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SHARAD INSTITUTE OF TECHNOLOGY, COLLEGE OF ENGINEERING

Yadrav (Ichalkarang Dist-Kolhapur (Maharashtra)

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Tarang

Technical Magazine

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Volume: VIII

DEPARTMENT OF ELECTRICAL ENGINEERING

Department Vision and Mission

VISION

To be a center of excellence in Electrical Engineering education to prepare professionally competent engineers with lifelong learning attitude for the accomplishment of ever-growing needs of society.

MISSION

- To prepare technically and professionally competent engineers by imparting quality education through effective teaching learning methodologies and providing stimulating environment for research and innovation.
- To develop professional skills and right attitude in students that will help them to succeed and progress in their personal and professional career.
- To imbibe moral and ethical values in students with concern to society and environment.

Program Educational Objectives (PEOs)

Graduates of the program will

- PEO I : Engage in design of system, tools & application in the field of electrical engineering & allied engineering industries.
- PEO II : Apply the knowledge of electrical engineering to solve problems of social relevance, pursue higher education & research.
- PEO III: Engage in lifelong learning, career enhancement & adapt to changing professional & societal needs.

Program Specific Outcomes (PSOs)

- PSO 1 : Identify, formulate and analyse electrical engineering problems for real life industrial and societal needs.
- PSO 2 : Design and develop systems in the emerging electrical engineering and allied disciplines to meet out the industry standards.

Executive Director 's Message:

Good things remain good only because they are always scant. I am glad to unfold this wonderful magazine as an appreciation of the admirable efforts put forth by the team. The effort taken to bring about content is appreciable. This is a productive technical material and subsidiary skill developing tool for the students. The release of this brilliant forth issue of the technical magazine "TARANG" has added the value of department. I also applaud the coordination & efforts behind the team to bring out this issue.

Hon. Shri Anil A Bagane

Executive Director

Principal's Message:

We have been gifted with this blessed life. The program of society is mainly depended on many people who are working behind the scenes, overtime round the clock planning things to the smallest. This technical magazine will be a medium to provide proper acknowledgement and respect to all of this effort and its results. This is only small step towards a long journey. This fourth issue of technical magazine should inspire all of us for a new beginning enlighten with hope, confidence and faith in each other In the road ahead for innovation work. It is expected that wide support for this mission will be provided through the reader's valuable suggestions and comments……. Happy reading.

Dr. Sanjay A Khot

Principal

HOD’S Message:

I feel delight to introduced Seventh Issue of Technical Magazine prepared by department of Electrical Engineering. We at SITCOE promise of increasing the knowledge, enhancing the critical thinking, ability to change information into knowledge & power of analyzing the things technically of each & every individual of ever-changing society through students.

Dr. K Hussain

Head of the Department

Dept. of Electrical Engineering

FACULTY editor Message:

Greetings from the Editorial members board of the Technical Magazine “TARANG Volume VIII”. It is the snap shot of the various technologies and technological changes associated with Electrical Engineering.

We profusely thank our Honorable Executive Director Shri Anil Bagane, Principal Dr. Sanjay A Khot and Head of Electrical Engineering Department Dr. K Hussain for giving support and encouragement and a free hand in this endeavor. This Technical Magazine will be a medium to provide proper acknowledgement and respect to all of those efforts and its results

Wishing you Happy Reading

Mr. Chandrashekhar Patil

Assistant Professor

Third Year Electrical Engineering:

It's truly an interesting and exciting experience for all of us as student editors of this technical magazine "TARANG Volume VIII for was one such cherished work that had its roots in the persuasion. It would be a snap shot of the various activities and advancements in the field of Electrical Engineering Dept.

This Technical Magazine will serve to reinforce and allow increased awareness about research activities. Interaction and Team Work among all of us, usually we fail to appreciate the good deeds of many people and activities that happen around us as we are engaged in irrelevant talks and assumptions. It could all change if we just pause to think of what is our contribution to the society.

Miss. Vaishnavi Arvind Mane

TY Electrical

Miss. Sharada Manoj Mane

TY Electrical

Miss. Vaibhavi Dilip Mali

TY Electrical

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2	PV BASED KY CONVERTER USING FUZZY LOGIC.
3	CHARGING MOBILE DEVICE WITH FREE ENERGY FROM PIEZO SENSOR IN SHOES.
4	CENTRALIZED MONITORING SYSTEM IN COLLEGE CAMPUS LIGHTING
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6	RE FOR RURAL ELECTRIFICATION IN INDIA
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HOME AUTOMATION USING IOT

Name: Mr. Aniket Vasant Patil
Mr. Nouman Shoukat Mujawar
Mr. Swapnil Subhash Nikam
Mr. Amit Anil Kurhade
Class: TY Electrical

Abstract

This project presents the design and implementation of a low-cost, wireless Home Automation System (HAS) using IoT. The system controls various home appliances through a Node MCU platform, enabling remote access via a smartphone. Utilizing cloud server- based communication, the system supports elderly and disabled individuals by automating home appliances, thereby enhancing convenience and quality of life.

Keywords

Home Automation, IoT, Node MCU, Wireless System, Smart Home

Introduction

With the rapid advancements in technology, home automation has emerged as a significant area of innovation, enhancing the quality of life by providing increased convenience, security, and energy efficiency. The integration of Internet of Things (IoT) in home automation systems allows for the seamless control of various home appliances through remote access. This project focuses on the design and implementation of an IoT-based Home Automation System (HAS) using the Node MCU platform, aimed at creating a flexible, cost-effective, and user-friendly solution.

Objectives

- To control and monitor a wide range of devices and systems from a centralized location using a smartphone or laptop.
- To develop an application with switch and voice control modes.
- To ensure secure connection channels between the application and Node MCU.

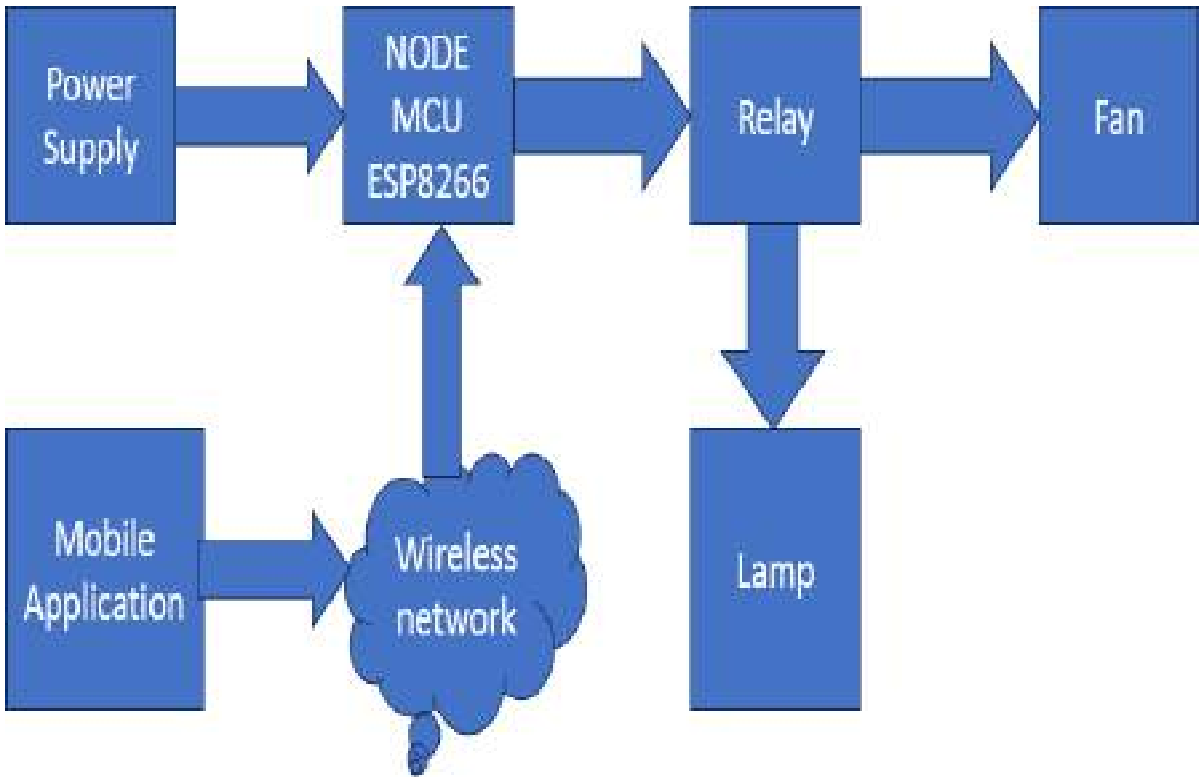
- To achieve flexibility in the control of home appliances using Wi-Fi-capable devices.

Problem Statement

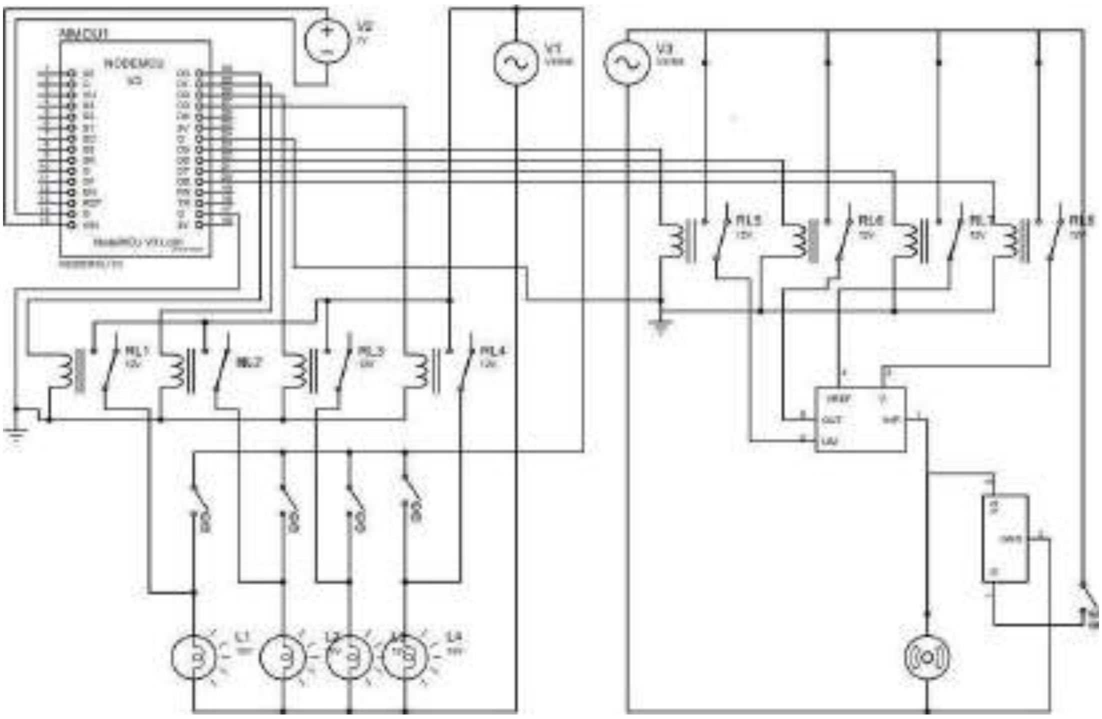
Traditional home automation systems often involve complex wiring and high costs, making them inaccessible to many households. There is a need for an affordable, flexible, and easy-to-install solution that leverages the capabilities of IoT to enhance the convenience and quality of life, especially for the elderly and disabled.

Methodology

Block Diagram: The block diagram of the system illustrates the interaction between various components, including the Node MCU, relay modules, and connected home appliances. The Node MCU acts as the central controller, receiving commands from the mobile application via a Wi-Fi network and controlling the relays to switch appliances on or off.



Circuit Diagram: The circuit setup includes the Node MCU connected to multiple relay modules, which in turn are connected to different home appliances. The Node MCU is programmed to communicate with the relays and execute commands received from the mobile application.



Hardware Description:

Node MCU: A low-cost, open-source IoT platform that provides a simple way to control appliances wirelessly.

Relay Modules: Used to control the power supply to the connected appliances, enabling or disabling them based on the received commands.

Power Supply: Ensures the operation of the Node MCU and relay modules.

Software Description:

Blynk App: A mobile application used for creating a graphical user interface (GUI) to control the home appliances remotely.

It communicates with the Node MCU via the cloud server.

Arduino IDE: Used for programming the Node MCU with the required code to handle the communication and control logic.

Implementation

The implementation process involved setting up the hardware components and programming the Node MCU. The steps included:

Connecting the Node MCU to the relay modules and configuring the power supply. Writing and uploading the control code to the Node MCU using the Arduino IDE.

Setting up the Blynk app on a smartphone and configuring it to communicate with the Node MCU.
Testing the system by sending commands from the app to control the connected appliances.

Results
The Home Automation System was successfully implemented, allowing for the remote control of various home appliances through the Blynk app. The system demonstrated reliable performance with quick response times and stable connections. It provided significant convenience, particularly for elderly and disabled individuals, by enabling easy control of home environments.

Applications
The system has numerous applications in real-life scenarios, including:
Enhancing the convenience and quality of life for elderly and disabled individuals by automating home appliances.
Improving energy efficiency by allowing for remote control and monitoring of electrical devices.
Increasing home security through the integration of smart sensors and automated controls.

Conclusion:
The project successfully demonstrated the feasibility of a low-cost, flexible, and user-friendly Home Automation System using IoT. The system's design and implementation provide a practical solution for enhancing home convenience and energy efficiency. Future improvements could include the integration of additional smart sensors and expanded control capabilities.

References

- By Aaditya Gupta Shah, Aashish Gaurav, Abhishek Anand, Ganesh Kumar Shah “HOME AUTOMATION SYSTEM” on International Research Journal of Modernization in Engineering Technology and Science Volume:03, Issue:04 April 2021.

Appendix

```
#defineBLYNK_TEMPLATE_ID "TMPL3cZwRsPeD"#define BLYNK_TEMPLATE_NAME
"NNN01"
#define BLYNK_AUTH_TOKEN "IRgdgDFQf51sC73LTDiRicMhhttBSsK1"
#define BLYNK_PRINT Serial#include <gpio.h>
#include     <ESP8266WiFi.h> #include
<BlynkSimpleEsp8266.h>char auth[]= BLYNK_AUTH_TOKEN;
char ssid[]="NNN"; // Your Wifi Name
char pass[]="nnnnnnnn"; // Your Wifi Password
//lamp01 BLYNK_WRITE(V0)
{
int value= param.asInt(); Serial.println(value);
if (value == 1)
{
digitalWrite(D0, LOW); Serial.println("LED ON
}
if (value == 0)
{
digitalWrite(D0, HIGH); Serial.println("LED OFF");
}
}

//lamp02 BLYNK_WRITE(V1)
{
int value = param.asInt(); Serial.println(value);
if (value == 1)
{
digitalWrite(D1, LOW); Serial.println("LED ON");
}
if(value == 0)
{
digitalWrite(D1, HIGH); Serial.println("LED OFF");
}
}
```

```
//lamp03 BLYNK_WRITE(V2)
{int value =param.asInt(); Serial.println(value);
if (value == 1)
{
digitalWrite(D2, LOW); Serial.println("LED ON");
}
if (value == 0)

{
digitalWrite(D2, HIGH); Serial.println("LED OFF");
}
}

//lamp04 BLYNK_WRITE(V3)

{
int value = param.asInt(); Serial.println(value);
if (value == 1)
{
digitalWrite(D3, LOW); Serial.println("LED ON");
}
if (value == 0)
{
digitalWrite(D3, HIGH); Serial.println("LED OFF");
}
}
//fan
//speed01 BLYNK_WRITE(V5)
{
int value = param.asInt(); Serial.println(value);
if (value == 1 )
{
digitalWrite(D5,        LOW);        Serial.println("LED        ON")
```

PV BASED KY CONVERTER USING FUZZY LOGIC

Name: Mr. Atharav Rajkumar Patil
Mr. Sahil Mahadev More
Mr. Shital Sujit Bharamgonda
Mr. Abhay Suresh Dhulasawant
Class: TY Electrical Engineering

Abstract:
A PV-based Ky converter with a fuzzy logic controller for efficient electric vehicle (EV) battery charging. The proposed system utilizes a Ky converter to optimize the power conversion from photovoltaic (PV) panels to the EV battery, while the fuzzy logic controller adapts to changing weather conditions, battery state of charge, and charging patterns to ensure efficient and safe charging. Simulation results show improved charging efficiency, reduced charging time, and enhanced overall performance compared to conventional charging systems. The fuzzy logic controller also ensures optimal PV power tracking, grid support, and battery longevity. This innovative approach has significant potential for widespread adoption in sustainable EV charging infrastructure, promoting renewable energy integration and reducing greenhouse gas emissions.
Keywords: PV-based Ky converter, fuzzy logic controller, electric vehicle battery charging, efficient charging, sustainable energy, renewable energy integration.

Introduction:

With the increasing expense and constrained accessibility of fossil fuels, much consideration has been converged around the utilization of renewable energy sources for electrical power generation. Renewable power is getting more consideration a wide scope of applications. with the growing demand for electric vehicle (EVs) comes the need for efficient and intelligent charging stations. However, the intermittent nature of solar power generation poses challenges for reliable and efficient charging station.

To address these challenges, this study proposes a PV- based KY converter integrated with a fuzzy logic controller (FLC) for EV battery charging. The KY converter is chosen for its robustness and ability to handle uncertainties in the system, making it suitable for the varying solar power output. Fuzzy logic control provides a flexible and adaptive approach to regulating the charging process, allowing for utilization of solar energy while ensuring battery health and safety. This Paper aims to investigate the feasibility and effectiveness of the proposed system improved in sustainable and intelligent charging for EVs. The integration of PV, KY converter, and FLC offers advantages such as increased energy efficiency, reduced dependency on the grid, and enhanced control over charging process. The study will include simulation and experimental results to validates the performance of the system under different operating condition and load profiles.Overall, this research contributes to the advancement of renewable energy integration in transportation ad lays the foundation in for smart and eco-friendly EV charging infrastructure.

Methodology:

Block Diagram

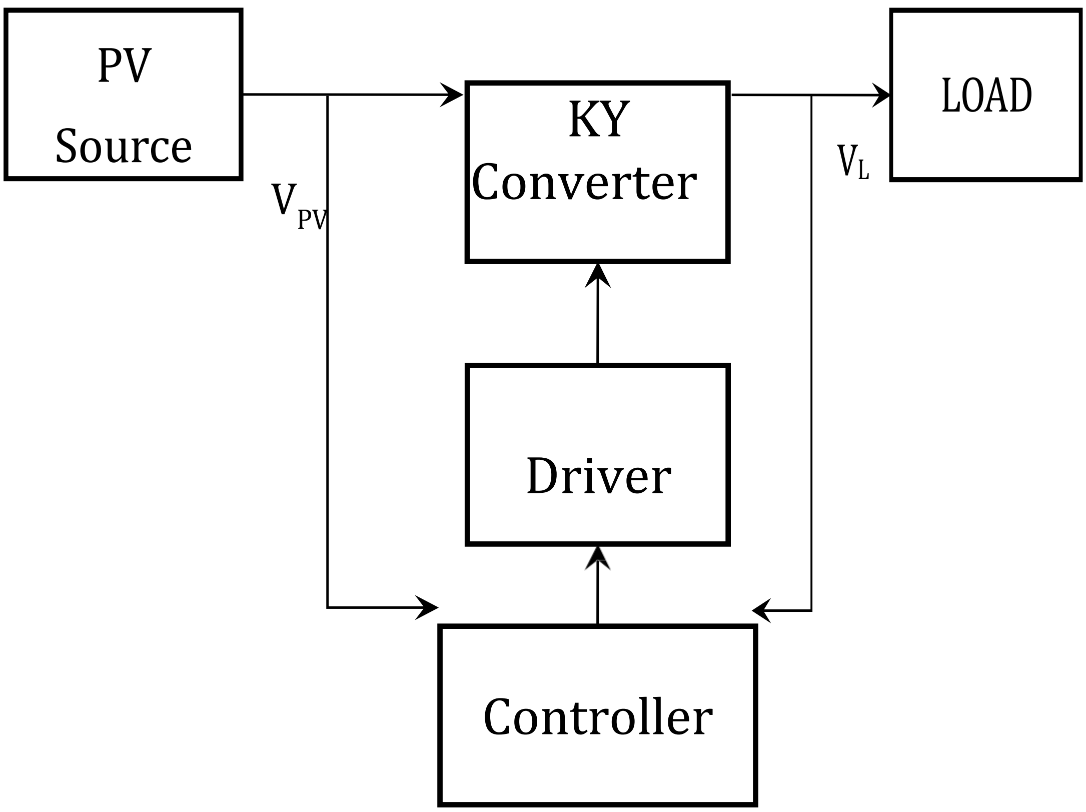


Fig. Block diagram of proposed system

Component Selection

MOSFET Selection

For selection of MOSFET, the voltage and current requirements of the load are considered. The voltage rating of load is rated at 20V and power rating is 50W, hence its current is considered to be 2.5A. For selecting MOSFET voltage rating shall be greater than three times working voltage (Voltage > 60V) and current rating shall be greater than two times working current (Current>5A). Hence MOSFET IRF250 is selected having following specifications.

Fig. IRF250MOSFET

V_{DSS}=200V

I_D= 20A

Driver Selection

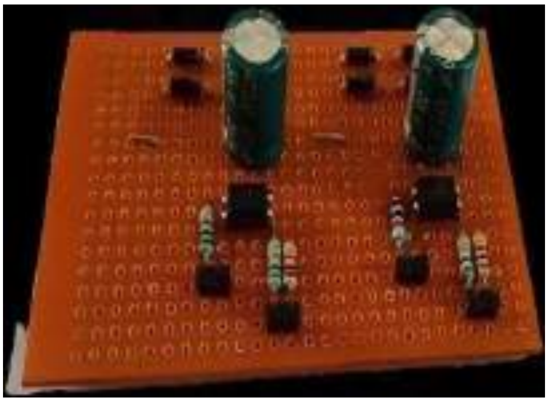


Fig. driver circuit for MOSFET

MOSFET is power electronic switching device operating at high voltage. The microcontroller gives control signal in form of PWM. The desired isolation and coupling between low voltage microcontroller and high voltage MOSFET is provided throughMCT2E based opto coupler driver circuit as mentioned in figure 4.

Voltage Sensor

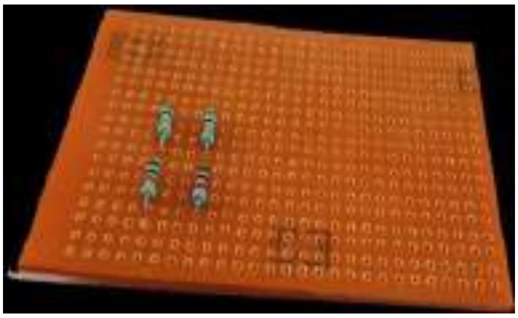


Fig. Voltage sensor with voltage divider arrangement

For voltage sensing, a voltage divider arrangement is used as shown in figure. The maximum possible input voltage is considered to be 50V.The PIC controller can with stand maximum of 5V voltage level. Hence voltage divider components should be designed to get output voltage of 5v.

Hence, the values of resistors in voltage divider configuration are selected as R1 = 10KΩ, 0.25W R2=1KΩ, 0.2

DC Supply for Gate Drive Circuit

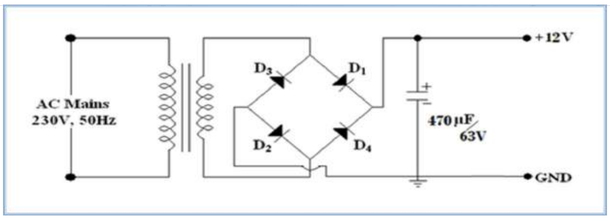


Fig. DC power Supply for drivers

DC supply for gate drive circuit is shown in figure. It comprises of transformer (step- down), bridge rectifier and capacitor filter.

Selection of Transformer:

The required output voltage from DC supply is 12 V and output current is 1A.

But output of filter should be 2 to 3V greater than 12V i.e. V_{dc} at filter=14V.

Selection of Diode:

The step-downed AC voltage is given to bridge rectifier which transforms into DC. During positive half cycle of AC signal, only two diodes (D_1, D_2) are in conducting state, while in negative half cycle, the remaining two diodes (D_3, D_4) are to be conducted. So, in both half cycles, current flows through load in only one direction but magnitude changes continuously.

Thus output of rectifier becomes pulsating DC. For rectification, diodes with following rating are required. Peak Inverse voltage of diode PIV>2V_m. i.e. PIV>2X22=44V. Diode current > load current > 1A So, 1N4007 diode has been selected.

Selection of Capacitor:

The frequency of rectifier output is 100Hz.Therefore, ΔT =1/F, the time period = 1/100Hz= 0.01S=10mS. Assume voltage change in capacitor of 10% when minimum input voltage of 207V.$\Delta V=184\times 0.1\times\sqrt{2}=26V$

The current drawn at full load I_{dc}=1A

Selected Capacitance

$C=470\mu F$

$C=0.000384F=384\mu F$

LCD Display

Fig. LCD display

This is a basic 16 character by 2-line alphanumeric display. Black text on green background. Utilizes the extremely common HD44780 parallel interface chipset. Interface code is freely available. You will need Minimum 6 general I/O pins to interface to this LCD screen. Includes LED backlight. Works in 4bit and 8-bit Mode.

Features:

16 Characters x2Lines

Green Backlight

5x7DotMatrixCharacter+Cursor

HD44780EquivalentLCDController/ driver Built-In

4-bitor8-bitMPUInterface

Standard Type

Works with almost any Microcontroller

PV Panel

Fig. Photograph of PV Panel

For development of prototype hardware, PV panels with following specifications are selected:

Voltage: 12V

Power: 50W

Current: 4.2A

Controller

Fig. PIC 16F877A Microcontroller

Flash memory (program memory, programmed using MPLAB devices)

SRAM (data memory)

EEPROM (programmable at run-time)

Sleep mode (power savings)

Watch dog timer

Various crystal or RC oscillator configurations, or an external clock

Battery Selection- Lithium Polymer

A lithium polymer battery (LiPo, LIP, or Li-Poly) is a rechargeable battery with a soft polymer casing and a soft external" pouch" for the lithium-ion battery inside. It could also be a lithium-ion battery with a gelled polymer as the electrolyte. However, the term is most commonly used to describe a type of lithium-ion battery that comes in a pouch. The more accurate name for this type of battery is lithium-ion polymer battery.

Lithium-polymer batteries are lighter and more flexible than other kinds of lithium-ion batteries because of their soft shells, allowing them to be used in mobile and other electronic devices, as well as in remote control vehicles.

Lithium-Polymer (LiPo) batteries are the latest iteration of rechargeable battery technology. They have a number of advantages over other types, such as the Li polymer battery having higher energy density and longer service life due to their pouch cell construction that uses less space than traditional cylindrical cells. LiPo batteries also boast better performance in high temperature environments because they can handle larger charge/discharge currents with more stability compared to other chemistries. The thin film packaging reduces possible damage from physical shock or vibration, while also enabling these power sources to be lighter weight for applications requiring portability or mobility like drones and wireless speakers. Finally, greater flexibility creates opportunities for customizing design size when powering consumer electronics including smart phones and tablets making the man ideal choice wherever reliability is essential!

Table- Difference between Lithium-ion and Lithium Polymer Battery

Parameters	Lithium-Ion	Lithium-Polymer
Energy Density	High	Low and decreased cycle count compared to Li-ion
Flexibility	Low	High, manufacturers are not bound by standard cell format
Weight	Relatively Heavier	Light
Capacity	Relatively Lower	Same Volume Li-Po batteries capacity is around two times of Li-ion battery
Lifespan	Long	Long
Explosive risk	Higher	Improved safety more resistant to overcharge; less chance for electrolyte leakage
Charging time	Relatively longer	Relatively shorter
Aging	Loseslessthan0.1 %per month	Lightly slower than LI-Ion
Price	Cheaper	Expensive

Future Scope:

It can be replaced in place of conventional DC-DC boost converter in various industrial applications where voltage boosting is done.

Applications in Renewable Energy:

Utilization of KY Converter with fuzzy logic controller in renewable energy systems like solar or wind power for efficient power conversion and grid integration.

Industrial Automation:

Implementation in industrial automation systems for power management, voltage Regulation, and energy efficiency improvement.

Research and Development:

Continued research and development to explore new applications, improve performance, and adapt the technology to emerging needs in various industries.

Electric Vehicles:

Application in electric vehicle charging stations for efficient power Conversion and control, enabling faster and smarter charging.

Results:

Simulation:

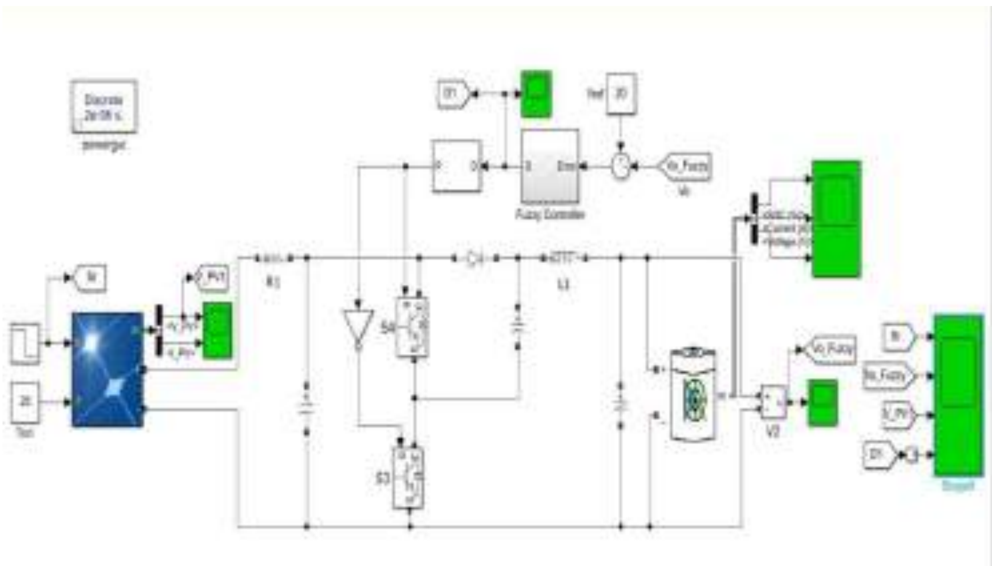


Fig. Simulation of KY Converter Using Fuzzy logic Controller

Simulation Results:

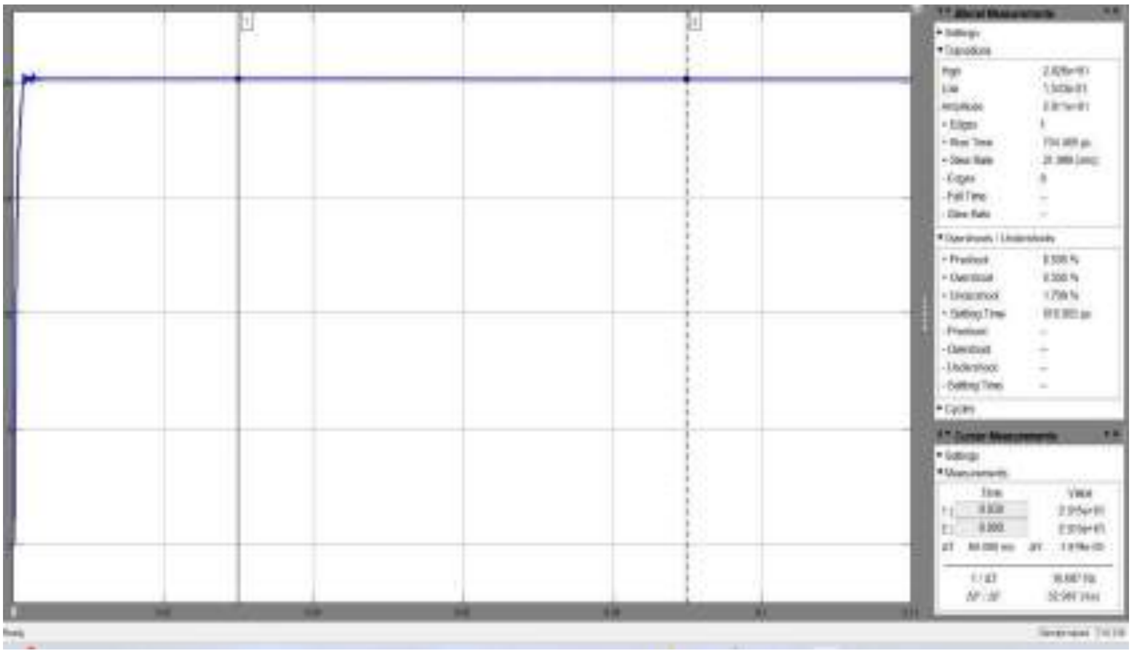


Fig.5.2 Output Voltage for Battery

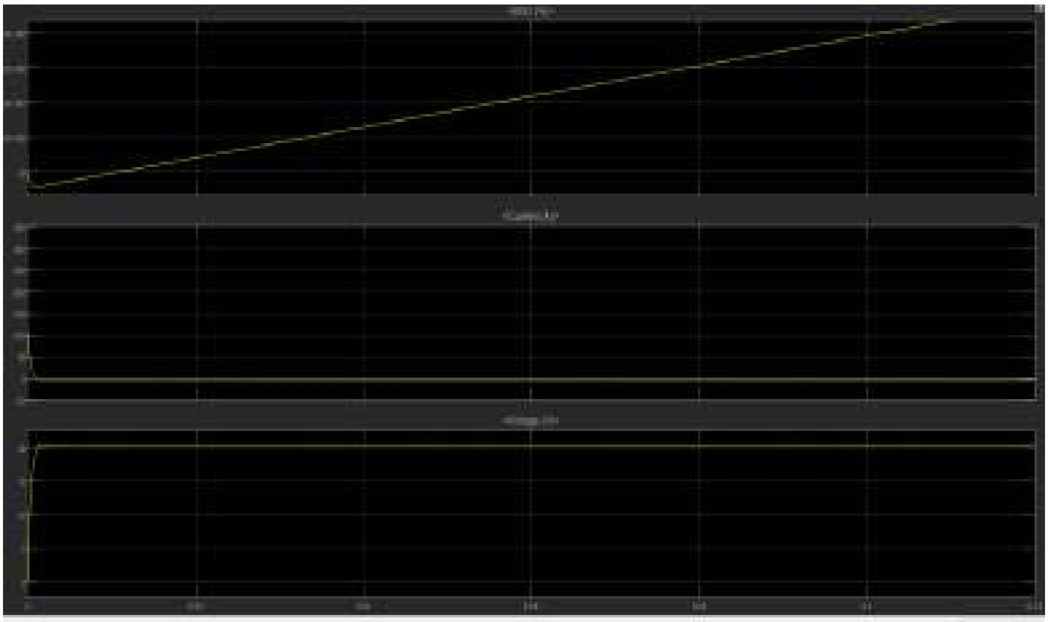


Fig. Battery Parameters

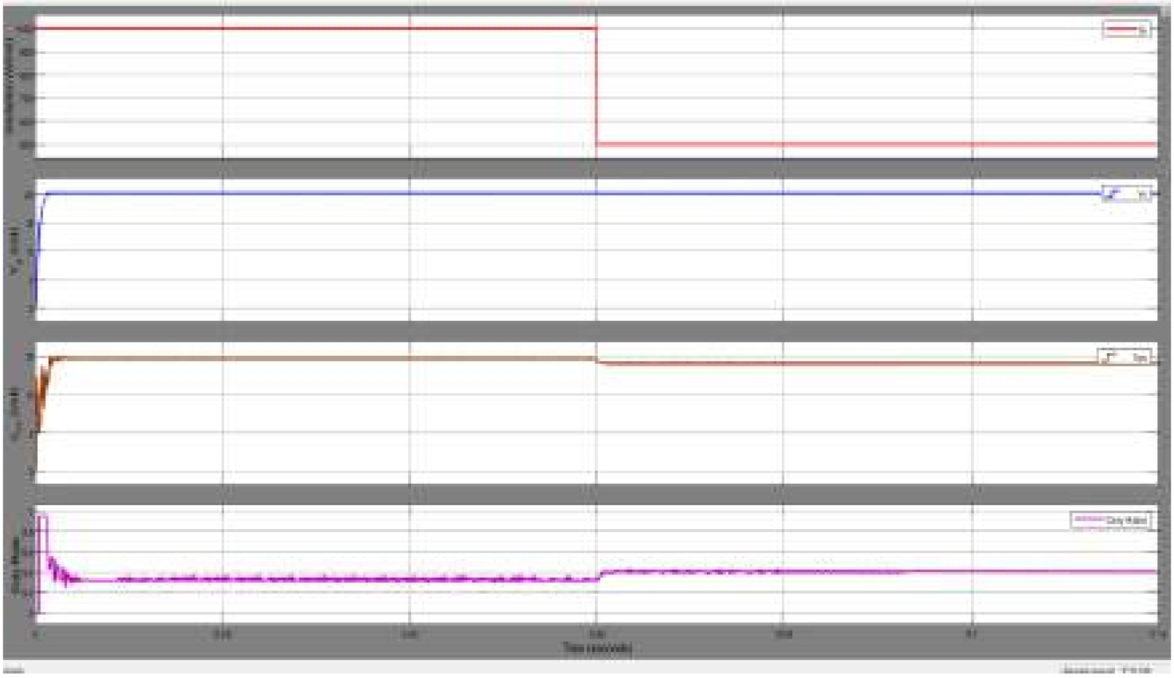


Fig. Solar Irradiation, Vout, Vpv & Duty Ratio

Result of Simulation & Discussion:

Now, Let’s discuss the results we got by the simulation, We are giving the input of 12 V and getting output 20V. This output power we are utilizing for battery charging. At the time of charging the voltage level is at 20 V and slightly increases and Current level is at −1 and slightly goes below this level. Negative sign of current level indicates battery is at charging condition. We can also see that when solar irradiation decreases voltage level of Pane also decreases but due to fuzzy logic controller duty ratio increases and it keep constant to the output voltage

Hardware Implementation

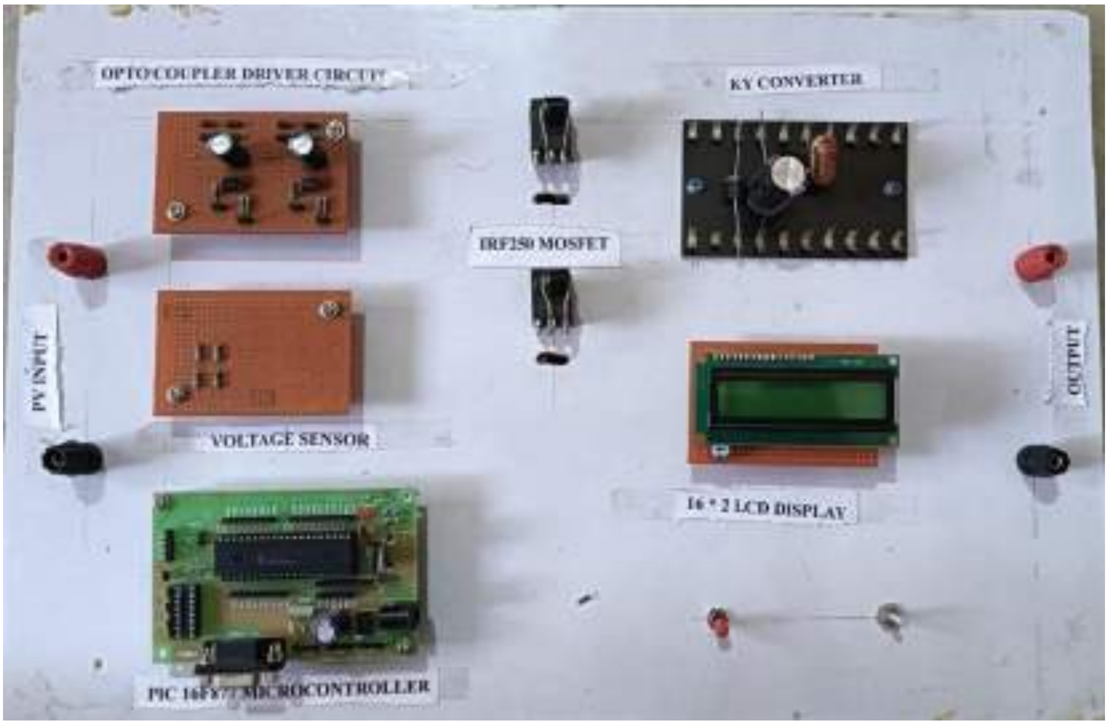


Fig. Hardware Implementation of KY converter.

References:

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Fuzzy Control Based High Voltage Gain Step-Up Converter Combining KY and Buck- Boost Converters Anju1, Rabiya Rasheed PG Student [PEPS], Dept. of EEE, Federal Institute of Science and Technology, Angamaly, Kerala, India1 Assistant Professor, Dept. of EEE, Federal Institute of Science and Technology, Angamaly, Kerala, India[2015]

CHARGING MOBILE DEVICE WITH FREE ENERGY FROM PIEZO SENSOR IN SHOES

Name: Mr. Avishkar Prashant Turambekar
Mr. Sumit Vijay Koshti
Mr. Shubham Sachin Pandharpatte
Mr. Aniket Prakash Patil
Class: TY Electrical

Abstract:

Harvesting mechanical energy from human movement is an appropriate approach for acquiring environment-friendly electrical energy. Common energy generation methods are pressure, heat and vibration. Researchers are consistently trying to find alternative ways to utilize clean energy wasted in environment in form of these resources. This paper demonstrates the method of harvesting energy from human walk. Generated electric energy can be used to power mobile phones, emergency flashlights, etc. It can also be utilized for uninterruptedly powering up a soldier's wearable electronics gadgets in military operations.

It can also be used to track any soldier's location in remote areas. It is based on a considerably designed structure of piezo transducers with a suitable thickness and diameter, which makes it easy-to-use and accordant with a shoe sole. When pressure is applied on piezoelectric discs, AC voltage is produced which is then converted for desired output. After receiving desired outcomes, this energy source can become a direct current (DC) power supply with a support from power management circuits. This energy can be stored in any external power storage. Our design will demonstrate the feasibility of harvesting electrical energy from piezoelectric to low power wearable devices.

Introduction:

In the recent years there has been an increasing interest in research and development of advanced smart phone technology. But as technology evolves so are the problems associated with it, and one among those is the fast draining of battery.

Almost every Smartphone user wishes he had more battery life. Now, imagine your phone getting charged where ever you go. This is possible by Piezo electric wire through power transfer mobile charging technique. The keys to this technique are the piezoelectricity.

The piezoelectric sensors are used in this innovative footstep power production system. The Piezo sensors are positioned below the platform to generate a voltage from footstep. The sensors are arranged in such a way that maximum output voltage is generated, which is then sent to Battery. We are used a piezoelectric module to the generator power and the power should be stored in the battery.

In order to fully appreciate the science behind this project, it is helpful to understand how it works. Essentially, the main power source that makes this project possible is something called a piezoelectric transducer (I know, it's a mouthful). Piezo electric transducers, or piezo elements, are comprised of materials such as crystals and certain ceramics that have a special property which allows them to convert physical energy into AC electricity. Fortunately, we can take advantage of this special property by putting piezo elements underneath our feet in such a way that every time we take a step, we are using our weight to push on the piezo electric elements- which then in turn convert that energy into electricity. The only issue with this, however is that we need DC, not AC in order to power our stuff. We can solve this problem by creating a bridge rectifier with diodes to convert the AC power to DC power we can use DC supply devices.

Literature Review:

Piezoelectric Energy Harvesting: Piezoelectric materials generate electrical energy when mechanical stress is applied. Researchers have been exploring ways to utilize this principle to capture energy from the movements of the human body, particularly from walking or running.

Material and Design Considerations: Research has focused on optimizing the materials and design of piezoelectric sensors to improve energy conversion efficiency and durability while maintaining comfort for the wearer.

Environmental Benefits: Energy harvesting from walking using piezoelectric sensors in shoes aligns with the broader goals of sustainable and eco-friendly energy sources, reducing the reliance on conventional batteries.

Market and Industry Trends: Some companies and startups have begun developing and marketing footwear with integrated energy harvesting technologies, indicating a growing interest in commercial applications.

Objectives:

The main purpose of foot step power generation is to provide more power by using Piezo. We generate free electricity using this sensor. Additionally, it can also be intended for lighting solutions like flashlights and emergency torch. the objective is to utilize piezoelectric sensors in shoes to capture energy from human motion, enhance the sustainability of wearable technology, reduce environmental impact, and improve the convenience of electronic devices, all while reducing the dependence on traditional power sources like batteries.

The objective is to develop energy harvesting systems that are unobtrusive and comfortable for the wearer. The technology should not impede natural movements or comfort while walking or running.

Block Diagram:

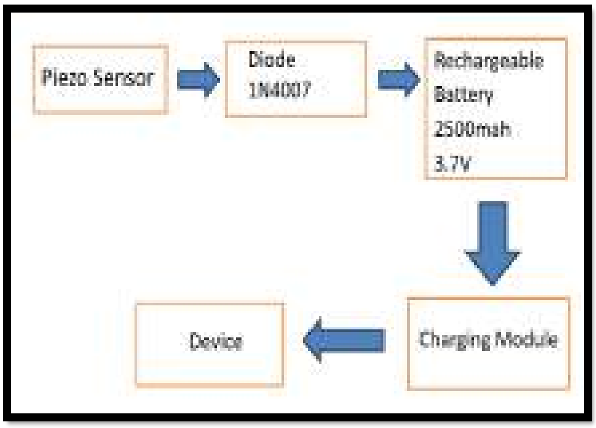

Fig.1. Block diagram of project

In this figure First piezo sensor is used for generate free energy; by applying pressure on piezo sensor this sensor is generate AC voltage. Piezo sensor is connected to 4 diodes connected as bridge rectifier for convert AC voltage to DC voltage. And this converted voltage flow to rechargeable battery is connected charging module to store the energy in battery.

This stored DC source used for charging devices using charging cable. This generated energy used for emergency for charging phone, torch and small appliances.

Circuit Diagram:

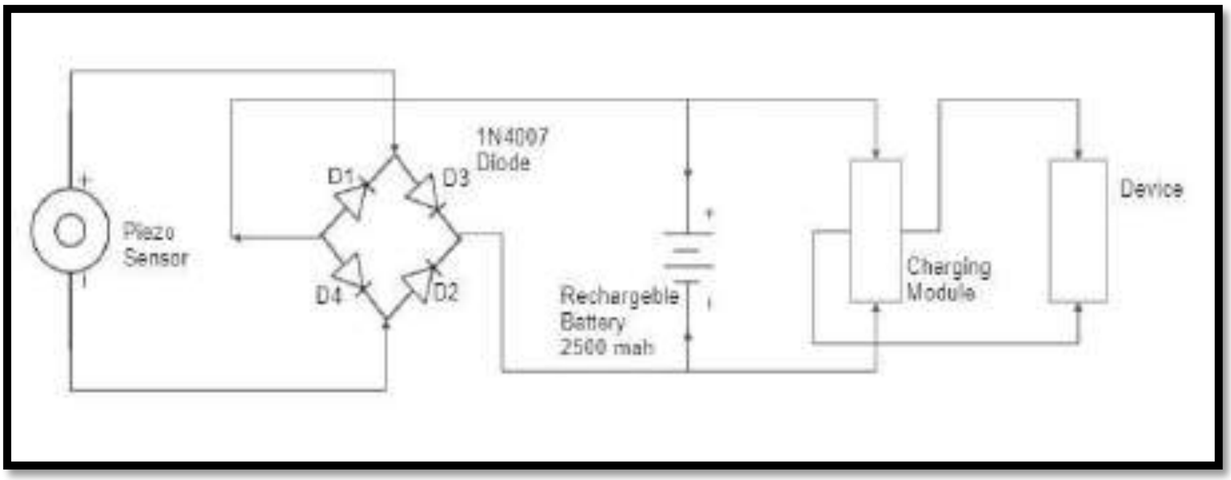

Fig.2.Circuit Diagram of project.

Working:

Essentially, the main power source that makes this project possible is something called a piezoelectric transducer. Piezo electric transducers, or piezo elements, are comprised of materials such as crystals and certain ceramics that have a special property which allows them to convert physical energy into AC electricity. Fortunately, we can take advantage of this special property by putting piezo elements underneath our feet in such a way that every time we take a step, we are using our weight to push on the piezo electric elements- which then in turn convert that energy into electricity.

The only issue with this, however is that we need DC, not AC in order to power our stuff. We can solve this problem by creating a bridge rectifier with diodes to convert the AC power to DC power we can use. In order to make our piezoelectric generator, we are going to need a plastic base. I have provided the links to my tinker cad files below. Feel free to customize them to suit your needs/foot measurements.

The piezo element holes are strategically placed so that they line up with the large indents on my shoe's insole, which indicate the areas of most pressure. These files are based off of my foot, which is a size US 9. Although my heel piece fit perfectly, my toe piece required a good bit of sanding in order to get it to fit properly.

Components Table:

Sr.No.	Components	Specification	Quantity
1	Piezo Sensor	25mm	12
2	Rechargeable battery	2500mah	2
3	Diode 1N40007	-	18
4	Battery case	-	2
5	Charging Module	-	1
6	Shoes	-	1
7	wires	1mm	As required
8	Charging Cable	C type	1
9	Device	-	1

Components:

Piezo Sensor:

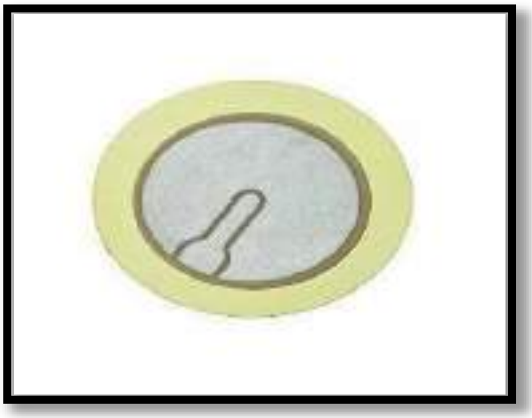

Fig.3. Piezo Sensor.

A piezo sensor, also known as a piezoelectric sensor, is a device that uses the piezoelectric effect to measure changes in pressure, acceleration, temperature, or force by converting them into electrical signals. The piezoelectric effect is a property of certain materials (such as quartz crystals and certain ceramics) where they generate a voltage when mechanical stress or deformation is applied to them generate electrical energy.

Diode 1N4007:

Fig.4. Diode 1N4007.

The 1N4007 diode is Rectifier Diode with molded plastic case. The rectifier diode has high current capability and low voltage drop. This diode is used for convert energy AC to DC energy. The 1N4007 is a commonly used rectifier diode. It is part of the 1N400x series of diodes, which includes a range of diodes with varying voltage and current ratings.

Rechargeable battery:

Fig. Rechargeable battery

Rechargeable batteries, also known as secondary batteries, are energy storage devices that can be charged and discharged multiple times. Unlike disposable or primary batteries, which are single-use and not rechargeable, rechargeable batteries are designed for repeated cycles of charging and discharging. These batteries are commonly used in a wide range of portable electronic devices and applications.

Battery case:

Fig.6. Battery Case.

A rechargeable battery case is used for install the battery and connects the battery to source or device. This case is installed on shoe for battery installed in case. This battery case is used for projection and connecting the wires.

Charging module:

Fig.7. Charging module.

A charging module typically refers to an electronic component or device used to manage the charging of batteries or devices. These modules can be found in various applications, such as smart phones, laptops, power banks, and electric vehicles. They often include features like voltage regulation, current control, and safety mechanisms to ensure safe and efficient charging. If you have specific questions about charging modules or need more information, please let me know, and I'll be happy to assist further.

Wires and cable:

Fig.8. wires.

Wires are conductive materials used to transmit electrical signals or power from one point to another. They come in various types and sizes, such as copper, aluminum, or steel wires, and are used for various applications, including electrical wiring, telecommunications, and more. If you have specific questions about wires, feel free to ask, and I'll provide more detailed information.

Advantages:

Generate free Energy

Low cost

Used in emergency

Easy to construct

Disadvantages:

Slow battery charging.

Use for Low power devices.

Application:

Morning walk

Tracking

Phone Charging

Small devices

Completion Of Hardware:

Fig.9. Completion of Hardware

Conclusion:

In this project we have illustrated the design of system which can harness the power generated by the human movements and transfer the power to a device through wire.

Harvesting energy from human motions is an attractive approach for obtaining clean and sustainable energy. This project has its root in all the areas of consumer electronics. This project also extends Future work includes designing authentication and monitoring systems for this project.

Future Scope:

The future scope of this project is promising as it can be utilized in various field such as wearable technology, smart cities and energy harvesting. It has the potential to generate renewable energy from human movement, which can be used to power small electronic device.

The future scope of the walk through generate free energy by piezo sensor in shoe project is quite promising. With advancement in technology, there is potential for this project to be implemented on a large scale. It could be integrated into everyday footwear, allowing individuals to generate individuals to generate electricity while walking or running. This energy could then be used to power various devices or even be stored for later use.

Research in this area is ongoing, and future work may focus on improving the efficiency, durability, and practicality of these energy harvesting systems, as well as exploring innovative applications in the Internet of Things (IOT) and beyond. Please note that there may have been further developments in this field beyond my last knowledge update in January 2022. You should consider conducting a more recent literature review to gain a comprehensive understanding of the current state of research in this area.

References:

https://www.researchgate.net/publication/362517336_Generation_of_Electricity_using_S hoesBu ilding_a_smart_shoe.

https://youtu.be/PNjc9tUs96Y?si=bnN87EDLRjePwnz-

https://www.instructables.com/Generate-Electricity-Using-Footwear-Charge-Your-Mo/

CENTRALIZED MONITORING SYSTEM IN COLLEGE CAMPUS LIGHTING

Name: Mr. Swaroop Vilas Patil
Mr. Gufaran Ainuddin Chougale
Mr. Sairaj Shrikant Bhojane
Mr. Soudagar Bharat Jadhav
Class: TY Electrical Engineering

Abstract:

The Conventional method of monitoring college campus lighting is very popular that is doing all this work in manual manner. All maintaining record is in conventional method. We were seeing in lots of colleges, street lights and other lighting system this conventional method is common and it is time consuming also. Now a days we were seeing in many colleges or street lighting system there is automation is present by using various components like Arduino, microcontroller and microprocessor. In this project by using microcontroller, various sensors, relays, contactor etc. we are going to implement centralized monitoring system in college campus lighting. By using Node MCUs Wi-Fi module we are going to collect data from all 5 poles to one monitoring device. In every project there is some advantages and disadvantages are present. So, it is having part of project we actually working on it so we are having many of its advantages and drawbacks. In working of this project there is some challenges are also present. One challenge is cost, by means for implement efficient system we have to use industrial components. The cost of these components is high so that is big problem in front of us. Advantage is that our college campus lighting is going to be modern.

Introduction:

In today's era of advancing technology and sustainability concerns, the effective management of resources and infrastructure within educational institutions has become paramount. Lighting plays a crucial role in ensuring safety, security, and comfort within college campuses, yet traditional systems often lack of efficiency and flexibility.

To address these challenges, the implementation of a centralized monitoring system for campus lighting emerges as a promising solution. This project aims to outline the design, implementation, and benefits of a centralized monitoring system tailored for the lighting infrastructure of our college campus. By consolidating control and monitoring functions into a single platform, this system offers a comprehensive approach to optimize energy usage, enhance maintenance efficiency, and improve overall lighting experience. This introduction provides an overview of the current landscape of campus lighting systems, highlight the need for a centralized monitoring solution, and outline the objectives and scope of this project. Additionally, discuss the methodology employed for system design and implementation, as well as the potential impact and benefits expected upon its deployment. Through this report, to showcase the potential of centralized monitoring systems in revolutionizing the management of campus lighting, paving the way for a more sustainable, efficient, and secure educational environment. In recent years, the modernization of infrastructure and the adoption of innovative technologies have become imperative for educational institutions to meet the evolving needs of students, faculty, and staff. Among the various components of campus infrastructure, lighting stands out as a critical element that significantly impacts safety, security, and the overall ambiance of the environment. However, traditional lighting systems often present challenges in terms of energy consumption, maintenance costs, and responsiveness to changing requirements.

Literature Review:

1. Implementation of Centralized Lighting Control Systems in Educational Institutions (Author: Johnson, Publisher: Springer, Year: 2019): This study explores the implementation of centralized lighting control systems in educational institutions, including colleges and universities. It discusses the benefits, challenges, and best practices for deploying such systems.[1]

2. Smart Campus Lighting Systems: A Review (Author: Smith, Publisher: IEEE, Year: 2020): This review paper provides an overview of various smart lighting systems implemented in campus environments.

It discusses the role of centralized monitoring in optimizing energy consumption and improving user experience.[2]

3. Advancements in Lighting Control Technologies: A Literature Review (Author: Williams, Publisher: Elsevier, Year: 2021): This literature review surveys recent advancements in lighting control technologies, with a focus on centralized monitoring systems. It examines the integration of IoT (Internet of Things) devices, wireless communication protocols, and data analytics for optimizing lighting operations.[3]

4. Energy-Efficient Campus Lighting: Case Studies and Best Practices (Author: Brown, Publisher: Wiley, Year: 2022): This research paper presents case studies of colleges and universities that have implemented centralized monitoring systems for campus lighting. It highlights successful strategies for reducing energy consumption, improving maintenance efficiency, and enhancing campus safety.[4]

5. Lighting Control Systems for Sustainable Buildings: A Review (Author: Garcia, Publisher: Taylor & Francis, Year: 2022): This review article discusses smart lighting control systems in the broader context of sustainable buildings. It explores various technologies and strategies for achieving energy efficiency and occupant comfort through centralized monitoring and control.[5]

Objectives:

To Provide centralize monitoring system for college campus lighting

Block Diagram:

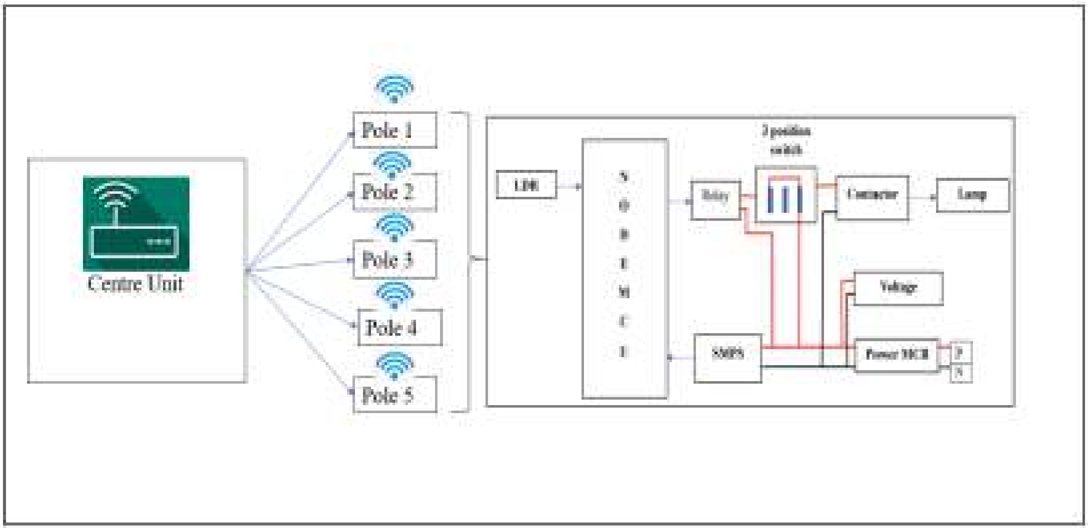

Fig.1. Block diagram of project.

Working:

Detection: The LDR senses the light level. Decision: Based on the LDR input, the Centre Unit decides whether to turn the lamp on or off.

Action: The Centre Unit sends a wireless signal to the respective pole to activate the relay and contactor, which then powers the lamp accordingly.

Energy Efficiency: The use of an LDR and automated controls can significantly reduce energy consumption by ensuring lights are only on when necessary, contributing to a greener and more cost-effective operation.

Scalability: The system appears to be scalable, allowing for the addition of more poles or lights without significant changes to the central unit, making it suitable for expanding infrastructure.

User Interface: There may be a user interface associated with the Centre Unit that allows for manual override, scheduling, and customization of lighting profiles for different scenarios or times of day.

Components used:

1. ESP8266 Module
2. Current sensor
3. Voltage sensor
4. Contactor
5. LDR
6. Relay
7. Wire

Conclusion:

The wireless communication with an electrical control circuit. The central unit communicates with multiple poles, potentially for data exchange or control purposes. The electrical circuit includes components like an LDR, relay, and contactor, indicating a setup that could be used for automated control based on ambient light levels, such as street lighting systems.

The system likely aims to achieve efficient operation and management of electrical devices, possibly in an outdoor environment, through remote monitoring and control.

This could be part of a smart city infrastructure, where lighting is adjusted based on environmental conditions, thereby conserving energy and reducing maintenance costs.

Future Scope:

1. Expansion to Smart City Solutions: The project could evolve into a comprehensive part of smart city solutions, enhancing urban management and sustainability.
2. Advanced IoT Capabilities: Incorporating advanced Internet of Things (IoT) features could enable sophisticated monitoring and management of resources.
3. Artificial Intelligence (AI): Implementing AI could provide predictive analytics for maintenance and energy usage optimization.
4. Modularity and Scalability: Designing the system to be modular would allow for easy expansion and customization to meet diverse needs.
5. Enhanced User Interface: A more intuitive user interface could be developed for better user engagement and system management.
6. Customization for Various Applications: The system could be tailored for different environments, such as residential, commercial, or industrial settings.

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[1]. Udhaya M, Susmitha K, Padmavathi V “Street Light Control and Air Quality Monitoring System”, International Journal of Creative Research Thoughts, Volume 9, Issue 5 May 2021, pp: 528-536.

[2]. Sindhu.A.M, Jerin George, Sumit Roy, Chandra J “Smart Streetlight Using IR Sensors”, IOSR Journal of Mobile Computing & Application (IOSR-JMCA), Volume 3, Issue 2. Mar. - Apr. 2016, pp: 39-44.

[3]. Sayali Arkade, Akshada Mohite, Shraddha Joshi, Rutuja Sonawane, Vikas Patil “IoT based Street Lights for Smart City”, International Journal for Scientific Research & Development, Vol. 5, Issue 03, 2017, pp: 1522-1524.

INNOVATIVE PROTECTION PHILOSOPHY

Name: Miss. Vaishnavi Baban Koli

Miss. Neha Sadashiv Patekar

Class: BTech Electrical

Unit Protection System to reduce the time delay of the phase and earth over-current protective relays, such that the fault anywhere in an industrial plant electrical network gets cleared instantaneously, to save the equipment from damage as well as, to prevent from the possibilities of plant black out. Stability of overall power system can be improved. Arcing fault incident energy can be reduced and hence PPE requirements can be reduced.

The major electrical assets in an Industrial Plant are Generators, Transformers, Motors, HT & LT switchgears, HT cables, Capacitor banks. The Generators and large power Transformers are usually provided with unit protection but rest of the equipment are usually protected with common Phase Over-Current and Earth Fault protective relays only. The Phase and Earth Over-current protections are pre-set with either Inverse Definite Time Delay (IDMT) or Definite Time Delay (DT). Normally these protective relays are coordinated with the downstream protective relays with desired time grading margin. This time graded over-current system being a conventional practice makes fault clearance at upstream locations prolonged and consequently equipment is subjected to possibilities of severe damages and also the same may cause loss of synchronism of Generators running in parallel with other Generators or Utility systems.

Problems Associated with the Conventional Protection Philosophy

In complex electrical network, delayed action of the relays is resulted due to time grading between upstream and downstream feeders and hence the fault gets cleared after a long time. The clearance of fault after a long time shall cause damage to the equipment and having to expose to fault for longer duration reduces operational life of apparatus drastically.

The operating time of upstream relays might be so high that it becomes nearly impossible to avoid loss of synchronism of Generator in event of severe faults. In industrial plants the numbers of generators run in parallel with each other and/or Utility. In that case it is more than desired that they all remain in synchronism and for instance if the fault clearing time is greater than Critical clearing time then it would severely affect the stability of machines running synchronously and would result in loss of synchronism and blackout of plant. Any three-phase fault that takes place in the system should be cleared before the critical, which can be determined from simulation studies carried out on transient analyser programs. Owing to large electrical paths of a typical industrial network, it is almost inevitable to co-ordinate each relay to operate below critical clearing time.

For any internal fault taking place in the equipment, the phase and earth over-current relay would operate after a certain time lag in co-ordination with downstream relay, which will cause the fault current to flow in the system for longer duration.

Equipment subjected to fault current for too long get affected adversely. The question arises how to safeguard the equipment from having to withstand fault current for a longer duration? Also, the difficulty of satisfactory co-ordination and the possibility of plant black out due to time delayed action of normal protection co-ordination ask for more reliable alternative.

Arcing energy is directly proportional to the fault clearing time. With conventional protection system, because of delayed operation of relays, fault clearing time shall be higher and as a result, arc energy level shall be high. Arc flash incident energy level shall be high and PPE requirements shall be comparatively high.

Furthermore, major drawback of the aforesaid protection philosophy is that for the fault nearest to the power source will result in most prolonged relay operation, which is even worse since the fault MVA is highest at that point.

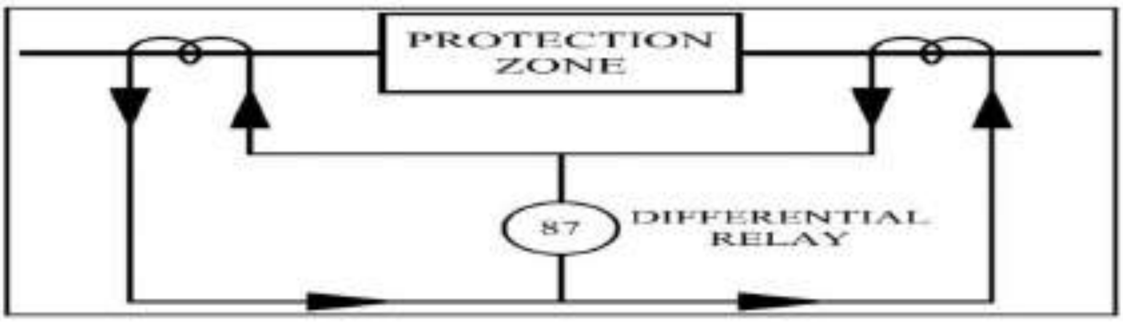
Perception of Unit Protection Scheme

Entire power system is divided into the sections, which are treated and protected individually as a unit. No reference of the other sections is taken into account while carrying out the settings for these relays. Moreover, the unit protection relays operate almost instantaneously within 100ms considering the breaker ON & OFF time.

Owing to immediate fault clearance, protection of each of the electrical equipment in a plant is assured thereby minimizing the likelihood of damages that they would have been subjected to when fault clearance was prolonged. Moreover, transient stability of synchronous generators shall not suffer since the fault is cleared within 100ms. Though there are lot many factors which affect the dynamic stability of synchronous machines but one of the crucial factors being fault clearance time if taken care of, then probability of loss of synchronism reduces. Unit protection is not a new concept but its application in different aspect is pioneering.

Unit Protection is a form of a Differential Protection whose main principle is to sense the difference in currents between the incoming and outgoing terminals of the equipment being protected.

Differential protection operates on the principle that current entering and leaving a zone of protection will be equal. Any difference between these currents is indicative of a fault being present in the zone. If CTs are connected as shown in Figure, it can be seen that current flowing through the zone of protection will cause current to circulate around the secondary wiring. If the CTs are of the same ratio and have identical magnetizing characteristics they will produce identical secondary currents and hence zero current will flow through the relay. If a fault exists within the zone of protection there will be a difference between the outputs from each CT; this difference flowing through the relay causing it to operate.



Simple Differential Protection Scheme

Adaptive Schemes of UPS

Generator Unit Protection

Transformer Unit Protection

Pilot Wire Cable Differential Protection

Motor Unit Protection

Capacitor Bank Unit Protection

Grid Islanding Protection

Busbar Differential Protection

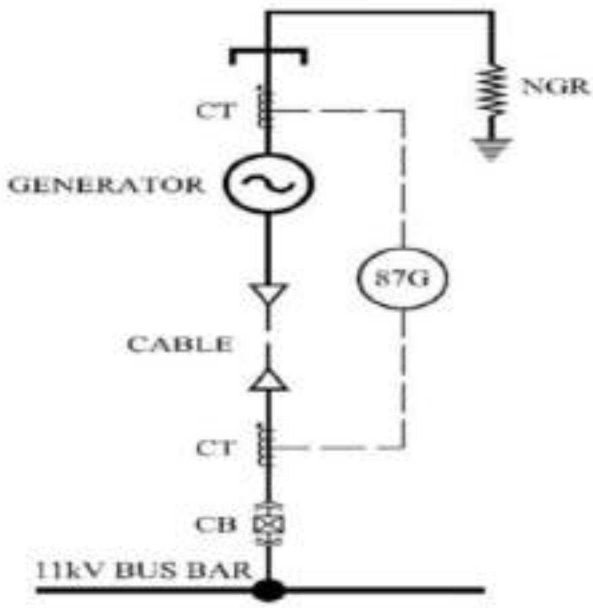
Brief Descriptions

The protections enlisted above are briefly described in the discussion that follows as under:

Generator Unit Protection

Generator being crucial part of any power system must always be provided with adequate protections.

Any fault that takes place inside or in the vicinity of the generator up to the connected busbar shall result in severe damage to the windings and the stator core, the extent of the damage will depend upon the fault current level and the duration of the fault.
For a generating plant or plants running in parallel with Grid, high-speed disconnection of the plant from the rest of the power system may also be necessary to maintain system stability. The generator differential protection is best suited in this case as any internal fault within its zone gets isolated from the rest of the power system almost instantaneously.



Typical Generator Differential Scheme…
3-Phase segregated generator differential protection is provided to detect stator phase faults. This can be set as either a percentage bias scheme with a dual slope characteristic or as a high impedance scheme. This form of unit protection allows discriminative detection of winding faults, with no intentional time delay, where a significant fault current arises. The zone of protection, defined by the location of the CTs, should be arranged to overlap protection for other items of plant, such as busbar or a step-up transformer.
Transformer Unit Protection
In applying the principles of differential protection to transformers, a variety of considerations have to be taken into account. These include compensation for any phase shift across the transformer, possible unbalance of signals from current transformers

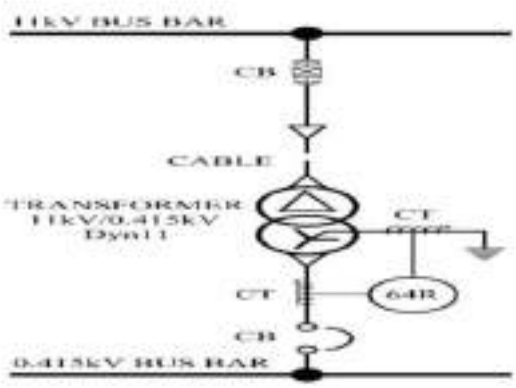
from either side of windings and the effects of the variety of earthing and winding arrangements. In addition to these factors, which can be compensated for by correct application of the relay, the effects of normal system conditions on relay operation must also be considered.

The differential element must be blocked for system conditions which could result in mal- operation of the relay, such as high levels of magnetizing current during inrush conditions or during transient over-fluxing. However, nowadays most of the numerical relays comes with blocking features based on the second and fifth harmonic in which case can be useful in preventing the relay mal-operation.

The considerations for a transformer protection package vary with the application and importance of the transformer. Small distribution transformers can be protected satisfactorily, from both technical and economic considerations, by the use of restricted earth fault relays. Any internal earth fault in small distribution transformers shall be detected by restricted earth fault relay which is also a kind of unit protection.

Transformer Restricted Earth Fault (REF) Protection Scheme

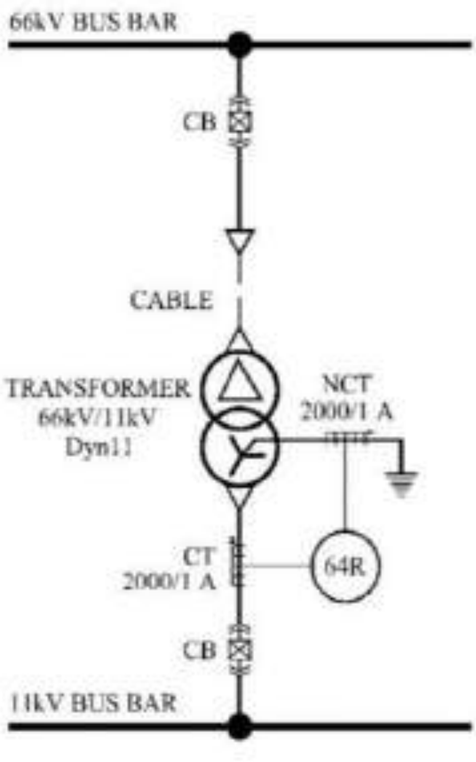
Depending on location of Neutral CT, 4-CTs or 5- CTs REF protection scheme is used. 5-CTs REF protection scheme is desirable. In 5-CTs REF scheme, 4 CTs (3-phase and neutral) in panel and 1 CT at transformer neutral is required to be installed. In 5-CTs scheme, transformer neutral CT is installed after bifurcation point. In 4-CTs scheme, transformer neutral CT is installed before bifurcation point. 3 CTs (3-phase) in panel and 1 CT at transformer neutral is required to be installed to incorporate 4-CTs REF protection scheme.



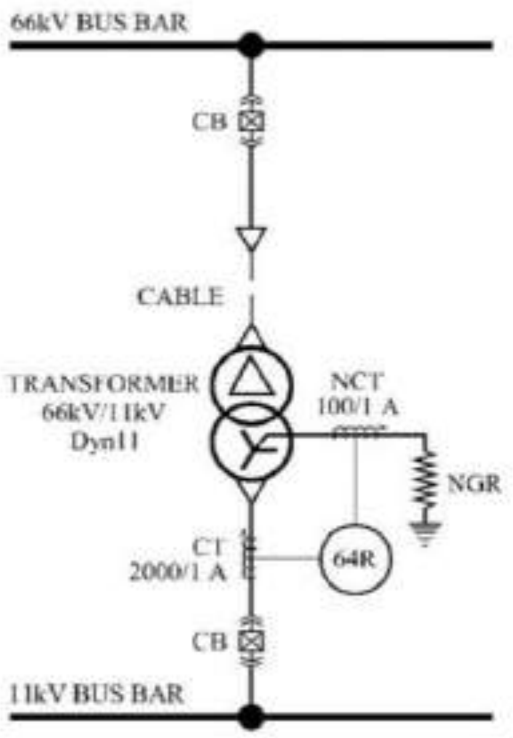
Restricted Earth Fault Protection Scheme

High/ Low Impedance Restricted Earth Fault (REF) Protection Scheme

Depending on the neutral earthing of transformer, high or low impedance REF scheme is selected. Low impedance REF scheme is adopted, if neutral point of transformer is NGR earthed (when Line CT and Neutral CT are not same) and model of relay is selected accordingly. Slope characteristic is used in Low Impedance REF scheme. High impedance REF scheme is adopted for transformer having solidly earthed neutral (Line CT and Neutral CT have identical ratio and magnetizing characteristics). As per requirement, stabilizing resistors and metro Sils are required in high impedance REF scheme.



High impedance REF scheme

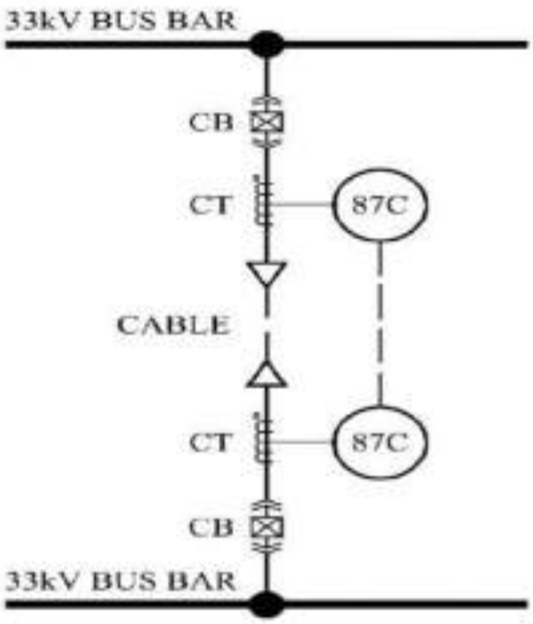


Low impedance REF scheme

Pilot Wire Cable Differential Protection

In industrial plants the distribution of power is usually done with the help of cables and in a normal over-current graded system; faults on cables usually end up with clearing times of around 600-700ms. This causes the generators to unnecessarily feed the fault for that long duration and having the cables undergo short circuit stresses. Further in case of ties between the stations in an industry, normal over-current grading results in even delayed tripping times due to added step. This difficulty can be easily overcome by implementing cable differential protection.

This is a well-established type of protection for feeders. It is based on the Merz-Price circulating current system and suitable for operation over privately owned two core pilots with a relatively high core resistance and low inter-core insulation level. It clears cable fault instantly.

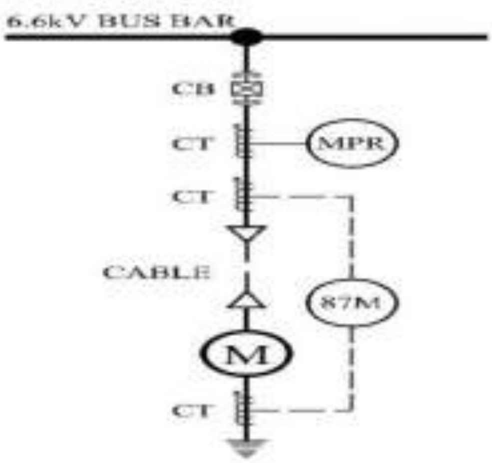


Pilot Wire Cable Differential Protection

Motor Protection

The major load of any industry comprises of motors, these motors depending upon their ratings as well as their importance should be provided with adequate protections. Possible faults against which motor should be protected are: inter- winding stator faults, faults outside the motor but within protected zone such as faults on motor terminals or on external connections and stator earth faults.

Possible faults against which motor should be protected are: inter-winding stator faults, faults outside the motor but within protected zone such as faults on motor terminals or on external connections and stator earth faults.



Motor Differential Protection

Three-phase machine differential protection is provided to detect faults within zone. This can be set either as percentage bias scheme with a dual slope characteristic or as a high impedance scheme. When high impedance is used, additional stabilizing resistance and metros will be required.

Further care must be taken to ensure the stability of differential scheme in the sense that it does not operate for through fault.

Capacitor Bank Unit Protection

The capacitor bank protection is an integrated protection, control, and monitoring device for shunt capacitor banks. The protection provides both, bank and system protection schemes for shunt capacitor bank protection.

The current and voltage-based protection functions are designed to provide sensitive protection for grounded, ungrounded single and parallel capacitor banks and banks with taps, for a variety of capacitor bank configurations.

Inherent unbalance in the large shunt capacitor banks may be so large that it may dominate the unbalance that results from loss of 1 or 2 capacitor units. This poses problem in designing the capacitor bank protection. However, voltage differential scheme can be useful in protecting the banks from abovesaid unbalances; the voltage inputs of which are derived from potential transformers employed two per phase. Relay mal- operation that may occur due to switching inrush must be prevented while considering the capacitor protection since the same might be as high as 20 times normal current.

The voltage differential is applicable for both grounded and ungrounded banks. In the ungrounded case, the algorithm uses the neutral point voltage to provide sensitive protection.

Busbar Differential Protection

Busbars are very critical element in a power system, since they are the points of coupling of many circuits, transmission, generation, or loads.

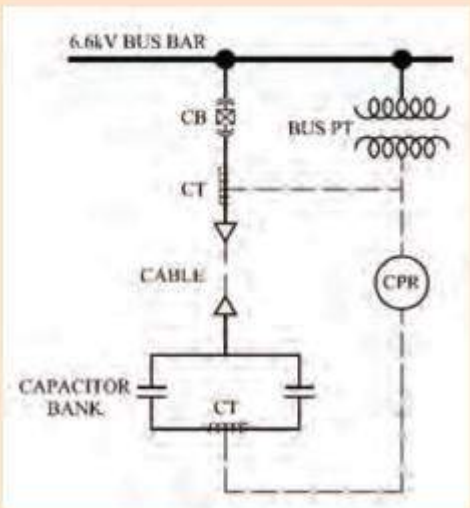
A single bus fault can cause damage equivalent to many simultaneous faults and such faults usually draw large currents. Also, these faults severely affect the system stability if not isolated immediately, this calls for busbar differential protection since fault isolation is as fast as 40ms much before the typical critical clearing time of the alternators. It also helps in maintaining the service to as much load as possible. Busbar differential scheme is depicted in below figure.

Bus bar differential schemes are not mandatory for all industrial applications. However, it is must for HV and MV systems of Oil and Gas industries.

Grid Islanding Protection

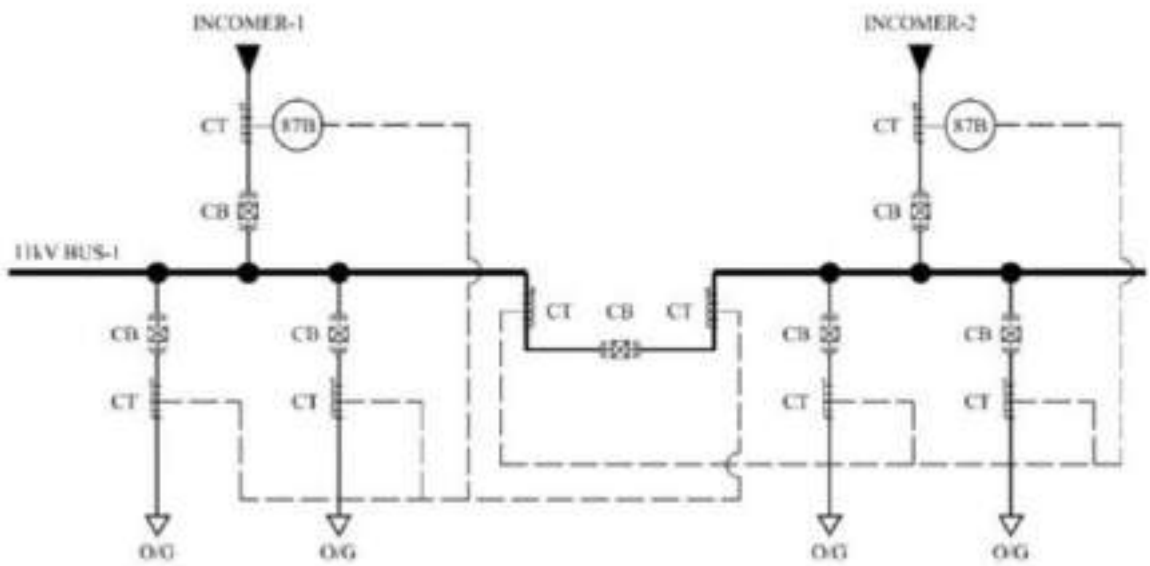
The process of disconnecting the Plant from the utility in case of Grid disturbance and vice-versa is called the Grid Islanding Scheme. Grid Islanding scheme is a set of protective relays, connected at the incomer bus – these relays will sense a disturbance in the grid or the plant and give a trip command to the incomer breaker whenever the grid/plant disturbance exceeds a set limit following a set logic. By opening a particular breaker, the plant is isolated from the Grid.

It is strongly advisable to disconnect the plant generator from the grid, when the grid is disturbed. The main reason is that the generator may get damaged due to grid disturbances resulting in heavy repair costs and shut downs.



Capacitor Bank Protection Scheme...

It is also better to disconnect the plant generator from utility whenever the utility fails, by opening the incomer. If not, the generator which is running will experience a severe jolt when the utility comes back as the restored supply may not be synchronous with the generator. After successful islanding the essential loads of the process industry plant should be supplied by in-house generators until the grid supply is restored. If successful and timely isolation of CPP plant does not take place during prolonged disturbances in the grid, there are chances of complete blackout in the process industry plant leading to significant loss in production. Equally important is the fact that after isolation from the grid, there should be a generation –load balance within the industrial plant. And this can be achieved by decrease of load demand to match with available generation. The term used for describing intentional switching off of electrical supply to parts of load is ‘Load Shedding’.



Overall Busbar Differential Scheme

Power system as such is never in a complete steady state. The kinds of changes that continuously take place are load variations, generation variations, occurrences of faults or large switching operations. These disturbances may lead to frequency or voltage collapse of the system, loss of synchronism of generating units or in worst case cascade tripping leading to complete blackout. If Industrial plant generators are not isolated in such a situation of large grid disturbances than they will also be tripped and plant shall have to suffer production loss until restoration process is completed.

However, to achieve proper Grid islanding by deciding settings of protective relays is little tricky; because too sensitive settings shall make frequent separations from grid which will lead to lost opportunities for revenue generation either from selling power to utility in case of plants exporting power or from production loss in case of plants importing power. And on the other hand, waiting too long and disconnecting at only extreme grid disturbances can lead to voltage and frequency sag with the consequences of possible equipment damage. The type of grid disturbances can be categorized as: Grid collapse which leads to loss of supply, faults in the grid due to which relay at the connection point trips the breaker resulting in loss of utility supply, wide fluctuations in frequency or voltage or both.

Choice of protective device used for grid islanding purpose play's vital role in proper realization of grid islanding. Relay selected should include protection functions as follows:

Directional phase overcurrent protection

Directional earth fault protection

Under/Over voltage protection

Under/Over frequency protection

Reverse power protection

Low forward power protection

Over power protection

Rate of change of frequency protection

Neutral voltage displacement / Residual over voltage protection

Voltage vector shift protection

Voltage transformer supervision

Circuit breaker failure protection

Programmable scheme logic

Individual protection functions without programmable scheme logics cannot form islanding scheme as operation/non-operation of combination of above cited protection functions is required to make appropriate judgment regarding whether to isolate the plant generators from grid or not. Other factors which contribute to proper grid islanding are: choice of location of protection transformers (CTs, PTs) which provides input to the protective relay, proper configuration of protective relay etc.

Actual Grid islanding protection settings vary according to source configurations, operating philosophy, load sensitivity and grid behavioural pattern but however the idea can be described on what should be the judging criteria which more or less remains same in all cases. Settings of individual protection functions described above should be done in at least two stages, one stage with comparatively lower threshold value should be used for alarm purpose and another stage with little higher threshold settings than previous stage should be used for tripping purpose. Besides these settings of individual protection functions certain logics are also required to be set. These logics shall help to judge grid islanding correctly and further avoid any chances of mal-operation.

Adaptive Generator Neutral Grounding methods and approach to install Transformer immediately after Generator

Primarily, this transformer avoids damages due to plant electric system disturbances as well as Grid disturbances when synchronized for import and export of power.

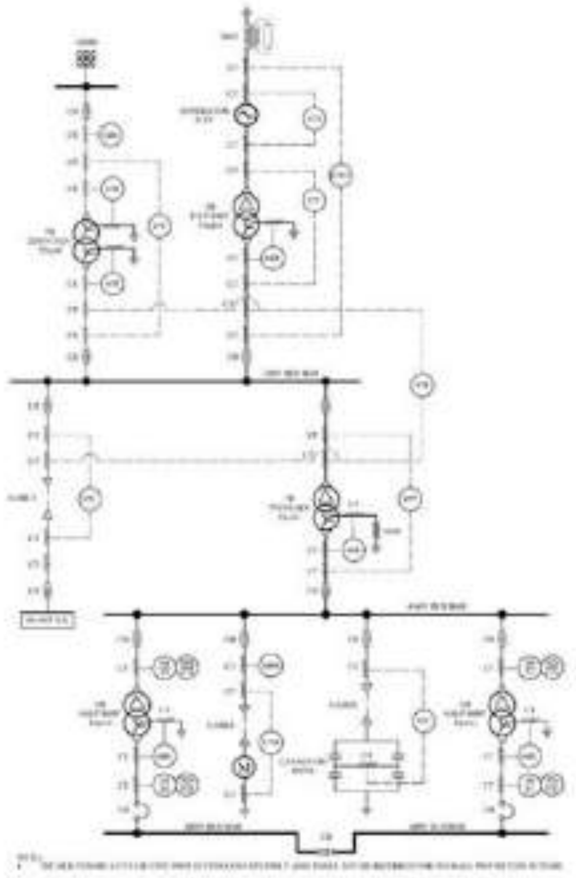
This Transformer shall restrict the reflection of the secondary side earth fault on the primary side and will thus isolate the Generator from the effect of secondary side earth faults due to Delta-Star configuration of transformer.

Safer value of generator E/F current can be selected by adopted NGT earthing of Generator neutral.

This transformer Limits the value of Phase faults current of the system. It increases the mechanical life of power plant equipment like turbine, generator and its auxiliaries due to avoidance of unnecessary frequent tripping of generator.

Sensitivity of all over current and Earth fault protections can be achieved for time graded protection and even the machine can be set to high set to get isolated from system faster.

It also provides the protection against plant electric system earth faults which are almost 85% of the electric faults.



System having Generator with Step-up Transformer

Generator with step-up Transformer

(Generator NGT earthed and Generator transformer solidly earthed)

This case explains typical industrial network comprising in-house generation, grid power support and certain plant load demand. It is illustrated in below figure. The distribution to the plant can be done via more than one feeder according to the plant load and process requirement.

Some key aspects of the shown system:

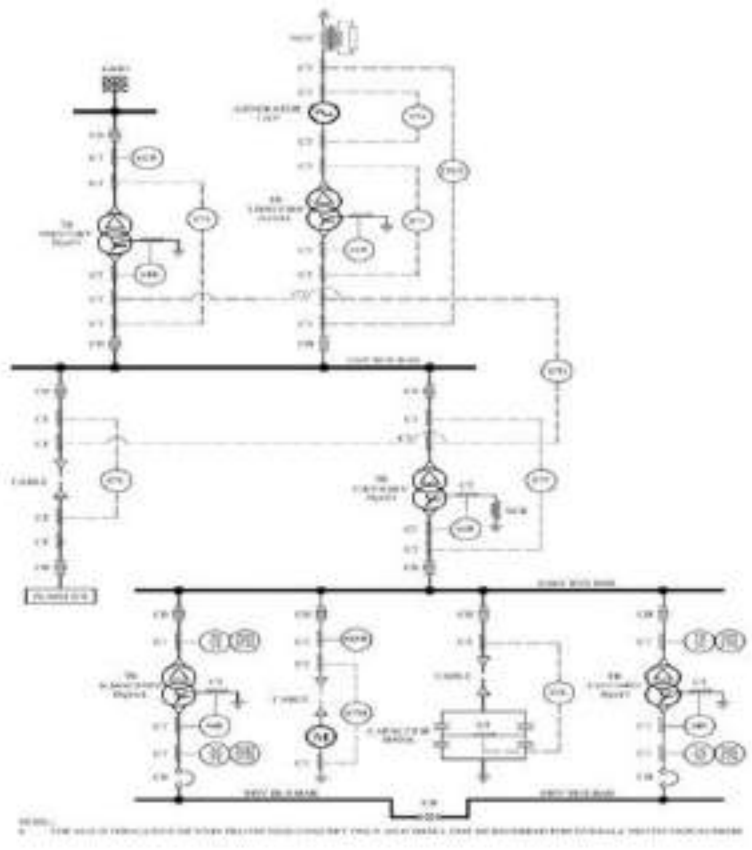
Generator grounding is done by Neutral Grounding Transformer and Ground Fault current can be limited to low value of about 2-5A.

Overall plant distribution is done at 33kV.

From example of above system, it is depicted that for the system having large distribution network, generated power can be stepped up at higher voltage level and equipment cost can be reduced comparatively due to lesser full load current than distribution at lower voltage level.

Ideally power generation should be at 11kV voltage level. In the system, if generation and utility are getting paralleled then generation shall be stepped up and utility power supply shall be stepped down to distribution voltage level.

Distribution of power should not be at lower voltage levels than 11kV. HT motors can be connected at 11kV, 6.6kV or 3.3kV voltage levels. Plant auxiliary loads can be connected at 415V by stepping down distribution power from 11kV or 6.6kV to 415V.



Generator with unit transformer

Generator with unit Transformer

(Generator NGT earthed and Generator transformer solidly earthed)

In industries where plant load is less, higher distribution voltage cannot be selected. So, generator should be provided with generator transformer of unity ratio. The case under discussion is similar to above case with respect to kind of plant load, in-house generation and grid power support. The distribution to the plant can be done via more than one feeder according to the plant load and process requirement.

Some key aspects of the shown system:

Generator transformer is provided with generator transformer of unit ratio. It provides electrical isolation to generator and hence earth fault in system does not get reflected on generator. Also, we can have limiting value of earth fault on generator to lower value of about 2-5A by providing neutral grounding transformer.

Solid earthing on 11kV distribution system can be provided and installation of CBCTs for earth fault sensitivity as the value earth fault current would not be required, as value of earth fault current would be in line with phase fault currents only and hence shall be sensed by residual connections.

Generator without generator transformer

Adding a generator transformer calls for more capital to be invested for which management may not give permissions then we can have direct connection of generator to plant distribution system.

Some key aspects of the shown system:

Owing to lesser plant load demand, one can have distribution of power at 11kV, and since generation is at 11kV generator transformer is not provided.

For system having neutral of generator and grid transformer is earthed through a neutral grounding resistor, the limiting value of earth fault current shall be selected in consideration with generator core damage curve.

The limiting value of earth fault current for generator cannot be kept too low as the same shall lead to sensitivity issues in downstream system.

Ideal Earth fault current limiting value of Transformer Star point based on voltage level and classification of system

Distribution at 33kV: 200A/300A NGR Distribution at 11kV: 300A/400A NGR Motor bus at 11kV/6.6kV/3.3kV: Transformer rated Amp NGR

Distribution at 415V: Solid

In case of Solidly earthed system in HV/MV network, due to higher value of E/F current, ionization of insulating medium causes Phase fault. It results in comparatively higher damage. And blackouts also.

At the same time while designing earthing system, it is required to achieve enough sensitivity of Earth fault detection. Transformer rate Amp NGR shall facilitate adequate sensitivity for Earth fault detection. So, Earth fault current value should be limited accordingly.

Grid Transformer

Above mentioned Earth fault current limiting value of LV side of Grid Transformer i.e. 33kV/11kV/6.6kV/3.3kV shall prevent the conversion of Earth faults into Phase faults.

Provision of Generator Transformer along with future Generator shall ascertain the safety of core against earth fault. Future Generator Transformer distribution side star point

Generator with Generator Transformer

Above mentioned Earth fault current limiting value of distribution side of Generator Transformer i.e. 33kV/11kV/6.6kV/3.3kV shall prevent the conversion of earth faults into Phase faults.

Provision of Generator Transformer along shall ascertain the safety of core against earth fault while CPP’s parallel operation with Grid Transformer in future. Future Grid Transformer distribution side star point shall be earthed through above mentioned NGR value.

Generator with Generator Transformer and Grid Transformer

Above mentioned Earth fault current limiting value of distribution side of Generator Transformer and Grid Transformer i.e., 33kV/11kV/6.6kV/3.3kV shall prevent the conversion of Earth faults into Phase faults.

Provision of Generator Transformer along shall ascertain the safety of core against earth fault while CPP’s parallel operation with Grid Transformer.

Conclusion

With the advent of newer technologies, it is essential that newer fundamentals shall be set in line with the problems faced in all the industrial plants. Using “Unit Protection” as a concept shall solve majority of the problems related to the time delayed actions of the relays. Any fault shall be isolated from the network almost instantaneously which means the fault current will not be circulating in the power system for a long time. This shall limit damage to the equipment.

Recent industries are already adopting the concept of Unit Protection System during design stage and perceiving the advantages of such schemes. However, it is not the case with old installations which are devoid of such schemes due to unawareness and later innovation. Increased black outs in the industrial plants causes heavy production loss which is not beneficial to the company. Hence, to avoid the black outs and production loss, it is essential that the electrical power system of any industrial plant is appropriate with adequate protections required. Using the “UNIT PROTECTION SYSTEM” concept will lead to fast clearance of faults from the power system and hence the number of black outs occurring in the plants can be saved which will in turn lead to no production loss to the plant. It shall compensate the cost of required infrastructure for scheme implementation and add the benefits over a period of time. Also, adoption of suggested distribution network i.e., Generator with Generator Transformer and limited Earth fault current value initially from project stage shall result in reduced blackout, less production downtime and improved power system reliability.

RE FOR RURAL ELECTRIFICATION IN INDIA

Name: Miss. Vaibhavi Dilip Mali
Miss. Aarti Gurudev Lokhande
Class: TY Electrical

The role of Renewable Energy (RE) in rural electrification in India is of paramount importance in improving living standards, education, healthcare, and economic growth in remote and underdeveloped areas. Additionally, the adoption of renewable energy sources reduces dependence on traditional fuels, promoting sustainability. Governments, NGOs, and international organizations collaborate to fund and implement rural electrification projects, bridging the urban-rural divide for a more equitable society. However, rural communities face various challenges in accessing electricity, including a lack of infrastructure, affordability constraints, distance to power sources, geographical barriers, and unreliable supply. Overcoming these challenges requires innovative solutions and strategic collaborations to empower rural populations with sustainable and reliable electricity, paving the way for a brighter and more prosperous future. This article provides an overview of the significance of extending electricity infrastructure to rural communities and challenges involved, enabling access to modern conveniences, communication, and enhanced agricultural productivity.

In areas with consistent wind resources, wind energy systems, or wind farms, present an opportunity for larger-scale rural electrification. These systems consist of multiple utility-scale wind turbines, often with capacities in megawatts, strategically placed to maximize energy output. By interconnecting with mini-grids or micro-grids, wind farms can supply electricity to clusters of communities, powering essential services and stimulating economic activities.

The potential benefits of wind power for rural electrification are vast. Wind energy is renewable, abundant, and widely distributed, making it an excellent fit for remote regions with favourable wind conditions. Unlike fossil fuel-based power sources, wind energy is clean and emits no greenhouse gases, contributing to climate change mitigation and environmental preservation. Furthermore, wind power projects create opportunities for local job creation, skill development, and community engagement, promoting a sense of ownership and sustainable growth.

Implementation of wind power in rural areas also poses challenges

Wind resource assessment is crucial to ensure viable energy production, requiring careful evaluation of wind patterns and seasonal variations. Initial investment costs, though decreasing, can still be a barrier, necessitating financial incentives and supportive policies to encourage adoption. Adequate technical expertise and maintenance support are essential for long-term sustainability, necessitating capacity building programs.

In short, small wind turbines and wind energy systems hold tremendous promise in illuminating the lives of those residing in remote areas. By tapping into the gentle giants of sustainable energy, rural communities can access reliable, clean, and independent electricity sources. Governments, in collaboration with private sectors and development organizations, should seize the opportunity to bring wind power to the forefront of rural electrification strategies, creating a more equitable and environmentally conscious world.

Biomass and biogas solutions

In rural settings, where access to traditional energy sources may be limited, biomass and biogas systems offer sustainable and decentralized solutions for energy generation and cooking purposes. Harnessing organic matter from agricultural residues, animal waste, and plant materials, these systems provide a reliable source of clean energy, transforming the lives of rural communities.

Biomass energy: This involves the combustion or conversion of organic materials to produce heat and electricity. In decentralized settings, small-scale biomass gasifiers or stoves are commonly used for cooking and heating. These gasifiers convert agricultural residues, such as crop stalks and husks, into combustible gases, providing an efficient and eco-friendly alternative to traditional wood or charcoal cooking methods. By utilizing agricultural waste, biomass systems offer a dual advantage of waste management and sustainable energy production, reducing environmental impacts.

Biogas systems, on the other hand, focus on harnessing methane-rich gas produced from the anaerobic digestion of organic matter. Animal dung, crop residues, and food waste are fed into sealed digesters, where bacterial decomposition produces biogas. This gas can then be utilized in biogas stoves for cooking or can fuel small-scale generators to produce electricity. Biogas systems not only provide clean cooking solutions but also address sanitation challenges by efficiently managing organic waste. (Refer figure 8)

Fig 8. Biogas production in villages of India

(Courtesy: Gaon Connection)

Use of biomass and biogas systems for rural energy and cooking

Firstly, it reduces reliance on traditional fuels like firewood and charcoal, which helps preserve forests and mitigates indoor air pollution, improving the health of rural inhabitants. Secondly, these systems provide energy independence to rural communities, enabling them to become self-sufficient in their energy needs and less vulnerable to fluctuations in fuel prices. Thirdly, biomass and biogas solutions offer an opportunity for income generation by enabling the production and sale of surplus energy or cooking gas.

However, challenges exist in the widespread adoption of biomass and biogas systems. Initial setup costs, technical know-how, and maintenance requirements can be daunting for some communities, necessitating financial support and capacity-building programs. Effective waste management and sourcing of feedstock may also require careful planning and community involvement.

In other words, biomass and biogas solutions hold great potential in empowering rural communities with decentralized energy generation and clean cooking options. By harnessing organic waste, these systems offer a sustainable and economically viable pathway to a greener and more energy-independent rural landscape. Governments, NGOs, and private sector players must collaborate to promote awareness, provide support, and facilitate the adoption of biomass and biogas systems, unlocking a brighter and more sustainable future for rural areas.

Micro-hydropower systems

Micro-hydropower projects have emerged as a potent force in electrifying hilly and water-abundant regions, bringing clean and sustainable energy to remote communities. Leveraging the natural flow of water, these small-scale hydroelectric systems have the potential to transform the lives of inhabitants in areas where conventional grid connectivity is challenging or uneconomical. (Refer figure 9)

Fig 9. Micro-hydro power electrification in India

(Courtesy: MNRE)

In hilly regions, where rivers and streams flow with considerable force, micro-hydropower projects capitalize on the kinetic energy of water to generate electricity. By diverting a portion of the water through a channel and directing it to a turbine, the flowing water drives the turbine, which, in turn, spins a generator to produce electricity. The generated power can be used to electrify nearby villages, schools, health centers, and small businesses.

The implementation of micro-hydropower systems offers several significant advantages for rural electrification. Firstly, these systems provide a stable and reliable source of renewable energy, reducing dependency on fossil fuels and mitigating greenhouse gas emissions. Secondly, micro-hydropower projects can function as standalone systems, eliminating the need for extensive transmission infrastructure, which can be prohibitively expensive in hilly and remote areas. Thirdly, by utilizing local water resources, these projects foster energy independence and resilience, promoting sustainable development in water-abundant regions.

Moreover, micro-hydropower systems contribute to socio-economic upliftment in these regions. Access to electricity enhances education through improved lighting and access to technology, supports healthcare facilities, and boosts agricultural productivity with the use of electric pumps for irrigation. Additionally, electrification fosters entrepreneurship by enabling the establishment of small-scale industries and cottage businesses, creating local job opportunities.

However, the implementation of micro-hydropower projects is not without challenges. Detailed technical surveys and assessments are crucial to ensure a reliable and economically viable project. Community engagement and participation are vital to gain local support and ownership, as well as to address any potential environmental or social concerns. Adequate maintenance and skilled manpower are essential for the sustainable operation of these systems.

In conclusion, micro-hydropower projects have the potential to revolutionize rural electrification in hilly and water-abundant regions. By harnessing the abundant and renewable energy of flowing water, these systems empower remote communities with clean electricity, fostering development and progress. Governments, NGOs, and private sector organizations must work in tandem to promote the implementation of micro-hydropower systems, driving the march towards a more sustainable, equitable, and energy-independent future for these regions.

Economic and social impact of renewable energy solutions for rural electrification

Implementing renewable energy solutions for rural electrification can yield significant economic and social benefits, transforming the lives of communities living in energy poverty. Access to electricity brings about a cascade of positive changes, positively impacting education, healthcare, livelihoods, and overall community development.

Education: Electricity enables the establishment of well-lit schools and access to electronic devices, revolutionizing educational opportunities in rural areas. Students can study after dark, access online resources, and benefit from modern teaching aids. Improved education empowers the youth with knowledge and skills, leading to better employment prospects and increased socio-economic mobility.

Healthcare: Reliable electricity supports healthcare facilities with lighting, medical equipment, and refrigeration for vaccines and medicines. Electrically powered medical devices enhance diagnosis and treatment options, improving overall healthcare outcomes and reducing maternal and infant mortality rates. Telemedicine and e-health initiatives also become feasible, extending healthcare services to remote areas.

Livelihoods: Renewable energy solutions stimulate rural economies by powering small-scale industries and businesses. Access to electricity encourages entrepreneurship and the establishment of ago-processing units, adding value to agricultural produce. Electric-powered machinery boosts productivity and income, supporting livelihoods and reducing dependence on traditional and labour-intensive methods.

Community Development: Electricity acts as a catalyst for overall community development. It enables the operation of community centres, communication facilities, and street lighting, enhancing safety and social interactions. Access to modern energy services fosters a sense of empowerment, self-reliance, and community cohesion.

Environmental Benefits: Renewable energy solutions like solar, wind, and micro-hydropower reduce reliance on fossil fuels, minimizing carbon emissions and environmental degradation. Sustainable energy sources promote eco-friendly practices, conserving natural resources and preserving biodiversity.

Poverty Alleviation: By providing access to affordable and clean energy, renewable solutions reduce the financial burden on households spent on traditional fuels. This enables families to allocate their resources towards education, health, and other essential needs, lifting them out of poverty.

Gender Empowerment: Access to electricity can have a profound impact on gender equality. Women and girls benefit from improved lighting, reduced drudgery through electric appliances, and opportunities for income-generating activities. Increased gender equality leads to more inclusive and equitable development.

The crux is, implementing renewable energy solutions for rural electrification not only improves access to clean and reliable energy but also brings about transformative economic and social changes. By powering education, healthcare, livelihoods, and community development, electricity acts as a catalyst for progress, helping rural communities thrive and contributing to a sustainable and inclusive future. Governments, development organizations, and private sectors must collaborate to accelerate the adoption of renewable energy solutions, paving the way for a brighter and more prosperous rural landscape.

Policy and regulatory framework for renewable energy in rural electrification in India

In recent years, India has made significant strides in promoting renewable energy for rural electrification through a well-crafted policy and regulatory framework. Recognizing the potential of clean energy to empower rural communities and drive sustainable development, the government has implemented various initiatives, subsidies, and incentives to accelerate renewable energy adoption.

National Policy Initiatives: The Indian government has formulated several policy initiatives to promote renewable energy deployment in rural areas. The National Solar Mission, launched in 2010, aims to deploy 100 GW of solar power capacity by 2022, including off-grid and decentralized solar applications for rural electrification. The National Bioenergy Mission focuses on promoting the use of biomass and biogas systems. Additionally, the National Wind Energy Mission encourages the development of wind power projects in windy regions.

Subsidies and financial incentives: To make renewable energy solutions affordable and attractive for rural communities, the government provides various subsidies and financial incentives. Capital subsidies and grants are offered to set up renewable energy projects, reducing the upfront costs for investors and project developers. In some cases, subsidies are also extended to end-users, making renewable energy technologies more accessible to rural households and businesses.

Rural electrification policies: The government's rural electrification policies aim to prioritize renewable energy in remote and off-grid areas. The Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) and Saubhagya Yojana have been instrumental in bringing electricity to un-electrified villages and households, with a focus on promoting renewable energy-based micro and mini-grids.

Net metering and feed-in tariffs: Net metering policies enable rural consumers to sell excess renewable energy generated from their systems back to the grid, providing an incentive for adopting solar rooftop systems. Feed-in tariffs ensure a fixed price for renewable energy producers, guaranteeing a return on investment and encouraging renewable energy project development.

Simplified regulatory procedures: The government has taken steps to streamline regulatory procedures and expedite approvals for renewable energy projects. Single-window clearances and fast-track project approvals facilitate smoother implementation and help attract private sector investments.

ENVIRONMENTAL IMPACT OF SOLAR PANELS

Name: Miss. Vaishnavi Arvind Mane
Miss. Sharada Manoj Mane
Class: TY Electrical

The annual increase in global energy consumption, along with environmental issues and concerns is playing a pivotal role in shifting toward sustainable and renewable energy. Among various non-conventional sources of energy, Solar Energy stands out as it has the potential to minimise climate change and pollution and protect ecosystems, wildlife, and human civilisations.

Solar power is very cheap and cost-effective compared to other sources of energy generation. They are also abundant and suitable for various applications. The maintenance cost of solar power systems is low. It has longevity of up to 25 years. The main demerit is the fact that they are subject to weather conditions. So, we require an energy storage system that will add to the overall cost of the technology.

The growth of solar power has increased exponentially over a few decades. It has evolved from small-scale applications to mainstream electricity sources. Solar power generation is forecast to nearly about double by 2028 compared to this year, continuously breaking records over the forecast period to reach almost 700 GW.

Positive Impacts

Solar energy production is a great example of clean and emission-free energy generation methods compared to the use of fossil fuels, which release harmful gases like carbon dioxide, leading to issues such as acid rain, smog, and health problems. Solar energy also helps to mitigate climate change as the emission of greenhouse gases is low, hence minimizing the adverse effects such as changes in rainfall patterns, melting of snow and ice caps, global warming, and erratic monsoons.

Solar energy systems, mainly photovoltaic panels (solar panels), play an important role in reducing the dependency on fossil fuels, including coal, oil, and natural gas, which have been the primary sources of global energy production for centuries. However, their extraction, refinement, and combustion processes resulted in significant environmental degradation and health problems. Meanwhile, solar energy harnesses the power of sunlight, which is an abundant and renewable source to generate electricity.

One of the key advantages of solar panels is the flexibility of installation, which contributes to their widespread adoption and accessibility. Unlike traditional power plants, which require a large and dedicated area for installation – solar panels can be installed on a wide range of surfaces. In densely populated urban areas where open space is minimal, it can be installed on rooftops of existing infrastructure without the need for additional land acquisition. Solar panels can be installed on non-traditional surfaces such as highways, water bodies, and parking lots, maximizing land use efficiency. Advanced solar panel designs and technologies have led to the development of Building-Integrated Photovoltaic (BIPV), which easily integrates solar panels into building facades, windows, and roofing materials.

Solar Panel installation plays an important role in reducing air pollution by displacing the use of fossil fuels for electricity generation. Different from conventional power plants fuelled by coal, oil, and gas, which emit harmful pollutants such as nitrous oxides, sulphur dioxide, and particulate matter, solar PV systems produce electricity without emitting any pollutants during operation. As the emission of these pollutants decreases, the ambient air quality is improved, reduces water use for energy production, and provides ecosystem services for host communities.

Negative Impacts

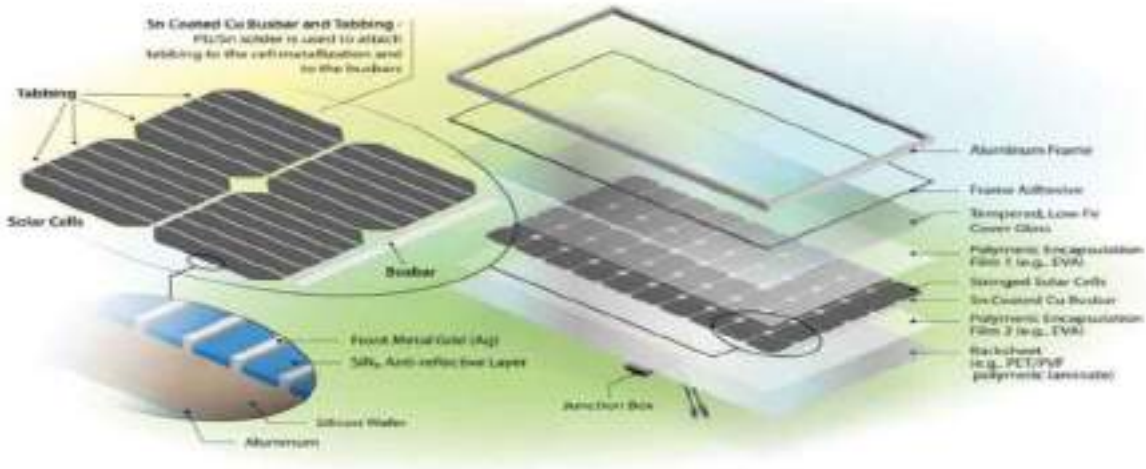
The production of solar panels requires a large amount of energy, starting from the mining of raw materials to manufacturing and transportation. A basic material for making solar modules is quartz, it undergoes extensive cleaning and processing, and semiconductor processing and the production of silicon-grade solar panels involves the use of chemicals, which can pose disposal challenges and environmental risks.

Ground-mounted solar panel installations can disrupt local ecosystems and wildlife habitats. Small mammals and reptiles may be disturbed by the presence of solar panel structures, leading to changes in their behaviour and migration patterns. According to studies, animals like tortoises may become disoriented and deterred from the usual path due to solar installation.

Land used for solar panel installation may experience a decrease in fertility as the solar panels block sunlight from reaching the ground. This can hamper plant growth and impact soil quality, leading to changes in local ecosystems. In addition to that changes in land use patterns can affect the natural balance of ecosystems and disturb the related biodiversity.

Solar energy systems are having an unintended negative impact that leads to the exhaustion of underground water – and there is a reduction in groundwater level. This is because solar panels need to be cleaned regularly for maximum yield of energy in which water is used as a cleaning agent.

According to some recent studies, although solar energy systems do not have any direct impacts on aquatic ecosystems, it is found that the installation of solar panels can increase sediment runoff into water bodies, affecting water quality and aquatic habitats. Additionally, the change in water temperature and flow pattern may impact aquatic species such as mussels and fish, leading to disturbances in their population and habitats.



Impact of Recycling and Disposal of Solar Panels

The manufacturing, recycling, and disposal of solar panels are critical aspects of the assessment of the environmental impact of solar energy. While solar panels help in clean energy generation, their end-of-life management has challenges that must be addressed to minimize environmental harm.

Studies have shown the potential for leaching problems associated with solar panels, particularly if they are not properly disposed of or recycled. PV panels contain materials such as silicon wafers and encapsulation made of ethyl vinyl acetate, which may release hazardous substances under specific conditions and leaching can result in the contamination of soil, water, and ecosystems, posing a risk to the environment.

The importance of responsible end-of-life management must be recognized, and several recycling programs must be established to facilitate the proper recycling and disposal of solar panels. This program mostly focuses on recovering valuable materials from waste or non-operational solar panels, such as silicon, metals, and glass for reuse in new manufacturing processes. By this, we can conserve valuable resources, and the environmental impact of waste disposal can be minimized.

Recycling Process of PV Panels

PV cycle distinguishes between silicon photovoltaic modules and non-silicon photovoltaic panels. Silicon solar panels share a similarity with other glass products such as windshields. PV cycle benefits from significant synergies with the glass recycling industry. The process involved in recycling solar panels consists of three main steps.

Preparation phase

The first step involves examining the aluminium frames and junction boxes of the used solar panels, then manually removing them.

Shredding and processing

Disassembled, the photovoltaic module is fed into a shredder. Then it is sent down a glass recycling conveyor belt to be manually pre-sorted. One side is dedicated to the grinding of the laminates and the other to the extraction of the materials.

Separation and other micro-recycling of simple materials

The main output materials extracted:

Metals such as aluminium or copper

Glass

Silicon particles

Plastic

The average recycling quota is 94.7%.

Conclusion

In brief, we can conclude that solar energy offers significant environmental benefits, but it is essential to address some of the challenges mainly related to the production, installation, recycling, and disposal of solar panels to ensure the long-term sustainability of renewable solar energy systems. Promoting research, innovation, and proper user policy can lead to the development of effective solutions for the responsible management of solar panel waste, minimizing environmental impacts, and maximizing resource efficiency.

THE POTENTIAL OF SMART GRID INNOVATION

Name: Miss. Arati Ananda Kamble

Miss. Amruta Tanaji Kamble

Class: Btech Electrical

The rising use of technology in our daily lives, along with factors like urbanisation and population expansion, are creating an unprecedented demand for electricity around the world. There is an urgent need for a more intelligent and sustainable method of managing the flow of electricity, since our energy systems are finding it increasingly difficult to meet this growing demand. This is where the technology of the smart grid is useful…

An enhanced electrical network known as a ‘smart grid’ combines modern information and communication technology with conventional power systems. It completely transforms how we generate, distribute, and use power, allowing for a more dependable and efficient grid that can handle rising demand and encourage the incorporation of renewable energy sources.

Important Elements and Features

Advanced Metering Infrastructure (AMI): The core component of a smart grid is its smart metres. They facilitate the exchange of data in both directions between utilities and customers, giving real-time information on consumption. Accurate billing, demand response initiatives, and more effective energy management are made possible by this kind of data.

Distribution Automation: To automate and monitor the distribution process, smart grids make use of sensors, remote control devices, and communication networks. This reduces the frequency of power outages, enhances problem detection and restoration, and guarantees that customers will always receive electricity.

Integration of Renewable Energy: As renewable energy sources become more widespread, smart grids are essential for controlling their unpredictability. Smart grids optimise the integration of intermittent sources, such as solar and wind, into the current system through sophisticated control algorithms.

Demand Response: Demand response programmes, which encourage customers to modify their electricity consumption in response to real-time price signals, are made possible by smart grids. As a result, there are financial and environmental savings as well as a reduction in peak demand and overall energy consumption due to the more effective use of electricity.

The Advantages of Smart Grids

Improved Grid Reliability: Smart grids provide for self-healing capabilities, fast fault detection, and real-time monitoring. They can minimise downtime and lessen the effects of outages by automatically rerouting electricity, isolating problematic areas, and restoring power more effectively.

Cost Savings and Energy Efficiency: Smart grids give users up-to-date information on how much energy they use, enabling them to cut waste and make wise decisions. Demand response programmes lower peak demand and increase energy efficiency by providing incentives for using electricity during off-peak hours. Both consumers and utilities save money as a result of this.

Renewable Energy Integration: Variable renewable energy sources can be efficiently integrated into the system thanks to smart grid technology. They optimise generation and minimise curtailment by balancing the intermittent nature of renewables with the demand for power through sophisticated control mechanisms and real-time monitoring.

Environmental Benefits: Smart grids play a major role in lowering greenhouse gas emissions and halting climate change by encouraging energy conservation and making it easier to integrate renewable energy sources. They open the door to a more sustainable and clean energy future.

Innovation-Driven Transformation of Energy Systems

Future prospects for the transformation of energy systems are quite promising, and smart grid technology is one of the main technologies facilitating this transition.

Through the integration of renewable energy sources and the application of cutting-edge computing and communication capabilities, smart grid technology makes it possible to optimise energy generation and transmission. With the use of this technology, supply and demand for power may be managed effectively, resulting in a stable and sustainable energy system.

We can lessen our reliance on fossil fuels and transition to a greener, more sustainable energy future by utilising smart grid technology. Moreover, smart grid technology presents chances for lower costs and higher energy efficiency.

Smart grid technology can help consumers make more informed energy decisions by identifying inefficient regions and tracking and analysing energy usage in real-time. Through the speedier detection and reaction to power outages made possible by this technology, grid dependability and resilience are also improved.

Furthermore, the integration of distributed energy resources into the current power system, including rooftop solar panels and tiny wind turbines, could be facilitated by smart grid technologies. This integration can encourage the use of renewable energy sources and boost the grid’s overall capacity and reliability.

We can dramatically improve the sustainability, efficiency, and resilience of our energy systems by putting smart grid technology into practice.

Smart grid technology presents a possible way forward for energy system transformation by combining cutting-edge communication and computing tools with renewable energy sources. It facilitates the incorporation of renewable energy sources, enhances grid resilience and dependability, and permits the optimisation of energy generation and transmission.

By integrating renewable energy sources, enhancing grid dependability, and optimising energy generation and transmission, the smart grid system has the potential to completely transform our energy systems.

The Potential of Smart Grid Technology

The potential of smart grid technology to transform energy systems and accelerate the shift to a more efficient and sustainable future is what makes it so promising.

Smart grid technology enables the optimisation of energy generation and transmission through the integration of sophisticated communication and computing capabilities. This optimisation can encourage the incorporation of renewable energy sources, such solar and wind power, and lessen reliance on fossil fuels. Through real-time monitoring and analysis of energy usage, smart grid technologies may pinpoint inefficient regions and assist consumers in making more informed energy decisions.

Furthermore, the use of smart grid technologies improves the resilience and dependability of the system.

Smart grid technology contributes to a more dependable and robust energy supply by making it possible to identify and react to power outages more quickly. Furthermore, smart grid technology enables the integration of dispersed energy resources into the current power infrastructure, such as tiny wind turbines and rooftop solar panels. This integration encourages the use of renewable energy sources while also boosting the grid’s overall capacity and reliability.

Smart Grids: Revolutionising Power Distribution

Power distribution could be completely changed by smart grid technology, which turns energy systems into more efficient and sustainable networks.

Smart grids facilitate the optimisation of energy generation and transmission through the utilisation of sophisticated communication and computing systems. This optimisation makes it possible to incorporate renewable energy sources, lessens dependency on fossil fuels, and encourages the use of a more sustainable mix of energy sources. Additionally, smart grids may pinpoint inefficient areas and empower customers to make more informed energy decisions by providing real-time monitoring and analysis of energy usage.

Furthermore, by detecting and responding to power failures more quickly, smart grids improve the resilience and reliability of the grid. Smart grids are able to reduce the impact of power outages and provide a more dependable and resilient energy supply by actively controlling and rerouting power flows. Moreover, distributed energy resources like tiny wind turbines and rooftop solar panels can be integrated with smart grids.

Smart Grids: The Secret to Efficient Energy Use

The groundbreaking technology known as smart grids has the capacity to completely change how we generate, distribute, and use energy. In essence, they are an improved version of the conventional energy grid that incorporates digital communication technology to allow utilities to interact with customers and provide customers greater control over how much energy they use.

The capacity of smart grids to increase energy efficiency is one of its main advantages. Because traditional energy grids are frequently inefficient, consumers pay more for lost energy. Conversely, smart grids may optimise energy distribution and consumption, which lowers total energy costs and minimises energy waste.

This is made possible by smart grids' many essential features. Among the most crucial characteristics is the capacity to collect and evaluate real-time energy consumption data.

Utilities may more precisely estimate demand and modify energy production by using this data to spot patterns and trends in energy consumption. This lessens energy waste and prevents overproduction.

Furthermore, the integration of renewable energy sources like solar and wind power into the grid is made possible by smart grids. This promotes a more environmentally friendly and sustainable energy system by lowering greenhouse gas emissions and dependence on fossil fuels.

Moreover, demand response programs which encourage customers to move their energy consumption to off-peak hours when energy is more affordable and plentiful are made possible by smart grids. This can eventually result in decreased total energy prices for consumers and less stress on the system during peak hours.

Obstacles and Prospects for the Future

There are difficulties in putting smart grid technologies into practice. Among the challenges are the upfront costs associated with implementing sophisticated infrastructure, protecting data security and privacy, and resolving interoperability problems.

Nonetheless, in order to overcome these obstacles and promote the global adoption of smart grids, governments, utilities, and technology companies are working together.

The potential for smart grids is enormous. Energy storage, smart appliances, and electric cars will all be integrated as technology develops, improving our energy systems' sustainability and efficiency. Furthermore, improvements in Machine Learning (ML) and Artificial Intelligence (AI) will make it possible for systems to self-heal, predict maintenance, and manage grids more intelligently.

Conclusion

In order to modernise our energy infrastructure, improve grid dependability, encourage energy conservation, and hasten the incorporation of renewable energy sources, smart grid technology presents an inventive and revolutionary answer. Through the utilisation of automation and information technology, smart grids open the door to a more environmentally friendly and sustainable energy future.

FACING INDIA'S GHG EMISSION Challenge

Name: Mr. Pratik Uttam Shinde

Mr. Prajwal Sanjay Shinde

Class: BTech Electrical

India has to develop, but a developing country needs more and more electricity. As per our country's commitments, we have to further accelerate the process of decarbonisation. However, it is much tougher than said. The country has to overcome multiple challenges that need to chalk out the most feasible and sustainable solutions

In a conversation with Microsoft co-founder Bill Gates last month, Prime Minister Narendra Modi said that the parameters used to 'measure progress' are detrimental to the climate. He said that if we continue to judge a country's development or economy by its steel consumption and energy usage, then progress would result in increased carbon emissions. He said that the world should develop and adopt the concept of Green Gross Domestic Product (GDP) that can be incorporated into the overall GDP.

He said the world needs to adopt a two-pronged strategy: first, nature and climate friendly innovation, and second, environmentally friendly lifestyles.

Understanding Greenhouse Gas (GHG) Emissions

Gases such as water vapour, carbon dioxide (CO_2) and methane are responsible for creating a greenhouse effect by warming the earth's surface and the air above it, and hence are referred to as Greenhouse Gases (GHG).

Global warming is proportional to cumulative GHG emissions, which means that the planet will keep heating for as long as global emissions remain more than zero. Climate damages, caused by global heating, will continue escalating for as long as emissions continue.

Climate Change in India

The average rainfall fell by 0.6m while the average temperature increased by 0.5^{0}C over the period 1950–2018 (see Figures 1 and 2). Particularly, in India, there has been an increase in weather variability, temperatures regularly above 50^{0}C in certain regions and unpredictable rains in timing and quantity during the monsoon season. Agriculture and transport sectors are harmed. Climate change and increased pollution have a direct negative impact on individual's health, over US$37 billion output loss due to premature deaths, morbidity, and increased deaths due to heat stress, malnutrition, malaria and diarrhoea.

Definition: Scope 1 and Scope 2 emissions are those that are owned or controlled by an organisation.

Scope 1 covers emissions from sources that an organisation owns or controls directly – for example from burning fuel in its fleet of ICE vehicles.

Scope 2 are emissions that an organisation produces indirectly from the energy it purchases and uses. For example, the emissions from the generation of electricity, used to power up EVs, fall into this category.

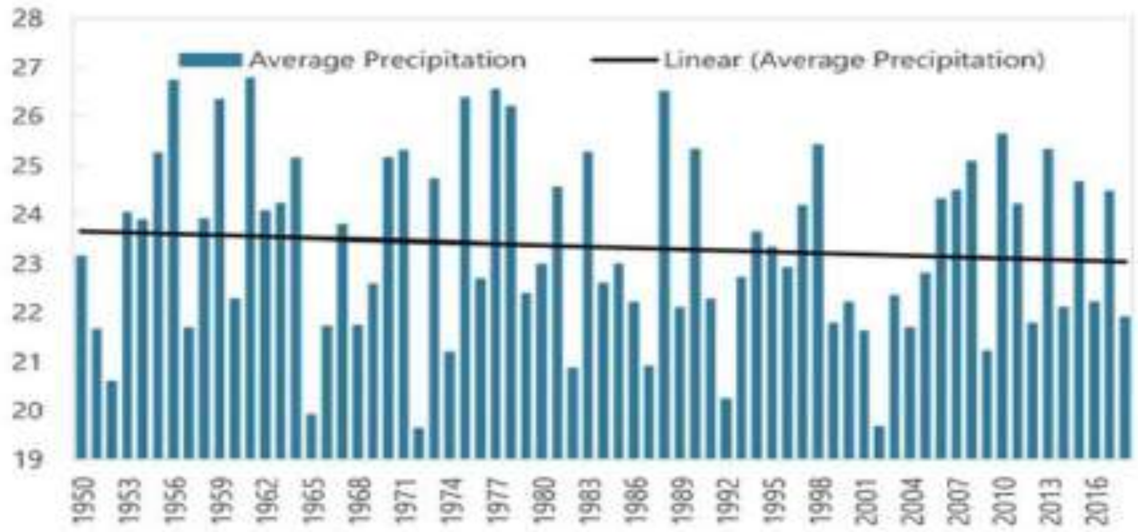


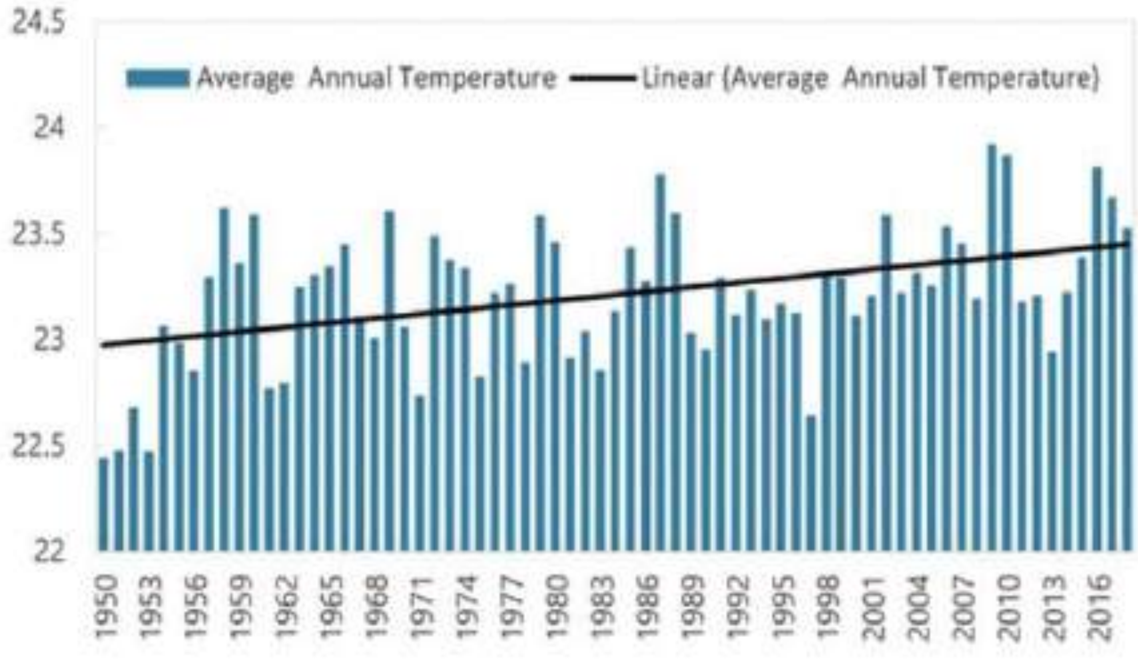
Figure 1. Annual Precipitation…

(Sources World Bank, IMF) Figure 2. Average Temperature…

(Sources World Bank, IMF)

Definition: Scope 3 emissions are a consequence of the activities of the organisation but occur from sources not owned or controlled by it.

Scope 3 encompasses emissions that are not produced by the organisation itself, nor from the result of activities from assets



owned or controlled by them, but by those that it’s indirectly responsible for, up and down its value chain. An example of this is when it buys, uses and disposes off products from suppliers. Scope 3 emissions include all sources not within the scope 1 and 2 boundaries.

For many businesses, Scope 3 emissions account for more than 70% of their carbon footprint. Scope 3 emissions are under the control of suppliers or customers, so they are affected by decisions made outside the company (see Figure 3).

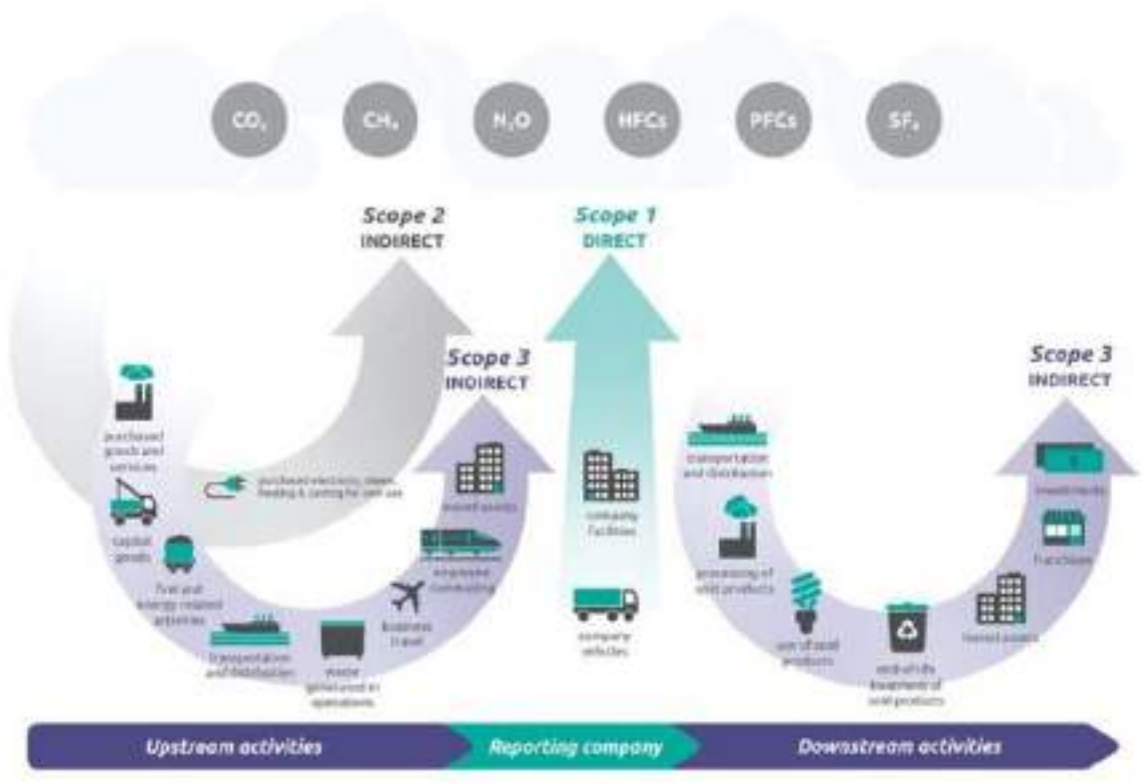


Figure 3. Different types (Scope) of Greenhouse Gas Emissions…

Net Zero Emissions

Net Zero refers to a state where anthropogenic emissions by sources are balanced by removals by sinks. In this state, the GHG going into the atmosphere balances its removal out of the atmosphere, and global warming stops.

Net Zero is different from Absolute Zero / Zero Emissions, where no GHG emissions are attributable to an actor’s activities across all scopes. Under this definition, no offsets or balancing of residual emissions with removals are used.

It (absolute zero) is a valid end-state target, but difficult to achieve initially.

It is international scientific consensus that, in order to prevent the worst climate damages, global net human-caused emissions of carbon dioxide (CO_2) need to fall by about 45% from 2010 levels by 2030, reaching net zero around 2050.

The Paris Agreement underlines the need for net zero. Net zero is the internationally agreed upon goal for mitigating global warming in the second half of the century. The IPCC concluded the need for net zero CO_2 by 2050 to remain consistent with the 1.5^{0}C target.

How to Reduce Your Greenhouse Gas Emissions?

By cutting carbon emissions, carbon footprints or seeking low-carbon alternatives should help to tackle climate change. This can be done in two ways:

Lowering the emissions we're sending into the atmosphere, from activities such as industrial processes, power generation, transport and intensive agriculture.

Removing greenhouse gas emissions from the atmosphere, for example by capturing carbon that's created during industrial processes, or by planting more trees.

Regardless of whether you belong to the industry, power generation, industry, transport, or agriculture, to reduce GHG emissions, you need to:

Develop a full greenhouse gas emissions inventory

Incorporate Scope 1, Scope 2 and Scope 3 emissions

Understand your full value chain emissions Focus your efforts on the greatest reduction opportunities

You need to treat Climate Change as a business problem rather than solely as a Corporate Social Responsibility (CSR). Committing to reach net zero will involve tackling your Scope 3 emissions.

GHG Emissions in India

India is the world's third largest greenhouse gas (GHG) emitter, however, in terms of emissions per capita it has the lowest level in the G20. Figure 4 shows India has slightly more emissions than the European Union (EU) but only one third of the emissions per capita,

while the United States has 7 times higher emissions per capita. Given India's modern economic development began considerably later than that of advanced economies, it has a small contribution to global historical cumulative GHG emissions of approximately 3% (UNEP, 2022).

In the updated Nationally Determined Contribution (NDC) to the UNFCCC, India has committed to lower the emissions intensity of its GDP by 45% from 2005 levels by 2030. It also committed to achieve 50% of total installed power capacity from non-fossil fuel-based energy resources by 2030 and to put forward and further propagate a healthy and sustainable way of living (Life). India also committed to get to net zero emissions (NZE) by 2070 at COP26.

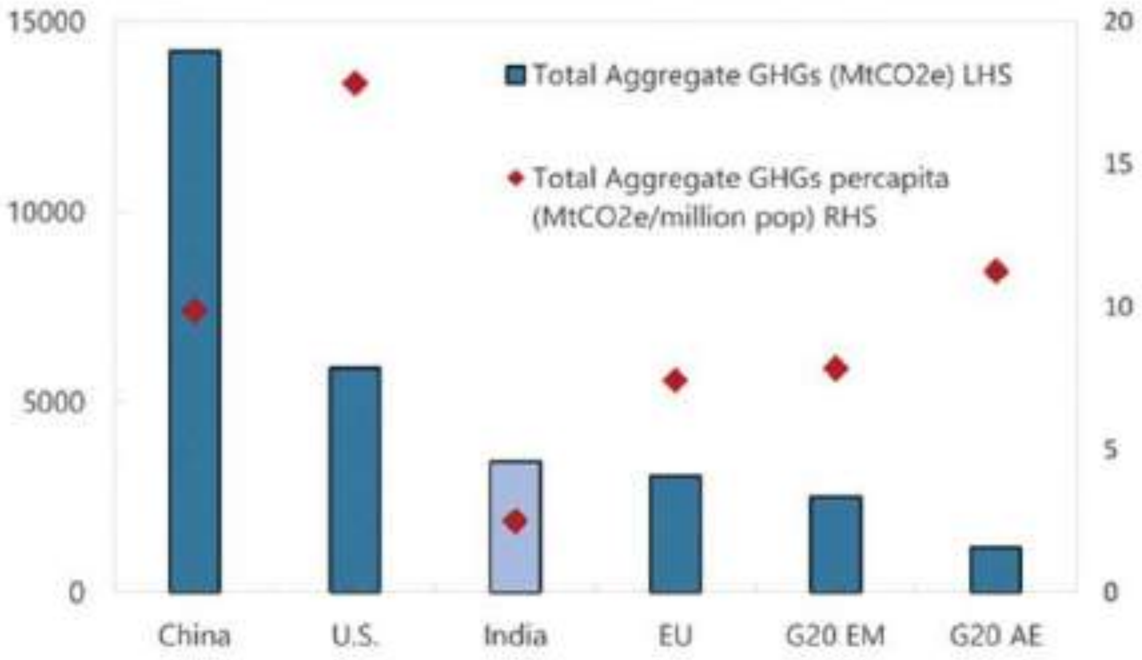


Figure 4. Aggregate GHG Emissions…
(Source IMF, EDGAR, UNFCCC, FAO, EU)

India’s Power Mix in 2030

In the ‘Report on Optimal Generation Mix 2030 – Version 2’ released in April 2023, the Central Electricity Authority (CEA) has projected

how India’s energy mix for the power sector would look like in 2030. In 2022-23, India generated 73% of its power from coal and only 12% from renewable energy sources such as solar, wind, small hydro, pumped hydro and biomass. In 2030, CEA expects that power from coal would go down to 55% while the share of generation from renewables would rise to 31%.

Compared to the version 1 report published in 2020, the projections are fairly the same – except for solar generation that has been projected to go up from 19% to 23%. The total installed power capacity in 2030 is projected to be 777 GW, while the gross generation is expected to be 2440.7 BU.

To meet peak demand (typically in the evenings) which often does not coincide with peak solar generation, CEA has projected a requirement of about 60 GW of storage capacity by 2030, from both pumped hydro and battery storage, to store the excess solar generation.

The report also states an additional energy requirement of 250 BU by 2030 to meet India’s green hydrogen aspirations. This means that the generation from solar and wind needs to be ramped up significantly from the 2022-23 levels of 173 BU if hydrogen production is to be given an added priority.

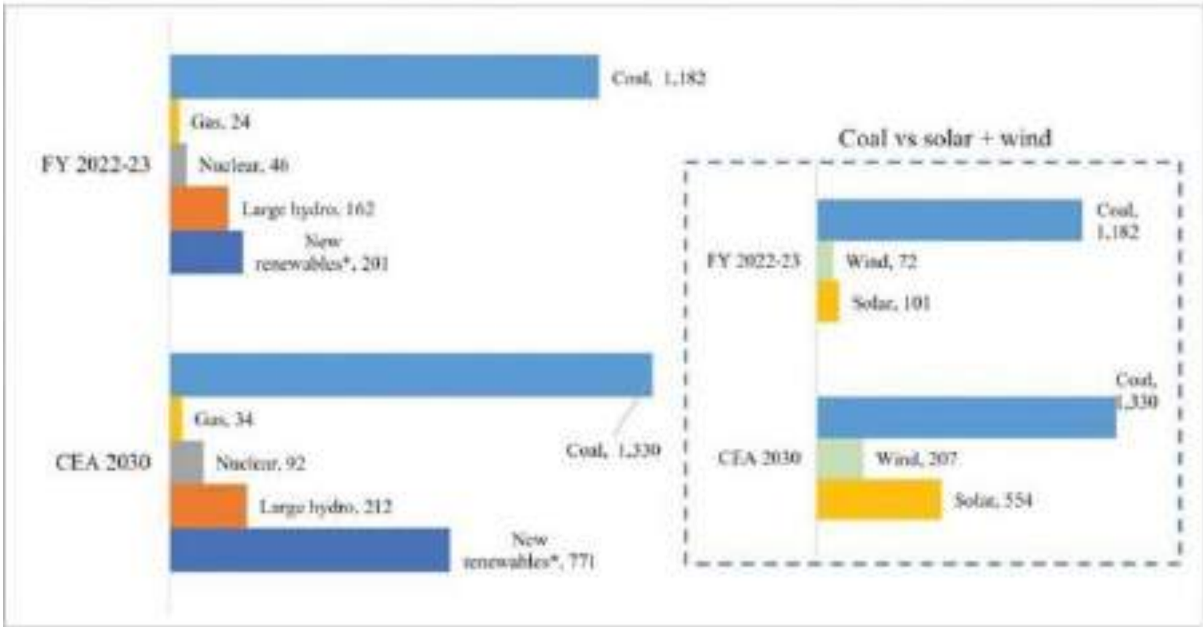


Figure 5. India’s power mix in 2023 vs 2030, generation (in BU) … (Courtesy CEA, downToEarth.org.in/news)

India’s GHG Emissions Are on an upward Trajectory

Under current policies, India’s GHG emissions are on an upward trajectory. The power sector is the largest emitter in India, accounting for 37% of total GHG emissions, followed by the agricultural sector (21%), manufacturing (17%) and the transportation sector (9%).

The blue line in Figure 5 shows India's historical and projected total GHG emissions under current policies.

Note that historical emissions have been slowly but steadily rising since 2014 in line with economic development. With India's ambitious growth plans a 41% increase in GHG emissions by 2030 is anticipated. Model estimates suggest that we will continue to see growing emissions levels up to 2040 and therefore, additional mitigation policies would be needed to bring India's emissions trajectory down.

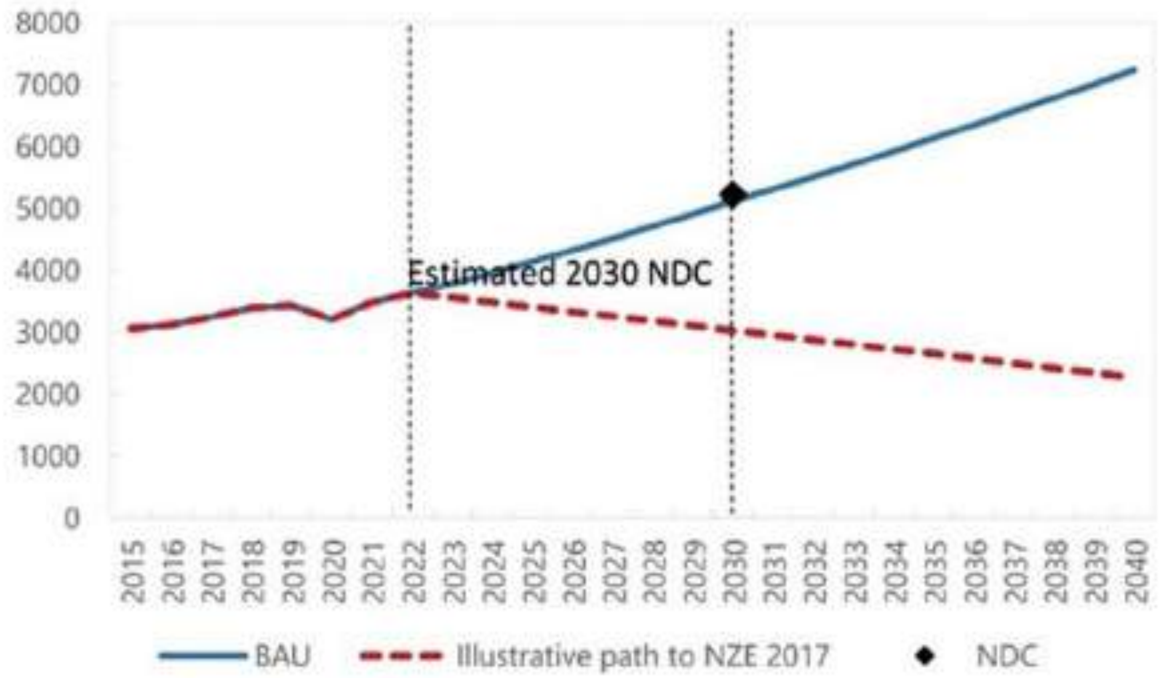


Figure 5. GHG All Emissions…

(Source IMF)

Delays in Transition Will Be Costly

Economic growth is a key priority for India and would be accompanied by increased demand for energy. The status quo energy composition that relies heavily on brown fuels puts India's emission trajectory

in the opposite direction of an illustrative linear path to Net Zero Emissions (NZE) by 2070 (shown in red in Figure 5).

Delaying the switch to green energy will be costly for India for three reasons. First, India is currently planning substantial

investments in coal-fired power plants that have typical lifespans of multiple decades and significant fixed costs.
If the country wishes to close these plants before their full lifespan, these fixed costs will be amortised over a shorter period inducing high transition costs and risking stranded assets. Second, scaling up renewable alternatives requires solving challenges such as intermittency problems, storage and grid connections, which are easier to do over longer periods of time. Third, to ensure a just transition it will be important to retrain workers currently in sectors that we see a decline. This is also easier and less disruptive over longer time horizons.

Growth vs Emissions Challenge

Climate change poses challenging policy trade-offs for India, but a path towards greener, stronger, and inclusive growth is possible. India faces important development goals, including to continue raising living standards for over a billion people. At the same time, it must be a critical contributor to reducing global GHG emissions as it is one of the largest emitters today in absolute terms.

Shifting away from coal is a formidable challenge, and the Indian government is taking a multipronged approach. The Indian economy relies heavily on coal that powers over 70% of electricity generation, and accounts for almost 40% of India's CO_2 emissions. Much of the industrial sector also runs on coal, and over 20 million people are dependent on the mineral, its extraction and use for employment either directly or indirectly.

The use of coal for electricity will remain a large component of source energy for the foreseeable future, but supercritical technology is being adopted to enhance the efficiency of coal fired power plants. Plans to adopt ultra-supercritical plants and develop advanced ultra-supercritical technology, which are estimated to have

emissions savings of 15-20%.

Missions under the National Action Plan on Climate Change

- National Solar Mission
- National Mission for Enhanced Energy Efficiency

National Mission for Sustainable Habitats

National Water Mission

National Mission for Sustaining the Himalayan Ecosystem

National Mission for Green India

National Mission for Sustainable Agriculture

In its effort to shift towards renewable energy sources and reduce emissions, the Indian government has deployed many policy tools. Various forms of subsidies for renewable energy adoption and generation are widespread (e.g., PLI schemes for solar module and battery manufacturing, National Motor Replacement Program, FAME for EVs, LED streetlights and bulbs), as are regulatory requirements (e.g., RPOs for electricity, building efficiency standards, vehicle emissions standards, standards & labelling, bioethanol), and tradable energy certificates (RECs, PAT). These policies are helping India begin its shift towards lowering emissions. Without further efforts, however, India's emissions are on track to continue to increase at a rapid pace. Investment in renewables will need to be scaled up substantially. This will require leveraging, in particular, technology transfer, international finance, and domestic debt markets.

DISCOMs – a Barrier to Decarbonize

One of the key challenges facing the power sector is the debt-distress of state DISCOMs. DISCOMs struggle to raise revenues amid underpriced electricity, inadequate subsidy payments and long-term purchase agreements with electricity generation companies. In addition, they face high energy losses (technical loss, theft, inefficiency in billing) and high commercial losses (default in payment and inefficiency in collection).

Given their heavy financial losses, DISCOMs have generally under-invested in improving power distribution or in upgrading the energy distribution infrastructure. Political constraints have historically impeded reforms to DISCOMs and their pricing structure. Furthermore, Discoms' payment delays to renewable energy generators act as one of the major barriers to scaling up renewable energy in India.

The GoI has undertaken several initiatives to resolve DISCOM debt stress. Around USD 60 billion has been allocated across several programs since 2015 aimed at resolving debt stress while trimming electricity losses, gradually narrowing the cost-revenue gap, improving the reliability and quality of power supplies, and promoting more sustainable competition in the sector (Ujwal DISCOM Assurance Yojana (UDAY) 1.0 and 2.0, and the Revamped Distribution Sector Scheme). State governments took on the debts of DISCOMs in UDAY 1.0, but they nonetheless continued to face financial strains.

The use of smart meters has been recognized as an additional solution to minimise DISCOM losses – and that could aid demand side management as well as narrow the cost-revenue gap of stressed DISCOMs – but this has had slow progress. Revising electricity tariffs will also be important to address the question of DISCOM viability. Looking forward, such schemes remain critical as DISCOMs face a further hit to their financial stability (from revenue loss), distribution system issues (from reactive power, voltage impacts and reverse power flows) and demand forecast uncertainty as renewable energy ramps up.

Net Metering to Net Billing

It is a common belief that an increase in solar generation would automatically result in a decrease in Greenhouse Gases (GHG) emission. So strong is this belief that prosumers having solar roof tops do not feel guilty to bank solar units with their local electric utility only to draw them later in the night to charge their EVs (Electric Vehicles). They believe that they are entitled to draw (import) fossil fuel units at night at no cost simply by offsetting them against solar units that they have earlier generated and banked with the utility in the daytime, under the Net-Metering (NM) tariff scheme offered by the utility. The flawed NM tariff is thus incapable of reducing GHG emissions. It also results in fossil fuel-based generation demand peaking in the evening and load shedding.

For the electric utility, NM results in a dual problem – (a) need to search for a buyer for the solar energy exported while (b) compensating the solar rooftop customer by offering expensive carbon based or fossil fuel-based energy at night at a discounted price that matches the lower cost of solar energy.

The solution is to shift from NM to Net Billing where the export and import of units are delinked and are independently billed.

Carbon Credits and Carbon Offsets

A carbon credit represents 1 tonne of CO2e that an organisation is permitted to emit. The number of credits issued to the organisation by a regulatory body represents its emissions limit or cap. Over-emitters turn to the carbon market to purchase carbon credits from an under-emitting organisation.

A carbon offset is also measured in tonnes of CO_2e. However, unlike carbon credits that are created or distributed by a regulatory body and limited to regulatory jurisdictions, carbon offsets can be traded freely on voluntary markets around the world.

Carbon Offsets can be sold at approx. USD 40/ ton. It is important that the carbon credits and offsets be carefully audited as its misuse could severely impact genuine efforts to reduce carbon emissions.

Tripling Renewable Capacity by 2030

At the 28th Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC), there was a push for countries to agree on a global renewables target – a tripling of renewable capacity by 2030. India's push to grow solar and wind bodes well in this context. CEA projects that India's renewable capacity and generation would quadruple from 109 GW to 392 GW and from 173 BU to 761 BU respectively in 2030.

CEA's projections indicate that India is likely to over-achieve on its pledge to the Paris Agreement – to have 50% of installed power capacity from non-fossil sources by 2030. As per the report, India's share of capacity from non-fossil sources - large hydro, small hydro, pumped hydro, solar, wind and biomass - will be 62% by 2030. The share will be 64% if nuclear power is considered.

It should be noted, however, that it is easy to quadruple the renewable capacity to 392 GW in 2030. However, it is difficult to substitute fossil fuel generation by the estimated 761 BU of renewable energy in 2030 and lower it down from the current levels.

With rising power demand, it is worth noting that while the share of coal is expected to reduce from 73% to 55% of power generation by

2030, coal power will rise in absolute terms between 2023 and 2030 – by 19% in terms of capacity and by 13 per cent in terms of generation.
The power sector contributes 37% of India's total GHG emissions. With growing energy demand as is expected of a developing country, power sector emissions are projected to rise by 11% – from 1.002 gigatonnes of carbon dioxide (Gt CO_2) in 2021-22, comprising 8% of global power sector emissions to 1.114 Gt CO_2 in 2030 at 10% of the corresponding global figure. On a per capita basis, this will be about half the world average even in 2030.

Conclusion

India faces a formidable challenge – on one side to continue raising living standards for over a billion people, while on the other to be a critical contributor to reducing global GHG emissions. India continues to be one of the largest emitters today in absolute terms. The Indian economy relies heavily on coal which powers over 70% of electricity generation, and accounts for almost 40% of India's CO_2 emissions. Much of the industrial sector also runs on coal, and over 20 million people are dependent on the mineral, its extraction and use for employment either directly or indirectly. In its effort to shift towards renewable energy sources and reduce emissions, the Indian government has taken a multipronged approach. Various forms of subsidies for renewable energy adoption and generation are widespread (e.g., PLI schemes for solar module and battery manufacturing, National Motor Replacement Program, FAME for EVs, LED streetlights and bulbs), as are regulatory requirements (e.g., RPOs for electricity, building efficiency standards, vehicle emissions standards, standards & labelling, bioethanol), and tradable energy certificates (RECs, PAT) and most recently a carbon trading market.

IMPROVED RECOVERY OF LITHIUM FROM SPENT LITHIUM-ION BATTERIES BY REDUCTION ROASTING AND $NAHCO_3$ LEACHING

Name: Mr. Vinod Padurang Patil

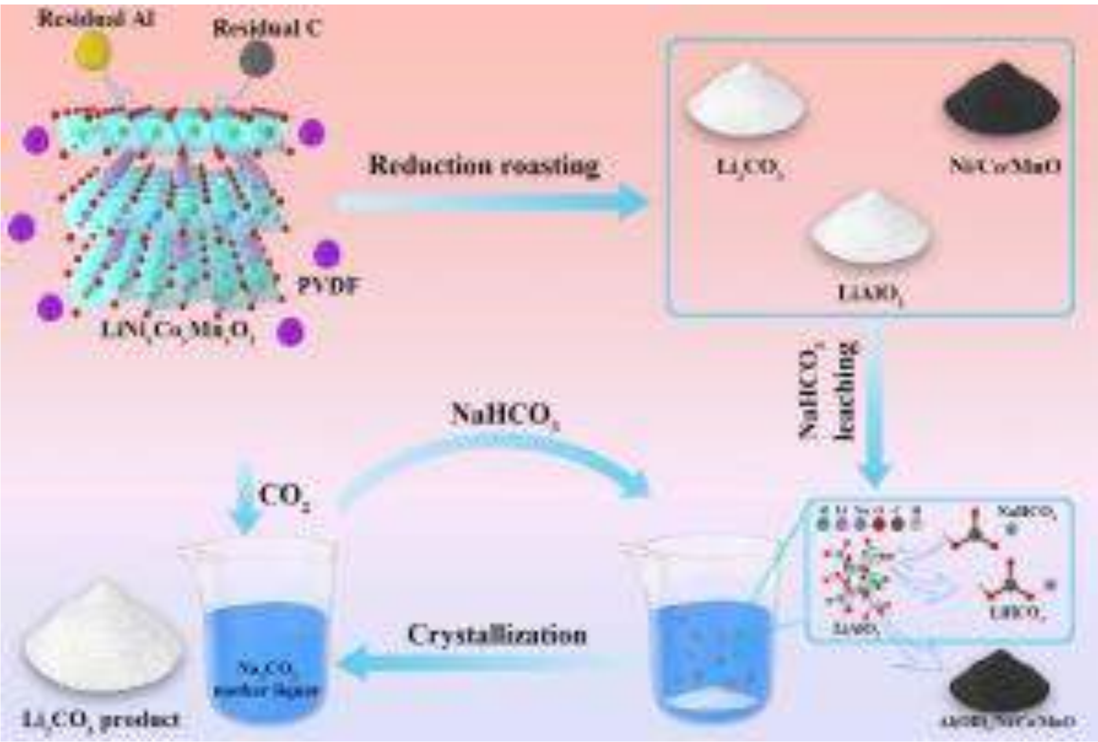
Mr. Piyush Malhari Pawar

Class: BTech Electrical

Abstract

Lithium supply risk is increasing and driving rapid progress in lithium recovery schemes from spent lithium-ion batteries (LIBs). In this study, a facile recycling process consisting mainly of reduction roasting and $NaHCO_3$ leaching was adopted to improve lithium recovery. The Li of spent $LiNi_xCo_yMn_{1-x-y}O_2$ powder were converted to Li_2CO_3 and $LiAlO_2$ with the reduction effect of C and residual Al in the roasting process. $NaHCO_3$ leaching was utilized to selectively dissolve lithium from Li_2CO_3 and water-insoluble $LiAlO_2$. The activation energy of $NaHCO_3$ leaching was 9.31 kJ•mol^{-1} and the leaching of lithium was a diffusion control reaction. More than 95.19 % lithium was leached and recovered as a Li_2CO_3 product with a purity of 99.80 %. Thus, this approach provides a green path to selective recovery of lithium with good economics.

Graphical abstract



Introduction

Lithium-ion batteries (LIBs) are widely applied in portable devices and large-scale energy-storage systems owing to their attractive properties (Fan et al., 2020). The global LIBs scale is projected to approach $95 billion by 2025. In particular, this trend is expected to create an increasing demand for LIBs (Roy et al., 2022).

Accordingly, they are simultaneously regarded as significant secondary resources for the recovery of valuable metals, such as nickel (Ni), cobalt (Co), and lithium (Li), considering the limited lifespan of LIBs. Sustainable recovery of these spent materials could help mitigate the supply of valuable metals and decrease the pollution of toxic metals concerning environmental and human health.

Recycling methods for spent LIBs can generally be classified as pyrometallurgy (Georgi-Maschler et al., 2012, Hu et al., 2021) and hydrometallurgy (Kang et al., 2010, Ilyas et al., 2022). Among which the hydrometallurgical process is the main way for the selective separation of valuable components due to its complete set of process and high recycling efficiency. Generally, the majority of hydro-approaches contains discharging, mechanical separation, pretreatment, acid-base leaching (Zhang et al., 2018, Harper et al., 2019), and then subjected to further separation and purification processing using selective precipitation, extraction separation, ion exchange and chemical adsorption (Chen et al., 2015, Liu et al., 2022, Wang et al., 2017). These methods typically focus on recovering high-value metals Co and Ni, while the recovery of Li is usually performed in the last procedure, resulting in a low levels of Li recovery due to the entrainment losses in a series of procedures. (Liu et al., 2019a, Yang et al., 2020, Huang et al., 2018). Therefore, it is necessary to explore efficient approaches for the improvement of Li recovery.

Recently, a carbothermal reduction roasting and water leaching process has been proven to be an effective method for Li extraction from spent LIBs (Hu et al., 2017, Lai et al., 2022). The Li of the spent LIBs powder was converted into water-soluble Li_2CO_3 via roasting, followed by water leaching to extract Li (Li et al., 2016, Lombardo et al., 2019). However, the water-insoluble $LiAlO_2$ phase is usually formed during the reduction procedure, since incompletely separated Al (approximately 3-10 %) from the spent LIBs powder also involves in the reduction reaction (Zeng et al., 2014, Zhang et al., 2022). This will lead to two subsequent problems, one of which is the low leaching efficiency of Li (Liao et al., 2022, Zhang et al., 2022, Yang et al., 2021, Jung et al., 2019). For instance, Zhang et al. identified the $LiAlO_2$ phase in a roasted sample and found that the recovery efficiency of Li was less than 81.26 % (Zhang et al., 2022). Jung et al. obtained a Li leaching yield of only 45 % due to most $LiAlO_2$ that could not be leached (Jung et al., 2019). On the other hand, the purity of the final Li_2CO_3 product will be reduced (Zhang et al., 2022, Stall meister and Friedrich, 2023a and b). As an example, Zhang et al. identified the $LiAl_2(OH)_7•2(H_2O)$ phase in the Li_2CO_3 product (Zhang et al., 2022). Stall meister and Friedrich detected 1.99–4.36 % of Al in the precipitated Li product (Stall meister and Friedrich, 2023b). This was because some of the dissolved Al in the leachate could not be efficiently removed and participated in the crystallization process (Zhang et al., 2022). Therefore, it is imperative to study the dissolution behaviour of $LiAlO_2$ for the enhancement of Li recovery and separation of Al.

In this work, an improved approach involving reduction roasting and $NaHCO_3$ leaching was proposed to enhance the extraction of Li and the separation of Al. The Li of spent $LiNi_xCo_yMn_{1-x-y}O_2$ powder was first transformed into Li_2CO_3 and $LiAlO_2$ with the reduction effect of C and residual Al. By adjusting different parameters, such as $NaHCO_3$ concentration, initial pH, temperature, and liquid–solid ratio, the selective leaching of Li from Li_2CO_3 and $LiAlO_2$ was realized via $NaHCO_3$ leaching, due to the fact that $LiAlO_2$ could be converted to $LiHCO_3$ solution and $Al(OH)_3$ precipitate in a weakly alkaline system. Li_2CO_3 product with a purity of 99.8 % was finally obtained via simple evaporation and crystallization. The present approach provides insight into the efficient and selective extraction of Li in the recycling process of spent LIBs.

Section snippets

Materials and reagents

The spent $LiNi_xCo_yMn_{1-x-y}O_2$ (NCM) powder used was obtained from Henan Kelong New Energy Co., Ltd, China. The chemical components, phase structure and EDS mapping of the spent NCM powder were shown in Table S1, Fig. S1, and Fig. S2, respectively. The main components identified in the powder were Ni, Co, Mn, Li, Al, and Cu, and the phase structure were dominated by $LiNi_xCo_yMn_zO_{1-x-y}$ and Al. Chemical reagents, such as sodium bicarbonate ($NaHCO_3$), sodium hydroxide (NaOH), and graphite (C), were

Reduction roasting

The thermochemical software HSC Chemistry 6.0 was used for the thermodynamic calculations of the chemical reactions possibly involved in the carbothermic (C as a reduing agent) and aluminothermic reaction (Al as a reduing agent) process, the relationship between Gibbs free energy (ΔG^{θ}) and temperature (°C) were plotted. According to Fig. 1a, the ΔG^{θ} value of all reactions are negative when the temperature in the range of 250–1000 °C, indicating that these reactions can proceed spontaneously.

Conclusions

This study demonstrated a facile method to improve the recovery of Li from spent NCM powder via reduction roasting and $NaHCO_3$ leaching. Residual C and Al could be used as reducing agents to convert spent NCM powder into Li_2CO_3, $LiAlO_2$, Ni, Co, and MnO in the roasting process. $NaHCO_3$ leaching could significantly increase the leaching efficiency of Li by dissolving the water-insoluble $LiAlO_2$ phase.

PASSWORD BASED CIRCUIT BREAKER

Name: Mr. Sahil Mahadev More
Mr. Abhay S Dhulasawant
Mr. Shitalkumar Sujitkumar Bharamgonda
Mr. Atharv Rajkumar Patil
Class: TY Electrical

Abstract

To avoid that we introduced our project password-based circuit breaker using 8051.when we enter the password the 8051 store the password and verify it whenever we enter. Once we enter the password the circuit may be turn on or off with the help of the password.

Keywords: Microcontroller 8051, Relay, LCD, Capacitor.

Introduction

Security is the prime concern in our day-to-day life. Everyone needs to be secure as much as possible. The electric line man safety system is designed to control a circuit breaker by using a password for the safety of electric man. Critical electrical accidents to line men are on the rise during electric line repair due to lack of communication and co-ordination between the maintenance staff and electric substation staff. This proposed system provides a solution that ensures safety of maintenance staff, i.e., line man. The control to turn on or off the line will be maintained by the line man only because this system has an arrangement such that a password is required to operate the circuit breaker (on/off). The system is fully controlled by a microcontroller from AVR family. A matrix keypad is interfaced to the microcontroller to enter the password. The entered password is compared with the password generated. If the password entered is correct, only then the line can be turned ON/OFF. The basic idea behind this project is shown in the following figure.1. To repair a particular section of the electric supply line, the lineman wants to turn off the supply to that line. For this he first put a request to the system. Then the system responds to him using the LCD display to enter the password. Then the system generates a password and it will be sent to the phone (the nod of which is stored in the program).

Objectives

A password is a word or string of characters used for user authentication top rove identity or access approval to gain access to a resource (example: an access code is a type of password), which is to be kept secret from those not allowed access The use of passwords is known to be ancient. Sentries would challenge those wishing to enter an area or approaching it to supply a password or watchword, and would only allow a person or group to pass if they knew the password. In modern times, user names and passwords are commonly used by people during a log in process that controls access to protected computer operating systems, mobile phones, cable TV decoders, automated teller machines (ATMs), etc. A typical computer user has passwords for many purposes: logging into accounts, retrieving e-mail, accessing applications, databases, networks, web sites, and even reading the morning newspaper online.

Problem statement

Traditional boost has low output voltage also output current in pulsating dc so we are proposing a system that include KY converter with fuzzy logic controller for efficient battery charging.

Methodology

Block diagram

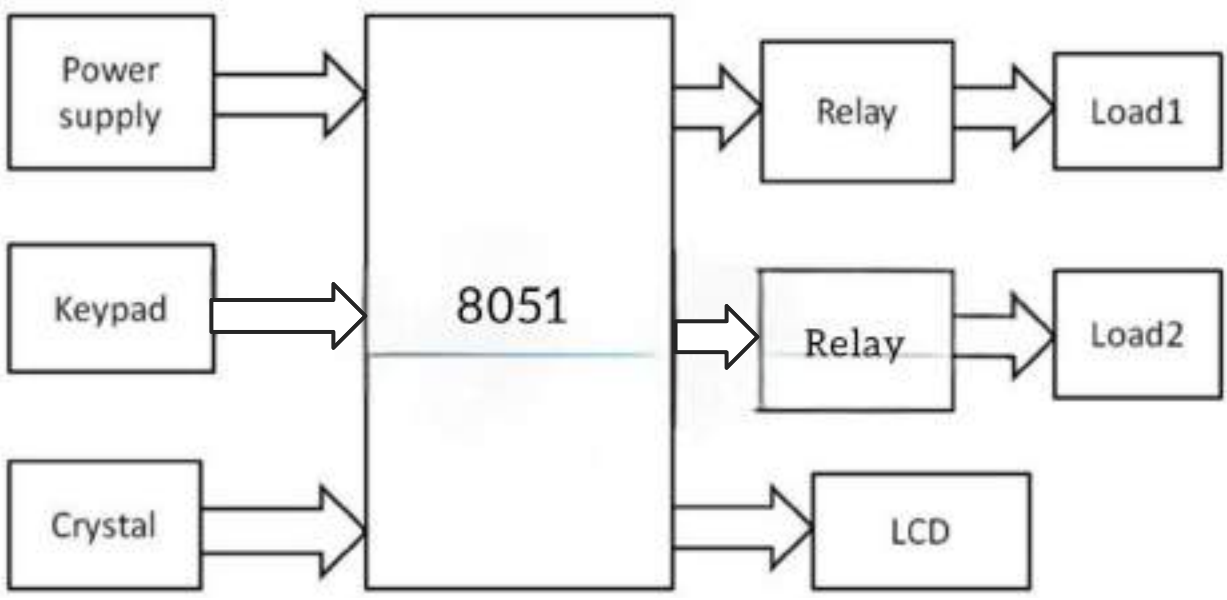


Fig 4.1 Block diagram

The electric line man safety system ensures the safety of the staff. It consists of only an embedded section. The major component is a micro controller from AVR family Based on the program done in the provides a control to turn on or off the line and thereby microcontroller a relay switches to turn on or off the circuit breaker. The system comprised of a LCD display, buzzer, matrix keypad, and a relay. The main attraction of this project is the OTP generation. It is an 8-bit micro- controller with 32KB memory and has 4 ports. Normally the supply to the line is always on and it is indicated by using a lamp which is always on. If there is any problem in any section of the supply line, then the line man wants to turn off the supply to that section and repair it. The LCD display provided along with the system gives visual assistance of―LINE MAN SAFETY SYSTEM ‖ for easy operation of the system. For that he first put a request to the system if the system is ready. The LCD display gives an indication of ―SYSTEM READY‖ if is ready to work. Then he put a request by pressing a switch. This gives an indication to the system to turn off the supply to the line. Then the system generates a 4-bit length onetime password. AND ASK ―ENTER OTP‖. After enter it using the keypad, it will be compared with the generated password (which is stored in the ROM). If the passwords are matched, then the LCD displays ―OTP MATCHED‖ and turn off the supply to the line i.e., the lamp will be turned off. Therefore, the line man can safely work on the line and repair it. When repair is over, he will reach the substation and again put a request to turn on the supply by pressing the switch. Then system generates another password and using it he can turn on the line. If the passwords are not matched up to or more than three times, an alarm will be activating. The PASSWORD in to which the OTP is stored in the program. This number may be either of the sub engineer's number or of the line man's number. It is possible to send the number to more people. But it will be based on the security only. It is also possible to use each password for a particular line. And also, wireless communication can also use depends on the distance The micro controller used for the implementation of this system is ATmega32.

It is an 8-bit microcontroller with 32KB on-chip programmable flash memory. Based on the program stored in the micro controller it will generate the OTP. And if the passwords are matched or not, it will switch a relay also OTP generation is the main part of this project. This is done by the micro controller. The RISC based micro controller consists of four ports. In which port A is dedicated for ADC.

Working

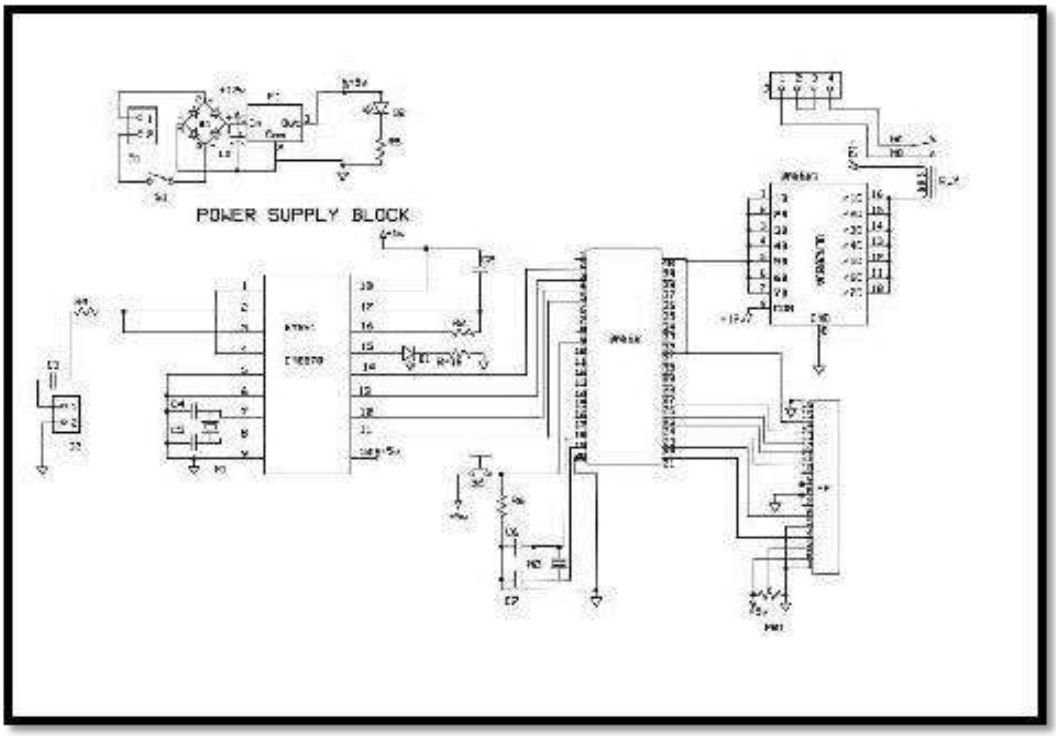


Fig 4.2 Circuit diagram

The above circuit consists of 8051 series controller (AT89C51), 4×4 Matrix Keypad, 16 x 2 LCD Display, 4 – Channel Relay Module and Four Loads. LCD data pins are connected to PORT1 and control pins RS, RW and EN pins are connected to P3.0, GND and P3.1 respectively. Here, the LCD is used to display the information related to the load.

Keypad is connected to PORT2 of the microcontroller. The four Row Pins of the Keypad are connected to P2.0 to P2.3 and the four Column Pins are connected to P2.4 to P2.7. Using this keypad, we need to enter the password.

Four Lamps (acting as Electrical Lines) are connected to P0.0 to P0.3 through the 4 – Channel Relay Module. These are used to indicate circuit breaker state (Light ON – Line Active and Light OFF – Line Not Active). Be extremely careful when wiring the AC load to the Relay and mains supply.

The system is fully controlled by a microcontroller from 8051 family. A matrix keypad is interfaced to the microcontroller to enter the password. The entered password is compared with the password stored in the ROM of the microcontroller. If the password entered is correct, then only the line can be turned ON/OFF. Activation / deactivation of the circuit breaker is indicated by a lamp (ON/OFF).

Fig 4.3 Prototype Module

POWER SUPPLY: The input is 230V AC which is step down using the transformer (12-0- 12). The 12V ac input is fed to the bridge diode to gives 12V pulsating DC. This DC voltage is filtered through the capacitor to remove the ripples. The filtered DC is fed to 7805 regulators to fetch +5v regulated output. This regulated voltage is given to all the components to function properly.

The main objective of the project is to develop a circuit breaker which can be controlled remotely using cell phone.
A unique password must be entered through the keypad of cell phone to activate/deactivate the circuit breaker. Each key of the password is identified with a frequency which is decoded to digital code through DTMF (digital tone multi frequency) decoder and that code is fed to a microcontroller which is programmed to recognize the code for operating the circuit breaker duly interfaced through driver IC for the load. Each number on the cell phone keypad has a distinct sound (called DTMF tones). This sound can be used to identify the key pressed using a M8870 DTMF decoder. Here the sound is firstly pre-amplified by the microphone unit. This sound is now fed into the CM8870 IC which decodes them in form of numbers. These decoded numbers are fed into the microcontroller though the CM8870 IC. The microcontroller here is 8051 family microcontroller AT89S8253 which is the main processing unit to check proper input and generate output. It checks the correctness of the code as per the programming. The programming is done in MIKRO C compiler using C logics If the code is correct then relay is energies and circuit is open else not and can be closed through a password. The outputs in the project are driving unit and the LCD display. The output of microcontroller (interfaced to port 0) is given to the ULN2803 (Darlington pair current amplifier) this acts as a relay driver. The function of this is to provide proper current and voltage to the relay. The relay finally selects the on/off of circuit in terms of ac voltage. Relays are electromagnetic switches that are triggered to enable desired supply to the load. The relays which are used here are 12V relay. There is 16x2 LCD interface also to display the status that is circuit on/off and the encrypted password. The LCD is interfaced to the microcontroller through its 6 pins (port2- pin 21-26). Proper display on LCD is managed through programming (refer programming section).

Program

```
void main()
{
int first=0; int second=0; int third=0;

Lcd_Init(); // Initialize LCD
Lcd_Cmd(LCD_CLEAR);   // Clear display
Lcd_Cmd(LCD_CURSOR_OFF);   // Cursor off p0_0=1;
lcd_out (1,1,"Welcome"); while(1)
{
if (P1==244)
{
Lcd_Out (1,1,"Enter pass"); while (p1==244);
first=p1;  Lcd_chr  (2,1,'*');  while  (p1==first);  second=p1;
Lcd_chr (2,2,'*');
while (p1==second); third=p1;
Lcd_chr (2,3,'*'); delay_ms (2000);
if ((first==242) & (second==241) & (third==242))
{
Lcd_Out  (1,1,"Correct  ");  Lcd_Out  (2,1,"Door  Open");  while
(p1==third);
Lcd_out  (2,1,"Door  closd");  p0_0=1;  delay_ms  (2000);  lcd_cmd
(lcd_clear);
goto start;
}
else
{
p3_1=0;
Lcd_Out (1,1,"Wrong "); delay_ms (2000); p3_1=1;
Lcd_cmd (Lcd_clear); goto start;
}
}
}

}
```

Application

Used in electrical substations to ensure line man safety

This system is used in buildings and houses

Used in hotels and shopping malls to save the power.

Can also be used as Password based electrical appliance control or Password based Load Control system.

Conclusion

Circuit breaker can work on a single given known password. The password to operate can be changed and system can be operated efficiently with the changed password. No other person can reclose the breaker once the changed password is given into system other than the person who had changed it.

BATTERY DISCHARGE MEASUREMENT CIRCUIT

Name: Mr. Sanket Sanjay Devmore

Mr. Samyak Mohan Kambale

Mr. Abhishek Ravasaheb Kerimane

Mr. Omkar Suresh Kore

Class: TY Elctrical

Abstract

Simple test circuit using a comparator and reference to measure battery drain. Measuring battery life for a portable system is a time-consuming task, and the methods that accelerate battery discharge don't provide reliable results. In the usual approach you simply measure elapsed time while operating the product to the point of battery discharge. Running several such systems in parallel obviously gives more data, if you can afford to tie up the lab equipment. You can try to derive battery life from data-sheet specifications associated with the circuit components, but a calculated value is usually far short of the actual operating time. Current-drain specs tend to be conservative for low-power ICs, because they are tested with high-speed equipment that cannot easily measure low supply currents. Unlike many electrical parameters, battery life (in most cases) is better specified as a realistic typical than as a guaranteed minimum.

Introduction

A battery discharge measurement circuit is designed to monitor and assess the voltage drop and capacity depletion of a battery over time. Typically, it includes components such as a precision voltage sensor, current sensing elements, and a microcontroller for data processing. The circuit measures the battery voltage and current during discharge, enabling the calculation of remaining capacity and providing insights into the battery's health. This data is valuable for understanding the performance characteristics of batteries in various applications, from portable electronics to electric vehicles. A battery discharge measurement circuit is a system designed to monitor and measure the state of health of a battery.

Such circuits are commonly used in various applications, including portable electronic devices, electric vehicles, renewable energy systems, and more, to ensure safe and efficient use of batteries. The primary functions of a battery discharge measurement circuit include the circuit measures the battery voltage to determine its state of charge and assess its health. Voltage can provide a rough estimate of a battery's SoC but may not be sufficient on its own. The circuit can assess the battery's by analysing its performance and degradation over time. This is crucial for predicting the remaining lifespan of the battery. Protection and Balancing: Some battery management systems incorporate protection mechanisms to prevent overcharging, over-discharging, and other dangerous conditions. Additionally, they can balance individual cells in multi-cell battery packs to ensure even wear and tear. These circuits can trigger alarms or safety measures when the battery reaches critical conditions, helping prevent accidents or damage. Battery discharge measurement circuits are essential in applications where reliable battery performance is critical, such as electric vehicles, drones, UPS systems, and renewable energy storage. They enable users to monitor and manage batteries effectively, extending their lifespan and ensuring safe operation. The specific design and features of such circuits can vary depending on the application and the type of battery being used.

Objective

The primary objectives of this project are:

- Capacity Assessment
- Health Monitoring
- Performance Optimization
- State of Charge (SOC)
- Estimation Safety Assurance
- Cycle Life Analysis

Problem Statement

1. Initial SOC error due to recursive integration.
2. Current measurement error caused by noise in current sensors.

3. Integration error from rectangular approximation methods.
4. Variability in battery capacity knowledge.
5. Timing oscillator error affecting SOC updates.

Components Used for Project

1. 10 μF Capacitor

Fig 1: Capacitor

A 10 μF capacitor is an electronic component that has a capacitance of 0.1 microfarads. The capacitor's primary function is to store and release electrical energy in a circuit

2. LM358L IC

Fig 2: LM358L IC

LM358 can be used as transducer amplifier, DC gain block etc. It has large dc voltage gain of 100dB. This IC can be operated on wide range of power supply from 3V to 32V for single power supply or from ±1.5V to ±16V for dual power supply and it also support large output voltage swing.

3. BC337 TRANSISTOR

Fig 3: BC337 TRANSISTOR

4. L7805CV (Fixed voltage regulator)

Fig 4: L7805CV

This regulator can provide local on-card regulation, eliminating the distribution problems associated with single point regulation. It employs internal current limiting, thermal shutdown and safe area protection, making it essentially indestructible. If adequate heat sinking is provided, it can deliver over 1A output current.

5. Battery

Fig 5: battery

9V Battery is the most commonly used and portable 9V battery. It is non- rechargeable and is a high capacity and low-cost solution for many electronic devices. It is based on Zinc Carbon Chemistry and can be used easily replaced if discharged

6. LED

Fig 6: LED

A light-emitting diode is a semiconductor device that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. The color of the light is determined by the energy required for electrons to cross the band gap of the semiconductor.

7. Analog Clock

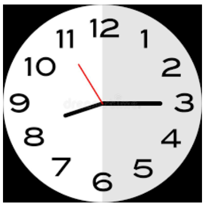
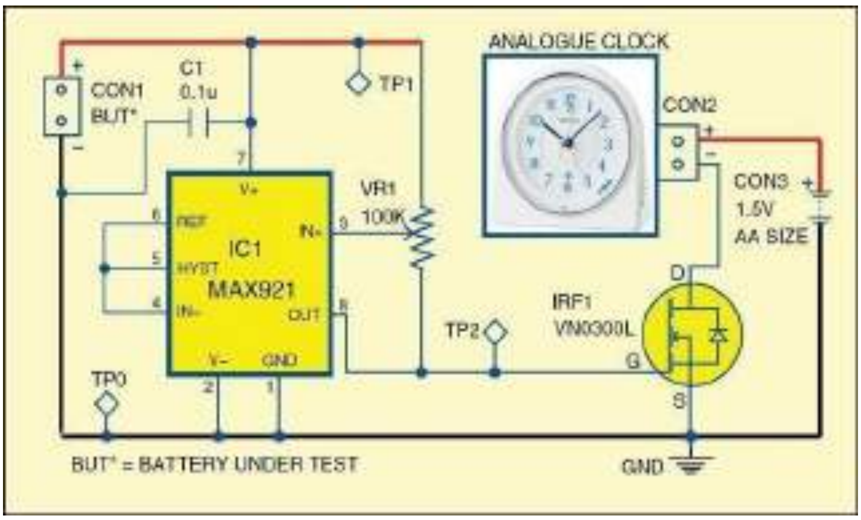


Fig 7: Clock

An analog clock is a to measure the battery discharge time.

Circuit Diagram



Explanation:

A single-side PCB for the circuit is shown in Fig. 2 and its component layout in Fig. 3. After assembling the circuit on PCB, enclose it in a suitable plastic box. Connect positive terminal of the analogue clock to positive terminal of a 1.5V AA-size battery and negative terminal to the drain of MOSFET. Before using the circuit, verify that voltages at the test points are as per table. For setting the threshold voltage, you need a variable DC power supply at CON1. For example, to measure the discharge time of a 6V battery (BUT), first decide its minimum threshold voltage, say 4.5V. Connect variable supply to CON1 and set it to 4.5V. Vary VR1 till the clock stops running. Now, remove the variable power supply, set the clock to 12:00 and connect the 6V battery at CON1. Connect the load across the battery. As the battery power is being consumed by the load, voltage level begins to drop. When BUT voltage drops below 4.5V, the clock stops running. The time shown on the analogue clock at this point is the discharge time.

Working

The circuit for battery-discharge measurement is shown in Fig. 1. It is built using low- power single-/dual-supply comparator LM358L, MOSFET VN0300L (IRF1), an analogue clock, resister, capacitor, transistor and a few other components a used.

In this circuit fist we will on the switch to start the flowing the supply on the circuit and start the clock rotating in clock wise direction. The MOSFET is used in this circuit he works as a switch if the MOSFETs are often used in battery management systems to protect the battery from over- discharge. If the battery voltage drops below a safe threshold, the VN0300L can be turned off to prevent further discharge, thus safeguarding the battery. The Ic is used for the Both of the operational amplifiers of the LM358 IC are used as comparators to detect the voltage of the battery attached to the circuit for monitoring. They both have a variable resistor of 10K ohms connected at their inputs to adjust the LEDs to go OFF on desired voltages. The capacitor is using

Capacitors can be used to filter and smooth voltage waveforms. In a battery discharge measurement circuit, they can help remove noise and fluctuations from the measured voltage signal, ensuring more stable and accurate measurements. Transistor are used in our day-to-day lives in many forms, which we are aware of as amplifiers and switching apparatuses. As amplifiers, they are being used in various oscillators, modulators, detectors and nearly any circuit to perform a unction. In a digital circuit, transistors are used as switches. The ic compare the both voltages and give the signal to the MOSFET and MOSFET get tune off. Hence the clock will be the stop rotating.IC1 monitors the life of the BUT (battery under test) and controls the power supply for the analogue clock. When the BUT voltage falls below the threshold value set by VR1, IC1's output becomes low, which turns off MOSFET IRF1. This means, power supply for the analogue clock is cut off and so the clock stops running. The reading on the clock at this point gives the discharge time of the BUT, provided you had set the clock to 12:00 before testing started. The circuit can test 2.5V to 11V batteries.

Working Operation

Result of battery discharge measurement circuit

Battery voltage	Battery Discharging time
4.2	20 min
4.0	16.6 5min
3.88	13.32 min
3.84	9.99 min
3.81	6.66 min
3.75	3.33 min
3.70	0 min

Applications

- Monitor the remaining charge left in the battery of a device such as MCU.
- Battery discharge measurement circuits are vital in electric vehicles to monitor the state of charge and state of heat of the battery.
- Battery discharge measurement circuits are commonly found in smartphones, laptops, and other portable devices.
- Battery discharge circuits are used in off-grid solar power systems to monitor the state of charge of the battery bank.
- In off-grid or hybrid renewable energy systems battery discharge measurement is essential for optimizing the use of stored energy.
- In large-scale energy storage projects, such as grid energy storage plants, battery discharge measurement circuits help manage and optimize the discharge of stored energy to the grid.

Conclusion

The battery discharge measurement circuit is an integral component for accurately monitoring and managing battery performance across various applications, ensuring safety, efficiency, and longevity of battery life.

References

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Telephone: (2322) 253000/01, Fax: 2322-252897, Email: contact@sitcoe.org.in