ESD2CANFD24 24-V, 2-Channel ESD Protection Diode for In-Vehicle Networks

1 Features
- IEC 61000-4-2 level 4 ESD protection:
  - ±25-kV contact discharge
  - ±25-kV air-gap discharge
- Tested in compliance to IEC 61000-4-5
- 24 V working voltage
- Bidirectional ESD protection
- 2-channel device provides complete ESD protection with single component
- Low clamping voltage protects downstream components
- I/O capacitance = 2.5 pF (typical)
- SOT-23 (DBZ) small, standard, common footprint
- Leaded packages used for automatic optical inspection (AOI)

2 Applications
- Industrial control networks:
  - DeviceNet IEC 62026-3
  - CANopen – CiA 301/302-2 and EN 50325-4

3 Description
The ESD2CANFD24 is a bidirectional ESD protection diode for Controller Area Network (CAN) interface protection. The ESD2CANFD24 is rated to dissipate contact ESD strikes beyond the maximum level specified in the IEC 61000-4-2 standard (±25-kV Contact, ±25-kV Airgap). The low dynamic resistance and low clamping voltage enables system level protection against transient events. This protection is key as systems require a high level of robustness and reliability for safety applications.

This device features a low I/O capacitance per channel and a pin-out to suit two CAN bus lines (CANH and CANL) from the damage caused by ElectroStatic Discharge (ESD) and other transients. Additionally, the 2.5 pF (typical) or less line capacitance of the ESD2CANFD24 is suitable for CAN, CANFD, CAN SiC, and CAN-XL applications that can support data rates up to 10 Mbps.

The ESD2CANFD24 is offered in a leaded package for easy flow through routing.

Package Information

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>PACKAGE</th>
<th>BODY SIZE (NOM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESD2CANFD24</td>
<td>DBZ (SOT-23, 3)</td>
<td>2.92 mm × 1.30 mm</td>
</tr>
</tbody>
</table>

(1) For all available packages, see the orderable addendum at the end of the data sheet.

ESD2CANFD24 Typical Application
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4 Revision History

<table>
<thead>
<tr>
<th>DATE</th>
<th>REVISION</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 2022</td>
<td>*</td>
<td>Initial Release</td>
</tr>
</tbody>
</table>

Submit Document Feedback
Product Folder Links: ESD2CANFD24
5 Pin Configuration and Functions

Figure 5-1. DBZ Package, 3-Pin SOT-23 (Top View)

Table 5-1. Pin Functions

<table>
<thead>
<tr>
<th>PIN</th>
<th>TYPE (1)</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>IO</td>
<td>1, 2</td>
<td>I/O, ESD protected IO</td>
</tr>
<tr>
<td>GND</td>
<td>3</td>
<td>G, Connect to ground.</td>
</tr>
</tbody>
</table>

(1) I = Input, O = Output, I/O = Input or Output, G = Ground, P = Power
6 Specifications

6.1 Absolute Maximum Ratings
over operating free-air temperature range (unless otherwise noted)\(^{(1)}\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DEVICE</th>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( P_{pp} )</td>
<td>IEC 61000-4-5 Power (( t_{p} ) – 8/20 µs) at 25°C</td>
<td>ESD2CANFD24</td>
<td>133</td>
<td>W</td>
</tr>
<tr>
<td>( I_{pp} )</td>
<td>IEC 61000-4-5 current (( t_{p} ) – 8/20 µs) at 25°C</td>
<td>ESD2CANFD24</td>
<td>3.5</td>
<td>A</td>
</tr>
<tr>
<td>( T_A ) Operating free-air temperature</td>
<td>ESD2CANFD24</td>
<td>-55</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>( T_J ) Junction temperature</td>
<td>ESD2CANFD24</td>
<td>-55</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>( T_{stg} ) Storage temperature</td>
<td>ESD2CANFD24</td>
<td>65</td>
<td>155</td>
<td>°C</td>
</tr>
</tbody>
</table>

(1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

6.2 ESD Ratings—JEDEC Specification

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITION</th>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{(ESD)} )</td>
<td>Electrostatic discharge</td>
<td>Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 (^{(1)})</td>
<td>± 2500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Charged device model (CDM), per JEDEC specification JS-002 (^{(2)})</td>
<td>± 1000</td>
</tr>
</tbody>
</table>

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 ESD Ratings—IEC Specification
over TA = 25°C (unless otherwise noted)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>DEVICE</th>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{(ESD)} )</td>
<td>Electrostatic discharge</td>
<td>IEC 61000-4-2 Contact Discharge, all pins</td>
<td>ESD2CANFD24</td>
<td>±25000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IEC 61000-4-2 Air-gap Discharge, all pins</td>
<td>ESD2CANFD24</td>
<td>±25000</td>
</tr>
</tbody>
</table>

6.4 Recommended Operating Conditions
over operating free-air temperature range (unless otherwise noted)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MIN</th>
<th>NOM</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{IN} )</td>
<td>-24</td>
<td>24</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>( T_A ) Operating free-air temperature</td>
<td>-55</td>
<td>150</td>
<td>°C</td>
<td></td>
</tr>
</tbody>
</table>

6.5 Thermal Information

<table>
<thead>
<tr>
<th>THERMAL METRIC(^{(1)})</th>
<th>ESD2CANFD24</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DBZ (SOT-23)</td>
</tr>
<tr>
<td>( R_{JA} ) Junction-to-ambient thermal resistance</td>
<td>316.3</td>
</tr>
<tr>
<td>( R_{JC(top)} ) Junction-to-case (top) thermal resistance</td>
<td>170.7</td>
</tr>
<tr>
<td>( R_{JB} ) Junction-to-board thermal resistance</td>
<td>156.2</td>
</tr>
<tr>
<td>( \Psi_{JT} ) Junction-to-top characterization parameter</td>
<td>45.9</td>
</tr>
<tr>
<td>( \Psi_{JB} ) Junction-to-board characterization parameter</td>
<td>155.1</td>
</tr>
<tr>
<td>( R_{JC(bot)} ) Junction-to-case (bottom) thermal resistance</td>
<td>N/A</td>
</tr>
</tbody>
</table>

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.
### 6.6 Electrical Characteristics

over $T_A = 25^\circ$C (unless otherwise noted)$^{(1)}$

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>DEVICE</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{RWM}$</td>
<td>Reverse stand-off voltage</td>
<td>ESD2CANFD24</td>
<td>–24</td>
<td>24</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{BRF}$</td>
<td>Breakdown voltage$^{(2)}$ $I_O = 10$ mA, IO to GND</td>
<td>ESD2CANFD24</td>
<td>25.5</td>
<td>35.5</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{BRR}$</td>
<td>Breakdown voltage$^{(2)}$ $I_O = –10$ mA, IO to GND</td>
<td>ESD2CANFD24</td>
<td>–35.5</td>
<td>–25.5</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{CLAMP}$</td>
<td>Clamping voltage$^{(3)}$ $I_{PP} = 3.5$ A, $t_p = 8/20$ µs, IO to GND</td>
<td>ESD2CANFD24</td>
<td>37</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$I_{LEAK}$</td>
<td>Leakage current $V_O = \pm 24$ V, IO to GND</td>
<td>ESD2CANFD24</td>
<td>-50</td>
<td>5</td>
<td>50</td>
<td>nA</td>
</tr>
<tr>
<td>$R_{DYN}$</td>
<td>Dynamic resistance$^{(4)}$ IO to GND or GND to IO</td>
<td>ESD2CANFD24</td>
<td>0.45</td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>$C_L$</td>
<td>Line capacitance$^{(5)}$ $V_O = 0$ V, $f = 1$ MHz, $V_{pp} = 30$ mV</td>
<td>ESD2CANFD24</td>
<td>2.5</td>
<td>4.2</td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>$V_{Hold}$</td>
<td>Holding voltage after snapback</td>
<td>TLP</td>
<td>30</td>
<td></td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>

$^{(1)}$ Measurements made on each IO channel

$^{(2)}$ $V_{BRF}$ and $V_{BRR}$ are defined as the voltage when ±10 mA is applied in the positive and negative going direction respectively, before the device latches into the snapback state

$^{(3)}$ Device stressed with 8/20 µs exponential decay waveform according to IEC 61000-4-5

$^{(4)}$ Non-repetitive current pulse, Transmission Line Pulse (TLP); square pulse; ANSI / ESD STM5.5.1-2008

$^{(5)}$ Measured from IO to GND on each channel
6.7 Typical Characteristics – ESD2CANFD24

Figure 6-1. Positive TLP Curve

Figure 6-2. Negative TLP Curve

Figure 6-3. +8-kV Clamped IEC Waveform

Figure 6-4. –8-kV Clamped IEC Waveform

Figure 6-5. Capacitance vs. Bias Voltage

Figure 6-6. Leakage Current vs. Bias Voltage Across Temperature
6.7 Typical Characteristics – ESD2CANFD24 (continued)

Figure 6-7. 8/20 μs Surge Response at 3.5 A
7 Detailed Description

7.1 Overview

The ESD2CANFD24 is a dual-channel ESD TVS diode in SOT-23 leaded package which is convenient for automatic optical inspection. This product offers IEC 61000-4-2 ±25-kV air-gap, ±25-kV contact ESD protection, and has a clamp circuit with a back-to-back TVS diode for bidirectional signal support. The 2.5 pF (typical) or less line capacitance of this ESD protection diode is suitable for CAN, CANFD, CAN SiC, and CAN-XL applications that can support data rates up to 10 Mbps. A typical application for this product is ESD circuit protection for CAN transceivers.

7.2 Functional Block Diagram

![Functional Block Diagram]

7.3 Feature Description

The ESD2CANFD24 is a bidirectional TVS with a high ESD protection level. This device protects the circuit from ESD strikes up to ±25-kV contact and ±25-kV air-gap specified in the IEC 61000-4-2 standard. The device can also handle up to 3.5 A surge current (IEC 61000-4-5 8/20 µs). The I/O capacitance of 2.5-pF (typical) supports a data rate up to 10 Mbps. This clamping device has a small dynamic resistance, which makes the clamping voltage low when the device is actively protecting other circuits. For example, the clamping voltage is only 37 V when the device is taking 3.5 A transient surge current. The breakdown is bidirectional so this protection device is a good fit for CAN which is a differential signal. Low leakage allows the diode to conserve power when working below the $V_{RWM}$. The temperature range of −55°C to +150°C makes this ESD device work at extensive temperatures in most environments. The leaded SOT-23 package is good for applications requiring automatic optical inspection (AOI).

7.3.1 Temperature Range

This device is qualified to operate from −55°C to +150°C.

7.3.2 IEC 61000-4-2 ESD Protection

The I/O pins can withstand ESD events of at least ±25-kV contact and ±25-kV air-gap in the leaded SOT-23 package according to the IEC 61000-4-2 standard. An ESD-surge clamp diverts the current to ground.

7.3.3 IEC 61000-4-5 Surge Protection

The IO pins can withstand surge events up to 3.5 A (8/20 µs waveform). An ESD-surge clamp diverts this current to ground.

7.3.4 IO Capacitance

The capacitance between the I/O pins is 2.5 pF (typical) or less. This capacitance supports data rates for CAN, CANFD, CAN SiC, and CAN-XL up to 10 Mbps.

7.3.5 Dynamic Resistance

The IO pins feature an ESD clamp that has a low $R_{DYN}$ of 0.45 Ω (Pin 1 or Pin 2 to Pin 3) and 0.45 Ω (Pin 3 to Pin 1 or Pin 2) or less which prevents system damage during ESD events.
7.3.6 DC Breakdown Voltage
The DC breakdown voltage between the IO pins is a minimum of ± 25.5 V. This protects sensitive equipment from surges above the reverse standoff voltage of ± 24 V.

7.3.7 Ultra Low Leakage Current
The IO pins feature an ultra-low leakage current of ± 50 nA (maximum) with a bias of ± 24 V.

7.3.8 Clamping Voltage
The IO pins feature an ESD clamp that is capable of clamping the voltage to 37 V (I_{PP} = 3.5 A) and 36 V (I_{PP} = 16 A for TLP).

7.3.9 Industry Standard Leaded Packages
This device features an industry standard SOT-23 (DBZ) leaded package for automatic optical inspection (AOI).

7.4 Device Functional Modes
The ESD2CANFD24 is a dual channel passive clamp that has low leakage during normal operation when the voltage between pin 1 or pin 2 and pin 3 is below V_{RWM}, and activates when the voltage between pin 1 or pin 2 and pin 3 goes above V_{BR}. During IEC 61000-4-2 ESD events, transient voltages as high as ±25 kV can be clamped on either channel. When the voltages on the protected lines fall below the V_{HOLD}, the device reverts back to the low leakage passive state.
8 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI’s customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

The ESD2CANFD24 is a dual channel TVS diode which is used to provide a path to ground for dissipating ESD events on differential CAN signal lines. As the current from ESD passes through the TVS, only a small voltage drop is present across the diode. This is the voltage presented to the protected IC. The low $R_{\text{DY}}$ of the triggered TVS holds this voltage, $V_{\text{CLAMP}}$, to a safe level for the protected IC.

8.2 Typical Application

![Figure 8-1. ESD2CANFD24 Typical Application](image)

8.2.1 Design Requirements

For this design example, the ESD2CANFD24 is used to provide ESD protection for a CAN transceiver. Table 8-1 lists the known design parameters for this application.

<table>
<thead>
<tr>
<th>Design Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diode configuration</td>
<td>Bidirectional</td>
</tr>
<tr>
<td>$V_{\text{IO}}$ differential signal range</td>
<td>$&gt; \pm 1.5$ V</td>
</tr>
<tr>
<td>$V_{\text{RWM}}$</td>
<td>$\pm 24$ V</td>
</tr>
<tr>
<td>Data rate</td>
<td>Up to 10 Mbps</td>
</tr>
<tr>
<td>$RT/2$</td>
<td>60 $\Omega$</td>
</tr>
</tbody>
</table>
8.2.2 Detailed Design Procedure

The ESD2CANFD24 has a V_{RWM} of ±24 V. The bidirectional characteristic enables the signal integrity of the differential CAN lines to not be impacted by the diode. The low capacitance of 2.5 pF (typical) or less enables data rates up to 10 Mbps, which allows the designer to meet the requirements for CAN, CANFD, CAN SiC, and CAN-XL. The 60 Ω split termination improves the electromagnetic emissions behavior of the network by filtering higher-frequency common-mode noise that may be present on the differential signal lines.

8.2.3 Application Curves

![Figure 8-2. +8-kV Clamped IEC Waveform](image_url1)

![Figure 8-3. −8-kV Clamped IEC Waveform](image_url2)

![Figure 8-4. 8/20 µs Surge Response at 3.5 A](image_url3)
9 Power Supply Recommendations
This device is a passive TVS diode-based ESD protection device, therefore there is no requirement to power it. Ensure that the maximum voltage specifications for each pin are not violated.

10 Layout
10.1 Layout Guidelines
- The optimum placement of the device is as close to the connector as possible.
  - EMI during an ESD event can couple from the trace being struck to other nearby unprotected traces, resulting in early system failures.
  - The PCB designer must minimize the possibility of EMI coupling by keeping any unprotected traces away from the protected traces which are between the TVS and the connector.
- Route the protected traces as straight as possible.
- Eliminate any sharp corners on the protected traces between the TVS and the connector by using rounded corners with the largest radii possible.
  - Electric fields tend to build up on corners, increasing EMI coupling.
- If pin 3 is connected to ground, use a thick and short trace for this return path.

10.2 Layout Example
This example is typical of a dual channel differential data pair application, such as CAN.

![Figure 10-1. Routing with DBZ Package](image-url)
11 Device and Documentation Support
TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

11.1 Documentation Support

11.1.1 Related Documentation
For related documentation, see the following:

- Texas Instruments, *ESD Layout Guide user's guide*
- Texas Instruments, *ESD Protection Diodes EVM user's guide*
- Texas Instruments, *Generic ESD Evaluation Module user's guide*
- Texas Instruments, *Reading and Understanding an ESD Protection data sheet*

11.2 Receiving Notification of Documentation Updates
To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

11.3 Support Resources
TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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11.4 Trademarks
TI E2E™ is a trademark of Texas Instruments. All trademarks are the property of their respective owners.

11.5 Electrostatic Discharge Caution
This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

11.6 Glossary
*TI Glossary* This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information
The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.
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