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# Web-Based Design and Implementation of Smart Home Appliances Control System

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**Abstract.** Minimising energy wastage is vital for economic development. This paper deployed a web-based design and implementation of smart electric home appliances control, which enable owners to remotely use web access to efficiently control their home appliances energy usage. Node MCU, breadboard, light emitting diodes (LED), relays, resistors, electric wires, Wi-Fi device (smart phone, tablets or computer), jumper wires, transistor, direct current (DC) motor, universal serial board (USB) cable, printed circuit board (PCB), C programming language and Arduino IDE (Integrated Development Environment) were used, for circuit design and implementation. C programming codes were written and compiled in Arduino IDE device, then uploaded into Node MCU through USB cable to control energy usage of electrical appliance (DC motor) connected to the circuit. The control was achieved by turning ON the DC motor when needed and OFF, when not in use, remotely via web. Whenever appliance was OFF, LED showed red color and green LED lights up when appliance was ON. Developed control system performed excellently and efficiently by significantly minimizing energy wastage, when appliances are not in use. Future research should consider smart home control systems able to record quantities of energy consumed at any period of the day.

## 1. Introduction

Technological advancements especially in information and communications technology (ICT), equally has a significant impact on control systems including Electrical Engineering. Control systems engineering [1] consist of ‘sets of equipment and software able to manage, command, direct or regulate the behaviour of other devices or systems for desired results’ [2]. Today, people use electrical appliances to perform domestic chores like cleaning, dusting, sweeping, vacuuming, washing dishes, laundry, preparing meals and cleanse bathrooms [3, 4]. This study used design and programming to implement an accurate and efficient control system of electric home appliance (DC motor as Sample), to either switch ON whenever it is needed, or OFF, if not needed, using web access of node multipoint control unit (MCU) [5]. It is an internet of things (IoT) endpoint device that uses local area network (LAN) to provide three or more terminals and gateways for multipoint conference participation [5]. MCU is (‘an open-source, interactive, programmable, low cost, simple, smart, WI-FI enabled device’ [6]) connected with other equipment for energy loss reduction. Efficient energy usage is achieved in this study, because only connected smart electric home appliances will consume energy, when commanded. This paper is organised into: introduction, related works, materials and methods, design and implementation, and conclusion.



## 2. Related Works

Jabbar and Kawaitkar [7], implemented smart home control using low cost Arduino & Android designs, [8, 9] developed lightweight wireless and traditional home appliances control systems using Global Systems Mobile (GSM) network and PIC 16F877A. IoT cloud data storage was used to implement smart power monitoring and control [10], [11] used mobile telephony for home appliances remote control, and [12] deployed electricity load management system in smart home control. Similarly, Labview was used to design and implement a smart house control system [13]. Furthermore, [14-21], have worked on other aspects of smart home electrical appliances energy control. The major contribution of this paper, is that there are not many people who have worked on smart home equipment control systems using Node MCU and web access. Further refinements can be made to extend electric home appliances control to include recording quantities of energy consumed at certain time instants and/or intervals.

## 3. Materials and Methods

Node MCU, breadboard, LED, relay, resistors, WI-FI devices (smart phone, tablets or computer), Jumper and electric wires, Transistor, DC motor (appliance controlled), USB cable, Printed Circuit Board (PCB), were used. Electric circuit designed on breadboard, wrote and compiled C program codes in Arduino IDE, uploaded into node MCU by USB cable for implementation and proper control.

### 3.1. NODE MCU

'NodeMCU is a single-board microcontroller, an eLua based firmware for the ESP8266 Wi-Fi SOC from Espressif. The NodeMCU *firmware* is a companion project to the popular NodeMCU device kits, ready-made open source development boards with ESP8266-12E chips' (Fig. 1) [22, 23].

It is 'an open- source effort that takes prototyping of internet of things applications to the next level by providing a development kit, which includes hardware module with robust firmware' [24].

### 3.2. RELAY

Relays are designed to open and close circuits electromechanically and electronically (Fig. 2) [25]. They have two contacts (NO: normally open and NC: normally closed contact). Once a relay is energized, 'the coil activates the armature which operates either to close normally open contacts or to open the normally closed contacts' [26, 27].

### 3.3. ARDUINO IDE

'Arduino Integrated Development Environment (Arduino Software (IDE)) contains text editor for writing code, message area, text console, toolbar with buttons for common functionalities and a host of menus. Thus, uploaded programs connected and communicated with the Arduino and Genuino hardware for needed control implementation' [28].

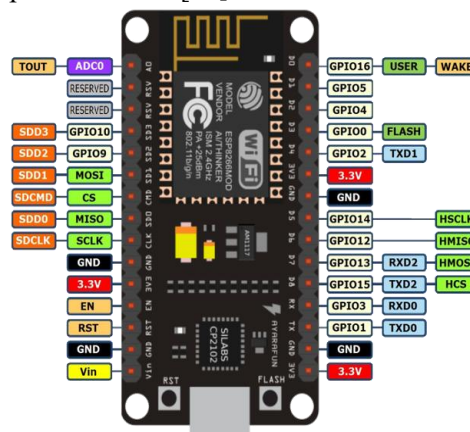
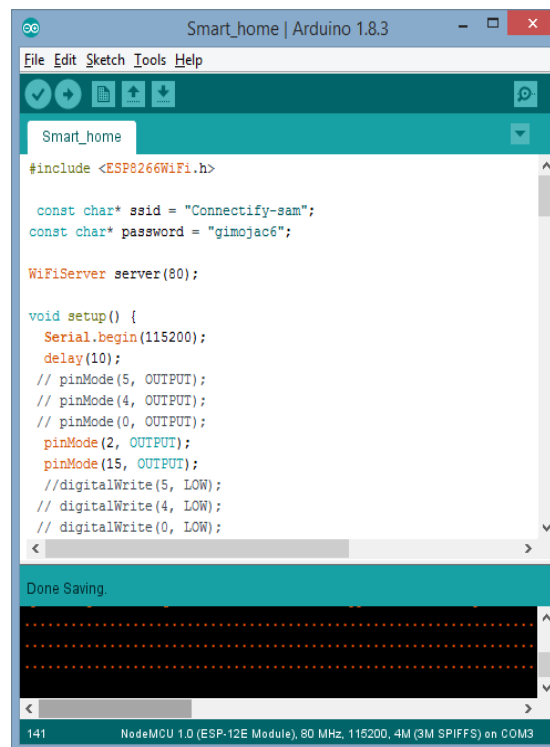


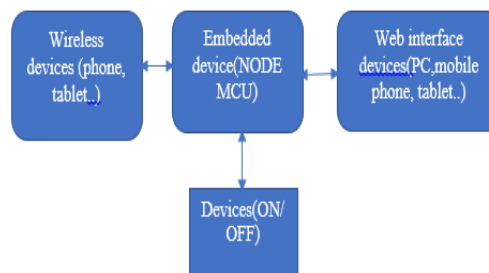
Figure 1. Node MCU pins layout [22]



**Figure 2.** SRD-03VDC-SL-C relay used [25]



**Figure 3.** Arduino IDE software homepage

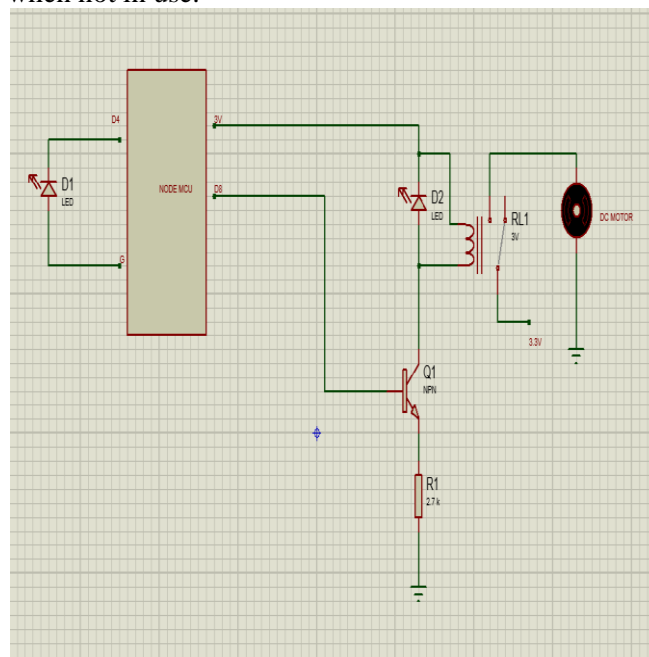


**Figure 4.** Block diagram of the proposed electric appliance home control system

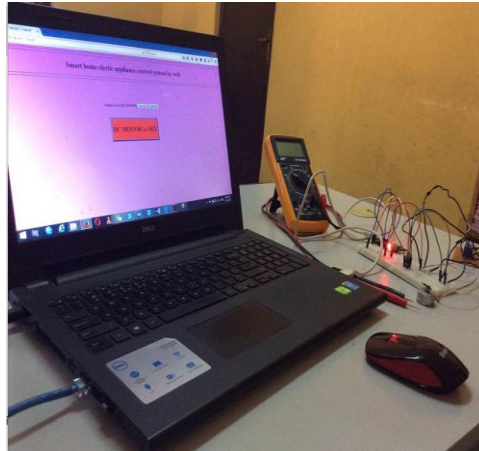
This study uses web interface to link NODE MCU with computer or other WI-FI device, which contains in-built browser. Another function of web is to display the status of device, when ON/OFF. The computer sends signals to microcontroller (NODE MCU), which process those signals and dispatch them to relay or power transistor to actuate the power device being controlled (DC motor in our case: RF-300CA-11440).

#### 4. Project Design and Implementation

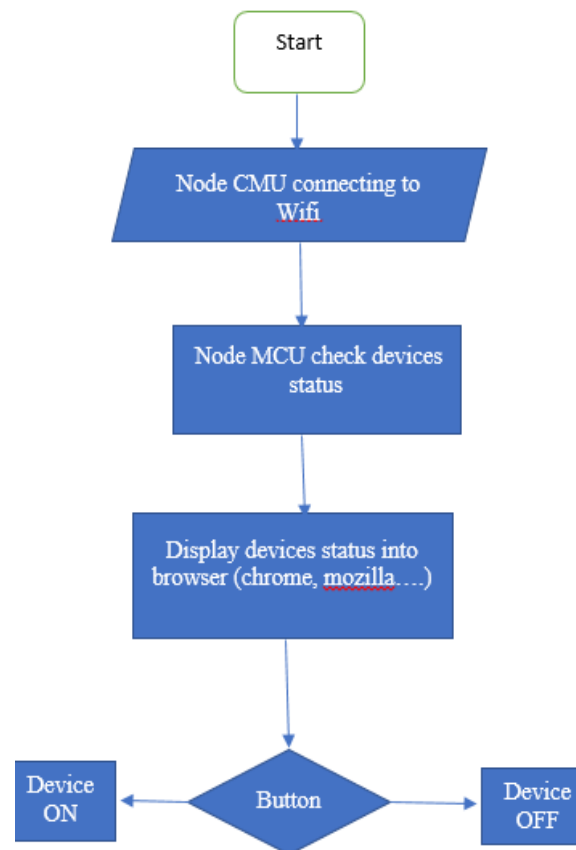
The control system shows the status of home appliance whether ON or OFF and the user can take decision to turn it ON or OFF remotely by web interface (Fig. 5). The web interface links NODE MCU to computer or other device built into browser and shows whether device was ON or OFF. There is computer communication with microcontroller (NODE MCU), relay and power transistor to activate the DC motor power device being monitored. Relays were used to switch external voltage to power the load. Transistors were used to switch ON 3.3 V from Node MCU to power the relay, and shunt resistors were used to avoid short-circuit, between Collector and Emitter terminals of the transistor. Red LED lights if DC motor is OFF and green LED shines, when DC motor is ON. Jumper wires were used to connect devices on breadboard, while electric wires were used to connect SRD-03VDC-SL-C relay from PCB to breadboard. USB cable was used to transfer and upload the C programming codes written and compiled in the Arduino IDE software in Node MCU. Upon circuit design and C programming codes compilation, Internet Protocol address (IP address) appears in the Arduino IDE software and this IP address can be used to control the electrical appliance remotely via web access, hence facilitating the reduction of energy wastage because the electrical appliance will only be ON when needed and OFF, when not in use.



**Figure 5.** Circuit design outlook of the proposed control system



**Figure 6.** Implementation layout of control system



**Figure 7.** Flowchart of the proposed control system

Compiling Codes in Arduino IDE

```
#include <ESP8266WiFi.h>
const char* ssid = "Connectify-sam";
const char* password = "gimojac6";
```

```
WiFiServer server(80);
void setup() {
```

```
Serial.begin(115200);
delay(10);
// pinMode(5, OUTPUT);
// pinMode(4, OUTPUT);
// pinMode(0, OUTPUT);
pinMode(2, OUTPUT);
pinMode(15, OUTPUT);
//digitalWrite(5, LOW);
// digitalWrite(4, LOW);
// digitalWrite(0, LOW);
digitalWrite(15, LOW);
digitalWrite(2, LOW);
// Connect to WiFi network
Serial.println();
Serial.println();
Serial.print("Connecting to ");
Serial.println(ssid);
WiFi.begin(ssid, password);
while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
}
Serial.println("");
Serial.println("WiFi connected");
// Start the server
server.begin();
Serial.println("Server started");
// Print the IP address
Serial.print("Use this URL to connect: ");
Serial.print("http://");
Serial.print(WiFi.localIP());
Serial.println("/");
}
void loop() {
    // Check if a client has connected
    WiFiClient client = server.available();
    if (!client) {
        return;
    }
    // Wait until the client sends some data
    Serial.println("new client");
    while(!client.available()){
        delay(1);
    }
    // Read the first line of the request
    String request = client.readStringUntil('\r');
    Serial.println(request);
    client.flush();
    // Match the request
```

```

    if (request.indexOf("/devon") > 0) {
        digitalWrite(15, HIGH);
        digitalWrite(2, LOW);
    }
    if (request.indexOf("/devoff") > 0) {
        digitalWrite(15, LOW);
        digitalWrite(2, HIGH);
    }
    // Set ledPin according to the request
    // Return the response
    client.println("HTTP/1.1 200 OK");
    client.println("Content-Type: text/html");
    client.println(""); // do not forget this one
    client.println("<!DOCTYPE HTML>");
    client.println("<html>");
    client.println("<head>");
    client.println("<meta name='apple-mobile-web-app-capable' content='yes' />");
    client.println("<meta name='apple-mobile-web-app-status-bar-style' content='black-translucent' />");
    client.println("</head>");
    client.println("<body bgcolor = \"#f7a6ec\">");
    client.println("<hr/><hr>");
    client.println("<h1><center> Smart home electric appliance control system by web </center></h1>");
    client.println("<hr/><hr>");
    client.println("<br><br>");
    client.println("<br><br>");
    client.println("<center>");
    client.println("Sample Device(DC MOTOR)");
    client.println("<a href=\"/devon\"><button>Turn On </button></a>");
    client.println("<a href=\"/devoff\"><button>Turn Off </button></a><br />");
    client.println("</center>");
    client.println("<br><br>");
    client.println("<center>");
    client.println("<table border=\"5\">");
    client.println("<tr>");
    if (digitalRead(2))
    {
        client.print("<td bgcolor = \"#FF0000\"><h1>DC MOTOR is OFF</h1></td>");
    }
    else
    {
        client.print("<td bgcolor = \"#00FF00\"><h1>DC MOTOR is ON</h1></td>");
    }
    client.println("</tr>");
    client.println("</table>");
    client.println("</center>");
    client.println("</html>");
    delay(1);
    Serial.println("Client disconnected");
    Serial.println("");
}

```



## 5. Conclusion

This web-based design was used to monitor the energy usage characteristics of a sample DC motor instrumented into a model smart electric home appliances control system, where user can monitor and control it remotely from any place. The control system showed to be reliable and efficient in facilitating energy wastage and loss reduction. Further work should consider electrical appliances control systems able to both control and record the quantities of energy consumed at any time instants, using web interface and Node MCU.

## 6. Acknowledgment

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