Overvoltage Protection Components

Introduction to Overvoltage and Its Effects

- **Overvoltage Issues**: Overvoltage can occur due to various events such as lightning strikes, inductive switching in electrical grids, or electrostatic discharge (ESD). While rare, these events can instantly destroy electronics.
- **Purpose of Protection**: Protective components are essential to prevent damage caused by overvoltage. These components absorb or dissipate excess energy, protecting the connected circuits.
- **Overvoltage Events**: Lightning strikes, power surges, and static electricity are some causes of overvoltage.

Creating an Overvoltage Pulse for Testing

- **Testing Overvoltage Protection**: An insulation tester is used to create a DC voltage between 125V to 1000V. This tool checks insulation between conductors and has a current output limited to 3.6mA, making it safe but too weak for overvoltage testing.
- **ESD Generator**: To simulate a more destructive overvoltage, an ESD generator is used, producing a high-voltage pulse (around 15,000V over a 5mm gap). This can cause destruction in microcontroller circuits.

Test Circuit

- **Test Setup**: A simple blink circuit is used as the test subject. After applying the overvoltage pulses to the circuit, destructive effects were observed without protection.

Protection Components

1. TVS Diode (Transient Voltage Suppressor)

- **Function**: TVS diodes protect circuits by clamping high voltage surges to a safe level. A typical TVS diode array includes multiple diodes packed into one IC package.
- **Working Principle**: In reverse, the diodes do not conduct. Once the voltage exceeds the reverse stand-off voltage (e.g., 6V), the diode conducts, clamping the voltage to a safe level (10-12V).

- **Power Handling**: TVS diodes can handle quick pulses of up to 100W, absorbing excess energy by converting it into heat. After the pulse is over, the diode returns to its non-conductive state.
- **Results**: After adding the TVS diode, the microcontroller circuit remained functional even after repeated overvoltage pulses.

2. MOV (Metal Oxide Varistor)

- **Function**: MOVs are another form of surge protection that works by having a variable resistance. Below a certain voltage, they act as insulators, and once the voltage increases, their resistance drops rapidly, allowing current to flow and clamping the voltage.
- **Behavior**: Similar to TVS diodes, MOVs dissipate excess energy as heat.
- **Example**: An MOV with a continuous voltage of 38V, clamping at 93V, was tested on the microcontroller circuit. The circuit survived multiple high-voltage pulses with the MOV in place.
- **Use Case**: MOVs are commonly used in power supplies and often paired with a thermal fuse to protect the circuit from extreme overvoltage.

3. GDT (Gas Discharge Tube)

- **Function**: GDTs are filled with inert gas that ionizes when voltage exceeds a threshold, creating a conductive path for the excess energy to be dissipated as heat.
- **Limitation**: GDTs are designed for higher voltages and did not protect the 5V microcontroller circuit effectively in the tests. They are more suited for industrial applications.

Comparison of Protection Components

- **Speed**: TVS diodes react the fastest to overvoltage surges.
- **Energy Handling**: MOVs handle larger energy bursts and are more suited for continuous surges.
- **Response**: GDTs have a slower response compared to TVS diodes but can handle high-voltage surges better.
- **Overall Effectiveness**: TVS diodes are effective for low-energy surges, while MOVs and GDTs are used for larger and more sustained surges.

Differences Between Cheap and Expensive Surge Protection

- **Cheap Surge Protectors**: Typically use multiple small MOVs and a simple LED to indicate function. These may provide basic protection but may not be as reliable.
- **Expensive Surge Protectors**: Feature a single, larger MOV combined with a spring lever system. This system disconnects the circuit when the current exceeds safe levels, offering more robust protection.
- **Conclusion**: While the cheap surge protectors are functional, the more expensive versions provide higher safety and are better suited for critical applications, especially in industrial settings.

Conclusion

- **Why Overvoltage Protection Matters**: Overvoltage events can lead to catastrophic damage to electronic circuits. Using protective components like TVS diodes, MOVs, and GDTs can prevent such damage.
- **Choosing the Right Protection**: The choice of protection depends on the type of overvoltage, the energy involved, and the speed of the surge. TVS diodes are ideal for fast surges, MOVs for larger energy surges, and GDTs for industrial-scale protection.
- **Practical Considerations**: When selecting surge protection, it's essential to understand the specific requirements of your circuit and choose components accordingly to ensure reliable and long-lasting protection.