TDS4501P
Transient Diverting Suppressor
1-Line, 45V (24VAC) EOS Protection

PROTECTION PRODUCTS

Description

Transient Diverting Suppressors (TDS) are designed to provide protection from Electrical Overstress (EOS) events. They have superior clamping and temperature characteristics when compared to standard TVS devices. The device uses a surge rated FET as the main protection element. A precisely tuned trigger circuit activates the shunt FET when an EOS event is detected. The TDS clamping voltage is nearly constant across the rated peak pulse current range due to the extremely low ON Resistance of the FET.

TDS4501P is designed to protect voltage bus or data lines with an operating voltage as high as 45V (24VAC). It is rated for a high-energy transient current up to 24A (t_p = 8/20µs) and may be used to meet the common industrial voltage surge standard of ±1kV (R_S = 42 Ohms, C_S= 0.5µF).

TDS4501P is in a small DFN 1.6 x1.6 x 0.55mm 6- Lead package and represents significant board space savings over traditional TVS solutions.

Features

- High ESD withstand Voltage: ±20kV (Contact) and ±30kV (Air) per IEC 61000-4-2
- High peak pulse current capability:
  24A (tp = 8/20µs) per IEC 61000-4-5
  ±1kV (tp = 1.2/50µs, R_S = 42Ω) per IEC 61000-4-5 for unsymmetrical lines
- High EFT Withstand Voltage: ±4kV (100kHz and 5kHz, 5/50ns) IEC 61000-4-4
- Protects one I/O or power line
- Working voltage: 45V
- Solid-state technology

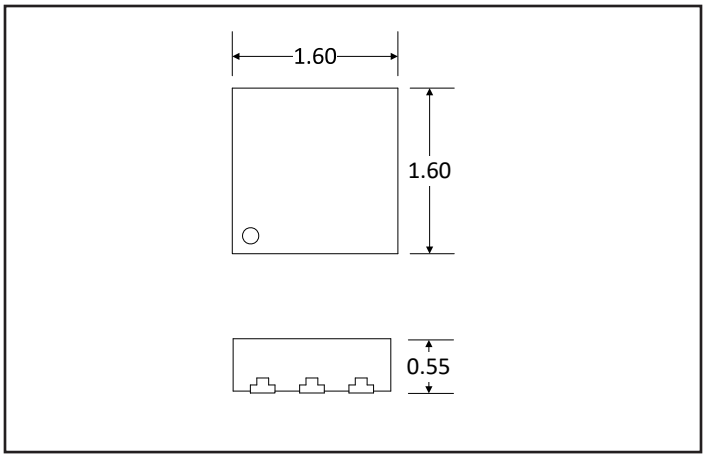
Mechanical Characteristics

- Package: DFN 1.6x 1.6 x 0.55mm 6-Lead
- Pb-Free, Halogen Free, RoHS/WEEE Compliant
- Molding compound flammability rating: UL 94V-0
- Lead Finish: Lead-Free
- Marking: Marking code and Date Code
- Packaging: Tape and Reel

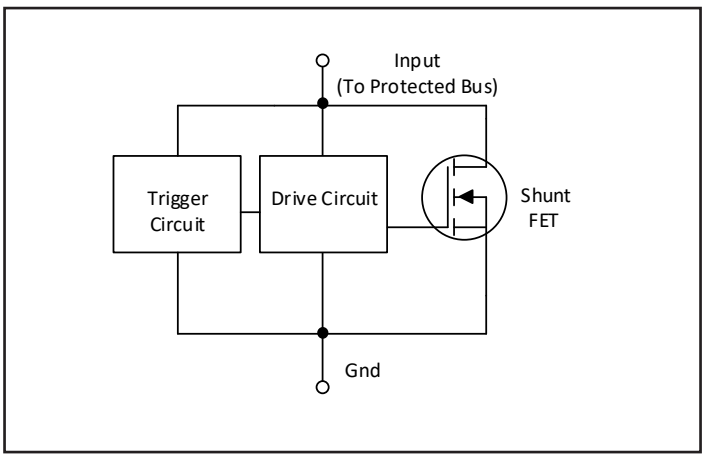
Applications

- 24V AC Lines
- IoT Devices
- Smart home devices
- Pachinko Machines
- Thermostats
- Security Cameras
- Industrial Equipment

Package Dimension (mm)



Functional Diagram



Absolute Maximum Rating

Rating	Symbol	Value	Units
Peak Pulse Power (t_p = 8/20µs)	P_{PK}	1344	W
Peak Pulse Current (t_p = 8/20µs)	I_{PP}	24	A
ESD per IEC 61000-4-2 (Air)(1) ESD per IEC 61000-4-2 (Contact)(1)	V_{ESD}	±30 ±20	kV
Operating Temperature	T_{OP}	-55 to +125	°C
Junction Temperature and Storage Temperature	T_J & T_{STG}	-55 to +150	°C

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

TDS4501P						
Parameter	**Symbol**	**Conditions**	**Min.**	**Typ.**	**Max.**	**Units**
Reverse Stand-Off Voltage	V_{RWM}	Pin 4, 5, 6 to Pin 1, 2, 3			45	V
Reverse Breakdown Voltage	V_{BR}	I_t = 1mA, Pin 4, 5, 6 to Pin 1, 2, 3	49	53.2	55	V
Forward Voltage	V_F	I_t = 1mA, Pin 1, 2, 3 to Pin 4, 5, 6		0.5		V
Reverse Leakage Current	I_R	V_{RWM} = 45V, Pin 4, 5, 6 to Pin 1, 2, 3		270	975	nA
Clamping Voltage (2)	V_C	I_{PP}=12A, t_p = 1.2/50µs (Voltage), 8/20µs (Current) Combination Waveform, R_S = 2Ω, Pin 4, 5, 6 to Pin 1, 2, 3		53.3	55.5	V
		I_{PP}=24A, t_p = 1.2/50µs (Voltage), 8/20µs (Current) Combination Waveform, R_S = 2Ω, Pin 4, 5, 6 to Pin 1, 2, 3		53.5	56	V
Dynamic Resistance (2), (3)	R_{DYN}	t_p = 8/20µs		11		mΩ
Junction Capacitance	C_J	V_R = 45V, f = 1MHz		90		pF

Notes:

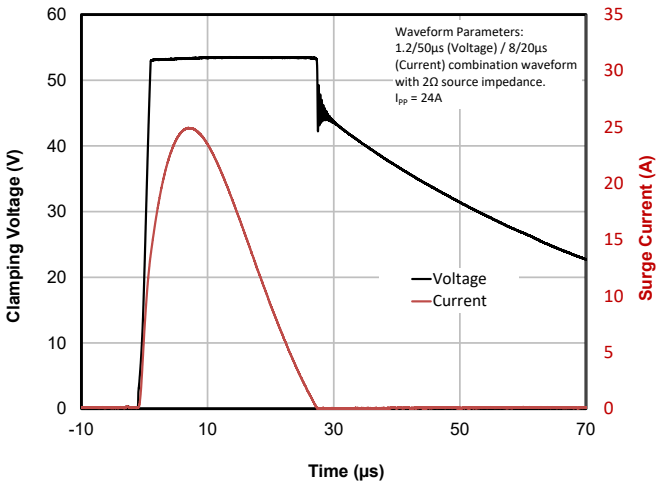
1) ESD gun return path connected to ESD ground plane.

2) Parameter guaranteed by design.

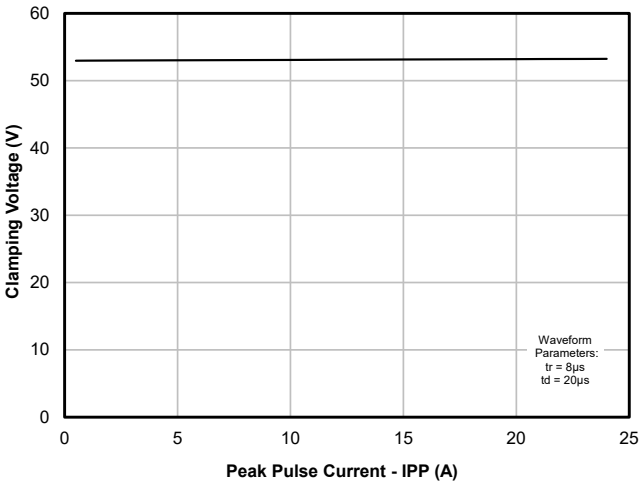
3) Dynamic resistance measured between 1A and 24A.

Typical Characteristics

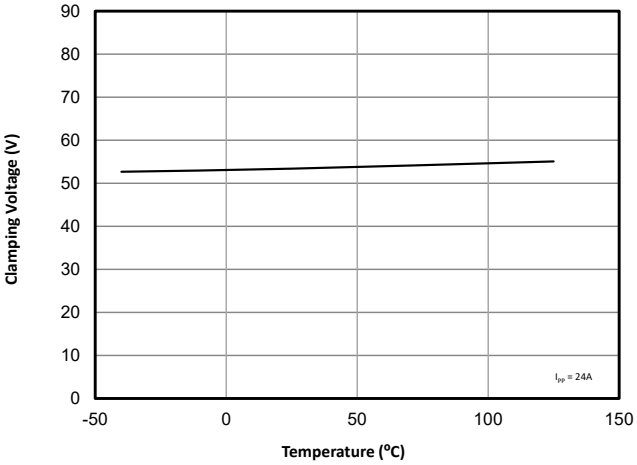
Clamping Voltage (t_p=1.2/50µs, I_{PP}= 24A)



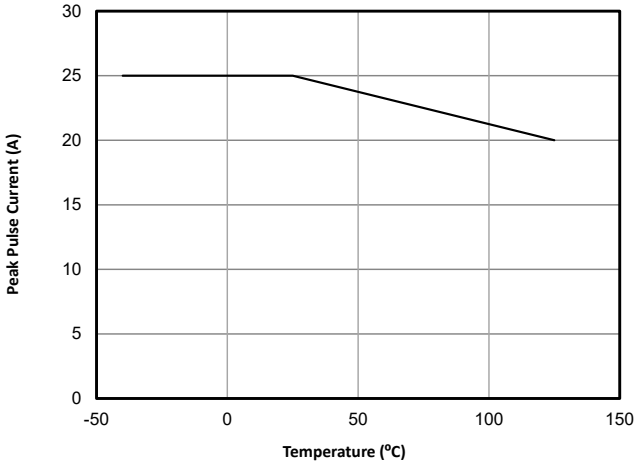
Clamping Voltage vs. Peak Pulse Current (t_p=8/20µs)



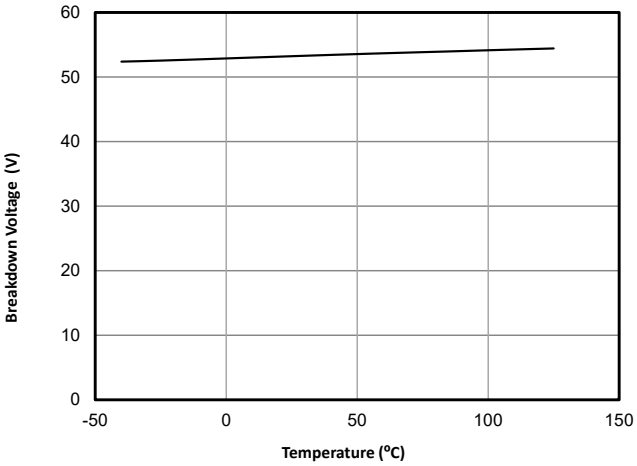
Clamping Voltage (t_p=1.2/50µs, I_{PP}= 24A) vs Temperature



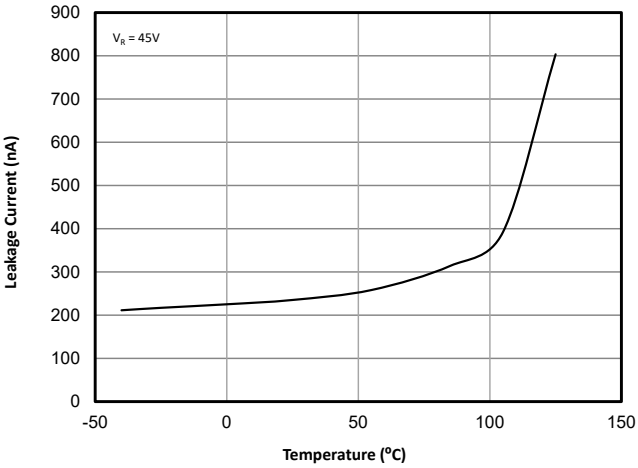
Peak Pulse Current (tp=8x20µs) vs Temperature



Breakdown Voltage vs. Temperature

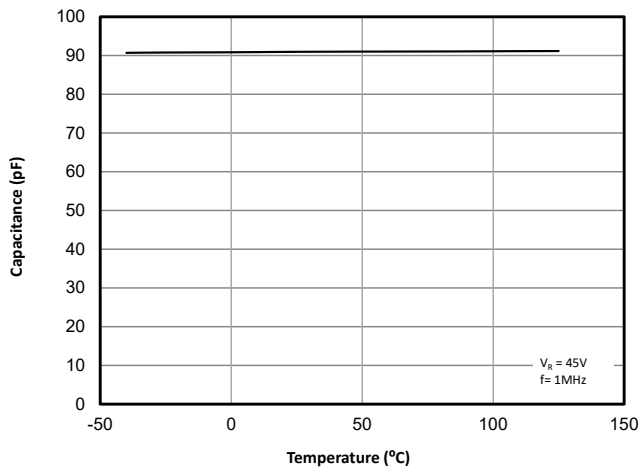


Reverse Leakage vs. Temperature

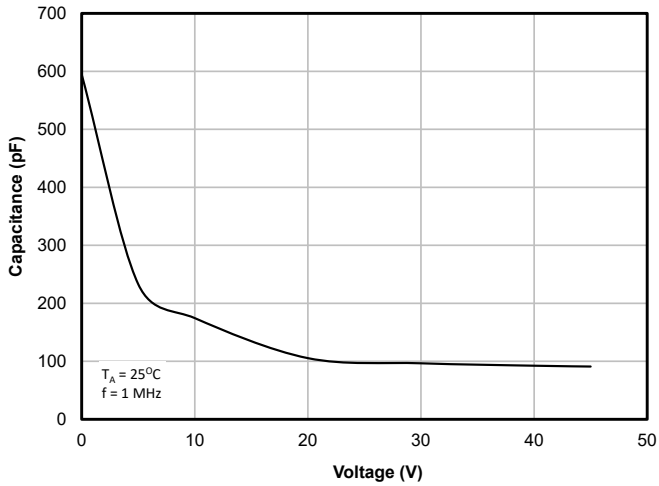


Typical Characteristics

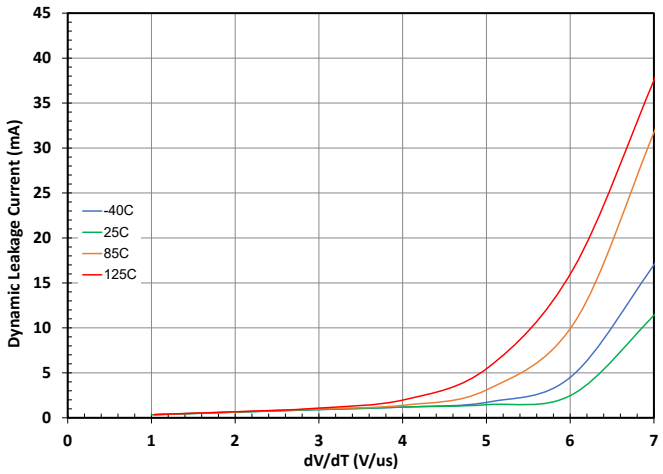
Capacitance vs. Temperature



Capacitance vs. Reverse Voltage



Dynamic Leakage vs. Signal Slew Rate over Temperature



Application Information

Description

Transient Diverting Suppressors(TDS) are designed to provide high energy EOS protection with superior clamping and temperature characteristics when compared to standard TVS devices.

Conventional pn-junction TVS diodes have an inherent, fixed resistance value or dynamic resistance (R_{dyn}). TVS clamping voltage is given by the equation: $V_{Clamp} = V_{BR} + I_{PP} * R_{dyn}$. Since the dynamic resistance is a fixed value, clamping voltage increases with increased I_{PP} resulting in a linear rise in clamping over the peak pulse current range. Additionally, conventional TVS dissipate surge energy in the junction of the device. Therefore, the capability to absorb transient current is related to the junction area and junction (ambient) temperature. As ambient temperature increases, the clamping voltage increases and the maximum I_{PP} capability decreases.

Transient Diverting Suppressors use a surge rated FET as the main protection element (Figure 1). The FET behaves like a voltage controlled switch which is activated by a precision trigger circuit (Figure 2). During an EOS event, transient voltage increases beyond the breakdown voltage of the trigger circuit. This in turn activates the drive circuit and turns on the shunt FET, effectively "closing the switch" and conducting transient current to ground. As the I_{PP} rises, the FET R_{ds}(on) decreases to a negligibly small value, resulting in a clamping voltage with the same approximate value as the trigger circuit breakdown voltage. Therefore, the TDS clamping voltage is nearly constant across the rated peak pulse current range. The clamping also remains stable over the operating temperature range.

A comparison of clamping voltage vs. peak pulse current and Temperature for a conventional TVS and TDS4501P is shown in Figure 4. In this example, the TVS diode has a working voltage of 45V and clamps at approximately 65V at I_{PP} = 25A. TDS4501P clamps at approximately 53V across the rated I_{PP} range. Clamping also remains the same over the rated temperature range compared to the TVS which increases with increasing temperature.

Figure 1- Functional Diagram

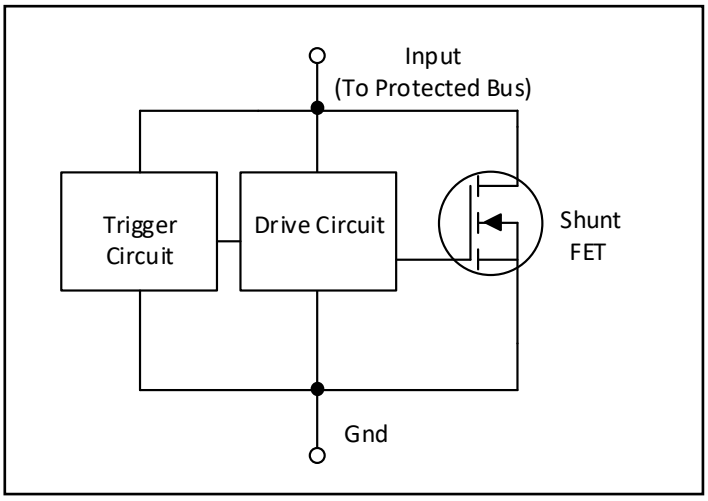


Figure 2- TDS Operation

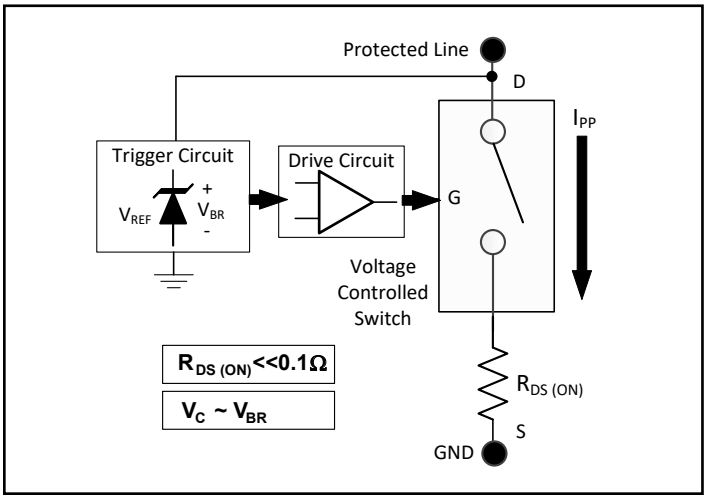
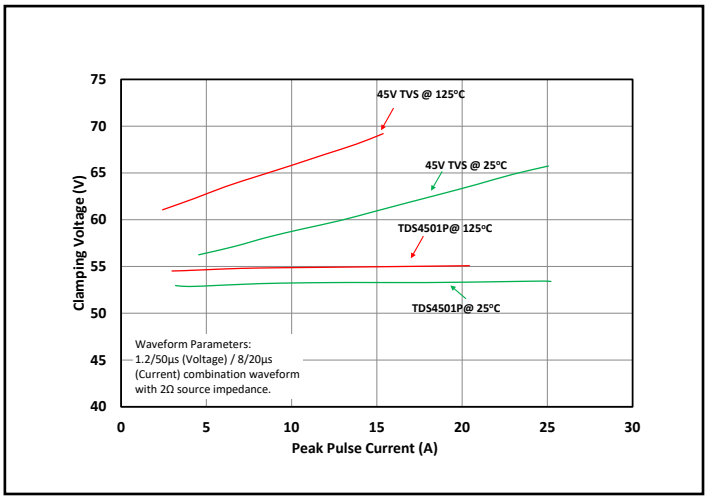


Figure 3- Clamping Comparison

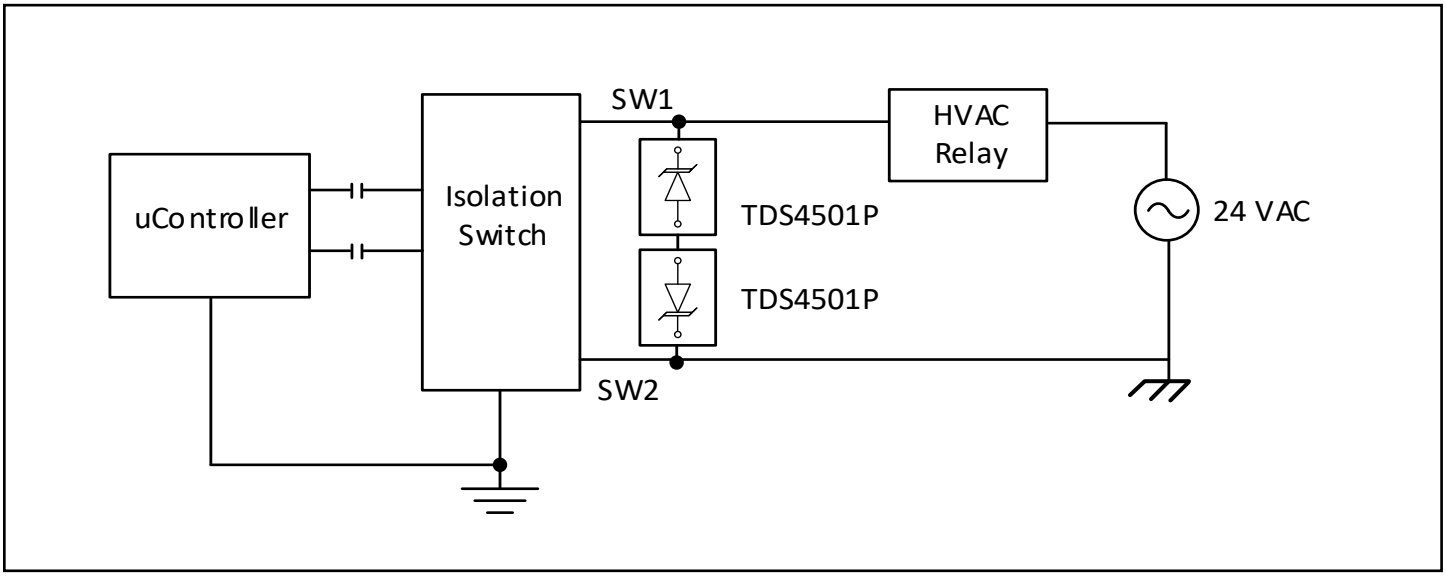


Application Information (Continued)

Typical Application

A typical application for TDS4501P is protecting 24VAC input lines in IoT devices such as a smart thermostat as shown in Figure 4. In this example, TDS4501P is connected on each line of a solid-state isolation switch. Relay switching in the HVAC system, or power supply transients can easily reach several hundreds of volts, and easily damage the switch. With TDS4501, the transient voltage will be clamped to less than 55V. They may be used to meet the common industrial voltage surge standard of +/-1kV per IEC61000-4-5 (R_S = 42 Ohms, C_S= 0.5uF).

Figure 4- TDS4501P Application Example

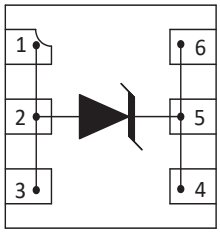


Application Information

Pin Configuration

TDS4501P is in a 1.6 x 1.6mm, 6-pin DFN package. The input or connection to the protected bus is made at pins 4, 5, and 6. Ground connection is made at pins 1, 2, and 3. All pins must be connected for maximum peak pulse current handling capability.

Figure 6 - Pin Configuration and Description



6-Pin DFN Package (Top View)

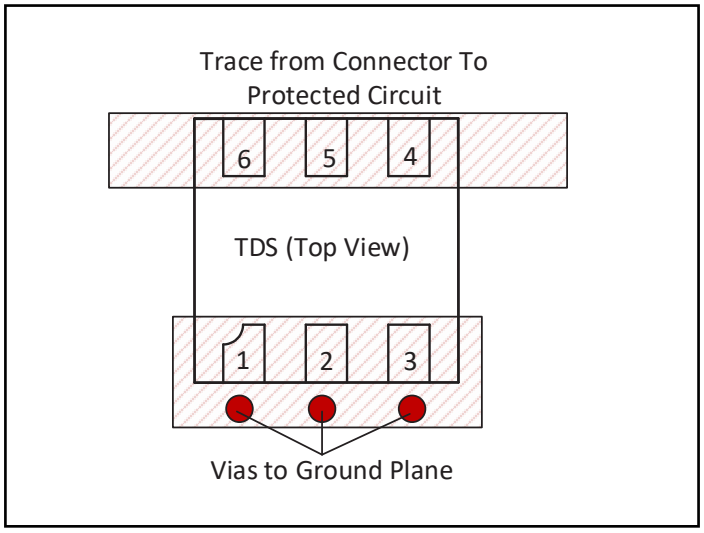
Pin Number	Pin name	Description
1,2,3	GND	Ground
4,5,6	IN	EOS and ESD Protection Input

Layout Guidelines

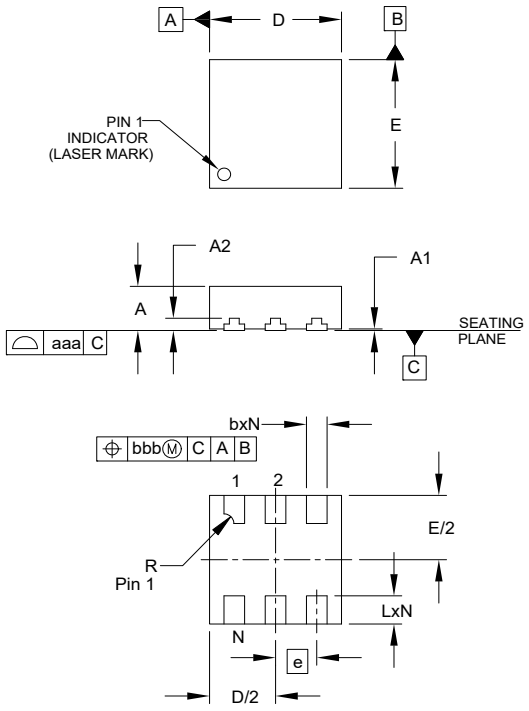
Figure 7 shows a recommended layout for TDS4501P. All the I/O pins (Pin 4, 5 and 6) are connected through a single straight trace. All of the I/O pins must be connected for maximum surge performance. Likewise, all GND pins (Pin 1, 2 and 3) must be connected for maximum surge current capability. If ground is on a different layer of the PCB, connection with multiple vias is recommended. This aids in reducing the parasitic inductance to ground. Note that under transient conditions, the energy is dissipated in the device and no "thermal pad" is needed.

TDS4501P should be located as close to the connector as possible. This aids in restricting transient coupling to adjacent traces, especially during fast rise time ESD events.

Figure 7 - PCB Layout Recommendation



Outline Drawing - DFN 1.6 x 1.6 x 0.55mm 6-Lead

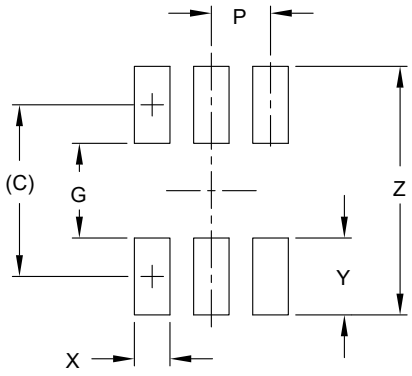


DIMENSIONS			
DIM	MILLIMETERS		
	MIN	NOM	MAX
A	0.50	0.55	0.60
A1	0.00	0.02	0.05
A2		(0.152)	
b	0.20	0.25	0.30
D	1.55	1.60	1.65
E	1.55	1.60	1.65
e		0.50 BSC	
L	0.30	0.35	0.40
N		6	
R	0.07	0.12	0.17
aaa		0.08	
bbb		0.10	

NOTES:

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

Land Pattern - DFN 1.6 x 1.6 x 0.55mm 6-Lead

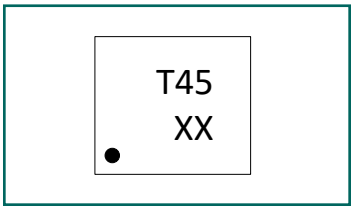


DIMENSIONS	
DIM	MILLIMETERS
C	(1.45)
G	0.80
P	0.50
X	0.30
Y	0.65
Z	2.10

NOTES:

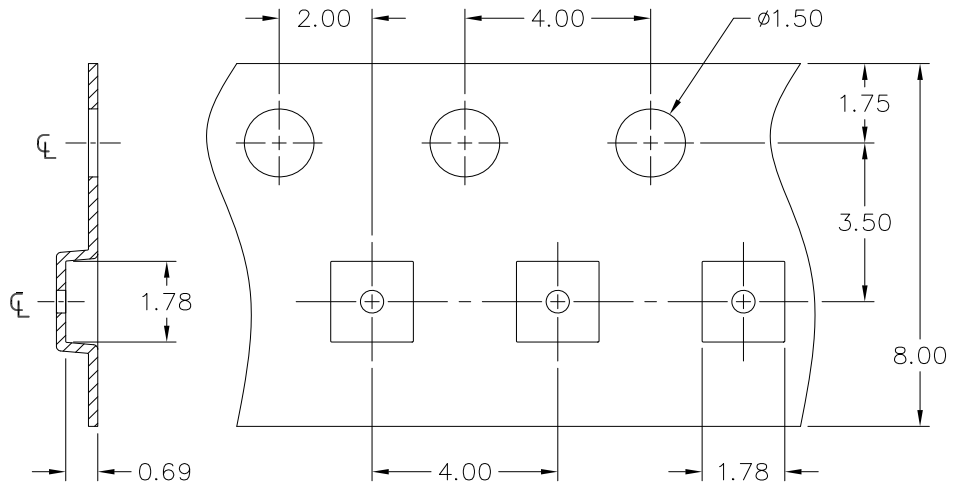
1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY.
   CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR
   COMPANY'S MANUFACTURING GUIDELINES ARE MET.

Marking Code

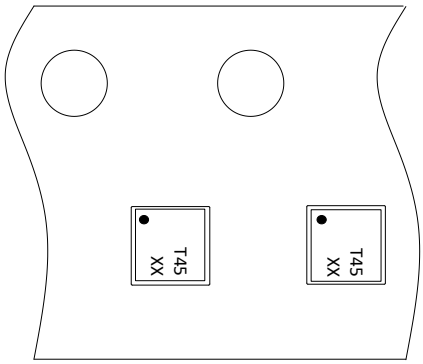


Notes:
1. XX: Date Code.
2. Dot indicates Pin 1 location.

Tape and Reel Specification



Note: All dimensions are nominal dimensions in mm.



Ordering Information

Part Number	V_{RWM}	Qty per Reel	Reel Size
TDS4501P.C	45V	3,000	7″

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