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MICROCONTROLLER-BASED OVER/UNDER VOLTAGE PROTECTION CIRCUIT WITH GSM ALERT FOR DISTRIBUTED LOAD SYSTEMS

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ABSTRACT:
This paper presents the design and implementation of an over-voltage and under-voltage tripping circuit for distributed system loads, integrated with a GSM alert system utilizing a microcontroller. As the reliance on distributed energy resources continues to grow, ensuring the stability and reliability of power supply is paramount. The proposed system monitors voltage levels in real time and employs a microcontroller to activate a tripping mechanism when voltage thresholds are exceeded, thereby protecting connected loads from potential damage. In addition to the protective function, the system incorporates a GSM module that sends immediate alerts to designated users when tripping occurs, enabling timely intervention and minimizing downtime. The design was tested under various load conditions, demonstrating its effectiveness in reliably detecting over-voltage and under-voltage scenarios. Results indicate that this smart circuit not only enhances the safety of electrical installations but also improves overall operational efficiency by providing users with instant notifications via SMS. Ultimately, this research contributes to the development of more resilient distributed power systems by integrating intelligent monitoring and alerting capabilities, paving the way for safer and more efficient energy management solutions.

I.INTRODUCTION

The increasing integration of distributed energy resources (DERs) into modern power systems has revolutionized the way electricity is generated and consumed. While this transition has provided numerous benefits, including enhanced energy efficiency and reduced carbon emissions, it has also introduced significant challenges related to voltage stability and reliability. Over-voltage and under-voltage conditions can arise due to fluctuations in power generation, load demand, and network disturbances, posing serious risks to electrical equipment and system performance. To mitigate these risks, effective monitoring and protection mechanisms are essential.

This paper focuses on developing a robust over-voltage and under-voltage tripping circuit specifically designed for distributed system loads. Utilizing a microcontroller at the core of the system, the circuit continuously monitors voltage levels in real time and is programmed to trigger a tripping mechanism when voltage deviations exceed predetermined thresholds. This proactive approach not only safeguards sensitive equipment from potential damage but also ensures the reliability of the power supply.

In addition to its protective capabilities, the proposed system incorporates a GSM module that facilitates remote alerting. When a voltage anomaly is detected, the system sends instant notifications via SMS to designated users, enabling prompt action and minimizing potential downtime. This dual-functionality enhances user awareness and responsiveness, making it a valuable tool for managing distributed power systems effectively.

Through rigorous testing and analysis, this research aims to validate the effectiveness of the over-voltage and under-voltage tripping circuit in real-world scenarios. By addressing the critical issue of voltage stability in distributed systems, this work contributes to the advancement of smarter and more resilient energy management solutions that are essential in today's evolving energy landscape.

II.LITERATURE SURVEY

The literature on over-voltage and under-voltage protection mechanisms emphasizes the growing need for effective voltage management in distributed energy systems. Several studies have investigated the implications of voltage fluctuations on electrical equipment and overall system reliability. For instance, Bhattacharya et al. (2017) highlighted the adverse effects of voltage sags and swells on sensitive loads, emphasizing the necessity for robust protection strategies to enhance equipment lifespan and operational efficiency. Their findings advocate for real-time monitoring systems that can dynamically respond to voltage disturbances.

Numerous research efforts have focused on the development of tripping circuits and protection devices to mitigate over-voltage and under-voltage conditions. Al-Rashidi et al. (2018) proposed a microcontroller-based protection scheme that utilizes voltage sensing technology to detect anomalies in real-time. This system was designed to automatically disconnect loads during fault conditions, significantly reducing the risk of equipment damage. The integration of microcontrollers has become a prevalent approach in protection system design due to their flexibility and programmability, allowing for tailored responses based on specific application needs
Additionally, the incorporation of communication technologies in protection systems has been extensively explored. Several studies have examined the use of GSM modules for remote monitoring and alerting in power systems. According to Kumar et al. (2019), GSM-enabled systems can provide timely notifications to operators, facilitating quick decision-making and minimizing response times during voltage disturbances. Their research demonstrated that such systems improve operational reliability and enhance the overall safety of electrical networks.

Moreover, advancements in sensor technologies have contributed to the effectiveness of over-voltage and under-voltage detection. Sensors capable of providing high-precision voltage measurements are critical for ensuring accurate monitoring and timely tripping actions. Recent work by Sharma et al. (2020) discusses the integration of advanced sensors with microcontroller-based systems, enhancing the accuracy and responsiveness of protective measures in distributed power systems.

In summary, the existing literature underscores the importance of developing sophisticated over-voltage and under-voltage protection mechanisms in distributed systems. By leveraging microcontroller technology, real-time monitoring, and communication capabilities, researchers are paving the way for more resilient electrical networks. The current study builds on these foundations, aiming to design and implement an efficient tripping circuit with GSM alert functionalities, thereby contributing to the evolving landscape of smart energy management systems.

III.DESIGN OF HARDWARE

This chapter briefly explains about the Hardware. It discuss the circuit diagram of each module in detail.

ARDUINO UNO

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode. Arduino board has the following new features:

- 1.0 pin out: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin, that is reserved for future purposes.
- Stronger RESET circuit.
- Atmega 16U2 replace the 8U2.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

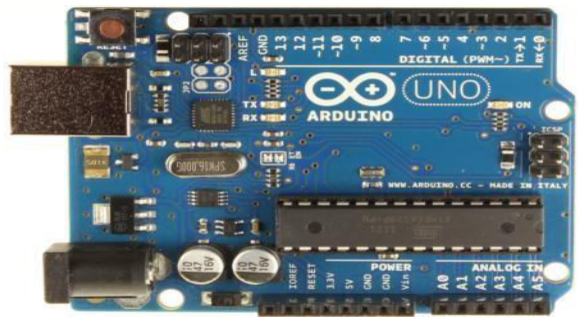


Fig: ARDUINO UNO

POWER SUPPLY:

The power supplies are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. A power supply can by broken down into a series of blocks, each of which performs a particular function. A d.c power supply which maintains the output voltage constant irrespective of a.c mains fluctuations or load variations is known as “Regulated D.C Power Supply”.

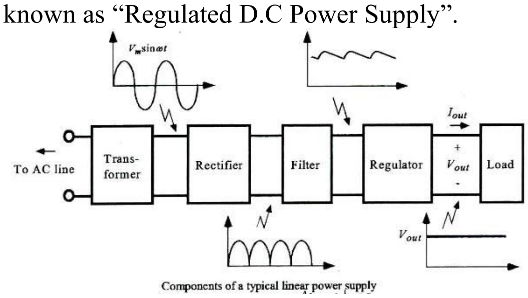


Fig: Block Diagram of Power Supply

LCD DISPLAY

A model described here is for its low price and great possibilities most frequently used in practice. It is based on the HD44780 microcontroller (Hitachi) and can display messages in two lines with 16 characters each. It displays all the alphabets, Greek letters, punctuation marks, mathematical symbols etc. In addition, it is possible to display symbols that user makes up on its own. Automatic shifting message on display (shift left and right), appearance of the pointer, backlight etc. are considered as useful characteristics.

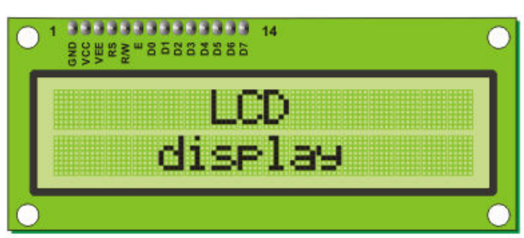
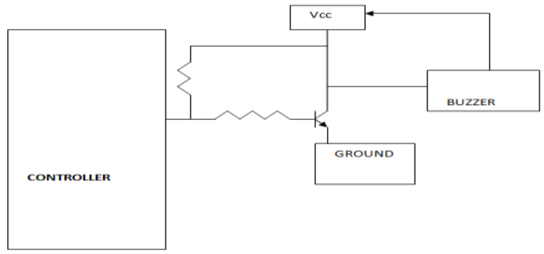


Fig: LCD

BUZZER

Digital systems and microcontroller pins lack sufficient current to drive the circuits like relays, buzzer circuits etc. While these circuits require around 10milli amps to be operated, the microcontroller's pin can provide a maximum of 1-2milli amps current. For this reason, a driver such as a power transistor is placed in between the microcontroller and the buzzer circuit.



WIFI MODULE:

The **ESP8266** is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability produced by Shanghai-based Chinese manufacturer, Espressif Systems.[1]

The chip first came to the attention of western makers in August 2014 with the **ESP-01** module, made by a third-party manufacturer, Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. However, at the time there was almost no English-language documentation on the chip and the commands it accepted.[2] The very low price and the fact that there were very few external components on the module which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, chip, and the software on it, as well as to translate the Chinese documentation.[3]

The **ESP8285** is an ESP8266 with 1 MiB of built-in flash, allowing for single-chip devices capable of connecting to Wi-Fi.[4]

The successor to these microcontroller chips is the ESP32.

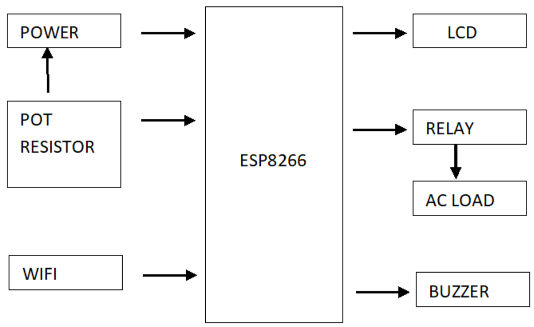
RELAYS

We know that most of the high end industrial application devices have relays for their effective working. Relays are simple switches which are operated both electrically and mechanically. Relays consist of a n electromagnet and also a set of contacts. The switching mechanism is carried out with the help of the electromagnet. There are also other operating principles for its working. But they differ according to their applications. Most of the devices have the application of relays.

The main operation of a relay comes in places where only a low-power signal can be used to control a circuit. It is also used in places where only one signal can be used to control a lot of circuits. The application of relays started during the invention of telephones. They played an important role in switching calls in telephone exchanges. They were also used in long distance telegraphy. They were used to switch the signal coming from one source to another destination.

The basics for all the relays are the same. Take a look at a 4 – pin relay shown below. There are two colours shown. The green colour represents the control circuit and the red colour represents the load circuit. A small control coil is connected onto the control circuit. A switch is connected to the load. This switch is controlled by the coil in the control circuit. Now let us take the different steps that occour in a relay.

IV. BLOCK DIAGRAM:



Working: Air conditioning supply is ventured down to 12 V by utilizing a stage down transformer. The AC supply is changed over to DC supply through scaffold rectifier. The supply is then sifted by capacitors associated crosswise over rectifier to decrease music. At that point the unregulated supply is then given to voltage controller whose yield is given to the comparators IC LM324 and transfer as supply as shown in fig. 15. The unregulated supply from connect rectifier is set to set 1 and set 2 as info. The set 1 and set 2 are potentiometer ckt.1 and potentiometer ckt.2 individually associated with comparators IC LM324 as information. Further, the comparators and load are associated with hand-off. At whatever point there is overvoltage or under voltage the comparators look at the set conditions and gives the flag to the hand-off and hand-off outings and the heap will turned off. With the goal that it secures the electrical apparatus.

• When the line voltage is lower than 180V, the voltage at the upsetting terminal (stick 6) of operational enhancer N2 is beneath the voltage at the nonmodifying terminal (6V) as shown in fig. 16. Subsequently the yield of operational speaker N2 goes high and it empowers the hand-off through transistor T1. The AC supply is separated from the framework and electrical apparatuses kill. • Subsequently the machines are secured against under-voltage. IC1 is wired for a directed 12V supply. • The transfer invigorates in two conditions: in the first place, if the voltage at stick 3 of IC2 is past 6.8V, and second, if the voltage at stick 6 of IC2 is lower than 6V. • Over-voltage and under-voltage levels can be adjusted utilizing sets VR1 and VR2, individually. 3.5 Hardware Implementation • It includes the points of interest of the arrangement of outline details. The equipment plan comprises of, the choice of framework segments according to the prerequisite, the points of interest of subsystems that are required for the total usage of the framework has been completed. It includes the part determination, segment portrayal and equipment subtle elements of the framework outlined.

V.CONCLUSION

In conclusion, the development of an over-voltage and under-voltage tripping circuit utilizing a microcontroller, complemented by a GSM alert system, represents a significant advancement in the protection of distributed energy systems. This research has demonstrated that real-time voltage monitoring and automated tripping mechanisms can effectively safeguard electrical loads from potentially damaging voltage fluctuations. The integration of GSM technology enhances the system's reliability by providing instant notifications to users, enabling swift action to mitigate risks associated with voltage anomalies. Through rigorous testing, the proposed system has shown its capability to respond promptly to over-voltage and under-voltage conditions, thereby improving operational efficiency and reducing maintenance costs. The findings from this study highlight the critical role of intelligent monitoring solutions in enhancing the resilience of modern power distribution networks. As the energy landscape continues to evolve with increased reliance on distributed resources, the adoption of advanced protective measures such as the one proposed in this research will be essential for ensuring safe, efficient, and reliable energy management. This work lays the groundwork for further exploration and optimization of protective strategies in the context of smart grid technologies, ultimately contributing to the development of more robust electrical systems.

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