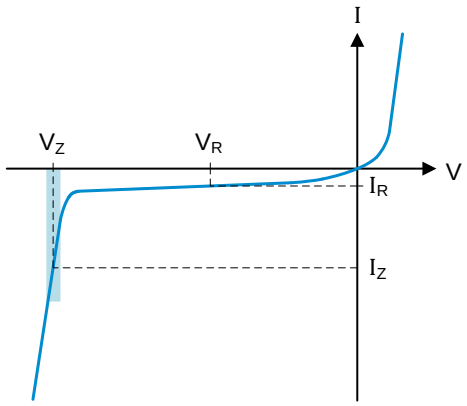
Diode

Differences between TVS and Zener Diodes

Transient voltage suppressor (TVS) diodes and Zener diodes have a common feature: when a reverse voltage is applied, a breakdown occurs at a certain voltage and the voltage is clamped. This application note explains the differences between the TVS and Zener diodes.

Difference in operating range in terms of I-V characteristics

Figures 1 and 2 show the I-V characteristics of the Zener and TVS diodes, respectively. Both diodes similarly utilize characteristics in the reverse direction. However, since the Zener diodes are mainly used for constant voltage applications, they are designed to stabilize the voltage in the small current region, such as between 1 mA and 40 mA. Therefore, a large current cannot be applied to them (shaded area in Figure 1). Zener voltage V_Z is specified as a voltage across the diode when the specified small current (I_Z) in the breakdown region is applied. Usually, they are always used in the breakdown state.



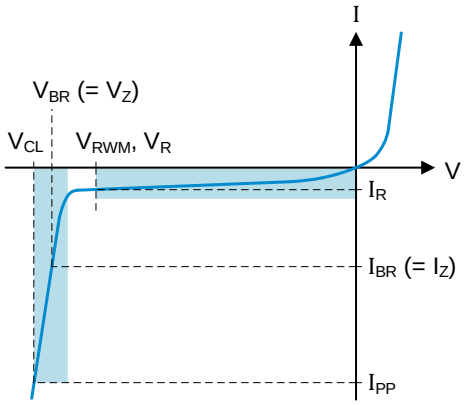
V_Z: Zener voltage
I_Z: Current to specify V_Z
I_R: Reverse current
V_R: Reverse voltage to specify I_R

Figure 1. I-V characteristics of Zener diode

The TVS diodes are usually used below standoff voltage V_{RWM} (shaded area on the right side in Figure 2), so that the driving voltage of the circuit to be protected is not interrupted. A breakdown occurs when an overvoltage such as a surge is applied, causing a current between a few A and several tens of A to flow (shaded area on the left side).

Since a breakdown must not occur usually, two values are specified: standoff voltage V_{RWM}, which is the maximum value of voltage that never causes a breakdown, and breakdown voltage V_{BR}.

Since breakdown voltage V_{BR} is measured with a small current similarly to Zener voltage V_Z, it is different from the avalanche voltage under actual application conditions. Therefore, clamping voltage V_{CL} is specified as the maximum breakdown voltage when a large current is applied.



V_{BR}: Breakdown voltage (same as Zener voltage)
I_{BR}: Current to specify V_{BR}
I_R: Reverse current
V_R: Reverse voltage to specify I_R
V_{RWM}: Standoff voltage
V_{CL}: Clamping voltage
I_{PP}: Peak pulse current

Figure 2. I-V characteristics of TVS diode

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Differences in specifications on data sheets

Table 1 shows differences in the specifications on data sheets between the TVS and Zener diodes. As explained in the previous section, since the Zener diodes are used mainly for constant voltage applications, only Zener voltage V_Z in the small current region is specified.

In contrast, the TVS diodes control a wide range of voltage with three parameters: breakdown voltage V_{BR} and standoff voltage V_{RWM} in the small current region, and clamping voltage V_{CL} in the large current region.

Peak pulse power P_{PP}, which represents the maximum surge power that can be withstood in a specific surge waveform, and peak pulse current I_{PP}, which represents the maximum surge current, are specified for the TVS diodes only.

The ESD rating is specified only for TVS diodes used as a countermeasure against ESD.

The capacitance between terminals must be selected so that data waveforms are not blunted due to the capacitance when the diodes are used in communication lines. Therefore, it is specified for the TVS diodes only.

As described above, since the Zener diodes are mainly used in constant voltage applications, they have fewer parameters such as the Zener voltage specified on the data sheets. Since the TVS diodes are intended to protect other devices from surges, their voltage specifications are widely controlled and important parameters are specified, including the ESD rating and the capacitance between terminals.

Table 1. Differences in specifications on data sheets between TVS and Zener diodes

Parameter	TVS	Zener Diode
Zener voltage V_Z Breakdown voltage V_{BR}	V_{BR}	V_Z
Reverse current I_R	Listed	Listed
Standoff voltage V_{RWM}	Listed	−
Clamping voltage V_{CL}	Listed	−
Peak pulse power P_{PP}	Listed	−
Peak pulse current I_{PP}	Listed	−
ESD rating	Listed	−
Capacitance between terminals	Listed	−

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