Overvoltage Protection

Introduction:

Overvoltage protection is essential in electronic circuits to shield sensitive components from unexpected voltage spikes or surges. These surges can result from various factors such as lightning, power supply fluctuations, or other transient events. NPN and PNP transistor-based overvoltage protection circuits are common methods for limiting the voltage that reaches sensitive components. This report details the working principles of both NPN and PNP overvoltage protection circuits, focusing on their design and operational differences.

NPN Overvoltage Protection Circuit (Without Zener Diode)

Circuit Description:

An NPN transistor-based overvoltage protection circuit can be designed without using a zener diode. Instead, the circuit relies on the inherent properties of the NPN transistor and a voltage divider network to detect overvoltage conditions and protect the load.

Working Principle

1. Normal Operation:

During normal operation, the input voltage is below the overvoltage threshold. The base of the NPN transistor is held at a potential that is too low to turn the transistor on. As a result,

the transistor remains off, and the full input voltage is delivered to the protected load.

2. Overvoltage Condition:

When the input voltage rises above a predetermined threshold, the voltage divider network (typically consisting of two resistors) raises the base voltage of the NPN transistor.

Once the base voltage exceeds the transistor's base-emitter threshold voltage (usually around 0.7V for silicon transistors), the NPN transistor turns on.

This causes the transistor to conduct heavily from the collector to the emitter, effectively shorting the input voltage to ground through the transistor.

The load is protected because the voltage across it is clamped to a level determined by the transistor's saturation voltage (a small voltage drop).

PNP Overvoltage Protection Circuit

Circuit Description

A PNP transistor-based overvoltage protection circuit operates similarly to the NPN circuit but uses a PNP transistor instead. This type of circuit is particularly useful when dealing with negative voltage spikes or when a different polarity of operation is required.

Working Principle

1. Normal Operation:

Under normal operating conditions, the input voltage is below the threshold level, and the PNP transistor remains off. The protected load receives the full input voltage without interference.

2. Overvoltage Condition:

When the input voltage exceeds a certain threshold, the voltage difference between the base and emitter of the PNP transistor increases.

This causes the PNP transistor to turn on, allowing current to flow from the emitter to the base.

The PNP transistor effectively shunts the excess voltage away from the load by diverting it back to the input supply or ground, depending on the circuit design.

Like the NPN circuit, a series resistor can limit the current flowing through the PNP transistor, protecting it from damage.

Simulation Video: https://drive.google.com/file/d/1Zfq-2RuRyQMJk7Yz6HRk-6jZ5hCZ7rs7/view?usp=sharing