Workshop Manual
"NC" Models

MFI Diagnostic (7.4 Gi/GSi, 8.2 GSi) - GM

**VOLVO
PENTA**®
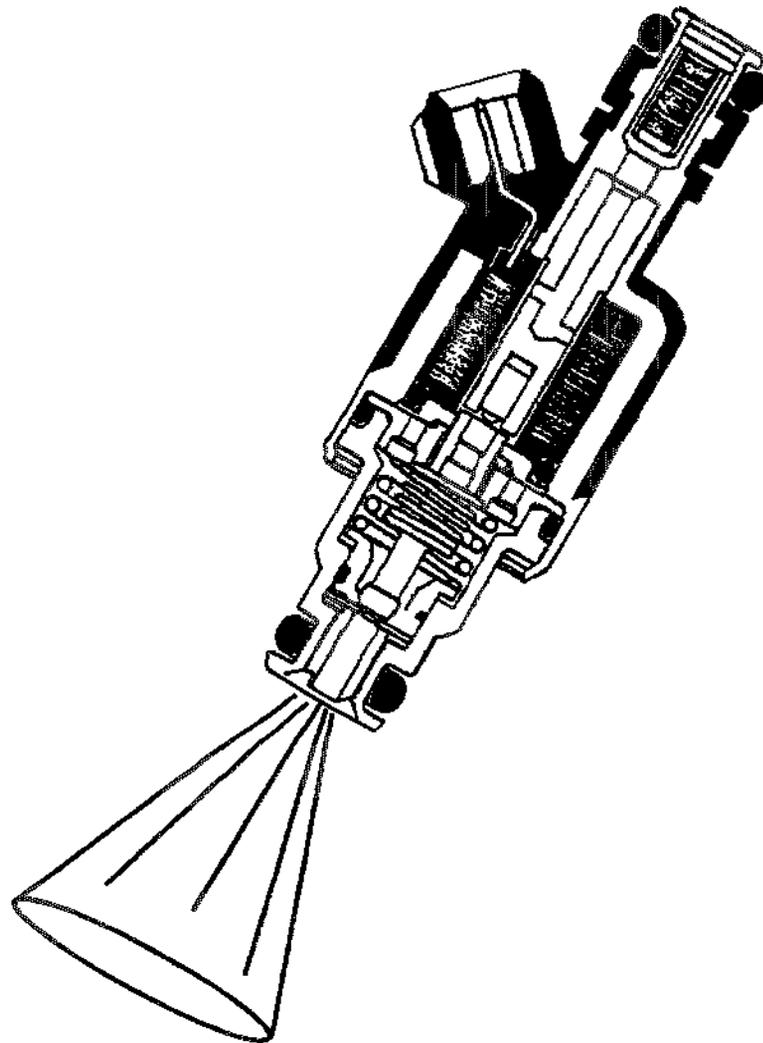
⚠ Safety Warning

This Workshop Manual will alert you to certain procedures that must be done very carefully. If you ignore this information, you could...

- Injure yourself or people around you
- Injure the boat operator, boat passengers, or people around the boat
- Damage the Volvo Penta product or its systems

Understand the following symbols before proceeding:

⚠ Safety Warning	Alerts you to the possibility of danger and identifies information that will help prevent injuries.
[Note]	Identifies information that will help prevent damage to machinery.
Important	Appears next to information that controls correct assembly and operation of the product.

This Workshop Manual is written for qualified, factory trained service technicians familiar with the use of Volvo Penta special tools.

This Workshop Manual tells you how to correctly maintain and service Volvo Penta products and systems. When correctly serviced, the Volvo Penta product will be reliable and safe to operate.

When Volvo Penta special tools are called for, use them. Where mentioned, the tools are required to perform the service procedure.

If you use service procedures or service tools that are not recommended in this manual, YOU ALONE must decided if your actions might injure people or damage the Volvo Penta product.

Contents

This Workshop Manual is one of a set of nine that covers *Volvo Penta* sterndrive models. All nine books can be ordered as a set from *Volvo Penta Parts.* Order P/N 7788880-8.

Individual Workshop Manuals covering these models are also available. Order the following part numbers from *Volvo Penta Parts.*

- **P/N 7788881-6 *SX, DP-S Drive Unit and Transom Shield***
  Includes information on Transom Shield, Upper Gear Unit and Lower Gear Unit service; Drive Unit removal and installation; Propellers; and Trim/Tilt hydraulic operation.

- **P/N 7788882-4 *MFI Diagnostic (5.0 Fi, 5.8 Fi/FSi) - Ford***
  Includes step by step troubleshooting procedures for all MFI Ford related components and wiring.

- **P/N 7788883-2 *TBI Diagnostic (4.3 Gi, 5.7 Gi/GSi) - GM***
  Contains troubleshooting procedures for all TBI GM models and related components.

- **P/N 7788884-0 *MFI Diagnostic (7.4 Gi/GSi, 8.2 GSi) - GM***
  Includes step by step troubleshooting procedures for all MFI GM related components and wiring.

- **P/N 7788885-7 *SP-DP Drive Unit and Transom Shield***
  Includes information on Transom Shield, Upper Gear Unit, Lower Gear Unit service; Drive Unit removal and installation; Propellers; and Trim/Tilt hydraulic operation and servicing procedures.

- **P/N 7788886-5 *Engine Components***
  Includes information on Engine service and troubleshooting; Engine removal and installation; Steering systems; Throttle and Shift Control systems; and Cooling systems.

- **P/N 7788887-3 *Electrical & Ignition System***
  Includes service and troubleshooting information on Cranking systems; Charging systems; Trim/Tilt electrical systems; Ignition systems; and Engine and Instrument wiring diagrams.

- **P/N 7788888-1 *Fuel System***
  Includes service and troubleshooting information on all carburetor, MFI and TBI fuel systems and related components.

- **P/N 7788889-9 *DPX-Lower Unit and Xact™ Steering System***
  Includes specific information for repair and overhaul of the DPX Lower unit and Xact™ steering systems not covered in the SP and DP Workshop manual.

This *Volvo Penta* MFI Workshop Manual
Covers The Following *Volvo Penta* "HU" Models

SX™

Engine	Model Nr.	Transom Shield	Drive Unit	Options
3.0 GS SX NPS	3868181	3868288/SX-LIMITED TRIM	3868159/SX-CT/1.85:1	3868176/SX-C
3.0 GS SX	3868182	3868288/SX-LIMITED TRIM	3868159/SX-CT/1.85:1	3868176/SX-C
4.3 GL SX	3868184	3868176/SX-C	3868160/SX-C/1.66:1	3868159/SX-C/1.85:1/H.A.
4.3 GS SX	3868186	3868176/SX-C	3868160/SX-C/1.66:1	3868159/SX-C/1.85:1/H.A.
5.0 FL SX	3868189	3868176/SX-C	3868160/SX-C/1.66:1	3868159/SX-C/1.85:1/H.A.
5.0 FI SX	3868193	3868176/SX-C	3868161/SX-C/1.60:1	3868160/SX-C/1.66:1/ H.A.
5.8 FL SX	3868190	3868176/SX-C	3868162/SX-C/1.51:1	3868160/SX-C/1.66:1/ H.A.
5.8 FI SX	3868194	3868176/SX-C	3868162/SX-C/1.51:1	3868160/SX-C/1.66:1/ H.A.
5.8 FSI SX	3868195	3868176/SX-C	3868208/SX-C/1.43:1	3868162/SX-C/1.51:1/H.A.

H.A. = high altitude applications

DuoProp®

Engine	Model Nr.	Transom Shield	Drive Unit	Options
4.3 GI DP	3868320	3868299/DP-S	3868008/DP-C1/2.30:1	
4.3 GS DP	3868321	3868299/DP-S	3868008/DP-C1/2.30:1	
5.0 FL DP	3868322	3868299/DP-S	3868002/DP-C1/1.95:1	3868008/DP-C1/2.30:1/H.A.
5.0 FI DP	3868323	3868299/DP-S	3868002/DP-C1/1.95:1	3868008/DP-C1/2.30:1/H.A.
5.7 GI DP	3868325	3868299/DP-S	3868002/DP-C1/1.95:1	3868008/DP-C1/2.30:1/H.A.
5.8 FL DP	3868324	3868299/DP-S	3868002/DP-C1/1.95:1	3868008/DP-C1/2.30:1/H.A.
5.8 FI DP *	3868326	3868299/DP-S	3868002/DP-C1/1.95:1	3868008/DP-C1/2.30:1/H.A.
5.8 FSI DP	3868327	3868299/DP-S	3868002/DP-C1/1.95:1	3868022/DP-D1/1.78:1
7.4 GL DP	3868328	3868299/DP-S	3868022/DP-D1/1.78:1	3868002/DP-C1/1.95:1/H.A.
7.4 GI DP	3868335	3868299/DP-S	3868022/DP-D1/1.78:1	N.A.

* = export only   H.A. = high altitude applications   N.A. = Not Available

DPX™

Engine	Model Number	Transom Shield	Drive Unit
7.4 GSI DPX-CA	3868198	3868289/DPX-C	3868020/DPX-C /1.59:1
7.4 GSI DPX-CB	3868198	3868289/DPX-C	3868021/DPX-C /1.68:1
7.4 GSi DPX-CC	3868198	3868289/DPX-C	3868023/DPX-C /1.78:1
8.2 GL DPX-CA	3868133	3868289/DPX-C	3868020/DPX-C /1.59:1
8.2 GL DPX-CB	3868133	3868289/DPX-C	3868021/DPX-C /1.68:1
8.2 GL DPX-CC	3868133	3868289/DPX-C	3868023/DPX-C /1.78:1

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Covers The Following *Volvo Penta* "NC" Models

SX™

Engine	Model Nr.	Transom Shield	Drive Unit	Options
3.0 GS SX NPS	3868181	3868432/SX-LIMITED TRIM	3868396/SX-CT/1.85:1	3868397/1.97/SXC 386404/TSK
3.0 GS SX	3868182	3868432/SX-LIMITED TRIM	3868396/SX-CT/1.85:1	3868397/1.97/SXC 386404/TSK
4.3 GL SX	3868184	3868404/SX/DP	3868395/SX/1.66	3868465/SX/1.85
4.3 GS SX	3868186	3868404/SX/DP	3868395/SX/1.66	3868465/SX/1.85
5.0 FL SX	3868414	3868404/SX/DP	3868395/SX/1.66	N.A.
5.0 Fi SX	3868416	3868404/SX/DP	3868394/SX/1.60	3868395/SX/1.66
5.7 Gi SX	3868429	3868404/SX/DP	3868393/SX/1.51	N.A.
5.8 FL SX	3868415	3868404/SX/DP	3868393/SX/1.51	N.A.
5.8 FSi SX	3868418	3868404/SX/DP	3868393/SX/1.51	N.A.

H.A. = high altitude applications

DuoProp®

Engine	Model Nr.	Transom Shield	Drive Unit	Options
4.3 GL DP	3868184	3868404/SX/DP	3868163/DP/2.30	N.A.
4.3 GS DP	3868186	3868404/SX/DP	3868163/DP/2.30	N.A.
4.3 GI DP	3868185	3868404/SX/DP	3868163/DP/2.30	N.A.
5.0 FL DP	3868414	3868404/SX/DP	3868164/DP/1.95	N.A.
5.0 FI DP	3868416	3868404/SX/DP	3868164/DP/1.95	N.A.
5.7 GI DP	3868429	3868404/SX/DP	3868164/DP/1.95	N.A.
5.8 FL DP	3868415	3868404/SX/DP	3868164/DP/1.95	N.A.
5.8 FSi DP	3868418	3868404/SX/DP	3868164/DP/1.95	3868165/DP/1.78
7.4 GL DP	3868196	3868404/SX/DP	3868022/DP-D1/1.78:1	N.A.
7.4 Gi DP	3868450	3868404/SX/DP	3868166/DP/1.68	N.A.

* = for export only   H.A. = high altitude applications   N.A. = Not Available

DPX™

Engine	Model Nr.	Transom Shield	Drive Unit
7.4 GSi DPX-CA	3868198	3868289/DPX	3868020/DPX /1.59:1
7.4 GSi DPX-CB	3868198	3868289/DPX	3868021/DPX /1.68:1
7.4 GSi DPX-CC	3868198	3868289/DPX	3868023/DPX /1.78:1
8.2 GL DPX-CA	3868133	3868289/DPX	3868020/DPX /1.59:1
8.2 GL DPX-CB	3868133	3868289/DPX	3868021/DPX /1.68:1
8.2 GL DPX-CC	3868133	3868289/DPX	3868023/DPX /1.78:1

General Information

Table of Contents

⚠ Safety Warning

To reduce the chance of personal injury and / or property damage, the following cautions must be carefully observed.

Proper service and repair are important to the safety of the service technician and safe, reliable operation of all Electronic Fuel Injection (EFI) equipped engines. If part replacement is necessary, the part must be replaced with one of the same part number or with an equivalent part. Do not use a replacement part of lesser quality.

The service procedures recommended and described in this service manual are effective methods of performing service and repair. Some of these procedures require the use of tools specially designed for the purpose.

Accordingly, anyone who intends to use a replacement part, service procedure or tool, which is not recommended by the manufacturer, must first determine that neither his safety nor the safe operation of the engine will be jeopardized by the replacement part, service procedure or tool selected.

It's important to note that this manual contains various "Safety Warnings" and "Notes" that must be carefully observed in order to reduce the risk of personal injury during service or repair, or the possibility that improper service or repair may damage the engine or render it unsafe. It's also important to understand that these "Safety Warnings" and "Notes" are not exhaustive, because it's impossible to warn of all the possible hazardous consequences that might result from failure to follow these instructions.

Basic Knowledge / Tools Required ___

To use this manual most effectively, a general understanding of basic electrical circuits and circuit testing tools is required. You should understand the meaning of voltage, ohms, and amps; the basic theories of electricity; what happens to an open, shorted or grounded wire; and be able to follow wiring diagrams.

To perform system diagnostics, several special tools and equipment are required. Become acquainted with the tools and their use before attempting to diagnose the system. Special tools which are required for system service are illustrated at the end of this section.

Electrostatic Discharge Damage ___

Electronic components used in control systems are often designed to carry very low voltages, and are very susceptible to damage caused by electrostatic discharge. **It's possible for less than 100 volts of static electricity to cause damage to some electronic components.** By comparison, it takes as much as 4,000 volts for a person to feel the zap of a static discharge.

There are several ways for a person to become statically charged. The most common methods of charging are by friction and induction. An example of charging by friction is a person sliding across a seat, in which a charge of as much as 25,000 volts can build up.

Charging by induction occurs when a person with well-insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off, leaving the person highly charged with the opposite polarity. Static charges of either type can cause damage; therefore, it's important to use care when handling and testing electronic components.

Diagnostic Information ___

The diagnostic charts and function checks in this manual are designed to locate a faulty circuit or component through logic based on the process of elimination. The charts are prepared with the assumption that the system functioned correctly at the time of assembly and that there are no multiple failures.

Engine control circuits contain many special design features not found in standard marine wiring. Electrical contacts are protected against environmental effects and proper splicing methods must be used when necessary. The proper operation of low amperage input / output circuits depends upon good continuity between circuit connectors.

It's important before component replacement and / or during normal troubleshooting procedures that a visual inspection of any questionable mating connector be performed. Mating surfaces should be properly formed, clean, and make good contact. Some typical causes of connector problems are listed below.

- Improperly formed contacts and / or connector housing

- Damaged contacts or housing due to improper engagement

- Corrosion, sealer or other contaminants on the contact mating surfaces

- Incomplete mating of the connector halves during initial assembly or during subsequent troubleshooting procedures

- Tendency for connectors to come apart due to vibration and / or temperature cycling

- Terminals not fully seated in the connector bodies

- Inadequate terminal crimps to the wire

DLC Connector

The ECM can communicate a variety of information through the Data Link Connector (DLC) at the front of the engine. Stored information can be acquired using a scan tool or a Marine Diagnostic Trouble Code (MDTC) tool. Step charts in the Diagnoses section incorporate procedures using the MDTC tool.

NOTE The marine DLC is a 10-pin connector; an automotive DLC is a 12-pin connector. Make sure the scan or code tool is an appropriate one for marine use.

Code / Scan Tools

A variety of devices attach to the DLC to aid technician diagnostics. They range from inexpensive blinking lights (code tools) to sophisticated LCD / LED readouts (scan tools). Choose one that has been designed for marine applications, and best suits your needs and budget. The text in this manual has been written in terms of using a Marine Dignostic trouble Code (MDTC) tool. If using a scan tool, follow the manufacturer's instructions.

ECM Self-Diagnosis

The ECM performs a continual self-diagnosis on certain control functions. This diagnostic capability is complemented by the diagnostic procedures contained in this manual. The ECM's language for communicating the source of a malfunction is a system of diagnostic codes. The codes are two digit numbers that can range from 12 to 51. When a malfunction is detected by the ECM, a code is set.

How Diagnostic Trouble Codes (DTC's) Are Set

The ECM is programmed to receive calibrated voltage signals from the sensors. The voltage signal from a sensor may range from as low as 0.1 volt to as high as 4.9 volts. The sensor voltage signal is calibrated for engine application. This would be the sensor's working parameter or "window." The ECM and sensors will be discussed further in the ECM and Sensor section.

If a sensor is within its working or acceptable parameters, the ECM will not detect a problem. When a sensor voltage signal falls out of this "window", or an open or short occurs in the wiring to the sensor, the ECM would not receive the "window" voltage for that sensor.

When the ECM does not receive the "window" voltage for a programmed length of time, a DTC will be stored. The Check Engine light (if so equipped) will be illuminated and a known default value will replace the sensed value to restore engine performance.

Visual / Physical Inspection

A careful visual and physical inspection must be performed as part of any diagnostic procedure. This can often lead to fixing a problem without further steps. Inspect all vacuum hoses for correct routing, pinches, cuts, or disconnects. Be sure to inspect hoses that are difficult to see. Inspect all the wires in the engine compartment for proper connections, burned or chafed spots, pinched wires, or contact with sharp edges or hot manifolds. This visual / physical inspection is very important. It must be done carefully and thoroughly.

On-Board Diagnostic (OBD) System Check

After the visual / physical inspection, the OBD system check is the starting point for all diagnostic procedures. Refer to the Diagnoses section.

The correct procedure to diagnose a problem is to follow two basic steps:

1. **Are the on-board diagnostics working?** This is determined by performing the OBD system check. Since this is the starting point for the diagnostic procedures, always begin here. If the on-board diagnostics aren't working, the OBD system check will lead to a diagnostic chart in the Diagnoses section to correct the problem. If the on-board diagnostics are working correctly, the next step is:

2. **Is there a DTC** stored? If a DTC is stored, go directly to the numbered DTC chart in the Diagnoses section. This will determine if the fault is still present.

Service Mode

When the MDTC tool is connected to the DLC, and the MDTC tool switch is in the "ON" position, the system will enter what is called Service Mode. In this mode the ECM will:

1. Display a DTC 12 by flashing the MDTC tool light (indicating the system is operating correctly).

2. Display any stored DTC's by flashing the MDTC tool light. Each DTC will be flashed three times, then DTC 12 will be flashed again.

3. Hold ignition timing at a fixed timing degree programmed into the ECM. This will allow base timing to be adjusted on distributor ignition engines.

4. Move the IAC valve to its fully extended position, blocking the idle air passage. This is important to remember, as an attempt to run the boat while in Service Mode will most likely result in an abnormally low idle speed.

Reading Diagnostic Trouble Codes (DTC)

The provision for communicating with the ECM is the Data Link Connector (DLC). It's part of the MFI engine wiring harness, and is a 10-pin connector. It's used in the assembly plant to check engine operation before it leaves the plant. The DTC's stored in the ECM's memory can be read either through a scan tool (a hand-held diagnostic scanner plugged into the DLC), or by counting the number of flashes of the MDTC tool when in Service Mode.

The ignition and MDTC tool switches must be in the "OFF" position when connecting the MDTC tool to the DLC. Then turn the ignition switch to the "ON" position with the engine not running. At this point, the MDTC tool light should be on. Push the MDTC tool switch to the "ON" position and the light should flash DTC 12 three times consecutively (i.e. flash pause - flash-flash - pause, then it would repeat two more times). DTC 12 indicates that the ECM's diagnostic system is operating. If DTC 12 is not indicated, a problem is present within the diagnostic system itself, and should be addressed by consulting the appropriate diagnostics chart in the Diagnoses section.

Following the output of DTC 12, the MDTC tool light will indicate a DTC three times if a DTC is present, or it will simply continue to output DTC 12. If more than one DTC has been stored in the ECM's memory, the DTC's will be displayed from the numerically lowest to the highest, with each DTC being displayed three times.

Malfunction Indicator Lamp (MIL)

This light is part of the Marine Dignostic Trouble Code (MDTC) tool 3851088-9 and has the following functions:

- It informs the operator that a problem has occurred and that the boat should be taken in for service as soon as reasonably possible.

- It displays DTC's stored by the ECM which help the technician diagnose system problems.

When the MDTC tool is attached to the DLC with its switch in the "OFF" position, and the key in the "ON" position and the engine not running, the MDTC tool light will come "ON". When the engine is started, the light will turn "OFF". If the light remains "ON", the self-diagnostic system has detected a problem. If the problem goes away, the light will go out in most cases after 10 seconds, but a code will remain stored in the ECM.

When the light remains "ON" while the engine is running, or when a malfunction is suspected due to a driveability problem, an MFI Diagnostic Circuit Check must be performed. These checks will expose malfunctions which may not be detected if other diagnostics are performed prematurely.

To retrieve a DTC, turn the key to the "ON" position with the engine not running. Push the MDTC tool switch to the "ON" position and the light should flash a Code 12 three times, and then any other Code(s) that are stored in the ECM memory.

Intermittent Light

In the case of an "intermittent" problem, the MDTC tool bulb will light for 10 seconds and then go out. However, the corresponding code will be stored in the memory of the ECM. When unexpected codes appear during the code reading process, one can assume that these codes were set by an intermittent malfunction and could be helpful in diagnosing the system.

An intermittent DTC, if cleared, may or may not reset. If it's an intermittent failure, consult the **Diagnostic Aids** on the page facing the diagnostic code chart corresponding to the intermittent DTC. **Symptoms** also covers the topic of "intermittents". A physical inspection of the applicable sub-system most often will resolve the problem.

Manually Clearing DTC's _____

1. Turn ignition switch to the "OFF" position.

2. Install Marine Diagmostic Trouble Code (MDTC) tool with push switch in the "OFF" position.

3. Turn ignition "ON", engine not running.

4. Push MDTC tool switch to "ON" position.

5. To clear DTC's, disengage the remote control's shift function, then SLOWLY move the throttle from 0% (idle) to 100% (WOT) then back to 0%.

6. Push MDTC tool switch to "OFF" position.

7. Turn ignition "OFF" for 20 seconds.

8. Start engine and let it run for 20 seconds.

9. Turn ignition "OFF" for 20 seconds.

Turn ignition "ON", engine not running. Push MDTC tool switch to "ON" position and verify DTC 12 only. Remove MDTC tool.

Note When clearing DTC's, the battery must be fully charged and cranking speed must be at least 200 RPM. The ability to clear DTC's is directly dependent on the battery being fully charged and able to crank engine with adequate cranking RPM.

ECM Clearing of DTC's _____

The ECM will automatically clear DTC's if they have not re-occurred within 25 "power-ups". One "power-up" is defined as any time the engine, either cranking or running, enters Run Mode by exceeding 300 RPM for 16 seconds or more.

Diagnosis of Driveability Concerns (With No DTC's Set)

If a driveability concern still exists after following the diagnostic circuit check and reviewing the **Symptoms** section, an out-of-range sensor may be suspected. Because of the unique design of the MFI system, failsafes have been incorporated into the ECM. A sensed value is replaced with a default value in the case of a sensor malfunction or sensor wiring problem. With this feature, limited engine performance is restored until the engine is repaired. A basic understanding of sensor operation is necessary to be able to diagnose an out-of-range sensor.

If a sensor is out of range, but still within the operating "window" of the ECM, the problem will go undetected by the ECM and may result in a driveability concern.

Example: coolant temperature is 150°, but the coolant sensor incorrectly reads 50°. This would cause the ECM to deliver more fuel than was actually needed and result in an overly rich, rough running condition. This condition would not have caused a DTC to set as the ECM interprets this as within it's "range".

To identify a sensor which is out of range, unplug it while running the engine. After approximately 2 minutes, the diagnostic DTC for that sensor will set, illuminate the Check Engine or Marine Diagnostic Trouble Code tool light, and replace the sensed value with a default value. If at that point a noticeable performance improvement is observed, the DTC chart for that particular sensor should be followed to correct the problem.

Be sure to clear each DTC after disconnecting and reconnecting each sensor. Failure to do so may result in a mis-diagnosis of the driveability concern.

Wiring Connector Service

Most connectors in the engine compartment are protected against moisture and dirt which could create oxidation and deposits on the terminals. This protection is important because of the very low voltage and current levels found in the electronics system. The connectors have a lock which secures the male and female terminals together. A secondary lock holds the seal and terminal into the connector.

When diagnosing, open circuits are often difficult to locate by sight because oxidation or terminal misalignment are hidden by the connectors. Merely wiggling a connector on a sensor or in the wiring harness may locate the open circuit condition. This should always be considered when an open circuit or failed sensor is indicated. Intermittent problems may also be caused by oxidized or loose connections.

Before making a connector repair, be certain of the type of connector. Some connectors look similar but are serviced differently. Replacement connectors and terminals are listed in the Parts Catalog.
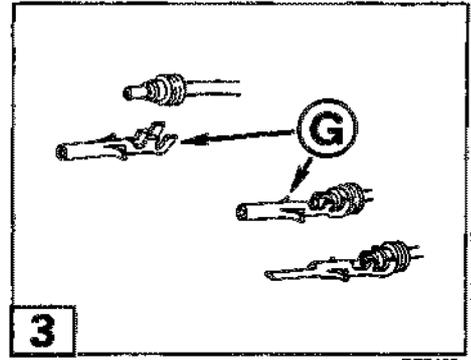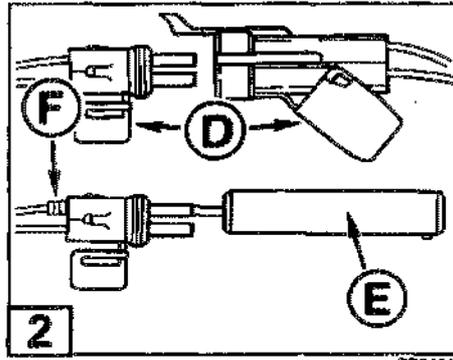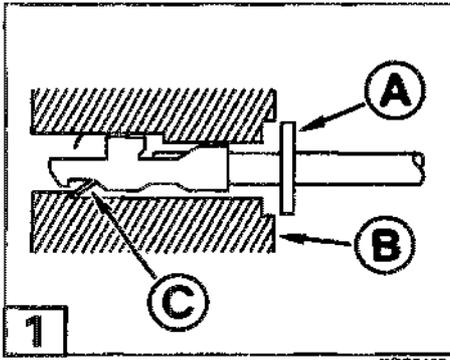
Metri-Pack Series 150 Terminals _____

Some ECM harness connectors contain terminals called Metri-Pack. These are used at some of the sensors and the distributor connectors. Metri-Pack connectors require tools J 35689, BT-8518 or an equivalent to service them.

1 Some Metri-Pack terminals are called "pull-to-seat". To remove the terminal, slide the seal (A) back on the wire. Insert a flat tool thru the back of the connector (B) to release the locking tang (C), and push the wire out through the front of the connector. To install a terminal, the wire is first inserted through the one piece seal then out the front of the connector. The terminal is crimped on the wire, and the terminal pulled back into the connector to seat it in place.

Weather-Pack Terminals _____

2 Some Weather-Pack terminals are called "push-to-seat". Weather-Pack connectors require tools J 28742, BT-8234-A or an equivalent to service them. These tools are used to remove pin and sleeve terminals. If terminal removal is attempted without using the special tool required, there is a good chance that the terminal will be bent or deformed. Unlike standard blade type terminals, these terminals cannot be straightened once they are bent.

2 **3** To remove the terminal, pivot the connector retaining hinge (D) out of the way. Insert the specified removal tool (E) thru the front of the connector, and push the terminal and seal (F) out of the connector. To install a terminal, the wire is first inserted through the seal. The wire and seal are crimped to the terminal (G). The terminal is then pushed back into the connector to seat and seal it in place. Make certain that the connectors are properly seated and all of the sealing rings are in place when closing the retaining hinge.

2 The retaining hinge (D) provides a secondary locking feature for the connector. It improves the connectors reliability by retaining the terminals if the small terminal lock tangs are not positioned properly.

Weather-Pack connectors cannot be replaced with standard connectors. Instructions are provided with Weather-Pack connector and terminal packages.
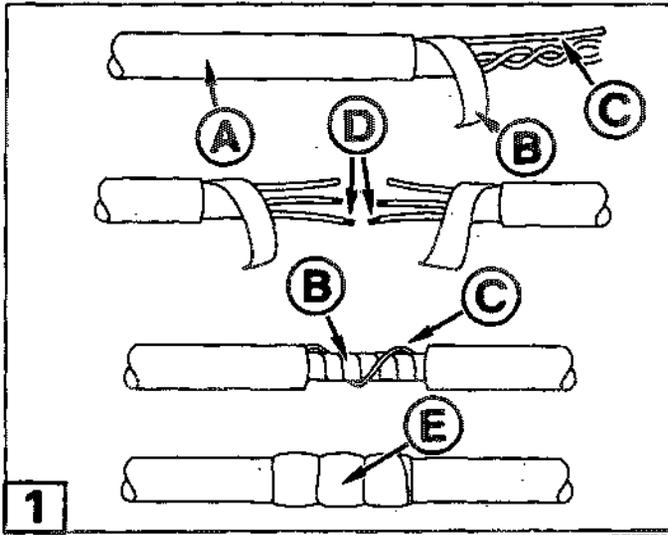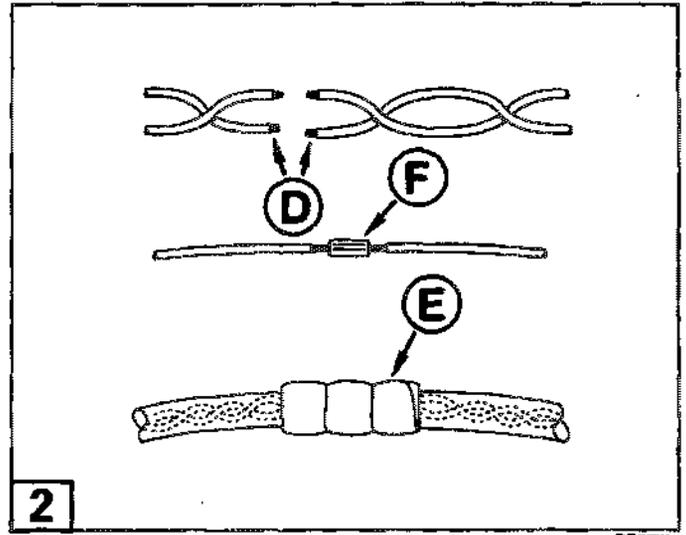
Wiring Harness Service _____

When signal wires are spliced into a harness, use the same gauge wire with high temperature insulation only. With the low current and voltage levels found in the system, it's important that the best possible bond be made at all wire splices by soldering the splices.

1 Twisted / Shielded Cable Repair

Step 1. Remove outer jacket Ⓐ.

Step 2. Unwrap aluminum / mylar tape and ground (uninsulated) wire. Do not remove mylar tape Ⓑ, or ground wire Ⓒ.

Step 3. Untwist conductors. Strip insulation Ⓓ as necessary.

Step 4. Splice wires using splice clips and rosin core solder. Wrap each splice to insulate.

Step 5. Wrap with mylar Ⓑ and ground wire Ⓒ.

Step 6. Tape Ⓔ over whole bundle to secure as before.

2 Twisted Lead Wire Repair

Step 1. Locate damaged wire. Remove insulation Ⓓ as required. If shrink tube is to be used as an insulator, cut and slide shrink tube over damaged wire.

Step 2. Splice wire together using splice clip Ⓕ and rosin core solder.

Step 3. Cover splice with electrical tape to insulate from other wires.

Step 4. Retwist as before and cover with electrical tape Ⓔ to hold in place.

Note Use care when probing a connector or replacing connector terminals. It's possible to short between opposite terminals. If this happens, certain components can be damaged. Always use jumper wires with the corresponding mating terminals between connectors for circuit checking. NEVER probe through connector seals, wire insulation, secondary ignition wires, boots, nipples or covers. Microscopic damage or holes may result in eventual water intrusion, corrosion, and component or circuit failure.

Service Tools Needed

For diagnosis the system requires a Code Tool (CT) (TA-06075), inductive pick-up timing light, fuel pressure test gauge, tachometer, test light, ohmmeter, digital voltmeter with 10 megohms impedance (J29125-A, J34029-A or equivalent), vacuum gauge and jumper wires. A test light or voltmeter must be used when specified in the procedures. For more complete information on the operation of these tools, consult the tool manufacturer's instructions.

[3] High Impedance Multi-Meter (Digital Volt-Ohmmeter DVOM)

A digital voltmeter with a 10 megohms input impedance is used because this type of meter will not load down the circuit and result in faulty readings. Some circuits require accurate voltage readings because they have very high resistance.

[4] Vacuum Pump With Gauge (20 In. Hg. Minimum)

Use the gauge to monitor engine manifold vacuum, and the hand pump to check vacuum controlled devices.

[5] Unpowered Test Light

Used for checking wiring for complete circuits, shorts to ground, or voltage.

**[6]** Tachometer

Must have inductive signal pick-up.

[7] Metri-Pack Terminal Remover

Used for removing 150 series Metri-Pack "pull-to-seat" terminals from connectors. Refer to **Wiring Harness Service** in this section for removal procedure.

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GENERAL INFORMATION

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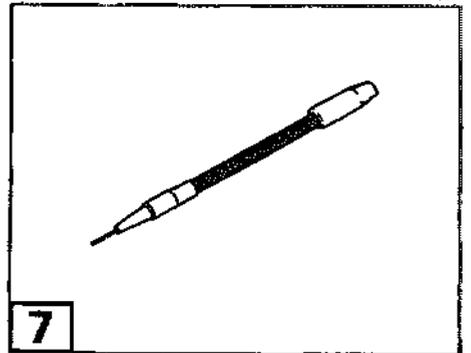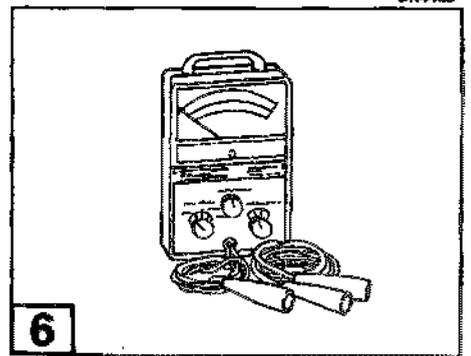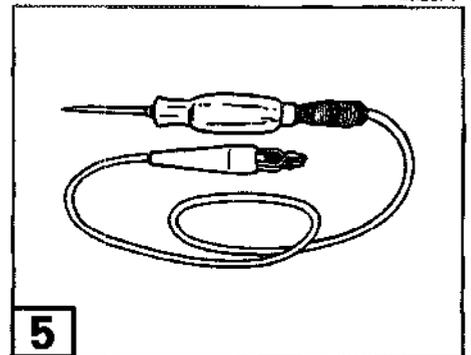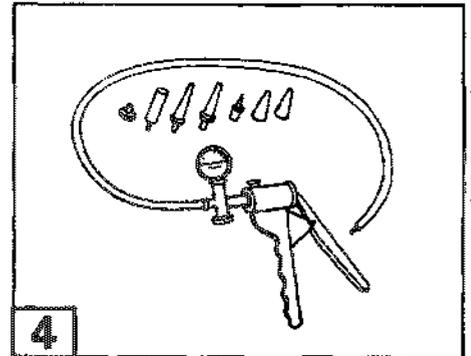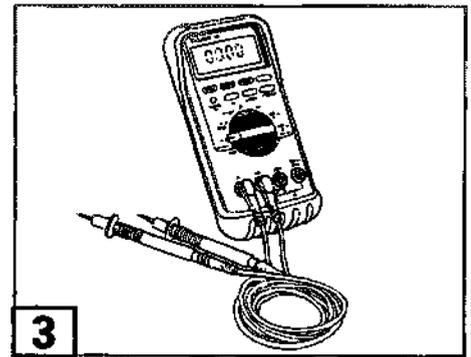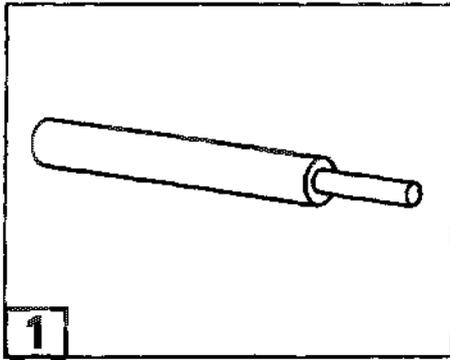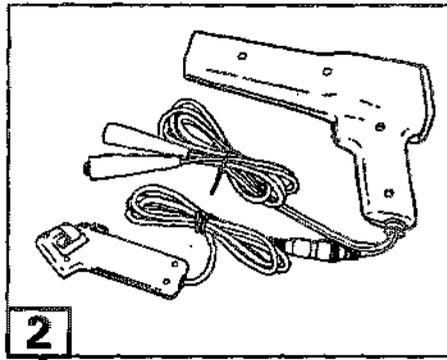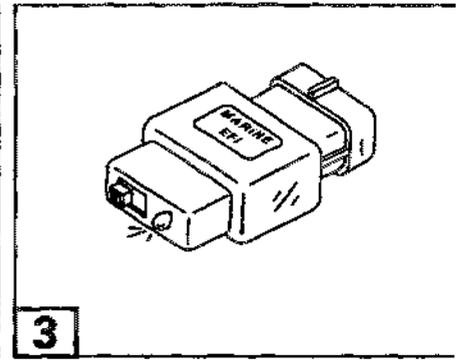
1 **Weather Pack Terminal Remover**

Used for removing terminals from Weather Pack connectors. Refer to Wiring Harness Service in this section for removal procedure.

2 **Timing Light**

Must have inductive signal pickup

3 **Marine Diagnostic Trouble Code (MDTC) Tool**

It will flash a DTC when a problem is detected.

4 **Fuel Pressure Gauge**

Used for checking fuel pump pressure and comparing injector pressure drop for equal fuel distribution.

5 **Injector Harness Test Light**

A specially designed light used to visually indicate injector electrical impulses from the ECM.

6 **Injector Tester (optional)**

Separately energizes each injector to compare for equal impulses over a constant time interval.

**Note** This function included in the VP 2000 scan tool.

7 **VP 2000 Scan Tool (optional)**

Universal hand held diagnostic tool that's used to determine MFI and TBI system problems. It will displays various engine operating parameters.

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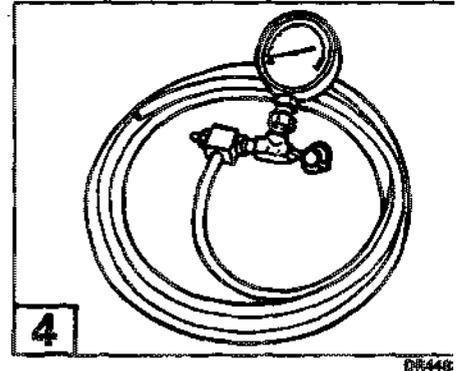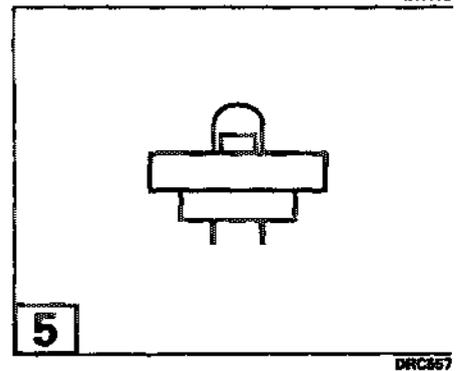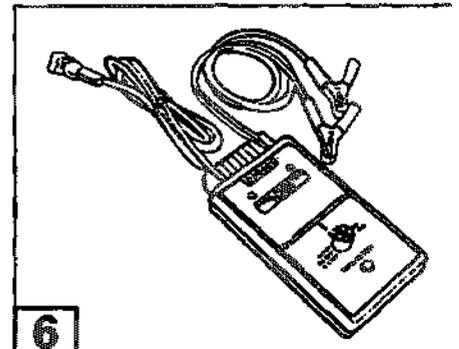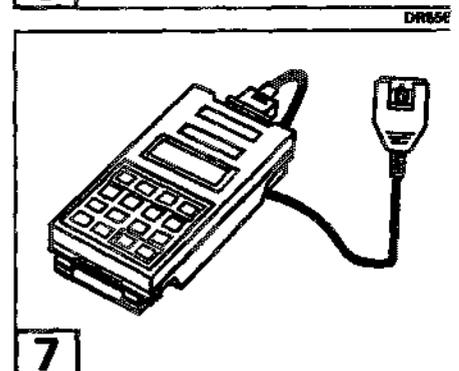
Section 2

Engine Control Module (ECM) and Sensors

Table of Contents

⚠ Safety Warning

Before working on any part of the electrical system, read the section called Safety at the end of this manual.

```
        TYPICAL                    ECM
        SENSOR
                                VOLTAGE OUT

                                SIGNAL INPUT
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1

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```
      TYPICAL                  ECM
      SENSOR
                          ──  SENSOR
                               SIGNAL
                            ┤├──── 5V

                              SENSOR
                              GROUND
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2

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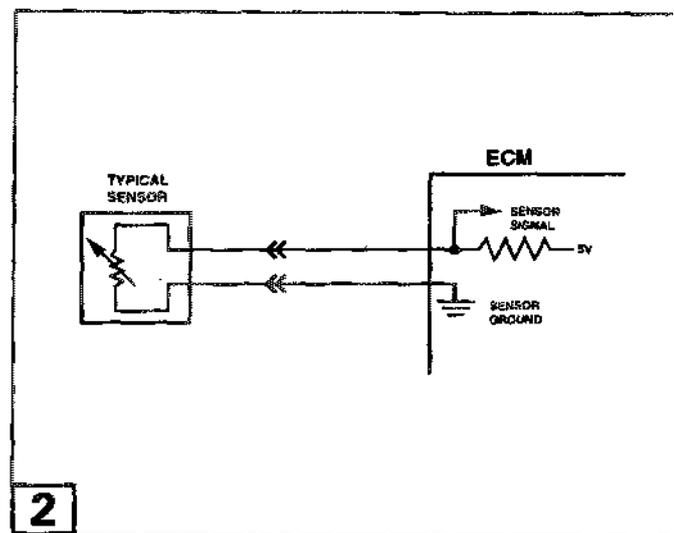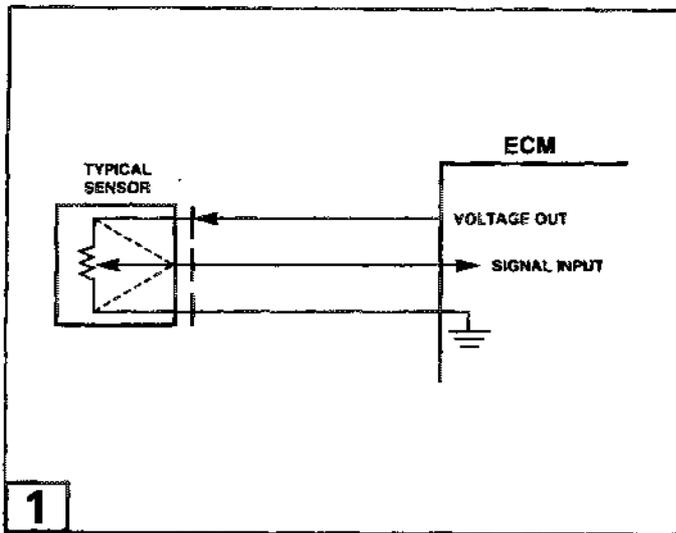
General Description _____

Volvo Penta's Multi-Point Fuel Injection (MFI) system is equipped with a computer that provides the operator with state-of-the-art control of fuel and spark delivery. Computers use voltage to send and receive information as described below.

Computers and Voltage Signals ____

Voltage is electrical pressure. Voltage does not flow through circuits; instead, voltage causes current. Current does the real work in electrical circuits. It's current, the flow of electrically charged particles, that energizes solenoids, closes relays and lights lamps.

Besides causing currents in circuits, voltage can be used as a signal. Voltage signals can send information by changing levels, changing waveform (shape), or changing the speed at which the signal switches from one level to another. Computers use voltage signals to communicate with one another. The different sections inside computers also use voltage signals to talk to each other.

There are two kinds of voltage signals, analog and digital. Both of these are used in computer systems. It's important to understand the difference between them and the different ways they're used.

Analog Signals _____

An analog signal is continuously variable. This means that the signal can be any voltage within a certain range.

An analog signal usually gives information about a condition that changes continuously over a certain range. For example, temperature is usually provided by an analog signal. There are two general types of sensors that produce an analog signal; the 3-wire and the 2-wire sensor.

Three wire Sensors

1 All 3-wire sensors have a reference voltage, a ground and a variable "wiper." The lead coming off the "wiper" will be the signal to the Engine Control Module (ECM). As the wiper position changes, the signal voltage returned to the computer also changes

Two Wire Sensors

2 This sensor is basically a variable resistor in series with a fixed known resistor within the computer By knowing the values of the input voltage and the voltage drop across the known resistor, the value of the variable resistor can be determined. The variable resistors that are commonly used are called thermistors. A thermistor's resistance varies with temperature.

DIGITAL BINARY SIGNAL

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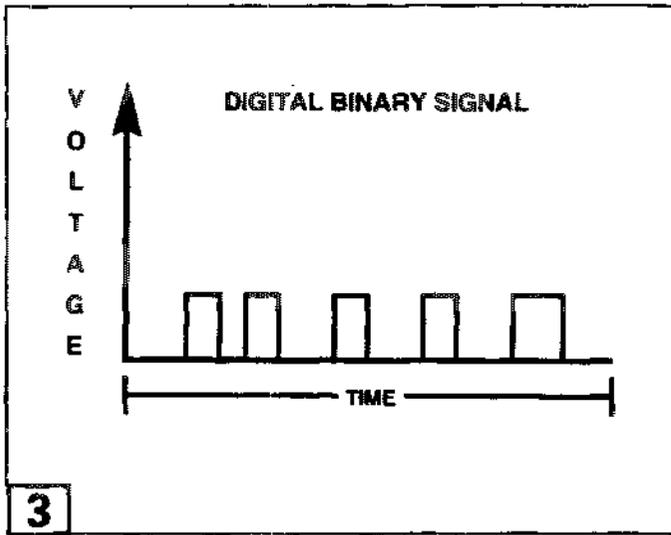
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Digital Signals

3 Digital signals are also variable, but not continuously. They can only be represented by distinct voltages within a range. For example, 1V, 2V or 3V would be allowed, but 1.27 V or 2.65 V would not. Digital signals are especially useful when the information can only refer to two conditions - "YES" and "NO," "ON" and "OFF," or "HIGH" and "LOW." This would be called a digital binary signal. A digital binary signal is limited to two voltage levels. One level is a positive voltage, the other is no voltage (zero volts). A digital binary signal is a square wave.

The computer uses digital signals in a code that contains only ones and zeros. The high voltage of the digital signal represents a one (1), and no voltage represents a zero (0). Each zero and each one is called a bit of information, or just a "bit." Eight bits together are called a word. A word, therefore, contains some combination of eight binary code bits: eight ones, eight zeros, five ones and three zeros, and so on.

Binary code is used inside a computer, and between a computer and any electronic device that understands the code. By stringing together thousands of bits, computers can communicate and store an infinite variety of information.

To a computer that understands binary, 11001011 might mean that it should turn an output device "ON" at a slow speed. Although the computer uses 8-bit digital codes internally and when talking to another computer, each bit can have a meaning.

Switch Types

Switched inputs (also known as discretes) to the computer can cause one bit to change, resulting in information being communicated to the computer. Switched inputs can come in two types; they are "pull-up" and "pull-down".

With a "pull-up" type switch, the ECM will sense a voltage when the switch is CLOSED. In the case of the "pull-down," the ECM "sees" the voltage when the switch is OPEN.

Pulse Counters

For a computer to determine frequency information from a switched input, the computer must measure the time between voltage pulses. As a number of pulses are recorded in a set amount of time, the computer can calculate the frequency. The meaning of the frequency number can have any number of meanings to the computer.

ECM & SENSORS
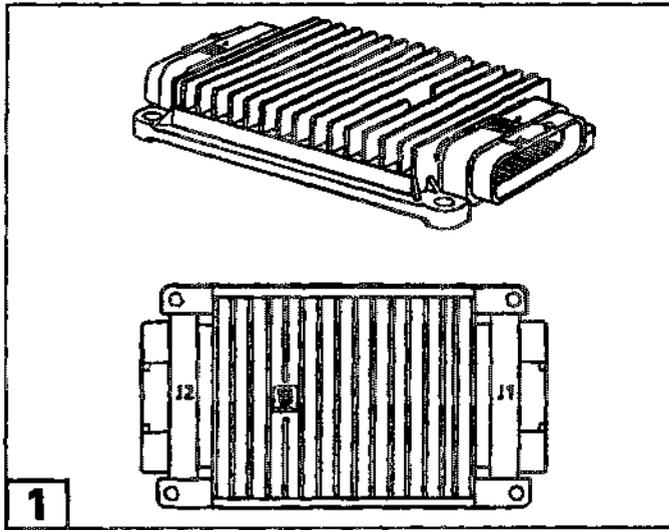
An example of a pulse counter type of input is the distributor reference pulse input. The computer can count a train of pulses, a given number of pulses per engine revolution. In this way, the computer can determine the RPM of the engine.

Engine Control Module (ECM)

1 The Engine Control Module (ECM) is the control center of the fuel injection system. It constantly monitors information from various sensors, and controls the systems that affect engine performance.

2 The ECM also performs a diagnostic function check of the system. It can recognize operational problems and store a Diagnostic Trouble Code(s) (DTC) which identifies the problem area to aid the technician in making repairs.

ECM Function

The ECM supplies 5 or 12 volts to power various sensors or switches. This is done through resistances in the ECM which are so high in value that a test light will not light when connected to the circuit. In some cases, even an ordinary shop voltmeter will not give an accurate reading because its resistance is too low. Therefore, the use of a 10 megohms or greater input impedance digital voltmeter is required to assure accurate voltage readings.
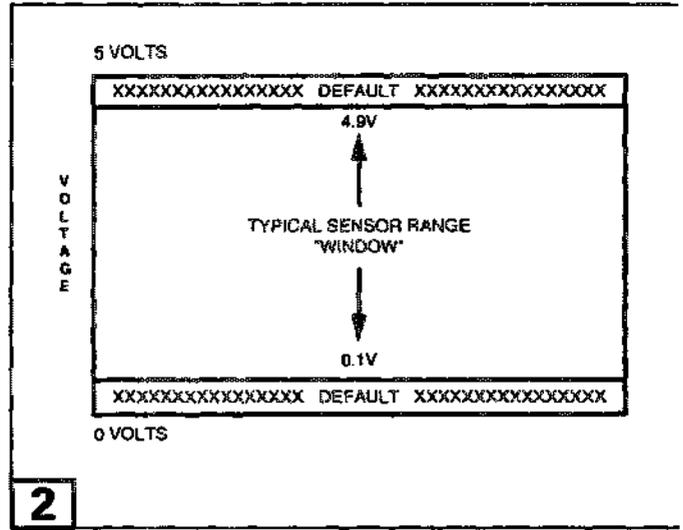
Memory

There are three types of memory storage within the ECM: ROM, RAM and EEPROM.

ROM

Read Only Memory (ROM) is a permanent memory that is physically soldered to the circuit boards within the ECM. The ROM contains the overall control programs. Once the ROM is programmed, it cannot be changed. ROM memory is non-erasable, and does not need power to be retained.

RAM

Random Access Memory (RAM) is the microprocessor "scratch pad." The processor can write into, or read from, this memory as needed. This memory is erasable and needs a constant supply of voltage to be retained. During normal engine operation, acquired DTC's are stored in RAM memory.

EEPROM

Electronic Erasable Programmable Read Only Memory (EEPROM) is the portion of the ECM that contains the different engine calibration information that is specific to each application. Upon engine shut-off, DTC's are stored to the EEPROM from RAM. DTC's will remain in the EEPROM even if B+ voltage is subsequently lost (i.e. battery removed, master switch turned off, etc.).