TI Designs

RS-232 Full Modem Interface (8-Wire) Module for Protection Relay, IED, and Substation Automation Reference Design

TI Designs

The worldwide electric-power infrastructure is a set of interconnected assets for power generation, transmission, conversion, and distribution commonly referred to as "the grid". Protection relays and IEDs (DTE) used in the grid measures a number of electrical parameters. These parameters are collected by automation systems for analysis. Data from the IEDs can be collected locally or remotely. For remote communication, modems (DCE) are used, which can be dial-up, GSM, or radio modems. Modems are interfaced to IEDs using an RS-232 interface. The RS-232 interface includes data, control, and status signals. Control and status signals can be hardware or software based. To maintain the data integrity in a noisy grid environment, galvanic isolation is provided between IEDs and modems. This TI design demonstrates the hardware flow control method for DTE or DCE. This TI design also demonstrates galvanic isolation between the modem and IEDs.

Design Resources

TIDA-00557	Design Folder
ISO7321C	Product Folder
ISO7341C	Product Folder
TRS3243E	Product Folder
TRSF3238E	Product Folder
SN6501	Product Folder
TPS7A6533	Product Folder

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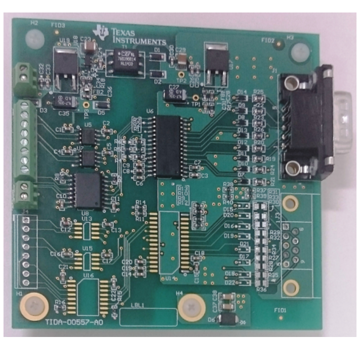
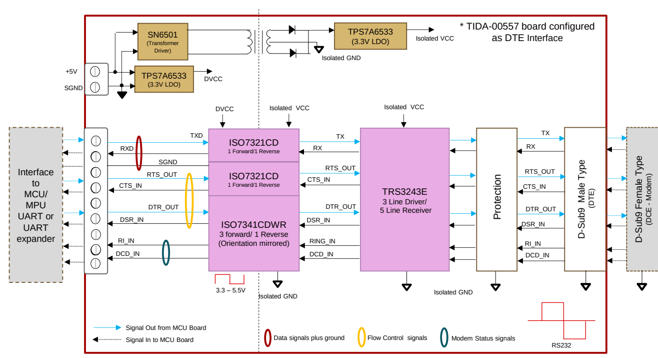
Design Features

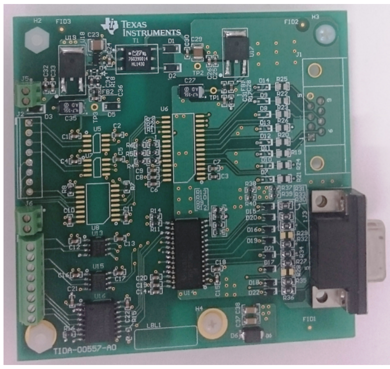
- Can be Configured as DTE or DCE Interface
- Galvanic Isolation Using Digital Isolators With Modular Options of 2-, 4-, or 8-Wire Interface
- Operates With Single 5.6-V Input
- 9-Pin D-Sub Connectors Provided for Easy Interface to External DTE or DCE
- Isolated Power Supply Generated Using SN6501 Transformer Driver
- Tested for the Following Data Rates: 1200, 2400, 4800, 9600, 19200, and 115000 bps
- Tested for ESD ±8-kV Contact Discharge
- Tested for Surge ±1-kV Common Mode

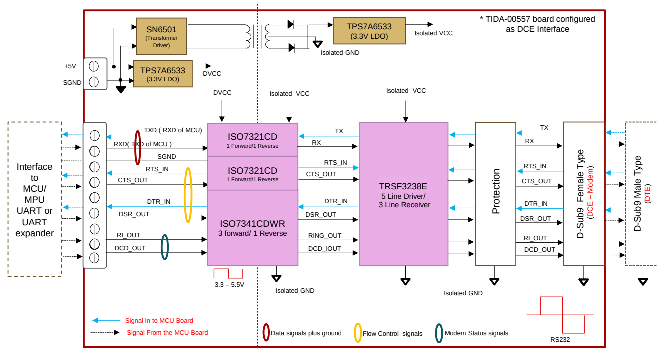
Featured Applications

- DTE Application
  - Data Concentrator, Substation Controllers, and Computers
  - RTU/DTU/FTU
  - Protection Relay or IEDs
  - Serial Servers
- DCE Application
  - GSM/GPRS and PSTN/DSL Modem
  - RF: LPR and Bluetooth Modules









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1 Key System Specifications

Table 1. Key System Specifications

SERIAL NUMBER	REQUIREMENTS	SPECIFICATIONS AND FEATURES
1	Transceiver for communication	• This design provides hardware for DTE or DCE interface • TRS3243E with 3 line drivers and 5 receivers for DTE interface • TRSF3238E with 5 line drivers and 3 receivers for DCE interface
2	Isolators for communication	• ISO7321CD — 1 forward / 1 reverse • ISO7341CDWR — 3 forward / 1 reverse-direction channels
3	Data transfer rate (Baud rate)	• 1200, 2400, 4800, 9600, 19200, and 115K
4	Configuration options	• The solution can be configured to function in different configurations as below for quick evaluation: – 2-wire interface (TXD, RXD) – 4-wire interface with hardware flow control (TXD, RXD, RTS, CTS) – 8-wire interface for full modem control (TXD, RXD, RTS, CTS , DTR, DSR, DCD, RI)
5	Isolated DC-DC converter	• Isolated power supply using SN6501
6	Power supply	• Non-isolated 3.3-V supply using LDO TPS7A6533QKVURQ1 • Isolated 3.3-V supply using LDO TPS7A6533QKVURQ1 and SN6501
7	Indication	• 1 LED for non-isolated 3.3-V
8	Interface	• Screw-type connectors • DB-9 plug connector for DTE interface • DB-9 socket connector for DCE interface • 2-, 8-pin 2.54-mm pitch connector for interface with MCU board
9	ESD protection	• IEC 61000-4-2: ±8-kV contact discharge
10	Surge protection	• IEC 61000-4-5: ±1.0 kV, common mode with respect to ground

2 System Description

This design provides an interface for a true RS-232 (eight signal+ground) physical layer interface for data terminal equipment (DTE) using a DB-9 plug-type connector with a provision for a data communication equipment (DCE) interface.

TI's RS-232 interface devices are commonly used in IEDs and protection relays. These devices generate their own higher voltage to drive the RS-232 and operate with 3.3 to 5.0 V.

TI's RS-232 devices also offer ESD protection up to ±15-kV air discharge as per IEC61000-4-2, higher data transfer rates, and auto-powerdown functionality that reduces power consumption significantly.

This design also shows galvanic isolation implementation between the MCU and RS-232 transceiver using TI digital isolators. This TI design also showcase small form factor isolated DC-DC converters using monolithic oscillator and power driver.

This TI design also shows a modular way of implementing the 2-wire RS-232 using TXD, RXD, and ground, 4-wire interface using TXD, RXD, RTS, CTS, and ground, and 8-wire RS-232 using TXD, RXD, RTS, CTS, DTR, DSR, DCD, RI, and ground using the DB-9 connector.

2.1 RS-232 Transceiver

This uses the TRS3243E RS-232 transceiver for DTE interfaces. The TRS3243E device consists of three line drivers, five line receivers, and a dual charge-pump circuit with ±15-kV ESD (HBM and IEC61000-4-2, air-gap discharge) and ±8-kV ESD (IEC61000-4-2, contact discharge) protection on serial-port connection pins. The device meets the requirements of TIA/EIA-232-F and provides the electrical interface between an asynchronous communication controller and the serial-port connector.

If this design has to be used for a DCE interface requirement, then the TRSF3238E interface section has to be populated alone along with power supply.

The TRSF3238E consists of five line drivers, three line receivers, and a dual charge-pump circuit with ±15-kV ESD (HBM) protection on the driver output (DOUT) and receiver input (RIN) terminals. The device meets the requirements of TIA/EIA-232-F.

2.2 Digital Isolators

The ISO7321C provides galvanic isolation up to 3000 V_{RMS} for one minute per UL and 4242 VPK per VDE. These devices have two isolated channels comprised of logic input and output buffers separated by silicon dioxide (SiO2) insulation barriers. The ISO7321C has the two channels in opposite direction.

The ISO7341C provides galvanic isolation up to 3000 V_{RMS} for one minute per UL and 4242 VPK per VDE. These devices have four isolated channels comprised of logic input and output buffers separated by a SiO2 insulation barrier. The ISO7341C has three forward and one reverse-direction channels.

2.3 Transformer Driver for Isolated Power Supply

The SN6501 Transformer Driver is used for generating isolated power. The SN6501 is a monolithic oscillator and power driver, specifically designed for small form factor, isolated power supplies in isolated interface applications.

2.4 LDO

The LDO TPS7A6533-Q1 is used in this design to generate 3.3 V for an isolated or non-isolated power supply.

3 Block Diagram

This design provides an interface for 2-, 4-, and 8-wire RS-232 interface for DTE and DCE. When used as DTE, components for DCE interface is not populated and vice versa.

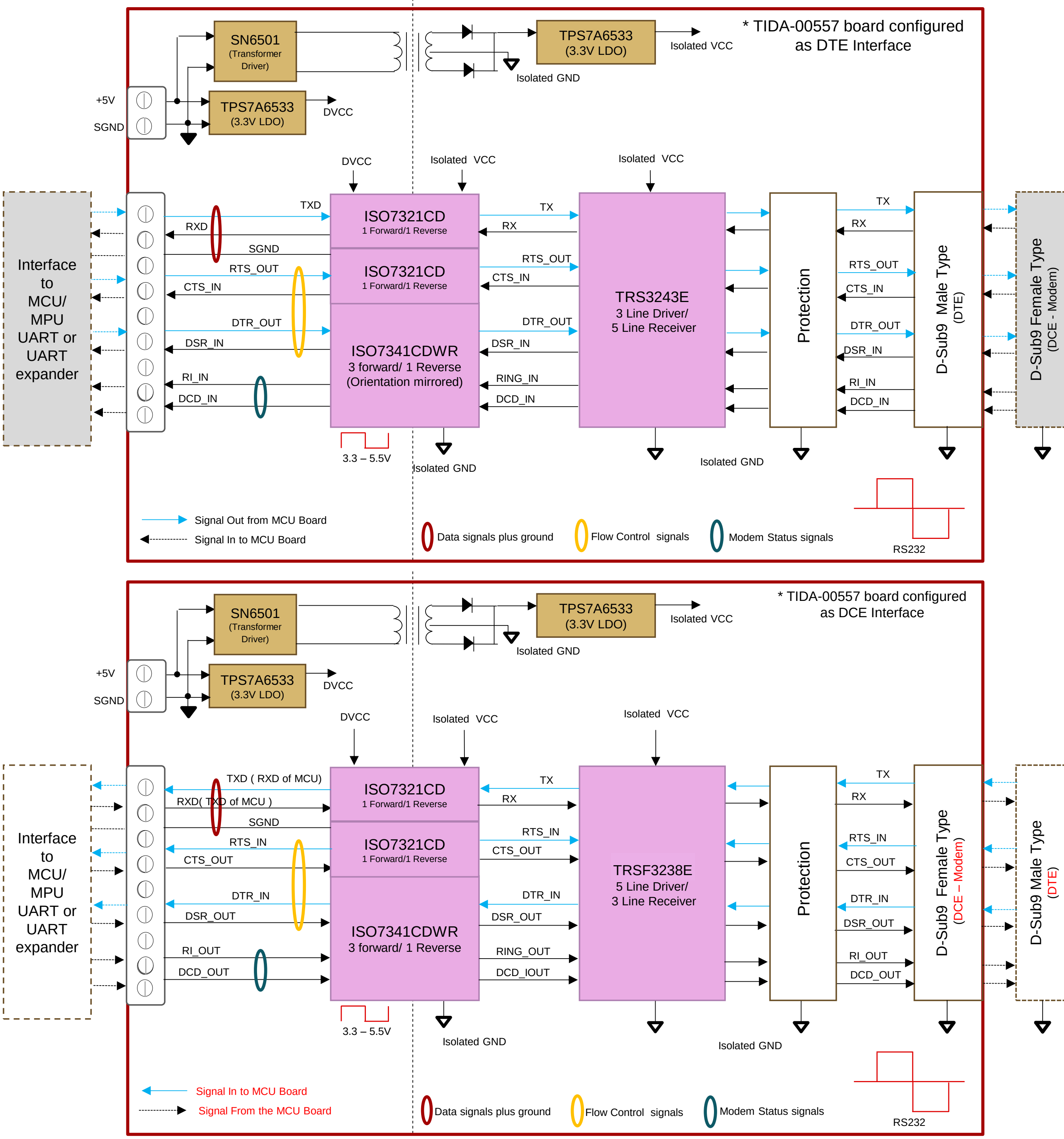


Figure 1. TIDA-00557 Block Diagram

3.1 Highlighted Products

3.1.1 TRS3243E

The TRS3243E device consists of three line drivers, five line receivers, and a dual charge-pump circuit with ±15-kV ESD (HBM and IEC61000-4-2, air-gap discharge) and ±8-kV ESD (IEC61000-4-2, contact discharge) protection on serial-port connection pins. The device meets the requirements of TIA/EIA-232-F and provides the electrical interface between an asynchronous communication controller and the serial-port connector. It has following features:

- Single-chip and single-supply interface for IBM™ PC/AT™ serial port
- ESD protection for RS-232 bus pins:
  - ±8-kV IEC61000-4-2, contact discharge
  - ±15-kV IEC61000-4-2, air-gap discharge
  - Meets or exceeds requirements of TIA/EIA-232-F and ITU v.28 standards
  - Operates with 3-V to 5.5-V VCC supply
  - Always-active non-inverting receiver output (ROUT2B)
  - Data rate of 500 kb/s for TRS3243E
  - Low standby current: 1 µA typical
  - External capacitors: 4 × 0.1 µF
  - Accepts 5-V logic input with 3.3-V supply
  - Designed to be interchangeable with industry standard 3243E devices
  - Serial-mouse driveability
  - Auto-powerdown feature to disable driver outputs when no valid RS-232 signal is sensed
  - Package options include plastic small-outline (DW), shrink small-outline (DB), and thin shrink small-outline (PW) packages

3.1.2 TRSF3238E

The TRSF3238E consists of five line drivers, three line receivers, and a dual charge-pump circuit with ±15-kV ESD (HBM) protection on the driver output (DOUT) and receiver input (RIN) terminals. The device meets the requirements of TIA/EIA-232-F and provides the electrical interface between notebook and sub-notebook computer applications. The charge pump and four small external capacitors allow operation from a single 3-V to 5.5-V supply. In addition, the device includes an always-active non-inverting output (ROUT1B), which allows applications using the ring indicator to transmit data while the device is powered down. It has following features:

- RS-232 bus-pin ESD protection exceeds ±15 kV using HBM
- Meets or exceeds the requirements of TIA/EIA-232-F and ITU v.28 standards
- Operates with 3-V to 5.5-V VCC supply
- Data rate of up to 1 Mbps
- Five drivers and three receivers
- Auto-power down plus feature enables flexible power-down mode
- Low standby current: 1 µA typical
- External capacitors: 4 × 0.1 µF
- Accept 5-V logic input with 3.3-V supply
- Always-active non-inverting receiver output (ROUT1B)
- ESD protection for RS-232 interface pins:
  - ±8-kV IEC61000-4-2, contact discharge
  - ±15-kV IEC61000-4-2, air-gap discharge

3.1.3 ISO7321C

The ISO7321C provides galvanic isolation up to 3000 V_{RMS} for one minute per UL and 4242 VPK per VDE. These devices have two isolated channels comprised of logic input and output buffers separated by SiO2 insulation barriers. The ISO7321C has the two channels in opposite direction. It has following features:

- Signaling rate: 25 Mbps
- Integrated noise filter on the inputs
- Default output "high" and "low" options
- Low power consumption — Typical ICC per channel at 1 Mbps:
  - ISO7320: 1.2 mA (5-V supplies), 0.9 mA (3.3-V supplies)
  - ISO7321C: 1.7 mA (5-V supplies), 1.2 mA (3.3-V supplies)
- Low propagation delay: 33 ns typical (5-V supplies)
- 3.3-V and 5-V level translation
- Wide temperature range: –40°C to 125°C
- 65 kV/μs transient immunity, typical (5-V supplies)
- Robust electromagnetic compatibility (EMC)
  - System-level ESD, EFT, and Surge immunity
  - Low emissions
- Isolation barrier life: > 25 years
- Operates from 3.3-V and 5-V supplies
- Narrow body SOIC-8 package
- Safety and regulatory approvals:
  - 4242 VPK isolation per DIN V VDE V 0884-10 and DIN EN 61010-1
  - 3000-V_{RMS} isolation for one minute per UL 1577
  - CSA component acceptance notice 5 A, IEC 60950-1 and IEC 61010-1 standards
  - CQC certification per GB4943.1-2011

3.1.4 ISO7341C

The ISO7341C provides galvanic isolation up to 3000 V_{RMS} for one minute per UL and 4242 VPK per VDE. These devices have four isolated channels comprised of logic input and output buffers separated by a SiO2 insulation barrier. The ISO7341C has three forward and one reverse-direction channels.

The ISO7341C has an integrated noise filter for harsh industrial environment where short noise pulses may be present at the device input pins. The ISO7341C has TTL input thresholds and operates from 3- to 5.5-V supply levels. Through innovative chip design and layout techniques, the EMC of the ISO7341C has been significantly enhanced to enable system-level ESD, EFT, Surge, and emissions compliance. It has following features:

- Signaling rate: 25 Mbps
- Integrated noise filter on the inputs
- Default output "high" and "low" options
- Low power consumption, typical ICC per channel at 1 Mbps:
  - ISO7341C: 1.2 mA (5-V supplies), 0.9 mA (3.3-V supplies)
- Low propagation delay: 31 ns typical (5-V supplies)
- 3.3-V and 5-V level translation
- Wide temperature range: –40°C to 125°C
- 70-kV/μs transient immunity, typical (5-V supplies)
- Robust EMC
  - System-level ESD, EFT, and Surge immunity
  - Low emissions
- Operates from 3.3-V and 5-V supplies
- Wide body SOIC-16 package

3.1.5 SN6501

The SN6501 is a monolithic oscillator and power driver, specifically designed for small form factor, isolated power supplies in isolated interface applications. It drives a low-profile, center-tapped transformer primary from a 3.3-V or 5-V DC power supply. The secondary can be wound to provide any isolated voltage based on transformer turns ratio. The SN6501 consists of an oscillator followed by a gate drive circuit that provides the complementary output signals to drive the ground-referenced, N-channel power switches. The internal logic ensures break-before-make action between the two switches. The SN6501 is available in a small SOT23-5 package, and is specified for operation at temperatures from –40°C to 125°C. It has following features:

- Push-pull driver for small transformers
- Single 3.3-V or 5-V supply
- High primary-side current drive:
  – 5-V supply: 350 mA (maximum)
  – 3.3-V supply: 150 mA (maximum)
- Low ripple on rectified output permits small output capacitors
- Small 5-pin SOT-23 package

3.1.6 TPS7A6533-Q1

The TPS7A6533-Q1 is a low-dropout linear voltage regulator designed for low power consumption and a quiescent current less than 25 µA in light-load applications. This device features integrated overcurrent protection and a design to achieve stable operation even with low-ESR ceramic output capacitors. It has following features:

- Low dropout voltage:
  – 300 mV at I_{OUT} = 150 mA
- 4-V to 40-V wide input voltage range with up to 45-V transients
- 300-mA maximum output current
- 25-µA (typical) ultra-low quiescent current at light loads
- 3.3-V and 5-V fixed output voltage with ±2% tolerance
- Low-ESR ceramic output stability capacitor
- Integrated fault protection
  – Short-circuit and overcurrent protection
  – Thermal shutdown
- Low-input voltage tracking
- Thermally enhanced power package
  – 3-pin TO-252 (KVU/DPAK)

4 System Design Theory

The following section describes the RS-232 physical layer interface in general and the implementation of the RS-232 interface with galvanic isolation using TI devices.

4.1 Introduction to RS-232 Communication and Digital Isolation

The worldwide electric-power infrastructure is a set of interconnected assets for power generation, transmission, conversion, and distribution commonly referred to as "the grid". Protection relays and IEDs (DTE) used in the grid measures a number of electrical parameters. These parameters are collected by automation systems for analysis. Data from the IEDs can be collected locally or remotely. For remote communication, modems (DCE) are used, which can be dial-up, radio, or GSM modems. Modems interface to IEDs using an RS-232 interface. The RS-232 interface includes data, control, and status signals. To maintain the data integrity in noisy grid environments, galvanic isolation is preferred between IEDs and modems. This TI design demonstrates the hardware flow control method for DTE or DCE. This TI design also demonstrates galvanic isolation between the internal signal processing system and the external world using digital isolators.

4.1.1 Serial Communication Using RS-232

The RS-232 interface is used as a standard communication interface involving modem communication between the two devices or equipment.

The RS-232 interface is the Electronic Industries Association (EIA) standard for the interchange of serial binary data between two devices. It was initially developed by the EIA to standardize the connection of computers with telephone line modems. This standard defines both the electrical and functional characteristics of the various serial interface circuits.

TIA/EIA-232-F Industry Standard for Data Transmission

The EIA introduced the 232 standard in 1962 in an effort to standardize the interface between DTE and DCE. The DTE comprises the data source, data link, or both. The DCE provides the functions to establish, maintain, and terminate a connection, and to code or decode the signals between the DTE and the data channel. Although an emphasis then was placed on interfacing between a modem unit and DTE, other applications were quick to adopt the 232 standard. The growing use of the personal computer (PC) quickly ensured that 232 became the industry standard for all low-cost serial interfaces between the DTE and peripheral. The mouse, plotter, printer, scanner, digitizer, and tracker ball, in addition to the external modems and test equipment, are all examples of peripherals that connect to a 232 port. Using a common standard allows widespread compatibility, plus a reliable method for interconnecting a PC to peripheral functions.

The EIA RS-232-C standard, revised in 1969, was superseded by EIA-232-D (1986). The EIA-232-D again was superseded by TIA/EIA-232-E, which brings it in line with ITU V.24, V.28, and ISO IS2110. This revision includes an update on the rise-time to unit-interval ratio and reverses the changes made by the D revision (see Figure 2). Although an older standard with problems such as high noise susceptibility, low data rates, and very limited transmission length, 232 fulfills a vital need as a low-cost communication system. Consequently, new products are being developed at a faster rate than ever. The most recent revision is the TIA/EIA-232-F, which does not have any technical changes that will create compatibility problems with equipment conforming to previous revisions of TIA/EIA-232. This latest version brings it in line once again with international standards ITU-T V.24, V.28, and ISO/IEC 2110.

TIA/EIA-232-F Electrical Specification

All RS-232 circuits carry voltage signals with the voltage at the connector pins not to exceed ±25 V. All pins must be able to withstand a short circuit to any other pin without sustaining permanent damage. Each line should have a minimum load of 3 kΩ and a maximum load of 7 kΩ, which usually is part of the receiver circuit. A logic of 0 is represented by a driven voltage between 5 V and 15 V and a logic of 1 between –5 V and –15 V. At the receiving end, a voltage between 3 V and 15 V represents a 0 and a voltage of between –3 V and –15 V represents a 1. Voltages between ±3 V are undefined and lie in the transition region. This effectively gives a 2-V minimum noise margin at the receiver. The maximum cable length originally was defined in RS-232-C as 15 meters; however, this has been revised in EIA-232-D and TIA/EIA-232-E and is now specified more correctly as a maximum capacitive load of 2500 pF. This equates to about 15 to 20 meters of line length, depending on cable capacitance.

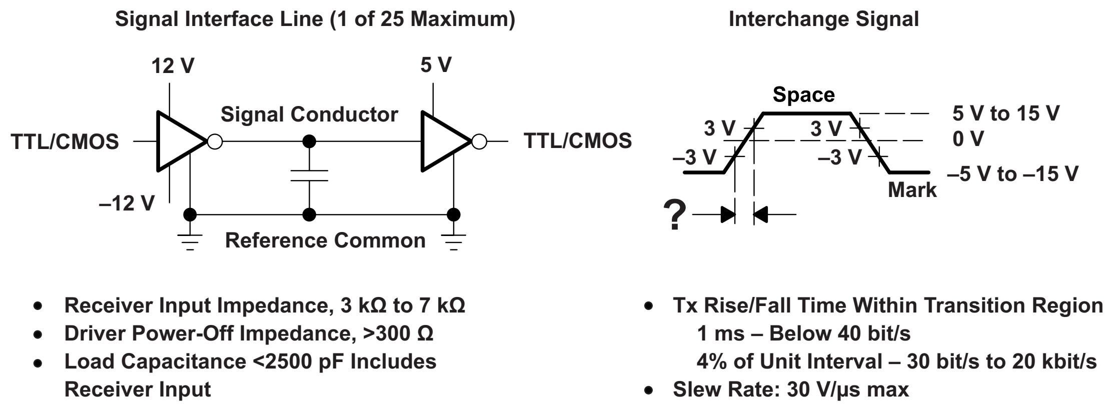


Figure 2. RS-232-F Electrical Specification

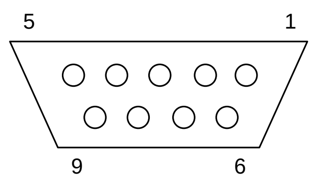
The RS-232 specifies a maximum slew rate of the signal at the output of the driver to be 30 V/µs. This limitation is concerned with the problem of crosstalk between conductors in a multi-conductor cable. The faster the transition edge, the greater the amount of crosstalk. This restriction, together with the fact that the drivers and receivers use a common signal ground and the associated noise introduced by the ground current, severely limits the maximum data throughput.

One can extrapolate this further by using the 4% figure. With the maximum slew rate of 30 V/µs, the maximum achievable data rate is 200 kbps; however, in practice, this is limited to around 120 kbps. A number of software programs operate at transfer rates of 116 kbps. Furthermore, over longer line lengths, the maximum drive current of the line driver becomes the dominant feature affecting data rate, displacing the 30-V/µs slew rate. As the line length increases, the load capacitance also increases, requiring more current to maintain the same transition time.

TIA/EIA-232-F Mechanical Specification

The RS-232 standard supports two types of connectors: a 25-pin D-type connector (DB-25) and a 9-pin D-type connector (DB-9). Figure 3 shows the pin diagram of the DB-9 connector, which is also used in the current TI design.

DB-9 Connector:



1. Data Carrier Detect (CD)
2. Receive Data (RD)
3. Transmit Data (TD)
4. Data Terminal Ready (DTR)
5. Ground
6. Data Set Ready (DSR)
7. Request To Send (RTS)
8. Clear To Send (CTS)
9. Ring Indicator (RI)

Figure 3. DB-9 Connector Pin Details

Although RS-232 specifies a 25-pin connector, this connector is often not used. Most applications do not require all the defined signals, so a 25-pin connector is larger than necessary. The most popular connector is the 9-pin DB9 connector, which provides the necessary signals for the serial communication in modem applications. Table 2 contains the functional details of all eight signals used with the DB-9 connector. RS-232 signals have a direction (in or out) depending on whether they are with respect to a DTE or a DCE.

Table 2. RS-232 Signal Details

DB-9 PIN NO	SIGNAL	TYPE	DIRECTION	FUNCTION
1	CD	Control	DCE to DTE	Determines whether the DCE is connected to a working phone line or not (only used in connection with modem).
2	TD	Data	DTE to DCE	Computer (DTE) sends information to the DCE.
3	RD	Data	DCE to DTE	Computer (DTE) receives information sent from the DCE.
4	DTR	Control	DTE to DCE	Computer (DTE) tells the DCE that it is ready to communicate. Raised by DTE when powered on. In auto-answer mode raised only when RI arrives from DCE.
5	SG	Ground	—	Signal ground
6	DSR	Control	DCE to DTE	Modem (DCE) tells the computer that it is ready to talk. Raised by DCE to indicate ready.
7	RTS	Control	DTE to DCE	Computer (DTE) asks the modem if it can send information. Raised by DTE when it wishes to send. Expects CTS from DCE.
8	CTS	Control	DCE to DTE	Modem (DCE) tells the computer (DTE) that it can send information. Raised by DCE in response to RTS from DTE.
9	RI	Control	DCE to DTE	Set when incoming ring detected, used for auto-answer application. DTE raises DTR to answer (only used in connection with modem).

TIA/EIA-232-F Handshaking Options

Connections and Signal Flow Control

Flow control is the process of managing the rate of data transmission between two nodes to prevent a fast sender from over running a slow receiver. For example, as DTE-to-DCE speed is a few times faster than DCE-to-DTE speed, the PC can send data to the modem at a higher rate. That means in this connection sooner or later the data may be lost because of the buffers overflow, so the control of data flow should be realized.

Flow control mechanisms can be classified by whether or not the receiving node sends feedback to the sending node. That is through a "handshake", an exchange of characters between a transmitter and a receiver is used to postpone transmission until the receiver is ready to receive the data. This character flow control is of two main types: Software and hardware.

Software Flow Control

One example is "Xon/Xoff". The two characters Xon and Xoff are used control the data flow. Xon is usually 17 characters, and Xoff is 19 characters. The modem will only have a small buffer. When the computer fills it, the modem sends an Xoff character to inform the computer about data transfer termination. As soon as the modem empties most of the memory for data, it will send the Xon character to the computer and start the data transfer again. The main advantage of this type of data flow control is that it does not need any other wires as the characters are sent through TD/RD lines. But if the connection is slow, every character needs 10 bits, which can reduce the connection speed.

Hardware Flow Control

Most serial communications uses software flow control, but there is an alternative: hardware handshaking. Hardware flow control is also known as RTS/CTS flow control. To realize this control, two additional wires (RTS and CTS) in the sequential cable are used. This results in increasing the data transmission rate, as no time is spent for Xon-Xoff characters transmission

Null Modem Connections

The serial communication standards show the use of DTE/DCE communication, the way a computer should communicate with a peripheral device like a modem. But in a null modem connection, the PCs are connected back-to-back with cables, each acting as a DTE, which means there is no DCE in this case. This type of connection finds many uses. The null modem can be configured in many ways using the number of signal lines available. In most situations, the original modem signal lines are reused to perform some sort of handshaking.

Handshaking has many advantages. It can increase the maximum allowed communication speed because then the computer will be able to control the flow of information. In a null modem connection without "flow control", the communication may be possible only at the speed at which the receiving side can handle the amount of data.

Used in null modem connections, there are different types of flow control signals used in RS-232. The first two flow control pins are known as request to send (RTS), an output signal from the DTE that comes as the input for the DCE, and clear to send (CTS), which comes as the answering signal from the DCE side. Before sending a character, the DTE asks permission by setting its RTS output. No information will be sent until the DCE grants permission by making the CTS line high.

The other two flow control signals, data terminal ready (DTR) and data set ready (DSR), are used to signal the status of one communication side to the other. The DTE uses the DTR signal to signal that it is ready to accept information, whereas the DCE uses the DSR signal for the same purpose. The last flow control signal present in DTE/DCE communication is the CD carrier detect. It is not used directly for flow control, but indicates the existence of a communication link between two modem devices.

4.1.2 Isolated Communication

Computer and industrial serial interfacing are areas where noise can seriously affect the integrity of data transfer. A tested method of improving noise performance for any interface circuit is galvanic isolation. Isolation in data communication systems is achieved without a direct galvanic connection (wires) between drivers and receivers. Magnetic linkage from transformers provides the power for the system, and TI's capacitively-coupled digital isolators provide the data connection. Galvanic isolation removes ground-loop currents, and the resulting noise voltage that corrupts data is eliminated. Also, common-mode noise effects and many forms of radiated noise can be reduced to negligible limits using this technique.

Unwanted currents and voltages on a cable bus connecting multiple systems could potentially cause severe problems. High voltages and currents can destroy components connected to the bus. These unwanted voltages and currents come primarily from two sources: ground loops and electrical line surges.

Ground loops occur when a bus or system uses multiple ground paths. It cannot be assumed that two system grounds connected to the bus and separated by hundreds or thousands of meters will be at the same potential. These grounds are unlikely to be at the same potential; current will flow between these points. This unintended current flow can damage or destroy components.

Electrical surges can be caused by many sources, the result of currents coupled onto cable lines through induction. Long cable lines in industrial environments are especially susceptible to this phenomena. The operation of electric motors, in particular, causes rapid changes in the ground potential. These changes can generate a current flow through any nearby lines to equalize the ground potential.

Other induction surge sources include electrostatic discharge (ESD) and lightning strikes. These induced surges can result in hundreds, or even thousands of volts of potential on the line, and manifest themselves as transient current and voltage surges. Therefore, a remote node may receive a 5-V switching signal superimposed on a high voltage level with respect to the local ground. These uncontrolled voltages and currents can corrupt the signal and be catastrophic to the device and system, causing damage or destruction of the components connected to the bus and resulting in system failure.

RS-232 systems that run over long distances and connect multiple systems are especially susceptible to these events. To protect against this potentially destructive energy, all devices on the bus and systems connected to the bus must be referenced to only one ground. Isolating the RS-232 system devices from each of the systems connected to the bus prevents ground loops and electrical surges from destroying circuits. Isolation prevents ground loops, as each system connected to RS-232 cable bus, and each RS-232 circuit, has a separate and isolated ground. By referencing each RS-232 circuit only to one ground, ground loops are eliminated.

Isolation also allows the RS-232 circuit reference voltage levels to rise and fall with any surges that appear on the cable line. Allowing the circuit voltage reference to move with surges, rather than being clamped to a fixed ground, prevents devices from being damaged or destroyed. To accomplish system isolation, both the RS-232 signal lines and power supplies must be isolated. Power isolation is obtained through the use of an isolated DC-to-DC power supply. Signal isolation is typically accomplished with opto-couplers or with TI digital isolators.

Isolated Communication Implementation

RS-232 system signal path isolation is accomplished by designing isolators into the digital signal path between the RS-232 driver and receiver and the local system. The isolator contains input and output circuits electrically isolated from one another. To complete the isolation of the RS-232 circuits from the local system, a DC-to-DC isolated power converter is required. The isolated power supply supplies power to the local RS-232 driver, receiver, and RS-232 side of the isolator. The isolated power supply is typically supplied from the local system. The combination of digital isolators and an isolated DC-to-DC power supply creates an effective protection against surge damage and eliminates ground loops

Isolation Device Selection

System performance requirements have the most impact on the selection of an isolation device. Other considerations include space constraints and cost.

Data Rate Requirements

System data rate requirements are often the single most important parameter for device selection. If the RS-232 network runs at a lower data rate speed, there are more possible device selection options.

Device costs typically rise in proportion to data rate performance. Therefore, a designer should take care not to specify a device with more performance than is required. However, a low-performance device selection can make future system performance upgrades more costly and involved, as all devices incompatible with upgraded system data speeds will require replacement.

Space Requirements

Space constraints are a second area of concern that can limit a designer’s choices. Maximum dimension requirements are a concern for virtually all applications. Some implementations can be severely space limited.

Cost Requirements

Cost constraints and concerns are a reality in virtually all system design work. Cost considerations can have an effect on the design choices for a system. As noted above, isolator device cost rises in proportion with data rate performance. Specifying a device with only the system performance required can reduce costs. Other cost issues include a consideration of the number of devices used. Additional cost benefits of integrating as many channels into one device include reducing board space and assembly costs. A lower device count results in smaller boards. Also, a lower device count typically results in a less complex board layout. The combination of smaller boards and less complex layout reduces board costs. In addition, circuit board assembly costs typically decrease proportionally as the number of devices required for the board assembly process decreases, thus designing with fewer devices results in lower manufacturing costs.

Reliability

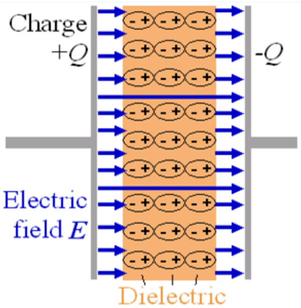
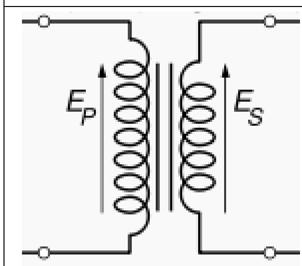
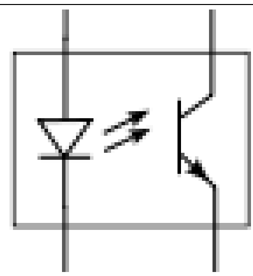
Mean time to failure (MTTF) is a standard measure for reliability of semiconductor devices. For digital isolators, this measure represents the reliability of both the integrated circuit and the isolation mechanism. Table 3 shows the MTTF of an optical, inductive, and capacitive digital isolator. The ISO7xxx series is very reliable when compared to inductive and optical solutions.

Table 3. MTTF Reliability Measurements

PART	COUPLING TECHNOLOGY	AMBIENT TEMPERATURE (°C)	TYPICAL, 60% CONFIDENCE		TYPICAL, 90% CONFIDENCE	
			MTTF (HR/FAIL)	FITs (FAIL/10^9 HR)	MTTF (HR/FAIL)	FITs (FAIL/10^9 HR)
ISO721	Capacitive	125	1,246,889	802	504,408	1983
HCPL-0900	Inductive	125	288,118	3471	114,654	8722
HCPL-0721	Optical	125	174,617	5727	69,487	14,391

Key Methods of Isolation

Table 4. Key Methods of Isolation

	SiO2: ISO72x; Typical BV is V_{PEAK}/µm • Inorganic • Highly stable (over temperature, moisture, time), high quality • Used extensively and for a long time as dielectric in semiconductor (low defunct rates) • Deposited in a controlled semiconductor process
	Polymide: ADI transformer core; Typical BV is 250 V_{PEAK}/µm • Organic • Retains moisture — affects lifetime especially at high voltages • Used in semiconductor mainly for stress relief and now as isolation barrier
	Epoxy: Opto-couplers; Typical BV is 50 V_{PEAK}/µm • Uses filler materials • Leaky (higher partial discharge) • Applied at packaging as mold compound • Voids and anomalies are common

Comparison

Table 5. Reliability Analysis of Different Isolation Methods

PARAMETER	OPTO	MAGNETIC	CAPACITIVE
Signaling rate (Mbps)	50	150	150
Propagation delay time (ns)	20	32	12
Pulse width distortion (ns)	2	2	1.5
Channel-to-channel skew (ns)	16	2	1.6
Part-to-part skew (ns)	20	10	2
ESD on all pins (kV)	±2	±2	±4
CM transient immunity (kV/µs)	20	25	25
Temperature (°C)	–45 to 125	–40 to 125	–55 to 125
MTTF @ 125°C, 90% confidence (years)	8	1746	2255
FIT @ 125°C, 90% confidence	14391	65	50
Magnetic immunity @ 1 kHz (Wb/m^2)	—	10^2	10^8
Radiated electromagnetic-field immunity IEC61000-4-3 (80 to 1000 MHz) MIL-STD 461E RS103 (30 to 1000 MHz)	 — —	 Fails Fails	 Compiles Compiles
High-voltage lifetime expectancy (years)	< 5	< 10	> 28

5 Design Implementation

This TI design has been configured as a DTE interface with an 8-wire true RS-232 interface. This board can be also configured as a DCE interface. Either a DTE or DCE interface can be used at a time with components for the alternative interface un-populated on the PCB.

5.1 DTE: RS-232 Physical Layer Interface Implementation

The TRS3243E device consists of three line drivers, five line receivers, and a dual charge-pump circuit with ±15-kV ESD (HBM and IEC61000-4-2, air-gap discharge) and ±8-kV ESD (IEC61000-4-2, contact discharge) protection on serial-port connection pins. The device meets the requirements of TIA/EIA-232-F and provides the electrical interface between an asynchronous communication controller and the serial-port connector. This combination of drivers and receivers matches that needed for the typical serial port used in an IBM PC/AT or compatible. The charge pump and four small external capacitors allow operation from a single 3-V to 5.5-V supply. In addition, the device includes an always-active non-inverting output (ROUT2B), which allows applications using the ring indicator to transmit data while the device is powered down. The device operates at data signaling rates up to 500 kb/s and a maximum of 30-V/µs driver output slew rate.

Flexible control options for power management are available when the serial port is inactive. The auto-powerdown feature functions when FORCEON is low and FORCEOFF is high. During this mode of operation, if the device does not sense a valid RS-232 signal, the driver outputs are disabled. If FORCEOFF is set low, both drivers and receivers (except ROUT2B) are shut off, and the supply current is reduced to 1 µA. Disconnecting the serial port or turning off the peripheral drivers causes the auto-powerdown condition to occur.

Auto-powerdown can be disabled when FORCEON and FORCEOFF are high and should be done when driving a serial mouse. With auto-powerdown enabled, the device is activated automatically when a valid signal is applied to any receiver input. The INVALID output is used to notify the user if an RS-232 signal is present at any receiver input. INVALID is high (valid data) if any receiver input voltage is greater than 2.7 V or less than –2.7 V or has been between –0.3 V and 0.3 V for less than 30 µs. INVALID is low (invalid data) if all receiver input voltages are between –0.3 V and 0.3 V for more than 30 µs.

5.1.1 Functional Diagram

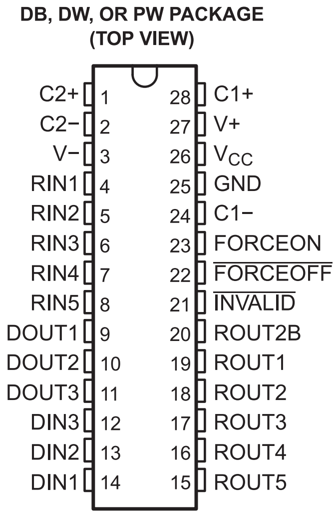


Figure 4. TRS3243E Package Details

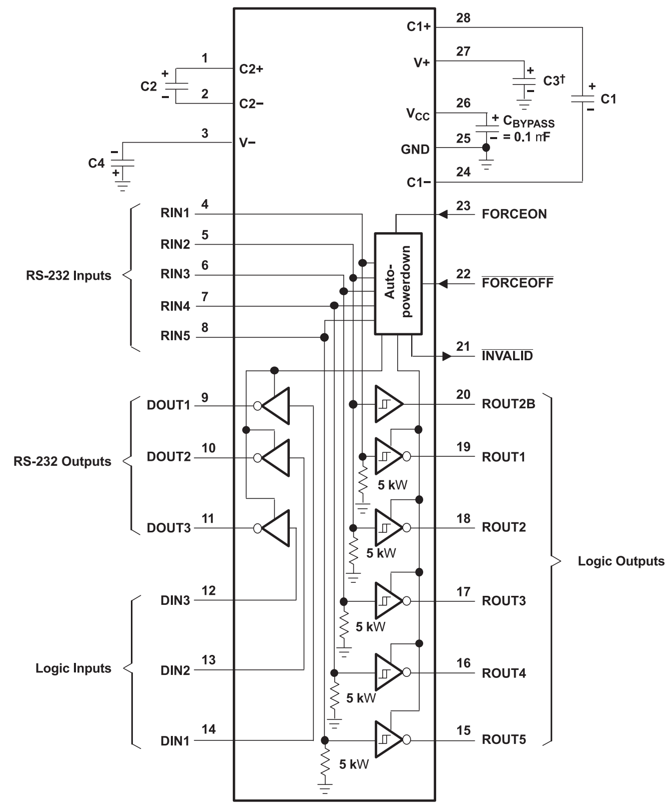


Figure 5. TRS3243E Functional Diagram

5.1.2 Charge Pump Capacitor Requirements

Table 6. Charge Pump Capacitor Values for Different VCC Inputs

VCC	C1	C2, C3, AND C4
3.3 V ±0.3 V 5 V ±0.5 V 3 to 5.5 V	0.1 µF 0.047 µF 0.1 µF	0.1 µF 0.33 µF 0.47 µF

5.1.3 DTE Transceiver

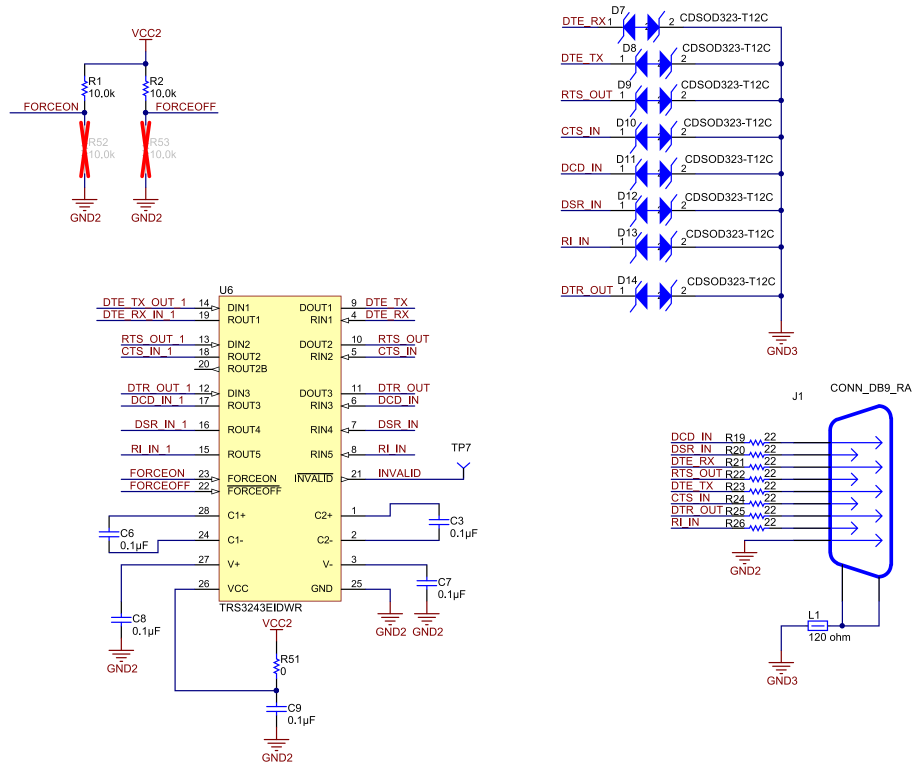


Figure 6. TRS3243E DTE Connections

5.1.4 Power Down Modes

Table 7. Each Driver(1)

INPUTS				OUTPUT	DRIVER STATUS
DIN	FORCEON	$\overline{\text{FORCEOFF}}$	VALID RIN RS-232 LEVEL	DOUT	
X	X	L	X	Z	Powered off
L H	H H	H H	X X	H L	Normal operation with auto-powerdown disabled
L H	L L	H H	Yes Yes	H L	Normal operation with auto-powerdown enabled
X	L	H	No	Z	Powered off by auto-powerdown feature

(1) H = high level, L = low level, X = irrelevant, Z = high impedance

Table 8. Each Receiver(1)

INPUTS			OUTPUT	DRIVER STATUS
RIN	FORCEON	$\overline{\text{FORCEOFF}}$	ROUT	
X	X	L	Z	Powered off
L	X	H	H	Normal operation with auto-powerdown disabled and enabled
H	X	H	L	
Open	X	H	H	

(1) H = high level, L = low level, X = irrelevant, Z = high impedance (off), Open = input disconnected or connected driver off

Power down modes can be controlled by R1, R2 and R52, R53. No separate signals from the MCU are given for this purpose.

5.2 DCE: RS-232 Physical Layer Interface Implementation

The TRSF3238E consists of five line drivers, three line receivers, and a dual charge-pump circuit with ±15-kV ESD (HBM) protection on the driver output (DOUT) and receiver input (RIN) terminals. The device meets the requirements of TIA/EIA-232-F and provides the electrical interface between notebook and sub-notebook computer applications. The charge pump and four small external capacitors allow operation from a single 3-V to 5.5-V supply. In addition, the device includes an always-active non-inverting output (ROUT1B), which allows applications using the ring indicator to transmit data while the device is powered down. The TRSF3238E operates at data signaling rates up to 1000 kbps.

Flexible control options for power management are featured when the serial port and driver inputs are inactive. The auto-powerdown plus feature functions when FORCEON is low and FORCEOFF is high. During this mode of operation, if the device does not sense valid signal transitions on all receiver and driver inputs for approximately 30 s, the built-in charge pump and drivers are powered down, reducing the supply current to 1 µA. By disconnecting the serial port or placing the peripheral drivers off, auto-powerdown plus occurs if there is no activity in the logic levels for the driver inputs. Auto-powerdown plus can be disabled when FORCEON and FORCEOFF are high. With auto-powerdown plus enabled, the device activates automatically when a valid signal is applied to any receiver or driver input. INVALID is high (valid data) if any receiver input voltage is greater than 2.7 V or less than –2.7 V, or has been between –0.3 V and 0.3 V for less than 30 µs. INVALID is low (invalid data) if all receiver input voltages are between –0.3 V and 0.3 V for more than 30 µs.

5.2.1 Functional Diagram

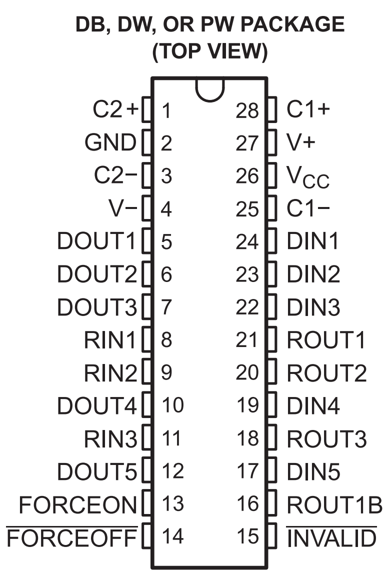


Figure 7. TRSF3238E Package Details

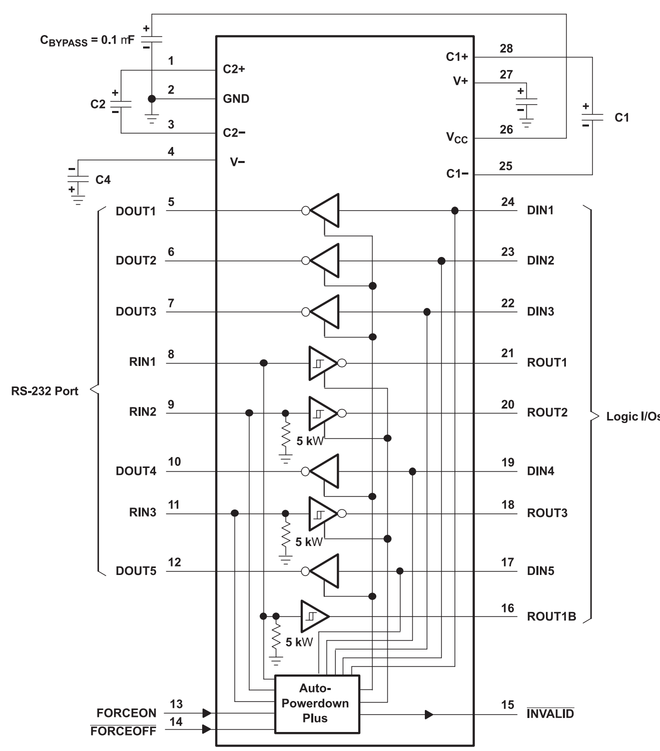


Figure 8. TRSF3238E Functional Diagram

5.2.2 DCE Transceiver

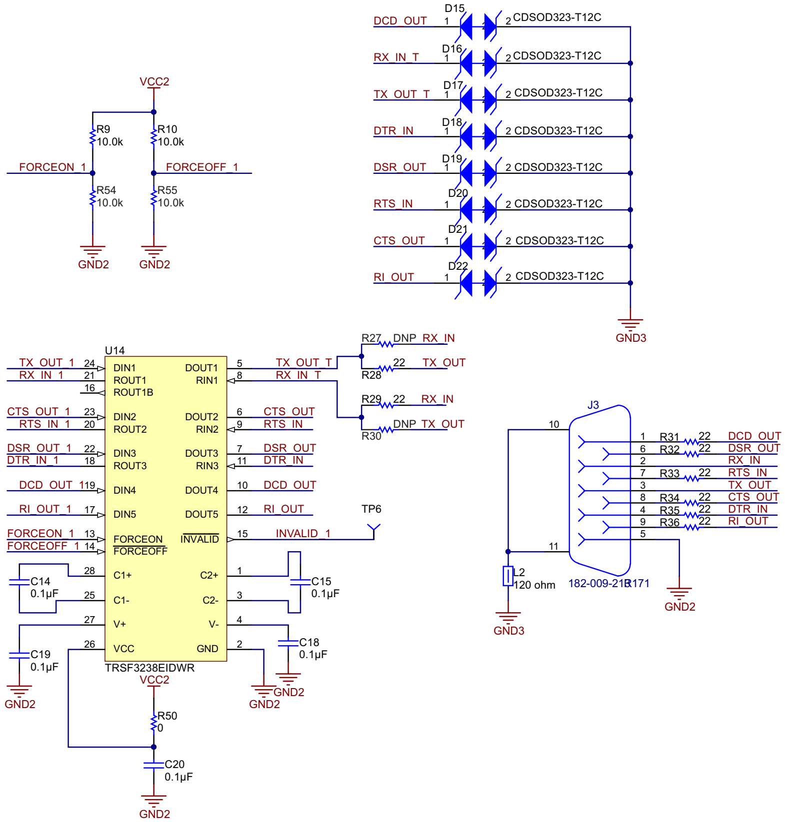


Figure 9. TRSF3238E DCE Implementation

5.2.3 Power Down Modes

Table 9. Each Driver

INPUTS				OUTPUT	DRIVER STATUS
DIN	FORCEON	$\overline{\text{FORCEOFF}}$	TIME ELAPSED SINCE LAST RIN OR DIN TRANSITION	DOUT	
X	X	L	X	Z	Powered off
L H	H H	H H	X X	H L	Normal operation with auto-powerdown plus disabled
L H	L L	H H	< 30 s < 30 s	H L	Normal operation with auto-powerdown plus enabled
L H	L L	H H	> 30 s > 30 s	Z Z	Powered off by auto-powerdown plus feature

Power down modes can be controlled by R9, R10 and R54, R55. No separate control signals are provided for this purpose.

5.3 Digital Isolators

Galvanic isolation between the MCU and external interface is implemented using digital isolators. Digital isolators are arranged for modular implementation of a 2-, 4-, and 8-wire interface.

5.3.1 Implementation for 2- and 4-Wire Interface

Implementing a 2-wire interface requires Rx and Tx signals whereas a 4-wire interface requires Rx and Tx signals as well as RTS and CTS signals. For implementing 2-wire and 4-wire interfaces, the ISO7321C digital isolator is used.

The ISO7321C provides galvanic isolation up to 3000 V_{RMS} for one minute per UL and 4242 VPK per VDE. These devices have two isolated channels comprised of logic input and output buffers separated by SiO2 insulation barriers. The ISO7321C has the two channels in opposite directions.

5.3.1.1 Functional Diagram

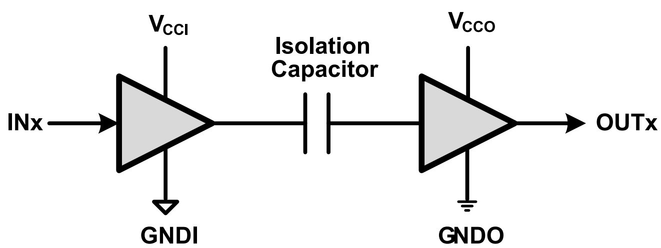


Figure 10. ISO7321C Functional Diagram

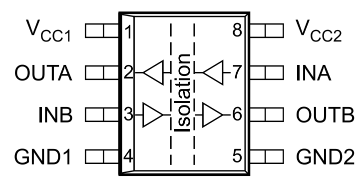


Figure 11. ISO7321C Package Details

Table 10. Pin Functions ISO7321C

PIN		I/O	DESCRIPTION
NAME	ISO7321C		
INA	7	I	Input, channel A
IBN	3	I	Input, channel B
GND1	4	—	Ground connection for V_{CC1}
GND2	5	—	Ground connection for V_{CC2}
OUTA	2	O	Output, channel A
OUTB	6	O	Output, channel B
V_{CC1}	1	—	Power supply, V_{CC1}
V_{CC2}	8	—	Power supply, V_{CC2}

5.3.2 Implementation for 8-Wire Interface

To implement the 8-wire interface, all eight signals are used. To meet the modularity requirement, four signals are galvanically isolated using the two-way digital isolator ISO7321CD, and the remaining four signals use the ISO7341C.

The ISO7341C provides galvanic isolation up to 3000 V_{RMS} for one minute per UL and 4242 VPK per VDE. These devices have four isolated channels comprised of logic input and output buffers separated by a SiO2 insulation barrier. The ISO7340 has four channels in forward direction; the ISO7341C has three forward and one reverse-direction channels.

The ISO7341C has an integrated noise filter for harsh industrial environment where short noise pulses may be present at the device input pins. The device has TTL input thresholds and operates from 3- to 5.5-V supply levels. Through innovative chip design and layout techniques, the EMC of the ISO7341C has been significantly enhanced to enable system-level ESD, EFT, Surge, and emissions compliance.

5.3.2.1 Functional Diagram and Details

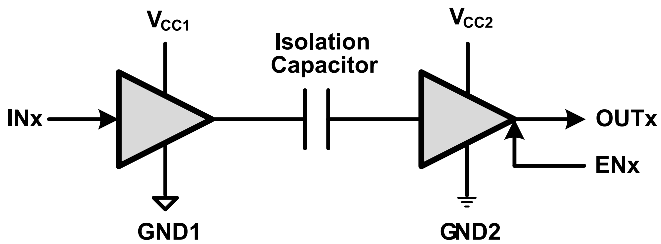


Figure 12. Functional Diagram for ISO7341C

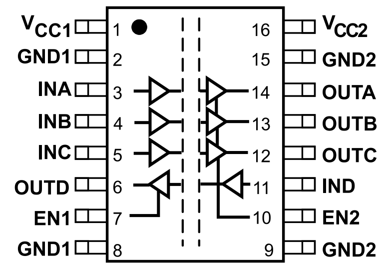


Figure 13. ISO7341C Pin Details

Table 11. Pin Functions ISO7341C

PIN		I/O	DESCRIPTION
NAME	ISO7341C		
INA	3	I	Input, channel A
INB	4	I	Input, channel B
INC	5	I	Input, channel C
IND	11	I	Input, channel D
OUTA	14	O	Output, channel A
OUTB	13	O	Output, channel B
OUTC	12	O	Output, channel C
OUTD	6	O	Output, channel D
EN1	7	I	Output enable 1. Output pins on side-1 are enabled when EN1 is high or disconnected and disabled when EN1 is low.
EN2	10	I	Output enable 2. Output pins on side-2 are enabled when EN2 is high or disconnected and disabled when EN2 is low.
EN	—	I	Output enable. All output pins on are enabled when EN is high or disconnected and disabled when EN is low.
V_{CC1}	1	—	Power supply, V_{CC1}
V_{CC2}	16	—	Power supply, V_{CC2}
GND1	2, 8	—	Ground connection for V_{CC1}
GND2	9, 15	—	Ground connection for V_{CC2}
NC	—	—	No connect pins are floating with no internal connection.

5.3.3 Isolators for DTE Interface

For the DTE interface, the ISO7341C is used with its placement mirrored compared to the DCE interface.

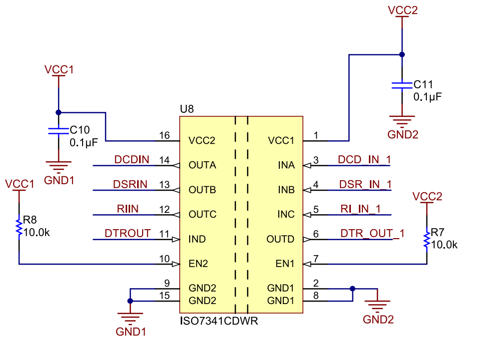


Figure 14. Isolation for Control and Status Signals in DTE Interface

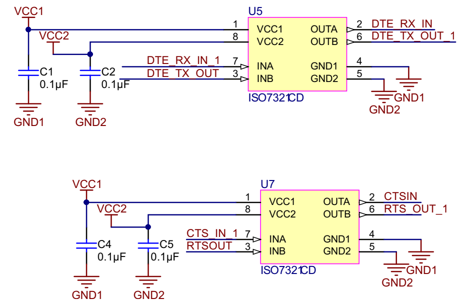


Figure 15. Isolation for Data and Control (2- and 4-Wire) DTE Interface

5.3.4 Isolators for DCE Interface

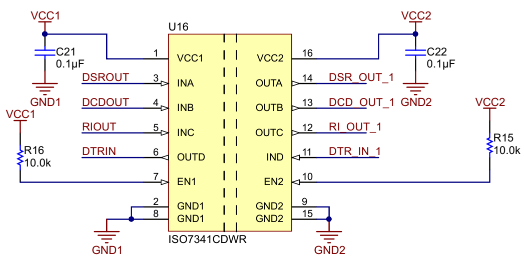


Figure 16. Isolation for Control and Status Signals in DCE Interface

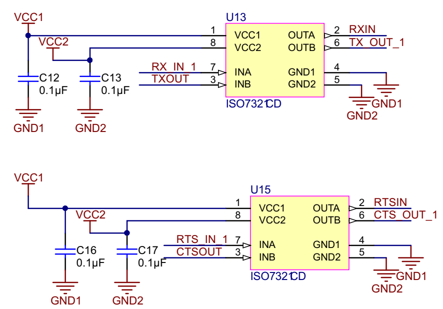


Figure 17. Isolation for Data and Control (2- and 4-Wire) DCE Interface

5.3.5 Configuring the Board for DTE or DCE

This TI design provides for both the DTE and DCE interface. The board can be configured as either DCE or DTE. Follow the instructions in Table 12 to configure the board as DTE or DCE.

Table 12. Configuration for DTE and DCE

CONFIGURATION	POPULATE	DO NOT POPULATE
DTE	U5, U7, U8 AND U6	U13, U15 U16 AND U14
DCE	U13, U15 U16 AND U14	U5, U7, U8 AND U6

5.4 Power Supply

The power supply is implemented in two stages. The input of 5.6 V is applied at the power supply connector at J5. The input is polarity protected using series diode. This connector feeds to the LDO to generate the 3.3 V required for the non-isolated supply for digital isolators.

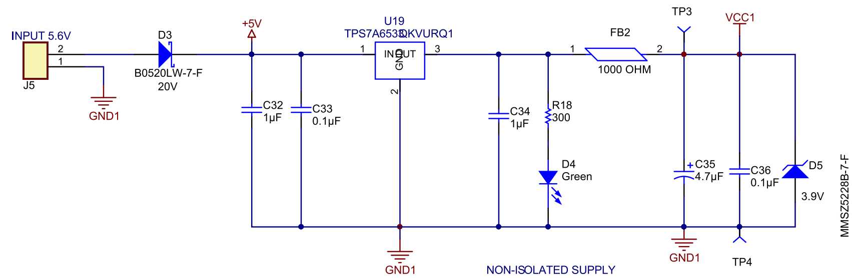


Figure 18. LDO for Non-Isolated 3.3-V Power Supply

The input supply connector J5 also feeds to isolated DC-DC converter using the transformer driver SN6501.

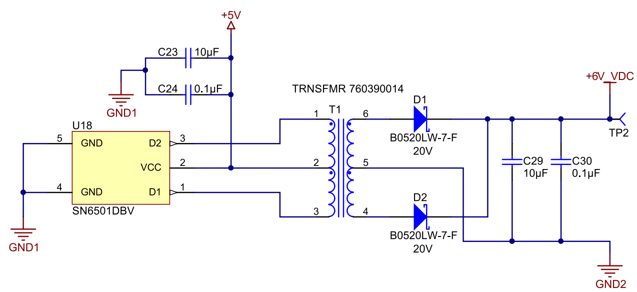


Figure 19. Transformer Driver for Isolated DC-DC Supply

The output of the isolated converter feeds to the LDO to generate the 3.3 V required for the isolated side of digital isolators and the RS-232 transceiver.

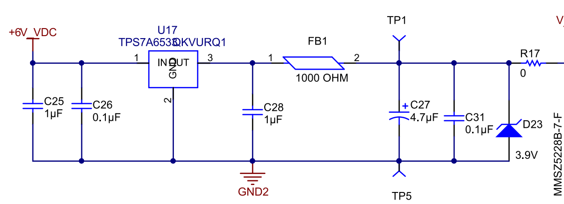


Figure 20. LDO for Isolated 3.3-V Supply

5.5 Connector Details

5.5.1 DTE Signal Connections

Connector J2 is used for digital connection from the MCU to the TIDA-00557 board. It is an 8-pin, 2.54-mm pitch connector.

Connector J6 is used exclusively for ground connection. It is a 2-pin, 2.54-mm pitch connector.

Connector J1 is a DB-9 plug-type connector.

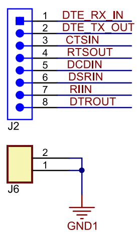


Figure 21. Input Connector for DTE Interface (MCU Interface)

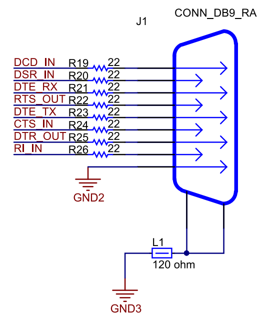


Figure 22. Connector for DTE Interface (RS-232 Level)

5.5.2 DCE Signal Connections

Connector J4 is used to connect the digital signals from the MCU. It is an 8-pin, 2.54-mm pitch connector.

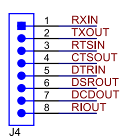


Figure 23. Input Connector for DCE Interface (MCU Interface)

Connector J3 is a standard DB-9 socket connector for the DCE interface.

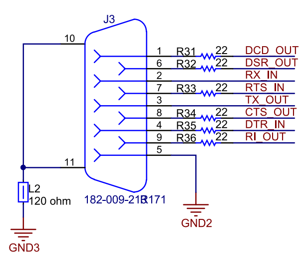


Figure 24. Connector for DCE Interface (RS-232 Level)

5.5.3 Power Supply Connections

Connector J5 is used for power supply input. It is a 2-pin, 2.54-mm pitch connector.

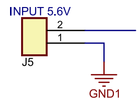


Figure 25. Input Connector for Power Supply

H4 is chassis ground.

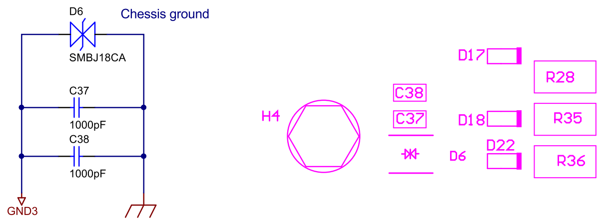


Figure 26. H4 Earth

6 Getting Started: Hardware

The following section gives details of how to get started with this hardware.

6.1 Power Supply

1. Connect the 5.6-V DC supply at connector J5 with a current limitation of < 200 mA.
2. Measure the voltage at TP3 with respect to TP4. It should be 3.3 V.
3. Measure the voltage at TP2 with respect to TP5. It should be around 6.0 V.
4. Measure the voltage at TP1 with respect to TP5. It should be around 3.3 V.

Once these requirements are met, D4 should light up.

6.2 RS-232 Transceiver

Measure the following voltages:

1. Measure the voltage at pin 26 of U6 (it should be 3.3 V).
2. Measure the voltage at pin 27 of U6 (it should be 6.0 V).
3. Measure the voltage at pin 3 of U6 (it should be –5.5-V to –6.0-V DC).

Measure the following voltages:

1. Measure the voltage at pin 26 of U14 (it should be 3.3 V).
2. Measure the voltage at pin 27 of U14 (it should be 6.0 V).
3. Measure the voltage at pin 4 of U14 (it should be –5.5-V to –6.0-V DC).

7 Test Setup

7.1 Functional Testing Setup

The first board (located on the left) is populated as DTE, and the second board (on the right) is populated as DCE. UART signals from the DTE board are cross fed to UART signals for the DCE board. The left board is connected to the computer through a DTE-DTE cable, and the right board is connected to another computer using a DCE-DTE cable. The software Docklight© was used for communication testing, but any similar software can be used, like HyperTerminal® or Tera Term. Both boards are fed with a single 5-V input supply.

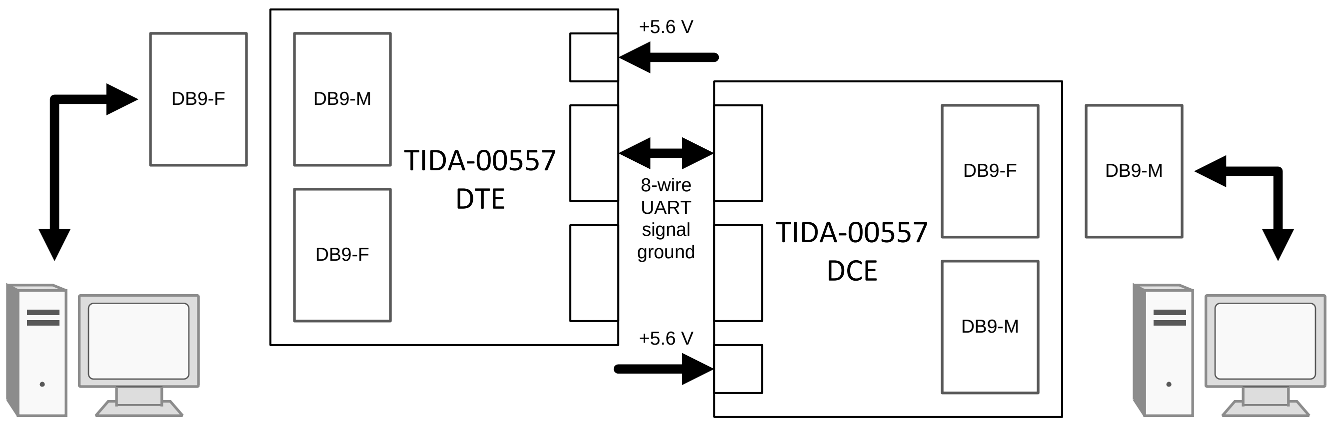


Figure 27. Test Setup for Functional Testing (Using Two TIDA-00557 Boards)

7.2 ESD Test Setup

The ESD test setup is as per the IEC61000-4-2 ESD standard.

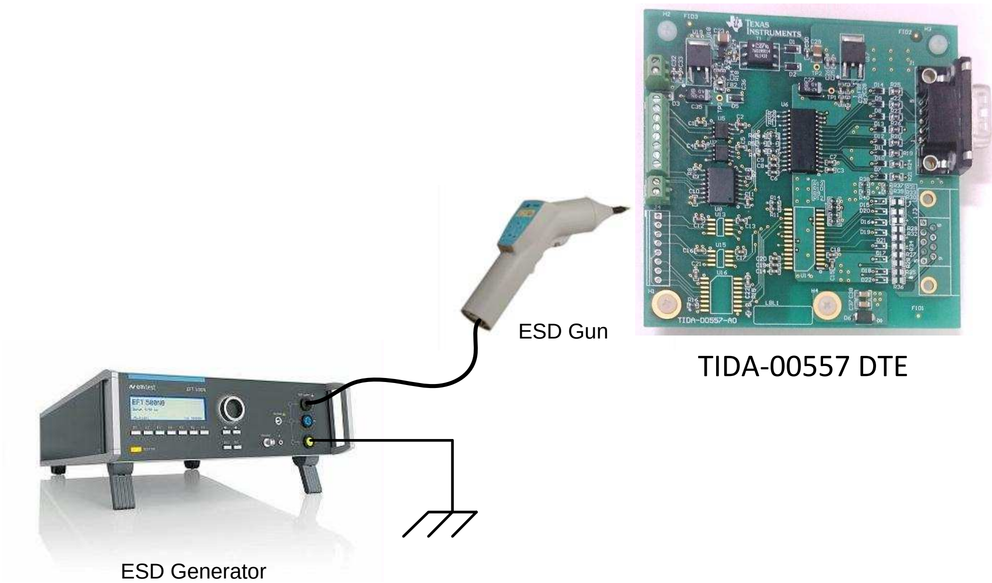


Figure 28. ESD Test Setup

7.3 Surge Test Setup

The Surge test setup is as per IEC61000-4-5 standard.

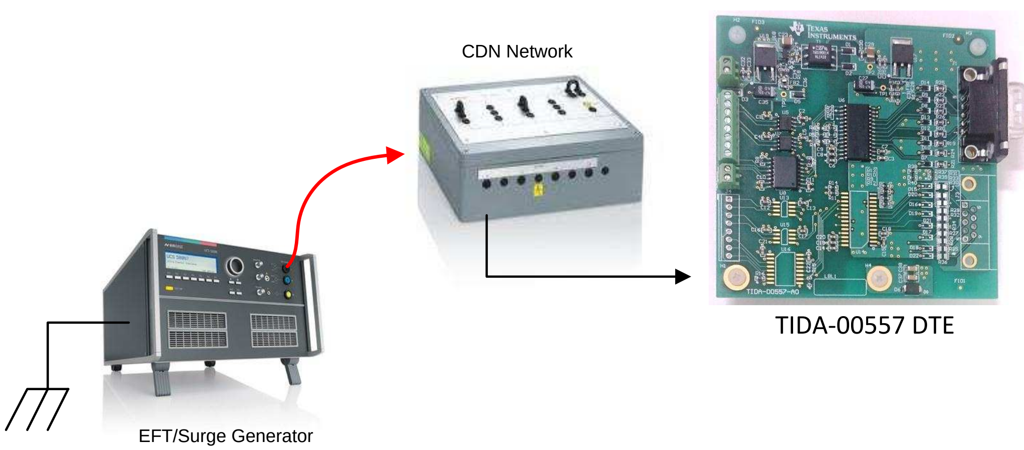


Figure 29. Surge Test Setup

8 Test Data

8.1 Power Supply

Table 13. Current Consumption

DTE BOARD			
SR NO	**MEASUREMENT POINT**	**LOAD**	**REMARK**
1	5.6-V input supply	29 mA	Standalone[1]
		45 mA	When connected to computer[1]
		49 mA	When connected to computer
2	3.3-V non-isolated supply	7.6 mA	1200 baud rate communication[1]
3	3.3-V isolated supply	22.5 mA	1200 baud rate communication[1]
4	3.3-V non-isolated supply	7.6 mA	115000 baud rate communication[1]
5	3.3-V isolated supply	21.75 mA	115000 baud rate communication[1]
DCE BOARD			
SR NO	**MEASUREMENT POINT**	**LOAD**	**REMARK**
1	5.6-V input supply	27 mA	Standalone[1]
		55 mA	When connected to computer[1]
		59 mA	When connected to computer
2	3.3-V non-isolated supply	7.14 mA	1200 baud rate communication[1]
3	3.3-V isolated supply	32.80 mA	1200 baud rate communication[1]
4	3.3-V non-isolated supply	7.17 mA	115000 baud rate communication[1]
5	3.3-V isolated supply	32.82 mA	115000 baud rate communication[1]

(1) LED D4 connected to 3.3-V non-isolated rail not populated to account for isolator and transceiver current

Table 14. Voltage Measurement

SR NO	MEASUREMENT POINT	VALUE	REMARK
1	Charge pump voltage		
	Pin 3	–5.59 V	TRS3243E charge pump voltage output
	Pin 27	6.02 V	TRS3243E charge pump voltage output
	Pin 4	–5.59 V	TRSF3238E charge pump output voltage
	Pin 27	6.02 V	TRSF3238E charge pump output voltage
2	At TP2 SN6501 output	5.93 V	DTE board
	At TP3 VCC1	3.30 V	
	At TP1 VCC2	3.29 V	
3	At TP2 SN6501 output	5.89 V	DCE board
	At TP3 VCC1	3.30 V	
	At TP1 VCC2	3.29 V	

8.2 Data Communication Testing

8.2.1 1200 Baud With 8 Data Bits, 1 Stop Bit, No Parity, and RTS and CTS Activated

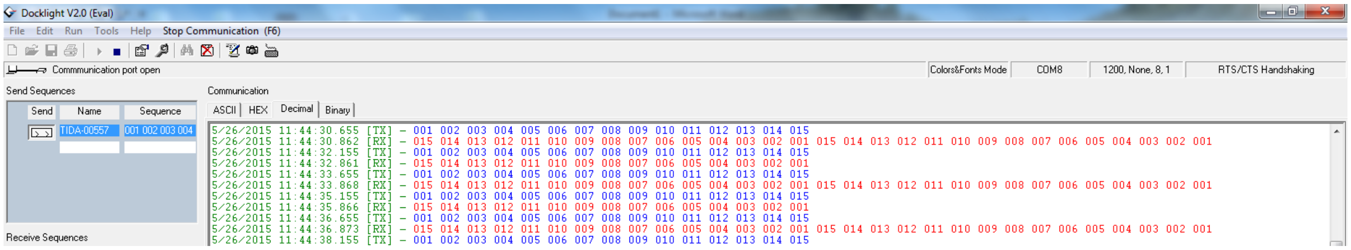


Figure 30. 1200 Baud 8N1 Data Format With RTS and CTS

Result: Communication and data transfer OK; No failure observed.

8.2.2 4800 Baud With 8 Data Bits, 1 Stop Bit, No Parity, and RTS and CTS Activated

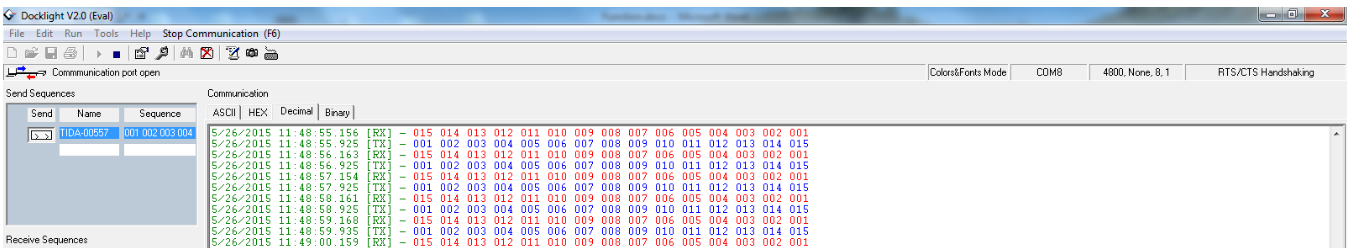


Figure 31. 4800 Baud 8N1 Data Format With RTS and CTS

Result: Communication and data transfer OK; No failure observed.

8.2.3 9600 Baud With 8 Data Bits, 1 Stop Bit, No Parity, and RTS and CTS Activated

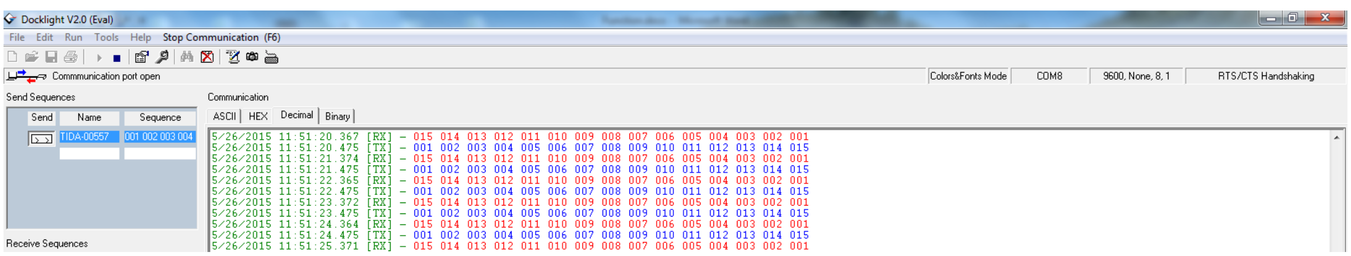


Figure 32. 9600 Baud 8N1 Data Format With RTS and CTS

Result: Communication and data transfer OK; No failure observed.

8.2.4 115000 Baud With 8 Data Bits, 1 Stop Bit, No Parity, and RTS and CTS Activated

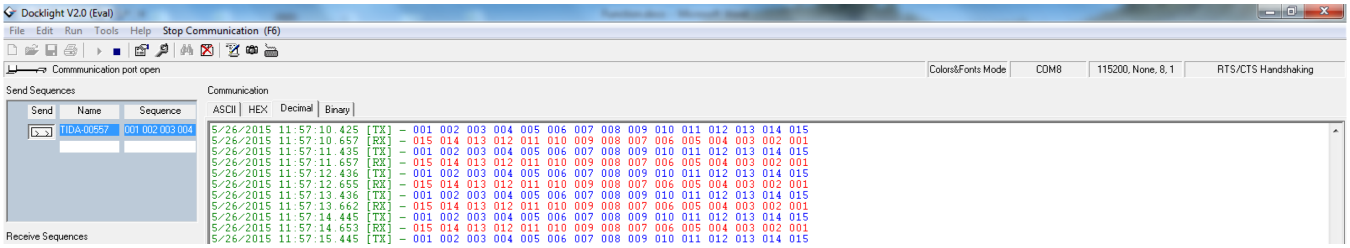


Figure 33. 115000 Baud 8N1 Data Format With RTS and CTS

Result: OK; No error observed.

8.2.5 115000 Baud With 8 Data Bits, 1 Stop Bit, Even Parity, and RTS and CTS Activated

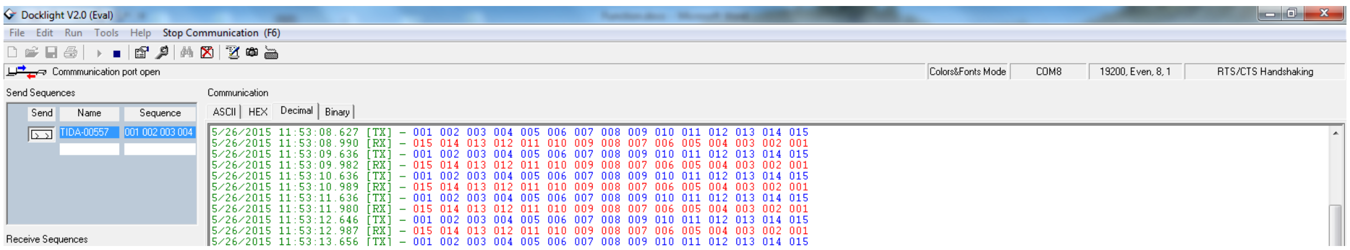


Figure 34. 115000 Baud 8N1 Data Format With RTS and CTS

Result: Communication and data transfer OK; No failure observed.

8.2.6 115000 Baud With RTS and DTR Set and Reset Manually

The effect of RTS and DTR set and reset has been tested using the Docklight Manual Handshake option.

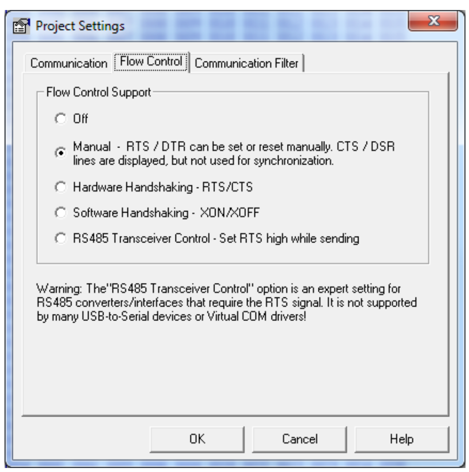


Figure 35. Setting for Manual RTS and DTR Control in Docklight

8.2.7 9600 Baud With 7 Data Bits, Even Parity, 1 Stop Bit, and RTS and CTS Activated

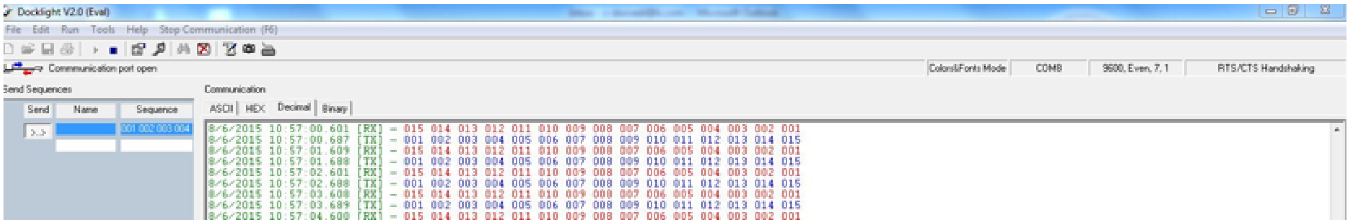


Figure 36. 9600 Baud 7E1 Data Format With RTS and CTS

Result: Communication and data transfer OK; No failure observed.

8.2.8 9600 Baud With 7 Data Bits, Odd Parity, 1 Stop Bit, and RTS and CTS Activated

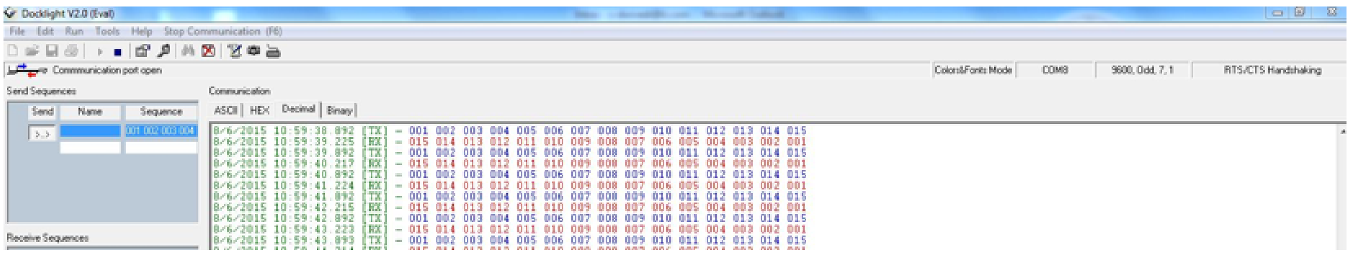


Figure 37. 9600 Baud 7O1 Data Format With RTS and CTS

Result: Communication and data transfer OK; No failure observed.

8.2.9 115000 Baud With 7 Data Bits, Even Parity, 1 Stop Bit, and RTS and CTS Activated

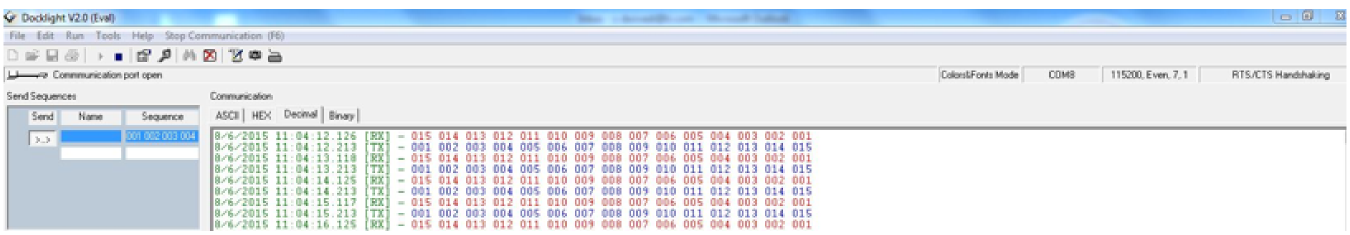


Figure 38. 115000 Baud, 7E1 Data Format With RTS and CTS

Result: Communication and data transfer OK; No failure observed.

8.2.10 115000 Baud With 7 Data Bits, Odd Parity, 1 Stop Bit, and RTS and CTS Activated

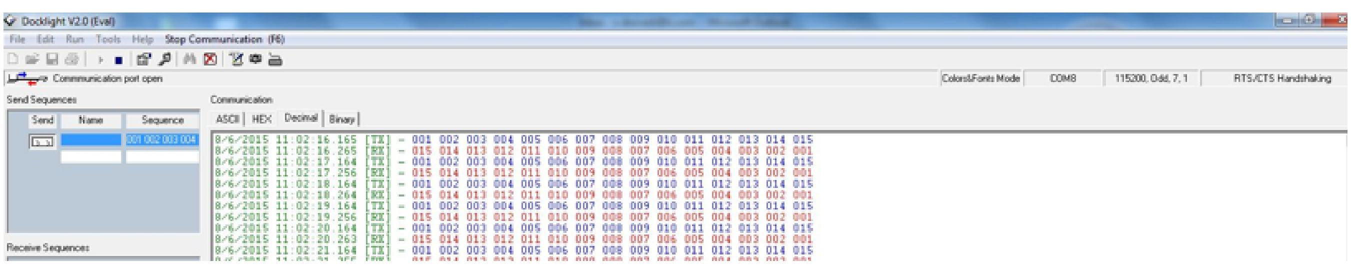


Figure 39. 115000 Baud, 7O1 Data Format With RTS and CTS

Result: Communication and data transfer OK; No failure observed.

8.3 IEC61000-4-2 ESD Test

The IEC61000-4-2 ESD test simulates the electrostatic discharge of an operator directly onto an adjacent electronic component. Electrostatic charge usually develops in low relative humidity, on low-conductivity carpets, or on vinyl garments. To simulate a discharge event, an ESD generator applies ESD pulses to the equipment under test (EUT), which happens through direct contact with the EUT (contact discharge) or through an air-gap (air-discharge). This is applied across signal inputs only. A series of 10 negative and positive pulses are applied directly on the DB-9 connector block screws during the test (contact discharge). After the test, board functional and communication testing is performed.

Table 15. ESD Test Observations

IMMUNITY TEST	STANDARD	PORT	TARGET VOLTAGE	RESULT
ESD	IEC 61000-4-2 Contact discharge	Signal lines at connector	±8-kV contact discharge	Class B

Table 16. ESD Test Readings

TEST NO	TEST MODE	RESULT
1	4-kV contact discharge	Pass
2	–4-kV contact discharge	Pass
3	6-kV contact discharge	Pass
4	–6-kV contact discharge	Pass
5	8-kV contact discharge	Pass
6	–8-kV contact discharge	Pass

8.4 IEC61000-4-5 Surge Test

The IEC61000-4-5 Surge test simulates switching transients caused by lightning strikes or the switching of power systems including load changes and short circuits. The test requires five positive and five negative surge pulses with a time interval between successive pulses of one minute or less. The unshielded symmetrical data line setup as defined by the IEC61000-4-5 specification was used for this test. The test generator was configured for 1.2/50-µs surges and diode clamps were used for line-to-ground coupling. A series of five positive and negative pulses with a 10-second space between each pulse were applied during the test. After the test, the board is tested for functionality and communication up to 115k.

Table 17. Surge Test Observations

IMMUNITY TEST	STANDARD	PORT	TARGET VOLTAGE	RESULT
Surge	IEC 61000-4-5: (1.2/50 µs to 8/20 µs), 42 Ω–0.5 µF	Signal lines at connector input	± 1 kV	Pass, Criteria B After the test, the module continued to operate as intended

Table 18. Surge Test Readings

TEST NO	TEST MODE	OBSERVATION
1	0.5 kV	Pass
2	–0.5 kV	Pass
3	1 kV	Pass
4	–1 kV	Pass

8.5 Summary of Test

Table 19. Summary of Test

TEST	FLOW CONTROL	DATA RATE (BAUD)	RESULT
Communication between DTE and DCE	Hardware flow control with 8 data bits, 1 stop bit, and no parity	1200, 4800, 9600, and 115K	No error during the communication
	Hardware flow control with 8 data bits, 1 stop bit, and even parity	115K	No error during the communication
	Manual RTS and DTR control	115K	Function of RTS and DTR validated
	Hardware flow control with 7 data bits, 1 stop bit, and odd parity	9600 and 115K	No error during the communication
	Hardware flow control with 7 data bits, 1 stop bit, and even parity	9600 and 115K	No error during the communication
Power supply	Isolated output with SN6501 transformer driver	—	OK
	LDO output for isolated and non-isolated power supplies	—	OK
	Charge pump voltage for RS-232 transceivers	—	OK
EMC	ESD	—	Complies
	Surge	—	Complies

9 Design Files

9.1 Schematics

To download the schematics, see the design files at TIDA-00557.

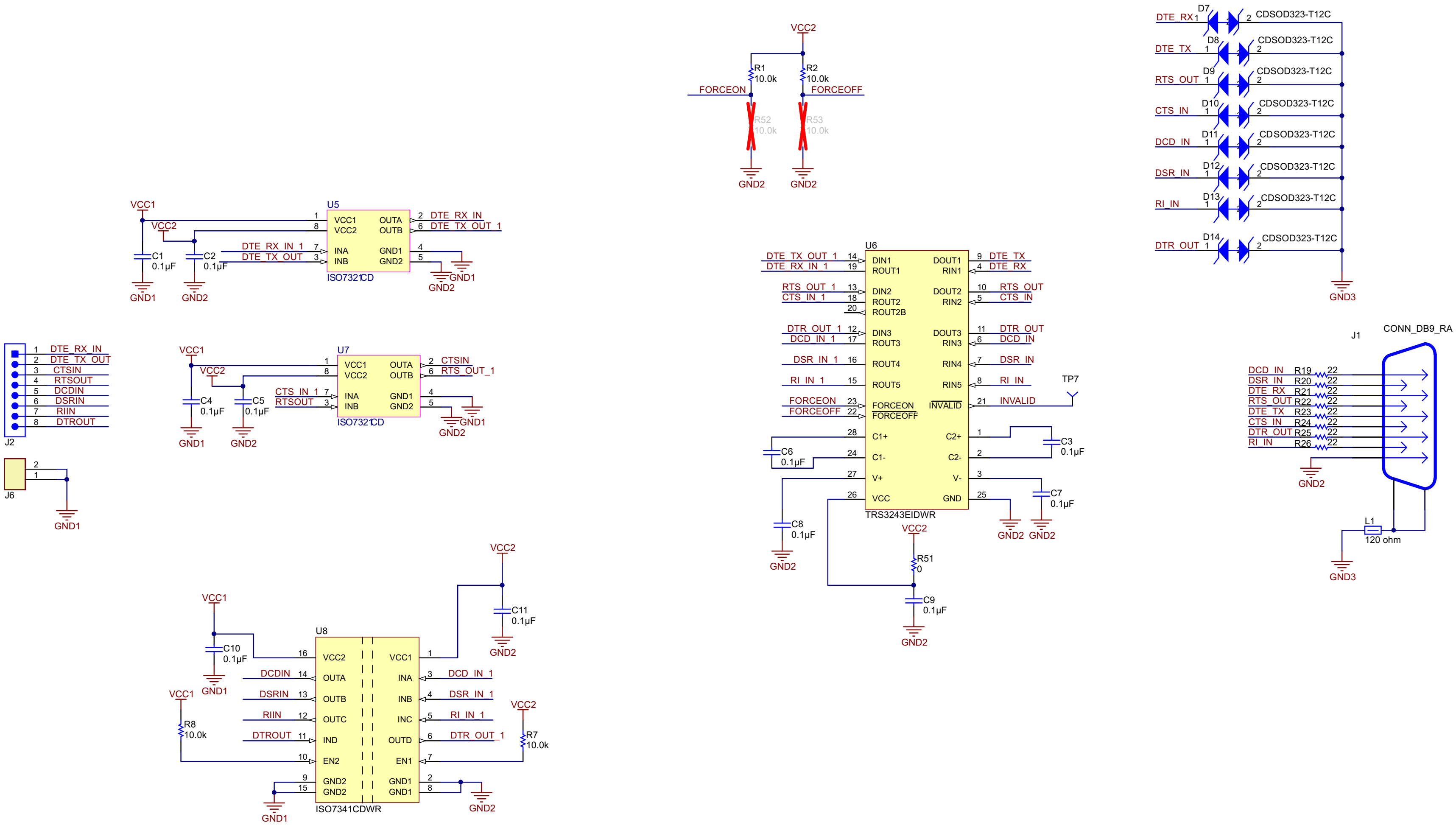


Figure 40. DTE Interface

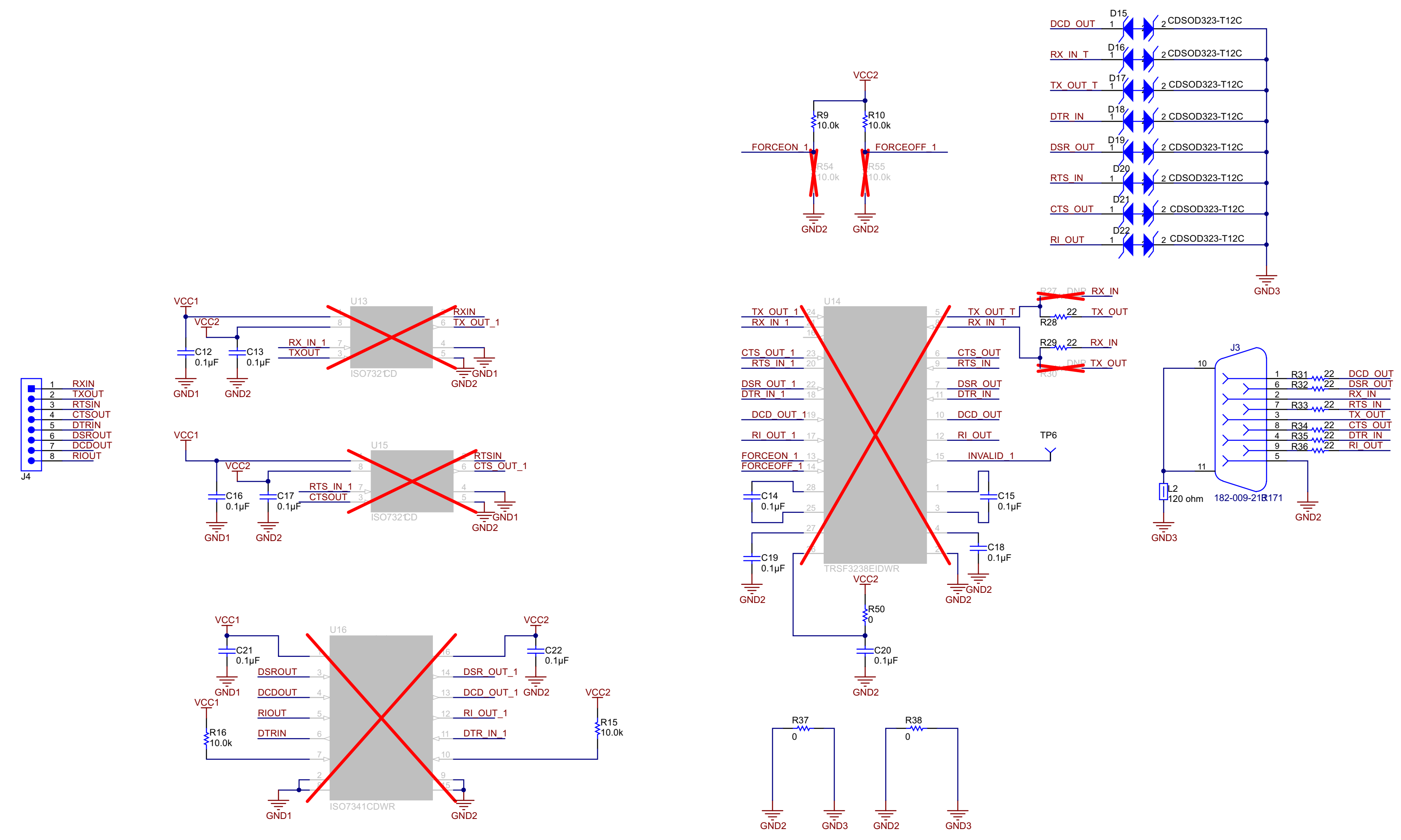


Figure 41. DCE Interface

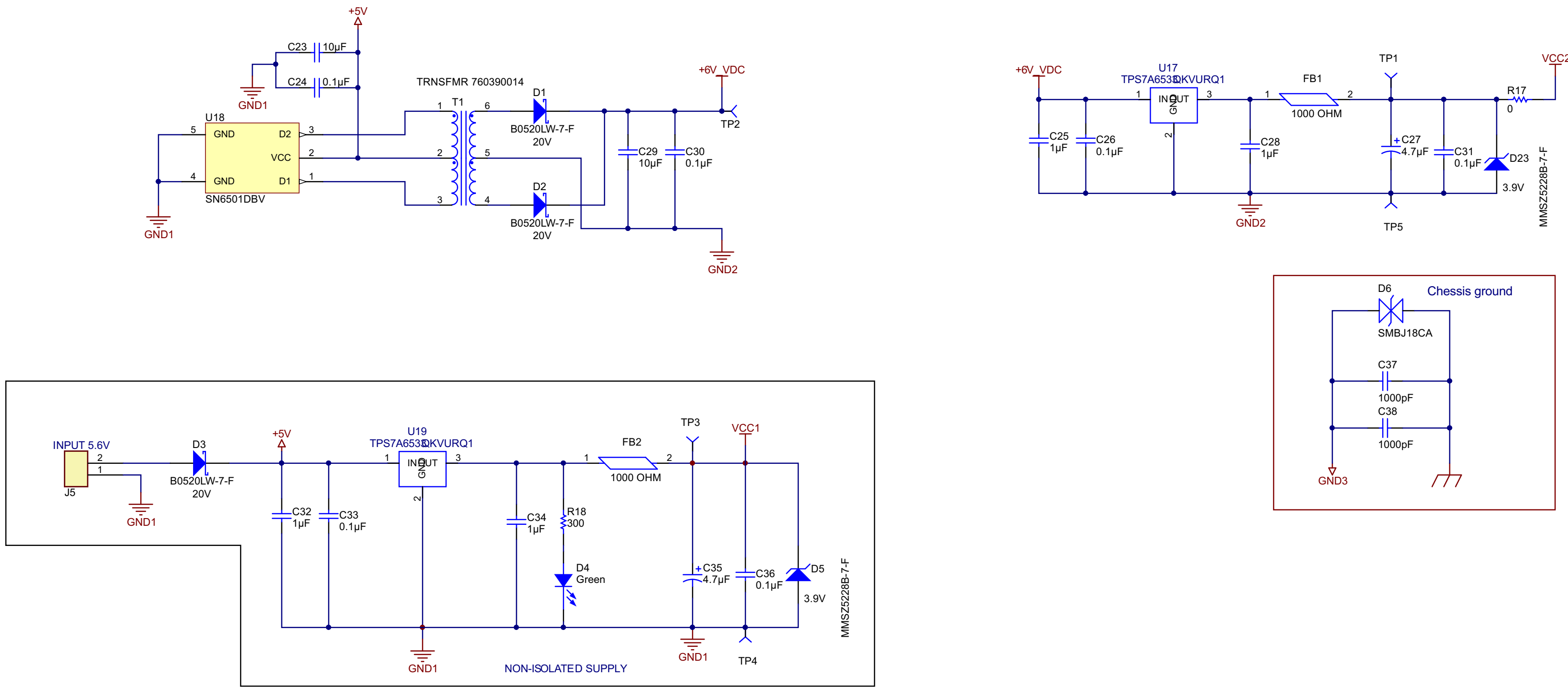


Figure 42. Isolated and Non-Isolated Power Supplies

9.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDA-00557.

9.3 PCB Layout Recommendations

- Creepage and clearance requirements should be applied according to the specific application isolation standards. Care should be taken to maintain these distances on the board design to ensure that the mounting pads for the isolator do not reduce this distance. Creepage and clearance on the printed circuit board become equal in certain cases. Techniques such as inserting grooves and/or ribs on the printed circuit board are used to help increase these specifications.
- An SMD ceramic bypass capacitor of approximately 0.1 μF in value is recommended. If leaded components are necessary, leads should be kept as short as possible to minimize lead inductance.
- A continuous ground plane is ideal for providing a low-impedance signal return path, as well as generating the lowest EMI signature by reducing phenomena such as unintended current loops.
- Should a continuous ground plane not be possible, minimize the length of the trace connecting VCC and ground.
- Isolated communication may often have to meet specified creepage and clearance criteria. Creepage and clearance requirements are determined by the end-use device specifications.
- PCB material - Standard FR-4 epoxy-glass as printed-circuit board (PCB) material is preferred for industrial applications with speed.
- Trace Routing - Use 45° bends (chamfered corners), instead of right-angle (90°) bends. Right-angle bends increase the effective trace width, and thus the trace impedance. This creates additional impedance mismatch, which may lead to higher reflections.

9.3.1 Layer Plots

To download the layer plots, see the design files at TIDA-00557.

9.4 Altium Project

To download the Altium project files, see the design files at TIDA-00557.

9.5 Gerber Files

To download the Gerber files, see the design files at TIDA-00557.

9.6 Assembly Drawings

To download the assembly rawings, see the design files at TIDA-00557.

9.7 Software Files

To download the software files, see the design files at TIDA-00557.

10 References

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7. Texas Instruments, *ISO732x Robust EMC, Low Power, Dual-Channel Digital Isolators*, ISO732x Datasheet (SLLSEK8)
8. Texas Instruments, *ISO734x Robust EMC, Low Power, Quad-Channel Digital Isolators*, ISO734x Datasheet (SLLSEI6)

11 About the Author

SUNIL DWIVEDI is a Systems Engineer at Texas Instruments where he is responsible for developing reference design solutions for the industrial segment. Sunil brings to this role his experience in high-speed digital and analog systems design. Sunil earned his bachelor of electronics (BE) in electronics and instrumentation engineering (BE E&I) from SGSITS, Indore, India.

Revision History

Changes from Original (June 2015) to A Revision	Page
• Changed from the preview page	1

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

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