
48 V CAN data lines enhanced ESD protection

Introduction

This application note focuses on electrostatic discharge (ESD) protection for the CAN_H and CAN_L data lines between 48 V automotive systems, including challenges such as GND loss, short circuits affecting the 48 V battery supply, and ESD events. The note shows that a simple circuit using available ESDCAN protection lineup provides better ESD performance than dedicated 48 V ESD protection product. The first part defines the basics of the ESDCAN family, ISO 21780 GND loss constraints, and battery short-circuit conditions.

The transition to 48 V electrical architectures is an important trend in the automotive industry. Power consumption increases with the contents of electronics requiring a new higher supply voltage step, the 48V is the chosen solution.

However, the 12 V system remains present in modern vehicles and continues to power many existing low-voltage loads and legacy functions. As a result, 48 V and 12 V or 24 V domains must coexist and communicate each others adding more design complexity. Efficient interaction between the networks is essential to ensure proper operation, power management, and functional safety.

This coexistence requires specific precautions in fault conditions and abnormal conditions. Examples include short circuits between data lines, 48 V battery issues, GND loss, and electrostatic discharge (ESD) damage. Failures in one domain can affect the other. Isolation, monitoring, and fail-safe strategies are therefore critical to maintain system reliability and protect vehicle electronics.

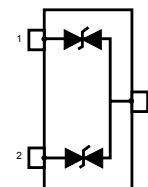
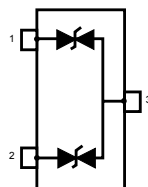
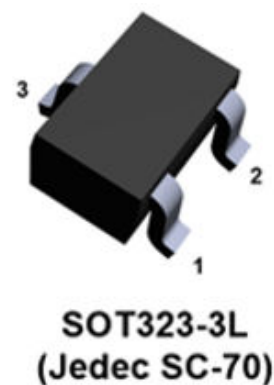


1 ESDCAN basics

CAN communication is widely used in embedded systems because it is reliable, efficient, and well suited for real-time data exchange between multiple nodes. CAN lines often run through noisy industrial or automotive environments. Right choice of protection improves robustness and protects the transceiver, it helps prevent electrical disturbances, surges and electrostatic discharge (ESD), especially during cable connection.

ST has developed a large family of ESDCAN products for automotive systems. These products support jump-start conditions that exceed 24 V, as defined in *ISO 16750-2*. They also protect truck systems against overvoltage above 36 V, according to *ISO 16750-2*. These products protect CAN transceivers and the passive components that are mandatory on the line against repetitive electrostatic discharge (ESD) (see "AN5878: How to design a robust automotive CAN system" for more details).

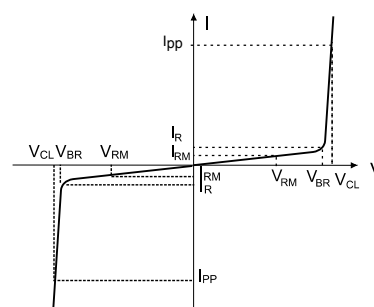
Both CAN lines protection are integrated in the same package, either SOT323 or SOT23, to save space.



Product status link	Product status link
ESDCAN01-2BLY , ESDCAN24-2BLY , ESDCAN04-2BLY , ESDCAN06-2BLY	ESDCAN02-2BWY , ESDCAN03-2BWY , ESDCAN04-2BWY , ESDCAN05-2BWY , ESDCAN06-2BWY

Figure 1. Electrical characteristics (definitions)

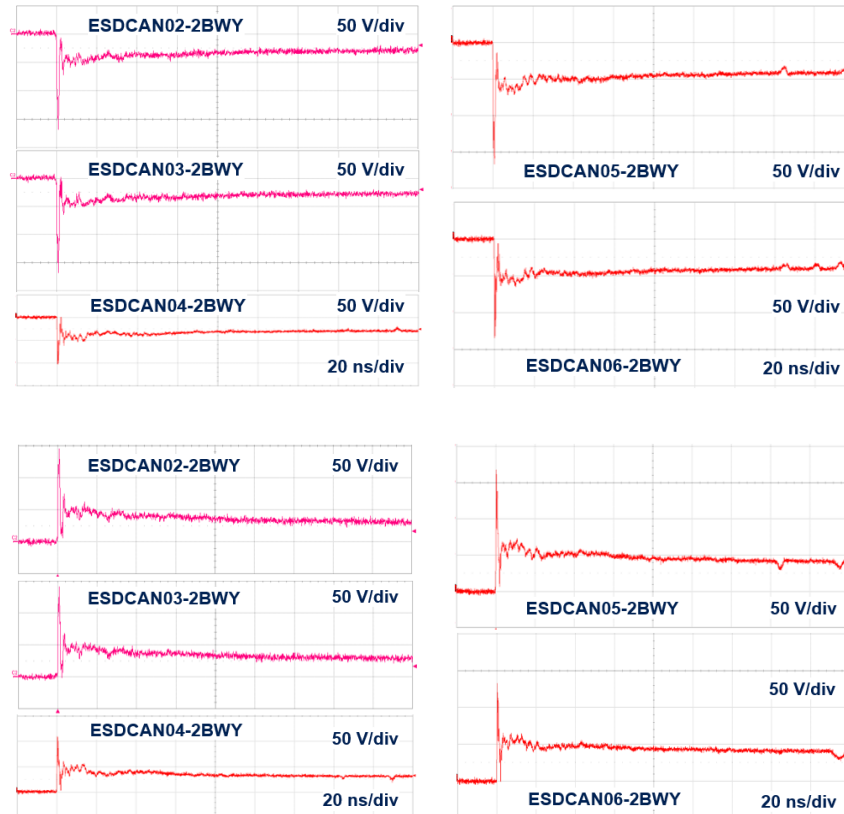
Symbol	Parameter
V_{BR}	= Breakdown voltage
V_{RM}	= Stand-off voltage
V_{CL}	= Clamping voltage
I_{RM}	= Leakage current at V_{RM}
I_{PP}	= Peak pulse current
R_d	= Dynamic impedance
C_{LINE}	= Input capacitance per line



The ESDCAN product protects an electronic device or circuit against bidirectional electrostatic discharge (ESD) events and other surges, usually defined in the *ISO 7637-3* standard for automotive applications. ESDCAN activates when the ESD or surge voltage across the protected device reaches breakdown voltage (V_{BR}). In the active state, ESDCAN becomes a low-impedance device. It clamps the surge voltage by absorbing the surge current. This action limits the ESD surge voltage and keeps the peak voltage low.

This protection helps protect ICs and other passive components connected to the data lines.

Figure 2. ESDCANxx response to *ISO 10605* ± 8 kV contact discharge, $C = 150$ pF, $R = 330\ \Omega$



Refer to [AN5241](#), [AN5686](#), and the ESDCANxx-2BWY series and ESDCANxx-2BLY series datasheet for full details.

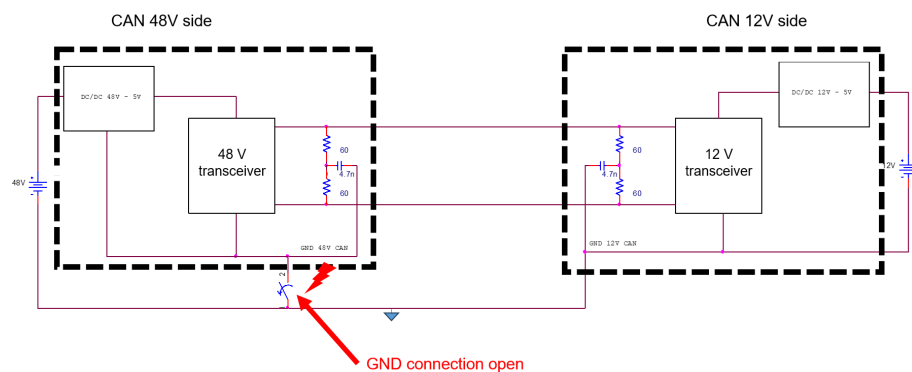
2 ISO 21780 standard and constraints

AN5958, an ST application note, summarizes the ISO 21780 descriptions and explains how to limit overvoltage with a transient voltage suppressor (TVS).

ISO 21780 defines the test setup for ground (GND) loss constraints in test 12. It simulates a scenario in which a 48 V component loses its ground connection while interfaces, for example, a controller area network (CAN) bus, remain connected to the 12 V or 24 V electrical system. Because this fault can cause significant damage, original equipment manufacturers (OEMs) want to implement a robust protection solution.

In case of GND loss, for example, because of a broken wire or a defective connector, when the 48 V side transmits a signal, the voltage across the data lines increases to 48 V. This increase can damage the 12 V CAN transceiver. The transceiver might not withstand this voltage level. For more information, see ISO 21780, test 12, and annex B.

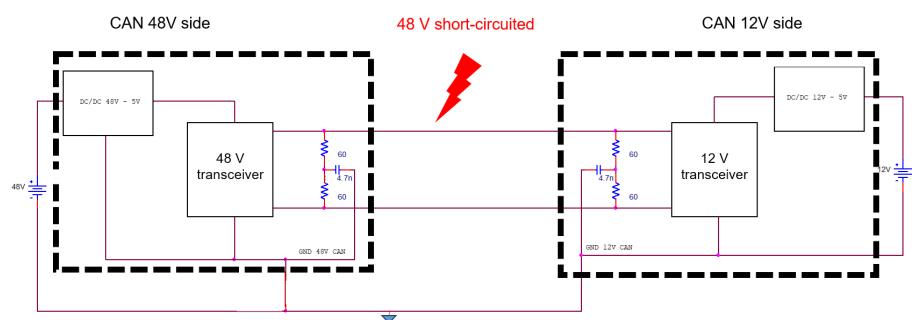
Figure 3. GND loss 48 V side



Another solution to avoid degradation is to use galvanic isolated components to isolate the 48 V supply to the 12 V side, but this solution increases cost.

ISO 21780 also describes a 48 V battery bus short circuit applied to 12 V or 24 V system pins in chapter 10.13, test 13, “fault current,” for example, communication pins. This test must ensure that components on the 12 V or 24 V side are not damaged in a system that requires different voltage ranges.

Figure 4. 48 V battery short-circuited with dataline



For both constraints described above, the easiest solution is to implement a transceiver CAN on 12 V side compatible with 48 V voltage levels. In addition, the electrostatic discharge (ESD) protection must withstand these voltage stresses.

This application note explains how to use the ST ESDCAN with an additional RC circuit to:

- Protect against ESD with better performance than dedicated 48 V ESD protection product
- Withstand GND loss
- Withstand a 48 V battery short circuit.

This solution supports communication between 48 V CAN transceiver domains or between 48 V CAN transceiver domains and 12 V CAN transceiver domains withstanding 48 V voltage level. Tests described later in this application note confirm the robustness of the ST ESD protection solution.

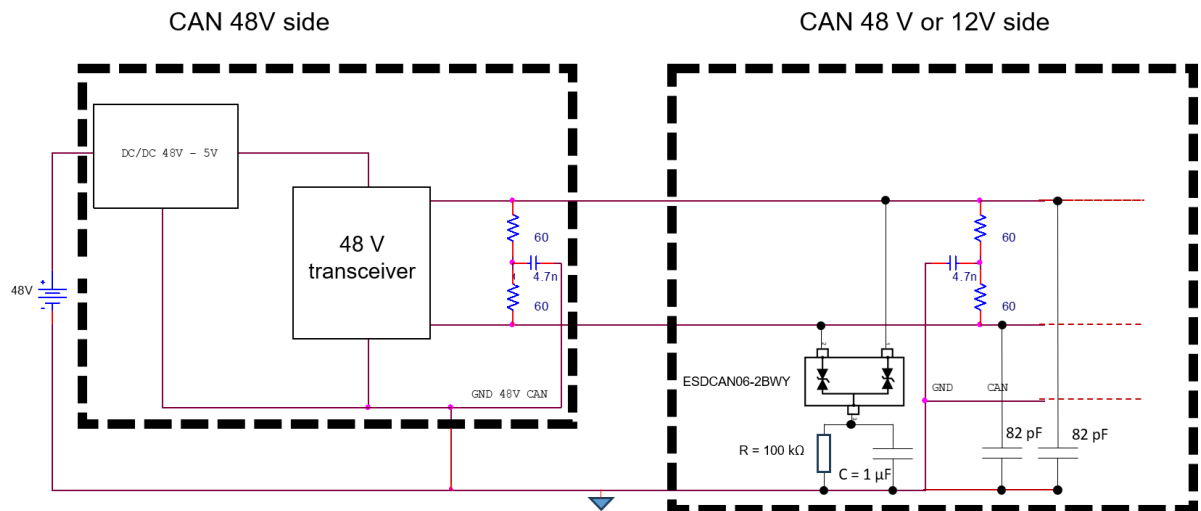
3 ESDCAN06-2BWY with R-C circuit

CAN signal common-mode voltage levels are between 0 V and +5 V, but they can reach -2 V to +7 V because of potential differences due to the distance between CAN transceiver nodes, wires, and other parasitic resistors. Therefore, if there are no additional constraints, the ESD protection can have a breakdown voltage of about 10 V. Nevertheless, other over-voltage stress have to be taken into account and in particular, for 48 V system, in case of a GND loss or a battery short circuit between data lines, the ESD protection must withstand a higher voltage (for ex higher than 48V for a 48V system).

It is possible to use ESD protection with a voltage lower than 48 V by adding a series resistor and a capacitor in parallel. During ESD events, a capacitor with a sufficiently high value is transparent to fast surges. In case of a long-duration surge, the capacitor charges and limits the current through the protection. The parallel resistor allows the capacitor to discharge. The total equivalent capacitance of this circuit is the lowest capacitor value because the components are connected in series, specifically that of the ESDCANxx product alone.

The following schematic shows an example of ESDCAN06-2BWY series with a 100 kΩ resistor connected in parallel with a 1 μF capacitor.

Figure 5. ESDCAN06-2BWY with R-C circuit



ESDCAN06-2BWY datasheet electrical parameters, SOT323-3L package:

Figure 6. ESDCAN06 datasheet parameters

Order code	I _{RM} max. at V _{RM}		V _{BR} at I _R			V _{CL} Pulse ISO7637-3		V _{CL} at I _{PP} (8/20 μs)		C		ΔC ⁽¹⁾	αT ⁽²⁾
			Min.	Max.		3a at -150 V min.	3b at +150 V max.	Max.		Typ.	Max.	Typ.	Typ.
	μA	V	V		mA	V		V	A	pF		pF	10 ⁻⁴ /°C
ESDCAN06-2BWY	0.1	35	38	42.2	1	-44	44	59	3	13	15	0.1	9

1. ΔC : capacitance variation between IO1 and IO2 versus GND

2. to calculate V_{BR} versus T_j: V_{BR} at T_j = V_{BR} at 25 °C x (1 + αT x (T_j - 25))

The typical breakdown voltage (V_{BR}) of ESDCAN06-2BWY is 40 V, which is lower than 48 V.

This application note shows that ESDCAN06-2BWY with an RC circuit is suitable for 48 V constraints, including GND loss and a 48 V battery short circuit on a data line, and provides a low ESD voltage response.

3.1 ESD voltage responses and comparison

10 shots at +8 kV and 10 shots at -8 kV, with 1 s between each shot, are applied using an electrostatic discharge (ESD) gun equipped with a contact tip, 330 Ohms, and 150 pF to the following:

- ESDCAN06 in series with $R = 100 \text{ k}\Omega$ (0603), connected in parallel with $1 \mu\text{F}$ (0603)
- Competitor CAN protection designed for a clamping voltage higher than 48 V.

Figure 7. ESDCAN06 in series with $R = 100 \text{ k}\Omega$ (0603), connected in parallel with $1 \mu\text{F}$ (0603), 48 V CAN protection ESD response

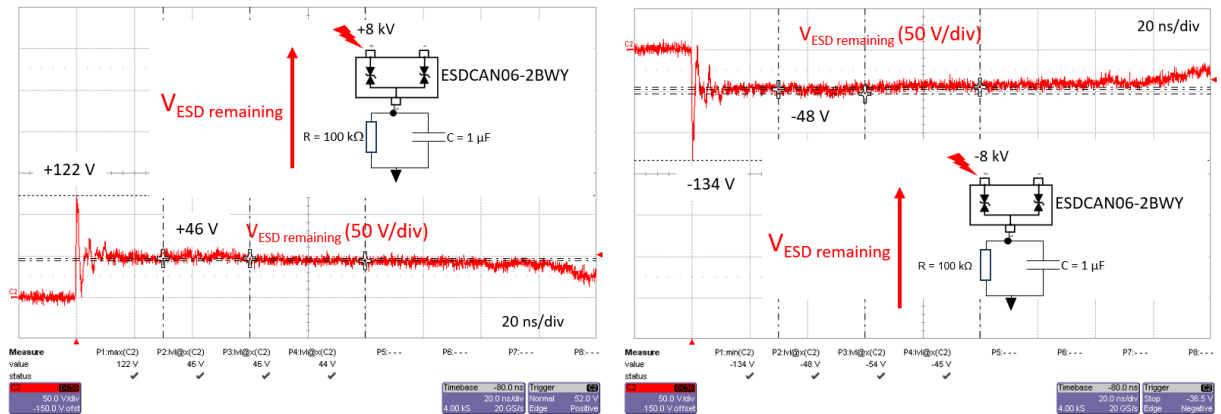
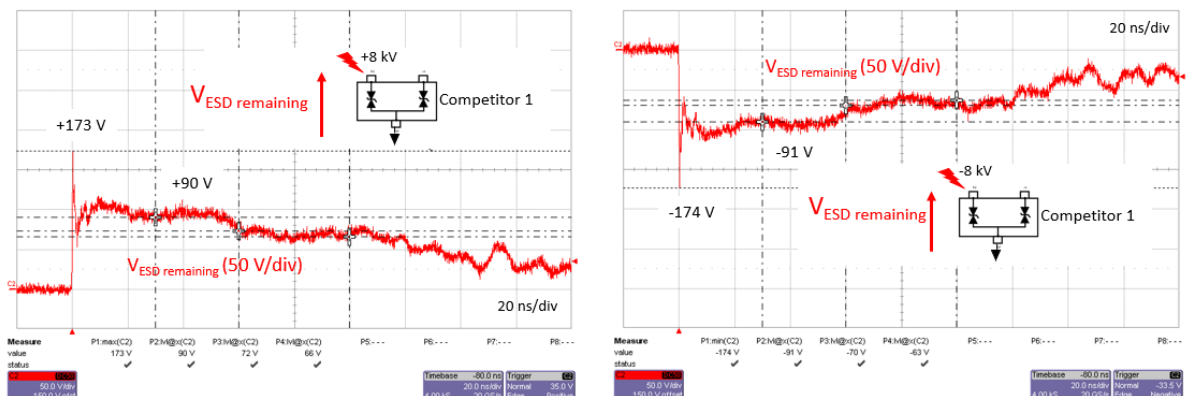


Figure 8. Competitor 48 V CAN protection ESD response



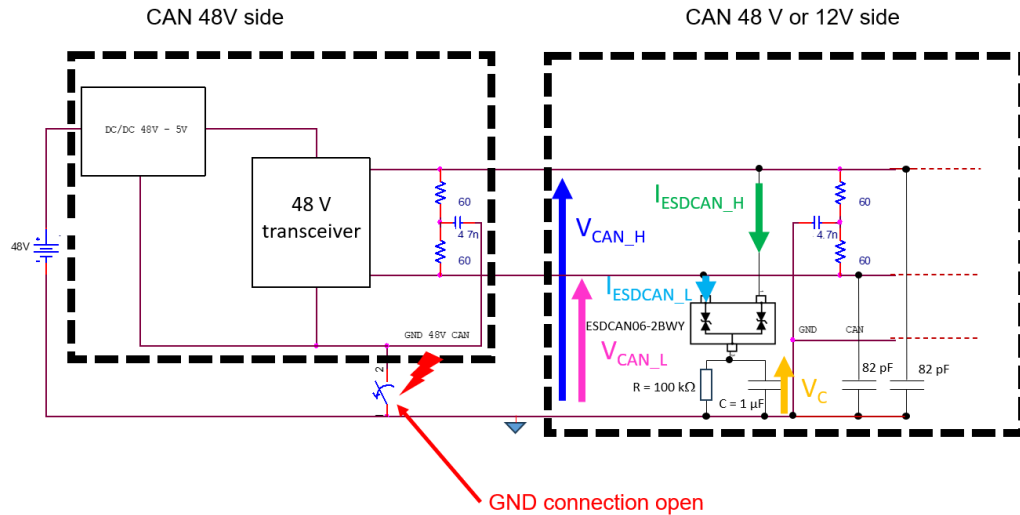
ESDCAN06 in series with a $100 \text{ k}\Omega$ resistor (0603) connected in parallel with a $1 \mu\text{F}$ capacitor (0603), shows much better electrostatic discharge (ESD) voltage response performance than the competitor. The voltage is more than 40 V lower for both first peak voltage and the remaining voltage at 30 ns as shown in the Figure 7. These remaining voltages are critical for the protected integrated circuit (IC).

This comparison shows that ESDCAN06 in series with a $100 \text{ k}\Omega$ resistor (0603) connected in parallel with a $1 \mu\text{F}$ capacitor (0603), provides very good electrostatic discharge (ESD) voltage response performance. The circuit can withstand 10 positive and 10 negative shots without component degradation or parameter drift.

3.2 GND loss study

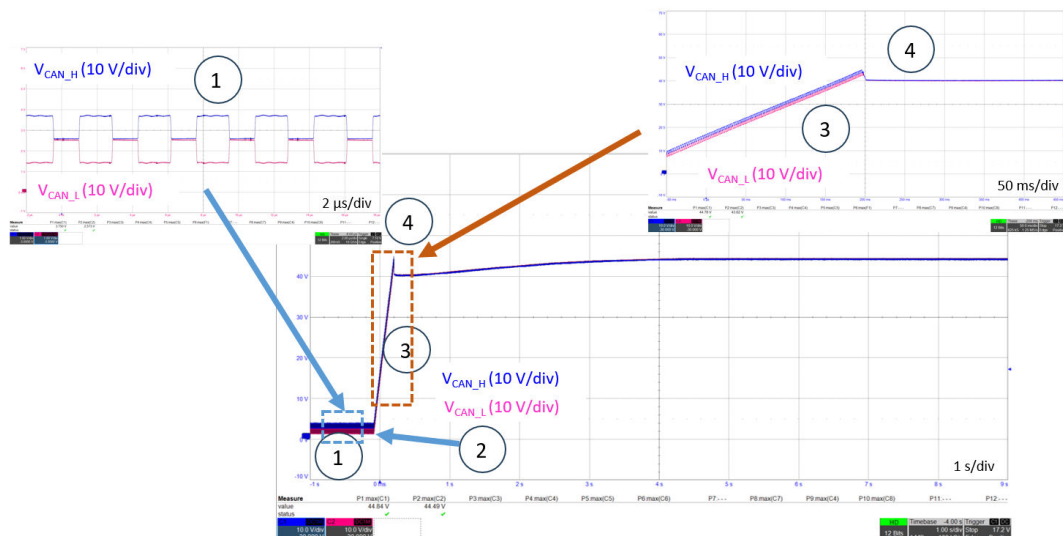
GND loss was measured while the CAN transceiver on the 48 V side transmitted signals. Current and voltage waveforms through the ESDCAN06-2BWY and the RC circuit were measured, as shown in the schematic below Figure 9.

Figure 9. GND loss study: ESDCAN06-2BWY with R-C circuit



Voltage waveform measurements during a GND loss condition:

Figure 10. V_{CAN_H} and V_{CAN_L} voltage waveforms during GND loss condition

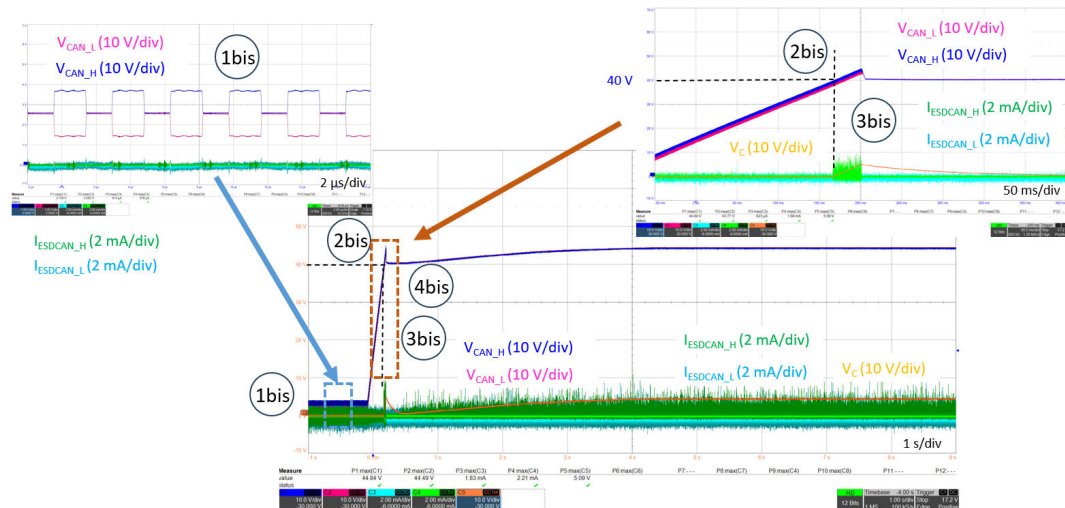


The following steps describe the analysis:

- Step 1: Normal communication runs. If an electrostatic discharge (ESD) event or another surge occurs, such as ISO 7637-3, the ESDCAN06-2BWY in series with $R = 100\text{ k}\Omega$ connected in parallel with $C = 1\text{ }\mu\text{F}$ protects the CAN transceivers against overvoltage.
- Step 2: GND loss occurs on the 48 V side
- Step 3: When the 48 V CAN transceiver sends a square-wave signal, the voltage increases to approximately 48 V
- Step 4: The DC-DC converter and its bulk capacitor can no longer supply the 48 V_{CAN} transceiver. V_{CAN_H} and V_{CAN_L} remain at approximately 48 V.

A deeper analysis was performed on the current waveforms through the protection circuit, with ESDCAN06-2BWY in series with $R = 100\text{ k}\Omega$ in parallel with $C = 1\text{ }\mu\text{F}$, and on the voltage across the capacitor, as shown in the Figure 11.

Figure 11. Voltage and current waveforms during a GND loss condition



- Step 1bis: During normal operation, only a small current flows through ESDCAN because of the signal dV/dt and measurement noise. No impact on communication, CAN transceiver exchange data normally.
- Step 2bis: Because the highest voltage is on the CAN_H wire in dominant mode, the branch of the ESDCAN06-2BWY connected to the CAN_H wire conducts first when reaches 40 V (ESDCAN06 V_{BR}). Current I_{ESDCAN_H} increases to approximately 2 mA. Because the CAN_H voltage is divided between the ESDCAN06-2BWY avalanche voltage and the capacitor voltage (V_C), which increases, the current decreases until the next dominant signal, and the capacitor starts to charge again.
- Step 3bis: The CAN_H and CAN_L voltages reach the maximum value because the DC-DC converter and its bulk capacitor on the 48 V side no longer provide enough energy. No current charges the capacitor because the CAN_H and CAN_L voltages are lower than the sum of the ESDCAN06-2BWY voltage and the capacitor voltage. The capacitor then discharges through its parallel resistor, and its voltage decreases.
- Step 4bis: CAN_H and CAN_L voltages reach the typical breakdown voltage of the ESDCAN06-2BWY. Both branches conduct and charge the capacitor, which limits the current because the capacitor voltage (V_C) increases. The CAN_H and CAN_L voltages are divided between the ESDCAN06-2BWY avalanche voltage, 40 V, and the capacitor voltage (V_C), which remains constant after a certain time.

The dissipated power and junction temperature of the ESDCAN06-2BWY can be calculated in this case.

Because the breakdown voltage is 40 V and the average current is less than approximately 1 mA in one branch, the total dissipated power is $40\text{ V} \times 1\text{ mA} \times 2 = 80\text{ mW}$. The $R_{th(j-a)}$ value for this package is approximately 440°C/W , so the junction temperature increases by approximately 35°C . In case of a max. ambient temperature of 85°C , the maximum junction temperature reaches 120°C , which is lower than the maximum junction temperature given in the datasheet, 175°C .

The ESDCAN06-2BWY in series with $R = 100\text{ k}\Omega$ (0603) mounted in parallel with $C = 1\text{ }\mu\text{F}$ (0603), is suitable for GND loss on the 48 V side while a signal is transmitted. After these tests, no degradation of the ESDCAN06-2BWY, $R = 100\text{ k}\Omega$, or $C = 1\text{ }\mu\text{F}$ was measured.

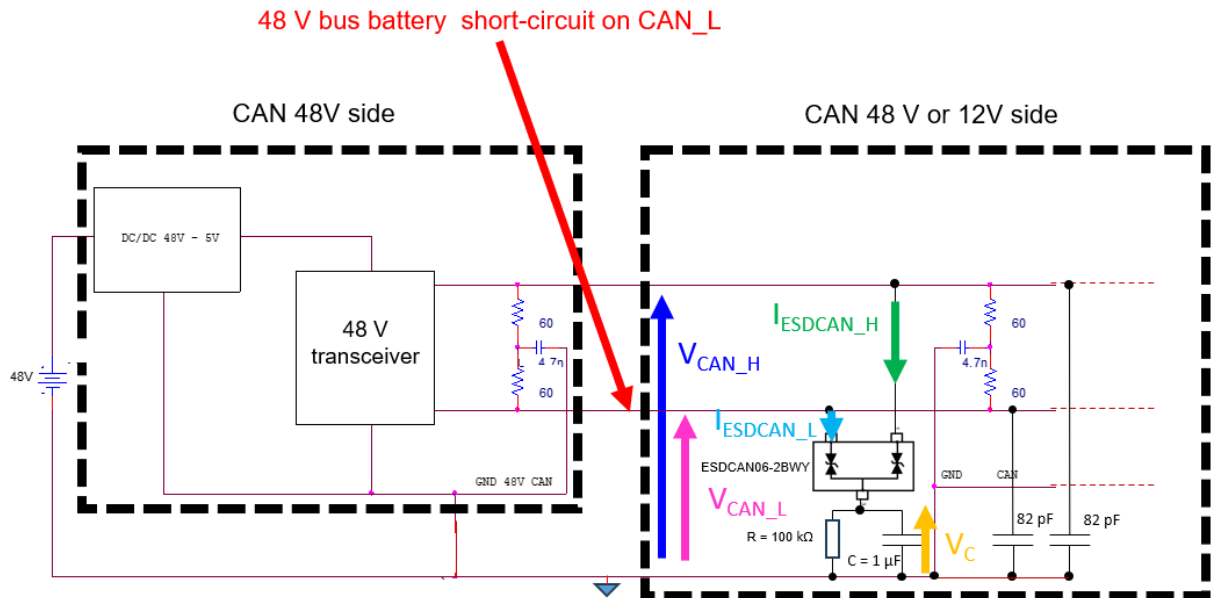
3.3

48 V battery short circuit on CAN_H or CAN_L data lines

ISO 21780 also specifies a short circuit from the 48 V battery to one CAN data line.

The same experimental method as for the ground-loss measurements described above was used.

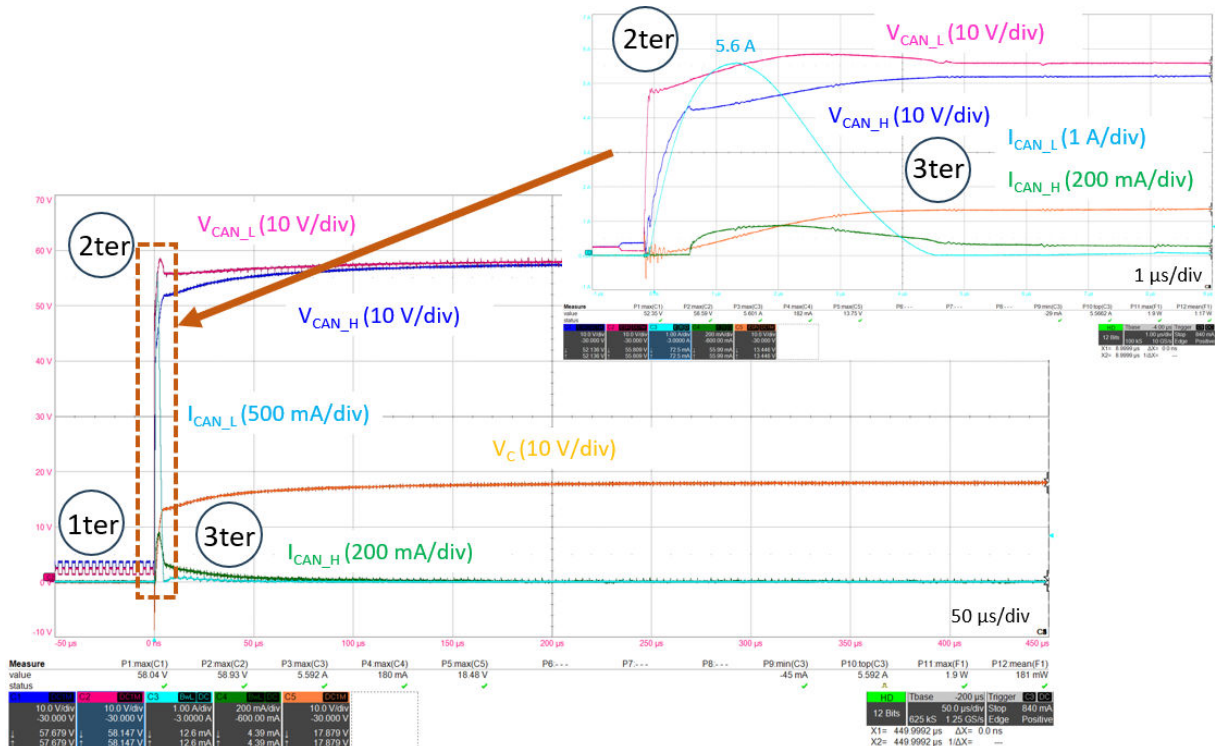
Figure 12. 48 V battery short circuit to one CAN data line with ESDCAN06-2BWY and an R-C circuit



The maximum voltage specified in *ISO 21780* for the battery short-circuit test is 70 V for 10 minutes (Table 21, test 13). In this trial, the CAN transceivers could not withstand 70 V. They could withstand only 58 V on CAN_H and CAN_L. Therefore, the tests were performed at 58 V. However, 70 V was applied only when ESDCAN06-2BWY was in series with $R = 100\text{ k}\Omega$ (0603) mounted in parallel with $C = 1\text{ }\mu\text{F}$ (0603) alone.

The [Figure 13](#) shows the 48 V battery short-circuit test at 58 V and the voltage and current measurement waveforms.

Figure 13. Voltage and current waveforms during a 48 V battery short circuit on the CAN_L data line at 58 V



- Step 1ter: Normal operation. No current flows through the protection circuit.
- Step 2ter: 48 V battery short circuit to the CAN_L data line. A voltage of 58 V is applied, and an exponential peak current of 5.6 A appears in the branch of ESDCAN06-2BWY that is connected to the CAN_L data line and charges capacitor C of 1 μ F.
- Step 3ter: The 1 μ F capacitor remains charged, and a very low current flows through ESDCAN06-2BWY because of the 100 k Ω resistor in series.

As explained above, due to the voltage limitation of the CAN transceiver, several short-circuit tests were performed at 70 V (ISO 21780 test 13), with ESDCAN06-2BWY in series with R = 100 k Ω (0603) mounted in parallel with C = 1 μ F (0603) alone. A peak current of about 11 A was measured without any component degradation.

If the short circuit occurs on the CAN_H data line, the peak current flows through the branch of ESDCAN06-2BWY that is connected to the CAN_H data line, and the voltage on the CAN_H data line is higher than the voltage on the CAN_L data line. The behavior remains the same as the one during a short circuit on CAN_L.

ESDCAN06-2BWY in series with R = 100 k Ω (0603) mounted in parallel with C = 1 μ F (0603), is suitable for a 48 V battery short circuit at 70 V on the CAN_L or CAN_H data line.

4 Conclusion

The 48 V network must coexist with 12 V and 24 V systems. *ISO 21780* describes constraints related to 48 V disturbances. It also introduces coexistence issues between different voltage networks. These issues include ground loss on the 48 V side and a short circuit on the 48 V battery supply. Automotive original equipment manufacturers (OEMs) require a robust solution that addresses all constraints in the standard. The solution must also handle other possible system conditions. The CAN transceivers on 12 V or 24 V side must withstand these accidental stresses. All components on the CAN data lines, particularly the electrostatic discharge (ESD) protection device, must also withstand them. This protection is mandatory for ESD discharges that occur when cables are plugged in. It also applies to surges on data lines caused by surge coupling, as *ISO 7637-3* defines. ST has developed the ESDCANxx family to protect standalone CAN data line transceivers and fully integrated transceivers ICs for 12 V and 24 V systems.

This application note presents tests for ESD discharges, ground loss, and short circuits. These tests involve the 48 V battery supply and the data lines. The ST [ESDCAN06-2BWY](#), in series with $R = 100\text{ k}\Omega$ mounted in parallel with $C = 1\text{ }\mu\text{F}$, can withstand all these constraints. This circuit provides lower residual peak voltages, including residual voltages at 30 ns, during a $\pm 8\text{ kV}$ discharge than existing 48 V ESD protection products.

Tests were performed with ESDCAN06-2BWY, $R = 100\text{ k}\Omega$, and $C = 1\text{ }\mu\text{F}$ as an example. Different ESDCANxx part numbers are available with other internal parameters (clamping voltage, capacitor value,...) and can be associated with other R and C values to get others compromises. The application laboratory can test and validate them.

This solution provides the best ESD protection response and is suitable for ground loss and short circuits between the 48 V battery supply and the data lines.

Revision history

Table 1. Document revision history

Date	Revision	Changes
15-Oct-2026	1	Initial release.

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