Power Monitoring and Alert System

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***Abstract* - This report describes the design and implementation of a power monitoring system that monitors and alerts the user in case of a power cut via email and also shows the status of the main supply and the uninterrupted power supply through a graphic user interface. The work has been accomplished on an ESP32 microcontroller-based M5Stack as well as on a single-board computer Raspberry Pi. The system comprises several components, including a microcontroller unit (MCU), a voltage converter, and software. For programming the M5Stack, Arduino IDE has been used, and Raspberry Pi has been programmed using Thonny MicroPython IDE. The controller communicates to the Python GUI wirelessly via TCP/IP protocol with the help of socket libraries in Python which enables the controller to send messages to the Python GUI side. The complete GUI has been developed using the Tkinter library.**

Keywords - M5Stack, Raspberry Pi, Tkinter, Socket Programming, TCP/IP

I. INTRODUCTION

Modern technologies have brought many advancements, but they have also brought a higher demand for power. This demand has led to the creation of power monitoring systems, which can monitor power availability in various applications and facilitate power management. Unavailability of power even for a short duration of time can cause major disruptions at work. Thus, a power monitoring system has been designed that dynamically monitors the power system of Nirma University.

The power monitoring system consists of hardware and software components. The hardware includes a microcontroller unit (MCU) and 230V to 5V converters to be installed at strategic points in the electrical system to sense the availability of power. MCU unit detects the voltages with the help of a converter and constantly keeps updating the GUI. Programming the MCU unit is an integral part of the software component of the power management system. The conditions for different combinations of the power status of the main supply and the UPS are defined, and the microcontroller is programmed to act accordingly.

The software component of the power management system includes programming the Microcontroller unit and GUI development. Conditions for different combinations of the power status of the main supply and ups were defined and the microcontroller was programmed to act accordingly. It displays the information in a user-friendly format. It provides real-time data to the user, enabling them to monitor the power status continuously. Additionally, the software also sends email alerts to the concerned parties whenever there is a power outage and the UPS gets connected or in case of a total power failure in the system.

II.COMPONENT DESCRIPTION

A. *M5Stack:*

M5Stack is a modular, open-source development kit based on the ESP32 microcontroller. It is designed for rapid prototyping and building of IoT devices, wearable devices, and other projects that require a compact and powerful hardware platform. The M5Stack kit consists of a core module that includes an ESP32 chip, a 2-inch color TFT display, a battery, and various sensors, including an accelerometer, a gyroscope, and a magnetometer. The core module also has several expansion ports for adding additional modules, such as cameras, GPS modules, and more.

The M5Stack platform is programmed using the Arduino IDE or the MicroPython language, and it comes with a comprehensive set of libraries and examples to help developers get started quickly. The platform also supports OTA (Over-The-Air) firmware updates, making it easy to update the firmware on the device remotely.M5Stack is a powerful and flexible development kit that makes it easy to build IoT and other projects quickly and efficiently.

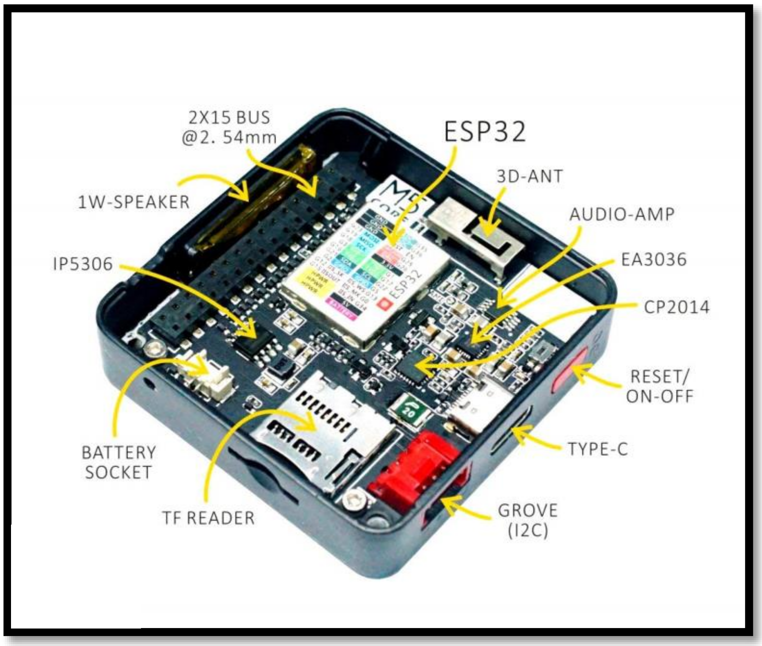

Figure 1 – M5Stack Development Board

B. *Raspberry Pi:*

Raspberry Pi is a series of single-board computers which are designed to be versatile and affordable and can be used for a wide range of applications. They are particularly popular for educational and hobbyist use but are also used in commercial and industrial applications.

Raspberry Pi boards are based on ARM processors and run on a variety of operating systems, including Raspbian, Ubuntu, and Windows. They come with a variety of input/output (I/O) ports, including USB ports, Ethernet ports, HDMI ports, audio jacks, and GPIO (General Purpose Input/Output) pins. The GPIO pins allow users to connect the board to a variety of sensors, motors, and other electronic components, making it possible to create custom projects.

One of the key benefits of Raspberry Pi boards is their affordability. They are designed to be low-cost, making them accessible to a wide range of users. It is an ideal platform for a wide range of applications, from simple programming and electronics projects to more complex projects like media centers, home automation, and robotics.

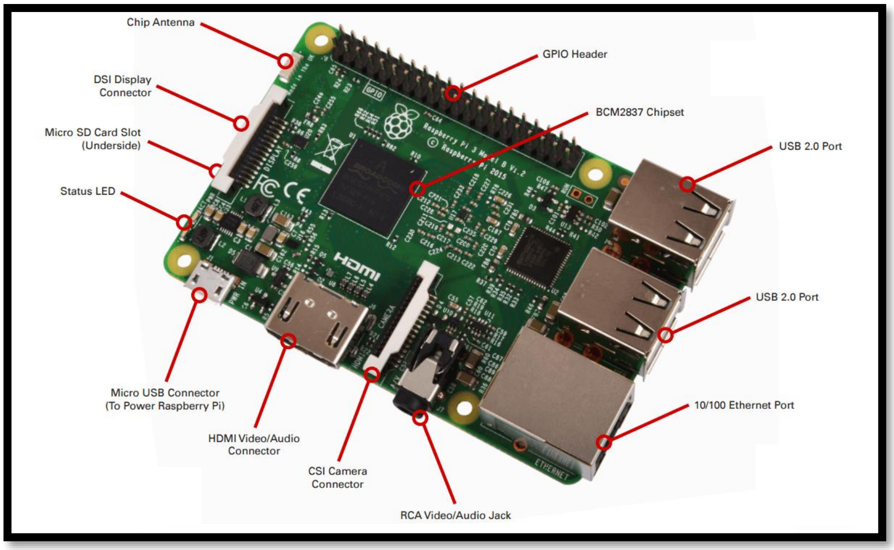

Figure 2 Raspberry Pi

C. 230V to 5V Converter

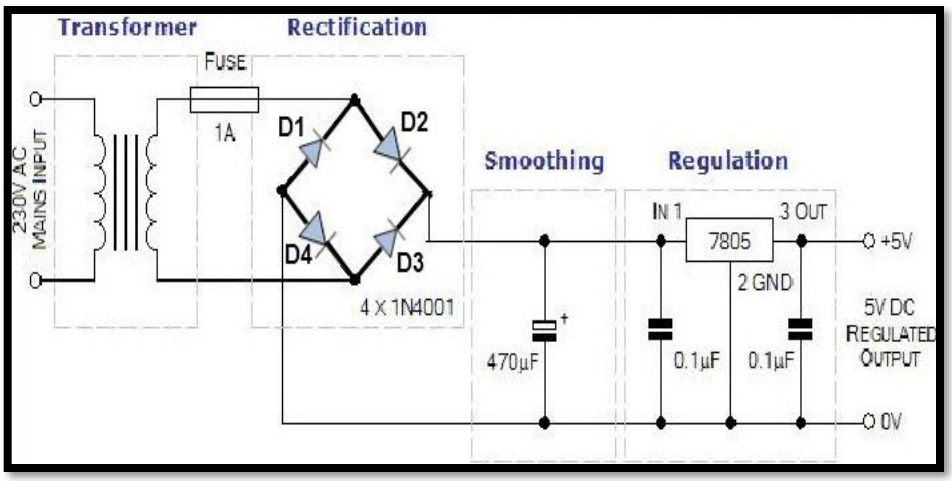

Figure 3 Circuit Diagram of 230V to 5V Converter

A 230V to 5V converter is an electronic device that transforms high-voltage AC power into low-voltage DC power. The conversion process involves two main stages: rectification and voltage regulation. Rectification is the process of converting AC voltage into DC voltage. This is usually done using a diode bridge, which converts the AC voltage into pulsating DC voltage. The pulsating DC voltage is then smoothed using a capacitor, which removes the fluctuations in voltage and produces a steady DC voltage.

The next stage is voltage regulation, which involves controlling the output voltage to a constant value. This is usually done using a voltage regulator, which is an electronic device that adjusts the output voltage based on a reference voltage. Here, a 5V voltage regulator has been chosen for the same.

In the context of a power monitoring system, a 230V to 5V converter is used to take input signals of the main supply and UPS of different blocks. The MCU uses the converted DC voltage to monitor the status of the power supply and UPS, and constantly updates the GUI to display the information to the user.

III. IMPLEMENTATION

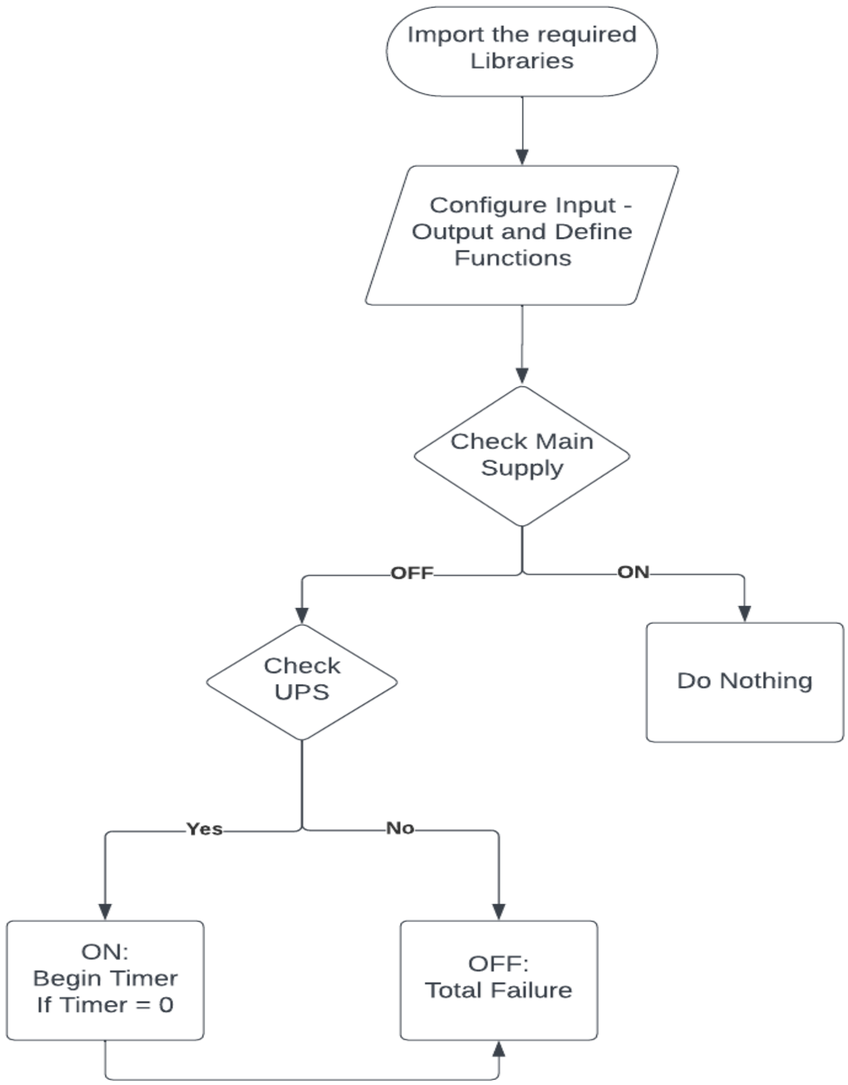

Figure 4 – General Code Flow for a single block

A. *Implementation on M5Stack*

The design has been implemented on the M5Stack Development board which is based on ESP32 Microcontroller. M5Stack continuously keeps sending data to the GUI wirelessly and GUI is updated based on the data received. The controller sends a notification on email whenever there is no power in the main supply and UPS is powered on as a consequence. The communication takes place through TCP/IP Protocol. The program flow is as follows:

1. Importing Required Libraries:

The first step is to import the necessary Python libraries required for the program. In this case, the program requires the "socket" and "Tkinter" libraries. "Socket" is used to create a socket object to establish a connection and send/receive data, while "Tkinter" is used to create the GUI for the program.

2. Host and Port definitions:

The next step is to define the host and port number for the socket connection. The host refers to the IP address of the device running the server, and the port number is the number that the server listens to for incoming connections.

3. Creating Tkinter Window:

In this step, a Tkinter window is created, which will be the main GUI for the program. The window is given a title and size, and other necessary properties are set.

4. Timer and Color change function definitions:

Two functions are defined in this step. The first function is the timer function, which is called whenever the UPS is on. This function updates the timer label in the GUI to show the current time duration for which the UPS has been running. The second function is the color change function, which is used to change the color of the lights on the GUI based on the status of the UPS and the Block (Main Supply).

5. Background design:

In this step, the background for the GUI is designed. This includes creating a canvas and drawing a rectangle and some lines on it to give the appearance of a control panel.

6. Adding labels and lights that represent power status:

Labels and lights are added to the GUI to display the power status of the UPS and the blocks. This includes labels to display the current status as well as lights to indicate whether the UPS and blocks are on or off.

7. Creating an infinite loop that listens to incoming connections at Host and Port:

The next step is to create an infinite loop that listens for incoming connections at the specified host and port number. This is done using the "socket" library. Whenever a connection is established, the loop continues and the program proceeds to the next step.

8. After the connection is established, received data is stored in a data variable:

Once a connection is established, the program receives data from the connected device and stores it in a variable called "data". The data is in the form of a string.

9. Whenever UPS is On, the timer function is called:

If the received data indicates that the UPS is on, the timer function is called. This function updates the timer label in the GUI to show the current time duration for which the UPS has been running.

10. GUI is updated using the update function:

Finally, the GUI is updated using the "update" function of the Tkinter library. This function is used to redraw the GUI with any changes made to its components. The update function is called at the end of the infinite loop so that any changes made to the GUI are reflected in real time.

Output Results:

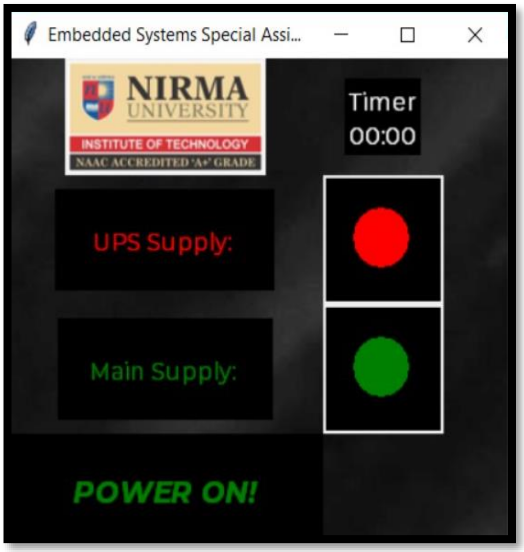

Figure 5 – Power in Main supply

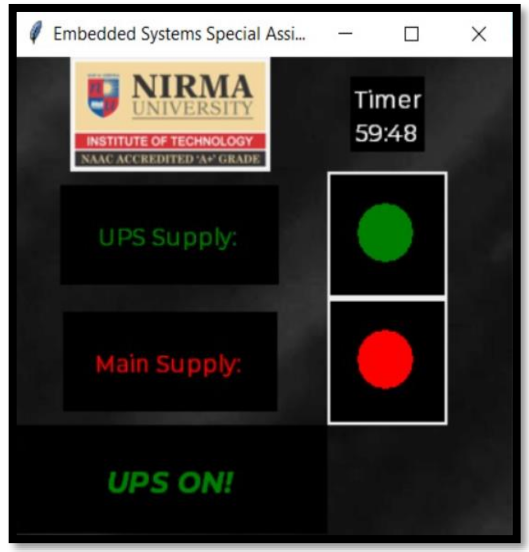

Figure 6 -UPS Powered On

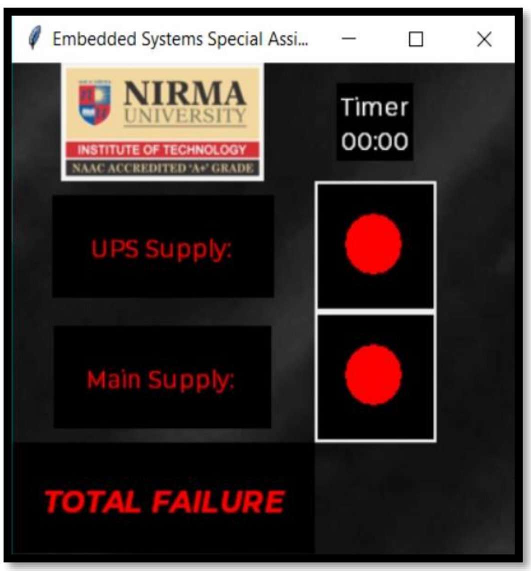

Figure 7 – Total Power failure

Figure 8 – Email sent as UPS is Powered On

B. Implementation on Raspberry Pi

The design has also been implemented on a Single Board Computing board. Raspberry Pi has been chosen for the same. The code flow is almost similar to M5Stack. The only difference is that the Controller and GUI program has been written in a single program which eliminates the need for socket programming. This is because the detection, as well as GUI updation, is being carried out on the same board. Here, The emailing is done via ethernet and not wirelessly.

Output Results:

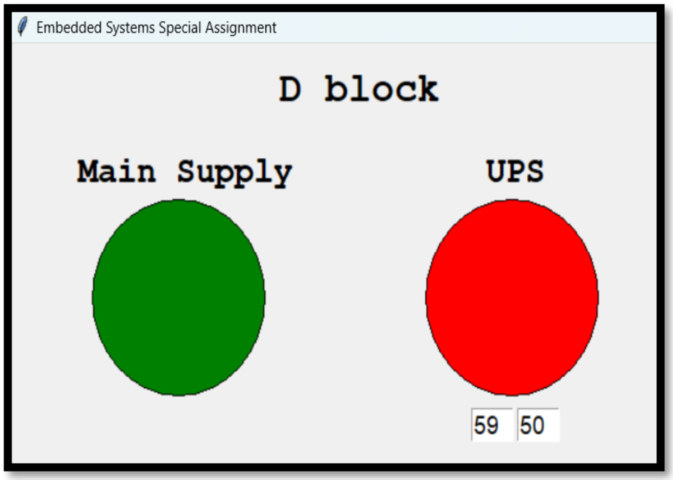

Figure 9 – Timer initiated as UPS is powered on

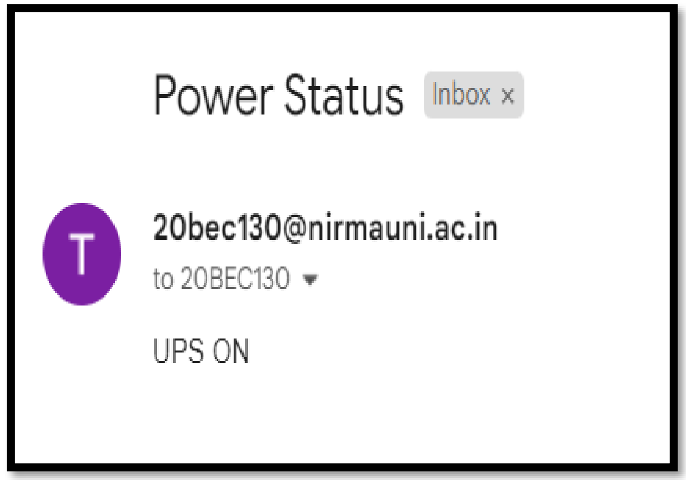

Figure 10 – Email sent as UPS is powered on

IV.PYTHON GUI

A. Tkinter

The user-friendly interface has been developed using Tkinter library which is a standard GUI (Graphical User Interface) library for Python. It provides a set of tools for building desktop applications with graphical components, such as buttons, labels, text boxes, and many others. Tkinter is based on the Tk GUI toolkit and provides a simple and easy-to-use interface for creating GUI applications. Widgets, Geometry Managers, Events, and Bindings are some of the key components of this library and have been widely utilized in the development of this interface.

B. Socket

The M5Stack communicates with the Python GUI using the socket library. The socket library in Python provides a way to create socket objects that can be used to establish and manage network connections. It is a low-level interface that allows one to send and receive data over a network using different protocols, including TCP/IP. A socket is an endpoint of a two-way communication link between two programs running on a network.

C. TCP/IP

TCP/IP is the communication protocol used here. TCP/IP (Transmission Control Protocol/Internet Protocol) is a suite of communication protocols used to connect devices on the internet. It consists of two main protocols viz. TCP (Breaks the data into packets) and IP (Provides routing framework). Together, TCP and IP form the foundation of the Internet and are used to transmit data across networks, including the Internet. The TCP/IP protocol suite provides a standard set of rules for communication between devices, allowing devices from different vendors to communicate with each other.

D. SMTP

SMTP stands for Simple Mail Transfer Protocol. SMTP is a set of communication guidelines that allow the software to transmit electronic mail over the internet is called Simple Mail Transfer Protocol. It is a program used for sending messages to other computer users based on e-mail addresses. The mail from RPi has been sent using the same. Also, the email sender library for M5Stack uses an SMTP server.

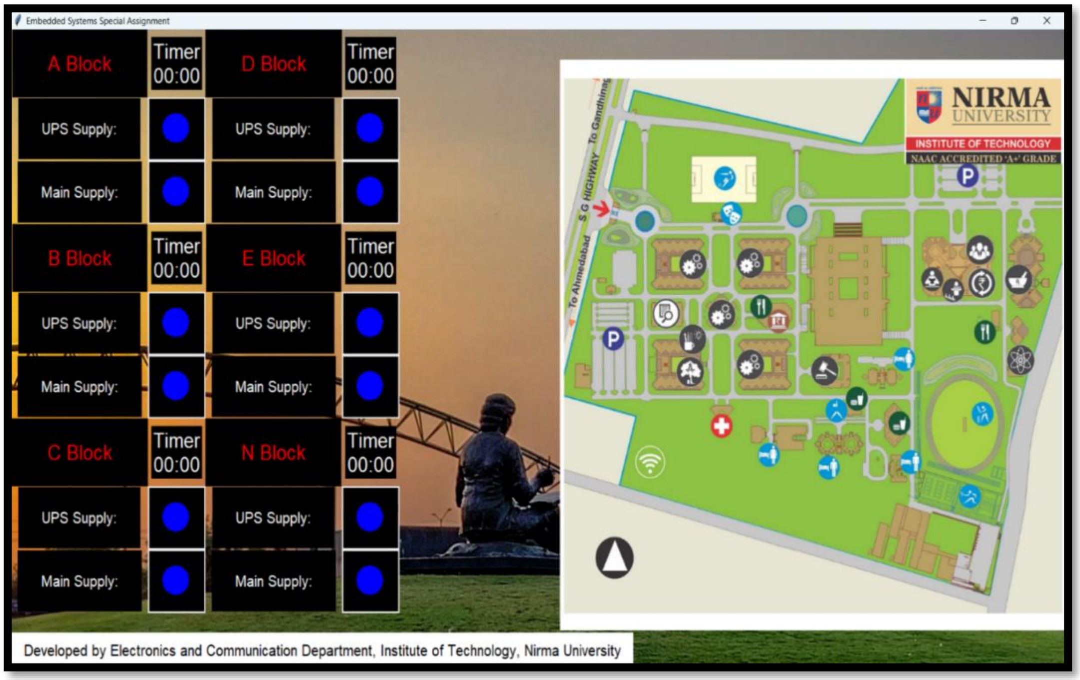

Figure 11 – Final GUI

V. DYNAMIC PYTHON GUI

A dynamic GUI was developed for implementing the design at the Nirma Campus. The user can select a number of blocks as per convenience. The blocks to be displayed can be selected from the drop-down menu. The blocks selected will be visible on the map image.

Figure 12 – Only selected blocks are displayed

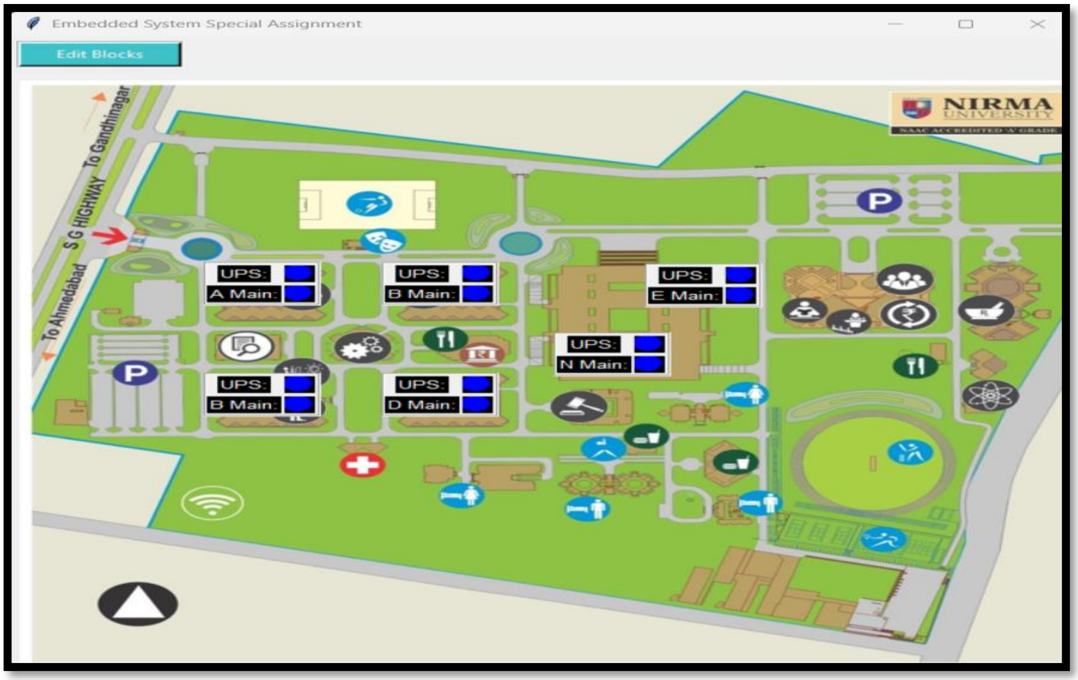

Figure 13 – All the blocks are displayed

VI.CONCLUSION

In conclusion, the power monitoring system developed in this project has proven to be an effective solution for real-time monitoring of the power status in a building. The system provides accurate and timely information on the status of the main power supply and the UPS, enabling prompt response to power failures and reducing downtime.

The system was designed using M5Stack as well as Raspberry Pi and Python programming language. A graphical user interface (GUI) was developed using Tkinter library to display the power status information in real time. The system was also equipped with email alerts to notify the concerned personnel in case of a power failure.

Overall, the system provides an affordable and scalable solution for power monitoring in buildings of different sizes. The system can be easily customized to meet specific power monitoring requirements and can be integrated with other monitoring systems for a comprehensive facility management solution.

Future work may include the integration of additional sensors to monitor other critical systems such as temperature, humidity, and air quality, as well as the integration of a data analytics module to provide insights into power consumption patterns and trends.

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REFERENCES

[1] https://ieeexplore.ieee.org/document/9264926
[2] https://m5stack.com/
[3] https://opensource.com/resources/raspberry-pi
[4] https://learn.sparkfun.com/tutorials/python-programming-tutorial-getting-started-with-the-raspberry-pi/all
[5] https://www.geeksforgeeks.org/python-gui-tkinter/
[6] http://docs.m5stack.com/en/quick_start/m5core/arduino
[7] https://www.google.co.uk/search?q=raspberrypi+gpio+numbering
[8] https://www.geeksforgeeks.org/create-countdown-timer-using-python-tkinter/
[9] https://circuitdigest.com/review/m5stack-core2-an-esp32-based-iot-development-kit