ESD/surge suppression in a smarter and more compact form.

Advantages of replacement to a chip varistor and selection points

There are various advantages in replacing a TVS diode (Zener diode) with a chip varistor.

CONTENTS

・Advantages of replacement to a chip varistor
・What is a chip varistor?
・Advantages of replacing to a TDK chip varistor
  1 Space advantages, Cost advantages
  2 Noise suppression + ESD suppression
  3 LC filter + ESD suppression

・Selection points for TDK chip varistors
・TDK chip varistor features and product types
・Selection guide & product sample purchase guide
・Contact

TDK Corporation
Piezo & Protection Devices BG
Advantages of replacement to a chip varistor

Mounting area has been reduced to 1/2 or less

There are various advantages in replacing a TVS diode with a chip varistor.

Electronic components used for ESD/surge protection include MLCC (Multilayer Ceramic Chip Capacitors), ESD suppressors, TVS diodes (Zener diodes), and chip varistors.

In recent times, it has become a trend to replace TVS diodes with chip varistors in areas where TVS diodes have been widely used up to now.

TDK's chip varistors have the strengths of excellent ESD/surge suppression capacity, and in addition, they are available in a wide range of products supporting a wide range of signal speeds. There are various advantages in replacing a TVS diode, mainly in terms of space saving, but also in terms of cost reduction and noise suppression.
It is an ESD/surge protection device which uses the resistance characteristics of ceramic semiconductors.

It is inserted between the circuit and ground, and bypasses static electricity and surges to the ground

A chip varistor is a chip component with a structures consisting of alternate layers of internal electrodes and varistor material (ceramic zinc oxide based semiconductor). Varistor material has non-linear resistance characteristics, and functions initially with high resistance as a capacitor, but once it exceeds a specified voltage (varistor voltage), the resistance value drops suddenly and allows current to flow. Using this property, by inserting it between the line and ground, it bypasses the static electricity and surges to the ground and protects the circuit.

- **Varistor voltage**: Voltage when direct current of 1mA flows between the terminals. If the varistor voltage is exceeded, the resistor value drops suddenly and current begins to flow.

- **Clamp voltage (discharge voltage)**: Shows how much surge can be absorbed by the varistor. During the design of the protection circuit, ensure that overvoltage which is greater than the clamping voltage does not enter the device.
The ESD/surge absorption capacity of a chip varistor is almost the same as that of a TVS diode

The graph alongside is a comparison of the measurement waveform during the IEC61000-4-2 compliant electrostatic discharge immunity test, when a TVS diode and chip varistor are used as ESD/surge suppression devices.

When there is no protection device, the peak waveform may be as high as 1500V, but for both TVS diodes and chip varistors, the peak voltage (Vpeak) is suppressed to 40V, and the average voltage (Vave) is suppressed to 10V, which shows excellent ESD absorption characteristics.
Advantages in replacing a TVS diode with a chip varistor

However, a TVS diode has the following features. Hence, in a circuit which requires capacitance components, a chip varistor is more effective than a TVS diode, and it is expected to replace TVS diodes in ICT devices such as smart phones, automotive electrical equipment, industrial equipment, and medical equipment.

<table>
<thead>
<tr>
<th>TVS diode characteristics</th>
<th>Chip varistor characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Due to its polarity, difficult to make it compact and low profile</td>
<td>● Since there is no polarity, a single element can be used for bidirectional ESD/surge suppression</td>
</tr>
<tr>
<td>A normal TVS diode has polarity, and it only has unidirectional ESD/surge suppression capability. There are products available which support both directions with a single element, but there are limits to how compact and low profile they can be.</td>
<td>● Easy to achieve high capacitance</td>
</tr>
<tr>
<td>● Excellent protection performance due to low capacitance</td>
<td>● Compact and low profile</td>
</tr>
<tr>
<td>Has excellent protection performance due to low capacitance, but due to the structure of the element, it is difficult to increase the capacitance.</td>
<td>● Excellent ESD/surge immunity</td>
</tr>
</tbody>
</table>

![Diagrams showing the replacement of a bidirectional TVS diode with a chip varistor](image)
Advantages of replacing to a TDK chip varistor (1)

There are various advantages in replacing a TVS diode with a chip varistor. They are space saving, reduction in number of components, noise suppression, etc.

1- Extremely effective replacing in case of an audio line.

**Space advantages**

**Mounting area 1/2 or less**

TVS diodes are widely used as ESD/surge protection devices between the circuit and ground in microphones, head phones/ear phones and speakers in the audio line of smart phones and tablets. By replacing it with a chip varistor, the mounting area is reduced to 1/2 or less, which is a considerable saving of space.

**Cost advantages**

**Reduction in the number of components**

In microphone lines, TVS diodes and MLCC are often connected in parallel in order to eliminate noise. Even in this case, by selecting a chip varistor with a suitable capacitance, you can achieve effective ESD/surge suppression with a single element.
Advantages of replacing to a TDK chip varistor (2)

2- Can also be used to replace MLCCs and LC filters used for noise suppression.

- Noise suppression + ESD suppression
Has the same functions as a MLCC, and by using it as a replacement for a MLCC, both noise suppression and ESD suppression are achieved.

A chip varistor functions as a capacitor at a voltage equal to or below the varistor voltage.
An example of the noise level - frequency characteristics when there are no beads or protective components, and when a 100pF chip varistor is used, is shown below. We can see that the noise suppression effect is the same as that of MLCCs, and that the capacitance component of the chip varistor functions as a capacitor.

- LC filter + ESD suppression
By using it to replace a MLCC for a LC filter, effective ESD suppression is achieved along with the functions of the LC filter.

It is also possible to use it to replace an MLCC for an LC filter. The graph below is an example of the insertion loss - frequency characteristics a100pF MLCC is replaced by a chip varistor with the same capacitance value. The same performance as an LC filter is obtained, and effective ESD suppression is also achieved.
TDK's chip varistors are available with a wide range of options, and you can select the best product for your requirements.

Consider striking a good balance between varistor voltage, capacitance and operating frequency.

The selection points for a chip varistor according to its application are described below. Varistor voltage and capacitance are parameters concerned with the basic characteristics of a chip varistor.

- Basic characteristics of a chip varistor

  **Varistor voltage**
  By using a product with a varistor voltage that is as much lower as possible than the voltage of the circuit being protected, it is possible to improve the protection performance against static electricity and surges.

  **Capacitance**
  Generally, the higher the capacitance, the higher is the ESD/surge absorption capacity.

- Covers a wide range of capacitance

  TDK chip varistors have the strengths of covering a wide range of capacitance, and being available in a comprehensive product range.

TDK chip varistors are available with the following capacitance

<table>
<thead>
<tr>
<th>Capacitance [pF]</th>
<th>0.5</th>
<th>1.1</th>
<th>3.3</th>
<th>6.8</th>
<th>15</th>
<th>33</th>
<th>80-100</th>
<th>330-500</th>
<th>650-800</th>
<th>1000-1050</th>
</tr>
</thead>
<tbody>
<tr>
<td>L x W size [mm]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.4 x 0.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.6 x 0.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0 x 0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.6 x 0.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0 x 1.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
- **Selection points according to the frequency**

An example of chip varistor insertion loss-frequency characteristics is shown below. It can be seen that as the frequency increases, there is a proportionate increase in insertion loss, and as the capacitance in a product decreases, it can be used in a higher frequency region.

In a high frequency region, the capacitance of a chip varistor becomes a factor in dampening the signal waveform. Hence, **an important point is to select a product with capacitance that is suitable for its application and frequency.**
It is an advantage and strength of TDK’s chip varistors that they have been developed from raw materials.

Antimony free, unique praseodymium oxide based zinc material adopted

In order to achieve miniaturization and implement the stringent characteristics required from a chip varistor, TDK carries out in-house development of varistor material from raw materials.

There are various varistor materials, and TDK uses materials made of zinc oxide doped with praseodymium. A chip varistor is made by laminating a raw material sheet on which internal electrodes are printed, shredding it into chips, and then sintering it. The sintering process requires the use of extremely sophisticated techniques such as temperature control and atmosphere control.
It is an advantage and strength of TDK’s chip varistors that they have been developed from raw materials.

A compact chip is produced by miniaturization and homogenization using microstructure control technologies

When the electrode area in a chip varistor is reduced to make it compact, capacity comes down, as a result of which ESD/surge immunity becomes low. To resolve this problem, TDK has introduced sophisticated microstructure control technologies and achieved miniaturization and homogenization of the crystal grains in a varistor sintered compact. It is not an exaggeration to say that it is the use of these technologies that has made it possible to use them as a replacement for TVS diodes.

They are also used for automotive applications where standards are extremely stringent, and highly valued by the automobile industry.

- Track record of supply in large numbers to major automobile manufacturers/component manufacturers
TDK’s automotive grade chip varistors are widely used for automotive applications where standards are extremely stringent, and they are highly valued by the automobile industry.

- Also published in the “Reference sheets” for the automobile industry
The body type ECU which performs the vital functions of “Run, turn, and stop”, requires especially reliable ESD/surge suppression. TDK’s automotive grade chip varistors whose strengths are compactness, high performance, and high reliability, are also published in the “Reference sheets” for the automobile industry.
TDK chip varistors are linked to the global electronic component database “netCOMPONENTS”, and you can instantly order the products of your choice online. You can also download information that you require such as RoHS, SVHC/REACH and other certificates, S parameters, etc.

**Search from the product map**

**ESD Protection devices Product map**


MLCCs can be used for relatively low speed signal lines of 1Mbps or below. TDK has provided the MLCC CGA3EA series which is specially designed for ESD/surge suppression at 1Mbps or below. In signal lines with higher speeds, chip varistors, TVS diodes, and ESD suppressors can be used.

A strength of TDK’s chip varistors is that they cover a wide range from approx. 10kbps to 1Gbps. We offer a comprehensive range of products from which you can select the most suitable product for a variety of applications.

---

**Chip varistor AVRM series**

A distinctive characteristic is excellent ESD/surge absorption capacity due to high capacitance. It covers a wide range from approx. 10kbps to 100Mbps.

**Chip varistor AVRL series**

Since the capacitance component of the varistor dampens the signal waveform in high speed signal lines, it must be kept as low as possible. The AVRL series is a low capacitance type which is suitable for high speed signal lines. Between approx. 50Mbps and 1Gbps, it has higher ESD/surge absorption capacity than ESD suppressors.

**Chip protector SGNE series**

It is an advanced product which combines low capacitance with high ESD/surge absorption performance. Its strength is that its ESD/surge absorption capacity is higher than ESD suppressors as well as the AVRL series. It can be used to replace TVS diodes, resulting in various advantages such as space saving and cost reduction.
Search based on size, application, and circuit

ESD Protection Device Selection Guide


TDK’s chip varistors are highly valued not only among ICT devices such as smart phones and tablets, but also in the automobile field which has extremely stringent standards.

You can also search for the chip varistor of your choice based on its size, application, and circuit.

Search using the characteristic value

Search by Characteristics

• Chip Varistors / Ceramic Transient Voltage Suppressors

• Multilayer Chip Protectors
  https://product.tdk.com/en/search/protection/voltage/chip_protector/list#pn=*&_l=20&_p=1&_c=part_no-part_no&_d=0

You can search for the chip varistor of your choice using the characteristic values such as:

• Product shape
• Size (L×W)
• Max. Operating Voltage (DC/AC)
• Capacitance
• Maximum surge current
• Operating Temperature Range

In addition to the above characteristic values, you can also perform an “Advanced search” by filtering on:

• Product status
• Application
• Feature
Sample Kit Purchase Guide

TDK has tied up with Digi-key, which is the world's largest online retailer of electronic components, to offer various sample kits.

There are 4 types of sample kits available for TDK's chip varistors.

Please select according to the size and application.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Product outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>445-174552-KIT</td>
<td>AVR VARISTOR 0201 KIT</td>
</tr>
<tr>
<td>445-174553-KIT</td>
<td>AVR VARISTOR 0402 KIT</td>
</tr>
<tr>
<td>445-174554-KIT</td>
<td>AVR VARISTOR COMM/AUTO 0603/0805</td>
</tr>
<tr>
<td>445-174555-KIT</td>
<td>AVR VARISTOR AUTO GRADE KIT</td>
</tr>
</tbody>
</table>
In case of any requests or questions, please do not hesitate to contact us.

inqmlv@jp.tdk.com

For detailed information on varistors

- Comparison of Chip Capacitors and Chip Varistors in Electrostatic Countermeasures

- Chip Varistors that Absorb Static Electricity

- Ring Varistors as Motor Noise Solutions