

# Real-Time Home Environment Monitoring And Control Using Iot Technologies

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**Abstract:** *This project presents a real-time home monitoring and control system utilizing Internet of Things (IoT) technologies to enhance residential comfort, efficiency, and sustainability. Through an integrated smartphone application, users are empowered to remotely control and monitor household appliances, creating a responsive and intelligent home environment. The system leverages IoT sensors and connectivity to provide accurate, real-time data and control functionalities for various devices such as lighting, temperature, and power systems. Designed with an intuitive user interface and a reliable backend infrastructure, the platform offers personalized automation features that align with user preferences and daily routines. By enabling efficient energy management and minimizing manual intervention, this solution contributes to sustainable living while enhancing convenience and user experience. Overall, the project exemplifies the potential of IoT in transforming traditional homes into smart, connected, and eco-conscious living spaces.*

**Keywords:** *Smart Home, IoT Technologies, Real-Time Monitoring, Home Automation, Energy Efficiency.*

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## 1. INTRODUCTION

The project titled "Home Automation Using IoT" aims to provide users with remote control over electrical appliances in their homes via a smartphone application. Additionally, the application displays real-time current and voltage readings from sensors connected to an Arduino Uno microcontroller. The system utilizes IoT technologies to enable seamless communication between the user's smartphone, the Arduino Uno, and NodeMCU ESP8266. In essence, our project harmonizes cutting-edge hardware components with sophisticated software solutions to deliver a seamless and intuitive experience for users. By bridging the gap between traditional appliances and modern connectivity, we empower users with unprecedented control and insight into their electrical systems.

## 2. PROPOSED PLAN

Our project is a smart device which is used to control and monitor electrical appliances from a smartphone application. For this we are using Arduino Uno microcontroller and NodeMCU ESP8266. NodeMCU ESP8266 is used to establish connection between the server and Arduino microcontroller.

### 2.1 Methodology

In our innovative project, we've seamlessly integrated electrical appliance control and monitoring into a user-friendly smartphone application. Through this intuitive interface, users can effortlessly access and manage their appliances, while also gaining real-time insights into their power consumption with detailed current and voltage readings. At the heart of our system lies the Arduino Uno, serving as the central hub for sensor integration and appliance control. Equipped with voltage and current sensors, the Arduino Uno effectively captures crucial electrical data. The connection between the Arduino Uno and electrical appliances is facilitated through relay modules, enabling seamless interaction.

Expanding the capabilities of our system, we've incorporated the NodeMCU ESP8266, enhancing connectivity with its built-in Wi-Fi capabilities. Leveraging this connectivity, the NodeMCU establishes a bridge to the internet, enabling seamless data transmission. Through a meticulously crafted process, the NodeMCU relays vital information, including appliance status and sensor readings, to a dedicated server hosted on PythonAnywhere. This server acts as the backbone of our system, efficiently managing incoming data and serving as a reliable repository. Leveraging the power of Flask, a robust web framework, we've crafted a dynamic smartphone application. This application acts as the conduit between users and their appliances,

providing a streamlined interface for monitoring and control.

### 3. HARDWARE

The prominent hardware products of our project are, Arduino Uno microcontroller, NodeMCU ESP8266 module, voltage sensor, current sensor and relays.

#### 3.1 Arduino Uno

The Arduino Uno is a versatile microcontroller board that has become synonymous with DIY electronics projects and prototyping endeavours. At the heart of its popularity lies its accessibility, flexibility, and robustness, making it an ideal choice for both beginners and seasoned enthusiasts alike. With its ATmega328P microcontroller at its core, the Arduino Uno boasts a myriad of input and output pins, allowing for seamless integration with a wide range of sensors, actuators, and peripherals. This versatility enables users to bring their ideas to life with ease, whether they're tinkering with home automation, robotics, IoT applications, or interactive art installations.



Figure-1

One of the key strengths of the Arduino Uno is its vibrant and supportive community. With a wealth of online resources, tutorials, and forums, users can quickly overcome hurdles, learn new skills, and collaborate with like-minded individuals. This thriving ecosystem not only fosters innovation but also empowers individuals from diverse backgrounds to explore the exciting world of electronics and programming. Furthermore, the Arduino Uno's open-source nature encourages experimentation and customization. Users can delve into the intricacies of its hardware and software, tailoring it to suit their specific needs and preferences.

Whether it's modifying the firmware, designing custom shields, or optimizing power consumption, the Arduino Uno offers endless possibilities for exploration and innovation. In addition to its technical capabilities, the Arduino Uno's affordability and accessibility democratize technology, making it accessible to individuals with varying budgets and backgrounds. This inclusivity is instrumental in inspiring a new generation of makers, inventors, and problem solvers, fostering a culture of creativity and empowerment.

#### 3.2 NodeMCU ESP8266

The NodeMCU ESP8266 is a powerful and cost-effective development board featuring the ESP8266 Wi-Fi module, renowned for its versatility and affordability. Operating at 80MHz with a Tensilica L106 microcontroller, it offers ample processing power for IoT applications while supporting Lua scripting and Arduino IDE compatibility, simplifying development. With onboard flash memory ranging from 512KB to 4MB and support for multiple communication protocols including SPI, I2C, UART, and GPIO, the NodeMCU ESP8266 provides extensive capabilities for interfacing with sensors, peripherals, and networks. Its integrated TCP/IP stack facilitates seamless network communication, enabling real-time data exchange and remote control over Wi-Fi.



**Figure-2**

Additionally, features such as deep sleep mode and secure connections (SSL/TLS) enhance its versatility and applicability in IoT deployments requiring power efficiency and data security. Its robust community support, extensive documentation, and open-source hardware and software design further foster innovation and collaboration, democratizing IoT development and enabling widespread adoption of connected technologies across diverse applications, from home automation to remote monitoring systems.

### **3.3 Interfacing Voltage Sensor**

Interfacing a voltage sensor with a microcontroller, such as the Arduino Uno or NodeMCU ESP8266, involves several key steps to accurately measure and interpret electrical signals. The voltage sensor typically operates on the principle of voltage division, where it converts a high voltage input signal into a lower, measurable output voltage proportional to the input voltage. To interface this sensor with a microcontroller, one must first ensure compatibility by selecting a sensor with appropriate voltage range and output specifications compatible with the microcontroller's input range. Next, the sensor's output is connected to one of the microcontroller's analog input pins, allowing it to measure the scaled voltage signal. Depending on the sensor and microcontroller used, additional circuitry such as voltage dividers or amplifiers may be necessary to adjust the signal levels or enhance accuracy. Once connected, the microcontroller can read the analog voltage value using its built-in Analog-to-Digital Converter (ADC), converting the analog voltage into a digital value that can be processed and utilized in various applications.



**Figure-3**

Calibration and testing are crucial steps to ensure accurate readings, often involving comparing the sensor's output against known reference voltages and adjusting calibration parameters accordingly. Overall, by carefully interfacing the voltage sensor with a microcontroller and implementing appropriate signal conditioning techniques, one can effectively measure and utilize voltage data in a wide range of electronic projects and applications, from monitoring battery levels to controlling power systems.

### 3.4 Current Sensor



Figure-4

The ACS712 is a Hall-effect current sensor IC that accurately measures AC and DC currents. It offers various models with different current ranges, features galvanic isolation, and integrates overcurrent protection. Widely used in power monitoring, motor control, and other applications, it operates on the Hall effect principle, converting magnetic fields into proportional voltage outputs. Calibration and temperature considerations are crucial for accurate measurements.

### 3.5 Relays



Figure-5

The 4-relay module is a compact and versatile component used for controlling multiple electrical circuits in various projects. Featuring four relays, it enables independent switching of devices and includes indicator LEDs for status monitoring. With opto-isolation for protection, it interfaces easily with microcontrollers and control systems. Commonly employed in home automation, industrial machinery, and DIY projects, it operates on low-voltage signals and offers simple screw terminal or pin header connections. Understanding its features, applications, and operational considerations is key to successful integration into electronic systems.

## 4. ALGORITHM, CODING AND TESTING

The algorithm for the project report begins with an overarching "Project Report Overview" section, serving as a brief introduction to the report's content. Following this, the "Introduction" section elaborates on the project's goals, emphasizing the integration of Arduino, NodeMCU, Flask, and PythonAnywhere in constructing a comprehensive home automation system. It outlines the primary objectives, including remote monitoring of electrical parameters and device control, setting the stage for subsequent discussions. Moving on to the "Circuit Design" section, detailed descriptions of the circuit layout and connections are provided. A schematic diagram illustrates the relationship between Arduino, voltage/current sensors, and other essential components. The significance of precise sensor readings and the implementation of calibration procedures are underscored to ensure accurate data acquisition for effective monitoring of home appliances.

### 4.1 Algorithm

Here's the algorithm for our code:

1. Include Libraries:

- Include necessary libraries such as ESP8266WiFi, ESP8266mDNS, WiFiUdp, ArduinoOTA, ESP8266WebServer, and ESP8266HTTPClient to enable various functionalities.
2. Define Pin Configurations and Variables:
    - Define pin configurations for LED, relays, and ACS712 sensor.
    - Set up variables for Wi-Fi connection credentials, HTML content, and other parameters.
  3. Setup Function:
    - Initialize serial communication and print booting message.
    - Configure Wi-Fi mode and connect to the specified network.
    - Initialize Over-The-Air (OTA) updates for firmware.
    - Start the web server and set up the root URL handler.
    - Initialize HTML content for monitoring page.
  4. Main Loop:
    - Continuously check the Wi-Fi connection status and update the status of the LED accordingly.
    - Handle OTA updates.
    - Handle incoming client requests to the web server.
    - Send HTTP GET request to the specified URL (PythonAnywhere).
    - If the request is successful, parse the response to control relay states based on received data.
    - Read the current from the ACS712 sensor and append it to the HTML content.
    - If the number of readings exceeds 50, reset the HTML content to refresh the monitoring page.
    - Increment the counter for the number of readings and delay for 1 second before the next iteration.
  5. Handle Root Function:
    - Define a function to handle requests to the root URL.
    - Send the HTML content as a response to the client.

This algorithm provides a structured overview of the code's functionality, detailing the initialization steps, main loop operation, and handling of client requests for monitoring and controlling relay states.

## 4.2 Testing

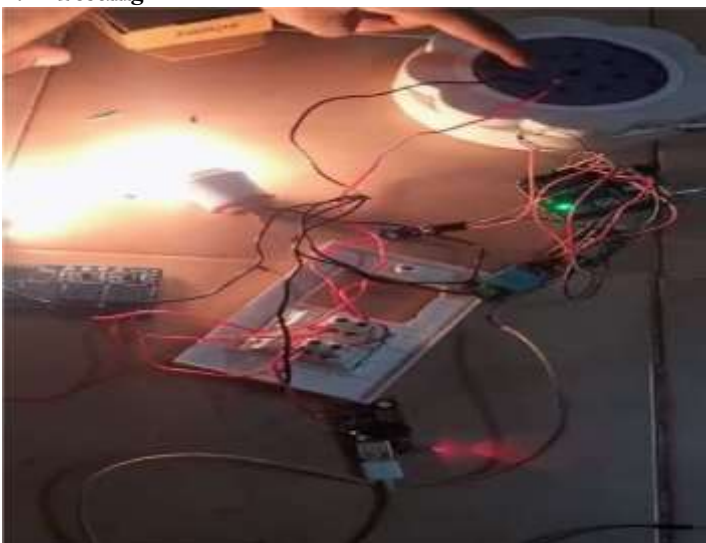


Figure-6

The "Data Transmission and Cloud Management" segment delves into the process of transmitting sensor data from NodeMCU to PythonAnywhere cloud servers. It encompasses configuring NodeMCU for Wi-Fi connectivity and elucidates the handling of sensor data on the cloud platform. The role of PythonAnywhere

in storing, managing, and processing sensor data is elaborated upon, highlighting its importance as a central hub for data management.

Moving forward, the "Remote Control Interface with Flask" section elaborates on the utilization of Flask to create a user-friendly web interface for controlling switch states and visualizing sensor data. It explains how Flask facilitates the development of an accessible interface, compatible with mobile applications, thereby enabling seamless remote interaction with the home automation system.

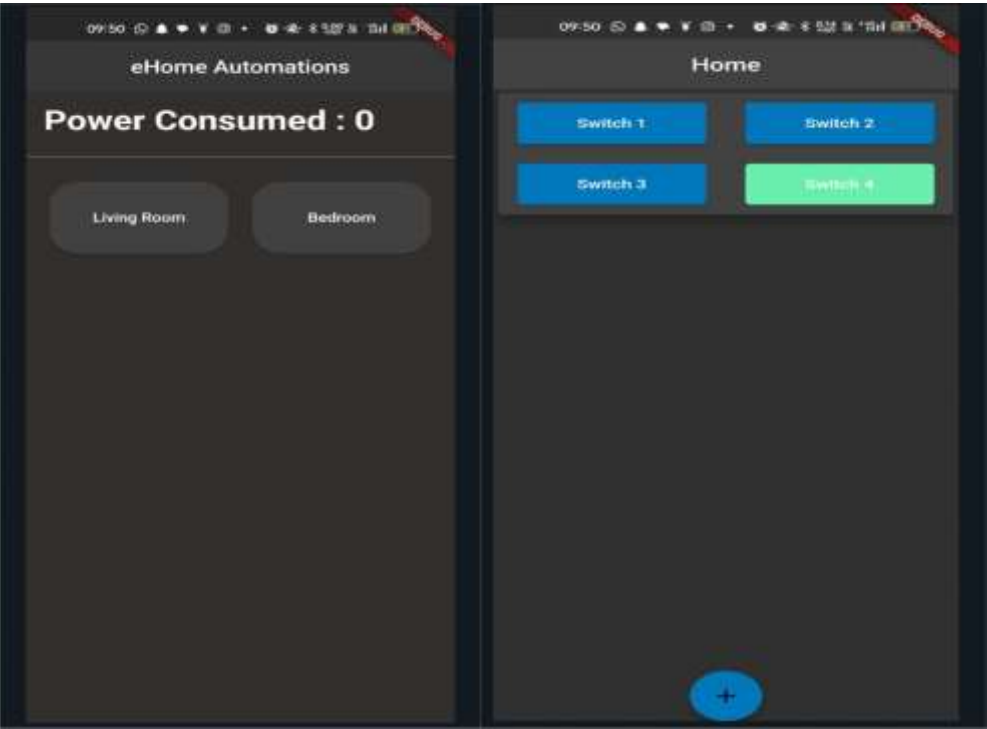


Figure-7

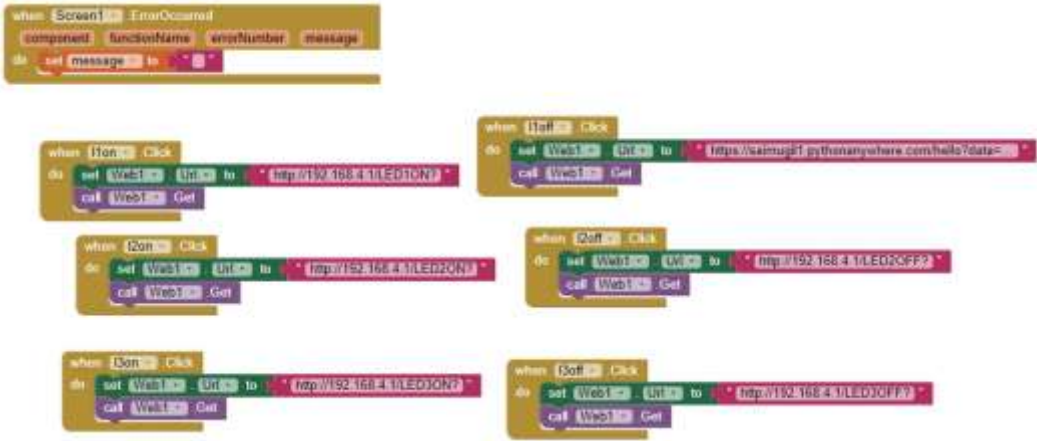


Figure-8 Sample algorithm for first trial.



[(1, 1), (2, 1), (3, 1)]

Figure-9 Relay states.



The "Data Visualization" section further expands on the project's capabilities by detailing the process of plotting sensor data as graphs using Flask and supplementary libraries like Matplotlib. The benefits of data visualization in understanding energy consumption patterns and optimizing device usage are discussed, underscoring its integration into the Flask web interface for enhanced user insights.

The "Integration and Testing" portion emphasizes the importance of integrating all system components and conducting rigorous testing procedures to ensure functionality and reliability. It outlines the steps taken to address potential issues and refine system configurations for optimal performance, ensuring a robust and dependable home automation solution.

Finally, in the "Conclusion" section, the key findings and accomplishments of the project are summarized. It highlights the successful implementation of the home automation system and proposes potential future enhancements to further augment its functionality and usability, providing closure to the project report algorithm.

The implemented code orchestrates a multifaceted system centred around an ESP8266 microcontroller, epitomizing seamless integration of IoT functionalities. Leveraging its built-in capabilities, the device establishes a robust Wi-Fi connection to a network, facilitated by the ESP8266WiFi library. Furthermore, the inclusion of the ArduinoOTA library empowers remote firmware updates, ensuring continuous adaptability and scalability of the device. Within a meticulously crafted loop, the code orchestrates continuous data retrieval from a specified URL, parsed to exert precise control over three relays (connected to pins D1, D2, and D3). Concurrently, real-time current values from an ACS712 sensor, interfaced with analog pin A0, are dynamically incorporated into an HTML string. This dynamic content is served to clients accessing the designated "/monitor" route, facilitating real-time monitoring of sensor data. Moreover, the webpage undergoes automatic refreshment every second, ensuring the display of up-to-date information. In the event of a Wi-Fi disconnection, an LED indicator on pin 2 provides immediate visual feedback, ensuring operational transparency. Additionally, robust error handling mechanisms ensure resilience against HTTP request failures, enhancing the system's reliability and user experience. This comprehensive integration of web-serving capabilities, sensor data acquisition, and remote-control functionalities underscores our project's commitment to innovation and efficiency in the realm of IoT development.

## 5. CONCLUSION

The "Real-Time Home Environment Monitoring and Control Using IoT Technologies" project highlights the seamless integration of IoT systems to enable intelligent, responsive, and efficient management of home environments. By offering real-time monitoring and remote control of electrical appliances, the system enhances user convenience, promotes energy conservation, and improves household safety. With scope for future upgrades and personalization, this project lays a strong groundwork for developing more advanced and adaptive IoT-based smart home solutions.

## REFERENCE

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