# *TI Designs: Verified Design*

# *Polarity Correcting Isolated CAN Node*

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## Circuit Description

This is a ready to use design that efficiently solves the problem of improper installation by adding antiparallel communication channels and appropriate control signal to enable polarity correction for the Controller Area Network (CAN) bus. In addition this design provides typical footprints for bus protection and filtering circuitry.

The design also has a 3.3V to 5V isolated DC-DC power supply that utilizes a push-pull converter, and a four channel digital isolator for safety applications

## Design Resources

| | |
|---|---|
| Design Archive | All Design Files |
| SN65HVD255 | Product Folder |
| ISO7842 | Product Folder |
| SN6501 | Product Folder |
| TPS76350 | Product Folder |
| TPS22968 | Product Folder |

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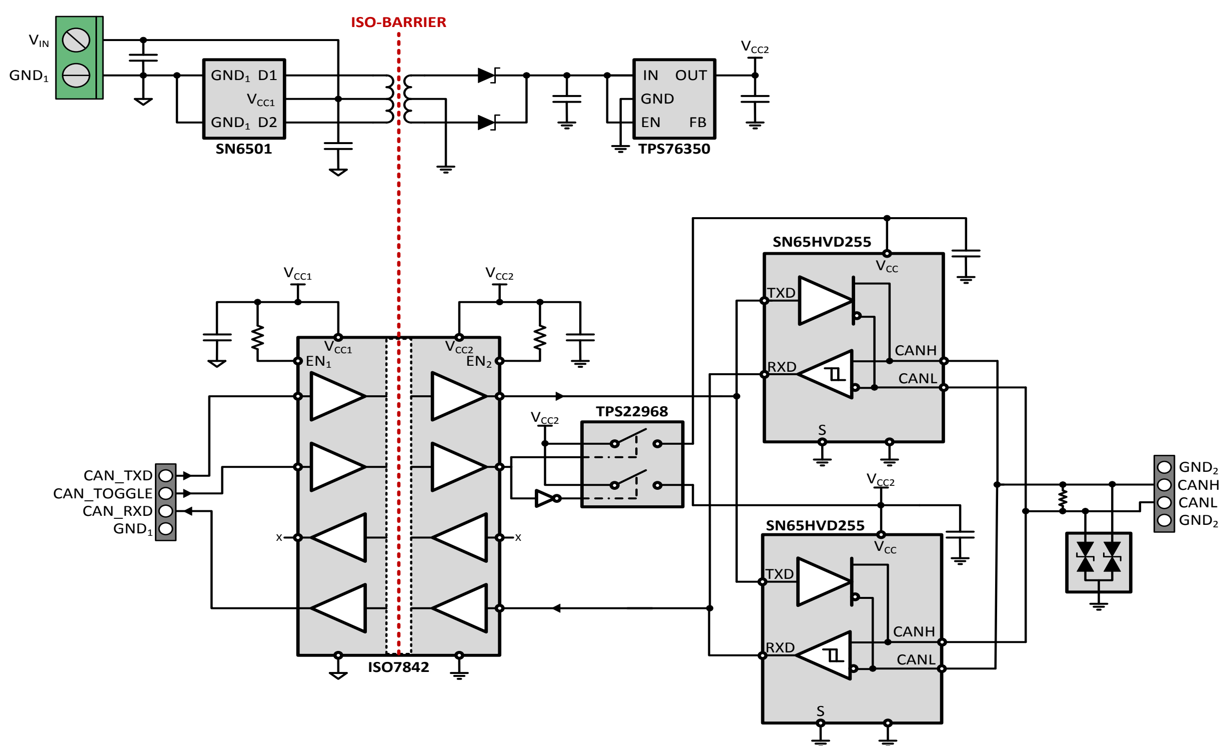


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## 1 Design Summary

This polarity correcting isolated CAN node is designed with the following specifications:

- Simplifies system installation with use of one control signal to enable polarity correction in case of cross wire fault
- Custom high efficiency isolated power supply
- Turbo CAN Transceiver with fast loop times for highly loaded networks and fast data-rates
- 5.7k$V_{RMS}$ four channel isolator with low propagation delays for time critical applications

## 2 Design Considerations

### *2.1 Controller Area Network (CAN) Transceiver*

The SN65HVD255 is a single supply High Speed CAN transceiver. The CAN bus has two states during powered operation; dominant and recessive. A dominant bus state is when the bus is driven differentially, corresponding to a logic low on the TXD and RXD pin. A recessive bus state is when the bus is biased to VCC / 2 via the high-resistance internal input resistors RIN of the receiver, corresponding to logic high on the TXD and RXD pins. These states are shown below in Figure 1.

**Figure 1: Bus States**

The receivers on these devices require a differential voltage of 900mV for a dominant signal. An issues arises if a cross wire fault occurs during installation (CANH is connected to the CANL terminal and CANL is connected to the CANH terminal). In this case a dominant voltage would appear to the local node as a -900mV differential signal. For any standard CAN transceiver this would not register as a dominant signal and therefore it would render the node unusable without any communication to the outside world. By connecting a second CAN transceiver in anti-parallel to the first this fault can be corrected in software.

### *2.2 Polarity Correction*

This design makes use of a single GPIO in addition to the standard CAN TXD and RXD signals from the node controller. This signal is transmitted across the isolation barrier via the ISO7842 (U4) and then is used to control the power supply voltage for both CAN transceivers. The signal is split with one path going to a power switch enable pin that is active high (U8 – ON1), and the other path is sent through an inverter (U6) to a second power switch enable pin (U8 – ON2) that is also active high. The inverter ensures that only one power switch enable pin will ever have logic high applied, thus only powering one of the two CAN transceivers at any time. This guarantees that there will be no contention on the bus lines or logic lines where the two transceivers could be driving a net in opposite directions.

### *2.3 Power Switch*

The TPS22968 is a dual channel ultra-low resistance load switch. In this design it manages the powering and un-powering of the two CAN transceivers that are wired in anti-parallel via a single logic signal and an inverter gate. Care must be taking in software to allow sufficient time for the output voltage to ramp and charge the output capacitors, the transceiver to go through Power On Reset (POR), and the driving to turn on. As can be seen from Figure 4 below, this can take a couple milliseconds or longer depending on the application.

### 2.4 Digital Isolator

The control side of the SN65HVD255 is isolated from the node controller via the ISO7842, a four-channel, reinforced digital isolator that provides isolation of up to 5.7k$V_{RMS}$. All TI isolators utilize capacitive isolation with silicon dioxide ($SiO_2$) as the dielectric. Digital capacitive isolators are industry's most reliable and most precise, low-power isolators.

This 4-channel isolator comes in an industry standard 16-pin DW package that can easily be substituted for different isolation and channel count needs. This design requires two control signals in the forward direction (TXD and CAN_TOGGLE) and one control signal in the reverse direction (RXD), leaving an extra channel for expanding the design.

NOTE: Controller Area Network should always be isolated with a failsafe high isolator since the recessive (idle) state of CAN is logic high.

### 2.5 Transient Protection

Diodes D3, D4, and D5 are optional components that can be populated to provide additional ESD, EFT, and Surge protection for applications requiring IEC 61000-4-2 (ESD), IEC 61000-4-4 (EFT), and IEC 61000-4-5 (Surge) immunity. D3 and D4 are used for any single bi-directional TVS diodes that come in a SC-70 package. D5 is used for any dual bi-directional TVS diodes that come in 3 pin SOT23 package (DBZ).

### 2.6 Electromagnetic Compatibility

For scalability with different design requirements for EMC performance, this design adds the ability to populate industry standard common mode chokes and bus capacitors. When used correctly these components create low-pass filter that will block noise that couples onto the bus lines from getting onto the board and effecting sensitive circuitry, and removes conducted noise from the transceiver from reaching the bus.

### 2.7 Power Supply

The isolated DC-DC power supply converter utilizes the push-pull converter principle. The SN6501 transformer driver drives an isolated transformer with center-tap configuration. The transformer output is rectified by two Schottky diodes (D1, D2) and capacitor (C4). The subsequent low dropout regulator, TPS76350, provides a regulated 5V output for up to 250mA output current. For best stability and lowest ripple, a low-ESR, 4.7µF ceramic capacitor (C4) buffers the 5V regulated output.

# 3 Measurement

## *3.1 Data Transmission*

**Figure 2: CAN_TOGGLE High – U3 CAN Transceiver Active**

**Figure 3: CAN_TOGGLE Low – U7 CAN Transceiver Active**

## *3.2 Polarity Correction*

**Figure 4: Polarity correction with U3 active (left) and U7 active (right)**

## 4 PCB Design

**Figure 5: PCB layout top**

**Figure 6: PCB layout ground**

**Figure 7: PCB layout power**

**Figure 8: PCB layout bottom**

# 5 Appendix

## *5.1 Schematic*

**Figure 9: Isolated auto-polarity RS-485 transceiver schematic**

## 5.2 Bill of Materials

### Table 1: Polarity Correcting Isolated CAN Node Bill of Materials

| Item | Quantity | Reference | Part | Footprint | Manufacturer | Manufacturer Part Number |
|---|---|---|---|---|---|---|
| 1 | 3 | C1,C4,C6 | 1µF | 805 | Any | Any |
| 2 | 2 | C2,C3 | .1µF | 805 | Any | Any |
| 3 | 1 | C5 | 4.7µF | 805 | Any | Any |
| 4 | 4 | C7,C8,C12,C14 | 0.1µ | 805 | Any | Any |
| 5 | 2 | C9,C15 | 82pF | 805 | Any | Any |
| 6 | 2 | C10,C11 | 1nF | 805 | Any | Any |
| 7 | 1 | C13 | 4.7nF | 805 | Any | Any |
| 8 | 2 | D1,D2 | MBR0520L | SOD123 | On-Semiconductor | MBR0520LT1G |
| 9 | 2 | D3,D4 | TVS | SC-70 | On-Semiconductor | MMBZ27VAWT1G |
| 10 | 1 | D5 | NUP2105 | SOT_3DBZ | On-Semiconductor | NUP2105LT1G |
| 11 | 2 | JMP1,JMP2 | Header 1x4 | HDR_THVT_1X4_100 | Any | Any |
| 12 | 1 | L1 | CHOKE CM14 | SMD Choke | EPCOS | B82789C0104N002 |
| 13 | 2 | R1,R5 | 4.7k | 805 | Any | Any |
| 14 | 2 | R2,R6 | 0 | 805 | Any | Any |
| 15 | 2 | R3,R7 | 60 | 805 | Any | Any |
| 16 | 1 | R4 | 120 | 805 | Any | Any |
| 17 | 1 | TB1 | Terminal Block 1x2 | TB_THRTSCR_1x2_100 | Any | Any |
| 18 | 1 | T1 | T_Wurth_7603900xx | SMT | Wurth Electronics | 760390015 |
| 19 | 1 | U1 | SN6501 | SOT_5DBV | Texas Instruments | SN6501DBV |
| 20 | 1 | U2 | TPS76350 | SOT_5DBV | Texas Instruments | TPS76350DBV |
| 21 | 2 | U3,U7 | SN65HVD255 | SOIC_8D | Texas Instruments | SN65HVD255D |
| 22 | 1 | U4 | ISO7842 | SOIC_16DW | Texas Instruments | ISO7842DW |
| 23 | 1 | U5 | TPS22968 | DPU | Texas Instruments | TPS22968DPU |
| 24 | 1 | U6 | SN74AHCT1G04 | SOT_5DBV | Texas Instruments | SN74AHCT1G04DBV |

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