

SERVICE TRAINING COURSE 881 V6 / V8 ENGINE MANAGEMENT



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***INSERT TAB FOR AJ26/AJ27
ENGINE MANAGEMENT
SECTION HERE***

AJ26 / AJ27 ENGINE MANAGEMENT SYSTEMS



- 1 AJ26 / AJ27 OVERVIEW**
- 2 CONTROL SUMMARIES
- 3 ENGINE CONTROL MODULES
- 4 EMS PRIMARY SENSING COMPONENTS
- 5 INDUCTION AIR THROTTLE CONTROL
- 6 FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL
- 7 FUEL INJECTION
- 8 IGNITION
- 9 VARIABLE VALVE TIMING
- 10 EXHAUST GAS RECIRCULATION (EGR): NORMALLY ASPIRATED
- 11 OTHER ECM ENGINE CONTROL AND INTERFACE FUNCTIONS
- 12 AJ26 / AJ27 SUPERCHARGED EMS
- 13 TASK SHEETS



AJ26 / AJ27 Engine Management Acronyms and Abbreviations:

A	'A' Bank (Bank 1)
AACV	Air Assist Control Valve
AAI	Air Assist Fuel Injection
A/C	Air Conditioning
A/CCM	Air Conditioning Control Module
AFR	Air : Fuel Ratio
B	'B' Bank (Bank 2)
BARO	Barometric Pressure (Sensor)
BTDC	Before Top Dead Center
CAN	Controller Area Network
CCV	Canister Close Valve
CKP(S)	Crankshaft Position (Sensor)
CMP(S)	Camshaft Position (Sensor)
DLC	Data Link Connector
DTC	Diagnostic Trouble Code
ECM	Engine Control Module
ECT(S)	Engine Coolant Temperature (Sensor)
EEPROM	Erasable Electronically Programmable Read-Only Memory
EGR	Exhaust Gas Recirculation
EMS	Engine Management System
EOT(S)	Engine Oil Temperature (Sensor)
EVAP	Evaporative Emission Control
FI	Fuel Injection
FP1	Fuel pump 1
FP2	Fuel pump 2
FTP(S)	Fuel Tank Pressure (Sensor)
HC	Hydrocarbon
HO2(S)	Exhaust Gas Heated Oxygen (Sensor)
IAT(S)	Intake Air Temperature (Sensor)
IAT2	Intake air temperature 2 (charge air temperature)
IATS2	Intake air temperature (Sensor) 2 (charge air temperature sensor)
KS	Knock Sensor
LED	Light Emitting Diode
LEV	Low Emissions Vehicle

NOTES

MAF(S)	Mass Air Flow (Sensor)
MAP(S)	Manifold Absolute Pressure (Sensor)
MIL	Malfunction Indicator Lamp
N/A	Normally Aspirated
NOx	Nitrous Oxide
NTC	Negative Temperature Coefficient
O2(S)	Exhaust Gas Oxygen (Sensor)
OBD	On-Board Diagnostics
ORVR	On-Board Refueling Vapor Recovery
PP(S)	Pedal Position (Sensor)
PWM	Pulse Width Modulated
RAM	Random Access Memory
ROM	Read Only Memory
SC	Supercharged
SCP	Standard Corporate Protocol Network
TCM	Transmission Control Module
TP(S)	Throttle Position (Sensor)
VVT	Variable Valve Timing
WOT	Wide Open Throttle

Measurement Values:

B+	Battery voltage
Hz	Hertz (cycles per second)
km/h	Kilometers per hour
mph	Miles per hour
ms	Milliseconds
rpm	Revolutions per minute
V	Voltage
°C	Degrees Celsius
°F	Degrees Fahrenheit
Ω	Ohms (resistance)
>	Greater than
<	Less than
bar	Unit of absolute pressure
in. hg.	Unit of absolute pressure (inches of mercury)

NOTES

AJ26 / AJ27 EMS OVERVIEW

The AJ26 engine management system was designed for the introduction of the V8 engine to the Jaguar range of vehicles starting with the 1997 model year XK8. A supercharged version was added for 1998 model year.

The AJ27 engine management system is a further development of the AJ26 system designed to meet more stringent emission control standards and enhance engine performance. The naturally aspirated AJ27 system was introduced for the 1999 model year; the supercharged AJ27 system was introduced for the 2000 model year.

System application is as follows:

Engine Management System	Model Year	Models
AJ26	1997	XK N/A
	1998	XK & XJ N/A
	1999	XJR (SC)
AJ27	1999	XK & XJ N/A
	2000	XK & XJ N/A and SC
	2001	XK & XJ N/A and SC
	2002	XK & XJ N/A and SC

Both systems are built around a two-microprocessor based Engine Control Module (ECM). The ECM is linked to and communicates with other powertrain control modules and other vehicle systems via the Controller Area Network (CAN).

The ECM governs all engine operating functions including:

- Air induction via an electronically controlled throttle
- Fuel delivery
- Sequential fuel injection
- Ignition via on-plug ignition coils
- Idle speed control
- Exhaust emission control
- Evaporative emission control
- Intake valve timing
- Exhaust gas recirculation (certain variants only)
- Cooling system radiator fan control
- Air conditioning compressor control
- Cruise control
- Engine speed limiting
- Engine torque reduction to aid transmission shift quality and enhance traction / stability control
- EMS and OBD II diagnostics
- Default operating modes including engine speed and throttle limits

NOTES

System Variant Summary (North America specification vehicles):

FUNCTION	AJ26 N/A	AJ26 SC	AJ27 N/A	AJ27 SC
Electronically controlled throttle <ul style="list-style-type: none"> Electronically controlled throttle with mechanical guard Full authority electronically controlled throttle 	X	X	X	X
Variable valve timing <ul style="list-style-type: none"> Two position variable intake valve timing Linear variable intake valve timing 	X		X	
Exhaust gas recirculation	X *	X		X
Oxygen sensors <ul style="list-style-type: none"> Upstream HO2S; downstream O2S Upstream Universal HO2S; downstream HO2S 	X	X	X	X
Ignition coils <ul style="list-style-type: none"> A Bank / B Bank ignition coil modules Individual integral ignition coil modules 	X	X	X	X
Security engine management immobilization	X **	X	X	X
On-board refueling vapor recovery	X ***	X	X ***	X
Air assisted fuel injection			X	
DTC memory <ul style="list-style-type: none"> DTCs and system adaptations stored in volatile memory DTCs and system adaptations stored in non-volatile memory 	X	X	X	X

* Early production only. EGR deleted on normally aspirated engine as a running change during 1997.

** Key transponder security input and diagnostic introduced for 1998 model year.

*** On-board refueling vapor recovery (ORVR) introduced for 1998 model year XJ8, 1999 model year XK8.

NOTES

AJ26 / AJ27 EMS OVERVIEW

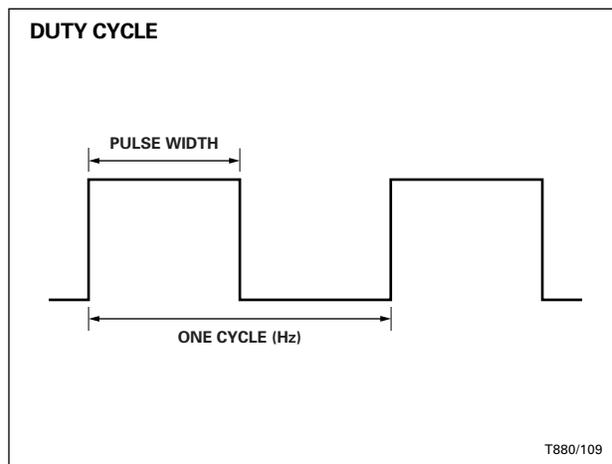
PWM (Pulse Width Modulated) Control

Pulse width modulated control is an electronic means of switching a control signal ON/OFF to a control device such as a hydraulic pressure control solenoid so that it can be positioned as necessary to achieve a required hydraulic pressure.

In order for the solenoid to be positioned somewhere between fully closed and fully open to achieve the required hydraulic pressure, the control signal to the solenoid must be controlled in a way that allows infinite positioning between closed / open.

Frequency

With pulse width modulation, the control signal to the solenoid is switched ON and OFF very quickly at a frequency (cycles per second) normally expressed in Hertz (Hz). An average frequency for automotive application is approximately 300 Hz.



Duty cycle

The length of time the control signal is switched ON during each cycle (pulse width) is varied by the control module and referred to as the duty cycle, normally expressed as a ratio percentage between 0 and 100. The duty cycle will determine the position of the solenoid because the solenoid cannot follow the rapid on / off control signal and assumes a position between the limits of travel proportional to the duty cycle.

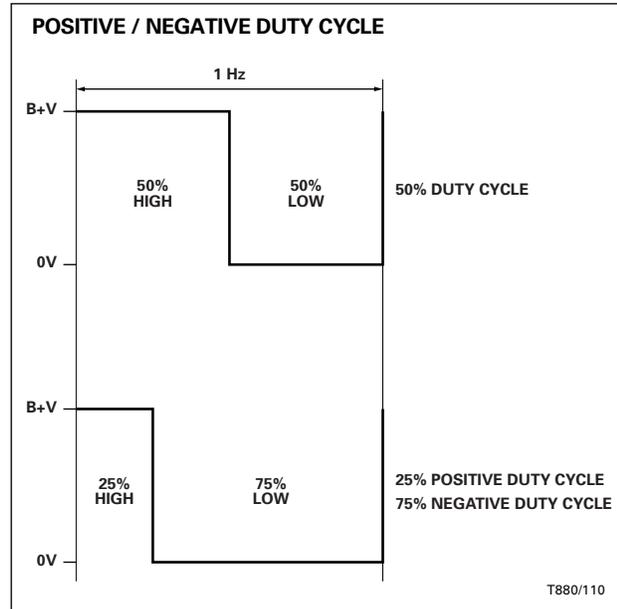
Pulse width

Only the pulse width is varied by the control module. The frequency usually remains fixed with PWM controlled devices.

NOTES

Positive / Negative Duty Cycle

The control signal can be either a power supply or ground. If the control signal is a power supply, the duty cycle is determined as the high voltage pulse (positive pulse). If the control signal is a ground, the duty cycle is determined as the zero voltage pulse (negative pulse). Before measuring or monitoring a PWM signal, first determine if the signal should be a positive or negative duty cycle.



NOTES

AJ26 / AJ27 ENGINE MANAGEMENT SYSTEMS



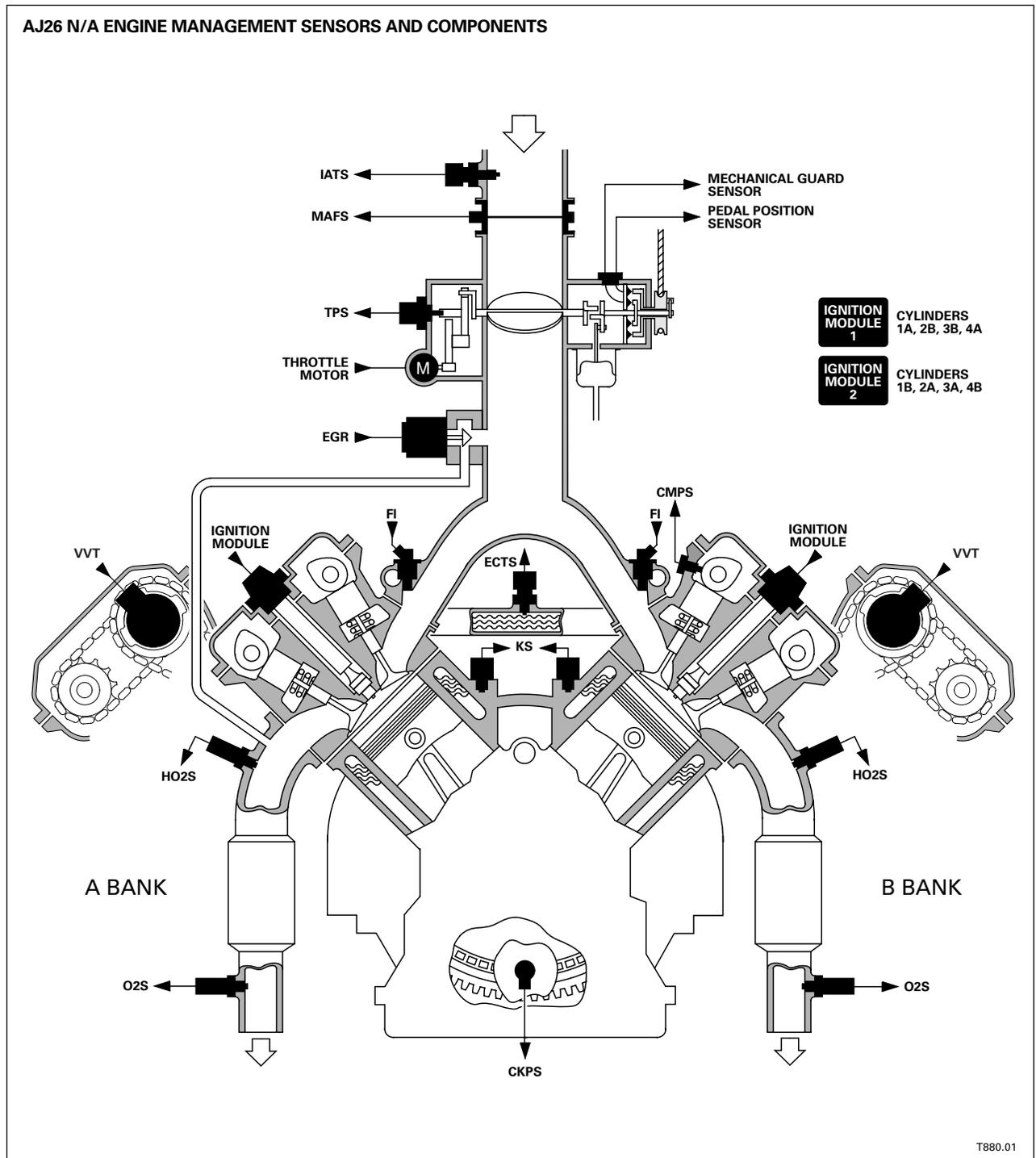
- 1 AJ26 / AJ27 OVERVIEW
- 2 **CONTROL SUMMARIES**
- 3 ENGINE CONTROL MODULES
- 4 EMS PRIMARY SENSING COMPONENTS
- 5 INDUCTION AIR THROTTLE CONTROL
- 6 FUEL DELIVERY AND
EVAPORATIVE EMISSION CONTROL
- 7 FUEL INJECTION
- 8 IGNITION
- 9 VARIABLE VALVE TIMING
- 10 EXHAUST GAS RECIRCULATION (EGR):
NORMALLY ASPIRATED
- 11 OTHER ECM ENGINE CONTROL AND
INTERFACE FUNCTIONS
- 12 AJ26 / AJ27 SUPERCHARGED EMS
- 13 TASK SHEETS



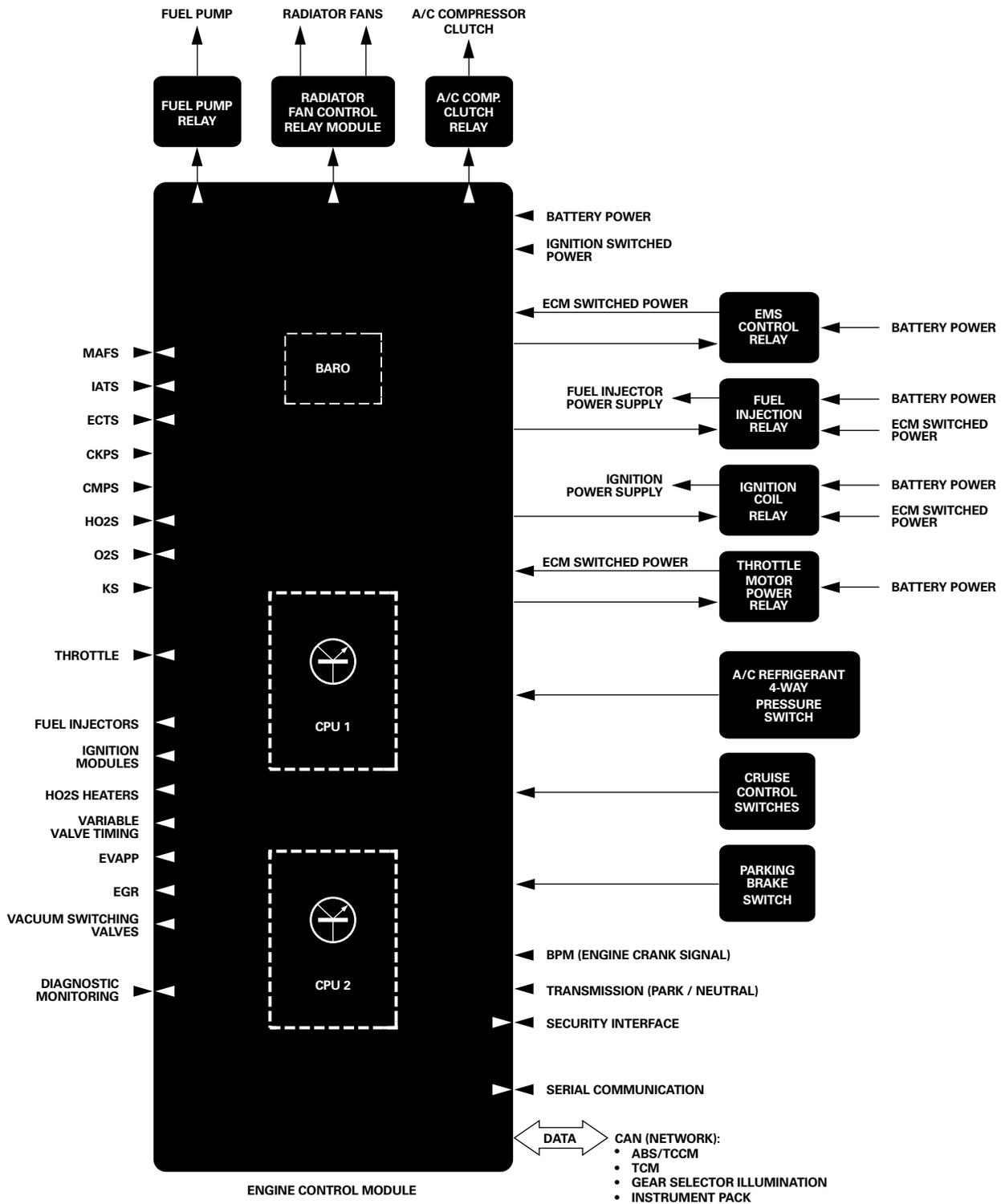
CONTROL SUMMARIES

The AJ26 and AJ27 engine management systems are comprehensive engine control systems that allow complete electronic control over all engine functions. The following eight pages provide control summaries for the four system variants. Specific pin-out data can be found in the applicable Electrical Guide.

System Logic: AJ26 N/A



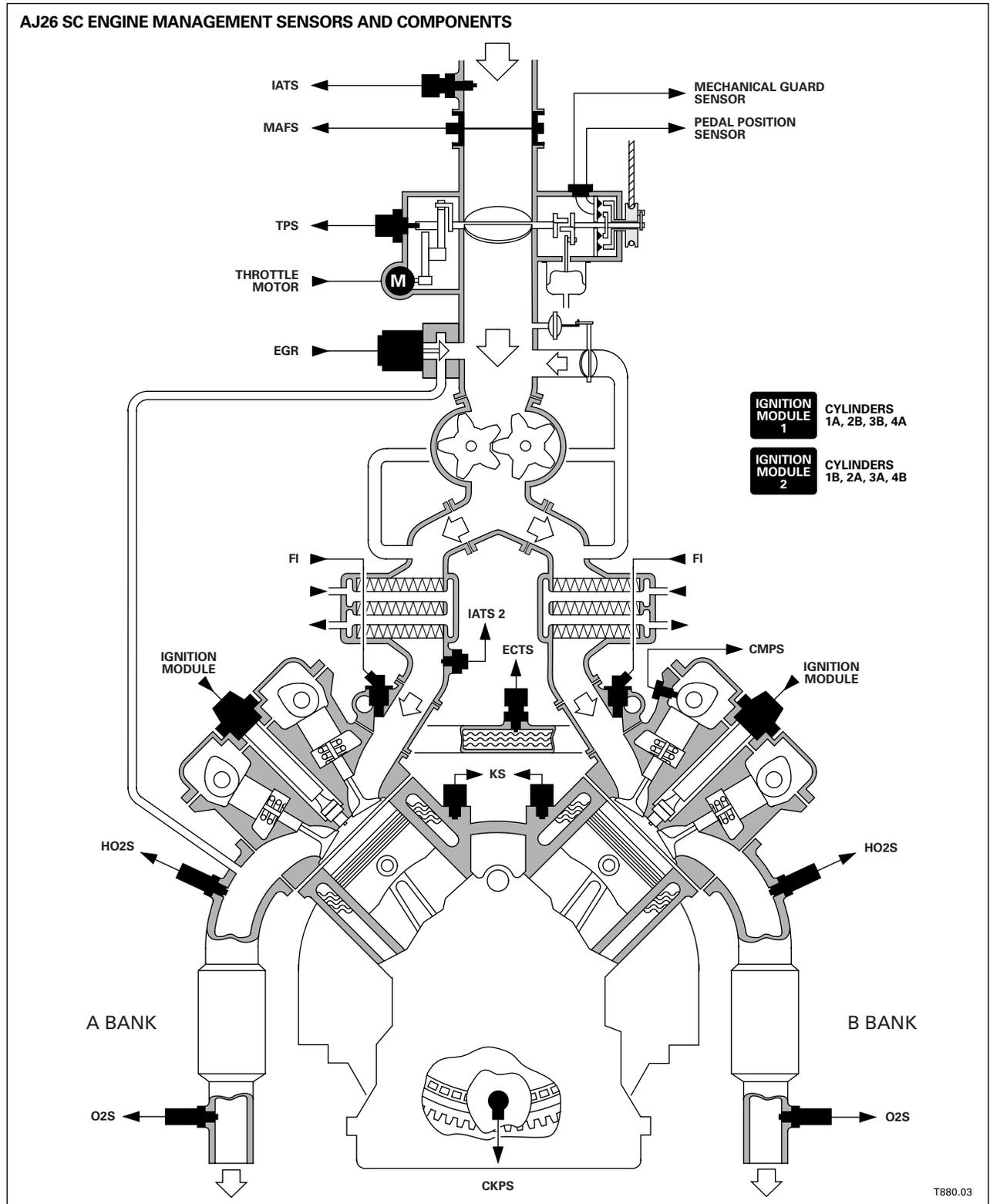
AJ26 N/A ENGINE MANAGEMENT INPUTS / OUTPUTS



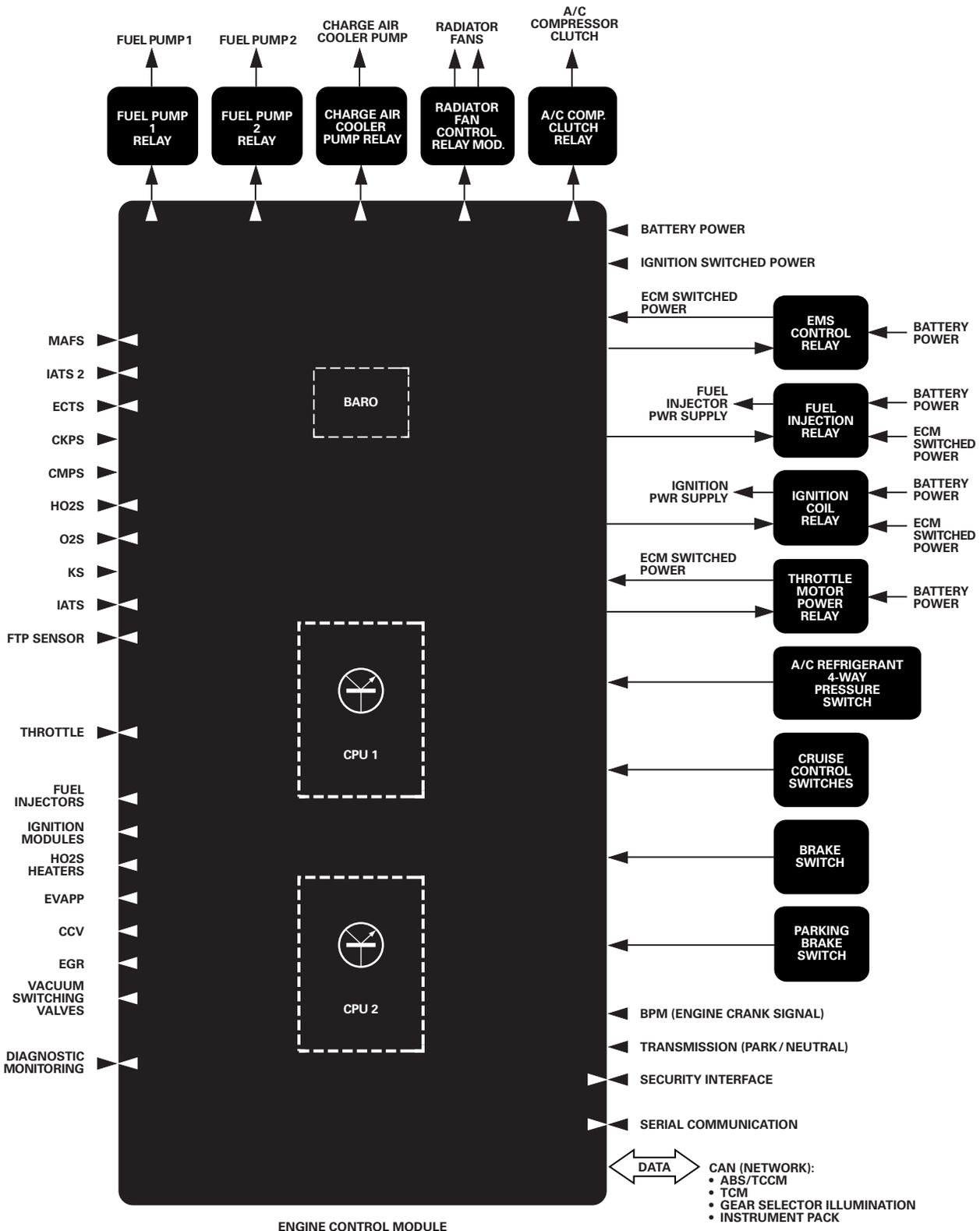
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CONTROL SUMMARIES

System Logic: AJ26 SC



AJ26 SC ENGINE MANAGEMENT INPUTS / OUTPUTS

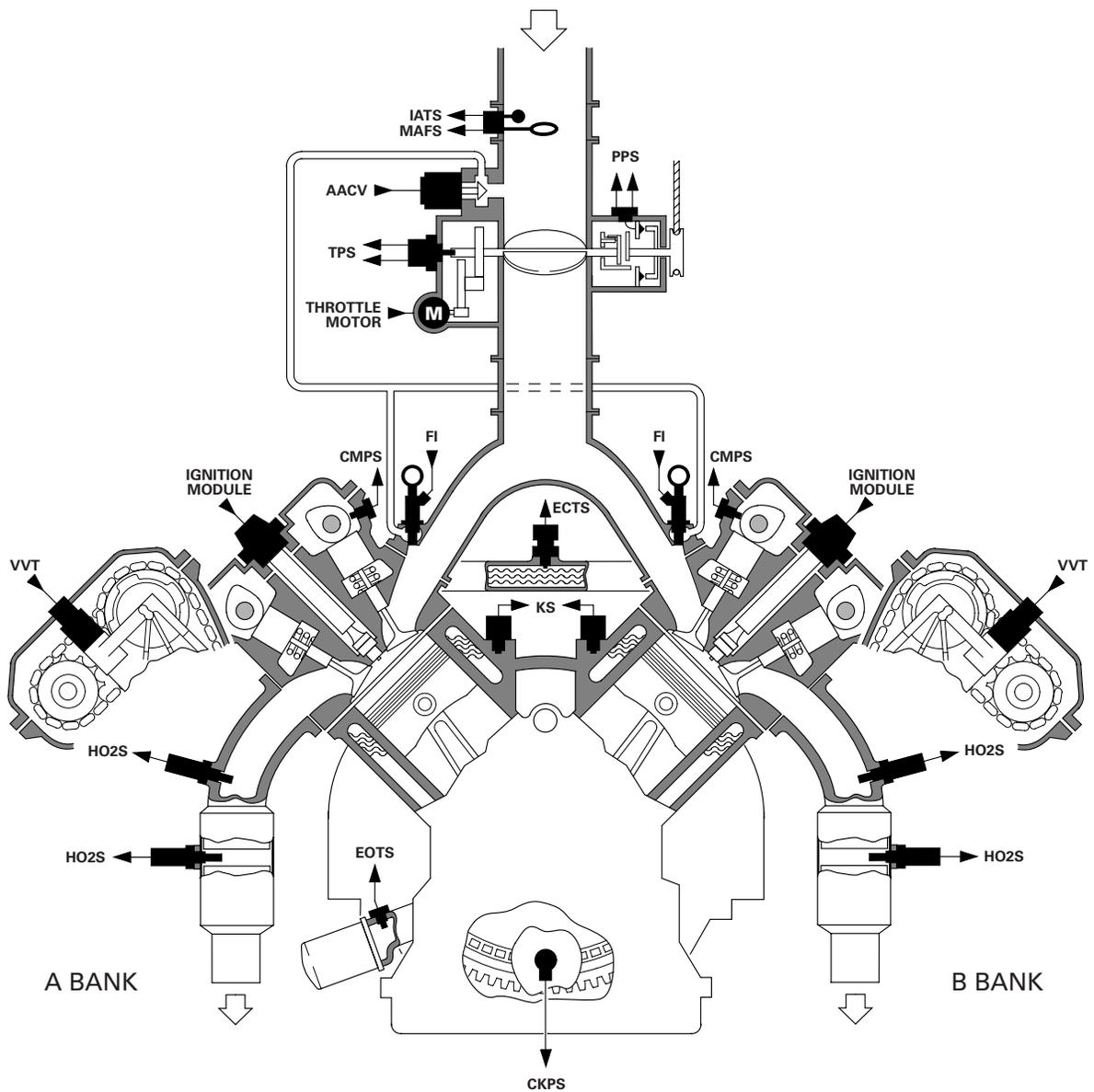


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CONTROL SUMMARIES

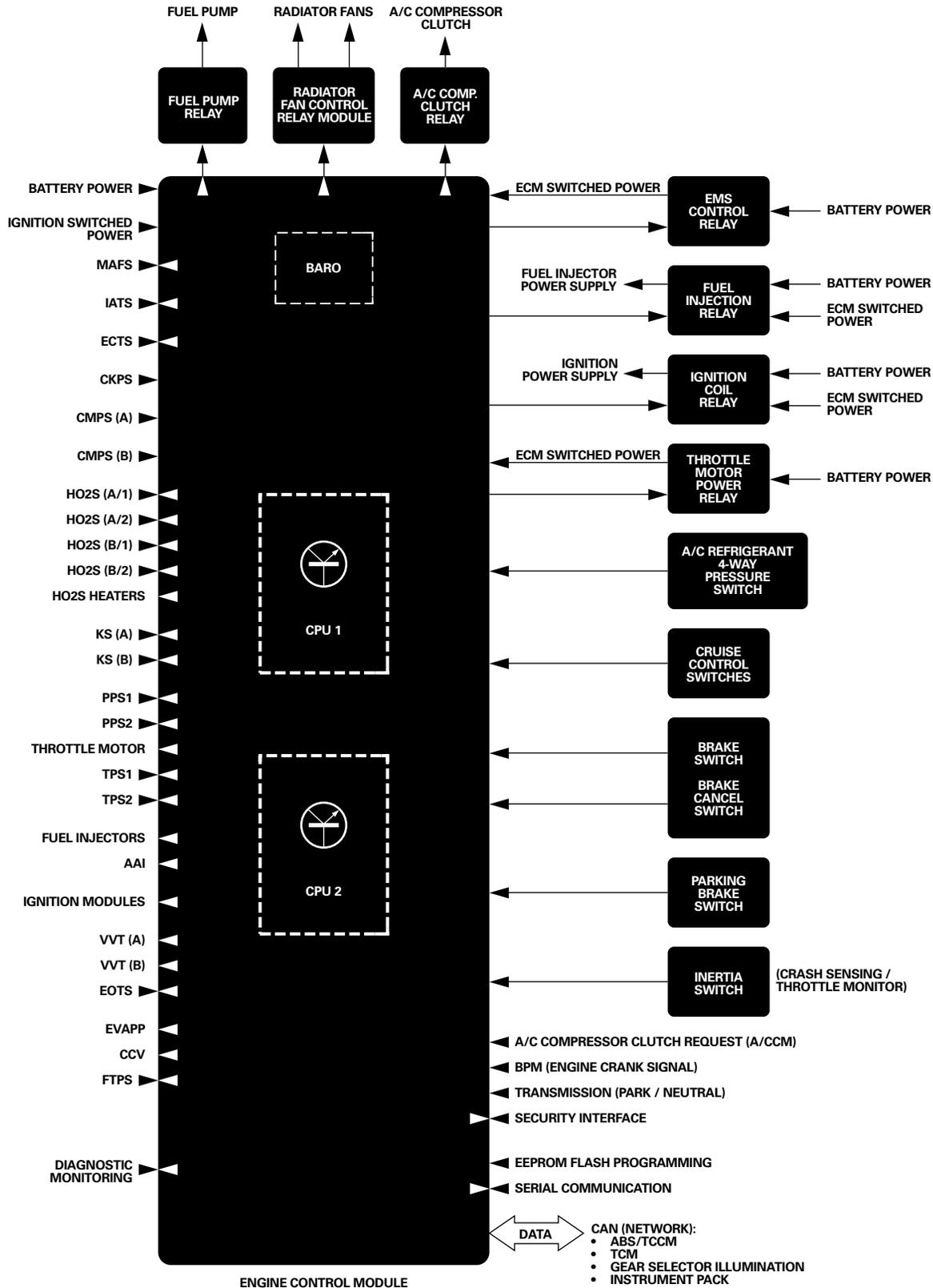
System Logic: AJ27 N/A

AJ27 N/A ENGINE MANAGEMENT SENSORS AND COMPONENTS



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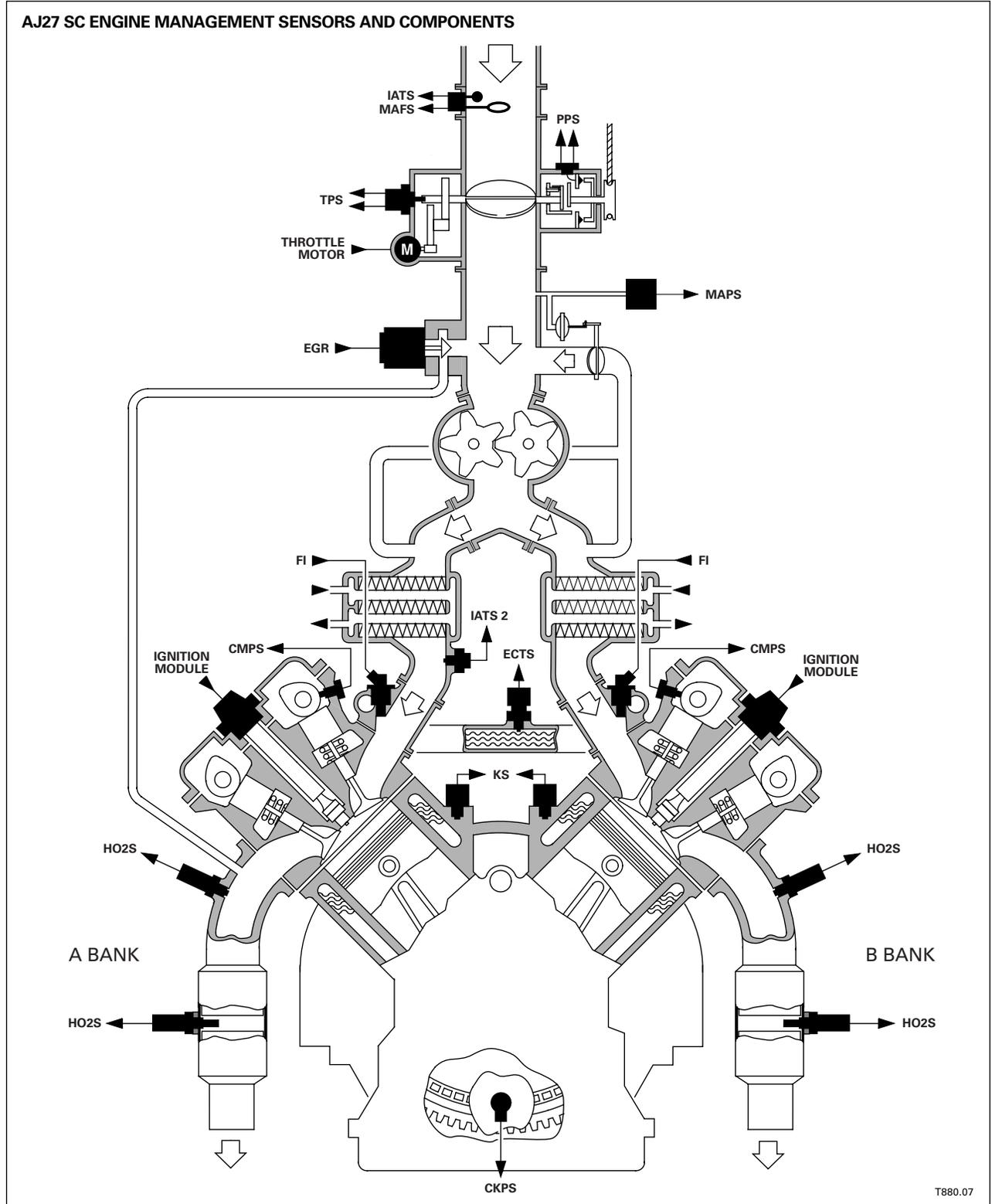
AJ27 N/A ENGINE MANAGEMENT INPUTS / OUTPUTS



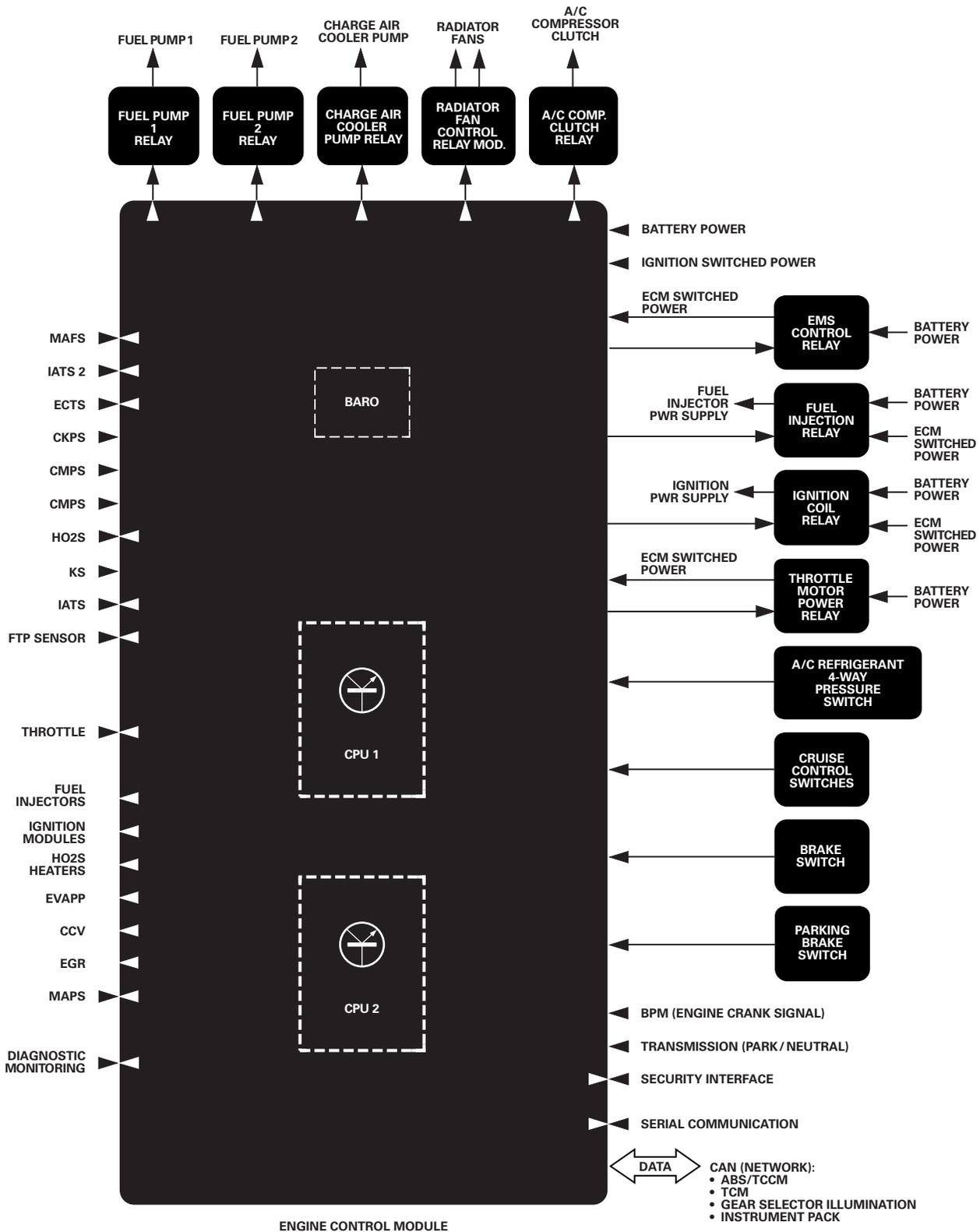
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CONTROL SUMMARIES

System Logic: AJ27 SC



AJ27 SC ENGINE MANAGEMENT INPUTS / OUTPUTS



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AJ26 / AJ27 ENGINE MANAGEMENT SYSTEMS

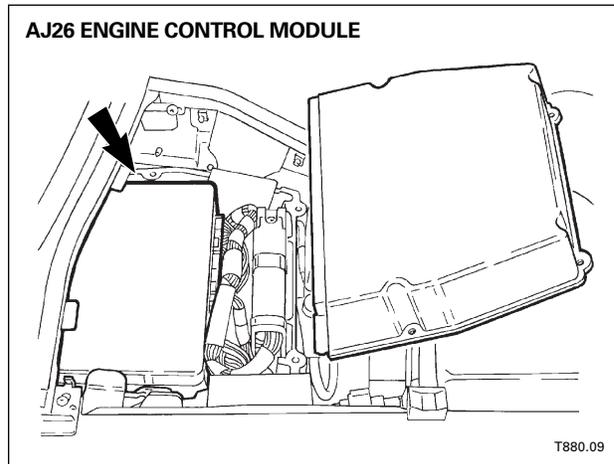


- 1 AJ26 / AJ27 OVERVIEW
- 2 CONTROL SUMMARIES
- 3 ENGINE CONTROL MODULES**
- 4 EMS PRIMARY SENSING COMPONENTS
- 5 INDUCTION AIR THROTTLE CONTROL
- 6 FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL
- 7 FUEL INJECTION
- 8 IGNITION
- 9 VARIABLE VALVE TIMING
- 10 EXHAUST GAS RECIRCULATION (EGR): NORMALLY ASPIRATED
- 11 OTHER ECM ENGINE CONTROL AND INTERFACE FUNCTIONS
- 12 AJ26 / AJ27 SUPERCHARGED EMS
- 13 TASK SHEETS



ENGINE CONTROL MODULES

AJ26 Engine Control Module



The two-microprocessor ECM is located in the engine compartment right hand control module enclosure (cool box).

All XK8 vehicles, and XJ8 Supercharged vehicles incorporate a cooling fan in the right hand control module enclosure. The cooling fan is operated continuously while the ECM is active from an ECM controlled power supply.

Volatile memory Quiescent current from the vehicle battery is used to keep the ECM random access memory (RAM) active so that OBD generated DTCs and adaptive values are maintained. If the vehicle battery is disconnected, the ECM will “relearn” adaptive values during the next driving cycle.

The ECM has several adaptive learning functions, including:

- Closed loop fuel metering
- Closed loop throttle control
- Idle speed
- Long term fuel metering feedback correction

Nonvolatile memory A nonvolatile memory stores the vehicle identification number (VIN).

Barometric Pressure Sensing

A barometric pressure sensor (BARO) is incorporated into the ECM. The BARO input is used for fuel metering barometric pressure correction. In addition, certain diagnostic monitoring is inhibited at high elevation. The BARO cannot be replaced separately.

ECM Default Action(s)

Most detected faults are accompanied by an ECM default action. In instances where the driver will notice a difference in vehicle performance and/or the vehicle requires fault correction, visual indication is displayed on the instrument pack. The indicators include: the general warnings – RED and AMBER MILs, the CHECK ENGINE MIL, and the message display. Specific ECM default action(s) are included with each DTC listed in the applicable DTC Summaries book section.

ECM Cooling

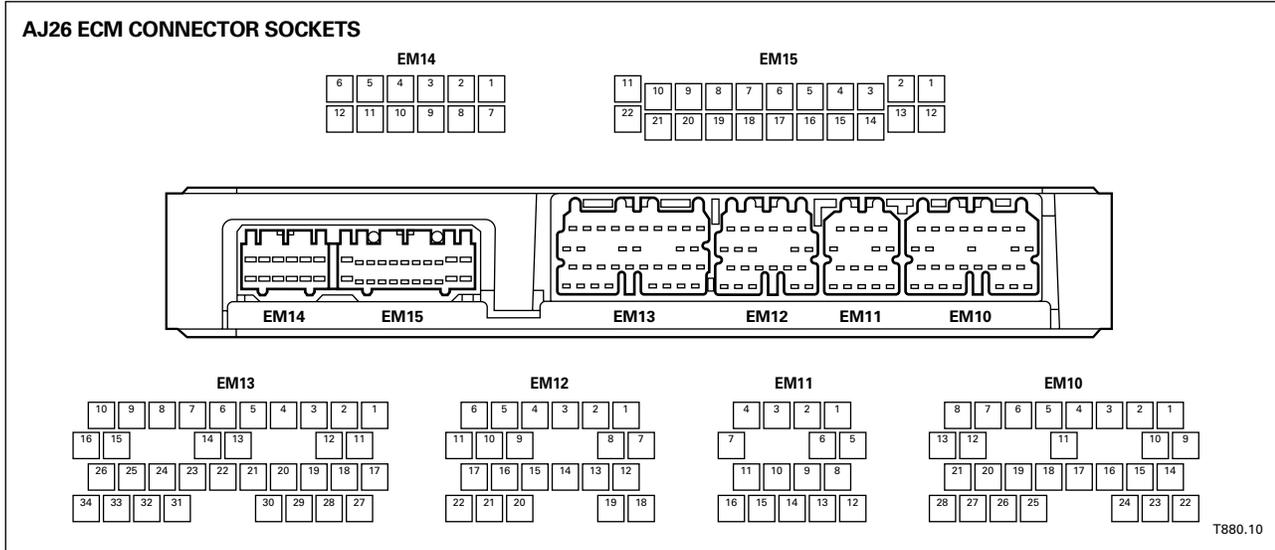
A fan is used to cool the ECM and the TCM. To prevent ECM overheating and subsequent degrading of performance, this fan, located in the control module enclosure, operates at all times when the ignition is switched ON and circulates air from the passenger compartment through the “cool box”.

ECM Electrical Connection

The ECM connects to the engine management harness via six multi-pin connectors. The applicable Electrical Guide shows the connector pin / wire color codes for the particular variant.

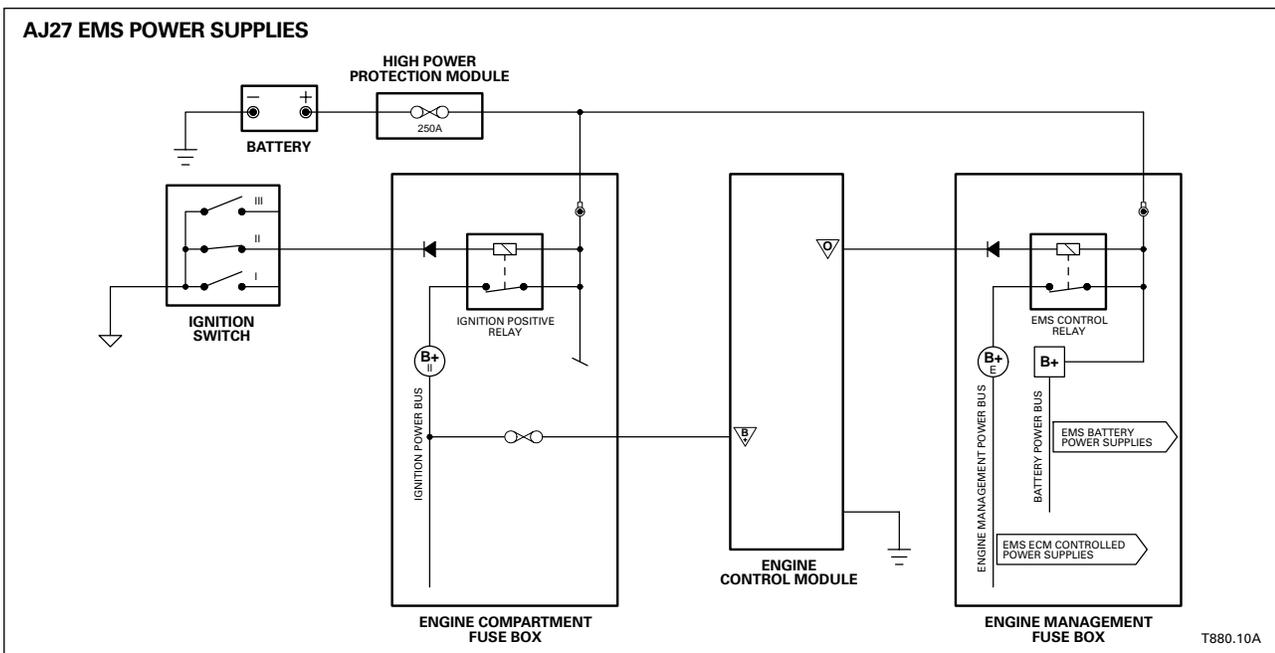


AJ26 / AJ27 ENGINE MANAGEMENT SYSTEMS



EMS Power Supplies

Engine management and transmission control module power supplies flow through the engine management fuse box located in the engine compartment. The engine management power bus is controlled by the ECM via the EMS control relay located in the fuse box. When the ignition is switched to position II, the ECM completes the relay coil circuit to ground to power the bus. When the ignition is switched OFF, the ECM will continue to activate the EMS control relay for a period of four seconds minimum to five minutes maximum. The power supplied during this period allows the ECM to complete diagnostics, perform closed throttle adaptations, close the EGR valve (if fitted), and operate the radiator fans. Refer to the applicable Electrical Guide for relay and fuse box locations



ENGINE CONTROL MODULES

AJ26 Engine Control Module (continued)

ECM “Limiting” Control

The ECM performs “limiting” functions to achieve refinement, aid in vehicle control, and to protect certain components from damage. The table summarizes how the ECM implements “limiting” control.

Function	ECM Intervention			ECM Control
	Throttle	Fuel Injection	Ignition	
Engine overspeed protection		X		Engine speed limited to 7100 rpm.
Engine default speed		X		Engine speed limited to 3000 rpm.
Engine power limiting	X			Throttle valve opening limited to 18° maximum – when TCM detects a transmission fault or when reverse gear is selected.
Vehicle speed limiting	X			Vehicle speed limited to 155 mph (248 km/h).
Traction / Stability control	X	X	X	Engine torque momentarily reduced for traction / stability control.
Shift energy management			X	Engine torque momentarily reduced to enhance transmission shift quality.

Engine overspeed protection

The ECM limits engine speed for overspeed protection by canceling fuel injection at 7100 rpm. Fuel injection is reinstated at 7050 rpm. Ignition retard is used to “smooth” the transition between fuel injection on / off / on.

Engine default speed

When the ECM detects an EMS fault that warrants a reduction in the available engine speed range, it limits the maximum engine speed to 3000 rpm. Engine default speed is limited by fuel injection intervention.

Engine power limiting

Engine power is limited in two instances – transmission faults and reverse gear selection. If the TCM detects a fault that requires engine torque reduction, it communicates with the ECM by the CAN message CAN TRANSMISSION OVERLOAD. In response, the ECM limits engine power by limiting the throttle valve opening to 18° maximum in all forward gears. Normal throttle operation is reinstated when the CAN message is no longer communicated by the TCM.

As REVERSE gear is selected, the TCM also communicates the CAN message CAN TRANSMISSION OVERLOAD and the ECM limits engine power by limiting the throttle valve opening to 18° maximum. Normal throttle operation is reinstated when the transmission is shifted out of REVERSE and the CAN message is no longer communicated by the TCM.

NOTES

Vehicle speed limiting

The maximum vehicle speed is limited to 155 mph (248 km/h) by throttle intervention. The ECM receives vehicle speed data from the CAN message CAN VEHICLE SPEED, transmitted by the ABS/TCCM.

Traction / Stability control

The ABS/TCCM determines when engine torque reduction is necessary for traction control and/or stability control. In addition, the ABS/TCCM determines what type of engine intervention should be applied, and the amount of torque reduction required. This determination is made based on the CAN data provided by the ECM CAN message CAN TRACTION CONTROL ESTIMATED ENGINE TORQUE. Three distinct ABS/TC CAN messages can be communicated by the ABS/TCCM:

- CAN TORQUE REDUCTION THROTTLE
- CAN FAST STABILITY CONTROL RESPONSE – CYLINDER FUEL CUTOFF
- CAN FAST STABILITY CONTROL RESPONSE – IGNITION RETARD.

In response, the ECM reduces engine torque by applying intervention to throttle, fuel injection, and/or ignition. Fuel injection and ignition intervention are used to provide an instantaneous response and to smooth the transition to throttle intervention. The ECM acknowledges that torque reduction is taking place by confirming with the CAN message CAN TRACTION ACKNOWLEDGE.

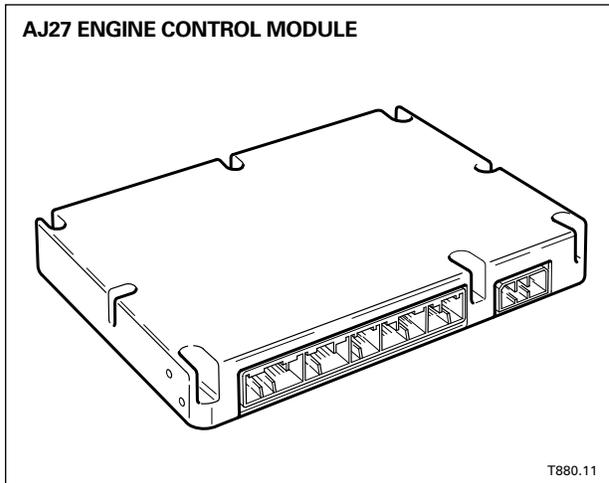
Shift energy management

Transmission shift quality is enhanced by “shift energy management”. The ECM provides engine torque data by the CAN message CAN SHIFT ENERGY MANAGEMENT ESTIMATED ENGINE TORQUE. The TCM determines the amount of torque reduction required. As gear shifts occur, the TCM communicates the CAN message CAN TORQUE REDUCTION REQUEST. The ECM responds by retarding the ignition to momentarily reduce torque.

NOTES

ENGINE CONTROL MODULES

AJ27 Engine Control Module



The AJ27 ECM incorporates two microprocessors (CPU) with increased processing power and memory capacity over the AJ26 module, and has expanded hardware to accommodate the increase in the number of system sensors and components.

Non-volatile memory OBD generated DTCs and adaptive values are stored and maintained in non-volatile memory. All stored DTCs and the adaptive values will be maintained if the vehicle battery is disconnected.

The ECM has new and revised functions as compared to AJ26. These include:

- Revised failure management modes.
- Revised traction and stability control
- Revised air conditioning interface
- Revised transmission interface
- “Black box, flight recorder” / Inertia switch monitor
- “Cool box” fan control
- Revised throttle control and cruise control operation.

AJ27 Revised Failure Management Modes

The ECM controls four failure management modes: cruise control inhibit, limp-home mode, engine shutdown mode, and power limiting mode. As with AJ26, driver warnings (CHECK ENGINE MIL, Red MIL, Amber MIL, Message) and DTCs accompany the initiation of these modes. Cruise control inhibit and engine shutdown mode remain unchanged. Specific revised ECM default actions are included with each DTC in the applicable section(s) of the DTC Summaries book.

Limp-home mode

In limp-home mode the full authority throttle is deactivated by the ECM. The throttle is then operated directly by the cable from the accelerator pedal. When the throttle limp-home lever is against the closed stop, the ECM maintains an idle speed of less than 1500 rpm (no load, Neutral / Park) by fuel injection intervention. Cruise control is inhibited.

Power limiting mode

When intake air flow cannot be controlled by the throttle (mechanical jam, large air leak), the ECM deactivates the throttle as in limp-home. Engine power is controlled by the ECM via fuel cutoff to some of the fuel injectors, disabling those cylinders. The amount of cylinder disablement is determined by the ECM from driver demand (PPS) and engine speed (CKPS).

NOTES

AJ27 Air Conditioning Interface

The radiator fan control strategy is based on the air conditioning four-way pressure switch inputs. This control strategy is applied only while the engine is running.

AJ27 Transmission Interface

Engine power limiting due to transmission control module (TCM) input occurs only when one or more of the following conditions occur:

- the transmission is in Reverse
- the transmission overload message is present (CAN)
- a gear selector fault occurs
- the TCM is not present on the CAN network

If the TCM receives the engine oil over temperature message (CAN), the transmission will hold fourth gear.

“Black Box, Flight Recorder” / Inertia Switch Monitor

The ECM records 10 seconds of throttle operational data in a “rolling” memory in the volatile battery backed RAM. The data is continuously updated and stored during engine operation. In the event of the inertia switch being tripped, an ignition switched ground is applied to ECM pin EM82-12. The ECM copies the last 10 seconds of recorded throttle data into nonvolatile EEPROM and DTC 1582 is flagged. The DTC is cleared using PDU.

“Cool box” Fan Control

On vehicles equipped with a “cool box” fan, the ECM operates the fan when the engine is running. Additionally, the fan is operated after engine shutdown as required based on operating and “heat soak” conditions.

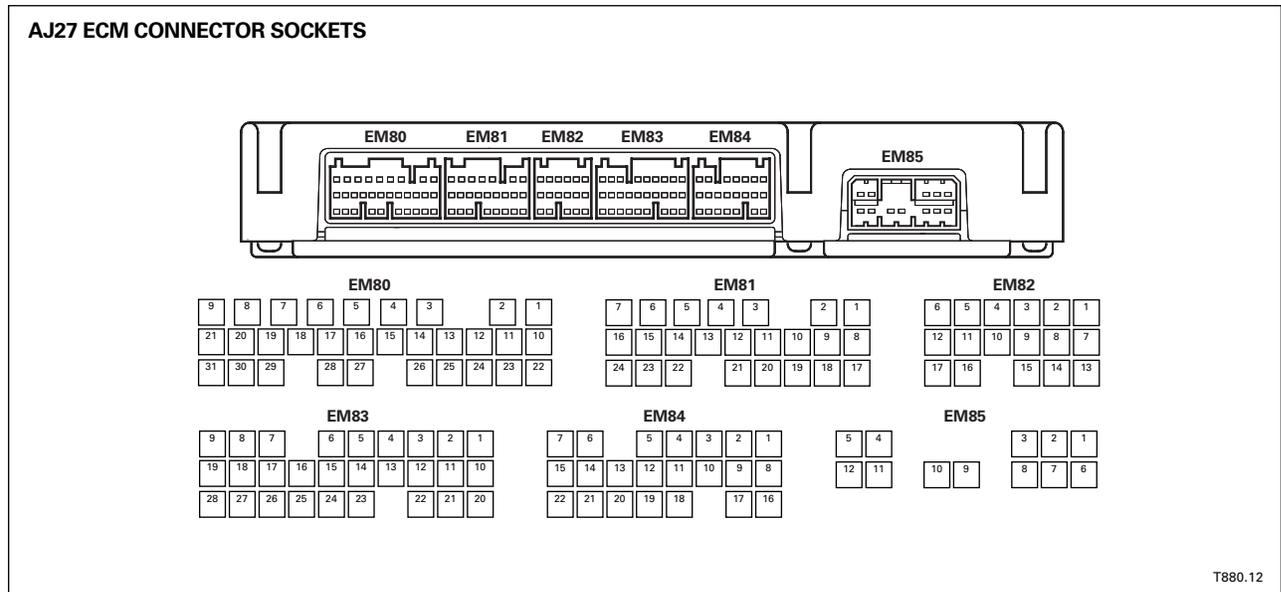
NOTES

ENGINE CONTROL MODULES

AJ27 Engine Control Module (continued)

ECM Electrical Connection

The ECM connects to the engine management harness via six multi-pin connectors. The applicable Electrical Guide shows the connector pin / wire color codes for the particular variant.



AJ26 and AJ27 ECM Service “Flash Programming”

The ECM EEPROM can be flash programmed in service using PDU via the data link connector (DLC). If such a service action is required, instructions are included in a Service Bulletin.

NOTES:

- ECMs must not be switched from one vehicle to another because the VIN will be mismatched.
- If an ECM has been replaced in service, the VIN will display as 999999.
- If a replacement ECM has not been factory programmed, a message will be displayed on the driver message center.
- The following originally equipped ECMs cannot be flash programmed in service:
 - 1998 MY XK8 VIN 020733 – 031302
 - 1998 MY XJ8 VIN 819772 – 853935
 These vehicles require a new pre-programmed replacement ECM. Refer to Technical Service Bulletins.
- Always check the VIN before carrying out ECM flash programming.

NOTES

AJ26 / AJ27 ENGINE MANAGEMENT SYSTEMS

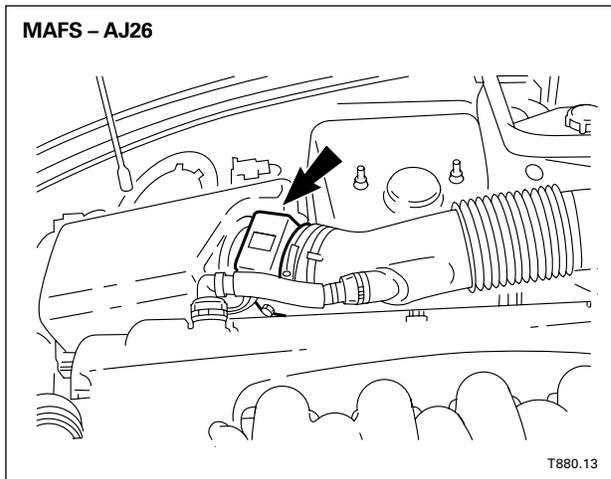


- 1 AJ26 / AJ27 OVERVIEW
- 2 CONTROL SUMMARIES
- 3 ENGINE CONTROL MODULES
- 4 **EMS PRIMARY SENSING COMPONENTS**
- 5 INDUCTION AIR THROTTLE CONTROL
- 6 FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL
- 7 FUEL INJECTION
- 8 IGNITION
- 9 VARIABLE VALVE TIMING
- 10 EXHAUST GAS RECIRCULATION (EGR): NORMALLY ASPIRATED
- 11 OTHER ECM ENGINE CONTROL AND INTERFACE FUNCTIONS
- 12 AJ26 / AJ27 SUPERCHARGED EMS
- 13 TASK SHEETS



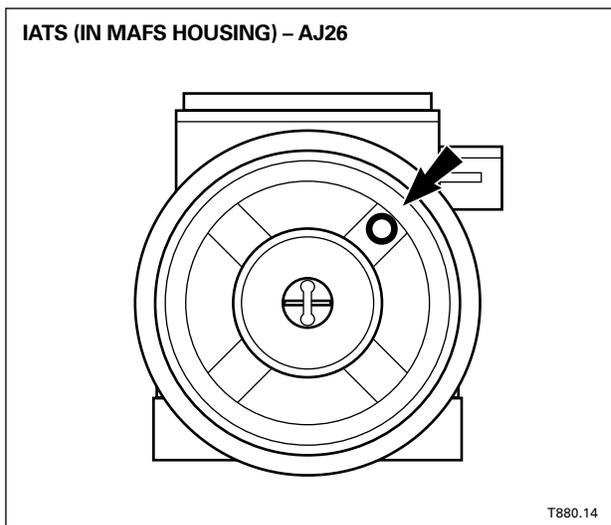
EMS PRIMARY SENSING COMPONENTS

Mass Air Flow Sensor (MAFS) – AJ26



- The MAFS, located between the air cleaner and the air intake duct, provides the ECM with an engine load input signal.
- The MAFS is a hot wire type that measures air flow volume by the cooling effect of air passing over a heated wire, altering the electrical resistance of the wire.
- The electrical resistance value is converted to an analog output voltage supplied to the ECM as a measure of air flow volume (engine load).
- 10% of the engine combustion air volume is routed over the heated wire allowing unrestricted air flow for 90% of the air.

Intake Air Temperature Sensor (IATS) – AJ26



- The IATS, located within the MAFS housing, provides the ECM with an intake air temperature signal.
- The IATS is a negative temperature coefficient (NTC) thermistor. Intake air temperature is determined by the ECM by a change in resistance within the sensor.
- The ECM applies 5 volts to the sensor and monitors the voltage drop through the thermistor.
- The IATS is not serviceable separately from the MAFS.

IATS Temperature / Resistance

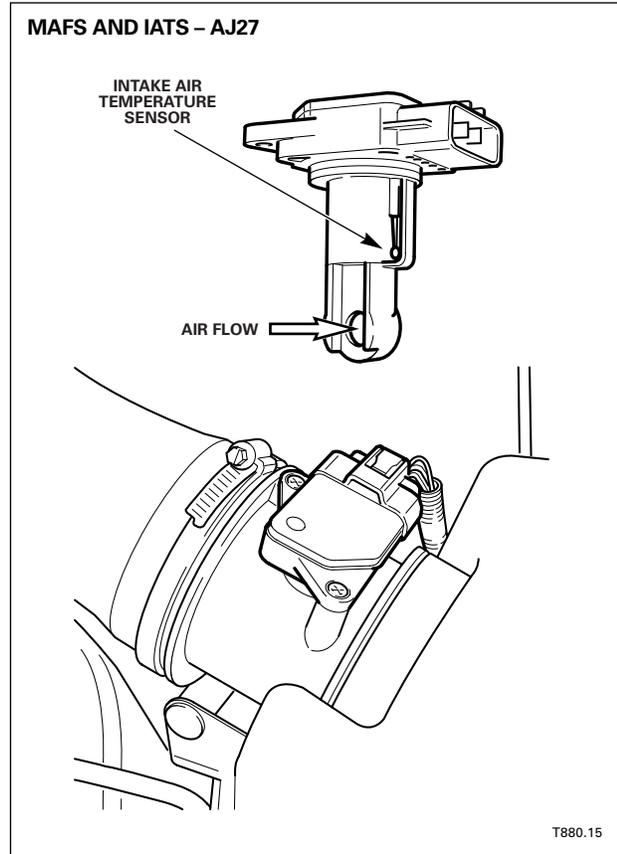
Intake air temperature		Resistance (kΩ)
°C	°F	
-20	-4	15
0	32	5.74
20	68	2.45
40	104	1.15
60	140	0.584
80	176	0.32
100	212	0.184

NOTES

Mass Air Flow and Intake Air Temperature Sensors (MAFS and IATS) – AJ27

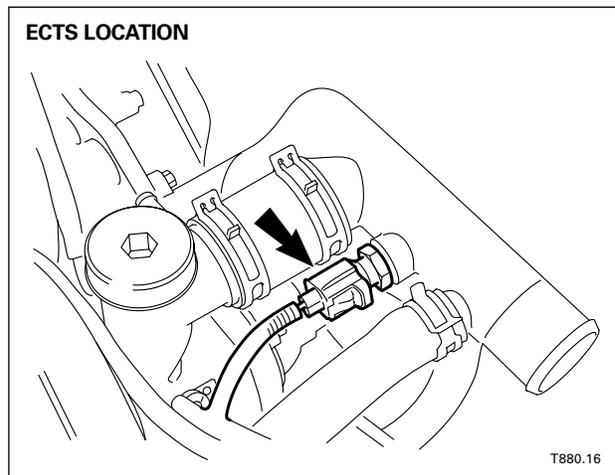
The AJ27 MAFS and IATS are combined in an integral, plug-in unit, secured by two screws to the duct. Sensor characteristics remain the same.

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EMS PRIMARY SENSING COMPONENTS

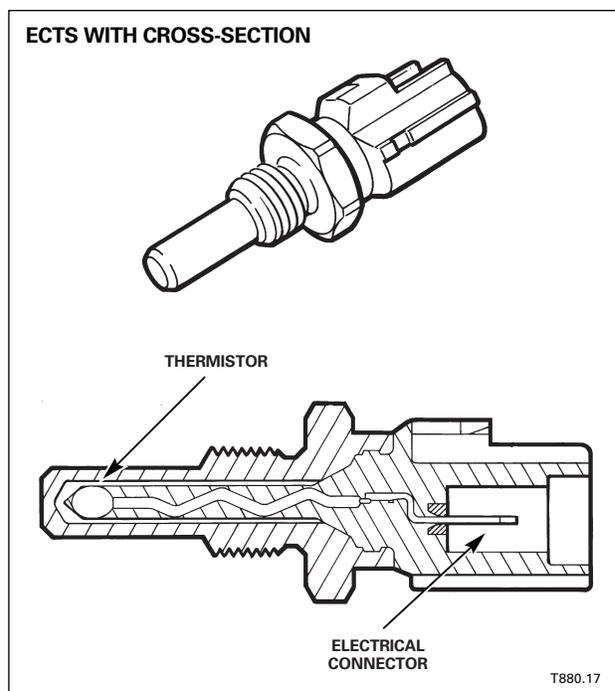
Engine Coolant Temperature Sensor (ECTS) – AJ26 and AJ27



- The ECTS is located on the coolant outlet elbow between the A and B bank cylinder heads.
- The ECTS is a negative temperature coefficient (NTC) thermistor.
- The ECM applies 5 volts to the sensor and monitors the voltage drop through the thermistor.
- Engine coolant temperature is determined by the ECM by a change in resistance within the sensor.

ECTS Temperature / Resistance

Coolant temperature		Resistance
°C	°F	(kΩ)
-10	14	9.20
0	32	5.90
20	68	2.50
40	104	1.18
60	140	0.60
80	176	0.325
100	212	0.19



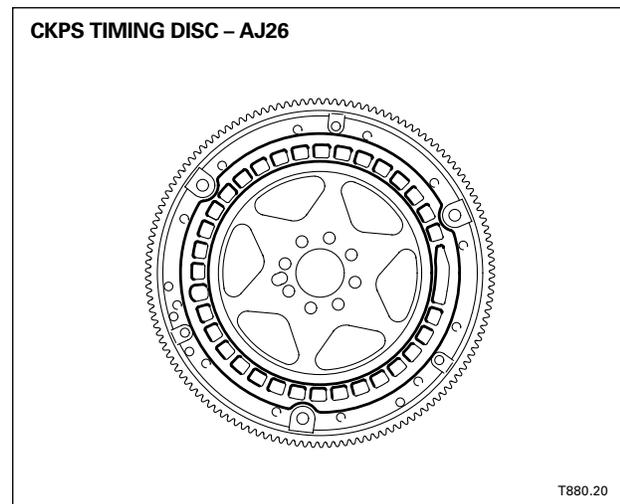
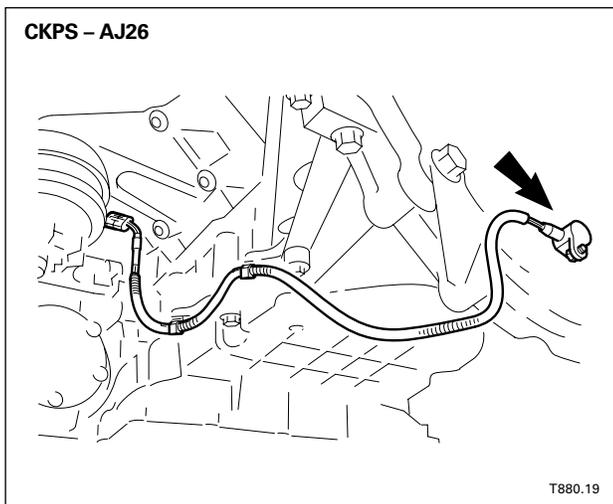
ECTS Temperature / Voltage

Coolant temperature		Voltage
°C	°F	(V)
-10	14	4.05
0	32	3.64
20	68	2.42
40	104	1.78
60	140	1.17
80	176	0.78
100	212	0.55

NOTES

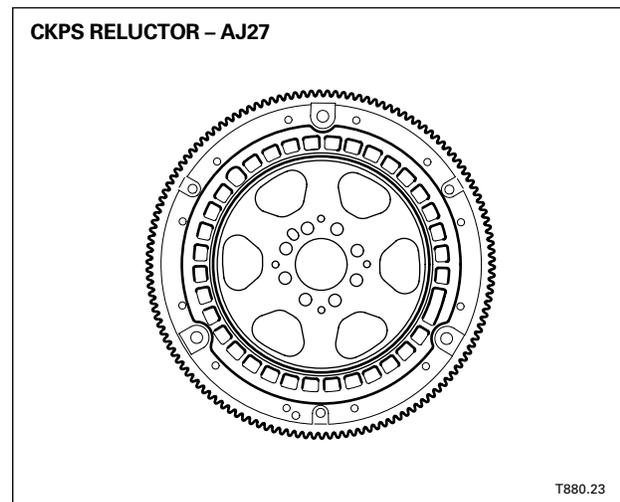
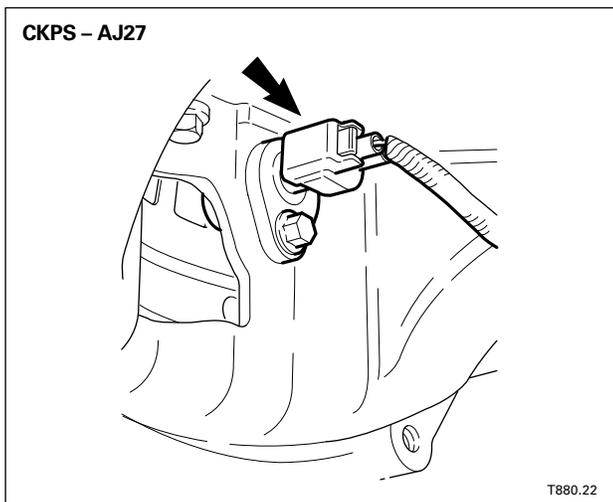
Crankshaft Position Sensor (CKPS) – AJ26

- The CKPS, located at the rear of the engine bed plate, provides the ECM with pulsed signals for crankshaft position and engine speed.
- The timing disc for the sensor is spot-welded to the front face of the transmission drive plate.
- The timing disc has 34 spokes spaced at 10° intervals, with two spokes deleted.
- The sensor is a variable reluctance device that provides a pulse to the ECM at 10° intervals.
- The CKPS input pulse is used by the ECM for ignition timing and fuel injection timing. In addition, the missing pulses (and the CMPS input) are used to identify cylinder 1A, compression stroke for starting synchronization.



Crankshaft Position Sensor (CKPS) – AJ27

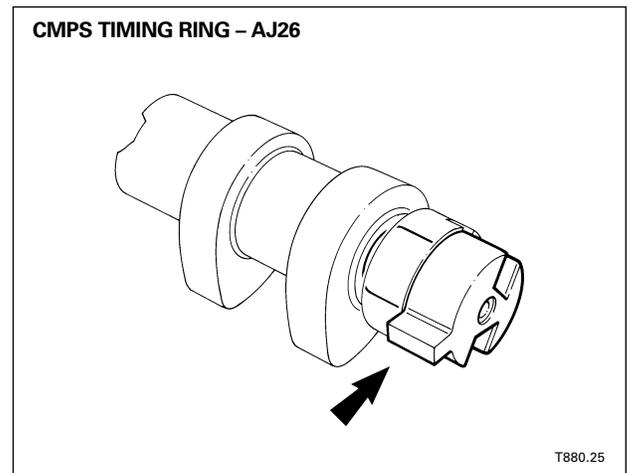
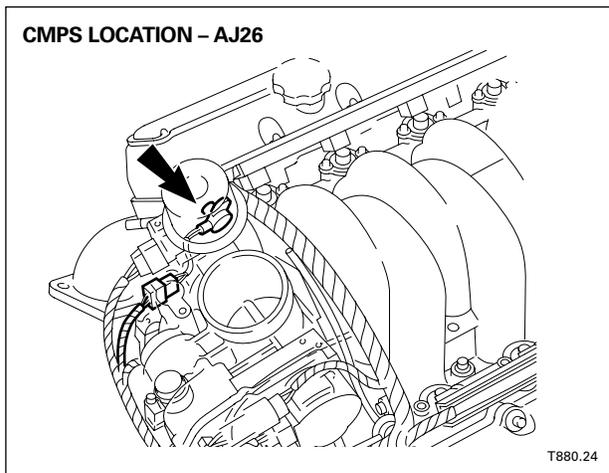
The AJ27 CKPS has a revised 36-tooth (minus one tooth) reluctor. The electrical connection to the CKPS is direct.



EMS PRIMARY SENSING COMPONENTS

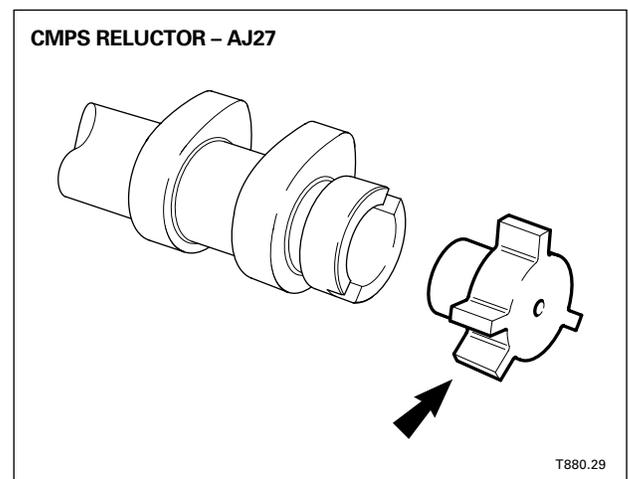
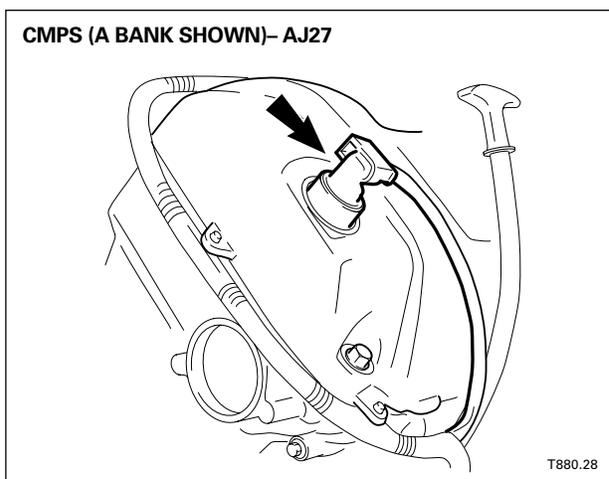
Camshaft Position Sensor (CMPS) – AJ26

- The variable reluctance CMPS, located on the rear of the B bank cylinder head, provides the ECM with a pulsed signal for cylinder 1A compression stroke identification (one pulse per two crankshaft revolutions).
- The pulse is generated by the raised segment of the camshaft timing ring as it passes the sensor tip.
- The CMPS input pulse is monitored along with the CKPS signal for synchronizing ignition timing and fuel injection timing with engine cycle position.
- In addition, the CMPS signal is used for variable valve timing (VVT) diagnostic monitoring.



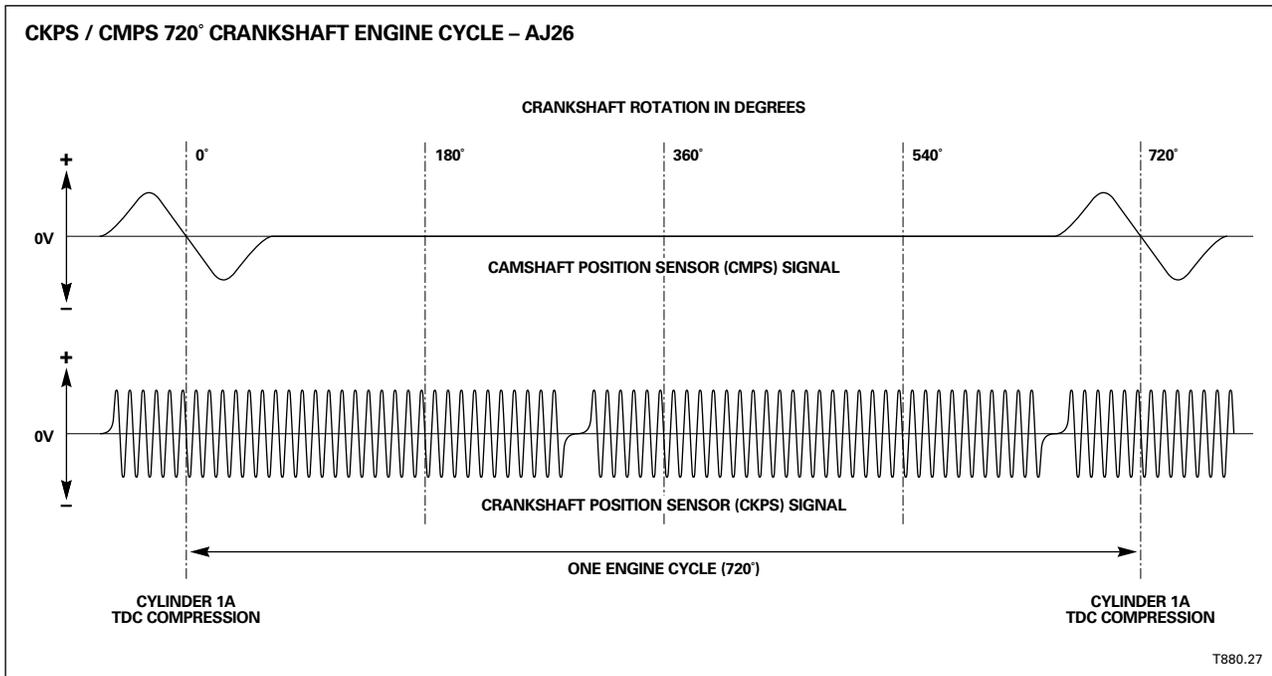
Camshaft Position Sensor (CMPS) – AJ27

- **Both** engine banks incorporate camshaft position sensors that sense the position of the intake camshafts.
- The CMP sensors are inductive pulse generators.
- The sensors have four-toothed reluctors mounted on the rear of both intake camshafts.
- The four-tooth reluctors provide faster camshaft position identification, improving engine start-up speed.
- ECM uses the CMP signals for cylinder identification to control starting, fuel injection sequential operation, ignition timing, and variable valve timing operation and diagnostics.



Engine Cycle Synchronization: CKPS and CMPS

The engine cycle sensor pulse traces illustrate the relationship between the CKPS and the CMPS.



Engine Start: CKPS / CMPS – AJ27

Faster engine firing on start-up is assisted by the four-toothed sensor rings on each camshaft. Each sensor ring provides 4 pulses per engine cycle (720°) to the ECM, compared with 1 pulse from the AJ26 single-tooth sensor ring fitted to B bank. The sensor teeth are asymmetrically positioned and produce a corresponding pulse pattern over the engine cycle, which is compared with the crank sensor output (one missing pulse per revolution). This feature enables the ECM to more quickly identify where the engine is positioned in the firing order and thus trigger ignition and fueling to fire the correct cylinder.

In normal operation, the ECM uses the inputs from the crank sensor and the A bank cam sensor for cylinder identification and ignition/fuel synchronization. If the A bank sensor system fails, the ECM switches to the B bank inputs. If the crank sensor system fails, the engine will start and run using the inputs from both cam position sensors.

NOTES

AJ26 / AJ27 ENGINE MANAGEMENT SYSTEMS



- 1 AJ26 / AJ27 OVERVIEW
- 2 CONTROL SUMMARIES
- 3 ENGINE CONTROL MODULES
- 4 EMS PRIMARY SENSING COMPONENTS
- 5 INDUCTION AIR THROTTLE CONTROL**
- 6 FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL
- 7 FUEL INJECTION
- 8 IGNITION
- 9 VARIABLE VALVE TIMING
- 10 EXHAUST GAS RECIRCULATION (EGR): NORMALLY ASPIRATED
- 11 OTHER ECM ENGINE CONTROL AND INTERFACE FUNCTIONS
- 12 AJ26 / AJ27 SUPERCHARGED EMS
- 13 TASK SHEETS



INDUCTION AIR THROTTLE CONTROL – AJ26

ECM Throttle Control

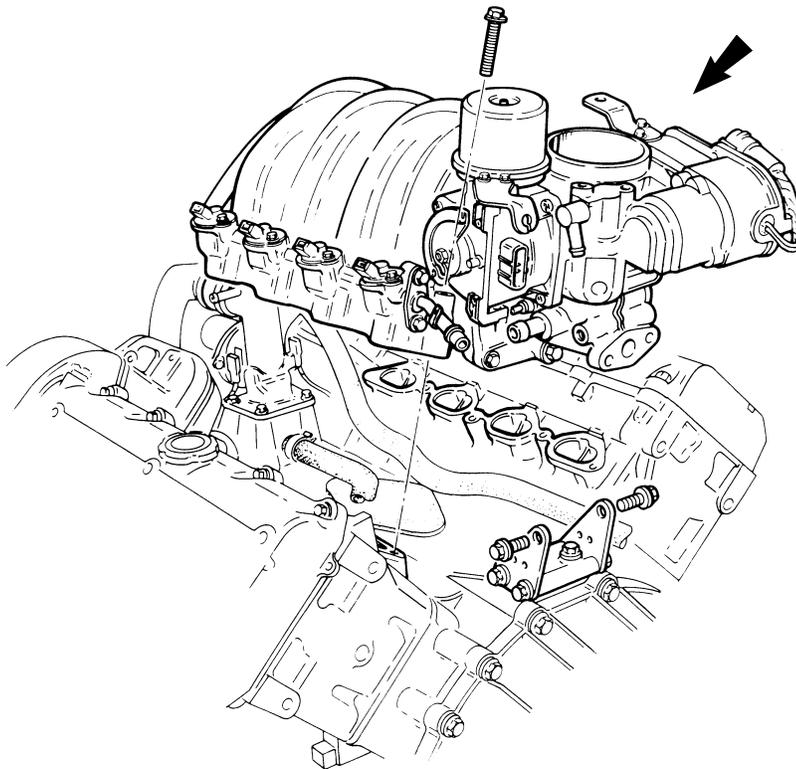
The electronic throttle allows the ECM to perform the following functions:

- Intake air flow control
- Idle speed control
- Cruise control
- Engine torque reduction requirements for traction / stability control
- Engine power limiting
- Vehicle speed limiting
- Throttle diagnostics
- Adopt default modes of operation

Electronic Throttle Assembly

Engine induction air is metered by the electronic throttle assembly in response to driver input and control by the ECM. ECM throttle control allows several previously independent subsystems such as engine power limiting and idle control to be incorporated as EMS functions.

THROTTLE ASSEMBLY – AJ26 N/A



T880.30

INDUCTION AIR THROTTLE CONTROL – AJ26

Throttle Assembly Components Identification

The main components of the AJ26 throttle assembly include:

- **Input shaft** Receives driver inputs from the accelerator pedal via a conventional throttle cable.
- **Pedal position sensor** A twin-track sensor (potentiometers) provides redundant pedal position signals to the ECM.
- **Mechanical guard** Device that prevents the throttle valve from opening beyond driver demand. The mechanical guard allows the throttle to be operated mechanically in the case of electronic control failure.
- **Mechanical guard sensor** A single-track sensor provides a mechanical guard position signal to the ECM.
- **Vacuum actuator** Active (vacuum applied to diaphragm chamber) when cruise control is activated. Operates the mechanical guard independently in cruise control mode.
- **Throttle valve** Conventional shaft/plate arrangement. Sprung toward open position. Mechanical guard lever holds throttle plate in closed position.
- **Thermostatic air valve** Controls throttle valve bypass port during engine warm-up. Fully closes during engine warm-up period.
- **Throttle motor** Driven by the ECM to operate the throttle valve only in the close direction.
- **Throttle position sensor (TPS)** Twin “hall-effect” sensor provides redundant throttle position signals to the ECM.
- **Springs** Springs connected to the input shaft and mechanical guard provide force against the driver input and provide the “feel” of an accelerator. Springs connected to the throttle motor drive gear and the throttle valve provide force against the throttle closing.

The arrangement of the sensors on both “sides” of the throttle valve allows the ECM to have closed loop throttle control.

Thermostatic air valve operation

- Before engine start-up, the throttle valve is in the default closed position (sprung against mechanical guard lever with throttle plate slightly open).
- At low engine temperature, the idle air opening at the throttle plate is insufficient to provide enough air flow for the engine to start.
- The thermostatic air valve is a wax capsule-operated valve that provides throttle bypass air for starting.
- The bypass valve is fully open at approximately -30 °C (-22 °F) and progressively closes until it is fully closed at 40 °C (104 °F).
- Engine coolant flow through the throttle body provides the temperature source to operate the valve.

NOTES

INDUCTION AIR THROTTLE CONTROL – AJ26

Throttle Sensors

The throttle assembly incorporates three sensors:

- A twin “hall-effect” throttle position sensor (TPS)
- A twin-track pedal position sensor (PPS)
- A single-track mechanical guard sensor

The input signals from the three sensors allow the ECM to control the throttle (closed loop), perform diagnostics, perform adaptations, and adopt throttle default modes. The three sensors share common power supply reference voltage, and reference ground circuits. The reference ground circuit is also shared with the ECTS and the IATS.

Throttle Position Sensor (TPS)

The throttle position sensor (TPS) is a twin “Hall effect” sensor, located at the throttle motor side of the throttle assembly. The throttle valve shaft drives the sensor mechanism, which acts upon the two Hall effect elements to provide the ECM with redundant TPS voltage signals. The voltage signals range from approximately 0.5 V at idle to 4.75 V at wide open throttle (WOT). PDU defines the redundant circuits as “1” and “2”. Circuit 1 is identified as TPS pin 3; circuit 2 is identified as TPS pin 2. Refer to the applicable Electrical Guide.

Pedal Position Sensor

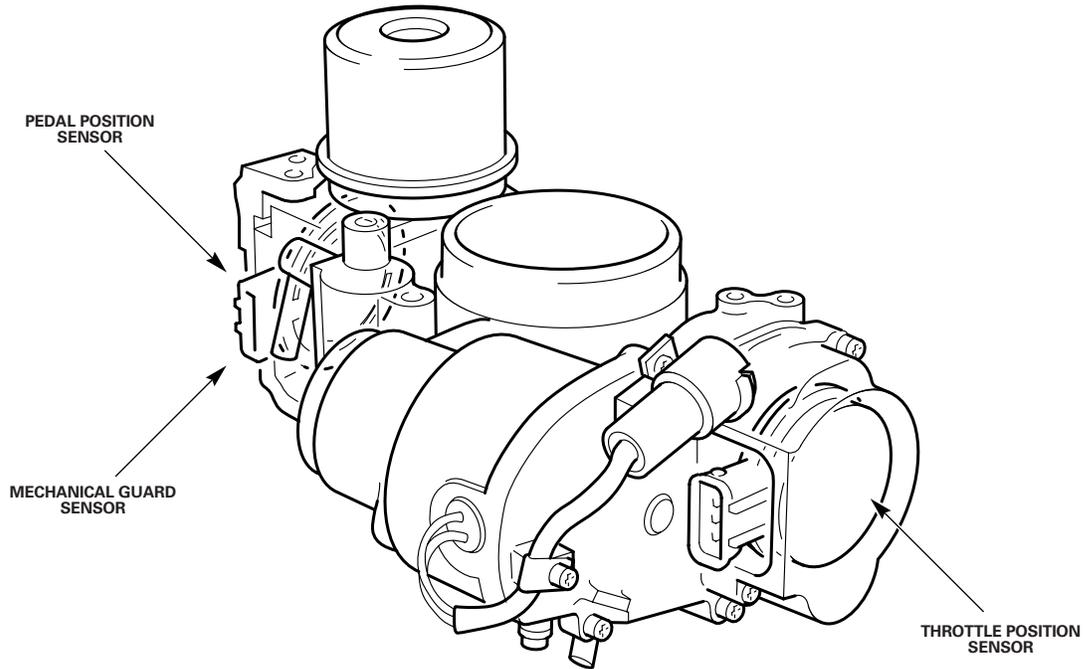
The pedal position sensor is a twin track potentiometer, located at the accelerator cable side of the throttle assembly. The throttle input shaft drives the potentiometer wipers to provide the ECM with redundant pedal position voltage signals. The voltage signals range from approximately 0.5 V at closed to 4.75 V at full throttle. PDU defines the redundant circuits as “A” and “B”. Circuit A is identified as pedal position sensor pin 5; circuit B is identified as pedal position sensor pin 3. Refer to the applicable Electrical Guide.

Mechanical Guard Sensor

The mechanical guard sensor is a single track potentiometer, located at the accelerator cable side of the throttle assembly. The mechanical guard shaft drives the potentiometer wiper to provide the ECM with a mechanical guard position signal voltage. The signal voltage ranges from approximately 0.5 V at closed to 4.75 V at full open.

NOTES

THROTTLE AND SENSORS – AJ26

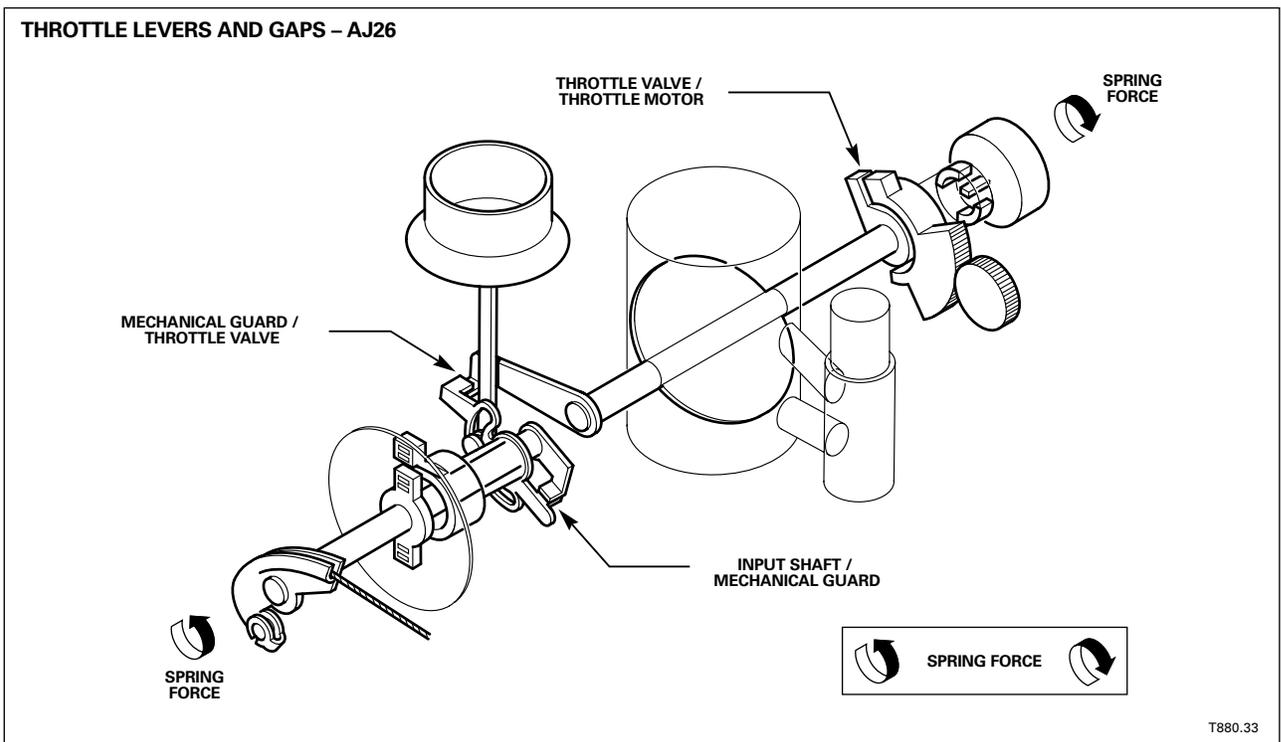


T880.33A

INDUCTION AIR THROTTLE CONTROL – AJ26

Throttle Assembly Design Overview

- The throttle assembly rotating components are arranged such that no fixed connection is made.
- The input shaft moves the mechanical guard via a lever.
- The throttle valve is restrained by the mechanical guard lever on one side and rotated by spring force on the drive side.
- The throttle motor segment gear rotates in one direction to allow throttle opening by spring force or motors in the other direction to close the throttle against spring force.



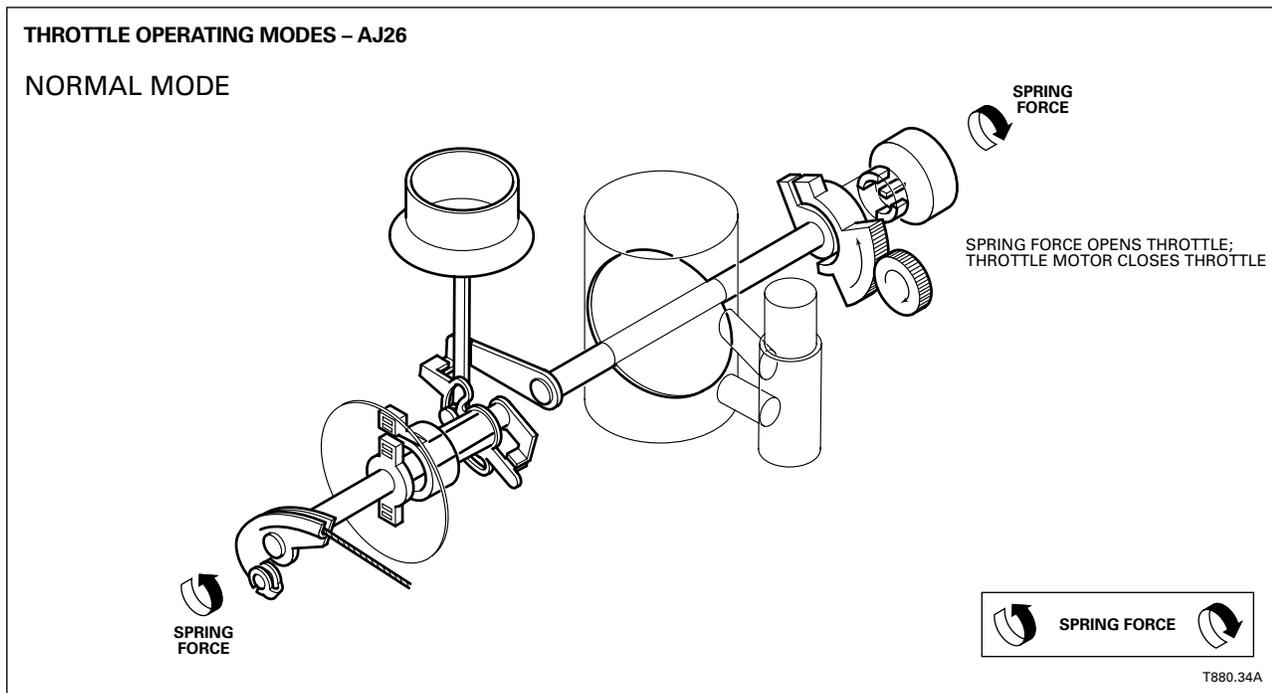
- The design of the input shaft and the mechanical guard, and the counter force applied by their respective springs, ensures that they always rotate together when driver input is being applied from the accelerator pedal.
- The accelerator rotates the input shaft and the mechanical guard in the open direction; the springs keep their adjacent levers in contact and rotate them in the closed direction.
- **The motor acts only to close the throttle valve from the mechanical guard position.**
- The ECM controls engine idle speed by activating the motor closed to regulate an idle air way in the throttle bore with throttle plate. This is achieved by closing the throttle plate past the default mechanical guard open limit to the factory-set stop on the throttle motor segment gear.

NOTES

Throttle Operation

Normal Mode

- The ECM monitors the position of the input shaft and the mechanical guard using signals from the pedal position and mechanical guard sensors.
- In response to the pedal position signal input, the ECM drives the throttle motor to follow the input shaft and mechanical guard rotation to maintain a constant gap between the mechanical guard and throttle valve levers.



- The throttle motor drive gears rotate the throttle valve in the closed direction; the throttle valve spring turns the throttle valve in the open direction while maintaining contact between the motor side throttle lever and the segment gear.
- The arrangement of the throttle valve drive prevents the ECM from exceeding driver demand. If the throttle is driven open (without driver input to move the mechanical guard), the drive side throttle lever will disengage from the segment gear, and the input side throttle lever will contact the mechanical guard lever preventing further throttle opening.
- Since the mechanical guard restricts throttle movement only in the open direction, the arrangement of the throttle valve also allows the ECM to reduce throttle opening to less than driver demand. Throttle opening is reduced during traction control / stability control and during engine power limiting.
- At idle, the ECM controls engine speed using the limited range of throttle valve movement available between the mechanical guard (open limit) and the factory set stop on the throttle motor segment gear (closed limit).

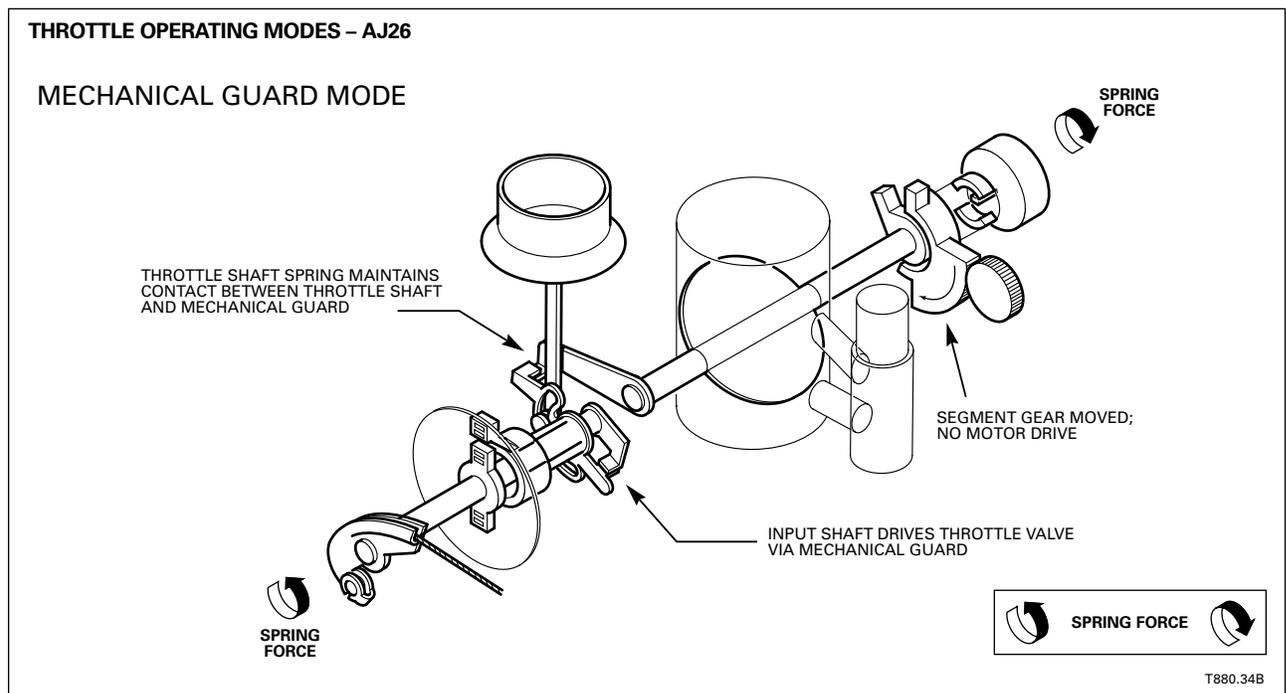
NOTES

INDUCTION AIR THROTTLE CONTROL – AJ26

Throttle Operation (continued)

Mechanical Guard Mode

- If a throttle fault is detected, the ECM defaults to mechanical guard operating mode. In mechanical guard mode, the throttle valve spring turns the throttle valve in the open direction until it engages the mechanical guard, and the ECM does not drive the throttle motor.
- The input shaft, mechanical guard and throttle valve are then effectively locked together by their springs, so that the accelerator pedal is in direct control of the throttle via the throttle cable.

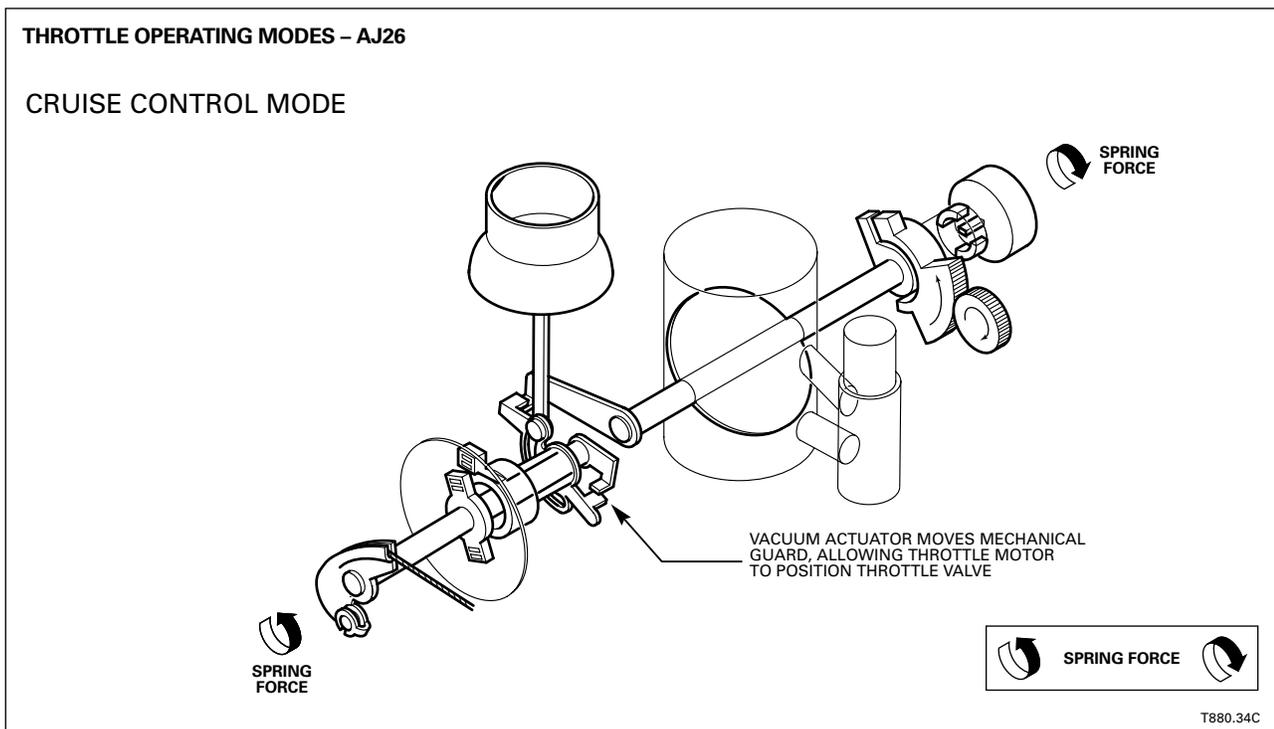


- When the throttle valve opens, it rotates the throttle motor drive gears. On subsequent closing of the throttle valve, the segment gear remains in the open position, disengaged from the throttle valve.
- Full throttle is available and engine speed is not limited in mechanical guard mode.
- Fuel injection intervention smoothes the transition from normal mode to mechanical guard mode to prevent a sudden increase in engine speed. In addition, fuel injection intervention limits idle speed by switching off selected injectors.
- Without fuel injection intervention, the idle speed would be approximately 2000 rpm and cause excessive shock loads on the transmission when shifting out of P or N. As engine load increases, the ECM progressively cancels idle fuel injection intervention.

NOTES

Cruise Control Mode

- When cruise control is engaged, the ECM calculates the required throttle valve angle and ports vacuum to the vacuum actuator.
- The vacuum actuator moves the mechanical guard to a position that allows the throttle motor to move the throttle to the desired angle.

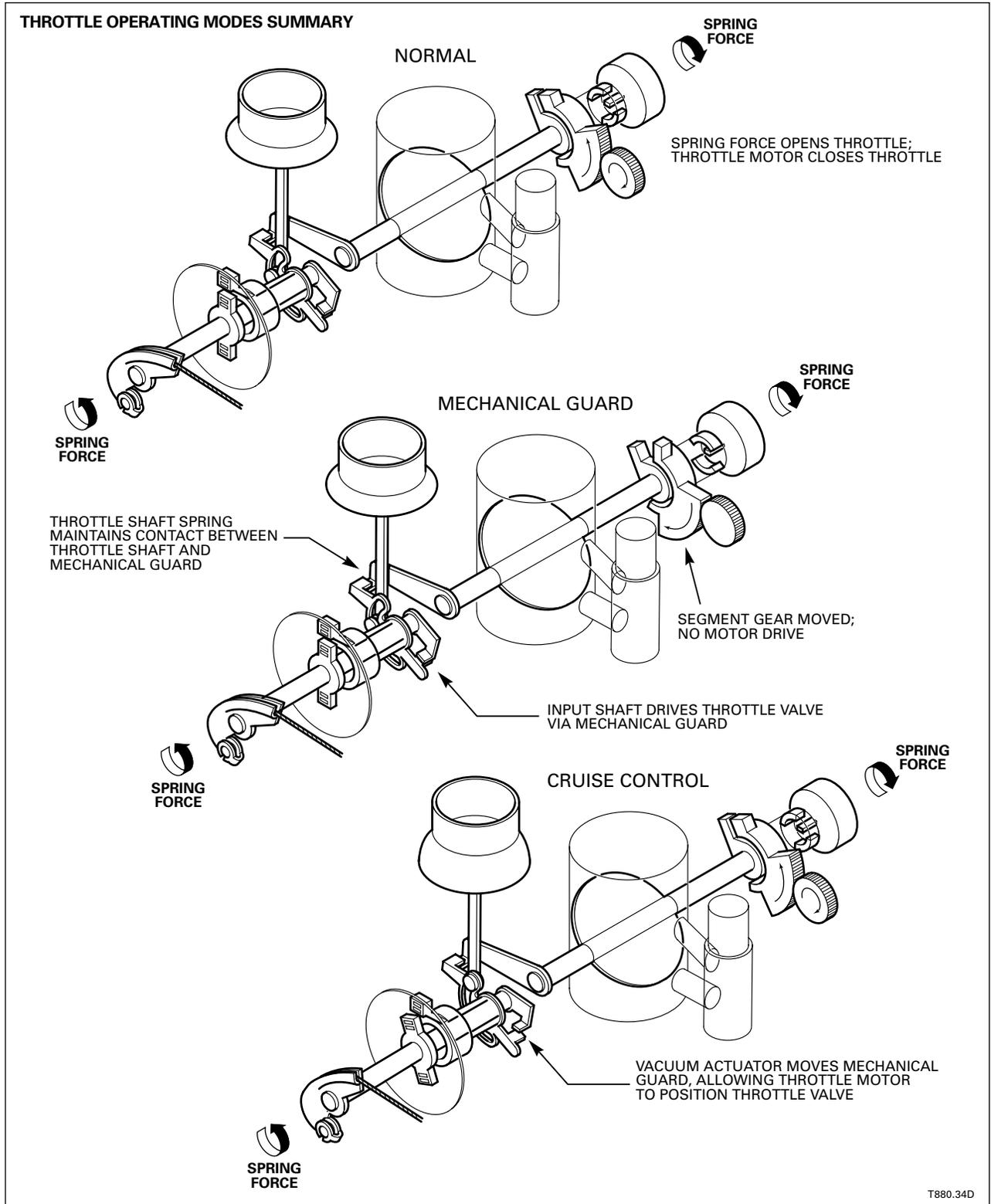


- Using the input signals from the throttle sensors, the ECM monitors and adjusts the mechanical guard and the throttle valve to maintain the cruise control set speed.
- As the driver releases the accelerator pedal, the input shaft disengages from the mechanical guard.
- When accelerating above the set speed during cruise control, the accelerator pedal has a “lighter feel” until the input shaft engages with the mechanical guard.

NOTES

INDUCTION AIR THROTTLE CONTROL – AJ26

Throttle Operation (continued)



Cruise Control – AJ26

Cruise Control Vacuum Components

Vacuum is supplied from the intake manifold and is applied to the mechanical guard vacuum actuator on the throttle assembly. The vacuum components include:

- One check valve
- Two vacuum reservoirs
- Three vacuum solenoid valves (VSV)

The vacuum components are installed in the right front fender, behind the wheel arch liner.

Vacuum check valve

The check valve maintains vacuum in the system when the throttle valve is in a position where little or no manifold vacuum is available (approximately 3/4 to full throttle).

Vacuum reservoirs

If the throttle valve is positioned so that little or no manifold vacuum is available, the vacuum reservoirs can maintain system vacuum for up to 20 minutes. If the reservoirs are depleted of vacuum, normal system operation can be restored by reducing vehicle speed for a short period of time.

VSV 1 (vacuum)

When cruise control is engaged, the ECM grounds the VSV 1 circuit and VSV 1 is driven to port vacuum to operate the mechanical guard vacuum actuator.

VSV 2 (atmosphere)

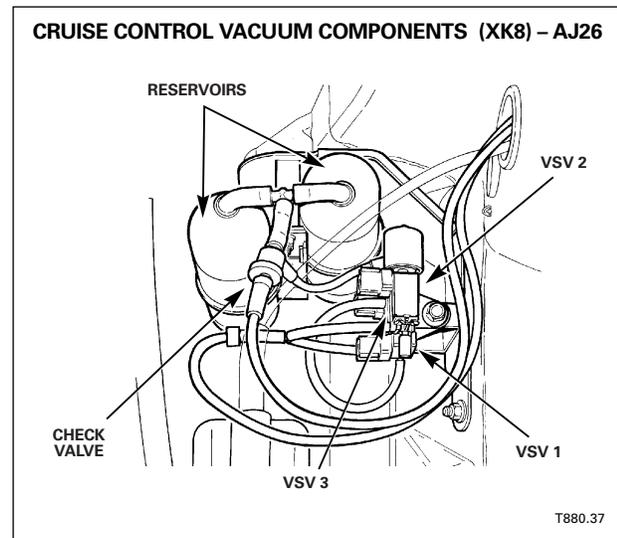
The ECM grounds the VSV 2 circuit. VSV 2 is driven to port the operating vacuum to atmosphere until the mechanical guard is set to the required position. The ECM determines the required position via the mechanical guard sensor. When cruise control is disengaged, the ECM grounds the VSV 2 circuit and VSV 2 is driven to port the operating vacuum to the atmosphere and release the mechanical guard vacuum actuator.

VSV 3 (release)

VSV 3 is driven by the ECM to act as a safety back up for VSV 2. The ECM switches the supply side of the VSV 3 circuit.

VSV Filters

VSV 2 and 3 incorporate filters to prevent moisture and debris from entering the system.

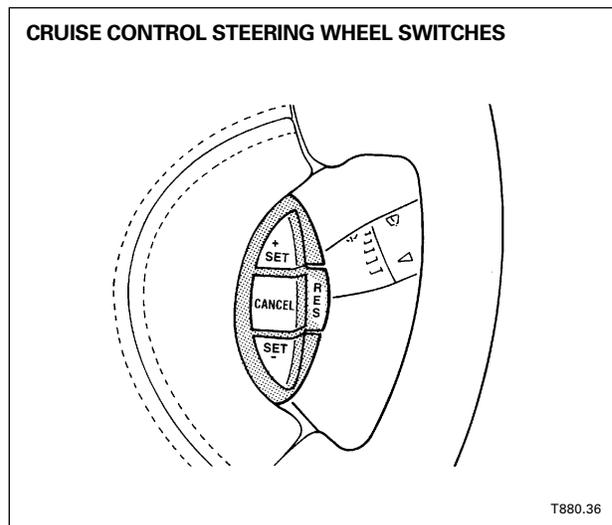
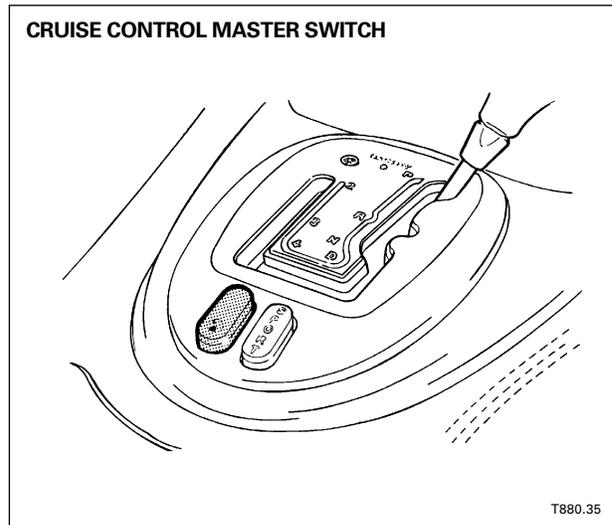


NOTES

INDUCTION AIR THROTTLE CONTROL – AJ26

Cruise Control – AJ26 (continued)

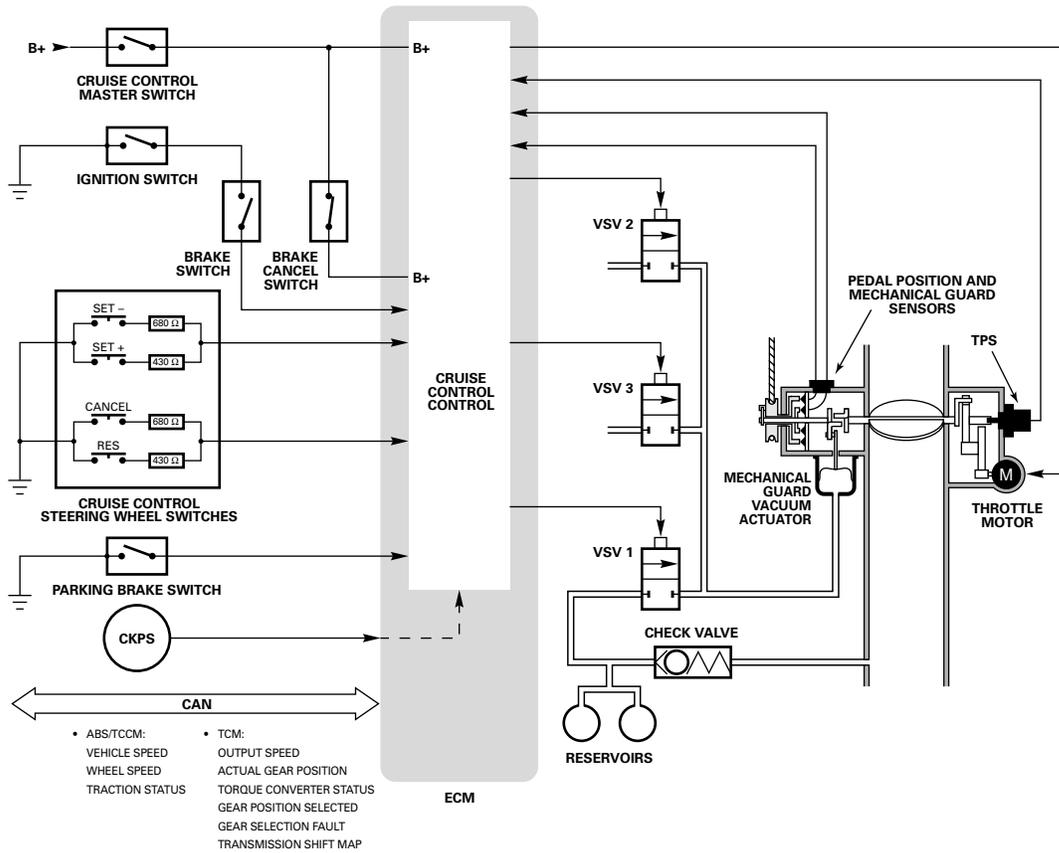
Cruise Control Operation



- The driver communicates with the ECM through the master switch in the center console and the SET+, SET-, CANCEL, and RESUME switches on the steering wheel.
- The ECM also monitors two brake switch inputs and the parking brake switch to cancel operation.
- The cruise control system is powered when the master switch is ON. Battery voltage is applied to the ECM directly from the master switch and via the normally closed brake cancel switch.
- With the system powered, a momentary press of either the SET+ or the SET- switch engages cruise control if the vehicle speed is 17.5 mph (28 km/h) or greater.
- The ECM responds by “memorizing” the current vehicle speed (CAN data) as the “set” speed.
- The ECM drives the vacuum system to position the mechanical guard so that the throttle can maintain the set speed. The input signals from the pedal position, mechanical guard and throttle sensors allow the ECM to monitor and adjust the mechanical guard and the throttle valve.

NOTES

CRUISE CONTROL LOGIC – AJ26



T880.38

INDUCTION AIR THROTTLE CONTROL – AJ26

Cruise Control – AJ26 (continued)

Cruise Control Operation

Acceleration / deceleration, change in set speed

- Once cruise control is engaged, a momentary press of the SET+ or SET- switches accelerates or decelerates the vehicle speed incrementally by 1 mph (1.6 km/h).
- Pressing and holding the SET+ or SET- switches causes the ECM to smoothly accelerate or decelerate the vehicle until the switch is released.
- The ECM distinguishes the switched ground inputs by a difference in circuit resistance.
- The ECM stores a maximum of five SET+ / SET - incremental acceleration or deceleration commands at any one time.
- Once the first stored command has been carried out, a further command can be added.
- If the opposite SET switch is pressed, the ECM deletes the last command from memory.
- After the vehicle is accelerated / decelerated incrementally, the ECM will adopt this speed as the set speed.

Accelerator pedal control

- Pressing the accelerator pedal will accelerate the vehicle higher than the set speed without disengaging cruise control.
- Since the vacuum actuator holds the mechanical guard “open”, there is noticeably less accelerator pedal load up to the point at which the throttle input shaft begins to move the mechanical guard.

CANCEL / RESUME

- A press of the CANCEL switch provides a cancel ground signal and the ECM smoothly disengages cruise control and clears the set speed from memory.
- Pressing the RESUME switch provides a resume ground signal and the ECM reengages cruise control and smoothly accelerates / decelerates the vehicle to the set speed.

Cruise control disengagement

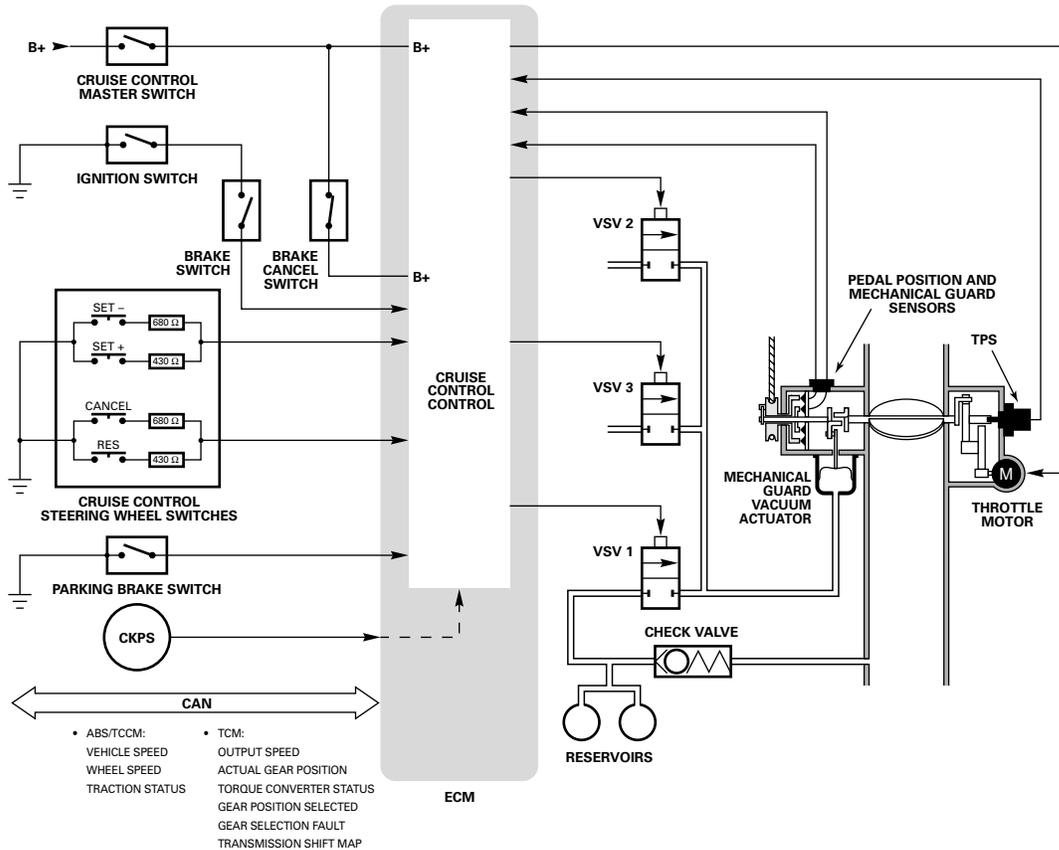
The ECM disengages cruise control and clears the set speed from memory if any of the following conditions occur:

- The master switch is moved to OFF
- A fault is detected in the throttle assembly
- A fault is detected in the brake switch
- A fault is detected in the cruise control switches
- The parking brake is applied
- The engine speed exceeds 7100 rpm

The ECM disengages cruise control but retains the set speed in memory if any of the following conditions occur:

- The brake pedal is pressed
- The vehicle decelerates too fast (in case the brake switch is not operating)
- The gear selector is moved to P, N, R
- After resuming cruise control, the vehicle accelerates to only 50% of the set speed (due to a steep incline)
- Traction control / stability control operation
- Vehicle speed falls below 16 mph (26 km/h)

CRUISE CONTROL LOGIC – AJ26



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INDUCTION AIR THROTTLE CONTROL – AJ27

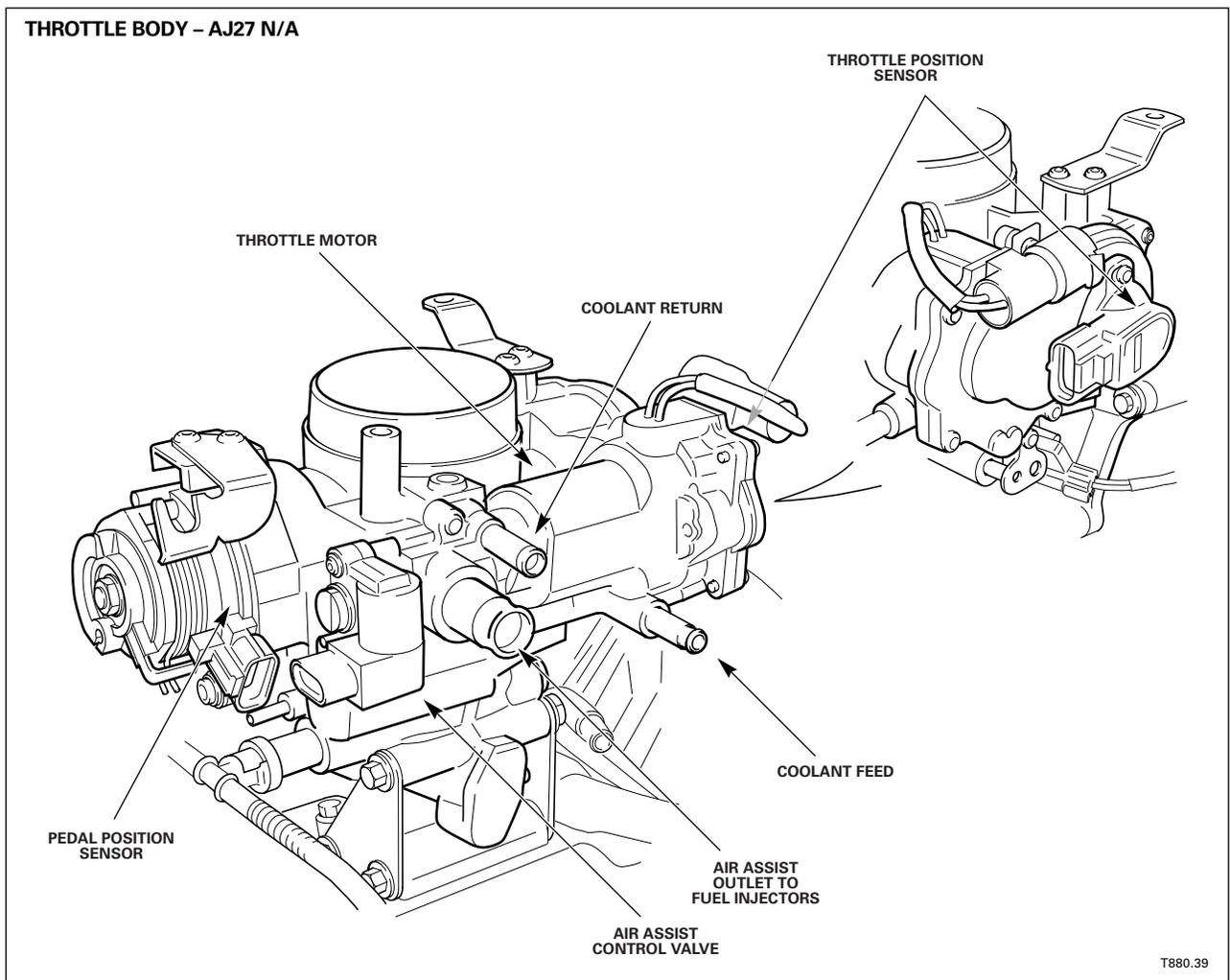
Full Authority Electronic Throttle Control

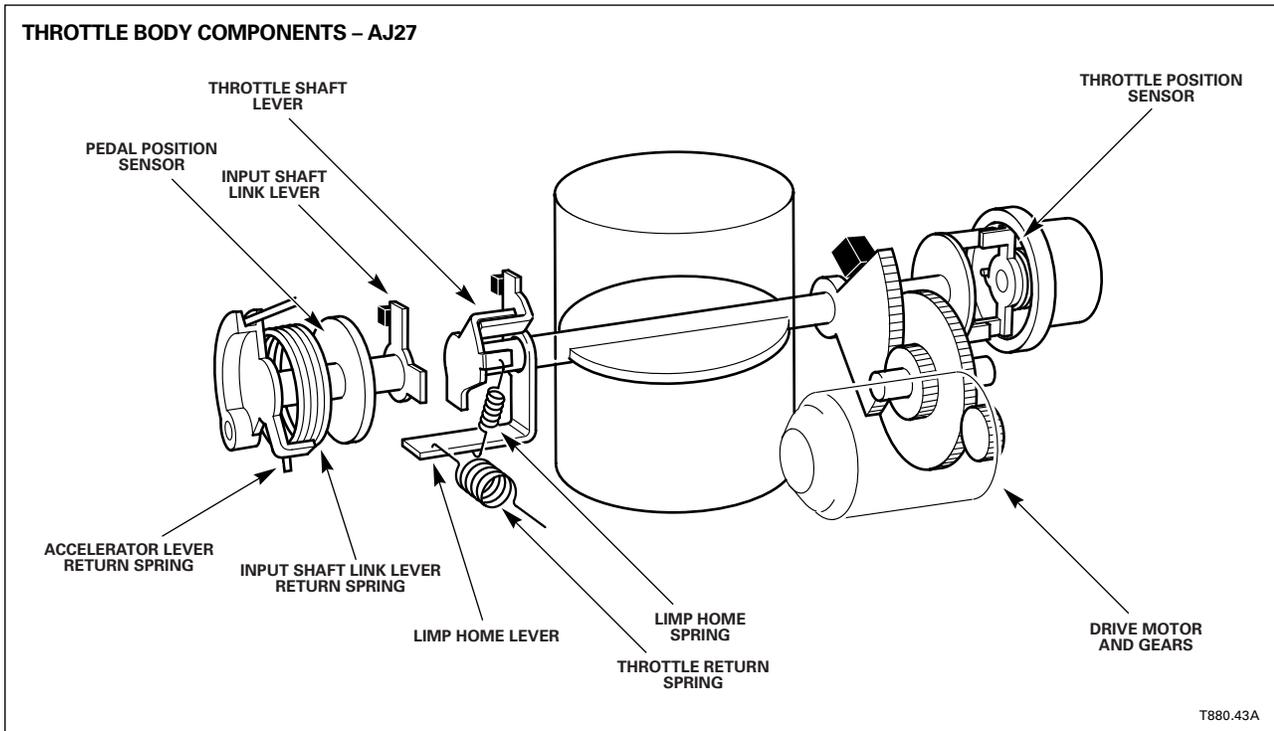
A full authority throttle body is fitted to the AJ27 engine. The throttle body does not incorporate a mechanical guard.

The main features of the AJ27 throttle body are:

- Full motorized control of the throttle valve from the ECM
- Mechanical, cable operated 'limp home' fail safe mode (restricted throttle opening)
- Mechanical, electrical and software safety features
- ECM cruise control drive (no vacuum components)
- Built-in air assist control valve (AACV) with integral air feed (normally aspirated only)

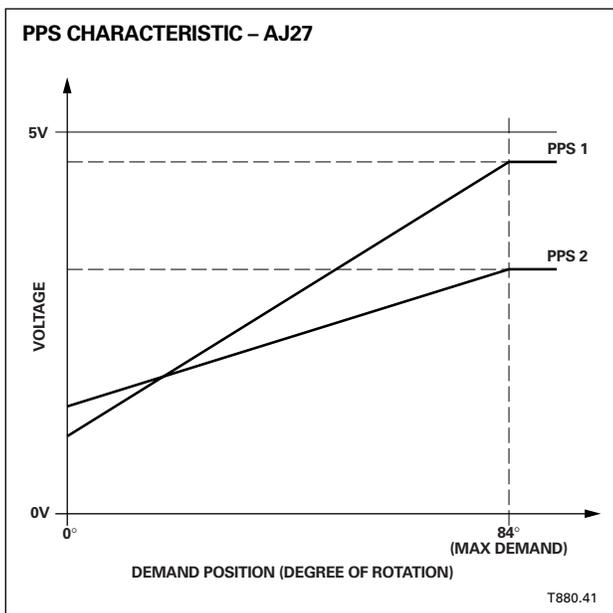
Throttle Components





Input Assembly

The accelerator pedal is linked to the input shaft link lever of the throttle assembly. As the driver depresses the pedal, the link lever is rotated against spring pressure with no mechanical connection to the throttle valve.



Pedal position sensor (PPS)

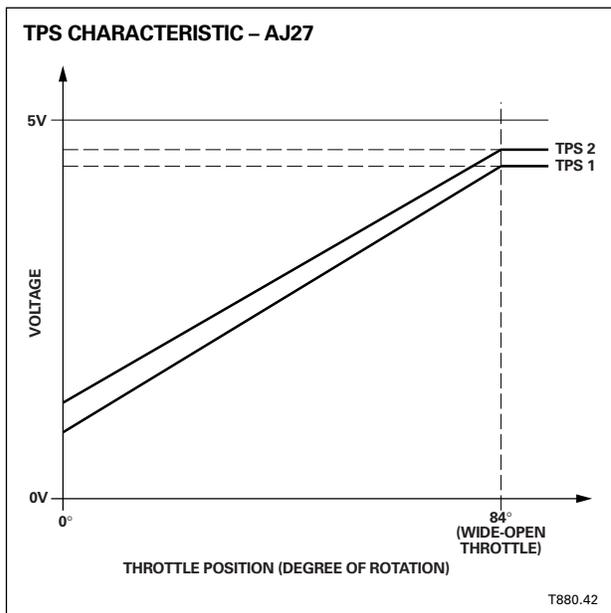
- Two individual rotary potentiometers comprise the PPS assembly located at the cable end of the throttle.
- The potentiometers are rotated by the throttle cable lever and provide separate analog voltage signals to the ECM proportional to pedal movement and position.
- The potentiometers have common reference voltage and reference ground circuits hard-wired to the ECM.
- Each potentiometer provides its unique pedal position signal (via hard-wire connection) directly to the ECM. The ECM detects faults by comparing the pedal position signals to expected values.
- If the ECM detects a fault, throttle operation defaults to the “limp home” mode (mechanical).

INDUCTION AIR THROTTLE CONTROL – AJ27

Throttle Components (continued)

Motorized Throttle Valve

- The throttle valve is coupled to a DC motor via reduction gears and is positively driven by the ECM in both directions between fully closed and fully open.
- The throttle position sensor on the motor end of the throttle shaft provides direct feedback of the actual valve angle to the ECM and is similar to the pedal position sensor in operation.



Throttle position sensor (TPS)

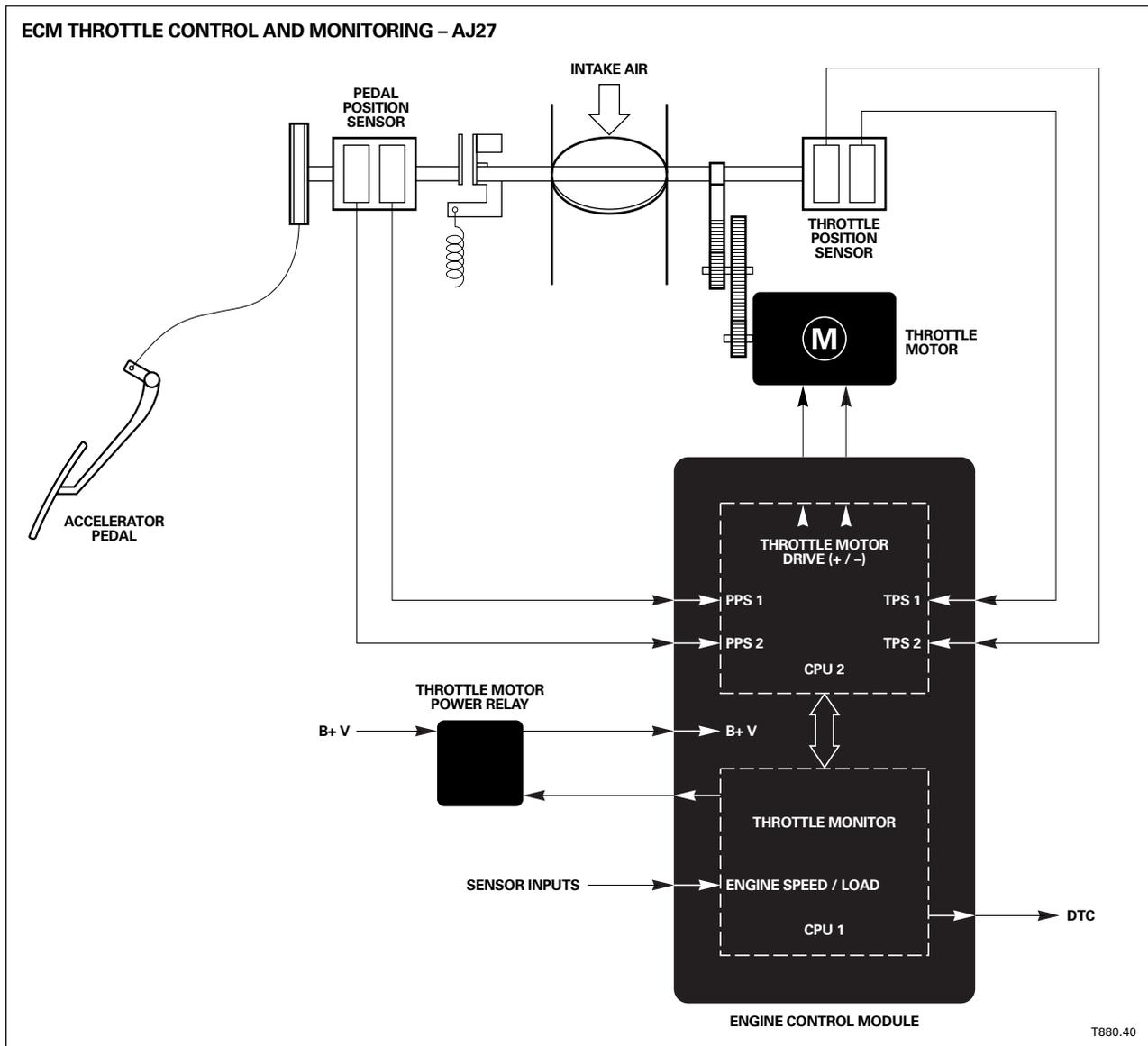
- The throttle position sensor assembly consists of two individual rotary potentiometers that are directly driven by the throttle valve shaft.
- The potentiometers have common reference voltage and reference ground circuits hard-wired to the ECM; each provides its unique throttle position signal (via hard-wire connection) directly to the ECM.
- The unique characteristics of both signals are used for identification, similar to the PPS signals.
- The ECM detects faults by comparing the throttle position signals to expected values. If the ECM detects a fault, throttle operation defaults to the “limp home” mode (mechanical).

NOTES

Throttle Operation

The throttle body contains two moving assemblies:

- the accelerator input assembly, which provides the driver demand to the ECM
- the motorized throttle valve, driven and controlled by the ECM in accordance with driver demand and other EMS factors.
- In normal operation, there is no mechanical coupling between the two assemblies.



NOTES

INDUCTION AIR THROTTLE CONTROL – AJ27

Throttle Operation (continued)

Limp Home Mechanism

- The limp home mechanism consists of the accelerator input shaft link lever and the two throttle shaft levers, all three levers being interlocked for limp home operation.
- On the throttle assembly, one lever is fixed to the end of the shaft and the second, the 'limp home' lever, pivots around the shaft.
- The two levers are connected by a spring and the throttle return spring is also connected to the limp home lever.
- As the throttle rotates, the action of the throttle lever (valve opening) and the springs (valve closing) maintain the two levers in contact.
- At the idle speed position, there is an angular separation between the accelerator link lever and the limp home lever and under normal closed loop control this difference is maintained as both input and drive assemblies rotate.

Limp Home Operation

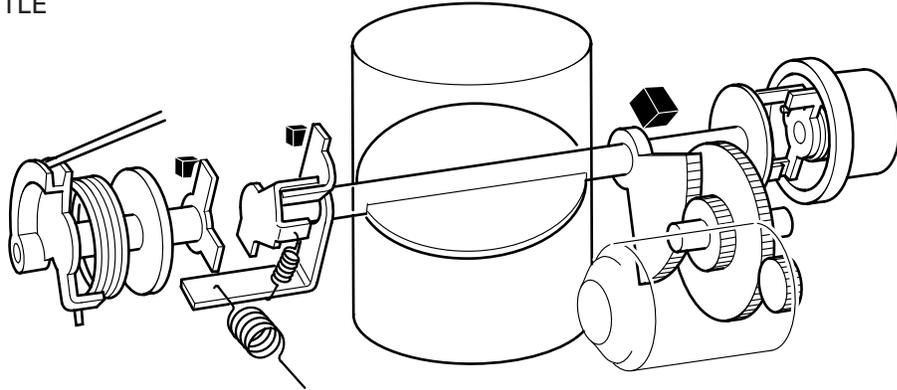
If a failure in the throttle mechanism or control system occurs, the ECM defaults throttle control to the limp home mode.

- The ECM de-energizes the throttle motor power supply relay and / or deactivates the ECM internal PWM motor drive signals.
- The throttle valve is operated mechanically from the drivers pedal and throttle opening is restricted to a range from idle to a maximum of approximately 30°.
- The accelerator input shaft link lever is mechanically coupled to the throttle shaft levers, enabling the shaft to be rotated against the unpowered motor and gearing.
- Due to the angular difference between the input shaft link lever and the limp home lever, there is no engagement of the two levers until the input shaft has rotated approximately 60° from idle.
- When the link lever contacts the limp home lever, causing it to rotate, the throttle valve is pulled open by the limp home spring. With the pedal fully depressed the throttle valve is open to a maximum of approximately 30°.
- On releasing the accelerator pedal, the throttle return spring causes the limp home lever to rotate to its stop at the throttle idle speed position.
- If loss of motor power occurs when the throttle is open beyond the idle position, the limp home lever will close to the point where it contacts the link lever. If the throttle has been driven closed (past the idle position) when loss of power occurs, the limp home spring will return the throttle to the idle position.
- When the throttle is in limp home mode, the ECM adjusts the fuel metering strategy as necessary to control engine power. At low throttle opening, fuel cutoff to individual cylinders may occur.

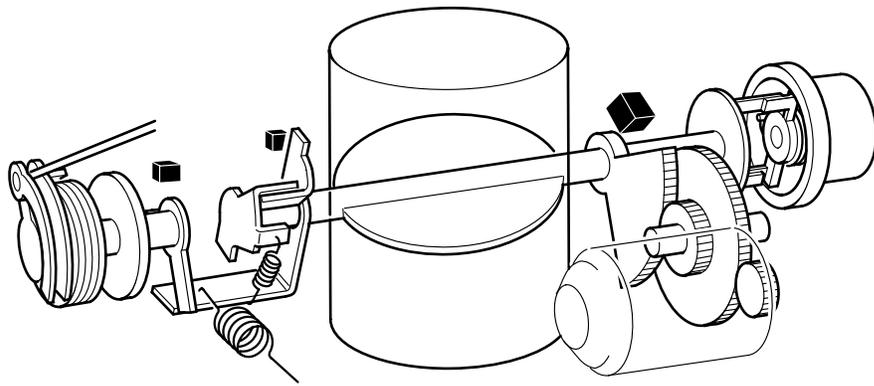
NOTES

THROTTLE OPERATION – AJ27

PART THROTTLE



LIMP HOME



T880.43B

NOTES

AJ26 / AJ27 ENGINE MANAGEMENT SYSTEMS

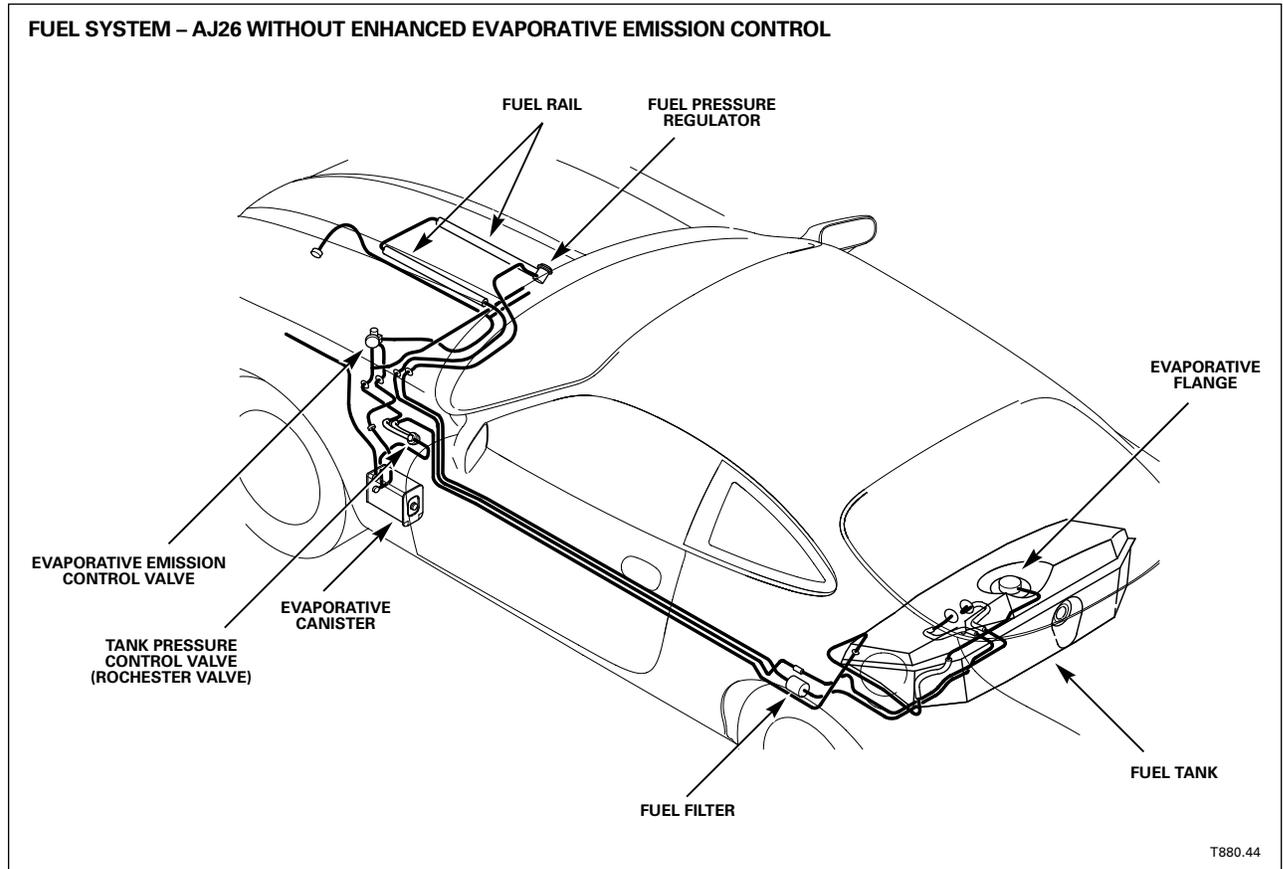


- 1 AJ26 / AJ27 OVERVIEW
- 2 CONTROL SUMMARIES
- 3 ENGINE CONTROL MODULES
- 4 EMS PRIMARY SENSING COMPONENTS
- 5 INDUCTION AIR THROTTLE CONTROL
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EVAPORATIVE EMISSION CONTROL**
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- 8 IGNITION
- 9 VARIABLE VALVE TIMING
- 10 EXHAUST GAS RECIRCULATION (EGR):
NORMALLY ASPIRATED
- 11 OTHER ECM ENGINE CONTROL AND
INTERFACE FUNCTIONS
- 12 AJ26 / AJ27 SUPERCHARGED EMS
- 13 TASK SHEETS



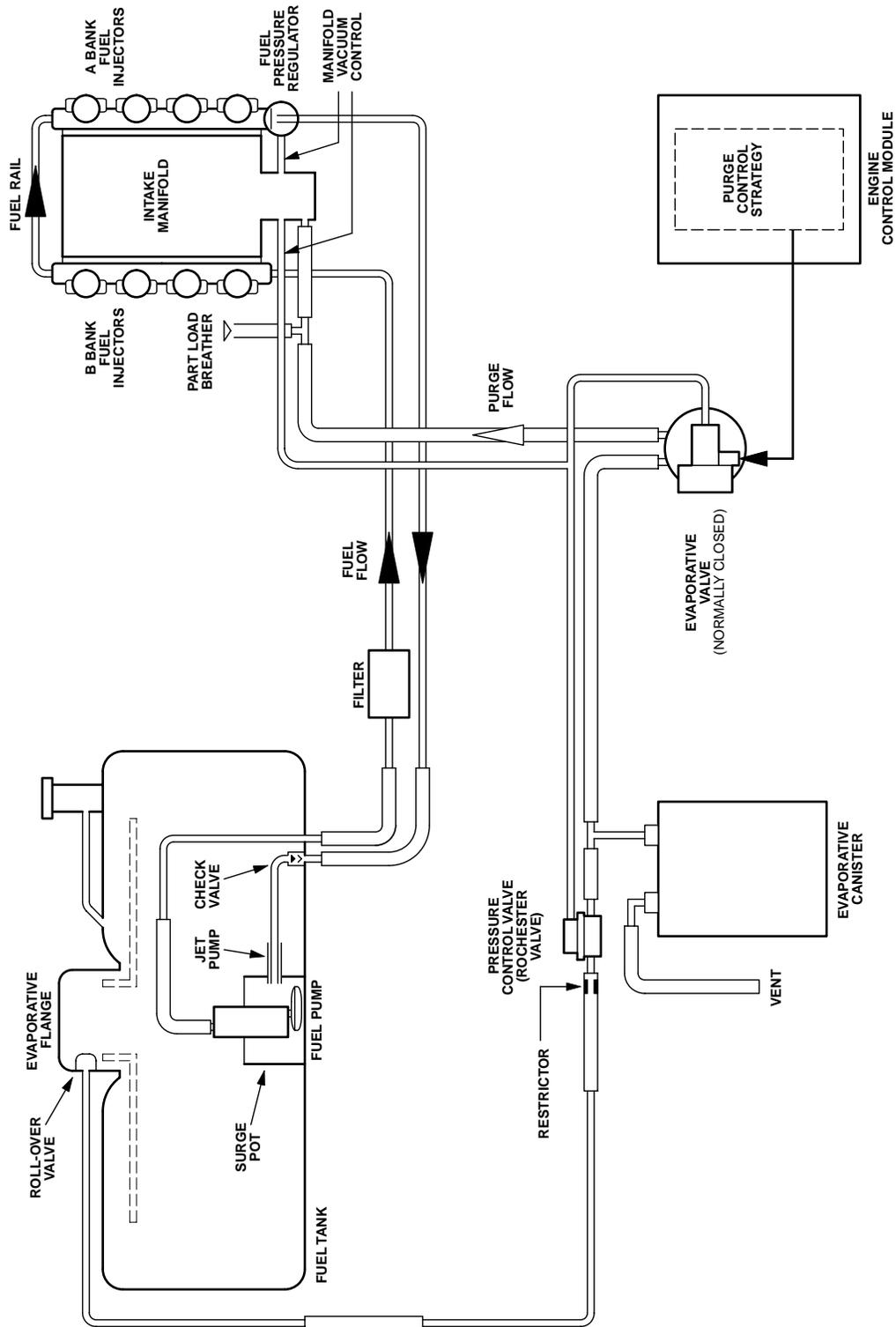
FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

The fuel system uses a rear mounted over-axle fuel tank installed in the trunk. Fuel and vapor pipes travel under the left hand side of the vehicle to the engine and evaporative emission components.



NOTES

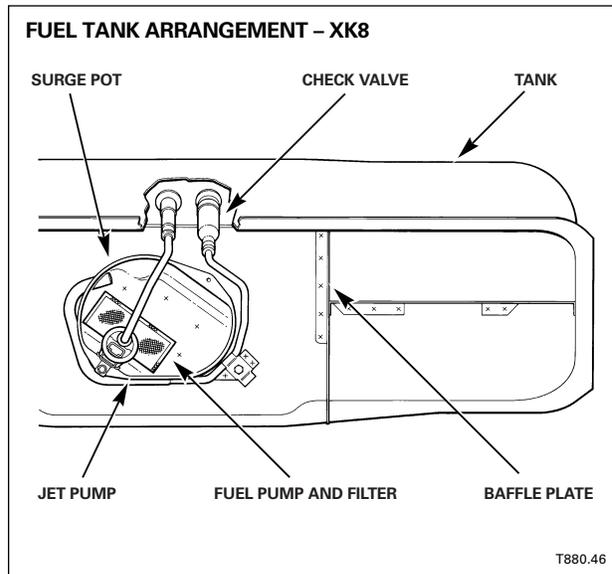
FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL SYSTEM – AJ26 WITHOUT ENHANCED EVAPORATIVE EMISSION CONTROL



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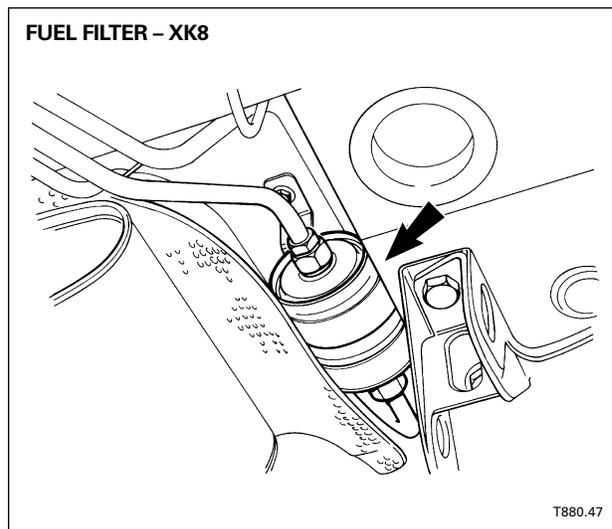
FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

Fuel Delivery



Fuel Tank

- The fuel tank incorporates the fuel pump and the necessary plumbing for fuel supply and return.
- The pump is located by a rubber mount and clamp attached to the surge pot.
- The tank interior piping incorporates a jet pump and a check valve in the fuel return line. Returning fuel flows through the jet pump, which draws additional cool fuel from the tank to supply the surge pot.
- This supplemented return flow ensures that the surge pot remains full of fuel. The return check valve prevents reverse flow through the fuel return line when it is disconnected.
- Access to the tank interior is through the evaporative flange at the top of the tank.



In-Line Fuel Filter

A replaceable in-line fuel filter is located in the supply line to the front of the rear axle on the left side.

Fuel Level Sensor

- The fuel level sensor is a conventional potentiometer that provides the instrument pack (INST) with a variable voltage signal indicating fuel tank fill level.
- The fill level signal voltage ranges between approximately B+ at empty to 0 V at full.
- The INST transmits two fuel level CAN messages: CAN FUEL LEVEL RAW – the raw (undamped) fuel tank level, and CAN FUEL LEVEL DAMPED – the damped (averaged over a period of time) fuel tank level.
- The INST provides the damped level message to compensate for surges within the fuel tank.

NOTES

Fuel Pump

- The single fuel pump unit consists of a turbine driven by a DC motor, a check valve and an inlet filter.
- The fuel output from the turbine pump provides a cooling flow around the motor before being discharged through the outlet check valve. The check valve prevents rapid fuel pressure loss when the engine is switched off.

Fuel pump specifications

Nominal pump delivery

26.45 gallons per hour at 3 bar (43.5 psi)

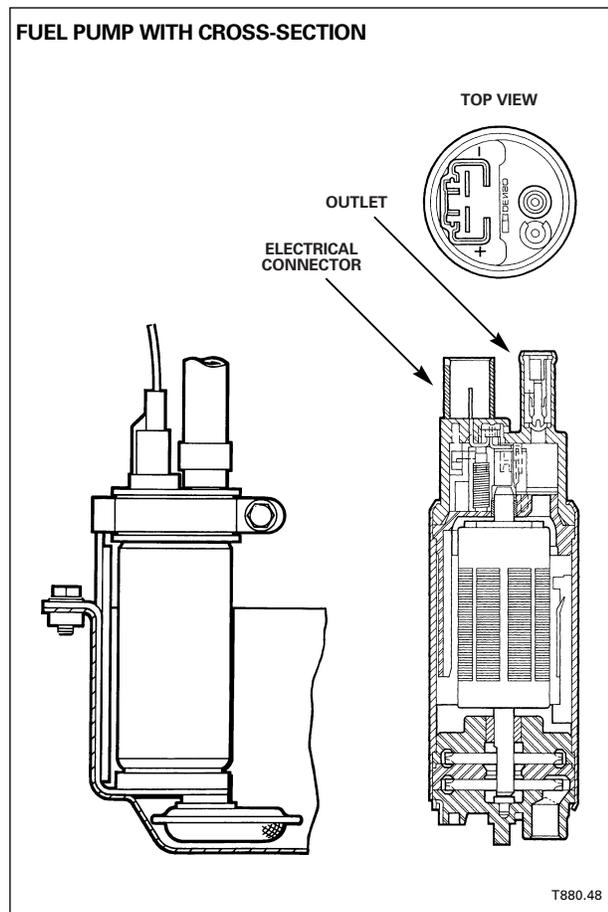
Current draw

7 amps at 13.2 V at 3 bar (43.5 psi)

Fuel pump operation

- The fuel pump is switched by the ECM via the fuel pump relay.
- When the ignition is switched on (position II), the ECM switches on the fuel pump after a delay of 0.1 second.
- If the ignition switch remains in position II without moving the key to crank (position III), the ECM will switch off the pump after a maximum of 2 seconds.
- When the ignition switch is moved to crank (position III), the fuel pump is activated and operates continuously while the engine is running.
- If the engine stops with the ignition on (position II), the ECM will switch OFF the pump after two seconds.

NOTE: In the event of a vehicle impact, the inertia switch will switch off all ignition powered circuits, including EMS power and fuel pump relay power. This action will switch off the fuel pump and prevent fuel flow.



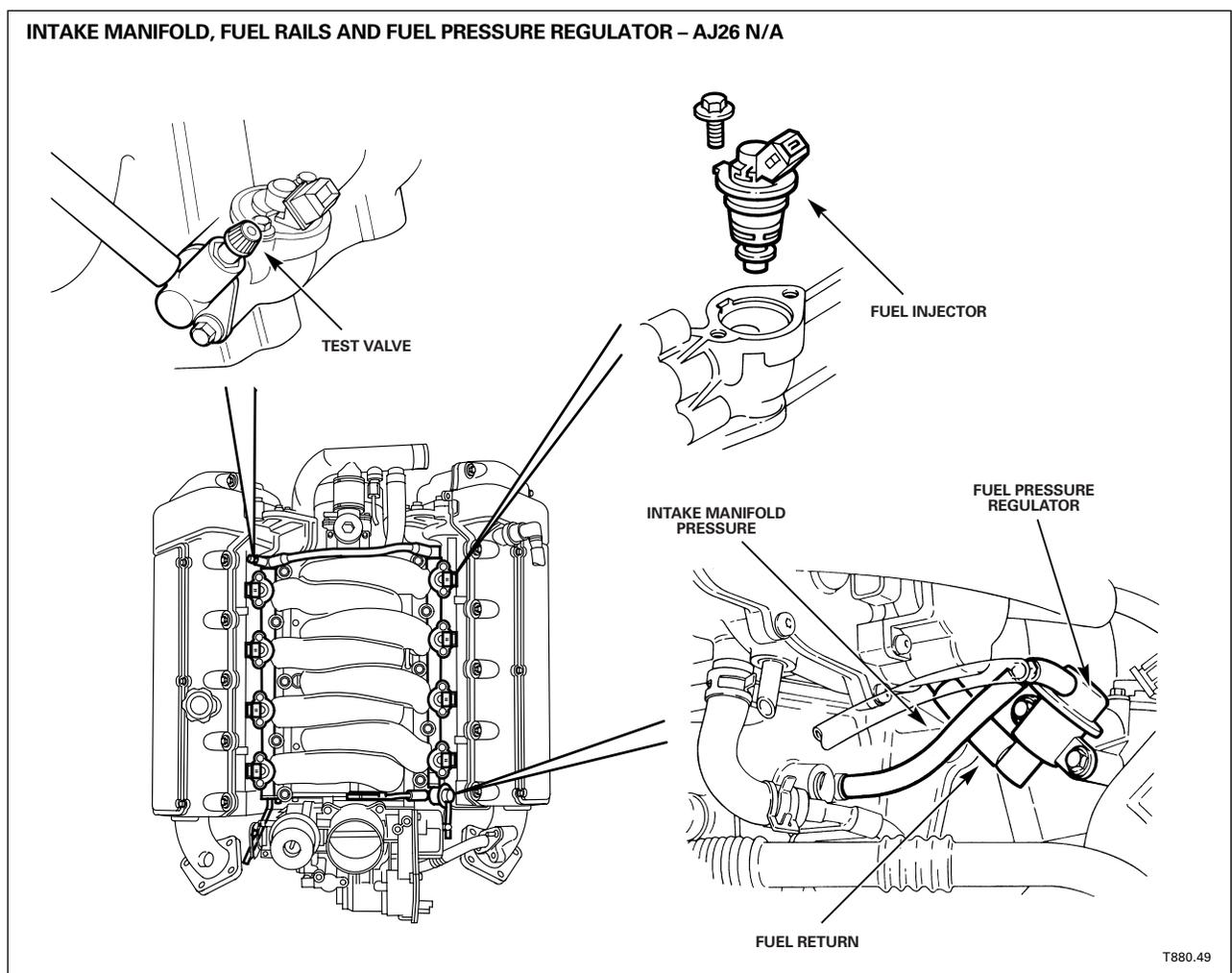
NOTES

FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

Fuel Delivery (continued)

Fuel Pressure Regulator

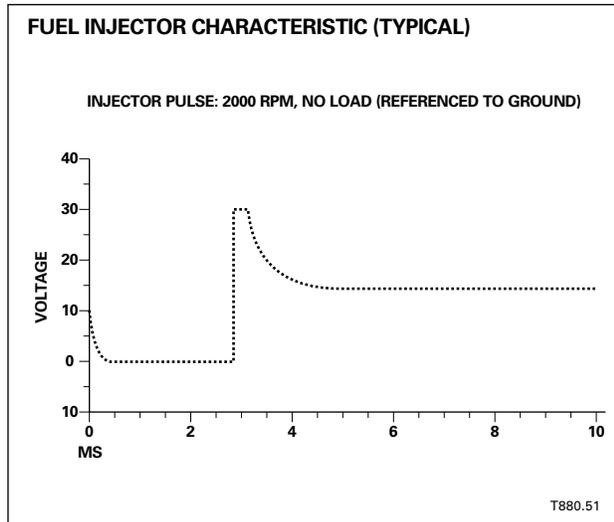
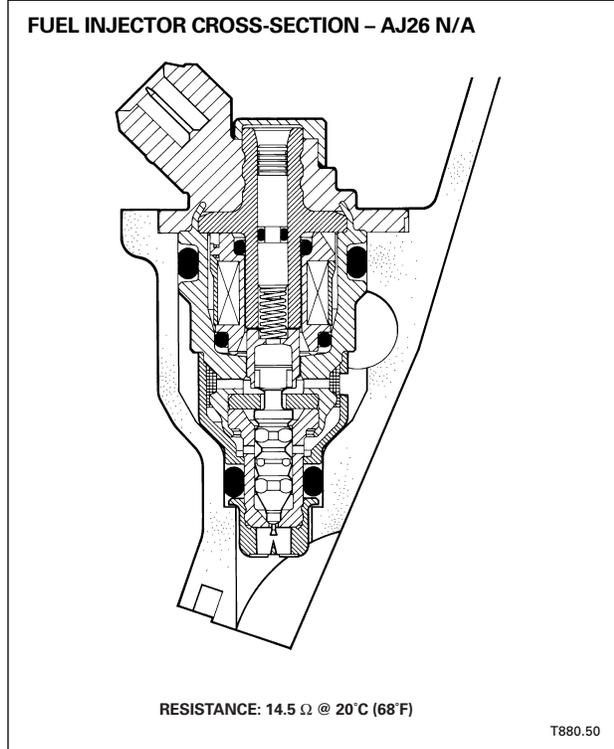
- Fuel is pumped to the fuel rail and injectors, where fuel pressure is controlled by the fuel pressure regulator. Excess fuel, above the engine requirement, is returned to the fuel tank through the fuel pressure regulator.
- The pressure regulator spring chamber above the diaphragm is referenced to intake manifold vacuum.
- The differential pressure across the fuel injector nozzles is therefore maintained constant and the quantity of fuel injected for a given injector pulse duration is also constant.
- Fuel pressure, measured on a test gauge, will vary between 2.7 bar (39 psi) at idle to 3.1 bar (45 psi) at full load to compensate for intake manifold absolute pressure.
- The fuel pressure regulator is located on the rear of the A bank fuel rail. This design provides the same pressure across each injector, and delivers an equal quantity of fuel to each of the eight cylinders.
- Fuel flows through the B bank fuel rail, across the crossover pipe and through the A bank fuel rail. The fuel rails are integral with the intake manifold.
- The test valve, located in the crossover pipe allows the fuel rail to be de pressurized and pressurized during testing and servicing. A standard fuel pressure gauge kit is used to connect to the test valve.



Fuel Injectors – AJ26

- Eight solenoid operated fuel injectors are secured to the fuel rail by cap screws.
- The unique fuel injectors are side fed and have dual straight jets.
- The fuel spray from each jet is directed toward the adjacent intake valve.
- Two O rings seal each injector in the fuel rail bores. B+ voltage is supplied to the injectors via the ignition switch activated (position II, III) fuel injection relay.
- The ECM drives the injectors with a single pulse and modulates the pulse width to control the injector pulse duration.

NOTES



FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

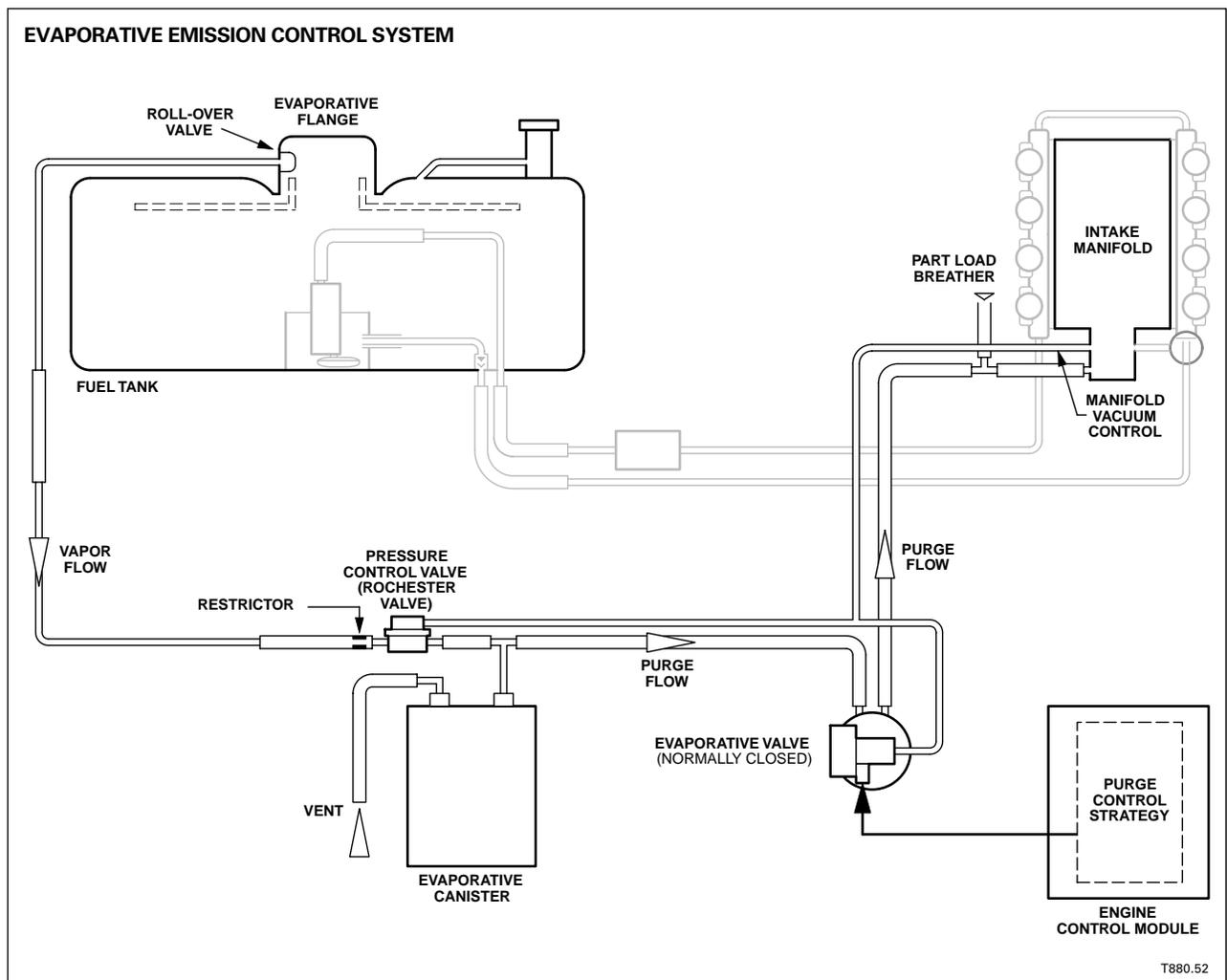
Evaporative Emission Control System – 1997 MY

The fuel tank can be filled to approximately 90% of its capacity. The additional 10% of volume allows for expansion of the fuel, without escape to the atmosphere.

To limit evaporative emissions when the engine is switched off, the fuel tank pressure is maintained at a positive pressure of 0.069 – 0.092 bar (1.0 – 1.33 psi) by the tank pressure control valve (Rochester valve). Pressure above 0.092 bar (1.33 psi) is released by the valve to the charcoal canister.

When the engine is running, manifold vacuum acts on the tank pressure control valve, which opens the vent line from the fuel tank to the charcoal canister. Air enters the charcoal canister and flows to the tank to replace the fuel delivered to the engine, and maintain atmospheric pressure in the tank.

If the tank pressure control valve fails, the fuel tank cap will vent the fuel tank to the atmosphere at 0.138 – 0.172 bar (2.0 – 2.5 psi).



ECM Canister Purge Control

- When the ECM enables canister purge, air flows in the vent and through the charcoal canister to the intake manifold via the normally closed evaporative emission control valve (EVAPP) (purge valve).
- The ECM drives the EVAPP to control purge using a variable pulsed duty cycle from a mapped strategy.
- The purge flow rate is based on engine operating conditions and the concentration of fuel vapor in the charcoal canister.

Engine operating conditions

The engine operating conditions that determine the rate of canister purge are:

- Engine load and speed
- Coolant temperature
- Time since engine starting
- Closed loop fuel metering correction

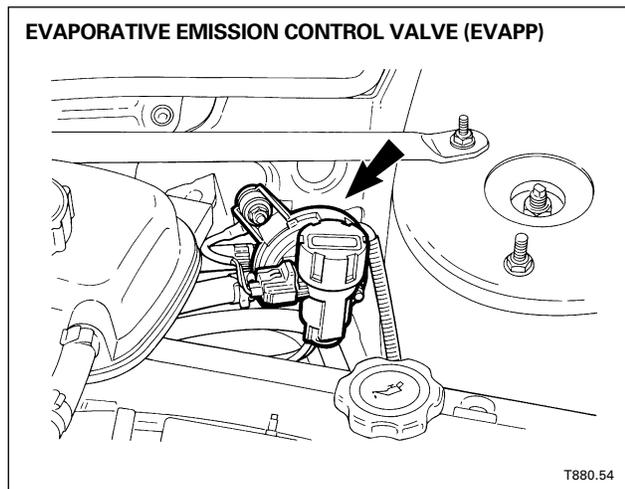
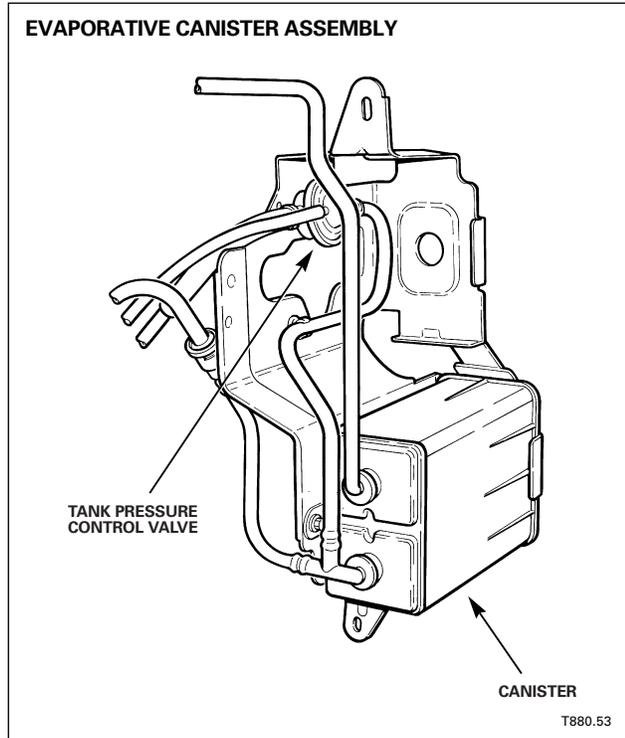
During canister purge, the ECM inhibits traction / stability fuel injection intervention and fuel injection cutoff.

Determination of fuel vapor concentration

- The ECM determines the concentration of fuel vapor being drawn from the charcoal canister and makes a correction to the base fuel metering map.
- The determination is made by the ECM making step changes to the purge flow rate while no correction is made to the fuel metering calculation.
- The ECM determines the fuel vapor concentration by analysis of the closed loop fuel metering deflection.

Evaporative Emission Control Valve (EVAPP)

- The EVAPP is a vacuum operated, normally closed purge valve.
- The EVAPP incorporates a vacuum switching valve (VSV) that is supplied with EMS switched B+ voltage.
- The ECM drives the VSV portion of the EVAPP (ground side switching), which ports manifold vacuum to a diaphragm and opens the valve to allow purge flow to the intake manifold.
- The valve opening is modulated by the ECM from an operating strategy to control purge flow.



FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

Enhanced Evaporative Emission Control System – 1998 MY ON

1998 MY ON vehicles are equipped with a twin canister enhanced evaporative emission system that provides reduced evaporative emissions and enhances the system's on-board diagnostic capabilities.

The enhanced evaporative emission system consists of the following components:

- Fuel tank pressure sensor (FTP Sensor)
- Fill level vent valve
- Two evaporative canisters
- Canister close valve (CCV) and filter
- Evaporative emission valve (EVAPP)

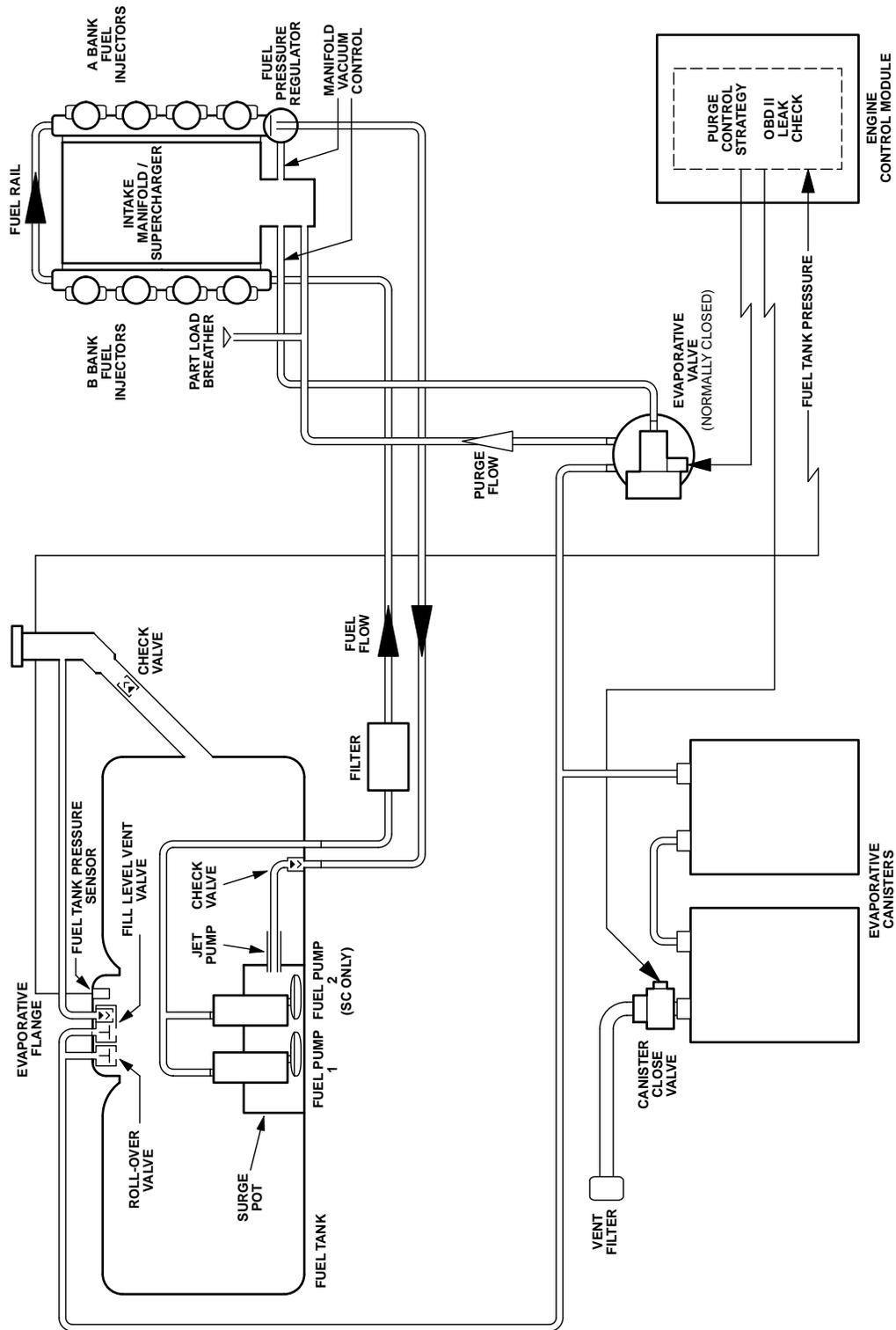
Enhanced Evaporative Emission Control System Operation

When the engine is switched off, the fill level vent valve and/or the roll-over valve ports fuel tank vapors through the vent line to the two carbon canisters. To maintain atmospheric pressure in the tank, air enters the canisters through a filter via the normally open canister close valve.

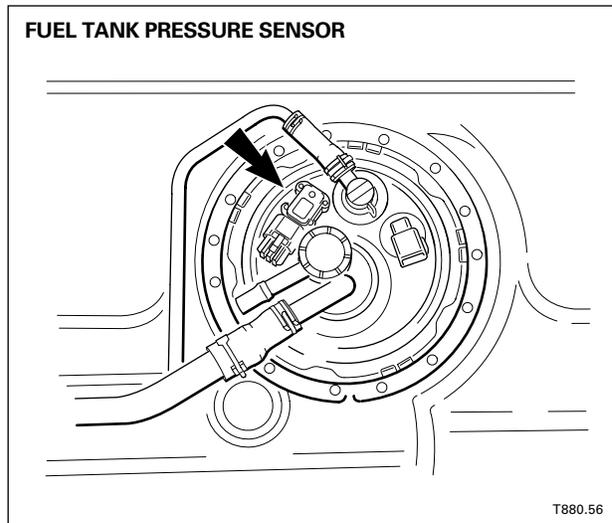
When the engine is running and canister purge is enabled, the ECM meters purge flow from the canisters and tank via the evaporative emission control (purge) valve (EVAPP). The ECM enables canister purge using a mapped strategy.

NOTES

FUEL DELIVERY AND ENHANCED EVAPORATIVE EMISSION CONTROL SYSTEM – AJ26



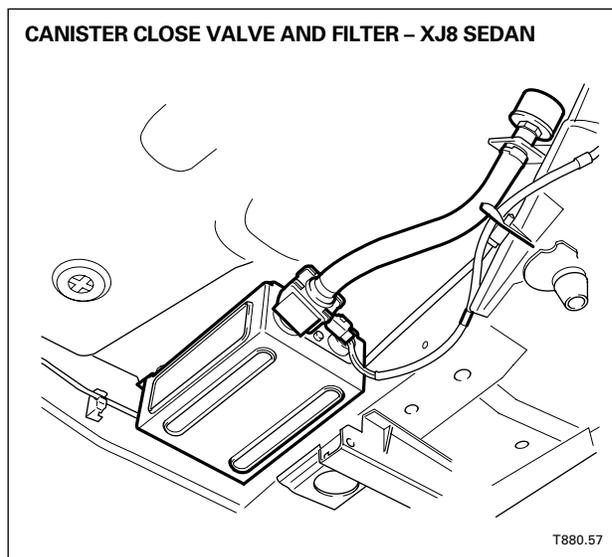
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FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL**Enhanced Evaporative Emission Control System – 1998 MY ON (continued)****Fuel Tank Pressure Sensor (FTP Sensor)**

- The FTP sensor, located on the fuel tank evaporative flange, incorporates a pressure sensor capsule connected to a resistive element.
- The ECM supplies 5 volts to the resistive element, which outputs a voltage signal proportional to the fuel tank pressure.

Canister Close Valve (CCV)

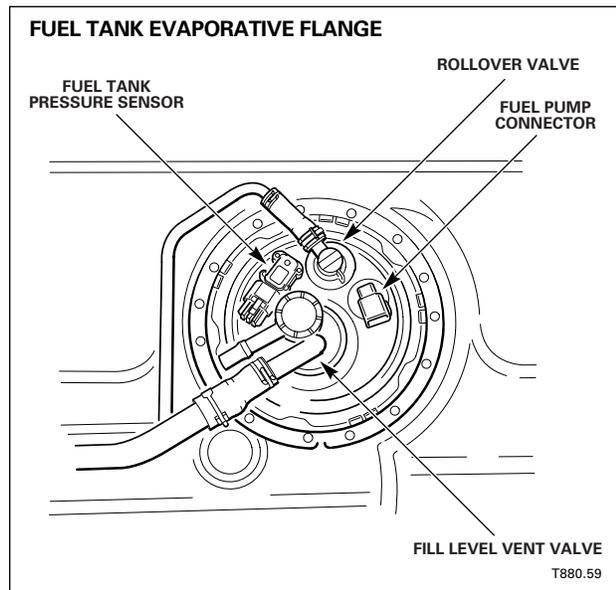
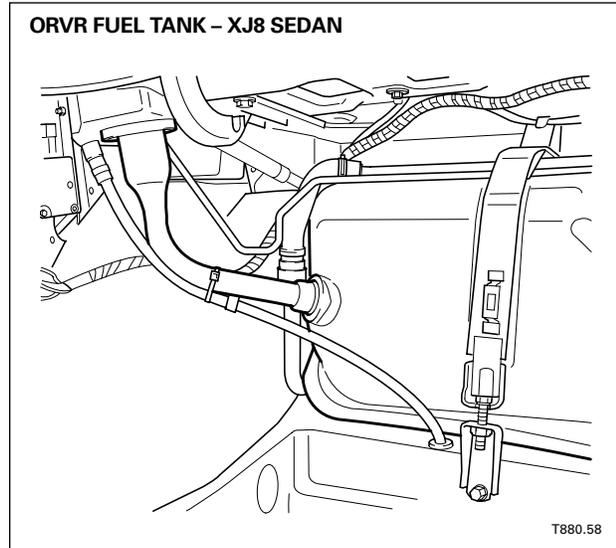
- The normally open CCV, located on the second evaporative canister outlet, is operated by the ECM from the purge control / leak check strategy.
- A filter is installed on the vent hose to prevent debris from entering the canister.

NOTES

On-Board Refueling Vapor Recovery (ORVR)

- ORVR, common to all 1998 MY ON vehicles, prevents the fuel tank vapor from being vented directly to the atmosphere during refueling.
- During refueling, vapor is vented through the EVAP system.
- The ORVR system consists of a unique fuel tank filler neck incorporating a check valve, unique vent lines and a fill level vent valve.
- The lower part of the filler neck has a reduced diameter.
- During refueling, the incoming fuel seals the gap between the reduced part of the filler neck and the refueling filler nozzle to prevent vapor from escaping up the filler neck.
- The check valve, located at the neck outlet to the tank, prevents fuel from backing-up in the filler neck.
- The fill level vent valve, located in the fuel tank evaporative flange, incorporates a float valve and a pressure relief valve.
- The valve sets the maximum fuel level in the tank and provides outlets to the EVAP system and to the filler neck.
- The roll-over valve also vents to the EVAP system. Note that the vapor inlet to the roll-over valve is located higher in the fuel tank than is the inlet to the fill level vent valve.

NOTES

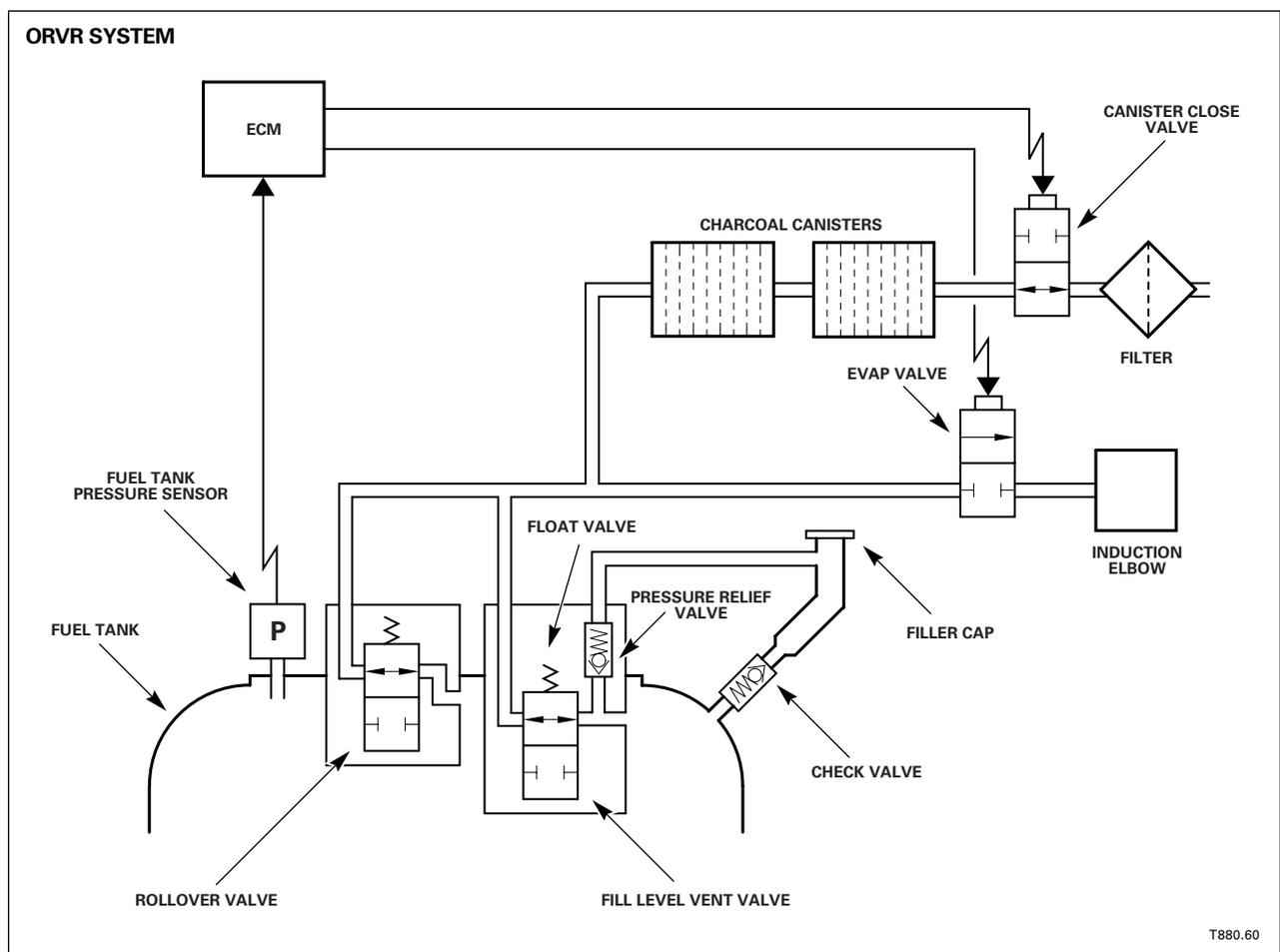


FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

On-Board Refueling Vapor Recovery (ORVR) (continued)

ORVR Operation

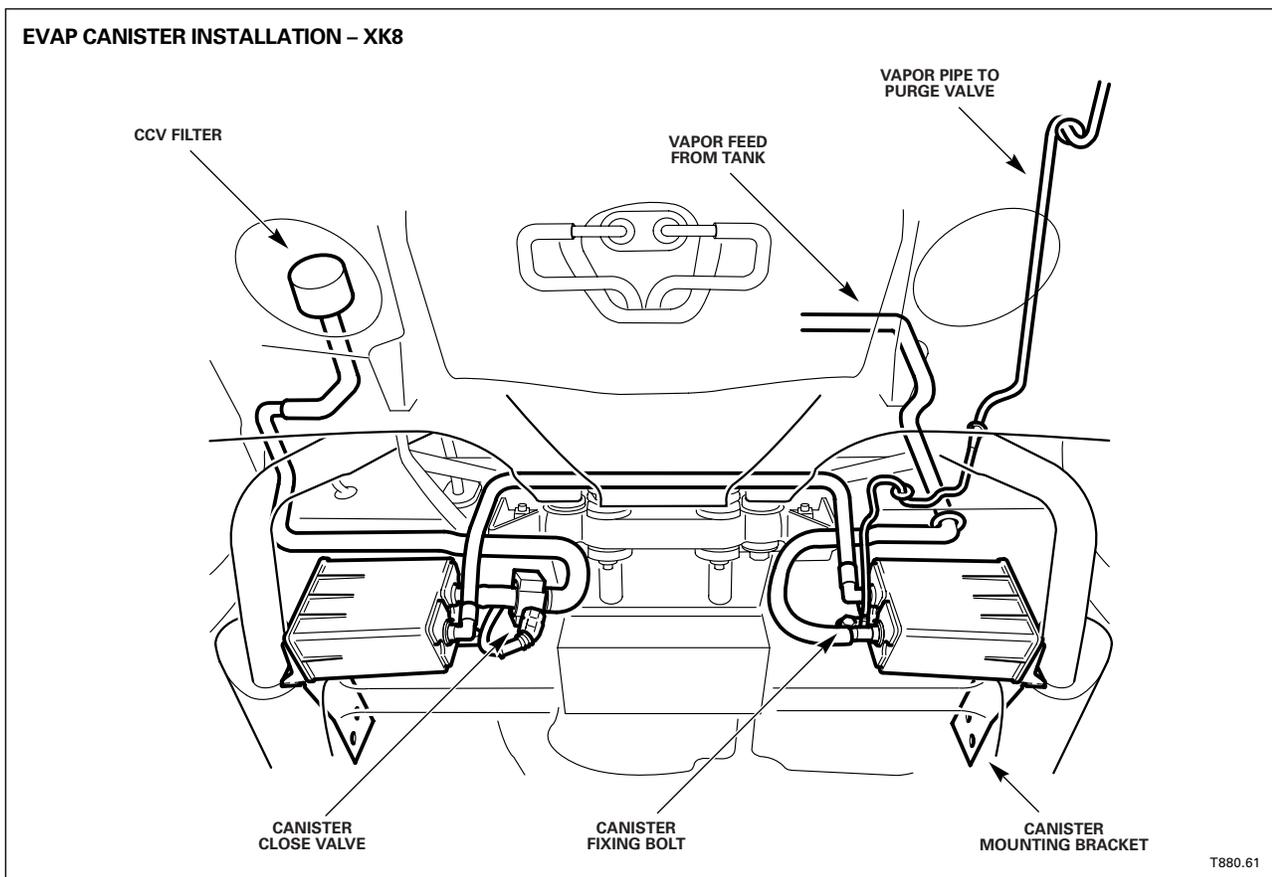
- During refueling, the incoming fuel pushes fuel vapor through the roll-over valve and the fill level vent valve to the EVAP system.
- When the fuel level rises to close the float valve, ventilation is restricted causing a back pressure in the filler neck sufficient to operate the refueling filler nozzle automatic shut-off.
- After installing the filler cap, the fuel tank vents only through the roll-over valve until the fuel level drops to a level that allows the float valve to open the fill level vent valve.
- If the EVAP system fails so that the fuel tank cannot vent correctly, the fill level vent valve pressure relief valve opens to allow vapor flow to the atmosphere through the filler neck and cap.



NOTES

On-Board Refueling Vapor Recovery (ORVR) – XK8

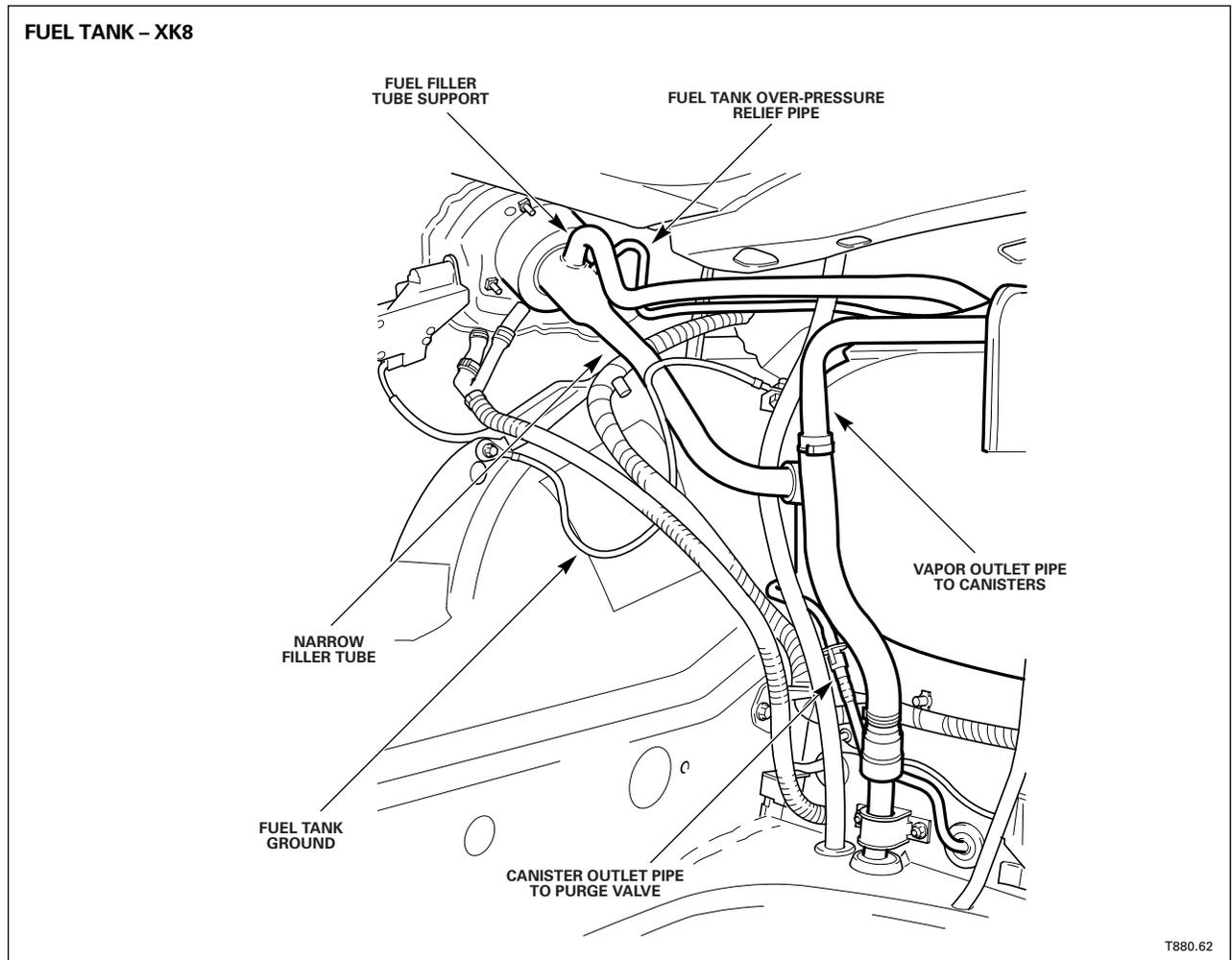
- The XK8 enhanced evaporative emission system with ORVR is similar to the system used on the XJ8 Sedan.
- Due to the large bore hoses required, the EVAP canisters and associated components are relocated to the rear of the vehicle behind the rear suspension/final drive assembly.
- The canister close valve (CCV) and vapor hoses are fixed directly to the bodywork.
- The EVAP canisters are bolted directly and via brackets to the body.
- The atmospheric vent pipe from the second canister is routed through a hole in the RH suspension housing with the CCV air filter fitted to the end of the pipe inside the housing.



NOTES

FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL**On-Board Refueling Vapor Recovery (ORVR) – XK8 (continued)****Fuel Tank Filler**

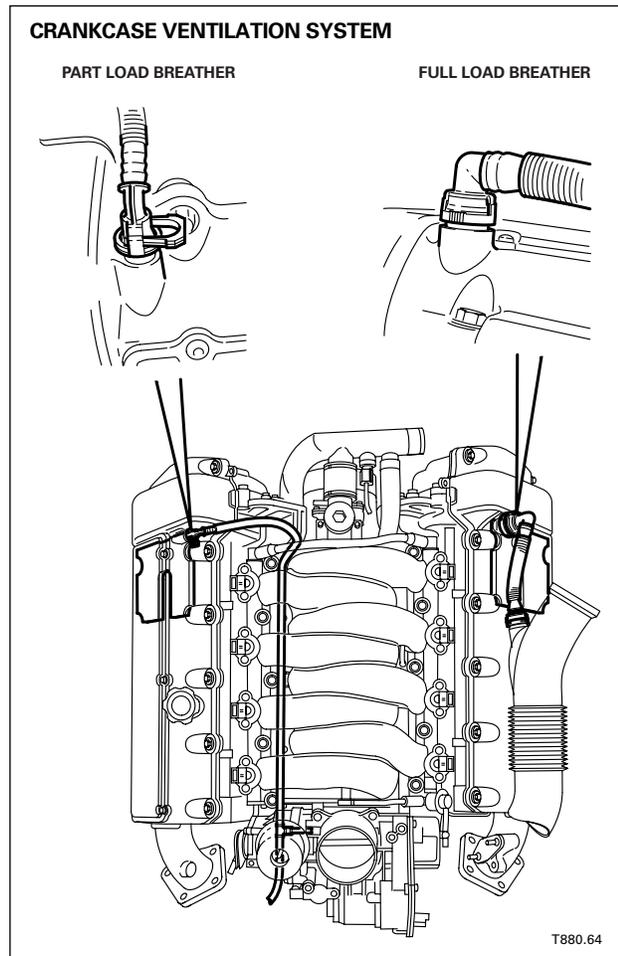
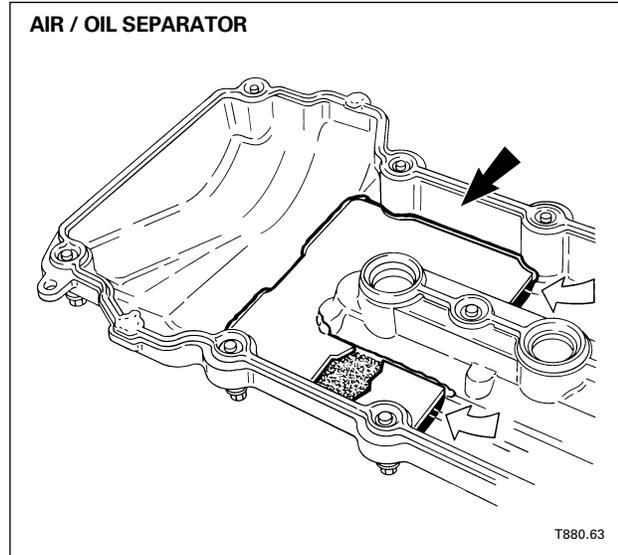
Due to the relocation of the EVAP canisters, the vapor pipes pass through the floor of the trunk. Note that, on the convertible model, the closing panel behind the tank is modified to accommodate the vapor pipes.

**NOTES**

Crankcase Ventilation System

- The engine crankcase is ventilated through a part load and a full load breather.
- Each camshaft cover incorporates a wire gauze air / oil separator.
- The part load breather connects between the B bank air / oil separator and the intake manifold induction elbow, and tees to the canister purge line.
- The full load breather connects between the A bank air / oil separator and the intake air duct, downstream from the MAFS.
- The breather hoses have quick release fittings.

NOTES



AJ26 / AJ27 ENGINE MANAGEMENT SYSTEMS



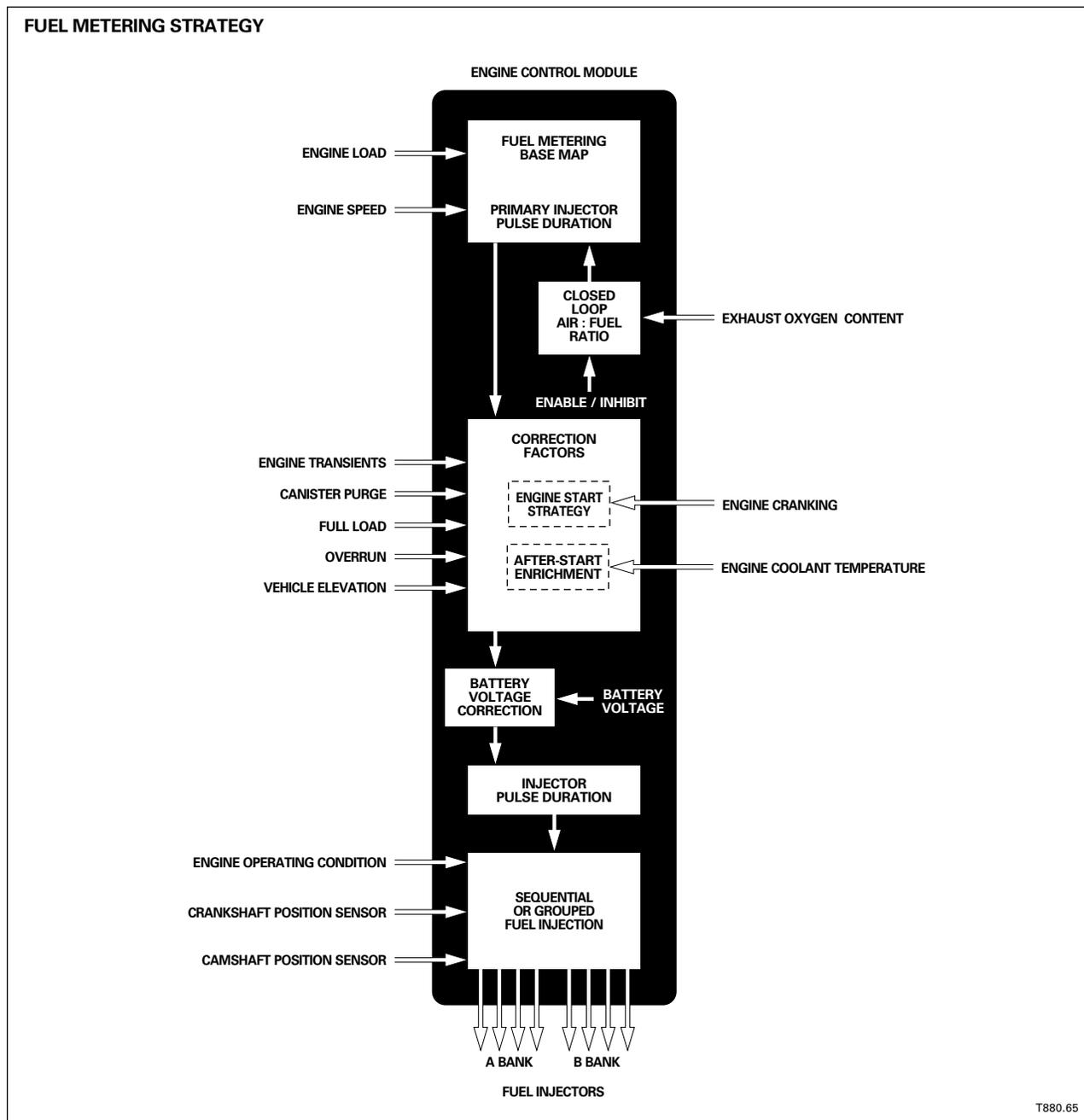
- 1 AJ26 / AJ27 OVERVIEW
- 2 CONTROL SUMMARIES
- 3 ENGINE CONTROL MODULES
- 4 EMS PRIMARY SENSING COMPONENTS
- 5 INDUCTION AIR THROTTLE CONTROL
- 6 FUEL DELIVERY AND
EVAPORATIVE EMISSION CONTROL
- 7 FUEL INJECTION**
- 8 IGNITION
- 9 VARIABLE VALVE TIMING
- 10 EXHAUST GAS RECIRCULATION (EGR):
NORMALLY ASPIRATED
- 11 OTHER ECM ENGINE CONTROL AND
INTERFACE FUNCTIONS
- 12 AJ26 / AJ27 SUPERCHARGED EMS
- 13 TASK SHEETS



FUEL INJECTION

Fuel Metering

Fuel metering is controlled by the ECM using a base fuel metering map, which is then corrected for the specific engine operating conditions. The ECM varies the fuel injector pulse duration and the number of pulses during each engine cycle (two crankshaft rotations) to achieve the necessary fuel metering. The injectors are pulsed sequentially, once per engine cycle (once every two engine revolutions) in the engine firing order, except during starting and acceleration.



Base Fuel Metering Map

- The base fuel metering map sets the base air : fuel ratio for normal engine operation throughout the full range of engine load and speed.
- Engine load is determined by measuring intake mass air flow.
- The MAFS supplies the ECM with a mass air flow signal.
- The ECM receives an engine speed signal from the CKPS.
- By monitoring the exhaust oxygen content from the HO2S (upstream oxygen sensors), the ECM is able to perform closed loop fuel metering control and adaptive fuel metering.

Closed Loop Fuel Metering

- The exhaust system incorporates 3-way catalytic converters that oxidize CO and HC, and reduce NOx. These converters operate efficiently only if engine combustion is as complete as possible.
- A closed loop system between fuel injection, ECM control, and exhaust oxygen content feedback maintains an air : fuel ratio as close to stoichiometric as possible.
- In response to oxygen sensor voltage swings, the ECM continuously drives the air : fuel ratio rich-lean-rich by adding to, or subtracting from the base fuel metering map.
- Separate channels within the ECM allow independent control of A and B bank injectors.

Adaptive Fuel Metering

- The ECM adapts fuel metering to variations in engine efficiency, subsystem tolerances, and changes caused by engine aging.
- Adaptions take place at normal operating temperature during engine idle, and at four other points within the engine load / speed range.
- While monitoring the HO2S feedback, the ECM centralizes fuel metering within the feedback range.
- These adaptions can be measured by the PDU Datalogger Long Term Fueling Trim (LTFT) parameter.
- The ECM retains the adaptions in memory, for use in subsequent drive cycles.
- During the next drive cycle, the ECM monitors the adaptions taking place and compares them to the adaptions that took place during the previous drive cycle for diagnostic purposes.
- If the ECM battery power supply is disconnected, all adaptions will be lost from memory.
- After reconnecting the battery power supply and starting the engine, engine operation may be uneven (especially at idle) until the ECM relearns the adaptions.

NOTES

FUEL INJECTION

Fuel Metering (continued)

Engine Starting

The engine start strategy is used when the ECM receives an ENGINE CRANK signal from the BPM. With the exception of wide open throttle (WOT), the engine start strategy operates independently of accelerator pedal position or movement. The engine start strategy initially increases injector pulse width to provide sufficient fuel for starting and progressively reduces the pulse width during the cranking cycle. During the first 360° of crankshaft rotation, all fuel injectors operate simultaneously. During subsequent revolutions the injectors are operated in the engine firing order, once per 360° of crankshaft rotation. At engine speeds above 400 rpm the injectors operate normally. The starting strategy produces steady-state running at the target idle speed within two seconds of firing after a maximum overshoot of 200 – 300 rpm. If the accelerator pedal demands WOT during cranking, the ECM cancels fuel injection and allows the throttle valve to full open to clear the fuel vapor from the “flooded” engine intake.

Warm-Up Enrichment

During engine warm-up, the ECM controls fuel metering from maps that add an enrichment factor based on coolant temperature, engine load and speed.

Transient Fuel Metering

During acceleration and deceleration, the ECM controls fuel metering to optimize the air : fuel ratio for exhaust emission, engine response, and economy. This function operates over the full engine temperature range for all rates of acceleration and deceleration.

NOTES

Full Load Enrichment

The ECM determines full load from the throttle valve angle and the engine speed. At full load, the ECM inhibits closed loop fuel metering control and increases fuel flow to enrich the air : fuel ratio. The amount of enrichment is determined from the engine speed.

Evaporative Canister Purge Flow

During evaporative canister purge flow to the engine, the ECM determines the concentration of fuel vapor being drawn from the evaporative canister and makes a correction to the base fuel metering map.

Overrun Fuel Injection Cutoff

When the throttle is closed during higher engine speeds, the ECM cancels fuel injection. The engine speeds at which fuel injection is canceled and reinstated are mapped against coolant temperature. On reinstatement, the ECM initially uses a lean air : fuel ratio to provide a smooth transition, then progressively returns to the nominal air : fuel ratio. The nominal air : fuel ratio for reinstatement is derived from throttle valve angle and engine speed. During overrun fuel injection cutoff, closed loop fuel metering control, EVAP and EGR are inhibited.

Engine Overspeed Protection

To protect the engine from overspeed damage, the ECM cancels fuel injection at 7100 rpm. Fuel injection is reinstated at 7050 rpm.

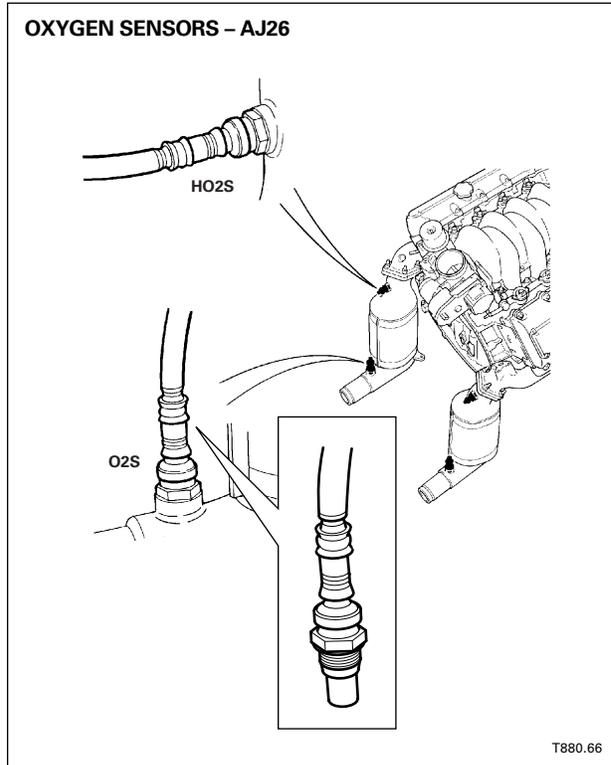
Traction / Stability Control

Fuel injection intervention is used for traction / stability control.

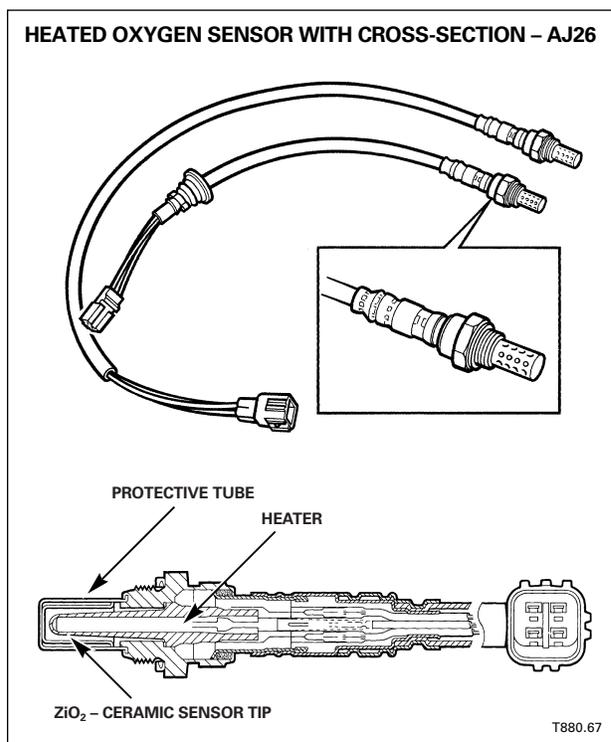
NOTES

FUEL INJECTION

Exhaust Gas Oxygen Content Monitoring: Oxygen Sensors – AJ26



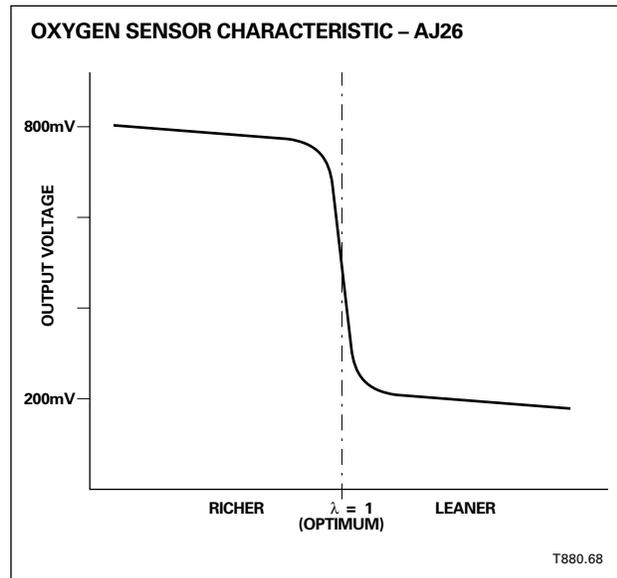
- The AJ26 EMS uses four zirconium dioxide type oxygen sensors.
- A heated oxygen sensor (HO2S) is located upstream of each catalytic converter; an unheated oxygen sensor (O2S) is located downstream of each catalytic converter.
- The two upstream sensors are used by the ECM for closed loop fuel metering correction. The downstream sensors for used for OBD catalyst monitoring.
- The oxygen sensors produce voltage by conducting oxygen ions at temperatures above 300 °C (572 °F).
- The tip portion of the sensor's ceramic element is in contact with the exhaust gas.
- The remaining portion of the ceramic element is in contact with ambient air via a filter through the sensor body.
- In order to reduce the time and resulting emission needed to bring the upstream sensors up to working temperature, an internal electric heater is used. The heaters are controlled by the ECM.
- At engine speeds above approximately 3000 rpm, the ECM switches off the heaters.
- The construction of the upstream and downstream sensor harnesses and connectors are different so that they can be easily identified and not be interchanged.
- The HO2S have a four-way connector; the O2S have a two-way connector.



NOTES

Oxygen Sensor Characteristic

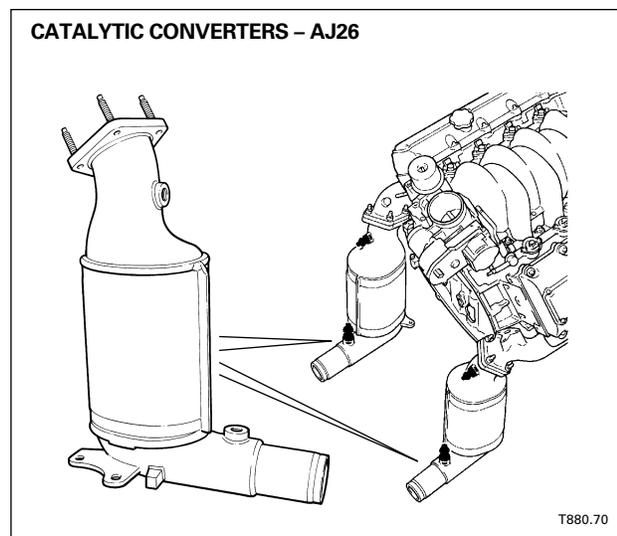
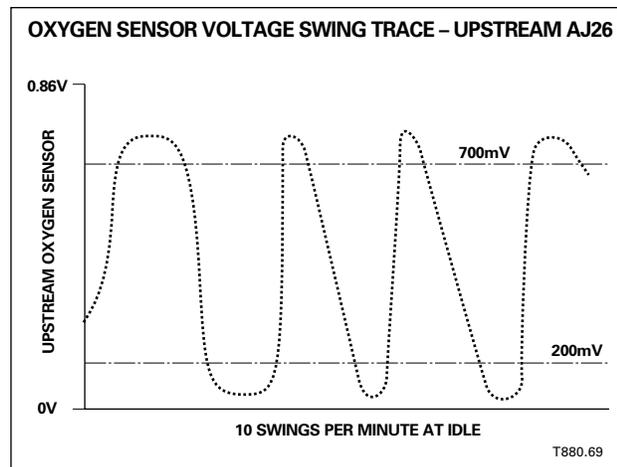
- The sensor voltage varies between approximately 800 millivolts and 200 millivolts, depending on the oxygen level in the exhaust gas.
- When the air : fuel ratio is richer than optimum, there is low oxygen in the exhaust gas and the voltage output is high.
- When the air : fuel ratio is leaner than optimum, oxygen in the exhaust is high and the output voltage is low.
- Only a very small change in air : fuel ratio is required to swing the oxygen sensor voltage from one extreme to the other, thus enabling precise fuel metering control.



Catalytic Converters – AJ26

The AJ26 engine exhaust system uses a single catalytic converter for each engine bank. The placement of the catalysts in the down pipes, adjacent to the exhaust manifolds, ensures rapid “light off” and eliminates the need for secondary catalysts.

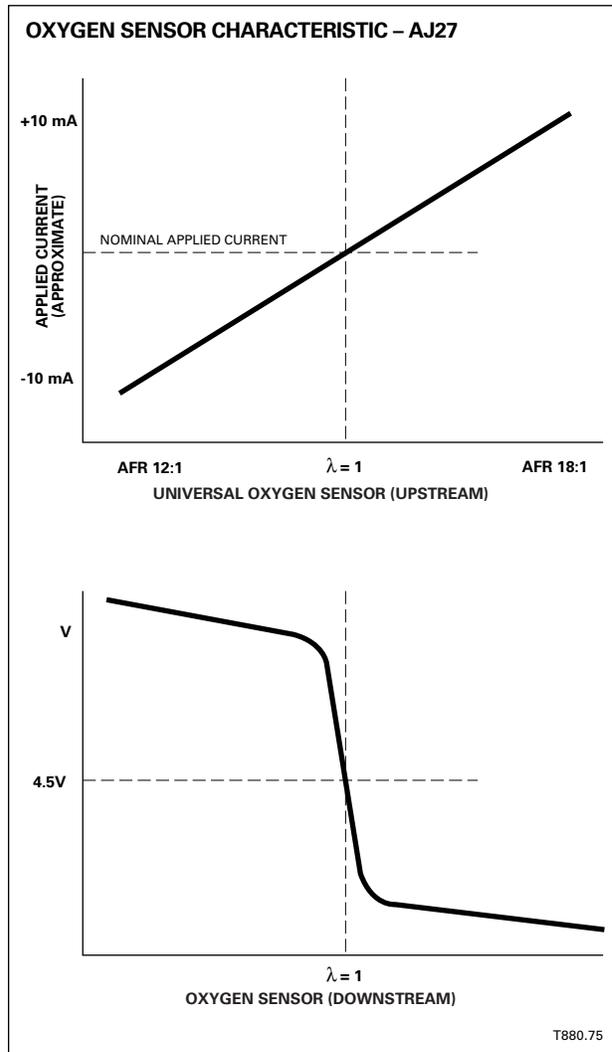
Deterioration of catalytic conversion efficiency will create unacceptable HC, CO and NO_x exhaust emission. The efficiency of the catalytic converter system is monitored and any deterioration in efficiency is flagged as a fault by the ECM. Catalyst efficiency is monitored by sampling both the incoming and outgoing exhaust gas at the catalysts. Two oxygen sensors are positioned in each exhaust downpipe assembly – one HO₂S upstream of the catalyst and one O₂S downstream of the catalyst. By comparing the voltage swings of each set of sensors, the ECM can detect when catalyst efficiency drops off.



NOTES

FUEL INJECTION

Oxygen Sensors – AJ27



“Universal” Oxygen Sensors

- In order to improve air : fuel ratio (AFR) control under varying engine conditions, a “universal” type heated oxygen sensor is fitted in the upstream position.
- The universal sensor has varying current response to changes in exhaust gas content.
- The AFR can be maintained more precisely within a range from approximately 12:1 to 18:1, not just stoichiometric.
- Voltage is maintained at approximately 450 mV by applying a current.
- The current required to maintain the constant voltage is directly proportional to the AFR.
- A higher current indicates a leaner condition; a lower current indicates a richer condition.
- The current varies with the temperature of the sensor and is therefore difficult to measure for technician diagnostic purposes.
- The downstream heated oxygen sensors, used for catalyst efficiency monitoring, remain unchanged. However, the location in the exhaust system has changed. Refer to the following page.

HO2S Heater Control

- The universal oxygen sensors require precise heater control to ensure accuracy and prevent sensor damage.
- After engine start, the ECM initially applies B+ voltage to the heaters to quickly warm the sensors, then reduces the voltage as necessary to maintain sensor temperature. The ECM varies the voltage by PWM control of the individual heater ground side circuits.

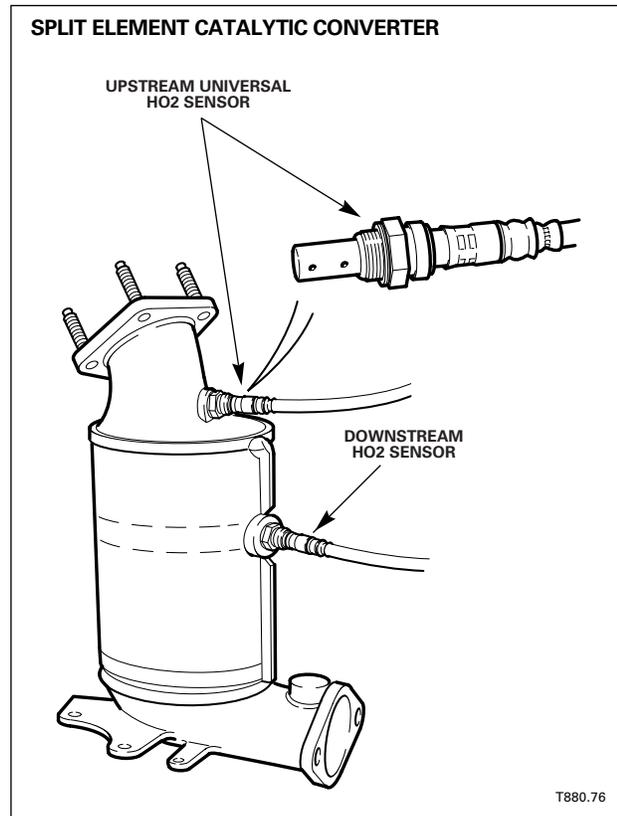
NOTES

Catalytic Converters – AJ27

Split Element Catalytic Converter

The AJ27 EMS produces very low levels on exhaust emission. In order to allow detection of catalytic converter deterioration at these very low levels, a split element catalytic converter is used.

To improve catalyst efficiency monitoring, the spacing between the two internal ceramic catalytic elements has been increased to allow the downstream HO₂ sensor to be relocated to the new position between the two elements. Due to the lower efficiency of the first (top) element compared to the second element, the level of exhaust emission at this location is sufficiently high to ensure accurate monitoring.



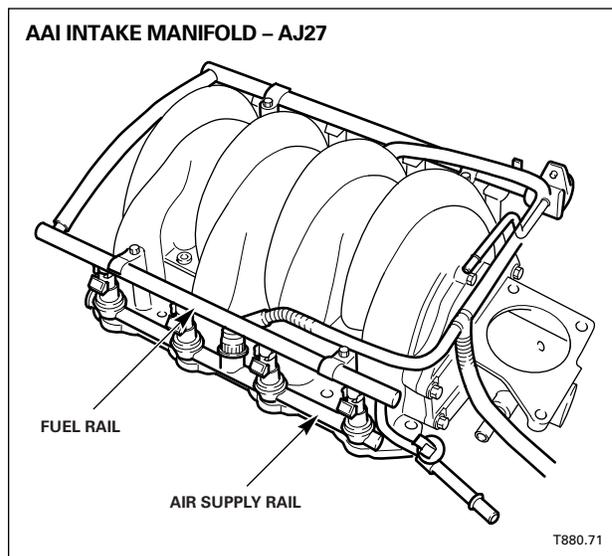
NOTES

FUEL INJECTION

Air Assisted Fuel Injection – AJ27

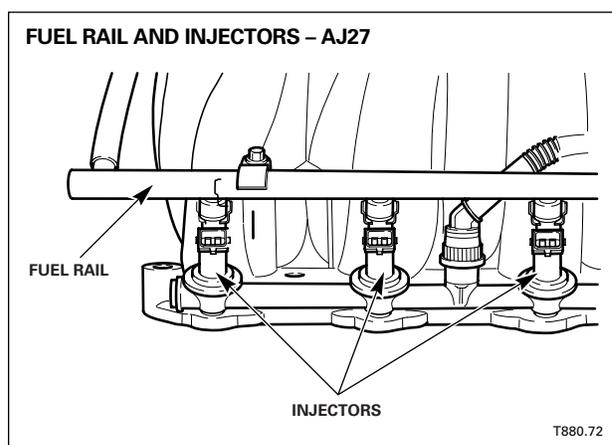
Air assisted fuel injection (AAI) improves combustion stability when the engine is cold, allowing the use of increased ignition retardation for faster catalyst warm-up, thus producing a further reduction of HC emission.

Under cold start/part throttle conditions, the system uses intake manifold vacuum to draw air through a modified injector nozzle, producing a jet which mixes with the fuel spray to increase atomization. At higher engine loads, the manifold vacuum is insufficient to have this effect. The injector air assistance supply is controlled by the ECM.



Injector Fuel and Air Supply

- Operation is based on the use of top (fuel) fed injectors with an air feed around the nozzle regions and therefore requires a modified induction manifold.
- The injectors are seated in two air supply rails which are integral with the manifold (similar to the AJ26 fuel rails).
- The rails are closed at both ends and are center fed via plastic hoses and 'T' piece from the air assist control valve (AACV).
- Two fuel rails, with a connecting crossover pipe, form a detachable assembly and are a push fit onto the injectors to which they are secured with clips. The fuel rails are then bolted to the induction manifold.



NOTES

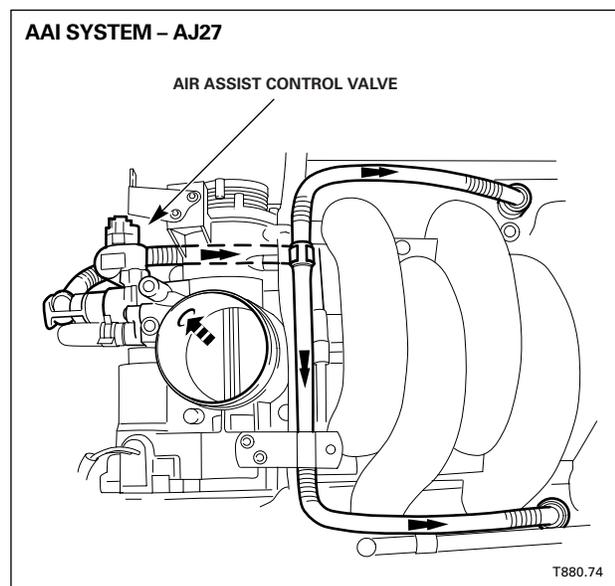
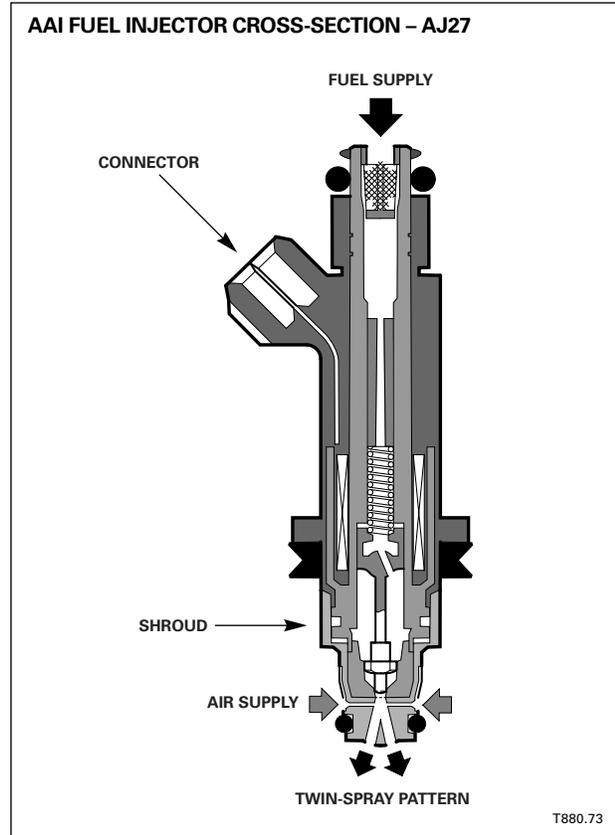
Fuel Injectors

- The injectors incorporate a shroud fitted over the nozzle end to direct the AAI air flow.
- Air from the supply rail is drawn by manifold vacuum through four small holes in the side of the shroud and past the fuel nozzle to exit via the two spray orifices in the shroud.
- When fuel is injected into this airflow, an improved spray mixture with reduced droplet size is produced.

Air Assist Control Valve (AACV)

- The air supply to the injectors is controlled by the solenoid operated air assist control valve (AACV), which is bolted to the throttle body.
- The control valve receives air, via an integral passage in the throttle body, from an entry hole in the upper throttle bore above the throttle valve.
- The ECM drives the AACV by a pulse width modulated (PWM) signal.
- The valve opens in direct proportion to an increase in the duty cycle.
- The valve is fully open from cold until a coolant temperature of 60°C (140 °F).
- Above 60°C (140 °F) a 50% duty cycle is applied until 70 °C (158 °F), at which point the valve is fully closed.

NOTES



AJ26 / AJ27 ENGINE MANAGEMENT SYSTEMS



- 1 AJ26 / AJ27 OVERVIEW
- 2 CONTROL SUMMARIES
- 3 ENGINE CONTROL MODULES
- 4 EMS PRIMARY SENSING COMPONENTS
- 5 INDUCTION AIR THROTTLE CONTROL
- 6 FUEL DELIVERY AND
EVAPORATIVE EMISSION CONTROL
- 7 FUEL INJECTION
- 8 IGNITION**
- 9 VARIABLE VALVE TIMING
- 10 EXHAUST GAS RECIRCULATION (EGR):
NORMALLY ASPIRATED
- 11 OTHER ECM ENGINE CONTROL AND
INTERFACE FUNCTIONS
- 12 AJ26 / AJ27 SUPERCHARGED EMS
- 13 TASK SHEETS



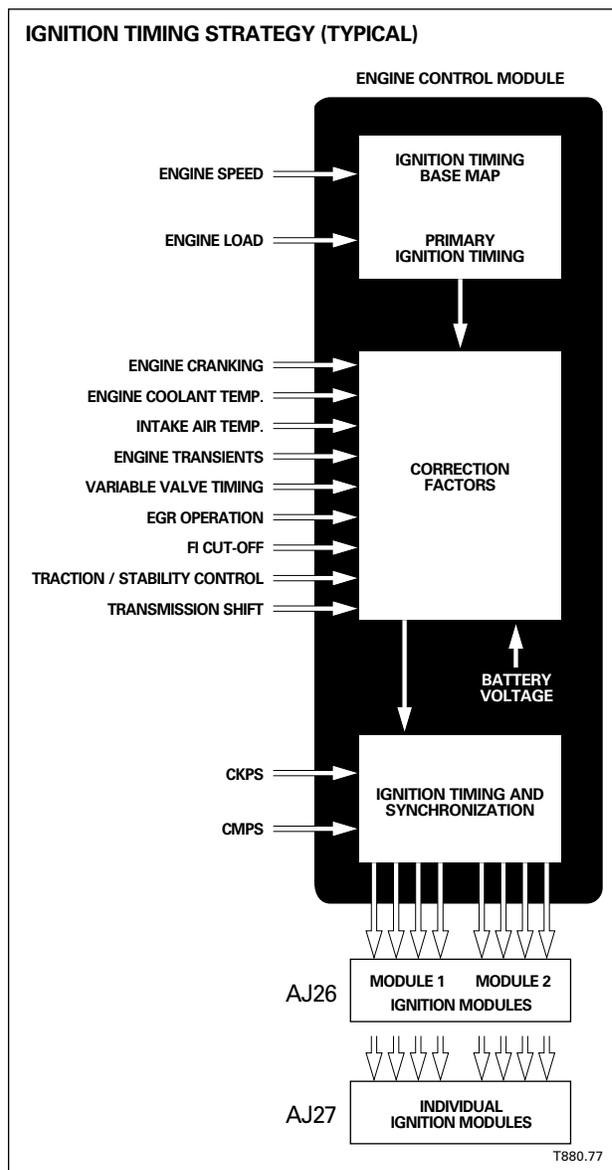
IGNITION

Ignition Timing and Distribution

Ignition timing and spark distribution are controlled by the ECM using a base ignition map, which is then corrected for the specific engine operating conditions. The spark plug for each cylinder is fired by an on-plug ignition coil. Two ignition modules, one for each group of 4 cylinders., provide the primary side switching for the coils, as signaled by the ECM. Ignition is synchronized using the input signals from the CKPS and CMPS.

Engine Firing Order

A1 – B1 – A4 – A2 – B2 – A3 – B3 – B4



Base Ignition Map

- The base ignition map sets the base ignition timing for the full range of engine load and speed.
- Engine load is determined by measuring intake mass air flow.
- The MAFS supplies the ECM with a mass air flow signal.
- The ECM receives an engine speed signal from the CKPS.

Engine Starting

- Ignition timing is fixed at one value for starting when the ECM receives an ENGINE CRANK signal from the BPM.

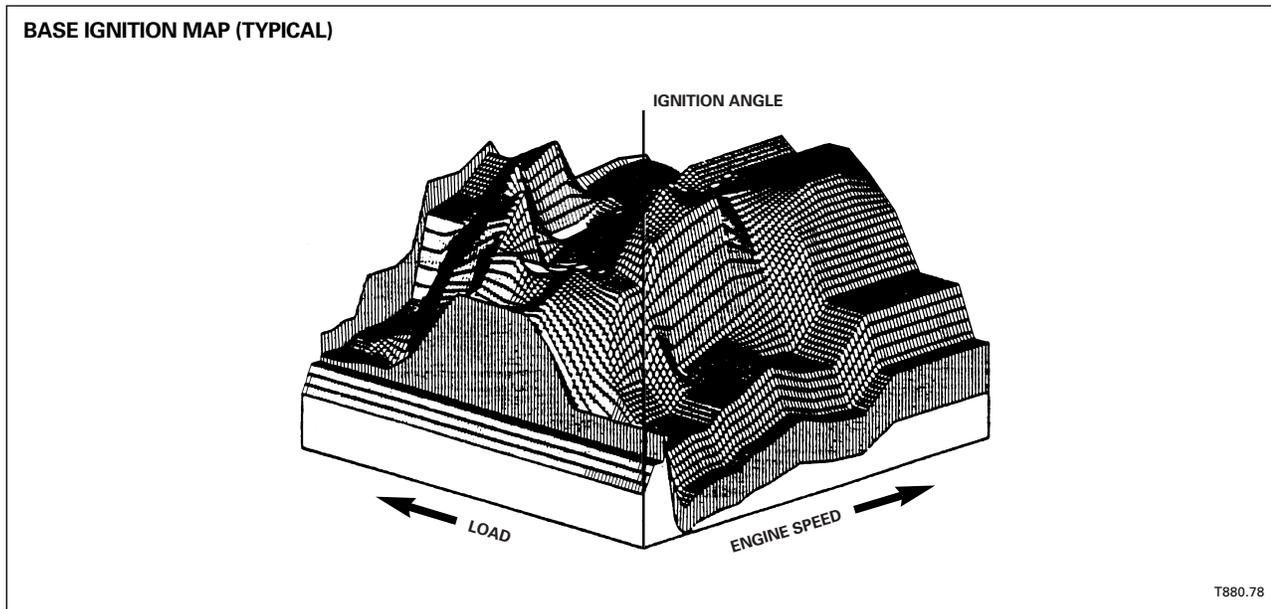
Temperature Correction

- Ignition timing corrections are applied to the ignition map by the ECM to compensate for variations in intake air temperature and engine coolant temperature.

Fuel injection cutoff interaction

- Just prior to fuel injection cutoff, the ECM retards the ignition timing to provide a smooth transition between the two operating states.
- As fuel injection is reinstated, the ECM progressively returns the ignition timing to nominal.

NOTES



Transient Interaction

During throttle transients (idle, steady state, acceleration, deceleration), the ECM applies ignition timing correction. The amount of timing correction depends on the throttle valve angle rate of change, and on the direction of throttle valve movement (opening / closing).

Variable Valve Timing Operation

During VVT transition, the ECM retards ignition timing to prevent transient ignition detonation.

EGR Operation

During EGR operation, the ECM advances ignition timing. The diluted combustion chamber charge requires more “burn time” and, therefore, more advanced ignition timing. The degree of ignition advance is proportional to engine load and speed.

Shift Energy Management

Ignition intervention is used for shift energy management.

Traction / Stability Control

Ignition intervention is used for traction / stability control.

Misfire Detection / CAN Data

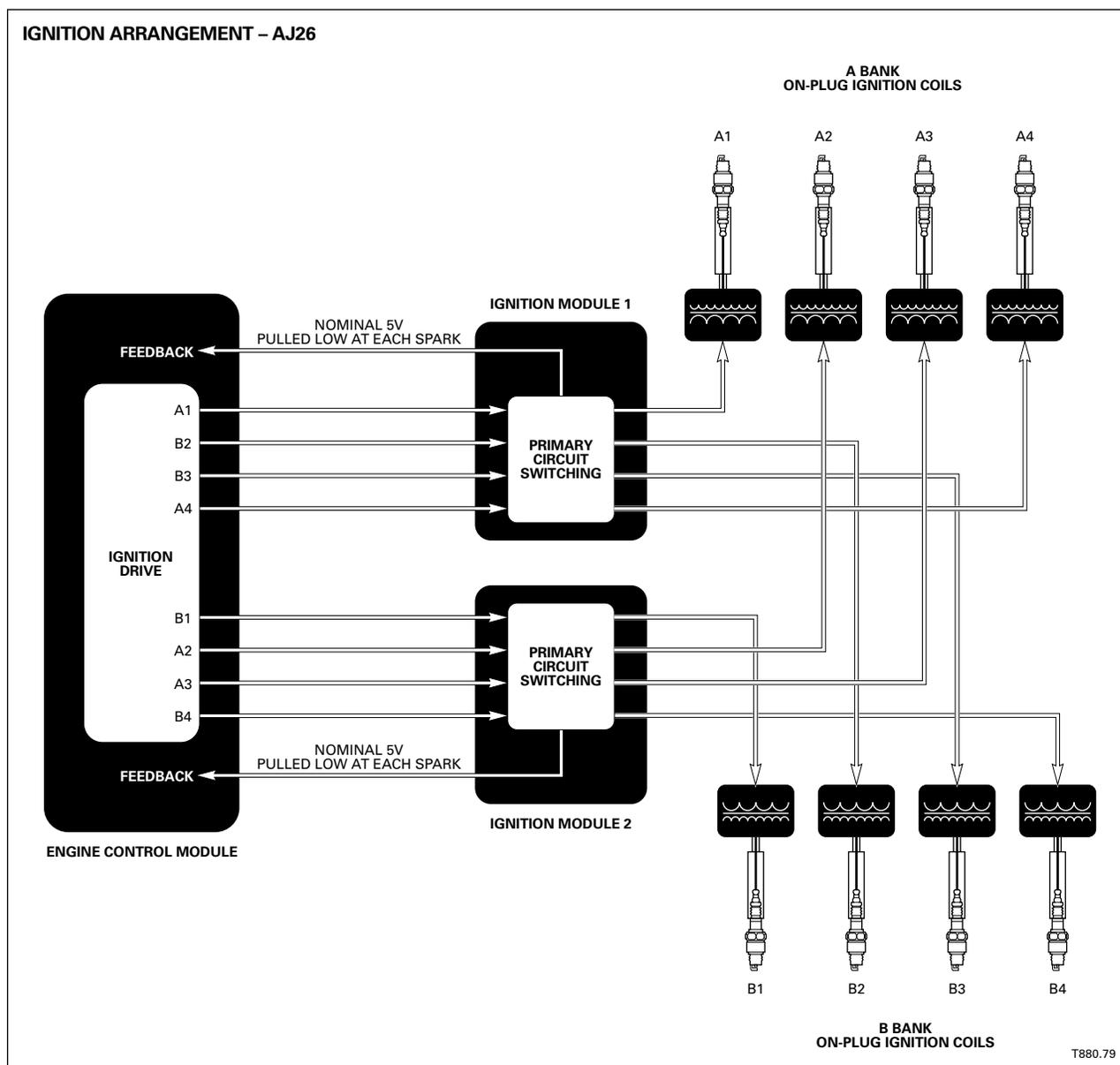
The ECM is able to detect misfire by monitoring crankshaft acceleration (CKPS signal). In order to reduce the possibility of false misfire diagnosis, the ECM uses the ABS/TCCM CAN data – left and right rear wheel speeds – to determine if the vehicle is operating on a rough road.

IGNITION

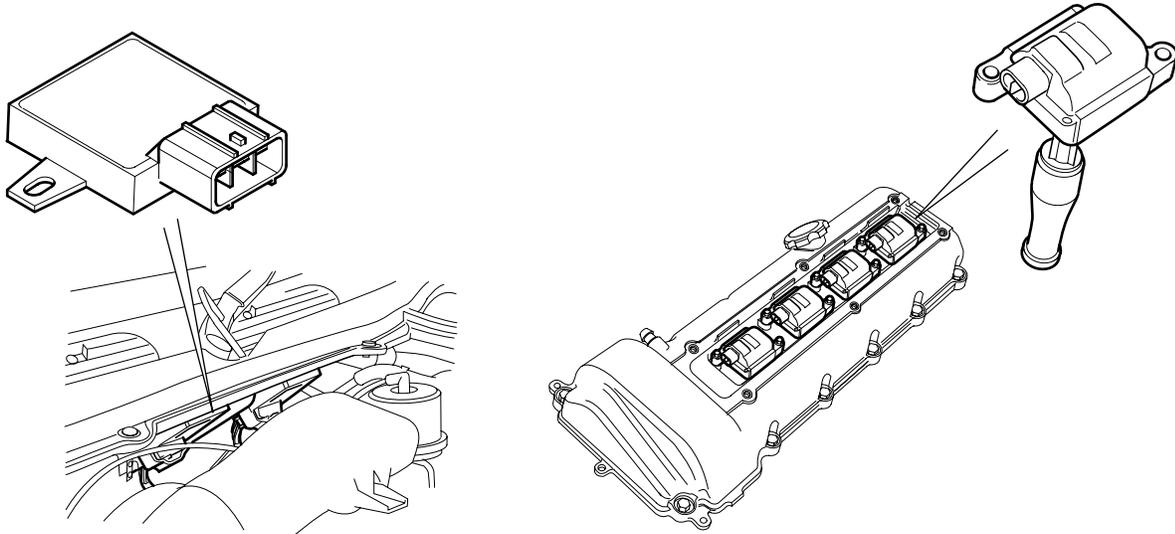
Ignition Coils and Modules – AJ26

Two ignition modules (amplifiers) are installed. The modules receive ignition drive signals from the ECM and, in turn control the primary current switching of the on-plug ignition coils. Dwell control for the ignition system is performed within the ECM.

- Module 1 switches coils A1, A4, B2, B3.
- Module 2 switches coils A2, A3, B1, B4.

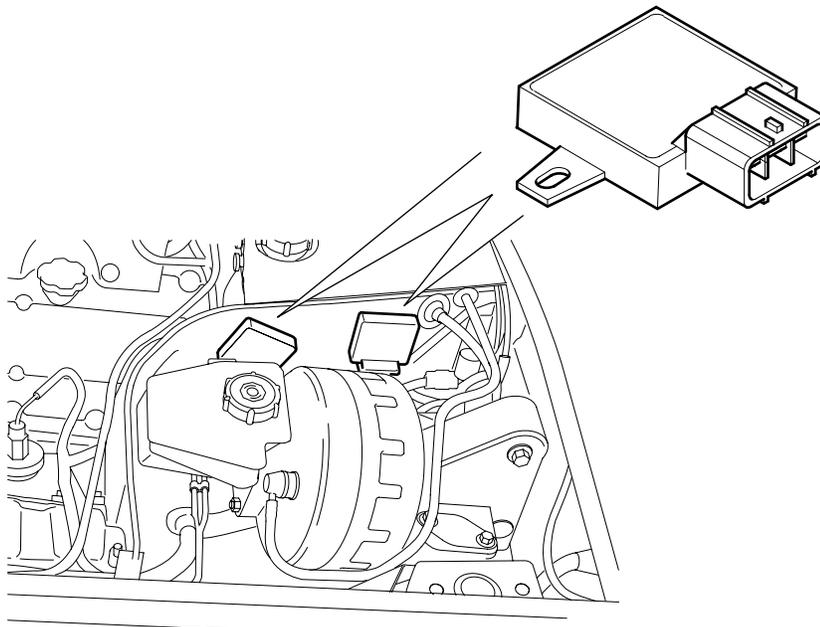


IGNITION COILS AND MODULES – XK8 AJ26



T880.80

IGNITION MODULES – XJ8 AJ26

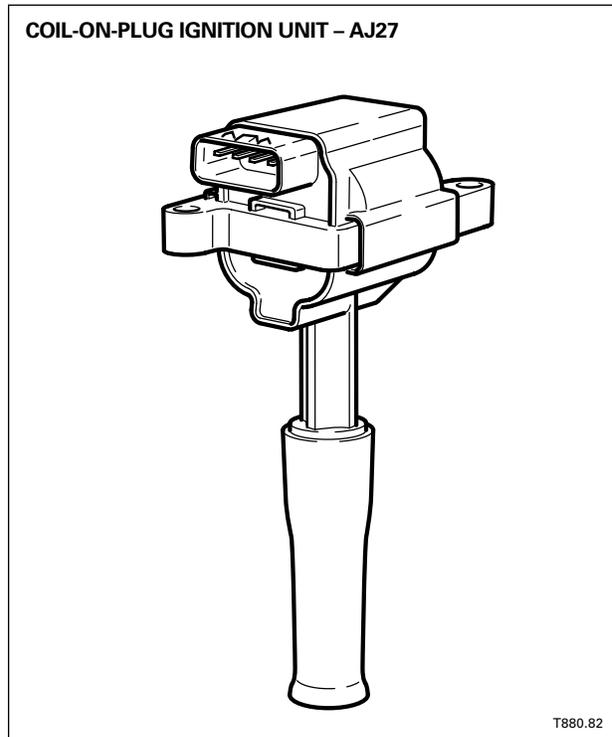


T880.80B

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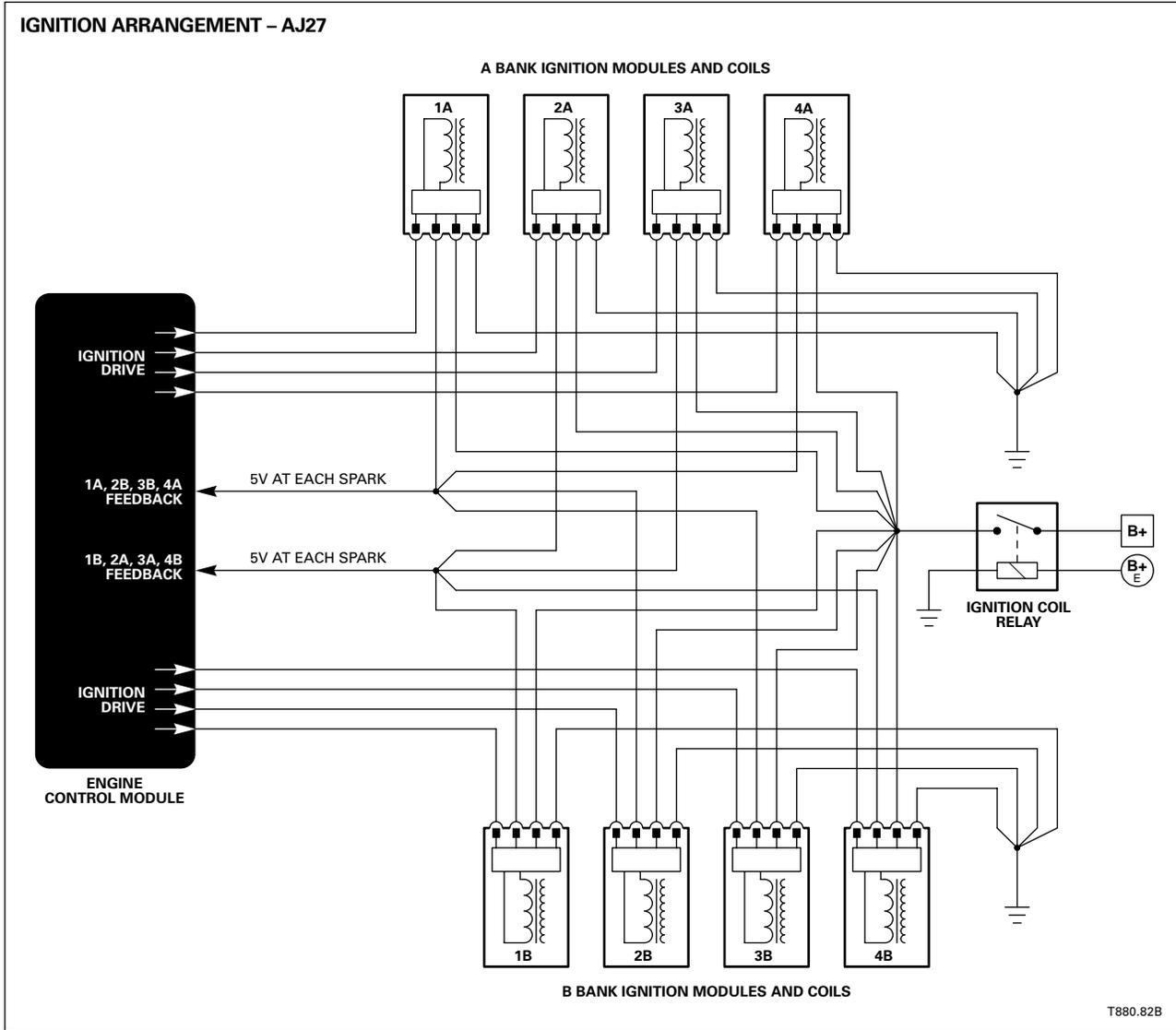
IGNITION

Ignition Coil-on-Plug Units – AJ27



- Each AJ27 coil-on-plug unit incorporates its own ignition module.
- The ignition modules are triggered directly from the ECM and drive the coil primary circuit, controlling current amplitude, switching point and dwell.
- Each ignition module provides a monitor output to the ECM.
- When an ignition trigger signal is received, an acknowledge pulse is sent to the ECM if the current drive to the coil primary is satisfactory.
- This pulse is initiated when the current reaches 2 amps and is terminated at 4 amps.
- If the trigger signal is not received or the coil current does not rise to 2 amps, the monitor line will remain at logic high, signaling an ignition failure to the ECM.
- As with AJ26, two ignition monitor inputs (one per group of four ignition coils) are provided to the ECM.
- Ignition monitor circuits from cylinders 1A, 2B, 3B and 4A are spliced together; ignition monitor circuits from cylinders 1B, 2A, 3A and 4B are spliced together.

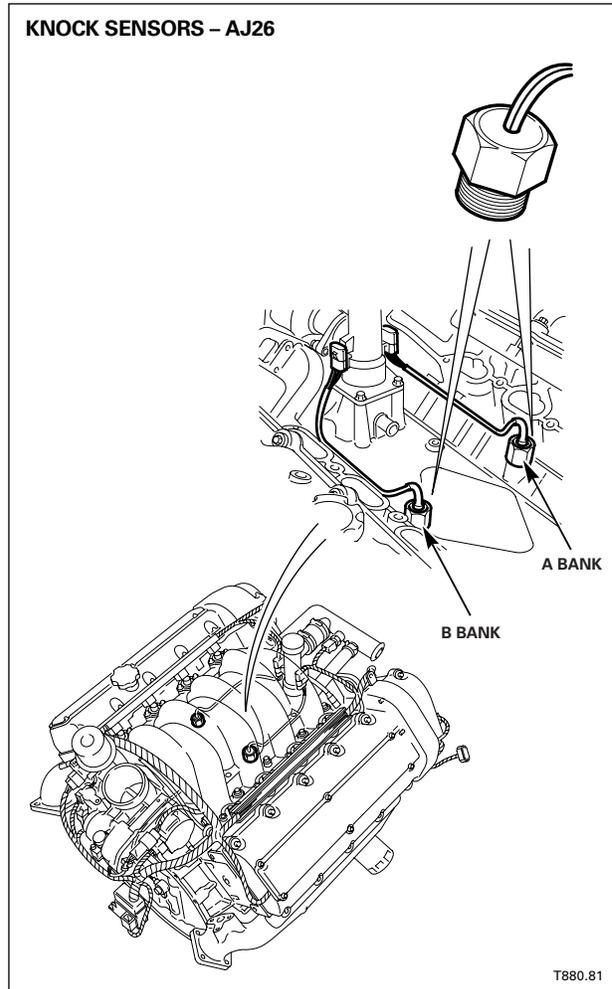
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IGNITION

Ignition Knock (Detonation) Control

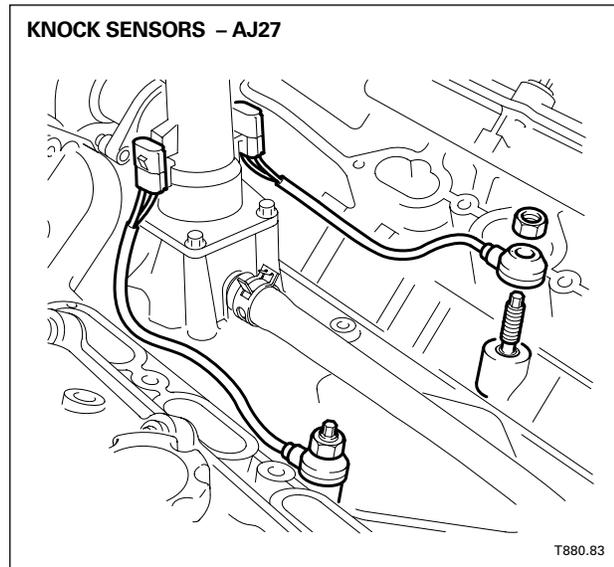


- The ECM retards ignition timing to individual cylinders to control ignition knock (detonation) and optimize engine power.
- Two knock sensors (KS) are positioned on the cylinder block in the engine vee to sense engine detonation.
- One KS is positioned on A bank and the other on B bank.
- Each knock sensor has a piezo electric sensing element to detect broad band (2 – 20 kHz) engine accelerations.
- If detonation is detected, between 700 and 6800 rpm, the ECM uses the crankshaft position sensor (CKPS) signal to determine which cylinder is firing, and retards the ignition timing for that cylinder only.
- If, on the next firing of that cylinder, the detonation reoccurs, the ECM will further retard the ignition timing; if the detonation does not reoccur on the next firing, the ECM will advance the ignition timing incrementally with each firing.
- The knock sensing ignition retard / advance process can continue for a particular cylinder up to a maximum retard of 9.4 degrees.
- During acceleration at critical engine speeds, the ECM retards the ignition timing to prevent the onset of detonation. This action occurs independent of input from the knock sensors.

NOTES

Knock Sensors (KS) – AJ27

- The AJ27 sensors are of an annular (doughnut) construction and are mounted via a stud and nut to the cylinder head.
- To improve cylinder identification, particularly at higher engine RPM, switched capacitive filters are incorporated in the ECM.
- Knock sensing performance is further enhanced by the use of improved ECM signal processing software.



Knock Sensing OBD Monitoring

KS sense circuit out of range (low voltage)

With the ignition switched ON, the ECM monitors the A bank KS signal for low voltage. If the signal voltage is less than 0.6V on the first trip, the ECM takes default action. If the signal voltage is less than 0.6V on two consecutive trips, the ECM flags a KS DTC and the CHECK ENGINE MIL is activated.

Default action: the ECM sets ignition retard to maximum.

KS sense circuit out of range (high voltage)

With the ignition switched ON, the ECM monitors the A bank KS signal for high voltage. If the signal voltage is greater than 4.15V on the first trip, the ECM takes default action. If the signal voltage is greater than 4.15V on two consecutive trips, the ECM flags a KS DTC and the CHECK ENGINE MIL is activated.

Default action: the ECM sets ignition retard to maximum.

NOTES

AJ26 / AJ27 ENGINE MANAGEMENT SYSTEMS



- 1 AJ26 / AJ27 OVERVIEW
- 2 CONTROL SUMMARIES
- 3 ENGINE CONTROL MODULES
- 4 EMS PRIMARY SENSING COMPONENTS
- 5 INDUCTION AIR THROTTLE CONTROL
- 6 FUEL DELIVERY AND
EVAPORATIVE EMISSION CONTROL
- 7 FUEL INJECTION
- 8 IGNITION
- 9 VARIABLE VALVE TIMING**
- 10 EXHAUST GAS RECIRCULATION (EGR):
NORMALLY ASPIRATED
- 11 OTHER ECM ENGINE CONTROL AND
INTERFACE FUNCTIONS
- 12 AJ26 / AJ27 SUPERCHARGED EMS
- 13 TASK SHEETS

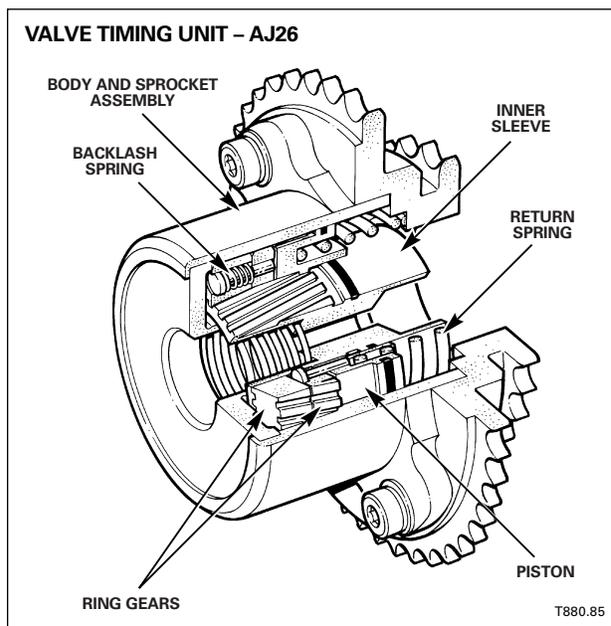
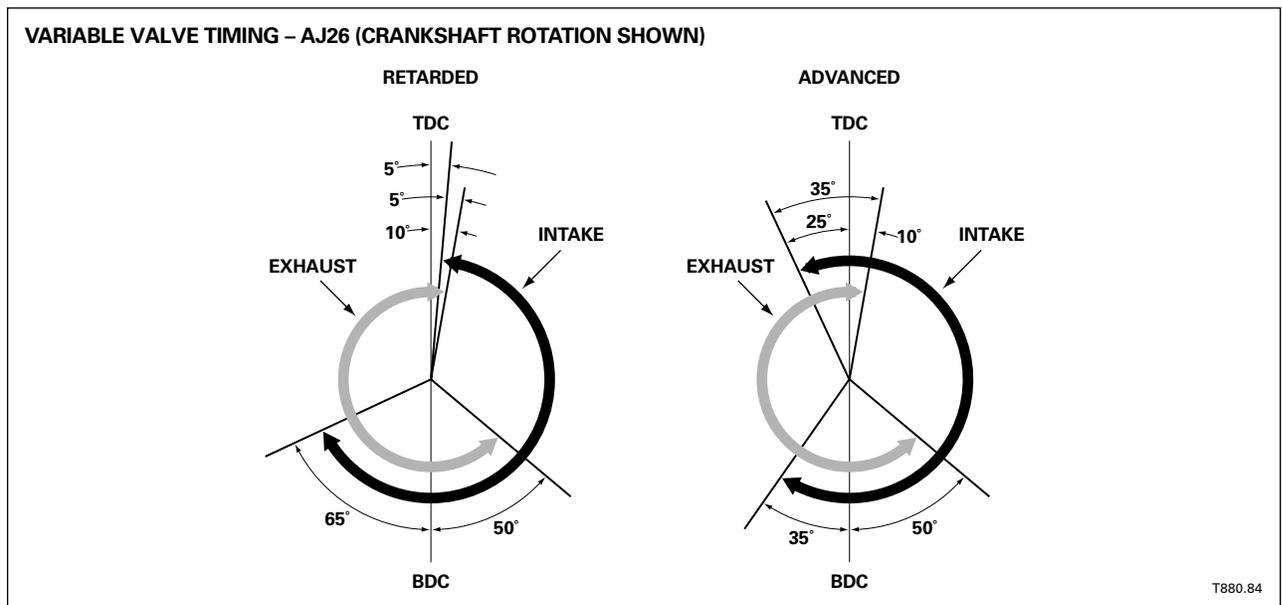


VARIABLE VALVE TIMING

Variable Valve Timing – AJ26

The AJ26 two-position variable valve timing (VVT) system improves low and high speed engine performance, idle quality, and exhaust emission. VVT is a two-position system that operates on the intake camshafts only. There are 30° of crankshaft rotation between the retarded and the advanced positions. The system is operated by engine oil pressure under the control of the ECM. The VVT hardware associated with each intake camshaft includes:

- Valve timing unit
- Bush carrier assembly
- Valve timing solenoid



Valve Timing Unit

- The valve timing unit rotates the intake camshaft in relation to the primary chain to advance or retard the intake valve timing.
- The unit is made up of a body and sprocket assembly separated from an inner sleeve by a ring piston and two ring gears.
- A bolt secures the inner sleeve to the camshaft
- The ring gears engage in opposing helical splines on the body and sprocket assembly, and on the sleeve.
- The ring gears transmit the drive from the body and sprocket assembly to the inner sleeve and, when moved axially, rotate the inner sleeve in relation to the body and sprocket assembly.

Engine oil pressure ported by the valve timing solenoid moves the ring gears and piston to rotate the inner sleeve in the advance timing direction. A return spring moves the ring gears and piston to rotate the inner sleeve in the retard timing direction.

A series of small springs absorb backlash to reduce noise and wear. The springs between the ring gears absorb rotational backlash. The springs between the inner sleeve and the end of the body and sprocket assembly absorb axial backlash.

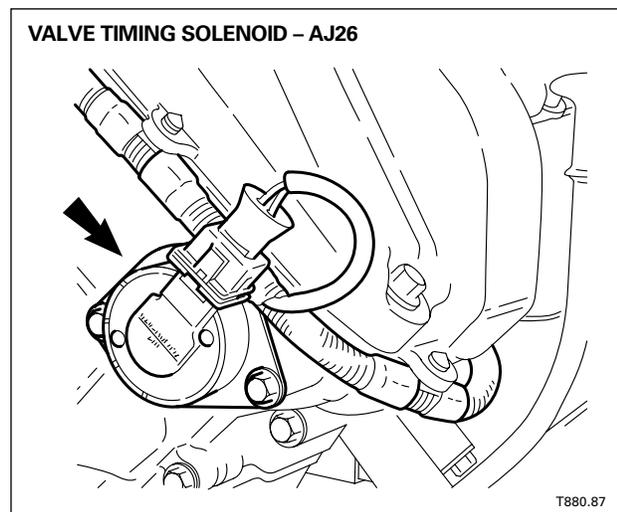
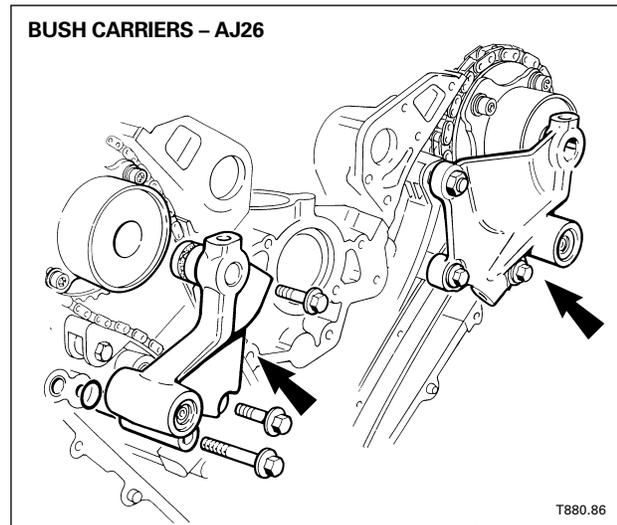
Bush Carrier

- The bush carriers contain oil passages that link the engine oil supply to the valve timing unit.
- The integral shuttle valve, connected to the valve timing solenoid and biased by a coil spring, controls the flow of oil through the passages.

Valve Timing Solenoid

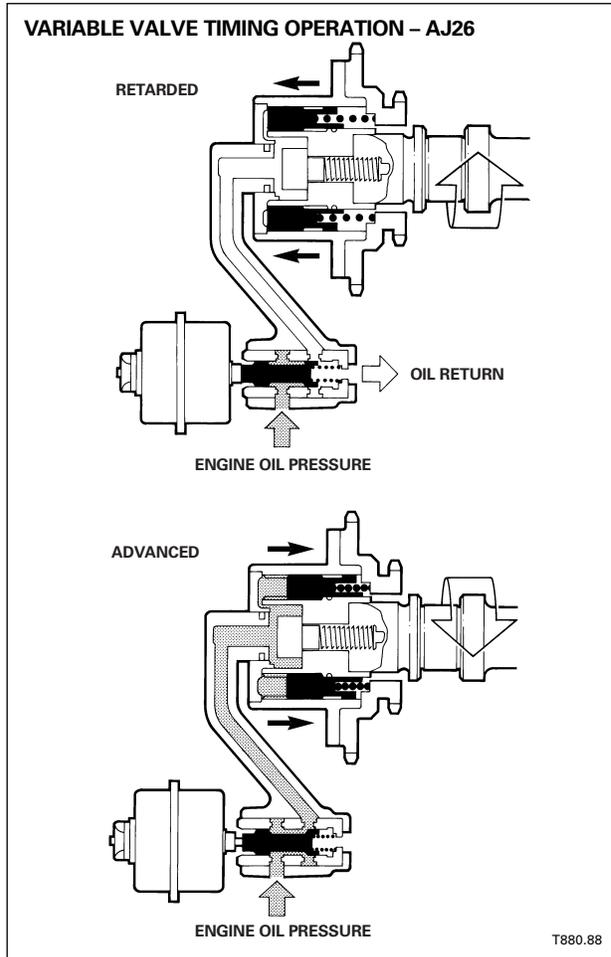
- The valve timing solenoid positions the shuttle valve in the bush carrier.
- A plunger on the solenoid extends a minimum of 6.8 mm (0.28 in.) when the solenoid is energized and retracts when the solenoid is deenergized.

NOTES



VARIABLE VALVE TIMING

Variable Valve Timing – AJ26



VVT Mechanical Operation

Intake valve timing retarded

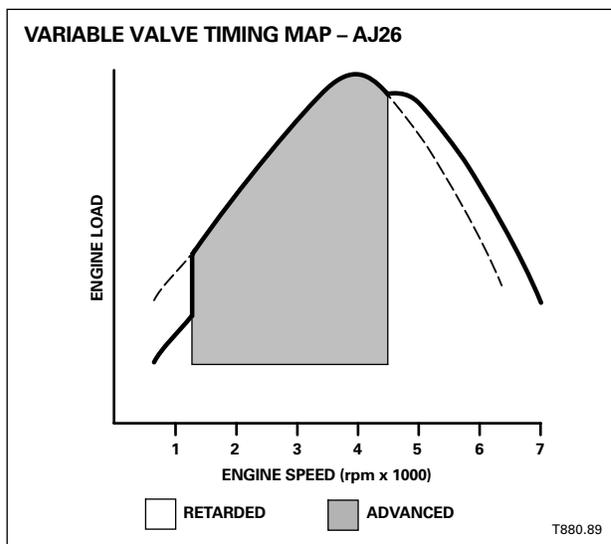
- When the valve timing solenoids are de energized, the coil springs in the bush carriers position the shuttle valves to port the valve timing units to drain.
- The valve timing units return springs hold the ring pistons and gears in the retarded position.

Intake valve timing advanced

- When the valve timing solenoids are energized, the solenoid plungers position the shuttle valves to port pressurized engine lubricating oil to the valve timing units.
- The oil pressure moves the gears and ring pistons to the advanced position.
- System response times are 1 second maximum for advance, 0.7 second maximum for retard.

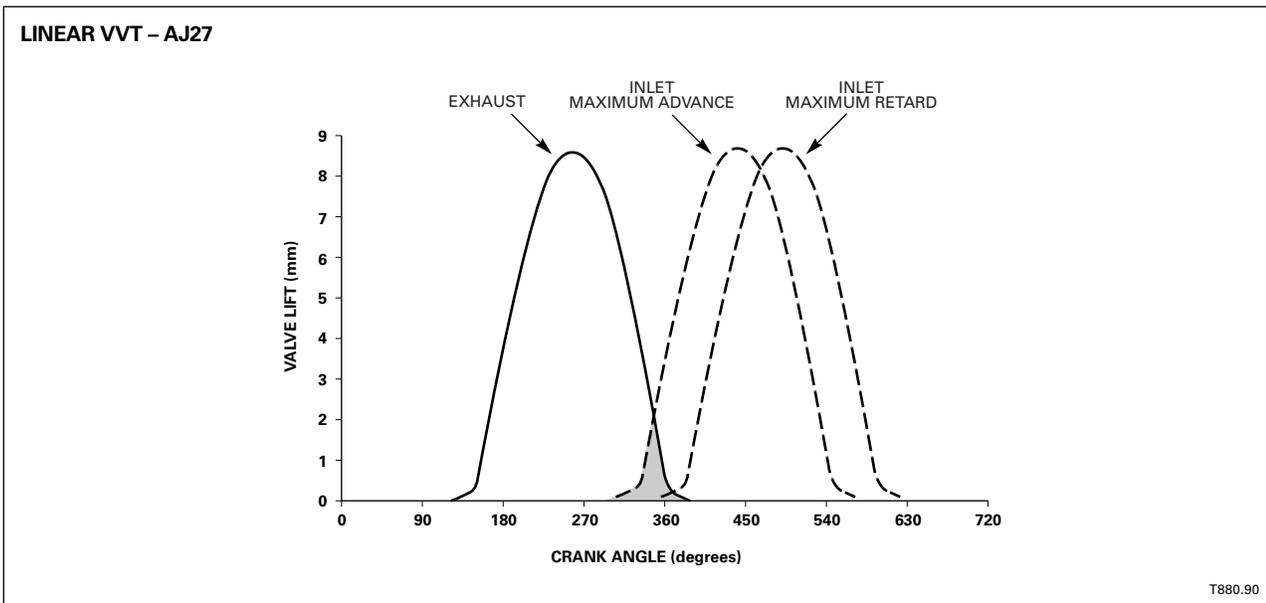
ECM VVT Control

- The ECM switches the valve timing solenoids to advance / retard intake valve timing based on a map of engine load and speed.
- The map incorporates both engine load and speed “hysteresis” (overlap) to prevent “hunting”.
- Between 1250 and 4500 rpm (nominal), at engine load greater than approximately 25%, the intake valve timing is advanced.
- The intake valve timing is retarded at low engine speed and at high engine speed.
- VVT is inhibited (intake valve timing remains retarded) at engine coolant temperatures less than -10 °C (14 °F).
- While the valve timing is retarded, the ECM periodically drives the valve timing solenoid open with a momentary pulse.
- This momentary pulse occurs every five minutes, and allows a spurt of oil flow to the valve timing units to prevent wear. It is possible to hear the lubrication pulse with the engine running and the hood open.



Linear Variable Valve Timing – AJ27

- The AJ27 Linear VVT system provides continuously variable inlet valve timing over a crankshaft range of $48^\circ \pm 2^\circ$.
- Depending on driver demand and engine speed / load conditions, the inlet valve timing is advanced or retarded to the optimum angle within this range.
- Compared to the two position system used on AJ26, inlet valve opening is advanced by an extra 8° , providing greater overlap and increasing the internal EGR effect (exhaust gases mixing with air in the inlet port).



The linear VVT system provides a number of advantages:

- Improves internal EGR, further reducing NOx emissions and eliminating the need for an external EGR system
- Optimizes torque over the engine speed range without the compromise of the two-position system: note that specified torque and power figures are unchanged
- Improves idle quality: the inlet valve opens 10° later, reducing valve overlap and thus the internal EGR effect (undesirable at idle speed)
- Faster VVT response time
- VVT operates at lower oil pressure

NOTES

VARIABLE VALVE TIMING

Linear Variable Valve Timing – AJ27 (continued)

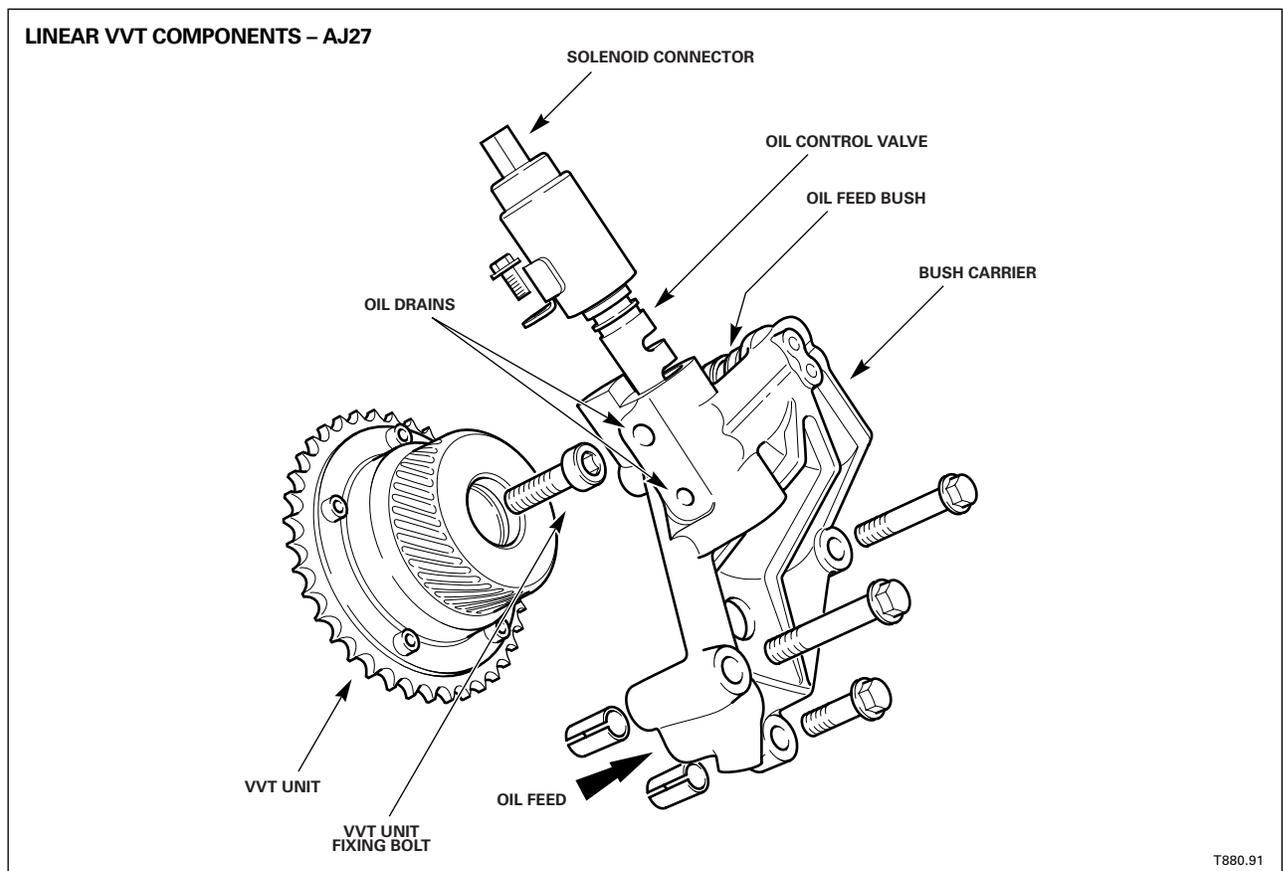
Linear VVT Components

Each cylinder bank has a VVT unit, bush carrier and solenoid operated oil control valve which are all unique to the linear VVT system. The VVT unit consists of an integral control mechanism with bolted on drive sprockets, the complete assembly being non-serviceable. The unit is fixed to the front end of the inlet camshaft via a hollow bolt and rotates about the oil feed bush on the bush carrier casting. The bush carrier is aligned to the cylinder head by two hollow spring dowels and secured by three bolts.

The oil control valve fits into the bush carrier to which it is secured by a single screw. The solenoid connector at the top of the valve protrudes through a hole in the camshaft cover but the cover must first be removed to take out the valve.

Engine oil enters the lower oilway in the bush carrier (via a filter) and is forced up through the oil control valve shuttle spools to either the advance or retard oilway and through the bush to the VVT unit. Oil is also returned from the VVT unit via these oilways and the control valve shuttle spools, exiting through the bush carrier drain holes.

NOTE: Only the bush carriers are left- and right-handed.

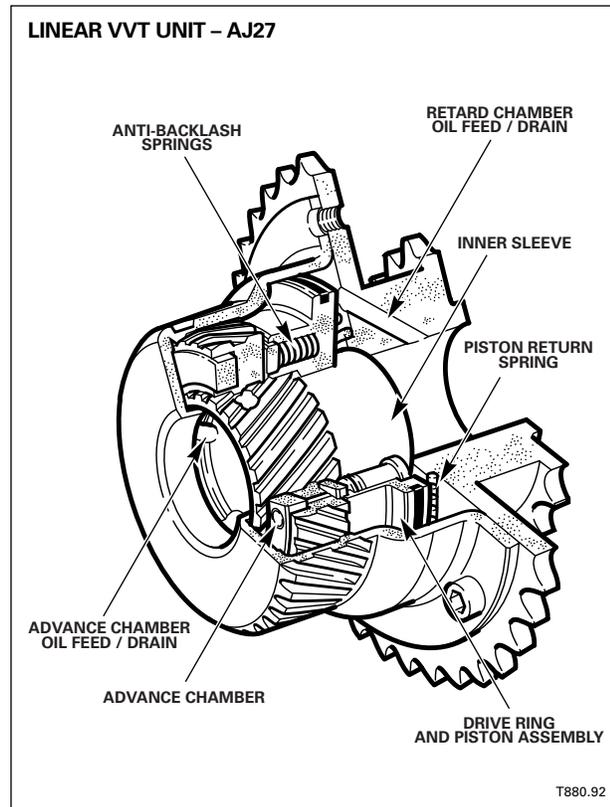


Linear VVT unit

The VVT unit transmits a fixed drive via the secondary chain to the exhaust camshaft. The inlet camshaft is driven from the body of the unit via internal helical splines: when commanded from the ECM this mechanism rotates the inlet camshaft relative to the body/sprocket assembly to advance or retard the valve timing.

The VVT unit has three main parts: the body/sprocket assembly, an inner sleeve bolted axially to the nose of the camshaft and a drive ring/piston assembly located between the body and inner sleeve and coupled to both via helical splines.

The basic operation is similar to that of the two position unit: oil pressure applied in the advance chamber forces the drive ring/piston assembly to move inwards along its axis while rotating clockwise on the helical body splines. Since the drive ring is also helically geared to the inner sleeve but with opposite angled splines, the inner sleeve is made to rotate in the same direction, turning the camshaft. The use of opposing helical gears (the angle is more acute than in the two position unit) produces a relatively large angular rotation for a small axial movement, thus keeping the VVT unit to a compact size. Note that the inner sleeve does not move axially.



To move back to a retard position, oil pressure is switched to the retard chamber and the piston and rotational movements are reversed. The use of oil pressure to move the piston in both directions eliminates the need for a return spring for VVT operation (as in the two position system). However, a lighter pressure spring is fitted in the retard chamber to assist the piston assembly to revert to the fully retarded position with the engine stopped. Note that rotating the engine backwards from the stopped position will cause the VVT unit body to move relative to the camshaft, advancing the timing. To avoid the possibility of incorrect timing being set after any associated service work, reference must be made to JTIS for the correct procedures.

Due to the use of bidirectional oil pressure actuation and light spring pressure, a much lower oil pressure is required to advance the VVT unit, making its operation more consistent at high oil temperatures/low engine speed. Also, response times to move in the advance direction are reduced by approximately 50% compared with the two position actuator.

NOTES

VARIABLE VALVE TIMING

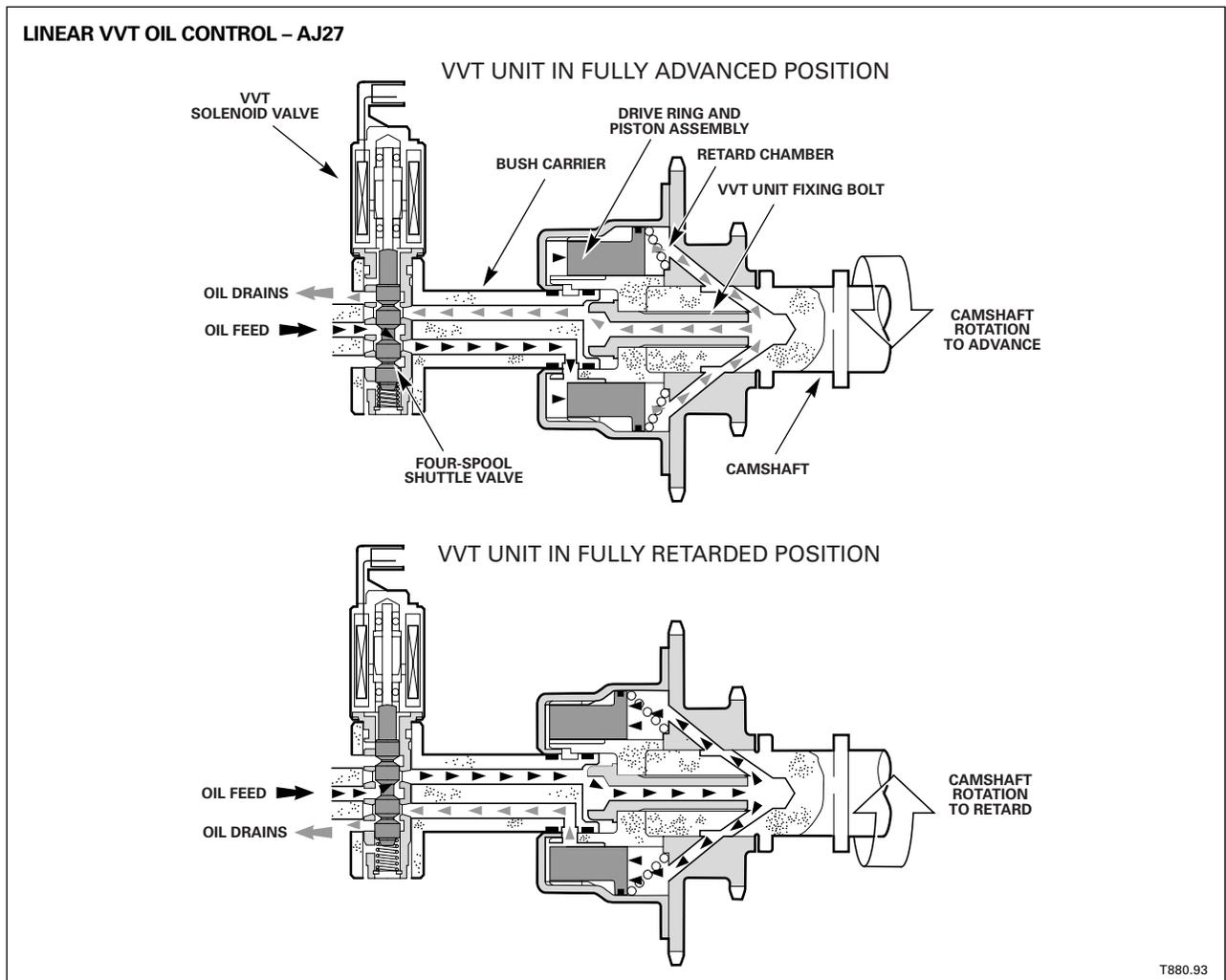
Linear Variable Valve Timing – AJ27 (continued)

Linear VVT Oil Control – Advance

- To fully advance the cams, the solenoid is energized pushing the shuttle valve down.
- This action causes the incoming oil feed to be directed through the lower oilway in the bush carrier and into the advance oil chamber where it pushes on the piston/drive ring assembly.
- As the piston moves in the advance direction (towards the camshaft), oil is forced out of the retard chamber through oilways in the sprocket unit, camshaft, hollow fixing bolt, bush carrier and the shuttle valve from which it drains into the engine.

Linear VVT Oil Control – Retard

- To move to the fully retarded position, the solenoid is de-energized, the return spring holds the shuttle valve in its upper position and the oil flow is directed through the bush carrier upper oilway into the VVT unit.
- Oil is channeled through the hollow VVT fixing bolt and via oilways in the camshaft and sprocket unit to the retard chamber where it acts on the moveable piston/drive ring assembly.
- As the piston moves, oil is forced from the advance chamber back through the shuttle valve to the engine.



Linear VVT ECM Control System

Closed loop control

- Continuously variable timing requires the VVT piston to be set to the optimal position between full advance and retard for a particular engine speed and load.
- The ECM positions the shuttle valve using a PWM control signal operating at a frequency of 300 Hz.
- The shuttle valve assumes a position between the limits of travel proportional to the “duty cycle” of the signal. An increasing duty cycle causes an increase in timing advance.
- The shuttle valve is continuously controlled by the ECM to maintain a given cam angle. The actual position of the camshaft is monitored by a magnetic sensor which generates pulses from the toothed sensor ring keyed on to the end of the camshaft and transmits them to the ECM. If a difference is sensed between the actual and demanded positions, the ECM will attempt to correct it. The new cam sensor fitted to A bank allows each bank to have its own feedback loop. The four tooth cam sensor rings increase the cam position feedback frequency, providing the enhanced control required by the new VVT system. The use of four-tooth sensor rings also improves starting (see Engine Management Sensors).

Engine oil temperature

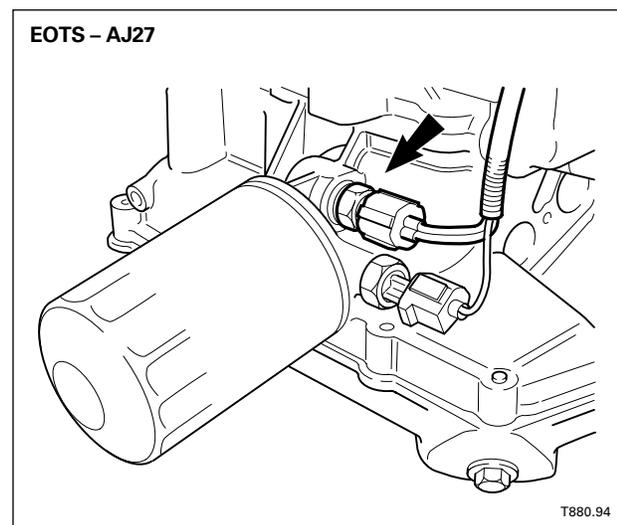
Engine oil properties and temperature can affect the ability of the VVT mechanism to follow demand changes to the cam phase angle. At very low oil temperatures, movement of the VVT mechanism is sluggish due to increased viscosity and at high temperatures the reduced viscosity may impair operation if the oil pressure is too low.

The VVT system is normally under closed loop control except in extreme temperature conditions such as cold starts below 0 °C (32 °F). At extremely high oil temperatures, the ECM may limit the amount of VVT advance to prevent the engine stalling when returning to idle speed. This could occur because of the slow response of the VVT unit to follow a rapid demand for speed reduction. Excessive cam advance at very light loads produces high levels of internal EGR which may result in unstable combustion or misfires.

Engine oil temperature sensor (EOTS)

The EOTS is a thermistor which has a negative temperature coefficient (NTC). Engine oil temperature is determined by the ECM by the change in the sensor resistance. The sensor is located on the engine block directly above the oil pressure switch.

The ECM applies 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance. The ECM uses the EOT signal for variable valve timing control.



NOTES

AJ26 / AJ27 ENGINE MANAGEMENT SYSTEMS

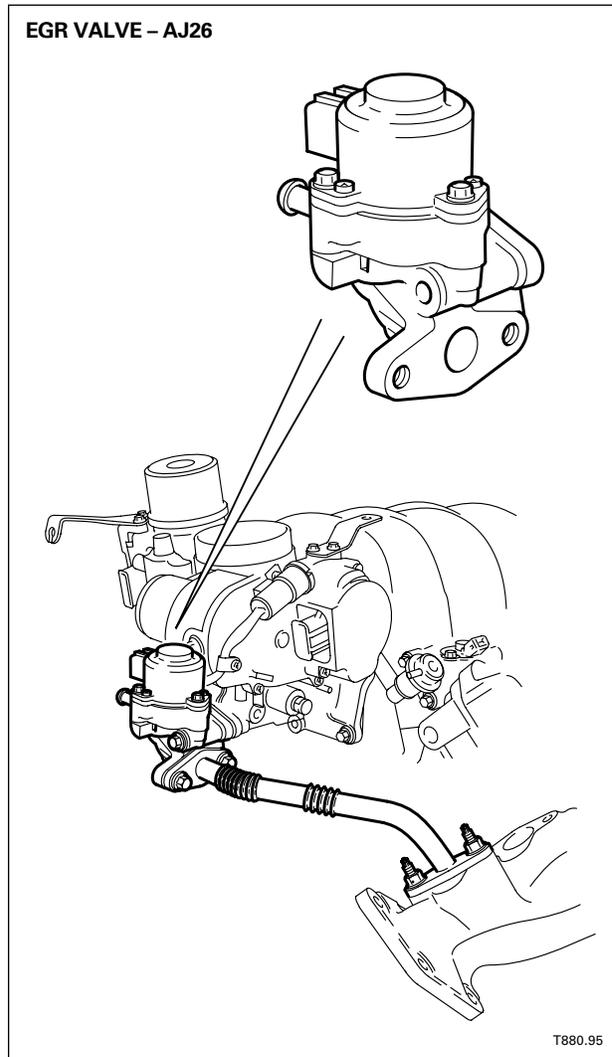


- 1 AJ26 / AJ27 OVERVIEW
- 2 CONTROL SUMMARIES
- 3 ENGINE CONTROL MODULES
- 4 EMS PRIMARY SENSING COMPONENTS
- 5 INDUCTION AIR THROTTLE CONTROL
- 6 FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL
- 7 FUEL INJECTION
- 8 IGNITION
- 9 VARIABLE VALVE TIMING
- 10 EXHAUST GAS RECIRCULATION (EGR):
NORMALLY ASPIRATED**
- 11 OTHER ECM ENGINE CONTROL AND INTERFACE FUNCTIONS
- 12 AJ26 / AJ27 SUPERCHARGED EMS
- 13 TASK SHEETS



EXHAUST GAS RECIRCULATION

Exhaust Gas Recirculation – AJ26



Exhaust gas recirculation (EGR) was fitted to 1997 model year XK8 vehicles and was deleted during the same model year.

NOTE: EGR is fitted to AJ26 and AJ27 super-charged engines.

EGR lowers combustion temperature, which in turn reduces NO_x exhaust emission. EGR is controlled by the ECM from a map that factors engine operating conditions such as engine load and speed, throttle position, and coolant temperature.

The EGR valve is mounted directly to the intake air induction elbow and connects to the A bank exhaust manifold by a transfer pipe. The EGR valve contains a four-pole stepper motor (60 step), which is driven by the ECM. Engine coolant returning from the throttle assembly is channeled through the valve to provide cooling.

NOTES

AJ26 / AJ27 ENGINE MANAGEMENT SYSTEMS



- 1 AJ26 / AJ27 OVERVIEW
- 2 CONTROL SUMMARIES
- 3 ENGINE CONTROL MODULES
- 4 EMS PRIMARY SENSING COMPONENTS
- 5 INDUCTION AIR THROTTLE CONTROL
- 6 FUEL DELIVERY AND
EVAPORATIVE EMISSION CONTROL
- 7 FUEL INJECTION
- 8 IGNITION
- 9 VARIABLE VALVE TIMING
- 10 EXHAUST GAS RECIRCULATION (EGR):
NORMALLY ASPIRATED
- 11 OTHER ECM ENGINE CONTROL AND
INTERFACE FUNCTIONS**
- 12 AJ26 / AJ27 SUPERCHARGED EMS
- 13 TASK SHEETS



OTHER ECM CONTROL AND INTERFACE FUNCTIONS

Engine Cranking / Starting (Normally Aspirated Engines)

When the ignition is switched ON (position II) and the transmission manual valve is in Park or Neutral, the ECM enables fuel injection and ignition, and outputs a “security acknowledge” encoded signal to the BPM. The Park / Neutral signal is received via the hard wired circuit from the transmission rotary switch. If the BPM receives a Park / Neutral signal from the gear selector neutral switch, it in turn, enables engine cranking. When the ignition key is moved to CRANK (position III) and the gear selector is in Park or Neutral, the BPM drives the starter relay to crank the engine. The ECM receives a “cranking” signal from the BPM / starter relay drive circuit. The ECM initiates engine start EMS values for the duration of the cranking signal.

Supercharged engines Both Park and Neutral signals are supplied from the dual linear switch located at the J gate.

Vehicles without Key Transponder Module (KTM) (1997 Model Year)

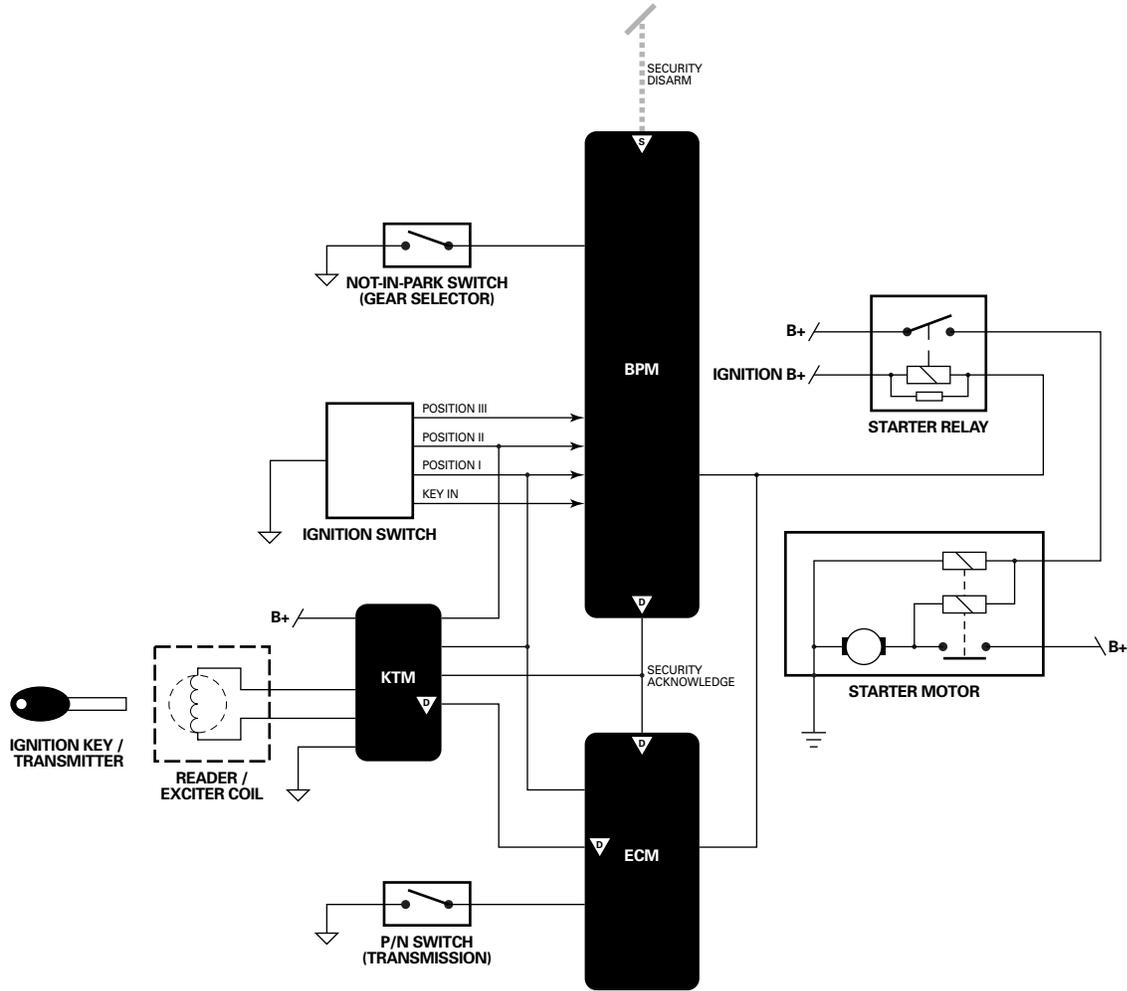
If the transmission manual valve is not in Park or Neutral (rotary switch signal) at ignition ON, the ECM inhibits fuel injection and ignition, and does not transmit the “security acknowledge” signal to the BPM.

Vehicles with Key Transponder Module (KTM)

If the transmission manual valve is not in Park or Neutral (rotary switch signal) at ignition ON, and/or the KTM does not transmit an encoded “security acknowledge” signal to the ECM and the BPM, the ECM inhibits fuel injection and ignition, and does not transmit the “security acknowledge” signal to the BPM.

NOTES

ENGINE CRANKING / STARTING



T880.95B

OTHER ECM CONTROL AND INTERFACE FUNCTIONS

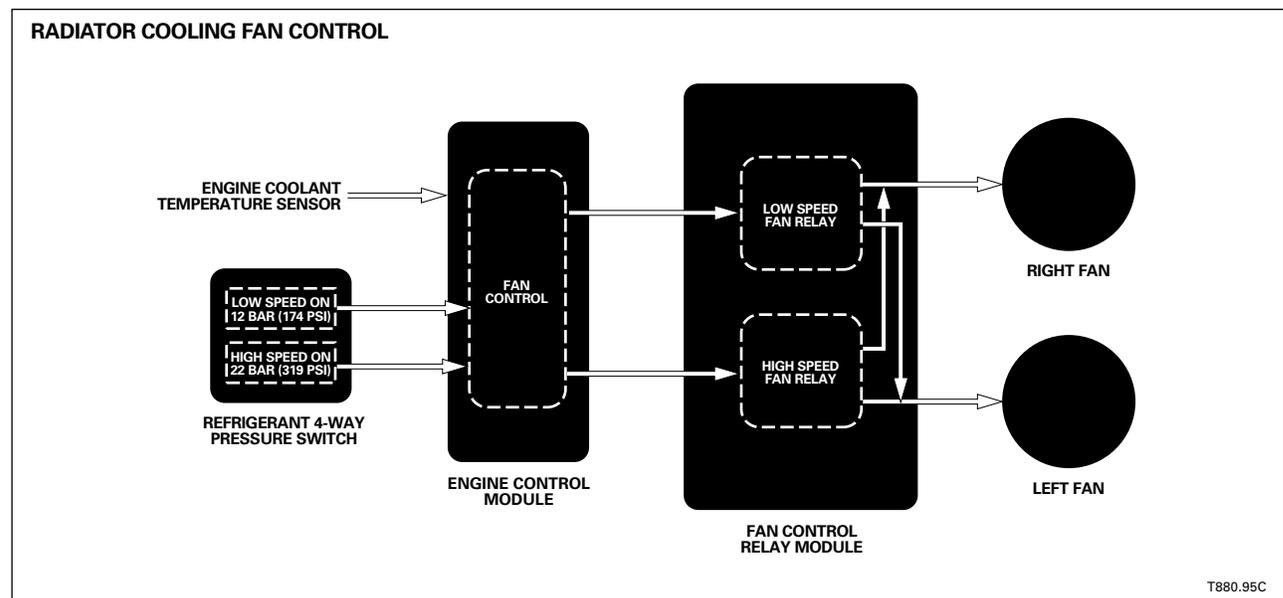
Radiator Cooling Fan Control

The ECM controls the radiator cooling fan operation. Using inputs from the air conditioning refrigerant four-way pressure switch and the ECTS, the ECM drives the fans in series (low speed) or in parallel (high speed). The four-way pressure switch contains a 12 bar (174 psi) switch element and a 22 bar (319 psi) switch element connected to the ECM. A two-pressure switch element signals the A/CCM for compressor operation.

As the ECM switches the fans, “hysteresis” or overlap between switch on / switch off prevents “hunting” between the fan modes.

Radiator Fan Switching Points				
Mode	Engine coolant temperature		Refrigerant pressure	
	ON	OFF	ON	OFF
• SLOW (SERIES)	• 90 °C (194 °F)	• 86 °C (187 °F)	• 12 bar (174 psi)	• 8 bar (116 psi)
• FAST (PARALLEL)	• 97.5 °C (207.5 °F)	• 93.5 °C (200.5 °F)	• 22 bar (319 psi)	• 17.5 bar (254 psi)

If the fans are operating when the engine is switched off, the ECM continues to drive the fans for up to five minutes or until the engine coolant temperature has fallen to a predetermined value, whichever occurs first. If the fans are off when the engine is switched off and the coolant temperature rises to the switch-on point during the few seconds time the ECM remains powered to complete throttle adaptations, the fans will switch on and continue to operate for up to five minutes, or until the engine coolant temperature has fallen to a predetermined value, whichever occurs first.



NOTES

Air Conditioning Compressor Clutch Control

The ECM controls the operation of the air conditioning compressor clutch to prevent idle instability and over heating. The air conditioning control module (A/CCM) determines when compressor clutch operation is required and signals the ECM via the A/C compressor clutch request hard wire circuit. Depending on the engine operating conditions, the ECM drives the air conditioning compressor clutch relay to operate the air conditioning compressor. The A/CCM receives confirmation that the compressor is operating from the clutch relay parallel power circuit.

Engine conditions for compressor ON:

- Engine not at idle*
 - Engine coolant temperature not greater than a programmed high temperature
 - Throttle valve less than full load (WOT)
- *Engine at idle – There is a momentary delay (approximately 50 ms) before the ECM drives the compressor clutch relay. This delay allows the ECM to compensate the idle speed for the impending high load.

Engine conditions for compressor OFF:

- Engine coolant temperature greater than a programmed high temperature
- Throttle valve at full load (WOT)

When the compressor clutch operation is inhibited, the ECM outputs a load inhibit signal to the A/CCM via the load inhibit hard wire circuit.

Windshield and Backlight Heaters Control

The ECM can also inhibit the operation of the windshield and backlight heaters to prevent idle instability. When the driver selects the heaters ON, the A/CCM signals the ECM for permission to switch ON the heaters via the electrical load request hard wire circuit. Depending on the engine operating conditions, the ECM inhibits heater operation by outputting a load inhibit signal to the A/CCM via the load inhibit hard wire circuit.

Engine conditions for heaters ON:

- Engine not at idle*
 - Engine coolant temperature not greater than a programmed high temperature
 - Throttle valve less than full load (WOT)
- *Engine at idle – There is a momentary delay (approximately 50 ms) before the ECM cancels the load inhibit signal. This delay allows the ECM to compensate the idle speed for the impending high load.

Engine conditions for heaters inhibited:

- Engine coolant temperature greater than a programmed high temperature
- Throttle valve at full load (WOT)

When the heaters are inhibited, the ECM outputs a load inhibit signal to the A/CCM via the load inhibit hard wire circuit.

NOTES

AJ26 / AJ27 ENGINE MANAGEMENT SYSTEMS



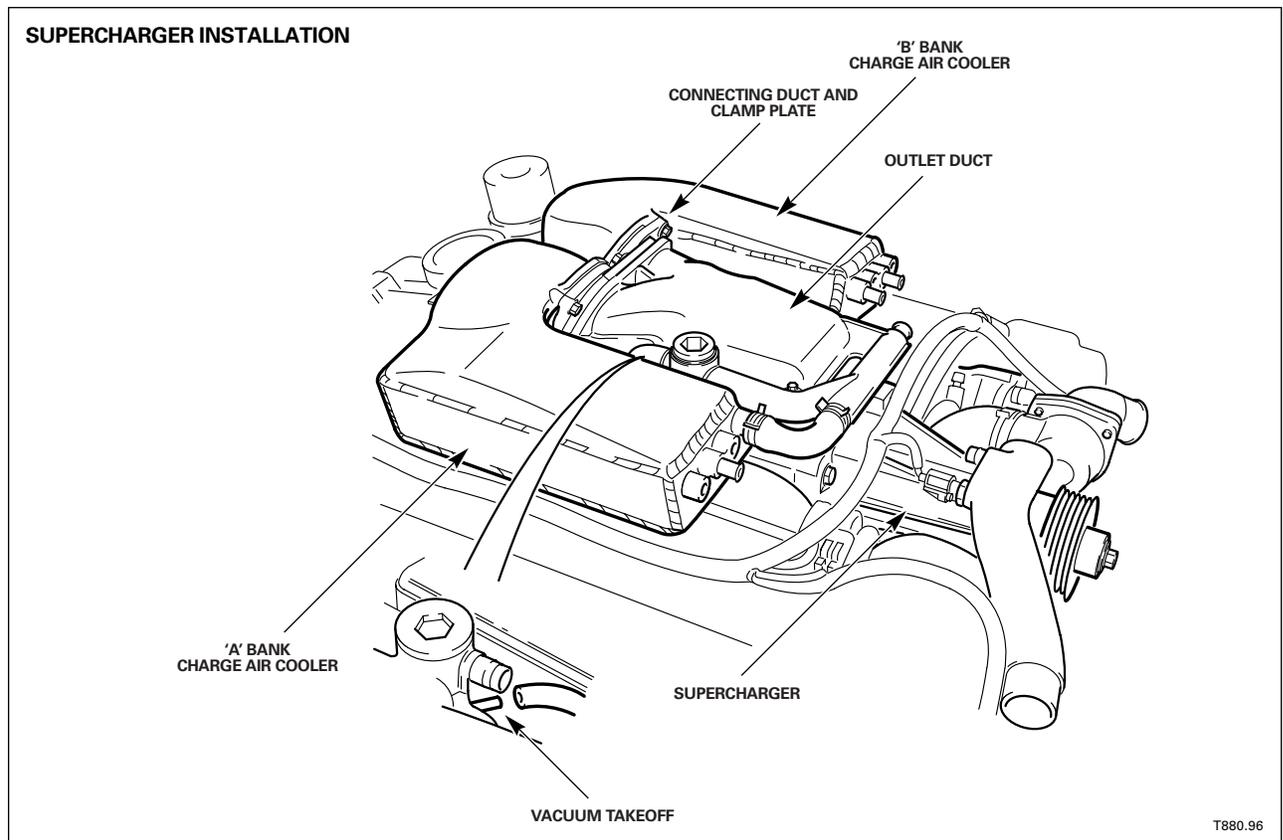
- 1 AJ26 / AJ27 OVERVIEW
- 2 CONTROL SUMMARIES
- 3 ENGINE CONTROL MODULES
- 4 EMS PRIMARY SENSING COMPONENTS
- 5 INDUCTION AIR THROTTLE CONTROL
- 6 FUEL DELIVERY AND
EVAPORATIVE EMISSION CONTROL
- 7 FUEL INJECTION
- 8 IGNITION
- 9 VARIABLE VALVE TIMING
- 10 EXHAUST GAS RECIRCULATION (EGR):
NORMALLY ASPIRATED
- 11 OTHER ECM ENGINE CONTROL AND
INTERFACE FUNCTIONS
- 12 AJ26 / AJ27 SUPERCHARGED EMS**
- 13 TASK SHEETS



AJ26 / AJ27 SUPERCHARGED EMS

AJ V8 Supercharged Engine

The AJ V8 supercharged (SC) engine is essentially mechanically identical to the normally aspirated engine with the exception of the pistons, the cylinder head gaskets and the repositioning of components to allow installation of the supercharger system. The normally aspirated intake manifold and induction elbow are replaced with unique supercharged components.

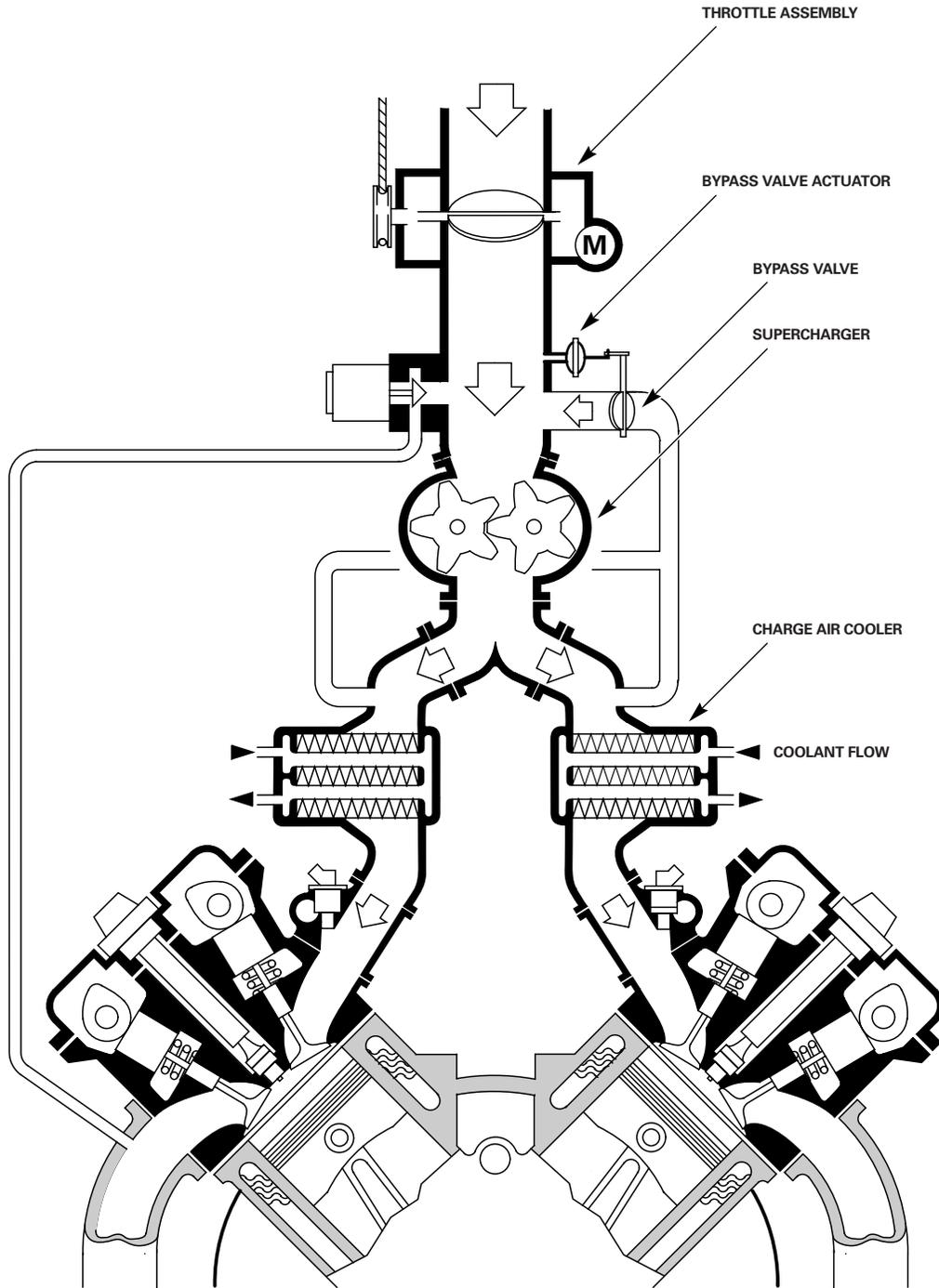


The supercharger is an Eaton M112 “Roots Type” unit mounted in the engine vee, driven by a separate poly v-belt from the crankshaft. Supercharger lubrication is “filled for life”. If servicing of the lubricant is required, the supercharger must be removed from the engine. The maximum boost pressure is 0.8 bar (11.6 psi).

Intake air flows through a revised mass air flow sensor (MAFS), through the intake duct, the electronic throttle assembly and the induction elbow to the supercharger. The AJ26 SC throttle assembly is unchanged from the normally aspirated system with EGR. The AJ27 SC throttle deletes AAI and adds EGR. A bypass valve attaches to the induction elbow. From the supercharger, compressed intake air flows through the outlet duct to the individual A and B bank air-to-liquid charge air coolers, then through the A and B bank charge air cooler adapters to the cylinder heads.

NOTES

SUPERCHARGED INTAKE SYSTEM

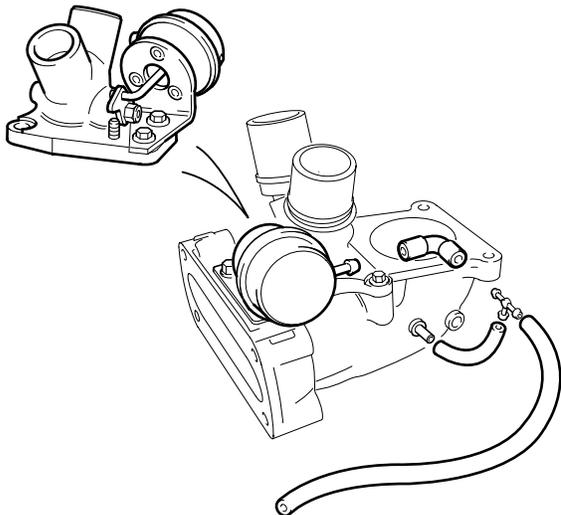


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AJ26 / AJ27 SUPERCHARGED EMS

Supercharger Mechanical Components

BYPASS VALVE AND ACTUATOR – AJ26



T880.98

Bypass Valve and Actuator

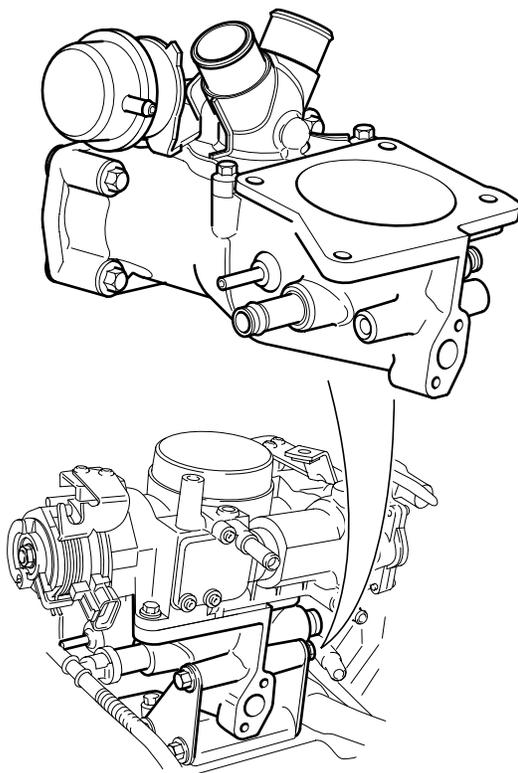
The “butterfly” bypass valve is contained in a housing attached to the induction elbow. The valve is operated by a vacuum actuator. The valve controls bypass air flow from the charge air coolers to the induction elbow in order to regulate supercharger “boost pressure”. The valve is held closed by spring pressure.

With closed (idle) or partially open (cruise) throttle, intake vacuum (between the induction elbow and the supercharger) acts on the actuator diaphragm to hold the valve full open to provide maximum supercharger bypass and optimum fuel economy. As the throttle is opened, intake vacuum falls progressively and spring force moves the valve toward closed until the valve is fully closed at full throttle, providing maximum supercharger boost and power.

Outlet Duct

The supercharger outlet duct directs the charge air from the supercharger to the two charge air coolers. The fill point and connections for the charge air cooler coolant circuit are integrated into the outlet duct. Vacuum source is provided for the fuel pressure regulator and for cruise control. Rubber ducts secured by clamp plates connect the outlet duct to the two charge air coolers.

THROTTLE INDUCTION ELBOW – AJ27



T880.99

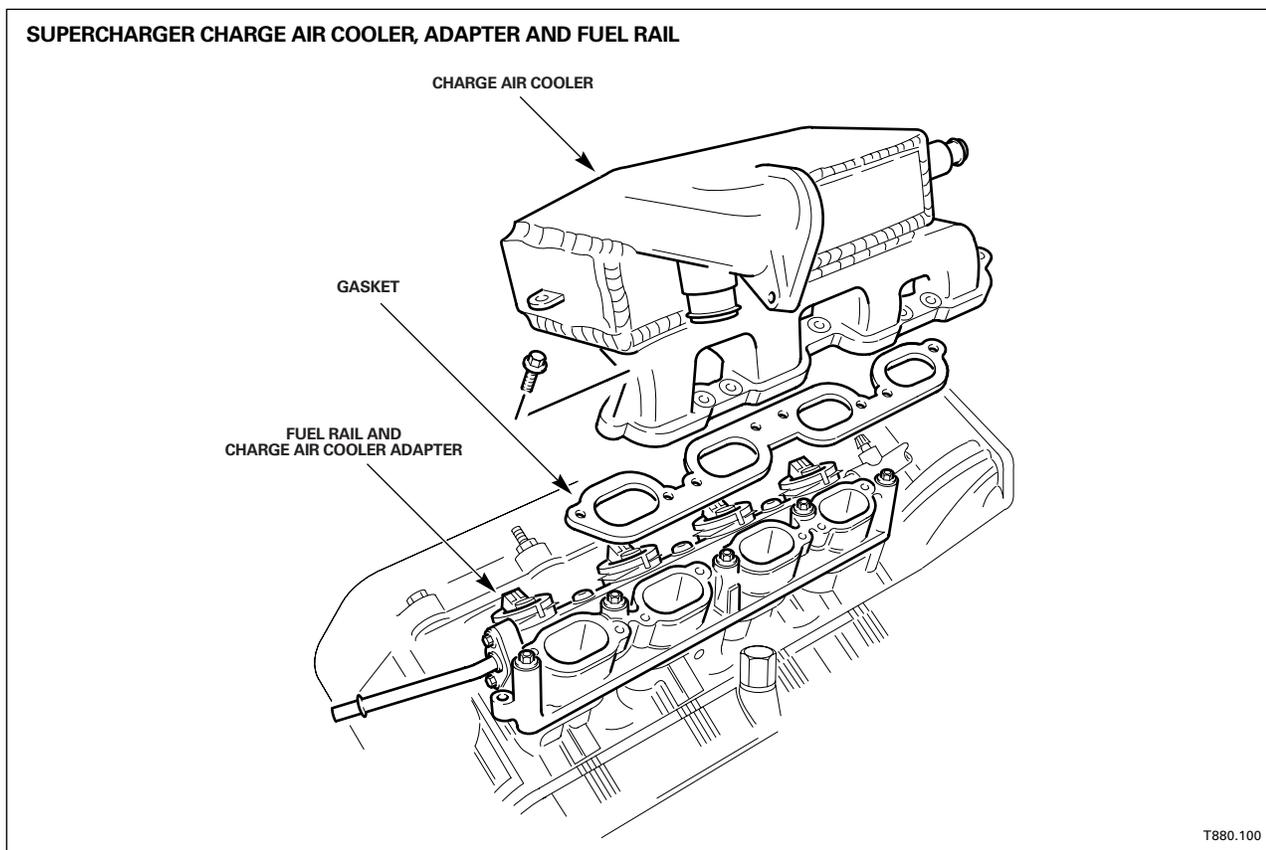
NOTES

Charge Air Coolers

Each cylinder bank has a separate charge air cooler assembly. The charge air coolers are fabricated fin and tube air-to-liquid heat exchangers with individual “risers” to supply charge air to each cylinder. The charge air coolers cool the charge air leaving the supercharger to increase the mass of the air entering the engine. Coolant flow is provided by a separate cooling system with an electric pump under ECM control.

Charge air cooler adapters / fuel rails

The charge air cooler adapters provide the interface between the charge air coolers and the cylinder heads, and incorporate the fuel rails and fuel injector mountings. A crossover pipe connects the fuel rails.



Fuel Injectors

The fuel injectors are high flow units designed for the supercharged engine. They are secured in the fuel rails by spring clips.

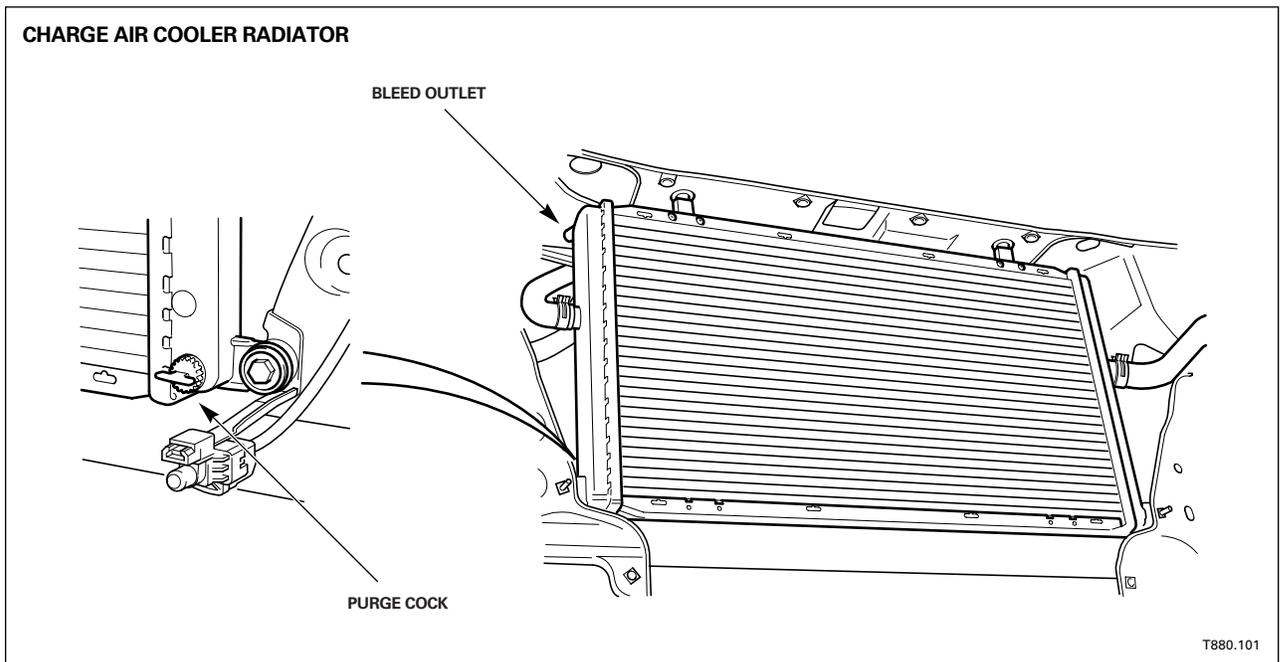
NOTES

AJ26 / AJ27 SUPERCHARGED EMS

Supercharger Mechanical Components (continued)

Charge Air Cooler Radiator and Pump

The charge air cooler radiator is mounted ahead of the engine radiator and incorporates a bleed outlet and a purge cock.

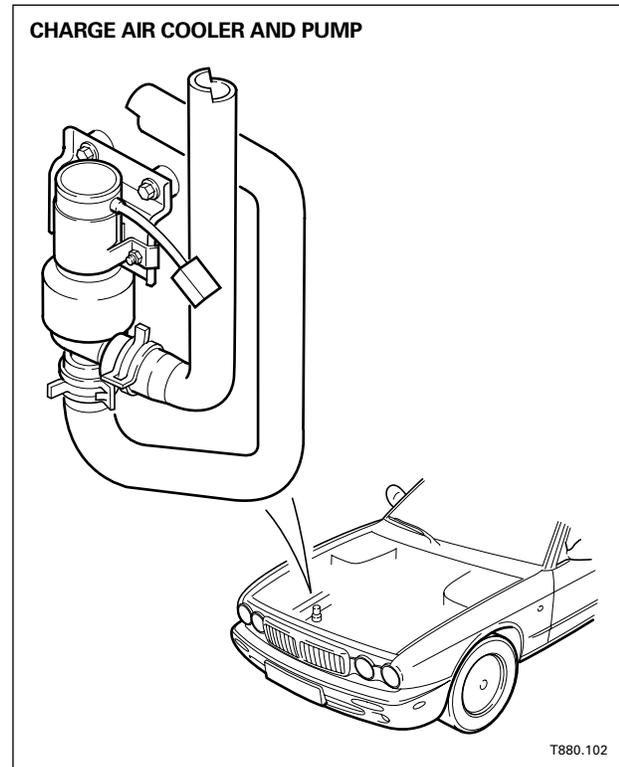


NOTES

Charge Air Cooler Coolant Pump

The charge air cooler coolant pump is activated via a relay under ECM control. During normal conditions, the ECM operates the pump continuously with the ignition switched ON.

NOTES



AJ26 / AJ27 SUPERCHARGED EMS

The supercharged Engine Management System is essentially identical to the normally aspirated system with software revisions to accommodate the operating characteristics of the supercharged engine. Additional functions for operating two fuel pumps, the charge air cooler coolant pump, and EGR are included. Variable valve timing and air assisted fuel injection (AJ27) are deleted.

Components / Functions deleted for Supercharged Engine Management:

- Variable valve timing
- Air assisted fuel injection (AJ27)

Components / Functions added for Supercharged Engine Management

- Two fuel pumps
- Charge air cooler coolant pump
- Exhaust gas recirculation
- Second intake air temperature sensor (charge air temperature sensor)

Supercharged EMS Components

Fuel Pumps

Two fuel pumps are used to provide adequate fuel flow during high engine loads. Both pumps are operated by the ECM via relays. Operation of fuel pump 1 is identical to the normally aspirated single fuel pump. Diagnostic monitoring for the N/A single fuel pump remains unchanged. The other warnings and default action differs for the SC pump 1. Fuel pump 2 is switched by the ECM as determined by engine operating conditions. Refer to page 6.5 for fuel pump details.

NOTES

Intake Air Temperature Sensor 2 (IATS 2)

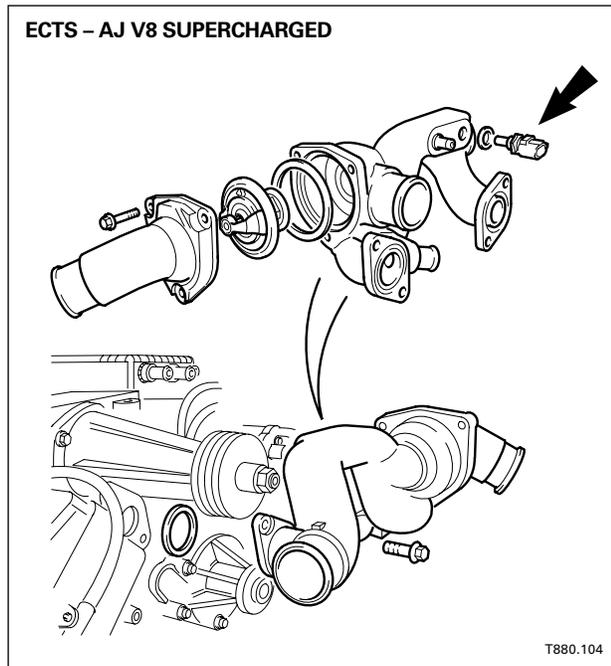
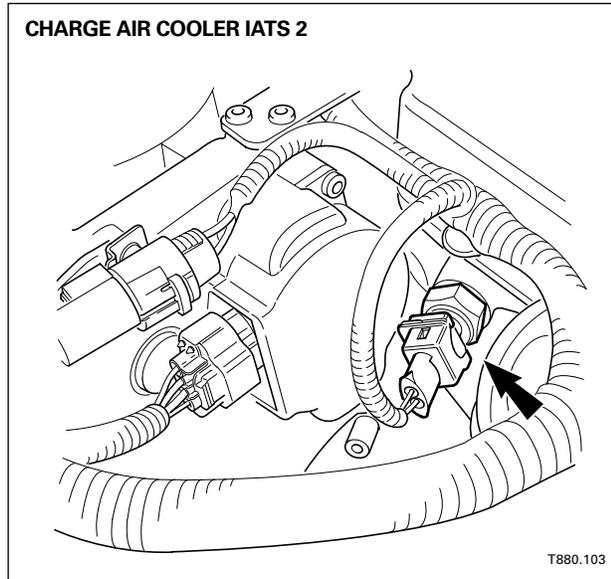
A separate intake air temperature sensor (IATS 2), located on the A bank charge air cooler outlet, provides the ECM with a “charge air” temperature signal.

As with previous air temperature sensors, the IATS 2 is a negative temperature coefficient (NTC) thermistor. Charge air temperature is determined by the ECM by a change in sensor resistance. The ECM applies 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance.

The IATS located within the MAFS remains active in the system and is used for diagnostic purposes.

IATS air temperature / resistance / voltage

Temperature °C	Temperature °F	Resistance	Voltage
-40	-40	53.1kΩ	4.75
-30	-22	28.6kΩ	4.57
-20	-4	16.2kΩ	4.29
-10	14	9.6kΩ	3.90
0	32	5.9kΩ	3.43
10	50	3.7kΩ	2.89
20	68	2.4kΩ	2.38
30	86	1.7kΩ	1.93
40	104	1.1kΩ	1.45
50	122	810Ω	1.15
60	140	580Ω	0.88
70	158	430Ω	0.69
80	176	320Ω	0.53
90	194	240Ω	0.41
100	212	190Ω	0.33
110	230	150Ω	0.26
120	248	120Ω	0.21

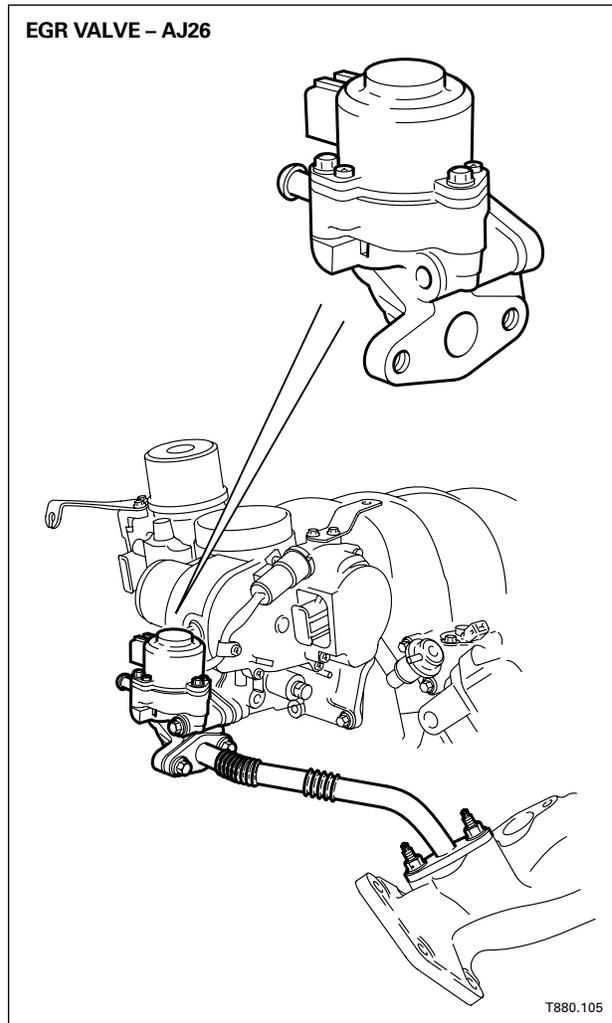


Engine Coolant Temperature Sensor (ECTS)

On supercharged engines, the ECTS is relocated to accommodate the supercharger installation.

AJ26 / AJ27 SUPERCHARGED EMS

Exhaust Gas Recirculation – AJ26



The AJ26 SC EMS uses the same EGR system as early production naturally aspirated engines.

Exhaust gas recirculation lowers combustion temperature, which in turn reduces NO_x exhaust emission. EGR is controlled by the ECM from a map that factors engine operating conditions such as engine load and speed, throttle position, and coolant temperature.

The EGR valve is mounted directly to the intake air induction elbow and connects to the A bank exhaust manifold by a transfer pipe. The EGR valve contains a four-pole stepper motor (60 step), which is driven by the ECM. Engine coolant returning from the throttle assembly is channeled through the valve to provide cooling.

NOTES

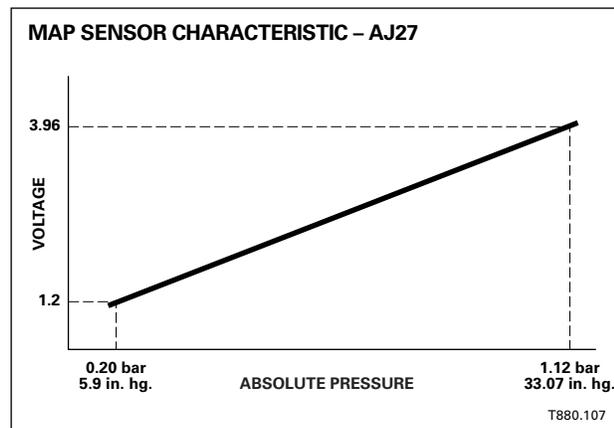
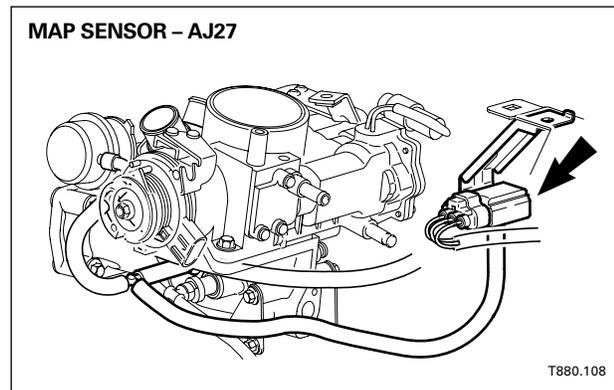
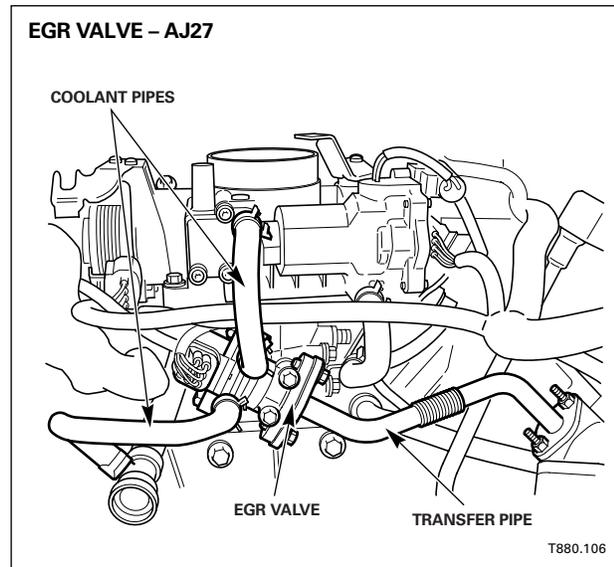
Exhaust Gas Recirculation – AJ27

The AJ27 SC EGR system provides increased exhaust gas flow over the AJ26 SC system. ECM control is enhanced by an EGR flow monitoring feedback signal.

Manifold Absolute Pressure Sensor (MAPS)

AJ27 EGR systems include a MAP sensor, which enables the ECM to monitor EGR gas flow into the intake manifold. When the EGR valve opens to allow exhaust gas flow into the throttle elbow, the intake manifold absolute pressure will drop directly proportional to the amount the valve is open. The ECM applies 5 volts to the MAP sensor, which produces a linear output voltage signal to the ECM.

NOTES



AJ26 / AJ27 ENGINE MANAGEMENT SYSTEMS



- 1 AJ26 / AJ27 OVERVIEW
- 2 CONTROL SUMMARIES
- 3 ENGINE CONTROL MODULES
- 4 EMS PRIMARY SENSING COMPONENTS
- 5 INDUCTION AIR THROTTLE CONTROL
- 6 FUEL DELIVERY AND
EVAPORATIVE EMISSION CONTROL
- 7 FUEL INJECTION
- 8 IGNITION
- 9 VARIABLE VALVE TIMING
- 10 EXHAUST GAS RECIRCULATION (EGR):
NORMALLY ASPIRATED
- 11 OTHER ECM ENGINE CONTROL AND
INTERFACE FUNCTIONS
- 12 AJ26 / AJ27 SUPERCHARGED EMS
- 13 TASK SHEETS**



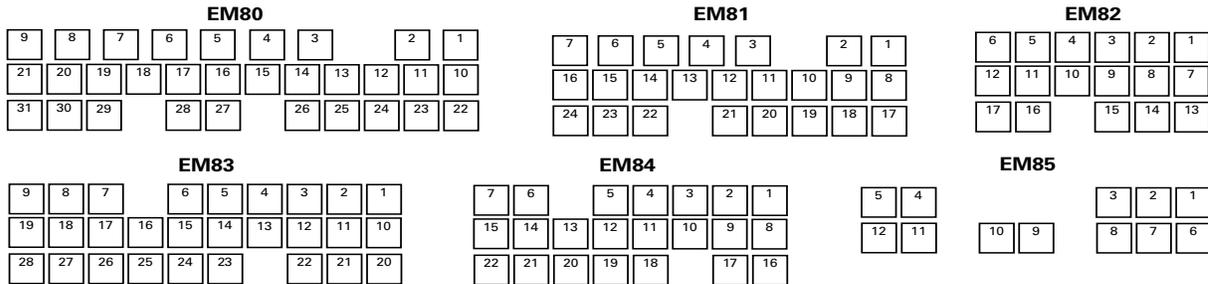
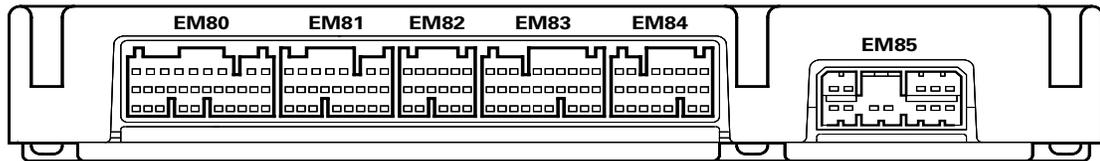
AJ27 - VVT System

Name: _____ Date: _____ Vehicle/VIN _____

Perform procedure with parking brake on & exhaust extraction hoses connected.

1. Reference the correct Electrical Guide, identify and mark the pin numbers and wire colors for each VVT circuit per cylinder bank.

Bank B= _____ Bank A = _____



2. Using a DVOM capable of measuring frequency, set the meter to DC volts - Hz.
3. Back probe the red lead of the meter to one VVT control circuit at the ECM.
4. With the **key on engine off**, check and record the signal frequency: _____.
Is it a fixed frequency?: Yes [] No []
5. Start engine and allow to idle. Switch the DVOM to duty cycle, what is the value?: _____
6. Increase the engine speed to 2500 RPM. What is the value?: _____
7. Switch the engine off, measure the resistance (Ω) of each solenoid: _____

“continued”

AJ27 - VVT System (Page 2)

8. Reference the correct DTC Summary Guide. List the DTCs that identify VVT system malfunction.

9. When the identified DTCs are stored, what is the default action of the ECM for each DTC.

10. List the possible malfunctions associated with each DTC.

Instructor Check: _____

AJ27 SC - Fuel Pressure Testing & SC Boost Demo

Name: _____ Date: _____ Vehicle/VIN _____

Perform procedure with parking brake on & exhaust extraction hoses connected.

Tools needed: Fuel pressure gauge and Vacuum gauge

1. Depressurize Fuel Rail. Install a fuel pressure gauge to the fuel rail and check for leaks. Install a vacuum gauge with T fitting to the vacuum supply at the fuel pressure regulator.

2. Key on. What is the displayed fuel pressure: _____ bar (psi)

3. Start engine and idle. What is the displayed fuel pressure: _____ bar (psi).

4. Quickly step on the accelerator pedal and release.

- What is the max fuel pressure: _____ bar (psi).
- What is the vacuum gauge positive pressure reading: _____
- What causes the pressure increases:

5. With the engine running, disconnect the vacuum hose from fuel pressure regulator, What is the pressure value: _____ bar (psi)

6. Switch the ignition off. Observe the pressure gauge reading and describe what happens to the pressure value after 1 minute. _____. Is this normal, [] Yes, [] No.

Instructor Check: _____

AJ27 - Air Assist Close Valve

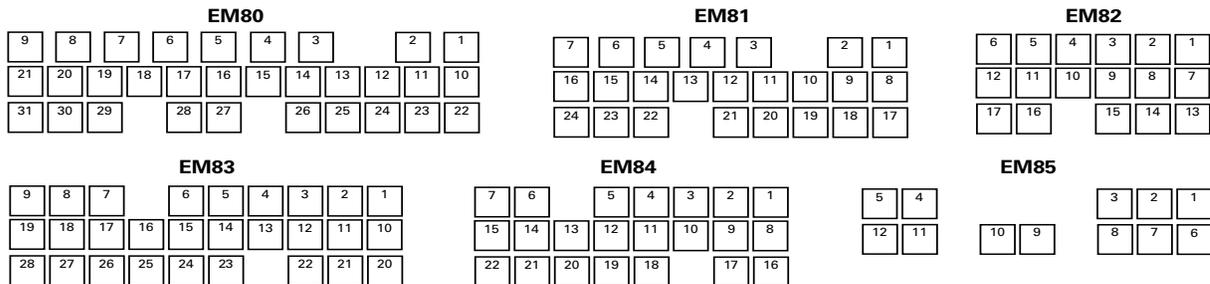
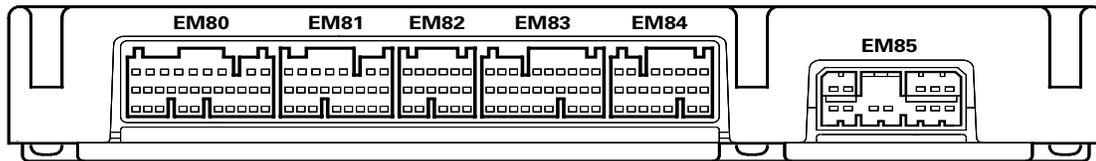
Name: _____ Date: _____ Vehicle/VIN _____

Perform procedure with parking brake on & exhaust extraction hoses connected.

1. Locate and identify the AAIC valve on the engine. What is it's functional purpose:

2. Reference the correct Electrical Guide, identify and mark the pin numbers and wire colors for the AAIC valve.

Power = _____ Ground = _____ Control = _____



3. Using a DVOM capable of measuring frequency, set the meter to DC volts - Hz.
4. Connect the meter to the AAIC control circuit pin and to ground at the ECM.
5. With the **key on engine off**, check and record the signal frequency: _____.
Is it a fixed frequency: Yes [] No []
6. **(Simulated Cold Engine)** Start the engine and monitor the engine temperature. Check and record the monitored frequency of the AAIC control signal _____ Hz.
Is it a fixed frequency: Yes [] No []
7. Start engine and allow to idle. What is the displayed duty cycle? _____
8. Increase the engine speed to 2500 RPM. What is the displayed duty cycle? _____
9. Measure the voltage at the control circuit pin: _____

“Continued on Back”

AJ27 - Air Assist Close Valve (Page 2)

10. **(Simulate Warm Engine)** Check and record the monitored frequency of the AAIC control signal _____ Hz. Is it a fixed frequency: Yes [] No []

11. Increase the engine speed to 2500 RPM. What is the displayed duty cycle _____

12. Measure the voltage at the control circuit pin: _____

13. Switch engine off. What is the resistance value of the AAI _____

14 Reference the correct DTC Summary Guide. List the DTCs that identify AAI system malfunction.

15. When the identified DTCs are stored, what is the default action of the ECM for each DTC.

16. List the possible malfunctions associated with each DTC.

Instructor Check: _____

AJ27 - DTC Summaries

Name: _____ Date: _____ Vehicle/VIN _____

1. What does P1000 and P1111 identify. _____

2. What is system readiness. _____.

3. How can system readiness information help you diagnose a vehicle that has an emission related DTC stored in memory.

4. Elaborate on DTC P1250.

- Is it an OBD II Fault: Yes [] No []
- Will the Check Engine Light illuminate when this fault is stored: Yes [] No []
- Does the ECM require two trips with the fault present to store this DTC: Yes [] No []
- Will any messages be displayed in the Instrument Cluster with this DTC: Yes [] No []
- If "Yes" please list the messages. _____

5. Referring to the correct Wiring Guide, list the pin numbers and wire colors for the following components/signals:

- CCV: _____
- FTPS: _____
- MAFS: _____
- EOT: _____
- ECT: _____
- CKPS: _____
- CMPS: _____

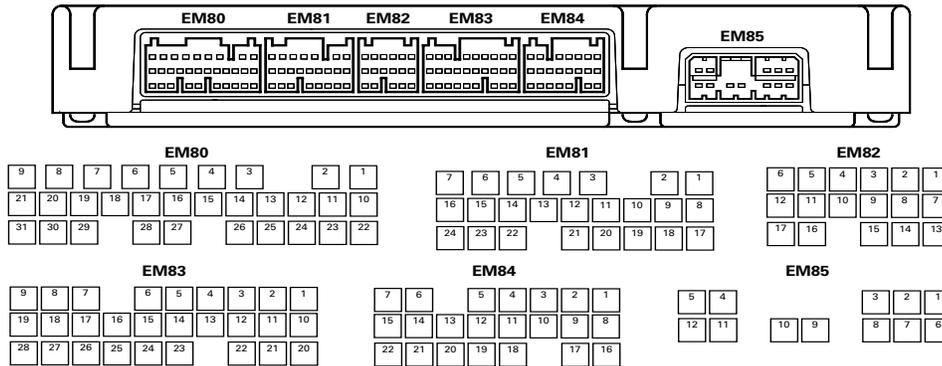
Instructor Check: _____

AJ27 - Component Monitoring

Name: _____ Date: _____ Vehicle/VIN _____

Perform procedure with parking brake on & exhaust extraction hoses connected.

1. Using the correct Wiring Guide, identify the component acronyms, their pin numbers and wire colors at the ECM for the components listed in the table below.
2. Use connector illustration to help locate the pins at the ECM when measuring signal.



3. Make sure meter is in appropriate setting (DC or AC). Using an approved probe adapter, back probe the correct pin to monitor the signal on the DVOM. Record the displayed values at the given engine speeds and note the signal voltage type (DC or AC).

Table 1:

Component	Reading @ Idle	Reading @ 2000 RPM	Reading @ 3000 RPM
MAFS =			
CMPS (A) =			
CMPS (B) =			
ECTS =			
EOTS =			
IATS =			
PPS1 =			
PPS2 =			
TPS1 =			
TPS2 =			

Instructor Check: _____

Evaporative System Leak Testing

Name: _____ Date: _____ Vehicle/VIN _____

Refer to TSB 05.1.29 This bulletin was issued for the 1996/97 MY Sedan vehicles. The procedure is valid for all Jaguar vehicles including current production.

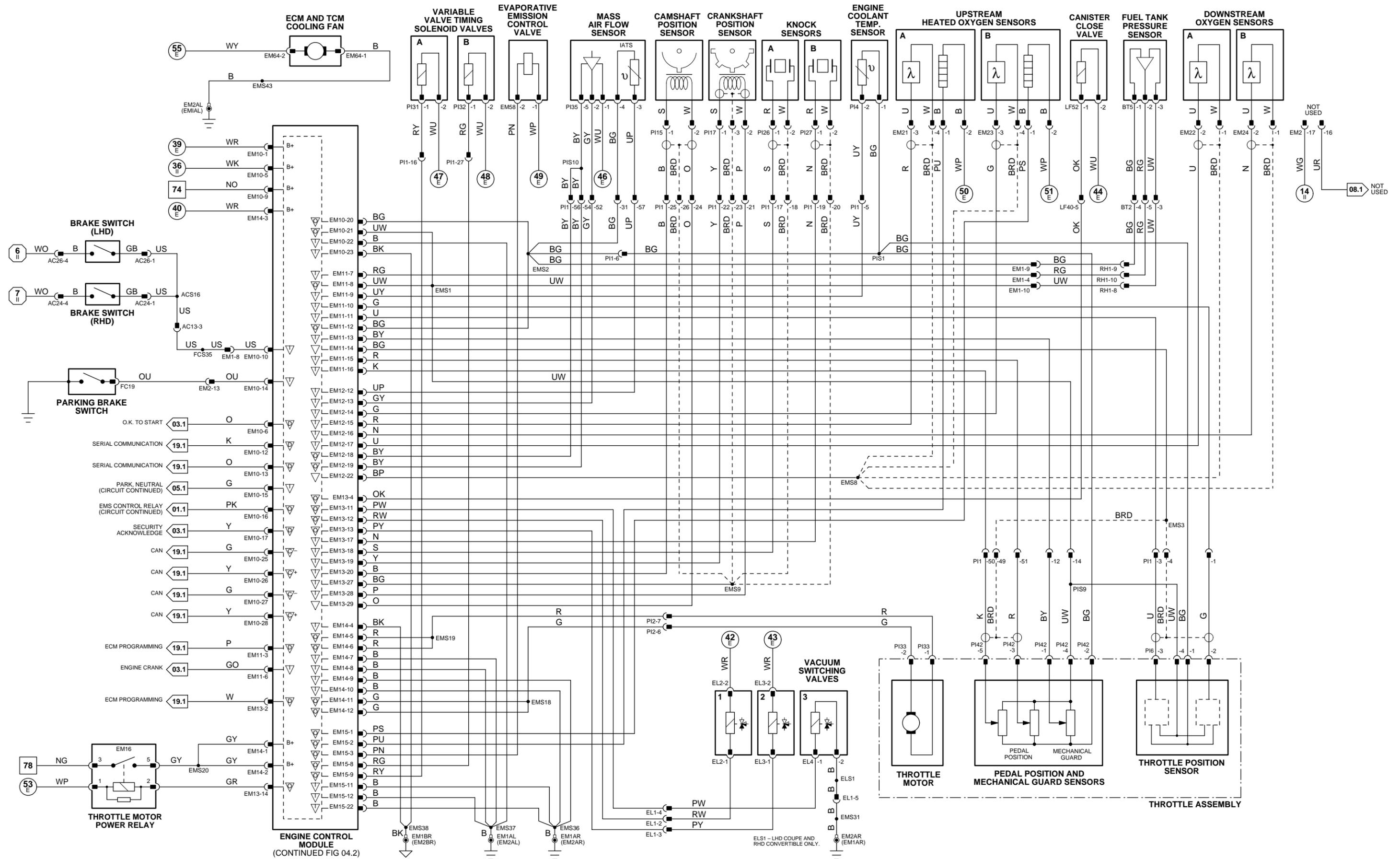
Note: The S-TYPE fuel cap is of a different design than all other Jaguar models and requires a unique filler cap adapter. (Ask your instructor for further information)

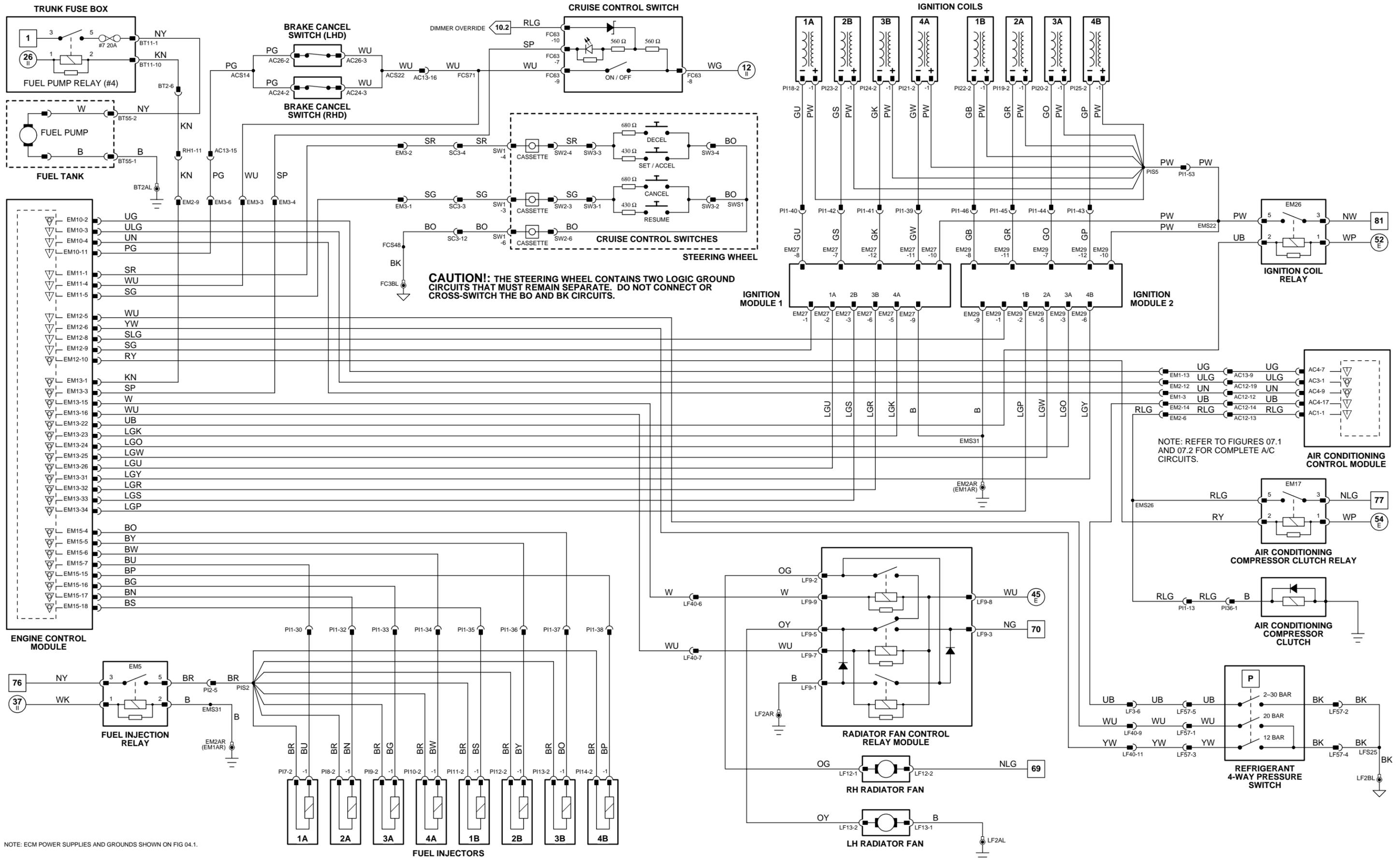
Customer Complaint = Check engine light on! Technician has connected connect PDU to vehicle and checked logged DTC(s). A DTC for a small evaporative system leak was logged.

1. Reference the DTC summary guide. What is the specific DTC for the vehicle you are currently working on? _____
2. List the probable causes for this logged DTC. _____

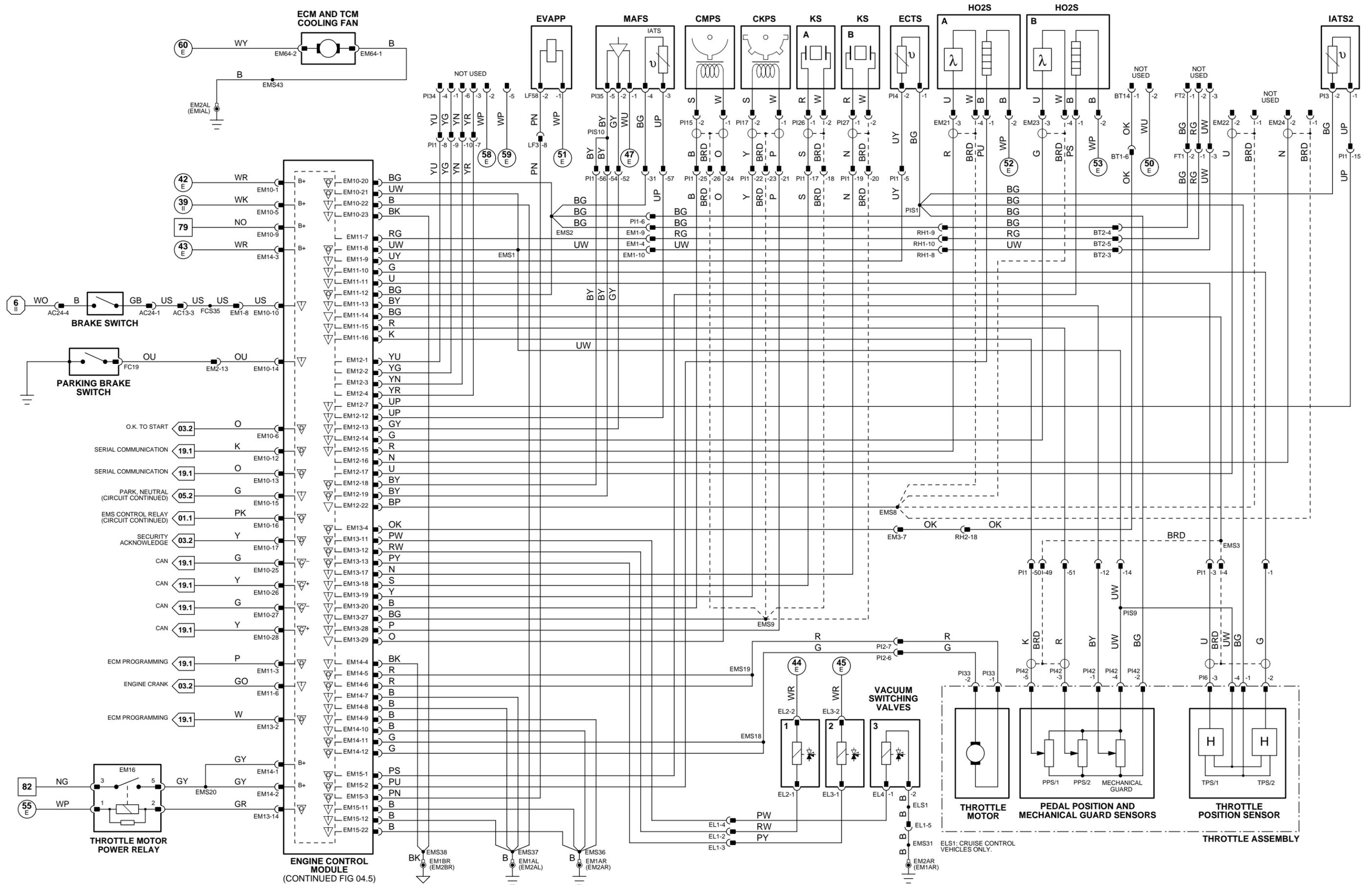
3. Follow the procedure as directed in TSB 05.1.29. Note progress and self recognized tips to help you perform this procedure easier at the dealership.

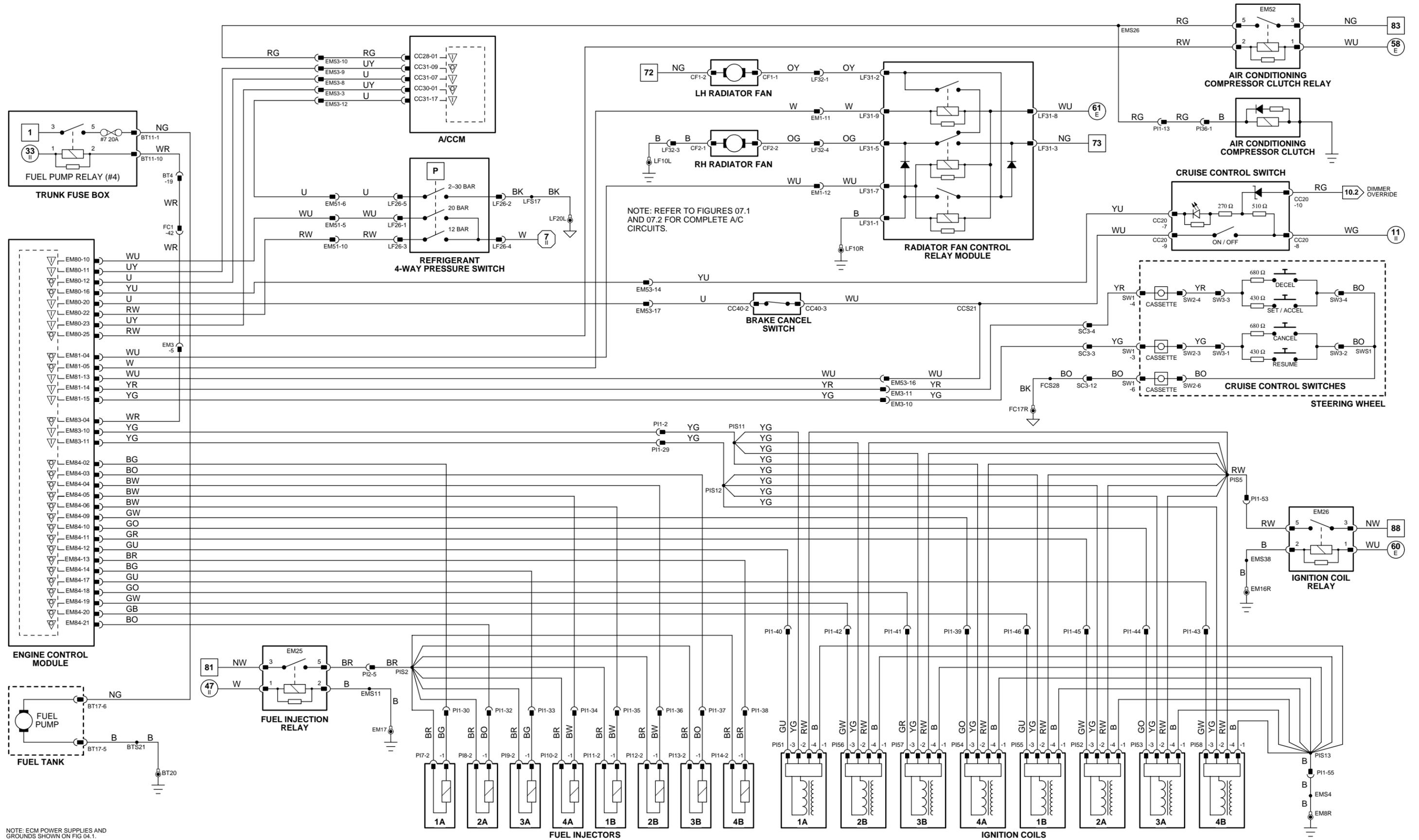
Instructor Check: _____



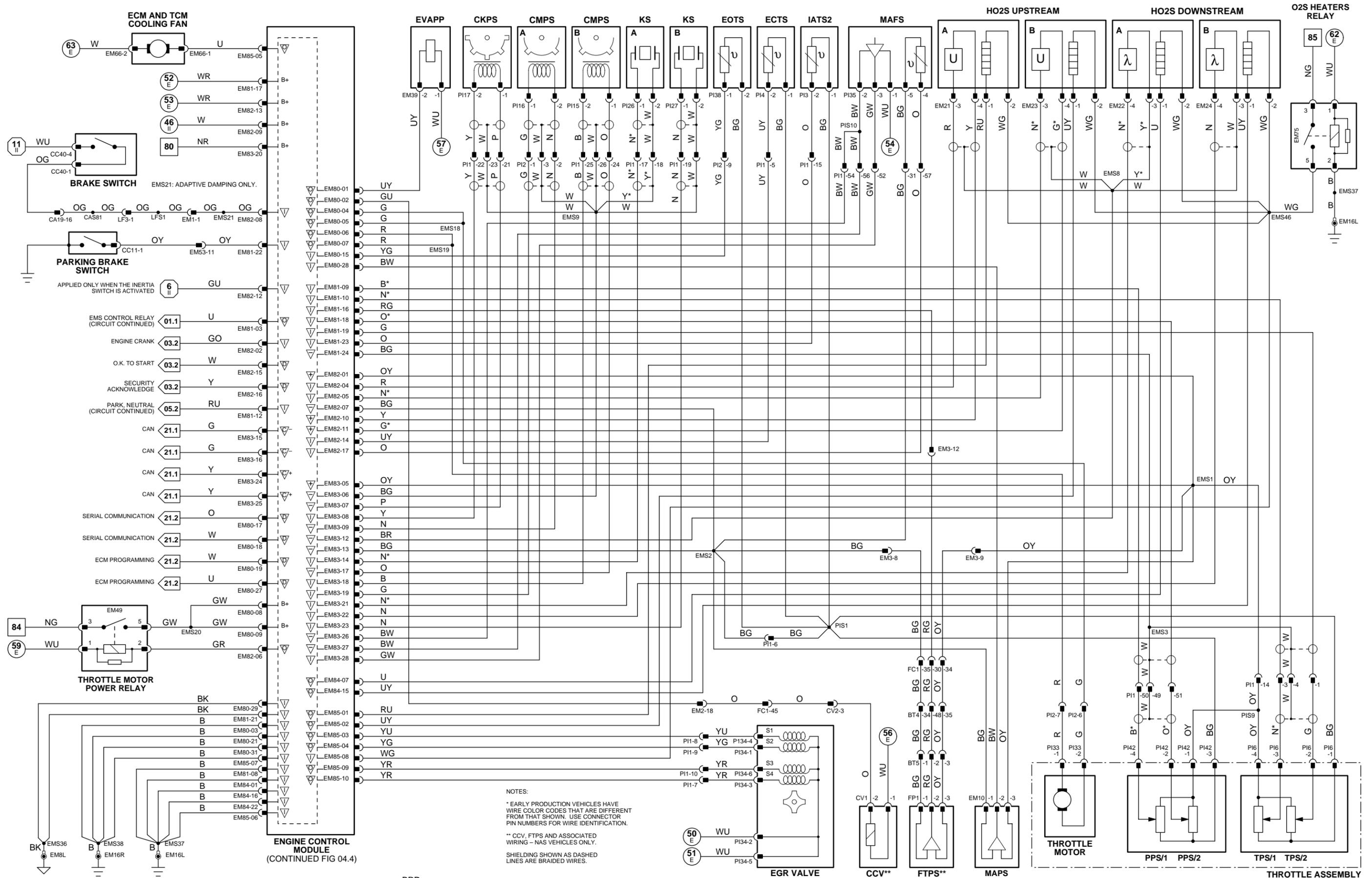


NOTE: ECM POWER SUPPLIES AND GROUNDS SHOWN ON FIG 04.1.





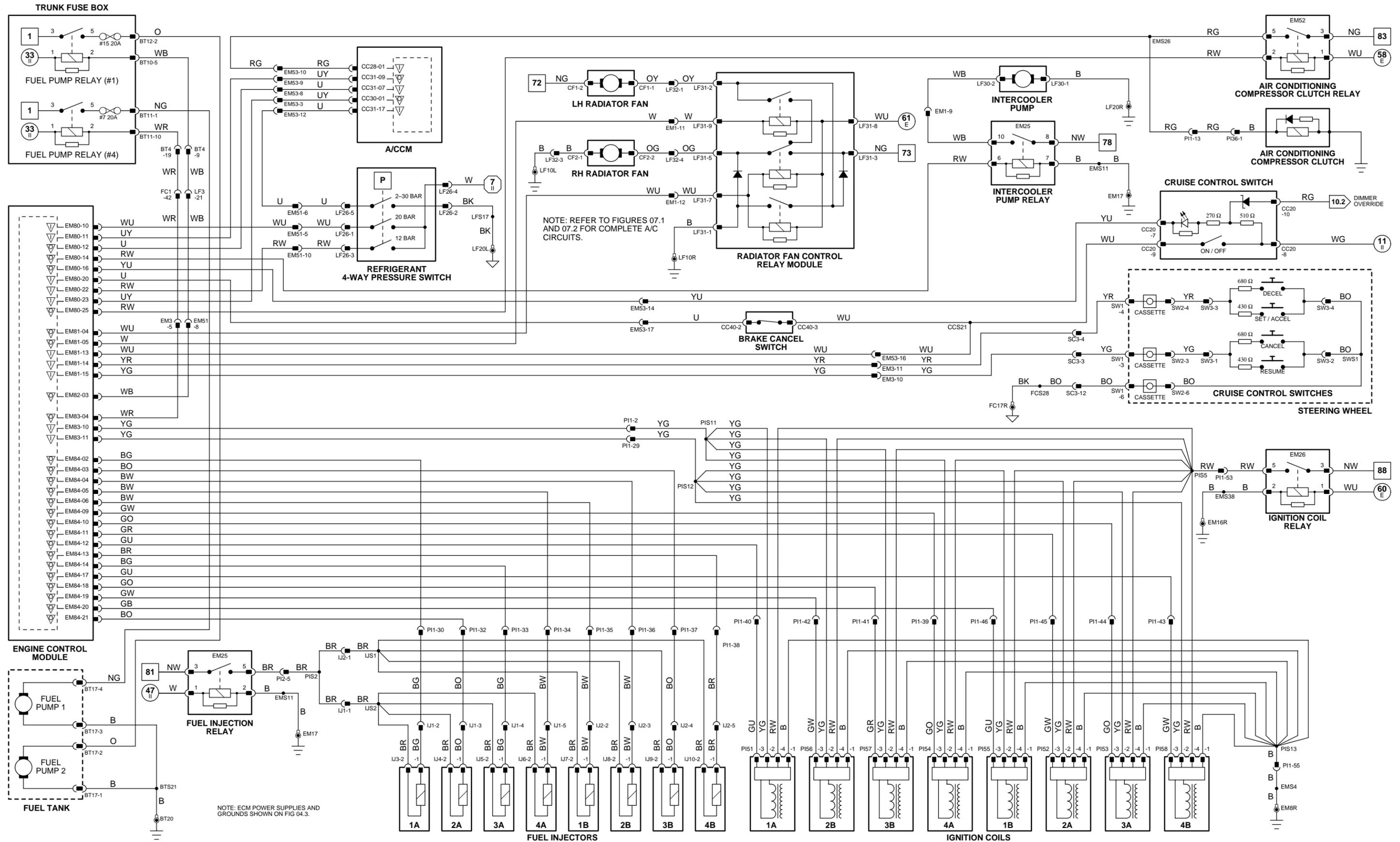
NOTE: ECM POWER SUPPLIES AND GROUNDS SHOWN ON FIG 04.1.



NOTES:
 * EARLY PRODUCTION VEHICLES HAVE WIRE COLOR CODES THAT ARE DIFFERENT FROM THAT SHOWN. USE CONNECTOR PIN NUMBERS FOR WIRE IDENTIFICATION.
 ** CCV, FTPS AND ASSOCIATED WIRING - NAS VEHICLES ONLY.
 SHIELDING SHOWN AS DASHED LINES ARE BRAIDED WIRES.

ENGINE CONTROL MODULE (CONTINUED FIG 04.4)

BRD



***INSERT TAB FOR PTEC
ENGINE MANAGEMENT
SECTION HERE***

PTEC ENGINE MANAGEMENT SYSTEM



- 1 PTEC OVERVIEW AND CONTROL SUMMARY**
- 2 POWERTRAIN CONTROL MODULE (PCM)
- 3 PCM SENSING COMPONENTS – ENGINE
- 4 INDUCTION AIR AND THROTTLE CONTROL
- 5 FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL
- 6 FUEL INJECTION
- 7 IGNITION
- 8 VARIABLE VALVE TIMING / VARIABLE INTAKE
- 9 EXHAUST GAS RECIRCULATION (EGR): V6 ONLY
- 10 OTHER PCM ENGINE CONTROL AND INTERFACE FUNCTIONS
- 11 TASK SHEETS



Jaguar S-TYPE PTEC Acronyms and Abbreviations

AAI Valve	Air Assist Injection Valve
APP Sensor	Accelerator Pedal Position Sensor
B+	Battery Voltage
CHT Sensor	Cylinder Head Temperature Sensor
CKP Sensor	Crankshaft Position Sensor
CMP Sensor 1	Camshaft Position Sensor – RH Bank
CMP Sensor 2	Camshaft Position Sensor – LH Bank
DLC	Data Link Connector
DPFE Sensor	Differential Pressure Feedback EGR Sensor
ECT Sensor	Engine Coolant Temperature Sensor
EFT Sensor	Engine Fuel Temperature Sensor
EGR	Exhaust Gas Recirculation
EOT Sensor	Engine Oil Temperature Sensor
EVAP Canister Close Valve	Evaporative Emission Canister Close Valve
EVAP Canister Purge Valve	Evaporative Emission Canister Purge Valve
FTP Sensor	Fuel Tank Pressure Sensor
GECM	General Electronic Control Module
HO2 Sensor 1 / 1	Heated Oxygen Sensor – RH Bank / Upstream
HO2 Sensor 1 / 2	Heated Oxygen Sensor – RH Bank / Downstream
HO2 Sensor 2 / 1	Heated Oxygen Sensor – LH Bank / Upstream
HO2 Sensor 2 / 2	Heated Oxygen Sensor – LH Bank / Downstream
IAT Sensor	Intake Air Temperature Sensor
IMT Valve	Intake Manifold Tuning Valve
IP Sensor	Injection Pressure Sensor
KS 1	Knock Sensor – RH Bank
KS 2	Knock Sensor – LH Bank
MAF Sensor	Mass Air Flow Sensor
NAS	North America Specification
PCM	Powertrain Control Module
PSP Switch	Power Steering Pressure Switch
PTEC	Powertrain Electronic Control
RECM	Rear Electronic Control Module
ROW	Rest of World Specification
SCP	Standard Corporate Protocol Network
TACM	Throttle Actuator Control Module
TFT Sensor	Transmission Fluid Temperature Sensor
TP Sensor	Throttle Position Sensor
VVT Valve 1	Variable Valve Timing Valve – RH Bank
VVT Valve 2	Variable Valve Timing Valve – LH Bank

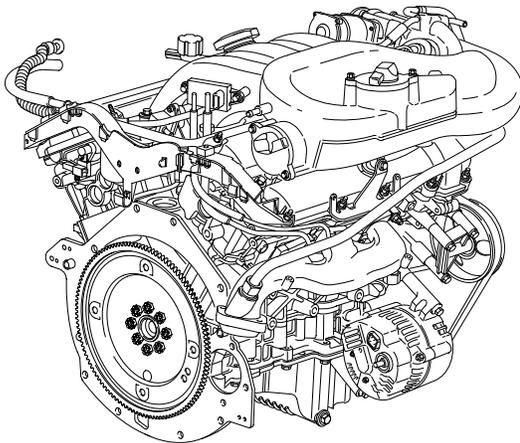
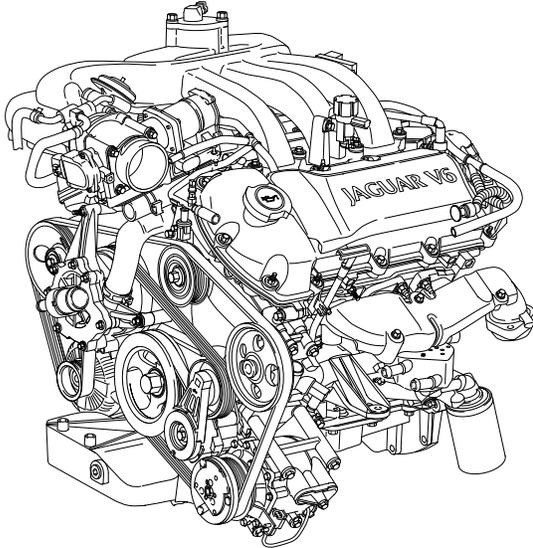
Note the following diagnostic PDU descriptions (refer to CMP Sensors, HO2 Sensors, KS and VVT Valves):

- 1 Right Hand engine bank (seated in the vehicle)
- 2 Left Hand engine bank (seated in the vehicle)
- /1 Upstream
- /2 Downstream

PTEC OVERVIEW

The PTEC (Powertrain Electronic Control) system is a comprehensive combined engine and transmission control system. The system is used on both the 3 liter AJ-V6 and the 4 liter AJ28 V8 engines installed in the Jaguar S-TYPE. There are detail sensor and control differences between V6 and V8, however the majority of the system is identical in its functions. PTEC complies with OBD II and is capable of achieving future LEV (Low Emission Vehicle) emission standards.

AJ-V6 ENGINE



PTEC.02

PTEC has several features that are unique from other Jaguar engine management systems:

Single control module

A single Powertrain Control Module (PCM) performs both engine and transmission control functions. This Student Guide covers only the engine management portion of the PTEC system.

SCP Network

PTEC communicates only on the vehicle SCP (Standard Corporate Protocol) multiplex network.

Returnless fuel system

The fuel delivery system is a supply only system with no provision for returning unused fuel from the fuel rail to the fuel tank.

Full authority throttle

PTEC employs a full authority electronic throttle assembly with no cable connection between the accelerator pedal and the throttle. The throttle assembly incorporates a separate control module with diagnostic capabilities.

Variable intake system (V6)

V6 engines are equipped with a variable length air intake manifold that optimizes engine torque across the entire speed/load range.

Fail safe cooling (V6)

V6 engines have a PCM “fail safe cooling” strategy that allows for limited engine operation with low or no coolant.

NOTES

PTEC ENGINE MANAGEMENT SYSTEM

PTEC CONTROL SUMMARY

The engine management systems for the 3.0 liter AJ-V6 engine and the 4.0 liter AJ28 V8 engine vehicles are virtually identical in function with differences in the control module parameters and the location of some components.

The major differences between the two systems are as follows:

AJ-V6

Two position VVT (variable valve timing)
Variable air intake system
EGR (exhaust gas recirculation) – 2000 MY only

AJ28 V8

Continuously variable VVT (variable valve timing)
AAI (air assisted injection)

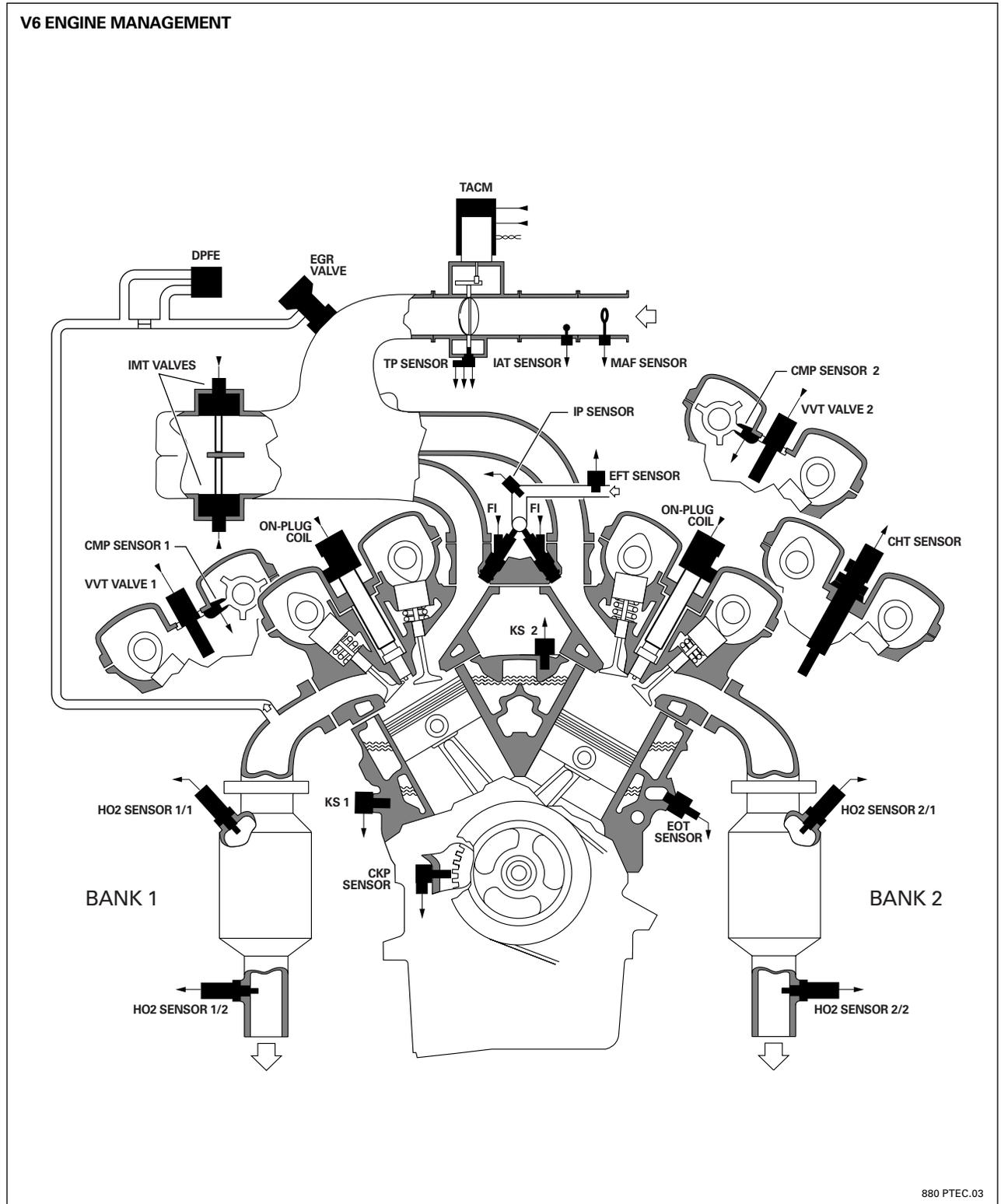
The PTEC powertrain control module (PCM) directly governs the following functions:

- Air assisted fuel injection (V8 only)
- Air conditioning compressor
- Automatic transmission
- Cooling system radiator fan
- Cruise control
- Default operating modes
- Engine power limiting
- Engine speed limiting
- Engine torque reduction control
- Evaporative emission control
- Exhaust emission control
- Exhaust gas recirculation (V6 only)
- Fail safe engine cooling
- Fuel delivery and injection (fuel pump via RECM)
- Fuel system leak check
- Full authority electronic throttle (via Throttle Actuator Control Module)
- Idle speed
- Ignition
- OBD II diagnostics
- Variable intake manifold tuning (V6 only)
- Variable intake valve timing
- Vehicle speed limiting

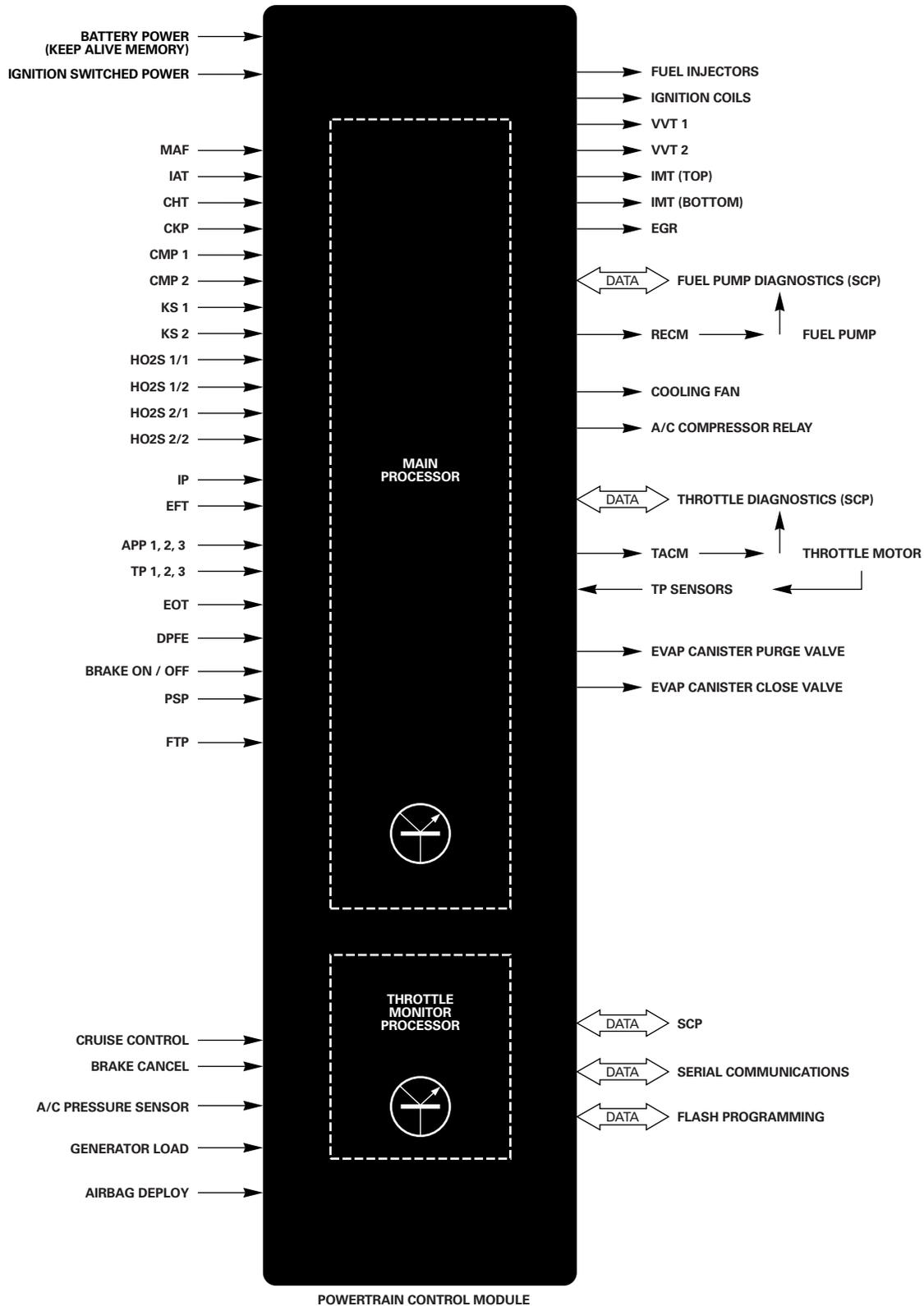
NOTES

PTEC CONTROL SUMMARY

System Logic – V6



V6 PCM ENGINE MANAGEMENT INPUTS AND OUTPUTS



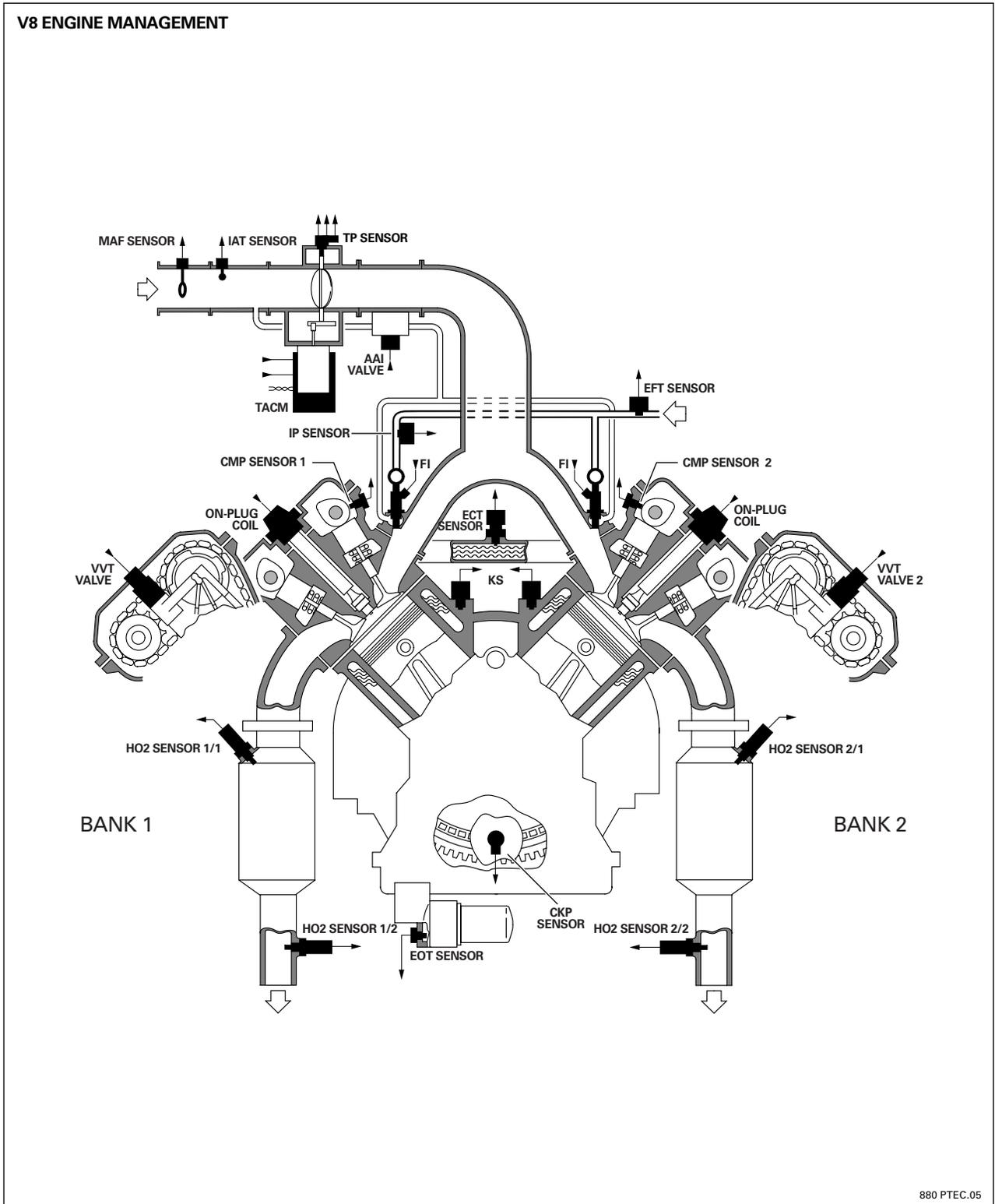
880 PTEC.04



PTEC ENGINE MANAGEMENT SYSTEM

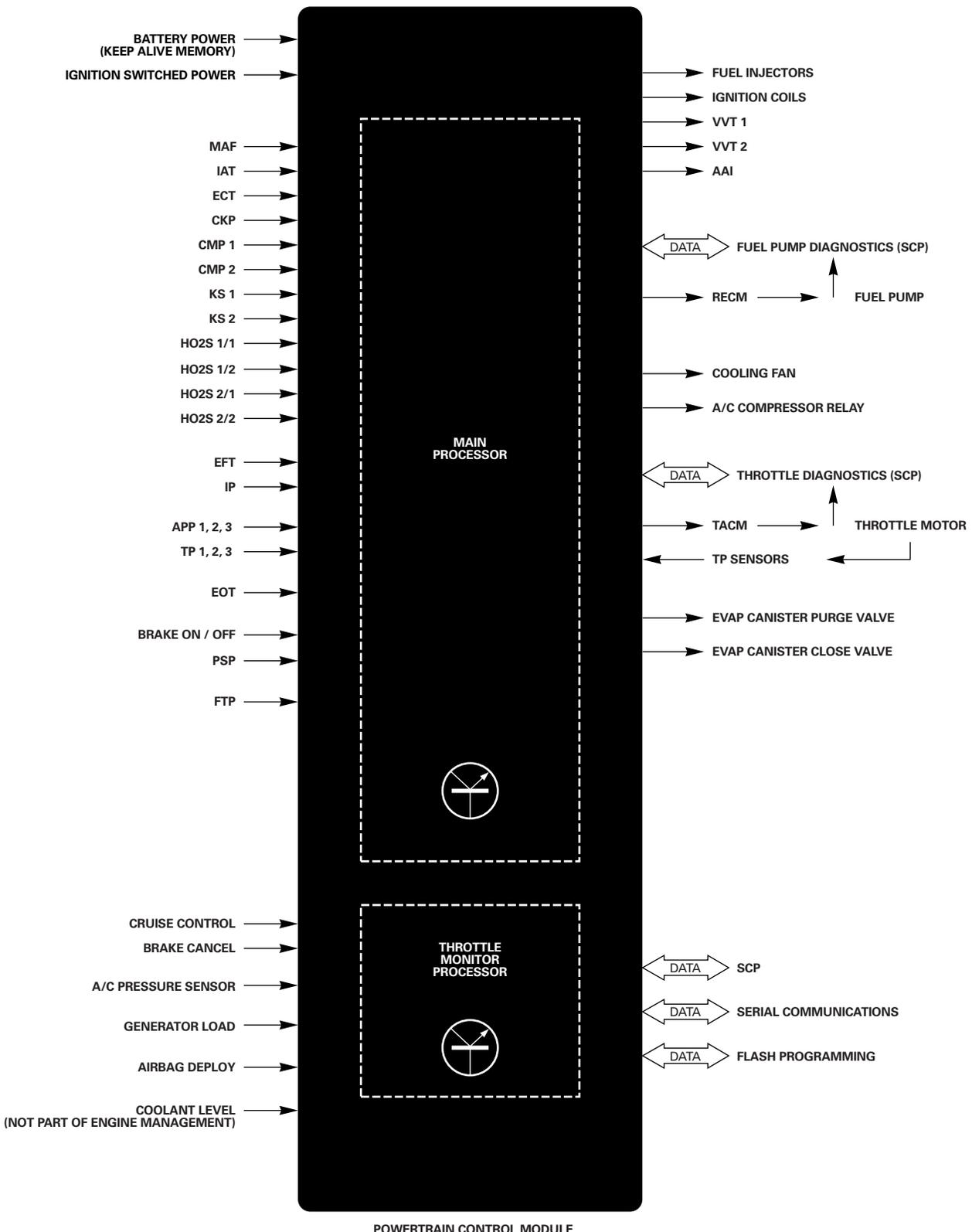
PTEC CONTROL SUMMARY

System Logic – V8



880 PTEC.05

V8 PCM ENGINE MANAGEMENT INPUTS AND OUTPUTS



880 PTEC.06

PTEC ENGINE MANAGEMENT SYSTEM

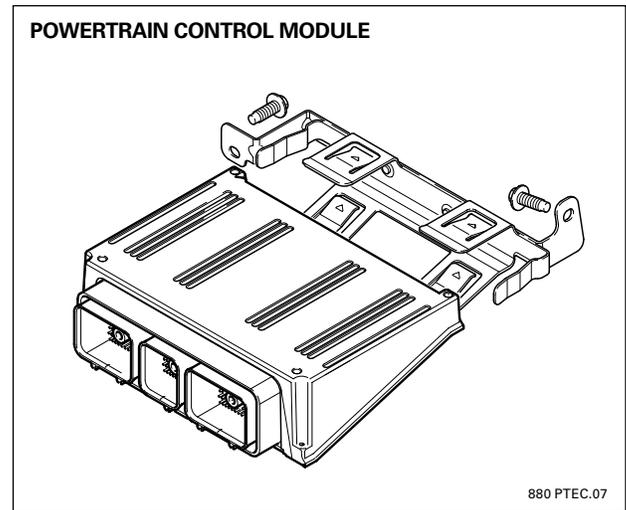


- 1 PTEC OVERVIEW AND CONTROL SUMMARY
- 2 **POWERTRAIN CONTROL MODULE (PCM)**
- 3 PCM SENSING COMPONENTS – ENGINE
- 4 INDUCTION AIR AND THROTTLE CONTROL
- 5 FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL
- 6 FUEL INJECTION
- 7 IGNITION
- 8 VARIABLE VALVE TIMING / VARIABLE INTAKE
- 9 EXHAUST GAS RECIRCULATION (EGR): V6 ONLY
- 10 OTHER PCM ENGINE CONTROL AND INTERFACE FUNCTIONS
- 11 TASK SHEETS



POWERTRAIN CONTROL MODULE (PCM)

- The PCMs for all S-TYPE Jaguars are almost identical but with unique programming for the characteristics of the various powertrain combinations. Also, some minor differences are required in the interface circuits to accommodate the sensors and actuators used on AJ-V6 or AJ28 engines.
- The vehicle powertrain configuration information and the vehicle identification number (VIN) are flash programmed into the PCM during vehicle production.
- Volatile memory Quiescent current from the vehicle battery is used to maintain OBD generated DTCs and adaptive values are maintained. If the vehicle battery is disconnected, stored DTCs and adaptive values will be lost. The ECM will “relearn” adaptive values during the next driving cycle.



NOTE: If the PCM or Instrument Pack are replaced, PDU must be used to match the control modules before the vehicle is operated.

CAUTION: The PCM must not be switched from one vehicle to another; the VIN will be mismatched and the powertrain configuration information may be incorrect for the vehicle.

PCM Power Supplies

- The PCM power supplies flow through a 40 Amp fuse to powertrain control relay 1.
- Powertrain control relay 2 supplies power to the A/C compressor clutch, generator, HO2S heaters, and coil-on-plug ignition coils.
- Both relays are located in the front power distribution board and are powered by the same fuse. 5 Amp fused B+ voltage activates the relays directly from the ignition switch when it is in positions II (RUN) and III (START).
- The PCM is located on the passenger side of the cabin below the climate control blower unit.
- The 150-way three-pocket connector housing protrudes through the bulkhead to accept the matching connectors from the engine bay side harnesses.
- The 60-way socket connects to the engine harness (PI).
- The 32-way socket connects to the transmission harness (GB).
- The 58-way socket connects to the vehicle forward harness (FH).

PCM Configuration

NOTE: Once a PCM is configured to a vehicle, it cannot be re configured to another vehicle.

After a PCM is replaced and the battery reconnected, connect WDS. Select Guided Diagnostics from the Main Menu followed by Vehicle Set Up and Vehicle CM Set Up / Configuration. WDS will perform the configuration during which you will be prompted to enter the Vehicle Identification Number.

During configuration WDS writes vehicle identification information into a section of the PCM memory called the VID Block (Vehicle Identification Block). Once the VID Block space is occupied, it cannot be overwritten. The VID Block stores data pertaining to certain other vehicle control modules. For example, the instrument pack identification data.

POWERTRAIN CONTROL MODULE (PCM)

Barometric Pressure

The PCM does not incorporate a barometric pressure sensor. Instead, it calculates barometric pressure based on input signals received from the mass air flow sensor and the throttle position sensor. If the PCM cannot calculate barometric pressure (failure mode), it defaults to an atmospheric pressure of 27 in. Hg. (902 mBar).

PCM Multiplex and Serial Data Communications

The PCM is part of the SCP vehicle multiplex data network that operates at 41.6 kb per second. In addition to the SCP network, the PCM is connected to the Serial Data Link, and has a dedicated flash programming circuit. All three circuits are accessed at the Data Link Connector (DLC) for DTC retrieval, system diagnostics and monitoring, and PCM EPROM flash programming.

Idle Speed Adaptions

If the vehicle battery is disconnected, idle speed adaptions will be lost. After battery reconnection, operate the vehicle as follows to restore the idle speed adaptions:

- Start the engine and warm to $>82^{\circ}\text{C}$ (180°F)
- Switch off the engine; restart the engine
- Idle in Neutral for two (2) minutes
- Depress and hold brake pedal; select Drive; idle for two (2) minutes

System Diagnostics – Faults / Default Action

The PCM continuously performs diagnostic monitoring for OBD II and non-OBD II functions. Diagnostics include: self-test routines, engine and transmission function monitoring, individual sensor circuit, signal, function and integrity monitoring, and critical sensors input signal validation. Detected faults are logged in the PCM memory as DTCs.

In most instances of detected sensor and/or component failure, the PCM takes default action. Specific default actions, messages and warnings are contained in the Jaguar Quick Reference Diagnostic Guide: S-TYPE POWERTRAIN DTC Summaries.

NOTES

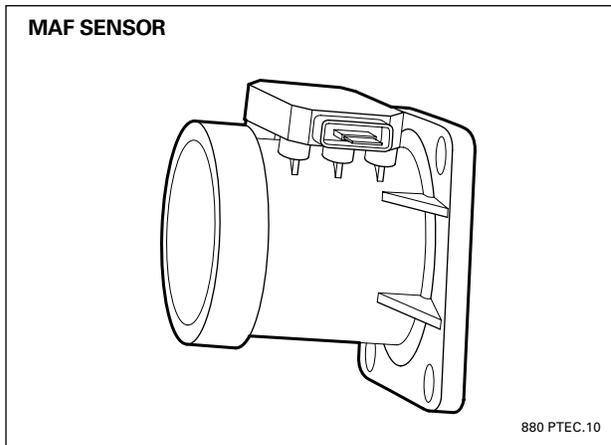
PTEC ENGINE MANAGEMENT SYSTEM



- 1 PTEC OVERVIEW AND CONTROL SUMMARY
- 2 POWERTRAIN CONTROL MODULE (PCM)
- 3 **PCM SENSING COMPONENTS – ENGINE**
- 4 INDUCTION AIR AND THROTTLE CONTROL
- 5 FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL
- 6 FUEL INJECTION
- 7 IGNITION
- 8 VARIABLE VALVE TIMING / VARIABLE INTAKE
- 9 EXHAUST GAS RECIRCULATION (EGR): V6 ONLY
- 10 OTHER PCM ENGINE CONTROL AND INTERFACE FUNCTIONS
- 11 TASK SHEETS

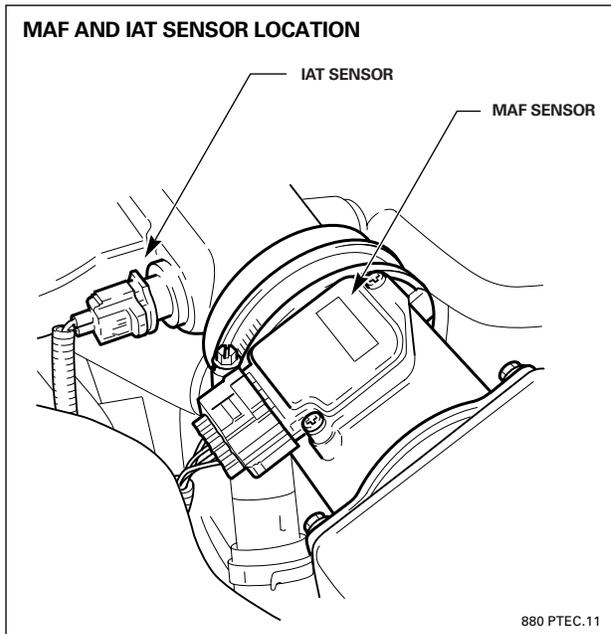


PCM SENSING COMPONENTS – ENGINE



Mass Air Flow (MAF) Sensor

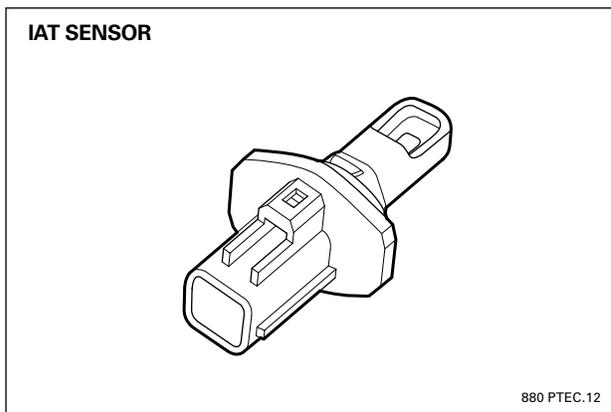
- The MAF sensor measures the mass of air entering the intake system, the measurement being based on the constant temperature hot wire principle.
- A hot wire probe and an air temperature probe are suspended in the air intake tract.
- The PCM ensures that the hot wire probe is always 200 °C hotter than the air temperature probe.
- The hot wire probe is cooled by the air flowing through the intake system and the PCM varies the heating current to maintain the 200 °C temperature difference.
- The change in heating current is measured as a voltage drop across a precision resistor and is assigned to a corresponding mass air flow calculation by the PCM.



Intake Air Temperature (IAT) Sensor

- The IAT sensor, located in the air induction duct, is a thermistor which has a negative temperature coefficient (NTC).
- Intake air temperature is determined by the PCM by the change in the sensor resistance.
- The PCM applies stable 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance.
- The PCM uses the IAT signal to adjust ignition timing to match intake air temperature.

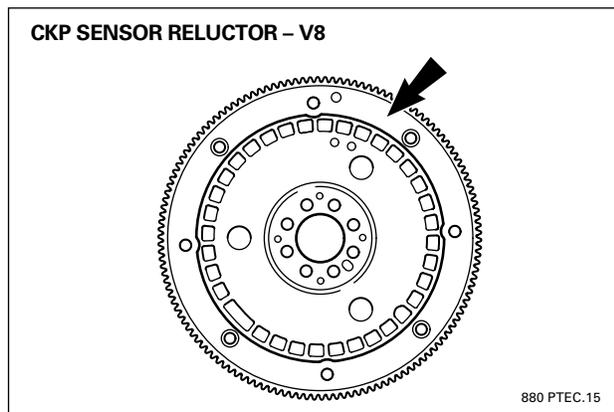
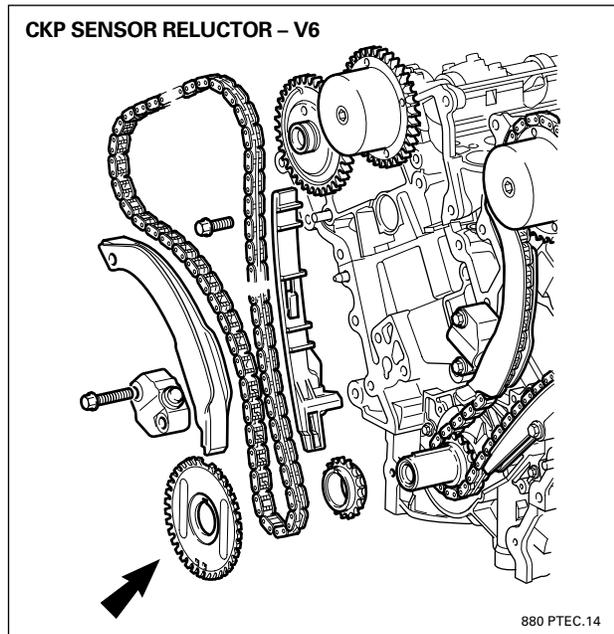
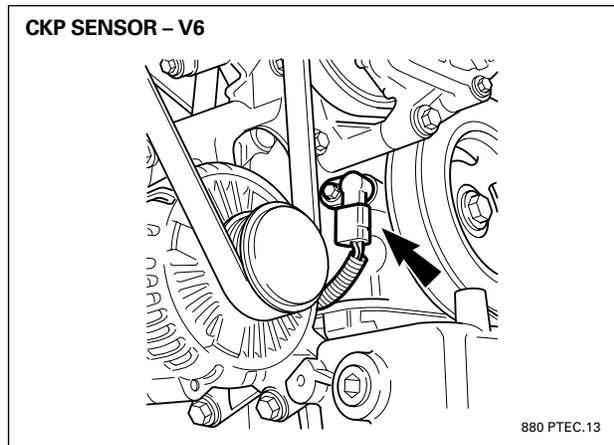
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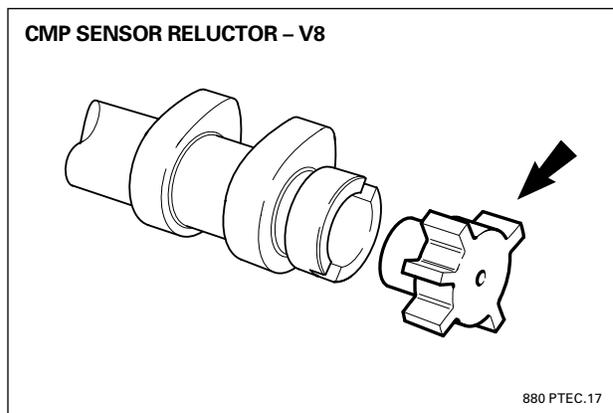
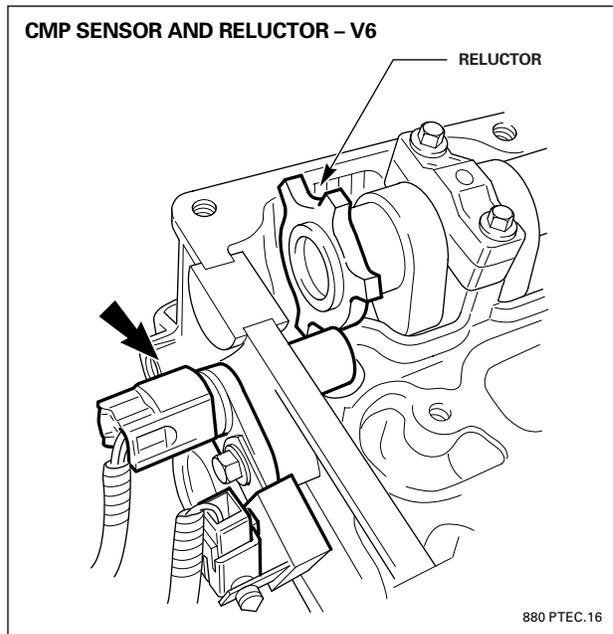
Crankshaft Position (CKP) Sensor

- The CKP sensor is an inductive pulse generator, which provides the PCM with an engine speed and position alternating voltage signal.
- The PCM uses the CKP signal to determine both engine speed and crankshaft position.
- The 36-tooth (minus one tooth) reluctor is located on the crankshaft at different locations in the V6 and V8.
 - V6 sensor is located on the front of the crankshaft, in the front timing cover.
 - V8 sensor is located on the transmission drive plate as in previous V8 engines.
- The missing tooth gap provides a PCM reference for crankshaft position.
 - V6 gap is located at 60° BTDC cylinder 1/1.
 - V8 gap is located at 50° BTDC cylinder 1/1.
- The PCM requires the input signal from the camshaft position sensor to determine the engine stroke.

NOTES



PCM SENSING COMPONENTS – ENGINE



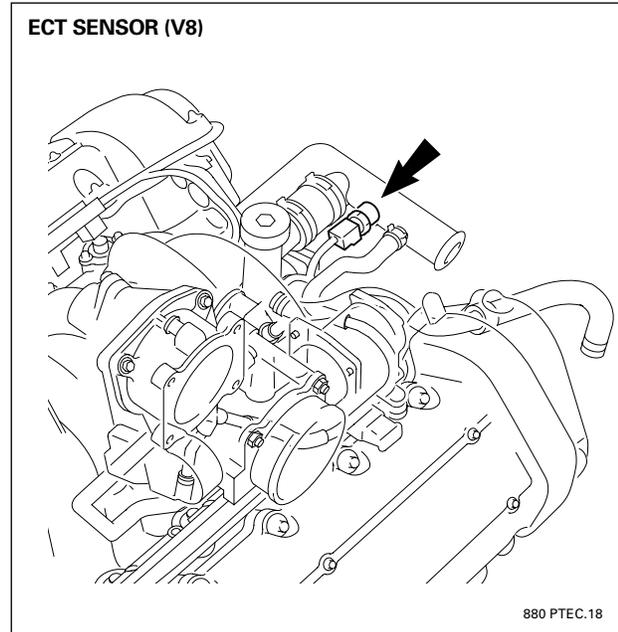
Camshaft Position (CMP) Sensors

- The CMP sensors are inductive pulse generators which provide the PCM with a cylinder identification alternating voltage signal.
- The PCM uses the CMP signals (one for each cylinder bank) for:
 - cylinder identification to control starting, fuel injection sequential operation
 - ignition timing
 - variable valve timing operation and diagnostics.
- The CMP reluctors are located on the inlet camshafts at the rear of the cylinder heads.
 - V6 reluctors have four teeth (three are equally spaced)
 - V8 reluctors have five teeth (four are equally spaced).
- The multi-tooth cam sensor rings increase the cam position feedback frequency, providing the enhanced control required by the VVT system.
- The use of multi-tooth sensor rings also improves starting by providing additional reference points for the PCM to determine camshaft position.

NOTES

Engine Coolant Temperature (ECT) Sensor (V8)

- The V8 ECT sensor, located on the coolant outlet elbow between the cylinder banks, is a thermistor which has a negative temperature coefficient (NTC).
- Engine coolant temperature is determined by the PCM by the change in the sensor resistance.
- The PCM applies 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance.



PTEC Temperature Sensors

The following Temperature / Resistance / Voltage chart applies to all of the PTEC Temperature Sensors except for the Cylinder Head Temperature (CHT) Sensor:

- Engine Coolant Temperature (ECT) Sensor
- Engine Fuel Temperature (EFT) Sensor
- Engine Oil Temperature (EOT) Sensor
- Intake Air Temperature (IAT) Sensor
- Transmission Fluid Temperature (TFT) Sensor

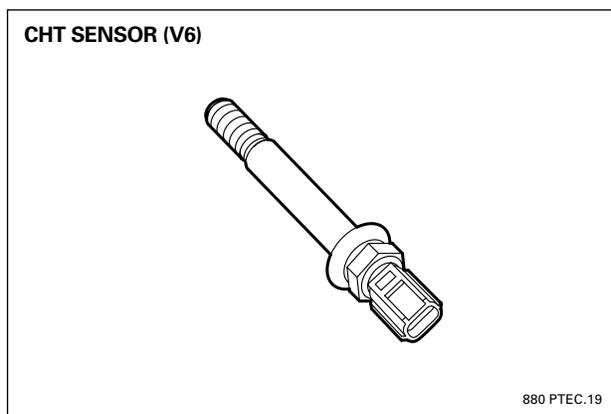
	Temperature		Nominal Resistance	Nominal Voltage at PCM
	°C	°F		
	0	32	95.851 kΩ	3.88v
	10	50	59.016 kΩ	3.52v
	20	68	37.352 kΩ	3.09v
	30	86	24.239 kΩ	2.62v
	40	104	16.092 kΩ	2.15v
	50	122	10.908 kΩ	1.72v
	60	140	7.556 kΩ	1.34v
	70	158	5.337 kΩ	1.04v
	80	176	3.837 kΩ	0.79v
	90	194	2.840 kΩ	0.61v
	100	212	2.080 kΩ	0.47v
	110	230	1.564 kΩ	0.36v
	120	248	1.191 kΩ	0.28v
	130	266	0.918 kΩ	0.22v
	140	284	0.715 kΩ	0.17v
	150	302	0.563 kΩ	0.14v

NOTES

PCM SENSING COMPONENTS – ENGINE

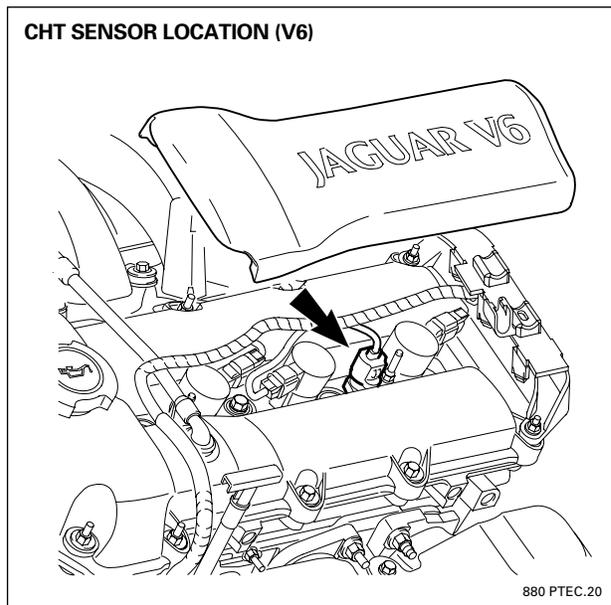
Cylinder Head Temperature (CHT) Sensor (V6)

- The CHT sensor, located between the two rear coil-on-plug units in the bank 2 cylinder head, is a thermistor which has a negative temperature coefficient (NTC).
- The sensor directly monitors the metal temperature of the cylinder head. This method of engine heat sensing is used in place of an engine coolant temperature sensor to enable the V6 fail safe cooling strategy to operate. Refer to page 10.4. The use of a metal temperature sensor allows cylinder head temperature to be measured even if coolant has been lost.
- Cylinder head temperature is determined by the PCM by the change in the sensor resistance. The PCM applies 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance.



V6 Cylinder Head Temperature Sensor

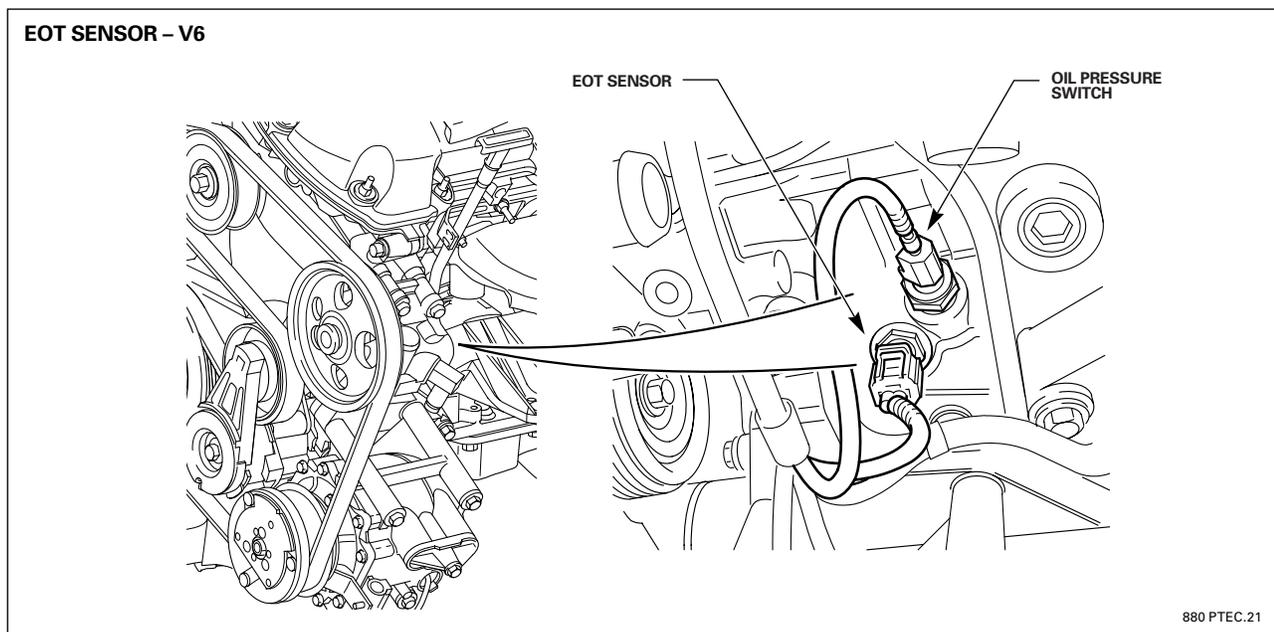
Temperature °C	Temperature °F	Nominal Resistance	Nominal Voltage at PCM
0	32	96.248 kΩ	4.140 v
10	50	59.173 kΩ	3.737 v
20	68	37.387 kΩ	3.257 v
30	86	24.216 kΩ	2.738 v
40	104	16.043 kΩ	2.226 v
50	122	10.851 kΩ	1.759 v
60	140	7.487 kΩ	1.362 v
70	158	5.269 kΩ	1.043 v
80	176	3.775 kΩ	0.794 v
90	194	2.750 kΩ	0.604 v
100	212	2.038 kΩ	0.462 v
110	230	1.523 kΩ	0.354 v
120	248	1.155 kΩ	0.273 v
130	266	0.887 kΩ	0.212 v
140	284	0.689 kΩ	0.167 v
150	302	0.542 kΩ	0.132 v
160	320	0.430 kΩ	0.105 v
170	338	0.345 kΩ	0.085 v



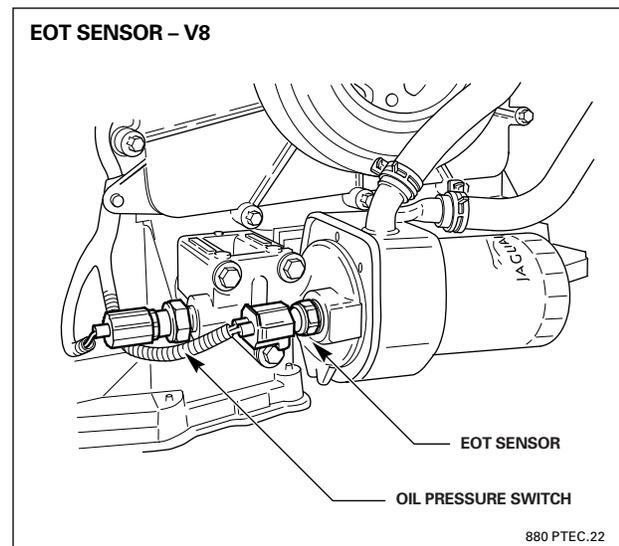
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Engine Oil Temperature (EOT) Sensor

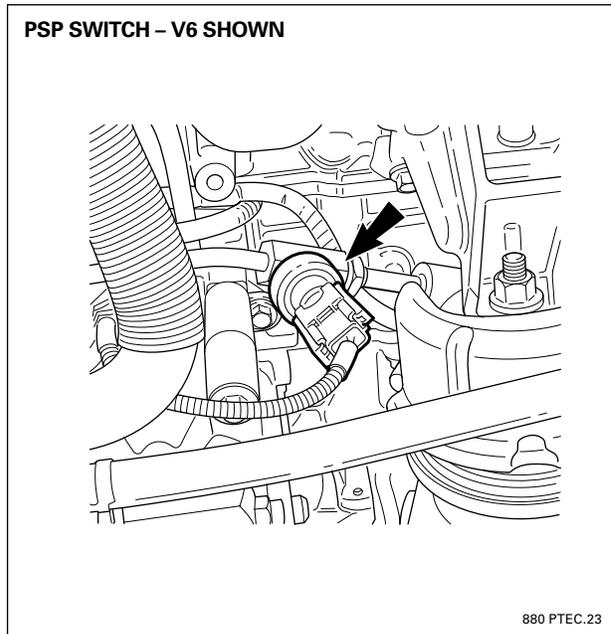
- The PCM uses the EOT signal for variable valve timing control.
- The EOT sensor is a thermistor which has a negative temperature coefficient (NTC).
- The PCM applies 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance.
- Engine oil temperature is determined by the PCM by the change in the sensor resistance.
- The V6 and V8 sensors are fitted to the engine lubrication system in different locations:
 - V6 EOT sensor is located on the left hand side of the cylinder block in the oil return channel from the oil cooler
 - V8 EOT sensor is located on the oil cooler / filter adapter.



NOTES



PCM SENSING COMPONENTS – ENGINE



Power Steering Pressure (PSP) Switch

- The PCM uses the input from the PSP switch to compensate for the additional accessory drive load on the engine by adjusting the engine idle speed and preventing engine stall during parking maneuvers.
- The PSP switch, located on the PAS pump outlet pipe, monitors the hydraulic pressure on the high pressure side of the power steering system.
- The switch is a normally open switch that closes when the hydraulic pressure reaches 24.13 ± 3.45 Bar (350 ± 50 psi).

Brake Switches

The PCM receives input signals from two brake pedal position switches:

- Brake switch (B+ voltage / normally open)
- Brake cancel switch

Two switches provide signal plausibility.

- The switch inputs to the PCM are used for cruise control cancel and multiple vehicle functions (via SCP).
 - On DSC equipped vehicles, the brake switch is hard wired to the DSC control module.

The DSC system uses an active brake booster, which when activated by the DSCCM, will cause the brake pedal to drop with the subsequent activation of the brake switches. During the DSC self test when the vehicle first moves off, the booster is momentarily activated by the DSCCM causing the brake pedal to drop.

When the DSCCM is performing the self test, it does not broadcast an SCP BRAKES APPLIED message, which prevents erroneous brake light activation.

NOTES

PTEC ENGINE MANAGEMENT SYSTEM



- 1 PTEC OVERVIEW AND CONTROL SUMMARY
- 2 POWERTRAIN CONTROL MODULE (PCM)
- 3 PCM SENSING COMPONENTS – ENGINE
- 4 **INDUCTION AIR AND THROTTLE CONTROL**
- 5 FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL
- 6 FUEL INJECTION
- 7 IGNITION
- 8 VARIABLE VALVE TIMING / VARIABLE INTAKE
- 9 EXHAUST GAS RECIRCULATION (EGR): V6 ONLY
- 10 OTHER PCM ENGINE CONTROL AND INTERFACE FUNCTIONS
- 11 TASK SHEETS

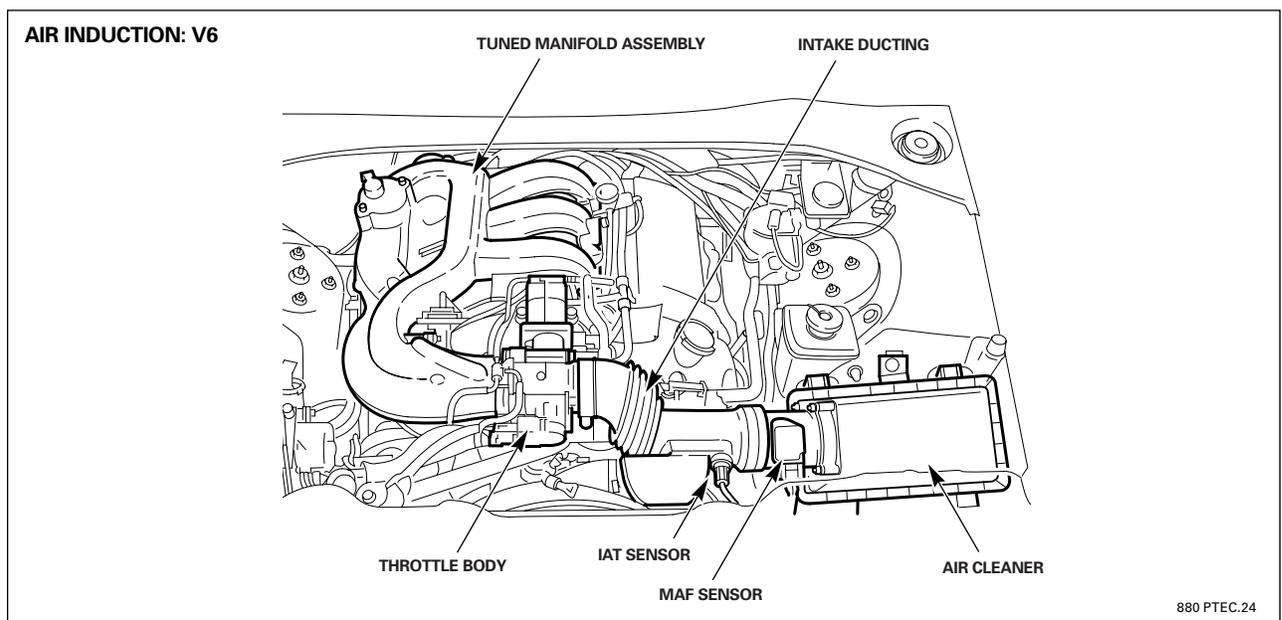
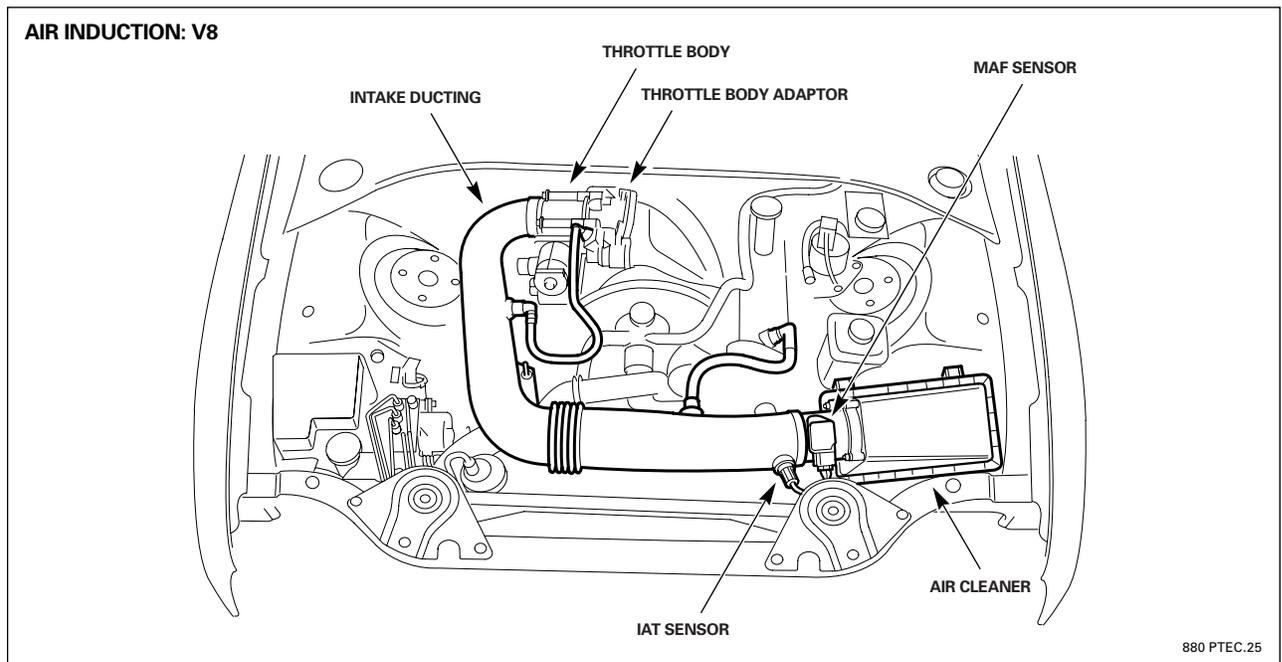


INDUCTION AIR AND THROTTLE CONTROL

Air Induction Systems

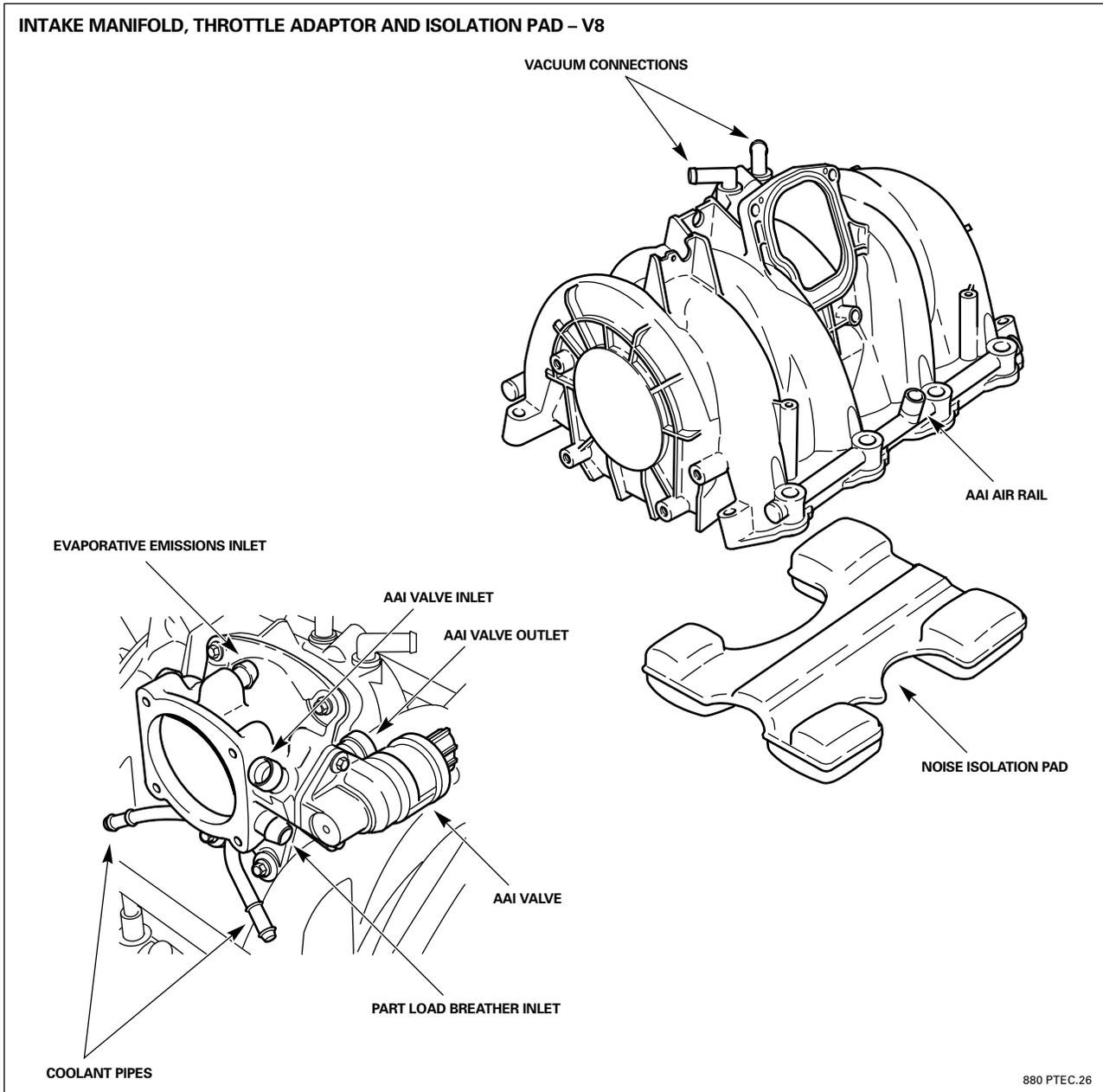
The V6 and V8 engines have air induction systems that are similar from the air cleaner inlet through the throttle body. The systems consist of the normal components with the MAF sensor located in the air cleaner outlet and the IAT sensor located in the air intake duct just downstream of the MAF sensor. Resonator chambers are fitted to the intake ducting to control intake air reverberation at certain throttle openings.

After exiting the throttle body, the V6 and V8 induction air systems differ greatly.



Air Intake – V8

Induction air flows into the manifold through a centrally located inlet. The manifold incorporates the air rails for air assisted fuel injection. The heated (engine coolant) throttle adaptor connects the throttle body to the manifold and provides EVAP, and vacuum source connections. The air assist injection valve is located on the throttle adaptor. A noise isolation pad locates between the induction manifold and the engine vee.



INDUCTION AIR AND THROTTLE CONTROL

Full Authority Throttle Control

The electronic throttle control system used in the PTEC engine management systems is designed with no mechanical connection between the vehicle accelerator pedal and the throttle valve. The PCM has full authority over throttle valve movement.

Accelerator pedal position is monitored by APP (accelerator pedal position) sensors that are hard wired to the PCM. The PCM calculates a throttle plate opening appropriate for the vehicle operating conditions using:

- pedal position
- engine speed
- vehicle speed
- cruise control status
- power reduction requirements for traction control, transmission torque input limits, and torque modulation required during transmission shifting.

The PCM issues redundant PWM throttle position command signals via hard wired connections to the throttle actuator control module (TACM), which is located on the throttle body assembly. The TACM drives the throttle valve to the desired position via the throttle drive motor.

Throttle position sensors communicate actual throttle angle feedback to the PCM via hard wires to provide closed loop control. The TACM communicates calculated throttle position to the PCM via hard wire connection as a cross-check.

The throttle control system uses multiple accelerator pedal position sensors, throttle position sensors, and multiple hard wired signals that allow the PCM to monitor individual signal validity. Two separate, dedicated, twisted pair (B+ around ground) provide supply power and ground to the TACM.

A dedicated electronic throttle monitor microprocessor, within the PCM, constantly monitors overall operation of the throttle control system. The throttle monitor microprocessor interfaces internally with the PCM main microprocessor logic and software.

In the event of a software or component failure, the system alerts the driver and, depending on the failure, adopts a default action to ensure driver safety. Refer to the Jaguar Quick Reference Diagnostic Guide: S-TYPE POWERTRAIN DTC Summaries.

Operation of the system is designed to be totally transparent to the driver with a total delay of less than 70 ms between pedal actuation and throttle movement.

Throttle Data Recorder

The PCM throttle monitor processor incorporates a throttle data recorder. If the throttle data recorder is stopped by an airbag deployed input, the current throttle data is retained in memory and the PCM main processor flags DTC P1582. The throttle data recorder will not function again until 100 ignition key cycles have been completed. The logged DTC P1582 will require an additional 40 key cycles to clear, or the DTC can be cleared using PDU.

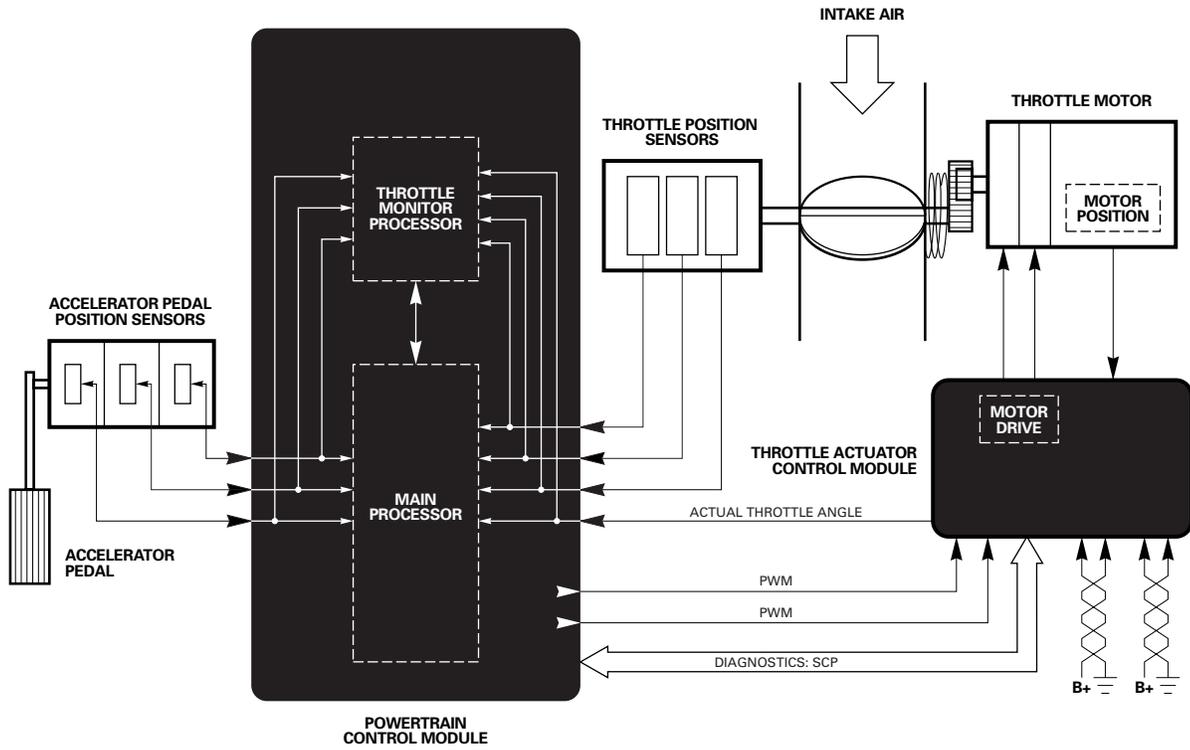
Throttle Motor Control Relay, 2001 Model Year ON

2001 Model Year ON PTEC systems have a PCM internal timer circuit to control a throttle motor control relay. This circuit allows the PCM to open the throttle, via the relay, after engine OFF to prevent exhaust gas from building-up in the intake manifold and creating difficult hot start conditions.

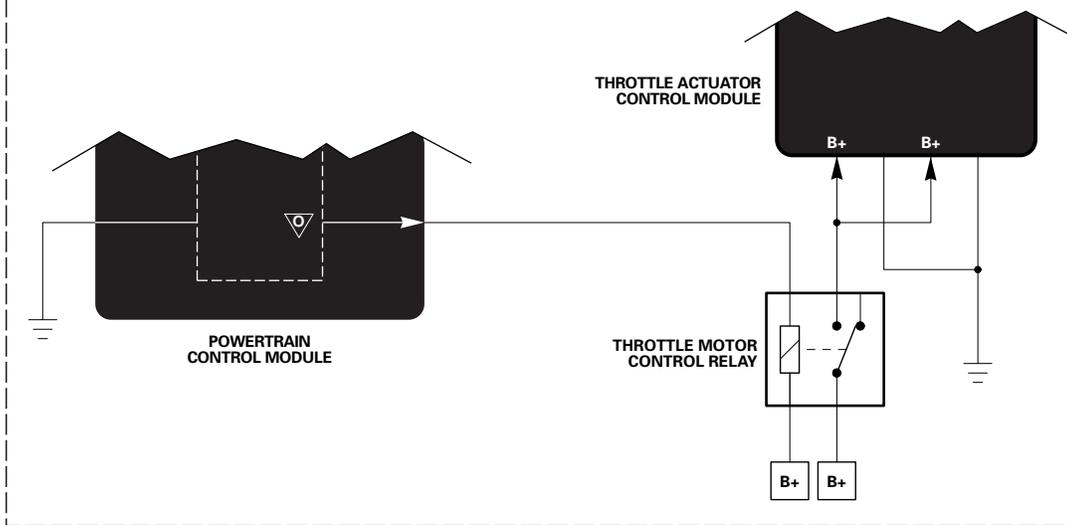


PTEC ENGINE MANAGEMENT SYSTEM

THROTTLE CONTROL LOGIC



THROTTLE MOTOR CONTROL RELAY – 2001 MY ON



880 PTEC.27

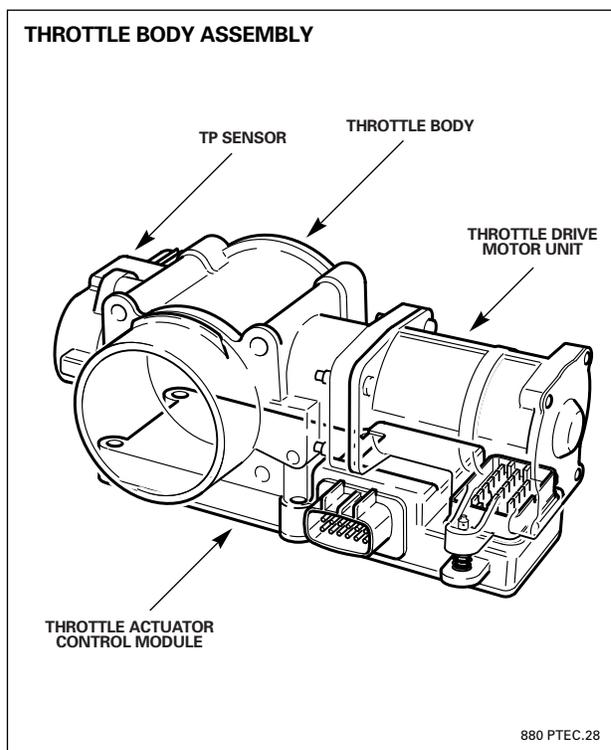
INDUCTION AIR AND THROTTLE CONTROL

Throttle Body Assembly

The throttle body assembly consists of the following sub components:

- Throttle body with valve and shaft
- Throttle actuator control module (TACM)
- Drive motor unit
- Throttle position (TP) sensor assembly

Because each throttle assembly is calibrated during assembly, no adjustments to the assembly or its components are required or permitted. The throttle body must not be disassembled. The only serviceable component is the TP sensor assembly.



Throttle body

The throttle body is an aluminum casting with a 70 mm (2.75 in.) intake bore. The throttle valve and shaft rotate on ball bearings with an internal tooth quadrant gear and two throttle return springs on the drive end of the shaft. Factory adjusted and sealed stop screws set the throttle closed and full open positions.

Throttle drive motor unit

The throttle drive motor unit consists of the motor and an integral position encoder. If the motor fails, the throttle return springs return the throttle valve to the closed position.

WARNING: DO NOT PUT YOUR FINGERS IN THE THROTTLE BODY BORE. THEY COULD BE INJURED IF TRAPPED BY THE THROTTLE PLATE.

CAUTION: Do not attempt to clean the throttle housing or remove any sealant from the assembly. Any air leakage will disturb the idle speed calibration.

NOTES

Accelerator Pedal Position (APP) Sensor Assembly

- Three individual rotary potentiometers comprise the APP sensor assembly located at the top of the accelerator pedal.
- The potentiometers are driven by the accelerator pedal pivot shaft and provide separate analog voltage signals to the PCM proportional to accelerator pedal movement and position.
- The accelerator pedal uses two return springs to provide a positive return if one should fail, and to simulate the feel of a conventional accelerator pedal.

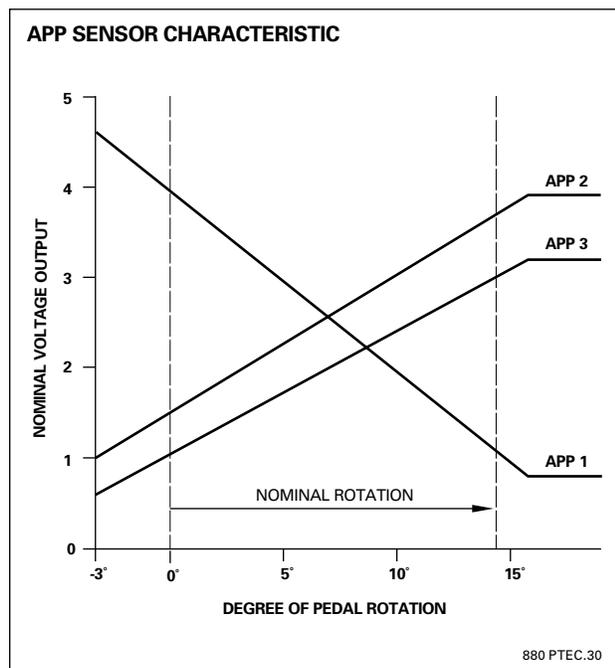
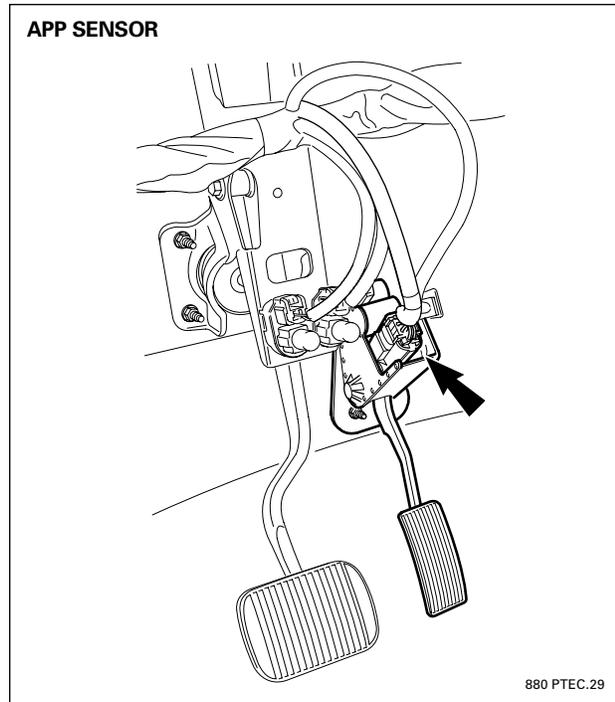
Each potentiometer has separate reference voltage and reference ground circuits hard-wired to the PCM; each provides its unique pedal position signal (via hard-wire connection) directly to the PCM. The PCM detects faults by comparing each pedal position signal to expected values as shown in the chart below.

PCM throttle control

The PCM calculates a required throttle position from the APP input signals and applies engine speed, cruise control status, engine torque reduction requirements, and other applicable data to generate duplicate 256 Hz PWM throttle command signals.

The command signal duty cycle is increased as more throttle opening is required. Duplicate throttle command signals are transmitted to the throttle actuator control module (TACM) over separate wires.

NOTES



INDUCTION AIR AND THROTTLE CONTROL

Throttle Actuator Control Module (TACM)

The TACM has two connectors and mounts to the throttle body and motor assembly. One connector plugs directly into the throttle motor. The second connector is the main interface with the PCM and also carries the twisted pair B+ voltage and ground supplies for TACM and throttle motor drive power. The two separate B+ voltage supplies from the front power distribution boxes are switched by powertrain relay 1 and the two separate ground supplies share the main ground stud used by the PCM.

The TACM processes the two throttle command PWM signals from the PCM and drives the throttle motor to the required position. The motor's position feedback to the TACM provides closed loop control and enables the TACM to maintain the desired throttle valve position. The PCM monitors actual throttle valve angle via the three-element TP sensor signals.

The TACM is on the SCP multiplex network and communicates with the PCM only for diagnostic purposes.

In addition to motor drive and positioning, the TACM also performs the following functions:

- Self diagnostics
- PCM throttle command signals validity comparison
- Requested throttle angle to actual throttle angle comparison
- Drive motor circuit operational comparison
- Failed throttle return spring detection
- Drive motor internal circuit continuity monitoring
- Inductive position encoder failure and out of range signals monitoring
- SCP transmission of diagnostic data to the PCM

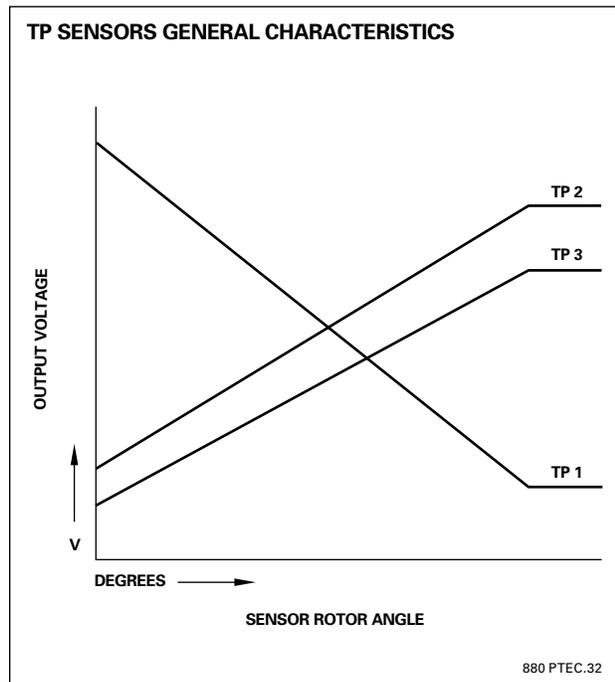
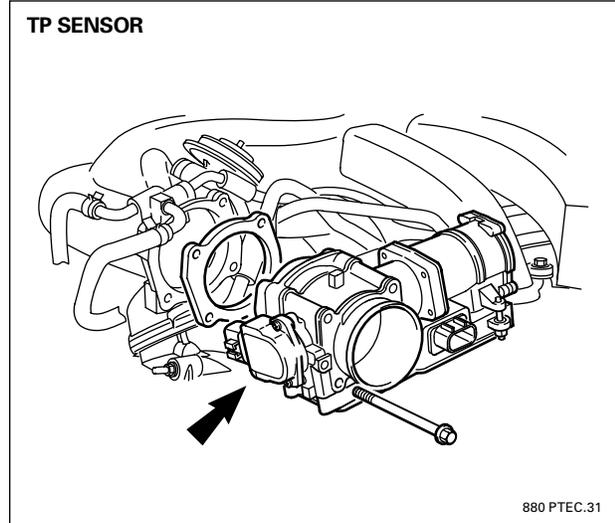
NOTES

Throttle Position Sensor (TPS) Assembly

The throttle position sensor assembly consists of three Hall effect sensing elements with conditioning circuits that are directly driven by the throttle valve shaft.

Each sensing element has separate reference voltage and reference ground circuits hard-wired to the PCM; each provides its unique throttle position signal (via hard-wire connection) directly to the PCM. The unique characteristics of each signal are used for identification, similar to the APP Sensor signals.

NOTES



INDUCTION AIR AND THROTTLE CONTROL

Cruise Control

The cruise control system is fully integrated within PTEC. The PCM maintains the driver selected vehicle speed to within ± 1 mph (1.5 km/h) via the normal throttle control and other engine and transmission control functions. The system uses inputs from illuminated steering wheel mounted ON / OFF, SET / ACCEL, COAST, CANCEL, and RESUME switches, the two brake pedal switches (normally open Brake Switch, normally closed Brake Cancel Switch), and vehicle speed. Cruise control is operational between 25 – 130 mph (40 – 209 km/h).

The cruise control strategy within the PCM uses engine control to provide smooth acceleration and deceleration. In cases such as driving downhill, where the vehicle tends to exceed the cruise control set speed, the PCM uses an engine braking strategy and transmission downshifts to help maintain the desired speed.

Cruise control switch functions

ON / OFF

When the system is switched ON or OFF, the PCM broadcasts an SCP VEHICLE SPEED CONTROL ON/OFF message. A SPEED CONTROL ON or OFF message is displayed in the message center for 4 seconds accompanied by a single audible chime. The PCM also broadcasts an SCP VEHICLE SPEED CONTROL SET SPEED ENABLE/DISABLE message whenever the Speed Control Set lamp in the instrument pack should be switched ON or OFF.

SET / ACCEL

Touching the SET / ACCEL switch with the cruise control switched ON and vehicle speed in the operating range puts the system into SET mode. The current vehicle speed is memorized and maintained. If the switch is held in the active position the vehicle will accelerate smoothly until it the switch is released. If the switch is touched momentarily (less than 640 ms), the vehicle speed increases by 1 mph. Pressing the accelerator pedal will accelerate the vehicle higher than the memorized speed without disengaging cruise control. When the pedal is released, the vehicle smoothly decelerates to the memorized speed.

COAST

Touching the COAST switch momentarily (less than 640 ms) decelerates the vehicle 1 mph. Holding the switch allows the vehicle to decelerate until the switch is released. When the switch is released, the vehicle will maintain the current speed.

CANCEL

Touching the CANCEL switch or applying the brakes puts the system into STANDBY mode and allows the vehicle to decelerate until either the SET / ACCEL or the RESUME switch is activated.

RESUME

When the system is STANDBY mode, touching the RESUME switch accelerates the vehicle to the memorized set speed. Resume will not function if the system has been switched OFF, the ignition has been switched OFF, or the vehicle is below the minimum operational speed.

NOTES

PTEC ENGINE MANAGEMENT SYSTEM



- 1 PTEC OVERVIEW AND CONTROL SUMMARY
- 2 POWERTRAIN CONTROL MODULE (PCM)
- 3 PCM SENSING COMPONENTS – ENGINE
- 4 INDUCTION AIR AND THROTTLE CONTROL
- 5 **FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL**
- 6 FUEL INJECTION
- 7 IGNITION
- 8 VARIABLE VALVE TIMING / VARIABLE INTAKE
- 9 EXHAUST GAS RECIRCULATION (EGR): V6 ONLY
- 10 OTHER PCM ENGINE CONTROL AND INTERFACE FUNCTIONS
- 11 TASK SHEETS



FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

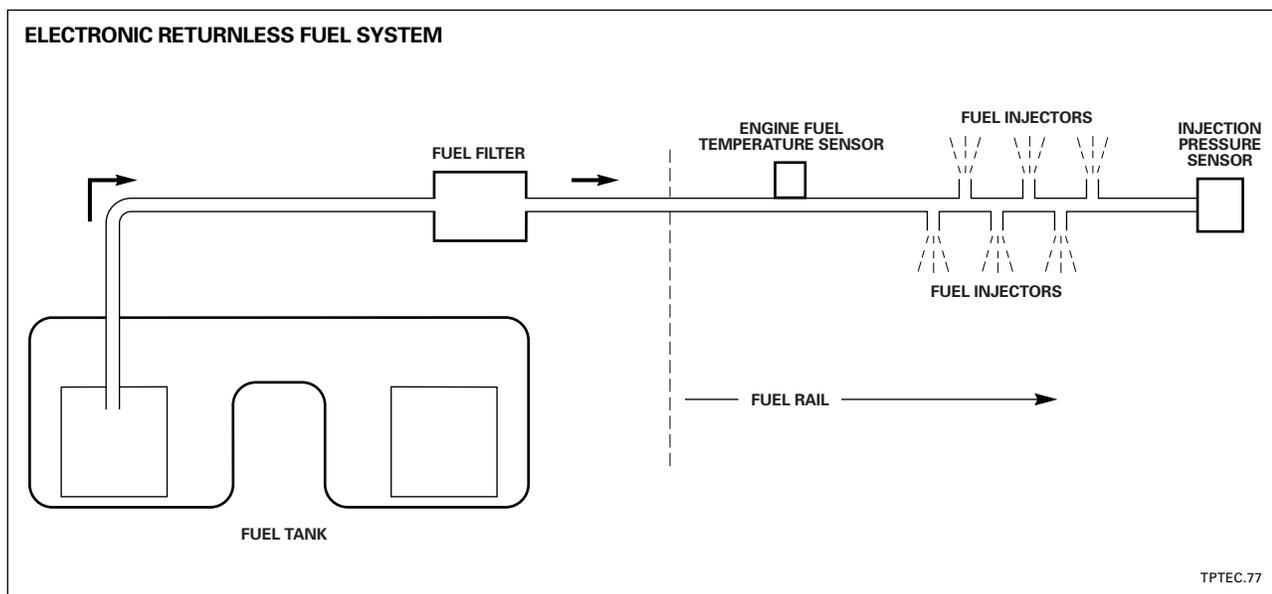
Electronic Returnless Fuel System

The electronic returnless fuel system used with the PTEC engine management system provides pressurized fuel at the fuel injectors and does not require a return line with its associated hardware. Additional benefits of the system include:

- Precise fuel pressure control
- Reduced fuel temperature and fuel tank vapor caused by constant fuel recirculation
- Reduced electrical system load
- Fuel pressure boost to prevent fuel vapor lock
- Reduce hot start cranking time

Fuel delivery volume and pressure from the single in-tank fuel pump are controlled by the PCM in a closed loop. The actual fuel pump “drive” is supplied and controlled by the Rear Electronic Control Module (RECM), which receives fuel pump control input from the PCM. The PCM / RECM fuel pump control circuit is hard wired.

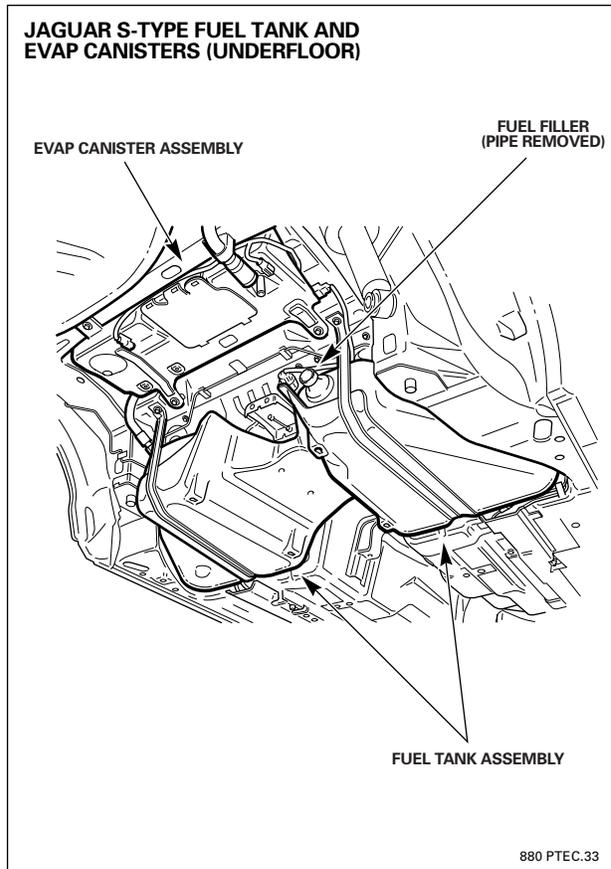
The system delivers the correct amount of fuel to the engine under all conditions and at a constant pressure differential with respect to manifold absolute pressure, without the need for a return line to the tank or a fuel rail pressure regulator.



NOTES

FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

Electronic Returnless Fuel System (continued)



Fuel tank (Jaguar S-TYPE)

The plastic blow-molded fuel tank is a saddle shape tank with LH and RH fuel compartments. The tank is located below the rear passenger seat with the drive shaft and exhaust running through the arch of the tank. The underside of the tank is protected by a heat shield. The tank assembly is retained by two metal straps which are fixed to the underbody at the front by removable hinge pins and at the rear by bolts.

Refueling is via a separate filler pipe and connecting hose to a stub pipe on the RH fuel compartment.

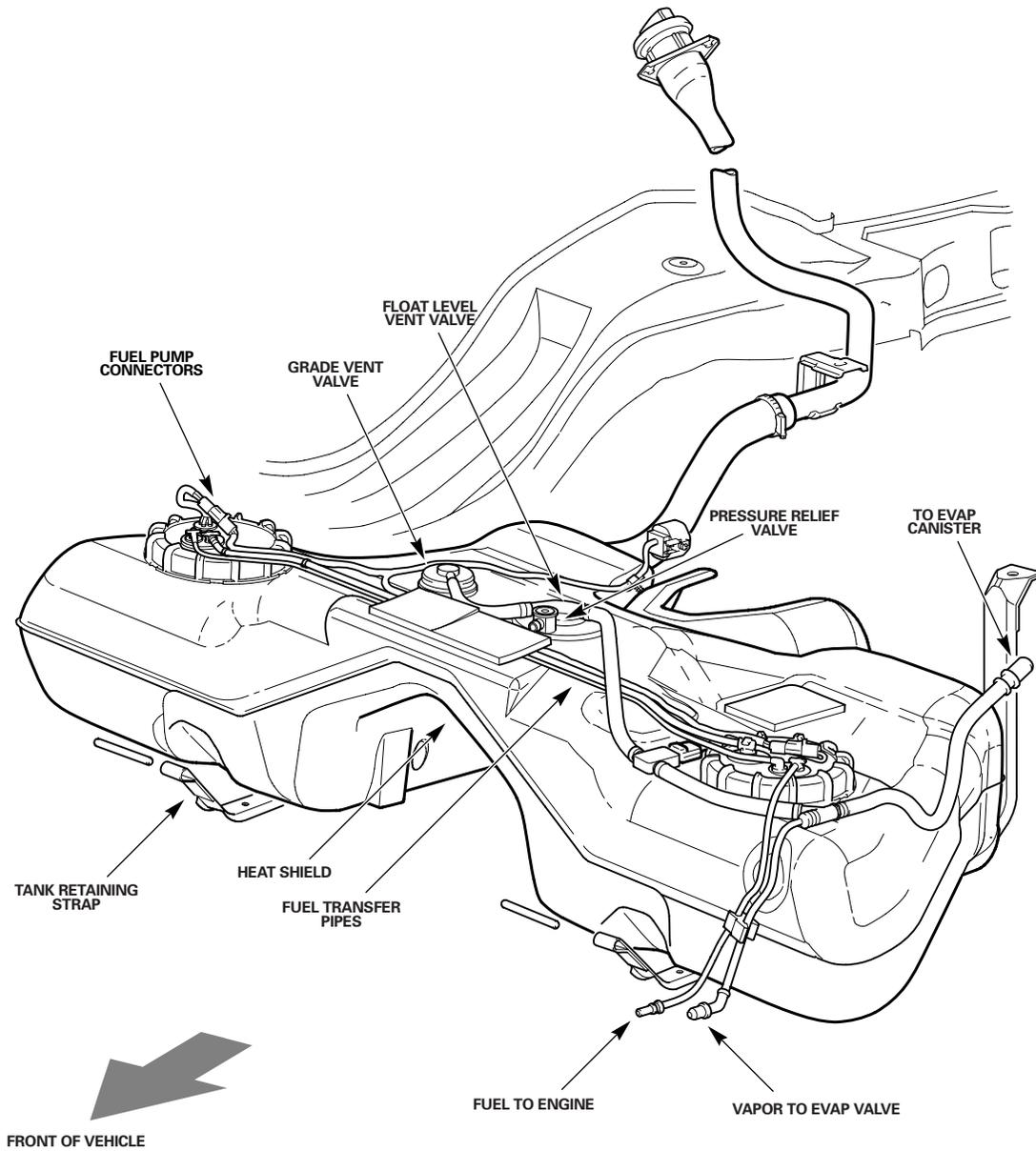
A variable speed fuel pump is located in the RH compartment. Jet pumps are located in both compartments with external crossover pipes for fuel transfer between the compartments. The crossover pipes and electrical connectors exit the fuel tank through top plates which are secured in the tank using screw-on closure rings. The components on the top of the fuel tank are accessible from inside the vehicle via two access holes in the floor panel, below the rear seat.

Fuel filter

The replaceable in-line fuel filter is located in the back of the left wheel well. All fuel supply lines use quick-fit connections that require a Jaguar service tool.

NOTES

JAGUAR S-TYPE FUEL TANK ASSEMBLY



880 PTEC.34

FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

Electronic Returnless Fuel System (continued)

Fuel flow

- The variable speed fuel pump is contained in a fuel reservoir in the RH compartment.
- Fuel is pumped from the reservoir through an external crossover pipe to the LH compartment where it flows via a “T” junction to the parallel pressure relief valve and then out to the engine fuel rail.
- The reservoir fuel level is maintained by the continual flow of fuel supplied by jet pumps in the LH and RH compartments.

Fuel from the LH compartment is pumped through an external crossover pipe to the reservoir. The RH compartment jet pump is located in the base of the reservoir.

Parallel pressure relief valve

The parallel pressure relief valve assembly contains two spring-loaded valves, which operate in opposite directions:

- The supply valve opens to allow fuel flow at approximately 0.014 Bar (0.2 psi) during normal operation.
- The fuel rail pressure relief valve opens at approximately 4.14 – 4.48 Bar (60 – 65 psi) to relieve excessive fuel rail pressure.

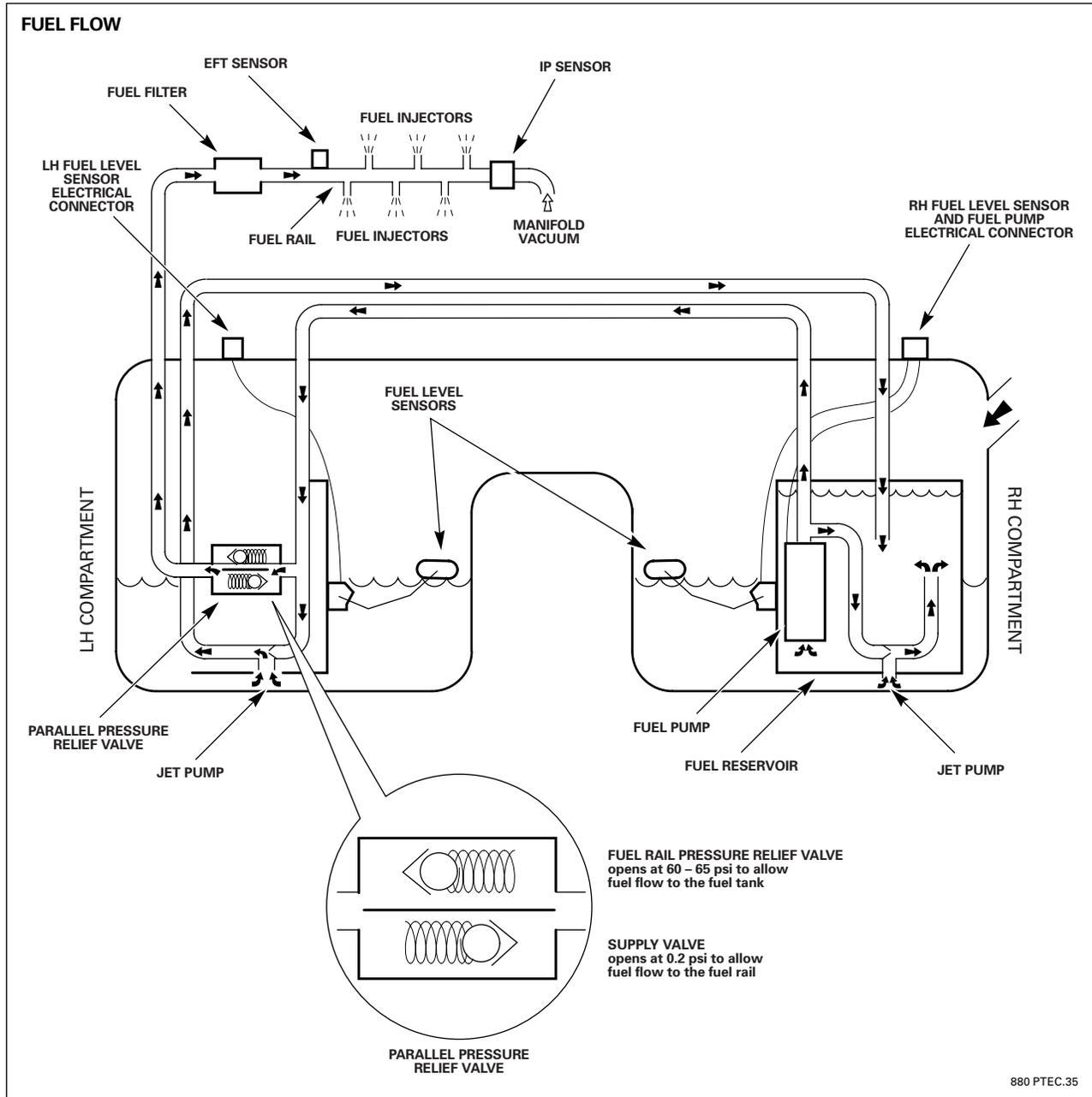
The main functions of the parallel pressure relief valve assembly are:

- To ensure fast engine starting by “checking” fuel in the supply lines and rail.
- To limit rail pressure due to temporary vapor increase during hot soak conditions (temperature and thus pressure drop after approximately 20 minutes.)
- To limit rail pressure caused by sudden load changes such as a full to closed throttle transition.
- To prevent siphoning from the tank in the even of the fuel line being severed with the pump inactive.

NOTES



PTEC ENGINE MANAGEMENT SYSTEM



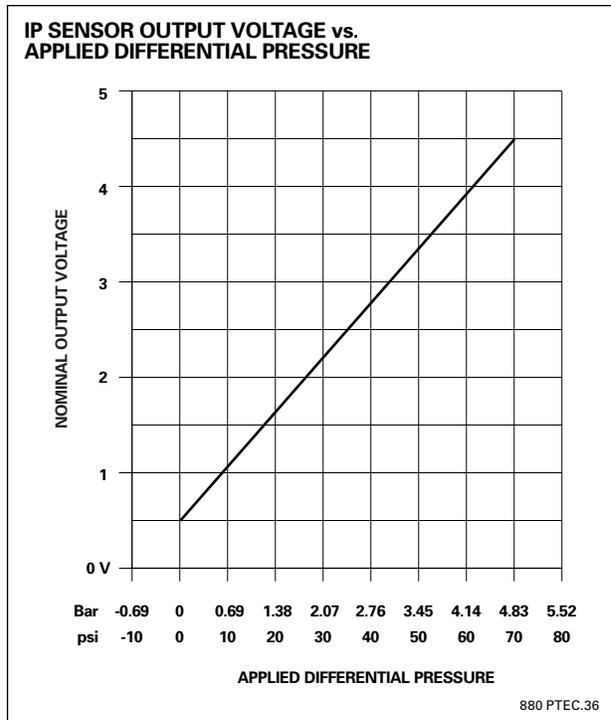
NOTES

FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

Electronic Returnless Fuel System (continued)

Fuel System Sensors

The fuel pump delivers fuel through a single fuel supply line to the closed-ended fuel rail. Two sensors feedback rail fuel pressure and temperature to the PCM. The IP (injector pressure) sensor is located at the end of the fuel rail, the EFT (engine fuel temperature) sensor is located at the supply end of the fuel rail.



Fuel injection pressure (IP) sensor

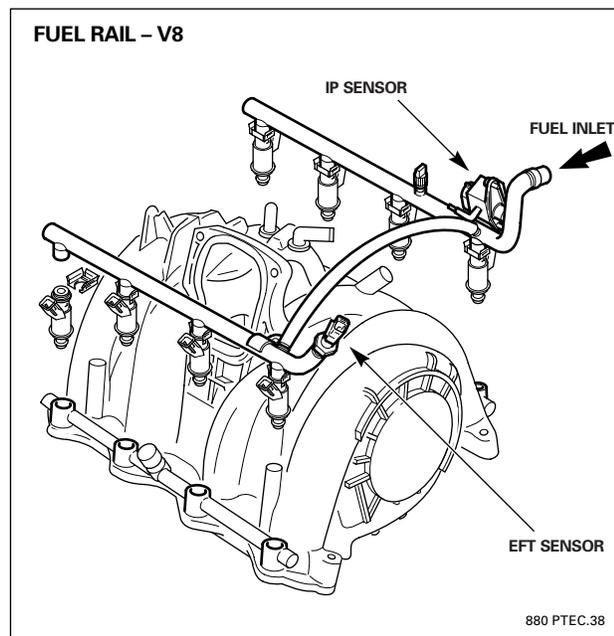
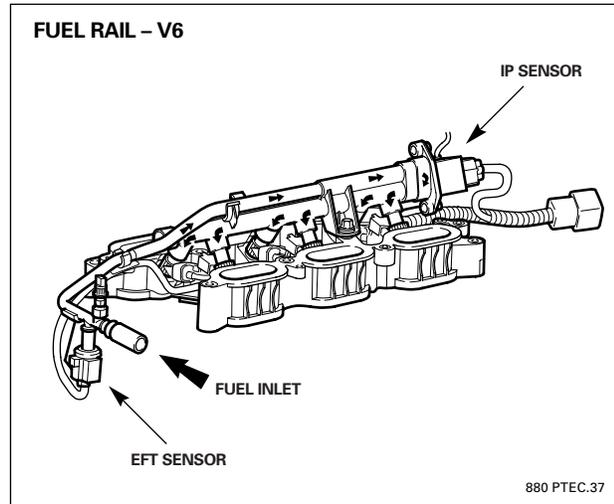
- The IP sensor, located on the fuel rail, is a pressure transducer device with a diaphragm separating the pressure transducer from direct contact with the fuel.
- A pipe connects the sensor to the intake manifold for sensing manifold depression (manifold vacuum).
- The voltage signal from the transducer is “conditioned” within the sensor.
- The PCM receives the conditioned voltage signal, which is proportional to differential fuel pressure in the rail.

NOTES

Engine fuel temperature (EFT) sensor

- The EFT sensor, located on the fuel rail, is a thermistor which has a negative temperature coefficient (NTC).
- Fuel temperature is determined by the PCM by the change in the sensor resistance.
- The PCM applies a 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance.
- The PCM uses the EFT signal to adjust fuel pump pressure to prevent fuel vaporization and ensure adequate fuel supply to the injectors.

NOTES



FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

Electronic Returnless Fuel System (continued)

Fuel pump control and operation

The fuel pump relay, located in the rear power distribution box, supplies power to the RECM to operate the fuel pump. The relay is activated by ignition switched B+ voltage via the inertia switch.

The PCM calculates engine fuel requirements using:

- engine load
- speed
- air flow
- engine temperatures:
 - cylinder head (V6)
 - engine coolant (V8)
 - intake air
- current fuel rail environment from the IP and EFT sensors.

The PCM communicates the fuel flow demand to the RECM as a pulse width modulated (PWM) signal over a single line at a frequency of approximately 256 Hz and a duty cycle of 0-50%.

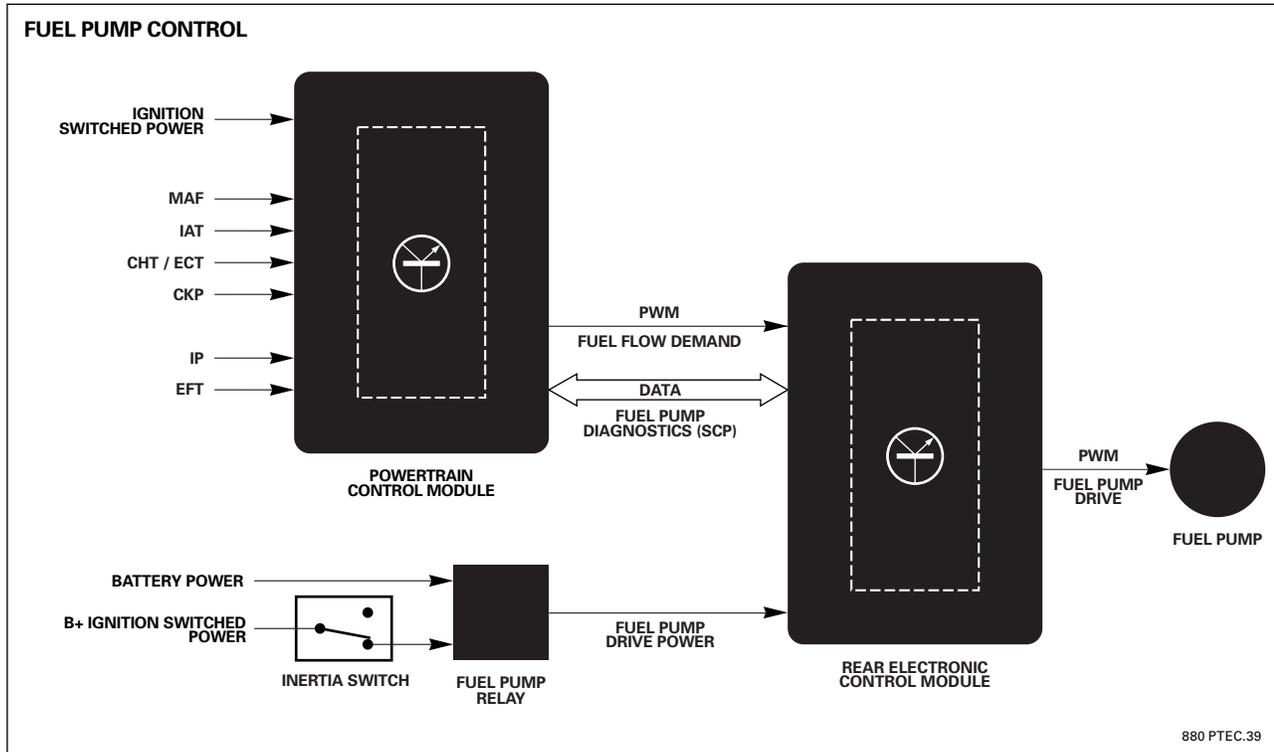
The RECM amplifies this signal by increasing the frequency by 64 and doubling the duty cycle, thus providing the variable high current drive for the fuel pump.

When the ignition switch is turned from OFF to RUN or START, the PCM primes the system by running the pump for 1 second. After prime, the pump is switched ON when the CKP signal is received. The pump is switched OFF 1 second after the engine is stopped. During all hot fuel conditions, fuel pressure is increased to prevent vapor lock.

Fuel pump drive status is monitored by the RECM and communicated to the PCM via the SCP network.

In the event of a vehicle impact, the inertia switch switches open deactivating the fuel pump relay and causing the RECM to cancel fuel pump drive.

NOTES



Fuel level sensors

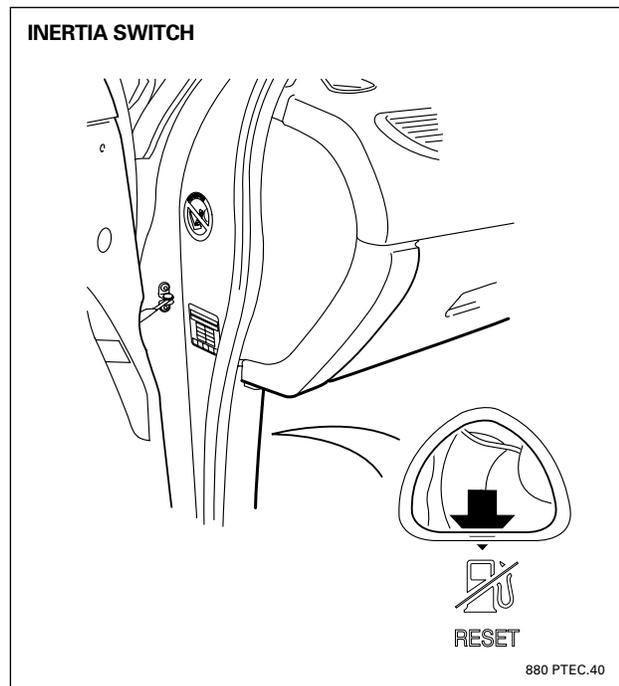
Outputs from the fuel level sensors are connected by independent wires to the RECM, which communicates the LH and RH sensor data independently to the instrument pack and the PCM via the SCP network.

Inertia switch

The inertia switch is located behind the trim on the left side of the vehicle, forward of the front door post and below the fascia. A finger access hole in the trim allows the switch to be reset.

If the inertia switch is tripped, it interrupts the ignition switched B+ voltage supply circuit to the fuel pump relay coil. The direct B+ voltage fuel pump supply to the RECM is interrupted and the pump immediately stops.

NOTES



FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

Evaporative Emission Control System

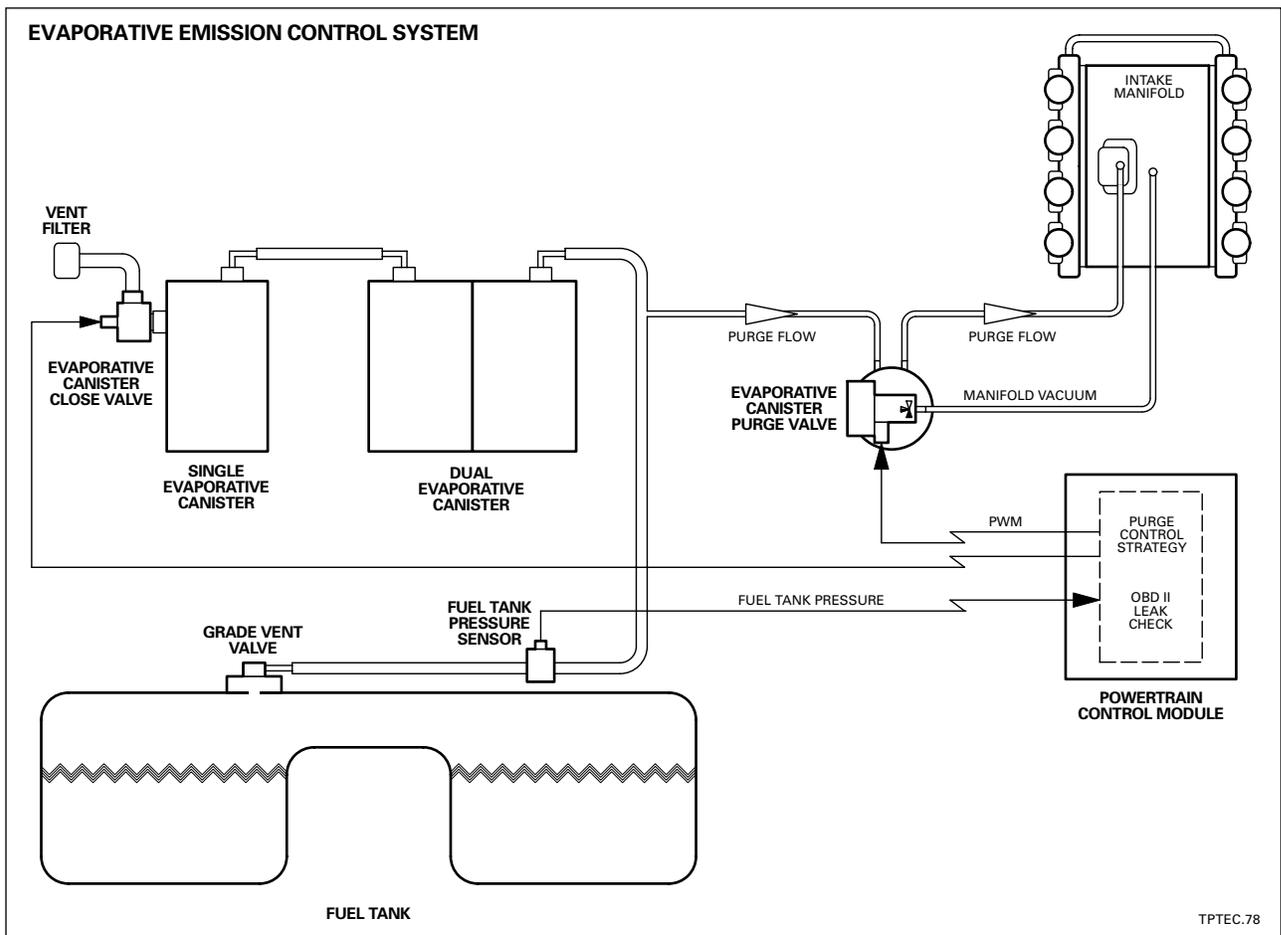
EVAP fuel tank components

To meet ORVR evaporative emission requirements, the tank and associated components are designed to minimize vapor losses. During refueling, the narrowed fuel filler tube below the nozzle region provides a liquid seal against the escape of vapor and a check valve in the tank inlet pipe opens to incoming fuel only to prevent splashback. As the tank fills, vapor escapes through the fuel level float valve, at the top of the tank, and passes through the adsorption canisters to atmosphere. When the rising fuel level closes the float valve, the resulting back pressure causes refueling cutoff. While the float valve is closed, any further rise in vapor pressure is relieved by the grade vent valve which connects to the canisters via the outlet of the float valve. At less than full tank level, the float valve is always open, providing an unrestricted vapor outlet to the canisters.

If the tank is over filled (e.g. a fault in the delivery system) an integral pressure relief valve in the float valve assembly opens to provide a direct vent to atmosphere.

The float level vent valve/pressure relief valve assembly and the grade valve are welded to the tank top and are non-serviceable. Note that both valve assemblies incorporate roll-over protection.

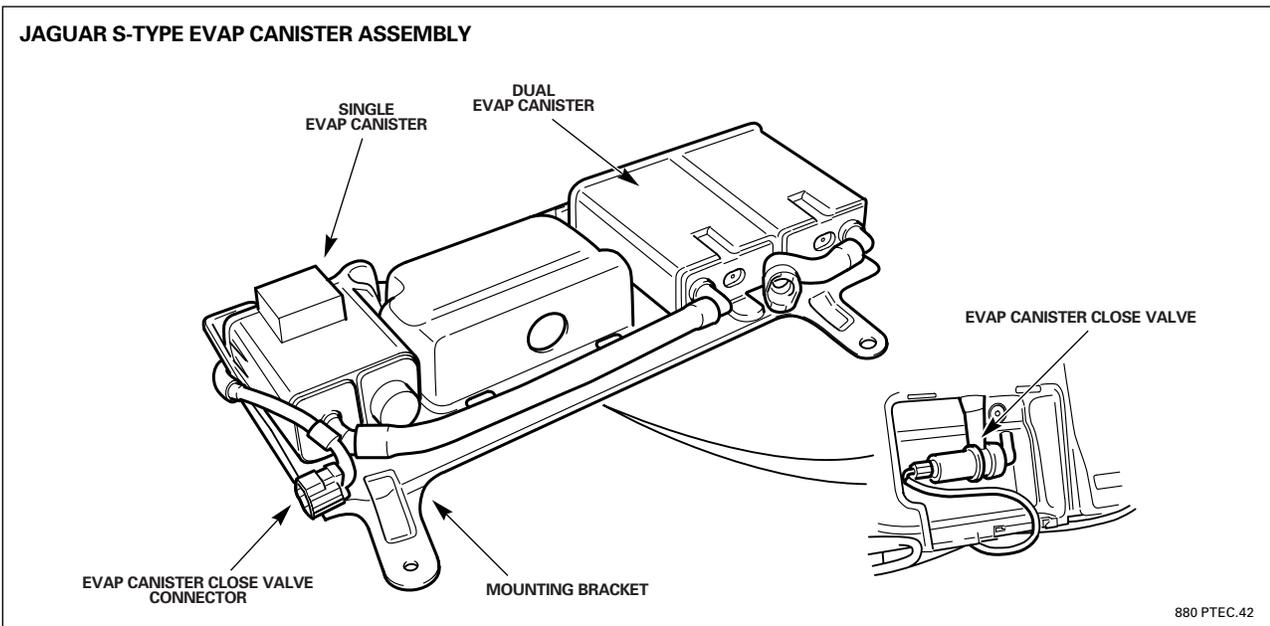
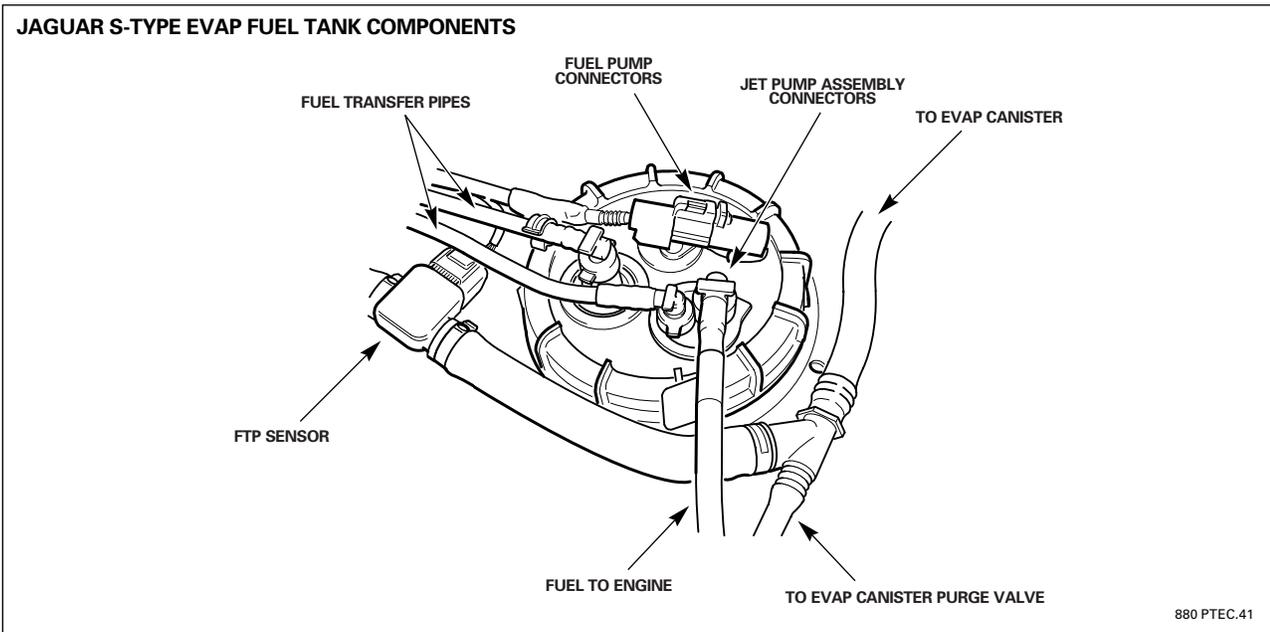
The fuel filler cap uses a 1/8 turn action and is tethered to the body. The filler cap assembly incorporates both pressure relief and vacuum relief valves (the latter is a new feature to Jaguar).



EVAP canister assembly

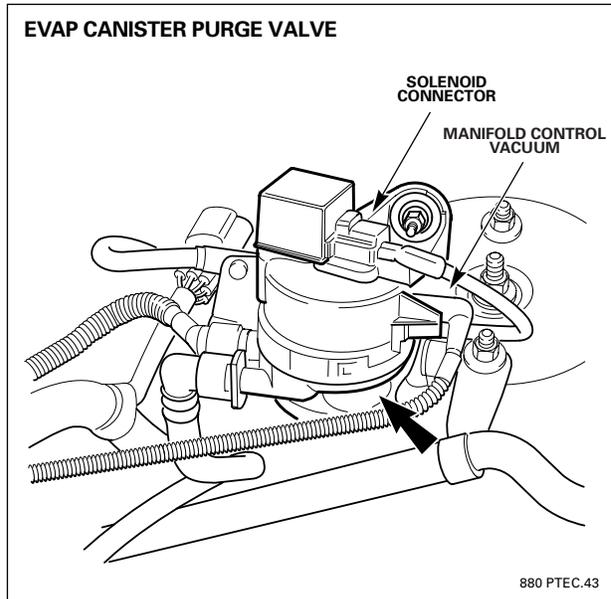
Three series connected EVAP carbon canisters (one single, one dual) are used for vapor storage and are mounted on a plastic bracket fixed to the underbody above the rear axle.

The EVAP canister close valve and fuel tank pressure sensor are components used by the PCM for leak check monitoring. The EVAP canister close valve is mounted on the canister bracket. The fuel tank pressure sensor is fitted to the vapor pipe.



FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

Evaporative Emission Control System (continued)



EVAP canister close valve

The EVAP canister close valve is a solenoid valve that closes the canister vent outlet when driven by the PCM. By closing the vent, the system can be monitored for leaks.

Fuel tank pressure (FTP) sensor

The FTP sensor is a pressure transducer device. The voltage signal from the transducer is “conditioned” within the sensor. The PCM receives the conditioned voltage signal, which is proportional to the vapor pressure in the fuel tank.

EVAP canister purge valve

The EVAP canister purge valve is mounted on the rear left hand side of the engine bay. The valve is controlled by the PCM with a PWM signal driving a solenoid valve, which in turn applies manifold vacuum to actuate the valve.

NOTES

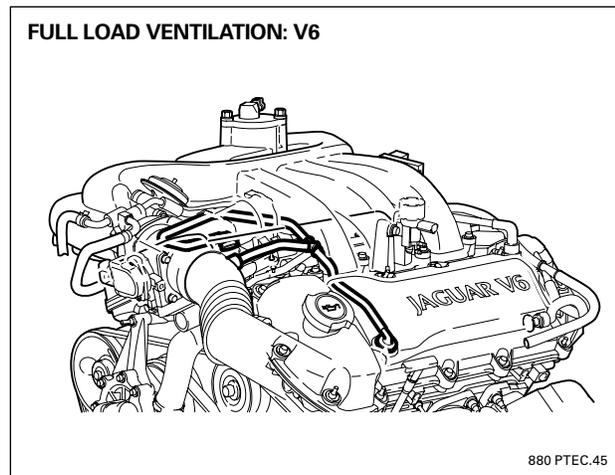
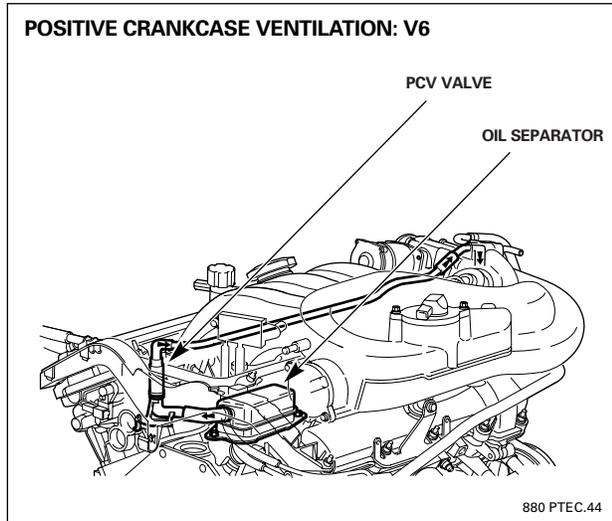
Crankcase Ventilation System: V6

The closed and part throttle crankcase ventilation system consists of an oil separator, externally mounted to the cylinder block between the cylinder banks, a spring-loaded in-line positive crankcase ventilation (PCV) valve, and a hose to the intake manifold. The intake manifold hose connection is downstream of the throttle valve and is warmed by engine coolant to prevent icing.

During closed and part throttle conditions, high manifold vacuum opens the spring loaded PCV valve allowing crankcase vapors to be drawn through the oil separator to the intake manifold. Any oil in the vapors is trapped by the separator and returns to the crankcase. As throttle opening increases, intake manifold vacuum decreases and the PCV valve closes in proportion to the manifold vacuum decrease.

The full load crankcase ventilation system consists of breather outlets on each camshaft cover connected to the intake duct via hoses and a tee connection. At full and near full load engine operation, intake duct pressure decreases drawing crankcase vapor to the intake via the hoses and tee connection.

NOTES



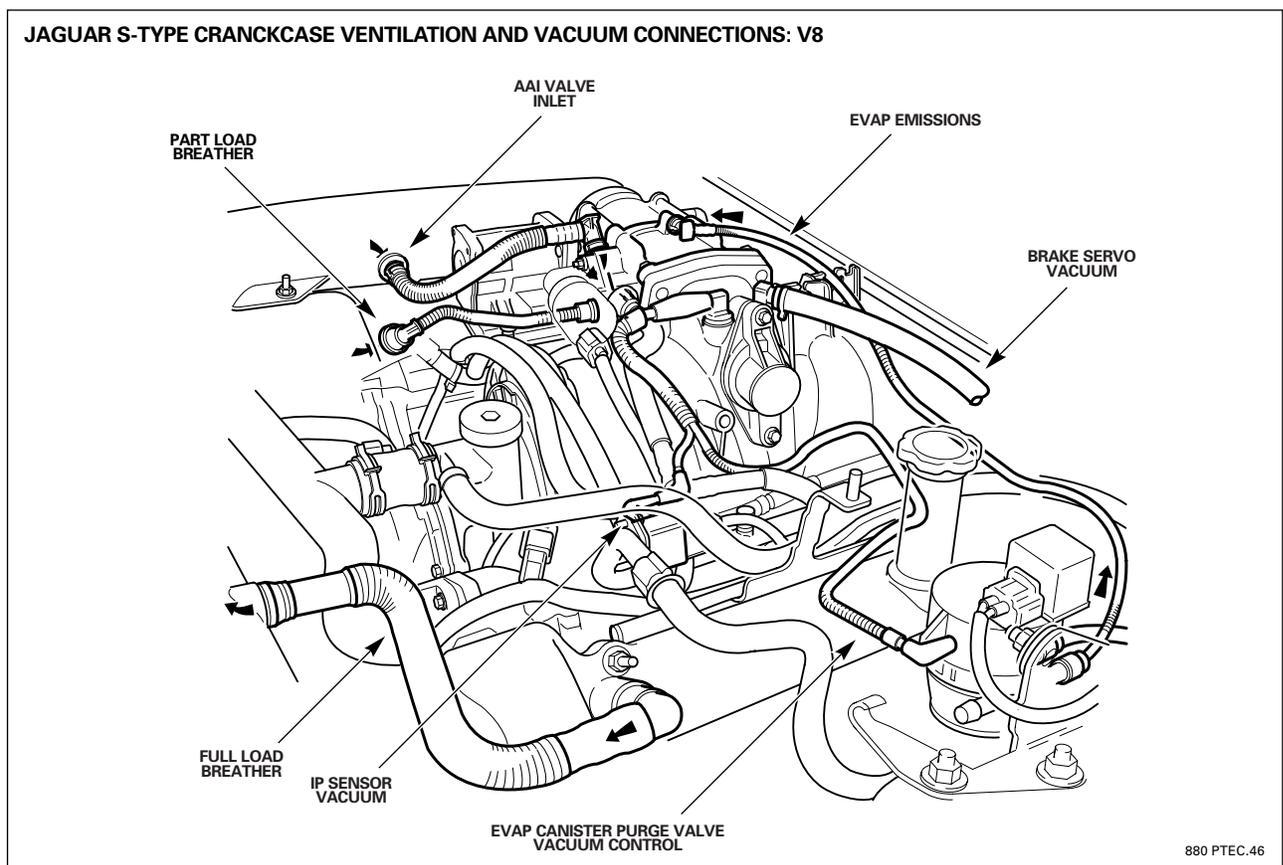
FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

Crankcase Ventilation System: V8

The V8 full load and part load breather pipes are reconfigured in the Jaguar S-TYPE to accommodate the induction manifold, camshaft covers and the engine installation.

During idle and part load operation, crankcase vapors are drawn through the bank 1 camshaft cover oil separator to the heated intake manifold connection downstream of the throttle valve. During full load operation the vapors flow through the bank 2 camshaft cover oil separator to the intake duct.

Vacuum connections for the EVAP system and the IP Sensor are also shown in the illustration.



NOTES

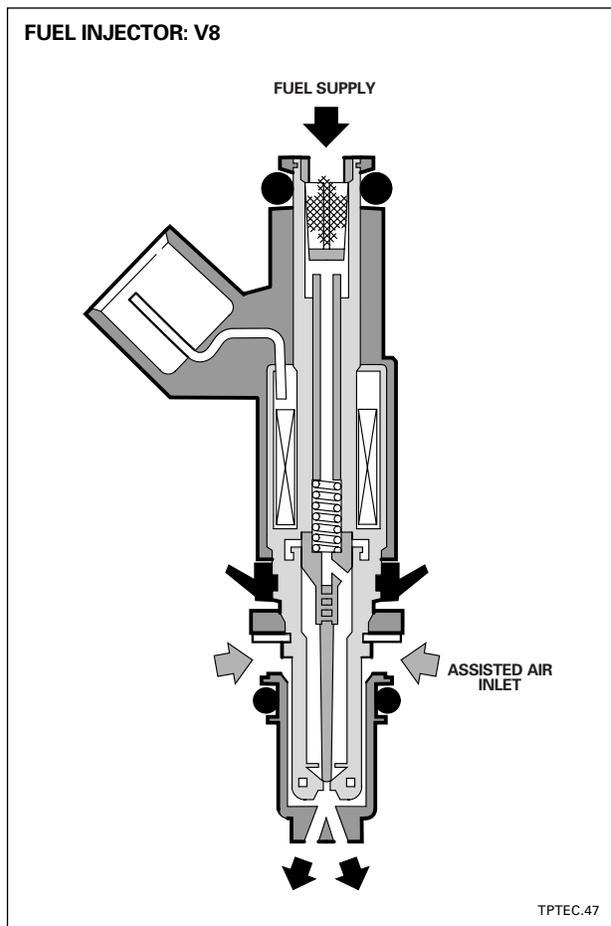
PTEC ENGINE MANAGEMENT SYSTEM



- 1 PTEC OVERVIEW AND CONTROL SUMMARY
- 2 POWERTRAIN CONTROL MODULE (PCM)
- 3 PCM SENSING COMPONENTS – ENGINE
- 4 INDUCTION AIR AND THROTTLE CONTROL
- 5 FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL
- 6 FUEL INJECTION**
- 7 IGNITION
- 8 VARIABLE VALVE TIMING / VARIABLE INTAKE
- 9 EXHAUST GAS RECIRCULATION (EGR): V6 ONLY
- 10 OTHER PCM ENGINE CONTROL AND INTERFACE FUNCTIONS
- 11 TASK SHEETS



FUEL INJECTION



PTEC fuel injection strategy follows the current standard practice of sequential operation with PCM control to suit the prevailing engine and vehicle operating modes and conditions.

The fuel injectors for the S-TYPE V6 and V8 are of the twin-spray pintle-type design. The injectors for each engine have unique flow rates. The V8 injectors are constructed with a shroud to accommodate the air assisted injection (AAI) system.

Fuel injectors are identified by engine bank and cylinder position (bank/position) as follows:

	V6			V8			
Right hand bank	1/1	1/2	1/3	1/1	1/2	1/3	1/4
Left hand bank	2/1	2/2	2/3	2/1	2/2	2/3	2/4

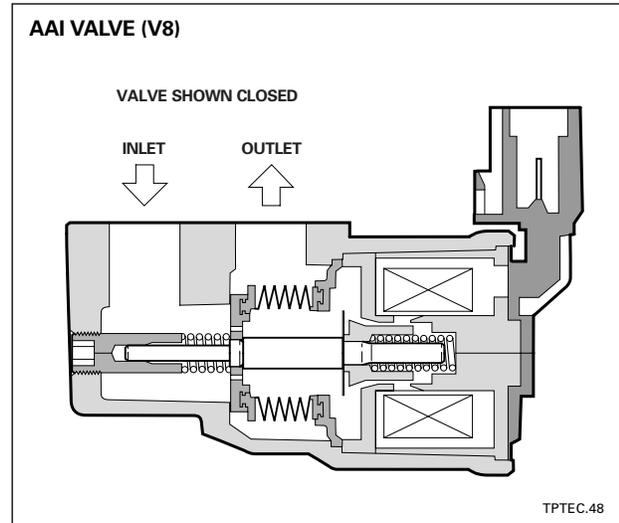
Fuel injector resistance

V8 (Siemens)	12 Ohms
V6 (Bosch / Ford)	14 Ohms

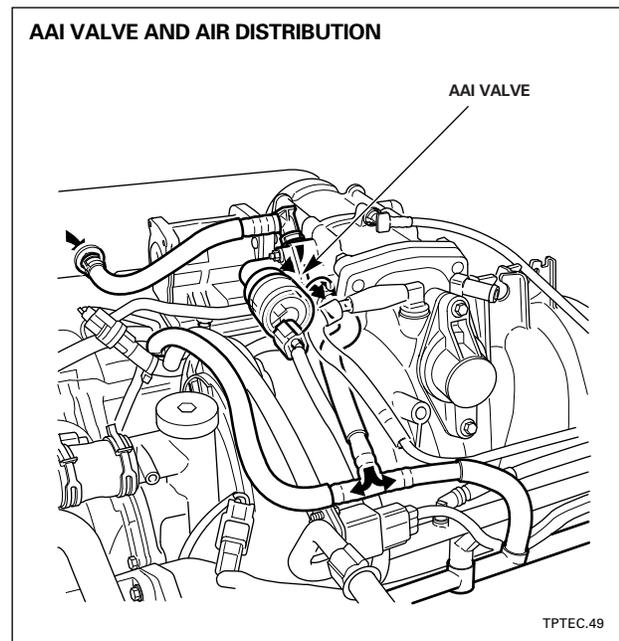
NOTES

Air Assisted Fuel Injection (V8)

- Air assisted injection decreases the formation of hydrocarbons and improves combustion stability during cold engine starts by admitting a metered amount of air to the base of each fuel injector to help atomize the fuel.
- The amount of air admitted reduces progressively as engine temperature increases.
- The PCM controlled AAI valve is attached to the throttle body adapter.
- The valve controls the air flow volume through the hoses to the air rails and fuel injectors.
- The air rails are part of each bank of the intake manifold.
- The difference between intake manifold pressure and atmospheric pressure causes the air to flow through the valve.

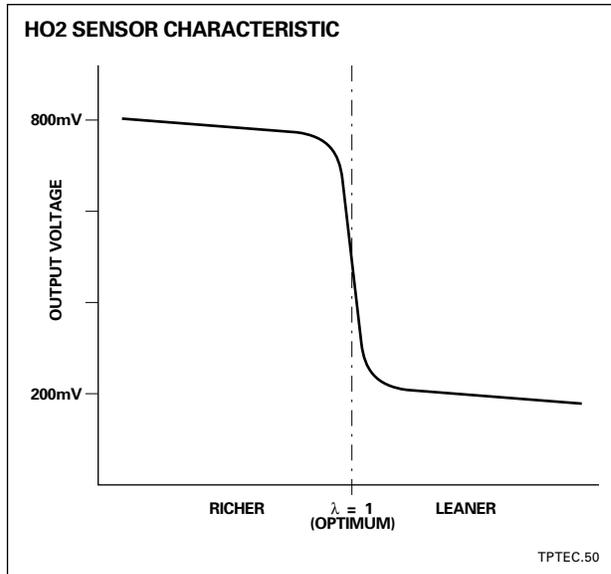


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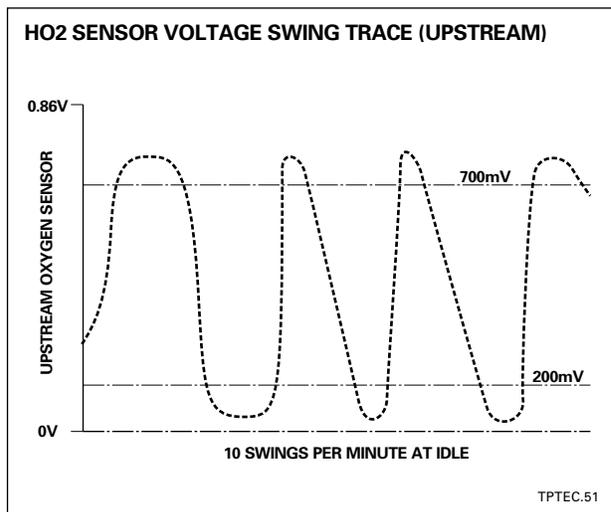


FUEL INJECTION

Heated Oxygen (HO2) Sensors

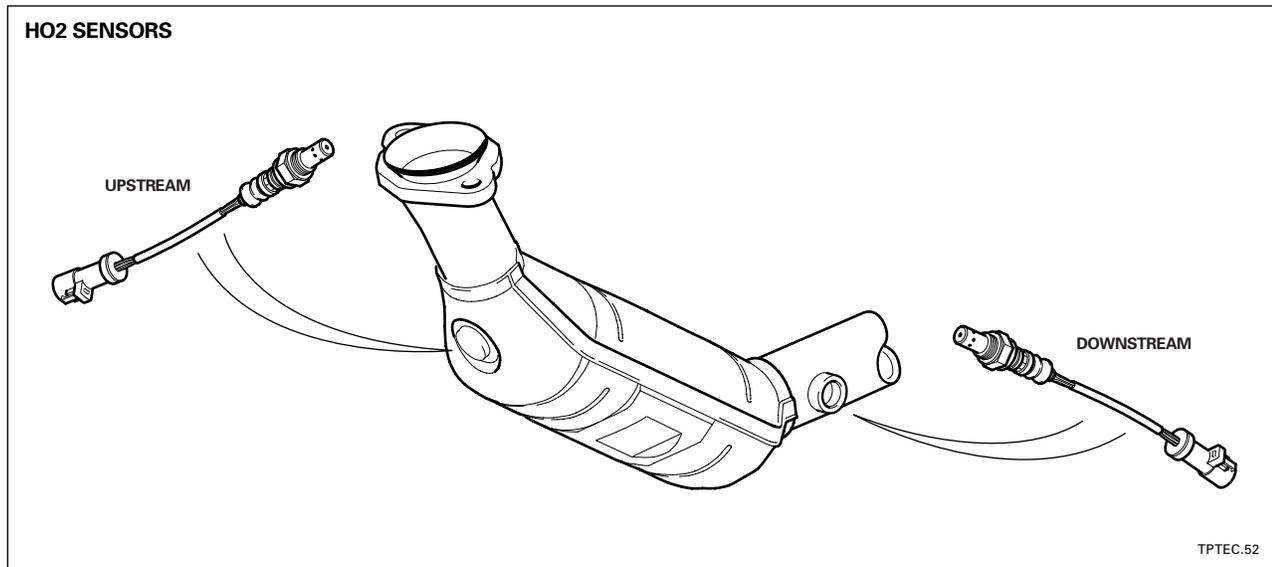


- Both the V6 and V8 engines use two conventional zirconium dioxide heated oxygen sensors for each cylinder bank.
- The oxygen sensors produce a voltage by conducting oxygen ions at temperatures above 300 °C (572 °F).
- The tip portion of the sensor's ceramic element is in contact with the exhaust gas.
- The remaining portion of the ceramic element is in contact with ambient air via a filter through the sensor body.
- Sensor output voltage switches between approximately 800 millivolts and 200 millivolts, depending on the oxygen content of the exhaust gas:
 - when the air : fuel ratio is richer than optimum, the oxygen content of the exhaust gas is low and the voltage output is high
 - when the air : fuel ratio is leaner than optimum, the oxygen in the exhaust is high and the output voltage is low.
- Only a very small change in air : fuel ratio is required to swing the oxygen sensor voltage from one extreme to the other, thus enabling precise fuel metering control.



NOTES

One sensor is located upstream and one is located downstream of each catalytic converter. The upstream sensors are used by the ECM for closed loop fuel metering correction. The downstream sensors are used to monitor catalyst efficiency.



HO2 sensors are identified by engine bank and exhaust position (bank/position) as follows:

	Upstream	Downstream
Right hand bank	HO2 sensor 1 / 1	HO2 sensor 1 / 2
Left hand bank	HO2 sensor 2 / 1	HO2 sensor 2 / 2

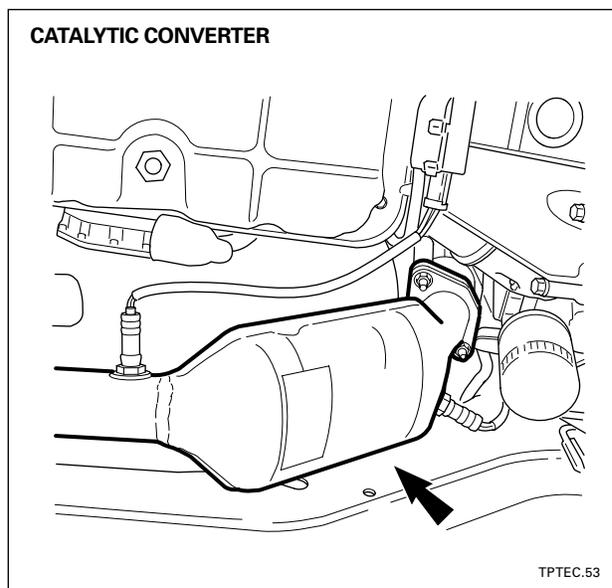
The HO2 sensor internal electric heaters reduce the time needed to bring the sensors up to operating temperature and maintain sensor temperature when the exhaust gasses are cool. B+ voltage is supplied to all four heaters from powertrain relay 2. Each heater has a separate ground circuit to the PCM for control and diagnostics.

Upstream HO2 Sensor heater resistance	3.3 Ω
Downstream HO2 Sensor heater resistance	5.0 Ω

The PCM switches the upstream heaters ON at 100% for about 10 seconds during engine cranking, then controls the voltage to maintain sensor temperature above 350 °C (662 °F). This action provides fast "light off". The downstream HO2 sensors operate in the cooler exhaust gas exiting from the catalytic converter and are always ON while the engine is running.

NOTE: The upstream sensors connect to the engine (PI) harness and the downstream sensors connect to the transmission (GB) harness. THE UPSTREAM AND DOWNSTREAM SENSORS ARE NOT INTERCHANGEABLE.

FUEL INJECTION



Catalytic Converters

Each two-element catalytic converter is attached to its exhaust manifold with a two bolt self sealing flange. The resonator and muffler assemblies connect to the converter outlets with Torca clamps. The entire exhaust system can be serviced from under the vehicle.

NOTES

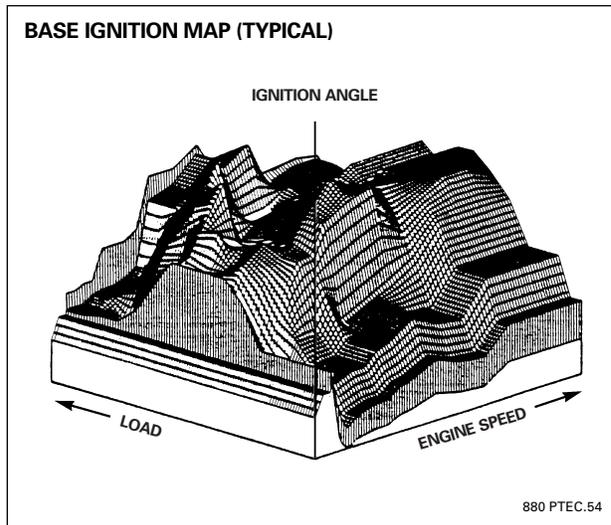
PTEC ENGINE MANAGEMENT SYSTEM



- 1 PTEC OVERVIEW AND CONTROL SUMMARY
- 2 POWERTRAIN CONTROL MODULE (PCM)
- 3 PCM SENSING COMPONENTS – ENGINE
- 4 INDUCTION AIR AND THROTTLE CONTROL
- 5 FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL
- 6 FUEL INJECTION
- 7 IGNITION**
- 8 VARIABLE VALVE TIMING / VARIABLE INTAKE
- 9 EXHAUST GAS RECIRCULATION (EGR): V6 ONLY
- 10 OTHER PCM ENGINE CONTROL AND INTERFACE FUNCTIONS
- 11 TASK SHEETS



IGNITION



PTEC ignition strategy follows the current standard practice of PCM control from a base ignition map, which is then corrected for the specific engine operating conditions. Ignition is synchronized by the PCM using the input signals from the CKP and CMP sensors.

Ignition coils are identified by engine bank and cylinder position (bank/position) as follows:

	V6	V8
Right hand bank	1/1 1/2 1/3	1/1 1/2 1/3 1/4
Left hand bank	2/1 2/2 2/3	2/1 2/2 2/3 2/4

Engine firing order

V6 1/1....2/1....1/2....2/2....1/3....2/3

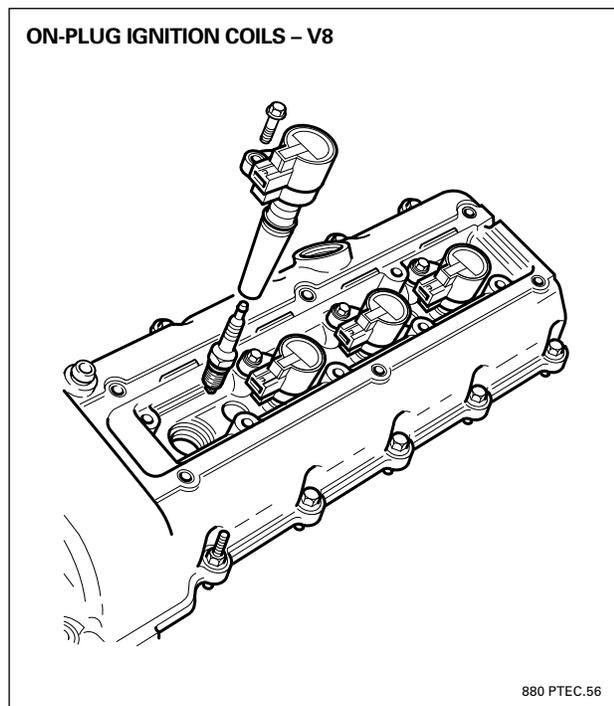
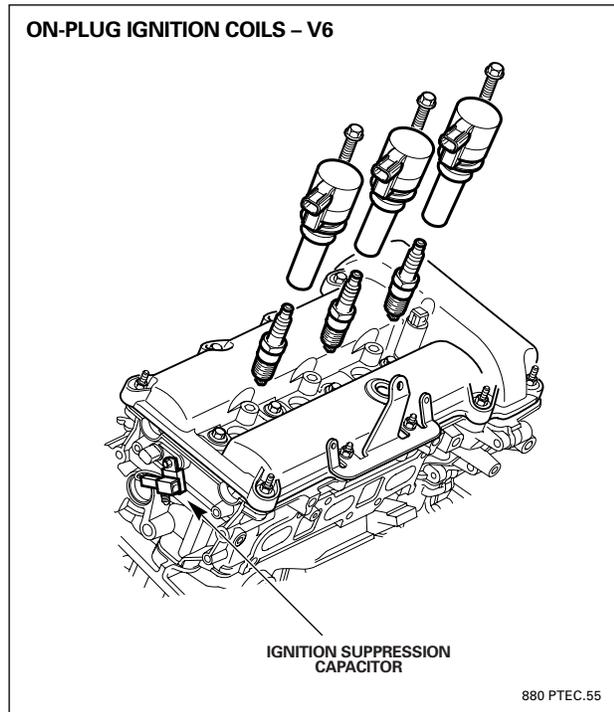
V8 1/1....2/1....1/4....1/2....2/2....1/3....2/3....2/4

NOTES

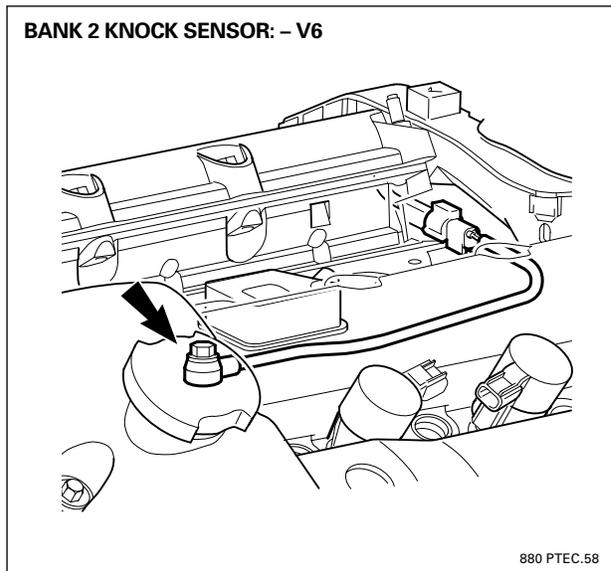
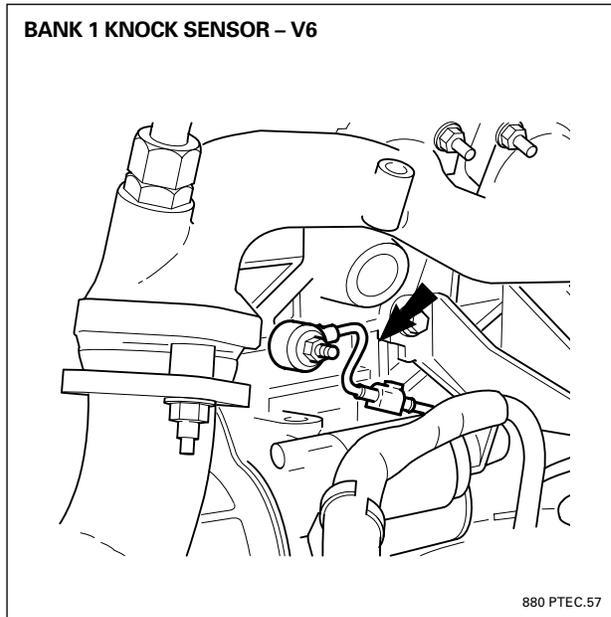
- The spark plug for each cylinder is fired by an on-plug ignition coil.
- The primary current side of each coil is supplied with ignition switched B+ power.
- The ground side of each coil is switched directly by the PCM with no additional ignition amplifiers required.
- The primary coil switching duration is limited by the PCM to manage the voltage at 9.0v through the coils.
- Damage to the coils will result if the PCM switched circuit is short circuited to ground.
- The ignition suppression capacitors in the B+ supply circuit, fitted to the rear of each cylinder head, prevent radio interference.

CAUTION: The ignition coils are rated at approximately 9 volts. Testing a coil by applying B+ voltage will cause permanent damage and may destroy the unit.

NOTES



IGNITION



Ignition Knock (detonation) Control

- The ECM retards ignition timing to individual cylinders to control ignition knock (detonation) and optimize engine power.
- Two knock sensors (KS) are positioned on the cylinder block to sense engine detonation. One KS is positioned on bank 1 and the other on bank 2.
- V6 knock sensors are attached to the engine bank in different locations.
 - the bank 1 sensor, with the short flying lead, is located on the right side of the engine block above the starter motor
 - the bank 2 sensor, with the long flying lead, is located near the oil separator on the top of the cylinder block.
- V8 knock sensors are unchanged from previous Jaguar V8 engines.
- Each knock sensor has a piezo electric sensing element to detect broad band (2 – 20 kHz) engine accelerations.
- If detonation is detected, the PCM determines which cylinder is firing, and retards the ignition timing for that cylinder only.
- If, on the next firing of that cylinder, the detonation reoccurs, the PCM will further retard the ignition timing
- If the detonation does not reoccur on the next firing, the PCM will advance the ignition timing incrementally with each firing.
- The knock sensing ignition retard / advance process can continue for a particular cylinder up to a specified maximum retard measured in degrees of crankshaft rotation.
- During acceleration at critical engine speeds, the PCM retards the ignition timing to prevent the onset of detonation. This action occurs independent of input from the knock sensors

NOTES

PTEC ENGINE MANAGEMENT SYSTEM



- 1 PTEC OVERVIEW AND CONTROL SUMMARY
- 2 POWERTRAIN CONTROL MODULE (PCM)
- 3 PCM SENSING COMPONENTS – ENGINE
- 4 INDUCTION AIR AND THROTTLE CONTROL
- 5 FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL
- 6 FUEL INJECTION
- 7 IGNITION
- 8 VARIABLE VALVE TIMING / VARIABLE INTAKE**
- 9 EXHAUST GAS RECIRCULATION (EGR): V6 ONLY
- 10 OTHER PCM ENGINE CONTROL AND INTERFACE FUNCTIONS
- 11 TASK SHEETS

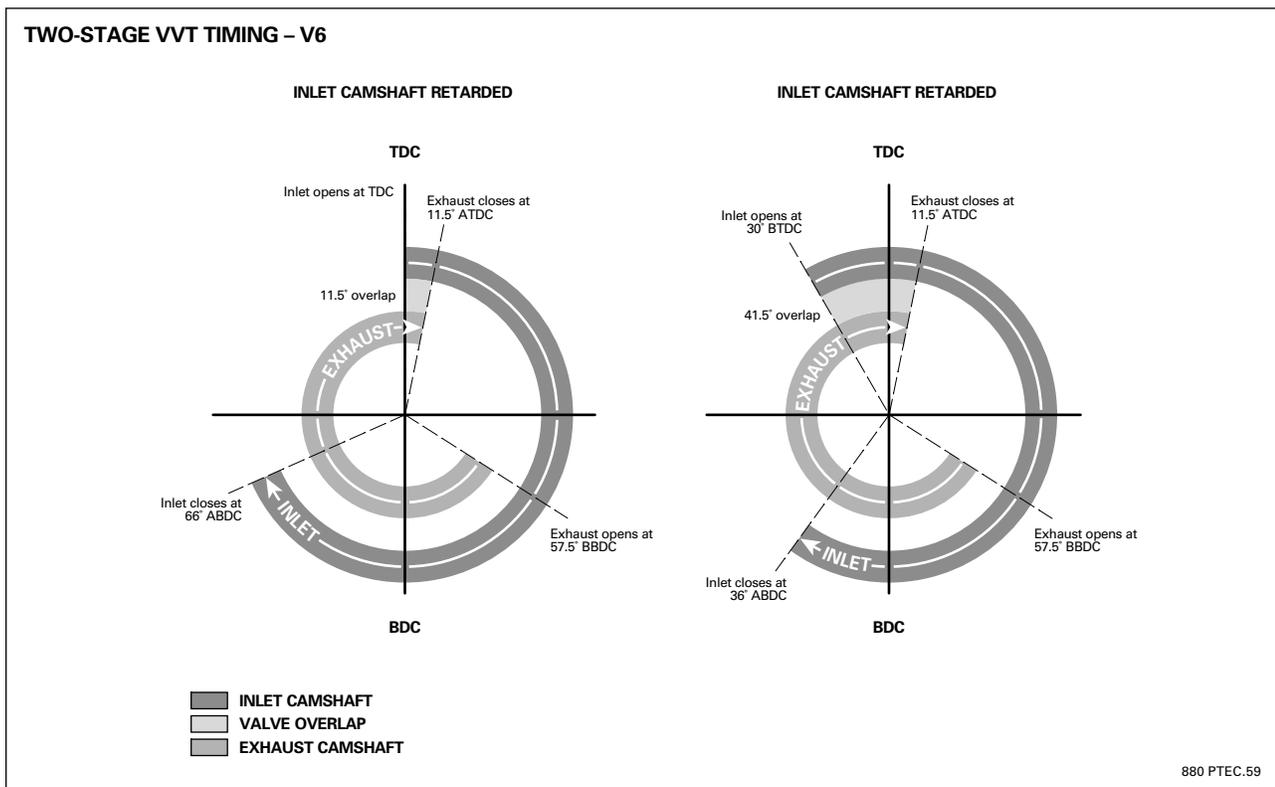


VARIABLE VALVE TIMING / VARIABLE INTAKE

Variable Valve Timing (VVT) – V6

A VVT system is used to allow the phasing of the inlet valve opening to be changed relative to the fixed timing of the exhaust valves. Two positions are used, 30° apart, with the advanced position occurring at 30° BTDC and overlapping with the exhaust opening.

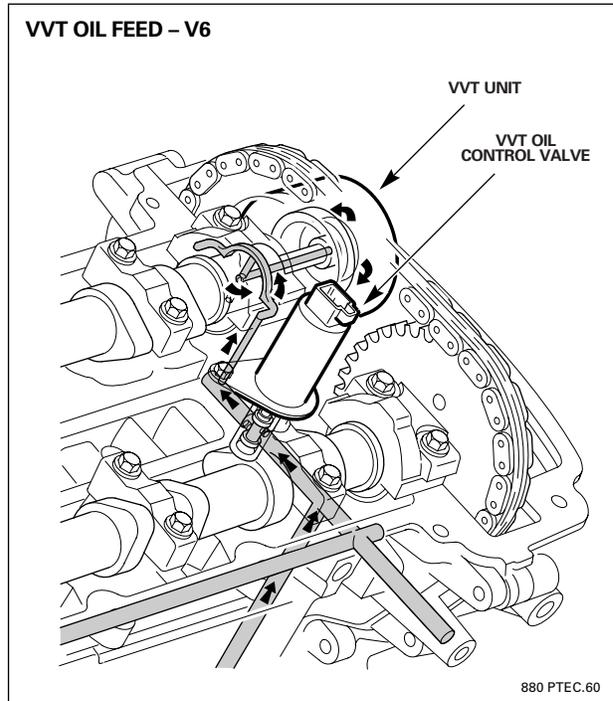
The operating strategy is controlled by the engine management system in conjunction with the variable geometry induction system so as to optimize torque characteristics over the engine speed/load range. The VVT system also provides increased amounts of ‘internal’ EGR under certain speed/load operating conditions.



NOTES

VARIABLE VALVE TIMING / VARIABLE INTAKE

Variable Valve Timing (VVT) – V6 (continued)



V6 VVT Oil Feed

- The VVT/sprocket unit is fixed on the nose of each inlet camshaft via a locating pin and hollow bolt and is driven directly by the timing chain.
- The oil feed to each VVT unit is supplied via fixed oilways in the cylinder heads
- The oil feed is controlled by the VVT solenoid operated oil control valves, which are bolted directly to each cylinder head.

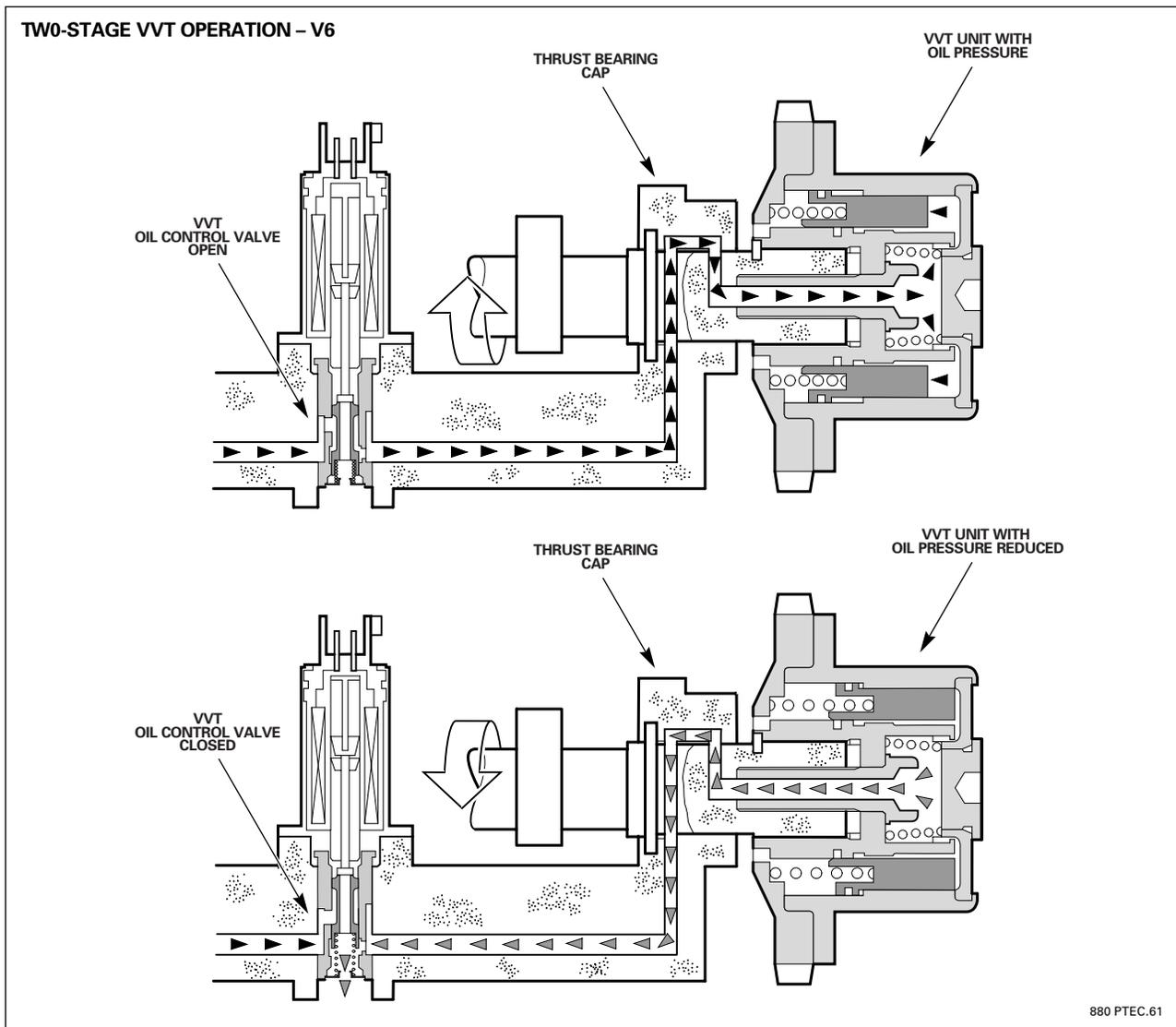
NOTES

V6 VVT Operation

From the oil control valve, the flow is via the thrust bearing cap, through drillings in the camshaft and then through the hollow fixing bolt which secures the VVT unit. Drain holes are provided at the rear (camside) face of the VVT unit for any residual oil which has seeped past the piston.

With the oil control valve open, oil pressure on the helical drive piston is increased, rotating the cams to the advanced position. When the valve closes, oil pressure reduces and the return spring pushes the piston back to the fully retarded position.

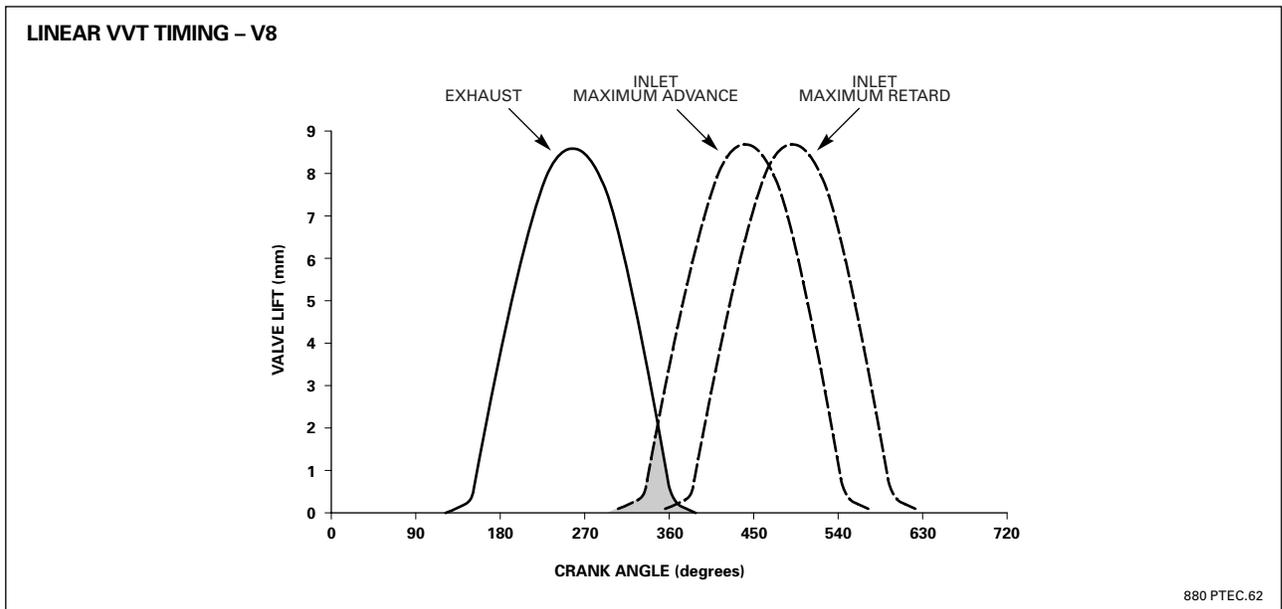
The oil control valve is controlled by a 300Hz PWM signal from the PCM which sets it to either the fully open or fully closed position.



VARIABLE VALVE TIMING / VARIABLE INTAKE

Variable Valve Timing – V8

The V8 variable valve timing (VVT) system is the same as the linear VVT system used on AJ27 V8 engines. The system provides continuously variable inlet valve timing over a crankshaft range of $48^\circ \pm 2^\circ$. Depending on driver demand, engine speed/load conditions and Powertrain Control requirements, the inlet valve timing is advanced or retarded to the optimum angle within this range. Compared to the two position system, inlet valve opening is advanced by an extra 8° , providing greater overlap and increasing the internal EGR effect (exhaust gases mixing with air in the inlet port).



The linear VVT system provides a number of advantages:

- Improves internal EGR, further reducing NOx emissions and eliminating the need for an external EGR system
- Optimizes torque over the engine speed range without the compromise of the two position system: note that specified torque and power figures are unchanged
- Improves idle quality: the inlet valve opens 10° later, reducing valve overlap and thus the internal EGR effect (undesirable at idle speed)
- Faster VVT response time
- VVT operates at lower oil pressure

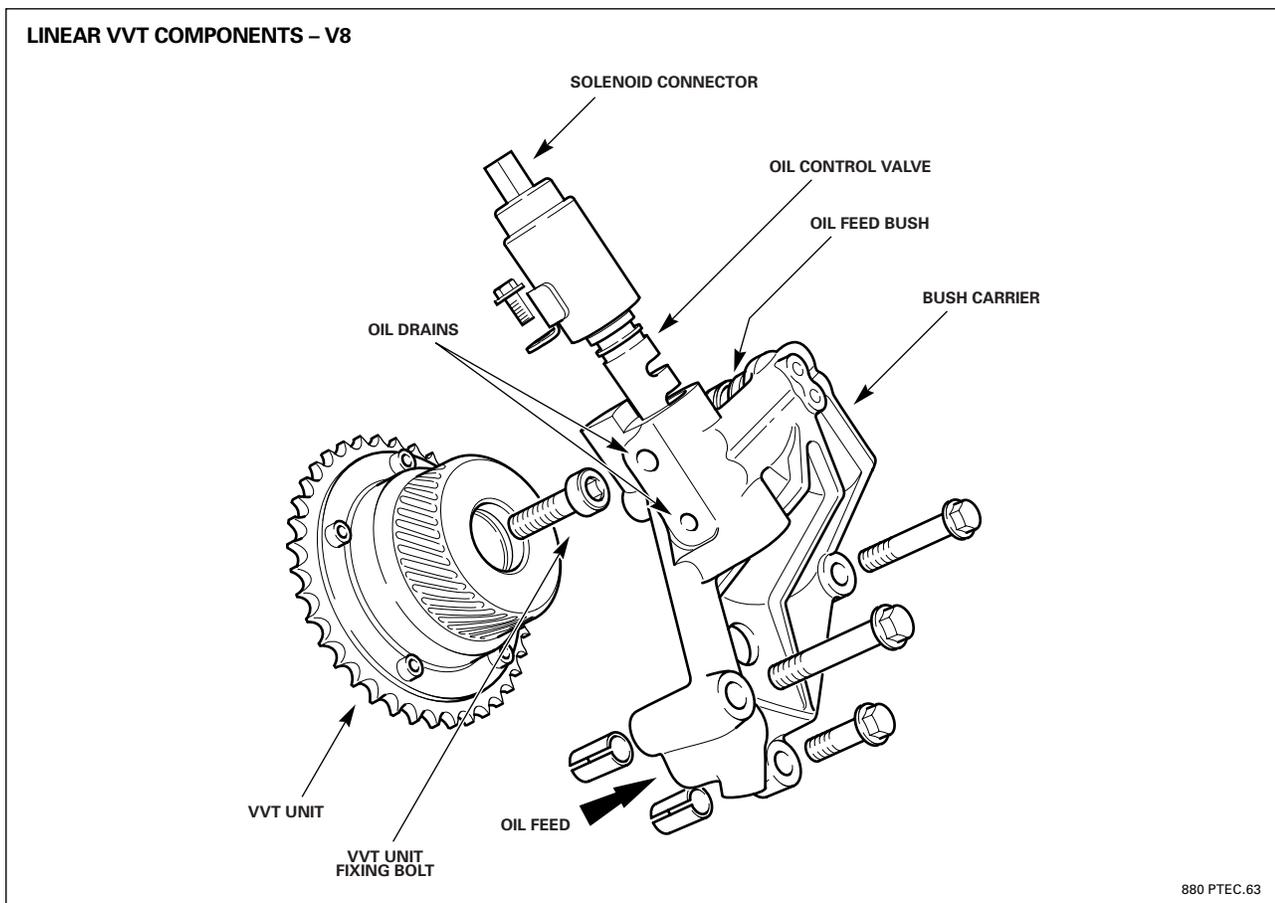
NOTES

V8 Linear VVT Components

Each cylinder bank has a VVT unit, bush carrier and solenoid operated oil control valve. The VVT unit consists of an integral control mechanism with bolted on drive sprockets, the complete assembly being non-serviceable. The unit is fixed to the front end of the inlet camshaft via a hollow bolt and rotates about the oil feed bush on the bush carrier casting. The bush carrier is aligned to the cylinder head by two hollow spring dowels and secured by three bolts.

The oil control valve fits into the bush carrier to which it is secured by a single screw. The solenoid connector at the top of the valve protrudes through a hole in the camshaft cover but the cover must first be removed to take out the valve.

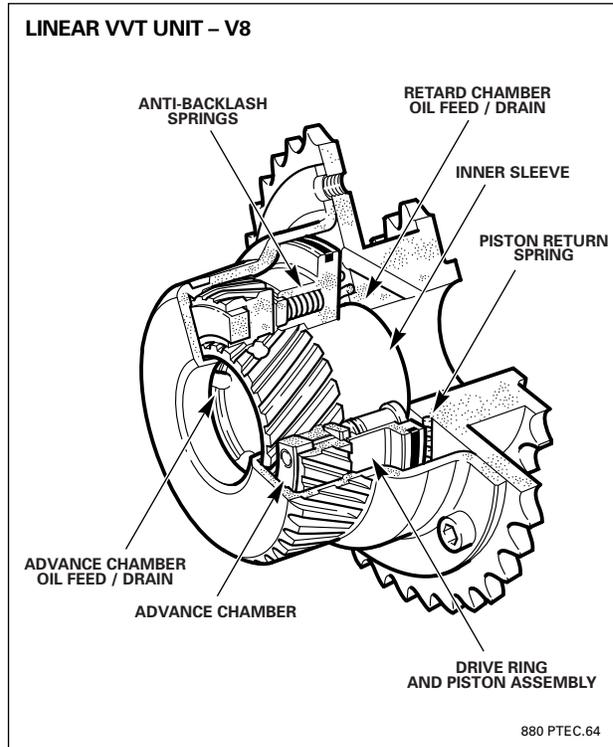
Note that only the bush carriers are left and right handed.



NOTES

VARIABLE VALVE TIMING / VARIABLE INTAKE

Variable Valve Timing: – V8 (continued)



V8 Linear VVT unit

The VVT unit drives the secondary chain to the exhaust camshaft. The inlet camshaft is driven from the body of the unit via internal helical splines. When commanded from the PCM, this mechanism rotates the inlet camshaft relative to the body/sprocket assembly to advance or retard the valve timing.

The VVT unit has three main parts:

- the body/sprocket assembly
- an inner sleeve bolted axially to the nose of the camshaft
- a drive ring/piston assembly located between the body and inner sleeve and coupled to both via helical splines.

Oil pressure applied in the advance chamber forces the drive ring/piston assembly to move inwards along its axis while rotating clockwise on the helical body splines. Since the drive ring is also helically geared to the inner sleeve but with opposite angled splines, the inner sleeve is made to rotate in the same direction, turning the camshaft.

To move back to a retard position, oil pressure is switched to the retard chamber and the piston and rotational movements are reversed. A light pressure spring is fitted in the retard chamber to assist the piston assembly to revert to the fully retarded position with the engine stopped.

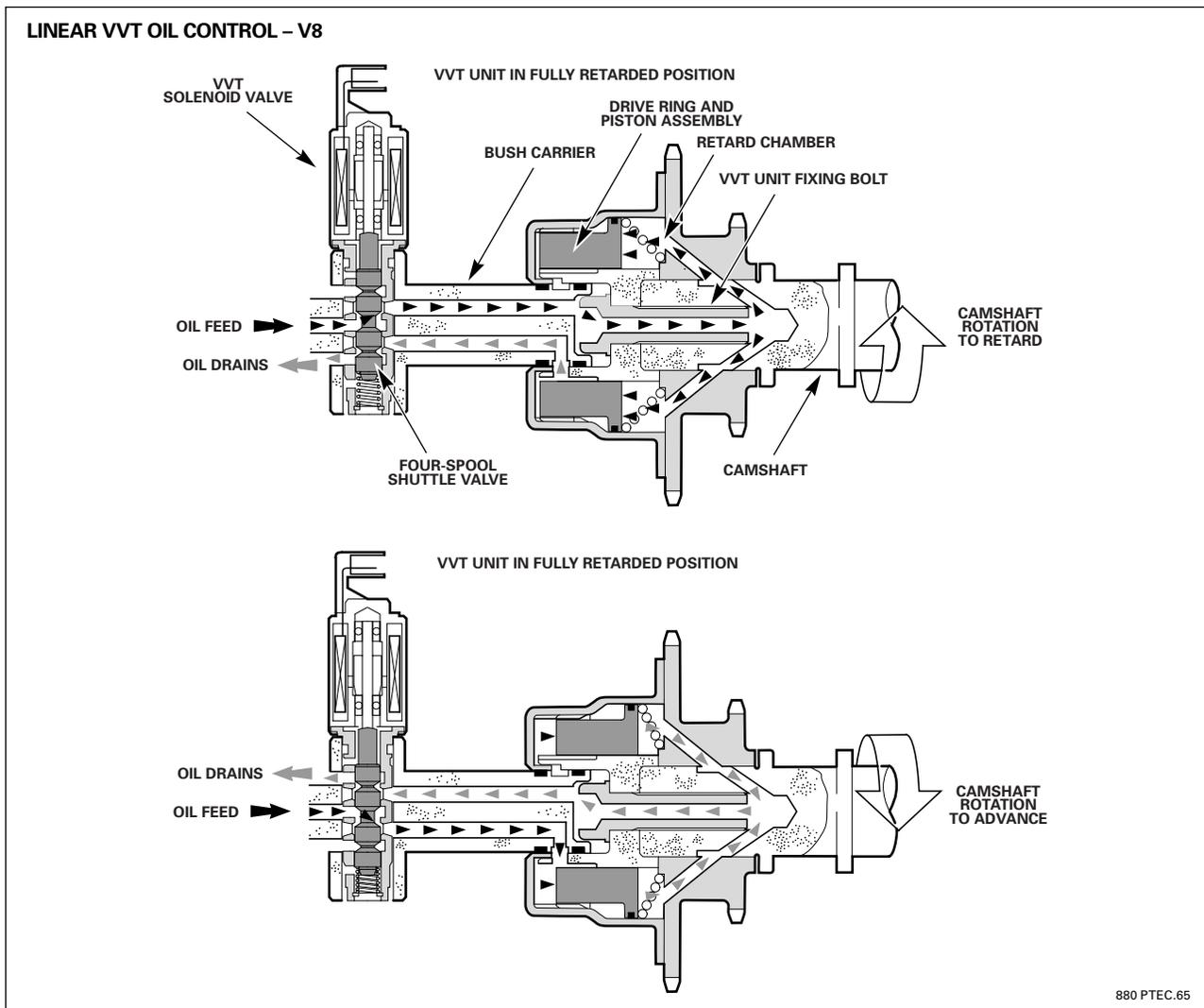
NOTES

Linear VVT Oil Control

Engine oil is supplied to the VVT unit via the bush carrier and is switched to either the advance or retard side of the moving piston assembly by the oil control valve. The oil control valve consists of a four spool shuttle valve directly operated by a solenoid plunger and fitted with a return spring. It is a non-serviceable component.

To fully advance the cams, the solenoid is energized pushing the shuttle valve down. This action causes the incoming oil feed to be directed through the lower oilway in the bush carrier and into the advance oil chamber where it pushes on the piston/drive ring assembly. As the piston moves in the advance direction (towards the camshaft), oil is forced out of the retard chamber through oilways in the sprocket unit, camshaft, hollow fixing bolt, bush carrier and the shuttle valve from which it drains into the engine.

To move to the fully retarded position, the solenoid is de-energized, the return spring holds the shuttle valve in its upper position and the oil flow is directed through the bush carrier upper oilway into the VVT unit. Oil is channelled through the hollow VVT fixing bolt and via oilways in the camshaft and sprocket unit to the retard chamber where it acts on the moveable piston/drive ring assembly. As the piston moves, oil is forced from the advance chamber back through the shuttle valve to the engine.



VARIABLE VALVE TIMING / VARIABLE INTAKE

Variable Valve Timing – V8 (continued)

Linear VVT-PCM Control System

Closed loop control

Normally, continuously variable timing requires the VVT piston to be set to the optimal position between full advance and retard for a particular engine speed and load. The PCM positions the shuttle valve using a PWM control signal operating at a frequency of 300 Hz. The shuttle valve assumes a position between the limits of travel proportional to the “duty cycle” of the signal. An increasing duty cycle causes an increase in timing advance.

The actual position of the camshaft is monitored by the PCM from the CMP sensor signal. If a difference is sensed between the actual and demanded positions, the PCM will attempt to correct it.

Engine oil temperature

Engine oil properties and temperature can affect the ability of the VVT mechanism to follow demand changes to the cam phase angle. At very low oil temperatures, movement of the VVT mechanism is sluggish due to increased viscosity and at high temperatures the reduced viscosity may impair operation if the oil pressure is too low.

The VVT system is normally under closed loop control except in extreme temperature conditions such as cold starts below 0 °C (32 °F). At extremely high oil temperatures, the PCM may limit the amount of VVT advance to prevent the engine stalling when returning to idle speed. This could occur because of the slow response of the VVT unit to follow a rapid demand for speed reduction. Excessive cam advance at very light loads produces high levels of internal EGR which may result in unstable combustion or misfires.

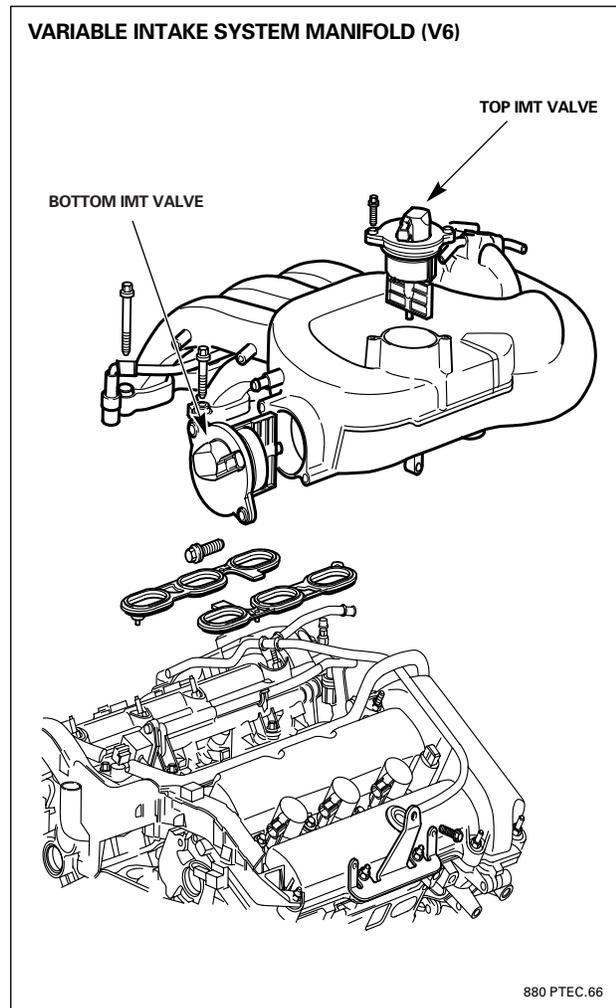
NOTES

Variable Intake System (V6)

V6 engines use a variable intake system designed to optimize engine torque across the engine speed / load range. Variable intake combined with variable valve timing provides an optimized engine torque curve throughout the engine operating range.

Variable Intake Components

- The throttle body connects directly to the induction manifold assembly, which is constructed of aluminum alloy.
- The manifold mounts to the cylinder heads with the lower intake manifold assembly “sandwiched” between.
- The manifold plenum chamber is split into upper and lower compartments with two interconnecting holes.
- Two identical Intake Manifold Tuning (IMT) Valves are located at the interconnecting holes.
- The IMT valves are solenoid operated gate valves, which rotate 90° for open / close.
- B+ voltage is separately supplied to each IMT valve via powertrain control relay 1 in the front power distribution box.
- The PCM switches the ground side of the valves via separate hard wires to activate the solenoids.
- The plenum chamber volume and the length of the intake air path are tuned by the positions of the IMT valve gates to assure that the natural charge air pressure waves or pulses are maximized for the ever-changing engine speed and load conditions.
- The plenum chamber volume and manifold geometry can be set to three different configurations based on the specific engine speed / load range:
 - short pipe
 - medium-length pipe
 - long pipe
- The two IMT valves, controlled by the PCM are set in combination to provide the three manifold configurations.



880 PTEC.66

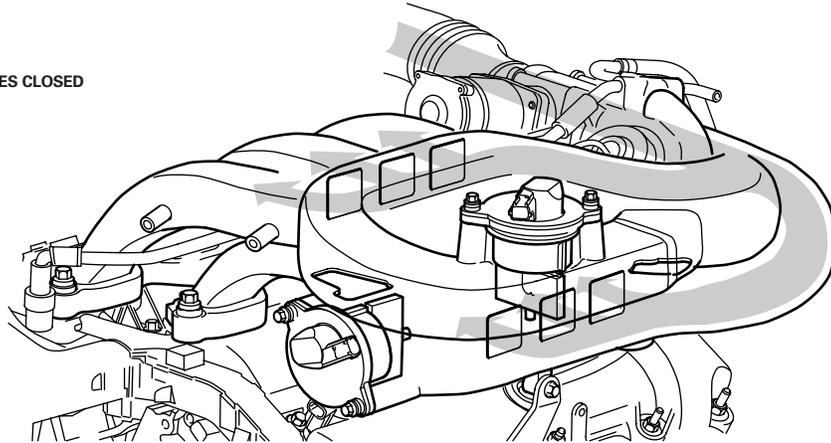
NOTES

VARIABLE VALVE TIMING / VARIABLE INTAKE

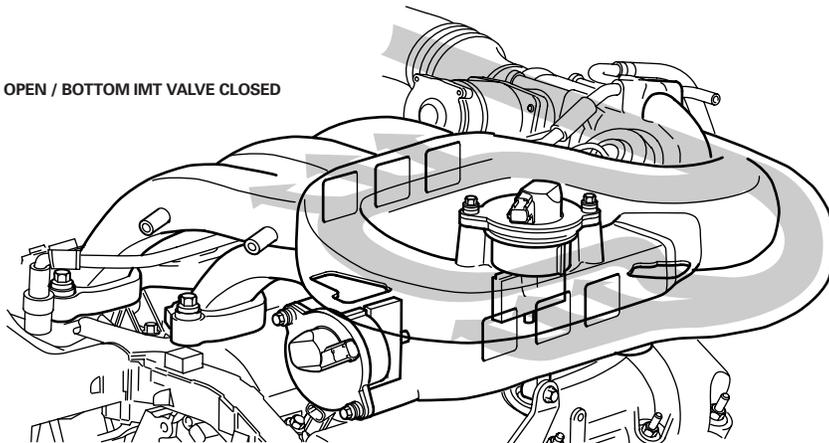
Variable Intake System (V6) (continued)

VARIABLE INTAKE SYSTEM OPERATION (V6)

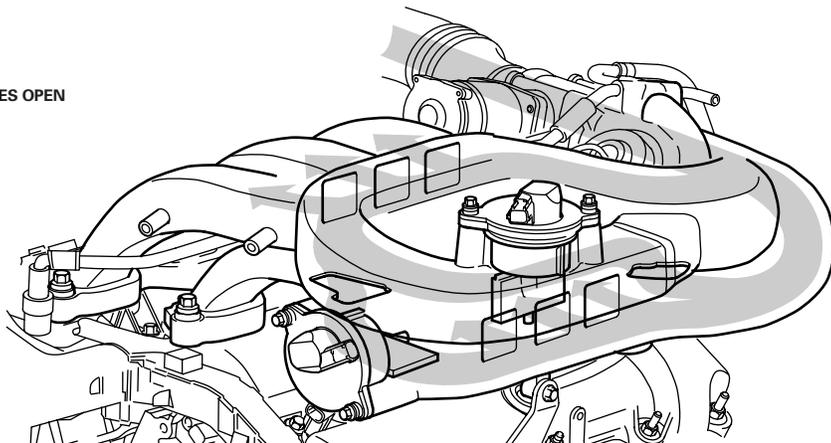
BOTH IMT VALVES CLOSED



TOP IMT VALVE OPEN / BOTTOM IMT VALVE CLOSED



BOTH IMT VALVES OPEN



880 PTEC.68

The PCM calculates the required valve positions using the following data:

- Engine speed from CKP sensor
- Throttle position from TP sensors
- Engine temperature from CHT sensor
- Charge air temperature from IAT sensor

Both valves closed

Both IMT valves closed provides the minimum plenum volume and the shortest intake air path to the cylinders.

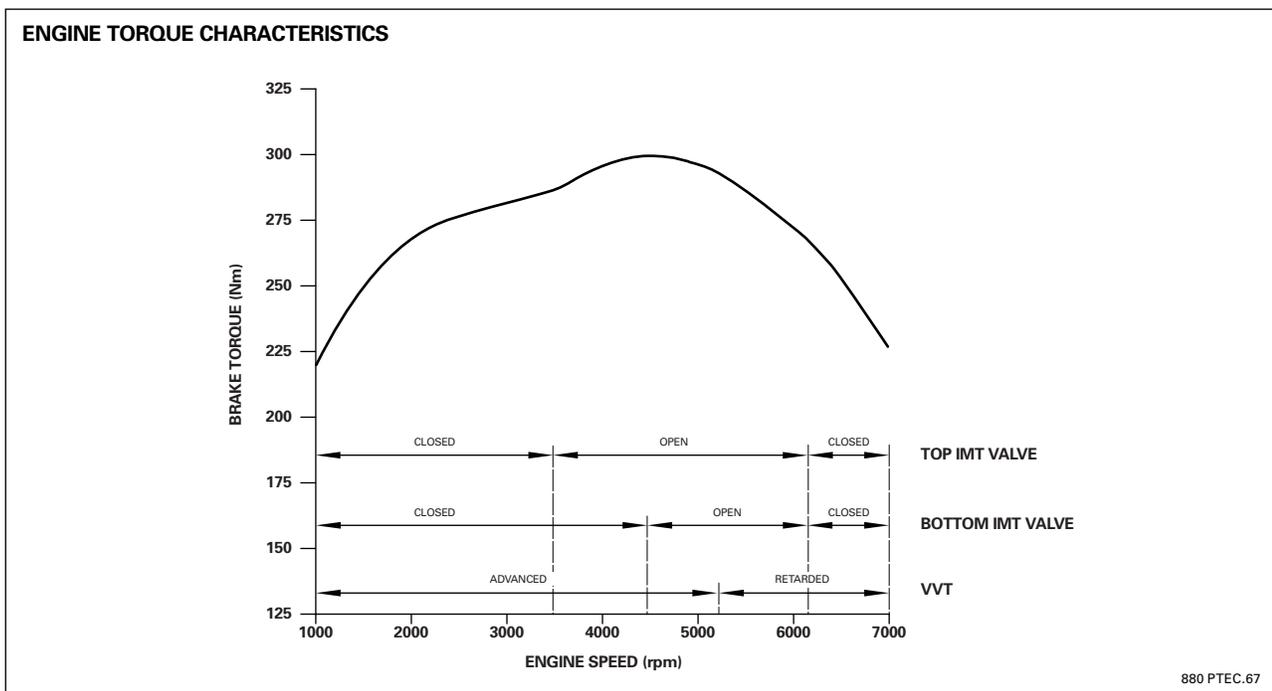
Top valve open / bottom valve closed

With the top valve open and the bottom valve closed, plenum volume and the effective length of the intake air path are both increased.

Both valves open

With both valves open, the plenum volume and the air intake path effective length are at their maximum.

The graph shows the how the PCM control of variable intake system optimizes the engine torque curve.



NOTES

PTEC ENGINE MANAGEMENT SYSTEM



- 1 PTEC OVERVIEW AND CONTROL SUMMARY
- 2 POWERTRAIN CONTROL MODULE (PCM)
- 3 PCM SENSING COMPONENTS – ENGINE
- 4 INDUCTION AIR AND THROTTLE CONTROL
- 5 FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL
- 6 FUEL INJECTION
- 7 IGNITION
- 8 VARIABLE VALVE TIMING / VARIABLE INTAKE
- 9 EXHAUST GAS RECIRCULATION (EGR): V6 ONLY**
- 10 OTHER PCM ENGINE CONTROL AND INTERFACE FUNCTIONS
- 11 TASK SHEETS



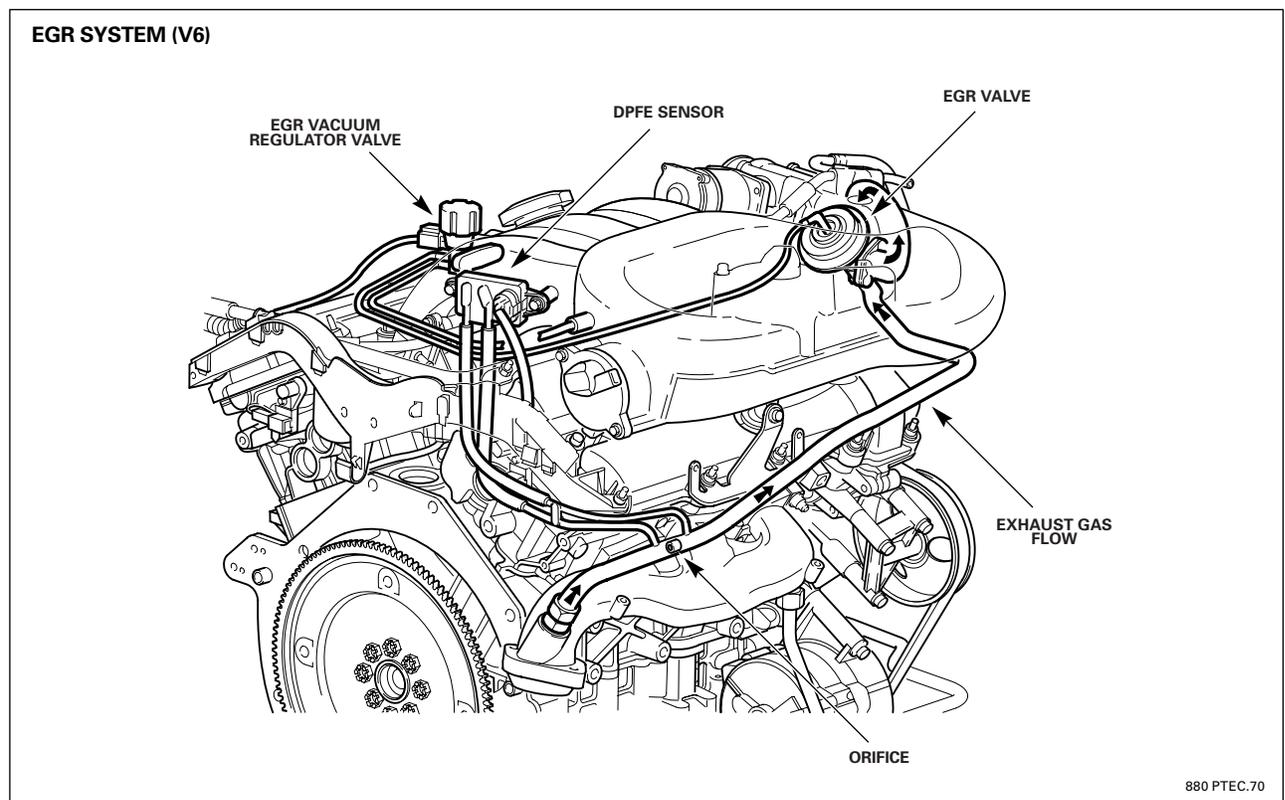
EXHAUST GAS RECIRCULATION (EGR): V6 ONLY

The EGR system is only fitted to V6 engines and comprises the following components:

- EGR vacuum regulator valve
- EGR valve
- Differential pressure feedback EGR sensor
- Exhaust gas feedback pipe with internal orifice

Exhaust gas is recirculated back to the engine intake in proportion to a measured pressure differential in the feedback pipe. The amount of gas recirculated varies primarily with engine speed and load but is also modified by the PCM to allow for other factors, e.g. coolant temperature, and also to achieve optimum emissions and fuel economy.

The recirculated exhaust gas is taken from the bank 1 exhaust manifold and fed into the engine via the EGR valve. The feedback pipe contains an internal tube with a small diameter orifice that creates a pressure differential in the feedback pipe. Two small pipes, connected to the feedback pipe each side of the orifice, transmit the pressure differential to the differential pressure feedback EGR sensor.

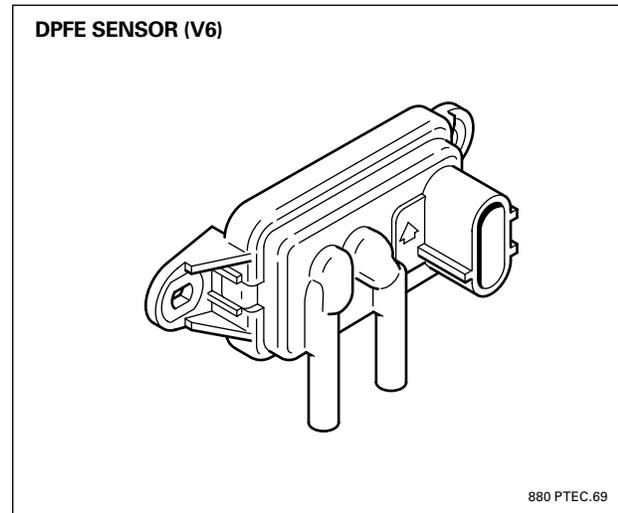


NOTES

Differential pressure feedback EGR (DPFE) sensor

The PCM receives an EGR feedback signal from the DPFE sensor. The sensor consists of a vacuum operated variable capacitor and a processing circuit, which convert the input pressure / vacuum value to a corresponding analogue voltage signal. The DPFE sensor has a linear response and the variations in exhaust pressure produce a signal voltage in the range of 1V – 3.5V dc.

- The EGR vacuum regulator valve and the EGR valve comprise the actuating components of the control loop.
- The EGR vacuum regulator valve has a vacuum input from the manifold distribution pipes, a vacuum output to the EGR valve, and receives a pulse width modulated (PWM) signal from the PCM.
- The PWM signal switches the vacuum control output to the EGR valve according to input demand from the differential pressure feedback EGR sensor or in response to override conditions determined by the engine management system.
- The EGR valve is a vacuum operated diaphragm valve with no electrical connections, which opens the EGR feed pipe to the induction manifold under the EGR vacuum regulator control.



EGR Control Conditions

EGR operates over most of the engine speed/load range but is disabled by the engine management system under certain conditions:

- During engine cranking
- Until normal operating temperature is reached
- When the diagnostic system registers a failure which affects the EGR system (e.g. a faulty sensor)
- During idling to avoid unstable or erratic running
- During wide open throttle operation
- When traction control is operative.

While the main control loop is based on feedback from the differential pressure feedback EGR sensor, the EGR rate is also modified by other engine conditions; coolant, ambient and charge air temperatures, barometric pressure, VVT cam position and charge air mass. Note also that the EGR rate increases gradually after it is enabled during each driving period.

NOTES

PTEC ENGINE MANAGEMENT SYSTEM



- 1 PTEC OVERVIEW AND CONTROL SUMMARY
- 2 POWERTRAIN CONTROL MODULE (PCM)
- 3 PCM SENSING COMPONENTS – ENGINE
- 4 INDUCTION AIR AND THROTTLE CONTROL
- 5 FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL
- 6 FUEL INJECTION
- 7 IGNITION
- 8 VARIABLE VALVE TIMING / VARIABLE INTAKE
- 9 EXHAUST GAS RECIRCULATION (EGR): V6 ONLY
- 10 OTHER PCM ENGINE CONTROL AND INTERFACE FUNCTIONS**
- 11 TASK SHEETS



OTHER PCM ENGINE CONTROL AND INTERFACE FUNCTIONS

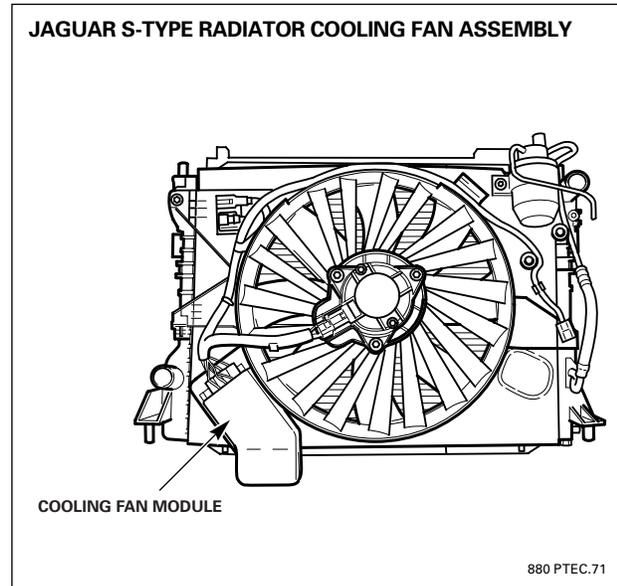
Radiator Cooling Fan and Air Conditioning Compressor Control

The Jaguar S-TYPE radiator cooling fan is driven by a variable speed 500W electric motor. An electronic cooling fan module, located under the radiator cooling pack, drives the fan motor.

The cooling fan module is supplied with:

- ignition switched 20 Amp fused B+ power supply from powertrain relay 1 for the control circuit
- battery direct B+ power supply via the 80 Amp fuse adjacent to the front power distribution box for fan motor drive.

When the engine is running, the cooling fan module receives a PWM control signal proportional to the engine cooling requirements from the PCM. In response to the PCM control signal, the cooling fan module switches the fan motor ON and OFF and varies fan speed between 300 rpm to 2900 rpm using PWM drive voltage.



As the engine is switched off, the A/CCM notes the engine coolant (V8) or cylinder head (V6) temperature (SCP MESSAGE) and provides a control signal to the cooling fan control module for a fixed period of time to operate the fan motor. The engine off fan operational time period is determined by the A/CCM based on the SCP temperature message.

In addition to radiator cooling fan control, the PCM controls the operation of the air conditioning compressor clutch. The PCM receives the air conditioning compressor operation request from the A/CCM via the SCP network.

The PCM calculates the engine cooling requirement from signal inputs received from the following sources:

- ECT sensor (V8)
- CHT sensor (V6)
- Air conditioning pressure sensor
- Air conditioning compressor status
- Transmission fluid temperature

NOTES

OTHER PCM ENGINE CONTROL AND INTERFACE FUNCTIONS

Radiator Cooling Fan and Air Conditioning Compressor Control (continued)

Air Conditioning Pressure Sensor

The air conditioning pressure sensor, located in the A/C “high side” is a pressure transducer sensing refrigerant system high side pressure. The feedback voltage from the transducer supplies the PCM with a signal proportional to refrigerant pressure. The PCM uses the refrigerant pressure signal for coolant fan requirement and compressor clutch control.

Fail Safe Engine Cooling (V6)

V6 PCMs are programmed with a function that monitors engine temperature and performs actions that prolong safe engine operation by controlling engine temperature. This “fail safe engine cooling” strategy is fully controlled by the PCM. Fail safe engine cooling strategy on V6 engines is made possible by monitoring the engine temperature with a cylinder head temperature (CHT) sensor (metal contact) instead of a ECT sensor (coolant).

If the PCM detects excessively high engine temperature, it switches off the fuel injector(s) of one or more cylinders. With no fuel being injected, ambient air is pumped through the cylinder cooling the engine. By switching individual injectors off for a period of time and in a sequence determined by the PCM, engine temperature can be controlled to allow the vehicle to be driven for a short distance.

The overall engine cooling strategy can be divided into five stages. The fail safe engine cooling (FSC) strategy operates in the three top stages as explained in the following chart.

Engine cooling strategy

Stage	Temperature	Warnings	Action
Normal	82 °C (180 °F) – 118 °C (245 °F)	Coolant temp gauge	Normal cooling fan control
Above normal	> 118 °C (245 °F) – < 121 °C (250 °F)	Coolant temp gauge in RED zone ENGINE OVERTEMP warning light CHECK ENGINE TEMP message Single chime	Cooling fan maximum
FSC Stage 1 Reduced power	> 121 °C (250 °F) – < 149 °C (300 °F)	Coolant temp gauge in RED zone ENGINE OVERTEMP warning light REDUCED ENGINE POWER message CHECK ENGINE MIL Three chimes	Cooling fan maximum PCM begins selectively and alternately shutting off the fuel injectors Engine speed limited
FSC Stage 2 Stop engine safely	> 149 °C (300 °F) – < 166 °C (330 °F)	Coolant temp gauge in RED zone Flashing ENGINE OVERTEMP warning light STOP ENGINE SAFELY message CHECK ENGINE MIL Five chimes	Cooling fan maximum PCM continues selectively and alternately shutting off the fuel injectors Engine speed limited
FSC Stage 3 Engine shut down	166 °C (330 °F)	Coolant temp gauge in RED zone ENGINE OVERTEMP warning light CHECK ENGINE MIL	Cooling fan maximum PCM shuts down engine

All temperatures shown are approximate.

Generator

The PCM is responsible for issuing SCP commands directing the instrument pack to switch the generator warning light OFF or ON. Each time the ignition is switched ON to position II, the instrument pack initiates its bulb check cycle. The generator warning light will remain active until the instrument pack receives an SCP LOW VOLTAGE TELLTALE (OFF) message from the PCM.

The PCM receives generator charging voltage information via a hard wire from generator pin marked ALTLMP on the generator. If the charging system is functioning correctly, the PCM transmits the SCP LOW VOLTAGE TELLTALE (OFF) message. If the PCM detects an out of range voltage (high or low) during normal operation, it transmits an SCP LOW VOLTAGE TELLTALE (ON) message signaling the instrument pack to activate the generator warning light. If the generator detects an internal fault it holds the ALTLMP signal at zero volts. After 15 seconds at zero volts the PCM transmits the SCP LOW VOLTAGE TELLTALE (ON) message and triggers a non OBD II DTC.

The PCM receives generator load information via a hard wire from the generator pin marked FRI. This circuit communicates a PWM signal proportional to generator field load. When the vehicle battery is fully charged and electrical demands are low, generator output can drop to zero resulting in a B+ voltage signal. As generator output increases to supply increased electrical demands the PWM duty cycle increases. At full generator output the duty cycle is 100% resulting in a continuous zero voltage signal. The PCM increases throttle valve opening at idle to compensate for the increased generator load.

NOTES

PTEC ENGINE MANAGEMENT SYSTEM



- 1 PTEC OVERVIEW AND CONTROL SUMMARY
- 2 POWERTRAIN CONTROL MODULE (PCM)
- 3 PCM SENSING COMPONENTS – ENGINE
- 4 INDUCTION AIR AND THROTTLE CONTROL
- 5 FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL
- 6 FUEL INJECTION
- 7 IGNITION
- 8 VARIABLE VALVE TIMING / VARIABLE INTAKE
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- 10 OTHER PCM ENGINE CONTROL AND INTERFACE FUNCTIONS

11 TASK SHEETS



S-TYPE - DTC Summaries

Name: _____ Date: _____ Vehicle/VIN _____

1. What is KOEO self test? _____

2. What is KOER self test? _____

3. What does DTC P1001 provide as a fault description? _____

4. If DTC P0102 is logged what self test should you perform? KOEO [], KOER [], Why?

5. Elaborate on DTC P1299.

- Can it be logged on an AJ V8 PTEC system: Yes [] No []
- How many trips does it require to log? 1 Trip [], 2 Trips []
- What is the PCM's default action if this fault is logged? _____

- Will any messages be displayed in the Instrument Cluster with this DTC: Yes [] No []
- If "Yes" please list the messages. _____

6. Is the drive cycle for comprehensive component monitoring longer for the AJV8 compared to the AJV6? Yes [] No []. If yes, why? _____

Instructor Check: _____

S-TYPE - PTEC Overview

Name: _____ Date: _____ Vehicle/VIN _____

1. Review the correct Electrical Guide and list the power distribution paths for the PCM.

2. How does the PCM control power to operate high amperage consumers (i.e., AC compressor).

3. Why is communication occurring between the PCM and the Throttle Motor Actuator.

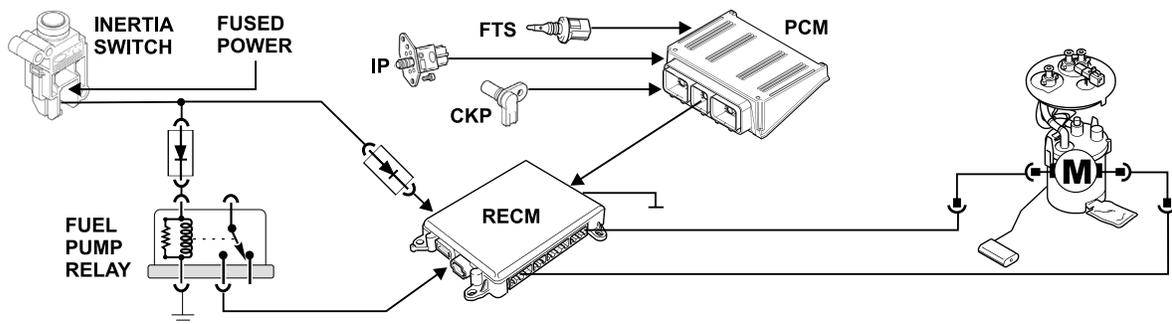
4. What signal does the PCM receive when the PSP switch closes? _____

5. Where does APP2 receive it's operating voltage from? _____,
Why? _____

Instructor Check: _____

S-TYPE - PTEC Fuel Pump Control

1. The illustration below Identifies the components and signals used to operate the fuel pump. What is the purpose of the IP sensor? _____



2. What is the purpose of the FTS? _____

Use the appropriate Electrical Guide to identify the wire colors and pin numbers at the RECM.

3. What type of signal is provided to the RECM by the PCM requesting for fuel pump operation. _____, What is the wire color and pin number _____
4. Signal frequency? _____. Is it fixed [] Yes, [] No
5. Signal duty cycle at idle = _____, under load (2500 RPM) _____
6. What type of signal is provided from the RECM to drive the fuel pump? _____, What is the wire color and pin number. _____
7. Signal frequency ? _____. Is it fixed [] Yes, [] No
8. Signal duty cycle at idle = _____, under load (2500 RPM) _____
9. Load PDU multimeter, load amp clamp. Connect the fuel pump control circuit and measure value. Record reading at the idle and under load.

Idle = _____ Under load = _____

Instructor Check: _____

S-TYPE - PCM Datalogger

Name: _____, Date: _____, Vehicle/VIN _____

Connect the PTU to the vehicle and enter the datalogger program.

1. With the engine running, highlight the information button on each signal. Observe and record the following signals.

•AIRI = Air Assist Injection _____

•CHT = Cylinder Head Temperature sensor (AJV6) _____

•DPFE V6 =Differential Pressure Sensor _____

•EFPT = Fuel Rail Pressure Transducer _____

•EFT = Fuel Rail Temperature Sensor _____

•FPDC = Fuel Pump Duty Cycle. _____

•EGRDC = EGR Duty Cycle _____

•H02SIU = Upstream O2 Sensor Signal _____

•H02SID = Downstream O2 Sensor Signal _____

•MAF= Mass Air Flow _____

•PURGEDC = Purge Valve Duty Cycle _____

2. Monitor and record the following signals with engine at idle and then at 1500 RPM.

•APP1 = _____

•APP2 = _____

•APP3 = _____

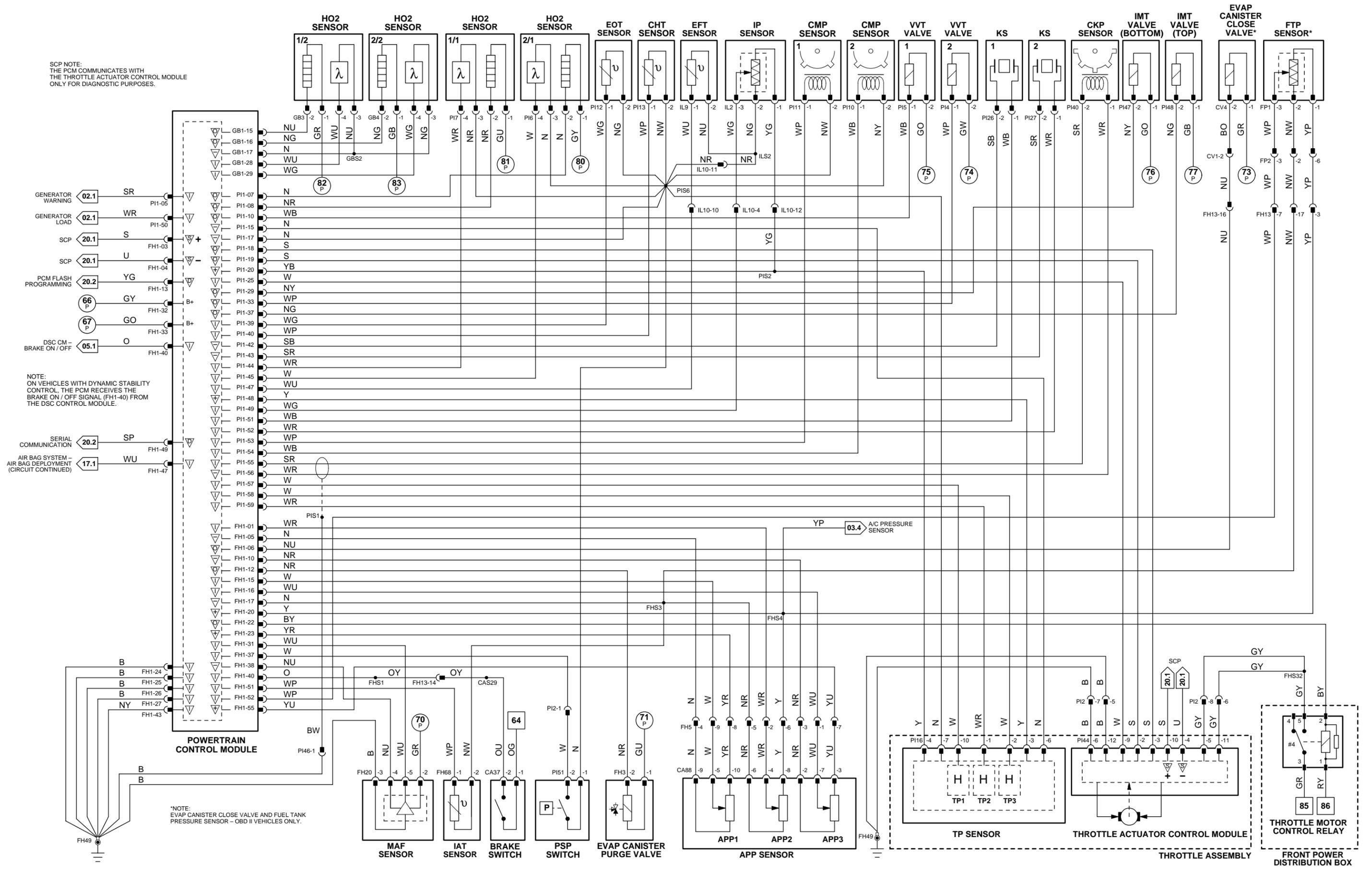
•TPS1 = _____

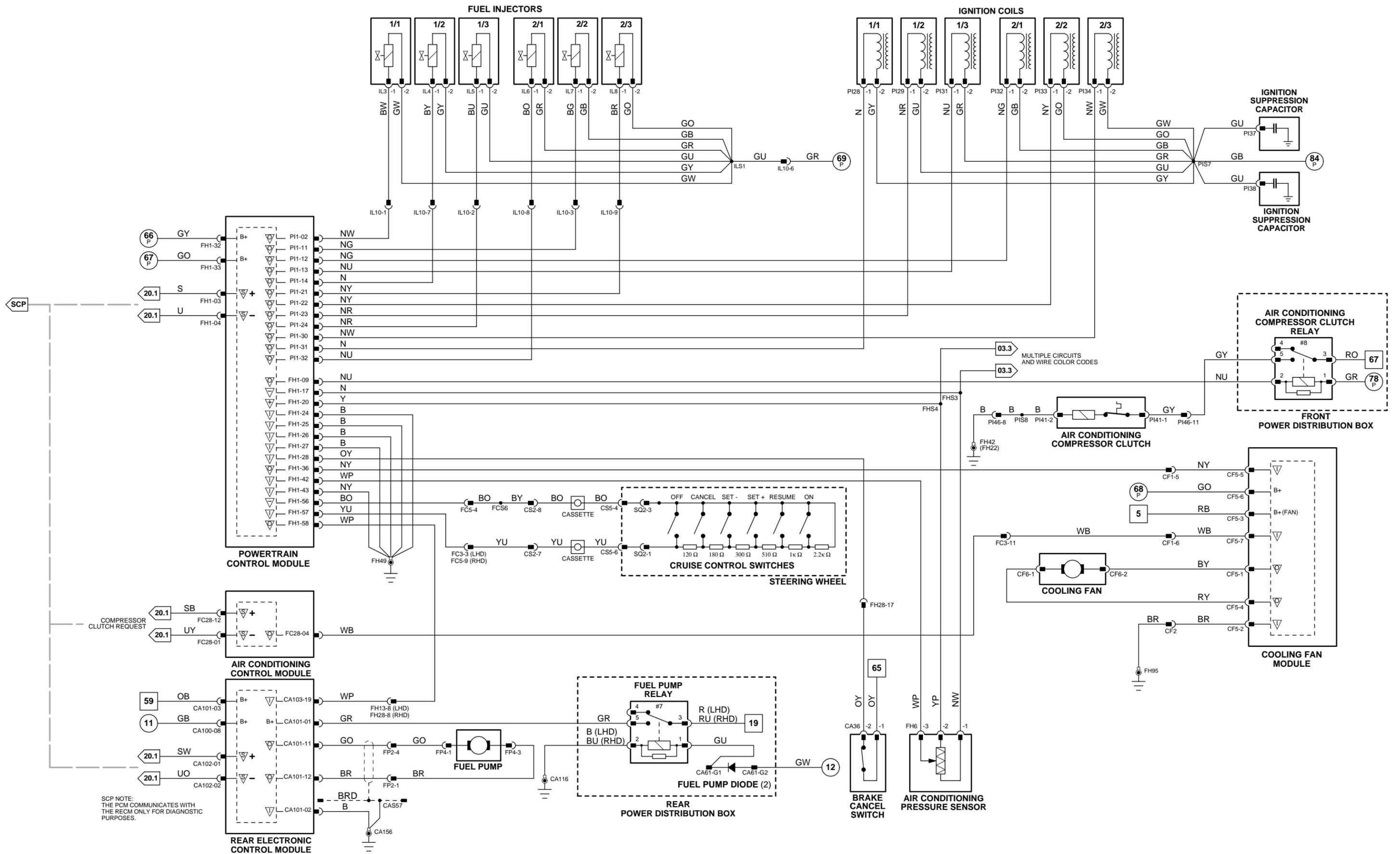
•TPS2 = _____

•TPS3 = _____

Instructor Check: _____

PTEC V8 ENGINE MANAGEMENT, PART 1 – 2001 MY S-TYPE





PTEC V6 ENGINE MANAGEMENT, PART 1 – 2001 MY S-TYPE

