

## Unidirectional versus Bidirectional Protection

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### APPLICATION NOTE

Protection products such as transient voltage suppressors (TVS) are often described as unidirectional and bidirectional. This terminology has often led to confusion. The most common misconception is that unidirectional devices only provide protection for positive or negative stresses, not both. This is not true. The vast majority of unidirectional TVS products provide protection for both stress polarities. This application note will clarify the meanings of unidirectional and bidirectional protection products and give simple examples of their use.

We will begin with the following definitions and then discuss each type in more detail.

**Unidirectional TVS:** A TVS device with asymmetrical current versus voltage (I–V) properties. A unidirectional TVS is best suited for protecting circuit nodes whose signals

are **unidirectional** or always above or below the reference voltage, usually ground.

**Bidirectional TVS:** A TVS device with symmetrical I–V properties. A bidirectional TVS is best suited for protecting electrical nodes whose signals are **bidirectional** or can have voltage levels both above and below the reference voltage, usually ground

#### Unidirectional TVS Devices

The simplest unidirectional TVS device is a Zener or avalanche diode as shown in Figure 1. For negative voltage from cathode to anode the TVS has high conductivity above a forward diode drop. For positive voltages there is high impedance up to the reverse bias breakdown voltage. Above the reverse bias breakdown voltage the diode has low resistance.

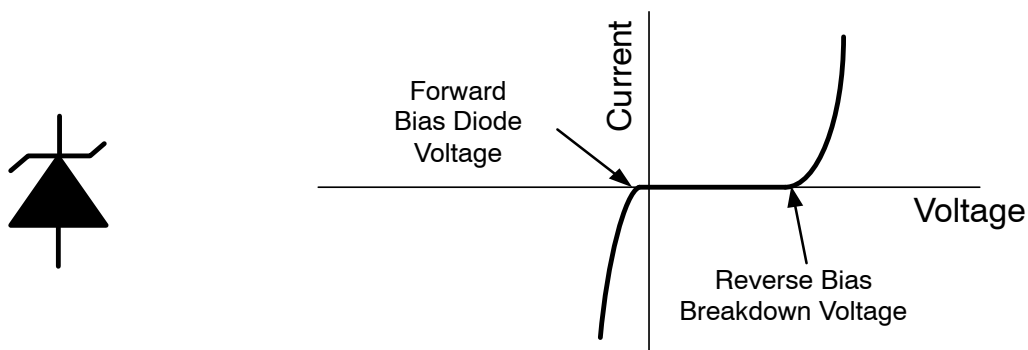


Figure 1. Unidirectional TVS Protection Properties

An application of a unidirectional TVS device is illustrated in Figure 2. A circuit has a sensitive input line which carries a normal signal which is always a positive voltage, for example a 0 to 5 V signal. The normal signal range is shown on the right side of Figure 2. If voltage on the input line goes significantly below 0 V or above 5 V damage

can occur to the circuit, as shown in Figure 2. A unidirectional TVS can be placed between the input and ground to direct current to ground and clamp the voltage below a value that will create damage to the sensitive circuit. The required I–V properties of the unidirectional TVS are shown in Figure 2.

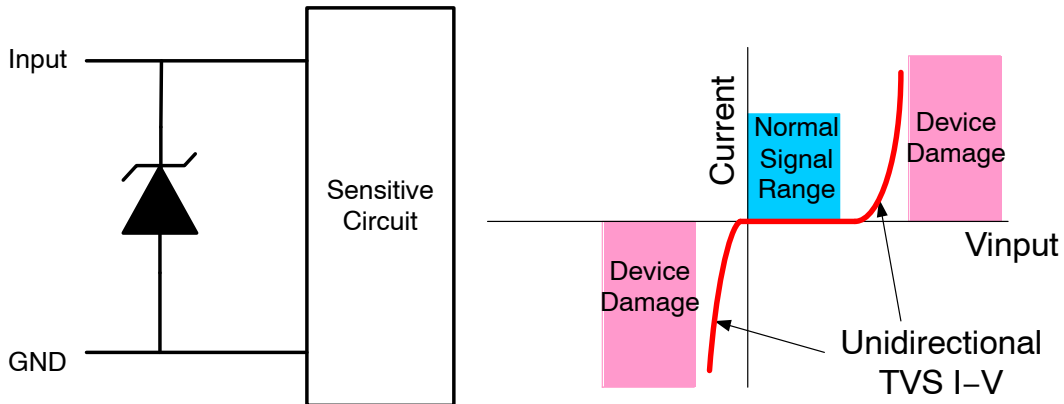


Figure 2. Application of a Unidirectional TVS Device

Note that for circuit nodes whose voltage is always below the reference voltage a unidirectional device can provide protection simply by switching the terminal leads.

positive and negative voltage the impedance is high up to the reverse bias breakdown voltage plus a forward bias diode drop. This is shown on the right side of Figure 3.

**Bidirectional TVS Devices**

A simple example of a TVS device is a pair of back to back Zener or avalanche diodes, as shown in Figure 3. For both

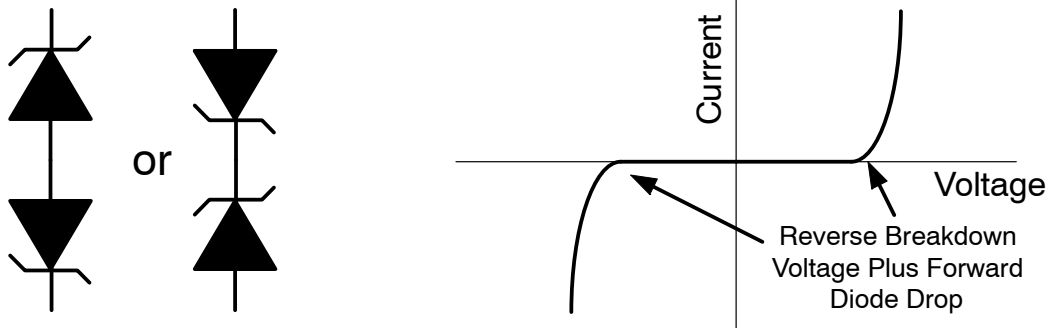


Figure 3. Bidirectional Protection Properties

An application of a bidirectional TVS device is illustrated in Figure 4. A circuit has a sensitive input line which carries a normal signal which ranges symmetrically above and below ground,  $\pm 12$  V for example. The normal signal range is shown on the right side of Figure 4. If voltage on the input line goes significantly below  $-12$  V or above  $+12$  V damage

can occur to the circuit, also shown in Figure 4. A bidirectional TVS can be placed between the input and ground to direct current to ground, clamping the voltage below voltages that can cause damage. The required I-V properties of the bidirectional TVS are shown in Figure 4.

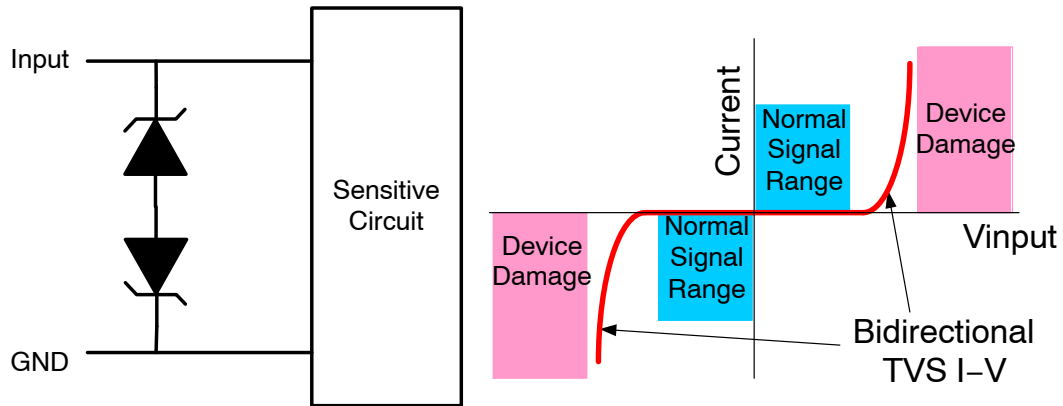


Figure 4. Application of a Bidirectional TVS Device

**Summary**

The choice of a unidirectional or bidirectional TVS product depends on the properties of the circuit being protected. Unidirectional TVS products protect signal or DC

power nodes with unidirectional signal swings and bidirectional TVS products protect signal or AC power nodes with bidirectional signal swings.

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