

SUPPORT NOTE

SN026 | Isolated RS-485 interface based on 4-channel digital isolator with integrated DC/DC converter



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This design example shows an isolated RS-485 interface using a 4-channel **reinforced** digital isolator with an integrated DC/DC converter, reducing component count and board space. The design is optimized for half-duplex operation at data rates up to 10 Mbps and meets CISPR 32 Class B radiated emission standard.

1. OVERVIEW OF RS-485

The RS-485 interface is widely used in industrial and commercial applications due to its robustness, long-distance data transmission capabilities, and resilience to electrical noise. RS-485 supports multiple devices on a single bus, making it ideal for complex systems and distributed networks. The main features of this interface include:

- **Long-Distance Communication:** Can transmit data up to 1200 meters at lower data rates (up to 100 kbps)
- **Flexible Data Rates:** Supports data rates from a few kbps up to 10 Mbps for short distances (~15 meters), with the data rate decreasing as the distance increases. However, with today's technology, signal rates beyond the specification of up to 50 Mbps are possible.
- **Multi-Device Support:** Allows up to 32 devices on a single bus (32-unit load (UL) or up to 256 low-unit-load transceivers where one transceiver is 1/8 UL), providing flexible connectivity for multi-node systems.
- **Differential Signaling:** Using differential signaling (balanced line), achieves high immunity to electrical noise, making it suitable for environments with significant EMI.

Thanks to these benefits, RS-485 is widely used in industrial automation, building automation, energy management, motor control and renewable energy systems, where stable and noise-resistant data communication is essential for reliable operation in demanding environments.

2. IMPORTANCE OF RS-485 ISOLATION

The differential nature of RS-485 signaling helps reduce noise, but it can still be affected by strong electromagnetic interference (EMI). For this reason, isolation is very important in modern applications where harsh conditions and high electrical noise levels are common. Isolated RS-485 provides extra protection and improves performance by separating the communication lines from the system ground, offering several benefits:

- **Protection Against Ground Loops:** Isolation prevents issues caused by ground potential differences, ensuring stable communication in large-scale systems with distributed equipment.
- **Noise Immunity:** Isolation (along with additional measures such as filtering, shielding and proper PCB layout) protects sensitive equipment from high levels of EMI and strong magnetic fields often found in industrial environments, helping maintain data integrity.
- **Surge and Transient Protection:** Galvanic isolation, complemented by surge protection devices (such as TVS diodes), allows to withstand voltage surges and

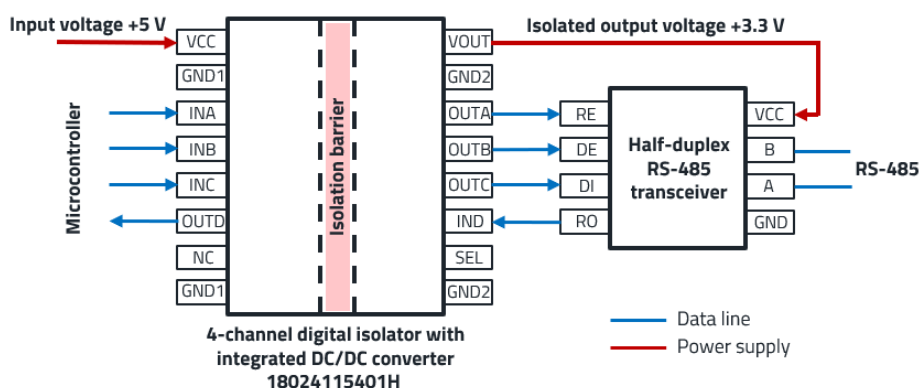


Figure 1: Block diagram of isolated half-duplex RS-485 interface.

SUPPORT NOTE

SN026 | Isolated RS-485 interface based on 4-channel digital isolator with integrated DC/DC converter

transients, protecting components and improving the system's overall reliability.

- **Safety in High-Voltage Applications:** In systems such as energy meters and renewable energy, isolation helps protect low-voltage control systems from high-voltage sections, ensuring operator and equipment safety.

3. DESCRIPTION OF DESIGN EXAMPLE BOARD

3.1 Key parameters

The board is optimized for a data rate of 10 Mbps and a shielded twisted cable length of 10 m (distance between the transmitter and receiver boards during radiated emission test).

Parameter	Value
Input supply voltage	5 V
Isolated output supply voltage (output voltage of integrated DC/DC converter)	3.3 V
Maximum data rate of the communication lines	10 Mbps
Radiated emission test standard	CISPR 32 Class B
Type of communication	Half-Duplex

Table 1: Key parameters of isolated RS-485 board.

The integrated DC/DC converter within the digital isolator cannot operate in boost mode therefore the output voltage must be less than or equal to the input voltage (VCC). In the design example the output voltage selection pin (SEL) of the digital isolator is connected to the ground (GND2) for 3.3 V output voltage.

3.2 Configuration

The top view of the application example board is shown in Figure 2. The board can be conditionally divided into 8 blocks:

1. Pins A and B: non-inverting and inverting bidirectional bus data lines (RS-485 input)
2. Filter circuit of the data lines and TVS diodes for overvoltage protection
3. Half-duplex RS-485 transceiver in SOIC-8NB package
4. 4-channel digital isolator with integrated isolated DC/DC converter
5. Filter circuit of the DC supply voltage line
6. Terminal block screw connector for power supply
7. THT 3-pin header for signals from controller
8. SMA connectors for RS-485 interface signals*

* The SMA connectors (high-speed connectors) are used for a test signal feed by a signal generator into the PCB. This is a simulation of a single ended board level signal source feeding the signal to the digital isolator.

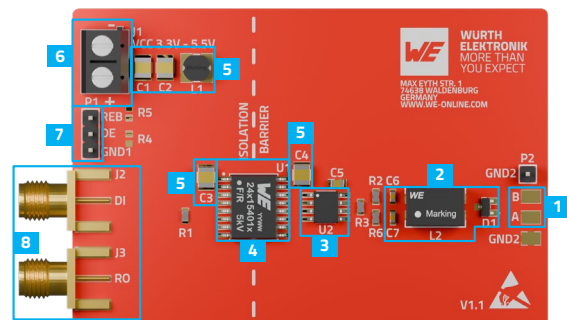


Figure 2: Top view of the application example board.

Figure 3 shows the schematic of the transceiver and receiver boards used during the radiated emission test. The differences between the boards are detailed in Section 6.1.

SUPPORT NOTE

SN026 | Isolated RS-485 interface based on 4-channel digital isolator with integrated DC/DC converter

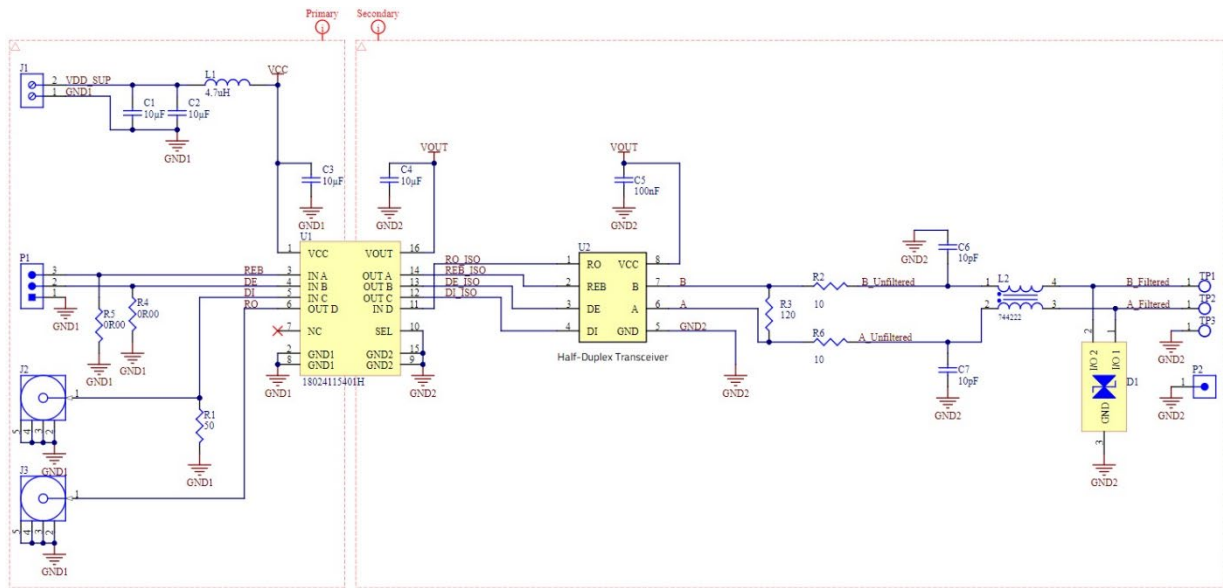


Figure 3: Schematic of isolated half-duplex RS-485 transceiver and receiver boards.

4. SELECTION OF COMPONENTS

4.1 Digital Isolator 18024115401H

The **18024115401H** is a 4-channel digital isolator with an integrated isolated DC/DC converter that provides up to 0.65 W of isolated power (for power supply of internal structure of the digital isolator and the half-duplex RS-485 transceiver) in a SOIC-16WB package. The availability of an integrated DC/DC converter significantly reduces the number of components in the design saving board space. In addition, the converter has integrated protection systems that guard against thermal overstress with thermal shutdown and protect against electrical damage using overcurrent, short-circuit and undervoltage circuitry. The **18024115401H** has a 3/1 channel configuration (3 forward and 1 reverse channels). This channel configuration is required for normal operation of the isolated RS-485 interface in half-duplex transmission. Two forward channels of the **18024115401H** are used to isolate control signals from a microcontroller that switch the half-duplex RS-485 transceiver (RE and DE pins) between transmit and receive modes. The other two channels of the digital isolator (1 forward and 1 reverse) are used to isolate bus interface signals passing through the half-duplex RS-485 transceiver (DI and RO pins) in transmit and receive modes.

Key Features of the **18024115401H**:

- 4-channel digital isolator with integrated 0.65 W Isolated DC/DC converter;
- UL1577 recognized:
 - 5000 V_{RMS} isolation voltage for 60 s;
- DIN EN IEC 60747-17 (VDE 0884-17):2021-10 certified:
 - Reinforced isolation;
 - Maximum repetitive peak isolation voltage: 1414 V_{PK};
 - Maximum working isolation voltage: 1000 V_{RMS} and 1414 V_{DC};
 - Maximum transient isolation voltage: 7070 V_{PK};
 - Maximum surge isolation voltage: 7070 V_{PK};
- Input voltage range: 3.15 V to 5.5 V;
- User-selectable output voltage: 3.3 V or 5 V;
- Data rate up to 100 Mbps;
- ±150 kV/μs typ. CMTI;
- Complies with EN55032 (CISPR-32) class B conducted and radiated emissions standard (with the reference layout specified in the data sheet);
- Ambient temperature range: -40°C to 125°C.

SUPPORT NOTE

SN026 | Isolated RS-485 interface based on 4-channel digital isolator with integrated DC/DC converter

4.2 Half-Duplex RS-485 Transceiver

Half-duplex RS-485 transceivers provide bidirectional communication over a single pair of wires by alternating between transmitting and receiving data. This allows multiple devices to share the same communication line efficiently, reducing the number of required wires and simplifying system design. The design example uses a standard half-duplex RS-485 transceiver in the SOIC-8NB package.

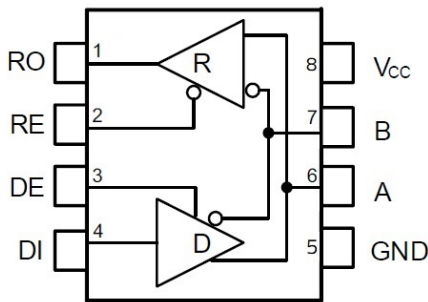


Figure 4: Simplified block diagram of non-isolated half-duplex RS-485 transceiver in SOIC-8NB package.

4.3 Transient Protection

The WE-TVS diode [824022](#) (two bidirectional TVS diodes in SOT-23 package) with a channel operating voltage of 5 V were selected to protect data line from overvoltage. The [824022](#) TVS diode has a very low input capacitance (15 pF), which helps minimize signal distortion, maintain high data rates and preserve the integrity of differential signals in high-speed RS-485 communication systems.

4.4 Filter circuit of the RS-485 data lines

The WE-SL2 [744222](#) common mode line filter was selected to filter the RS-485 data lines. A detailed description of how to select the right components for the filter can be found in the Application Note [ANP083](#) "Adapter PCB for filtering electromagnetic interference on an RS-485 interface" (Section 2.1 Filter circuit of the data lines).

4.5 Filter circuit of the supply voltage line

The WE-PD2 SMT power inductor [744773047](#) (4.7 μ H) and WCAP-CSGP MLCC chip ceramic capacitors [885012209014](#) (10 μ F/16 V, X7R, 1210) were selected for the input and output filter of the integrated DC/DC converter. For detailed information on filter selection and layout of the converter, refer to the [18024x15401x](#) digital isolator datasheet (Section 20 Design example) and the online tool, [REDEXPERT EMI Filter Designer](#).

5. REDUCING COMMON-MODE INTERFERENCE WITH OVERLAPPING STITCHING CAPACITANCE

The 18024115401H digital isolator provides galvanic isolation between the input and output of the system, but parasitic coupling capacitance of an isolation barrier allows common mode currents to flow. As a result, the isolator may be a source of common-mode interference. Typically, design engineers address this issue using an external Y-capacitor between the input and output. However, an alternative approach is to utilize the parasitic capacitance between PCB layers as an integrated Y-capacitor. This method, commonly referred to as stitching capacitance, provides an effective high-frequency return path for common-mode noise, reducing EMI without requiring external components.

Careful attention needs to be taken regarding the layout to meet any safety isolation standards. Depending on the targeted safety standard the requirements applying to inner layers for thickness and distance along a cemented joint. The outer layers and any exposed inner layer edges are subject to the creepage and clearance rules. This design example is designed to meet reinforced isolation.

This design example board has a 4-layer PCB structure. The stitching capacitance is formed by the parasitic properties of overlapping copper planes in different PCB layers (between internal layer 1, internal layer 2 and bottom layer). The PCB layers and the overlap that form the stitching capacitance of the board are shown in Figure 5.

SUPPORT NOTE

SN026 | Isolated RS-485 interface based on 4-channel digital isolator with integrated DC/DC converter

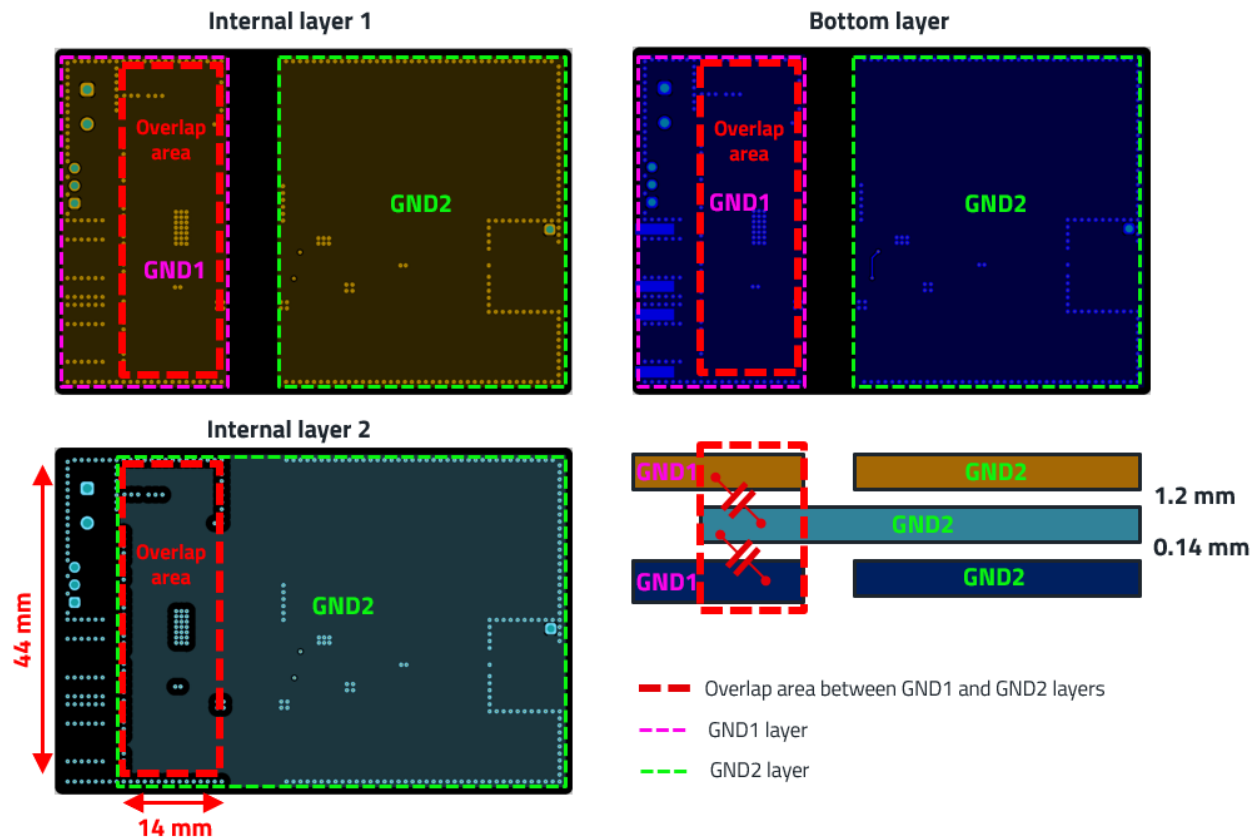


Figure 5: Overlap area of isolated RS-485 design example board.

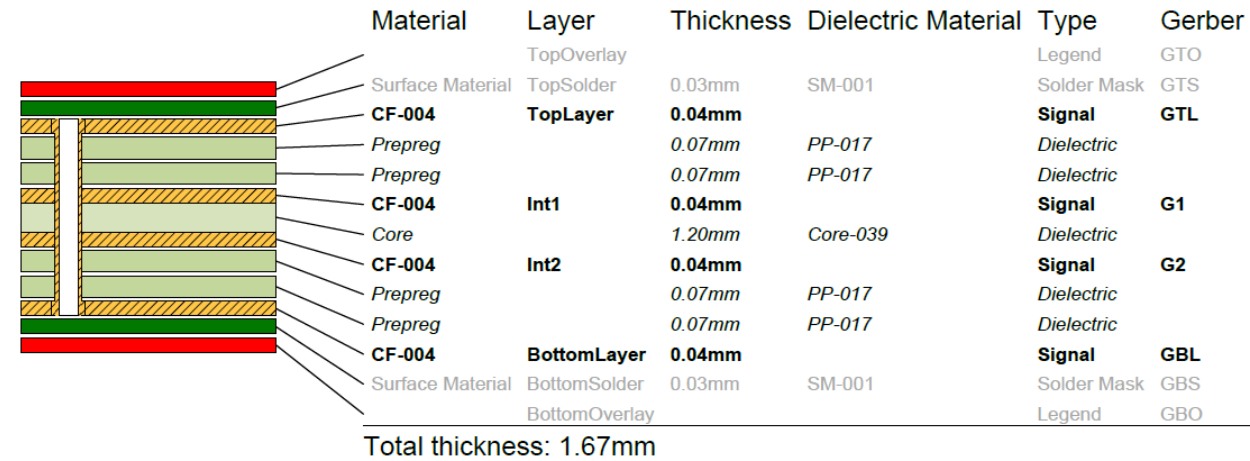


Figure 6: Layer stack legend.

SUPPORT NOTE

SN026 | Isolated RS-485 interface based on 4-channel digital isolator with integrated DC/DC converter

The parasitic capacitance between two overlapping PCB planes can be approximated by the parallel plate capacitance formula:

$$C = \frac{\epsilon_0 \cdot \epsilon_r \cdot A}{d} \quad (1)$$

Where:

- C is the stitching capacitance in farads (F);
- ϵ_0 is the vacuum permittivity $\approx 8.854 \times 10^{-12}$ F/m;
- ϵ_r is the relative dielectric constant of the PCB material (this information is provided by a PCB manufacturer, typically 4-5);
- A is the overlapping area of the planes in square meters (m²);
- d is the distance between the planes (dielectric thickness) in meters (m).

Key parameters of the board for the stitching capacitance calculation:

- Overlap area (between GND1 and GND2 layers):
14 x 44 mm² = 616 mm²;
- Distance between overlap layers and relative dielectric constant:
 - Internal layer 1 to internal layer 2: 1.2 mm, $\epsilon_r = 4.6$;
 - Internal layer 2 to bottom layer: 0.14 mm, $\epsilon_r = 4$.

The total stitching capacitance of the PCB is the sum of the capacitances between the two overlapping regions:

$$C = C_{In1-In2} + C_{In2-Bottom} = 21 \text{ pF} + 156 \text{ pF} = 177 \text{ pF} \quad (2)$$

The approximate stitching capacitance of the design is 177 pF, providing an effective high-frequency return path for common-mode noise and significantly improving EMI performance. Measurements of radiated emissions demonstrate the success of this approach (Figure 9), as the 4-layer board with stitching capacitance remains well below the required limits, proving that this integrated design effectively suppresses common-mode interference. More detailed information about common mode interference and coupling capacitance can be found in Application Note [ANS022](#).

6. TESTING

6.1 Test Setup

The test setup for the radiated emission measurement is shown in Figure 7.

The configuration differences between the transmitter and the receiver boards are:

- The transmitter board: resistors R4 and R5 are not installed.
- The receiver board: resistors R4 and R5 are installed.

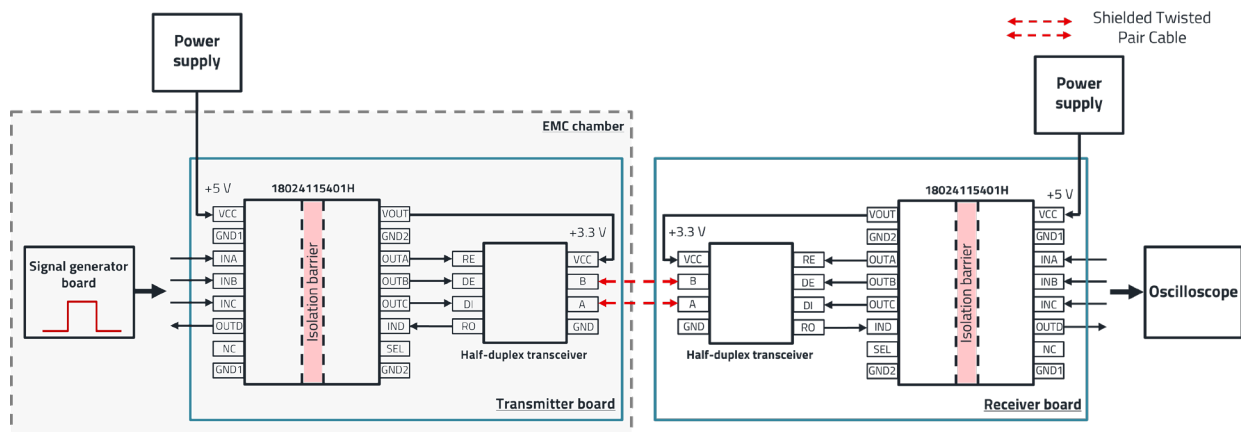


Figure 7: Test setup for radiated emission measurement with 10 m of shielded twisted cable between units.

SUPPORT NOTE

SN026 | Isolated RS-485 interface based on 4-channel digital isolator with integrated DC/DC converter

6.2 Radiated Emission

Measurements made with 10 m shielded twisted cable length between transmitter and receiver boards and 10 Mbps data rate.

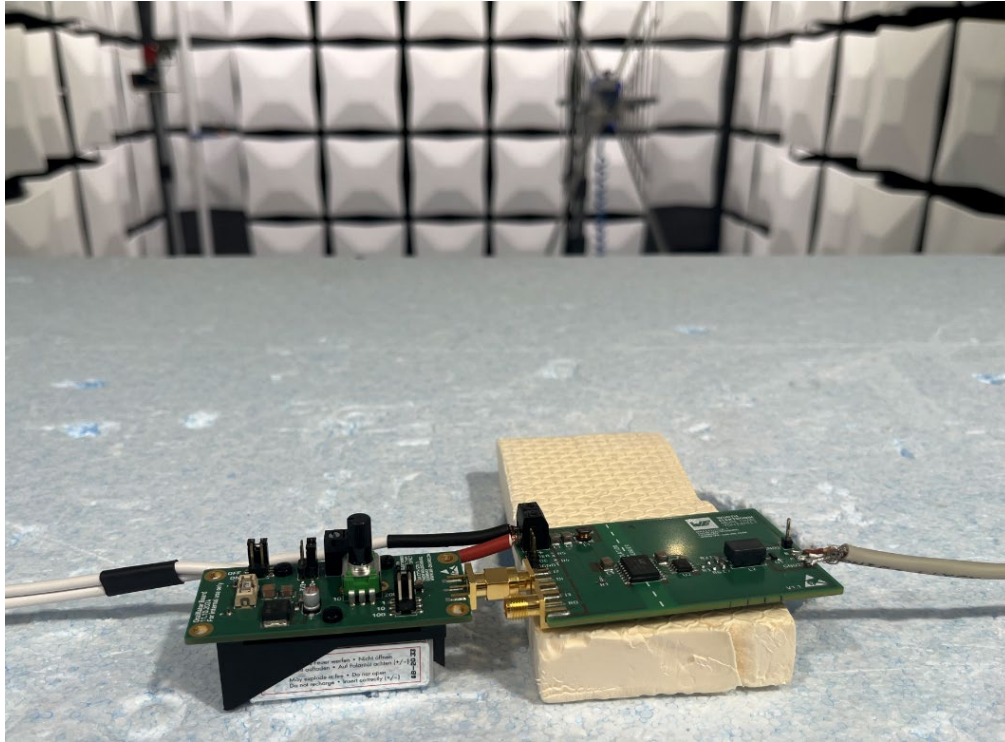


Figure 8: Transmitter board and signal generator board in EMC test chamber.

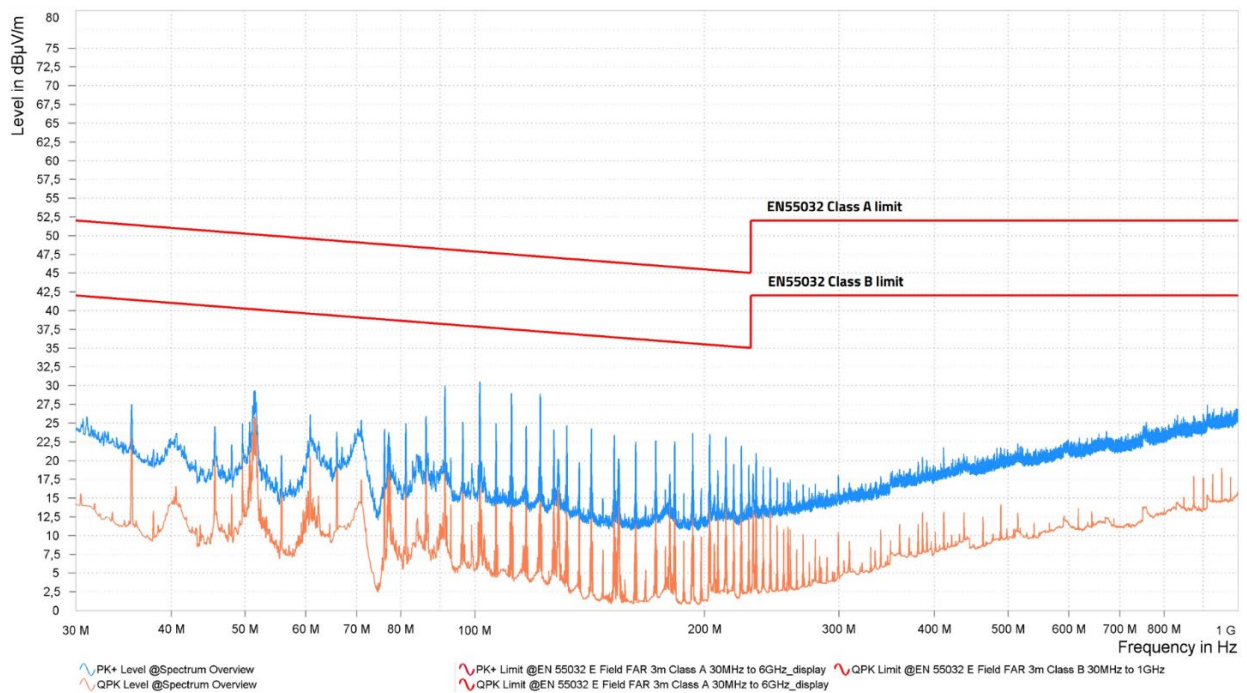


Figure 9: Radiated emission (CISPR 32 Class B).

SUPPORT NOTE

SN026 | Isolated RS-485 interface based on 4-channel digital isolator with integrated DC/DC converter

6.3 Propagation Delay

The propagation delay between the input and output signals of the digital isolator is ~15 ns (Figure 10), ensuring fast switching, minimal signal distortion and stable communication via the RS-485 interface.

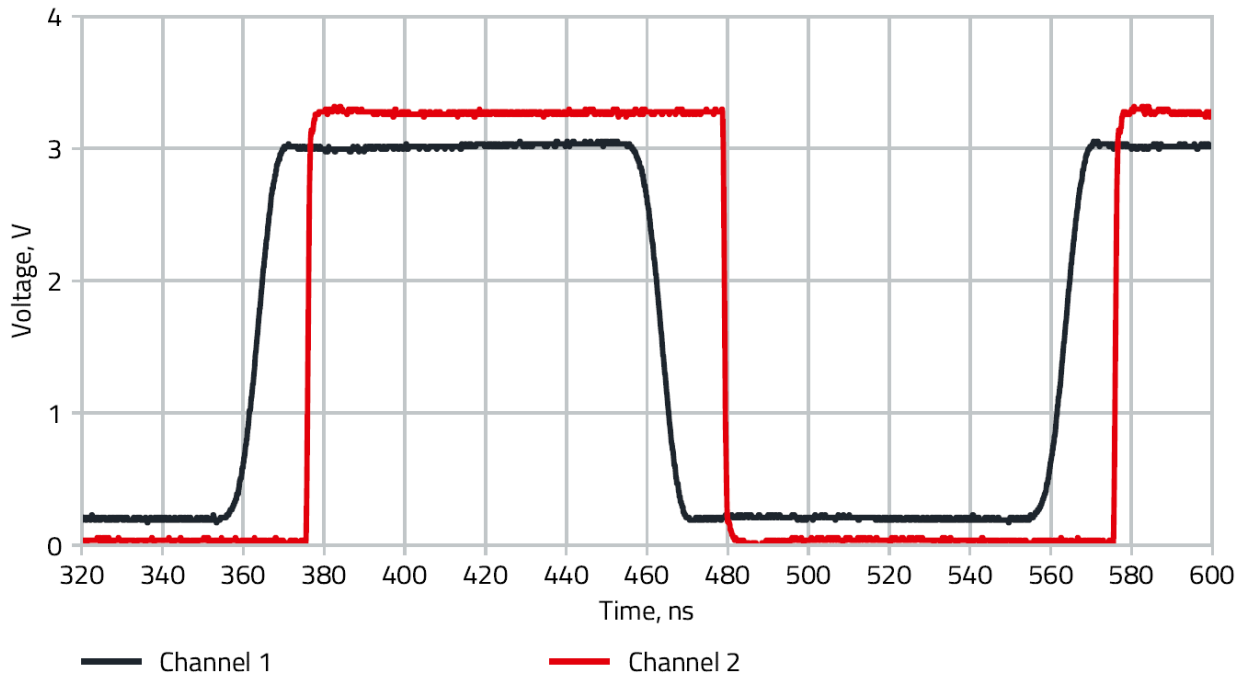


Figure 10: Propagation delay between input (Channel 1) and output (Channel 2) signals of the digital isolator 18024115401H.

SUPPORT NOTE

SN026 | Isolated RS-485 interface based on 4-channel digital isolator with integrated DC/DC converter

A APPENDIX

A.1 Bill of Material

Designator	Description	WE series	Order Code	Manufacturer	Quantity
C1, C2	Filter ceramic chip capacitor 10 μ F, 16 V, X7R, 1210	WCAP-CSGP	885012209014	Würth Elektronik	2
C3, C4	Ceramic chip capacitor 10 μ F, 16 V, X7R, 1210	WCAP-CSGP	885012209014	Würth Elektronik	2
C5	Ceramic chip capacitor 100 nF, 100 V, X7R, 0805	WCAP-CSGP	885012207128	Würth Elektronik	1
C6, C7	Ceramic chip capacitor 10 pF, 25 V, NP0, 0603	WCAP-CSGP	885012006032	Würth Elektronik	2
R1	SMD resistor 50 Ω , 0.1 W, 0603	---			1
R2, R6	SMD resistor 10 Ω , 0.1 W, 0603	WRIS-RSKS	560112116013	Würth Elektronik	2
R3	SMD resistor 120 Ω , 0.1 W, 0603	WRIS-RSKS	560112116119	Würth Elektronik	1
R4, R5	SMD resistor 0 Ω , 0.1 W, 0603	WRIS-RSKS	560112116001	Würth Elektronik	2
U1	4-channel digital isolator with integrated DC/DC, SOIC-16WB	WPME-CDIP	18024115401H	Würth Elektronik	1
U2	Half-duplex RS-485 transceiver 50 Mbps, SOIC-8NB	---			1
D1	2-channel TVS Diode, 5 V, 12 pF, SOT23-3L	WE-TVS	824022	Würth Elektronik	1
L1	Filter SMD inductor 4.7 μ H, 4532	WE-PD2	744773047	Würth Elektronik	1
L2	SMT common mode line filter 1000 μ H, 0.8 A, 80 V	WE-SL2	744222	Würth Elektronik	1
J1	THT horizontal entry modular, pitch 5 mm, 2p	WR-TBL	691502710002	Würth Elektronik	1
J2, J3	SMA PCB end launch connector	WR-SMA	60312202114509	Würth Elektronik	2
P1	THT 3-pin header, vertical, single row, pitch 2.54 mm	WR-PHD	61300311121	Würth Elektronik	1
P2	THT 1-pin header, vertical, single row, pitch 2.54 mm	WR-PHD	61300111121	Würth Elektronik	1

A.2 Supporting design file archive

Supporting design file archive contains Support Note, Schematic, Bill of materials, Gerber files, NC Drill files, Support Note, Layer Definition and Layer Stack Legend. The link to the file archive is available:

<https://www.we-online.com/components/products/media/860161>

SUPPORT NOTE

SN026 | Isolated RS-485 interface based on 4-channel digital isolator with integrated DC/DC converter

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SUPPORT NOTE

SN026 | Isolated RS-485 interface based on 4-channel digital isolator
with integrated DC/DC converter

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Note: The current version of the document and the release date are indicated in the footer of each page of this document.