NUMOUT outputs
(NOT IN SYNC)           |  are fired simultaneously.
                        | .Outputs included are INJ-1 thru INJ-NUMOUT.
                        | .PIPOUT and NUMOUT define the firing pattern.
                        | .FN1329 governs the firing order.
                        | .FN1327 governs the use of FUELPW1 or FUELPW2
                        |  as the injector pulsewidth.
                        | .The injector offset PWOFF is included in
                        |  the actual injector pulse output.
                        | .Add FUELPWn to FUEL_SUM; increment
                        |    PULSCT
                        |
                        | --- ELSE ---
                        |
                        | RUN IN SYNC, SINGLE FIRE
                        | .Fire the appropriate injector outputs at the
                        |  desired injector timing. Injector timing is
                        |  defined by strategy and calibration.
                        | .If OUTINJ = 1, the outputs are fired
                        |  sequentially. If OUTINJ = 2, NUMOUT outputs
                        |  are fired simultaneously.
                        | .Outputs included are INJ-1 thru INJ-NUMOUT.
PIPOUT=ENGCYL --------| .PIPOUT and NUMOUT define the firing pattern.
(SINGLE FIRE)           | .FN1329 governs the firing order.

                        | .FN1327 governs the use of FUELPW1 or FUELPW2
                        |  as the injector pulsewidth.
                        | .The injector offset PWOFF is included in
                        |  the actual injector pulse output.
                        | .Upon the "not in sync" to "sync" transition,
                        |  injector timing is initialized to match
                        |  the pre-sync random timing. Injector timing
                        |  then walks to desired timing.
                        | .Add FUELPWn to FUEL_SUM; increment
                        |    PULSCT
                        |
                        | --- ELSE ---
                        |
                        |    ...continued next page...
```

...continued from previous page...

RUN, IN SYNC, DOUBLE FIRE

.Fire the appropriate injector outputs upon receiving the rising edge of the proper PIP signal. Injector timing is random.

.If OUTINJ = 1, the outputs are fired sequentially. If OUTINJ = 2, NUMOUT outputs are fired simultaneously.

.Outputs included are INJ-1 thru INJ-NUMOUT.

.PIPOUT and NUMOUT define the firing pattern.

.FN1329 governs the firing order.

.FN1327 governs the use of FUELPW1 or FUELPW2 as the injector pulsewidth.

.The injector offset PWOFF is included in the actual injector pulse output.

.Upon the "not in sync" to "sync" transition, the injector firing pattern is adjusted to line up INJ-1 with signature PIP.

.Add FUELPWn to FUEL_SUM (for the DOL_COUNT Calculation

.Increment PULSCT

During the Fuel Pulsewidth output routine, the Speed Limiter flag is checked to see if alternate injectors should be turned off. This strategy reduces the power output of the engine without a sudden drop in RPM.

```
FOFFLG = 0 ------------------|  Output pulse to appropriate
  (Normal Engine Operation)  |    injector.
                             |  FGFFLG = 0
                             |
                             | --- ELSE ---
                             |
FGFFLG = 0 ------------------|  Output pulse to appropriate
                             |    injector.
                             |  Set Flag to disable next
                             |    fuel pulse output.
                             |  FGFFLG = 1
                             |
                             | --- ELSE ---
                             |
                             |  Do NOT output pulse.
                             |  Clear flag to enable
                             |    next fuel pulse.
                             |  FGFFLG = 0
```

NOTE: the appropriate output is determined by FN1329.

INJECTOR OUTPUT LOAD

On stereo EGO applications, each injector output must be linked to the proper EGO sensor. FN1327 is a 1x9 table that is used to match injector output to EGO sensor. Each slot in the table corresponds to an individual injector output. The table value is an address offset to select between FUELPW1 and FUELPW2.

IF FN1327 = 0, use FUELPW1.

IF FN1327 = 2, use FUELPW2.

For this register addressing scheme, FUELPW1 and FUELPW2 must be consecutive word registers and FUELPW1 must be first.

The FN1327 table reserves space to control up to 8 injector outputs (the zero slot is never referenced). The actual number is determined by NUMOUT, which is the number of injector ports. The user must fill the table locations to match NUMOUT.

The FN1327 table must be calibrated for all applications, regardless of the EGO type (stereo or mono). NOTE that if NUMEGO = 1 (mono-EGO), all values in FN1327 must be zero (corresponding to FUELPW1), or no fuel will be sent to Bank 2.

5.0L INJECTOR OUTPUT LOAD EXAMPLES

TABLE SLOT	INJECTOR OUTPUT	SEFI STEREO EGO NUMOUT=8,NUMEGO=2 FN1327	SEFI STEREO EGO NUMOUT=8,NUMEGO=2 PULSEWIDTH	2 CHANNEL CFI BANK TO BANK EFI STEREO EGO NUMOUT=2,NUMEGO=2 FN1327	2 CHANNEL CFI BANK TO BANK EFI STEREO EGO NUMOUT=2,NUMEGO=2 PULSEWIDTH
0	NOT USED	0	FILLER	0	not used
1	INJ-1	2	FUELPW2	2	FUELPW2
2	INJ-2	2	FUELPW2	0	FUELPW1
3	INJ-3	2	FUELPW2	X	not used
4	INJ-4	2	FUELPW2	X	not used
5	INJ-5	0	FUELPW1	X	not used
6	INJ-6	0	FUELPW1	X	not used
7	INJ-7	0	FUELPW1	X	not used
8	INJ-8	0	FUELPW1	X	not used

SEFI MONO-EGO NUMOUT=8,NUMEGO=1 FN1327	SEFI MONO-EGO NUMOUT=8,NUMEGO=1 PULSEWIDTH	2 CHANNEL CFI BANK TO BANK EFI MONO-EGO NUMOUT=2,NUMEGO=1 FN1327	2 CHANNEL CFI BANK TO BANK EFI MONO-EGO NUMOUT=2,NUMEGO=1 PULSEWIDTH
0	FILLER	0	not used
0	FUELPW1	0	FUELPW1
0	FUELPW1	0	FUELPW1
0	FUELPW1	X	not used
0	FUELPW1	X	not used
0	FUELPW1	X	not used
0	FUELPW1	X	not used
0	FUELPW1	X	not used
0	FUELPW1	X	not used

INJECTOR FIRING ORDER

On SEFI applications, each injector output is linked to it's matching engine cylinder. The injector output number is the cylinder number. The injectors must be fired in the proper order to achieve sequential operation.

FN1329 is a 1x8 table which is used to control the injector firing order. The table contains the firing order of the engine.

5.0L INJECTOR FIRING ORDER EXAMPLES

FN1329 TABLE SLOT	SEFI NUMOUT = 8		2 CHANNEL CFI BANK TO BANK EFI NUMOUT =2	
	FN1329	OUTPUT	FN1329	OUTPUT
0	1	INJ-1	1	INJ-1
1	5	INJ-5	2	INJ-2
2	4	INJ-4	X	not used
3	2	INJ-2	X	not used
4	6	INJ-6	X	not used
5	3	INJ-3	X	not used
6	7	INJ-7	X	not used
7	8	INJ-8	X	not used

FUEL PUMP CONTROL LOGIC

EFI vehicles are equipped with an electric fuel pump controlled by the computer via a relay. The fuel pump relay is energized according to the logic below;

```
TSLPIP < 1 SECOND -----------------| ENABLE PUMP
                                   |
                                   | --- ELSE ---
                                   |
                                   | DISABLE PUMP
```

```
PIP interrupt ---------------------| TSLPIP = 0
                                   |
                                   | --- ELSE ---
                                   |
                                   | Count up TSLPIP
```

DEFINITIONS

TSLPIP = Timer which track time since last PIP, msec.

CHAPTER 7

IGNITION TIMING STRATEGY

IGNITION TIMING STRATEGY

The base engine spark advance strategy provided by the computer depends on the engine operating mode. The base spark advance for each engine mode can then be adjusted for unusual engine conditions by one or more spark modulators.

The spark strategy is divided into four modes:

1. CRANK/UNDERSPEED mode
2. CLOSED THROTTLE mode
3. PART THROTTLE mode
4. WIDE OPEN THROTTLE mode

DEFINITIONS

INPUTS

Registers:

- ACT = Air Charge Temperature, deg F.
- APT = Throttle Mode Flag.
  (Set = -1 = Closed Throttle)
  (Set = 1 = Wide Open Throttle)
  (Set = 0 = Part Throttle)
- ATMR1 = Time since start (time since exiting CRANK mode), sec.
- DIFCTR = Counter for TL0FLG state changes.
- DIFF0 = Steady State Spark TL0 error.
- DIFF1 = Transient Spark TL0 error.
- DSDRPM = Idle speed control desired RPM.
- DT12S = Last PIP period.
- DT23S = Previous PIP period before DT12S.
- DTPCYC = PIP period ENGCYL * 2 + 1 cylinders previous.
- DTSIG = PIP period of last signature PIP.
- ECT = Engine Coolant Temperature, deg F.
- HFDLTA = Last period from PIP up-edge to down-edge.
- HFPCYC = Period from PIP up to down-edge ENGCYL * 2 cylinders previous.
- KAYCTR = A counter to indicate how often to update MKAY.
- LOAD = Universal normalized load parameter.
- LUGTMR = Load transition timer defined in the TIMER section.
- MFAMUL = MFA table ramp-in multiplier, unitless.
- MKAY = Half period multiplier to correct for average error caused by hall effect sensor in distributor and armature.
- N = Engine RPM, RPM.
- PHFDLT = Previous time elapsed between up-edge to down-edge of PIP.

- PIPACL = Percentage of PIP that PIP will decrease under Maximum Acceleration, Beta. Initial value = 14%.

- PSGDLT = Previous uncorrected signature PIP half period.

- SAF = Final spark advance in degrees.

- SAPW = Spark Angle Pulse Width, msec.

- SIGDC = Signature PIP Duty Cycle.

- SIGDLT = Uncorrected signature PIP half period.

- SIGKAL = Signature PIP half period multiplier
  - initial value = 1.66666 for 30% duty cycle signature PIP
    = 1.42857 for 35% duty cycle signature PIP.

- SPKAD(n) = Spark adder for the nth cylinder. It is added to SAF and may be positive or negative degrees.

- SPKMUL = Spark Feedback multiplier used to enhance idle speed control. It is used in closed throttle mode only and is calculated within the Idle Speed Control Strategy.

- TCSTRT = Temperature of ECT at startup, deg. F.

- TEMDWL = Time required for coil to charge to 100% percent of desired voltage.

- TIPRET = Tip in retard, degrees.

- TL0FLG = Transient Spark calculation flag.

- TSLPIP = Timer indicating time since last PIP Low-to High transition, sec.

- VBAT = Time-dependent rolling average filter of instantaneous battery voltage.

- VSBAR = Filtered vehicle speed.

Bit Flags:

- CRKFLG = Flag indicating Engine in Crank mode if set to one.
- DOUBLE_EDGE FLAG = Foreground (EOS) flag used to indicate current spark output calculation method.
- HSPFLG = High Speed Mode flag; 1 = High Speed alternate fuel/spark.
- MFAFLG = Managed Fuel Air State Flag.
- NDSFLG = Neutral/Drive flag, 1 = Drive.

- NFLG = Neutral Idle flag.

- SIGPIP = A flag that indicates that signature PIP half period has been identified.

- SYNFLG = Flag when set indicates Signature PIP has been identified; else Signature PIP not yet seen. It is initialized to 0.

- UNDSP = Flag indicating engine in Underspeed Mode or Crank.

Calibration Constants:

- CCDSW = Calibration Switch to select Computer Controlled Dwell. (1 = Computer Controlled Dwell; 0 = TFI Controlled Dwell)

- CTHIGH = Coolant Temperature at Hot start, deg F.

- DELTA = Closed throttle/Part throttle breakpoint value above RATCH.

- DFMIN0 = Minimum number of TS0FLG 1 to 0 state changes.

- DFMIN1 = Minimum number of TS0FLG 0 to 1 state changes.

- DWLTBP = Temperature switch point that controls function use, Deg F.

- DWLTSW = Switch point for change of maximum permitted DWELL,sec.

- DWLWF = Weighting factor determining effect of ECT and ACT on Base Dwell, unitless.

- ENGCYL = The number of cylinders in one engine revolution.

- FKMKAY = Filter constant of update rate to MKAY.

- FKSKAY = Filter constant of update rate to SIGKAL.

- FN033 = ECT normalizing function.

- FN071 = Load normalizing function; used for table lookup. Input = LOAD and Output = Normalized Load.

- FN082 = Load normalizing Function; generates table entry point. Input = LOAD and Output = Normalized Load.

- FN083 = RPM Normalizing function ;generates table entry point. Input = N and Output = Normalized N.

- FN111 = Closed Throttle Base spark advance as a function of engine speed N. Input = Engine speed, RPM and Output = spark advance, deg BTDC.

- FN112 = Closed Throttle Spark advance adder as a function of Engine Coolant Temperature ECT (to generate cold temperature spark advance). Input = ECT, deg F and Output = spark adder.

- FN115 = Spark adder as a function of Barometric Pressure BP. Input = BP and Output = spark adder.

- FN125 = LOM Load function, used to activate LOM spark strategy, RPM.

- FN126 = Spark advance adder as a function of ACT (Air Charge Temperature).

- FN129A = LOMALT table multiplier as a function of Barometric Pressure, BP.

- FN131 = Wide Open Throttle Base spark advance as a function of engine speed N, DEG BTDC.

- FN133 = Wide Open throttle Spark advance adder as a function of BP (Barometric Pressure), Deg.

- FN134 = Wide Open throttle Spark advance adder as a function of ECT, Deg.

- FN135 = Wide Open Throttle Spark Adder as a function of ACT, Deg.

- FN160A = Minimum DWELL time versus VBAT (below 77 deg F, sec.

- FN160B = Minimum DWELL time versus VBAT (above 77 deg F, sec.

- FN179A = High Speed Spark retard, mph.

- FN180(CTNTMR) = Idle Spark subtractor, deg.

- FN212A = LOMSEA table multiplier as a function of Barometric Pressure, BP.

- FN311 = MFA altitude multiplier, unitless.

- FN396A = High Speed Fuel enrichment, mph.

- FN400 = Time since startup kicker time delay, sec. It's input is TCSTRT and has a maximum repetition of 6.

- FN839 = Spark multiplier vs. DASPOT. Input = Dashpot air flow adder (DASPOT) Output = Multiplier (SPKMUL)

- FN841D = Spark Multiplier vs. RPM Error to provide spark feedback for Idle Speed Control, in Drive Input = Speed Error (DSDRPM (word) - N) Output = Multiplier (SPKMUL)

- FN841N = Spark Multiplier vs. RPM Error to provide spark feedback for Idle Speed Control, in Neutral
Input = Speed Error (DSDRPM (word) - N)
Output = Multiplier (SPKMUL)

- FN901 (SPKSEA) = Base sea level table.
X-input = FN070 - Normalized Engine speed, RPM
Y-input = FN071 - Normlized load

- FN904A (LOMSEA) = Sea level LOM table.
X-input = FN070 - Normalized engine speed, RPM
Y-input = FN071 - Normalized load

- FN905A (LOMALT) = Altitude LOM table.
X-input = FN070 - Normalized engine speed, RPM
Y-input = FN071 - Normalized load

- FN1119 = Torque Truncation Table.

- FN1121 = Spark advance adder for EGR as a function of RPM and LOAD;
X-input = Normalized engine speed on RPM - FN070,
Y-input = Normalized LOAD - FN071,
Output = Spark advance adder for EGR, deg per 1 percent EGR.

- FN1124 = 4 x 3 table of spark adders as a function of engine speed N and LOAD. The (X-input) normalizing function for N is FN083 and the (Y-input) normalizing function for LOAD is FN082.

- FN1133(ECT,LOAD) = Part throttle spark modifier table.
X-input = Normalized ECT (FN033)
Y-input = Normalized LOAD (FN071).

- FN1223 = Managed fuel Air EGR Table.
X-input = FN083 - Normalized Engine Speed, RPM
Y-input = FN082 - Normalized load.
Output = Multiplier.

- FN1328 = Managed fuel air fuel table.
X-input = Normalized engine speed, RPM - FN070
Y-input = Normalized Perload - FN072A

- FRCBFT = ACT Fraction for FN1305 lookup.
- FRCSFT = ACT fraction for FN1306 lookup.
- HCSD = Minimum RPM for High CAM Spark Retard.
- HCSDH = Hysteresis for HCSD.
- HP_HIDRES = Hardware present - High Data Rate Electronic Spark.
- KCS1 = Closed throttle spark adder.
- KLLIM = Lowest value for MKAY multiplier - initial value = 0.9.
- KULMT = Highest value for MKAY multiplier - initial value = 1.1.

- KPS1 = Part throttle spark advance adder.
- KWS1 = Wide Open Throttle spark advance adder, Deg.
- LUGTIM = Engine load transition time, sec.
- MHPFD = Calibration constant dependent on number of cylinders and Signature PIP Duty Cycle.
- MINDLA = Minimum DWELL clip above 20 msec PIP period, Beta.
- MINDLB = Minimum DWELL clip below 20 msec PIP period, Beta.
- NSADD = Neutral spark adder, deg.
- NTIP = Maximum RPM to enable Tip-in retard (restricted to less than or equal to 2000 to assure TIPRET ramp back function.)
- NUMCYL = Number of cylinders in the engine.
- PACLIM = Maximum limit of PIP acceleration in percent of PIP period, Beta.
- PACOFF = Offset for linear equation describing PIP Period and percent of PIP period for acceleration, (Units = (Beta - cyl)/Rev).
- PACPER = PIP period when equation for PIPACL changes, (Units = (Rev - seconds)/cyl).
- PACSLO = Slope for linear equation describing PIP period and percent of PIP period for acceleration, (Units = Beta/second).
- SIGKLL = Lowest value for signature PIP multiplier
  - initial value = 1.42857 for 30% duty cycle signature PIP
    = 1.25000 for 35% duty cycle signature PIP.
- SIGKLU = Highest value for signature PIP multiplier
  - initial value = 1.99996 for 30% duty cycle signature PIP
    = 1.66666 for 35% duty cycle signature PIP.
- SPKLIM = Maximum allowable advance in spark timing between spout outputs, Beta.
- SPKSWH = Value (in clock ticks) equivalent to a minimum RPM threshold, at which the strategy will time the next SPOUT during the previous Rising-Edge of PIP without any adjustments during the Falling-Edge.
- SPKSWL = Value (in clock ticks) equivalent to maximum RPM at which the strategy will correct the timing of the next SPOUT during the Falling-Edge of PIP. The difference between SPKSWH and SPKSWL provides hysteresis. (NOTE: SPKSWL is longer than SPKSWH).

- SPLCLP = Lower limit spark clip for rotor registry.
- SPTADV = Percentage of PIP that spark may be advanced, (Percent of PIP).
- SPUCLP = Upper limit spark clip for rotor registry.
- SSFCTR = Steady state factor for MKAY and signature KAY calculations.
- TICKS_DOUBLE = Value (in clock ticks) when there is insufficient time to put out spark from Rising-Edge Calculation to put out spark from Falling-Edge. (Current value = 0.0012 seconds).
- TICKS_SINGLE = Value (in clock ticks) indicating there is insufficient time to put out spark from Falling-Edge of PIP (Current value = 0.0010 seconds).
- TRSRPM = Minimum RPM to enable transient spark routine.
- TRSRPH = Hysteresis for TRSRPM.
- TTNOV = RPM - Vehicle Speed (N/V) ratio corresponding to first gear.
- Y = Normal Part throttle spark multiplier.

OUTPUTS

Registers:

- DIFCTR = Counter for TL0FLG state changes.
- DTPCYC = PIP period ENGCYL * 2 + 1 cylinders previous.
- DTSIG = PIP period of last signature PIP.
- DWLBSE = Base amount of DWELL as a function of VBAT and TEMDWL, sec. Initial value = 0.005.
- HFDLTA = Last period from PIP up-edge to down-edge.
- HFPCYC = Period from PIP up to down-edge ENGCYL * 2 cylinders previous.
- KAYCTR = A counter to indicate how often to update MKAY.
- MKAY = Half period multiplier to correct for average error caused by Hall effect sensor in distributor and armature.
- PIPACL = Percentage of PIP that PIP will decrease under Maximum Acceleration, Beta. Initial value = 14%.

- PSGDLT = Previous uncorrected signature PIP half period.
- SAF = Final spark advance in degrees.
- SAFTOT = Total spark advance, including knock and tip-in retard, deg BTDC.
- SIGDLT = Uncorrected signature PIP half period.
- SIGKAL = Signature PIP half period multiplier
  - initial value = 1.66666 for 30% duty cycle signature PIP
  = 1.42857 for 35% duty cycle signature PIP.
- TL0FLG = Transient Spark calculation flag.

SAFTOT, a DAC-able parameter has been added to the Spark Chapter. SAFTOT allows dac'ing of total spark advance. It is updated each background loop and will NOT display every SPKAD/TIPRET term if the background loop time is longer than a PIP period. (NOTE: SPKAD(n) refers to the current SPKAD referenced by the PIP_Counter [being added to Spark]) The equation for SAFTOT is as follows:

SAFTOT = SAF + SPKAD(n) + TIPRET

1. CRANK/UNDERSPEED MODE SPARK:

In the crank or underspeed mode, spark advance is fixed at 10 deg BTDC. Spark is fired when the rising edge of the PIP signal is received.

2. CLOSED THROTTLE MODE SPARK:

Normal Closed Throttle Spark is a function of RPM and ECT, modified by the Spark Feedback Multiplier, SPKMUL. During High Cam (as determined by RPM and Startup Timer ATMR1), the spark advance is reduced by FN115 to light off the catalysts (by heating up the exhaust gas). Spark is adjusted by a function of BP, which can only occur when the Engine RPM rises above a set value. If the Engine RPM dips below the value set by HCSD - HCSDH (these values are calibratible), then BP correction is no longer required. FN400 provides a maximum time for altitude compensation to spark.

```
APT = -1 (CLOSED THROTTLE) ----|
                               |
N > HCSD ------------|S Q------|       | "Hi Cam" Spark
                     |         |AND ---| SAF = (FN111 + FN112
N < HCSD - HCSDH ----|C        |       |        - FN115 + KCS1-'C')
                               |       |         * SPKMUL
                               |       |
ATMR1 < FN400 -----------------|       | --- ELSE ---
                                       |
NFLG = 1 ------------------------------| Normal Closed Throttle
 (Closed Throttle, Neutral)            |  Spark
                                       | SAF = (FN111(N) + FN112(ECT)
                                       |       + NSADD - FN180(CTNTMR)
                                       |       + KCS1-'C') * SPKMUL
                                       |
                                       | --- ELSE ---

                                       |
APT = -1 ------------------------------| SAF = (FN111 + FN112 + KCS1
                                       |        - 'C' * SPKMUL)
```

SPKMUL is a calibratible constant which is set in the Idle Speed Logic to one of two possible functions (FN839 and FN841N/D), giving it a range of 0 to 0.996. The input to FN839 is the Dashpot Air flow Adder (DASPOT) and the input to FN841 is the speed error (DSDRPM minus N). SPKMUL provides a correction factor to the spark advance. FN841N and FN841D are separately calibratible for neutral or drive. (See Idle Speed Duty Cycle calculations at the end of ISC chapter).

'C' Logic is defined in Part Throttle Spark Section.

3. PART THROTTLE MODE SPARK:

Normal Part throttle is (FN904A * FN212A + FN905A * FN129A).

During normal part throttle operation, the logic "interpolates" between sea level table (FN904A) and altitude table (FN905A) to calculate base spark.

Tip-in Spark (LOM) is (1 - LUGTMR/LUGTIM) * FN901

On accelerating from a standstill, the strategy uses a more aggressive spark table (FN901) for improved performance. Over a period of time (LUGTIM), the spark shifts from LOM spark to normal part throttle spark. The LUGTMR logic is described in the Timer Chapter.

BASE SPARK - LOM SPARK RELATIONSHIP

```
         -------------------------------------------
         |                                         |
         |                                         |
  LOAD   |                  Use FN904A             |
         |                        or               |
FN125 -> |-----                 FN905A             |
BOUNDARY |      \                                  |
         |       \                                 |
         | LOM    \                                |
         | Use     \                               |
         | FN901    \                              |
         |           \                             |
         -------------------------------------------

                              N
```

Actual percent EGR, EGRACT, modifies spark via FN1121 (RPM,LOAD) and high air charge temperature via FN126(ACT).

TEMPERATURE COMPENSATION - [FN1133(ECT,LOAD)]

The temperature compensation serves these functions:

1. Provide spark advance for improved fuel economy (at very cold temperatures);

2. Provide cold start spark retard to light off the catalysts for improved emissions.

3. Adjust spark during engine overtemp.

4. Adjust temperature compensated spark for LOAD.

MANAGED FUEL AIR - 'B' LOGIC (FN1124 * FN311)

During MFA mode, the strategy may use Open Loop Fuel FN1328 (usually lean of stoichiometry) and modified EGR (FN1223). The base spark is further advanced by FN1124. The amount of spark advance increment is reduced at altitude by FN311. To avoid spark jumps during the transition from normal mode to MFA Mode, the strategy ramps the MFA spark using MFAMUL (defined in the Fuel Strategy).

TORQUE TRUNCATION SPARK - 'C' LOGIC (FN1119)

If the AXOD (or AOD) transmission is in 1st gear or reverse, the torque of the engine may exceed the capacity of the transmission. Therefore, the torque truncation strategy is designed to reduce the engine torque by retarding the spark. FN1119 should be calibrated to achieve this torque reduction for all speed-load points.

Because the strategy is unable to directly distinguish between first and second gear, first gear is inferred from N/V, TTNOV. TTNOV should correspond to the RPM-Speed ratio for first gear.

OVERSPEED PROTECTION

If the vehicle speed is too high, the spark advance is reduced by FN179A. Under these circumstances, the Fuel Strategy forces Open Loop Fuel enrichment (FN396A).

Note: FN396A should be calibrated to 0.996 if FN179A is equal to 0.

SAF LOGIC

```
SAF = Y * ['S' + B - C + FN1133(ECT,LOAD)] + KPS1


HSPFLG = 1 -----------------------| SAF = SAF - FN179A(VSBAR)
```

'B' LOGIC

```
MFAFLG = 1 ------------------------| Managed Fuel Air Mode
                                   | 'B' = FN1124 * FN311
                                   |      * MFAMUL
                                   |
                                   | --- ELSE ---
                                   |
                                   | 'B' = 0
```

'C' LOGIC
(Used in all Throttle modes)

```
N > TTNOV * VSBAR ---------------------------| Torque Truncation Spark
                                             | 'C' = FN1119
                                             |
                                             | --- ELSE ---
                                             |
                                             | 'C' = 0
```

NOTE: 1) FN212A should be equal to 1.0 at Sea Level and 0 at high altitudes;

2) FN129A should be equal to 1.0 at high altitudes and 0 at Sea Level;

3) LUGTIM should be non-zero;

4) LOM spark may be calibrated out by setting FN125 = 0.

4. WIDE OPEN THROTTLE MODE SPARK:

At Wide Open throttle, SAF is determined from the following equation. It is the combined result of FOUR VARIABLE Spark Advance Adders based upon the functions of engine speed (N), BP, ECT, ACT, and ONE CONSTANT spark advance adder (KWS1).

SAF = FN131 + FN133 + FN134 + KWS1 + FN135 - 'C'

HSPFLG = 1 -----------------------| SAF = SAF - FN179A(VSBAR)

NOTE

1. The displayed SAF does not include the output of the individual cylinder knock strategy. The knock registers, SPKAD(n) and TIPRET may be displayed separately and are added to SAF by the EOS when the waiting time is calculated. Refer to the knock strategy documentation within this chapter for additional information.

2. The final value of spark advance, [SAF + SPKAD(n) + TIPRET], is limited to the range:

SPLCLP <OR= [SAF + SPKAD(n) + TIPRET] <OR= SPUCLP

SPLCLP is the lower spark clip. SPUCLP is the upper spark clip. SPLCLP and SPUCLP are calibrated to match the rotor registry of the distributor. Intermediate spark calculations and results are maintained in an unlimited fashion.

3. The software allows the lower spark clip, SPLCLP, to be calibrated to values down to -10 deg (10 deg ATC). This feature has been initially provided for the sole use of the Ignition Department in performing rotor registry tests. Unless prior approval has been received from the Ignition Department, Engine Systems engineers are hereby requested to refrain from calibrating SPLCLP to a value which is less than the minimum value of the "Spark Range" which is shown on the Rotor Registry page of this Chapter. Otherwise, such a calibration may result in mis/crossfire.

4. Due to physical time constraints for arming the coil and firing the next spark, the largest spark advance increase allowed between consecutive spark events is limited to SPKLIM*360/ENGCYL degrees. There is no limit on the amount of spark advance decrease allowed on consecutive spark events. NOTE: SPKLIM is set to .06 and should not be increased without the prior approval of the Ignition Department.

Final SAF <OR= Previous SAF + SPKLIM * 360/ENGCYL

Two Spout calculation routines are used in the strategy:

1. RISING-EDGE SPARK

2. FALLING-EDGE SPARK

RISING-EDGE SPARK

This method calculates the Spout output time based upon the times of the last two Pip rising edges and assumes that the next Pip rising edge will occur at the same delta-time.

```
                                             SPOUT
                                               :
          :                   :                :
          :.......DT12S.......:                :
          :                   :                :
                                               :
          .---------.         .---------.      :  .----
          |         |         |         |      :  |
PIP       |         |         |         |      :  |
SIGNAL    |         |         |         |      :  |
          |         |         |         |      :  |
      ----.         .---------.         .---------.

          :                   :                :
          :                   :..WAITING TIME..:
          :                   :                :
         RE1                 RE2
     (10 deg B)          (10 deg B)
```

SPOUT = RE2 + WAITING TIME

      = RE2 + {[(360/ENGCYL) + 10 - SAF] / (360/ENGCYL)} * DT12S

2. FALLING-EDGE SPARK

This method calculates the spout output time based upon the delta-time between the rising edge and falling edge of the current Pip and assumes that the next Pip rising edge will occur at the same delta-time after the falling edge.

However, a problem exists with the Hall Effect sensor which results in an inaccurate recognition of the falling edge. The accuracy varies as a function of the sensor's temperature and voltage. To compensate for this inaccuracy, an adaptive correction factor, MKAY, is continuously calculated and applied to the observed falling edge time to create a corrected falling edge time, FEC, as shown in the sketch below. The MKAY/SIGKAL calculations are shown on the next page.

```
                                             SPOUT
          :                 :                  :
          :......HFDLTA.....:                  :
          :                 :                  :
                                               :
          .-----------------...                :  .----
          |                 | :                :  |
PIP       |                 | :                :  |
SIGNAL    |                 | :                :  |
          |                 | :                :  |
      ----.                 .---------------------.

          :                 : :                :
          :                 : :.....WAITING....:
          :                 : :      TIME      :
         RE                FE FEC
      (10 deg B)
```

where,
RE = Rising Edge Time
FE = Falling Edge Time
FEC = Corrected Falling Edge Time

SPOUT = FEC + WAITING TIME

      = FE + {{[(180/ENGCYL) + 10 - SAF] / (180/ENGCYL)} * MKAY

        - (1-MKAY)} * HFDLTA

MKAY/SIGKAL CALCULATIONS

```
1.a. At every PIP down-edge transition, clear SIGPIP. (existing)
  b. PIP down-edge transition ----------|
                                        |AND --| Set SIGPIP
     Signature half period identified --|
  c. SIGPIP is set ------------------|
                                     |       | PSGDLT = SIGDLT
     SYNFLG is set ------------------|AND ---| SIGDLT = HFDLTA
                                     |       | HFDLTA = (HFDLTA*SIGKAL)/MKAY
     PIP down-edge transition -------|
2. PIP up-edge transition -----------|
                                     |       |
   SIGPIP is set --------------------|AND ---| Do Signature Kay
                                     |       |     Calculation
   SYNFLG is set --------------------|
3. Signature Kay Calculation
   |DT12S - DTSIG| < SSFCTR * DT12S -----|       | DTSIG = DT12S
                                         |       | sigkal' = DT12S/(SIGDLT*2)
   |DT12S - DT23S| < SSFCTR * DT12S -----|AND ---| SIGKAL = FKSKAY*sigkal' +
                                         |       |        (1 - FKSKAY)*SIGKAL
   |SIGDLT - PSGDLT| < SSFCTR * SIGDLT --|       | SIGKLL < SIGKAL < SIGKLU
                                                 |
                                                 |--- ELSE ---
                                                 |
                                                 | DTSIG = DT12S
4. PIP up_edge transition ---------------|       | Increment KAYCTR
                                         |AND ---| Do MKAY Calculation
   KAYCTR <OR= ENGCYL * 2 ---------------|       |
                                                 |- - - ELSE - - - - -
                                                 |
   PIP up_edge transition -----------------------| Set KAYCTR = 1
                                                 | Set DTPCYC = DT12S
                                                 | Set HFPCYC = HFDLTA
5. MKAY Calculation
   SIGPIP = 0 ------------------------------|
                                            |
   KAYCTR > ENGCYL * 2 ---------------------|       | mkay' =
                                            |       |  0.5*(DT12S+DTPCYC)/
   |DT12S - DTPCYC| <or= SSFCTR * DT12S ----|AND ---|    (HFDLTA + HFPCYC)
                                            |       | MKAY =
   |HFDLTA - HFPCYC| <or= SSFCTR * HFDLTA --|       |  FKMKAY * mkay' +
                                            |       |    (1 - FKMKAY) * MKAY
   mkay' < 1.2 -----------------------------|       |
                                                    | KLLIM < MKAY < KULMT
```

(NOTE: KAYCTR must be incremented prior to MKAY calculation!)

RISING-EDGE vs FALLING-EDGE DECISION

The decision of which method to use is based upon the real time which is available to do the Spout calculation and scheduling after the falling edge of PIP is recognized. If sufficient time is available, the falling-edge calculation will be used. Otherwise, the rising-edge calculation will be used.

The available time to send Spout after receiving the falling edge of PIP is equal to the distance in degrees between the two events divided by the

velocity in degrees/second, or;

$$\text{AVAILABLE TIME} = \frac{\text{DISTANCE}}{\text{VELOCITY}} = \frac{(180/\text{ENGCYL}) + 10 - \text{SAF}}{\text{ENGINE RPM} * 6}$$

SPKSWH and SPKSWL are provided to allow the switch to Rising-Edge spark calculation above some RPM when the error in detection of the Falling-Edge of PIP or other factors will cause excessive spark scatter using the Falling-Edge spark calculation. Because SPKWSH and SPKSWL are used in foreground, the value entered in VECTOR for each must be in clock-ticks. To convert the desired values of RPM into clock-ticks, perform the following conversions:

SPKSWH = 60/(ENGCYL * "Clock_Frequency" * upper switch RPM)

SPKSWL = 60/(ENGCYL * "Clock_Frequency" * lower switch RPM)

Where Clock_Frequency is 3.0E-6 for 12 MHz and 2.4E-06 for 15 MHz. The lower switch RPM should be a minimum of 25 RPM and and a maximum of 250 RPM below upper switch RPM, if used. Both SPKSWL and SPKSWH are normally set to the equivalent of 6375 RPM, which will disable this portion of the decision

routine.

NOTE: SPKSWH and SPKSWL should not be changed without consultation with the ESD Strategy Section.

The following logic is used for the Falling versus Rising-Edge decision.

All values in ticks.

```
Dual_Edge -----------------------------|           | Use Single Edge
   (In Falling-Edge Mode)              |AND -------| (Rising-Edge)
                                       |           |
DT12S < SPKSWH ------------------|     |           |
                                 |OR --|           | --- ELSE ---
AVAILABLE TIME < Ticks_Single ---|                 |
                                                   | Use Dual_Edge
Single_Edge ----------------------------|          | (Falling-Edge)
  (In Rising-Edge Mode)                 |          |
AVAILABLE TIME > Ticks_Double ----------|AND ------|
                                        |
DT12S > SPKSWL -------------------------|
```

Based upon this logic, if the desired spark advance, SAF, is assumed to be 30 degrees, then the maximum RPM at which the Falling-edge spark calculation can be used is 11667, 6667, and 4167 for the 4, 6, and 8-cylinder engines, respectively. The Rising-edge calculation is used at higher engine speeds.

HIGH DATA RATE ELECTRONIC SPARK (HIDRES) SYSTEM
(HP_HIDRES = 1)

The High Data Rate Electronic Spark System consists of three components:

a) EEC-IV processor
b) HESC module
c) a 36-tooth wheel and sensor

The 36 tooth wheel is located on the crankshaft with a variable reluctance sensor (VRS) to produce a signal. The wheel is missing one tooth at 90 BTDC for one cylinder to allow signal reference.

The HESC module is an EED supplied module which has the capability to receive the output of the VRS sensor, as well as a signal from the EEC-IV processor. The HESC module provides coil switching for distributorless ignition and outputs signals to the coil for charging and firing. In addition, the module provides a signal to the EEC-IV processor, specifically, a synthetic 50% duty cycle with the low-to-high transition occuring at 10 degrees BTDC and a high-to-low transition occuring at 100 degrees BTDC for each cylinder. The module also provides LOS function whenever the EEC-IV processor fails to provide a Spark Angle Pulse Width (SAPW) within the accepted window for each cylinder.

The EEC-IV processor uses the synthetic 50% duty cycle as reference for scheduling fuel and spark pulse widths. The EEC-IV processor calculates: 1) The time that the Spark Output (SPOUT) line to the HESC should be transitioned from low-to-high, (with a targeted position of 20 degrees ATDC); 2) The SAPW; and 3) The time of the SPOUT high-to-low transition.

The following strategy modules are disabled in the EEC-IV processor when HIDRES is in use.

a) Dwell Calculation
b) MKAY Calculation
c) Transient Spark Determination and Calculation
d) Rising Edge/Falling Edge decision logic
e) Double Edge Spark Calculation
f) PIP echoed SPOUT during CRANK and UNDERSPEED
g) 6% spark advance limit

The "desired_spark" calculated in the EEC-IV processor is composed of SAF, Tip-in retard, and Knock Spark Adder. "Desired_spark" is checked to ensure that it is within the HESC module limits, (-10 to +57.5), and then converted into SAPW by the following:

a) Calculate and schedule SPOUT low-to-high transition at:

```
up_transition_time = LAST_HI_PIP + (30 * ENGCYL / 360) * DT12S

where:
LAST_HI_PIP is the time of the latest PIP up-edge
ENGCYL is the number of cylinders firing per engine revolution
DT12S is the time between the last two PIP up-edges
30 is the number of degrees after PIP up-edge to start pulsewidth
360 is the number of degrees per revolution
```

b) Calculate and schedule SPOUT high-to-low transition at:

```
down_transition_time = up_transition_time + SAPW

where:
SAPW = 1540 - ((256 * "desired_spark") / 10)
and
68 usec <OR= SAPW <OR= 1796 usec
```

SPOUT is initialized low on EEC-IV processor power-up and will remain low through CRANK and UNDERSPEED engine modes causing spark to be delivered at 10 degrees BTDC. Upon transition into RUN mode, the EEC-IV processor will schedule a low-to-high transition of the SPOUT line to occur at 20 degrees ATDC of each cylinder followed by a high-to-low transition SAPW microseconds later. If the SPOUT line remains in either a high or low state for more than one PIP period or if the pulsewidth of the signal is outside the clip limits, the HESC module will assume an EEC-IV processor failure and revert to spark placement at 10 degrees BTDC.

EEC-CONTROLLED DWELL (CCDSW = 1)

In the past, the EEC only provided spark timing to the Thick Film Ignition (TFI) module, which, in turn, controlled the Dwell. This algorithm provides a software replacement to the TFI Dwell with opportunities for improved spark control and shorter coil-on time. The following strategy can be used with a distributorless ignition system.

Perform the following calculations in background:

The following determines the minimum time required for the coil to charge to 100% of desired voltage. The charging time is a function of battery voltage and coil temperature. The values for FN160A, FN160B and the temperature switch point between them has been determined by the Ignition Department and should NOT be changed without their approval.

```
TEMDWL = DWLWF * ACT + (1 - DWLWF) * ECT
```

```
TEMDWL <OR= DWLTBP -------------| DWLBSE = FN160A (VBAT)
                                |
                                | --- ELSE ---
                                |
                                | DWLBSE = FN160B (VBAT)
```

NOTE: If CCDSW = 0, the TFI module determines the dwell. The output will then transition from High to Low at SPOUT time and HFDLTA.

The following logic and calculations are performed in foreground:

DWLTOT (Dwell turn-on time) is the time when the coil should start charging to allow sufficient charging time (DWLBSE) as well as time for maximum engine acceleration movement of PIP (PIPACL) and maximum change of requested spark advance allowed (6% of PIP) (SPTADV).

```
DWLTOT = SPOUT - DWLBSE + [1 - (SPTADV + PIPACL)] * DT12S
```

PIPACL is set by the following conditions and calculations:

PIPACL (a function of Engine Speed) is the maximum possible rate of PIP acceleration. The latest engine speed is available as DT12S (PIP Period), PIPACL is described as two equations to produce an approximation to the expontential function describing the initial engine speed and the percentage of a PIP period that PIP may change.

```
DT12S >OR= PACPER/ENGCYL -----------| PIPACL = PACSLO * DT12S
                                    |  - (PACOFF / ENGCYL)
                                    | Clip PIPACL to PACLIM
                                    |
                                    | --- ELSE ---
                                    |
                                    | PIPACL = 2(BETAs/seconds)
                                    |   * DT12S
```

DWLTOT LOGIC

DWLTOT is clipped to 50% of PIP period (MINDLA) at low RPMs and to 20% of PIP period (MINDLB) at ALL other times, to prevent excess coil charge time. The spout output is sent low at DWLTOT only in Run mode. In Crank and Underspeed, Spout is sent low on PIP-down edge.

```
(DWLTOT - SPOUT)/DT12S <OR=
    MINDLA ------------------|        | DWLTOT = SPOUT + MINDLA
                             |AND ----|  * DT12S
DT12S > DWLTSW --------------|        |
                                      | --- ELSE ---
                                      |
(DWLTOT - SPOUT)/DT12S <OR= MINDLB ---| DWLTOT = SPOUT + MINDLB
                                      |   * DT12S
```

```
TSLPIP > 800 msec ------------|
                              |OR ---| Set SPOUT_OUTPUT
CRKFLG = 1 -------------------|      |  to High
                                     |
CRKFLG = 1 --------------|           | --- ELSE ---
                         |AND-|      |
PIP High-to-Low          |    |      | Set SPOUT_OUTPUT
 transition -------------|    |      |  to Low on
                              |OR ---|  PIP High-to-Low
CRKFLG = 0 --------------|    |      |  transition
                         |    |      |
UNDSP = 1 ---------------|AND-|      |
                         |           |
PIP High-to-Low          |           |
 transition -------------|           |
                                     | --- ELSE ---
CRKFLG = 0 -------------------|      |
                              |AND --| Set SPOUT_OUTPUT
UNDSP = 0 --------------------|      |  to Low at
                                     |  time DWLTOT
```

Note the diagrams below.

```
      -----    -----    -----    -----           /
  PIP |   |    |   |    |   |    |   |           | FIRST PIP
______|   |____|   |____|   |____|   |______-->  | INTERRUPT IS
                                                 | UP EDGE
                                                 |
----------|    |---|    |---|    |---|           |
  SPOUT   |    |   |    |   |    |   |           |
          |____|   |____|   |____|   |______-->  |


______    ____    ____    ____    ____           /
     |   |   |   |   |   |   |   |   |           |
 PIP |   |   |   |   |   |   |   |   |           |
     |___|   |___|   |___|   |___|   |______-->  | FIRST PIP
                                                 | INTERRUPT
                                                 | IS DOWN EDGE
______    ____    ____    ____    ____           |
     |   |   |   |   |   |   |   |   |           |
SPOUT|   |   |   |   |   |   |   |   |           |
     |___|   |___|   |___|   |___|   |______-->  |
```

```
    :<---------DT23S----------->:<-----------DT12S---------->:

    :<- PHFDLT ->:              :<- HFDLTA ->:

    .------------.              .------------.              .---
    |            |              |            |              |
    |            |              |            |<-----TL0----->|
    |            |              |            |              |
----.            .--------------.            .---------------.

                                             :<--TSPKUP-->:
                                             :            :
                                           TPPLW        SPOUT
```

After a PIP up-edge occurs, the following logic is executed:

```
DIFF0 <OR= DIFF1 ---|
                    |AND ---|
TL0FLG = 1 ---------|       |
                            |OR -----| DIFCTR = DIFCTR + 1
DIFF0 > DIFF1 ------|       |        |
                    |AND ---|        | --- ELSE ---
TL0FLG = 0 ---------|                |
                                     | DIFCTR = 0


DIFF0 <OR= DIFF1 ---|
                    |AND ---| TL0FLG = 0
DIFCTR >OR= DFMIN0 -|


DIFF0 > DIFF1 ------|
                    |AND ---| TL0FLG = 1
DIFCTR >OR= DFMIN1 -|
```

DIFF0 = |DT12S - 2 * HFDLTA * MKAY|

DIFF1 = |DT12S - HFDLTA - (HFDLTA * (DT23S - PHFDLT))/PHFDLT|

After a PIP down-edge occurs, TL0FLG is checked and the appropriate TL0 calculation is included for SPOUT.

```
TL0FLG = 1 --------------------|
                               |
N > TRSRPM -----------|S   Q ---|AND ---| TL0 = HFDLTA * (DT12S
                      |                 | - PHFDLT * MKAY)/
N < TRSRPM - TRSRPH --|C                | PHFDLT
                                        |
                                        | --- ELSE ---
                                        |
                                        | TL0 = HFDLTA * MKAY
```

The Signature Pip Distributor has a unique duty cycle on the shutter used to fire cylinder #1. The purpose of this unique shutter is to allow the fuel injectors to be fired at some optimum time relative to intake valve position. This is accomplished by first identifying the cylinder #1 Pip and then synchronizing the fuel injectors to it as described in the fuel section.

The engineer must indicate which type of distributor is used as follows:

If a Signature Pip Distributor is used, then set MHPFD to the appropriate value as defined in the injector synchronization routine.

If a Conventional Pip Distributor is used, then set MHPFD = .99.

When MHPFD < .99, then another consideration in the FALLING-EDGE vs RISING-EDGE decision is the state of SYNFLG. As described in the fuel section, when SYNFLG = 0, then the Signature Pip has not yet been identified. Only the RISING-EDGE calculation is allowed during this time.

When SYNFLG = 1, then the Signature Pip has been identified and its delta-time, HFDLTA, can be normalized. Signature PIP may not be exactly 30 or 35%; thus, any error from these values will introduce error in the output spark. To prevent this error, the Signature PIP will be normalized by replacing the HFDLTA with the HFDLTA from the previous PIP period (PHFDLT).

HFDLTA (for Sig Pip) = HFDLTA / (2 * SIGDC)

The normalized falling edge, FE, is generated as follows:

FE (for Sig Pip) = RISING EDGE + HFDLTA

When SYNFLG = 1 and the RPM is low enough, then the FALLING-EDGE calculation is performed in the standard manner except that the times generated by the Signature Pip are first normalized.

EEC DISTRIBUTOR ROTOR REGISTRY

Although the computer signals the ignition module and the ignition coil when to fire the spark, the computer does not know which cylinder it is trying to ignite. In order to get the spark from the ignition coil to the correct cylinder, it is necessary for the distributor rotor to be lined up with the correct terminals on the cap so that only a small air gap need be jumped. This condition is achieved by adjusting mechanically the orientation of the distributor rotor and cap with respect to the crank position sensor which may be a part of distributor or remote from it.

A slight error in registry may cause mis/crossfire at one end of the spark range.

The range of rotation in which the spark will go to the correct cylinder is given in the chart below

ENGINE SIZE	TOTAL REGISTRY	PIP SENSOR LOCATION	SPARK RANGE	LOS SPARK
4-CYL	60	10 BTDC	0-60	10
6-CYL	50	10 BTDC	0-50	10
8-CYL	42	10 BTDC	5-47	10

All values are in Engine Degrees. LOS spark is BTDC.
It is also necessary that the distributor adjustments be specified with these values. For this reason, the Ignition Department must be notified of any changes in these clip values or pip sensor location (initial timing), so that production distributors will be correct. It is important that the 543 chart affecting rotor alignment be updated by the engine design activity involved.

ADJUSTMENT PROCEDURE:

The Universal Distributor will be assembled with the correct rotor registry, and the Hall Effect Sensor (PIP Sensor) located at the correct position in relation to the rotor registry constants. It is necessary to locate the distributor correctly, in relation to the crankshaft position of the engine.

When a Universal Distributor is installed in the engine, it is held in place by two screws. To set the initial timing of 10 deg BTDC unplug the EEC from memory or disconnect the SPOUT wire and adjust distributor angular location by rotating the body till 10 deg BTDC is observed with a timing light.

KNOCK HARDWARE DESCRIPTION

The knock sensor is a piezo-electric accelerometer that resonates at engine knock frequencies of approximately 5.45, 5.7, 6.0 or 8.05 kHz. The bandwidth of the resonant frequency is quite narrow (<+/- 150 Hz) to avoid resonance due to noise from other sources. The resonation causes the sensor to transmit a positive voltage, KNOCK, to the EEC hardware circuit. This hardware circuit compares the KNOCK voltage to a threshold voltage, NOISE. When KNOCK > NOISE, the hardware circuit sends a KNOCK INPUT signal to the EEC software. This event is represented on the next page as KI = 1. The EEC software stores this information until the next rising edge of PIP is received. At that time, the information is used by the KNOCK LOGIC as described in the remainder of this document.

NOISE, the threshold voltage, is a positive voltage in an RC circuit which is proportional to the Knock Input level at the time that a charging pulse, KTS, is output. This threshold voltage is established to avoid treating rod knock, piston slap, valve train noise and other noise as spark knock.

During normal engine operation, the software opens and closes a window once per PIP period. While the window is open, KTS charges up the capacitor in the RC circuit. While the window is closed, the NOISE level decays (decreases) at a steady rate determined by the time constant of the RC circuit.

NOISE ~ (D.C. Bias + KNOCK(A))*(1-exp(-KTS/RC)) + LAST NOISE

where, NOISE is the noise threshold level

KNOCK(A) is the Knock input level at the time KTS is being output.

KTS is the pulsewidth (secs) of the charging pulse.
KTS Start time is calculated as follows:
NEWTIME = LAST_HIPIP + (WINDOW_BETA*MKAY*2*HFDLTA)

RC is the RC time constant.

LAST NOISE is the noise level at the time KTS is output.

WARNING: To avoid raising the NOISE threshold level too high, the KTS pulse should charge the RC circuit only during that portion of the PIP period wherein no Knock is indicated, normally late in the current PIP period or early in the following PIP period. The calibration of the pulsewidth and timing of the window is described in the Knock Threshold Sense Logic section of this strategy.

Since the noise level is a function of RPM, the NOISE threshold tends to increase with increasing RPM. At high RPM and heavy detonation conditions, knock usually continues well into the following PIP period. To avoid opening the window during the knock period, the software withholds KTS for WINCLD PIP periods to avoid raising the noise threshold too high.

DEFINITIONS

INPUTS

Registers:

- APT = Throttle Mode Flag.
  (Set = -1 = closed throttle)
  (Set = 1 = wide open throttle)
  (Set = 0 = part throttle)

- ECT = Engine coolant temperature, deg F.

- KI = Knock indicated, knock level is higher than noise level; called KNK_HIGH in code.

- KNK_HIGH = Knock level input flag.

- KWCTR = Cancel window counter incorporated each PIP period.

- LOAD = Universal normalized load parameter.

- N = Engine speed, RPM.

- N_BYTE = Low resolution RPM.

- RETINC = Calculated as a function of RPM and is subtracted from each SPKAD corresponding to a knocking cylinder. (positive degree)

- SAF = Final spark advance in degrees.

- SPKADn = Spark adder terms for the nth cylinder. It is added to SAF, may be positive or negative degrees.

- TBART = Average Filtered Throttle Position = UROLAV (TP,TCTPT)

- TCF = Value of the difference between Throttle position (TP) and TBART.
- TIPRET = Tip-in retard.
- TP = Instantaneous throttle position, counts.
- TSLADV = Free-running millisecond timer which counts the time since the spark was last advanced by the KNOCK Strategy.

Bit Flags:

- CTFLG = Flag set to 1 to indicate closed throttle Tip-in.
- KNOCK_DETECTED = Flag set to 1 if Knock occured in current PIP half period.
- KNOCK_ENABLED = Knock Strategy enabled.
- KNOCK_OCCURED = Flag set to 1 (in the knock routine), if knock occured in the current or last PIP period.
- TIPFLG = Flag set to 1 to indicate a Tip-in.

Calibration Constants:

- ADVLIM = Maximum degrees of advance control.
- ECTIP = Minimum ECT to enable Tip-in Retard, deg F.
- ECTNOK = Disable Knock control below this value of ECT.
- ENGCYL = Number of cylinders per engine revolution (NUMCYL/2); or number of PIPs per engine revolution.
- FN143A = Retard increment versus RPM, deg.
- FN144A = Variable knock Threshold window open time, msec. Input is Engine speed in RPM; output is fraction of PIP Period.
- FN145A = Variable Knock threshold window position. Input = Engine Speed in RPM, output = fraction of PIP period.
- FN146B = Spark advance Rate versus RPM, sec/deg.
- KACRAT = Change in TP equivalent to a Tip-in Retard, counts.
- KIHP = Knock Hardware Present Switch. 1 = Knock sensor present.

- KNKCYL = Change in TP equivalent to a Tip-in Retard, counts.

- LODNOK = Minimum load for knock control.

- NTIP = Maximum RPM to enable Tip-in retard (restricted to less than or equal to 2000 to assure TIPRET ramp back function.)

- RETLIM = Maximum degrees of retard control.

- RPMCNL = Threshold RPM below which the window is always open.

- RPMMIN = Disable Knock control below this RPM.

- TCTPT = Time constant for TBART (TP filter).

- TIPHYS = TIPLOD Hysteresis term to prevent multiple Tip-in retards, unitless.

- TIPINC = Advance per PIP following a Tip-in retard. (Must be a positive number; units are degrees)

- TIPLOD = Minimum Load to clear CTFLG for Tip-in Retard.

- TIPMAX = Initial amount of retard following a Tip-in. (Must be a negative number; units are degrees)

- WINCLD = Number of PIPs threshold window is to be closed.

- WINLEN = Minimum amount of time threshold window is open, msec.

- WOPEN = Position of window opening, Beta.

- Y = Normal Part throttle spark multiplier.

OUTPUTS

Registers:

- KWCTR = Cancel window counter incorporated each PIP period.
- RETINC = Calculated as a function of RPM and is subtracted from each SPKAD corresponding to a knocking cylinder. (positive degree)
- SPKADn = Spark adder terms for the nth cylinder. It is added to SAF, may be positive or negative degrees.
- TIPRET = Tip-in retard.
- TSLADV = Free-running millisecond timer which counts the time since the spark was last advanced by the KNOCK Strategy.

Bit Flags:

- CTFLG = Flag set to 1 to indicate closed throttle Tip-in.
- KNOCK_DETECTED = Flag set to 1 if Knock occured in current PIP half period.
- KNOCK_OCCURED = Flag set to 1 (in the knock routine), if knock occured in the current or last PIP period.

- TIPFLG = Flag set to 1 to indicate a Tip-in.

KNOCK SIGNAL DETECTION

```
        :                                       :
        :............. PIP PERIOD ..............:
        :                                       :
        ---------------------                   ----------
        |                   |                   |
PIP     |                   |                   |
        |                   |                   |
   ------                   ---------------------
        :                                        :
        :<-- (WOPEN + FN145(N)) * PIP PERIOD --> :
        :                                        :
         ------                                  ------
         |    |                                  |    |
KTS  --->|    |<--- WINLEN+FN144(N)*PIP PERIOD   |    |
         |    |                                  |    |
----------    ------------------------------------    ----
         :    :                                  :    :
         :    :                                  :    :
         :    :                                  :    :
         :    :                **                :    :
         :    :               *  *               :    :
         :    :              *    *              :    :
         :    :             *      *             :    :
         :    :-------     *        *            :    :---
NOISE    :   /:       ----*--        *           :   /:
-        :  / :          *   -------  *          :  / :
 ----    : /  :         * :         ---*---      : /  :
   -------/   :        *  :             *  -------/   :
         :    :       *   :            : *       :    :
         :    :      *    :            :  *      :    :
         :    :     *     :            :   *     :    :
KNOCK    :    :    *      :            :    *    :    :
SENSOR   :    :   *       :            :     *   :    :
     *************        :            :      ************
                          :            :
                          :            :
                          :            :
                          :            :
                          --------------
                          |            |
KI                        |            |
                          |            |
    -----------------------            -------------------
    (IF KNOCK > NOISE, KI=1; OTHERWISE, KI=0)
```

The Individual Cylinder Knock Strategy consists of four major sub-strategies:

1. KNOCK STRATEGY ENABLE LOGIC
2. KNOCK THRESHOLD SENSE LOGIC
3. SPARK RETARD LOGIC

1. KNOCK STRATEGY ENABLE LOGIC

The following logic is checked every background loop:

```
KIHP = 1 ------------|
                     |
LOAD > LODNOK -------|
                     |
ECT > ECTNOK --------|AND ----| ENABLE KNOCK STRATEGY
                     |        |
N_BYTE > RPMMIN -----|        | --- ELSE ---
                              |
                              | DISABLE KNOCK STRATEGY
                              | SET SPKAD (ALL) = 0
                              | SET TSLADV = 0
```

LODNOK, ECTNOK, and RPMMIN define the minimum engine operating conditions to enable the Knock Control Strategy. These are calibration parameters accessible through VECTOR and through the calibration console.

SPKAD(ALL) are spark adder terms; SPKAD1, SPKAD2, SPKAD3, ... SPKADn; where n = KNKCYL. If KNKCYL is calibrated to be equal to the number of cylinders, then there is a unique SPKAD term for each cylinder -- INDIVIDUAL CYLINDER KNOCK. If KNKCYL is calibrated to 1, the Knock Strategy functions as a Multi-Cylinder Knock Strategy; i.e., there is only one SPKAD term. It is applied to all cylinders. If one cylinder knocks, then all cylinders get retarded an equal amount. Negative values for SPKAD mean that spark is being retarded.

2. KNOCK THRESHOLD SENSE (KTS) LOGIC

The software periodically opens a window which allows a Noise threshold charging pulse called KTS to raise the Knock Threshold level of the Hardware circuit. The window always opens once per PIP period unless the RPM exceeds RPMCNL. The engine developer defines the window during which the charging pulse is on by means of two fox functions and two calibration constants. The pulsewidth of KTS defines the period of time that the capacitor in the RC circuit will be charged. Wide KTS pulses cause the threshold to increase. The timing of the KTS pulse must coincide with the optimum non-knocking portion of the PIP period over all engine RPM. Since Knock tends to to extend longer through the PIP period with increasing RPM, the KTS pulse should be timed late in the current PIP period or early in the

following PIP period (95-110% PIP period).

Noise threshold elevation will result when the capacitor charging rate greatly exceeds the discharge rate or when the KTS pulse is output during conditions of Knock. When knock occurs at high RPM, the charging pulse window is kept closed for WINCLD PIP periods to prevent elevating the NOISE threshold to the level of KNOCK, thereby preventing the EEC hardware circuit from sensing additional spark knock.

The calculations shown below are checked every rising edge of PIP:

The pulsewidth of KTS is equal to:

WINLEN + FN144 (N) * ("LAST PIP PERIOD")

Where, WINLEN is minimum KTS pulsewidth, clock ticks.

FN144(N) is fraction of pip period, BETA Units.

"LAST PIP PERIOD" is equal to 60/(ENGCYL*N).

ENGCYL is number of PIPs per revolution.

The timing of KTS is equal to:

(WOPEN + FN145(N))*("LAST PIP PERIOD")

Where, WOPEN is the minimum delay after the rising edge of PIP before the KTS pulse will be output.

FN145(N) is a fraction of PIP period, BETA Units.

Note: The KTS pulse is output even if the knock strategy is disabled to refresh the threshold level in the event that the Knock strategy becomes enabled. The absence of the KTS pulse for more than a few PIP periods would result in full retard upon entering Knock strategy.

The following logic is checked every PIP UP edge before calculating spout.

```
KIHP = 0 --------------------------| NO KNOCK SENSOR
                                   | Do not output KTS
                                   |
                                   | --- ELSE ---
                                   |
N <OR= RPMCNL ---------------|     |
                             |     |
KWCTR > WINCLD --------------|OR ---| SET KWCTR = 0
                             |     | OPEN WINDOW AT
KNOCK_DETECTED = 0 ---|AND --|     |   CALCULATED TIME
                      |            |
                      |            | --- ELSE ---
 (no KNOCK in current |            |
  PIP half period)    |            | INCREMENT KWCTR
                      |            | DO NOT OPEN WINDOW
NOT SIGNATURE PIP ----|
```

RPMCNL is the threshold RPM below which the WINDOW is always open. The WINDOW is not opened during a signature PIP period (if Signature PIP distributor is present), or if KNOCK has been detected during the current PIP first half period.

```
KNOCK_DETECTED = 1 ----|
                       |AND ----| KNOCK_OCCURRED = 1
KNK_HIGH = 1 ----------|        |
                                | --- ELSE ---
KNOCK_DETECTED = 1 ----|        |
                       |AND ----| KNOCK_OCCURRED = 1
KNK_HIGH = 0 ----------|        | KNOCK_DETECTED = 0
 (KI currently                  |
  indicates NO KNOCK)           | --- ELSE ---

                                |
                                | KNOCK_OCCURRED = 0
```

The following line of logic is executed "almost in real time".

```
KIHP = 0 ----------------| Prevent knock interrupts
                         | from occuring
                         |
                         | --- ELSE ---
                         |
                         | Allow knock interrupts
                         | to occur
```

NOTE: KNOCK_DETECTED & VIP_KNOCK are both set in the Knock Interrupt Routine.

```
        |<--"LAST PIP PERIOD"-->|

        _____________           _____________           ____
        |           |           |           |           |
        |           |           |           |           |
        |           |           |           |           |
PIP  ___|           |___________|           |___________|

        |<-----------A------->|


       _____                   _____
       |   |                   |   |
       |<B>|         |         | | |         |           |
       |   |                   |   |
 KTS  _|   |___________________|   |__________________________



               ___________
               |         |
         |     |     |   |       |           |           |
               |         |
 KI   ---------|         |------------------------------------


               ___________________
               |                 |
               |                 |
         |     |     |           |           |
 KNOCK ________|                 |_______________________|____
 DETECTED

                                 _________________________
                                 |                       |
         |           |           |           |           |
                                 |                       |
 KNOCK __________________________|                       |_____
 OCCURRED
```

Where A = (WOPEN + FN145)*("LAST PIP PERIOD")
B = WINLEN + FN144*("LAST PIP PERIOD") = KTS

Note: Range of A is typically 90 - 110 % of PIP period.

3. SPARK RETARD LOGIC

Whenever the Knock strategy is enabled, the software calculates RETINC as a funcion of RPM. RETINC is subtracted from each SPKAD that corresponds to a "knocking" cylinder. The software keeps track of the cylinders by means of a "PIP counter". The "PIP counter" is incremented once per PIP period and is set to 1 every time it exceeds KNKCYL. To prevent excessive retard (perhaps due to erroneous knock sense) each SPKAD is clipped to RETLIM.

RETINC = FN143A (N)

During a particular PIP period ("PIP counter" = n), the software makes adjustments to SPKAD(n-1) based on whether Knock was sensed during the previous PIP period and uses SPKAD(n), calculated during the previous engine cycle (KNKCYL PIP periods ago) to determine the final value of spark advance for the next spark output.

```
KNOCK STRATEGY ENABLED -|
                        |
KNOCK_OCCURRED = 1 -----|
 (knock sensed          |
  during last PIP       |AND --| SET SPKAD(n-1) = SPKAD(n-1)
  Period)               |      |    - RETINC
                        |      | (Clip min. SPKAD(n-1) to RETLIM)
TIPRET = 0 -------------|
```

THROTTLE POSITION FILTER (TBART)

The TBART calculation is a time-dependent rolling average filter of instantaneous throttle position (TP). It is updated each background pass while in RUN or UNDERSPEED mode. The TBART time constant TCTP, is a calibratable parameter.

TBART = UROLAV (TP,TCTPT)

A separate part of the retard logic responds to Tip-in detonation, and even to potential Tip-in detonation, by retarding the spark TIPRET degrees.

Tip-in detonation is a result of the relatively slow response of both LOAD and N, which are average values during a PIP period, to the sudden increase in manifold pressure and decrease in engine speed, respectively, which occur within a PIP period during a Tip-in. The result is that the delivered spark is over-advanced for the instantaneous conditions until the LOAD calculation has updated to reflect the higher manifold pressure and the engine speed has recovered. The recovery from a Tip-in is normally complete within a few PIP periods.

The KNOCK STRATEGY is designed to anticipate detonation following a Tip-in from idle (the worst case Tip-in condition) and respond by retarding the spark before detonation occurs. Tip-in from part- throttle results in retarded spark only if knock is sensed. In both cases, Tip-in retard is applied to whichever cylinders follow the Tip-in, not to individual cylinders as is usually done in the individual cylinder knock strategy. Thus, there is no need to wait an entire engine cycle before responding to Tip-in detonation.

The Tip-in condition is recognized by comparing TP to a filtered TP, called TBART. (NOTE that TBART is initialized to the same initialization value as RATCH) If TCF, the difference between TP and TBART, exceeds KACRAT, and if either the Tip-in occurred from idle or if the knock is sensed following a Tip-in from part-throttle, then the spark for the next PIP is retarded by TIPMAX degrees. On the ensuing PIPS, the amount of retard is decremented by TIPINC degrees until all Tip-in retard is removed. The Tip-in logic can be disabled by setting KACRAT = 1023.

The following Tip-in logic is checked every background loop:

```
ECT > ECTIP ----------|
                      |
TCF >OR= KACRAT ------|AND -----| SET TIPFLG = 1
                      |         |
N < NTIP -------------|         | --- ELSE ---
                                |
                                | TIPFLG = 0
```

```
APT = -1 --------|AND ----|S Q--| SET CTFLG = 1
                 |        |     |
LOAD < TIPLOD ---|        |     | --- ELSE ---
                          |     |
LOAD > TIPLOD + TIPHYS ---|C    | SET CTFLG = 0
```

NOTE: The Sum of TIPLOD + TIPHYS is clipped to 1.99

The following Tip-in logic is checked before SPOUT issues (rising or falling edge of PIP):

```
TIPRET = 0 --------------------|
                               |
TIPFLG = 1 --------------------|AND --| SET TIPRET = TIPMAX
                               |      | TBART = TP
KNKCYL NOT=1 ---------|AND-|   |      |
                      |    |   |      |
                      |    |   |      |
KNOCK_ENABLE = 1 -----|    |   |      |
                      |    |   |      |
KNOCK_OCCURRED = 1 ---|    |OR-|      | --- ELSE ---
  (knock sensed)           |          |
                           |          |
CTFLG = 1 -----------------|          | SET TIPRET = TIPRET + TIPINC
                                      | (CLIP MAX TIPRET TO 0)
```

4. SPARK ADVANCE LOGIC

The following logic is checked every rising edge of PIP:

```
KNOCK STRATEGY ENABLED -|
                        |AND --| SET SPKAD(ALL) = SPKAD(ALL) +
TSLADV >OR= FN146B/4 ---|      |   0.25 deg.  (CLIP MAX
                               |   SPKAD(ALL) TO ADVLIM)
                               | SET TSLADV = TSLADV - FN146B/4
```

If the Knock Strategy is enabled, all of the spark adders, SPKAD1 through SPKADn are incremented 0.25 degrees every FN146B/4 seconds. Each of the SPKADn's is clipped to ADVLIM. If ADVLIM = 0, the KNOCK STRATEGY will not advance the spark beyond SAF.

NOTE: If the Knock Strategy is enabled and no cylinders are knocking, the spark to each cylinder will advance to SAF + ADVLIM. If a particular cylinder is knocking, the Retard Strategy will tend to dominate the advancing mechanism. To insure that the spark to knocking cylinders is retarded more than the strategy can advance it, FN146B should be greater than or equal to 1/FN143A. FN146B is in degrees of advance per second while FN143 is in degrees of retard per PIP, therefore, FN143 must be converted to degrees per second at a given RPM for a valid comparison to be made. When FN146B is large, then the spark advance rate is small. For example, FN146B = 0.5 is equivalent to a spark advance rate of 2 degrees/sec. FN146B = 0.25 is equivalent to spark advance rate of 4 degrees/sec.

The final value of spark advance is calculated by the EOS immediately prior to calculating the waiting time:

CALCULATED SPARK OUT (n+1) = SAF + SPKAD(n+1) + TIPRET

The table shown below is included as an illustration of the Individual Cylinder Knock Control adjustment to the Spark Advance.

Example of Individual Cylinder Knock Control (4 cyl)

PIP Counter	1	2	3	4
Adjustment to Spark	TIPRET+ SPKAD1 = +2	TIPRET+ SPKAD2 = +4	TIPRET+ SPKAD3 = -6	TIPRET+ SPKAD4 = +6
Base Spark (SAF)	24	24	24	24
Calculated Spark Out	26	28	18	30
Actual Spark Out	26	28	18	28.8

Due to the physical time constraints for arming the coil and firing the next spark, the maximum spark advance increase between consecutive spark events must be no more than SPKLIM*360/ENGCYL degrees.

In this example, SPKLIM = .06 and ENGCYL = 2. Therefore, the largest spark advance increase allowed between cylinders is 10.8 deg. There is no limit on the amount of spark advance decrease allowed between cylinders.

CHAPTER 8

EGR STRATEGY

DEFINITIONS
INPUTS
Registers:

- AM = Air mass flow (lb/min).

- AMPEM = Air mass flow plus EGR mass flow.

- APT = Throttle Mode Flag.
  (Set = -1 = Closed Throttle)
  (Set = 1 = Wide Open Throttle)
  (Set = 0 = Part Throttle)

- ATMR1 = Time since start (time since exiting Crank mode), sec.

- ATMR2 = Time since ECT became greater than TEMPBF sec.

- BP = Barometric pressure.

- DELOPT = Filtered desired EGR valve position.

- EGRERR = DELOPT - EVP

- EM = EGR mass flow.

- EOFF = The EGR valve reading when the valve is fully closed in A/D counts.

- EVP = EGR valve position reading in A/D counts.

- ISCFLG = Mode Indicator Flag
  -1 = Dashpot, 0 = Pre-pos.
  1 = RPM Control, 2 = MAP RPM Control

- MFAMUL = MFA table ramp-in multiplier, unitless.

- PEXH = Absolute exhaust pressure (in Hg).
  = FN074A(AM)*29.875/BP + BP

- TCSTRT = Temperature of ECT at cold start, deg F.

Bit Flags:
- AFMFLG = Flag indicating that ACT sensor has failed.
- BFMFLG = Flag indicating that BP sensor has failed: 1 -> failure.
- CFMFLG = Flag indicating that ECT sensor is in/out of range.
- CRKFLG = Flag indicating engine status, set to 1 if in Crank mode.
- EFMFLG = Flag indicating that EVP EGR sensor has failed (This flag performs for both Sonic and PFE EGR).

- EGREN = Flag which indicates EGR enabled if set to 1.

- EGRFLG = Flag that indicates whether DCOFF has been added to EGRDC.

- MFAFLG = Managed Fuel/Air Ratio Flag. This is set to one if MFA is being used.

- MFMFLG = Flag indicating that MAF sensor has failed.

- TFMFLG = Flag indicating that TP sensor has failed.

Calibration Constants:

- CTHIGH = Hot Start Minimm Engine Coolant Temperature, Deg F.

- CTLOW = Cold Start maximum ECT, deg F.

- DCOFF = Duty cycle required to start to open the valve equivalent to LGA0O in the Vent/Vac system.

- EGRDED = Deadband value for EVP - DELOPT, counts.

- EGRMPT = Calibration time delay to ramp EGR in, sec. (EGRATE Ramp time for TCSTRT <or= CTLOW)

- EGRTD1 = EGR time delay (TCSTRT <or= CTLOW) for low mileage.

- EGRTD2 = EGR time delay (CTLOW < TCSTRT < CTHIGH) for low mileage.

- EGRTD3 = EGR time delay (TCSTRT >or= CTHIGH) for low mileage.

- EGRTD4 = EGR time delay (TCSTRT <or= CTLOW) for high mileage or NO IMS hardware.

- EGRTD5 = EGR time delay if CTLOW < TCSTRT < CTHIGH for high mileage or no IMS hardware.

- FN070 = Engine speed N normalizing function for FN908A and FN908B, generates table entry point. Input = N and Output = table entry point.

- FN074 = EGR Valve upstream pressure. Input: AM * KAMRF1 and Output = H2O.

- FN082 = LOAD normalized function for FN1223. Input = LOAD and Output = Row Number (table entry point).

- FN083 = RPM normalizing function; generates table entry point. Input = N and Output = Normalized N.

- FN211 = Part throttle EGR multiplier as a function of Engine Coolant Temperature ECT.

- FN212A = EGRSEA multiplier as a function of Barometric Pressure BP.

- FN217A = EGRALT multiplier as a function of Barometric Pressure BP.

- FN219A = EGR mass flow as a function of EGR valve position (EVP-EOFF).

- FN220 = Multiplier as a function of Air Charge Temperature ACT.

- FN221 = EGR valve position as a function of desired mass flow.

- FN239 = Change in EVR duty cycle as a function of the position error, EGRERR (IF PFEHP = 0); or as a function of Pressure Error PRESER (If PFEHP = 1).

- FN246 = EGR Mass flow as a function of DELPR, lb/min.

- FN247 = Desired Pressure Drop as a function of Desired EGR Mass flow, inches H2O.

- FN311 = MFA altitude multiplier, unitless.

- FN908A (EGRSEA) = Sea level EGR table.
X-input = FN070 - Normalized engine speed, RPM
Y-input = FN071 - Normalized load.
Output = Percent EGR

- FN908B (EGRALT) = Altitude EGR table.
X-input = FN070 - Normalized engine speed, RPM
Y-input = FN071 - Normalized load.

- FN1223 = (Managed fuel air EGR table) 4 x 3 table of multipliers.
X-input = FN083 - Normalized engine speed, RPM
Y-input = FN082 - Normalized Load

- KPEI = Part throttle EGR adder.

- PFEHP = Switch to select EGR strategy. 1 = PFE; 0 = Sonic; 2 = No EGR.

- TCDLOP = Time constant for DELOPT, sec.

- TCDP = Time constant fpr DESDP, sec.

- TCEACT = Time constant for EGRACT, sec.

- TSEGRE = Accumulated time EGR is enabled.

- X = EGR table multplier.

OUTPUTS

Registers:

- DELOPT = Filtered desired EGR valve position.
- DESEM = Desired EM, lb/min. (EGRATE * AMPEM /100)
- EGRACT = Actual EGR percent = 100*EM/AMPEM.
- EGRATE = Desired EGR rate in percent.
- EGRDC = Duty cycle of the EVR output, fraction.
- EM = EGR mass flow.

Bit Flags:

- EGREN = Flag which indicates EGR enabled if set to 1.
- EGRFLG = Flag that indicates whether DCOFF has been added to EGRDC.

EGR STRATEGY

OVERVIEW

The GX strategy provides the capability to select one of two EGR systems: Sonic EGR or PFE EGR.

The EGR strategy is divided into:

1) Enable/Disable Logic - Common
2) EGRATE Calculation - Common
3) EM Calculation - Unique
4) EGR Error Calculation - Unique
5) EGRDC Update - Unique
6) EVR Output Routine - Common

The calibrator selects the desired EGR system by setting PFEHP equal to 1 (for PFE EGR - Pressure Feedback EGR); or, to zero (for Sonic EGR); or to 2, to disable both EGR strategies. The Switch logic is described below.

EGR SELECT LOGIC

```
PFEHP = 0 ------------------------| Do SONIC EGR Control
                                  |
                                  | --- ELSE ---
                                  |
PFEHP = 1 ------------------------| Do PRESSURE FEEDBACK EGR
                                  | Control
                                  |
PFEHP = 2 ------------------------| --- ELSE ---
                                  |
                                  | EGR disabled, NO EGR Control
                                  | required
                                  |
                                  | Set EM = 0
                                  | Set EGRACT = 0
                                  |

                                  | Return
```

EGR ENABLE LOGIC - COMMON

The following logic describes the operating conditions during which EGR is enabled (When PFEHP = 2, no EGR is required and the EGR strategy is always disabled).

```
TCSTRT >OR= CTHIGH ---------|
                            |AND --|
ATMR1 >OR= EGRTD3 ----------|      |
                                   |
                                   |
CTLOW < TCSTRT < CTHIGH ----|      |
                            |AND --|OR -|AND -| ENABLE EGR
ATMR1 >OR= EGRTD2 ----|     |      |    |     | EGREN = 1
                      |AND -|      |    |     |
ATMR2 >OR= EGRTD5 ----|            |    |     | --- ELSE ---
                                   |    |     |
                                   |    |     | EGREN = 0
TCSTRT <OR= CTLOW ----------|      |    |     | DISABLE EGR
                            |      |    |     | EGRATE = 0
                            |AND --|    |     | DESEM = 0
ATMR1 >OR= EGRTD1 ----|     |           |     | EGRACT = 0
                      |AND -|           |
ATMR2 >OR= EGRTD4 ----|                 |
                                        |
APT = 0 (PART THROTTLE) ----------------|
                                        |
EVP >OR= EOFF - EGRDED ----|            |
                           |OR ---------|
PFEHP = 0 -----------------|            |
                                        |
CRKFLG = 0 -----------------------------|
                                        |
AFMFLG = 0 ------------|                |
                       |                |
CFMFLG = 0 ------------|                |
                       |                |
EFMFLG = 0 ------------|AND ------------|
                       |
MFMFLG = 0 ------------|
                       |
TFMFLG = 0 ------------|
                       |
BFMFLG = 0 ------------|
```

DESIRED EGR FLOW RATE EQUATIONS - COMMON

If EGR is enabled, the base amount of EGR to be added is determined from two 10 x 8 tables the format of which is identical to that used for the PART THROTTLE spark timing determinations.

The table values are a function of engine speed N and LOAD.

The base amount can be adjusted by several EGR modulators to reflect special engine operating conditions.

The amount of EGR to be added is determined as shown below.

```
MFAFLG = 1 -------| EGRATE = ['E' * (1 - {FN1223
                  |   * MFAMUL * FN311})] + KPEI
                  |
                  | --- ELSE ---
                  |
                  | EGRATE = 'E' + KPEI
```

'E' is defined below.

'E' = X*'R'*[FN211 * FN220 * (FN908A * FN212A + FN908B * FN217A)]

'R' is defined below.

'R' = TSEGRE/EGRMPT (CLIPPED AT 1.0)

TSEGRE LOGIC

```
TCSTRT > CTLOW -------------| SET TSEGRE = EGRMPT ('R' = 1)
                            |
                            | --- ELSE ---
                            |
EGR ENABLED ----------------| INCREMENT TSEGRE
                            |  (CLIP AT EGRMPT)
                            |
                            | --- ELSE ---
                            |
                            | FREEZE TSEGRE
```

SONIC EGR VALVE STRATEGY (PFEHP = 0)

The Sonic Exhaust Gas Recirculation (EGR) system offers a high degree of flexibility. The chief benefit is improved drive and fuel economy. The abilities are:

1. EGR flow can be precisely varied depending upon engine operating conditions.

2. Spark advance can be precisely adjusted to compensate for the actual EGR flow.

The Sonic EGR system consists of:

1. Sonic EGR valve

2. EGR valve position (EVP) sensor

3. Electronic Vacuum Regulator (EVR)

The EGR valve controls the flow of exhaust gases to the intake manifold. The pintle valve and seat assembly are designed such that EGR flow is proportional to pintle position. Further, the output of the EVP sensor is directly proportional to the pintle position. This design allows direct calculation of EGR flow.

The EGR valve is operated by manifold vacuum. The EVR:

1. Applies vacuum to the EGR valve (increases EGR flow).

2. Holds in existing EGR valve vacuum (maintains EGR flow).

3. Vents EGR valve vacuum to atmosphere (decreases EGR flow).

The strategy enables EGR during various engine operating modes. These modes are calibration items. Typical calibrations will enable EGR when these conditions are met:

1. Time since start is greater than a calibration value.

2. Engine is in part throttle mode.

3. Current EGR valve position is not less than the fully closed position.

ACTUAL EGR MASS FLOW EQUATIONS - SONIC (PFEHP = 0)

For interactive spark and EGR control:

1. The EGR mass flow is calculated based upon actual valve position.

2. The percent EGR is then calculated and used to modify the spark advance.

EM CALCULATION - SONIC (PFEHP = 0)

```
ISCFLG = 1 OR 2 ----------|
  (Idle RPM Control)      |AND -|OR --| (EGR is OFF)
                          |     |     | EM = 0
DELOPT = 0 ---------------|     |     |
                                |     | --- ELSE ---
                                |     |
AFMFLG = 1 ---------------|     |     | EM = FN219A *
                          |     |     |  BP/29.875
CFMFLG = 1 ---------------|     |
                          |     |
EFMFLG = 1 ---------------|OR --|
                          |
MFMFLG = 1 ---------------|
                          |
TFMFLG = 1 ---------------|
```

Percent EGR = EGRACT = (EM/AMPEM)*100

DESIRED EGR MASS FLOW - SONIC (PFEHP = 0)

The desired EGR mass flow = 0.01 * EGRATE * AMPEM * 29.875/BP

To enhance the control of the EGR valve, the valve is controlled to a filtered desired position as follows:

```
EGREN = 1 ------------| DELOPT =
 (EGR Enabled)        |  UROLAV (FN221+EOFF,TCDLOP)
                      |
                      | --- ELSE ---
                      |
                      | DELOPT = 0
```

Notes:

1. When the desired EGR rate EGRATE equals zero, DELOPT is then set to zero. This action will close the EGR valve when zero EGR is requested.

2. When the desired EGR rate EGRATE is nonzero and DELOPT is zero, then DELOPT is set to EOFF before the DELOPT filter is run. This makes the DELOPT filter start at the closed EGR valve position when EGR is desired.

3. DELOPT is clipped to 922 counts (90% of VREF).

SONIC EGR VALVE OUTPUT CONTROL (PFEHP = 0)

The EGR valve is controlled in a closed loop manner using proportional control, and the EGR valve position, EVP, as the feedback variable. The valve is moved to the desired EGR position DELOPT through output commands to the Electronic Vacuum Regulator, EVR.

EGR FLOW	EVR OUTPUT
HOLD	MAINTAIN DUTY CYCLE
INCREASE	INCREASE DUTY CYCLE
DECREASE	DECREASE DUTY CYCLE
NONE (FULLY CLOSED)	DUTY CYCLE = 0

The change in the EVR duty cycle is a function of the sign and magnitude of the error in control pressure according to the following logic.

```
DELOPT = 0 ------------------------|  EGRDC = 0
                                   |  CLEAR EGRFLG
                                   |
                                   | --- ELSE ---
EVP <OR= EOFF + EGRDED -|          |
                        |AND ------|  EGRDC = DCOFF +
EGRFLG CLEAR -----------|          |        FN239(EGRERR)
                                   |  SET EGRFLG
                                   |
                                   | --- ELSE ---
                                   |
EVP > EOFF + EGRDED ---------|     |
                             |OR --|  EGRDC = EGRDC +
EVP <OR= EOFF + EGRDED-|     |     |        FN239(EGRERR)
                       |AND -|
EGRFLG SET ----------- |
```

EGRDC is clipped to 0.90

An EVR calibration method, EVR.MEM, is available in the Strategy group user area. Copies can be made by exercising the Xerox option as explained on page 2 of this Strategy Book.

PRESSURE FEEDBACK ELECTRONIC (PFE) EGR STRATEGY (PFEHP = 1)

The PFE EGR system was developed as a subsonic alternative to the Sonic EGR system. The PFE EGR provides a projected reliability improvement over the Sonic system while still providing the flexibility and spark compensation characteristics of Sonic EGR.

Like the Sonic EGR subsystem, PFE EGR precisely regulates the EGR flow according to calibrated Tables and fox functions. However, the PFE EGR strategy uses pressure (EPT) as the feedback signal rather than pintle position (EVP).

The PFE_EGR system consists of:

1) Tapered pintle ported EGR valve.

2) Downstream pressure sensor (EPT).

3) Control orifice.

4) Electronic Vacuum Regulator (EVR).

Since PFE EGR is a subsonic flow system, the EGR flow is proportional to the pressure drop across a sharp-edged orifice (PE - DP). PE, the upstream pressure, is calculated by the software. DP, the downstream pressure, is measured by means of a piezo-resistive transducer (EPT). The EGR valve itself operates as the downstream pressure regulator. When the valve is closed, the downstream and upstream pressures are equal. As the valve opens, the downstream pressure decreases due to the influence of the intake manifold vacuum.

Fig. 1

```
          Control               EGR
          Orifice              Valve
             |                   |
             V                   V
          ---------------------------------------------
             |                 \    /
             |                  \  /      Intake
    PE, "H20       DP, "H20      \/      Manifold
             |                   /\       Vacuum
             |  Control chamber /  \
             |                 /    \
         ----------------------------------------------
```

The EEC operates the EGR valve by outputting a variable duty cycle to the EVR. The EVR applies a vacuum signal, which is proportional to the duty cycle, to the EGR valve. The frequency of the duty cycle ranges from 90-180 Hz. The operation of the EVR is described near the end of this Chapter.

The strategy enables EGR during various engine operating modes. These modes are calibration items. Typical calibrations will enable EGR when the following conditions are met:

1) Time since start is greater than a calibration value.

2) Engine is in part throttle mode.

PRESSURE FEEDBACK ELECTRONIC (PFE) EGR STRATEGY (PFEHP = 1)

DEFINITIONS

INPUTS

Registers:

- AM = Air mass flow, (lb/min).
- AMPEM = Air mass plus EGR mass flow.
- BP = Barometric pressure, "Hg.
- BPCOR = BP corrected = FN004(BP). FN074 should be calibrated at sea level since the altitude correction is made by the (29.875/BPCOR) term. Note that the altitude correction used to be (29.875/BP) however actual data obtained from the altitude chamber disagreed with the calculated correction. Therefore FN004(BP) was added to allow an empirical correction. If no correction is desired, calibrate FN004 on a diagonal, that is (0,0), (31.875,31.875). Actual data indicates that backpressure does not increase linearly with BP, but at about half that rate, roughly (0,8), (31.875,31.875). This will generate a corrected BP to be used in calculating a more accurate PEXH and PE (PFE EGR only).
- DELPR = Pressure drop across the control orifice, " H20
  = PE - DP
- DESEM = Desired EM, lb/min. (EGRATE * AMPEM/100)
- DESDP = Filtered desired downstream pressure, " H2O.
  = ROLAV (DP',TCDP)
- DP = Downstream pressure, " H2O (gauge).
  = XFREPT * (EPTBAR - EPTZER)
  DP' = PE - DESDEL
- EGRACT = Actual EGR percent = 100*EM/AMPEM.
- EGRATE = Desired EGR rate in percent.
- EGRCNT = Background EGR ON-TIME counter.
- EGRDC = Duty cycle of the EVR output, fraction.
- EGRERR = Error in EGR valve position (DELOPT-EVP).
- EGRPER = Foreground EGR period.
- EM = Actual EGR mass Flow.
- EPTBAR = Rolling average of the synchronously sampled EPT sensor (time constant = TCEPT), secs.
- EPTZER = Rolling average of the synchronously sampled EPT sensor at idle (time constant = TCEPT), stored in Keep Alive Memory, counts.

- PE = Upstream pressure, " H2O (gauge).
  = (29.875/BPCOR) * FN074.

- PRESER = EPTBAR - CONPR, counts.

Bit Flags:

- EGREN = Flag which indicates EGR enabled if set to 1.

- EGRFLG = Flag that indicates whether DCOFF has been added to EGRDC.

Calibration Constants:

- DCOFF = Duty cycle required to start to open the valve equivalent to LGA0O in the Vent/Vac system.

- FN004 = BP correction for exhaust backpressure calculation, "Hg.

- FN074 = Upstream pressure as a function of (AM * KAMREF).
  (KAMREF = Adaptive fuel correction factor), "H20.

- FN211 = Multiplier as a function of ECT.

- FN212A = Multiplier as a function of BP.

- FN239 = Change in EVR duty cycle as a function of the pressure error, PRESER (if PFEHP = 1).

- FN246 = EGR mass flow as a function of DELPR, lb/min.

- IXFRPR = Transfer function = 1/XFREPT, Counts/" H2O.
- KPEI = Constant EGR adder.
- PFEHP = Switch to select EGR strategy. 1 = PFE; 0 = Sonic;
  2 = No EGR.
- SQRT (BP/29.875) = Altitude compensation represented by a linear approximation for 21 < BP <OR= 31.875.
  = (0.1*BP + 2.50)/5.47
- TCDP = DP filter time constant.
- X = Multiplier.
- XFREPT = Transfer function of EPT sensor, " H20/counts.

OUTPUTS

Registers:

- CONPR = Desired PRT sensor value.
- DESEM = Desired EM, lb/min. (EGRATE * AMPEM/100)
- DESDP = Filtered desired downstream pressure, " H2O.
- EGRCNT = Background EGR ON-TIME counter.
- EGRDC = Duty cycle of the EVR output, fraction.
- EGRPER = Foreground EGR period.
- EM = Actual EGR mass Flow.

Bit Flags:

- EGRFLG = Flag that indicates whether DCOFF has been added to EGRDC.

ACTUAL EGR MASS FLOW EQUATIONS (PFEHP = 1)

For interactive spark and EGR control:

1) The EGR mass flow is calculated based upon the pressure drop across the control orifice.

2) The percent EGR is then calculated and used to modify the spark advance.

```
EGREN = 1 ------------------| EM = SQRT (BP/29.875)
 (EGR enabled)              |   * FN246
                            |
                            | --- ELSE ---
                            |
                            | EM = 0
```

EGRACT' = 100 * EM/AMPEM

EGRACT = UROLAV (EGRACT',TCEACT)

DESIRED EGR MASS FLOW (PFEHP = 1)

The PFE EGR system achieves the desired EGR flow by controlling it to a particular downstream pressure. The desired flow, DESEM, is calculated from the desired EGR rate and actual airflow. To promote control stability, the strategy avoids operation in the low flow non-linear region of the EGR transfer function.

```
EGREN = 1 -------------------|      | EGR ON
                             |AND --| DESEM = EGRATE * AMPEM/100
EGRATE * AMPEM/100           |      | DESDEL = FN247
>OR= MINDES + DESHYS --|S Q -|      | DP' = PE - DESDEL
                       |            | DESDP = ROLAV (DP',TCDP)
EGRATE * AMPEM/100     |            | CONPR = (IXFRPR * DESDP)
   < MINDES -----------|C           |  + EPTZER
                                    |
                                    | --- ELSE ---
                                    |
                                    | DESEM = 0
                                    | DESDEL = 0
                                    | DESDP = PE
                                    | CONPR = EPTBAR
```

EVR OUTPUT CONTROL (PFEHP = 1)

The downstream pressure, DP, is controlled in a closed loop manner using the EPT sensor as the feedback signal. The valve pintle is moved until CONPR (the control pressure) is equal to the EPTBAR (measured downstream pressure) by means of output commands to the EVR. The output commands take the form of a variable duty cycle voltage output.

EGR FLOW	EVR OUTPUT
HOLD	MAINTAIN DUTY CYCLE
INCREASE	INCREASE DUTY CYCLE
DECREASE	DECREASE DUTY CYCLE
NONE (FULLY CLOSED)	DUTY CYCLE = 0

The change in the EVR duty cycle is a function of the sign and magnitude of the error in control pressure according to the following logic.

```
DESEM = 0 -------------------------| EGRDC = 0
                                   | CLEAR EGRFLG
                                   |
                                   | --- ELSE ---
                                   |
EGRFLG CLEAR ----------------------| EGRDC = DCOFF
                                   |  + FN239
                                   | SET EGRFLG
                                   |
                                   | --- ELSE ---
                                   |
                                   | EGRDC = EGRDC
                                   |  + FN239
```

NOTE: During On-Demand Self-Test, EGRDC is to zero.
The Sonic EGR and PFE EGR strategies BOTH
use FN239

```
PFEHP = 1 ----------------------| Use PRESER as input
                                |  to FN239
                                |
                                | --- ELSE ---
                                |
                                | Use EGRERR as input
                                |  to FN239
```

WARNING: The Control Algorithm was designed for use with EPT Sensors which have a POSITIVE sloped transfer function.

Calibration Guides for both PFE and EVR are available. Xerox copies may be obtained in the same manner as Strategy Books. The file names are PFE1.MEM and EVR.MEM.

The EVR Control Routine was designed to operate the EVR within a 90-200 Hz frequency range. The algorithm selects an "ON" time, EGRCNT, based on the desired duty cycle, EGRDC. The period is calculated by dividing the ON-time by the duty cycle. (All definitions for this section will be listed in the beginning of Chapter 8.)

```
0 <OR= EGRDC <OR= 0.08 ----------------| EGRCNT = 0
                                       | (Turn EVR off)
                                       |
                                       | --- ELSE ---
                                       |
0.08 < EGRDC <OR= 0.18 ----------------| EGRCNT = 1
                                       |
                                       | --- ELSE ---
                                       |
0.18 < EGRDC <OR= 0.31 ----------------| EGRCNT = 2
                                       |
                                       | --- ELSE ---
                                       |
0.31 < EGRDC <OR= 0.46 ----------------| EGRCNT = 3
                                       |
                                       | --- ELSE ---
                                       |
0.46 < EGRDC <OR= 0.59 ----------------| EGRCNT = 4
                                       |
                                       | --- ELSE ---
                                       |
0.59 < EGRDC <OR= 0.74 ----------------| EGRCNT = 5
                                       |
                                       | --- ELSE ---
                                       |
                                       | EGRCNT = 6
```

```
    0 <OR= EGRDC <OR= 0.08 -------| EGRPER = 0
                                  |
                                  | --- ELSE ---
                                  |
    EGRPER <OR= 0 ----------------| EGRPER = (EGRCNT/EGRDC)
                                  |  + EGRPER
                                  | Clip EGRPER to 12 as
                                  |  a maximum
```

EXAMPLE (EGRDC = 0.40)

```
   -----------            ------------               ----
   |         |            |          |               |
   +  +   +  +--+--+--+---+  +    +  +--+--+--+--+---+
```

Clip EGRPER to maximum of 12.

```
EGRCNT > 0 ----------------------------| Turn EVR on
                                       | EGRCNT = EGRCNT - 1
                                       | EGRPER = EGRPER - 1
                                       |
                                       | --- ELSE ---
                                       |
                                       | Turn EVR off
                                       | EGRPER = EGRPER - 1
```

NOTE: This Algorithm was intended to minimize real-time execution. In the experimental version, the EGRCNT and EGRPER calculations are done in the background. The foreground merely toggles the EVR output. (Reference: ENQDA version)

CHAPTER 9

IDLE SPEED CONTROL STRATEGY

ADAPTIVE BYPASS AIR IDLE SPEED CONTROL

This chapter describes the adaptive air bypass idle speed control system. In general, the ISC system is designed to regulate the duty cycle to an air bypass solenoid as necessary to obtain the desired engine speed for all idle operating conditions (base idle, hi-cam, various accessory loads) and provide for a dashpot action. Predicted airflows for the different load states at idle are adaptively corrected to minimize the impact of hardware variability. Acceptable quality on engines utilizing a speed density determined air mass requires a coupling of the ISC logic with both fuel (adaptive fuel, transient fuel, special AM filtering routine) and spark control strategies.

An overview description is illustrated below:

```
                   _________
                  (enter ISC)
                   ---------
                       |-------------------|-------------------
                       |                   |                  |
                       |           __________________    --------------
                       |           |   CRANK MODE   |    |    FMEM    |
                       |           |----------------|    |            |
                ___________________| FN884(TCSTRT)  |    | ISCDTY =   |
                |-calculate DSDRPM|------------------    |  FMMISC    |
                |-predict DESMAF  |        |             --------------
                |-update FAM      |     _________              |
                |-calc DSTPBR     |    (exit ISC )          --------
                -------------------     ---------          (exit ISC)
                       |                                    --------
                       |
                ________________
               (decrement DASPOT)
                ----------------
                       |  (Mode Select)
      _________________________________________________
      |              |               |                 |
______________   ______________   _______________   ________________
|DAS_PRE_POS |   | DASHPOT    |   | RPM CONTROL |   |  RPM LOCKOUT |
| ISCFLG=0   |   | ISCFLG=-1  |   | ISCFLG = 1  |   | ISCFLG = 2   |
|-calc DASPOT|   |-calc spark |   |-calc airflow|   |-calc airflow |
|-elim spark |   | vs airflow |   |  correction |   |  correction  |
|  feedback  |   |  (FN839)   |   |-calc spark  |   |-calc spark   |
--------------   --------------   | mult vs RPM |   |  mult vs RPM |
    |                  |          |   (FN841)   |   |   (FN841)    |
    |                  |          ---------------   ----------------
    |                  |               |                 |
    -----------------------------------------------------
                          |
               _____________________________
               | -fold in airflow          |
               |   corrections to DESMAF   |
               | -calc actual ISC actuator |
               |   airflow DEBYMA          |
               | -calc ISCDTY              |
               -----------------------------
                         |
                 ________________________
                 | -update KAM for      |
                 |   corrected airflows |
                 ------------------------
                         |
                     ________
                    (exit ISC)
                     --------
```

ISC MODE SELECT

DEFINITIONS

REGISTERS/FLAGS/TIMERS:

- CTPTFG = Closed throttle to Part/WOT transition flag, unitless.
- FLG_DASMNQ = VSBAR flip-flop flag for minimum Daspot.

CALIBRATION CONSTANTS:

- DASCTK = A background-driven decrement to the dashpot pre-position airflow register (DASPOT).

- It provides a time based dashpot. Calculate dashpot time as follows: If the maximum allowed dashpot pre-position (DASPOT) = 0.5 ppm; the DASCTK value = 0.004 ppm; and, assuming a 0.012 background time or 83.3 background slices per second, then (83.3 * 0.004) = 0.33 ppm/sec; and therefore, a 0.5 ppm dashpot will last 1.5 seconds. ..Typical value - 0.004 ppm.

- DASMPH = Minimum VSBAR for declutch Daspot Clip, mph.
- DASMHYST = Hysteresis for DASMPH, mph.
- DASMIN = Minimum Daspot Clip for declutch, ppm.
- DELTA = Closed throttle/Part Throttle breakpoint value above RATCH.
- DNDSUP = Flag used to delay Strategy response to PRNDL change. If Change occurs, then DNDSUP is set equal to NDSFLG.
- ENGCYL = Number of PIPs per engine revolution; or number of cylinders/2.
- FAMINC = FAM increment/decrement when entering FAM region, lb/min.
- FMMDSD = Failure Mode Management default desired RPM.
- FN884(TCSTRT) = ISC Duty Cycle in Crank, deg.
- MINMPH = Minimum speed to enter C/L RPM control.

- MINMPH applies to systems having VSS only. Resolution of the VSS (3 mph) makes it undesirable at this time to remove the lockout logic. Typical value - 0.5 mph.

- RPMCTL = Deadband above desired Idle RPM for recognition of Normal Closed Loop Idle.

- Added to DSDRPM. The total defines the engine speed threshold below which entry into C/L RPM control is allowed. This value should be reasonably small to avoid inadvertent entry into C/L ISC. ..Typical value - 90 RPM.

- ISCTM = Time interval over which the rate of change in engine speed is evaluated.

- Value should be small enough to avoid prolonged speed hang-ups if the ISC system were locked out of C/L speed control, but not too short such that the rate of speed change check becomes meaningless. ..Typical value - 4 sec.

- NDIF = The deviation in engine speed allowed over the ISCTM specified time interval. NDIF values too small could lock the ISC system out of C/L speed control indefinitely. Values too large invalidate the check. Typical value - 32 RPM.

- LOWLOD = LOWLOD is a key parameter which is engine specific. Selected value must differentiate between deceleration and idle conditions over the expected range of operating conditions.

- ACLOD = An adder to LOWLOD when A/C is on.

- ACLOD should be based on observed differences between A/C on & A/C off idle LOAD readings. ..Typical value - 2" Hg (engine specific parameter).

- DELRAT = Throttle position adder to RATCH. Should be set equal to DELTA + HYSTS (See throttle mode select logic). ..Typical value - 15 counts.

- FMMISC = Default Duty cycle to ISC, fraction.

- NDDELT = Time before N/D, D/N switch registers.

- TRLOAD = Transmission Load.
  - 0 = Manual Transmission, no clutch or gerar switches, forced neutral state (NDSFLG = 0).
  - 1 = Manual Transmission, no clutch or gear switch.
  - 2 = Manual Transmission, one clutch or gear switch.
  - 3 = Manual Transmission, both clutch and gear switches.
  - 4 = Auto Transmission, non-electronic, neutral drive switch.
  - 5 = Auto Transmission, non-electronic, neutral pressure switch, (AXOD).
  - 6 = Auto Transmission, electronic, PRNDL sensor - park, reverse, neutral, overdrive, manual 1, manual 2.

ISC MODE SELECT

This section describes the mode select logic for the air bypass idle speed control system. There are basically four distinct modes in which the ISC system functions; however, two modes: Closed Loop RPM and Lock-out of Closed Loop RPM, are identical with respect to actual Idle Speed Control. A flag is used to identify the three primary ISC modes for both calibrator convenience and required interaction with fuel control strategy.

- ISCFLG = -1 DASHPOT CONTROL (Note: Cal. console will show 255).
- ISCFLG = 0 DASHPOT PRE-POSITION.
- ISCFLG = 1 CLOSED LOOP RPM CONTROL.
- ISCFLG = 2 CLOSED LOOP RPM CONTROL (Lock-out entry to RPM control).

-ENGINE CRANK MODE

Entry/exit conditions for this mode are defined in the engine mode select logic of the strategy book. In engine crank mode, the ISC duty cycle (ISDTY) is a function of temperature at start, TCSTRT. If the time between PIP signals exceeds two seconds, it is assumed that the operator is not cranking and the duty cycle is set to 0%.

-DASHPOT PRE-POSITION MODE (ISCFLG = 0)

In engine run/underspeed mode and when operating at part or wide open throttle, the ISC system is placed in dashpot pre-position mode. In this mode the ISC duty cycle is incremented a calibratible amount in anticipation of a required dashpot action. Proper dashpot operation is essential on systems having speed density fuel controls in order to avoid tip-in/tip-out stalls and HC (Hydrocarbon) spiking on decels.

-DASHPOT MODE (ISCFLG = -1)

In engine run/underspeed mode and having just transitioned from part to closed throttle, the system is placed in ISC dashpot control mode. The length of time the ISC system will remain in dashpot control is both hardware/strategy dependent (some applications have VSS; some manual transmission applications have gear and clutch switches) and calibration dependent. Regardless of the length of time required to enter RPM control, as long as closed throttle operation is maintained the amount of airflow specified by the dashpot pre-position (see dashpot pre-position logic) is decremented at a constant rate until exhausted (until DASPOT = 0).

-CLOSED LOOP RPM CONTROL (ISCFLG = 1 OR 2) NORMAL CLOSED LOOP RPM CONROL (ISCFLG = 1)

For normal entry into Closed Loop (C/L) RPM control, the following conditions must be satisfied:

. If VSS hardware used it must indicate a speed less than MINMPH.
. If a manual trans. with gear/clutch switches, must indicate neutral.

- Note: Although the system can provide acceptable function without the above-mentioned hardware, either item will increase reliability in production. The vehicle speed sensor has calibration benefits outside of ISC (lean Cruise control, etc.) and should be considered when specifying system assumptions for future applications utilizing ISC.

. Regardless whether the above hardware is used, normal entry into RPM control requires that actual engine speed be less than or equal to (DSDRPM + RPMCTL) and that throttle position be less than or equal to (RATCH + DELRAT).

-DASHPOT LOCKOUT OF RPM CONTROL (ISCFLG = 2)

The following discussion will attempt to describe entry into C/L RPM control through the lock-out logic (ISCFLG = 2).

In a normal deceleration the dashpot bleed time will be short relative to the vehicle coastdown time. As soon as engine speed drops low enough, the ISC system should enter RPM control. However, due to hysteresis in the bypass valve, overspecification of idle airflow requirements prior to adaptive ISC learning, and/or ISC learning in an unusually high state of engine load (400 psi A/C head pressure, etc.), the ISC actuator may pass too much air at the specified idle duty cycle to allow normal entry in RPM control. When this condition occurs the system will remain in dashpot control until it can recognize that it should, in fact, be in RPM control.

CALIBRATION HINTS:

This task is easy should you have a VSS or a manual calibration with gear/clutch switches. If this hardware is not present, then it is difficult to differentiate between a constant deceleration (as in a coast down a mountain) and a true locked-out of Idle condition. Most of the logic in the Dashpot and RPM lockout Mode Selection deals with recognition of distinguishing features of each.

To differentiate between deceleration and idle, the rate of change in RPM is first evaluated over a calibrated period of time (ISCTM). If the speed has remained within a specified deadband (NDIF) for this time period, a second check is performed to compare LOAD with a calibrated LOAD value (LOWLOD for A/C off; LOWLOD + ACLOD for A/C on). The assumption is that all idle LOAD values, (including green engine, altitude effects, etc.) will be greater than this calibration parameter; and all true deceleration conditions, including the same variabilities, will yield lower LOAD. To avoid incorrect interpretation of the LOAD value, great care must be taken in selecting the correct LOWLOD value.

If the ISC system were locked in dashpot control and both the rate of engine speed change and LOAD criteria were satisfied, the strategy would then be forced into C/L RPM control with ISCFLG indicating 2. This state would be present until the speed fell below the normal entry point. The adaptive ISC would learn the required correction, assuming sufficient time at idle, and subsequent dashpot to RPM control transitions should follow a normal entry path.

ISC MODE SELECT

```
CRKFLG = 1 -------------|              | Set DSTPBR = RATCH
 (in crank mode)        |              |  (set dashpot filtered TP
                        |AND ----------|   to RATCH)
TSLPIP >OR= 2 sec. -----|              | Set SPKMUL = 0.99
 (no PIPs yet or stall)                | Set ISCDTY = 0
                                       |  (ISC duty cycle = 0%)
                                       |
                                       | --- ELSE ---
                                       |
                                       | Set SPKMUL = 0.99
CRKFLG = 1 ----------------------------| Set DSTPBR = RATCH
 (in crank mode)                       | Set ISCDTY = FN884(TCSTRT)
                                       |
                                       | --- ELSE ---
MFMFLG = 1 -------------|              |
                        |AND ----------| Set DSDRPM = FMMDSD
TFMFLG = 1 -------------|              | Set ISCDTY = FMMISC
                                       | Set SPKMUL = 0.99
                                       |
                                       | --- ELSE ---
                                       |
                                       | GO TO DSD_RPM
                                       | (calculate desired RPM and
                                       |  base airflow requirements)


VSBAR > DASMPH + DASMHYST -------|S Q --| SET FLG_DASMNQ = 1
                                 |      | (prepare to add dashpot
VSBAR <OR= DASMPH ---------------|C     |  to prevent declutch stall)
                                        |
                                        | --- ELSE ---
                                        |
                                        | SET FLG_DASMNQ = 0
```

IDLE SPEED CONTROL - MODE SELECT - GUFA

PEDD-PTOPE, FoMoCo, PROPRIETARY & CONFIDENTIAL

```
APT = 0 OR 1 --------------------------| Enter Dashpot Preposition
 (not closed throttle - dashpot        | Set ISCFLG = 0
  pre-position mode)                   | NLAST = N (Save last RPM
                                       |   value)
                                       | ISCTMR = 0 (Reset RPM
                                       |  sampling timer)
                                       | SPKMUL = 0.996
                                       |
                                       | --- ELSE ---
                                       |
                                       | Check Other ISC Modes
```

RPM CONTROL MODE (ISCFLG = 1)

```
TRLOAD NOT= 3 ---------|
 (auto trans or manual |
  trans w/o both       |
  switches)            |
                       |OR --|
TRLOAD = 3 ------|     |     |
 (manual trans   |AND -|     |
  with both      |           |
  switches)      |           |
                 |           |
DNDSUP = 0 ------|           |
 (In Neutral)                |AND -|
                             |     |
N <OR= DSDRPM + RPMCTL ------|     |
 (RPM within control range)  |     |
                             |     |
DASPOT = 0 ------------------|     |
                             |     |OR -| Set ISCFLG = 1
VSBAR <OR= MINMPH -----------|     |    | (RPM control mode)
 (vehicle speed                    |    |
  almost zero)                     |    | (RPM within control
                                   |    | range and TP near
RUNNING = 1 -----------------|     |    | closed throttle)
 (In Running Self-Test)      |     |    |
                             |AND -|
DASPOT = 0 ------------------|
```

RPM LOCKOUT MODE (ISCFLG = 2)

```
VSBAR <OR= MINMPH -------------------------------|
 (vehicle speed almost zero)                     |
                                                 |
DASPOT = 0 --------------------------------------|
                                                 |
N > DSDRPM + RPMCTL -----------------------------|
 (RPM too high for RPM control)                  |
                                                 |
ISCFLG = -1 OR 0 ------------|                   |
 (last mode was dashpot      |                   |
  or pre-position)           |                   |
                             |AND ---|           |
ISCTMR >OR= ISCTM -----------|       |OR --------|
 (OK to sample RPM)          |       |           |
                             |       |           |AND -|Set ISCFLG=2
|NLAST-N| < NDIF ------------|       |           |     | (RPM LOCKOUT
 (RPM indicates steady state)        |           |     |  MODE)
                                     |           |     | (RPM is steady
ISCFLG = 1 OR 2 ---------------------|           |     | state, LOAD
 (last mode was RPM                              |     | indicates idle
  control or lockout)                            |     | TP near closed
                                                 |     | throttle, but
TRLOAD >OR= 3 ------------|                      |     | rpm is too high)
 (auto trans or man. with |                      |     |
  both switches)          |AND -|                |
                          |     |                |
DNDSUP = 1 ---------------|     |                |
 (in drive,in gear)             |OR -|           |
                                |    |           |
TRLOAD < 3 ---------------------|    |           |
 (manual w/o both switches)          |           |
                                     |           |
ACCFLG = 1 ---------------|          |           |
 (A/C clutch engaged)     |          |AND -|     |
                          |AND -|    |     |     |
LOAD >OR= LOWLOD          |     |    |     |     |
 + ACLOD -----------------|     |    |     |     |
 (LOAD near idle)               |    |     |     |
                                |OR -|     |     |
ACCFLG = 0 ---------------|     |          |OR --|
 (A/C off)                |     |          |
                          |AND -|          |
LOAD >OR= LOWLOD ---------|                |
 (LOAD near idle)                          |
                                           |
TRLOAD >OR= 3 -----------------------|     |
 (auto trans or manual               |     |
  with both switches)                |AND -|
                                     |
DNDSUP = 0 --------------------------|
 (in neutral)
```

DASHPOT MODE (ISCFLG = -1)

```
VSBAR > MINMPH ------------------|
 (vehicle speed high)            |
                                 |
DASPOT > 0 ----------------------|
                                 |
TRLOAD = 3 -------------|        |
 (Manual Trans with     |        |       |
  both switches)        |AND----|        | Set ISCFLG = -1
                        |        |       | (dashpot mode)
DNDSUP = 1 -------------|        |       |
 (in gear)                       |       |
                                 |       |
TRLOAD NOT= 3 -----------|       |OR ----| Set SPKMUL = FN839
 (not manual trans       |       |       | (spark feedback)
  with both switches)    |       |       |
                         |       |       | (Dashpot not bled
N > DSDRPM + RPMCTL -----|AND --|        |  down, not OK to
 (RPM too high for RPM   |               |  sample RPM)
  control)               |               |
                         |               |
ISCFLG = -1 OR 0 --------|               |
 (last mode was dashpot  |               |
  or pre-position)       |               |
                         |               |
ISCTMR < ISCTM ----------|               |
 (Not OK to                              |
   sample RPM)                           |
                                         |  --- ELSE ---
```

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```
VSBAR <OR= MINMPH --------------|       |
 (vehicle speed almost zero)    |       |
                                |       |
DASPOT = 0 ---------------------|       |
                                |       |
TRLOAD = 3 -----|               |       |
 (manual with   |               |       |
  both switches)|AND ---|       |       |
                |       |       |       |
DNDSUP = 0 -----|       |OR ----|       |
 (in neutral)           |       |       |
                        |       |       |
TRLOAD NOT= 3 ----------|       |       |
 (not manual with both          |AND ---| Set ISCFLG = -1
  switches)                     |       | (dashpot mode)
                                |       |
N > DSDRPM + RPMCTL ------------|       | Set SPKMUL = FN839
 (RPM too high for RPM control) |       | (spark feedback)
                                |       |
ISCFLG = -1 OR 0 ---------------|       | Set NLAST = N
 (last mode was dashpot or      |       | Set ISCTMR = 0
  pre-position)                 |       | (continue RPM check)
                                |       |
DASPOT = 0 ---------------------|       |
 (Dashpot has bled down)        |       | (Dashpot has bled down, but
                                |       |  RPM indicates decel)
ISCTMR >OR= ISCTM --------------|       |
 (OK to sample RPM)             |       |
                                |       | --- ELSE ---
|NLAST - N| > NDIF -------------|       |
 (RPM Indicates Decel)
```

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```
VSBAR <OR= MINMPH ---------------|       |
 (vehicle speed almost zero)     |       |
                                 |       |
DASPOT = 0 ----------------------|       |
                                 |       |
TRLOAD = 3 ---------|            |       |
 (manual trans with |AND -|      |       |
  both switches)    |     |      |       |
                    |     |OR ---|       |
DNDSUP = 0 ---------|     |      |       |
 (in neutral)             |      |       |
                          |      |       |
TRLOAD NOT= 3 ------------|      |       |
 (not manual with both           |       |
  switches)                      |       |
                                 |       |
N > DSDRPM + RPMCTL -------------|       |
 (RPM too high for RPM control)  |       |
                                 |       |
ISCFLG = -1 OR 0 ---|            |       |
 (last mode was     |            |       |
 dashpot or pre-pos)|            |       |
                    |AND -|      |       | Set ISCFLG = -1
ISCTMR >OR= ISCTM --|     |      |       |  (dashpot mode)
 (due to sample RPM)|     |OR ---|AND ---|
                    |     |      |       | Set NLAST = N
|NLAST-N| <OR=NDIF -|     |      |       | Set ISCTMR = 0
 (RPM indicates           |      |       |  (continue RPM check)
  steady state)           |      |       |
                          |      |       |  (Dashpot has bled down,
ISCFLG = 1 OR 2 ----------|      |       |    RPM is steady state
 (last mode was RPM              |       |    but LOAD indicates
  control or lockout)            |       |    decel)
```

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```
TRLOAD >OR= 3 --|                |       |
 (auto trans or |                |       |
  man. with     |AND -|          |       |
  both switches |     |          |       |
                |     |OR -|     |       |
DNDSUP = 1 -----|     |    |     |       |
 (In Drive, in gear)  |    |     |       |
                      |    |     |       |
TRLOAD < 3 -----------|    |     |       |
 (manual w/o both          |     |       |
  switches)                |     |       |
                           |     |       |
ACCFLG = 1 ----|           |AND -|       |
 (A/C clutch   |AND -|     |             |
  engaged)     |     |     |             |
               |     |     |             |
LOAD <OR=      |     |     |             |
LOWLOD+ACLOD --|     |     |             |
 (decel LOAD)        |OR --|             |
                     |                   |
ACCFLG = 0 ----|     |                   |
 (A/C off)     |     |                   |
               |AND -|                   |
LOAD < LOWLOD -|                         |
 (LOAD indicates decel)                  |
                                         |
```

DSTPBR CALCULATION

The DSTPBR calculation is a time-dependent rolling average filter of throttle position. It is updated once per background loop while in RUN or UNDERSPEED mode. The two time constants, TCDASU and TCDASD are calibratible. TCDASU is used when DSTPBR is filtering UP to TP. TCDASD is used to filter DSTPBR DOWN to TP.

```
TP > DSTPBR ------------------| DSTPBR = UROLAV (TP,TCDASU)
 (TP increasing)              |
                              | (Filter TP w/increasing TP)
                              |
                              | --- ELSE ---
                              |
                              | DSTPBR = UROLAV (TP,TCDASD)
                              |
                              | (Filter TP w/decreasing TP)
```

TCDASU = Time constant used when TP is greater than the filtered TP value (TP > DSTPBR). The smaller the time constant the more rapidly pre-position airflow will be available to respond to tip in/tip out actions. Fast response can also be obtained by use of the offset value DASPTO without the potential runaway feel that may come with too fast a time constant/airflow gain (DASPTK) combination. ..Typical value - 0.49.

TCDASD = Time constant used when TP is less than or equal to the filtered TP value (TP <OR= DSTPBR). Should be calibrated such that part throttle backouts, where closed throttle is not entered, do not exhibit a run-on feel. Too small a time constant can have the effect of greatly reducing dashpot airflow prior to entry into dashpot control. ..Typical value - 0.93.

DASPOT CALCULATION

Logic controlling the dashpot pre-position airflow is intended to increase the ISC duty cycle during part/WOT operation. Strategy determines the rate at which ISC valve flow increases/decreases in part/WOT operation, as well as the maximum allowed pre-position airflow. Adequate pre-position airflow (DASPOT) is essential prior to entering the dashpot control mode in order to avoid HC (Hydrocarbon) spiking and/or deceleration stalls. The calculated pre-position airflow increment is added to an adaptively-corrected idle flow requirement (DESMAF) prior to output of the ISC duty cycle. Pre-position airflow (DASPOT) is a function of the difference between a filtered throttle position (DSTPBR) and a throttle position equal to the Closed Throttle breakpoint (RATCH + DELHYS). This value is clipped to zero as a minimum, if this difference becomes a negative value. DELHYS should be set equal to DELTA + HYSTS (Closed Throttle breakpoint). DASPOT can be clipped to DASMIN as a minimum if vehicle speed is high enough to prepare for declutch.

During Closed throttle mode, the DASPOT airflow is "bled off" by decrementing it. This action smooths the transition into RPM control by gradually eliminating the DASHPOT contribution to the idle airflow, DESMAF. The bleed rate is determined by FN879, unless clipped to DASMIN. When vehicle speed falls below DASMPH, normal bleed off will resume.

```
APT = -1 --------------------| Bleed off DASPOT
 (Closed throttle -          |
  determine ISC mode)        | Set DASPOT = DASPOT - FN879
                             |  (Bleed down dashpot)
                             | Clip DASPOT to 0 as minimum
                             | Continue through the ISC Mode
                             |  select logic
                             |
                             | --- ELSE ---
                             |
                             | Filter DASPOT to Preposition
                             | Idle speed airflow for next
                             | decel.
                             | DASPOT = [DASPTK * (DSTPBR
                             |  - RATCH + DELHYS)] + DASPTO
                             | Clip DASPOT at FN882(N) as
                             |  maximum
                             | (Clip (DSTPBR-RATCH+DELHYS) to
                             |  zero if negative.)

FLG_DASMNQ = 1 ---------------| Clip DASPOT to DASMIN as a minimum
                              | (add additional minimum airflow
                              |  to prevent declutch stall)
                              |
                              | --- ELSE ---
                              |
                              | Allow normal computation and bleed
                              | down of dashpot
```

The DASPOT value is adjusted as TP changes to provide the desired dashpot action to decelerations as initiated over the range of possible engine operating conditions. Separate filter constants are available (TCDASU/TCDASD) to control the response of DSTPBR as described above.

The following calibration constants control operation of the dashpot pre-position strategy:

DASPTO = An offset term applied to the DASPOT calculation. Insures at least some dashpot airflow on rapid tip-in/tip-outs. ..Typical value - 0.10 lbs/min.

DASPTK = Gain associated with the desired DASPOT airflow. To calibrate this value first determine the throttle position above RATCH at which maximum DASPOT airflow is desired. Subtract DASPTO from FN882 and divide the result by the throttle delta between RATCH and this maximum dashpot airflow to determine the DASPTK value. ..Typical value - 0.002 Lbs per min/TP count.

FN879 = A background driven decrement to the dashpot preposition airflow register (DASPOT) as a function of DASPOT. FN879 can be calibrated to achieve an exponentially decaying dashpot which is useful in decaying the large DASPOT values used to control over-rich tip-out conditions. Typical vaues - (0, 0.001) (.1, .002) (.3, .006) (.75, .05) (2.00, .10)

FN882 = Maximum allowed dashpot pre-position airflow. DASPOT calculation clipped at this value. ..Typical value - 100% of base idle airflow requirement.

DESIRED RPM CALCULATION

OVERVIEW

This section describes the ISC logic designed to perform the DSDRPM calculation each background pass

- Calculate the desired engine speed: The desired engine speed (DSDRPM) is used to determine the correct ISC mode; used as the control speed for closed loop RPM ISC; used by the filtered air mass logic to determine entry/exit conditions for filtering.

  . Desired engine speed (DSDRPM = [base desired speed (NUBASE for neutral DRBASE for drive) + RPM adder (DNAC) if A/C is on + RPM adder (DNPOWS) if a power steering pressure switch is used and power steering load is high + ECT and ACT and start-up modulator functions (FN825A, FN825B & FN826)].

- Calculate the initial idle airflow requirement: An open loop prediction of idle airflow required vs. the various requested idle operating conditions is calculated as follows:

  . Desired idle airflow (DESMAF) = [base desired airflow (FN875N for neutral; FN875D for drive)) * an airflow modulator as a function of ATMR3 and ECT (FN1861)] + discrete airflow increments for A/C (ACPPM) and power steering (PSPPM) if either load is present.

- Provide a feed foward mechanism for fuel control: The filtered air mass value (FAM) is incremented a calibrated amount when unloaded to loaded engine transitions are noted to avoid speed sags related to manifold filling delays.

  . Neutral to drive change; FAM = (FAM + NDPPM)
  . Drive to Neutral change, FAM = FAM - DNPPM
  . A/C off to on change; FAM = (FAM + ACPPM)
  . Power steering switch off to on; FAM = (FAM + PSPPM)

- Control a flag (ISFLAG) which indicates the engine load state at idle: Flag tracks state transitions at idle and is used to:

  . Point to the correct adaptive fuel cell at idle (LTMTBnrc). The first four cells of the first column in the adaptive fuel table are dedicated to idle operation eg. (ISFLAG = 0 points to adaptive cell Row 8/Col. 0; ISFLAG = 1 points to Row 8/Col. 1; etc).

  . Point to a corresponding adaptive ISC correction (ISCKAMn). Each idle load state has a unique correction cell which indicates the increment or decrement to a predicted airflow necessary to control to the desired engine speed.

. Track changes in the load state at idle. When state changes are noted compensating actions involving fuel and ISC may be made.

DEFINITIONS

INPUTS

Registers:

- ACCTMR = A/C state transition timer. Timer is reset to 0 on every A/C state change.
- ATMR1 = Timer which counts up in run/underspeed mode.
- ATMR3 = Timer which counts up in run mode. (Reset to 0 only at powerup).
- DSDRPM = Desired engine speed. See overview section for definition of the various uses of this register.
- DESMAF = The desired airflow necessary to operate at a specified idle condition. This register is fed with the base calibrated airflow requirements in the desired RPM calculation routine each pass through the background. It is later modified in the ISC duty cycle output routine to account for the C/L ISC corrections (IPSIBR & ISCKAM) and any dashpot component (DASPOT). DESMAF is then used in calculating the input to the ISC transfer function (FN800).

- DESNLO = High cam portion of the DSDRPM register. Used to filter DSDRPM. DESNLO + NUBASE or DRBASE = DSDRPM. TCDESN is the time constant.

Bit Flags:

- ACCFLG = A/C engaged flag: 1 -> A/C engaged; 0 -> A/C disengaged.
- ACIFLG = A/C engagement impending flag: 1 -> A/C about to engage - adjust airflow and fuel immediately; 0 -> A/C not about to engage.
- DNDSUP = Delayed neutral/drive flag: 0 -> in neutral, no load; 1 -> in drive, loaded.
- HWFLAG = Heated windshield flag: 0 -> heated windshield off; 1 -> heated windshield on.
- HWFLGL = Latched heated windshield flag: 0 -> heated windshield has never been on; 1 -> heated windshield has been on at least once since start-up.
- POWSFG = Flag used to indicate that power steering load is high: 1 -> power steering on.
- PSPSHP = Flag used to indicate if Power Steering Pressure Switch is present; 1 -> switch used; 0 = no switch.
- PTSCR = Part throttle since crank mode flag: 0 -> driver has not tipped in since start; 1 -> driver tipped in, kick down desired RPM.

- RUNNING = Flag which indicates that idle speed is being controlled by Engine Running VIP: 1 -> in Engine Running VIP; 0 -> not in Engine Running VIP.

Calibration Constants:

- ACCPM = Airflow increment required with A/C on. Value is used to increment both the desired flow through the ISC actuator (account for increased load) and the filtered air mass - FAM. ..Typical value - 0.15 ppm

- BZZRPM = RPM adder intended to provide a short increase in RPM for engine cleanout on start-up. The buzz-up function is not affected by the part throttle kickdown until BZZTM expires. ..Typical value - 300 RPM.
- BZZTM = Time for which BZZRPM adder is in effect. ..Typical value - 3 seconds.
- DACTM = Time to maintain A/C rpm adder after A/C has been disengaged. Used to prevent RPM changes when A/C cycles rapidly. ..Typical value - 30 sec.
- DNAC = RPM increment requested with the A/C on. ..Typical value - 75 RPM.
- DNPOWS = If a power steering pressure switch is used, this parameter increments the desired RPM when an increased load is sensed. ..Typical value - 75 RPM.
- DNPPM = Feed forward mechanism for fuel control. Decrements filtered air mass for drive/neutral transition.
- DRBASE = Base desired engine speed in drive.
- FN825A(ECT) = RPM adder as a function of ECT. Provides base Hi-Cam function.
- FN825B(ACT) = RPM adder as a function of ACT. Provides higher idle at very low ambients.
- FN826A(TCSTRT) = RPM adder as a function of ECT at start. This adder is deleted when either the first part throttle transition since exiting crank is observed or the time since start exceeds a calibrated value (TKDTM).
- FN875D(DSDRPM) = Airflow required for closed throttle operation in drive. Input to this function is absolute DSDRPM.

** Airflow requirements must be measured as accurately as possible over a representative population of vehicles. Data should be collected over a range of anticipated desired speeds on a stabilized engine for both neutral and drive (a temperature modulator (FN1861) will automatically adjust calibrated airflow to account for increased requirements at low ambients).

Data can be collected using two methods. A hot wire can be remotely mounted to measure airflow directly over the desired speed range. Equipment is available at APTL to perform this procedure. A second approach is to use adaptive fuel in combination with the calculated speed density air mass (AM) to infer the true airflow. In this case the engine must be stabilized at each speed and remain in C/L fuel control long enough for LAMBSE to be driven into a deadband around 1.0 by the adaptive fuel strategy. At this point, readings can be taken of:

- CALCULATED AIR MASS (AM)
- ADAPTIVE FUEL CORRECTION (KAMREF)
- IDLE SPEED DUTY CYCLE (ISCDTY)

The inferred airflow will equal (AM * KAMREF). By knowing the leakage due to the throttle body, PCV, ISC actuator and gaskets, the above obtained ISC duty cycle information can be used to derive/check the ISC transfer function accurately. Actual airflow (AM * KAMREF) minus the total leakage (ITHBMA - see section on ISC duty cycle output) should represent the ISC valve flow for the recorded duty cycle.

- FN875N(DSDRPM) = Airflow required for closed throttle operation in neutral. Input to this function is absolute DSDRPM.

- FN880(IDLTMR) = DSDRPM adder vs. time at idle (IDLTMR). Used as part of the inspection/maintenance strategy. Rember that any RPM above base idle disables ISCKAM adaptive learning via HCAMFG. Also, IDLTMR requires RPM to be below IDLRPM, an absolute parameter which is not tied to DSDRPM. Too high an RPM adder in FN880 could disable IDLTMR.

- FN1861(ECT,ATMR3) = Airflow multiplier vs. ECT and ATMR3. Used to compensate for additional friction at start-up as a function of time in addition to normal ECT compensation. Increased friction effects tend to go away after about one minute. Inputs are ECT normalizing by FN020C, ATMR3 normalizing by FN018B.

- HWPPM = Airflow increment required when heated windshield load is sensed, ppm.

- HWRPM = Minimum neutral idle speed when heated windshield is on (first time on only). ..Typical value - 1400.

- ISCLPD = A clip on the maximum desired speed that can be requested with vehicle in drive. Usually the GPAS defined speed allowed at 0.2 mi. on a cold start. ..Typical value - 1100 RPM.

- NDPPM = Expected change in airflow between engine in neutral and in drive. Used as a feed forward mechanism for fuel control (increments the filtered air mass on neutral/drive transition). ..Typical value - 0.15 ppm. NUBASE = Base desired engine speed in neutral.

- PSPPM = Airflow increment required when power steering load is sensed. Value increments both the desired flow through the ISC actuator (account for increased speed/load) and the filtered air mass - FAM. ..Typical value - 0.10 ppm.

- RVIPRPM = Desired RPM controlled by Engine Running VIP strategy.

- TCDESN = Time constant for DESNLO, secs.

- TKDTM = Time since start after which FN826A is eliminated as a desired RPM adder. ..Typical value - 20 seconds.

- TRLOAD = Transmission Load. 0 = Manual Transmission, no clutch or gerar switches, forced neutral state (NDSFLG = 0).

1 = Manual Transmission, no clutch or gear switch.
2 = Manual Transmission, one clutch or gear switch.
3 = Manual Transmission, both clutch and gear switches.
4 = Auto Transmission, non-electronic, neutral drive switch.
5 = Auto Transmission, non-electronic, neutral pressure switch, (AXOD).
6 = Auto Transmission, electronic, PRNDL sensor-park, reverse, neutral, overdrive, manual 1, manual 2.

OUTPUTS

Registers:

- DSDRPM = See INPUTS above.
- DESMAF = See INPUTS above.
- DESNLO = See INPUTS above.

Bit Flags:

- HCAMFG = Flag indicating the completion of Hi-Cam. HCAMFG = 0 indicates no desired engine speed adder exists; HCAMFG = 1 indicates an RPM adder above base idle is present. Flag is used in the ISC adaptive update routine to disable updates when HCAMFG = 1.

PROCESS

DSDRPM AND PREDICTED DESMAF CALCULATION

The desired idle RPM, DSDRPM, calculation is divided into three parts:

A) START-UP HI-CAM,
B) NEUTRAL/DRIVE, and
C) ACCESSORY LOAD.

The predicted desired airflow, DESMAF is also calculated based on transmission and accessory load. The Hi-Cam adjustments are the electronic equivalent of an electric choke. The engine idles at a higher RPM to compensate for the friction due to higher viscosity of cold oil, as well as to warm up the catalyst and EGO sensor.

A) START-UP HI-CAM

```
RUNNING = 1 ------------------------| DSDRPM = RVIPRPM - NUBASE
 (in VIP)                           | FILTER CONSTANT = VKDESN
                                    |
                                    | --- ELSE ---
ATMR1 < BZZTM ----------------|     |
 (time for engine cleanout)   |     |
                              |AND -| DSDRPM = FN825A(ECT) + FN825B(ACT)
                              |     |         + FN826A(TCSTRT) + BZZRPM
                              |     |         + FN880(CTNTMR)
ATMR1 < TKDTM ----------------|     | (start-up kicker +
 (time for RPM kickdown)            |  Hi-Cam + Buzz Up RPM)
                                    |
                                    |--- ELSE ---
PTSCR = 0 --------------------|     |
 (no driver kickdown)         |     |
                              |AND -| DSDRPM = FN825A(ECT) + FN825B(ACT)
ATMR1 < TKDTM ----------------|     |         + FN826A(TCSTRT)
 (time for RPM kickdown)            |         + FN880(CTNTMR)
                                    |  (start-up kicker + Hi-Cam RPM)
                                    |
                                    |--- ELSE ---
                                    |
ATMR1 < BZZTM ----------------------| DSDRPM = FN825A(ECT) + FN825B(ACT)
 (time for engine cleanout)         |         + BZZRPM + FN880(CTNTMR)
                                    |  (Hi-Cam + Buzz Up RPM)
                                    |
                                    |--- ELSE ---
                                    |
                                    | DSDRPM = FN825A(ECT) + FN825B(ACT)
                                    |         + FN880(CTNTMR)
                                    |  (Base Hi-Cam desired RPM increment)
```

NOTE: FN880(CTNTMR) is added to DSDRPM only when CTNFLG = 1. This means that FN880 is never used in drive even though CTNTMR = 0.

HEATED WINDSHIELD MINIMUM CLIP

```
HWFLAG = 1 ------|
                 |
HWFLGL = 1 ------|AND -----| Clip DSDRPM at (HWRPM - NUBASE)
                 |         | as a minimum
DNDSUP = 0 ------|

(Heated Windshield is on for the first time)
```

DESIRED RPM FILTER

```
DESNLO > DSDRPM -------------| Set DESNLO = ROLAV (DSDRPM,TCDESN)
 (filtered RPM > actual RPM  |
                             |  (filter RPM when RPM is dropping)
                             |
                             | --- ELSE ---
                             |
                             | Set DESNLO = DSDRPM
                                (do not filter when RPM is increasing)
```

"HI-CAM FLAG CHECK"

```
DSDRPM = 0 -------------------------| Set HCAMFG = 0
 (Hi-Cam desired RPM = 0)           | (not on Hi-Cam)
                                    |
                                    | --- ELSE ---
                                    |
                                    | Set HCAMFG = 1
                                    |  (on Hi-Cam, this disables the
                                    |   adaptive airflow update)
```

This is the end of the start-up calculation of Desired RPM. Next check for neutral or drive.

B) NEUTRAL/DRIVE

```
TRLOAD <OR= 3 -----|       | NEUTRAL
 (manual trans)    |OR ----| -------
                   |       |
DNDSUP = 0 --------|       | Set DSDRPM = DSDRPM + NUBASE
 (auto trans in neutral)   |
                           |
                           | --- ELSE ---
                           |
                           |
DNDSUP = 1 ----------------| DRIVE
 (auto trans in drive)     | -----
                           | Set DSDRPM = DSDRPM + DRBASE
```

C) ACCESSORY LOAD

1) If A/C is on add A/C adder to desired RPM

```
ACCFLG = 1 -----------|
 (A/C clutch engaged) |
                      |
ACIFLG = 1 -----------|OR --------| Set DSDRPM = DSDRPM + DNAC
 (A/C load impending) |              ( increase RPM for A/C)
                      |
ACCTMR < DACTM -------|
 (delay to turn off A/C adder)
```

2) If power steering load is on then add power sterring adder to desired RPM.

```
PSPSHP = 1 -------------|
                        |AND ---| Set DSDRPM = DSDRPM + DNPOWS
POWSFG = 1 -------------|       |  (power steering RPM adder)
 (power steering on)            | Set HCAMFG = 1
                                | (Disable Adaptive Airflow Update)
```

GPAS CLIP

```
TRLOAD >OR= 4 ----|
 (auto trans)     |AND -----| Clip DSDRPM to ISCLPD
                  |         | as a maximum
DNDSUP = 1 -------|
 (in drive)       |
                  |
ATMR3 > CRKTIM ---|
```

PREDICTED DESMAF CALCULATION

```
TRLOAD <OR= 3 -------|
                     |OR -----| Set DESMAF = FN875N(DSDRPM) *
DNDSUP = 0 ----------|        |             FN1861(ECT,ATMR3)
(auto trans in neutral)       |
                              |
                              | --- ELSE ---
                              |
DNDSUP = 1 -------------------| Set DESMAF = FN875D(DSDRPM) *
 (auto trans in drive)        |             FN1861(ECT,ATMR3)
```

Now check for A/C and power steering adders.

```
ACCFLG = 1 -----------|
 (A/C clutch engaged) |OR -| Set DESMAF = DESMAF + ACPPM
                      |    |  (increase DESMAF for A/C)
ACIFLG = 1 -----------|
 (A/C load impending)

PSPSHP = 1 ----------|
                     |AND ---| Set DESMAF = DESMAF + PSPPM
POWSFG = 1 ----------|       | (increase airflow for P.S.)
 (power steering on)

HWFLAG = 1 ------|
                 |
HWFLGL = 1 ------|AND -----| Set DESMAF = DESMAF + HWPPM
                 |
DNDSUP = 0 ------|
```

(Heated Windshield is on for the first time)

ISFLAG/ISLAST LOGIC

ISLAST reflects the state of ISFLAG on the last program pass. ISFLAG is set according to the following chart:

	AUTO in DRIVE (DNDSUP = 1)	MANUAL TRANSMISSION or AUTO in NEUTRAL (DNDSUP = 0)
A/C off	0	2
A/C on	1	3

By comparing ISFLAG and ISLAST, you can determine if there were any A/C or N/D transitions since the last program pass.

FAM ADJUSTMENTS

OVERVIEW

The Filtered Air Mass, FAM, is adjusted for load transitions at this point as a software convenience. Sections A, B, and C are executed each program pass in order.

DEFINITIONS

INPUTS

Registers:

- BGCNT = Background counter used to pace the filtered AM algorithm. See SAMRAT.
- FAM = Filtered Air Mass.
- IBGPSI = Background counter used to control pacing of the C/L integrator value (IPSIBR).
- ISLAST = Register which tracks the state of engine load from the previous background pass. Used in determing when it is necessary to increment the filtered air mass (FAM) and clip the C/L idle speed integrator to a minimum value.

Bit Flags:

- ACCFLG = A/C engaged flag: 1 -> A/C engaged; 0 -> A/C disengaged.
- ACIFLG = A/C engagement impending flag: 1 -> A/C about to engage - adjust airflow and fuel immediately; 0 -> A/C not about to engage.
- DNDSUP = Delayed neutral/drive flag: 0 -> in neutral, no load; 1 -> in drive loaded.
- POWSFG = Flag used to indicate that power steering load is high: 1 -> power steering on.
- PSFLAG = Flag to indicate last pass value of power steering to check for transitions: 1 -> power steering was on.

Calibration Constants:

- ACPPM = Airflow increment required with A/C on. Value is used to increment both the desired flow through the ISC actuator (account for increased load) and the filtered air mass - FAM. ..Typical value - 0.15 ppm.
- DACPPM = Filtered air mass decrement used when A/C turns off.
- DNPPM = Feed forward mechanism for fuel control. Decrements filtered air mass for drive/neutral transition.

- NDPPM = Expected change in airflow between engine in neutral and in drive. Used as a feed forward mechanism for fuel control (increments the filtered air mass on neutral/drive transition). ..Typical value - 0.15 ppm.

OUTPUTS

Registers:

- FAM = Filtered Air Mass.

Bit Flags:

- PSFLAG = Flag to indicate last pass value of power steering to check for transitions: 1 -> power steering was on.

PROCESS

FAM ADJUSTMENTS

A) NEUTRAL/DRIVE ADJUSTMENTS

```
DNDSUP = 1 --|
 (in drive)  |AND ---------| Set FAM = FAM + NDPPM
             |             |  (immediately increase filtered air mass)
ISLAST > 1 --|             |
 (last pass was neutral)   |--- ELSE ---
                           |
DNDSUP = 0 ---|            |
 (in neutral) |AND --------| Set FAM = FAM - DNPPM
              |               (immediately decrease filtered air mass)
ISLAST < 2 ---|
 (last pass was drive)
```

B) A/C STATE CHANGES

```
ACCFLG = 1 ----------|
 (A/C clutch engaged)|OR -|
                     |    |
ACIFLG = 1 ----------|    |
 (A/C load impending)     |AND -| Set FAM = FAM + ACPPM
                          |     |  (immediately increase filtered air mass)
ISLAST NOT= 1 OR 3 -------|     |
 (A/C on state change)          |--- ELSE ---
                                |
ACIFLG = 0 ---------------|     |
                          |     |
ACCFLG = 0 ---------------|AND -| Set FAM = FAM - DACPPM
 (A/C clutch not engaged) |        (immediately decrease filtered air mass)
                          |
ISLAST NOT= 0 OR 2 -------|
 (A/C off state change)
```

C) POWER STEERING STATE CHANGES

```
POWSFG = 1 ----------|
 (power steering on) |AND -| Set FAM = FAM + PSPPM
                     |     |  (immediately increase FAM)
PSFLAG = 0 ----------|     | Set PSFLAG = 1
 (P.S. on state change)    |  (store current state of POWSFG)
                           | Set IBGPSI = 0
                           | Set BGCNT = 0
```

EXAMPLE OF ANTICIPATORY FAM CHANGES
TO A/C

```
                           -----------------------
                          |                       |
                          |                       |
A3C  OFF -----------------                         ----------
 (Pressure Switch)

        1                   ----------
                           |          |
                           |          |
ACIFLG  0 ----------------- <-IDLCOT-> ----------------------

        ON                             -----------
                                      |           |
                                      |           |
ACCFLG OFF ----------------|--|--|--|-|            ----------

       A/C ON   1 or 3      ----------------------
                           |                      |
                0 or 2     |                      |
ISLAST A/C OFF ------------  | | | | | | | | | | | ------------

                        -->| |<--Background Loop Time

                           |      |
                           V      V

     0.6            ACPPM  |* * *
FAM  0.4 ------------------       *                         * *
     0.2                             * * * * * *  *       *
     0.0                                          |     *
                                                   *****
```

DESIRED IDLE AIRFLOW AND ISC DUTY CYCLE OUTPUT

This section describes the following features of the ISC strategy:

- ISC and fuel responses to state changes at idle: When either the FAM logic has just been entered or a load change at idle has been sensed (ISLAST does not equal ISFLAG), the following actions are taken:

. The C/L RPM integrator (IPSIBR) is clipped to 0 as a minimum value to avoid potential speed dips.

. The pacer for the C/L RPM integrator (IBGPSI) is zero'd to avoid unnecessary reaction by the ISC system.

. The flag tracking the idle load state (ISLAST) is set to the appropriate state for use the next background slice.

In addition to the above, if a load state change is sensed, the fuel control system is in C/L operation, the engine is in closed throttle operation, and the fuel control integrator (LAMBSE1 and LAMBSE2) is greater than 1.0, then LAMBSE1 and LAMBSE2 is reset to 1.0. This action avoids potential lean stall/sag problems should there be significant differences between the degree of maturation of the adaptive fuel cells for the various idle states.

- Closed loop ISC control: C/L RPM control logic is entered as described in the ISC mode selection section. The intent of C/L speed control is to adjust the ISC valve as necessary to provide the correct desired idle speed. This is accomplished through integration of a proportionally derived airflow correction which is added to the predicted airflow requirement (DESMAF). Integration of this correction factor is paced in terms of background loop by a calibratible function (FN860). Depending on the direction of the speed error, and neutal/drive status, separate gains are used to calculate the proportional correction factor used for integration. (KPSIND, KPSINU, KPSIDU, KPSIDD are the gains, defined below) A common function (FN824) is available for gain modulation. The speed error is driven into a calibrated deadband within which integrator updates are disabled. Integrator updates are also disabled when the ISC duty cycle is greater than or equal to 98%.

- ISC duty cycle output; Once the desired mass flow value is finalized, the appropriate duty cycle is calculated and output. The final DESMAF value is calculated as follows:

. DESMAF = [DESMAF + DASPOT + IPSIBR + ISCKAM]

Then DESMAF, initial predicted value, is added to the factors noted above; and the value of ISCKAM is used, where ISFLAG points to the correct adaptive cells. (See discussion on "ISC_KAM update).

The calibrated leakage term (ITHBMA) is subtracted from DESMAF to obtain the actual flow required from the ISC actuator (DEBYMA). This value, clipped at DEBYCP as a minimum allowed actuator airflow, becomes the input to the ISC duty cycle transfer function (FN800). Output from FN800 is the specified ISC duty cycle. The nature of the bypass air solenoid is such that at high manifold vacuum the device flows less air than at idle vacuum levels, assuming a constant duty cycle. To account for this difference, a modulator (FN820B) is available to increment the duty cycle as necessary to hold constant flow.

- In addition, the closed throttle spark can be aggressively modified via SPKMUL (See Ignition Timing chapter for definition and usage). Two unctions, FN841N for neutral, and FN841D for drive, are used based on RPM error, RPMERR.

CALIBRATION CONSTANTS:

The following calibration constants are used in the duty cycle output and C/L RPM control routines.

- RPMDED = Specifies the engine speed deadband within which the C/L RPM integrator is frozen. To be in this zone, the absolute value of the engine speed error cannot exceed RPMDED where the speed error is defined as RPMERR = (DSDRPM - N). ..Typical value - 25 RPM.

- KPSIDU = Gain for underspeed condition in drive (same as KPSINU for neutral).

- VPSINU = VIP gain for underspeed conditions.

- KPSINU = Gain for underspeed condition in neutral. When multiplied by the engine speed error and the gain modulator (FN824), it provides the input for IPSIBR integration. Using the duty cycle vs. RPM information generated for the airflow predictions, FN875N / FN875D (see Desired RPM section), approximate gains can be calculated. On 2.3l OHC EFI Truck calibrations, a 0.01 ppm change in airflow corresponds to an approximate 30 RPM speed-delta. This assumes a transport delay of about 1.25 seconds. If the pacing requested for the C/L integrator is less than the actual transport delay (which it should to have a responsive system), then the gain should be decreased proportionately. Eg., In the case of the 2.3L OHC, (0.01 ppm/30 RPM) = a calculated gain of 0.00033 ppm/RPM: If the desired pacing for underspeed conditions is 0.36 seconds (assume 30 background passes 0.012 sec/pass), then the resultant gain would be [(0.36 / 1.25) * 0.00033] = 0.000095 ppm/RPM. .Typical value - 0.00009 ppm/RPM.

- KPSIND = Gain for overspeed condition in neutral. Used same as KPSINU above. ..Typical value - 0.000075 ppm/RPM.

- VPSIND = VIP gain for overspeed conditions.

- KPSIDD = Gain for overspeed condition in drive (Same as KPSIND in neutral).

- ITHBMA = Throttle body idle mass air flow with throttle plate at idle screw stop and 0% ISC duty cycle.

- PSIBRM = Maximum allowed value for the IPSIBR. Must provide adequate range of authority to correct for anticipated errors in the initial airflow predications. ..Typical value - 0.25 ppm.

- VSIBRM = Maximum allowed value for IPSIBR when in running VIP.

- PSIBRN = Minimum allowed value for IPSIBR. Range is -1.0 to 0.0.

- DEBYCP = Minimum allowed airflow through the ISC actuator.

- VSIBRN = Minimum allowed value for IPSIBR when in running VIP.

- FN860 = Function which paces the integration of the C/L RPM correction. Input to this function is the engine speed error. Typically the integration is paced more rapidly the further under the control speed that the engine speed falls. In overspeed conditions, the pacing is slowed to provide an overdamped response to a torque disturbance at idle. .Typical values

- V860 = VIP calibration parameter which sets pacing intergration of the C/L RPM correction.

RPM ERROR	Pacing (BACKGROUND PASS)
-500	250
-200	150
-125	125
- 25	125
+ 25	45
+ 75	25
+150	15

RPMERR = DSDRPM - N

- FN824(N_BYTE) = Gain multiplier vs. RPMERR (RPMERR = DSDRPM - N) for KPSINU and KPSIND used to vary the response of the proportional correction term in C/L RPM control.

- FN800 = Transfer function for the ISC actuator. Initial values for this function should come directly from flow data provided by fuel systems. Data must be generated at the expected idle vacuum setting for each particular application. Subsequent data generated in the airflow prediction study, as described in the desired RPM section, can be used to fine-tune the transfer function as sufficient numbers of vehicles are sampled.

|

- FN810 = Adder to DEBYMA vs. RPM. This function is similar to a proportional control term. It adds air flow to correct dips in RPM.

- FN820B = ISC duty cycle multiplier vs. LOAD. Used to hold constant actuator airflow on a decel. after a dashpot action is complete.

- FN841D = ISC Spark Multiplier versus RPM Error in Drive. Input = RPMERR in RPM.

- FN841N = ISC Spark Multiplier versus RPM Error in Neutral. Input = RPMERR in RPM.

KEY REGISTERS/FLAGS:

The following registers/flags are used in the duty cycle output and/or C/L RPM control routines.

- DEBYMA_FM = DEBYMA without BP correction, for MAF FMEM, units are lbma/min.

- IBGPSI = Background counter used to control pacing of the C/L integrator value (IPSIBR).

- IPSIBR = Integrated value of the proportional C/L RPM correction.

TOTAL DESMAF CALCULATION and LAMBSE CLIP
(DESMAF and DEBYMA)

```
ISFLAG = ISLAST --------|
 (No Idle Load Change)  |
                        |AND ----------------| Set DESMAF = DESMAF
CTPTFG = 0 -------------|                    | + IPSIBR + DASPOT
(no transition from C.T.)                    |
                                             | --- ELSE ---
                                             |
                                             | Clip IPSIBR to zero
                                             |  as a minimum
                                             |
                                             | DESMAF = DESMAF + IPSIBR
                                             |  + DASPOT
                                             | IBGPSI = 0
                                             | BGCNT = 0
```

ISCKAM QUALIFICATION

```
KAM_ERROR = 0 ------------------| DESMAF = DESMAF + ISCKAM(n)
  (KAM is ok)                   |  n = ISFLAG
```

NOTE: LAMBSE resets are done when:

- entering/exiting FAM region
- load state changes at closed throttle at idle
- open loop to closed loop transition

See the LAMBSE RESET LOGIC in the Closed Loop Fuel section.

ISC DUTY CYCLE CALCULATION
(ISCDTY)

```
ISCFLG = 1 OR 2 -----------|          | Set RPMERR = DSDRPM - N
 (RPM control or lockout)  |          |  (determine RPM error)
                           |AND ------| Set SPKMUL = FN841N
DNDSUP = 0 ----------------|          |  (spark feedback, neutral)
 (neutral)                            | Set IBGPSI = IBGPSI + 1
                                      |  (increment C/L correction
                                      |   pacer)
                                      |
                                      | --- ELSE ---
ISCFLG = 1 OR 2 -----------|          |
                           |AND ------| Set RPMERR = DSDRPM - N
DNDSUP = 1 ----------------|          | Set SPKMUL = FN841D
 (drive)                              | Set IBGPSI = IBGPSI + 1
                                      |
                                      | --- ELSE ---
                                      |
ISCFLG = -1 OR 0 ---------------------| GO TO DEBYMA calculation
 (dashpot or pre-position)
|RPMERR| > RPMDED --------------------| Set ISCTMR = 0
 (RPM not within deadband)            |  (set RPM sampling timer
                                      |   to 0)
                                      |
                                      | --- ELSE ---
                                      |
                                      | GO TO DEBYMA calculation

RUNNING = 0 ----------|
 (normal strategy)    |AND --|
                      |      |
IBGPSI >OR= FN860 ----|      |OR -----| Set IBGPSI = 0
 (OK to correct RPM)         |        |  (reset C/L correction
                             |        |   pacer)
RUNNING = 1 ----------|      |        |
 (in self test)       |      |        |
                      |AND --|        | --- ELSE ---

IBGPSI >OR= V860 -----|               |
                                      | GO TO DEBYMA calculation

N < DSDRPM - RPMCTL ----|
 (RPM is too low)       |
                        |
RUNNING = 0 ------------|AND ---------| GO TO DEBYMA calculation
 (not in VIP)           |
                        |
ISCDTY >OR= 0.98 -------|
 (ISC duty cycle
   already at maximum)
```

```
     RPMERR < 0 --------------------------| Set ISCPSI = "B" *
      (overspeed error)                   |  RPMERR * "F"
                                          |  (determine C/L overspeed
                                          |   air mass correction)
                                          |
                                          | --- ELSE ---
                                          |
     RPMERR >OR= 0 -----------------------| Set ISCPSI = "C" *
                                          |  RPMERR * "F"
                                          |  (determine C/L
                                          |   underspeed air mass
                                          |   correction)
                                          | Set IPSIBR = IPSIBR
                                          |  + ISCPSI
                                          |  (update C/L air mass
                                          |   correction)
                                          |
                                          | Clip IPSIBR to
                                          |  "D" as a maximum
                                          |  "E" as a minimum
                                          |
                                          | GO TO DEBYMA calculation

|    Enter DEBYMA calculation ---| Set DEBYMA = ((DESMAF - ITHBMA) +
|     (calculate corrected,      |  FN810) * (29.92/BP)
|      actual airflow)           | DEBYMA_FM = (DESMAF - ITHBMA) + FN810
                                 | (calculate airflow through
                                 |  the bypass solenoid)
                                 | Clip DEBYMA and DEBYMA_FM
                                 |  at DEBYCP as a minimum
                                 |
                                 | Set ISCDTY = "A" * FN800
                                 |
                                 |  (calculate ISC duty cycle)
                                 | Clip ISCDTY at 1.0 as a
                                 |  maximum
                                 |
                                 | GO TO KAM_UPDATE
                                 |  (update keep alive cells)
     RUNNING = 0 ----------------| "A" = FN820B     "D" = PSIBRM
      (normal strategy)          | "B" = KPSIND     "E" = PSIBRN
                                 | "C" = KPSINU     "F" = FN824(N_BYTE)
                                 |
                                 | --- ELSE ---
                                 |
     RUNNING = 1 ----------------| "A" = V820A      "D" = VSIBRM
      (in self test)             | "B" = VPSIND     "E" = VSIBRN
                                 | "C" = VPSINU     "F" = 1.0
                                 |                  (VIP GAIN MULTIPLIER)
```

This section describes the adaptive ISC update routine. In general, under steady state conditions on a stabilized engine at idle, the adaptive ISC logic will evaluate whether the open loop prediction of airflow requires correction. If a correction factor was applied and IPSIBR has a non-zero value, then adaptive ISC strategy will roll this correction value into KAM and drive the IPSIBR term back to zero. Control of the rate at which the IPSIBR value is driven to zero is calibration dependent.

There are four ISCKAM cells designated for idle corrections. The appropriate cell is pointed to by the flag ISFLAG which tracks the load state at idle. A checksum has also been added, ISKSUM, (see KAM Chapter), the total of the four ISCKAM cells minus the value in ISKSUM must be less than or equal to one during Power Up Sequencing; otherwise, a reinitializing occurs. The following logic must be satisfied to update KAM:

* In RPM control.
* Within the RPM deadband for a calibrated time interval (UPDISC).
* No hi-cam adder present (HCAMFG = 0).
* IBGPSI >OR= UPDATM.

ISCKAM corrections are clipped to the same maximum and minimum limits as the C/L RPM integrator (PSIBRM/PSIBRN). Each time the update criteria are satisfied both IPSIBR and ISCKAM are adjusted one bit (0.00024 ppm) in opposite directions until IPSIBR = 0.

CALIBRATION CONSTANTS

The following calibration constants are used to control the ISCKAM update routine:

- UPDISC = Time that engine speed must be within the specified deadband (RPMDED) prior to KAM update. ..Typical value - 3 seconds.

- UPDATM = Pacing at which the IPSIBR correction factor is rolled into KAM. Value is in terms of background loop counts...Typical value - 5 background passes.

KAM_UPDATE

```
ISCFLG NOT= 1 --------------|            | Exit KAM_UPDATE
 (not in RPM control mode)  |            |  (do not update KAM)
                            |            |
ISCTMR < UPDISC ------------|OR --------| END OF ISC LOGIC
 (not at DSDRPM long enough)|            |
                            |            |
HCAMFG = 1 -----------------|            |
 (on hi-cam)                |            |
                            |            |
IPSIBR = 0 -----------------|            |
 (closed loop ISC           |            |
  correction is 0)          |            |
                            |            |
IBGPSI < UPDATM ------------|            |
 (not time to update KAM)                | --- ELSE ---
                                         |
IPSIBR > 0 -----------------|            | Increment ISCKAM(N)
 (positive C/L correction)  |AND -------|  (roll correction into
                            |            |   KAM)
ISCKAM(N) < PSIBRM ---------|            | Increment ISKSUM
 (< max allowed value)                   | Decrement IPSIBR
                                         |  (balance DESMAF equation)
                                         |
                                         | Set IBGPSI = 0
                                         |  (reset closed loop
                                         |   correction to 0)
                                         |
                                         | END OF ISC LOGIC
IPSIBR <OR= 0 --------------|            |
 (negative C/L correction)  |            | --- ELSE ---
                            |AND -------|
ISCKAM(N) > PSIBRN ---------|            | Decrement ISCKAM(N)
 (> min allowed value)                   |  (roll correction into
                                         |   KAM)
                                         | Decrement ISKSUM
                                         | Increment IPSIBR
                                         |  (balance DESMAF equation)
                                         |
                                         | Set IBGPSI = 0
                                         |  (reset closed loop
                                         |   correction to 0)
                                         |
                                         | END OF ISC LOGIC
                                         |
                                         | --- ELSE ---
                                         |
                                         | IBGPSI = 0
```

FILTERED AIR MASS (FAM) LOGIC/AIR MASS DETERMINATION

This section describes logic associated with filtering of the calculated air mass at idle. Specifically it details:

- Entry/Exit conditions for FAM region. Air mass filtering is required to provide acceptable engine performance at stabilized idle operation. When conditions (throttle position, desired engine speed, actual idle speed) indicate filtering is desired, a control flag (REFFLG) is set and an adaptation of the common rolling average filter routine is entered. This action, in effect, drives the filtered air mass (FAM) into a calibrated deadband approximately centered about the instantaneous air mass (N*ENGCYL*ARCHG). This procedure should provide a near fixed AM signal at idle.

- Determination of the idle air mass: Either the instantaneous (N*ENGCYL*ARCHG) or the filtered (FAM) air mass can feed the AM register at idle for use in the fuel pulsewidth calculation. In general if the control flag (REFFLG) is set, the filtered air mass value will feed the AM register -- unless the instantaneous air mass exceeds FAM by a calibrated percent difference (DELTAM). When FAM is referenced, it is clipped at a calibrated percent (MAXFAM) above (N*ENGCYL*ARCHG) as a maximum allowed value. The AM register is always clipped at a minimum value (MINAM) regardless of whether the filtered or instantaneous AM is used.

CALIBRATION CONSTANTS:

The following calibration constants are used to specify entry conditions into the FAM region, control of the filter routine and selection of the appropriate AM value.

- AMDESN = Defines the desired engine speed below which air mass filtering can be enabled. Should be kept at a minumum to avoid unnecessary activation of the FAM filter routine. ..Typical value - 900 RPM.

- AMRPM = Incremental adder to DSDRPM; total defines an engine speed limit below which air mass filtering can occur. Should be kept to a minimum to avoid unnecessary activation of the FAM filter routine. ..Typical value - 75 to 125 RPM.

- AMRPMH = Hysteresis term for AMRPM; after entry into the FAM region the total of DSDRPM + AMRPM + AMRPMH defines the engine speed exit condition. Should be large enough so that it not triggered by normal fluctuations in engine speed at idle due to load transitions (eg. A/C or power steering cycling). ..Typical value - 350 RPM.

- DELRAT = Throttle position adder to RATCH. Used to describe a throttle position below which air mass filtering is enabled. Should be set equal to DELTA + HYSTS (see throttle mode select logic). ..Typical value - 15 counts.

- DLHYST = TP hysteresis on exit from FAM.
- EFAMPH = Upper (AMPEM-EM) clip on entry to FAM.
- EFAMPL = Lower (AMPEM-EM) clip on entry to FAM.
- FAMINC = FAM increment/decrement when entering FAM region, lb/min.
- FAMLIM = Establishes a deadband centered around FAM. The filter is run only if the instananeous AM is outside this deadband; (FAM plus or minus FAMLIM * N * ENGCYL * ARCHG). FAMLIM may be thought of as the deadband size. Eg., if FAMLIM was 0.05, then the deadband would be FAM plus or minus 5 percent of the instantaneous AM. If FAMLIM is too large, the filter will not respond to changes in instantaneous Idle AM. If FAMLIM is too small, the filter will vary with the oscillations in instantaneous AM. Typical value - 0.035.

- IFAM = Initial FAM - Upper FAM clip on exit from FAM.
- SAMRAT = SAMRAT is used to pace the filter in terms of background loop counts. ..Typical value - 5.

- DELTAM = Multiplier of the filtered air mass. Establishes a threshold which if exceeded by the instantaneous AM, forces the AM register to reference the instantaneous AM value. This provides a breakout capacity of the filtered routine which may be necessary due to unanticipated loads at idle. ..Typical value - 1.15.

- MAXFAM = Multiplier of the instantaneous AM value. When referencing the FAM register at idle, MAXFAM * (N*ENGCYL*ARCHG) establishes an upper clip on the AM value. ..Typical value - 1.25.

- MINAM = A minimum clip on the AM register. TCFAM = Time constant for FAM, sec.

DEDICATED REGISTERS/FLAGS:

The following registers/flags are used by this routine.

- FAM_FLG = Flag indicating in FAM region and AM = FAM.

- FFMTMR = FAM filter Timer, sec.

- RATCH = Lowest filtered throttle position (see System Equations in this book for a better description).

- REFFLG = Flag indicating (when set) that conditions to enter the filtered region have been satisfied. Flag is also referenced by adaptive fuel control to indicate when to use/update specific idle cells.

- BGCNT = Background counter used to pace the filtered AM algorithm.

FILTERED AIR MASS LOGIC (FAM)

```
ALWAYS ------------------------| AM = N * ENGCYL * ARCHG

---->(Tip-in into normal AM)

TP > RATCH + DELRAT + DLHYST ----------------|OR ---| Set REFFLG = 0
 (not closed throttle)                       |      |  (use AM)
                                             |      |
DSDRPM > AMDESN -----------------------------|      | Clip FAM to IFAM
 (desired RPM too high for FAM)              |      |
                                             |      |
N_BYTE > DSDRPM + AMRPM + AMRPMH ------------|      |
 (RPM higher than desired idle RPM)                 |
                                                    | --- ELSE ---
                                                    |
                                                    | Enter FAM region
                                                    |
                                                    | Set BGCNT = 0
---->(Tip-out into closed throttle and FAM)         | (reset FAM
                                                    |  update counter)
TP <OR= RATCH + DELRAT ----------------------|AND --|
 (near closed throttle)                      |      | Set REFFLG = 1
                                             |      | Clip AM to
DSDRPM <OR= AMDESN --------------------------|      | EFAMPH*FAM as max.
                                             |      | EFAMPL*FAM as min.
 (desired RPM within FAM region)             |      | Set FAM =
                                             |      | AM + FAMINC
N_BYTE <OR= DSDRPM + AMRPM ------------------|      |
 (RPM closed to desired idle RPM)            |      |
                                             |      |  Set FFMTMR = 0
REFFLG = 0 ----------------------------------|      |
 (last state was normal AM)                         | (initialize FAM
                                                    |  filter timer
                                                    |  during entry)
                                                    |
                                                    | --- ELSE ---
---->(FAM update delay)                             |
                                                    |
REFFLG = 1 ----------------------------------|      |
 (in FAM region)                             |      |
                                             |      |
BGCNT + 1 < SAMRAT --------------------------|AND --| Increment BGCNT
 (sampling counter too low)                  |      |
                                             |      |
|(N*ENGCYL*ARCHG) - FAM | >                  |      |
  (N*ENGCYL*ARCHG) * FAMLIM -----------------|      |
 (AM within reasonable limits)                      |
                                                    |
                                                    |
                                                    |
                                                    | --- ELSE ---
                                                    |
```

```
----->(FAM update)                                    |
                                                      |
REFFLG = 1 -----------------------------------|       | Set FAM = UROLAV
 (in FAM region)                              |       |  (AM,TCFAM)
                                              |       | FFMTMR is the
BGCNT + 1 >OR= SAMRAT ------------------------|AND --|  sample period
 (sampling counter OK)                        |       | Set FFMTMR = 0
                                              |       |  (reset FAM timer
|(N*ENGCYL*ARCHG) - FAM| > (N*ENGCYL*ARCHG)   |       |   for next update)
  * FAMLIM -----------------------------------|       | Set BGCNT = 0
 (AM within reasonable limits)                        |
                                                      | --- ELSE ---
                                                      |
                                                      | Set BGCNT = 0
                                                      |  do not update
                                                      |   FAM
```

Determine state of FAM_FLG:

```
REFFLG = 1 ---------------------------------|
                                            |AND ---| FAM_FLG = 1
(N * ENGCYL * ARCHG) <OR= (FAM * DELTAM) --|        |
                                                    | --- ELSE ---
                                                    |
                                                    | FAM_FLG = 0
```

Determine state of FAMREG:

```
REFFLG = 0 ---------------------------| FAMREG = 0
                                      |
                                      | --- ELSE ---
                                      |
FAM_FLG = 1 --------------------------| FAMREG = 255
                                      |
                                      | --- ELSE ---
                                      |
                                      | FAMREG = 128
```

CHAPTER 10

A/C CLUTCH STRATEGY

NOTES:

1. This strategy is based on the "CH" version (6E-031). Additions or revisions include:

a) Minimum A/C enabled time feature. ACCTMR replaces ACDTMR.

c) A variable time period for WOT A/C Cut-out, varies as a function of relative throttle position.

2. This strategy includes provisions for a brake input. On applications without the brake input, set BRKCOT = 0 which will disable this feature. Also, software should include the BIFLG Flag with an initial value of ZERO (clear). This also disables the brake input feature as long as the BIFLG is kept clear.

AIR CONDITIONER CLUTCH CONTROL

BRIEF DESCRIPTION:

This routine controls the state of the A/C clutch. The strategy can disable the A/C clutch by energizing a normally closed relay. The A/C clutch is disabled when the A/C clutch has been enabled for a minimum time period and when any of the following conditions are met:

1. Time since start is less than a calibration value.

2. ECT is greater than an "over-heat" calibration value.

3. Engine RPM is less than a "near stall" calibration value.

4. Brake is applied. (Duration of A/C disable period is a calibration value.

5. TP is greater than a "WOT" calibration value. (Duration of A/C disable period is a calibration value.)

After the clutch is disabled, the routine prevents it from being re-enabled until all of the following conditions are met:

1. The A/C cycling control switch is closed.

2. The clutch has been off longer than a minimum off-time.

3. If, at closed throttle, the idle speed control system has been given time to prepare for the impending increase in load.

DEFINITIONS
INPUTS
Registers:

- ACBTMR = Time since brake went on.
- ACCTMR = Time since A/C clutch transition.
- ACITMR = Time since Idle Speed Control system was warned of impending increase in load.
- A3CTMR = Free running timer that is reset to 0 on every A3C state change. Described in the TIMER Chapter.
- APT = If equal to -1, Closed throttle.
- ATMR1 = Time since start.
- ECT = Engine Coolant Temperature, Deg F.
- HWFLAG = Flag that is set to 1 if the Heated Windshield is on.
- HWFLGL = Latched Heated Windshield Flag.
  0 -> H/W never actuated,
  1 -> H/W on for the first time.
- HWTMR = Free running timer that is reset to 0 on if A3CTMR > H/W switching frequency. Described in the timer chapter.
- LSTA3C = State of A3C the last pass. DAC same bit number as A3C to see state changes.
- N = Engine speed, RPM.
- WCOTMR = WOT A/C cut-out timer.

Bit Flags:

- A3C = If equal to 1, A/C cycling control switch is closed.

- ACCFLG = If set to 0, A/C clutch is disabled; if set to 1, A/C clutch is enabled.

- BIFLG = If equal to 1, Brake is on.

Calibration Constants:

- ACRT = Air conditioning recognition time threshold, msec.

- ACSTRD = Maximum time to keep A/C disabled after start, sec.

- ACMNDT = Minimum disable time for A/C clutch, 1/8 sec.

- ACMNET = Minimum enable time for A/C clutch.
- ACOFFH = Hysteresis for ACOFFN, RPM.
- ACOFFN = Minimum RPM for enabling A/C clutch, RPM.
- ACWDLY = Delay time to enable A/C after WOT, 1/8 sec.
- A3CTT = Heated windshield transition time threshold. This is longest time for a H/W frequency half period and is calibrated to 250 msec. This Vector calibratable value should not be changed.
- BRKCOT = Maximum time to disable A/C due to brake, 1/8 sec.
- CTAC = Maximum value of ECT to enable A/C Clutch, Deg F.
- CTACH = Hysteresis for CTAC, Deg F.
- HWRT = Heated Windshield recognition time threshold. This is time required to set the HWFLAG and is calibrated to 300 msec. This Vector calibratable value should not be changed.
- HWPPM = Airflow increment required when heated windshield load is sensed, ppm.
- HWRPM = RPM required for Heated Windshield operation. Should be calibrated to 1400 RPM.
- IDLCOT = Maximum time to delay A/C when at idle, msec.

OUTPUTS

Registers:

- A3CTMR = Free running timer that is reset to 0 on every A3C state change. Described in the TIMER Chapter.

- HWFLAG = Flag that is set to 1 if the Heated Windshield is on.

- HWFLGL = Latched Heated Windshield Flag.
  0 -> H/W never actuated,
  1 -> H/W on for the first time.

- HWTMR = Free running timer that is reset to 0 on if A3CTMR > H/W switching frequency. Described in the timer chapter.

- LSTA3C = State of A3C the last pass. DAC same bit number as A3C to see state changes.

Bit Flags:

- ACCFLG = See Inputs above.

- ACIFLG = If equal to 1, Flag to indicate that Idle Speed control system should prepare for load increase.

A/C CLUTCH CONTROL LOGIC

```
ECT > CTAC ------------|S  Q---|
                       |       |
ECT < CTAC - CTACH ----|C      |
                               |
N < ACOFFN ------------|S  Q---|
                       |       |
N > ACOFFN + ACOFFH ---|C      |
                               |
A3C = 0 -----------------------|
                               |
ATMR1 < ACSTRD ----------------|
                               |OR -|
BIFLG = 1 -------------|       |    |
                       |AND ---|    |
ACBTMR < BRKCOT -------|       |    |
                               |    |
WCOTMR < ACWDLY ---------------|    |
                               |    |AND-|OR-| DISABLE A/C
ACCTMR >OR= ACMNET ----|            |    |   | CLUTCH (A/C Off)
 (Min ON time)         |OR ---------|    |   | (turn OUTPUT on)
                       |                 |   | SET ACCFLG = 0
ACCFLG = 0 ------------|                 |   | CLEAR ACIFLG = 0
 (Clutch disabled)                       |   |
                                         |   |
A3C = 0 ---------------------------------|   |
 (A/C Pressure Switch off)                   | --- ELSE ---
                                             |
AC3TMR > ACRT --------------------|          |
 (H/W is off)                     |          |
                                  |          |
ACCTMR >OR= ACMNDT ---------------|          | ENABLE A/C
 (Min OFF time)                   |AND ------| CLUTCH (A/C on)
                                  |          | (Turn OUTPUT off)
APT NOT= -1 --------------|       |          | SET ACCFLG = 1
                          |OR ----|          | CLEAR ACIFLG = 0
ACITMR >OR= IDLCOT -------|                  |
                                             | --- ELSE ---
ACCFLG = 0 ---------------|                  |
 (A/C Off)                |                  |
                          |                  |
ACCTMR >OR= ACMNDT -------|AND --------------| SET ACIFLG = 1
 (Min OFF time)           |                  | (ISC warning flag)
                          |
A3CTMR > ACRT ------------|
 (H/W is off)
```

HEATED WINDSHIELD RECOGNITION STRATEGY

Both the heated windshield and the A/C clutch share a common input (ACCS) to the EEC module. When the A/C is on, the ACCS input is high and the CPU flag A3C is 1. The heated windshield signal is a 5 Hz (3-8 Hz) square wave frequency input. Recognition of the frequency input is accomplished using two free running millisecond timers. A3CTMR resets on any A3C transition while HWTMR is used to set the heated windshield flag HWFLAG. Many closely spaced A3C transitions will keep the value of A3CTMR low and this indicates that heated windshield is in use.

EEC has no control over the heated windshield. External hardware performs all control, switching and timing functions. The EEC does, however increase idle RPM in neutral or park to increase alternator power output. The heated windshield strategy is as follows:

- H/W will operate in all driving modes with A/C either on or off.
- H/W idle RPM will be a minimum of 1400 RPM in park or neutral and normal RPM in drive.
- RPM will be increased for the first H/W actuation only.
- RPM will be increased when the H/W is first sensed and will remain high (even if masked by the A/C on signal) until A/C is off and the H/W signal is no longer present.

HEATED WINDSHIELD VS. A/C RECOGNITION

```
LSTA3C - A3C NOT= 0 -----------| Set LSTA3C = A3C
 (A3C state change)            | Set A3CTMR = 0

A3CTMR > A3CTT (250 msec) -----| Set HWTMR = 0

HWTMR > HWRT (300 msec) -|AND -| Set HWFLAG = 1
                         |     | Set HWFLGL = 1
HWFLAG = 0 --------------|     |  (latch current state of H/W on)
                         |     |
HWFLGL = 0 --------------|     |--- ELSE ---
 (first time H/W on)           |
                               |

A3CTMR > ACRT -----|AND -------| Set HWFLAG = 0
                   |           |  (explicitly turn off H/W)
A3C = 0 -----------|
 (A/C off)
```

CHAPTER 11

CANISTER PURGE

CANISTER PURGE STRATEGY

Canister Purge refers to the solenoid and valve combination that is located in the line between the intake manifold and the carbon canister. When the solenoid is energized the valve opens, allowing the flow of vapors from the canister to the intake manifold.

The strategy enables canister purge during various engine operating modes. These modes are calibration items. Typical calibrations will enable purge when these conditions are met:

1) Fuel control is in the desired mode. The calibrator can choose between purging during closed loop only or during both open loop and closed loop.

2) The engine has warmed up.

3) The engine has not overheated.

4) The 'Not at Closed Throttle' delay has been met.

The strategy includes a feature to prevent the rich surge that may occur on purge turn on. When the purge is enabled the output is cycled on and off at a 10Hz frequency with a variable duty cycle. The duty cycle ramps up to slowly introduce the canister vapors. The duty cycle ramp is determined from FN600 * FN602 * FN605A.

DEFINITIONS

INPUTS

Registers:

- AM = Air Mass flow (lb/min).
- ATMR1 = Time since initial engine startup, secs.
- ATMR2 = Time since Engine Coolant Temp (ECT) reached TEMPFB, (sec).
- CPRGTMR = Current Purge on time.
- ECT = Engine Coolant Temperature, deg F.
- N = Engine RPM.
- NACTMR = Not at Closed Throttle Timer, sec.
- PRGTMR = Total Purge on time.
- TCSTRT = Temperature of Engine Coolant at Cold Startup, deg F.

Calibration Constants:

- CTHIGH = Temperature of Engine Coolant (ECT) at Hot Startup, deg F.
- CTLOW = Temperature of Engine Coolant at Cold Startup, deg F.
- CTPRG = Overheat temperature to turn off purge, deg F.
- CTPRGH = Hysteresis term for CTPRG, deg F.
- EVRPM = Minimum Engine Speed to Purge, RPM.
- EVRPMH = Hysteresis term for EVRPM.
- EVTDOT = Purge time delay at Part throttle or WOT.
- FN600 = Canister Purge Duty Cycle Multiplier

X-input = PRGTMR
Y-output = Duty Cycle Multiplier.

- FN602 = Canister Purge Duty Cycle Multiplier

X-input = CPRGTMR
Y-output = Duty Cycle Multiplier.

- FN605A = Canister Purge Duty Cycle vs. AM

X-input = AM
Y-output = Purge Duty Cycle.

- PRGTD1 = Canister purge cold startup delay time.

- PRGTD2 = Canister purge medium temp startup delay time.

- PRGTD3 = Canister purge hot startup delay time.

- PRGTD4 = Canister purge cold startup delay time, used with ATRM2.

- PRGTD5 = Canister purge delay timer, used with ATMR2.

- PURGSW = Switch to select Open Loop Purge, 1 = Allow Open Loop Purge.

- TEMPFB = Minimum ECT required to start ATMR2 timer, deg F.

OUTPUTS

Registers:

- CPRGTMR = Current Purge on time.

- PRGTMR = Total Purge on time.

- PURGDC = Canister Purge Duty Cycle.

CANISTER PURGE LOGIC

```
TCSTRT >OR= CTHIGH -----------|
                              |AND -|
ATMR1 >OR= PRGTD3 ------------|     |
                                    |
                                    |
CTLOW < TCSTRT < CTHIGH ------|     |
                              |AND -|OR -|
ATMR1 >OR= PRGTD2 ------|     |     |    |
                        |AND -|     |    |
ATMR2 >OR= PRGTD5 ------|           |    |
                                    |    |
                                    |    |
TCSTRT <OR= CTLOW ------------|     |    |
                              |AND -|    |
ATMR1 >OR= PRGTD1 ----|       |          |
                      |AND ---|          |
ATMR2 >OR= PRGTD4 ----|                  |
                                         |
ECT < CTPRG - CTPRGH ---|S Q-------------|AND -| ENABLE PURGE
                        |                |     |
ECT > CTPRG ------------|C               |     | SET PURGDC =
 (Over temp. disable)                    |     | FN600(PRGTMR) *
                                         |     | FN602(CPRGTMR) *
NACTMR >OR= EVTDOT ----------------------|     | FN605A(AM)
                                         |     |
                                         |     | --- ELSE ---
CLOSED LOOP FUEL CONTROL ------|         |     |
                               |OR ------|     | DISABLE PURGE
PURGSW = 1 --------------------|               |
 (to allow Open Loop Purge)                    | SET PURGDC = 0
```

NOTES;

1. When purge is enabled, the purge output is cycled at 10Hz +/- 30%
2. Set EVTDOT to 0 to Purge at Closed Throttle.

TIMER LOGIC

```
PURGE ENABLED -------|            | COUNT UP PRGTMR
                     |AND --------| COUNT UP CPRGTMR
FN605A(AM) NOT= 0 ---|            |
                                  | --- ELSE ---
                                  |
                                  | FREEZE PRGTMR
                                  | SET CPRGTMR = 0
```

CHAPTER 12

THERMACTOR AIR STRATEGY

This section contains three related strategies which are discussed in the order shown below.

- Thermactor Air
- Inlet Air Control
- Supercharger Strategy

The THRMHP assists in determining which of the strategies is activated. This is a calibratible switch and has four settings.

- THRMHP = 0 - Disables Inlet Air Control (IACFLG = 0)
- THRMHP = 3 - Enables Inlet Air Control (IACFLG = 1)
- THRMHP = 2 - Enables Supercharger Strategy
- THRMHP = 1 - Enables Thermactor Air

THERMACTOR AIR STRATEGY

Thermactor air refers to air added to the exhaust gas mixture from the belt driven thermactor air pump.

The computer controls two solenoids to create three mutually exclusive air states:

Thermactor Air State	TAB Solenoid	TAD Solenoid
Upstream	on	on
Downstream	on	off
Bypass	off	off
Bypass	off	on

TAB - Thermactor Air Bypass (AM1)
TAD - Thermactor Air Divert (AM2)

Upstream refers to air added at or near the exhaust ports. This is done to provide better oxidation of the exhaust gas mixture when a richer exhaust gas mixture is anticipated. It is not possible to operate in closed loop fuel control while air is introduced upstream (the EGO sensor may always indicate a lean condition).

Downstream refers to air added to the catalyst mid-bed. Downstream air is compatible with closed loop fuel control and is the normal thermactor air state.

Bypass refers to the condition in which no thermactor air is added to the exhaust gas mixture. This feature is used primarily to protect the catalyst from over-temperature conditions.

The THERMACTOR AIR CONTROL LOGIC is executed if the Off-chip port selection switch (THRMHP) is set = 1. In order to disable thermactor logic, (without enabling Inlet Air Control [3.0L SHO] or Supercharger (3.8L SC) Strategy), set THRMHP = 0. The thermactor air control logic is shown on the next page.

DEFINITIONS

INPUTS

Registers:

- ACT = Air Charge Temperature, deg F.
- APT = Part throttle flag.
- ATMR1 = Time since Engine Startup, sec.
- ATMR2 = Time since ECT greater than TEMPFB, sec.
- AWOTMR = Time at WOT, sec.
- CTATMR = Closed throttle Upstream Air Timer, sec. (See Timer Chapter).
- ECT = Engine Coolant Temperature, deg F.
- HMTMR = High Power Demand Timer, sec. (See Timer Chapter).
- LOAD = Universal Load parameters, unitless. It also equal Aircharge normalized to sea.
- MFATMR = Managed Fuel Air Timer, sec. (See Timer Chapter)
- N = Engine speed, RPM.
- NACTMR = Not at Closed throttle Timer, sec.
- RATCH = Filtered throttle position.
- TCSTRT = Temperature of ECT at startup, deg F.
- TP = Throttle Position.

Bit Flags:

- AFMFLG = Flag indicating that ACT sensor has failed.
- CFMFLG = Flag indicating that ECT sensor is in/out of range, 0 = in range.
- CHKAIR = Thermactor Air Status Flag. (1 = Air diverted upstream or dumped)
- CRKFLG = Flag indicating status of Crank.
- CTAFLG = Flag indicating state of CTATMR (Closed Throttle Upstream Air timer).
- HSPFLG = High Speed Mode flag; 1 = High speed alternate fuel/spark.
- LEGOFG1 = Flag indicating lack of EGO-1 switching, if set.

- LEGOFG2 = Flag indicating lack of EGO-2 switching, if set.
- MFMFLG = Flag indicating that MAF sensor has failed.
- TFMFLG = Flag indicating that TP sensor has failed.
- UNDSP = Flag if set to 1 indicates Underspeed Mode, or Crank.

Calibration Constants:

- ATBYS = Minimum ACT to Bypass thermactor Air, deg F.
- BYHTMR = Bankline timer time delay for Thermactor Bypass.
- BYPWOT = Wide Open Throttle Bypass Time delay.
- BYSTM1 = ATMR1 Thermactor Bypass Time Delay for TCSTRT <or= CTLOW.
- BYSTM2 = ATMR1 Thermactor Bypass Time Delay for CTLOW < TCSTRT < CTHIGH.
- BYSTM3 = ATMR1 Thermactor Bypass time Delay for TCSTRT >or= CTHIGH.
- BYSTM4 = ATMR2 Thermactor Bypass Time delay for TCSTRT <or=CTLOW.
- BYSTM5 = ATMR2 thermactor Bypass Time Delay for CTLOW < TCSTRT < CTHIGH.
- CTARTM = Upstream air time delay during Decel, sec.
- CTBYS = Minimum ECT to Bypass thermactor Air, deg F.
- CTBYSH = Hysteresis for ATBYS and CTBYS.
- CTHIGH = Hot start minimum engine coolant temperature, Deg F.
- CTLOW = Cold Start Maximum ECT, deg F.
- DMPDLY = Managed Fuel Air State Time Delay to Bypass Thermactor Air, sec.
- DNLOD = Maximum load for downstream air.
- DNLODH = Hysteresis for DNLOD.
- DNSTMI = Time delay for Downstream air when not at Closed Throttle, sec.
- HMCTM = Upstream Air Time Delay, sec.
- HMSTM = Maximum time that Upstream Air occurs during crowds (after startup).

- MFATM1 = ATMR1 MFA enable time delay for TCSTRT <or= CTLOW.
- MFATM2 = ATMR1 MFA enable time delay for CTLOW < TCSTRT < CTHIGH.
- MFATM3 = ATMR1 MFA enable time delay for TCSTRT >or= CTHIGH.
- MFATM4 = ATMR2 MFA enable time delay for TCSTRT <or= CTLOW> CTHIGH.

- MFATM5 = ATMR2 MFA enable time delay for CTLOW < TCSTRT < CTHIGH.

- NIAC = Maximum RPM for single inlet airflow path, RPM.

- NIACH = Hysteresis term for turning OFF IAC, RPM.

- NUMEGO = Calibration switch which indicates number of EGO sensors present, mono or stereo.

- THRMHP = Off chip port selection switch.
  = 0 - Disables Inlet Air Control (IACFLG = 0)
  = 3 - Enables Inlet Air Control (IACFLG = 1)
  = 2 - Enables Supercharger Strategy
  = 1 - Enables Thermactor Air

- TEMPFB = Minimum ECT required to start ATMR2 timer, deg. F.

- THBPSC = Throttle breakpoint for Supercharger Bypass, A/D counts.

- THBPSH = Hysteresis for THBPSC, A/D counts.

- UPLOD = Minimum Percent LOAD for upstream air.

- UPLODH = Hysteresis for UPLODH.

- UPRPM2 = Maximum RPM for Decel Upstream Air.

- UPRPMH = Hysteresis term for UPRPM.

- UPSTM1 = ATMR1 Thermactor Upstream Time Delay for TCSTRT <OR= CTLOW.
- UPSTM2 = ATMR1 Thermactor Upstream time delay CTLOW < TCSTRT < CTHIGH.
- UPSTM3 = ATMR1 Thermactor Upstream time delay for TCSTRT >OR= CTHIGH.
- UPSTM4 = ATMR2 Thermactor Upstream Time Delay for TCSTRT <OR= CTLOW.
- UPSTM5 = ATMR2 Thermactor Upstream Time Delay for CTLOW < TCSTRT < CTHIGH.
- UPSWOT = WOT Upstream Air Time Delay.

OUTPUTS
Bit Flags:

- CHKAIR = Thermactor Air Status Flag. (1 = Air diverted upstream or dumped)
- IACFLG = Flag which indicates setting of (IAC). If set to 1, IAC valve is open and IAC is enabled; cleared (0), then IAC is disabled.
- USAFLG = Upstream Air Flag; 0 = Not in Upstream Air, 1 = In Upstream Air.

UNIVERSAL CHKAIR LOGIC

Under certain circumstances, it is necessary to force Open Loop fuel control independently of the presence of Thermactor hardware. The following logic is used with and without thermactor air. If the engine system does NOT have thermactor air, (THRMHP NOT=1), this CHKAIR logic will only be used to force Open Loop fuel. On systems WITH thermactor air, this universal logic can force air bypass in addition to Open Loop fuel.

```
ECT > CTBYS ------------|               |
                        |AND ---|S Q----|
ACT > ATBYS ------------|       |       |
                                |       |
ECT < CTBYS - CTBYSH ---|       |       |
                        |OR ----|C      |
ACT < ATBYS - CTBYSH ---|               |
                                        |
NUMEGO = 1 (MONO EGO) ----------|       |
                                |AND ---|
LEGOFG1 = 1 --------------------|       |OR --| CHKAIR = 0
                                        |     | (Force Open Loop
NUMEGO = 2 (STEREO EGO) --------|       |     |  Fuel)
                                |       |     | (Systems which
LEGOFG1 = 1 --------------------|AND ---|     |  have Thermactor
                                |       |     |  Air will Bypass

LEGOFG2 = 1 --------------------|       |     |  according to the
                                        |     |  Thermactor Logic)
APT = 1 (WIDE OPEN THROTTLE) ---|       |     |
                                |AND ---|     | --- ELSE ---
AWOTMR >OR= BYPWOT -------------|             |
                                              | CHKAIR = 1
                                              | (Do NOT force
                                              |  Open Loop Fuel)
                                              | NOTE: Thermactor
                                              |  may still set
                                              |  CHKAIR = 0
                                              |  if hardware is
                                              |  present and
                                              |  Upstream Air is
                                              |  requested)
```

THERMACTOR AIR CONTROL LOGIC

```
THRMHP NOT= 1 ---------------------------------| Exit Thermactor
                                               |  strategy
                                               | (Fuel strategy
                                               |  will use
                                               |  Universal
AFMFLG = 1 --------------------|               |  CHKAIR logic)
                               |               |
CFMFLG = 1 --------------------|               | --- ELSE ---
                               |               |
TFMFLG = 1 --------------------|OR ------------| BYPASS AIR
                               |               | (No change to
MFMFLG = 1 --------------------|               |   CHKAIR)
                                               |  SET USAFLG = 0
                                               |
                                               | --- ELSE ---
"A" ------------------------------------|      |
                                        |OR ---| BYPASS AIR
CHKAIR = 0 -----------------------------|      | SET CHKAIR = 0
   (Universal CHKAIR flag)              |      |  (forced open
                                        |      |   loop fuel)
HSPFLG = 1 -----------------------------|      |
                                               | SET USAFLG = 0
"B" ------------------------------------|      |
                                        |      | --- ELSE ---
ATRMR1 <OR= HMSTM --------------|       |      |
                                |       |      |
APT = 1 (WIDE OPEN THROTTLE) ---|       |      |
                                |AND ---|      |
AWOTMR < UPSWOT ----------------|       |      |
                                        |      | UPSTREAM AIR
CTATMR >OR= CTARTM -------------|       |      | SET CHKAIR = 0
                                |AND ---|OR ---|  (forced open
CTAFLG = 1 ---------------------|       |      |   loop fuel)
                                        |      | SET USAFLG = 1
ATMR1 <OR= HMSTM ---------------|       |      |
                                |       |      |
HMTMR <OR= HMCTM ---------------|       |      |
                                |AND ---|      |
PERLOAD > UPLOD + UPLODH -|S Q -|              |
                          |                    |
PERLOAD < UPLOD ----------|C                   | --- ELSE ---
                                               |
MFATMR <OR= DMPDLY ---------------------|      | DOWNSTREAM AIR
                                        |AND --| SET CHKAIR = 1
NACTMR <OR= DNSTMI -------------|       |      |  (not forced
                                |OR ----|      |   open loop fuel)
LOAD < DNLOD - DNLODH --|S Q----|              | SET USAFLG = 0
                        |                      |
LOAD > DNLOD -----------|C                     | --- ELSE ---
                                               |
                                               | BYPASS AIR
                                               | SET CHKAIR = 1
                                               |  (not forced
                                               |   open loop fuel)
                                               | SET USAFLG = 0
```

NOTE: CTAFLG = 1 requirement allows Upstream air immediately during Decel if CTARTM = 0.

"A" LOGIC

Normal startup Bypass logic: Air is bypassed as long as time is less than the relevant time delay.

```
TCSTRT >OR= CTHIGH -------------|
                                |AND ---|
ATMR1 < BYSTM3 -----------------|       |
                                        |
CTLOW < TCSTRT < CTHIGH --------|       |
                                |AND ---|OR -- "A"
ATMR1 < BYSTM2 ---------|       |       |
                        |OR ----|       |
ATMR2 < BYSTM5 ---------|               |
                                        |
TCSTRT <OR= CTLOW --------------|       |
                                |AND ---|
ATMR1 < BYSTM1 ---------|       |
                        |OR ----|
ATMR2 < BYSTM4 ---------|
```

"B" LOGIC

Normal Start Upstream Logic: Air is diverted upstream as long as it is not bypassed and as long as the time since start is less that the relevant time delay.

```
TCSTRT >OR= CTHIGH -------------|
                                |AND ---|
ATMR1 < UPSTM3 -----------------|       |
                                        |
                                        |
CTLOW < TCSTRT < CTHIGH --------|       |
                                |AND ---|OR ----| "B"
ATMR1 < UPSTM2 ---------|       |       |
                        |OR ----|       |
ATMR2 < UPSTM5 ---------|               |
                                        |
                                        |
TCSTRT <OR= CTLOW --------------|       |
                                |AND ---|
ATMR1 < UPSTM1 ---------|       |
                        |OR ----|
ATMR2 < UPSTM4 ---------|
```

INLET AIR CONTROL (THRMHP = 3)

When enabled by the THRMHP, the inlet air control (IAC) strategy opens a normally-closed valve to increase the airflow to the engine and improve top-end performance. The valve is located on one side of the split plenum intake manifold. The strategy controls the valve through a normally closed vacuum solenoid.

```
THRMHP NOT= 2 ----------------| IACFLG = 0
                              |  Exit IAC logic
                              |
                              | --- ELSE ---
                              |
N > NIAC -----------|S Q------| Open IAC Valve
                    |         | IACFLG = 1
N < NIAC - NIACH ---|C        |
                              | --- ELSE ---
                              |
                              | Close IAC Valve
                              | IACFLG = 0
```

SUPERCHARGER BYPASS SOLENOID (THRMHP = 2)

This Section describes the Supercharger Bypass Solenoid Strategy which has been designed to support the 3.8L Mass Air Sequential Fuel Injection program.

```
THRMHP NOT= 2 ----------------------| No change, exit this
                                    |  Logic.
TFMFLG = 0 ----------------|        |
                           |        | --- ELSE ---
CRKFLG = 0 ----------------|        |
                           |AND ----| Enable Supercharger
UNDSP = 0 -----------------|        |  Bypass Output
 (Run Mode)                |        |
                           |        | --- ELSE ---
TP > RATCH + THBPSC -|S Q--|        |
                     |              | Disable Supercharger
TP < RATCH +         |              |  Bypass Output
  THBPSC - THBPSH ---|C
```

NOTE: The initial Supercharger hardware is a three-way vacuum solenoid which is normally OPEN. When the Supercharger Bypass Output is OFF, vacuum is applied to the Actuator. When the output is ON, the actuator is vented to the atmosphere. WHEN THRMHP NOT= 1, CHKAIR must be set = 1 or cleared (thermactor logic) to insure Open Loop/Closed loop fuel control.

CHAPTER 13

ELECTRO-DRIVE FAN STRATEGY

TWO-SPEED ELECTRO DRIVE FAN CONTROL
(EDFHP = 1)

The electric fan provides additional air circulation for engine cooling purposes under circumstances where an engine-driven fan is inadequate, i.e., low vehicle speed or unusually high engine temperatures. To minimize accessory load on the engine, the fan is always turned off during CRANK Mode.

The EEC controls the state of the cooling fan. The fan may be operated at either high or low speed. The strategy controls the state of the fan via two outputs as shown in the truth table below.

The cooling fan is turned on at low speed if:

1) The engine temperature is higher than normal (approximately 216 deg F);

2) The A/C is ON and the vehicle speed does not provide enough natural airflow (approximately 43 MPH).

The cooling fan will turn on at high speed if:

1) The engine temperature is higher than desirable (approximately 230 deg F) and the fan has been operating at low speed.

2) ECT sensor is out of specification.

The cooling fan will turn off if:

1) The driver demand is high (WOT type Mode as defined by A/C Cutout Strategy);
   or
2) The A/C clutch is not cycling rapidly;
   OR
3) Vehicle speed is high enough to provide enough airflow for engine cooling.

provided the engine coolant temperature is not too high.

	CPU OUTPUT (Software)		EEC OUTPUT (Hardware)	
FAN STATE	EDF	HEDF	EDF	HEDF
Off	1	0	On	Off
Low speed	0	0	Off	Off
High speed	0	1	Off	On
Not Used	1	1	On	On --> NOT USED

Note: OFF = 12V (Referenced to ground)
      ON = <1V (Referenced to ground)

DEFINITIONS

INPUTS

Registers:

- ACCTMR = Time since A/C State transition (off to On, or On to Off), sec. (See TIMER chapter).
- ECT = Engine Coolant Temperature, deg F.
- EDFTMR = Set to 0 when the EDF (low speed fan) is de-energized or CRKFLG = 1. Otherwise, it is free-running.
- HSFFLG = High Speed Fan Flag.
- RATCH = Warm curb Idle throttle position, counts.
- TP = Throttle Position, counts.
- VSBAR = Vehicle Speed, MPH.
- WCOTMR = Time since near WOT A/C Cutout. This timer will re-enable the A/C and Fan regardless of the throttle mode after the engine responds to the driver (ACWDLY sec).

Bit Flags:

- ACCFLG = Flag that is set to 1 when A/C clutch is enabled.
- CFMFLG = Flag indication that ECT sensor is in/out of range; 0 = in range.
- CRKFLG = Flag that is set when in CRANK mode.

Calibration Constants:

- ACMNFT = Minimum amount of time that the A/C Clutch must be disengaged before turning off the fan, secs. This prevents rapid Fan cycling. (This value must be > 2 seconds.)
- ACWDLY = Time delay before turning the A/C on and allowing the fan to turn on, ie, at low vehicle speeds. Units are seconds. (This value must be less than 25 seconds.)
- EDFHP = Electro drive fan hardware present switch.
- EDFTM = Minimum low speed fan time to turn on high speed fan, secs.
- HEDFHP = Two speed fan output present switch.
- HSFEC1 = ECT for Grade Load High Speed Fan turn on, lower than HSFEC2.
- HSFEC2 = ECT for normal High Speed Fan turn on, higher than HSFEC1.
- HSFHYS = Hysteresis for HSFECT, deg F. (Should be 6 deg F, per Car Engineering Direction)

- HSFLOD = Minimum LOAD for Grade Load High Speed Fan.

- HSFRPM = Minimum RPM for Grade Load High Speed Fan.

- HSFVS = Maximum VSBAR for Grade Load High Speed Fan.

- LSFECT = Minimum ECT for Low Speed Fan, deg F. (Should be 216 deg F, per Car Engineering Direction)

- LSFHYS = Hysteresis for LSFECT, deg F. (Should be 4 deg F, per Car Engineering Direction)

- LSFVS = Minimum vehicle speed at which electric fan cooling is not required, MPH. (Should be 48 MPH, per Car Engineering Direction)

- LSFVSH = Hysteresis term to prevent cycling of FAN output, MPH. (Should be 5 MPH, per Car Engineering Direction)

OUTPUTS

Registers:

- EDF = Low Speed Electro-drive Fan Output (See truth table).

- EDFTMR = Set to 0 when the EDF (low speed fan) is de-energized or CRKFLG = 1. Otherwise, it is free-running.

- HEDF = High Speed Electro-drive Fan Output (See truth table).

- HSFFLG = High Speed Fan Flag.

The electric fan is controlled according to the logic shown below.

```
EDFHP = 0 -----------------------------------| No Fan Control
                                             | Exit logic
                                             |
                                             | --- ELSE ---
                                             |
CRKFLG = 1 ----------------------------------| TURN FAN OFF
 (crank mode)                                | SET EDFTMR = 0
                                             | EDF = 1
                                             | HEDF = 0
                                             |
                                             | --- ELSE ---
HEDFHP = 1 ------------------------|         |
                                   |AND -----| TURN ON HIGH
HSFFLG = 1 ---------|AND ---|S Q --|         | SPEED FAN
 (overheated)       |       |                | EDF = 0
                    |       |                | HEDF = 1
EDFTMR >OR= EDFTM --|       |                |
 (low speed fan on)         |                |
                            |                |
ECT < HSFEC1 - HSFHYS ------|C               |
                                             |
                                             | --- ELSE ---
CFMFLG = 1 ---------------------------|      |
                                      |      |
ECT > LSFECT -----------|S Q ---------|      |
 (hot engine)           |             |      |
                        |             |      |
ECT < LSFECT - LSFHYS --|C            |      |
                                      |OR ---| TURN ON LOW
                                      |      | SPEED FAN
VSBAR < LSFVS - LSFVSH -------|       |      | EDF = 0
 (vehicle speed low)          |       |      | HEDF = 0
                              |AND ---|      |
ACCFLG = 1 -------------------|              | --- ELSE ---
  (A/C on)                                   |
                                             |
ACCTMR >OR= ACMNFT ---------|                |
  (fan turn off delay)      |AND -----|      |
                            |         |      |
ACCFLG = 0 -----------------|         |      |
                                      |      |
WCOTMR < ACWDLY ----------------------|OR ---| TURN FAN OFF
  (WOT fan re-enable)                 |      | EDF = 1
                                      |      | HEDF = 0
VSBAR > LSFVS ------------------------|      |
  (vehicle speed high)                       | --- ELSE ---
                                             |
                                             | NO CHANGE
                                             | TO FAN STATE
```

Where HSFFLG logic is described on the following page:

```
N_BYTE >OR= HSFRPM -------|
 (high rpm)               |
                          |
LOAD >OR= HSFLOD ---------|           |
 (high load)              |AND -------| Set HSFFLG = 1
                          |           |
VSBAR <OR= HSFVS ---------|           | (high speed fan flag,
 (low speed)              |           |  grade load condition)
                          |           |
ECT >OR= HSFEC1 ----------|           | --- ELSE ---
 (lower temp. turn on)                |
                                      |
ECT >OR= HSFEC2 ----------------------| Set HSFFLG = 1
 (higher temp. turn on)               |
                                      | (high speed fan flag,
                                      |  boilover, no load)
                                      |
                                      | --- ELSE ---
                                      |
                                      | Set HSFFLG = 0
```

CHAPTER 14

DATA OUTPUT LINK

DATA OUTPUT LINK - TRIPMINDER

The Data Output Link (DOL) provides a communication line between the EEC and the vehicle dashboard computer, Tripminder, for the transfer of fuel consumption information. The fuel flow information sent by the EEC is used for computation of instantaneous and average fuel economy, which is then displayed to the driver.

The Tripminder requires an appropriate integer number of pulses within 100 msec period. Therefore, within each background loop or each 100 msec period, whichever is shorter, the EEC sums the fuel flow and through the injectors output since the summing period started, converts this sum into DOL pulses, and outputs these pulses at a maximum frequency of 500 Hz during the following summation period.

The fuel flow is converted into DOL pulses according to the following equation:

DOL_COUNT = INTEGER (FUEL_SUM * 7804.19 * INJOUT) + DOL_COUNT

The FUEL_SUM is then reduced by the amount converted into DOL_COUNTS (One DOL_COUNT = 1.282E-4 lbm).

where,

DOL_COUNT = Number of pulses to be output beginning in the next summation period. One DOL_COUNT = 1.282E-4 lbm.

FUEL_SUM = Sum of fuel flow per injector, which was initiated since last summation period. It is updated during the Fuel PW output routine.

7804.19 = (48000 pulses/gal)/6.15 lbm/gal, pulses/lmb.

INJOUT = Number of injectors per output port. (See Fuel Strategy)

FUEL_SUM = FUEL_SUM + LBMF_INJn

LBMF_INJn = Fuel Flow per injector, calculated from
FUELFLOWn (n= 1, 2). (See Fuel Strategy).

```
       ----     ----     ----     ----     ----     ----
       |  |     |  |     |  |     |  |     |  |     |  |
       |  |     |  |     |  |     |  |     |  |     |  |
FUELPW     -----    -----    -----    -----    -----    ------

       |<-- 1 BACKGROUND LOOP -->|----
                                 ||  |
                                 ||  |
DOL                               |  |
OUTPUT ---------------------------    ------------------------
```

CHAPTER 15

VEHICLE SPEED CONTROL STRATEGY

VEHICLE SPEED CONTROL STRATEGY
(VSTYPE = 2)

The strategy now utilizies a Vehicle Speed Sensor. The logic for this sensor appears in both Systems Equations and EEC Overview of this Text.

The integrated Vehicle Speed Control (VSC) models the mechanical Cruise Control of previous model years. When activated, the system is designed to maintain the vehicle speed within prescribed limits, at any driver-selected speed above 25 MPH. The value added by the integrated VSC includes accurate digital control and the Favorite Speed Set feature as well as Component complexity reduction. While the hardware is no longer provided for Favorite Speed Set, the software still exists. As this strategy book is meant to represent the total system, the logic for Favorite Speed is included.

Brake ON/OFF Switch (BOO)
Neutral/Drive Switch (NDS)
Throttle Position Sensor (TPS)
Vehicle Speed Sensor (VSS)
Speed Control Command Switch (VSCCS)

The VSC strategy controls the vehicle speed by means of a pulsetrain sent to a Vent solenoid (to decrease speed) or to a Vacuum Solenoid (to increase speed).

Speed Control Command Switch Input

The driver operates the VSC system by pressing buttons on the steering wheel as is done with the mechanical system. The five traditional buttons (ON, OFF, ACCEL, RESUME and COAST) are incorporated into the integrated VSC as switches. ON-OFF is one switch; SET ACCEL-COAST another; and RESUME is on a switch by itself. Depression of any of these switches causes a unique voltage level at the VSCCS input.

The strategy reads the VSCCS input and sets a flag corresponding to the button pressed. If no buttons are currently depressed, the strategy interprets the voltage level as a HOLD state (if the VSC is operating) which means that the state selected by the most recent button depression is maintained.

VEHICLE SPEED CONTROL SOFTWARE MODULE OVERVIEW

```
   _________________
  ( ENTER VSC LOGIC )
   -----------------
          |

     -----------     NO      ------
    < VSTYPE = 2 >-----------( EXIT )
     -----------             ------
          | YES
 _______________________
| VEHICLE SPEED CONTROL |
| COMMAND SWITCH LOGIC  |
 -----------------------
          |
      _________      Y      _______________
     < STATE 1 >----------| STATE 1 LOGIC |---
      ---------             ---------------   |
        N |                                    |
      _________      Y      _______________    |
     < STATE 2 >----------| STATE 2 LOGIC |---|
      ---------             ---------------    |
        N |                                    |
      _________      Y      _______________    |
     < STATE 3 >----------| STATE 3 LOGIC |---|
      ---------             ---------------    |
        N |                                    |
      _________      Y      _______________    |
     < STATE 4 >----------| STATE 4 LOGIC-----|
      ---------             ---------------    |
        N |                                    |
      _________      Y      _______________    |
     < STATE 5 >----------| STATE 5 LOGIC |---|
      ---------             ---------------    |
        N |                                    |
      _________      Y      _______________    |
     < STATE 6 >----------| STATE 6 LOGIC |---|
      ---------             ---------------    |
        N |                                    |
      _________      Y      _______________    |
     < STATE 7 >----------| STATE 7 LOGIC |---|
      ---------             ---------------    |
        N |                                    |
      _______________                          |
     | STATE 8 LOGIC |------------------------|
      ---------------                          |
```

(cont.)

```
                 ___________________________________|
                |
      ______________________
     | SET SPEED RAMP LOGIC |
      ----------------------
                |
         _________________
        | VSC_ERROR LOGIC |
         -----------------
                |
       ____________________
      | VSC_DC CALCULATION |
       --------------------
                |
   _____________________________
  | DUTY CYCLE OUTPUT ALGORITHM |
   -----------------------------
                |
            _______
          ( RETURN )
            --------
```

INPUTS

Registers:

- DEBTMR = IVSCCS debounce timer.
- IVSCCS = Input vehicle speed control command switch.
- IVSCCS_LST = Last input vehicle speed control command switch.
- MPH = Current (or actual) Vehicle speed, MPH.
- N = Engine Speed, RPM.
- RATCH = Closed Throttle Position, counts.
- RES_SPEED = Vehicle Control Speed set by Driver, mph.
- SET_SPEED = Current Desired Vehicle Control Speed.
- TP = Throttle Position, counts.
- VBAT = Filtered Inferred Battery Voltage, volts; it is initialized to 12.5 Volts.
- VSC_BUTTONS = Flag register containing VSC button status.
- VSC_DC = Vehicle Speed Control output duty cycle.
- VSC_STATES = Flag register containing VSC state status, unitless.
- VSCCS = Vehicle Speed Control Command Switch.

Bit Flags:

- ACCEL_BUT = Flag that indicates that the ACCEL button is depressed (1 = ACCEL button depressed).
- ACCEL_STATE = Flag that indicates that the VSC is in ACCEL Mode (1 = ACCEL Mode).
- BIFLG = Flag that indicates that the brake has been depressed (1 = Brake depressed).
- BRAKE_STATE = Flag that indicates that the Brake has been depressed (1 = Brake depressed).
- COAST_BUT = Flag that indicates that the driver depressed the COAST Button (1 = Button depressed).
- COAST_STATE = Flag that indicates that the driver depressed the COAST Button recently.

- HOLD_STATE = Flag that indicates normal VSC (1 = Stable Speed).
- NDSFLG = Flag that indicates that the transmission is in drive (1 = Drive).
- OFF_BUT = Flag that indicates that the driver depressed OFF button (1 = Button depressed).
- ON_STATE = Flag that is set equal to zero when VSC is OFF. (1 = Enabled).
- RESUM_BUT = Flag that indicates that RESUME button was depressed (1 = Button Depressed).
- RESUM_STATE = Flag that indicates that the VSC is in RESUME Mode (1 = RESUME Mode).
- VSCCS_ERROR = VSC_Buttons error range identifier.
- VSC_PULSE = Background flag indicating to EOS that a dither pulse is in progress.

Calibration Constants:

- DEBAMP = Minimum IVSCCS amplitude change, counts.
- DEBTIM = Debounce time delay, seconds.
- ACLDED = Maximum increment above MPH to which SET_SPEED can increase, mph.
- ACLINC = Acceleration ramp rate, MPH/sec.
- DCBIAS = DC correction factor.
- HACCEL = Input VSCCS input range, counts.
- HCOAST = Input VSCCS input range, counts.
- HIHOLD = Input VSCCS input range, counts.
- HI_OFF = Input VSC command Switch input range, counts.
- HLDREF = Offset for the Duty Cycle.
- HLDRNG = Error deadband for no pulses required.
- HRESUM = Upper limit for recognition of RESUME request, counts.
- LACCEL = Input VSCCS input range, counts.
- LCOAST = Input VSCCS input range, counts.
- LOWBAT = Minimum Reliable Battery Voltage, volts.
- LOHOLD = Input VSCCS input range, counts.

- LOW_ON = Input VSCCS input range, counts.

- LRESUM = Inputs VSCCS input range, counts.

- MAXVSP = Maximum Vehicle Speed to Enable Vehicle
  Speed Control, MPH.

- MINVSP = Minimum Vehicle Speed to enable Vehicle
  Speed Control, MPH.

- MPHDED = Deadband for Vehicle Speed Control, mph. If the
  actual speed is less than the SET_SPEED - MPHDED,
  then the VSC should be disabled.

- MPHH = Hysteresis term to promote VSC stability.

- NCGSHP = Neutral gear/Clutch switch
  0 = No switches present;
  1 = Either/both switches present.

- SETGN = SET_SPEED proportional gain.

- TAPGN = Throttle position proportional gain.

- TRLOAD = Transmission Load.
  0 = Manual Transmission, no clutch or gerar switches,
  forced neutral state (NDSFLG = 0).
  1 = Manual Transmission, no clutch or gear switch.
  2 = Manual Transmission, one clutch or gear switch.
  3 = Manual Transmission, both clutch and gear switches.
  4 = Auto Transmission, non-electronic, neutral drive switch.
  5 = Auto Transmission, non-electronic, neutral pressure switch,
  (AXOD).
  6 = Auto Transmission, electronic, PRNDL sensor - park, reverse,
  neutral, overdrive, manual 1, manual 2.

- VEHGN = Vehicle Speed proportional gain.

- VSCFRQ = Desired VSC Frequency, Hz.

- VSNMAX = Maximum RPM for vehicle Speed Control function,
  Rev/Min.

- VSTYPE = Vehicle speed sensor cruise control hardware present switch;
  0 = No vehicle speed and no cruise control,
  1 = Vehicle speed sensor, no cruise control (VSS),
  2 = Both vehicle speed sensor and cruise control (VSS+VSC).

OUTPUTS
Registers:

- DEBTMR = IVSCCS debounce timer.

- IVSCCS_LST = Last input vehicle speed control command switch.

- RES_SPEED = Vehicle Control Speed set by Driver, mph.
- SCVAC = Vacuum solenoid used to increase speed.
- SCVNT = Vent solenoid used to decrease speed.
- VSCCS = Vehicle Speed Control Command Switch; input, debounced counts.
- VSC_ERROR = Vehicle Speed Control Error.
- VSC_OFF_COUNT = Number of scheduler passes with output off.
- VSC_ON_COUNT = Number of scheduler passes with output on.

Bit Flags:

- ACC_REQ = Flag set when ACCEL_BUT is depressed.
- ACCEL_BUT = Flag that indicates that the ACCEL button is depressed (1 = ACCEL button depressed).
- ACCEL_STATE = Flag that indicates that the VSC is in ACCEL Mode (1 = ACCEL Mode).
- BRAKE_STATE = Flag that indicates that the Brake has been depressed (1 = Brake depressed).
- COAST_BUT = Flag that indicates that the driver depressed the COAST Button (1 = Button depressed).
- COAST_STATE = Flag that indicates that the driver depressed the COAST Button recently.
- HOLD_STATE = Flag that indicates normal VSC (1 = Stable Speed).
- OFF_BUT = Flag that indicates that the driver depressed OFF button (1 = Button depressed).
- ON_STATE = Flag that is set equal to zero when VSC is OFF. (1 = Enabled).
- RESUM_BUT = Flag that indicates that RESUME button was depressed (1 = Button Depressed).
- RESUM_STATE = Flag that indicates that the VSC is in RESUME Mode (1 = RESUME Mode).
- VSCCS_ERROR = VSC_Buttons error range identifier.
- VSC_PULSE = Background flag indicating to EOS that a dither pulse is in progress.

The VSCCS debounce logic attempts to reject spurious noise on the vehicle speed control input signal. The timer, DEBTMR, is loaded with DEBTIM seconds whenever the last raw input, IVSCCS_LST, differs from the current raw input, IVSCCS, by more than DEBAMP counts. If the current raw input does not change by more than DEBAMP counts over a period of DEBTIM seconds, DEBTMR is allowed to count down to zero. Upon reaching zero, the actual vehicle speed control register, VSCCS, is loaded with the current raw input, IVSCCS.

VSCCS DEBOUNCE LOGIC

```
|IVSCCS_LST - IVSCCS| > DEBAMP ----------| Set DEBTMR = DEBTIM
                                         |  (load debounce timer)
                                         |
                                         | Set IVSCCS_LST = IVSCCS
                                         |  (update last register)

DEBTMR = 0 ------------------------------| Set VSCCS = IVSCCS
```

Vehicle Speed Control Command Switch Logic

The following logic interprets the speed control switch inputs.

```
VBAT > LOWBAT ------------|
 (Check Voltage Range)    |
                          |AND -----| SET OFF_BUT = 1
VSCCS < HI_OFF -----------|         |  (No change to ON_STATE
 (Off Button Depressed)             |   or VSCCS_ERROR)
                                    |
                                    | --- ELSE ---
VBAT > LOWBAT ------------|         |
                          |AND -----| SET COAST_BUT = 1
LCOAST < VSCCS < HCOAST ---|        |  (No Change to ON_STATE
 (COAST button Depressed)           |   or VSCCS_ERROR)
                                    |
                                    | --- ELSE ---
VBAT > LOWBAT ------------|         |
                          |AND -----| SET ACCEL_BUT = 1
LACCEL < VSCCS < HACCEL ---|        |  (No Change to ON_STATE
 (ACCEL button depressed)           |   or VSCCS_ERROR)
                                    |
                                    | --- ELSE ---
VBAT > LOWBAT ------------|         |
                          |AND -----| SET RESUM_BUT = 1
LRESUM < VSCCS < HRESUM ---|        |  (No Change to ON_STATE
 (RESUME button depressed)          |   or VSCCS_ERROR)
                                    |
                                    | --- ELSE ---
VBAT > LOWBAT ------------|         |
                          |AND -----| SET VSCCS_ERROR = 0
LOHOLD < VSCCS < HIHOLD ---|        |  (No Change to ON_STATE)
 (No Buttons depressed)             |
                                    | --- ELSE ---
                                    |
VBAT > LOWBAT ------------|         |
                          |AND -----| SET ON_STATE = 1
VSCCS > LOW_ON -----------|         |  (No Change to
 (ON button depressed)              |   VSCCS_ERROR)
                                    |
                                    | --- ELSE ---
                                    |
                                    | SET ON_STATE = 0
                                    | SET VSCCS_ERROR = 1
                                    |  (Battery Voltage
                                    |   outside permissible
                                    |   range.)
```

If VBAT < LOWBAT, then Battery Voltage is too low; Vehicle Speed Control must be disabled (but NOTE that VBAT is initialized to 12.5 Volts).

NOTE: The VSCCS ranges (HI_OFF, LCOAST, HCOAST, etc.) are defined by EED Vehicle Controls and Convenience Product Systems and Applications Department and should not be changed from the base release values unless they have given specific permission.

VSC SPEED CONTROL LOGIC

The Integrated Vehicle Speed Control was designed to operate in the similar manner as the standalone version (Cruise Control). The driver enables the Speed Control by pressing the ON button. The speed is selected by pressing SET ACCEL or COAST (sets current speed). Continuous depressing of SET ACCEL will increase the speed until released and Coast, of course, will slow it down. Hitting the brake will deactivate it as will shifting the transmission into neutral or turning the Vehicle Speed Control OFF. The speed of the vehicle MUST be above 25 MPH to use Vehicle Speed Control.

The VSC strategy uses a hierarchical State Diagram Logic. In other words, the strategy will enter a particular State if its entry conditions are met and if the entry conditions of a higher priority state are not met. The various states are mutually exclusive (except for ON_STATE). In general, conditions to disable (turn it Off) or otherwise de-activate (put on standby) the VSC are checked first. Redundant Brake condition is the one exception to this rule.

When all other states are equal to zero, the VSC strategy is either in Standby Mode (ON_STATE = 1) or OFF Mode (ON_STATE = 0).

The Vehicle speed Control strategy has three parts:

A. VSC State Determination
B. VSC Duty Cycle
C. VSC Duty Cycle Output Routine
   (Pulsewidth calculation)

A. VSC STATE DETERMINATION

STATE 1 - DRIVER DEPRESSED OFF-BUTTON OR HAS NOT DEPRESSED ON-BUTTON

```
ON_STATE = 0 -------|
 (VSC is OFF)       |OR ---| CLEAR all VSC STATE Flags
                    |      |
OFF_BUT = 1 --------|      | SET RES__SPEED = 0
 (Off But depressed)       | Set ACC_REQ = 0
                           | Set VSC_PULSE = 0
                           | (This forces a 100% duty

                           |  cycle to the Vent Solenoid)
                           |
                           | --- ELSE ---
                           |
                           | Check STATE 2
```

STATE 2 - VEHICLE SPEED OUTSIDE ACCEPTABLE RANGE

If VSC has a fault in the button logic, the Vehicle Speed is outside the normal range of operation; or, the VSC buttons have a fault. In either instance, Standby Mode is entered and all VSC States, except ON_STATE, are cleared and Vehicle Speed Control is exited. However, if none of the "OR GATE" conditions described below is met, the logic runs through a comparison

of factors which should indicate that vehicle speed is within normal range and continues on to check STATE 3.

```
N > VSNMAX -------------------|
                              |
MPH < MINVSP ---------|S Q----|
                      |       |      | Clear All VSC States
MPH > MINVSP + MPHH --|C      |      |  except ON_STATE and
                              |OR ---|  BRAKE_STATE
MPH > MAXVSP ---------|S Q----|      | ACC_REQ = 0
                      |       |      | VSC_PULSE = 0
MPH < MAXVSP - MPHH --|C      |      | (This will force 100%
                              |      |  vent pulse)
VSCCS_ERROR = 1 --------------|      |
                                     | --- ELSE ---
                                     |
                                     | Check STATE 3
```

STATE 3 - BRAKE APPLIED OR TRANSMISSION IN NEUTRAL

When the driver depresses the brake pedal, a flag is set which this logic seeks. If BIFLG is set equal to one (brake depressed), VSC is disengaged, but not turned OFF. The driver may press RESUME to attain the speed set before braking (or disengagement) took place.

```
BIFLG = 0 -------------------|          | Check STATE 4
 (Brake Not Depressed)       |AND -----|
                             |          |
NDSFLG = 1 ----------|       |          |
                     |OR ----|          |
TRLOAD = 0 ----------|                  | --- ELSE ---
                                        |
ACCEL_BUT = 1 ----------|               | Button is stuck;disable VSC
 (ACCEL_BUT depressed)  |               |
                        |               | VSCCS_ERROR = 1
RESUM_BUT = 1 ----------|OR -----------| Set BRAKE_STATE = 1
 (RESUM_BUT depressed)  |               | Clear all other states
                        |               | except ON_STATE
COAST_BUT = 1 ----------|               | ACC_REQ = 0
                                        | VSC_PULSE = 0
                                        | (100% Vent pulse)
                                        |
                                        | --- ELSE ---
                                        |
                                        | (Brake depressed or
                                        |  Transmission in Neutral)
                                        | Set BRAKE_STATE = 1
                                        | Clear all other States
                                        |  except ON_STATE.
                                        | ACC_REQ = 0
                                        | VSC_PULSE = 0
                                        | (100% Vent Pulse)
```

STATE 4 - VEHICLE SPEED IS COASTING DOWN

If the driver needs to slow down, the driver may press COAST until the new, slower speed is reached.

```
COAST_BUT = 1 -----------| SET COAST_STATE = 1
 (COAST But depressed)   | CLEAR all other States
                         |  except ON_STATE.
                         | SET_SPEED = MPH
                         | RES_SPEED = MPH
                         | VSC_PULSE = 0
                         | ACC_REQ = 0
                         |  (100% Vent pulse)
                         |
                         | --- ELSE ---
                         |
COAST_STATE = 1 ---------| Do normal Duty Cycle
 (Driver released button)|  calculation)
                         | SET VSC_PULSE = 1
                         | SET HOLD_STATE = 1
                         | CLEAR all other States
                         |  except ON_STATE
                         | SET SPEED = MPH
                         | RES_SPEED = MPH
                         |
                         | --- ELSE ---
                         |
                         | Check STATE 5
```

NOTE: If the COAST_BUT = 0 and COAST_STATE = 1, the driver wants to stop coasting.

STATE 5 - VEHICLE IS ACCELERATING

This button actually provides two functions. It sets the initial speed the driver chooses to drive; or it can increase the speed if the driver continuously holds it down.

```
ACCEL_BUT = 1 -------------|
 (ACCEL Button depressed)  |
                           |AND ---| SET ACCEL_STATE = 1
ACCEL_STATE = 0 -----------|       | CLEAR all other STATES
 (Entered ACCEL State)             |  except ON_STATE
                                   | SET VSC_PULSE = 1
                                   | (Do Normal Duty Cycle
                                   |  calculation)
                                   | SET_SPEED = MPH
                                   | RES_SPEED = MPH
                                   |
                                   | --- ELSE ---
                                   |
ACCEL_BUT = 1 -------------|       | Set ACCEL_STATE = 1
 (ACCEL Button depressed)  |       | Clear all other States
                           |AND ---|  except ON_STATE
                           |       | SET VSC_PULSE = 1
ACCEL_STATE = 1 -----------|       | (Do normal duty cycle
                                   |  calculation)
                                   | (The SET_SPEED will ramp
                                   |  and cause the vehicle
                                   |  to accelerate)
                                   | RES_SPEED = MPH
                                   |
                                   | --- ELSE ---
ACCEL_BUT = 0 -------------|       |
                           |AND ---| SET HOLD_STATE = 1
ACCEL_STATE = 1 -----------|       | CLEAR all other States
 (ACCEL But no                     |  (except ON_STATE)
  longer depressed)                | SET_SPEED = MPH
                                   | RES_SPEED = MPH
                                   | SET VSC_PULSE = 1
                                   |
                                   | --- ELSE ---
                                   |
                                   | Check STATE 6
```

NOTE: If ACCEL_BUT = 0 and ACCEL_STATE = 1, then exit ACCEL Mode.

STATE 6 - RESUME VEHICLE SPEED TO RES_SPEED VALUE

This button allows the driver to resume the vehicle speed that was set before braking or manually accelerating. It does not store this "former" speed if the VSC is turned OFF (that is the function of Favorite Speed setting when the hardware is installed).

```
RESUM_BUT = 1 ------------|
 (Driver depressed        |
  resume button)          |
                          |
RESUM_STATE = 0 ----------|
                          |
BRAKE_STATE = 1 ----------|AND ----| SET RESUM_STATE = 1
 (Brake was applied)      |        | CLEAR all other states
                          |        | Except ON_STATE
                          |        | SET_SPEED = MPH
RES_SPEED > MINVSP -------|        | SET VSC_PULSE = 1
 (RESUM speed OK)                  |
                                   | --- ELSE ---
                                   |
                                   | Check State 7
```

STATE 7 - ACCEL/DECEL DECISION TO RESUME SPEED

This logic compares the existing speed against the speed the vehicle traveled previous to braking, accelerating or coasting down. It determines whether it needs to increase or decrease speed to meet the former setting.

```
RESUM_STATE = 1 -------|        | Set RESUM_STATE = 1
                       |AND ----| Clear all other States except
MPH < RES_SPEED -------|        |  ON_STATE
                                | Set VSC_PULSE = 1
                                | Set ACC_REQ = 1
                                | (Ramp speed up)
                                |
                                | --- ELSE ---
                                |
RESUM_STATE = 1 ----------------| SET HOLD_STATE = 1
                                | CLEAR all other States
                                |  except ON_STATE.
                                | ACC_REQ = 0
                                | VSC_PULSE = 1
                                |  (Do normal D.C. Calculations)
                                | SET_SPEED = RES_SPEED
                                |
                                | --- ELSE ---
                                |
                                | Check STATE 8 logic
```

STATE 8 - MAINTAIN VEHICLE SPEED

HOLD State keeps the VSC at the most recent setting. It allows a very narrow band of fluctuation and functions until the driver depresses a button.

```
HOLD_STATE = 1 -------------|       | Set HOLD_STATE = 1
                            |AND --| Clear all other States
SET_SPEED <OR= MPH+MPHDED --|       |  except ON_STATE
                                    | Set VSC_PULSE = 1
                                    |
                                    | --- ELSE ---
                                    |
HOLD_STATE = 1 --------------------| SET BRAKE_STATE = 1
                                    | CLEAR all other States
                                    |  except ON_STATE.
                                    | SET VSC_PULSE = 0
```

SET_SPEED RAMP FOR RESUME STATE AND ACCEL STATE

This logic ramps the SET_SPEED up to RES_SPEED at a rate of ACLINC MPH/sec, to provide smooth acceleration. The rate of acceleration is clipped to MPH as a minimum to prevent the SET_SPEED from lagging.

```
ACCEL_REQ = 1 -----|
                   |OR ----|
ACCEL_BUT = 1 -----|       |
                           |AND ---| SET_SPEED = SET_SPEED
SET_SPEED >OR=             |       | + ACLINC* (Time since
 MPH - ACLDED -------------|       |           last update)
                                   |
                                   | --- ELSE ---
ACCEL_REQ = 1 -------------|       |
                           |OR ----| SET_SPEED = MPH
ACCEL_BUT = 1 -------------|
```

B. VSC_DC OUTPUT ROUTINE

For purposes of Strategy Description, the VSC_DC OUTPUT Routine is divided into two subroutines: VSC_DC Calculation and DUTY CYCLE OUTPUT.

VSC_DC CALCULATION

The VSC_DC is based on the difference between the set speed and the actual vehicle speed with some adjustments for relative throttle position. The calculation is done in two steps to more closely model the analog system.

```
VSC_PULSE = 1 ---------| VSC_ERROR = DCBIAS + [SETGN * SET_SPEED]
                       |  - [VEHGN * MPH] - TAPGN * (TP - RATCH)
                       |
                       | --- ELSE ---
                       |
                       | VSC_ERROR = 0 (This will force VENT action)
```

VSC_DC = VSC_ERROR - HLDREF

NOTE: DCBIAS, SETGN, VEHGN, TAPGN, HLDRNG and HLDREF are hardware constants. Any changes to the base values should be co-ordinated through the Vehicle Controls and Convenience Products Systems and Applications Engineering Dept, EED.

```
|VSC_DC| < HLDRNG ---------------| Hold position
                                 | VSC_DC = 0
                                 | (Turn OFF SCVAC)
                                 | (Turn ON SCVNT)
                                 |
                                 | --- ELSE ---
                                 |
VSC_DC < 0 ----------------------| Slow Down
                                 | VSC_DC = |VSC_DC|
                                 | (Turn OFF SCVAC)
                                 | (Duty cycle to SCVNT = VSC_DC)
                                 |
                                 | --- ELSE ---
                                 |
                                 | Speed Up
                                 | (Turn ON SCVNT)
                                 | (Duty cycle to SCVAC = VSC_DC)
```

VSC_ON_COUNT = VSC_DC/(VSCFRQ * 1 * 10E-3)

VSC_OFF_COUNT = (1-VSC_DC) / (VSCFRQ * 1*10E-3)

OUTPUT to appropriate solenoid.

Fixed Frequency/Variable Pulsewidth

The Fixed Frequency/Variable Pulsewidth method "best fits" the duty cycle (ON_TIME) to 10 msec. (If VSCFRQ = 100) period which is divided into 10 "slices". Each of these 10 slices is equal to 1 msecs (10E-6 seconds). ON_TIME is "rounded" up or down to the nearest integer.

Example of Fixed Frequency/Variable Pulsewidth Method

```
ON_TIME   +-+-+-+-+-+-+-+           +-+-+-+-+-+-+-+
          |             |           |
          |             |           |
OFF_TIME -+             +-+-+-+-+-+-+
          |<--5.0 ms -->|<-5.0 ms ->|
```

50% Duty Cycle

CHAPTER 16

RIDE CONTROL STRATEGY

ADJUSTABLE SHOCK ABSORBER OUTPUT

OVERVIEW

The adjustable shock absorber module is a stand alone module, separate from the EEC IV, which controls shock absorber firmness. The EEC IV output ACL provides an indication of vehicle acceleration to the shock control module. Other inputs to the shock module come directly from the appropriate sensor (VSS brake input, etc.). The ACL output will be energized under engine running conditions by the logic shown below to indicate hard acceleration. The ACL output may also be energized during key on, engine off conditions by a high TP value in order to verify wiring harness integrity during VIP.

```
HPACL = 0 ---------------------------------| No change
                                           | Exit Logic
CRKFLG = 0 ----------|                     |
 (Underspeed/Run     |                     | --- ELSE ---
  Mode)              |AND ----|            |
                     |        |            | Set ACL = 1
ARCHG >OR= SHKCHG ---|        |OR ---------| (energize ACL output-
 (high engine load)           |            |  hard acceleration)
                              |            |
TP >OR= RATCH+SHKTP ----------|            | --- ELSE ---
 (large throttle opening)                  |
                                           | Set ACL = 0
                                           | (deenergize ACL output)
```

DEFINITIONS

INPUTS

Registers:

- ARCHG = Air Charge Mass inducted per Intake Stroke, lbm/Intake.

- TP = Instantaneous Throttle Position, counts.

- RATCH = Lowest filtered Throttle Position, counts.

Bit Flag:

- CRKFLG = Indicates status of engine, if = 1, engine is in CRANK mode.

Calibration Constants:

- HPACL = Hardware present switch to indicate if module includes output for adjustable shock absorber. 1 = Hardware present.

- SHKCHG = Minimum ARCHG value to indicate if hard acceleration. Typical value: .00015

- SHKTP = Minimum number of throttle counts above the closed throttle position (RATCH) to indicate hard acceleration. Typical value: 650 counts.

OUTPUT

Bit Flag:

- ACL = Provides an indication of vehicle acceleration to the shock control module.

CHAPTER 17

ELECTRONICALLY CONTROLLED ACCESSORY DRIVE

ELECTRONICALLY CONTROLLED ACCESSORY DRIVE (ECAD)

OVERVIEW

The Electronically Controlled Accessory Drive (ECAD) module is a stand alone unit. It determines alternator demand, and if alternator demand will allow half speed accessory drive operation, the module inputs a signal to the EEC-IV processor. This signal is essentially asking EEC to check certain additional conditions, necessary before half speed mode can be allowed. If these conditions (outlined below) do exist, EEC outputs a signal to the ECAD module telling it to operate at half speed. The ECAD module then actuates half speed operation.

The following conditions are checked in every case:

- ECAD unit is asking for half speed mode
- ECT is below a maximum temperature
- Engine speed is above a minimum RPM, and
- Vehicle speed is above a minimum value.

Additionally, if the system has Thermactor Air (THRMHP = 1), the progam checks that an upstream air condition does not exist. On non-thermactor systems, the program checks that a minimum temperature and time since start-up has been reached.

DEFINITIONS

INPUTS

Registers:

- ECT = Engine Coolant Temperature.
- N_BYTE = Engine speed, RPM.
- VSBAR = Filtered Vehicle Speed.

Bit Flags:

- ECADI = Input from stand alone ECAD module to EEC: 0 -> full speed mode only; 1 -> half speed mode allowed.
- USAFLG = Upstream air flag: 0 -> not in upstream air; 1 -> in upstream air.

Calibration Constants:

- ECADECT = ECT threshold for ECAD. If the ECT is greater than ECADECT, then the ECAD unit must be in full speed mode.
- ECADHP = Hardware present switch for ECAD: 1 -> ECAD hardware present.

- ECADN = RPM threshold for ECAD. If N_BYTE is greater than ECADN, then the ECAD unit may go into half speed mode.

- ECADVS = Vehicle speed threshold for ECAD. If VS is greater than ECADVS, then the ECAD unit may go into half speed mode.

- EDETHYS = ECAD ECT hysteresis term = ECADECT - bandwidth.

- EDNHYS = ECAD RPM hysteresis term = ECADN - bandwidth.

- EDTM1 = ATMR1 ECAD time delay for TCSTRT <OR= CTLOW.

- EDTM2 = ATMR1 ECAD time delay for CTLOW < TCSTRT < CTHIGH.

- EDTM3 = ATMR1 ECAD time delay for TCSTRT >OR= CTHIGH.

- EDTM4 = ATMR2 ECAD time delay for TCSTRT <OR= CTLOW.

- EDTM5 = ATMR2 ECAD time delay for CTLOW < TCSTRT < CTHIGH.

- EDVSHYS = ECAD VS hysteresis term = ECADVS - bandwidth.

OUTPUTS

Bit Flags:

- ECADOT = Output from EEC to ECAD stand alone unit: 0 -> half speed mode; 1 -> full speed mode.

PROCESS

```
ECADHP = 0 --------------------------| NO CHANGE
 (no ECAD hardware)                  | EXIT LOGIC
                                     |
AFMFLG = 0 ---|                      | --- ELSE ---
              |                      |
CFMFLG = 0 ---|                      |
              |AND ------------|     |
TFMFLG = 0 ---|                |     |
              |                |     |
MFMFLG = 0 ---|                |     |
 (not in failure mode)         |     |
                               |     |
THRMHP = 1 ------|             |     |
 (thermactor air |AND -|       |     |
  system)        |     |       |     |
                 |     |OR ----|     |
USAFLG = 0 ------|     |       |     |
                       |       |     |
"A" --------|          |       |     |
            |AND ------|       |     |
THRMHP = 0 -|                  |     |
                               |     |
ECADI = 1 ---------------------|AND -| HALF SPEED MODE
                               |     | Clear ECADOT
ECT < ECADECT ----------|S  Q -|     |
 (over temp protection) |      |     | --- ELSE ---
                        |      |     |
ECT > EDETHYS ----------|C     |     | FULL SPEED MODE
                               |     | Set ECADOT
N_BYTE > ECADN --|S  Q --------|
 (RPM > min RPM) |             |
                 |             |
N_BYTE < EDNHYS -|C            |
                               |
VSBAR > ECADVS ----|S  Q ------|
 (VS > minimum VS) |
                   |
VSBAR < EDVSHYS ---|C
```

When there is no Thermactor air system, the ECAD operates at full speed before a minimum temperature and time start-up is reached.

```
TCSTRT >OR= CTHIGH -|
                    |AND ------|
ATMR1 < EDTM3 ------|          |
                               |
CTLOW < TCSTRT < CTHIGH -|     |
                         |AND -|OR -----| "A"
ATMR1 < EDTM2 -|         |     |
               |OR ------|     |
ATMR2 < EDTM5 -|               |
                               |
TCSTRT <OR= CTLOW --|          |
                    |AND ------|
ATMR1 < EDTM1 -|    |
               |OR -|
ATMR2 < EDTM4 -|
```

CHAPTER 18

SHIFT INDICATOR LIGHT

DEFINITIONS

INPUTS

Registers:

- N = Engine RPM.

- SLTMR = Shift Light Timer.

Bit Flags:

- CRKFLG = Flag indicating state of engine mode.

Calibration Constants:

- FN651 = Incremental Indicated RPM shift point as a function of ECT.

- FN652A = Indicated RPM shift point as a function of LOAD.

- SHIRPM = Overspeed RPM.

- SLTIM1 = Time delay to validate the Shift Indicator Light, sec.

- SLTIM2 = Maximum time that SIL (shift indicator light) is on, sec.

- SPTRPM = Minimum RPM at which SIL timer enables.

- TSTRAT = Transmission Strategy Switch,
  The TSTRAT software switch selects which transmission control strategy is to be executed.

```
TSTRAT = 0 -> No transmission control;
              (Manual trans., AOD, ATX, C6, C3, etc.),
       = 1 -> SIL (Shift Indicator Light),
       = 2 -> A4LD with 3-4 shift control and convertor
              clutch control,
       = 3 -> AXOD,
       = 4 -> C6E4 (E4OD),
       = 5 -> A4LD-E
       = 6 -> FAX-4,
       = 7 -> AOD-E (AOD-I),
       = 8 -> 4EAT,
       = 9 -> CD4E.
```

OUTPUTS

Registers:

- SLTMR = See Inputs above.

SHIFT INDICATOR LIGHT LOGIC (TSTRAT = 1)

Shift Indicator Light refers to the light located in the instrument cluster. The light is used to signal the driver when to up-shift on a manual transmission for best fuel economy.

The strategy turns the shift light on when either of the following conditions are met:

1) Engine RPM is greater than an "over speed" calibration value; or

2) The shift light timer SLTMR is between a lower calibration value and an upper calibration value.

Control of SLTMR (and the shift light) is based on engine RPM and load. The SLTMR counts up when engine RPM goes above a trigger value. The trigger value varies as a function of LOAD and ECT (engine coolant temperature). The time delay before the shift light turns on eliminates light flicker due to RPM jitter about the trigger value. The upper time limit prevents driver annoyance.

LIGHT ON/OFF LOGIC

```
N > SHIRPM --------------------|
                               |OR -|
SLTIM1 < SLTMR <OR= SLTIM2 ----|    |
                                    |AND -| TURN ON SHIFT LIGHT
TSTRAT = 1 ------------------------|      |
                                    |     | --- ELSE ---
CRKFLG = 0 ------------------------|      |
                                          | TURN OFF SHIFT LIGHT
```

NOTE: The calibration parameter, TSTRAT, selects the appropriate transmission strategy. The Shift Indicator Light strategy will execute only if TSTRAT = 1.

SLTMR LOGIC

```
N > SPTRPM -------------|
                        |OR ----|
N > FN651 + FN652A -----|       |AND ---| COUNT UP SLTMR
                                |       |
PART THROTTLE Mode -------------|       | --- ELSE ---
                                        |
                                        | Set SLTMR = 0
```

CHAPTER 19

INPUT CONVERSIONS AND FILTERS

DEFINITIONS

INPUTS

Registers:

- ACT = Air charge temperature.

- AELOAD = Filtered LOAD for manifold filling effect.

- AIR37 = The maximum air charge for a particular engine speed(N) as described by FN037.

- AM = Air Mass Flow, lbm/min.

- AMINT = Integrated Air Mass flow (lbm).

- APT = Throttle Mode Flag.

- ARCHCOR = Backflow correction for Mass Air Meter.

- ARCHG = Air Charge Mass inducted per Intake Stroke, lbm/Intake.

- ARCHLI = Air charge leakage (lbm/intake).

- BAPBAR = Rolling average of barometric pressure sensor values.

- BAPCNT = BAP transition counter.

- BAPTMR = Barometric pressure update, msecs.

- BPKFLG = Update enable flag for key on updates, unitless.

- DEBTMR = VSCCS Debounce timer, sec.

- DATA_TIME = 3 byte time of transition.

- DSDRPM = Desired RPM (from ISC logic).

- ECT = Coolant temperature, deg F.

- EGO = Exhaust Gas Oxygen Sensor.

- EM = EGR mass flow, lbm/min.

- EPTBAR = Rolling average EPT Transducer.

- EPTZER = EPT sensor value at idle.

- EVP = EGR valve position, counts.

- FAM = Filtered air mass.

- HEGO = Heated Exhaust Gas Oxygen Sensor. (EGO and HEGO provide the same function, See HEGO Section in this Chapter)

- IACC_NDS = AC Clutch/Neutral-Drive input.

- IACT = Voltage output by the ACT sensor converted to counts, A/D.

- IBAP = Instantaneous BP sensor reading (FN000)

- IECT = Voltage output by the ECT sensor converted to counts, A/D.

- IEGO = Voltage output by the EGO (or HEGO Sensor) converted to counts, A/D.

- IEPT = EPT sensor data for PFE EGR.

- IIVPWR = Ignition key-on power (A/D counts).

- IMAF = Input Air Meter Reading, A/D counts.

- INTM = Delta time between Air Meter Samples, sec.
  = current Sample time - Last Sample time.

- ITAR = Voltage output by TAR converted to A/D counts.

- IVCAL = Calibration input voltage used to correct MAF and VBAT (A/D counts).

- IVSCCS = Input VSC command switch.

- KNK_HIGH = Knock level input flag.

- LOAD = Normalized ARCHG/SARCHG.

- MAF = Instantaneous Mass Air flow (lbm/min).
  (MAF = FN036 (VMAF))

- MAFCON = MAF voltage correction gain calibrated for the particular EEC processor in use.
  (MAFCON = VCAL / MAFK1)

- MAF_TIME = OUTINT 1 time for MAF fuel.

- MPH = Rolling average Vehicle Speed.

- MINTIM1 = Last SCAP edge prior to the background calculation of BAP.

- MINTIM2 = Last SCAP edge prior to the previous SCAP edge prior to the background loop calculation of BAP.

- MPHCNT = MPH sensor transition count.

- MPHTIM1 = Last MPH transition time.
- MPHTIM2 = First MPH transition time.
- N = RPM - engine speed in revolutions per minute.
- NBAR = Rolling average RPM.
- NDBAR = Filtered Engine Speed.
- NDDTIM = Timer which tracks time since Neutral/Drive (Drive/Neutral) Switch State change, sec.
- N_BYTE = Single precision (BYTE) engine speed, Rev/Min. It is used whenever possible to save memory.
- OLDTP = The last value of TP.
- PINPT = Pressure input switch, 0 = 1st, 2nd, 3rd gear; 1 = 4th gear.
- PINPT2 = Pressure input switch, 0 = 1st, 2nd gear; 1 = 3rd, 4th gear.
- PIPCNT = Number of PIPs which have occurred.
- PIP Period = Amount of time between consecutive PIP signals.
- PSPS = Power Steering Pressure Switch.
- PUTMR = Counts up after hardware reset.
- RATCH = Kicker off lowest filtered TP.
- RAWAIRCHG = Raw Air charge from the air mass integration.
- TP = Throttle position.
- TBART = Rolling average of TP for Knock Strategy.
- TPBAR = Rolling average Throttle Angl.
- VBAT = Battery Voltage.
- VMAF = Corrected Air Meter Voltage (volts).
  VMAF = (IMAF/IVCAL + MAFK2) * MAFCON
- VSBAR = Filtered Vehicle Speed.

Bit Flags:

- BPUFLG = Keyon update flag in RAM, unitless.

- CRKFLG = Crank Flag.

- DNDSUP = Drive/Neutral Select.

- FAM_FLG = Flag indicating in FAM region and AM = FAM.

- INDFLG = AXOD Instantaneous N/D Flag.

- KAM_ERROR = Indicates Keep Alive RAM invalid.

- KNOCK_DETECTED = Flag set to 1, if knock occurred in current PIP half-period.

- KNOCK_OCCURRED = Flag set to 1 (in the Knock Interrupt routine), if knock occurred in current or last PIP period.

- NDSFLG = Neutral/Drive Flag 1 = Drive.

- PTPFLG = PIP occurred after 50 msec.

- REFFLG = 1 when in idle air flow region.

- UNDSP = Underspeed Flag.

Calibration Constants:

- AMDESN = Desired RPM threshold to enter Idle AM logic, RPM.

- AMRPM = Actual RPM (byte) threshold to enter Idle AM logic.

- AMRPMH = RPM (byte) threshold hysteresis.

- ARCHLK = Air flow leakage (lbm/min).
- BIHP = Brake Input Hardware Switch.
- BPSSW = Calibration switch:
  1 = Barometric pressure sensor
  0 = No sensor (use constant BP value)
- CTEHI = Calibration constant for minimum ECT (engine coolant temperature) to enable EPTZER at idle, degrees F.
- DEBTIM = Debounce time delay, secs.
- DELRAT = Change in RATCH.
- DELTAM = Air Mass Delta to enter/exit filtered AM at Idle.
- ENGCYL = Number of PIPs per Engine Revolution; or Number of Intake Strokes Per Engine Revolution. (Number of cylinders/2)

- EPTSW = Calibration switch to enable or disable rolling average EPTZER at idle.

- FAMLIM = Multiplier for FAM deadband.

- FN000 = Frequency versus pressure data; used in conversion of frequency to pressure.
  X-input = frequency
  Y-output = Pressure, "Hg.

- FN036 = Mass Air Transfer function as a function of corrected Air Mass Sampling voltage (VMAF).
  Input = Calculated MAF sensor voltage;
  Output = Mass Air Flow (Lb/min).

- FN037 = A function that relates engine speed to maximum air charge.

- FN394F = Time delay before recognition of N/D Transition
  - forward gear Input = ECT; OUTPUT = Seconds.

- FN394R = Time delay before recognition of N/D Transition
  - reverse gear Input = ECT; OUTPUT = Seconds.

- FN703A = ECT/ACT Transfer function. Input = A/D converter counts and Output = temperature, deg F.

- FN1035(N,LOAD) = Air Meter Backflow Correction Table.
X-input = FN070 - Normalized engine speed, RPM
Y-input = FN021 - Normalized LOAD
Output = LOAD.

- IDLDEL = A/D count equivalent to Idle back pressure, "H2O * IXFRPR, counts.

- IERPMH = Idle RPM hysteresis term for EPTZER update.

- KONBP = BP constant used in absence of sensor. Range of 0 to 31.875.

- KSF = Keypower Scaling Factor; a calibration constant which has historically been 3.731; this value can be changed on VECTOR to satisfy the requirements of different processors; a newer value for KSF is 5.5991; the user should check with the EEC Design Group to determine which value for KSF is applicable to a specific processor level.

- MAFK1 = Universal Mass Air Flow Voltage Correction Gain, unitless. (0 <OR= MAFK1 <OR= 1.99)
- MAFK2 = Universal Mass Air Flow Voltage Correction Offset, unitless. (1.0 <OR= MAFK2 <OR = 1.99)
- MAXFAM = Difference between FAM & AMPEM at idle.
- MINAM = Minimum Air Mass Clip, lb air/min.

- MNPIP4 = Minimum PIP period for 4-cylinder engine, clock ticks.
- MNPIP6 = Minimum PIP period for 6-cylinder engine, clock ticks.
- MNPIP8 = Minimum PIP period for 8-cylinder engine, clock ticks.
- NDDELT = Time before N/D, D/N switch registers, Range of 0 to 31.875.
- NRUN = Minimum engine speed to exit Crank mode.
- PFEHP = Switch to select EGR strategy: 1 = PFE; 0 = Sonic.
- SAMRAT = Sample rate for AM filter.
- SARCHG = Standard Air Charge, lb.
  = 4.4256 * 10E-5 * (Engine Size in Cubic Inches/number of cylinders).
- TCAELD = Time constant for AELOAD, sec.
- TCBBAR = Time constant for BAPBAR, sec.
- TCDASD = Time constant for DSTPBR, sec.
- TCDASU = Time constant for DSTPBR, sec.
- TCDESN = Time constant for DESNLO, sec.
- TCDLOP = Time constant for DELOPT, sec.
- TCDP = Time constant for DESDP, sec.
- TCEACT = Time constant for EGR ACT, sec.
- TCECT = Time constant for ECT, sec.
- TCEGR = Time constant for EGRBAR, sec.
- TCEPT = Time constant for EPT, sec.
- TCFAM = Time constant for FAM, sec.
- TCINJD = Time constant for INJDLY, sec.
- TCMPH = Time constant for MPH, sec.
- TCN = Time constant for N, sec.
- TCNDBR = Time constant for NDBAR, sec.
- TCTP = Time constant for TPBAR, sec.
- TCTPT = Time constant for TBART, sec.
- TCVBAT = Time constant for VBAT, sec.

- TCVS = Time constant for VSBAR, sec.
- TKYON1 = Minimum time delay before PIPs are recognized, sec.
- TKYON2 = Time delay before Keyon Updates are permitted, sec.
- TKYON3 = Maximum time keyon updates are allowed, sec.
- TKYON4 = Time delay before resetting BPKFLG, sec.
- TPDLTA = Minimum TP change for Tip-Out. Range 0 to 1023.
- TSTALL = Elapsed time necessary to indicate a stall, msec.
- VBPMAX = Maximum time since last BP update, secs.
- VCAL = Calibration constant; the value is normally 2.5 volts; this value can be changed on VECTOR to satisfy the requirements of certain processors.

OUTPUTS

Registers:

- ACT = Air charge temperature.
- AELOAD = Filtered LOAD for manifold filling effect.
- AM = Air Mass Flow, lbm/min.
- AMINT = Integrated Air Mass flow (lbm).
- ARCHG = Air Charge Mass inducted per Intake Stroke, lbm/Intake.
- ARCHCOR = Backflow correction for Mass Air Meter.
- ARCHI = Air Charge (lbm/intake), foreground corrected integrated value.
- BAPBAR = Rolling average of barometric pressure sensor values.
- BAPCNT = BAP transition counter.
- BP = Barometric pressure value stored in volatile RAM.
- BPKFLG = Update enable flag for key on updates, unitless.
- ECT = Coolant temperature, deg F.
- EPTBAR = Rolling average EPT Transducer.
- EPTZER = EPT sensor value at idle.

- EVP = EGR valve position, counts.

- FAM = Filtered air mass.

- FAMREG = 0; not in FAM region.
  128; in FAM region, AM = N * ENGCYL * ARCHG
  255; in FAM region, AM = FAM

- IBAP = Instantaneous BP sensor reading (FN000)

- IEPT = EPT sensor data for PFE EGR.

- INTM = Delta time between Air Meter Samples, sec.
  = current Sample time - Last Sample time.

- LST_IACC = Last ACC/NDS input.

- MAF_TIME = OUTINT 1 time for MAF fuel.

- MINTIM1 = Last SCAP edge prior to the background
  calculation of BAP.

- MINTIM2 = Last SCAP edge prior to the previous SCAP
  edge prior to the background loop calculation
  of BAP.

- MPH = Rolling average Vehicle Speed.

- MPHCNT = MPH sensor transition count.

- MPHTIM1 = Last MPH transition time.

- MPHTIM2 = First MPH transition time.

- NBAR = Rolling average RPM.

- NDBAR = Filtered Engine Speed.

- RATCH = Kicker off lowest filtered TP.

- RAWAIRCHG = Raw Air charge from the air mass
  integration.

- TAR = Throttle Angle Rate of change.

- TPBAR = Rolling average Throttle Angl.

- VBAT = Battery Voltage.

- VMAF = Corrected Air Meter Voltage (volts).
  VMAF = (IMAF/IVCAL + MAFK2) * MAFCON

- VSBAR = Filtered Vehicle Speed.

- VSCCS = Debounced IVSCCS.

Bit Flags:

- A3C = A/C Flag, 1 = ACC on.
- BIFLG = Brake on.
- BPUFLG = Keyon update flag in RAM, unitless.
- DNDSUP = Drive/Neutral Select.
- EGOFL1 = Rich EGO-1 Flag.
- EGOFL2 = Rich EGO-2 Flag.
- INDFLG = AXOD Instantaneous N/D Flag.
- KNOCK_OCCURRED = Flag set to 1 (in the Knock Interrupt routine), if knock occurred in current or last PIP period.
- NDSFLG = Neutral/Drive Flag 1 = Drive.
- POWSFG = Power Steering Flag.
- PTPFLG = PIP occurred after 50 msec.
- REFFLG = 1 when in idle air flow region.

MULTIPLEXED ACC_NDS INPUT - (Analog Input)

The ACC input reflects the state of the A/C Cycling Switch. As a multiplexed input, however, the logic also includes setting of the Neutral Drive Switch. This switch reflects the change in transmission states (i.e., neutral/park, drive/in gear). Automatic transmissions use a Neutral/Drive switch from the transmission; Manuals use a clutch switch, gear switch or no switch. A clutch or gear switch is recommended for manuals. Among its many uses (primarily fuel control), it is most heavily used in controlling Idle Speed. The output sets a flag (NDSFLG) equal to one if the transmission is in gear (or drive) and equal to zero if the transmission is in neutral.

A diagram follows the logic set forth below which explains the "steps" or settings.

```
|IACC_NDS - LST_IACC| > 10 ----------| Could be NOISE
                                     | DO NOT UPDATE A3C
                                     |  or NDS
                                     | LST_IACC = IACC_NDS
                                     |
                                     | --- ELSE ---
                                     |
IACC_NDS >OR= 952 -------------------| Neutral/Drive input is high
                                     |  A/C OFF
                                     | INDFLG = 1
                                     | A3C = 0
                                     | LST_IACC = IACC_NDS
                                     |
                                     | --- ELSE ---
                                     |
IACC_NDS >OR= 556 -------------------| Neutral/Drive input is low
                                     |  A/C OFF
                                     | INDFLG = 0
                                     | A3C = 0
                                     | LAST_IACC = IACC_NDS
                                     |
                                     | --- ELSE ---
                                     |
IACC_NDS >OR= 412 -------------------| Neutral/Drive input is high
                                     |  A/C ON
                                     | INDFLG = 1
                                     | A3C = 1
                                     | LST_IACC = IACC_NDS
                                     |
                                     | --- ELSE ---
                                     |
                                     | Neutral/Drive input is low
                                     | A/C ON
                                     | INDFLG = 0
                                     | A3C = 1
                                     | LST_IACC = IACC_NDS
```

```
IACC_NDS                 FLAG STATE
(counts)
                      -----------------
  1023                |               |
                      |   INDFLG = 1  |
                      |   A3C = 0     |
                      |               |
   952                -----------------
                      |               |
                      |   INDFLG = 0  |
                      |   A3C = 0     |
                      |               |
   556                -----------------
                      |               |
                      |   INDFLG = 1  |
                      |   A3C = 1     |
                      |               |
   412                -----------------
                      |               |

                      |   INDFLG = 0  |
                      |   A3C = 1     |
                      |               |
     0                -----------------
```

LOAD CALCULATION (LOAD)

OVERVIEW

Air charge is normalized by dividing by Standard Air Charge. Standard Air Charge is a constant equal to 4.4256 * 10E-5 * (Engine Size in Cubic Inches/number of cylinders).

DEFINITIONS

INPUTS

Registers:

- ARCHG = Air Charge Mass inducted per Intake Stroke, lbm/Intake.

- SARCHG = Standard Air Charge, lbm/Intake.

OUTPUTS

Registers:

- LOAD = Normalized load parameter, unitless.

PROCESS

LOAD = ARCHG/SARCHG

PERCENT LOAD CALCULATION (PERLOAD)

OVERVIEW

PERLOAD is percent of peak load at any altitude.

DEFINITIONS

INPUTS

Registers:

- LOAD = Normalized load parameter, unitless.
- N = Revolutions per minute.
- BP = Barometric Pressure, in Hg.

Calibration Constants:

- FN035(N) = Peak load at sea level as a function of RPM.

OUTPUTS

Registers:

- peak_load_sl = Output of FN035(N), temporary register.
- PERLOAD = Percent of peak load at any altitude.
- PEAK_LOAD =Peak load at any altitude and RPM.

PROCESS

always: PEAK_LOAD = BP/29.9 * peak_load_sl

```
PRLDSW = 0 --------| PERLOAD = LOAD/PEAK_LOAD
                   |
                   | --- ELSE ---
                   |
                   | PERLOAD = LOAD
```

ACCEL ENRICHMENT LOAD FILTER (AELOAD)

The AELOAD calculation is a time-dependent rolling average filter of LOAD. It is used to sense the manifold filling effect during an acceleration, especially from Idle. The AELOAD time constant TCAELD is a calibration constant which should be small enough to prevent a false inference of manifold filling after the LOAD has reached a stable value and AE fuel is no longer required.

AELOAD = UROLAV (LOAD,TCAELD)

DEFINITIONS

INPUTS

Registers:

- RAWAIRCHG = Integrated MAFS output over a PIP period.
- N = RPM.

Bit Flags:

- IMFMFLG = Instantaneous mass air flow sensor FMEM flag.

Calibration Constants:

- ARCHSW = Air charge select switch, 0 = no filtering, 1 = use filling model.
- FN037 = Backflow clip.
- FKARCH = Manifold filling model slow filter constant.
- FILFRC = Fraction to select slow transient vs fast. transient filter.
- FKARC1 = Fast filter constant for manifold filling.

OUTPUTS

Registers:

- ARCHG = Actual air charge.
- ARCHFG = Filtered air charge according to filling model.
- ARCHI = Instantaneous air charge.
- FILRC1 = Ratio ARCHI/ARCHFG, background calculation for calibration purposes.

The strategy integrates the instantaneous airflow, MAF, over each PIP period. To calculate the average air charge, ARCHG, this integration is accomplished by summing the average MAF over a finite period of time.

The air meter sample period starts at each rising PIP edge. Successive samples are then obtained at fixed intervals of approximately one msec. This

sampling continues until the next rising PIP edge occurs (at which time the final sample is taken). The MAF sensor is described in the EEC Overview Chapter.

```
             n = n
             -----
             \
AMINT =      /     1/2*[MAF(n) + MAF(n-1) ] (Tn - T(n-1))
             -----
             n=1
```

ARCHG = Final AMINT when integration is complete.

AIRFLOW INTEGRATION SCHEME

```
      |<------------------ PIP PERIOD --------------------->|

      |------------------------                            |---
      PIP UP                  |                        PIP UP
      EDGE                    |                          EDGE
      |                       |                            |
  ----                        ------------------------------

                         CORRECTED AIR METER SAMPLES
                                MAF;(LBM/MIN)


      |       |        * * * *     |              |         |   *  |
      |   * * |* * * *    |     * * |              ************ *   |
      ** *   1|         2|        3* * * * * * * 4|/////////|      |
      |       |          |         |              |/////////|      |
      |       |          |         |              |//AREA*//|      |
      |       |          |         |              |/////////|      |
      |       |          |         |              |/////////|      |
-------------------------------------------------------------------------
     T0      T1         T2        T3 .....      T(n-1)      Tn   T(n+1)
```

MAF(n) = Instantaneous MAF at time, Tn.

AREA* = Instantaneous integrated Air Charge.
(AREA = 1/2[MAF(n) + MAF(n-1)]*(Tn - T(n-1))

At time T(n+1), the sum of the AREA*s, AMINT, is stored as RAWAIRCHG and then set to 0. Approximately every millisecond, the software will do an A/D conversion of the MAF sensor input, calculate the instantaneous airlow, MAF and update AMINT (the instantaneous integrated aircharge).

Once every millisecond:

```
VMAF = IMAF * 2.5/IVCAL                                __ volts
INTM = DATA_TIME - MAF_TIME                            __ clock ticks
AMINT = prev. AMINT + 1/2 * [MAF + FN036] * INTM       __ lbm
MAF = FN036(VMAF)                                      __ lbm/clock ticks
MAF_TIME = DATA_TIME                                   __  clock ticks
```

At each rising-edge of PIP, the software will do an A/D conversion of the MAF sensor, calculate the instantaneous airflow, MAF, and store the final integrated AMINT as RAWAIRCHG.

At each rising edge of PIP, 1) Complete the integration, 2) Start the next integration, 3) Correct airflow for pulsations, 4) Filter the aircharge for manifold filling effects.

```
1) VMAF = IMAF * 2.5/IVCAL                                __ volts
   INTM = DATA_TIME - MAF_TIME                            __ clock ticks
   AMINT = prev. AMINT + 1/2 * [MAF + FN036] * INTM       __ lbm
   MAF = FN036(VMAF)                                      __ lbm/clock ticks
   MAF_TIME = DATA_TIME                                   __ clock ticks
   RAWAIRCHG = AMINT                                      __ lbm/intake
2) AMINT = 0                                              __ lbm
```

3) During low engine speed operation, intake pressure pulsing may produce backflow through the air meter. Backflow is misinterpreted as positive air flow by the MAF sensor, which inflates the air mass values. To prevent erroneous ARCHI calculations due to backflow, the strategy clips ARCHI to AIR37 as a maximum value.

In the foreground at the PIP interrupt at the completion of the airmeter integration, and perform the following:

```
RAWAIRCHG * ARCHCOR
+ ARCHLI <OR=  AIR37  -----------------------| ARCHI = RAWAIRCHG * ARCHCOR
                                             |          + ARCHLI
                                             |
                                             | ---- ELSE ----
                                             |
                                             | ARCHI = AIR37
```

In background, evaluate FN037, where the input is N (engine speed) and the output is AIR37.

AIR37 = FN037(N)

In background, look up the airflow correction for pulsation:

ARCHCOR = FN1035(N,LOAD)

In background, calculate the aircharge offset for leakage, ARCHLI (lbm/intake). The calibration constant, ARCHLK (lbm/min), includes all leakage terms not measured by the air flow meter (such as PCV, CANP, EVR solenoid, etc.) Typical calibration value is 0.15 lbm/min for 5.0L.

ARCHLI (lbm/intake) = ARCHLK (lbm/min) / N * ENGCYL

MANIFOLD FILLING MODEL

OVERVIEW

Because of the delays associated with manifold filling, the airflow through a meter mounted up- stream of the throttle body is not equal to the port airflow on an instantaneous basis. This leads to fueling errors during transients. To compensate for these errors, a filtering algorithm was developed.

When the throttle body airflow changes slowly, the filling filter constant is proportional to engine displacement/manifold volume and volumetric efficiency. A close approximation is an air charge filter constant, FKARCH, that is proportional to (VEFF) * (engine displacement/manifold volume)/ (2 * ENGCYL).

During a fast tip-in the air charge can be approximated by a different filter constant. The constant, FKARC1 is proportional to 1/2 * (VEFF) * (engine displacement/manifold volume)/ENGCYL, however the volumetric efficiency at wide open throttle is used.

4) In the foreground at the PIP interrupt at the completion of the ARCHI clip (item 3 above), filter the instantaneous aircharge using the Manifold Filling Model:

```
                       FOREGROUND FILTERED AIR CHARGE
                       ------------------------------

ARCHSW = 0  ------------------------| ARCHFG = ARCHI
 (no filter on archg)               |
                                    | ---- ELSE ----
                                    |
ARCHI/ARCHFG <OR= FILFRC -----------| ARCHFG = (1-FKARCH) * ARCHFG +
 (fast vs. slow transient)          |          FKARCH * ARCHI
                                    | (slow transient archg filter)
                                    |
                                    |
                                    | --- ELSE ---
                                    |
                                    | ARCHFG = (1-FKARC1) * ARCHFG +
                                    |          FKARC1 * ARCHI
```

Air charge is the air mass inducted per intake stroke. Once per background loop, the strategy updates ARCHG to the most recent integration, ARCHFG.

In the background calculations:

```
IMFMFLG = 0 -----------| ARCHG = ARCHFG
                       | FILRC1 = ARCHI/ARCHFG
                       |
                       | --- ELSE ---
                       |
                       | ARCHG update is calculated during
                       | MAF sensor FMEM. See FMEM logic.
                       | ARCHFG = ARCHG
```

Note: ARCHG update can be inhibited during MAF sensor FMEM. See FMEM logic.

CALIBRATION EXAMPLES:

Slow filter:

```
FKARCH ~ (VEFF) * (engine displacement/manifold volume)/(2 * ENGCYL)



        Assume:
                ENGCYL     = 3
                VEFF       ~ 0.60
                eng.disp.  = 231 in.3 (3.8L super charge)
                man.vol.   = 1200 in.3 (    "    )
                FKARCH     = (0.6)*(231/1200) / 2*3
                           = 0.019
        Note:
                As the manifold volume gets smaller the ratio,
                engine displacement/manifold volume gets larger
                and the 'slow' filter becomes very fast.
```

Fast filter:

```
FKARC1 ~ (VEFF) * (engine displacement/manifold volume)/(2 * ENGCYL)


        Assume:
                VEFF       = 0.80   (wide open throttle)
                FKARC1     = (0.80)*(231/1200)/2*3
                FKARC1     = 0.026
```

AIR CHARGE TEMPERATURE SENSOR (ACT)

FN703A (IACT) is the transfer function for the air charge temperature sensor. It converts from raw A/D counts to degrees F. IACT is the raw A/D counts from the ACT sensor.

Air Mass (AM)

Determine Air Mass (AM) value:

```
REFFLG = 0 ---------------| AM = (N * ENGCYL * ARCHG)
                          |
                          | --- ELSE ---
                          |
FAM_FLG = 1 --------------| AM = FAM
                          | where:
                          |    MINAM <OR= AM <OR=
                          |        (N * ENGCYL * ARCHG * MAXFAM)
                          |
                          | --- ELSE ---
                          |
                          | AM = (N * ENGCYL * ARCHG)
                          | where:
                          |    MINAM <OR= AM
```

The barometric pressure will be read with a sensor, or alternatively, a constant value will be used (KONBP). A calibration switch is used to indicate that a sensor is to be read.

```
BPSSW = 1 ---------------------------| BP = BAPBAR
                                     |
                                     | --- ELSE ---
                                     |
                                     | BP = KONBP
```

BAROMETRIC PRESSURE FILTER (BAPBAR)

The BAPBAR calculation is a time-dependent rolling average filter of Barometric pressure BAP. The BAPBAR time constant TCBBAR is a calibration constant.

BAPBAR = UROLAV (IBAP,TCBBAR)

See BP FMEM logic in the FMEM chapter.

INSTANTANEOUS BAROMETRIC PRESSURE (IBAP) (BPSSW = 1)

The BAP calculation is a conversion of the SCAP (Digital BAP) sensor period into the corresponding barometric pressure. BAP is updated each background loop, using the largest even number of SCAP transitions which have occurred since the last update. The following parameters have been redefined but have an equivalent in MX strategy.

GX	MX
IBAP	MAP
BAPCNT	MAPCNT
BAPCNTFLG	MAPCNTFLG
BAPTMR	MAPTMR
VBPMAX	VMPMAX
BAPBAR	MAPBAR

Upon each SCAP transition:

```
SCAP TRANSITION -----------------| Set BAPCNT = BAPCNT + 1
                                 | Set MINTIM1 = Time of Scap
                                 |  Transition
                                 | Set MDELTA = Time since last
                                 |  transition
```

If the BP sensor was detected faulty, reset the counters:

```
BAPTMR > VBPMAX -----|           | Set BAPCNT = 0
                     |OR --------| Set MINTIM2 = Clock
MDELTA < VBPDL1 -----|
```

When BAP update is required:

```
BAPCNT is odd ------------------| Set BAPCNT = BAPCNT - 1
                                | Set MINTIM1 = MINTIM1 - MDELTA
                                | Set BAPCNTFLG = 1


BAPCNT NOT= 0 -------------------| Set IBAP = FN000 (BAPCNT/2*
                                 |    (MINTIM1 - MINTIM2))
                                 | Set MINTIM2 = MINTIM1
                                 | Set BAPCNT = 0


BAPCNTFLG = 1 -------------------| Set BAPCNT = 1
                                 | Set BAPCNTFLG = 0
```

BAPTMR is a free-running timer which is set to zero after a SCAP transition, during the background routines. See timer chapter.

BATTERY VOLTAGE FILTER (VBAT)

The VBAT calculation is a time-dependent rolling average filter of

instantaneous battery voltage. The VBAT time constant TCVBAT is not a calibration constant and is set to produce a 0.1 second VBAT average time constant.

VBAT = UROLAV (VBAT',TCVBAT)

Instantaneous Battery Voltage is calculated from:

VBAT' = IIVPWR * VCAL * KSF/IVCAL

BOO - BRAKE ON/OFF (Digital input)

This input is the voltage of the vehicle brake and stop lamp circuitry. If the Brake input hardware is present, a flag named BIHP is set to 1. If the switch is not present in the system, then BIHP ijs set to 0.

```
BIHP = 1 ---------------------|
                              |AND -----| Brake Applied
BOO HIGH ---------------------|         | BIFLG = 1
                                        |
                                        | --- ELSE ---
                                        |
                                        | Brake Not Applied
                                        | BIFLG = 0
```

ENGINE COOLANT TEMPERATURE SENSOR (ECT)

FN703A (IECT) is the transfer function for the ECT sensor. It converts from raw A/D counts to degrees F. IECT is the raw A/D counts from the ECT sensor.

ENGINE COOLANT TEMPERATURE FILTER (ECT)

The ECT calculation is a time-dependent rolling average of instantaneous engine coolant temperature. The ECT time constant TCECT is calibratable.

ECT = ROLAV (FN703A(IECT),TCECT)

EGR POSITION FILTER (EGRBAR) (PFEHP = 0)

The EGRBAR calculation is a time dependent rolling average filter of instantaneous EGR valve position EVP. It is updated each background pass while in RUN or UNDERSPEED mode. The EGRBAR time constant TCEGR is a calibration parameter.

EGRBAR = UROLAV (EVP,TCEGR)

EGR POSITION RATCHET (E0FF) (PFEHP = 0)

The lowest filtered EGR position EOFF is controlled by the following logic:

```
EGRBAR < EOFF -------------|
                           |
CRKFLG = 0 ----------------|AND ---| SET EOFF = EGRBAR
 (RUN or UNDERSPEED mode)  |
                           |
APT = -1 ------------------|
 (closed throttle mode)
```

IDLE DOWNSTREAM PRESSURE (EPTZER) LOGIC

```
CRKFLG = 1 --------------------| EPTBAR = EPTZER
                               |
                               | --- ELSE ---
                               |
APT = -1 ---------------|      | Idle EPTZER Update
                        |      |
N <OR= DSDRPM + IERPMH -|      | EPTZER =
                        |AND --|        ROLAV (IEPT,TCEPT)
EPTSW = 1 --------------|      |
                        |      |
ECT >OR= CTEHI ---------|      | --- ELSE ---
                               |
                               | EPTBAR =
                               |        ROLAV (IEPT,TCEPT)
                               |
                               | No Update to EPTZER
```

KEY ON EPTZER UPDATE (PFEHP = 1)

EPTZER is a KAM register. Conditions for EPTZER update are similar to those for Inferred BP. The same enabling logic may be used. BPUFLG is the BP update enable flag.

```
BPUFLG = 0 -------------|
  (Power reset may      |
   have occurred)       |
                        |
PTPFLG = 1 -------------|OR ------| Do NOT Update
  (PIP Occurred)        |         |  EPTZER
                        |         |
PUTMR < TKYON2 ---------|         |
  (Too soon to update)  |         | --- ELSE ---
                        |         |
PUTMR > TKYON3 ---------|         |
  (Too late to update)            | Conditions are
                                  |  appropriate for update
                                  |
IEPT > VEPTLL -----------|        | EPTZER =
                         |AND ----|        ROLAV (IEPT+IDLDEL,TCEPT)
IEPT < VEPTHL -----------|        |
                                  | --- ELSE ---
                                  |
                                  | Sensor out of range
                                  | Initialize EPTZER
                                  | EPTZER = 650
```

GX does not have Inferred BP, therefore, the following logic needs to be defined for GX.

```
PUTMR < TKYON1 --------------| Ignore any PIPs; probably
                             |   due to noise transients
                             | PTPFLG = 0


PUTMR < TKYON1 --------------|
                             |AND ---| Allow Key On updates
KAM_ERROR = 1 ----|          |       | BPUFLG = 1
                  |OR -------|
BPKFLG = 0 -------|
 (Not a reset)


PUTMR > TKYON2 --------------|
                             |AND ---| Begin ECTCNT for TCSTRT
ECTCNT = 0 ------------------|       | Calculation
                                     | TCSTRT = Arithmetic average
                                     | of the first 8 consecutive
                                     | ECT readings (ECTCNT is the counter)


UNDSP = 0 -------------------|
  (RUN Mode)                 |AND ---| Enable Key On updates
                             |       | for next startup
ATMR1 > TKYON4 --------------|       |
                                     | BPKFLG = 0
```

EVP - EGR VALVE POSITION SENSOR (PFEHP = 1)
(Analog Sensor)

The EVP sensor provides a signal proportional to the valve position. As a rule of thumb, pintle position (percent of Full Travel) is equal to (IEVP - EOFF)*0.14.

The strategy converts pintle position (counts) into EGR mass flow (EM), in the EGR strategy.

HEGO - HEATED EXHAUST GAS OXYGEN SENSOR (Analog Input)

The HEGO sensor is a modified (it is connected to a power and a ground wire) EGO sensor and provides the same functions as the EGO. The modification allows it to heat up more quickly than the unmodified EGO sensor (approximately 18 seconds versus 80 seconds), thus providing an earlier Closed Loop operation on a cold start. This modification also allows it to operate at cooler locations in the exhaust system providing greater flexibility in sensor packaging. Associated with this property is more accurate sampling of the exhaust when the HEGO may be placed closer to the catalytic converter.

There is a slightly longer transport delay between EGO switch and fuel injection changes which may cause a longer "tracking" effect, but the bottom line is the ability to elicit a more even and accurate sampling.

Additionally, the more stable sensor temperature of the HEGO is known to keep contaminants away from the sensor, reducing degradation of the sensor over 50K miles. It also avoids the EGO cool-down during Idle which occurs with the normal EGO.

```
IEGOn > 855 ------------------| HEGO is Lean
                              | EGOFLn = 0
                              |
                              | --- ELSE ---
                              |
                              | HEGO is Rich
                              | EGOFLn = 1
```

NOTE: The A/D conversion of the "HEGO" is inverse to the analog signal (low signal translates to high counts). Low Oxygen level = Rich gas = High voltage (approximately 1.0 volt); High Oxygen level = Lean gas = Low voltage (approximately 0.0 volt).

KS - KNOCK SENSOR
(Digital Input)

KS is an accelerometer tuned to measure engine vibration over a range within which knock typically occurs. KS is mounted on a strategic location of the engine structure. The following logic is checked every PIP up-edge BEFORE calculating the SPOUT.

KNOCK DETECTION LOGIC

```
KNOCK_DETECTED = 1 ---------|
                            |AND ---| Set KNOCK_OCCURRED = 1
KNK_HIGH = 1 ---------------|       |
  (KI currently indicating          | --- ELSE ---
   knock)                           |
                                    |
KNOCK_DETECTED = 1 ---------|       | KNOCK_OCCURRED = 1
                            |AND ---| KNOCK_DETECTED = 0
KNK_HIGH = 0 ---------------|       |
  (KI currently indicating          | --- ELSE ---
   NO knock)                        |
                                    | KNOCK_OCCURRED = 0
```

MNPIPn - PIP FILTER

The PIP filter ignores PIP transitions which occur at a higher rate than the maximum possible engine RPM. (The maximum possible engine RPM is generally assumed to be the RPM at which the valves begin to "float".)

MNPIPn = 60/(ENGCYL*"MAXRPM") * "Clock Freq"/36

```
n = 4 for a 4-cylinder engine  MNPIP4 = 1923 at 15 MHz
n = 6 for a 6-cylinder engine  MNPIP6 = 1282 at 15 MHz
n = 8 for a 8-cylinder engine  MNPIP8 =  961 at 15 MHz
```

NOTE: MNPIP should correspond to an RPM which is greater than the speed at which the strategy turns off the Fuel (Speed Limiter). The base values are equivalent to 6500 RPM.

ENGINE SPEED CALCULATION (N and N_BYTE)

The engine speed calculation converts the PIP period (time between consecutive PIP signals) into the equivalent engine speed (N) in revolutions per minute (RPM). The calculation is done each background loop.

N_BYTE = N = 30/PIP PERIOD (4-cylinder, ENGCYL = 2)

N_BYTE = N = 20/PIP PERIOD (6-cylinder, ENGCYL = 3)

N_BYTE = N = 15/PIP PERIOD (8-cylinder, ENGCYL = 4)

NOTE:

1) If the PIP period becomes >OR= TSTALL, N and N_BYTE are set to zero. This insures that if the PIP signal goes away because of a stall, N and N_BYTE will become zero to trigger CRANK mode.

2) A comparison of N and N_BYTE is shown below:

	N	N_BYTE
Precision:	double (word)	single (byte)
Range:	0 to 7000+	0 to 4080
Resolution:	.25	16
Units:	RPM	RPM
Initial Value:	0	0

ENGINE SPEED FILTER (NBAR)

The NBAR calculation is a time-dependent rolling average filter of instantaneous engine speed N. It is updated each background pass while in RUN or UNDERSPEED mode. The NBAR time constant TCN is calibratable.

NBAR = UROLAV (N,TCN)

ENGINE SPEED FILTER (NDBAR)

The NDBAR calculation is a time dependent rolling average filter of instantaneous engine speed N. It is updated each background pass while in RUN or UNDERSPEED mode. The NDBAR time constant TCNDBR is a calibration parameter.

NDBAR = UROLAV (N,TCNDBR)

INDS INPUT - NEUTRAL/DRIVE SWITCH INPUT

OVERVIEW

This input reflects the applied transmission load to the engine, ie. neutral/park, drive/in gear.

- Manual transmissons can be configurated with a clutch and gear switch, a clutch switch only, a gear switch only, or neither switch. The input therefore can be used to determine a neutral state (trans in neutral or clutch depressed) versus in gear state. If neither clutch or gear switch is used, the 5 volt module pull up provides an "in gear" indication which can be overridden by proper selection of the TRLOAD software switch. (Set TRLOAD = 0).

- Non-electronic automatic transmissions typically have a two state switch which indicates neutral or drive. All transmissions except the AXOD use a mechanical switch connected to the gearshift lever. Drive is indicated by a 5 volt signal, neutral is indicated by a 0 volt signal. AXOD are unique in that instead of using a Neutral/Drive switch, the AXOD uses a Neutral Pressure switch. This is a hydraulic switch which senses hydraulic pressure in the forward clutch. The voltage indicated by the NPS is opposite to that indicated by the NDS. Drive is indicated by 0 volts and neutral is indicated by 5 volts (except in overdrive). The NPS must be used in conjunction with the two other transmission hydraulic switches (THS 2/3 and THS 3/4) to properly decode neutral, forward, and reverse states.

- Electronic automatic transmissions typically use a 6 position PRNDL sensor to determine the operator selected gear. The PRNDL sensor is a ratiometric sensor with six discrete resistors in series. The sensor is decoded by looking at the differing voltages produced by each of the PRNDL positions.

The engine control strategy typically requires information on the current state of engine loading. This is prioviided by NDSFLG. If NDSFLG = 1, the engine is loaded (trans. in gear or in drive). If NDSFLG = 0, the engine is unloaded (trans. in neutral or clutch depressed). DNDSUP, the delayed neutral/drive flag contains exactly the same information as NDSFLG except that it is delayed (see FN394 F/R, NDDTIM, etc.) in an attempt to match PRNDL movement with actual application of transmission load. (Manual transmission automatically get a 0 delay time).

NDSFLG or DNDSUP are typically used in idle speed control mode select and air flow computations, fuel enrichment on auto transmission neutral/drive transitions, adaptive fuel, decel fuel shutoff and vehicle speed control (as well as VIP).

DEFINITIONS

INPUTS

Registers:

- INDS = IACC_NDS = Raw input from A/D in counts. Indicated transmission state.

- NDDTIM = Timer which tracks time since Neutral/Drive switch state change, sec.

Bit Flags:

- INDFLG = Instantaneous Neutral/Drive flag.

- NDSFLG = For automatic transmissions: 1 = PRNDL indicates in gear, 0 = PRNDL indicates neutral. For manual transmissions: 1 = clutch out and/or transmission in gear, 0 = clutch in and/or transmission in neutral.

Calibration Constants:

- FN394F(ECT) = Time delay before transmission engages - forward gear.

- NDDELT = Time delay before N/D to D/N switch registers in DNDSUP.

- TRLOAD = Transmission Load switch.
  - 0 = Manual Transmission, no clutch or gear switches, forced neutral state (NDSFLG = 0).
  - 1 = Manual Transmission, no clutch or gear switch.
  - 2 = Manual Transmission, one clutch or gear switch.
  - 3 = Manual Transmission, both clutch and gear switches.
  - 4 = Auto Transmission, non-electronic, neutral drive switch.
  - 5 = Auto Transmission, non-electronic, neutral pressure switch, (AXOD).
  - 6 = Auto Transmission, electronic, PRNDL sensor - park, reverse, neutral, overdrive, manual 1, manual 2.

OUTPUTS

Bit Flags:

- DNDSUP = Delayed neutral drive indication. For automatic transmissions: 1 = transmission is in gear, 0 = transmission is in neutral. For manual transmissions: DNDSUP = 0.

- NDSFLG = For automatic transmissions: 1 = PRNDL indicates in gear, 0 = PRNDL indicates neutral. For manual transmissions: 1 = clutch out and/or transmission in gear, 0 = clutch in and/or transmission in neutral.

NDSFLG - INSTANTANEOUS (NON-DELAYED) TRANSMISSION STATE

```
INDFLG = 0 ------------|
                       |OR ---| Set NDSFLG = 0
TRLOAD = 0 ------------|      |  (neutral state)
 (forced neutral)             |
                              | (Zero NDDTIM timer on
                              |  the transition)
                              |
                              | --- ELSE ---
                              |
                              | Set NDSFLG = 1
                              |  (drive/loaded state)
                              |
                              | (Zero NDDTIM timer on
                              |  the transition)
```

DNDSUP FLAG LOGIC

The DNDSUP flag is used to delay the strategy response to a "PRNDL" change until the transmission actually shifts. The transmission shift response is inferred using a time delay since the PRNDL change.

```
NDDTIM >OR= NDDELT ----------| DNDSUP = NDSFLG
                             |
                             | --- ELSE ---
                             |
                             | No Change to
                             | DNDSUP
```

DNDSUP - DELAYED TRANSMISSION STATE

```
Neutral Indication --------------|
 (NDSFLG = 0)                    |AND ---|
                                 |       |
Transmission Disengaged --|      |       |
 (NDDTIM >OR= NDDELT)     |OR ---|       |
                          |              |OR --| Set DNDSUP = NDSFLG
TRLOAD <OR= 3 ------------|              |     |  (Update delayed
 (Manual Transmission)                   |     |   Neutral/Drive flag)
                                         |
Drive Indication ----------------|       |
 (NDSFLG = 1)                    |AND ---|
                                 |
Transmission Engaged -----|      |
 (NDDTIM >OR= FN394F)     |      |
                          |OR ---|
TRLOAD <OR= 3 ------------|
 (Manual Transmission)
```

Automatic Transmission:

DNDSUP delays strategy recognition of a transmission shift until the transmission actually engages or disengages (regardless of the state of the gear switch (or pressure switch) inputs). The time delay, FN394F is dependant upon the type of transmission used. Therefore, calibration of these functions should be coordinated with the appropriate transmission development activity.

Manual Transmission

If TRLOAD = 0, NDSFLG is forced to 0, therefore DNDSUP is always 0. If TRLOAD is 1,2 or 3, DNDSUP will follow the state of NDSFLG with no time delay.

PIP - PROFILE IGNITION PICKUP (Digital Input)

The PIP Sensor is the Hall Effect Sensor. The Hall Effect Sensor outputs a square wave pulse producing one profile pulse of the narrow band of the cycle being sampled. A discrepancy exists between the Hall Effect Sensor and PIP since PIP is not precisely a 50 percent duty cycle. The software has been designed to accomodate this difference providing greater accuracy by use of the KAY factor. The timer which keeps track of the time since last PIP (TSLPIP) functions with 0.001 second resolution. An example of PIP's use in Knock control is shown below.

N(RPM) = 60/(ENGCYL * "PIP PERIOD")

"PIP PERIOD" has units of secs.
If the PIP period (time elapsed since the last PIP signal) becomes greater than or equal to TSTALL (800 msec), the engine speed RPM is set to zero. This insures that if the PIP signal goes away because of a stall, RPM will become zero to trigger CRANK mode.

PIP COUNTER CONTROL LOGIC

```
CRKFLG = 1-----|
 (CRANK mode)  |AND ----| Count PIP signals as they occur.
               |        |  (PIPCNT is the counter)
N > NRUN ------|        |
                        |
                        | --- ELSE ---
                        |
                        | Stop counting PIP signals
                        | PIPCNT = 0
```

```
************            *************
*          *            *           *
*          *            *           *
*          *            *           *
*          *            *           *
*          **************           ************

| <-------------------> |

PIP up edge to PIP up edge
        filter

| <-----> |

PIP up edge to PIP down edge
        filter
```

In the EEC-IV system, there is a method of noise blanking to eliminate some of the noise that occurs on the PIP input. There is a PIP up edge to PIP up edge filter. An interval value is usually picked out of a table and is in the units of clock ticks. The equivalent millisecond value of this time corresponds to some high value of engine rpm. If a PIP up edge follows a previous PIP up edge at an interval less than this time, then that PIP up edge is ignored, and treated as noise.

The table value (TABVAL) is divided by four and is used to filter the PIP up edge to PIP down edge interval. If the computed time from the PIP down edge to the previous PIP up edge is less than (TABVAL/4), then that PIP down edge is ignored.

A typical value for the table value would be the equivalent time interval for the PIP input at maximum engine rpm. For an 8 cylinder engine, the value would be: 2.5 milliseconds (833 clock ticks for 12 mhz). In GU, the calibration values are MNPIPn. They are defined in this chapter where MNPIPn is described.

PSPS - POWER STEERING SWITCH (Available but NOT currently used) (Digital Input)

PSPS is a switch which opens/closes based on the level of the power steering pressure. If the pressure is greater than, or equal to that exerted by the switch the circuit is opened; if the switch is closed (PSPS is greater than pressure) then a signal is output of 0.4 Volts direct current or less.

```
PSPS LOW ------------------------| No Power Steering Load
                                 | POWSFG = 1
                                 |
                                 | --- ELSE ---
                                 |
                                 | Power Steering Load
                                 | POWSFG = 0
```

TAR - THROTTLE ANGLE RATE
(Analog Input)

TAR input comes from an analog differentiator circuit which is fed by the TP Sensor (Described below). Units of TAR are degrees per second. TAR is an important factor in controlling the amount of fuel injection as well as a vital part of Idle Speed control. Both NQ and MX provide this function through a hardware/software combination, while 9X uses a software TAR.

```
OLDTP - TP > TPDLTA ----------| TAR = 0
                              |
                              | --- ELSE ---
                              |
                              | TAR = (655 - ITAR)/5.42
```

TP - THROTTLE POSITION SENSOR
(Analog Input)

TP sensor is a rotary ratiometric device responding to the throttle shaft position outputting a voltage which is high if the TP angle is great and small when the TP angle is small. TP sensor measures a range of 0-50 degrees of throttle movement. One degree of throttle travel is equal to approximately 9.6 counts.

THROTTLE POSITION FILTER (TPBAR)

The TPBAR calculation is a time-dependent rolling average filter of instantaneous throttle position (TP). It is updated each background pass while in RUN or UNDERSPEED mode. The TPBAR time constant, TCTP, is calibratable parameter.

TPBAR = UROLAV (TP,TCTP)

THROTTLE POSITION FILTER (TBART)

The TBART calculation, used in the Knock Strategy, is a time-dependent rolling average filter of instantaneous throttle position (TP). It is updated each background pass while in RUN or UNDERSPEED mode. The TBART time constant, TCTPT, is calibratable parameter.

TBART = UROLAV (TP,TCTPT)

THROTTLE POSITION RATCHET (RATCH)

The throttle position ratchet (RATCH) continuously seeks a lower value for both throttle angle breakpoints, CLOSED THROTTLE/PART THROTTLE and PART THROTTLE/WOT, by seeking the lowest filtered throttle angle (TPBAR). The algorithm is not used during CRANK mode.

```
CRKFLG = 0 -----------------|
                            |         | RATCH = TPBAR
TPBAR <OR= RATCH -----------|AND -----|
                            |         | --- ELSE ---
N > 450 RPM ----------------|         |
                                      | NO CHANGE TO RATCH
```

VSS - VEHICLE SPEED SENSOR
(Digital Input)

VSS is part of the EEC system and is used also by the dashboard computer. VSS is a digital input whose frequency is proportional to vehicle speed (similar to relationship of PIP signal to RPM).

VS CALCULATION

The vehicle speed sensor signal frequency is proportional to the vehicle speed. The sensor frequency varies from 0 to 280 Hz.

VEHICLE SPEED = 0.45 / (VSS Period)

The strategy updates VS once per background loop if the sensor voltage crossed zero volts (MPHCNT > 0) during the previous background loop.

DURING VEHICLE SPEED SENSOR INTERRUPT:
(Rising Edge Only)

MPHCNT = MPHCNT + 1
MPHTIM1 = Clock Time

```
IF FIRST_MPH = 0 ---| MPHTIM1 = Clock Time, FIRST_MPH = 1
                    |
                    | --- ELSE ---
                    |
                    | MPHCNT = MPHCNT + 1
                    | MPHTIM1 = Clock Time
```

Once per background, the following logic is executed.

```
TSLMPH >OR= 255 msec -------| Set FIRST_MPH = 0
                            | VS = 0
                            | MPHTIM2 = MPHTIM1
                            |
                            | --- ELSE ---
                            |
MPHCNT > 0 -----------------| VS = 0.45 * MPHCNT/
                            |  (MPHTIM1 - MPHTIM2)
                            | MPHCNT = 0
                            | MPHTIM2 = MPHTIM1
                            |
                            | --- ELSE ---
                            |
                            | Do NOT Update VS
                            | MPHTIM2 = MPHTIM1
```

NOTE: The software will handle the unit conversion from clock ticks to seconds (1 tick = 3.0*10E-6 sec, 12 MHz EEC; 1 tick = 2.4*10E-6 sec, 15 MHz EEC)

VSCCS - VEHICLE SPEED CONTROL COMMAND SWITCH
(Analog Input)

The VSCCS is the output of a voltage divider network. The range of the VSCCS output is selected by the vehicle's driver by means of steering wheel-mounted switches. The software uses a timer to debounce the switch input. If the instantaneous input IVSCCS is stable, the VSCCS register is updated.

```
DEBTMR >OR= DEBTIM ------|
                         |AND ---| VSCCS = IVSCCS
VSCHP = 1 ---------------|
```

VEHICLE SPEED (MPH)

The MPH calculation is a time-dependent rolling average filter of instantaneous vehicle speed, VS. The MPH time constant, TCMPH, is a calibratible parameter.

MPH = UROLAV (VS,TCMPH)

VEHICLE SPEED (VSBAR)

VSBAR calculation is a time-dependent rolling average filter of instantaneous vehicle speed, VS. The time constant, TCVS, is a calibratible parameter.

VSBAR = UROLAV (VS,TCVS)

ROLLING AVERAGE ROUTINE (ROLAV/UROLAV)

OVERVIEW

The EEC-IV filters inputs using a rolling average routine. This routine requires a time constant, a sampling rate, an old average, and a new value to compute the new average. The equation is:

```
NEW AVERAGE = FILTER CONSTANT * NEW VALUE + (1 - FILTER CONSTANT) *
              OLD AVERAGE
```

where FILTER CONSTANT = 1/(1 + TIME CONSTANT / SAMPLE PERIOD); the sampling period is the time elapsed between new calculations. For most filters, the sampling period will equal the background loop time. The time constant is a function of the input being filtered. When the (NEW VALUE - OLD AVERAGE) * FILTER CONSTANT is less than the bit resolution of new average, the old average is incremented or decremented by 1 bit per calculation until the new average equals the old average. The strategy will specify rolling average filters using the following structure:

```
Set new_avg      = (U)ROLAV(new_value,time_const)
where new_avg    = output of rolling average filter
      ROLAV      = signed rolling average routine
      UROLAV     = unsigned rolling average routine
      new_value  = input value to filter
      time_const = time constant
```

DEFINITIONS

INPUTS

Registers:

- TCxxxx = Time constant (seconds).
- FK_TMR = sampling period (seconds).
- old average = Last output from filter routine.
- new value = Most recent value of input to be filtered.

OUTPUTS

Registers:

- new average = Latest filtered value.

```
FKxxxx = 1/[1 + (TCxxx/FK_TMR)]


 -1 Bit < FKxxxx * (new value - old average) < 0 -| new average =
                                                  |  old average - 1 bit
                                                  |
                                                  | --- ELSE ---
                                                  |
0 < FKxxxx * (new value - old average) < 1 Bit ---| new average =
                                                  | old average  + 1 bit
                                                  |
                                                  | --- ELSE ---
                                                  |
                                                  | new average =
                                                  |  old average +
                                                  | FKxxxx * (new value -
                                                  |           old average)


Note:  If (new value - old average) equals zero,
       then new average = old average.
```

INPUT LIST FOR ROLLING AVERAGE FILTER ROUTINE

new value	old average	FK_TMR	TCxxxx
LOAD	AELOAD	BG_TIMER	TCAELD
BAP	BAPBAR	BG_TIMER	TCBBAR
FN703A(IECT)	ECT	BG_TIMER	TCECT
IEPT+IDLDEL	EPTZER	BG_TIMER	TCEPT
IEPT	EPTZER	BG_TIMER	TCEPT
IEPT	EPTBAR	BG_TIMER	TCEPT
N	NDBAR	BG_TIMER	TCNDBR
N	NBAR	BG_TIMER	TCN
TP	TPBAR	BG_TIMER	TCTP
VS	VSBAR	BG_TIMER	TCVS
FN1341	INJDLY	BG_TIMER	TCINJD
CINTV	INJDLY	BG_TIMER	TCINJD
INJDLY'	INJDLY	BG_TIMER	TCINJD
FN221+EOFF	DELOPT	BG_TIMER	TCDLOP
DP'	DESDP	BG_TIMER	TCDP
DSDRPM	DESNLO	BG_TIMER	TCDESN
AM	FAM	FFMTMR	TCFAM
ACT	ECT	BG_TIMER	TCECT
IEGO	EGOBAR	BG_TIMER	TCVEGO (VIP)
IEPT	CFIEPT	BG_TIMER	VTCEPT (VIP)
EVP	EGRBAR	BG_TIMER	TCEGR
TP	TBART	BG_TIMER	TCTPT
VBAT'	VBAT	BG_TIMER	TCVBAT
VS	MPH	BG_TIMER	TCMPH
EGRACT'	EGRACT	BG_TIMER	TCEACT
TP	DSTPBR	BG_TIMER	TCDASD
TP	DSTPBR	BG_TIMER	TCDASU

CALIBRATION PHILOSOPHY

1) The values for the time constants in the base calibration were calculated using the filter constants in the base calibration an assumed background loop time of 25 msec, and the following equation:

   time constant = [(1/filter constant) - 1] * sampling period.

   (Sample period approximately equals background loop time for most filters. FAM is the exception.)

2) Several filter constants are currently non-calibratable. With this EMR (8-092), the time constants for these become calibratable. The effective time constants for these have been increasing as the background loops have increased. This could develop into some problems in the calibration if the time constants were to suddenly change, so the values in the base calibration are equal to the current effective time constant (assume 25 msec loop time).

3) In previous releases the filter constant was the calibration parameter. This gave an increasing time constant as rpm (loop time) increased. Now the time constant is fixed. All filters will act differently with the implementation of EMR 8-092.

CHAPTER 20

TIMERS

TIMER SUMMARY

TIMER	DESCRIPTION
ACBTMR	A/C Clutch Brake Timer (sec)
ACCTMR	Time since A/C Clutch Cycled (sec)
ACITMR	A/C Clutch Idle Turn-on Delay Msec Timer (msec)
ACWTMR	Time since A/C WOT Mode (sec)
ADPTMR	Adaptive fuel timer (sec)
ATMR1	Time since start (time since exiting crank mode) (sec)
ATMR2	Time since engine coolant temperature became greater than TEMPFB (sec)
ATMR3	Time since Entering RUN Mode (sec)
A3CTMR	Time between A3C state changes.
BAPTMR	Time since last BP sensor interrupt (msec)
CRKTMR	Time in CRANK Mode (sec)
CTATMR	Closed Throttle Upstream Air Timer (sec)
CTNTMR	Closed Throttle mode neutral timer (sec)
CTTMR	Time at closed throttle timer (sec)
DEBTMR	Vehicle Speed Command Switch Debounce Timer (sec)
DLTMR	Decel fuel low load timer, sec.
EDFTMR	Electro-Drive Fan Timer (sec)
FFMTMR	FAM filter timer (sec)
HLTMR	High LOAD timer (sec)
HMTMR	Timer limiting Upstream Air (sec)
HWTMR	Time at which A3CTMR remains below threshold.
LESTMR1	EGO-1 lack of switching timer (sec)
LESTMR2	EGO-2 lack of switching timer (sec)
LUGTMR	LOM load transition timer (sec)
MFATMR	Managed Fuel/Air timer (sec)

MULTMR	Time since incrementing LAMMUL (msec)
NACTMR	Time not at closed throttle (sec)
NDDTIM	Time since neutral/drive switch state change (sec)
NWOTMR	Not at Wide Open Throttle Timer. (sec)
PRGTMR	Canister purge accumulation timer (sec)
PUTMR	Time since CPU power-up (msec)
TSEGRE	Accumulated time EGR is enabled (sec)
TSLPIP	Time since last PIP (msec)
WCOTMR	A/C Clutch WOT Cutout Timer (sec)

INPUTS

Registers:

- APT = Throttle mode flag (-1 = closed throttle; 0 = part throttle; 1 = wide open throttle)
- BP = Barometric absolute pressure.
- ECT = Engine coolant temperature, deg. F.
- EDF = Electro drive fan flag, if set to 0, energized.
- IVSCCS = A/D Conversion of the speed control command switch, counts.
- IVSCCS_LST = Previous valid SCCS input.
- LOAD = Universal normalized load parameter.
- N = Engine speed, RPM.
- NDBAR = Filtered engine speed.
- RATCH = Lowest filtered throttle position, counts.
- TCSTRT = Temperature of ECT at cold start-up, deg.F.
- TP = Instantaneous throttle position, counts.
- VSCCS = Previous valid SCCS input.

Bit Flags:

- ACCFLG = A/C status flag (0 = A/C disabled; 1 = A/C enabled).
- ACIFLG = Flag to indicate that idle speed control system should prepare for load increase.
- AFMFLG = Flag indicating that ACT sensor has failed.
- BIFLG = Brake is on.
- CFMFLG = Flag indicating that ECT sensor is in/out of range.
- CRKFLG = Crank flag (1 = engine in Crank mode).
- CTNFLG = 1 = closed throttle neutral idle.
- DNDSUP = Drive/Neutral select.
- IDLFLG = Flag indicating transmission in drive and at idle.
- MFAFLG = Managed Fuel Air State flag, set to 1 if MFA is being used.
- MFMFLG = Flag indicating that MAF sensor has failed.
- NDSFLG = Neutral/Drive flag, 1 = Drive.
- SWTFLG = Managed Fuel Air State Flag.
- UNDSP = Underspeed flag, if set to 1 indicates Underspeed mode or Crank.
- WMEGOL = Flag indicating Wrmego was 1 at least once.

Calibration Constants:

- AFECT1 = Minimum ECT for starting the Adaptive Fuel timer, deg F.

- AFECT2 = Overtemp ECT to zero the adaptive fuel timer.

- BYHTMR = Bankline timer time delay for Thermactor bypass.

- BYPLES = Time delay before bypass after last Ego switch.

- CTHIGH = Hot start minimum engine coolant temperature, Deg F.

- CTLOW = Cold start maximum ECT, deg F.

- DEBAMP = Minimum change in IVSCCS to reset the debounce timer.

- DEBTIM = Debounce time delay.

- DFLDH = Decel Fuel low load hysteresis.

- DFLDL = Decel Fuel low load shut off.

- FN087 = Time delay to enable A/C Clutch; maximum allowable time A/C disabled at WOT. Input = TP-RATCH (A/D Counts)

- FN125 = LOM Load function to activate LOM spark strategy. Input: RPM and Output: load.

- FN306 = Cranking fuel pulsewidth multiplier versus time in crank, sec. X-input = CRKTMR.

- FN880(CTNTMR) = DSDRPM adder vs. time at Idle, sec.

- EGRMPT = Egrate ramp time for TCSTRT <or= CTLOW, sec.

- HLODH = Upper LOAD Limit for Closed Loop Fuel Control, unitless.

- IDLRPM = Maximum RPM for Closed Throttle Mode Idle, rpm. Range of 0 to 7000, accuracy of 25 RPM.

- IDRPMH = Hysteresis for IDLRPM. Range of 0 to 1000, accuracy of 25 RPM.

- INLRPM = Maximum RPM to increment CTHTMR.

- INLRPH = Hysteresis for INLRPM.

- LOESSW = Logic switch to reenter closed loop due to lack of Ego switching open loop.

- LUGSW = LUGTMR logic switch.

- LUGTIM = Engine load transition time, sec.
- MFALH = Managed fuel air state maximum Load condition.
- MFALHH = Hysteresis for MFALH.
- MFALL = Managed Fuel Air State Minimum load value.
- MFANLO = Managed Fuel Air State minimum RPM.
- MFANHH = Hysteresis for MFANHI.
- MFANHI = Managed Fuel Air State Maximum RPM.
- MFANLH = Hysteresis for MFANLO.
- MFASN = Managed fuel air state constant RPM entry condition.
- MFATM1 = ATMR1 MFA enable time delay for TCSTRT <or= CTLOW.
- MFATM2 = ATMR1 MFA enable time delay for CTLOW < TCSTRT < CTHIGH.
- MFATM3 = ATMR1 MFA enable time delay for TCSTRT >or= CTHIGH.
- MFATM4 = ATMR2 MFA enable time delay for TCSTRT <or= CTLOW.
- MFATM5 = ATMR2 MFA enable time delay for CTLOW < TCSTRT < CTHIGH.
- MPMNBP = Minimum BP for fuel economy mode; used in MFATMR logic.
- MPNBPH = BP Hysteresis for MPMNBP in SWTFLG logic.
- NIHYS = Neutral Idle Hysteresis, sec. Base value is 2, range is 0 to 100.
- NIOLD = Neutral Idle Open Loop Delay, sec. Base value is 255, range is 0 to 255.
- SWTCNT = Managed fuel air state EGO switch requirement.
- TEMPFB = Minimum ECT required to start ATMR2 timer, deg F.
- THBP4 = Minimum throttle position above RATCH for WOT A/C cut-out, counts.
- THBP4H = Hysteresis term for throttle position, counts.
- UPLOD = Minimum PERLOAD to disable Upstream Air.

- UPLODH = Hysteresis term added to UPLOD to define Minimum LOAD to enable Upstream Air.

- UPRPM2 = Maximum RPM for decel upstream air.

- UPRPMH = Hysteresis for INLRPM.

- VSMPG = Minimum Vehicle Speed to remain in MFA Mode (if speed sensor is present), mph.

- VSMPGH = Hysteresis term for entering MFA mode.

- VSTYPE = Vehicle speed sensor cruise control H/W present switch;
  0 = No vehicle speed and no cruise control,
  1 = Vehicle speed sensor, no cruise control (VSS),
  2 = Both vehicle speed sensor and cruise control (VSS+VSC).

OUTPUTS

Bit Flags:

- ADPTMR_FLG = Adaptive Fuel Time Flag.

- CTAFLG = Closed throttle decel upstream air flag.

- CTNFLG = 1 = closed throttle neutral idle.

- DMFLG = Decel fuel low load timer enabled flag, 1 = Count up timer.

- IDLFLG = Flag indicating transmission in drive and at idle.

- LEGOFG1 = Lack of EGO-1 switching.

- LEGOFG2 = Lack of EGO-2 switching.

- MFAFLG = Managed Fuel Air State flag, set to 1 if MFA is being used.

- SWTFLG = Managed Fuel Air State Flag.

TIMER CONTROL LOGIC

ACBTMR - A/C CLUTCH BRAKE TIMER
(0.125 SEC RESOLUTION)

BRIEF DESCRIPTION:

The purpose of this timer is to provide a means of controlling the maximum amount of time that the A/C clutch is disabled after the brake is applied. NOTE: If BRKCOT is calibrated to zero, (See A/C clutch control routine), this time routine has no control of the A/C clutch.

```
BIFLG = 1 ----------------------| COUNT UP ACBTMR
                                |
                                | --- ELSE ---
                                |
                                | SET ACBTMR = 0
```

ACCTMR - A/C CLUTCH TRANSITION TIMER
(0.125 SEC RESOLUTION)

BRIEF DESCRIPTION:

The purpose of this timer is to prevent rapid cycling of the A/C output. ACCTMR forces the A/C state to remain static (ON or OFF) for a minimum amount of time, ACMNET.

```
PRESENT ACCFLG = 1 -----|
(clutch engaged)        |AND ---|
                        |       |
PREVIOUS ACCFLG = 0 ----|       |
                                |OR ----| SET ACCTMR = 0
PRESENT ACCFLG = 0 -----|       |       | (any transition)
                        |AND ---|       |
PREVIOUS ACCFLG = 1 ----|               | --- ELSE ---
                                        |
                                        | COUNT UP ACCTMR
```

NOTE: ACCTMR is initialized to maximum value.

ACITMR - A/C CLUTCH TURN-ON DELAY TIMER
(MSEC RESOLUTION)

BRIEF DESCRIPTION:

The purpose of this timer is to provide a means of delaying the turn-on of the A/C clutch while at idle in order to give the idle speed control system time to prepare for the impending increase in load.

```
ACIFLG = 1 ---------------------| COUNT UP ACITMR
                                |
                                | --- ELSE ---
                                |
                                | SET ACITMR = 0
```

ACWTMR - A/C CLUTCH WIDE OPEN THROTTLE TIMER (SECONDS)
(SEC RESOLUTION)

BRIEF DESCRIPTION:

The purpose of this timer is to provide a means of controlling the maximum amount of time that the A/C clutch is disabled while at WOT. This timer is used as an input to the WCOTMR logic. NOTE: If FN087 is calibrated to zero (See WCOTMR routine below), this timer routine has no control of the A/C clutch.

```
TP > RATCH + THBP4 --------------|S Q-----| COUNT UP ACWTMR
                                 |        | (Clip at 254 sec max)
TP < RATCH + THBP4 - THBP4H -----|C       |
                                          | --- ELSE ---
                                          |
                                          | SET ACWTMR = 0
```

ADPTMR - ADAPTIVE FUEL ENABLE TIMER

BRIEF DESCRIPTION:

This timer allows Adaptive Fuel to be enabled if the Engine is in Run Mode and the Engine Coolant Temperature is within a certain band. Adaptive Fuel is disabled if either of these conditions is not met.

```
RUN mode ------------------------|
                                 |AND-----| COUNT UP ADPTMR
AFECT1 <OR= ECT <OR= AFECT2 -----|        | Set ADPTMR_FLG
                                          |
                                          | --- ELSE ---
                                          |
                                          | SET ADPTMR = 0
                                          | Clear ADPTMR_FLG
```

ATMR1 - TIME SINCE ENGINE START-UP

```
CRKFLG = 0 --------------------------| COUNT UP ATMR1
(RUN or UNDERSPEED mode)             |
                                     | --- ELSE ---
                                     |
                                     | SET ATMR1 = 0
```

ATMR2 - TIME SINCE ENGINE COOLANT TEMPERATURE BECAME GREATER THAN TEMPFB

```
ECT > TEMPFB --------|S  Q-----------| COUNT UP ATMR2
                     |               |
NEVER----------------|C              | --- ELSE ---
                                     |
                                     | SET ATMR2 = 0
(EXCEPT AT POWER-UP
 INITIALIZATION)
```

ATMR3 - TIME SINCE ENTERING RUN MODE

```
UNDSP = 0 -------------------------| Increment ATMR3
  (Run Mode)
```

A3CTMR - A3C TRANSITION TIMER (.001 sec)

The A3CTMR measures the time between A3C state changes. If the time is small (<250 msec), then the Heated Windshield is probably on.

```
ALWAYS ----------| Increment A3CTMR
```

A3CTMR is reset to 0 on any A3C transition - (LSTA3C - A3C NOT= 0 in successive background passes). See A/C Clutch Section.

BAPTMR - TIME SINCE LAST BP SENSOR INTERRUPT (msec)

```
BP sensor transition -----------------| Reset BAPTMR = 0
 (reset occurs in background          |
  routine. Flag is NEW_BAP)           | --- ELSE ---
                                      |
                                      | Count up
```

CRKTMR - TIME IN CRANK MODE

This timer indicates time since RPM not equal to zero, and provides a means for decreasing cranking fuel pulsewidth as a function of time (using FN306).

```
N = 0 ---------------------------------| Set CRKTMR = 0
 (Engine not running                   |
  or stalled)                          | --- ELSE ---
                                       |
                                       | Increment CRKTMR
```

CTATMR - CLOSED THROTTLE UPSTREAM AIR TIMER
(0.125 sec Resolution)

BRIEF DESCRIPTION:

This Timer is used to delay Upstream Air after Closed Throttle Mode is entered during a Decel.

```
APT = -1 ----------------------|          | Count Up CTATMR
                               |AND ------| CTAFLG = 1
N > UPRPM2 + UPRPMH ------|S Q--|          |
                          |               | --- ELSE ---
N < UPRPM2 ---------------|C              |
                                          | CTATMR = 0
                                          | CTAFLG = 0
```

CTNTMR - CLOSED THROTTLE NEUTRAL TIMER

```
ECT > CTHIGH --------------------|
                                 |
APT = -1 (CLOSED THROTTLE) ------|       | Count up CTNTMR
                                 |       | Clip to NIOLD + NIHYS
NDSFLG = 0 (NEUTRAL) ------------|AND ---| Set CTNFLG = 1
                                 |       |
N < INLRPM + FN880 --------|S Q--|       | --- ELSE ---
                           |             |
N > INLRPM+FN880+INLRPH ---|C            | Count down CTNTMR
                                         | Set CTNFLG = 0
                                         | Clip CTNTMR to 0
```

CTTMR - TIME AT CLOSED THROTTLE

```
APT = -1 (CLOSED THROTTLE mode) --------| COUNT UP CTTMR
                                        |
                                        | --- ELSE ---
                                        |
                                        | SET CTTMR = 0
```

DEBTMR - VEHICLE SPEED COMMAND SWITCH DEBOUNCE TIMER
(msec resolution)

BRIEF DESCRIPTION:

The debounce timer, DEBTMR, prevents the strategy from treating noise or intermittents as valid switch command inputs.

Registers:

IVSCCS = A/D conversion of the Speed Control Command switch, counts.

IVSCCS_LST = Previous valid SCCS input.

DEBTMR = SCCS debounce timer, secs.

Calibration Constant:

DEBAMP = Minimum change in IVSCCS to reset the debounce timer.

DEBTIM = Debounce time delay.

```
|IVSCCS_LST - IVSCCS| > DEBAMP ------| SET DEBTMR = DEBTIM


ALWAYS ------------------------------| Count down DEBTMR to zero
```

DLTMR LOGIC

```
APT = -1 ---------------------|
 (Closed Throttle)            |AND ----| DMFLG = 1
                              |        | COUNT UP DLTMR
PERLOAD < FN320A -|S  Q ------|        |
 (Decel)          |                    | --- ELSE ---
                  |                    |

PERLOAD > FN320A  |                    | DLTMR = 0
         + HLODH -|                    | DMFLG = 0
```

EDFTMR - ELECTRO-DRIVE FAN TIMER (SEC)
(One Sec Resolution)

This timer routine provides a means of delaying the turn-on of the high speed fan until after the low speed fan has been on for a minimum amount of time.

```
EDF DE-ENERGIZED ------------|
  (EDF = 1)                  |OR ---| EDFTMR = 0
                             |      |
CRKFLG = 1 ------------------|      | --- ELSE ---
                                    |
                                    | Count Up EDFTMR
```

FFMTMR - FAM FILTER TIMER (SEC)

The FAM filter timer is a free running timer used as the sample period for the FAM filter. FFMTMR is reset when entering FAM region, and after each FAM filter update, as shown in the FAM logic at the end of the Idle Speed Control chapter.

HLTMR - HIGH LOAD TIMER
(0.125 sec Resolution)

The HLTMR delays Open Loop fuel control during crowds. Running Closed Loop fuel during crowds elimiates the need for Upstream Air during those conditions.

```
PERLOAD < FN320A -------------|S Q---| HLTMR = 0
                              |      |
PERLOAD > FN320A + HLODH -----|C     | --- ELSE ---
                                     |
                                     | Count Up
                                     | HLTMR
```

HMTMR - TIMER LIMITING UPSTREAM AIR
(1 sec Resolution)

BRIEF DESCRIPTION:

The HMTMR limits the length of time that the air is directed Upstream during heavy crowds. See Thermactor Chapter.

```
PERLOAD > UPLOD + UPLODH -|S Q----| Count Up HMTMR
                          |       | Clip to 255
PERLOAD < UPLOD ----------|       |
                                  | --- ELSE ---
                                  |
                                  | HMTMR = 0
```

HWTMR - HEATED WINDSHIELD TIMER (.001 sec)

The HWTMR measures the time at which A3CTMR remains below a threshold value (<OR= 300 msec). It is used to set the heated windshield flag HWFLG.

```
ALWAYS ----------| Increment HWTMR
```

HWTMR is reset to 0 if A3CTMR > 250 msec. See A/C Clutch Section.

IDLFLG - IDLE WITH TRANSMISSION IN DRIVE

```
   DNDSUP = 1 (DRIVE) ---------------|
                                     |
   APT = -1 (CLOSED THROTTLE mode) --|
                                     |AND ---| SET IDLFLG = 1
   N < IDLRPM ---------------|S Q----|       |
                             |               | --- ELSE ---
   N > IDLRPM + IDRPMH ------|C              |
                                             | SET IDLFLG = 0
```

LESTMR1 - LACK OF EGO SWITCHING TIMER (TIME SINCE LAST EGO SWITCH)

```
   EGO-1 SWITCH ----------------|      | SET LESTMR1 = 0
                                |OR ---|
   OPEN LOOP FUEL CONTROL-------|      | --- ELSE ---
                                       |
                                       | COUNT UP LESTMR1
```

Additional logic associated with LESTMR1;

```
   LESTMR1 >OR= BYPLES ----------------| SET LEGOFG1 = 1


   LOESSW > 0 ---------------|
                             |AND ----| SET LEGOFG1 = 0
   EGO-1 SWITCH -------------|
```

LESTMR2 - LACK OF EGO SWITCHING TIMER (TIME SINCE LAST EGO SWITCH)

```
   EGO-2 SWITCH ----------------|     | SET LESTMR2 = 0
                                |OR --|
   OPEN LOOP FUEL CONTROL-------|     | --- ELSE ---
                                      |
                                      | COUNT UP LESTMR2
```

Additional logic associated with LESTMR2.

```
   LESTMR2 >OR= BYPLES -----------------| SET LEGOFG2 = 1

   LOESSW > 0 ----------------|
                              |AND -----| SET LEGOFG2 = 0
   EGO-2 SWITCH --------------|
```

LUGTMR - LOM LOAD TRANSITION TIMER

```
LOAD > FN125 -------------------|
                                |OR ---| COUNT UP LUGTMR
APT = 1 (WIDE OPEN THROTTLE) ---|      |  (CLIP AT LUGTIM)
                                       |
                                       | --- ELSE ---
                                       |
LOAD <OR= FN125 ----------------|      |
                                |AND --| SET LUGTMR = 0
LUGSW = 1 ----------------------|      |
                                       |
                                       | --- ELSE ---
                                       |
                                       | COUNT DOWN LUGTMR
                                       | (CLIP AT 0)
```

MFATMR - MANAGED FUEL AIR TIMER

```
MFACTR >OR= SWTCNT -------------| SET MFAFLG = 1
                                | COUNT UP MFATMR

APT = 1 (WIDE OPEN THROTTLE) ---|
                                |
N > MFANHI + MFANHH ------------|
                                |
N < MFANLO - MFANLH ------------|
                                |OR --| SET MFAFLG = 0
PERLOAD < MFALL ----------------|     | SET MFATMR = 0
                                |
PERLOAD > MFALH + MFALHH -------|
                                |
NDSFLG = 0 (NEUTRAL) -----------|
                                |
MFMFLG = 1 ---------------------|
                                |
AFMFLG = 1 ---------------------|
                                |
CFMFLG = 1 ---------------------|
                                |
BP < MPMNBP --------------------|
                                |
VSBAR < VSMPG -------|          |
                     |AND ------|
VSTYPE NOT = 0 ------|
```

SWTFLG LOGIC FOR MANAGED FUEL AIR TIMER MFATMR

```
   "A" ------------------------------|
                                     |
   APT = 0 (PART THROTTLE) ----------|
                                     |
   CLOSED LOOP FUEL CONTROL ---------|
                                     |
   N > MFANLO -----------------------|
                                     |
   N < MFANHI -----------------------|AND ---|
                                     |       |OR --| SET SWTFLG = 1
   |N - NDBAR| < MFASN --------------|       |     |
                                     |       |     | --- ELSE ---
   PERLOAD < MFALH ------------------|       |     |
                                     |       |     | SET SWTFLG = 0
   NDSFLG = 1 (DRIVE) ---------------|       |
                                     |       |
   BP >OR= MPMNBP + MPNBPH ----------|       |
                                     |       |
   VSBAR >OR= VSMPG + VSMPGH --|     |       |
                               |OR --|       |
   VSTYPE = 0 -----------------|             |
                                             |
   MFAFLG = 1 -------------------------------|
```

MFACTR LOGIC FOR MANAGED FUEL AIR TIMER MFATMR

```
   SWTFLG = 1 ------------------------| Increment MFACTR
                                      |  every EGO switch
                                      |
                                      | --- ELSE ---
                                      |
                                      | Set MFACTR = 0
```

STARTUP DELAY LOGIC FOR MANAGED FUEL AIR TIMER MFATMR

```
   TCSTRT >OR= CTHIGH ---------|
                               |AND ---|
   ATMR1 >OR= MFATM3 ----------|       |
                                       |
   CTLOW <TCSTRT < CTHIGH -----|       |OR --- "A"
                               |AND ---|
   ATMR1 >OR= MFATM2 ---|      |       |
                        |AND --|       |
   ATMR2 >OR= MFATM5 ---|              |
                                       |
   TCSTRT <OR= CTLOW ----------|       |
                               |AND ---|
   ATMR1 >OR= MFATM1 ---|      |
                        |AND --|
   ATMR2 >OR= MFATM4 ---|
```

MULTMR - TIME SINCE INCREMENTING LAMMUL

```
   Always -------------------------------------| COUNT UP MULTMR

       (Note: MULTMR is periodically set to 0 within
        the Open Loop Fuel Logic)
```

NACTMR - NOT AT CLOSED THROTTLE TIME

```
   APT = 0 (PART THROTTLE mode)-----|
                                    |OR ----| COUNT UP NACTMR
   APT = 1 (WIDE OPEN THROTTLE mode)|       |
                                            | --- ELSE ---
                                            |
                                            | SET NACTMR = 0
```

NDDTIM - TIME SINCE NEUTRAL/DRIVE SWITCH STATE CHANGE

```
   NEUTRAL/DRIVE SWITCH STATE CHANGE ------| SET NDDTIM = 0
                                           |
                                           | --- ELSE ---
                                           |
                                           | COUNT UP NDDTIM
```

NWOTMR LOGIC (NOT AT WIDE OPEN THROTTLE TIMER)

```
   APT = 1 ------------------------| SET NWOTMR = 0
     (Wide Open Throttle)          |
                                   | --- ELSE ---
                                   |
                                   | COUNT UP NWOTMR
```

PRGTMR - CANISTER PURGE TIMER

```
   CANISTER PURGE OUTPUT ON --------------| COUNT UP PRGTMR
                                          |
                                          | --- ELSE ---
                                          |
                                          | FREEZE PRGTMR
```

PUTMR - TIME SINCE CPU POWER-UP

```
CPU POWER ON --------------------------------| COUNT UP PUTMR
```

TSEGRE - ACCUMULATED TIME EGR IS ENABLED

```
TCSTRT > CTLOW ------------| SET TSEGRE = EGRMPT ('R' = 1)
                           |
                           | --- ELSE ---
                           |
EGR ENABLED ---------------| COUNT UP TSEGRE
 (EGREN = 1)               |  (CLIP AT EGRMPT)
                           |
                           | --- ELSE ---
                           |
                           | FREEZE TSEGRE
```

TSLPIP - TIME SINCE LAST PIP

```
PIP INTERRUPT ----------------------------------| SET TSLPIP = 0
                                                |
                                                | --- ELSE ---
                                                |
                                                | COUNT UP TSLPIP
```

WCOTMR - A/C CLUTCH WOT CUTOUT TIMER
(0.125 SEC RESOLUTION)

In the calculation below, if TP - RATCH gives a negative value, then that result should be clipped to zero before calculating FN087.

```
ACWTMR < FN087 (TP - RATCH) ---------------| SET WCOTMR = 0
                                            |
                                            | --- ELSE ---
                                            |
                                            | COUNT UP WCOTMR
```

CHAPTER 21

FAILURE MODE MANAGEMENT

FAILURE MODE STRATEGY

The Failure Mode (FMEM) strategy protects vehicle function from adverse effects of an EEC component failure. The strategy recognizes open or short circuit failure for six sensors: MAF, TP, ECT, ACT EVP/EPT, and BP. In general, if the continuous Self-Test strategy recognizes a failure the FMEM strategy will execute an alternative vehicle strategy. The alternative strategy disables logic which relies on realistic sensor values. Some sensor FMEM strategies also substitute a "safe" value for the bad sensor. A summary of the alternate strategies is tabulated below.

Alternate Strategy	Sensors					
	MAF	TP	ECT	ACT	EGR	BP
SUPERCHARGE - Not Bypassed		X				
Adaptive Fuel - No Learning	X	X	X	X		
Idle Speed - Fixed Duty Cycle	X	X				
EGR - Disabled	X	X	X	X	X	X
Thermactor Air - Bypass	X	X	X	X		
Decel Fuel Shutoff - Disable	X	X	X	X	X	
Foreground Fuel - Disable	X					
Managed Fuel Air - Disable	X		X	X		
ECAD - Full Speed mode	X	X	X	X		
EDF - Turn on low speed			X			

INPUTS

Registers:

- ACT = Air Charge Temperature, deg F.
- AM = Air Mass Flow, lbm/min.
- APT = Part Throttle flag.
- ATMR1 = Time since Engine Startup, sec.
- BAPTMR = Timer indicating time since last BP sensor low to high transition, seconds.
- C22FIL = Self-Test Register which counts the number of BP sensor failures, counts.
- C31FIL = Self-Test Register which counts the number of EVP low failures.
- C35FIL = Self-Test Register which counts the number of EVP high failures.
- C51FIL = Self-Test Register which counts the number of ECT low failures.
- C53FIL = Self-Test Register which counts the number of TP-High failures. It increments by C53UP each time a failure occurs and decrements by one count each time the sensor data is valid.
- C54FIL = Self-Test Register which counts the number of ACT low failures.
- C61FIL = Self-Test Register which counts the number of ECT high failures.
- C63FIL = Self-Test Register which counts the number of TP-Low failures. It increments by C63UP each time a failure occurs and decrements by one each time the sensor data is valid.
- C64FIL = Self-Test Register which counts the number of ACT high failures.
- DEBYMA_FM = ISC airflow adder for ARCHI when Mass Air Flow sensor fails (units are lbma/min. same as DEBYMA, but without BP correction). DEBYMA_FM is readable in a register for use when calibrating.
- ECT = Engine Coolant Temperature, deg F.
- EOFF = The EGR valve reading when the valve is fully closed in A/D counts.
- IBAP = Output of BP sensor transfer function FN000, in. mercury.
- IACT = A/D conversion of ACT sensor input, counts.
- IECT = A/D conversion of ECT sensor, counts.
- IEVP = A/D conversion of EVP sensor, counts.

- IMAF = Input Air Meter Reading. A/D counts.

- ITP = Throttle position value from A/D conversion, counts.

- MDELTA = Time between BP SCAP pulses, clock ticks. (1 clock tick = 2.4 usec for 15.0 MHz EEC; 1 clock tick = 3.0 usec fpr 12 MHz EEC)

- N = Engine RPM.

- RATCH = Closed throttle position, counts.

- TCSTRT = Temperature of ECT at cold start-up, deg F.

Bit Flags:

- AFMFLG = Flag indicating that ACT sensor has failed.

- BFMFLG = Flag indicating that the BP sensor has failed. 1 -> failure.

- CFMFLG = Flag indicating that ECT sensor is in/out of range.

- EFMFLG = Flag indicating that EVP EGR sensor has failed. (This flag performs for both Sonic and PFE EGR.)

- IMFMFLG = Instantaneous mass air flow sensor FMEM flag.

- TFMFLG = Flag indicating that TP sensor has failed.

- UNDSP = Run/Underspeed Flag. (1 = Underspeed (or Crank), 0 = Run).

- WMEGOL = Indicates WRMEGO was 1 at least once.

Calibration Constants:

- ACTFMM = FMEM default value for ACT.

- ACTMAX = Maximum ACT (ACT Open), Counts.

- ACTMIN = Minimum ACT (ACT Shorted), Counts.
- BAPFMM = Default value for BP failure.
- C22LVL = Threshold for BP sensor failure, unitless.
- C31LVL = Threshold for EVP fault, unitless.
- C35LVL = Threshold for (PFE) EVP fault, unitless.
- C51LVL = Threshold for ECT Open fault, unitless.
- C53LVL = Threshold level for recognition of TP-High Failure. When C53FIL equals (or exceeds) C53LVL, the Self-Test strategy will set an error code 53. NOTE: The value of C53LVL must be equal to 254.

- C54LVL = Threshold for ACT Open fault, unitless.
- C56LVL = Threshold level for fault 56.

- C61LVL = Threshold for ECT Short Fault, unitless.

- C63LVL = Threshold level for recognize of TP-Low failure. When C63FIL equals (or exceeds) the Self-Test strategy will set an error code 63. NOTE: The value of C63LVL must be equal to 254.

- C64LVL = Threshold for ACT short fault, unitless.

- C66LVL = Threshold level for fault 66.

- CTHIGH = Hot start minimum ECT, deg F. Range of 100 to 200.

- ECTFMM = FMEM default value for ECT, deg F.

- ECTMAX = Maximum engine ECT, Counts.

- ECTMIN = Minimum engine ECT, Counts.

- EVPMAX = Maximum EGR Valve position, counts.

- EVPMIN = Minimum EGR Valve position, counts.

- FILHYS = Hysteresis term to prevent spurious exit of Failure Mode strategy.

- FMCTTP = Change in TP if not at idle (as indicated by AM). This parameter is designed to permit Part Throttle operation.

- FN040(N) = Default ARCHI for failed Mass Air Flow sensor AND TP sensor.

- FN098(ITP-RATCH) = Normalized delta TP, used for MAF sensor failure table lookup.

- FN1358 (FN070,FN098) = Table lookup for failed Mass Air Flow Sensor, replaces ARCHI, units lbma/PIP.

- FN070 (N) = Normalized RPM

- FN098 (ITP-RATCH) = Normalized delta TP.

- FN703 = ECT/ACT transfer function.

- IDLMAF = Maximum AM at Idle, lb/min.
- MFMHYS = Calibration for IMFMFLG background loop hysteresis, counts.
- OPCLT1 = ATMR1 timed delay to enter closed loop fuel after Cold Start, sec.
- OPCLT2 = ATMR1 timed delay to enter closed loop fuel after medium start, sec.
- OPCLT3 = ATMR1 timed delay to enter closed loop fuel after HOT start, sec.
- OPCLT4 = ATMR2 timed delay to enter closed loop fuel after Cold Start, sec.

- OPCLT5 = ATMR2 timed delay to enger closed loop fuel after Medium start, sec.
- PFEHP = Switch to select EGR strategy; 0 = PFE and 1 = Sonic.
- RATIV = Inititializing value for RATCH, typically 250 counts.
- TAPMAX = Maximum valid TP value, counts. (Calibrated by Self-Test Design Section)
- TAPMIN = Minimum valid TP value, counts. (Calibrated by Self-Test Design Section)
- TCECT = Time constant for ECT, sec.
- VBPDL1 = Minimum BP sensor frequency, ticks.
- VBPDL2 = Maximum BP sensor frequency, ticks.
- VBPMAX = Maximum BP sensor period measured by BAPTMR, seconds.
- VMAMAX = Maximum MAF sensor reading, counts.
- VMAMIN = Minimum MAF sensor reading, counts.
- VMARPM = Maximum RPM for checking MAF sensor high limit.

OUTPUTS

Registers:

- ACT = Air Charge Temperature, deg F.
- ARCHI = Foreground corrected air charge value.
- ECT = Engine Coolant Temperature, deg F.
- EPTZER = Rolling average of the EPT sensor at Idle, counts.
- EVP = EGR valve position reading in A/D counts.
- IMFMCTR = Provides hysteresis for IMFMFLG, background loop counter, counts.
- TP = Throttle position, counts.

Bit Flags:

- AFMFLG = Flag indicating that ACT sensor has failed.
- BFMFLG = Flag indicating that the BP sensor has failed. 1 -> failure.
- IMFMFLG = Instantaneous mass air flow sensor FMEM flag.
- CFMFLG = Flag indicating that ECT sensor is in/out of range.
- EFMFLG = Flag indicating that EVP EGR sensor has failed. (This flag performs for both Sonic and PFE EGR.)
- MFMFLG = Flag indicating that MAF sensor has failed.
- TFMFLG = Flag indicating that TP sensor has failed.

The FMEM strategy checks the "Continuous Self-Test Code" Filters to ascertain whether a sensor has failed. If the sensor failure lasts long enough to trigger a Self-Test Code, the FMEM strategy will substitute an alternate value and strategy. Until the Self-Test filters exceed their fault thresholds, the strategy continues to use the last known valid value. The logic diagram below describes the entire Fault recognition and value substitution strategy, in general. However, to more effectively use the Self-Test Fault filters, the actual logic is divided into two sections; the Fault Flag logic and the Sensor input process logic. (See Specific Sensor FMEMs.)

```
SENSOR >OR= SENSOR MIN ---|          | SENSOR WITHIN
                          |          |  ACCEPTABLE RANGE
C**FIL < C**LVL - FILHYS -|          |  UPDATE SENSOR INPUT
 (sensor high fault       |          |
  filter OK)              |AND ------|  Failure Flags = 0
                          |          |
SENSOR <OR= SENSOR MAX ---|          |
                          |          |
C**FIL < C**LVL - FILHYS -|          | --- ELSE ---
 (sensor low fault                   |
  filter OK)                         |
                                     | SENSOR OUTSIDE
CRANK MODE (CRKFLG = 1) -------------|  RANGE
 (Optional)                          |  SENSOR = INITIAL VALUE
                                     |
                                     | --- ELSE ---
 (Fault present for a long time)     |
                                     |
C**FIL > C**LVL -----------|         | SENSOR OUTSIDE
 (sensor high fault)       |         |  RANGE - NOT DUE TO
                           |OR ------|  LOW BATTERY VOLTAGE
C**FIL > C**LVL -----------|         |  Failure Flags = 1
 (sensor low fault)                  |
                                     |  ALTERNATE STRATEGY
                                     |  SENSOR = SUBSTITUTED
                                     |    VALUE
                                     |
                                     | --- ELSE ---
                                     |
                                     | SENSOR DATA IS NOT
                                     |  RELIABLE - DO NOT
                                     |  UPDATE UNTIL CHECK
                                     |  PROVES VALUE VALID.
```

MASS AIR FLOW SENSOR FMEM
(Performed during MAF sensor engineering units conversion)

Check for sensor within limits:

```
   MFMFLG = 0 -----------------------|
                                     |
   N >OR= VMARPM ---------|          |
                          |OR -------|
   IMAF <OR= VMAMAX ------|          |AND -----| MAF Sensor output
                                     |         | within limits
   IMAF >OR= VMAMIN -----------------|         |
                                               | --- ELSE ---
                                               |
                                               | Set IMFMFLG = 1
                                               | Set IMFMCTR = MFMHYS
```

IMFMFLG and IMFMCTR logic:

```
   CRKFLG = 1 ---------------------------------| Set IMFMFLG = 0
    (sensor test disabled in crank mode)       | Set IMFMCTR = 0
                                               |
                                               | --- ELSE ---
                                               |
   IMFMCTR = 0 --------------------------------| Set IMFMFLG = 0
                                               |
                                               | --- ELSE ---
                                               |
                                               | Decrement IMFMCTR
                                               |  (clip to zero)
```

NOTE: This logic provides a calibratible delay after the sensor returns in range, equal to MFMHYS - 1 background loops, before exiting FMEM.

ARCHG Calculations:

```
   IMFMFLG = 0 --------------------------------| MAF sensor output
                                               | within limits, use
                                               | normal strategy.
                                               | ARCHG = ARCHFG
                                               |
                                               | --- ELSE ---
MAF Sensor out of limits, but TP sensor OK:    |
                                               | FMEM: substitute
                                               |       immediately
                                               |
   TFMFLG = 0 ---------------------------------| ARCHG = [FN1358(N,TP) +
    (TP sensor OK)                             | (DEBYMA_FM / (N*ENGCYL))]
                                               |             * BP/29.9
                                               |
                                               | --- ELSE ---
                                               |
   TP sensor failed also: ---------------------| Both TP and MAF failed
                                               | ARCHG = FN040(N)
```

FAILURE FLAG LOGIC FOR MASS AIR FLOW SENSOR

Performed during continuous self test routines

```
C66FIL >OR= C66LVL -------------|
                                |OR ---| MFMFLG = 1
C56FIL >OR= C56LVL -------------|      |  (failed)
                                       |
                                       | --- ELSE ---
                                       |
C66FIL < C66LVL - FILHYS -------|      |
                                |OR ---| MFMFLG = 0
C56FIL < C56LVL - FILHYS -------|      |  (sensor OK)
```

NOTE: Failure Mode recognition using the continuous self test filters controls MFMFLG. The IMFMFLG controls foreground/background fuel and ARCHG calculations

BP SENSOR FMEM
(Performed during engineering units conversion)

```
BPSSW = 0 -------------------| No BP sensor
                             | Do not do BP FMEM logic or
                             | IBAP calculations
                             | BP = KONBP
                             |
BFMFLG = 0 -----------|      | --- ELSE ---
                      |      |
BAPTMR <OR= VBPMAX ---|      |
                      |AND --| IBAP = FN000
VBPDL1 <OR= MDELTA ---|      | BP = BAPBAR
                             |
                             | --- ELSE ---
                             |
BFMFLG = 1 ------------------| IBAP = BAPFMM
                             | BP = BAPBAR
                             | BAPCNT = 0
                             | MINTIM2 = CLOCK
                             |
                             | --- ELSE ---
                             |
                             | Do not update IBAP,BP,or BAPBAR
```

FAILURE FLAG LOGIC (FOR BP SENSOR)
Continuous self-test

```
C22FIL < C22LVL - FILHYS ----------| BFMFLG = 0
                                   | (BP Sensor OK)
                                   |
                                   | --- ELSE ---
                                   |
C22FIL >OR= C22LVL ----------------| BFMFLG = 1
                                   | (BP Sensor failed)
```

This logic is performed after A/D conversions during all engine modes, including SELF-TEST. The FMEM strategy checks the continuous Self-Test Code Filters to ascertain whether the TP sensor failed. If the sensor failure lasts long enough to trigger a SELF-TEST code, FMEM strategy will infer throttle position based upon airflow. AM has protective logic in the event of a load sensor failure. (See the AM calculation contained in this section and Systems Equation)

The TP sensor Update logic substitutes a function of MAF for a failed TP sensor. This action permits recognition of the various throttle modes (Closed, Part or WOT). However, AE fuel will be disabled due to lack of TAR signal.

The load parameters have protective logic in event of load sensor failure. (See the BP calculation in the EEC OVERVIEW Chapter.)

PERFORM DURING ENGINEERING UNITS CONVERSION

```
TFMFLG = 0 ------------|
                       |AND -------| TP = ITP
ITP >OR= TAPMIN -------|           | (TP sensor within
                       |           |  acceptable range)
ITP <OR= TAPMAX -------|           |
                                   | --- ELSE ---
                                   |
                                   | (TP sensor out of limits)
CRANK MODE (CRKFLG = 1) ---|       | TP = RATCH
                           |OR ----|
AM < IDLMAF ---------------|       | --- ELSE ---
                                   |
                                   | (TP sensor out of limits
                                   |  but NOT due to Low
                                   |  battery voltage)
                                   | RATCH = RATIV
                                   |
TFMFLG = 1 ------------------------| TP = RATCH + FMCTTP
                                   |
                                   | --- ELSE ---
                                   |
                                   | (TP sensor data unreliable
                                   |  DO NOT update until
                                   |  confident data valid)
                                   | NO CHANGE TO TP
```

FAILURE FLAG LOGIC (FOR TP SENSOR)

CONTINUOUS SELF-TEST CHECK

```
C63FIL > C63LVL ---------------|
                               |OR -----| TFMFLG = 1
C53FIL > C53LVL ---------------|        |
                                        | --- ELSE ---
                                        |
C63FIL < C63LVL - FILHYS ------|        | TFMFLG = 0
                               |AND ----|
C53FIL < C53LVL - FILHYS ------|
```

ECT SENSOR UPDATE

If the ECT Sensor fails, the FMEM strategy will substitute ACT (during CRANK) or a default value (during ENGINE RUNNING Mode). The Normal engine strategy will not recognize a need for Cold Weather Fuel compensation.

PERFORM DURING ENGINEERING UNITS CONVERSION

```
CFMFLG = 0 ----------|
                     |
IECT <OR= ECTMAX ----|AND ---| ECT = ROLAV
                     |       |  (FN703,TCECT)
                     |       |
IECT >OR= ECTMIN ----|       | --- ELSE ---
                             |
CRANK MODE  -------------|   |
 (CRKFLG = 1)            |   |
                         |   | ECT = ROLAV
TCSTRT >OR= CTHIGH -|    |   |  (ACT,TCECT)
                    |AND-|   |
ATMR1 < OPCLT3 -----|    |   |
                         |OR-|
TCSTRT < CTHIGH ----|    |   |
                    |AND-|   |
ATMR1 < OPCLT2 -----|        |
                             | --- ELSE ---
                             |
CFMFLG = 1 ------------------| ECT = ROLAV(ECTFMM,TCECT)
                             |
                             | --- ELSE ---
                             |
                             | DO NOT UPDATE ECT
```

FAILURE FLAG LOGIC (FOR ECT SENSOR)

CONTINUOUS SELF-TEST

```
C61FIL > C61LVL ---------------|
                               |OR ----| CFMFLG = 1
C51FIL > C51LVL ---------------|       |
                                       | --- ELSE ---
C61FIL < C61LVL - FILHYS ------|       |
                               |AND ---| CFMFLG = 0
C51FIL < C51LVL - FILHYS ------|
```

ACT SENSOR UPDATE

If the ACT Sensor fails, the FMEM Strategy will use the initial value for ACT (by preventing an Update) until the failure is recognized as bona fide. An ACT failure will cause incorrect airflow calculation (with some degradation in fuel control).

PERFORM DURING ENGINEERING UNITS CONVERSION

```
AFMFLG = 0  -----------|
                       |
IACT <OR= ACTMAX ------|AND -------| ACT = FN703 (IACT)
                       |           |
IACT >OR= ACTMIN ------|           | --- ELSE ---
                                   |
WMEGOL = 0 ------------------------| ACT = ECT
 (Start up Open Loop)              |
                                   | --- ELSE ---
                                   |
AFMFLG = 1 ------------------------| ACT = ACTFMM
                                   |
                                   | --- ELSE ---
                                   |
                                   | DO NOT UPDATE ACT
```

FAILURE FLAG LOGIC (FOR ACT SENSOR)

CONTINUOUS SELF-TEST

```
C64FIL < C64LVL - FILHYS ------|
                               |AND --| AFMFLG = 0
C54FIL < C54LVL - FILHYS ------|      |
                                      | --- ELSE ---
C64FIL > C64LVL ---------------|      |
                               |OR ---| AFMFLG = 1
C54FIL > C54LVL ---------------|
```

PFE SENSOR UPDATE (PFEHP = 1)

The EPT FMEM Logic checks the A/D value of the EPT sensor and compares it to the permissible range of values (as defined by the Self-Test Strategy).

1. If the value is within the allowed range, the strategy clears a flag (which permits normal EGR strategy execution).

2. If the sensor value is outside the allowed range long enough for Self-Test to recognize and flag an error code, the strategy will force the valve to close.

PERFORM DURING ENGINEERING UNITS CONVERSION

```
EFMFLG = 0 ----------|
                     |AND ----| Reinitial EPTZER
Previous EFMFLG = 1 -|        | EPTZER = 650
```

FAILURE FLAG LOGIC (for PFE EGR Sensor)

CONTINUOUS SELF-TEST

```
APT NOT= -1 -------------------| Do NOT Do Failure
 (Not Closed Throttle)         | Mode Check
                               |  --- ELSE ---
C31FIL > C31LVL -----|         |
                     |OR ------| EFMFLG = 1
C35FIL > C35LVL -----|         |
                               | --- ELSE ---
C31FIL < C31LVL - FILHYS -|    |
                          |AND-| EFMFLG = 0
C35FIL < C35LVL - FILHYS -|
```

EVP SENSOR UPDATE (PFEHP = 0)

The EVP sensor failure Mode strategy will force the EGR valve to close and will have no adverse impact on Spark or Fuel.

PERFORM DURING ENGINEERING UNITS CONVERSION

```
EFMFLG = 0 -------|
                  |AND ----| EVP = IEVP
IEVP <OR= EVPMAX -|        |
                  |        | --- ELSE ---
IEVP >OR= EVPMIN -|        |
                           |
EFMFLG = 1 ----------------| EVP = EOFF
                           |
                           | --- ELSE ---
                           |
                           | Do NOT update
                           | EVP
```

FAILURE FLAG LOGIC (for EVP Sensor)

CONTINUOUS SELF-TEST

```
C31FIL > C31LVL -----|
                     |OR ------| EFMFLG = 1
C35FIL > C35LVL -----|         |
                               | --- ELSE ---
C31FIL < C31LVL - FILHYS -|    |
                          |AND-| EFMFLG = 0
C35FIL < C35LVL - FILHYS -|
```

MALFUNCTION INDICATOR LIGHT

OVERVIEW

The MIL warning system was implemented to comply with California regulations for the 1988 model year. To gain early field experience a pilot MIL exposure is planned for selected car lines in 1987.

The warning system will be activated whenever the EEC module is using an alternate strategy due to the failure of any of the monitored sensors. The malfunction light, located in the instrument cluster, will flash at a calibratable frequency (1/[2 * MILTM1]) as long as the fault is present or will be on full time if the EEC system is operating in hardware LOS.

MILTMR, a .125 second timer, is used to control the MIL logic. MILTMR is allowed to count up only when self-test is not in progress, when not in CRANK mode, and when an FMEM fault is present. It is reset to zero otherwise. When MILTMR excedes a calibratable delay time (FMDTM), the light will flash.

Additional features of the MIL are:

1. It is disabled during VIP tests.

2. It is turned on continuously in CRANK mode until a PIP is detected as a bulb check. The bulb check can be disabled by setting MILLIM equal to zero.

DEFINITIONS
INPUTS
Registers:

- C41FIL = Continuous Self-Test fault counter which counts the number of EGO1 sensor failures.

- C91FIL = Continuous Self-Test fault counter which counts the number of EGO2 sensor failures (Stereo EGO systems only).

- MILTMR = Timer used to record the time that an FMEM fault has been present, sec.

Bit Flags:

- AFMFLG = Flag indicating the ACT sensor has failed.

- BFMFLG = Flag indicating that the BP sensor has failed: 1 -> failure.

- CFMFLG = Flag indicating the ECT sensor has failed.

- CRKFLG = Flag indicating status of CRANK MODE (1 -> in CRANK MODE, 0 -> not in CRANK MODE).

- DISABLE_NO_START = Flag set to 1 when KOEO VIP test is entered. Disables bulb check when KOEO test is exited.

- EFMFLG = Flag indicating the EVP/EPT sensor has failed.

- FIRST_PIP = Flag set to 1 when the first PIP is detected. Reset to zero on power-up or stall.

- IGNFL = Flag indicating the state of the Ignition Switch (1 -> switch on; 0 -> switch off).

- MFMFLG = Flag indicating the MAP sensor has failed.

- STIFLG = Flag indicating the state of STI (1 -> low, Self-Test requested; 0 -> high, Self-Test not requested).

- TFMFLG = Flag indicating the TP sensor has failed.

Calibration Constants:

- C41LVL = Threshold for EGO1 fault, unitless.

- C91LVL = Threshold for EGO2 fault, unitless (Stereo EGO only).

- FMDTM = Time delay after fault is detected to start flashing MIL, sec. To disable MIL, set equal to 255.

- MILLIM = Software switch to enable/disable bulb check, unitless (1 -> enable; 0 -> disable).

- MILTM1 = MIL flashing on/off period, sec. Flashing frequency = 1/[2 * MILTM1].

OUTPUTS

Registers:

- MILTMR = See above.

MIL LOGIC

```
STIFLG = 1 ------------------| DO NOT DO MIL LOGIC
 (Self-Test requested)       |
                             |--- ELSE ---
CRKFLG = 1 ------------|     |
                       |     |
IGNFL = 1 -------------|     |
                       |AND -| DO BULB CHECK
DISABLE_NO_START = 0 --|     | TURN MIL ON
                       |     |
FIRST_PIP = 0 ---------|     |
                       |     |
MILLIM = 1 ------------|     |--- ELSE ---
                             |
MILTMR <OR= FMDTM -----------| TURN MIL OFF
                             |
                             |--- ELSE ---
                             |
                             | FLASH MIL
                             | TOGGLE EVERY MILTM1 SEC.
```

MILTMR LOGIC

```
STIFLG = 0 -------------|
                        |
CRKFLG = 0 -------------|
                        |
EGO FAILURE -------|    |AND -| COUNT UP MILTMR
                   |    |     |
AFMFLG = 1 --------|    |     |--- ELSE ---
                   |    |     |
BFMFLG = 1 --------|    |     | MILTMR = 0
                   |    |     |
CFMFLG = 1 --------|    |
                   |OR -|
EFMFLG = 1 --------|
                   |
MFMFLG = 1 --------|
                   |
TFMFLG = 1 --------|
```

CHAPTER 22

KEEP ALIVE MEMORY

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KEEP ALIVE MEMORY (KAM) QUALIFICATION TEST

Each time the vehicle is started, the data stored in KAM may not be valid. Power interruptions, noise, etc., may have altered KAM contents. Or, the computer may not be reading KAM registers correctly because of a hardware fault. When the KAM registers are intialized, a special binary pattern is written into three bytes of KAM. The KAM register names are KAMQA, KAMQB, and KAMQC. During each background loop, the KAM registers are tested. The KAM qualification test judges the validity of the KAM data by looking for the

proper binary pattern. The alternate courses of action are either:

1) If the proper pattern is present, the KAM data is considered OK for use by the strategy.

2) If not present, the KAM data is suspect. The KAM is over-written to a set of initial values. The inital values are also used in place of the KAM data when the strategy references KAM.

The KAM registers KAMQA, KAMQB, and KAMQC are assigned to different areas of the KAM. This will help protect for partial KAM failures. The assignments are:

KAM Register	KAM Address
KAMQA	B80 HEX
KAMQB	BC9 HEX
KAMQC	BF6 HEX

The KAM qualification test is normally performed each background loop when the computer is running.

INPUTS

Registers:

- EPTZER = Rolling average of the EPT sensor at Idle, counts.
- ISCKAM1 = Idle Speed KAM IPSIBR cell 1.
- ISCKAM2 = Idle Speed KAM IPSIBR cell 2.
- ISCKAM3 = Idle Speed KAM IPSIBR cell 3.
- ISKSUM = Idle Adaptive airflow check sum.
- KAMQA = KAM Qualification test register 1.
- KAMQB = KAM Qualification test register 2.
- KAMQC = KAM Qualification test register 3.

Calibration Constants:

- VEPTHL = Self-Test lower Idle limit (defined in Self Test Strategy). (Upper limit for KEYON EPTZER)
- VEPTLL = Self-Test upper Idle limit (defined in Self Test Strategy). (Lower limit for KEYON EPTZER.)

OUTPUTS

Registers:

- EPTZER = See Inputs above.
- ISCKAM1 (2,3) = See Inputs above.
- ISKSUM = See Inputs above.
- KAMQA (B,C) = See Inputs above.
- KWUCTR = KAM warm_up counter. Stores number of warm_ups in KAM. Reset to zero if KAM is corrupted. (battery disconnect, etc.)

Bit Flag:

- VIP_KAM = Indicates KAM invalid for VIP.

KAM QUALIFICATION TEST LOGIC

Performed each background loop.

```
KAMQA = 10101010 BINARY---|
                          |
KAMQB = 11000110 BINARY---|AND ------| SET KAMOK = 1
                          |          | ASSUME KAM DATA IS VALID
KAMQC = 01110101 BINARY---|          | ALL STRATEGY REFERENCES TO
                                     | KAM WILL USE KAM DATA.
                                     |
                                     | --- ELSE ---
                                     |
                                     | CLEAR KAMOK = 0
                                     | SET VIPKAM = 1
                                     | ASSUME KAM DATA IS BAD.
                                     | INITIALIZE ALL KAM
                                     | LOCATIONS USED IN THE
                                     | STRATEGY.
                                     | WRITE THE SPECIAL
                                     | BINARY PATTERNS TO KAM:
                                     |  KAMQA = 10101010 BINARY
                                     |  KAMQB = 11000110 BINARY
                                     |  KAMQC = 01110101 BINARY
                                     |
                                     | SET LTMTB1rc = 0.5
                                     | SET LTMTB2rc = 0.5
                                     | SET CHKSUM = 22016
                                     | SET ISCKAMn = 0.0
                                     | SET ISKSUM = 0.0
                                     | SET EPTZER = 650
                                     | KWUCTR = 0
```

ADAPTIVE FUEL TABLE VALIDATION PROCEDURE (POWER UP SEQUENCE)

Each time the vehicle is started, the data stored in KAM may or may not be valid. Power interruptions, noise, etc., may have altered the KAM contents. Alternatively, the computer may not be reading KAM registers correctly because of a hardware fault. The KAM qualification test judges the validity of the KAM data, and KAM can be initialized as required. Based on the results of the KAM qualification test, validate the adaptive fuel table as follows;

```
|(SUM OF ALL ADAPTIVE                | ASSUME THE ADAPTIVE FUEL
  FUEL KAM CELLS)                    | DATA IN KAM IS VALID.
 - CHKSUM| <OR= 1 ----------------| CHKSUM = SUM OF ADAPTIVE FUEL
                                     | CELLS
                                     |
                                     | --- ELSE ---
                                     |
                                     | ASSUME THE ADAPTIVE FUEL
                                     | DATA IN KAM IS WRONG.
                                     | DO A TOTAL INITIALIZATION
                                     | OF THE ADAPTIVE FUEL
                                     | DATA IN KAM.
                                     | FOR EACH CELL:
                                     | 1) SET LTMTB1rc = 0.5
                                     |    SET LTMTB2rc = 0.5
                                     | 2) SET CHKSUM = 22016
                                     | SET KWUCTR = 0
```

CHKSUM is a KAM memory word containing the sum of the LTMTB1 or LTMTB2 contents. CHKSUM is incremented or decremented each time any LTMTB1 or LTMTB2 cell is updated. A one count difference between the present sum and the stored sum is allowed to account for the case of power down after a KAM update but prior to CHKSUM update.

ISCKAM QUALIFICATION

(Done during Power-up sequence)

```
|ISCKAM0 + ISCKAM1          |        | Assume the ISCKAMs are valid
  + ISCKAM2 + ISCKAM3       |--------| NO ACTION TAKEN
  - ISKSUM| <OR= 1 Bit ---|          | ISKSUM = ISCKAM0 + ISCKAM1
                                     |  + ISCKAM2 + ISCKAM3
                                     |
                                     | --- ELSE ---
                                     |
                                     | Assume ISCKAMs Data are
                                     |  invalid.
                                     | Re-Initialize the ISCKAM
                                     |  ISCKAM0 = 0
                                     |  ISCKAM1 = 0
                                     |  ISCKAM2 = 0
                                     |  ISCKAM3 = 0
                                     |  ISKSUM = 0
```

KAM QUALIFICATION (EPTZER)

During Power-up sequence, check the range of EPTZER.

```
EPTZER > VEPTLL --------|       | EPTZER is OK
                        |AND --|
EPTZER < VEPTHL --------|       | --- ELSE ---
                                |
                                | EPTZER is NOT OK
                                | Set EPTZER = 650
```

CHAPTER 23

ROM IDENTIFICATION CODE

ROM IDENTIFICATION CODE

ROM identification codes are used by both IC and module suppliers. The IC suppliers require a means of identifying ROM chip contents quickly since they produce different calibration bit patterns on the same wafer. The module suppliers utilize these codes to insure that the ROM/module combination is correct.

In the past, the ROM identification codes (CALID and VERID) were generated by hand. They were then distributed to Engine Systems to put in their calibrations for Cert. If any change to the Cert calibration was made or a different strategy used, new values had to be generated and calibrated in.

For 1988 and beyond, the procedure has been changed to make this process easier. The new process removes CALID and replaces it with ROM_TO. In addition, VERID has been deleted and a new parameter "FIXSUM" has been added. FIXSUM should always be set to 0. Specifically:

1. The non-modifiable Vector parameter "ROM_TO" replaces the old CALID parameter as the ROM chip identifier. The ROM_TO value is generated by Vector during a calibration release and is located at 200A HEX. This value is the complement of the ROM pattern CHECKSUM and is also used to perform the EEC-IV diagnostic "CHECKSUM Memory Test".

2. The new parameter "FIXSUM" is a Vector calibration parameter located at 2004 HEX and should always be set to 0. This parameter will be used to assure the ROM_TO values are unique and will only be changed by the SWDV engineer if a duplicate ROM_TO value is found.

ROM IDENTIFICATION CODE PROCEDURES

1. PEDD SW will set the value of the calibration parameter FIXSUM to 0 in the base release.

2. When Engine Systems releases a CERT calibration, the ROM chip ID code, ROM_TO, will be automatically generated by VECTOR, and the value is to be recorded on the calibration release sheet submitted to SWDV.

3. PEDD SWDV will verify that the ROM_TO value is not the same as any other previous ROM_TO prior to sending the binary file to EED. If the ROM_TO value matches another, PEDD SWDV will change the value of FIXSUM and generate a new ROM_TO value, which will be checked again for a match. This process is repeated until a unique ROM_TO value is generated.

4. For production calibrations only, EED systems will receive and record the value of ROM_TO for final ROM verification.

5. EED will then transmit the binary file to the vendors, verify the ROM chip against the binary file, verify the checksum, verify the RAM read/write test, and verify the ROM_TO value and location.

SPECIAL VIP SECTION
EEC-EPCD, FoMoCo, PROPRIETARY & CONFIDENTIAL

1988
ELECTRONIC FUEL INJECTION (SFI-MA2)
SELF-TEST STRATEGY BOOK

STRATEGY LEVELS "GUF1"

(VIP-60C)

FOR USE WITH EEC-IV MODULE

COMMENTS OR QUESTIONS SHOULD BE DIRECTED TO TOM MELVILLE ON EXTENSION 76851

T. R. MELVILLE
SELF TEST DESIGN
POWERTRAIN ELEC-
TRONIC DEVELOPMENT
DEPARTMENT
FEBRUARY 12, 1987
REVISED 2/19/87

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CHAPTER 24

EEC-IV SELF-TEST OVERVIEW

EEC-IV Self-Test Overview

Self-Test is divided into two types of testing, one which occurs only at the "request" of the service technician (the "on-demand" tests), and one which continuously surveys the system during normal operating modes (the "continuous" tests). The on-demand portion is further divided into "engine-running" and "engine-off" tests.

The engine-off portion of the test "looks" for normal engine-off sensor readings. Any out-of-limits, open, or shorted sensor input is signalled by sending a service code. If all sensors are within expected ranges, a "11" code is issued. Codes are repeated to make it easier for the technician to verify the code sequence. After the service codes, a single pulse occurs to signal the technician that the next set of codes will be from the continuous test. Continuous test codes are issued using the same format as the service codes, and are also repeated. Finally, the test enters the "output state test", which simply turns actuator outputs "on" and "off" based on "requests" from the technician (these consist of depressing the throttle and letting it return to closed position). STO is also turned "on" and "off" in this mode, so that the technician knows the state in which the other outputs should be.

The engine-running portion signals that it has begun by sending an "identification" code (=no. of cylinders/2). It then tests inputs and EEC-IV-controlled functions by forcing various conditions and "looking" for expected engine response to them. A single output pulse is sent to signal the test operator to "goose" the throttle, during which inputs are tested for dynamic response. If no RPM change is detected, a special code (code 77) will be sent to indicate that the test was incorrectly performed. (No other 70-series codes will be sent except codes 74 and 75.) When the "goose" test has completed, service codes are sent.

The "continuous" self-test monitors inputs during normal operation, and stores information in keep-alive memory (KAM) when errors are detected. In general, checks are made only for open-or short-circuits. In a few cases, "irrational" sensor readings are noted (eg: if engine coolant temperature changes from cold to warm to cold again, an error is noted.) When the number of errors in a given time period exceeds a calibratable threshold, that code is stored in KAM. As a special diagnostic aid, in engine-off conditions and when STI=GND and the on-demand (running) test has completed, codes will be stored every time an error is detected, and STO will be turned on as long as the fault is present. This is designed to help isolate intermittent faults (eg.: the test operator can "wiggle" the harness and connectors, and STO will indicate when the intermittent fault recurs). Codes which indicate faults that have not recurred in 20 engine warm-up cycles are "erased". Codes can also be manually "erased" by opening up STI while codes are being output in the engine-off mode.

EEC-IV SELF-TEST BLOCK DIAGRAMS
"ON-DEMAND" TESTS (STI=GND)

```
   ENGINE-OFF:                      ENGINE-RUNNING:

 !-------------!                  !--------------!
 ! ENGINE-OFF  !                  !  I.D. CODE   !
 !    TEST     !                  !              !
 !-------------!                  !--------------!
       |                                 |
       v                                 v
 !-------------!                  !--------------!
 !   SERVICE   !                  !    ENGINE    !
 !    CODE     !                  !   RUNNING    !
 !-------------!                  !     TEST     !
       |                          !--------------!
       v                                 v
 !-------------!                  !--------------!
 !   SINGLE    !                  !    SINGLE    !
 !   PULSE     !                  !    PULSE     !
 !-------------!                  !--------------!
       |                                 |
       v                                 v
 !-------------!                  !--------------!
 ! CONTINUOUS  !     REQUIRES     !   DYNAMIC    !
 !    TEST     !     MECHANIC----->!   RESPONSE   !
 !   CODES     !   INTERVENTION   !     TEST     !
 !-------------!        |         !--------------!
       |                |                |
       v                |                v
 !-------------!        |         !--------------!
 !   OUTPUT    !<--------|         !    SERVICE   !
 !   PULSING   !                  !     CODES    !
 !-------------!                  !--------------!
                                         |
                                         v
NOTE:  TEST CODES CAN BE                  !--------------!
       MANUALLY ERASED BY                 ! 2 MIN. DELAY !
       UN-GROUNDING STI DURING            !(TIMING CHECK)!
       CODE OUTPUT (ENGINE-OFF).          !--------------!
                                         |
                                         v
                                  !--------------!
                     REQUIRES----->!   "WIGGLE"   !
                     MECHANIC     !     TEST     !
                   INTERVENTION   !--------------!
```

"CONTINUOUS" TESTS (STI=OPEN)

```
   ENGINE-OFF:                      ENGINE-RUNNING:
 !-------------!                  !---------------!
 !   "WIGGLE"  !                  !  CONTINUOUS   !
 !     TEST    !                  !  TEST MODE    !
 !-------------!                  !---------------!
```

CHAPTER 25

SELF-TEST ENTRY/EXIT LOGIC

EFI SELF-TEST ENTRY LOGIC
ENGINE OFF AND VSC STATIC TEST

```
TIME SINCE POWER-UP > 4 SEC---------|            !------------!
                                    |            !  ENTER     !
SELF-TEST REQUESTED-----------------| AND--------! ENGINE OFF !
 (STI INPUT=LOW)                    |            !    TEST    !
                                    |            !------------!
ENGINE-OFF TEST ENABLED-------------|
                                    |
IN CRANK MODE-----------------------|


IN CRANK MODE-----------------------|
                                    |            !------------!
STI INPUT = HIGH--------------------|            !   ENTER    !
                                    | AND--------! ENGINE-OFF !
VSTYPE = 2--------------------------|            !  VSC TEST  !
                                    |            !------------!
TS_PIP > 1 SECOND-------------------|
                                    |
PUTMR < 10 SECONDS------------------|
                                    |
ON_STATE = 1------------------------|
```

ENGINE RUNNING AND VSC DYNAMIC TEST

```
TIME SINCE POWER-UP > 6 SEC---------|            !----------------!
                                    |            !. ENTER VSC     !
SELF-TEST REQUESTED-----------------|            ! DYNAMIC TEST   !
 (STI INPUT=LOW > 1 SEC )           | AND--------!.DISABLE ENGINE !
                                    |            ! RUNNING TEST   !
VSTYPE = 2--------------------------|            !----------------!
                                    |
RUN MODE----------------------------|
                                    |
VSC DYNAMIC TEST ENABLED------------|
                                    |
ON_STATE = 1------------------------|
                                    |
PUTMR < VVSCET----------------------|
                                      --------------ELSE-----------


                                                 !-------------!
TIME SINCE POWER-UP > 6 SEC---------|            !.ENTER ENGINE!
                                    | AND--------! RUNNING TEST!
SELF-TEST REQUESTED-----------------|            !.DISABLE VSC !
 (STI INPUT =LOW > 1 SEC )          |            ! DYNAMIC TEST!
                                    |            !-------------!
RUN MODE----------------------------|
                                    |
ENGINE-RUNNING TEST ENABLED---------|
```

EFI SELF-TEST ENTRY LOGIC (CONT'D)

CONTINUOUS TEST

```
                                                      !-------------!
TIME SINCE POWER-UP > 4 SEC---------|            !    RUN      !
                                    | AND--------! CONTINUOUS  !
NOT IN ENGINE-OFF OR----------------|            !    TEST     !
 ENGINE-RUNNING TEST OR             |            !-------------!
 VEHICLE SPEED CONTROL TEST         |
                                    |
 IN UNDERSPEED OR RUN MODE----------|
```

EFI SELF-TEST EXIT LOGIC

```
IN ENGINE-OFF TEST----------------------|        !---------------!
                                        |        !EXIT & DISABLE !
IN UNDERSPEED/RUN MODE------|           | AND----!  ENGINE-OFF   !
                            |OR---------|        !    TEST       !
SELF TEST NOT REQUESTED-----|                    !---------------!


                                        |
IN ENGINE RUNNING TEST------------------|        !---------------!
                                        |        ! EXIT & DISABLE!
SELF-TEST NOT REQUESTED--------|OR------| AND----!ENGINE-RUNNING !
                               |                 !    TEST       !
TRLOAD = 3 OR 4--------|       |                 !---------------!
                       |AND----|
NDSFLG = 1 (DRIVE)-----|
```

VSC EXIT LOGIC

```
IN ENGINE-OFF VSC TEST------------------|        !---------------!
                                        |        !  EXIT AND     !
STI INPUT = LOW--------|                |AND-----!DISABLE ENGINE !
                       |OR--------------|        !OFF VSC TEST   !
IN UNDERSPEED/RUN MODE-|                         !---------------!


IN ENGINE RUNNING VSC TEST--------------|        !---------------!

                                        |        !  EXIT AND     !
VSBAR > 2 MPH--------|                  |AND-----!DISABLE ENGINE !
                     |                  |        !RUNNING VSC    !
OFF_BUT = 1----------|                  |        !      TEST     !
                     |OR----------------|        !---------------!
STI=HIGH (UNGRDED)---|
                     |
BRAKE APPLIED--------|
```

CHAPTER 26

ENGINE-OFF SEQUENCE

ENGINE OFF SEQUENCE

```
        -----------
      (    ENTER    )
        -----------
             |
             v
       !-----------!
       !   TURN    !
       !  STO OFF  !
       !-----------!
             |
       /-----------\
      / DO MODULE   \  FAIL
     / INSTRUCTION   \--------------------|
     \     TEST      /                    |
      \             /                     |
       \-----------/                      |
             |PASS                        v
        /--------\     FAIL        !--------------!
       /   TEST   \--------------->!  TURN STO ON !
       \ KAM/RAM  /                ! CONTINUOUSLY !
        \--------/                 !   AND EXIT   !
             |PASS                 !--------------!
        /---------\    FAIL        !--------------!
       / TEST ROM  \-------------->!     SET      !
       \           /               ! SERVICE CODE !
        \---------/                !--------------!
             |PASS                        |
             |                            |
             v                            |
   !--------------------------!           |
   !SEND TWO 2MS PULSES ON STO!           |
   !2MS BETWEEN PULSES        !           |
   !--------------------------!           |
             |                            |
|----------->|<---------------------------|
|            v
|       /---------\
|  NO  /  PUTMR >  \
|------\   4 SEC   /
        \---------/
             |
|----------->|YES
|            v
|       /---------\
|      /FUEL PUMP  \
|  NO / TURNED OFF  \
|-----\ (TIMED OUT) /
       \           /
        \---------/
             |YES
             v
            (B)
```

ENGINE OFF SEQUENCE CONT'D

```
                           (B)
                            |
                            v
                      /-----------\                !-----------------!
                     /    TEST     \      FAIL     !       SET       !
                    /   A/D'S AND   \------------->! SERVICE CODE(S) !
                    \   SWITCHES    /              !-----------------!
                     \             /                         |
                      \-----------/PASS                      |
                            |<-------------------------------|
                            v
                       /---------\    FAIL         !-----------------!
  FAIL /---------\    / TEST OCC  \--------------->!       SET       !
   |<-/FUEL PUMP  \<-|\           /                ! SERVICE CODE(S) !
   |  \CKT TEST** /  | \---------/                 !-----------------!
   |   \---------/   |      |     PASS                       |
   |       |         |------|<-------------------------------|
   |       |
   |       |PASS!-----------------------!
   |       |--->!   . SEND SERVICE CODES !

   v         ^  !-----------------------!
!--------!   |            |
!  SET   !   |            v
!SERVICE !---|  !--------------------------!
!CODE(S) !      !   . SEND SEPARATOR PULSE !
!--------!      !--------------------------!
                          |
                          v
                     /---------\    YES        !--------------!
                    / VIPKAM =1 \------------->! SEND CODE 15*!
                    \     ?     /              !--------------!
                     \---------/                     |
                          | NO                       |
                          v                          |
                  !-------------------!              |
                  ! . SEND CODES FROM !              |
                  !   CONTINUOUS TEST !              |
                  !-------------------!              |
                          |<-------------------------|
                          v
              !----------------------------!
              !   . ENTER OUTPUT TEST MODE !
              !----------------------------!
```

*See Normal Strategy KAM qualification test logic for setting of VIPKAM=1. Code 15 is output during continuous code output.

** NOTE: FUEL PUMP CKT TEST MUST BE PERFORMED AFTER OCC TEST

KAM/RAM TEST

```
                 -----------
               (    ENTER    )
                 -----------
                      |
                      v
     !-----------------------------------!
     ! SET POINTER TO BEGINNING OF       !
     ! EXT_RAM                           !
     !-----------------------------------!
|-------------------->|
|                     v
|        !-------------------------!
|        ! SAVE REGISTER CONTENTS  !
|        !-------------------------!
|                     |
|                     v
|        !-------------------------!
|        !   WRITE HEX AAAA TO     !
|        !   REGISTER              !
|        !-------------------------!
|                     |
|                     v
|        !-------------------------!
|        ! READ REGISTER CONTENTS  !
|        !-------------------------!
|                     |
|                     v
|              /-------------\
|             / IS CONTENTS   \  NO
|             \  = AAAA       /-------------|
|              \-------------/              |
|                     | YES                 |
|                     v                     |
|        !------------------------!         |
|        !   WRITE HEX 5555 TO    !         |
|        !     REGISTER           !         |
|        !------------------------!         |
|                     |                     |
|                     v                     |
|        !------------------------!         |
|        ! READ REGISTER CONTENTS !         |
|        !------------------------!         |
|                     |                     |
|                     v                     |
|                /---------\                |
|               /    IS     \ NO             |
|              /  CONTENTS   \------------->|
|              \   = 5555    /              |
|               \           /               v
|                \---------/           !-----------!
|                     | YES            !TURN STO ON!
|                     v                !   EXIT    !
|                    (A)               !-----------!
```

KAM/RAM TEST CONTINUED

```
                         (A)
                          |
     |                    v
     |           !-------------------!
     |           ! RESTORE REGISTER !
     |           !     CONTENTS      !
     |           !-------------------!
!------------!            |
!INCREMENT  !             |
! POINTER   !             |
!------------!            |
     ^                    |
     |       NO    /-------------\
     |<-----------/  END OF 2K    \
                  \  EXT-RAM ?    /
                   \-------------/
                          | YES
                          |
                          v
                   --------------
                (  GO TO ROM_TEST  )
                   --------------
```

READ-ONLY MEMORY TEST (ROM)

```
                 -----------
               (    ENTER    )
                 -----------
                      |
                      v
     !-----------------------------------!
     ! DO A 16-BIT ADDITION OF CONTENTS !
     ! OF ALL ROM LOCATIONS RETAINING    !
     ! THE 16 LEAST SIGNIFICANT BITS     !
     ! OF THE RESULT.                    !
     !-----------------------------------!
                      |
                      v
                 /---------\    NO    !---------!
                /  SUM=0 ?  \-------->!   SET   !
                \           /         ! CODE 15 !
                 \---------/          !---------!
                      |   YES              |
                      |<-------------------|
                      v
                 -----------
               (     EXIT    )
                 -----------
```

NOTE: A specific location will contain checksum such that sum of correct ROM contents (including checksum)=0.
Location is labeled "Rom To" or "Rom Total".

ENGINE-OFF A/D TESTS

```
   -----------
 (    ENTER    )
   -----------
        |
        v
   /---------\
  / TEST ECT  \
  \           /
   \---------/
        |
        v
   /---------\
  / TEST BP  \
  \           /
   \---------/
        |
        v
   /---------\
  /  TEST TP  \
  \           /
   \---------/
        |
        v
   /---------\
  / TEST ACT  \
  \           /
   \---------/
        |
        v
   /---------\
  / TEST MAF  \
  \           /
   \---------/
        |
        v
      ( A )
```

ENGINE-OFF A/D TESTS (CONT'D)

```
         ( A )
           |
      /---------\
     / TEST EGR  \
     \           /
      \---------/
           |
           v
      /---------\
     /   TEST    \
     \  ACC/NDS  /
      \---------/
           |
           v
      /--------\
     /   TEST   \
     \ IVPOWER  /
      \--------/
           |
           v
      /---------\
     / TEST PSPS \
     \           /
      \---------/
           |
           v
      -----------
    (     EXIT    )
      -----------
```

ECT SENSOR TEST

```
      -----------
    (    ENTER    )
      -----------
           |
           v
      /---------\    NO      !---------!
     /  IECT >=  \---------->! CODE 61 !---|
     \  ECTMIN ? /           !---------!   |
      \---------/                          |
           |   YES                         |
           |<------------------------------|
           v
      /---------\    NO      !---------!
     /  IECT <=  \---------->! CODE 51 !---|
     \ ECTMAX ?  /           !---------!   |
      \---------/                          |
           |   YES                         |
           v                               |
      /---------\                          |
     /   VIECT1  \   NO      !---------!   |
    /  <= IECT <= \--------->! CODE 21 !-->|
    \    VIECT2 ? /          !---------!   |
     \           /                         |
      \---------/                          |
           |   YES                         |
           |<------------------------------|
           v
      -----------
    (     EXIT    )
      -----------
```

PARAMETER NAME	DESCRIPTION	TYPICAL CALIB-RATION VALUE
ECTMIN	MIN. ENGINE OFF ECT	40 COUNTS
ECTMAX	MAX. ENGINE OFF ECT	935 COUNTS
VIECT1	MIN. COOLANT TEMP	717 COUNTS
VIECT2	MAX. COOLANT TEMP	63 COUNTS

BP SENSOR TEST

```
                  -----------
                (    ENTER    )
                  -----------
                       |
                       v
                   /---------\NO
                  /BPSSW = 1  \----------------------->|
                  \           /                        |
                   \---------/                         |
                       |YES                            |
                       v                               |
                  /---------\    NO                    |
                 /  BPTMR<=  \----------------|        |
                 \  VBPMAX ? /                |        |
                  \---------/                 |        |
                       |  YES                 |        |
                       v                      |        |
                  /---------\                 v        |
                 /  VPBDL1   \   NO      !---------!   |
                / <= MDELTA<= \--------->! CODE 22 !   |
                \   VBPDL2    /          !---------!   |
                 \           /                |        |
                  \---------/                 |        |
                       |   YES                |        |
                       |<---------------------|<-------|
                       v
                  -----------
                (     EXIT    )
                  -----------
```

PARAMETER NAME	DESCRIPTION	TYPICAL CALIB-RATION VALUE
VBPMAX	MAX. TIME SINCE LAST BP UPDATE	15 MS
VBPDL1	MIN BP DURING ENGINE OFF VIP	1200 TICKS
VMDEL2	MAX BP DURING ENGINE OFF VIP	1563 TICKS (FOR 15 MHZ)

RELATED INITIALIZATION PARAMETERS

TP SENSOR TEST

```
   -----------
 (    ENTER    )
   -----------
        |
        v
   /---------\   NO       !---------!
  /  ITP >=   \---------->! CODE 63 !-->|
  \ TAPMIN ?  /           !---------!   |
   \---------/                          |
        |   YES                         |
        |                               |
        v                               |
   /---------\     NO     !---------!   |
  /   ITP <=  \---------->! CODE 53 !-->|
  \ TAPMAX ?  /           !---------!   |
   \---------/                          |
        |   YES                         |
        v                               |
   /---------\                          |
  /   VTAP1   \   NO      !---------!   |
 /  <=ITP <=   \--------->! CODE 23 !-->|
 \    VTAP2 ?  /          !---------!   |
  \           /                         |
   \---------/                          |
        |  YES                          |
        |<------------------------------|
        v
   -----------
 (     EXIT    )
   -----------
```

PARAMETER NAME	DESCRIPTION	TYPICAL CALIB-RATION VALUE
TAPMIN	MIN. TP SENSOR READING	40 COUNTS
TAPMAX	MAX. TP SENSOR READING	990 COUNTS
VTAP1	MIN. ENGINE-OFF THROTTLE POS	150 COUNTS
VTAP2	MAX. ENGINE-OFF THROTTLE POS	250 COUNTS

RELATED INITIALIZATION PARAMETERS

ACT SENSOR TEST

```
     -----------
   (    ENTER    )
     -----------
          |
          v
     /---------\    NO      !---------!
    /  IACT >=  \---------->! CODE 64 !---|
    \  ACTMIN ? /           !---------!   |
     \---------/                          |
          |   YES                         |
          |                               |
          v                               |
     /---------\    NO      !---------!   |
    /  IACT <=  \---------->! CODE 54 !---|
    \ ACTMAX ?  /           !---------!   |
     \---------/                          |
          |   YES                         |
          v                               |
     /---------\                          |
    /   VIACT1  \   NO      !---------!   |
   /  =>IACT =>  \--------->! CODE 24 !-->|
   \    VIACT2 ? /          !---------!   |
    \           /                         |
     \---------/                          |

          |   YES                         |
          |<------------------------------|
          v
     -----------
   (     EXIT    )
     -----------
```

PARAMETER NAME	DESCRIPTION	TYPICAL CALIB-RATION VALUE
ACTMIN	MIN ACT (ACT SHORTED)	40 COUNTS
ACTMAX	MAX ACT (ACT OPEN)	935 COUNTS
VIACT1	MIN. CHARGE TEMP (ENGINE-OFF)	717 COUNTS
VIACT2	MAX. CHARGE TEMP (ENGINE-OFF)	63 COUNTS

RELATED INITIALIZATION PARAMETERS

MAF SENSOR TEST

```
  --------
(  ENTER   )
  --------
     |
     v
 /--------\ NO
/ IMAF =>  \----------------->|
\ VMAFO1   /                  |
 \--------/                   |
     | YES                    |
     v                        |
 /--------\ YES   !-------!   |
/ IMAF =>  \----->!CODE 56!-->|
\ VMAMAX   /      !-------!   |
 \--------/                   |
     | NO                     |
     v                        |
 !--------!                   |
 ! CODE 26!                   |
 !--------!                   |
     |                        |
     |<-----------------------|
     v
  --------
(   EXIT   )
  --------
```

EGR SENSOR TEST

```
     (PFE)
  -----------
(    ENTER    )
  -----------
       |
       v
  /---------\  YES       -----------
 / PFEHP =2  \-------->(    EXIT      )
 \           /           -----------
  \---------/
       | NO
       v                                (SONIC)
  /---------\
 /  PFEHP=1  \  NO                    /---------\  NO
 \     ?     /---------------------->/  PFEHP=0  \-------------------|
  \---------/                        \     ?     /                   |
       |  YES                         \---------/                    |
       |                                   |  YES                    |
       |                                   v                         |
       v                              /---------\ YES !---------!    |
  /---------\                        /  IEVP <=  \--->! CODE 31 !--->|
 /   IEPT<=  \ YES !---------!       \  EVPMIN   /    !---------!    |
 \   EPTMIN  /---->! CODE 31 !----|   \---------/                    |
  \---------/      !---------!    |        | NO                      |
       |  NO                      |        v                         |
       v                          |   /---------\ YES !---------!    |
  /---------\                     |  /  IEVP >=  \--->! CODE 35 !--->|
 /   IEPT >= \ YES !---------!    |  \  EVPMAX   /    !---------!    |
 \   EPTMAX  /---->! CODE 35 !--->|   \---------/                    |
  \---------/      !---------!    |        | NO                      |
       |  NO                      |        v                         |
       v                          |   /---------\ YES !---------!    |
  /---------\                     |  /  IEVP <   \--->! CODE 32 !--->|
 /   VEPTLL  \ NO  !---------!    |  \  VEVPLL ? /    !---------!    |
/ <= IEPT <=  \--->! CODE 34 !--->|   \---------/                    |
\    VEPTHL   /    !---------!    |        | NO                      |
 \           /                    |        v                         |
  \---------/                     |   /---------\ YES !---------!    |
       |  YES                     |  /  IEVP >   \--->! CODE 34 !--->|
       |<-------------------------|  \  VEVPHL ? /    !---------!    |
       v                              \---------/                    |
  -----------                              | NO                      |
(     EXIT    )                            |<------------------------|
  -----------                              v
                                      -----------
                                    (     EXIT    )
                                      -----------
```

ACC/NDS INPUT TEST

```
            ------
         (  ENTER  )
            ------
              |
              v
       NO /--------\
|<------ /TRLOAD =  \
|        \ 3 OR 4   /
|         \--------/
|             | YES
|             v
|         /--------\ NO       !-------!
|        /IS NDSFLG \------->!CODE 67!
|        \  = 0     /        !-------!
|         \--------/             |
|             | YES              |
|------------>|<-----------------|
              |
              v
          /--------\ NO       !-------!
         /IS A3C=0? \------->!CODE 79!
         \          /        !-------!
          \--------/             |
              | YES              |
              |<-----------------|
              |
              v
            ------
          (  EXIT  )
            ------
```

IVPWR INPUT TEST

```
  ----------
(   ENTER    )
  ----------
      |
      v
 /---------\
/ IIVPWR    \  YES     !---------!
\ < VKYPWR  /--------->! CODE 19 !
 \---------/           !---------!
      |  NO                 |
      |<--------------------|
      v
  ---------
(  EXIT     )
  ---------
```

NOTE: This test is designed to check continuity of the IVPWR circuit internal to the EEC module. It is not to be used as a battery voltage check. If the IVPWR circuit opens up, an incorrect fuel pulse width will result.

$$COUNTS = \frac{IIVPWR * .1786 * 1023}{VREF}$$

$$IIVPWR = \frac{VREF * COUNTS}{.1786 * 1023}$$

RECOMMENDED VKYPWR VALUE: 200 COUNTS (5.47 VOLTS)

POWER STEERING PRESSURE SWITCH TEST

```
      ----------
    (   ENTER    )
      ----------
          |
          |
          v
     /---------\  NO
    / PSPSHP=1 ?\----->( GO TO NEXT TEST )
    \           /
     \---------/
          | YES
          v
    /-----------\
   /  POWSFG = 1 \ YES       !---------!
  /      ?        \-------->! CODE 52 !----|
  \ (SWITCH OPEN) /          !---------!    |

   \             /                          |
    \-----------/                           |
          | NO                              |
          |<--------------------------------|
          v
    -----------
  (   EXIT      )
    -----------
```

OUTPUT CIRCUIT CHECK (OCC)

The OCC uses special module hardware to test certain output channels for open circuits/shorted drivers. The hardware consists of a resistor- divider network which is fed back into an A/D channel. The test begins by turning off all outputs in the network. Outputs are then turned on and off, one at a time, and the A/D channel is used to determine the change in voltage associated with each. A voltage change smaller than expected causes a fault code to be registered. The output channels, their associated fault codes, and expected voltage change calibration parameters for each appear below.

	OC#	CIRCUIT FUNCT.	CAL. PARAMETER	ERROR CODE
	4	EVR	OCCDT4	84
9X,NU	7	FP	OCCDT7	87
	1	AM2 1)	OCCDT1	81
	2	AM1 1)	OCCDT2	82
LU	4	EVR 2)	OCCDT4	84
	5	CANP 3)	OCCDT5	85
	7	FP	OCCDT7	87
	9	CCO 4)	OCCDT9	89
	1	AM2 1)	OCCDT1	81
	2	AM1 1)	OCCDT2	82
	3	HEDF 5)	OCCDT3	83
MU,GU	4	EVR 2)	OCCDT4	84
	5	CANP	OCCDT5	85
	7	FP	OCCDT7	87
	8	EDF 6)	OCCDT8	88
MU ONLY	9	LUS 10)	OCCDT9	89
		SCVNT 11)	OCCDTA	81
		SCVAC 11)	OCCDTB	82
	1	BOOST	OCCDT1	81
	2	HEDF	OCCDT2	82
	4	EGR-S/O	OCCDT4	84
1U	6	FP	OCCDT6	86
	7	EDF	OCCDT7	87
	8	CCO	OCCDT8	88

ENGINE-OFF SEQUENCE
EEC-EPCD, FoMoCo, PROPRIETARY & CONFIDENTIAL

	OC#	CIRCUIT FUNCT.	CAL. PARAMETER	ERROR CODE
	1	SCVNT	OCCDT1	81 *
	2	SCVAC	OCCDT2	82 *
	3	HEDF 8)	OCCDT3	83
NQ	4	EVR	OCCDT4	84
	5	CANP	OCCDT5	85
	7	FP	OCCDT7	87
	8	EDF	OCCDT8	88
	9	LUS 4)	OCCDT9	89
	1	SCVNT	OCCDT1	81 *
	2	SCVAC	OCCDT2	82 *
	3	HEDF	OCCDT3	83
CJ	4	EVR 2)	OCCDT4	84
	5	CANP	OCCDT5	85
	6	AM-1 1)	OCCDT6	86
	7	FP	OCCDT7	87
	8	EDF	OCCDT8	88
	9	LUS/CCO 9)	OCCDT9	89

NOTES:

FP - FUEL PUMP
EVR - ELECTRONIC VACUUM REG.

1) ONLY IF THRMHP=1
2) ONLY IF PFEHP=0 OR 1
3) ONLY IF CANPHP-1 OR 2
4) ONLY IF TRANSW=0 OR 2
5) ONLY IF HEDFHP=1
6) ONLY IF EDFHP=1
7) ONLY IF TRANSW=0 (AXOD)
8) ONLY IF MTXSW=0 (ATX)
9) ONLY IF TRANSW=0(AXOD) OR =2 (A4LD)
10) ONLY IF TRTYPE=0 (AXOD) MU ONLY
11) ONLY IF VSTYPE=2 (Veh. Spd. Cont.)

* Functioned during VSC Self Test Only

OCC TEST STRUCTURE

```
                    -----------
                  (    ENTER    )
                    -----------
                         |
          !--------------------------!
          !DE-ENERGIZE ALL OUTPUTS   !
          !(EXCEPT EDF)**
          ! . OC=1                   !
          !--------------------------!
                         |              NOTE: HEDF TEST MUST
                 !----------------!        IMMEDIATELY FOLLOW
                 ! DELAY 50 MSEC. !        EDF TEST
                 !----------------!
                         |          **ONLY WHEN EDF IS PRESENT
 |---------------------->|
 |            !----------------------!
 |            ! SAVE IOCC IN OCCSAV  !
 |            !----------------------!
 |                       |
 |           !------------------------!
 |           !ENERGIZE* OUTPUT #(OC)  !
 |           !------------------------!
 |                       |         *EXCEPT OC #8(EDF)**WHICH
 |               !----------------! SHOULD BE DE-ENERGIZED
 |               ! DELAY 50 MSEC. ! DURING THIS STEP
 |               !----------------!
 |                       |
 |                /-------------\          !-------------!
 |               /  ABS[OCCSAV-  \     NO  !     SET     !
 |              /   IOCC]    >=   \------->! APPROPRIATE !
 |              \ OCCDT(OC) COUNTS/        !  FAIL CODE  !
 |               \       ?       /         ! (SEE TABLE) !
 |                \-------------/          !-------------!
 |                       |  YES                  |
 |                       |<----------------------|
 |                       v
(A)                 /--------\ YES     !-----------!
                   /IS THIS   \------->!  DELAY    !
                   \  EDF ?   /        !VDLEDF-SEC !
                    \--------/         !-----------!
                         |<------------------|
                      NO |
                         v
                    /--------\ YES     !-----------!
                   / IS THIS  \------->!  DELAY    !
                   \   HEDF ? /        !VDLHED-SEC !
                    \--------/         !-----------!
                         |<------------------|
                      N0 |
                         v
                        (B)
```

OCC TEST STRUCTURE

```
                            (B)
    (A)                      |
     ^                       v
     |         !--------------------------!
     |         !DE-ENERGIZE  OUTPUT #(OC) !
     |         !--------------------------!
     |                       |
     |               !----------------!
     |               ! DELAY 50 MSEC. !
!----------!         !----------------!
! OC= OC+1 !                 |
!----------!            /---------\
     |           NO    /    IS     \
     |<---------------/ OC= LASTOC ?\
                      \             /
                       \           /
                        \---------/
                             |  YES
                             v
                        -----------
                      (    EXIT     )
                        -----------
```

OCC PARAMETER DEFINITIONS

NAME	DESCRIPTION	UNITS	RANGE MIN	RANGE MAX	BASE
OC	OUTPUT CIRCUIT #	-	0	9	-
OCCSAV	SAVED OCC A/D	COUNTS	0	1023	-
IOCC	OCC A/D	COUNTS	0	1023	-
OCCDTx(1-9)	MIN A/D CHANGE	COUNTS	-1023	1023	36

FUEL PUMP CIRCUIT TEST

```
                --------
              (  ENTER   )
                --------
                   |
                   v
           NO  /--------\
|<------------/ IS V_    \
|             \FPMFLG=1? /
|              \--------/
|                  |YES
|                  v
|          YES /--------\
|<------------/IS CODE   \
|             \  87 SET? /
|              \--------/
|                  |NO
|                  v
|          !------------------!
|          !1)TURN FP "ON"    !
|          !2)DELAY V_FPMDLY  !
|          !------------------!
|                  |
|                  v
|             /--------\ NO       !---------!
|            / IS FPM   \-------->! CODE 96 !
|            \ HIGH ?   /         !---------!
|             \--------/               |
|                  |YES                |
|                  |<------------------|
|                  v
|          !------------------!
|          !1)TURN FP "OFF"   !
|          !2)DELAY V_FPMDLY  !
|          !------------------!
|                  |
|                  v
|             /--------\ NO       !----------!
|            / IS FPM   \-------->! CODE 95  !
|            \ LOW ?    /         !----------!
|             \--------/               |
|                  | YES               |
|----------------->|<------------------|
                   v
                --------
              (  EXIT    )
                --------
```

KAM QUALIFICATION TEST

PERFORMED EACH BACKGROUND LOOP

```
KAMQA= 10101010 BINARY----|         | .SET KAMOK =1
                          |         | .ASSUME KAM DATA IS VALID
KAMQB= 11000110 BINARY----| AND-----| .ALL STRATEGY REFERENCES
                          |         |  TO KAM WILL USE RAM DATA.
KAMQC= 01110101 BINARY----|         |
                                    |     ---ELSE---
                                    |
                                    | .CLEAR KAMOK =0 & SET
                                    |  VIPKAM =1
                                    | .ASSUME KAM DATA IS BAD.
                                    | .INITIALIZE ALL KAM
                                    | LOCATIONS USED IN THE
                                    | STRATEGY.
                                    | .WRITE THE SPECIAL BINARY
                                    |  PATTERNS TO KAM:
                                    |    KAMQA= 10101010 BINARY
                                    |    KAMQB= 11000110 BINARY
                                    |    KAMQC= 01110101 BINARY
                                    | .SUBSTITUTE THE KAM INITIAL
                                    |  VALUES FOR ALL STRATEGY
                                    |  REFERENCES TO KAM.
                                    |
                                    | NOTE:
                                    |   VIPKAM INITIALIZED TO 0
                                    |   ON POWER-UP.
```

OUTPUT TEST MODE

In this mode, normal outputs, EDF or HEDF can be turned on/off based on operator requests.

NORMAL OUTPUTS ON/OFF LOGIC --------------------------- Move throttle part mid-range, then release to turn on/off normal outputs.

EDF ON/OFF LOGIC ---------------- With STO high, move throttle past mid-range and hold until Code 10 is displayed on Star Tester (approx. 10 sec.), then release throttle to turn "on" EDF and normal outputs. To turn "off" outputs move throttle past mid-range and then release.

HEDF ON/OFF LOGIC ----------------- With STO high, move throttle past mid-range and hold until Code 10 and then Code 20 is displayed on Star Tester (approx. 15 sec.), then release throttle to run "on" HEDF and normal outputs. To turn "off" outputs move throttle past mid-range and then release.

NORMAL OUTPUTS

1) AM1	2) EDF	3) HEDF
1) AM2	EVR	ISC
CANP		
5) SCVAC	STO	
SCVNT	WAC	

1) FUNCTION ONLY WHEN THRMHP=1
2) FUNCTION ONLY WHEN EDFHP=1
3) FUNCTION ONLY WHEN HEDFHP=1
4) FUNCTION ONLY WHEN TRTYPE=0 - MU ONLY
5) FUNCTION ONLY WHEN VSTYPE=2

OUTPUT TEST MODE (CONT'D)
For Application with EDF or HEDF

1. RESET OUTTMR & VIP TIMER 2. CLEAR VLFNON & VHFN ON
   PRIOR TO ENTRY

```
  -----           /--------\ YES      -----
( ENTER )------->/ARE CODES \------>( EXIT  )
  -----         /  BEING     \        -----
                \  OUTPUTTED?/
                 \          /
                  \--------/
                      | NO
     |<---------------|
     v
 /--------\ NO        /--------\ NO        /--------\ NO
/ ITP >    \-------->/IS REQFLG \-------->/IS OUTTMR \----->|
\ VTAP5    /  ^  ^   \  SET ?   /   ^     \=> 10 MIN /      |
 \--------/   |  |    \--------/    |      \--------/       |
     |YES     | (B)       | YES     |          | YES        |
     v        |           v         |          |            |
 !-------!    |       /--------\NO  |          |            |
 !. SET  !    |      / ITP <=   \---|          |            |
 !REQFLG !    |      \  VTAP6   /              |            |
 !-------!    |       \--------/               |            |
     |        |           |YES                 v            |
     v        |           |               !----------!      |
 /-------\YES |           v               !TURN ALL  !      |
/ARE OUT- \---|       /--------\YES       !ACTUATORS !      |
\PUTS ON? /          /ARE OUT-  \-------->!"OFF" IN- !      |
 \-------/           \PUTS ON?  /         !CLUDING   !      |
     | NO             \--------/          !EDF & HEDF!      |
     v                    |NO             !----------!      |
    (A)                   |                    |            |
                          v                    |            |
     !---------!   YES/--------\               |            |
     !TURN "ON"!<----/IS "VLFN  \              |            |
     !  EDF    !     \ON"FLG SET/              |            |
     !---------!      \--------/               |            |
         |                |NO                  |            |
         |--------------->|                    |            |
     !---------!   YES/--------\               |            |
     !TURN "ON"!<----/IS "VHFN  \              |            |
     ! HEDF    !     \ON"FLG SET/              |            |
     !---------!      \--------/               |            |
         |                |NO                  |            |
         |--------------->|                    |            |
                  !---------------!     !-------------!     |
                  !TURN "ON"      !---->!.CLEAR VLFNON!     |
                  !REGULAR OUTPUTS!     !VHFNON&REQFLG!     |
                  !---------------!     !.SET OUTTMR=0!     |
                                        !-------------!     |
        -----        !---------!               |            |
      ( EXIT  )<-----!SET VIP  !<---------------------------|
        -----        !TMR =0   !
                     !---------!
```

OUTPUT TEST MODE (CONT'D)
For Application with EDF or HEDF

```
        (A)
         |
         v
 !---------------!
 !ALLOW VIP-TMR  !
 !   TO RUN      !
 !---------------!
         |
    /--------\ NO
   /IS HEDFHP \-----------|
   \    =1 ?  /           |
    \--------/            |      /--------\ N0
         | YES            |---->/IS EDFHP  \----->(B)
         v                |     \   =1?    /
    /---------\NO         |      \--------/
   /IS VIPTMR >\----------|          | YES
   \  VHFNTM   /                     v
    \---------/                  /--------\NO
         |YES                   /IS VIPTMR \-----------|
         v                      \> VLFNTM  /           |
    /---------\NO                \--------/            |
   /IS "VHFNON"\---------|           |YES              |
   \   =0?     /         |           v                 |
    \---------/          |       /--------\NO          |
         |YES            |      /IS VLFNON \---------->|
         v               |      \   =0 ?   /           |
!-----------------!      |       \--------/            |
!.SET "VHFNON"=1  !      |           |YES              |
!.SET "VLFNON"=0  !----->|           v                 |
!OUTPUT CODE 20   !      |    !--------------!         |
!-----------------!      |    !.SET VLFNON=1 !-------->|
                         |    !OUTPUT CODE 10!         |
                         |    !--------------!         |
                         v                             v
                       ------                        ------
                     (  EXIT  )                    (  EXIT  )
                       ------                        ------
```

CHAPTER 27

ENGINE-RUNNING SEQUENCE

```
                ENGINE-RUNNING
                TEST STRUCTURE

      -----------
     (    ENTER    )
       -----------
          |
!---------------------!
!   ENGINE-RUNNING    !
! TEST INITIALIZATION !
!---------------------!
          |
   /--------------\
  /HIGH RPM ISC    \
  \     TEST       /
   \--------------/
          |
   /---------------\
  /    A/D  AND     \
  \  SWITCH TESTS   /
   \---------------/
          |
  /-----------------\
 /       FUEL AND     \
 \ THERMACTOR TESTS  /
  \-----------------/
          |
     /---------\
    /   EGR     \
    \   TEST    /
     \---------/
          |
    /----------\
   / LOW RPM    \             |---------->|<---------|
   \ ISC TEST   /             |           v          |
    \----------/              |  NO  /-----------\   |
          |                   |  |<-/IS CYLINDER  \  |
          |                   |  | /BALANCE TEST   \ |
          |                   |  | \   REQUESTED ? / |
          |                   |  |  \             /  |
          |                   |  |   \-----------/   |
 !--------------------!       |  |        | YES      |
 ! SEND SERVICE CODES !------>|  |        v          |
 !--------------------!          |   /-----------\   |
                                 |  / DO CYLINDER \  |
  !-------------------!          |  \ BALANCE TEST/  |
  !   2 MINUTE DELAY  !<---------|   \-----------/   |
  ! FOR TIMING CHECK  !                   |          |
  !-------------------!                   v          |
          |                         !----------!     |
     /---------\      ----          ! CYLINDER !     |
    /  WIGGLE   \--->(EXIT)         ! BALANCE  !---->|
    \   TEST    /     ----          ! SERVICE  !
     \---------/                    !----------!
```

EGOBAR FILTER AND STATE FLAGS

IEGO is filtered in EGOBAR (side) -where side =left or right on stereo systems, left only on mono systems. Time constant for EGOBAR is VTCEGO (a calibratible parameter). EGOSTE (side) is the resultant ego state flag, determined as follows:

```
Non-shared ego{EGOBAR (side) > 855 counts-->EGOSTE (side)=lean(1)
              {EGOBAR (side) <=855 counts-->EGOSTE (side)=rich(0)

Shared ego/STI{EGOBAR (side) > 425 counts-->EGOSTE (side)=lean(1)
              {EGOBAR (side) <=425 counts-->EGOSTE (side)=rich(0)
```

DELAY LOGIC CLARIFICATION:

DELAY VDLY(x) MEANS:

```
!----------!
!   SET    !
! VIPTMR=0 !
!----------!
      |
      |<------------|
      v             |
 /---------\    YES |
/ VIPTMR <  \-------|
\ VDLY(x) ? /
 \---------/
      |  NO
      |
      v
   CONTINUE
```

TIMER LOGIC CLARIFICATION:

"RESTART VIPTMR" MEANS:
SET VIPTMR=0

ENGINE-RUNNING INITIALIZATION

```
   N0  /-------\        -----------
|-----/VDISFM = \<----(     ENTER    )
|     \   0?    /       -----------
|      \-------/
|          |YES   /--------------------\        !-----------!
|          |     /IS ANY OF THE FOLLOW- \YES    !OUTPUT CODE!
|          |--->/ING FMEMFLG SET =1?     \----->!98 AND THE !
|              *\MFMFLG,TFMFLG,AFMFLG,OR /      !CORRESPOND-!
|                \      CFMFLG          /       !ING FMEM   !
|                 \--------------------/        !FAULT CODE !
|                          | NO                 !-----------!
|--------------------------->|                        |
 *MAF FMEM FLAG IN GX        |                      ------
                             |                    (  EXIT  )
                             v                      ------
          !-----------------------------------!
          ! .LAMBSE1=LAMBSE2=VRLAM(OPEN LOOP)!
          ! .SPARK ADVANCE =VIPSPK             !
          ! .KNOCKEABLE = 0 (DISABLE KTS       !
          !    PULSES                          !
          ! .EVRDC = 0                         !
          ! .AM1, AM2 AND CANP "OFF"           !
          ! .DE-ACTIVATE DECELL FUEL SHUTOFF !
          ! .TURN WAC "OFF"  (A/C OFF)         !
          ! .KAMRF1=KAMRF2=KAMREF=1.0          !
          ! .ENABLE AE THROUGHOUT TEST         !
          ! .DSDRPM = VISCN                    !
          ! .DISABLE TRANSIENT FUEL            !
          ! .SET TCDESN=VTCDSN WHEN VTCDSN     !
          !    NOT = 0                         !
          ! .SET CODES 74,75 & 52              !
          ! .ENABLE SELF-TEST IEPT FILTER:     !
          !   FIEPT=(1=VFIEPT)=FIEPT+VFIEPT= !
          !   IEPT                             !
          ! .DISABLE ADAPTIVE FUEL             !
          ! .SET KPSIND = VPSIND               !
          ! .SET KPSINU = VPSINU               !
          ! .SET PSIBRM = VSIBRM               !
          ! .SET PSIBRN = VSIBRN               !
          ! .SET FN860 = V860                  !
          ! .SET FN820B = V820A                !
          ! .SET FN824 = 1.0                   !
          !-----------------------------------!
                             |
                             v
                            (A)
```

ENGINE-RUNNING INITIALIZATION (CONT'D)

```
                                (A)
                                 |
                                 v
NOTE: USE "ENGCYL" TO   !------------------!
  SELECT PROPER ENGINE  ! SEND ENGINE I.D. !
  ID CODE.              !      CODE        !
  ID CODE= # OF CYL/2   !------------------!
                                 |  --WAIT HERE UNTIL PULSING
                                 v    IS COMPLETE
                             --------
                           (   EXIT   )
                             --------
```

HIGH RPM ISC TEST

```
                              --------
                            (   ENTER  )
                              --------
                                 |
                                 v
                  !-----------------------------!
                  !     DO VIP DESIRED RPM      !
                  !        CALCULATION          !
                  !-----------------------------!
                                 |
                                 v
                          !------------!
                          !DELAY VISDL1!
                          !------------!
                                 |
           NO  /---------------------------------\
     |--------/ (VISCN+ISUBND)>RPM>(VISCN-ISUBND) \
     |        \                ?                  /
     |         \---------------------------------/
     |                           | YES
     v                           v
!-----------!           !--------------------!
!SET CODE 12!---------->!.FIX DC (OPEN LOOP) !
!-----------!           !.IGNORE DSDRPM CALC.!
                        !--------------------!
                                 |
                                 v
                             ---------
                           (   EXIT    )
                             ---------
```

ENGINE-RUNNING
A/D TEST STRUCTURE

```
  -----------
(    ENTER    )
  -----------
       |
       v
  /---------\
 / TEST ECT  \
 \           /
  \---------/
       |
  /---------\
 /  TEST TP  \
 \           /
  \---------/
       |
  /---------\
 / TEST ACT  \
 \           /
  \---------/
       |
  /---------\
 /   BRAKE   \
 \   ON/OFF  /
  \---------/
       |
  /---------\
 /   PSPS    \
 \           /
  \---------/
       |
  /---------\
 / TEST MAF  \
 \           /
  \---------/
       |
  -----------
(     EXIT    )
  -----------
```

ECT SENSOR TEST

```
   -----------
 (    ENTER    )
   -----------
        |
        v
   /---------\
  /   VIECT3  \   NO       !---------!
 /  <=IECT <=  \---------->! CODE 21 !
 \    VIECT4 ? /           !---------!
  \           /                 |
   \---------/                  |
        |  YES                  |
        |<----------------------|
        v
   ----------
 (     EXIT   )
   ----------
```

PARAMETER NAME	DESCRIPTION	TYPICAL CALIBRATION VALUE
VIECT3	MIN. COOLANT TEMP (ENGINE-ON)	235 COUNTS
VIECT4	MAX. COOLANT TEMP (ENGINE-ON)	63 COUNTS

RELATED INITIALIZATION PARAMETERS

TP SENSOR TEST

```
  -----------
 (    ENTER    )
  -----------
       |
       v
  /---------\
 /   VTAP3   \   NO      !---------!
/  <=ITP <=   \--------->! CODE 23 !
\    VTAP4 ?  /          !---------!
 \           /                |
  \---------/                 |
       |  YES                 |
       |<---------------------|
       v
  -----------
 (     EXIT    )
  -----------
```

PARAMETER NAME	DESCRIPTION	TYPICAL CALIB-RATION VALUE
VTAP3	MIN. THROTTLE POSITION	150 COUNTS
VTAP4	MAX. THROTTLE POSITION	250 COUNTS (CALIB. DEP)

RELATED INITIALIZATION PARAMETERS

ACT SENSOR TEST

```
  -----------
(    ENTER    )
  -----------
       |
       v
  /---------\
 /   VIACT3  \    NO      !---------!
/  <=IACT <=  \---------->! CODE 24 !
\    VIACT4 ? /           !---------!
 \           /                 |
  \---------/                  |
       |  YES                  |
       |<----------------------|
       v
  -----------
(     EXIT    )
  -----------
```

PARAMETER NAME	DESCRIPTION	TYPICAL CALI- BRATION VALUE
VIACT3	MIN. CHARGE TEMP. (ENGINE-ON)	670 COUNTS
VIACT4	MAX. CHARGE TEMP. (ENGINE-ON)	63 COUNTS
	IF IN AIR CLEANER	760 COUNTS

RELATED INITIALIZATION PARAMETERS

BRAKE ON/OFF TEST

```
                 NO /--------\        --------
     |<-----------/ VB1SW    \<---(  ENTER   )
     |            \  = 1     /        --------
     |             \--------/
     |                  | YES
     v                  v
 !-------!        /---------\
 ! CLEAR !    NO /  BIHP=1   \
 ! CODES !<------\     ?     /
 !74 & 75!        \---------/
 !-------!             |
     |                 | YES
     |                 v
     |            /---------\         !--------!
     |           / BIFLG=1   \ YES    ! CLEAR  !
     |          /(BRAKE ON    \----->! CODE 74!
     |          \ BOO HIGH) ? /       !--------!
     |           \           /            |
     |            \---------/             |
     |                 |                  |
     |                 | NO               |
     |                 v                  |
     |           !----------!             |
     |           !CLEAR CODE!             |
     |           !    75    !             |
     |           !----------!             |
     |                 |                  |
     |---------------->|<-----------------|
                       v
                   ---------
                 (   EXIT    )
                   ---------
```

NOTE: This test is run continuously from I.D. code output to service code output (including "Goose" test).

PSPS TEST

```
          --------
        (  ENTER   )
          --------
             |
             v
        /---------\NO
       / VPSSW = 1 \------------->|
       \           /              |
        \---------/               |
             |                    |
        /---------\ NO            |
       / PSPSHP=1? \------------->|
       \     ?     /              |
        \---------/               |
             | YES                |
             |                    |
      /-------------\YES    !----------!
     /PSPS CHANGED   \----->!  CLEAR   !
     \     STATE ?   /      ! CODE 52  !
      \-------------/       !----------!
             | NO                 |
             |<-------------------|
             v
         --------
       (  EXIT    )
         --------
```

NOTE: TEST TO BE PERFORMED JUST AFTER THE "ENGINE I.D. PULSE BY TURNING STEERING WHEEL 1/4 TO 1/2 TURN THEN RELEASING.

MAF SENSOR TEST

```
      --------
    (  ENTER   )
      --------
         |
         |
         v
 /-----------------\  YES      !---------!
/IMAF => VMAFR2 OR \--------->!CODE 26 !
\   IMAF <= VMAFR1 /          !---------!
 \-----------------/               |
         | NO                      |
         |                         |
         |<------------------------|
         |
         v
      --------
    (  EXIT    )
      --------
```

EGO SWITCHING TEST
(STEREO)

```
  ---------
(   ENTER   )
  ---------
      |            !-------------!
      v            !IF NUMEGO=1  !      !-----------------!
  /---------\ YES  !SET CODE 42 &!      !.RAMP FUEL LEAN !
 / NBAR >=   \---->!IF NUMEGO=2  !----->!   VIPLR1        !
 \  VNMIN    /     !.SET CODES 42!  ^   !.CLIP AT LEAN   !
  \---------/      !& 92         !  |   !  LIMIT LEQV    !
      | NO         !.START VIPTMR!  |   !-----------------!
      |            !-------------!  |            |
      |                             |            v
      |                             |     /----------\ YES
      |                             |    / EGOSTE1=1  \------|
      |                             |    \  LEAN ?    /      |
      |                             |     \----------/       |
      v                             |            | NO        v
  -------------      !----------!   |            |       !---------!
(  EXIT ENGINE   )   ! CONTINUE !--->|           |<------!  CLEAR  !
   RUNNING TEST      ! RAMPING  !                |       ! CODE 42 !
  -------------      !----------!                v       !---------!
                          ^               /----------\YES
                          |              / EGOSTE2=1  \------|
                          |              \  LEAN ?    /      |

                          |               \----------/       |
                          |                      | NO        v
                          |                      |       !---------!
                          | NO                   |<------!  CLEAR  !
                          |                      |       ! CODE 92 !
                          |                      v       !---------!
                    /----------\       YES /----------\
                   / VIPTMR >=  \<--------/IS 42 OR 92 \
                   \ VIPTM3     /         \  PRESENT   /
                    \----------/           \----------/
                          |                      | NO
                          v                      v
                   !--------------!            ( A )
                   !STORE CODE(s) !
                   !WHICH DID NOT !
                   !    CLEAR     !
                   !--------------!
                          |
                          v
                         (AA)
```

EGO SWITCHING TEST (CONT'D)

```
          !-----------------!
          !IF NUMEGO=1 SET  !
          !CODE 41 & IF     !       !------------------!
(A)------>!NUMEGO=2 THEN    !       !.RAMP FUEL RICH AT!
          !SET CODES 41 & 91!------>!    VIPRR1        !
          !START VIPTMR     !   ^   !.CLIP AT RICH     !
          !-----------------!   |   !    LIMIT REQV    !
                                |   !------------------!
                                |            |
                |-------------------------->|
                |               ^            v
                |               |      /---------\ YES
                |               |     / EGOSTE1=0 \-------|
                |               |     \   RICH ?  /       |
                |               |      \---------/        |
                |               |            | NO         |
                |        !-----------!       |            v
                |        !CONTINUE   !       |      !----------!
                |        !RAMPING    !       |<-----!CLEAR CODE!
                |        !ZERO VIPTMR!       |      !    41    !
                |        !-----------!       |      !----------!
                |               ^            v
                |               |      /---------\ YES
                |               |     / EGOSTE2=0 \-------|
                |               |     \   RICH ?  /       |
                |               |      \---------/        |
                |               |            | NO         |
                |               |            |            v
                |               |            |      !----------!
                |               |            |<-----!CLEAR CODE!
                |               |N0          |      !    91    !
                |               |            |      !----------!
                |               |            |
          /---------\ YES /---------\ YES/---------\
         / VIPTM >=  \<--/IS LAMBSE  \<-/IS 41 OR 91\
         \ VIPTM4    /   \ =< REQV ? /  \ PRESENT ? /
          \---------/     \---------/    \---------/
                |NO                          | NO
                v                            v
        !-------------!              -----------------
(AA)<---!STORE CODE(s)!             ( EXIT TO NEXT TEST )
        !WHICH DO NOT !              -----------------
        !    CLEAR    !
        !-------------!

        !--------------!     !----------!      ----------------
(AA)--->!SET LAMBSE1 & !---->!  DELAY   !--->( EXIT TO EGR TEST )
        !LAMBSE2=VRLAM !     !  VDLY8   !      ----------------
        !--------------!     !----------!
```

AIR TEST

```
    (C)                 (C)
     ^                   ^
     |NO                 |NO
 /--------\      YES /--------\             -----
/VAIRFL=1  \<-------/THRMHP=1? \<--------(  ENTER  )
\          /        \          /            -----
 \--------/          \--------/
     | YES
     v
!------------!
!IF NUMEGO=1 !
!SET CODE 44 !
!& IF NUMEGO=!
!2 THEN      !     !----------!      !-------------!
!SET CODES 44!---->!RAMP FUEL !----->!AIR UPSTREAM,!
!& 94 START  !     !RICH AT   !      !AM1 & AM2    !
! VIPTMR     !     !VIPRR1    !      !    BOTH ON  !
!------------!     !FOR VDLY1 !      !-------------!
                   !----------!             |
                    |---------------------->|
                    |                       v
                    |                 /---------\ YES
                    |                /EGOSTE1=1  \------|
                    |                \ (LEAN) ?  /      |
                    |                 \---------/       |
                    |                       | NO        |
                    |                       |        !---------!
                    |                       |<------!  CLEAR  !
                    |                       |       ! CODE 44 !
                    |                       |       !---------!
                    |                       v
                    |                 /---------\ YES
                    |                /EGOSTE2=1  \----->|
                    |                \  (LEAN) ? /      |
                    |                 \---------/       |
                    | NO                    | NO        |
                    |                       |       !---------!
                    |                       |<------!  CLEAR  !
                    |                       |       ! CODE 94 !
                    |                       |       !---------!
                    |                       |
               /---------\    YES    /----------\
              /VIPTMR >   \<--------/IS 44 OR 94 \
              \ VIPTM2    /         \  PRESENT   /
               \---------/           \----------/
                    | YES                   | NO
                    v                       v
            !------------------!          ( B )
            !STORE CODES WHICH!
            ! DID NOT CLEAR   !
            !------------------!
                    |
                    v
                  ( C )
```

AIR TEST (CONT'D)

```
               ( B )
                 |
                 v
     !-----------------------!
     !.AIR DOWN STREAM,AM1   !
     !   ON, AM2 OFF         !            /--------\NO
     !. START VIPTMR         !           / VTABFL=1 \--->(C)
     !-----------------------! |-------->\          /
                 |             |          \--------/
|--------------->|             |               |
|                v             |               v
|           /---------\        |       !---------------!
|          /EGOSTE1 OR \ YES   |       !AIR UPSTREAM & !
|         /EGOSTE2 = 0  \-------       !BYPASSED,AM1   !
|         \  (RICH) ?   /      ^       !   OFF, AM2 ON !
|          \           /       |       !DELAY VDLY2    !
|           \---------/        |       !    SEC        !
|                | NO          |       !---------------!
|                |        !--------!           |
|                |        !SET CODE!           |
|                |        !  45    !           |
|                |        !--------!           |
|                |             |               v
|     NO   /----------\ YES    |         /-----------\ YES
|<--------/ VIPTMR >=  \------>|        / EGOSTE1 OR  \----|
          \ VATMR2     /                \ EGOSTE2 =0 ?/    |
           \----------/                  \-----------/     |
                                               |           |
                                               v           |
                                          !----------!     |
                                          !SET CODE  !---->|
                                          !   46     !     v
                                          !----------!   ( C)

       ( C )
         |
  !--------------!         !-----------!         --------
  !SET LAMBSE1 & !--------->!DELAY VDLY8!------->(  EXIT    )
  !LAMBSE2=VRLAM !         !-----------!         --------
  !BOTH AM1 & AM2!
  !    OFF       !
  !--------------!
```

EGR SYSTEM TEST

(PFE/SONIC)

```
    (PFE)
  ---------
(  ENTER    )
  ---------
      |
      v
  /---------\  YES       -----------
 / PFEHP =2  \-------->(    EXIT     )
 \           /           -----------
  \---------/
       | NO
       v                               (SONIC)
  /---------\
 /  PFEHP=1  \  NO                    /---------\  NO
 \     ?     /---------------------->/  PFEHP=0  \--------------------|
  \---------/                        \     ?     /                    |
       |  YES                         \---------/                     |
       |                                   |  YES                     |
       |                                   v                          |
       v                              /---------\ YES  !---------!    |
 /---------\                         /  IEVP <=  \---->! CODE 31 !--->|
/ FIEPT <=  \YES  !--------!         \  EVPMIN ? /     !---------!    |
\ EPTMIN    /---->!CODE 31 !----|     \---------/                     |
 \---------/      !--------!    |          | NO                       |
      |                         |          v                          |
      | NO                      |     /---------\ YES  !---------!    |
      v                         |    /  IEVP >=  \---->! CODE 35 !--->|
 /---------\                    |    \  EVPMAX ? /     !---------!    |
/ FIEPT >=  \ YES !--------!    |     \---------/                     |
\ EPTMAX    /---->!CODE 35 !--->|          | NO                       |
 \---------/      !--------!    |          v                          |
      |                         |     /---------\ YES  !---------!    |
      | NO                      |    /  IEVP <   \---->! CODE 32 !--->|
      v                         |    \  VEVPLL ? /     !---------!    |
 /---------\                    |     \---------/                     |
/ FIEPT <   \ YES !--------!    |          | NO                       |
\ VEPTRL    /---->!CODE 32 !--->|          v                          |
 \---------/      !--------!    |     /---------\ YES  !---------!    |
      |                         |    /  IEVP >   \---->! CODE 34 !--->|
      | NO                      |    \  VEVPHL ? /     !---------!    |
      v                         |     \---------/                     |
 /---------\                    |          | NO                       |
/ FIEPT >   \ YES !--------!    |          v                          |
\ VEPTRH    /---->!CODE 34 !--->|        ( B )          ( EXIT )<-----|
 \---------/      !--------!    |
      |                         |
      | NO                      |
      v                         v
     (A)                    ---------
                          (   EXIT    )
                            ---------
```

EGR SYSTEM TEST (CONT'D)

```
              (A)
               |
               v
  !-----------------------!
  !.SET VIPTMR=0          !
  !.SAVE FIEPT -> FEPTSV  !
  !-----------------------!
               |
|------------->|
|              v
|   !-----------------------!
|   !.RAMP EGRDC AT VEGRAT  !
|   ! START FROM VDCMIN TO  !
|   ! VDCMAX.               !
|   !.EGRDC=VDCMIN +        !
|   ! VEGRAT*VIPTMR         !
|   !-----------------------!
|              |
|              |
|              v
|         /----------\
|        / FEPTSV-    \  YES
|       /  FIEPT >     \----|
|       \  VEPTDL ?    /    |
|        \            /     |
|         \----------/      |
|              | NO         |
|              v            |
|    NO   /----------\      |
|-------/ EGRDC >=    \     |
        \ VDCMAX ?    /     |
         \----------/       |
               | YES        |
               |            |
               |            |
               v            |
         !-----------!      |
         ! CODE 33   !      |
         !-----------!      |
               |            |
               |            |
               |<-----------|
               v
      !----------------!
      !.SET EGRDC=0    !
      !.SET VIPTMR=0   !
      !----------------!
               |
               |
               v
           ---------
         (   EXIT    )
           ---------
```

```
            ( B )
              |
              v
   !---------------------!
   !.SET VIPTMR =0       !
   !.SAVE IEVP -> IEVPSV !
   !---------------------!
              |
|------------>|
|             v
|   !----------------------!
|   !.RAMP EGRDC AT VEGRAT !
|   ! START FROM VDCMIN TO !
|   ! VDCMAX.              !
|   !.EGRDC=VDCMIN +       !
|   ! VEGRAT*VIPTMR        !
|   !----------------------!
|             |
|             |
|             |
|             v
|       /-----------\   YES
|      / IEVP-IEVPSV \----|
|      \ > VEVPDL ?  /    |
|       \-----------/     |
|             | NO        |
|             |           |
|             v           |
|    NO  /---------\      |
|-------/ EGRDC >=  \     |
        \  VDCMAX   /     |
         \---------/      |
              |           |
              |           |
              | YES       |
              v           |
         !----------!     |
         ! CODE 33  !     |
         !----------!     |
              |           |
              |           |
              |<----------|
              v
      !---------------!
      !.SET EGRDC=0   !
      !.SET VIPTMR=0  !
      !---------------!
              |
              |
              v
          ---------
        (   EXIT    )
          ---------
```

SPOUT CHECK TEST

```
  --------          /--------\ NO        ----
(  ENTER   )------>/IS VSPTEN \------>(  EXIT  )
  --------         \  = 1?    /          ----
                    \--------/
                        | YES
                        v
             !--------------------------!
             ! 1)SET SPK ADV TO "VSPRET"!
             ! 2)DELAY FOR "VSPTDL" SEC !
             ! 3)SAVE NBAR -> "VSPTN"   !
             !--------------------------!
                        |
                        v
             !--------------------------!
             ! 1)SET SPK ADV TO "VSPADV"!
             ! 2)DELAY FOR "VSPTDL" SEC !
             !--------------------------!
                        |
                        v
               /------------------\ NO    !--------!
              / NBAR - VSPTN =>    \----->!CODE 18 !
              \        VSPRPM      /      !--------!
               \------------------/           |
                        | YES                 |
                        |<--------------------|
                        v
             !--------------------------!
             !RESET SPK ADV TO "VIPSPK" !
             !--------------------------!
                        |
                        v
                     -------
                   (  EXIT   )
                     -------
```

LOW RPM ISC TEST

```
                         -----------
                       (    ENTER    )
                         -----------
                              |
                              v
               !----------------------------!
               !  .LOAD NGOOSE -> VIPRPM    !
               !  .DO ISC DESIRED RPM       !
               !    CALCULATION (EACH BG    !
               !          LOOP              !
               !----------------------------!
                              |
                              v
                       !------------!
                       !DELAY VISDL3!
                       !------------!
                              |
                              v
!--------! NO  /----------------------------------\
!SET CODE!<---/(NGOOSE+ISLBND)>RPM>(NGOOSE-ISLBND) \
!   13   !    \                                    /
!--------!     \----------------------------------/
    |                         | YES
    |------------------------>|
                              v
                           -------
                         (  EXIT   )
                           -------
```

VTCDSN - Self test idle speed ramp down time constant. This parameter takes the place of the normal strategy filter constant "TCDESN" when in self test. Calibrating "VTCDSN" to zero will result in defaulting to the "TCDESN" value.

CYLINDER BALANCE TEST

```
                   -------
                 (  ENTER  )
                   -------
                      |
                      v
              !----------------!
              !SET ABORT FLG =0!
              !CYL BAL FLG =0  !
              !----------------!
                      |
                     (A)
                      |
                      v
             1=  /---------\
           |<---/ ABORT FLG \
           |    \   STATE   /
           |     \---------/
           |          | =0
           |          v
  -----    | 0=  /--------\ > 0
( EXIT  )<------/ VCBFLG   \--------->|
  -----    |    \  STATE   /          |
           |     \--------/           |
           |          | < 0           |
           |          v               |------>(B)
           | 1=  /-------\ = 0        |
           |<---/CYL BAL  \---------->|
                \FLG STATE/
                 \-------/
```

CYLINDER BALANCE TEST (CONT'D)

```
                    (B)
                     |
                     v
              !-------------!
              !.SET TPOFLG=0!
              !.RESET VIPTMR!
              !-------------!
                     |
                     |<------------------------|
       (APT NOT= -1) v                         |
!------!  OPEN   /--------\                    |
! SET  !<-------/   TP     \                   |
!TPOFLG!        \  STATE   /                   |
! = 1  !         \--------/                    |
!------!             | CLOSE (APT = -1)        |
   |                 |                         |
   |---------------->|                         |
                     v                         |
                  /-------\ = 0                | < 2 MIN
                 / TPOFLG  \------|            |
                 \  STATE  /      |       /--------\
                  \-------/       |----->/   TMR    \
                     | = 1        |      \  STATE   /
                     |            |       \--------/
                     v            |            | > 2 MIN
           CLOSE /-------\ OPEN   |            |
       |<-------/   TP    \-------|            |
       |        \  STATE  /                    v
       |         \-------/                 ----------
       |                                (   EXIT TO   )
       v                                  WIGGLE TEST
      (C)                                  ----------
```

CYLINDER BALANCE TEST (CONT'D)

```
      (C)
       |
       v
!-------------------!
!SET: SPARK ADVANCE!
!        =VIPSPK   !
!CYLNUM=ENG CYL NO.!           !---------!
!LAMBSE1=LAMBSE2=  !---------->!  DELAY  !
!         VLAMCB   !           !  VCBDLY !
!DSDRPM(RVIPRPM)=  !           !---------!
!         VISCN1   !                |
!CLEAR ALL FAULT   !         /-------------\YES
!         CODES    !        /IS RVIP-CYL.BAL\-------|
!OPEN LOOP FUEL    !        \     =0  ?     /       |
!------------------!         \-------------/        |
                                    |NO             v
                                    |        !--------------!
                                    |        !SET VCBPCT-   !
                                    |        !THIS- TIME =  !
                                    |        !  VCBPCT      !
                                    |        !--------------!
                                    v               |
                           !----------------!       |
                           !SET VCBPCT-THIS-!       |
                           !TIME=(VCBPCT-   !       |
                           !THIS-TIME)+     !------>|
                           !VCBPAD  CLIP    !       |
                           !TO VCBCLP       !       |
                           !----------------!       |
                                                    v
                                                   (D)
```

CYLINDER BALANCE TEST (CONT'D)

```
                             (D)
                              |
                              v
                        !-------------!
                        !RESET VIPTMR !
                        !-------------!
                              |
                              |<-----------------|
!---------------!             v                  | NO
!.CLEAR FAULTs) !  OPEN  /-------\ CLOSE   /-------\
! CODE(s)       !<------/   TP    \------>/IS VIPTMR\
!.SET ABORT FIG=!(ABORT \  STATE  /       \ VISDL4  /
! 1             !        \-------/         \-------/
!.TURN "ON" IN- !<------|          |<--------- |YES
! INJECTOR I    !       |     !----------!
!.SET FAULT CODE!       |     !OPEN LOOP !   !-----------!
!  77           !       |     !ISC-CONS- !   !DO "VCBHN" !
!               !       |     !TANT PULSE!-->!CALCULATION!
!---------------!       |     !WIDTH     !   !-----------!
        |               |     !----------!         |
        v               |                          |-----|
       (E)              |----------|                     |
                                   |OPEN                 v
!----------!                  /-------\        !------------------!
!DO "VCBLN"!  NO/--------\   /  TP     \       !.SET VNPASSCB = & !
!CALCULA-  !<--/IS VIPTMR \<- \  STATE  /<------!  (VCBHN)*[1-     !
!TION      !   \< VISDL5  /    \-------/    ^   ! (VCBPCT-THIS-    !
!----------!    \--------/ CLOSED           |   ! TIME)]           !
      |        YES  |---------------------- |   !.RESET VIPTMR=0   !
      v                                         !.TURN "OFF"       !
   /-------\YES                                 ! INJECTOR I = CYL-!
  /IS VCBLN \                                   ! NUM (VCUTCOUT)   !
 /=> VNPASSCB\                                  !------------------!
 \(VIPNORM 2)/---------------->|
  \        /                   |
   \-------/                   |
      |                        |
      v                        |
  !-------------!              |
  !.TURN "ON"   !              |
  ! INJECTOR I  !              |
  !.SET CYL-NUM !<---|         |
  ! =(CYL-NUM)-1!    |         |
  !-------------!    |         |
        |            |         v
        v            |    !----------!
   /---------\ YES   |<---!SET FAULT !
  /IS CYL-NUM \---|       !CODE I0   !
  \    > 0    /   |       !----------!
   \---------/    |
        |NO       |-------------------------->(D)
        |-------------->(E)
```

CYLINDER BALANCE TEST (CONT'D)

```
                     (E)
                      |
                      v
          !----------------------------!
          !SET: DSDRPM=NGOOSE          !
          !     CLOSED IDLE SPD CONTROL!
          !     LAMBSE1=LAMBSE2=VRLAM  !
          !----------------------------!
                      |
                      v
 !-------!    YES /--------\
 !OUTPUT !<------/ IS ANY   \
 ! CODES !   ^  /   CODE     \
 !-------!   |  \  PRESENT   /
     |       |   \----------/
     |       |        | NO
     |       |        v
     |       |    !--------!
     |       |<---!  SET   !
     |            !CODE 90 !
     |            !--------!
     |
     |
     |
     |
     v
!----------!
!SET CYL-  !
!BAL-FLG = !--------->( A )
!    1     !
!----------!
```

"VCBHN" CALCULATION

```
          ------
        ( ENTER  )
          ------
            |
            v
    !-------------------!
    !.RESET VIPTMR      !
    !.CLEAR VCB-PIP-CNT!
    !.SAVE LAST PIPTIME!
    ! IN "VLPTM"        !
    !-------------------!
            |
            |<---------------------------|
            v                            |
    !-------------------!                |
    !.WHEN PIPHIGH IN-  !                |
    ! CREMENT           !                |
    !   VCB-PIP-CNT     !                |
    !-------------------!                |
            |                            |
            |                            |
            v                            |
      /-----------\ N0                   |
     /IS VIPTMR => \---------------------|
     \   VCBTM2    /
      \-----------/
            | YES
            v
 !-----------------------------!
 !.CALCULATE CYL. BAL HIGH RPM!
 !                             !
 ! VCBHN = VCB-PIP-CNT   120   !
 !         ----------- * ---   !
 !(VCBN) (LAST PIPTIME-  NO.   !
 !        TIME - VLPTM   OF    !
 !                       CLY   !
 !-----------------------------!
            |
            |
            v
          ------
        ( EXIT   )
          ------
```

"VCBLN" CALCULATION

```
          ------
        ( ENTER  )
          ------
            |
            v
    !-------------------!
    !.RESET VIPTMR      !
    !.CLEAR VCB-PIP-CNT!
    !.SAVE LAST PIPTIME!
    ! IN "VLPTM"        !
    !-------------------!
            |
            |<---------------------------|
            v                            |
    !-------------------!                |
    !.WHEN PIPHIGH IN-  !                |
    ! CREMENT           !                |
    !   VCB-PIP-CNT     !                |
    !-------------------!                |
            |                            |
            |                            |
            v                            |
      /-----------\ N0                   |
     /IS VIPTMR => \---------------------|
     \   VCBTM1    /
      \-----------/
            | YES
            v
 !-----------------------------!
 !.CALCULATE CYL. BAL LOW RPM  !
 !                             !
 ! VCBLN = VCB-PIP-CNT    120  !
 !         ----------- *  ---  !
 !(VCBN) (LAST PIPTIME-   NO.  !
 !         TIME - VLPTM   OF   !
 !                        CLY  !
 !-----------------------------!
            |
            |
            v
          ------
        ( EXIT   )
          ------
```

CHAPTER 28

CONTINUOUS TEST STRUCTURE

CONTINUOUS TEST STRUCTURE

```
     ----------
   (    ENTER    )
     -----------
          |
 /------------------\
/     ECT TEST       \
\  AND FILTERING     /
 \------------------/
          |
 /------------------\
/     ACT TEST       \
\  AND FILTERING     /
 \------------------/
          |
 /------------------\
/     BP TEST        \
\  AND FILTERING     /
 \------------------/
          |
 /------------------\
/     MAF TEST       \
\  AND FILTERING     /
 \------------------/
          |
 /------------------\
/     EGR TEST       \
\  AND FILTERING     /
 \------------------/
          |
 /------------------\
/ PIP AND IDM TEST   \
\  AND FILTERING     /
 \------------------/
          |
 /------------------\
/      TP TEST       \
\  AND FILTERING     /
 \------------------/
          |
 /------------------\
/    EGO TEST        \
\ AND FILTERING      /
 \------------------/
          |
 /------------------\
/    VSS TEST        \
\  AND FILTERING     /
 \------------------/
          |
         (A)
```

CONTINUOUS TEST STRUCTURE (CONT'D)

```
                              (A)
                               |      NOTE:  "WIGGLE TEST IS
                    NO    /---------\          DEFINED AS:
|-----------------------/ IN WIGGLE \   1) NOT IN SELF-TEST AND
|                        \   TEST ?  /   2) STI=GND OR TIME SINCE
|                         \---------/       LAST PIP >1 SEC
|                              |
|                         /---------\
|   !---------!    NO    /    ANY    \  YES  !-------------!
|   ! STO OFF !<--------/ FAULT FILTER\----->!.STO ON      !
|   !---------!         \ > THRESHOLD?/      !.SET ADVLIM=0!
|        |               \           /       !-------------!
|        |                \---------/               |
|        |                                          |
|        v                -----------               |
|---------------------->(     EXIT    )<------------|
                          -----------
```

FILTERING LOGIC

Each fault to be detected and stored requires an event counter-timer which will be incremented by an "Up-count" value (calibratable) each time a fault is detected, and decremented by 1 each time the fault is not detected. Fault detection and up/down counting are done once per background loop. When the counter-timer for a particular fault exceeds a "threshold" value (calibratable) for that fault, the corresponding KAM fault code will be stored.

The "Wiggle Test" is a special case. When STI is low and Self-Test is not in progress, or in Engine-Off conditions when Self-Test is not in progress, any time any event counter-timer (filter) has exceeded its threshold, STO is turned "on" (otherwise it will be "off").

```
                     -----------
                    (   ENTER    )
                     -----------
                          |
                          v
              NO    /---------\    YES
       |-------------/ FAULT (N) \-------------|
       |             \ DETECTED ?/             |
       v              \---------/              v
   !--------------!                        !--------------!
   ! CXXFIL  =    !                        ! CXXFIL =     !
   ! CXXFIL -1    !                        ! CXXFIL  +    !
   !--------------!                        ! CXXUP        !
       |                                   !--------------!
       |                                       |
       |------------->|<-----------------------|
                      v
                    (I1)
```

FILTERING LOGIC CONTINUED

```
            (I1)
             |
             v
        /---------\
       /IS FAULT   \ NO
      /(N) 31,32,33,\-----------|
      \  34 OR 35   /           |
       \PRESENT ?  /            |
        \---------/             |
             | YES              |
             v                  |
        /---------\             |
       /ARE ANY    \ N0         |
      /CODES 31,32, \---------->|
      \33,34,35     /           |
       \STORED IN  /            |
        \  KAM  ? /             |
         ---------              |
             | YES              |
             v                  |
        /-----------\           |
    N0 /IS FAULT (N) \          |
|<----/ SAME AS CODE  \         |
|     \ STORED IN KAM /         |
|      \     ?       /          |
|       \-----------/           |
|            | YES              |
|            |<-----------------|
|            v
|       /---------\
|      /  CXXFIL   \    YES
|     /     >       \----------------|
|     \   CXXLVL    /                |
|      \     ?     /                 |
|       \---------/                  |
|----------->|  NO                   v
             v            !---------------------!
        -----------       ! STORE KAM CODE (N)  !
      (     EXIT    )<----! ZERO WARM-UP CYCLE  !
        -----------       ! COUNTER (N)         !
                          !---------------------!
```

CONTINUOUS TEST STRUCTURE
EEC-EPCD, FoMoCo, PROPRIETARY & CONFIDENTIAL
FAULT THRESHOLD/UPCOUNT VALUE SELECTION
"WIGGLE" VERSUS NORMAL CONTINUOUS TEST

```
CRANK OR UNDERSPEED------|     |
                         |AND--|
DISABLE NO START---------|     |   |
                               | OR|       !------------------------!
NOT CRANK OR UNDERSPEED--|     |   |       !"WIGGLE TEST:SET C32UP &!
                         |AND--|   | AND---!C33UP,C34UP=0 & ALL     !
DISABLE RUNNING----------|     |   |       !THRESHOLDS=WIGLVL* ALL  !
                                   |       !NON-ZERO UPCOUNTS =255  !
STI=GND----------------------------|       !------------------------!
                                               -----ELSE-----
IN UNDERSPEED OR RUNNING------------------>  (NORMAL CONTINUOUS TEST)

                                          !--------------------------!
                                          ! USE CALIBRATED           !
                                          ! THRESHOLD/UPCOUNT VALUES !
                                          !--------------------------!
```

PARAMETER NAMES:

FAULT	FILTER	UPCOUNT	THRESHOLD	WARM-UP COUNTER
ERRATIC PIP	C14FIL	C14UP	C14LVL	C14CNT
IDM	IDM FAULT CNT	IDMUP	IDMLVL	IDM WARMUP CNT
ECT LOW	C61FIL	C61UP	C61LVL	C61CNT
ECT HIGH	C51FIL	C51UP	C51LVL	C51CNT
BP OUT OF RANGE	C22FIL	C22UP	C22LVL	C22CNT
ACT LOW	C64FIL	C64UP	C64LVL	C64CNT
ACT HIGH	C54FIL	C54UP	C54LVL	C54CNT
TP LOW	C63FIL	C63UP	C63LVL	C63CNT
TP HIGH	C53FIL	C53UP	C53LVL	C53CNT
1)EPT BELOW MIN	C31FIL	C31UP	C31LVL	C31CNT
2)EVP INPUT LOW	C31FIL	C31UP	C31LVL	C31CNT
1)EPT LOW	C32FIL	C32UP	C32LVL	C32CNT
2)EVP OUT OF LIM	C32FIL	C32UP	C32LVL	C32CNT
1)EPT ABOVE MAX	C35FIL	C35UP	C35LVL	C35CNT
2)EVP INPUT HIGH	C35FIL	C35UP	C35LVL	C35CNT
1)NO EGR FLOW	C33FIL	C33UP	C33LVL	C33CNT
2)NO EGR FLOW	C33FIL	C33UP	C33LVL	C33CNT
1)EPT HIGH	C34FIL	C34UP	C34LVL	C34CNT
2)EGR VALVE OUT	C34FIL	C34UP	C34LVL	C34CNT
OF LIMITS				
LACK OF EGO SW	C41FIL	C41UP	C41LVL	C41CNT
LACK OF EGO SW	C91FIL	C91UP	C91LVL	C91CNT
VSS FAILURE	C29FIL	C29UP	C69LVL	C69CNT
FP RELAY	C87FIL	C87UP	C87LVL	C87CNT
MAF SHORT TO PWR	C56FIL	C56UP	C56LVL	C56CNT
MAF CKT OPEN	C66FIL	C66UP	C66LVL	C66CNT

FAULT THRESHOLD/UPCOUNT VALUE SELECTION (CONT'D)

PARAMETER NAMES

FAULT	FILTER	UPCOUNT	THRESHOLD	WARM-UP COUNTER
FP CKT OPEN ECA TO MTR GND	C95FIL	C95UP	C95LVL	C95 CNT
FP CKT OPEN	C96FIL	C96UP	C96LVL	C96CNT

WIGLVL - Threshold for wiggle test- no units -range 0 to 255
resolution=1 Base value = 200 Cal level = CCV

1)PARAMETERS APPLY WHEN USING PFE EGR SYSTEMS (PFEHP SWITCH =1)
2)PARAMETERS APPLY WHEN USING SONIC EGR SYSTEMS (PFEHP SWITCH =0)

NOTE: SET C32UP, C33UP, C34UP AND C41AND C91UP TO ZERO WHEN IN WIGGLE TEST MODE TO EXCLUDE CODE FROM WIGGLE TEST

KAM CODE ERASE LOGIC

Each KAM code has a counter for "Number of Engine warm-ups" since fault was last detected. Each code is erased when its counter is >= 40. Codes can also be manually cleared during Engine-Off code output mode.

```
"WARM-UP" FLAG CLEAR--|
                      |
TCSTRT < VECT5--------|
                      | AND---|------SET "WARM-UP FLAG
ECT > VECT3-----------|       |
                      |       |
RUN MODE--------------|       |
                              |           !--------------------!
                              |---|       ! INCREMENT ALL CODE !
                                  | AND---! WARM-UP COUNTERS   !
                STI=OPEN----------|       ! DISABLE FURTHER    !
                                          ! INCREMENTS (UNTIL  !
                                          ! NEXT POWER-UP)     !
                                          !--------------------!


IN ENGINE-OFF CODE OUTPUT MODE*----|
                                   | AND----ERASE ALL KAM CODE
SELF-TEST NOT REQUESTED------------|


WARM-UP COUNTER(N) >= 40--------------ERASE KAM CODE(N)
```

* Note: This means during the output of any codes in Engine-Off Self-Test; service codes, separator pulse, and continuous codes.

ECT OPEN/SHORT TEST

```
     -----------
   (    ENTER    )
     -----------
          |
          v
     /---------\   NO      !-----------!
    /  IECT >=  \--------->! FAULT 61 !
    \  ECTMIN ? /          !-----------!
     \---------/                 |
          |  YES                 |
          v<---------------------|
  !--------------!
  !  DO FAULT    !
  ! FILTERING 61 !
  !--------------!
          |
          v
     /---------\   NO      !-----------!
    /  IECT <=  \--------->! FAULT 51 !
    \  ECTMAX ? /          !-----------!
     \---------/                 |
          |  YES                 |
          v<---------------------|
  !--------------!
  !  DO FAULT    !
  ! FILTERING 51 !
  !--------------!
          |
          v
     -----------
   (     EXIT    )
     -----------
```

ACT SENSOR TESTS

```
     -----------
   (    ENTER    )
     -----------
          |
          v
     /---------\   NO       !----------!
    /  IACT >=  \--------->! FAULT 64 !
    \  ACTMIN ? /           !----------!
     \---------/                 |
          |  YES                 |
          |<---------------------|
          v
  !--------------!
  !   DO FAULT   !
  ! FILTERING 64 !
  !--------------!
          |
          v
     /---------\   NO       !----------!
    /  IACT <=  \--------->! FAULT 54 !
    \  ACTMAX ? /           !----------!
     \---------/                 |
          |  YES                 |
          |<---------------------|
          v
  !--------------!
  !   DO FAULT   !
  ! FILTERING 54 !
  !--------------!
          |
          v
     -----------
   (    EXIT     )
     -----------
```

BP SENSOR TEST

```
   ------
 (  ENTER  )
   ------
      |
      v
  /--------\ NO         ------
 / BPSSW=1  \-------> (  EXIT  )
 \          /           ------
  \--------/
      | YES
  /---------\NO
 / BPTMR <=  \-----------|
 \ VBPMAX ?  /           |
  \---------/            |
      | YES              v
  /---------\        !----------!
 /  VBPDL1   \------>! FAULT 22 !
/ <=MDELTA <= \      !----------!
\   VBPDL2    /          |
 \           /           |
  \---------/            |
      | YES              |
      |<-----------------|
!------------!
!  DO FAULT  !
!FILTERING 22!
!------------!
      |
      v
   -------
 (  EXIT   )
   -------
```

MAF SENSOR TEST

```
        --------
      (  ENTER   )
        --------
           |
           v
      /---------\ NO      /---------\ YES    !---------!
     / NBAR =>   \------>/  IMAF =>  \------>!FAULT 56 !
     \ VMARPM    /       \  VMAMAX   /       !---------!
      \---------/         \---------/            |
           |YES                | NO              |
           |<------------------------------------|
           |
           v
      !----------!
      !DO FAULT  !
      !FILTERING !
      !    56    !
      !----------!
           |
     NO/--------\
|<----/ RUN MODE \
|     \          /
|      \--------/
|          | YES
|          v
|     /---------\ NO     /---------\ YES     !--------!
|    /IS TSLPIP  \----->/ IMAF <=   \------->!FAULT 66!
|   /      >      \     \ VMAMIN    /        !--------!
|   \ VMAFPIPLMT  /      \---------/           |
|    \           /           | NO              |
|     \---------/            |                 |
|          |YES              |                 |
|          v                 |                 |
|--------------------------->|<----------------|
                             |
                             v
                       !-------------!
                       !DO FAULT     !
                       !FILTERING 66 !
                       !-------------!
                             |
                             v
                          ------
                        (  EXIT  )
                          ------
```

NOTE: DO NOT CHECK FOR FAULT 66 DURING KOEO WIGGLE TEST.
AIR FLOW AND IMAF WILL BE AT OR NEAR ZERO.

EGR SYSTEM TEST (PFE/SONIC)

```
       ---------
     (  ENTER    ) (PFE)
       ---------
           |
       /--------\  NO        --------
      / PFEHP=>2 \------->(  EXIT    )
      \    ?     /           --------
       \--------/                          (SONIC)
           | NO
       /--------\ NO
      / PFEHP=1  \----------------------------|
      \          /                            |
       \--------/                             |
           | YES                              | YES
      /---------\ NO                          v
     / APT= -1   \-----------|           /--------\  YES !----------!
     \           /           |          / IEVP <=  \---->! FAULT 31 !
      \---------/            |          \ EVPMIN ? /     !----------!
           | YES             |           \--------/           |
      /---------\ NO         |                | NO              |
     / NBAR < VN \---------->|                |<----------------|
     \           /           v                v
      \---------/           (A)    !-----------------------!
           | YES                   ! DO FAULT FILTERING 31 !
!----------------------!           !-----------------------!
!FIEPT=VROLAV(IEPT,    !                      |
!      VTCEPT)         !                      |
!----------------------!                      v
           |                             /--------\ YES  !----------!
      /---------\ YES  !-------!        / IEVP >=  \---->! FAULT 35 !
     / FIEPT <=  \---->! FAULT !-----|  \ EVPMAX ? /     !----------!
     \ EPTMIN    /     !  31   !     |   \--------/           |
      \---------/      !-------!     |        | NO              |
           | NO                      |        |<----------------|
      /---------\ YES  !-------!     |        v
     / FIEPT >=  \---->! FAULT !---->|  !--------------! NOTE: For
     \ EPTMAX    /     !  35   !     |  ! DO FAULT     ! wiggle test
      \---------/      !-------!     |  ! FILTERING 35 ! set C32UP,
           | NO                      |  !--------------! C33UP & C34UP
      /---------\ YES  !-------!     |        |          = 0.
     / FIEPT <   \---->! FAULT !---->|        v
     \ VEPTIL    /     !  32   !     |   /--------\ YES  !----------!
      \---------/      !-------!     |  / IEVP <   \---->! FAULT 32 !
           | NO                      |  \ VEVPLL   /     !----------!
      /---------\ YES  !-------!     |   \--------/           |
     / FIEPT >   \---->! FAULT !---->|        | NO              |
     \ VEPTIH    /     !  34   !     |        |<----------------|
      \---------/      !-------!     |        v
           | NO                      |  !--------------!
           |<------------------------|  ! DO FAULT     !--->(B)
           v                            ! FILTERING 32 !
         ( AA )                         !--------------!
```

EGR SYSTEM TEST (CONT'D)

(PFE/SONIC)

```
          ( AA )
            |
            v
!----------------------!
!DO FAULT FILTERING 1)!  1) For Wiggle Test
!31, 35, 32 and 34    !     set C32UP and
!----------------------!     C34UP = 0
            |
            v
        ---------
    (    EXIT     )
        ---------
```

EGR SYSTEM TEST

(PFE/SONIC)

```
      (A)                                                 (B)
       |                                                   |
       v                                                   v
  /---------\ NO                    !-----------!  NO /---------\
 /  LOAD <=  \-----------|          !.SET EGRFG2!<---/ EGRDC =0  \
 \ VEGRLOAD? /           |          !.VIPTMR=0  !    \     ?     /
  \---------/            |          !-----------!     \---------/
       | YES             |                |                | YES
       v                 |                v                v
  /---------\ NO         v              ( C )         /---------\ YES
 /  EGRDC >  \     !---------!                       / EGRFG2=1  \---|
 \  VCRTDC ? /---->!   SET   !--|                    \     ?     /   |
  \---------/      !EGRFG1=0 !  |                     \---------/    |
      | YES        !---------!  |                          | NO      |
      |                         |                          v         |
      |                         |                  !--------------!  |
      |                         |                  !.SET EGRFG2   !  |
      v                         |                  ! = 1          !  |
 /--------\ N0                  |                  !.START VIPTMR !  |
/ EGRFG1=1 \    !-------------! |                  !--------------!  |
\          /--->!.SET EGRFG1=1! |                          |         |
 \--------/     !.SET VIPTMR=0! |                          |--->|<---|
      | YES     !-------------! |                               |
      |                |        |                               v
      |<---------------|        |   YES /---------\   YES /---------\
      v                         | |----/ VIPTMR <  \<----/  IEVP >  \
!------------------!            | |    \ VEITMR ?  /     \  VEVPHL ? /
!CFIEPT=VROLAV     !            | |     \---------/       \---------/
!(IEPT,VTCEPT)     !            | |          | NO              | NO
!                  !            | |          v                 v
!------------------!            | |    !----------!    !-------------!
      |                         | |    ! FAULT 34 !--->! DO FAULT    !
      v                         | |    !----------!    ! FILTERING 34!
 /---------\ YES                | |                    !-------------!
/ CFIEPT <  \------------------>| |                           |
\ VEPTCL    /                   | |-------------------------->|
 \---------/                    |                             v
      | NO                      |                         ----------
      v                         |                       (    EXIT    )
 /---------\ NO  !----------!   |                         ----------
/ VIPTMR <  \--->! FAULT 33 !-->|
\ VECTMR    /    !----------!   |
 \---------/                    v
      | YES        !--------------------------!
      v<-----------! DO FAULT FILTERING 33 (2 !
  ---------        !--------------------------!
(   EXIT    )
  ---------          (2  For wiggle test
                         set C33UP=0
```

EGR SYSTEM TEST (CONT'D)

(PFE/SONIC)

```
                           ( C )
                             |
                             v
                    NO  /---------\
             |---------/  LOAD <=  \
             |         \ VEGRLOAD ?/
             |          \---------/
             |               | YES
             |               v
             |      NO  /---------\
             |---------/  EGRDC >  \
             |         \  VCRTDC ? /
             |          \---------/
             |               |  YES
             |               v
             v          /---------\  YES
       !-----------!   /  EGRFG1   \---------|
       !.SET EGRFG1!   \    =1 ?    /         |
(C)<---!   = 0     !    \---------/          |
       !.SET VIPTMR!          |  NO           |
       !   = 0     !          |               |
       !-----------!          v               |
                       !-------------!        |
                       !.SET EGRFG1  !        |
         ---------     !   =1 ?      !        |
|----->(   EXIT    )   !.START VIPTMR!        |
|        ---------     !-------------!        |
|            ^                |               |
|            |                |<--------------|
|            | YES            v
|       /---------\  NO /---------\
|      / VIPTMR <  \<--/  IEVP >   \
|      \ VECTMR ?  /   \  VEVPCL ? /
|       \---------/     \---------/
|            | NO             |  YES
|            v                |
|      !----------!           |
|      ! FAULT 33 !---------->|
|      !----------!           |<-----------(C)
|                             v
|                     !-------------!
|                     ! DO FAULT    !
|---------------------! FILTERING 33!
                      !-------------!
```

PIP AND IDM TEST

A new continuous PIP/IDM routine has been implemented for 1986. Instead of the rather complex hand shaking method as used in previous IDM versions, the new routine basically checks if time since last pip (TSLPIP) and time since last idm (TSLIDM) have exceeded a calibrated timeout period.

Additional decisions are made in softwre to assure the engine is running and stabilized before the test is executed.

Both the PIP and IDM timers are free-running and high speed digital inputs are used to re-start the timers.

Each transition of pip starts a new time-out function. When the time since last pip > VPIPTM, a pip fault is present.

If a pip fault has been detected, software bypasses the IDM test. This feature has been added to discriminate between a true pip failure or idm (tach) failure once pips have been restored.

Time since last IDM is determined by a buffered tach signal used as input, and the timer resets on the rising edge of this buffered signal.

```
                    |\^----
                    |      |     VBATT
                    |       ^^^^------|
       TACH --------|                 |       |---------
                                      |       |
                                      |       |
                                      |       |
                               GND     -------


                                       -------
                                      |       |
                                      |       |
                                      |       |
   TACH BUFFER                        |       |
     OUTPUT --------------------------|       |---------

                                      ^
  NOTE:  RISING EDGE OF BUFFER OUTPUT
         IS BASED ON VBATT-->GND TRANSITION.
```

Each VBATT--->GND transition of tach starts a new time-out function When the time since the last transition is > VIDMTM, an idm failure is present.

Faults are filtered by an event-counter method, as done for all continuous test faults, and the first "upcount" will occur on the first time the PIP/IDM routine determined that a fault has occured.

NOTE: DEPENDING ON THE STATE OF THE IDM BYPASS FLAG, TSLIDM IS ACTUALLY ONE OF TWO FUNCTIONALLY DIFFERENT TIMERS. (1) WHEN IDM_BYPASS FLAG IS CLEAR (=0), THEN TSLIDM IS THE TIME SINCE THE LAST IDM. (2) WHEN IDM_BYPASS FLAG IS SET (=1), THEN TSLIDM IS THE TIME SINCE THE IDM_BYPASS FLAG WAS SET.

PIP/IDM LOGIC
(FOR TACH BUFFER)

```
                YES/------------\          -----------
               |--/IS IGNFG = 1  \<------(    ENTER    )
               |  \   *  ?       /         -----------
               |   \------------/
               v         |NO
          /---------\YES v    !-----------!           -------
         /  IS N <   \------->!   SET     !------->(   EXIT    )
         \  VLORPM ? /   ^    ! TSLIDM =0 !           -------
          \---------/    |    !-----------!  *APPLIES TO NU, NX,
               | NO      |                    & 9X STRATEGIES
               v         |------------------  ONLY
       !---------------!                   ^
       ! CLEAR ERROR   !                   | NO
       !DETECTED FLAGS !              /----------\
       !---------------!             / KPRTMR > * \
               |-------------------->\  VKPRTM    /
                                      \----------/
 !---------------------------!             | YES
 !.SET ERROR DETECTED FLAG=1 !             v
 !.SET IDM_BYPASS FLAG=1     !   YES  /---------\
 !.RESET IDM_FAULT CNT=0     !<------/  TSLPIP   \
 !.RESET TSLIDM =0           !       \ > VPIPTM ?/
 !---------------------------!        \---------/
               |                           | NO
               |-------------------------->|
                                           v
                                     !------------!
                                     ! CALL FAULT !
                                     ! FILTER C14 !
                                     !------------!
                                            |
!-----------!  YES /---------\    NO /-------------\ YES
!.SET ERROR !<----/  TSLIDM   \<----/ IS IDM_BYPASS \----|
! DETECTED  !     \ > VIDMTM ?/     \   FLAG =1?    /     |
! FLAG =1   !      \---------/       \-------------/     |
!-----------!           | NO                             |
      |                 |                     YES /------------\
      |---------------->|                    |---/ IS TSLIDM >  \
                        |                    |   \   VIDMST ?   /
                        |                    |    \------------/
                        v          !------------------!  |NO
              !------------------! !.CLEAR IDM_BYPASS !  |
              !.CALL FAULT FILTER! !   FLAG           !  |
              ! IDM_FAULT_CNT C18! !.SET TSLIDM=0     !  |
              !------------------! !------------------!  |
                        |                    |           |
                   -----------               v           |
                 (     EXIT    )<------------------------|
                   -----------
```

NOTE: Pip fault filtering uses C14LVL.
       IDM fault filtering uses IDMLVL.

TP SENSOR TESTS

```
                    -----------
                  (    ENTER    )
                    -----------
                         |
                         v
                    /---------\   NO      !----------!
                   / ITP >=    \--------->! FAULT 63 !
                   \ TAPMIN ?  /          !----------!
                    \---------/                 |
                         |  YES                 |
                         |<---------------------|
                         v
                 !--------------!
                 !   DO FAULT   !
                 ! FILTERING 63 !
                 !--------------!
                         |
                         v
               YES  /---------\
     |-------------/  CTFFLG   \
     |             \   SET ?   /
     |              \---------/
     |                   | NO
     |                   v
     |              /---------\   NO      !----------!
     |             / ITP <=    \--------->! FAULT 53 !
     |             \ TAPMAX ?  /          !----------!
     |              \---------/                 |
     |                   |  YES                 |
     |                   |<---------------------|
     v                   v
!----------!     !--------------!
! FAULT 53 !     !   DO FAULT   !
!----------!     ! FILTERING 53 !
     |           !--------------!
     |                   |
     |------------------>|
                         v
                    -----------
                  (     EXIT    )
                    -----------
```

CONTINUOUS VEHICLE SPEED SENSOR TEST

The vehicle speed sensor is tested under conditions that cannot be acheived unless the vehicle is moving.

<u>Manual Transmission</u> - Engine is being motored as indicated by a low map value, closed throttle and high engine speed.

<u>Automatic Transmission</u> - Transmission is in drive and engine speed is above the torque convertor stall speed.

If the above conditions are true for a prolonged period of time, (VSSTMR >= VVSTIM) then the vehicle speed sensor is checked against a minimum value. The continuous VSS test may be calibrated out by setting VIP calibration parameter VSSSW to 0

The VSS test will use traditional fault filtering if a VSS fault is detected.

CONTINUOUS VSS TEST CONT'D

```
VSSSW=1 ----------------|
                        |
VSTYPE > 0--------------|        |
                        |        | VSS FAILURE
N >=VSMMIN -------------|        | SET CONTINUOUS CODE 29
(ENGINE SPEED HIGH)     | AND----|
  Manual & Auto         |        |
                        |        |
VSSTMR >=VSSTIM --------|        |
(STABLE TEST CONDITIONS)|        |
                        |        |
VSBAR < VSSMN1 ---------|        |
(NO VSS READING)                 |---------ELSE------------
                                 |
                                 | VSS IS OK
                                 | USE FAULT FILTERING 29
                                 |
```

```
VSSTMR - VEHICLE SPEED SENSOR TIMER (.125 SEC)
         VSSTMR INCREMENTS WHEN THE PROPER CONDITIONS
         EXIST TO PERFORM A VSS TEST.
```

```
TFMFLG=0---------|
(TP Sensor OK)   |
                 |
TRLOAD < 4-------|
(MANUAL TRANS)   |
                 |
APT= -1 ---------| AND---|
(CLOSED THROTTLE)|       | OR----|
                 |       |       | INCREMENT VSSTMR
LOAD<= VSLOAD ---|       |       |
(DECEL MODE)     |       |       |
                 |       |       |
                         |       |
                         |       |-------ELSE---------
TRLOAD = 4-------|       |       |
                 |       |       |
NDSFLG=1 --------| AND---|       | SET VSSTMR=0
(AUTO IN DRIVE)  |               |
                 |
N >= VSAMIN -----|
(ENGINE SPEED HIGH)
  For Auto Trans.
```

EGO SWITCHING TEST
PART THROTTLE COUNTER (PTCNT)

```
  -----------
(    ENTER    )
  -----------
       |
       v             !-------------------!
   /-------\  YES    ! SET PART THROTTLE !
  / IS APT  \------->! FLAG (VPTFLG)=1   !
  \  = 0 ?  /        !-------------------!
   \-------/                   |
       | NO                    |
       |<----------------------|
       v                                 !-----------------!
   /-------\  YES     /--------\  YES    ! .PTCNT=PTCNT+1  !
  / IS APT  \------->/    IS    \------->! .CLEAR VPTFLG=0 !
  \ = -1 ?  /        \ VPTFLG=1?/        !-----------------!
   \-------/          \--------/                   |
       | NO               | NO                     |
       |<-----------------|                        |
       |                                           |
       |                                           |
       |<------------------------------------------|
       |
       v
  -----------
(    EXIT     )
  -----------
```

* INITIALIZE VPTFLG TO ZERO ON POWER-UP

EGO SWITCHING TEST CONT'D

```
               -----------
             (    ENTER    )
               -----------
                    |
                    v
            NO  /-------\
        |------/ VEGOBP  \
        |      \  =1 ?   /
        |       \-------/
        |           | YES
        |           v
        |   NO  /-------\
        |<-----/ ATMR2 > \
        |      \ VEGOTM ?/
        |       \-------/
        |           | YES
        |           v
        |      /---------\
        | YES /   IS ECT  \NO     /---------\ NO
        |<---/ ACT, TP OR  \---->/ THRMHP=1  \---|
        |    \  MAP FMEM   /    \           /   |
        |     \   SET ?   /      \---------/    |
        |      \---------/            |YES      |
        |           | NO              |         |
        |           v                 |         |
        |  YES /---------\            |         |
        |<----/ IS AIR    \<--------- |    NOTE:| FOR APPLICATIONS
        |     \ UPSTREAM? /                     | WITH SECONDARY
        |      \---------/                      | AIR ONLY
        v           | NO                        |
!----------------!  |                           |

! CLEAR PART     !  |<--------------------------|
!THROTTLE COUNTER!  |
!   (PTCNT)      !  |-------------------|
!----------------!                      |
        |                               |
        |------|                        v
               v                /-----------\
         NO/--------\          /PART THROTTLE\ YES
 (C)<-----/ VEGOBP   \        /COUNTER (PTCNT)\---->(B)
          \ = 1      /        \  > VPTCNT ?   /
           \--------/          \             /
               | YES            \-----------/
               v                      |NO
             ------                   |
           (  EXIT  )<----------------|
             ------
```

EGO SWITCHING TEST CONT'D

```
                (B)
                 |
          /----------\ NO       !---------!
         / EGOSS1 >   \------->!FAULT 41 !
         \ VEGOSW     /         !---------!
          \----------/               |
                 |YES                |
(C)---------->|                      |
          !------------!             |
          ! DO FAULT   !<-----------|
          !FILTERING 41!
          !------------!
                 |
          /-----------\ YES       ----
         / NUMEGO =1?  \------->( EXIT )
         \             /          ----
          \-----------/
                 |NO
          /-----------\NO       !---------!
         /EGOSS2>VEGOSW\------>!FAULT 91 !
         \             /        !---------!
          \-----------/              |
(C)---------->| YES                  |
          !------------!             |
          ! DO FAULT   !<-----------|
          !FILTERING 91!
          !------------!
                 |
                 |
                 v
            -------
          (  EXIT   )
            -------
```

FUEL PUMP CIRCUIT TEST

```
                   --------         /--------\ NO      ------
                 (  ENTER   )----->/ IS V_    \----->(  EXIT  )
                   --------        \FPMFLG SET/        ------
                                    \--------/
                                         | YES
                                         v
                                     /--------\NO
                  |-----------|     /  IS FP   \--->(A)
                  v           |     \  "OFF"   /
              /--------\      |      \--------/
             /IS VIP_FP \NO   |          |YES
            /MTMR=>V_    \--| |          v
            \  FPMTM     /  | |   NO /--------\
             \          /   v |<----/IS RMSPRU \
              \--------/    |       \   = 1    /
                  |YES      |        \--------/
                  v         |            |YES
          NO  /--------\    |            |
     |<------/  IS FPM  \   |            v
     |       \  LOW ?   /   |    !-----------------------!
     |        \--------/YES |    !.DE-ENERGIZE ALL OUTPUTS!
     v            |<--------|    !.DELAY 50 MSEC.        !
!--------!        |              !.SAVE IOCC IN OCCSAV   !
! FAULT  !        |              !.ENERGIZE FUEL PUMP    !
!  95    !------->|              !.DELAY 50 MSEC         !
!--------!        |              !-----------------------!
                  v                        |
            !------------!                 v
            ! DO FAULT   !           /----------\
            !FILTERING 95!          /ABS [OCCSAV \NO  !----------!
            !------------!         / -IOCC] >=    \-->! FAULT 87 !
                  |                \  OCCDT7 ?    /   !----------!
                  |                 \            /         |
                  |                  \----------/          |
                  |                        |YES            |
                  |                        |<--------------|
                  |                        v
                  |                !------------------!
                  |                !TURN OFF FUEL PUMP!
                  |                !CLEAR "RMSPRU"=0  !
                  |                !------------------!
                  |                        |
                  |                 !------------!
                  |                 !  DO FAULT  !
                  |                 !FILTERING 87!
                  |                 !------------!
                  |----------------------->|
                                           v
                                        -------
                                   (    EXIT    )
                                        -------
```

NOTE: TEST MUST BE PERFORMED AS LONG AS POWER IS "ON" AND NOT
      JUST IN RUN MODE.

FUEL PUMP CIRCUIT TEST CONT'D

```
              (A)
               |
               v
     !---------------------!
     !  RESET VIP-FPMTMR  !
     !---------------------!
               |
               |
               v
          /---------\NO
         / IS FPM    \----------->|
         \   HIGH    /            |
          \---------/             |
               | YES              |
               |                  v
               |            !-------!
               |            ! FAULT !
               |<-----------!   96  !
               |            !-------!
               v
         !-------------!
         !  DO FAULT   !
         !FILTERING 96 !
         !-------------!
               |
               v
            -------
         (   EXIT   )
            -------
```

CHAPTER 29

VEHICLE SPEED CONTROL SELF TEST

VSC ENGINE-OFF TEST INITIALIZATION
AND TEST STRUCTURE

```
           ---------
          (  ENTER    )
           ---------
               |
               |
               v
     !-------------------!
     !.EXIT WIGGLE TEST !
     !.STO OFF           !
     !.EDF ON            !
     !.HEDF OFF          !
     !-------------------!
               |
               v
          ------------
      (SEND 1/2 SECOND )
            PULSE
          ------------
               |
               v
      !------------------!
      !DO STATIC INPUT   !
      !     TEST         !
      !------------------!
               |
               v
      !------------------!
      !DO VSC OUTPUT     !
      ! CIRCUIT CHECK    !
      !------------------!
               |
               v
      !------------------!
      !SEND FAST & SLOW  !
      !SERVICE CODES     ! Use same format
      !------------------! as Engine Self
               |           Test
               v
          ---------
         (  EXIT     )
          ---------
```

```
         VEHICLE SPEED CONTROL SELF TEST
           EEC-EPCD, FoMoCo, PROPRIETARY & CONFIDENTIAL
                     ENGINE OFF
                  STATIC INPUT TEST
              ---------
            (  ENTER    )
              ---------
                 |
                 v
            !-----------!
            !SET CODES  !
            !67,74,75   !
            !SET FLAGS  !
            !VSB1,VSB2, !
            !VSB3,VSB4  !
            !-----------!
                 |
                 v
          !---------------!
          !ZERO AND START !
          !   VIPTMR      !
          !---------------!
                 |
  (B)----------->|
                 v
            /---------\ YES      !---------!
           /IS OFF_BUT \-------->! CLEAR   !
           \ = 1  ?    /         !FLAG VSB1!
            \---------/          !---------!
                 |  NO                |
                 |<-------------------|
                 v
            /---------\ YES      !---------!
           /IS COAST_  \-------->! CLEAR   !
           \BUT = 1 ?  /         !FLAG VSB2!
            \---------/          !---------!
                 |  N0                |
                 |<-------------------|
                 v
            /---------\ YES      !---------!
           /IS ACCEL_  \-------->! CLEAR   !
           \BUT = 1  ? /         !FLAG VSB3!
            \---------/          !---------!
                 |  NO                |
                 |<-------------------|
                 v
            /---------\ YES      !---------!
           /IS RESUM_  \-------->! CLEAR   !
           \BUT = 1  ? /         !FLAG VSB4!
            \---------/          !---------!
                 | NO                 |
                 |<-------------------|
                 v
                (A)
```

STATIC INPUT TEST CONTINUED

```
                      (A)
                       |
                       v
                  !-----------!
                  !SET CODE 48!
                  !-----------!
                       |
                       v
                  /---------\
NOTE:LoHold & Hi-/  LOHOLD   \ YES     !---------!
  Hold are      / < VSCCS <   \------->! CLEAR   !
  normal strat- \   HIHOLD    /        ! CODE 48 !
  egy parameters \           /         !---------!
  NOT self test   \---------/               |
  calibratible.        | NO                 |
                       |<-------------------|
                       v
                  /---------\ YES      !---------!
                 /    IS     \Brake On ! CLEAR   !
                /  BIFLG = 1  \------->! CODE 74 !
                \     ?       /        !---------!
                 \           /              |
                  \---------/               |
                       | NO                 |
                       |                    |
                       v                    |
                  !---------!               |
                  ! CLEAR   !               |
                  ! CODE 75 !               |
                  !---------!               |
                       |                    |
                       |<-------------------|
                       v
                      (A1)
```

STATIC INPUT TEST CONTINUED

```
                      (A1)
                       |
                       v
NOTE: Clutch     /-----------\
  pedal must be / IS NDSFLG=  \ YES (Drive)
  depressed    /      1  ?     \------------------|
  once during  \               /                  |
  the test      \             /                   |
                 \-----------/                    |
                       | NO                       |
                       |                          |
                       v                          |
                  !---------!                     |
                  ! CLEAR   !                     |
                  ! CODE 67 !                     |
                  !---------!                     |
                       |                          |
                       |<-------------------------|
                       v
                 /-----------\
                /ARE ALL OF   \ YES
               /CODES 48,67,74,\-------------> (D)
               \75 & FLAGS VSB1/
                \VSB2,VSB3,VS-/
                 \B4 CLEARED /
                  \---------/
                       | NO
                       v
                 /-----------\ N0
                /IS VIPTMR >  \------------->  (B)
                \ VIPT1  ?    /
                 \-----------/
                       | YES
                       v
                      (C)
```

```
                 VEHICLE SPEED CONTROL SELF TEST
          EEC-EPCD, FoMoCo, PROPRIETARY & CONFIDENTIAL
                  STATIC INPUT TEST (CONTINUED)
               (C)
                |
                v
          /---------\ NO
         / IS CODE   \--------------------------------|
         \48 CLEARED?/                                |
          \---------/                                 |

                | YES                                 |
                v                                     |
          /---------\        /---------\              |
         / ARE ALL   \ NO   / ARE ANY OF\NO  !-----!  |
        /FLAGS VSB1,  \--->/ THE FLAGS   \-->! SET !->|
       /VSB2,VSB3,VSB4 \  /VSB1,VSB2,VSB3 \  !CODE !  |
       \    CLEARED ?  /  \ VSB4 CLEARED ?/  !  49 !  |
        \             /    \             /   !-----!  |
         \           /      \           /             |
          \---------/        \---------/              |
                | YES              | YES              |
                |                  v                  |
                |            !------------!           |
                |            !SET CODE 47 !           |
                |            !------------!           |
                |                  |                  |
                v                  v                  |
               (D)<-----------------------------------|
                |
                v
NOTE: TP Test     /---------\ NO     !------------!
 same as engine /  ITP =>   \------>!SET CODE 63 !--------|
 self test key  \  TAPMIN   /       !------------!        |
 on engine off   \---------/                              |
                | YES                                     |
                v                                         |
          /---------\ NO     !------------!               |
         /  ITP <=   \------>!SET CODE 53 !------->|
         \  TAPMAX   /       !------------!               |
          \---------/                                     |
                | YES                                     |
                v                                         |
          /---------\                                     |
         /  VTAP1    \ NO    !------------!               |
        / <=ITP <=    \----->!SET CODE 23 !------->|
        \   VTAP2     /      !------------!               |
         \           /                                    |
          \---------/                                     |
                | YES                                     |
                |<----------------------------------------|
                v
           ----------
         (   EXIT     )
           ----------
```

VSC OUTPUT CIRCUIT CHECK

```
                     ---------
                   (  ENTER    )
                     ---------
                        |
                        v
                  !------------!
                  !.DE-ENERGIZE!
                  ! ALL OUTPUTS!
                  ! EXCEPT EDF !
                  !  ON        !
                  !.SET OC=1   !
                  !------------!
                        |
                        v
                  --------------
                ( DELAY 50 MSEC. )
                  --------------
                        |
      |---------------->|
      |                 v
      |           !------------!
      |           ! SAVE IOCC  !
      |           ! IN OCCSAV  !
      |           !------------!
      |                 |
      |                 v
      |            /---------\ NO      !---------!
      |           / IS OC =1  \------>!ENERGIZE !
      |           \           /       ! SCVAC   !
      |            \---------/        !---------!
      |                 | YES              |
      |                 v                  |
      |            !---------!             |
      |            !ENERGIZE !             |
      |            ! SCVNT   !             |
      |            !---------!             |
      |                 |                  |
      |                 |<-----------------|
      |                 v
      |          --------------
      |        ( DELAY 50 MSEC.  )
      |          --------------
  ---------             |
(OC = OC + 1)           v
  ---------       /----------\
      ^          /ABS[OCCSAV- \ NO      !-------------!
      |         / IOCC] =>     \------->!SET APPROPRI-!
      |         \OCCDT (OC)    /        !ATE FAIL CODE!
      |          \  COUNTS    /         !(SEE TABLE)  !
      |           \----------/          !-------------!
      |                 | YES                  |
      |                 |<---------------------|
      |                 v
                       (A)
```

VSC OUTPUT CIRCUIT CHECK (CONTINUED)

```
                 (A)
                  |
                  v
|           /---------\
|       NO /IS OC = 2  \
|----------\           /
            \---------/
                  | YES
                  v
            !-------------!
            !DE-ENERGIZE  !
            !SCVNT & SCVAC!
            !-------------!
                  |
                  v
              ---------
            (  EXIT     )
              ---------
```

OCC PARAMETER DEFINITIONS

NAME	DESCRIPTION	UNITS	RANGE MIN	RANGE MAX	BASE
OC	OUTPUT CIRCUIT #	--	0	9	--
OCCSAV	SAVED OCC A/D	COUNTS	0	1023	--
IOCC	OCC A/D	COUNTS	0	1023	--
OCCDIX(1-9)	MIN A/D CHANGE	COUNTS	-1023	1023	36

OC #	CODE	FUNCTION	CAL. PAR.	OUTPUT TO BE FUNCTIONED DURING: VSC OCC	OUTPUT TO BE FUNCTIONED DURING: OCC
1	81	SCVNT	OCCDTA	X	-
2	82	SCVAC	OCCDTB	X	-
3	83	HEDF	OCCDT3	-	X
4	84	EVR	OCCDT4	-	X
5	85	CANP	OCCDT5	-	X
7	87	FP	OCCDT7	-	X
8	88	EDF	OCCDT8	-	X
9	89	LUS	OCCDT9	-	X

VEHICLE SPEED CONTROL SELF TEST
EEC-EPCD, FoMoCo, PROPRIETARY & CONFIDENTIAL
DYNAMIC VSC TEST
(ENGINE RUNNING)

```
           ---------
         (  ENTER    )
           ---------
              |
              v
!------------------------------!
!  SEND 1/2 SECOND PULSE       !
!------------------------------!
              |
    !---------------------!
    !.ON-STATE =1         !
    !.VSCDT =1            !
    !.ALLOW NORMAL CONTROL!
    ! OF EDF AND HEDF     !
    !---------------------!
              |
              v
        --------------
     (  DELAY VDLY10   )
            SECS.
        --------------
              |
    !--------------------!
    !SUBSTITUTE RPM FOR  !
    !MPH  MPH = N/32     !
    !--------------------!
              |
              v
        -----------
     (  ZERO AND    )
       START VIPTMR
        -----------
              |<-----------------|
              v                  |
    !-------------------!        |
    !INCREASE VEHICLE   !        |
    !SPEED (N/32)       !        |
    !.SET VVSFL1=1      !        |

    !.RESUM_SPEED=VRSS  !        |
    !-------------------!        |
              |                  |
              v                  v
         /---------\       /---------\
        / IS MPH >  \ NO  /IS VIPTMR  \ YES !------!
       /VRSS - VRSH  \-->/ => VIPT2 ?  \--->!  SET !
       \     ?       /   \             /    ! CODE !
        \           /     \           /     !  36  !
         \---------/       \---------/      !------!
              | YES                             |

              v                                 v
             (1)                               (C)
```

DYNAMIC VSC TEST (CONTINUED)

```
              (1)
               |
               v

     !-------------------!
     !.CLEAR ALL STATES  !
     ! EXCEPT ON-STATE   !
     !.CLEAR VVSFL1      !
     !.TURN SCVNT ON AND!
     !  SCVAC OFF        !
     !-------------------!
               |
               v
         -------------
       ( DELAY VDLY11  )
              SEC.
         -------------
               |
               v
     !-------------------!
     !SAVE CURRENT TP    !
     ! IN TPSAV          !
     !-------------------!
               |
               v
          ----------
       (   ZERO AND   )
         START VIPTMR
          ----------
               |
(B)------------>|
               |
               v
              (A)
```

DYNAMIC VSC TEST (CONTINUED)

```
       (A)
        |
   /---------\ YES !--------!
  /IS TPSAV-  \--->!SET CODE!----------|
  \TP > VTPLD /    !   27   !          |
   \---------/     !--------!          |
        | NO                           |
   /---------\ YES !--------!          |
  /  IS TP-   \--->!SET CODE!--------->|
 /  TPSAV >    \   !   28   !          |
 \   VTPLU     /   !--------!          |
  \           /                        |
   \---------/                         |
        | NO                           v
   /---------\ NO                     (C)
  /IS VIPTMR  \------->(B)
  \=> VIPT3 ? /
   \---------/
        |
 !---------------!
 !DECREASE SPEED !  NOTE: Rate will be depen-
 !TURN SCVNT AND !    dent upon engine inertia
 !  SCVAC OFF    !    and/or ISC dashpot.
 !---------------!
        |
    ----------
 ( ZERO & START )
       VIPTMR
    ----------
        |<-----------------|NO
   /---------\        /---------\      !------!
  /IS MPH <   \ NO   /IS VIPTMR  \ YES !  SET !
  \ VMLO  ?   /----->\=> VIPT4 ? /---->! CODE !
   \---------/        \---------/      !  37  !
        | YES                          !------!
       (C)<--------------------------------|
        |
        v
!-----------------!
!VSCDT =0         !
!RESUM_SPEED =0   !
!SCVNT & SCVAC OFF!
!RETURN MPH REGIS-!
!TER TO NORMAL    !
!-----------------!
        |
!-----------------!
!SEND FAST AND    ! use same code format
!SLOW CODES       ! as engine self test
!-----------------!
        |
    --------
  (  EXIT    )
    --------
```

DYNAMIC VSC TEST VEHICLE SPEED RAMP EQUATIONS

SELF TEST SET_SPEED RAMP FOR RESUME STATE AND ACCEL STATE

This logic ramps the SET_SPEED up to RES_SPEED at a rate of VACRR MPH/sec, to provide smooth acceleration. The rate of acceleration is clipped to MPH + NSTRAT1 to prevent the SET_SPEED from accelerating too fast.

```
ACCEL = REQUIRED ----------|
                           |AND---| SET_SPEED = SET_SPEED
SET_SPEED < MPH + NSTRAT1--|      |  +VACRR * (Time since
                                  |  last update)
                                  |
                                  | ---ELSE---
                                  |
                                  | SET_SPEED = MPH + NSTRAT1
```

SELF TEST VSC_DC OUTPUT ROUTINE

For purposes of Strategy Description, the VSC_DC OUTPUT Routine is divided into two subroutines: VSC_DC Calculation and DUTY CYCLE OUTPUT.

VSC_DC CALCULATION

The VSC_DC is based on the difference between the set speed and the actual vehicle speed with some adjustments for relative throttle position. The calculation is done in two steps to more closely model the analog system.

VSC_ERROR = VDCBIA+[VSTGN*SET_SPEED]
-[VVHGN*MPH] - VTPGN*(TP-RATCH)

VSC_DC = VSC_ERROR - NSTRAT2

SELF TEST CALIBRATION PARAMETERS

VDCBIA = Self Test DC correction factor
VSTGN = Self Test SET_SPEED proportional gain
VVHGN = Self Test Vehicle Speed proportional gain
VTPGN = Self Test throttle position proportional gain
VACRR = Self Test acceleration ramp rate, MPH/sec
NSTRAT1= Normal strategy term - Max. increment above MPH to which set speed can increase MPH.
NSTRAT2= Normal strategy term - Duty cycle offset

CHAPTER 30

ERROR CODE DESCRIPTION

ERROR CODE DESCRIPTION

ERROR CODE	DESCRIPTION	SELF TEST SECTION K.O.E.O	E.R.	CONT
10	CYL #1 LOW -CYL BALANCE TEST		X	
11	PASS	X	X	X
12	RPM NOT WITHIN SELF-TEST UPPER RPM LIMIT BAND		X	
13	RPM NOT WITHIN SELF-TEST LOWER RPM LIMIT BAND		X	
14	PIP CKT FAULT			X
15	ROM TEST FAILED/KAM IN CONTIN- UOUS	X		X
16	RPM TOO LOW TO PERFORM FUEL TEST		X	
18	LOSS OF TACH INPUT TO PROCESSOR- SPOUT CKT. GROUNDED			X
18	SPOUT CKT. OPEN		X	
19	FAILURE IN EEC REFERENCE VOLTAGE	X		
20	CYL. #2 LOW -CYL BALANCE TEST		X	
21	INDICATES ECT OUT OF SELF-TEST RANGE	X	X	
22	INDICATES MAP/BP OUT OF SELF- TEST RANGE	X	X	X
23	INDICATES TP OUT OF SELF-TEST RANGE	X	X	
24	INDICATES ACT OUT OF SELF-TEST RANGE	X	X	
26	MAF SENSOR OUT OF RANGE	X	X	
27	SERVO LEAKS DOWN DURING IVSC TEST	VEHICLE SPEED CONTROL TEST		
28	SERVO LEAKS UP DURING IVSC TEST	VEHICLE SPD CNTRL TEST		
29	INSUFFICIENT INPUT FROM V.S.S.			X
30	CYL #3 LOW -CYL BALANCE TEST		X	
31	EPT/EVP BELOW MINIMUM VOLTAGE	X	X	X
32	EVP VOLTAGE BELOW CLOSED LIMIT (SONIC)	X	X	X
33	EGR VALVE NOT OPENING(PFE,SONIC)		X	X
34	EVP VOLTAGE ABOVE CLOSED LIMIT (SONIC)	X	X	X
35	EPT/EVP CKT. ABOVE MAX. VOLTAGE	X	X	X
36	INSUFFICIENT RPM INCREASE DURING IVSC TEST	VEHICLE SPD CNTRL TEST		
37	INSUFFICIENT RPM DECREASE DURING IVSC TEST	X	X	X
40	CYL #4 LOW -CYL BALANCE TEST		X	
41	EGO SENSOR CKT INDICATES SYSTEM LEAN		X	
41	NO EGO SWITCH DETECTED			X
42	EGO SENSOR CKT INDICATES SYSTEM RICH		X	
44	THERMACTOR AIR SYSTEM INOPER- ATIVE(CYL. 1-4, DUAL EGO)		X	

ERROR CODE DESCRIPTION (CONT'D)

ERROR CODE	DESCRIPTION	SELF TEST SECTION K.O.E.R.	E.R.	CONT.
45	THERMACTOR AIR UPSTREAM DURING SELF-TEST		X	
46	THERMACTOR AIR NOT BYPASSED DURING SELF-TEST		X	
47	SPEED CONTROL COMMAND SWITCH(S) -CKT NOT FUNCTIONING	VEHICLE SPD CNTRL TEST		
48	SPEED CONTROL COMMAND SWITCH(S) STUCK -CKT. GROUNDED	VEHICLE SPD CNTRL TEST		
49	SPEED CONTROL GROUND CKT. OPEN	VEHICLE SPD CNTRL TEST		
50	CYL. #5 LOW -CYL. BALANCE TEST		X	
51	-40 DEGREES F INDICATED ECT - SENSOR CKT. OPEN	X		X
52	PSPS CKT. OPEN	X		
53	TPS CKT ABOVE MAX VOLTAGE	X		X
54	-40 DEGREES F INDICATED ACT - SENSOR CKT. OPEN	X		X
56	MAF SENSOR CKT SHORT TO PWR	X		X
60	CYL #6 LOW -CYL BALANCE TEST		X	
61	254 DEGREES F INDICATED ECT - CKT. GROUNDED	X		X
63	TPS CKT. BELOW MIN. VOLTAGE	X		X
64	254 DEGREES F INDICATED ACT - CKT. GROUNDED	X		X
66	MAF SENSOR CKT OPEN			X
67	NDS CKT. OPEN - A/C ON DURING SELF-TEST	X		
70	CYL #7 LOW -CYL BALANCE TEST		X	
74	BOO SWITCH CKT. OPEN		X	
75	BOO SWITCH CKT. CLOSED - ECA INPUT OPEN		X	
77	OPERATOR ERROR -(DYNAMIC RESPONSE/CYL BALANCE TEST)			
79	A/C ON DURING SELF-TEST	X		
80	CYL. #8 LOW -CYL BALANCE TEST		X	
81	AIR MANAGEMENT 1(AM1)CKT FAILURE	X		
81	SPEED CONTROL VENT (SCVNT) CKT FAILURE	VEHICLE SPD CNTRL TEST		
82	SPEED CONTROL VACUUM(SCVAC) CKT FAILURE	VEHICLE SPD CNTRL TEST		
82	AIR MANAGEMENT 2(AM2)CKT FAILURE	X		
83	ELECTRO DRIVE FAN (EDF) CKT FAILURE	X		
84	ELECTRONIC VAC REGULATOR (EVR) CKT FAILURE	X		
85	CANNISTER PURGE(CANP)CKT FAILURE	X		
87	FUEL PUMP CKT FAILURE	X		X
88	ELECTRO DRIVE FAN (EDF) CKT FAILURE	X		

ERROR CODE DESCRIPTION (CONT'D)

ERROR CODE	DESCRIPTION	SELF TEST SECTION K.O.E.O	E.R.	CONT
90	PASS (CYL BALANCE TEST)		X	
91	EGO SENSOR INPUT INDICATES SYS. LEAN - NO EGO SWITCH		X	
92	EGO SENSOR INPUT INDICATES SYS. RICH		X	
94	THERMACTOR AIR SYS. INOPERATIVE		X	
95	FP CKT OPEN -ECA TO MTR GND	X		X
96	FP CKT OPEN - BAT TO ECA	X		X
98	HARD FAULT PRESENT		X	

CHAPTER 31

VIP PARAMETER DICTIONARY

VIP PARAMETER DICTIONARY

PARAMETER	CALIB.	DESCRIPTION
ACTMAX	935	MAX ACT (ACT OPEN) UNITS ARE COUNTS
ACTMIN	40	MIN ACT (ACT SHORTED) UNITS ARE COUNTS
BIHP	1	BRAKE INPUT HDWR PRESENT 0=NOT PRESENT
BPSSW		1=DO TEST; 0=DO NOT DO TEST
C14LVL	200	THRESHOLD FOR PIP FAULT -UNITLESS
C14UP	202	UPCOUNT VALUE FOR PIP FAULT FIL. -UNITLESS
C22LVL	200	THRESHOLD FOR BP FAULT -UNITLESS
C22UP	210	UPCOUNT FOR BP FAULT FILTER -UNITLESS
C29LVL	254	THRESHOLD FOR VSS FAULT -COUNTS
C29UP	10	UPCOUNT FOR VSS FILTER -COUNTS
C31LVL	200	THRESHOLD FOR EVP FAULT -UNITLESS
C31UP	100	UPCOUNT FOR EVP FAULT FILTER -UNITLESS
C32LVL	254	THRESHOLD FOR EVP OUT-OF-LIMIT
C32UP	20	UPCOUNT VALUE FOR EVP OUT-OF-LIMIT
C33LVL	200	THRESHOLD FOR NO EGR FLOW
C33UP	10	UPCOUNT VALUE FOR NO EGR FLOW
C34LVL	254	THRESHOLD FOR EGR VALUE OUT-OF-LIMIT
C34UP	20	UPCOUNT VALUE FOR EGR VALUE OUT-OF-LIMIT
C35LVL	200	THRESHOLD FOR EVP INPUT HIGH
C35UP	100	UPCOUNT VALUE FOR EVP INPUT HIGH
C41LVL	200	THRESHOLD FOR EGO FAULT -COUNTS
C41UP	100	UPCOUNT FOR EGO FAULT -COUNTS
C51LVL	200	THRESHOLD FOR ECT OPEN FAULT -UNITLESS
C51UP	100	UPCOUNT FOR ECT OPEN FAULT -UNITLESS
C53LVL	200	THRESHOLD FOR TP OPEN FAULT FIL. -UNITLESS
C53UP	100	UPCOUNT FOR TP OPEN FAULT FILTER -UNITLESS
C54LVL	200	THRESHOLD FOR ACT OPEN FAULT -UNITLESS
C54UP	100	UPCOUNT FOR ACT OPEN FAULT FIL. -UNITLESS
C56LVL	200	THRESHOLD LEVEL FOR FAULT 56
C56UP	20	UPCOUNT FOR FAULT 56
C61LVL	200	THRESHOLD FOR ECT SHORT FAULT -UNITLESS
C61UP	100	UPCOUNT FOR ECT SHORT FAULT FIL. -UNITLESS
C63LVL	200	THRESHOLD FOR TP SHORT FAULT -UNITLESS
C63UP	100	UPCOUNT FOR TP SHORT FAULT -UNITLESS
C64LVL	200	THRESHOLD FOR ACT SHORT FAULT -UNITLESS
C64UP	100	UPCOUNT FOR ACT SHORT FAULT -UNITLESS
C66LVL	200	THRESHOLD LEVEL FOR FAULT 66
C66UP	100	UPCOUNT FOR FAULT 66
C87LVL	200	THRESHOLD FOR FP RELAY FAULT -COUNTS
C87UP	255	UPCOUNT FOR FP RELAY FAULT -COUNTS
C91LVL	200	THRESHOLD FOR EGO FAULT -COUNTS
C91UP	100	UPCOUNT FOR EGO FAULT -COUNTS
C95LVL	200	THRESHOLD FOR CODE 95 -COUNTS
C95UP	100	UPCOUNT FOR CODE 95 -COUNTS
C96LVL	200	THRESHOLD FOR CODE 96 -COUNTS
C96UP	100	UPCOUNT FOR CODE 96 -COUNTS

VIP PARAMETER DICTIONARY (CONT'D)

PARAMETER	CALIB	DESCRIPTION
ECTMAX	935	MAX. ENGINE OFF ECT -UNITS ARE COUNTS
ECTMIN	40	MIN. ENGINE OFF ECT -UNITS ARE COUNTS
EDFHP	0	FAN HARDWARE PRESENT SWITCH
EPTMAX	985	MAX. EPT READING -COUNTS
EPTMIN	40	MIN. EPT READING -COUNTS
EVPMAX	985	MAX. EVP READING -UNITS ARE COUNTS
EVPMIN	40	MIN. EVP READING -UNITS ARE COUNTS
FMDTM	0	TIME DELAY BEFORE MIL IS ACTIVATED -SEC
HEDFHP	0	TWO SPEED FAN PRESENT
IDMLVL	200	THRESHOLD FOR IDM -UNITLESS
IDMUP	100	UPCOUNT VALUE FOR IDM -UNITLESS
ISLBND	250	GOOSE IDLE TEST CONTROL BAND LIMIT
ISUBND	250	EXTENDED IDLE TEST CONTROL BAND LIMIT
LEQV	1.3	LEAN LIMIT FOR LAMBDA -UNITS ARE LAMBDAS
LOWBAT	11	LOW BATTERY VOLTAGE -VOLTS
MILLIM	1	MAX. TIME FOR MIL ROUTINE -SEC
MILTM1	0	FLASH RATE FOR MIL -SEC.
NGOOSE	1100	GOOSE TEST DESIRED RPM
NUMEGO	2	NUMBER OF EGO SENSORS
OCCDT1	25	MIN. CHANGE IN OCC AM1 -UNITS ARE COUNTS
OCCDT2	25	MIN. CHANGE IN OCC AM2 -UNITS ARE COUNTS
OCCDT3	0	MIN. CHANGE IN OUTPUT CKT CHECK -COUNTS
OCCDT4	30	MIN. CHANGE IN OCC EVR -UNITS ARE COUNTS
OCCDT5	30	MIN. CHANGE IN OCC CANP -UNITS ARE COUNTS
OCCDT7	30	MIN. CHANGE IN OCC FP -UNITS ARE COUNTS
OCCDT8	0	MIN. CHANGE IN OUTPUT CKT CHECK -COUNTS
OCCDTA	25	MIN. CHANGE IN OCC SCVNT -COUNTS
OCCDTB	25	MIN. CHANGE IN OCC SCVAC -COUNTS
PFEHP	0	SWTCH TO SELECT EGR STRAT, 1=PFE 0=SONIC
PSPSHP	0	PSPS HARDWARE, NO PRESSURE SWITCH
REQV	0.75	RICH LIMIT FOR LAMBDA -UNITS ARE LAMBDAS
TAPMAX	990	MAX. TP SENSOR READING -UNITS ARE COUNTS
TAPMIN	40	MIN. TP SENSOR READING -UNITS ARE COUNTS
THRMHP	1	THERMACTOR AIR HARDWARE SWITCH
V820A	1	ISC DUTY CYCLE MULTIPLIER
V860	5	C/L PACING FUNCTION
VACRR	4	VEH. SPEED RAMP RATE MPH/SEC
VAIRFL	1	SECONDARY AIR TEST FLAG 1=DO TEST
VATMR2	10	TIME TO WAIT BEFORE DOWN STREAM AIR TEST -SEC.
VBISW	0	BRAKE ON/OFF TEST, 1=ENABLE 0=DISABLE
VBPDL1	1200	MIN. BP DURING VIP TEST -TICKS

VIP PARAMETER DICTIONARY

PARAMETER		DESCRIPTION
VBPDL2	1563	MAX. BP DURING VIP TEST - TICKS
VBPMAX	0.15	MAX. TIME SINCE LAST BP UPDATE -SEC
VCBCLP	.065	MAX. CLIP ON DROP REQD FOR CYL BAL TEST RPM/100
VCBDLY	22	DELAY BEFORE STARTING CYL BAL TEST -SEC.
VCBFLG	1	FLAG:0=BYPASS TEST, -1=ALLOW TEST 1=ALLOW MULTIPLE TEST ENTRY
VCBPAD	0.0075	ADDED TO VCBPCT EA. REPEAT OF C.B. TEST
VCBPCT	.05	% RPM DROP REQ'D FOR CYLINDER BAL. TEST
VCBTM1	3	TIME TO AVG. N, ALL INJECTORS ON -SEC
VCBTM2	3	TIME TO AVG. N, ALL INJECTORS OFF -SEC
VCRTDC	.85	EVR DC FOR CRUISE TEST -DC
VDCBIA	2.3	VEH. SPEED DC BIAS
VDCMAX	.85	MAX. EVR DC FOR ENGINE-ON EGR TEST -DC
VDCMIN	.25	MIN. EVR DC FOR ENGINE-ON EGR TEST -DC
VDISFM	0	FMEM FAULT BYPASS FLAG
VDLEDF	4	MIN. TIME TO HOLD ON LOW FAN WHILE PER- FORMING OCC TEST -SEC
VDLHED	2	MIN. TIME TO HOLD ON HI FAN WHILE PER- FORMING OCC TEST -SEC
VDLY1	1	DELAY FOR FUEL RICH TEST -UNITS ARE SEC
VDLY10	15	DELAY BEFORE STARTING SPEED RAMP -SEC
VDLY11	3	DELAY AFTER SPEED RAMP -SEC
VDLY2	3	TIME TO DELAY BEFORE DUMP/UPSTREAM AIR -SEC
VDLY8	0	DELAY BEFORE EXIT FROM FUEL TEST
VECT3	150	MIN. COOLANT TEMP. (ENGINE-ON)-DEG. F
VECT5	120	STARTING COOLANT TEMP. FOR WARM-UP CNT -DEG
VECTMR	2	TIMER FOR EGR CRUISE TEST -SEC
VEGOBP	1	EGO SWITCHING TEST 1=ENABLE
VEGOSW	8	NO. OF EGO SWITCHES REQ'D TO PASS
VEGOTM	240	MIN. TIME TO ENABLE EGO TEST AFTER REACHING CLOSED LOOP TEMP
VEGRAT	.07	EVR DC RATE FOR ENGINE-ON EGR TEST DC/SEC
VEGRLOAD	.35	MAX. LOAD TO DO CONT. EGR FLOW TESTD
VEGVAC	7	MIN. MAN. VAC. FOR EGR CRUISE TEST -IN HG
VEPTIL	605	EPT LOW LIMIT AT IDLE
VEPTLL	610	EPT LOW LIMIT ENG OFF -COUNTS
VEPTRH	850	EPT HIGH LIMIT, ENG. RUN -COUNTS
VEPTRL	615	EPT LOW LIMIT, ENG RUN -COUNTS
VEVPCL	160	EVP CRUISE LIMIT TEST -COUNTS
VEVPDL	80	EVP DELTA FOR ENGINE-ON EGR TEST -COUNTS
VEVPHL	138	EVP UPPER LIMIT -COUNTS
VEVPLL	60	EVP LOWER LIMIT -COUNTS

VIP PARAMETER DICTIONARY

PARAMETER	CALIB	DESCRIPTION
V_FPMDLY	2	DELAY PRIOR TO ENG OFF F.P. CKT TEST -SEC
V_FPMFLG	1	F.P. CKT FLAG, 1=DO TEST
V_FPMTM	1	TIME DELAY PRIOR TO CONT. F.P. TEST -SEC
VFPREQ	1	FUEL PUMP RELAY TEST, 1=DO TEST
VHFNTM	15	MIN. TIME TO HOLD DOWN TP TO ENABLE HI FAN OUTPUT -SEC
VIACT1	717	MIN. CHARGE TEMP. (ENGINE-OFF)- COUNTS
VIACT2	63	MAX. CHARGE TEMP. (ENGINE-0FF) -COUNTS
VIACT3	761	MIN. CHARGE TEMP. (ENGINE-ON) -COUNTS
VIACT4	63	MAX. CHARGE TEMP. (ENGINE-ON) -COUNTS
VIDMST	4	TIME FOR IDM BYPASS AFTER PIP RECOVERY-SEC
VIDMTM	130	TIME OUT FOR IDM FAULT -UNITS ARE MILLI-SECONDS
VIECT1	717	MIN. COOLANT TEMP. (ENGINE-OFF) -COUNTS
VIECT2	63	MAX. COOLANT TEMP. (ENGINE-OFF) -COUNTS
VIECT3	235	MIN. COOLANT TEMP. (ENGINE-ON) -COUNTS
VIECT4	63	MAX. COOLANT TEMP. (ENGINE-ON) -COUNTS
VIPLR1	.025	RATE TO RAMP LEAN -LAMBDAS/SEC
VIPRR1	.05	RATE TO RAMP RICH -LAMBDAS/SEC
VIPSPK	30	VIP SPARK ADVANCE -DEG.
VIPT1	20	MAX. TIME IN STATIC VSC TEST -SEC
VIPT2	20	MAX. RAMP TIME VSC TEST -SEC
VIPT3	15	MAX. TIME IN HOLD TEST -SEC
VIPT4	15	MAX. TIME FOR SPEED DECREASE -SEC
VIPTM2	10	TIME TO WAIT FOR EGO SWITCH -SEC
VIPTM3	20	TIME IN LOOP FOR LEAN FUEL -SEC
VIPTM4	10	TIME TO WAIT FOR EGO RICH -SEC
VISCN	1600	VIP DESIRED RPM
VISCN1	1550	DESIRED RPM TO DO CYLINDER BALANCE TEST
VISDL1	16	ISC DELAY TIME -SEC
VISDL3	10	GOOSE IDLE DELAY TIME -SEC
VISDL4	6	DELAY PRIOR TO CYLINDER BALANCE TEST
VISDL5	6	TIME TO WAIT FOR RPM DROP IN CYL. BALANCE TEST
VKYPWR	200	IV POWER LOWER LIMIT -COUNTS
VLAMCB	.955	LAMBDA FOR CYLINDER BALANCE TEST
VLFNTM	10	MIN. TIME TO HOLD DOWN TP TO ENABLE LOW FAN-SEC
VLORPM	500	MIN RPM FOR PIP/IDM TEST -RPM
VMAF01	20	MAF ENG. OFF VIP LOW LIMIT -COUNT
VMAFPIPLMT	50	MASS AIR FLOW PIP LIMIT -MSEC
VMAFR1	200	MAF. ENG RUNNING VIP LOWER LIMIT -COUNT
VMAFR2	400	MAF ENG RUNNING VIP UPPER LIMIT -COUNT
VMAMAX	1000	MAF CONT. VIP SHORT TO PWR LIMIT -COUNT
VMAMIN	100	MAF CONT. VIP OPEN CKT LIMIT -COUNT
VMARPM	4500	MAF THRESHOLD RPM FOR FAULT 56 -RPM
VML0	35	LOW MPH LIMIT FOR SPD DECREASE IN VSC TEST
VN	900	MAX. IDLE SPEED FOR EPT TEST
VNMIN	900	MIN. RPM FOR FUEL TEST -RPM

VIP PARAMETER DICTIONARY CONT'D

PARAMETER	CALIB	DESCRIPTION
VPIPTM	60	TIME OUT FOR PIP FAULT -MSEC
VPSIND	.000035	VIP GAIN FOR OVERSPEED CONDITIONS
VPSINU	.000045	VIP GAIN FOR UNDERSPEED CONDITIONS
VPSSW	0	POWER STEERING PRESS. SWITCH TEST, 1=ENABLE
VPTCNT	10	NO. OF CLOSED TO PART THROT. TRANS. TO ENABLE
VRLAM	0.9	LAMBDA FOR EGO TEST
VRSH	3	BAND FOR VEH. SPD TEST
VRSS	60	SET SPEED FOR VEH. SPEED TEST
VSAMIN	2000	MIN. RPM TO DO VSS TEST WITH A/T
VSIBRM	0.6	MAX. ALLOWED VALUE FOR IPSIBR
VSIBRN	-0.6	MIN. ALLOWED VALUE FOR IPSIBR
VSLOAD	.266	MAX DECEL LOAD M/T VSS TEST
VSMAPL	7	MAX. DECEL MAP TO DO VSS TEST M/T, IN HG
VSMMIN	1250	MIN. RPM TO DO VSS TEST WITH M/T
VSPADV	30	SPARK ADVANCED FOR SPOUT TEST
VSPRET	10	RETARDED SPARK FOR SPOUT TES
VSPRPM	200	MIN. RPM TO PASS SPOUT TEST
VSPTDL	5	MIN. STABILIZED TIME FOR SPOUT TEST
VSPTEN	1	SPOUT TEST ENABLE SWITCH WHEN =1
VSSMN1	5	MIN. VEH. SPD TO PASS VSS TEST
VSSSW	1	VSS TEST ENABLE SWITCH WHEN =1
VSSTIM	3	MIN. STABILIZED TIME BEFORE VSS TEST
VSTGN	.014	SET SPD PROPORTIONAL GAIN -D.C./MPH
VSTYPE	2	VSC SYSTEM PRESENT WHEN =1
VTABFL	1	FLAG TO DO THERMACTOR TEST 1=DO TEST
VTAP1	150	MIN. ENGINE-OFF THROTTLE POSITION -COUNTS
VTAP2	250	MAX. ENGINE-OFF THROTTLE POSITION -COUNTS
VTAP3	150	MIN. TP -COUNTS
VTAP4	250	MAX. TP -COUNTS
VTAP5	400	UPPER LIMIT OF TP FOR OUTPUT TEST -COUNTS
VTAP6	350	LOWER LIMIT OF TP FOR OUTPUT TEST -COUNTS
VTCDSN	2.75	DSDRPM TIME CONSTANT FOR VIP -SEC
VTCEGO	1.250	TIME CONSTANT FOR EGO -SEC
VTCEPT	0.025	TIME CONSTANT FOR EPT -SEC
VTPGN	.005	THROT POS PROPORTIONAL GAIN, DC/COUNT
VTPLD	10	MIN. TP GAIN FOR VSC TEST -COUNTS
VTPLU	10	MAX. TP GAIN FOR VSC TEST -COUNTS
VVHGN	.014	VEH. SPD PROPORTIONAL GAIN, DC/MPH
VVSCET	60	MAX. TIME IN VSC TEST -SEC
WIGLVL	200	UPCOUNT VALUE IN WIGGLE TEST -UNITLESS

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