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Design and Implementation of an IoT-Enabled Smart Home Automation with Mobile Integration

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Abstract: This project explores the implementation of IoT technologies in home automation, enabling remote control and monitoring of household appliances for enhanced convenience, energy efficiency, and security. By integrating smart devices with a user-friendly interface, the system allows users to manage their home environment through smartphones or voice commands, demonstrating the potential of IoT to transform everyday living.

This project introduces a novel IoT-based home automation system designed to enhance convenience, energy efficiency, and security in residential environments. The system leverages a network of sensors, actuators, and a central control unit (e.g., NodeMCU or Raspberry Pi) to monitor and control various home appliances and devices. Key features include remote access via a mobile application, automated temperature and humidity control, smart lighting management, and security alerts. The project aims to demonstrate the feasibility and benefits of using IoT for creating a smart, interconnected home that adapts to the user's needs and preferences.

The system is developed using technologies such as [mention specific technologies like NodeMCU, ESP8266, Arduino, etc.], along with cloud-based platforms for data storage and communication, offering a scalable and user-friendly solution for home automation.

Keywords: IoT technologies, home automation, NodeMCU, ESP8266, Arduino.

I. INTRODUCTION

This paper presents a low cost and flexible home control and environmental monitoring system. It employs an embedded micro – web server in NODE MCU microcontroller, with IP connectivity for accessing and controlling devices and appliances remotely. These devices can be controlled through a web application or via Bluetooth Android based Smart phone app.

The proposed system does not require a dedicated server PC with respect to similar systems and offers a novel communication protocol to monitor and control the home environment with more than just the switching functionality. To demonstrate the feasibility and effectiveness of this system, devices such as light switches, power plug, temperature sensor, gas sensor and motion sensors have been integrated with the proposed home control system. Therefore this system has been successfully designed and implemented in real time.

Internet of Things is a concept where each device is assign to an IP address and through that IP address anyone makes that device identifiable on internet. Basically it started as the “Internet of Computers.” Research studies have forecast an explosive growth in the number of “things” or devices that will be connected to the Internet.

The resulting network is called the “Internet of Things” (IoT) [1]. The recent developments in technology which permit the use of Bluetooth and Wi-Fi have enabled different devices to have capabilities of connecting with each other. A WiFi shield is used to function as a micro web server for the Arduino, eliminating the need for wired connections between the Arduino board and a computer. This reduces costs and allows the system to operate as a standalone device. The Wi-Fi shield needs connection to the internet from a wireless router or wireless hotspot and this would act as the gateway for the Arduino to communicate with the internet. With this objective, an internet-based home automation system has been designed to enable remote control of household appliances.

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II. FUNCTIONAL BLOCK DIAGRAM

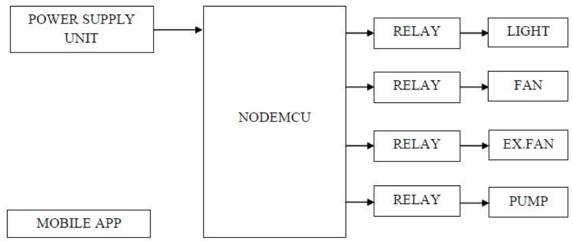


Fig 2.1 Functional Block Diagram

A. *Hardware Requirement*

1) NodeMCU Microcontroller
2) Relay Modules
3) Light
4) Fan
5) Ex.Fan
6) Pump

B. *Software Requirement*

1) Arduino Software
2) Proteus Simulation

III.BLOCK DIAGRAM OF THE POWER SUPPLY

The ac voltage, typically 220V RMS, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit removes the ripples and also remains the same dc value even if the input dc voltage varies. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

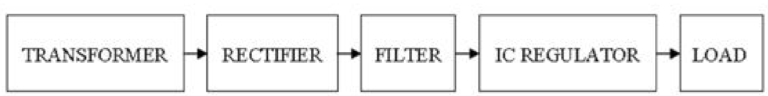


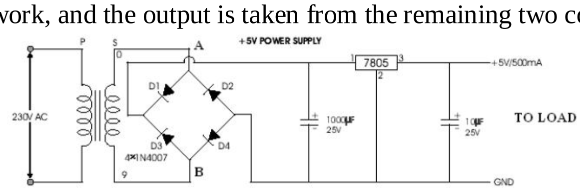
Fig 2.1 Block diagram (Power supply)

A. *Transformer*

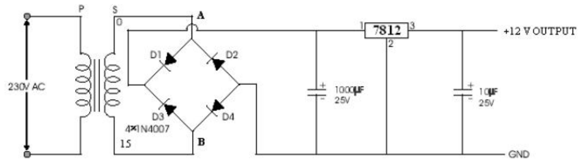
The potential transformer will step down the power supply voltage (0-230V) to (0-15V and 0-9V) a level. If the secondary has less turns in the coil then the primary, the secondary coil's voltage will decrease and the current or AMPS will increase or decreased depend upon the wire gauge. This is called a STEP-DOWN transformer. Then the secondary of the potential transformer will be connected to the rectifier.

B. *Bridge rectifier*

When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners.



3.1 Schematic diagram

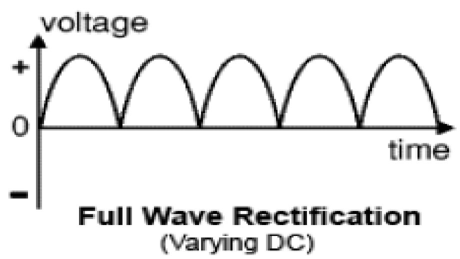


3.2 Working principle of the Schematic diagram

Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B. the positive potential at point A will forward bias D3 and reverse bias D4.

The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow. The path for current flow is from point B through D1, up through Load, through D3, through the secondary of the transformer back to point B. One-half cycle later the polarity across the secondary of the transformer reverse, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through Load, through D2, through the secondary of transformer, and back to point A. Across D2 and D4 the current flow through load is always in the same direction. In flowing through load this current develops a voltage corresponding to that. Since current flows through the load during both half cycles of the applied voltage, this bridge rectifier is a full-wave rectifier.

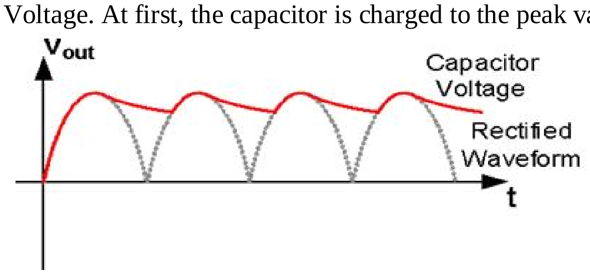
One advantage of a bridge rectifier over a conventional full-wave rectifier is that with a given transformer the bridge rectifier produces a voltage output that is nearly twice that of the conventional half-wave circuit. This bridge rectifier always drops 1.4Volt of the input voltage because of the diode. We are using 1N4007 PN junction diode, its cut off region is 0.7Volt.So any two diodes are always conducting, and total drop voltage is 1.4 volt.



3.3 output waveform of full wave rectifier

C. Filter

If a Capacitor is added in parallel with the load resistor of a Rectifier to form a simple Filter Circuit, the output of the Rectifier will be transformed into a more stable DC Voltage. At first, the capacitor is charged to the peak value of the rectified Waveform.



3.4 output waveform of filter

Beyond the peak, the capacitor is discharged through the load until the time at which the rectified voltage exceeds the capacitor voltage. Then the capacitor is charged again and the process repeats itself.

D. IC voltage regulators

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage.

A fixed three-terminal voltage regulator has an unregulated dc input voltage, it is applied to one input terminal, a regulated dc output voltage from a third terminal, with the second terminal connected to ground.

The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts.

This is a regulated power supply circuit using the 78xx IC series. These regulators can deliver current around 1A to 1.5A at a fix voltage levels. The common regulated voltages are 5V, 6V, 8V, 9V, 10V, 12V, 15V, 18V, and 24V. It is important to add capacitors across the input and output of the regulator IC to improve the regulation.

This circuit uses 7805 and 7812 voltage regulators to convert variable DC input into stable positive 5V and 12V outputs, respectively.

IV. SOFTWARE REQUIREMENTS

A. *Blynk APP WORKING*

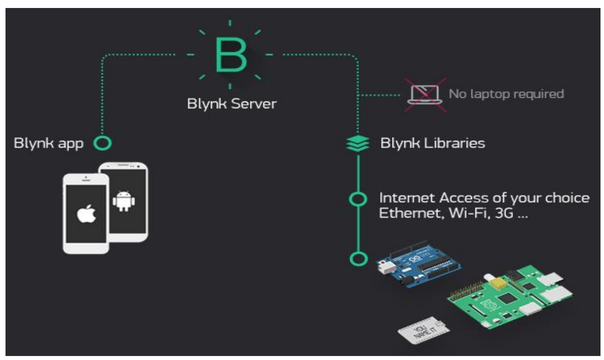
Blynk is specifically designed for the Internet of Things (IoT). It enables remote control of hardware, real-time display of sensor data, data storage, visualization, and a variety of other powerful features.

There are three major components in the platform:

Blynk App – Allows you to create intuitive and visually appealing interfaces for your projects using a variety of built-in widgets.

Blynk Server – Manages all communication between the smartphone and the hardware components.

Blynk Libraries – Available for all major hardware platforms, these libraries enable communication with the server and handle both incoming and outgoing commands.



4.1 Blynk App

V. HARDWARE

An Arduino, Raspberry Pi, or a similar development kit.

Blynk operates over the Internet, which means the hardware used must be capable of connecting to the Internet. Some boards, such as Arduino, require an Ethernet or Wi-Fi shield for communication, while others—like the ESP8266, Raspberry Pi with a Wi-Fi dongle, Particle Photon, or Spark Fun Blynk Board—come with built-in internet connectivity.

A. *Smartphone.*

The Blynk App is a well-designed interface builder. It works on both iOS and Android.

B. *Create a Blynk Account*

Once the Blynk app is downloaded, creating a new Blynk account is mandatory. This account is independent of any existing Blynk Forum accounts. It is advisable to use a valid email address during registration, as it facilitates easier account recovery and future communication.

C. *Create a New Project*

After logging into Blynk account, new project is created to get started.

D. *Choose Hardware*

The Arduino hardware model is selected.

E. Augh Token

The Authentication Token functioned as a unique identifier, essential for establishing connectivity between a user's hardware and their smartphone. Each newly created project was assigned a distinct Augh Token, which was automatically dispatched to the user's email upon the project's creation. The most important parameter to set is PIN.

F. Add a Widget Box

To initiate interaction within the project canvas, a button widget was added to enable control over the LED. This was accomplished by tapping on the empty canvas, which opened the widget box containing all available interface components. A button was then selected from this collection for integration into the project interface.

G. Run the Project

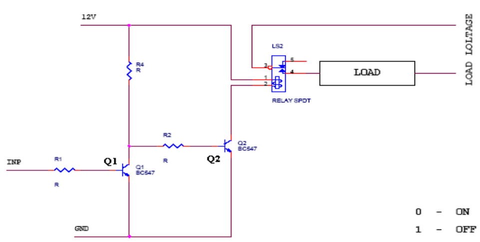
Upon completion of the configuration settings, the 'PLAY' button was pressed to initiate the project. This action transitioned the system from EDIT mode to PLAY mode, enabling real-time interaction with the connected hardware components. It was observed that widget customization was disabled in PLAY mode, reinforcing its dedicated role for active device engagement. Subsequently, a system message indicated that 'Arduino UNO is offline,' a condition noted for resolution in the subsequent phase of the project.

VI. CIRCUIT DESIGN FOR IOT-DRIVEN LOAD MANAGEMENT IN SMART HOMES

This circuit is designed to control the load. The load may be motor or any other load. The load is turned ON and OFF through relay. The relay ON and OFF is controlled by the pair of switching transistors (BC 547). The relay is connected in the Q2 transistor collector terminal. A Relay is nothing but electromagnetic switching device which consists of three pins. They are Common, Normally close (NC) and normally open (NO).

The relay common pin is connected to supply voltage. The normally open (NO) pin connected to load. When high (5 Volt) pulse signal is given to base of the Q1 transistors, the transistor is conducting and shorts the collector and emitter terminal and zero (0 Volt) signals is given to base of the Q2 transistor. So the relay is turned OFF state.

When low pulse is given to base of transistor Q1 transistor, the transistor is turned OFF. Now 12v is given to base of Q2 transistor so the transistor is conducting and relay is turned ON. Hence the common terminal and NO terminal of relay are shorted. Now load gets the supply voltage through relay.



6.1 Load Control Circuit for Home Automation

A. Relay

The relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. Relays are usually SPDT or DPDT but they can have many more sets of switch contacts, for example relays with 4 sets of changeover contacts are readily available. Most relays are designed for PCB mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay. The picture shows a working relay with its coil and switch contacts. You can see a lever on the left being attracted by magnetism when the coil is switched on. This lever moves the switch contacts. There is one set of contacts (SPDT) in the foreground and another behind them, making the relay DPDT.

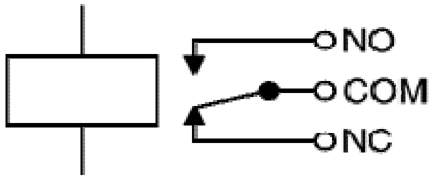


Fig 6.2 Simple Diagram of Relay Switch Connections

The relay's switch connections are usually labeled COM, NC and NO:
COM = Common, always connect to this, it is the moving part of the switch.
NC = Normally Closed, COM is connected to this when the relay coil is off.
NO = Normally Open, COM is connected to this when the relay coil is on.

VII. CONCLUSION

This study presented the design and implementation of a low-cost, IoT-enabled home automation system integrating mobile control. Employing locally available components, the developed circuit effectively controlled various household appliances—ranging from security lamps and entertainment systems to air conditioning and entire house lighting—while being compact enough for inconspicuous installation. The system was subjected to multiple tests, confirming its capability to reliably manage different home appliances. This demonstrates both the scalability and flexibility of the proposed design.

By integrating an embedded load-control circuit with IoT connectivity and mobile app support, the project addresses the growing demand for accessible smart home solutions. Its low-cost, modular design makes it highly adaptable, offering practical utility in diverse residential settings. These findings contribute valuable insights to the advancement of smart-home engineering and IoT-driven power control systems.

Looking ahead, future research can explore incorporating energy consumption monitoring, enhanced security features like encryption and authentication, and extending support to voice command integration (e.g., with Alexa or Google Assistant). Further investigation into network resilience and interoperability with existing smart-home ecosystems will improve commercial viability and user experience.

This work establishes a robust foundation for affordable, scalable smart-home automation, opening avenues for continued innovation and real-world applications.

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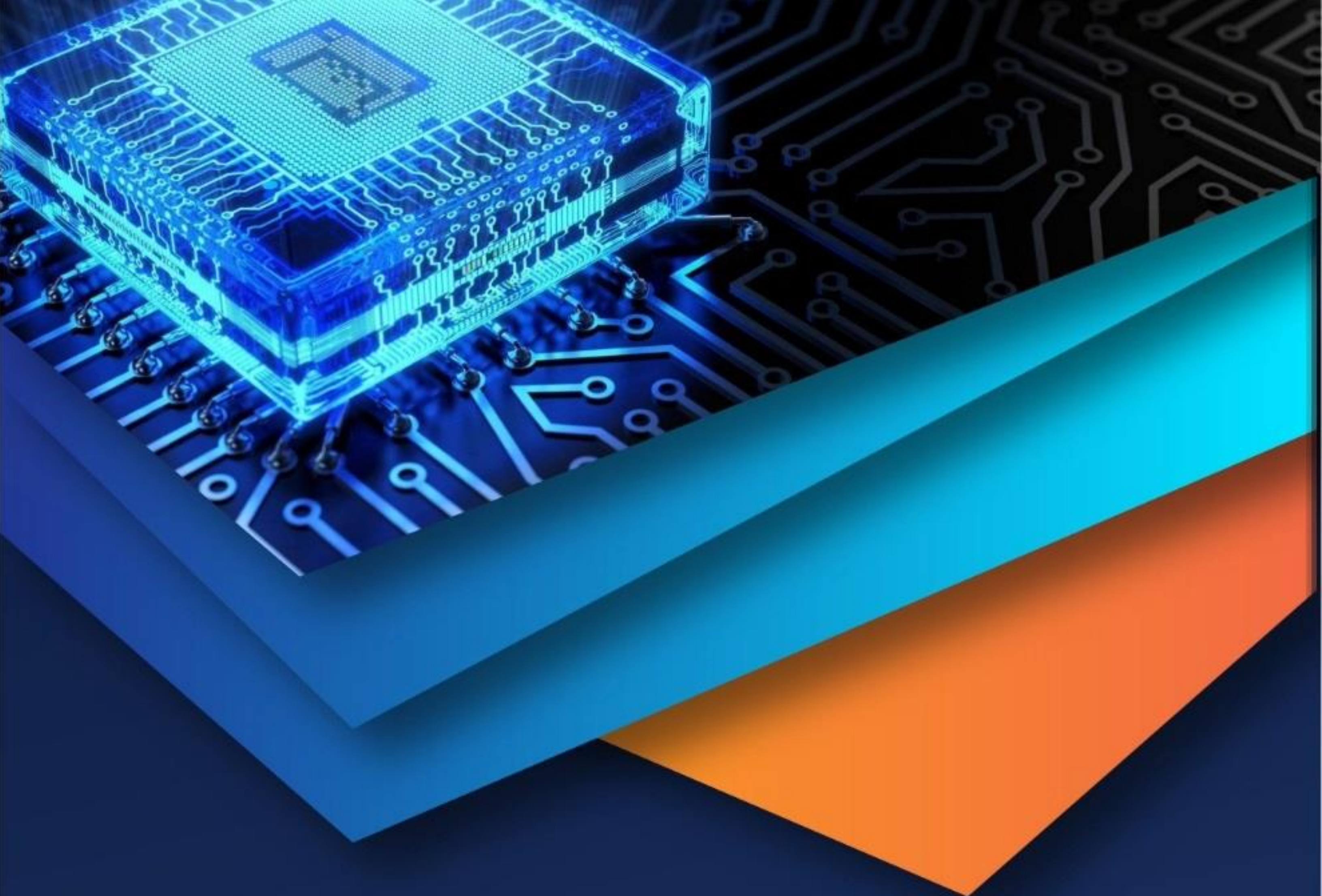

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