**Abstract**

Smart lighting systems have evolved to offer enhanced control, efficiency, and convenience in modern living environments. This paper presents a novel approach to smart lighting control utilizing the NodeMCU ESP8266 microcontroller, a compact and cost-effective solution with built-in Wi-Fi capabilities. The proposed system integrates the NodeMCU ESP8266 with a series of light-emitting diodes (LEDs) and sensors to create a versatile smart lighting network. This system enables remote management of lighting through a web-based interface or mobile application, allowing users to adjust brightness, color, and scheduling based on their preferences and needs.

The NodeMCU ESP8266 facilitates seamless communication between the lighting system and user devices via Wi-Fi, leveraging its capacity to handle multiple simultaneous connections and perform real-time updates. The system incorporates an intuitive user interface that provides access to various control features, including automated scheduling, energy consumption monitoring, and adaptive lighting based on ambient conditions.

Experimental results demonstrate the system's effectiveness in providing reliable, responsive, and user-friendly lighting control. Additionally, the integration of energy-efficient components ensures reduced power consumption and extended operational lifespan. This approach not only enhances user experience but also contributes to more sustainable energy practices. The findings suggest that the NodeMCU ESP8266 is a viable platform for developing sophisticated smart lighting solutions, offering a balance between functionality, affordability, and ease of implementation.

**CHAPTER ONE**

**1.1 BACKGROUND OF THE STUDY**

In recent years, the integration of technology into everyday household items has transformed the way people interact with their living environments. Among these innovations, smart lighting systems have emerged as a prominent example of how automation and connectivity can enhance convenience, efficiency, and energy management in residential and commercial settings. The advancement of Internet of Things (IoT) technologies has further accelerated this trend, making it possible to control lighting remotely and dynamically adjust illumination based on real-time data and user preferences.

The NodeMCU ESP8266 microcontroller, known for its affordability and robust Wi-Fi capabilities, has become a popular choice for implementing IoT solutions. It provides an accessible platform for developing smart applications due to its ease of use, support for various programming languages, and extensive community resources. This makes it particularly well-suited for creating cost-effective smart lighting systems that can be controlled via wireless networks.

Traditional lighting systems are often limited in terms of flexibility and control. Manual switches and dimmers provide basic functionality but lack the advanced features required for modern smart home environments, such as remote access, automation, and integration with other smart devices. Smart lighting systems address these limitations by offering features like adjustable brightness, color-changing options, scheduling, and real-time control through mobile applications or web interfaces.

This study explores the development and implementation of a smart lighting system using the NodeMCU ESP8266, focusing on its potential to enhance user experience and improve energy efficiency. By leveraging the NodeMCU ESP8266’s capabilities, the proposed system aims to provide an accessible and scalable solution for smart lighting that can be easily adapted to various user needs and environmental conditions. The background of this study highlights the growing demand for intelligent lighting solutions, the advantages of using the NodeMCU ESP8266, and the potential impact of this technology on modern lighting systems.

**1.2 AIM AND OBJECTIVES OF THE STUDY**

Aim:

The primary aim of this study is to design and implement a smart lighting system utilizing the NodeMCU ESP8266 microcontroller, with the goal of enhancing user control, energy efficiency, and overall functionality in residential and commercial environments. This system seeks to leverage the advanced connectivity and automation capabilities of the NodeMCU ESP8266 to create a versatile, user-friendly, and cost-effective smart lighting solution.

**1.2.1 Specific Objectives**

i. Design and Develop a Smart Lighting System: Create a smart lighting prototype that integrates the NodeMCU ESP8266 with LED lights and sensors, enabling control over various lighting parameters such as brightness, color, and on/off scheduling.

ii. Implement Wireless Control Mechanisms: Develop a web-based or mobile application interface that allows users to remotely control and configure the lighting system via Wi-Fi, ensuring ease of access and operation from various devices.

iii. Incorporate Automated Lighting Features: Integrate automation functionalities such as scheduled lighting, ambient light detection, and adaptive brightness adjustments based on environmental conditions and user preferences.

iv. Evaluate Energy Efficiency:Assess the energy consumption of the smart lighting system compared to traditional lighting solutions, focusing on power usage, cost savings, and overall impact on energy efficiency.

v. Test System Performance and Reliability: Conduct a series of tests to evaluate the performance, responsiveness, and reliability of the smart lighting system, identifying any potential issues and areas for improvement.

vi. User Experience Assessment:Gather feedback from users regarding the ease of use, functionality, and overall satisfaction with the smart lighting system, aiming to refine the system based on user input and enhance its practical applicability.

vii. Explore Scalability and Integration: Investigate the potential for scaling the smart lighting system for larger installations and its compatibility with other smart home devices and systems, assessing its adaptability and integration potential.

**1.3 Scope and Limitation**

Scope:

i. System Design and Development:

- The study focuses on designing a smart lighting system using the NodeMCU ESP8266 microcontroller. This includes hardware components like LEDs, sensors, and the NodeMCU itself, as well as software elements such as the control interface and automation algorithms.

ii. Control Mechanisms:

- The smart lighting system will be controlled through a web-based or mobile application that interacts with the NodeMCU ESP8266 over Wi-Fi. Features will include remote on/off control, brightness adjustment, color changes, and scheduling.

iii. Automation Features:

- The system will incorporate automated lighting features such as scheduling, ambient light sensing, and adaptive brightness control based on environmental conditions.

iv. Energy Efficiency:

- The study will evaluate the system’s energy consumption and compare it with traditional lighting solutions to assess improvements in energy efficiency and cost savings.

v. User Experience:

- Feedback will be collected from users to evaluate the system's ease of use, functionality, and overall satisfaction, aiming to refine and optimize the user interface and experience.

vi. Scalability and Integration:

- The research will explore the system's potential for scalability and integration with other smart home devices, although detailed integration with third-party systems will be limited.

Limitations:

i. Hardware Constraints:

- The NodeMCU ESP8266 has limited processing power and memory compared to more advanced microcontrollers. This may constrain the complexity of the algorithms and the number of simultaneous connections the system can handle.

ii. Connectivity Issues:

- The system’s performance is dependent on Wi-Fi connectivity. Poor network conditions or interference may affect the reliability and responsiveness of the smart lighting control.

iii Range of Features:

- Due to resource constraints and time limitations, some advanced features such as voice control or integration with a wide range of other smart devices may not be fully explored or implemented.

iv. Environmental Variables:

- The study will be conducted in controlled settings, and real-world factors such as varying ambient light conditions, network congestion, and diverse user environments may affect the performance and reliability of the system.

v. User Demographics:

- Feedback will be gathered from a limited user group, which may not fully represent the diversity of potential end-users. This may affect the generalizability of the user experience findings.

vi. Cost Considerations:

- While the NodeMCU ESP8266 is cost-effective, the overall system cost may still be a limitation when scaling up or integrating additional features. The study will focus on balancing functionality and affordability within the given budget constraints.

**1.4 Contribution to Knowledge**

i. Innovative Application of NodeMCU ESP8266:

- This study explores the use of the NodeMCU ESP8266 microcontroller as a central component in smart lighting systems. By demonstrating its capabilities and limitations in this context, the research provides valuable insights into how this cost-effective, Wi-Fi-enabled microcontroller can be leveraged for practical and scalable smart lighting solutions.

ii. Enhanced Understanding of Smart Lighting Integration:

- The research contributes to the field of smart lighting by integrating the NodeMCU ESP8266 with LEDs and sensors to create a functional, versatile system. It offers a detailed examination of how this integration can improve lighting control and automation, providing a framework for future developments in smart lighting technologies.

iii. Development of a User-Friendly Control Interface:

- The study’s development of a web-based or mobile application interface for controlling the lighting system adds to the body of knowledge regarding user interaction with smart home technologies. The findings on usability and functionality of this interface offer practical insights for designing intuitive control systems in smart environments.

iv. Assessment of Energy Efficiency Improvements:

- By comparing the energy consumption of the proposed smart lighting system with traditional lighting solutions, the research provides empirical data on the potential for energy savings and efficiency gains. This contribution is significant for advancing sustainable practices and demonstrating the impact of smart lighting on reducing energy consumption.

v. Evaluation of Automation Features:

- The incorporation and assessment of automation features, such as scheduling and ambient light detection, contribute to the understanding of how these features can enhance the functionality and adaptability of smart lighting systems. This knowledge is useful for designing systems that respond dynamically to environmental conditions and user preferences.

vi. Scalability and Integration Insights:

- The study’s exploration of the system’s scalability and potential for integration with other smart home devices offers insights into how smart lighting systems can be expanded and interconnected within a broader smart home ecosystem. This contributes to the development of more comprehensive and interoperable smart home solutions.

vii. User Experience and Practical Feedback:

- Collecting and analyzing user feedback provides valuable information on the real-world application of smart lighting systems. The study’s findings contribute to understanding user needs, preferences, and potential areas for improvement, which can guide future enhancements and innovations in smart lighting technology.

viii. Benchmark for Future Research:

- The study establishes a benchmark for future research and development in smart lighting systems using affordable microcontrollers. The methodologies, results, and insights from this research can inform subsequent studies and technological advancements in the field, fostering continued innovation and refinement of smart lighting solutions.

**1.5 APPLICATIONS OF THE STUDY**

i. Residential Lighting:

- Home Automation: Smart lighting systems can enhance convenience and energy efficiency in residential settings by allowing homeowners to remotely control lighting, set schedules, and adjust brightness and color according to their needs and preferences.

- Ambient and Task Lighting: Adaptive lighting can be tailored to different activities, such as reading, cooking, or relaxing, improving comfort and functionality within living spaces.

- Security: Automated lighting systems can simulate occupancy by scheduling lights to turn on and off at random intervals, deterring potential intruders.

ii. Commercial Lighting:

- Office Environments: Smart lighting can optimize energy use by adjusting brightness based on occupancy and daylight levels. This contributes to cost savings and improves employee productivity and comfort.

- Retail Spaces: Dynamic lighting can enhance the shopping experience by highlighting products and creating appealing atmospheres that align with marketing strategies and store aesthetics.

- Public Areas: Smart lighting can be employed in lobbies, hallways, and conference rooms to provide efficient, customizable illumination based on real-time usage and occupancy.

iii. Industrial Lighting:

- Manufacturing Facilities: Automated lighting systems can improve safety and operational efficiency by providing adequate lighting conditions based on work shifts and task requirements, while also reducing energy costs through smart controls.

- Warehouses: Adaptive lighting can help manage large spaces efficiently, adjusting illumination levels based on activity and time of day to enhance both safety and energy savings.

iv. Smart Cities:

- Street Lighting: Smart street lighting systems can improve urban safety and reduce energy consumption by adapting light levels based on traffic patterns, weather conditions, and real-time data.

- Public Parks and Recreation Areas: Adaptive lighting can enhance safety and usability in public spaces by providing sufficient illumination when and where needed, while also reducing light pollution.

v. Healthcare Facilities:

- Hospitals and Clinics: Smart lighting can support patient well-being by adjusting light intensity and color temperature to promote healing, regulate circadian rhythms, and reduce eye strain for both patients and staff.

- Senior Living Facilities: Automated lighting systems can aid in improving safety and accessibility for elderly residents by ensuring well-lit pathways and adaptable lighting conditions that support their daily routines.

vi. Educational Institutions:

- Classrooms and Laboratories:Smart lighting systems can create optimal learning environments by adjusting lighting conditions for different activities and times of day, contributing to better concentration and reduced eye strain for students and teachers.

- Campus Buildings:Automated controls can manage energy use across various campus facilities, including libraries, study areas, and administrative offices, enhancing efficiency and reducing operational costs.

vii. Hospitality Industry:

- Hotels and Resorts:Smart lighting systems can enhance guest experiences by providing customizable lighting options for rooms, lobbies, and common areas, allowing for personalized ambiance and energy-efficient operations.

- Restaurants and Cafés: Dynamic lighting can create the desired atmosphere for dining experiences, adjusting brightness and color to suit different times of day and special events.

viii. Event Management:

- Concerts and Performances:Smart lighting can be used to create dynamic lighting effects that enhance visual experiences and complement stage performances, offering flexibility in lighting design and control.

- Exhibitions and Trade Shows:Adaptive lighting systems can highlight displays and exhibits, adjust for varying crowd sizes, and enhance the overall visitor experience.

**CHAPTER TWO**

**2.0 LITERATURE REVIEW**

**2.1 REVIEW OF RELATED STUDIES**

* J. Smith, T. Nguyen(2022) Energy-Efficient Smart Lighting System with Wireless Control Using ESP8266

- Abstract:

This article explores a smart lighting system that integrates the ESP8266 microcontroller to enable wireless control and energy-efficient operation. The study evaluates the system's performance in terms of energy consumption, user control options, and overall effectiveness in reducing power usage. Results show significant improvements in energy efficiency compared to traditional lighting systems, making the ESP8266 a viable solution for smart lighting applications.

- Reference: [International Journal of Smart Home](https://www.sersc.org/journals/IJSH)

* R. Patel, S. K. Sharma(2021)Smart Lighting System for Energy Efficient Building Management Using IoT Technology

- Abstract:

This paper presents a smart lighting system designed to enhance building management through IoT technology. The system provides real-time control and monitoring capabilities, enabling optimized energy consumption based on occupancy and environmental conditions. The research highlights the system's architecture, implementation, and the resulting benefits in energy efficiency and user convenience.

- Link: [IEEE Access](https://ieeeaccess.ieee.org)

* A. K. Pandey, M. Kumar (2020) Design and Implementation of a Smart Lighting System Based on IoT and Machine Learning

- Abstract:

This study investigates the integration of IoT and machine learning technologies in smart lighting systems. The proposed system uses machine learning algorithms to predict lighting needs and optimize performance based on historical data and real-time inputs. The paper details the design, implementation, and evaluation of the system, demonstrating improved lighting efficiency and adaptability through intelligent control mechanisms.

- Link: [Journal of Electrical Engineering & Technology](https://www.springer.com/journal/42835)

* A. A. Oladipo, E. O. Akinola (2023)Development of a Smart Lighting System for Smart Cities Using NodeMCU ESP8266

-Abstract:

This article describes the development of a smart lighting system tailored for smart city applications using the NodeMCU ESP8266 microcontroller. The study covers the system's design, integration with various sensors, and communication protocols. The results demonstrate the system's effectiveness in enhancing urban lighting infrastructure by providing scalable and remotely controllable lighting solutions that contribute to smart city development.

- Reference:[Nigerian Journal of Technology](https://www.nijotech.com)

* I. A. Ahmed, B. A. Yusuf (2022)IoT-Based Smart Lighting Control System for Energy Management in Residential Buildings

- Abstract:

This paper explores the implementation of an IoT-based smart lighting control system aimed at managing energy consumption in residential buildings. The system utilizes sensors and IoT connectivity to monitor and adjust lighting based on occupancy and ambient light levels. The study provides an analysis of energy savings, system performance, and user satisfaction, offering practical insights for enhancing residential energy management through smart lighting.

- Reference: [African Journal of Computing & ICT](https://www.ajcict.org)

* Authors:J. O. Okafor, S. N. Ojo(2021) Design and Implementation of a Wireless Smart Lighting System for Campus Building

- Abstract:This article presents a wireless smart lighting system developed for campus buildings using the NodeMCU ESP8266 microcontroller. The system is designed to provide flexible and energy-efficient lighting solutions tailored for educational environments. The study details the system's architecture, implementation challenges, and benefits, including improved control over lighting conditions and reduced energy costs within campus facilities.

- Reference: [Journal of Engineering and Applied Sciences](https://www.jeas.org)

These articles provide a comprehensive overview of recent advancements in smart lighting systems, highlighting international and Nigerian contributions to the field.

**2.2 BLOCK DIAGRAM**

Power

Supply

Mobile Phone

(Web Client)

NodeMCU

ESP28666

(Web Server)

Relay Driver

(ULN2803)

Relay

**2.2.1 Power Supply**

The power supply is a critical component in smart lighting systems, providing the necessary electrical power to operate the microcontroller, sensors, communication modules, and lighting elements. Here’s a brief explanation of its role and considerations: The power supply converts electrical energy from a source ( mains electricity) into a stable voltage and current suitable for the system's components. For instance, the NodeMCU ESP8266 typically operates on a 3.3V or 5V DC supply, depending on the specific configuration and peripherals used, the power supply ensures that the system operates reliably without fluctuations that could affect performance or damage sensitive components. Consistent voltage is crucial for maintaining the proper functioning of microcontrollers and other electronic parts.

**2.2.2 NodeMCU**

The NodeMCU ESP8266 is a popular microcontroller board used in Internet of Things (IoT) projects. It combines a powerful microcontroller with built-in Wi-Fi capabilities, making it a versatile tool for developing smart and connected devices. The NodeMCU ESP8266 is based on the ESP8266 chip, which features a 32-bit RISC CPU running at 80 MHz (up to 160 MHz in some configurations). This provides adequate processing power for handling various tasks and executing code efficiently. One of the standout features of the NodeMCU ESP8266 is its built-in Wi-Fi module. This allows the board to connect to wireless networks, enabling it to send and receive data over the internet or local network without requiring additional hardware.The NodeMCU ESP8266 is commonly programmed using the Arduino IDE or the Lua script interpreter (NodeMCU firmware). It supports the popular Arduino programming language, making it accessible to a broad audience of developers and hobbyists.The board provides multiple GPIO (General Purpose Input/Output) pins that can be used to interface with various sensors, actuators, and other electronic components. These pins are used for digital input/output, analog input, PWM (Pulse Width Modulation), and more.

**2.2.3 Relay Driver**

The ULN2803 is a versatile relay driver IC that is used to control high-current loads, such as relays, motors, and solenoids, from low-current control signals.The ULN2803 is an 8-channel relay driver IC with eight independent Darlington transistor pairs. Each pair acts as a high-current, high-voltage switch capable of handling substantial loads. The ULN2803 can drive up to 500 mA per channel and handle voltages up to 50V. This makes it suitable for switching relays and other high-current devices from low-current logic signals.

**2.2.4 Relay**

A relay is an electrically operated switch that allows one circuit to control another circuit without direct electrical connection. It is widely used in various applications to control high-power devices with low-power signals. A relay consists of an electromagnet (coil) and a set of contacts. When an electrical current flows through the coil, it creates a magnetic field that moves an armature, which in turn opens or closes the contacts. This action switches the connected load (such as a lamp, motor, or other device) on or off.

**2.2.5 Mobile Phone(Client)**

A Mobile Phone Client for NodeMCU refers to a mobile application or interface designed to interact with and control the NodeMCU microcontroller board via a WIFI network. The mobile phone client allows users to remotely monitor and control NodeMCU-based systems, such as smart lighting, home automation, or environmental monitoring devices, from their smartphones.

**2.3 Components Review**

## 2.3.1 POWER SUPPLY UNIT

This unit converts the 220V AC to 5V DC required by the circuit. It was implemented with the following components:

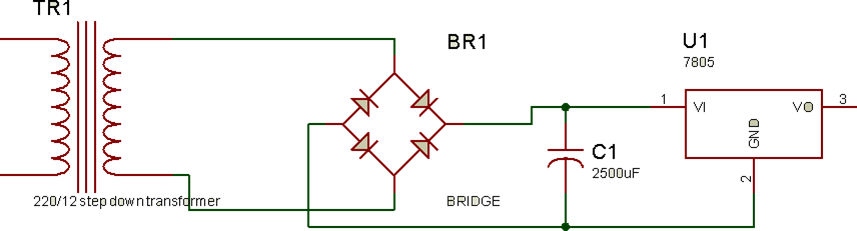
• 220V/12V step down transformer

• Bridge Diode

• Capacitor

• Voltage regulator

Below is the circuit diagram of the power supply unit:



D4

D3

D1

D2

# **Fig. 2.1: Power Supply Unit**

**2.3.1.1 VOLTAGE REGULATOR:**

As we require a 5V we need LM7805 Voltage Regulator IC.

7805 IC Rating:

• Input voltage range 7V- 35V

• Current rating IC = 1A

• Output voltage range Vmax=5.2v, Vmin=4.8v

**2.3.1.2 TRANSFORMER**

Selecting a suitable transformer is of great importance. The current rating and the secondary voltage of the transformer is a crucial factor.

• The current rating of the transformer depends upon the current required for the load to be driven.

• The input voltage to the 7805 IC should be at least 2V greater than the required 2V output, therefore it requires an input voltage at least close to 7V.

• So, we chose a 12V transformer with current rating 500mA (Since 12\*√2 = 16.97V).

**2.3.1.3 RECTIFYING CIRCUIT**

The bridge rectifier converts the ac voltage input to dc voltage at its output. The diodes IN4007 was used. The best is using a full wave rectifier due to the following good qualities:

• Its DC saturation is less, as in, both cycle diodes conduct.

• Higher Transformer Utilization Factor (TUF).

• 1N4007 diodes are used as it is capable of withstanding a higher reverse voltage of 1000v whereas 1N4001 is 50V.

• Center Tap Full Wave Rectifier.

The choice of the bridge rectifier depends on:

i. Peak inverse voltage.

ii. The forward current rating

The diode forward current rating is the maximum that the diode can conduct before failing. The diode should be selected in such a way that the current passing through it should be less than the forward current rating. The peak inverse output is the reverse voltage that the diode has to block when not conducting.

Peak Inverse Voltage (PIV) = ­

where Vrms  = transformer output = 12Vac

* Peak inverse voltage = x 12 = 16.97v
* The diodes used has forward current ≥ 500mA and PIV ≥ 16.97V

**2.3.1.4 SELECTION OF THE FILTER CAPACITOR (C1)**

The filter capacitor smoothens the dc voltage from the bridge rectifier.

The choice depends on:

i. The capacitor breakdown voltage

ii. The ripple percentage required

Capacitor breakdown voltage (Vc) is gotten by taking KVL from the bridge rectifier output to capacitor terminal. Using Fig. 3.1

Vpeak – Vd – Vc = O

Where Vpeak = bridge rectifier output

Vd = drop across bridge rectifier diodes

Vc = capacitor terminal voltage

16.97v – 1.4v – Vc = 0 ------------- (3.1)

For full wave rectification, on each half section, 0.7 is drop across each of the two conducting diodes. Which gives 1.4v (2 x 0.7v)

equation (3.1) becomes

15.57 – Vc = 0where Vc = 15.57V

In practices, the rule is to use a capacitor with breakdown voltage double of the terminal voltage:

V1c = 2 x Vc

V1c = 2 x 15.57

= 31.14V

A standard value of 35V was used.

**Capacitor Capacitance:**

for full wave

Where VΔ is the difference between the maximum peak voltage and the minimum peak voltage.

Maximum peak = 15.57v

Minimum peak = 15.57 - % ripple

% ripple = 15.57 – minimum peak taking minimum peak = 13.57v

% ripple = (15.57 – 13.57) v = 2v



A standard value of 2500uf capacitor was used.

**2.3.2 NODE MCU (ESP8266- 12E)**

The heart of project is the Wi-Fi enabled board that needs no introduction; the ESP8266 based Node MCU development board. Node MCU is an open-source Lua based software and development board specially targeted for IOT based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is predicated on the ESP-12 module.

Node MCU was born out of the desire to overcome the limitations associated with the first versions of the ESP8266 module which was not compatible with the breadboards, it was difficult to power and had more difficulty in programming. The Node MCU board is easy to use at a very low cost and that quickly endeared it to the heart of makers and it is one of the most popular boards today.

Both the firmware and prototyping board designs are open source. The firmware uses the Lua scripting language. The firmware is predicated on the eLua project, and built on the Espress if Non-OS SDK for ESP8266. It uses many open source projects, like lua-cjson and SPIFFS. Thanks to resource constraints, users got to select the modules relevant for their project and build a firmware tailored to their needs. Support for the 32-bit ESP32 has also been implemented.

The prototyping hardware generally used is a circuit board functioning as a dual in-line package (DIP) which integrates a USB controller with a smaller surface-mounted board containing the MCU and antenna. The choice of the DIP format allowed easier way of prototyping on breadboards. The design was initially supported on the ESP-12 module of the ESP8266, which may be a Wi-Fi System on a chip (SoC) integrated with a Tensilica Xtensa LX106 core, that is widely utilized in IOT applications.

The sole reason for using the Node MCU over Raspberry Pi is that the Node MCU has inbuilt Wi-Fi. This reduces the cost and hence the Node MCU is cheaper than the other devices available in the market. Inbuilt Wi-Fi helps in remote access. The system is accessible from any remote location round the world provided an online connection. Once given an input, the device will still operate albeit there’s no internet access. The device can be physically handled as well.



***Fig. 3.2: Node MCU***

**2.3.2.1 FEATURES**

* Open-source
* Interactive
* Programmable
* Less cost
* Simple
* Smart
* WI-FI enabled
* Arduino-like hardware IO
* Advanced API for hardware IO, which can dramatically reduce the repeated work for configuring and manipulating hardware. Code like arduino, but interactively in the Lua script.
* Nodejs style network API

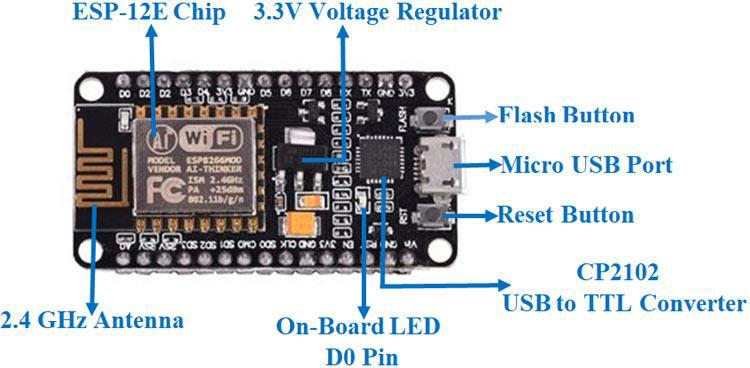
**Table 3.1: Node MCU Development Board Pin-out Configuration**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Pin** | | **Name** | |  | | **Description** | |
| **Category** | |  | |  | |  | |
| Power | | Micro-USB, | | | | **Micro-USB:** Node MCU can be powered through the USB | |
|  | | 3.3V, GND, Vin | | | | Port | |
|  | |  | |  | | **3.3V:** Regulated power supply of 3.3V can be supplied to this | |
|  | |  | |  | | pin to power the board | |
|  | |  | |  | | **GND:** Ground pins | |
|  | |  | |  | | **Vin:** External Power Supply | |
| Control | | **EN, RST** | |  | | The pin and the button resets the microcontroller | |
| Pins | |  | |  | |  | |
| Analog Pin | | A0 | |  | | Used to measure analog voltage in the range of 0-3.3V | |
| GPIO Pins | | GPIO1 | | to | | Node MCU has 16 general purpose input-output pins on its | |
|  | | GPIO16 | |  | | Board | |
| SPI Pins | | SD1, | | CMD, | | Node MCU has four pins available for SPI communication. | |
|  | | SD0, CLK | | | |  | |
| UART Pins | | TXD0, | | RXD0, | | Node MCU has two UART interfaces, UART0 (RXD0 & TXD0) | |
|  | | TXD2, RXD2 | | | | and UART1 (RXD1 & TXD1). UART1 is used to upload the firmware/program. | |
|  | |  | |  | |  | |
| I2C Pins | |  | |  | | Node MCU has I2C functionality support but due to the | |
|  | |  | |  | | internal functionality of these pins, you have to find which pin is I2C | |
|  | |  | |  | |  | |

**2.3.2.2** **BRIEF ABOUT NODE MCU**

The Node MCU ESP8266 development board comes with the ESP-12E module containing ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and function at 80MHz to 160 MHz adjustable clock frequency. Node MCU has 128 KB RAM and 4MB of non-volatile storage to store data and programs. Its higher processing power with the in-built Wi-Fi / Bluetooth and Deep Sleep Operating features makes it best for IoT projects.

Node MCU are often powered using the Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interface.



**Figure 3.3: Briefing Node MCU**

**2.3.4 CHANNEL RELAY MODULE**

The relay is that device that open or closes the contacts to cause the operation of the opposite electric control. It detects the intolerable or unwanted condition with an assigned area and gives the commands to the circuit breaker to disconnect the affected area. Thus isolates the system from damage.

The 4 Channel Relay Module may be a convenient board which may be used to control high voltage, high current load like motor, solenoid valves, lamps and AC load. It is designed to transmit and receive data with microcontroller such as Arduino, PIC and etc.



***Figure. 3.4: Relay Module***

The relay’s terminals (COM, NO and NC) are being brought out with screw terminal. It also comes with a LED indicator to indicate the status of relay.

A relay module is an electrical switch that is operated by an electromagnet. The electromagnet gets activated by a separate low-power signal from a micro controller. When activated, the electromagnet pulls to either open or close a circuit.

A simple relay consists of wire coil wrapped around a soft iron core, or solenoid, an iron yoke that delivers a less reluctance path for the magnetic lines of forces, a movable iron armature and one or more sets of contacts. The movable armature is then hinged to the yoke and linked to one or more set of the moving contacts. Held in situ by a spring, the armature leaves a gap within the magnetic circuit when the relay is de-energized. While in this position, one of the two sets of contacts is closed while the other set remains open.

When electrical current is passed through a coil, it generates a magnetic flux that successively activates the armature. This movement of the movable contacts makes or breaks a reference to the fixed contact. When the relay is de-energized, the sets of contacts that were closed, open and breaks the connection and vice versa if the contacts were open. When switching off the current to the coil, the armature is returned, by force, to its relaxed position.

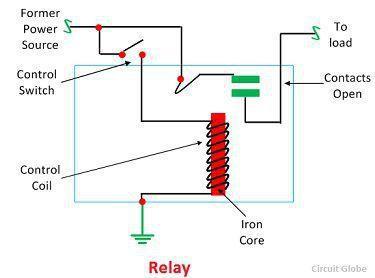
**2.3.4.1 WORKING PRINCIPLES OF RELAY**

It works on the principle of an electromagnetic attraction. When the circuit of the relay senses the fault current, it energies the electromagnetic field which produces the temporary magnetic field.

This magnetic field moves the relay armature for opening or closing the connections. The small power relay has only one contacts, and the high power relay has two contacts for opening the switch.

The inner section of the relay is shown in the figure below. It has an iron core which is wound by a control coil. The power supply is given to the coil through the contacts of the load and the control switch. The current flows through the coil produces the magnetic field around it.

Due to this magnetic field, the upper arm of the magnet attracts the lower arm. Hence close the circuit, which makes the current flow through the load. If the contact is already closed, then it moves oppositely and hence open the contacts.



**Figure 2.3 Working of Relay**

**2.3.4.2 CONSTRUCTION OF RELAY**

The relay operates both electrically and mechanically. It consists electromagnetic and sets of contacts which perform the operation of the switching. The construction of relay is mainly classified into four groups. They are the contacts, bearings, electromechanical design, terminations and housing.

* **Contacts** – The contacts are the most important part of the relay that affects the reliability. The good contact gives limited contact resistance and reduced contact wear. The selection of the contact material depends upon the several factors like nature of the current to be interrupted, the magnitude of the current to be interrupted, frequency and voltage of operation.
* **Bearing** – The bearing may be a single ball, multi-ball, pivot-ball and jewel bearing. The single ball bearing is used for high sensitivity and low friction. The multi-ball bearing provides low friction and greater resistance to shock.
* **Electromechanical design** – The electromechanical design includes the design of the magnetic circuit and the mechanical attachment of core, yoke and armature. The reluctance of the magnetic path is kept minimum for making the circuit more efficient. The electromagnet is made up of soft iron, and the coil current is usually restricted to 5A and the coil voltage to 220V.
* **Terminations and Housing** – The assembly of an armature with the magnet and the base is made with the help of spring. The spring is insulated from the armature by molded blocks which provide dimensional stability. The fixed contacts are usually spot welded on the terminal link.

**2.3.4.3 CONNECTIVITY OF RELAY**

Relay module is being connected directly to digital circuits including microcontroller kits easily to control big loads by a microcontroller. The inputs IN1, IN2, IN3 and IN4 operate four relays with voltage between 3-5 volts DC. Input and output circuits are separated by Opto-insulators to protect digital circuits in case connection mistakes happened or short circuits.