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FULL ONE (1) YEAR WARRANTY

Actron Manufacturing Company, 15825 Industrial Parkway, Cleveland, Ohio 44135, warrants to the user that this unit will be free from defects in materials and workmanship for a period of two (2) years from the date of original purchase.

Any unit that fails within this period will be repaired or replaced at Actron's option and without charge when returned to the Factory. Actron requests that a copy of the original, dated sales receipt be returned with the unit to determine if the warranty period is still in effect.

This warranty does not apply to damages caused by accident, alterations, or improper or unreasonable use.

ACTRON MANUFACTURING COMPANY DISCLAIMS ANY LIABILITY FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES FOR BREACH OF ANY WRITTEN WARRANTY ON THE UNIT.



15825 Industrial Parkway
Cleveland, Ohio 44135
U.S.A.

Toll free U.S.: (800)228-7667

Vehicle Service Information

The following is a list of publishers who have manuals containing electronic engine control diagnostic information. Some manuals may be available at auto parts stores or your local public library. For others, you need to write for availability and pricing, specifying the make, model and year of your vehicle.

Vehicle Service Manuals:

Chilton Book Company

Chilton Way
Radnor, PA 19089

Haynes Publications

861 Lawrence Drive
Newbury Park, CA 91320

Cordura Publications

Mitchell Manuals, Inc.
Post Office Box 26260
San Diego, CA 92126

Motor's Auto Repair Manual

Hearst Company
250 W. 55th Street
New York, NY 10019

Suitable manuals have titles such as:

"Electronic Engine Controls"

"Fuel Injection and Feedback Carburetors"

"Fuel Injection and Electronic Engine Controls"

"Emissions Control Manual"

. . . or similar titles

Vehicle Service Manuals from General Motors Corporation:

Buick, Cadillac, Chevrolet, GEO, GMC, Oldsmobile, & Pontiac

Helm Incorporated
Post Office Box 07130
Detroit, MI 48207

Saturn

Adistra Corporation
c/o Saturn Publications
101 Union St.
Post Office Box 1000
Plymouth, MI 48170

Vehicle Service Manuals from Ford Motor Company:

Ford, Lincoln, & Mercury

Ford Publication Department
Helm Incorporated
Post Office Box 07150
Detroit, MI 48207

Vehicle Service Manuals from Chrysler Corporation:

Chrysler, Plymouth, & Dodge

Chrysler Motors Service Training
26001 Lawrence Avenue
Center Line, MI 48015

All information, illustrations and specifications contained in this manual are based on the latest information available from industry sources at the time of publication. No warranty (expressed or implied) can be made for its accuracy or completeness, nor is any responsibility assumed by Actron Manufacturing Co. or anyone connected with it for loss or damages suffered through reliance on any information contained in this manual or misuse of accompanying product. Actron Manufacturing Co. reserves the right to make changes at any time to this manual or accompanying product without obligation to notify any person or organization of such changes.

General Safety Guidelines to Follow When Working on Vehicles

To prevent accidents that could result in serious injury and/or damage to your vehicle or test equipment, carefully follow these safety rules and test procedures at all times when working on vehicles:

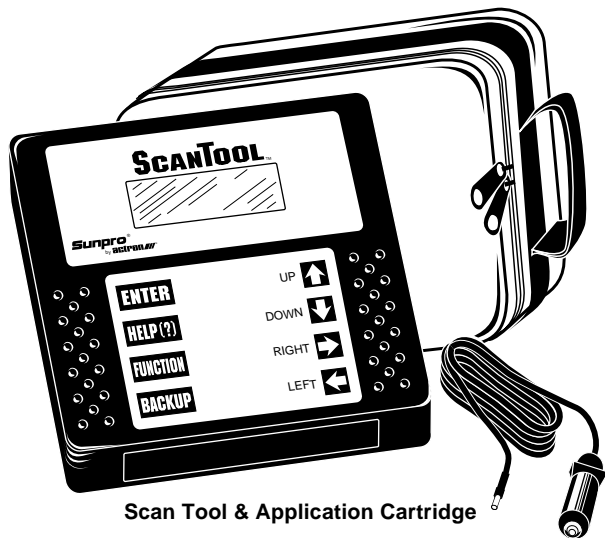
- Always wear approved eye protection.
- Always operate the vehicle in a well-ventilated area. Do not inhale exhaust gases — they are very poisonous!
- Always keep yourself, tools and test equipment away from all moving or hot engine parts.
- Always make sure the vehicle is in **Park** (Automatic transmission) or **neutral** (manual transmission) and that the **parking brake is firmly set**. Block the drive wheels.
- Never lay tools on vehicle battery. You may short the terminals together causing harm to yourself, the tools or the battery.
- Never use scan tool if its internal circuitry has been exposed to any liquids. This includes the scan tool and Application Cartridges.
- Never smoke or have open flames near vehicle. Vapors from gasoline and charging battery are highly flammable and explosive.
- Never leave vehicle unattended while running tests.
- Always keep a fire extinguisher suitable for gasoline/electrical/chemical fires handy.
- Always use extreme caution when working around the ignition coil, distributor cap, ignition wires, and spark plugs. These components contain **high voltage** when the engine is running.
- When performing a road test, **never** operate the scan tool alone while driving the vehicle. **Always** have one person drive the vehicle while an assistant operates the scan tool.
- Always turn ignition key OFF when connecting or disconnecting electrical components, unless otherwise instructed.
- Always follow vehicle manufacturer's warnings, cautions and service procedures.

CAUTION:

Some vehicles are equipped with safety air bags. You *must* follow vehicle service manual cautions when working around the air bag components or wiring. If the cautions are not followed, the air bag may open up unexpectedly, resulting in personal injury. Note that the air bag can still open up several minutes after the ignition key is off (or even if the vehicle battery is disconnected) because of a special energy reserve module.

Section 1: Welcome to the Scan Tool – Basics

1-1 Actron Scan Tool Features



The Actron scan tool has many features that you would expect in scan tools used by the professionals:

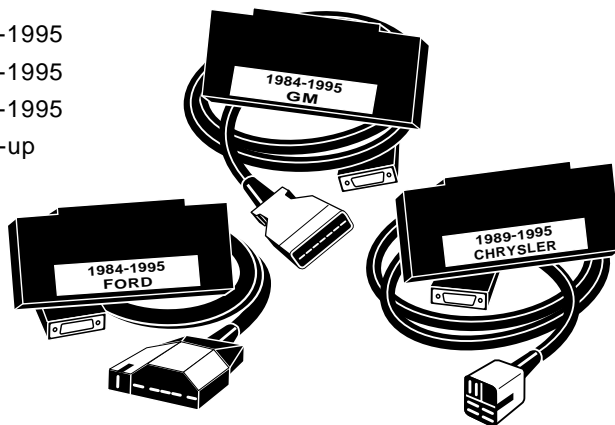
- Large 4 line x 20 character LCD display
- High-impact plastic case
- Durable, easy to use keyboard
- Removable vehicle cable adapter
- Removable power cable

Vehicle Manufacturer Application Cartridges

The manufacturer-specific Application Cartridges offer a universal approach in changing software as vehicle technology changes. Actron's separate cartridge and cable system lets you add vehicle applications to meet your needs.

Cartridge Systems:

GM Cartridge	1984-1995
Ford Cartridge	1984-1995
Chrysler Cartridge	1989-1995
OBD II	1996-up



Professional-Style Adapter Cables:

- GM ALDL — 12 Pin
- Ford EEC-IV/MCU — 7 Pin
- Chrysler SCI — 6 Pin

Optional Cable Adapters:

- Chrysler CCD / LH – 6 Pin
- Ford/Mazda MECS – 6 Pin
- GM J1962-OBD-II – 16 Pin
- Ford J1962-OBD-II – 16 Pin
- Chrysler J1962-OBD-II – 16 Pin

1-2 The Scan Tool

Actron's scan tool was developed by experts in the automotive service industry to help you diagnose today's vehicles and assist you in trouble-shooting procedures. Computer-controlled vehicles have a network of sensors that creates a series of inputs to the engine computer. The computer interprets these inputs and sends outputs (commands) back to the network to control air, fuel, vacuum, spark and other critical functions. When a problem occurs, the computer will store a record of the event, and take corrective action to adjust the circuit at fault. If the circuit does not respond, or the problem cannot be corrected, a trouble code is stored in the computer's memory. In some cases, the Check Engine light may also be activated. The scan tool will allow you to monitor these vehicle events for trouble-shooting and diagnosis, and to read codes from the computer's memory to pinpoint problem areas.

The scan tool uses state-of-the-art 16 "bit" microprocessor technology and has twice the computing power of some scan tools costing thousands of dollars! The scan tool is programmed to interpret the computer signals and provide you with a "real time" readout of vehicle data. More importantly, the software programs are written to provide you with detailed, full-screen readouts of all data. In addition, the Code

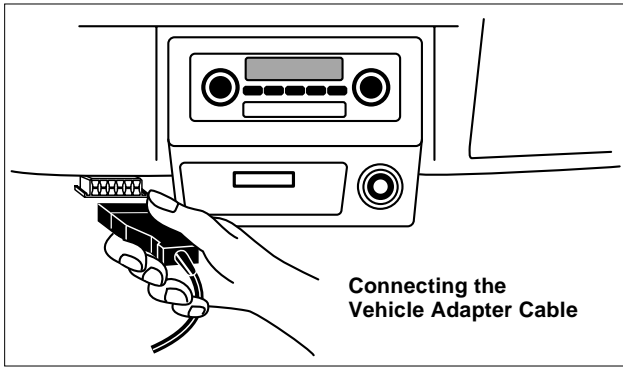
Lookup feature allows you to reference code descriptions without having to page through an instruction manual.

When the scan tool is connected to the data connector, a communication link is established, allowing the scan tool and the vehicle's on-board computer to exchange information. The way in which this information is exchanged is referred to as a **data stream**.

As you use the scan tool, you will become more proficient in trouble-shooting vehicles using the detailed help messages and code description information. Actron will also help you become skilled in using the scan tool for more than just "scanning" the vehicle data list. We will show you many other uses that will expand your diagnostic limits by using the information contained in the application manuals that come with your Application Cartridge. No-start, driveability, and emission problems will be easier to diagnose than ever before.

Vehicle Cable Adapters

Your scan tool Vehicle Application Cartridge pack will contain the Application Cartridge, application manual and vehicle cable adapter for one manufacturer (GM, Ford, or Chrysler). The vehicle cable adapter will be installed on the scan tool by locating the large connector receptacle on the top right side of the main tool.



Insert the vehicle cable into the scan tool receptacle and use the two “thumb screws” to secure it to the connector as shown in the illustration below. Note that you will feel a firm seating of the cable as you secure it to the scan tool connector. The vehicle cable adapter should always be connected to the vehicle before power is applied to the scan tool. This will enable the scan tool to maintain a proper ground between itself and the vehicle. If you have connected to the vehicle, powered-up the tool, and have difficulty establishing a link between the scan tool and the vehicle, check the following:

1. Is the ignition on?
2. Verify you have connected the vehicle data cable to the vehicle’s Data Link Connector (DLC).
3. Confirm that proper vehicle information was entered into scan tool.

When attaching the data cable to the vehicle, take time to review the specific application manual for the cartridge you are using. This will instruct you on correctly connecting the cable to the vehicle. Many of the vehicle adapters are “keyed” so that the adapter will fit only one way. If you find that you have a special vehicle situation or the adapter does not fit, call 1-800-ACTRON-7 for assistance. Always double check the application section to be sure that you are following the proper hook-up directions. For further help that is not available in the scan tool help screens, see **Section 3: Actron Help** for solutions to your scan tool problems.

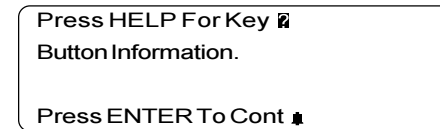
As you review the CP9110 Features section on page 1-1 and 1-2, you will note there is a complete view of accessory vehicle adapter cables. They are for special applications that only apply to certain vehicles. If your vehicle is one of these, you can order cables direct from Actron by calling (800) 228-7667.

1-6 Operating the Scan Tool

Powering-up the scan tool

The scan tool can be powered-up in three ways. The most widely used way is with the supplied cigarette lighter adapter. The scan tool can also be powered up by using the optional Battery Clip Adapter or 110/12V AC Power Adapter. If you are powering-up the scan tool for vehicle testing, then make sure you connect the appropriate cable to the data connector before you supply power to the scan tool. If you do not connect the vehicle data cable now, the scan tool will let you know that you have not connected the data cable. If you just want to power-up the scan tool to do self-tests, then you do not need to attach the cable to the data connector.

When the scan tool powers-up, a series of screens is displayed. The screens start with a “Welcome” screen and end with a “Key Button Help” screen.



Welcome & Key Button Help Screens

The screens in between the “Welcome” and the “Key Button Help” screen are for a tool self-test and the cartridge **software version**. Refer to this software version if you need to contact Actron’s technical support line with a problem. If you wish to review the key button definitions, then push the HELP key; otherwise, press ENTER to continue forward.

Keyboard

The scan tool software was designed for a “userfriendly” approach in navigating through operational menus. This makes the scan tool easy to operate. Simply follow the instructions that match the keyboard symbols and you will be using your scan tool like an expert in no time. Since the keyboard is sealed, a damp cloth can be used to gently clean the surface. **(Caution: DO NOT USE SOLVENTS LIKE ALCOHOL! This could remove the keyboard paint!)**


Scan Tool Keyboard and Display



Keyboard Functions


The scan tool uses 8 keys to navigate through the software-user interface:

ENTER Used to enter or answer a software request.

HELP Used to request help when the  symbol is in the upper right hand corner of the display.

FUNCTION Used to return user to manufacturer’s function list.

BACKUP Used to move one screen back in scan tool flow.

ARROWS UP or DOWN are always used to move the solid cursor  in the direction of the arrow or scroll the data list in the direction you want to move the list

LEFT or RIGHT arrows move the cursor in the direction of the arrow and allow you to customize a vehicle data parameter list.

Display

The scan tool has a 4 line x 20 character liquid crystal display (LCD) for easy viewing. This makes the scan tool “user friendly” by offering a large viewing area to display most Help and Instructional messages. This also puts more information on the display instead of referring you to printed materials. Again the display will support a number of helpful characters that will prompt you through test routines. These characters are shown below:

❓ Question Mark in upper right corner means there is **help** available for this screen.

🔔 Bell in lower right corner means the **sound** alert is on or active.

▶ Cursor used to **select** menu choice.

⏴ Down Arrow indicates there is additional information on the **next** screen.

⏵ Up Arrow indicates there is additional information on **previous** screen(s).

Below is a screen showing how these symbols will look on your display (**NOTE:** This is a GM Function List – Function Lists for other manufacturers may differ slightly.):

```
GM Function List ❓
▶4)Record Data ⏵
5)Playback Data ⏴
6)Field Service 🔔
```

Lists, Menus, and Questions

The scan tool is designed to be as intuitive as possible. That is, its functions and controls should be easy to understand and use the first time you try it. All scan tool menus and screen lists operate the same way. By using the UP and DOWN arrow keys, you can move the cursor to a menu selection of your choice. The ENTER key selects that function. Below is an example of a Function List with several choices

(**NOTE:** This is a GM Function List – Function Lists for other manufacturers may differ slightly.):

```
GM Function List ❓
▶1)Read Codes
2)Erase Codes ⏴
3)View Data 🔔
```

Note how the cursor is pointing at **1) Read Codes**. If you wish to read trouble codes, press ENTER to select that function. To make a different choice, such as viewing data, use the DOWN arrow key to move the cursor down next to **3) View Data** and press ENTER. This will select the View Data function.

Sometimes, a list will be longer than three or four items, and will not fit on a single screen. In these cases, the down arrow symbol (⏴) is visible in the last column of the display, indicating that there are more choices on the next screen:

```
GM Function List ❓
▶1)Read Codes
2)Erase Codes ⏴
3)View Data 🔔
```

To go to the next choice, use the DOWN arrow key to move the cursor down the list. **NOTE:** Pressing the DOWN arrow key moves the function list one line at a time. After several DOWN arrow key presses, the screen below appears.

```
GM Function List ❓
▶4)Record Data ⏵
5)Playback Data ⏴
6)Field Service 🔔
```

Now notice that there are arrows pointing up and pointing down in the last column. This indicates that you can use the UP arrow key to move the cursor to the previous screen or press the DOWN arrow key several times to move the cursor to the third screen, shown below:

```
GM Function List ❓
▶7)Beeper On-Off ⏵
8)English-Metric
9)Code Lookup 🔔
```

Notice now that there is only an arrow pointing up in the last column. This indicates that you have reached the end of this list, and that all other choices are on previous screens. You can return to those screens by pressing the UP arrow key. (**NOTE:** This is a GM Function List – Function Lists for other manufacturers may differ slightly.).

These up and down arrow characters on the screen are used throughout the scan tool’s software. The UP and Down arrow keys work exactly the same way, even if you are just scrolling through text such as the On-Line Help screen shown below:

```
3.TESTCONNECTOR:
DAMAGED/LOOSE PINS? ⏵
4.TOOL SETUP OK ? ⏴
CORRECT VIN'S,ETC? 🔔
```

Note that there are no choices to make here, and that there is no cursor to move. There are, however, up and down arrows in the last column. These arrows indicate that there are other screens before and after this one. Using the UP and DOWN arrow keys, you can scroll through the entire message.

Occasionally, you may be asked a question by the scan tool which requires a response. These will always be YES or NO questions, and are answered in almost the same way you make choices on a Function List. Below is an example of a YES/NO question:

```
View Instructions
For Creating Custom
Data List?
Yes <No> 🔔
```

In these screens, brackets will automatically be next to the default response. If you wish to accept the default choice, simply press ENTER. If you wish to change the answer, use the LEFT or RIGHT arrow key to move the brackets next to the other response and press ENTER.

Other Functions & Keys


As you have reviewed moving through lists and functions in earlier sections, you probably noticed several other symbols on the screen. In the upper right-hand corner of some screens, there is a large ❓. This question mark indicates that **On-Line Help** is available for that particular screen:




```
Operating Error. ❓
Check Connections!
Try Again?
<Yes> No 🔔
```



To enter On-Line Help, press the HELP key. For the screen above, the help message would look like this:


```
RECHECK FOLLOWING:
1.IGNITION KEY ON?
2.HOOKUP TO VEHICLE ⏴
TEST CONNECTOR OK? 🔔
```


All On-Line Help screens have their text typed in ALL CAPITAL LETTERS. This is another reminder that you are viewing On-Line Help screens and not screens associated with a function of the Function List. Some On-Line Help messages are longer than one screen. If this is the case, the arrow symbols (⏵ ⏴) will appear in the last column of the display. A ⏴ means there is more On-Line Help information available on the next screen. A ⏵ means there is more On-Line Help information available on the previous screen. Use the UP and DOWN arrow keys to page up or down through a series of On-Line Help screens.


The On-Line Help screen shown above has a  in the last column. To view the next On-Line Help screen, press the DOWN arrow key. That screen is shown below:

3. TESTCONNECTOR:
DAMAGED/LOOSE PINS? 
4. TOOL SETUP OK? 
CORRECT VIN'S, ETC? 

Notice now that both arrow symbols ( ) are visible in the last column of the display. This indicates that you can either page up to a previous On-Line Help screen, or page down to the next On-Line Help screen by using the UP and DOWN arrow keys. The previous On-Line Help screen is always the one you just viewed, just as with Function Lists.

Another symbol on the screen you might have noticed is the bell () symbol in the lower right-hand corner as shown below:




Press HELP For Key 
Button Information.


Press ENTER To Cont 

This bell symbol indicates that the sound alert is on or active. Each time you press a key, you should hear a beep. If you do not see this symbol, then the keys should remain silent when pressed. Information on changing this setting is found in section 1-7: Scan Tool Setup.

1-7: ScanTool Setup


Tool Setup is used to change the scan tool's default sound and measurement unit settings. To change the scan tool's default settings, select the Tool Setup option from the Function List (**NOTE:** This is a GM Function List – Function Lists for other manufacturers may differ slightly.):


GM Function List 
▶ 7) Beeper On-Off 
8) English-Metric
9) Code Lookup 


After selecting the Tool Setup option, you are given the choice to change either the ScanTool's measurement units or whether the beeper will be On or Off. If the bell () symbol appears in the lower right hand corner of the display, then the beeper is turned On.

Setup Tool For
▶ 1) English/Metric
2) Beeper On/Off 

Depending on whether you select English/Metric or Beeper On/Off, the ScanTool will display one of the following screens:

Measurement Units
▶ English (Default)
Metric 

Beeper Sound
▶ On (Default)
Off 

When the beeper sound is turned Off, the bell () symbol will no longer appear on the lower right hand corner of the display.

NOTE: If you change the Beeper and Measurement Units to a setting other than the default, then all changes will revert back to the default settings the next time the scan tool is used.

Section 2: Vehicle Computer Basics

2-1 Basics of Computer-Controlled Cars

This section explains the engine computer control system, the types of sensors and how the computer controls engine fuel delivery, idle speed and timing. Additional information may be found in technical support books at your local library or auto parts store. The more you know about the computer system, the better you can diagnose vehicle computer problems.

Computer controls were originally installed on vehicles to meet federal government regulations for lower emissions levels and improved fuel economy. This began in the early 1980's when basic mechanical systems were no longer able to accurately control key engine parameters. A computer could be programmed to control the engine under various operating conditions, making the engine more reliable. While these early systems were very limited in the scope of their control, providing only 10-14 trouble codes, they did help guide the vehicle repair process.

Today, computer controls have made cars and trucks faster, cleaner, and more efficient than ever before. In fact, without the government mandates for fuel efficiency and emissions control, cars and trucks today would not be nearly as powerful, reliable, and comfortable as they are.

What the computer controls:

The main control areas of the vehicle computer are fuel delivery, idle speed, spark advance, and emissions controls. Some on-board computers may also control the transmission, brakes, and suspension systems as well.

What has not changed?

A computer-controlled engine is very similar to the older, non-computerized en-

gine. It is still an internal combustion engine with pistons, spark plugs, valves, and camshaft(s). The ignition, charging, starting, and exhaust systems are very similar as well. You test and repair these systems just as before. The technical manuals for these components show you how to perform the tests. Additionally, compression gauges, vacuum pumps, dwell/tach meters, engine analyzers, and timing lights will continue to be used.

The Engine Computer Control system

The vehicle's on-board computer, or Powertrain Control Module (PCM), is the "heart" of the system. It is sealed in a metal box and connected to the rest of the engine by a main wiring harness. The PCM is located, in most cases, in the passenger compartment, behind the dashboard or in the "kick panel" position, although some manufacturers locate the computer control module in the engine compartment area. Most PCMs can withstand a lot of vibration and are built to live in a rugged environment.

The PCM is permanently programmed by the factory engineers. The program is a complex list of look-up tables and instructions telling the computer how to control the engine based on various driving conditions. To do its job, the computer uses sensors to know what is happening and then provide instructions back to a network of switches and actuators throughout the vehicle.

Sensors, switches, and actuators give the computer information

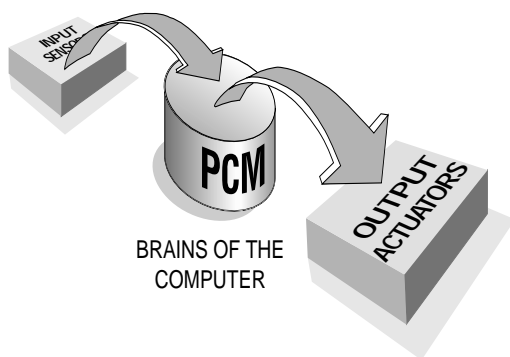
Sensors are devices which measure operating conditions and translate them into signals the computer can understand.

Some examples of sensors: thermistors (for temperature readings), potentiometers (like a throttle position sensor), relays (for voltage and signal readings), and signal generators (such as an O2 sensor).

The network of sensors has the job of delivering information the computer needs to know by converting it into electrical signals the computer can understand. Signals running from sensors to the PCM are referred to as “inputs.”

Sensors monitor key things such as:

- Engine Temperature
- Intake Manifold Vacuum
- Throttle position
- RPM
- Incoming Air Temperature
- Volume of Incoming air
- Air Fuel Ratio, in percentage (%)



Switches and Actuators are electric devices energized by the computer to allow commands to perform a specific function. Switches are often called relays (such as the coolant fan switch). Actuators might include solenoids (such as fuel injector valves) and small motors (such as the Idle Speed Control). Not all of the computer's outgoing signals are routed to switches and actuators. Sometimes information is sent to other system computers like transmission, brakes, ignition modules, and trip computers. Signals running from the PCM to other components are called “outputs.”

How the computer controls fuel delivery

Engine operation and emissions performance depend upon precise fuel delivery and ignition control. Early computer systems controlled fuel by electronically adjusting the carburetor metering and jet systems. Soon, however, this was replaced by the more precise fuel delivery of fuel injection.

In an electronically carbureted system, the computer simply controls fuel flow based on how far the throttle is opened by the driver. The computer “knows” how much air can flow through the carburetor at various throttle openings, and adds the appropriate amount of fuel to the mixture at the carburetor.

Fuel injection is somewhat more sophisticated in the way it delivers fuel. The computer still adds an appropriate amount of fuel to the entering air, but now it uses fuel injectors (either in a throttle body or at each intake port). Fuel injectors are far more precise than carburetor jets, and create a much finer fuel “mist” for better combustion and increased efficiency. In addition, most fuel injection systems have ways of measuring exactly how much air is entering the engine, and can calculate the proper air/fuel ratio using lookup tables. Computers no longer have to “estimate” how much air the engine is using.

In many modern systems, the computer also uses information provided by sensors to give it an idea of how well it is doing its job, and how to do it better. Sensors can tell the computer how warm the engine is, how rich or lean the fuel mixture is, and whether accessories (like the air conditioner) are running. This feedback information allows the computer to “fine tune” the air/fuel mixture, keeping the engine operating at its peak.

What the Computer needs to know:

- **Engine operating condition.** Sensors used are: coolant temperature, throttle

position, manifold pressure (vacuum), air flow and RPM.

- **Air intake.** Sensors used are: mass air flow, manifold absolute pressure, manifold air temperature and RPM.
- **Air/fuel mixture status.** Sensors used are: oxygen sensor(s).

NOTE: Not all engines use every sensor listed above.

Open and Closed Loop Modes:

Open or closed loop operation refers to the way the computer is deciding how much fuel to add to the air entering the engine. During cold start and other low demand, low temperature situations, the computer operates in **open loop** mode. This means that it is relying on a set of internal calculations and data tables to decide how much fuel to add to the incoming air. It uses sensors such as the coolant temperature sensor (CTS), the throttle position sensor (TPS), and the manifold absolute pressure sensor (MAP) to determine optimum mixtures. The important difference here is that it *does not* check to see if the mixtures are correct, leaving the computer adjustment loop **open**.

In **closed loop** mode, the computer still decides how much fuel to add by using the sensors listed above, and by looking up the appropriate numbers on a data table. However, it now checks itself to determine whether the fuel mixture is correct. It is able to check itself by using the information provided by the oxygen sensor(s) (O2S) in the exhaust manifold. The oxygen sensors will tell the computer if the engine is running rich or lean, and the computer can take steps to correct the situation. In this way, the computer **closes** the adjustment loop by checking itself and making necessary corrections. It should be noted that the O2 sensors must be at a very high operating temperature (approximately 650° F) before they will begin to feed information back to the computer. This is why open loop mode is neces-

sary—to give the O2 sensors time to warm up to operating temperature.

As long as the engine and O2 and Coolant Temperature Sensors are at operating temperature, the computer can operate in the closed loop mode. Closed loop mode insures that the air/fuel mixture is at the ideal 14.7:1 air/fuel ratio needed for efficient combustion. But in stop and go cycles, the O2 sensor may in fact cool down enough that the computer will need to rely on a set of internal parameters and go into open loop mode again. In some cases, this may also happen during extended periods of idling. Many newer vehicles now use heated O2 (HO2S) sensors to prevent this condition.

In many vehicles, the computer controls other systems related to open and closed loop modes, including idle speed, electronic spark control, exhaust gas recirculation, and transmission torque converter clutches. In open loop mode, some of these systems will be adjusted to speed the warming of the engine and get the computer into closed loop mode as quickly as possible.

OBD II: The Next Horizon

In 1994, many manufacturers began equipping cars with a new class of computer technology which puts more processing power under your dash than ever before. It is called On-Board Diagnostics, Second Generation, or OBD-II. It is required on all vehicles sold in the US beginning January 1, 1996 (though most domestic manufacturers introduced it earlier than required), and offers increased system monitoring and diagnostic information. This new system will store a library of 400 general trouble codes and another 400 manufacturer-specific codes. These codes cover Body Systems (B-Codes), Chassis Systems (C-Codes), and Power Train Systems

(P-Codes). Now, basic terms are standardized and all generic codes will share a common format and terminology that the manufacturers and the Society of Automotive Engineers (SAE) designed. You will be glad to know that as your car gets smarter, it will be easier for you to keep track of what is going on under the hood.

2-2 About Codes

Where do Trouble Codes come from and what are they for?

Engine computers can *find* problems

The computer systems in today's vehicles do more than control engine operations—they can help you find problems, too! Special testing abilities are permanently programmed into the computer by factory engineers. These tests check the components connected to the computer which are used for (typically): fuel delivery, idle speed control, spark timing, emission systems, and transmission shifting. Mechanics have used these tests for years. Now you can do the same thing by using your Actron scan tool!

Engine computers perform special tests

The engine computer runs the special tests, depending on the manufacturer, engine, model year, etc. There is no "universal" test that is the same for all vehicles. The tests examine INPUTS (electrical signals going INTO the computer) and OUTPUTS (electrical signals coming OUT of the computer), as well as internal calculations made by the computer. Input signals which have "incorrect" values, or output circuits which do not operate properly are noted by the test program and the results are stored in the computer's memory. These tests are important. The computer cannot control the engine properly if it has incorrect input information or faulty output circuits.

Code numbers reveal test results

The test results are stored by using code numbers, usually called "trouble codes" or "diagnostic codes." For example, a code 22 might mean "throttle position sensor signal voltage is too low." Code meanings are a part of your scan tool's software—all you have to do is look them up! But since code definitions vary with manufacturer, model year, and engine, you may also want to refer to a vehicle service manual for additional information. These manuals are available from the manufacturer, other publishers, or your local public library. See page 2 for more information on ordering service manuals.

Read Trouble Codes with the scan tool

You can obtain trouble codes from the engine computer memory by using the scan tool. You can also monitor the operation of systems throughout the vehicle, helping to pinpoint the system where there may be a problem. Once you have read the trouble codes, you can either:

- Have your vehicle professionally serviced.
- Or,
- Repair the vehicle yourself using the trouble codes to locate the source of the problem.

Trouble Codes and Diagnostics help you fix the problem

To find the cause of the problem yourself, you need to perform special test procedures called "diagnostics." These procedures are in the vehicle service manual, and your scan tool makes it easy to locate and diagnose malfunctioning systems. There are many possible causes for any problem. For example, suppose you turned on a wall switch in your home and the ceiling light did not turn on. Is it a bad bulb or light socket? Are there problems with the wiring or wall switch? Maybe there is no power coming into the house! As you can see, there are many possible causes. The diagnostics are written for

servicing a particular trouble code take into account all the possibilities. If you follow these procedures, you should be able to find the problem causing the code and fix it yourself.

Actron makes it easy to fix computer-controlled vehicles

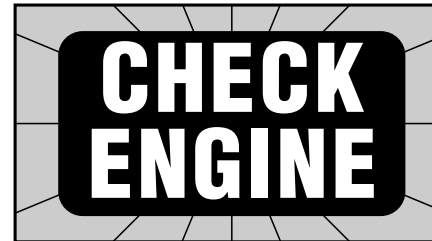
Using the Actron scan tool to obtain trouble codes is fast and easy. Trouble codes give you valuable knowledge - whether you go for professional service or do it yourself. Now that you know what trouble codes are and where they come from, you are well on your way to fixing today's computer-controlled vehicles!

2-3 When to Read Codes

Many vehicles have a "Malfunction Indicator Lamp" or MIL, which has been referred to as a "Check Engine" light in the past. With the advent of OBD-II, all engine trouble lights are now called "Malfunction Indicator Lamps" or MIL.

Use the Malfunction Indicator Lamp to tell you when trouble codes have been stored in memory:

About the Malfunction Indicator Lamp



- "Check Engine"
- "Service Engine Soon"
- "Service Engine Now"
- marked with a small engine picture or diagram

Malfunction Indicator Lamp: normal operation

The engine computer turns the Malfunction Indicator Lamp on and off as needed. This dashboard message is either amber or red and labeled:

The Malfunction Indicator Lamp is normally OFF when the engine is RUNNING.

NOTE: The Malfunction Indicator Lamp will turn on when the ignition key is in ON position, but the engine is OFF prior to starting the vehicle. This is a normal test of all the dashboard message lights.

Malfunction Indicator Lamp: problem spotted

If the Malfunction Indicator Lamp does not come on, you may have an electrical problem which needs repair. Refer to the "Diagnostic Circuit Check" steps in the "Basic Diagnostic Procedures" section of your vehicle service manual.

Malfunction Indicator Lamp: intermittent problem

When the light remains ON after the engine is RUNNING:

- The computer sees a problem that does not go away (known as a "current" failure).
- The light will stay on as long as the problem is present.
- A trouble code is stored in computer memory (a "history" or "memory" code).
- Use the scan tool at the earliest convenient time to obtain codes.

When the light comes ON, then goes OFF while the engine is running:

- The computer saw a problem, but the problem went away (known as an "intermittent" failure).
- A trouble code is stored in computer memory (a "history" or "memory" code).
- The light went out because the problem went away, but the code stays in memory.
- Use the scan tool at the earliest convenient time to obtain codes.

NOTE: The computer will automatically erase these codes after several restarts if the problem does not return.

Poorly running engine, no Malfunction Indicator Lamp

Most likely, this condition is not due to computer system failures, but reading codes can still be useful as part of a basic trouble-shooting procedure. Check wiring and bulb for "Check Engine" light failures. Refer to vehicle service manual for additional diagnostic information.

IMPORTANT: Some vehicles may not be equipped with Malfunction Indicator Lamps. Some mid-80's Fords, for example, did not use a Malfunction Indicator Lamp to warn of problems. On vehicles without Malfunction Indicator Lamps, it is more difficult to recognize problems. Some symptoms of a computer- or sensor-related problem might be:

- Hard starting
- Poor idle quality
- Poor fuel mileage
- Misfiring or hesitation
- Black or dark gray smoke from tailpipe
- Failure of emissions tests

In vehicles without a Malfunction Indicator Lamp, it is important to be alert to any warning signs of computer system trouble. This is why the scan tool is so valuable. With it, you can diagnose any vehicle's electronic systems, regardless of whether the vehicle is equipped with a Malfunction Indicator Lamp. It is also important to note that vehicles without Malfunction Indicator Lamps DO store trouble codes just like any other computer-controlled vehicle. Reading codes is still a very important part of diagnosing problems on these vehicles.

NOTE: On vehicles equipped with OBD-II, the Malfunction Indicator Lamp also signals an emissions-control related failure. The vehicle may not run any differently, but the OBD-II system is designed to note very small changes in the engine's operation which could lead to emissions damage or failure.

Section 3: Actron Help

3-1 Tool Problems

There may be times when your scan tool does not seem to be communicating with the vehicle. It is possible that the vehicle's computer will stop communicating, but for the most part, if you lose the "link," you should check the vehicle power adapter and the cigarette lighter circuit first. Since the scan tool has built-in diagnostics, it is easy to isolate a problem with the ScanTool itself. There will be two basic types of problems that you will deal with: vehicle problems and tool problems. Both might affect your test. Remember, the scan tool always goes through a SELF CHECK each time you power the unit up, before testing. Use the trouble-shooting tips below to help diagnose scan tool problems before calling Actron's Technical Support line:

1. The scan tool will not power-up:

- A. Check the cartridge – Is it properly seated?
- B. Check the cigarette lighter for power. Take the cigarette lighter element and plug it in to verify that it is heating up. If not, check lighter fuse.
- C. UN-plug and plug back in to verify the cigarette lighter end is properly seating in

the vehicle cigarette lighter receptacle.

2. Tool will not "Link" to the vehicle computer:

- A. Unplug the vehicle Data Link Connector (DLC) adapter and plug it back in to verify that it is properly plugged into the vehicle DLC.
- B. Review the vehicle VIN information and verify that you have properly entered the correct vehicle VIN information in the scan tool setup. Also review the Actron supported vehicle list (found in scan tool Application Cartridge manual).
- C. In some GM cars, if there is a Trouble Code set that refers to the internal MEMCAL-PROM, you may not get a vehicle data stream.

3. Your scan tool will not record data:

- A. Take time to review the vehicle application manual for the vehicle that you are working on. Refer to the data recording section, following the instructions and try again.
- B. Verify that the scan tool memory buffer is not already full.
- C. Use the scan tool self-test and verify that the on-board RAM memory is okay.

4. Your Keyboard does not function properly:

- A. Perform the Keyboard Test by entering the Self-Test and select the Keyboard Test function. This will test out all buttons along with the sound alert.
- B. If the keyboard test shows nothing and you still experience the problem, then call Actron's technical support personnel at 1-800-ACTRON-7.

3-2 Car Problems

If your scan tool is having difficulty “linking” with the vehicle computer, be sure that you have double checked all scan tool interfaces, including the power connectors and the DLC connection. When you are sure that the scan tool is not malfunctioning (run scan tool Self-Tests), then the problem may be with the vehicle’s electrical system or with the vehicle computer itself. Check the following:

- If you are using the cigarette lighter power adapter, verify that the vehicle’s cigarette lighter and fuse are OK.
- If the cigarette lighter adapter is used to power-up the scan tool, then make sure the vehicle’s battery has a minimum 8 volt charge. The scan tool requires a minimum of 8 volts to power-up.
- Verify the ignition key is ON and not in the accessories (ACC.) position.
- Check the vehicle’s on-board computer for a blown PCM fuse. The PCM fuse is located on the fuse block in the passenger compartment. If the PCM fuse is blown, the vehicle’s on-board computer cannot transmit data.
- Check to be sure your vehicle’s calibra-

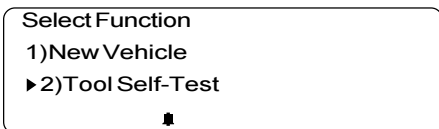
3-3 Scan Tool Self-Tests

Scan tool Self-Tests are used to test the operation of the scan tool’s display, keyboard, and internal memory. The Tool Self-Tests menu can be accessed when the scan tool is initially powered-up, and from the Function List. Convenience is the reason the Tool Self-Tests menu is accessible in two ways. If the scan tool has a display problem on power-up, you do not want to enter vehicle set-up information just to get to the Function List to run the Display Self-Test. It is far more convenient to have the Tool Self-Tests menu acces-

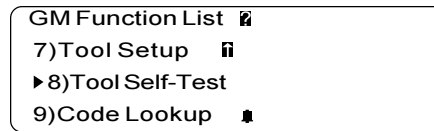
sible during scan tool power-up. If a keyboard problem happens while you are Viewing Data, it is easier to run a Keyboard Self-Test from the Function List than to remove and then re-apply power to the scan tool.

- Make sure the vehicle’s on-board computer has a good ground. If your vehicle’s on-board computer has a ground going directly to the computer’s case, then clean up this connection and apply a conductive grease to the mating surfaces.
- On some carbureted engines, the ignition key must be ON and the engine OFF in order to establish communication between the scan tool and the vehicle’s on-board computer. If the engine was running when the Operating Error occurred, then turn the ignition key OFF and then ON, but *do not start the engine*.
- As a last resort, the vehicle’s on-board computer or calibration PROM may be defective. Check vehicle service manual to determine correct computer tests for your particular vehicle.

After the ENTER key is pressed, the display on power-up looks like this:

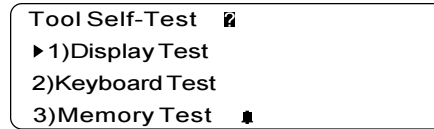


The screen below is how the Tool Self-Tests option appears on the Function List (**NOTE:** This is a GM Function List. Function Lists for other manufacturers may differ slightly):



To select Tool Self-Tests on either screen, use the UP and DOWN arrow keys to move the cursor so it is pointing to the Tool Self-Tests option, then push the ENTER key to select this option.

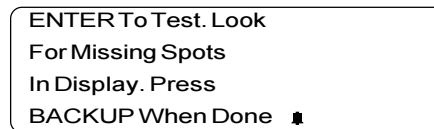
After selecting the Tool Self-Tests option, you will be given a menu of scan tool self-tests to choose from:



From the above menu, use the UP and DOWN arrow keys to move the cursor so it is pointing to the Self-Test option of your choice, then push the ENTER key to select this option.

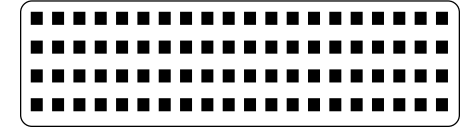
Display Test

After you have selected Display Test as your choice, a screen detailing the test is displayed. The Display Test will fill every pixel of the ScanTool’s LCD display with a solid black character. Press ENTER to display solid black characters.



The Display Test Screen is shown below. Look for pixels that are not black. In other words, look for missing spots in the solid black characters. Press the BACKUP key to return to the Tool Self Test Menu when

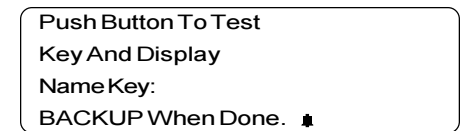
done. If you selected Tool Self-Test from the Function List, then press the FUNCTION key to return to the function list at any time.



NOTE: The beeper is disabled while the Display Test Screen is visible. Therefore any key press will not register a beep.

Keyboard Test

The Keyboard Test is used to check the functionality of the scan tool’s keyboard. After you select Keyboard Test from the Tool Self-Test Menu, the Keyboard Test screen with instructions is displayed.



Each time you press a key, check scan tool display. The key name should appear and the scan tool should beep. For example, if you press the UP arrow, the screen will display “Key: UP ARROW.” If the button name is not displayed, the key is not working. The only exception is the BACKUP key. When the BACKUP key is pressed, the scan tool returns to the Tool Self-Test Menu. If you are not returned to the Tool Self-Test Menu, then the BACKUP key is not working. **NOTE:** The FUNCTION key will not return you to the Function List while you are keyboard testing.

Memory Test

The scan tool has already run a Memory Self-Test during power-up. It is assumed that the scan tool passed the Memory Self-Test on power-up, because you should not have proceeded any farther if it failed. Once you have reached the Function List, the scan tool may have trouble playing

back recorded data, displaying trouble code definitions, or doing any other function that uses the scan tool's internal memory. If this happens, it is a good idea to run the Memory Test again. From the Tool Self-Test Menu, select the Memory Test option. A "working please wait" message is displayed while the scan tool tests its internal memory:

Working
** Please Wait **

When the Memory Test is completed, either a "Memory Test Failed!" or a "Memory Test Passed!" message is displayed.

played. Press the ENTER key to return to the Tool Self-Test Menu.

Memory Test Failed

Press ENTER To Cont ▶

Memory Test Passed

Press ENTER To Cont ▶

NOTE: If you selected Tool Self-Test from the Function List, then press the FUNCTION key to return to the function list at any time.

Section 4: Accessories and How to Order

4-1 Where to Buy

Actron offers a complete line of high quality automotive diagnostic and repair equipment. Additional cartridges, cables, connectors, and adapters for the scan

tool are available from the local retail store where you originally purchased your scan tool. The table below lists the scan tool accessories.

Kits:	Actron Model Number	Replacement Parts:	Actron Part Number
GM OBD II cable kit	CP9115	Cigarette power cable	38-1908
Ford Probe MECS cable kit	CP9116	Carrying Case	400-2080
Chrysler L-H engine cable kit	CP9120	Main Tool operators manual	2-218601
Chrysler OBD II cable kit	CP9117	GM cartridge manual	2-218301
Battery Clip Adapters	CP9118	Ford cartridge manual	2-218401
AC power converter 110/12V	CP9119	Chrysler cartridge manual	2-218501

4-2 Call Actron

In addition to your local dealer, all Actron equipment and replacement parts are available directly from the Actron factory. Product catalogs, pricing information, and replacement components can be ordered by contacting Actron directly.

By US mail:
Actron Manufacturing Company
15825 Industrial Parkway
Cleveland, OH 44135, USA

By phone:
1-800-228-7667

By fax:
(216) 651-2388

For Technical Support call:
1-800-ACTRON-7

4-3 E-Mail & Internet Address

Actron is also available electronically for comments and ordering information. Actron's E-Mail address is:

sunpro@actron.com

And while you're on-line, be sure to check out Actron's Website, where you'll find equipment information, new products, and technical tips to help you make the most of your new Actron ScanTool.

On the World Wide Web:
<http://www.actron.com>

Section 5: Glossary of Terms

Actuator: Devices that are powered by the PCM to control things. Actuator types include relays, solenoids, and motors. Actuators allow the PCM to control engine operation.

A/F: Air/Fuel ratio. This refers to the proportion of air and fuel delivered to the cylinder for combustion. For example, if you have 14 times more air than fuel (by weight) then the A/F ratio is 14:1 (read as “fourteen to one”). The ideal operating A/F ratio in an automotive application is 14.7:1.

Check Engine Light (CEL): The “Check Engine” light (CEL) will illuminate when the PCM detects a circuit malfunction in any of the engine feedback circuits. When the malfunction occurs, the CEL will remain lit as long as the PCM detects the circuit problem. This will automatically set and store a trouble code in the PCM’s memory. Some manufacturers also refer to the CEL as a Malfunction Indicator Light (MIL), or the Emissions Maintenance Lamp (EMR) on some Chrysler trucks.

C3 or CCC: Computer Command Control. The name of the General Motors electronic engine control system used on most vehicles built since 1982.

Chrysler Serial Communication Interface (SCI): This is Chrysler’s vehicle adapter (or Data Link Connector) used to link scan tools with the PCM. Early Chrysler OBD systems (1981-83) broadcast trouble codes, but gave no operating parameter data. In 1983, the second phase of Chrysler OBD, called the Serial Communication Interface (SCI), was introduced with expanded serial data and many test modes for the technician to access with a scan tool. SCI provides the following modes to access vehicle data: Diagnostic Test Mode, Circuit Actuation Test Mode (ATM), Switch Test Mode, Sensor Test Mode, and Engine Running Test Mode. Each of these modes allow for different procedures of diagnostic tests and test routines. These routines are programmed into the Chrysler Logic Module (LM) which then passes the information on to the power module or Single Board Engine Controller (SBEC). The vehicle diagnostic adapter is located in the engine compartment on the right-hand side, next to the SBEC unit with a dust cap marked “Diagnostic.”

Closed Loop (C/L): This is when a control system performs an action (expecting a certain result), then checks the results and corrects its actions (if necessary) until the desired results are achieved. Example: Fuel delivery. The PCM operates a fuel injector in a way that should deliver an optimum air/fuel mixture, as long as everything in the fuel system is operating as expected. In closed loop operation, the PCM uses the oxygen sensor to check the results (fuel delivery may be different than expected because of variations in fuel pressure or injector operation). If the oxygen sensor indicates a “rich” condition, the PCM will compensate by reducing fuel delivery until the oxygen sensor signals an optimum air/fuel mixture. Likewise, the PCM will compensate for a “lean” condition by adding fuel until the oxygen sensor once again signals an optimum air/fuel mixture.

Thus, closed loop operation means the PCM can “fine tune” control of a system to achieve an exact result providing the PCM has a means to check results (like an oxygen sensor).

Data Link Connector (DLC): The Data Link Connector (DLC) is a universal term for the interface port between the vehicle’s on-board computer and the ScanTool. It is sometimes referred to as the Assembly Line Diagnostic Link (ALDL), Vehicle Interface Port (VIP), or Serial Communication Interface (SCI). The DLC is able to transmit PCM data to the ScanTool as it is processed. The DLC may be located in the engine compartment or in the passenger compartment, depending on manufacturer. DLC design also varies from manufacturer to manufacturer, ranging from a 6-pin to a 17-pin connector interface. All vehicles with OBD-II use a 16-pin connector located in the passenger compartment. The ScanTool requires manufacturer-specific adapter cables to link with non-OBD-II DLCs.

Data Stream: This is the actual data communications broadcast from the vehicle’s PCM to the diagnostic connector. The individual manufacturers determine the number of “data bytes” a specific engine will broadcast. The size of the data stream is usually dependent on the complexity of the engine, transmission, ABS, and other systems supported by the PCM. All manufacturers supply program documents for each year, engine, and option combination that a particular PCM supports in all the manufacturer’s

vehicles. This information is used to design and build aftermarket diagnostic equipment.

Detonation: Uncontrolled ignition of the air/fuel mixture in the cylinder. Also referred to as “knock,” detonation indicates extreme cylinder pressures or “hotspots” which are causing the air/fuel mixture to detonate early. High cylinder pressures may be caused by excessive load (trailer towing, A/C operation, etc.) or by too much spark advance. High octane fuel has a higher resistance to uncontrolled ignition, and may be used to control detonation when the PCM is unable to retard timing sufficiently to prevent it from occurring. NOTE: High octane fuel is not a cure for the problem, only the symptom. If your vehicle experiences long-term detonation, check for other causes.

Diagnostic Trouble Codes: Diagnostic Trouble Codes (DTC) indicate a malfunction flagged by the PCM. The PCM will display a corresponding numerical code number based on a look-up table in the program of the on-board computer. Depending on the manufacturer, the number of DTCs vary by vehicle and supported systems. Most systems have the ability to store codes in memory, which are commonly referred to as “history codes” or “soft codes.” Malfunctioning circuits will generate continuous Check Engine lamp illumination, called “current codes” or “hard codes.” History codes, based on the manufacturer’s diagnostic strategy, will be cleared from the PCM’s memory after several ignition circuit start cycles if the circuit does not reflect the failure again. This capability does allow the technician to access some information on which circuits were malfunctioning at a previous point. OBD-II systems will transmit many more DTCs than the past systems, and therefore will allow a technician the ability to better pin-point failures and past events. They only way to clear codes on OBD-II systems will be with a scan tool that has the proper programming to perform the function.

DIS: Distributorless Ignition System or Direct Ignition System. A system that produces the ignition spark without the use of a distributor.

Duty Cycle: A term applied to frequency signals — those which are constantly switching between a small voltage value (close to zero) and a larger value (usually 5 volts or more). Duty cycle is the percentage of time the signal has a large voltage value. For example, if the signal is “high” (large voltage) half of the time, the duty cycle is 50%. If the signal is “high” only one fourth of the time,

then the duty cycle is 25%. A duty cycle of 0% means the signal is always at a “low” value and not changing. A duty cycle of 100% means the signal is always at a “high” value and not changing. The PCM uses duty cycle type signals when it wants more than just “on-off” control of an actuator. This is how it works: A 50% duty cycle signal going to a vacuum switching solenoid means the solenoid will be “on” (passing full vacuum) half the time, and “off” (passing no vacuum) half the time. The average amount of vacuum passing through the solenoid will be one half the full value because the solenoid is only “on” for half the time. This signal changes at a rapid rate, as often as ten times per second. Thus the PCM can get a vacuum controlled actuator to move halfway between “no vacuum” and “full vacuum.” Other positions can be achieved by changing the duty cycle of the control signal which in turn changes the average amount of control vacuum.

DVM: Digital Volt Meter. An instrument using a numeric readout to display measured voltage values as opposed to a moving needle on a gauge face. Usually the instrument has other measuring capabilities, such as resistance and current, and may be called a Digital Multi-Meter (DMM). Most DVMs have 10 Megaohm input impedance. This means the circuit under test will not be electronically disturbed when the DVM is connected for a measurement.

ECM: Electronic Control Module. The “brains” of the engine control system. It is a computer housed in a metal box with a number of sensors and actuators connected with a wiring harness. Its job is to control fuel delivery, idle speed, spark advance timing, and emission systems. The PCM receives information from sensors, then energizes various actuators to control the engine. The ECM is frequently called the PCM (Powertrain Control Module) in vehicles having other computers. These other computers are used for climate control, entertainment systems, transmissions, etc.

EFI: Electronic Fuel Injection. A term applied to any system where a computer controls fuel delivery to the engine by using fuel injectors.

Engine Parameters: This is the translated information that is displayed on the scan tool screen. Parameters will include the information inputs and the output signals from the PCM.

ESC: Electronic Spark Control. This is an ignition system function that works on vehicles having a knock sensor mounted on the engine block. The knock sensor is wired to circuitry in a separate module (early version) or inside the PCM (later versions). If the sensor detects engine knock, the ESC function alerts the PCM which will immediately retard the spark to eliminate the knocking condition.

EST: Electronic Spark Timing. An ignition system where the PCM controls the spark advance timing. A signal called EST goes from the PCM to the ignition module which fires the spark coil. The PCM determines optimum spark timing from sensor information – engine speed, throttle position, coolant temperature, engine load, vehicle speed, Park/Neutral switch position, and knock sensor condition.

FBC: Feedback Carburetor. This is used on early versions of computer-controlled engines. It is a carburetor which can have its fuel delivery modified by an electronic signal from the PCM. The signal controls a mixture control solenoid (MCS) attached to the carburetor body.

Ford Electronic Engine Control IV (EEC-IV): This is the name of Ford's Powertrain Control Module (PCM) used in all Ford cars and trucks since the mid-1980's. It is designed to be read by aftermarket scan tools. Earlier versions of this PCM were referred to as EEC-I, EEC-II, or EEC-III, and were only accessible by the dealer via a specific diagnostic tool. On carbureted vehicles, Ford used a system called the Microprocessor Controlled Unit (MCU), which is accessible through an adapter similar to the EEC-IV's. Other variations of the EEC-IV vehicle adapter are used on Ford's hybrid vehicles, such as the Probe and some Escort/Tracer models, which use Mazda PCMs and have different protocols and codes. Information on these vehicles is widely available, and most scan tools support these vehicles as well as the standard Ford EEC-IV systems. Ford's diagnostic strategy offers several avenues to access codes and test procedures.

Fuel Injector: An electronically controlled flow valve. Fuel injectors are connected to a pressurized fuel supply (fuel pressure is created by a fuel pump). No flow occurs when the injector is off (not energized). When the injector is energized, it opens fully, allowing fuel to flow. The PCM controls fuel delivery by varying the amount of time the injector solenoids are turned on.

Functional Tests: These are tests of PCM-controlled systems, such as the fuel pump, the "Check Engine" light, and other switches and actuators. Functional Tests are generally dependent on the vehicle manufacturer's OBD strategy and the PCM diagnostic architecture. Functional tests require that the scan tool have the ability to perform bi-directional communications with the vehicle's PCM. This means that the scan tool must "talk" to the vehicle's PCM, instead of just "listening" to the incoming vehicle data stream. Examples of functional tests are: Chrysler's actuator/switch tests that allow you to review the operation of a switch as you turn it on or off from the driver's seat, and turning the fuel pump on and off. On a GM vehicle, a functional test is placing the vehicle in Ground Mode to check the PCM's self-test diagnostics and the "Check Engine" lamp operation.

Ground: The return path for current to flow back to its source (Usually the negative battery terminal). It is also the reference point from which voltage measurements are made (the connection place for the negative (-) test lead from a voltmeter).

Inputs: Electrical signals running into the PCM. These signals come from sensors, switches or other electronic modules. They give the PCM information about vehicle operation.

KOEO: Key On, Engine Off. A test mode where the PCM is active and feeding data parameters, but the engine is not running. Because the engine is not running, some data parameters may not be accurate or available in this mode. On Ford vehicles, KOEO testing is the only way to read memory codes stored in the PCM.

KOER: Key On, Engine Running. A test mode where the PCM is active and feeding data parameters, and the engine is running. Since the engine is running, most data parameters should be available and accurate.

Knock: See "Detonation."

Knock Sensor: This sensor is used to detect engine detonation (or "knock"). When spark knock occurs, the sensor emits a pulsing signal. Depending on the vehicle, this signal either goes to the PCM or a separate ESC (Electronic Spark Control) module. Then the spark advance is retarded until detonation stops. The sensor contains a piezoelectric element and is threaded into the engine block. Vibrating the element generates the signal pulse. Special construction

makes the element sensitive only to engine vibrations associated with detonation ("knocking").

MFI: Multi-Port Fuel Injection. See "MPFI" definition.

MIL: Malfunction Indicator Lamp. Also known as a Check Engine Light or CEL.

Mode: A type of operating condition, such as "idle mode" or "cruise mode."

MPFI: Multi-Port Fuel Injection. A fuel injection system using one (or more) injector(s) for each cylinder. The injectors are mounted in the intake manifold, and fired in groups rather than individually.

M/T: Manual transmission or manual transaxle.

NOx: Oxides of Nitrogen. A pollutant. The EGR system injects exhaust gases into the intake manifold to reduce these gases at the tailpipe.

On-Board Diagnostics (OBD): As vehicle manufacturers developed on-board diagnostics for their service procedures and to meet EPA regulations, the first phase of this computerization was referred to as OBD. This technology started in the late 1970's and carried through to the early 1980's. Most of these early systems were very crude, especially when compared to today's OBD. Many required a manufacturer-specific tool to read trouble codes and other computer information. This technology used a feedback loop system to monitor exhaust emissions and provided computer control of the vehicle's fuel system.

On-Board Diagnostics, Phase I (OBD-I): By 1985, the California Air Resources Board (CARB) had called for more uniform diagnostic systems to be used on vehicles sold in California. Combined with federal exhaust emission regulations enacted in the early 1990's, CARB required that all vehicles sold in California have an integrated PCM structure that monitored all critical emissions components. Manufacturers found that it was simpler to incorporate this system into all their vehicles built in the USA. In fact, by the end of 1986, most diagnostic procedures were uniform within each manufacturer, providing an opportunity for generic scan tools to come to market for the home mechanic.

On-Board Diagnostics, Phase II (OBD-II): With the passing of the 1990 Clean Air Act Amendment, the EPA imposed more stringent requirements which include the addition of multiple oxygen sensors, one before the catalytic converter and one after to provide the PCM with information on catalyst efficiency and condition. There are also computer-controlled EGR, fuel pressure regulators, and smart ignition systems. In addition, OBD-II requires a common diagnostic connector and location, as well as an industry-standard data message, both defined by an industry committee made up of engineers from most major manufacturers and the SAE. Vehicle manufacturers are required by law to provide at least a minimum amount of data for emissions programs to access the critical emissions data available through OBD-II. OBD-II began to appear in vehicles in late 1994, and is required equipment on all cars sold in the US after January 1, 1996.

Open (Circuit): A break in the continuity of a circuit such that no current may flow through it.

Open Loop (O/L): This is when the control system performs an action (expecting a certain result), but has no way of verifying if the desired results were achieved. Example: The PCM operates a fuel injector expecting a certain amount of fuel to be delivered (The PCM assumes everything in the fuel system is performing properly). In open loop operation, the PCM has no way of checking the actual amount of fuel delivered. Thus, a faulty fuel injector or incorrect fuel pressure can change the amount of fuel delivered and the PCM would not know it.

In general, a control system operates in open loop mode only when there is no practical way to monitor the results of an action. Example: Fuel delivery during cold engine warm-up. The computer runs in open loop mode because the oxygen sensor is not hot enough to send a signal. Without the sensor signal, the computer cannot check the actual amount of fuel delivered.

O2S: Oxygen Sensor. The oxygen sensor is threaded into the exhaust manifold, directly in the stream of exhaust gases. The PCM uses the sensor to "fine tune" fuel delivery. The sensor generates a voltage of 0.6 to 1.1 volts when the exhaust gas is rich (low oxygen content). The voltage changes to 0.4 volts or less when the exhaust gas is lean (high oxygen content). The sensor only operates after it reaches a temperature of approximately 349°C (660°F).

Outputs: Electrical signals sent from the PCM. These signals may activate relays or other actuators for control purposes throughout the vehicle. The signals can also send information from the PCM to other electronic modules, such as the ignition or trip computer.

PCM: Powertrain Control Module. The “brains” of the engine control system. It is a computer housed in a metal box with a number of sensors and actuators connected with a wiring harness. Its job is to control fuel delivery, idle speed, spark advance timing, and emission systems. The PCM receives information from sensors, then energizes various actuators to control the engine. The PCM is frequently called the ECM (Engine Control Module) in vehicles having other computers. These other computers are used for climate control, entertainment systems, transmissions, etc.

PROM: Programmable Read-Only Memory. A small, replaceable electrical component hidden behind an access door on the PCM. The PROM contains permanent programming information the PCM needs to operate a specific vehicle model. Included are vehicle weight, engine and transmission type, axle ratio, and other specifics.

Relay: A mechanical device for switching high current circuits on and off. It is electronically controlled by a low current circuit. Relays allow a low power PCM signal to control a high power device such as an electric cooling fan.

ROM: Read-Only Memory. Permanent programming information stored inside the PCM, containing the information the PCM needs to operate a specific vehicle model.

Sensor: Device which gives the PCM information. The PCM can only work with electrical signals. The job of the sensor is to take something the PCM needs to know, such as engine temperature, and convert it to an electrical signal that the PCM can understand. The PCM uses sensors to measure such things as throttle position, coolant temperature, engine speed, incoming air mass and temperature, etc.

SFI or SEFI: Sequential Fuel Injection or Sequential Electronic Fuel Injection. A fuel injection system that uses one or more injectors for each cylinder. The injectors are mounted in the intake manifold, and are fired individually in the same sequence as the spark plug firing order.

Solenoid: A device to convert an electrical signal to mechanical movement. It consists of a coil with a wire with a moveable metal rod in the center. When the power is applied to the coil, the resulting electromagnetism moves the rod and performs some mechanical action. The PCM often uses solenoids to switch vacuum lines on and off. This allows the PCM to control vacuum operated devices such as the EGR valve. Fuel injectors are operated by another type of solenoid.

TBI: Throttle Body Injection. A fuel injection system having one or more injectors mounted in a centrally-located throttle body, as opposed to positioning the injectors close to an intake valve port. Also called Central Fuel Injection (CFI) in some vehicles.

Thermistor: A resistor whose resistance changes with temperature. Thermistors are used as sensors for vehicle coolant and manifold air temperature. The resistance decreases as temperature goes up, sending a voltage signal to the PCM where it is converted to a temperature measurement.

Throttle Body: A device which performs the same function as a carburetor in a fuel injection system. On a throttle body injection (TBI) system, the throttle body is both the air door and the location of the fuel injectors. On port fuel injection systems (PFI, MPFI, SFI, etc.) the throttle body is simply an air door. Fuel is not added until the injectors at each intake port are activated. In each case, the throttle body is attached to the accelerator pedal.

Vehicle Adapter: Like General Motors and the ALDL connector, Ford and Chrysler use Vehicle Adapter as the name of their diagnostic link. Ford uses a 7-pin adapter called the EEC-IV self test adapter. This is generally located in the engine compartment of Ford vehicles, though specific location varies (generally it is close to the PCM).

Chrysler has a similar adapter for access to the Serial Communications Interface (SCI) diagnostic program on those vehicles that support SCI. This adapter is located on the right-hand side of the engine compartment, and is a 6-pin configuration. This adapter is usually near the Logic Controller on the SCI computer.

VIN: Vehicle Identification Number. This is the factory-assigned vehicle serial number. This number is stamped on a number of locations throughout the vehicle, but the most prominent location is on top of the dashboard on the driver’s side, visible from outside the car. The VIN includes information about the car, including where it was built, body and engine codes, options, colors, and a sequential build number. The VIN can also tell you what adapters you may need to use the ScanTool with your particular vehicle.

WOT: Wide-Open Throttle. The vehicle operating condition brought about when the throttle is completely (or nearly so) open. The PCM will typically deliver extra fuel to the engine and de-energize the A/C compressor at this time for acceleration purposes. The PCM uses a switch or the Throttle Position Sensor to identify the WOT condition.