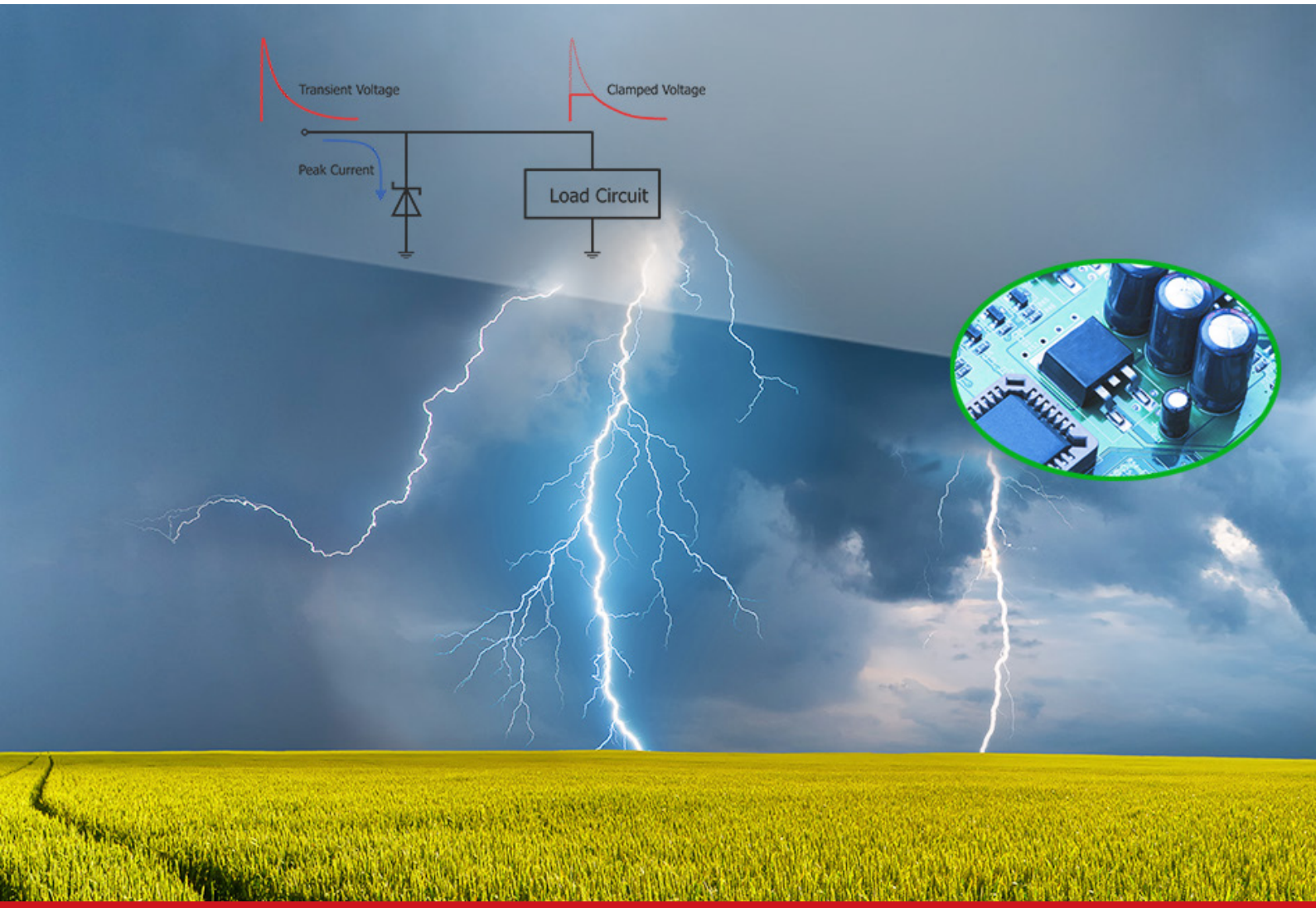
APPLICATION NOTE

Diotec Semiconductor



TVS Diodes

Green and sustainable technologies require high performance and low power electronics that operate at low voltages. Interfacing sensitive components like sensors, microcontrollers, data converters etc. to the real world, or connecting them to other circuits like inductive loads can expose them to voltage surges higher than their specified maximum limits. In order to avoid permanent damage, caused by voltage transients, designers must take protection measures that isolate the active circuit from such events while not affecting operation during normal conditions. Diotec's portfolio of Transient Voltage Suppressors (TVS) offers a wide variety of solutions for a broad range of applications.

TVS Diodes are silicon devices designed to protect against voltage surges greater than a desired maximum level. When connected in parallel to the circuit, they create a protective path around it (Fig. 1, Fig. 2). During normal conditions, when the input voltage stays within the desired limits, the TVS diode exhibits a high impedance, thus not affecting the behaviour of the downstream circuitry. As soon as the maximum voltage level is reached, the avalanche effect kicks in and the TVS Diode creates a low impedance path, thus diverting all excessive energy into the ground. Like this, the circuit remains unharmed and normal operation can continue.

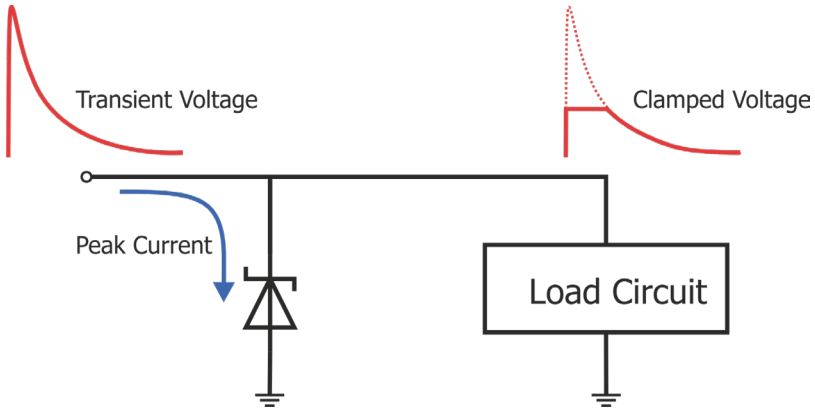


Figure 1: Unidirectional TVS Protection

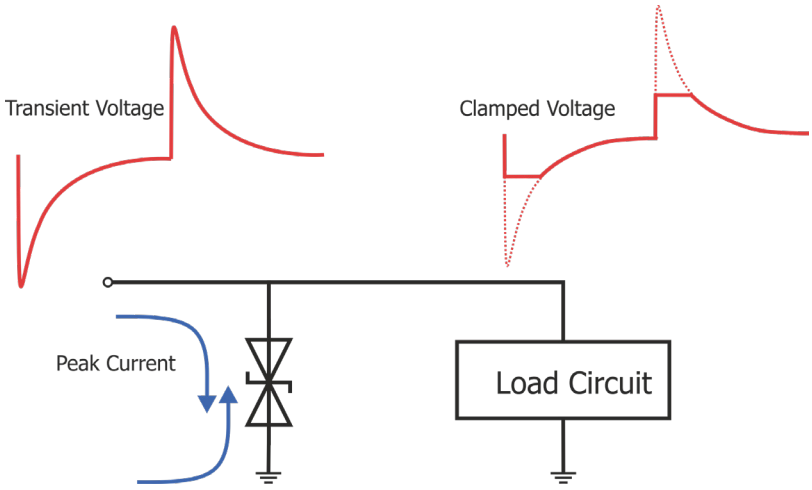


Figure 2: Bidirectional TVS Protection

TVS Diodes are available for a multitude of voltage ranges, both as unidirectional and bidirectional types.
Unidirectional TVS Diodes have an asymmetrical behaviour protecting against surges of one polarity (Fig. 1., Fig. 3). For signals of the opposite polarity they work much like a standard rectifier. Some applications require protection against both positive and negative voltage spikes. For these cases, bidirectional TVS diodes are the solution of choice (Fig. 2). They have a symmetrical characteristic, blocking excessive energy of both polarities (Fig. 4).

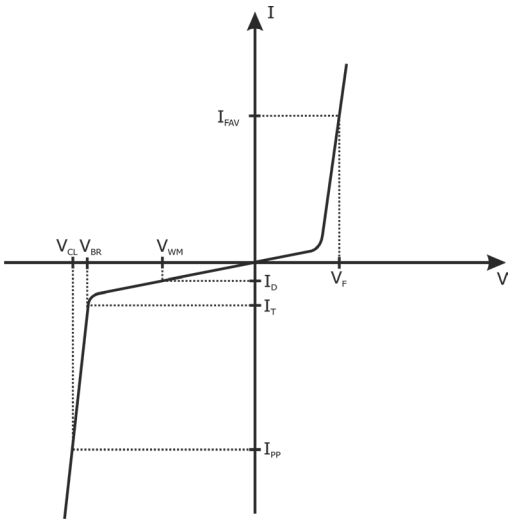


Figure 3: Unidirectional TVS Characteristic

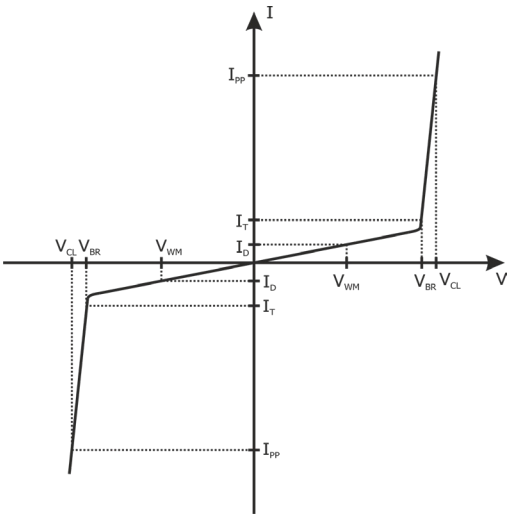


Figure 4: Bidirectional TVS Characteristic

When selecting a TVS Diode, designers must make sure that it is capable of accommodating the maximum expected voltage spikes. The definitions below shall provide a better understanding of the datasheet parameters.

- P_{PPM}: The Peak Pulse Power Dissipation is a measure of the diode's ability to dissipate energy and is defined as the peak pulse current I_{PPM} multiplied by the maximum clamping voltage V_C. Because surges are time-dependent, transient phenomena, P_{PPM} is specified with a pulse current of 10/1000 µs: 10 µs rise to peak and 1000 µs exponential decay to one-half peak (Fig. 5). For non-repetitive pulses, the peak power must stay below the curve in Fig. 6 at all times.

- V_{WM}: The Stand-off Voltage is the maximum specified voltage at which the TVS diode operates in high impedance mode without entering in breakdown.

- V_{BR}: The Breakdown Voltage is the value at which the TVS device will start con ducting.
  V_{BR} is specified at a fixed current level and is usually ca. 10% higher than V_{WM}.

- V_C: The Maximum Clamping Voltage defines the voltage across the TVS diode at maximum current I_{PPM}. The below formula applies:

$$P_{PPM} = I_{PPM} \times V_C$$

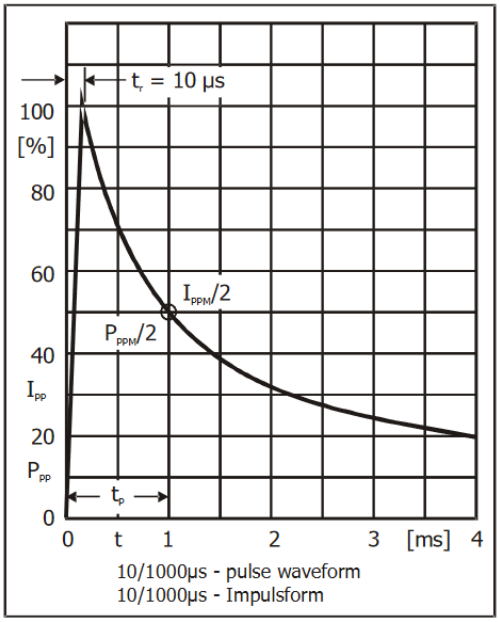


Figure 5: 10/1000 µs waveform (P6SMBJ65)

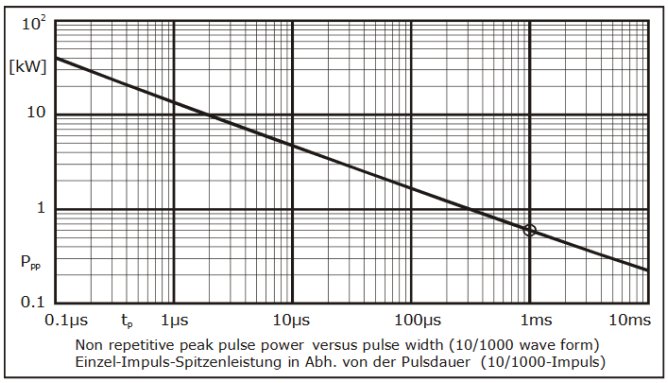


Figure 6: Non-repetitive peak pulse power vs. pulse width (P6SMBJ65)

The following table gives an overview of Diotec's TVS portfolio for different power ratings and package types.

Part [1])		P_{PPM} [W]	V_{BR} [V]	Outline
Uni-directional	SMF5.0A ... 220A	200	6.8 ... 260	 SOD-123FL
Bi-directional	SMF5.0CA ... 220CA			
Uni-directional	P4SMAJ5.0(A) ... 170(A) P4SMA220(A) ... 550(A)	400	6.8 ... 200 220 ... 550	 DO-214AC
Bi-directional	P4SMAJ5.0C(A) ... 170C(A) P4SMA220C(A) ... 550C(A)			
Uni-directional	P6SMBJ5.0(A) ... 170(A) P6SMB220(A) ... 550(A)	600	6.8 ... 200 220 ... 550	 DO-214AA
Bi-directional	P6SMBJ5.0C(A) ... 170C(A) P6SMB220C(A) ... 550C(A)			
Uni-directional	1.5SMCJ5.0(A) ... 170(A) 1.5SMC220(A) ... 550(A)	1500	6.8 ... 200 220 ... 550	 DO-214AB
Bi-directional	1.5SMCJ5.0C(A) ... 170C(A) 1.5SMC220C(A) ... 550C(A)			
Uni-directional	3.0SMCJ5.0A ... 170A	3000	6.8 ... 200	
Uni-directional	3.0SMCJ5.0A ... 170A			
Uni-directional	5.0SMCJ12A ... 170A	5000	14 ... 200	
Bi-directional	5.0SMCJ12CA ... 170CA			

[1] Check Datasheet for AEC-Q101 Qualification Status

Part [1])		P_{PPM} [W]	V_{BR} [V]	Outline
Uni-directional	TGL34-6.8(A) ... 200(A)	150	6.8 ... 200	 DO-213AA
Bi-directional	TGL34-6.8C(A) ... 200C(A)			
Bi-directional	SDA2AK SDA4AK	300	1V 2V	 DO-213AB
Uni-directional	TGL41-6.8(A) ... 520	400	6.8 ... 520	
Bi-directional	TGL41-6.8C(A) ... 520C			
Uni-directional	BZW04-5V8 ... 376/ P4KE6.8(A) ... 440(A)	400	6.8 ... 440	 DO-15
Bi-directional	BZW04-5V8B ... 376B/ P4KE6.8C(A) ... 440C(A)			
Uni-directional	BZW06-5V8 ... 376/ P6KE6.8(A) ... 480(A)	600	6.8 ... 440 6.8 ... 520	
Bi-directional	BZW06-5V8B ... 376B/ P6KE6.8C(A) ... 520C(A)			
Uni-directional	Protectifiers® F5K120	400	130	 DO-201

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Part [1])		P_{PPM} [W]	V_{BR} [V]	Outline
Uni-directional	1.5KE6.8(A) ... 440(A)	1500	6.8 ... 440	 Ø 5.4 x 7.5
Bi-directional	1.5KE6.8C(A) ... 440C(A)			
Uni-directional	5KP6.5(A) ... 120A	5000	7.2 ... 133	 Ø 8 x 7.5
Bi-directional	5KP6.5C(A) ... 120CA			
Uni-directional	Protectifiers® F12K120 (12A)	750	130	
Uni-directional	Protectifiers® FX20K120 (20A) FX20K150 (20A)	750	130 160	
Uni-directional	BYZ35x22 ... BYZ35x47	I_{FAV} 35A	22 ... 47	 Press-fit
Uni-directional	BYZ50x22 ... BYZ50x47	I_{FAV} 50A	19.8 ... 42.3	

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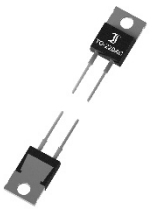
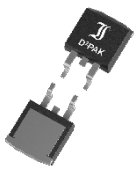
Part [1])		P_{PPM} [W]	V_{BR} [V]	Outline
Uni-directional	6.6SM8Z10A ... 6.6SM8Z43A	6600	11.1 ... 52.8	 DO-218AB
Uni-directional	Protectifiers® KT20K120, KT20K150 KT20A120, KT20A150	750	150, 160	 TO-220AC
Uni-directional	LDP01-26AYD2-AQ ... LDP01-82AYD2-AQ	5000	26 ... 82	 D2PAK
Bi-directional	LDP01-26CAYD2 ... LDP01-82CAYD2			
Uni-directional	LDP02-26AYD2-AQ ... LDP02-82AYD2-AQ	6600	26 ... 82	
Bi-directional	LDP02-26AYD2-AQ ... LDP02-82AYD2-AQ			

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