SUPPORT NOTE

SN028 | Isolated CAN Interface Based on a 2-Channel Digital Isolator and an Isolated Power Supply Module

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This design example shows an isolated CAN interface using a 2-channel digital isolator and an isolated power supply module, reducing components count and board space. The design is tested to operate at 1 Mbps data rate and meets CISPR 32 Class B radiated emission standard. The block diagram of the circuit is shown in Figure 1.

1. OVERVIEW OF CAN INTERFACE

The Controller Area Network (CAN) is a special type of communication protocol that enables multiple electronic devices to exchange information efficiently and reliably. It was originally developed for automobiles, where sub systems such as the engine, brakes and airbags need to communicate with each other. Today, it is used in a wide range of applications beyond the automotive industry.

The CAN bus is one of the most widely used communication protocols worldwide, valued for its simplicity, reliability and efficiency. Renowned for its robust performance and real-time capabilities, CAN enables seamless communication between electronic systems across a wide range of applications, including industrial automation and control, automotive and transportation, building automation, energy management and smart grids.

What makes CAN special?

Multi-Device Support

Unlike some communication systems that require a separate connection for each device, CAN allows multiple devices to share just two wires. This makes the system simpler, more cost-effective and easier to maintain.

Differential Signaling for Noise Immunity

By using differential signaling (balanced line), CAN achieves high immunity to electrical noise, making it well-suited for harsh environments with significant electromagnetic interference (EMI).

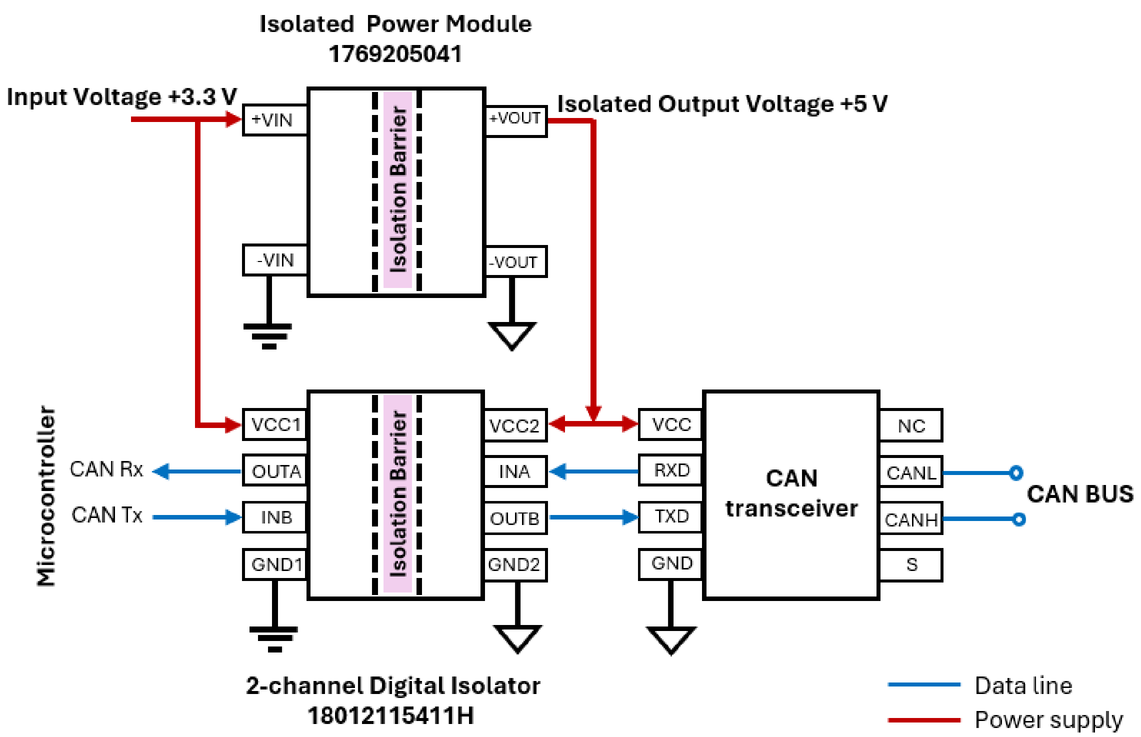


Figure 1: Block diagram of isolated CAN interface board.

Arbitration (Smart Message Handling)

CAN uses a priority-based system in which messages with higher priority (i.e., lower ID values) are transmitted first without conflicts.

Error Detection

CAN ensures reliable data transmission through its built-in automatic error-checking mechanisms. These allow the CAN bus to detect, isolate, and, to some extent, correct errors in real-time. When an error is detected, the system automatically discards the faulty data, initiates retransmission, and - if necessary - disables malfunctioning nodes to prevent system-wide failures. This makes the CAN bus one of the most robust communication protocols for safety-critical applications.

Flexible Data Rate and Long-Distance Communication

Standard CAN bus exhibits a trade-off between data rate and maximum bus length:

- 1 Mbps → up to 40 meters
- 500 kbps → up to 100 meters
- 125 kbps → up to 500 meters
- 50 kbps → up to 1 km

2. IMPORTANCE OF CAN BUS ISOLATION

As mentioned above, the CAN bus is highly reliable and uses differential signaling, which provides excellent noise immunity and minimizes electromagnetic interference (EMI). However, isolation in the CAN interface remains crucial in many applications to protect devices, ensure stable communication, and prevent system failures. Below are the key reasons why isolation is important in CAN-based systems:

2.1 Preventing Ground Loops and Voltage Differences

In large or complex CAN networks, different nodes - individual electronic devices or modules connected to the CAN bus that communicate with each other - may have varying ground potentials. If these nodes share a direct electrical ground, ground loops can form, causing unwanted currents that interfere with communication and lead to data corruption.

- Galvanic isolation separates the grounds of different CAN nodes, effectively preventing ground loops.
- It ensures that each device operates independently, free from electrical interference.

2.2 Protection Against High Voltage Surges and Transients

CAN networks often experience voltage spikes caused by power fluctuations in industrial environments, lightning strikes in outdoor applications, or switching of large electrical loads in factories and vehicles. These surges can disrupt communication, damage sensitive electronic components, and lead to system failures.

- Galvanic isolation, combined with surge protection devices (such as TVS diodes), helps withstand voltage surges and transients, protecting components and enhancing overall system reliability.
- It ensures that a voltage surge affecting one device does not propagate to others.

2.3 Noise Immunity

In environments with motors, inverters, welding machines or other high-power electronics, electromagnetic interference (EMI) can disrupt CAN signals. Although CAN uses differential signaling, this alone may not be sufficient under extreme conditions.

- Isolation combined with additional measures such as filtering, shielding, and proper PCB layout, protects sensitive equipment from high levels of EMI and strong magnetic fields commonly found in industrial settings, helping to maintain data integrity.

2.4 Ensuring Safety

Industrial machines must comply with strict safety standards to prevent electrical hazards and equipment failures. When different devices in a CAN network share a direct electrical connection, unexpected voltage differences or electrical faults can damage components, cause communication failures, or even pose safety risks to operators.

- Isolation prevents electrical faults from propagating, ensuring that a failure in one machine does not disrupt the entire network.
- Isolated CAN protects workers and control systems from high-voltage leakage in electrically noisy environments.
- Isolation improves system reliability by ensuring stable communication between sensors, controllers and actuators.

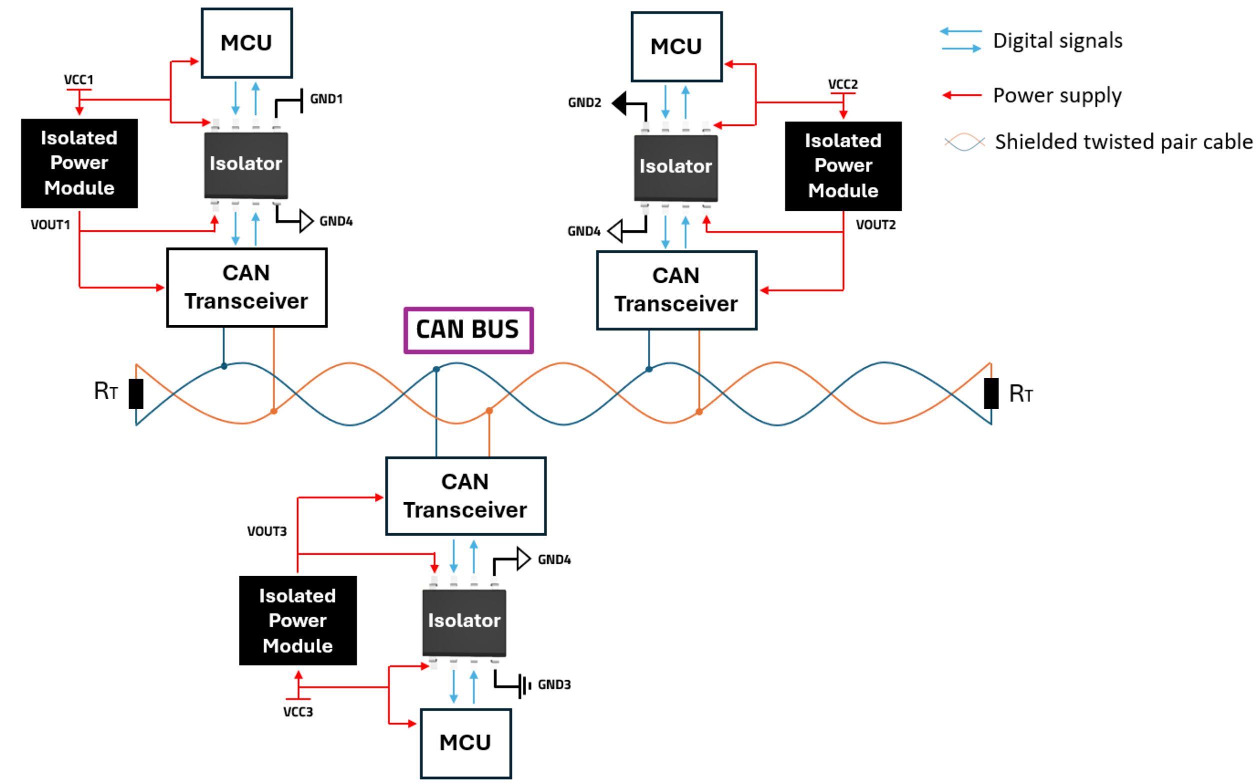


Figure 2: Typical isolated CAN bus system.

Figure 2 shows a typical isolated CAN bus system with power supplied from isolated modules.

3. DESCRIPTION OF DESIGN EXAMPLE BOARD

3.1 Key Parameters

The design example board features a 4-layer structure and has been tested to operate at a data rate of 1 Mbps with 25 meter shielded twisted-pair cable between the transmitter and receiver boards during the radiated emission test (Table 1).

Parameter	Value
Input supply voltage	3.3 V
Isolated output supply voltage (output voltage of isolated power module)	5 V
Maximum data rate of the communication lines	1 Mbps
Isolation	Functional*
Radiated emission test standard	CISPR 32 Class B

Table 1: Key parameters of the isolated CAN board.

* Although the digital isolator 18012115411H provides a basic level of isolation, the isolated CAN board offers only functional isolation because the isolated power module 1769205041 itself provides only functional-level isolation.

3.2 Configuration

A top view of the application example board is shown in Figure 3.

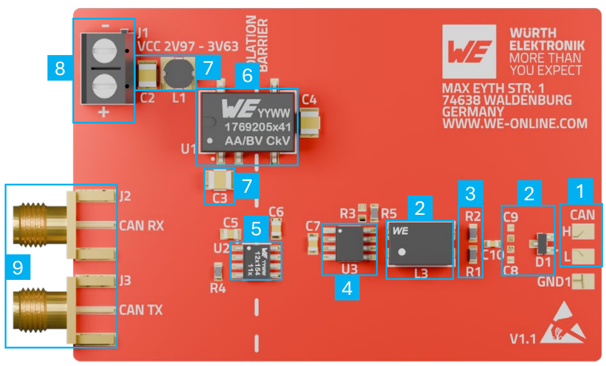


Figure 3: Top view of the application example board.

The board can be logically divided into 9 functional blocks:

1. CANL and CANH pads: Low- and High-level CAN bus lines (CAN input)
2. Data line filter and TVS diodes: Provide RF-filtering and overvoltage protection
3. Termination resistors: Ensure proper bus impedance matching
4. CAN transceiver (SOIC-8NB package): Interfaces the physical CAN bus
5. 2-channel digital isolator (SOIC-8NB, basic isolation): Provides signal isolation
6. 1 W isolated power module (SMT-8 package, functional isolation): Supplies isolated power
7. DC supply voltage filter circuit: Filters the input power line
8. Terminal block screw connector: For power supply connection
9. SMA connectors: For CAN interface signals**

** The SMA connectors (high-speed connectors) are used to feed a test signal from a signal generator into the PCB. This setup simulates a single-ended board-level signal source driving the input of the digital isolator.

Figure 4 shows the schematics of the transmitter and receiver boards used during the radiated emission test. The differences between the boards are described in Section 6.1.

- R_1, R_2, and C_{10} form a commonly used split termination circuit for CAN communication.
- C_8 and C_9 are signal filtering capacitors, selected based on the wire length and data rate.
- R_4 is a termination resistor, required only on the transmitter board.
- R_3 and R_5 configure the CAN transceiver for either transmit or receive mode — only one is used at a time: R_3 for receive mode (required only on the receiver board), and R_5 for transmit mode (required only on the transmitter board). In real-world applications, this selection is typically controlled by the logic level of a microcontroller pin (high or low).

4. SELECTION OF COMPONENTS

4.1 Digital Isolator

The 18012115411H is a 2-channel digital isolator (U_2) in an SOIC-8NB package that provides basic isolation. It features a 1/1 channel configuration - 1 reverse and 1 forward channel – which is essential for the proper operation of the isolated CAN interface. The forward channel transmits data from the microcontroller (MCU) to the transceiver, which then sends it onto the CAN bus. The reverse channel carries data received from the CAN bus via the transceiver back to the MCU.

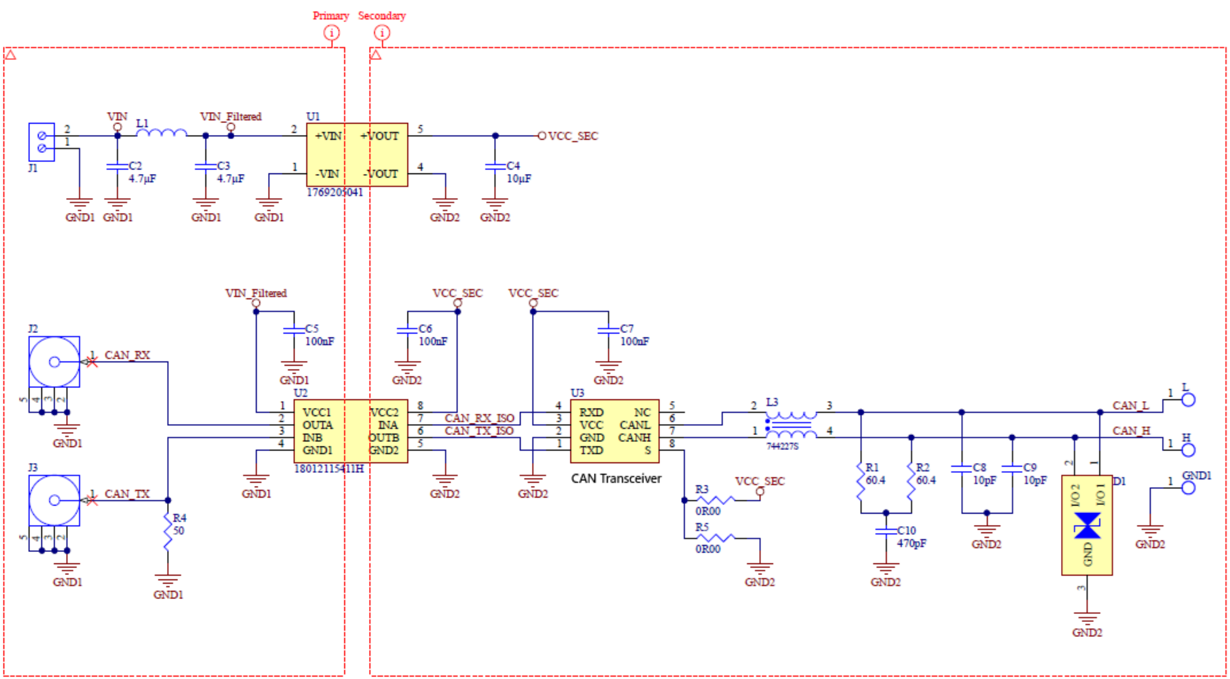


Figure 4: Schematics of isolated CAN transceiver and receiver boards.

Key Features of the 18012115411H:

- UL1577 recognized
  - 3750 V_{RMS} isolation voltage per 60 s
- DIN EN IEC 60747-17 (VDE 0884-17):2021-10 certified
  - Basic isolation
  - Maximum repetitive peak isolation voltage: 566 V_{PK}
  - Maximum working isolation voltage: 400 V_{RMS} and 566 V_{DC}
  - Maximum transient isolation voltage: 5300 V_{PK}
  - Maximum surge isolation voltage: 5000 V_{PK}
- Input voltage range: 2.375 V to 5.5 V
- Data rate: Up to 150 Mbps
- CMTI: ±150 kV/µs typ.
- Ambient temperature range: -40°C to 125°C

Key Considerations when Using High-Speed Digital Isolators

Signal Routing & Layout Guidelines

- Use short signal paths and minimal loop areas to maintain high signal quality.
- Route differential trace pairs symmetrically, without stubs, and with as few vias as possible.
- Prefer inner signal layers with a continuous ground plane underneath to ensure consistent impedance.
- Avoid sharp angles when routing signal traces; use smooth, gradual bends instead.
- Place input capacitors as close as possible to the Vin and GND pins.
- Design a low-impedance layout for the digital isolator by using solid Vin and GND planes.
- Ensure impedance-controlled layout for high-speed signal traces.

Y-Capacitance as PCB Area

- Create Y-capacitance suitable for high frequencies by overlapping primary and secondary GND copper planes on adjacent PCB layers beneath the digital isolator. Avoid placing vias within the Y-capacitance area to maintain its effectiveness.
- The Y-capacitance formed under the digital isolator helps suppress high-frequency common-mode noise.

4.2 Isolated Power Module

The 1769205041 is an isolated power module (U_1) that provides functional isolation and delivers up to 1 W (0.2 A) of isolated power in a SMT-8 package. Its high level of integration— including the switching power stage, control circuitry, transformer, and input/output capacitors — significantly reduces the component count, saving valuable board space. The module operates without the need of any external components, minimizing design effort and complexity. Additionally, the 1769205041 features continuous short-circuit protection for enhanced reliability.

Key Features of the 1769205041:

- 4 kV DC functional isolation for 1 s
- 3 kV DC functional isolation for 60 s
- Input voltage: 2.97 to 3.63 V
- Output voltage: 5 V
- Low output voltage ripple: Typ. 55 mV at full load
- Output voltage accuracy: Typ. 1.6% at full load
- Dynamic power boost: Up to 0.3 A for 0.5 s
- Operating ambient temperature range: -40°C to 105°C
- Complies with EN55032 (CISPR-32) class B conducted and radiated emissions standard (with the reference layout specified in the datasheet)
- UL62368-1 recognized

4.3 CAN Transceiver

CAN transceivers enable robust, differential communication between nodes in a Controller Area Network (CAN). They handle both transmission and reception over a shared two-wire bus (CANH and CANL), simplifying wiring and ensuring stable network operation.

Functionally, the CAN transceiver acts as the physical layer interface between the CAN protocol controller - typically integrated within a microcontroller - and the physical CAN bus. On the transmit side, it converts the microcontroller´s logic-level TXD signal into a differential voltage signal on the bus. On the receive side, it monitors the voltage difference between CANH and CANL and translates it into a logic-level RXD signal for the microcontroller.

The design example uses a standard CAN transceiver (U_3) in a **SOIC-8NB** package (see Figure 5), offering a compact footprint well-suited for space-constrained applications.

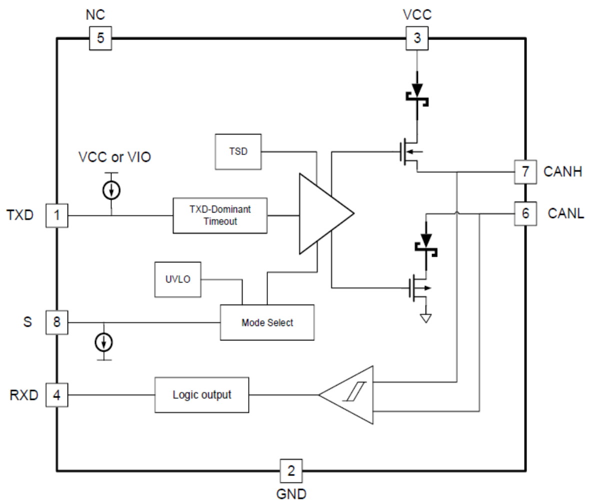


*Figure 5: Simplified block diagram of non-isolated CAN transceiver in **SOIC-8NB** package.*

4.4 Transient Protection

The WE-TVS diode D_1 824022 consists of two bidirectional TVS diodes in a compact SOT-23 package and is used to protect the data lines from overvoltage. Designed for a channel operating voltage of 5 V, the 824022 features very low input capacitance (15 pF), which helps minimize signal distortion, support high data rates, and preserve the integrity of differential signals in high-speed CAN communication systems.

4.5 Filter Circuit of the CAN Data Lines

The WE-SL2 744227S common-mode line filter (L_3), recommended for use in CAN applications, was selected to filter the CAN data lines. For detailed information on filter selection, refer to the online tool REDEXPERT.

4.6 Filter Circuit of the Supply Voltage Line

The WE-PD2 SMT power inductor L_1 744773068 (6.8 µH) and WCAP-CSGP MLCC ceramic capacitors C_2 and C_3 885012209004 (4.7 µF/10 V, X7R, 1210) were selected for the input filter of the isolated power module. For detailed information on filter component selection and PCB layout recommendations, refer to the 1769205041 power module datasheet (Section 19: Design Example) and the online tool, REDEXPERT EMI Filter Designer.

5. REDUCING COMMON-MODE INTERFERENCE WITH OVERLAPPING STITCHING CAPACITANCE

The isolated power module (U_1) and digital isolator (U_2) provide galvanic isolation between the input and output of the system. However, the parasitic coupling capacitance across the isolation barrier allows common-mode currents to flow, making the isolator and power module potential sources of common-mode interference.

To mitigate this, designers typically use an external Y-capacitor between the input and output. An alternative approach is to utilize the parasitic capacitance between PCB layers - commonly referred to as stitching capacitance – as an integrated Y-capacitor. This technique creates a high-frequency return path for common-mode noise, helping to reduce EMI without the need for additional components.

In this design example, the board features a 4-layer PCB structure. The stitching capacitance is formed by overlapping copper areas across different PCB layers - specifically between internal layer 1, internal layer 2 and the bottom layer. The layer stack-up and the regions contributing to the stitching capacitance are illustrated in Figure 6, the PCB layer stack is shown in Figure 7.

Note: There is no stitching capacitance between the top layer and the internal layer 1. GND1 and GND2, located on the internal layer 1, serve as the reference grounds for the signal and power circuits placed on the top layer.

In the following, the capacitance resulting from the overlapping of the copper areas as shown in Figure 6 is calculated.

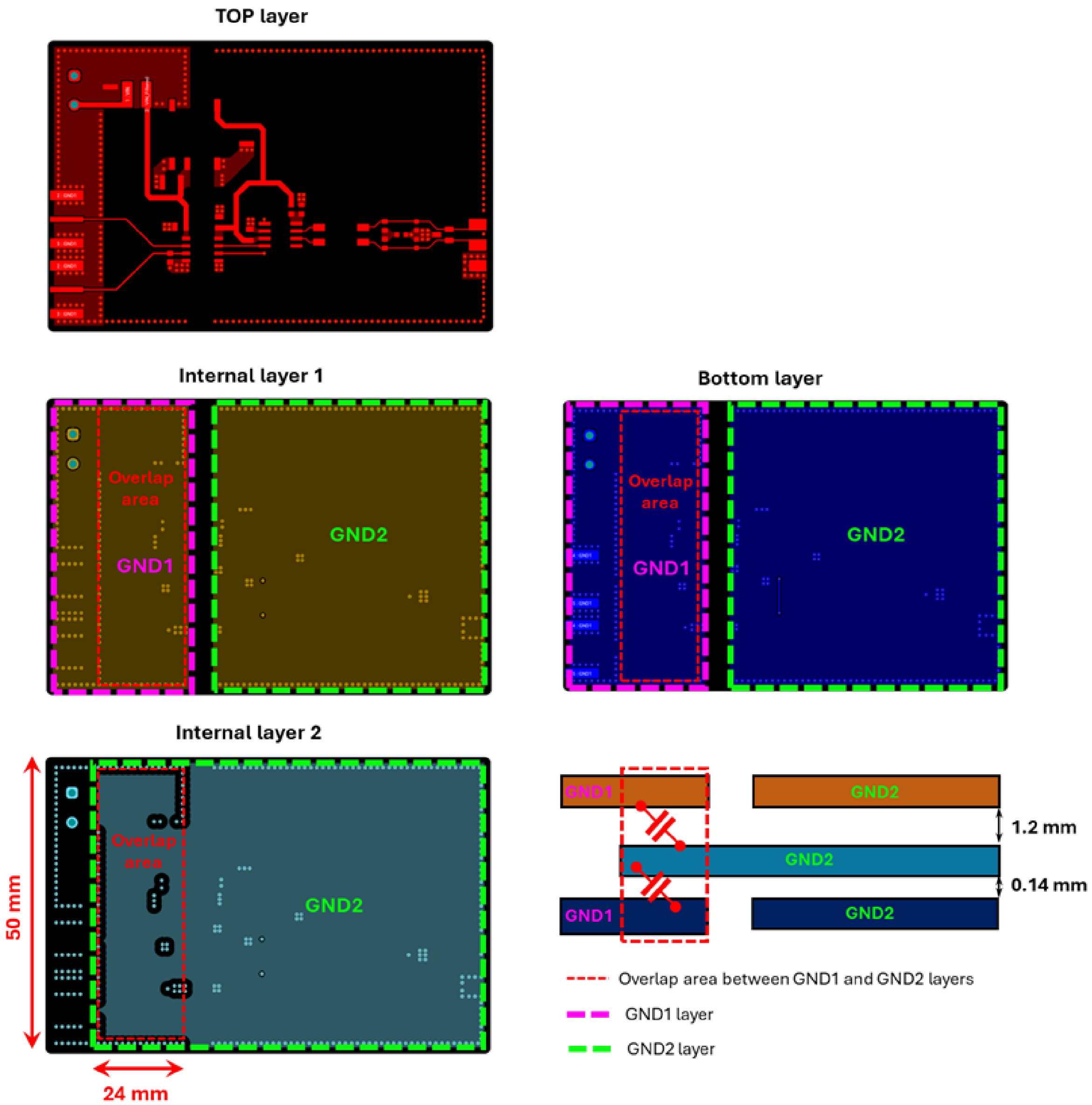
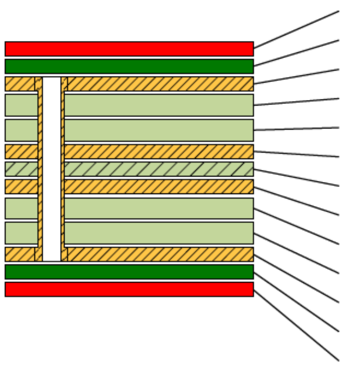


Figure 6: Overlap area of CAN design example board.



Material	Layer	Thickness	Dielectric Material	Type	Gerber
	Top Overlay			Legend	GTO
Surface Material	Top Solder	0.010mm	SM-001	Solder Mask	GTS
CF-004	**TOP**	**0.035mm**		**Signal**	**GTL**
Prepreg		*0.070mm*	*PP-010*	*Dielectric*	
Prepreg		*0.070mm*	*PP-010*	*Dielectric*	
Copper	**IN1**	**0.035mm**		**Signal**	**G1**
		1.200mm	*FR-4*	*Dielectric*	
Copper	**IN2**	**0.035mm**		**Signal**	**G2**
Prepreg		*0.070mm*	*PP-010*	*Dielectric*	
Prepreg		*0.070mm*	*PP-010*	*Dielectric*	
CF-004	**BOTTOM**	**0.035mm**		**Signal**	**GBL**
Surface Material	Bottom Solder	0.010mm	SM-001	Solder Mask	GBS
	Bottom Overlay			Legend	GBO

Total thickness: 1.640mm

Figure 7: PCB Layer stack legend.

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

$$C = \frac{\varepsilon_0 \cdot \varepsilon_r \cdot A}{d} \qquad (1)$$

where:

C is the stitching capacitance in farads (F)
ε_0 is the vacuum permittivity, approximately $8.854 \cdot 10^{-12}$ F/m
ε_r is the relative dielectric constant of the PCB material (typically 4-5, as provided by the manufacturer)
A is the overlapping area of the planes in square meters (m^2)
d is the distance between the planes (dielectric thickness) in meters (m)

Board parameters for stitching capacitance calculation:

- Overlapping area: The nominal overlap is 50 × 24 mm^2, but after accounting for clearance around the board outline and vias, the effective overlap is approximately 549 mm^2.
- Layer spacing and relative dielectric constants:
  - Internal layer 1 to internal layer 2: d = 1.2 mm, $\varepsilon_r = 4.6$
  - Internal layer 2 to bottom layer: d = 0.14 mm, $\varepsilon_r = 4$

Resulting stitching capacitance calculation:

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

$$C = C_{IN1\text{-}IN2} + C_{IN2\text{-}BOTTOM}$$
$$C = 18.6\ \text{pF} + 138.9\ \text{pF} = 157.5\ \text{pF} \qquad (2)$$

Impact on EMI performance:

The calculated stitching capacitance of approximately 157.5 pF creates an effective high-frequency return path for common-mode noise. This significantly improves EMI performance. Radiated emissions measurements (see Figure 10) confirm the effectiveness of this approach. The 4-layer PCB design with integrated stitching capacitance stays well below the required emission limits, demonstrating successful EMI mitigation.

For more detailed information on common-mode interference and coupling capacitance, refer to Application Note ANS022.

6. TESTING

6.1 Tested Configuration and Test set-up

Configuration of the EUT (Equipment Under Test) tested for radiated emission measurement is shown in Figure 8.

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

- Resistors R_4 and R_5 are required only on the transmitter board
- Resistor R_3 is required only on the receiver board

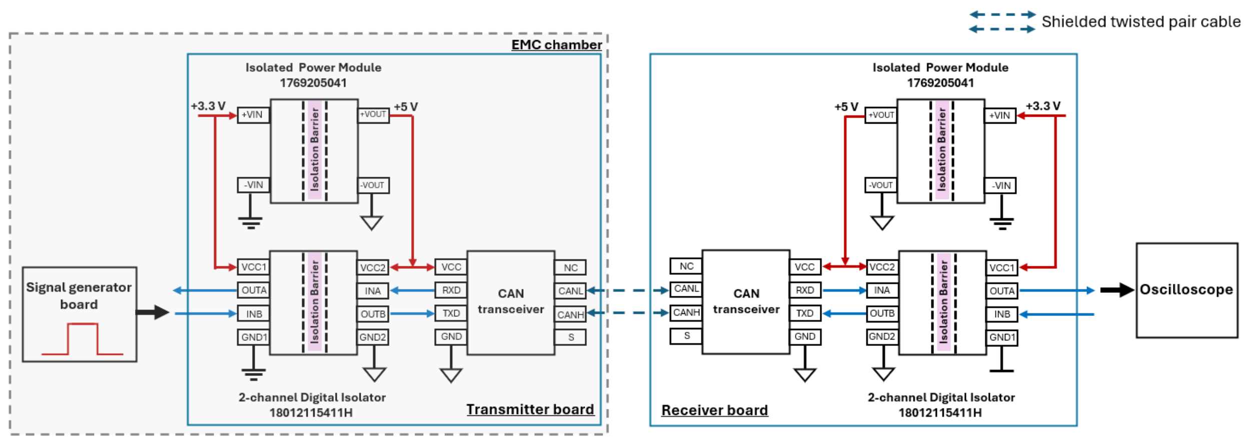


Figure 8: Test configuration for radiated emission measurement with 25 m of shielded twisted pair-cable between units.

6.2 Radiated Emission

Measurements were conducted using a 25 m shielded twisted-pair cable length between the transmitter and receiver boards, with a data rate of 1 Mbps. The test set-up is illustrated in Figure 9.

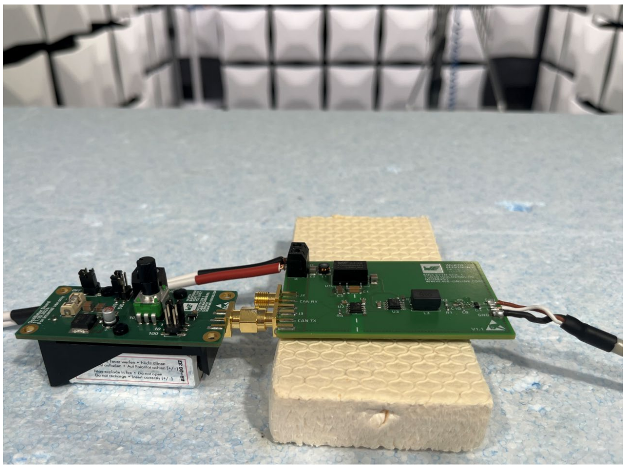


Figure 9: Test set-up in the EMC test chamber, signal generator board on the left and transmitter board on the right.

The results of the radiated emission test, conducted using the setup shown in Figure 9, are presented in Figure 10. The data indicates that the equipment under test (EUT) exhibits only minimal radiated emissions. The blue trace represents the peak level, the orange trace indicates the quasi-peak level, and the red lines correspond to the limits of class A and class B, defined by EN 55032 respectively CISPR 32.

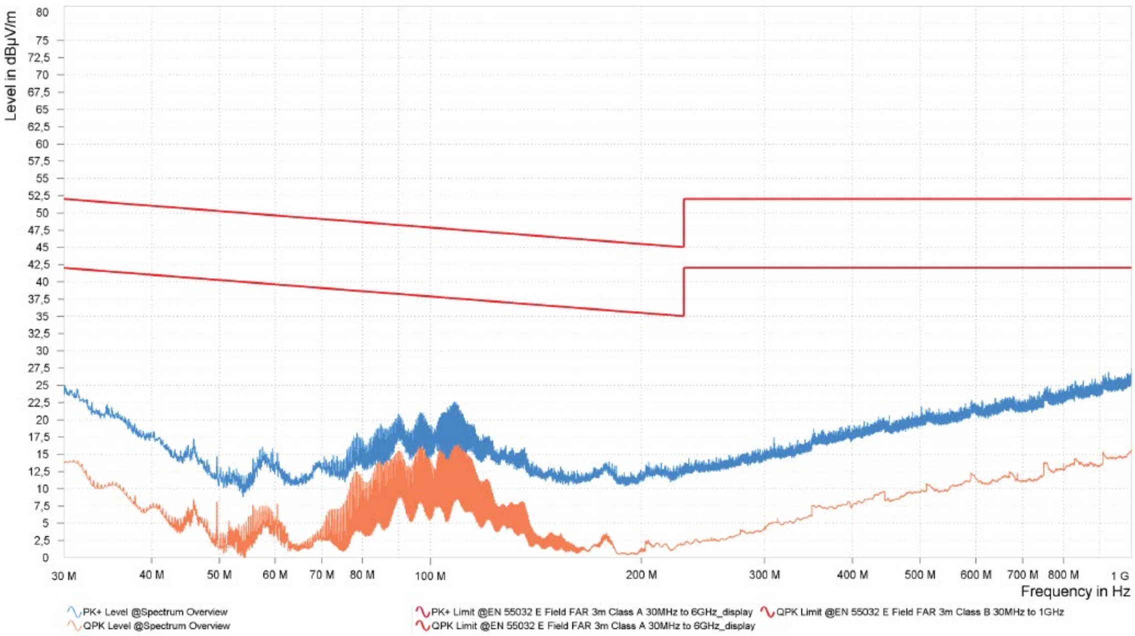


Figure 10: Radiated emission (CISPR 32 Class B) of the EUT.

6.3 Propagation Delay

The propagation delay between the input and output signals of the digital isolator is approximately 10 ns (Figure 11), enabling fast switching, minimal signal distortion, and reliable communication over the CAN interface.

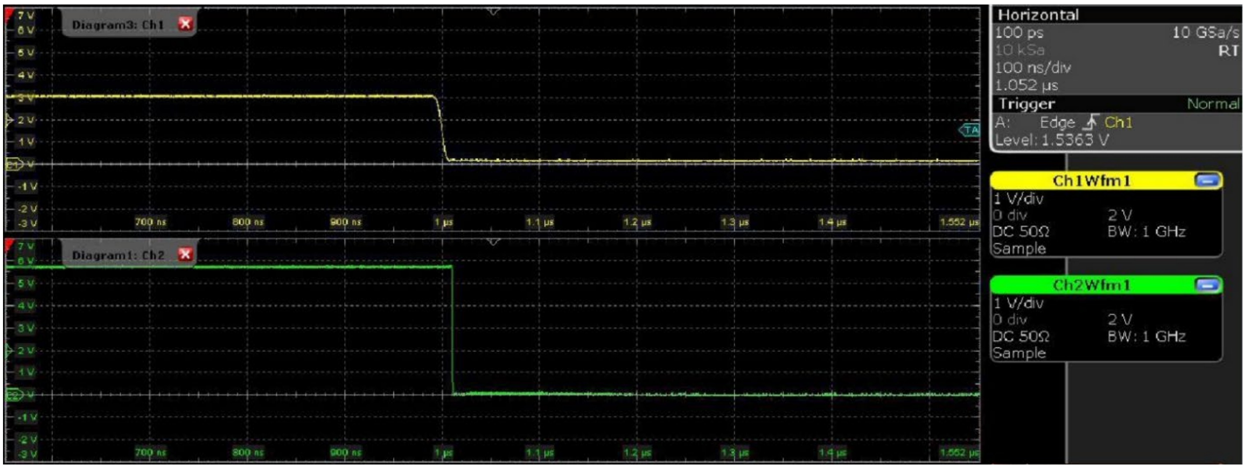


Figure 11: Propagation delay between input (Channel 1) and output (Channel 2) signals of the digital isolator 18012115411H.

A APPENDIX

A.1 Bill of Materials

Designator	Description	WE series	Order Code	Manufacturer	Quantity
C_2, C_3	Filter ceramic chip capacitor 4.7 µF, 10 V, X7R, 1210	WCAP-CSGP	885012209004	Würth Elektronik	2
C_4	Ceramic chip capacitor 10 µF, 16 V, X7R, 1210	WCAP-CSGP	885012209014	Würth Elektronik	1
C_5, C_6, C_7	Ceramic chip capacitor 100 nF, 16 V, X7R, 0805	WCAP-CSGP	885012207045	Würth Elektronik	3
C_8, C_9	Ceramic chip capacitor 10 pF, 10 V, NP0, 0603 (not mounted on the PCB)	WCAP-CSGP	885012006032	Würth Elektronik	2
C_{10}	Ceramic chip capacitor 470 pF, 10 V, NP0, 0603	WCAP-CSGP	885012006012	Würth Elektronik	1
R_1, R_2	SMD resistor 60.4 Ω, 0.1 W, 0603	---			2
R_3	SMD resistor 0 Ω, 0.1 W, 0603 (only for the receiver board)	WRIS-RSKS	560112116001	Würth Elektronik	1
R_4	SMD resistor 50 Ω, 0.1 W, 0603 (only for the transmitter board)	---			1
R_5	SMD resistor 0 Ω, 0.1 W, 0603 (only for the transmitter board)	WRIS-RSKS	560112116001	Würth Elektronik	1
U_1	1 W isolated power module, SMT-8	WPME-FISM	1769205041	Würth Elektronik	1
U_2	2-channel digital isolator, 3750 V_{RMS}, 1/1, SOIC-8NB	WPME-CDIS	18012115411H	Würth Elektronik	1
U_3	CAN transceiver, SOIC-8NB	---			1
D_1	2-channel TVS Diode, 5 V, 12 pF, SOT23-3L	WE-TVS	824022	Würth Elektronik	1
L_1	Filter SMD inductor 6.8 µH, 4532	WE-PD2	744773068	Würth Elektronik	1
L_3	SMT common mode line filter 51 µH, 1 A, 80 V	WE-SL2	744227S	Würth Elektronik	1
J_1	THT horizontal entry modular, pitch 5 mm, 2p	WR-TBL	691502710002	Würth Elektronik	1
J_2, J_3	SMA PCB end launch connector	WR-SMA	60312202114509	Würth Elektronik	2

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.

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