Multiplexed Control System Harness

On current production vehicles, the major control modules connect to one of two multiplex electrical circuits. One multiplex circuit (CAN network) typically provides communication between the power train system modules. The second multiplex circuit (SCP network) typically provides communication between the body systems control modules. Both networks connect to the major instrument cluster (INST), which allows communication of certain data between the CAN and SCP networks.

CAN Powertrain Multiplex Harness

The control modules for the engine, transmission and braking systems connect to each other with a two wire "twisted pair" multiplex circuit. The multiplex circuit allows the control modules to share data and systems control responsibility via "real time" high speed data communication. Sensors "owned" by each module and components directly controlled by the module connect with conventional "hard wired" circuits.

SCP Body Systems Multiplex Harness

The vehicle body systems control modules are similarly connected, utilizing a separate "twisted pair" multiplex circuit allowing the modules to share data and zoned component control responsibilities via multiplex data communication.

D2B Harness

The D2B Network harness is comprised of a 3.5 mm (0.138 in.) diameter Black Optical Fiber (BOF), plastic tubing internally lined with a 1 mm (0.039 in.) polymer fiber core. The D2B bus is a unidirectional ring with two "lines", one acting as an input and the other as the output, to complete the communication ring needed to successfully control all ICE modules or "nodes" on the vehicle.

CAUTION:

Multiplex harnesses require special repair procedures. Refer to the applicable Service Literature for special tools and procedures.

CAN (CONTROLLER AREA NETWORK)

The CAN bus is two standard 0.5 mm (0.020 in.) copper wires twisted as a pair, with 40 twists per meter (approx. one twist per inch). One wire of the pair is designated as CAN High (+) and the other is designated as CAN Low (–). Although CAN appears wired as a series circuit, it is parallel because of internal module wiring. However, a fault in the internal wiring or connector can stop the network from communicating across the fault. But, each module will still continue to control its own functions by substituting default information for any missing data messages. Refer to the Electrical Guide Appendix pages for individual module messages.

CAN is called "real time" communication because its speed allows extremely fast response time for controlling time critical operations.

The following X308 control modules communicate directly through the CAN network:

* Anti-lock braking/traction control module (ABS/TCCM)
* Engine control module (ECM)
* Transmission control module (TCM)
* Gear selector illumination module – does not transmit, used only for gear selector position illumination
* Instrument pack (INST)

The CAN network is also connected to the DLC (data link connector) for diagnostics.

CAN does not communicate directly with SCP. However, the INST converts specific message data allowing communication between networks.

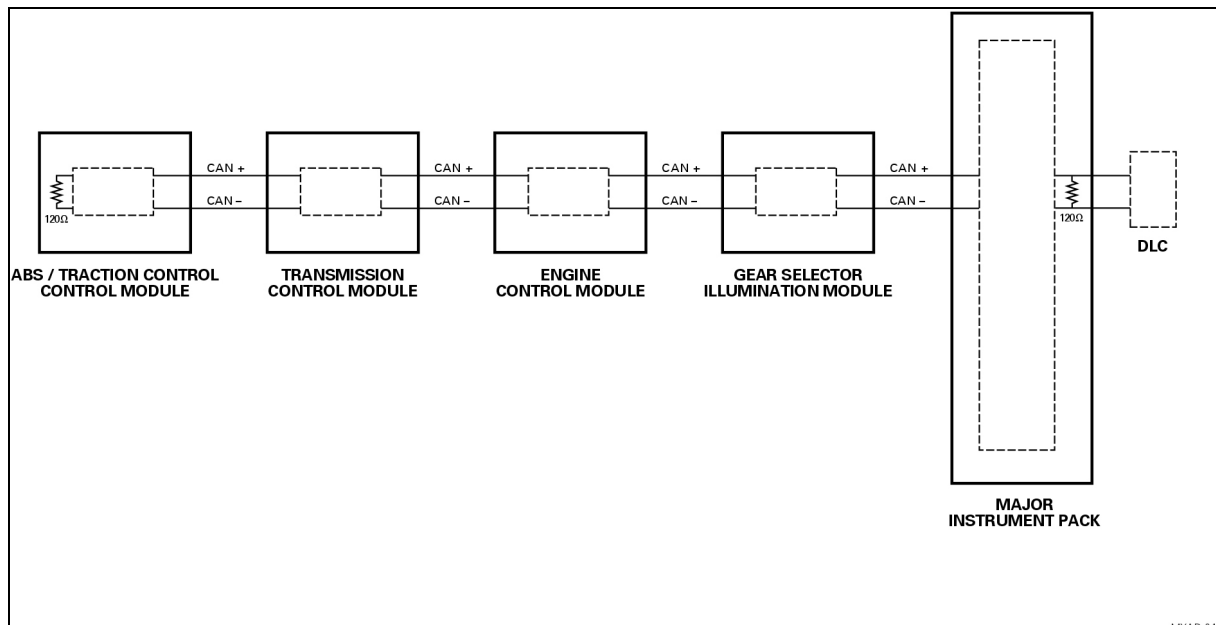Most modules can have fail-safe default modes in the event of a network failure.

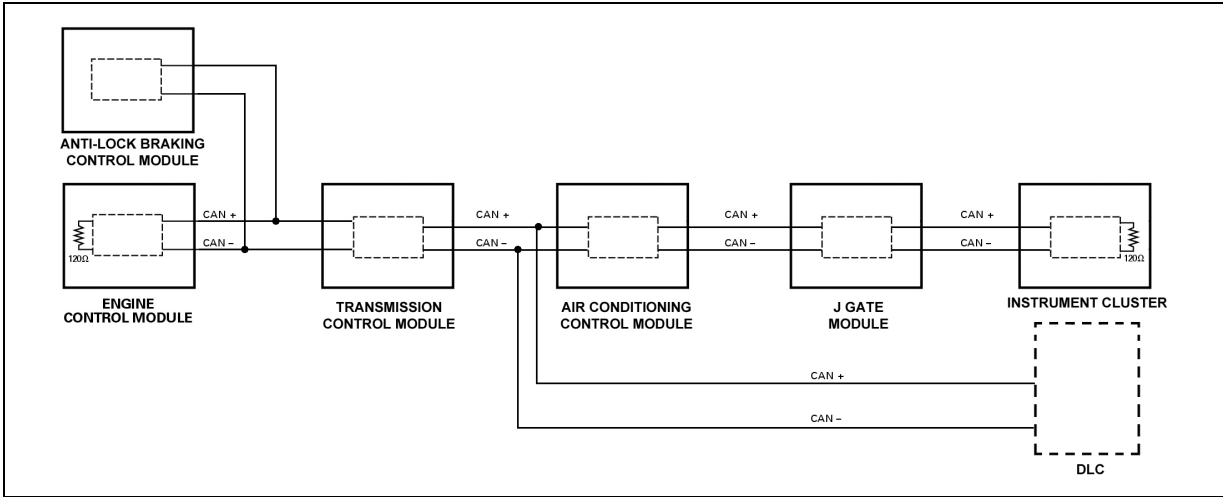**Fig. 9   Typical CAN Multiplex Circuit Layout: X308**

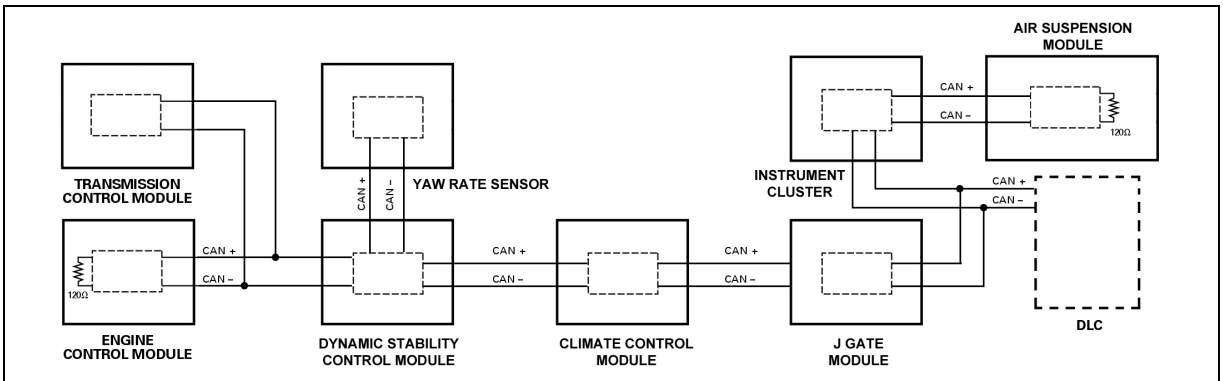**Fig. 10   Typical CAN Multiplex Circuit Layout: X400**

Fig. 11   Typical CAN Multiplex Circuit Layout: X350

CAN Data Message Frames

CAN data message frames generally contain more data than SCP message frames. CAN message frames are transmitted at intervals of from 4 to 20 ms. depending on the message. The data is available to all modules but is only "used" by those modules that require it.

Each CAN module transmits three types of data message frames.

- Token data message frames (cyclical transmission) – The token message tells the network that the module is "alive."
- Diagnostic data message frames (request transmission) – The diagnostic message is a response to a WDS request for specific diagnostic information.
- Vehicle operation data message frames (cyclical transmission) – The vehicle operation message contains the vehicle operational information from the module.

Modules transmit more than one vehicle operation data frame because the amount of data from the module exceeds the capacity of a single data frame. The ID (identification) field of each CAN message frame not only identifies the transmitting module, it also identifies the type of data and its precise location within the frame's data message field.
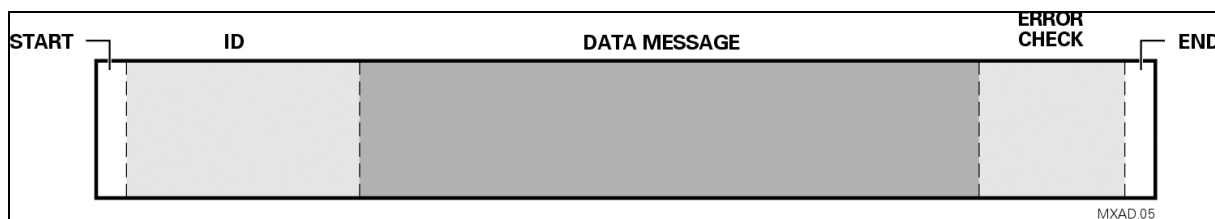

START	ID	DATA MESSAGE	ERROR CHECK	END

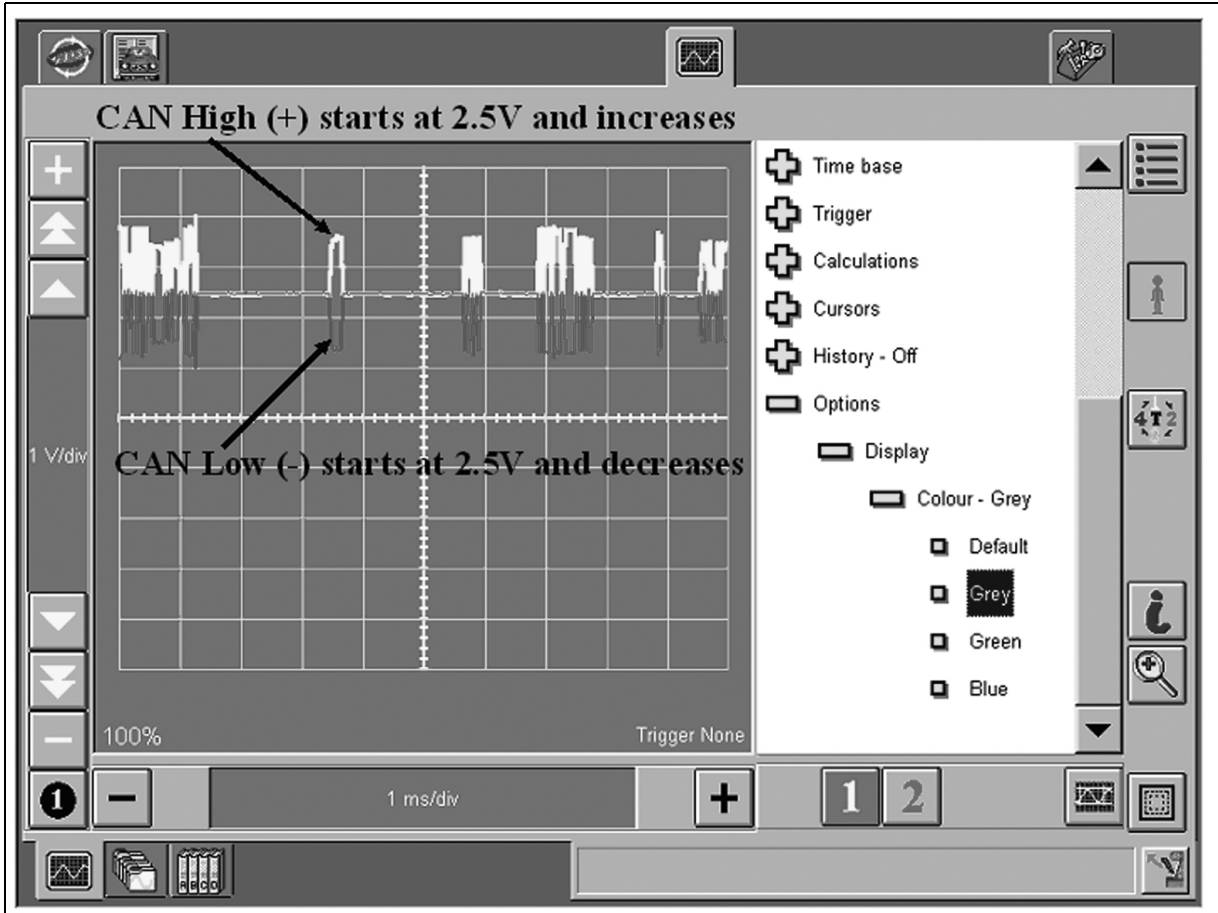MXAD.05

Fig. 12   Typical CAN Data Message Frame

Fig. 13   CAN Oscilloscope Pattern On WDS

CSMA and Non-Destructive Arbitration

The protocols use Carrier Sense Multiple Access (CSMA). Each control module has the intelligence to monitor each bit on the line and detect when it is an "idle" condition and when it may try to transmit on the bus. However, more than one control module may try to communicate at the same time, and there are various mechanisms to detect and control this. A popular one is the Non-Destructive Arbitration (NDA) system. In this example, a "0" is Dominant and a "1" is Recessive. A Dominant "0" always wins over a Recessive "1". In Non-Return to Zero (NRZ), bit synchronization is restored using the bit stuffing technique.
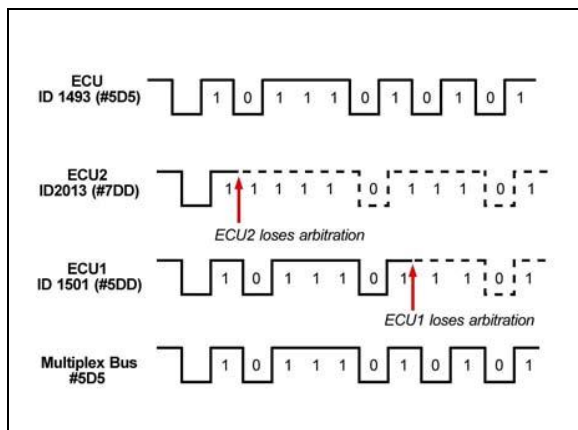

Fig. 14   CSMA

CAN NETWORK DIAGNOSTICS USING WDS

WDS automatically tests the network integrity and communications before running specific diagnostic routines. First, WDS establishes communication with the vehicle via the DLC and begins its automatic test sequence. Once network integrity and communications are both confirmed, WDS begins the specific diagnostic routine. If the network communications and integrity test is failed, WDS directs the user to an appropriate test from the CAN network menu.

CAN Network Failure Modes

The WDS diagnostic routine tests the network wiring but will not pin point an individual module failure. If a network failure is established using WDS, then pin point the fault using the following information and a DVOM.

An open circuit in both the CAN high (+) AND the CAN low (-) wires will stop communications at the open circuit. Modules on either side of the open circuit will continue to communicate with modules on the same side of the open circuit but no data will be cross the open circuit. Modules will continue to operate by substituting default values for the missing data.

CAN modules will communicate only when the CAN high (+) and CAN low (-) are in an acceptable electrical state. The following shows communication possibilities depending on the electrical state of each wire. If all communication is lost on the CAN bus, the modules will continue to function but will substitute default values for any missing data.

Table 7 CAN Network Failure Modes

Wire	Condition	Communication
CAN high (+)	open circuit	NO
CAN high (+)	short circuit to ground	NO
CAN high (+)	short circuit to B+ voltage	NO
CAN high (+)	short circuit to CAN low (-)	NO
CAN low (-)	open circuit	YES (if CAN high (+) is functioning)
CAN low (-)	short circuit to ground	YES (if CAN high (+) is functioning)
CAN low (-)	short circuit to B+ voltage	NO

SCP (STANDARD CORPORATE PROTOCOL) NETWORK

SCP Overview

The SCP bus is two standard 0.5 mm (0.020 in.) copper wires twisted together with 40 twists per meter (approximately one twist per inch). One wire in the bus is designated as SCP high (+) and the other is designated as SCP low (-). The network is wired as a "star" circuit. This method of wiring keeps the network bus as short as possible and allows the rest of the system to continue communication should one module fail. Bus integrity is maintained by using the vehicle speed data message as a "keep alive" signal. If a module does not receive the "keep alive" message, the module assumes a fault and takes itself off line.

During normal operation SCP networks allow the electronic control modules linked to the network to exchange information directly with each other. For example, on X200, the Powertrain Control Module (PCM) supplies the A/CCM with engine temperature information. This allows the A/CCM to consider engine temperature when activating the heater blower motor.

Input data that is received by one control module can also be broadcast to any other module through the data bus. An example of this is the X350 Anti-Lock Brake System/Traction Control Module broadcasting vehicle speed to both the ECM, for engine operation strategy, and to the air suspension module, which uses the information to set correct ride height and firmness for changing driving conditions.

A module may also request information from another module on the network. For example, the ECM requests an all-clear message from the Passive Anti-Theft System (PATS) module before allowing the engine to run.

SCP Data Message Frames

Each SCP data message frame is a complete message unit communicating only the data for one action. Messages on the bus are available to all of the modules connected to the bus but are only "used" by a module if required. There are three general types of SCP data messages:

Cyclical messages

Cyclical messages are transmitted on the bus at specified intervals. VEHICLE SPEED, ENGINE RUNNING and CHARGING OK are examples of three separate cyclical messages that are transmitted by the INST at least every 150 ms.
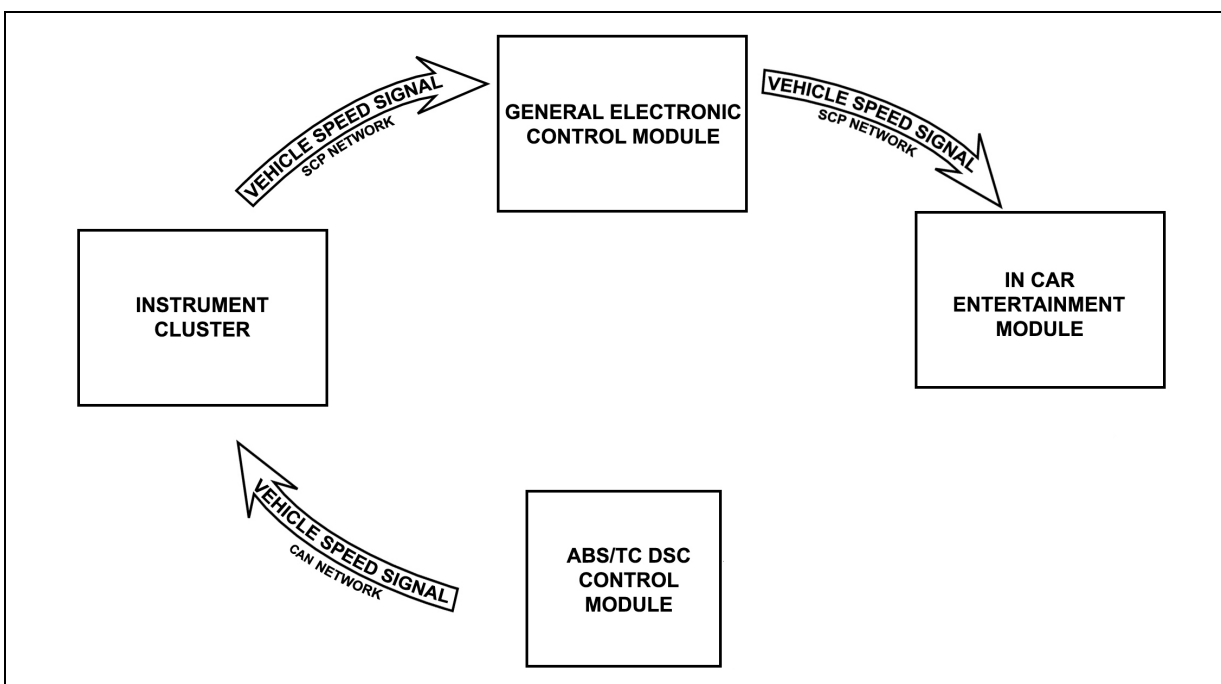

Fig. 15   Typical Cyclical Messages: X400

Event messages

Event messages are sent either once or for a specified number of times when something specific happens. For example, on X100 series and X308, KEY IN IGNITION is a message sent by the BPM. The message is transmitted when the key is put into the ignition switch.

When the key is withdrawn from the switch, KEY NOT IN IGNITION is sent by the BPM. Event messages are often used to "toggle" a function ON and OFF through other modules.

Periodic Event Messages

Periodic event messages are broadcast repeatedly only until a particular result is achieved. For example, during traction control operation, the ABS/TC control module may request a reduction in engine torque. The control module will continue to broadcast this request until it receives the message that the engine torque has been reduced.

Modules on the SCP network are connected with pairs of twisted wires, similar to previous Jaguar vehicles. Some vehicles had portions of the network wires shielded to prevent interference. The primary wire colors are slate (+) and blue (-).

The network will remain operational if one of the bus wires is open circuit, short circuit to ground or short circuit to B+ voltage. In addition, the network will remain operational if some, but not all, control module termination resistors have failed.

Request messages

Request messages ask for a specific piece of data. An example of a request message on an X308 is REQUEST KEY-IN STATUS sent by the SLCM, DDCM or PDCM. The BPM then responds with a key status message – either KEY IN IGNITION or KEY NOT IN IGNITION .

The above request also occurs on X200, X202, X350, X400, and X404, except that the broadcasting module is INST, not BPM.
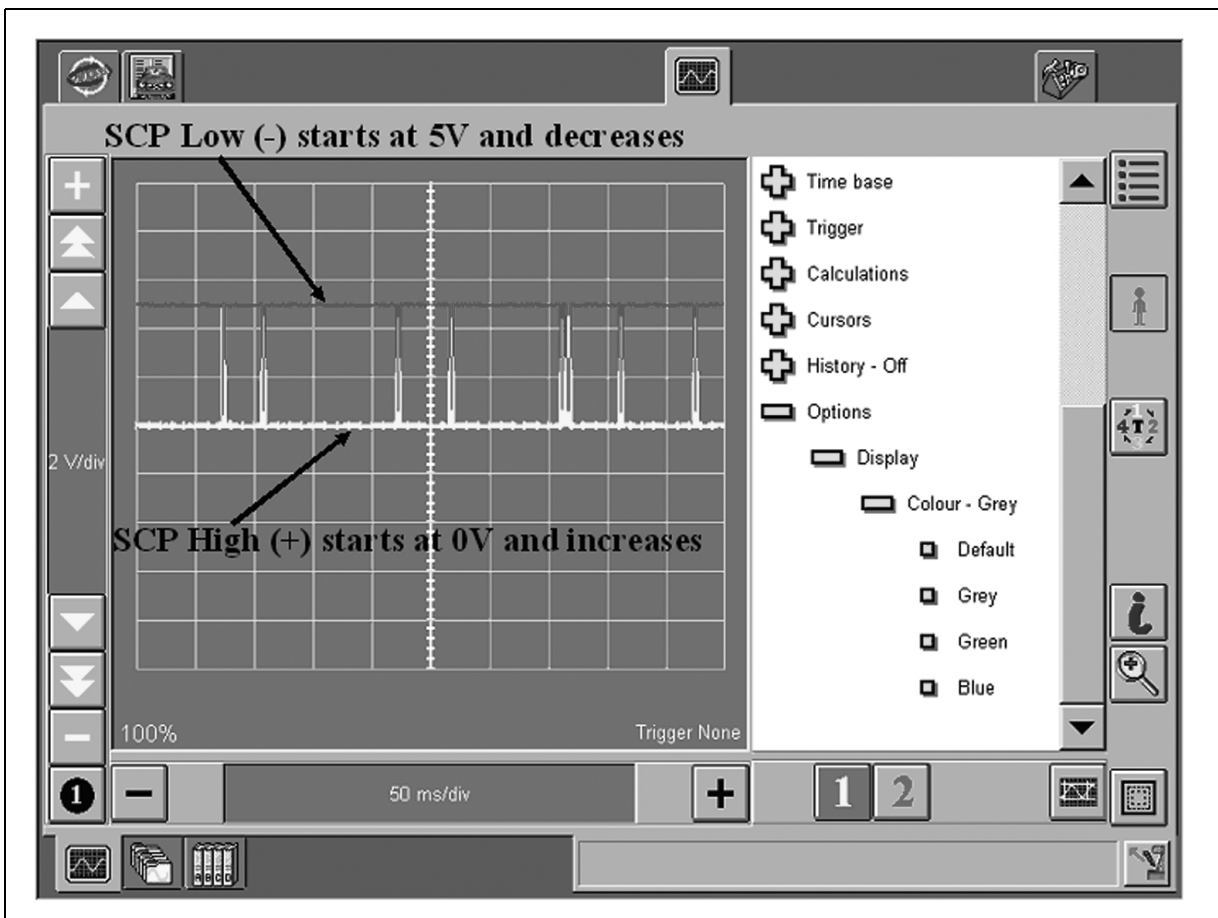

Fig. 16 SCP Oscilloscope Pattern on WDS

Network Protocol

Standard Corporate Protocol (SCP) enables the network to communicate using electric signals over a data bus. The wires in this data bus are twisted to help resist electromagnetic interference.

* The data bus wires are designed Bus + and Bus – .
* Electrical impulses vary between 5.0 volts and zero volts to represent a digital logic "1" or "0".

* When there are no messages, Bus – is 5.0 volts and Bus + is zero volts.
* When messages are being sent, the readings are reversed.
* Data bus wires are usually identified in an Electrical Guide wiring diagram as circuits SCP (+) and SCP (-).
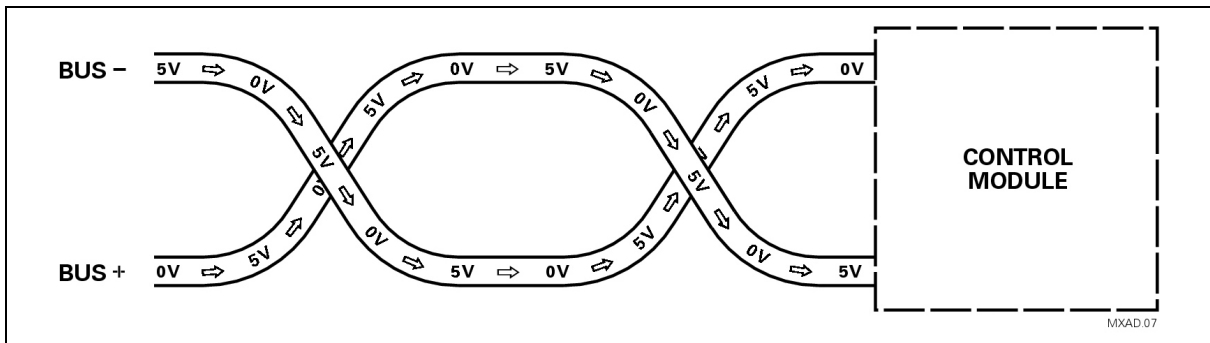
NOTE: Wires are not always shown as twisted pair in schematics.

Fig. 17 SCP Data Transmission