Verifying CAN bus signals with a Fluke ScopeMeter® 120 Series

Application Note

The CAN (Controller Area Network) 2-wire differential serial bus system cannot easily be debugged with protocol analyzers and digital testers since these look only at the protocol layers of the bus and require the physical layers to be up and running before they can be of use. Here's where the Fluke ScopeMeter 120 Series can prove invaluable by allowing you to take a detailed look at the bus signals themselves to find the cause of communication problems.

Potential faults on a CAN system

The Controller Area Network (CAN) was originally developed by Bosch, Germany specifically for the automotive market. Although this is still its primary application area, CAN is also ideal as a general industrial bus and has found its way into many applications.

Being a simple two-wire differential serial bus, CAN systems are ideal for reducing wiring. They offer flexible control on actuators and readout of sensors and, in automotive applications, they provide easy diagnosis with a digital tester. However, if communication is not possible due to a fault in the bus system itself, debugging becomes a problem that can be solved only with more powerful diagnostic tools like the Fluke ScopeMeter 120.

Many faults found in CAN bus systems have physical causes. Like badly terminated busses, poor signal quality, inadequate transmission levels, incorrectly installed cables, faulty connectors, cable routing in high EMC environments and many others.

With the Fluke 120 Series you can reveal the cause of these problems by looking at the bus signals, the so called physical layer signals.

Viewing CAN signals

The CAN standard supports half-duplex communication with only two wires to send and receive data forming the bus. The nodes have a CAN transceiver and a CAN controller for bus access. At both ends, the bus must be terminated with a resistor, typically 120 Ω.

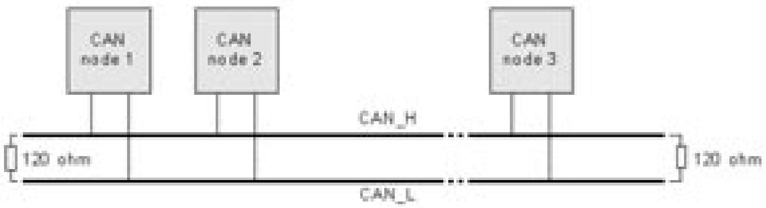

Figure 1. Two-wire CAN architecture

The CAN bus signals are designated CAN-High and CAN-Low. These 2 wires carry antiphase signals in opposite directions to minimize noise interruption that simultaneously interfere on the bus. The CAN bus line can have one of two logical states: "recessive" and "dominant". Typically, the voltage level corresponding to recessive (logical "1") is 2.5 V and the levels corresponding to dominant (logical "0") are 3.5 V for CAN-High and 1.5 V for CAN-Low. The voltage level on the CAN bus is recessive when the bus is idle.

To display the CAN bus signals, connect the A and B inputs of the ScopeMeter to CAN_H and CAN_L, and the ScopeMeter COM to signal ground.

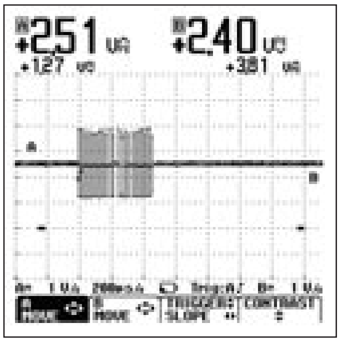

Figure 2: Fluke ScopeMeter 120 showing a CAN bus data packet. CAN-High on Input B and CAN-Low on Input A.

Peak-to-peak voltage measurements

When analyzing the CAN bus signals, it is of interest to measure the peak-to-peak voltages and to verify that the CAN signals are disturbance free.

The Fluke 120 Series has an easy menu structure that allows the peak measurement to be selected. Each input allows two measurements to be made simultaneously. The meter's unique Connect-and–View™ triggering automatically gives a stable signal display even with complex signals.

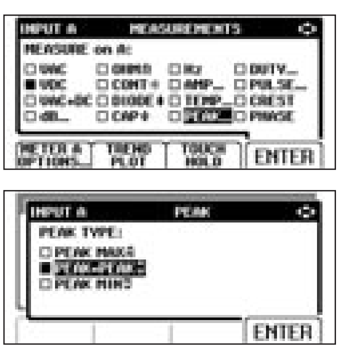

Figure 3. Easy menu selections for max-peak, min-peak or peak-peak measurements

To analyze the signals for disturbance, the instrument allows zooming in on details by changing the time base setting.

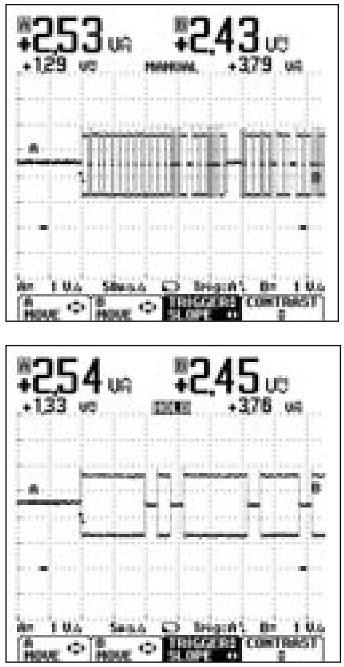

Figure 4. Changing the time-base allows you to zoom in and analyze signal details

Rise-time measurement

To determine the quality of the edges of the bits, the steepness is determined by measuring the rise and fall times between recessive and dominant levels and vice versa. These rise and fall times are determined in 1/32 nds of the bit time. Rise or fall times of greater than 5/32 nds are considered to be a bus fault. The Fluke 124, top model of the 120 Series, is capable of making cursor measurements and has a 40 MHz bandwidth, providing a 10 ns time-base range and automatic rise- and fall-time measurements. This makes it easy to verify the rise and fall times.

To be able to use the full signal span for accurate rise-time measurement, AC coupling is used on the instrument to remove the DC offset, and the time base is set to 10 ns per division, so full signal details are revealed.

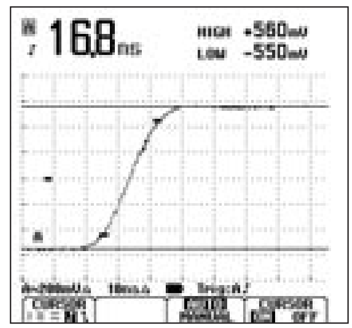

Figure 5: Fluke 124 measuring rise time automatically

Conclusion

Many faults found in CAN bus systems have physical causes. To find and troubleshoot these you need to look at signal detail. The Fluke 120 Series provides an easy battery operated 20 or 40 MHz digital scope, which allows you to look as signal details and simultaneously make full bandwidth measurements on both channels.

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