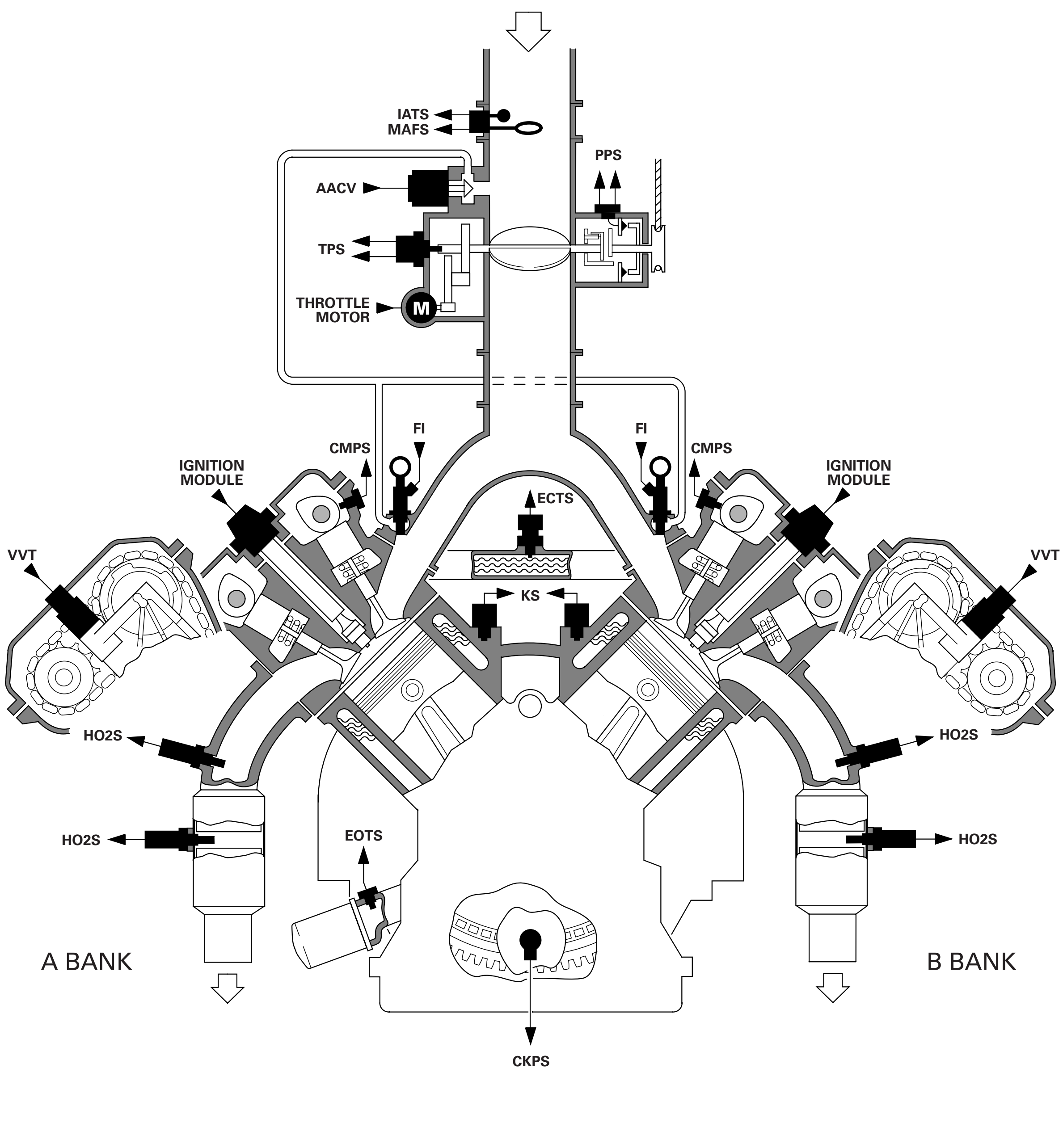
CONTROL SUMMARIES

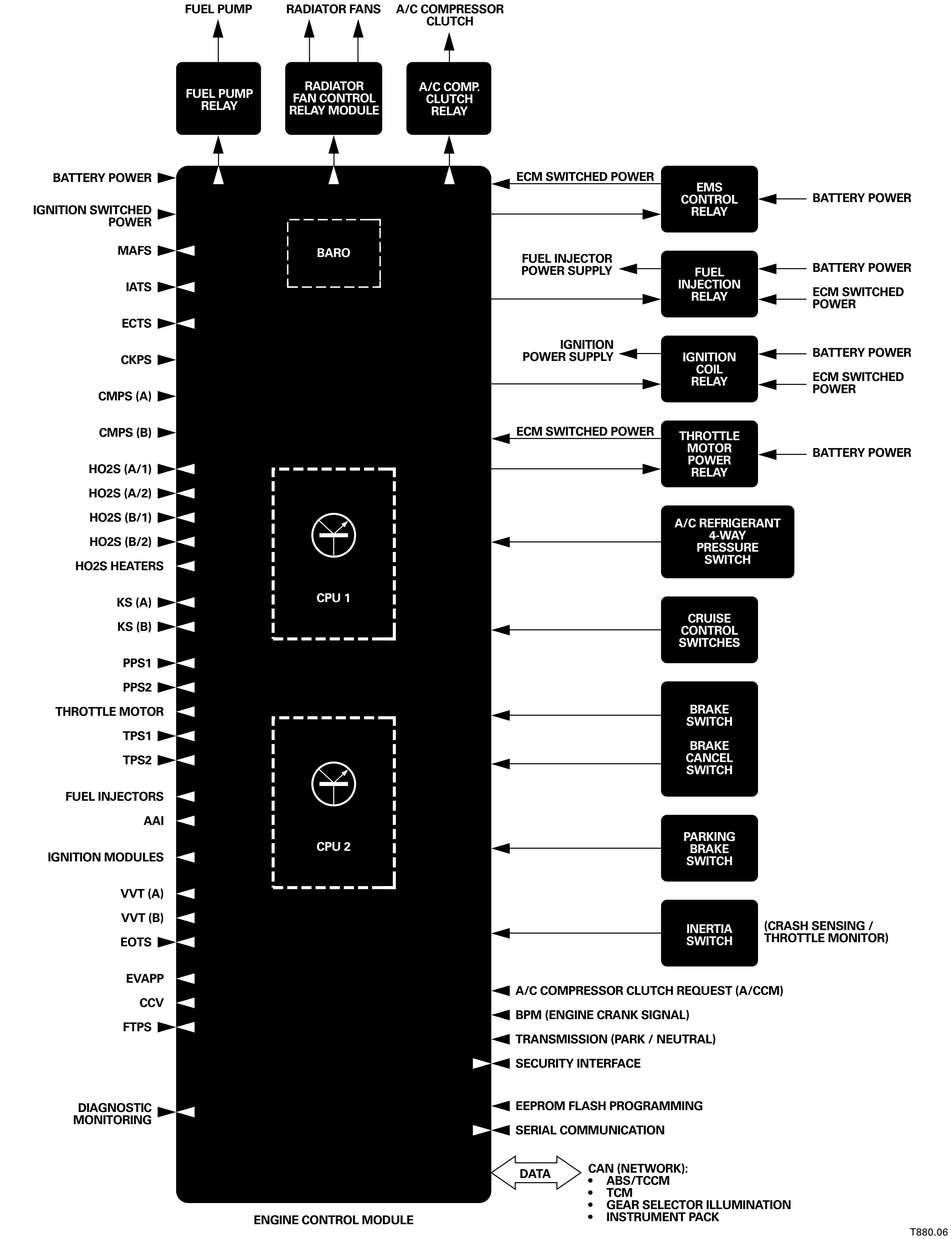
System Logic: AJ27 N/A

AJ27 N/A ENGINE MANAGEMENT SENSORS AND COMPONENTS



T880.05

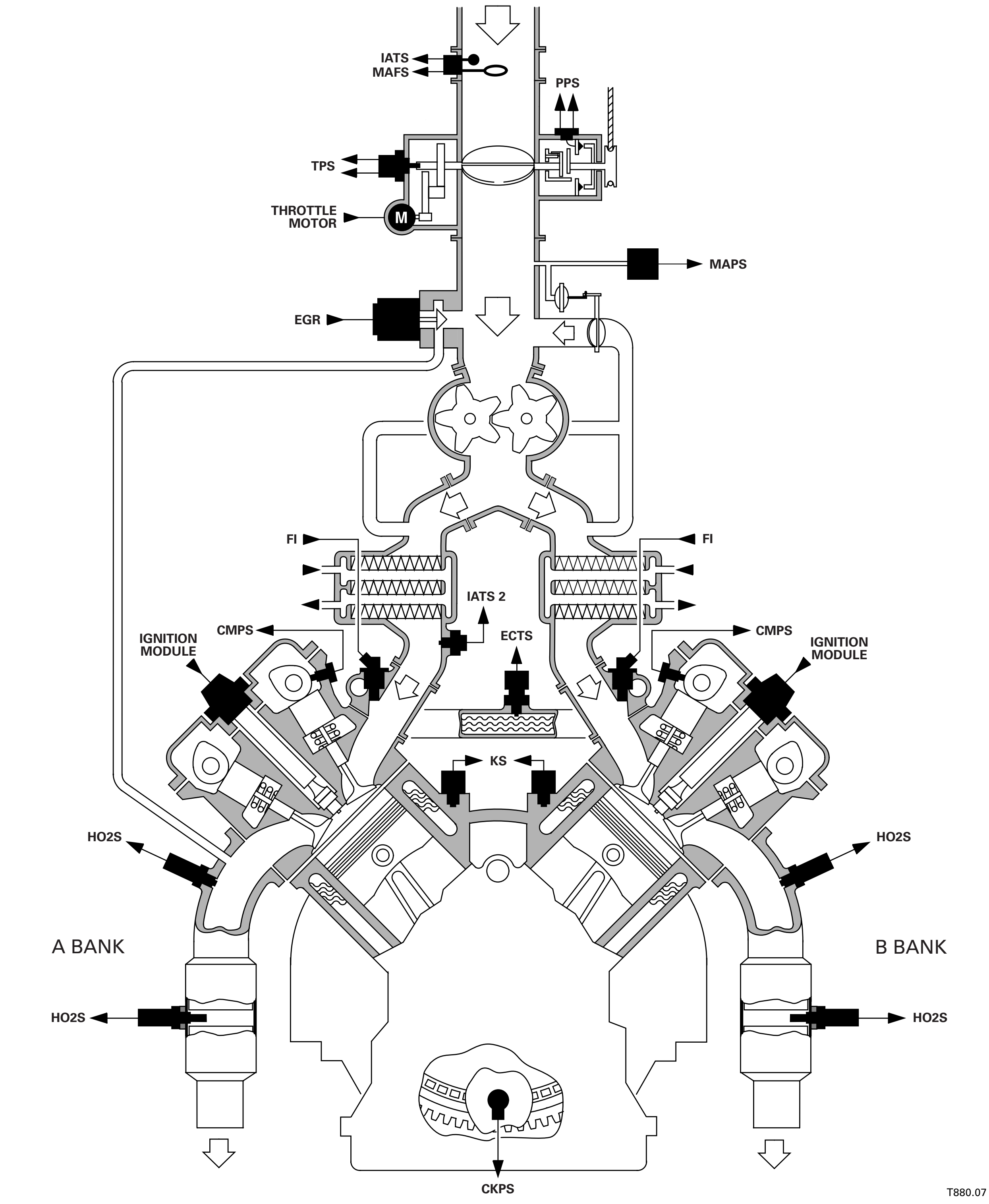
AJ27 N/A ENGINE MANAGEMENT INPUTS / OUTPUTS



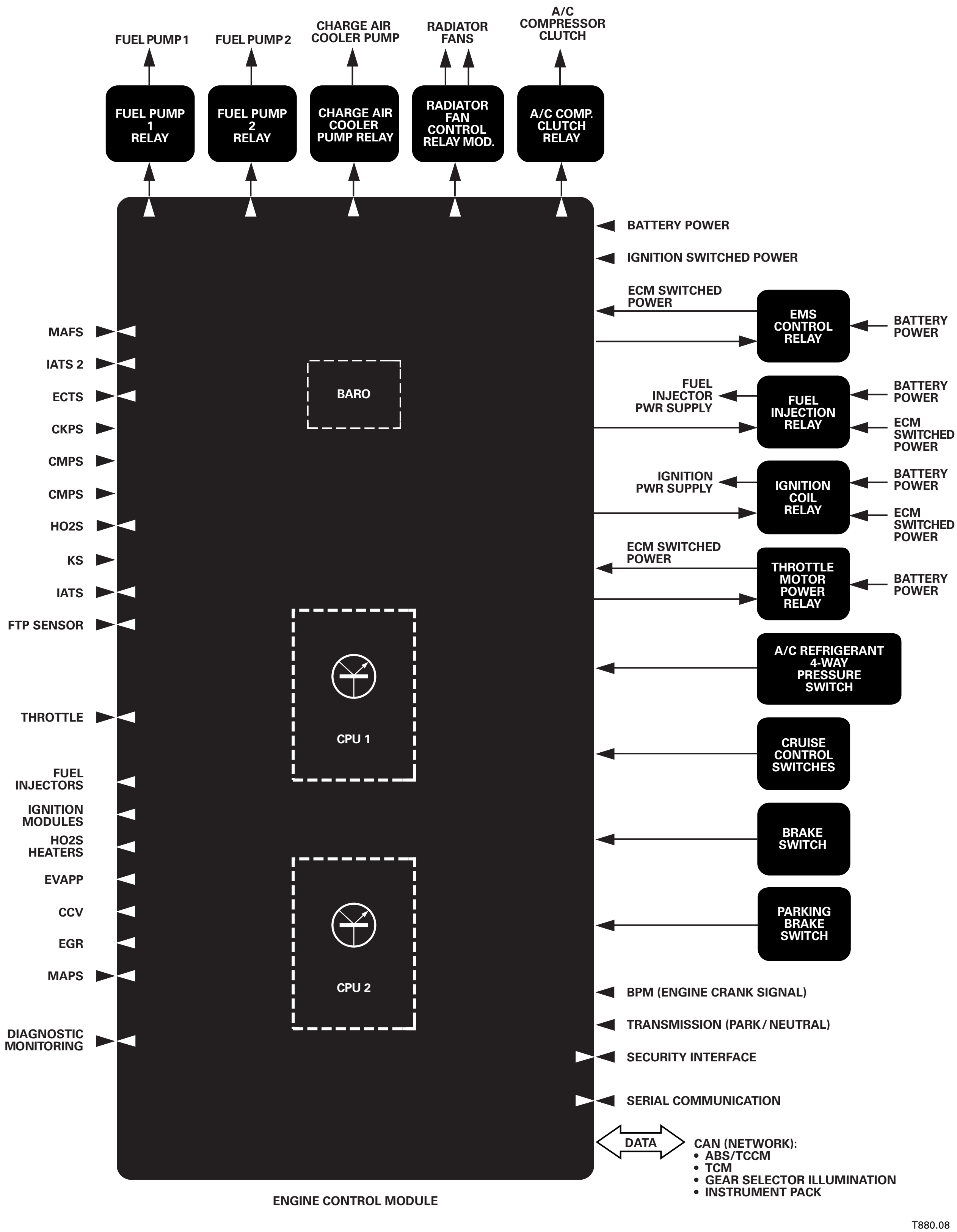
CONTROL SUMMARIES

System Logic: AJ27 SC

AJ27 SC ENGINE MANAGEMENT SENSORS AND COMPONENTS



AJ27 SC ENGINE MANAGEMENT INPUTS / OUTPUTS



AJ26 / AJ27
ENGINE MANAGEMENT SYSTEMS

AJ26/27 V8

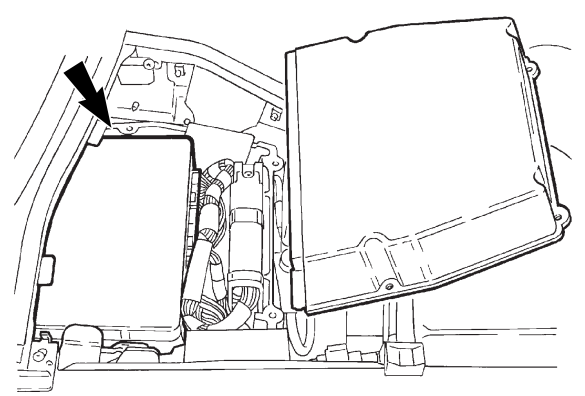
JAGUAR

Service Training Course 881
DATE OF ISSUE: 9/2001

ENGINE CONTROL MODULES

AJ26 Engine Control Module

AJ26 ENGINE CONTROL MODULE



T880.09

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.

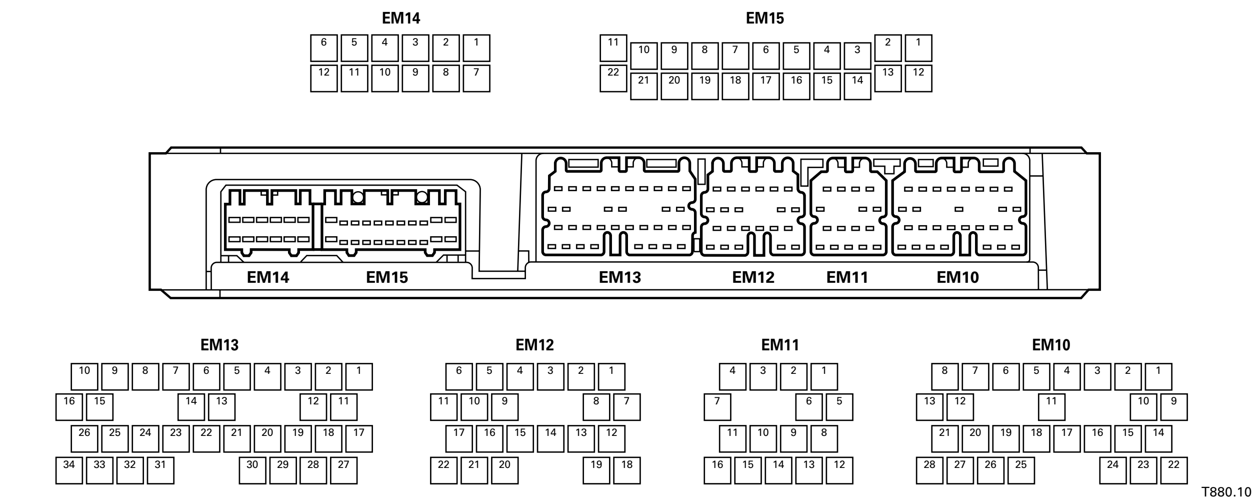
ECM Cooling

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.

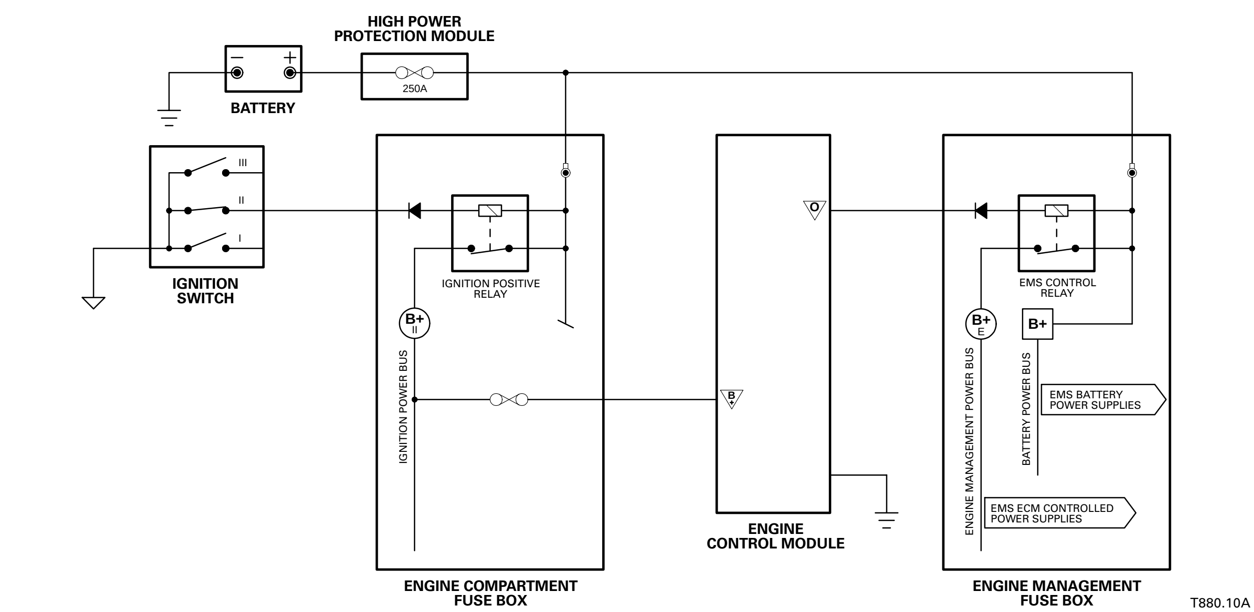
AJ26 ECM CONNECTOR SOCKETS



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 adaptions, close the EGR valve (if fitted), and operate the radiator fans. Refer to the applicable Electrical Guide for relay and fuse box locations

AJ27 EMS POWER SUPPLIES



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 Throttle	Fuel Injection	Ignition	ECM Control
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.

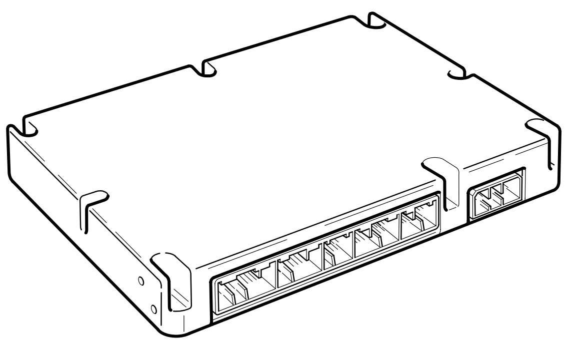
Shift energy management
Transmission shift quality is enhanced by “shift energy management”. The ECM provides engine torque data by the CAN message CAN SHIFT ENERGY MANAGEMENT ESTIMATED ENGINE TORQUE. The TCM determines the amount of torque reduction required. As gear shifts occur, the TCM communicates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

AJ27 ENGINE CONTROL MODULE



T880.11

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

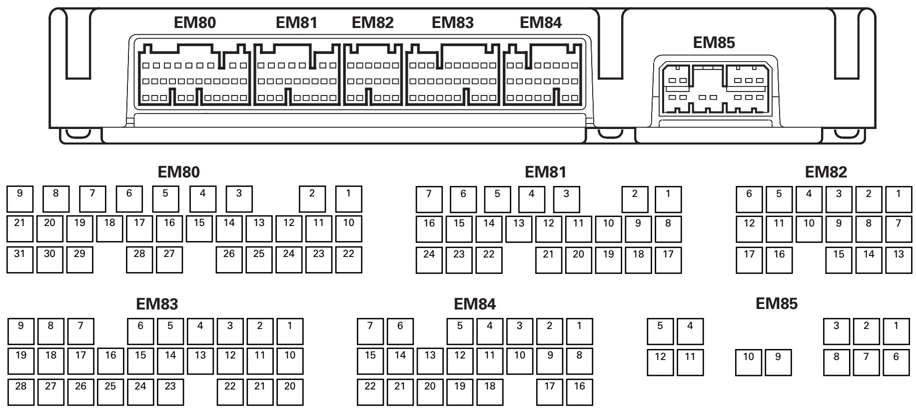
ENGINE CONTROL MODULES

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.

AJ27 ECM CONNECTOR SOCKETS



T880.12

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

AJ26/27 V8

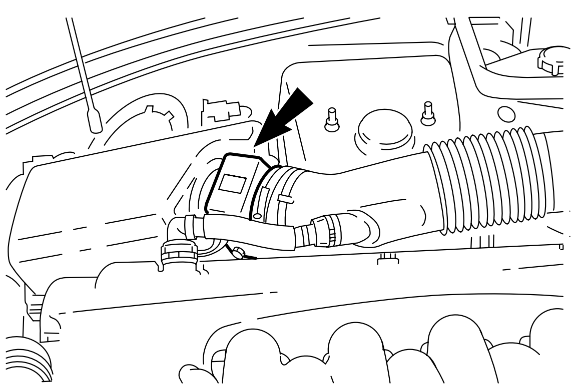
JAGUAR

Service Training Course 881
DATE OF ISSUE: 9/2001

EMS PRIMARY SENSING COMPONENTS

Mass Air Flow Sensor (MAFS) – AJ26

MAFS – AJ26

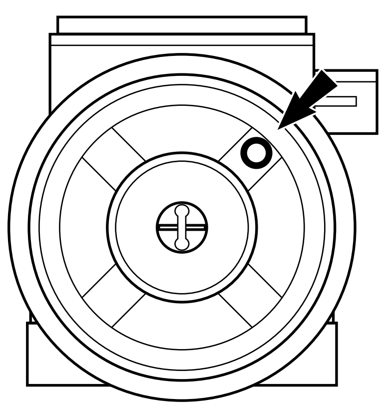


T880.13

- 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

IATS (IN MAFS HOUSING) – AJ26



T880.14

- 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 ˚C	˚F	Resistance (kΩ)
-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

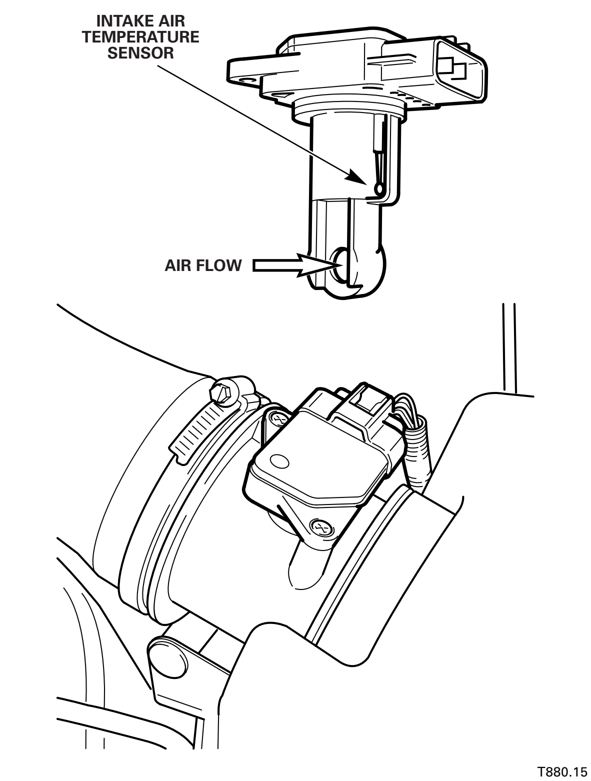
NOTES

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.

NOTES

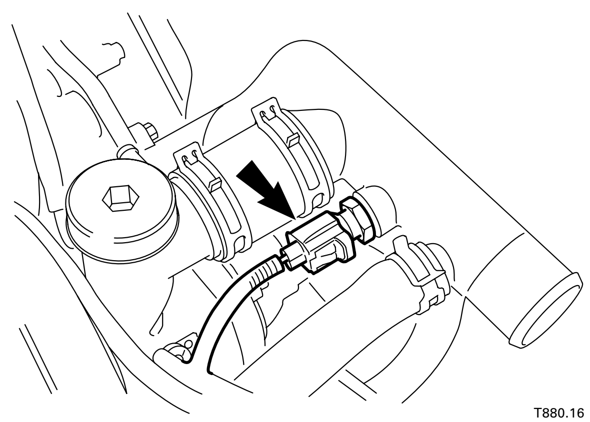
MAFS AND IATS – AJ27



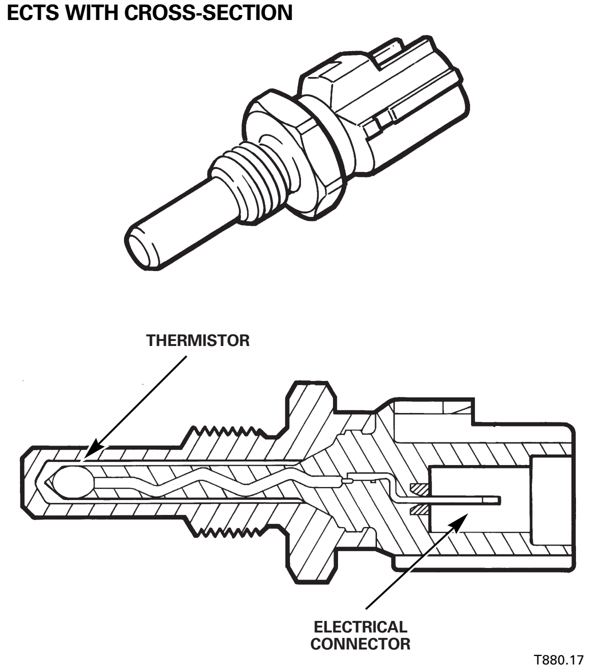
EMS PRIMARY SENSING COMPONENTS

Engine Coolant Temperature Sensor (ECTS) – AJ26 and AJ27

ECTS LOCATION



ECTS WITH CROSS-SECTION



- 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 ˚C	˚F	Resistance (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

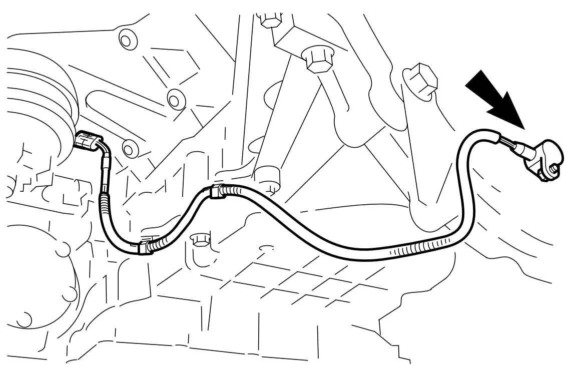
Coolant temperature ˚C	˚F	Voltage (V)
-10	14	4.05
0	32	3.64
20	68	2.42
40	104	1.78
60	140	1.17
80	176	0.78
100	212	0.55

NOTES

Crankshaft Position Sensor (CKPS) – AJ26

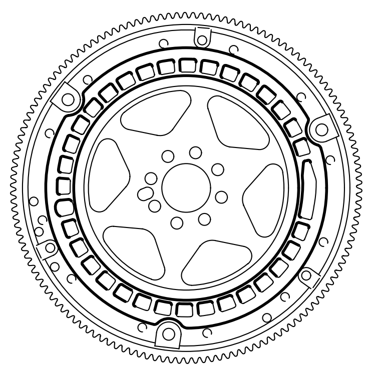
- The CKPS, located at the rear of the engine bed plate, provides the ECM with pulsed signals for crankshaft position and engine speed.
- The timing disc for the sensor is spot-welded to the front face of the transmission drive plate.
- The timing disc has 34 spokes spaced at 10° intervals, with two 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.

CKPS – AJ26



T880.19

CKPS TIMING DISC – AJ26

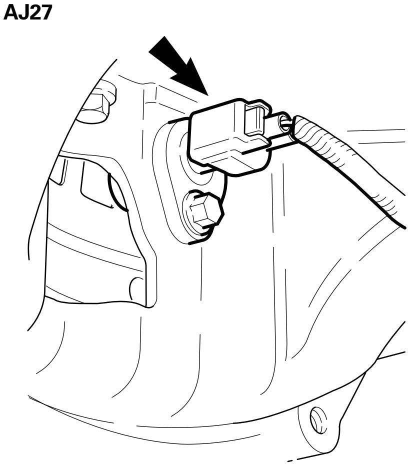


T880.20

Crankshaft Position Sensor (CKPS) – AJ27

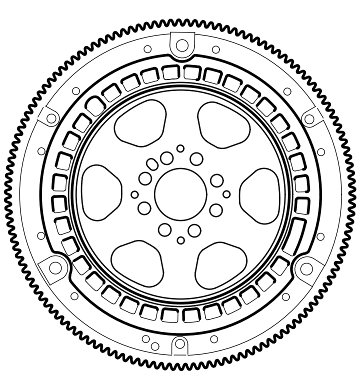
The AJ27 CKPS has a revised 36-tooth (minus one tooth) reluctor. The electrical connection to the CKPS is direct.

CKPS – AJ27



T880.22

CKPS RELUCTOR – AJ27



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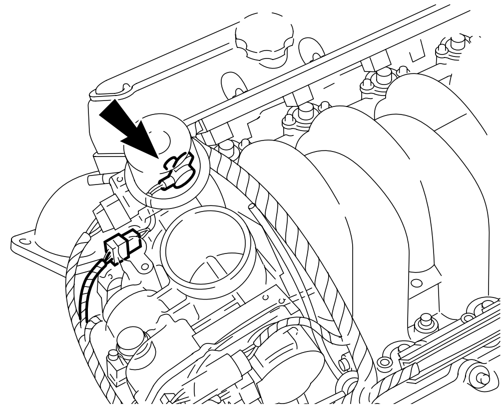
EMS PRIMARY SENSING COMPONENTS

Camshaft Position Sensor (CMPS) – AJ26

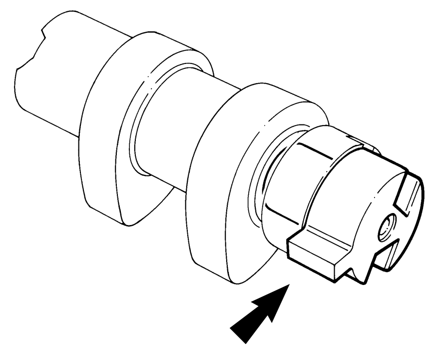
- The variable reluctance CMPS, located on the rear of the B bank cylinder head, provides the ECM with a pulsed signal for cylinder 1A compression stroke identification (one pulse per two crankshaft revolutions).
- The pulse is generated by the raised segment of the camshaft timing ring as it passes 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.

CMPS LOCATION – AJ26



T880.24

CMPS TIMING RING – AJ26

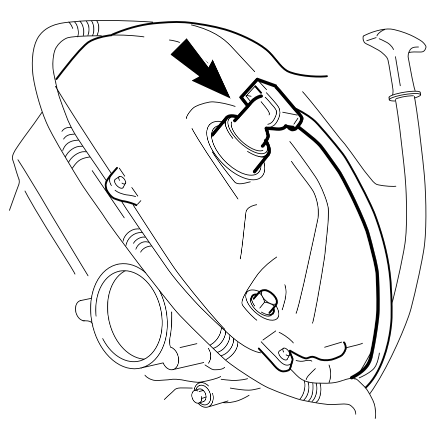


T880.25

Camshaft Position Sensor (CMPS) – AJ27

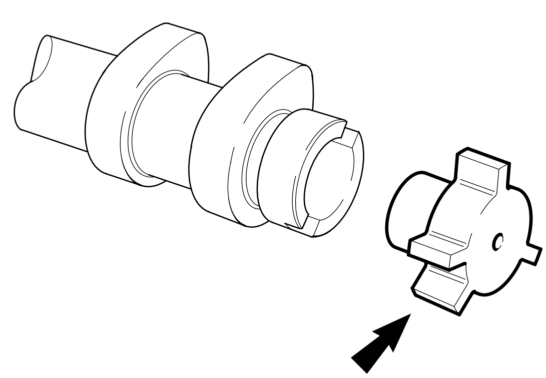
- **Both** engine banks incorporate camshaft position sensors that sense the position of the intake camshafts.
- The CMP sensors are inductive pulse generators.
- The sensors have four-toothed reluctors mounted on the rear of both intake camshafts.
- The four-tooth reluctors provide faster camshaft position 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.

CMPS (A BANK SHOWN)– AJ27



T880.28

CMPS RELUCTOR – AJ27

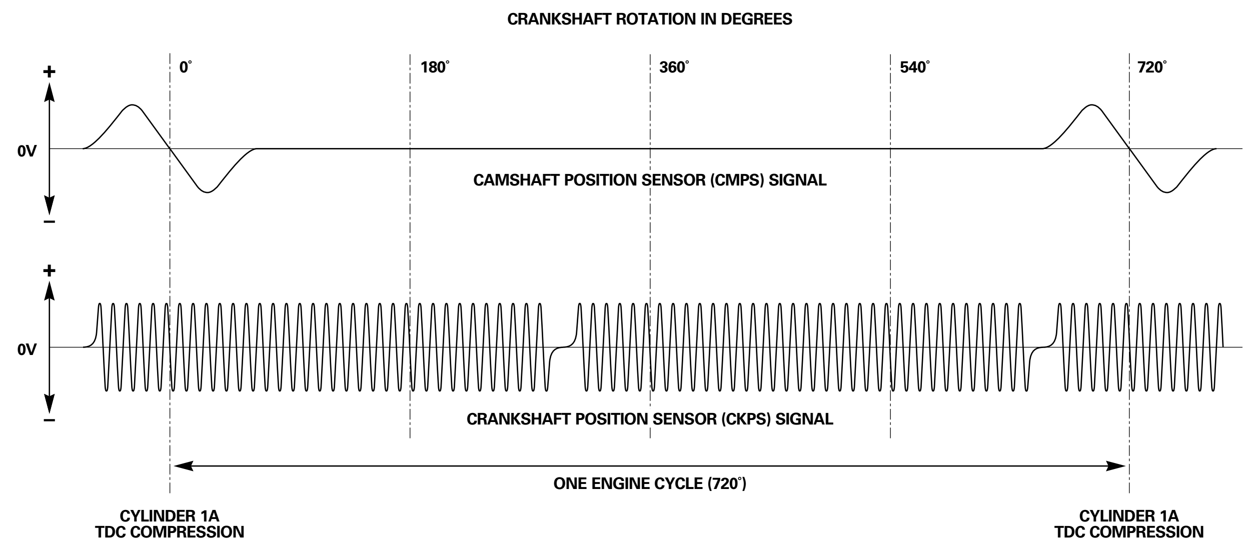


T880.29

Engine Cycle Synchronization: CKPS and CMPS

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

CKPS / CMPS 720˚ CRANKSHAFT ENGINE CYCLE – AJ26



T880.27

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

JAGUAR

Service Training Course 881
DATE OF ISSUE: 9/2001

INDUCTION AIR THROTTLE CONTROL – AJ26

ECM Throttle Control

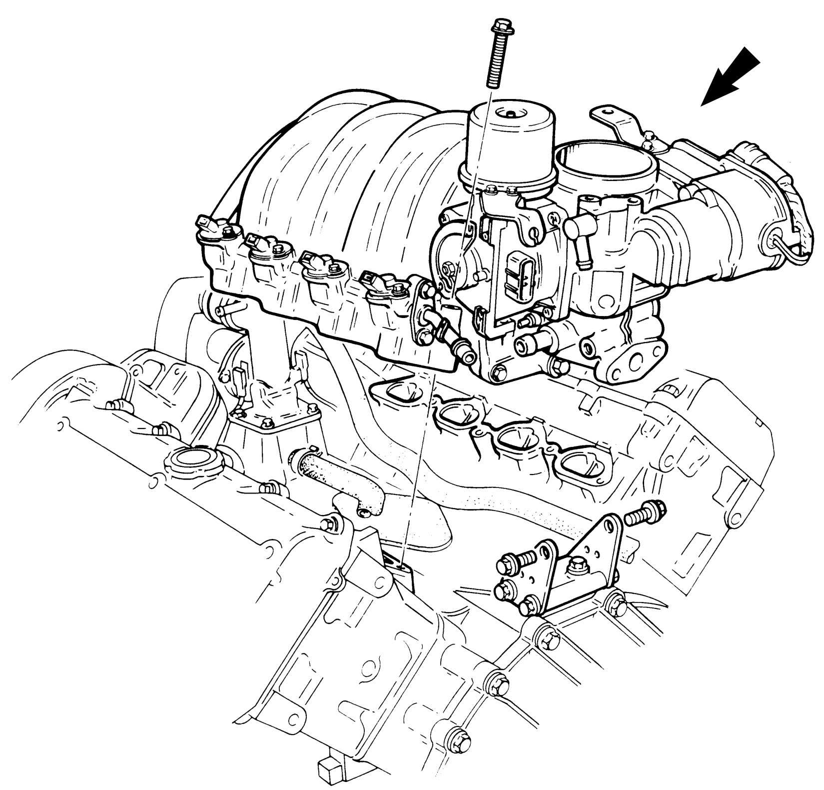
The electronic throttle allows the ECM to perform the following functions:

- 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.

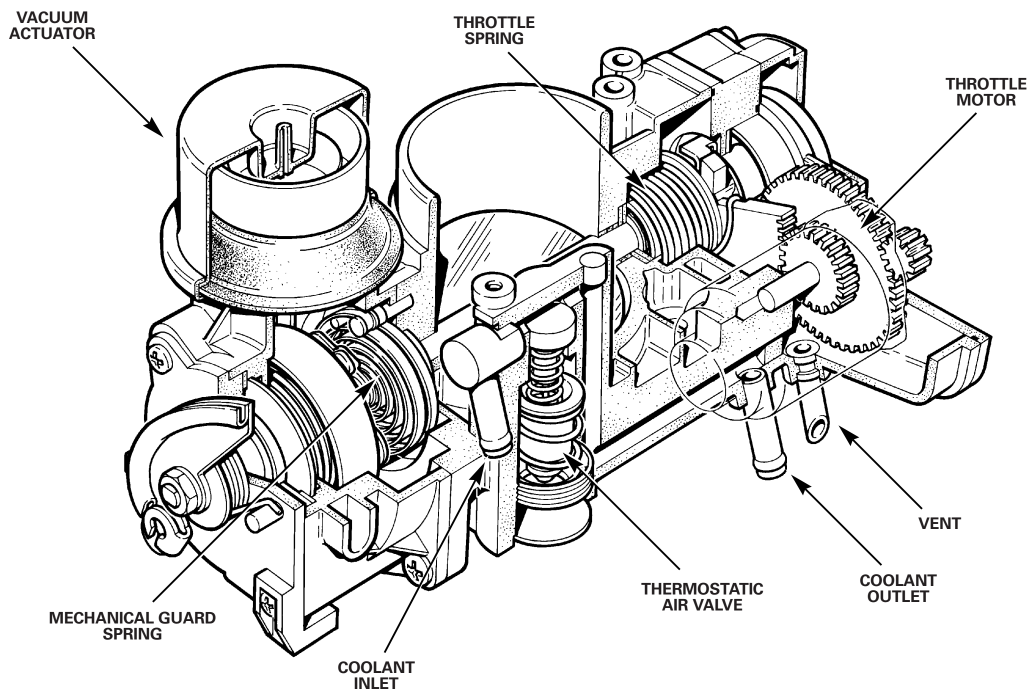
The arrangement of the sensors on both "sides" of the throttle valve allows the ECM to have closed loop throttle control.

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.

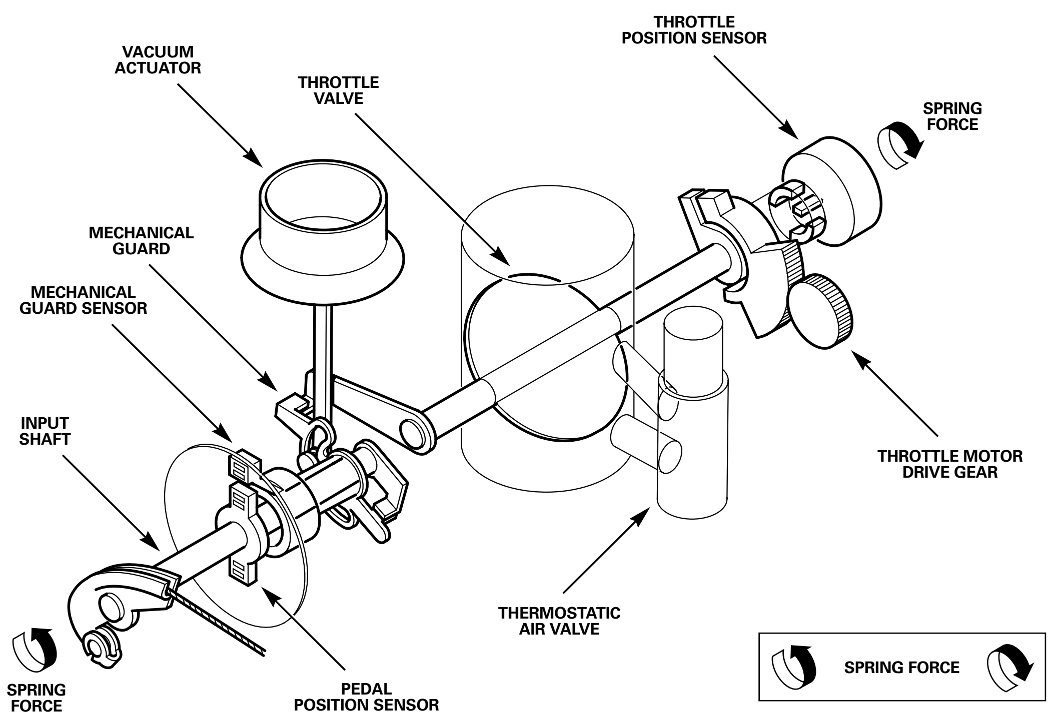
NOTES

ELECTRONIC THROTTLE – AJ26



T880.31

SIMPLIFIED VIEW OF ELECTRONIC THROTTLE – AJ26



T880.32

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 adaptions, 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

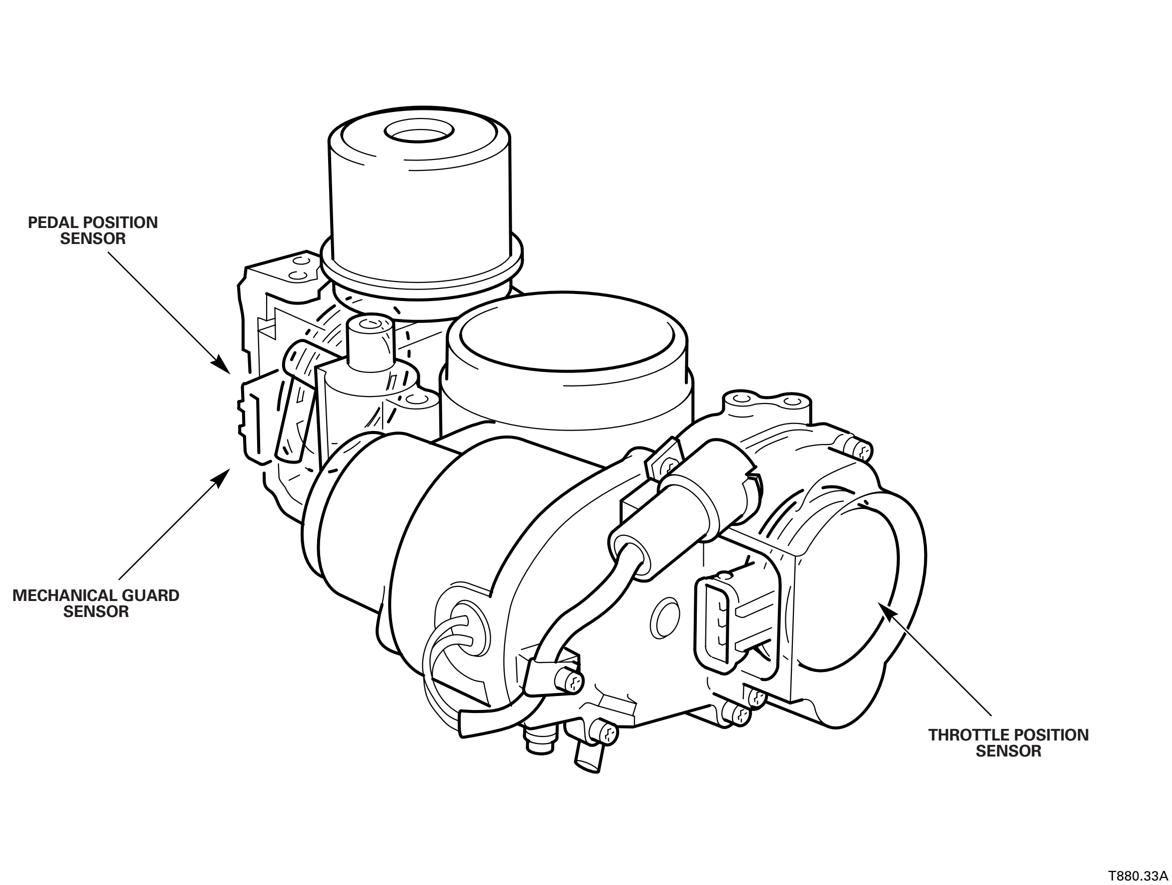
The pedal position sensor is a twin track potentiometer, located at the accelerator cable side of the throttle assembly. The throttle input shaft drives the potentiometer wipers to provide the ECM with redundant pedal position voltage signals. The voltage signals range from approximately 0.5 V at closed 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

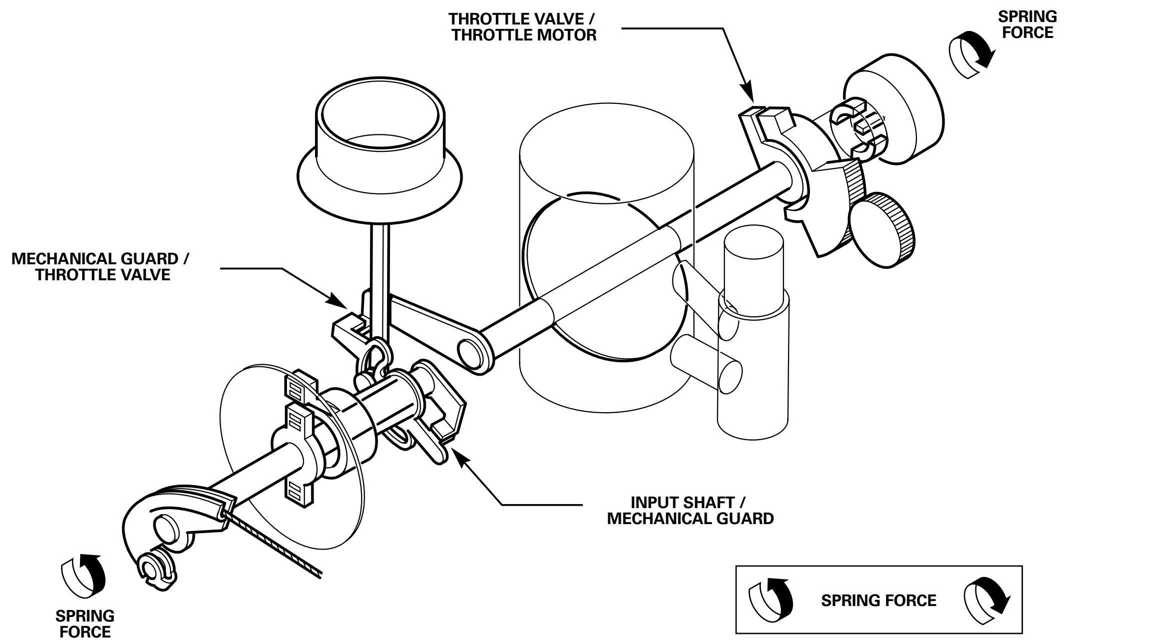


INDUCTION AIR THROTTLE CONTROL – AJ26

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.

THROTTLE LEVERS AND GAPS – AJ26



T880.33

- 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.

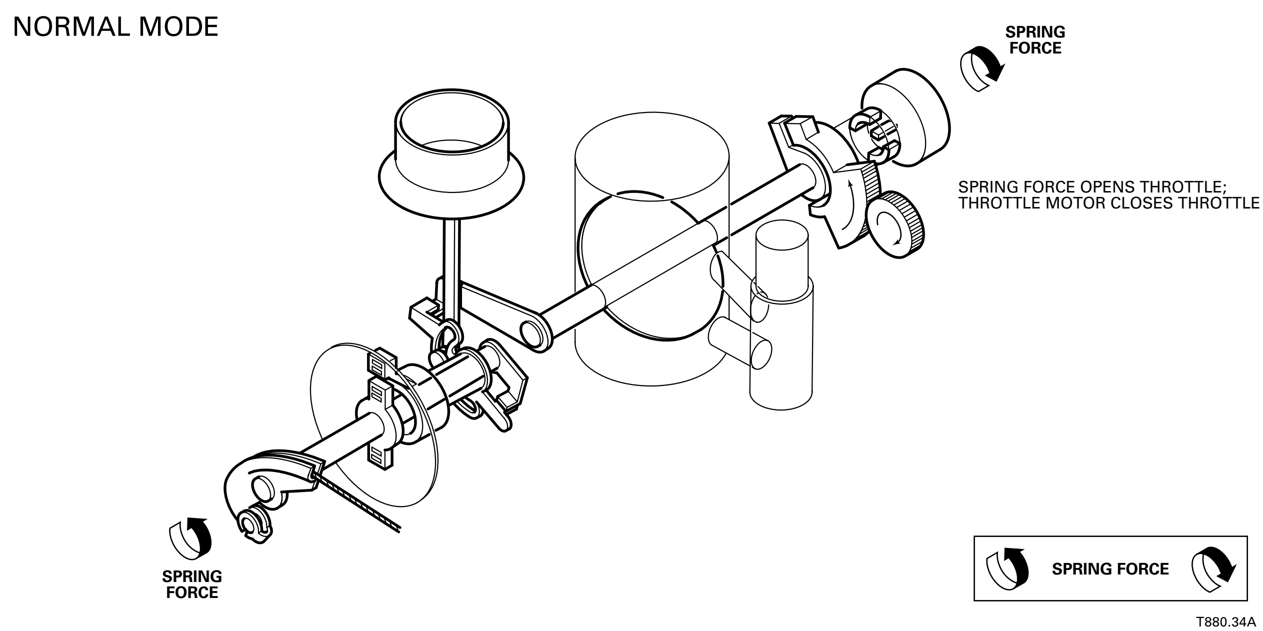
NOTES

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.

THROTTLE OPERATING MODES – AJ26



- 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

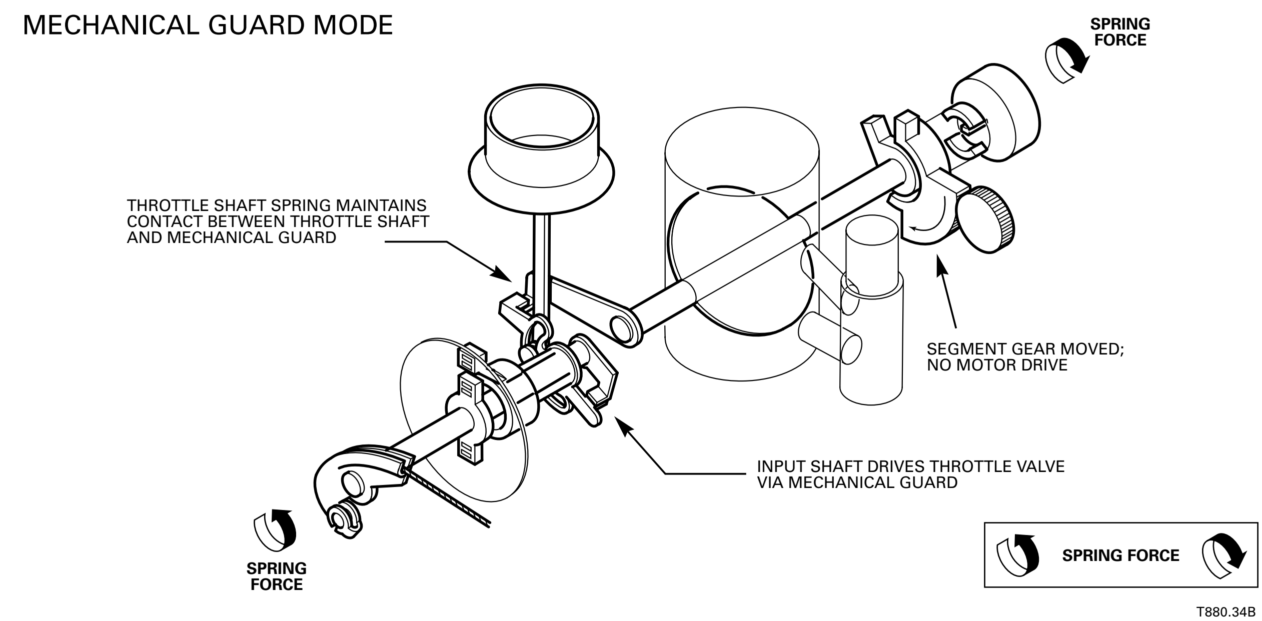
INDUCTION AIR THROTTLE CONTROL – AJ26

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.

THROTTLE OPERATING MODES – AJ26



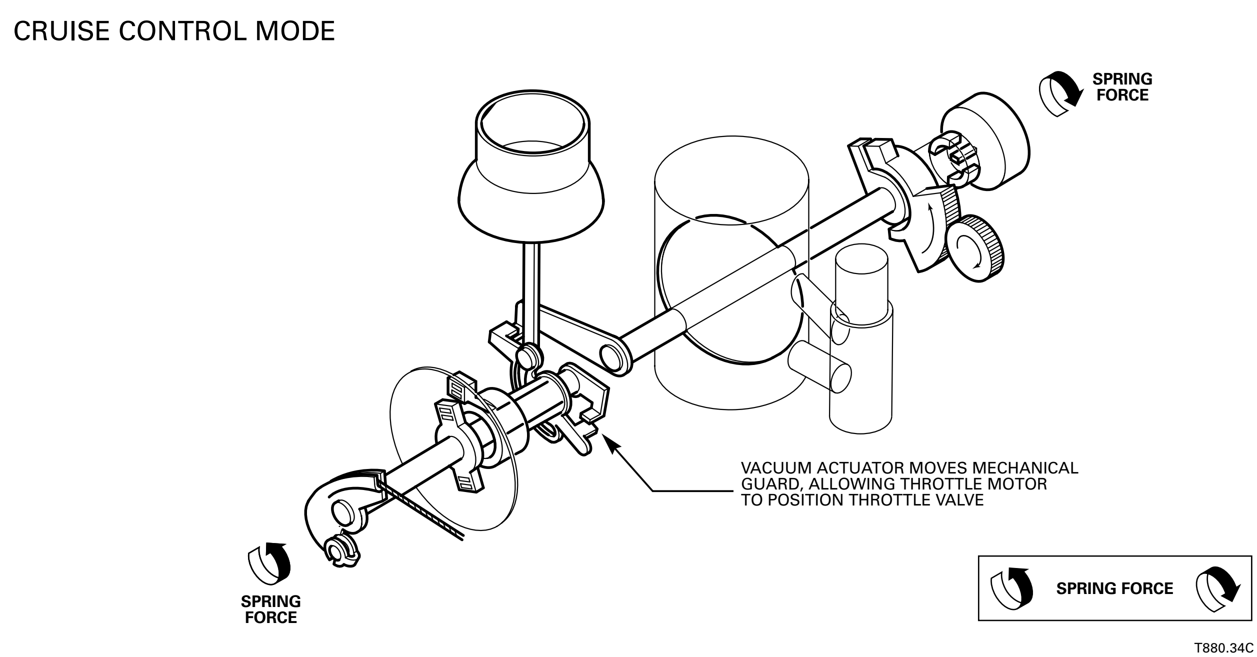
- When the throttle valve opens, it rotates the throttle motor drive gears. On subsequent closing of the throttle valve, the segment gear remains in the open position, disengaged from the throttle valve.
- Full throttle is available and engine speed is not limited in mechanical guard mode.
- Fuel injection 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.

THROTTLE OPERATING MODES – AJ26

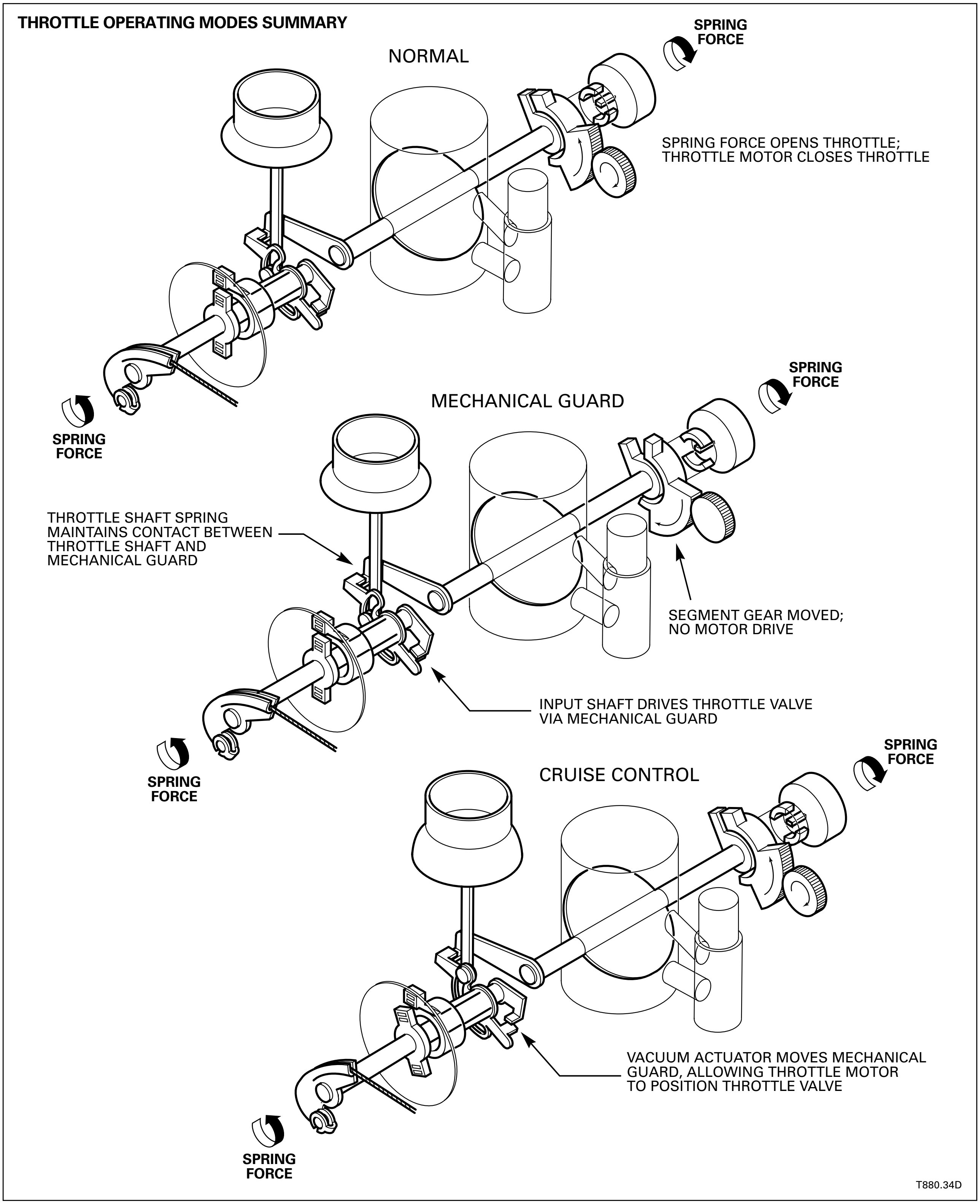


- Using the input signals from the throttle sensors, the ECM monitors and adjusts the mechanical guard and the throttle valve to maintain the cruise control set speed.
- As the driver releases the accelerator pedal, the input shaft disengages from the mechanical guard.
- When accelerating above the set 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

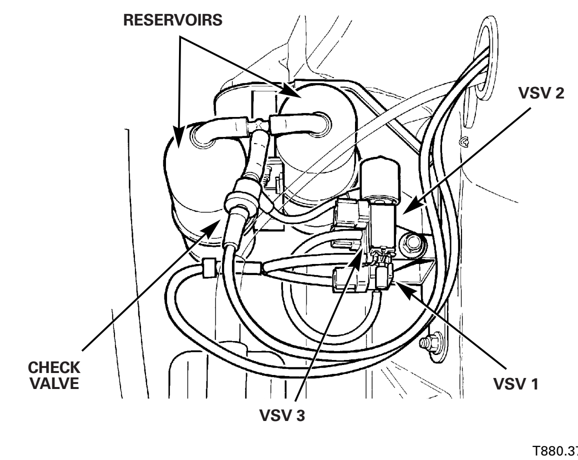
Cruise Control Vacuum Components

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.

CRUISE CONTROL VACUUM COMPONENTS (XK8) – AJ26



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.

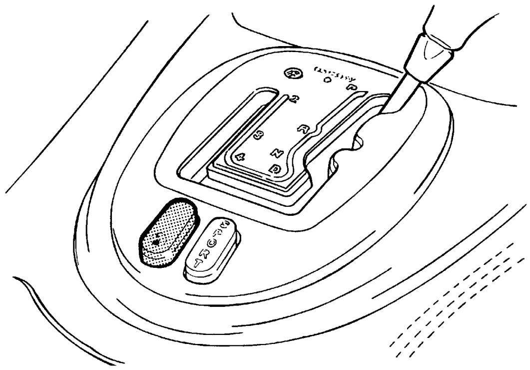
NOTES

INDUCTION AIR THROTTLE CONTROL – AJ26

Cruise Control – AJ26 (continued)

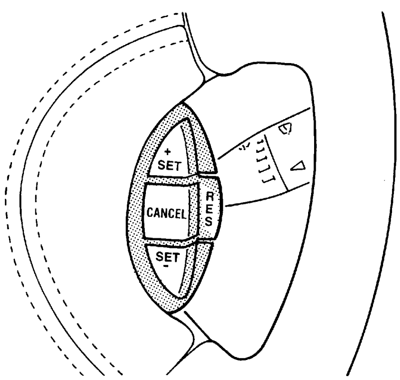
Cruise Control Operation

CRUISE CONTROL MASTER SWITCH



T880.35

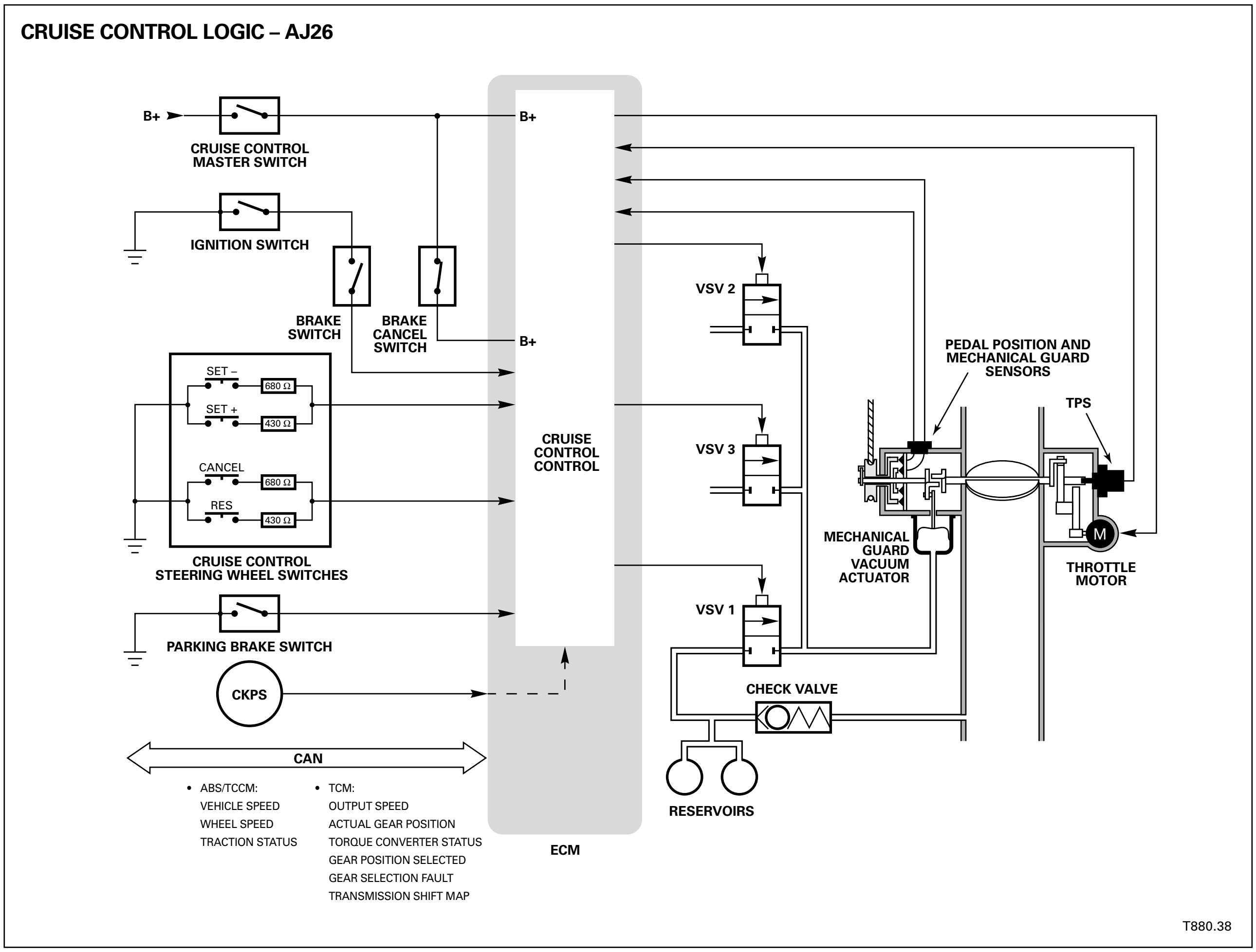
CRUISE CONTROL STEERING WHEEL SWITCHES



T880.36

- 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
B+
CRUISE CONTROL MASTER SWITCH
IGNITION SWITCH
BRAKE SWITCH
BRAKE CANCEL SWITCH
B+
B+
SET –
680 Ω
SET +
430 Ω
CANCEL
680 Ω
RES
430 Ω
CRUISE CONTROL STEERING WHEEL SWITCHES
PARKING BRAKE SWITCH
CKPS
CAN
• ABS/TCCM:
VEHICLE SPEED
WHEEL SPEED
TRACTION STATUS
• TCM:
OUTPUT SPEED
ACTUAL GEAR POSITION
TORQUE CONVERTER STATUS
GEAR POSITION SELECTED
GEAR SELECTION FAULT
TRANSMISSION SHIFT MAP
CRUISE CONTROL CONTROL
ECM
VSV 2
VSV 3
VSV 1
PEDAL POSITION AND MECHANICAL GUARD SENSORS
TPS
M
MECHANICAL GUARD VACUUM ACTUATOR
THROTTLE MOTOR
CHECK VALVE
RESERVOIRS
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.

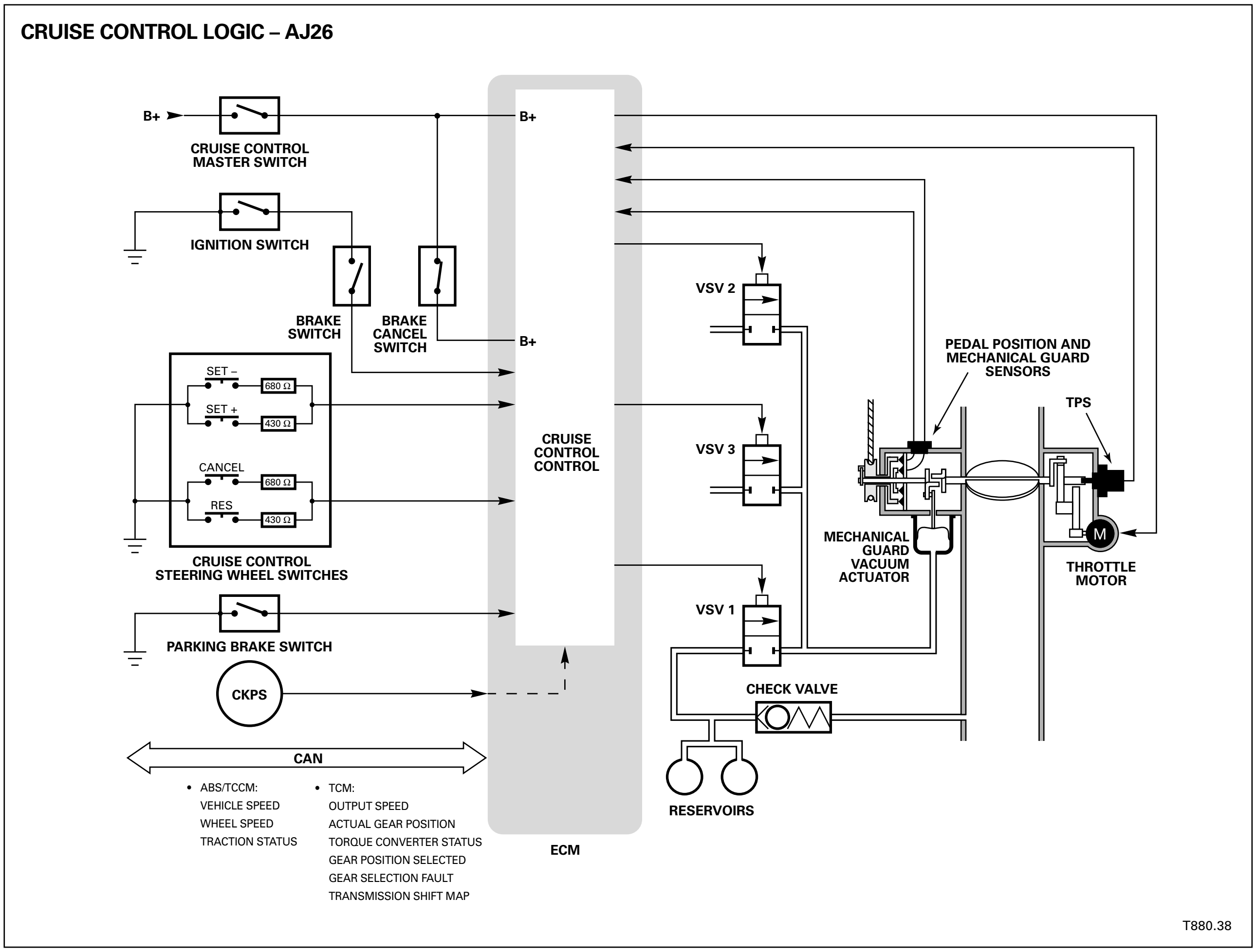
Cruise control disengagement

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
B+
CRUISE CONTROL MASTER SWITCH
IGNITION SWITCH
BRAKE SWITCH
BRAKE CANCEL SWITCH
B+
B+
SET –
680 Ω
SET +
430 Ω
CANCEL
680 Ω
RES
430 Ω
CRUISE CONTROL STEERING WHEEL SWITCHES
PARKING BRAKE SWITCH
CKPS
CAN
• ABS/TCCM:
VEHICLE SPEED
WHEEL SPEED
TRACTION STATUS
• TCM:
OUTPUT SPEED
ACTUAL GEAR POSITION
TORQUE CONVERTER STATUS
GEAR POSITION SELECTED
GEAR SELECTION FAULT
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VSV 3
VSV 1
CHECK VALVE
RESERVOIRS
PEDAL POSITION AND MECHANICAL GUARD SENSORS
TPS
MECHANICAL GUARD VACUUM ACTUATOR
M
THROTTLE MOTOR
T880.38

INDUCTION AIR THROTTLE CONTROL – AJ27

Full Authority Electronic Throttle Control

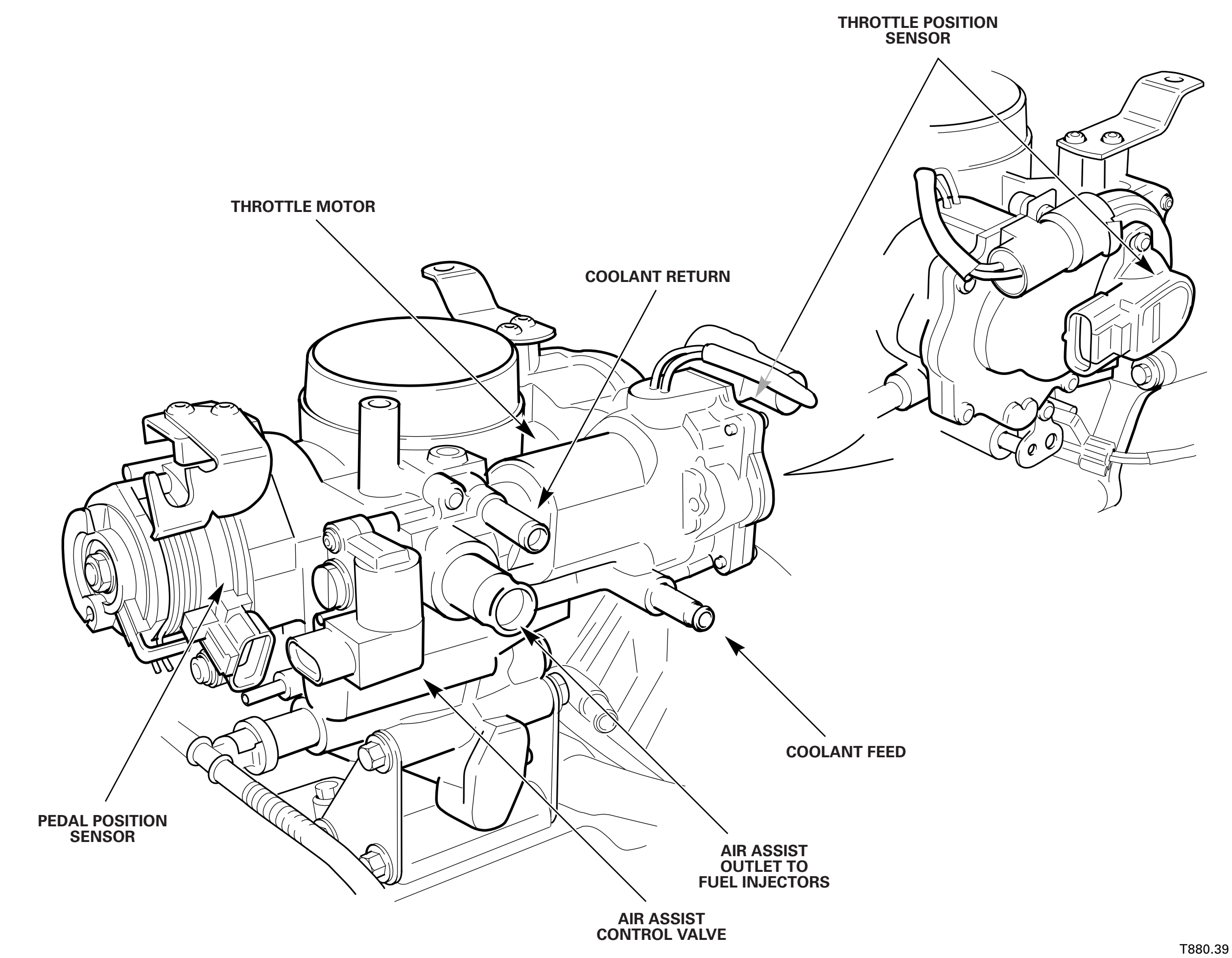
A full authority throttle body is fitted to the AJ27 engine. The throttle body does not incorporate a mechanical guard.

The main features of the AJ27 throttle body are:

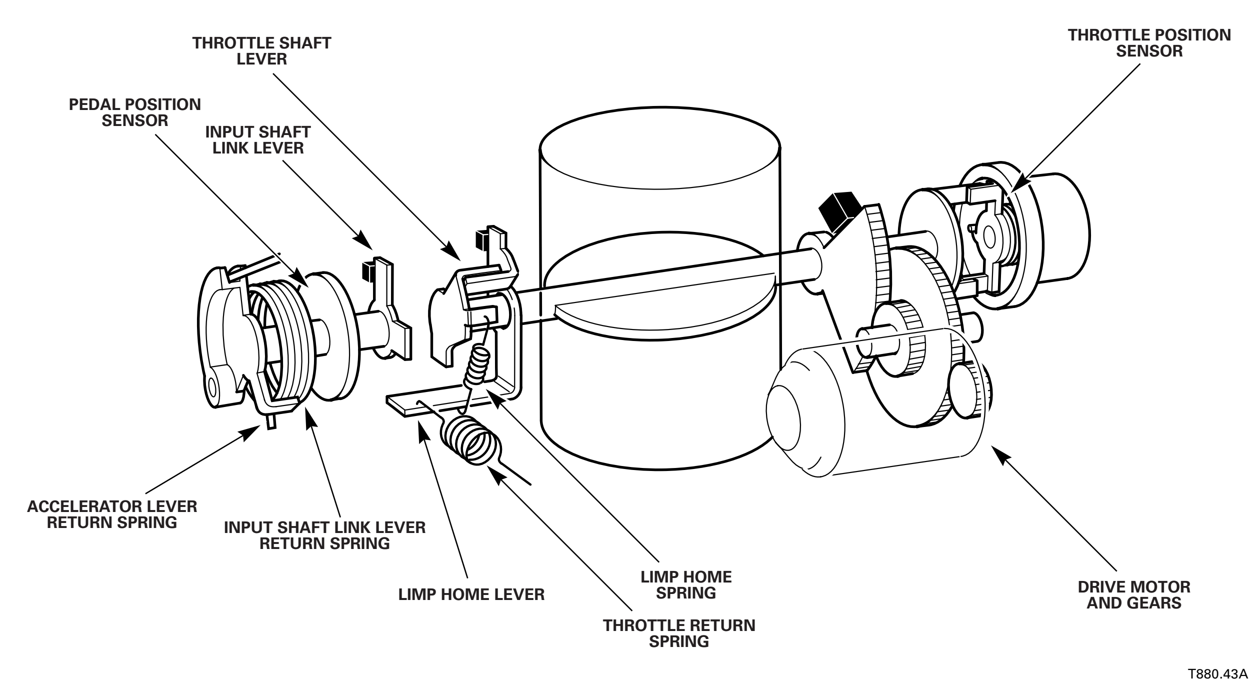
- Full motorized control of the throttle valve from the ECM
- Mechanical, cable operated 'limp home' fail safe mode (restricted throttle opening)
- Mechanical, electrical and software safety features
- ECM cruise control drive (no vacuum components)
- Built-in air assist control valve (AACV) with integral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

Throttle Components

THROTTLE BODY – AJ27 N/A



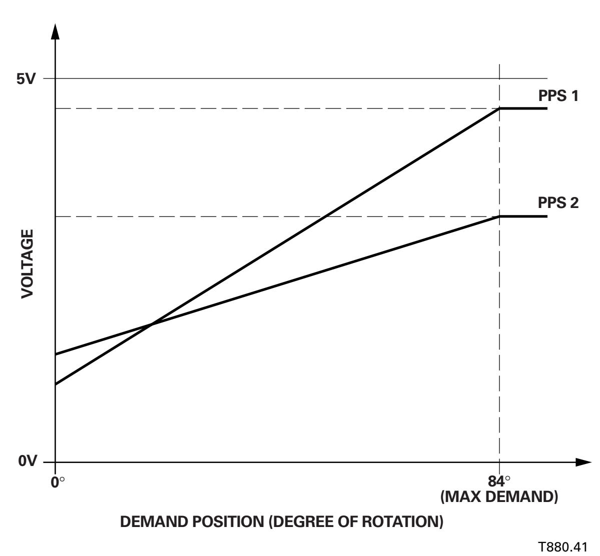
THROTTLE BODY COMPONENTS – AJ27



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.

PPS CHARACTERISTIC – AJ27



Pedal position sensor (PPS)

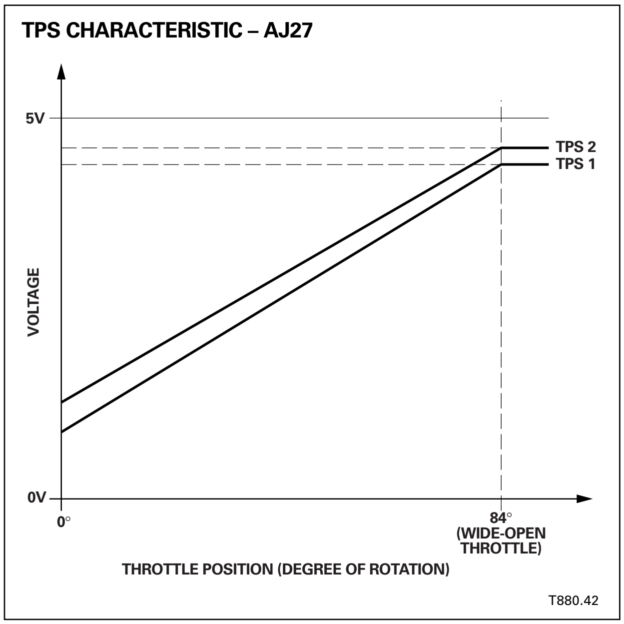
- Two individual rotary potentiometers comprise the PPS assembly located at the cable end of the throttle.
- The potentiometers are rotated by the throttle cable lever and provide separate analog voltage signals to the ECM proportional to pedal movement and position.
- The potentiometers have common 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).

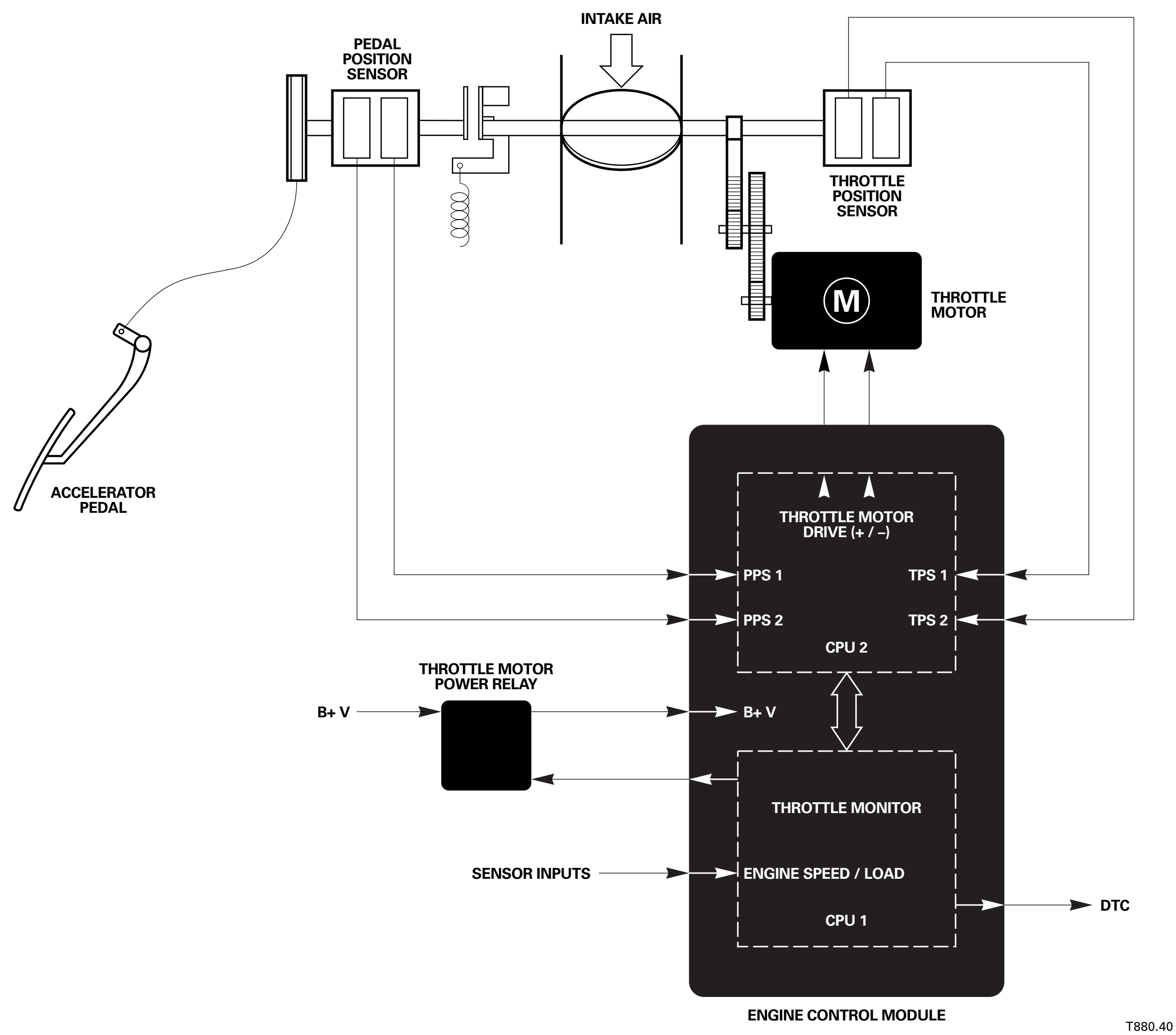
NOTES

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.

ECM THROTTLE CONTROL AND MONITORING – AJ27



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.

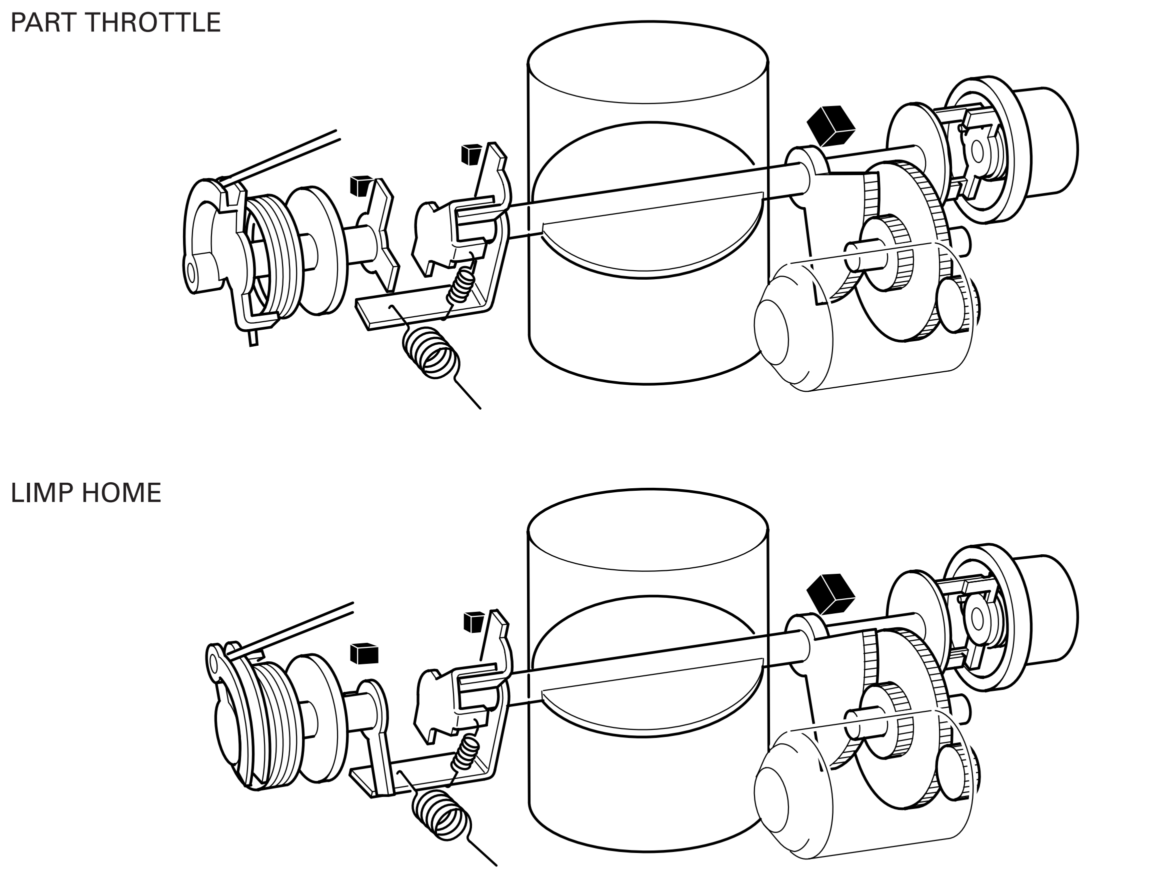
Limp Home Operation

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



NOTES

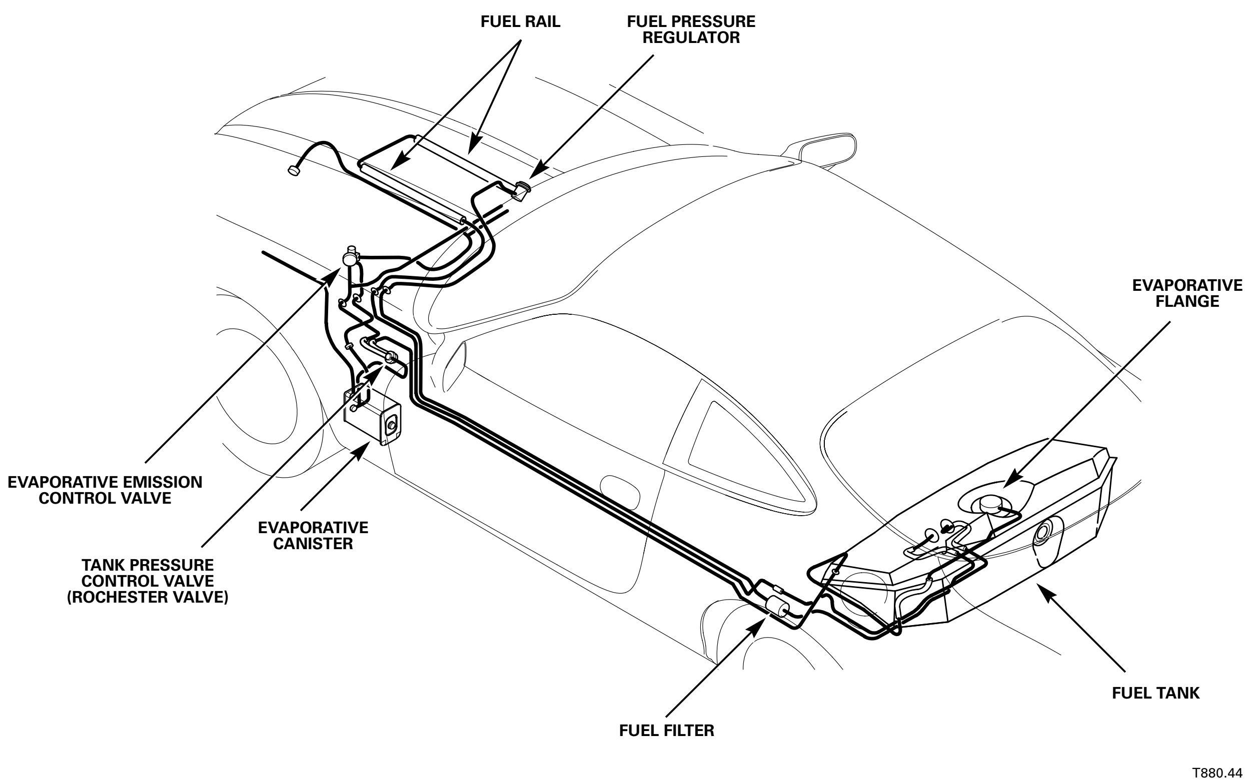
AJ26 / AJ27
ENGINE MANAGEMENT SYSTEMS

Service Training Course 881
DATE OF ISSUE: 9/2001

FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

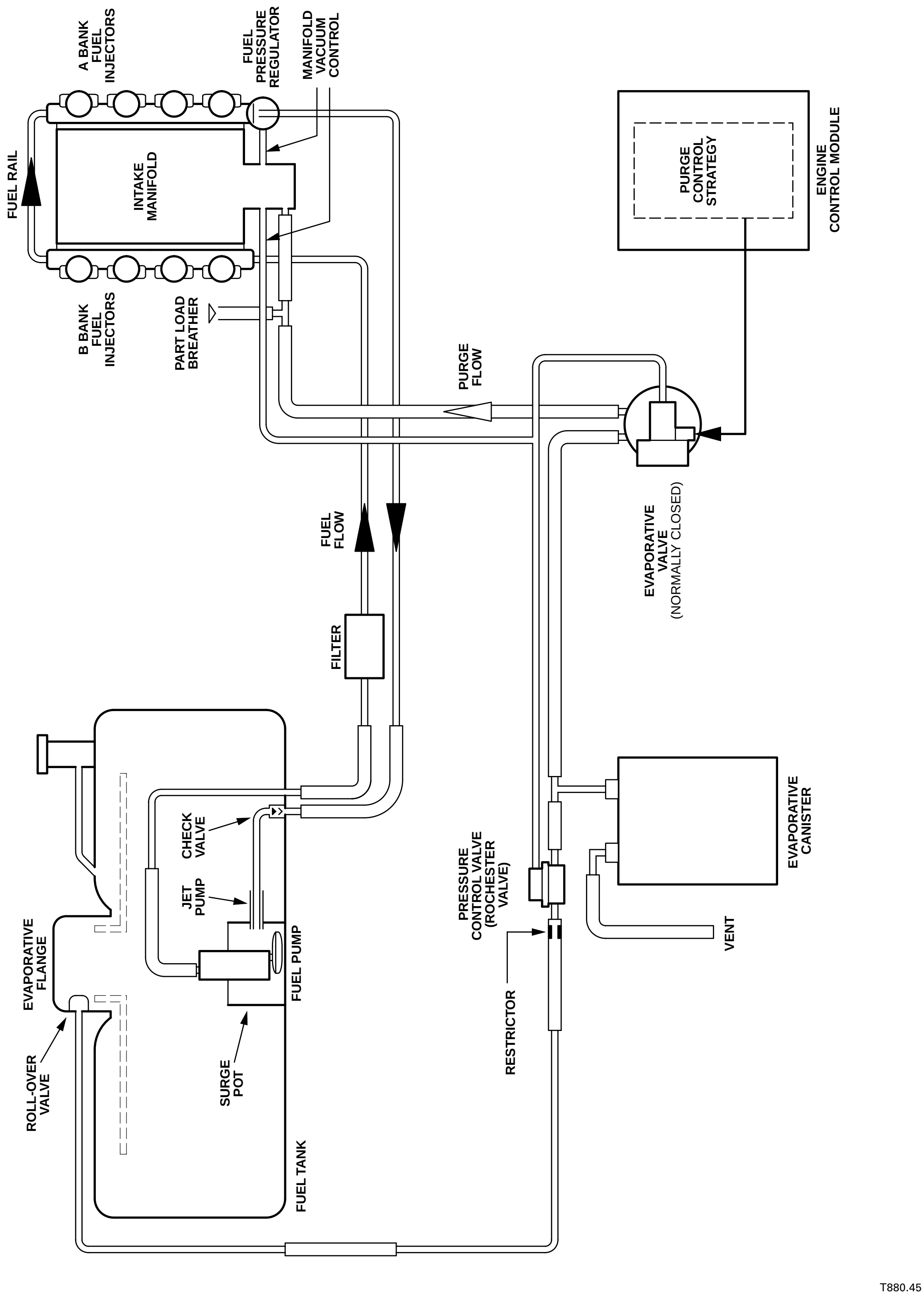
The fuel system uses a rear mounted over-axle fuel tank installed in the trunk. Fuel and vapor pipes travel under the left hand side of the vehicle to the engine and evaporative emission components.

FUEL SYSTEM – AJ26 WITHOUT ENHANCED EVAPORATIVE EMISSION CONTROL



NOTES

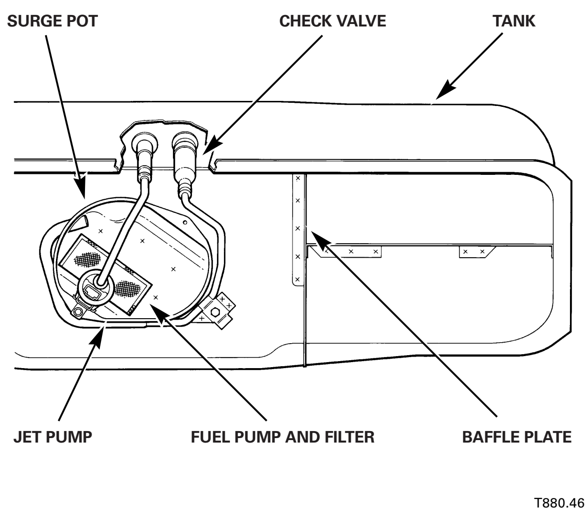
FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL SYSTEM – AJ26 WITHOUT ENHANCED EVAPORATIVE EMISSION CONTROL



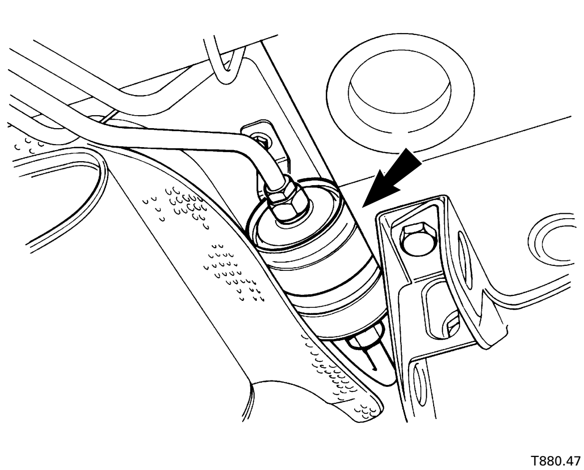
FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

Fuel Delivery

FUEL TANK ARRANGEMENT – XK8



FUEL FILTER – XK8



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

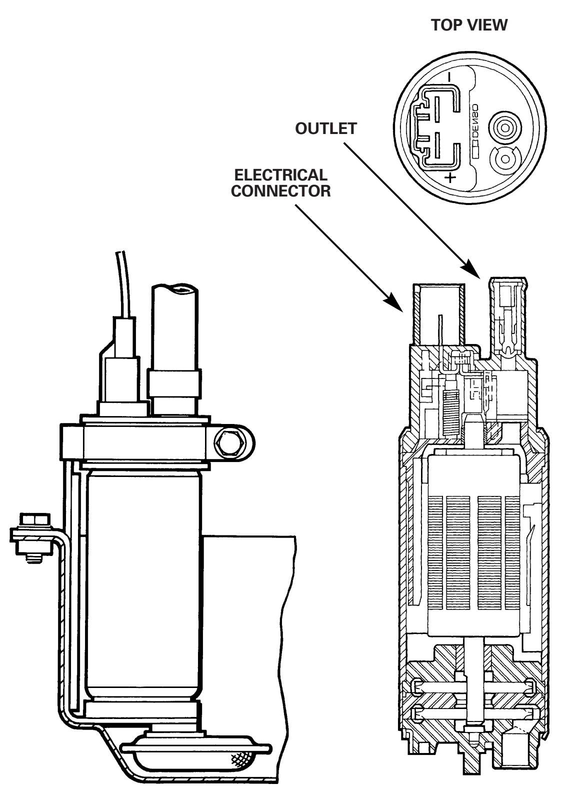
- The fuel level sensor is a conventional potentiometer that provides the instrument pack (INST) with a variable voltage signal indicating fuel tank fill level.
- The fill level signal voltage ranges between approximately B+ at empty to 0 V at full.
- The INST transmits two fuel level CAN messages: CAN 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 WITH CROSS-SECTION



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

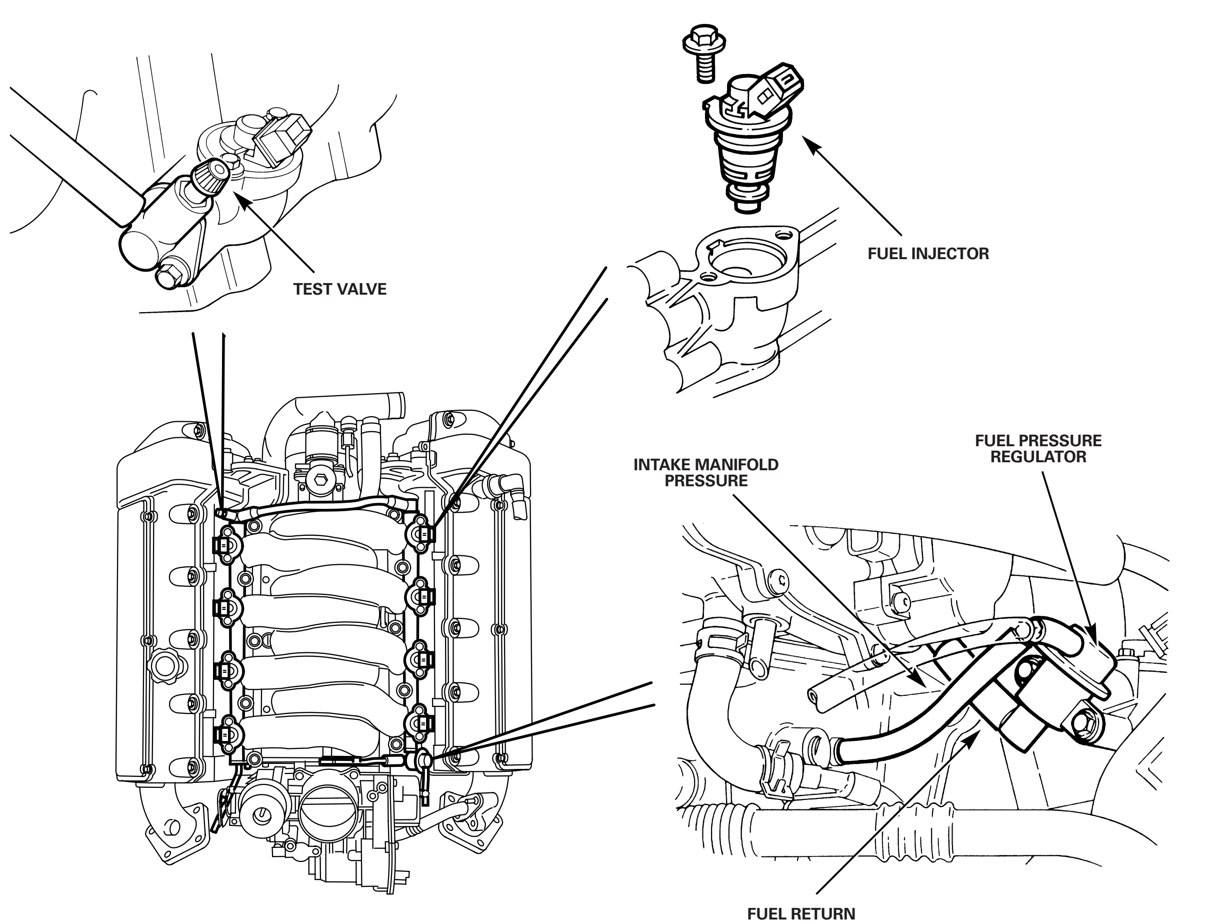
FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

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.

INTAKE MANIFOLD, FUEL RAILS AND FUEL PRESSURE REGULATOR – AJ26 N/A

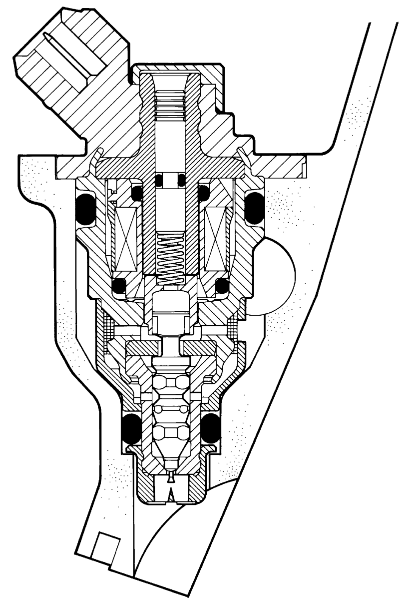


Fuel Injectors – AJ26

- 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

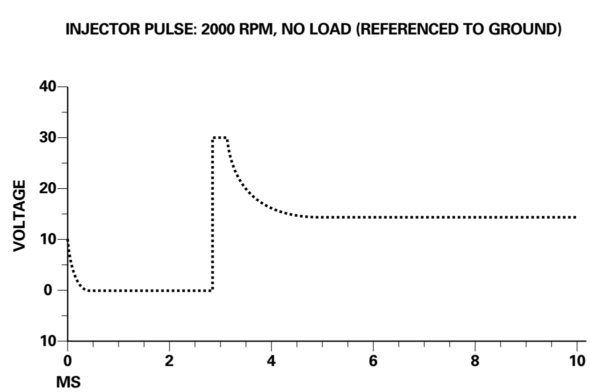
FUEL INJECTOR CROSS-SECTION – AJ26 N/A



RESISTANCE: 14.5 Ω @ 20˚C (68˚F)

T880.50

FUEL INJECTOR CHARACTERISTIC (TYPICAL)



T880.51

FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

Evaporative Emission Control System – 1997 MY

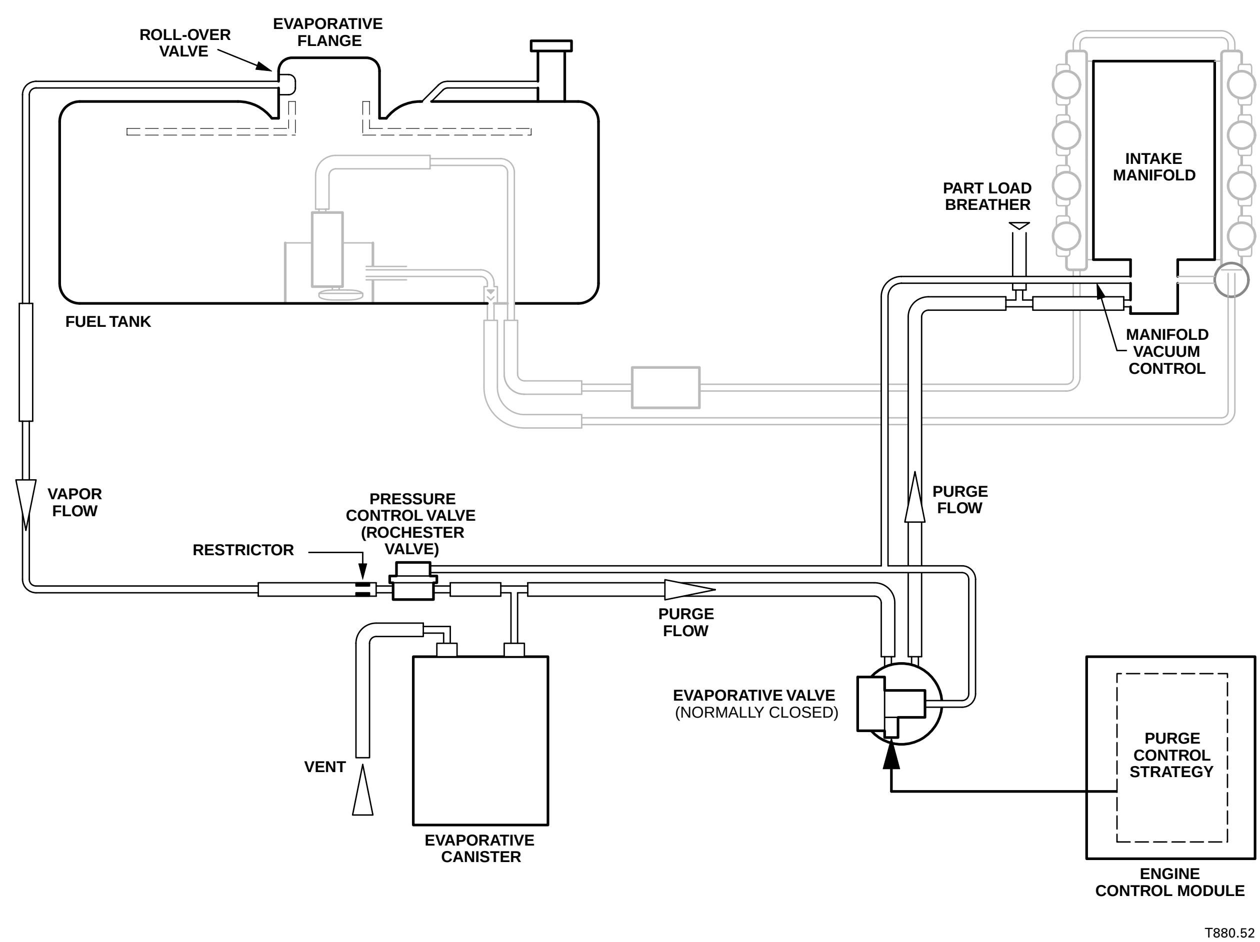
The fuel tank can be filled to approximately 90% of its capacity. The additional 10% of volume allows for expansion of the fuel, without escape to the atmosphere.

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).

EVAPORATIVE EMISSION CONTROL SYSTEM



T880.52

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:

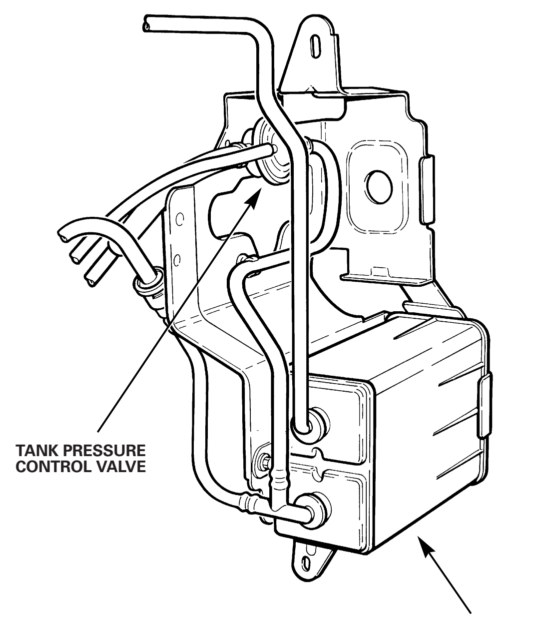
- Engine load and speed
- Coolant temperature
- Time since engine starting
- Closed loop fuel metering correction

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

Determination of fuel vapor concentration

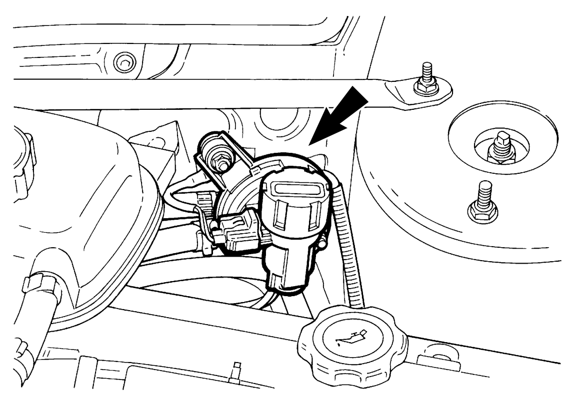
- The ECM determines the concentration of fuel vapor being drawn from the charcoal canister and makes a correction to the base fuel metering map.
- The determination is made by the ECM making step changes to the purge flow rate while no correction is made to the fuel metering calculation.
- The ECM determines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

EVAPORATIVE CANISTER ASSEMBLY



T880.53

EVAPORATIVE EMISSION CONTROL VALVE (EVAPP)



T880.54

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)

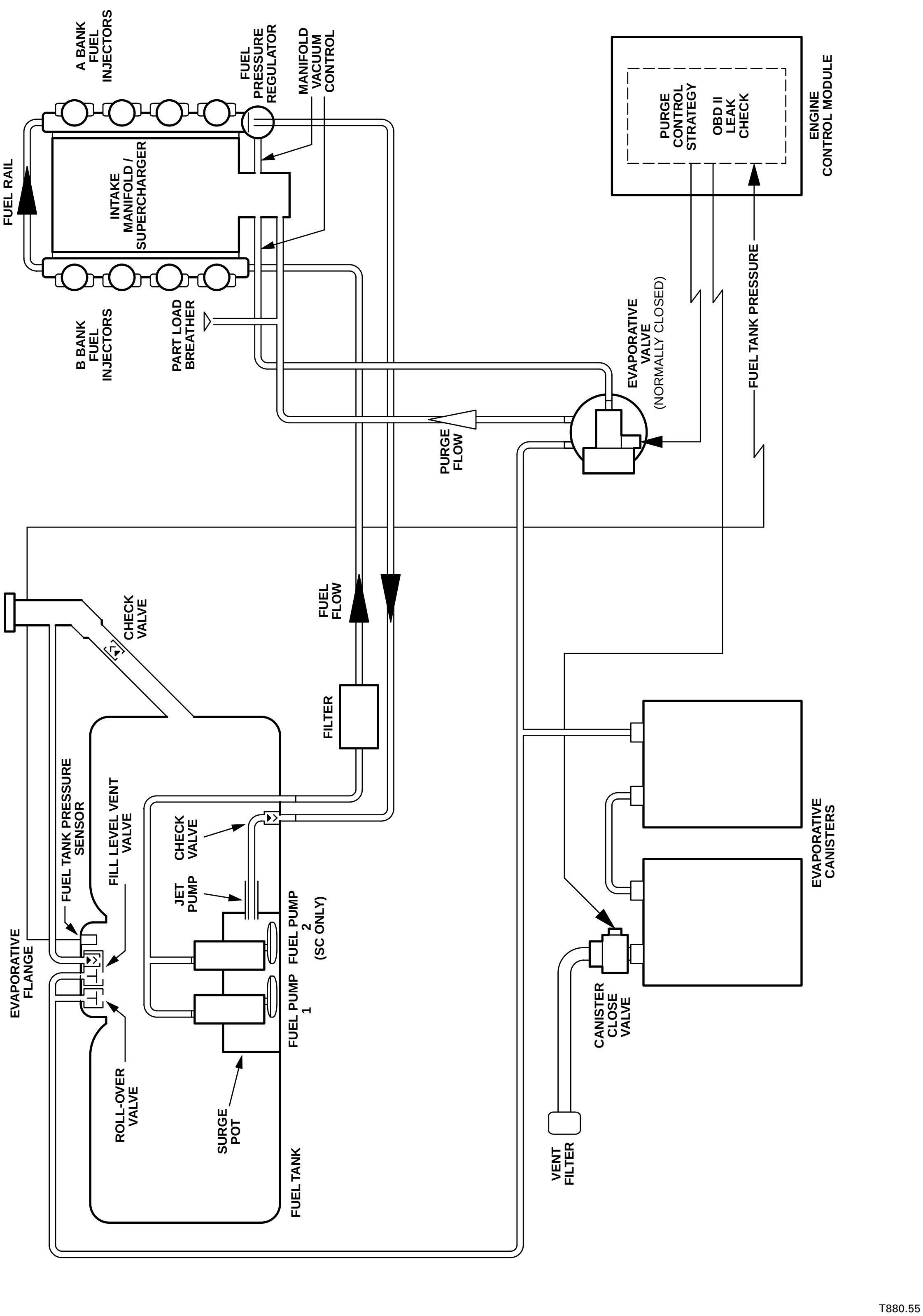
Enhanced Evaporative Emission Control System Operation

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

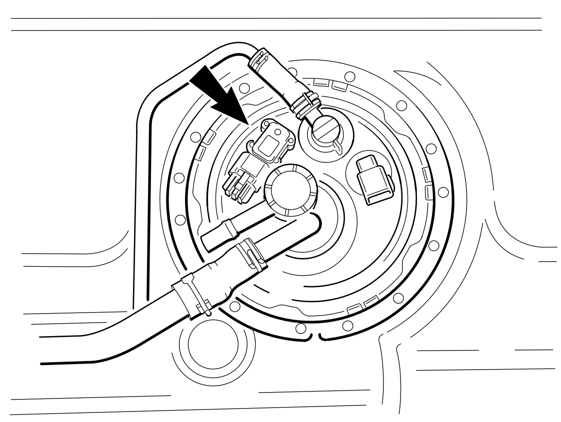
FUEL DELIVERY AND ENHANCED EVAPORATIVE EMISSION CONTROL SYSTEM – AJ26



FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

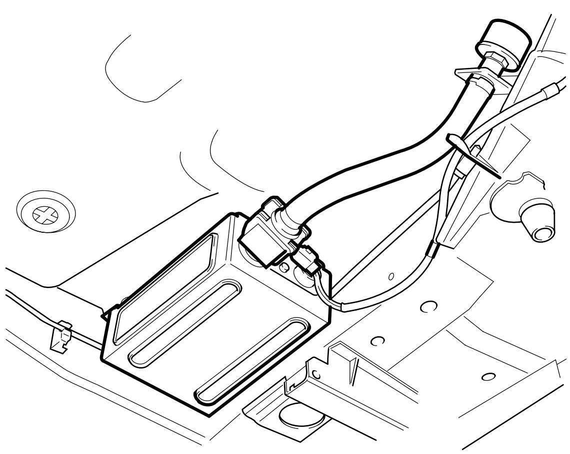
Enhanced Evaporative Emission Control System – 1998 MY ON (continued)

FUEL TANK PRESSURE SENSOR



T880.56

CANISTER CLOSE VALVE AND FILTER – XJ8 SEDAN



T880.57

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.

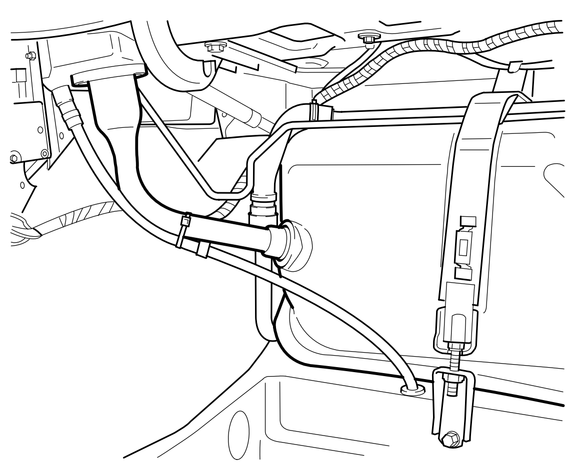
NOTES

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.

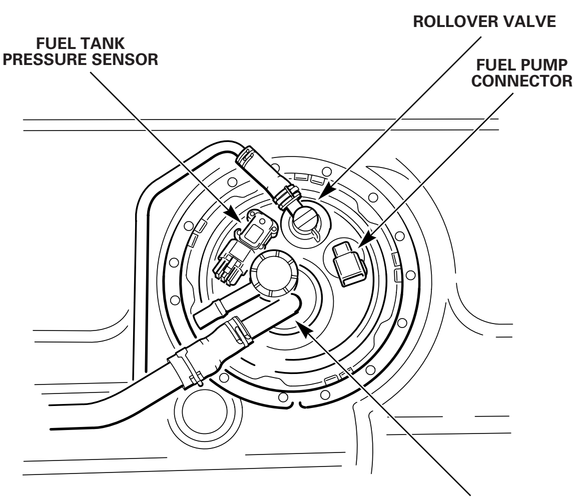
NOTES

ORVR FUEL TANK – XJ8 SEDAN



T880.58

FUEL TANK EVAPORATIVE FLANGE



T880.59

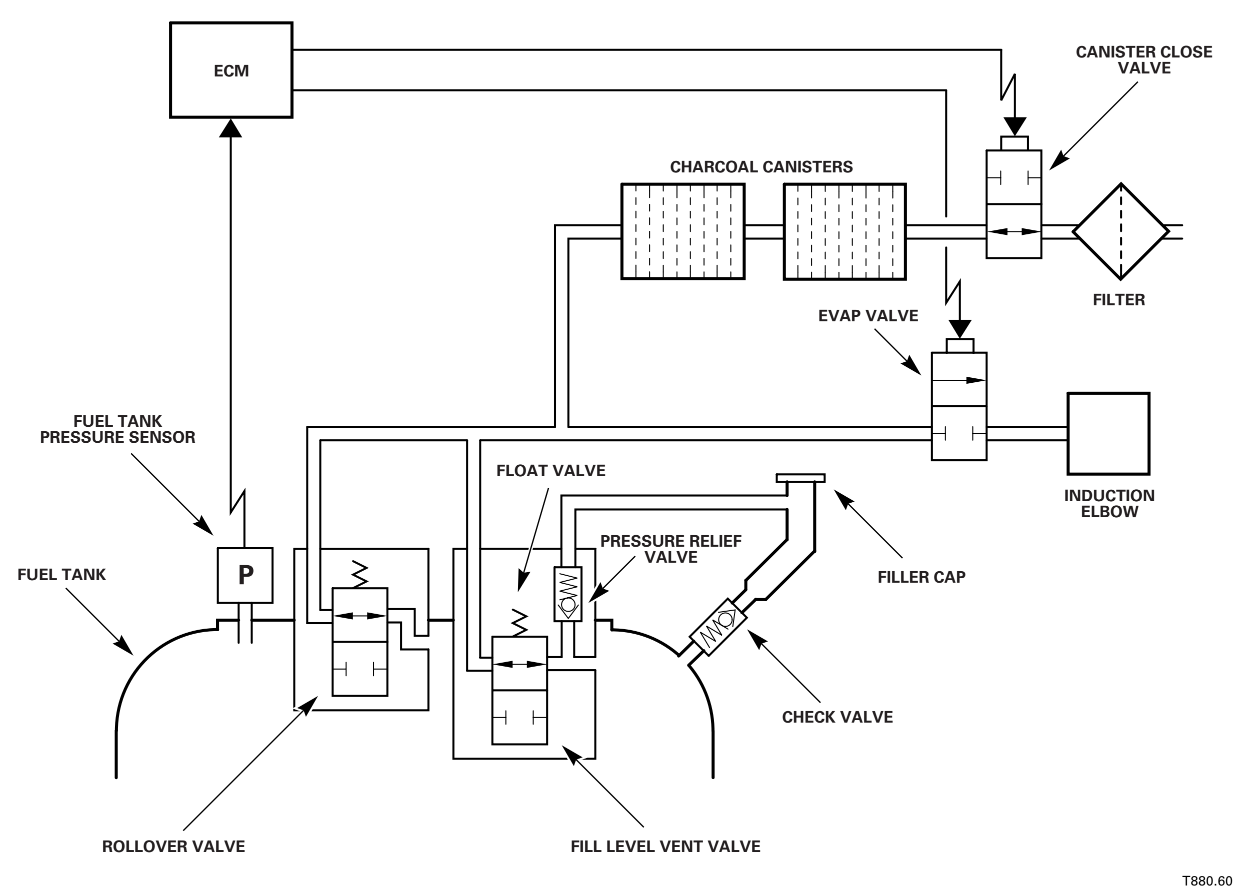
FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

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.

ORVR SYSTEM

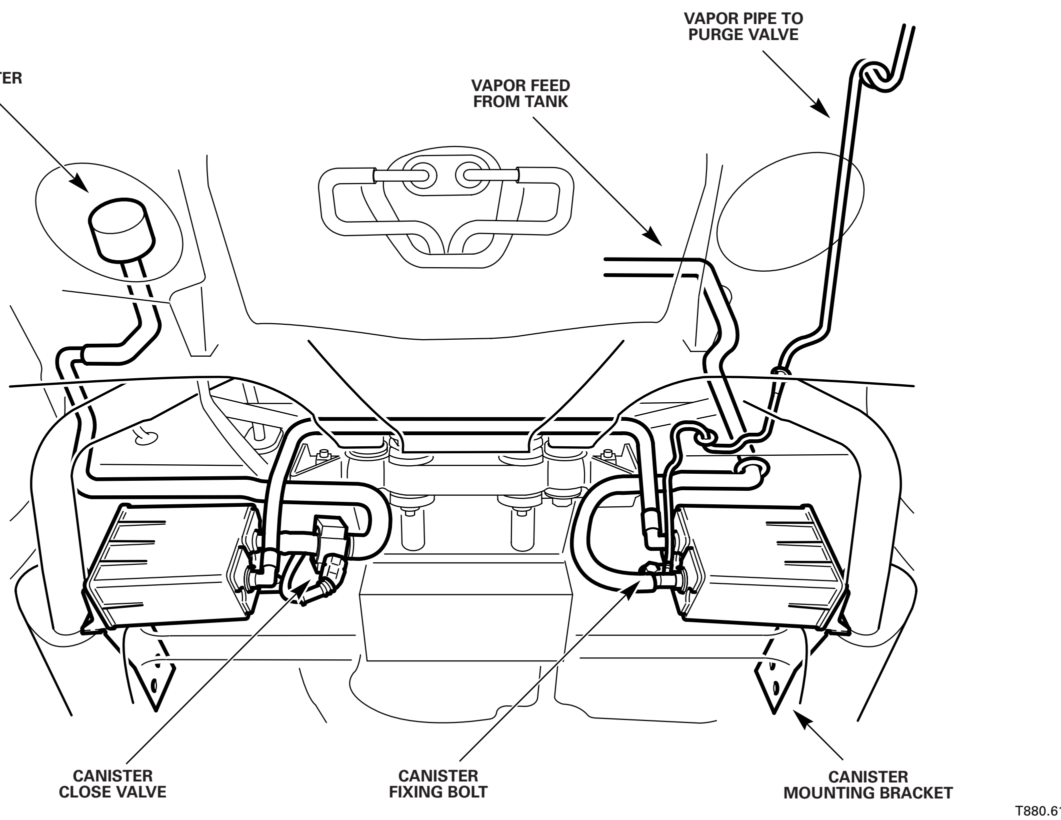


NOTES

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.

EVAP CANISTER INSTALLATION – XK8



NOTES

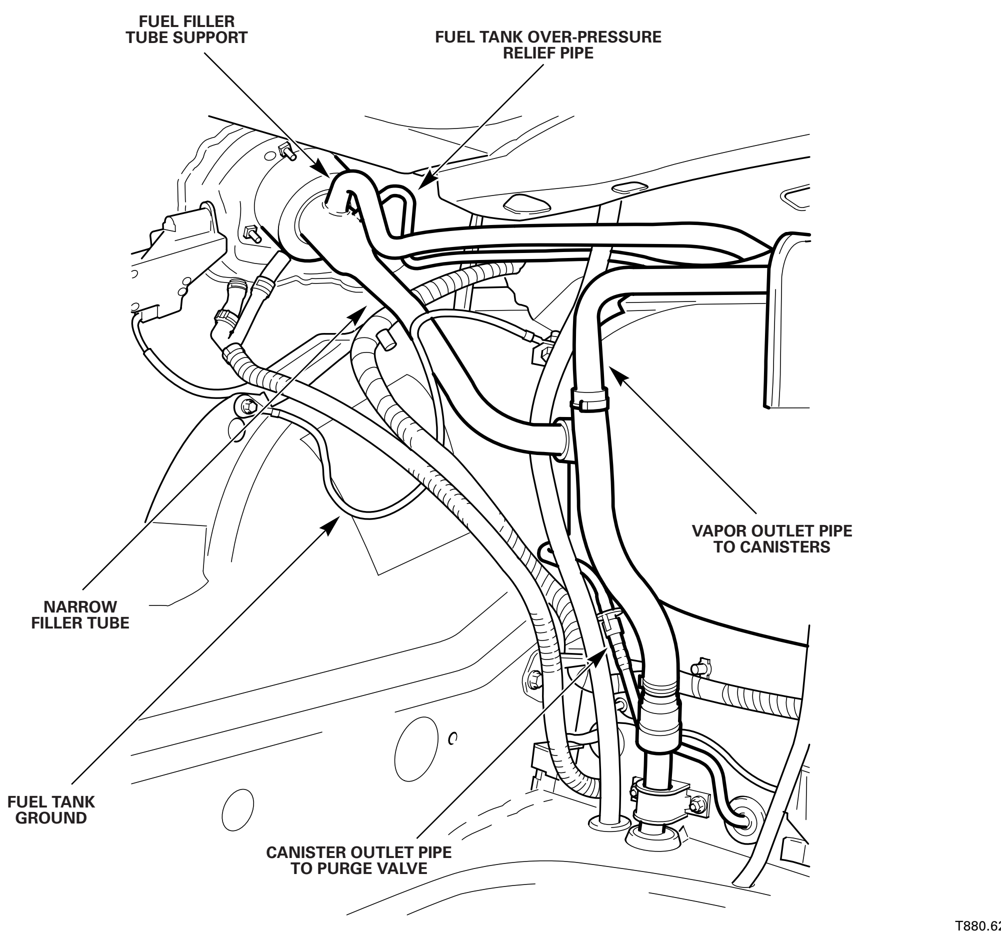
FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

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.

FUEL TANK – XK8



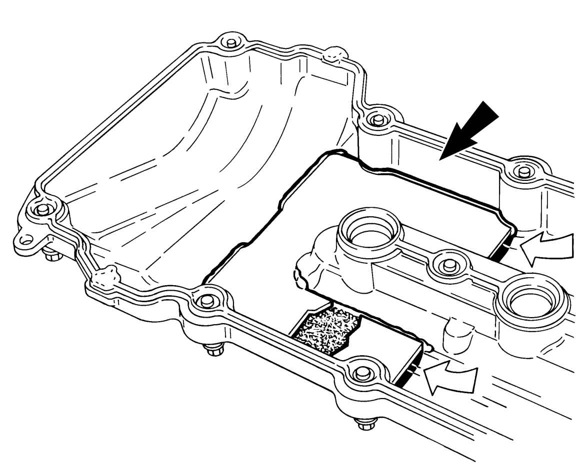
NOTES

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.

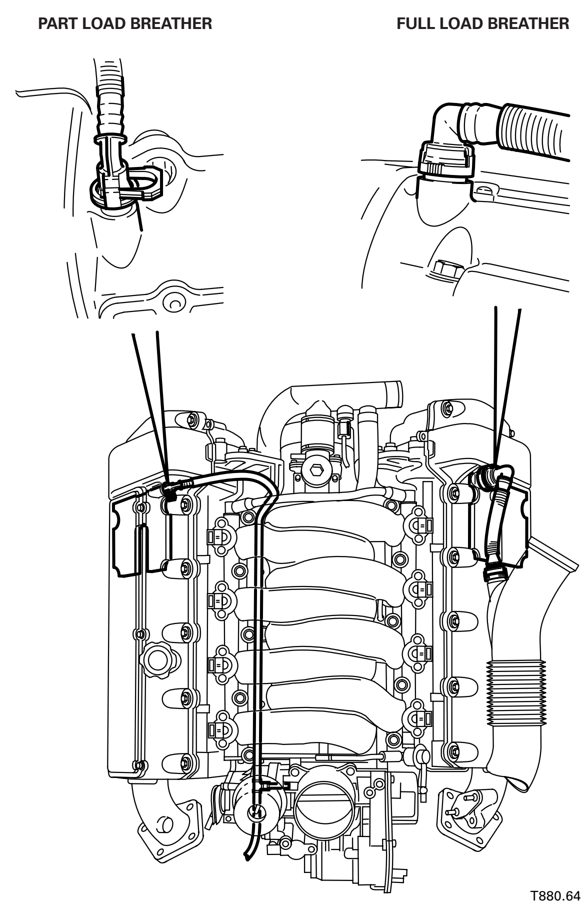
NOTES

AIR / OIL SEPARATOR



T880.63

CRANKCASE VENTILATION SYSTEM



T880.64

AJ26 / AJ27
ENGINE MANAGEMENT SYSTEMS

AJ26/27 V8

JAGUAR

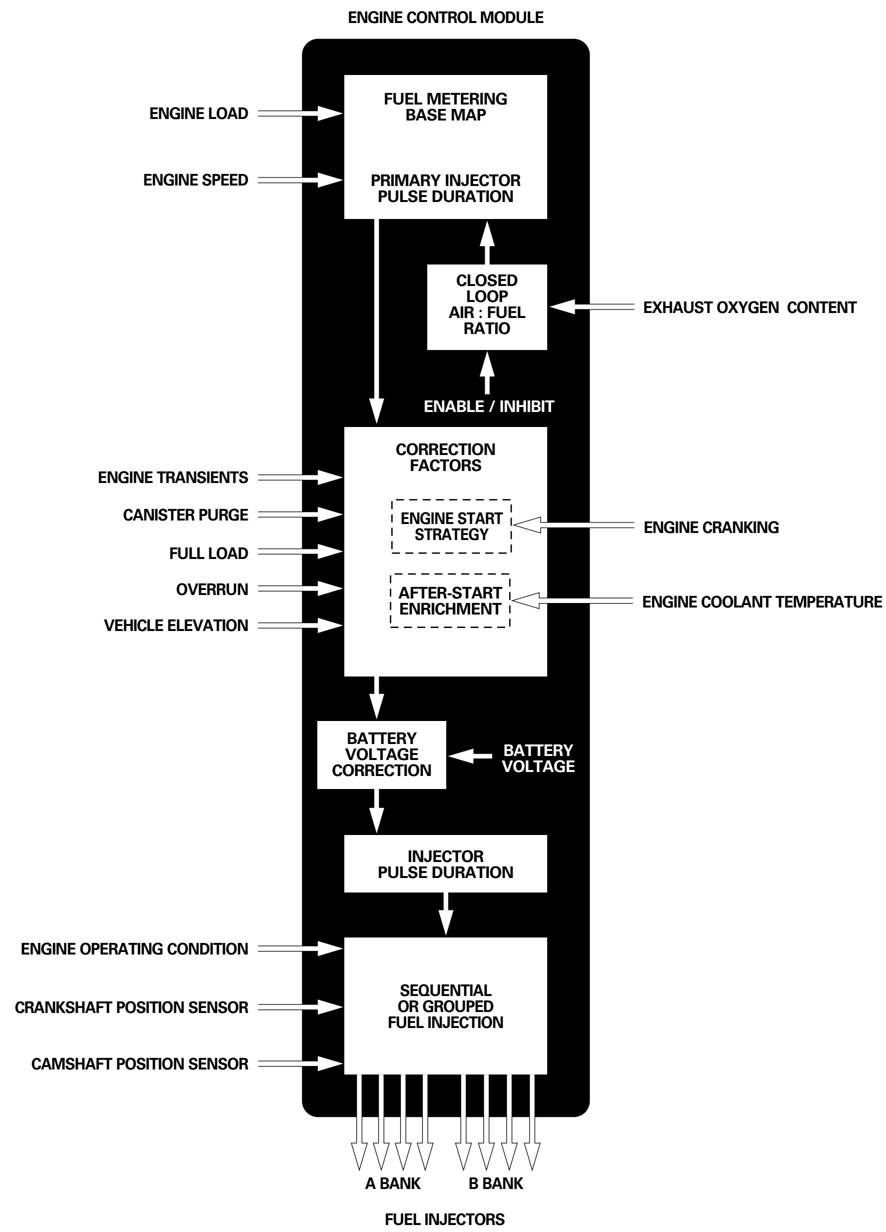
Service Training Course 881
DATE OF ISSUE: 9/2001

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.

FUEL METERING STRATEGY



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

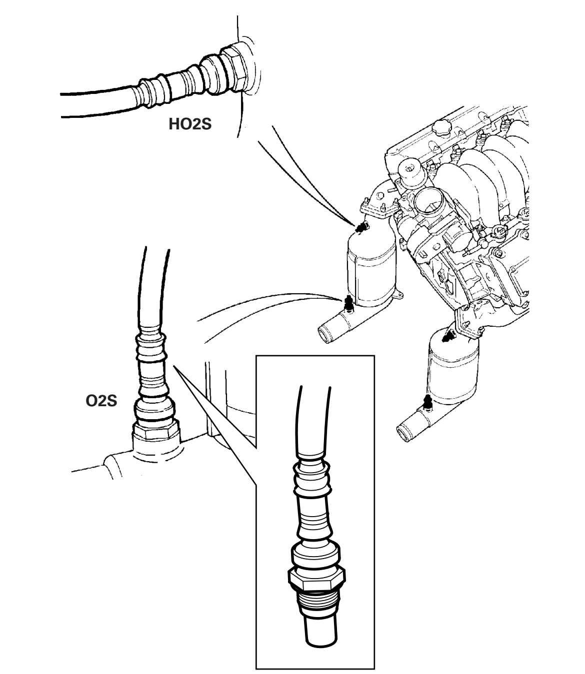
Fuel injection intervention is used for traction / stability control.

NOTES

FUEL INJECTION

Exhaust Gas Oxygen Content Monitoring: Oxygen Sensors – AJ26

OXYGEN SENSORS – AJ26



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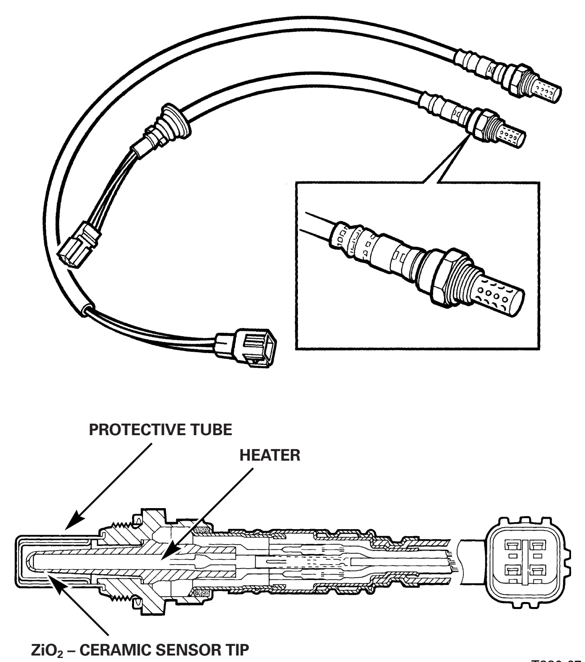
HEATED OXYGEN SENSOR WITH CROSS-SECTION – AJ26



T880.67

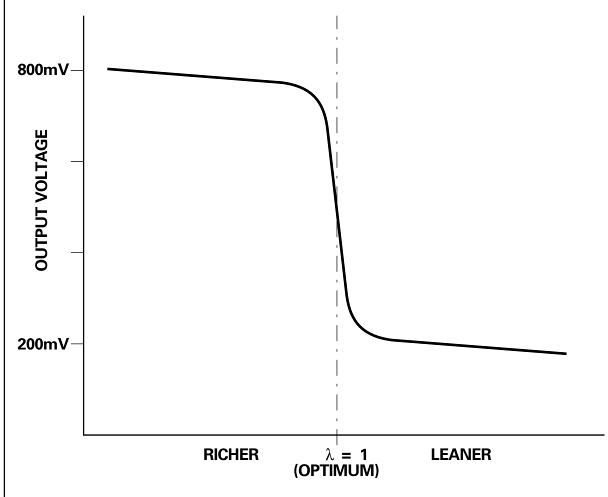
- The AJ26 EMS uses four zirconium dioxide type oxygen sensors.
- A heated oxygen sensor (HO2S) is located upstream of each catalytic converter; an unheated oxygen sensor (O2S) is located downstream of each catalytic converter.
- The two upstream sensors are used by the ECM for closed loop fuel metering 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.

OXYGEN SENSOR CHARACTERISTIC – AJ26

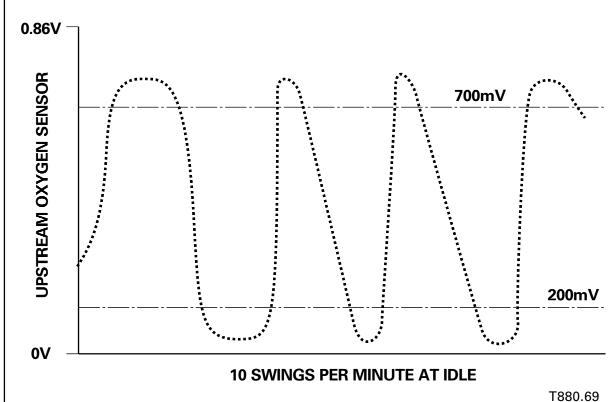


Catalytic Converters – AJ26

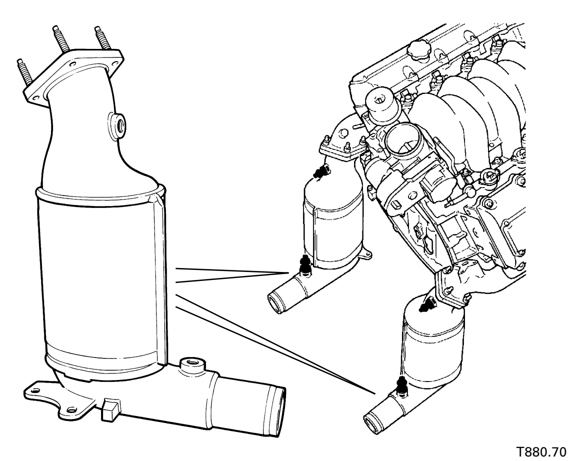
The AJ26 engine exhaust system uses a single catalytic converter for each engine bank. The placement of the catalysts in the down pipes, adjacent to the exhaust manifolds, ensures rapid “light off” and eliminates the need for secondary catalysts.

Deterioration of catalytic conversion efficiency will create unacceptable HC, CO and NOx 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.

OXYGEN SENSOR VOLTAGE SWING TRACE – UPSTREAM AJ26



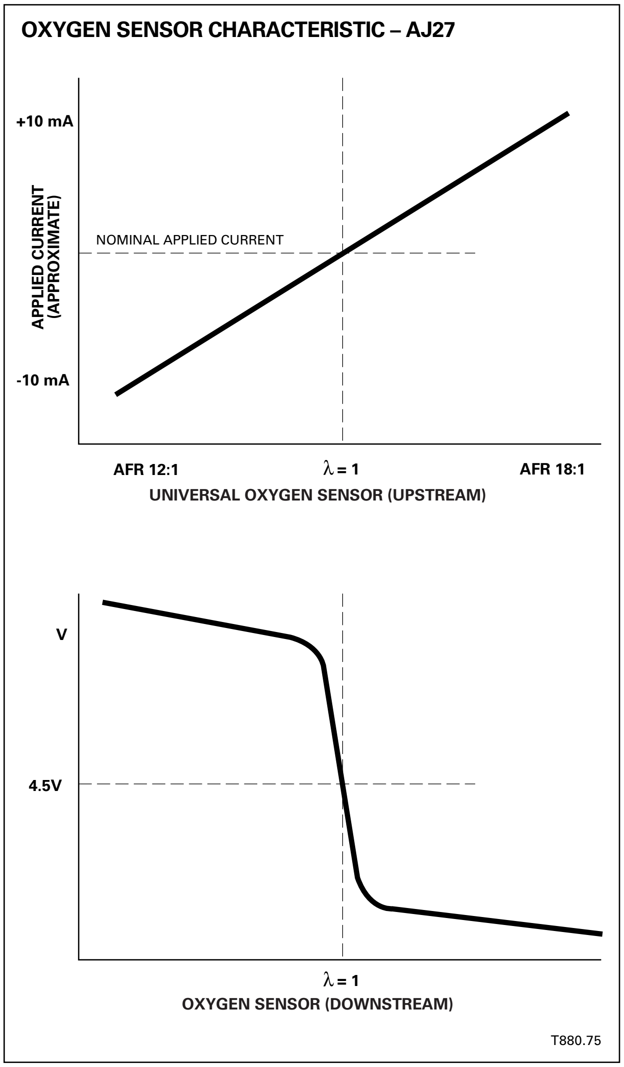
CATALYTIC CONVERTERS – AJ26



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

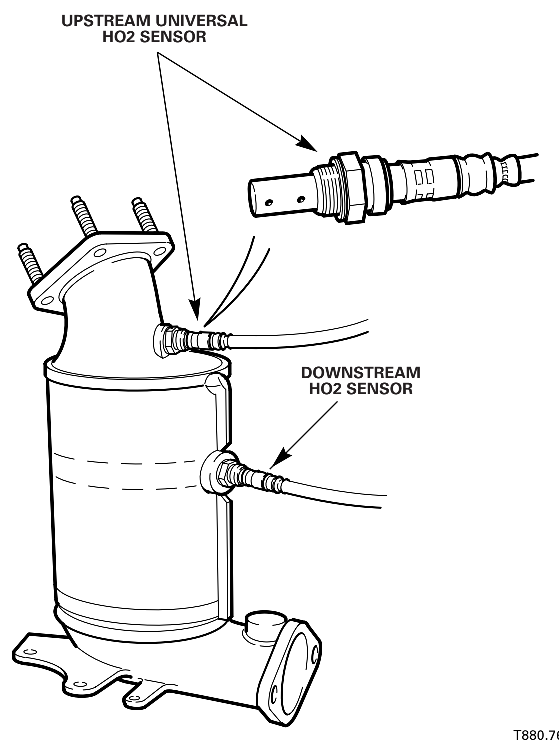
Catalytic Converters – AJ27

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.

SPLIT ELEMENT CATALYTIC CONVERTER



NOTES

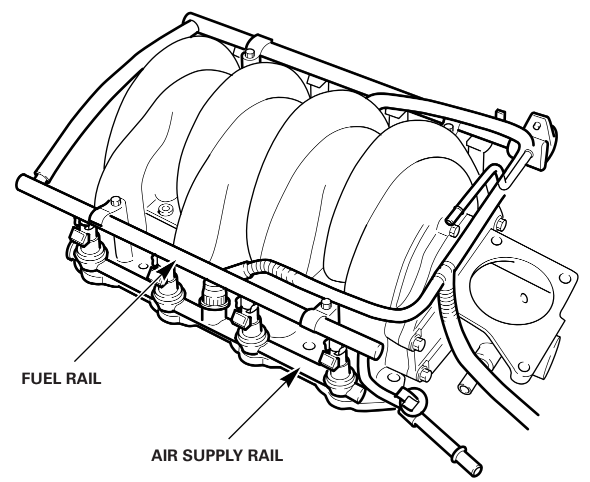
FUEL INJECTION

Air Assisted Fuel Injection – AJ27

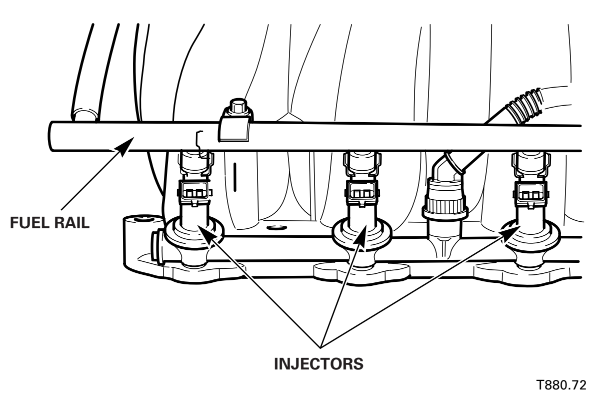
Air assisted fuel injection (AAI) improves combustion stability when the engine is cold, allowing the use of increased ignition retardation for faster catalyst warm-up, thus producing a further reduction of HC emission.

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.

AAI INTAKE MANIFOLD – AJ27



FUEL RAIL AND INJECTORS – AJ27



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

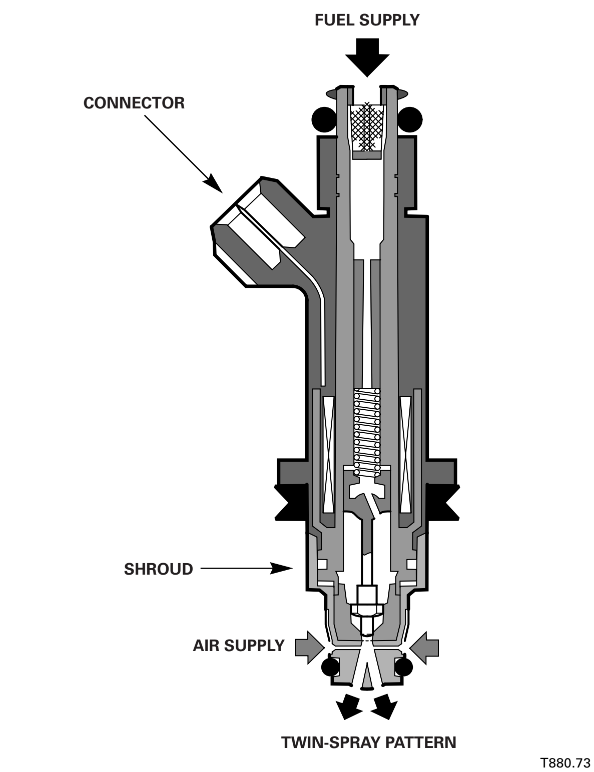
- The injectors incorporate a shroud fitted over the nozzle end to direct the AAI air flow.
- Air from the supply rail is drawn by manifold vacuum through four small holes in the side of the shroud and past the fuel nozzle to exit via the two spray orifices in the shroud.
- When fuel is injected into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

Air Assist Control Valve (AACV)

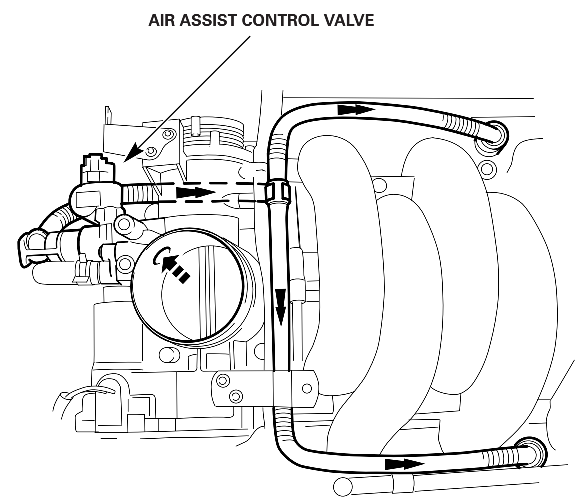
- The air supply to the injectors is controlled by the solenoid operated air assist control valve (AACV), which is bolted to the throttle body.
- The control valve receives air, via an integral passage in the throttle body, from an entry hole in the upper throttle bore above the throttle valve.
- The 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

AAI FUEL INJECTOR CROSS-SECTION – AJ27



AAI SYSTEM – AJ27



AJ26 / AJ27
ENGINE MANAGEMENT SYSTEMS

Service Training Course 881
DATE OF ISSUE: 9/2001

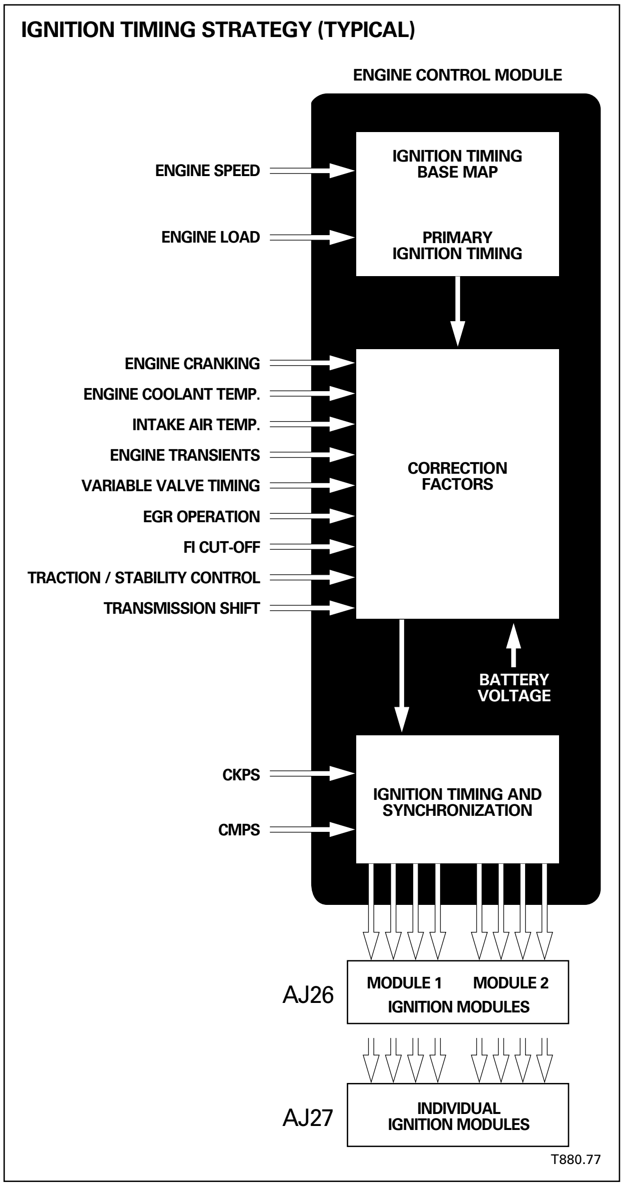
IGNITION

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

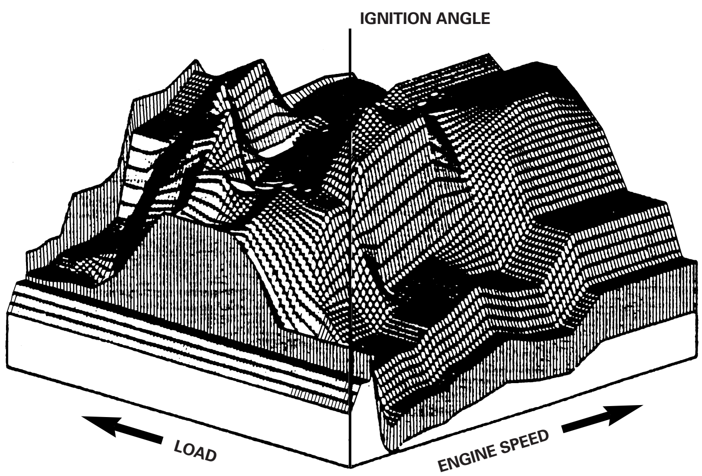
- Ignition timing corrections are applied to the ignition map by the ECM to compensate for variations in intake air temperature and engine coolant temperature.

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

BASE IGNITION MAP (TYPICAL)



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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.

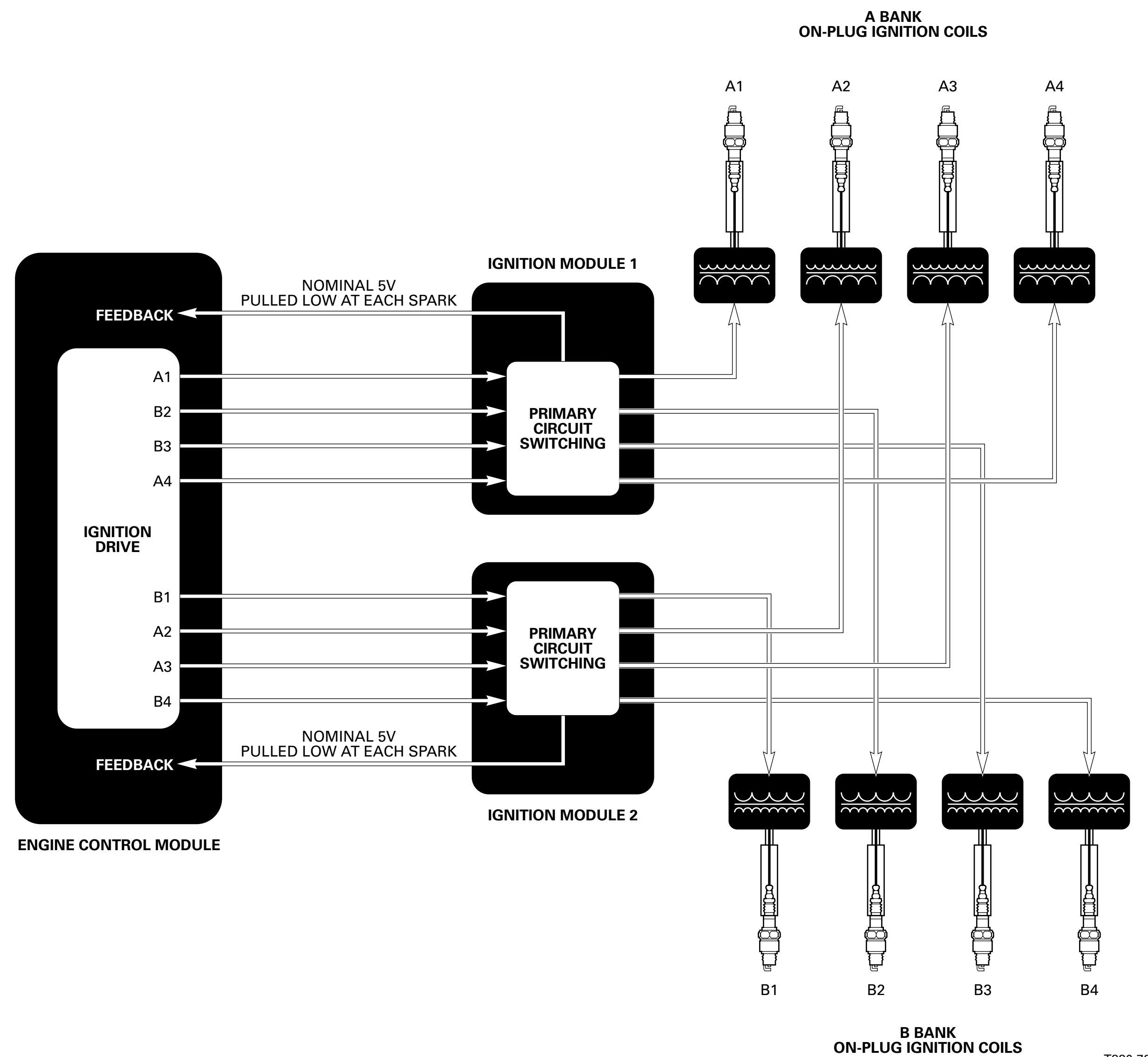
IGNITION

Ignition Coils and Modules – AJ26

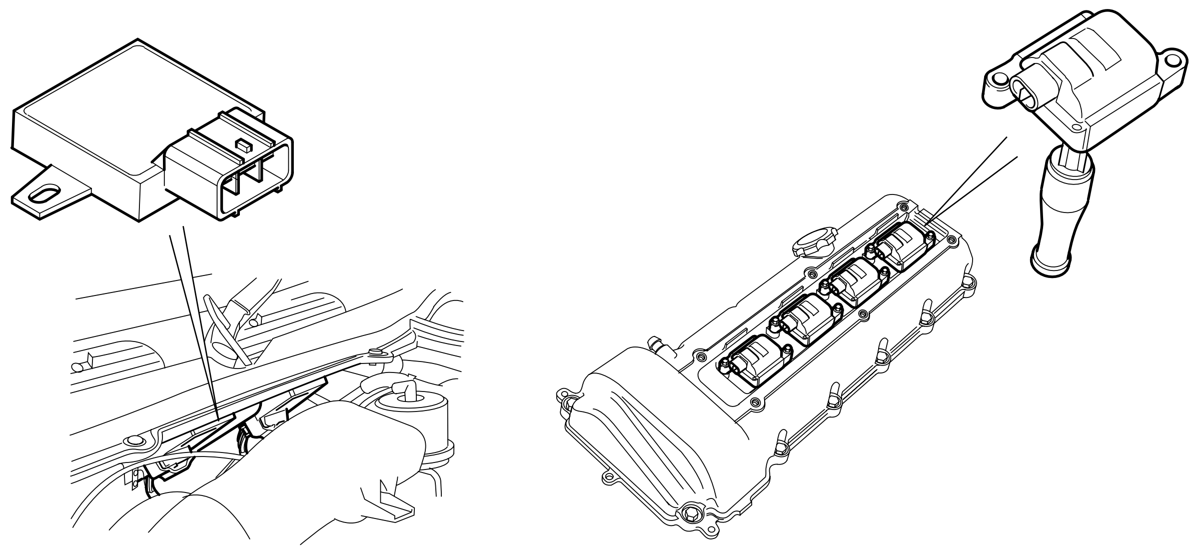
Two ignition modules (amplifiers) are installed. The modules receive ignition drive signals from the ECM and, in turn control the primary current switching of the on-plug ignition coils. Dwell control for the ignition system is performed within the ECM.

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

IGNITION ARRANGEMENT – AJ26



IGNITION COILS AND MODULES – XK8 AJ26



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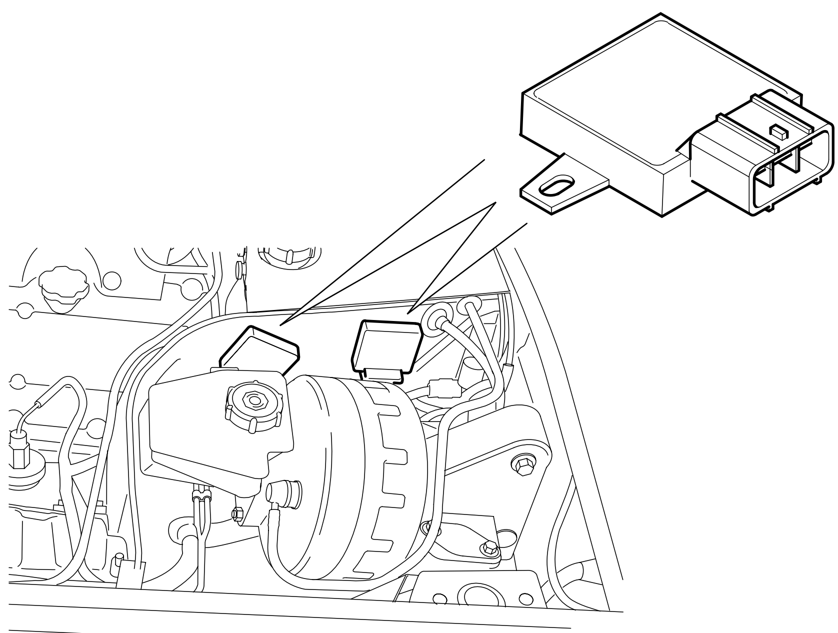
IGNITION MODULES – XJ8 AJ26



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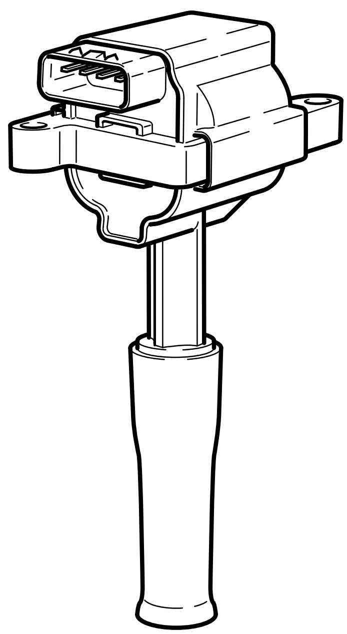
NOTES

IGNITION

Ignition Coil-on-Plug Units – AJ27

COIL-ON-PLUG IGNITION UNIT – AJ27



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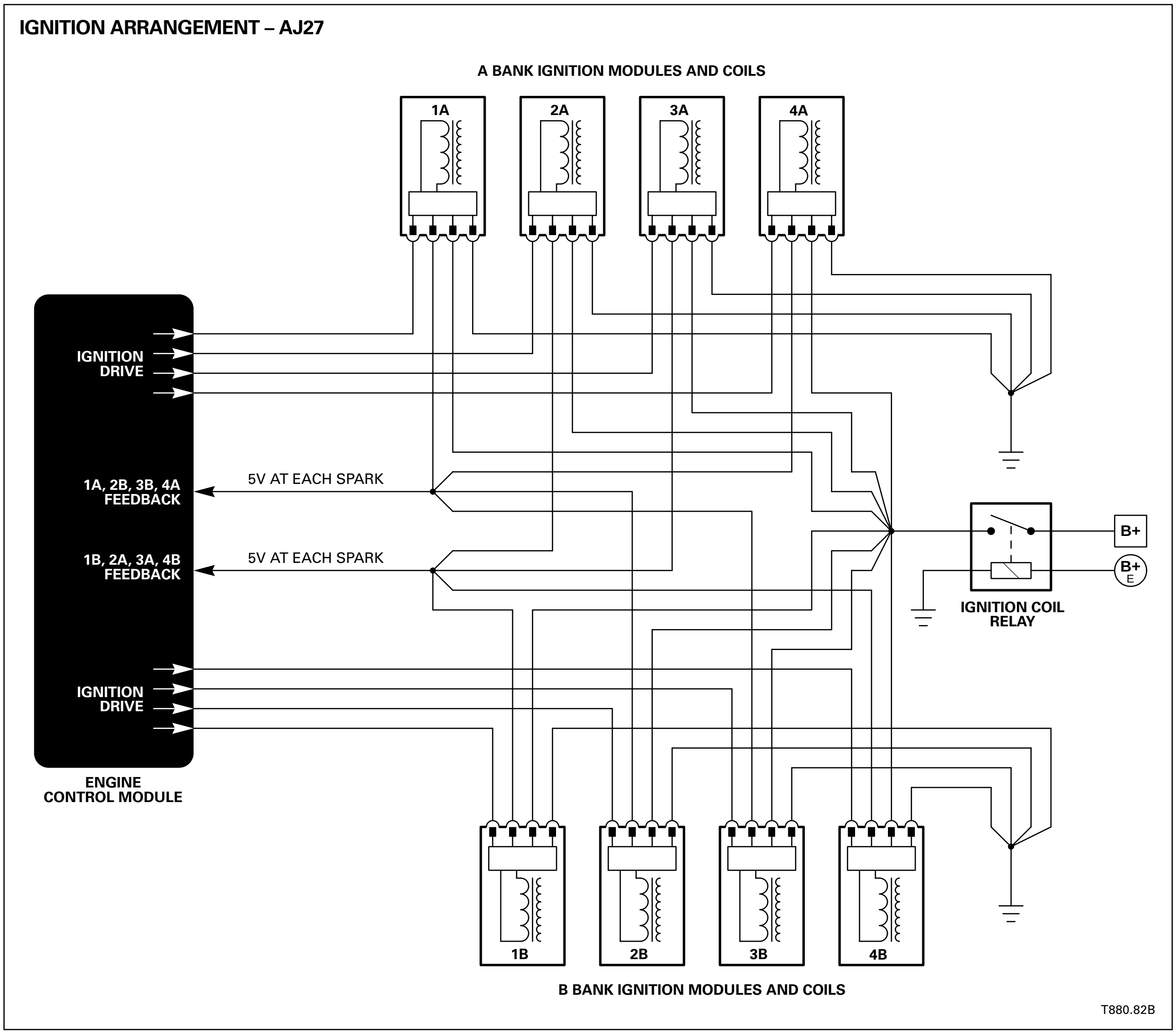
- Each AJ27coil-on-plug unit incorporates its own ignition module.
- The ignition modules are triggered directly from the ECM and drive the coil primary circuit, controlling current amplitude, switching point and dwell.
- Each ignition module provides a monitor output to the ECM.
- When an ignition trigger 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.

NOTES

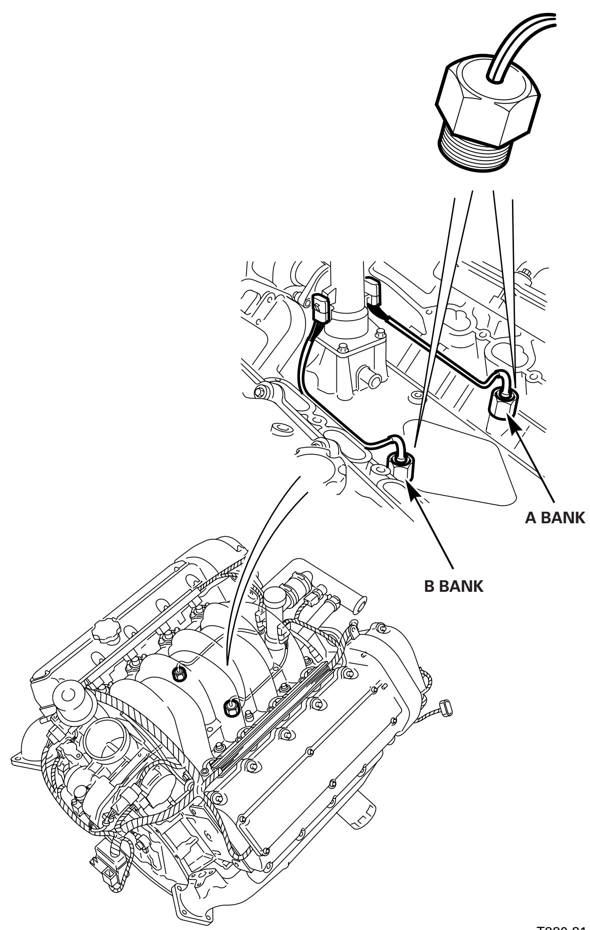

IGNITION ARRANGEMENT – AJ27
A BANK IGNITION MODULES AND COILS
1A
2A
3A
4A
IGNITION DRIVE
1A, 2B, 3B, 4A FEEDBACK
5V AT EACH SPARK
1B, 2A, 3A, 4B FEEDBACK
5V AT EACH SPARK
IGNITION DRIVE
ENGINE CONTROL MODULE
B+
B+ E
IGNITION COIL RELAY
1B
2B
3B
4B
B BANK IGNITION MODULES AND COILS
T880.82B

NOTES

IGNITION

Ignition Knock (Detonation) Control

KNOCK SENSORS – AJ26



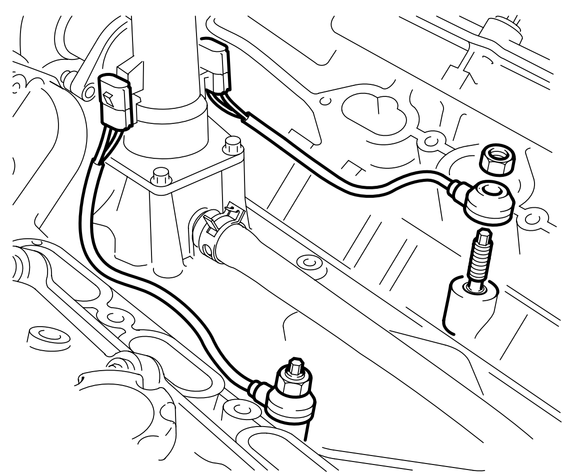
- The ECM retards ignition timing to individual cylinders to control ignition knock (detonation) and optimize engine power.
- Two knock sensors (KS) are positioned on the cylinder block in the engine vee to sense engine detonation.
- One KS is positioned on A bank and the other on B bank.
- Each knock 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 SENSORS – AJ27



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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

JAGUAR

Service Training Course 881
DATE OF ISSUE: 9/2001

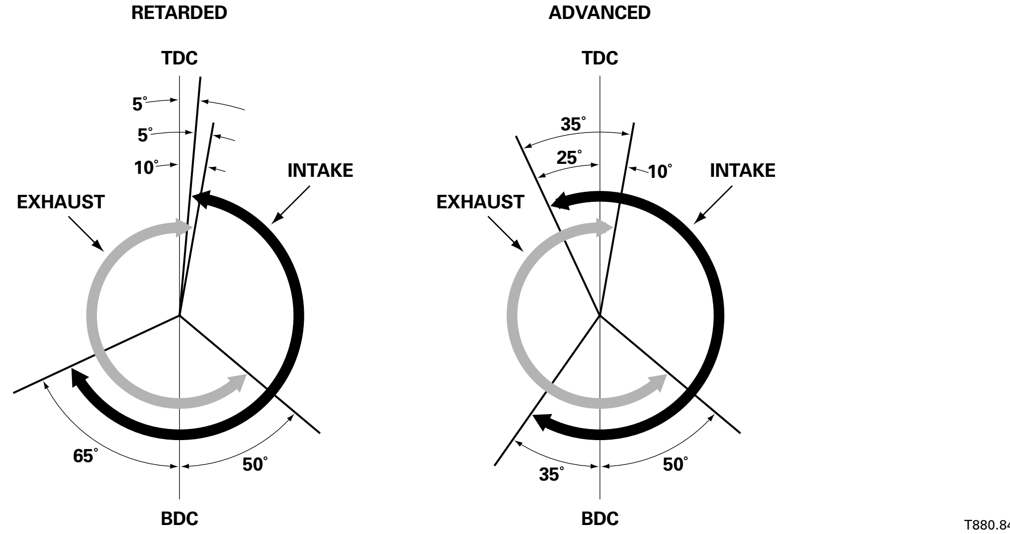
VARIABLE VALVE TIMING

Variable Valve Timing – AJ26

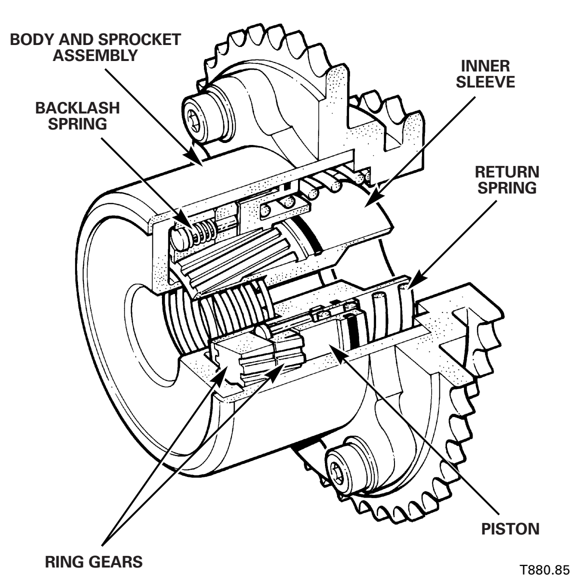
The AJ26 two-position variable valve timing (VVT) system improves low and high speed engine performance, idle quality, and exhaust emission. VVT is a two-position system that operates on the intake camshafts only. There are 30° of crankshaft rotation between the retarded and the advanced positions. The 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

VARIABLE VALVE TIMING – AJ26 (CRANKSHAFT ROTATION SHOWN)



VALVE TIMING UNIT – AJ26



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

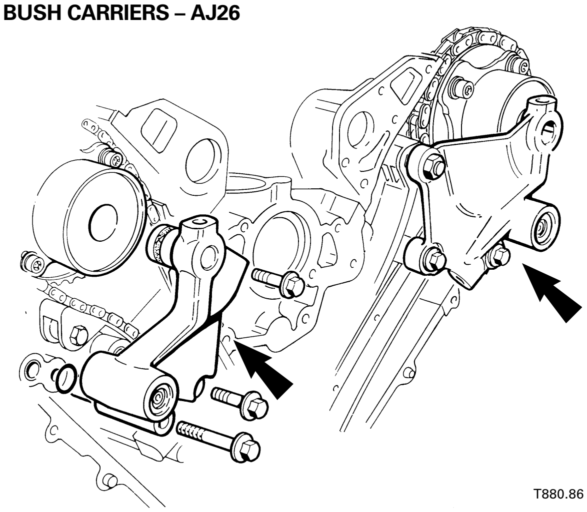
- The bush carriers contain oil passages that link the engine oil supply to the valve timing unit.
- The integral shuttle valve, connected to the valve timing solenoid and biased by a coil spring, controls the flow of oil through the passages.

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

BUSH CARRIERS – AJ26



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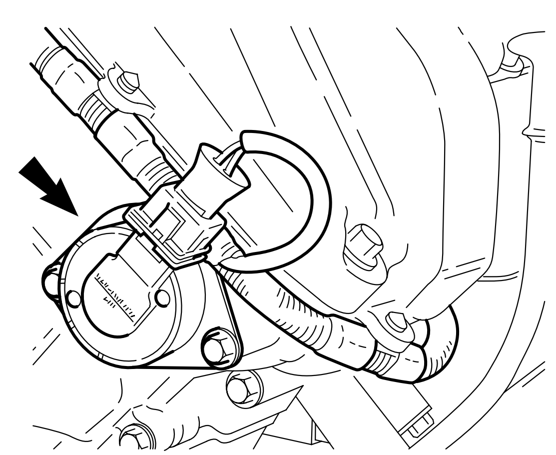
VALVE TIMING SOLENOID – AJ26



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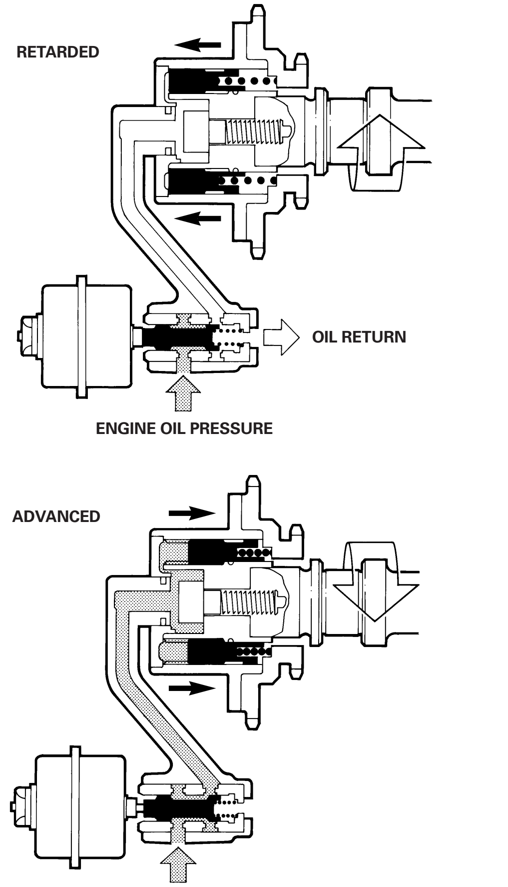
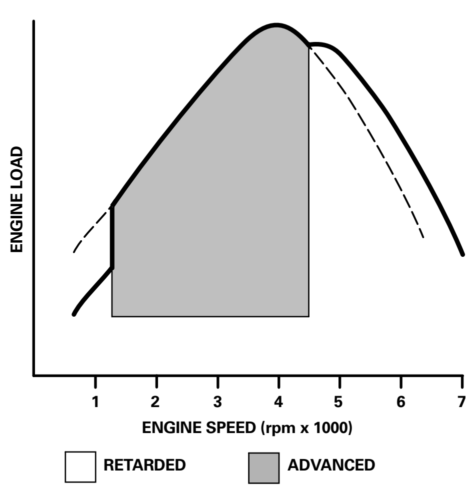
VARIABLE VALVE TIMING

Variable Valve Timing – AJ26

VARIABLE VALVE TIMING OPERATION – AJ26



VARIABLE VALVE TIMING MAP – 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.

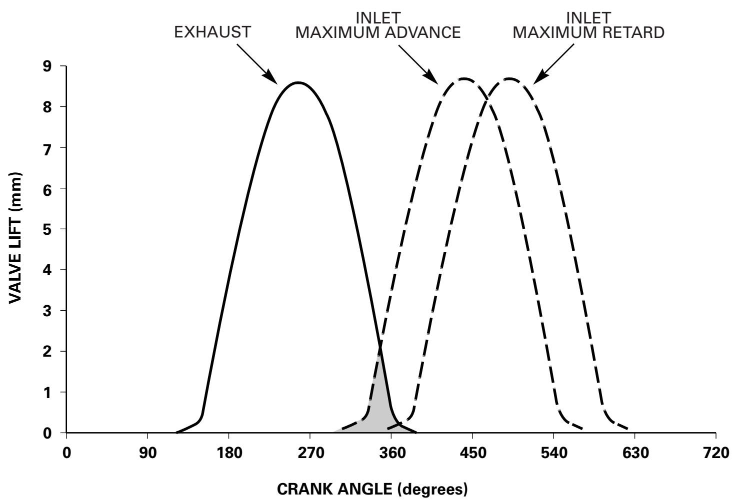
ECM VVT Control

- 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° ± 2°.
- 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).

LINEAR VVT – AJ27



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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

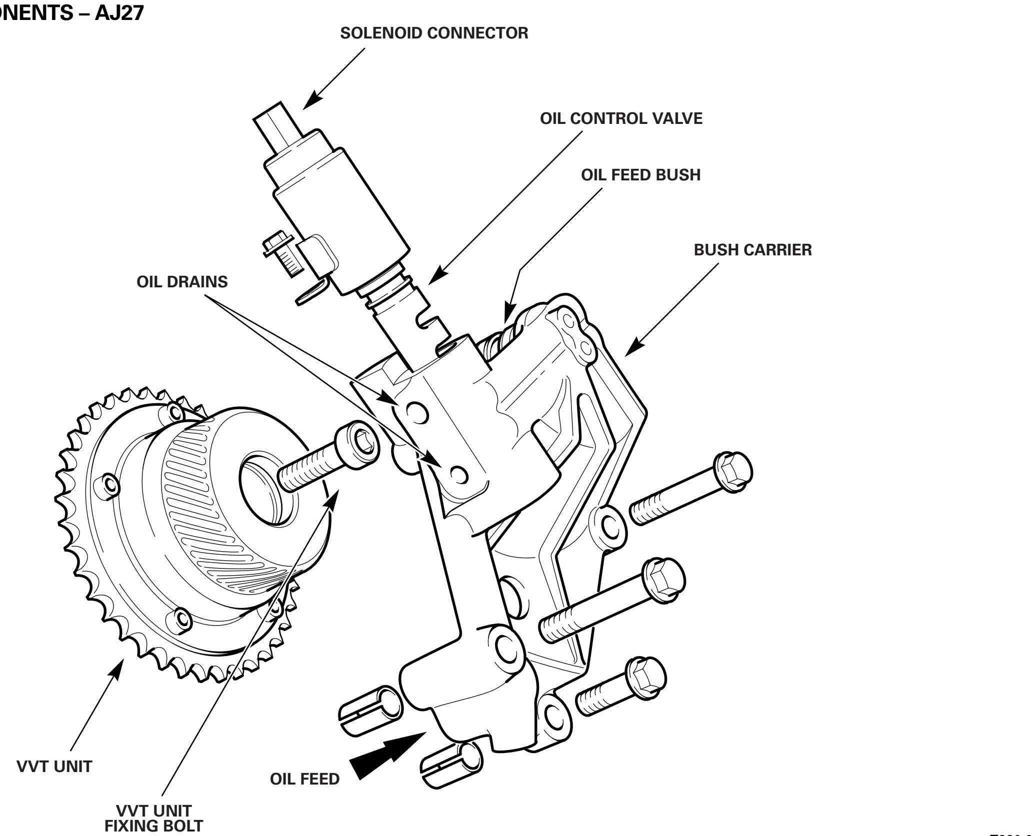
Each cylinder bank has a VVT unit, bush carrier and solenoid operated oil control valve which are all unique to the linear VVT system. The VVT unit consists of an integral control mechanism with bolted on drive sprockets, the complete assembly being non-serviceable. The unit is fixed to the front end 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 COMPONENTS – AJ27



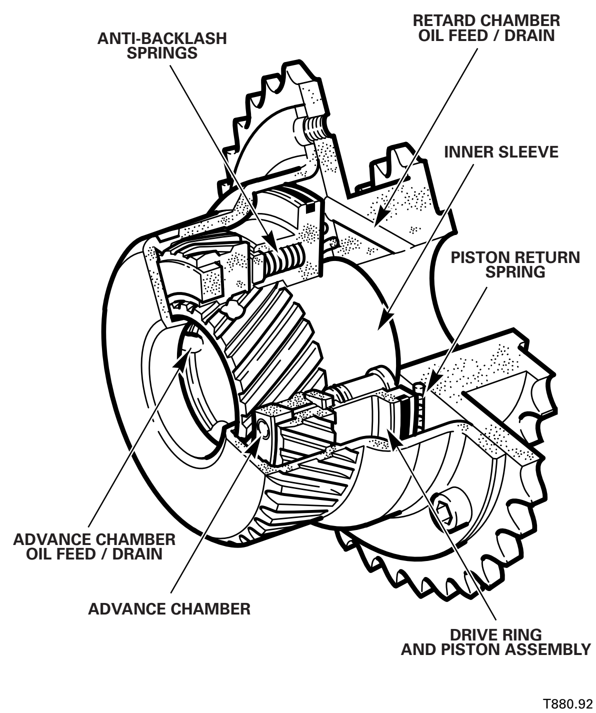
Linear VVT unit

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.

LINEAR VVT UNIT – AJ27



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)

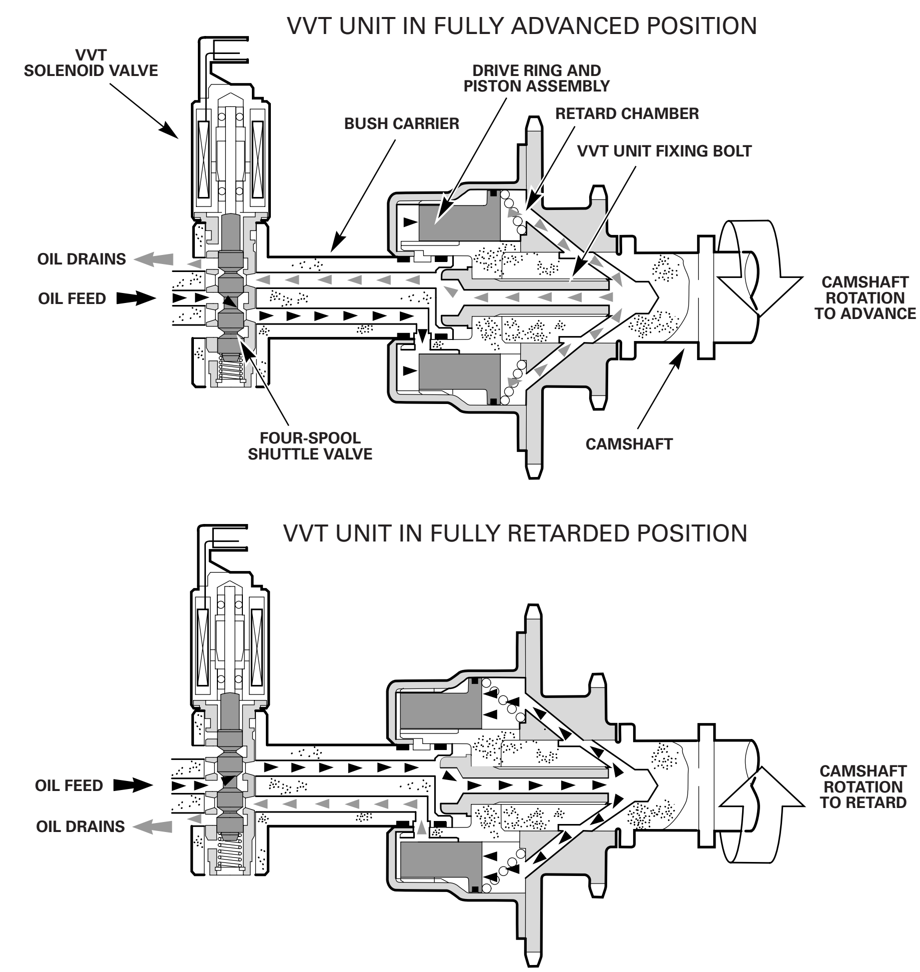
Linear VVT Oil Control – Advance

- 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 OIL CONTROL – AJ27



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.

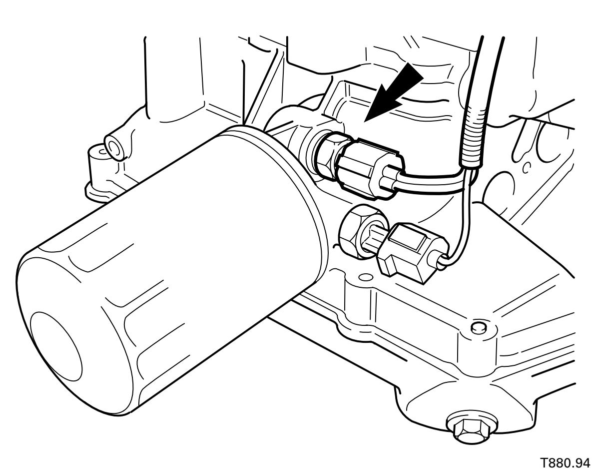
The VVT system is normally under closed loop control except in extreme temperature conditions such as cold starts below 0 °C (32 °F). At extremely high oil temperatures, the ECM may limit the amount of VVT advance to prevent the engine stalling when returning to idle speed. This could occur because of 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.

EOTS – AJ27



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NOTES

AJ26 / AJ27
ENGINE MANAGEMENT SYSTEMS

AJ26/27 V8

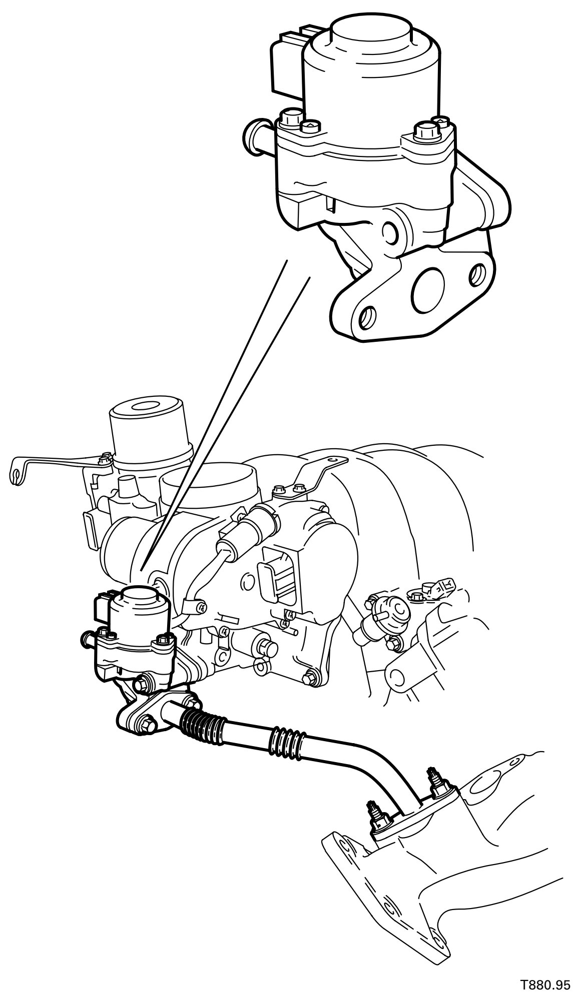
JAGUAR

Service Training Course 881
DATE OF ISSUE: 9/2001

EXHAUST GAS RECIRCULATION

Exhaust Gas Recirculation – AJ26

EGR VALVE – 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 supercharged engines.

EGR lowers combustion temperature, which in turn reduces NOx 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

J A G U A R   S E R V I C E   T R A I N I N G

AJ26 / AJ27
ENGINE MANAGEMENT SYSTEMS

JAGUAR

Service Training Course 881

DATE OF ISSUE: 9/2001

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.

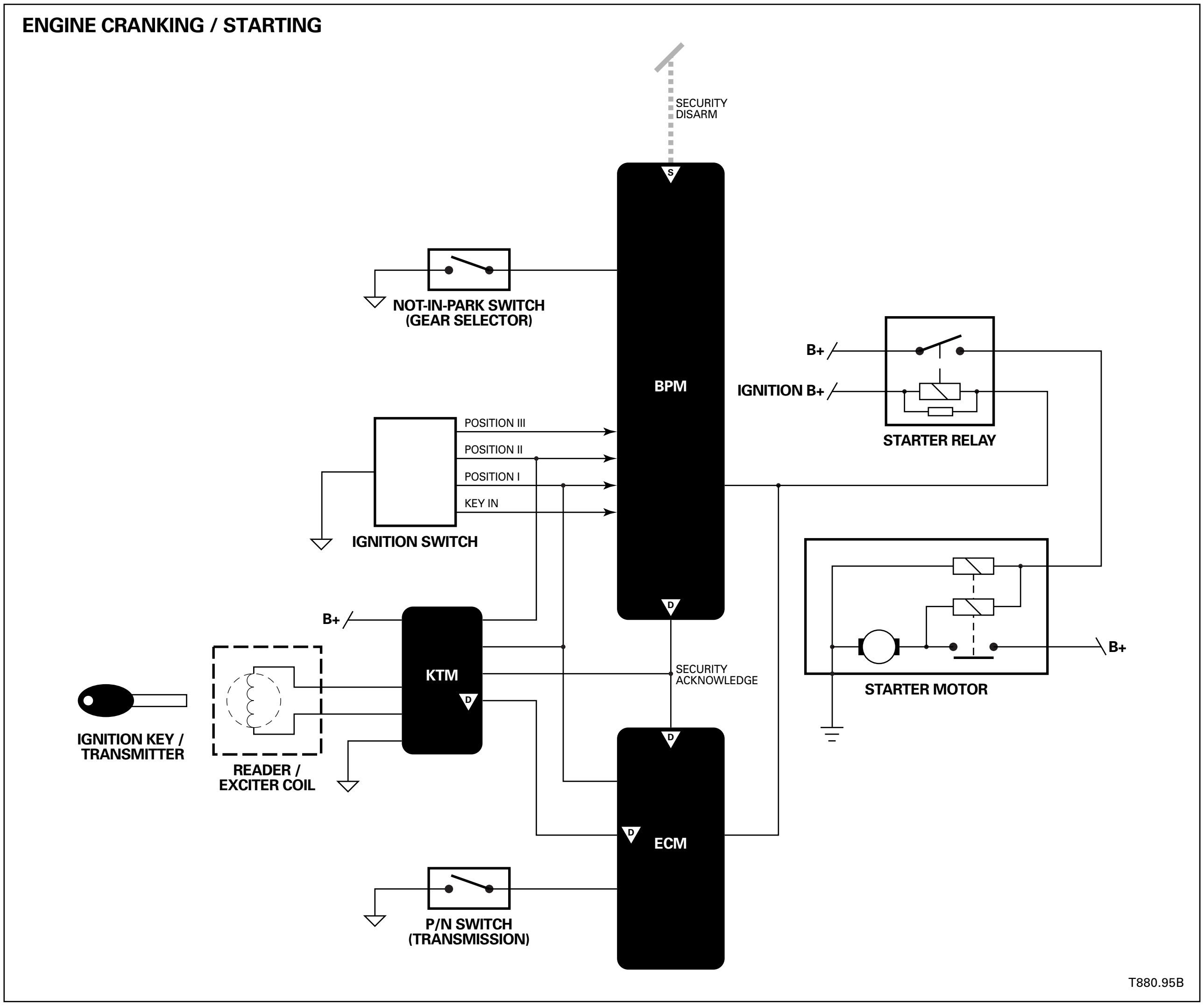
Vehicles without Key Transponder Module (KTM) (1997 Model Year)

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
SECURITY DISARM
S
NOT-IN-PARK SWITCH (GEAR SELECTOR)
BPM
B+
IGNITION B+
STARTER RELAY
POSITION III
POSITION II
POSITION I
KEY IN
IGNITION SWITCH
STARTER MOTOR
B+
D
KTM
D
SECURITY ACKNOWLEDGE
IGNITION KEY / TRANSMITTER
READER / EXCITER COIL
D
D
ECM
P/N SWITCH (TRANSMISSION)
T880.95B

OTHER ECM CONTROL AND INTERFACE FUNCTIONS

Radiator Cooling Fan Control

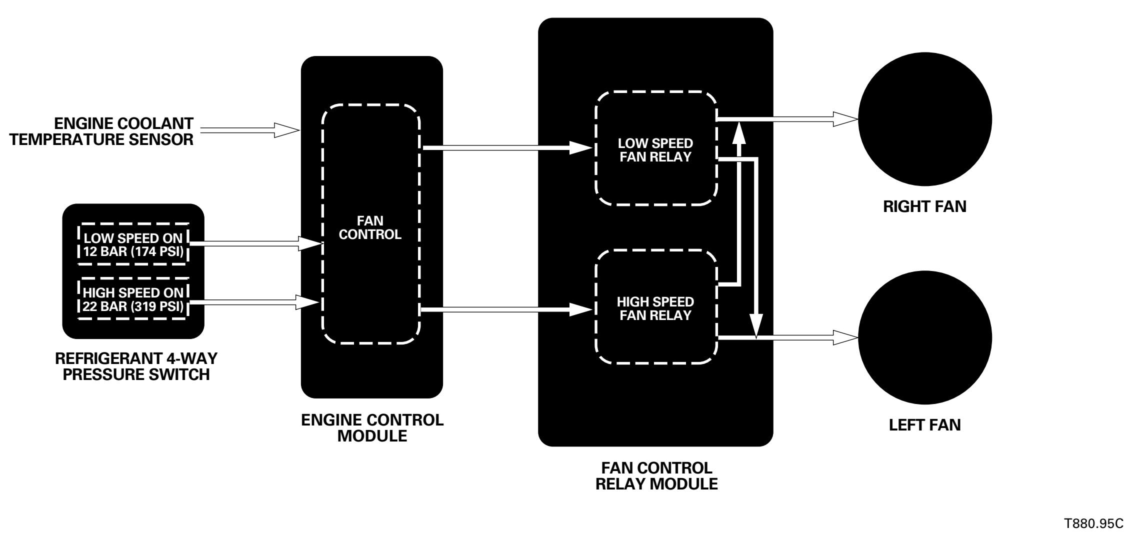
The ECM controls the radiator cooling fan operation. Using inputs from the air conditioning refrigerant four-way pressure switch and the ECTS, the ECM drives the fans in series (low speed) or in parallel (high speed). The four-way pressure switch contains a 12 bar (174 psi) switch element and a 22 bar (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 adaptions, 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.

RADIATOR COOLING FAN CONTROL



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

JAGUAR

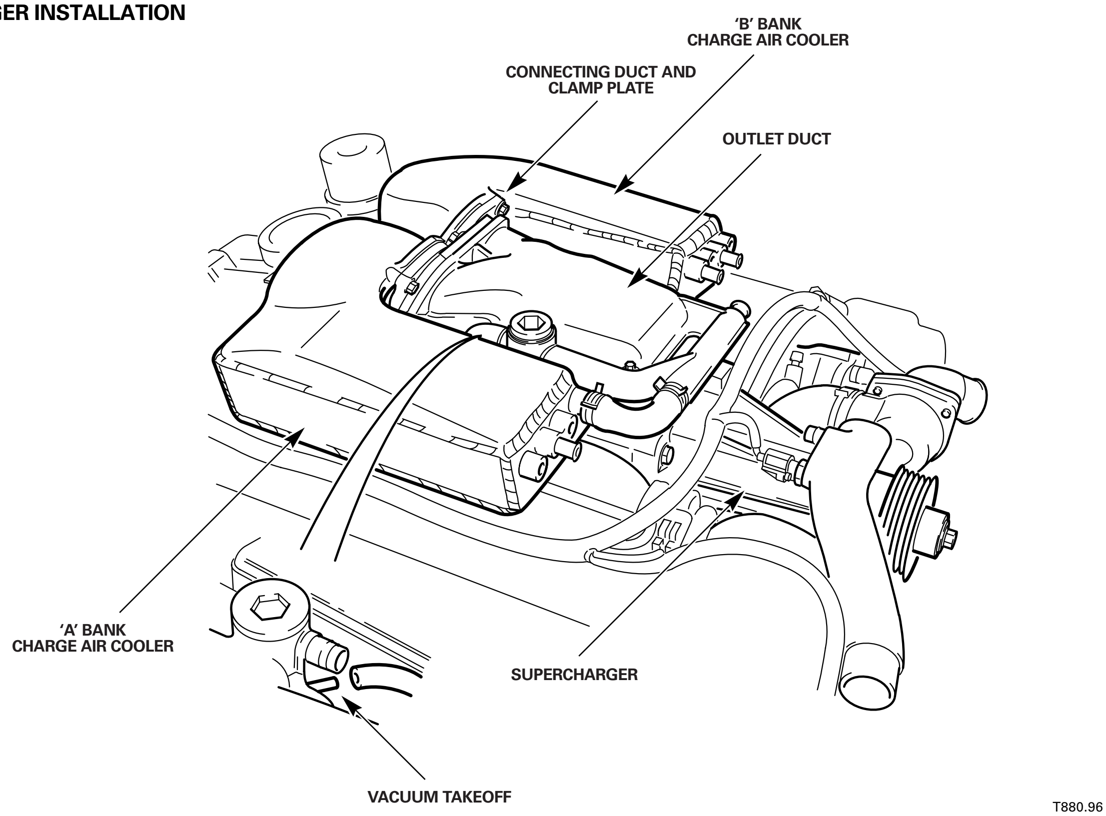
Service Training Course 881
DATE OF ISSUE: 9/2001

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.

SUPERCHARGER INSTALLATION

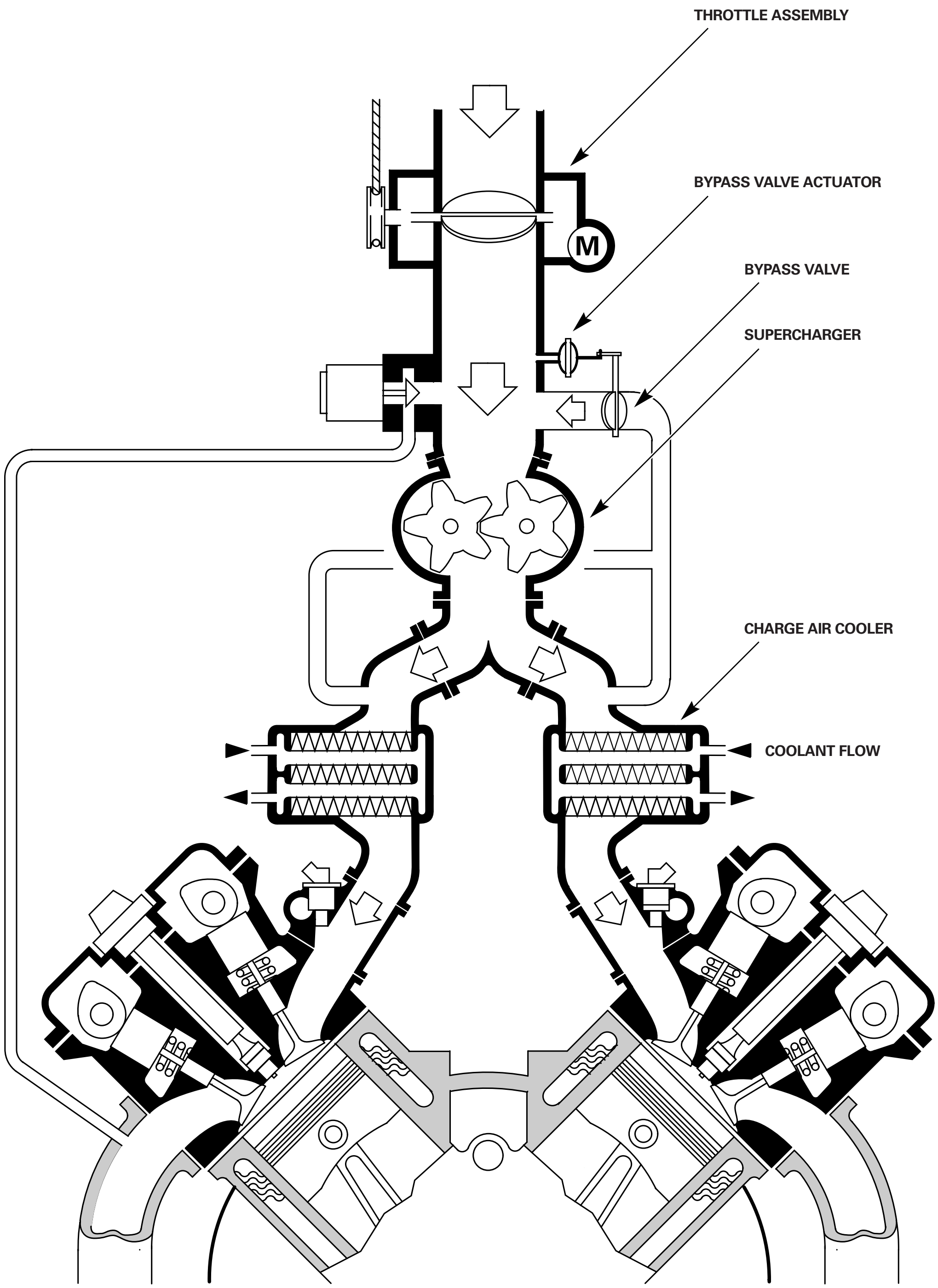


The supercharger is an Eaton M112 "Roots Type" unit mounted in the engine vee, driven by a separate poly v-belt from the crankshaft. Supercharger lubrication is "filled for life". If servicing of the lubricant is required, the supercharger must be removed from the engine. The maximum boost pressure is 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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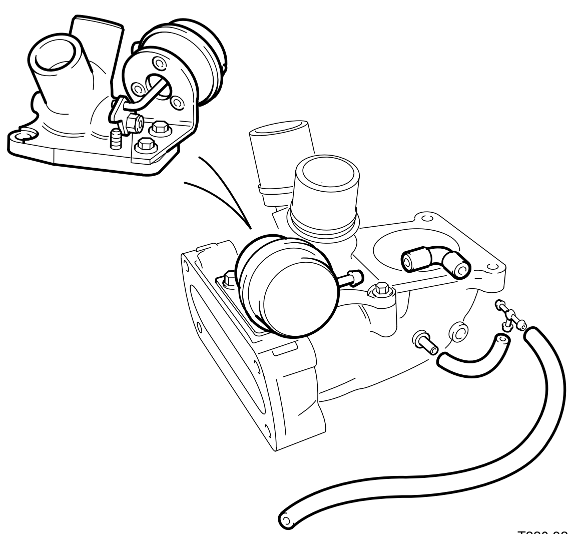
AJ26 / AJ27 SUPERCHARGED EMS

Supercharger Mechanical Components

BYPASS VALVE AND ACTUATOR – AJ26



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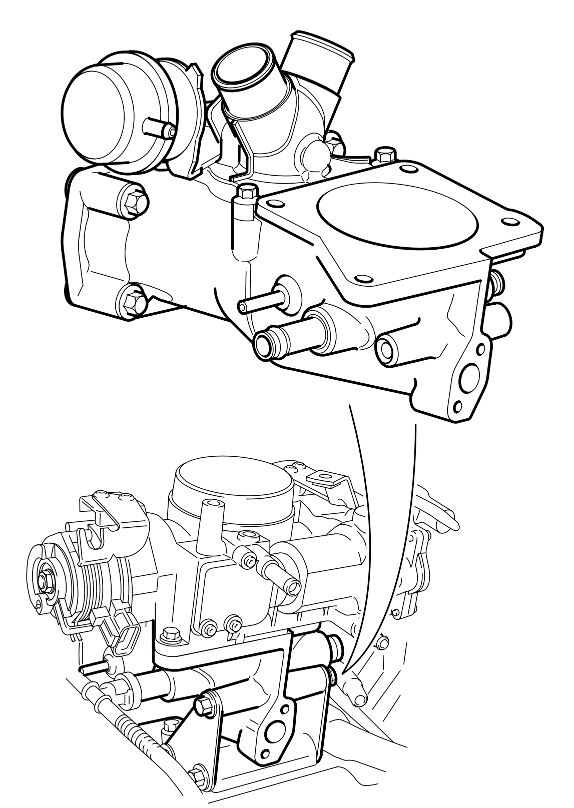
THROTTLE INDUCTION ELBOW – AJ27



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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.

NOTES

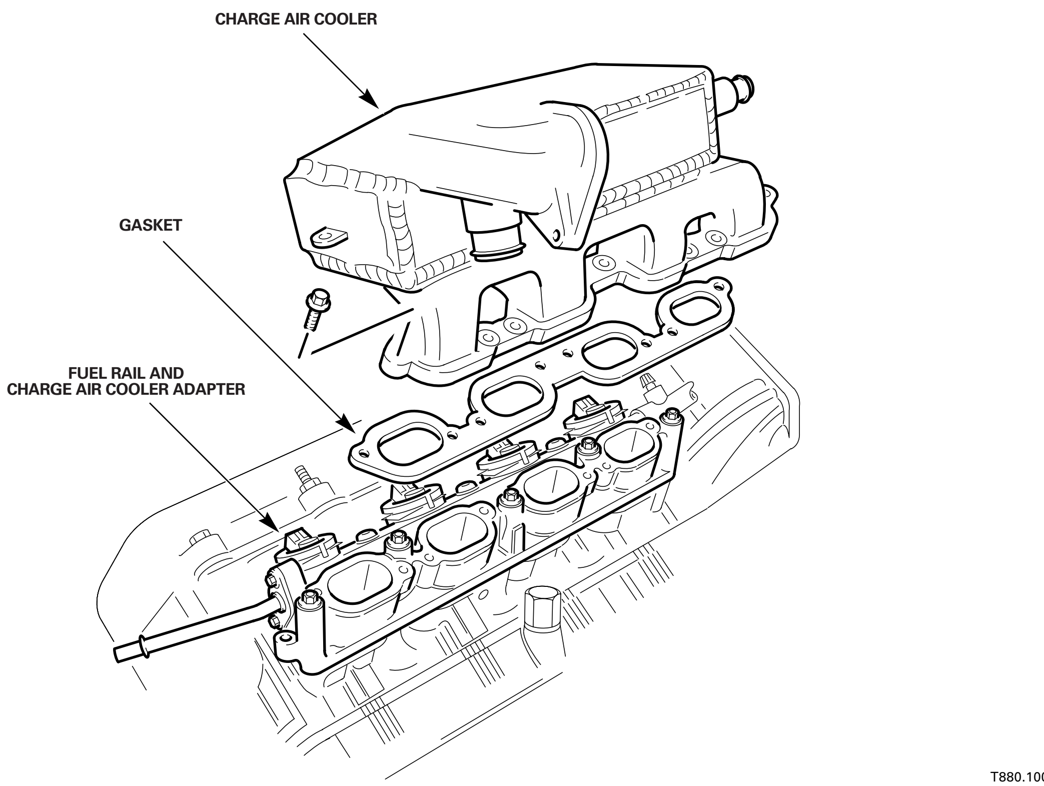
Charge Air Coolers

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.

SUPERCHARGER CHARGE AIR COOLER, ADAPTER AND FUEL RAIL



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

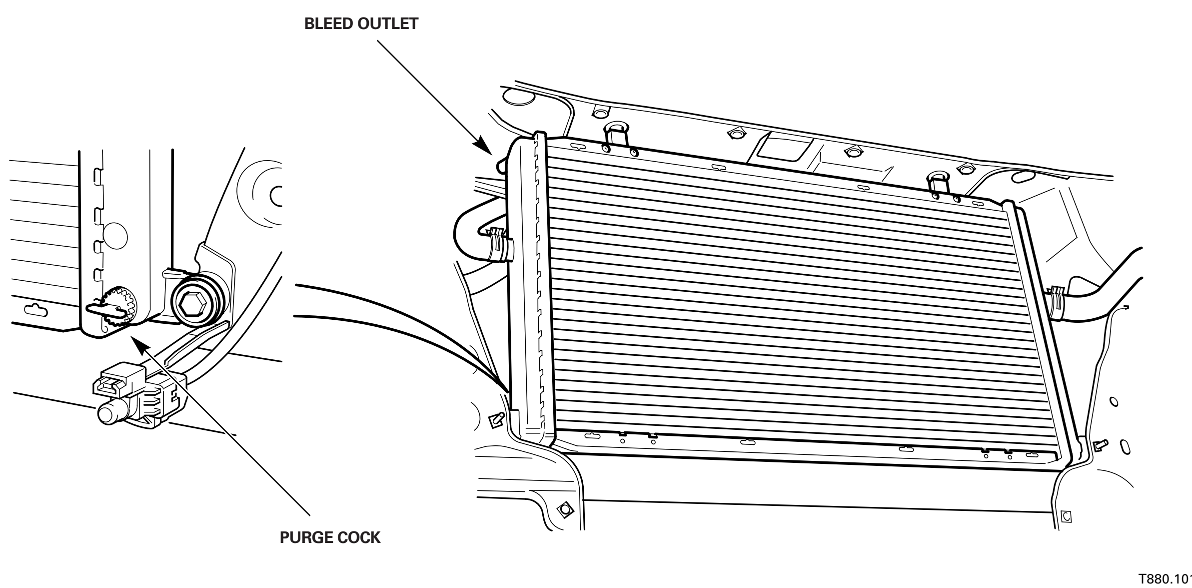
AJ26 / AJ27 SUPERCHARGED EMS

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.

CHARGE AIR COOLER RADIATOR



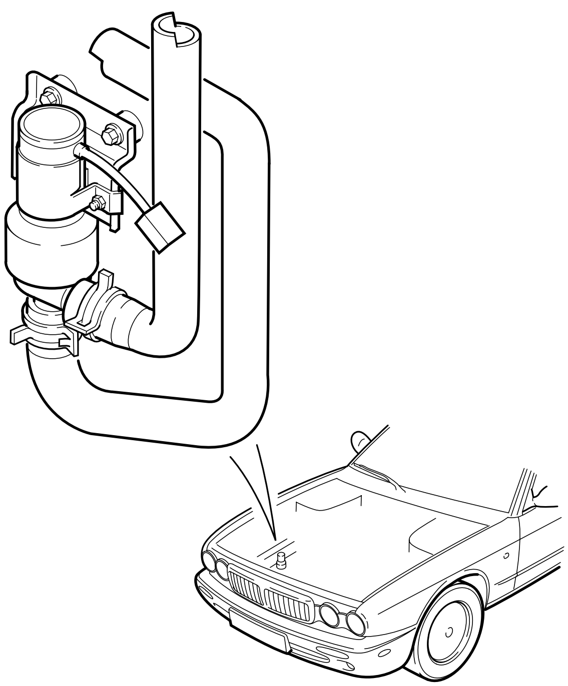
NOTES

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

CHARGE AIR COOLER AND PUMP



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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

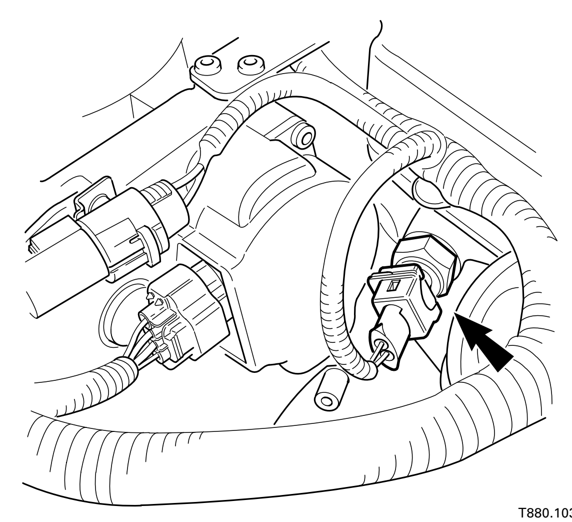
Intake Air Temperature Sensor 2 (IATS 2)

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.

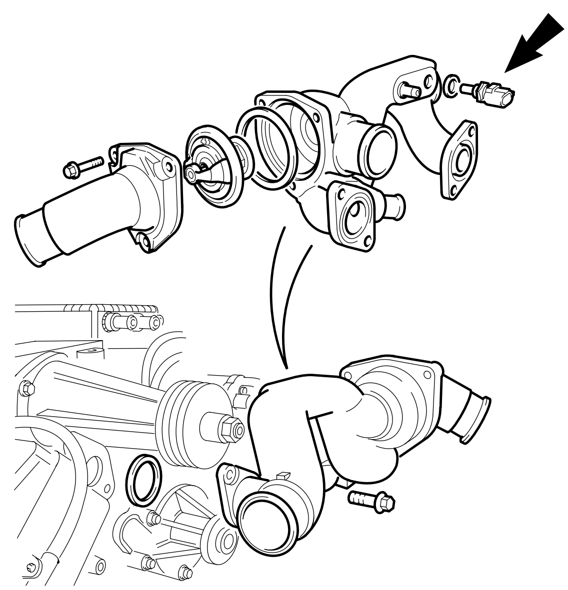
CHARGE AIR COOLER IATS 2



IATS air temperature / resistance / voltage

Temperature °C	°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

ECTS – AJ V8 SUPERCHARGED



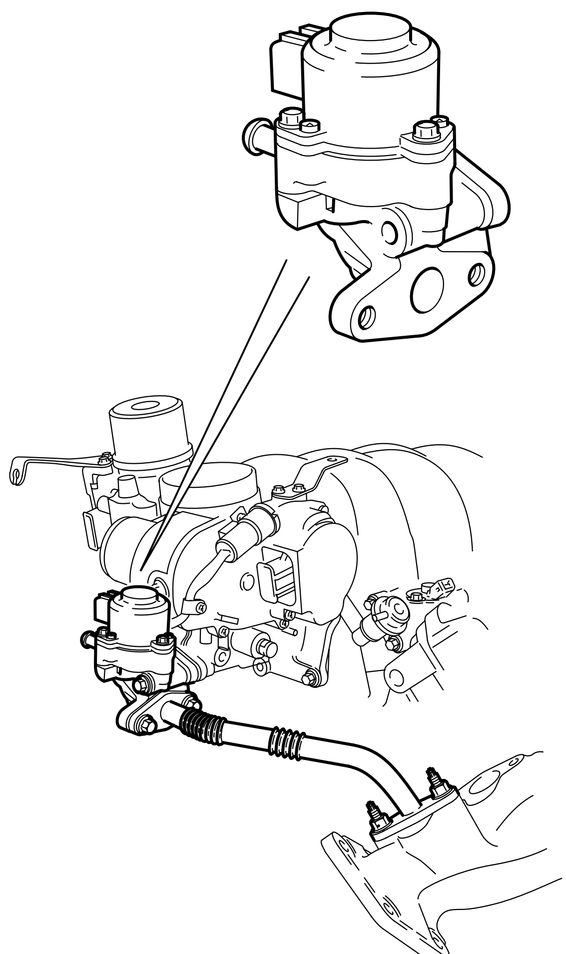
Engine Coolant Temperature Sensor (ECTS)

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

AJ26 / AJ27 SUPERCHARGED EMS

Exhaust Gas Recirculation – AJ26

EGR VALVE – AJ26



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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 NOx 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

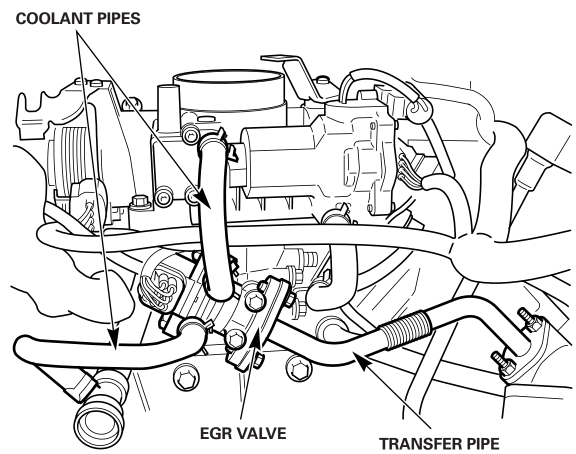
The AJ27 SC EGR system provides increased exhaust gas flow over the AJ26 SC system. ECM control is enhanced by an EGR flow monitoring feedback signal.

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

EGR VALVE – AJ27



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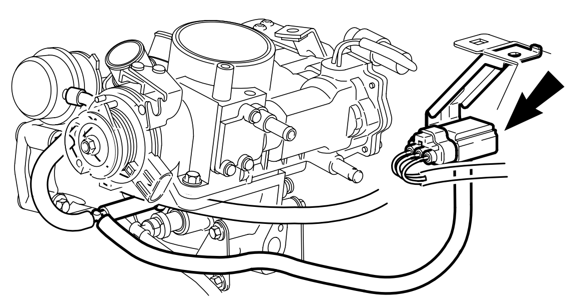
MAP SENSOR – AJ27



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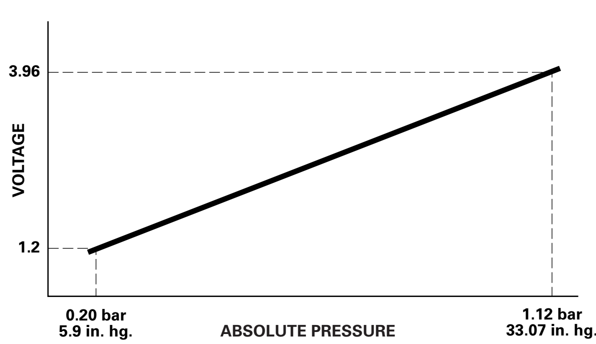
MAP SENSOR CHARACTERISTIC – AJ27



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AJ26 / AJ27
ENGINE MANAGEMENT SYSTEMS

Service Training Course 881
DATE OF ISSUE: 9/2001

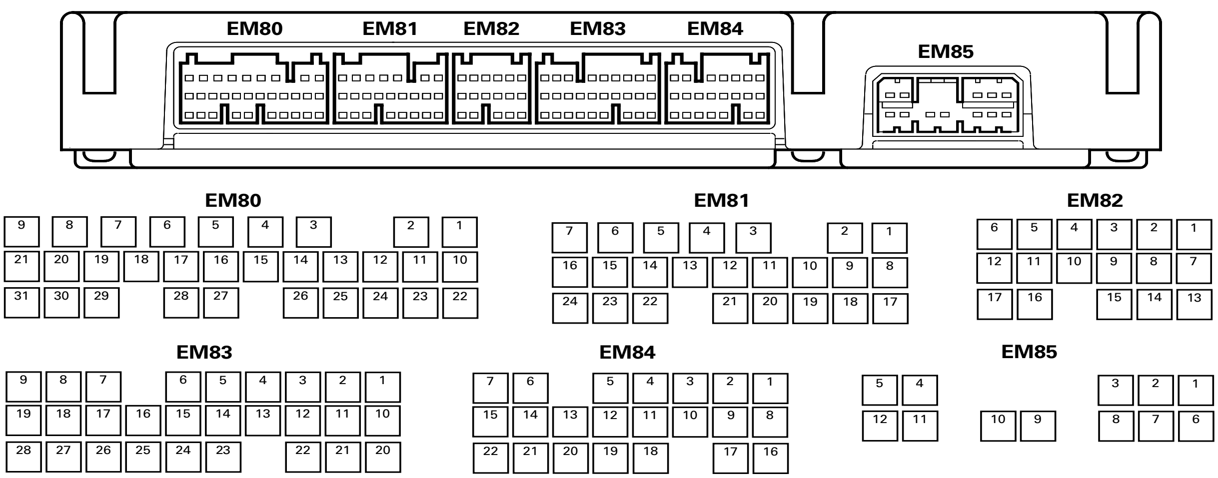
AJ27 - VVT System

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.

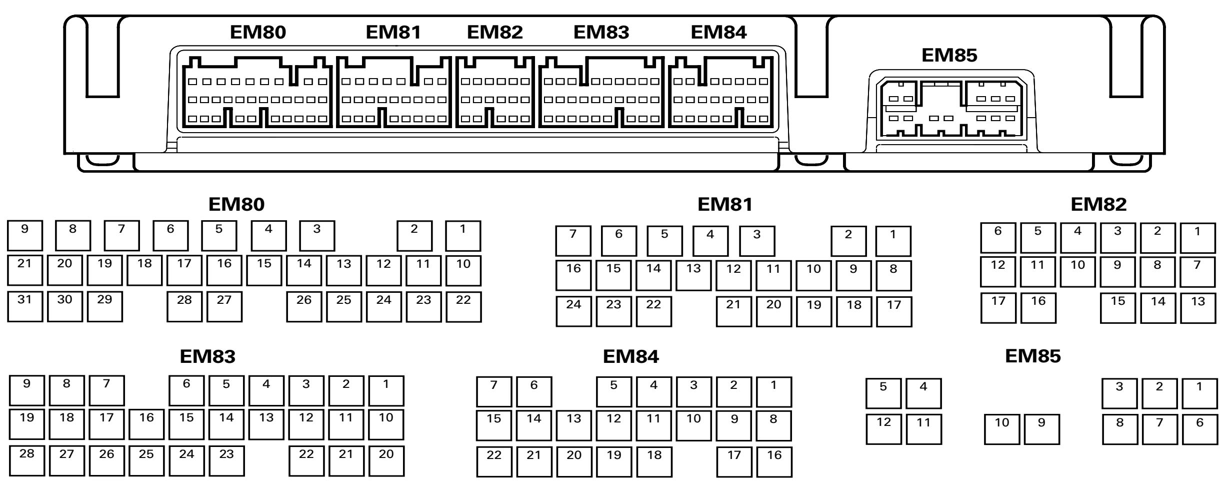
1. Locate and identify the AAIC valve on the engine. What is it's functional purpose:

   ____

   ____

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:____

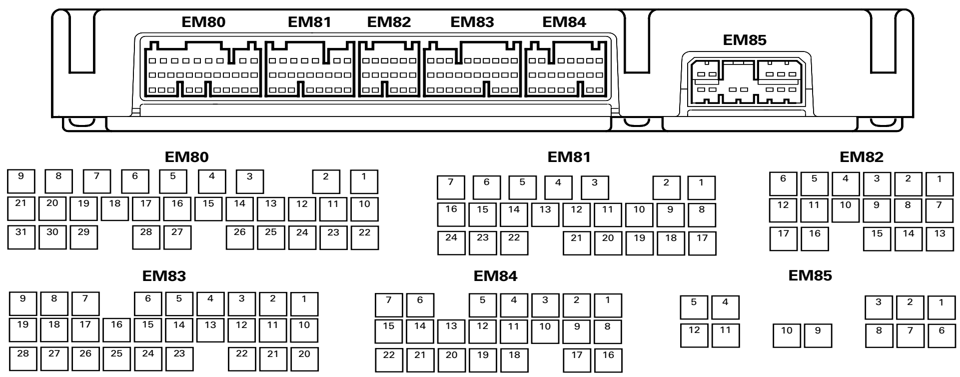
AJ27 - Component Monitoring

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: ______________________