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Original Article

Grid Stability Management Using Ml and Block Chain

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Abstract: *The increasing complexity and demand on electrical grids necessitate advanced solutions for ensuring stability and reliability. This project explores the integration of machine learning (ml), block chain technology, and hardware-based frequency controllers for grid stability management. Machine learning models offer predictive maintenance, demand forecasting, and anomaly detection, leveraging historical and real-time data to optimize grid performance. Block chain technology enhances security and transparency through decentralized data management, immutable ledgers, and smart contracts. The combined approach ensures data integrity, automates operational responses, and facilitates decentralized decision-making, resulting in enhanced grid stability, increased security, and cost efficiency. Despite challenges such as data privacy, integration complexity, and regulatory compliance, the synergy of ml, block chain, and frequency-based hardware controllers holds significant promise for the future of grid management, offering a scalable and resilient solution for modern energy systems.*

Keywords*: Grid Stability, Machine Learning (Ml), Block Chain Technology, Energy Management, Smart Grids, Real-Time Monitoring, Predictive Analytics, Decentralized Systems, Demand Response, Load Forecasting, Fault Detection, Grid Resilience, Data Integrity, Secure Transactions, Energy Efficiency, Distributed Ledger, Optimization Algorithms, Dynamic Pricing, Renewable Energy Integration, Automated Control Systems*.

INTRODUCTION

Electrical power is a little bit like the air you breathe: You don't really think about it until it is missing. Power is just "there," meeting your every need, constantly. It's only during a power failure, when you walk into a dark room and instinctively hit the useless light switch that you realize how important power is in your daily life. You use electrical power for heating, cooling, cooking, refrigeration, light, sound, entertainment, computers, mobile devices and maybe even your car. Without power, life as we know it doesn't exist. Electrical power travels from the power plant to your house through an amazing system called the power distribution grid. The grid is quite public if you live in a suburban or rural area, chances are it is right out in the open for all to see. It is so public, in fact, that you probably don't even notice it anymore. Your brain likely ignores all of the power lines because it has seen them so often. Since large amounts of energy cannot be stored, electricity must be produced as it is used. The power distribution grid must respond quickly to shifting demand and continuously generate and route electricity to where it's needed the most.

The power grid is also evolving. Upgrades in technology now let us connect our own home-generated electricity to the grid using solar panels or wind generators and get paid back by utilities. The U.S. federal government is also investing in a so-called smart grid that employs digital technology to more efficiently manage energy resources. The smart grid project also will extend the reach of the grid to access remote sources of renewable energy like geothermal power and wind farms In this Project we will look at all of the equipment that brings electrical power to your home and what kinds of glitches can cause a blackout. Compared to conventional fossil fuels, it is seen as a sustainable and environmentally beneficial substitute. Renewable energy can meet global energy demands while lowering greenhouse gas emissions and enhancing air quality. The intermittent nature of renewable energy sources, which can cause variations in the supply and demand of energy, is one of the primary obstacles. This problem has been solved by the development of energy storage technologies, including batteries and pumped hydro storage. The high price of renewable energy technology in comparison to conventional fossil fuels is another problem.

SYSTEM IMPLEMENTATAION

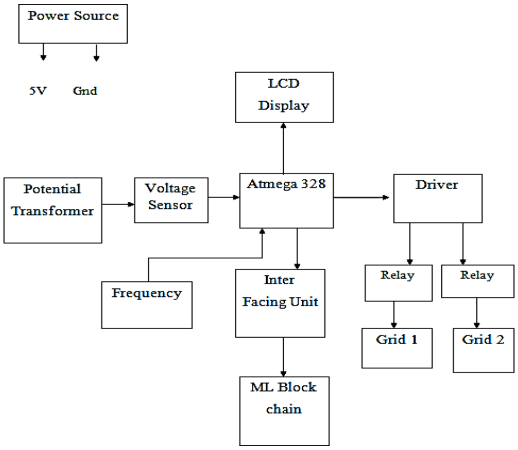
2.1 EXISTING SYSTEM:

The existing systems in blockchain energy management integrate advanced technologies like smart grids, IOT, and blockchain to create a more efficient, transparent, and decentralized approach to managing energy production, distribution, and consumption. These systems address the limitations of traditional energy management by providing real-time monitoring, automated processes, and enhanced security, thereby revolutionizing how energy is managed and traded.

2.2 PROPOSED SYSTEM:

- The proposed blockchain-based energy management system enhances current methodologies by introducing decentralization, transparency, and efficiency into energy management.
- By leveraging advanced technologies such as IOT, smart contracts, and blockchain, the system aims to create a more resilient, secure, and user-centric energy ecosystem.

2.3 BLOCK DIAGRAM:



2.3.1 BLOCK DIAGRAM DESCRIPTION

Power Source

The power source component is the initial input providing electrical energy to the system. This can be a renewable source like solar panels or wind turbines, or a conventional power grid.

Potential Transformer

The potential transformer steps down the high voltage from the power source to a lower, safer voltage level for measurement and monitoring purposes. It ensures that the voltage levels are compatible with the other components in the system.

Voltage Source

The voltage source refers to the stable supply of voltage provided to the system. It may be regulated by the potential transformer and is used to power the electronic components, such as the microcontroller and sensors.

ATmega 328

The ATmega 328 is a microcontroller used to process data and control other components. It reads inputs from sensors, performs computations, and sends control signals to actuators like the servo motor.

Frequency

Frequency measurement is crucial in energy systems to ensure that the electrical energy is being supplied at the correct frequency (e.g., 50Hz or 60Hz). Frequency sensors or measurement circuits provide this data to the ATmega 328.

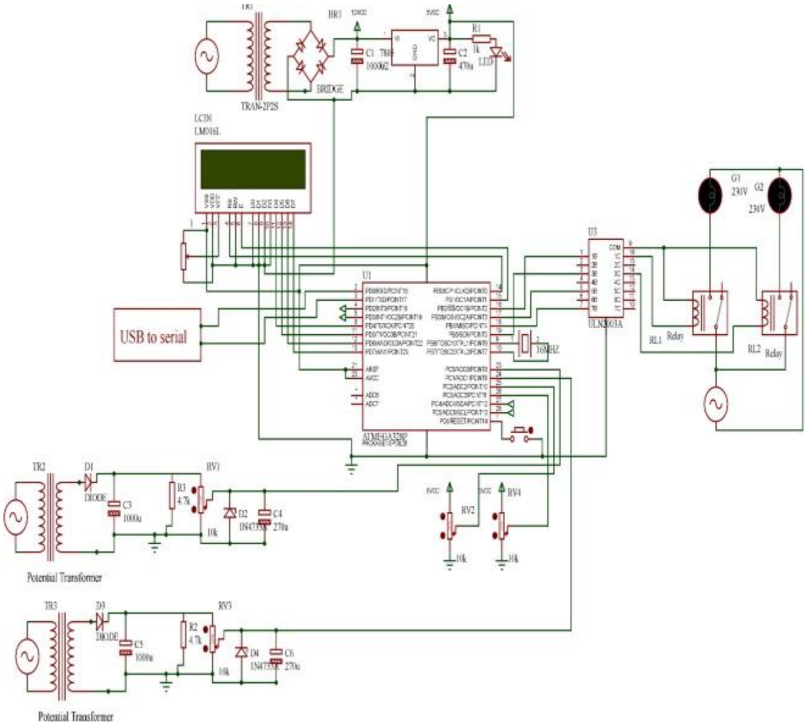
Interfacing Unit

The interfacing unit connects the microcontroller to the blockchain network and other components. This could involve communication modules like Wi-Fi, Zigbee, or other protocols to transmit data securely to the block chain.

Block chain

The block chain component records and verifies transactions and data related to energy production, consumption, and management. It ensures transparency, security, and immutability of the data. Smart contracts on the block chain can automate energy trading and management processes.

2.4 CIRCUIT DIAGRAM



2.4.1 CIRCUIT DIAGRAM DESCRIPTION

Connect the power source output to the primary winding of the potential transformer.Connect the secondary winding of the potential transformer to the voltage measurement circuit and to a voltage regulator if necessary.The regulated voltage output serves as the voltage source for the ATmega 328 and other components.Connect the voltage source output to the Vcc and GND pins of the ATmega 328 microcontroller. Connect the output of the voltage measurement circuit (after the potential transformer) to one of the analog input pins on the ATmega 328.Connect the frequency measurement circuit to a digital input pin or a specialized frequency input pin on the ATmega 328.Connect one of the PWM-capable digital output pins on the ATmega 328 to the control input of the servo motor.Provide power and ground connections to the servo motor from the voltage source. Connect the ATmega 328 to the interfacing unit (e.g., Wi-Fi module) via UART, SPI, or I2C interfaces.Provide power and ground connections to the interfacing unit from the voltage source.

HARDWARE DETAILS

3.1 POTENTIAL TRANSFORMER:

A Potential transformer or voltage transformer can be defined as an electrical device that gets used in electrical power system for stepping down the system voltage to a safe value which can be fed to low ratings meters and relays. This so because the commercially available relays and meters used for protection and metering, are designed for low voltage. This is perhaps the simplest definition for a potential transformer

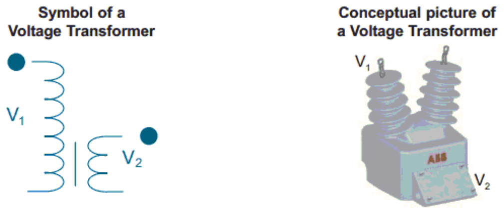


Fig. 3.1 Potential transformer or voltage transformer

3.2 ATMEGA-328 IC:

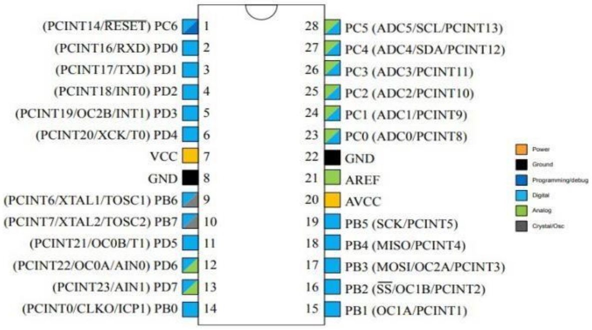
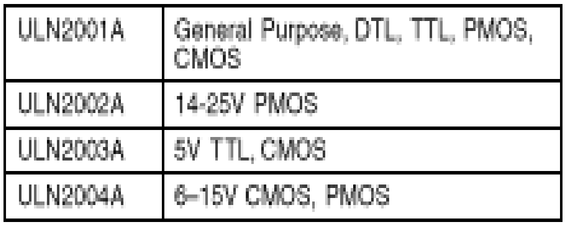


Fig. 3.2 ATMEGA-328 PIN Diagram

This ATMEGA-328 integrated chip consists of 28 pins. It consists of 6 analog inputs that are shown in the pin diagram. Analog inputs can be represented as PC0 to PC5. These analog input pins possess the continuous time signal which acts as an analog input for the system. Further it also consists of 12 digital inputs. It can be represented as PD1 to PD11 which act as a digital input ports based on pulse width modulation (PWM). These PWM, which transmits the signal in the form of discredited form. Both analog and digital input ports can be used for various applications for the input power supply, VCC and GND pins are used. Pins PB6 and PB7, which acts as a crystal to generate a clock signal. By using these crystal, we can generate the clock signals and by these clock signals, we can use this clock signals for input sources. PC6 pin are the one where it can be used for the reset option. Resetting the program can be done by using this PC6 pin.

3.3 ULN2003 DRIVER:

The ULN2001A, ULN2002A, ULN2003 and ULN2004Aare high voltage, high current Darlington arrays each containing seven open collector dar-lington pairs with common emitters. Each channel rated at 500mAand can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout. The four versions interface to all common logic families



ULN2001A	General Purpose, DTL, TTL, PMOS, CMOS
ULN2002A	14-25V PMOS
ULN2003A	5V TTL, CMOS
ULN2004A	6–15V CMOS, PMOS

These versatile devices are useful for driving a wide range of loads including solenoids, relays DC motors; LED displays filament lamps, thermal print-head sand high power buffers ULN2001A/2002A/2003Aand 2004A is sup-plied in 16 pin plastic DIP packages with a copper lead frame to reduce thermal resistance. They are available also in small outline package (SO-16) as ULN2001D/2002D/2003D/2004D.

3.3.1 Pin Diagram - ULN 2003

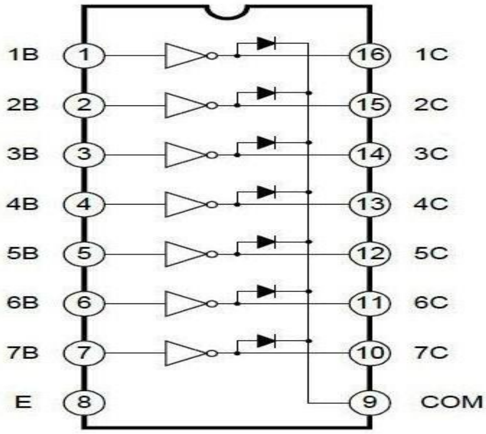


Fig. 3.3 Pin Diagram - ULN 2003

The ULN2003A is a high voltage, high current, Darlington Arrays each containing seven open collection Darlington pairs with common emitters. Each channel rated at 500mA and can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite to outputs to simplify layout. It is a 5V TTL, CMOS. This versatile device is useful for driving a wide range of loads including solenoids, relays, DC motors, LED displays,and high power buffers. Outputs can be paralleled for higher current.

3.4 RELAY

Relay Pin Diagram

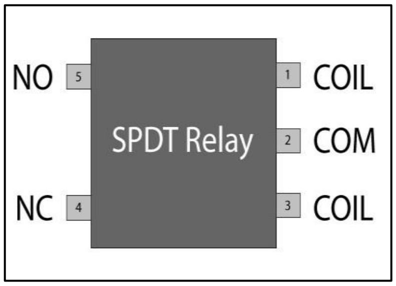


Fig. 3.4 Relay Pin Diagram

Relays are switching devices. Switching devices are the heart of industrial electronic systems. When a relay is energized or activated, contacts are made or broken. They are used to control ac or dc power. They are used to control the sequence of events in the operation of a system such as an electronic heater, counter, welding circuits, and X-ray equipment, measuring systems, alarm systems and telephony. Electromagnetic relays are forms of electromagnets in which the coil current produces a magnetic effect. It pulls or pushes flat soft iron armatures or strips carrying relay contacts. Several relay contact can be operated to get several possible ON/OFF combinations.

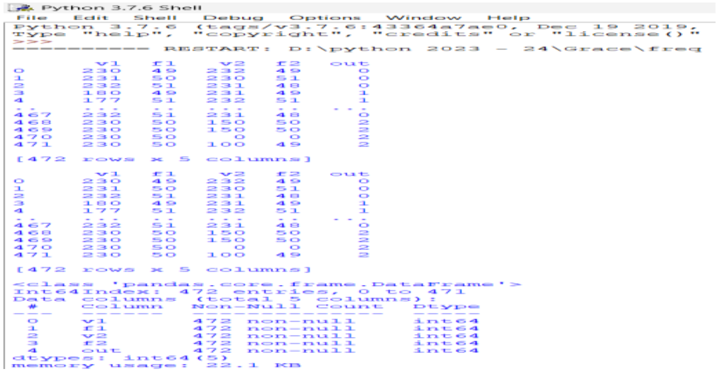
3.5 LCD DISPLAY

Fig 3.5 LCD Display

Liquid Crystal Displays (LCDs) have materials, which combine the properties of both liquid and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal. An LCD consists of two glass panels, with the liquid crystal material sand witched in between them. The inner surface of the glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle. One each polarizer are pasted outside the two glass panels. This polarizer would rotate the light rays passing through them to a definite angle, in a particular direction. When the LCD is in the off state, light rays are rotated by the two polarizer and the liquid crystal, such that the light rays come out of the LCD without any orientation, and hence the LCD appears transparent. When sufficient voltage is applied to the electrodes, the liquid crystal molecules would be aligned in a specific direction.

RESULT

4.1 TRAINING

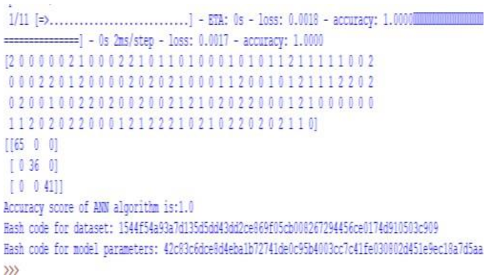


```
Python 3.7.6 (tags/v3.7.6:43364a7ae0, Dec 19 2019,
Type "help", "copyright", "credits" or "license()"
>>>
=========== RESTART: D:\python 2023 - 24\Grace\freq
        v1   f1    v2   f2  out
0      230   49   232   49    0
1      231   50   230   51    0
2      232   51   231   48    0
3      180   49   231   49    1
4      177   51   232   51    1
..     ...   ..   ...   ..  ...
467    232   51   231   48    0
468    230   50   150   50    2
469    230   50   150   50    2
470    230   50     0    0    2
471    230   50   100   49    2

[472 rows x 5 columns]
        v1   f1    v2   f2  out
0      230   49   232   49    0
1      231   50   230   51    0
2      232   51   231   48    0
3      180   49   231   49    1
4      177   51   232   51    1
..     ...   ..   ...   ..  ...
467    232   51   231   48    0
468    230   50   150   50    2
469    230   50   150   50    2
470    230   50     0    0    2
471    230   50   100   49    2

[472 rows x 5 columns]
<class 'pandas.core.frame.DataFrame'>
Int64Index: 472 entries, 0 to 471
Data columns (total 5 columns):
 #   Column  Non-Null Count  Dtype
---  ------  --------------  -----
 0   v1      472 non-null    int64
 1   f1      472 non-null    int64
 2   v2      472 non-null    int64
 3   f2      472 non-null    int64
 4   out     472 non-null    int64
dtypes: int64(5)
memory usage: 22.1 KB
```

Fig 4.1 Training Process



```
 1/11 [=>............................] - ETA: 0s - loss: 0.0018 - accuracy: 1.0000
==============] - 0s 2ms/step - loss: 0.0017 - accuracy: 1.0000
[2 0 0 0 0 0 2 1 0 0 0 2 2 1 0 1 1 0 1 0 0 0 1 0 1 0 1 1 2 1 1 1 1 1 0 0 2
 0 0 0 2 2 0 1 2 0 0 0 0 2 0 2 0 2 1 0 0 0 1 1 2 0 0 1 0 1 2 1 1 1 1 2 2 0 2
 0 2 0 0 1 0 0 2 2 0 2 0 0 2 0 0 2 1 2 1 0 2 0 2 2 0 0 0 1 2 1 0 0 0 0 0 0
 1 1 2 0 2 0 2 2 0 0 0 1 2 1 2 2 2 1 0 2 1 0 2 2 0 2 0 2 1 1 0]
[[65  0  0]
 [ 0 36  0]
 [ 0  0 41]]
Accuracy score of ANN algorithm is:1.0
Hash code for dataset: 1544f54a93a7d135d5dd43dd2ce869f05cb008267294456ce0174d910503c909
Hash code for model parameters: 42c83c6dce8d4eba1b72741de0c95b4003cc7c41fe030802d451e9ec18a7d5aa
>>>
```

Fig 4.2 Training Result in accuracy in block chain

The above figure 4.2 Training Result in Accuracy score of ANN Algorithm is 1.0,Hash code for dataset and Hash code for model parameter generate to using block chain

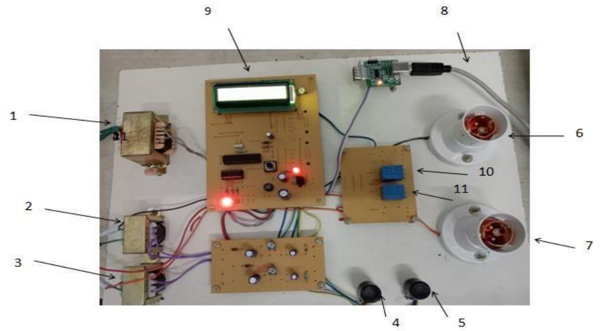


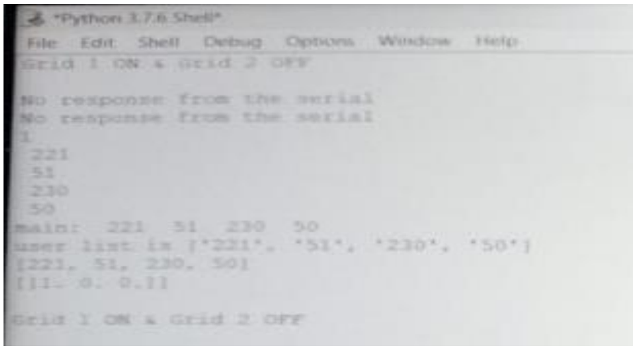
Fig 4.3 Hardware Setup for Grid stability management using **ML and Block chain**

1. Power Transformer
2. Potential Transformer for Grid 1
3. Potential Transformer for Grid 2
4. Frequency 1
5. Frequency 2
6. Grid 1
7. Grid 2
8. USB to Serial
9. LCD Display
10. Relay 1
11. Relay 2

4.2 TESTING

Fig 4.4 Hardware display Side

Grid 1 voltage (V) and Grid 1 Frequency(F) 51 . Grid 2 voltage (V1) 230 and Grid 2 Frequency (F1) 50 Status (S) this status monitoring the which grid is ON.



```
Grid 1 ON & Grid 2 OFF

No response from the serial
No response from the serial
1
 221
 51
 230
 50
main: 221 51 230 50
user list is ['221', '51', '230', '50']
[221, 51, 230, 50]
[[1. 0. 0.]]

Grid 1 ON & Grid 2 OFF
```

Fig 4.5 Test Result

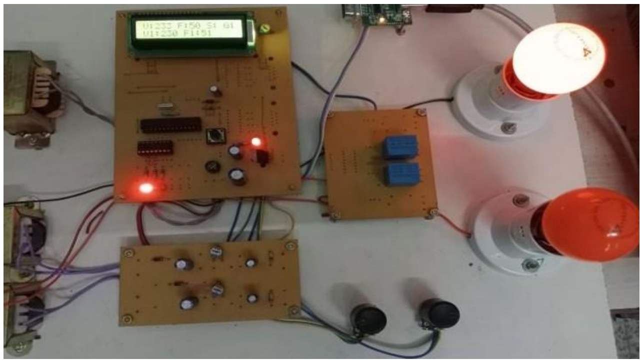
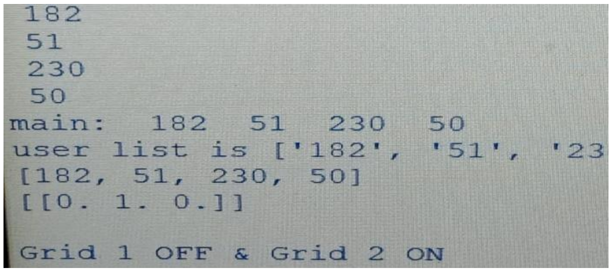


Fig 4.6 Hardware setup for Grid 1 is on

The above figure 4.4,4.5 , 4.6 In our project The Grid1 voltage 221 at same time the Frequency 51 and The voltage above 200 so the Grid 1 is ON

Fig 4.7 Hardware Display side

Grid 1 voltage(V) 182 and Grid 1 Frequency(F) 51. Grid 2 voltage(V1) 230 and Grid 2 Frequency(F1) 50 Status(G2)



```
182
51
230
50
main:  182  51  230  50
user list is ['182', '51', '23
[182, 51, 230, 50]
[[0. 1. 0.]]

Grid 1 OFF & Grid 2 ON
```

Fig 4.8 Test Result

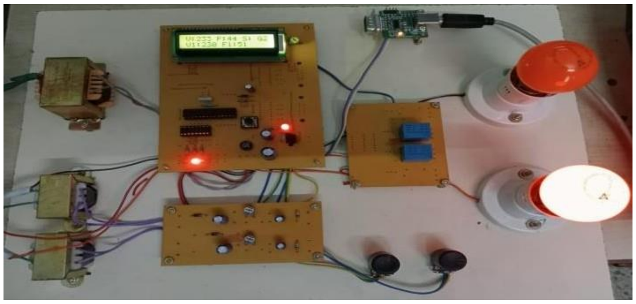


Fig 4.9 Hardware setup for Grid 2 is on

The above figure 4.7, 4.8, 4.9 1, In Our project The Grid1 voltage 182 at same time the frequency 51 and the voltage below 200 the Grid 1 Voltage is OFF so the grid 2 is ON.

4.3 WORKING PROCESS:

Block chain facilitates peer-to-peer energy trading among prosumers (producers and consumers) in a decentralized manner. Prosumers with excess energy from renewable sources like solar panels can sell their surplus to other users on the grid. Smart contracts on the block chain can automate these transactions, ensuring transparency and real-time settlement without intermediaries. Block chain can provide real-time data on energy production, consumption, and storage. This data, secured and immutable on the block chain, allows grid operators to monitor the grid's status more effectively. Block chain can help aggregate various distributed energy resources (DERs) such as solar panels, wind turbines, and battery storage systems. By using smart contracts, these resources can be optimized to stabilize the grid, either by providing power during peak demand or absorbing excess power during low demand. Block chain-enabled demand response programs can automatically adjust the energy usage of participating consumers based on grid conditions. Smart contracts can be used to incentivize consumers to reduce or shift their energy usage during peak times. Block chain can facilitate the management of micro grids, which are localized grids that can operate independently or in conjunction with the main grid. Micro grids can enhance grid stability by providing localized energy generation and storage. Block chain technology presents a promising solution for enhancing grid stability and energy management by enabling decentralized transactions, real-time monitoring, and integration of distributed energy resources.

CONCLUSION

This project demonstrates the significant potential of integrating machine learning (ML), blockchain technology, and hardware-based frequency controllers for enhancing the stability and reliability of electrical grids. The ML models provide powerful predictive capabilities for maintenance, demand forecasting, and anomaly detection, ensuring proactive grid management. Blockchain technology adds a layer of security and transparency through decentralized data management, immutable ledgers, and smart contracts, ensuring data integrity and facilitating automated and efficient operations.

The inclusion of hardware-based frequency controllers for Grid1 and Grid2 further strengthens grid stability by enabling precise real-time adjustments to maintain frequency stability, thus preventing deviations that could lead to outages or equipment damage. This multi-faceted approach addresses various aspects of grid management, from predictive analytics to secure data handling and real-time operational control.

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