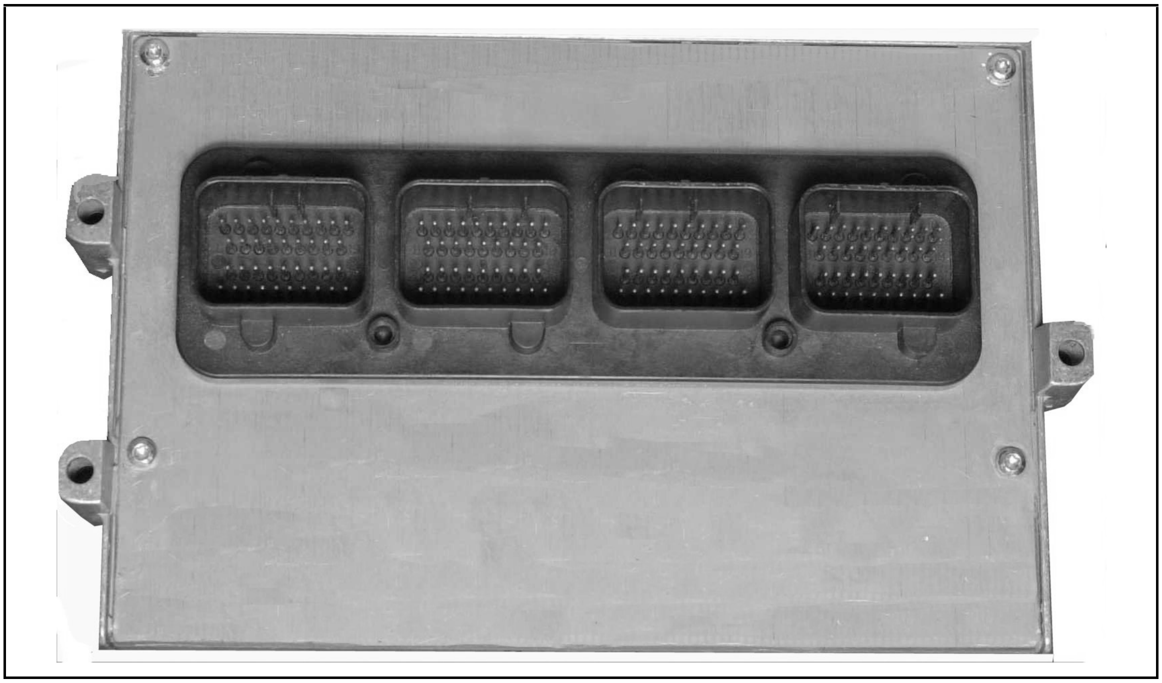
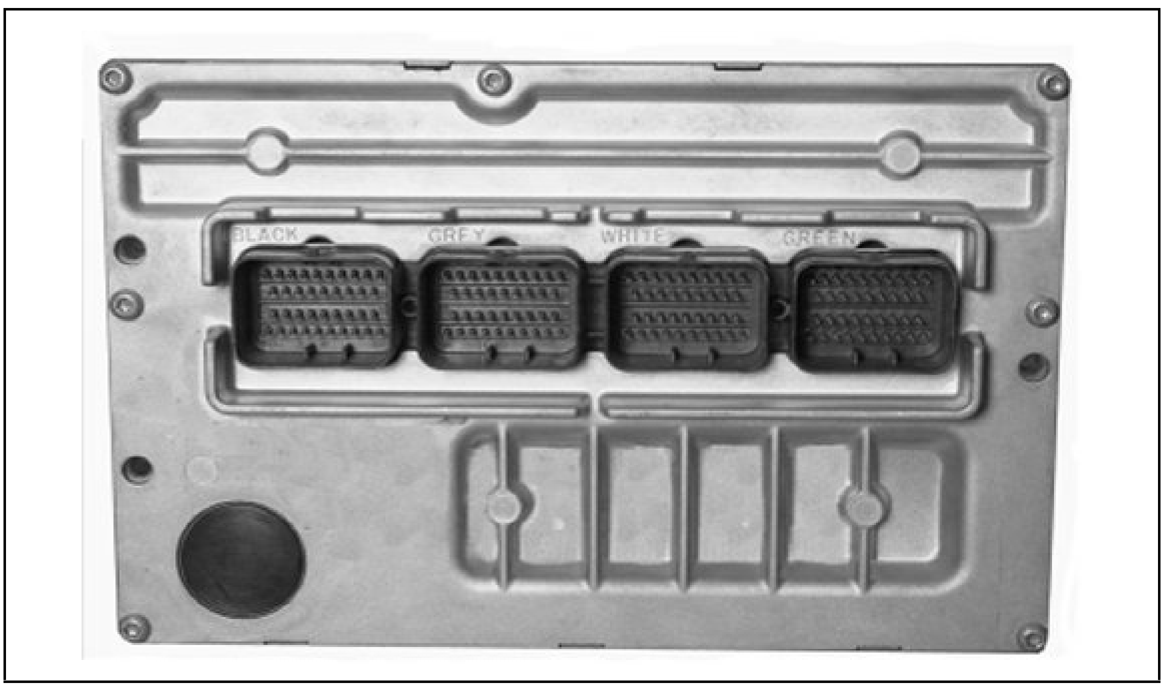


Motorola PCM



Huntsville PCM

TABLE OF CONTENTS

INTRODUCTION

STUDENT LEARNING OBJECTIVES

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

- Identify and explain the hardware differences between the NGC PCM and previous PCMs
- Demonstrate how to use all special tools
- Identify, explain and diagnose all engine controller power and ground supplies, as well as communication networks that are unique to NGC
- Identify, explain and diagnose all PCM inputs and outputs that are unique to NGC
- Demonstrate an understanding of the unique differences of the “Model-Based” fuel strategy on NGC vehicles
- Demonstrate an understanding of the unique differences in purge and EGR strategies
- Demonstrate an understanding of the unique differences in accessory controls
- Identify, explain and diagnose the NVLD system

ACRONYMS

The acronyms listed here are commonly used in Chrysler Group vehicles:

- A/C Air Conditioning
- ACM Airbag Control Module
- ASD Relay Auto Shutdown Relay
- Baro Barometric Pressure
- BCM Body Control Module
- BOSS Basic Octal Serial Switch
- BTS Battery Temperature Sensor
- CAA Clean Air Act
- CAB Controller Anti-lock Brakes
- CARB California Air Resources Board
- CCD BUS Chrysler Collision Detection Bus
- CKP Crankshaft Position Sensor
- CMP Camshaft Position Sensor
- CO Carbon Monoxide
- COP Coil On Plug Ignition
- CTM Central Timer Module
- DCP Duty-Cycle Purge Solenoid
- DHSS Dual High Side Switch
- DIS Direct Ignition System
- DLC Data Link Connector
- DMM Digital Multimeter
- DRBIII® Diagnostic Readout Box – 3rd Generation
- DTC Diagnostic Trouble Code
- EATX III Electronic Automatic Transmission Controller 3 rd Generation
- EC European Community
- ECT Engine Coolant Temperature Sensor
- EEPROM Electrically Erasable Programmable Read Only Memory
- EGR Exhaust Gas Recirculation Valve
- EMI Electro-Magnetic Interference

- EOBD European OBD (Euro Stage III)
- EPA Environmental Protection Agency
- EPP Engine Position Pulse
- EU European Union
- EVAP Evaporative Emission System
- EWMA Exponentially Weighted Moving Average
- FTP Federal Test Procedure
- GPM Grams Per Mile
- HC Hydrocarbons
- HO2S Heated Oxygen Sensor
- IAC Idle Air Control Motor
- IAT Intake Air Temperature Sensor
- JTEC Jeep/Truck Engine Controller
- LEV Low Emissions Vehicle
- LDP Leak Detection Pump
- LSIACV Linear Solenoid Idle Air Control Valve
- LTFT Long Term Fuel Trim
- MAF Mass Airflow
- MAP Manifold Absolute Pressure Sensor
- MDS2® Mopar Diagnostic System - 2nd Generation
- MIL Malfunction Indicator Lamp
- MTV Manifold Tuning Valve
- NGC Next Generation Controller
- NLEV National Low Emissions Vehicle
- NMHC Non-Methane Hydrocarbons
- NTC Negative Temperature Coefficient
- NVLD Natural Vacuum Leak Detection
- OBD I On-Board Diagnostics – First Generation
- OBD II On-Board Diagnostics – Second Generation
- ORVR On-Board Refueling Vapor Recovery
- P/N Park/Neutral

- PCI BUS Programmable Communications Interface BUS (J1850)
- PCM Powertrain Control Module
- PDC Power Distribution Center
- PEP Peripheral Expansion Port
- PPS Proportional Purge Solenoid
- PS Power Steering
- PSP Power Steering Pressure (Switch)
- PTC Positive Temperature Coefficient (resistor)
- PWM Pulse-Width Modulation
- PZEV Partial Zero Emissions Vehicle
- QHSS Quad High Side Switch
- RAM Random Access Memory
- RFI Radio Frequency Interference
- RKE Remote Keyless Entry
- RPM Revolutions Per Minute
- SAE Society of Automotive Engineers
- SBEC Single Board Engine Controller
- SCW Similar Conditions Window
- Siemens PCM used in 1.6L PT and 1.6L PL
- SKIM Sentry Key Immobilizer Module
- SRV Short Runner Valve
- STFT Short Term Fuel Trim
- TCM Transmission Control Module
- TDC Top Dead Center
- TLEV Transitional Low Emissions Vehicle
- TPS Throttle Position Sensor
- VSS Vehicle Speed Signal
- VTSS Vehicle Theft Security System
- ZEV Zero Emissions Vehicle (electric)

GENERAL INFORMATION

This publication contains information describing the operation and diagnosis of the new, Next Generation Controller (NGC) fuel injection system. The NGC controller is a state of the art PCM that will eventually replace all SBEC and JTEC PCMs, as well as the EATX III and EATX IV family of TCMs. This new PCM makes its official debut in all 2002 LH family of vehicles, followed by the 2002 ½ Durango vehicles equipped with a 4.7L engine. Each year we will see the utilization of this technology expanded to include other vehicle lines, with the full transition expected to be completed by the 2005-model year.

Two computers, a logic module that processed information from sensors and other inputs, and the power module that actuated all output devices, controlled the first electronic fuel injection systems. These two controllers were eventually placed into one housing and was named the Single Module Engine Controller or SMEC. A few years later, the logic and power module function were combined onto one, printed circuit board and was called the Single Board Engine Controller or SBEC. In 1995, the SBECIII engine controller, for use on passenger cars and minivans replaced the previous SBEC controllers, and a new controller, the Jeep and Truck Engine Controller (JTEC) made its debut for all Jeep, Dodge Truck and Viper vehicles, replaced the SBEC controller.

The NGC controller is the latest technological advance in powertrain controller modules (PCMs). This state of the art controller incorporates both the engine and transmission controller functions into one unit. Eventually, we will see a third controller added to NGC module for Electronic Throttle Control (ETC.) The NGC control module will be the sole PCM used on all Chrysler Group vehicles in the future.

NGC HARDWARE

GENERAL CONTROLLER INFORMATION

Overview

As mentioned earlier, the NGC controller combines the function of the PCM and TCM into one package. The NGC controller was designed for superior computational power, to meet the tough demands of recent and future government regulations. However, this is just one of the many advantages of the new controller. The NGC controller:

- Requires less under hood space due to the integration of the PCM and TCM
- Eliminates many external wiring circuits because of the ability of the PCM and TCM to share information via a dual-port RAM chip
- Provides 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.
- Eliminates the hardware and software differences between SBEC and JTEC, with all platforms having to decide on one, common approach of implementation
- Has improved resistance against radio frequency interference (RFI) and electro-magnetic induction (EMI)
- Improves fault detection and circuit protection through the use of Smart Drivers and enhanced diagnostics
- Provides faster computational speed with an all-new 32 bit/32MHz engine processor, and carryover 16 bit/16MHz transmission processor

Two Manufacturers

The NGC controller is manufactured by two different plants, the DaimlerChrysler Huntsville Electronics plant, and by Motorola. Initially, these controllers are **not** interchangeable, however, interchangeability is predicted for the future. In the 2002 model year launch, the Huntsville controller will be used on the LH, while the Motorola controller will be used on the DN. They are easily distinguishable, with the Huntsville controller having cooling fins, while the Motorola does not have fins.

The TCM controller will be removed from the NGC controller in 2003 on 5.7L engine applications with Electronic Throttle Control (ETC). For this one application only, there will be a standalone EATX TCM to control the fully automatic transmission. The transmission controller functionality is expected to be back into the NGC controller the following year.

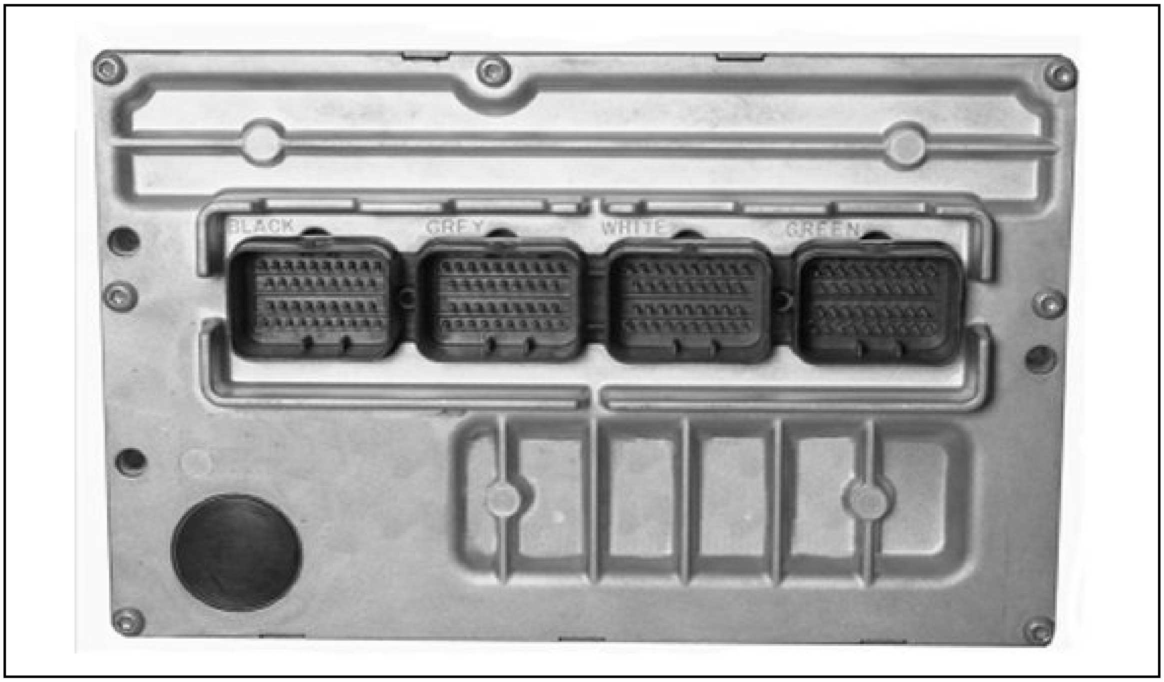


Figure 1 Huntsville PCM

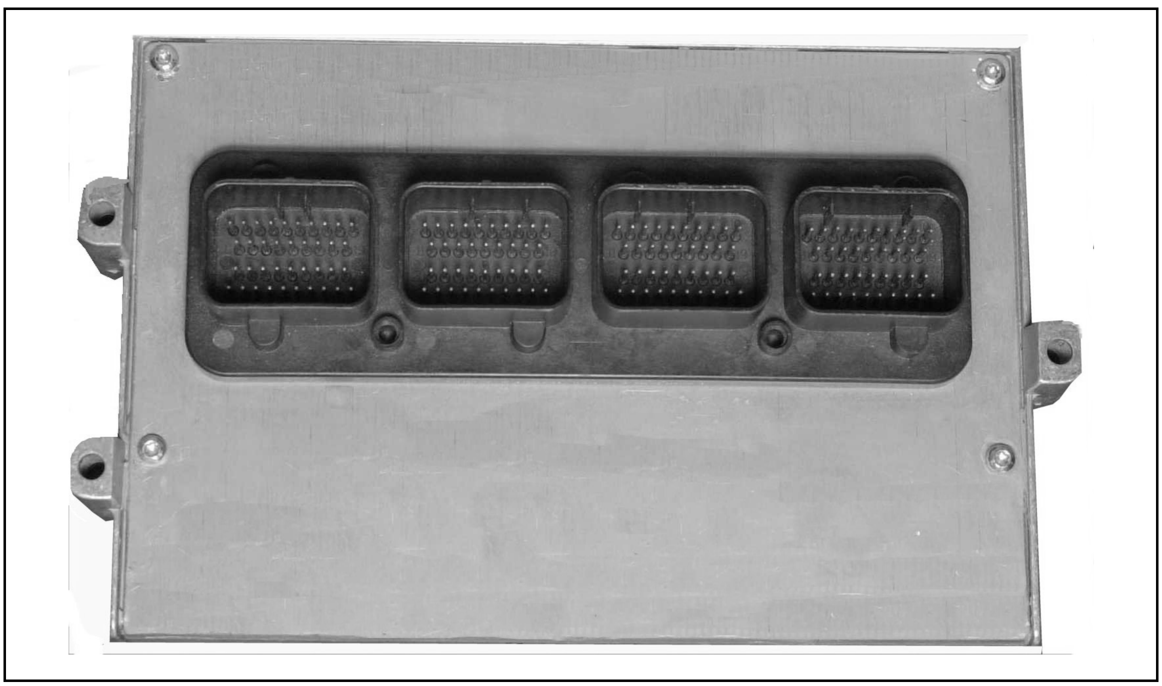


Figure 2 Motorola PCM

Controller Mounting

The PCM housing is constructed of a special alloy, designed for efficient transfer of heat and reduction of RFI and EMI. Special mounting bolts are required to ensure proper heat and electrical conductivity. Do not substitute hardware that has not been designed for this specific application.

CONNECTORS AND WIRING

Connectors

There are four, 38-pin connectors that connect to the PCM. They can be identified as:

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

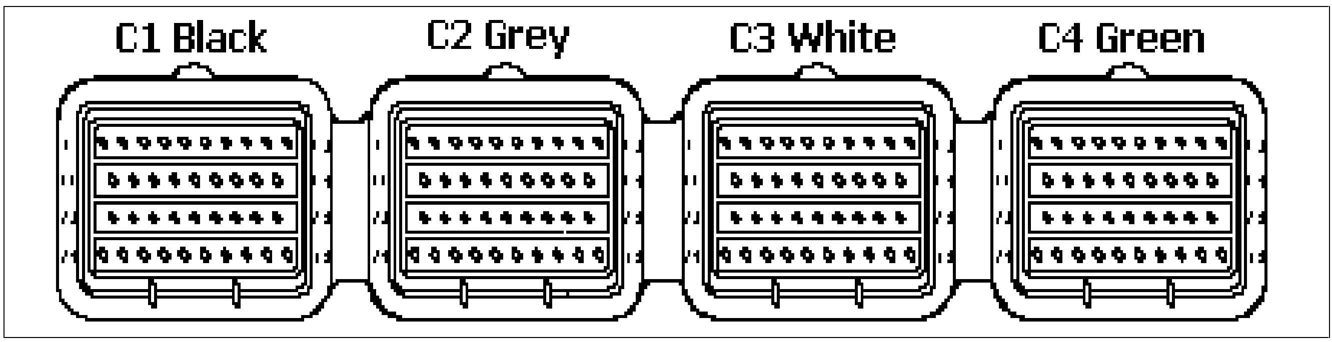


Figure 3 PCM Connectors

When performing wiring harness diagnostics, it is important to **not** probe or back probe the connector. Damage to the connector **will** occur if this procedure is not followed. There are two special tools that have been designed for these connectors. The first is a pin-out box (Miller #8815) that will allow 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.

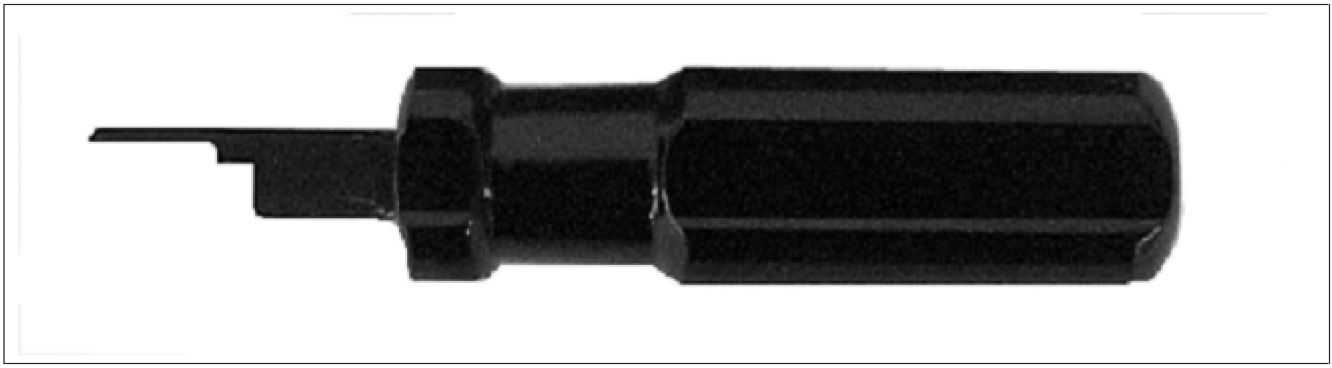


Figure 4 Miller #8638 Pin Removal Tool

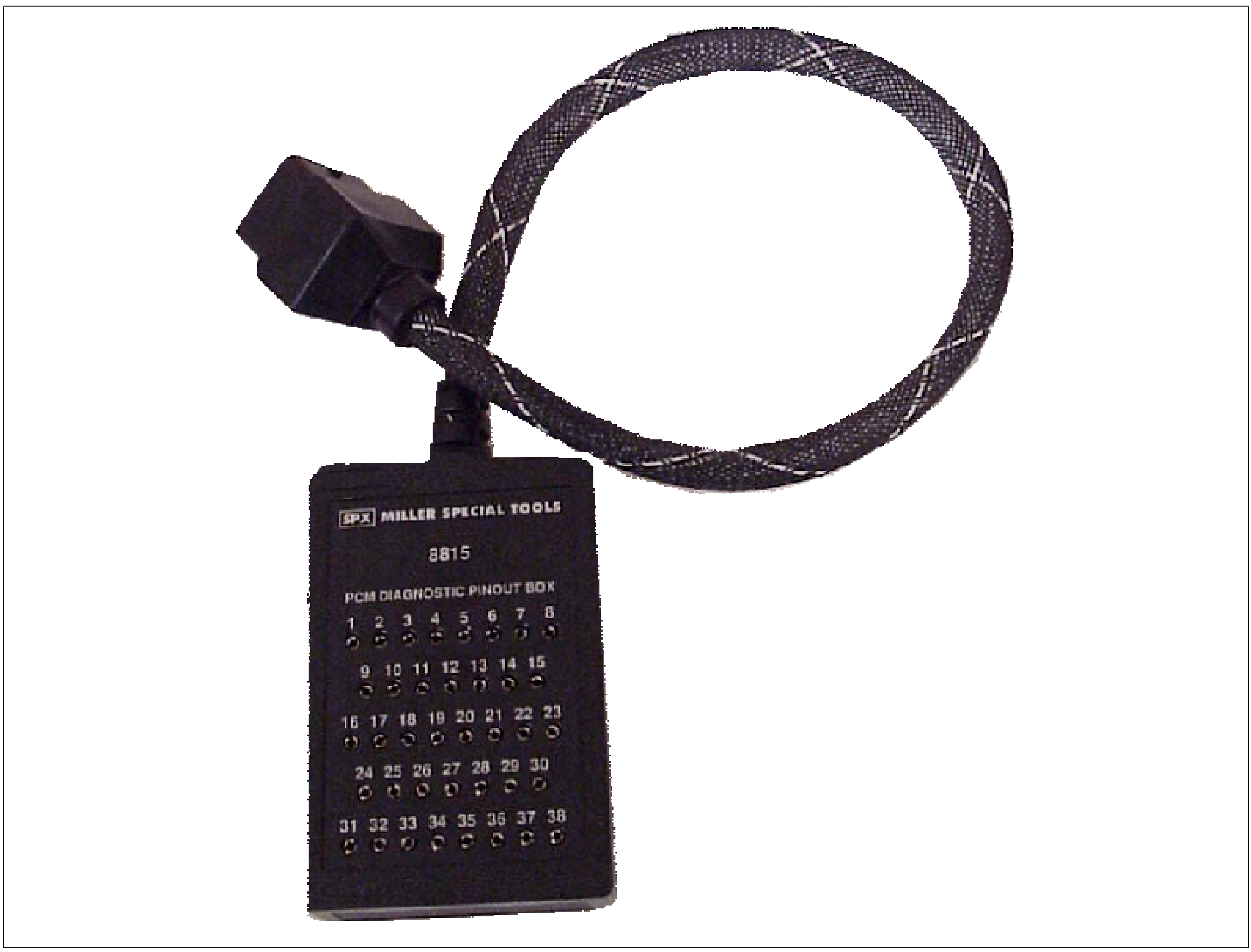


Figure 5 Miller #8815 Pinout Box

POWER SUPPLIES, GROUNDS AND COMMUNICATIONS

POWER SUPPLIES

Direct Battery (to PCM)

The direct battery feed to the PCM originates at the Power Distribution Center (PDC). It is used by the PCM for a few different purposes. First, it is used to retain certain information after the vehicle has been turned off, such as DTCs, OBDII data, etc. 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.

Ignition Feeds (to PCM)

The PCM also receives one of three ignition-fed sources of voltage from the ignition switch while in the OFF, RUN and START positions. In the OFF and RUN positions, the ignition feeds act as a wake-up signal the PCM. This signals the microprocessor to turn on the 5-volt power supply. In the START position, the ignition feed signals the TCM not to perform diagnostics on certain circuits in order to prevent errors that may occur because of voltage fluctuation.

Switched Battery Voltage / ASD (to PCM)

When energized by the PCM, the ASD relay will supply voltage to various circuits including:

- Fuel injectors
- Short Runner Valve
- COP ignition coils
- Capacitors
- PCM

The ASD relay outputs three voltage feeds to the PCM. Like 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, this source of voltage is also used:

- To power the high-side driver circuits
- To allow the engine to keep running in the event direct battery power is lost. However, the vehicle will not start without a direct battery feed.

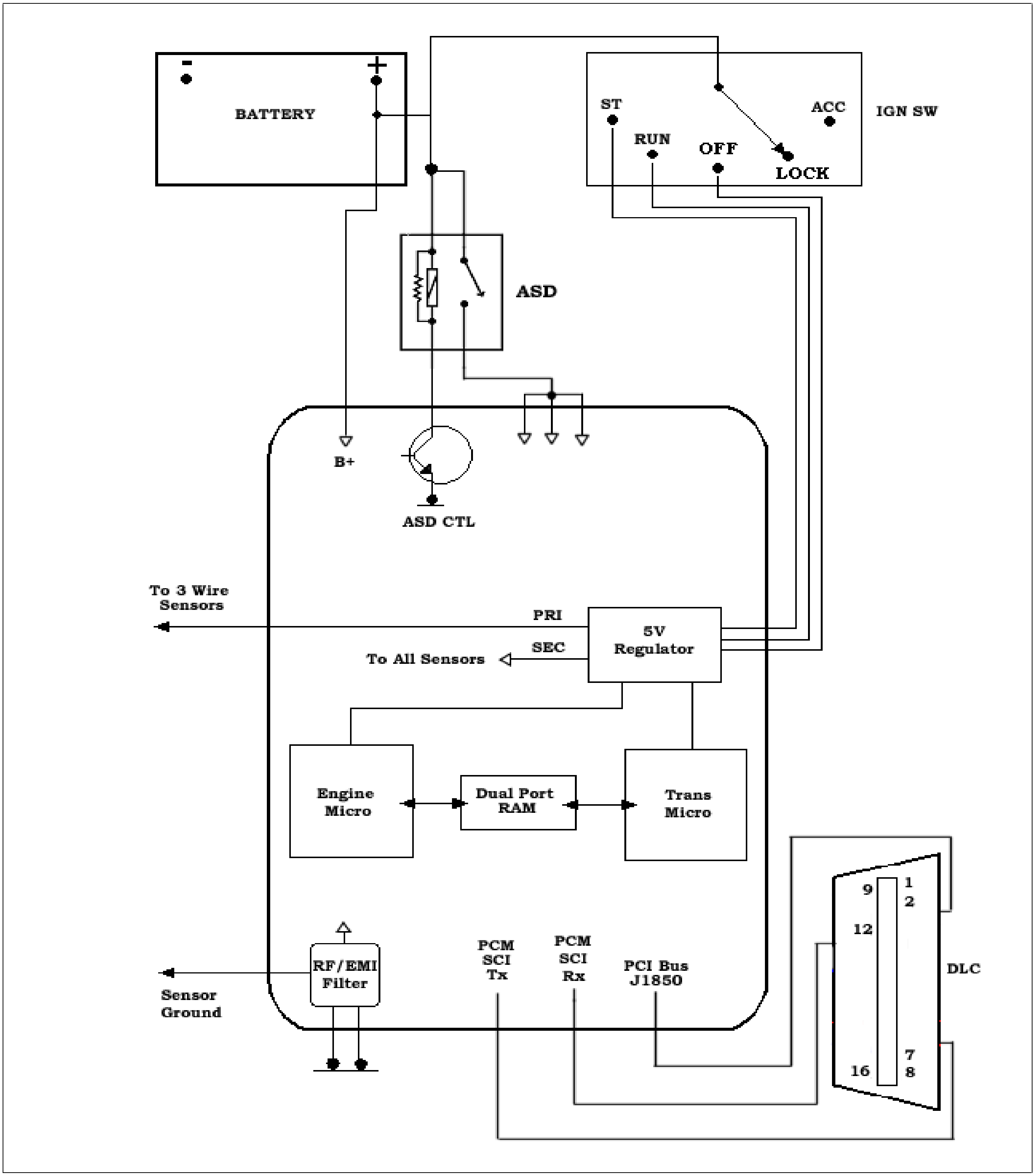


Figure 6 Power and Grounds (Engine control shown)

5 Volt Regulated Power Supply (from PCM)

The PCM utilizes the direct battery feed to power a 5-volt regulator, which supplies Primary and Secondary voltage feeds to power and bias the sensors and switches. This is similar to the previous JTEC vehicles. However, unlike JTEC, this is a 5-volt power supply and not a 5-volt transformer. SBEC vehicles had both an 8-volt and a 5-volt regulator.

On the 2002 LH, all 3-wire sensors are powered directly by the Primary feed. The Secondary feed supplies the bias for the signal circuits. It is up to each platform's discretion on how they apply the Primary and Secondary 5-volt feed circuits, so the LH configuration may not be typical.

The 5-volt regulator is protected from shorts to ground, and is self-recovering. Unlike SBEC and JTEC vehicles, cycling the ignition is not required for the 5-volt supply to recover.

Upon shutdown, the internal, as well as the external 5.0V power supply stays alive for ten minutes. All the sensors during this time will remain powered-up until the PCM goes into sleep mode. But even in this mode, a small section of memory will stay alive to monitor the NVLD switch for closure. This will be discussed in depth in the emissions module of the course.

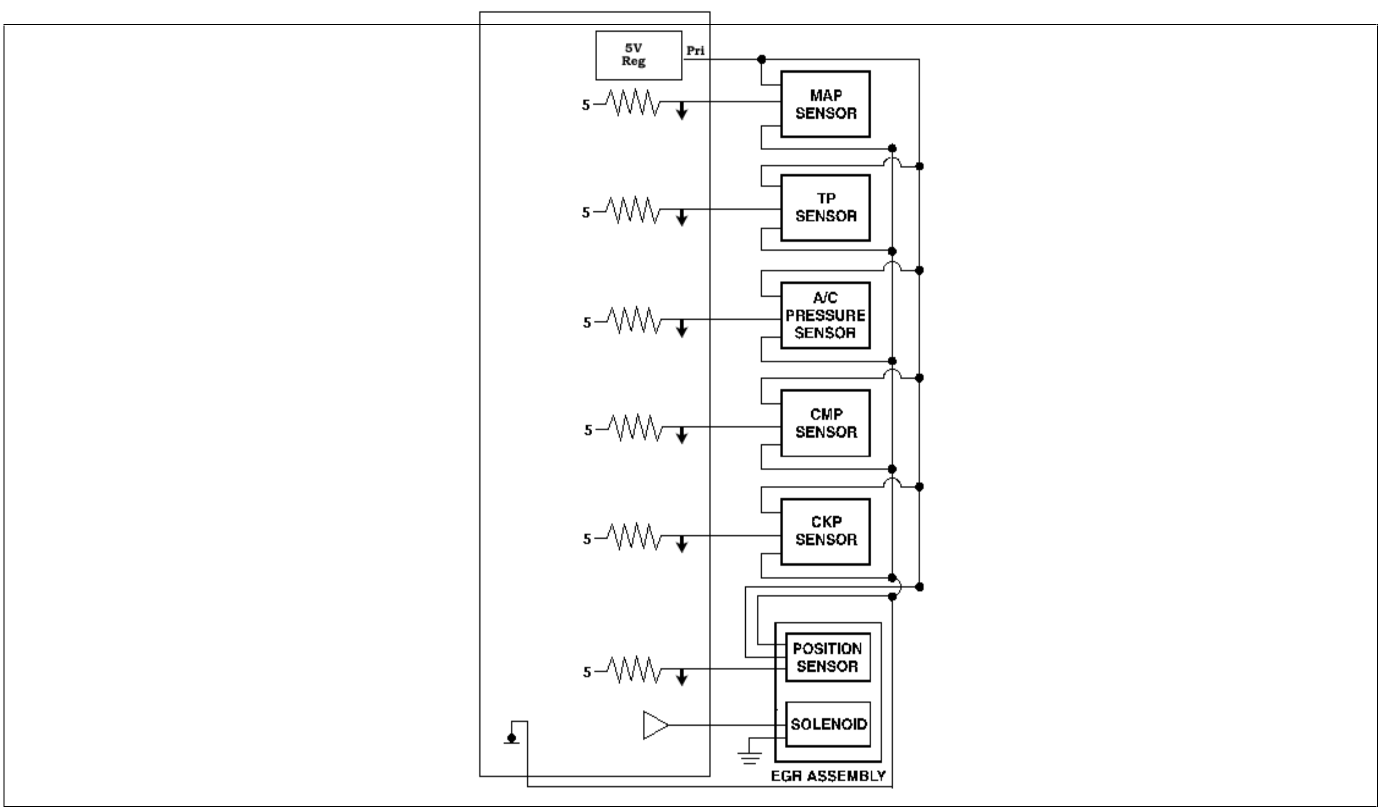


Figure 7 5-Volt Power Supply

GROUNDS

Chassis Grounds and Sensor Ground

There are two chassis grounds that run to the PCM for use by the engine control microprocessor, and three grounds for use 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. Additionally, the grounds are run through 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 side is biased to supply 2.50 volts on the sensor return side of the circuit, instead of having a path to ground. This circuit will be discussed in detail in the input section of this publication.

COMMUNICATION PROTOCOLS

Internal via Dual-Port RAM

The first thing to think about when we discuss communications is the internal communication that occurs between the ECM and TCM microprocessors via the dual-port RAM chip. This dual-port RAM chip allows the two microprocessors to directly share high-speed digital information internally without having to rely on the PCI BUS for all communication. There are some signals, however, that do occur over the PCI BUS. These are for the most part slow-changing analog signals. All high-speed communications occur internally in the PCM.

PCI Bus (J1850)

The Programmable Communication Interface (PCI) Bus, also know as the J1850 Bus, is used for communication between the PCM and other modules. This single-wire communication protocol is additionally 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.

SCI Bus

The Serial Communication Interface (SCI) Bus is the communication protocol used to enable 2-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. The SCI Receive (SCI Rx) is used for flash programming of either the PCM or TCM.

J1962 DLC Connector

Chrysler Group vehicles are beginning to switch over to a new J1962 connector layout to comply with the revised specification made by the SAE. This change is required to plan for the introduction of the Controller Area Network (CAN) bus in the future. Pins 6 and 14 were originally designated as "manufacture specific" by SAE, but have been recalled to be used for the CAN bus. This has forced a relocation of the SCI circuits that were previously assigned to these terminals. The 2002 LH, AN, DN and DR vehicles are the first vehicles to get this change. More models will be added each year. Please take note that this is NOT an NGC specific change.

PCM REPLACEMENT AND FLASH PROGRAMMING

PCM Replacement

Anytime the PCM is replaced, the procedure in the Service or Diagnostic Procedure Manuals must be followed closely. A partial list of high-level tasks that must be completed after replacement are:

- Program the VIN. If the vehicle is equipped with the Sentry Key Immobilizer System (SKIS), this programming **must** be done via the SKIM module
- If the vehicle is equipped with a fully electronic automatic transmission or transaxle, (41TE/42LE/45RFE, etc.) the pinion factor must also be programmed into the transmission control module.

Flash Programming

The TCM and PCM sections of the NGC controller are independent of each other, and will be accessed separately when accessing with the DRBIII®. When it comes to Flash Programming, the PCM can be flashed separately from the TCM. However, when the TCM is flashed, the PCM is automatically flashed as well. This is because the PCM is responsible for storing the new part number.

One additional note: 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.

Powertrain Control Module Info

2002 LH 3.5L V6 SFI
Natural Asp, Unleaded Fuel
50 State Only
Automatic Trans, FW Drive
Chrysler Engine, NGC1 2P05V16.1
Two Fans, Two Speed
PCM Part#: 04606683AG.**02**
Homologation ID:
CARB OBD II Vehicle

Figure 8 PCM Module Display Screen

ACTIVITY 1 PCM HARDWARE, POWER AND GROUNDS

1. Visually identify which of the two possible controllers is installed on the classroom vehicle: ☐ Huntsville ☐ Motorola
2. Using the DRBIII®, access the Module Display screen.
3. What is the year that is displayed? ______________________
4. What is the source of the displayed year? ______________________
5. What emission package is the vehicle equipped with? ______________________
6. How does the PCM's part number differ from previous controllers? __________

   ____
7. Access the DRBIII® Sensor Display menu. Record the following information and significance of each item:

   Time from Start to Run: ______________________

   Ignition Off Time: ______________________
8. Access the DRBIII® Input/Output Display menu. Record the following information and significance of each item:

   ASD Relay Sense: ______________________

   Ign Start Sw Sense: ______________________

   Ign Run Sw Sense: ______________________
9. Cycle the ignition switch to the lock position. Unplug the TPS and MAP sensors. Using an applicable service manual for the vehicle, identify the 5V power supply to both the TPS and MAP sensors. Using a DMM, record the voltage on these circuits:

   TPS Voltage ______________ MAP Voltage ______________
10. Explain your measurements: ______________________

    ____
11. Using the service manual, locate and record the following information applicable to the PCM's C1 connector. Note that this information applies to the PCM microprocessor only, and not to the additional information that supplies the TCM microprocessor.

    Disconnect the PCM's C1 connector, and install Miller Tool #8815 Pinout Box.

    Using a DMM, record the values in the Measurement column below observing the proper position of the ignition switch:

NGC (PCM Only) Power / Ground / Communications

Note: Check the following with the ignition switch in the appropriate position.

C1 / Cavity	Circuit Number/ Color	Function	Measurements
		Ign. Run/Start	V
		Ign. Off/Run/Start	V
		Ign. Start	V
		Fused B+	V
		Ground (PCM)	Ω to B-
		Ground (PCM)	Ω to B-

12. Using an applicable service manual, locate the sensor ground circuit:

Sensor Ground

C2 / Cavity	Circuit Number/ Color	Function
		Sensor Ground

13. What is the significance of the sensor ground circuit? ______________________

____

14. What circuits are not supplied with a sensor ground that previously were with SBEC and JTEC systems? ____

15. Using a service manual, locate the ASD Relay feeds to the PCM:

PCM ASD Feeds

C3 / Cavity	Circuit Number	Color

16. In addition to being used as a power source for the high side drivers and as a diagnostic input to the PCM, what other function does the ASD relay have?

____

17. Your instructor will now demo the use of Miller Tool #8638 Terminal Removal Tool.
18. After a PCM is replaced, what procedures need to be performed and how?

    a. ____

    b. ____
19. Using an applicable service manual, identify the 5V power supply to either the CMP or CKP sensor. Back probe this wire at the sensor and jumper to ground. Attempt to start the vehicle, leaving the key in the "ON" position. Does the vehicle start? ☐ Yes ☐No
20. Remove the jumper and attempt to start the vehicle. Do not cycle the key. Did the vehicle start? ☐ Yes ☐No
21. How does this differ from the circuit protection strategy used in SBEC or JTEC vehicles? ____

PCM INPUTS: SENSOR AND SWITCH

The PCM receives input from many sensors and switches. These inputs are used to calculate different operating conditions that will influence the PCM's decision-making processes, as well as provide feedback on specific conditions. Inputs can take the form of a sensor (analog) input, or of a switch (digital) input. To define these terms further, 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 an ON/OFF signal to the PCM.

DIGITAL INPUTS

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

Like previous SBEC and JTEC models, the CMP and CKP sensors are hall-effect switch inputs to the PCM. The CKP sensor is used to identify the position of the crankshaft, and is the primary input for determining when to inject the fuel and fire the ignition. The CMP sensor is used to identify which cylinder should be receiving the fuel and spark. The CMP and CKP sensors on NGC vehicles have been designed with much closer tolerances than ever before, to increase misfire detection accuracy.

Each hall-effect switch is a three-wire sensor. One wire, which is common to both CKP and CMP sensors, is the five-volt power supply, which is required to power the internal electronics. Each sensor will also share a common sensor ground wire. The remaining wire on each sensor is an individual signal wire. The purpose of the hall-effect is to toggle the five-volt signal that is sent out from the PCM to ground. Based on these toggling signals, 5.0V – 0.0V, the PCM can identify engine position and TDC.

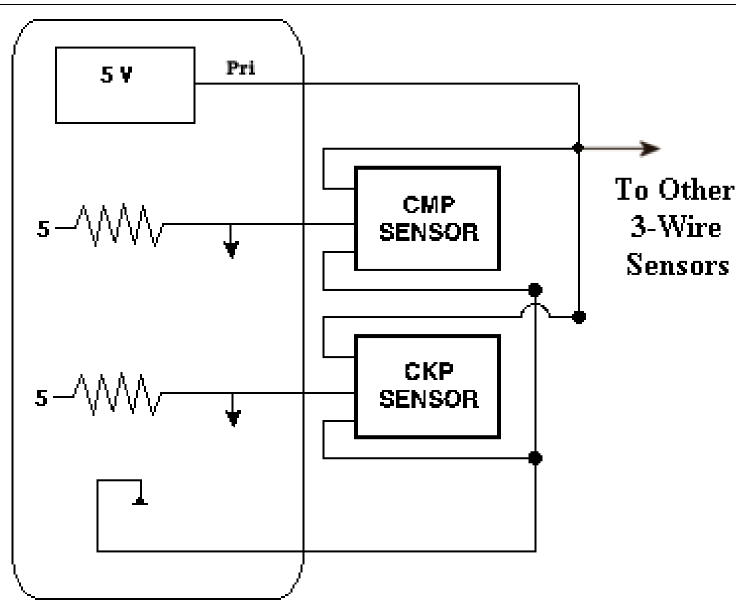


Figure 9 CMP and CKP Sensors

The engine is capable of starting if one of these two sensors fails. Like the 4.7L on previous JTEC vehicles, 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 the start time, until the PCM can establish sync.

As we discussed earlier, one of the goals of NGC is commonality among all vehicle lines. Engineering needed to decide on a benchmark that would be used for all applications. One example of this is with the signals generated by the CMP and CKP sensors. All vehicles, regardless of the number of cylinders, will generate the exact same CKP signal. The triggering device, whether it be a flexplate or tone wheel, will have a tooth or notch every 10° of crankshaft rotation except for two missing notches and two fused notches which are 180° apart. When performing oscilloscope diagnosis, all NGC CKP sensor patterns will be identical among all vehicles and engines. For the reasons above, it is important that the correct components are installed in an NGC vehicle. Flexplates or trigger wheels are not interchangeable with SBEC or JTEC vehicle applications.

Figure 10 Typical CKP Trigger (LH shown)

Figure 11 Typical CKP Scope Patterm (all vehicles)

The engineering community also benchmarked the CMP triggers. Due to the different number of cylinders, however, four, six and eight cylinder engines 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 12 Typical 6 Cylinder CMP Triggers (2.7L / 3.5L shown)

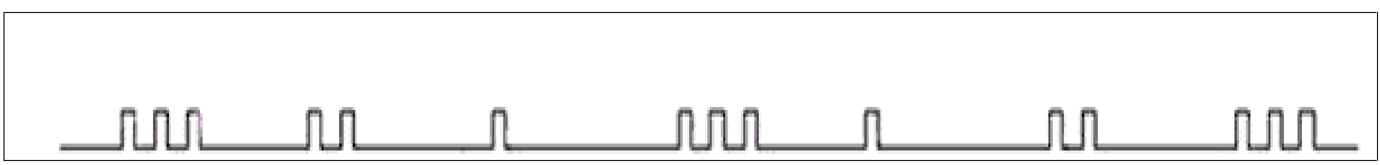


Figure 13 Typical V-6 / Inline 6 CMP Scope Pattern

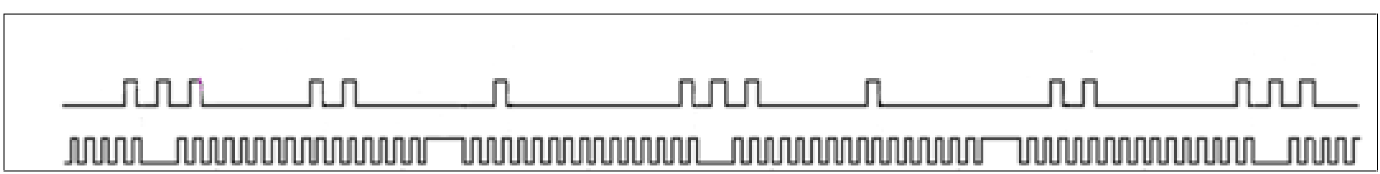


Figure 14 Typical CMP / CKP Scope Patterns (Superimposed)

DIGITAL INPUTS CON'T.

Vehicle Speed

- 41TE / 42LE Transmissions

  Vehicle speed is communicated directly between the engine and transmission microprocessors via the dual-port RAM chip. The TCM micro is responsible for generating 8,000 pulses per mile VS signal to the ECM micro.

- Manual Transmission / 3-speed Automatics with Hall-Effect VSS

  The operation of the hall-effect VSS is similar to the CMP and CKP signals, in that a five volt signal, originating in the ECM, is toggled to ground by the VSS at a rate of 8,000 pulses per mile.

- All Other Vehicles

  Vehicles that use the ABS system to generate a speed signal, work similar to the hall-effect type of VSS. The PCM outputs a five-volt signal, which is toggled to ground by the ABS control module (CAB) 8,000 pulses per mile.

Other Digital (Switched) Inputs

The following list of PCM inputs will be fed battery voltage by the PCM, and will be toggled to ground as the switch state changes. Some of these inputs will be normally grounded (brake switch) while others will be normally open:

- A/C Request
- Clutch Up-stop Switch
- A/C Select
- Brake Switch
- Power Steering Switch
- Brake Fluid Level
- NVLD Switch

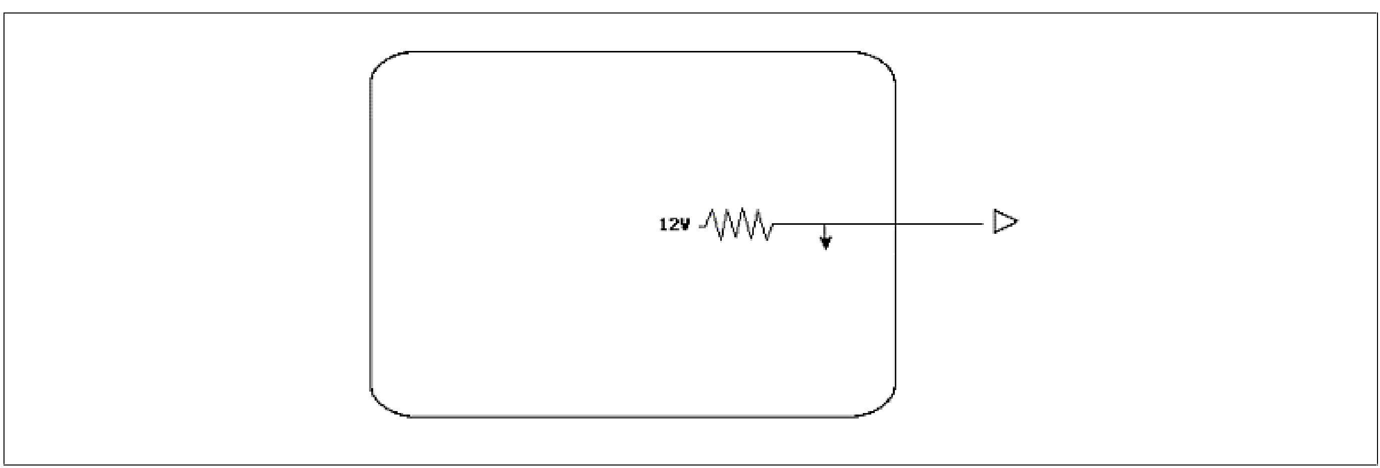


Figure 15 PCM Digital (Switched) Inputs

ANALOG (SENSOR) INPUTS -- THREE-WIRE

Unlike the digital inputs just discussed, the analog inputs to the PCM will provide the PCM with a variable voltage signal, representative of the condition they are monitoring. The analog inputs can be broken down into two classes of inputs. The first is the three-wire sensors that are fed a common five-volt power source, a specific five-volt bias signal, and the common sensor ground. The only exceptions are the oxygen sensors and knock sensor which all have dedicated sensor return paths. All analog input voltages from the sensors are measured relative to sensor return 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.

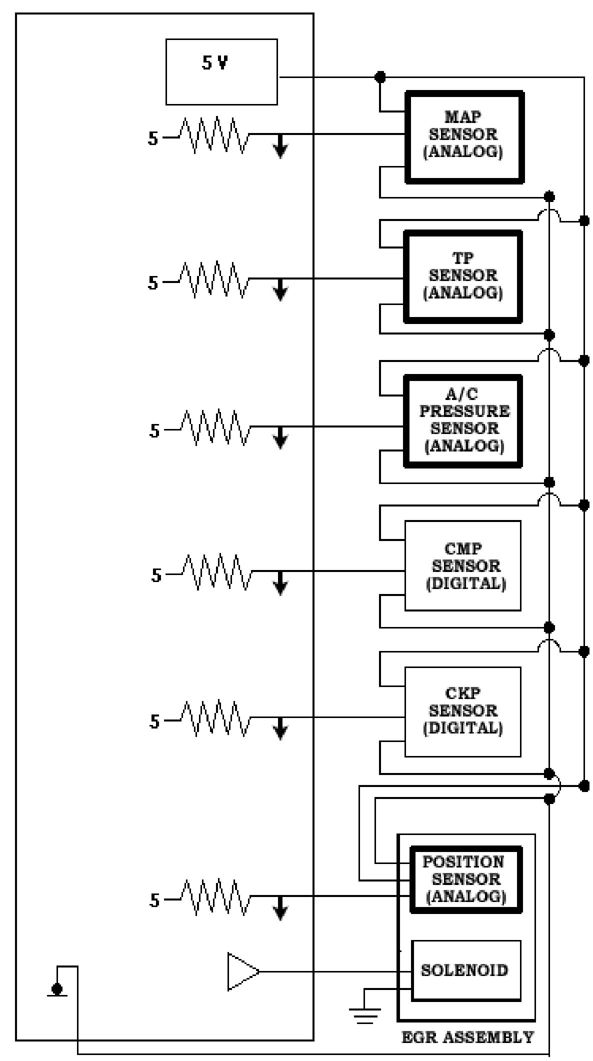


Figure 16 Three-Wire Analog Sensors (plus CMP & CKP)

Manifold Absolute Pressure (MAP) Sensor

NGC vehicles are equipped with the Next Generation MAP sensor. This new MAP sensor has a wider operating range than sensors used in the past, resulting in higher and lower voltages before setting a fault. The MAP sensor is the most important input to the PCM for determining the injector pulsewidth. Minor calibration errors can make a tremendous difference in the final pulsewidth.

Keeping this fact in mind, NGC vehicles initially calculate what the MAP value **should be** by estimating its value based on throttle position, barometric pressure and IAC position. The MAP sensor input is used to validate the calculated value. This is part of the “Model-based Fuel” strategy we mentioned a little earlier. This calculated MAP value is also known as TMAP (throttle MAP, not the combination IAT/MAP). This TMAP value is used by the PCM because there is always a slight lag in response on the real MAP sensor. It takes time for the reciprocating masses inside the engine to get up to speed, resulting in a lag time in generating a true MAP value. TMAP allows the engine to respond immediately to changes in the throttle opening.

Throttle Position (TP) Sensor

The throttle position sensor is a standard, 3-wire potentiometer that has been used on previous vehicles. There is a possibility that NGC vehicles may begin to see a new hall-effect TPS, similar to the sensor introduced on the 3.7L Liberty and DR trucks. The TPS is responsible for determining calculated MAP (TMAP), idle position (Min TPS), acceleration, wide open throttle (open loop and clear-flood mode) and adjusting the pulsewidth according to these changing requirements. When observing the Calculated TPS value on the DRBIII® while in limp-in, the TPS will track as if there were no problem with the circuit. In limp-in mode, the TPS calculation will be based on RPM and MAP values.

A/C Pressure Transducer

The A/C pressure transducer is a standard, 3-wire pressure transducer used on previous models. The A/C pressure transducer is responsible for monitoring the A/C discharge pressure, which will be used by the PCM for idle speed control, cooling fan operation, and A/C inhibit. Like previous models, the voltage generated by the sensor is almost a 1:1 ratio to the A/C discharge line temperature. For example, 2.75 volts = Approx. 275° F.

EGR Valve Position Sensor

The EGR position sensor is a linear potentiometer responsible for providing feedback to the PCM regarding how far the EGR valve is open. This sensor is part of the Linear EGR Valve assembly, and is carryover from previous models.

ANALOG (SENSOR) INPUTS - TWO-WIRE

All 2-wire sensors receive a specific five-volt bias signal from the PCM, and a common sensor ground. 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. This will be discussed further under the heading of oxygen sensors.

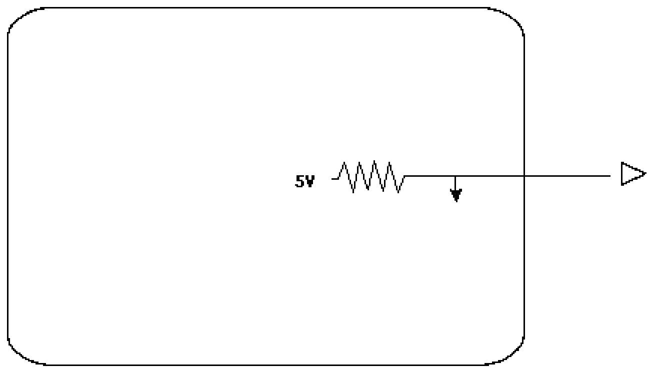


Figure 17 Two-Wire Analog Inputs

NTC Thermistors

An NTC thermistor has a high resistance value when cold, resulting in a high sensed voltage by the PCM. As the thermistor warms up, the resistance value decreases, resulting in a lower voltage sensed by the PCM. The following is a list of the NTC thermistors used on NGC vehicles:

- Engine Coolant Temperature (ECT)- used to modify the injector pulsewidth, enable OBDII monitors and to control cooling fan operation. Its biggest influence on the pulsewidth occurs at cold engine, key-on. After the vehicle has started, it loses some of its influence on the pulsewidth. The PCM uses the IAT temp as a limp-in value.
- Inlet Air Temperature (IAT)- used to modify injector pulsewidth and to enable OBDII monitors. Its biggest influence on pulsewidth occurs during extreme cold, wide-open-throttle conditions. It is also used as a backup to ECT in case of failure. The PCM uses Ambient/Battery temp as a limp-in value.
- Ambient or Battery Temperature- used to enable OBDII monitors and to control charging system target voltage. It is also used as a backup to the IAT in case of failure. The PCM uses a default value of 68° F as a limp-in value.

Like JTEC but unlike SBEC, all NTC thermistors are single-range sensors.

Knock Sensor

All NGC vehicles use a wide band knock sensor. This piezo-electric sensor will generate a frequency proportional to the level of engine detonation. The two wires that run to the knock sensor are twisted three times per inch in order to minimize EMI and RFI. The knock sensor has a dedicated sensor ground that is not shared with any other input.

Fuel Level

The fuel level is not a direct input to the PCM on LH vehicles, but is a PCI Bus input from the Body Control Module (BCM). Some applications in the future will use the fuel level sensor as a direct input. The method used will vary from one vehicle to the next. The three methods that are planned are:

- Indirect input via the PCI Bus
- Direct input from the fuel level sensor to the PCM – current monitored
- Direct input from the fuel level sensor to the PCM – monitored 5-volt bias circuit

Proportional Purge / Linear IAC Sense

Even though these are both output devices, they are monitored by the PCM and can be considered indirectly as an input. Both of these output devices are high side controlled by the PCM, with the PCM also supplying the ground. The groundside of the circuit is monitored by the PCM to determine the position of both devices.

Speed Control Multiplexed (MUX) Input

The cruise control switches are connected to the PCM via a single input. Each switch has a pull down resistor associated with it. When the switch is pushed a voltage division is created with the pull-up resistor in the Powertrain Control Module. This voltage is read via an analog to digital converter (A2D). The voltage is then compared to determine which state the switch is in.

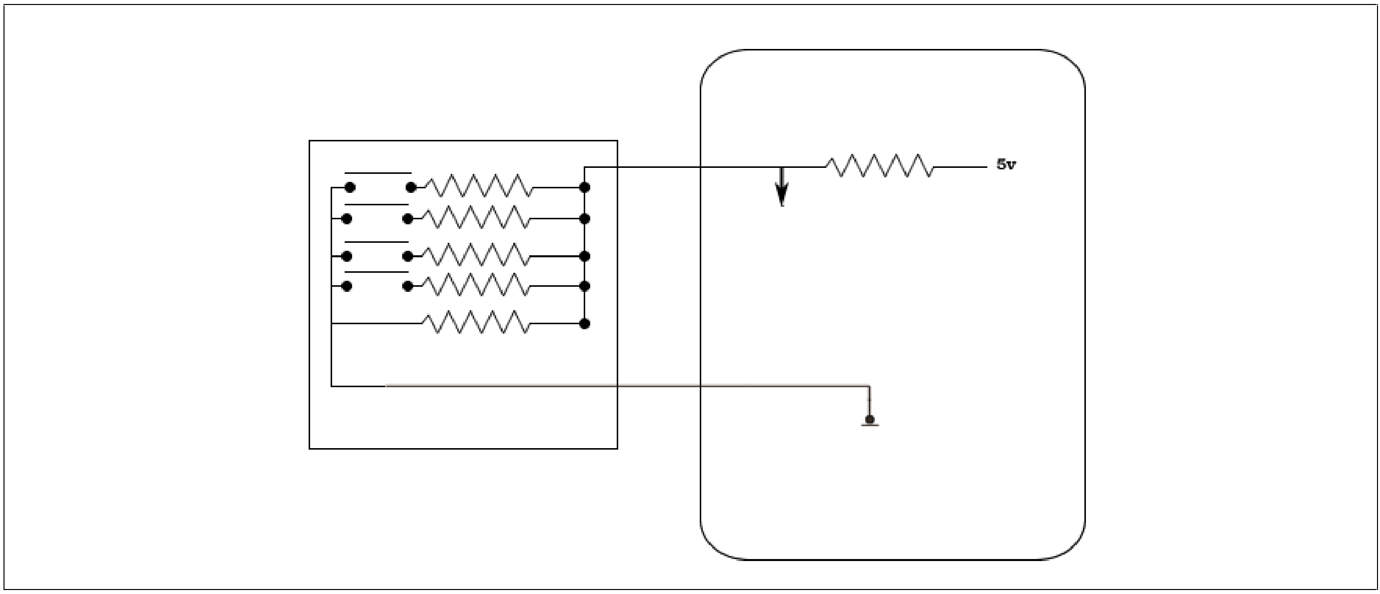


Figure 18 Integrated Cruise Control MUX Switches

By knowing what the divided down voltage is when a switch is activated, the state that is appropriate for that switch (i.e. resume, set, etc.) will be set. The range of voltages is listed in the following table:

Table 1 Integrated Cruise Control MUX Switch Voltages

Switch	Min/Max Voltage Range
Resume / Accell	3.89V – 4.19V
Set **or** Set / Coast	3.17V – 3.57V
Coast	2.55V – 2.95V
Cancel	1.60V – 2.00V
On / Off	0.60V – 1.15V

Heated Oxygen (O_2) Sensors

The heated O_2 sensors are a standard, zirconium dioxide oxygen sensor that generate a voltage signal between 0.0V – 1.0V. However, when this signal is monitored on the DRBIII® or with a voltmeter, 2.5V – 3.5V will be observed. This is a result of biasing the sensor return to 2.5V. This was done to prevent the O_2 sensor voltages from inverting, going below 0.0V, resulting in a possible open-loop condition that could occur under the following conditions:

- 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)

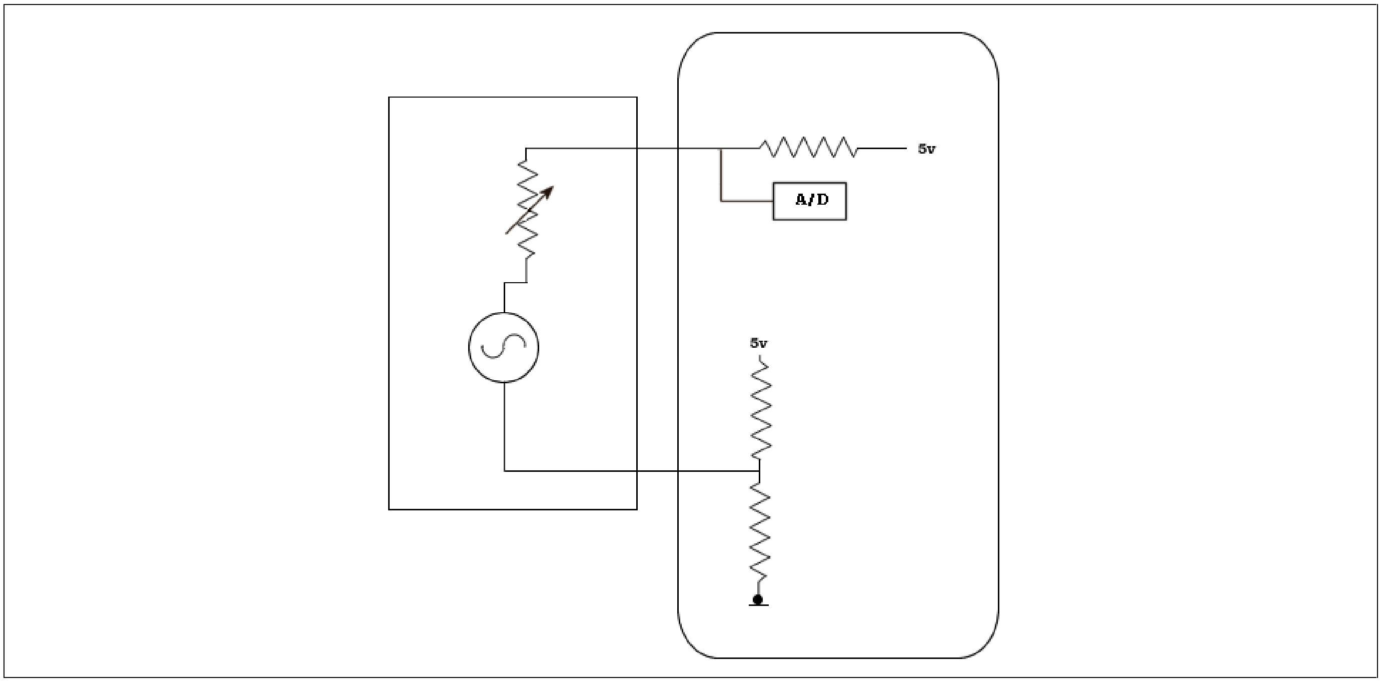


Figure 19 O_2 Sensor Signal Circuit

Like the SBEC and JTEC systems it replaces, the NGC fuel system is dependent on the O_2 sensor to verify 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. At 14.7:1, the O_2 sensor voltage will be fluctuating between 2.50V and 3.5V. When the O_2 sensor is detecting excessive oxygen, the voltage will be closer to 2.50V, while a lack of oxygen will result in a voltage reading closer to 3.50V.

Depending on the vehicle's emission calibration, vehicles may be equipped with multiple upstream and downstream O_2 sensors. As previously described, the upstream O_2 sensors are used by the PCM to verify that the proper fuel ratio is being maintained. Most current production vehicles control both banks of cylinders independently of each other.

The downstream O_2 sensor signals are compared to the upstream O_2 signals to verify proper catalytic converter efficiency. Anytime the upstream to downstream switching ratio exceeds a predetermined value, a catalyst efficiency fault will be stored. The downstream O_2 sensors are also used by the PCM to "trim" the upstream O_2 sensor goal voltage. The upstream goal voltage, also known as the switching point, is used to ensure long catalytic converter life by allowing the PCM to control the amount of air and fuel (CAT Food) that is supplied to the catalytic converter.

O_2 Sensor Heaters

The O2 sensor heaters help get the sensors up to operating temperature quickly after a start, and to maintain the temperature that is most efficient for proper operation. The O2 heaters will be discussed in detail in the output section of this publication.

ACTIVITY 2 PCM INPUTS

1. Disconnect the CKP sensor and attempt to start. ☐ Yes ☐No
2. Disconnect the CMP sensor and attempt to start. ☐ Yes ☐No
3. Explain your observations and the results: ______________________________

   ____
4. With either the CMP or CKP sensor disconnected, raise the engine RPM until fuel cutout occurs. What is the maximum limp-in RPM value for a failed CMP or CKP sensor? ___________________________RPM
5. Clear all DTCs from memory.
6. Disconnect both CMP and CKP sensors. Crank engine for 10 seconds and check for DTCs. Are any DTCs stored? ☐ Yes ☐No
7. How does this differ from the strategy used by SBEC and JTEC controllers?

   ____
8. Using a service manual, identify the CMP and CKP signal circuits. Using the menu option for 5V Square Waves, setup the DRBIII® as a Lab Scope to record both CMP and CKP sensors.
9. While observing the CMP and CKP patterns, can you determine why the vehicle is able to start with only a CMP or a CKP input? __________________________

   ____

   ____
10. Access the Sensor Display Menu of the DRBIII®. Display the 1/1 and 2/1 oxygen sensor voltage values and record their readings:

    1/1 __________ to __________ 2/1 ___________ to ___________
11. Unplug one of the upstream oxygen sensors. Using the service manual, locate the oxygen sensor signal return wire. With the ignition key in the "Run" position, measure the voltage on the sensor return circuit on the harness side of the connector: _______________ volts.
12. How does this reading differ from what you would see on an SBEC or JTEC vehicle? ____
13. Using insulated DMM leads, connect the DMM to the oxygen sensor signal and signal return pins at the oxygen sensor. Start the engine, raise to 1200 RPM, observe the readings and record: ___________________________________
14. How does this reading differ from what was seen on the DRBIII®? ___________

    ____

15. Why? ____
16. Raise RPM to about 1200 RPM, unplug the MAP sensor and record the limp-in value: ____
17. Reconnect the MAP sensor. Unplug the TP sensor and record the limp-in value: ____
18. How does this limp-in value differ from SBEC and JTEC vehicles?

    ____
19. Slowly open and close the throttle while the TP sensor is disconnected. Does the voltage change smoothly with the sensor disconnected? ☐ Yes ☐No
20. Explain your results: ____

PCM CONTROLLED OUTPUT DEVICES

The NGC control module may use either a high-side or low-side driver to control the 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 the 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.

LOW SIDE CONTROLLED DEVICES

Ignition Coils

All NGC-equipped vehicles utilize Coil-On-Plug ignition systems. Each individual ignition coil is supplied voltage by the Automatic Shutdown (ASD) relay and controlled by a low side, pulsewidth modulating driver. A capacitor is wired in parallel to the circuit to prevent RFI.

Like previous LH vehicles equipped with the SBEC controller, the PCM is capable of varying the 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.

A unique feature on passenger car and minivan applications is that the PCM is able to store ionization DTC's for each cylinder. If the spark duration (primary circuit firing line) is above or below specs, a fault will be stored. This is accomplished by monitoring the coil's primary circuit current flow.

NOTE: As of the date of this publication, trucks and Jeeps are NOT equipped with variable dwell.

NOTE: During diagnosis and testing, it is extremely important to use a commercially available Spark Tester to test for spark or cylinder misfire. Do NOT fire a coil into open air, or PCM driver failure will result!

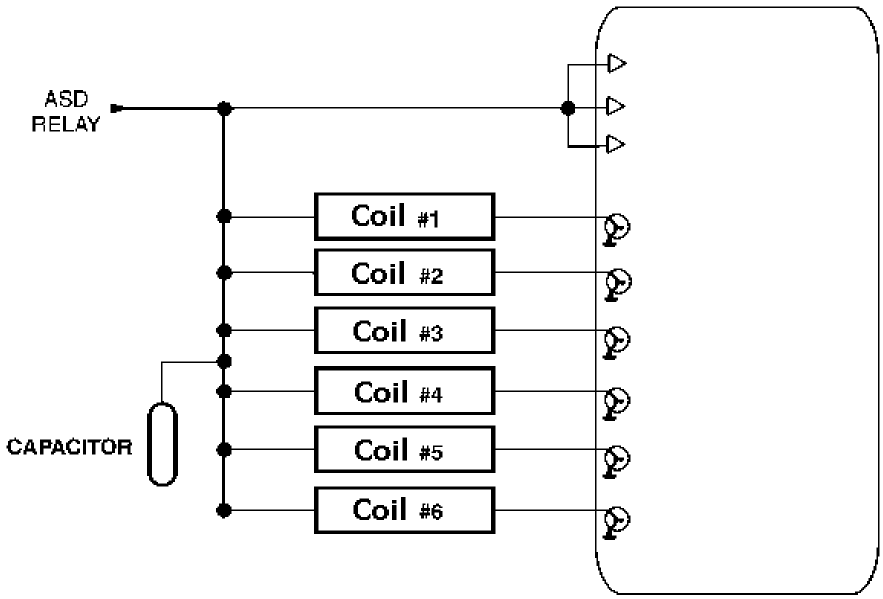


Figure 20 Ignition Coil (COP) Circuits

Injectors

All NGC engines use 12 ohm, top feed injectors. The ASD relay supplies voltage to the injectors, while the PCM controls the injectors using a low side, pulsewidth-modulating driver. All injector circuits are clamped to 62.0V to prevent damage from inductive kicks. A single capacitor is wired in parallel to the injectors to prevent RFI.

Unique to NGC is a “Triple Shot” strategy of injecting fuel. This strategy allows fuel to be delivered to the engine earlier than with other systems, but at the same time allows late fuel delivery, if needed, depending on the engine’s changing requirements. A fraction of the total working pulse width is delivered to the engine in three different pulses during each cylinder's firing event. Since the fuel is delivered this way for each intake stroke, it is possible to stop injection by eliminating the second or third pulse if a “change mind” tip-out of the throttle occurs. This results in better fuel economy and lower emissions.

The first pulse is delivered right after the intake valve is closed, starting the combustion process, but is not large enough to cause a rich mixture in the event of throttle tip-out. This is very similar to pilot-injection on some diesel engines. The second pulse of the remaining fuel is delivered just before the intake and exhaust valve overlap period. If a tip out occurs after the second pulse is delivered, the cylinder will be slightly rich. If a tip in occurs after the second pulse, the extra fuel needed is calculated then delivered in a third pulse - while the intake valve is open.

This "Triple-Shot" strategy cannot be seen on the DRBIII® or even a lab scope due to the refresh rate of these devices. Think of it this way, each injector will fire 30 times per second at idle speed. There is no possible way of monitoring this phenomenon at this fast a rate.

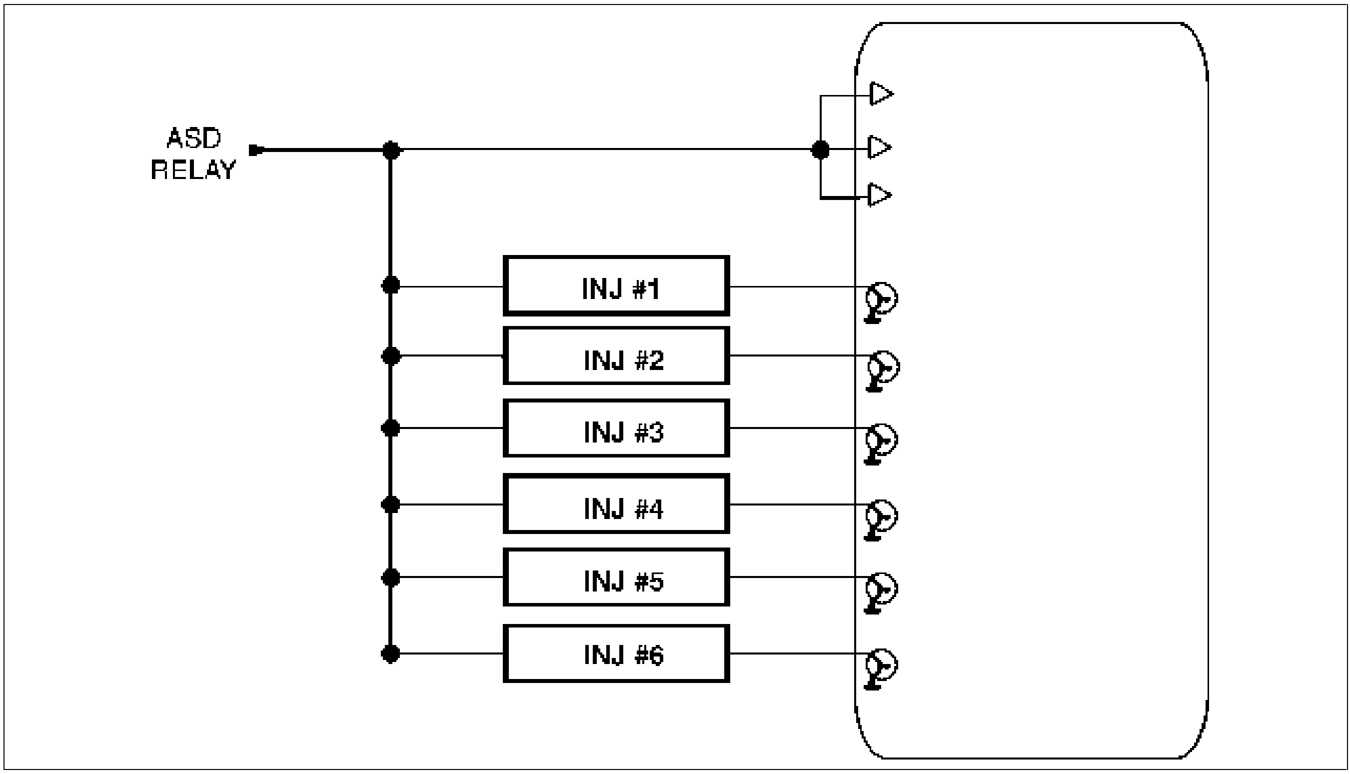


Figure 21 Injector Control Circuits

Basic Octal Serial Switch (BOSS) Outputs

The NGC controller contains two IC chips, which function as low side, latching (always on) drivers to control various low-current devices such as relays and solenoids. Each BOSS IC is capable of controlling **eight** low-side controlled devices, and is clamped to 53V per device. Not all circuits are currently used, but as new features are added to the NGC, both IC1 and IC2 will be fully utilized.

Table 2 Low-Side BOSS Outputs (2002 LH Shown)

IC1	IC2
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

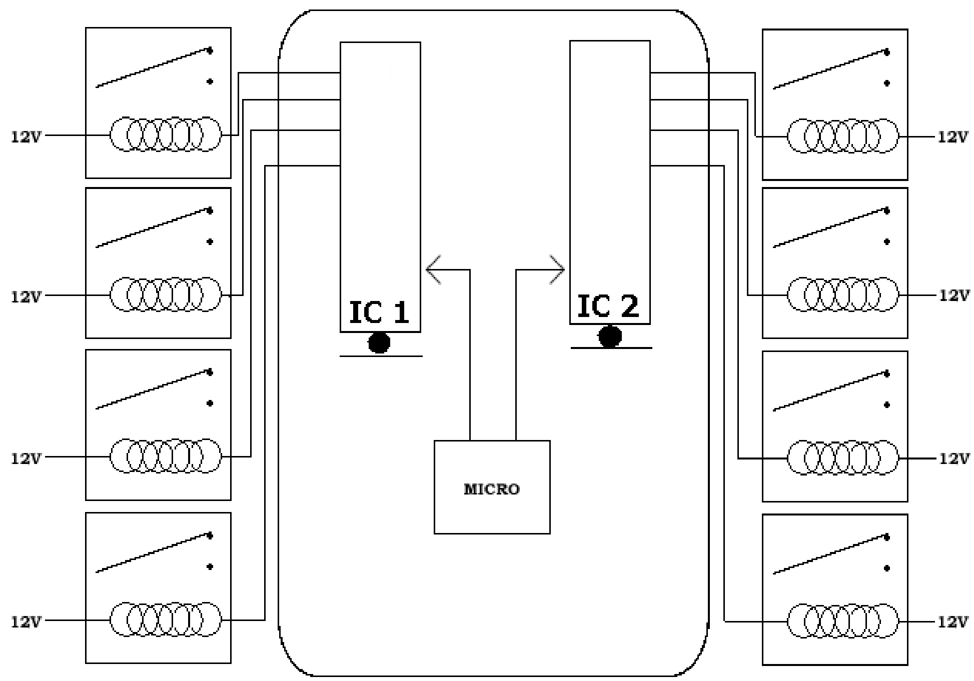


Figure 22 BOSS Output Control

Short Runner Tuning Valve (SRTV)

The short runner-tuning valve is used on vehicles equipped with an active intake manifold. Its purpose is to optimize the intake runner length to increase **horsepower** at high RPM. It accomplishes this by opening passageways that will allow the shortest path possible 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. Unlike previous models, the SRTV is now controlled electrically instead of by vacuum.

HIGH SIDE CONTROLLED DEVICES

As previously discussed, high-side drivers are used to control high-current devices. Though low-side drivers can control high-current devices, it is extremely difficult and expensive to place these drivers onto one integrated circuit chip. Either a Dual High Side Switch (DHSS) or a Quad High Side Switch (QHSS) is used to control all high-side controlled devices. 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 Speed Control (LSIAC) and Proportional Purge Solenoid (PPS) have their ground connection made by the PCM. In these cases, the PCM also monitors the ground circuit to determine the position of the device.

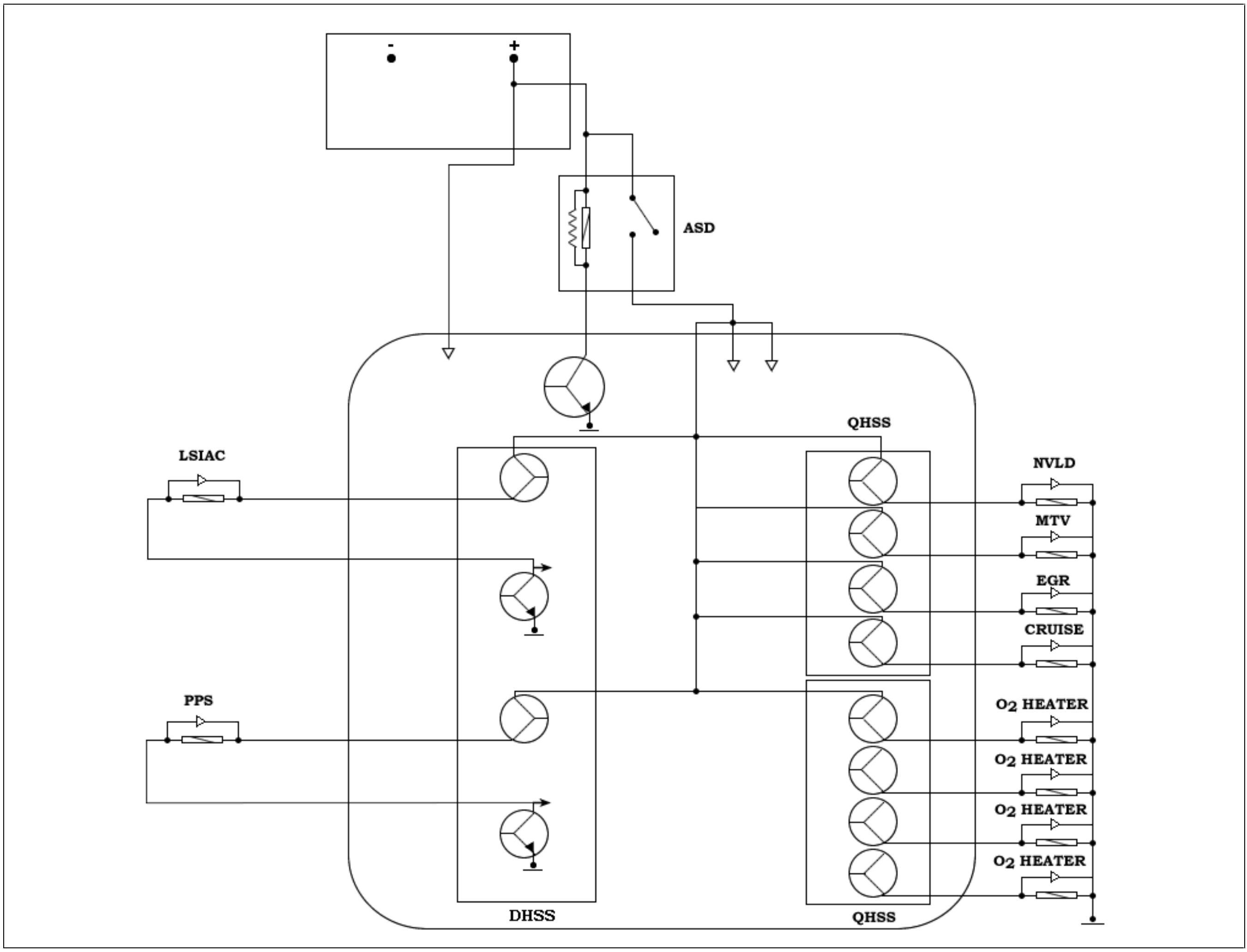


Figure 23 High Side Controlled Outputs

Proportional Purge Solenoid (PPS)

The PCM supplies a high-side duty-cycle of 0-60% @200 Hz. to control the Proportional Purge Solenoid. The PCM is also responsible for providing a path to ground for the circuit. The current flow on this ground is also monitored to determine the position of the PPS. The PCM compares the target current flow against the actual current flow that is sensed, to determine PPS position. Purge flow is an integral part of the pulsewidth equation and will be discussed in detail later.

Linear Solenoid Idle Air Control Valve (LSIAC)

The PCM supplies a high-side duty cycle of 10-90% at 1.5 kHz - 2.5 kHz. Like the PPS, the PCM is also responsible for providing a path to ground for the circuit. The current flow on this ground is also monitored to determine the position of the LSIAC. The PCM compares the target idle speed current flow against the actual idle speed current flow that is sensed, to determine the proper position of the valve. The valve defaults to a closed position in case of malfunction.

Natural Vacuum Leak Detection Solenoid (NVLD)

The NVLD solenoid is controlled by a high-side driver, and is grounded externally of the PCM. NVLD will be discussed in detail later.

Manifold Tuning Valve (MTV)

Like the SRV discussed previously, the Manifold Tuning Valve is used on vehicles equipped with an active intake manifold. Its purpose is to optimize the intake runner length to increase torque at lower RPM. It accomplishes this by opening passageways that will allow a shorter path between the air inlet and cylinders. A high-side driver, with a ground external of the PCM, controls the circuit.

Speed Control Servo

The speed control servo's solenoids are fed battery voltage from a PCM high-side driver via the brake switch. The PCM is also responsible for controlling the servo solenoids by low-side drivers. Speed control will be covered in detail later.

Linear EGR Solenoid

The linear EGR solenoid is controlled by a 128 Hz., PWM high-side signal from the PCM, and grounded externally of the PCM. The linear EGR valve assembly also contains a linear potentiometer that provides feedback to the PCM.

Oxygen Sensor Heaters

The heated oxygen sensor circuits on NGC vehicles are controlled differently than SBEC and JTEC vehicles. The oxygen sensors on NGC vehicles are electrically heated 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.

Another unique feature of the NGC O2 sensor heaters is that their resistance 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 O2 sensor. The PCM uses this feedback to determine the proper level of PWM required to maintain the optimum temperature required for most efficient operation. 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 O2 heater circuit. The PCM then adjusts the PWM to achieve the proper current flow to maintain proper temperature.

The NGC also provides a 5-volt pull-up that is used to perform open circuit, short to ground and short to power diagnostics, when the heater is in an off state.

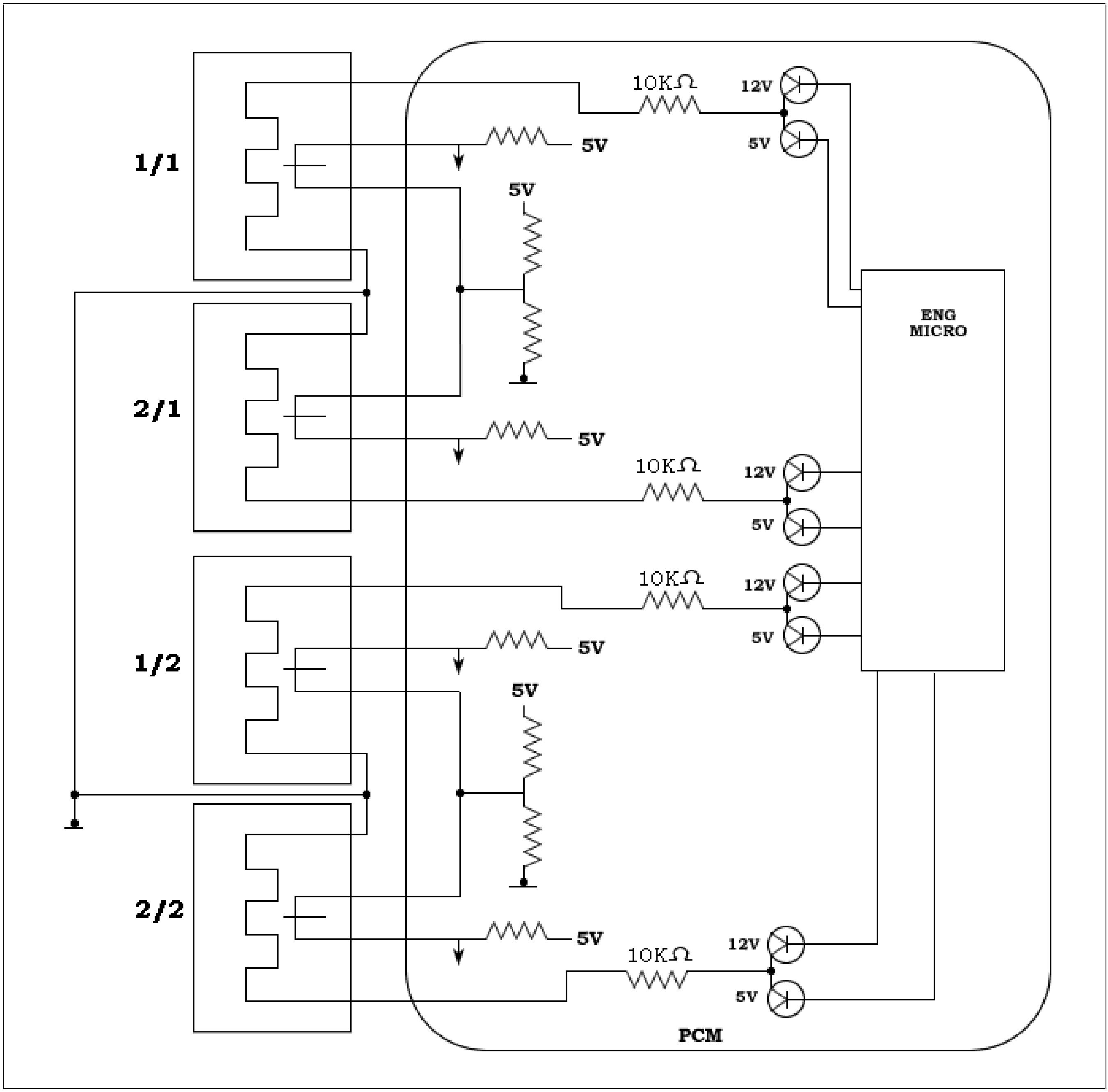


Figure 24 O2 Sensor Heater Circuits

Generator Field Control

The charging system maintains the system voltage at a desired level by turning the generator field on and off. When the generator field is turned on, the system voltage increases. When the generator field is turned off, the system voltage slowly drops. The rate at which this happens is dependent upon the existing electrical loads, ambient under hood temperature or battery temperature, and the engine RPM. A constant system voltage can be maintained only when the generator field is switched on and off at a duty cycle to compensate for the existing electrical loads. The desired charging system voltage is based on the battery or ambient temperature and is then compared to the sensed battery voltage entering the NGC controller.

The NGC controlled charging system differs from previous systems, in that a PWM high-side driver instead of a duty-cycled low-side driver controls the generator. The generator ground brush is permanently grounded externally of the NGC controller. The positive brush receives a PWM power supply from 2 drivers wired together in parallel to handle the potentially high current demands of the system. The PCM also checks the generator field circuit for a short to ground or power, or for an open circuit by supplying a 5V pull-up through a 10KΩ resistor, while the drivers are de-energized.

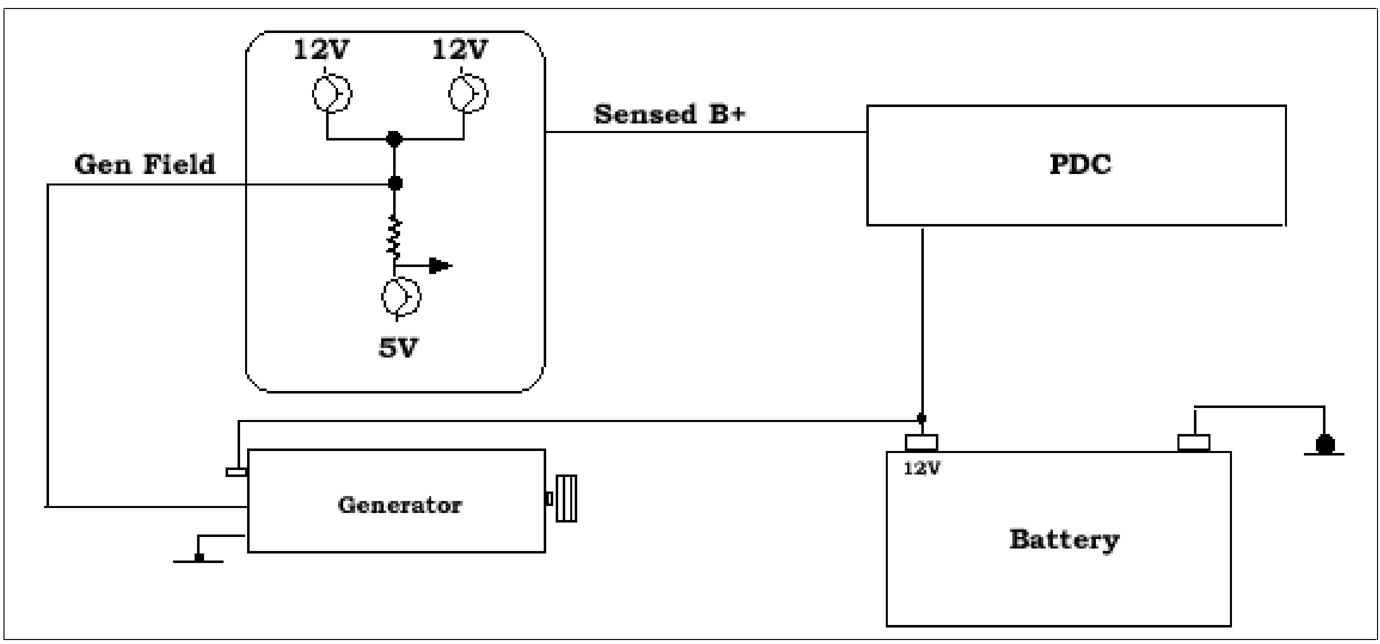


Figure 25 Charging System Control

ACTIVITY 3 OUTPUT DEVICES

OXYGEN SENSOR HEATER CIRCUITS

1. Access the No Start monitor. Notice that cranking pulsewidth is listed, similar to JTEC.
2. Using a service manual, locate and identify the oxygen sensor heater control circuit for one of the upstream oxygen sensors. How does the oxygen sensor control circuit differ from previous SBEC and JTEC vehicles?

   ____

3. Setup the DRBIII® Lab Scope to view the oxygen sensor heater trace. Which option on the scope menu would be most appropriate to view this type of signal?

   ____

4. Start the engine and view the oxygen sensor heater signal on the lab scope.
5. What type of signal are you viewing? ______________________
6. What is the range of voltage that you observe? MIN ________ MAX __________
7. What would it indicate if the voltage did not go all the way to the maximum voltage that you observed in the previous step?

   ____

8. What would it indicate if the voltage did not go all the way to the minimum voltage that you observed in step 6?

   ____

9. Can these types of problems be detected easily using the DRBIII® in Standalone mode, or with a DMM? ______________________
10. When the vehicle is first started, how does the percentage of ON time compare to the percentage of OFF time? ______________________
11. What happens to this percentage of ON time as the sensor begins to reach operating temperature? ______________________
12. Does the percentage of ON time stabilize after reaching operating temperature, or does it vary? ______________________
13. If the percentage of ON time is varying, explain why you think that this is occurring: ______________________
14. In conclusion, the PCM is continually monitoring the ________________ of the oxygen sensor heaters by measuring the voltage drop across a fixed resistor inside of the NGC controller. To maintain proper oxygen sensor operating

temperature, the PCM will send a varying __________________ signal that will regulate the current flow through the oxygen sensor heater.

GENERATOR FIELD CONTROL CIRCUIT

15. Using the service manual, locate and identify the generator field control circuit.
16. How is this circuit similar to the oxygen sensor heater circuit?

    ____

17. Setup the lab scope to view the generator field control circuit.
18. Which menu option of the Lab Scope should be used to view this signal?

    ____

19. Start the vehicle and observe the generator's lab scope trace.
20. Turn on electrical loads such as headlamps, rear defroster, etc. and observe the trace. What effect do the additional loads have on the PWM signal?

    ____

21. Disconnect all equipment and clear DTCs

FUEL CONTROL

SPEED DENSITY FUEL SYSTEM

Like its predecessors, the NGC controller utilizes the Speed Density formula to calculate airflow and mass. However, unlike SBEC and JTEC, this Speed Density equation is used more for verification, than for actual computation.

A conventional Speed Density system utilizes the following equation:

Load	Base PW Calculation	O2	Adaptives	P.W.
RPM / Max RPM (X) MAP / Baro	(X) TPS (X) ECT (X) IAT (X) Sensed B+ (X) LT	(X) UpO2	(X) STFT (X) LTFT	= Pulse Width

Figure 26 Speed Density Equation (prior to NGC)

"Model Based" Fuel Strategy

Chrysler Group vehicles have used the Speed Density formula for calculating airflow and mass since the introduction of fuel injection in the early 1980's. Since this time, engineering has learned that they can predict how much fuel an engine will need before the PCM actually measures the engine's air intake and load. Based on these assumptions, a "Model Based" fuel algorithm has evolved. This "Model Based" fuel system predicts how much fuel the engine will need under different operating conditions, before the inputs to the PCM actually verify these conditions.

The "Model Based" fuel algorithm offers the benefits of better fuel control under all operating conditions. This new system also takes into consideration sources of fuel from the purge system, as well as the effects of the EGR system while the inert gasses are flowing. The following is a graphical representation of the "Model Based" equation:

Load	Base PW Calculation	O2	Adaptives	P.W.
RPM / Max RPM (X) TMAP / BARO	(X)MAP (X) ECT (X) IAT (X) Sensed B+ (X) LT (X) Purge Vapor Ratio (X) EGR Flow	(X) UpO2	(X) STFT (X) LTFT	= Pulse Width

TMAP= Calculated MAP, based on TPS, IAC & Baro

Figure 27 "Model Based" Equation

Load Calculation

The NGC fuel system determines load in the following manner. Current RPM is divided by the Max RPM that the vehicle is rated (MAP/MAX RPM). This allows the

PCM to determine how much airflow is currently entering the engine, or the percentage of the total capacity. The PCM then calculates how much load is actually on the vehicle. On SBEC and JTEC vehicles, this is done my measuring the actual manifold absolute pressure (MAP). NGC vehicles calculate this a little differently. Since it takes time for the reciprocating masses in the engine to directly cause a change in manifold absolute pressure to occur, the PCM will use a calculated MAP value, known as Throttle-MAP, or TMAP in its initial calculation. The value TMAP is calculated based on throttle position, IAC position and barometric pressure. This calculated value can be generated much quicker than an actual MAP value from the MAP sensor. The TMAP value is then compared against the actual MAP value to verify the calculation. Now that the PCM knows how much load the vehicle is under, a starting pulsewidth based on load is established.

Base Pulsewidth Calculation

The initial Pulsewidth will now be modified to meet the changing needs of the vehicle:

- TMAP is compared to actual MAP to see if any corrections are required.
- The TPS is monitored for any throttle changes that require modification to the starting PW:
  - Acceleration enrichment
  - Deceleration enleanment
  - WOT as an indication for open loop while running or engine-cranking fuel kill
- ECT is monitored to determine initial cranking injector pulsewidth, and temperature compensation. The ECT has a large effect on the cranking pulsewidth, but acts only as a modifier after the vehicle is started.
- IAT is monitored for temperature compensation of the fuel pulsewidth, and for spark timing correction.
- Sensed B+ is used by the PCM to correct the injector pulsewidth and the ignition system dwell period.
- The values stored in the long-term fuel cells are used to correct the fuel pulsewidth based on previous requirements of the engine under different load conditions.
- The PCM also takes into consideration other factors that may affect the total airflow into the engine, thus the fuel requirements of the vehicle.
  - The percentage of HC vapors in the purge flow (Purge Vapor Ratio) is taken into consideration when calculating the base pulsewidth. If purge flow contains a high ratio of HC vapors, less fuel from the injectors is required.
  - EGR flow is also taken into consideration by the PCM. EGR flow effectively makes the combustion chamber smaller. Since there is less room allocated

for the air/fuel mixture, the PCM needs to reduce the fuel pulsewidth to compensate for the decrease in oxygen content.

O2 Feedback, Short-Term Correction and Long-Term Adaptives

After receiving information from all of the above-mentioned inputs, the PCM is now able to calculate the base pulsewidth required for the specific operating condition of the engine. The goal of the PCM is to maintain the stoichiometric fuel ratio of 14.7:1. It is only at this ratio that we can be assured that all vehicle tailpipe emissions are at their lowest point possible simultaneously and that the catalytic converter is getting what it needs, "Cat Food", to make it efficient. The upstream oxygen sensor(s) should be switching between 2.5V and 3.5V if the PCM's calculation was correct, and if the vehicle is operating with a 14.7:1 air/fuel ratio.

The downstream oxygen sensor(s) are used in conjunction with the upstream oxygen sensor(s) to measure the efficiency of the catalytic converter. It is also used, however, to trim or adjust the upstream oxygen sensor goal voltage. This goal voltage is the switching point between "rich" and "lean" conditions. The PCM will adjust this goal voltage to ensure that the catalytic converter operates efficiently for the life of the vehicle.

If after the vehicle enters closed loop operation, the upstream oxygen sensor(s) voltages are not switching between 2.5V -3.5V, it is an indication to the PCM that a miscalculation may have occurred, and it will compensate by adjusting the injector pulsewidth until a switching O2 sensor voltage can be achieved. This immediate correction is known as Short Term Correction, or Short Term Fuel Trim (STFT), and begins very shortly after the vehicle has been started. This miscalculation may be a result of vehicle operating conditions, vehicle wear, fuel quality, etc. The PCM is capable of instantaneously correcting the fuel ratio by up to +/- 33%.

After the vehicle has reached full operating temperature, these correction factors will be stored in Long Term memory cells based on vehicle load (RPM/MAP) and the STFT will be brought to within +/- 3% of zero. Once this correction factor is stored in memory, it will be used by the PCM under all operating conditions, open loop or closed-loop. However, the values stored in Long-term can only be updated after the vehicle has entered long-term closed loop (full operating temperature.) The total range of correction in long-term is +/- 33% of the injector pulsewidth. Between STFT and LTFT, the PCM is capable of adjusting the base pulsewidth up to a total of +/- 66%, 33% ST and 33% LT.

One very important difference between the long-term cells stored in NGC vehicles versus what we have seen in the past on SBEC and JTEC vehicles is that all long term cells represent fuel correction without purge flow. In other words, all long-term cells are purge-free cells. Purge vapor content is learned shortly after short-term closed loop, and is factored into the pulsewidth equation.

```
-- 1/1 ADAPTIVE MONITOR --
MAP : 13.4  Loop:CLOSE  Time: 1.30
RPM : 1897  ECT :  194  Baro:   25
c1Ij:  7.4  O2G1: 0.37  Volt: 13.6
1102: 0.20  1202: 0.49  Vss:     0
SAd1: -2.6  LAd1: -4.4  P-AD: 0.10

Adaptive Memory Cell % Values
 C3   C7   C11  C15  C19  C23
 -1   -4   -6   -4   -2   +0
 C2   C6   C10  C14  C18  C22
 -4   -2   -3   -2   -1   +1
 C1   C5   C9   C13  C17  C21  C25
 -3   -4   -2   -1   -1   +0   -15
 C0   C4   C8   C12  C16  C20  C24
 -3   -4   -2   -1   -1   +0   -5
```

Figure 28 Adaptive Fuel Monitor (sample DRBIII® screen)

The sample DRBIII® screen shown above is similar in layout what we have seen previously. This split screen shows information relevant in determining the pulsewidth on the upper half of the screen, and a mapping of long-term fuel trim cells on the lower half.

The information on the top half of the screen is identical to previous vehicles with the following exceptions. Notice that there are two cells listed on the upper half, cells C24 (P/N) and C25 (D). These represent the two idle cells either in or out of gear. These idle cells have been previously shown on the lower half of the screen, but due to the number of LT cells available on NGC, there was insufficient room on the lower half of the screen for these two cells. Just below the two idle cells is "Purg Ad." Unlike previous vehicles, this value does not represent the duty-cycle percentage of the purge solenoid. This value represents fuel correction as a result of the HC content of purge vapor. Purge is an integral part of the pulsewidth equation and is potentially an additional source of fuel that will be used by the engine if HC percentage in purge is sufficient.

The layout of lower half of the screen is similar in layout to what we have seen previously. The long-term cells are broken down into four rows and six columns. Each row represents a different RPM range, while each column represents a different P/Ratio (MAP/BARO) range. Unlike previous models, all long-term cells represent fuel correction without purge flow influence. That is why there are no "PF" cells listed on the upper half of the screen.

Canister Purge

As mentioned previously, purge is an integral part of the pulsewidth equation and is factored into the pulsewidth determination. The purge system used on NGC vehicles has identical components to previous vehicles; however, the integration of purge into the pulsewidth equation is completely different. On NGC equipped vehicles, the PCM learns the HC content within the components of the evaporative system, which allows it to predict the effect of purge flow on the speed density equation. All purge learning is achieved through O2 feedback and the PCM operates in three different modes to learn how purge should fit into this equation.

- **Mode 0** 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.
- **Mode 1**- Once the PCM has learned the engine's fuel requirements, it slowly starts to ramp in purge at a very low rate. The objective of Mode 1 is to learn the HC loading of the fuel tank and vapor canister. This is accomplished by monitoring the effects of purge on STFT, and comparing the results against the data accumulated during Mode 0. Once purge loading has been learned, the vehicle enters into Mode 2 operation.
- **Mode 2** is the normal operating mode of the purge system. During this mode of operation, purge flow is increased to the normal high-flow levels required to deplete the evaporative system of HC vapors. The PCM adjusts the injector pulsewidth automatically to compensate for this extra source of fuel. Remember that the PCM learned during Modes 0 and 1 what the effect of purge is. It can therefore adjust the pulsewidth 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. Earlier we discussed that the PPS is monitored by the PCM on the groundside of the circuit. The PCM uses this data to regulate the opening of the solenoid to ensure proper purge flow under changing operating conditions.

Linear EGR Flow

Exhaust Gas Recirculation (EGR) is used for control of NOx emissions and fuel economy improvement. During the EGR process exhaust gas is taken from the exhaust manifold, metered through a valve, and fed into the intake manifold.

Exhaust is mostly inert gas consisting of CO2. In the combustion chamber the inert gas absorbs heat, having the effect of lowering the flame temperature. The rate of NOx formation is highly dependent on temperature. Therefore, the addition of EGR lowers the flame temperature and thus, decreases the formation of NOx.

Fuel economy benefits are achieved with EGR because EGR flow effectively reduces the size of the combustion chamber, allowing less room for the air/fuel mixture. EGR has a major impact on the exhaust oxygen levels, and the PCM must compensate for EGR flow by reducing the injector pulsewidth to compensate for the reduction in exhaust oxygen content. The PCM will regulate the flow of EGR based on operating conditions, by pulsewidth-modulating (PWM) the EGR solenoid. The position of the EGR solenoid is monitored by the linear potentiometer discussed earlier, and the PCM will adjust the current flow to meet requirements.

The normally occurring exhaust pulsation can have a tendency of unseating the EGR pintle off of its seat during idle conditions. To prevent this from occurring, the PCM applies a 7% duty-cycle to the EGR solenoid to stabilize the pintle. This duty-cycle is not enough to allow EGR flow during idle conditions.

ACTIVITY 4 FUEL CONTROL

ADAPTIVE FUEL TRIM CORRECTION AND COMPENSATION

1. Access the Linear IAC valve under Sensors in the DRBIII®. What is the LIAC valve flow rate at idle? ___________________ (g/p/s)
2. Create a vacuum leak. What is the LIAC valve flow rate? _________ (g/p/s)
3. Repair vacuum leak.
4. What happens to the LIAC airflow as the throttle opening changes?

   ____
5. Shut off the vehicle, unplug the LIAC valve and attempt to start the engine.
6. What do you observe and why? ____

   ____
7. Access the 1/1 Adaptive Memory Monitor under Monitors in the DRBIII®.
8. Start the vehicle and observed when it goes into closed-loop. Is the vehicle in short-term or long-term closed loop? ____
9. What is the difference between STFT and LTFT? _____________________________

   ____
10. Which two cells are the idle cells? Cells ____________ & ______________
11. How do you identify which cell the vehicle is operating in? ___________________

   ____
12. Attach the OBDII/Fuel Simulator to the vehicle and reduce the fuel pressure. Alternately, toggle the fuel pump relay in and out of the PDC to achieve the same result. Explain the reaction of the injector pulsewidth, as well as STFT and LTFT cell values:

   ____

   ____
13. Bring the fuel pump back to full power. After the STFT and LTFT values have returned to normal, introduce propane into the air inlet. Explain the reaction of the injector pulsewidth, as well as STFT and LTFT cells:

   ____

   ____
14. What was the maximum and minimum fuel correction that was observed in questions 13 and 14? MAX +/- __________ % MIN +/- ______ %
15. Is this percentage more similar to SBEC or JTEC vehicles? ___________________

EVAPORATIVE SYSTEM PURGE

16. Access the DRBIII® Fuel Control Monitor Screen. Scroll down the list until the values shown below are seen:

```
         FUEL CONTROL
PURGE AIRFLOW        : 0.0 gm/sec
PURGE VAPOR RATIO    :     35.8 %
PURGE ADAPTIVE       :     -0.3 %
1/1 SHORT TERM ADAP :     -0.8 %
1/1 LONG TERM ADAP  :      5.5 %
2/1 SHORT TERM ADAP :     -0.6 %
2/1 LONG TERM ADAP  :      7.4 %
1/1 O2S VOLTS        : 2.86 VOLTS
2/1 O2S VOLTS        : 3.17 VOLTS
 Item   6 of  16           PCM
```

17. Setup a DMM as follows: Using a service manual, identify the Proportional Purge Solenoid control circuit. Back-probe the purge solenoid with a "T-pin" and attach the DMM. Setup the DMM to measure Duty Cycle percentage.

NOTE: When measuring the Duty Cycle % of the purge solenoid with a DMM, the values will read backwards because the DMM is setup to measure ground-side control, but the PPS is actually controlled on the high-side. As an example: if the meter is reading 80% DC, the actual value of the PPS will really be 20%. Keep this in mind while performing the rest of the activity.

18. Start the vehicle and observe the DRBIII® screen. What is the default value of Purge Vapor Ratio after the vehicle is first started? ______________________

As soon as the vehicle enters short-term closed loop, you should notice that the STFT begins to update; shortly after that, the LTFT values begin to update. This is Purge Mode 0. The PCM is learning what fuel correction is needed to maintain stoichiometry **without** purge flow.

19. How do you know that the vehicle has entered purge Mode 1 (the purge learning mode)?____

Notice that the PCM will energize the PPS, check for purge's influence on the fuel adaptives and then de-energize the PPS and recheck the adaptives without purge flowing. The PCM is learning the HC concentration of the purge vapor and what effect purge flow has on the stoichiometric fuel ratio.

20. During Mode 1, did the LTFT cells indicate that they were updating?

☐ YES ☐ NO

21. Why or why not? ____

22. Describe your observations when the vehicle enters Mode 2 purge flow: ________

____

____

Purge Mode 2 is the normal purge mode after the PCM has learned the effect of purge flow on the stoichiometric fuel ratio. At this stage, the PCM is using the HC content of purge flow as a source of fuel in the fuel equation. Purge should be enabled for a significant amount of time once entering Mode 2. However, the PCM will periodically disable purge in order to verify that its initial calculations have not changed as a result of increasing temperature/pressure in the evaporative system. During Purge Mode 2, the PCM will be utilizing the values stored in the LTFT cells, in addition to the calculated HC content in purge flow to calculate the injector pulsewidth requirements.

23. When the vehicle is operating in Purge Mode 1 or 2, what happens to the value Purge Vapor Ratio? ____

24. When the vehicle is operating in Purge Mode 1 or 2, what happens to the value Purge Adaptive? ____

The Purge Adaptive value is an indication of pulsewidth correction based on the HC content in purge flow.

25. Disconnect the air intake hose to the throttle body and restart the engine. When the vehicle indicates that it is entering Purge Mode 1 (both on the DRBIII® and the DMM) slowly start to flow propane. Observe the Purge Vapor Ratio and Purge Adaptive values displayed on the DRBIII®.

CAUTION: Do NOT use the Purge Airflow value on the DRBIII® to determine when the vehicle enters purge mode 1 during this part of the activity. Use only the value displayed on the DMM as an indication. Purge flow may be too subtle to see a change in the Purge Airflow value as seen on the DRBIII®.

26. When the PCM de-energizes the purge solenoid (as indicated on the DMM), stop the flow of propane. Repeat this procedure through several cycles of purge. Record your observations of Purge Vapor Ratio and Purge Adaptive values, as well as the effect of propane flow on the purge duty cycle as observed on the DMM:

____

____

During the previous step, our intent was to deceive the PCM into believing that the canister was saturated. As propane was flown, the PCM begins to sense that a saturated canister condition may exist. It responds by reducing the purge flow, while observing the effect on STFT. When the PCM de-energized the purge solenoid, and we stopped flowing propane, STFT values return to normal. Each time we flowed propane during the solenoid-on period, the PCM recognized that the STFT values were indicating that a saturated canister existed because normal values were indicated during the solenoid-off period. The PCM responds to this condition as indicated in the Purge Adaptive value displayed on the DRBIII®.

CAUTION: A leaking PPS solenoid will corrupt the LTFT values as displayed on the DRBIII® because the PCM believes the problem exists with purge off.

27. Based on the previous steps, what value displayed on the DRBIII® can be used as an indication of a saturated canister? ____________________

28. Using the DRBIII®, perform an electronic battery disconnect to clear all learned values.

EGR SYSTEM

29. Access the DRBIII® Sensor Display. What EGR% value is displayed at idle and why? ____________________

30. With the vehicle securely setup on a hoist, accelerated the vehicle through the gears and record the values below:

    EGR % __________ EGR Sense: __________ EGR Flow: __________

CONCLUSIONS

31. In conclusion, the NGC PCM accounts for ALL sources of airflow into the engine including (a)__________ (b) __________ and (c) __________ when it calculates the desired pulsewidth.

EMISSION CONTROLS

There are several inter-related and tightly integrated systems that make up the emissions control system. The EGR and Purge systems are two that have been previously discussed. Out of all the individual systems, the most important emission control device is the PCM. The PCM is the heart of emission controls system, responsible for maintaining the stoichiometric fuel ratio. It is only at this fuel ratio that HC, CO and NOx tailpipe emissions are simultaneously maintained at their lowest points possible.

EVAPORATIVE EMISSION LEAK TESTING

Current PCM technologies do an excellent job of maintaining acceptable tailpipe emissions. However, a large percentage of all HC emissions are a result of evaporating gasoline, and not from tailpipe emissions. It is for this reason that the standards for evaporative emission control have been tightening on an ongoing basis. A change occurring with NGC is the adoption of a new evaporative leak detection system called Natural Vacuum Leak Detection (NVLD). This new technology replaces the Leak Detection Pump (LDP) assemblies used on SBEC and JTEC equipped vehicles.

The current California Air Resource Board (CARB) requirement is to detect a leak equivalent to a 0.020" (0.5 mm) hole. This system has the capability to detect holes of this size very dependably. In addition to the detection of very small leaks, this system has the capability of detecting medium as well as large evaporative system leaks.

Vehicles equipped with the NGC PCM can perform two types of tests to ensure proper evaporative system sealing. The first type of test is a passive test, known as the Natural Vacuum Leak Detection. This test checks the evaporative system for small leaks (0.020") and is run after a set of enabling conditions are met and the vehicle is turned off. The second type of test, an intrusive test, and checks the evaporative system for medium or large leaks (0.040" - 0.090") upon a cold-start, but **only** if the small leak test was "inconclusive." After all, if there is no small leak, there obviously is no medium or large leak.

NVLD Principles

The NVLD system takes advantage of the "Gas Law." This law in physics states that the "pressure in a sealed vessel will change if the temperature of the gas in the vessel changes." The vessel can only see this effect if it is sealed. Even small leaks will allow the pressure in the vessel to equalize with the outside ambient pressure.

A vent valve seals the canister vent during engine off conditions. If the evaporative system has a leak of less than the failure threshold, the evaporative system will be pulled into a vacuum, either due to a cool down from ambient temperatures or day to night temperature cycling.

When the vacuum in the system exceeds about 1" H2O (0.25 KPA), a vacuum switch closes. If the PCM detects that the switch has closed, the small leak monitor test will record a "pass" on the next start. If the switch state does not change, either the system has a leak, or the proper temperature changes did not occur. In either case, the results of the test are "inconclusive."

Figure 29 Natural Vacuum Principle Demonstrated

In the above figure we can see an example of the principle of Natural Vacuum at work. This tanker had been steam cleaned, and someone carelessly forgot to open the vents while it cooled. OOPS!

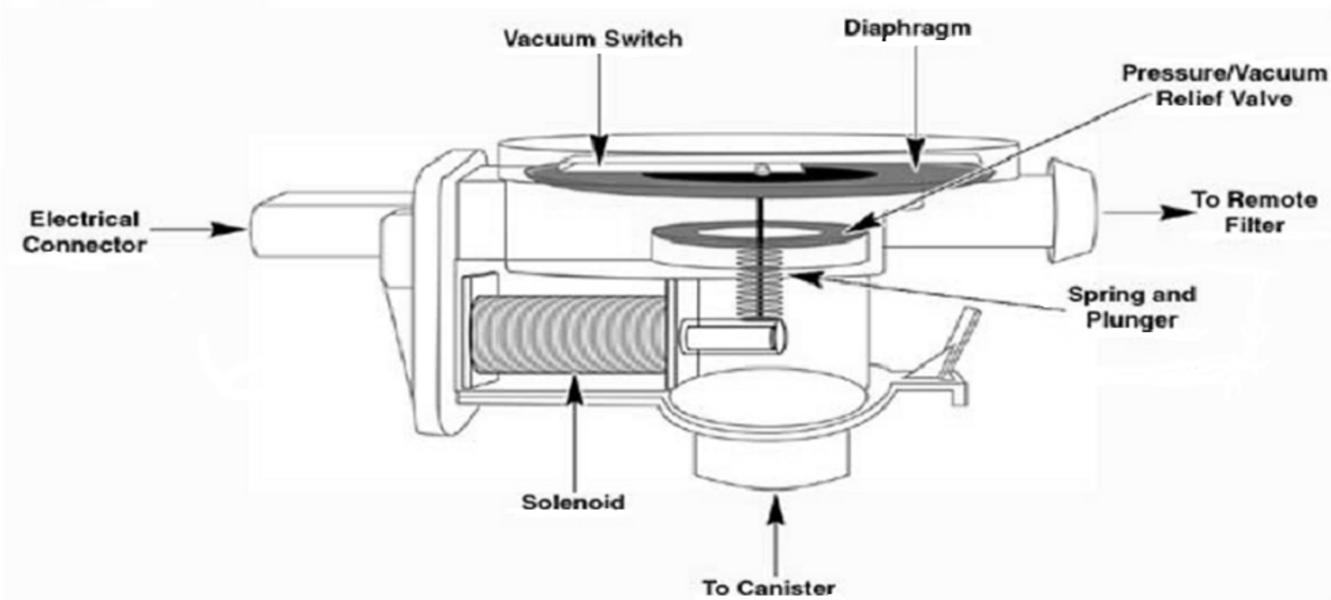


Figure 30 NVLD Assembly (Canister mounted type shown)

NVLD Assembly Operation

The NVLD assembly is designed with a normally open vacuum switch, a normally closed (de-energized) solenoid, and a pressure/vacuum relief valve, which is actuated by both the solenoid and a diaphragm. The NVLD is located on the atmospheric vent side of the canister. The NVLD assembly may be mounted on top of the canister outlet, or in-line between the canister and atmospheric vent filter.

The normally open vacuum switch will close when about 1" H2O (0.25 KPA) vacuum lifts the diaphragm. The normally closed pressure/vacuum relief valve in the NVLD is intended to maintain the seal on the evaporative system during engine off conditions. If vacuum in the evaporative system exceeds 3" to 6" H2O (0.75 to 1.5 KPA), the valve will be pulled off the seat, opening the seal. This will protect the system from excessive vacuum as well as allowing sufficient purge flow in the event that the solenoid was to become inoperative.

The solenoid actuates the valve to unseal the canister vent while the engine is running. It will be de-energized to close the vent during the medium and large leak tests and during the purge flow check.

Another feature of the device is that the diaphragm will open the seal in the NVLD with pressure in the evaporative system. The device will vent pressure from the evaporative system at about 0.5" H2O (0.12 KPA) to permit the venting of vapors, via the canister, during refueling. An added benefit to this is that it will also allow the tank to "breathe" during increasing temperatures, thus limiting the pressure in the tank to this low-pressure level. It is beneficial to limit pressure build-up because vacuum can be achieved sooner during declining temperatures after shutdown, allowing the switch to close sooner than if the tank had to decay this pressure.

The device itself has three wires: Switch sense, solenoid driver and ground. It also includes a resistor to protect the switch from a short to battery or a short to ground. The NGC utilizes a high-side driver to energize and duty-cycle the solenoid.

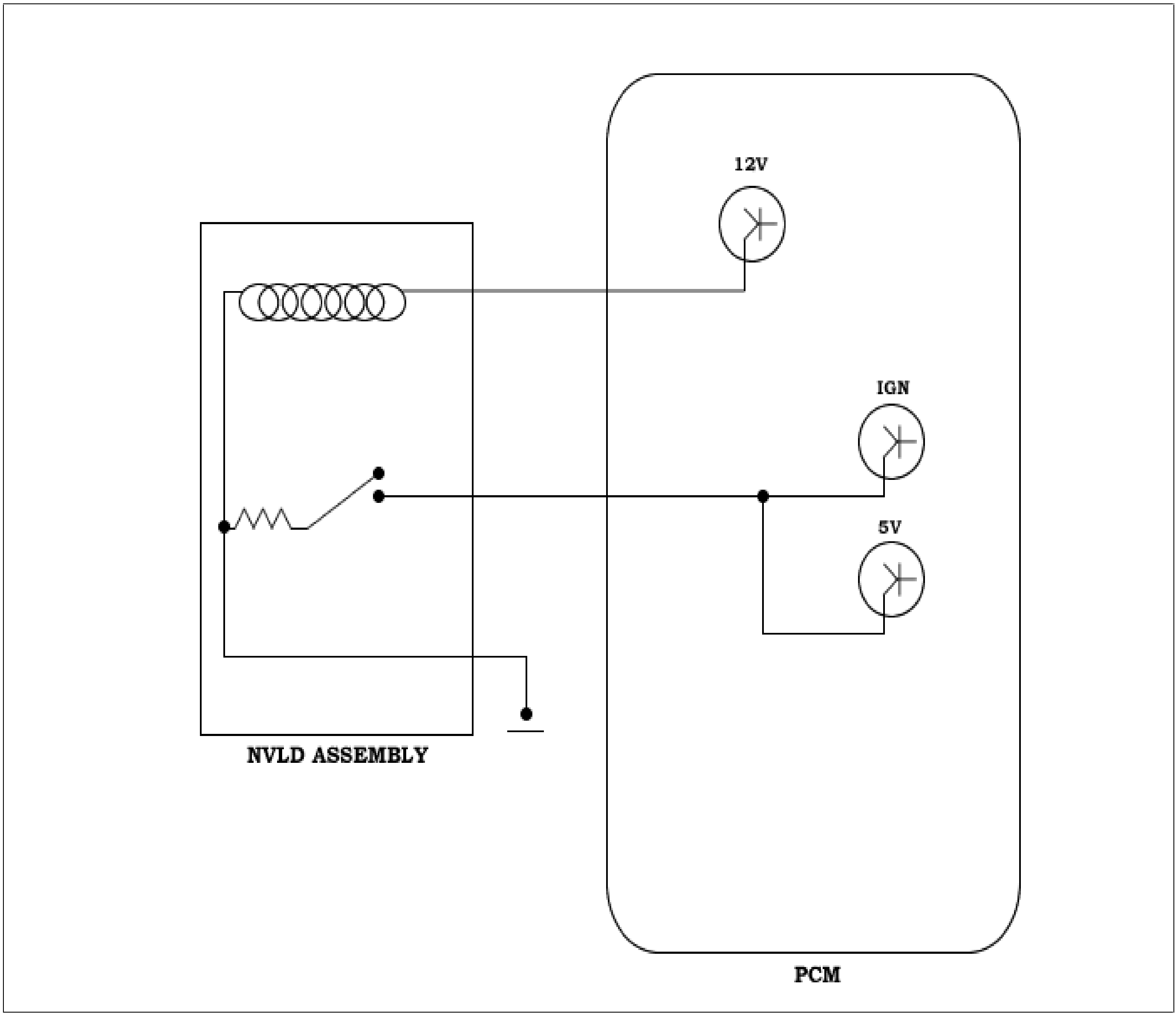


Figure 31 NVLD Schematic

NVLD LEAK DETECTION

Small Leak Test (Natural Vacuum Method: Passive)

The integral part of the diagnostic system that makes engine-off leak detection possible is a special circuit in the NGC controller. After the vehicle is turned off, a small section of the controller stays alive and monitors for an NVLD switch closure. This circuit within the NGC is very specific in its function and consumes very little power. If the switch closes after a specified delay period after key-off, the test will pass, indicating that there is no leak. The NGC will log the event and time from key-off, and then power down. When the engine is started the next time, the switch closure is recorded as a “Pass,” and the timers that are recording accumulated time are reset.

This diagnostic test can take at least a week to mature a leak fault. A week has been chosen for this because the vehicle will have been exposed to the largest possible drive scenarios before a decision is made. This also satisfies CARB's stated goal of getting three MIL illuminations within a month for 0.020" (0.5 mm) leak detection diagnostic.

The diagnostics will log engine run time and engine off time to determine when a week has elapsed. There is a limit on the total amount of run time that is applied to the one-week timer. There is also a limit on the total soak time that will be allowed to be applied to the one-week timer and a limit on the amount of accrued run time during one specific drive that can be applied to the one-week timer.

The enabling criteria to run this monitor are:

- Fuel level less than 85% (there is no low limit)
- Ambient temperature greater than 40 °F (4.4 °C)

Switch and solenoid Rationality Tests:

- At key-on, the NVLD solenoid will be energized to vent any vacuum that may be trapped in the evaporative system from the previous soak. This should result in an open switch condition. If the switch state does not indicate an open condition, the DTC "NVLD Pressure Switch Stuck Closed" will be set.
- The solenoid will be de-energized (to seal the system) and purge will be ramped on. The system / NVLD component rationality passes for that drive cycle if the switch closes after purge begins.
- The solenoid is then re-energized for the remainder of the drive cycle. If the switch events are not seen within 2-trips, the rationality test will fail.
- This rationality check is considered sufficient to confirm proper purge solenoid operation.

Purge Flow Monitor

The Purge Flow Monitor can be based upon switch activity when purge is turned on or on a shift in STFT values when purge is turned on.

Medium and Large Leak Test (Vacuum Decay Method: Intrusive)

> **Note: This intrusive test will only be run if the Small Leak test is inconclusive (the switch does not close.)**

Enabling Conditions:

- 40 °F to 90 °F
- Engine temperature at startup within 10 °F of the ambient temperature
- Fuel level less than 85% (there is no low limit like LDP)

The intrusive Medium and Large leak are conducted as follows:

- The NVLD solenoid is de-energized to seal the canister vent.
- Purge is activated shortly after closed loop. Vacuum is pulled on the evaporative system, past the vacuum switch point (1" H_2O vacuum) of the NVLD, for a specific time.
- Purge is turned off and a determination is made on how long it takes for the tank vacuum to decay and the switch to reopen. This is also known as the "vacuum decay" method. Leak size is determined by the time it took for the switch to reopen. Medium or Large leak DTCs will be set if the switch closes, and then re-opens before the allotted time. If the switch does not close, a more aggressive purge flow will be applied to determine if it is a very large leak, if the fuel cap is missing, if there is a problem with the NVLD device, if a purge flow problem exists, etc… If the switch never closes, a "General Evap System Failure" DTC will be set.

ACTIVITY 5 NVLD DIAGNOSTICS

Note: **Make sure that the fuel level is below 85%, or the ORVR control valve will seal the tank. Low fuel level is not a factor as it is on LDP systems.**

Note 2: **Evaporative systems are extremely sensitive to pressure changes as a result of temperature changes. EVAP diagnostics should be performed on a cold vehicle, as increasing temperatures can lead to an erroneous false failure. The same thing applies to ST22 vehicles. SBEC and JTEC vehicles will result in false passes if temperatures increase.**

1. Using an appropriate service manual, identify and locate the NVLD switch sense circuit. At an appropriate connector (under the rear seat on LH vehicles) back-probe the NVLD switch sense circuit with a "T-Pin" and attach a DMM.
2. Remove the gas cap and turn the ignition key to the ON position.
3. Using the DRBIII®, access Inputs and Outputs.
4. What is the displayed NVLD Switch State? ________________________________
5. What is the desired state of the NVLD Solenoid? ___________________________
6. What is the displayed voltage on the DMM? ______________________________
7. Turn off the ignition. What is the displayed voltage on the DMM? ___________
8. Install Miller #8382 gas cap adapter. Install gas cap onto adapter. Use vacuum line adapters as necessary to connect a hand-held vacuum pump to the threaded fitting on the 8382 adapter. Install a Manometer, or Miller #6872A to the green, under hood Evap test port. Turn the ignition key on.
9. While slowing pumping the hand held vacuum pump, observe the NVLD Switch State on the DRBIII®, the voltmeter and the manometer.
10. At what level of vacuum did the switch state change? _____________________
11. What voltage is observed on the DMM when the switch state changes? _______
12. Start the engine. What happens to the switch state and DMM voltage? _______

    ____
13. What is the desired NVLD Solenoid state? _________________________________
14. What have we just tested? ____

    ____

    ____
15. Shut off the engine and remove gas cap adapter, manometer and voltmeter. Reinstall gas cap. Raise vehicle on a hoist. Locate the atmospheric vent line at the NVLD assembly. On canister mounted systems, gently clamp the line with

hose crimp pliers. On remote systems, plug the vent line using an appropriate plug from Miller #6872A kit. Lower vehicle.

16. Evaporative emissions leak detector (EELD) hookup:
   - Connect the red power lead to a 12V DC power supply.
   - Connect the black lead to a chassis ground.
   - Connect shop air to the 8404 Evaporative Emissions Leak Detector (EELD).
17. Set the control knob to air.
18. Insert the tester's air supply tip (clear hose) into the appropriate calibration orifice on the tester's control panel (based on the DTC).
19. Press the remote start button.
20. Position the red flag on the flow meter so it is aligned with the indicator ball. When calibration is complete, release the remote button. This calibrates the flow meter in liters per minute to the size leak (based on the DTC) you are looking for.
21. Install the Service Port Adapter (Miller tool #8404-14) on the vehicle's service port, or to the service port on the Fuel Tank Adapter (Miller tool #6922 or Miller tool #8382).
22. Connect the air supply hose from the EELD to the service port or fuel tank adapter.
23. Press the remote button to activate airflow.

Note: Larger volume fuel tanks, and/or those with lower fuel levels, may require four or five minutes to completely fill the system with air.

24. If the fuel level is over 85% on vehicles with ORVR, it may be necessary to perform this procedure from both the service valve and tank adapter, due to closure of the ORVR flow control valve.
25. Compare the flow meter indicator ball reading to the red flag.
26. Above the red flag is an unacceptable leak (vehicle failed: go to **Phase Two**).
27. Below the red flag is acceptable (vehicle passed: Test Complete).
28. Did the EELD indicate that the system has a leak above the acceptable limit?
   ☐ YES ☐ NO

   If not, create a leak by removing the gas cap or an evaporative hose.

Phase 2 Test: Locating the Leak

29. Remove the air supply hose from the service port of Fuel Tank Adapter
30. Connect the smoke supply tip (black hose) to the service port or fuel tank adapter.

31. Set the control switch to smoke.
32. Press the remote start button.
33. If inputting the smoke through the service port adapter, verify smoke has filled the evaporative system by removing the fuel cap until the smoke begins to escape. Reinstall the cap.
34. If inputting smoke through the fuel tank adapter, verify smoke has filled the evaporative system by depressing the Schraeder valve on the service port adapter until smoke begins to escape from the adapter.
35. Once smoke is observed, close the EVAP system by either reinstalling the fuel cap, or releasing the Schraeder valve.

Note: For optimal performance, introduce smoke into the system for an additional 60 seconds. Continue introducing smoke at 15-second intervals as necessary.

Note: Smoke will NOT be seen if on the fresh air side of the canister.

36. Using the white light, follow the evaporative system path and look for the source of the leak (exiting smoke). Make sure to check that the normally closed purge solenoid is not leaking into the intake manifold.
37. If the leak is in a concealed area, stop the smoke and use the ultraviolet black light, while wearing the supplied yellow glasses, to locate the residual ultraviolet dye left behind by the escaping smoke. The leak deposits a residual fluid that is either bright green or yellow in color when viewed with a UV light source.
38. After the source of the leak has been repaired, how can you verify your repair was successful? ______________________________
39. When available, run the DRBIII®'s NVLD System Test.
40. Under the OBDII Monitors of the DRBIII®, view the EVAP Last Result Monitor.
41. Disconnect EELD and restore evaporative system vent.

Notes:

ACTIVITY 6 DTCS AND FREEZE FRAME

1. Make sure that all DTCs are cleared from memory.
2. With the ignition ON, unplug the TPS. Restore TPS connection and read DTCs. Notice that DTCs can be read either in numerical (All-P-code) or chronological order.
3. Read and record the stored DTC in Freeze Frame 1 through Freeze Frame 5:
   - CARB Freeze Frame 1: ____________________
   - Freeze Frame 1 (First sequential DTC): ____________________
   - Freeze Frame 2 (Second sequential DTC):____________________
   - Freeze Frame 3 (Third sequential DTC): ____________________
   - Most Recent Freeze Frame: ____________________
4. Clear DTCs from memory
5. Remove A/C Clutch Relay, start engine, turn on A/C. Check for DTCs and any Freeze Frames. Was a DTC set? __________ Which FF(s) stored the DTC?_______
6. Reinstall relay
7. Unplug a COP assembly for 10 seconds and then plug back in.
8. Unplug an upstream O2 sensor for 15 seconds then plug back in.
9. Unplug CMP sensor for 5 seconds then plug back in.
10. Raise engine RPM to prevent stalling, unplug MAP for 5 seconds, then plug back in.
11. Read DTCs using READ ALL option and record: ____________________

    ____

    ____
12. Read DTCs using CHRONOLOGICAL option and record: ____________________

    ____

    ____
13. View and record all Freeze Frames:
    - CARB Freeze Frame 1: ____________________
    - Freeze Frame 1 (First sequential DTC): ____________________
    - Freeze Frame 2 (Second sequential DTC):____________________
    - Freeze Frame 3 (Third sequential DTC): ____________________
    - Most Recent Freeze Frame: ____________________

14. Why does the COP appear in two Freeze Frames? ____________________________

____

15. Access All OBD2 Monitor Status under the DRBIII® OBD2 Monitors. Will most OBDII Monitors run? ______________ Why or why not? ______________________

____

16. How does this screen differ from SBEC and JTEC screens? ___________________

____

ACCESSORIES

INTEGRATED CRUISE CONTROL

The Integrated Cruise Control (ICC) system allows the driver to control the speed of the vehicle through a set of switches on the steering wheel, rather than by using the throttle pedal. The system consists of:

- Cable connected between the throttle body and the speed control servo
- Vacuum servo which includes three electronically controlled solenoids
- Vacuum reservoir and harness that supplies vacuum to the servo, including a check valve to store vacuum for use when engine vacuum is low

The three servo solenoids have the following separate functions:

- Vacuum Solenoid- controls vacuum supplied to the servo diaphragm chamber
- Vent Solenoid- vents the servo vacuum from the diaphragm chamber
- Dump Solenoid- provides a complete dump of servo vacuum from the chamber

By applying vacuum to the servo, the throttle opening is increased. By controlling the Vent solenoid the throttle opening is decreased. When the power to the servo is shut off, both the Dump and Vent solenoids are opened to close the throttle. A servo solenoid timer is used to keep track of which solenoids are energized and for how long.

The most basic function of speed control is to establish a target Set speed and maintain that speed as conditions vary. Before a Set speed can be established, first the On/Off switch must be pressed, to turn the cruise system On, "enabling" it to accept a set speed. The On/Off switch function alternates between turning the system On and Off each time the switch is pressed. The word "CRUISE" lights up on the dash to indicate when the speed control system is turned on.

Driving at the desired vehicle speed, then pressing and releasing the Set switch establishes the Set speed. For 4-switch systems, the Set /Coast switch must be quickly pressed and released, and if already engaged, a Tap-Down will occur. The minimum speed that can be set is 30 MPH, while the maximum permitted SET speed is 85 MPH.

Once the set speed is established, modification of the vehicle speed can be accomplished through use of the other speed control switches. It can be "tapped up" or "tapped down" in small increments, accelerated or decelerated to another valid Set speed, disengaged or re-engaged, or the whole system can be shut down.

A "Tap Up" increases the Set speed by a small increment (2 MPH) when the Resume/Accel switch is quickly pressed and released. A vacuum pulse is delivered to the servo to open the throttle to achieve the new set speed.

A "Tap Down" decreases the Set speed by a small increment (1 mph) when the Coast switch is quickly pressed and released. For 4-switch systems, the Set/Coast switch must be quickly pressed and released. A vent pulse is delivered to the servo to close the throttle to achieve the new Set speed.

Accel mode provides a controlled acceleration rate when the Resume/Accel switch is held down for a longer time. When the Resume/Accel switch is released, the vehicle's current speed is established as the new set speed, and a small vent pulse is delivered to the servo to stop the acceleration.

Coast mode provides a controlled deceleration rate when the Coast switch, or Set/Coast switch for 4-switch systems, is held down for a longer time. When the Coast switch is released, if the vehicle speed is above the minimum set speed limit, then the vehicle's current speed is established as the new set speed, and a vacuum pulses is delivered to the servo to stop the deceleration.

Cancel disengages throttle control from the speed control servo, returning control to the driver, when the Cancel switch is pressed, but saves the set speed in memory. The following actions will do the same:

- Depressing the brake pedal
- Shifting any electronic automatic transmission into Neutral
- Shifting an Auto-Stick transmission into 2nd or 1st gear
- Depressing the clutch pedal on manual transmission vehicles

Resume re-engages control of the throttle to the speed control servo when the Resume/Accel switch is pressed following a system disengagement that did not erase the set speed. When the Resume first occurs, if the vehicle speed is far enough below the set speed, an additional vacuum pulse is added to the normal set pulse. When the vehicle speed gets close to the set speed, the normal acceleration rates are used. Speed control can also be turned off by pressing the On/Off switch or turning the ignition switch Off. These methods, however, erase the set speed from the controller's memory, and require the On/Off switch be pressed again, to turn cruise On, before establishing a set speed again.

The interactive cruise control system interacts with the electronic automatic transmission in several ways. The transmission prevents normal requests for kick-downs while speed control is engaged, until an excessive speed error, over or under the set speed, has been detected. To control excessive over-speeds, the transmission will provide engine braking by performing a 4-3 downshift. To control excessive under-speeds, the transmission will perform a 4-3, or if the under-speed error is large enough, a 3-2 downshift. There is cruise logic that identifies when the driver's foot on the throttle pedal is overriding the cruise servo control of the throttle body. When a driver override is detected, the transmission allows normal requests for transmission kick-downs.

Another interaction between cruise and transmission operation is a slight throttle "cut back" to a target throttle position after a kick-down. Normally, there is harshness associated with the change in torque due to the gear reduction from a kick-down. By backing off the throttle slightly and compensating for the hydraulic delay of the downshift, a smoother transition in torque levels can be obtained.

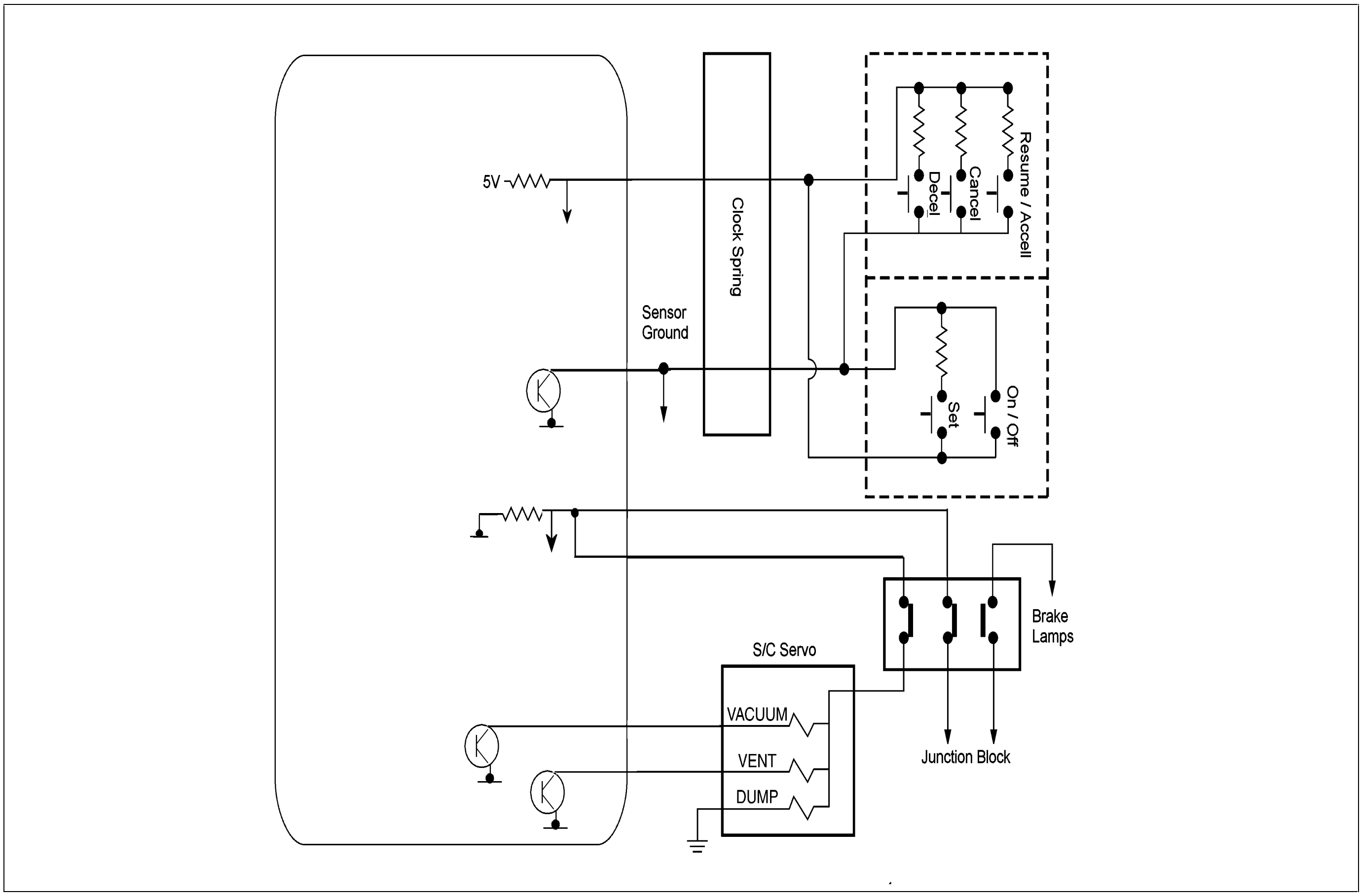


Figure 32 Integrated Cruise Control System

DRBIII® Enhancements to ICC

Vehicles equipped with an NGC controller will store the last eight cutouts for cruise control and the reason for the cutout in memory. These cutouts are arranged in a circular buffer, and are stored sequentially until all eight positions are used. When the ninth cutout occurs, the data will overwrite buffer number one, the tenth will overwrite buffer number 2, etc. This is similar to the strategy used to store Co-pilot® events.

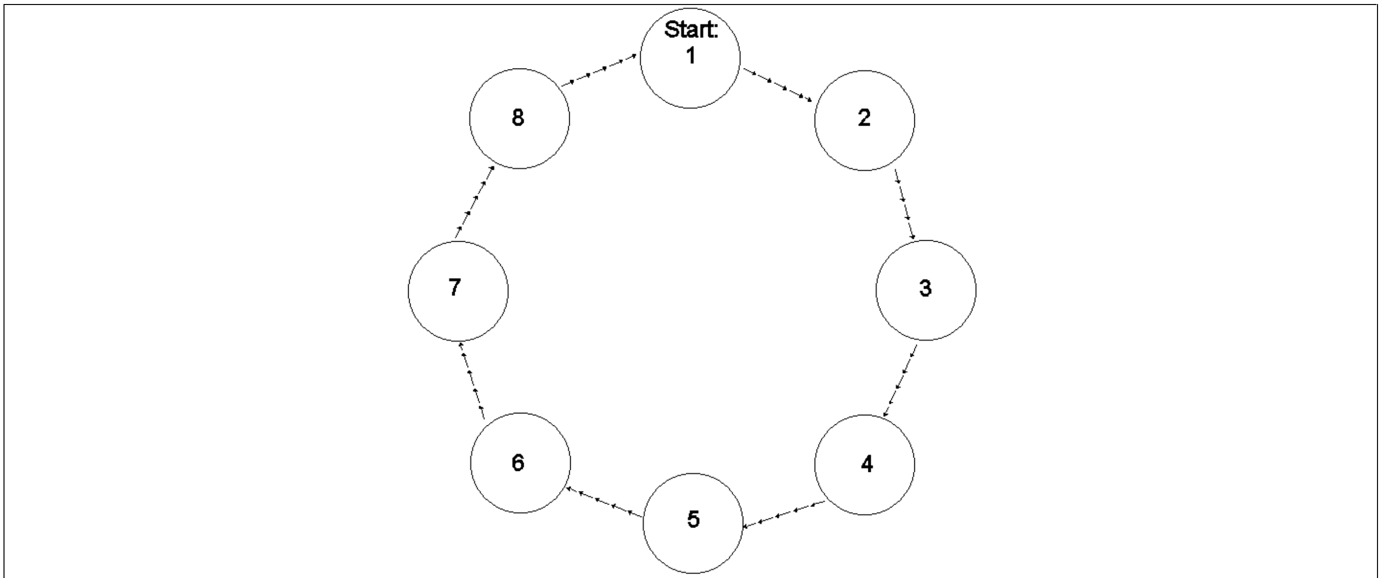


Figure 33 ICC Cutout Buffers

It is important to note that the information contained in these buffers does not necessarily indicate that a problem has occurred. Information will be stored for any cutout, whether a normal cutout or a problem related cutout.

- So how do you use this information to diagnose a malfunction?
- Which record do you investigate?

Explain to a customer that a “bookmark” needs to be created. Ask them to follow this procedure: When an abnormal cruise cutout occurs,

- Turn the ICC system on and set to a legal speed range
- Immediately deactivate the system by depressing the On/Off switch to Off
- Perform this procedure a total of three times

The abnormal cutout is the one that occurred immediately before the three On/Off switch cutouts that were created by the customer.

DOUBLE-START OVERRIDE (STARTER RELAY)
This feature protects the starter motor drive gear and the gear teeth on the flex-plate or flywheel by preventing the starter motor from being engaged if the engine is already running. The starter will also be disabled when Smart Key Immobilizer Module (SKIM) equipped vehicles have received a series of bad keys.
If a start condition is detected, the starter relay is enabled. Enabling the relay causes the starter to engage. When a start condition is no longer indicated the starter relay is disabled which causes the starter to disengage. The relay cannot be enabled if the engine is already running. The starter relay control circuit is part of the cranking system, shown in Figure 30.

To enable the starter relay, the ignition switch must be in the START position. On vehicles with automatic transmissions, battery voltage is provided through the ignition switch to one end of the relay coil. The controller provides body ground to the other end of the relay. The Park/Neutral switch must be in Park or Neutral to enable the Starter. Vehicles with SKIM will also have a check to insure the "bad key counter" has not exceeded the maximum allowable "bad key" count. If too many bad keys are received, the feature will not enable the starter relay.

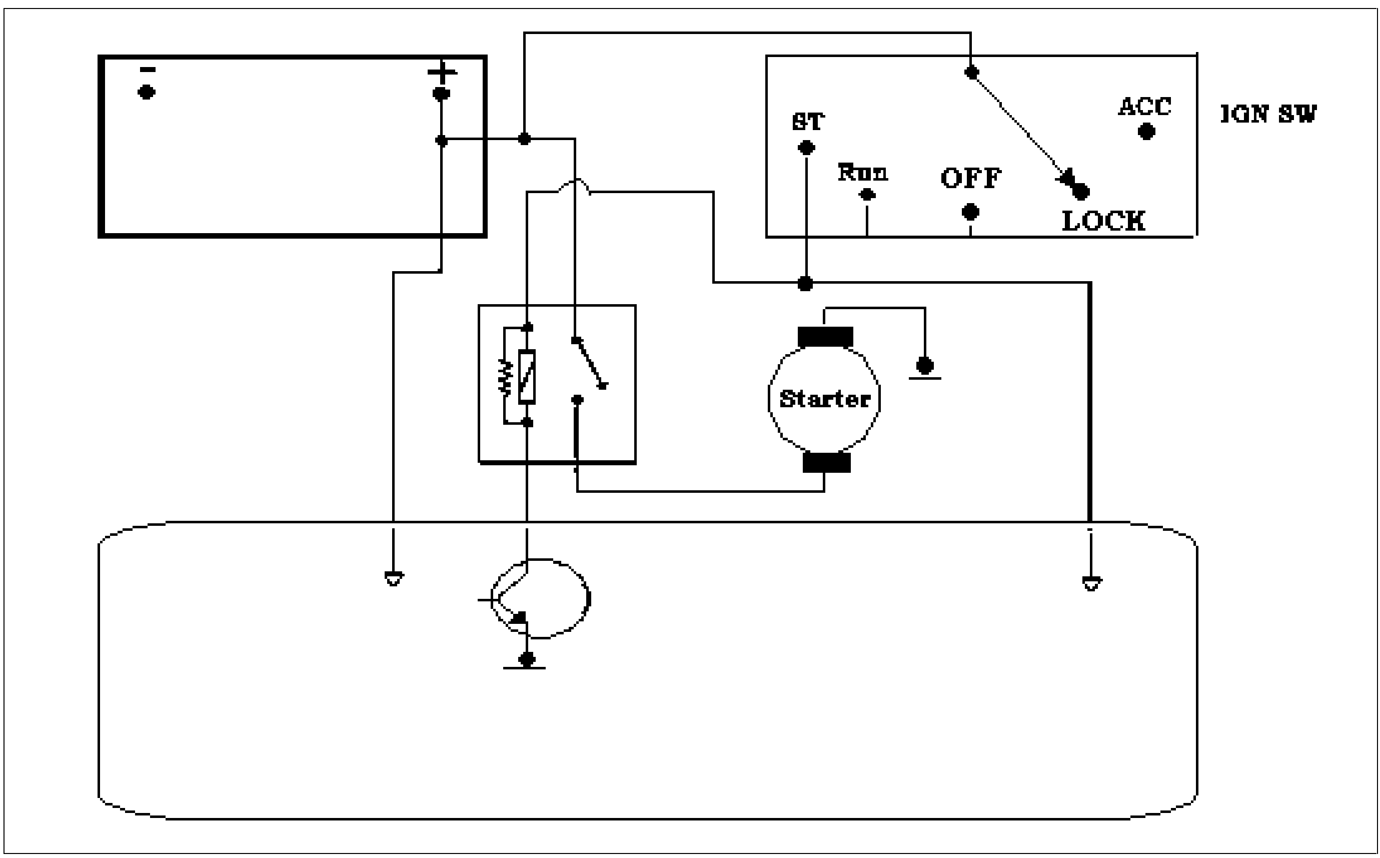


Figure 34 Double Start Override System

COOLING FAN CONTROL

The primary function of the cooling fan control circuit is to determine the steady-state fan operational speed. The desired fan state is dependent on the vehicle application and combination of engine coolant temperature, transmission oil temperature, A/C compressor head pressure, A/C state, inlet/intake/battery temperature, and vehicle speed during normal operations.

The cooling fan control strategy consists of three parts:

- Desired fan state- takes into consideration various inputs and determines whether the fan(s) should be off, or on low or high speeds:
  - Coolant temperature
  - Intake/inlet air temperature
  - Transmission temperature
  - A/C head pressure
  - Vehicle speed
- Idle load compensation- checks to see if idle compensation is needed due to cooling fan load and requests IAC adjustment if necessary
- Desired relay state/duty cycle- takes the desired fan state, load compensation status, determines what the corresponding low-speed relay/high-speed relay/duty cycle should be, and sends the appropriate signal to the fan system

Anti-Steaming

The primary function of Anti-steaming program is the elimination of visible vaporized condensation from the radiator. Condensation can form within the engine compartment under specific cold soak conditions. This condensation will vaporize from the radiator shortly after warm engine coolant starts to circulate through the radiator. To eliminate visible steam and prevent customer concern, the fans will be turned on low when conditions are favorable for condensation, the radiator is warm and the vehicle is stopped or moving slowly.

Fan Cutout

The primary function of Fan Cutout is to reduce engine accessory loading during high vehicle speed operation when fans are not needed or during a vehicle low-speed acceleration, so that engine output can be utilized for acceleration. The high-speed cutout is based only on vehicle speed. The low speed cutout is based on engine coolant temperature; engine speed, throttle position, vehicle speed, and transmission oil temperature and are limited to a calibrateable maximum time.

Load Compensation

The primary function of Load Compensation is to provide compensation for the change in load on the powertrain that results from a cooling fan turning on. It will also ensure that in closed throttle conditions loads are turned on only after the engine has been allowed to stabilize from previous load engagements. A compensation request is initiated in a relay system when the engine is in idle mode and the fan desired state changes from off to low, off to high, or low to high. Once the compensation is completed, the fan state can be changed. A compensation request is initiated in a PWM system when the engine is at closed throttle, the fan desired state changes from off to low or off to high, and the previous fan duty cycle was zero.

Injector Rail Cooling

This new feature is necessary to reduce the possibility of fuel vaporization in the fuel rail during hot idle and hot soak. The objective is to reduce under hood temperatures through additional radiator fan operation based on intake/inlet temperature and under hood soak heat potential. This feature consists of two main programs:

- The inlet/intake air temperature sensor is used to mimic the coolant temperature sensor-based "low speed" radiator fan control. The fan is cycled between low and high speeds while the injector control algorithm is calling for the fans to be "on."
- A program has been created that attempts to reduce the "hot-soak" potential in the engine compartment by monitoring vehicle speed, elapsed time at either "high" vehicle speed or "low" vehicle speed, and coolant temperature to control the low speed fan.

Both of the new fan control programs create requests for desired fan operation. The new programs don't directly control the fan operation. The existing fan control system still determines whether the fan is "OFF" or "ON" in either low speed or high-speed mode. Whichever component in the overall fan control system that is calling for the highest fan speed operation still takes priority. These new fan control programs are integrated into the entire existing fan control program so that they provide additional fan "ON" times.

The following chart is only a general overview of the intended operation of the fan control logic:

Table 2 Cooling Fan Control Logic

					A/C Head Pressure								
					Low			**Med**			**High**		
					Trans Temp			**Trans Temp**			**Trans Temp**		
					Low	Med	High	Low	Med	High	Low	Med	High
AC On				Low	Off	Low	High	Low	Low	High	High	High	High
				Med	Low	Low	High	Low	Low	High	High	High	High
				High	High	High	High	High	High	High	High	High	High
AC Off	**MPH**	**Low**		Low	Off	Low	High	Low	Low	High	High	High	High
				Med	Low	Low	High	Low	Low	High	High	High	High
				High	High	High	High	High	High	High	High	High	High
		High		Low	Off	Low	High	Low	Low	High	High	High	High
				Med	Low	Low	High	Low	Low	High	High	High	High
				High	High	High	High	High	High	High	High	High	High

Electrical Operation

The cooling fan(s) may be controlled by one of the following methods:

- High/Low Speed Relay and High Speed Relay
- High Speed Relay and Low Speed Relay
- Electronically controlled 2 Speed Pulsewidth Modulated (PWM) relay

2-Speed PWM Controlled Systems

The primary function of the 2-Speed PWM Duty Cycle control is to calculate and control the duty cycle to the PWM relay. The duty cycle of the PWM relay are based on the desired fan state during normal vehicle operation. The base frequency of the PWM signal is 55Hz. If unusual operation is detected in the relay or a coolant sensor fault is active, the fan control system will operate in a limp-in mode. This limp-in mode is to protect the powertrain from a catastrophic overheating condition.

Relay Controlled Systems

The cooling fan module on LH vehicles is comprised of dual, two-speed motor assemblies. Each motor is capable of running on Low or High speed. On low speed, each motor is fed current via the Hi/Lo cooling fan module relay. In high-speed mode, the Hi/Lo relay remains energized, while the Hi speed relay is also energized.

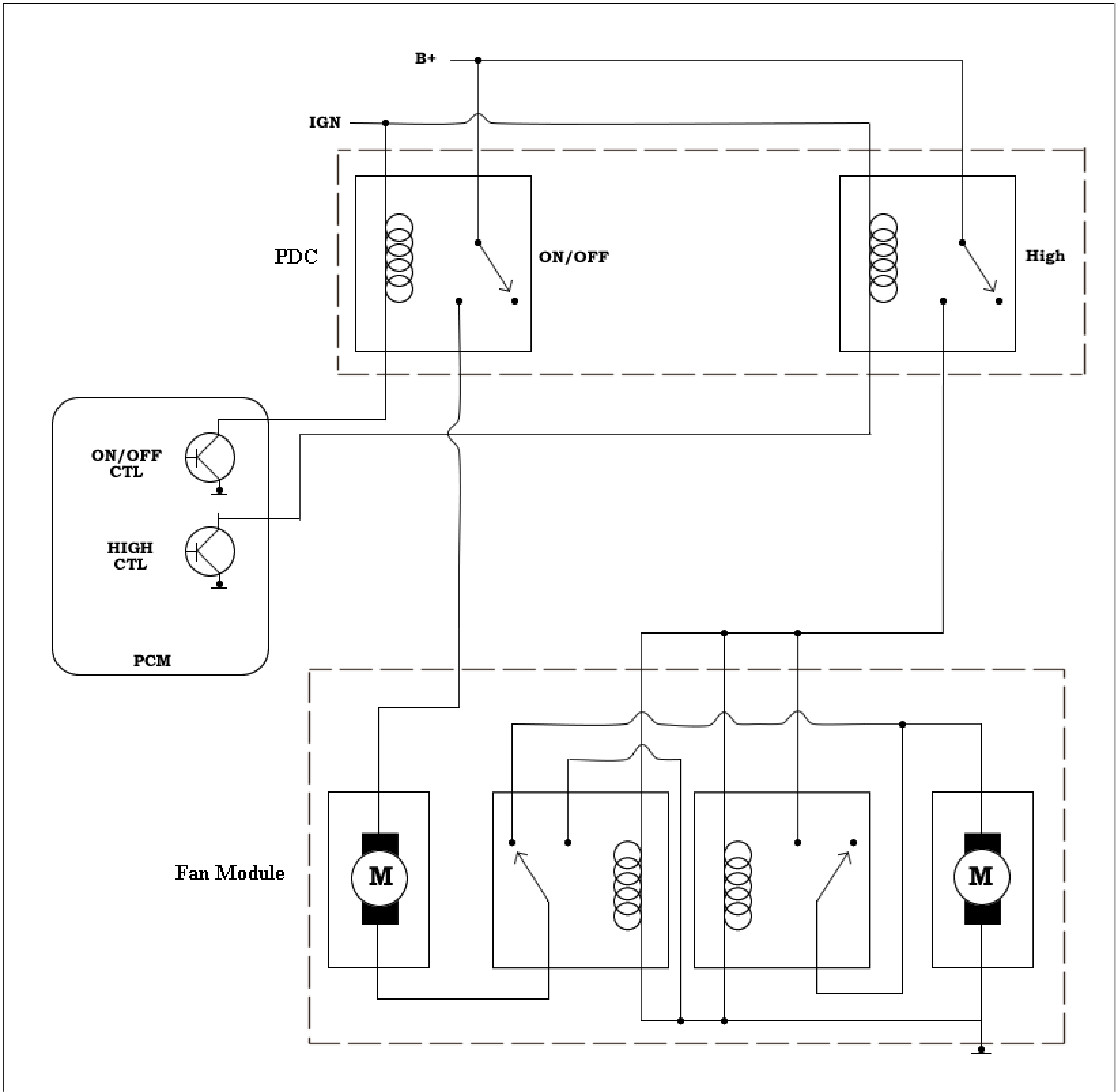


Figure 35 Relay Controlled Cooling Fan Module (LH Shown)

A/C CONTROL SYSTEM

As on previous SBEC and JTEC vehicles, the PCM on vehicles equipped with the NGC controller has the ultimate authority on whether the vehicle conditions are appropriate for the A/C compressor clutch to be energized or not. The method used by the PCM to make this decision depends on specific vehicle configuration. The A/C control system can be broken down into three subsystems:

- A/C Select- Has the driver (or the HVAC system) selected A/C compressor operation?
- A/C Request- Have the conditions required for A/C compressor operation, both the refrigeration system and engine parameters, been satisfied?
- Desired A/C Clutch Actuation

A/C Request

The requested state of the A/C system is sent to the PCM in a number of different ways depending on the hardware of the specific vehicle configuration. This signal may consist of the select switch, pressure switches, evaporator temperature, high engine speed, and coolant temperature information.

A/C Select Switch

The AC select switch can either be a hardwired switch or one that comes from the body control module (BCM). The AC select switch can also have a dual pressure switch and an evaporator temperature switch inline.

A/C System Pressure

A/C system pressure may either be a function of the A/C pressure transducer, or of the high-pressure and low-pressure cutout switches. These pressure inputs prevent A/C compressor clutch operation and system damage when A/C system pressures are at an excessively high or low-pressure state.

Evaporator Temperature Sensor

On vehicles equipped with a negative temperature coefficient (NTC) evaporator temperature thermistor, information is sent over the BUS to the BCM or A/C control module. This signal is then sent to the PCM via the BUS or hardwired signal from the responsible control module as an "A/C Select" input. If the evaporator temperature is approaching a point where it may freeze, the PCM will de-energize the A/C compressor based upon a signal from the responsible control module. When the evaporator has warmed to the point where freeze-up will not occur, the PCM is signaled to re-energize the A/C compressor clutch.

A/C Compressor Inhibits

The PCM may refuse to energize the A/C compressor if one of the following conditions is present:

- Coolant temperature too high

- Engine speed too high
- A/C Low Pressure Cutout Switch Input
- EGR Monitor interaction- when the OBDII monitor is in progress, the clutch will not be allowed to turn on if it is off. If EGR monitor is in progress the clutch will be allowed to turn off.

A/C Cutouts

Any of the below listed cutouts turn off the clutch immediately and informs the IAC control circuit that the AC clutch control has shut off. Cutouts are based on throttle, engine speed, and time in run mode.

- Wide Open Throttle- When wide-open throttle is detected and vehicle speed is below a certain calibrated vehicle speed, the AC clutch will be immediately turned off for a calibrated length of time. Above the vehicle speed calibration, no AC cutout will occur. This cutout will not occur if coolant temp, throttle position, or vehicle speed signal faults exist.
- Part Throttle- Part throttle disable conditions are met when the change in throttle position exceeds a threshold and engine speed and vehicle speeds are below a threshold. When part throttle disable conditions are met, the AC clutch is immediately turned off, and the part throttle disable timer starts. The disable time is based on the current battery (ambient) temperature. The disable ends when the conditions are no longer met or when the disable time has expired. This cutout will not occur if coolant temp, throttle position, or vehicle signal faults exist
- Engine RPM too Low- When the engine RPM is below a certain threshold, the AC clutch is turned off. It is not turned back on until the engine speed exceeds a calibrated threshold.
- Time in Run Mode (Delay after Start)- Normal A/C clutch control only begins a calibrated time after the engine has started. If the engine stalls or is turned off, this delay must reoccur.

Desired A/C Clutch State

The AC desired state is the combination of the requested state, A/C cutout and A/C cycling input. When the requested state, and AC cutout all indicate that a clutch state change can occur, a final check against the AC cycling conditions will occur to insure that sufficient time in the current state has passed.

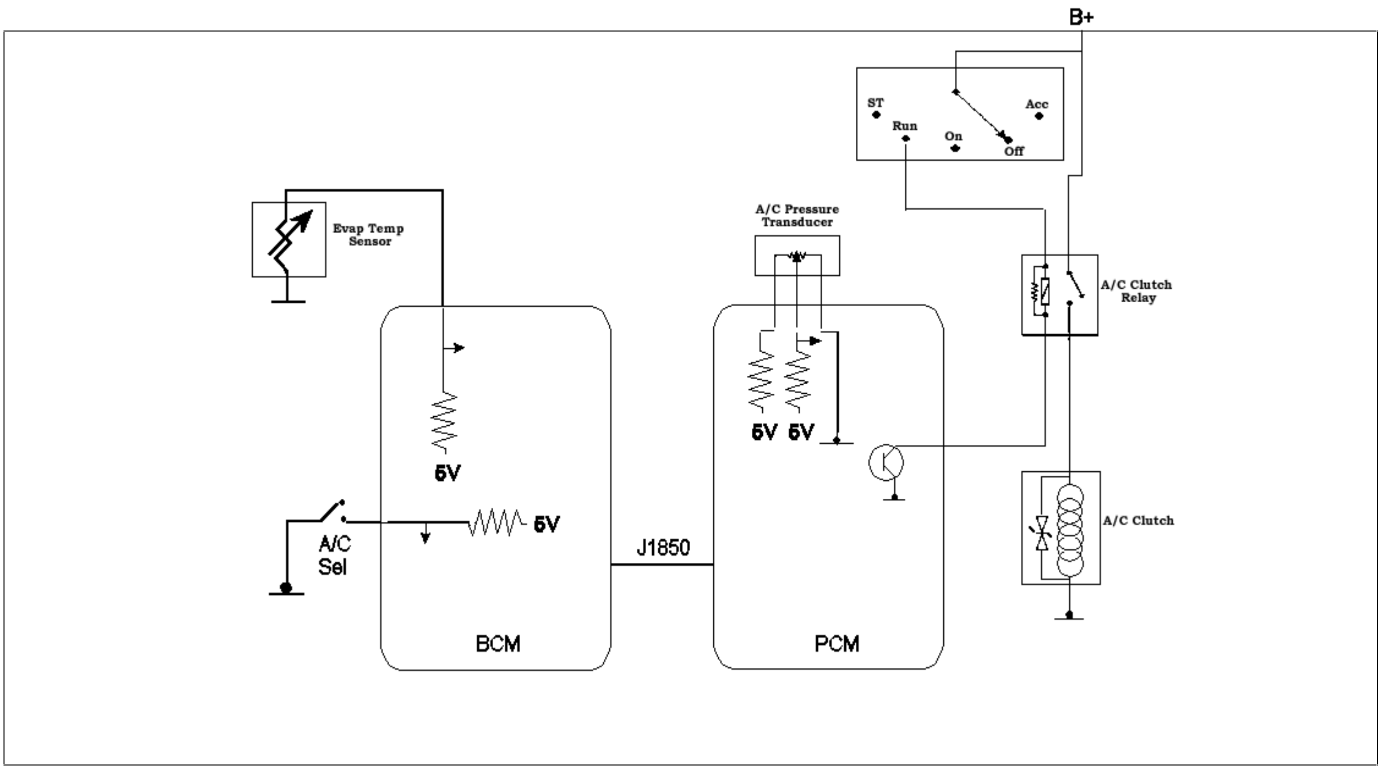


Figure 36 A/C Control Circuit (LH Shown)

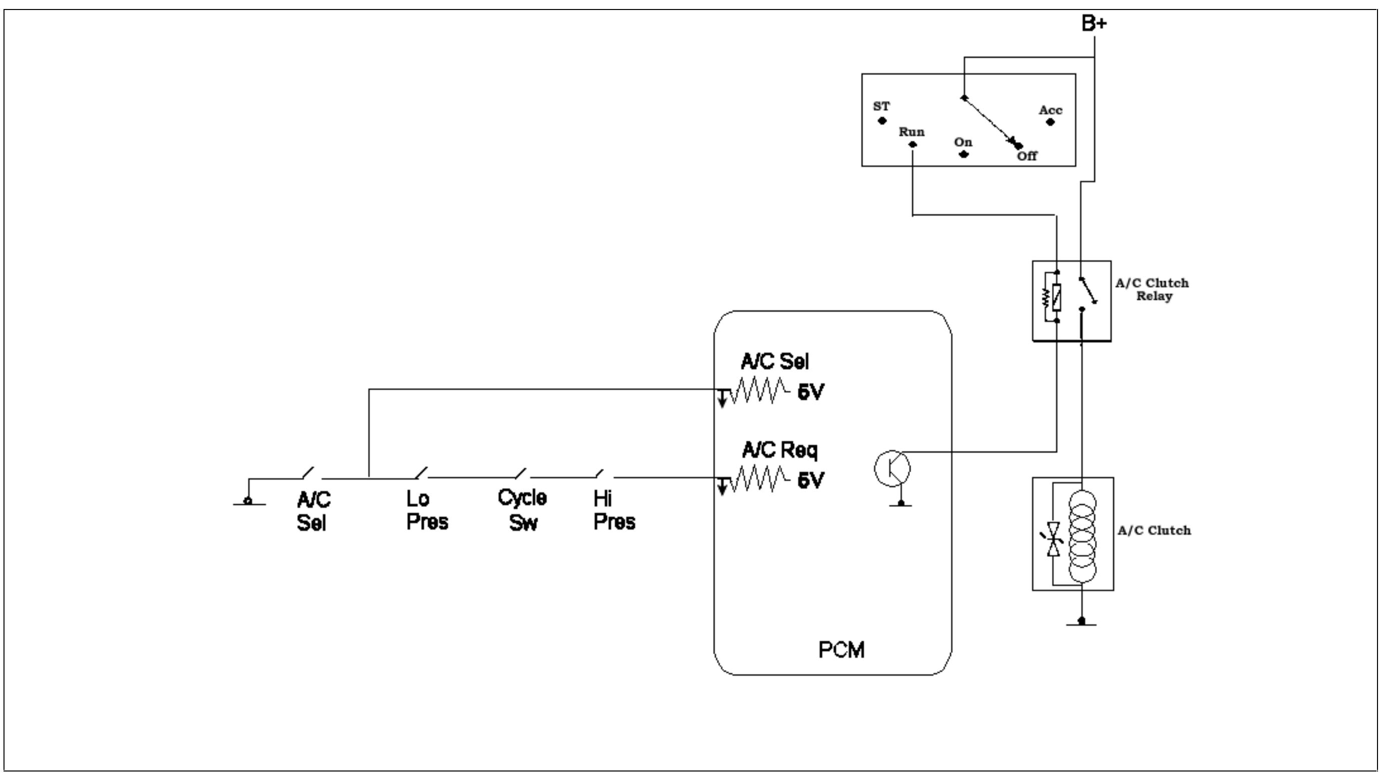


Figure 37 A/C Control Circuit (DN Shown)

ACTIVITY 7 INTEGRATED SPEED CONTROL (ISC)

1. With the vehicle securely raised on the hoist, observe the Vehicle Speed Signal and S/C Set values on the S/C Input Monitor screen. Start the vehicle, disable traction control (if equipped) and place vehicle into gear. Turn on the S/C system and determine the minimum speed that the PCM will set while observing the DRBIII® S/C Set Speed value:

   ☐ 25 MPH ☐ 30 MPH ☐ 35 MPH ☐ 40 MPH

2. Briefly tap the Accel button. The set speed increases by ________________ MPH
3. Briefly tap the Coast button. The set speed decreases by ________________ MPH
4. Set cruise to 35 MPH and tap brake pedal.
5. Set cruise to 35 MPH and place shifter into neutral (manual trans, depress clutch pedal)
6. Set cruise to 35 MPH and cycle ignition switch to OFF.
7. Restart vehicle. Set cruise to 35 MPH, and then drop into LOW.
8. Shift back to OD, set cruise to 35 MPH, repeatedly tap COAST until S/C turns off.
9. Set cruise to 35 and depress CANCEL.
10. Set cruise to 35 and depress CANCEL again.
11. Set cruise to 35 and depress ON/OFF; repeat 2 additional times.
12. Under Monitors, view all eight S/C Cutout screens and record the cutout reasons below:

S/C 1	Reason:
S/C 2	Reason:
S/C 3	Reason:
S/C 4	Reason:
S/C 5	Reason:
S/C 6	Reason:
S/C 7	Reason:
S/C 8	Reason:

13. Why wasn't the brake switch listed as one of the cutout reasons?______________

    ____

14. Which cutout and reason was the last recorded?______________________________

15. Which cutout was overwritten? ____
16. Set the S/C system to 35 MPH. Unplug the S/C Servo and record any DTCs:

    ____
17. Plug in servo and clear DTCs. Go to Actuators, and while watching servo actuate All Sol/Relays. Does the throttle open at least twice? _______________
18. What is this confirmation of? ____

    ____

Notes:

Notes:

Notes:

Notes:

Notes:

Notes: