Metal Oxide Varistor: Introduction

Introduction
Varistors, variable resistors, are voltage-dependent resistors with bidirectional and symmetrical V/I characteristics. Metal Oxide Varistors, MOV, are primarily made of Zinc Oxide and some suitable additives.

When varistors are exposed to over voltage transient or surge, the varistors switch from standby state (nearly open circuits) to clamping state (highly conductive state).

The major function is to protect equipments from being damaged by over voltage transient. The varistors electrical characteristics, V-I curve, are normally expressed in the Fig.2.

At leakage region, the V-I curve shows a linear relationship. The varistor is in high resistance mode and shows as an open circuit.

In normal operation, the V-I curve of a varistor can be described by power law:
\[ I = KV^{\alpha} \]
Where K is a constant and \( \alpha \) defines the degree of nonlinearity.

At high current, the varistor is in low resistance mode and shows as a short circuit.

Advantage Compared with Other Transient Suppressors:

1. Better Thermal Properties
   Unlike a silicon suppressor which has only one P-N junction available to handle the current, varistor has millions of P-N junction as an integral part of the device which gives better energy dissipation capability and peak current handling capability.

2. Speed of Response
   The action of varistor is similar to other semiconductor devices. The conduction happens very fast which has no significant time delay even in the nanosecond range. Varistors are fast enough to response to any practical requirements.

3. Stable Clamping Voltage over Temperature
   Beyond the breakdown point, the clamping voltage of varistor is almost constant over wide range of operating temperature while the clamping voltage of zener diode is higher at upper operation temperature. The clamping voltage of varistor is temperature independent while leakage current increasing as temperature increase for both devices.

4. Capacitance
   Compared to zener diodes, varistors have a higher capacitance. Depending on the application, transient suppressor capacitance can be a desirable or undesirable feature. In DC circuits, the capacitance of varistors provides both decoupling and transient voltage clamping functions.

5. Less Expensive
   Varistors are both cost and size effective compared with diode.
Metal Oxide Varistor:
Glossary

- **Varistor Voltage**
  The voltage across the varistor measured with the specified DC current 1mA.

- **Max. Operating Voltage**
  The max. operating voltage (AC/DC) that can be applied continuously across the varistor.

- **Max. Clamping Voltage**
  The max. voltage across the varistor with the specified standard impulse current (8/20µs) applied as shown below.

- **Max. Energy**
  The max. energy within the varistor voltage change of ±10% when a single impulse current of 10/1000µs is applied.

- **Max. Surge Current (8/20µs)**
  The max. current within the varistor voltage change of ±10% with a single standard impulse current of 8/20µs is applied or two times with an interval of 5 minutes.

- **Rated Power**
  The power can be applied in the specified ambient temperature.

- **Reference Capacitance**
  The capacitance of the varistor at a specified frequency (1KHz or 1MHz) and bias (1Vp-p).
Metal Oxide Varistor: Application Note

- **Equipment Protection against Line Transient Damage**

  The varistors have many advantages which make it ideal for use as a suppressor on AC or DC power line.

  ![Figure 3](image)
  **Fig.3**
  Absorption of line-line surge in single-phase system

  ![Figure 4](image)
  **Fig.4**
  Absorption of line-line and line-ground surge in single-phase system

  ![Figure 5](image)
  **Fig.5**
  Absorption of line-line surge in three-phase system

  ![Figure 6](image)
  **Fig.6**
  Absorption of line-line and line-ground surge in three-phase system

- **Protection of Components Switching Inductive Load**

  The transistor in Fig.7 is to operate a solenoid, inductive load. The energy stored in inductor is dissipated in the reverse bias conduction of the transistor and might cause transistor breakdown. A varistor can be connected, collector-to-base, to dissipate the stored energy in the forward bias state without damaging the transistor.

  ![Figure 7](image)
  **Fig.7**
  Solenoid circuit with varistor protection.
Metal Oxide Varistor: Application Note

- **Transient Protection of Solid State Circuit**
  Modern electronic equipments and appliances contain solid state circuits that are susceptible to malfunction or damage caused by transient voltage spikes.

![Semiconductor protection](image)

- **Extend the Life of Relay Contacts**
  When the current in inductive load is interrupted by mechanical contacts, the voltage across the contacts builds up and cause arcing which is destructive to the contacts. Varistors can be applied to prevent initiation of the arc.

![Contact protection](image)

- **IC Protection against Electro-static Discharge (ESD)**

![IC protection](image)

- **Noise Suppression**

![Protection of signal equipment](image)