Does The CAN Bus Need a Common Ground?

Jon Titus - May 21, 2010

An engineer asked me a question about how to implement a CAN-bus circuit with the Texas Instruments SN65HVD251 transceiver. He had already studied data sheets and application notes. His key question was, "Does CAN require a common ground?"

I checked out the data sheet for TI's SN65HVD251 chip and noticed a ground reference in a schematic diagram of test conditions for a single driver/receiver. But the data sheet's application diagram does not include a common ground among devices on a network.

The TI data sheet mentions, "...cross-wire, over-voltage and loss of ground protection..." but the loss of ground at what point? It's not clear. The TI Application Report SLLA270, Controller Area Network Physical Layer Requirements, notes, "To prevent transceiver damage, the voltage difference between reference grounds of the nodes on a bus should be held to a minimum. This is the common-mode voltage across the entire system and although many transceivers such as the SN65HVD251 are designed to operate over an extended common-mode range, the cumulative current demand of too many devices at a common-mode voltage extreme may jeopardize network security. To enhance this common-mode security, most higher layer protocols like DeviceNet specify that power and ground wires be carried along with the signaling pair of wires."

I asked my sources at Microchip Technology, which manufactures CAN-bus expanders, and got the answer, "No common reference is required. The definition states that CAN communication is a two-wire differential protocol (CANH and CANL) bus. Dominant and recessive states of the bus are determined based upon the differential voltage read between CANH and CANL."

On the other hand, AN015, CANopen Network CAN bus Cabling Guide, from Copley Controls notes, "Copley recommends that the CAN_GND be connected between devices. Even when using isolation, Copley recommends that the CAN_GND still find a path to earth ground."

The CAN pinouts at www.interfacebus.com show ground contacts on CAN bus connectors. And information about the CAN bus on this Web site clearly shows a common ground. Information on other Web sites also shows a ground connection, but not all sources agree on whether to use a common ground.

Many CAN transceivers will tolerate a "ground offset," a difference in ground potential between network nodes. That offset is specified as between -2 and +7 volts, but transceiver IC often tolerate larger offsets, such as ±12V for the Microchip MCP2551 device. But, the offset can affect bit rates.

In the book, CAN System Engineering: From Theory to Practical Applications, author Wolfhard Lawrenz notes, "...ground offset generally has the effect of increasing the effective propagation delay between bus nodes and thus decreasing [the] achievable bit-rate times bus-length product."
So, should a CAN circuit include a common ground connection between nodes? It depends, but given a choice, I'd use one—at least to start.