Next Generation Engine Management Part 1, Speed Density Operation and Diagnosis

Course Code 0831124

Speed Density Operation and Diagnosis

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Speed Density Operation and Diagnosis

INTRODUCTION

This publication contains information regarding the Speed Density fuel systems used on most Chrysler Group vehicles. The emphasis is on NGC engine management systems, but differences with older JTEC and SBEC systems are also included. The NGC controller is being phased-in and will replace JTEC and SBEC controllers in most gasoline-powered vehicles by the 2005 model year.

The fuel injection system for all of these engines is sequential multiport with an in-tank fuel pump module. Ignition systems are distributorless waste-spark or direct coil-on-plug.

A brief review of basic electrical principles will help your understanding of PCM operation, PCM inputs and outputs. This course will discuss the Speed Density Equation, which describes how the PCM determines the correct fuel quantity. Fuel adaptives and electronic throttle control are also included.

STUDENT LEARNING OBJECTIVES

Upon completion of this course, you should be able to:

- have a general understanding of PCM operation.
- locate and test the components of the wet side of the speed density fuel system.
- locate and test PCM power and ground circuits.
- apply the speed density equation to NGC controllers.
- identify PCM inputs and diagnose a faulty PCM input.
- describe the operation of the ETC/APPS systems, and diagnose a fault in the system.
- identify PCM outputs and diagnose a faulty PCM output.

ACRONYMS

The acronyms listed here are used throughout this course:

- APPS Accelerator Pedal Position Sensor
- ASD Auto Shutdown Relay
- BARO Barometric Pressure Sensor
- BCM Body Control Module
- BTS Battery Temperature Sensor
- CAB Controller Antilock Brakes
- CAN Controller Area Network
- CCD Chrysler Collision Detection Bus
- CKP Crankshaft Position Sensor
- CMP Camshaft Position Sensor
- COP Coil On Plug Ignition
- DHSS Dual High Side Switch
- DIS Distributorless Ignition System
- DLC Data Link Connector
- DMM Digital Multimeter
- DRBIII ® Diagnostic Readout Box – 3rd Generation
- DTC Diagnostic Trouble Code
- EATX Electronic Automatic Transmission Controller
- ECT Engine Coolant Temperature Sensor
- EGR Exhaust Gas Recirculation
- EMI Electromagnetic Interference
- ETC Electronic Throttle Control
- IAC Idle Air Control
- IAT Intake Air Temperature Sensor

- JTEC Jeep/Truck Engine Controller
- KOEO Key On Engine Off
- KOER Key On Engine Running
- LDP Leak Detection Pump
- LEV Low Emission Vehicle
- LSIAC Linear Solenoid Idle Air Control Valve
- LTFT Long Term Fuel Trim
- MAP Manifold Absolute Pressure Sensor
- MDS2 ® Mopar Diagnostic System – 2nd Generation
- MIC Mechanical Instrument Cluster
- MIL Malfunction Indicator Lamp
- MTV Manifold Tuning Valve
- MUX Multiplex
- NC Normally Closed (switch state)
- NGC Next Generation Controller
- NO Normally Open (switch state)
- NTC Negative Temperature Coefficient
- NVLD Natural Vacuum Leak Detection
- OBD II On-Board Diagnostics – 2nd Generation
- ORVR On-Board Refueling Vapor Recovery
- PCI Programmable Communication Interface Bus (J1850)
- PCM Powertrain Control Module
- PCV Positive Crankcase Ventilation Valve
- PDC Power Distribution Center
- PEP Peripheral Expansion Port
- PPS Proportional Purge Solenoid
- PTC Positive Temperature Coefficient

- PWM Pulse Width Modulated
- QHSS Quad High Side Switch
- RAM Random Access Memory
- RFI Radio Frequency Interference
- RPM Revolutions Per Minute
- SBEC Single Board Engine Controller
- SC Speed Control
- SCI Serial Communication Interface Bus
- SKIM Sentry Key Immobilizer Module
- SKIS Sentry Key Immobilizer System
- SPIO Serial Peripheral Interface/Output Circuit
- SRTV Short Runner Tuning Valve
- STFT Short Term Fuel Trim
- TCM Transmission Control Module
- TDC Top Dead Center
- TIP Throttle Inlet Pressure Sensor
- T-MAP Throttle MAP (calculated MAP value)
- TPS Throttle Position Sensor
- ULEV Ultra Low Emission Vehicle
- VSS Vehicle Speed Signal
- WOT Wide Open Throttle

Notes:

MODULE 1 BASIC ELECTRICITY

The basic principles of electricity are essential to understanding PCM circuit operation. Let's review several concepts.

The circuit shown is a simple series circuit with a battery, a bulb and a switch. As shown, the switch is open and no current is flowing. The bulb is the load and it is not illuminated. There is no voltage drop when no current flows, so voltage on the ground side of the bulb (point 2) measures 12V.

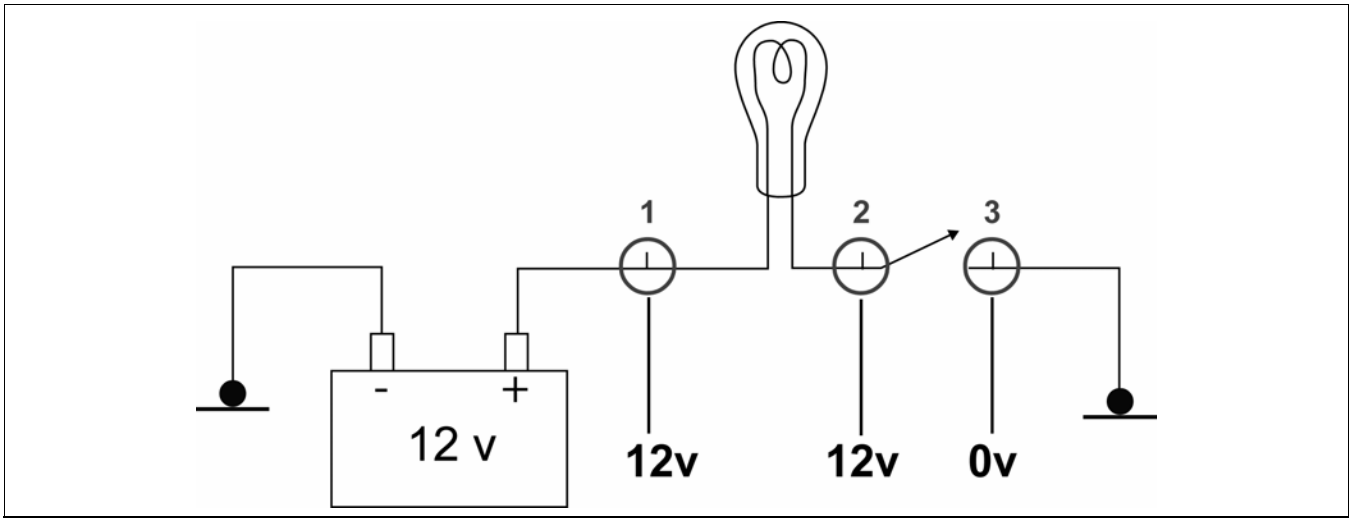


Figure 1 Open Series Circuit

When the switch closes, the circuit is complete and current flows (voltage drops across the bulb). The ground side of the bulb now measures 0V, and the bulb is illuminated.

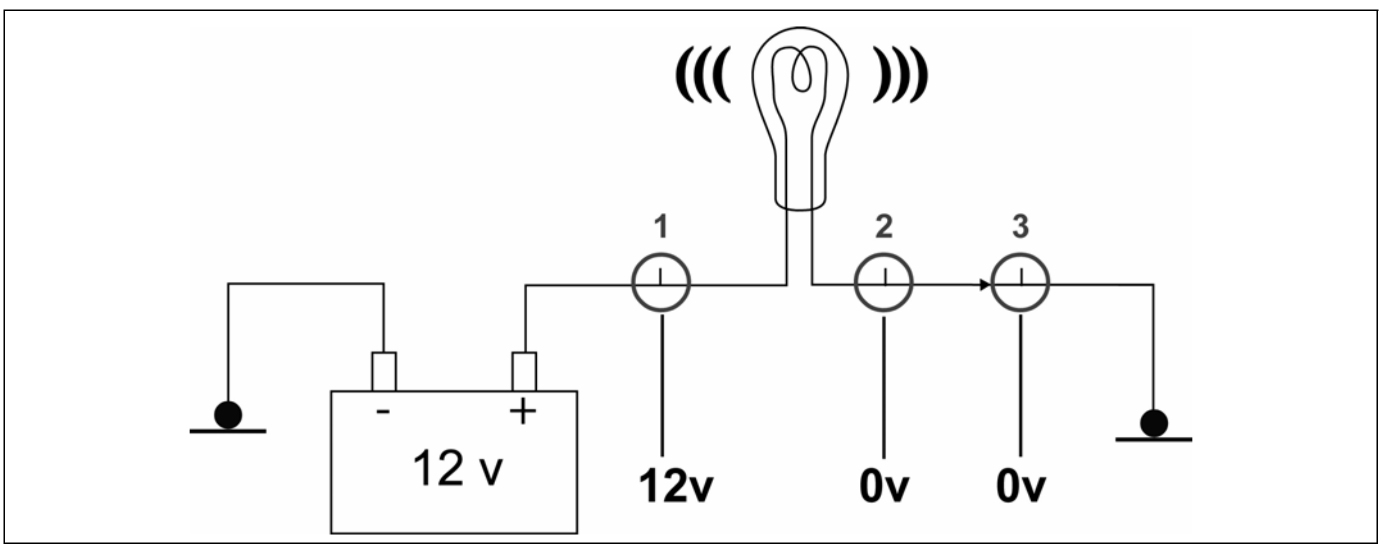


Figure 2 Closed Series Circuit

We have replaced the switch with a variable resistor. In Figure 3, the resistance of the variable resistor is low, the voltage at point 2 is close to 0V and the bulb is bright. In Figure 4, the resistance of the variable resistor is increased, the voltage at point 2 is also increased, and the bulb is dimmer.

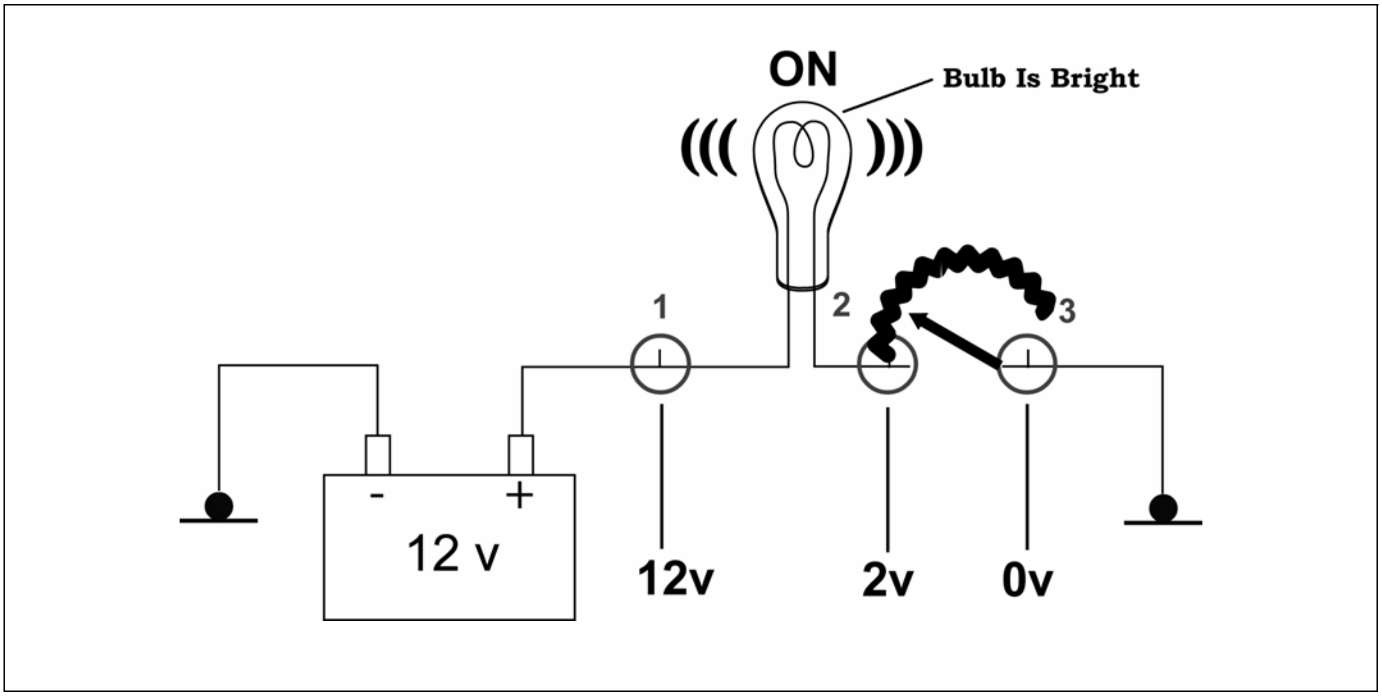


Figure 3 Variable Resistor, Low Ohm Setting

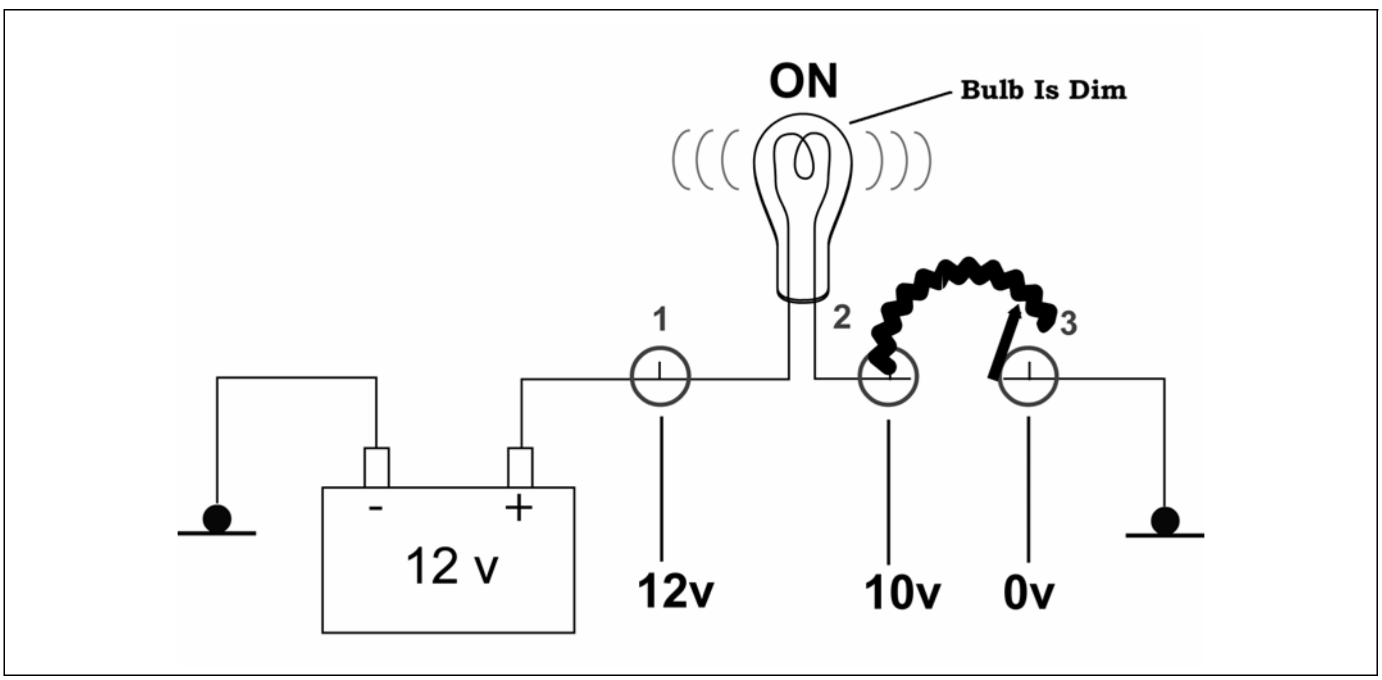


Figure 4 Variable Resistor, High Ohm Setting

PCM TWO-STATE INPUT CIRCUIT

Let's apply these concepts to a PCM Two-State Input circuit. The PCM has a 12V reference voltage and an internal pull-up resistor. PCM sensor reference voltages typically are 12V or 5V.

In Figure 5, the switch is open. The PCM voltmeter circuit sees the voltage at point 2. The PCM sees a high voltage when the circuit is open. No current is flowing, and there is no voltage drop across the pull-up resistor, so the full reference voltage is at point 2.

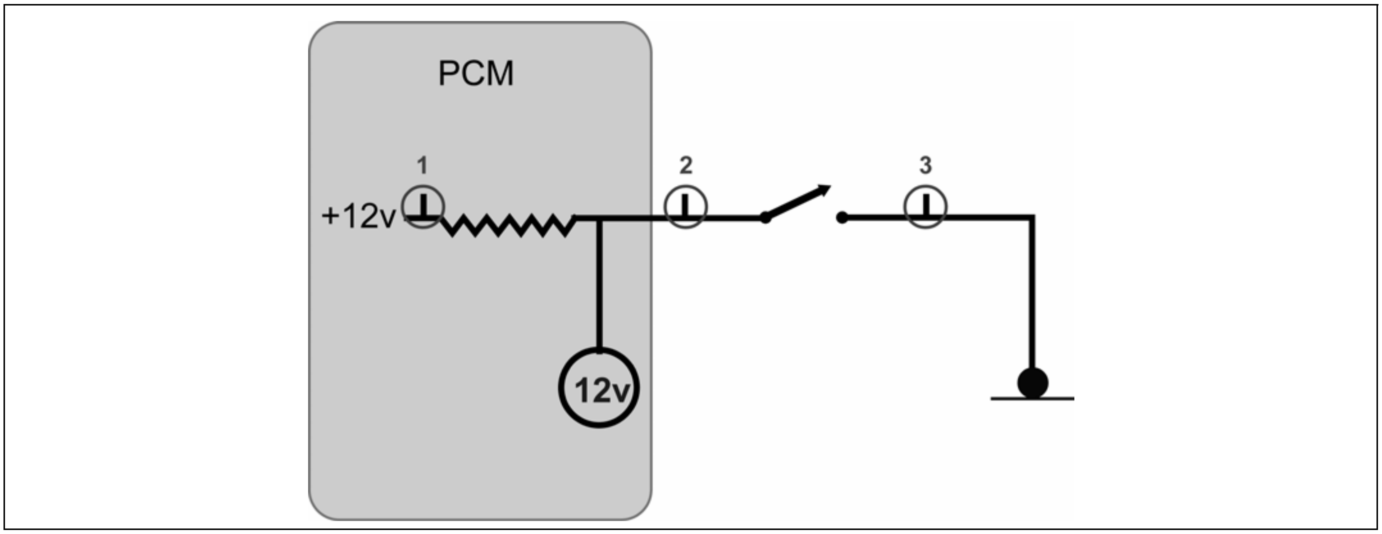


Figure 5 PCM Circuit, High Input

In Figure 6, the Two-State Input circuit switch is closed. The PCM now sees 0V when the circuit is closed. Current is flowing and the voltage drop across the pull-up resistor pulls voltage low on the ground side.

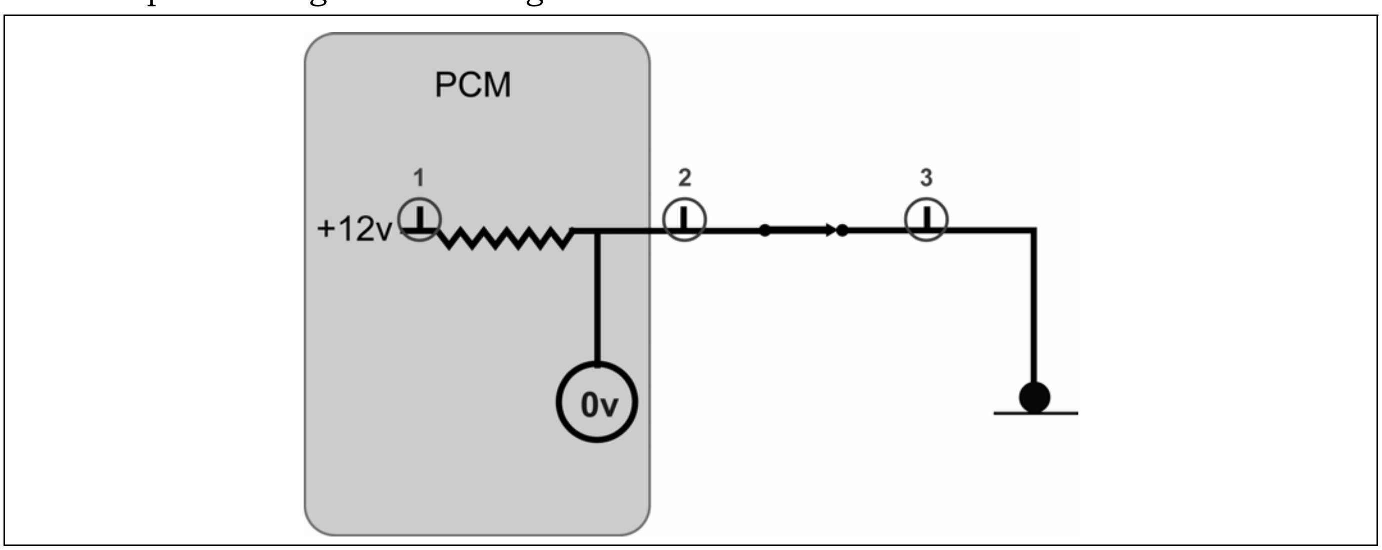


Figure 6 PCM Circuit, Low Input

In Figure 7, the PCM is monitoring an Engine Coolant Temperature (ECT) Sensor. This sensor is a Negative Temperature Coefficient (NTC) thermistor. Note that the sensor reference voltage in this example is 5V.

Because the ECT is a NTC sensor, sensor resistance decreases as temperature increases. As the sensor resistance decreases, the signal voltage also decreases. This sensor provides an analog signal which varies continuously with changes in temperature.

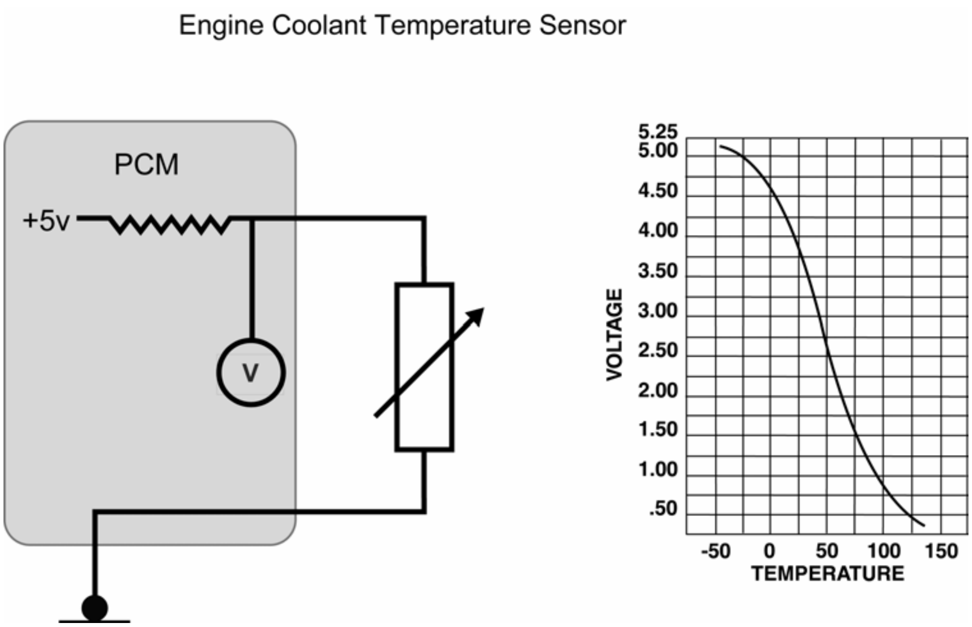


Figure 7 PCM Circuit, Variable Input

PCM FAULT RECOGNITION

The PCM monitors sensor voltage signals and will set a DTC when an abnormal condition occurs. There are three basic types of faults that the PCM can recognize:

- Short to Ground
- Open Circuit
- Short to Positive

SHORT TO GROUND

In Figure 8, there is a short to ground in the sensor circuit. The PCM sensor signal voltage now reads 0V, and the PCM interprets this voltage as a fault.

The PCM stores DTC P0117-ECT SENSOR CIRCUIT LOW and illuminates the MIL lamp.

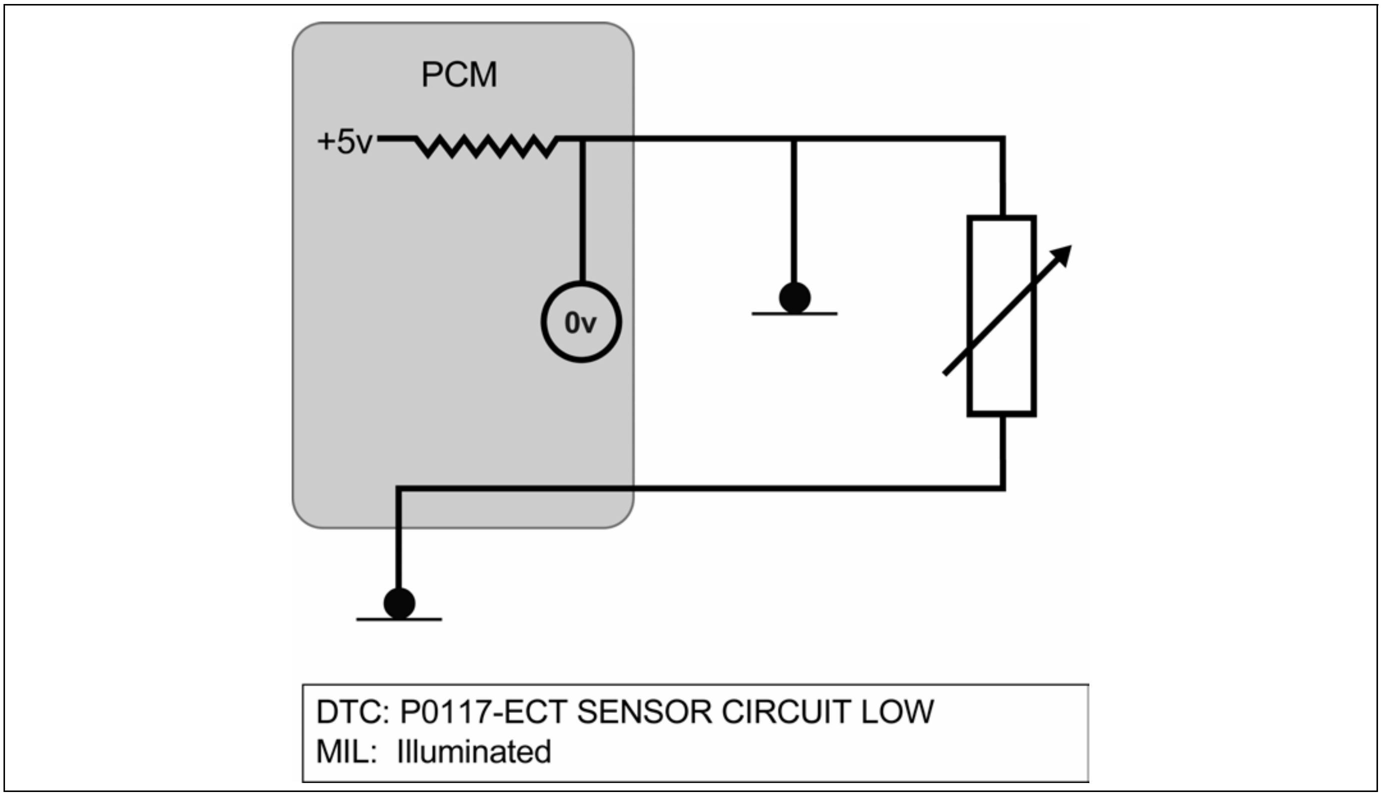


Figure 8 PCM Circuit, Short to Ground

OPEN CIRCUIT

In Figure 9, there is an open in the sensor circuit. The PCM sensor signal voltage now reads the full reference voltage, 5V, and the PCM interprets this voltage as a fault.

The PCM stores DTC P0118-ECT SENSOR CIRCUIT HIGH and illuminates the MIL lamp.

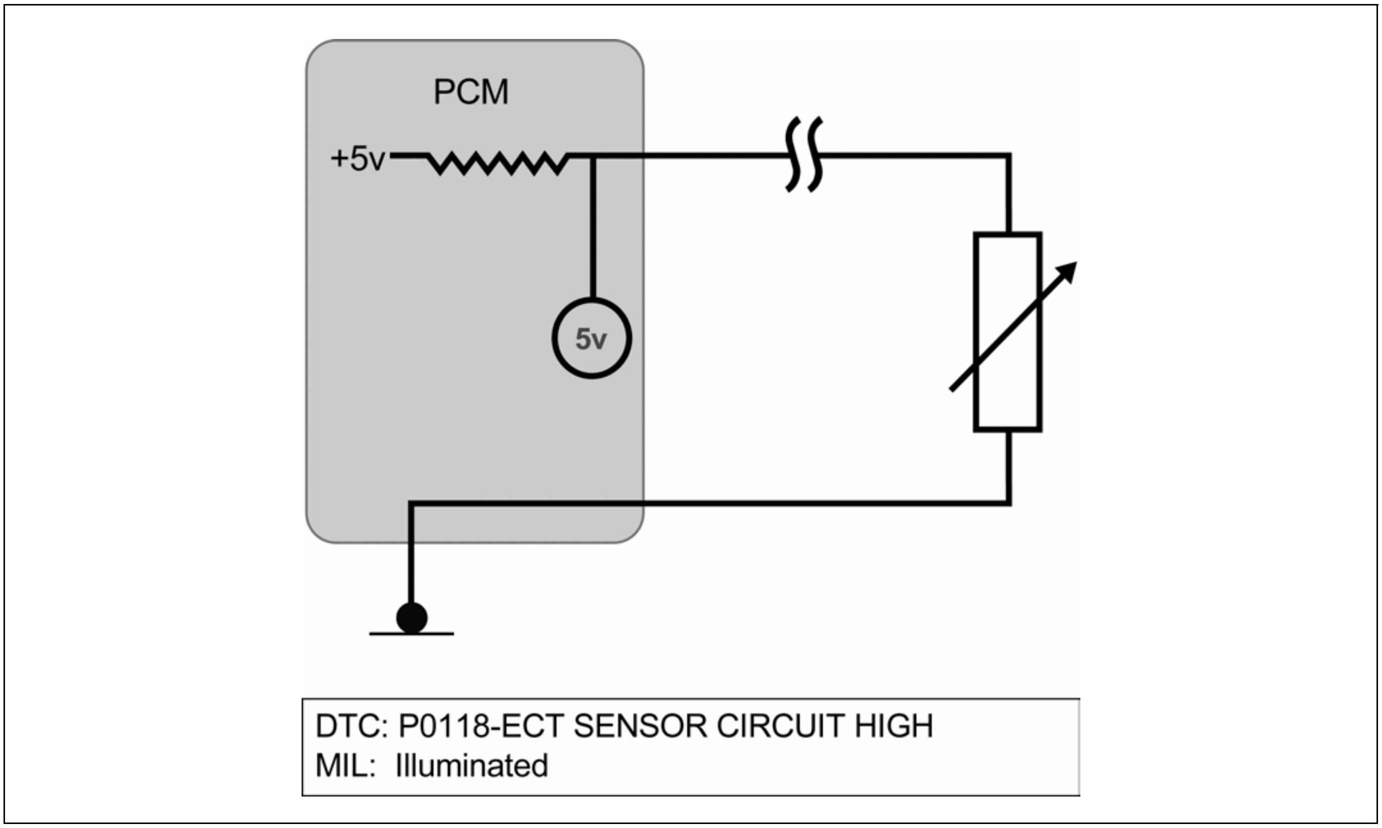


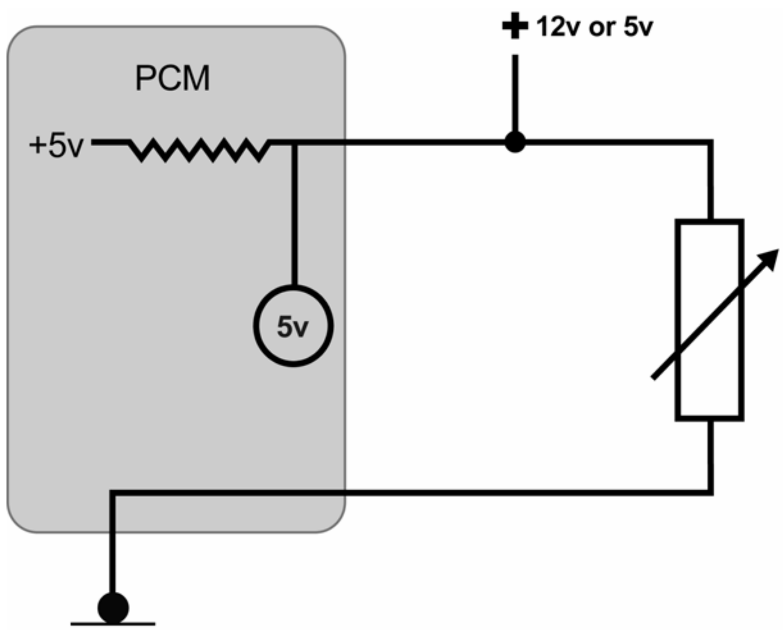
Figure 9 PCM Circuit, Open Circuit

SHORT TO POSITIVE

In Figure 10, there is a short to positive in the sensor circuit. The PCM sensor signal voltage again reads 5V, and the PCM interprets this voltage as a fault.

The PCM stores DTC P0118-ECT SENSOR CIRCUIT HIGH and illuminates the MIL lamp.

Note that an open circuit or a short to positive will generate the same DTC.



DTC: P0118-ECT SENSOR CIRCUIT HIGH
MIL: Illuminated

Figure 10 Short to Positive

Notes:

MODULE 2 SPEED DENSITY FUEL SYSTEM

FUEL DELIVERY SYSTEM

The fuel delivery system is returnless. All fuel leaving the fuel tank and pump is used by the engine. There is no fuel return line so no fuel returns to the tank.

An in-tank pump module pressurizes the fuel system. The PCM controls the operation of the fuel system by providing battery voltage to the fuel pump through the fuel pump relay. The PCM requires only three inputs and a good ground to operate the fuel pump relay. The three inputs are:

- Ignition voltage
- Crankshaft position (CKP) sensor
- Camshaft position (CMP) sensor

Most passenger cars use a high-density polyethylene fuel tank. Since 1998, all fuel systems are returnless to minimize heat in the fuel tank, which leads to excessive hydrocarbon vapors.

The fuel delivery system components include:

- Fuel pump module
- Fuel filter/Fuel pressure regulator
- Check valve
- Fuel level sensor
- Lines and hoses
- Fuel rail and injectors

Fuel Pump Module

The in-tank fuel pump module contains the 12V electric fuel pump, fuel level sensor and pressure regulator. The pump is a positive displacement, gearotor, immersible pump with a permanent magnet electric motor. The pump is serviced only as part of the fuel pump module. Most fuel pump modules are retained by a “Mason Jar” flange ring on top of the fuel tank.

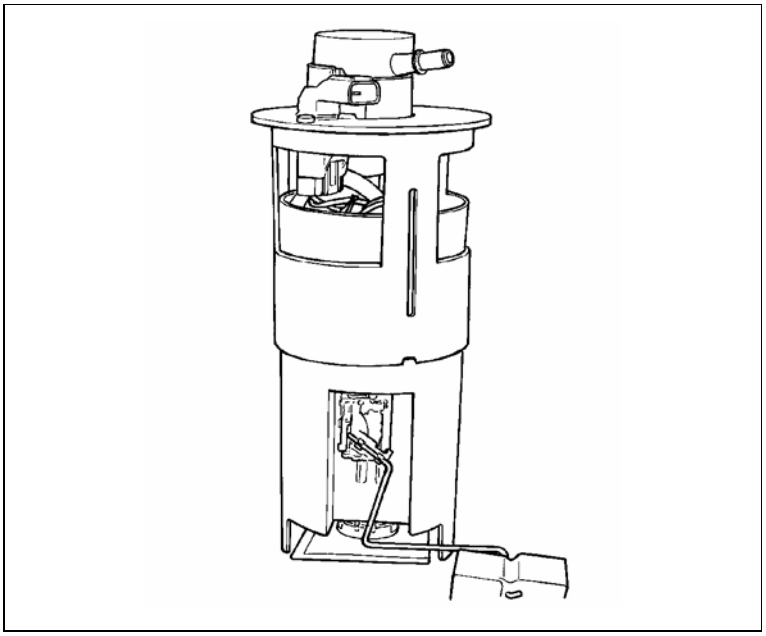


Figure 11 Typical Fuel Pump Module

Fuel Filter/Fuel Pressure Regulator

A combination fuel filter and fuel pressure regulator is currently used on all gas powered engines. It is located on the side of the fuel pump module in the fuel tank.

The pressure regulator is a mechanical device that is not controlled by the PCM. On NGC vehicles, the regulator controls fuel pressure to a constant 58 psi (400 kPa). JTEC vehicles regulate fuel pressure to 49 psi ±5 psi (338 ±34 kPa). Beginning in 2000 on some SBEC models, and extending to all 2001 SBEC vehicles, fuel pressure has been increased from 48 psi to 58 psi ±5 psi (400 kPa ±34 kPa). Consult Service Information for vehicle-specific information.

The PCM uses a special formula utilizing MAP sensor information to adjust injector pulse width based on the pressure differential across the injector.

Some fuel filter and pressure regulator assemblies are replaceable separately. Consult Service Information for vehicle-specific information.

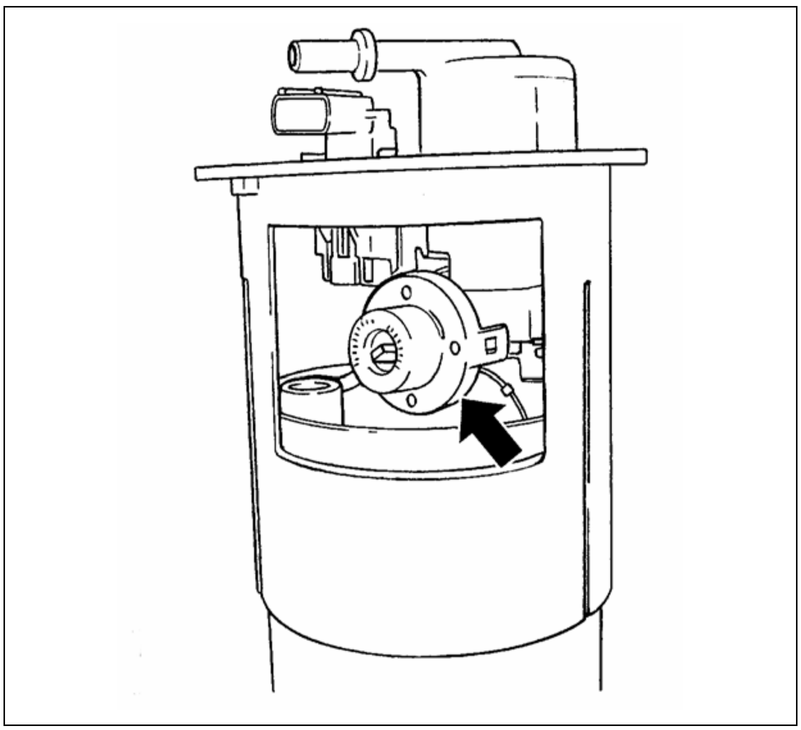


Figure 12 Typical Fuel Filter and Pressure Regulator

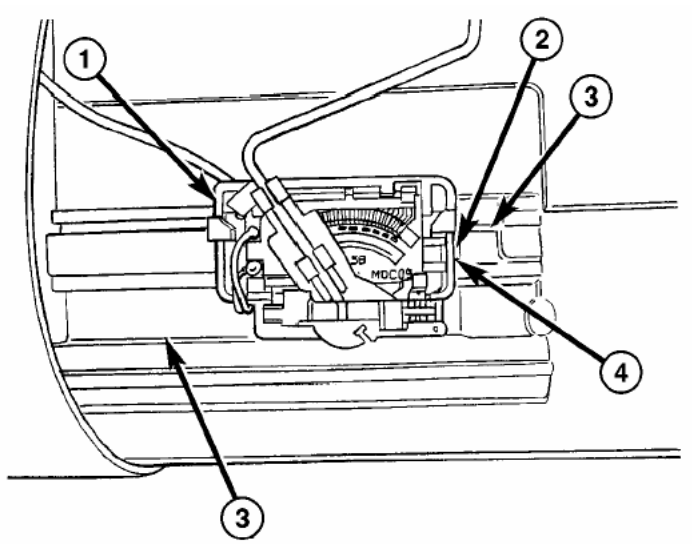
Check Valve

The fuel pump outlet contains a one-way check valve to prevent fuel return back into the tank when the pump is not running. With engine OFF, fuel pressure may drop to 0 psi (0 kPa) as the fuel cools, but the fuel supply line between the check valve and the fuel injectors will remain full of fuel. This is normal. When the fuel pump is activated, fuel pressure should immediately rise to specification.

Fuel Level Sensor

A fuel gauge level sending unit is attached to the fuel pump module. The resistance of the sensor rheostat changes with the amount of fuel in the tank. The sensor float arm moves as the fuel level changes.

LX models have a non-contact type sensor which uses magnets.

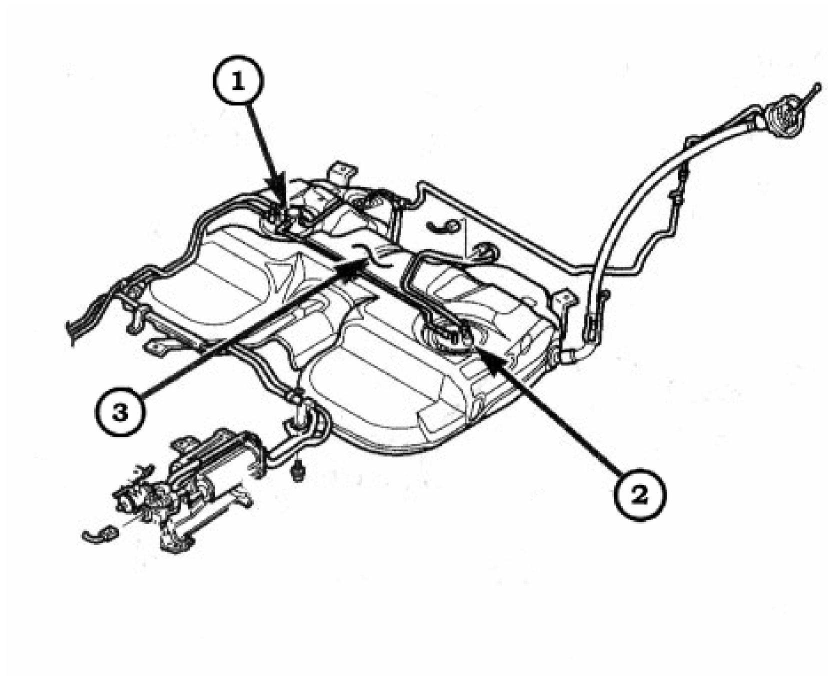


1	Sending Unit
2	Lock Tab
3	Tracks
4	Notch

Figure 13 Typical Fuel Level Sending Unit

Dual Fuel Level Sensor - CS

On CS vehicles, there are two fuel level sensors. The two sensor signals are averaged by the BCM to determine fuel level.



1	Fuel Pump Module and Fuel Level Sensor 1
2	Fuel Level Sensor 2
3	Fuel Tank

Figure 14 Dual Fuel Level Sending Units on Pacifica (CS)

Lines and Hoses

The high pressure lines from the tank to the engine can be rubber, plastic or steel lines. The lines and hoses are of a special construction due to the higher fuel pressures and the possibility of contaminated fuel in this system. Use only replacement lines marked EFM/EFI.

Caution: Always follow procedures found in the Service Manual when removing fuel system components. Always lube the O-rings in the quick connect fittings with engine oil before reassembly.

Fuel Rail and Injectors

The fuel rail supplies fuel to each individual fuel injector and is mounted to the intake manifold. A fuel pressure test port is provided on the fuel rail for some applications.

FUEL DELIVERY SYSTEM DIAGNOSTICS

The fuel level input is used as an input for OBD II. If the fuel level is below 15% or above 85% of total tank capacity, several monitors are disabled.

The fuel pump has a maximum pressure output of approximately 130 psi (880 kPa).

Recommended test procedures may include line pressure test, pump volume test, and pump current draw test.

Caution: Pump volume testing must be completed within the specified time to prevent pumping all fuel from the pump well.

ACTIVITY 1: FUEL PRESSURE

Notes:

Notes:

MODULE 3 PCM

PCM OPERATION

The PCM controls the operation of the following fuel-related systems:

- Fuel delivery
- Emission controls
- Charging voltage
- Idle speed
- Radiator fan
- Air conditioning
- Speed control system

The PCM receives information from input sensors, switches and the data bus that monitor specific operating conditions. The PCM processes this information in order to operate outputs that regulate engine performance. Outputs include the following:

- Ignition system
- Fuel injectors
- Generator field
- Air conditioning compressor
- Radiator fans
- Speed control servos

NEXT GENERATION CONTROLLER (NGC) PCM

The Next Generation Controller (NGC) is a state of the art PCM that will eventually replace all SBEC and JTEC PCMs as well as EATX III and EATX IV Transmission Control Modules (TCMs). The NGC PCM first appeared on 2002 LH vehicles and 2002 ½ DN vehicles with the 4.7L engine. The use of NGC controllers will expand to include other vehicle lines, with the full transition expected by the 2005 model year.

NGC I and NGC III controllers incorporate both engine and transmission controller functions in one unit. The TCM controller was removed from the NGC II controller in 2003 model DR trucks with the 5.7L engine and Electronic Throttle Control (ETC). For this one application only, there is a standalone EATX TCM to control the fully automatic transmission. The transmission controller function is expected to be back in the NGC controller in 2004.

NGC controllers:

- Require less under hood space due to the integration of the PCM and TCM
- Eliminate many external wiring circuits because of the ability of the PCM and TCM to share information via a dual-port RAM chip
- Provide cleaner emissions, better fuel economy, drivability, and idle quality, as a result of a “model-based” fuel injection strategy. This strategy works on all engine applications, regardless of displacement.
- Eliminate the hardware and software differences between SBEC and JTEC
- Have improved resistance against radio frequency interference (RFI) and electromagnetic induction (EMI)
- Improve fault detection and circuit protection through the use of Smart Drivers and enhanced diagnostics
- Provide faster computational speed with an all-new 32 bit/32MHz engine processor, and carryover 16 bit/16MHz transmission processor

NGC controllers are manufactured by two different plants: Motorola and Huntsville. These controllers are **not** interchangeable, however, interchangeability is predicted for the future. Huntsville controllers have cooling fins, while Motorola controllers do not have fins.

Figure 15 5.7L NGC PCM

Four 38-pin connectors are used on the NGC PCM. The connectors are identified by color:

- C1 (black)
- C2 (orange)
- C3 (white)
- C4 (green)

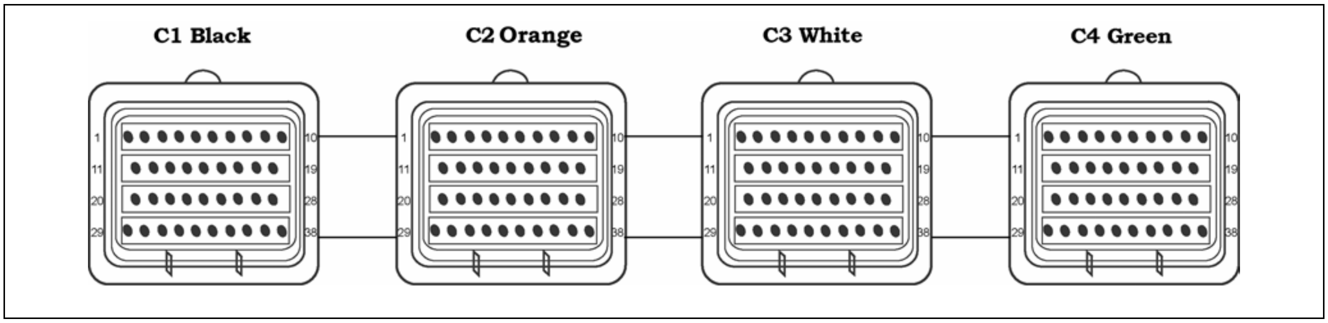


Figure 16 NGC PCM Connectors

When performing wiring harness diagnostics, it is important to not probe or back probe the connector. Connector damage will occur if this procedure is not followed. Two special tools have been designed for these connectors. The first is a pin-out box (Miller #8815) that allows you to perform wiring harness tests, and the other is a pin removal tool (Miller #8638), which is used to remove the terminal end from the connector.

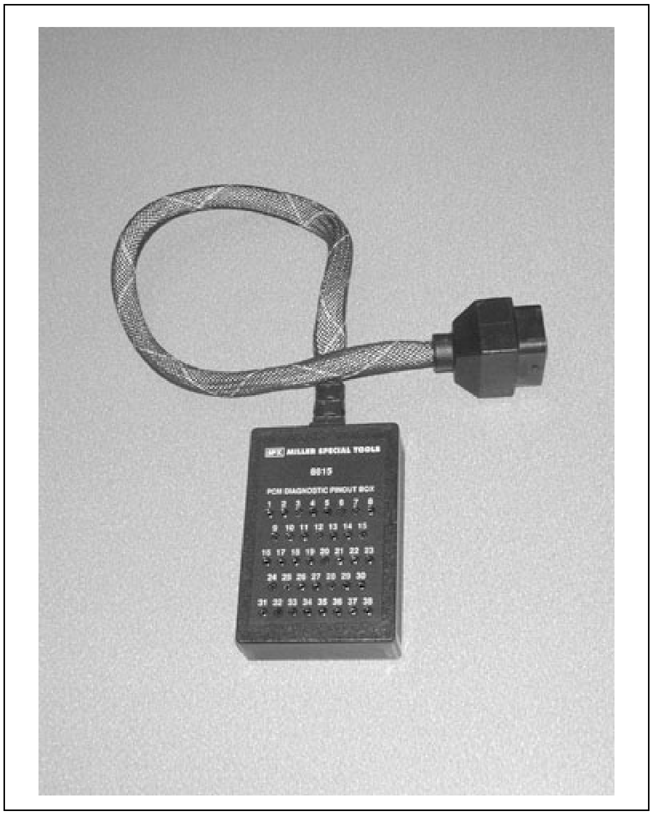


Figure 17 Miller #8815 Pinout Box

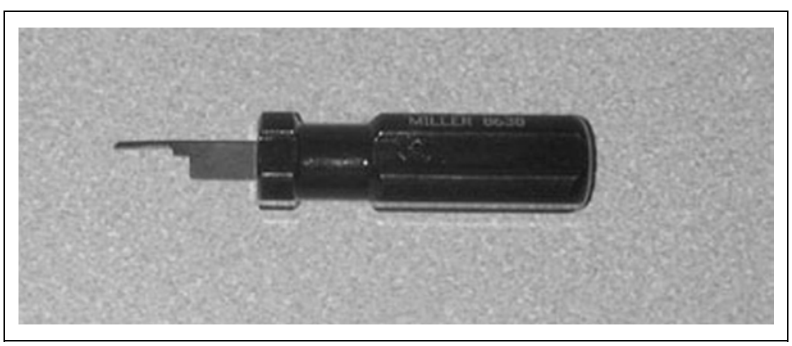


Figure 18 Miller #8638 Pin Removal Tool – NGC

SBEC PCMS

The Single Board Engine Controller or SBEC was the first to combine on one printed circuit board the logic module that processed information from sensors and other inputs, and the power module that actuated all output devices.

The Single Board Engine Controller III (SBEC III) was introduced in 1995. SBEC III has a shielded case to prevent Radio Frequency Interference (RFI) and Electro–Magnetic Interference (EMI). The SBEC III does not require air flow through the controller for cooling.

Figure 19 SBEC PCM

SBEC I and SBEC II PCMs have one 60-pin connector. The SBEC III PCM changed to two 40-pin connectors. Note: Pin locations for various functions are not the same between platforms. 1998 and later SBEC IIIA controllers have different pin arrangements than SBEC III and SBEC III+ controllers to prevent inadvertent interchange. Tool #6932 is used to service SBEC connector terminals.

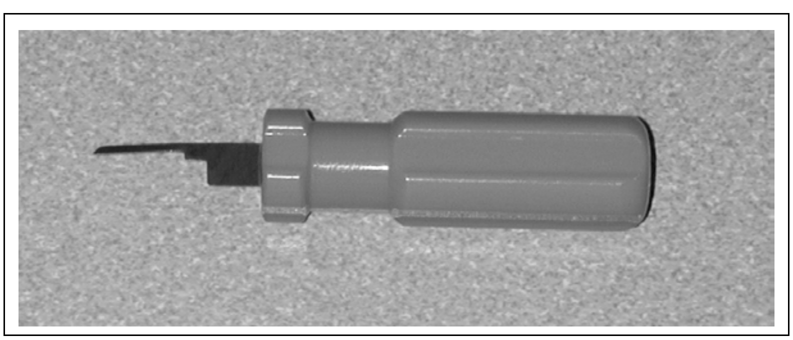


Figure 20 Miller #6932 Pin Removal Tool - SBEC

JTEC PCMS

The Jeep/Truck Engine Controller (JTEC) was introduced in 1996 and replaced the SBEC controller in all Jeep, Dodge Truck and Viper vehicles.

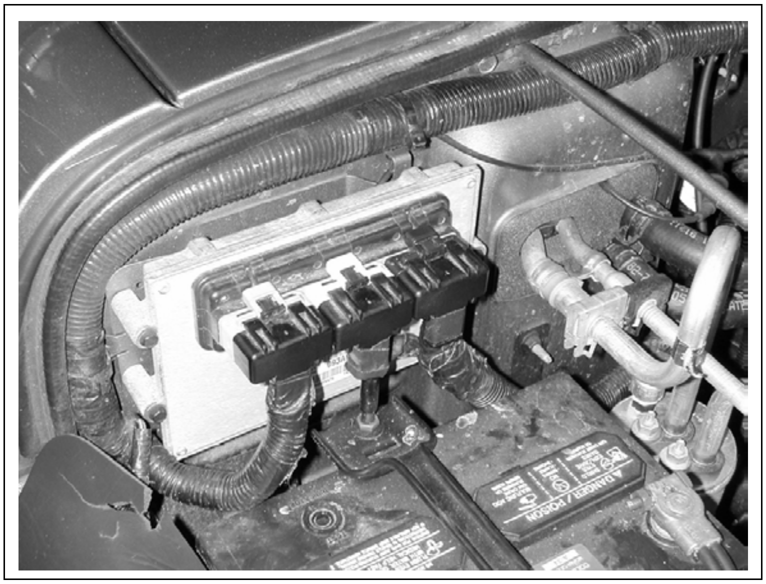


Figure 21 JTEC PCM

JTEC PCMs have three 32-pin connectors. The terminals are gold-plated, low insertion-force type. Tool #6934 is used to service JTEC terminals.

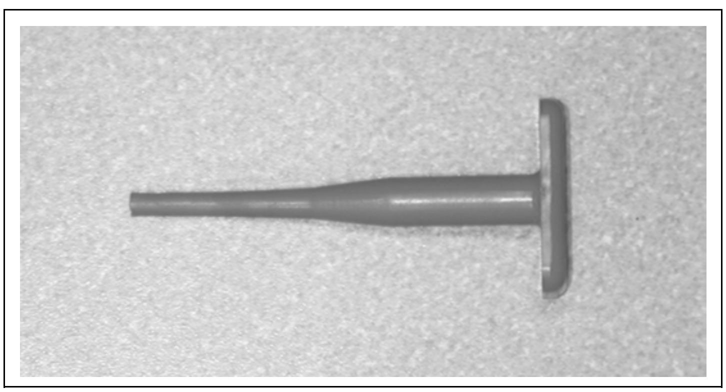


Figure 22 Miller #6934 Pin Removal Tool – JTEC

COMMUNICATION PROTOCOLS

SCI Bus

The Serial Communication Interface (SCI) Bus is the communication protocol used to enable two-way communications between the engine control microprocessor and the DRBIII® while in Standalone Mode. SCI Transmit (SCI Tx) is also used to record engine and/or transmission events while Data Recording. SCI Receive (SCI Rx) is used for flash programming either the PCM or TCM.

PCI Bus (J1850)

Beginning in 1998, LH vehicles use a single wire Programmable Controller Interface (PCI) Data Bus, also know as the J1850 Bus, for communication between the PCM and its shared inputs and outputs. This new system requires only one circuit instead of two circuits that the CCD Bus needed.

The PCI Bus is used for communication between the PCM and other modules. This single-wire communication protocol is also used by the DRBIII® to communicate with the engine control microprocessor in the PCM while in the Generic Tool Mode using the J1979 protocol. The PCI Bus is the primary communication protocol used by the transmission control microprocessor in the PCM.

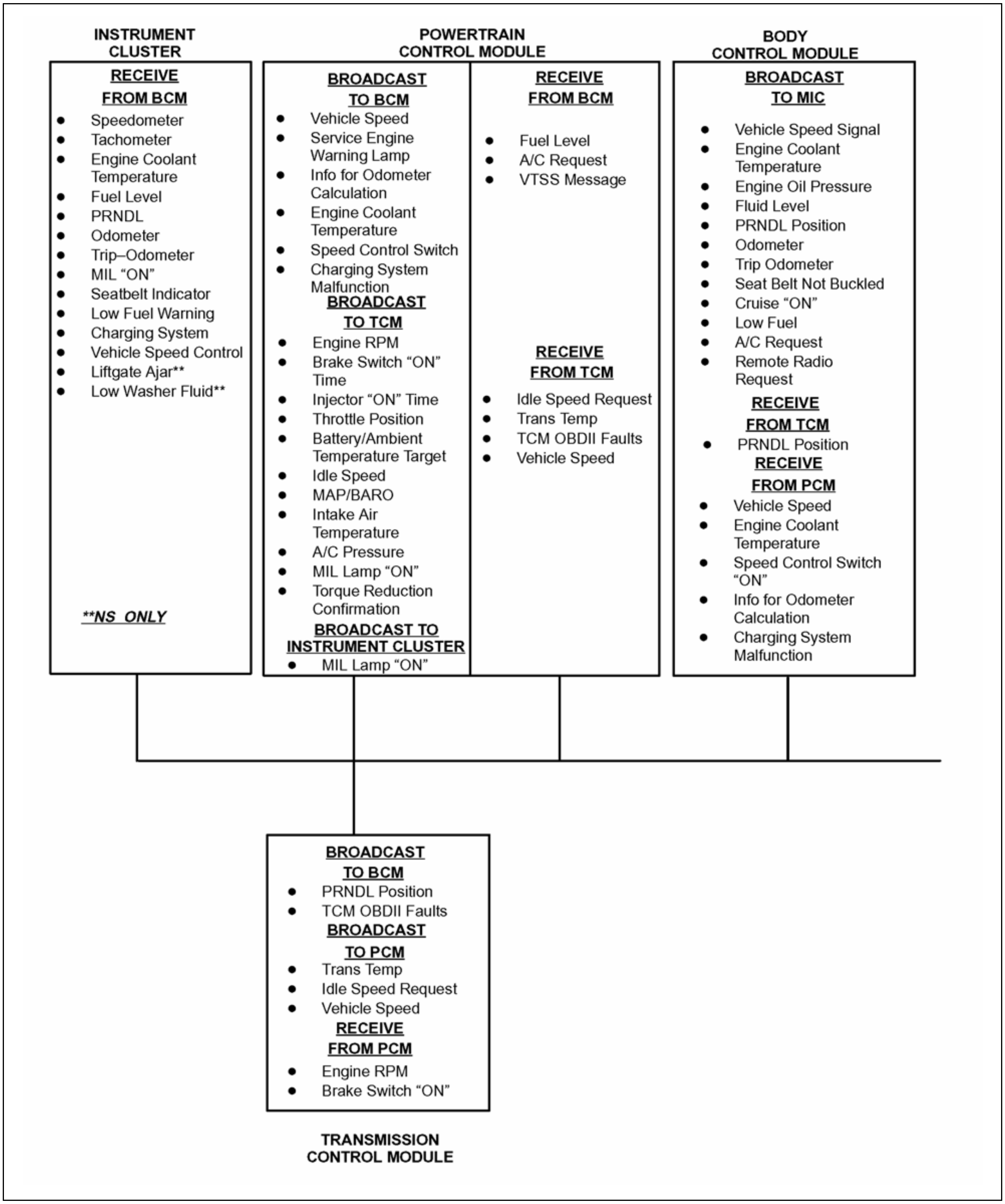


Figure 23 Typical PCI Data Bus Communication

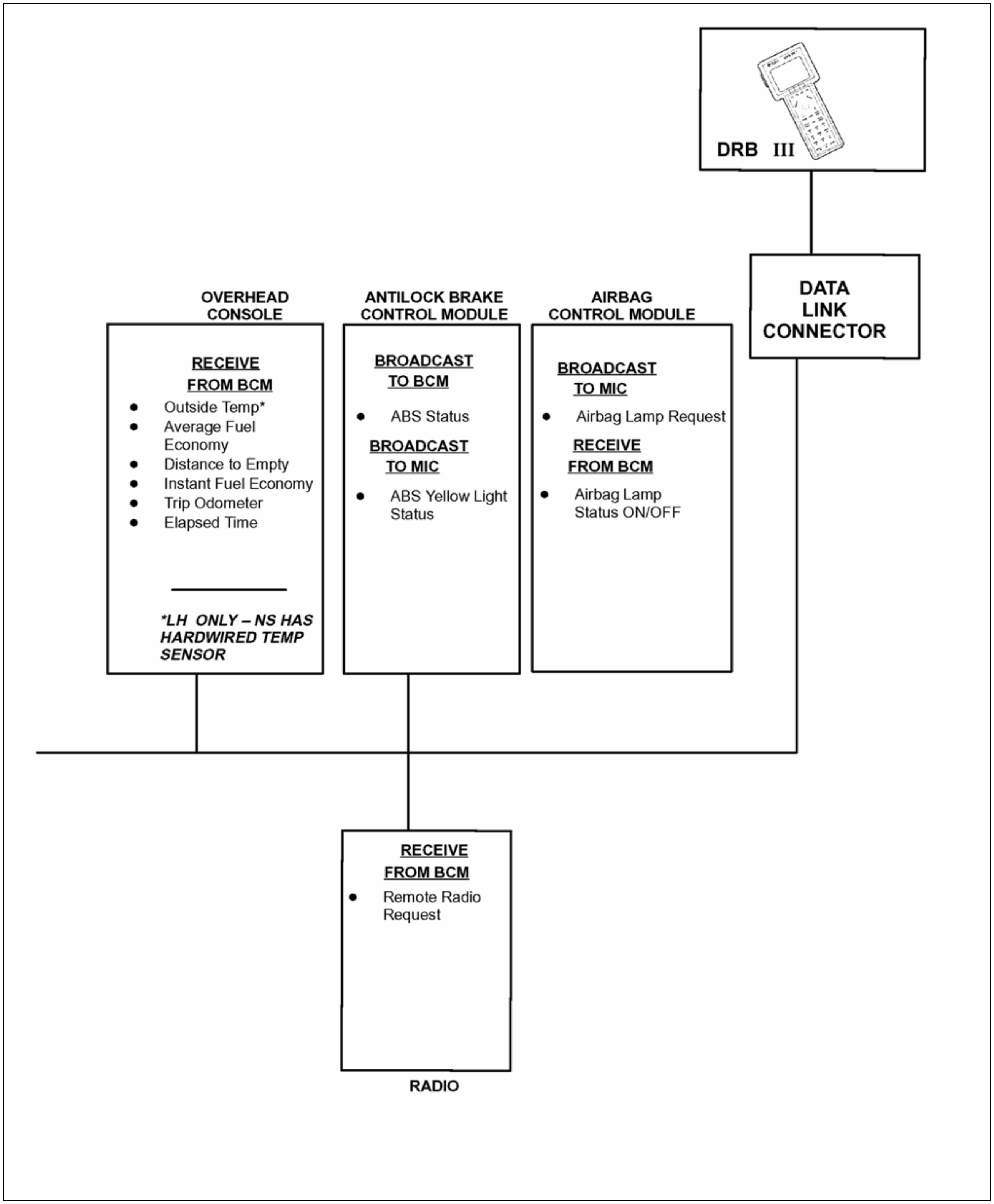


Figure 24 Typical PCI Data Bus Communication

CAN Bus (NGC only)

Controller Area Network (CAN) is a serial bus system developed by Bosch in the early 1980s. It is usually configured as a two wire communications system for transferring data between control modules. It is similar to other bus systems, except it can carry more information. Like the PCI Bus, CAN Bus modules broadcast messages almost simultaneously over the data bus.

CAN Bus was first introduced on DaimlerChrysler vehicles on the Grand Cherokee export with MB supplied engine and transmission and on Ram trucks with the Cummins Diesel. CAN Bus will be installed on 2004 model HB and LX vehicles.

CAN Bus allows sensors to be wired to the closest module and share data with other modules. This is possible with increased data transfer speed and no lost messages.

In a typical vehicle, the CAN consists of two busses: one medium speed and one high speed. CAN B is the medium speed Bus which operates at 83.3 kbps. CAN C is the high speed Bus which operates at 500 kbps.

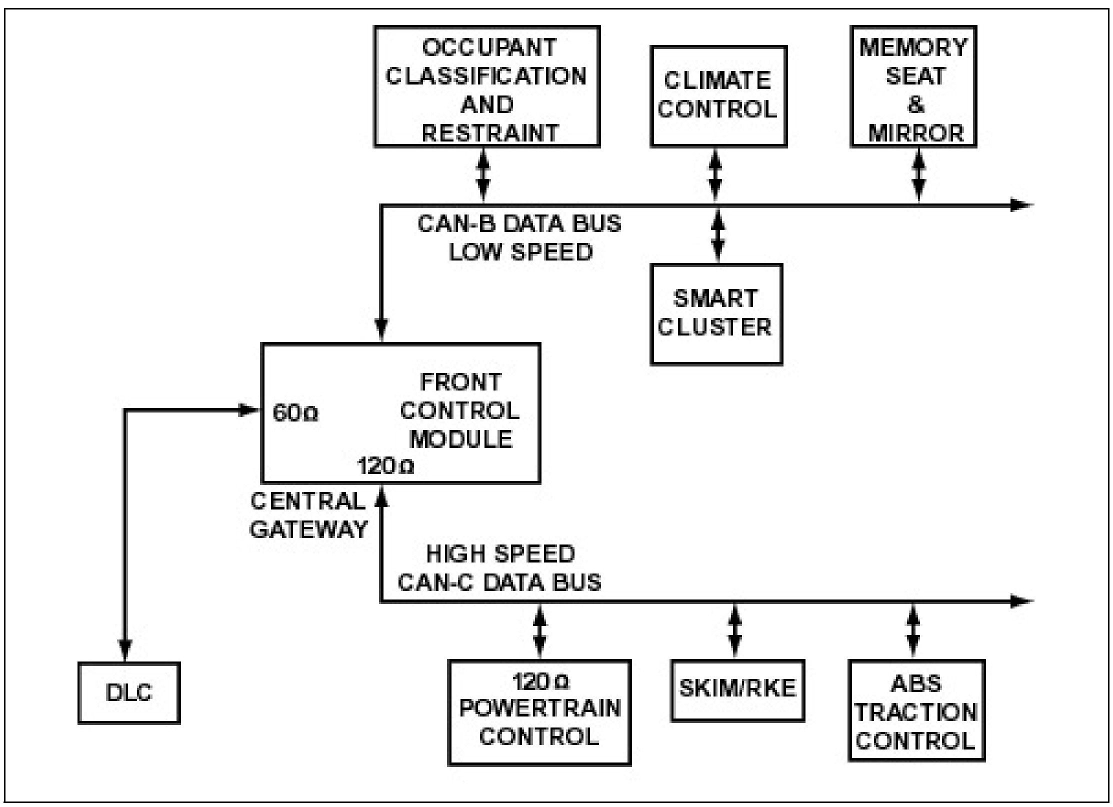


Figure 25 Typical CAN Bus

CCD Bus Communication

The Chrysler Collision Detection (CCD) data bus system is a two-wire communication port which allows various controllers and modules to exchange information. CCD was not used for Scan Tool-to-PCM communications and diagnostics.

It was introduced in the 1988 model year on the Chrysler New Yorker and Dodge Dynasty and was the dominant communication method used for ten years. CCD Bus was gradually phased out between 1998 and 2003.

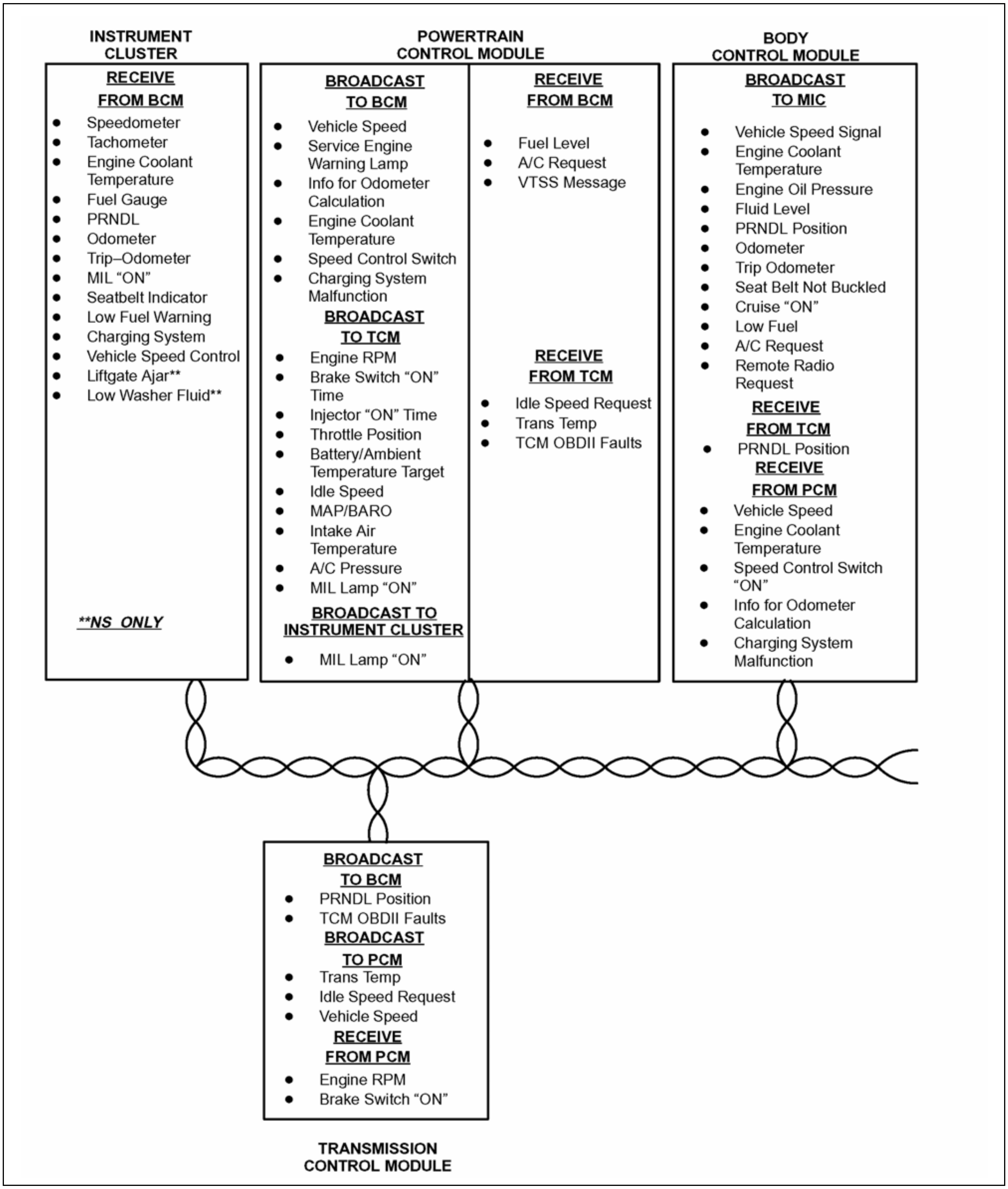


Figure 26 Typical CCD Bus Communication

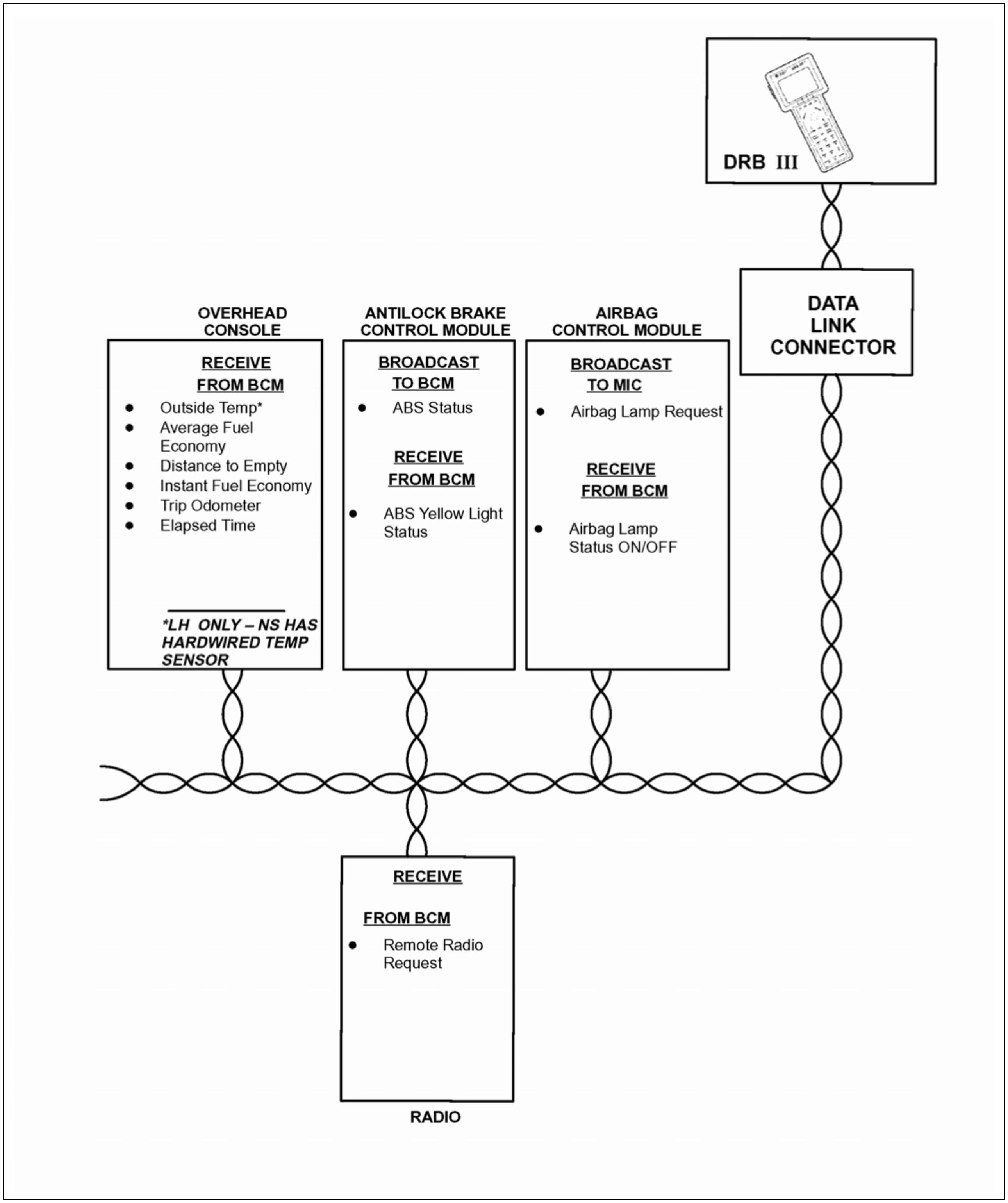


Figure 27 Typical CCD Bus Communication

Internal via Dual-Port RAM (NGC only)

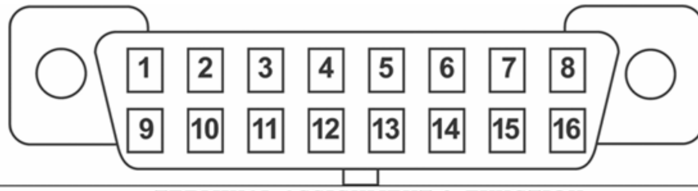
On NGC I and NGC III controllers, internal communications between the PCM and TCM microprocessors takes place via the Dual-Port RAM chip. This integrated circuit allows the two microprocessors to directly share high-speed digital information internally without having to rely on the PCI Bus for all communications.

2003 DR models with the 5.7L engine and NGC II controllers utilize a separate TCM and share information and communicate with the TCM over the PCI Bus. Removing the TCM function from the PCM provides space in the PCM to integrate the ETC function.

J1962 Data Link Connector (DLC) Connector

The PCM maintains communication with scan tools through the vehicle Data Link Connector (DLC). The DLC connector is located under the instrument panel, near the steering column.

Beginning with 2002 LH, AN, DN and DR models, Chrysler Group vehicles are switching over to a new J1962 DLC connector layout to comply with a revised SAE specification. This change is required for the introduction of the Controller Area Network (CAN) Bus in the future. Pins 6 and 14 were originally designated as "manufacturer specific" by SAE, but have been recalled to be used for the CAN Bus. This has forced a relocation of the SCI Bus circuits that were previously assigned to these terminals. Note that this is NOT an NGC-specific change. Refer to the appropriate Service Information.



TERMINAL ASSIGNMENT & FUNCTION			
		DaimlerChrysler Corporation	
PIN	**SAE/ ISO**	**A (1994MY - 2002MY+)**	**B (2002MY+)**
1	Manufacturer Discretionary	RKE Programming Input	not used
2	SAE J1850 (+)	SAE J1850 10.4 Kbps	SAE J1850 10.4 Kbps
3	Manufacturer Discretionary	CCD (+)	not used
4	Chassis Ground	Power Ground	Power Ground
5	Signal Ground	Signal Ground	Signal Ground
6	ISO 15765-4 CAN-C (+)	SCI A Rx (Receive) (*Engine*)	ISO 15765-4 CAN-C (+)
7	ISO 9141-2 K-line ISO 1423-4 K-line	ISO 9141-2 K-line/ SCI Tx (Transmit) (*Engine/Transmission*)	SCI Tx (Transmit) (*Engine*)
8	Manufacturer Discretionary	A/D Signal Output/Switched Ignition	Switched Ignition
9	Manufacturer Discretionary	SCI B Rx (Receive)/ J1850 Flash Enable	SCI Rx (Receive) (*Trans.*)/ J1850 Flash Enable
10	SAE J1850 (-)	Reserved	Reserved
11	Manufacturer Discretionary	CCD (-)	not used
12	Manufacturer Discretionary	SCI C Rx (Receive)	SCI Rx (Receive) (*Engine*)
13	Manufacturer Discretionary	Lo-Driver/SCI Tx (Transmit) (*Body/Chassis*)	not used
14	ISO 1565-4 CAN-C (-)	SCI D Rx (Receive) (*Transmission*)	ISO 15765-4 CAN-C (-)
15	ISO 9141-2 L-line/ ISO 14230-4 L-line	Inverted SCI Tx (Transmit)	SCI Tx Transmit (*Trans.)*
16	Unswitched Battery Voltage	Battery Voltage	Battery Voltage

Figure 28 Data Link Connector Pin Assignment

PCM REPLACEMENT

Pre-programmed PCMs will be phased-out. Future replacement PCMs will require programming with the appropriate Scan Tool. The PCM will not operate until programmed and a DTC will be set "Not Programmed". See Service Bulletin 18-007-03 after verifying that there are no revisions or more recent service bulletins, for the procedure to program the generic PCM.

When replacing the PCM, follow the procedure in the Service or Diagnostic Procedure Manuals. Also complete the following after replacement:

- Program the VIN. If the vehicle is equipped with the Sentry Key Immobilizer System (SKIS), this programming **must** be done via the Sentry Key Immobilizer Module (SKIM).
- Program the Pinion Factor in the transmission control module on some NGC vehicles with automatic transmissions or transaxles.

WARNING: VEHICLES EQUIPPED WITH SKIM REQUIRE A SPECIFIC PROCEDURE FOR WRITING THE VIN IN THE PCM. IF THE PROPER PROCEDURE IS NOT FOLLOWED, PCM AND SKIM MODULE DAMAGE COULD OCCUR.

FLASH PROGRAMMING

The TCM and PCM sections of the NGC I and NGC III controllers are independent and are accessed separately with the DRBIII®. When Flash Programming, the PCM can be flashed separately from the TCM. However, when the TCM is flashed, the PCM is automatically flashed as well because the PCM stores the new part number.

When the Module Display screen is accessed on the DRBIII®, the software year that is displayed is not programmed directly into the PCM, but is actually determined from the VIN number that has been programmed into the vehicle's controllers. Also, note that the last two digits following the part number refer to the software year of the module. Be aware that the vehicle year may not always match the actual software year in the module.

Notes:

Notes:

MODULE 4 PCM POWER FEEDS AND GROUNDS

NGC POWER FEEDS AND GROUNDS

Caution: In order to avoid damage to the PCM, always turn the key OFF before disconnecting any PCM related circuits or connectors.

Unswitched Battery Feeds

The Power Distribution Center (PDC) provides a direct B+ battery feed to the NGC PCM. It is used by the PCM to retain DTCs and OBD II data after the vehicle has been turned off. It is also used to supply power to low voltage components and the internal power supply that is used for power and biasing the sensors.

The PCM monitors the direct battery feed input to determine charging rate, control the injector pulse width, and back–up RAM used to store DTC functions. Direct battery feed is also used to perform key-off diagnostics and to supply working voltage to the controller. This is called Sensed Battery Voltage.

Switched Ignition Feeds

The PCM also receives switched voltage from the ignition switch while in the RUN and START positions. In the RUN positions, the ignition feed is a “wake-up” signal to the PCM and a source of B+ power. This signals the microprocessor to turn on the 5V power supply. In the START position, the ignition feed signals the TCM to prohibit diagnostics on certain circuits in order to prevent errors that may occur because of voltage fluctuations.

Power and Sensor Grounds

Two chassis grounds to the PCM are used by the engine control microprocessor, and three grounds are used by the TCM microprocessor. The two engine grounds are used for low-side driver control and for a return path for high side driver controlled devices. The grounds include an RFI/EMI filter to supply an electrically clean, common ground for all sensors except oxygen sensors, knock sensors and transmission input and output shaft speed sensors. It is important to note that unlike SBEC and JTEC, the oxygen sensors do not use a “sensor ground” for the return side of their circuits. The return (ground) side is biased to supply 2.5V on the sensor return side of the circuit, instead of having a direct path to ground.

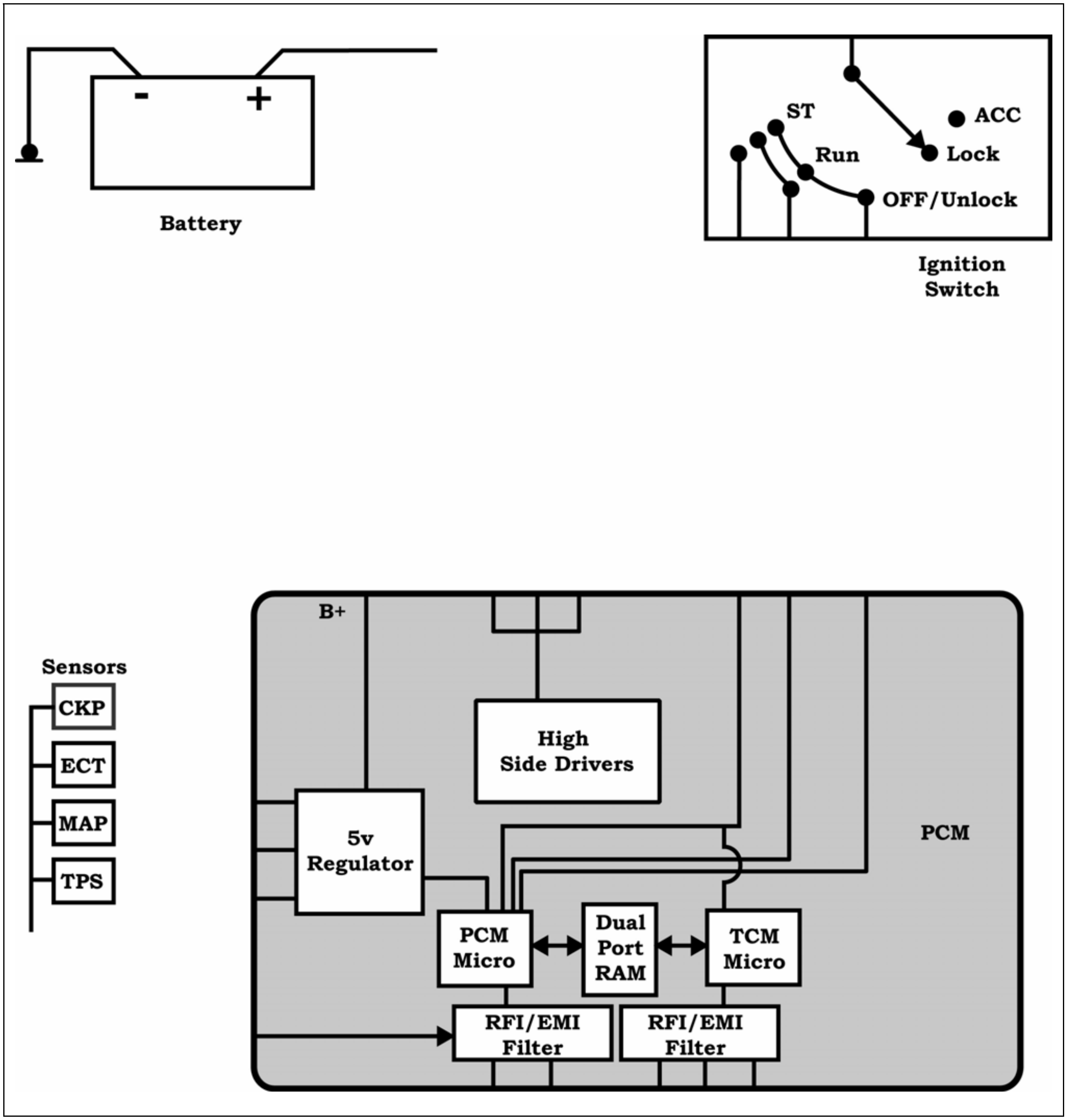


Figure 29 NGC Power and Grounds (Completed by Student)

Auto Shutdown Relay

When energized by the PCM, the Auto Shutdown (ASD) Relay will supply voltage to various circuits including:

- PCM
- Fuel injectors
- Ignition coils
- Short Runner Valve

The ASD relay outputs two or three voltage feeds to the PCM. Just as in previous controllers, this information is used by the PCM as a confirmation that the output side of the ASD relay is operating correctly. Unlike previous systems, these voltage feeds are used:

- To power the high-side driver circuits
- To allow the engine to keep running in the event direct battery power is lost

Note: The vehicle will not start without a direct battery feed to the PCM.

5 Volt Regulated Power Supply

The NGC PCM utilizes the direct 12V battery feed to power 5V regulators which supplies the Primary and Secondary voltage feeds. These 5 V circuits supply power to the various three-wire sensors and transducers utilized. The application of the primary and secondary 5 Volt power supplies is vehicle and power train specific. Internally the 5 V regulators also bias the sensor input circuits. This is similar to JTEC vehicles, however, unlike JTEC, this is a 5V power supply and not a 5V transformer. SBEC vehicles had utilized both 9V and a 5V regulators in its operation.

On SBEC systems the output of the 9 Volt regulator was not self-recovering. In the event that this circuit was shorted to Ground, the ignition key would need to be cycled to recover. The 5V regulator is protected from shorts to ground, and is self-recovering. On some NGC PCMs, both 5V power supplies stay alive with the key OFF. NGC 1 up to 10 minutes, and NGC 3 up to 20 minutes. During this time, all sensors will remain powered-up until the PCM goes into sleep mode. NGC 2 went into sleep mode when the key was turned OFF, and did not have the extended Stay Alive feature. But on all NGC PCMs while in sleep mode, a 5V power source and some memory will stay alive to monitor the NVLD switch for closure. This will be discussed in detail in the OBD II course.

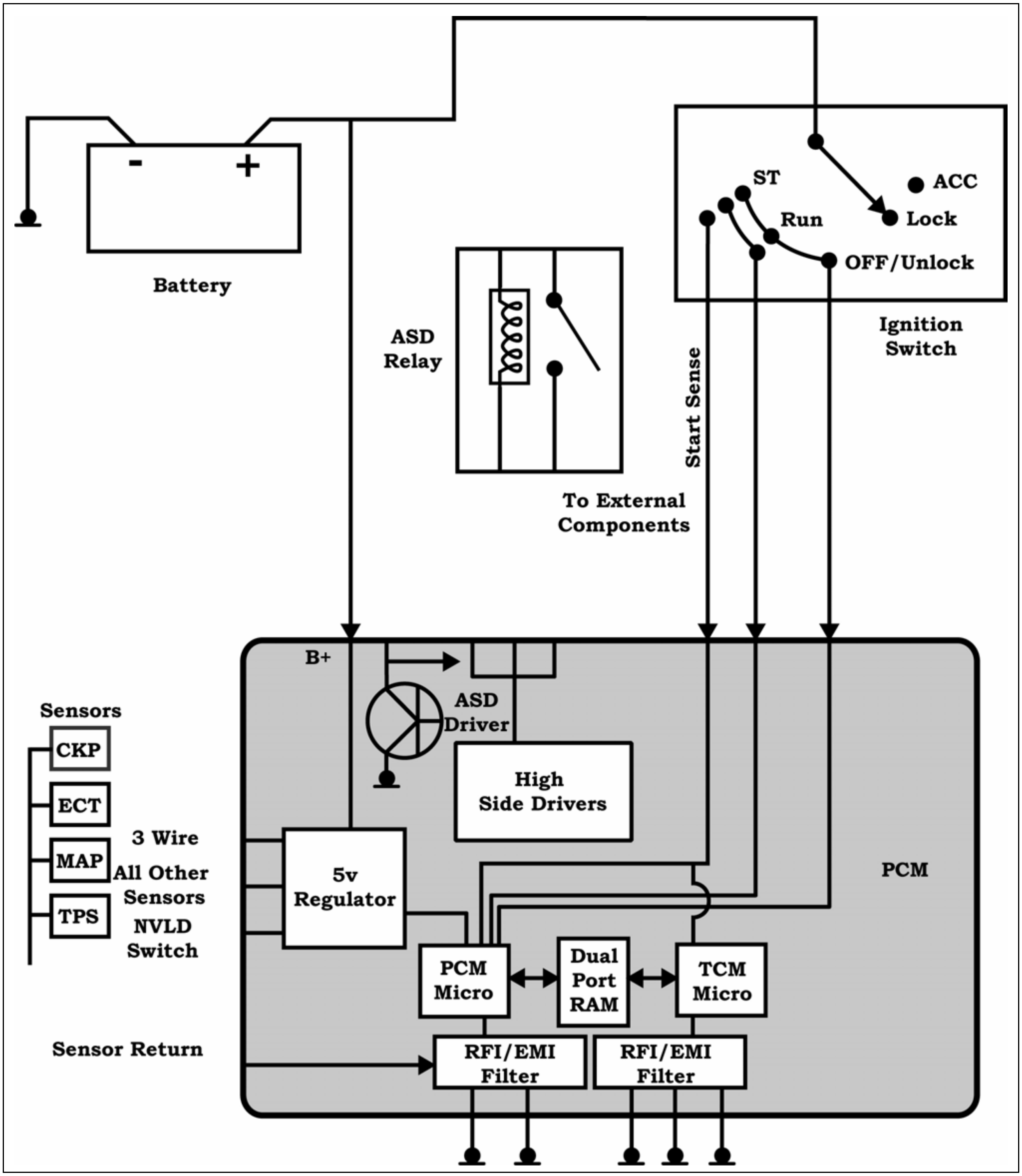


Figure 30 NGC ASD Relay and 5V Regulator (Completed by Student)

NGC Testing and Diagnosis

The vehicle will not start without a direct battery feed to the PCM.

It is important that the sensors be properly connected to the sensor return (ground) circuit, and that the sensor return circuit is not directly connected to Ground. Bypassing the sensor return (ground) may bypass RFI/EMI filter circuitry and may introduce problems. For example, the PCM may see blips in the TPS signal and assume that the throttle is opening.

The PCM stores diagnostic information in battery–backed RAM. Once a DTC is read by the technician, it can be erased from RAM by disconnecting the battery for several seconds, by running three Good Trips and 40 Warm-Up Cycles, or by using the DRBIII ® scan tool.

JTEC/SBEC POWER FEEDS AND GROUNDS

Caution: In order to avoid damage to the PCM, always turn the key OFF before disconnecting any PCM related circuits or connectors.

B+ and Switched Ignition Feeds

When the ignition switched is turned to RUN or CRANK, a switched 12V input is fed to the PCM. This is called Ignition Sense and is used as a "wake-up" signal to a PCM integrated circuit to turn the power supply ON.

The JTEC battery feed circuit (Sensed B+) supplies a 12V transformer which drops the voltage to 5V when the switched ignition circuit turns the transformer ON. All of the microprocessors within the control unit use 5V. There are two 5V outputs: Primary and Secondary. The Primary output sends a reference voltage to the CMP, CKP, TPS, and MAP sensors. The Secondary output provides the governor pressure sensor (if equipped), the three-wire oil pressure sensor (if equipped), the Hall-effect vehicle speed sensor (if equipped), and the A/C pressure transducer (if equipped) with a regulated voltage.

On SBEC, Battery voltage (Sensed B+) is supplied to the 9V regulator which then feeds the 5V regulator when the switched ignition circuit turns the circuit ON. 9V regulated power is provided to the VSS (3-speed A/T and M/T only), the CKP sensor and the CMP sensor. The 5V regulator supplies the microprocessor and 5V sensor circuits.

Power and Sensor Grounds

Ground is provided through multiple pins on the PCM. Depending on the vehicle, there may be as many as three different ground pins. Internally, all of the ground pins are connected.

A filtered ground called Sensor Return or Sensor Ground has noise suppression for Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI) protection. The Sensor Ground is used for any input that uses the sensor return circuit as a ground, and as the ground side of any internal processing component.

The Power Grounds are used to control the ground side of relays, solenoids, ignition coils, and injectors.

For EMI and RFI protection, the case is also grounded separately from the ground pins. The PCM on WJ vehicles uses case grounding to accommodate the increased number of drivers present.

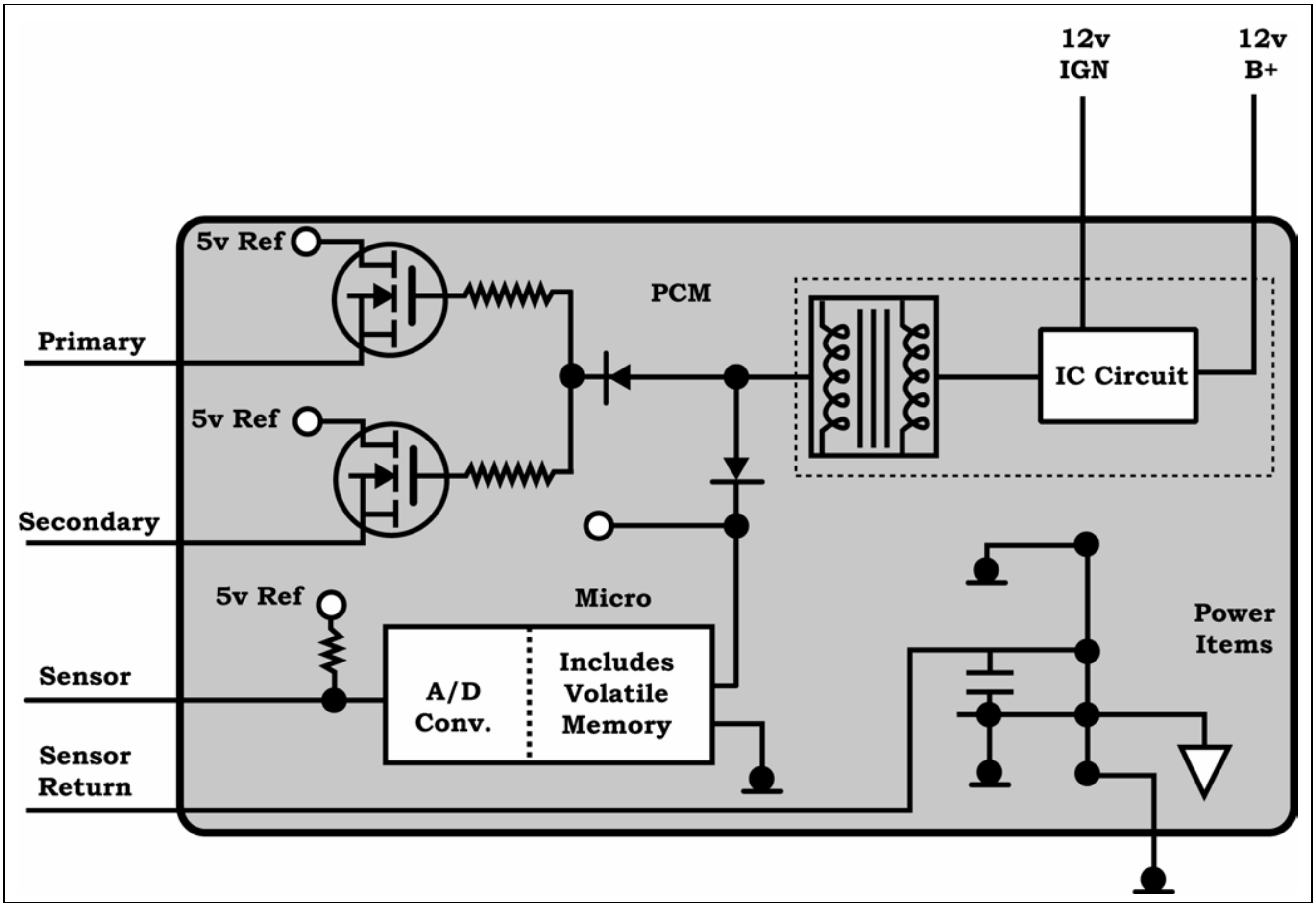


Figure 31 JTEC PCM Power Supplies and Grounds

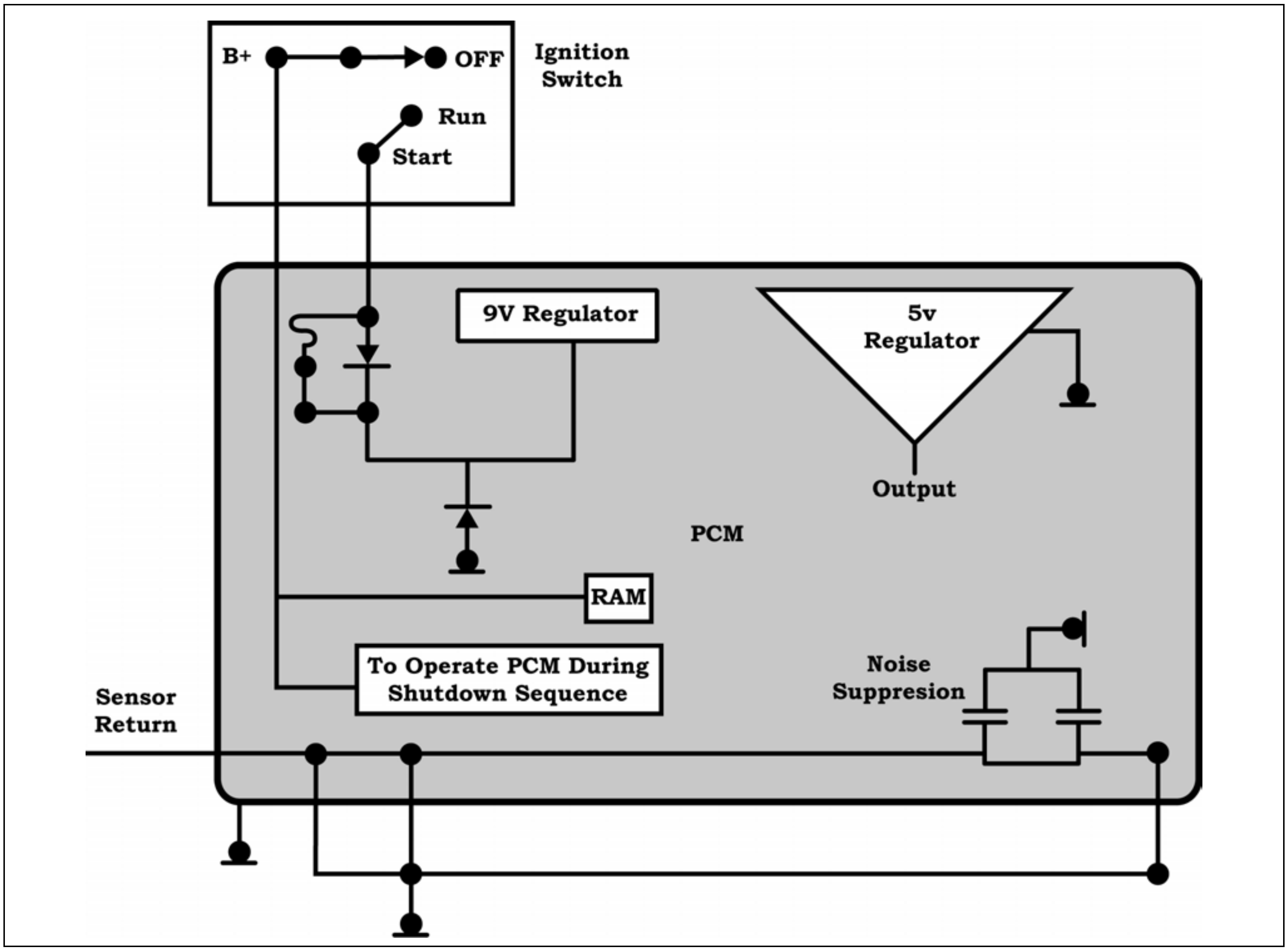


Figure 32 SBEC PCM Power Supplies and Grounds

JTEC/SBEC Testing and Diagnosis

The JTEC 5V power supply is used to provide a regulated power supply to most of the inputs to the PCM. This circuit is also protected from shorts to ground, and a circuit in the regulator allows the 5V signal to be sent to other inputs if the 5V power supply were shorted to ground at the MAP sensor, TPS, Linear EGR solenoid (if equipped), or the A/C pressure transducer. Previously, shorting the 5V power supply at any of these sensors would cause the PCM to shut down completely. This would cause not only a "No Start" condition, but it would also cause a total loss of all PCM functions, including diagnostics. With the protected 5V power supply, the engine still shuts down, but diagnostics can still be performed. Refer to the Diagnostic Procedures Manual for more details on any On-Board diagnostic information.

The SBEC 9V regulator is protected from short circuits. If the regulator is externally shorted to ground, a circuit in the regulator causes the external supply voltage to shut down and still provide power to the 5V regulator. Voltage on the ignition input can be as low as 6V and the PCM may still function, but certain diagnostic routines may not run.

If resistance develops in the Sensor Ground circuit, the sensor signal voltages rise above their normal values and result in performance and emission problems. A DTC will most likely not be set because the sensor voltages are still within a range that the PCM accepts as normal. However, if the oxygen sensor uses the sensor return circuit as ground, a DTC is set. On these vehicles, excessive resistance eventually sets the DTC “O2 Sensor Shorted to Voltage.”

JTEC and SBEC vehicles use the K4 circuit as Sensor Ground. Beginning in 1998 and on all packages by 1999, the oxygen sensors gained their own dedicated sensor ground circuit, K127, to reduce the burden on the K4 circuit.

For EMI and RFI protection, the case is also grounded separately from the ground pins. Be sure an adequate ground connection is made between the PCM case and the chassis.

ACTIVITY 2: PCM POWER AND GROUNDS / B+

Notes: ____

MODULE 5 SPEED DENSITY EQUATION

NGC SPEED DENSITY EQUATION

Chrysler Group vehicles have used the Speed Density Equation since the introduction of fuel injection in the early 1980s. The formula demonstrates how the PCM uses these inputs to modify fuel injector pulse width in order to maintain the stoichiometric air/fuel ratio of 14.7:1.

When the air/fuel ratio is rich (lower than 14.7:1, low oxygen content), HC and CO emissions increase. When the air/fuel ratio is lean (higher than 14.7:1, high oxygen content), NOx emissions increase.

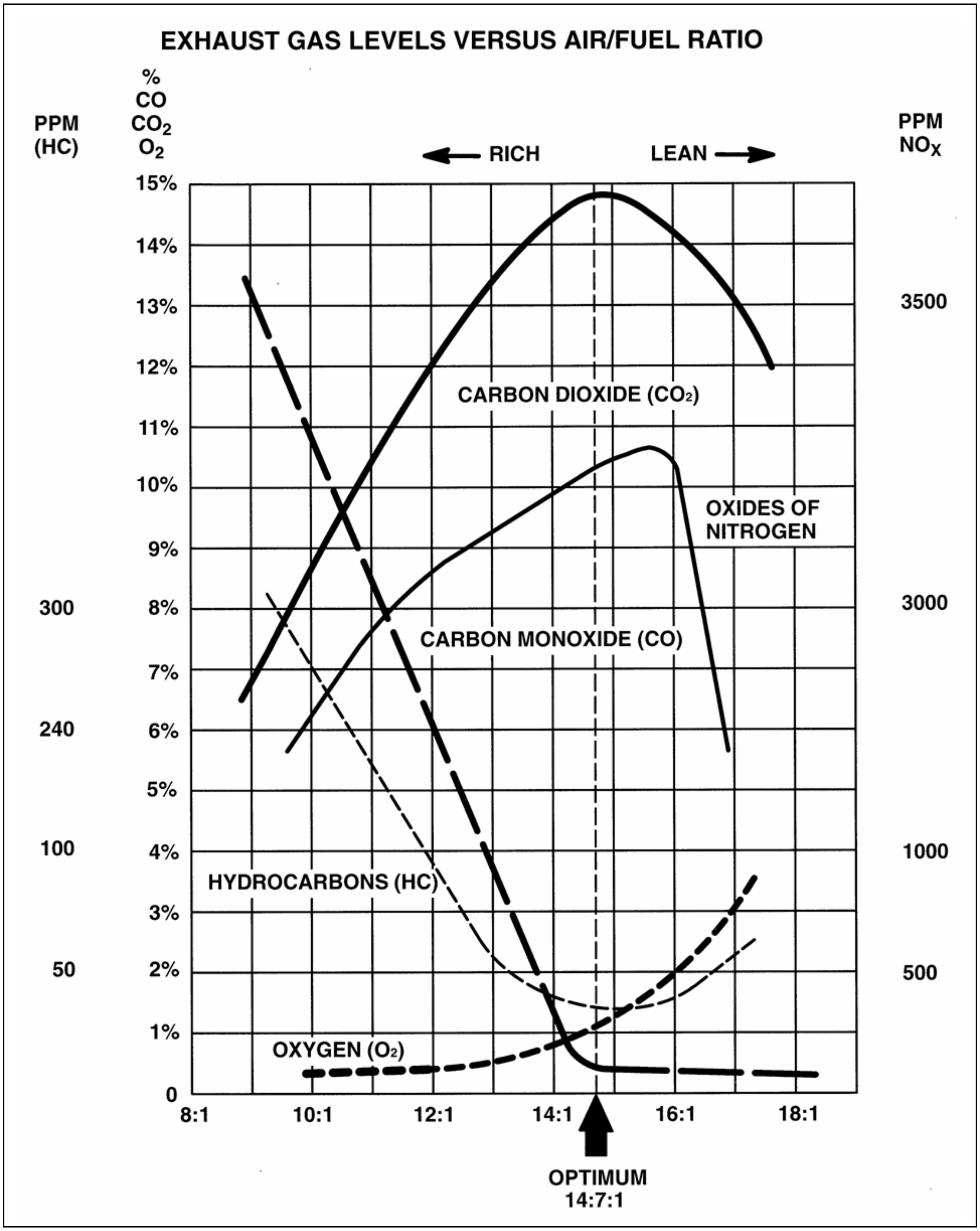


Figure 33 Exhaust Emissions vs. Air/Fuel Ratio

This is a representation of the Speed Density Equation used by SBEC and JTEC controllers to modify fuel injection quantity:

Load	Base PW Calculation	O2	Adaptive	P.W.
$\frac{\text{RPM}}{\text{Max RPM}}$ (X) $\frac{\text{MAP}}{\text{Baro}}$	(X) TPS (X) ECT (X) IAT (X) Sensed B+ (X) LT	(X) Up02	(X) STFT (X) LTFT	= Pulse Width

Figure 34 JTEC/SBEC Speed Density Equation

NGC controllers utilize a new updated representation of the Speed Density Equation to modify fuel injection quantity. Because of the increased capabilities of NGC, the equation is a little different. EGR flow and extra fuel from EVAP purge are also part of the equation now. This is a representation of the NGC Speed Density Equation:

Air Flow	Fuel Modifiers	Feedback Input	Adaptives	P.W.
$\frac{\text{RPM}}{\text{Max RPM}}$ (X) $\frac{\text{MAP}}{\text{Baro}}$ (X) EGR Flow*	(X) TPS (X) ECT (X) IAT (X) Sensed B+	(X) Up O2	(X) ST (X) LT (X) Purge Vapor Ratio*	= Pulse Width

*Where Equipped

Figure 35 NGC Speed Density Equation

The following explains how the PCM derives each multiplier in the NGC Speed Density Equation:

Air Flow

The PCM calculates engine RPM from the Crankshaft Position (CKP) Sensor signal. The sensor is a Hall-effect sensor that detects notches in a pulse ring machined into the crankshaft on 4.7L engines or slots in the flywheel or flex plate on other engines. The high-low digital signals allow the PCM to determine crankshaft RPM. The Camshaft Position Sensor (CMP) sensor determines which of the two companion cylinders should receive fuel and spark. Basic airflow requirements are determined by dividing the current engine RPM value by the theoretical MAXIMUM (rated) RPM. The Speed Density Equation allows the PCM to determine the percentage of the maximum possible airflow currently entering the engine.

To determine the level of engine load, the Manifold Absolute Pressure (MAP) Sensor measures the level of pressure (vacuum) in the intake manifold. This measurement is compared with atmospheric (barometric) pressure. On non-turbo vehicles, during startup and at WOT, the MAP sensor reading is assumed to be atmospheric pressure and is stored as a BARO value. This is accomplished with a separate sensor on turbo vehicles. The Speed Density Equation divides MAP by BARO to determine the level of engine load. The MAP value approaches BARO at higher loads.

There is always a slight lag in response from the MAP sensor itself. Therefore, NGC vehicles calculate the expected MAP value based on inputs for throttle position, barometric pressure and IAC position. This is part of the “Model-Based Fuel Strategy” and this calculated value is called “T-MAP”. MAP sensor input validates this calculated value. Whenever a MAP DTC is set or a MAP problem occurs, the PCM will use the T-MAP value. T-MAP values will appear on the DRB III as “real” MAP values.

Exhaust Gas Recirculation (EGR) is used for control of NOx emissions and to improve fuel economy. During EGR, exhaust gases from the exhaust manifold are metered through a valve and fed into the intake manifold. These gases are mostly inert carbon dioxide and nitrogen, and in the engine cylinder they displace a percentage of the incoming mixture. Because EGR gases effectively reduce the size of the combustion chamber, there is less room for air/fuel mixture. Less oxygen is drawn in and therefore less fuel is required.

Fuel Modifiers

The Speed Density Equation uses Throttle Position Sensor (TPS) input to inform the PCM of certain operating conditions such as idle (Min TPS), wide open throttle (WOT), decel and the rate of throttle opening. These conditions can affect engine fuel requirements and the fuel injection pulse width calculation: acceleration enrichment, decel fuel shutoff, WOT indicating open loop while running or fuel injector shutoff (clear-flood) while cranking.

Engine temperature affects fuel requirements, therefore input from the Engine Coolant Temperature (ECT) Sensor is part of the Speed Density Equation. A cold engine requires enrichment compensation. Fuel does not vaporize well when cold and can puddle in the intake. The ECT is monitored to determine initial cranking injector pulse width and also temperature compensation while the engine is running.

Air density changes as a factor of air temperature and altitude. Denser air requires more fuel to maintain a stoichiometric air/fuel ratio. The Intake Air Temperature (IAT) Sensor assists the PCM in calculating the density of the incoming air and modifies the Speed Density calculation accordingly.

The voltage applied to the fuel injectors affects how rapidly and how far the injector pintle opens. The quantity of fuel injected in a given amount of time changes with variations in voltage. Sensed B+ or sensed system voltage is monitored and used by the PCM to correct injector pulse width.

Feedback Input

The oxygen sensor measures oxygen levels in the exhaust and provides the PCM with a feedback signal. The PCM infers air/fuel ratio from this signal to see how well the Speed Density calculation has predicted fuel requirements for current engine speed, load and other conditions.

When the air/fuel ratio is at stoichiometry, the oxygen sensor signal switches above and below a predetermined switching point (goal voltage). When the oxygen sensor stops switching and the signal is consistently high or low, the PCM responds by changing injector pulse width until the O_2 sensor switches again. It does this through the Short Term Adaptive, Long Term Adaptive and Purge Adaptives.

Adaptives

Short Term Adaptive (Short Term Fuel Trim or STFT), is an immediate correction to fuel injector pulse width. It is an immediate response to an O_2 sensor signal that is not switching or is consistently high or low. Short Term Adaptive begins functioning shortly after the vehicle has started, as soon as the oxygen sensor is heated to operating temperature. Short Term Adaptive values change very quickly and are not stored when ignition is OFF.

After the vehicle has reached full operating temperature, the correction factors generated by Short Term Adaptive will be stored in Long Term Adaptive (Long Term Fuel Trim or LTFT) memory cells. These long term values allow the Short Term Adaptive value to be brought back to near zero. Once this correction factor is stored in memory, it will be used by the PCM under all operating conditions, open loop and closed-loop.

The final correction in the Speed Density Equation for NGC vehicles is the Purge Adaptive. This is the proportion or concentration of fuel (Hydrocarbon) vapors in the EVAP system purge flow. If purge flow contains a high ratio of HC vapors, less fuel from the injectors is required. During purge operation, Long Term Adaptive values are not updated, and necessary fuel adjustments are accomplished through changes in Purge Adaptive.

Notes:

MODULE 6 PCM INPUTS

The PCM receives inputs from sensors and switches that inform the PCM about physical conditions such as temperatures, speeds and the position of various components. This information influences the PCMs output decisions. Inputs can be either a sensor (analog) input, or a switch (digital) input. A sensor or analog input will generate or modify a varying voltage signal that is sent to the PCM, whereas a switch or digital input will send a HIGH/LOW or ON/OFF signal to the PCM.

PCM DIGITAL INPUTS

Hall-effect devices are frequently used for digital PCM inputs where accuracy and fast response are important. Hall-effect devices provide the PCM with digital inputs that do not need analog to digital conversion.

The PCM supplies 5V (NGC and JTEC) or 9V (SBEC) to the Hall-effect sensor. This voltage powers the Hall-effect chip and the electronics in the sensor. A ground for the sensor is provided through the sensor ground circuit. The signal to the PCM is on a 5V reference circuit. The Hall-effect sensor contains a powerful magnet. As the magnetic field passes over the dense portion of a counterweight, flex plate or trigger wheel, the 5V signal is pulled low to approx. 0.3V through a transistor in the sensor. When the magnetic field passes over the notches in the crankshaft counterweight, flex plate or trigger wheel, the magnetic field is lost, turning OFF the transistor in the sensor and supplying the PCM with a 5V signal.

NGC Crankshaft Position (CKP) and Camshaft Position (CMP) Sensors

The CKP and CMP sensors are Hall-effect switch inputs to the PCM. Hall-effect devices toggle the 5V reference from the PCM ON and OFF.

Each Hall-effect switch is a three-wire sensor. One wire is the 5V power supply, common to both CKP and CMP sensors. This feed powers the internal electronics. Each sensor will share a common sensor ground wire. The remaining wire on each sensor is an individual signal wire.

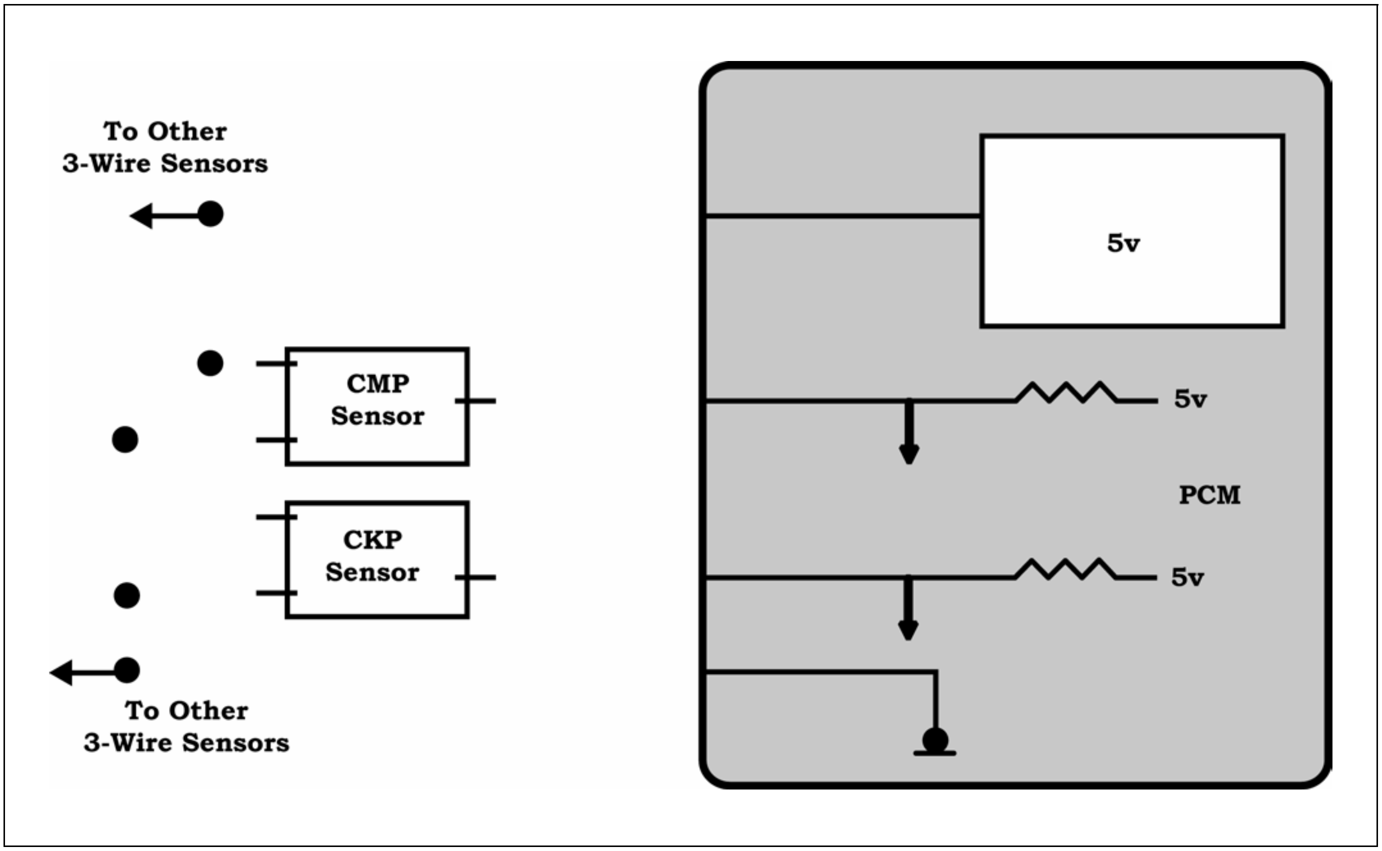


Figure 36 CMP and CKP Sensors (Completed by Student)

One of the goals of NGC is commonality among all vehicle lines. Achieving this requires benchmarks that would be used for all applications. One example of this is the signals generated by the CMP and CKP sensors. All vehicles, regardless of the number of cylinders, will generate exactly the same CKP signal. The triggering device, whether a flex plate or a tone wheel, will have a tooth or notch every 10° of crankshaft rotation, with two missing notches and two fused notches 180° apart.

Figure 37 Typical CKP Trigger (NGC shown)

Figure 38 Typical CKP Scope Pattern (NGC shown)

CMP sensor triggers are also benchmarked. However, four, six and eight cylinder engines each need a specific trigger to determine cylinder location. The result is three separate trigger patterns, specific to the number of cylinders. All four-cylinder engines will generate the same scope pattern, all six-cylinder engines regardless whether it is inline or “V” will generate the same pattern, and all V-8 triggers will generate the same pattern.

Figure 39 Typical 6 Cylinder CMP Triggers (2.7L NGC shown)

Figure 40 Typical V-6 / Inline 6 CMP Scope Pattern (NGC shown)

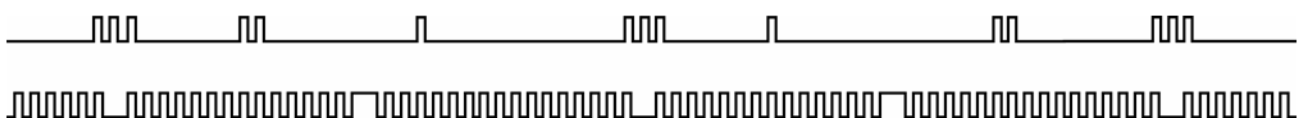


Figure 41 Typical CMP / CKP Scope Patterns Superimposed (NGC shown)

NGC Crankshaft Position (CKP) and Camshaft Position (CMP) Sensor Diagnostics

The engine will start even if one of these two sensors fails. The PCM will eventually sort out engine position and start the vehicle on just one of these two inputs. However, there will be a slight delay in starting until the PCM can establish sync.

A DTC is set and the MIL will illuminate if either or both CKP and CMP signals are not present during engine cranking.

When performing oscilloscope diagnosis, all NGC CKP sensor patterns will be identical for all vehicles and engines. It is important that the correct components are installed in an NGC vehicle. Flex plates or trigger wheels are not interchangeable with parts for SBEC or JTEC applications.

JTEC/SBEC Crankshaft Position (CKP) and Camshaft Position (CMP) Sensors

JTEC CKP sensors are located on the passenger side of the engine block on 4.7L, 8.0L engines and on the transmission housing on other engines.

The CMP sensor in 2.5L/3.9L/4.0L*/5.2L and 5.9L engines is located in the distributor housing. A pulse ring rotates with the distributor shaft to indicate the position of the cylinder. *4.0L engines with coil rail ignition have the sensor on the oil pump drive assembly.

If the distributor has to be removed for repair, consult Section 8D of the Service Manual for specific instructions **BEFORE** removing the distributor. Failure to do so could result in loss of the "sync" signal, which will cause the loss of fuel injector synchronization. 4.7L engines use a sensor that is located on the forward side of the right cylinder head. 8.0L engines use a sensor mounted on the timing cover to determine cylinder positioning. There is a timing step (SR) or low machined area (BR) on the camshaft sprocket which indicates the cylinder position. The PCM calculates cylinder position by counting CKP pulses following a CMP pulse.

JTEC/SBEC Crankshaft Position (CKP) and Camshaft Position (CMP) Sensor Diagnostics

On JTEC-equipped vehicles, the primary circuit feeds the CMP, CKP, TPS, and MAP sensors. If there is a short to ground on any sensor on the primary OR secondary power supplies all sensors on those circuits are affected, usually resulting in a No-Start condition.

A DTC is set and the MIL will illuminate if either the CKP or CMP signal is not present during engine cranking.

On SBEC-equipped vehicles, the 9V supply feeding the CKP, CMP and VSS sensors all comes from the same PCM pin. A VSS shorted internally can result in a No-Start.

Depending on the Model Year and engine, both CKP and CMP sensors are needed for engine operation.

ACTIVITY 3: CKP AND CMP SENSORS

Notes: ____

PCM ANALOG INPUTS – THREE WIRE

Analog inputs to the PCM provide a variable voltage signal which varies with the changes to the condition monitored. Analog inputs typically are three-wire sensors with a common 5V power source, a 5V bias signal, and a common sensor ground.

All analog input voltages from the sensors are measured relative to the sensor bias voltage internally in the PCM. Since all three-wire sensors are fed by the same power supply, a short to ground or an open circuit at a common location will result in a no-start.

NGC Manifold Absolute Pressure (MAP) Sensor

The MAP Sensor measures the level of pressure or vacuum existing in the intake manifold. The MAP sensor also determines ambient barometric pressure. The PCM needs this information to know if the vehicle is at or above sea level because air density changes with altitude. The MAP sensor also helps to correct for varying weather conditions.

The NGC MAP sensor is supplied 5V from the PCM and varies a voltage signal to the PCM in proportion to manifold pressure (vacuum). The 5V power supply to the MAP Sensor may be shared with other sensors. The MAP sensor operating range is typically from approximately 0.45V (high vacuum) to 4.8V (low vacuum). Like the cam and crank sensors, ground is provided through the sensor ground circuit.

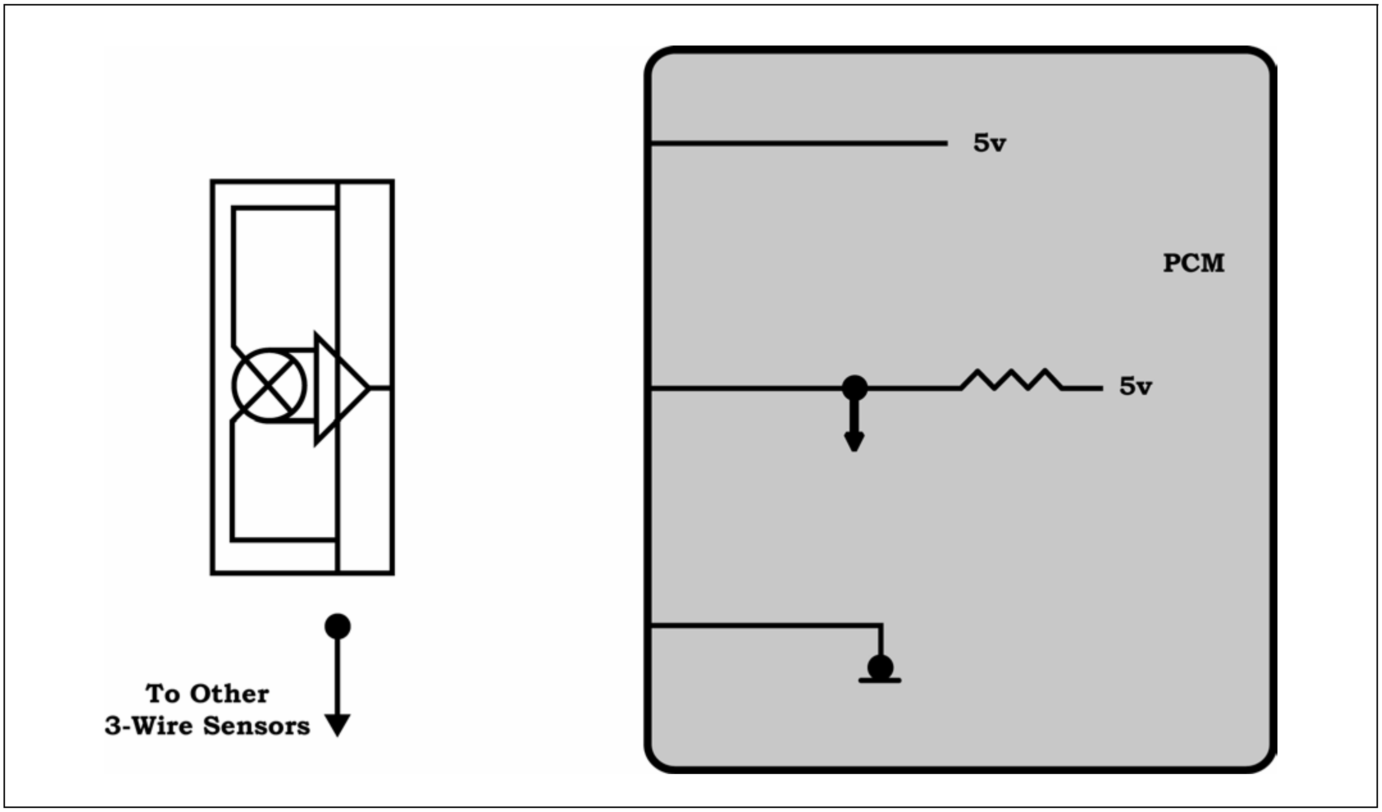


Figure 42 MAP Sensor (Completed by Student)

The MAP sensor has the most authority for determining injector pulse width. The MAP sensor also influences spark advance, IAC position and deceleration fuel shutoff.

Table 1 Typical NCG MAP Sensor Signal vs. Pressure

MAP Sensor Voltage	Barometer Reading	Altitude
4.43V	29.92 in. Hg	Sea Level
4.36V	29.42 in. Hg	500 ft.
4.29V	28.92 in. Hg	1000 ft.
4.22V	28.42 in. Hg	1500 ft.
4.15V	27.92 in. Hg	2000 ft.
4.08V	27.42 in. Hg	2500 ft.
4.01V	26.92 in. Hg	3000 ft.
3.94V	26.42 in. Hg	3500 ft.
3.87V	25.92 in. Hg	4000 ft.
3.80V	25.42 in. Hg	4500 ft.
3.73V	24.92 in. Hg	5000 ft.

Table 2 Typical JTEC and SBEC MAP Sensor Signal vs. Pressure

MAP Sensor Voltage	Barometer Reading	Altitude
4.60V	29.92 in. Hg	Sea Level
4.52V	29.42 in. Hg	500 ft.
4.44V	28.92 in. Hg	1000 ft.
4.36V	28.42 in. Hg	1500 ft.
4.28V	27.92 in. Hg	2000 ft.
4.20V	27.42 in. Hg	2500 ft.
4.12V	26.92 in. Hg	3000 ft.
4.04V	26.42 in. Hg	3500 ft.
3.96V	25.92 in. Hg	4000 ft.
3.88V	25.42 in. Hg	4500 ft.
3.80V	24.92 in. Hg	5000 ft.

MAP Sensors on Turbocharged NGC Vehicles

Turbocharged NGC vehicles have MAP Sensors that are calibrated to measure positive as well as negative pressures in the intake manifold. These vehicles have a second sensor called the Throttle Inlet Pressure/Baro Sensor. This sensor is just like a MAP sensor and measures two different conditions: barometric (atmospheric) pressure and also inlet boost pressure. Inlet boost pressure is sensed in the pipe after the charge air cooler and before the throttle body. The Throttle Inlet Pressure/Baro Solenoid is switched by the PCM to allow the TIP/Baro Sensor to sense throttle inlet pressure 95% of the time, and barometric pressure 5% of the time.

Table 3 Typical NGC Turbo MAP Sensor Signal vs. Pressure

MAP Sensor Voltage	Barometer Reading	Manifold Vacuum/Pressure
4.46V	60.46 in. Hg	15 lb (boost)
4.01V	54.35 in. Hg	12 lb (boost)
3.56V	48.24 in. Hg	9 lb (boost)
3.11V	42.14 in. Hg	6 lb (boost)
2.66V	36.03 in. Hg	3 lb (boost)
2.21V	29.92 in. Hg (Sea Level)	0 lb (boost)
2.11V	28.7 in. Hg	1.2 in. Hg
2.02V	27.42 in. Hg	2.5 in. Hg
1.91V	25.92 in. Hg	4.0 in. Hg
1.76V	23.92 in. Hg	6.0 in. Hg
1.62V	21.9 in. Hg	8.0 in. Hg
1.40V	18.9 in. Hg	11.0 in. Hg
1.25V	16.9 in. Hg	13.0 in. Hg
1.03V	13.9 in. Hg	16.0 in. Hg
0.88V	11.9 in. Hg	18.0 in. Hg

(Voltage values will vary with changes in altitude and atmospheric pressure)

NGC Manifold Absolute Pressure (MAP) Sensor Diagnostics

There are typically five MAP Sensor diagnostic routines:

- MAP voltage high
- MAP voltage low
- No change in MAP voltage at START to RUN transfer (vacuum)
- MAP/TPS correlation (TPS values do not agree with MAP signals)
- MAP/TPS correlation (high flow, vacuum leak)

Whenever a MAP DTC is set or a MAP problem occurs, the PCM enters "limp-in" and uses the T-MAP value. T-MAP values will appear on the DRB III as "real" MAP values.

JTEC/SBEC Manifold Absolute Pressure (MAP) Sensor

The MAP is provided with a 5V power supply that is shared with the TPS, CMP and CKP on JTEC vehicles. On SBEC, the MAP is provided with a 5V power supply that is shared with the TPS and Linear EGR (if equipped). The MAP sensor signal range is from approximately 0.45V (high vacuum) to 4.8V (low vacuum). The sensor is supplied a regulated 4.8 to 5.1V to operate the sensor. Like the cam and crank sensors, ground is provided through the sensor ground circuit.

JTEC/SBEC Manifold Absolute Pressure (MAP) Sensor Diagnostics

Listed below are the MAP sensor diagnostic routines:

- MAP voltage high: signal open or shorted to power, may be caused by a faulty upstream O_2 sensor or circuit
- MAP voltage low: signal shorted to ground
- No change in MAP voltage at START to RUN transfer (vacuum)
- No 5V (power) to MAP sensor (JTEC only)
- TPS does not agree with MAP

With the engine running between 600 to 3500 rpm, near closed throttle, if MAP voltage is above 4.6V, the voltage high fault is set. There are three different ways to set the voltage low fault:

- If MAP voltage is below 1.2V at startup
- If MAP voltage is below 0.02V while the engine is running.
- If there is an open in the MAP power feed
- Short to Ground in MAP signal wire

If the PCM considers MAP Sensor information inaccurate, the PCM enters “limp–in” mode. When the MAP Sensor is in limp–in, the PCM limits the engine speed as a function of the Throttle Position Sensor (TPS) to between 1500 and 4000 rpm. If the MAP Sensor sends realistic signals once again, the PCM discontinues limp–in and resumes using MAP values. A DTC is set and the MIL illuminates when the limp-in mode is entered.

Note: If you are attempting to generate the opposite code while performing diagnostics, it is important to remember the PCM does not perform diagnostics unless the engine is within the specified rpm range (the vehicle must be running).

Note: Make sure the ignition is OFF, prior to unplugging the MAP sensor, or MAP sensor damage will occur.

ACTIVITY 4: MAP SENSOR

Notes:

NGC Throttle Position Sensor (TPS)

The Throttle Position Sensor is a three wire potentiometer mounted on the side of the throttle body. The TPS is responsible for determining idle position (Min TPS), acceleration, wide open throttle (open loop and clear-flood mode) and influencing fuel injector pulse width and ignition timing according to these changing requirements:

- Idle: With key ON and engine running, the PCM assumes that the lowest voltage signal value received, above the fault threshold, must be where the throttle blade hits the idle stop. This voltage signal (typically 0.5–1.0V) is recorded by the PCM as “idle”, or “minimum TPS”.
- Off–Idle: Once the throttle is opened and the TPS signal value is approximately 0.04 volt over minimum TPS, the PCM moves into its off–idle program. Spark–scatter advance idle control is shut off and the IAC is set to act as a dashpot to prevent stalling from sudden deceleration.
- Acceleration: A rapid rise in TPS voltage within a specified time causes the injector pulse–width to increase. The amount of PW increase is determined by the rate of TPS voltage rise.
- Wide Open Throttle (WOT): The PCM is programmed to go into open loop whenever TPS voltage exceeds a programmed value, typically 2.5–2.7V above minimum TPS voltage. This enables the PCM to increase pulse width at WOT to improve full throttle performance.
- Deceleration: If the TPS is closed and manifold vacuum is high while the vehicle is in motion (as indicated by the VSS), the PCM narrows the injector pulse width to reduce emissions. Under some conditions, the injector pulse width may be zero.
- WOT fuel cutoff during cranking: In case of flooding, the driver can depress the accelerator pedal to WOT so that the PCM will de-energize all injectors. This program is enabled only during cranking and when TPS voltage indicates WOT.

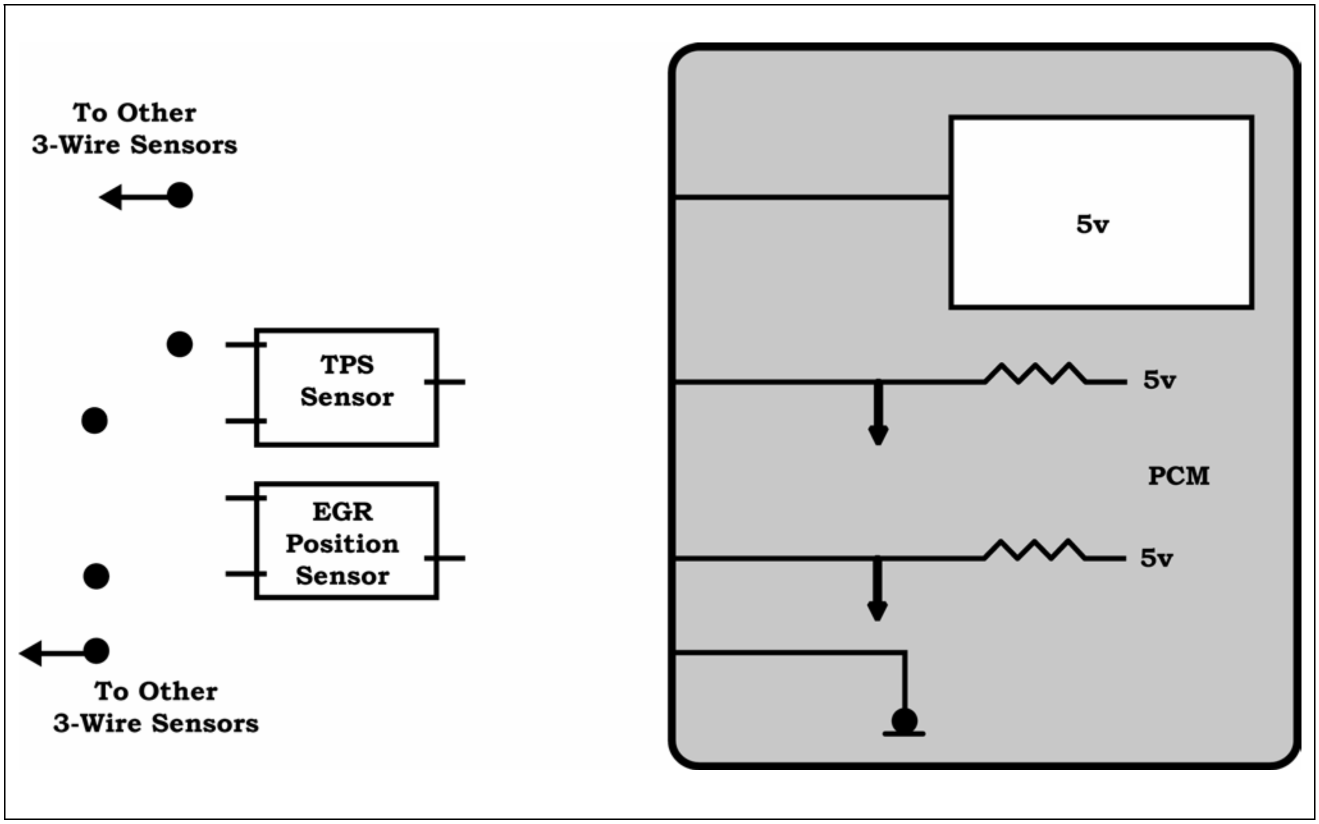


Figure 43 TPS and EGR Position Sensors (Completed by Student)

NGC Hall-Effect Throttle Position Sensor – CS and KJ

CS and KJ vehicles with NGC controllers have a new Hall-effect TPS. These Hall-effect sensors output an analog signal voltage similar to conventional TPS sensors, but the connector pin assignments are different. Consult Service Information for vehicle-specific information.

NGC Throttle Position Sensor (TPS) Diagnostics

There are three TPS diagnostic routines:

- TPS voltage too high (signal open or short to power).
- TPS voltage too low (signal shorted to ground or no 5V supply).
- TPS voltage does not agree with MAP (rationality fault).

When the TPS signal voltage is too high, too low or not believable, the PCM sets a DTC. When the DTC is set, the MIL is illuminated and the PCM moves into limp–in mode. Limp–in for TPS is divided into three categories:

- Idle
- Part–throttle
- Wide open throttle (WOT)

When observing the Calculated TPS value on the DRBIII® while in limp-in mode, the TPS display will change as if there were no problem with the circuit. In limp-in mode, the TPS calculation will be based on RPM and MAP values, and the T-MAP value may appear unusual.

JTEC/SBEC Throttle Position Sensor (TPS)

The TPS is supplied with a regulated 5V (JTEC) from the PCM. This output regulated voltage is the same regulated voltage the MAP sensor uses. The TPS receives its ground from the PCM. The input of the TPS to the PCM is through a 5V sensor circuit.

JTEC/SBEC Throttle Position Sensor (TPS) Diagnostics

The “TPS voltage does not agree with MAP” fault is set when the PCM interprets the MAP indication as a load condition which does not agree with what it sees from the TPS. If the voltage gets too low, the PCM sets the short to ground (voltage low) fault. If the voltage gets too high, it sets the open circuit (voltage high) fault. This may be caused by a faulty cruise MUX (shorted to voltage) circuit.

Note: On vehicles equipped with a TCM, the TPS open-circuit voltage does not go to 5V due to the pull-down circuit in the TCM.

JTEC Shared Inputs

On JTEC-equipped vehicles, there are more PCM inputs than there are available microprocessor input pins. To accommodate all required inputs, the microprocessor may receive inputs from two circuits on one pin by multiplexing internally. The microprocessor keeps track of which input is received by the discharge of a capacitor controlled by the PCM internal clock. If there is a problem that does not allow the capacitor to discharge (for example, an input shorted to voltage), the PCM may set a DTC for the companion input. For example, a speed control MUX circuit that is shorted to power may set a TPS fault. This ONLY applies to JTEC vehicles. The following tables reference shared inputs on JTEC-equipped vehicles:

Table 4 1996-1998 JTEC Multiplexed Inputs

Name	Comments	JTEC Pin #
TPS Cruise MUX		A23
O_2S Up L MAP	1/1 (All applicable models)	C32
O_2S Up R Fuel Pressure	2/1 (5.9L HD 8.0L HD) CNG	A24
O_2 Dn L Trans Press	1/2 (All LD) 1/3 (8.0L MD)	A27
O_2S Dn R PTO	1/2 (8.0L MD) BR only	A26
Spare Fuel Level		A28

Table 5 1999 and Later JTEC+ Multiplexed Inputs

Name	Comments	JTEC Pin #
TPS Cruise MUX		A23 C32
O2S Up L MAP	1/1 (All applicable models)	A24 A27
O2S Up R Fuel Pressure	2/1 (5.9L HD 8.0L HD) CNG	A26 A28
O2 Dn L Trans Press	1/2 (All LD) 1/3 (8.0L MD)	A25 B29
O2S Dn R Spare	1/2 (8.0L MD)	A29 A13
Spare Fuel Level		A30 A14

NGC EGR Position Sensor

The EGR position sensor is a three wire linear potentiometer providing feedback to the PCM for EGR valve position. This allows for more precise control over EGR flow for better NOx control. The EGR position sensor signal is an input to the Speed Density Equation.

The EGR position sensor shares the same feed as MAP, TPS and A/C pressure sensor and works similar to the TPS. This sensor is part of the Linear EGR Valve assembly, and is carried over from previous models.

EGR Position Sensor Diagnostics

- EGR Rationality Fault is set when flow or valve movement is not what is expected.
- EGR Position Sensor Too Low is set when the signal is less than 0.157V.
- EGR Position Sensor Too High is set when the signal is greater than 4.9V for 6 seconds.

ACTIVITY 5: TPS SENSOR

Notes:

PCM ANALOG INPUTS – TWO WIRE

All two wire sensors receive a 5V bias signal from the PCM and have a common sensor ground. On NGC vehicles, the only two-wire sensors that do not use the same sensor return are the knock sensor and oxygen sensors. The knock sensor has its own dedicated ground. The oxygen sensors do not use ground at all for the sensor return. Their sensor return circuits are biased to 2.5V.

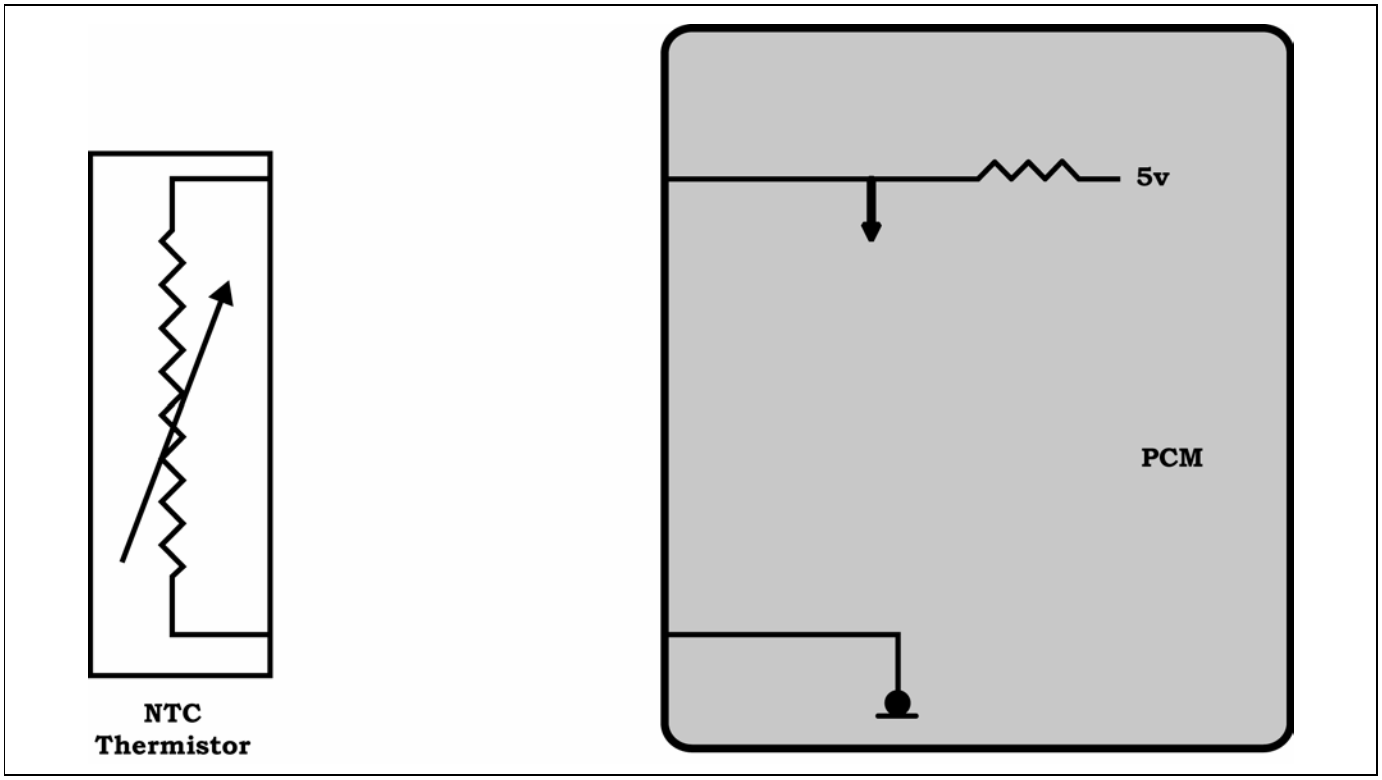


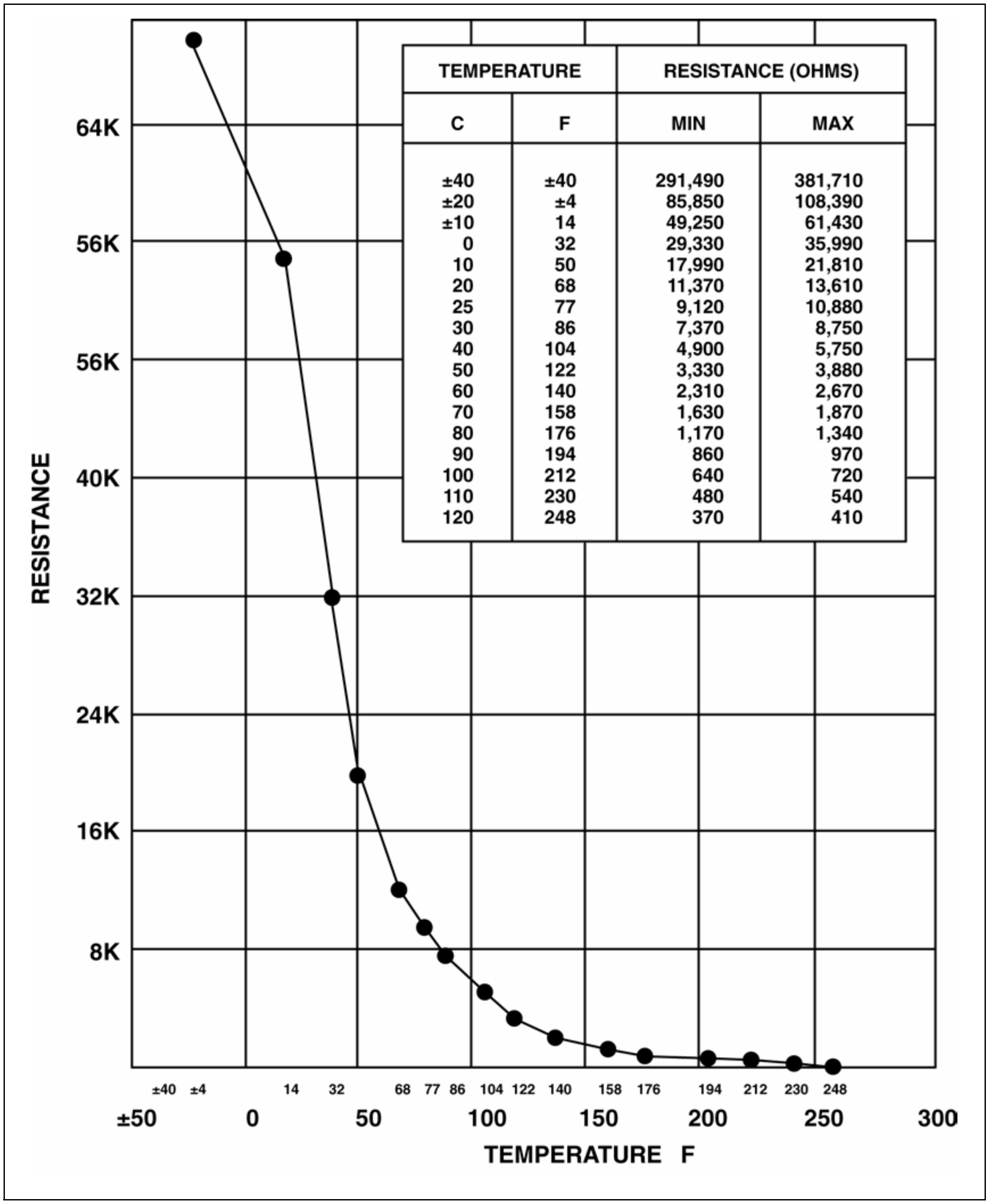
Figure 44 Typical NTC Thermistor Circuit (Completed by Student)

NTC Thermistors

Temperature sensors are thermistors, resistors that significantly change resistance value with changes in temperature. All of the temperature sensors listed below are Negative Temperature Coefficient (NTC) thermistors. This means that their resistance changes inversely with temperature. They have high resistance when cold and low resistance when hot.

The PCM sends 5V through a fixed resistor to each sensor and measures the voltage drop to sensor ground through the thermistor. When the sensor is cold, its resistance is high and voltage sensed on the feed side remains high. As the temperature increases, sensor resistance drops and the signal voltage gets pulled low.

NGC and JTEC NTC thermistors use a single-range PCM circuit. SBEC NTC thermistors use a dual-range PCM circuit.



TEMPERATURE		RESISTANCE (OHMS)	
C	F	MIN	MAX
±40	±40	291,490	381,710
±20	±4	85,850	108,390
±10	14	49,250	61,430
0	32	29,330	35,990
10	50	17,990	21,810
20	68	11,370	13,610
25	77	9,120	10,880
30	86	7,370	8,750
40	104	4,900	5,750
50	122	3,330	3,880
60	140	2,310	2,670
70	158	1,630	1,870
80	176	1,170	1,340
90	194	860	970
100	212	640	720
110	230	480	540
120	248	370	410

Figure 45 Typical NTC Thermistor Temperature-Resistance Curve

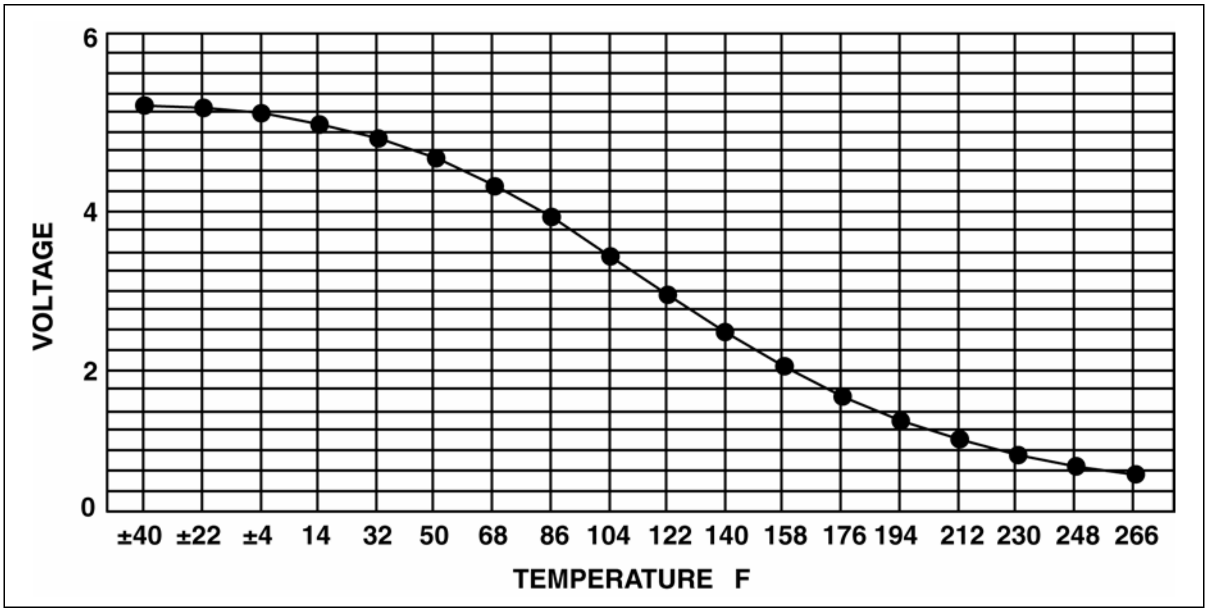


Figure 46 Typical NTC Thermistor Temperature-Voltage Curve

NGC Engine Coolant Temperature (ECT) Sensor

The ECT modifies injector pulse width, enables OBDII monitors and controls cooling fan operation. Its biggest influence on pulse width occurs with cold engine, key-on to determine cranking pulse width. After the vehicle has reached operating temperature, the PCM uses the ECT value to aid in calculating air density. ECT only has the authority to increase the base calculated pulse width. For example, in a cold engine, poor fuel atomization can require increased pulse width.

The ECT also affects spark advance curves, engine idle speed, cooling fan, A/C, transmission, and purge solenoid operation.

NGC Engine Coolant Temperature (ECT) Sensor Diagnostics

There are four ECT Sensor diagnostic routines:

- ECT Sensor voltage too high (signal open)
- ECT Sensor voltage too low (signal shorted to ground)
- ECT Sensor too cold too long (rationality)
- Closed loop temperature not reached (rationality)

The limp–in mode for the ECT Sensor is initially the IAT value (then uses a timer and ramps up value with run time) and the radiator fans operate at high speed.

SBEC Dual-Range Engine Coolant Temperature (ECT) Sensor

SBEC PCMs use a dual ranging temperature sensor circuit. The 5V signal normally flows through a 10,000 ohm pull-up resistor. When the PCM senses about 120°F (49° C) (signal voltage approx. 1.25V), it turns on a transistor that places a 1,000 ohm resistor in parallel with the 10,000 ohm resistor. This lowers the total circuit resistance to 909 ohms. As a result, there is less of a voltage drop across the pull-up resistors, and the signal voltage goes back up. This increases the accuracy of the coolant temperature sensor.

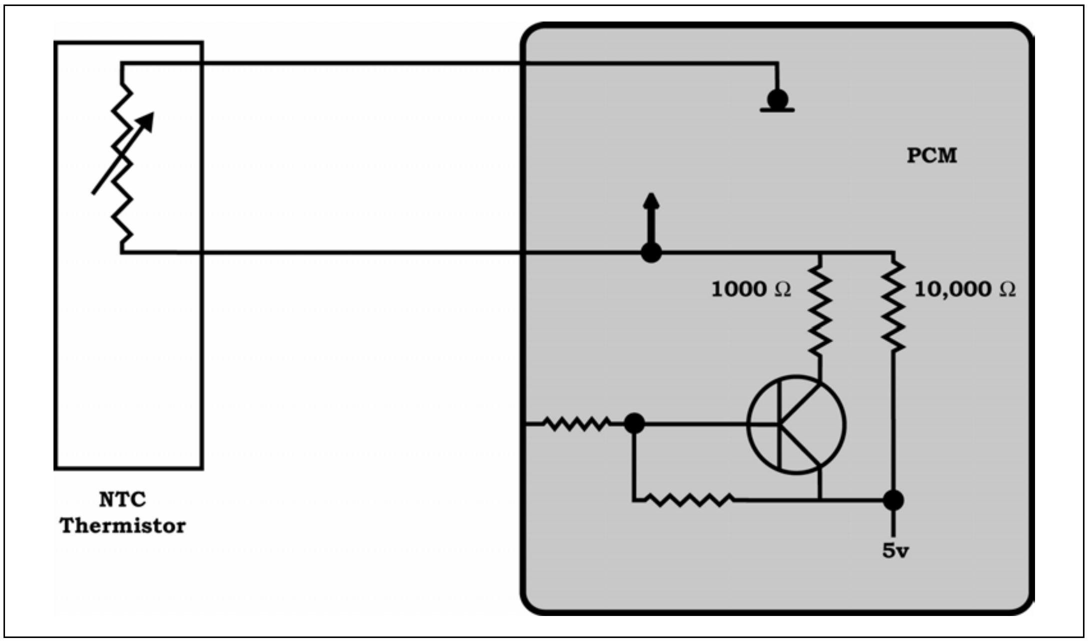


Figure 47 SBEC Dual Range Engine Coolant Temperature Sensor

Intake Air Temperature (IAT) Sensor

Air density changes as a factor of air temperature. The PCM uses the IAT signal to calculate the density of the incoming air. The IAT's greatest influence on pulse width occurs during extremely cold intake air temperatures with wide-open throttle conditions. The PCM may retard ignition timing to prevent spark knock at high intake air temperatures.

The IAT is typically located in the air tube instead of the intake manifold.

The IAT is also used as a backup to ECT. Typically, the resistance specifications for the ECT and IAT Sensors are the same.

Intake Air Temperature (IAT) Sensor Diagnostics

There are two IAT Sensor diagnostic routines:

- Voltage Too Low (near 0V)
- Voltage Too High (near 5V)

When the IAT Sensor indicates a voltage that is too high or too low, the PCM moves into limp–in mode. In case of IAT failure, the PCM uses Ambient/Battery temperature for a limp-in value. The PCM uses the Ambient/Battery Temperature Sensor information as long as this information is believed to be accurate.

OTHER PCM INPUTS

Sensed B+ Battery Voltage

The direct battery feed to the PCM is used as a reference to sense battery voltage.

Fuel injectors are rated for operation at a specific voltage. If voltage increases, the plunger will open faster and farther and conversely, if voltage is low, the injector will be slow to open and will not open as far. If sensed battery voltage drops, the PCM increases injector pulse width to maintain the same volume of fuel through the injector.

If the charging voltage is too high, check resistance in the Sensed B+ circuit.

If a loose connection in the B+ circuit is suspected, check the DTC # of starts since the counts were cleared.

ACTIVITY 6: ECT SENSOR

Notes:

ACTIVITY 7: IAT SENSOR

Notes:

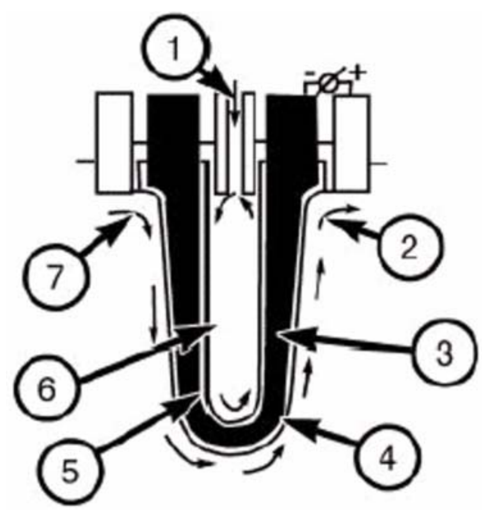
Oxygen (O_2) Sensors

The heated O_2 sensors are four-wire zirconium dioxide sensors placed in the exhaust system to measure oxygen content in the exhaust stream.

When hot, the O_2 sensor becomes a galvanic battery that typically generates a voltage signal between 0.0 - 1.0V. This is the signal voltage range that you will see on SBEC and JTEC vehicles. On NGC vehicles, when the O_2 sensor signal is monitored using a DRBIII® or a voltmeter, you will see 2.5 - 3.5V. This is because the sensor return is biased 2.5V to prevent O_2 sensor voltages from inverting and going below 0V, which would result in a possible open-loop condition that could occur under the following conditions:

- Sensor contamination
- O_2 air inlet clogged (preventing oxygen from being drawn into the sensor via the wiring harness)
- High-load, extreme heat conditions (trailer tow up a mountain in the desert)

The PCM infers air/fuel ratio from this information on oxygen content. The PCM then adjusts injector pulse width in order to achieve optimum air/fuel ratio, proper engine operation, and control emissions.



1	Outside Air	5	Inner Electrode
2	Exhaust Oxygen	6	Ambient Oxygen
3	Solid Electrolyte	7	Exhaust Oxygen
4	Outer Electrode		

Figure 48 Oxygen Sensor Operation

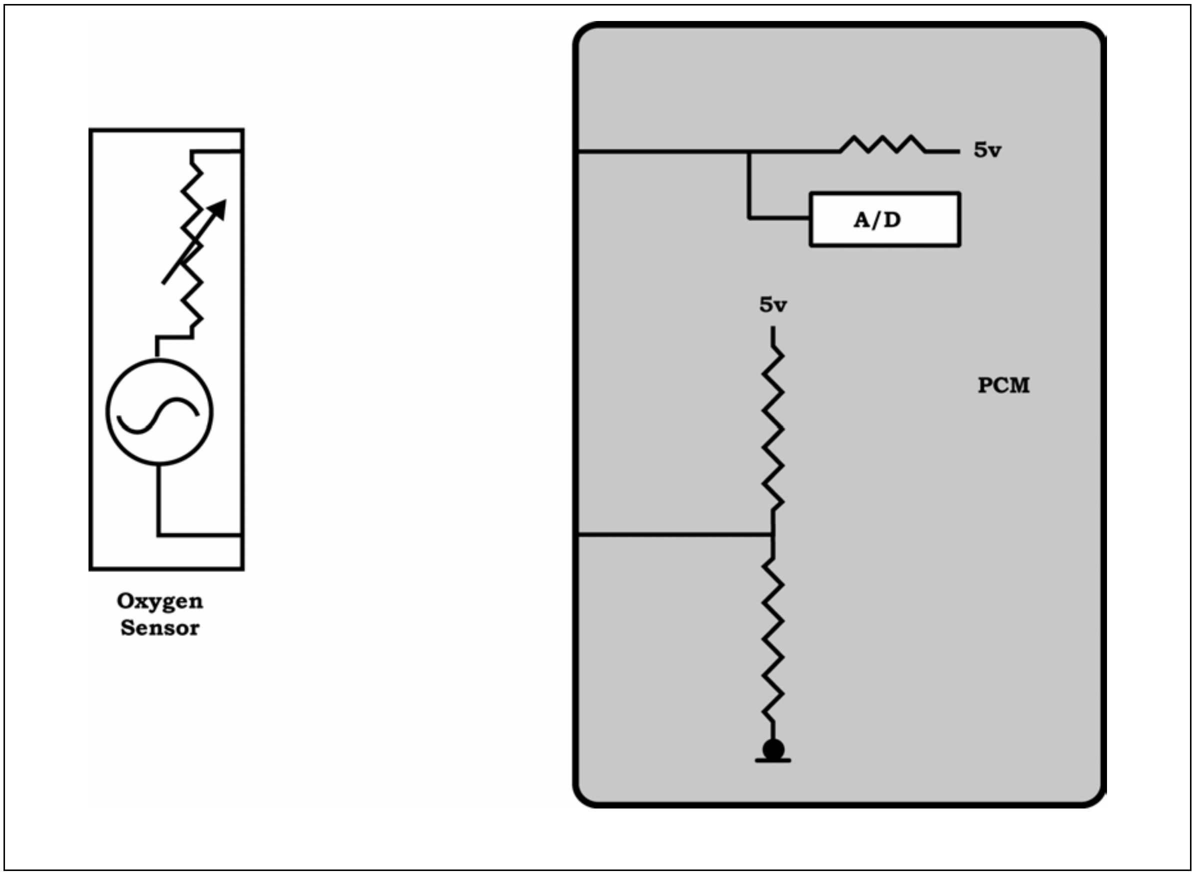
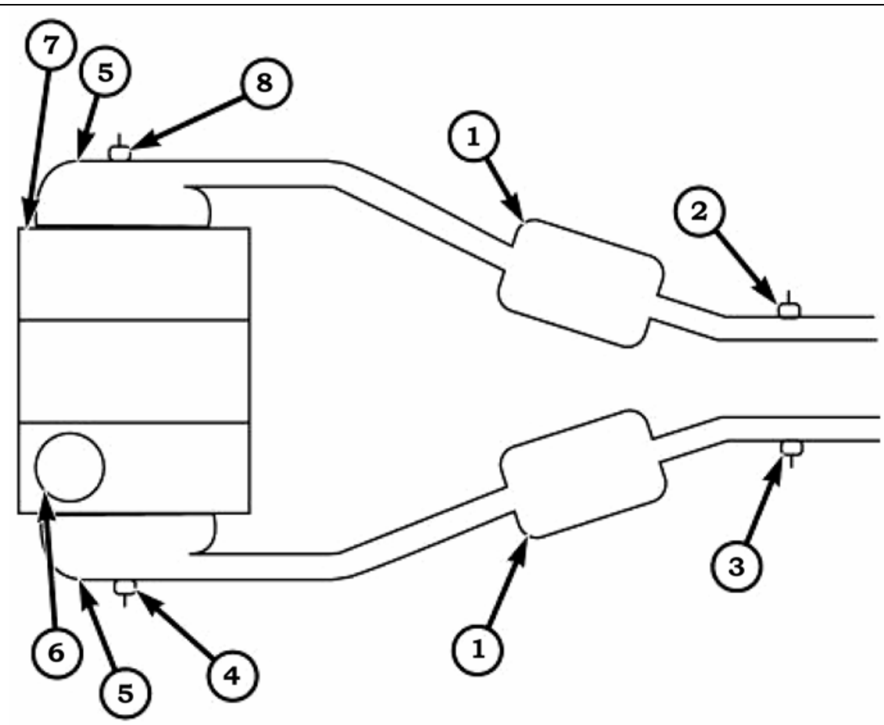


Figure 49 NGC Oxygen Sensor Signal Circuit (Completed by Student)

Oxygen Sensor Locations and Naming

Starting in 1996, all vehicles use at least one upstream and one downstream oxygen sensor. O_2 sensors are typically named 1/1, 1/2, 1/3, 2/1, etc. The first digit indicates the bank of the engine served by the O_2 sensor. A first digit "1" indicates the O_2 sensor is on the same bank as number 1 cylinder. A first digit "2" represents a location on the bank opposite number 1 cylinder. The second digit represents upstream (1), downstream (2) or mid-catalyst (3) locations. As an example, 1/2 would represent an O_2 sensor located downstream, on the bank with number 1 cylinder. Upstream and downstream sensors operate in a similar way but may not be interchangeable due to physical differences.



1	Catalytic Converter	5	Exhaust Manifold
2	Oxygen Sensor (2/2)	6	Cylinder #1
3	Oxygen Sensor (1/2)	7	Engine
4	Oxygen Sensor (1/1)	8	Oxygen Sensor (2/1)

Figure 50 Oxygen Sensor Naming Conventions

Open Loop Operation

The PCM is in Open Loop mode during a cold start when the O_2 sensors are below 660°F (349°C), and also when the engine is operated at wide open throttle (WOT). In Open Loop, the PCM ignores the O_2 sensors and performs air/fuel ratio adjustments based on pre-programmed values and inputs from other sensors.

A heater element heats the O_2 sensor in order to bring it to operating temperature and into Closed Loop operation quickly. Typical conditions for closed loop operation are:

- Engine temperature above 35°F (2°C)
- O_2 sensor temperature above 660°F (349°C)
- All timers have timed out following the START–TO–RUN transfer (timer lengths vary, based on engine temperature at key ON). The O_2 sensor must read either greater than 0.745V or less than 0.1V.

Table 6 Typical Time to Closed Loop Operation*

Engine Temperature (°F)	Time to Closed Loop Operations
35	41 Seconds
50	36 Seconds
70	19 Seconds
167	11 Seconds

**These times and temperatures may vary for each engine package.*

Closed Loop Operation

In Closed Loop operation, the PCM monitors oxygen levels in the exhaust and makes air/fuel ratio adjustments based on O_2 sensor feedback. The upstream O_2 sensor voltage signal verifies that the fuel system is operating at the 14.7:1 stoichiometric ratio. All tailpipe emissions, HC, CO and NOx are at their lowest points simultaneously when this fuel ratio is maintained.

There are two types of Closed Loop operation:

Short-Term: Immediate corrections are made to the pulse-width in response to the oxygen sensor, but these values are not stored in memory. The parameters are:

- Engine temperature exceeds 30 - 35°F (-1 - 2°C)
- O_2 sensor is switching
- All timers have timed-out following the START-to-RUN transfer (the timer lengths vary, based upon engine temperature at key-on)

Long-Term: Values are stored in non-volatile memory based on short-term corrective values. The parameters are:

- Full operating temperature
- All timers have expired

Note: Times and temperatures may vary for each engine package.

At 14.7:1, the O_2 sensor voltage will fluctuate between 2.5V and 3.5V. When the O_2 sensor detects excess oxygen, the signal voltage will be closer to 2.5V. A lack of oxygen will result in a voltage signal closer to 3.5V.

Zirconia O_2 sensors do not respond in a linear way. The voltage generated by the sensor is consistently high at air/fuel ratios richer than ideal (low O2), and the voltage generated is consistently low at air/fuel ratios leaner than ideal (high O2). The sensor signal voltage switches dramatically at stoichiometry and is relatively unchanging at all other air/fuel ratios. This means that the oxygen sensor signal can tell the PCM that the air/fuel ratio is leaner or richer than stoichiometry, but it can't tell the PCM how rich or how lean the mixture is.

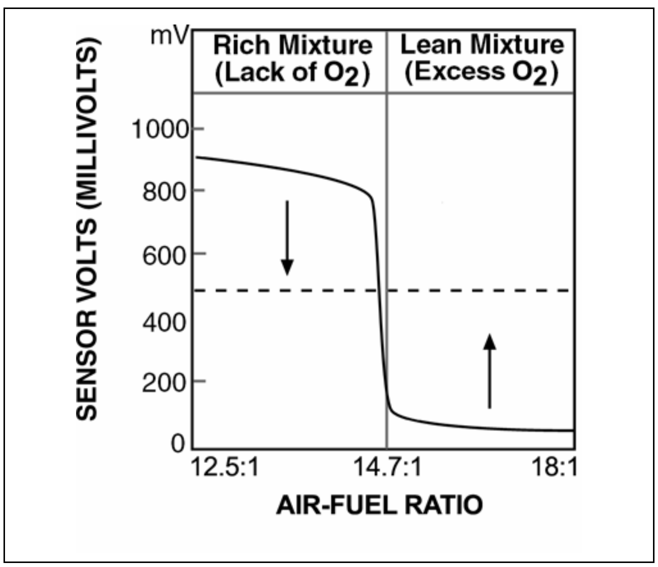


Figure 51 Oxygen Sensor Signal

When voltage exceeds preset high or low thresholds, called Switch Points, the PCM begins to add or remove fuel until the change in oxygen content causes the sensor to reach its opposite preset threshold. The process then repeats itself in the opposite direction.

NGC O_2 Sensor Diagnostics

The O_2 sensor must have a source of oxygen from outside the exhaust stream for comparison. O_2 sensors receive their fresh oxygen supply through the wire harness. Never solder an O_2 sensor connector or pack the connector with grease.

Exhaust system leaks ahead of the O_2 sensor can allow false air to be drawn into the exhaust stream. The sensor will report this extra oxygen to the PCM, and the PCM may incorrectly add extra fuel to compensate.

NGC diagnostics react much more quickly than JTEC/SBEC. For example, unplugging the O2 sensor will typically set a DTC in less than 15 seconds.

If the O2 sensor heater performance is poor, the 5V heater diagnostic voltage can cause the NGC PCM to think that the mixture is rich. The PCM will then respond with negative Adaptives.

JTEC/SBEC O_2 Sensor Diagnostics

When the engine is at operating temperature and signal voltage from the sensor is higher than a calibrated value, the PCM considers the signal shorted to voltage and sets a fault. If the voltage is lower than a calibrated value, the PCM considers the signal shorted to ground and sets a fault. Resistance in the signal (sensor) ground circuit can set the DTC “O_2 Sensor Shorted to Voltage.”

There are also tests required for OBD II that test the ability of the oxygen sensor to generate a voltage above and below calibrated threshold voltages, and to respond quickly to changes in fuel injector pulse width.

If the O2 sensor heater performance is poor, the 5V heater diagnostic voltage can cause the JTEC PCM to think that the mixture is rich. The PCM will then respond with negative Adaptives.

ACTIVITY 8: OXYGEN SENSORS

Notes:

Downstream O_2 Sensor

Depending on the vehicle's emission calibration, it may be equipped with multiple upstream and downstream O_2 sensors. Downstream sensors were first used in 1996 and have two functions.

The first function is to measure catalyst efficiency to meet OBD II requirements. If the catalytic converter is working properly, the oxygen content of the exhaust gases at the converter outlet fluctuates significantly less than at the converter inlet. The PCM compares the switching rates of both downstream and upstream O_2 sensors under specific operating conditions to determine if the catalyst is functioning properly. Any time the upstream to downstream switching ratio exceeds a calibrated value, a catalyst efficiency fault will be stored.

The second function is downstream fuel control. This function adjusts the upstream O_2 Goal Voltage within the range of operation of the upstream O_2 sensor. The upstream Goal Voltage is used to ensure long catalytic converter life by allowing the PCM to control the amount of air and fuel that is supplied to the catalytic converter.

Before 1996, the Goal Voltage was a pre-programmed fixed value based upon where it was believed the catalyst was most efficient. While the upstream O_2 sensor input was used to maintain the 14.7:1 air/fuel ratio, variations in engines, exhaust systems and catalytic converter ageing can cause this ratio to be less than ideal for a given vehicle. If gases leaving the catalyst contain too much oxygen, the mixture is too lean. The PCM responds by raising the upstream O_2 Goal Voltage. This increases fuel quantity and reduces excess oxygen. Conversely, if the gasses leaving the catalyst do not contain enough oxygen, the PCM lowers the upstream O_2 Goal Voltage. This reduces fuel quantity and increases excess oxygen. This function is active only during downstream closed loop operation.

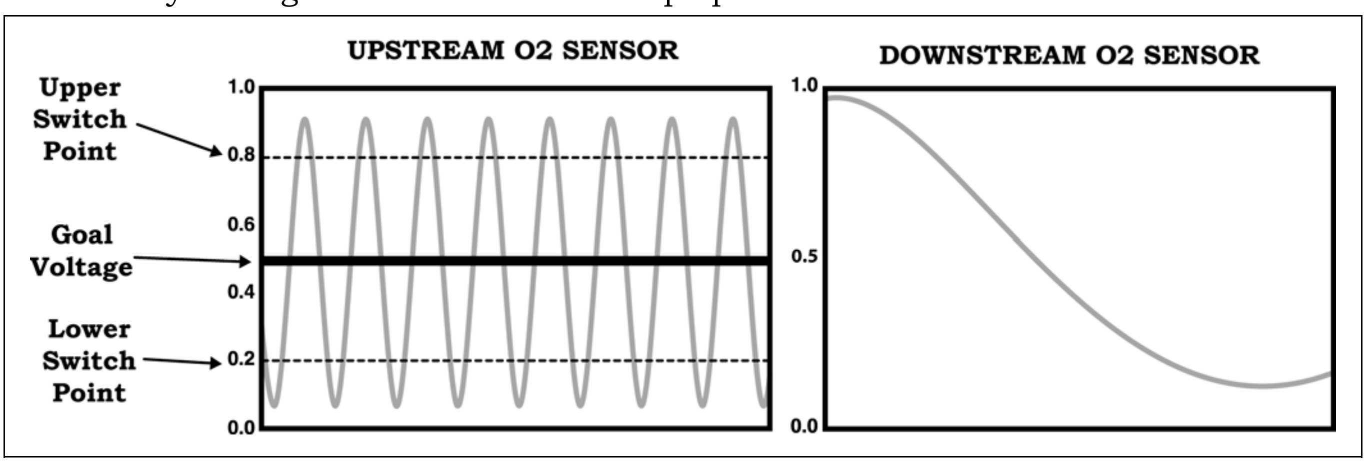


Figure 52 Upstream and Downstream O_2 Signal with Efficient Catalyst

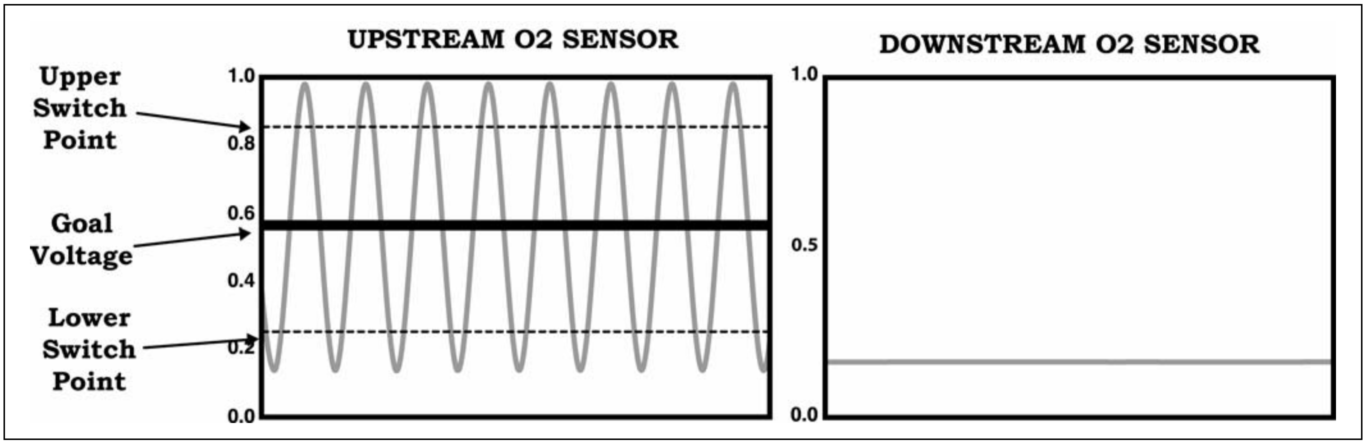


Figure 53 Goal Voltage and Switch Points Shift to Reduce High O_2 Content

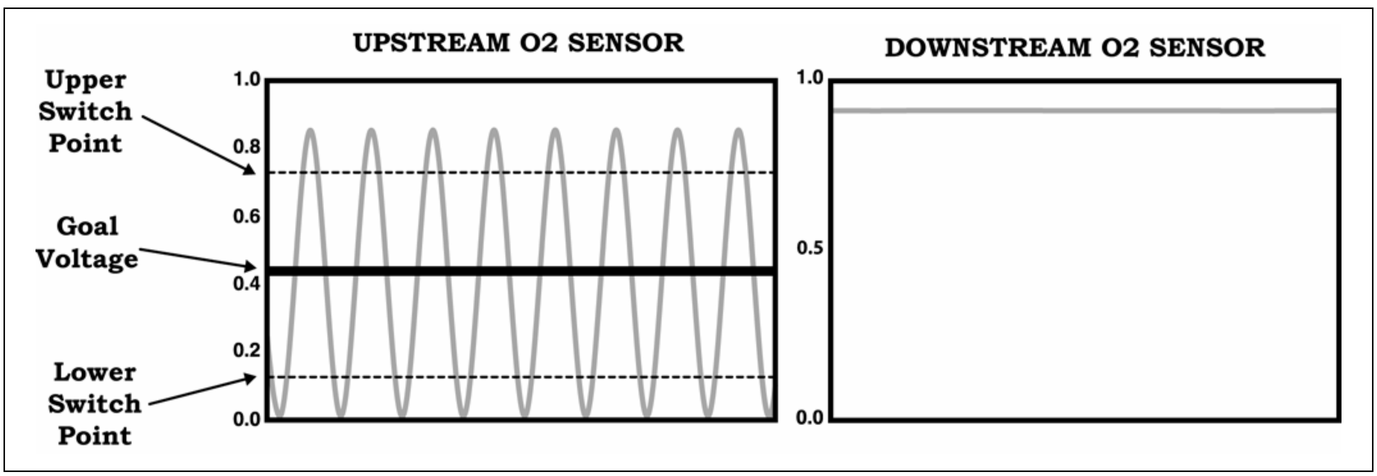


Figure 54 Goal Voltage and Switch Points Shift to Increase Low O_2 Content

NGC Oxygen Sensor Heaters

O_2 sensors use Positive Thermal Coefficient (PTC) heater elements. As temperature increases, resistance increases. O_2 sensor heaters get the sensors up to operating temperature quickly after startup. The heaters also help keep the sensor above operating temperature of 660°F (349°C). The heater uses two of the sensor's four wires.

The oxygen sensor heaters on NGC vehicles are controlled using a PWM high-side driver, whereas the heaters on SBEC and JTEC vehicles are either low side controlled by the PCM, or are ASD controlled. The resistance of NGC sensor heaters is constantly monitored by the PCM. This information is used to verify proper operation of the heater circuit, and to indirectly determine the temperature of the O_2 sensor. To determine the operating resistance of the heater circuit, the PCM performs a voltage drop test across a 10K-ohm resistor that is inline between the high-side driver and the O_2 heater circuit. The PCM then adjusts the PWM to achieve the proper current flow to maintain proper temperature. The NGC also provides a 5V pull-up that is used to perform open circuit, short to ground and short to power diagnostics, when the heater is in the OFF state.

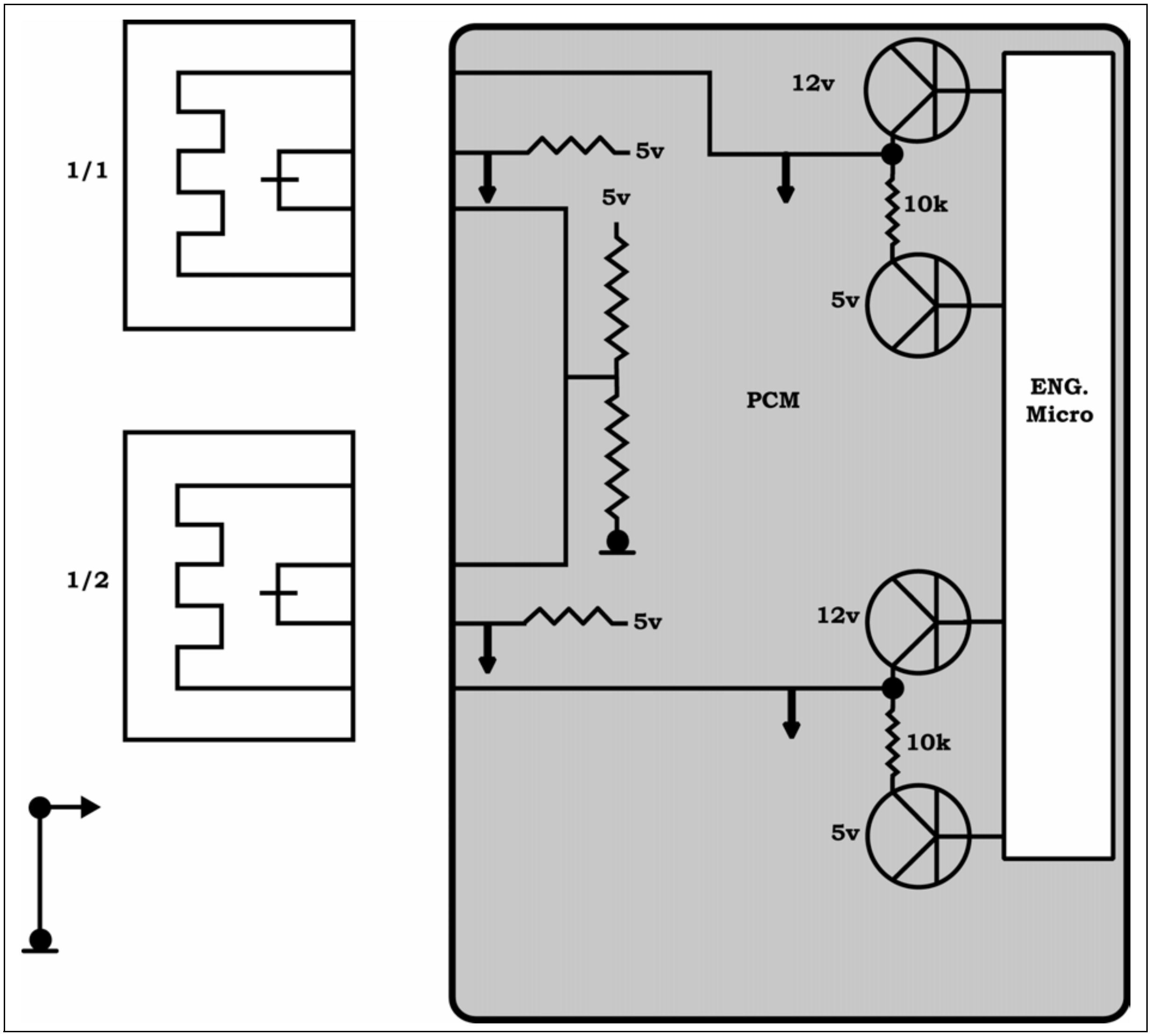


Figure 55 O_2 Sensor Heater Circuits (Completed by Student)

JTEC/SBEC O_2 Sensor Heaters

The heaters are fed battery voltage either from the ASD relay or from the sensor relay. Both relays are controlled by the PCM. Sensor heaters either uses a common ground, or they are pulse-width modulated (PWM) by the PCM.

The upstream O_2 heater has an internal resistance of 4.5 ohms and the downstream sensor is 6.0 ohms. As sensor temperature increases, resistance in the heater element also increases. Current flow through the heating elements is low. At 70°F (21°C) current flow is approximately 600 mA. At operating temperature, it drops to approximately 200 mA. This allows the heater to maintain the optimum operating temperature of approximately 930 - 1,100°F (500 - 600°C).

Vehicles with California Emissions (NAE) Package have four oxygen sensors. To control the current surge from simultaneously powering up 4 O_2 sensors heaters, two additional O_2 sensor heater relays have been added to the PDC. The relays control power to the heaters. This allows the PCM to delay the operation of the downstream heaters for up to two seconds. There are four new circuits, two for sensor inputs and two for heater relay control. The two new relays are found only on NAE vehicles. The two main reasons for the relays are:

- The ability to turn the heaters OFF to increase their lifespan. Because the mini–cats are close to the exhaust manifold, the O_2 sensors run very hot. Heaters will be turned OFF based on MAP and rpm, generally during high engine speed and/or load. As soon as the MAP/rpm window is exited, the heaters will turn back ON.
- The ability to stagger the turn-on of the heaters. The downstream heater will come on after the upstream heater.

There are three methods of heating oxygen sensors. The first method utilizes a Positive Temperature Coefficient (PTC) heater element. This heater element receives power from the ASD relay and has a constant ground. The second method is a Pulse-Width Modulated (PWM) heater circuit. The heater element receives power from the ASD relay and the ground is pulse-width modulated by the PCM. Current is varied on a duty-cycle of 0 - 100%. The heaters in the PWM O_2 sensor cannot tolerate continuous 12V. Therefore, 100% duty cycle is applied after start up for a period, and then the duty-cycle is ramped down to protect the heater element. PWM O_2 sensor heaters allow for a faster transition to closed loop, as early as 5 - 10 seconds after start up. The conventionally heated O_2 sensors take as long as 35 seconds to go into short-term closed loop. Going into closed loop faster reduces cold-start emissions.

Some of the advantages of the PWM heaters are:

- Meet tighter LEV and ULEV emissions regulations
- Allow closed loop operation as early as 5 - 10 seconds after start
- Delays activation after an overnight soak to allow moisture to burn off to prevent cracking of the thimble

The third method includes an O_2 heater relay. On these vehicles, power is provided to the O_2 heater element by the O_2 heater relay and its ground is fixed. The O_2 heater relay receives power from the ASD relay and the PCM controls the O_2 heater relay ground.

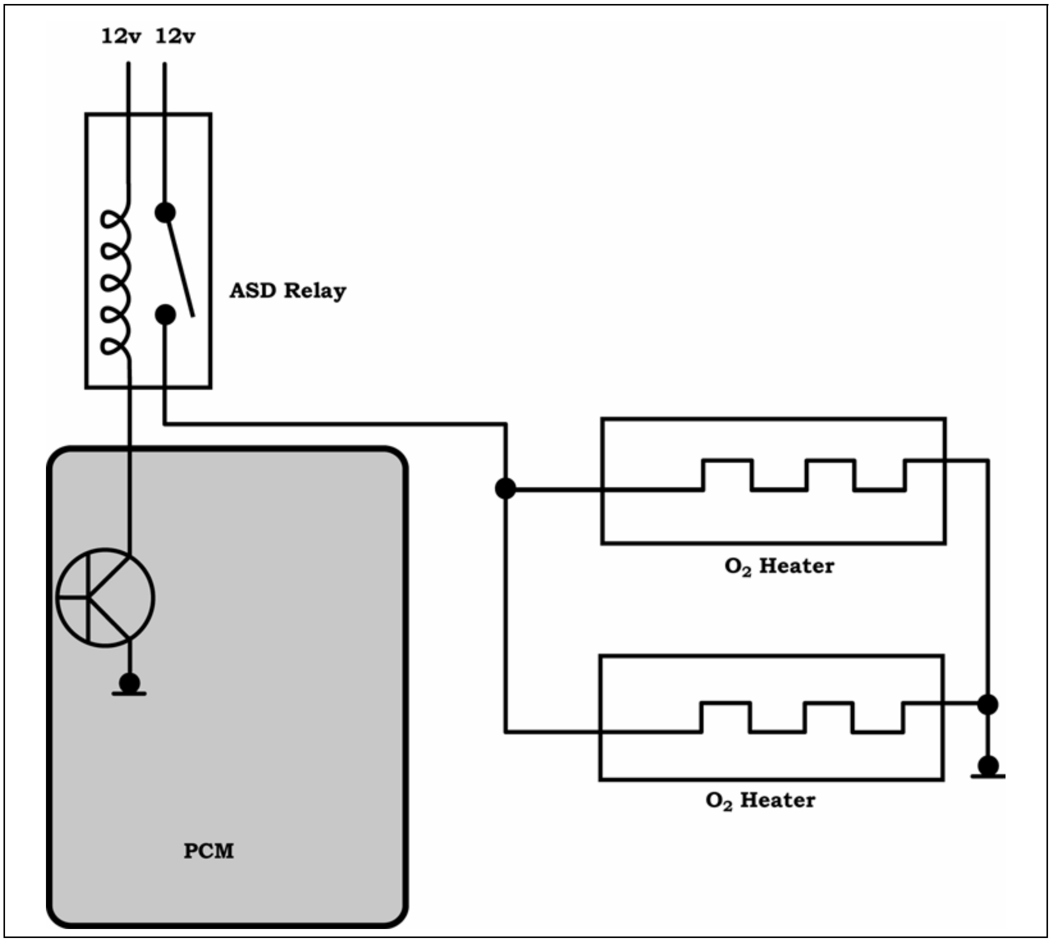


Figure 56 Oxygen Sensor Heater Element - ASD Power / Constant Ground

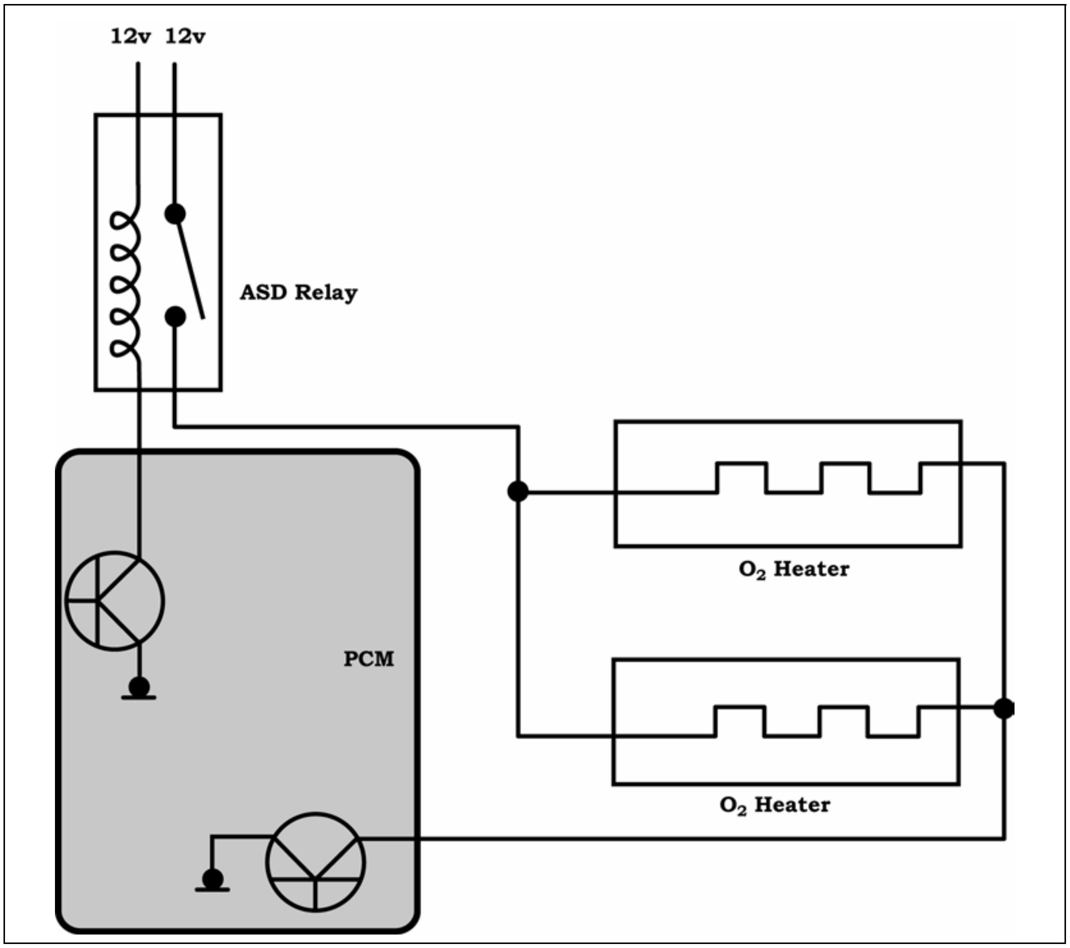


Figure 57 Oxygen Sensor Heater Element - ASD Power / PWM Ground

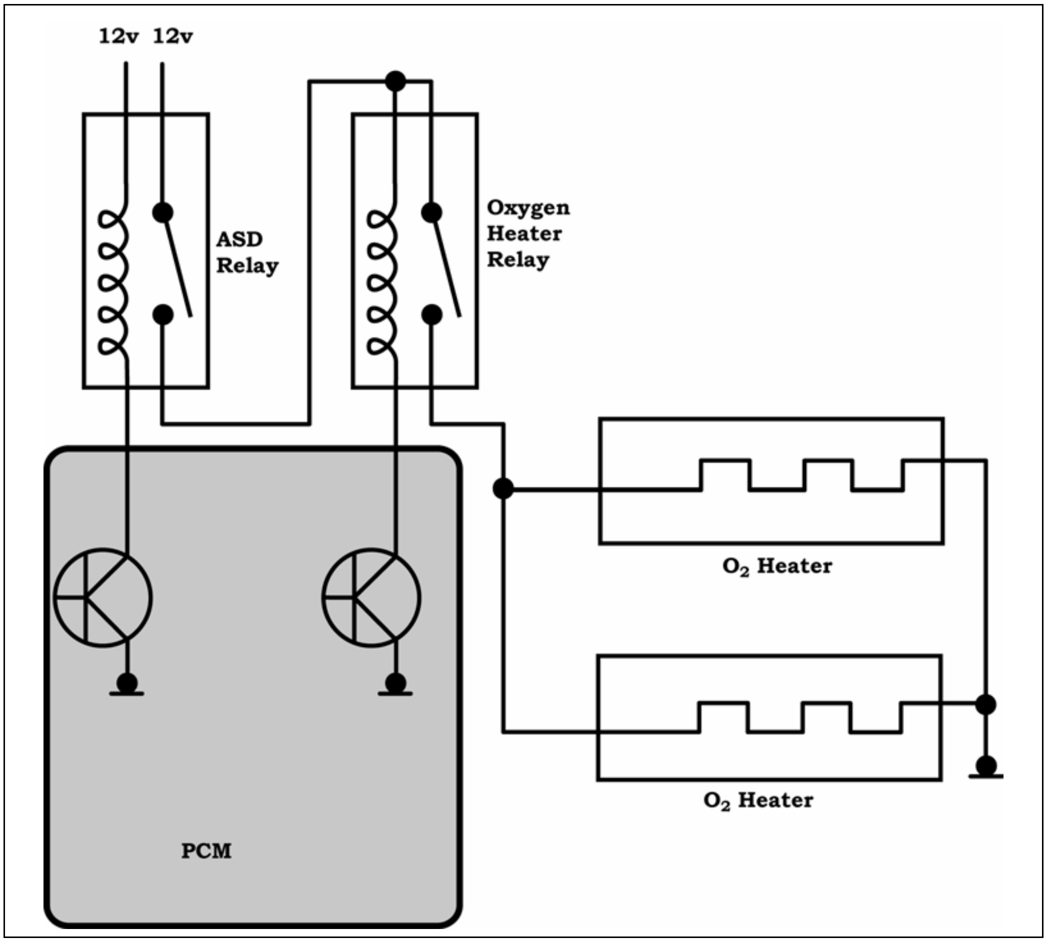


Figure 58 Oxygen Sensor Heater Element - Relay Power / Constant Ground

ACTIVITY 9: OXYGEN SENSOR HEATERS

Notes:

MODULE 7 ADAPTIVES

OXYGEN SENSOR FEEDBACK

The PCM uses the Speed Density Equation to calculate the base pulse width required for the specific operating conditions. The goal is to maintain the stoichiometric air/fuel ratio of 14.7:1. At this ratio, all vehicle tailpipe emissions are at their lowest point possible and the catalytic converter is also getting what it needs to be efficient.

The upstream oxygen sensor signal should be switching between 0 – 1.0V if the PCM's calculation is correct and if the vehicle is operating with a 14.7:1 air/fuel ratio. NGC PCMs add a 2.5V bias voltage to the oxygen sensor return circuit. On the DRB III, the oxygen sensor signal will be 2.5 – 3.5V for NGC vehicles.

When the fuel system goes into closed loop operation, there are two adaptive memory programs that begin to operate. The PCM operates these two fuel correction programs to modify fuel delivery based on oxygen sensor feedback. These two programs are:

- Short Term Adaptive
- Long Term Adaptive

SHORT TERM ADAPTIVE

During closed loop operation, Short Term Adaptive makes immediate adjustments to fuel delivery in direct response to the signal from the upstream O_2 sensor. The PCM infers air/fuel ratio by monitoring oxygen content measured by the upstream O_2 sensor.

If the upstream oxygen sensor voltage is not switching between 2.5 -3.5V (NGC) or 0 – 1.0V (JTEC and SBEC), the PCM knows that the base pulse width calculation needs to be modified by adjusting the injector pulse width until a switching O_2 sensor voltage is achieved. This immediate correction is known as Short Term Adaptive, or Short Term Fuel Trim (STFT), and begins functioning shortly after the vehicle has started.

The need to adjust the injector pulse width may be a result of vehicle operating conditions, vehicle wear, fuel quality, etc. The maximum range of authority for Short Term Adaptive is ±33% for NGC and JTEC, and ±25% for SBEC.

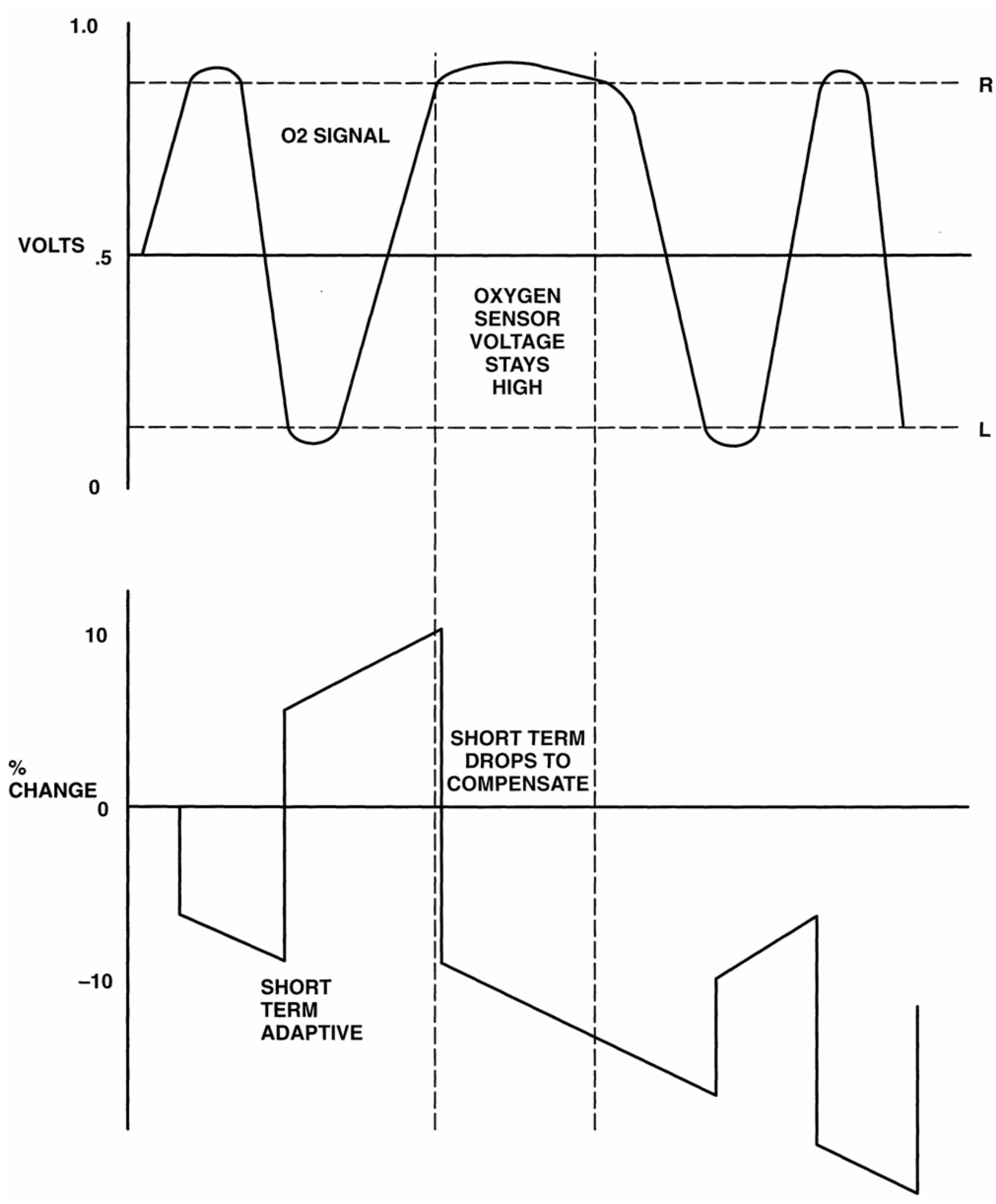


Figure 59 Short Term Adaptive vs. O_2 Sensor Voltage

LONG TERM ADAPTIVE

The values shown in Figure 60 are for example only. The main function of Long Term Adaptive is to make fuel corrections that allow Short Term Adaptive to hover around zero. In order to maintain correct emissions throughout all operating ranges of the engine, a cell structure based on engine rpm and load (MAP) is used.

There are 26 cells on NGC vehicles, up to 22 cells on JTEC-equipped vehicles and up to 16 cells on SBEC-equipped vehicles. Two of the cells are used only during idle, as determined by TPS and Park/Neutral switch inputs. The other cells each represent specific off-idle manifold pressure and rpm ranges.

After the vehicle has reached full operating temperature, short term correction factors will be stored in Long Term Adaptive memory cells based on vehicle load (RPM/MAP) to allow the Short Term Adaptive value to be brought back to near zero. Once this correction factor is stored in memory, it will be used by the PCM under all operating conditions, open loop and closed-loop. However, the values stored in Long-term are updated only after the vehicle has entered long-term closed loop at full operating temperature. This is done to prevent any transition temperature or start–up compensation from corrupting long term fuel correction.

Long Term and Short Term Adaptive can each change the pulse width by as much as ±33% (NGC and JTEC) or ±25% (SBEC) for a maximum total correction of ±66% (NGC and JTEC) or ±50% (SBEC) from the base pulse width calculation.

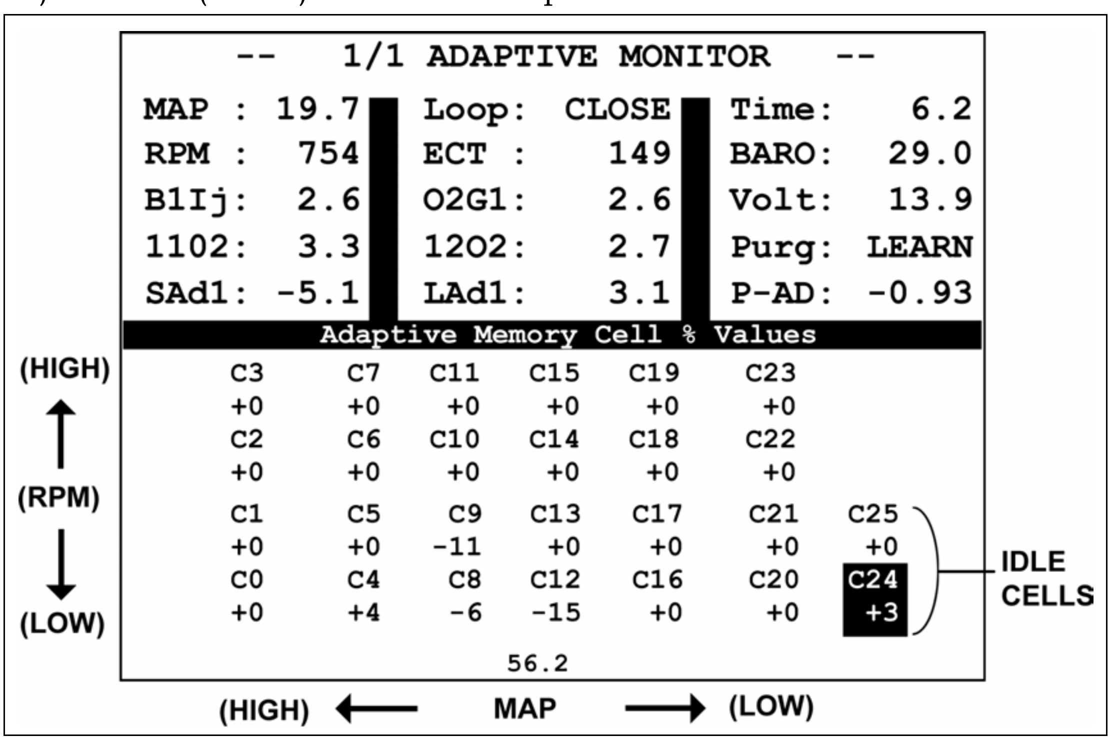


Figure 60 NGC Adaptive Fuel Monitor Screen

The cell structure is a matrix based on RPM and MAP characteristics that is calibrated for each power train package. Each row represents a different RPM range and each column represents a different range of MAP values.

RPM								
(HIGH)	Open Throttle	Open Throttle	Open Throttle	Open Throttle	Open Throttle	Open Throttle	Decel	Idle
↑	C2	C5	C8	C11	C14	C17	N/A	N/A
RPM	C1	C4	C7	C10	C13	C16	C19	C21
↓ (LOW)	C0	C3	C6	C9	C12	C15	C18	C20
	(HIGH)		←	MAP	→			(LOW)

Figure 61 Typical JTEC Long Term Adaptive Memory Fuel Cells

(not all cells are used on every package)

RPM								
(HIGH)	Open Throttle	Open Throttle	Open Throttle	Open Throttle	Open Throttle	Open Throttle	Idle	Decel
↑ RPM	C1	C3	C5	C7	C9	C11	C13 "D"	C15
↓ (LOW)	C0	C2	C4	C6	C8	C10	C12 "N"	C14
	(HIGH)		←	MAP	→			(LOW)

Figure 62 Typical SBEC Long Term Adaptive Memory Fuel Cells

Note: Whenever components that affect engine operation are replaced, the Adaptive Memory should be reset. If this is not done, when the engine is started and runs in Open Loop, it will use the Long Term Adaptive values stored while the component was malfunctioning. This could cause rough operation during warmup after repairs.

NGC PURGE VAPOR RATIO

Canister purge is part of the Speed Density Equation. The purge system used on NGC vehicles has components similar to previous vehicles; however, the integration of purge into the Speed Density Equation is completely different. On NGC vehicles, the PCM learns the HC content within the components of the EVAP system, which allows it to predict the effect of purge flow on the final pulse width. Purge Vapor Ratio is learned on every start through O_2 feedback and Short Term Adaptive shift. The PCM operates in three different modes to learn how purge fits into this equation:

- **OFF (Mode 0) –** This occurs shortly after the vehicle has been started and has entered short-term closed loop. During Mode 0, purge is disabled while the PCM learns what it takes to operate the vehicle at stoichiometry without the extra load of purge vapors. This is when Long Term Adaptive memory values are allowed to update.
- **LEARN (Mode 1) -** Once the PCM has learned the engine's fuel requirements, Long Term Adaptive memory values are locked, and purge flow slowly starts to ramp-in. The objective of Mode 1 is to learn the HC loading of the fuel tank and the vapor canister. This is accomplished by monitoring the effects of purge on Short Term Adaptive and comparing the results against the data accumulated during Mode 0. Once purge loading has been learned, the vehicle enters Mode 2 operation.
- **NORMAL (Mode 2) –** During this mode of operation, Long Term Adaptive memory values remain locked, and purge flow is increased to normal high-flow levels required to deplete the EVAP system of HC vapors. The PCM adjusts the injector pulse width to automatically compensate for this extra source of fuel. Remember that the PCM learned during Modes 0 and 1 what the effect of the additional HC from purge is. It can therefore adjust the pulse width in anticipation of what will occur once purge is ramped-up to normal levels.

Proper purge flow is achieved by adjusting the flow through the Proportional Purge Solenoid. The PPS is monitored by the PCM on the ground side of the circuit. The PCM uses this data to regulate the opening of the solenoid to ensure proper purge flow under changing operating conditions. This is monitored by the PCM and displayed on the DRB III as "P-Ad" or Purge Adaptive.

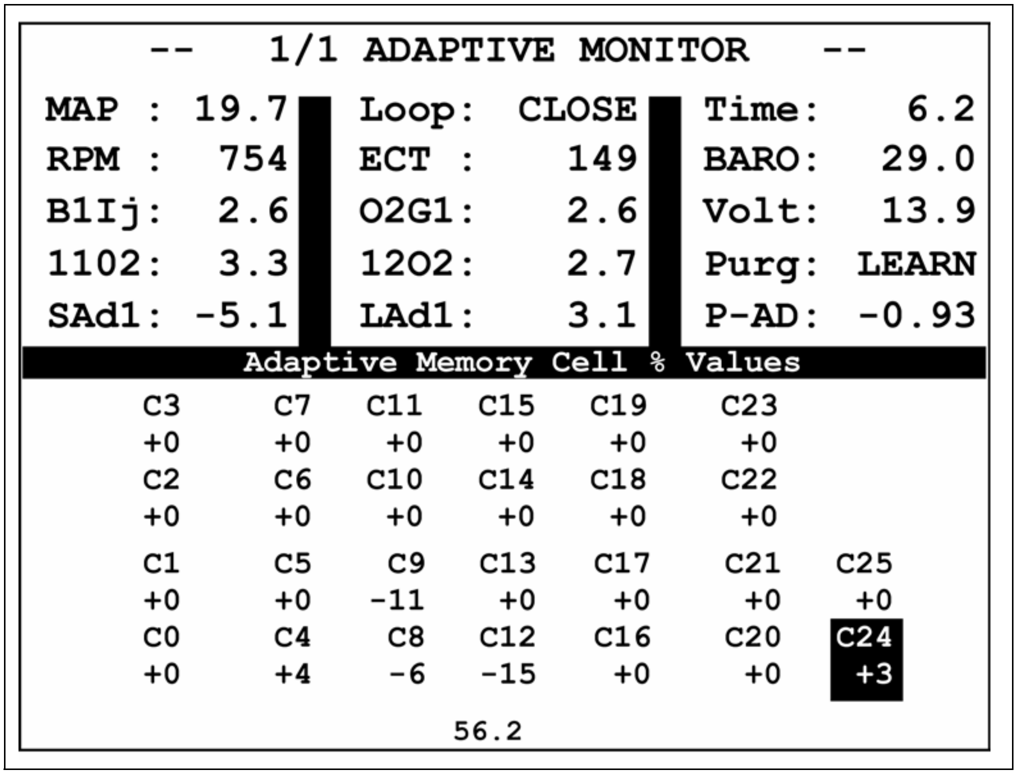


Figure 63 NGC Adaptive Fuel Monitor Screen

If the PCM determines that the HC level in the charcoal canister is below a calibrated amount by monitoring the Purge Vapor Ratio, purge operation will be turned OFF. Periodically the PCM will re-enter the LEARN Mode to determine whether there is sufficient HC in the EVAP system to again initiate purge flow. These events can occur on the same key-cycle.

In other words, purge vapor content is learned shortly after short-term closed loop operation begins and is factored into the Speed Density Equation. All long-term cells represent fuel correction without purge flow. In other words, all long-term cells are purge-free cells.

JTEC/SBEC Purge-Free Cells

On JTEC and SBEC vehicles, purge-free memory cells are used to identify the HC content of the charcoal canister. The only difference between purge-free and normal adaptive cells is that in purge-free cells, the purge is turned completely off. Baseline values in the purge-free memory cells are compared with Long Term Adaptive cells of the same operating range (rpm and MAP) with normal purge operation. The level of HC is determined by comparing the difference in adaptive values between the long term cells and the corresponding purge-free cells. Purge-free cells can be monitored by the DRB III® scan tool. Vehicle calibration determines which cells and how many cells will have corresponding purge-free cells.

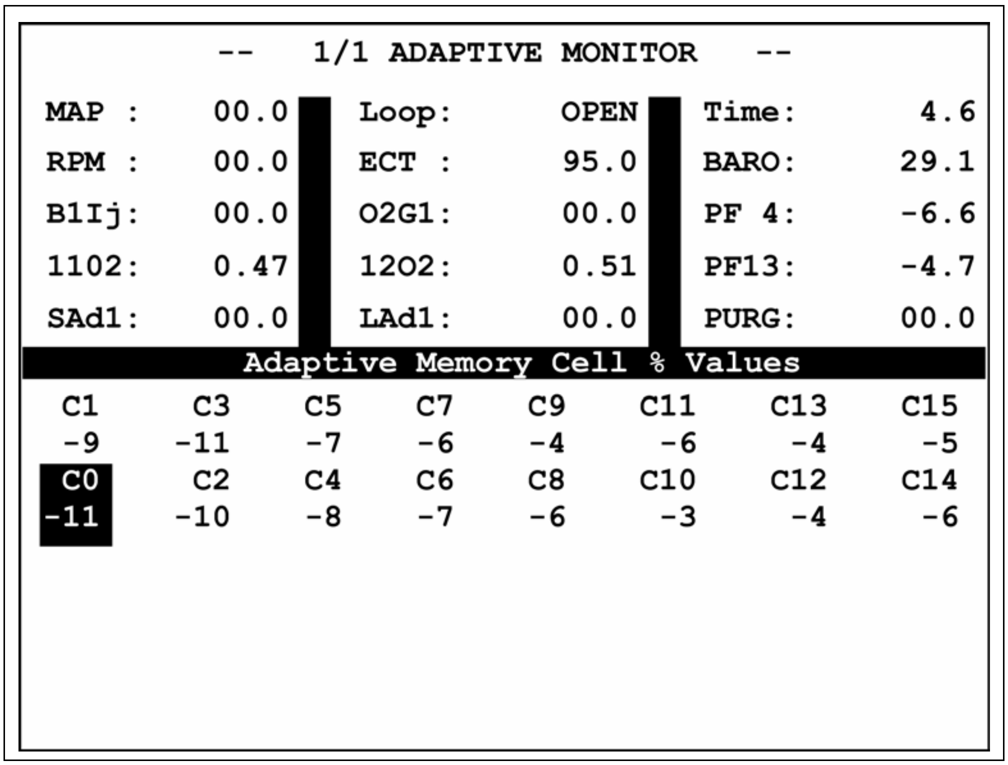


Figure 64 SBEC Purge Free Cells on Adaptive Monitor Screen

Purge Corruption Reset (JTEC/SBEC)

Some operating conditions, such as the use of winter-blend fuel on an unusually hot day, can cause an abnormally large shift in the Long Term Adaptive memory cells. To ensure that on the next key cycle, the adaptives do not try to correct for conditions that are no longer present (i.e. an unusually hot day), a process called Purge Corruption Reset is used.

During each start, the PCM compares the value of the purge-free cell to the value in its corresponding long term cell. If the difference is too great, the PCM will replace the value in the long term cell with the corresponding purge-free cell value. The cells that do not have a corresponding purge-free value will be replaced with the most positive purge-free cell value. If a cell value is already more positive than the purge-free cell value, it will not be changed.

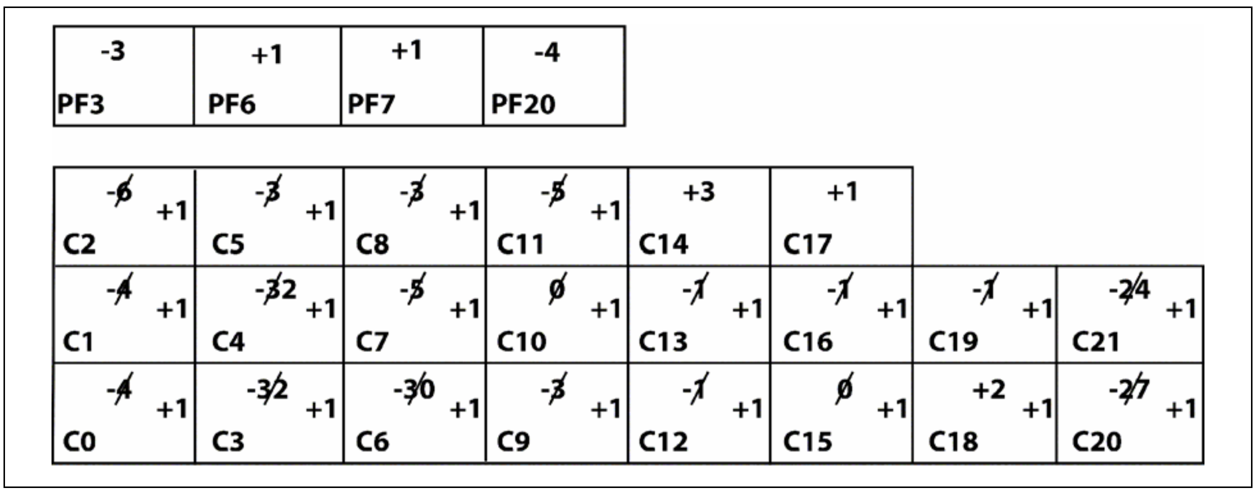


Figure 65 Purge Corruption Reset

ACTIVITY 10: FUEL TRIM AND PURGE

Notes:

Notes:

MODULE 8 PCM OUTPUTS

PCM CONTROLLED OUTPUT DEVICES

NGC controllers may use either high-side or low-side drivers to control output devices. The NGC PCM differs from previous controllers in that high-side drivers (power supplying transistors) now control several devices that used to be controlled by low-side drivers (ground supplying transistors). High-side drivers are used by the NGC to control high-current devices. In NGC, there was a need for multiple high-current drivers to be located on the same silica chip. This is only possible with high-side drivers. For low-current devices, a high-side or low-side driver can be utilized, but since low-side drivers were already developed and validated, their use has been carried over from previous applications.

JTEC and SBEC controllers only use low-side drivers.

NGC LOW-SIDE CONTROLLED DEVICES

The NGC controller contains two latching (always-on) drivers to control various low-current devices such as relays and solenoids. Each IC chip is capable of controlling eight low-side controlled devices. Not all circuits are currently used, but as new features are added to the NGC controller, both IC chips may be fully utilized.

Table 7 Low-Side Outputs (2002 LH Shown)

IC Chip 1	IC Chip 2
Double Start Override (starter) Relay	A/C Clutch Relay
Fuel Pump Relay	S/C Vacuum Solenoid
S/C Vent Solenoid	Spare
Low Speed Radiator Fan	Spare
High Speed Radiator Fan	Spare
ASD Relay	Spare
Spare	Spare
Spare	Spare

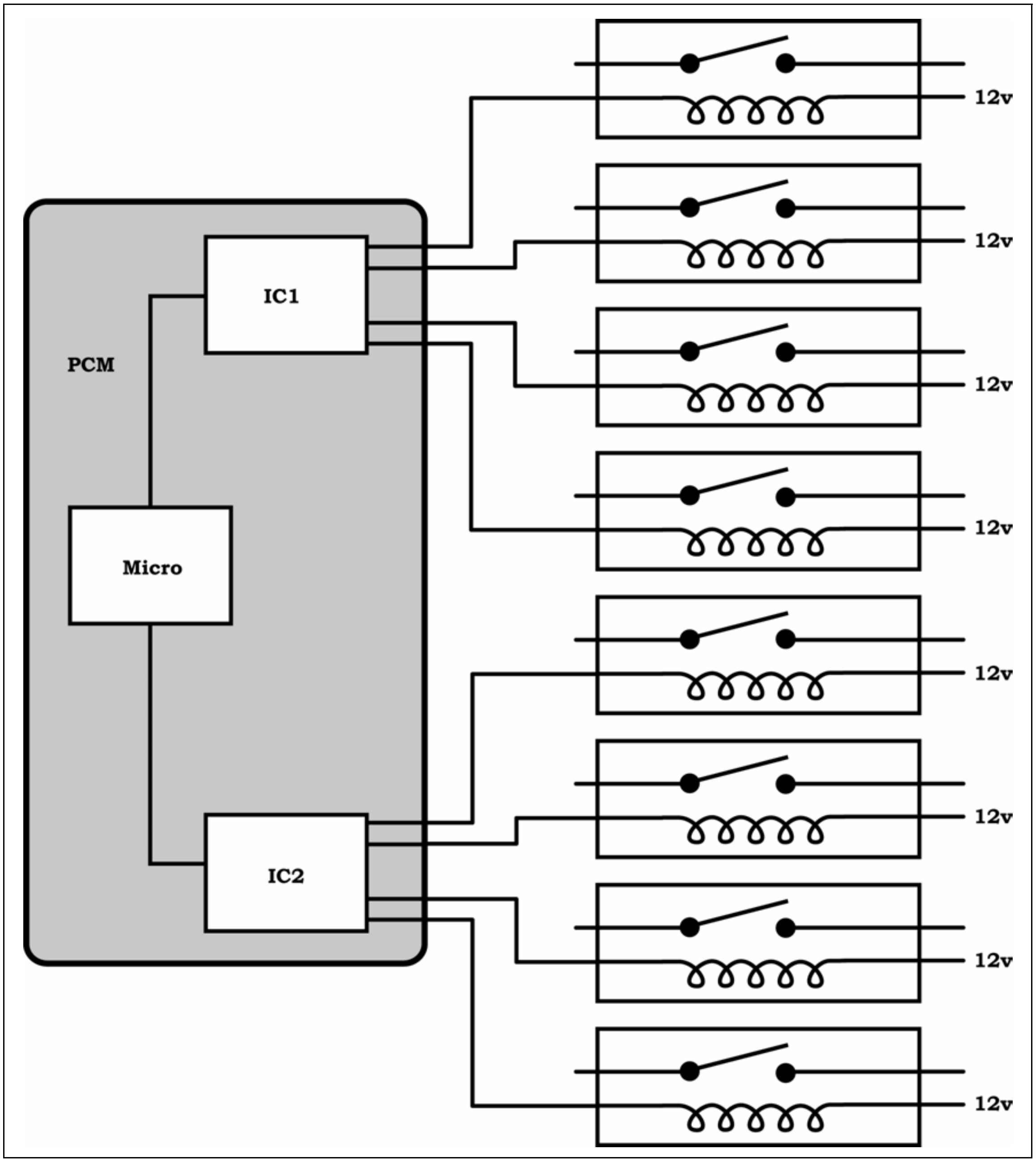


Figure 66 Low Side Output Control

JTEC/SBEC LOW-SIDE CONTROLLED DEVICES

On JTEC-equipped vehicles, most of the output relays and solenoids are controlled by quad drivers. A quad driver is a single microchip that contains four separate driver circuits that are used for controlling high current output devices. A voltage divider circuit has been added to diagnose the operation of the driver circuit.

This voltage divider is located between the output of the driver and the input command (from microprocessor) to the driver.

On SBEC-equipped vehicles, a Serial Peripheral Interface/Output (SPIO) circuit controls most of the output relays and solenoids. This circuit in the PCM is used for controlling high current output devices. The SPIO circuit also provides diagnostics. The SPIO circuit can determine whether the actual state of the relay or solenoid matches the PCM's expected state. When the PCM is not controlling the device, a high voltage state should be seen (CONTROL HI). When the PCM energizes the device, there should be a voltage drop (CONTROL LO).

Note: The PCM performs diagnostics on SOME circuits only when a change of state has been requested. This means a circuit could fail and the PCM would not know until it was told to change the state.

CAUTION: Both diode-suppressed and resistor-suppressed relays have been used. If an incorrect relay is used, damage may occur to the relay, circuit, or PCM. Never swap relays for diagnostic purposes unless the relays have the EXACT part number.

NGC HIGH-SIDE CONTROLLED DEVICES

On NGC vehicles, high-side drivers are used to control high-current devices. Although low-side drivers can control high-current devices, it is difficult and expensive to place these drivers onto one integrated circuit chip. NGC controllers use either a Dual High Side Switch (DHSS) or a Quad High Side Switch (QHSS) to control all high-side controlled devices. JTEC and SBEC vehicles do not use high-side drivers.

The difference between the two is the way they are packaged. A DHSS integrates two high-side drivers into one chip (dual), where as a QHSS integrates four drivers onto each chip (quad).

Variable output devices, such as the Linear Solenoid Idle Air Control (LSIAC) Valve and Proportional Purge Solenoid (PPS) have their ground connection made through the PCM. In these cases, the PCM is capable of monitoring the ground circuit to determine the position of the device.

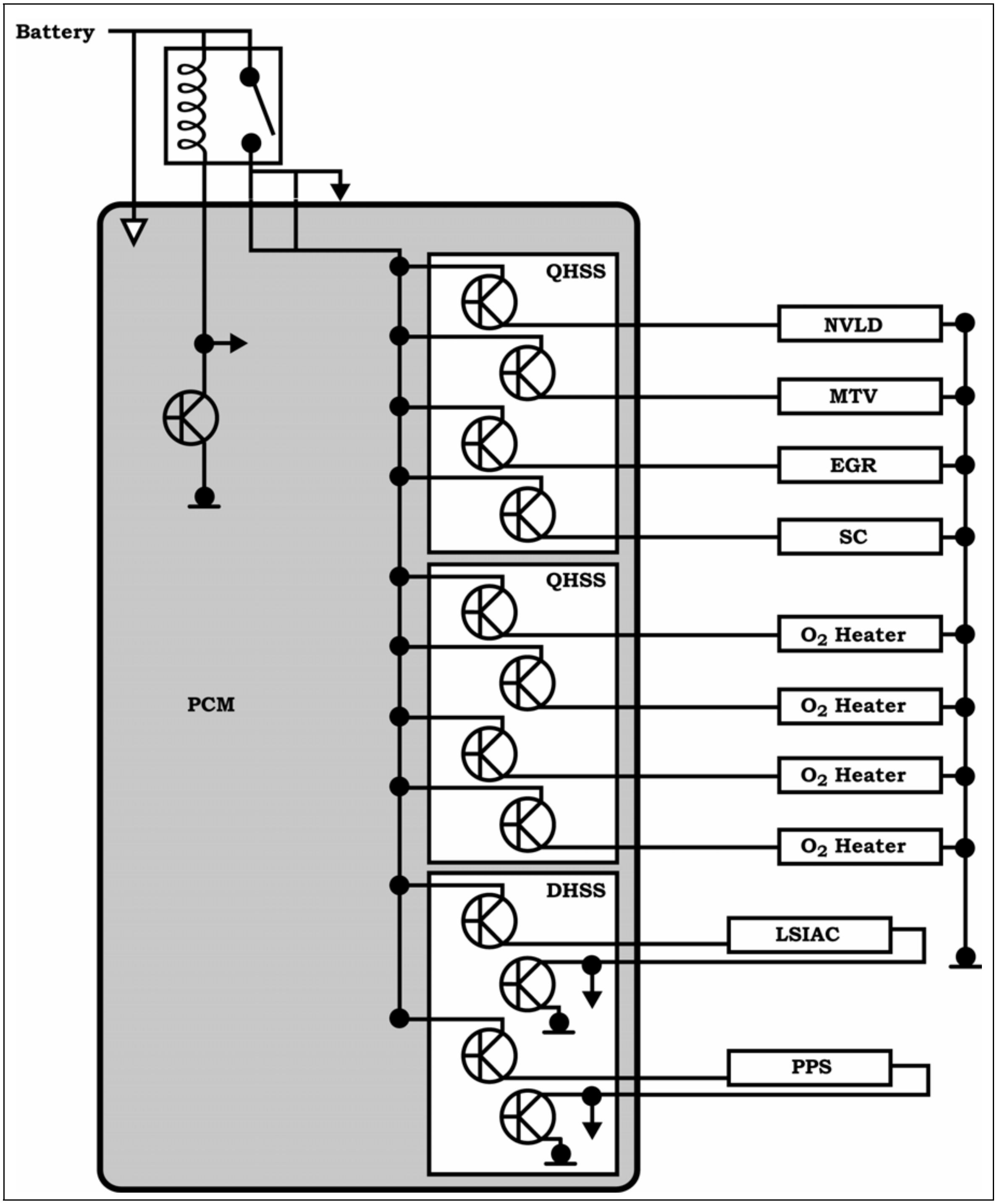


Figure 67 NGC High Side Output Control

AUTOMATIC SHUTDOWN RELAY (ASD)

When energized, the ASD Relay provides power to operate the injectors and ignition coils. On SBEC and JTEC vehicles, the ASD Relay also powers the generator field and O_2 sensor heaters (upstream and downstream). The relay provides a sense circuit to the PCM for diagnostic purposes.

The PCM energizes the ASD:

- For approximately 2.0 seconds during initial key–ON cycle.
- Whenever the Crankshaft Position Sensor signal exceeds a certain value.

On NGC vehicles, the ASD Relay coil is fed battery voltage and the PCM provides the ground. The ASD output may be distributed to the PCM and other components.

With JTEC, the ASD Relay coil is powered with battery voltage from the ignition switch and the PCM provides the ground. On JTEC vehicles, the ASD output may be distributed to other circuits through the PCM.

On SBEC vehicles, the ASD Relay coil is fed battery voltage. For OBD II diagnostics, the PCM can provide a ground after the key is turned off.

Consult Service Information for vehicle-specific information.

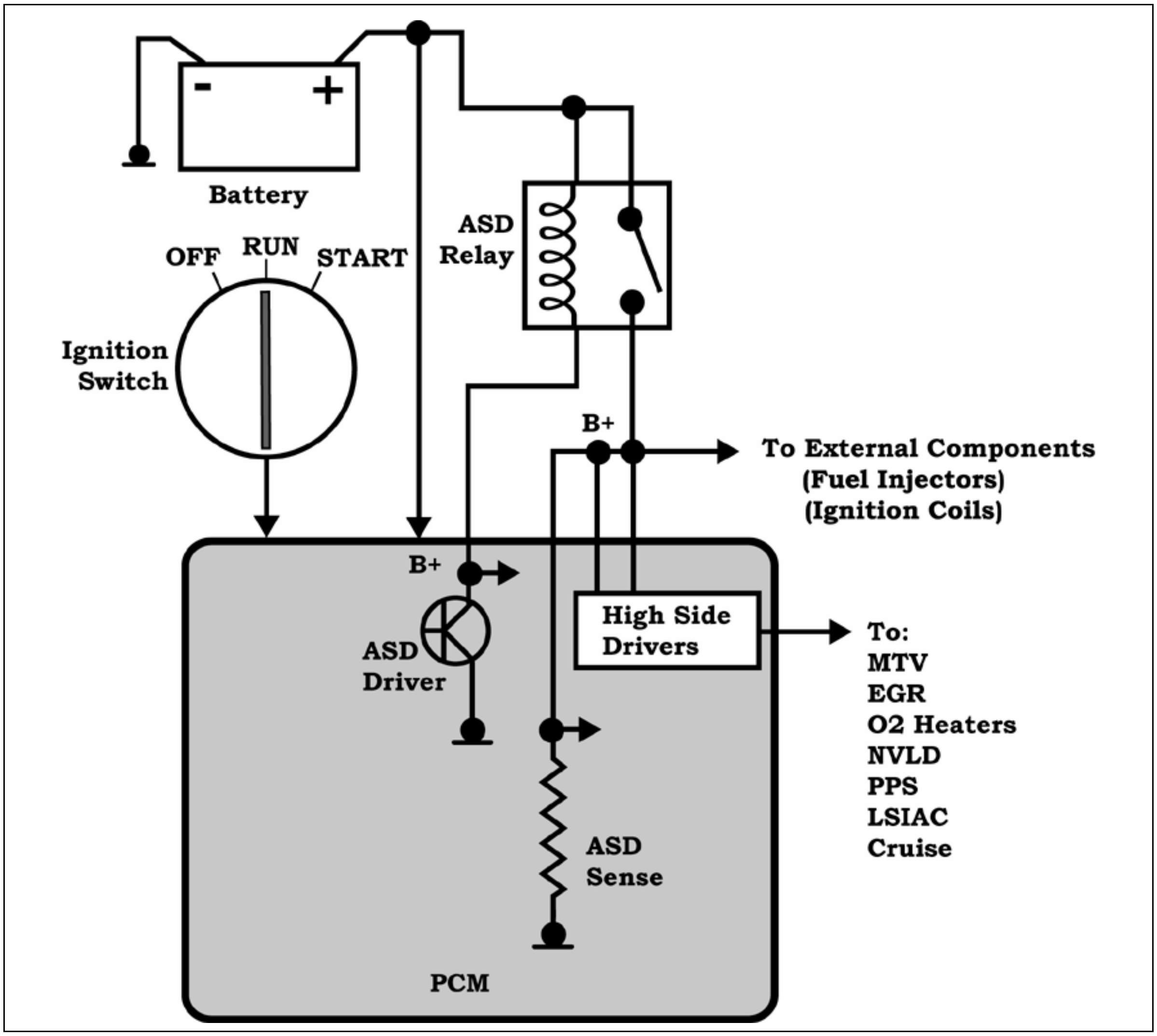


Figure 68 NGC ASD Relay

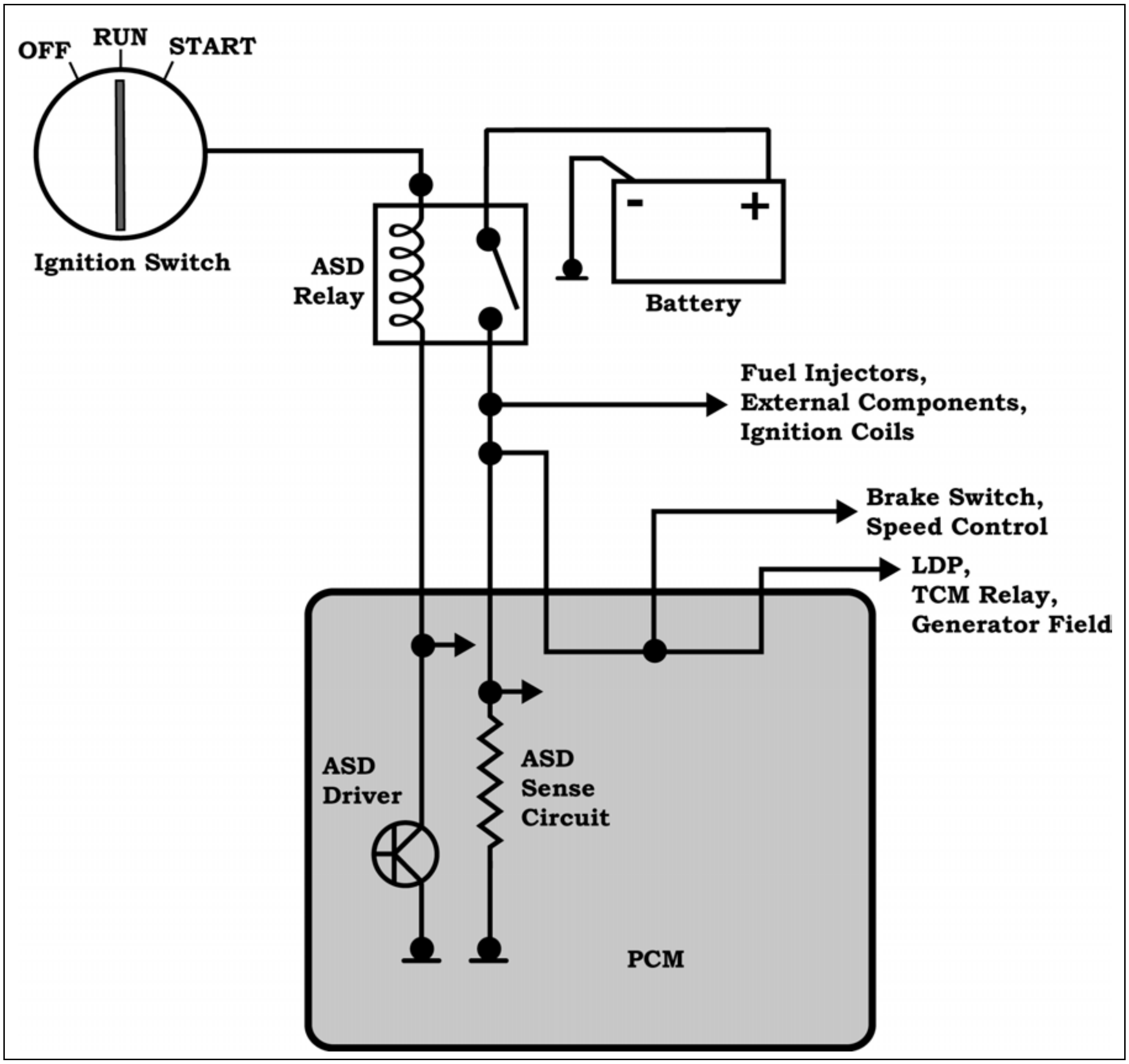


Figure 69 JTEC ASD Relay

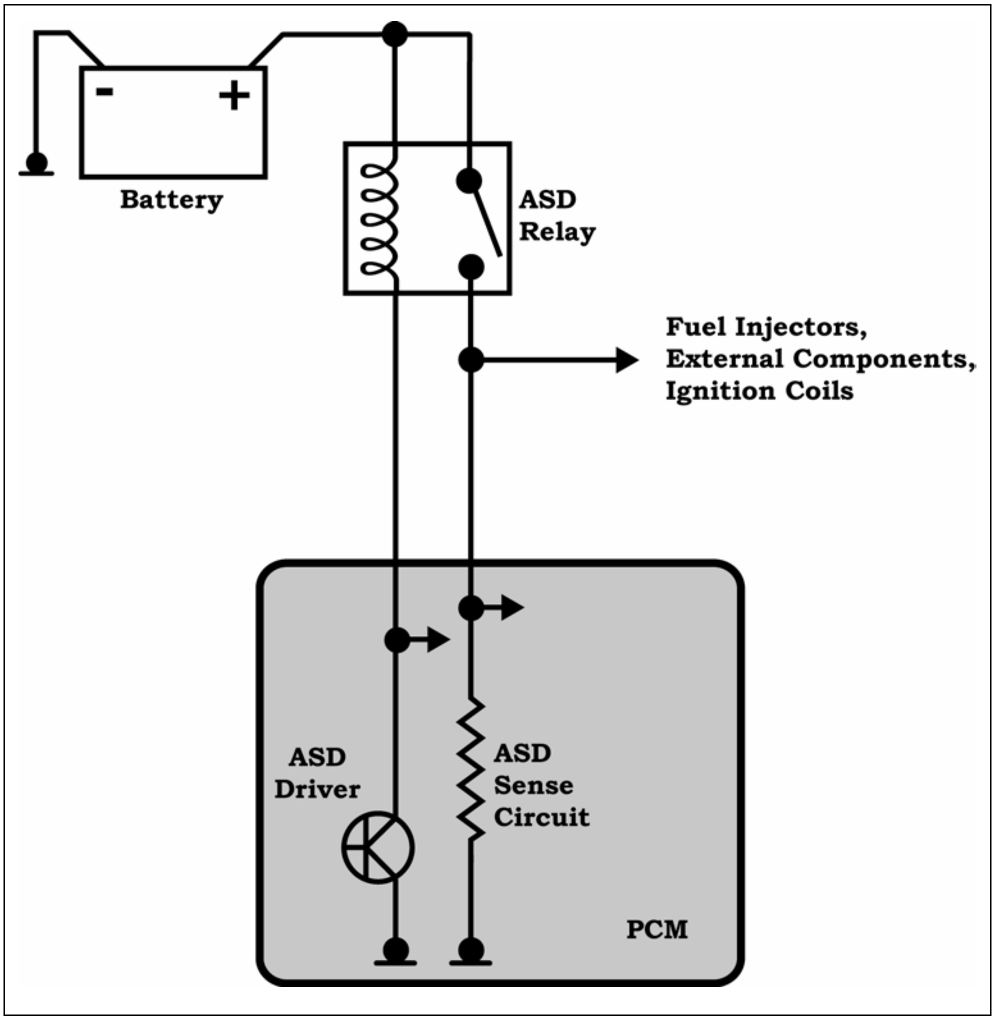
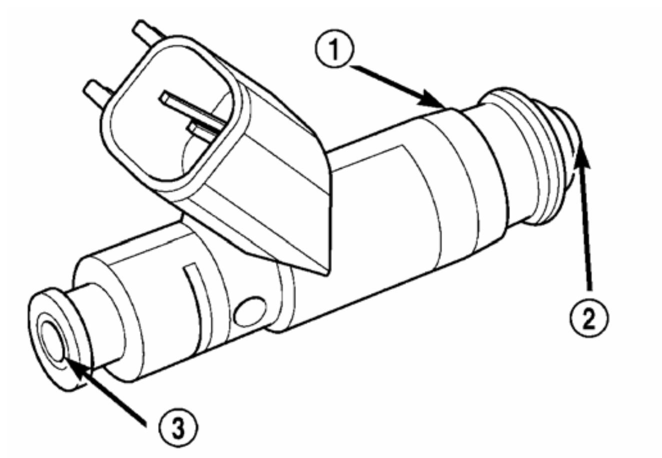


Figure 70 SBEC ASD Relay

FUEL INJECTOR CONTROL

NGC Fuel Injector Control

All NGC engines use 12 ohm, top feed injectors. The ASD relay supplies voltage to the injectors, and the PCM controls the injectors using a low side, pulse width modulated driver. All injector circuits are clamped to 62V to prevent damage from inductive kicks.



1	Fuel Injector
2	Discharge Nozzle
3	Fuel Inlet

Figure 71 Fuel Injector

Unique to NGC is a “Triple Shot” fuel injection strategy. This strategy gives the controller the ability to pulse the fuel injector up to three times per cycle. This can provide enrichment during tip-in. One or two pulses can be eliminated to reduce fuel delivery during tip-out. Advantages include reduced emissions and improved drivability.

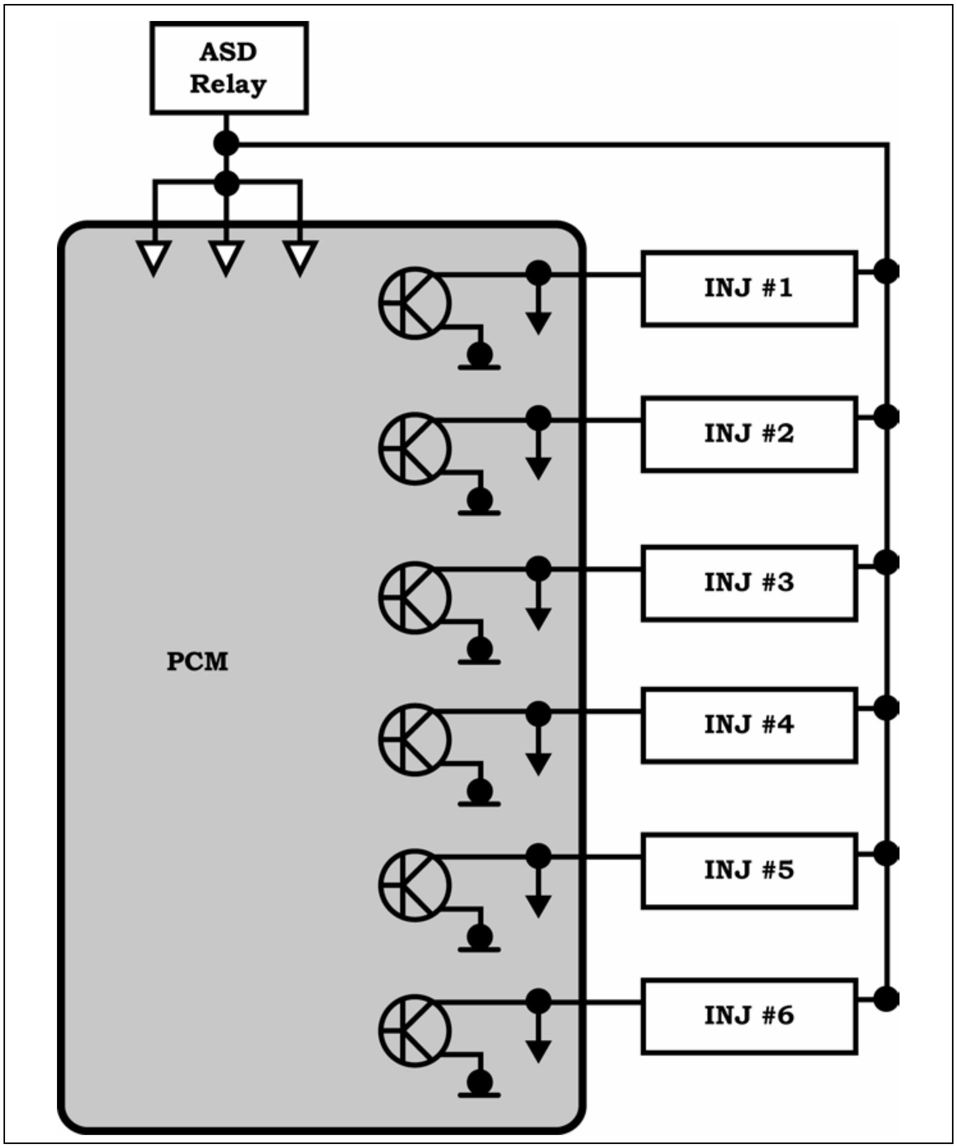


Figure 72 NGC Fuel Injector Control Circuit

JTEC/SBEC Fuel Injector Control

All JTEC Jeep/Dodge truck engines use top feed injectors. Viper V10 engines through 2002 models use bottom feed fuel injectors. All SBEC 4 cylinder and V6 engines use top feed injectors with the exception of the cast iron 3.5L engine, which uses bottom feed injectors. The ASD relay supplies voltage to the injectors, and the PCM controls the ground path.

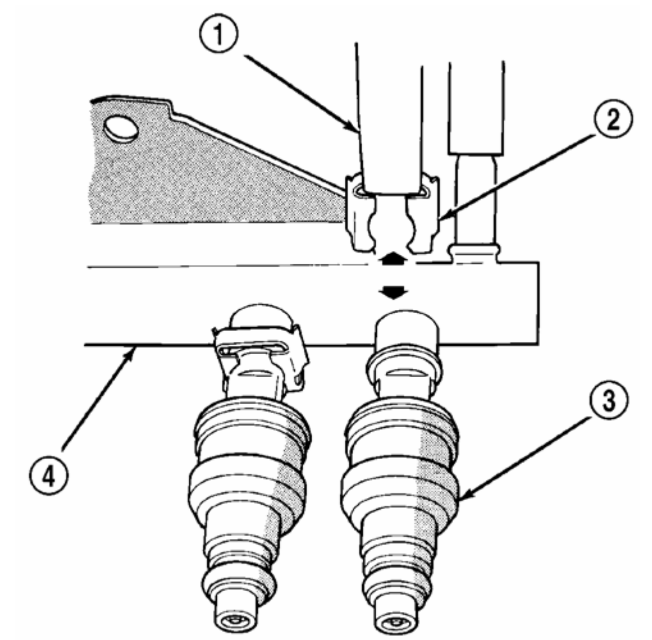
Caution: Care must be taken when removing bottom feed fuel injectors. Fuel from the fuel rail can leak into the combustion chamber, causing a "Hydrostatic Lock" condition.

Fuel Injector Diagnostics

The PCM monitors the continuity of the circuit as well as the voltage spike (inductive kick) created by the collapse of the magnetic field in the injector coil. The inductive kick is typically above 60V. Any condition that reduces the maximum current flow or the magnitude of the kick can set a DTC (Injector Peak Current Not Reached).

WARNING: FUEL SYSTEM PRESSURE MUST BE RELEASED BEFORE SERVICING CERTAIN FUEL SYSTEM COMPONENTS. ALWAYS FOLLOW PROCEDURES IN SERVICE INFORMATION. SERVICE VEHICLES AND FUEL SYSTEM COMPONENTS IN WELL VENTILATED AREAS. AVOID SPARKS, FLAMES, AND OTHER IGNITION SOURCES. NEVER SMOKE WHILE SERVICING THE VEHICLE'S FUEL SYSTEM.

WARNING: FUEL INJECTOR CLIPS ARE FOR ASSEMBLY PURPOSES. THE FUEL RAIL SHOULD NOT BE PRESSURIZED WHEN NOT PROPERLY INSTALLED ON THE ENGINE.



1	Pliers (tool)
2	Clip
3	Fuel Injector - Typical
4	Fuel Rail - Typical

Figure 73 Fuel Injector Clips

IGNITION SYSTEMS

Ignition System Operation

The ignition system creates the high voltage spark that ignites the air/fuel mixture in the engine cylinder to begin the power stroke. To accomplish this, the ignition system does three jobs:

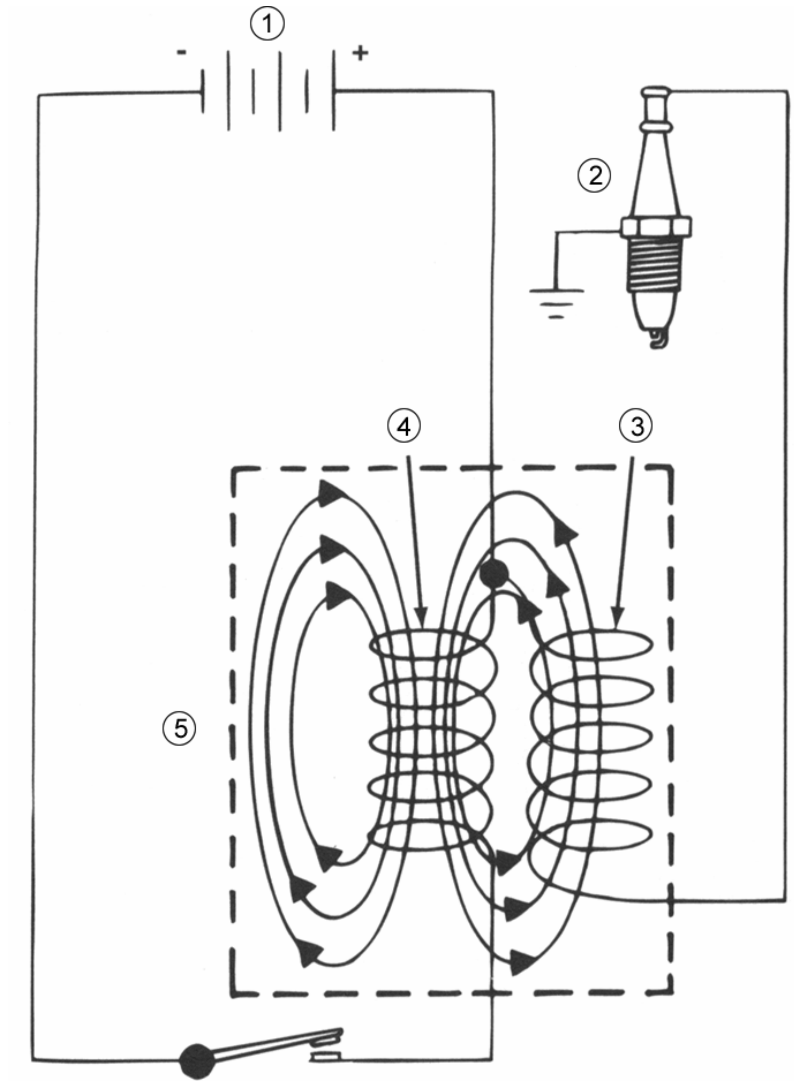
- Generates a high voltage pulse
- Decides which spark plug and cylinder will receive the high voltage
- Decides when in the cycle the high voltage is sent to the spark plug

In the past, these jobs were performed by electromechanical components. Today, these tasks are managed electronically by the PCM, sensors and actuators.

The ignition coil generates the high voltage needed to create a spark across the spark plug electrodes. The coil contains two windings, the Primary and the Secondary. The primary winding typically has about 200 turns of copper wire, and the secondary typically has about 100 times as many turns or about 20000 turns. The ratio of the number of turns of wire is the Turns Ratio.

Voltage is induced in the coil by a process called Magnetic Induction. When a current flows through a wire, a magnetic field exists around that wire. Conversely, if a wire is moved through a magnetic field, a voltage will be induced in the wire. You can move either the wire or the magnetic field. As long as there is relative motion between the two, a voltage will be induced in the wire.

When current flows through the primary coil windings, a magnetic field builds in the coil. When the primary current is quickly interrupted, this magnetic field collapses rapidly. The magnetic lines of force pass through the primary and secondary coil windings, inducing several hundred volts in the primary and thousands of volts in the secondary. This secondary voltage is sent to fire the correct spark plug.



1	Battery	4	Primary Winding
2	Spark Plug	5	Ignition Coil
3	Secondary Winding		

Figure 74 Basic Ignition System

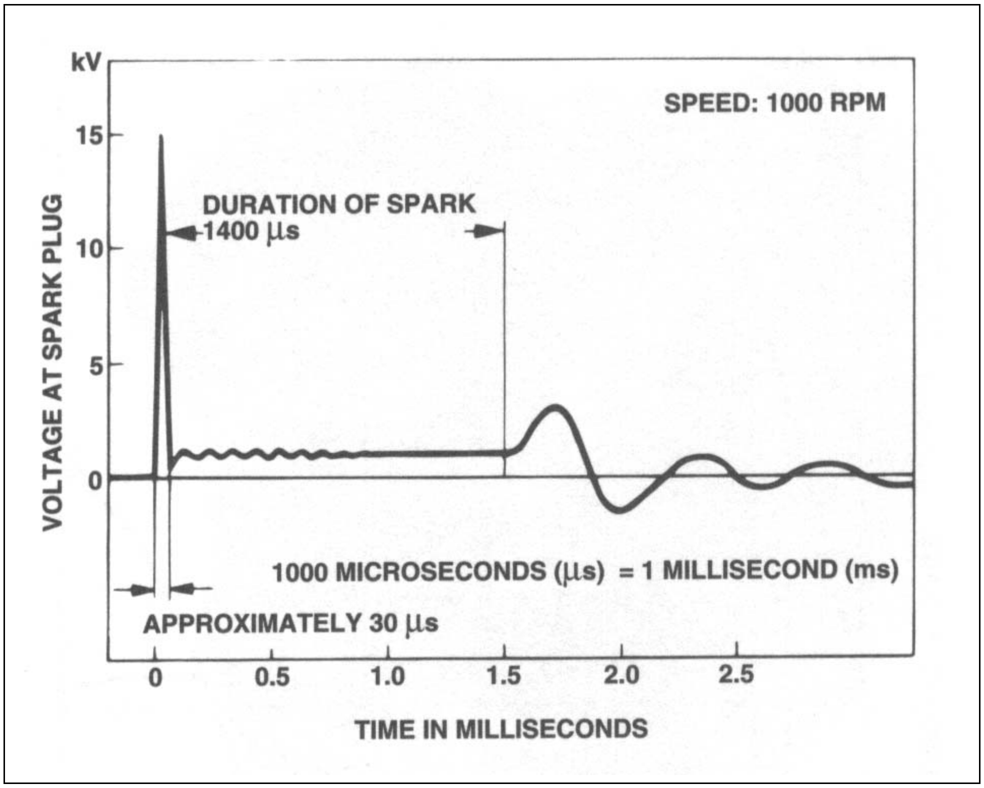


Figure 75 Secondary Ignition Voltages

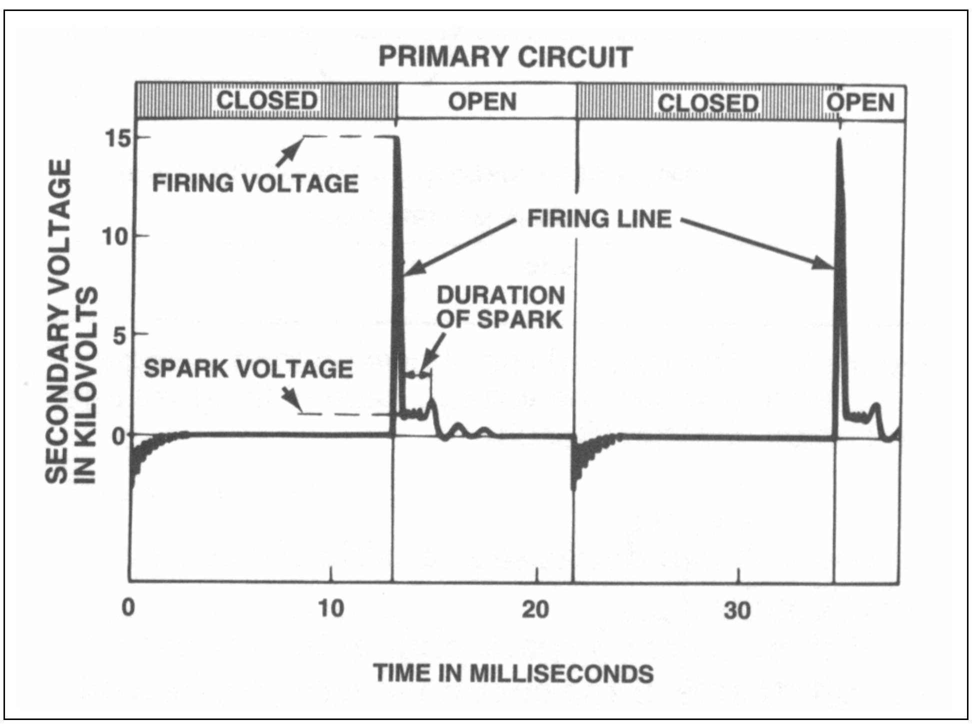
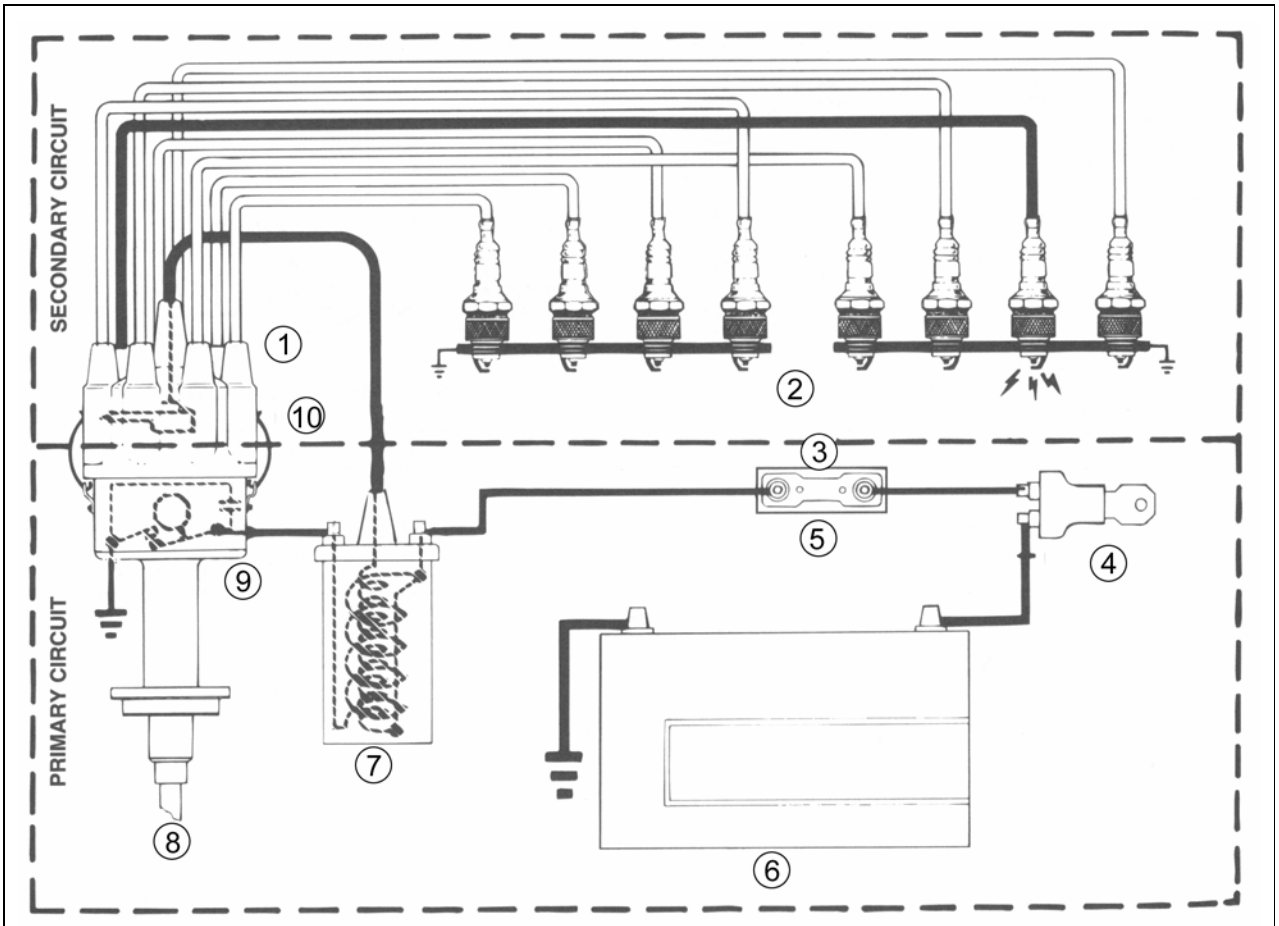


Figure 76 Primary and Secondary Circuits

In older vehicles with distributor-type ignition, one coil is used to generate a high voltage for every cylinder in the engine. The rotor inside the distributor cap is a rotating selector switch that sends the high voltage to the correct cylinder.



1	Cap	6	Battery
2	Spark Plugs	7	Coil
3	Primary Resistor	8	Distributor
4	Ignition Switch	9	Switching Device
5	Resistor Wire or Ballast Resistor	10	Rotor

Figure 77 Distributor Type Ignition System

The correct firing sequence is the same as the engine firing order. For example, the firing order for the 2.4L four-cylinder engine is 1-3-4-2, and the firing order for the 3.3L six-cylinder engine is 1-2-3-4-5-6.

NGC Ignition Systems

Some NGC-equipped vehicles utilize Coil-On-Plug (COP) direct ignition systems. Other engines continue to use Distributorless (DIS) Waste Spark ignition systems. Spark timing and cylinder selection are controlled by the PCM.

With COP ignition, each spark plug fires once every two revolutions of the crankshaft. Engines with DIS Waste Spark ignition fire each spark plug every revolution of the crankshaft. The 5.7L engine has a Waste Spark system with two spark plugs per cylinder.

Each individual ignition coil is supplied voltage by the Automatic Shutdown (ASD) Relay. Each coil is controlled by a low side pulse width modulated driver. A capacitor may be wired in parallel with the circuit to prevent RFI.

NGC PCMs in passenger cars are capable of varying dwell and current to meet the engine's changing requirements. Cold engines, lean fuel mixtures, EGR flow and engine idle conditions require a hotter spark to maintain combustion stability and achieve smooth idle. Under high speeds and heavy engine loads, the engine has more inertia and is more stable, so the hotter spark is no longer required. Current flow is limited to 7-11 amps in low current mode, and 11-15.8 amps in high current mode. NGC PCMs in Jeep and truck models typically do not utilize variable dwell.

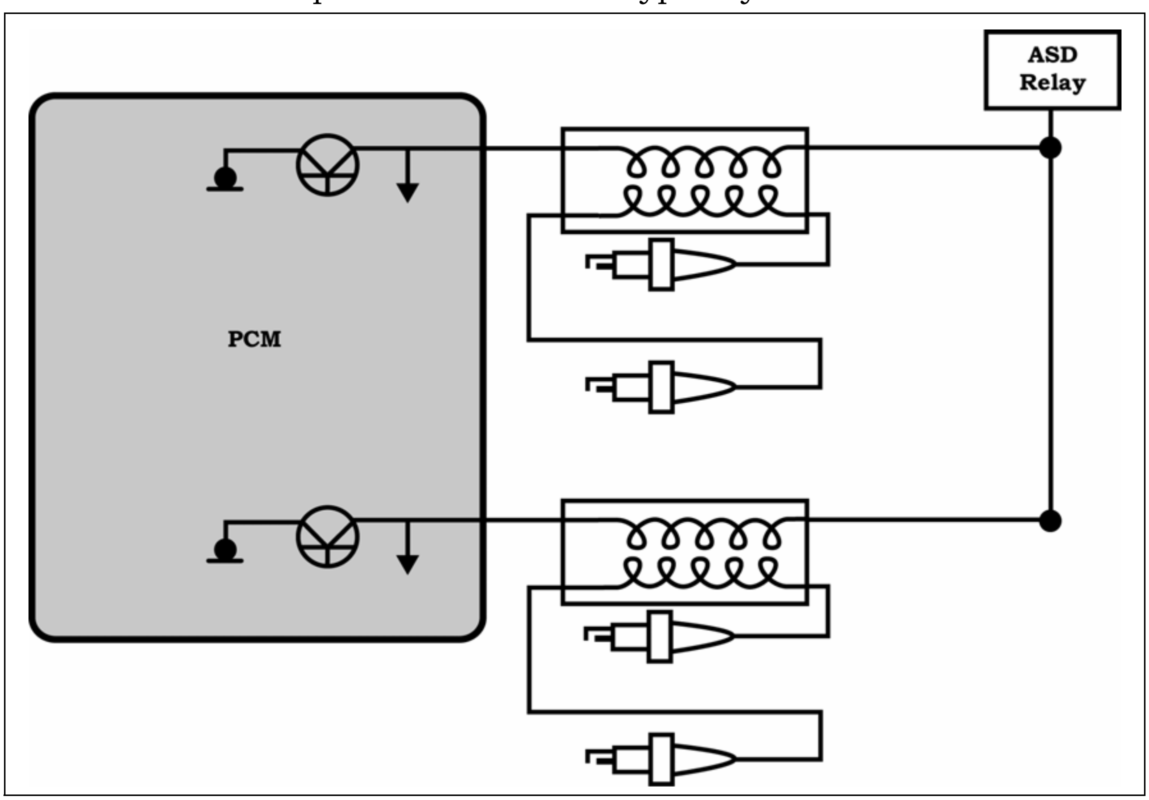


Figure 78 DIS (Waste Spark) Ignition Coil Circuit

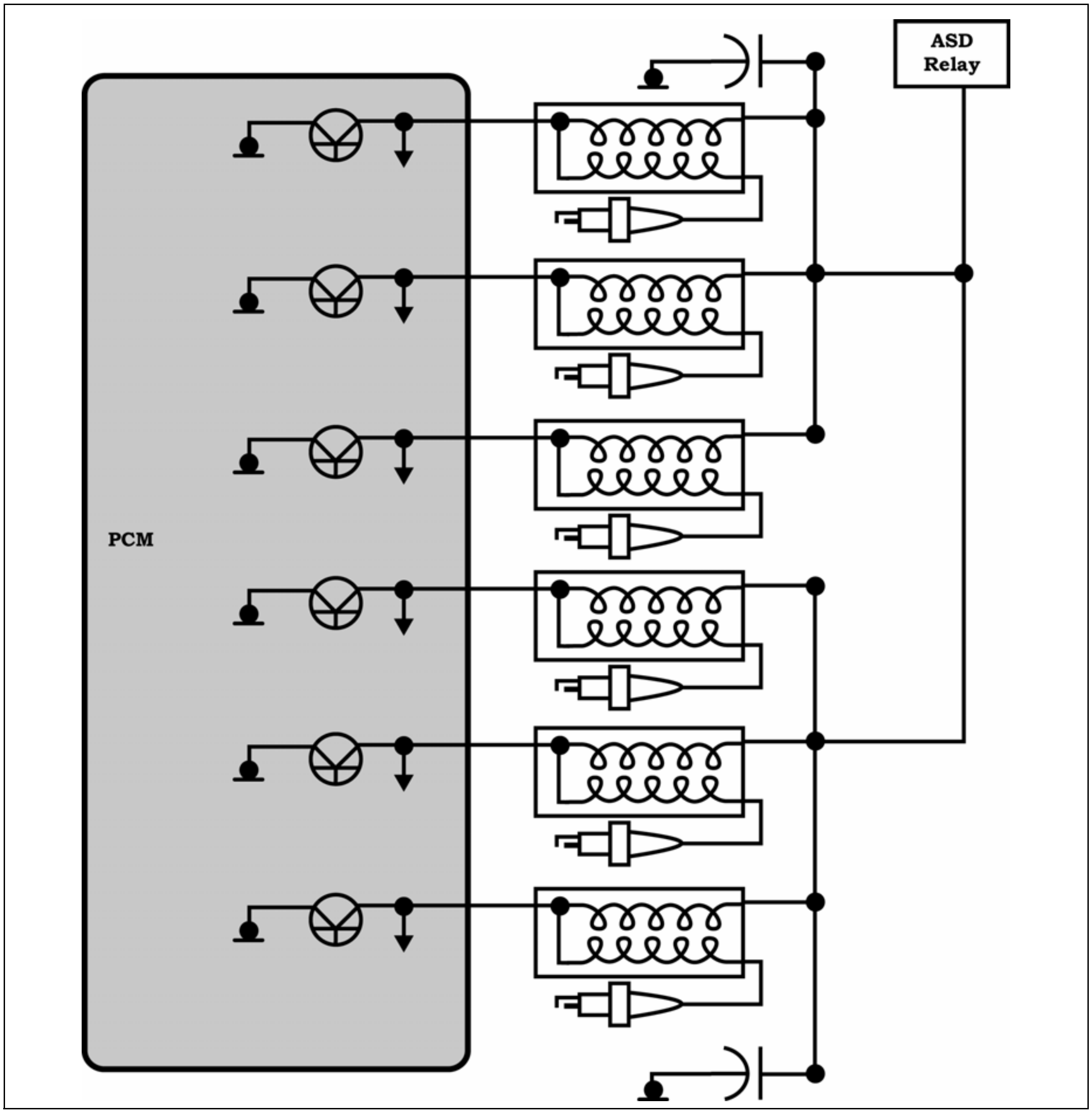
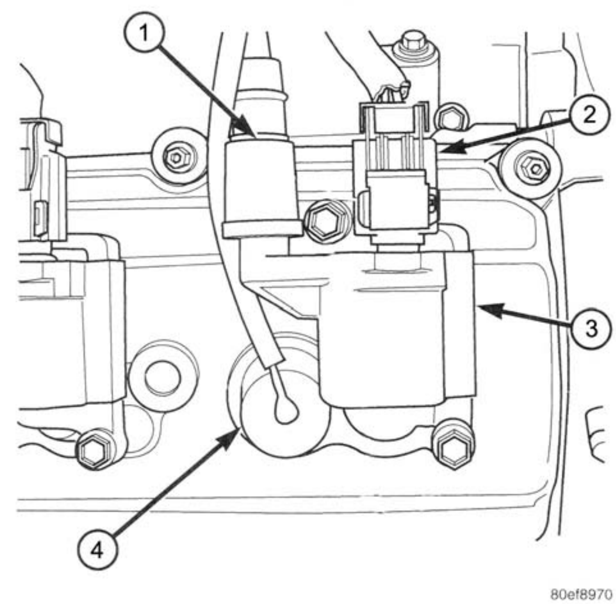


Figure 79 COP Ignition Coil Circuit

NGC 5.7L Engine

The 5.7L engine use a Waste Spark ignition system and two spark plugs per cylinder. Each coil is connected to two spark plugs, one directly under the coil and one in the companion cylinder. In this engine, every coil and every spark plug fires with every revolution of the crankshaft. When a coil is firing its COP fired spark plug on the compression stroke to begin the power stroke event, at the same time it fires the remote fired spark plug in the companion cylinder on the exhaust stroke for the Waste Spark event. During the next revolution of the crankshaft, the same coil fires again, but this time it fires its remote fired spark plug on the compression stroke and the COP fired spark plug on the exhaust stroke. Both spark plugs in a cylinder fire at the same time, but they are fired by different coils.



1	Spark Plug Cable (to remote fired spark plug in companion cylinder)
2	Electrical Connector
3	Ignition Coil
4	Spark Plug Cable (from ignition coil in companion cylinder)

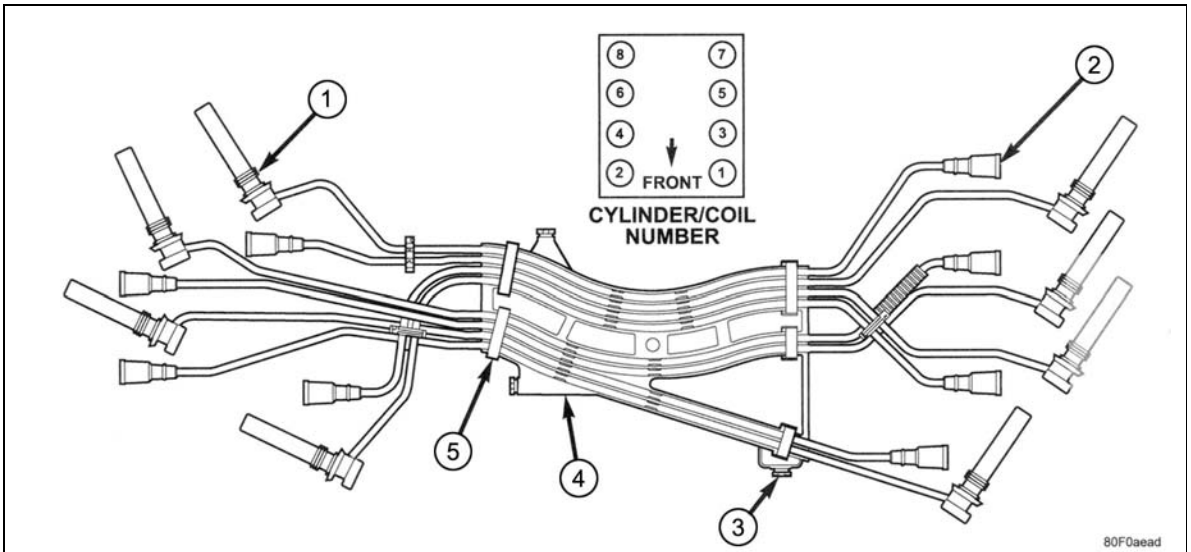
Figure 80 5.7L Ignition Coil Installation

A plastic cable tray holds the secondary cables in position to prevent crossfire. Before removing any spark plug cables, note their original position. Remove cables one at a time.

Both the secondary cables and the cable tray are marked with cylinder numbers to help routing. The cables and the cable tray are replaced as an assembly. At this time, the cables are not available separately.

Before installing spark plug cables, apply dielectric grease to the inside of the terminal boots.

Caution: The cables MUST be properly positioned in the tray to prevent crossfire. Cable retention clips must also be securely locked.



1	Secondary Cable Spark Plug Connector (typical)
2	Secondary Cable Coil Connector (typical)
3	Clips (tray–to–manifold retention)
4	Cable Tray
5	Clips (Spark Plug Cable–to–tray retention)

Figure 81 5.7L Spark Plug Cable Routing and Cable Tray

JTEC/SBEC Ignition Systems

JTEC vehicles may have distributor or distributorless type ignition systems. Battery voltage is supplied to the ignition coil(s) through the ASD Relay and the ground path is controlled by the PCM. Rear wheel drive vehicles have one of the following:

1. Single coil with distributor – 2.5L/4.0L/3.9L/5.2L/5.9L
2. DIS Waste Spark – 2.0L/2.4L/3.3L/3.8L/8.0L
3. DIS with Coil Rail – 4.0L (starting with 1999 WJ, 2000 TJ)
4. DIS with Coil On Plug (COP) – 2.7L/3.2L/3.5L/3.7L/4.7L

Ignition System Diagnostics

In vehicles with DIS Waste Spark ignition, an open ignition secondary circuit may affect one or both spark plugs in the circuit depending upon engine load. Under light load, only one spark plug may misfire, and the capacitive effect of the open circuit may fire the second plug. Under heavy load, both spark plugs may misfire.

On NGC passenger car and minivan applications, the PCM may monitor spark plug ionization (burn time) and may set a DTC if an out-of-range condition is detected. If the spark duration (primary circuit firing line) is above or below specifications, a fault will be stored. This is accomplished by monitoring the coil's primary circuit current flow.

WARNING: DURING DIAGNOSIS AND TESTING, IT IS IMPORTANT TO USE A SPARK TESTER WHEN TESTING FOR SPARK OR CYLINDER MISFIRE. DO NOT ALLOW COILS TO FIRE OPEN CIRCUIT. PCM DRIVER FAILURE WILL RESULT!

LINEAR SOLENOID IDLE AIR CONTROL VALVE (LSIAC)

The Linear Solenoid Idle Air Control (LSIAC) Valve is a two-wire air bypass solenoid controlled by the PCM. It was first used on the 2001 RS and PL. The PCM uses a high-side driver to regulate current flow to the LSIAC with a duty cycle of 10 - 90% at 1.5 - 2.5 kHz.

The biggest advantage to the LSIAC valve is quick response: 20 ms from closed to full open, versus 200 ms on the old style IAC motor. This results in more accurate idle air control and less tendency for idle undershoot.

The PCM also provides a path to ground. Current flow on this ground circuit is monitored to determine the position of the LSIAC. The PCM compares the target current flow against the actual current flow to determine LSIAC position, rather than counting "steps" as in the old style IAC motor.

Table 8 Typical LSIAC Values

LSIAC Condition	**LSIAC Current (ma)**
Fully Closed	180-200
Engine Idle	300-450
Engine at Light Cruise	500-700
Fully Open	900-950

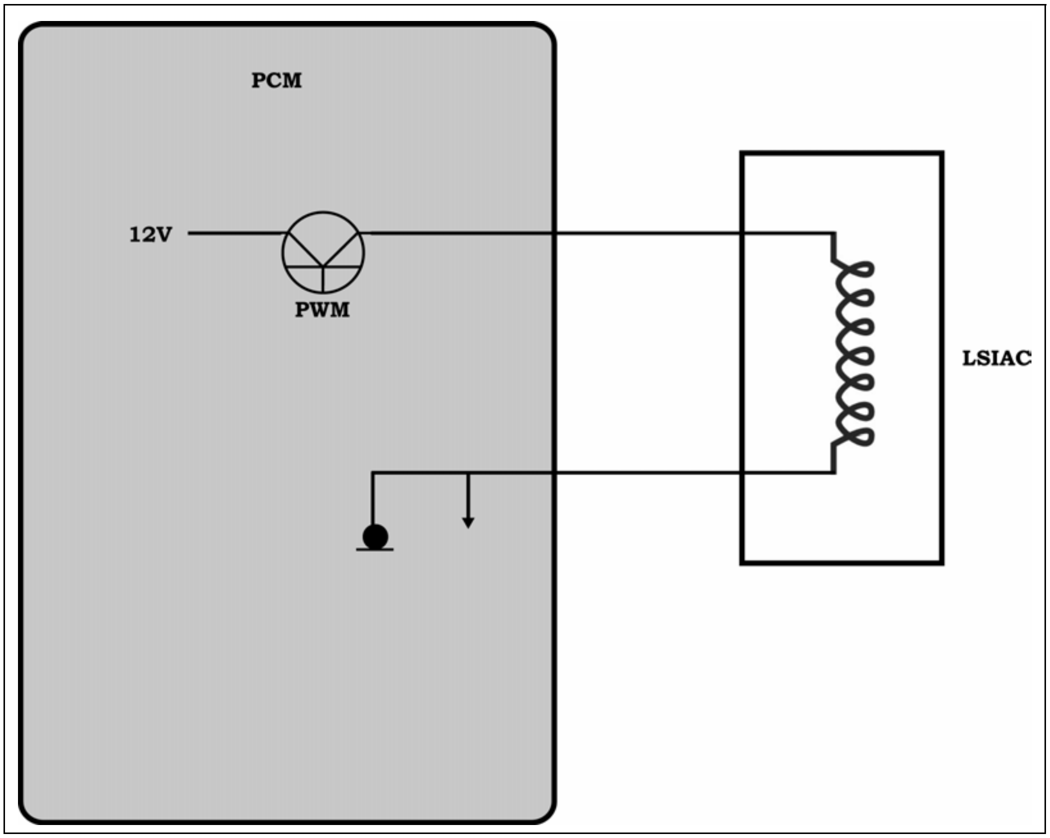


Figure 82 Linear Solenoid Idle Air Control Valve

IDLE AIR CONTROL (IAC) STEPPER MOTOR (JTEC AND SBEC)

The PCM controls circuit polarity to control direction of the IAC stepper motor and maintain target engine idle speed. The IAC motor is capable of 255 total steps from fully closed to fully open. The IAC regulates the amount of air bypassing the throttle blade. A pintle on the IAC stepper motor moves into a passage in the throttle body, controlling the air flow through the passage.

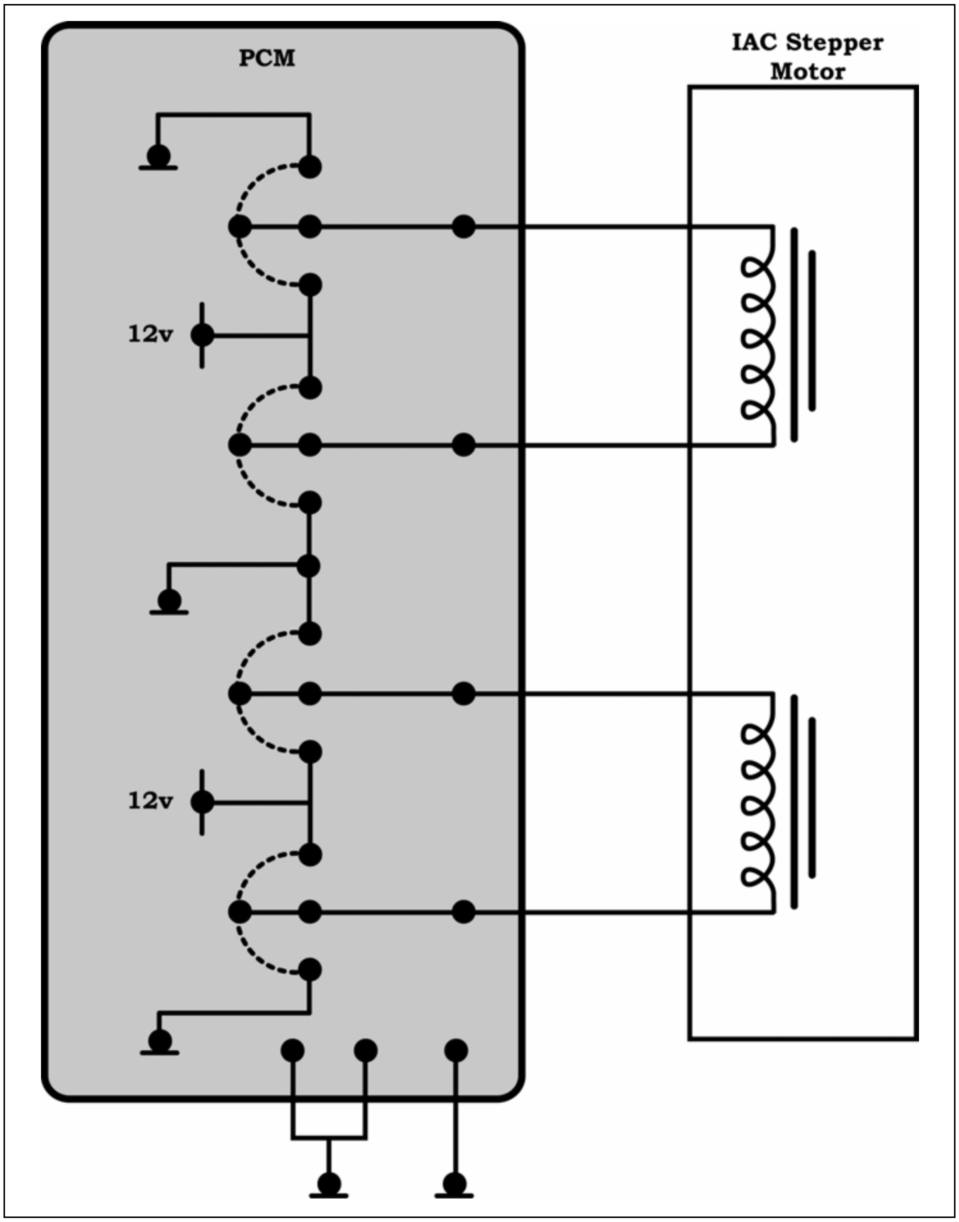


Figure 83 IAC Stepper Motor

IAC Stepper Motor Diagnostics

Typically, a DTC is set when the PCM senses a short to ground or battery voltage on any of the four driver circuits for at least 2.75 sec when the stepper motor is active. With JTEC, open circuits are diagnosed if they are present at key–ON. If the driver circuit opens while the engine is running, it will not be diagnosed until the next key–ON cycle.

Any time the IAC stepper motor or its circuit is serviced, the IAC memory must be updated. Use the DRB III to "Reset IAC". This ensures that the PCM can identify step 0. Also make sure that when the IAC Stepper Motor is installed into the throttle body that the passage is clear of debris and that the pintle is in the retracted position. This will ensure that the pintle and seat are not damaged when the IAC motor is installed.

LSIAC AND IAC AIR FLOW MANAGEMENT

Target Idle speed is mainly determined by the following inputs:

- TPS
- ECT sensor
- Gear position (P/N Switch)

Other factors affecting Target Idle speed may include:

- Battery voltage
- Ambient/Battery temperature sensor
- VSS
- MAP sensor

When engine rpm is above idle speed, the LSIAC and IAC are used for the following functions:

- Off–idle dashpot
- Deceleration air flow control

Under all engine operating conditions, the PCM will compensate for A/C compressor load by opening the passage slightly before the compressor is engaged so that engine rpm does not dip down when the compressor engages.

MINIMUM IDLE AIR FLOW

Minimum air flow is the volume of air flowing past the throttle plate at idle, plus any other components that might allow air to flow into the intake manifold at idle, such as the PCV valve. Minimum air flow specifications aid in engine diagnostics. Worn or out of adjustment components, exhaust restrictions and other items can have an effect on minimum air flow. All fuel, ignition, emission and engine mechanical components must be checked “good” before a minimum air flow check can be done. When performing the minimum air flow check, all other components that load the engine must be OFF or not operating during the airflow check. Consult Service Information for vehicle-specific procedures.

PROPORTIONAL PURGE SOLENOID (PPS)

On all NGC and some SBEC vehicles, the Proportional Purge Solenoid (PPS) controls the purge rate of HC vapors from the vapor canister and fuel tank to the intake manifold. The PCM uses a high-side driver to control the PPS. The PCM regulates the current flow with a duty-cycle of 0-60% at 200 Hz. This 200 Hz frequency is twice that of the previous Duty Cycle Purge Solenoid.

The PCM also provides a ground path for the circuit. Current flow on this ground circuit is monitored to determine the position of the PPS. The PCM compares the target current flow against the actual current flow to determine PPS position.

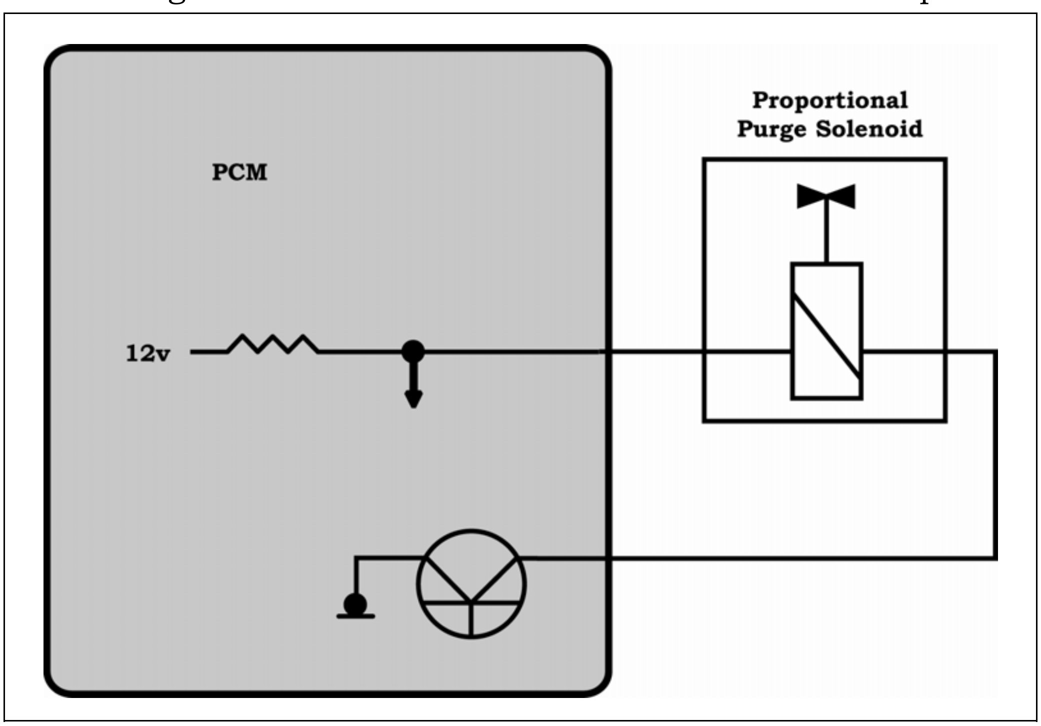


Figure 84 Proportional Purge Solenoid

Proportional Purge Solenoid Diagnostics

A DTC is set when the PCM determines that the actual state of the solenoid does not match the intended state. The PCM monitors the EVAP System and the following DTCs may set if a fault is detected:

- P0441 EVAP PURGE SYSTEM PERFORMANCE – This fault is set when the PCM does not see the NVLD switch state change as expected or the PCM does not see a Short Term Adaptive shift as expected.
- P0443 EVAP PURGE SOLENOID CIRCUIT - This fault is set when the commanded state of the solenoid does not agree with the monitored state of the solenoid.

DUTY CYCLE PURGE (DCP) SOLENOID

The Duty Cycle Purge (DCP) Solenoid on all JTEC and most SBEC vehicles controls the flow of fuel vapor from the charcoal canister to the intake manifold. A switched ignition feed powers the solenoid. The PCM controls the solenoid by means of a duty-cycle on the ground side.

Typically the system is disabled during WOT and while the engine is below a specified coolant temperature. When engine temperature exceeds a calibrated parameter, duty cycle purge is delayed for a calibrated time. Once purge delay is over, purge will be ramped-in to reduce the effect of adding extra fuel into the engine.

The PCM duty-cycle operates at 5 Hz (with closed throttle) or 10 Hz (with open throttle) to control this system. The duty-cycle is based upon a calculated air flow (based on TPS and RPM) and is adjusted to compensate for changes in flow due to varying engine load conditions.

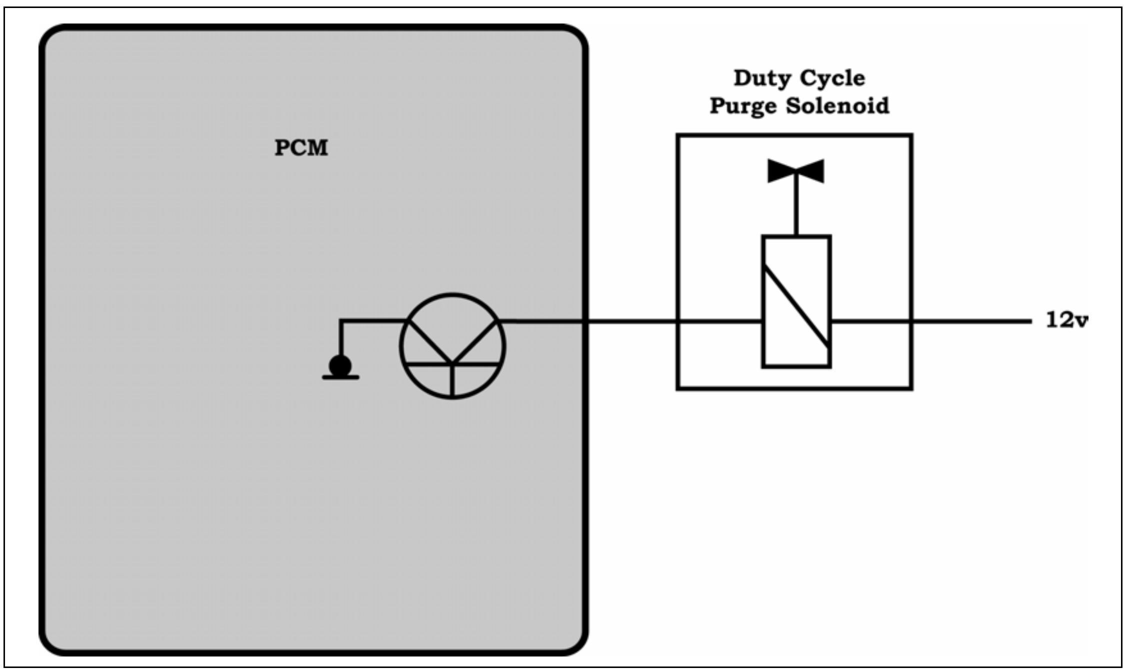


Figure 85 Duty Cycle Purge Solenoid

Duty Cycle Purge Solenoid Diagnostics

A DTC is set when the PCM determines that the actual state of the solenoid does not match the intended state. The PCM monitors the EVAP System and a DTC is set under the following conditions:

- EVAP Purge Flow Monitor Failure – No flow through the EVAP system detected
- EVAP Purge Solenoid Circuit (Open or Shorted)

LINEAR EGR VALVE

The Linear EGR Valve was first used on 1998 LH models. The Linear EGR Valve controls the metering of exhaust gases into the intake manifold. The PCM uses a high-side driver to control the Linear EGR Valve solenoid. The PCM controls the valve position by varying the duty-cycle supplied to the solenoid. The circuit is grounded externally.

The linear EGR valve assembly also contains a three-wire potentiometer that provides feedback to the PCM on valve position.

Vacuum-operated EGR valves as used on JTEC and SBEC vehicles will be covered in the self-study portion of this course.

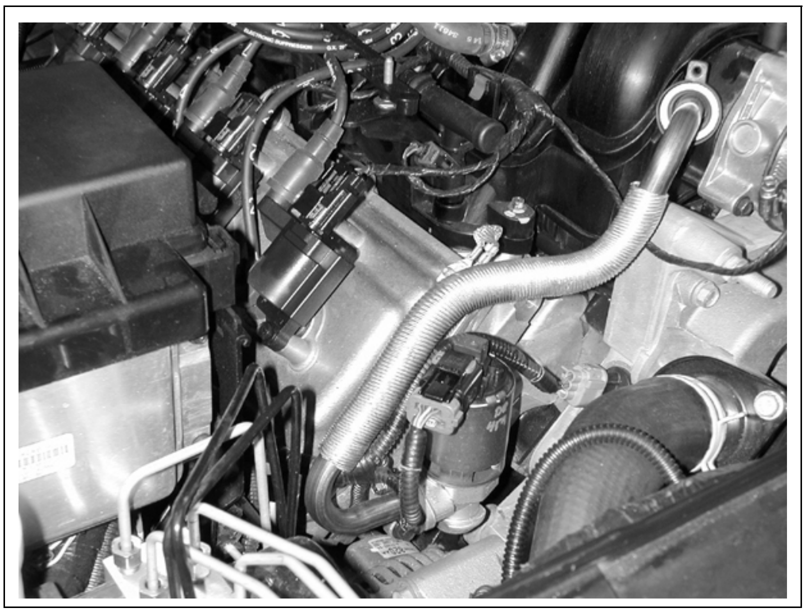


Figure 86 Linear EGR Valve

SHORT RUNNER TUNING VALVE (SRTV)

The Short Runner Tuning Valve (SRTV) is used on vehicles equipped with an active intake manifold. It optimizes the intake runner length to increase horsepower at high RPM. It accomplishes this by opening passageways that shorten the path between the air inlet and cylinders. The SRTV is supplied power by the ASD Relay and is controlled by the PCM via a latching, low-side driver. This circuit is either full ON or full OFF. The SRTV is actuated by an electric motor on NGC vehicles and by a solenoid-controlled vacuum diaphragm on SBEC vehicles.

MANIFOLD TUNING VALVE (MTV)

Like the SRTV, the Manifold Tuning Valve (MTV) is used on vehicles equipped with an active intake manifold. Its purpose is to vary the intake manifold runner configuration to optimize torque over a wider RPM range. It is a two-state device that electrically opens and closes a passageway that connects two separate plenums within the intake manifold. A high-side driver controls the circuit, and there is an external ground.

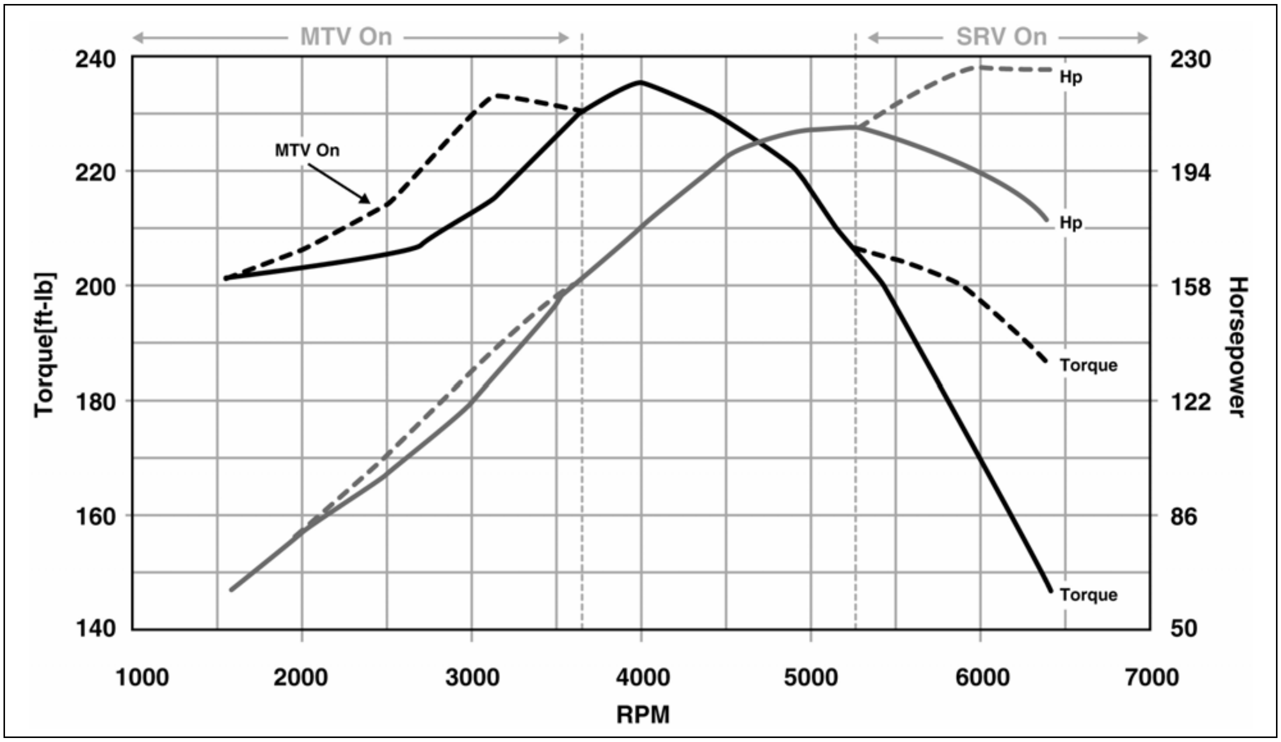


Figure 87 MTV and SRTV Benefits

NGC NATURAL VACUUM LEAK DETECTION SOLENOID (NVLD)

The Natural Vacuum Leak Detection (NVLD) system used on NGC vehicles replaces the EVAP Leak Detection Pump used on JTEC and SBEC vehicles. The NVLD assembly contains a solenoid, a switch and a pressure operated diaphragm.

The NVLD solenoid is controlled by a PCM high-side driver, and is grounded externally. The solenoid actuates a normally-closed valve to open the EVAP system vent while the engine is running to allow fresh air to enter the system during purge. The solenoid will be de-energized to close the vent during the medium and large leak tests. A switch in the NVLD assembly has normally-open contacts which will close when a vacuum equal to or greater than 1 in. H_2O is present.

The NVLD assembly has three wires: switch sense, solenoid driver and a shared ground.

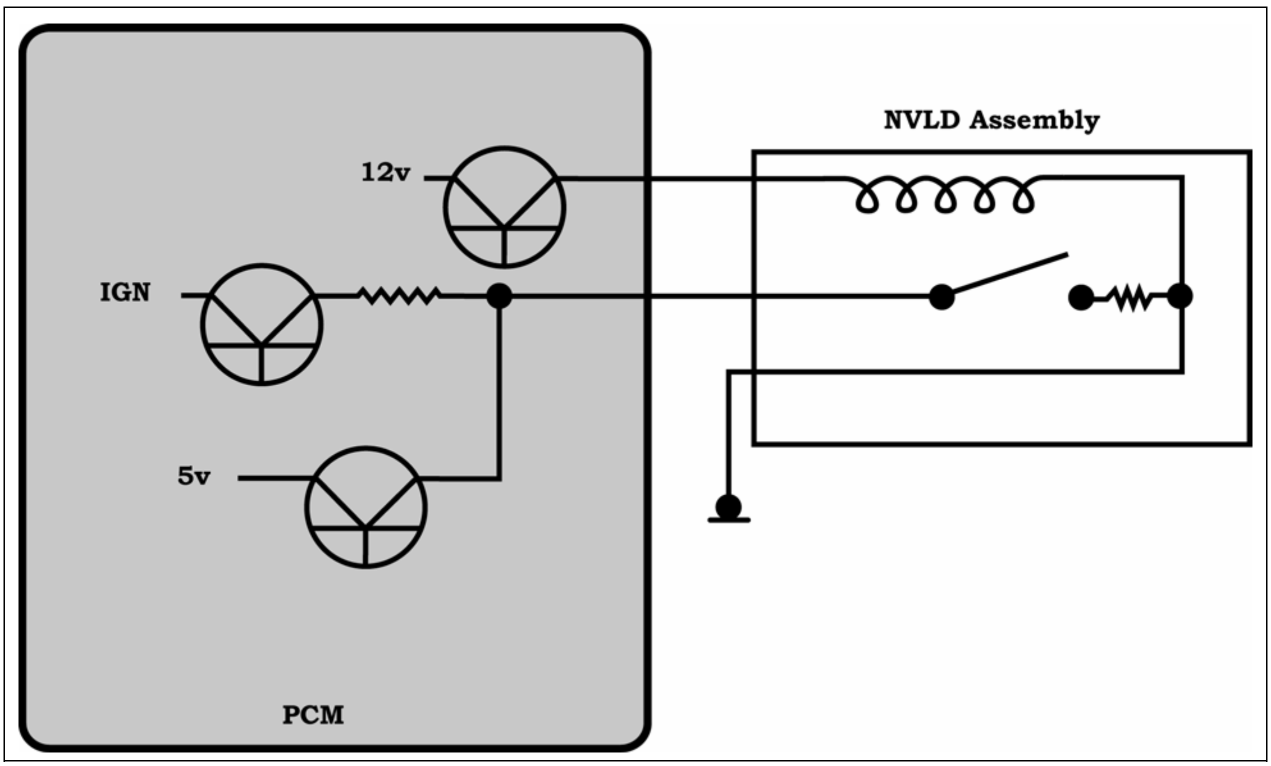


Figure 88 NVLD Assembly

JTEC/SBEC LEAK DETECTION PUMP (LDP)

On JTEC and SBEC vehicles, the Leak Detection Pump pressurizes the EVAP system to detect leaks. It was first used in 1996 on vehicles with California emissions, and on all Federal packages starting in the 2001 model year.

The Leak Detection Pump contains a vacuum solenoid, a diaphragm, an atmospheric vent control valve, two check valves, and a reed switch. The solenoid is cycled ON and OFF during EVAP system leak testing. This allows engine vacuum to be applied to the Leak Detection Pump diaphragm to pressurize the EVAP system. The reed switch state is used to monitor the position of the diaphragm. This testing is typically done if the ambient temperature is between 40 - 90°F (4 - 32°C), engine coolant temperature is within 10°F (5.56°C) of intake air temperature and fuel level is 15 - 85%.

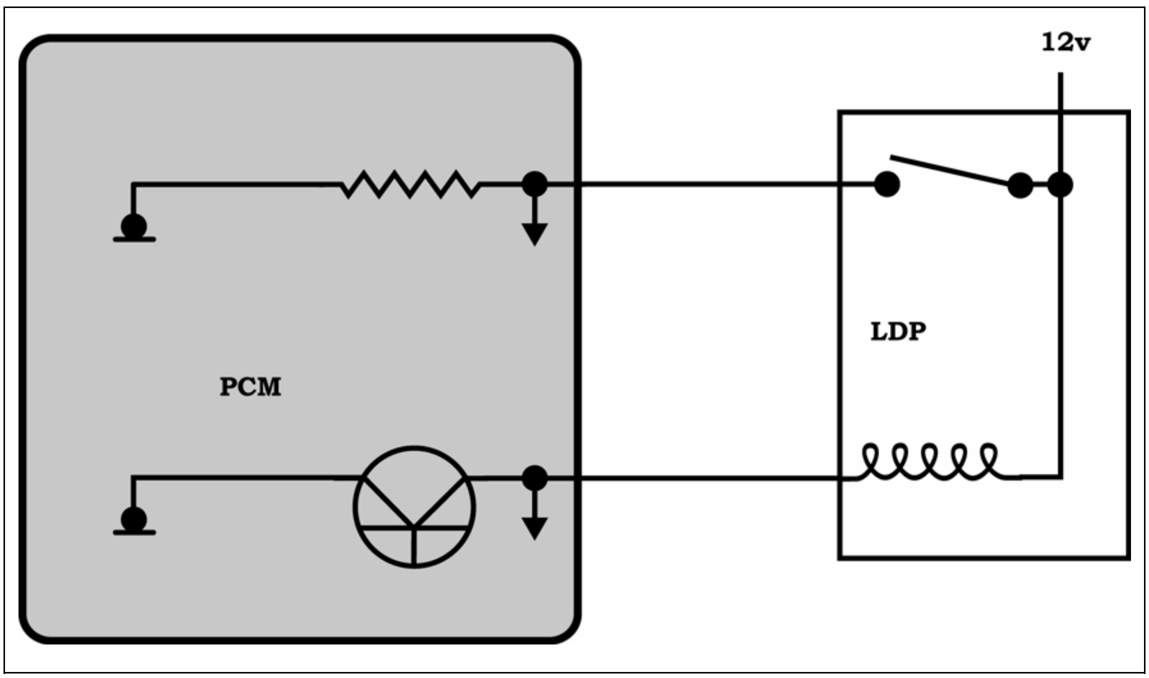


Figure 89 Leak Detection Pump

MALFUNCTION INDICATOR LAMP (MIL)

The MIL is controlled by the PCM. It illuminates for a 3-second bulb test each time the ignition is turned to ON and remains continuously illuminated when an emissions component fails, or when the vehicle enters limp-in mode. The MIL flashes if the onboard diagnostic system detects engine misfire severe enough to damage the catalytic converter.

Beginning with 2001 SBEC, 2002 JTEC and all NGC models, after the PCM performs a bulb check at Key-On, the lamp stays illuminated until the vehicle is started. In addition, with Key-On-Engine-Off for approximately ten seconds, the MIL lamp flashes ON and OFF if the CARB Readiness Indicator does not indicate that all “Once per Trip” monitors have been successfully completed. This has been integrated into the software to address the IM240 states that require all "Once per Trip” monitors be completed prior to an IM test.

Notes:

MODULE 9 ELECTRONIC THROTTLE CONTROL SYSTEM

The Electronic Throttle Control (ETC) system was first used on 2003 DR trucks with NGC II controllers and the 5.7L HEMI engine. With ETC, the throttle plate is moved by an electric motor under PCM control and is no longer mechanically connected to the accelerator pedal. Accelerator pedal position is one of several inputs that determine throttle position.

The PCM receives inputs from sensors, calculates the desired torque request and outputs control signals to the throttle motor, ignition and fuel injectors. In this system, the PCM manages intake airflow, ignition timing and fuel quantity control. ETC also handles speed control function and engine idle speed. No separate speed control unit or processor or IAC motor are necessary.

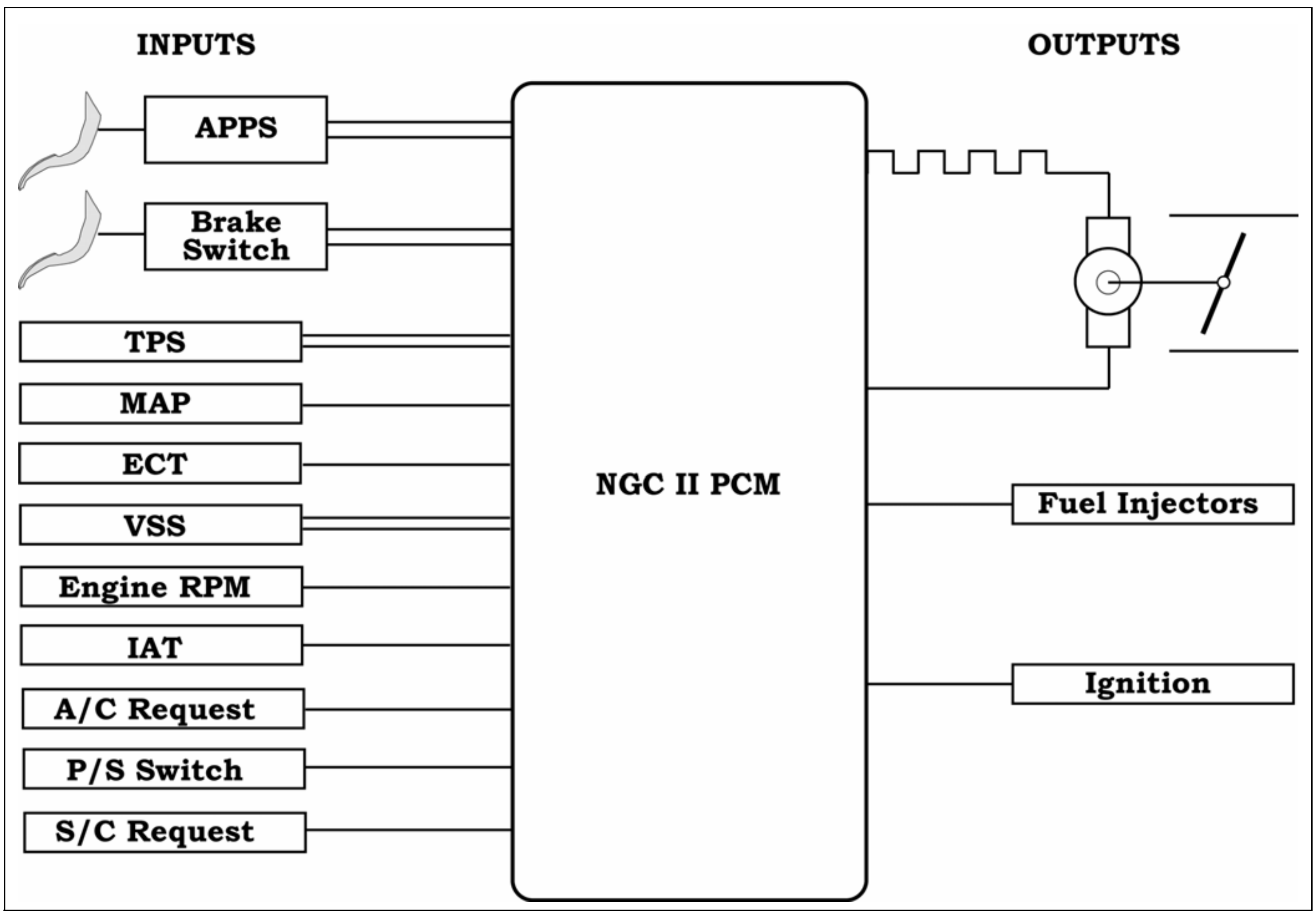


Figure 90 NGC II PCM Inputs and Outputs

ACCELERATOR PEDAL POSITION SENSORS (APPS)

Two Accelerator Pedal Position Sensors (APPS) input the driver's torque-demand signal to the PCM.

Two sensors are in one housing. In earlier systems, the sensors are located in the engine compartment on the left side under the battery. A cable connects the accelerator pedal to the APPS sensors. Later systems have the sensors with the accelerator pedal.

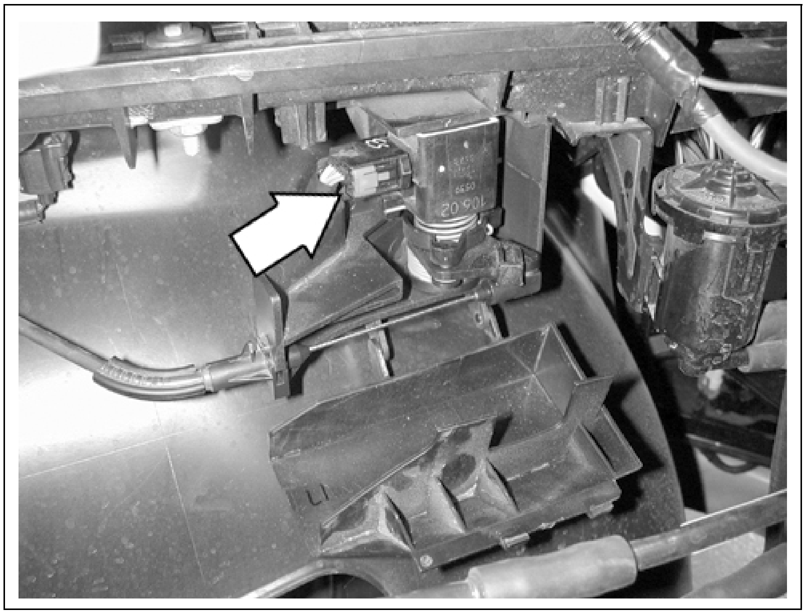


Figure 91 Accelerator Pedal Position Sensors - 2003 5.7L DR

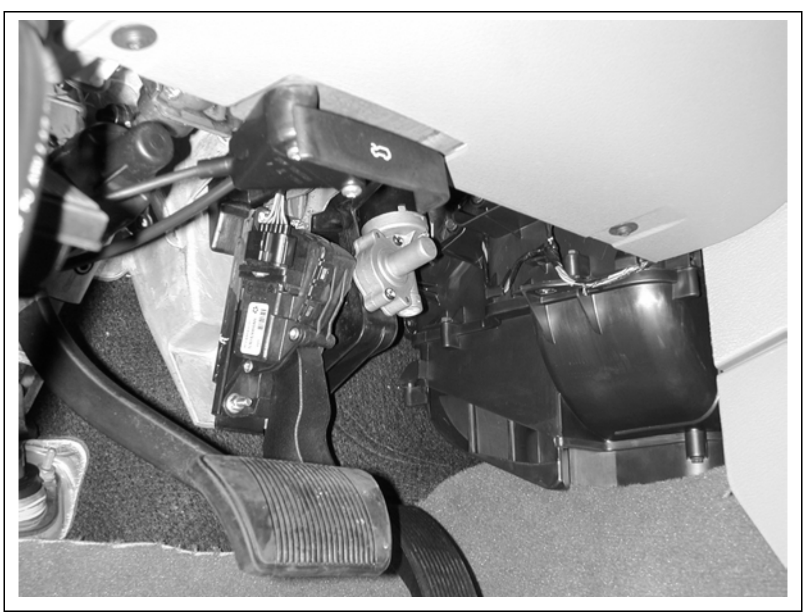


Figure 92 Accelerator Pedal Position Sensors – 2004 HB Durango

The sensors are two three-wire linear Hall-effect sensors that provide the PCM with two voltage signals in proportion to accelerator pedal position. Redundant sensors are used because of their critical function.

The signals from the two sensors are not identical. As the throttle opens, the signal from one sensor increases at about twice the rate of the signal from the other sensor. The two sensors have completely separate circuits, with separate 5V references, signals and grounds.

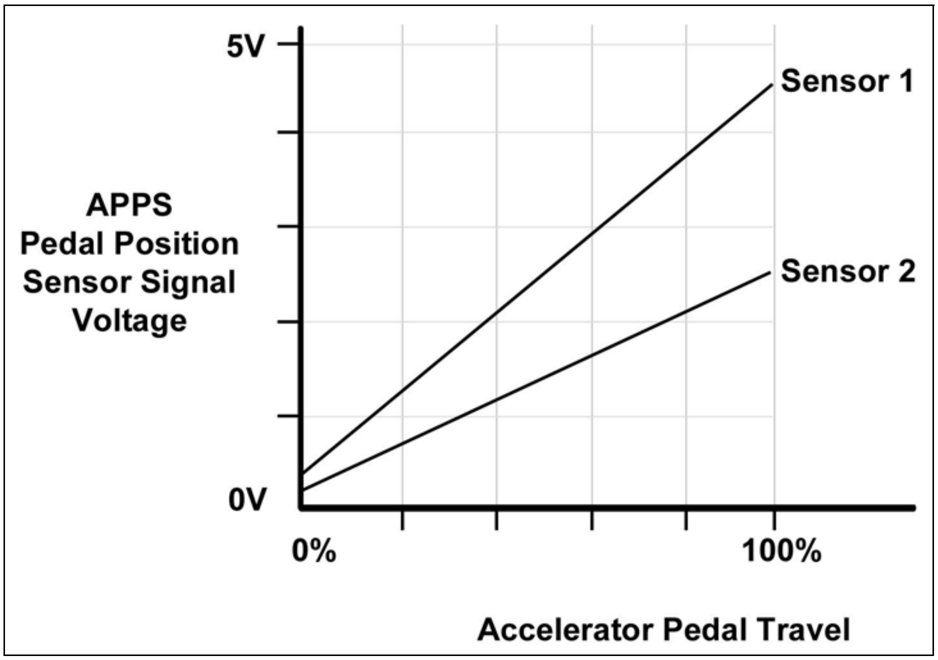


Figure 93 APPS Signal Voltages vs Accelerator Pedal Travel

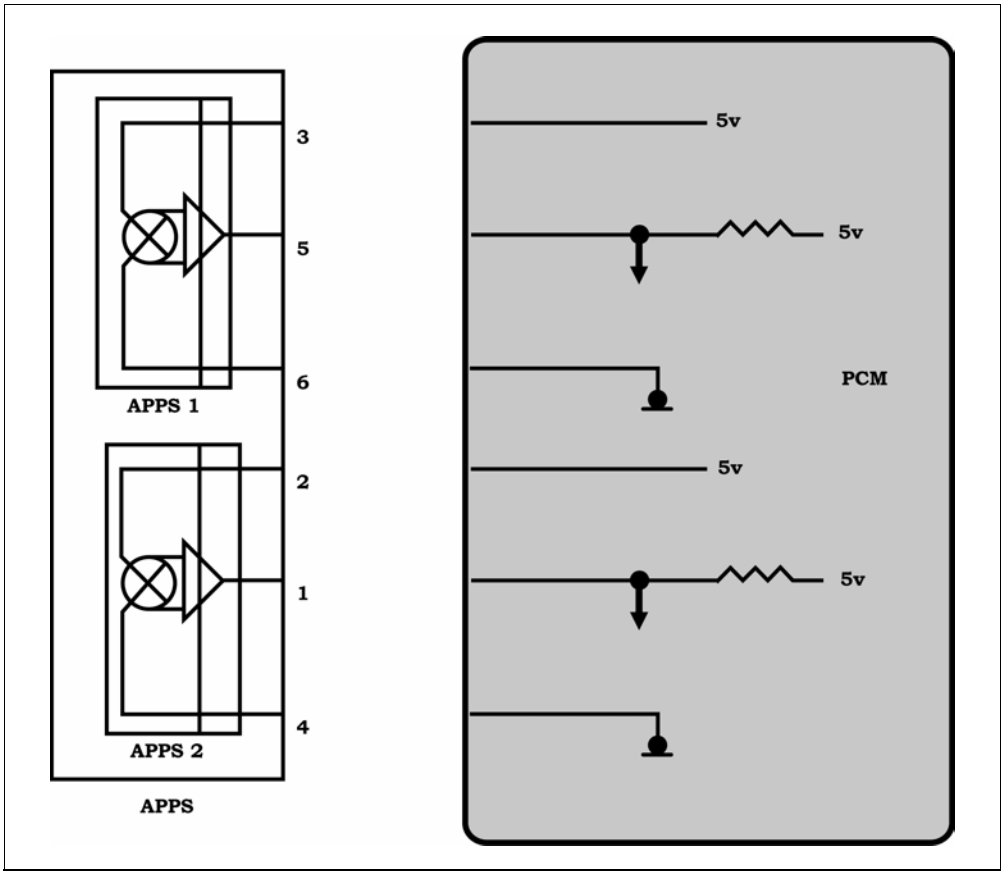


Figure 94 5.7L APPS Circuit (Completed by Student)

ETC THROTTLE BODY

The ETC throttle body houses the throttle plate, electric actuator motor, dual throttle position sensors, gears and a spring.

The throttle actuator motor is controlled by a duty-cycle signal from the PCM. A concentric clockspring works to close the throttle plate when it is opened beyond a nearly-closed position. If electric power is lost, the spring will close the throttle to this default position. The spring also tries to open the throttle plate when it is fully closed.

<u>WARNING</u>: KEEP FINGERS AWAY FROM THE THROTTLE PLATE WHEN THE IGNITION IS ON. DO NOT OPEN THE THROTTLE PLATE MANUALLY FOR ANY REASON. ALWAYS USE THE DRB III THROTTLE FOLLOWER TEST TO OPEN THE THROTTLE PLATE.

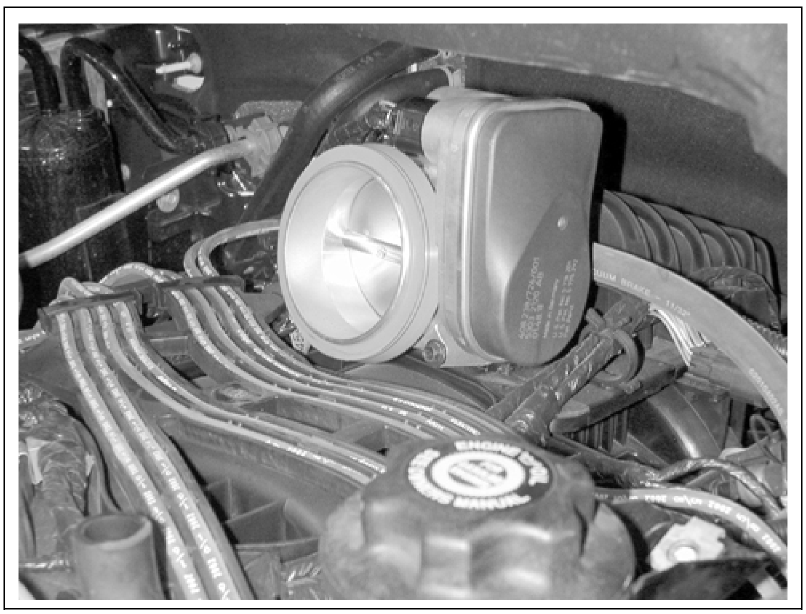


Figure 95 5.7L ETC Throttle Body

THROTTLE PLATE MOTOR CIRCUIT

The motor circuit reverses polarity to drive the throttle plate either open or closed. ETC connector Pin 5 is the Pulse Width Modulated side of the motor circuit. The motor circuit is completed through Pin 3. Most of the time, circuit polarity causes the actuator motor to either open the throttle plate or hold the throttle plate open against spring tension. To do this, Pin 3 is grounded and Pin 5 is powered. To reverse the motor and rapidly close the throttle, the circuit reverses polarity. Pin 3 supplies 12V and Pin 5 is grounded. Regardless of polarity, the motor circuit is always PWM on Pin 5. See Figures 96 and 97:

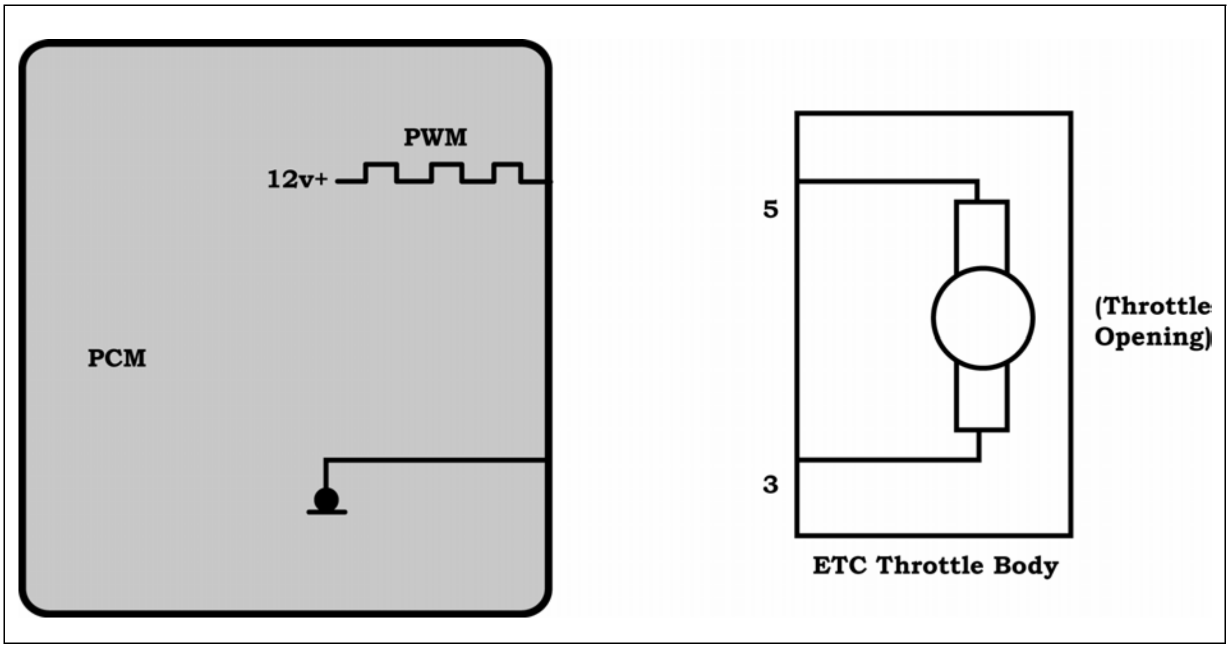


Figure 96 ETC Motor Polarity with Throttle Opening (Completed by Student)

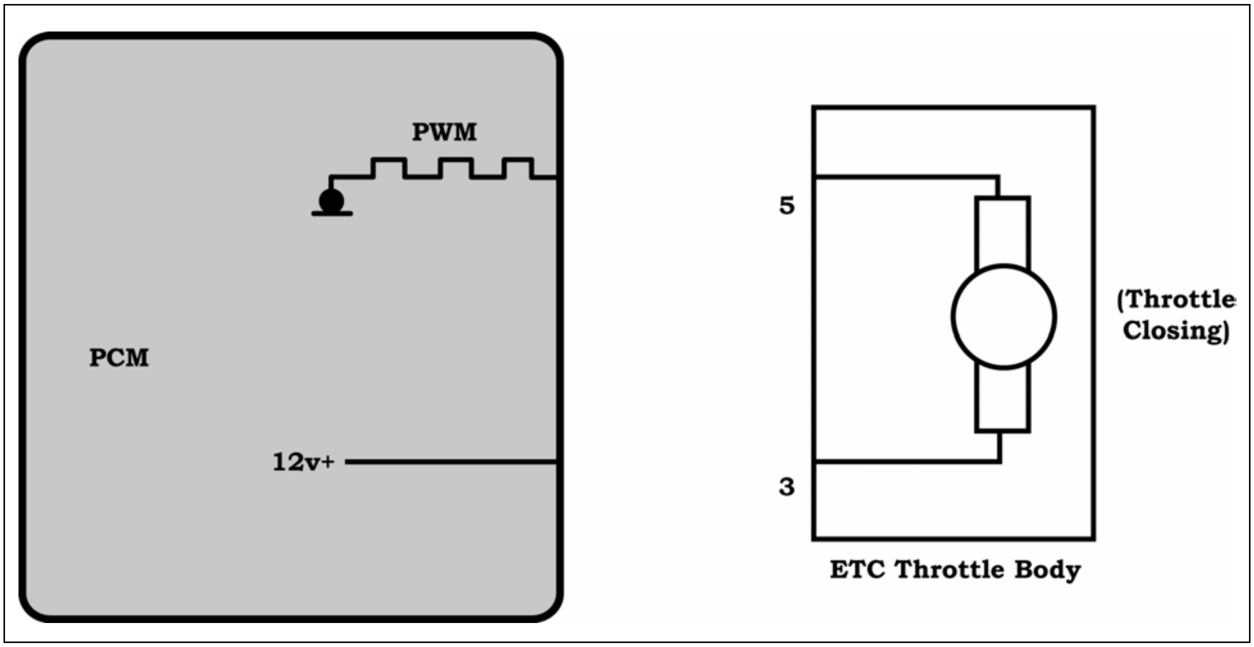
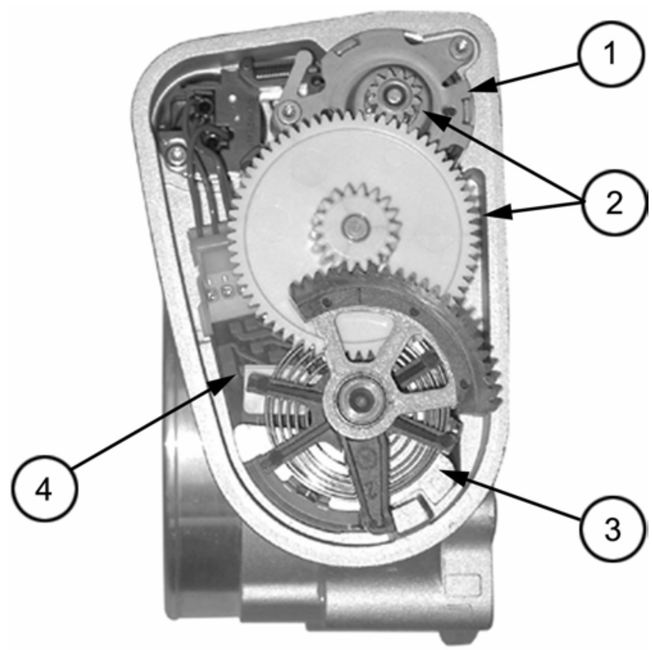


Figure 97 ETC Motor Polarity with Throttle Closing Completed by Student)

THROTTLE POSITION SENSOR (TPS)

Two Throttle Position Sensors (TPS) are built into the ETC throttle body and provide two throttle position signals to the PCM. Two sensors are used for fail-safe redundancy and error checking. The sensors output analog signals to inform the PCM that the throttle plate moves as expected.



1	Throttle Actuator Motor
2	Gears
3	Spring
4	Throttle Position Sensors (2)

Figure 98 5.7L ETC Throttle Actuator Motor, TPS, Spring and Gears

Two three-wire potentiometer sensors are used. The sensors use a common 5V reference and sensor return. Each sensor outputs an analog signal in proportion to throttle plate position, but one sensor uses reverse logic. As the throttle plate opens, the signal voltage from TPS#1 increases, and the signal voltage from TPS#2 decreases. The sum of the two TPS signal voltages should always equal approx. 5V. The PCM monitors this value to check system integrity.

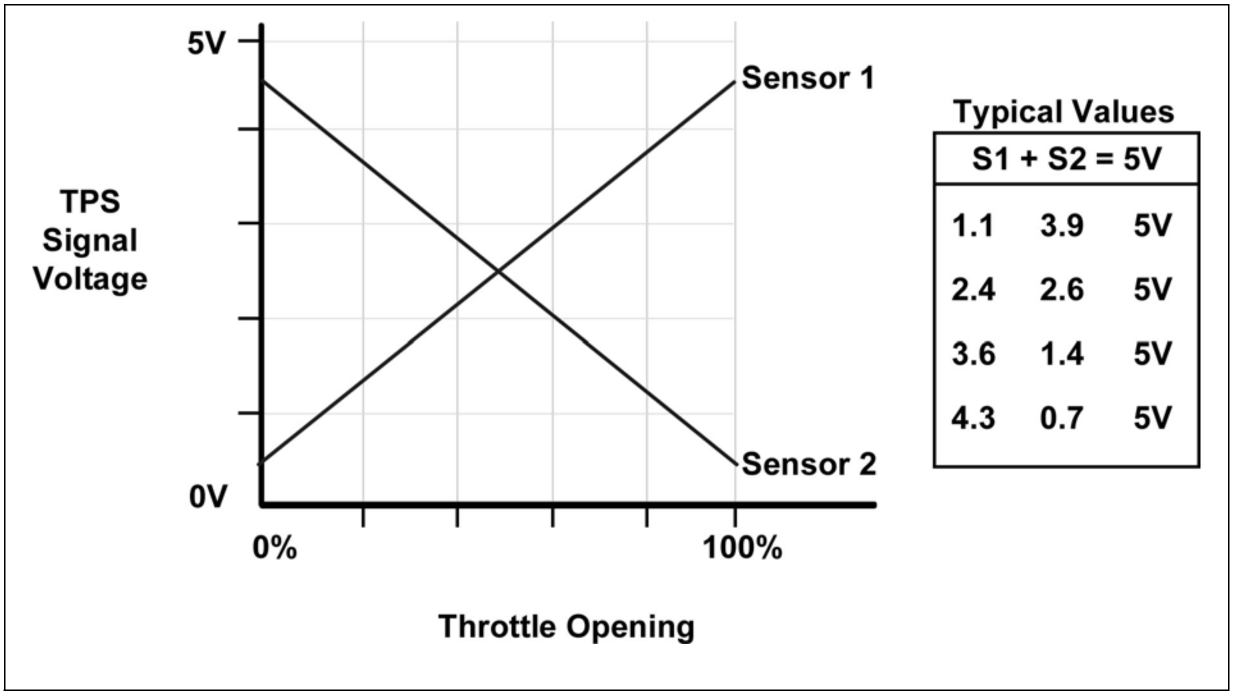


Figure 99 TPS Signal Voltages vs Throttle Plate Position

The ETC throttle body has a six-pin connector for the throttle plate actuator motor and the two TPS.

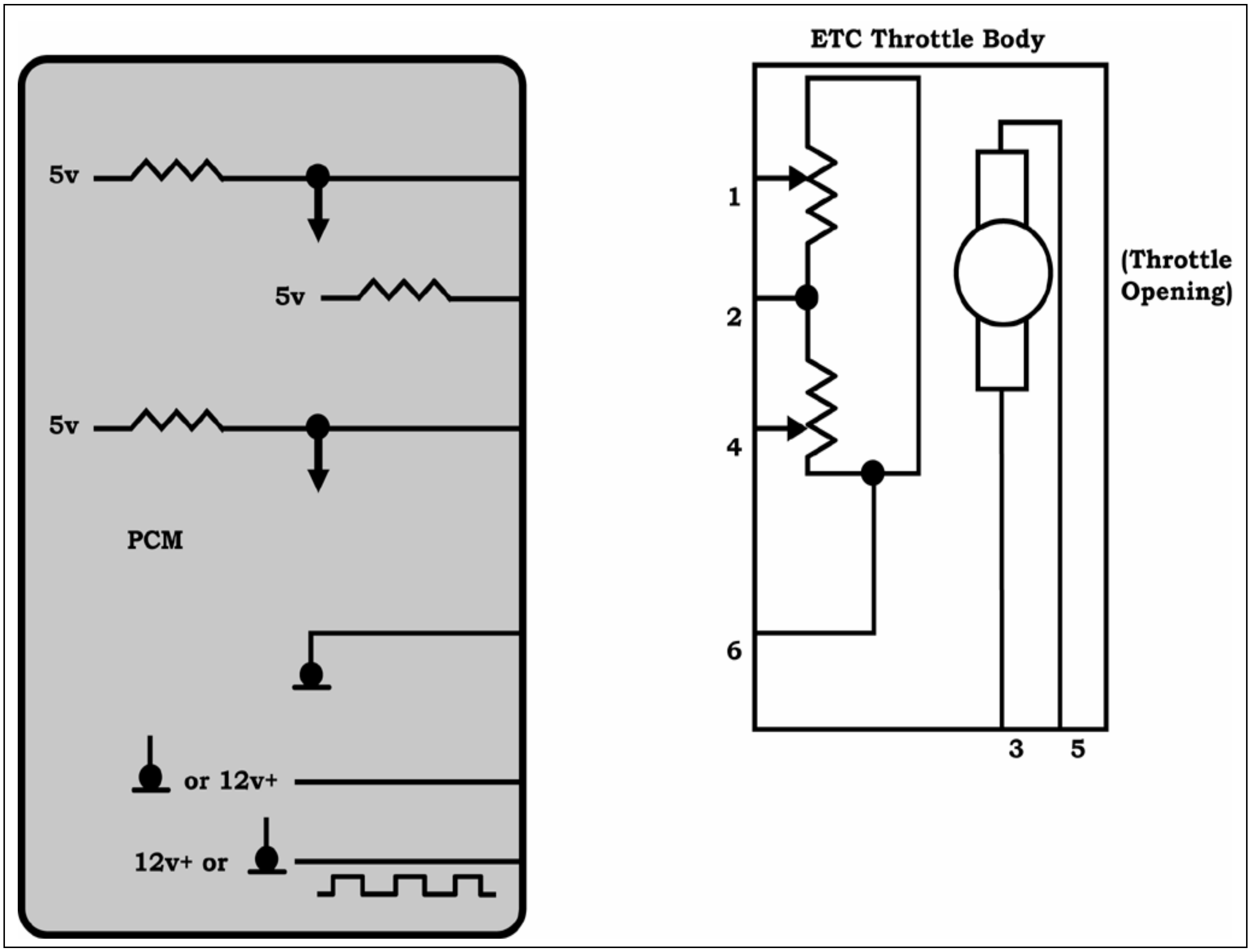


Figure 100 Electronic Throttle Control Circuit (Completed by Student)

OTHER INPUTS

Unlike NGC I and SBEC vehicles, DR vehicles with NGC II controllers receive vehicle speed information from the CAB. There are two vehicle speed inputs which are compared for rationality. One vehicle speed signal is from the rear wheel speed sensor. The second vehicle speed input is an average of both front wheel speed sensors.

Two brake switch inputs are also used. The switches are in a common housing near the brake pedal.

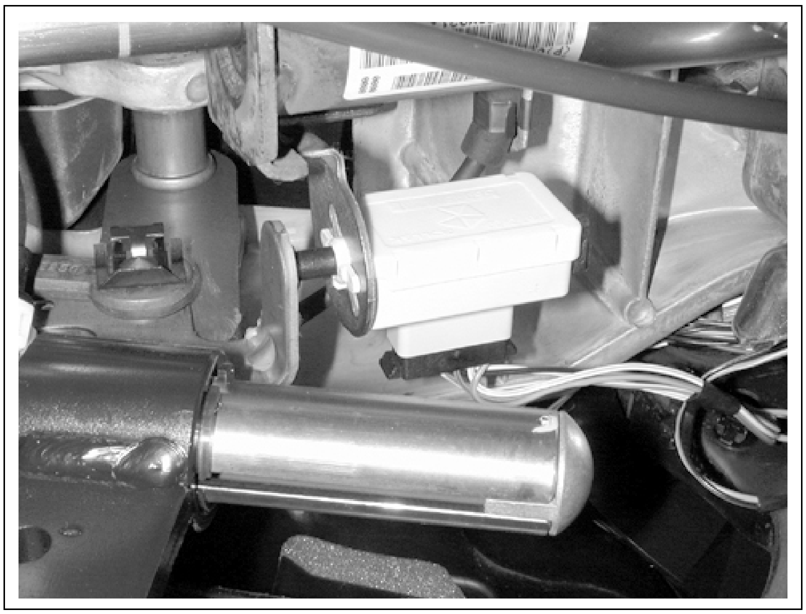


Figure 101 5.7L Brake Switch

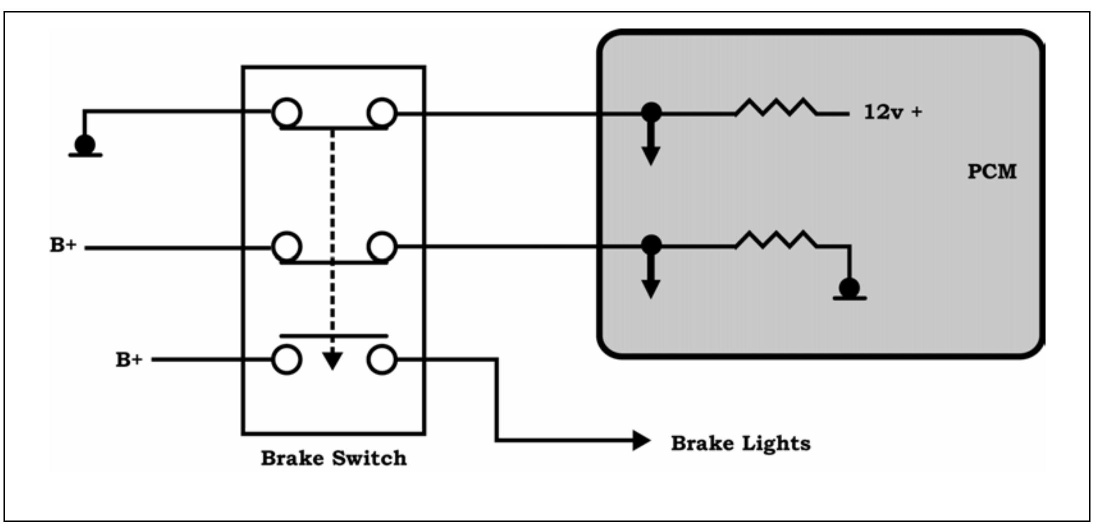


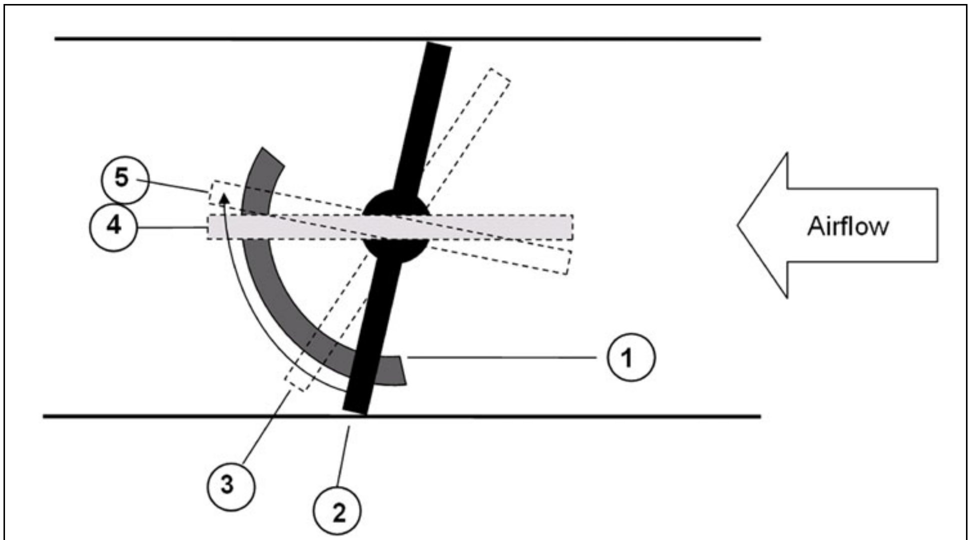
Figure 102 Brake Switch Circuit

ETC RESPONSE TO NORMAL AND ABNORMAL CONDITIONS

The PCM looks at the accelerator pedal sensor signals (and many other inputs) and determines throttle plate position. If all is OK, then the driver will get the requested torque. If not, then the PCM will take some other course of action (reduced power, power-free, zero RPM, etc.)

Starting a Vehicle with ETC

With NGC II PCMs, starter engagement may be delayed briefly every start-up while the PCM conducts an ETC Spring Test. The throttle plate is quickly driven open, then completely closed. The delay is approx. 0.2 sec. and the driver may or may not notice this delay. Throttle plate movement can make noises that are unfamiliar to the driver. The throttle plate has a full range of travel that is greater than the normal operating range.



1	Position sensor range (~105°)
2	Lower Mech. Stop (DELTHR = 0.0V)
3	Mechanical Limp-Home (default) position. Defined by platform, adjusted by supplier.
4	Wide Open Throttle
5	Upper Mech. Stop

Figure 103 5.7L ETC Throttle Plate Stops

This start-up delay may be noticed only if the driver goes directly from the Lock position to the Start position. In rare cases, the delay can be up to 2 sec. before starter engagement is allowed. This will only happen if all of the following are true:

- The battery has been disconnected.
- Both engine coolant and ambient temperature sensors indicate that no ice may be present.
- The ETC Throttle learned Limp-In values don't match the actual Limp-In values (this would most likely happen if the entire Throttle Body Assembly is replaced).

If the above conditions are all true, then the PCM will do an entire throttle plate range sweep (min. to WOT and closed again) which takes place before starter engagement is allowed. This may last up to 2 sec. The DRBIII® displays when the starter was last disabled with "ETC STARTER INHIBIT: Miles".

With NGC III PCMs, the PCM may decide to abort the ETC Spring Test if the key is turned rapidly to the start position.

Normal Operation

Regardless of accelerator pedal position, the PCM has the ability to reduce maximum engine rpm. For example, on DR models with 5.7L engine, in-gear, maximum rpm at WOT request is approx. 5900 rpm. If the WOT request is maintained, maximum rpm drops to approx. 5600 rpm. The In-Neutral Rev Limiter holds rpm to approx. 3,500 rpm.

Note: The throttle plate will not open with accelerator pedal input if the engine is not running, even with the key ON.

FAILURE MODES

Fail-Safe Mode

Loss of one input will cause the PCM to start the Fail-Safe mode. The ETC system will limit throttle opening, slow the response to the accelerator pedal, drop engine speed to idle with brake application and disable the speed control function. A DTC will be set and the ETC warning light will illuminate.

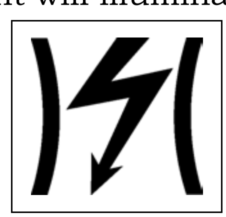


Figure 104 ETC Warning Light

Limp-In Mode

More serious faults will cause the system to enter the Limp-In mode. In this mode, the ETC light flashes, a DTC will be set and the MIL illuminates. The engine will run but the vehicle can be driven with severe restrictions. Speed control operation is not permitted. In the Limp-In mode, accelerator pedal position has no effect on throttle plate opening or engine speed. The engine runs at two different rpms, with engine speed controlled by the action of the brake pedal. When the brakes are applied, engine speed is controlled at approx. 800 rpm. With brakes released, engine speed slowly increases to 1200-1500 rpm. The PCM controls engine speed by controlling the ETC motor, spark timing and fuel. If the PCM cannot control throttle blade position, the PCM attempts to control rpm with spark timing and fuel.

Below are reasons for the NGC ETC system to enter the Limp-In mode:

- Low battery voltage
- ASD Relay OFF
- ETC throttle adaptation routine Limp-In learning
- PCM failure
- Auxiliary 5V supply failed (Not Primary)
- One TPS and the MAP sensor have failed
- Both TPS have failed
- ETC actuator motor failure
- Spring test open or close failure
- APPS internal signal failure
- One brake switch and one APPS failure

VACUUM LEAKS

The ETC system can compensate for some vacuum leaks. A vacuum leak in the intake manifold will allow air into the manifold that has not come through the throttle body, but this air is not unmeasured air, since there is no mass airflow sensor. There is no Idle Air Control system, so the ETC system will simply adjust throttle plate opening to compensate for the leak.

APPS SENSOR FAILURE

Loss of one APPS signal will initiate the Fail-Safe mode.

Loss of both APPS signals will cause the system to enter the Limp-In mode.

THROTTLE BODY AND TPS FAILURES

A blocked or sticking throttle plate will cause an out-of-range duty cycle response in the ETC motor circuit. The PCM compares TPS signals and actuator motor circuit duty cycle, and if it senses a disparity, it will remove power to the motor and enter the Limp-In mode.

Failure of one TPS will initiate the Fail-Safe mode. Loss of both TPS signals will cause the system to enter the Limp-In mode.

WARNING: THE THROTTLE BODY CANNOT BE CLEANED. DO NOT USE SPRAY (CARBURETOR) CLEANERS OR SILICONE LUBRICANTS ON ANY PART OF THE THROTTLE BODY.

The throttle body has no serviceable components and is replaced as a unit. Disconnect the battery before replacing the throttle body. After replacement, the new throttle body must be adapted. A typical procedure is below, refer to the latest service information for specific procedures.

- Disconnect the battery negative cable and leave disconnected for at least 90 seconds.
- Reconnect the negative cable.
- Turn the ignition key to the KOEO position, do not crank.
- Leave the ignition switch ON for at least ten seconds. The PCM will adapt to the throttle body.

This procedure will be performed whenever the battery has been disconnected. The PCM will move the throttle plate through its full travel.

DIAGNOSTIC PROCEDURES

New diagnostic procedures have been created to help diagnose and repair this new technology. Several P2100 series DTCs have been added specifically for ETC-equipped vehicles. There are new Verification Tests and module replacement procedures for the new PCM.

To assist in diagnosis, use the Throttle Follower Test on the Scan Tool. In this mode, depressing the accelerator pedal will cause the PCM to actuate the throttle plate motor. With this test, you can verify throttle plate movement with accelerator pedal input. This Throttle Follower Test must be performed with KOEO.

ETC System Test allows you to actuate the throttle plate directly with the Scan Tool. See service information for complete testing information.

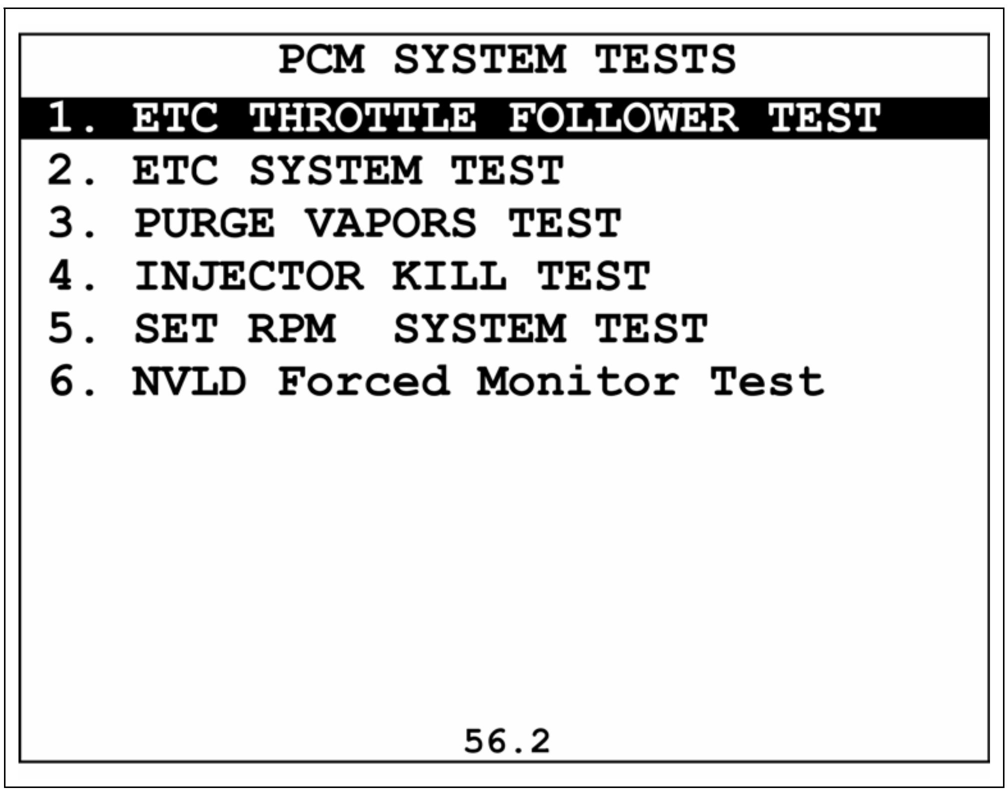


Figure 105 ETC Tests on the DRBIII

ACTIVITY 11: ETC

Notes:

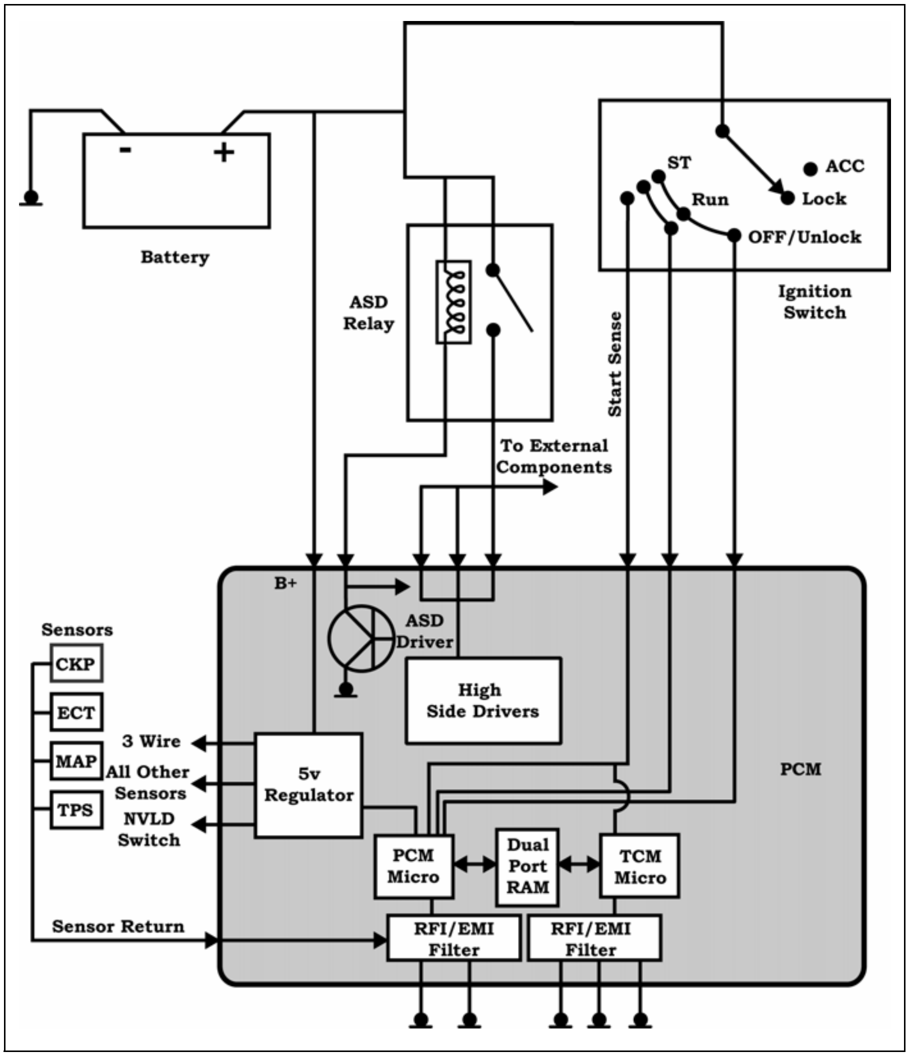
GLOSSARY

Accelerator Pedal Position Sensor	A Hall-effect sensor which outputs an analog signal to the PCM for accelerator pedal position in vehicles with ETC.
Actuator	Devices controlled by the PCM. The PCM provides outputs to actuators.
Analog	A signal that can continuously vary over a range. Also see Digital.
Backprobe	Inserting a test probe into a connector from the wire-side to contact a circuit without disconnecting the terminal connector.
Clear Flood Mode	A mode of operation in which fuel injectors are not pulsed. Cranking the engine while the accelerator pedal is fully depressed initiates this mode.
Diagnostic Trouble Code (DTC)	A set of unique five-digit alphanumeric identification codes which identify fault conditions in the On-Board Diagnostic system.
Digital	A signal that has only two values or a small number of discrete values. Also see Analog.
Duty-Cycle	A measurement of the On-Time in a Pulse Width Modulated digital circuit. A percentage based on comparing the On-Time with the Total-Time for a cycle.
Electronic Throttle Control (ETC) System	A drive-by-wire system with no mechanical connection between the accelerator pedal and the throttle plate. The PCM determines throttle plate position based on inputs from numerous sensors.
Hall-Effect Sensor	A type of electronic sensor which is capable of producing an accurate and stable signal. In vehicles with ETC, the Accelerator Pedal Position Sensor is a Hall-effect sensor.
High-Side Control	Circuit is controlled by switching the power on and off. Also see Low-Side Control.
Intake Air Temperature (IAT) Sensor	An NTC thermistor which outputs an analog signal to the PCM for intake air temperature.
Low Side Control	Circuit is controlled by switching the ground on and off. Also see High-Side Control.

Manifold Absolute Pressure (MAP) Sensor	A sensor which outputs an analog signal to the PCM for intake manifold vacuum. Under some conditions it can also provide barometric pressure information to the PCM.
Multiplexing (MUX)	Using one circuit to provide signals from multiple components.
Oxygen Sensor	Oxygen Sensors provide a signal to the PCM for oxygen content in the exhaust and make the closed-loop feedback engine management system possible. The PCM infers air/fuel ratio from the sensor signal for oxygen content and adjusts the quantity of fuel injected to keep the air/fuel ratio at stoichiometry (14.7:1).
Potentiometer	A variable resistor with three wires. Also see Rheostat.
Pulse Width Modulated	A digital circuit in which the On-Time changes. See Duty-Cycle.
Relay	An electromechanical switch capable of handling high current but activated by a low current voltage supply.
Rheostat	A variable resistor with two wires. Also see Potentiometer.
Sensor	A device that responds to changes in some physical condition such as temperature, speed, pressure or position. It sends a signal to the PCM that varies with changes in the condition sensed. Sensors provide inputs to the PCM.
Stoichiometry	The ideal air/fuel ratio. For gasoline, it is 14.7 parts air to 1 part fuel. Other fuels have different ratios.
Thermistor	A resistor that changes resistance with changes in temperature.
Throttle Position Sensor (TPS)	A sensor which outputs an analog signal to the PCM for throttle plate position.
Turbocharger	Assembly consisting of a turbine wheel driven by engine exhaust connected to a compressor wheel which draws in and compresses the intake air.
Vacuum	A pressure lower than atmospheric pressure.
Waste Spark	An ignition system in which one ignition coil fires two spark plugs simultaneously. The spark plug pairs are in companion cylinders. One spark plug fires during the compression stroke and the other spark plug “wastes” its spark firing during the exhaust stroke.

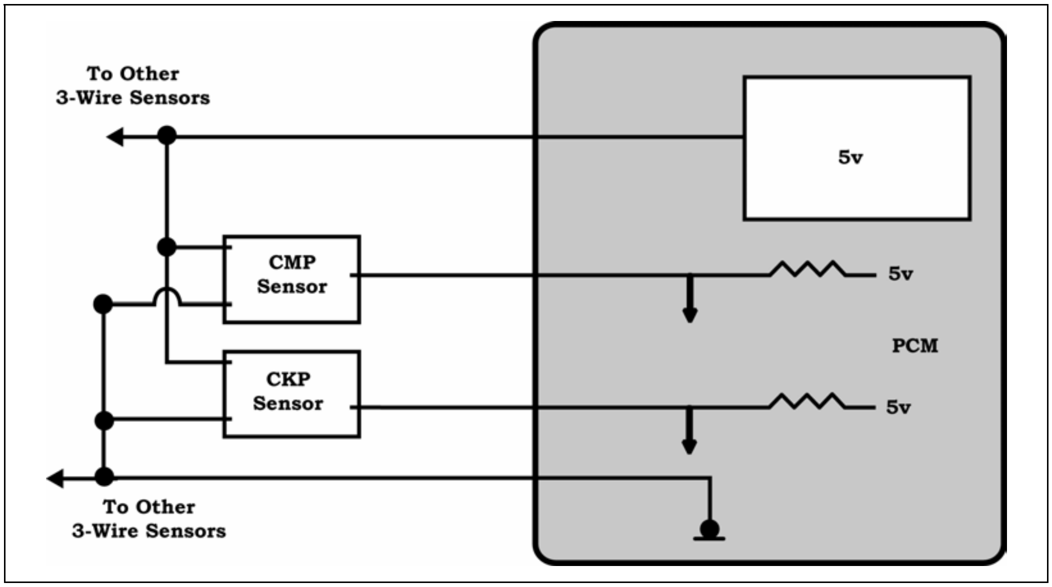
APPENDIX

MODULE 4 PCM POWER FEEDS AND GROUNDS:

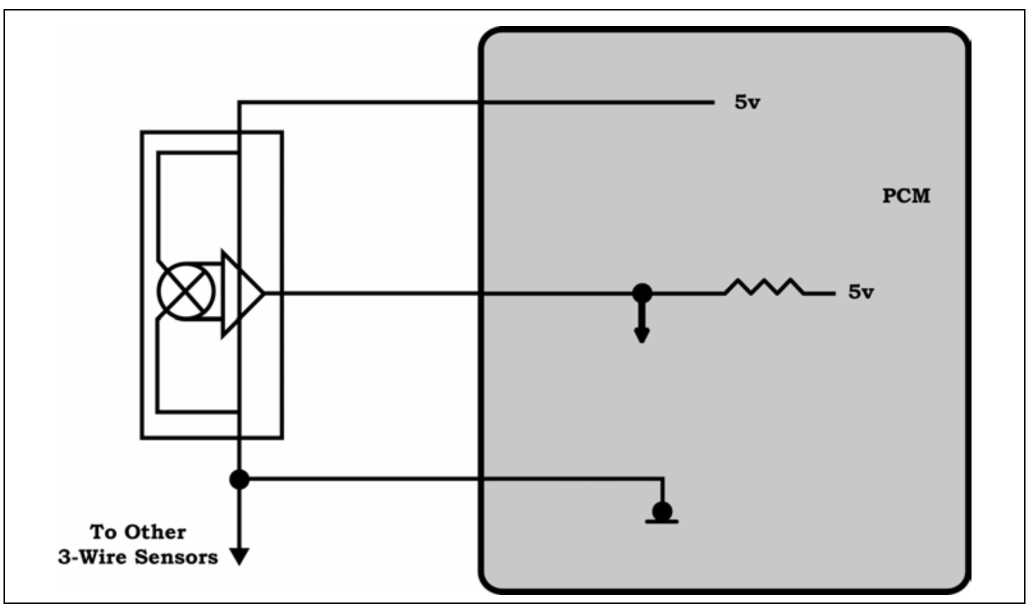


See Figure 29, Page 42 NGC Power and Grounds

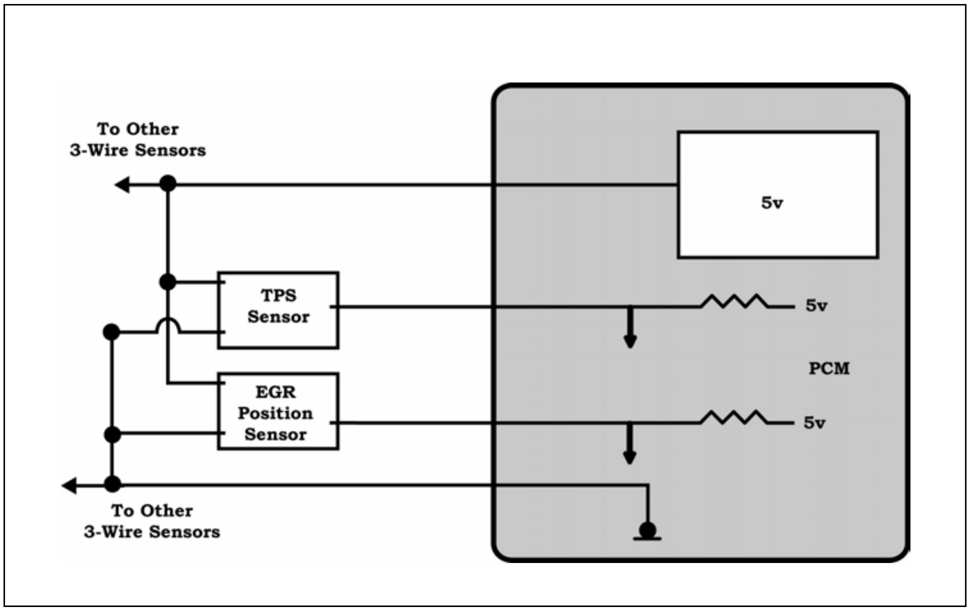
MODULE 6 PCM INPUTS:



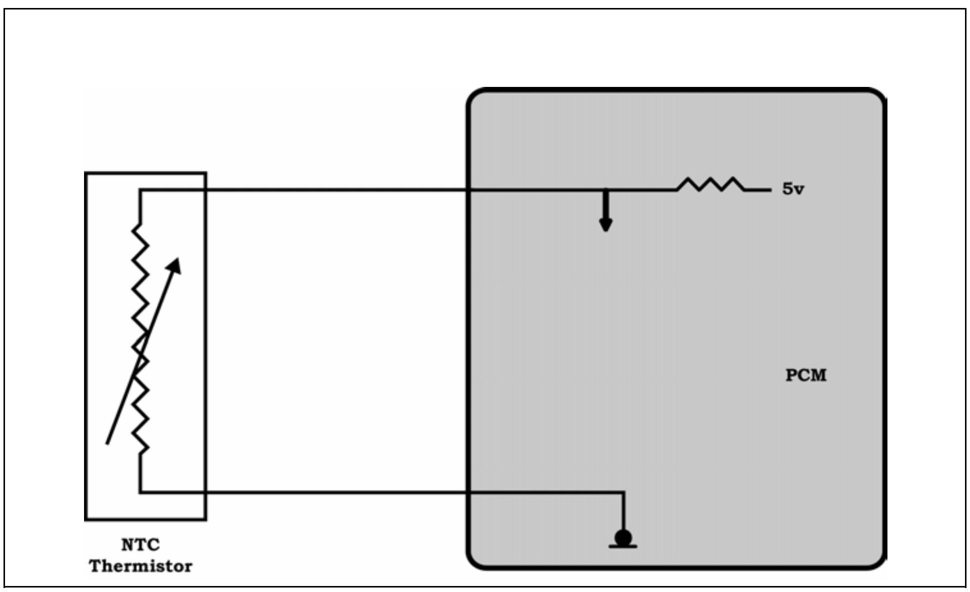
See Figure 36, Page 58 CKP and CMP Sensors



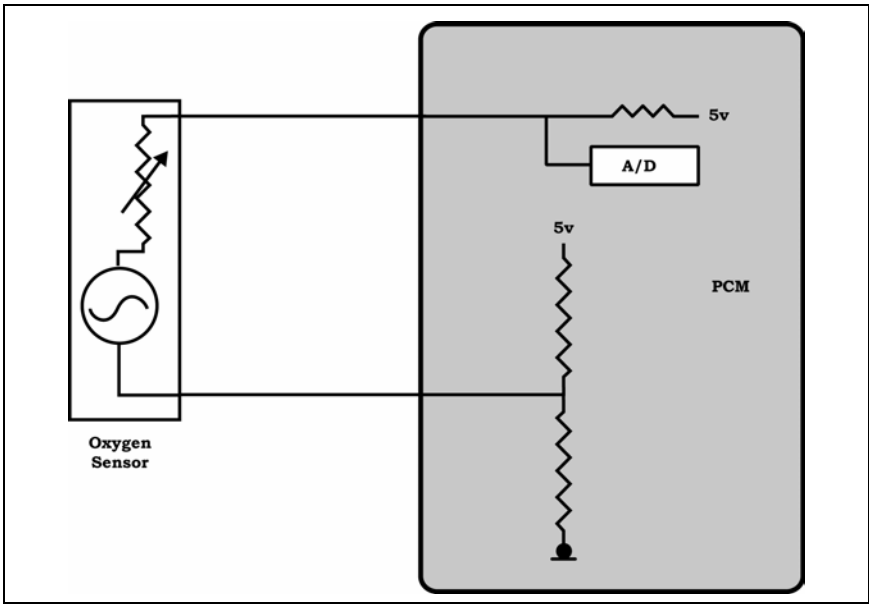
See Figure 42, Page 64 MAP Sensor



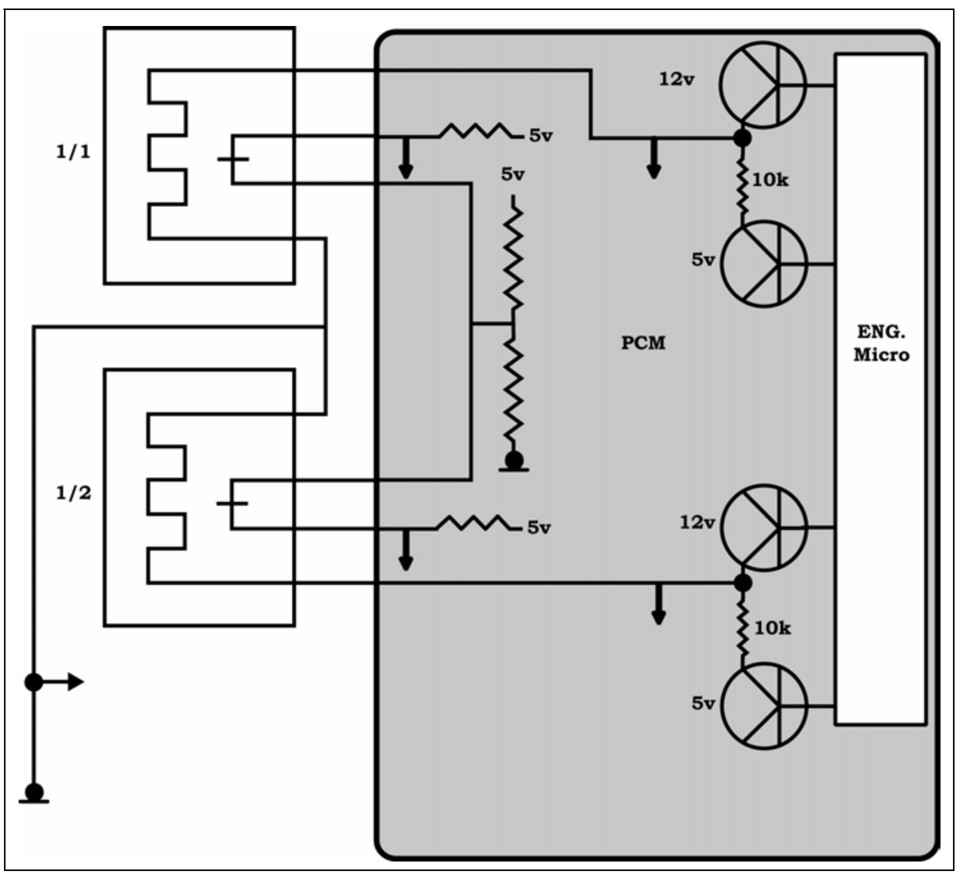
See Figure 43, Page 71 TPS and EGR Position Sensors



See Figure 44, Page 76 NTC Thermistor Sensor

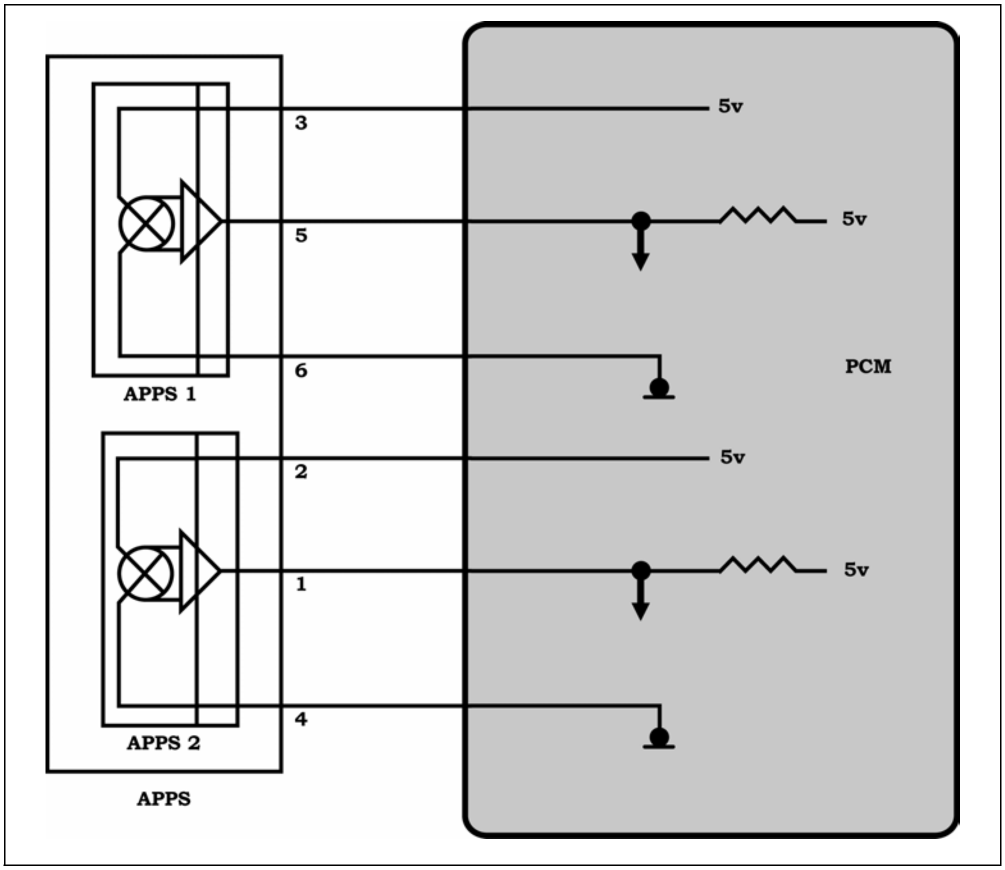


See Figure 49, Page 84 Oxygen Sensor Signal Circuit

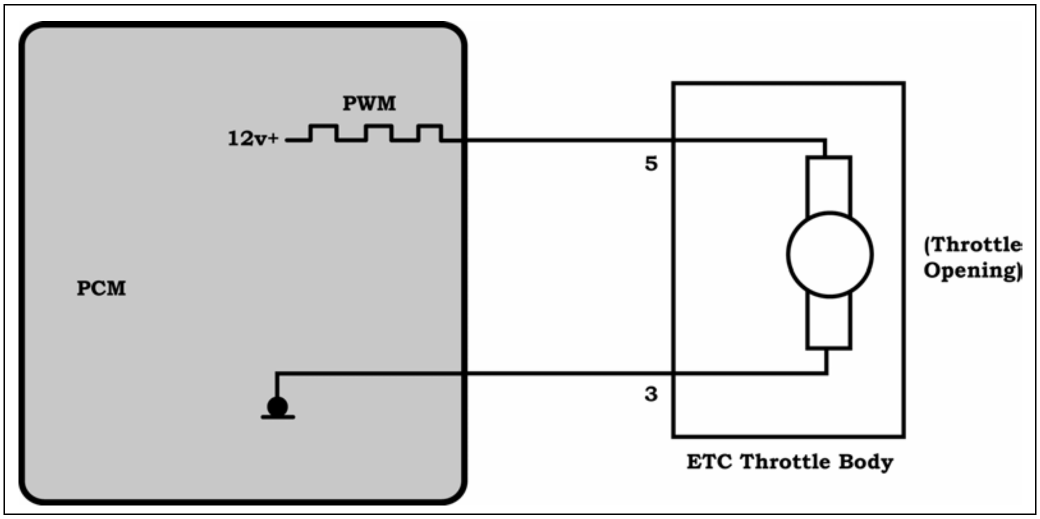


See Figure 55, Page 93 Oxygen Sensor Heater Circuit

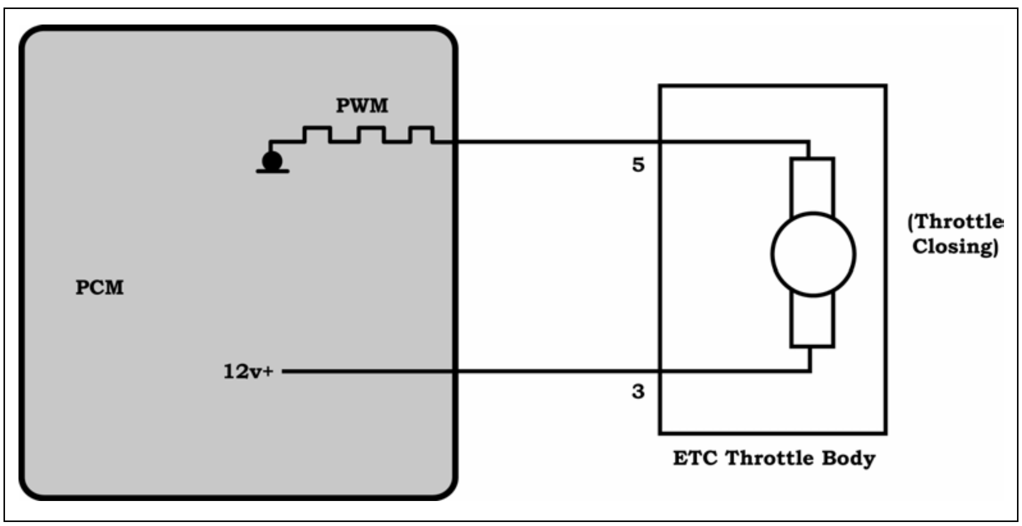
MODULE 9 ELECTRONIC THROTTLE CONTROL:



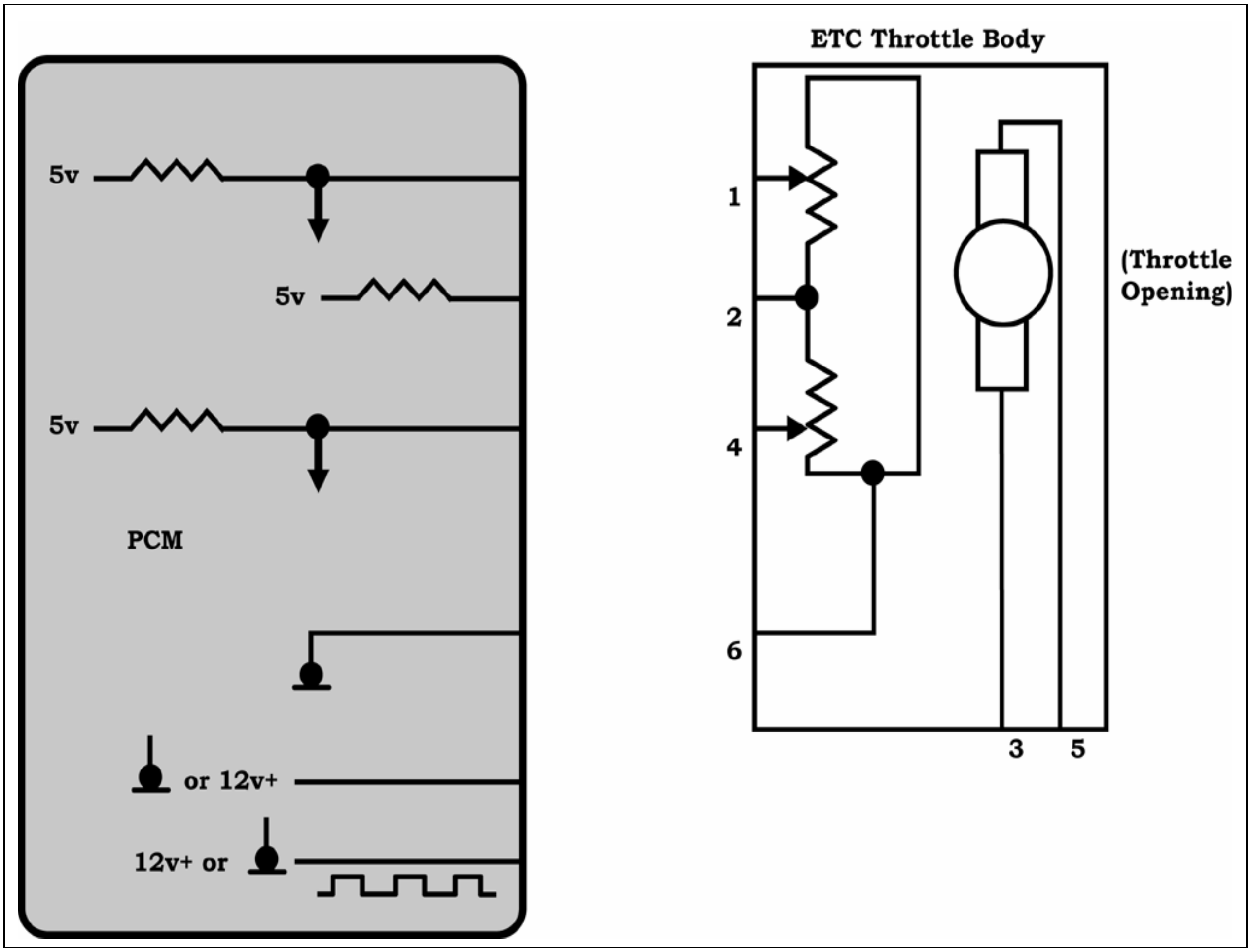
See Figure 94, Page 146 5.7L APPS Circuit



See Figure 96, Page 148 ETC Motor Polarity with Throttle Opening

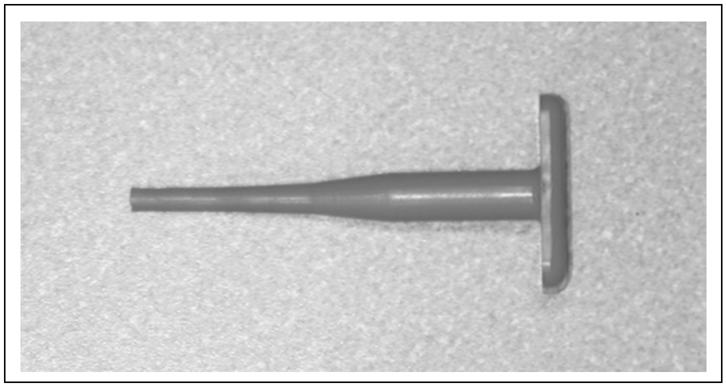


See Figure 97, Page 149 ETC Motor Polarity with Throttle Closing

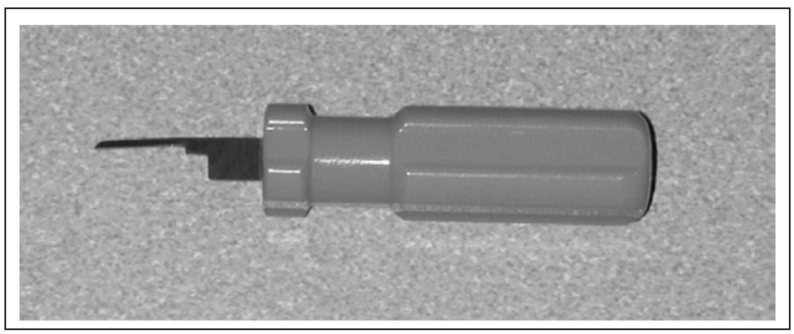


See Figure 100, Page 152 Electronic Throttle Control Circuit

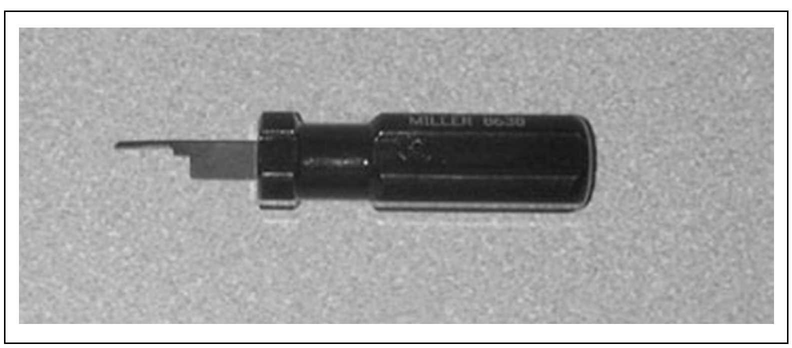
TOOL APPENDIX



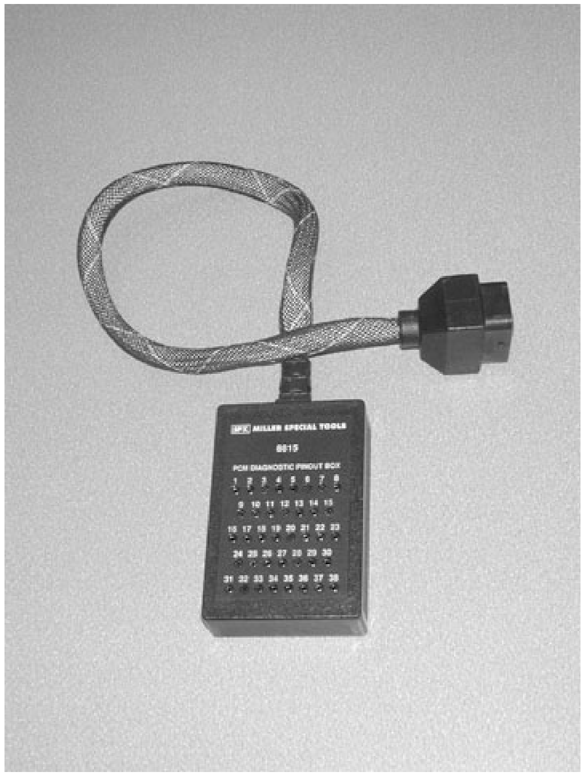
Miller #6934 Pin Removal Tool – JTEC



Miller #6932 Pin Removal Tool - SBEC



Miller #8638 Pin Removal Tool – NGC



Miller #8815 Pinout Box