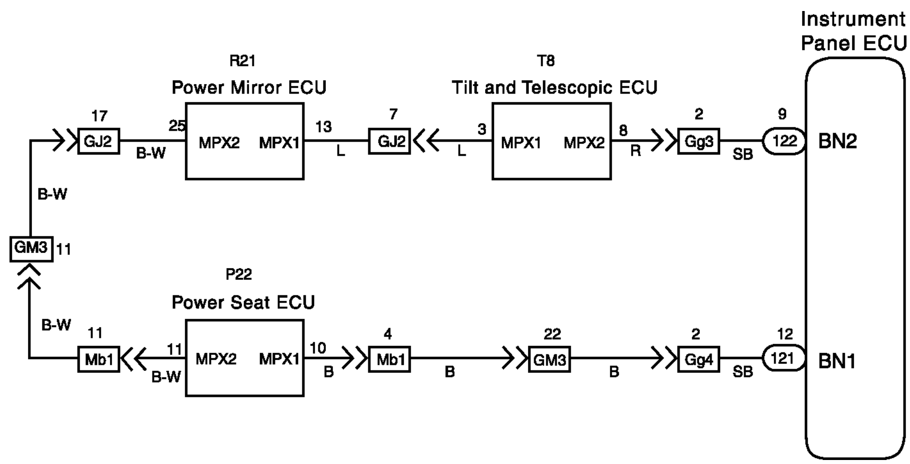
Section 6

General Development of Multiplexing



Learning Objectives:

1. To review the development of automotive multiplexing.
2. To discuss the application of multiplexing systems.
3. To correctly use the Hand-held tester to retrieve codes and access Freeze Frame Data.
4. To effectively use the Active Test Mode using the Hand-held tester.

Notes

Multiplexing

In-vehicle networking involving time division is also known as multiplexing. It is a method for transferring data among distributed electronic modules via a serial data bus. Serial data is electronically coded information which is transmitted by one computer and received and displayed by another computer. The term serial ***data*** implies that the information is digitally coded and transmitted in a series of data words.

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.

Transmission of Data and Rates

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. 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.

Without serial networking, inter-module communication requires dedicated, point-to-point wiring resulting in bulky, expensive, complex, and difficult to install wiring harnesses. Applying a serial data bus reduces the number of wires by combining the signals on a single wire through time division multiplexing. Information is sent to individual control modules that control each function, such as anti-lock braking, turn signals, power windows, dashboard displays, and audio systems.

Advances and Standards

In-vehicle networking provides system-level benefits, many of which are only beginning to be realized:

- A decreased number of dedicated wires is required for each function, and thus reduces the size of the wiring harness. System cost, weight, reliability, serviceability, and installation are improved.
- Common sensor data, such as vehicle speed, engine temperature, etc. are available on the network, so data can be shared, thus eliminating the need for redundant sensors.

- Networking allows greater vehicle content flexibility because functions can be added through software changes. Existing systems require an additional module or additional I/O pins for each function added.
- Car manufacturers are discovering new features that are enabled by networking. For example, multiplexing allows driver's preference for such things as ride firmness, seat positions, steering assist effort, mirror positions, and radio station presets.

Recently, there have been efforts to standardize protocols at the data link and physical layers. Systems designers are also seeing the benefits of standardized application layer protocols. Multiplexing Standards are also appearing in automotive applications. Examples include: SAE J1939, OSEK from the German automotive consortium, SDS from Honeywell, and DeviceNet from Allen-Bradley. These standards allow system designers to avoid low-level protocol details and focus on the application itself. However, the impact of this type of standardization is increased demand on the microcontrollers and protocol devices; and thus the need for efficient message handling and standardized protocol.

Typical Multiplexing System

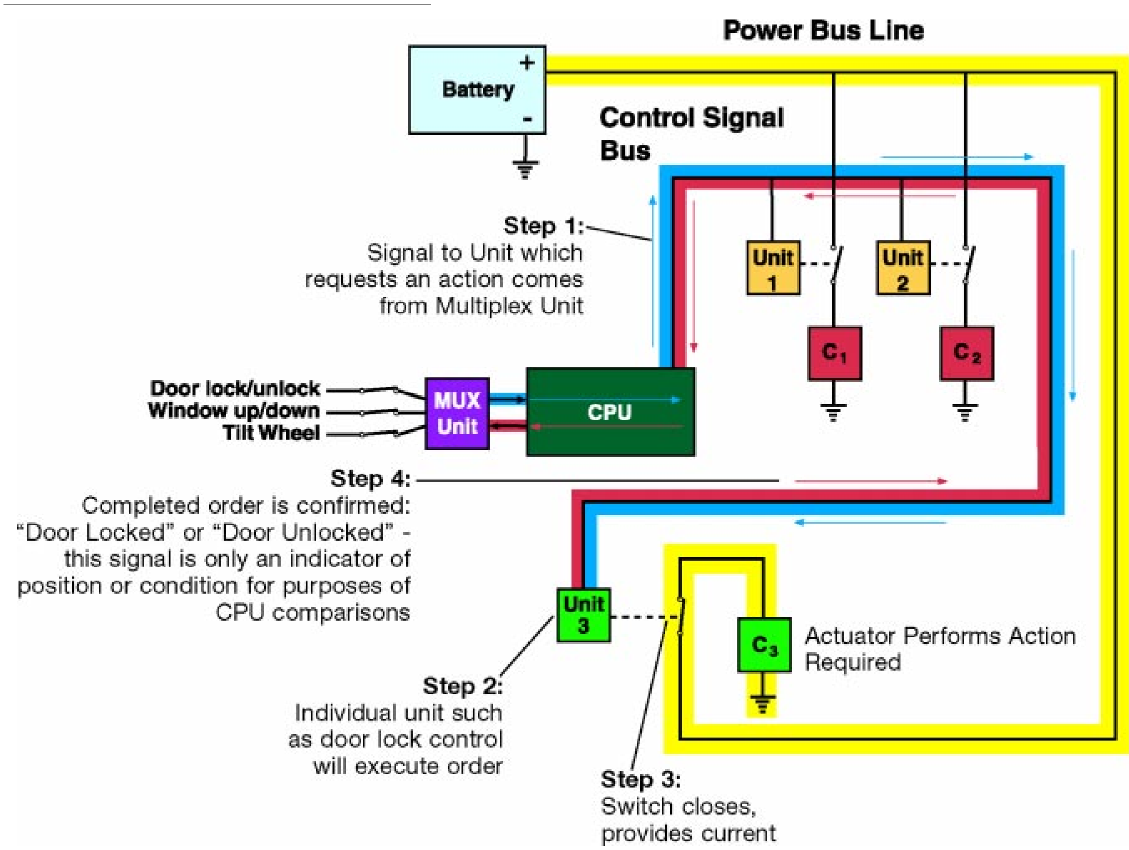


Fig. 6-1
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Early Designs

The early days of networking involved proprietary serial buses using generic UART (Universal Asynchronous Receiver/Transmitter) or custom devices. This type of networking was acceptable in the United States because the Big Three (Ford, GM, Chrysler) were vertically integrated and were not highly dependent on external suppliers.

However, in Europe and increasingly now in the U.S.A., car manufacturers utilize many external suppliers. Proprietary protocols pose many difficulties with suppliers who need many special system designs to conform to the different protocols. Standard protocols allow modules from many suppliers to easily link together forming a type of "open architecture." An open architecture will allow standardized diagnostic and emissions testers and will allow suppliers to benefit from economies of scale of mass-produced standard protocol devices.

These facts help to explain why diagnostics and systems designs were not widely published in many repair manuals or other forms of literature published by automotive manufacturers. Since the advent of standards the information regarding these multiplexing systems has become increasingly more accessible.

SAE Classifications/ Speeds

Class A

- Low Speed (<10 kbps [kilobits/second])
- Convenience features (entertainment, audio, trip computer, etc.)

Class B

- Medium Speed (10 kbps to 125 kbps)
- General information transfer (instrument cluster, vehicle speed, emissions data, etc.)

Class C

- High Speed (125 kbps to 1 Mbps [Megabits per second] or greater)
- Real-time control (powertrain control, vehicle dynamics, brake by wire)

Wiring Diagram for a Typical Class B Multiplex System

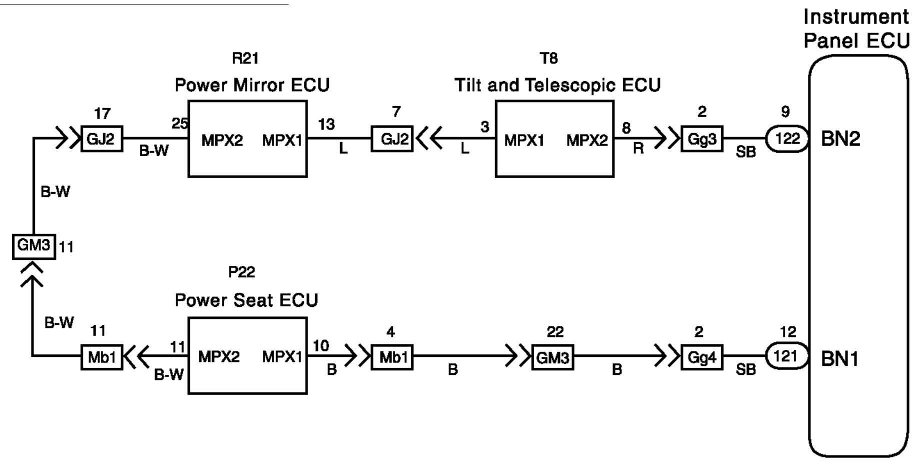

Fig. 6-2
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Lexus systems such as the one pictured here it is possible to view the signal transmissions to and from the control unit along the data links with an oscilloscope. Assuming that the scope is set at the appropriate capture rate the signal pattern will be displayed. Unfortunately, without signal printouts and engineering specifications these scope patterns cannot be fully analyzed. This type of diagnosis does tell the technician that communication is occurring. What it does not reveal is the nature of the communication or its accuracy. Nevertheless, it can be valuable when tracing the presence of a signal along a specific pathway—connector to connector. The first line of diagnostics when dealing with Lexus multiplexing must be the verification, the Repair Manual, and the Diagnostic Tester. Anything less is simply guess work.

Diagnostic Trouble Codes include SAE controlled codes and manufacturer controlled codes. SAE controlled codes must be set as prescribed by the SAE, while manufacturer controlled codes can be set freely by the manufacturer within the prescribed limits. There is also a check mode for technicians to simulate malfunction symptoms and to troubleshoot. Basically, the Body ECU monitors the communication within the network and triggers a code when there is an interruption in communication, a +B short, or a GND short.

Using the Lexus Diagnostic Tester

The use of the Lexus Diagnostic Tester for the diagnosis of multiplexing DTCs is explained in detail in the Repair Manual. As these systems evolve, changes occur from model year to model year. In order to avoid unnecessary repairs and loss of valuable shop time, it is very important that the technician read and understand the repair manual instructions for a particular model and year.

Example: In the 1998 LX 470 Repair Manual it is noted during the Pre-Check instructions that unless the Body ECU is functioning normally there is the “possibility” the diagnosis for other units will not be accurate. Also, there are conditions under which an accurate DTC will not be given even though the Body ECU is normal.

Next, there is a procedure for checking the Body ECU/CPU in order to determine whether or not it is working properly. It involves confirming the operation of the Body ECU and the Open Door Indicator. This procedure falls under the heading of “Basic Inspection”. The important thing to keep in mind is that unless you can be sure that the ECU responsible for diagnostics is functioning properly, all other information may not be of value. There are also certain malfunction configurations where a DTC will not be detected.

Pre-Check

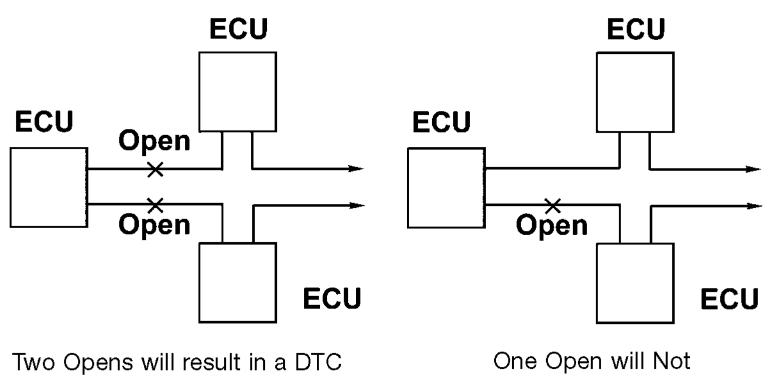

Fig. 6-3
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Circuit Operation

There are several layers of operation to consider when troubleshooting a Lexus multiplexing system. Let's take a look at the construction of a system. Keep in mind that these systems are very sensitive to electronic variables within the environment. Furthermore, we have mechanical operation of various components and these too can cause problems for the system. Take a look at a typical Tilt/Telescopic Switch. In this case it comes from an LX 470.

Now that the ECU has the signal from the switch it executes a command to the Telescopic motor. In this example, the command is "Contract". Remember, all positions of components (motors, switches) are known to the Instrument ECU. This memory function is one of the wonders of multiplexing; but it is also one of the potential problems. Why? Because all signals, confirmations, positions, ON/OFF settings must travel through the communication lines in order to make adjustments. If there are any breakdowns along these lines then the system will not function properly. Also, bear in mind that any "out of range" transmissions can be misinterpreted and the result will be a DTC, a malfunction, or an inoperative condition. Look at the following diagram as the ECU interacts with the motor in the Telescopic circuit.

Keep in mind that the procedures for diagnosing these systems may vary from year to year and from model to model. Once again, the diagnosis of any multiplex system should not be attempted without the Repair Manual in hand.

Circuit Operation Control and DTCs

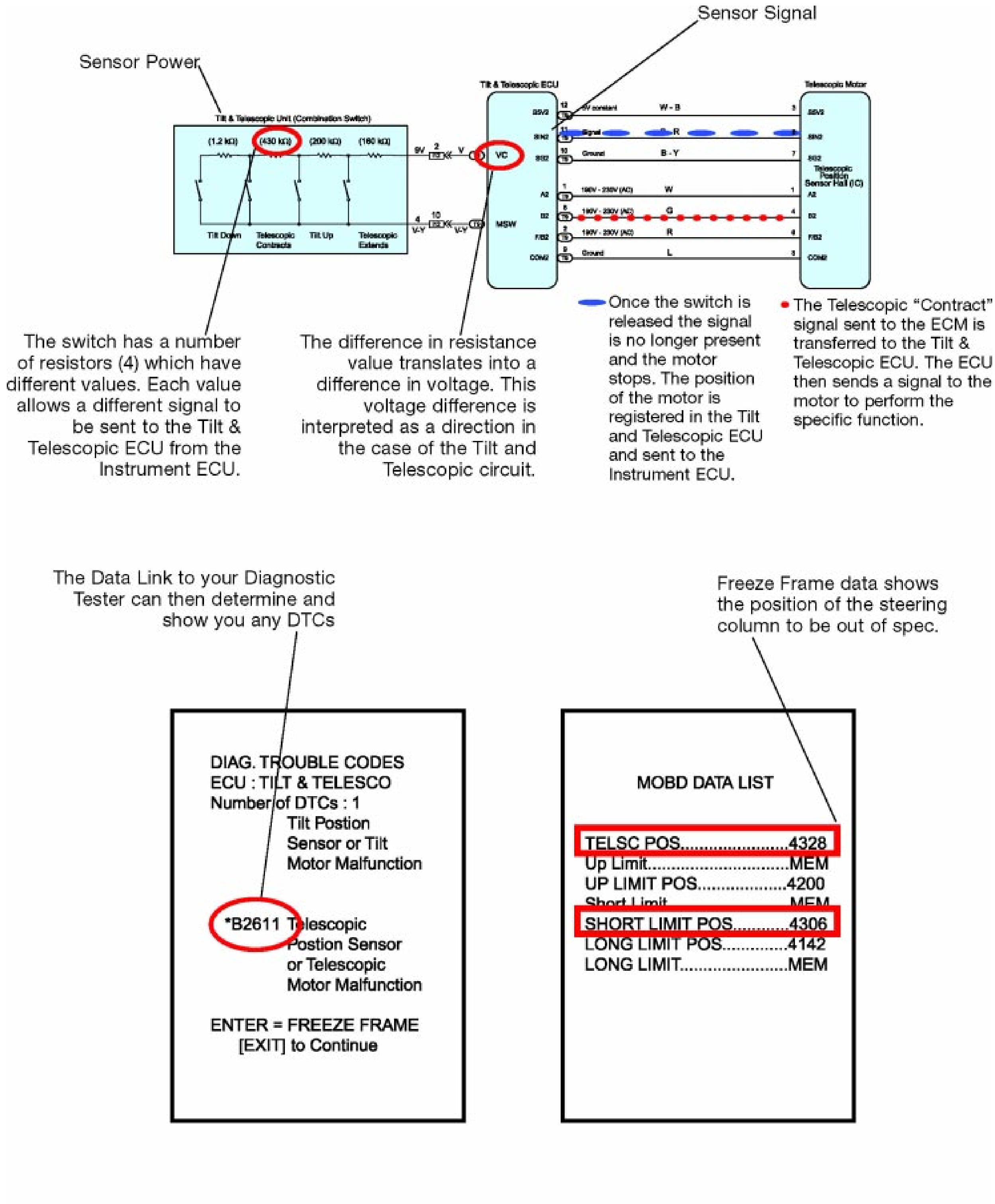

Fig. 6-4
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Multiplexing Communication Bus

1998 LX 470 EWD p. 136

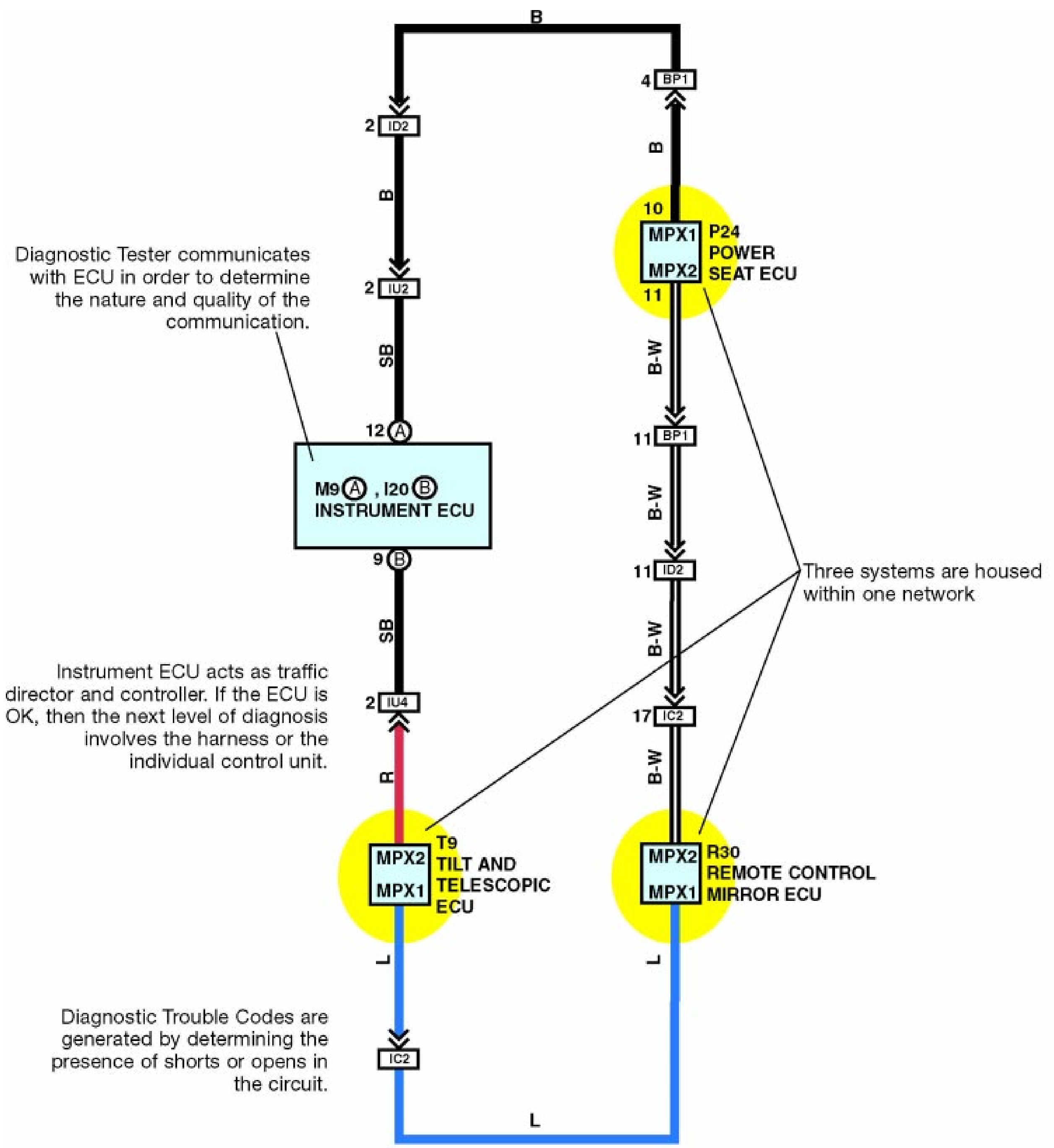

Fig. 6-5
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Using the Diagnostic Tester

Although the theory of multiplexing is important to diagnostics, it is just as important to understand the use of the hardware and software designed to assist in the diagnosis of the various systems. The most critical tool you have for evaluating the newest Lexus vehicles and the on-board multiplexing system is the Diagnostic Tester. You are already familiar with the basic operation of this tool. Our next level of diagnostics includes the "Active Test" mode which allows us to judge the operation or non-operation of certain components. It is through these procedures that we are able to make judgements about the system in question and begin to move toward a diagnosis which will ultimately repair the car.

Diagnostic Tester and Cables

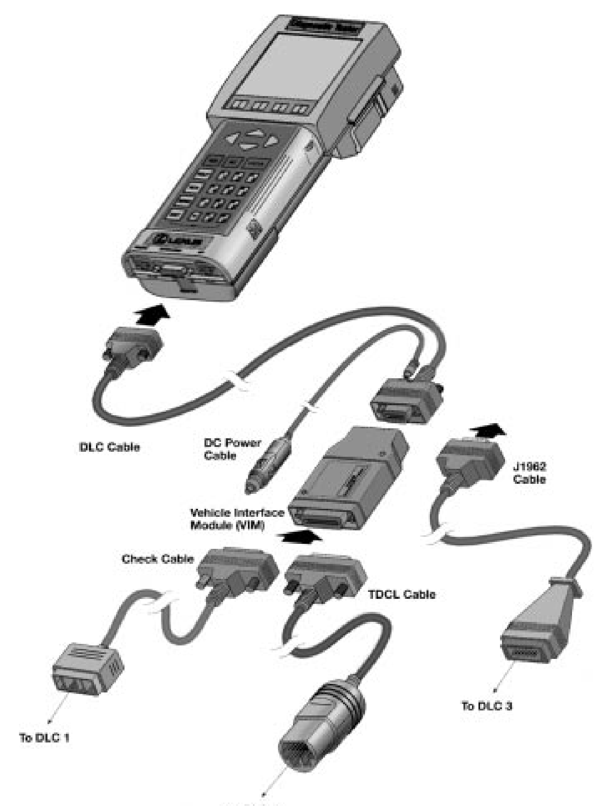

Fig. 6-6
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The Complaint

The first step in diagnosing the complaint involves verifying that the system is exhibiting the stated complaint. It is important that you are able to duplicate the same condition that the customer experiences when they operate the system.

DTCs

Remember that all of the systems in a multiplexing circuit are in one way or another connected to the central control unit. This central control unit (Body ECU) may be called by different names but it is essentially the "brains" of the operation. Every other control unit is involved in one of three basic things: they are receiving orders, executing orders, or delivering status reports. When any of these three things fails to occur there is a likelihood that a DTC will be set. You have already seen what is required to set a DTC (two opens, +B Short, Ground short) which shows that a particular ECU has been isolated from the main control unit. Its pathway of communication or power has been broken; it is now isolated. The bottom line is that we are back to basics. A connector is loose, a wiring harness has been cut, or a component has an internal failure. Let's go through a step by step look at what we might expect to see when we are faced with a diagnostic problem.

System Check

First, we need to make certain that we have communication with the central processing unit. There will be a procedure in the Repair Manual for checking this operation and currently that procedure involves turning on the windshield wipers in the INT mode. If the wipers function normally then we have communication with the control unit. This procedure can change from year to year and model to model. Second, we need to open a door to see if the "Door Open" indicator light turns on.

If the light turns on, then we have confirmed that trouble codes can be output to our Diagnostic Tester.

System Check

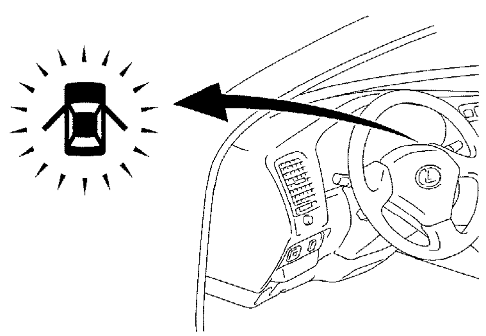

Fig. 6-7
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Accessing the Multiplex System

The next step is to hook up the scan tool and go to the OBD/MOBD selection menu. You will notice that there are several areas which you can test and there are more selections visible beyond the first screen.

OBD/MOBD Menu

Screen 1

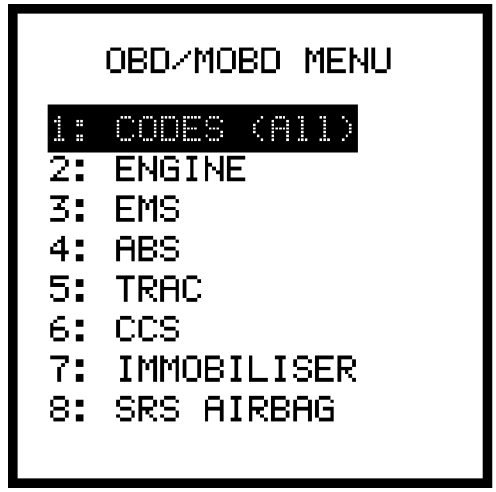

Fig. 6-8
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Single System Check You will need to scroll down to the system description and the item you wish to check. For this example let's look at Tilt and Telescopic.

OBD/MOBD Menu

Screen 2

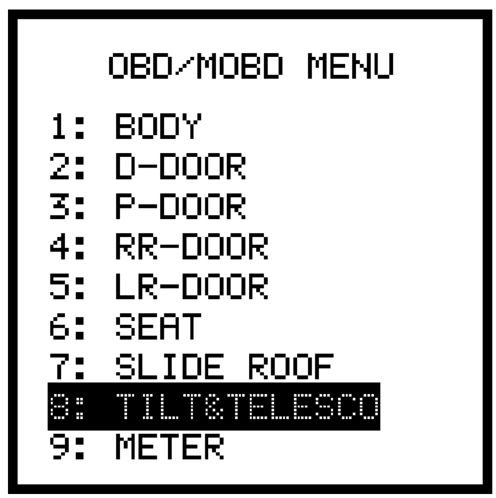

Fig. 6-9
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Gathering Evidence From this menu we are taken to the actual values which are found within the Tilt and Telescopic system. Notice that the Tilt Position is 4136 and the Telescopic "TELSC" Position is 4270. In the example you saw earlier there was a difference between the Actual" and the "Position Limit". Knowing that this difference existed gives a clue that there is a problem in the control unit or the mechanism itself. It is extremely unlikely that it is a harness or connector problem.

Tilt & Telescopic Data

Fig. 6-10
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Choosing the Right Items for the List

By using these kinds of tests we begin to gather data about the condition we are trying to diagnose. On the one hand, we are looking at the codes which may or may not be set in a system; on the other hand, we are looking at values which may or may not be correct in a given group of output values. The values below were selected from the data list available. There would be no point in looking at everything. Select only what is necessary.

Freeze Frame Data

Telescopic Position should not be greater than Short Limit Position

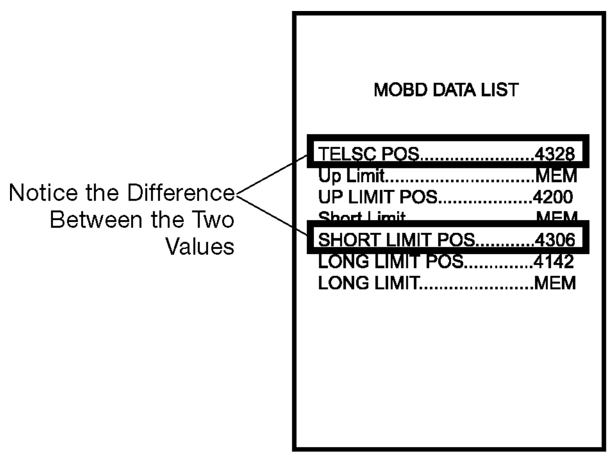

Fig. 6-11
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Thinking It Through

Remember this example? The position of the telescopic wheel is beyond the "Short Limit Position". Therefore, it is out of specifications. The difficult part of this diagnosis is making the comparison between these things and determining what each value stands for from available information. If we follow a logical pathway in the diagnosis of this condition we might conclude that there is something internal to the telescopic motor which is causing it to travel too far. This additional travel may give rise to a host of other problems within the system. It may lead to an inability to set a memory position. Also, we might see that the return to rest is not where it was previously. There are many possibilities. What is a good bet is that given these values, the replacement of the Tilt and Telescopic Motor assembly may resolve the problem.

The key to this type of diagnosis is patience above all. There are a number of things going on at the same time. A close reading of the repair manual and supplemental material is critical. Finally, you must be prepared to spend time with the car and use the diagnostic scan tool carefully and deliberately. In the work we will do in the shop, we are only going to focus on becoming familiar with the Diagnostic Tester so that we can move from system to system and view the various inputs and outputs. The subject of more advanced diagnostics will be covered later in a more detailed course. For now, learn to use the Diagnostic Tester to enter into the multiplexing systems and take a look around. You will find that this new area of electronic testing may be easier than you thought.

Diagnostic Tester Help

On some screens *Help will show important parameter information. If there is some doubt about the value you see on the screen, press *Help to see whether or not there is additional information.

Finally, another reference book you should have close by is the *Diagnostic Tester Operator's Manual*. This publication lists all the functions on the scantool and has many other useful hints.

Diagnostic Tester Operator's Manual

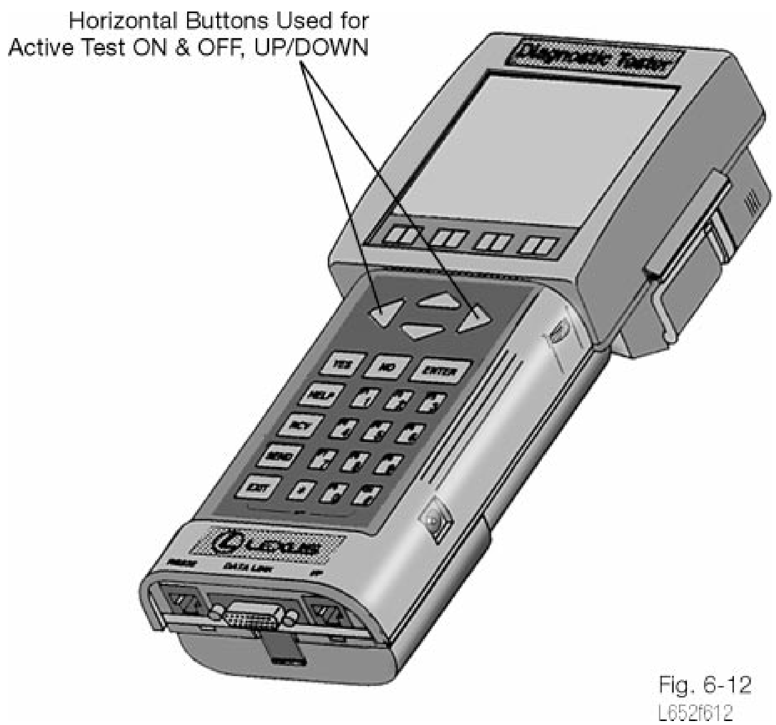

Fig. 6-12
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Active Keys

ACTIVE KEYS

△▽	Move the cursor (highlight) up and down.
(YES)	Changes the highlighted parameter to the next parameter in the list.
(NO)	Changes the highlighted parameter to the previous parameter in the list.
(✱)(YES)	Changes to the next parameter not currently displayed.
(✱)(NO)	Changes to the previous parameter not currently displayed.
(F1)	Go to <DATA LIST> mode.
(F3)	Go to <BAR GRAPH> mode.
(F4)	Go to <LINE GRAPH> mode.
(F5)	Go to <CUSTOM LIST> mode.
(F6)	Setup <STRIP CHART> mode.
(F9)	Changes between large and compressed character size.
(F0)	Turn cursor on and off.
(#)(F8)	Start Strip Chart.
(#)(F9)	Stop Strip Chart.
(✱)(HELP)	Display parameter information.
(SEND)	Print data list.

Fig. 6-13
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