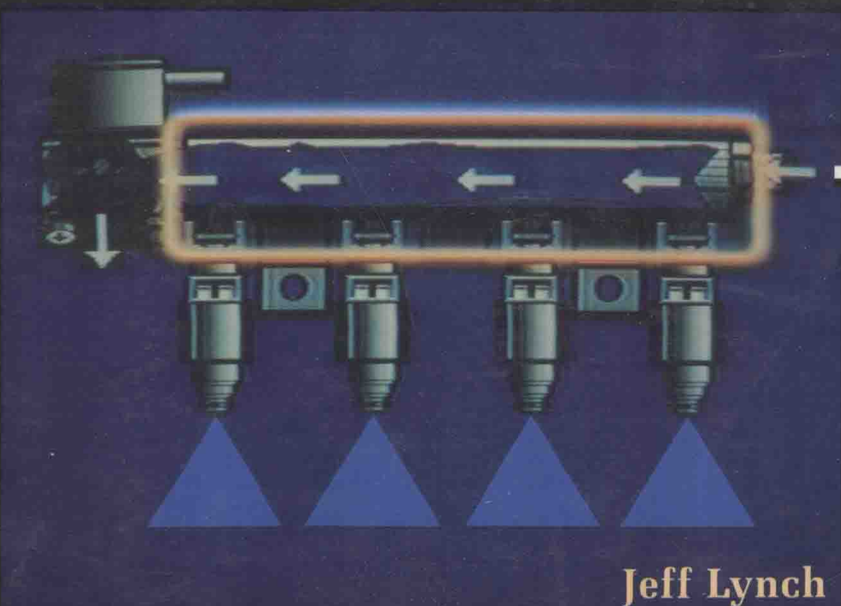
TROUBLESHOOTING

GENERAL MOTORS Fuel Injection Systems & Computerized Engine Controls



Jeff Lynch

Troubleshooting General Motors Fuel Injection Systems and Computerized Engine Controls

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Delmar Publishers Inc.®

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Preface

This manual consists of the culmination of years of work, both as an automotive technician and an automotive instructor. The basic premise of this guide is to present the parts, pieces, and systems of the electrical and electronic engine controls you will find in modern General Motors vehicles. Instead of concentrating on each engine individually this guide deals with the various components that can be found in General Motors vehicles. This guide allows the reader to look up the components and systems present on the application at hand and explains these systems in an easy to understand format. The guide is divided into four basic sections;

1) Devices—the more common parts and systems found on modern GM applications
2) Fuel Injection—starting with a basic, generic approach to GM fuel injection systems, then getting specific with Throttle Body Fuel Injection and Port Fuel Injection
3) GM Ignition Systems—starting with points and traveling through High Energy Ignition and "Distributorless" Ignition Systems
4) Scanner Terms—some of the more common terms used by the diagnostic scan tools and their definitions, including some expected readings and a chart for throttle position sensor reading adjustments

Instead of reinventing the wheel each time this guide allows the reader to use just the sections needed, without wasting time going over the same material several times. Each section is explained in basic terms and sometimes in more technical ways. Use what suits you the best and enjoy the modern world of automotive electronics; it's easier than you may think.

Contents

SECTION 1

Devices

CHAPTER 1

Basic Computer

OBJECTIVES

The objectives of this chapter are to:

- Identify and recognize the different computer components
- Understand serial data and internal computer communication techniques
- Utilize on board computer diagnostics
- Be familiar with PROMs, MEM-CALs, and Fuel Cal-Paks
- Check and install these components safely
- Learn basic computer language

This car has a computer, and that makes me nervous.

WELL, IT SHOULDN'T! Computers are not very smart, as they relate to automobiles, but they sure can make calculations and perform tasks faster than you and me.

As a matter of fact, computers only have the ability to perform a few different functions. Most of what a computer does is based on two numbers, zero and one. You may have heard the term **BINARY** before. This term defines a counting system that consists strictly of the numbers zero and one. You and I count with a system consisting of ten digits, or numbers. This system is called the **DECIMAL** system. Binary or decimal are both just a way of counting, but they each use a different set of numbers. Not only does a computer count with numbers, it also communicates internally between its different components with numbers and externally to other components in the car, as well as to your scan tool. Your scan tool receives a series of ones and zeroes, translates them into information you can understand, and displays them. Each computer has its own way of interpreting the information that it receives, and that is why you have to program your scanner to properly assimilate and display the correct information. See Figure 1–1 for typical information scanner.

It is pretty obvious, though, that the computer does not *actually* talk to its inputs and outputs with actual numbers, so it has to handle the task by some other method. This is done with voltages. Generally speaking, the **ECM**

Figure 1–1. Tech™ computer information scanner

(ELECTRONIC CONTROL MODULE) (Figure 1–2), or the computer, tries to deal mainly with **DIGITAL** circuits because it is a digital device. Do not get scared by the word digital. A digit is nothing more than a number, and by this time you are aware that these computers communicate with numbers. A digital input to the ECM could be very easily displayed as something like

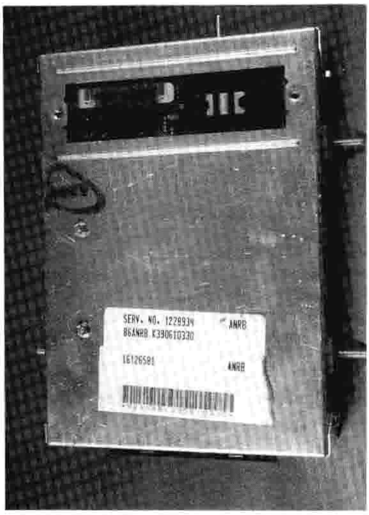


Figure 1–2. Electronic control module—ECM

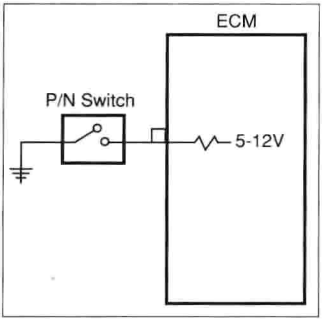


Figure 1–3. Park/neutral switch circuit

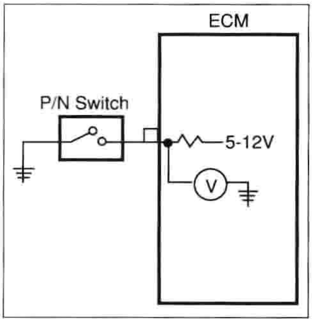


Figure 1–4. Voltmeter connected to the park/neutral switch

a Park/Neutral switch, which has the ability to show only two things—whether the transmission is in gear or in neutral.

Looking at Figure 1–3 doesn't reveal a whole lot, so take a look at Figure 1–4. This is the same circuit with a voltmeter added to show you what the ECM is actually looking at.

With the P/N switch in the open position, the voltage applied to the circuit by the ECM has no place to go except through the voltmeter to ground. This would indicate a high voltage to the ECM, and therefore the ECM would know that the switch is open, which, by the way, means that the transmission is in gear.

With the switch closed there is less resistance for the electricity applied to the circuit by the ECM to go to ground through the switch, and this causes the reading at the voltmeter to drop to near zero. This is the signal the ECM uses to identify that the transmission has been placed in park or neutral.

We have just looked at a circuit that deals with voltages, but to make it even clearer we must go a step further. The ECM knows numbers from its digital inputs by the following method. This explanation may not be completely accurate as far as actual computer logic is concerned, but it does work when you are looking at discrete circuits used by the ECM, and when checked with the scanner. If you double check you will find this to be reasonably accurate as far as voltages are concerned.

With a digital circuit, any voltage above 2.5 volts is equal to the number one, and any voltage under 2.5 volts is equal to the number zero. We have now constructed a circuit that the ECM can read directly, where a voltage identifies a specific number. At this point you should also be aware that on circuits like these the exactness of the voltages is of no consequence, as long as they are over or under 2.5 volts.

Simple switching circuits like this are called **DISCRETE** switching circuits.

There are two basic types of circuits with which we will deal. One is digital, and the other is **ANALOG.** A digital circuit is one made up of a whole bunch of ones and zeroes. An analog circuit is one made from a voltage signal that is infinitely and continuously variable. The ECM cannot read an analog signal directly, and the signal has to be processed internally to the ECM before the ECM's main brain can understand it.

Most of the inputs to the ECM are of the digital variety, so dealing with them is relatively simple. There are those circuits, however, which are analog, and that makes things a little more complex, but more so for the people who design and build the ECM's than for you or me. We are going to deal with either of those circuits with our typical tools. None of that will change, but it is nice to learn some of the terms that are used by the people in the electronics business.

As far as analog signals, there are going to be quite a few of them in the guide as you go through, including the following:

- Manifold Absolute Pressure Sensor (MAP), Figure 1-5
- Manifold Air Temperature Sensor (MAT)
- Barometric Pressure Sensor (BARO)
- Coolant Temperature Sensor (CTS), Figure 1-6
- Differential Pressure Sensor
- Bosch Mass Air Flow (MAF) Sensor, Figure 1-7
- Charging System Voltage

Throughout each section of the guide I will make sure to mention what sort of a device with which we are dealing at the moment (digital or analog) just to familiarize you with the terms.

As stated earlier, the ECMs we are dealing with are digital. This means that when a sensor comes up with an input to the ECM that is a variable voltage, or analog signal, something must be done with that signal before it actually hits the decision making part of the ECM, which is called the **MICRO-PROCESSOR**, or the **CPU (CENTRAL PROCESSING UNIT)**.

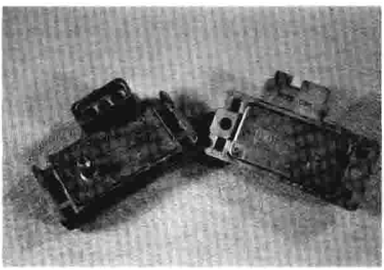


Figure 1-5. Typical MAP sensor

Figure 1-6. Coolant sensor

Figure 1–7. Analog mass air flow sensor

The digital signals, like park/neutral, tach signal, and third and fourth gear switches, can be directly understood by the CPU, but the analog signals have to be processed first. This is taken care of by an **ANALOG TO DIGITAL CONVERTOR (A/D)**, a circuit which is internal to the ECM (Figure 1–8).

With a scan tool connected to the ECM you can very simply and quickly determine if the A/D convertor is functioning by comparing the signal voltage on an analog circuit, as shown on the scanner, with actual voltage measured at the device, with a digital multi-meter.

The two measurements should be the same, give or take a few hundredths of a volt. If not, then you either have a computer power feed problem, positive or ground, a wiring problem between the device tested and the ECM, or the ECM itself is ill.

Before the days of scanners there was really no way of being so quick and accurate with a diagnosis. You could check a circuit externally, but whether

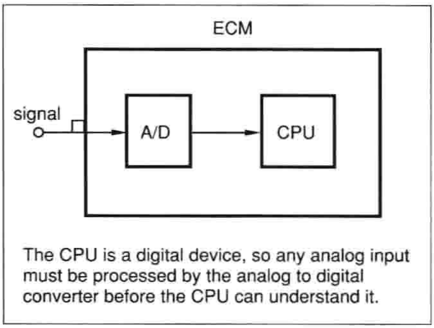


Figure 1–8. Analog to digital converter

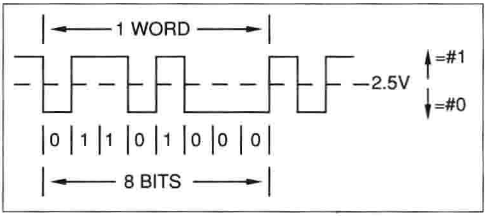


Figure 1–9. Explanation of an eight bit word

or not the ECM could process the information was another story. With scanners, you can see that the process has occurred, or has not, whatever the case may be.

Another term with which you should be familiar is **BIT**. Bit is a shortened word made up from the words binary and digit. You know what the word binary means, and you also know what the word digit means, so you should have no problem with this word. A bit is nothing more than a small piece of information, or voltage, which refers directly to a number. These bits make up the computer's language. Computers communicate by linking millions of these little bits of information together. Putting all of these bits together is only the beginning, so if you are ready to do a little intense thinking, then let's go. Figure 1–9 shows a typical example of a word on the serial data stream of the computer.

This may be a little complicated to digest all at once, so let's take it one step at a time. First of all, most of the computers that we deal with communicate with what is known as an eight bit word. This means that the words with which the computer speaks consist of eight separate bits or distinct voltages. The above diagram should help illustrate this.

Referring to the diagram you can easily see what is meant by an eight bit word. You can also see that each bit occupies the same size space as any of the others. The size of the space that the bit occupies is controlled through the use of a component in the ECM known as the **CLOCK** (Figure 1–10). The clock broadcasts an internal frequency to all of the ECM's components to synchronize them so that they can all talk, or listen, in harmony. Figure 1–11 shows the clock and how it is common to each of the processing components, so that synchronization can take place. If the clock became inoperative, the ECM would not be able to function at all.

The only reason that I am mentioning these components is for your general knowledge. I generally list information in two categories

1) Need to Know

2) Good to Know

A lot of what we are talking about in this section falls into the "Good to Know" category, but it can only help in rounding out your basic understandings of a basic computer system.

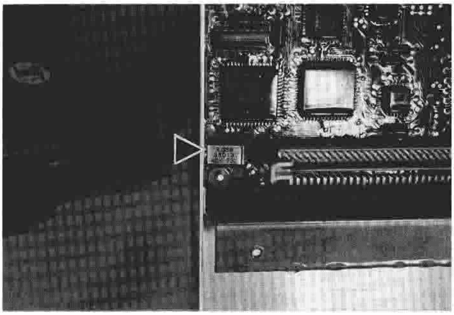
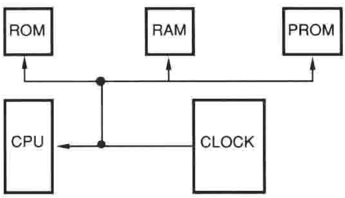


Figure 1-10. Computer clock

Going back to the eight bit word, at this point you should be formulating a question or two. For instance, how does a computer component know when to start reading, or stop reading a word? This is accomplished by placing a special bit of information at the end of each word that is broadcast by the component. This special bit is called a **STOP BIT** or a **START BIT**. These bits vary as to their identity from computer to computer.

We have already discussed the computers main brain, the CPU, or central processing unit, which makes all the decisions based upon inputs and programming. The CPU has no real programming of its own; it relies on the information which it receives from its **ROMs**. A ROM is a small component within the ECM that has a great deal of information stored in it. The CPU reads the information that it needs to perform its daily tasks directly from these ROMs. The CPU can "read out" information from a ROM, but it can't "write in" any information into the ROM, and this is how the term ROM came



The clock signal is a square wave that always rises and falls at the same frequency. To get an idea of how often the signal changes, the typical clock in an ECM generates a frequency of 4,194,000 cycles per second. With a scope the signal would look like this

Figure 1-11. Computer "clock" explanation

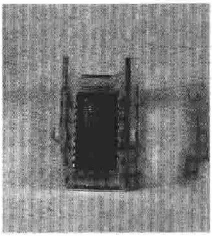


Figure 1–12. Typical early PROM

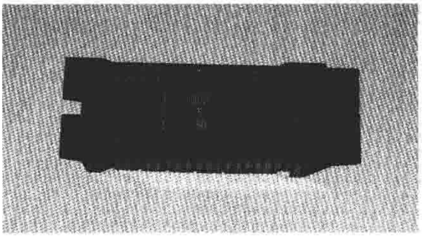


Figure 1–13. EEPROM

about: ROM stands for **R**ead **O**nly **M**emory. There are all kinds of ROMs that we will discuss, or that you will read about. Some of the common ones are;

- **ROM**—read only memory
- **PROM**—programmable read only memory, Figures 1–12 and 1–13
- **EPROM**—electrically programmable read only memory
- **EEPROM**—electrically programmable, electrically erasable, read only memory.

You may be familiar with the PROM already. A PROM is the same thing as a ROM except that a PROM can be easily removed and replaced. If the PROM becomes inoperative, or if there is a new program for a particular system, then the PROM can be updated by replacing it. For several examples of PROMs, see Figure 1–14. With automobiles there always seems to be a need for a PROM change to improve the driveability of an engine, or to change the speed at which the torque convertor clutch should apply. Some of the PROMs in the new cars have a piece of Mylar tape across the top of them. This tape covers a window which is used to erase the information that is stored in the PROM. If that tape is removed, the transparent window can be seen, and through the window a micro-circuit is visible. When this circuit is exposed to ultra-violet light its memory is erased. Obviously, if you come across a

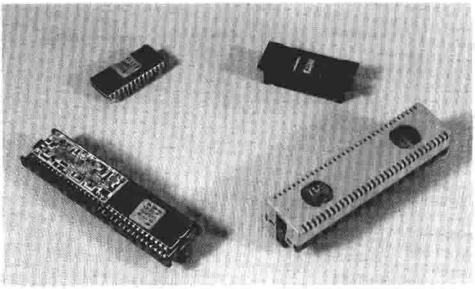


Figure 1–14. An assortment of PROMs

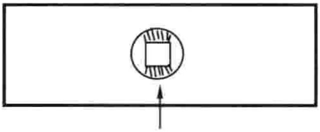


Figure 1–15. Window for erasing information in PROM that is normally covered with Mylar™ tape

PROM like this it would not be wise to take the patch off, because white light has some U-V in it and could partially destroy the program stored in the PROM. If you really must check one of these out, get a junk one to play with. Figure 1–15 shows this type of PROM.

Tip

Information systems on new cars, such as PROM updates, are available, but they are very expensive. If you can't afford or simply don't wish to purchase an information system for your garage, make sure that you can get in touch with someone who has one, so you can get the information from them as necessary. This will save you countless hours on most diagnosis.

Some companies offer a telephone information system for which you can buy a membership. This is a lot less expensive than buying a full system of your own.

EEPROMs are not used in very many cars. Mostly they are found in **BCMs (BODY COMPUTER MODULES)**, which would be found in the more expensive luxury automobiles. Body computers are similar to ECMs, except that their purpose is to control body functions, such as lighting, electronic dash, cruise control, etc. (Figure 1–16).

I might also mention that in the luxury cars equipped with BCMs, mileage, vehicle identification number, and options are also stored in the **EEPROM**. This is the only **PROM** in the car that carries a core charge because of the touchy information stored in it. As a matter of fact, when one of these is returned as defective, by Federal law it must be held in storage for a number of years.

PROMs vary in size and shape, but there are a few things that are common to them all. One is that they are to be handled only by their plastic carriers because **ELECTROSTATIC DISCHARGE (ESD)** will destroy one as quickly as installing one backwards, which is the second thing I was going to tell you

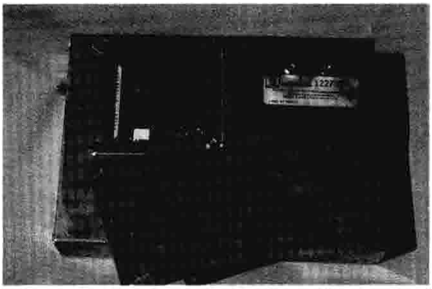


Figure 1-16. BCM—Body control module

to be careful not to do. If you are not sure of the correct way to install a PROM, then it is a good idea to take a good look at the one that you are taking out for reference. If it is too late, and you have already removed the original PROM, then look in the appropriate service manual for the correct installation. Placing a PROM into the ECM backwards will destroy it as soon as the ignition is turned on. Look at Figure 1-17 to see some typical PROMs and their carriers.

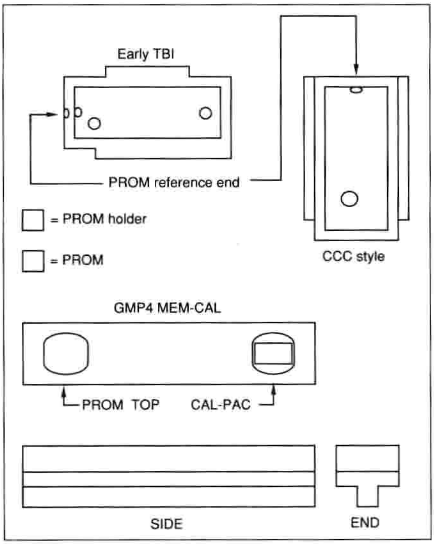


Figure 1-17. Different PROMs and their reference markings