

Crowbar Circuit for Overvoltage Protection

Introduction:

A Crowbar Circuit is a simple electrical circuit that prevents damage to the circuits (load of the power supply) in the event of an overvoltage of the power supply. It protects the load by shorting the output terminals of the power supply when an overvoltage is detected.

When the output terminals of the power supply are shorted, the huge current flow will blow the fuse and thus disconnecting the power supply from the rest of the circuit. Hence, in simple terms, the job of the Crowbar Circuit is to detect the overvoltage and blow the fuse.

Working of Crowbar Circuit

A Crowbar circuit monitors the input voltage and when it exceeds the limit it creates a short circuit across the power lines and blows up the fuse. Once the fuse is blown the power supply will be disconnected from the load and thus preventing it from high voltage. The circuit works by creating a direct short circuit across the power lines, as if a crowbar is dropped between power lines of the circuit. Hence it gets its iconic name crowbar circuit.

The voltage over which the circuit should create a short depends on the Zener voltage. The circuit consists of a SCR which is directly connected across the Input voltage and ground of the circuit, but this SCR is by default kept in turned off state by grounding the gate pin of the SCR. When the Input voltage exceeds the Zener voltage the Zener diode begins to conduct and hence a voltage is supplied to the Gate pin of the SCR making it to close the connection between the Input Voltage and Ground thus creating a short circuit. This short circuit will draw a maximum current from the power supply and blow up the fuse isolating the power supply from the load.

Zener Diode here is rated for 7.5V but the input voltage has exceeded the value and is currently at 9.75V. So, the Zener Diode opens and begins to conduct by providing a voltage to the Gate pin of the SCR. The SCR then begins to conduct by shorting the Input voltage and Ground and thus blows up the fuse due to maximum current draw.

Methodology:

Materials:

1) Fuse (1 A)

- Purpose: Protects the circuit by disconnecting the power supply during an overvoltage condition.
- Function: The fuse blows when excessive current flows through the circuit due to the SCR shorting the power lines. This isolates the power supply from the load, preventing damage.
- Selection Criteria: The fuse rating should be higher than the load's normal operating current but lower than the maximum current rating of the SCR.

2. Zener Diode (7.5V)

- Purpose: Sets the overvoltage threshold for the circuit.
- Function: Conducts when the input voltage exceeds its breakdown voltage, providing a trigger voltage to the gate of the SCR.
- Selection Criteria: The Zener voltage determines the circuit's overvoltage response point. A 7.5V Zener diode ensures protection for voltages above 7.5V.

3. Thyristor (SCR, C106D)

- Purpose: Acts as a switch to create a short circuit during overvoltage conditions.
- Function: When triggered by the Zener diode, the SCR conducts, shorting the input voltage to the ground. This causes the fuse to blow and disconnects the load.
- Selection Criteria: The maximum rating of SCR is 4A, which is specified on datasheet.

4. Resistor (1k Ω)

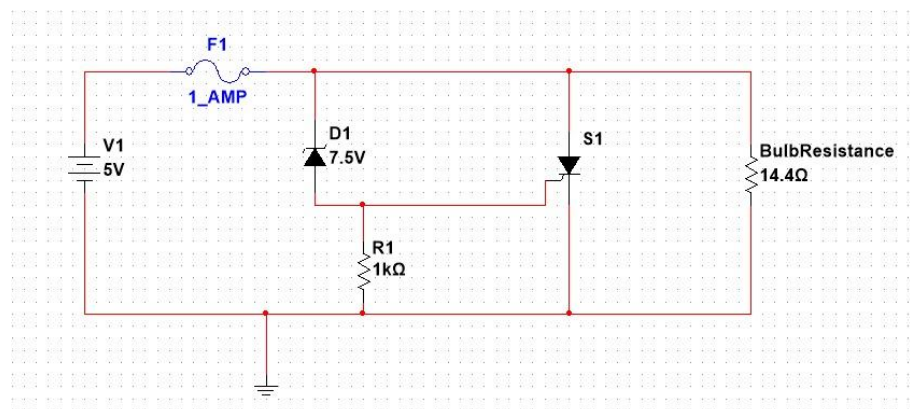
- Purpose: Pulls down the SCR gate to ground when the Zener diode is not conducting.
- Function: Ensures the SCR remains off under normal operating conditions.
- Selection Criteria: The resistance value should be high enough to avoid unnecessary current draw but low enough to maintain effective gate control.

5. Bulb Resistance:

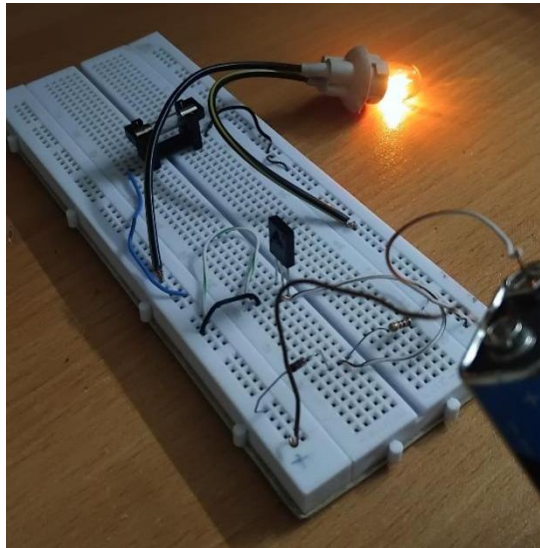
- Purpose: It used as load resistance.

Circuit Diagram:

1. Multisim Simulation:



2. Circuit Picture:



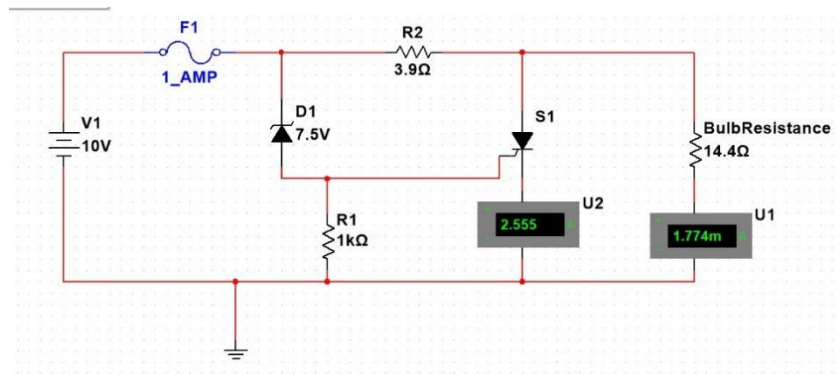
Observations Table:

Input Voltage(V)	Fuse Condition
4V	Intact
5V	Intact
7.2	Fuse blown

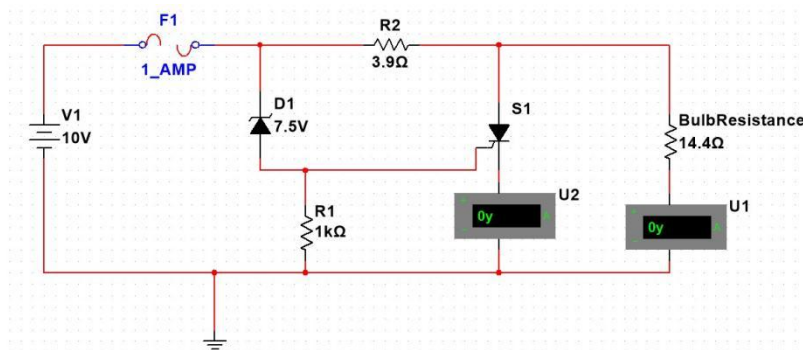
Calculations:

Results:

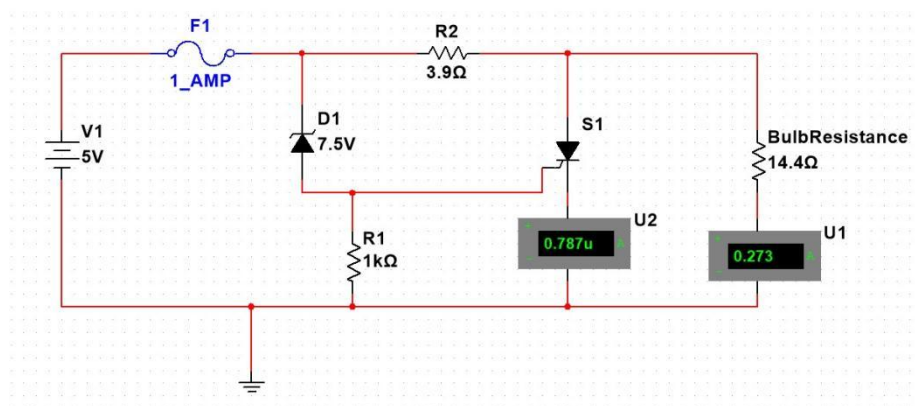
1. Overvoltage condition (fuse soon to blow)



2. Over voltage condition (fuse blown)



3. normal condition (scr off)



Conclusion:

- **Circuit Functionality:**

The crowbar circuit successfully demonstrates its ability to protect the load from overvoltage conditions by triggering the SCR when the voltage across the zener diode exceeds the breakdown voltage. Once triggered, the SCR effectively creates a short circuit across the load, ensuring that the load is disconnected from the supply, preventing potential damage.

- **Performance:**

In the circuit, the SCR is rated for 4 A, which is adequate to handle the high current (e.g., 2.5 A) during short-circuit conditions. The presence of a 1 A fuse ensures that the circuit remains protected, as the fuse will blow to isolate the short circuit within milliseconds, thus safeguarding the load and other components.

- **Practical Applications:**

This circuit is ideal for protecting sensitive equipment such as microcontrollers, voltage regulators, and other low-voltage devices that could be damaged by voltage surges or regulator faults.

The use of a zener diode and SCR in this design aligns with the recommendations from the research paper, which highlights their efficiency and fast response in overvoltage protection scenarios.

- **Efficiency of Overvoltage Protection:**

The circuit design is consistent with the principles discussed in the research paper, which emphasizes that the crowbar approach provides a quick and effective method for handling overvoltage transients. By instantly shorting the circuit and causing the fuse to blow, the load is fully protected from any harmful overvoltage.

- **Limitations and Improvements:**

The circuit requires precise selection of components like the zener diode (voltage rating), SCR (current rating), and fuse (blow time and current rating) to ensure proper operation.

Adding features such as an indicator LED (to signal when the fuse has blown) or a resettable fuse (polyfuse) could improve usability and reduce maintenance.

Final Remark:

This crowbar circuit is a robust and practical solution for protecting low-voltage loads from overvoltage conditions, as verified through simulation and supported by the principles outlined in the research paper. It demonstrates the essential attributes of fast response, simplicity, and reliability, making it a viable choice for applications requiring effective overvoltage protection.