Functional Features

Of the

1988 GM P-4 2.0 Turbo PFI System

This info is also applicable to the ‘91-’93 P-4 4.3 Turbo PFI System

Table of Contents

1 SUMMARY

1.1 SCOPE

This specification describes the functional features of the CPC-N 2.0L Turbo PFI system for MY'88. These features are contained in software program P0188BXZ0.

2 GENERAL INFORMATION

2.1 Subject

General Information

2.2 Scope

This general information document provides information not suited to be included in any other section or information which would have to be included in a number of places.

2.3 GMP-4 Turbo Hardware

2.3.1 Inputs

2.3.1.1 Analog Inputs

2.3.1.1.1 Oxygen Sensor

The oxygen sensor signal is a voltage ranging from low level to high level as the air/fuel ratio ranges from lean to rich.

2.3.1.1.2 Coolant Temperature

The coolant temperature is sensed by a thermistor and is determined as a percentage of the A/D reference voltage.

2.3.1.1.3 Throttle Position

The throttle position sensor input is sensed by a potentiometer on the throttle shaft and determined a percent of the A/D reference voltage per a percent of full scale throttle travel.

2.3.1.1.4 Manifold Air Temperature (MAT)

The manifold air temperature is sensed by a thermistor and is determined as a percentage of the A/0 reference voltage (1K internal pull-up resistor).

2.3.1.1.5 Manifold Absolute Pressure (MAP)

The manifold pressure is sensed by an absolute pressure transducer, and is determined as a percentage of the A/D reference voltage.

2.3.1.1.6 Diagnostics/ALDL Input

This signal is used to select the mode of operation; normal, factory test, diagnostics or ALDL made.

2.3.1.1.7 Electronic Spark Control Knock Sensor

The Electronic Spark Control Knock Sensor input is sensed by a mechanical vibration sensitive sensor mounted on the engine and determined analog signal per noise enhancement.

2.3.1.2 Discrete Inputs

2.3.1.2.1 Park/Neutral (P/N)

The P/N input Is a switch to ground input, where a grounded input indicates P/N.

2.3.1.2.2 A/C High Head Pressure Switch (Fan Request)

This signal comes from a normally closed switch to ignition and signifies high A/C head pressure for use as a fan request. Fan is requested when this switch is open.

2.3.1.2.3 Power Steering Pressure Switch (PSPS*)

This signal comes from a normally open switch to ground and signifies high power steering pressure when closed (power steering cramped).

2.3.1.2.4 Air Conditioner Dash Switch (A/C)

This signal comes from a normally open switch to ignition which is closed when air conditioning is requested.

2.3.1.2.5 Exhaust Gas Re-circulation Control (EGR)

This signal comes from a normally open switch to ground and signifies to direct exhaust gases from the exhaust manifold into the intake manifold when closed.

2.3.1.3 Other Inputs

2.3.1.3.1 Engine RPM

Reference pulses input from the HEI module are used to compute engine RPM.

2.3.1.3.2 Vehicle Speed

2.3.1.3.2.1 Optical Speed Input

An optical Vehicle Speed Sensor (VSS) provides a signal which changes from low level to high level 2002 times per mile. The time between each of these pulses is used to compute vehicle speed in MPH.

2.3.1.3.2.2 Magnetic Speed Input

A magnetic Vehicle Speed Sensor (MVSSA, MVSSB) provides a signal which changes from low level to high level. The pulse range can be from 2002 pulses per mile to 28,624 pulses per mile. The time between each of these pulses is used to compute vehicle speed in MPH.

2.3.2 Outputs

2.3.2.1 EST/Bypass

These outputs are used in conjunction with the Computer Controlled Coil Ignition (CCCI) module or HEI module for the electronic spark timing algorithm.

2.3.2.2 Check Engine Light

This output is used to flag a malfunction within the system and to flash out malfunction codes or rich/lean status.

2.3.2.3 Idle Air Control Motor Outputs

Four outputs are provided to control movement (speed and direction) of the IAC stepper motor.

2.3.2.4 Injector Driver Output

One output line is provided to drive a single 1.25 ohm ramp and hold injector.

2.3.2.5 Solenoid Outputs

- Torque Converter Clutch
- Fan Control Relay
- Air conditioner Clutch Relay/Air Switch
- Wastegate
- Electronic Vacuum Regulator Valve

2.3.2.6 Fuel Pump Relay Driver

2.3.2.7 Serial Data Output

The Serial Data Output driver is a unidirectional (output only) driver circuit for high-speed (3192 baud) data.

2.4 PFI Software

2.4.1 Coolant Temperature

Due to the nature of the transducer interface configuration and the characteristics of the temperature sensing thermistor, the A/D conversion is non-linear with coolant temperature. ROM tables *FCLT348* and *FCLT4K* linearize coolant temperature to provide a coolant range from -40 to +152 Deg C (3/4 of a degree per count).

2.4.1.1 Dual Coolant Temperature Pull-up Logic

Software has the capability to switch between a 348 ohm pull-up and a 3996 ohm pull-up if the system is not operation in back-up fuel. The software controlling this pull-up is described below.

- Initialized to 3998 ohm pull-up on power-up
- Switches to 348 ohm pull-up once temperature exceeds 50 Deg C and COP2 has been toggled for at least 100 msec.
- Switches to 3998 ohm pull-up if temperature drops to or below 39.5 Deg C or software has stopped toggling COP2

2.4.2 Oxygen Sensor Input Voltage

The relationship between the oxygen sensor A/D value and the actual oxygen sensor input voltage is given by the following equation.

02AD = VIN * 1152/VREF = VIN * 225.88 (nominal)

Where: 02AD = Oxygen sensor voltage in A/D counts
VIN = Oxygen sensor voltage
VREF = A/D reference voltage (5.1 volts nominal)

This provides a usable range of oxygen sensor voltages from 0 to 1.1289V with a resolution of 4.427 mV when the reference voltage is 5.1V.

2.4.2.1 Filtered Oxygen Sensor (ADOZFILT)

Oxygen sensor voltage is filtered each 12.5 msec with *KAOOZAF* specifying the filter coefficient. The filtered value of oxygen sensor is initialized to *K02FFO* whenever the engine is not running or a system initialization occurs.

2.4.2.2 Slow Trim Filtered Oxygen Sensor (AOO2AFSC)

AOO2AFSC is a version of AOO2A used in the fuel logic. *KFILTOZS* is the filter constant. For initialization, ADO2FSC is set equal to *KO2FFO*. For conditions when the fuel integrator is reset, AOOZAFSC is set equal to *KCLOXTH*.

2.4.3 Throttle Position Load (NTPSLD) Calculation

NTPSLD = (*K3*) * (ADTHROT - ADTAOFF)

Where:	*K3*	= Gain Calibration
	ADTHROT	= Throttle Position in AID Counts
	ADTAOFF	= Filtered 'lower' TPS Readings

2.4.3.1 Lower TPS Filtering for TPS Offset

ADTHROT Is filtered at a 12.5 msec rate when the current value of AOTHROT is less than or equal to the current filtered value of TPS. AOTAOFF is initialized to a value of *K4* and *KTAOFF* specifies the filter coefficient.

2.4.3.2 Throttle Position for Use in Calculating Delta TPS

Filtered values of throttle position are maintained for DE and AE calculations (see Fuel Section). They are called Transient Fuel Filtered Variables. Filter coefficients are selected from the following table. The "hot" coefficients are used when the coolant temperature exceeds *KTFFTT* and *KAFOPTL*, bit 4 = 1. If *KAFOPTZ*, bit 4 = 1, manifold air temperature is used. The "hot" manifold air temperature threshold is *KTFFTTM*.

Filtered	Filter Coefficient		
Variable	Cold	Hot	
AE TPS	TFTAAV	KFILTTAC	KFILTTAH
DE TPS	TFTAAVDE	KFIDETAC	KFIDETAH

2.4.4 Engine Speed (RPM)

Engine RPM is computed from the time between the distributor reference pulses per the following equation:

RPM = 12O/(CYL * TREF)

Where:	RPM	= Engine speed in RPM
	TREF	= Time interval between the falling edge of the last two reference pulses
	CYL	= Number of Cylinders

Number of Cylinders	*KNUMCYL*	
3	96	($60)
4	128	($80)
6	192	($C0)
8	0	($00)

2.4.4.1 Filtered RPM

RPM is filtered each 12.5 msec with *KRPMFILT* specifying the filter coefficient.

2.4.4.2 NTREY65

NTREV65 represents the period of 90 degrees of engine revolution. Its value is obtained from a counter which is triggered from reference pulses. The transfer function is given.

NTREV65 = (15 * 2^16)/RPM

where: T = reference period in seconds
REF = 216 * TREF

2.4.4.3 NTRPMX

Engine speed variable NTRPMX is calculated in inverse proportion to the reference period.

NTRPMX = (155.6 * 256)/NTREV65
= RPM/25

2.4.5 Vehicle Speed (MPH)

The vehicle speed sensor generates 2002 pulses per mile. This corresponds to a frequency of 0.556 pulses per second per MPH. The minimum detectable vehicle speed is that which corresponds to a pulse to pulse interval of 1 second or 1.798 MPH. If no pulse is received within a 1 second interval, the speed will be considered as 0 MPH.

The vehicle speed variable most commonly used in the software is NMPH.

NMPH = (16/5) * FILTMPH

Where: NMPH = Normalized miles per hour
FILTMPH = Filtered miles per hour (see software filtering technique)

NMPH is limited to 224 which corresponds to 70 MPH.

2.4.5.1 Filtered Vehicle Speed

Vehicle speed is filtered each 5Oms with *KFILTMPH* specifying the filter coefficient.

2.4.7 Software Filtering Technique

Various input signals and software variables are conditioned by a software first order lag filter. Some of these signals and oxygen sensor voltage, vehicle speed, and manifold vacuum pressure. The filter can be expressed as follows:

FX1 = FXO + (I - FXO) * K

Where: FX2 = New filtered value
FXO = Old filtered value
I = Current unfiltered input value
K = Filter coefficient (0 to .996)

or FX1 = $\frac{\text{FXO + (I-FXO)*N}}{256}$

- $\frac{\text{FXO + (I-FXO)*256*K}}{256}$

$$= \frac{FXO + (I-FXO)*256*(1-e**(-T/t))}{256}$$

Where: N = Filter coefficient value in computer units
= 256*K
= 256(1-e**(-T/t))
T = Software loop time (update rate) in seconds
t = Filter time constant in seconds
- -T/In(1-(N/256))

NOTE: The filter coefficient should not be set to 0. This will result in the output of the filter being forced to 0.

2.4.8 Table Lookup

The software has the capability to interpolate between points for purposes of two and three dimensional table lookups. If the value of an X or Y parameter exceeds the range of the tables, the nearest endpoint will be selected.

2.4.9 Diagnostic Checksum

For purposes of testing the integrity of non-volatile memory a rotate and add incrementing checksum is applied to the malfunction flag words.

2.4.9.1 Non-Volatile RAM Failure

The non-volatile RAM is indicated as failed if any of the following conditions are satisfied.

- Initialization checksum (double byte) of the five malfunction flag words does not agree with the value last calculated.

  The above condition will result in the block learn memory cells being set to 128, the present IAC motor position being set to *KISSWNA* + *KISPKDL*, the following IAC terms being set as follows:

  ISWNAC = *KISSWNA*
  ISWWAC = *KISSWNA* + *KACDLD*
  ISWWAC (park) = *KISSWNA*
  ISWWAC (park) = *KISSWNA* + *KACOLD*

  The rest of non-volatile memory is cleared.

- BLM contents greater than *KBLMMAX* or less than *KBLMMIN* (checked each 50 msec during block learn).
- This condition will result in the block learn memorv cells being set to 128.

2.4.10 High Voltage Disable of ECM Outputs

If ignition voltage is greater than or equal to 16.9 volts all PWM and discrete outputs will be disabled except for the check-engine light output.

2.4.11 Computation Rates

2.4.11.1 6.25 Msec Logic

2.4.11.2 12.5 Msec Logic

2.4.11.3 50 Msec Logic

2.4.11.4 100 Msec Logic

2.4.11.5 100 Msec Logic

2.4.11.6 RAM Refresh

RAM is refreshed during the dead time while waiting for the next real time interrupt to occur. Bench testing will insure that all of RAM is refreshed at least nnce every 100 msec.

2.5 Instrumentation Module (IM) Information

Two possible Heads-up Display (HUD) configurations are selectable utilizing the CAL A/B switch on the HUD unit.

2.5.1 Display "A'" (Cal A) Selector Switch Information

Display ""A"' Selector Switch (Upper and Lower) Positions

0	1		
9		2	
8			3
7		4	
6	5		

2.5.1.1 Upper Switch Position Display Function Table

Position	Display Parameter	Label
0	Spark Advance (Degrees)	SATDC
1	Barometric Pressure (kPa)	ADBARO
2	Engine Coolant Temperature (Degrees C)	COOLDEG
3	Manifold Air Temperature (Degrees C)	MATDEG
4	IAC Present Motor Position (Steps)	ISSPMP
5	Data Change Slew Value	IDATAMOD
6	RAM Address Slew Value	IADDRMOD
7	Vehicle Read Speed (KPH)	FILTMPH
8	A/F or Base Pulse Change Slew Value	IAFMOD
9	Block Learn Multiplier	BLM

2.5.1.2 Lower Switch Position Display Function Table

Position	Display Parameter	Label
0	Spark Advance Change-Slew Value	ISPKMOD
1	Knock Spark Retard	NOCKRTD
2	Closed Loop Integrator Value	INT

3	Wastegate Duty Cycle (Percent)	WGATEDC
4	IAC Desired Motor Position (Steps)	IMPMOD
5	Base Pulse Width (Msec)	BPW
6	Contents of RAM Location	CONTENTS
7	Throttle Angle (Percent)	NTPSLD
8	A/F Ratio	AIRFUEL
9	EGR Duty Cycle (Percent)	EGRDC

2.5.2 Discrete Status Word Display Information (Display "A")

Discrete Display of Status Word

Status #1

NVM	BLM	BKR	TCC	FAN	AC	PFM	Acc
S7	S6	S5	S4	S3	S2	S1	S0

Status #2

IAC	ASYNCH	LE	AE	DE	PE	CL	R

2.5.2.1 Status Word #1 Display Information

Position	Status Information
S7	Non-Volatile Memory Failure
S6	BLM Cell
S5	Burst Knock Retard
S4	TCC Enabled
S3	Fan ON
S2	Air Conditioning Request
SI	Premium Fuel Mode
SO	Air Conditioning Clutch Disabled

2.5.2.2 Status Word #2 Display Information

Position	Status Information
S7	IAC Motor Moving
S6	Asynch Pulse Mode
S5	Learn Enabled
S4	Acceleration Enrichment
S3	Decel Enleanment
S2	Power Enrichment
S1	Closed Loop Enabled
SO	Oxygen Sensor RICH

2.5.3 Display "B" (Cal B) Selector Switch Information

Display "B'.		Selector Switch (Upper and Lower) Positions	
0	1		
9		2	
8			3
7		4	
5	5		

2.5.3.1 Upper Switch Position Display Function Table

Position	Display Parameter	Label
0	Average MPG	MPGMEAN
1	Power Steering Stall	ISALPA
2	Cold Control IAC Bias for P/N	NBIASPN
3	IAC Drive Motor Position, Warm With No A/C	ISWNAC
4	Manifold Absolute Pressure	MAPP
5	IAC Drive MQtOr Position, Warm With A/C	ISWWAC
6	Filtered RPM	ISES
7	Battery Voltage	ADBAT
8	FAN On Time	FAN
9	Filtered O2 Value (A/D Counts)	ADO2AFSC

2.5.3.2 Lower Switch Position Display Function Table

Position	Display Parameter	Label
0	IAC Extended Throttle Cracker With No A/C	ETCACOFF
1	Coolant Offset for IAC	ISMPTV
2	Cold Control IAC Bias For Drive	NBIASDR
3	IAC P/N Motor Position, Warm With No A/C	ISWNACP
4	IAC Desired Motor Position	ISDSMP
5	IAC P/N Motor Position, Warm With A/C	ISWWACP
6	Desired Engine Speed (RPM)	DESSPD
7	Instantaneous MPG	MPG
8	Delay Counter For P/S Crack Decay	PSTCLC
9	IAC Extended Throttle Cracker With A/C	ETCACON

2.5.6 Analog Channel Assignments (Continued)

Block	Parameter	Min. Scale	Max. Scale
14	IAC OMP Slew Value	0 Counts	255 Counts
15	Base Pulse Width	0 mSec	0 mSec
16	IMMW3 (Octal)	--	--
17	TPS Load	0%	100%
18	Air/Fuel Ratio	0 A/F	25.5 A/F
19	Battery Voltage	0V	25.5V
20	IMMW1	0V	25.5V
21	IMMW2		
22	RPM	0 RPM	6400 RPM
23	Manifold Absolute Pressure	10.35KPa	104.4KPa
24	Closed Loop Correction	--	
25	IAC Present Motor Position		
26	Not Used		
27	Not Used		
28	Not Used		
29	Not Used		
30	vehicle Road Speed (MPH)	0 KPH	200 KPH
31	Base Pulse Width	0 msec	100 msec
32	IMMW1B		
33	IMMW28		
34	RPM	0 RPM	3200 RPM
35	RPM (Filtered)	0 RPM	1600 RPM
36	Base Pulse Width	0 msec	200 msec

37	IAC Present Motor Position	0 Counts	200 Counts
38	Manifold Air Temperature	-40 Deg	152 Deg
39	A.E. Delta MAP	0 kPa	100 kPa
40	A.E. Delta Throttle	0%	100%
41	D.E. Delta MAP	0 kPa	100 kPa
42	D.E. Delta Throttle	0%	100%
43	N/V Ratio for Shift Light	0 Ratio	144 RA
44-100	Not Used		

3 POWER MODING

3.1 SPECIFICATION

Power Moding

3.1.1 ECM Battery voltage Moding

The ECM shall take the actions listed below for the conditions indicated:

Function	Action	Condition
Idle Air Control	Off	IGNN GT 16.9 V
A/C Clutch	Off	IGNN GT 16.9 V
Wastegate	Off	IGNN GT 16.9 V
TCC/Shift Light	Off	IGNN GT 16.9 V
FAN	Off	IGNN GT 16.9 V
EGR	Off	IGNN GT 16.9 V
Idle Air Control	Off	IGNN LE KISSPVT2
Total ECM	Reset	Battery LT 6.3 V

4 FACTORY TEST MODE

4.2 SCOPE

The factory test mode is designed to provide a way to monitor/exercise ECMs inputs and outputs for use in manufacturing/production covers on test. It is independent of customer software algorithms and calibration values so that a production ECM test can be implemented prior to production.

4.3 SPECIFICATION

4.3.1 Factory Test Mode Enable Criteria

The factory test mode is enabled if the following criteria are satisfied following a system reset.

1. In factory test mode (3.9K resistor to ground on diagnostic request input)
2. PPSW voltage greater than 16V
3. Battery voltage less than 10V

Once the factory test mode is enabled, it will remain enabled as long as the factory test mode is requested on the diagnostic request input and no system reset occurs. (Note that if ignition is cycled off while in Mode 1 with COP 2 not being toggled, a power down reset will immediately occur).

As soon as the factory test mode is enabled, the following actions take place.

1. $AA stored in all nonvolatile RAM locations, if the ECM powers up in Mode 1.
2. 16K Checksum of Pluggable Memory Calculated

4.3.2 Factory Test Mode Function

The factory test made is divided into three basic modes based on the state of Bits 1 and 0 of the FMD #1 input discrete word (inputs IDH2 and IDH1 respectively) at the time an ignition OFF to ON transition occurs. These modes are selected as shown below:

FMD #1 Bit 1 IDH2 (3rd gear)	FMD #1 Bit 0 IDH1 (P/N)	
0	0	Mode 1 - All off made
x	1	Mode 2 - I/O check mode
1	0	Mode 3 - Miscellaneous test mode

4.3.2.1 High Speed UART Serial Data Format (Reference XDE-5024)

The approach used for the high speed transmission is intended to be the same as that used in a UART system. A description follows:

4.3.2.1.1 Bit Format

A bit time shall be 122.07 microseconds ± 0.5%. This is equivalent to 8192 Baud. A high voltage state indicates a logic one condition and a low voltage state indicates a logic zero condition.

4.3.2.1.2 Word Format

A word consists of ten bit times. The first bit is a logic zero and is called the Start Bit. The last (tenth bit) in the word is always a logic one and is called the Stop Bit. The remaining eight center bits are data bits and are transmitted LSB first. A Start Bit inust always be preceded by at least one logic one bit time (either the stop bit of the preceding word or an Idle Line).

4.3.2.1.3 Message Format

Any and all data transmitted on the serial data bus must be part of a message. All messages must be of the following format:

- Idle line
- Message Identification Word (ID)
- Message Length (35+N)
- N Bytes of Data
- Sum Check
- Idle Line

4.3.2.1.3.1 Idle Line

Ten or more consecutive logic one bit times constitute an Idle Line. All receivers on the bus will use the occurrence of an Idle Line followed by a Start Bit to indicate the start of a message.

4.3.2.1.3.2 Message Identification Word

When used in a UART system, the first word of each message is a message Identification (ID) word. Each Message ID must be unique; therefore, all Message ID's must be assigned in the particular Applications Document. The total number of unique message ID's is limited to 254. ID's of $00 and $FF shall not be used in UART system. For Factory Test the identification word is $00.

4.3.2.1.3.3 Message Length Word

The message length word indicates the total number of data words in the remainder of the message plus 85 (decimal). The maximum number of data words within one message which can be transmitted by any transmitter is 64. Thus a valid message length word must lie in the range of 85 to 149. Many messages with no data words are possible; for such messages, the Message Length Word would contain the binary word 0101 0101 (MSB-LSB). This pattern has been selected because, under an abnormally severe noise environment, there is a higher probability that an erroneously received message will be detected as such.

4.3.2.1.3.4 Sum Check

The last word to be transmitted in a message is the two's complement of the sum of all the other words in the message, including the Message ID and message length words. Any carry-outs of this eight-bit word while it is being formed by both the transmitter and receivers shall be neglected. The two's complement is used so that if the receivers sum all the words in the message, then the result should be zero for a valid message.

4.3.2.1.2 Serial Data Output

The serial data streams output for each particular mode are shown below. It should be noted that this information represents the data bytes only. The identifier code ($00 for Factory Test) and number of bytes transmitted precede these data bytes and the checksum will follow the data bytes.

4.3.2.1.2.1 Mode 1

No serial data is output in Mode 1

4.3.2.1.2.2 Mode 2 and Mode 3

Data Byte	Description
1	PROMIDA (Upper Byte)
2	PROMIDA (Lower Byte)
3	DATECODE (Upper Byte)
4	DATECODE (Lower Byte)
5	SEQNUMB (Upper Byte)
6	SEQNUMB (Lower Byte)
7	ROMSUM (Upper Byte)
8	ROMSUM (Lower Byte)
9	NVMSUM (Upper Byte)
10	NVMSUM (Lower Byte)
11	SAD CHANNEL AN0
12	SAD CHANNEL AN1
13	SAD CHANNEL ANZ
14	SAD CHANNEL AN3
15	SAD CHANNEL AN4 (Coolant A/D-alternating pull-ups each 25 msec.)
16	SAD CHANNEL ANS
17	SAD CHANNEL AN6
18	SAD CHANNEL AN7
19	SAD CHANNEL AN8
20	SAD CHANNEL AN9-0
21	SAD CHANNEL AN9-l
22	SAD CHANNEL AN9-2
23	SAD CHANNEL AN9-3
24	SAD CHANNEL AN9-4
25	SAD CHANNEL AN9-5
26	SAD CHANNEL AN9-6
27	SAD CHANNEL AN9-7
28	SAD CHANNEL AN10
29	SAD TEST CHANNEL
30	C00L348 (Coolant AID with 348 ohm pull-up)
31	COOL4K (Coolant A/D with 4K ohm pull-up)
32	TESTWORD Bit 7 = In Factory Test Mode Bit 6 = NOT USED Bit 5 =NOT USED Bit 4 = EPROM CHECKSUM TEST (Code 51), 1= Failed Bit 3 = NOT USED Bit 2 = NOT USED Bit 1 = NOT USED Bit 0 = NOT USED
33	REFPER - Reference Period (Upper Byte)
34	REFPER - Reference Period (Lower Byte)
35	PP1TIMD - Vehicle Speed Delta (Upper Byte)

36	PPITIMD - Vehicle Speed Delta (Lower Byte)
37	PP2TIMD - 6X Reference Delta (Upper Byte)
38	PP2TIMD - 6x Reference Delta (Lower Byte)
39	PA1CTR - Frequency Mass Air Flow/Vats Pulse Accumulator
40	PA1CTR - Frequency Mass Air Flow/Vats Pulse Accumulator
41	PA2CTR - EST Monitor Integration Period (Upper Byte)
42	PA2CTR - EST Monitor Integration Period (Lower Byte)
43	PA3CTR - ESC Integration Period (Upper Byte)
44	PA3CTR - ESC Integration Period (Lower Byte)
45	PA4CTR - Vehicle Speed Pulse Accumulator (Upper Byte)
46	PA4CTR - Vehicle Speed Pulse Accumulator (Lower Byte)
47	PAlTIMD - Frequency MAF/VATS Delta (Upper Byte)
48	PAlTIMD - Frequency MAF/VATS Delta (Lower Byte)
49	GMP4 Programmable Port I/O Status
50	GMP4 Programmable Port Data Direction (0 = Input, l = Output)
51	FMDBYTE1 (FMD #1) Bit 7 = A/C Bit 6 = IDH5 Bit 5 = IDH6 Bit 4 = IDL1 Bit 3 = IDH4 Bit 2 = IDH3 Bit 1 = IDH2 Bit 0 = IDH1
52	FMDBYTE2 (FMD #1) BIT 7 = IRQ Occurred BIT 6 = Injector 'A' shorted BIT 5 = .4V sensed on Driver 'A' (Peak and Hold usage) BIT 4,3 = 1,1 - TBI or alternating TBI/PFI 1,0 - 4 Cylinder PFI SSDF 0,1 - 6 Cylinder PFI SSOF 0,0 - 8 Cylinder PFI SSDF BIT 2 = NOT USED BIT 1 = NOT USED BIT 0 = NOT USED
53	FMDBYTE1 (FMD #2)
54	FMDBYTE2 (FMD #2) BIT 7 = IRQ Occurred BIT 6 = Injector 'B' shorted BIT 5 = .4V sensed on Driver 'B' (Peak and Hold Usage) BIT 4,3 = 1,1 - TBI or alternating TBI/PFI BIT 2 = NOT USED BIT 1 = NOT USED BIT 0 = NOT USED
55	SC1 INPUT STATUS

4.3.2.2 Mode 1 - All Off Mode

When Mode 1 is enabled the following actions take place:

1. Check engine light turned off
2. Serial data driver turned off
3. EST mode disabled

4. Synchronous fuel delivery disabled
5. Asynchronous fuel delivery disabled
6. All discrete outputs de-energized NOTE: An attempt will be made to activate 0F6* and 0F7* through software, but these outputs should be de-energized since the QDMs handling these signals are disabled in backup fuel.
7. All PWM outputs de-energized (0% duty cycle) NOTE: The FAN output will default to ON after a short delay in back-up fuel.
8. IAC output disabled (OFF in backup; on but not moving when not in backup)
9. COP Z not toggled if Mode 1 input conditions remain satisfied (FMD#1 BITS 0 and 1=0)
10. One second ECM turn off delay

It is possible to check backup fuel operation in Mode 1 by applying reference pulses to the ECM

4.3.2.3 Mode 2 - Input/Output Check Mode

When Mode 2 is enabled, the following actions take place:

1. All A/D inputs read
2. All discrete inputs read
3. All pulse accumulator/pulse period/pulse integrator inputs read
4. PWM outputs activated as follows:

PW1 (   ) 30% duty cycle at a 32 Hz PWM rate.
PW2 (   ) 40% duty cycle at a 32 Hz PWM rate.
PW3 (   ) 50% duty cycle at a 32 Hz PWM rate.
PW4 (   ) 60% duty cycle at a 32 Hz PWM rate.
PWS (   ) 70% duty cycle at a 32 Hz PWM rate.
PW6 (   ) 80% duty cycle at a 32 Hz PWM rate.

5. Discrete outputs energized individually each 100 msec
   - TCC*
   - Check Engine Light
   - 0F5*
6. FAN* and FUEL PUMP cycled as follows:
   - FAN* discrete ON; FUEL PUMP 50% duty cycle at a 32 Hz PWM rate
   - FAN* discrete OFF; FUEL PUMP 50% duty cycle at a 32 Hz PWM rate
   - FAN* 50% duty cycle at a 32 Hz PWM rate; FUEL PUMP discrete ON
7. Vehicle speed buffer option selects (SCI 08,07, and 06) incremented MODULO-8 every 100 msec
8. Step AC motor every 100 msec
9. second ECM turn off Delay

1. If reference period is greater than 10 msec, the following occurs:
   - Synchronous fuel output set at 10 msec, simultaneously delivered
   - No delayed start of injection
   - Spark is set at Reference Period/4 Retard, (45 degrees for 4 cylinder)
   - Dwell time is fixed at 5 msec.

2. If reference period is between 5 and 10 msec, the following occurs:
   - Synchronous fuel output set at 5 msec, alternately delivered
   - No delayed start of injection
   - Spark advance set at 0 deg.
   - Dwell time is fixed at 4 msec.

3. If reference period is less than 5 msec, the following occurs:

- Synchronous fuel output set at 1 msec, simultaneously delivered
- msec delayed start of injection
- Spark is set at Reference Period/4 advance (45 degrees for 4 cylinder)
- Dwell time is fixed at 3 msec

4.3.2.4 Mode 3 - Miscellaneous Test Mode

When Mode 3 is enabled the following actions take place:

1. Check engine light turned off
2. EST mode disabled
3. Synchronous fuel delivery disabled
4. All discrete outputs de-energized
5. All PWM outputs de-energized (0% duty cycle) except for asynchronous fuel
6. COP2 toggled
7. Asynchronous fuel output fixed at 3 msec every 6.25 msec
8. Checksum of nonvolatile RAM calculated
9. One second ECM turn off delay
10. IAC outputs on, but not changing state

4.4 Special Consideration

4.4.1 RAM Usage

When implementing Factory Test Software, RAM locations in all devices containing RAM should be utilized to provide some automatic test of RAM.

4.4.2 EPROM Checksum

The checksum sent out on serial data (ROMSUM) is the sum of all bytes in the EPROM.

The factory test software also performs a code 51 type test of the EPROM checksum. That is, it compares a calculated checksum against a checksum value located in the EPROM. The result of this test is transmitted by one of the bits in serial data byte named TESTWORD If the code 51 checksum test is bypassed in the EPROM, a test passed indication will be transmitted.

5 HIGH SPEED SERIAL DATA

5.1 PURPOSE AND SCOPE

This document describes the operational characteristics, communication protocol, and transmitted data for the serial data stream. The serial data output is to be utilized to transmit predetermined data parameters to intelligent receiving devices external to the vehicle. Receivers external to the vehicle shall utilize the transmitted information to identify ECM type and for testing during the ECM assembly and in-car installation procedures. A high speed UART link option is available for GMAD assembly line diagnostics.

5.2 REFERENCE DOCUMENTS

- Serial Communications Protocol Specification (EE-1800-003, Revision A), Delco/Kokomo, dated April 7, 1979.
- ECM Serial Output Specification (EE-1810-004, Revision A), Delco/Kokomo, dated April 17, 1979.
- XDE 5024, system Design Specification for High Speed Serial Data Communication between Microcomputer Assemblies, dated November 17, 1982.

5.3 SERIAL DATA TRANSMISSION RATE

Low speed serial data is not implemented. The high speed serial data transmits data at the rate of one bit each 122.07 microseconds ± 0.5% This is equivalent to 8192 baud. The high speed serial data is transmitted on the serial data output.

5.4 MESSAGE TYPE

Different data message types are transmitted by the ECM via the serial data output port if the ignition is on. The message type sent at any point in time is dependent upon the state of the diagnostic request line as summarized in the table below:

Resistance to Power Ground	Mode	Serial Data
Greater Than20K	Normal	Normal Mode *
10K +-5%	End of Line Test (ALDL Mode)	ALDL *
3.9K +-5%	ECM Factory Test	See Factory Test Section
Less Than 500 ohms	Diagnostics/Field Service	ALDL *

* See High Speed Serial Data Specification, Section 2.0

5.5 TRANSMITTED DATA SPECIFICATION

5.5.1 Low Speed Serial Data Specification

Low speed serial data is not implemented.

5.5.2 High Speed Serial Data Specification

5.5.2.1 High Speed Serial Data Format

The approach used for the high speed transmission is intended to be the same as that used in a UART system. A description follows:

5.5.2.1.1 Bit Format

A bit time is 122.07 microseconds +-0.5%. This is equivalent to 819? Baud. A high voltage state indicates a logic one "1" condition and a low voltage state indicates a lo9ic zero "0" condition. The high speed serial data is output on the serial data output port.

5.5.2.1.2 Word Format

A word consists of ten bit times. The first bit is a logic zero and is called the Start Bit. The last (tenth bit) in the word is always 3 logic one and is called the Stop Bit. The remaining eight center bits are data bits and are transmitted LSB first. A Start Bit must always be preceded by at least one logic one bit time (either the stop bit of the preceding word or an Idle Line).

5.5.2.2 Message Format

Any and all data transmitted on the serial data bus must be part of a message. All messages must be of the following format:

- Idle Line
- Message Identification Word (ID)
- Message Length Word (85 + 1 + N)
- Mode Number Word
- Message Data (N Bytes)
- Sum Check
- Idle Line

5.5.2.2.1 Idle Line

Ten or more consecutive logic one bit times constitute an Idle Line. All receivers on the bus will use the occurrence of an Idle Line followed by a Start Bit to indicate the start of a message.

5.5.2.2.2 Message Identification Word

The first word of each message is a message identification (ID) word. Each message ID must be unique; therefore, all message ID's must be assigned in the particular Application Document. The total number of unique message ID's is limited to 254. ID's of $00 and $FF shall not be used in the vehicle.

5.5.2.2.3 Message Length Word

The message length word indicated the total number of data words in the remainder of the message plus 85 (decimal). The maximum number of data words within one message which can be transmitted by any transmitter is 64. Thus a valid message length word must lie in the range of 85 to 149. Many messages with no data words are possible; for such messages, the Message Length Word would contain the binary word 0101 0101 (MSB-LSB). This pattern has been selected because, under an abnormally severe noise environment, there is a higher probability that an erroneously received message will be detected as such.

5.5.2.2.4 Mode Number Word

All high speed messages have an assigned mode number. An external ALDL tester that requests high speed communications will specify the desired mode of operation.

5.5.2.2.5 Sum Check

The last word to be transmitted in a message is the two's complement of the sum of all the other words in the message, including the message ID and message length words. Any carrycuts of this eight-bit word while it is being formed by both the transmitter and receivers are neglected. The two's complement is used so that the sum of all the words in the message is zero for a valid message.

5.6 HIGH SPEED SERIAL DATA MESSAGES

The following sections define the input and output message formats for the various modes of high speed serial data.

The operating modes are divided into two categories, normal and ALDL modes. The ALDL modes can be entered independent of the diagnostic request line.

5.6.1 Normal Mode

The normal mode will be enabled if any of the following conditions are satisfied:

- ALDL device not present.
- Mode 0 requested by ALDL device.
- No ALDL message received for a time of 5 seconds.

When the normal mode is enabled, messages will be continuously transmitted by the scheduler unless the ALDL mode is enabled. The scheduler consists of a table of message addresses corresponding to messages that can be transmitted at a given 12.5 msec interval. Onlv one message can be transmitted in a given 12.5 msec interval.

The scheduler table *F9OMST* shown below, shows the expected messages and rates for this application:

Schedules Message Code	Message
0	No Message
1	No Message
2	No Message
3	No Message
4	*F97*
5	No Message
6	No Message
7	No Message
8	No Message
9	No Message
A	No Message
B	No Message
C	No Message
D	No Message
E	No Message
F	No Message

The scheduler shows that message *F97* is transmitted once every 200 msec.

*5.6.1.1 Normal Mode Message *F97**

Message *F97* is used to poll for the presence of an ALDL testing device The message ID for the testing device is = $FO Hex, and the message length is zero.

5.6.2 ALDL Mode

The ALDL Mode is enabled when the ALDL device responds to the normal mode ALDL polling message (*F97*).

Once in the ALDL mode, the ECM will cease transmitting the normal mode messages.

The ALDL mode is divided into the following sub-modes and uses a message ID of $FO Hex:

- Mode 0 (Return to normal mode)
- Mode 1 (Transmit fixed data stream)
- Mode 2 (Selectable memory dump)
- Mode 3 (RAM contents)
- Mode 4 (Controller function)
- Mode 7 (Command normal mode message)

5.6.2.1 ALDL Mode 0 (Return to Normal Mode)

When the ALDL device requests Mode 0, the ECM will revert back to the normal mode. The ALDL device requests Mode 0 by sending the following message:

- Message ID = $F0 Hex.
- Message Length = 85 + 1 = 86 = $56 Hex.
- Mode = $00 Hex.
- Sum Check.

The ECM will respond by transmitting the normal mode messages as described in previous sections.

5.6.2.2 ALDL Mode 1 (Transmit Fixed Data Stream)

When the ALDL device requests Mode 1, the ECM will respond by transmitting a predetermined 63 byte message as defined in table *F95*. See Figure 3.

The ALDL device requests Mode I by sending the following message:

- Message ID + $FO Hex.
- Message Length = 85 + 1 = 86 = $56 Hex.
- Mode = $01 Hex.
- Sum Check.

The ECM will respond with the following message:

- Message ID = $F0 Hex.
- Message Length = 85 + 64 = 149 = $95 Hex.
- Mode = $01 Hex.
- Data Byte 1
- -
- -
- Data Byte 63
- Sum Check

5.6.2.3 ALDL Mode 2 (Selectable Memory Dump)

When the ALDL device request Mode 2, the ECM will respond by transmitting the contents of 64 memory locations be9innin9 with the address specified in the Mode 2 request.

The ALDL device request Mode a by sending the following message:

- Message ID = $F0 Hex.
- Message Length = 85 + 3 = 86 = $58 Hex.
- Mode = $02 Hex.
- Starting Address Upper byte.
- Starting Address Lower byte.
- Sum Check.

The ECM will respond with the following message:

- Message ID = $F0 Hex.
- Message Length = 85 + 65 = 150 = $96 Hex.
- Mode = $02 Hex.
- Contents of Address 1
- -
- -
- Contents of Address (1 + 63)
- Sum Check

5.6.2.4 ALDL Mode 3 (RAM Contents)

When the ALDL device requests Mode 3, the ECM will respond by transmitting the contents of the RAM locations specified in the request (from 0 to 8 locations).

The ALDL device requests Mode 3 by sending the following message:

- Message ID = $F0 Hex.
- Message Length = 85 + 2N + 1 (N = 0 to 8).
- Mode = $03 Hex.
- Address I Upper byte
- Address I Lower byte
- -
- -
- Address N Upper byte
- Address N Lower byte
- Sum Check

The ECM will respond with the following message:

- Message ID = $F0 Hex.
- Message Length = 85 + N + I (N = 0 to 8).
- Mode = $03 Hex.
- Contents of Address 1
- -
- -
- Contents of Address N
- Sum Check

5.6.2.5 Mode 4 Input Message (ALDL Tester Request)

- ID
- MESSAGE LENGTH (2N + 11 + 85)

- MODE 4
- DISCRETE OUTPUT ENABLE CONTROL WORD *
- DISCRETE OUTPUT STATE WORD *
- MODE CONTROL ENABLE WORD *
- MODE CONTROL STATE WORD *
- PWM OUTPUT ENABLE CONTROL WORD *
- PWM OUTPUT DUTY CYCLE *
- FUNCTION MODIFICATION CONTROL WORD*
- IAC DESIRED POSITION/IDLE RPM *
- DESIRED A/F RATIO *
- SPARK ABSOLUTE/DELTA MODIFICATION *
- START ADDRESS HIGH
- START ADDRESS LOW
- -
- -
- ADDRESS N HIGH
- ADDRESS N LOW
- CHECK SUM

Where N is the number of data bytes requested (0 to 8). See "Mode 4 - ECM Function Modification Mode Table".

The ECM will respond with the following message:

- ID
- MESSAGE LENGTH = 85 + N + 1 (N = 0 to 8)
- MODE = $04 Hex.
- ADDRESS 1 CONTENTS
- -
- -
- ADDRESS N CONTENTS
- CHECK SUM

The Function Modifications will have immediate response (next applicable program loop), and will override the normal operation of the Outputs.

6.2.5.1 MODE 4 - ECM FUNCTION MODIFICATION MODE TABLE

1. Discrete Output Enable Control Word
   Bit 0 = Check engine Light Control
   Bit 1 = Fan Control
   Bit 2 = Not Used
   Bit 3 = Not Used
   Bit 4 = Not Used
      1 = Control enabled
      0 = Control disabled

2. Discrete Output State Word
   Bit 0 = Check Engine Light: 1 = On, 0 = Off
   Bit 1 = Fan: 1 = On, 0 = Off
   Bit 2 = Not Used
   Bit 3 = Not Used
   Bit 4 = Not Used

3. Mode Control Enable Word

Bit 0 = Fuel Closed Loop (C/L)
Bit 1 = Idle Air Control (IAC) C/L
Bit 2 = Not Used
Bit 3 = Spark Back-up (Does Not Force Fuel Backup)
Bit 4 = Block Learn Memory (BLM) Reset, (see Note 1)
Bit 5 = IAC Motor Reset, (See Note 2)
Bit 6 = Clear Malfunction Codes, (See Note 1)
Bit 7 = Fuel Back-up (COP 2 not toggled, also forces Spark Backup)

1= Select Function or feature
0 = Deselect

Note 1: Block Learn Memory Reset and Malfunction Code clearing can only occur during the first pass through the Mode 4 logic.

Note 2: IAC Motor Reset can occur at any time while in Mode 4 logic, however, it can only occur once

4. Mode Control State Word

Bit 0 = Fuel C/L: I = C/L, 0 = Not C/L
Bit I = IAC C/L: 1 = C/L, 0 = Not C/L
Bit 2 = Not Used
Bit 3 = Not Used
Bit 4 = Not Used

5. PWM Output Control Enable Word

Bit 0 = EGR Output
Bit 1 = A/C Output
Bit 2 = TCC Output
Bit 3 = Not Used
Bit 4 = Not Used
Bit 5 = Not Used
Bit 6 = Not Used
Bit 7 = Waste Gate

6. PWM Output Duty Cycle (0 - 100%)

7. Function Modification Control Word

Bit 0 = IAC Modification: 1 = Selected
Bit 1 = IAC: 0 = Position; 1 = RPM
Bit 2 = A/F Modification: 1 = Selected
Bit 3 = Spark Modification: 1 = Selected
Bit 4 = Spark: 0 = A8S; 1= Delta
Bit 5 = Spark: 0 = ADV; 1 = RTD
Bit 6 = Not Used
Bit 7 = Not Used

8.IAC Desired Position/Idle RPM

IAC Position (0 - 255) or RPM (0 - 3200)

9. Desired A/F Ratio

Open Loop A/F (0.0 - 25.5, N = A/F * 10)

10. Spark Absolute/Delta Modification (0 - 90 deg.)

5.6.2.6 ALDL Mode 7 (Command Normal Mode Message)

When the ALDL device requests Mode 7, the ECM will transmit the normal mode scheduler message specified in the request.

The ALDL device requests Mode 7 by sending the following message:

- Message ID = $F0 Hex.
- Message Length = 85 + 2 = 87 = $57 Hex.
- Mode = $07 Hex.
- ECM Scheduler Message Code (0-F)
- Sum Check

The ECM will respond with the appropriate normal mode scheduler message if one exists for that particular scheduler message code.

5.7 ERROR DETECTION/REMEDIAL ACTION

If any of the following errors are detected the complete message is ignored and the serial data handler is put into the wake-up mode in preparation for the next message:

- Overrun Error, indicates that one or more characters in the Data Stream were lost.
- Framing Error, indicates that the Data Byte received was improperly framed by a start and stop bit
- Device Code riot recognizable by ECM.
- Data Byte Count received does not match Data Byte Count expected as defined in message control block.
- Checksum Error, indicates calculated check sum does not match transmitted check sum.
- Noise Error, indicates that one of three samples of the transmitted bit was different from other two.

5.8 SERIAL DATA TRANSMITTER SPECIFICATIONS

5.8.1 High Speed Serial Data Transmitter Specifications

Characteristics of the serial data output are as follows:

- V_{OH} GE 4.0V @ I_{OH} = -2.5mA, V_{OH} LE 5.1 V (max.)
- V_{OL} LE 0.9V @ I_{OL} = 10.0 mA, V_{OL} GE ECM. Ground (min.)

Serial Data Receiver Requirements

The following specifications are required to be met by any device transmitting serial data to the ECM:

- V_{IH} GE 3.1V, -360uA LE I_{IH} LE -165uA **
- V_{IH} LE l6V, (absolute max. allowed)
- V_{IL} LE 1.7V, -360uA LE I_{IH} LE -l65uA **
- V_{IL} GE -0.5V, (absolute min allowed)

*All voltages relative to ECM Ground and measured at ECM connector.

*All currents directed into ECM.
**Current levels defined by ECM receiver in tri-state mode.

Requiring each receiver to meet these specifications insures that the ECMs serial data output will drive at least eight receivers in parallel.

*Figure 1 *F9OMST* SC: Message Schedule Table*

Time	*Message*
0	No Message
1	No Message
2	No Message
3	No Message
4	*F97*
5	No Message
6	No Message
7	No Message
8	No Message
9	No Message
A	No Message
B	No Message
C	No Message
0	No Message
E	No Message
F	No Message

This table defines the order in which the Mode 0 (normal mode) ALDL transmit tables will be transmitted in the serial data stream.

In this application, the *F97* is transmitted every 200 msec.

*Figure 2 *F97* Transmit Table for Mode 0 (Normal Mode).*

Location	*Content*
1	$F0

*Figure 3 *F95* Mode 1 ALDL Transmit Table.*

Loc.	*Variable*	*Description*	
1	PROMIDA	Last 4 digits of ECM serial #	
2	PROMIDA+l		
3	MALFFLG1	Bit 0 = MALF CODE 24	Vehicle Speed Sensor
		Bit 1 = MALF CODE 23	Manifold Air Temperature Sensor Low
		Bit 2 = MALF CODE 22	Throttle Position Sensor Low
		Bit 3 = MALF CODE 21	Throttle Position Sensor High
		Bit 4 = MALF CODE 15	Coolant Sensor Low Temperature
		Bit 5 = MALF CODE 14	Coolant Sensor High Temperature
		Bit 6 = MALF CODE 13	Oxygen Sensor
		Bit 7 = MALF CODE 12	No Reference Pulses (Engine Not Running)
4	MALFFLG2	Bit 0 = MALF CODE 42	EST Monitor Error

		Bit 1 = MALF CODE 41	
		Bit 2 = MALF CODE 35	IAC Error
		Bit 3 = MALF CODE 34	MAP Sensor Low
		Bit 4 = MALF CODE 33	MAP Sensor High
		Bit 5 = MALF CODE 32	EVRV/EGR
		Bit 6 = MALF CODE 31	Wastegate Overboost
		Bit 7 = MALF CODE 25	Manifold Air Temperature Sensor High
5	MALFFLG3	Bit 0 = MALF CODE 55	ADV Error
		Bit 1 = MALF CODE 54	
		Bit 2 = MALF CODE 53	High Battery Voltage
		Bit 3 = MALF CODE 52	
		Bit 4 = MALF CODE 51	PROM Error
		Bit 5 = MALF CODE 45	Oxygen Sensor Rich
		Bit 6 = MALF CODE 44	Oxygen Sensor Lean
		Bit 7 = MALF CODE 43	ESC Failure
6	COOLDEGA	N = ((Degrees C) + 40) * 256/192	
7	COOLTSU	N = ((Degrees C) + 40) * 256/192	
8	ADTHROT	TPS Position in A/D Counts	
9	NTPSLD	N = (Percent Throttle) * 16/6.25	
10	NTRPMX	N = RPM/25	
11	OLDREFPER	N = 65536 * ISIRPM	
12	OLDRFPER+1		
13	FILTMPH	(Integer) N = MPH * 256 (2 Byte Variable)	
14	FILTMPH+1	(Fraction)	
15	ADO2A N =	Volts * 226	
16	ALDLCNTR	N = Counts	
17	CORRCL	N = Value * 128 (Simply a 0 to 2 multiplier)	
18	BLM	N = Value * 128 (Simple a 0 to 2 multiplier)	
19	BLMCELL	N = Cell (0 or 1 only)	
20	INT	N = Units	
22	ISDWNA	N = RPM/12.5	
23	RAWADMAT	Degrees C in A/D Counts	
24	ADBAT	N = Volts * 10	
25	SAP	N = Degrees * 256/90	
26	SAP+1		
27	SAC	N = Degrees * 256/90	
23	AOBARO	N = kPa * 2.71 - 28.06	
29	ADVAC	N = kPa * 2.71 - 28.06	
30	ADMAP	N = kPa * 2.71 - 28.06	
31	TREF	N = Seconds * 80	
32	BPW	N = MSEC * 65.536	
33	BPW+1		
34	DESSPD	N = RPM/12.5	
35	ISDSMP	N = Steps	
36	OLDPA3		
37	OLDPA3+l		
38	NOCKRTD	N = Degrees * 256/45	
39	TIME	N = Seconds	
40	TIME+1		
41	AFCR	N = A/F Ratio * 10	
42	EGRDES	N = Percent (1 to 100 Percent)	
43	EGRDC	N = Percent (1 to 100 Percent)	
44	AIRFLOW	N = Grams/(4 * Second)	
45	BSTPRESS	N = kPa * 1.28	

46	DESBOOST	N = kPa * 1.28	
47	LCKDLY	N = Seconds * 10	
48	APPW	N = MSEC * 65.536	
49	APPW+1		
50	EGRDESA	N = Percent (1 to 100 Percent	
51	DBSTBASE	N = kPa * 1.28	
52	ADESCMON	N = A/D Counts	
53	EGRTITMR	N = Seconds * 40	
54	VE	N = Percent * 2.56	
55	AIRFUEL	N = A/F Ratio * 10	
56	WGATEDC	N = Percent * 2.56	
57	MWl	Bit 0	Advance Flag (0 = Advance, 1 = Retard)
		Bit 1	Vehicle Moving Flag (0 = At Rest)
		Bit 2	Interrupt Service Execution Exceeded 6.25 MSEC
		Bit 3	Premium Fuel Active Flag (1 = Active)
		Bit 4	Road Speed 1st Time Flag (0 = First Time)
		Bit 5	A/C Clutch Flag (1 = Disable)
		Bit 6	1 = Bypass Check Enabled (EST Monitor)
		Bit 7	Engine Running Flag (1 = Running)
58	MW2	Bit 0	Not Used
		Bit 1	Road Speed Filter Exercise Flag
		Bit 2	Reference Pulse Occurred (6.25 MSEC Check)
		Bit 3	Diagnostic Switch In Factory Test Position
		Bit 4	Diagnostic Switch In Diagnostic Position
		Bit 5	Diagnostic Switch In ALDL Position
		Bit 6	High Battery Voltage - Disable Solenoid Discretes
		Bit 7	Old Cell Flag (Air/Fuel)
59	MW3	Bit 0	Loop Timing Flag For Timing Error Logic
		Bit 1	1 = Synch Map Read With 2X REF Pulses Enabled
		Bit 2	1 = 6X Enable Criteria Met Last 6.25 MS Loop
		Bit 3	0 = IAC P/S First Time
		Bit 4	1 = EGR On
		Bit S	1 = A/C Disengaged At High RPM
		Bit 6	1 = REF Pulse Occurred (Used For FILTRPM Logic)
		Bit 7	1 = ESC Active
60	NVMW	Bit 0	02 Sensor Ready Flag, 1 = Ready
		Bit 1	Closed Loop Timer O.K. Flag, 1 = Timer O.K.
		Bit 2	Motor Reset Complete (1 = Yes)
		Bit 3	Improper Shutdown Flag, 0 = Proper, 1 = Improper.
		Bit 4	Extended Throttle Cracker A/C Off Enabled Flag
		Bit 5	IAC Kickdown Enable Flag, 1 = Enabled
		Bit 6	Extended Throttle Cracker A/C On Enabled Flag
		Bit 7	MALF 42 Fail Flag (EST Monitor)
61	FMIDBYTE1	Bit 0	Park/Neutral (1 = Drive)
		Bit 1	Not Used
		Bit 2	Vacuum (0 = Vacuum Present)
		Bit 3	Power Steering (0 = Cramp)
		Bit 4	VS Cooling Fan Discrete (1 = Fan Requested)
		Bit 5	Not Used
		Bit 6	Not Used
		Bit 7	Air Conditioner (1 = A/C Requested)
62	LCCPMW	Bit 0	Fan On
		Bit 1	Check Engine Light Delay Flag
		Bit 2	Power Steering Mode Flag (1 = Active)

		Bit 3	MALF 42A Repeat Flag	
		Bit 4.	ICC MPH HYST BIT	
		Bit 5	1ST Time Hot Flag	
		Bit 6	First Time Fan Run Flag (Used In IGN OFF Logic)	
		Bit 7	Transmission Locked Flag (1 = LOCKJP Enabled)	
			..Or Shift Light Status (1 = On)	
63	MWAF1	Bit 0	Clear Flood Flag (1 = Cranked In Clear Flood Mode)	
		Bit 1	Learn Control Enable Flag (1 = Enable Store, 0 = Disable)	
		Bit 2	Low Battery IAC Inhibit Flag (1 = IAC Inhibited)	
		Bit 3	Not Used	
		Bit 4	Quast - Asynchronous Pulse Flag (QAP Flag)	
		Bit S	First Time CIL Flag	(1 = First Time)
		Bit 6	Rich - Lean Flag (1	= Rich, 0 = Lean)
		Bit 7	Closed Loop Flag (1	= Closed Loop, 0 = Open Loop)

6 PROM ID

6.1 PROM ID

Three (3) calibration PROM bytes are used for the PROM ID. The data in the two bytes is specified by agreement between Delco Electronics and Car Divisions.

6.2 Calibration Summary

Relative Address	Contents
0	PROMIDA (Upper Byte)
1	PROMIDA (Lower Byte)
2	DATECODE (Upper Byte)
3	DATECODE (Lower Byte)
4	SEQNUM8 (Upper Byte)
5	SEQNUMR (Lower Byte)
6	KKSUM Check Sum for socketed Device

The first six values are not included in the Malfunction Code 51 checksum since they are inserted by manufacturing after the Mem/Cal is tested.

7	KKPGMID	Program ID for 1988 2.0L PFI is $58

7 RAM ERROR DETECTION

7.1 Specification

RAM Error Detection and Corrective Action

7.1.1 Non-volatile Memory (NVM)

256 bytes of non-volatile RAM are maintained in the CPU by the standby power supply. Errors can occur within this RAM due to loss of battery voltage to the ECM or due to electrical noise originating within or external to the ECM This software feature provides a means by which loss of the contents of the NVM is detected and appropriate remedial action taken.

7.1.1.1 Memory Loss Detection

Loss of non-volatile memory due to loss of standby voltage to the CPU, NVM is tested by a checksum test on the three diagnostic memory cells (MALFFLG1, MALFFLG2, and MALFFLG3) located in non-volatile RAM. In operation, each time the system software stores information in one of the diagnostic memory locations, a checksum calculation is made on all three diagnostic locations, and the result Plus 1, is stored in the checksum NVM location (DCKSUM). Upon each reset initialization sequence, the same checksum calculation is performed and the result compared with the contents of DCKSUM. If the two differ, it is concluded that an NVM loss has occurred.

7.1.1.2 Memory Loss Remedial Action

Upon detection of a non-volatile memory loss, the ECM software performs the following operations:

1. The three diagnostic bytes are cleared, and the checksum byte is set equal to one.
2. All memory utilized as NVM by the ECM software, except the block learn table and idle air control variables are zeroed.
3. The block learn table and idle air control variables shall be initialized to starting values.
4. Upon detection of the NVM loss, the ECM shall set the NVM fail flag (Bit 6 of CLCCMW) for use by the IM to indicate this condition. This NVM fail flag is reset on any power-up sequence where an NVM alteration is not detected.

7.1.2 RAM Refresh

RAM cells may change state if the cell is not periodically refreshed. To prevent this possibility, the software reads and stores all active RAM at a rate of not less than once each 100 msec.

8 DIAGNOSTICS

8.1 DIAGNOSTIC CONTROL LOGIC

The diagnostic control logic shall monitor the status of enabled malfunction detection algorithms and control the vehicle check engine lamp. A particular malfunction detection algorithm is enabled when its associated mask bit (KKMASK1, KKMASK2, KKMASK3) is set to a logic one. Functionally, the diagnostic control logic can be divided into these basic areas:

1. Control logging of detected malfunctions into nonvolatile memory for later display.
2. Control of check engine lamp to alert the operator to the presence of a malfunction condition.
3. Display of logged malfunctions as an aid in diagnosing vehicle problems.
4. Control of erasing detected malfunctions from nonvolatile memory.
5. Special diagnostic functions provided as an aid to system testing and troubleshooting.

8.1.1 Diagnostic Control Counter

The diagnostic control counter controls the logging and check engine lamp control functions associated with most of the various malfunction detection algorithms. The diagnostic control counter consists of an up/down counter function which may be incremented or decremented on a "real time" basis once per 100 msec. The diagnostic control counter has a range from 0 to 255 counts. The purpose of the diagnostic control counter and its associated control logic is twofold:

1. Prevent a momentarily detected malfunction condition from turning on the check engine lamp and/or being logged in nonvolatile memory.
2. Assure that a legitimately detected malfunction condition will turn on the check engine lamp for minimum period of time.

8.1.2 Diagnostic Control Counter Operation

In general, when the diagnostic control logic recognizes the presence of a detected malfunction, the diagnostic control counter counts for-ward. Conversely, when no malfunctions are being detected, the diagnostic control counter counts backward until it reaches zero.

8.1.2.1 Initialization

After a power-up initialization or system reset, the diagnostic control counter is initialized to zero.

8.1.2.2 Normal Made

8.1.2.2.1 Normal Mode Enable Criteria

When the diagnostic control counter is equal to zero, the diagnostic control logic is in the normal mode. In the normal mode, the diagnostic control logic monitors the status of the enabled malfunction detection algorithms.

8.1.2.2.2 Normal Mode Exit Criteria

When the diagnostic control logic is In the normal mode and any of the enabled malfunction algorithms detects the presence of a malfunction, the diagnostic control logic disables the normal mode. When the normal mode is disabled, the diagnostic control logic recognizes (and remembers) any enabled malfunctions that were present at the time the normal mode was disabled.

8.1.2.3 Malfunction Log Delay

When the normal mode is disabled, the diagnostic control logic enables the malfunction log delay mode. In this mode, the diagnostic counter counts in the forward direction and diagnostic control logic monitors the current status of recognized malfunctions (See 1.2.2.2). The status of all other malfunction algorithms is ignored. If a recognized malfunction ceases to exist; i.e., is no longer detected by its associated detection algorithm, it is removed from the recognized malfunction list.

8.1.2.3.1 Malfunction Log Delay Disable

The malfunction log delay mode shall be disabled by either of the following conditions:

1. No recognized malfunctions exist.
2. The diagnostic control counter reaches a value equal to or greater than KMCNT2.

In Case 1, the diagnostic control logic will:

1. Enable the lamp off reverse counter mode.
2. Set the diagnostic control counter to a value equal to KMCNTl if it exceeds KMCNTl.

In Case 2, the diagnostic control logic will:

1. Log all recognized malfunctions into nonvolatile memory provided the associated mask bit in is set to a logic one.
2. Actuate the check engine lamp.
3. Check the status of the malfunction detection algorithms and recognize any malfunctions that are present.
4. Set the diagnostic control counter to a value equal to calibration memory parameter KMCNT3-1.
5. Enable the lamp on mode.

8.1.2.4 Reverse Counter Mode

The reverse counter mode is entered from the malfunction log delay or the lamp on delay modes when no malfunctions are currently being detected in the system. When the diagnostic control logic is in the lamp off reverse counter mode, the diagnostic control counter counts backward and the control logic monitors the status of the enabled malfunction detection algorithms.

8.1.2.4.1 Reverse Counter Mode Disable

The diagnostic control logic disables the reverse counter mode when either of the two following conditions exist:

1. A malfunction is detected by one of the enabled malfunction detection algorithms.
2. The diagnostic control counter reaches zero.

In Case 1, the diagnostic control logic recognizes the detected malfunction and enters the malfunction log delay mode (See 4.1.2.3) if the check engine lamp is off or the lamp on delay mode (See 4.1.2.5) if the check engine lamp is on. In case 2, the diagnostic control logic enters the normal mode (See 4.1.2.2).

8.1.2.5 Lamp On Mode

When the lamp on mode is enabled, the diagnostic control counter counts forward and the control logic shall monitor the status of recognized malfunctions. The status of all other malfunction detection algorithms is ignored. When a malfunction detection algorithm associated with a recognized malfunction indicates the condition is no longer present, that malfunction is removed from the list of recognized malfunctions.

When the diagnostic control counter reaches a value equal to KMCNT4, the diagnostic control logic shall perform the following operation in the listed order:

1. Log all currently recognized malfunctions into nonvolatile memory provided the associated mask bit (KKMASK1, KKMASK2, or KKMASK3) is set to a logic one.
2. Check the status of the enabled malfunction detection algorithms and recognize any malfunctions currently detected.
3. Set the diagnostic control counter to a value equal to KMCNT3-1 and continue counting the diagnostic control counter forward. The lamp on mode logic continues to cycle in this manner as long as any recognized malfunction remains in the system.

8.1.2.5.1 Lamp On Mode Disable

When the check engine lamp is on and no recognized malfunctions are present in the system, the diagnostic control logic disables the lamp on mode, the diagnostic control counter sets to KMCNT3, and enters the reverse counter mode.

8.1.3 Nonvolatile Memory Clear

The diagnostic control logic shall clear any malfunctions stored in nonvolatile memory under the following circumstances.

8.1.3.1 Nonvolatile Memory Loss

The ECM shall perform a nonvolatile memory loss test (See RAM Error Detection, Section 9) during the power-up initialization to determine if the current data in nonvolatile memory is valid. When a nonvolatile memory loss is indicated, the diagnostic control logic will clear any malfunctions stored in nonvolatile memory.

8.1.3.2 Power Restarts

A startup counter is maintained in nonvolatile memory and is incremented each time the ECM has detected an engine running condition (See EST, Section 7) for a period of 10 seconds. The startup counter is reset to zero when any malfunction is logged into nonvolatile memory.

The diagnostic control logic will clear all malfunctions stored in nonvolatile memory when the startup counter is equal to KKN0MALF.

8.1.4 Diagnostic Request Line

The ECM hardware provides a diagnostic request input by which users can command the various functions in the diagnostic algorithm. The diagnostic request line is configured such that four (4) separate input states are recognized when various values of resistance are connected from the diagnostic request line to system ground. The various states and their nominal resistance values are listed below:

R GE 20K ohm - Normal Mode
R=10K ohm - Assembly Line Diagnostic Mode
R=3.9K ohm - Factory Test Mode

R=0 ohm - Diagnostic Display Mode [Engine Not Running (See EST XDE)]
- Field Service Mode (Engine Running)

8.1.4.1 Normal Mode

When the normal mode is detected the ECM shall operate as described in the various XDE documents.

8.1.4.2 Assembly Line Diagnostic Mode

When the assembly line diagnostic mode is detected the ECM shall modify its operation as follows.

8.1.4.2.1 Closed Loop Timers

When the assembly line diagnostic mode is detected, the fuel logic will bypass the closed loop time criteria. The fuel logic will thus enter the closed loop mode as soon as the coolant temperature and oxygen sensor ready criteria are met (see Fuel, Closed Loop Enable Criteria).

8.1.4.2.2 Integrator Reset Modification

When the assembly line diagnostic mode is enabled, the set of conditions described under Items 5, 6, and 7 (see Fuel XDE, Integrator Reset Mode Enable) shall not result in an integrator reset.

8.1.4.2.3 IAC Modifications

When the assembly line diagnostic mode is enabled, the IAC logic will:

- Use the calibration memory Table F13 value corresponding 0 a battery voltage of 8 volts.
- Bypass certain criteria for RPM closed loop enable (see IAC).
- Trigger an IAC motor reset RPM is greater than 2000 the first time.
- Bypass coolant restrictions (engine warm up time = KICKTM) for enabling IAC kick-down mode.

8.1.4.2.4 EST Test Function

8.1.4.2.4.1 When the assembly line diagnostic mode is enabled the following modifications to the EST system will be made.

1. Disable the Burst Knock logic.
2. Bypass the RPM and coolant temperature criteria for ESC retard enable.

The above actions force the engine into a condition where spark knock should occur if the throttle is suddenly opened (Burst Knock).

8.1.4.2.4.2 Additionally if ALDL mode has been enabled longer than KSAALDLL seconds, the term will be removed from the spark advance calculation.

8.1.4.2.5 TCC Test Function

When the assemble line diagnostic mode is enabled, the following modification to the TCC logic will be made.

1) Bypass coolant temperature criteria to allow TCC to be enabled sooner. The remaining conditions to enable TCC are described in Section 12, ICC.

8.1.4.3 Factory Test Mode

When the factory test mode is detected, the ECM shall turn on the check engine lamp and force the system into the backup fuel mode (see Backup Fuel) by discontinuing the COP 2 signal. The primary purpose of this feature is to enable the backup fuel system to be tested.

8.1.4.4 Diagnostic Display Mode

The diagnostic control logic will display malfunctions stored in nonvolatile memory and perform certain other functions as described below when the diagnostic display mode is enabled. Enabling of this mode requires that the diagnostic request line be grounded and that the engine not be running (see EST).

8.1.4.4.1 Solenoid Energization

When the diagnostic display mode is enabled and the battery voltage is less than 16.9V, the diagnostic control logic will energize the air control, air select, locking converter clutch, exhaust gas re-circulation, A/C and canister purge solenoids. In addition, the idle air control motor will be continuously pulsed to retract while in diagnostic display mode.

The solenoid energization function is capable of operating without a calibration PROM installed in the ECM. The purpose of this function is to allow service personnel a means to force the ECM to energize its outputs for troubleshooting purposes, and to provide a means for exercising the ECM output devices during burn-in at Delco Electronics.

8.1.4.4.2 Malfunction Suppression

While the diagnostic display mode is enabled, the diagnostic control logic will force the diagnostic control counter to zero. This action has the effect of preventing new malfunctions from being logged into nonvolatile memory while the diagnostic display mode is enabled.

8.1.4.4.3 Malfunction Code Display

Each malfunction condition is associated with a two digit code number. When the diagnostic display mode is enabled, the diagnostic control logic wi1l flash the check engine lamp in a logical sequence to depict the two digit code associated with each malfunction stored in nonvolatile memory.

Each code displayed will consist of a number of flashes representing the first digit followed by a short pause, followed by a number of flashes representing the second digit, followed by a long pause indicating the end of the code.

Each stored code is displayed three times before proceeding to the next code. After all malfunction codes stored in nonvolatile memory have been thus displayed, the entire flashing sequence is repeated.

The flash rates for the sequence are as follows:

On Flash	400 msec
Off Flash	400msec
Pause Between Characters	1.2 sec
Pause Between Codes	3.2 sec

8.1.4.4.3.1 Diagnostic Mask Bits

KKMASKl, KKMASK2, and KKMASK3 are provided to enable or disable the logging and display of the various malfunction codes. Each malfunction code has a corresponding bit in one of the three calibration memory parameters. When the bit associated with a particular malfunction code is set to a logic 0, that code will not be displayed by the diagnostic display logic nor logged into nonvolatile memory by the diagnostic control counter logic.

Diagnostic Code Mask

Mask Word	B7	66	65	64	B3	B2	61	60
KKMASK1	12	13	14	15	21	22	23	24
KKMASK2	25	31	32	33	34	35	41	42
KKMASK3	43	44	45	51	52	53	54	55

8.1.4.5 Field Service Mode

The field service mode is enabled when the ECM detects that the diagnostics request line is grounded and the engine is running (see EST). In this mode the following functions will be performed by the ECM.

8.1.4.5.1 Oxygen Sensor Annunciation

When the fuel system is operating in the open lOOD mode (See Fuel). the ECM will flash the check engine lamp at a 2.5 Hz rate. The o? and off time of the flash shall be equal (200 msec each).

When the fuel system is operating in the closed loop mode. the ECM will control the check engine lamp as follows. The ECM shall energize the check engine lamp for one second if the ECM detects a rich oxygen sensor condition at the time the fuel system makes an open loop to closed loop transition. Similarly, the ECM will de-energized the check engine lamp for one second if the ECM detects a lean oxygen sensor condition at the time the fuel system makes an open loop to closed loop transition.

At the end of the first one second period and at one second intervals thereafter, the ECM will toggle the state of the check engine lamp if during the preceding 1 second interval the oxygen sensor has made one or more transitions from rich to lean or lean to rich. If no transitions are detected, a rich condition will result in turning the check engine lamp on and a lean condition turning it off.

When the field service mode is enabled, the various enabled malfunction detection algorithms will continue to operate and apply their associated remedial actions when a malfunction is detected. The diagnostic control logic will not log detected malfunctions into nonvolatile memory while the field service mode is enabled.

8.1.4.5.2 Fixed Spark

When the field service mode is enabled, the EST system will output a constant spark advance with respect to the reference angle as specified by KDIAGADV.

8.1.4.5.3 Closed Loop Timers

When the field service mode is enabled, the fuel logic will bypass the closed loop time criteria. The fuel logic thus enters the closed loop mode as soon as the coolant temperature and oxygen sensor ready criteria are met (see Fuel, Closed Loop Enable Criteria).

8.2 MALFUNCTION DETECTION ALGORITHMS

8.2.1 Code 12 - No Reference Pulses

Malfunction Code 12 is detected when the ECM detects an "engine not running" condition (See EST).

Malfunction Code 12 is handled as a special case by the diagnostic control logic. When Malfunction Code 12 is detected, the check engine lamp is actuated.

Conversely, when Malfunction Code 12 is not detected, the check engine lamp is deactivated, provided the diagnostic control logic does not require it to be on far another condition. Malfunction Code 12 is not stored in nonvolatile memory; however, it will displayed when the condition is present and the system is in the diagnostic display mode.

Malfunction Code 12 logic is performed once every 100 msec.

8.2.2 Code 13 - Oxygen Sensor

The Malfunction Code 13 detection algorithm consists of an up/down control counter with a range from 0 to 255 counts. The Malfunction Code 13 control counter will be incremented at a rate of one count every 100 msec when throttle position is greater than *KKO2LOD*. Conversely, the Malfunction Code 13 control counter will be decremented at a rate of one count every 100 msec when throttle position is less than or equal to *KKO2LOD*. The Malfunction Code 13 control counter is set equal to zero when any of the following conditions exist:

1. The engine running condition has been present for a period of time less than *KKO2MPT1*.
2. Malfunction Code 21 or 22 is currently being detected.
3. The oxygen sensor input voltage (See Fuel) is greater than or equal to parameter *KKO2HIGH*.
4. The oxygen sensor input voltage (See Fuel) is less than or equal to *KKO2LOW*.

Malfunction Code 13 is detected when the value of the Malfunction Code 13 control counter is greater than *KKO2OLTM*. Once Malfunction Code 13 has been detected, it will not be reset unless the oxygen sensor voltage is less than *KKO2LOW*, or greater than *KKO2HIGH*, or if Malf 21 or Malf 22 are detected. When *KKOZOLTM* is set to a value 255 (Hex FF) in the ECM PROM, the associated timer shall have an infinite value.

Malfunction Code 13 logic shall be performed once every 100 msec.

8.2.2.1 Code 13 Enable

If either of Malfunction Codes 21 or 22 are not present, then Malfunction Code 13 will be enabled when MAP exceeds *KKO2MAP* and engine RPM exceeds *KKO2RPM* for longer than *KKO2MPT1* seconds. The Malfunction Code 13 Enable Flag will be cleared if the engine is not running (MWI, bit 7=0).

8.2.2.2 Code 13 Detection

Once Malfunction Code 13 is enabled and the conditions for disable do not exist, then logging of the code is dependent on a timer and the associated conditions to increment or decrement the timer. The timer has an up/down control range of 0 to 255 counts, and is incremented or decremented one count every 100 msec. If the 02 sensor ADU counts go outside a window defined by *KKO2LOW* and *KKO2HIGH* Indicating proper operation of the 02 sensor, then the timer will be forced to zero, and Malfunction Code 13 will not be logged.

However, when the 02 sensor ADU counts remain within the window defined above, and the throttle position is greater than *KKO2LOD*, the timer will be incremented. If all the above conditions are met, hut throttle position drops below *KKO2LOD*, the timer will be decremented. Once the timer exceeds *KKO2OLTM*, then Malfunction Code 13 will be detected and logged. The 02 sensor ADU counter and the up/down timer are set to zero when the engine is not running (MW1, bit 7=0).

8.2.3 Code 14 - High Coolant Temperature

Malfunction Code 14 is detected when the engine running condition (See EST) has been present for a period of time greater than *KKETMPTH* and the coolant temperature sensor reading is greater than calibration memory parameter *KKCTMPHI*. Additionally; when *KKCTMPHI* is set to a value of 255 (Hex FF), the associated timer shall have an infinite value.

The diagnostic control logic will substitute *KKTCDF* in place of the coolant temperature sensor reading when one of the following sets of conditions exists:

Condition 1

A. Malfunction Code 14 is logged into nonvolatile memory.
B. The coolant temperature sensor reading is greater than *KKCTMPHI*.

Condition 2

A. Malfunction Code 14 is being detected (see above). Malfunction Code 14 logic is performed once per 100 msec.

8.2.4 Code 15 - Low Coolant Temperature

Malfunction Code 15 is detected when the engine running condition (See EST) has been present for a period of time greater than *KKETMPTL*, and the coolant temperature sensor reading is less than *KKETMPLO*.

When *KKETMPTL* Is set to a value of 255 (Hex FF) the associated timer will have an infinite value.

The diagnostic control logic will substitute *KKTCDF* in place of the coolant temperature sensor reading when:

1. The coolant temperature sensor reading is less than *KKETMPLO*, and either:
    a. engine run time has exceeded *KKETMPTL*, or
    b. a potential malfunction code 15 has been detected to be present after ignition on but before engine running conditions were met. (See section 2.4.3).

The coolant temperature sensor is considered to have failed open (= low coolant temperature) when ignition is on but before engine running conditions have been met, the coolant temperature sensor reading is less than *KKETMPLO*, malfunction code 23 has not been logged, and the raw A/D manifold air temperature value is less than or equal to *KKETMTLO*.

8.2.5 Code 21 - High Throttle Position

Malfunction Code 21 is detected when all of the following conditions are met:

1. Malfunction Codes 33 or 34 have not been detected.

2. Throttle position sensor reading is greater than *KKTA21*.
3. Engine speed is less than or equal to *KKRMZ1*.
4. Manifold pressure sensor reading is less than *KKPM21*.
5. Conditions I through 4 above have been present for a period of time greater than KKZ1TIM.

Once Malfunction Code 21 has been detected, it will not be reset unless the throttle position sensor reading falls to a value less than or equal to *KKTA21*; or Malfunction codes 33 or 34 have been detected .

When KK21TIM is set to a value of 255 in the ECM PROM (Hex FF), the associated timer will have an infinite value. While Malfunction Code 21 is being detected, the throttle position criterion for DECEL fuel cutoff is bypassed and all system algorithms except diagnostics will substitute a value from F78 table as a function of RPM in place of the current throttle position sensor reading. Malfunction Code 21 logic is performed once per 100 msec.

8.2.6 Code 22 - Low Throttle Position

Malfunction Code 22 logic is enabled when *KKMASK1*, bit 2 is set.

Malfunction Code 22 is detected when the engine is running (see EST) and the throttle position sensor reading is less than *KKTA22*.

While Malfunction Code 22 is being detected, the throttle position) criterion for DECEL fuel cutoff is bypassed and all system algorithms except diagnostics will substitute a value from F78 table as a function of RPM in place of the current throttle position sensor reading.

Malfunction Code 22 logic is performed once per 12.5 msec.

8.2.7 Code 23 - Low Manifold Air Temperature

8.2.7.1 Malfunction Code 23 is detected when the engine running condition (see EST) has been present for a period of time greater than *KKETMPTL*, the manifold air temperature sensor reading is greater than *KKETMPLO*.

When *KKETMPTL* is set to a value of 255 (FF Hex) the associated timer will have an infinite value.

8.2.7.2 The diagnostic control logic will substitute *KKMATDF* in place of the manifold air temperature sensor reading when:

1. The manifold air temperature sensor reading is greater than *KKETMPLO*, and the engine run time has exceeded *KKETMPTL*
2. Coolant temperature is greater than equal to *KKETCH*.

8.2.7.3 The manifold air temperature sensor is considered to have failed open (=low manifold air temperature) when ignition is on but before engine running conditions have been met, the manifold air temperature sensor reading is greater than *KKETMPLO*, malfunction code 15 is not logged, and coolant temperature sensor reading is less than *KKETCTLO*.

8.2.7.4 Malfunction code 23 is flagged under the following conditions:

8.2.7.4.1 Turbo option selected. The turbo option is selected by setting Bit 3 of KAFOPTZF mode word to a logic "1".

8.2.7.4.1.1 Malfunction code 23 will be flagged when the engine running conditions have been met for *KKETMPTL*, line manifold air temperature sensor reading is greater than *KKETMPLO*, and the turbo boost mode has been enabled for a time greater than *KK23BSTM*. If malfunction code 23 has been flagged it will be logged in accordance with conditions specified in section 1.2.3.1. Malfunction code 23 will be continually flagged when all conditions are met to guarantee check engine is latched on.

8.2.7.4.2 Non-turbo Option Selection Malfunction code 23 will be flagged when the engine running condition has been met for *KKETMPTL* and the manifold air temperature sensor reading is greater than *KKETMPLO*.

8.2.8 Code 24 - Vehicle Speed Sensor

Malfunction Code 24 logic is bypassed if coolant temperature is less than *KKDIAGWM*.

Malfunction Code 24 is detected when all of the following conditions are met:

1. Malfunction Codes 21, 22, 33, 34 are not being detected.
2. The vehicle speed sensor indicates a speed less than or equal to *KKVSPD*.
3. The MAP sensor reading is less than *KK24MAP*.
4. The park/neutral switch input indicates the vehicle is not in park/neutral .
5. Throttle is closed.
6. Engine RPM is greater than *KKVRPMLA* and less than or equal to *KKVRPMH*.
7. Conditions 1 through 6 above have been present for a period of time greater than *KKVST*. When *KKVST* is set to a value of 255 (Hex FF) in the ECM PROM, the value of the associated timer will be infinite.

Once Malfunction Code 24 is detected, it will not reset unless the vehicle speed sensor indicates a speed greater than *KKVSPO* or malfunction codes 21, 22, 33 or 34 are detected.

The Malfunction Code 24 logic is executed once every 100 msec.

8.2.9 Code 25 - High Manifold Air Temperature

8.2.9.1 Malfunction Code 25 is detected when the engine running condition (see £ST) has been present for a period of time greater than or equal to *KKETMPTH*, the manifold air temperature value is greater than *KKETMPHI*, and the turbo boost mode is not enabled.

8.2.9.2 When *KKETMPTH* is set to a value of 255 (FF Hex) the associated timer will have an infinite value.

The diagnostic control logic will substitute *KKMATDF* in place of the manifold air temperature sensor reading when one of the following sets of conditions exists.

Condition 1

a. Malfunction Code 25 is logged into nonvolatile memory
b. The manifold air temperature sensor reading is less than *KKETMPHI*.

Condition 2

a. Malfunction Code 25 is currently being detected.
b. Manifold air temperature sensor is less than *KKEMPHI*. The malfunction code 25 logic is performed once every 100 msec.

8.2.10 Code 31. Wastegate Overboost

Malfunction Code 31 is detected when the following conditions exist:

1. Malfunction code 31/33 logic has been enabled (See Paragraph 2.12.2).
2. And either:

   a. Malfunction Code 31 is being detected, or
   b. Malfunction Code 31 is not being detected, Malfunction Code 33 is not being detected, a high manifold air pressure condition has existed for a time equal to *KKM33CNT*, and the manifold air pressure sensor reading is less than or equal to *KK2ATM33*.

The malfunction code 31 logic is performed every 100 msec.

8.2.11 Code 32 - EGR Malfunction

Malfunction Code 32 indicates a failure in the EGR The EGR is tested 6 by shutting off the EGR valve under steady state conditions and checking the increase in integrator rate. since the rate will rise to compensate for the lack of EGR If the rate within the test period exceeds the threshold, the EGR is deemed to have passed the test; otherwise, the EGR is assumed to have failed.

The diagnostic test is run every *KKEGRTIM* seconds. The check engine light is not illuminated until the test has failed *KKEGRDFA* times.

The diagnostic test is enabled under the following conditions:

1. Malfunction 32 not masked out (*KKMASK2*, bit 5=1).
2. Malf 32 timer greater than *KKEGRTIM*.
3. Vacuum load variable greater than *KKEGRLLV* but less than *KKEGRHLV* .
4. Throttle position (TPS) greater than *KKEGRLLT* but less than *KKEGRHLT*.
5. Delta TPS less than or equal to *KKEGRTDL*.
6. Vehicle speed greater than or equal to *KKEGRMPH*.
7. Closed loop operation (MWAF1, bit 7=1).
8. Malf 32 integrator change flag not set (DIAGMW4, bit 6=0).
9. Maximum integrator change less than or equal to *KKINTCH*.
10. Last time's integrator value greater than *KCLITMI* but less than (*KCLITMX-*KK32DL*-10)
11. EGR duty cycle greater than *KKMEGRDC*.
12. M32 timer greater than *KKEGRDLT*.

The Malfunction 32 flag is set under the following conditions:

1. Malf 32 test enabled (DIAGMW4, bit 7=1).
2. Change in integrator value less than *KK32DL*.
3. Malf 32 timer value greater than or equal to *KK32TIME*.
4. Malf 32 failure counter greater than or equal to *KKEGRDFA*.

8.2.12 Code 33 - High Manifold Air Pressure

Malfunction code 33 is detected when one of the following conditions exist:

Condition 1

1. Malfunction Code 31/33 logic has been enabled (see Paragraph 2.12.2).

2. Malfunction Code 31 is not being detected.
3. And either of the two following conditions:
    a. Malfunction Code 33 has already been detected, or
    b. Malfunction Code 33 has not been detected, and the 2-atmosphere MAP sensor reading is still above *KK2ATM33* after a period of time equal to *KKM33CNT*.

Condition 2

1. Malfunction Code 31, 33 logic has not been enabled.
2. Either A or B:

    A.

    1. Manifold Air Pressure failure detected when engine not running.

    B.

    1. Manifold Air Pressure failure not detected when engine not running.
    2. Malfunction Codes 21 or 22 have not been detected.
    3. Manifold Air Pressure is greater than *KKPM33* (A/C is not active) or *KKPMAC33* (A/C is active).
    4. Power Steering load is active.
    5. Throttle position is greater than *KKTA33*.
    6. Condition 1 thru 5 have been present for a time greater than *KK33TIME*.

Malfunction Codes 31/33 are considered enabled when any of the following conditions have been met:

1. The fuel is being delivered synchronously and the two-atmosphere manifold air pressure sensor reading has exceeded either *KWGMAPL* (if the high load fuel shut off mode is enabled) or *KWGMAPH* (if the high load fuel shut off mode is disabled), for a period time greater than *KWGMAPTM*, or
2. Two atmosphere MAP option has been selected, engine running conditions have not been met, engine is being cranked, and the manifold air pressure sensor reading is greater than *KK2ATM33*.

8.2.13 Code 34 - Manifold Pressure Too Low

Malfunction Code 34 is detected when either of the following sets of conditions exist:

Condition 1

1. Malfunction Code 21 is not currently being detected.
2. The manifold absolute pressure sensor is less than *KKPM34*.
3. The engine speed pressure sensor reading is less than *KKES34A* .
4. Conditions 1 through 3 above have been present for a period of time greater than *KK34TIM*.

Condition 2

1. Malfunction Code 21 is not currently being detected.
2. The engine speed is greater than or equal to *KKES34A*
3. The manifold absolute pressure sensor reading is less than*KKPM34*.
4. The throttle position sensor reading is greater than *KKTA34* .
5. Conditions 1 through 4 above have been present for a period of time greater than *KK34TIM*.

Once Malfunction Code 34 has been detected, it will not reset unless the manifold pressure raises to a value equal to or greater than *KKPM34* or if Malfunction Code 21 is present.

When *KK34TIM* is set to a value of 255 (Hex FF), the associated timer will have an infinite valve.

While Malfunction Code 34 is being detected, block learn control will be disabled and all system algorithms except diagnostics will substitute the default value of manifold absolute pressure in place of the manifold pressure sensor reading. In addition, the MAP criteria for DECEL fuel cutoff will be bypassed. The default value of manifold absolute pressure is a function of throttle position plus a value from the F69 table as a function of RPM, when the engine is running. If the engine is not running, manifold pressure will default to *KKPMDF*.

8.2 .14 Code 35 - IAC Error

Malfunction Code 35 is detected when all of the following conditions are met:

1. Coolant temperature is greater than or equal to *KIACWARM*.
2. Malfunction Code 21, 22 or 24 are not being detected.
3. Throttle position is zero.
4. The magnitude of the desired idle speed minus the actual idle speed is greater than *KKIADIAG*.
5. Conditions 1 thru 4 have been present for a period of time greater than *KK35TIME*.

Once Malfunction Code 35 has been detected, it will not be reset until one of the conditions 1 thru 4 above no longer exist. If *KK3STIME* is set to a value of 255, the associated timer will have a infinite value.

8.2.15 Code 42 - EST Monitor

Malfunction Code 42 shall consist of two separate detection algorithms. Malfunction Code 42 is detected when either or both conditions exist.

8.2.15.1 Code 42A

This portion of Malfunction Code 42 is intended to detect an open circuit in the EST wire between the ECM and HEI ignition module. This "Open Line" condition occurs when the EST monitor input indicates the EST signal was toggling while the ECM was commanding the EST bypass mode. The "Open EST Line" condition (code 42A) is detected when either of the following sets of conditions exist:

Condition 1

A. Malfunction code 42 logic is enabled, bit 0 of *KKMASKZ* is set.
B. The major loop of the EST Monitor is not enabled.
C. The minor loop of the EST Monitor is enabled.

Condition 2

A. Malfunction Code 42 logic is enabled.
B. Major Loop of EST Monitor is not enabled.
C. Minor loop of EST Monitor is not enabled.
D. The number of pulses on the EST line caused by electrical noise is greater than *KK42ACT*.

When the "open EST line" condition is detected, the diagnostic control logic will not allow the EST mode to be enabled.

This portion of malfunction code 42 logic is executed once each 12/5 msec until the first reference pulse has been detected, provided the entire code 42A logic has not been disabled by setting *KKMASK2* bit 0 equal to 0.

8.2.15.2 Code 42B

This portion of malfunction code 42 is intended to detail an open or grounded bypass line or a grounded EST line. This condition is detected under the following conditions:

1. Not in ALDL mode, Fuel backup mode or Spark backup mode.
2. Not in Factory test mode.
3. ?QO msec time is enabled.
4. EST Major Loop Monitor is enabled.
5. Not in crank mode.
6. Engine speed greater than *KK42RM*.
7. No pulses received in the EST feedback counter.
8. This is the second consecutive occurrence of items 5, 6, and 7.

When the above conditions are met the EST logic will force the system into the bypass spark mode until the ignition switch is turned off.

Malfunction code 42 logic is executed once every 200 msec.

8.2.16 Code 43 - ESC Failure

Malfunction Code 43 will be detected when the following conditions are met:

Condition 1

1. The Knock A/D counts are greater than or equal to *KKM43ATH* or less than or equal to *KKM43ATL*.
2. M43ATIME is greater than *KK43ATIM*.

Condition 2

1. The Knock AID counts are greater than or equal to *KKM43ATH* or less than or equal to *KKM43ATL*.
2. The ESC input signal has been in the logic low state for a period of time greater than *KKESCP* during 3.9 second clock internal .

Malfunction code 43 logic shall be executed once every 3.9 seconds.

Malfunction Code 43 logic will be disabled when the ESC input signal has been in the logic low state for a period of time less than or equal to *KK£SCP* during 3.9 second clock interval.

8.2.17 Code 44 - Lean Oxygen Sensor

Malfunction Code 44 is detected when either of the following sets of conditions are net:

Condition 1

A. Malfunction Codes 33 or 34 are not present.
B. The filtered oxygen sensor voltage is less than *KKO2MIN*. (See Fuel)
C. Malfunction Codes 44 or 45 are not present.
D. The system is operating is closed loop mode.
E. Closed loop fuel integrator has not been forced to 128.
F. Conditions A thru 0 have been present for a period of time greater than a threshold. The threshold is set to *KK44TIMF* if the closed loop integrator rate from the

F25 table exceeds *KKTNTRAT*. Otherwise, the threshold is set to *KK44TIMS*.

Condition 2

A. Malfunction Codes 33 or 34 are not present.
B. The filtered oxygen sensor voltage is less than *KKO2MIN*, (See Fuel).
C. Malfunction Codes 44 or 45 have already been detected.

Once Malfunction Code 44 has been detected, it will not reset i'nless the filtered sensor voltage becomes greater than or equal to *KKO2MIN*, or unless Malfunction Code 33 or 34 have been detected.

When KK44TIM* is set tp a value of 255 seconds (Hex FF), the associated timer will have an infinite value.

While Malfunction Code 44 is being detected, the diagnostic control logic will force the fuel algorithm to the open loop mode.

Malfunction code 44 logic is executed once every 100 msec.

8.2.18 Code 45 - Rich Oxygen Sensor

Malfunction Code 45 is detected when the following conditions are met:

1. Malfunction codes 33 or 34 are not present.
2. The filtered oxygen sensor AID value is greater than *KKO2MAX* .
3. The system is operating in the closed loop mode.
4. The closed loop integrator has not been forced to 128.
5. Conditions l thru 4 have been present for a period of time greater than *KK45TIM*

Once Malfunction Code 45 has been detected, it will not reset unless the filtered oxygen sensor voltage becomes less than or equal to *KKO2MAX* or malfunction codes 23 or 34 have been detected. When *KK45TIM* is set to a value of 255 (Hex FF), the associated timer will have an infinite value.

While malfunction Code 45 is being detected, the diagnostic control logic will force the fuel algorithm to the open loop mode.

Malfunction Code 45 logic is executed once each 100 msec. Malfunction code 44 logic shall be executed once every 100 msec.

8.2.19 Code 51 - EPROM Calibration Error

Code 51 indicates the ECM is not able to read correct data from the calibration EPROM. Code 51 is indicated if the following conditions are met.

- KKPROMID does not equal 5AA and is not equal to the unique identifier for this ROM program.
- KKPROMID does not equal $AA and is equal to the unique identifier for this ROM program, but the check sum of the contents of the PROM is incorrect.

During calibration development, KKPGMID can be set to $AA to bypass the initialization checksum. For production, it is set to 349 which is a unique identifier for this ROM program.

8.2.19.1 Code 51 Remedial Action

If the checksum or PROM correctness check fail the software will stay in a loop until a cop reset occurs thereby recalculating the checksum.

If the running PROM integrity check fails the following action is taken:

- Force engine not running
- Force EST bypass mode
- Force backup fuel by inhibiting COP2 signal
- Activate check engine lamp if not in diagnostic display mode
- Suspend all malfunction timers (no new MALF codes can be stored)

8.2.19.2 Code 41 Logging Criteria

Code 51 is logged in nonvolatile memory immediately upon a checksum failure or PROM correctness failure Code 51 will also be logged if the running PROM integrity check failure is present for 200 msec.

8.2. 20 Code 52 - Calpak Missing

Malfunction Code 52 is detected by sensing the logic state of P6 of ???. This pin (IC pin 30) is connected to R 15 of the resistor calpak. The resistor value is chosen such that when the resistor calpak is present a logic 1 is forced onto P6 of MCU1. If the resistor calpak is missing a logic 0 is on P6 of MCU1.

If malfunction code 52 logic detects a logic Q state on P6 of MCU1, code 52 is detected.

8.2.21 Code 52 - High Battery Voltage

Malfunction Code 52 is detected when the battery voltage exceeds 16.9V for a period of time greater than KK52TIM.

8.2.22 Code 55 - A/D Error

Malfunction Code 55 indicates the A/D conversion time exceeds a reasonable time limit of 325 microseconds.

9 FUEL CONTROL

9.1 BASE PULSE WIDTH CALCULATION

The base pulse width calculation for fuel delivery is shown below:

BPW = BPC * MAPP * T' * A/F' * VE * F33C * BLM * DFCO * DE * CLT * F77

Where:

BPW	=	Base Pulse Width
BPC	=	Base Pulse Constant Term
MAPP	=	Manifold Pressure Term
T'	=	Inverse Temperature Term
A/F'	=	Inverse Air Fuel Ratio Term
VE	=	Volumetric Efficiency Term
F33C	=	Battery Voltage Correction Term
BLM	=	Block Learn Correction Term
DFCO	=	Decel Fuel Cutoff Term
DE	=	Decel Enleanment Term
CLT	=	Closed Loop Correction Term
F77	=	Turbo Boost Multiplier

In the paragraphs to follow, each of the terms of the base pulse width calculation are described.

9.1.1 Base Pulse Constant (BPC)

The base pulse constant term serves a dual purpose. Its primary function is to provide the system the means of accounting for the displacement of the engine and the injector flow rate. The secondary function is to compensate fuel delivery for EGR

The base pulse constant is calculated as follows; based on whether or not EGR is active.

9.1.1.1 EGR not Desired (EGR OFF)

BPC = *F28A* (Desired EGR = 0%)

9.1.1.2 EGR Desired (EGR ON)

An EGR "tip-in" mode will be used to make the transition between EGR OFF and EGR ON.

9.1.1.2.1 EGR "Tip-In" Mode Enable

The "tip-in" mode will be enabled when the throttle position rate of change (increasing throttle) exceeds *KEGRTIND* percent per 25 mSec.

After being enabled, the "tip-in" function will become active immediately when the throttle position rate of change drops below *KEGRTIND* percent per 25 mSec.

9.1.1.2.2 EGR "Tip-In" Mode Function

After being enabled, the "tip-in" function will become active immediately when the throttle position rate of change drops below *KEGRTIND* percent per 25 mSec.

When EGR "tip-in" mode is active, the base pulse constant is calculated as BPC = *F28* (filtered desired EGR duty cycle) This value of base pulse constant is used until EGR 'tip-in" mode is reentered or EGR is disabled (EGR OFF).

9.1.1.2.2.1 Filtered Desired EGR (Duty Cycle)

The filtered desired EGR (duty cycle) is generated using a first-order software filtering technique (see General Information). The filtering coefficient is *KFILEGRD*. The filtering period is 25 mSec.

9.1.2 Pressure Term (MAP)

The pressure term shall be derived from the filtered value of the manifold absolute pressure transducer input (ADMAP). See General Information section 2.

9.1.2.1 Two-Atmosphere MAP Multiplier

The use of a two-atmosphere manifold absolute pressure (MAP) sensor is selected as follows:

KAFOPT3	b5=0.	Single atmosphere MAP sensor
KAFOPT3	b5=1	Two-atmosphere MAP sensor

When the two-atmosphere MAP sensor is selected, the base pulse width is multiplied by a factor of two.

9.1.3 Temperature Term

In the speed density equation, the temperature term appears as a divisor. For purposes of software expediency, the temperature term is implemented by multiplying by a term equal to the inverse of temperature.

The inverse temperature term used in the BPW calculation is determined in the following manner:

KAFOPT2, b5 = I Inverse Temperature = table lookup *F31M* (Inverse Manifold Air Temperature)
KAFOPT2, b5 = 0 Inverse temperature = table lookup *F31C* (Inverse Coolant Temperature)

Both *F31* table values should be selected such that the respective inverse temperature value is equal to 50,000/Degrees, Kelvin.

9.1.4 Air Fuel Ratio Term (A/F)

The air fuel ratio term is adjusted under various conditions to meet the requirements of the engine for emissions and drivability. The following paragraphs describe the algorithms that control the value of the air fuel ratio term.

9.1.4.1 Crank Air Fuel Ratio

When the crank air fuel ratio is enabled on the air fuel ratio is set to a value obtained from Table *F54* as a function of coolant temperature minus the value of the time-out crank air fuel term as determined below.

9.1.4.1.1 Crank Air Fuel Ratio Enable

The crank air fuel ratio is applied when the ignition is ON, the run fuel mode is not enabled and the throttle position is less than *KAFCFTA*.

9.1.4.1.2 Crank-to-Run Air Fuel Blend

The crank-to-run air fuel blend logic provides the means to smoothly ramp from the richer crank air fuel mixture to the leaner run air fuel mixture. The crank-to-run air fuel blend logic utilizes an initial value and "target" final value.

Crank-to-Run Air Fuel Blend Initial Value

The initial value is determined at the transition between the crank fuel and run fuel modes. The value of the air fuel crank-to-run term is calculated as follows:

AFTICRT = AIRFUEL = AFCRDLTA

where: AFTICRT = Crank-to-run air fuel time-out term
AIRFUEL = Air-fuel ratio at the time run fuel mode is enabled
AFCRDLTA = *F54* (Coolant) - *KCAFTI*

9.1.4.1.3 Crank-to-Run Air Fuel Blend Decay Function

The blending of the air fuel ratio between crank air-fuel ratio to run air-fuel ratio Is accomplished by decaying the crank-to-run air fuel term from the following equation for air-fuel ratio.

AIRFUEL = AIRFUEL - AFTICRT

where: AIRFUEL = Air fuel ratio
AFTICRT = Crank-to-run air fuel time-out term

The time-out term is decayed as follows:

AFTICRT = AFTICRT * (*KRAFTDM*)

where: *KRAFTDM* = Crank air-fuel to run air-fuel decay multiplier

The time-out term is decayed at a rate determined by the *F64* table as a function of coolant temperature.

9.1.4.2 Clear Flood Air Fuel Ratio

9.1.4.2.1 Clear Flood Air Fuel Ratio Enable

The clear flood air fuel ratio enable is applied when the ignition is ON and either of the following sets of conditions are true.

Condition #1

1. Not in Run Fuel Mode.
2. Throttle position greater than or equal to *KAFCFTA*.

Condition #2

1. In Run Fuel Mode.
2. Engine not running.
3. Throttle position greater than or equal to *KAFCFTA*.

9.1.4.2.2 Clear Flood Air Fuel Ratio Function

When the clear flood air fuel ratio is enabled, the air fuel ratio is set to *KAFCF*.

9.1.4.3 Cold Engine Air Fuel Ratio

9.1.4.3.1 Cold Engine Air Fuel Ratio Enable

The cold engine air fuel ratio mode is enabled when all of the following are met:

1. Coolant temperature is less than or equal to *KAFTCTH*.

9.1.4.3.2 Cold Engine Air Fuel Ratio Function

The cold engine A/F ratio used depends on the TPS position. For closed throttle (CLCCMW, bit 7=1) the air fuel ratio is given by the *F57* table as a function of coolant temperature. For throttle not closed (CLCCMW, bit 7=0) the air fuel ratio is given by the *F56* table as a function of coolant temperature and manifold pressure.

9.1.4.3.3 Cold Engine Air Fuel Ratio Limit

A limit is placed on the cold engine air fuel ratio to improve idle quality.

9.1.4.3.3.1 Cold Engine Air Fuel Ratio Limit Enable

The cold engine air fuel ratio limit is enabled under the following set of conditions.

1. Cold engine air fuel ratio enabled.
2. Air fuel ratio is greater than 14.6:1.
3. Throttle is closed.
4. Vehicle speed is less than *KSTOKPH*.

9.1.4.3.3.2 Cold Engine Air Fuel Ratio Function

The cold engine air duel ratio is determined by one of two methods, selected by a combination of throttle position (OPEN or CLOSED) and vehicle speed.

Condition 1

1. Open throttle, or open throttle and vehicle speed greater than or equal to *KVSIDLE*.

   Under this condition, cold engine air fuel ratio is derived from the *56* table, as a function of engine coolant temperature and manifold absolute pressure. A single atmosphere MAP reading or two-atmosphere MAP reading is used depending on the option selected.

Condition 2

1. Open throttle, and vehicle speed less than *KVSIDLE*. Under this condition, Cold engine air fuel ratio is derived from the *57* table, as a function of engine coolant temperature only.

9.1.4.3.3.3 Cold Engine Air Fuel Ratio Limit (Lean Clamp)

A limit is placed on the cold engine air fuel ratio.

9.1.4.3.3.4 Lean Clamp Enable

Immediately following determination of the cold engine air fuel ratio (see section 1.4.3.2), the cold engine air fuel ratio will be clamped. if the following conditions are met:

1. Cold engine air fuel ratio greater than *KMAXLEAN*, and start-up coolant temperature is less than *KAFTCLOW* or greater than or equal to *KAFTCHI*.

9.1.4.4 Warm Engine Air Fuel Ratio

9.1.4.4.1 Warm Engine Air Fuel Ratio Enable

The warm engine air fuel ratio is enabled when the following condition is met.

1. Engine coolant temperature greater than *KAFTCTH*.

9.1.4.4.3 Warm Engine Air Fuel Ratio Function

When the warm engine air fuel ratio is enabled, the air fuel ratio is set to *KAFSTCN*.

9.1.4.5 Time-out Run Air Fuel Ratio

The purpose of the time-cut run air fuel ratio function is to simulate the choke action of a conventional carburetor.

The time-out run air fuel ratio function is composed of two parts: the initial value and a decay rate. The following paragraphs describe the various aspects of time-out run air fuel ratio in detail.

9.1.4.5.1 Time-out Run Air Fuel Ratio Initialization

The time-out rtin air fuel ratio function is initialized when a legitimate shutdown sequence is detected prior to the last ECM reset and the system makes an engine not running to engine running transition. The time-out run air fuel ratio initialization consists of calculating new values of initial value and decay rate.

When the ECM does not detect a legitimate shutdown sequence prior to the last ECM reset, the time-out run air fuel logic calculates the value of the decay rate only. The previous value of time-out run air fuel ratio that existed at the time of the ECM reset is retained.

9.1.4.5.2 Time-out Run Air Fuel Ratio Initial Value

The time-out run air fuel ratio initial value is obtained from Table *F51* as function of coolant temperature.

9.1.4.5.3 Time-out Run Air Fuel Ratio Function

The ECM subtracts the time-cut run air fuel ratio term from the value of air fuel ratio as determined by the cold engine or warm engine logic. The value of the time-out run air fuel ratio begins as the initial value. The decay function then proceeds until the value of the time-out run air fuel ratio is reduced to zero.

9.1.4.5.4 Time-out Run Air Fuel Ratio Decay

The time-out run air fuel ratio decay rate is made up of two terms: the decay scale factor and the computation rate.

Engine running conditions must be met before air fuel ratio time out decay can begin.

9.1.4.5.4.1 Time-out Run Air Fuel Ratio Decay Calculation

The time-out run air fuel ratio decay function is accomplished by performing the calculation:

$$AFTI_N = AFTI_{N-l} * (*KAFDM*)$$

where: $AFTI_N$ = Value of the time-out run air fuel ratio term on this computation

$AFTI_{N-l}$ = Value of the time-air fuel ratio on the last computation
KAFDM = time-out run air fuel ratio decay scale factor (calibration value)

9.1.4.5.4.2 Time-out Run Air Fuel Ratio Decay Computation Rate

The time-out run air fuel ratio decay computation rate is obtained from the *F52* table as a function of coolant temperature.

9.1.4.6 Time-out Crank Air Fuel Ratio

The purpose of the time-out crank air fuel ratio function is to enrich the crank air fuel ratio during the early part of cranking. The clear flood mode will disable this function.

The time-cut crank air fuel ratio function is composed of two parts: the initial value and a decay rate. The following paragraphs describe the various aspects of time-out crank air fuel ratio in detail.

9.1.4.6.1 Time-out Crank Air Fuel Ratio Initialization

The time-out crank air fuel ratio function is initialized after a system reset, or the system makes an engine not cranking to engine cranking transition. The time-out crank air fuel ratio initialization consists of calculating new values of initial value and decay rate.

9.1.4.6.2 Time-out Crank Air Fuel Ratio Initial Value

The time-out crank air fuel ratio initial value is set to *KCAFTI*

9.1.4.6.3 Time-out Crank Air Fuel Ratio Function

The ECM subtracts the time-out crank air fuel ratio tern from the value of air fuel ratio when the ECM is not in the Run Fuel Mode and throttle position is less than *KAFCFTA*. The value of the time-out crank air fuel ratio begins as the initial value. The decay function then proceeds until the value of the time-out crank air fuel ratio is reduced to zero.

The time-out crank air fuel ratio is computed once each major loop or optionally at once per 2x reference pulse

KAFOPT1, b3 = 0   2x reference pulse air/fuel time-out
KAFOPTI, b3 = 1   Exponential crank air/fuel time-out

9.1.4.6.4 Time-out Crank Air Fuel Ratio Decay

The time-out crank air fuel ratio decay rate is made up of two terms: the decay scale factor and the computation rate.

9.1.4.6.4.1 Time-out Crank Air Fuel Ratio Decay Calculation

The time-out crank air fuel ratio dec3y function is accomplished by performing the calculation:

$$CAFTI_N = CAFTI_{N-l} * (*KCAFDM*)$$

where: $CAFTI_N$ = Value of the time-out crank air fuel ratio term on this computation
$CAFTI_{N-l}$ = Value of the time-out crank air fuel ratio term during previous
KCAFDM = Crank air fuel time out decay multiplier

9.1.4.6.4.2 Time-out Crank Air Fuel Ratio Decay Computation Rate

The time-out crank air fuel ratio decay computation rate is equal to *KCFTMl*. *KCFTM1* seconds must occur between each successive decay. When the computation rate is based on 2x reference pulses it is equal to *KCFTM2*. *KCFTM2* reference pulses must occur between each successive decay. (See Section 1.4.6.3)

9.1.4.7 Power Enrichment Air Fuel Ratio

The power enrichment function modifies the system air fuel ratio as a function of RPM and BARO to allow a "best torque" under a heavy engine load condition.

9.1.4.7.1 Power Enrichment Enable

Power enrichment is enabled when in the Run Fuel Mode, the engine is running in the EST mode and one of the following sets of conditions are met.

Condition #1

1. Manifold Absolute Pressure (MAP) exceeds *KPEMAPl*.

The MAP variable used depends on the engine application and sensor installed.

KAFOPT3, b5 = 0 Single atmosphere MAP sensor.
KAFOPT3, b5 = 1 Two-atmosphere MAP sensor.

Condition #2

1. Manifold Absolute Pressure (MAP) less than or equal to *KPEMAPl*, EST enabled, throttle position greater than or equal to *KPETPS*, and any of the following additional conditions:
   - Engine speed greater than or equal to *KPERPM*, or
   - Rate of change of throttle position (over 25 mSec) greater than or equal to a value from the *F63* table as a function of barometric pressure), or
   - Throttle position greater than *KPEATPS*.

Condition #3

Manifold Absolute Pressure (MAP) less than or equal to *KPEMAPi*, EST enabled, throttle position less than *KPETPS*, and any of the following additional conditions:

a. Manifold Absolute Pressure (MAP, selected according to the installed sensor, as defined above) greater than or equal to *KPEMAP2*, and engine coolant temperature greater than or equal to *KPETCTH*, or
b. Manifold Absolute Pressure (MAP, selected according to the installed sensor, as defined above) greater than or equal to *KPEMAP2*, engine coolant temperature less than *KPEMAP3*, filtered vehicle speed (MPH) less than *KPEMPH*, and engine speed greater than or equal to *KPERPM*, or
c. Manifold Absolute Pressure (MAP, selected according to the installed sensor, as defined above) greater than or equal to *KPEMAP2*, engine coolant temperature less than *KPETCTH*, MAP greater than or equal to *KPEMAP3*, filtered vehicle speed (MPH) greater than or equal to *KPEMPH*, and engine speed greater than or equal to *KPERPM1*.

Condition #4 **-** Forced Power Enrichment Mode.

Satisfying the criteria of this Condition will force power enrichment in the event that EST is disabled due to Malfunction Code 42 or operation in backup spark mode.

1. manifold Absolute Pressure (MAP, selected according to the installed sensor, as defined above) less than or equal to *KPEMAP1*, and,
2. EST disabled, and

3. MAP greater than *KPEMAP4Z*, and
4. Engine speed greater than *KPERPM4Z*

9.1.4.7.2 Power Enrichment Disable

The Power Enrichment mode will be disabled when the throttle position drops below *KPETPS* - *KTPSHYS*, and any of the following conditions are met:

1. Manifold Absolute Pressure (MAP, selected according to the installed sensor, as defined above) drops below *KPEMAP2*, or
2. Engine coolant temperature is greater than or equal to *KpETCTH*, and engine RPM drops below *KPERPM*, or
3. Engine coolant temperature is less than (*KPETCTH* -2'C) and manifold Absolute Pressure (MAP, selected according to the installed sensor, as defined above) drops below *KPEMAP3*, or
4. Engine coolant temperature is less than (*KPETCTH* -2'C) and Manifold absolute pressure (MAP, selected according to the installed sensor, as defined above) is greater than or equal to *KPEMAP3*, vehicle speed is greater than or equal to *KPEMPH*, and engine RPM drops below *KPERPM1*.

9.1.4.7.3 Power Enrichment Mode Function

When power enrichment is enabled, the air fuel ratio is set equal to a power enrichment air fuel ratio, which is derived from the *F61* table, as a function of engine RPM.

If vehicle speed exceeds *KPEHMPH*, and turbocharger boost mode is active, (Manifold Absolute Pressure, MAP, is greater than or equal to *KPEMAP4* (=IOOKPA)) for at least *KPEMPHTM* seconds, then the power enrichment air/fuel ratio will be reduced (air/fuel mixture made richer) by an amount *KPEAFDLT*.

The power enrichment air/fuel will continue to be reduced by *KPEAFDLT* as long as vehicle speed exceeds *KPEHMPH*. Once the reduction in air/fuel ratio is enabled, it will remain enabled until vehicle speed becomes less than or equal to *KPEHMPH*.

9.1.4.7.4 Power Enrichment Air Fuel Ratio Limit.

The final air fuel ratio calculated for power enrichment is compared against the current air fuel ratio. The richer of the two air fuel ratios is used.

This comparison is performed every 25 mSec when power enrichment is enabled.

9.1.4.8 Inverse Air Fuel Ratio (A/F')

In the speed density equation, the air fuel ratio term appears as a divisor. For purposes of software expediency the inverse air fuel ratio term is implemented by multiplying by the inverse of air fuel ratio (A/F'). The inverse air fuel ratio is derived from air fuel ratio by means of lookup Table *F32*.

9.1.5 Volumetric Efficiency Term (VE)

The volumetric efficiency term in the base pulse width equation is used to account for flow losses and other induction system characteristics that cause the amount of air ingested per cylinder to be less than expected under ideal (no flow loss) conditions.

The value of volumetric efficiency is calculated as the sum of two individual volumetric efficiency terms, VEl and VE2.

VE = VE1 + VEZ

9.1.5.1 VE1 Term

The value of the VE1 term is calculated under three conditions, based on throttle position, engine speed, and vehicle speed.

Condition 1

The VE1 term will derived from the *F29C* table (as a function of MAP and engine RPM (NTRPMX)) when:

- throttle is not closed, or
- throttle closed and engine RPM greater than 1600 RPM

Condition 2

The VE1 term will be derived from the *F29S* table (as a function of MAP and engine RPM (NTRPMX)) when:

- throttle is closed, engine RPM is less than or equal to 1600 RPM, and vehicle speed is greater than *KVSIDLE*.

Condition 3

The VE1 term will be derived from the *F29S* table (as a function of MAP and engine RPM (filtered over 12.5 mSec)) when:

- throttle is closed, engine RPM is less than or equal to 1600 RPM, and vehicle speed is less than or equal to *KVSIDLE*.

9.1.5.2 VE2 Term

The value of the VE2 term is derived from the *F30* table as a function of engine RPM.

9.1.6 Battery Voltage Correction

The purpose of the battery voltage correction term is to compensate for the variation of the fuel pump with battery voltage.

The battery voltage correction term is a multiplicative factor to the base pulse width term.

The fuel logic derives the battery voltage correction term from Table *F33* as a function of battery voltage.

9.1.7 Closed Loop Correction (CLT)

The closed loop correction term provides the means for the system to maintain the air fuel ratio at stoichiometry. This is accomplished by monitoring the oxygen content of the exhaust with a zirconia oxygen sensor and making adjustments to the closed loop correction term based on the oxygen sensor input. The following paragraphs describe the algorithm that is used to calculate the closed loop correction.

9.1.7.1 Closed Loop Mode Enable

The closed loop mode is enabled when the following criteria are met:

- The ECM detects the oxygen sensor ready conditions. (1.7.1.1)
- The coolant temperature criteria are met. (1.7.1.2)
- The engine run time criteria are met. (1.7.1.3)
- Malfunction Code 44 or 45 is not present. (See DIagnostics)
- HUD BPW Slew is not active. (1.7.1.4)

9.1.7.1.1 Oxygen Sensor Ready Test

The ECM supplies a bias voltage of approximately 450 mV through an impedance of 1MOhm to the oxygen sensor input terminals. When the oxygen sensor is cold, its internal impedance is extremely high. In this situation the voltage seen by the ECM is the bias voltage.

As the oxygen sensor warms, its internal resistance drops enabling it to overcome the bias voltage. The ECM determines the "oxygen sensor ready" state by monitoring the voltage from the oxygen sensor.

9.1.7.1.1.1 Oxygen Sensor Ready Criteria

The fuel control logic indicates an oxygen sensor ready *KO2AMAX* condition when the oxygen sensor Input voltage is greater than or less than *KO2AMIN*. Once the oxygen sensor ready condition is indicated, it will remain in effect until the "not ready" criteria are met or a legitimate shutdown sequence is detected.

9.1.7.1.1.2 Oxygen Sensor Not Ready Criteria

The oxygen sensor not ready state is indicated if the oxygen sensor input voltage does not exceed *KO2AMAX* or is not less than *K02AMIN* for a period of time greater than *KO2ATIME*.

Once the oxygen sensor not ready condition is indicated, it will remain in effect until the oxygen sensor ready criteria are met.

If *KO2ATIME* is set equal to zero, closed loop operation will not occur.

9.1.7.1.1.3 Ready Test Initialization

If a legitimate shutdown sequence was detected prior to the last ECM reset, the fuel logic will initialize the oxygen sensor to the not ready state during the initialization sequence.

If a legitimate shutdown sequence was not detected prior to the last ECM reset, the fuel logic retains the oxygen sensor status that existed prior to the reset. The timers associated with the not ready test are set to zero.

9.1.7.1.2 Closed Loop Temperature Criterion

The coolant temperature criterion for closed loop operation is met when the coolant temperature is greater than *KCLTC*.

9.1.7.1.3 Time Criterion

The engine run time criterion for closed loop operation is met when one of the following conditions exist:

- Coolant temperature at the time of the last engine not running to running transition (See EST Logic) is less than or equal to *KADSUCT* and the engine run time since the last legitimate shutdown sequence is greater than or equal to *KT2A*.

OR

- The coolant temperature at the time of the last engine not running to engine running transition is greater than *KADSUCT* and the engine run time since the last legitimate shutdown sequence is greater than or equal to *KT1A*.

The user is reminded that in an engine stall and subsequent restart situation (ignition switch not turned off), the legitimate shutdown sequence is not detected. Additionally, in an ECM reset and subsequent re-initialization sequence, the system is initialized to the engine not running state.

Both of these situations result in an engine not running to engine running transition, which will cause the fuel logic to reevaluate the engine run time requirement for closed loop operation provided it has not already expired.

Once the engine run time criteria for closed loop is met, it will remain in effect until the ECM detects a legitimate shutdown sequence.

9.1.7.1.4 HUD BPW SLEW Mode

If the HUD BPW SLEW is active, open loop operation is forced. If HUD BPW SLEW is not active or EGROC option has been selected closed loop will be enabled.

9.1.7.2 Closed Loop Correction

The closed loop correction term is derived by monitoring the value of the oxygen sensor input voltage. When the oxygen sensor indicates 3 lean air fuel ratio, the closed loop correction term is adjusted to cause a rich mixture. Conversely, when a rich air fuel ratio is indicated, the closed loop correction term is adjusted to cause a leaner mixture.

The closed loop correction term is calculated as the sum of three terms:

CORRCL = INT±CLPROP-l28
where: CORRCL = closed loop correction term
INT = integrator term
±CLPROP = proportional closed loop term

CLPROP is (+) if oxygen sensor indicates lean CLPROP is (-) if oxygen sensor indicates rich Each term is described below, along with the algorithm that controls this function.

9.1.7.2.1 Oxygen Sensor Rich/Lean Determination -

When the oxygen sensor input voltage is greater than *KCLOXTH*, a rich air fuel ratio is indicated. Conversely, if the oxygen sensor input voltage is less than or equal to *KCLOXTH*, a lean air fuel ratio is indicated.

The oxygen sensor rich/lean determination logic is performed once every 25 msec.

9.1.7.2.2 Closed Loop Correction Term

The closed loop correction term consists of the sum of two parts, these being the integral and proportional terms.

9.1.7.2.2.1 Integral Term

The operational sequence of the integrator function is as follows:

1. When the system detects an oxygen sensor transition, the fuel logic calculates a transport delay time based on engine speed (first time transition mode). The integrator does not update until this delay time is expired.
2. If the transport delay time expires without an intervening oxygen sensor transition, the integrator is updated and a new value of integrator delay is calculated based on engine speed (not first time transition mode).
3. If the new value of integrator delay expires without an oxygen sensor transition, the integrator is updated again.
4. Step 3 is repeated until an oxygen sensor transition is detected.

The above sequence continues as long as the system is operating in closed loop and the integrator reset mode is not enabled. The following paragraphs describe the various aspects of the integrator and integrator delay function in detail.

9.1.7.2.2.1.1 Transport Delay Time Calculation

The transport delay time is calculated as the sum of two terms.

MAP term - the MAP contribution to transport delay time is obtained from the *F23* table, as a function of MSP (Manifold Absolute Pressure).

RPM term - the RPM contribution to transport delay time is obtained from the *F24* table, as a function of engine speed.

The value of transport delay time is limited to a value less than or equal 6.375 seconds will result in the integrator never being updated.

9.1.7.2.2.1.2 Integrator Reset Mode Enable

The integrator reset mode is enabled when any of the following conditions are present. If none of the conditions are present, the integrator reset mode is disabled.

1. The closed loop mode is not enable (that is, system is operating in open loop fuel mode).
2. Low engine RPM reset mode enabled. The integrator will be reset when
    - engine coolant temperature greater than *KINTTCTH*.
    - filtered engine RPM drops below the desired idle speed (without air conditioning) plus *KRPMOFFL*.

    The low engine RPM reset mode will remain enabled until engine RPM increases above the desired idle speed (without air conditioning) plus *KRPMOFFH*.

3. The deceleration fuel cutoff mode is enabled.
4. First time transition has occurred (see section 1.7.2.2.1.3).
5. Power enrichment mode is enabled and the integrator is less than or equal to 1.0.
6. ALDL Fuel closed loop mode is enabled, but system is not in closed loop.
7. The integrator is greater than or equal to 1.0, the oxygen sensor indicates lean, and one of the following conditions is met:
    - Not closed throttle
    - Closed throttle, vehicle speed greater than or equal to *KVSIDLE*.

When the integrator reset mode is enabled, the following action is taken:

1. The integrator is set to 1.0.
2. The integrator delay counter is set to 0.
3. The proportional correction term is set to 0.
4. The oxygen sensor variable used for the integrator slow trim logic is set to *KCLOXTH*.

9.1.7.2.2.1.3 First Time Transition Mode

The first time transition mode is enabled when the oxygen sensor makes a rich to lean transition or a lean to rich transition.

When the first time transition mode is enabled, the value of the integrator delay time is set equal to the transport delay time.

9.1.7.2.2.1.4 Not First Time Transition Mode

If the oxygen sensor has not detected a transition (rich/lean or lean/rich), the integrator delay time is derived as follows:

If engine coolant temperature is greater than or equal to *KINTDLTC*

Or

if engine coolant temperature is less than *KINTDLTC*, and open throttle, then integrator delay is derived from the *F25* table (as a function of engine speed).

Or

if engine coolant temperature is less than *KINTDLTC* and closed throttle, then integrator delay is sum of a value from the *F25* table (as a function of engine speed) and *KINTDLTA*.

9.1.7.2.2.1.5 Integrator Update Criteria

The integrator update calculation is performed when the integrator delay counter equals the integrator delay time. The integrator delay counter is reset when this condition is met.

9.1.7.2.2.1.6 Integrator Update Calculation

The integrator update calculation is performed as illustrated below:

$$INT_N = INT_{N-l} + STEP$$

where: INT_N = Value of integrator for this calculation
INT_{N-l} = Previous value of the integrator
STEP = + 1/128 for a lean condition
- 1/128 for a rich condition

9.1.7.2.2.1.7 Integrator Limits

When the oxygen sensor is indicating rich, the value of the integrator term is limited to a value greater than or equal to *KCLITMI*. When the oxygen sensor is indicating lean, the value of the integrator term is limited to a value less than or equal to *KCLITMX*

9.1.7.2.2.1.8 Integrator Slow Trim

The integrator slow trim function is enabled when the integrator reset mode is not enabled.

The slow trim logic updates the integrator at one of two different gain rates, based on the state of the throttle (open or closed).

(a) For closed throttle conditions, the following actions take place.

When the filtered value of oxygen sensor input voltage is greater than *KO2FILHC*, the integrator is decremented by 1/128. When the filtered value of oxygen sensor input voltage is less than *KO2FILLC* the integrator is incremented by 1/128.

(b) For open throttle conditions, the following actions take place.

When the filtered value of oxygen sensor input voltage is greater than a value defined by the *F67* table, as a function of MAP, the integrator is decremented by an amount determined by 1/128. When the filtered value of oxygen sensor input voltage is less than a value defined by the

F68 table, as a function of MAP, the integrator is incremented by an amount determined by 1/128.

The value of the filtered oxygen sensor is set to *KCLOXTh* when the integrator reset mode is enabled.

Slow trim logic is executed at a frequency defined by *KCNTRC* if throttle is closed, or by *KCNTRO* if throttle is open.

The integrator is limited to a maximum value of *KCCITMX* and a minimum value of *KCLITMI*.

9.1.7.2.2.2 Proportional Term

The proportional term is the second of the two terms that comprise the closed loop correction term. When the oxygen sensor is indicating rich, the proportional term is negative. Conversely, when the oxygen sensor is indicating lean, the proportional term is positive. The sum of the integrator and proportional terms form the closed loop correction term.

The proportional term is determined by the conditions listed below:

Prop Term = *KCLPROP* if the manifold vacuum is less than *KPROPVAC*.

- *KPWOEGR* if the manifold vacuum is not less than *KPROPVAC* and EGR is not enabled.
- *KPWEGR* if the manifold vacuum is not less than *KPROPVAC* and EGR is enabled.

9.1.7.2.2.2.1 Proportional Term Time Limit

If *KPWOEGR* is selected and the time since the last integrator update calculation exceeds *KPCDUR*, then the proportional term is set equal to zero.

9.1.8 Block Learn Correction

The block learn term provides the means for the system to compensate for engine to engine variation and changes in engine operating characteristics. The block learn term may be thought of as a correction or trim of the volumetric efficiency term. It is derived from the integral portion of the closed loop correction and is arranged such that corrections made by the integral term are minimized. In an ideal system, the block learn term would learn values such that the integrator never moved and the proportional term caused the oxygen sensor to change state.

9.1.8.1 Block Learn Correction Implementation

The block learn correction is implemented as a conditional multiplicative correction term to the base pulse width calculation.

If power enrichment is not enabled, then

BPW = BPW * BLM

where: BPW = base pulse width term
BLM = block learn multiplier

If power enrichment is enabled and the value of the block learn multiplier is greater than or equal to 1.0, then

BPW = BPW * BLM

otherwise, if the value of the block learn multiplier is less than1.0, then the base pulse width is left unchanged.

9.1.8.2 Block Learn Memory Cell Selection

The fuel algorithm provides two variables which will be referred to as block learn memory cells. Selection between block learn memory cells is made on the basis of open or closed throttle.

The open throttle cell is selected when the throttle sensor value is greater than the applicable threshold value. The closed throttle cell is selected when the open throttle cell is not selected.

Threshold = *KF4TPS1* if throttle is closed.
- *KF4TPS2* if throttle is open.

9.1.8.3 Block Learn Memory Update

The block learn memory cell values are updated by comparing the state of the integrator with the oxygen sensor indication. If the integrator was making a rich correction (increasing fuel) and the oxygen sensor indicates lean, the active block learn cell is adjusted rich. Conversely, if the integrator was making a lean correction (decreasing fuel), the active block learn cell is adjusted lean.

9.1.8.4 Learn Enable Criteria (Learn Control Store)

The block learn memory update calculation is performed when all of the following condition are met:

1. None of the following malfunction codes are set: Malf 21, 22, 33, 34.
2. The current coolant temperature is greater than *KLCTCLL*.
3. Air fuel ratio is equal to *KAFSTCN*.
4. For closed throttle, engine speed is less than both *KLCRPM1* and *KLCESTHU*.
5. For open throttle, manifold vacuum is not less than *KLCVAC0*, altitude compensated MAP is not less than *KLCLDLO*, and engine speed is less than *KLCESTHU*.

9.1.8.5 Block Learn Memory Timer

Block learn memory timer shall be reset for the following conditions:

1. Closed loop integrator reset
2. The learn enable criteria are not met
3. The last block learn memory update
4. A change in block learn cell.

The block learn calculation will be made when the length of time since reset is equal to *K8LMCNT*.

9.1.8.6 Block Learn Memory Update Calculation

The block learn memory update calculation shown will be performed under the stated conditions.

Integrator	Oxygen Sensor Status	Block Learn Update Calculation
INT GT 128 + KLCITTH	Lean	BLM = BLM + 1/128
INT LT 128 - KLCITTH	Rich	BLM = BLM - 1/123

For all other states no block learn update is performed

9.1.8.7 Block Learn Memory Limits

The fuel control logic will limit the value of block learn memory cells to values greater than or equal to *KBLMMIN* and less than *KBLMMAX*.

9.1.8.8 Block Learn Initialization

The block learn multiplier cell values are stored in nonvolatile memory and thus retained during normal power-off conditions. The block learn memory cells are initialized to a value of 1.0 (128) if any of the following conditions detected.

Condition #1

During system initialization, if the RAM error detection logic detects a nonvolatile memory failure. (See RAM Error detection and Correction.)

Condition #2

During normal system operation, if the value of the currently active block learn memory cell is greater than *KBLMMAX*.

Condition #3

During normal system operation, if the value of the currently active block learn memory cell is less than *KBLMMIN*

9.1.9 Decel Fuel Cutoff

The purpose of the decel fuel cutoff function is to remove fuel from the engine during deceleration conditions.

9.1.9.1 Decel Fuel Cutoff Enable Criteria

The decel fuel cutoff mode is enabled when all the following conditions are met:

1. Vehicle is not in Park/Neutral and IN GEAR. If malfunction code 24 is present, then the "IN GEAR" check is bypassed.
2. Altitude compensated manifold pressure less than *KDFCOMAP*, or, altitude compensated manifold pressure greater than or equal to *KDFCOMAP* and decel fuel cutoff mode enabled and altitude compensated manifold pressure less than *KDFCOMAP* +8kPa. If either malfunction code 33 or 34 are present, then the altitude compensated manifold pressure criteria is bypassed.
3. Throttle position less than *KDFCOTP*. If either malfunction code 21 or 22 is present, then the throttle position criteria is bypassed.
4. Filtered vehicle speed greater than *KDFCOSLK*. If malfunction code 24 is detected, the vehicle speed criteria is bypassed.
5. Engine RPM greater than *KDFCDSPH*. If decel fuel cutoff mode is enabled, engine RPM must remain greater than *KDFCOSPL* for decel fuel cutoff to remain enabled.

9.1.9.2 Decel Fuel Cutoff Stall Saver Fuel

When Decel Fuel Cutoff mode has been enabled for a long time period (in excess of *KDFCDTMR*), the manifold has essentially dried out, and no fuel exists in the induction system.

To prevent an engine stall due to fuel starvation, an amount of asynchronous fuel will be delivered under the following conditions. Decel Fuel Cutoff mode must have been enabled for an amount of time greater than *KDFCDTMR*.

1. Altitude compensated MAP increases above *KDFCOMAP* + 8kPa, or
2. Throttle position increases above *KOFCOTP*, or
3. Filtered MPH drops below *KDFCOSLK*, or
4. Transmission is in Park/Neutral or Nat in gear.

After meeting any of the above criteria, an amount of fuel equal to the product of a value from the *F58* table (as a function of elapsed time in Decel Fuel Cutoff Made) times a value from the *F75* table (as a function of engine coolant temperature) times a factor of eight.

This fuel is delivered as a synchronous AE fuel pulses.

The air fuel ratio is adjusted when exiting decel fuel cutoff mode by an amount determined by one of two conditions.

1. If the difference of the filtered RPM minus the unfiltered RPM exceeds *KDITARPM*, then the air fuel ratio is adjusted by an amount equal to the product of a value from the *F58* table (as a function of elapsed time in decel fuel cutoff mode) times a value from the *F74* table (as a function of engine coolant temperature), or

2. If the difference between the filtered RPM minus the unfiltered RPM does not exceed *KDLTARPM*, then the air fuel ratio is adjusted by an amount equal to the product of a value from the *F58* table (as a function of elapsed time in decel fuel cutoff mode) times a value from the *F73* table (as a function of engine coolant temperature).

9.1.9.3 Decel Fuel Cutoff Function

The decel fuel cutoff function takes the form of a multiplicative term to the base pulse width equation. When the decel fuel cutoff mode is disabled, the decel fuel cutoff term is not applied. The decel fuel cutoff mode overrides the decel enleanment mode.

When the decel fuel cutoff mode is enabled, the decel fuel cutoff term is calculated according to the equation:

$$DFCOSF_N = DFCOSF_{N-1} - {}^*KDFCOG^*$$

where: $DFCOSF_N$ = Value of decel cutoff term at this computation
$DFCOSF_{N-1}$ = Previous value of decel fuel cutoff term
KDFCOG = Decel fuel cutoff rate (calibration)

The above calculation is performed once each 12.5 msec. The value of the decel cutoff term is limited to a value greater than or equal to zero.

9.1.10 Deceleration Enleanment Term

The deceleration enleanment is a multiplicative term to the base pulse width calculation and the transient fuel accumulator (see Asynchronous Fuel.) The deceleration enleanment term is applied to the transipnt fuel accumulator once each minor loop. The user should note that this results in a "decaying action" of the transient fuel accumulator as long as deceleration enleanment is taking place. The deceleration enleanment term is calculated as described below.

9.1.10.1 Deceleration Enleanment Mode Enable

The deceleration enleanment mode is enabled when Power Enrichment mode is not enabled, and the current value of throttle position is less than the filter value of throttle position by a factor greater than *KDETATH*.

The power enrichment mode overrides the deceleration enleanment mode.

9.1.10.2 Deceleration Enleanment Delta Throttle Term

The rate of change of throttle position (decreasing) is used to calculate a delta throttle contribution tn the deceleration enleanment term.

If the rate of change of throttle position (decreasing) is greater than a threshold (defined below), the delta throttle contribution to the decel enleanment term is calculated as follows:

DETHROT = *E36*((THRESHOLD-TPS)*8)

where: *F36* table is defined as a function of rate of change of throttle position.
TPS is the current throttle position.
THRESHOLD = Filtered throttle position if *KAFOPT3*, bit 4 = I = 12.5 mSec old throttle position if *KAFOPT3*, bit 4 = 0.
DETHROT u delta throttle contribution to decel enleanment term.

9.1.10.3 Deceleration Enleanment Delta MAP Term

When the current manifold pressure is greater than the filtered manifold pressure, the delta MAP term is set equal to zero.

When the current manifold pressure is less than the filtered manifold pressure by a factor greater than *KDEPMTH*, the fuel logic calculates a delta MAP deceleration enleanment as a value from Table *F35* times engine speed.

9.1.10.4 Deceleration Enleanment Term Calculation

The deceleration enleanment term is calculated according to the relationship:

DE = 1 - (DEMAP + DETHROT) * F34 * F39

where: DEMAP = Deceleration enleanment delta MAP term
DETHROT = Deceleration enleanment delta throttle position term
F34 = Value from calibration memory Table *F34, as a function of temperature.
F39 = DE modifier as a function of MAP or throttle position.

If the rate of change of throttle is increasing, the delta throttle contribution to the decel enleanment term is set to zero.

9.1.11 Turbo Boost Multiplier, *F77*

The base pulse width is compensated for turbo boost mode by a turbo boost multiplier term.

This turbo boost multiplier term is derived from the *F77* table as a function of engine RPM.

9.2 FUEL DELIVERY MODES

The fuel logic delivers fuel in three modes, synchronous, quasi -asynchronous and asynchronous.

When both synchronous and asynchronous modes are operating simultaneously, the output to the injector(s) is the logical OR of the delivery pulses delivered b-v the two modes.

9.2.1 Synchronous Fuel Delivery

9.2.1.1 Synchronous Fuel Enable Criteria

The synchronous fuel delivery mode will be enabled when ignition is ON, and any of the following conditions:

1. Engine not running, or
2. Engine running and engine RPM greater than or equal to *KQASRPMD*, or
3. Engine running, engine RPM less than *KQASRPMD*, and base pulse width greater than *KAPLH*, or if base pulse width is less than or equal to *KAPLH*, then not in quasi-asynchronous mode and base pulse width greater than *KAPLL*.

Once synchronous fuel delivery mode is enabled, it will remain enabled until base pulse width becomes less than or equal to *KAPLC*.

9.2.1.2 Synchronous Fuel Delivery Mode Function

When the synchronous fuel delivery mode is enabled, the fuel injector pulse width is calculated as follows:

Pulse width = BPW + INJOFFST + BPWLIN

where BPW = Base pulse width.
INJOFFST a Injector offset term.

The injector bias is a tern which compensates the delivered pulse width for the delays associated with opening and closing the injector. It is calculated as:

INJOFFST = *F92*

where the *F92* table is a function of battery voltage.

BPWLIN = Injector linearity term

The injector linearity term is calculated as:

BPWLIN = *F94*

where the *F94* table is a function of BPW (base pulse width) if BPW is less than 3.9 mSec. Otherwise, BPWLIN is set to zero.

9.2.2 Quasi-Asynchronous Fuel Delivery

Quasi-Asynchronous fuel delivery is used when the synchronous fuel base pulse width becomes so small that the fuel pulses cannot be accurately delivered.

Enabling quasi-asynchronous fuel mode will cause the fuel injectors to be energized every other reference pulse but for twice the duration (of the normal synchronous base pulse width). This results in the same amount of fuel being delivered, but with an accurately controllable injector pulse width.

9.2.2.1 Quasi-Asynchronous Fuel Enable

Quasi-Asynchronous fuel mode is enabled when the following conditions are present:

- Ignition ON
- Engine RUNNING
- Engine RPM less than *KQASRPMD*.
- Base pulse width less than or equal to *KAPLL*.

9.2.2.2 Quasi-Asynchronous Fuel Delivery Mode Calculation

When the quasi-asynchronous fuel delivery mode is enabled, the fuel algorithm energizes the fuel injector as follows:

Once every other reference pulse for an amount of time as follows:

EFIPWD = (BPW * 2) + BPWLIN + INJOFFST

where	EFIPWO	= quasi-asynchronous pulse width to be delivered by the injector.
	BPW	= base pulse width calculated by the fuel algorithm.
	BPWLIN	= base pulse width linearity term.

The injector linearity term is calculated as:

BPWLIN = *F94*

where the *F94* table is a function of BPW (base pulse width) if BPW is less than 3.9 mSec. Otherwise, BPWLIN is set to zero.

INJOFFST = Injector offset term.

The injector bias is a term which comoensates the delivered pulse width for the delays associated with opening and closing the injector. It is calculated as:

INJOFFST = *F92*

where the *F92* table is a function of battery voltage.

9.2.2.3 Quasi-Asynchronous to Synchronous Transition Mode.

This mode is used to make the transition from quasi-asynchronous fuel delivery to synchronous fuel delivery.

Once the base pulse width becomes larger than *KAPLH, a quasi-asynchronous to synchronous transition mode is enabled for a time period based on a multiple of 12.5 mSec.

This period is calculated as follows.

when vehicle speed is greater than or equal to *KQSYNMPH* then transition time 3 (*KREFMAXH*) * 12.5 mSec when vehicle speed is less than *KQSYNMPH* then transition time a (KREFMAXL*) * 12.5 mSec

Ouasi-Asynchronous fuel delivery will continue until the transition time elapses.

9.2.3 Asynchronous Fuel Delivery

Asynchronous fuel delivery mode is used to deliver fuel pulses for acceleration enrichment. These acceleration enrichment fuel pulses may be due to transient increasing engine loads such as vehicle acceleration, idle air control (IAC) transient air, and engine accessory load transients.

The fuel system provides two accumulators that contain the running sum of fuel required as a result of asynchronous base fuel and transient fuel. Each time the fuel system performs a base pulse width to asynchronous pulse width conversion, the result is added to the asynchronous base fuel accumulator. Similarly, each time the transient fuel system requires fuel delivery, the length of the required pulse is also added to the transient fuel accumulator.

9.2.3.1 Asynchronous Fuel Delivery Enable

When the sum of the asynchronous base fuel accumulator and the transient fuel accumulator is greater than *KAPMIN*, an asynchronous fuel pulse is delivered. If the sum of the asynchronous base and transient fuel accumulators is greater than *KAPMAX*, then a fuel pulse equal to *KAPMAX* plus INJBIAS is issued. The *KAPMAX* is subtracted from the asynchronous base fuel accumulator. If the result is less than zero, the remainder of *KAPMAX* is subtracted from the transient fuel accumulator. This process continues until the sum of the asynchronous base and transient

If the sum of the asynchronous and transient fuel accumulators is less than or equal to *KAPMAX*, a fuel pulse equal to the sum of the two accumulators plus INJBIAS (per paragraph 2.4) is issued and the two accumulators cleared. fuel accumulators is less than *KAPMIN* If the asynchronous base fuel delivery mode is disabled, the fuel logic will clear the asynchronous base fuel accumulator.

9.2.3.2 Acceleration Enrichment - Transient Asynchronous Fuel Term

The acceleration enrichment logic calculates and delivers additional fuel when certain engine conditions are detected. All fuel required by the acceleration enrichment logic is delivered asynchronously The acceleration enrichment fuel is composed of the sum of three terms: delta MAP, delta throttle, and IAC acceleration enrichment fuel.

9.2.3.2.1 Acceleration Enrichment - Delta MAP Contribution

The delta MAP logic calculates a contribution to the quantity of fuel delivery scheduled for acceleration enrichment fuel.

The delta MAP contribution will be calculated when:

1. MAP is increasing (opening throttle) at a rate in excess of *KAEPMTH*. (TWO times *KAEPMTH* tf throttle opening is greater than *KAEPMTPS*).

Otherwise the delta MAP contribution is set equal to zero. The delta MSP contribution is calculated as follows:

AEDP = *F21* (MAP_N - MAP_{N-1}).

where AEDP = delta MSP contribution to acceleration enrichment
F21 = delta MSP term
MAP_N = current MAP load value.
MAP_{N-1} = 12.5 mSec old MAP load value.

If the throttle opening exceeds *KAETATR*, then the final delta MAP contribution is multiplied by a factor of four, otherwise it remains as calculated above.

9.2.3.2.1 Acceleration Enrichment-Delta Throttle Contribution

The delta throttle logic calculates a contribution to the quantity of fuel scheduled for acceleration enrichment fuel delivery.

The delta throttle contribution will be calculated when:

1. Throttle position is increasing (opening) at a rate greater than *KAETATH*.

Otherwise, the delta throttle contribution is set equal to zero. The delta throttle contribution is calculated as follows:

$$AEDT = *F22* ((TFS_N - TPS_{N-l}) * 8)$$

where AEDT = delta TPS contribution to acceleration enrichment.
F22 = delta throttle term
TPS_N = current TPS load value.
TPS_{N-l} = 12.5 mSec old TPS load value.

If the throttle opening exceeds *KAETATR*, then the final delta throttle contribution is multiplied by a factor of four, otherwise it remains unchanged.

9.2.3.2.2 Acceleration Enrichment - Increasing IAC Contribution

If the IAC logic is commanding increasing idle air, a contribution of fuel defined by *KAEISCN* is added to the quantity of fuel scheduled for acceleration enrichment fuel delivery.

If the IAC logic is commanding either no idle air change or decreasing idle air, the acceleration enrichment contribution is set to zero.

9.2.3.2.4 Acceleration Enrichment - Output Scaling

After each of the individual contribution terms is computed and summed, the sum term is scaled for engine temperature and engine speed compensation.

The final scaled acceleration enrichment pulse width is determined as follows:

$$AE = AESUM * (*F37*) * (*F38*)$$

where:
AESUM = Sum term of individual contributions to acceleration enrichment (delta throttle term, delta MAP term, and IAC term)
F37 = Coolant temperature scaling table
F38 = Engine speed scaling table

The scaled value of acceleration enrichment fuel is then summed into the asynchronous fuel accumulator.

9.2.4 Fuel Cutoff

Fuel delivery Is Inhibited by the presence of either of the following cutoff conditions.

9.2.4.1 Ignition Off Cutoff

When ignition is off (MWBG, bit 5-1), then:

(a) The ECM will not, energize the injector solenoids.
(b) The synchronous delayed TBI BPW, EFIPWD, is set to zero.
(c) The pending synchronous fuel term for accumulated fuel calculation, PENOFUEL, is set to zero.

9.2.4.2 High Engine Speed Cutoff

To prevent prolonged high engine speed the fuel base pulse width is set equal to zero.

9.2.4.2.1 High Engine Speed Enable

High engine speed fuel cutoff mode is enabled under the following conditions.:

1. Engine running (MW1, bit 7=1) and either
2. Engine speed exceeds *KFRPMHI* for time *KFRPMTIM* (if not currently in high RPM fuel shutoff Mode)

Or

3. Engine speed exceeds *KFRPMLOW* for time *KFRPMTIM* (if currently in high RPM fuel shutoff mode).

9.2.4.2.2 High Engine Speed Disable

High engine speed fuel cutoff mode will be disabled (fuel delivery resumed) when engine speed becomes less than or equal to *KFRPMLOW*

9.2.4.3 High Engine Load Fuel Shutoff

9.2.4.3.1 High Engine Load Fuel Shutoff Enable.

Synchronous fuel delivery will be disabled when MAP (Manifold Absolute Pressure), engine load, increases above *KWGMAPL* to all fuel delivery to be reenabled.

9.2.5 Accumulated Fuel Update

The fuel algorithm accounts for all fuel delivered to the engine for the purpose of computing miles per gallon.

The value of accumulated fuel is equal to the sum of all synchronous, quasi-asynchronous and acceleration enrichment fuel.

10 Wastegate

I don’t have that data…

11 ELECTRONIC SPARK TIMING (EST)

11.1 SPECIFICATION

Electronic Spark Timing Control

11.1.1 Introduction

The optimum spark timing output is defined in terms of its relation-ship to various input parameters, manifold pressure, RPM, coolant temperature, etc. Data tables are provided to allow calibration of the spark timing function in terms of these input parameters. This function controls the spark distributor module which in turn energizes and de-energizes the ignition coil.

There are two basic controls which are included in the electronic spark timing function. Dwell control is provided to allow sufficient energy in the ignition coil for a proper ignition system voltage output without over stressing the coil. Spark timing is then provided to control the proper crankshaft angle at which the spark plug should be ignited for optimum performance.

11.2 OPERATION

11.2.1 Modes of Operation

Two system modes of operation which are exclusive are described below:

- Bypass Mode
- EST Mode

These modes are determined by hardware constraints and algorithrn tests. During the bypass mode, the electronic spark timing control signal is bypassed to the distributor, this means that spark timing and dwell are controlled by the distributor. During the EST mode, the electronic spark timing control signal is a programmed function of engine speed, vacuum or manifold absolute pressure, coolant temperature. and various other sensor signals.

11.2.1.1 Bypass Mode

The bypass mode is intended to insure an ignition firing signal to the ignition coil within the distributor when proper ECM execution of the electronic spark timing control function cannot be guaranteed. The bypass mode overrides the EST run mode; The HEI/EST ignition module will be in the bypass mode whenever the bypass terminal is at a low voltage or open circuit. When the bypass mode is enabled by the ECM opening the bypass line, the ignition module will have complete control of on time (dwell) and ignition spark timing.

No ignition secondary voltage is generated by the sudden application of battery voltage to the ignition voltage supply line. This means that the ECM bypass control signal must remain below the ignition module threshold during power on initialization. During a crank sequence, no ignition secondary voltage is generated until the first pickup pulse falls from a value above the ignition module "on" threshold to a value below the ignition module "off" threshold. This includes the indeterminate time between key on and starting motor engagement and any noise generated by accessory switching during that time.

11.2.1.2 EST Mode

During the EST mode, the electronic spark timing control signal is a programmed function of engine speed, load, coolant temperature, and various other sensor signals.

The EST mode shall be enabled whenever the EST enable criteria are met (see 2.2.2). Once enabled, the ECM will cause the ignition module bypass terminal to be at a high voltage state. The ECM will then have complete control of on time (dwell) and ignition spark timing.

11.2.2 Mode Control

As described in the previous section, there are two modes of operation:

- Bypass Mode
- EST Mode

The following describes the software enable criteria for each of these modes.

11.2.2.1 Bypass Enable Criteria

The bypass mode shall be enabled whenever the EST mode is disabled.

11.2.2.2 EST Mode Enable Criteria

EST mode will become enabled by the following sequence of events:

1. ECM detects proper power requirements.
2. The engine is running as detected by an RPM exceeding calibration parameter *KRPMUP* for a period of time greater than or equal to *KERUNCTR*.
3. Malfunction code 42 is disabled or if enabled the criteria for setting malfunction code 42, when in the bypass mode, is not met. (See Diagnostics)
4. At least two reference pulses have been received since the last ECM reset.

11.2.2.3 EST Mode Disable Criteria

The EST mode will be disabled and the bypass mode re-enabled by any of the following:

1. A defective calibration PROM is detected by the ECM software resulting in EST being disabled and bypass mode operation a maximum of four reference pulses later.
2. The ECM detects that the ignition is off. When this occurs EST is disabled and the bypass mode is entered a maximum of four reference pulses later.
3. The ECM software determines that the time since the last reference pulse has exceeded 200 milliseconds. EST is then disabled and the bypass mode entered a maximum of four reference pulses later.
4. Software ceases to execute properly resulting in the ECM being reset and the bypass mode enabled.
5. An ECM low voltage reset or power failure.

11.3 EST CONTROL ALGORITHM

The EST algorithm controls both ignition timing and dwell.

11.3.1 Dwell Control

This feature is designed to provide optimum EST signal on time (dwell) requirements. In order to build up sufficient coil primary current to generate the required secondary voltage, minimum on time (dwell) is required. To prevent excessive module dissipation at low speeds and to provide sufficient burn time at high speeds, maximum on times are also required. To meet these requirements, the software sums static dwell with dynamic dwell, compensates the sum for battery voltage level, and limits the compensated sum to guarantee a minimum burn (EST off) time.

11.3.1.1 Static Dwell

This portion of the dwell calculation computes the nominal dwell required by the distributor during steady state engine conditions. This three-slope straight line function is accomplished in software by computing the slope and reference period for each of the three sections defined on the curve.

CONDITION	REFERENCE PERIOD	STATIC DWELL CALCULATION
1	LT 7.0 ms	Static Dwell = 4.7 ms + (Ref. Period - 7ms)/2
2	GT 7.0 ms and LT 25 ms	Static Dwell =4.7 ms + (Ref. Period - 7 ms)/16
3	GT 25 ms	Static Dwell = 5.825 ms + (Ref. Period - 25 ms)/4 6

11.3.1.2 Dynamic Dwell

The dynamic dwell portion of the dwell calculations computes the nominal additional dwell (added to static dwell) required to maintain the desired dwell under conditions of acceleration.

Dynamic dwell is added to static dwell when acceleration is detected via a reduction in reference period or acceleration enrichment fuel mode is active. If the acceleration enrichment criterion is met, the change in reference period test is not made.

11.3.1.2.1 Reference Period Detected Acceleration

Every 12.5msec, the software tests for an acceleration by comparing the present reference period to the previous. If the present reference period is shorter than the previous, an acceleration is Occurring and dynamic dwell is added to the static dwell output.

The reference period acceleration test performs the following calculation:

2* (REFPER (OLD) - REFPER (NEW)

where: REFPER (NEW) is present reference period

REFPER (OLD) is previously calculated reference period

if the result of this calculation is positive and is greater than or equal to the value of dynamic dwell, then it becomes dynamic dwell subject to the maximum restrictions of Paragraph 3.1.2.3. If the result of the calculation is less than dynamic dwell, then dynamic dwell remains unchanged.

11.3.1.2.2 Acceleration Enrichment

If acceleration enrichment fuel mode is active, dynamic dwell is set to the maximum (See Paragraph 3.1.4).

11.3.1.2.3 Maximum Dynamic Dwell

Dynamic dwell is limited for all operating conditions to a value not to exceed (Reference Period)/8.

11.3.1.2.4 Dynamic Dwell Recovery

The dynamic dwell parameter shall be exponentially decayed to zero every 12.5msec interval in which a new reference pulse occurs. The exponential decay shall be accomplished by subtracting (Dynamic Dwell)/8 from Dynamic Dwell.

DO1 = (DD0-(DD0/8+l) Limited to 0

where: DO1 = Present dynamic dwell
DD0 = Dynamic dwell from previous 12.5msec interval calculation

11.3.1.3 Voltage Compensated Dwell

This feature is designed to increase dwell time as battery voltage decreases. As battery voltage decreases, the energy available in the coil to fire the spark plugs is also decreased. By increasing dwell in the reduced voltage situation, the available firing energy can be maintained at a level sufficient to fire the spark plugs.

Dwell is voltage compensated whenever battery voltage drops below 12V via the following formula:

DWELL = STATIC DWELL(N) + DYNAMIC DWELL(N) + (12 - BATTERY VOLTAGE) x 610 µsec/volt

11.3.1.4 Desired Dwell Limiting

Desired dwell HEI on-time is the battery voltage compensated summation of static and dynamic dwells. To insure sufficient burn time (coil discharge time), desired dwell is limited to a maximum on-time of (Reference Period) - 600 µsec.

11.3.1.5 Increasing Spark Advance Limitation

The ECM software insures that ECU module calculations cannot truncate dwell due to an increase in spark advance. This is accomplished by limiting any increase in spark advance to (Reference Period)/16 at each spark advance calculation intervals Spark is calculated every 12.5msec. No limiting is done in the increasing retard direction.

11.3.2 Spark Timing Calculations

The spark timing control calculations are performed in the following manner:

Spark timing advance calculations are the sum of the following term:

- Main Spark Advance Table (*F1*)
- Coolant Temperature Correction Table (*F2)
- EGR Correction Table (*F4*)
- Power Enrichment Spark Advance
- Spark Advance Boost Table (*F3*)
- Minus the Following Bias Values:
    1. Coolant Advance Bias (*KCTBIAS*)
    2. Manifold Air Temperature Bias (*KMATBIAS*)
    3. Boost Advance Bias (*KBSTBIAS*)
    4. Spark Advance Run Time-out
    5. EGR Advance Bias (*KEGRBIAS*)
    6. Malfunction 32 Test term (*KKEGRSPK*), if applicable.

System spark advance is calculated relative to top dead center (TDC) but must be output relative to the HEI reference signal. The difference between TDC and the reference signal is accounted for by subtracting the value *KREFANGL* is the same as the static advance angle.

Output Spark Advance (w.r.t. TDC) = System Spark Advance - *KREFANGL*

11.3.2.1 Main Spark Advance Table (*F1*)

The (*F1*) table is the primary lookup table for spark advance as a function of engine RPM ana manifold pressure (MAP). This three dimensional table contains a 14x17 matrix of lookup values. If the throttle is closed, the 600 RPM row of the table is forced.

When RPM exceeds 4800 (highest RPM value of table Fl), the Fl table advance is calculated by accessing the X parameter (RPM) end point at the appropriate Y parameter (MAP) value and adding to it an additional advance as follows:

Fl Value = Fl Table Value + (Measured RPM - 4800) * KADVSLHr *2

where: KADVSLHI is a calibration parameter representing degrees advance per RPM for RPM in excess of 4800.

A second calibration parameter (*KRPMXHI*) represents the maximum RPM for which an advance addition factor is calculated. If "measured RPM" exceeds *KRPMXHI* then *KRPMXHI* will be substituted for "measured RPM" in the above formulation.

The Y axis can be scaled for a 1 Atm. or 2 Atm. MAP sensor via Bit 5 of *KAFOPT3*. The X axis is *NTRPMP* units.

11.3.2.2 Coolant Temperature Correction Table (*F2*)

The coolant temperature correction table (*F2*) shall consist of a 15 x 5 three dimensional lookup table. The independent variables shall be coolant temperature and load. The load is manifold air temperature if bit 3 of COOLKUPS is set or manifold vacuum if bit 2 of COOLKUPS is set.

The manifold vacuum points in the P2 table shall consist of 5 values of vacuum ranging from 0 to 40 kPa in 10 kPa increments. The manifold air pressure consists of 5 values of air pressure ranging from 60 to 100 kPa in 10 kPa increments. The coolant temperature shall be NCT units limited to 152C. If coolant temperature is less than *KF2ENA* and throttle is closed, the F2 value shall be forced to *KCTBIAS*.

The constant value *KCTBIAS* shall be provided to allow the F2 coolant temperature correction values to be either positive or negative at user option. This is accomplished by subtracting *KCTBIAS* from the spark advance calculation after the value from the F2 table is added.

The user would therefore specify the F2 table values using the formula:

F2 Table Value = desired correction + *KCTBIAS*

11.3.2.5 Power Enrichment Advance

If the power enrichment mode is active, (see Fuel), a value from the F80 table as a function of engine RPM will be added to the spark advance calculation.

If the power enrichment mode is not active, a value of zero will be added to the spark advance calculation.

3.3.5.1 ALDL Spark Control

If ALDL spark control is not active, a value of zero will be added to the spark advance calculation.

IF ALDL spark control is active, spark advance is calculated as follows:

SAPN = ALSPARK (Absolute and Advance Modification)

SAPN = ALSPARK (Absolute and Retard Modification)

SAP = SAP + ALSPARK (Delta and Advance Modification) N N-1

SAPN = SAPN-l - ALSPARK (Delta and Retard Modification)

SAP = New Spark Advance

SAP = Previous Spark Advance

N-1

ALSPARK = Desired Spark Advance

11.3.2.6 ESC Retard

The value calculated for knock retard is subtracted from the spark advance calculation. (See Electronic Spark Control)

11.3.2.7 Initial Timing

Initial timing is defined as the spark timing in engine degrees referenced to top dead center with EST system in the bypass mode. A parameter, *KREFANGL* degrees, must be set to this initial timing value. After all the advances are added together, *KREFANGL* is subtracted from the sum to reference the degrees advanced from the position of initial timing.

11.3.2.8 Spark Advance Run Time-out Logic

The spark advance run time-out is subtracted from spark advance calculation. The spark advance run time-out is used to ramp out the initial spark advance. The ramp value is chosen during EST disable from the "F46(coolant)* table. This value is decayed by the multiplier, *KSADM*, every *KSATM1* seconds.

11.3.2.9 EST Advance/Retard Limits

Two ECM calibration memory values (*KMAXADV2* and *KMAXRTD2*) define the maximum advance and minimum advance angles acceptable by the distributor. These limits are relative to the static advance or reference angle *KREFANGL*. Advance angles outside these limits may result in ignition secondary voltage being applied to the wrong cylinder (crossfire). These limits shall be defined by Delco Remy, the ignition system design responsible division, on their distributor outline drawing. The limits are applied after all of the advance tables and their biases have been summed.

KMAXADV2 and *KMAXRTD2* can be either positive or negative relative to the reference angle.

11.3.2.10 Malfunction 32 Test Term

If a Malfunction 32 Test (EGR) is in progress, (DIAGMW4, bit 7 = 1), the spark advance term is decremented by *KKEGRSPK*.

11.3.2.11 Spark Calculation Override

11.3.2.11.1 Power Steering Override

If the system detects a power steering load during a closed throttle condition, while not in diagnostics, and the coolant temperature is greater than *KPSTEMP*, the output spark advance is made equal to *KPSDAOV* before the lag correction is performed.

11.3.2.11.2 Diagnostic Mode Override

When the system is put into the diagnostic mode the threshold is set to *KDIARPMH* (DIAGMW2 Bit 5 = 0) or *KDIARPML* (DIAGMW2 Bit 5 = 1). If the engine RPM is less than or equal to the threshold, the spark advance is made equal to *KDIAGADV* before the laq correction is performed. If the engine RPM is greater than threshold and ESC option is active the spark advance equals *KESCDADV* before the lag correction is performed.

11.3.2.12 Lag Correction

Lag correction is a feature designed to compensate for all mechanical and electronic time lags to which the reference signal and EST signal are subjected.

Lag correction is accomplished by subtracting *KTIMELAG* from the advance being Output after it has been converted to the time domain. Lag correction is performed after all EST calculations including application of the maximum retard limit are complete but before the application of the maximum advance limit.

11.3.2.13 Computation Rate

All EST calculations shall be executed within one minor loop cycle of 12.5 msec.

12 ELECTRONIC SPARK CONTROL

12.1 Specification

Electronic Spark Control

12.2 Introduction

Electronic Spark is a system applied to automotive engines where undesirable fuel detonation may occur with advanced spark calculations. The ESC system provides a spark retard function when fuel detonation conditions are detected by a mechanical vibration sensitive sensor mounted on the engine.

The spark retard magnitude is proportional to a time interval of the detonation conditions. The spark retard is removed in an exponentially decaying manner so that when the detonation condition ceases, the retard is reduced to zero.

12.2.1 ESC/ECM System Description

The electronic spark control function is added to the electronic spark timing control by means of connecting the ESC module to the proper ECM input. The signal derived from the detonation sensor is processed by an analog signal to noise enhancement filter (SNEF). The processed signal is supplied to the ECM as an indication of the presence of detonation. The output of the SNEF shall be in a logic "low" level for the detection of detonation.

The ECM spark calculations retard spark when either the electronic spark control retard or the burst knock retard conditions are satisfied. However each function has a different calculation to determine the retard value.

12.3 Spark Retard Modes

Spark retard is calculated in either ESC retard mode or burst knock retard mode. These two modes are mutually exclusive.

12.3.1 ESC Retard Mode

12.3.1.1 ESC Retard Enable Criteria

The ESC retard function is enabled when burst knock retard is not enabled and either of the following conditions are satisfied:

1. The engine coolant temperature is greater than the value *KESCOOL* and the engine RPM is greater than or equal to *KRPMKNOB* at the same time.
2. The ALDL mode is active.

12.3.1.2 ESC Retard Calculation

When the ESC function is enabled, a spark retard value is added to the EST calculated spark. The ESC retard value is limited to *KRETARDM*.

The ESC Retard Value is calculated as follows:

NOCKRTDN = NOCKRTDN-1 (2 * Data PA3* A)

Where: NOCKRTDN = New Retard Value
NO CKRTDN-1 = Old Retard Value
Delta PA3 = Reference Pulse Coefficient
A = A value from F6 (RPM) table

12.3.1.3 ESC Retard Decay

The ESC retard value is to be decayed every 200 msec. The rate of retard decay is calculated as follows:

NOCKRTDN U NOCKRTDN-l-(NDCKRTDN-l*A)

Where: NOCKRTDN = New Retard Value NOCKRTDN~l = Old Retard Value
A = Value from F7 (RPM) table

KESCMPEC is substituted for value from F7 (RPM) table when manifold air pressure is less than *KESCMAP*.

12.3.1.4 Default Retard Application

If the ESC spark retard function is enabled and either an ESC failure has been detected (see Diagnostics) or the battery voltage is less than 9 volts, the retard value will be forced to a default value *KKRTBF*.

12.3.2 Burst Knock Retard Mode

12.3.2.1 Burst Knock Retard Enable Criteria

The burst knock retard function is enabled when all of the following criteria are satisfied:

1. The ALDL mode is not enabled.
2. The engine RPM is less than the value *KRPMKNOB*.
3. The change in throttle position within the last 12.5 msec is greater than or equal to *KBKRTPS*.
4. The engine coolant temperature is greater than the value *KESCOOL*.

12.3.2.2 Burst Knock Retard Disable Criteria

Once the Burst Knock function has been enabled, it will remain enabled until that time, since the function was enabled exceeds the value *KBKRTIM*, at which time it will be disabled.

12.3.2.3 Burst Knock Retard Calculation

When the burst knock function is enabled, a spark retard value is added to the EST calculated spark. This value is equal to *KBKRTDI*.

12.3.2.4 Burst Knock Retard Decay

The burst knock retard value is to be decayed only after the function has been disabled. When disabled, the retard value is decayed every 200 msec. The burst Knock Retard value is calculated as follows:

NOCKRTDN = NOCxRTDN~l~(N0CxRTD~~l*A)

Where: NOCxRTD = New Retard Value N
NOCKRTD
A N-1 = Old Retard Value
= Value from F7 (RPM) table

KESCMPEC is substituted for value from F7 (RPM) table when manifold air pressure is less than *KESCMAP*.

d. 0 ESC Operational Determination Logic

The Operational Determination Logic is performed every 12.5 msec to determine if Knock sensor is active. The ESC Operational flag is enabled as follows:

1. ESC operational timer is less than *KESCNOP*.
2. Delta PA3 is not equal to zero.

12.4.1 ESC Operational Determination Logic Disable Criteria

Once ESC Operational Determination Logic is enabled, it will remain enabled until the following conditions are met:

1. Delta PA3 equal zero.
2. Premium fuel active flag is set.
3. ESC operational timer is greater than or equal to *KESCNOP*.

12.5 Computation Rate

Retard computation is performed every minor loop (12.5 msec). Retard recovery is performed every 200 msec.

13 IAC

Sorry, I don’t have that info..

14 TCC

Sorry, I don’t have that info..

15 Shift Light

Sorry, I don’t have that info..

16 A/C Clutch

Sorry, I don’t have that info..

17 Road Speed

Sorry, I don’t have that info..

18 FAN

18.1 SUBJECT

Fan Control

18.2 SCOPE

This specification describes the logic used to implement the electronically controlled engine cooling fan.

18.3 SPECIFICATION

18.3.1 Fan Enable

Either of two sets of conditions can enable the low speed fan (FAN).

Condition 1:

Malf Codes 14 or 15 set or engine coolant temperature greater than or equal to *KFAN2THH*. Under this condition, the low speed fan (FAN) will be turned on after *KFANTIM1* seconds. *KFANTIM1* is the fan anticipate timer for idle air control (IAC)

Condition 2:

Malf Codes 14 or 15 not set and engine coolant temperature below *KFAN2THH* (or *KFAN2THL* if the conditions to enable the high speed have been met).

Under Condition 2, all of the following conditions must be satisfied to enable the low speed fan (FAN). The fan will be turned on *KFANTIMI* seconds after being enabled. *KFANTIM1* is the fan anticipate timer for idle air control (IAC)

1. Engine coolant temperature greater than *KFANCTHH*. The lower hysteresis value of coolant temperature is *KFANCTHL*.
2. Either conditions A, B, or C.

Condition A

- VS A/C compressor option selected and VS fan discrete high.

Condition B

- V5 A/C option not selected (KAFOP2, b2=0).
- A/C discrete is selected (IACMWl b5=1).

Condition C

- V5 A/C compressor option not selected (KAFOP2, b2=0).
- A/C discrete low (IACMW1, b5=0).
- A/C is active.
- Fan run time is less than *KFANTIM2*.

3. If a MAT sensor is used in the system, manifold air temperature (MAT) A/D counts less than *KFANMTCH* (temperature exceeds a threshold). The corresponding hysteresis value of manifold air temperature is *KFANMTCL*.

4. If a MAT sensor is not used in the system, engine coolant A/D counts less than *KFANCTCH* (temperature exceeds a threshold). The corresponding hysteresis value of coolant temperature is *KFANCTCL*.

5. Vehicle speed less than *KFANVSLK* or coolant temperature greater than or equal to *KFANCLTH*. The hysteresis value of vehicle speed is *KFANVSHK*. The hysteresis value of coolant temperature is *KFACCLTL*.

18.3.2 Fan Disable

The following conditions will disable and turn off the low-speed fan (FAN).
Engine coolant temperature dropping below the hysteresis value *KFANCTHL*, and any of the following:

1. V5 A/C compressor option selected and V5 fan discrete low
2. V5 A/C compressor option not selected (KAFop2, b3=0), A/C is active, and FAN Run timer is greater than or equal to *KFANTIM2*.
3. v5 A/C compressor option not selected (KAFOP2, b2=0), and a/c is not active
4. If a MAT sensor is used in the system, manifold air temperature dropping below the hysteresis value *KFANMTCL*.
5. If a MAT sensor is not used in the system, engine coolant temperatures dropping below the hysteresis value *KFANCTCL*.
6. Vehicle speed dropping below the hysteresis value *KFANVSK*.

19 EXHAUST GAS RE-CIRCULATION CONTROL

19.1 SPECIFICATION

Exhaust Gas Re-circulation Control (EGR)

19.1.1 Introduction

The exhaust gas re-circulation system provides a means to direct exhaust gases from the exhaust manifold into the intake manifold. This is accomplished using a vacuum diaphragm valve and an electronic vacuum regulator valve (EVRV). Ported engine vacuum is directed to the EVRV which processes a 128 Hz pulse width modulated signal from the ECM to determine the amount of regulated vacuum signal to be applied to the vacuum diaphragm value (EGR is active with vacuum applied The regulated vacuum signal is also electronically fed back to the ECM for use in EGR diagnostics (see ?.1I Section 8).

19.2 Special Electronic Vacuum Regulator Value (EVRV) Control Conditions

Under certain conditions, the E'IRV is controlled independently of the EGR control algorithm. These conditions involve high battery voltage engine not running, diagnostic/factory test, I~U active and reset.

19.2.1 High Battery Voltage

The EGR duty cycle is set to 0% (EGR off) if the battery voltage is greater than a nominal 16.9 volts for 200 msec.

19.2.2 Engine Not Running/Diagnostic Mode

The EGR duty cycle set to 100% (EGR on) if the engine is not running and the diagnostic mode is selected. The EGR duty cycle is set 0% (EGR off) if the engine is not running and diagnostic mode is not selected.

19.2.3 Reset

The EGR duty cycle is set to 100% (EGR on) when the ECM is reset.

19.2.4 Factory Test Mode

Duty cycle of the EGR output in factory test mode is dependent on which test mode function is enabled (see 3.2 Section 4). See the following chart:

Test Mode function	EGR Duty Cycle
Mode 1 (All Off Mode)	0% (EGR off)
Mode 2 (I/O Check Mode)	50% @ 32 Hz. PWM rate
Mode 3 (Misc. Test Mode)	0% (EGR Off)
Mode 4 (I/O Check Mode)	50% @ 32 Hz. PWM rate

19.2.5 I^2U

EGR duty cycle may be slewed if the HUD and I^2U are active and *KAFOPTI*, bit 0 is zero (=0).

19.3 Control Algorithm

Provided that the engine is running and special control conditions are not present, the EVRV is controlled by the EGR control algorithm. In accordance with the control algorithm, the ECM will enable EGR when coolant temperature, throttle position, and engine vacuum criteria have been met. Conversely, if any of the above criteria are not met, EGR is not enabled.

19.3.1 Enable/Disable Criteria

19.3.1.1 Coolant Temperature Criteria

The coolant temperature criteria for EGR on is met when the coolant temperature equals or exceeds *KEGRTEMI*. The coolant temperature criteria shall always be met if *KEGRTEM1* is set equal to 0. Setting *KEGRTEMI* equal to 255 will result in the coolant temperature criteria never being met and EGR never enabled.

19.3.1.2 Throttle Position Criteria

When the EGR is disabled, the throttle position criteria for EGR on shall be met when throttle position is greater than calibration memory parameter *KF4TPSl*. When the EGR is enabled, it shall remain on if the throttle position remains greater than calibration memory parameter *KF4TPS2*. For proper system operation, *KF4TPS1* must equal or exceed *KF4TPS2*. Setting *KF4TPS1* and *KF4TPS2* equal to 255 will result in the throttle position criteria never being met which disables EGR

19.3.1.3. Engine Vacuum Criteria

When EGR is disabled, the engine vacuum criteria for EGR on shall be met when engine vacuum is less than or equal to the calibration memory parameter *KEGRVAC2*. When EGR is enabled, it shall remain enabled if engine vacuum remains less than or equal to the calibration memory parameter *KEGRVAC1* for proper system operation, *KEGRVAC1* must equal or exceed *KEGRAVAC2*. Setting *KEGRVAC1* and *KEGRVAC2* to 255 will result in the engine vacuum criteria always being met.

19.3.2 Tables

19.3.2.1 *F60* Table

The *F60* table provides the altitude factor for adjusting BPW and EGR versus barometric pressure and manifold air pressure.

The *F60* table is a two dimensional lookup table with barometric pressure and manifold air pressure as independent variables.

19.3.2.2 *F72* Table

The *F72* table provides the desired percent EGR versus manifold vacuum and engine RPM.

The *F72* table is a three dimensional lookup table with manifold vacuum and engine RPM as the independent variables.

Manifold vacuum is defined as Barometric pressure minus manifold absolute pressure.

*19.3.2.3 *F73* Table*

The *F73* table provides the EGR duty cycle versus the EGR valve effective flow area.

The *F73* table is a two dimensional lookup table with EGR valve effective flow area in units of grams per second per kPa as the independent variable.

*19.3.2.4 *F75* Table.*

The *F75* table provides EGR flow pressure. compensation versus pressure.

The *F75* table is a two dimensional lookup table with barometric pressure in kPa as the independent variable.

19.4 Computations

19.4.1 Engine Air Flow

The following computation shall be used to obtain the airflow (1 bit = 0.25 grams/sec.) through the engine:

Air Flow = BPWM*KAIRF~w*2l8*KNUMcyL*25*AIRFUEL*NTRPMx32

Where:	BPWM	= Base pulse width for EGR
	KAIRFLOW	= Air Flow multiplier.
	KNUNCYL	= Number of cylinders*32.
	AIR FUEL	= Engine running air fuel ratio*IO.
	NTRPMX	= Computed engine RPM scaled 25 RPM/bit.

19.4.2 Exhaust Back Pressure

The following computation shall be used to obtain the exhaust system back pressure (kPa gage):

Rack Pressure = KBP2*(AirFlow**2)+KBPI*AIRFL0W+KBP0

Where KBP0 = Back pressure multiplier in KPA.
KBP1 = Back pressure multiplier in KPA*sec/gram.
KBP2 = Back pressure multiplier in KPA*sec*sec/gram*gram.

19.4.3 EGRFLOW

The following computation shall be used to obtain the EGR value equivalent flow area for the desired percent EGR

EGRFLOW = EGRDESA*AIRFLOW*F75(BP+VAC)
256

Where	EGRDESA	= Desired Percent EGR (altitude compensated).
	AIRFLOW	= Computed engine air flow.
	F75 Table	= EGR Flow pressure compensation versus pressure.

19.4.4 EGR Solenoid Duty Cycle

The following computation shall be used to obtain the EGR solenoid duty cycle:

EGR Duty Cycle = F73(EGRFLOW)

Where: F73 Table = EGR duty cycle versus EGR valve Flow normalized to pressure across the valve (grams/sec)/F75(KPA).

19.5 Computation Rate

The EGR logic is performed once per 100 msec.

20 COORDINATED VALUES

Coordinated Values for Program P0188AXZO2 TCOO 8/7/86

ABS.	REL.	COMPUTER		DATA	ENG. DATA	
SYMBOL	ADDR	ADDR		DEC	HEX	DEC
DATECODE	OOCOO2	0002	65535	FFFF		
SEQNUMB	OOCOO4	0004	65535	FFFF		
KKPGMID	00C008	0008	88	58		
F69	OOCO7E	007£	4	04		
F83	0OCOBB	0088	4	04		
F84	OOCOC1	00C1	4	04		
F59A	00C117	0117	16	10		
F59A	00C118	0119	48	30		
F59A	00C119	0119	6	06		
F1C	00C18E	018£	0	00		
F1C	OOC18F	018F	0	00		
F1C	00C190	0190	17	11		
F2E	00C280	0280	32	20		
F2E	00C281	0281	64	40		
F2E	00C282	0282	5	Os		
F3	00C2CE	02CE	0	00		
F3	OOC2CF	02CF	0	00		
F3	OOC2DO	02D0	9	09		
F80	OOC3OF	030F	4	04		
F6B	OOC31A	031A	4	04		
F7B	00C320	0320	4	04		
F7OB	OOC3BE	038£	48	30		
F7OB	00C3BF	03SF	48	30		
F7OB	00C3C0	03C0	6	06		
F71	OOC3ES	03E5	8	08		
F23	OOC3EF	03EF	8	08		
F24	00C3F9	03F9	8	08		
F25C	00C403	0403	8	08		
F29C	OOC41E	041£	32	20		
F29C	00C41F	041F	0	00		
F29C	00C420	0420	9	09		
F29S	00C472	0472	48	30		
F29S	00C473	0473	0	00		
F29S	00C474	0474	9	09		
F30	OOC4AB	04A6	16	10		
F31C	00C480	0480	16	10		
F31M	OOC4CF	04CF	16	10		
F35B	00C4F3	04F3	4	04		
F36A	00C4F9	04F9	4	04		
F39	00C500	0500	8	08		
F21A	OOCSOA	050A	4	04		
F22A	00C510	0510	4	04		
F56A	00C55D	055D	0	00		
F56A	OOCSSE	055E	0	00		

F56A	00C55F	055F	9	09
F60	OOCSC4	05C4	96	60
F60	00C5C5	05C5	0	00
F60	00C5C6	05C6	9	09
F61	OOC5EB	05E3	8	08
F67	00C500	0600	4	04
F68	00C506	0606	4	04
F92	00C617	0617	16	10
F72	00C6E1	06E1	32	20
F72	00C6E2	06E2	0	00
F72	00C6E3	06E3	12	0C
F9OMST	00C74F	074F	0	0000
F9OMST	00C751	0751	0	0000
F9OMST	00C753	0753	0	0000
F9OMST	00C755	0755	0	0000
F9OMST	00C757	0757	51227	C81B
F9OMST	00C759	0759	0	0000
F9OMST	00C7SB	0758	0	0000
F9OMST	00C75D	0750	0	0000
F9OMST	00C75F	075F	0	0000
F9OMST	00C761	0761	0	0000
F9OMST	00C763	0763	0	0000
F9OMST	00C765	0765	0	0000
F9OMST	00C767	0767	0	0000
F9OMST	00C769	0769	0	0000
F9OMST	00C76B	0768	0	0000
F9OMST	00C760	0760	0	0000

21 INSTRUMENTATION

21.1 Specification

Instrumentation Interface Module (IM)

21.1.1 Introduction

The purpose of the Instrumentation Interface Module (IM) is to provide a means of monitoring and/or modifying system operation to facilitate development   This document will describe the application of the IM to this system.

21.1.2 Electrical Interface

The IM will access 12 volt battery, 12 volt ignition and power ground by means of a 3-pin connector. Interface to the ECM is made by means of a 50-pin connector attached to the GBAM (General Buffer Auxiliary Memory). This interface operates as a continuation of the ECM address, data and control bus structure.

21.1.3 Data Display

ECM data is displayed on a Heads-Up-Display (HUD) unit which will have the capability to be mounted on the vehicle dashboard remote from the IM mainframe.

Four digital displays are available; each composed of three, seven segment display devises with a right-hand decimal point. Eight discrete indicators are suitable for function status indicators, with a switch selection for a total of sixteen status flags.

21.1.3.1 Dedicated Digital Displays

Two of the four digital displays are dedicated to displaying onlv one parameter at all times. The top left-hand display will always display engine speed in revolutions per minute (RPM). The bottom left-hand display is available to display Manifold Absolute Pressure (MAP) in units of kilopascals.

When the engine speed is less than 1000 RPM, the respective display value has "units" resolution of speed. When the engine speed is greater than 1000 RPM, the display value has "tens" resolution.

21.1.3.2 Selectable Digital Displays

The two displays to the right of RPM and MAP are controlled by a ten position rotary selector switch to the right of the respective display and a "Cal A/B" switch.

Display "A" (Cal A) Selector Switch Information

Display "A" Selector Switch (Upper and Lower) Positions

```
      0   1
    9       2
8               3
    7       4
      6   5
```

Upper Switch Position Display Function Table

Position	Display Parameter	Label
0	Spark Advance (Degrees)	SATDC
1	Barometric Pressure (kPa)	ADBARO
2	Engine Coolant Temperature (Degrees C)	COOLDEG
3	Manifold Air Temperature (Degrees C)	MATDEG
4	IAC Present Motor Position (Steps)	ISSPMP
5	Data Change Slew Value	IDATAMOD
6	RAM Address Slew Value	IADORMOD
7	Vehicle Read Speed (KPH)	FILTMPH
8	A/F or Base Pulse Change Slew Value	IAFMOD
9	Block Learn Multiplier	BLM

Lower Switch Position Display Function Table

Position	Display Parameter	Label
0	Spark Advance Chanqe-Slew Value	ISPKMOD
1	Knock Spark Retard	NOCKRTD
2	Closed Loop Integrator Value	INT
3	Wastegate Duty Cycle (percent)	WGATEDC
4	IAC Desired Motor Position (Steps)	IMPMOD
5	Base Pulse Width (Msec)	BPW
6	Contents of RAM Location	CONTENTS
7	Throttle Angle (Percent)	NTPSLD
8	A/F Ratio	AIRFUEL
9	EGR Duty Cycle (Percent)	EGRDC

Display "B" (Cal (B) Selector Switch Information Display "B" Selector Switch (Upper and Lower) Positions

```
        0   1
      9       2
    8           3
      7       4
        6   5
```

Upper Switch Position Display Function Table

Position	Display Parameter	Label
0	Average MPG	MPGMEAN
1	Power Steering Stall	ISALPA
2	Cold Control IAC Bias For P/N	NBIASPN
3	IAC Drive Motor Position, Warm With No A/C	ISWNAC
4	Manifold Absolute Pressure	MAPP
5	IAC Drive Motor Position, Warm With A/C	ISWWAC
6	Filtered RPM	ISES
7	Battery Voltage	ADRAT
8	FAN On Time	FAN
9	Filtered O2 Value (A/D Counts)	ADO2AFSC

Lower Switch Position Display Function Table

Position	Display Parameter	Label

0	IAC Extended Throttle Cracker With No A/C	ETCACOFF
1	Coolant Offset for IAC	ISMPTV
2	Cold Control IAC Bias For Drive	NBIASDR
3	IAC P/N Motor Position, Warm With No A/C	ISWNACP
4	IAC Desired Motor Position	ISDSMP
5	IAC P/N Motor Position, Warm With A/C	ISWWACP
6	Desired Engine Speed (RPM)	DESSPD
7	Instantaneous MPG	MPG
8	Delay Counter For P/S Crack Decay	PSTCLC
9	IAC Extended Throttle Cracker With A/C	ETCACON

21.1.3.3 Discrete Indicators

Eight discrete indicators located below the digital displays on the HUD are used to display ECM function status. The indicators are selectable between Status I and Status 2 by means of a toggle switch located to the left of the indicator lights. Each mode shall represent a group of eight discrete function indicators. The indicators individual functions are listed below. The indicators will be listed in order from left to right as they appear on the HUD. The lights will be lit if the statements are true.

Discrete Status Word Display Information (Display "A") Discrete Display of Status Word

Status #1								
	NVM	BLM	BKR	TCC	FAN	AC	PFM	ACC
	37	S6	55	54	33	32	51	50
Status #2								
	IAC	ASYNCH	LE	AE	DE	PE	CL	R

Status Word #1 Display Information

Position	Status Information
57	Non-Volatile Memory Failure
S6	BLM Cell
S5	BST Knock Reduction Activity
S4	TCC Enabled
S3	Fan
S2	Air Conditioning Request
S1	Premium Fuel Mode
S0	Air Conditioning Clutch Disabled

Status Word #2 Display Information

Position	Status Information
S7	IAC Motor Moving
S6	Asynch Pulse Mode
S5	Learn Enabled
S4	Acceleration Enrichment
S3	Decel Enleanment
S2	Power Enrichment
S1	Closed Loop Enabled
S0	Oxygen Sensor RICH

Discrete Status Word Display Information (Display "R") Discrete Display of Status Word

Status #1

	IN GEAR	FAN	FAN ANT	ISM	IPCM	ITC	SSM	ICC
	S7	S6	S5	S4	S3	S2	S1	S0
Status #2								
	FO OPT	ESC ACT	ESC TIPIN	EGR	EGR/VAC	bB	VM	R

Status Word #1 Display Information

Position	Status Information
S7	In Gear
S6	Fan On
S5	Fan Anticipated Mode
S4	IAC SAG Mode
S3	IAC PS Crank Mode
S2	IAC Throttle Crank
S1	Stall Saver Mode
S0	IAC Cold Control

Status Word #2 Display Information

Position	Status Information
S7	Fuel Determination Disable
S6	ESC Option
S5	ESC Active
S4	EGR Tipin
S3	EGR VAC Switch Closed
S2	Limit Boost 1st TM
S1	Vehicle Moving
S0	Rich O2 Sensor

21.1.3.4 Display Control

All elements of the digital display will be updated with information at the control of the ECM This is primarily at integral multiplies of the ECM major loop time to prevent display jitters. In the event the operator desires a "snap shot" of displayed digital data, the switch labeled CONT/HOLD is used.

21.1.4 Analog Recording

The IM provides interface to the D/A module which has eight channels of analog data for strip chart recording purposes. Data from the ECM is selectable from the hand held 0/A unit and directed to any one of the eight analog output channels. These analog signals are Output via BNC connectors mounted on the 0/A chassis. The analog output has the following electrical characteristics:

Range	0 to 5 volts
Bandwidth	100 cycles/second
Resolution	19.6 mV/bit

21.1.4.1 Recording Channel/Parameter Selection

To enable the 0/A to update a channel, the thumbwheel selector switch should be moved to channel eight and address 5000 entered by rotating the address thumb wheel selector switches to 5000 and pushing the enter button.

If a scaling PROM has been installed in the D/A main frame the ootioo exists of outputting the specific parameters listed in Table 1.4.2. This is done by switching the left most toggle switch to "Scaling PROM" then entering the desired channel output (0-7) and desired parameter channel numbers in the address windows. Always hit the enter button for each channel used after entering channel number and parameter channel.

When other parameters are wanted to be viewed switch the channel to desired Output number and enter address in the address section, hit enter. With channel 7 any address may be output (0000-FFFF) channels 0-6 are limited to the first 2K block. Be sure to set the left most switch to 1 Byte or 2 Byte depending on the parameter wanted when in this mode.

21.1.4.2 Parameter Selection for HUD Meter Viewing

The two digit decimal thumb wheel selector switch assembly on the HUD specifies one of 41 parameters within the ECM function for viewing on the HUD analog meter. Listed below are the available parameters and corresponding channel numbers.

Analog Channel Assignments

Block	Parameter	Min. Scale	Max. Scale
0	Spark Advance	10 Deg.	60 Deg.
1	Barometric Pressure	0 KPa	105 kPa
2	Coolant Temperature	-40 Deg.	152 Deg.
3	Oxygen Sensor Voltage	0 mV	999 mV
4	Volumetric Efficiency	0 Counts	255 Counts
5	Data Change-Slew Value	--	--
6	RAM Address-Slew Value	--	--
7	Vehicle Road Speed (MPH)	--	--
8	A/F or BPW Slew Value	0	25.5
9	Block Learn Multiplier	0 Counts	255 Counts
10	Spark Advance Slew Value	0 Deg.	90 Deg.
11	Not Used		
12	Closed Loop Integrator	0 Counts	255 Counts
13	Block Learn Cell 0 Counts	12 Counts	
14	IAC OMP Slew Value	0 Counts	255 Counts
15	Base Pulse Width	0 mSec	0 mSec

Analog Channel Assignments (Continued)

Block	Parameter	Min. Scale	Max. Scale
16	IMMW3 (Octal)	--	--
17	TPS Load	0%	100%
18	Air/Fuel Ratio	0 A/F	25.5 A/F
19	Battery Voltage	0V	25.5V
20	INNW1	0V	25.5V
21	IMMW2		
22	RPM	0 RPM	5400 RPM
23	Manifold Absolute Pressure	10.35KPa	104.4KPa
24	Closed Loop Correction	--	--

25	IAC Present Motor Position		
26	Not Used		
27	Not Used		
28	Not Used		
29	Not Used		
30	Vehicle Road Speed (MPH)	0 KPH	200 KPH
31	Base Pulse Width	0 msec	100 msec
32	IMMW1B		
33	IMMW2B		
34	RPM	0 RPM	3200 RPM
35	RPM (Filtered)	0 RPM	1600 RPM
36	Base Pulse Width	0 msec	200 msec
37	IAC Present Motor Position	0 Counts	200 Counts
38	Manifold Air Temperature	-40 Deg.	152 Deg.
39	A.E. Delta MAP	0 kPa	100 kPa
40	A.E. Delta Throttle	0%	100%
41	D.E. Delta MAP	0 kPa	100 kPa
42	D.E. Delta Throttle	0%	100%
43	N/V Ratio for Shift Light	0 Ratio	144 RA
44-100	Not Used		

Since the introduction of the 0/A module, the single-digit decimal thumb wheel selector has no control over the Analog Output Channels. No matter what channel (1-5) the thumb-wheel is on you may only view on the analog meter on the HUD one of the variables listed above. The variables for viewing are still selected by the parameter selection switches.

21.1.5 ECM Function Modification

A group of eight control switches provide ECM function modification during operation. This function requires ECM functional requirements not covered by this specification.

21.1.5.1 Spark Change

The spark advance angle can be modifiable by the IM

When the bottom digital display selector switch is positioned to "spark advance change", a value is displayed which can be incremented or decremented in a continuous manner by the slew switch under the "spark" label. This value will be either combined with the ECM computed value or substituted for the ECM computed value based upon a front panel control switch labeled "ABS/NORM/MOD" under the "spark" label.

21.1.5.2 Air/Fuel Ratio Change

The air/fuel ratio can be modifiable by the IM

When the top digital display selector switch is positioned to "A/F change", a value is displayed which can be incremented or decremented in a continuous manner by the slew switch labeled "air fuel/Function A". This value will then either be combined with the ECM computed value, or substituted for the ECM computed value based upon a front panel control switch labeled "ABS/NORM/MOD" under the "Air Fuel/Function A" labeled region.

21.1.5.3 IAC Motor Position Change

The idle air control motor position can be controlled directly by the IM

When the bottom digital display selector switch is positioned to the "IAC change" position, a value is displayed which can be incremented or decremented in a continuous manner by the slew switch labeled "idle speed/Function B". This value will then either be combined with the ECM computed value, or substituted for the ECM computed value based upon a front panel control switch labeled "ABS/NORM/MOD" under the "idle speed/Function B'" labeled region.

When a negative value is placed in the slew and the ABS mode selected, an IAC Motor Reset will be performed.

21.1.5.4 RAM Address Change (Function B)

The IM has the capability to display the contents of each ECM RAM cell. Thi3 is accomplished by placing the top digital display selector switch in the "RAM address" position and the bottom digital display selector switch im the "RAM contents'" position. The selector switch under the "Function B" heading must also be in the "B" position.

The RAM address may then be incremented or decremented by using the "Function B slew" switch, and the RAM contents can be observed in the bottom right-hand digital display.

21.1.6 IM Subroutines

Software routines in the ECM program which are dedicated to supporting the IM are written in the form of subroutines and located in EPROM’s physically located in the GBAM hardware. In operation, the ECM will perform a test at power-up initialization to determine if an IM is present. If the test is positive, the ECM will transfer program control to the IM subroutines in the IM at appropriate times to perform IM functions. The purpose of this feature is to minimize the IM software overhead in production programs.

21.1.7 Miscellaneous Controls

The functional controller of the IM will be reset by the "RESET" switch independent of the ECM controller. The reset state will enable all display segments and status bits as well as turning on the HUD fail indicator.

21.1.8 Environmental Considerations

Normal operating temperature of the IM is 40°C to 85°C. This constraint is imposed because of operating temperature characteristics of the EPROM memory modules.

22 Calibration Parameter Summary

Sorry, that section is not available