EClamp10012PQ

EMIClamp®
2-Line Interface Circuit for Automotive Ethernet

PROTECTION PRODUCTS

Description

EClamp®10012PQ is a 2-line interface solution designed specifically for ESD protection and termination of Ethernet interfaces in automotive applications. EClamp10012PQ integrates precision resistors with low capacitance TVS for protection and termination of one differential pair. These devices utilize silicon avalanche technology for superior protection performance compared to ceramic-based solutions. The bidirectional TVS diodes have a trigger voltage >100V and have a deep snap-back characteristic for minimizing ESD clamping voltage. They feature maximum ESD withstand voltage of ±12kV contact, ±17kV air discharge per IEC 61000-4-2. The integrated resistors have a nominal value of 1kΩ and a maximum matching tolerance of 1%. The devices are characterized to meet the ESD, insertion loss, and RF clamping requirements of the OPEN Alliance IEEE 100BASE-T1 EMC Test Specification for ESD Suppression Devices and are qualified to AEC-Q100, Grade 1.

EClamp10012PQ is in a DFN 2.0 x 1.0 x 0.60 mm-5 Lead package. Flow- through package design simplifies PCB layout and maintains signal integrity on high-speed lines.

Features

- Transient Protection to
  - IEC 61000-4-2 (ESD) 17kV (Air), 12kV (Contact)
  - IEC 61000-4-4 (EFT) 4kV (5/50ns)
  - IEC 61000-4-5 (Lightning) 3A (8/20µs)
- ESD protection and precision termination for two high-speed lines
- Package design optimized for easy layout
- Resistor Matching Tolerance: 1%
- TVS Trigger Voltage: >100V
- Solid-State Silicon-Avalanche Technology
- Qualified to AEC-Q100, Grade 1
- Qualified to OPEN Alliance: IEEE 100BASE-T1 EMC Test Specification for ESD suppression devices

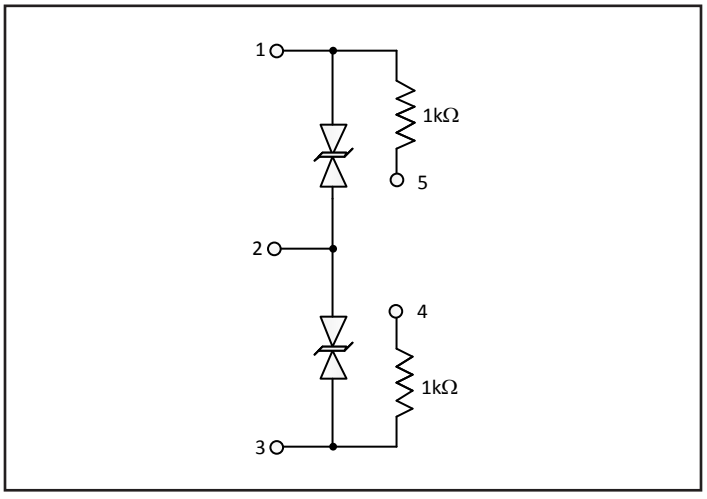
Mechanical Characteristics

- DFN 2.0 x 1.0 x 0.60 mm-5 Lead
- Pb-Free, Halogen Free, RoHS/WEEE Compliant
- Molding Compound Flammability Rating: UL 94V-0
- Marking : Marking Code + Date Code
- Packaging : Tape and Reel

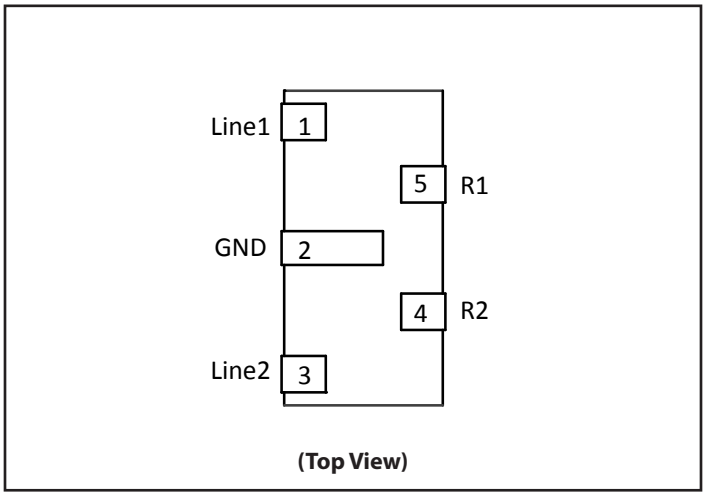
Applications

- OPEN Alliance Automotive Ethernet
- Automotive in-vehicle network lines

Circuit Diagram



Pin Configuration



(Top View)

Absolute Maximum Ratings

Rating	Symbol	Value	Units
Peak Pulse Current (tp = 8/20µs)	I_{PP}	3	A
ESD per IEC 61000-4-2 (Contact) (1), (2) ESD per IEC 61000-4-2 (Air) (1), (2)	V_{ESD}	±12 ±17	kV
ESD per ISO-10605 (Contact)(2) (3) ESD per ISO-10605 (Air)(2) (3)	V_{ESD}	±15 ±22	kV
Operating Temperature	T_{OP}	-40 to +125	°C
Storage Temperature	T_{STG}	-55 to +150	°C

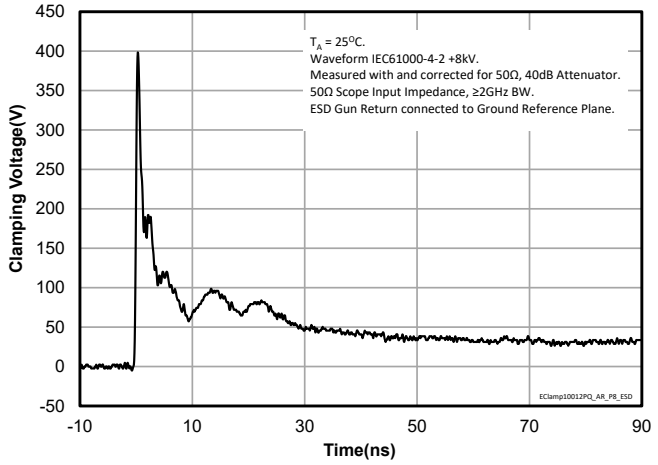
Electrical Characteristics (T=25°C unless otherwise specified)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Units
Reverse Stand-Off Voltage	V_{RWM}	-40°C to 125°C, Pin 1 or 3 to Pin 2				30	V
Trigger Voltage	V_{Trig}	Pin 1 or 3 to Pin 2	T = 25°C	110	125	140	V
			-40°C to 125°C	105		150	
Reverse Leakage Current	I_R	V_{RWM} = 30V Pin 1 or 3 to Pin 2	T = 25°C		<0.001	0.20	µA
			T = 125°C		0.010	0.50	
Clamping Voltage	V_C	I_{PP} = 3A, tp = 1.2/50µs (Voltage), 8/20µs (Current) Combination Waveform			25		V
ESD Clamping Voltage(4)	V_C	tp = 0.2/100ns (TLP), Pin 1 or 3 to Pin 2	I_{TLP} = 4A		30		V
			I_{TLP} = 16A		57		
Dynamic Resistance(4), (5)	R_{DYN}	tp = 0.2/100ns (TLP), Pin 1 or 3 to Pin 2			2.3		Ohms
Capacitance	C_J	V_R = 0V, f = 1MHz, Pin 1 or 3 to Pin 2			1.2	1.4	pF
Capacitance matching	$_{\Delta}C$	C_{Line1} - C_{Line2}, or C_{Line2} - C_{Line1}			0.03	0.1	pF
Termination Resistors	R_1, R_2	Pin 5 to 1, Pin 4 to 3		0.95	1.0	1.1	kΩ
Resistance matching	R_1 - R_2					1	%

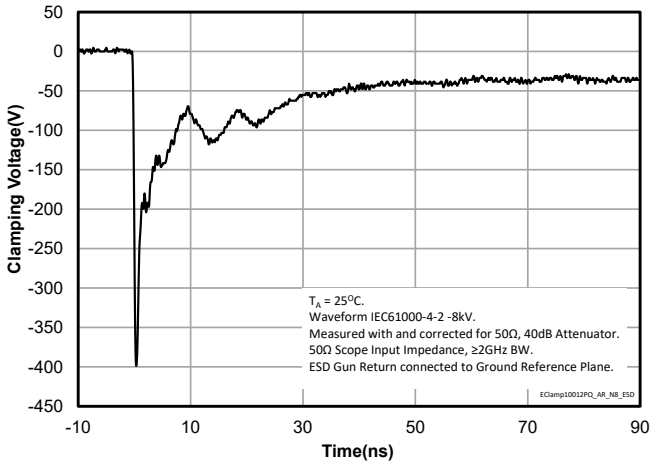
Notes:
(1): ESD Gun return path to Ground Reference Plane (GRP)
(2): ESD pulse applied to Pin 1 or Pin 3
(3): ESD Gun return path to Horizontal Coupling Plane (HCP); Test conditions: 150pF/330pF, 2kΩ
(4): Transmission Line Pulse Test (TLP) Settings: tp = 100ns, tr = 0.2ns, I_{TLP} and V_{TLP} averaging window: t_1 = 70ns to t_2 = 90ns.
(5): Dynamic resistance calculated from I_{TLP} = 4A to I_{TLP} = 16A

Typical Characteristics

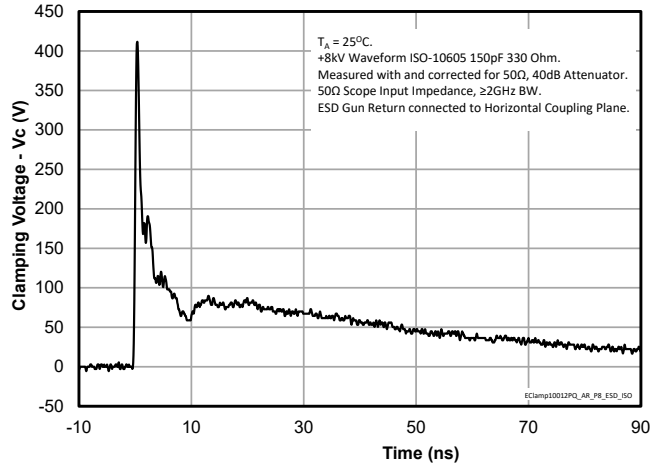
ESD Clamping (+8kV Contact per IEC 61000-4-2)



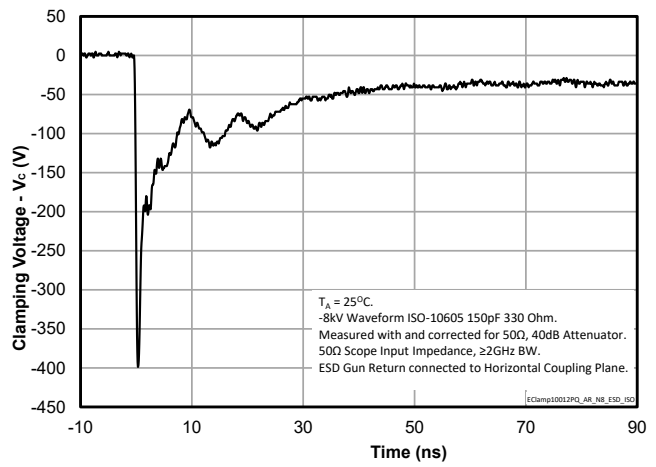
ESD Clamping (-8kV Contact per IEC 61000-4-2)



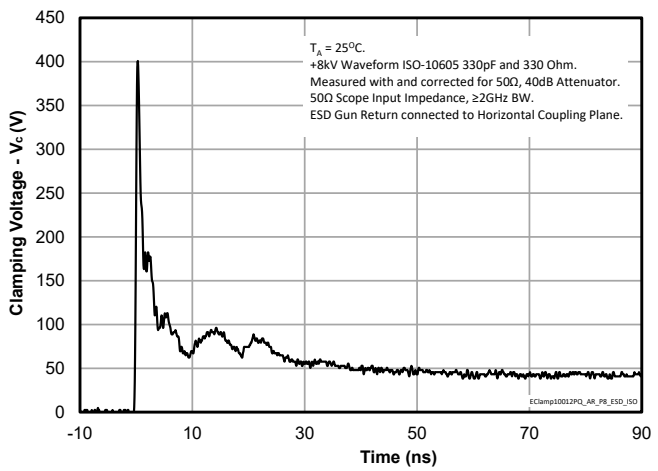
ESD Clamping (+8kV Contact ISO-10605 150pF 330 Ohm)



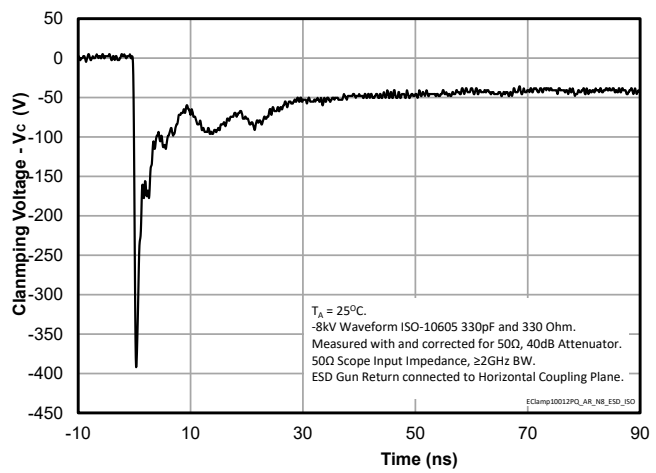
ESD Clamping (-8kV Contact ISO-10605 150pF 330 Ohm)



ESD Clamping (+8kV Contact ISO-10605 330pF 330 Ohm)

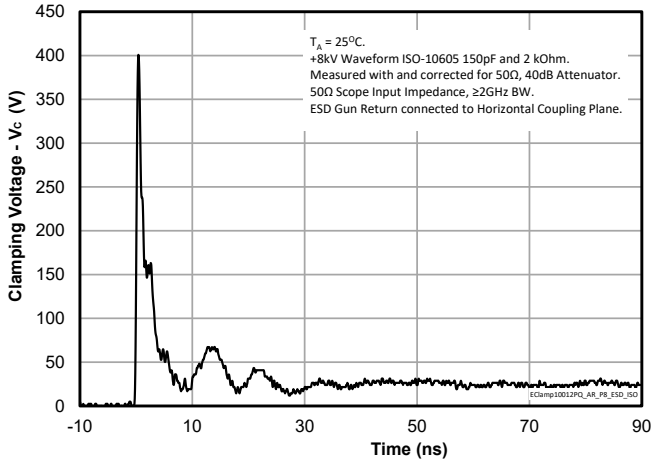


ESD Clamping (-8kV Contact ISO-10605 330pF 330 Ohm)

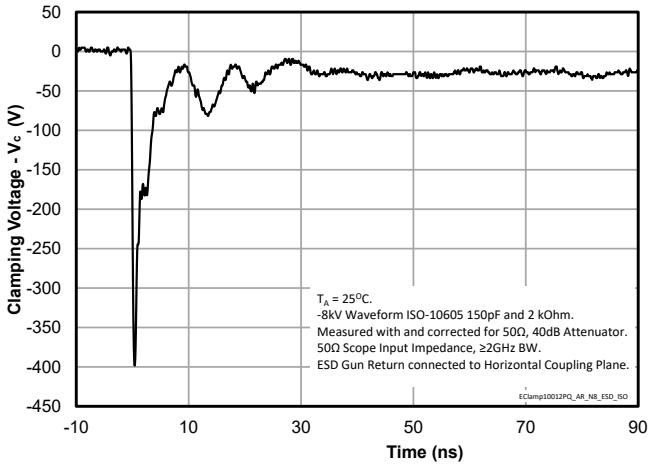


Typical Characteristics

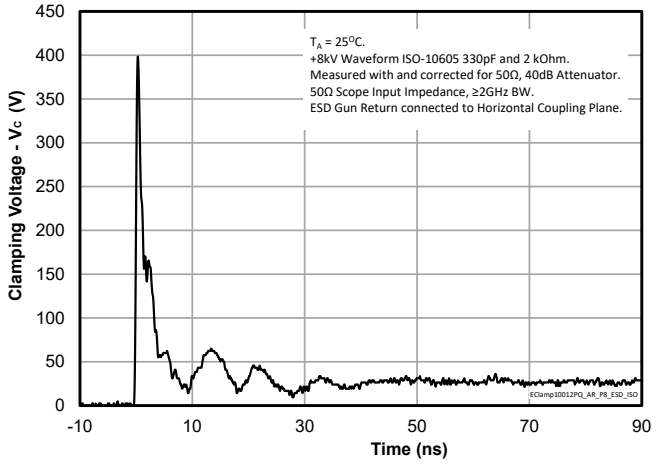
ESD Clamping (+8kV Contact ISO-10605 150pF 2 kOhm)



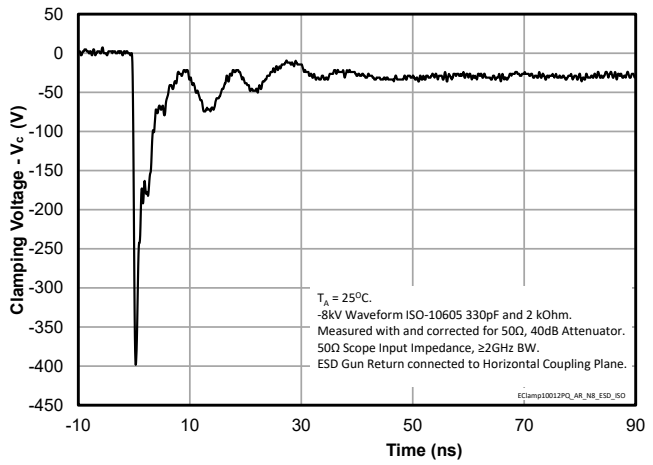
ESD Clamping (-8kV Contact ISO-10605 150pF 2 kOhm)



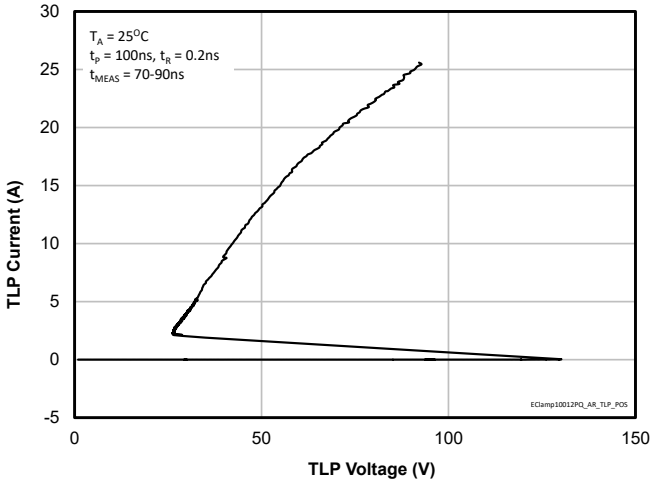
ESD Clamping (+8kV Contact ISO-10605 330pF 2 kOhm)



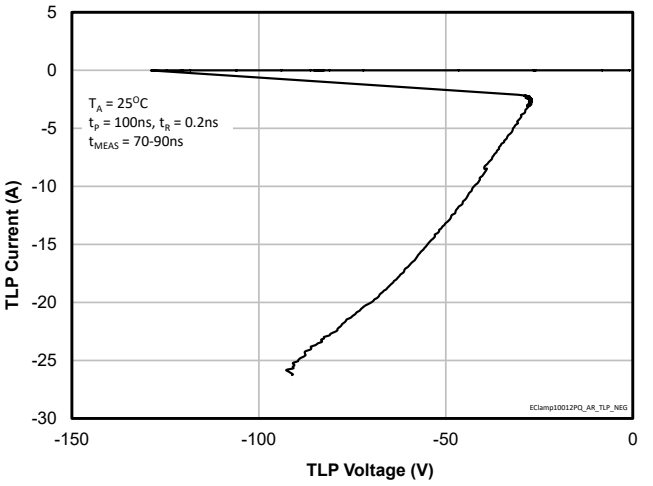
ESD Clamping (-8kV Contact ISO-10605 330pF 2 kOhm)



TLP Characteristic (Positive)

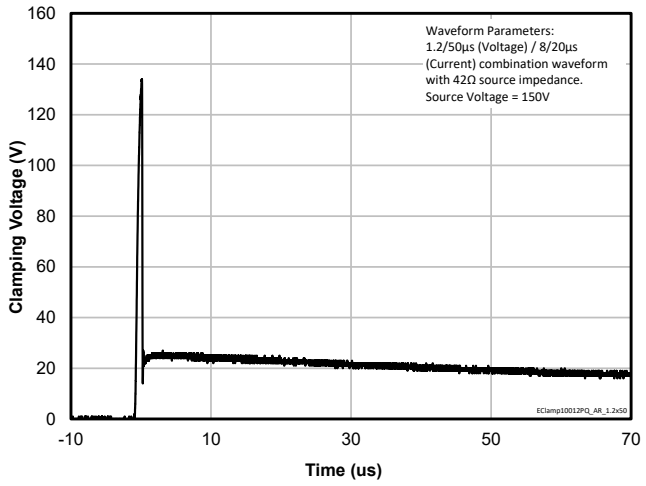


TLP Characteristic (Negative)

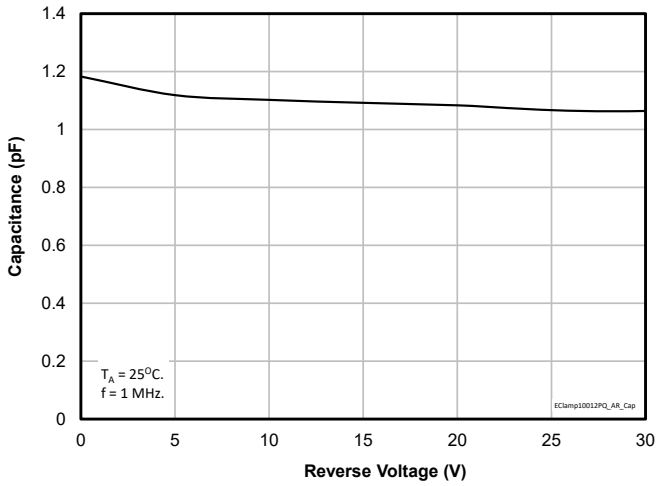


Typical Characteristics

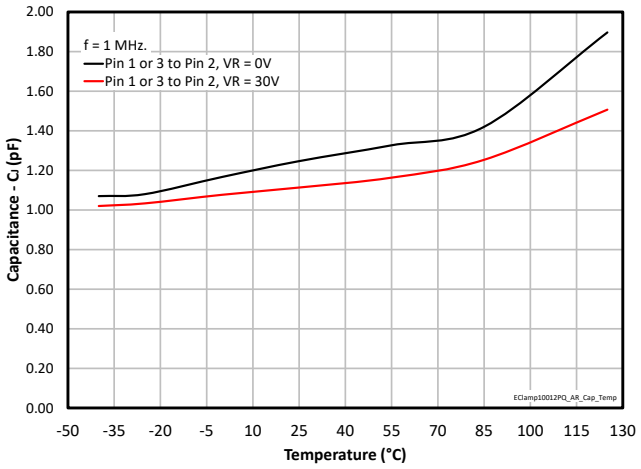
Clamping Characteristic (Ipp = 3A, tp=1.2/50us)



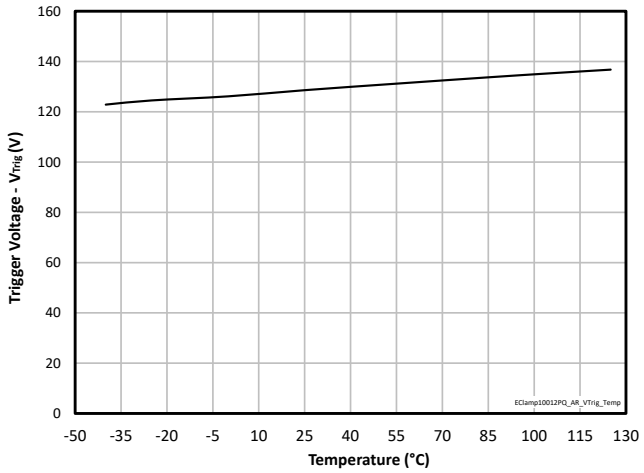
Junction Capacitance vs. Reverse Voltage



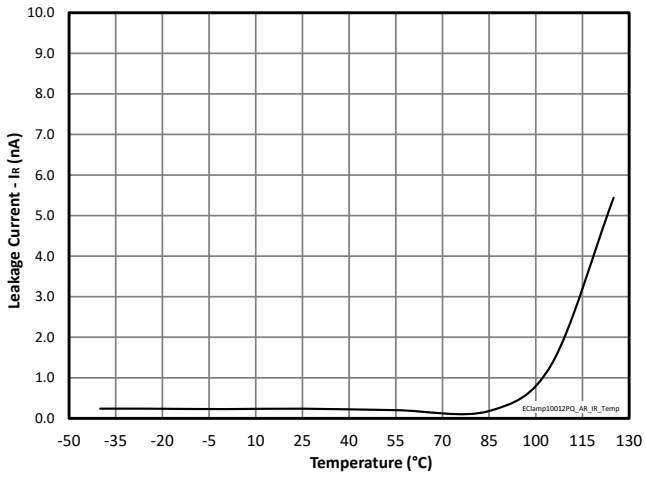
Junction Capacitance vs. Temperature



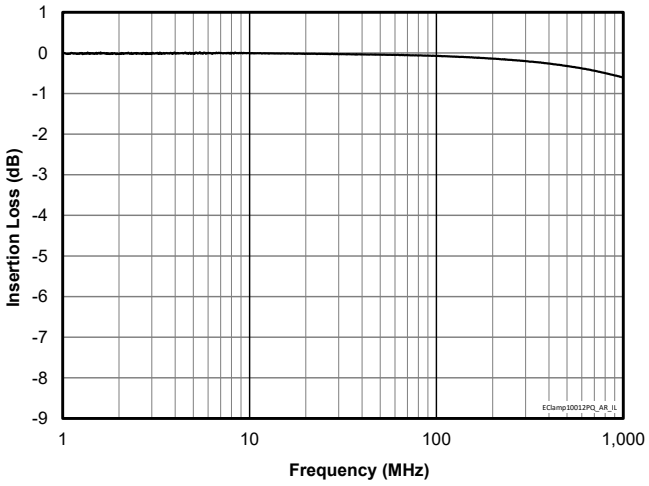
Trigger Voltage (VTrig) vs. Temperature



Reverse Leakage vs. Temperature

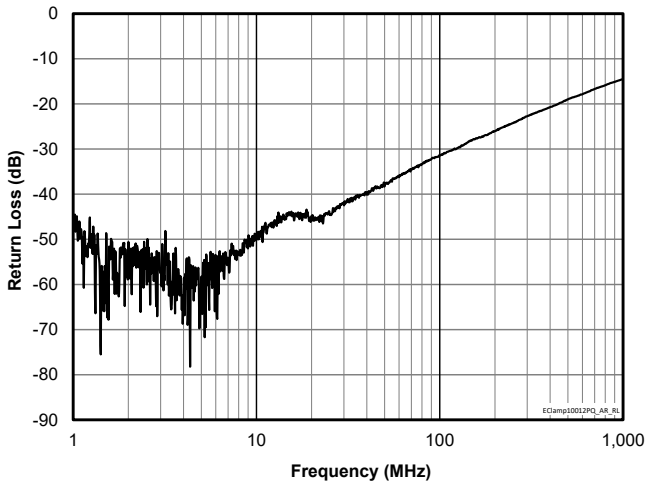


Insertion Loss (S_{DD21})

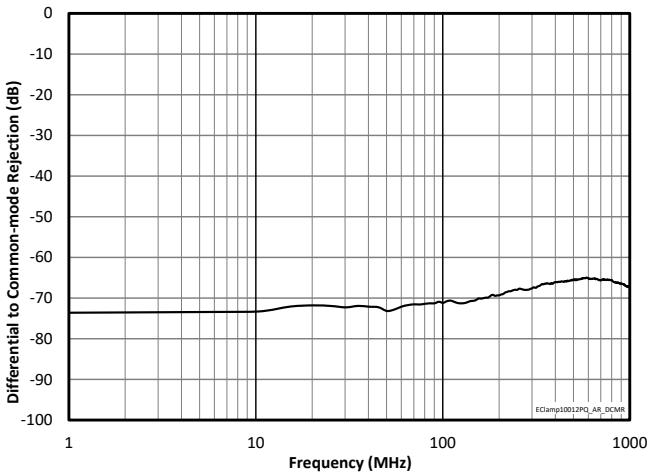


Typical Characteristics

Return Loss (S_{DD11})



Differential to Common Mode Rejection (S_{sd21})



Application Information

Overview

EClamp10012PQ is an ESD/EOS protection device with integrated termination resistors designed for 100BASE-T1 Ethernet interfaces in automotive applications. Each device integrates two TVS diodes with a rated working voltage of 100V and two 1kΩ termination resistors. The resistors are matched to within ±1%. EClamp10012PQ is qualified to AEC-Q100, Grade 1.

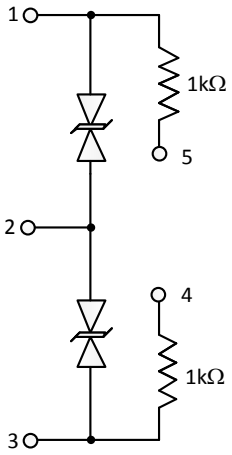


Figure 1 - EClamp10012PQ Schematic Diagram

OPEN Alliance IEEE 100BASE-T1 EMC Test Specification for ESD Suppression Devices

The OPEN Alliance test specification is intended to be a standardized scale for EMC testing of ESD protection devices intended to be used in 100BASE-T1 Ethernet interfaces in automotive applications. It includes test set up, test procedures, and recommended limits for the following:

- Evaluation of datasheet parameters
- Mixed mode S-Parameter measurement
- ESD Withstand Voltage
- Impact to ESD discharge current in a defined 100BASE-T1 network
- Unwanted clamping effect at RF immunity tests

EClamp10012PQ has been characterized to the ESD and mixed mode insertion loss requirements of the OPEN Alliance IEEE 100BASE-T1 EMC Test Specification for ESD suppression devices. A summary of test results is detailed below. For detailed set up information and test procedures, refer to the OPEN Alliance IEEE 100BASE-T1 EMC Test Specification for ESD suppression devices.

ESD Withstand Voltage

EClamp10012PQ is designed using silicon avalanche technology which yields low TLP dynamic resistance resulting in low ESD clamping voltage. Additionally, there is no inherent wear out mechanism associated with solid-state protection technology, therefore EClamp10012PQ will withstand >1000 discharges as required by the OPEN Alliance test specification without damage or degradation. EClamp10012PQ has a maximum ESD withstand voltage of ±12kV contact, ±17kV air discharge per IEC 61000-4-2.

ESD Discharge Current

Simulating ESD discharge current through a 100BASE-T1 transceiver is defined in the OPEN Alliance specification. A contact ESD discharge of 4kV and 6kV (per IEC 61000-4-2) is applied to an evaluation board with a simulated 100BASE-T1 front end. This includes EClamp10012PQ, common mode choke, and a termination network. ESD current flow is measured into a defined load resistor for each line. Limits are set by the specification for each discharge level. Figures 2 and 3 show test results using EClamp10012PQ. For each discharge level, EClamp10012PQ limits the current flow well below the specification recommendation.

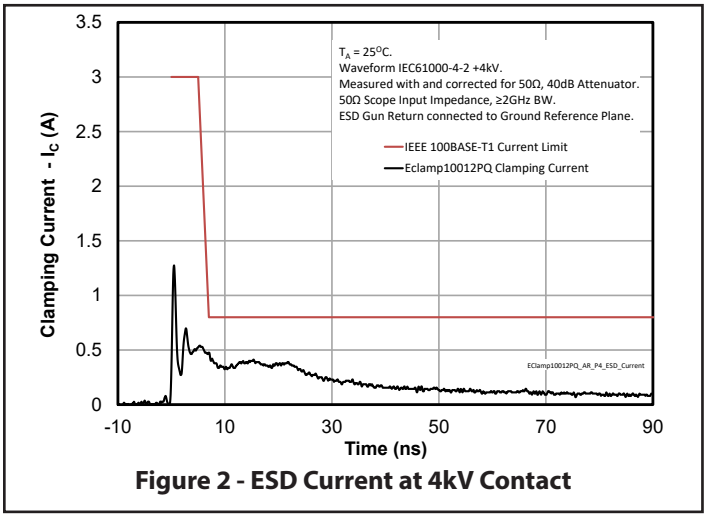


Figure 2 - ESD Current at 4kV Contact

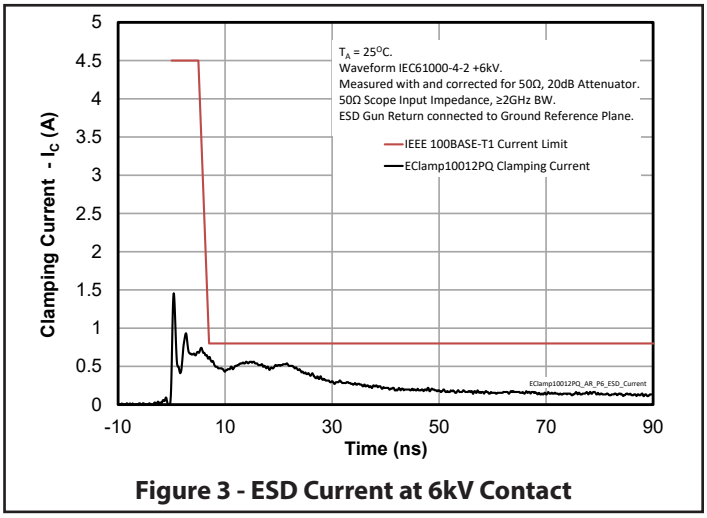


Figure 3 - ESD Current at 6kV Contact

Mixed Mode S-Parameters

EClamp10012PQ is evaluated for mixed mode s-parameters which include Insertion Loss (IL) (SDD21), Return Loss (RL) (SDD11), and Differential to Common Mode Rejection (DCMR) (Ssd21). After the initial measurements, the device is subjected to 20 ESD discharges of ±8kV on each signal pin per ISO-10605 (C=150pF, R=330Ω). Insertion loss and return loss measurements are repeated to verify no change in performance. Results are shown in Figures 4 – 6 below. In each case, EClamp10012PQ results safely meet the recommended limits of the OPEN Alliance test specification.

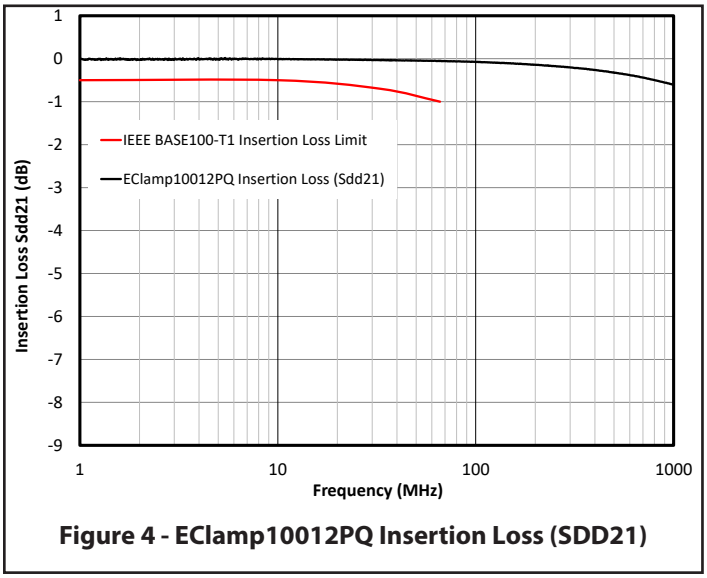


Figure 4 - EClamp10012PQ Insertion Loss (SDD21)

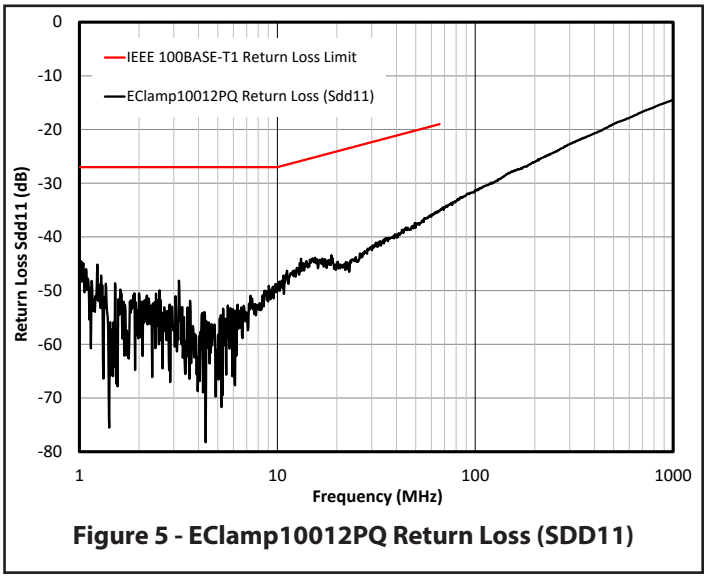


Figure 5 - EClamp10012PQ Return Loss (SDD11)

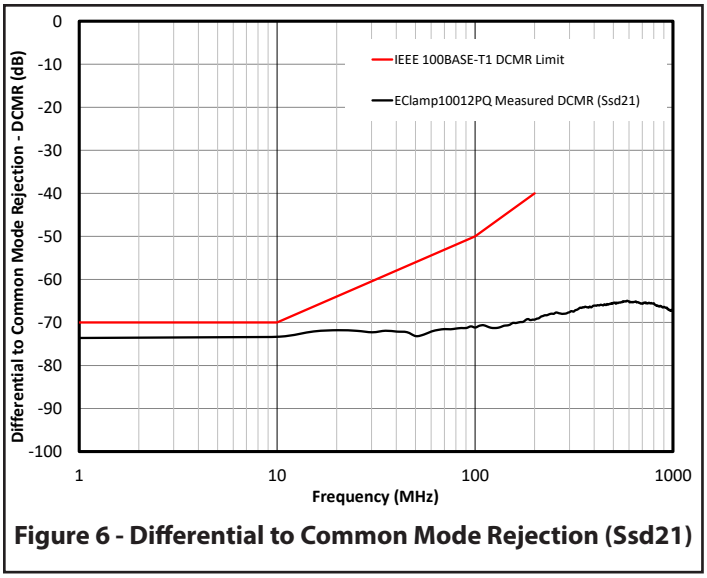


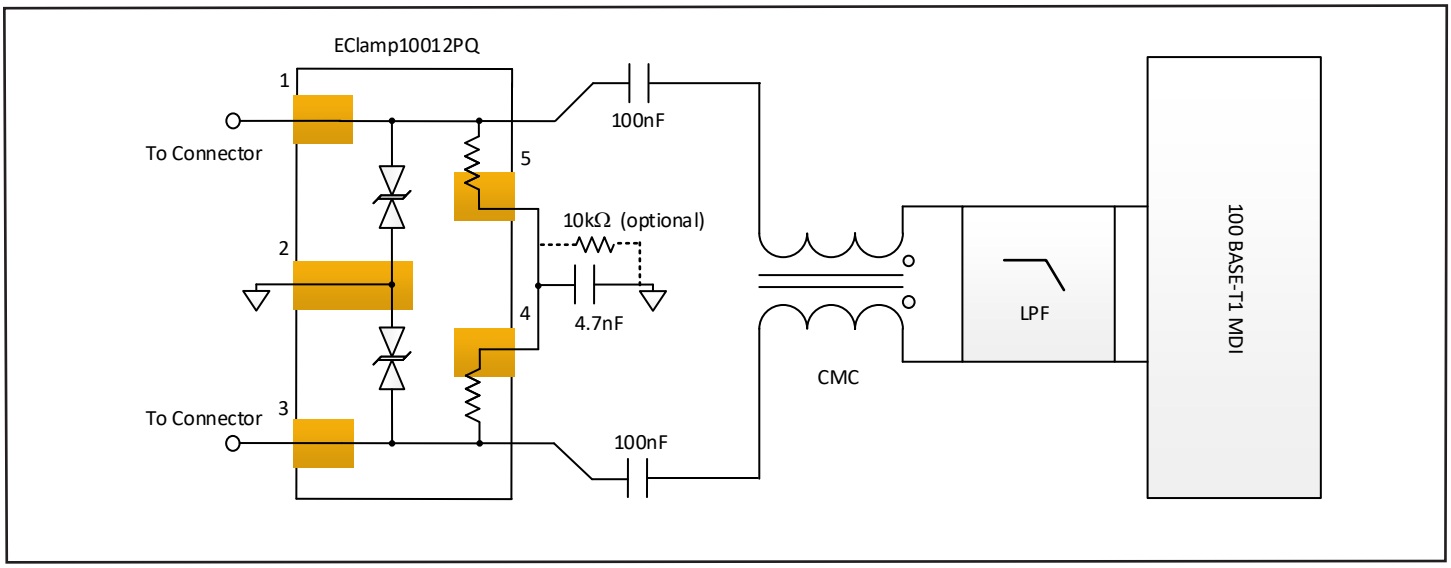
Figure 6 - Differential to Common Mode Rejection (Ssd21)

RF Clamping

An RF clamping test is defined in the OPEN Alliance specification to ensure the TVS device does not affect the EMC performance of the complete module. EClamp10012PQ is evaluated for unwanted RF clamping using a network analyzer in conjunction with a specified RF amplifier, RF attenuator, and device test fixture. The test fixture includes EClamp10012PQ and a common mode choke designed for 100BASE-T1 applications. EClamp10012PQ was evaluated for Class I (33dBm), Class II (36dBm), and Class III (39dBm). EClamp10012PQ does not exhibit an RF clamping effect up to 39dBm (Class III).

Device Connection and Layout Guidelines

A typical 100BASE-T1 protection example using EClamp10012PQ is shown in Figure 7. Signal lines enter at pins 1 and 3 and connect to external coupling capacitors in series with a common mode choke. A bidirectional TVS (ESD protection diode) is connected between each line and pin 2. Pin 2 is connected to ground. The capacitance of each TVS diode to ground is limited to 1.4pF to ensure signal integrity. Termination resistors are connected between pins 1 and 5 and pins 3 and 4. The resistors are connected externally to ground via a capacitor (a parallel 10kΩ resistor is optional). It is recommended that the capacitor have a minimum voltage rating of 100V. The internal TVS diodes will protect the capacitors from damage during an ESD event.



Layout Guidelines

Placement of the protection component is a critical element for effective ESD suppression. EClamp10012PQ should be placed before the CM choke and as close to the connector as possible. Placing the protection device close to the connector minimizes transient coupling into nearby traces. Ground connections should be made directly to the ground plane using micro-vias. This reduces parasitic inductance in the ground path and minimizes the clamping voltage seen by the protected device.

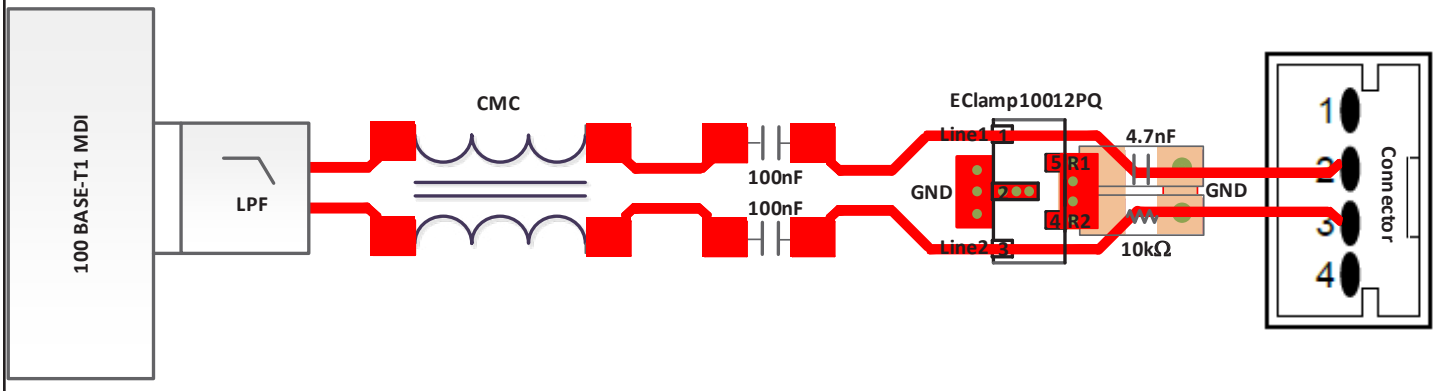


Figure 7 - Layout Example of ECLAMP10012PQ Protection for 100 BASE-T1 MDT.
Placement of 10K Resistor and 4.7nF Cap is on Bottom (Yellow) Layer

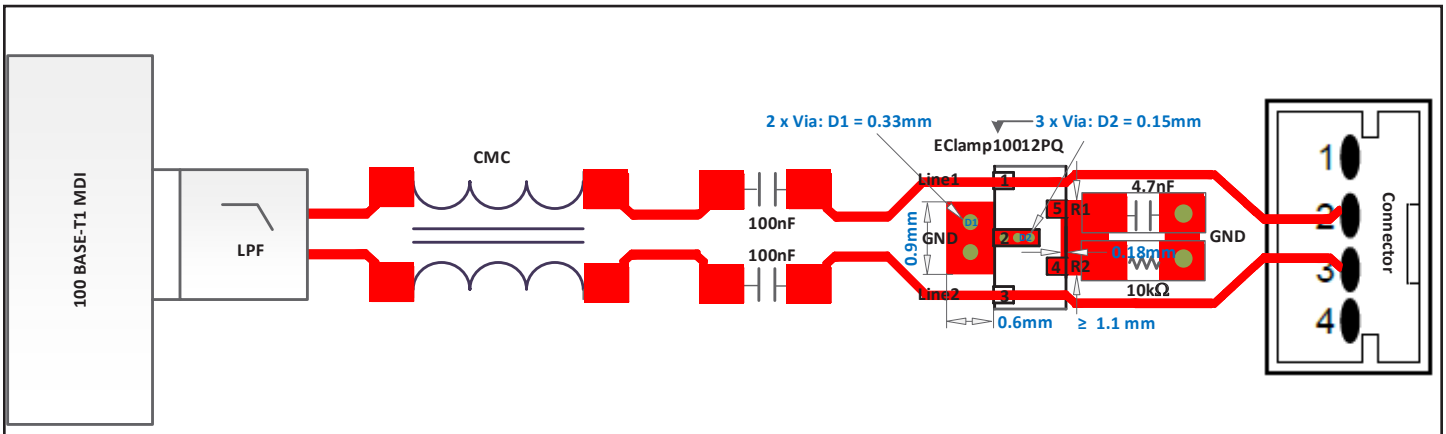


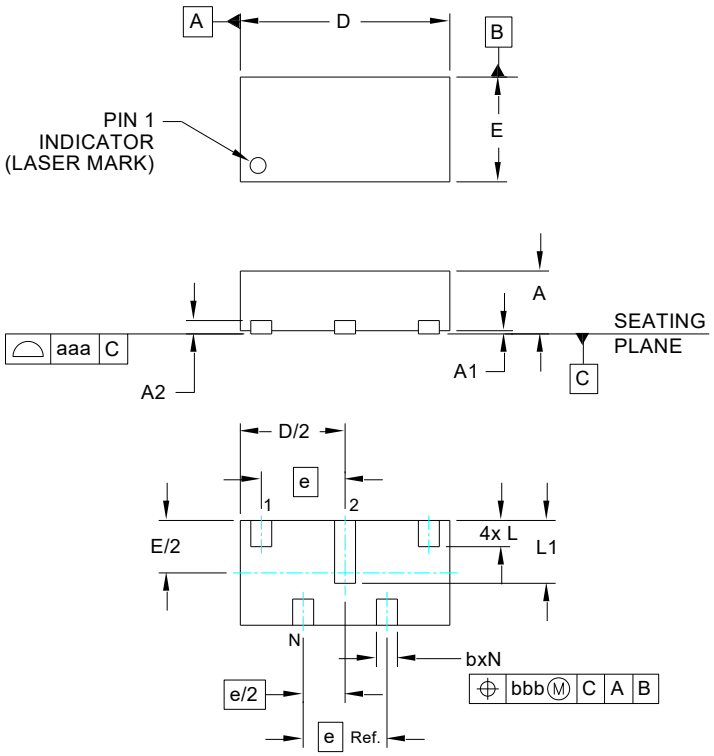
Figure 8 - Layout Example of ECLAMP10012PQ Protection for 100 BASE-T1 MDT

MDI interface

Figures 7 and 8 illustrates the layout examples of MDI circuitry which is used for each PHY port. The common mode termination depends on OEM requirements and might vary for different OEMs. The common mode choke is expected to be compliant to the OPEN Alliance CMC specification. The 100nF coupling capacitors should have maximum 10% tolerance and ≥100V voltage range. For the 10kΩ resistor and 4.7nF capacitor, there is no specific power rating required, but components should be rated for a minimum of 50V.

The differential signal pair TRX_P/TRX_M shall be routed close together with a controlled impedance of 100 Ohm. Since the symmetry is critical for the EMC performance, keep both traces of the differential pair as identical as possible. To increase the effectiveness of the choke or transformer for higher frequencies and to minimize parasitic capacitances, a cut-out of the ground plane may be placed beneath the differential signal path from the PHY to the connector. The choke shall be placed close to the PHY. Larger pads should be used for GND and R1/R2 termination resistor's connection on EClamp10012PQ.

Outline Drawing - DFN 2.0 x 1.0 x 0.60 mm-5 Lead

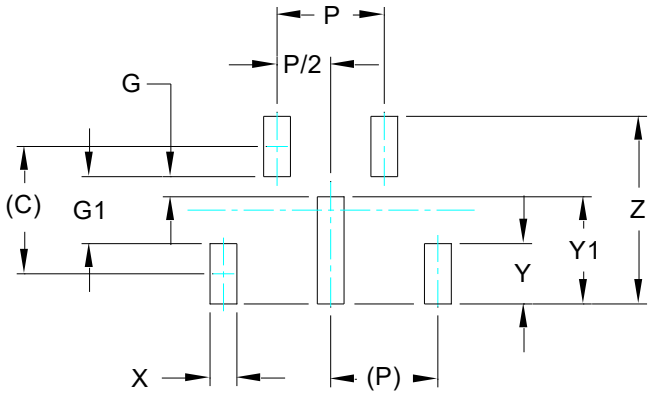


DIMENSIONS			
DIM	MILLIMETERS		
	MIN	NOM	MAX
A	0.55	0.60	0.65
A1	0.00	0.03	0.05
A2		(0.127)	
b	0.15	0.20	0.25
D	1.95	2.00	2.05
E	0.95	1.00	1.05
e		0.80 BSC	
L	0.20	0.25	0.30
L1	0.55	0.60	0.65
N		5	
aaa		0.08	
bbb		0.10	

NOTES:

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).

Land Pattern - DFN 2.0 x 1.0 x 0.60 mm-5 Lead

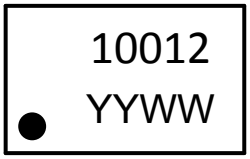


DIMENSIONS	
DIM	MILLIMETERS
C	(0.95)
G	0.15
G1	0.50
P	0.80
X	0.20
Y	0.45
Y1	0.80
Z	1.40

NOTES:

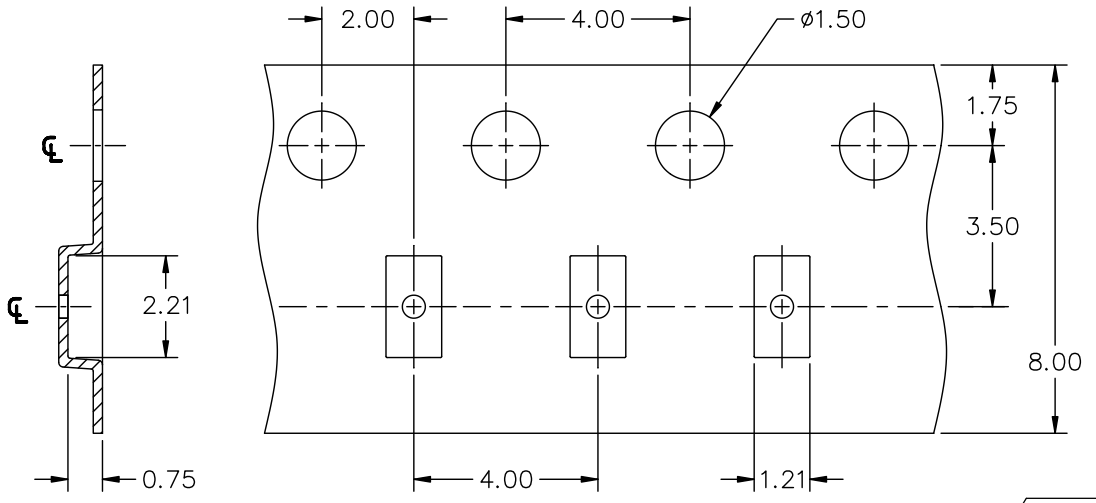
1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY.
   CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR
   COMPANY'S MANUFACTURING GUIDELINES ARE MET.

Marking Code

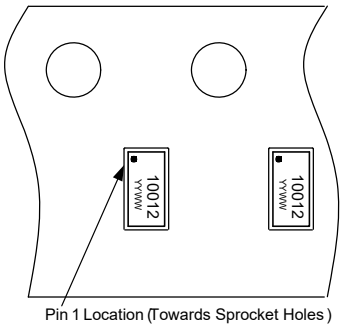


YYWW = Alphanumeric character Date Code

Tape and Reel Specification



Note: All dimensions are nominal dimensions in mm.



Ordering Information

Part Number	Qty per Reel	Reel Size	Carrier Tape	Pitch
EClamp10012PQTCT	3000	7 Inch	Plastic	4mm
EMIClamp and EClamp are trademarks of Semtech Corporation.				

Important Notice

Information relating to this product and the application or design described herein is believed to be reliable, however such information is provided as a guide only and Semtech assumes no liability for any errors in this document, or for the application or design described herein. Semtech reserves the right to make changes to the product or this document at any time without notice. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. Semtech warrants performance of its products to the specifications applicable at the time of sale, and all sales are made in accordance with Semtech's standard terms and conditions of sale.

SEMTECH PRODUCTS ARE NOT DESIGNED, INTENDED, AUTHORIZED OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT APPLICATIONS, DEVICES OR SYSTEMS, OR IN NUCLEAR APPLICATIONS IN WHICH THE FAILURE COULD BE REASONABLY EXPECTED TO RESULT IN PERSONAL INJURY, LOSS OF LIFE OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. INCLUSION OF SEMTECH PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE UNDERTAKEN SOLELY AT THE CUSTOMER'S OWN RISK. Should a customer purchase or use Semtech products for any such unauthorized application, the customer shall indemnify and hold Semtech and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs damages and attorney fees which could arise.

Contact Information

Semtech Corporation
200 Flynn Road, Camarillo, CA 93012
Phone: (805) 498-2111, Fax: (805) 498-3804
www.semtech.com