Serial Data

Let's get something straight before we get started. Despite what you might have heard, serial data isn't packaged in a brightly colored cardboard box that has Michael Jordan's picture on the front. Now that we're sure what it isn't, let's try to understand what serial data is.

Serial data is the method an electronic control unit uses to receive information from its sensors and send commands to its outputs. To make a comparison to human communication, the ECU talks, listens, and interprets the world around itself using serial data.

Computers that are capable of using and understanding human speech are still very rare and expensive. So if we want to understand the information that an automotive ECU can tell us, we'll need to learn its language. Fortunately, learning the serial data language doesn't have to be as hard as getting through the first semester of French class back in junior high school.

Diagnostic scan tools have been available for several years for use on domestic cars. Once it's plugged into the car's diagnostic connector, a scanner acts as a translator between us and the ECU. The scanner takes the serial data contained in the ECU's "data stream" and translates it into simple English that we can all understand.

As import engine management systems have become more complex, some import manufacturers have also added serial data capability to their systems. With the right wiring harness adapters, we can tap a scanner into these systems to retrieve valuable diagnostic information.

Computer Communication

While you don't need to understand computer language to operate a diagnostic scanner, we thought a brief description of how computers use serial data to communicate might be helpful.

Bits

The smallest building block of all computer communication is called a bit. A bit in computer language is similar to the job handled by letters in our alphabet. But instead of 26 different letters to deal with, computers use the binary system. There are only two different kinds of bits. A bit is either a 0 or a 1.

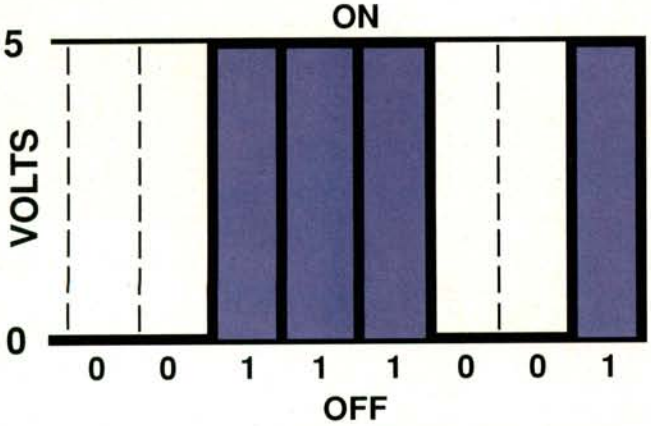
0 bit = voltage is not present
1 bit = voltage is present

0 bit = signal off or low (0.0 to 1.0 volts)
1 bit = signal on or high (4.0 to 5.0 volts)

Bytes

The ECU uses different combinations of 0 and 1 bits to make computer "words." These words are called bytes. In human language, words come in a variety of lengths and letter combinations. In computer language, a byte always contains exactly eight bits, no more and no less.

Different combinations of 0 and 1 bits allow for a wide variety of bytes. For example, a 00111001 byte might mean the coolant temperature is 182 degrees F. Changing just one bit would give the byte a whole different meaning.



Eight Bits Per Byte

Serial Data

In written communication, we understand what we read one letter at a time. We use capital letters, commas, periods, and other punctuation to divide up the words and to signal the beginning and end of sentences. Without these handy devices, all the words would run together on the page. There would be no way to find the beginning or end, and it would be very difficult to understand the meaning of the words.

Like written communication, computer data is also transmitted one bit at a time (in series). Computer communication also requires its own form of punctuation to keep all of the data from running together and to help the ECU sort out the beginning and end of bytes and data sentences.

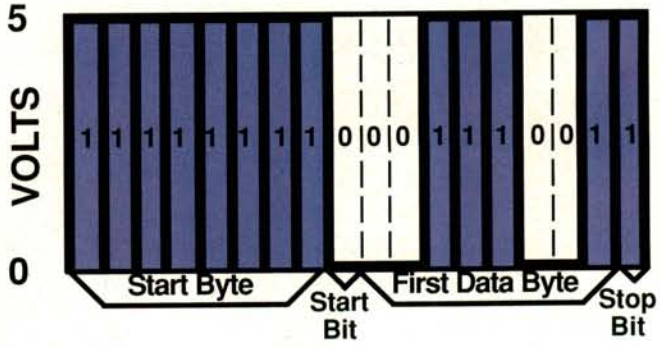
Each new sentence of serial data communication begins with something called a start byte. The start byte's only purpose is to help the ECU identify the beginning of the sentence and get ready for the serial data that will be coming up in the following bytes. The start byte is easily recognized by the ECU because it always contains the same combination of eight 1 bit signals.

Start Byte = Beginning of Serial Data Sentence

Depending on the complexity of the engine management system, there may be twenty or more separate bytes of information in the serial data sentence that follows the start byte. After the serial data sentence has been completed, the start byte is repeated and the next serial data sentence begins.

To separate the individual bytes of information in the serial data sentence, each byte is preceded and followed by a single start bit (0), and a single stop bit (1). The start and stop bits provide the spacing between bytes in data stream communication and keep all of the bytes in the serial data sentences from running together.

Start and Stop Bits = Spaces Between Words

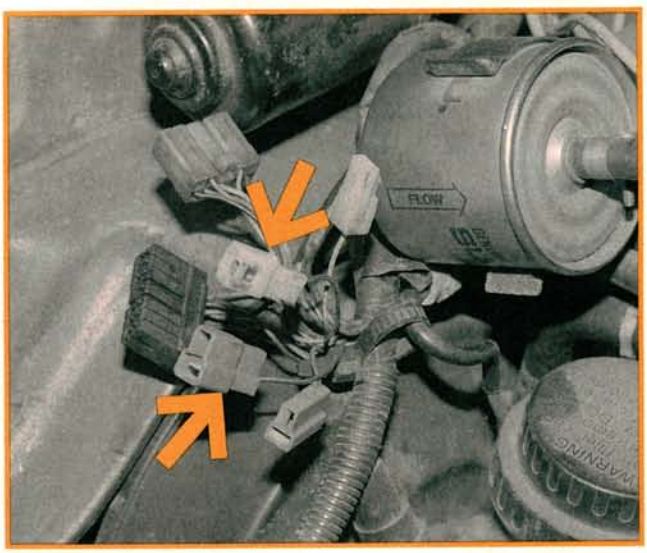


Serial Data Sequence

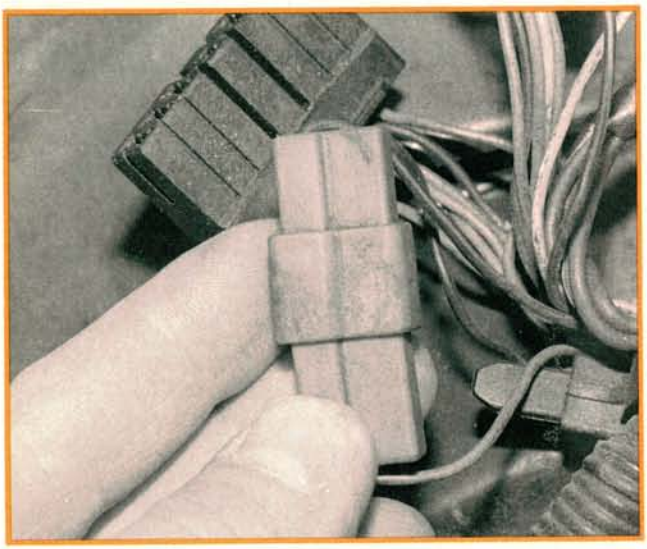
Plugging our scanner into the vehicle wiring harness allows us listen in on the ECU's serial data conversation. By listening for the start byte, the scanner also knows when the ECU is beginning a new sentence. Each time a new sentence ends, the scanner updates its data display to reflect any data changes that have taken place since the last serial data sentence ended. We can see the serial data updating process by watching the scanner's LCD screen. We'll demonstrate several diagnostic techniques using a scanner on a serial data Subaru in the following photo sequence.

DRIVEABILITY CLINIC

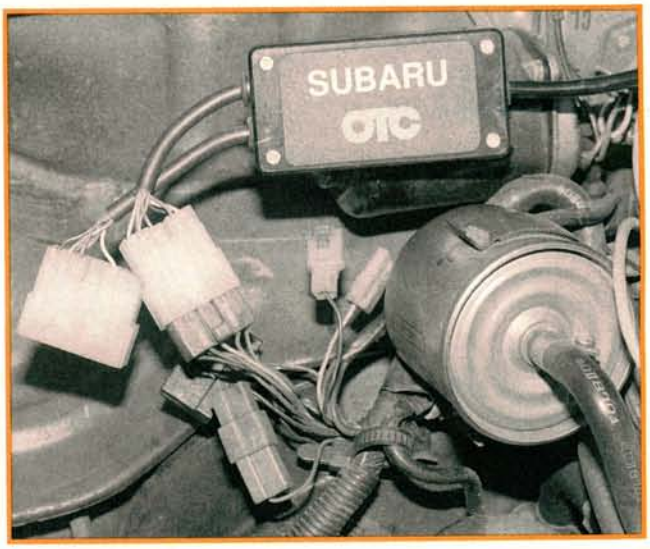
1 For years, the self diagnostic ability of many Japanese cars consisted of a Check Engine light. When the light came on, you knew there was a problem. The ECU might also include one or more diagnostic LEDs to retrieve trouble codes and measure oxygen sensor activity (arrow). Technicians with domestic car experience considered this absolutely primitive. But engine management system problems were few, and import technicians seldom missed the serial data diagnostics the domestic guys took for granted.



2 Late model import engine management systems are every bit as sophisticated as their domestic counterparts. Subaru was one of the first import manufacturers to add serial data output capability to their engine management systems to help technicians diagnose these more complicated systems. Oxygen sensor information and diagnostic trouble codes can still be retrieved by connecting or disconnecting the Read Memory and Test Mode connectors located under the hood (arrow).



3 The Subaru system has four separate diagnostic modes (U-Check, Read Memory, D-Check, and Clear Memory). The ECU can be run through the different modes by either connecting or disconnecting the Read Memory and Test Mode connectors. We uncover our first glitch on this 1989 GL while running through the modes. The Check Engine light won't light, although the bulb and wiring are good. The engine seems to run normally, but the ECU can't call for help if a problem does exist.



4 A scanner will give us a more complete look at the engine management system. Until standardized diagnostic connectors and locations become a reality, we'll have to deal with an assortment of jumper harnesses to adapt the scanner to different vehicles. Our Subaru diagnostic connector is located near the brake master cylinder, right next to the Test Mode and Read Memory connectors. Attach the scanner leads to the battery terminals for an uninterrupted power supply to the scanner.

5 Subaru dealer technicians use a dedicated scanner called a Select Monitor to retrieve data from the engine management, cruise control, automatic climate control, and air suspension systems. We'll be using the OTC Monitor 4000E. One cartridge lets the Monitor handle the engine management systems on ten different Japanese and Korean vehicle lines, as well as automatic transmission tests on some Toyota models. After hook up, we run through a short procedure to acquaint the scanner with our Subaru.

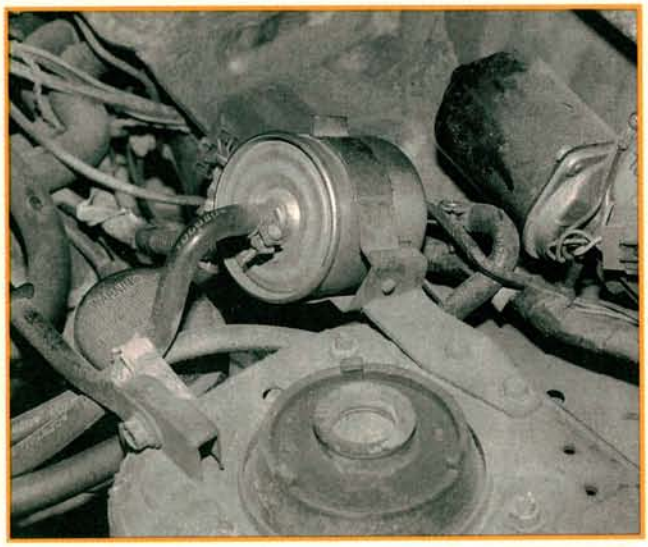
6 The ECU will set a trouble code if the sensor data it receives goes outside the limits that are programmed into the ECU's memory. The engine is running normally, but we'll check for stored codes just in case. Reading the scanner is faster than counting the LED flashes on the ECU. Two types of code storage are available. Hard codes signal a problem that exists right now. Stored codes are intermittent problems that cause a code number to be stored, but may not exist now. We have a clean slate.

7 As long as all sensors are operating within range, the ECU probably won't set a trouble code. But a sensor that is operating at the high or low end of its acceptable range may cause a driveability problem, without setting a code. This is where serial data comes in handy. In Standard Mode, we can scroll through all available data stream information, one or two sensors at a time. If you already know which part of the system is causing problems, select the Standard Mode that shows only the information you need.

8 Custom Display allows viewing of up to eight different data stream readings at the same time. The selection and placement of the eight data items can be changed to suit the problem being diagnosed. A wider range of data can also be selected to find intermittent problems. The scanner update rate for some sensors is slower than a DVOM reading taken directly from the wiring harness. With practice, you'll recognize abnormal data stream readings before the ECU has a chance to signal a trouble code.

9 Two important data stream readings indicate the ECU's response to its sensor inputs. Alpha readings reflects the ECU's efforts to control the air/fuel ratio and are based on oxygen sensor signals to the ECU. Alpha readings are expressed as positive or negative percentages. Readings above zero indicate the air/fuel ratio is trending toward a rich mixture. The ECU will lean the mixture until Alpha reaches zero. The opposite process occurs when the Alpha reading is negative.

10 Load Data is the second ECU data stream reading and may also serve as a marker for other problems. At idle speed, a normal Load Data reading for our Subaru should be 50 +/- 20. At 2500 RPM, Load Data should be 40 +/- 20. If Load Data is outside the allowable limits, check other data stream readings to find the source of the problem. Load Data is based on signals from the compressor clutch switch, transmission neutral switch, and other load inputs. Load Data also adjusts to account for changes in engine temperature.



11 Suppose the car runs poorly, but there are no trouble codes. An external factor may be causing the problem. Low fuel pressure caused by a clogged fuel filter or other restriction may be forcing the ECU to keep the injectors open longer to compensate. This may show up as an abnormal Alpha reading, but the oxygen sensor reading may not indicate a lean mixture. Keep records. After practice with the same type of car, you will be able to identify normal and abnormal serial data readings.

12 Intermittent problems may not show up while the car is sitting in the service bay. Using the extension cable, we can watch the scanner while an assistant drives the car. Customize the scanner to display the data stream information related to the problem. A portable printer (arrow) gives a written record of 13 different data items. Back at the shop, compare your readings to known good readings taken under similar driving conditions with a properly operating vehicle of the same type.