Bangladesh University of Engineering and Technology

Department of Electrical and Electronic Engineering

Project Report

Project Title: Electronic Fuse

Course No.: EEE 208 (Simulation)

Course Title: Electronic Circuits II Laboratory

Level: 2 **Term:** 2

Section: C1

Performed by:

Md. Asif Kabir 1906153
Tamim Hasan Bhuiyan 1906154

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Introduction:

Electronic Fuse is an electrical safety device that operates to provide overcurrent protection to any circuit. The operating range of the fuse may vary according to the load used. Whenever the current exceeds the maximum allowed range, the fuse will set the high current to an alternative path instead of the load hence protecting the load from any kind of damage. As our power supply to household electric instruments does not remain consistent over time, an unexpected current or voltage may appear at any moment into the load. The electronic fuse will monitor the voltage according to the rating of the instrument and will safeguard our costly and essential electrical drives.

Circuit Setup:

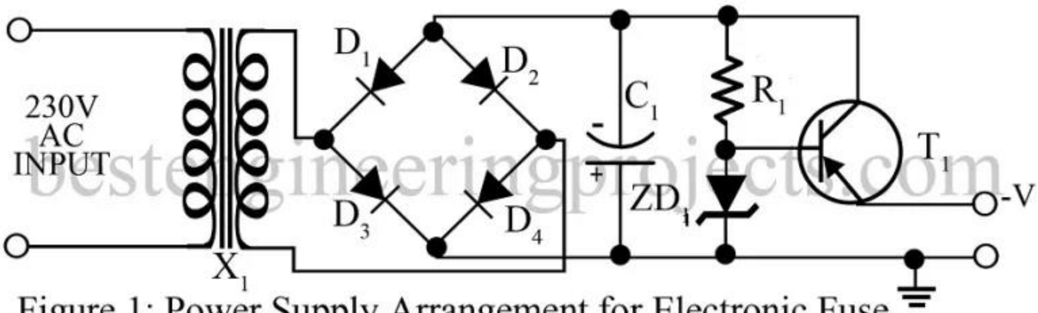


Figure 1: Power Supply Arrangement for Electronic Fuse

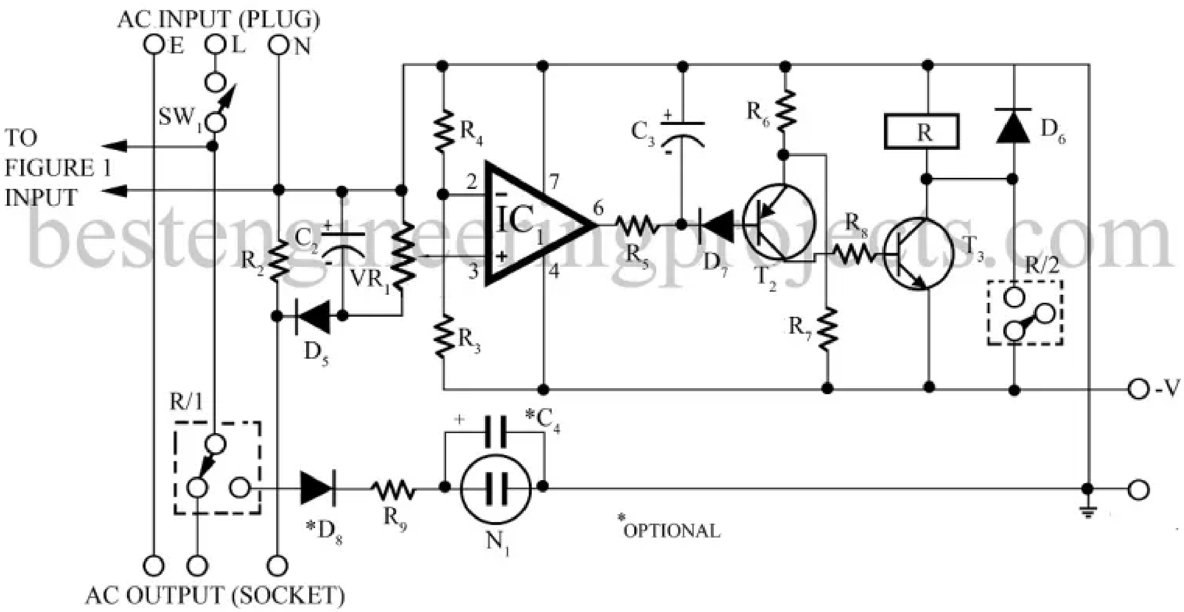


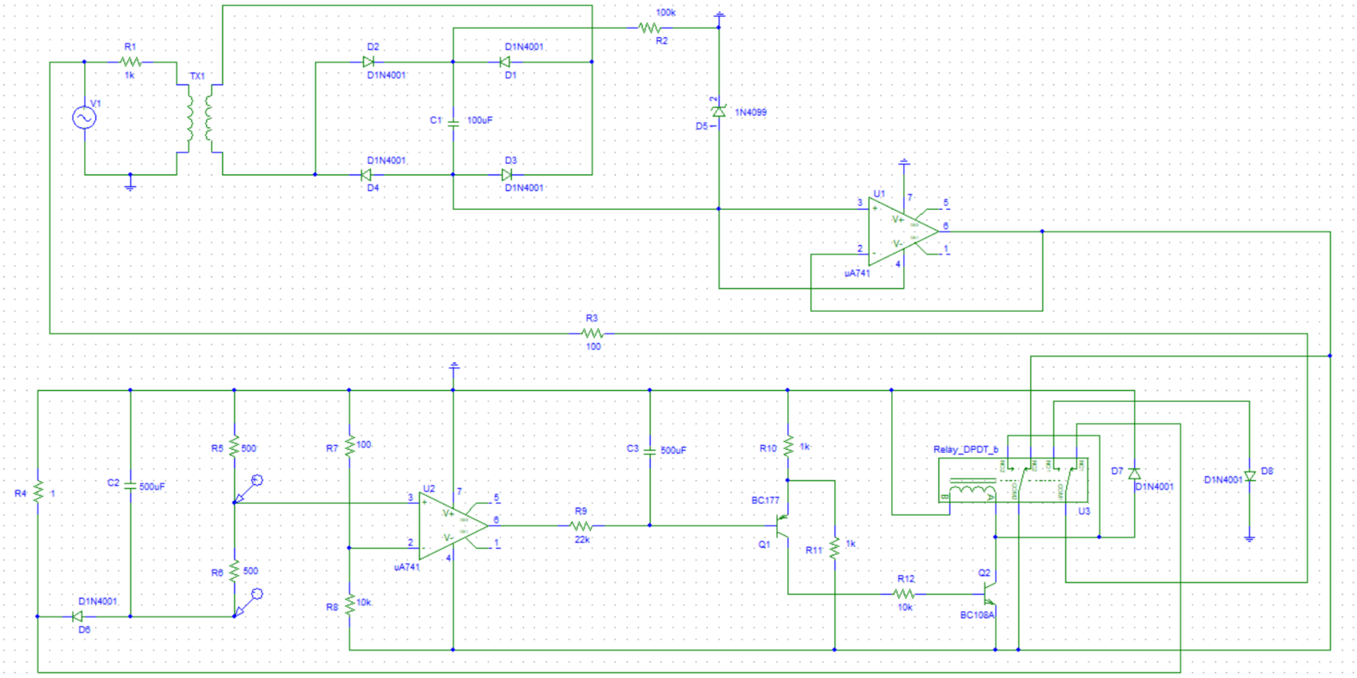
Figure 2: Circuit Diagram of Electronic Fuse Using Op-Amp 741 IC

Courtesy: https://bestengineeringprojects.com/electronic-fuse-using-op-amp-741/

Working Principle:

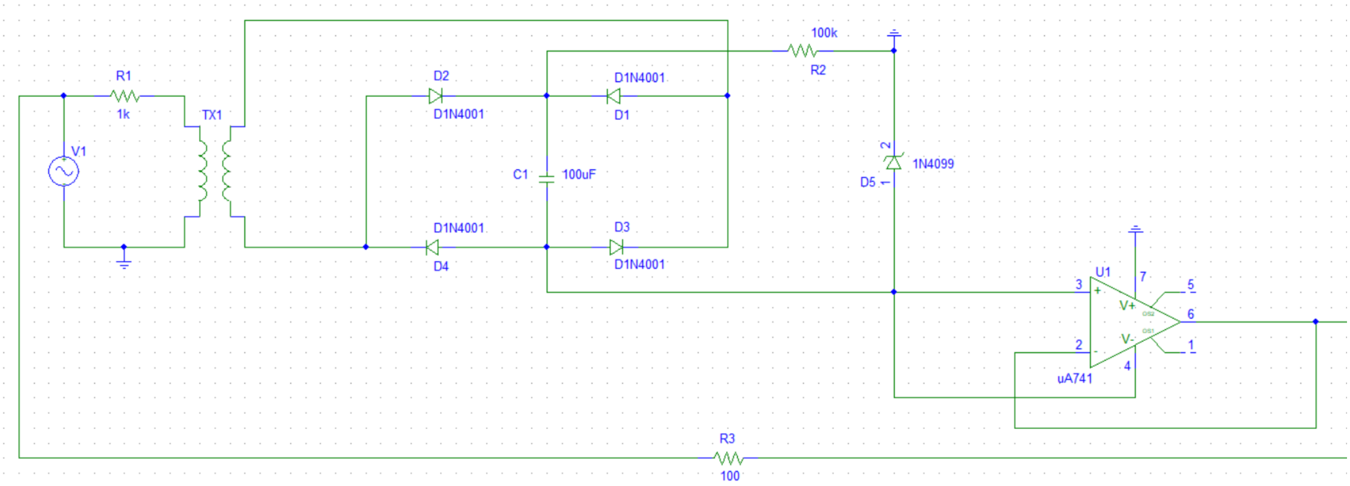
The main power supply will be stepped down using a transformer and rectified. The rectified voltage will appear at the inverting terminal of an Op-Amp via a potential divider. This inverting terminal voltage will be referenced as the safety level of the load voltage. A potentiometer is used to act as the load. The variation of the potentiometer is referred to as a change of load. The main power supply is fed into the potentiometer and the voltage across the load appears in the non-inverting terminal of the Op-Amp. The Op-Amp will act as a comparator. If the voltage at the non-inverting terminal is lower than the inverting terminal, the output of the Op-Amp will be low. It means the load is safe to function and current will flow into the load. However, if the voltage at the non-inverting terminal is higher than the inverting terminal, the output of the Op-Amp will be high. A relay will then be energized and switch an alternative path in the circuit for the current to flow instead of the load. This alternate path will have an LED lamp. Whenever the LED is illuminated, we will understand that a high voltage exists in the circuit and the fuse is safeguarding the load bypassing the current into the LED. Our load may intake some inrush current or remain in transient state at the starting. So, will insert a time-delay circuit into the main circuit in order for the comparator to act after a while since the circuit is switched on.

Schematic Diagram:

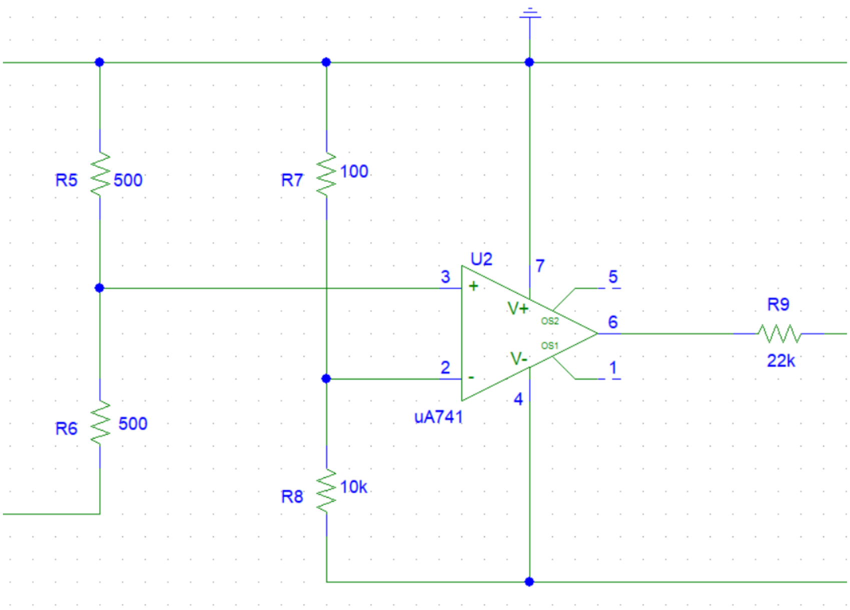


Explanation:

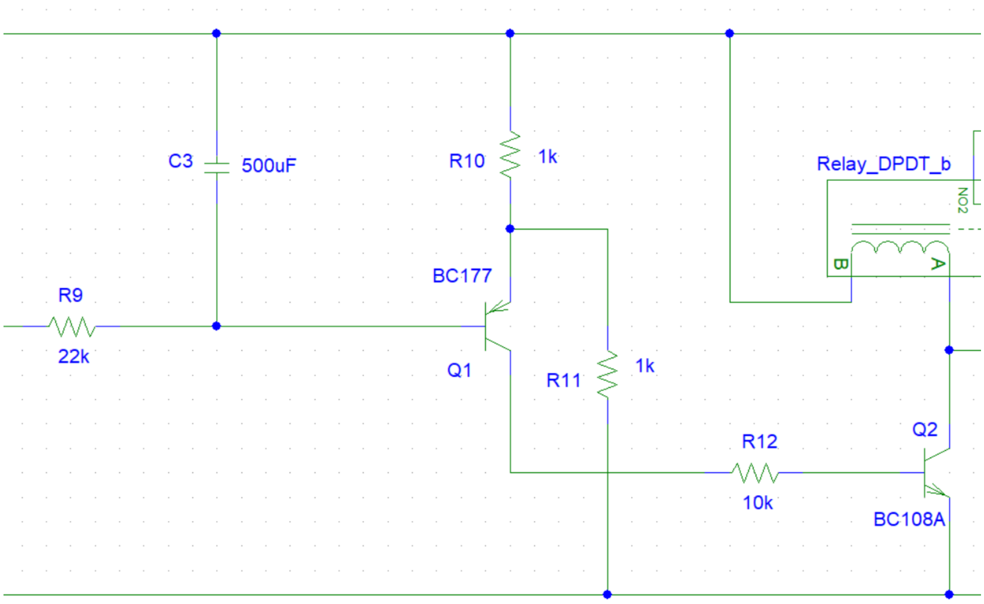
Let's discuss the circuit part-by-part.



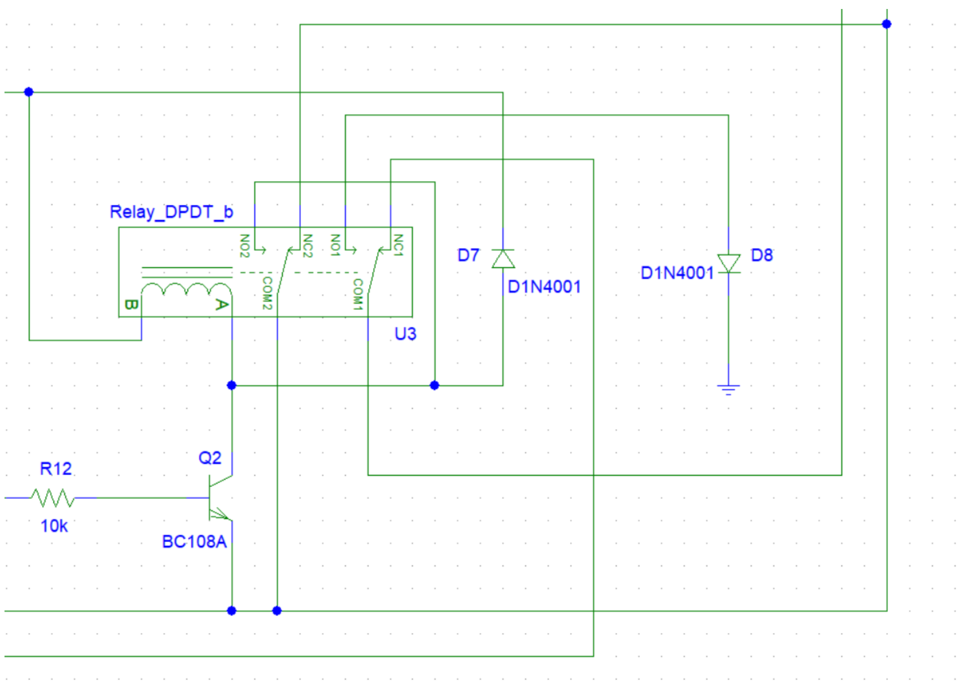
Here, V1 is our main power supply which is sinusoidal in nature with amplitude 240 V and 50 Hz frequency. TX1 is a step-down transformer with turns ratio 16:1. That means, the output of the transformer will be a sinusoidal wave with amplitude 15 V and frequency 50 Hz. The diodes D1 to D4 form a bridge rectifier that rectifies the output of the transformer and the capacitor C1 and the zener diode D5 smooths the pulsating DC. U1 is an Op-Amp that is used as a voltage follower in order to minimize the loading effect. Another branch is created by taking out the voltage from the supply through a resistance R3 which resembles line loss. This voltage will be supplied to the load.



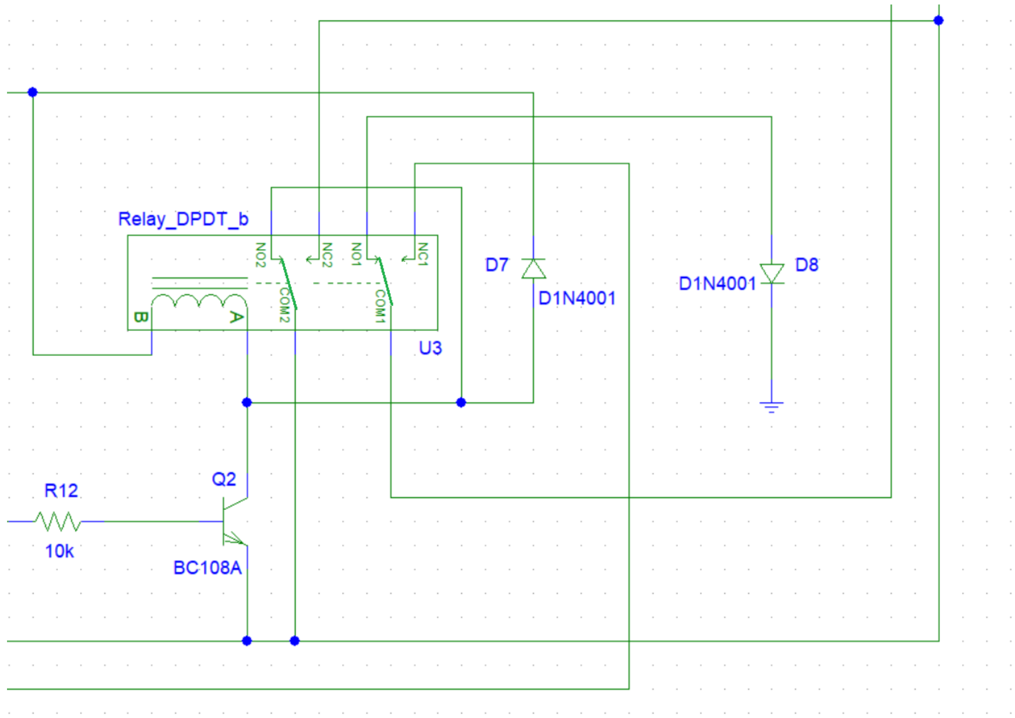
Here, R5 and R6 actually build up a potentiometer. The variation of load might be applied through a change in the potentiometer and the voltage of the load appears into the non-inverting terminal of the Op-Amp U2. The output of the voltage follower appears at the inverting terminal of the Op-Amp U2 through a voltage divider. The voltage at the pin 2 is actually our reference voltage which will vary according to the safety range of the load. The Op-Amp U2 functions in the circuit as a comparator. Whenever the voltage at the non-inverting terminal is lower than the voltage at the inverting terminal, the output of the comparator is Low. This output actually means that the voltage across the load has not yet exceeded the safety limit. So, the circuit will function as it is and the load will perform safely. However, when the voltage at the non-inverting terminal is higher than the voltage at the inverting terminal, the output of the comparator is High. This output actually means that the voltage across the load has exceeded the safety limit.



When the output of the comparator is Low, there is not much concern. But the output may be High for two reasons. Firstly, the load may intake a high voltage at the starting which is safe for the load. So, we need to pause the fuse from operating at the beginning, which means we need to delay the operation time of the comparator. BJT holds the property of propagation delay. We used the two BJTs Q1 and Q2 in order to achieve this property of BJT. So, Q1 and Q2 in together will delay the fuse operation at the starting. But after that starting delay, the load will require a suitable voltage for safe operating.

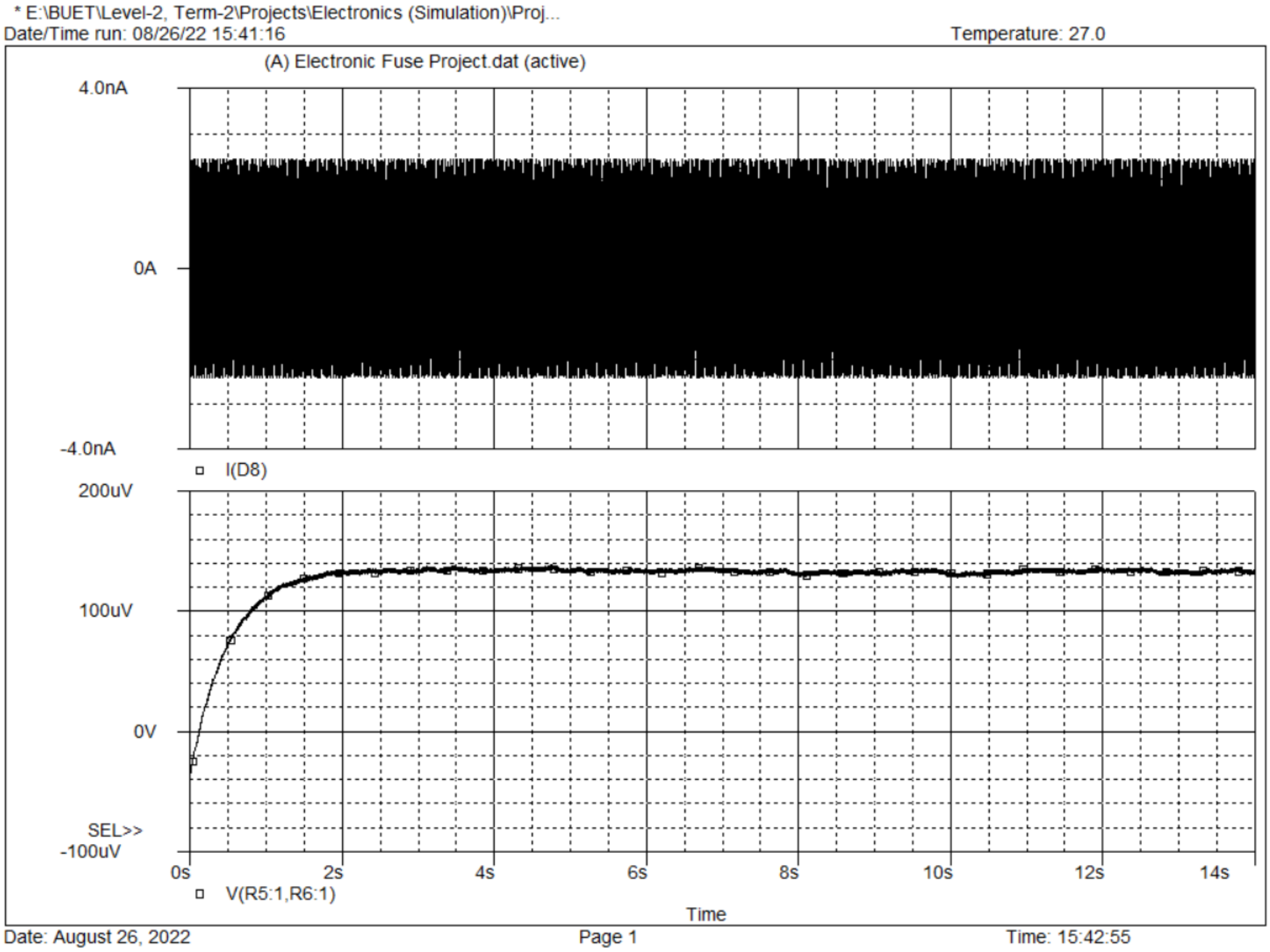


This is the original state of the relay circuit. We are using a diode D8 instead of an LED. The other end NO1 of the diode is open, that means the LED will not glow. The voltage coming from the main source passing through the line resistance R3 will pass here in the relay from COM1 to NC1 and then travel to the load. Thus the load is operating.

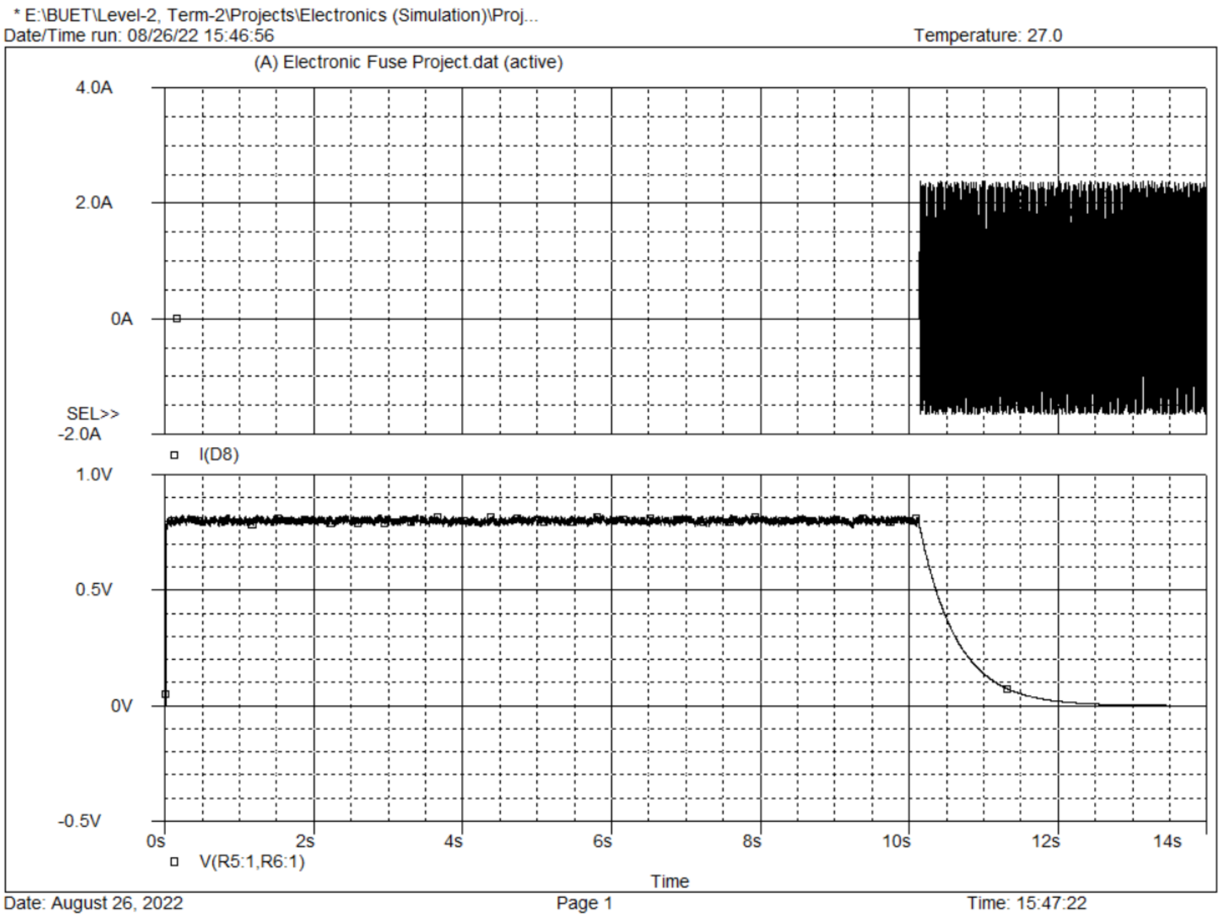


But whenever the comparator gives a high output after the starting time delay, the relay switch will change the position accordingly. Now the relay nob COM1 is connected to NO1, that means the high voltage from the main supply after passing through the line resistance will now pass through the LED D8. As the nob NC1 is open now, the load is disconnected from the main supply and hence protected from the danger of high voltage.

Sample Output:



This is the output of a sample case. Here, the upper plot shows the current passing through the LED which is in nA range, that means almost zero. So, the voltage is safe for the load and the voltage is appearing in the load as we can see from the lower plot from the starting.



This is another sample case. Here, the upper plot shows the current passing through the LED which is 0A upto 10s. But after 10s, we can see a huge current (around 2.5 A) passing through the LED. That means the LED is glowing. The high voltage is passing through the LED instead of the load. We can also see this from the lower plot where the voltage across the load becomes 0V after 10s, hence protecting the load from any harms of the high voltage. Thus our electronic fuse operates.

Future Developments:

We can change the circuit parameters to vary the output of the fuse. The required time delay at the starting varies according to the device we have in our hand. We can change the resistors attached with the two BJTs to manipulate the time delay.

Our project is built for a specific device. If we change the device, the variation can be visualized by changing the potentiometer that actually changes the load of the circuit. However, a change of device means a change in the safety range of voltage across the load. We can change the reference safety of the fuse by changing the turns ratio of the step down transformer and the voltage dividing resistor that puts the reference safety voltage at the inverting terminal of the comparator.

Discussion:

We intend to make an electronic fuse that will provide safety to our electrical devices. The fuse will separate the device from the main electric line at any risky situation. However, we saw that our project fuse cannot instantly cut-off the voltage across the load. Rather, it takes a little time (about 500 ms) to make the voltage zero. The capacitors and other instruments used to build the circuit is the reason behind such problems.

We commonly use electrical fuses in our households. This fuse will melt at the sight of high current which eventually opens the whole circuit. We will need an operator to manually fix the fuse again to operate the circuit. This is troublesome work as we have to perform the fixation manually every single time. In contrast, our project, the electronic fuse, is fully automatic. We will not require an operator to fix the circuit every time the fuse safeguard our instruments.

Our project is very effective for the contemporary world where electrical and electronic instruments are making miracles. The continuous use of our project may help to protect the instruments from any harms and will increase their longevity.