Application Report
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# SymPol™ Transceivers are Immune to Cross-Wire Faults

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**ABSTRACT**

Cross-wire faults are a significant problem in many applications where installation of end-equipment and cable connections are made by third party installers, rather than by OEM technicians. Texas Instruments has developed a transceiver which is immune to cross-wire faults.

Data signaling between the various parts of a system enables "smart" functions such as power management, diagnostics, and optimal operation. For this reason, networking and interconnection of equipment is a valuable and growing area of innovation for all sorts of industrial equipment.

In many networked equipment applications, the end-equipment units are installed at a site and connected together by local installers. For example, heating/ventilation/air-conditioning system or building security systems have several components, which are typically located around various points in a building, and which must be connected with cables which are cut-to-length at time of installation. This installation is prone to mis-wiring, which can cause data corruption or even equipment damage with most existing types of network signaling schemes (e.g. RS-232, RS-422, RS-485). Identification and correction of the mis-wiring can be difficult once the system is installed, as the entire network may be affected by a single cross-wired node.

Texas Instruments has developed a transceiver which uses symmetric polarity to ensure immunity to cross-wire faults. The SN65HVD96 can be used to replace an RS-485 (or RS-422) network with a SymPol network, which will not be affected by cross-wire faults anywhere in the system. The package and pin-out of the HVD96 is identical to the industry-standard '176' footprint used by a majority of RS-485 transceivers. This allows designers to evaluate SymPol signaling without revision to existing interface boards. The HVD96 SymPol transceiver is designed to operate using the same twisted-pair cabling with 120 Ohm characteristic impedance that is standard for RS-422 and RS-485 signaling. Using balanced differential signaling, SymPol exhibits the same basic advantages of noise immunity and low emissions as established interface standards. The HVD96 also has integrated fault protection features such as driver output current limiting and thermal shutdown circuits to ensure robust operation.

In the following figures, the cross-wire immunity of SymPol signaling with the HVD96 is demonstrated, as well as reliable signaling over long cables typical of the intended applications.

SymPol is a trademark of Texas Instruments.

In Figure 1, the simplified test set-up is shown. At one end of a 1000 meter cable, one transceiver transmits at 150 kbps with a “1 1 0 1 1 0…” data pattern. At the other end of the cable, a transceiver receives the data. Channel 1 (yellow) shows the input to the transmitting driver, Channels 2 and 3 (blue and cyan) are the differential signals after transmission through the 1000 meter cable. Channel 4 (green) is the output of the SymPol receiver at the receiving end of the cable.

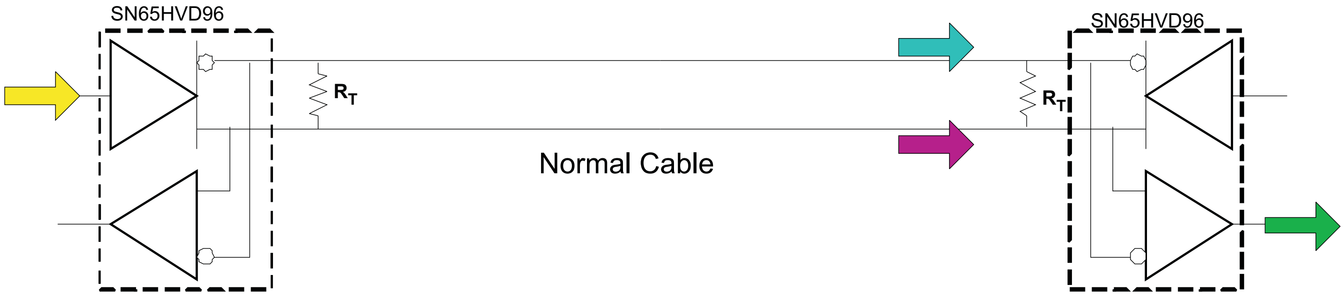


**Figure 1. Test Set-up With Normal Cable**

The oscilloscope plot below shows several features of this signaling. The SymPol bus levels are such that a logic “high” on the driver input creates a Passive state, with both outputs at the same voltage, giving a zero differential voltage. When the driver input is logic “low”, the driver goes to an Active state, producing a non-zero differential voltage on the cable.

The time delay between Channel 1 going low and Channels 2 and 3 showing the Active state is due to the propagation delay in the 1000 meter cable. Typical twisted pair cable has a propagation delay of about 5 nanoseconds per meter (5 ns/m), so the delay of about 5000 ns (5 µs) is expected. The cable has also attenuated the signal, reducing the high-frequency components of the waveform. This causes the “rounded” look of the transition edges at the receiving node.

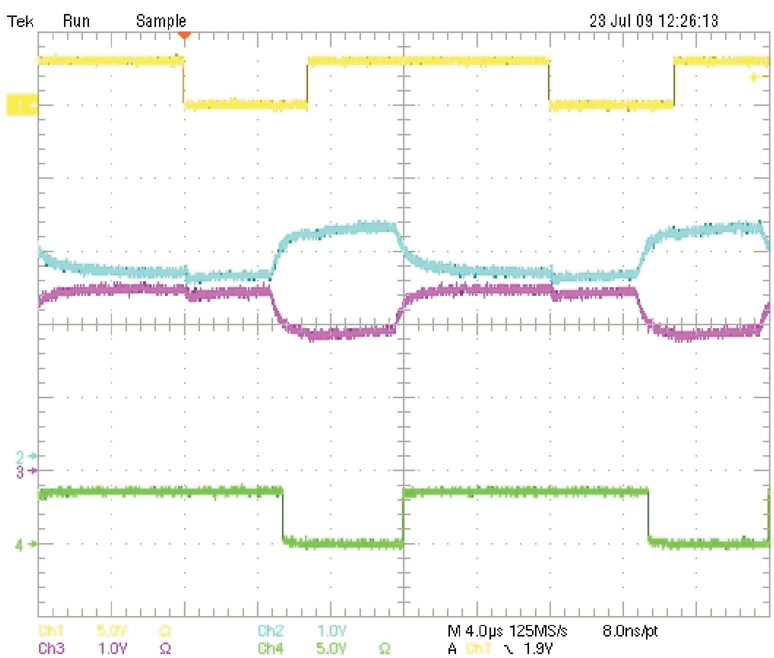


**Figure 2. SymPol Signaling at 150 kbps Over 1000 Meter Cable**

In Figure 3, the test set-up is modified to cause a cross-wire fault in the cable between the two nodes. With RS-485 transceivers, this would cause a polarity inversion and corrupt the data at the receiving node.

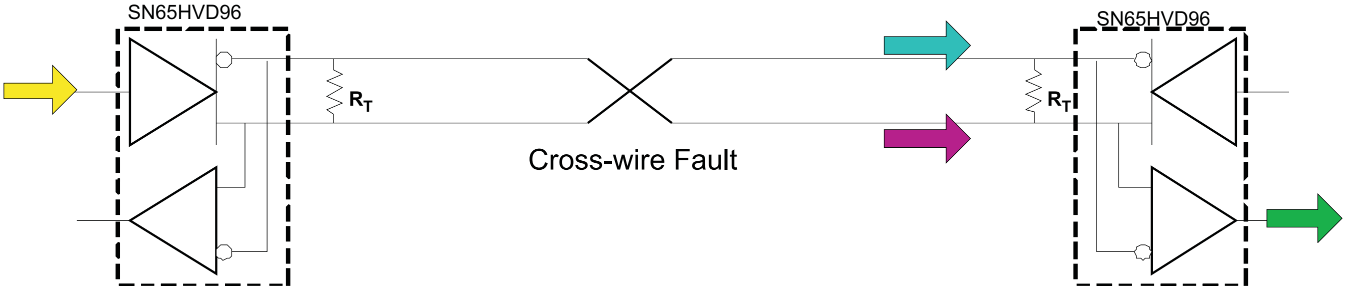


**Figure 3. Test Set-up With Cross-Wire Fault**

Figure 4 shows the results with the induced cross-wire fault. By comparing the receiver output to the driver input, it is seen that the original data pattern “1 1 0 1 1 0…” has not been corrupted by the inverted data. This is due to the (patent pending) SymPol signaling used by the HVD96. SymPol uses symmetric polarity differential signaling to achieve immunity to cross-wire faults.

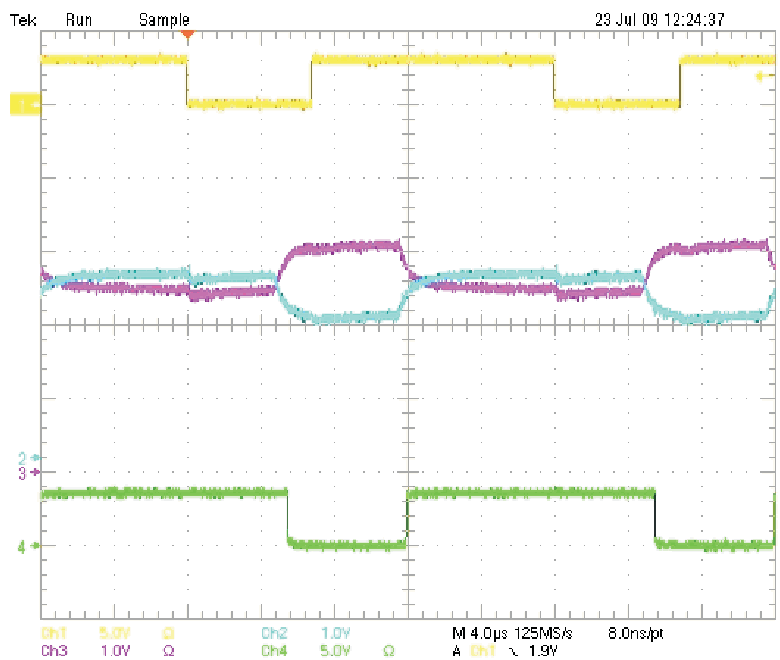


**Figure 4. SymPol Signaling is Unaffected by Cross-Wire Faults**

In summary, the HVD96 offers designers a solution for cross-wire faults, with no need for intervention by a technician, and with many of the same features as established RS-422 or RS-485 signaling.

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