Improved CAN network security with TI's SN65HVD1050 transceiver

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New Product Definition

A CAN transceiver must reliably transmit data in extremely harsh operating environments that place an extraordinary electrical burden on the device. Since the transceiver is typically the only interface between expensive node electronics and the CAN bus, many operational security features of the Texas Instruments (TI) SN65HVD1050 take on additional importance in CAN applications. These features include electromagnetic (EM) immunity, low EM emissions, noise rejection, electrostatic discharge (ESD) protection, fault tolerance, and protection during hot plugging or power cycling.

EM immunity

As the EM spectrum becomes more fully utilized, EM fields radiated by a wide range of devices are increasing the probability of interference with other electronic equipment. Due in part to the wireless revolution in electronics, EM interference is increasingly becoming a widespread concern.

Every electronic device has its own unique EM characteristics. The inductance and capacitance of any circuit may develop a common-mode resonance at discrete frequencies that either amplify or attenuate emissions.

The HVD1050 CAN transceiver is designed and tested for EM compatibility without malfunction or degradation of performance in rugged EM environments. "Compatibility" in this definition means both low emissions and high immunity to external EM fields.

Low EM emissions: Balanced signaling and common-mode output

An important requirement of products intended for networking applications is that they behave in a way that does not interfere with the operation of other nearby components or systems. The desired behavior is referred to as "low radiated emissions" and is typically tested according to various quantitative requirements specified at the system or electronic module level.

EM noise is generated by imbalanced high-frequency voltage or current switching. In a CAN transceiver, system-level emission performance must be translated into transceiver characteristics. Specifically, driver output signals are typically mismatched on CANH and CANL, and the resultant EM fields fail to differentially cancel each other as equal and opposite. This output mismatch (displayed in Figures 1 and 2) is referred to in TI datasheets as the peak-to-peak common-mode output voltage, $V_{OC(PP)}$, and may be considered to be a figure of merit for balanced differential signaling.

Measurement of the common-mode output signal is believed to provide all the information necessary to predict performance of system-level emissions. Both time and frequency representations of the output common-mode signal can be analyzed for the purpose of evaluating emissions behavior.

Figure 1. Typical CAN bus $V_{OC(PP)}$ waveform

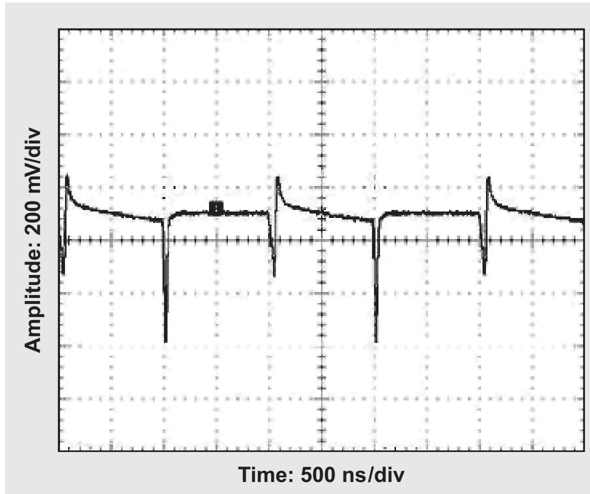


Figure 2. $V_{OC(PP)}$ test setup

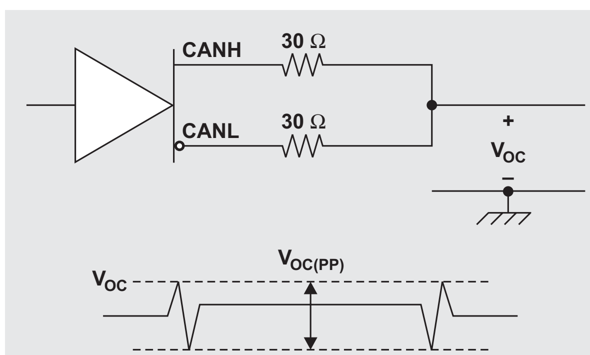
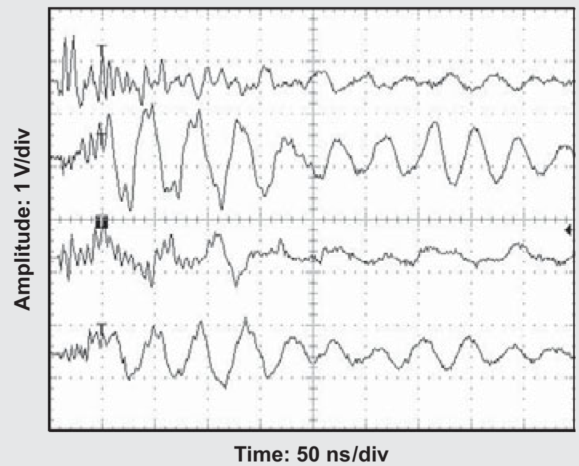


Figure 3. Common-mode noise coupled onto four twisted-pair bus lines



High immunity: Common-mode noise rejection

Common-mode noise rejection is an inherent feature of true differential receivers, just as it is with other differential-input circuits such as operational amplifiers. Differential signal pairs are physically close together and are generally exposed to the same noise sources—noise common to each wire. This ensures that exposure to EM fields is nearly equal and common to each line, canceling the differential influence from magnetic field coupling by reversing the polarity in adjacent loops of twist in twisted-pair wiring.

Unwanted noise of various magnitudes easily links the antenna-like bus lines of CAN applications. Pulsing motor controllers, switch-mode power supplies, and fluorescent lighting are typical noise sources that couple onto bus lines (displayed in Figure 3).

A CAN transceiver not specifically designed to reject this coupled noise will respond as if it were data on a bus and send corrupted and meaningless data to a controller.

TI's HVD1050 CAN transceiver is specifically designed and tested for its ability to reject this noise over an extremely wide (–12-V to +12-V) common-mode operating range. The high degree to which the differential receiver rejects coupled noise is evidence of the careful electrical and mechanical design of the receiver components that ensures that input matching is as close to ideal as possible.

Voltage transients and integrated-circuit protection

ESD can occur in any of four ways: A charged body can touch an IC; a charged IC can touch a grounded surface; a charged machine can touch an IC; or an electrostatic field can induce a voltage across a dielectric that is sufficient to break it down. It becomes readily apparent that a high ESD rating indicates not only a robust transceiver but a robust circuit design as well.

Comparable CAN transceivers on the market provide only 4-kV ESD protection, while the HVD1050 CAN transceiver has an ESD rating of 8 kV when tested in accordance with the Human Body Model (HBM) of JEDEC Standard 22 A114-B. With this ESD rating, the HVD1050 is much better suited to harsh electrical environments than the earlier transceiver versions of other vendors.

To ensure the HVD1050's robustness, it is also tested to ±200 V in accordance with ISO 7637, test pulses 1, 2, 3a, 3b, 5, 6, and 7.

Fault tolerance

Bus hangs and dominant time-out

CAN bus operators occasionally report that all bus communication comes to a halt when a faulty node places a continuous dominant bit on the bus. This stuck-dominant condition occurs either from a faulty controller or from random slivers of wire, a solder ball, or metal shaving shorts across a transceiver's input (TXD) pin and the adjoining ground (GND) pin.

A dominant-time-out circuit in the HVD1050 prevents the driver from blocking network communication with a hardware or software failure. The time-out circuit is triggered by a falling edge on TXD. If no rising edge occurs before the time-out constant of the circuit expires, the driver is output-disabled, releasing the bus from the stuck-dominant condition. Once the fault is corrected, the circuit is reset by the next rising edge on TXD.

Crushed-cable and short-circuit protection

Bus-cable polarity reversals, accidentally crushed cable, and unintentional shorts of the bus wires to power supplies or ground are common in many CAN applications. To provide protection from these real-world operating events that are common on 24-V industrial buses, the HVD1050 provides short-circuit protection from –27 V up to +40 V. This short-circuit protection extends over any length of time and guarantees that the device will continue normal operation once the fault is removed.

Additional circuit protection is provided with the thermal shutdown circuitry. In the event of a bus short with a runaway current condition, the HVD1050 automatically shuts the device down when thermal conditions exist that could damage internal circuitry.

Hot plugging, power cycling, and glitch-free outputs

Adding additional components to a network most often requires shutting down the entire network to prevent costly system errors. Therefore the ability to plug directly into an operating system becomes a valued asset in many CAN applications.

Plugging an unpowered module directly into a powered system is referred to as "hot plugging" and requires that the transceiver output remain stable during the unpowered to power-up transition without disturbing ongoing network communications.

Many CAN transceivers on the market today have a very low output impedance when unpowered. This causes the device to sink any signal present on the bus and effectively shuts down all data transmission.

For this purpose, the HVD1050's bus pins are biased internally to a high-impedance recessive state. This provides for a power-up into a known recessive condition without disturbing ongoing bus communication. It also maintains the integrity of the bus when power or ground is added to or removed from the circuit.

Together these features of the HVD1050 serve to greatly enhance the operational security of any CAN application.

Related Web sites

interface.ti.com
www.ti.com/sc/device/SN65HVD1050

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

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