

AUTOMATIC VOLTAGE CUT-OFF AND RESTORATION FOR APPLIANCE SAFETY

THOMAS G¹, GOWTHAM K², ARULSRIBA I³, DR. G. KRITHIGA⁴

4 (DEPARTMENT OF EEE, ASSOCIATE PROFESSOR, PARISUTHAM INSTITUTE OF THCHNOLGY AND SCIENCE, THANJAVUR)

3(DEPARTMENT OF EEE, PARISUTHAM INSTITUTE OF THCHNOLGY AND SCIENCE, THANJAVUR)

2(DEPARTMENT OF EEE, PARISUTHAM INSTITUTE OF THCHNOLGY AND SCIENCE, THANJAVUR)

1(DEPARTMENT OF EEE, PARISUTHAM INSTITUTE OF THCHNOLGY AND SCIENCE, THANJAVUR)

ABSTRACT

Voltage fluctuations such as over-voltage and under-voltage are major causes of electrical appliance damage in domestic and small industrial environments. Continuous exposure to unstable voltage conditions reduces appliance lifespan and may lead to safety hazards such as overheating and short circuits. The project Automatic Voltage Cut-off and Restoration for Appliance Safety present a reliable and low-cost solution to overcome these problems using a microcontroller-based protection system.

KEYWORDS

Voltage Protection, Automatic Cut-off, Under-Voltage, Over-Voltage, Microcontroller, Relay Control, Appliance Safety

INTRODUCTION

Overvoltage and undervoltage are two common electrical phenomena that can have adverse effects on electronic devices, electrical systems, and overall power supply stability. These voltage fluctuations, occurring either above or below the standard voltage levels, can result in significant damage, malfunctions, and safety hazards. Therefore, implementing effective overvoltage and

undervoltage protection mechanisms is essential to safeguarding equipment, ensuring uninterrupted operation, and preventing potential risks.

Overvoltage can occur due to insulation failure, overcompensation in power systems, and lightning strikes. Overvoltage causes spikes and surges in the electrical power system. Overvoltage can cause various problems like distortion of electrical signals, burnout of sensitive equipment, fire hazards, and permanent

damage to the electrical equipment. On the other hand, under voltages condition occur when the system voltage reduces to 90% of rated voltage and it occurs due to overloads, short circuits and improper power supply system [1]. Undervoltage can lead to voltage instability, increased current drawn by motors, high reactive power demand and overall failure or malfunction of electrical equipment. Figure 1 and Figure 2 shows overvoltage and undervoltage in power systems [2].

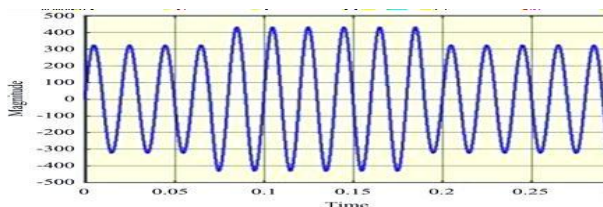


Figure 1 Overvoltage [2].

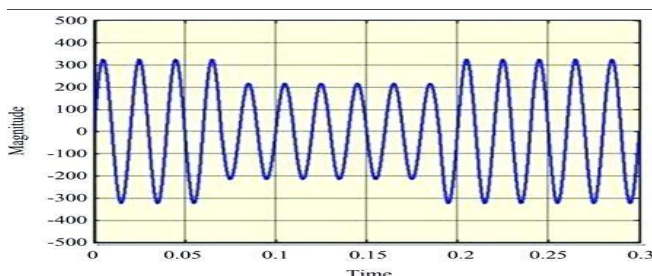


Figure 2 Under voltage [2].

SYSTEM OPTIMIZATION

The AC supply voltage is stepped down and sensed using a voltage sensor. The sensor output is fed to the microcontroller, which converts the Analog signal into digital values using its ADC. These values

are compared with preset upper and lower voltage limits.

- Normal Voltage → Load remains ON
- Over-Voltage / Under-Voltage → Load is disconnected
- Voltage Restored → Load is reconnected automatically

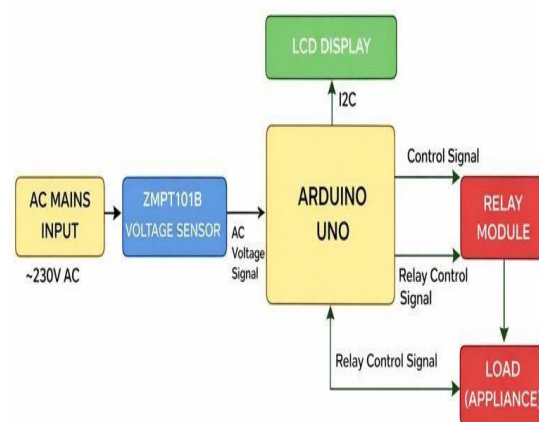


Figure 3

The AC supply provides the input voltage to be monitored, which is then measured by the voltage sensor that converts it into a proportional Analog signal. This signal is processed by the microcontroller unit, which compares voltage levels and controls the relay. The relay module acts as an electrically operated switch that connects or disconnects the load, while the LCD display

shows the real-time voltage value and system status. Finally, the load, which is the electrical appliance being protected, benefits from this system by being safeguarded against abnormal voltage conditions.

HARDWARE DESIGN

Voltage Regulator: It includes TRIAC (BT 136), Film Capacitor-104j 450v, Resistor- 10k ohm, Diac- DB3, Potentiometer-470kohm. **Transformer:** Step down (12-0-12) transformer is used here to step down the 230v AC supply to 12v AC. **Full Bridge rectifier:** 4 diodes (IN 4007) are used to design bridge rectifier circuit to convert AC voltage into DC voltage. Here full bridge rectifier is used because it provides purer and rectified DC as compared to half bridge rectifier circuit. **Filter Circuit:** To reduce ripples, filter circuit is used and for this purpose two capacitors (25v, 1000uf) are connected in parallel, and one inductor are placed between them in series. Resistors are used to drop down the voltage to 5volt and keep it in the range of 0volt to 5volt with the corresponding input voltage changes from 0volt to 220volt.

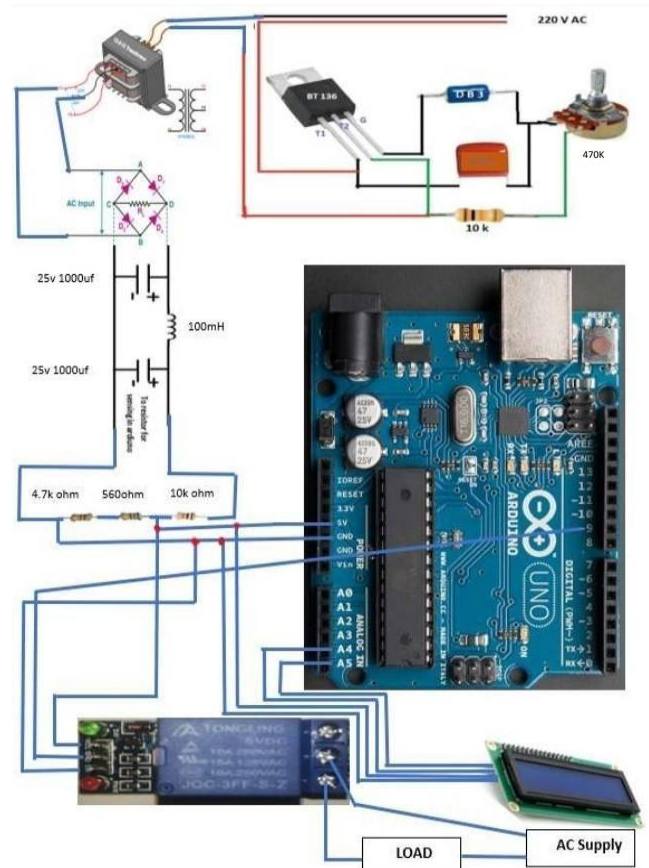


Figure 4

Hardware Design

PROTEUS SIMULATION

Here, with the help of Proteus simulation software, overvoltage and under voltage circuit using Arduino is designed. The main problem while designing this circuit is the presence of ripples in rectified output and to mitigate this ripple appropriate value of capacitors and inductors are used which is basically a filter circuit. The second is to get the voltage across resistor (R3 and R2) under 5volts because Arduino can sense voltage up to 5volts only and generates corresponding ADC value i.e., when input voltage is 220volt then the corresponding ADC value is 1023 and when input voltage is 0volt then 0 ADC value is generated and corresponding to which

normal voltage, overvoltage and under voltage will be shown on LCD display.

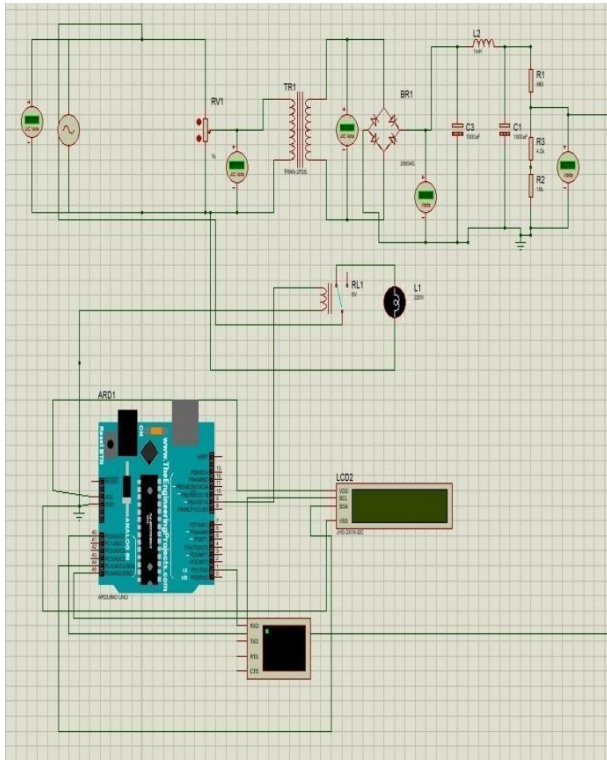
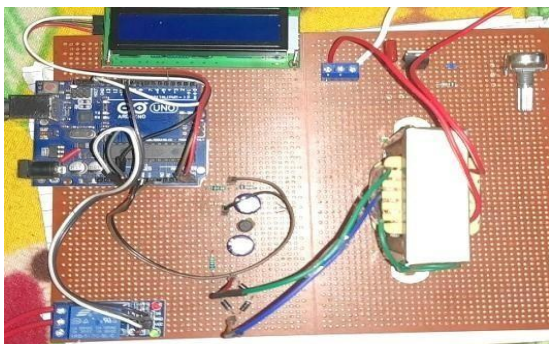


Figure 5
Simulation model

RESULT AND DISCUSSION

Here, for demonstration purposes we have used a voltage regulator which we have made with the help of TRIAC and a



100watt bulb is used as a load.

Voltage regulator: Used for controlling the voltage i.e., we can create overvoltage and undervoltage and normal voltage and the ranges of these have been manually provided which can be changed according to the need.

The ranges that we have selected are:

Normal voltage range- 210volts

to 225 volts Under voltage range

– below 210volts

Overvoltage range – beyond 225volts

These voltages will appear across step down transformer (12 0 12). And then it will be rectified with the help of bridge rectifier. This rectified voltage may have ripples and it will either not let the Arduino to sense the voltage accurately or might damage the device as well, so first we have filtered the output of rectified dc through LC filter circuit. As the Arduino can sense maximum 5volt (i.e., 0v generates 0 ADC and 5volts generates 1023 ADC) so here with the help of resistor voltage will be brought to level at which Arduino can sense and given to the Arduino pin (A0) and corresponding input voltage of load(bulb) will be shown on LCD display. Here, LCD is connected with the help of I2C LCD display module with Arduino.

Relay Pins are connected with Arduino and load(bulb) is connected with relay and Purpose of relay is to disconnect the load(bulb) from main supply as soon as range goes beyond normal voltage.

Here, the benefit is that we can change voltage range according to our needs and with this flexibility loads of different ratings can be protected from overvoltage and undervoltage.

Figure 6

Automatic voltage cut-off and restoration
for appliance safety

APPLICATIONS

Home Electrical Systems: An Arduino-based protection system can be used to protect household electrical systems from overvoltage and undervoltage events. It can monitor the incoming voltage and automatically disconnect power when the voltage exceeds or falls below safe thresholds.

Industrial Automation: In industries, an Arduino-based protection system can be implemented to prevent equipment damage caused by voltage fluctuations. It can monitor voltage levels and trigger alarms or safety measures when overvoltage or undervoltage conditions are detected, hence ensuring the reliability and longevity of critical machinery.

Medical Devices: Medical equipment, such as diagnostic machines or life support systems, require stable and reliable power.

By implementing an Arduino-based overvoltage and undervoltage protection system in these applications, the risk of equipment damage, electrical failures, and potential hazards can be minimized, ensuring the safe and efficient operation of various electrical systems.

FUTURE SCOPE

Remote Monitoring and Control: Adding wireless connectivity to the Arduino-based system can enable remote monitoring and control of voltage levels.

Intelligent Fault Diagnosis: Incorporating machine learning algorithms or pattern recognition techniques into the protection system can enable intelligent fault diagnosis.

Implementation In Renewable Energy Systems: With the increasing adoption of renewable energy sources, extending the Arduino-based protection system to address specific challenges related to

renewable energy integration, such as voltage fluctuations from solar or wind power systems, would be an interesting avenue for future research.

Operating multiple loads: From a single Arduino, multiple loads of different voltage ratings can be monitored, and effective measures can be taken during fault (overvoltage and undervoltage) conditions.

CONCLUSION

Overall, the objectives of Automatic voltage cut-off and restoration for appliance safety revolve around equipment protection, safety assurance, operational continuity, real-time monitoring, flexibility, adaptability, and cost-effectiveness. By achieving these objectives, the system aims to enhance the reliability, longevity, and safety of electrical systems in various settings, including industries, residences, and commercial establishments.

REFERENCES

- [1] Rama Mohan, P., Neeli Mallikarjuna, A., & Niteesh Kumar, K. (2020). A Novel Over Voltage and Under Voltage Protecting System for Industrial and Domestic Applications. *International Journal of Innovative Science and Research Technology*, 5(10).
- [2] Bhosale, G., Vak hare, A., Keysha, A. and Aher, A. (2018) Overvoltage Undervoltage Protection Electrical Equipment. *International Research Journal of Engineering and Technology (IRJET)*,5, 29-32.
- [3] Chattopadhyay, S., Mitra, M. and Sengupta, S. (2011) *Electric Power*

Quality. Springer, New York.
<https://doi.org/10.1007/978-94-007-0635-4>

Novel Over Voltage and Under Voltage Protecting System for Industrial and Domestic Applications. 5. 885-889.

- [4] Institute of Electrical and Electronics Engineers (1995) IEEE Standard 1159-1995. IEEE Recommended Practices for Monitoring Electric Power Quality. Institute of Electrical and Electronics Engineers, New York.
- [5] Arif, Mohammad & Than Oo, Aman & Ali, A B M Shawkat. (2012). Integration of renewable energy resources into the distribution network: a review on required power quality.
- [6] Joni Welman Simatupang, Andrián, L., Zhuang, W., & Heri Presto. (2019). A Prototype of an Arduino-Based Protection System to Overcome Voltage Fluctuations.
<https://doi.org/10.1109/ic3ina48034.2019.8949584>
- [7] Sarder, M. A., Rahman, M., Mustakim, M. N., Rahman, M. M., & Islam, M. S. (2021). A Prototype of AC Voltage Measurement and Over & Under Voltage Protector Using Arduino. International Journal of Multidisciplinary Informative Research and Review, 1(4), 176–184.
<https://doi.org/10.5281/zenodo.5103172>
- [8] Omojoyegbe, Michael. (2014). Development of a Low-Cost Microcontroller Based Under and Over Voltage Protection Device. International Journal of Scientific Engineering and Technology. Volume No.3. 1225-1229.
- [9] P Rama Mohan, Dr & Mallikarjuna, Neeli & Kumar, K Nitesh. (2020). A