Technical Reference & Specifications

Diagnostic Tester

Fig. D-1

TL874fD01

DIAGNOSTIC REFERENCE INFORMATION

Vane Air Flow Meter (Vs)

Circuit Description

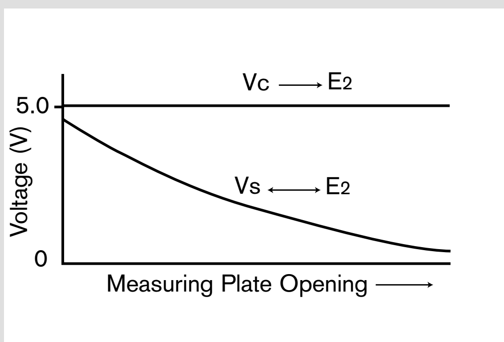
The vane air flow meter is located in the intake air duct between the air cleaner housing and the engine throttle body. It provides the ECM information on the amount of load placed on the engine by directly measuring intake air volume.

During engine operation, intake air flow reacts against the meter's measuring plate, which causes it to deflect in proportion to the volume of air flow. This movement is transferred through a shaft to a movable arm on the meter's potentiometer (variable resistor). The Vs signal to ECM varies according to the potentiometer's position.

The vane air flow meter also houses the intake air temperature sensor and a fuel pump switch. The fuel pump switch is used to maintain fuel pump operation after start-up (when sufficient air flow exists to open the measuring plate).

Vane Air Flow Meter

The Vs signal represents the amount of load placed on the engine. The potentiometer provides a variable voltage signal back to the Vs terminal of the ECM.



As shown in the graph, Vs signal voltage decreases with higher air flow (larger measuring plate opening). The Vc - E2 line represents the 5V reference source.

NOTE: The 22R-E and 4A-GE engines use an air flow meter with opposite voltage logic.

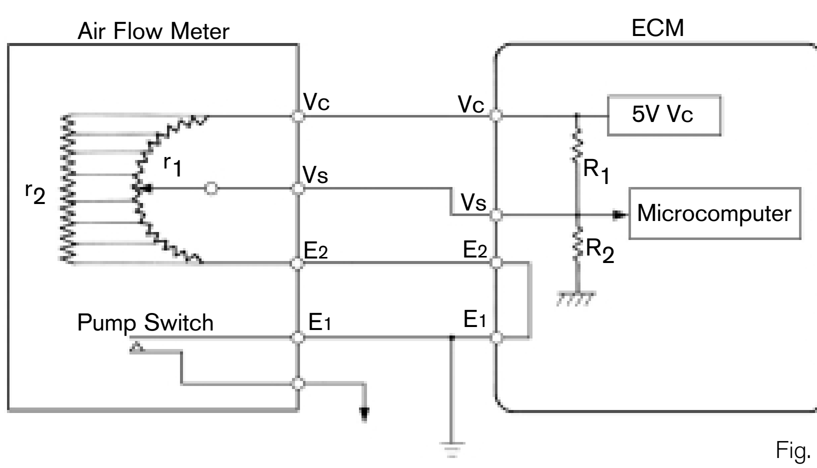


Fig. D-2

TL874fD02

Troubleshooting Hints

- The air flow meter is provided a regulated 5V reference at Vc terminal.
- As indicated in the graph, the voltage reading at Vs terminal with Ignition ON, Engine OFF should be between 3.7V - 4.3V.
- Once the engine is started, Vs signal voltage should decrease to indicate initial measuring plate opening.
- The r_2 resistor (which is connected in parallel to the r_1) allows the meter to continue to provide a Vs signal in the event an open occurs in the main potentiometer (r_1).
- The R_1 and R_2 resistors provide the ECM with self-diagnostic capabilities and also provides a fail-safe voltage in the event of an open circuit.

OBD Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
31	Vs Circuit	Open or Short (Vc) in Air Flow Meter Circuit for Specified Time
32	Vs Circuit	Open or Short (Vc – Vs) in Air Flow Meter Circuit for Specified Time

OBD II Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
P0100	Air Flow Meter Circuit	Air Flow Meter Circuit Malfunction
P0101	Air Flow Meter Circuit	Air Flow Meter Circuit Range/Performance Problem

Typical Serial Data

Data Source	Name	Units	Warm Idle
OBD	Vs	volts	2.5V ± 0.5V[1]
OBD II	———	———	———
V-BoB	Vs	volts	2.5V ± 0.5V[1]

1. 3VZ-FE = 2.8V ± 0.6V

DIAGNOSTIC REFERENCE INFORMATION

Karman Vortex Air Flow Meter (Ks)

Circuit Description

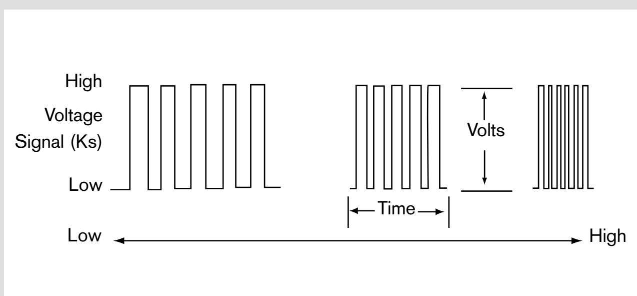
Like the vane air flow meter, the Karman Vortex Air Flow Meter is located between the air cleaner housing and the engine's throttle body. It also provides the ECM with the same type of information; an intake air volume signal that is used to determine the amount of load placed on the engine.

The operation of the Karman Vortex Air Flow Meter differs from that of the vane type. During engine operation, a swirling effect is created in the intake air stream when it reacts against the meter's vortex generator. A sample of this pulsating air is then applied to a movable metal foil mirror, which causes it to flutter. The oscillating mirror causes light from the photo coupler's LED to be alternately applied and diverted from a phototransistor.

As a result, the phototransistor rapidly switches the 5V Ks signal to the ECM. As shown in the diagram, the frequency of the Ks signal increases proportionally with intake air flow.

Karman Vortex Air Flow Meter

Inside the Karman Vortex air flow meter, intake airflow oscillates a movable mirror which turns a light sensitive photo transistor on and off.



As shown in the diagram, the Ks 5V square wave signal increases in frequency with higher intake air volume.

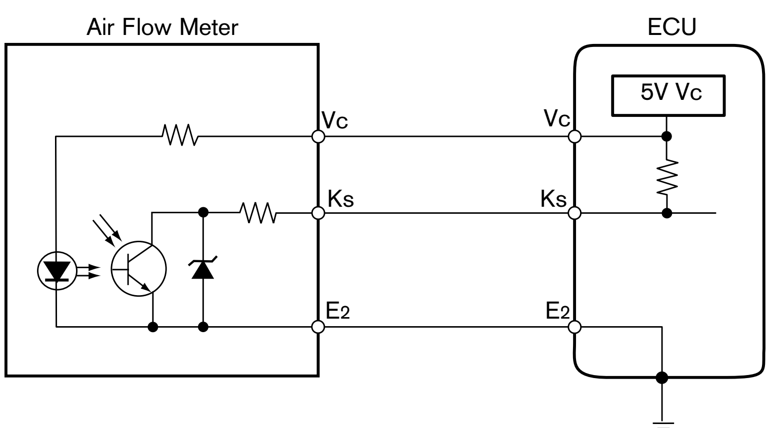


Fig. D-3

TL874fD03

Troubleshooting Hints

- Remember a 5V signal operating at a 50% duty cycle will read approximately 2.5V. Since Ks operates at approximately 50% duty cycle during engine operation, Ks signal voltage will provide little useful information during diagnosis.
- Ks signal frequency changes dramatically with engine load changes. For this reason, observing Ks frequency changes would provide the most useful diagnostic information. Accurate Ks signal inspection requires using an oscilloscope or high quality digital multimeter with frequency capabilities (non-OBD vehicles).

OBD Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
31	Ks Circuit	Open or Short in Air Flow Meter Circuit for Specified Time

OBD II Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
P0100	Air Flow Meter Circuit	Air Flow Meter Circuit Malfunction
P0101	Air Flow Meter Circuit	Air Flow Meter Circuit Range/Performance Problem

Typical Serial Data

Data Source	Name	Units	Warm Idle
OBD	Ks	ms	40ms ± 15ms
OBD II	———	———	———
V-BoB	Ks	ms	40ms ± 15ms

DIAGNOSTIC REFERENCE INFORMATION

Mass (Hot-Wire) Air Flow Meter (VG)

Circuit Description

The Mass Air Flow Meter provides some distinct advantages over the "volume" type air flow meters. Since this type of air flow meter directly measures air mass (and not just volume), any factor affecting the density of the intake air will influence the output signal. These factors include air temperature, humidity and altitude.

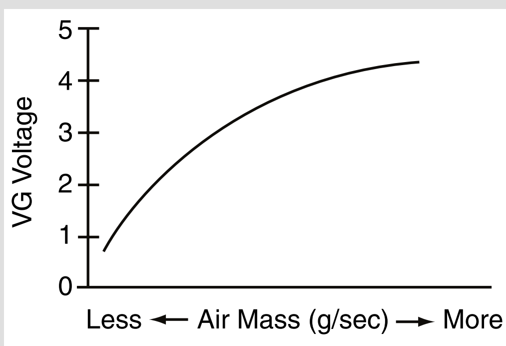
This type of Mass Air Flow Meter uses a "hot wire" and thermistor placed in a path of sample intake air flow. It operates on the theory that the hot wire is cooled by incoming air mass, in proportion to air flow. The circuit is the hot wire and incoming air flow by regulating bot wire current flow with the power transistor.

The circuit operates as a "feedback" system to equalize the electrical potential between points A and B. If a difference exists, the operational amplifier varies the output of the power transistor to rebalance the circuit. In this way, a variable DC voltage signal is output to the VG terminal of the ECM.

Mass Air Flow Meter

The Mass Air Flow Meter signal takes into account any factor affecting air mass or density, such as: air temperature, humidity and altitude.

Incoming air cools the "hot wire," lowering its resistance value and increasing output voltage at point B (VG signal).



As shown in the graph, VG signal voltage increases with higher intake air mass. The ECM interprets higher VG voltage as increased load placed on the engine, increasing injection quality and retarding spark.

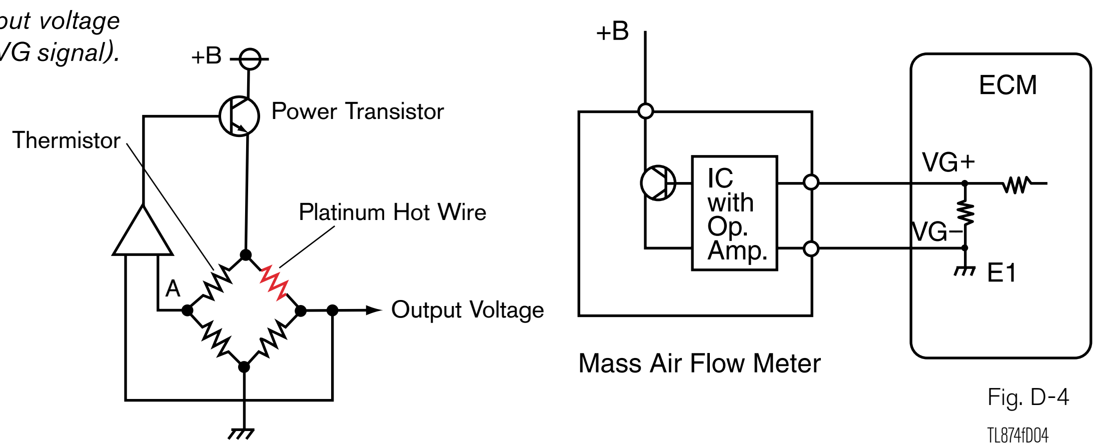


Fig. D-4

TL874fD04

Troubleshooting Hints

- Unlike volume airflow meters, this hot-wire mass air flow meter uses battery voltage (+B) rather than the 5V-reference voltage source VC.
- A VG signal check may be performed with Ignition ON, Engine OFF: While blowing towards the hot wire, observe the VG signal changes.
- **On OBD II vehicles** the following diagnostic rule applies:
  - a MAF reading of **0 gm/sec** would indicate an open in +B circuit or open or short in VG circuit.
  - a MAF reading of **271 gm/sec or more** would indicate an open in VG- (ground) circuit.

OBD Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
31	VG Circuit	Open or Short in Air Flow Meter Circuit for Specified Time

OBD II Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
P0100	Air Flow Meter Circuit	Air Flow Meter Circuit Malfunction
P0101	Air Flow Meter Circuit	Air Flow Meter Circuit Range/Performance Problem

Typical Serial Data

Data Source	Name	Units	Warm Idle
OBD	VG	gm/sec	3.8 ± 1.2 gm/sec
OBD II	VG	gm/sec	3.8 ± 1.2 gm/sec
V-BoB	VG	volts	0.7V to 1.7V

DIAGNOSTIC REFERENCE INFORMATION

Engine Coolant Temperature Sensor Circuit (ECT)

Circuit Description

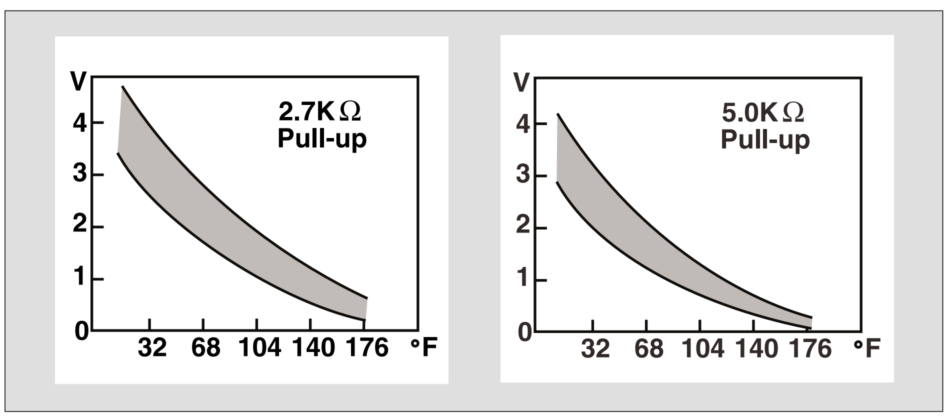
The Engine Coolant Temperature sensor circuit is used to monitor engine temperature, supplying the ECM with important information to determine fuel enrichment, spark angle, idle speed control, and emissions control system status.

The sensor, which is typically located near the thermostat housing, is a negative temperature coefficient (NTC) thermistor. Sensor resistance falls as the temperature rises. The sensor is connected in series with a pull-up resistor in the ECM, which acts as a voltage divider. As resistance of the sensor falls with increasing coolant temperatures, the voltage drop across the sensor also falls. The sensor circuit, therefore, generates an analog voltage signal, which varies inversely with the temperature of the engine coolant.

Pull-up resistor R_1 can have a resistance value of either 2.7KΩ or 5KΩ depending on engine application The chart below shows the normal signal voltage characteristics for both resistance values.

Engine Coolant Temperature Sensor Circuit

The Engine Coolant Temperature sensor monitors engine temperature by use of a voltage divider circuit. The pull-up resistor in the ECM is fixed value while the resistance of the sensor thermistor varies inversely with coolant temperature.



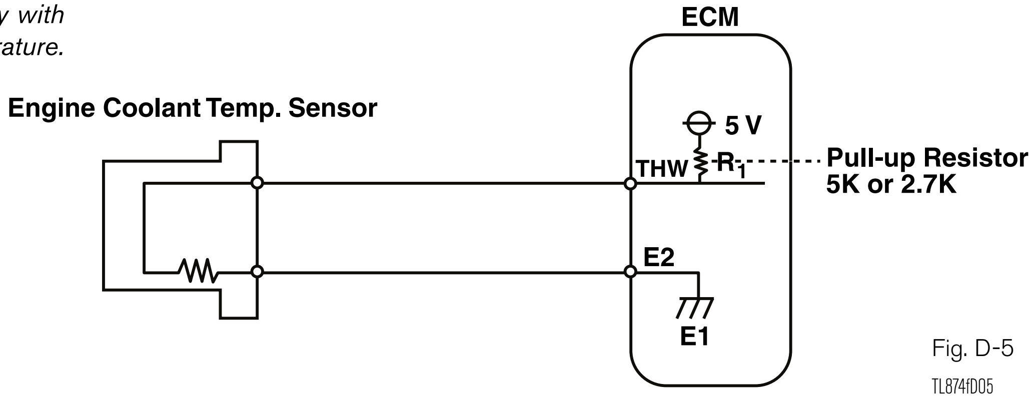


Fig. D-5

TL874fD05

Troubleshooting Hints

- The Engine Coolant Temperature sensor signal is represented on a Diagnostic Tester in °F or °C temperature units. When using the Vehicle Break-out Box (V-BoB), coolant temperature can be displayed either in temperature units or as a voltage (by toggling the F7 key.)

- Engine Coolant Temperature sensor information is replaced by a failsafe value whenever the ECM detects a fault in the circuit. When troubleshooting with a Diagnostic Tester, using the OBD data stream, failsafe value is displayed rather than actual value.

- To quick check circuit integrity using the OBD data stream, install a 1.2KW resistor across the ECT sensor harness terminals. If temperature displayed on Diagnostic Tester reads between approximately 35°C (95°F) to 43°C (110°F), the electrical circuit is good.

- To quick check circuit integrity using OBD II or V-BoB data stream:

  - Disconnect sensor harness: displayed temperature should go to approximately -40°C (-40°F) (5V)

  - Short sensor harness THW to E2: displayed temperature should go to approximately 120°C (248°F) (0V)

OBD Diagnostic Trouble Codes

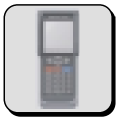
DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
22	Engine Coolant Temperature Sensor Circuit	Detects an open or short circuit in the Engine Coolant Temperature circuit for more than a specified amount of time.

OBD II Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
P0115	Engine Coolant Temp. Circuit Malfuntion	Detects an open or short circuit in the Engine Coolant Temperature circuit for more than a specified amount of time.
P0116	Engine Coolant Temp. Circuit Range Problem	Detects sensor range or performance problem by monitoring the time it takes for sensor signal to reach and exceed a specified minimum temperature.

Typical Serial Data

Data Source	Name	Units	Warm Idle	THW shorted to E2	Circuit Open
OBD	ECT	°F or °C	85°C to 104°C (185°F) to (220°F)	80°C (176°F)	80°C (176°F)
OBD II	COOLANT TEMP.	°F or °C	85°C to 104°C (185°F) to (220°F)	120°C (248°F)	-40°C (-40°F)
V-BoB	THW	°F or °C or volts	85°C to 104°C (185°F) to (220°F) 0.1V to 0.5V	120°C (248°F) or 0V	-40°C (-40°F) or 5V



DIAGNOSTIC REFERENCE INFORMATION

Throttle Position (TP) and Closed Throttle Position (CTP) Sensor Circuit

Circuit Description

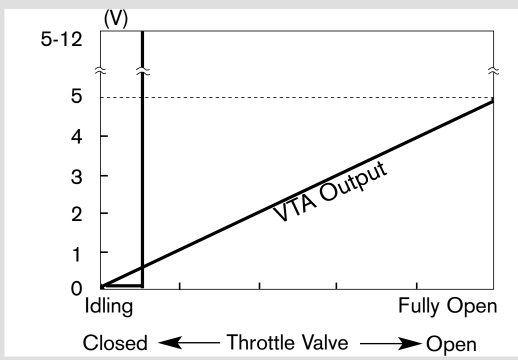
The Throttle Position sensor is attached to the throttle body. It monitors throttle valve opening angle and closed throttle status.

The sensor generates an analog voltage signal, which varies in proportion to throttle opening, from low to high as the throttle is opened. The TP sensor also includes a digital idle contact switch, which is closed at idle and opens as the throttle is tipped open. Signal characteristics are represented by the graph shown below.

Information from the this sensor is used by the ECM to make judgments about power enrichment, deceleration fuel cut, idle air control, spark advance angle corrections, and the status of emissions control sub-systems.

Throttle and Closed Throttle Position Sensor Circuit

Throttle position sensor uses a potentiometer and simple switch contact to monitor throttle angle and closed throttle status.



TP signal can be easily measured with a voltmeter or a scan tool. The voltage signal moves from low to high as the throttle opens. The CTP signal is low at idle and goes high when the throttle is opened.

Scan data is displayed in degrees throttle valve angle or in percentage of opening.

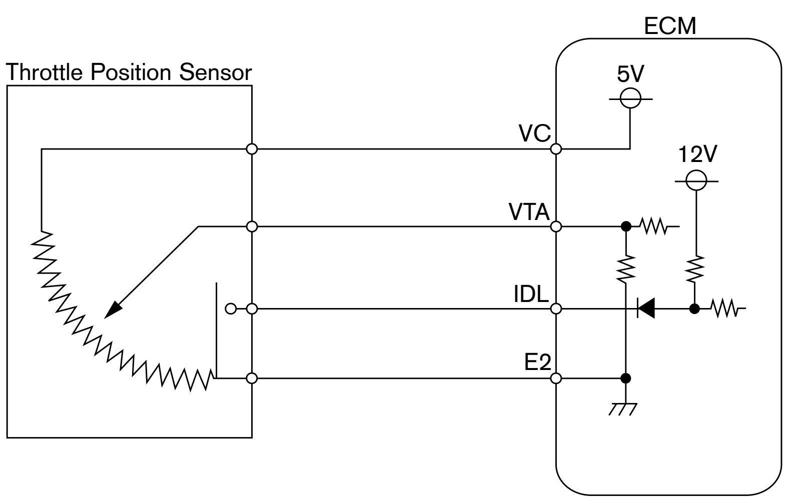


Fig. D-6

TL874fD06

Troubleshooting Hints

- Throttle Position sensor signal is represented differently on OBD and OBD II data streams. OBD displays opening angle in degrees ranging from 0° to 75°. OBD II displays throttle opening as a percentage of wide-open throttle, ranging from about 5% to 80%.
- On V-BoB, TP sensor signal is represented in degrees opening angle or as an analog voltage (by toggling the F7 key).
- Throttle angle scan data defaults to a failsafe value when a fault is detected in the TP sensor circuit. Depending on application, throttle angle will go to either 30° or 0° when a fault is detected, as long as the CTP switch remains open. When the CTP switch closes, the signal defaults to 0° and remains there. If the fault is intermittent, the TP signal will return to normal only after the vehicle speed sensor indicates 0 mph.
- To quick check the circuit using a Diagnostic Tester, observe serial data while depressing the accelerator pedal to wide open. Signal should increase to near maximum. For intermittent problems, use V-BoB data or oscilloscope.
- Code 51 for CTP switch contact will only set when an open circuit fault is detected. Shorted CTP will cause fuel cut to occur above fuel cut rpm threshold.

OBD Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
41	Throttle Position Sensor Circuit	Open or short detected in the VTA line to ECM for more than a specified amount of time. (NOTE: disconnected sensor will not set code 41)
51	Switch Condition Signal	Open detected in Closed Throttle Position switch circuit (NOTE: Only displays when TE1 is grounded [code display mode]. Will also display if PNP signal indicates trans in gear or if A/C input is ON. Code does not store in memory.

OBD II Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
P0100	Throttle Position Sensor Circuit	Open detected in circuit (VTA lower than specified with CTP switch open) Short detected in circuit (VTA higher than specified voltage)
P0121	Throttle Position Sensor Signal Range Problem	With CTP switch closed, VTA is greater than specified voltage

Typical Serial Data

Data Source	Name	Units	Key ON/Wide Open Throttle	Warm Idle
OBD	Throttle	° Open	> 70°	0°
OBD II	Throttle POS	% Open	≈65% to 75%	7% to 11%
V-BoB	VTA	° Open or volts	>70° or 3.5V to 4.8V	0° or 0.2V to 0.8V

DIAGNOSTIC REFERENCE INFORMATION

Power Distribution Circuit

Circuit Description

The power distribution circuit consists of a Main Relay, the ignition switch, the ECM, and related wiring. There are basically two different types of power distribution circuits, ECM controlled and ignition switch controlled.

ECM controlled power distribution is used on applications with a Step Motor IAC system. All other applications use the ignition switch controlled system. In both cases, the power distribution electrical wiring carries electrical current from the battery, through the Main Relay, through the ECM, and back to the battery through the E1 ground.

Power Distribution Circuit

With Step Motor IACV
When the ignition switch is in the Start or Run position, current flows to the ECM IGSW terminal, signaling the ECM to turn on the MREL circuit. The ECM sends current through the MREL circuit and Main Relay pull-in winding, to ground. This closes the power contact, causing current to flow to the ECM +B terminals.

Without Step Motor IACV
When the Ignition switch is in the Start or Run position, current flows through the main relay pull-in winding, to ground, causing the power contact to close. This causes current to flow through the power contact to the ECM +B terminals.

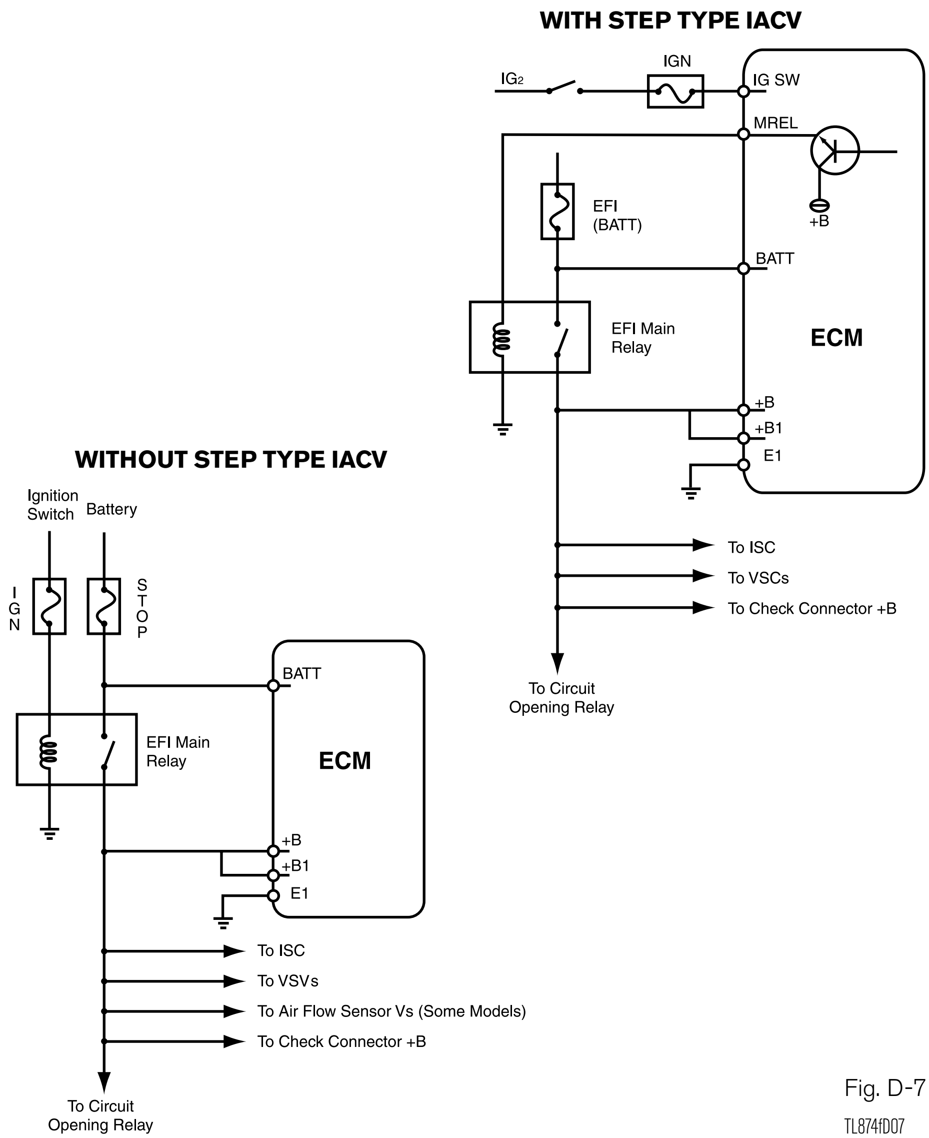


Fig. D-7

DIAGNOSTIC REFERENCE INFORMATION

Fuel Pump Control Circuit

Circuit Description

Fuel pump control methods differ between models that use a vane air flow meter and those that do not. On models using a vane air flow meter, a fuel pump switch located inside the meter is used to maintain fuel pump operation once the engine has started. During cranking, the STA signal commands the circuit opening relay to provide power to the fuel pump. After start-up, intake air flow opens the air flow meter's measuring plate closing the fuel pump switch. As a result, the circuit opening relay will maintain fuel pump operation after the engine has started.

On other systems, the circuit opening relay still operates the fuel pump from the STA command during cranking; however after the engine has started, the ECM must switch on the Fc circuit to continue pump operation. On this type of system, the ECM must continue to see an engine speed signal (NE) in order to continue operating the fuel pump after the engine has started.

Fuel Pump Control Circuit

During cranking, the circuit opening relay powers the fuel pump based on the STA signal command.

After start-up fuel control differs in that systems using a vane air flow meter use a fuel pump switch to maintain pump operation. All others use ECM control of the Fc signal to maintain fuel pump operation.

Condition \ Terminal	+B	Fc	Fp
Cranking	12V	–	12V
Engine Running	12V	< 1V	12V

As shown in the chart, Fc control voltage is pulled low (grounded) by either the fuel pump switch (when intake air flow is sufficient) or the ECM (when Ne signal is above a specified rpm) to keep the fuel pump operating after start-up.

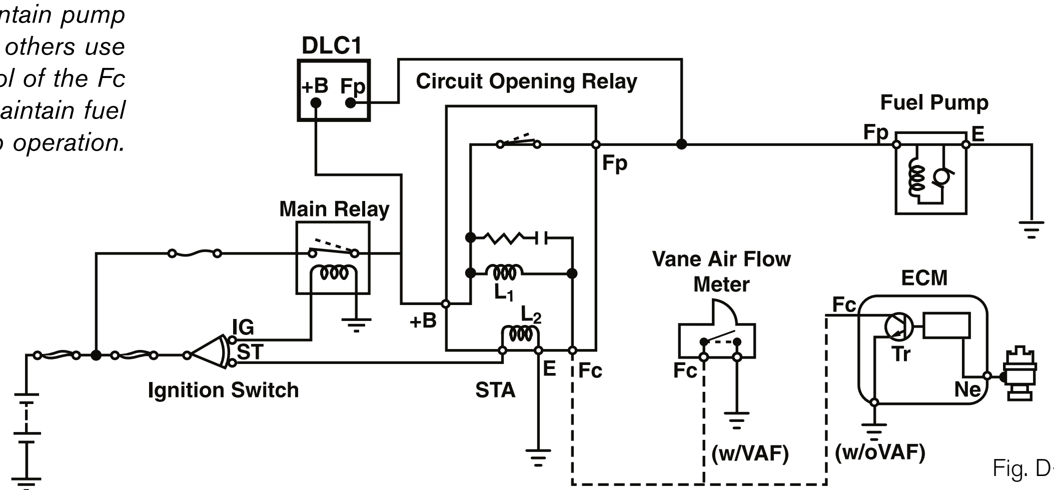


Fig. D-8

TL874fD08

DIAGNOSTIC REFERENCE INFORMATION

Injector Drive Circuit

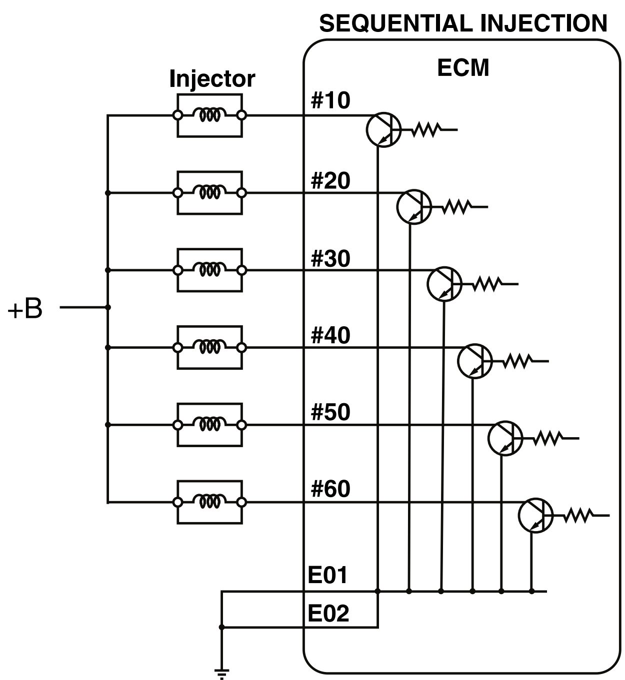
Circuit Description

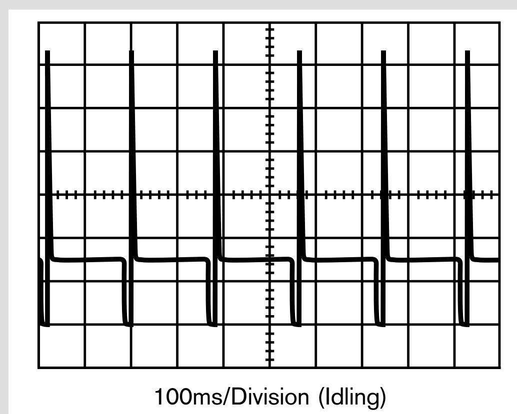
The design of the injector drive circuit determines when each injector delivers fuel in relation to the operating cycle of the engine. Depending on the engine application, the drive circuit design may be either a Simultaneous, Grouped, or Sequential type. In all designs, voltage is supplied to the injectors from the ignition switch or EFI main relay and the ECM controls injector operation by turning on the driver transistor grounding the injector circuit.

On Simultaneous type drive circuits, all injectors are pulsed at the same time by a common driver circuit. Injection occurs once per engine revolution, just prior to TDC No. 1 cylinder. Twice per engine cycle, one-half of the calculated fuel is delivered by the injectors. With Grouped drive circuits, injectors are grouped in pairs and a separate driver controls each group of injectors. Injection is timed to pulse just prior to TDC for the leading cylinder in the pair. On Sequential drive circuits, each injector is controlled separately and is timed to pulse just prior to each intake valve opening.

Injector Drive Signal

Depending on engine application, the injector drive circuit may be either a Simultaneous, Grouped or Sequential type.





The horizontal line in the scope pattern above represents battery voltage applied to the injector circuit. As the injector driver turns on (to open the injector) the signal drops to near 0V. Once the driver opens (to close the injector) a voltage spike occurs as a result of the collapsing magnetic field.

Fig. D-9

TL874fD09

Troubleshooting Hints

- Diagnostic Trouble Code for injector circuit can set for any misfire, regardless of cause.
- No Diagnostic Trouble Codes for injector circuit on OBD equipped engines.

OBD II Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
P0201	Injector Circuit #1	Specified cylinder misfire continuously (two trip detection logic)
P0202	Injector Circuit #2	
P0203	Injector Circuit #3	
P0204	Injector Circuit #4	
P0205	Injector Circuit #5	
P0206	Injector Circuit #6	

DIAGNOSTIC REFERENCE INFORMATION

Ignition Circuit (IGT & IGF Signals)

Circuit Description

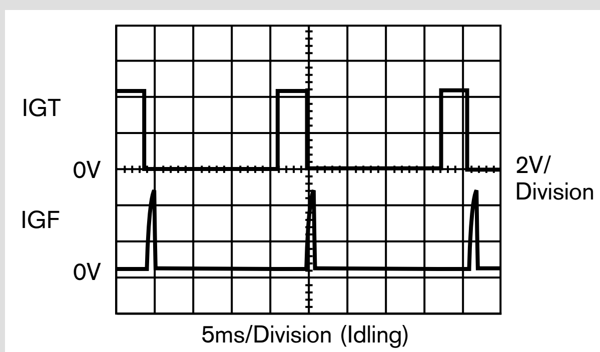
The ignition timing (IGT) and ignition fail (IGF) signals provide crucial information in the control of ignition system timing, injection timing, and Fail-Safe activation. Based on an initial timing angle calculated from the NE and G signals, the ECM outputs an IGT signal to the igniter as a reference point from which it determines ignition dwell period. A special circuit inside the igniter controls the ignition dwell period by controlling when the power transistor is switched on. When the ECM determines the proper time to provide spark, it turns the IGT signal off, which turns the igniter power transistor off, producing a spark.

The IGF signal is used by the ECM to determine if the ignition system is working and to protect the catalytic converter. When the ECM does not detect the IGF signal, the ECM goes into fail-safe mode. With no IGF signal, the ECM will store a DTC(s), depending on model year and number of cylinders affected. There are different fail-safe modes depending on the ignition system, cylinder displacement and model year. The following is general summary.

IGT & IGF Signal Relationship

The IGT signal triggers the igniter power transistor. Without IGT, spark will not occur.

The IGF signal confirms that an ignition event has occurred. Without IGF, the ECM shuts down injection pules.



The IGT signal trailing edge indicates the point where the power transistor is turned off, firing the coil.

The IGF signal is generated by the igniter each time spark occurs.

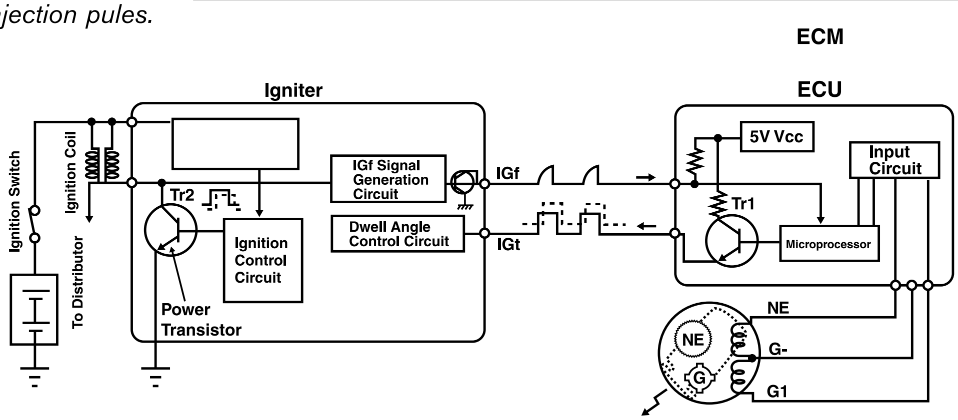


Fig. D-10

TL874fD10

If there is no IGF signal on engines before 1998 model year, the ECM will enter fail-safe and turn off all the fuel injectors.

Beginning with the 1998 model year, V-6 and V-8 engines equipped with direct ignition system with integrated ignition coil/igniter (1 ignition coil/lighter per cylinder), the engine will still run without the IGF signal, but the MIL will be on.

Beginning with the 2001 model year on 1 ignition coil/igniter per cylinder engines, the ECM fail-safe will turn off the fuel injector if there is no IGF signal for that cylinder and if engine conditions (such as load and temperature) are sufficient to damage the catalytic converter. If the IGF signal returns to normal while the engine is running, the injector may remain off until the next engine start.

Due to the rapid, high frequency nature of these signals, inspection should be performed using an oscilloscope or high quality digital multimeter with frequency capabilities.

Troubleshooting Hints

- On older systems, if engine will not start due to missing IGF, injectors will pulse once or twice during cranking. Use injector test light to confirm this condition.
- Scan data indicates an injection duration even when injectors are disabled due to IGF fuel cut fail-safe.
- Regardless of the type of IGF fail-safe mode, the IGF DTCs must be diagnosed **before** attempting to diagnose a fuel system/injection problem. The IGF DTCs are one trip DTCs.
- Use oscilloscope to diagnose IGT and IGF circuits.

OBD Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
14	IGF Circuit	ECM does not detect IGF signal for 6 consecutive IGT signals.

OBD II Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
P1300 Series	IGF/Igniter Circuit Malfunction	ECM does not detect IGF signal for 6 or 8 consecutive IGT signals with engine running.