ESD Protection Diode

27 V Dual Line CAN Bus Protector

NUP2105L, SZNUP2105L

The SZ/NUP2105L has been designed to protect the CAN transceiver in high-speed and fault tolerant networks from ESD and other harmful transient voltage events. This device provides bidirectional protection for each data line with a single compact SOT-23 package, giving the system designer a low cost option for improving system reliability and meeting stringent EMI requirements.

Features

- 350 W Peak Power Dissipation per Line (8/20 μsec Waveform)
- Low Reverse Leakage Current (< 100 nA)
- Low Capacitance High-Speed CAN Data Rates
- IEC Compatibility:
  - – IEC 61000-4-2 (ESD): Level 4, 30 kV
  - – IEC 61000-4-4 (EFT): 40 A – 5/50 ns
  - – IEC 61000-4-5 (Lighting) 8.0 A (8/20 μs)
- ISO 7637-2 Pulse 2a: 9.5 A
- ISO 7637-3 Pulse 3a, b: 50 A
- SZ Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q101 Qualified and PPAP Capable
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

Applications

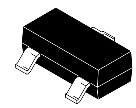
- Industrial Control Networks
  - Smart Distribution Systems (SDS®)
  - DeviceNet™
- Automotive Networks
  - Low and High-Speed CAN
  - Fault Tolerant CAN

MAXIMUM RATINGS (T_J = 25 °C, unless otherwise specified)

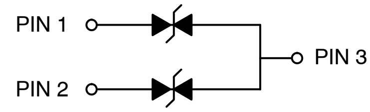
Rating	Symbol	Max	Unit
Peak Power Dissipation (Note 1) 8/20 μs Double Exponential Waveform	PPK	350	W
Junction and Storage Temperature Range	T_J, T_{stg}	−55 to +150	°C
Lead Solder Temperature (10 s)	T_L	260	°C
Human Body Model (HBM) Machine Model (MM) IEC 61000-4-2 Contact IEC 61000-4-2 Air ISO 10605 Contact (330 pF / 330 Ω) ISO 10605 Contact (330 pF / 2 kΩ) ISO 10605 Contact (150 pF / 2 kΩ)	ESD	±16 ±0.4 ±30 ±30 ±30 ±30 ±30	kV
Maximum Peak Pulse Current, 8/20 μs	I_{PP}	8.0	A

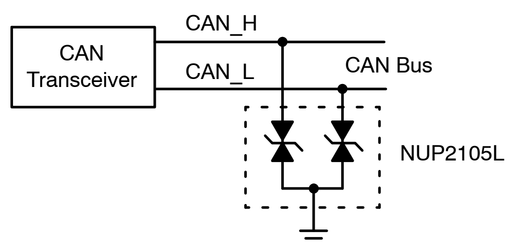
Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.
1. Non-repetitive current pulse per Figure 6.

SOT-23
DUAL BIDIRECTIONAL
VOLTAGE SUPPRESSOR
350 W PEAK POWER

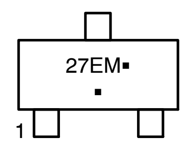


SOT-23
CASE 318
STYLE 28





MARKING DIAGRAM



27E = Device Code
M = Date Code
▪ = Pb-Free Package
(Note: Microdot may be in either location)

ORDERING INFORMATION

Device	Package	Shipping†
NUP2105LT1G	SOT-23 (Pb-Free)	3000 / Tape & Reel
SZNUP2105LT1G*		
SZNUP2105LT3G		10000 / Tape & Reel

† For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

* SZ Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q101 Qualified and PPAP Capable

ELECTRICAL CHARACTERISTICS

(T_A = 25 °C unless otherwise noted)

Symbol	Parameter
I_{PP}	Maximum Reverse Peak Pulse Current
V_C	Clamping Voltage @ I_{PP}
V_{RWM}	Working Peak Reverse Voltage
I_R	Maximum Reverse Leakage Current @ V_{RWM}
V_{BR}	Breakdown Voltage @ I_T
I_T	Test Current

*See Application Note AND8308/D for detailed explanations of data sheet parameters.

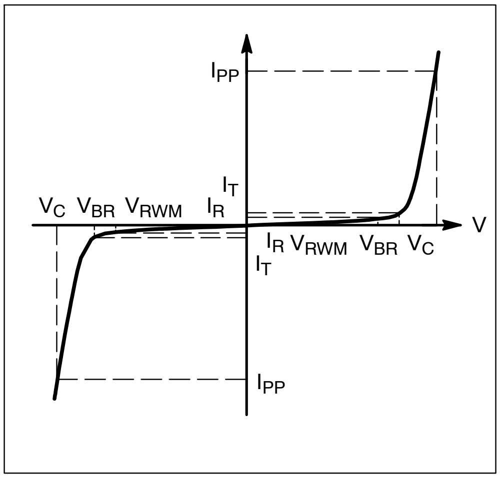


Figure 1. Bi-Directional

ELECTRICAL CHARACTERISTICS (T_J = 25 °C, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{RWM}	Reverse Working Voltage	(Note 2)	24	–	–	V
V_{BR}	Breakdown Voltage	I_T = 1 mA (Note 3)	26.2	–	32	V
I_R	Reverse Leakage Current	V_{RWM} = 24 V	–	1.5	100	nA
V_C	Clamping Voltage	IEC61000-4-2, +/– 8 kV Contact	See Figures 8–9			
V_C	Clamping Voltage TLP (See Figures 12–13) (Note 3)	ITLP = 4 A ITLP = 8 A ITLP = 16 A ITLP = 20 A	– – – –	33 37 43 46	– – – –	V
V_C	Clamping Voltage 8/20 μs Waveform (See Figures 6–7)	IPP = 5 A IPP = 8 A	– –	33 37	40 44	V
R_{dyn}	Dynamic Resistance	TLP Pulse	–	1	–	Ω
C_J	Capacitance	V_R = 0 V, f = 1 MHz (Line to GND)	–	26	30	pF
ΔC	Diode Capacitance	V_R = 0 V, f = 1 MHz (Line 1 to GND and Line 2 to GND)	–	0.3	–	%
I_L	Insertion Loss	f = 1 GHz f = 5 GHz	– –	12 2	– –	dB
R_L	Return Loss	f = 1 GHz f = 5 GHz	– –	0.8 5	– –	dB

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

2. Surge protection devices are normally selected according to the working peak reverse voltage (V_{RWM}), which should be equal or greater than the DC or continuous peak operating voltage level.
3. V_{BR} is measured at pulse test current I_T.
4. Pulse waveform per Figure 6.

TYPICAL PERFORMANCE CURVES (T_J = 25 °C unless otherwise noted)

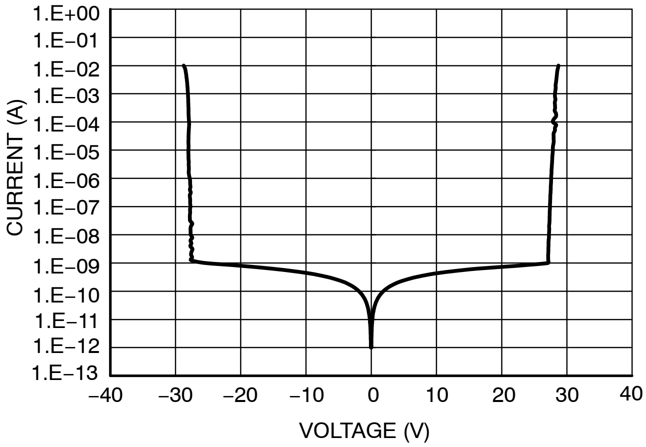


Figure 2. IV Characteristics

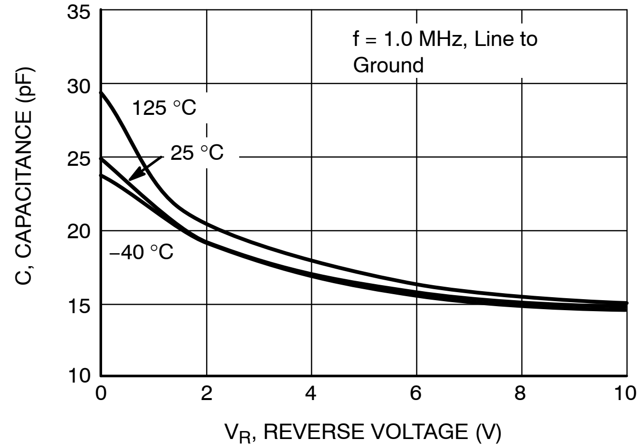


Figure 3. Typical Junction Capacitance vs Reverse Voltage

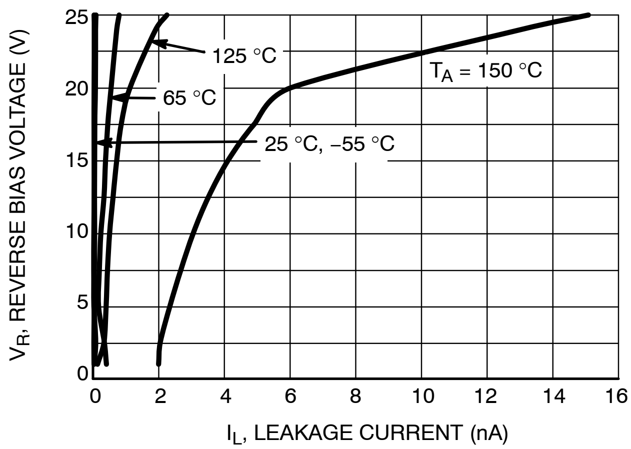


Figure 4. I_R vs. Temperature Characteristics

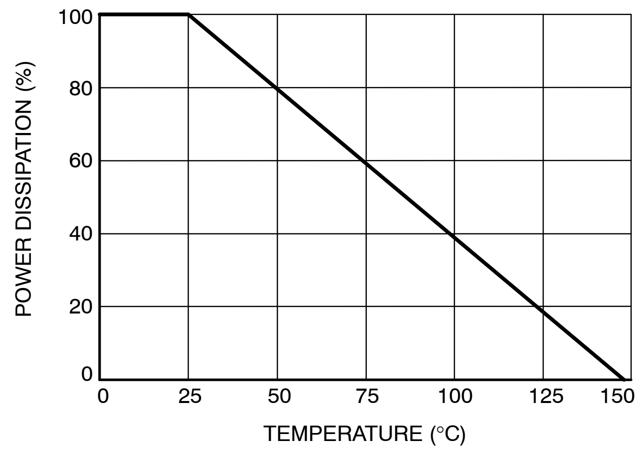


Figure 5. Steady State Power Derating

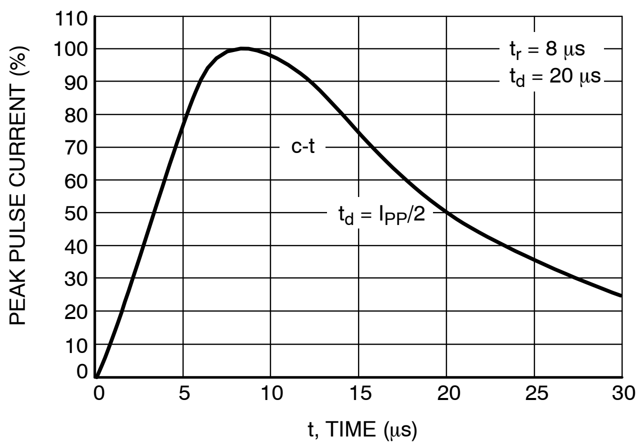


Figure 6. Pulse Waveform (8/20 μs)

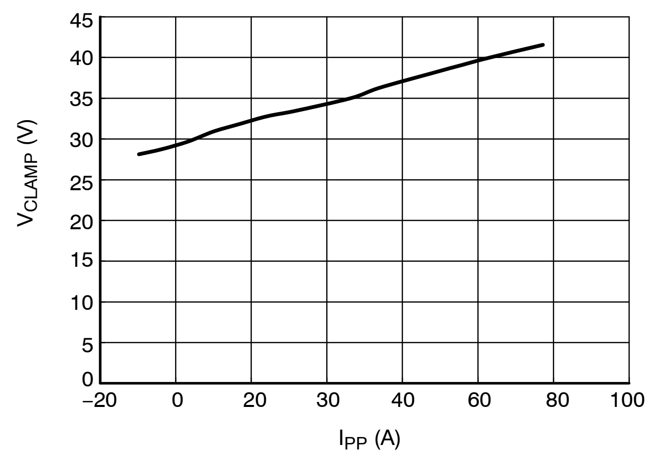


Figure 7. Clamping Voltage vs. Peak Pulse Current (8/20 μs)

TYPICAL PERFORMANCE CURVES (T_J = 25 °C unless otherwise noted) (continued)

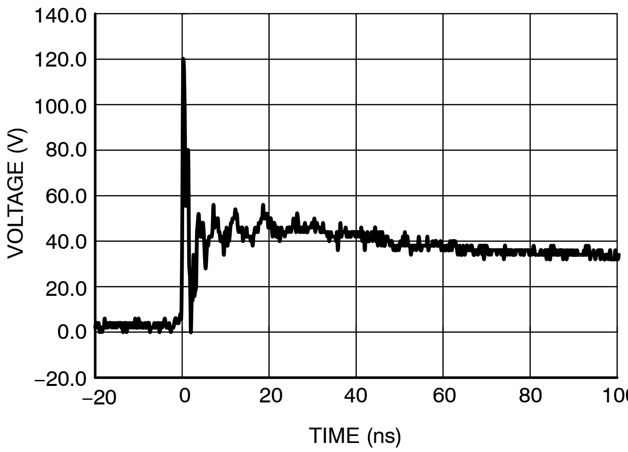


Figure 8. IEC61000-4-2 +8 kV Contact

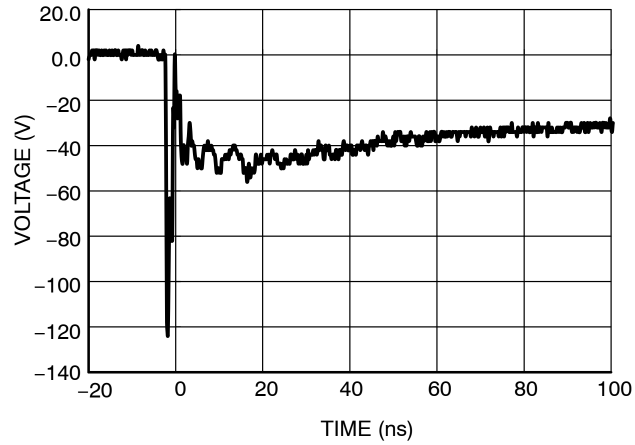


Figure 9. IEC61000-4-2 −8 kV Contact

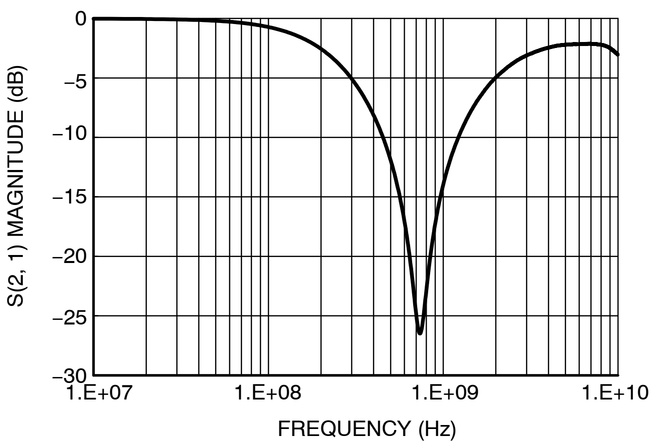


Figure 10. Typical Insertion Loss

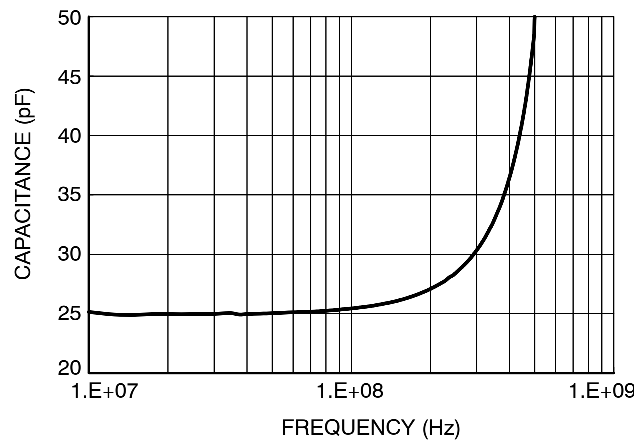


Figure 11. Typical Capacitance vs. Frequency

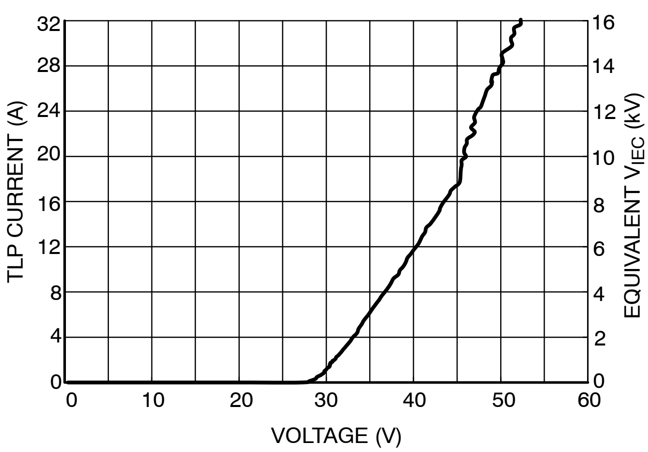


Figure 12. Positive TLP IV Curve

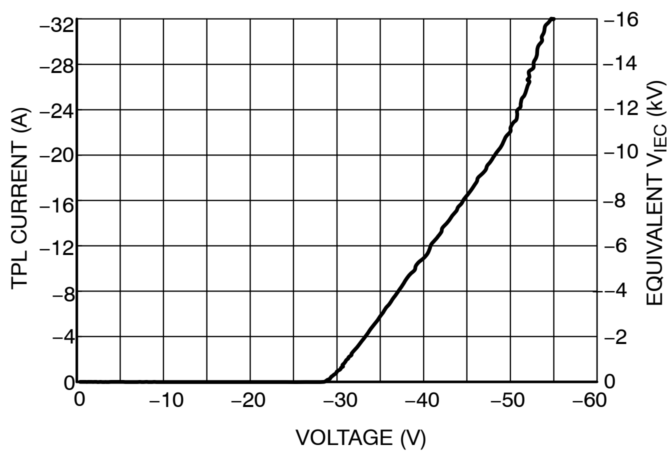


Figure 13. Negative TLP IV Curve

APPLICATIONS

Background

The Controller Area Network (CAN) is a serial communication protocol designed for providing reliable high speed data transmission in harsh environments. surge protection diodes provide a low cost solution to conducted and radiated Electromagnetic Interference (EMI) and Electrostatic Discharge (ESD) noise problems. The noise immunity level and reliability of CAN transceivers can be easily increased by adding external surge protection diodes to prevent transient voltage failures.

The NUP2105L provides a surge protection solution for CAN data communication lines. The NUP2105L is a dual bidirectional surge protection device in a compact SOT-23 package. This device is based on Zener technology that optimizes the active area of a PN junction to provide robust protection against transient EMI surge voltage and ESD. The NUP2105L has been tested to EMI and ESD levels that exceed the specifications of popular high speed CAN networks.

CAN Physical Layer Requirements

Table 1 provides a summary of the system requirements for a CAN transceiver. The ISO 11898-2 physical layer specification forms the baseline for most CAN systems. The transceiver requirements for the Honeywell® Smart Distribution Systems (SDS®) and Rockwell (Allen-Bradley) DeviceNet™ high speed CAN networks are similar to ISO 11898-2. The SDS and DeviceNet transceiver requirements are similar to ISO 11898-2; however, they include minor modifications required in an industrial environment.

Table 1. Transceiver Requirements for High-Speed CAN Networks

Parameter	ISO 11898-2	SDS Physical Layer Specification 2.0	DeviceNet
Min / Max Bus Voltage (12 V System)	−3.0 V / 16 V	11 V / 25 V	Same as ISO 11898-2
Common Mode Bus Voltage	CAN_L: −2.0 V (min) 2.5 V (nom) CAN_H: 2.5 V (nom) 7.0 V (max)	Same as ISO 11898-2	Same as ISO 11898-2
Transmission Speed	1.0 Mb/s @ 40 m 125 kb/s @ 500 m	Same as ISO 11898-2	500 kb/s @ 100 m 125 kb/s @ 500 m
ESD	Not specified, recommended ≥ ±8.0 kV (contact)	Not specified, recommended ≥ ±8.0 kV (contact)	Not specified, recommended ≥ ±8.0 kV (contact)
EMI Immunity	ISO 7637-3, pulses ‘a’ and ‘b’	IEC 61000-4-4 EFT	Same as ISO 11898-2
Popular Applications	Automotive, Truck, Medical and Marine Systems	Industrial Control Systems	Industrial Control Systems

EMI Specifications

The EMI protection level provided by the surge protection device can be measured using the International Organization for Standardization (ISO) 7637-2 and -3 specifications that are representative of various noise sources. The ISO 7637-2 specification is used to define the susceptibility to coupled transient noise on a 12 V power supply, while ISO 7637-3 defines the noise immunity tests for data lines. The ISO 7637 tests also verify the robustness and reliability of a design by applying the surge voltage for extended durations.

The IEC 61000-4-X specifications can also be used to quantify the EMI immunity level of a CAN system. The IEC 61000-4 and ISO 7637 tests are similar; however, the IEC standard was created as a generic test for any electronic system, while the ISO 7637 standard was designed for vehicular applications. The IEC61000-4-4 Electrical Fast Transient (EFT) specification is similar to the ISO 7637-3 pulse 3a and b tests and is a requirement of SDS CAN systems. The IEC 61000-4-5 test is used to define the power absorption capacity of a surge protection device and long duration voltage transients such as lightning. Table 2 provides a summary of the ISO 7637 and IEC 61000-4-X test specifications. Table 3 provides the NUP2105L's ESD test results.

Table 2. ISO 7637 and IEC 61000-4-X Test Specifications

Test	Waveform	Test Specifications	NUP2105L Results	Simulated Noise Source
ISO 7637-2 12 V Power Supply Lines (Note 2)	Pulse 1	V_s = 0 to −100 V I_{max} = 10 A $t_{duration}$ = 5000 pulses	I_{max} = 1.75 A V_{clamp_max} = 31 V $t_{duration}$ = 5000 pulses R_i = 10 Ω, t_r = 1.0 μs, $t_{d\_10\%}$ = 2000 μs, t_1 = 2.5 s, t_2 = 200 ms, t_3 = 100 μs	DUT (Note 1) in parallel with inductive load that is disconnected from power supply.
	Pulse 2a	V_s = 0 to +50 V coupled onto 14 V battery I_{max} = 10 A $t_{duration}$ = 5000 pulses	I_{max} = 9.5 A V_{clamp_max} = 42 V $t_{duration}$ = 5000 pulses Ri = 2 Ω, t_r = 1.0 μs, $t_{d\_10\%}$ = 50 μs, t_1 = 2.5 s, t_2 = 200 ms	DUT in series with inductor (wire harness) that is disconnected from load.
ISO 7637-3 Repetitive data line fast transients (Note 3)	Pulse 'a'	V_s = −60 V I_{max} = 1.2 A $t_{duration}$ = 10 minutes	I_{max} = 50 A (Note 4) V_{clamp_max} = 40 V $t_{duration}$ = 60 minutes R_i = 50 Ω, t_r = 5.0 ns, $t_{d\_10\%}$ = 100 ns, t_1 = 100 μs, t_2 = 10 ms, t_3 = 90 ms	Switching noise of inductive loads.
	Pulse 'b'	V_s = +40 V I_{max} = 0.8 A $t_{duration}$ = 10 minutes		
IEC 61000-4-4 Data Line EFT		$V_{open\ circuit}$ = 2.0 kV $I_{short\ circuit}$ = 40 A (Level 4 = Severe Industrial Environment) R_i = 50 Ω, t_r < 5.0 ns, $t_{d\_50\%}$ = 50 ns, t_{burst} = 15 ms, f_{burst} = 2.0 to 5.0 kHz, t_{repeat} = 300 ms $t_{duration}$ = 1 minute	(Note 5)	Switching noise of inductive loads.
IEC 61000-4-5		$V_{open\ circuit}$ = 1.2/50 μs, $I_{short\ circuit}$ = 8/20 μs R_i = 50 Ω	I_{max} = 8.0 A	Lightning, nonrepetitive power line and load switching

1. DUT = device under test.
2. Test specifications were taken from ISO7637-2: 2004 version.
3. Test specifications were taken from ISO7637-3: 1995 version.
4. DUT was tested to ISO7637-2: 2004 pulse 3a,b specification for more rigorous test.
5. The EFT immunity level was measured with test limits beyond the IEC 61000-4-4 test, but with the more severe test conditions of ISO 7637-3.

Table 3. NUP2105L ESD Test Results

ESD Specification	Test	Test Level	Pass / Fail
Human Body Model	Contact	16 kV	Pass
IEC 61000-4-2	Contact	30 kV (Note 6)	Pass
	Non-contact (Air Discharge)	30 kV (Note 6)	Pass

6. Test equipment maximum test voltage is 30 kV.

Surge protection Diode Protection Circuit

surge protection diodes provide protection to a transceiver by clamping a surge voltage to a safe level. surge protection diodes have high impedance below and low impedance above their breakdown voltage. A surge protection Zener diode has its junction optimized to absorb the high peak energy of a transient event, while a standard Zener diode is designed and specified to clamp a steady state voltage.

Figure 14 provides an example of a dual bidirectional surge protection diode array that can be used for protection with the high-speed CAN network. The bidirectional array is created from four identical Zener surge protection diodes. The clamping voltage of the composite device is equal to the breakdown voltage of the diode that is reversed biased, plus the diode drop of the second diode that is forwarded biased.

ESD Voltage Clamping

For sensitive circuit elements it is important to limit the voltage that an IC will be exposed to during an ESD event to as low a voltage as possible. The ESD clamping voltage is the voltage drop across the ESD protection diode during an ESD event per the IEC61000-4-2 waveform. Since the IEC61000-4-2 was written as a pass/fail spec for larger systems such as cell phones or laptop computers it is not clearly defined in the spec how to specify a clamping voltage at the device level. **onsemi** has developed a way to examine the entire voltage waveform across the ESD protection diode over the time domain of an ESD pulse in the form of an oscilloscope screenshot, which can be found on the datasheets for all ESD protection diodes. For more information on how creates these screenshots and how to interpret them please refer to AND8307/D.

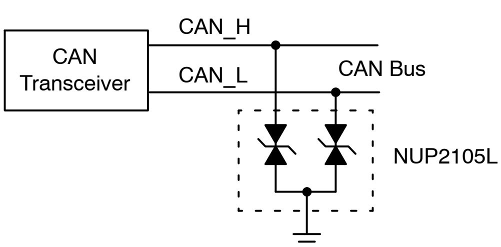


Figure 14. High-Speed and Fault Tolerant CAN Surge Protection Circuit

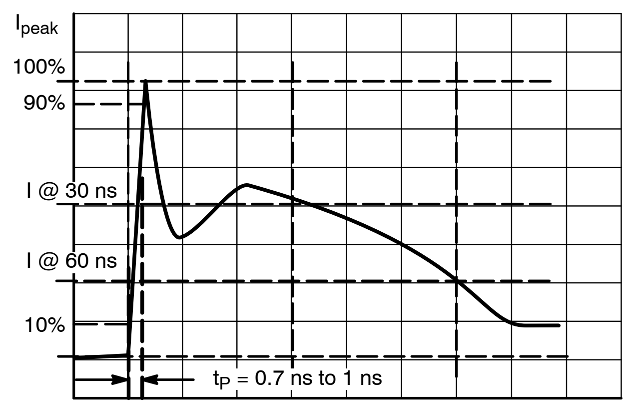


Figure 15. IEC61000-4-2 Current Waveform

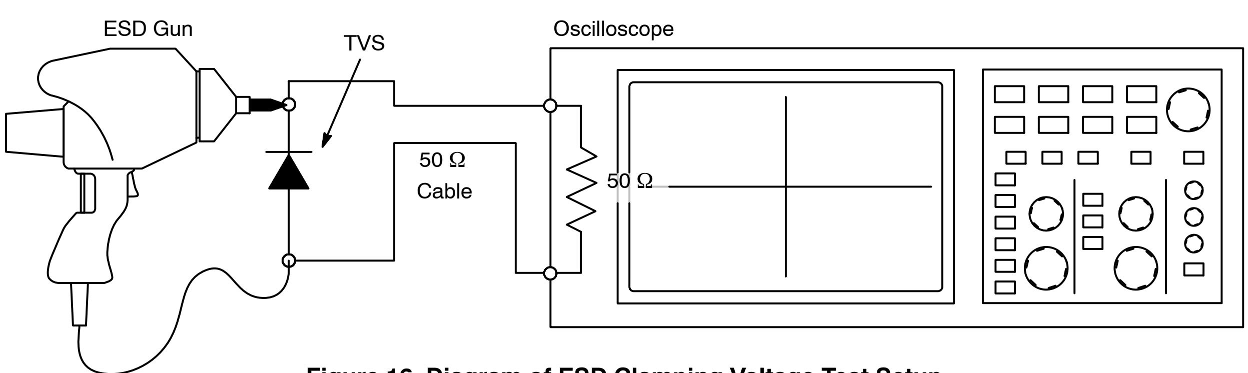


Figure 16. Diagram of ESD Clamping Voltage Test Setup

Transmission Line Pulse (TLP) Measurement

TLP provides current versus voltage (I-V) curves in which each data point is obtained from a 100 ns long rectangular pulse from a charged transmission line. A simplified schematic of a typical TLP system is shown in Figure 17. TLP I-V curves of ESD protection devices accurately demonstrate the product's ESD capability because the 10s of amps current levels and under 100 ns time scale match those of an ESD event. This is illustrated in Figure 18 where an 8 kV IEC 61000-4-2 current waveform is compared with TLP current pulses at 8 A and 16 A. A TLP I-V curve shows the voltage at which the device turns on as well as how well the device clamps voltage over a range of current levels.

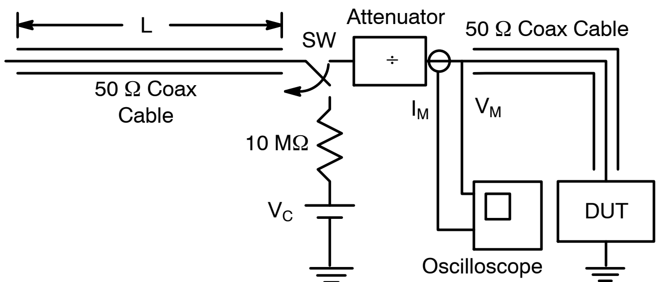


Figure 17. Basic TLP System

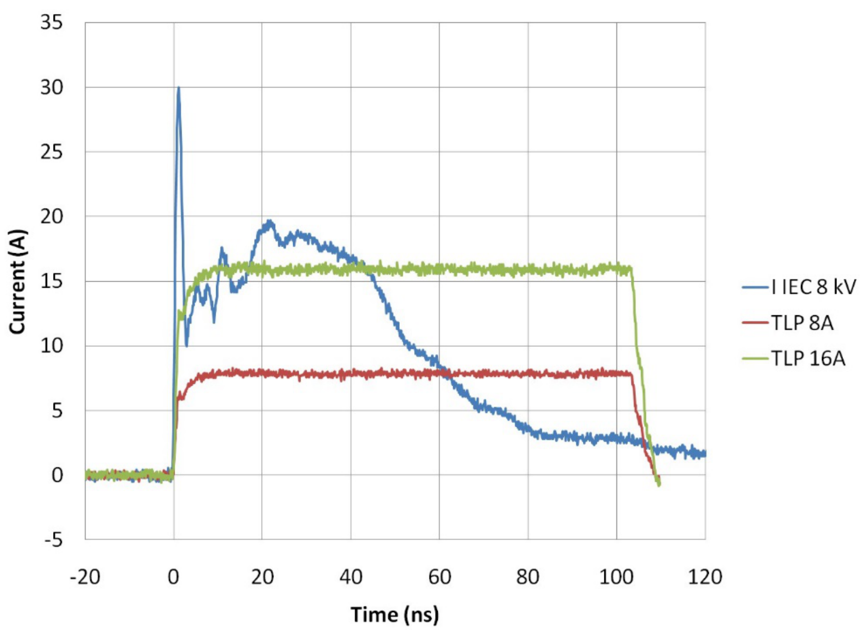
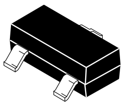


Figure 18. Comparison Between 8 kV IEC 61000-4-2 and 8 A and 16 A TLP Waveforms

REVISION HISTORY

Revision	Description of Changes	Date
11	Updated datasheet with new information to ensure standardized format and up-to-date data.	5/11/2026

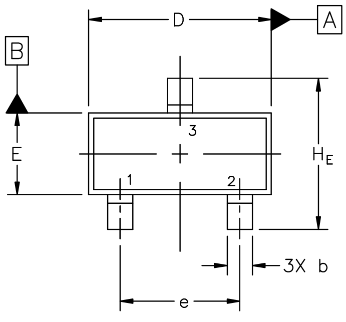
This document has undergone updates prior to the inclusion of this revision history table. The changes tracked here only reflect updates made on the noted approval dates.



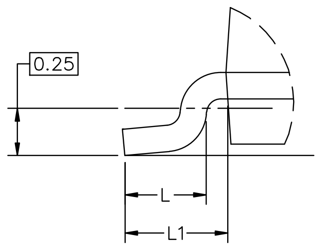
SCALE 4:1

SOT−23 (TO−236) 2.90x1.30x1.00 1.90P
CASE 318
ISSUE AU

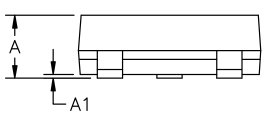
DATE 14 AUG 2024



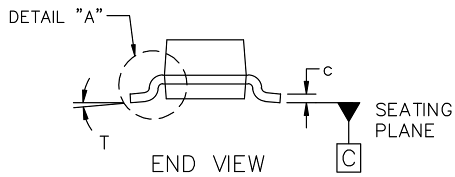
TOP VIEW



DETAIL "A"
Scale 3:1



SIDE VIEW

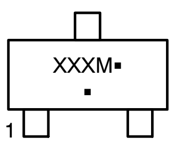


END VIEW

MILLIMETERS			
DIM	MIN	NOM	MAX
A	0.89	1.00	1.11
A1	0.01	0.06	0.10
b	0.37	0.44	0.50
c	0.08	0.14	0.20
D	2.80	2.90	3.04
E	1.20	1.30	1.40
e	1.78	1.90	2.04
L	0.30	0.43	0.55
L1	0.35	0.54	0.69
H_E	2.10	2.40	2.64
T	0°	−−−	10°

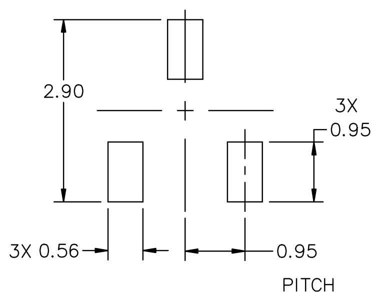
NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2018.
2. CONTROLLING DIMENSIONS: MILLIMETERS.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF THE BASE MATERIAL.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

GENERIC MARKING DIAGRAM*



XXX = Specific Device Code
M = Date Code
▪ = Pb−Free Package

*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.



RECOMMENDED
MOUNTING FOOTPRINT

* For additional information on our Pb−Free strategy and soldering details, please download the onsemi Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

STYLES ON PAGE 2

DOCUMENT NUMBER:	**98ASB42226B**	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red.
DESCRIPTION:	**SOT−23 (TO−236) 2.90x1.30x1.00 1.90P**	**PAGE 1 OF 2**

SOT−23 (TO−236) 2.90x1.30x1.00 1.90P
CASE 318
ISSUE AU

DATE 14 AUG 2024

STYLE 1 THRU 5:
CANCELLED

STYLE 6:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

STYLE 7:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 8:
PIN 1. ANODE
2. NO CONNECTION
3. CATHODE

STYLE 9:
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 10:
PIN 1. DRAIN
2. SOURCE
3. GATE

STYLE 11:
PIN 1. ANODE
2. CATHODE
3. CATHODE−ANODE

STYLE 12:
PIN 1. CATHODE
2. CATHODE
3. ANODE

STYLE 13:
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 14:
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 15:
PIN 1. GATE
2. CATHODE
3. ANODE

STYLE 16:
PIN 1. ANODE
2. CATHODE
3. CATHODE

STYLE 17:
PIN 1. NO CONNECTION
2. ANODE
3. CATHODE

STYLE 18:
PIN 1. NO CONNECTION
2. CATHODE
3. ANODE

STYLE 19:
PIN 1. CATHODE
2. ANODE
3. CATHODE−ANODE

STYLE 20:
PIN 1. CATHODE
2. ANODE
3. GATE

STYLE 21:
PIN 1. GATE
2. SOURCE
3. DRAIN

STYLE 22:
PIN 1. RETURN
2. OUTPUT
3. INPUT

STYLE 23:
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 24:
PIN 1. GATE
2. DRAIN
3. SOURCE

STYLE 25:
PIN 1. ANODE
2. CATHODE
3. GATE

STYLE 26:
PIN 1. CATHODE
2. ANODE
3. NO CONNECTION

STYLE 27:
PIN 1. CATHODE
2. CATHODE
3. CATHODE

STYLE 28:
PIN 1. ANODE
2. ANODE
3. ANODE

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