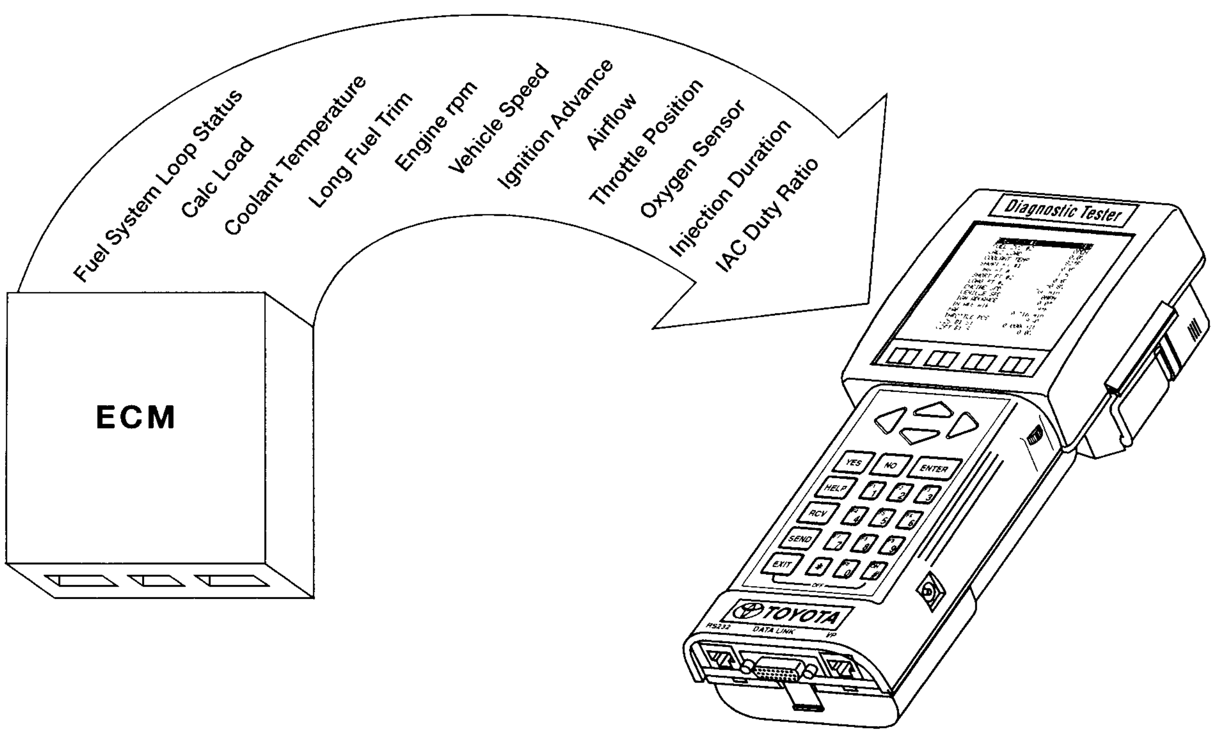
What is Serial Data?

Serial data is electronically coded information which is transmitted by one computer and received and displayed by another computer. Using an analog/digital circuit, the transmitting computer digitizes the data from sensors, actuators, and other calculated information. Typically, this means that each sensor or actuator value is converted into a one byte (8 bits) binary word before it is transmitted to the receiving computer.

In order to display the data in familiar units that you are used to working with, the receiving computer interprets each binary word as it is received and displays it as an analog voltage, temperature, speed, time, or other familiar unit of measurement.

Serial data gets its name from the fact that data parameters are transmitted, one after another, in series. The display on the receiving computer updates or refreshes once each data cycle, after all data has been received. Therefore the refresh rate of the data is determined by how many words are on the data stream and how quickly the data is transmitted.

The data transmission rate is referred to as the **baud** rate. Baud rate refers to the number of data bits that can be transmitted per second. For example, if a data stream has 12 parameters, and each parameter is converted into an 8 bit data word, the total size of the data transmission is 96 bits of data (12 words x 8 bits per word.) If this data can be transmitted once every second, the baud rate is 96 bits/second or 96 baud. In this case, the display screen will refresh data values once every second.

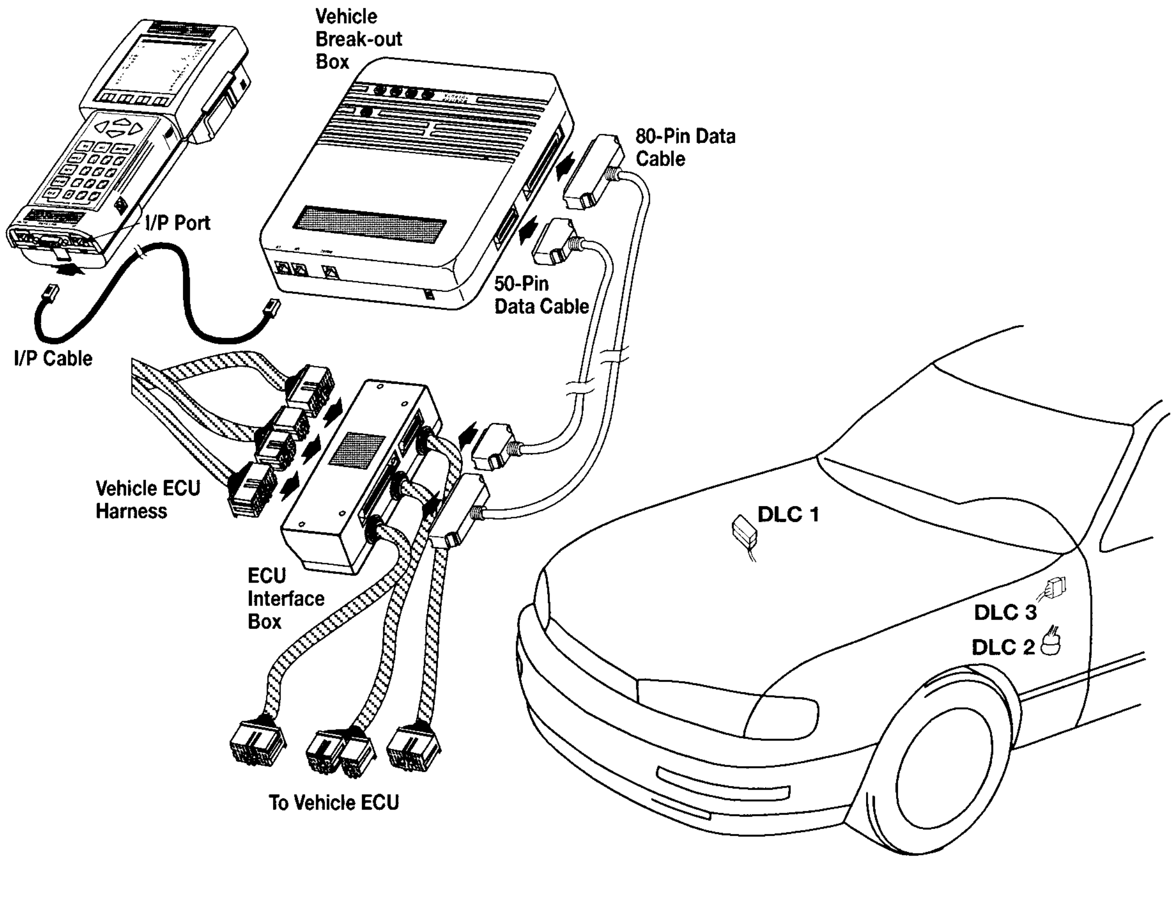


In the case of Toyota engine control systems, there are three different types of serial data which can be received and displayed by your Diagnostic Tester, depending on application. These are OBD, OBD-II, and V-BoB. In all three cases, data is digitized by the transmitting computer (ECM or V-BoB) and displayed by the Diagnostic Tester. The main difference between these three data sources are the specific parameters available on the data stream and the speed at which data can be transmitted and refreshed on the Diagnostic Tester display.

Serial Data Sources

Serial data can be received through one of the Diagnostic Link Connectors (DLC), or on applications which do not support serial data, from the Vehicle Break-out Box.

Fig. 5-2



Displaying Engine Data

The type of serial data available depends on the vehicle you are working on. Many Toyota vehicles with OBD, manufactured since 1989, have a serial data stream available on the VF1 terminal of DLC 1 (Check connector) or the ENG terminal of DLC 2 (TDCL).

Vehicles which support a serial data stream can be identified by the presence of a TE2 circuit (see the application matrix on page 86 of this handbook). Depending on the vehicle, there can be as many as 20 different sensor, actuator, and diagnostic data parameters represented on the OBD data stream.

The OBD-II system, which phased in during the 1994 through 1996 model years, has a high speed data stream available on terminal 2 of DLC 3 01962 connector). There are in excess of 50 data parameters represented on the OBD-II engine data stream.

Accessing serial data on any of these vehicles is a simple matter using the Diagnostic Tester.

Typical Serial Data Parameters

There are as many as 20 data parameters on the OBD data stream and more than 50 with Enhanced OBD-II

Fig. 5-3

OBD Data List

INJECTOR	5.8ms
IGNITION	22°CA
IAC STEP#	53
ENGINE SPD	1825rpm
VAF	1.28V
ECT	194°F
THROTTLE	7°
VEHICLE SPD	45MPH
TARGET A/F L	1.25V
TARGET A/F R	1.25V
A/F FB LEFT	ON
KNOCK RETARD	ON
A/F FB RIGHT	ON
STA SIGNAL	OFF
CTP SIGNAL	OFF
A/C SIGNAL	OFF

OBD-II Data List

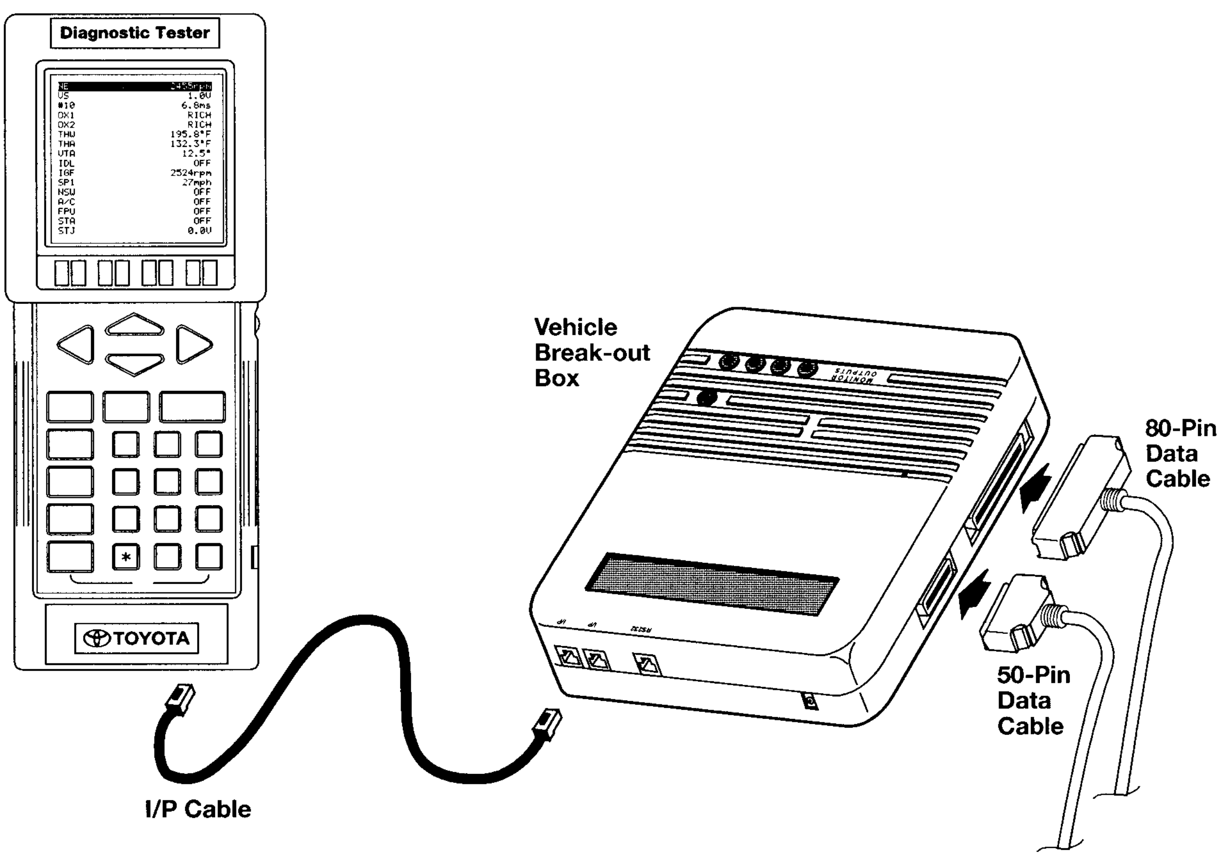
FUEL SYS #1	OPEN
FUEL SYS #2	OPEN
CALC LOAD	0.0%
COOLANT TEMP	82°F
SHORT FT #1	0.0%
LONG FT #1	1.5%
SHORT FT #2	0.0%
LONG FT #2	-0.8%
ENGINE SPD	76r/min
VEHICLE SPD	0MPH
IGN ADVANCE	0.0°
INTAKE AIR	79°F
MAF	0.7lb/min
THROTTLE POS	9.4%
O2S B1,S1	0.000volt
O2FT B1,S1	0.0%

For 1989 and later models which do not support serial data streams, the Vehicle Break-out Box gives you the ability to create one. By connecting the V-BoB in series with the ECM, information from every wire can be serialized and displayed by the Diagnostic Tester. Although it takes a little bit longer to install the V-BoB, the unlimited amount of high speed data makes the effort well worth the time invested.

Making a Serial Data Stream

Using the V-BoB, you can make a serial data stream capable of displaying every wire connected to the ECM.

Fig. 5-4



The OBD Diagnostic Circuit

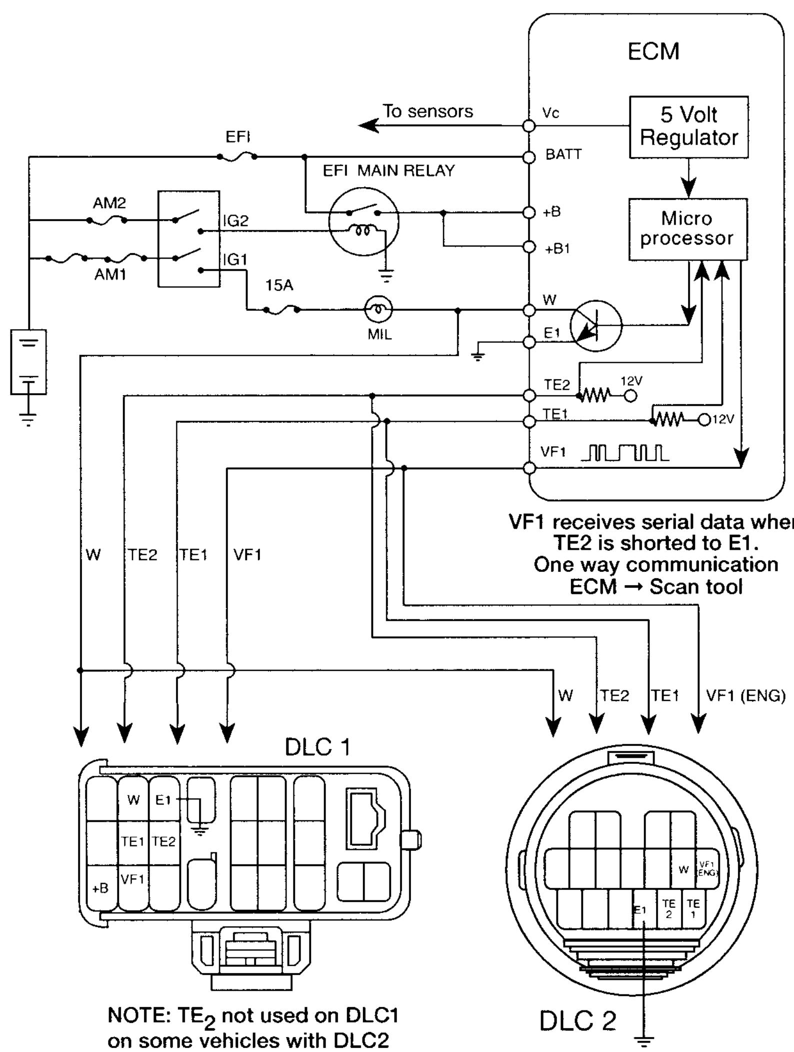
This unidirectional data stream typically consists of 14 to 20 data words representing primarily sensor inputs and three outputs; injection pulse width, spark advance angle, and idle speed control command. Data is transmitted at a rate of 100 baud, updating on the Diagnostic Tester display approximately once every 1.25 seconds. Depending on application, the data is accessed from either DLC 1 or DLC 2. Data is triggered by grounding the TE2 circuit and reading the VF1 circuit.

Diagnostic Trouble Codes can be displayed using the Diagnostic Tester or by grounding the TE1 circuit and counting the Malfunction Indicator Lamp (MIL) flashes. The scan tool reads codes by counting the low voltage pulses on the W terminal of the Diagnostic Link Connector (DLC). Therefore, code retrieval is a relatively slow process, especially when multiple codes are stored.

OBD Diagnostic Circuit

The OBD diagnostic circuit is triggered by grounding the TE1 or TE2 circuits. With TE1 grounded, diagnostic trouble codes are transmitted on the W circuit. With TE2 grounded, serial data is transmitted on the VF1 (ENG) circuit.

Fig. 5-5



The OBD-II Diagnostic Circuit

The OBD-II data line is a bi-directional communication link which is capable of transmitting and receiving data. This feature allows the Diagnostic Tester to operate system actuators and send commands to the ECM in addition to displaying system data.

The high speed OBD-II data stream typically consists of 50 to 75 data words representing virtually all sensor inputs, actuator outputs, several calculated parameters, many fuel feedback related parameters, and cylinder misfire data. The data is transmitted at a rate of 10.4 Kilo baud, giving the Diagnostic Tester a display refresh rate capability of approximately once every 200 milliseconds.

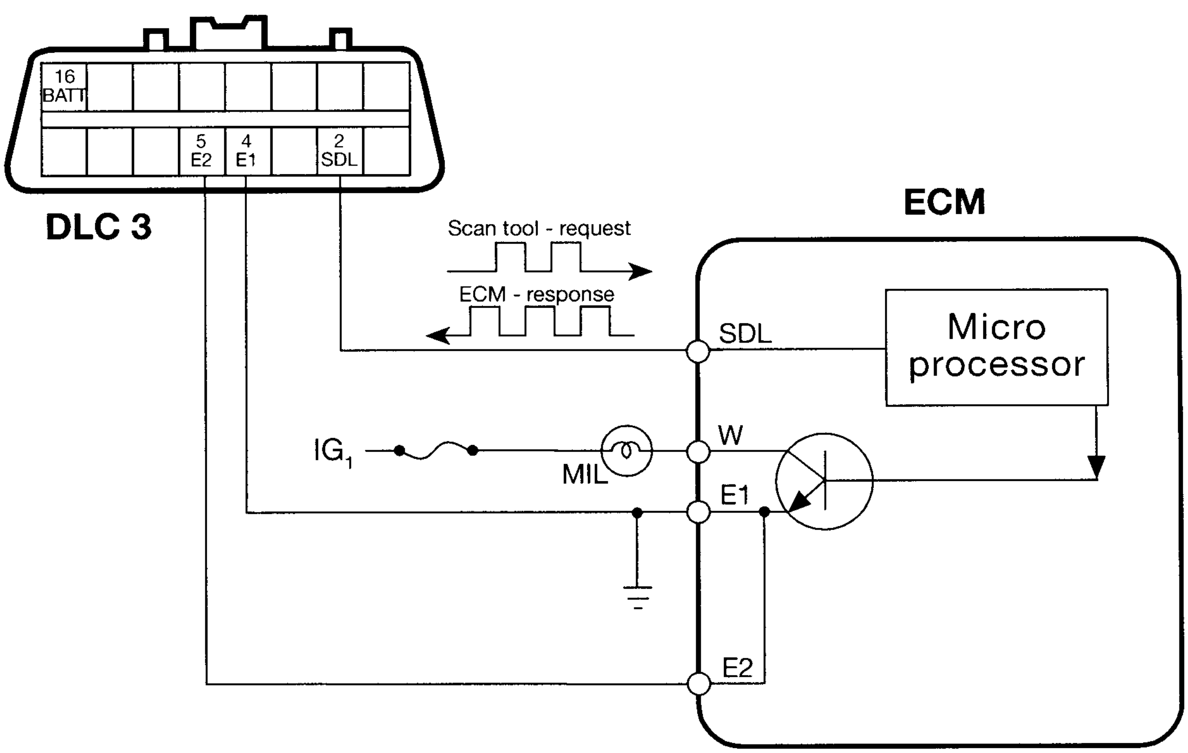
Data is accessed from DLC 3, terminal 2. It is triggered by a communication signal generated by the Diagnostic Tester when any OBD-II function has been selected.

On OBD-Il vehicles, the scan tool reads DTCs directly from the serial data stream, therefore, codes are displayed almost instantly. Codes can only be retrieved and displayed using the Diagnostic Tester or an equivalent J1978 scan tool.

The OBD-II Diagnostic Circuit

The OBD-II diagnostic circuit is triggered by signals from the diagnostic tester. When an OBD-II function is selected, a Variable Pulse Width (VPW) signal is transmitted to the ECM on the SDL terminal of DLC 3. This establishes two way communications between the ECM and the scan tool. Once communication is established, time is shared between the two devices, communication going from scan tool to ECM for a specified amount of time, then communication from ECM to scan tool.

Fig. 5-18



SDL receives serial data when request is transmitted by scan tool.
Two way communication on SDL bus line.
ECM ⇔ Scan Tool

Uses and Limitations of Scan Tool Serial Data for Diagnosis

A scan tool is an exceptionally useful tool when diagnosing engine control system problems. It gives you access to vast quantities of information from a conveniently located diagnostic connector.

- A scan tool allows a "quick check" of sensors, actuators, and ECM calculated data. For example, when checking for sensor signals which may be shifted out of normal range, scan data allows you to quickly compare selected data to repair manual specifications or known good vehicle data.

- When checking for intermittent fault conditions, it provides an easy way to monitor input signals while wiring or components are manipulated, heated, and cooled.

There are, however, several important limitations you need to consider when attempting to diagnose certain types of problems using serial data.

- Serial data is processed information rather than a live signal. It represents what the ECM "thinks" it is seeing rather than the actual signal which would be measured at the ECM terminal. Serial data can also reflect a signal value the ECM has defaulted to, rather than the actual signal.

For example, with OBD, the Engine Coolant Temperature sensor data displayed with an open circuit is the failsafe value of 176’F. If the actual voltage was measured at the THW terminal of the ECM, it would be 5 volts, equivalent to -40'F.

In the case of output commands, serial data represents the calculated output, not necessarily what the circuit driver is doing. For example, when cranking an engine which is in fuel cut failsafe (due to an open IGf line), calculated injection pulse is displayed on serial data even though the injector driver is not being operated.

Knowing the Limitations of the Scan Tool

Sometimes data interpretation requires you to recognize subtle differences between "normal" and "abnormal" data. Can you pick the data stream displaying the open Engine Coolant Temperature sensor?

Fig. 5-38

INJECTOR	2.1ms
IGNITION	42°CA
ISC STEP#	68
ENGINE SPD	2000rpm
AIRFLOW	2.18V
COOLANT	176°F
THROTTLE	0°
VEHICLE SPD	57MPH
TARGET A/F L	1.25V
TARGET A/F R	0.00V
A/F FB LEFT	OFF
KNOCK RETARD	OFF

FUEL SYS #1	CLOSED
FUEL SYS #2	CLOSED
CALC LOAD	37.2%
COOLANT TEMP	185°F
SHORT FT #1	-3.1%
LONG FT #1	-2.4%
SHORT FT #2	0.7%
LONG FT #2	2.2%
ENGINE SPD	1648r/min
VEHICLE SPD	31MPH
IGN ADVANCE	31.5°
INTAKE AIR	75°F

Using serial data to troubleshoot intermittent problems also has its limitations because of data transmission speed.

When the data refresh rate is slow, as it is with slower baud rate data streams, it is easy to miss changes which occur in a signal between display updates. As a result, intermittent signal problems are often not detected on a slow serial data stream.

For example, a Throttle Position Sensor signal wire that goes open circuit every time the vehicle drives over a bump. If the open condition does not last for at least 1.25 seconds, there is a good possibility that the change in signal value will go undetected by your scan tool.

When troubleshooting intermittent problems on vehicles without high speed serial data (like Enhanced OBD-II), it is much better to use serial data generated by V-BoB than to use the OBD serial data. It takes more time to connect V-BoB to the ECM, but if an intermittent problem occurs, the high speed serial data generated by V-BoB will catch the fault.

Given this information, it is clear that care must be exercised when interpreting serial data and using it to make diagnostic decisions. Once you are familiar with irregularities like these, the risk of diagnostic error is significantly reduced.

