



DYNAMIC LOAD SHEDDING MANAGEMENT WITH IOT

Abhishek J Kumar^{1,a)}, Hamal Thomas Paul^{2,b)}, Muhammed Rasheed^{3,c)}, Sudev V K^{4,d)}, Ninu Joy^{5,e)}

^{1,2,3,4,5} *Department of Electrical and Electronics Engineering, Mar Athanasius College of Engineering,
Kothamangalam, Ernakulam, India*

Abstract: When electricity is intentionally turned off for extended periods of time over a certain distribution region, this is known as load shedding. In these situations, dynamic load shedding optimizes the power distribution. The connected loads are prioritized by microcontroller units called NodeMCU and Arduino NANO based on a predetermined threshold for power consumption. Current sensors provide input to the microprocessor, which are used to compute power usage. In a 16x2 LCD module, the overall power consumption of various loads is displayed. The microcontroller unit determines whether or not the power usage falls within the parameters. The alarm buzzer functions to alert the user for a set amount of time if the NodeMCU module detects overuse. A signal is sent to the relay to shut off the power supply if the overuse persists. A Wi-Fi module is integrated into the NodeMCU module. Consequently, it is possible to connect this load system to the authority server. After that, control over policing energy use will be in the hands of authority. The power supply might be manually shut off if the authority notices excessive usage. Similar to this, different loads can be tracked, and when there is an excessive use, or above the threshold, the power supply can be shut off. Power-consuming loads that are below the threshold may continue to function uninterrupted. Proteus 8 Professional is used to complete the simulation of the arrangement. Hardware circuit is completed and the model measures the power consumed and performs the load shedding procedure accordingly. The data collected is then send to the server through the ESP8266 module. The website for both the admin side and the consumer side was designed using HTML and PHP. The website receives data like the power consumed, peak hour setting, consumer details and energy billing.

Keywords: NodeMCU, Arduino NANO, IoT-Internet of Things, Dynamic Load Shedding, Load Management

I. INTRODUCTION:

Load shedding is a method used to address electricity supply and demand imbalances, but the traditional approach of completely cutting off power to an area leads to extreme blackouts and inefficiency. To ensure minimal loads can still operate, a more effective strategy is needed. This involves setting a specific power threshold for peak hours and using electromechanical relay mechanisms in consumer modules to turn off power when utilization exceeds the limit. A microcontroller unit tracks module currents, comparing them to the threshold, and issues a warning before activating the relay. Users are expected to reduce excessive appliance usage, and if they ignore the warning, power to their module is shut down. Real-time clocks record the process duration, while the Electrical Base Station monitors relay operation and power usage data, transmitted via a microcontroller's WiFi module to a web page for load control and energy tracking. The emerging Computer Aided Energy Management System (CAEMS) utilizes sensors and microcontrollers to identify energy wastage and improve efficiency. Smart energy metering should be adopted to replace manual metering, reducing costs and allowing for automated processes without personnel intervention..

II. METHODOLOGY:

A dynamic load shedding process includes identifying loads in a residential or industrial area during a particular period and shedding the excess power consuming loads automatically. If the loads consume power above the operating limit during a period the loads are shed for a preset interval of time before they are available for usage again. This can be made practical by utilising relay mechanism, real time clock and continuous monitoring of power consumption.

SYSTEM CONFIGURATION:

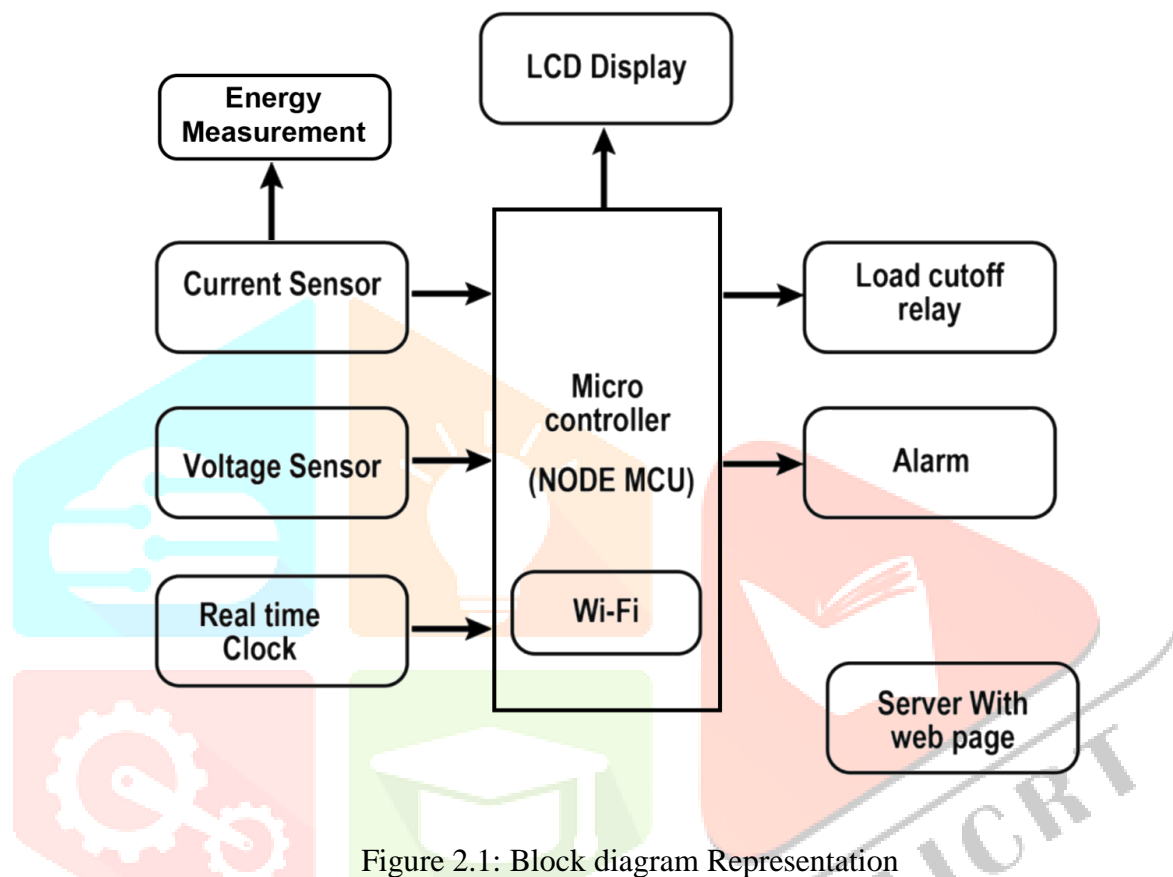


Figure 2.1: Block diagram Representation

During the peak period, the NodeMCU compares the received current sensor values (power consumption) to the threshold value. Assuming stable voltage without fluctuations due to the absence of high loads, if the consumer's power consumption stays within the threshold, normal operations continue. However, if consumption exceeds the threshold, an alarm buzzer connected to the system warns the consumer, with the duration customizable in the programming code. The user is expected to reduce power usage by turning off excessive loads during this limited period. If the user complies and power consumption falls within the threshold, normal operations resume. However, if the user persists in excess power usage, the consumer's loads are automatically shed for a specified time period using electromechanical relays and the real-time clock. After a predetermined power outage duration, the power is automatically restored, and the system checks for over-usage again. These processes are continuously monitored by an Electrical Base Station, with data sent via Wi-Fi to the station's server, enabling manual checks of consumption levels and necessary actions in case of system failure. Continuous power monitoring also facilitates the implementation of a billing system, where power consumption values can be transmitted to the consumer side of the website, providing billing facilities through the recharging option.

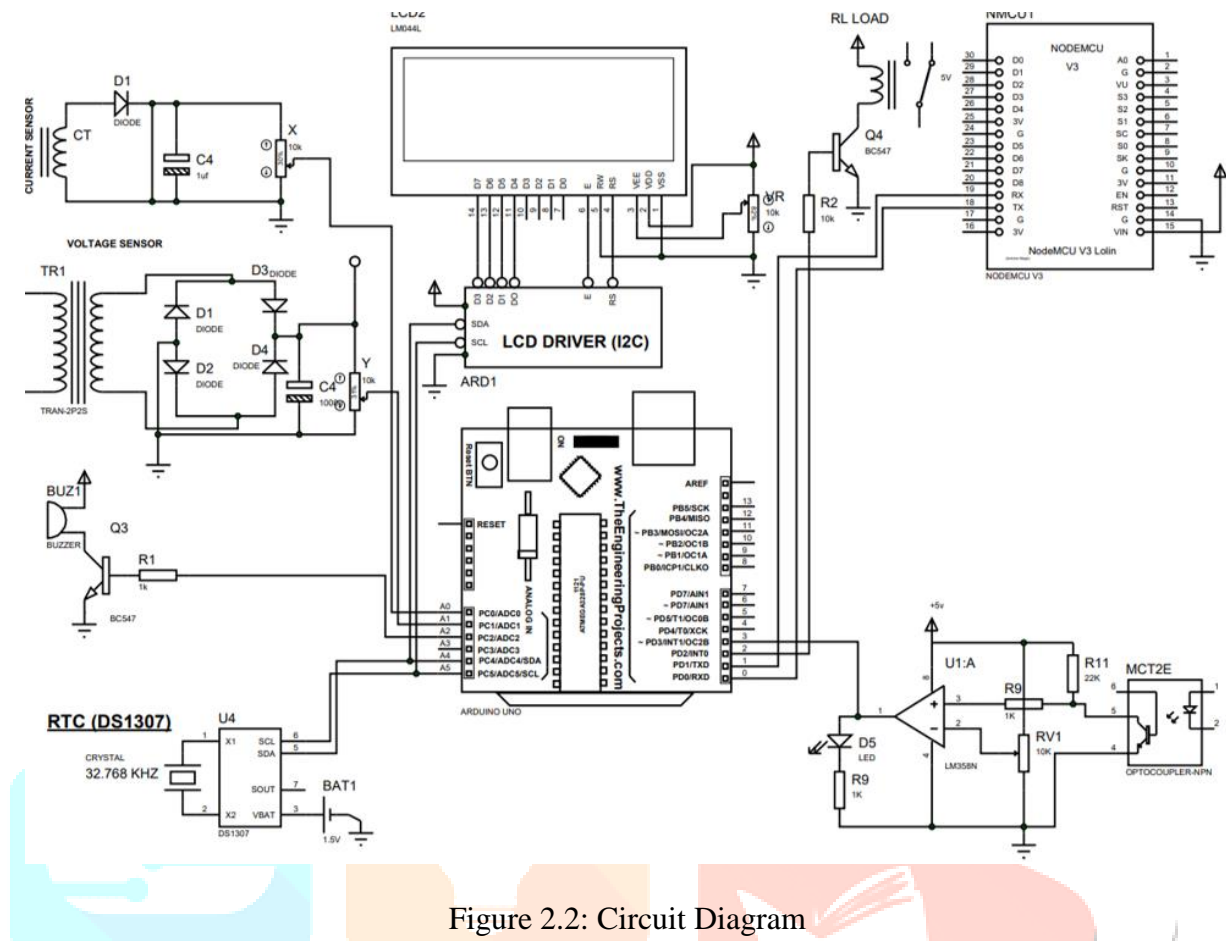
SCHEMATIC DIAGRAM:

Figure 2.2: Circuit Diagram

During peak periods, the NodeMCU initiates the comparison of received current sensor values (power consumption) with the threshold value. Assuming stable voltage without fluctuations, if the consumer's power consumption remains within the threshold, normal operations continue. However, if consumption exceeds the threshold, an alarm buzzer sounds to warn the consumer, with the duration of the warning customizable in the programming code.

The user is expected to turn off excessive power-consuming loads during this limited warning period. If the user complies and power consumption falls within the threshold, normal operations resume. However, if the user persists in excessive power usage, the consumer's loads are automatically shed for a specified period using electromechanical relays and the real-time clock. After a predetermined power outage duration, power is automatically restored, and the system checks for over-usage again. This cycle repeats during peak hours.

These processes are continuously monitored at an Electrical Base Station. Data is transmitted via Wi-Fi to the station's server, enabling manual checks of consumption levels and necessary interventions if the automatic system fails. Continuous power measurement also facilitates the implementation of a billing system, where power consumption values can be accessed by consumers through a website. The recharging option provides billing facilities to the consumers based on their consumption.

III. SIMULATION:

The simulation for Dynamic Load Shedding is done on Proteus 8 Professional. Simulation components of some of the components are not available in the standard Arduino library. NodeMCU library is not available to simulate in the Proteus. Hence Arduino UNO is interfaced with a Wi-Fi module and thereby producing an operation similar to NodeMCU. Here the simulation of a single load module was observed.

The peak hour selection can be done by pressing a switch designated to turn on a variable for peak hour. This is done because there is no available module for a real time clock in the software and there is no other provision to manually tweak the peak time settings. Once this peak hour selection switch is pressed to turn on the peak hour, an indication appears in the LCD module of the simulation with the word 'Peak'. The current, voltage

and power consumed is calculated and is displayed on an LCD screen. The brightness and contrast of the LCD screen can be controlled using a variable resistor in the simulation. The connection to the Wi-Fi module is made possible through serial connection of the Arduino i.e through TXD pin and the RXD pin.

Here the limit or the threshold is set to be 10 Ampere(A). The over usage when detected,alarm goes off for a preset time. If the load is removed after detecting excess usage ,the normal operation is allowed to continue. If the over usage persists the load is cut-off automatically. Then the power to the load is again automatically restored after a particular time interval.

The overusage of power is only detected for peak hour. The alarm is integrated in the simulation in the form of an LED. The turning on of the LED symbolises that the alarm warning is on. The alarm operation and load shedding procedure remains in idle condition during normal hours. The user can connect heavy loads during this time and no loads are shed in these hours. The load to be shed is displayed in the simulation by an LED. For the simulation purpose a click switch is used to alternate between peak and normal hours. Once the switch is clicked the simulation for the model is then performed under the peak settings.

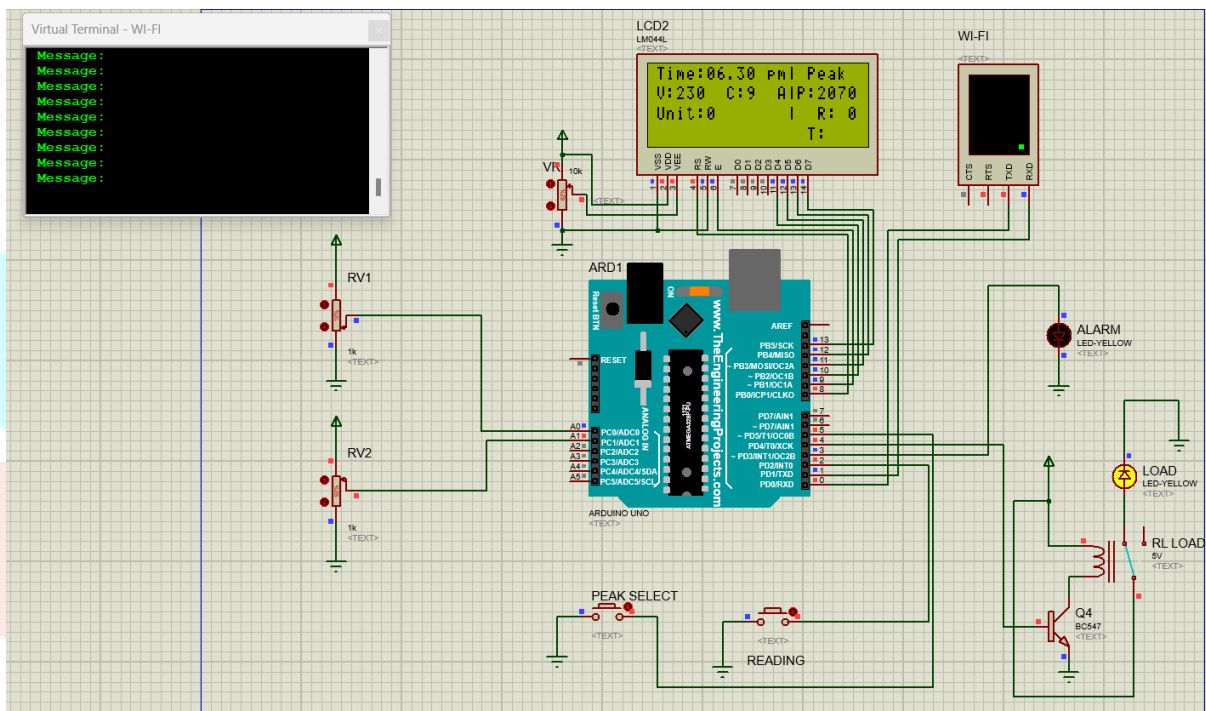


Figure 3.1: Peak Hour Simulation

The peak setting of the simulation include total power calculation,comparison of the power output and the threshold. If the switch is pressed again the whole system is set back to the normal settings. The current values are measured during peak hour. If the limit is exceeded ,then a warning signal is given by an alarm module. The alarm buzzer operates for a particular time interval. In the simulation this time is set to be 10 seconds. This time count is also displayed in the LCD screen next to 'T'.

The power cut-off measures are employed only if the warning signals are avoided by the consumer and continues the overusage of power. The consumer is expected to turn off loads to prevent the automatic load cut-off procedure. The load is then removed for a particular time interval if overusage is detected and the consumer ignores the warning signals.The power is restored after after a preset time interval.The LCD screen then displays a message announcing that the power has been restored. It is observed that the switch is back to the initial position. This completes the electrical circuit and the power is restored.

Virtual Terminal is a tool in Proteus, which is used to view data coming from Serial Port (DB9) and also used to send the data to Serial Port.Arduino UNO has builtin single serial port at its pins 0 and 1, while Arduino Mega 2560 has built in four Serial ports in it. Virtual Terminal in Proteus is used to send or receive data to or from a serial port. Here in this simulation virtual terminal displays the messages of power cut-off and power restoration.

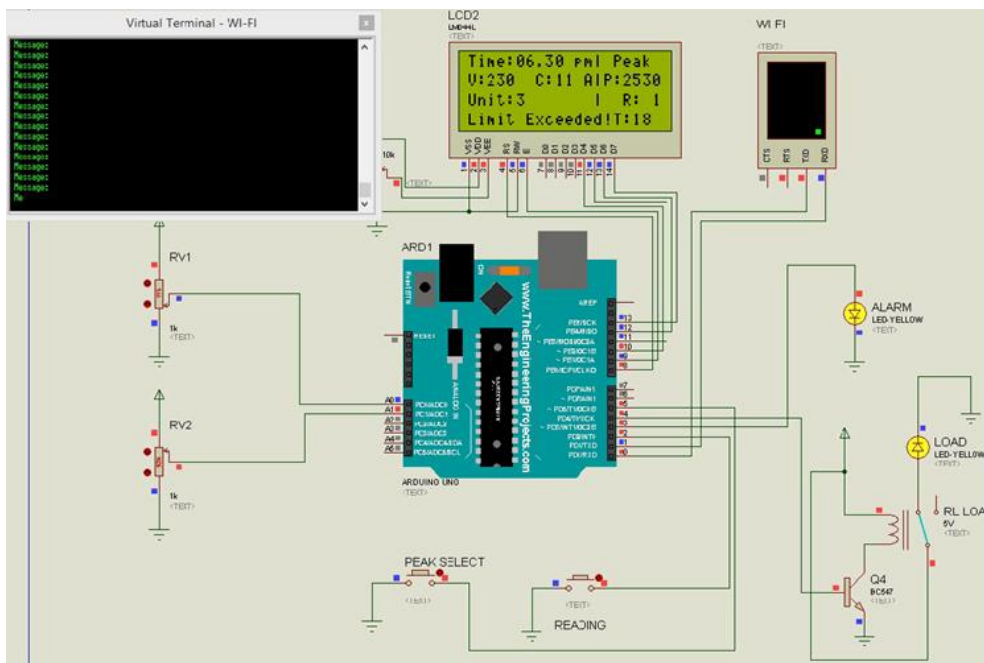


Figure 3.2: Detection Of Over Usage

The reading switch in the simulation is analogous to the real energy meter reading. The reading switch when pressed counts as one reading. Similarly when the reading switch is pressed ten times , LCD displays the count of ten readings. Each time ten readings are reached ,the units are incremented and is displayed in the LCD.

The process of evaluating and comparing of the power consumption is again carried out in the simulation software. Various different values of current and voltages are given to observe results. These different values of voltage and current are provided by using variable resistors.

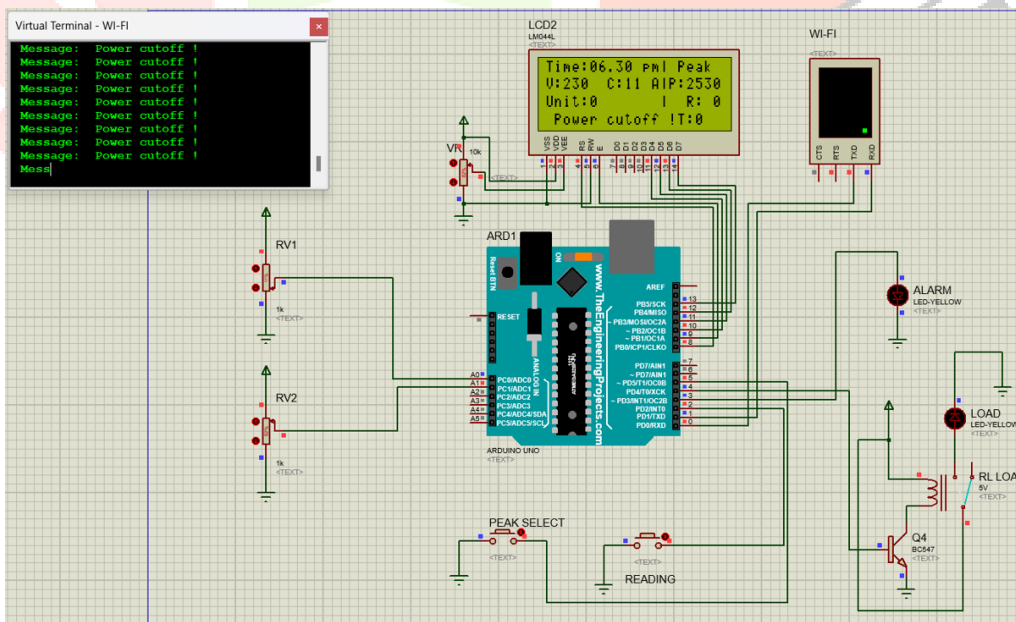


Figure 3.3: Power Cut Off

IV. HARDWARE SETUP:

The proposed hardware unit consists of two sets of consumer modules each containing two lamps of 60 W and 200 W for demonstrating loads. Each module has a microcontroller unit of NodeMCU and Arduino NANO.

The pulses of energy meter is calculated and send to the NodeMCU unit through optocoupler. Optocoupler electrically isolates and protects the micro controller unit. Energy meters often measure high voltages and currents, which can be dangerous to interface directly with low-voltage circuits. Therefore the usage of optocoupler ensures electrical isolation, preventing the high-voltage side from affecting the low-voltage side. Energy meters typically generate pulses to indicate the consumption of energy. These pulses can be transmitted through an optocoupler, allowing them to be safely received by another circuit, such as a microcontroller or a data acquisition system, for further processing or logging. The output from the optocoupler is a very small value such that it cannot be directly fed to the microcontroller unit. For this purpose a comparator is used. The comparator compares the output from the optocoupler with a threshold value. Then the comparator sends a high value to the unit if the output from the optocoupler is above the threshold. If it is below the limit then the comparator sends a low signal. The current transformer CT 20 A is used to measure the average real power information.

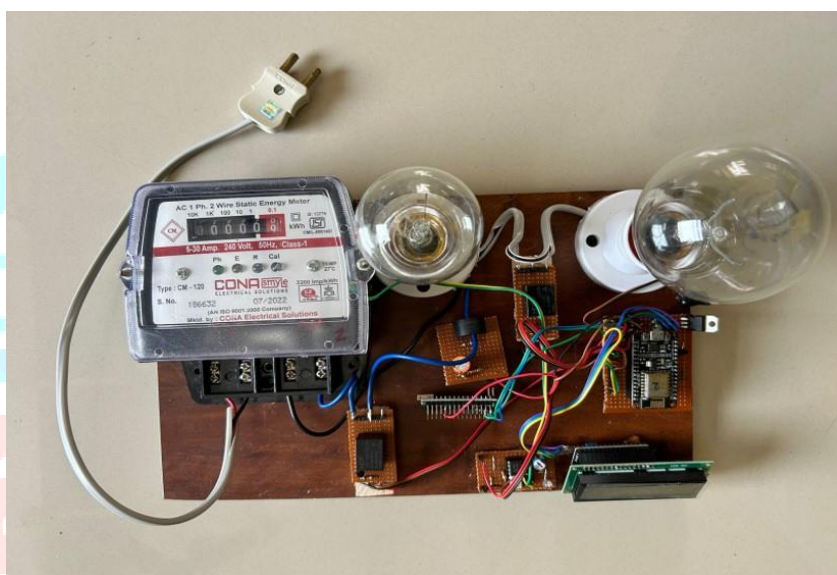


Figure 4.1: Hardware Circuit

The CT 20 A module may show signs of fluctuations in the measurement. The 12V DC relay is connected to the Arduino NANO and the load to be cut off. A RTC module can be connected to the Arduino for keeping track of the time. There is also an option of taking the time from the server. This can prove beneficial when the RTC module gets damaged. The power consumption and peak hour details are displayed in the LCD screen. The LCD driver I2C is used to tweak the LCD.

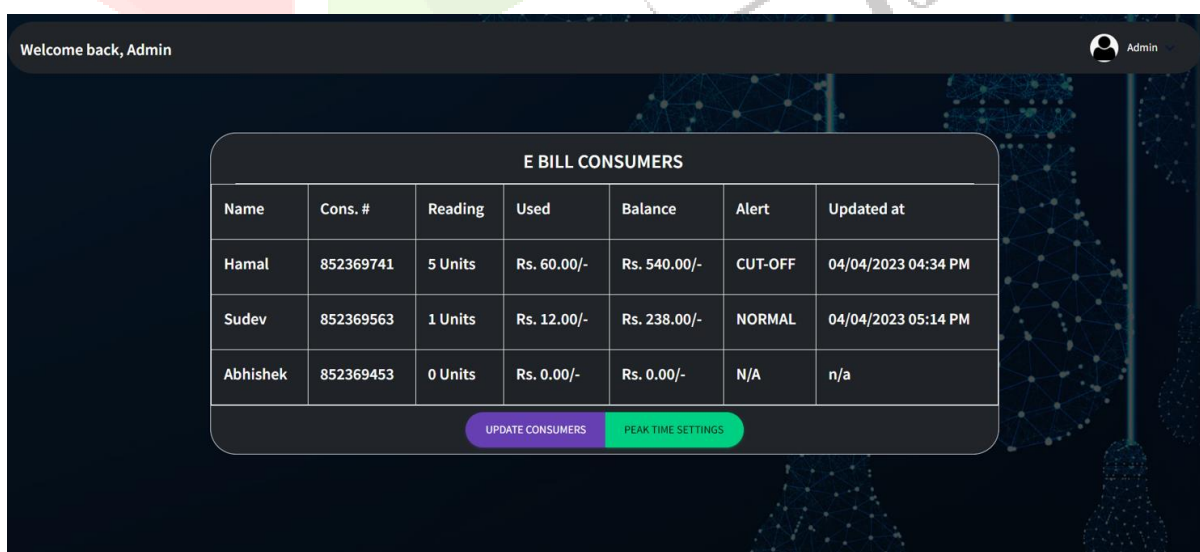
The hardware test is performed and the power consumption is obtained. The loads are shed when the system detects over consumption during the peak hours. The collected data is then send to the web through the NodeMCU unit. The NodeMCU has only a few analog pins and it cannot process the current sensor values. This is the reason why an Arduino NANO unit is used. There is a serial connection through RX and TX pins of both the units for data transmission and receiving

WEBSITE:

The administrator/utility area manager can monitor the status of the users and their electricity use on the admin page. On the admin page, the users in the region are visible. Based on the amount of electricity used during various seasons, the administrator has the authority to change the peak time. As new users are added or if any of the current ones have expired, the administrator can also update the user list. This gives the admin liberty to change and tweak peak hour accordingly. During different seasons the amount of electricity produced varies. Therefore it is necessary to provide these options to the admin.

The home page or User page of an electricity utility account is the critical point of access for the customers to manage their energy consumption and payment information. The page features a dashboard that displays information such as user name ,consumer ID ,account balance, energy usage, alert status.Users can view their current electricity usage by entering their user id and password. The consumer website will allow the users to manage and monitor the electricity consumption in real time. The real time is obtained from the servers to avoid any kind of errors. There is a column in the dashboard which displays the current alert situation of the consumer. This is directly linked to the load shedding procedure. If the loads are shed after a warning to the consumer then it displays 'CUT OFF'. An option to remotely turn on and off the loads are also given. This button functionality is proportional to network accessibility of the model. A very high speed network connectivity will provide a speedy response. If the network is slow then there is small time lag in the response of the relay action. The To recharge their account, users can select a monetary value out of the four options and recharge their account.

The user is provided with an option of prepaid recharging. The user can recharge their account with four amount options. It is to be noted that the proposed system also gives warning signals to the users if the system detects low amount of balance in their account. A low balance amount will also leads to the cut-off operation. It can be avoided by prepaid recharging. The amount will be periodically deducted from the total pool proportional to the energy consumption. In the proposed system an amount of Rs 12 is fixed per unit of energy consumed.



Welcome back, Admin Admin

E BILL CONSUMERS						
Name	Cons. #	Reading	Used	Balance	Alert	Updated at
Hamal	852369741	5 Units	Rs. 60.00/-	Rs. 540.00/-	CUT-OFF	04/04/2023 04:34 PM
Sudev	852369563	1 Units	Rs. 12.00/-	Rs. 238.00/-	NORMAL	04/04/2023 05:14 PM
Abhishek	852369453	0 Units	Rs. 0.00/-	Rs. 0.00/-	N/A	n/a

UPDATE CONSUMERS
PEAK TIME SETTINGS

Figure 4.2:Admin Side Website

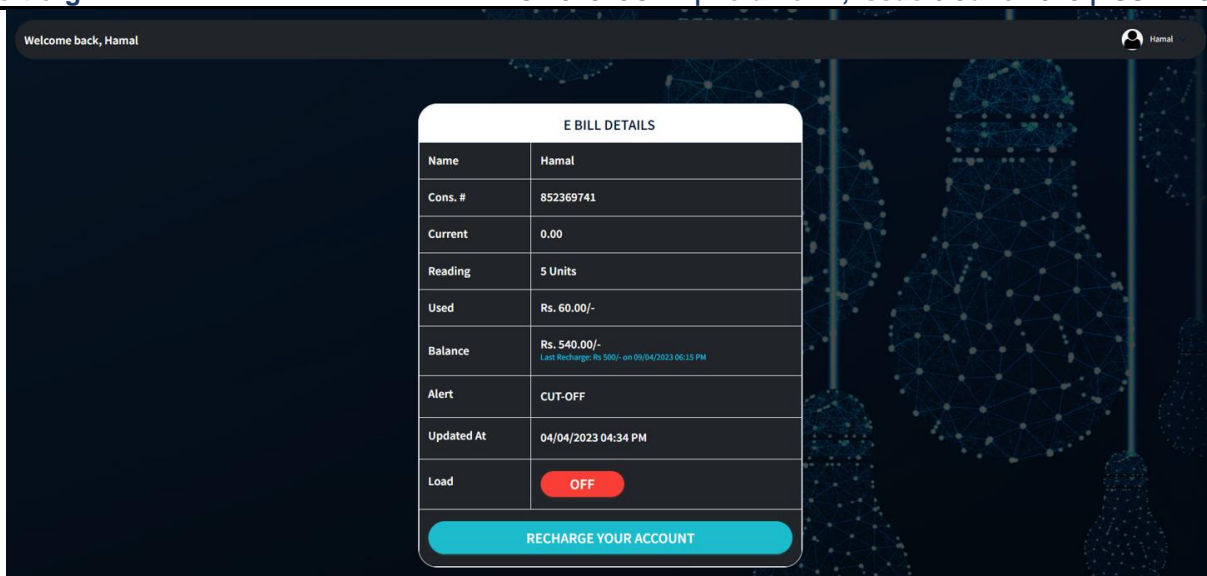


Figure 4.3:User Side Website

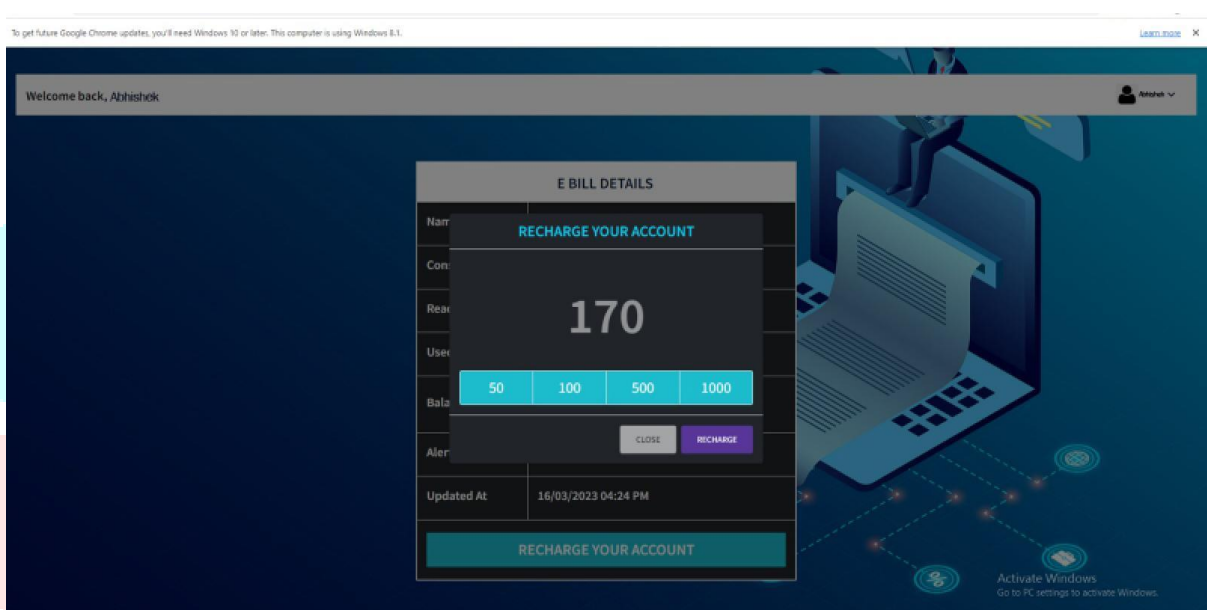


Figure 4.4:Recharging Page

V. CONCLUSION:

A dynamic load shedding management is an efficient method by which the monitoring authority can ensure that no power outage is unnecessarily forced upon a consumer. The concept of electricity being a basic right is kept in mind by designing a user friendly system. The consumer can choose to perform tasks within the operating limit without complete power outage. This helps the consumer to complete works in limited efficiency. The simulation for a single load model was completed. The hardware implementation was completed and the desired results were obtained. The webpages for both the admin and user side was designed and the power consumption data and other details were measured and monitored in the website. The energy billing system is also included in the consumer side of the website. The recharging is done in the prepaid manner. The power consumption monitoring helps in the efficient usage of energy and helps in reducing the energy costs of consumers.

VI. ACKNOWLEDGEMENT

We would like to acknowledge the technical and financial support given by APJ Abdul Kalam Technological University and Mar Athanasius College of Engineering, Kothamangalam for the successful completion of this research.

VII. REFERENCES

- [1] J. A. Laghari, H. Mokhlis, M. Karimi, A. H. Abu Bakar and H. Mohamad, "A New Under-Frequency Load Shedding Technique Based on Combination of Fixed and Random Priority of Loads for Smart Grid Applications," in IEEE Transactions on Power Systems, vol. 30, no. 5, pp. 2507-2515, Sept. 2015, doi: 10.1109/TPWRS.2014.2360520.
- [2] H. Mortaji, S. H. Ow, M. Moghavvemi and H. A. F. Almurib, "Load Shedding and Smart-Direct Load Control Using Internet of Things in Smart Grid Demand Response Management," in IEEE Transactions on Industry Applications, vol. 53, no. 6, pp. 5155-5163, Nov.-Dec. 2017, doi: 10.1109/TIA.2017.2740832.
- [3] P. V. Ilyushin and S. P. Filippov, "Under-Frequency Load Shedding Strategies for Power Districts with Distributed Generation," 2019 International Conference on Industrial Engineering, Applications and Manufacturing (ICIEAM), 2019, pp. 1-5, doi: 10.1109/ICIEAM.2019.8743001.
- [4] P. V. Dudhe, N. V. Kadam, R. M. Hushangabade and M. S. Deshmukh, "Internet of Things (IOT): An overview and its applications," 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS), 2017, pp. 2650-2653, doi:10.1109/ICECDS.2017.8389935.
- [5] S. Naik and S. Patil, "Smart Electricity Measuring System," 2020 International Conference for Emerging Technology (INCET), Belgaum, India, 2020, pp. 1-7, doi: 10.1109/INCET49848.2020.9153974
- [6] S.Kucuk, "Intelligent electrical load shedding in heavy loaded industrial establishments with a case study", 3rd International Conference on Electrical and Electronic Engineering, 2018, pp. 463-467.
- [7] B. Otomega, M. Glavic and T. Van Cutsem, "Distributed Under Voltage Load Shedding" , IEEE Xplore Transactions on Power Systems, vol. 22, no.4, pp. 2283-2284, Nov. 2007.

