PROTOTYPE HARDWARE DESIGN AND SOFTWARE DEVELOPMENT OF PASSWORD CODED ESP32 WEB SERVER BASED HOME APPLIANCES CONTROLLING SYSTEM ACCESSIBLE FROM ANYWHERE USING NGROK SOFTWARE

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Abstract

Web server based appliances controlling system is mostly built up by using any microcontroller and Wi-Fi or Bluetooth module. The system can control appliances in the coverage range of Wi-Fi or Bluetooth, not from anywhere. To solve this, the controlling system which is accessible from anywhere with internet access is built up by using ESP32 and ngrok software. ESP 32 is connected to the local network and IP address is obtained. This IP is inserted to the terminal window of ngrok software and a uniform resources locator (URL) is obtained. For security purposes, the password coded program is developed by using "base64encode" software. Using this URL and password, the home appliances are monitored and controlled from anywhere with internet access in the world. The web server home page is created with HTML (hypertext markup language) and CSS (cascading style sheets) to control the devices as well as to express the current status of home appliances. The communication between a web server and clients takes place via Hypertext Transfer Protocol (HTTP). This system is useful to monitor the status of home appliances and to control the switch "on "and "off" of the devices from anywhere with internet access.

Keywords: ESP 32 web server, HTTP, HTML.CSS, ngrok, Base64encode

Introduction

Internet of things (IoT) based Home automation system is mostly implemented by using microcontrollers that are communicating the cloud server such as "thingspeak", "firebase", "blynk", "azure", "adafruit io" etc via the internet. Phone screen pages are created by the MIT inventor 2 app or Blynk app separately. In this research, the home automation system is developed by using ESP32 as hardware and HTML, CSS, ngrok and base64encode as software. ESP 32 is a system on chip (soc) with integrated Wi-Fi and dual-mode Bluetooth and it is compatible with Arduino IDE. One of the features of ESP32 is that it can connect to a Wi-Fi network or it can set up a web server itself. ESP32 is used as a web server to communicate between servers and clients. The web server homepage is created by HTML tags and CSS functions to express the current status of appliances and to control the devices. The web server such as ESP32 is communicated to a local existing network via the Wi-Fi hotspot of a phone while the Android phone, laptop, or tablets are communicated to the same router with Wi-Fi or Ethernet cable. So, all are on the same local area network. That means that the home appliances controlling system only works in the Wi-Fi network coverage area. This problem is solved by using "ngrok "software.

Web server based electric appliances can be controlled and monitored the latest state of devices from anywhere. Moreover, the web page is protected by the password by using Base64encode software.

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Materials and Methods

The main components are ESP32 and 4-channel relay. ESP 32 board and ESP32 library are required to be included in Arduino IDE. Ngrok server software is used to control electric devices from anywhere. The web server home page is protected by using Base64encode. The web server home page is created by using HTML and CSS. Communication between Server and client takes place on the HTTP platform.

ESP 32

ESP32 development board equips Tensilica Xtensa dual-core 32 bit LX6 microprocessor. This processor operates at **80 to 240 MHz** adjustable clock frequency and performs at up to **600 DMIPS** (Dhrystone Million Instructions Per Second). ESP32 integrates Wi-Fi transceiver and dual-mode Bluetooth capabilities. It can not only connect to a Wi-Fi network and interact with the internet but also it can set up an own network. It composes 448KB of ROM, 520 KB of SRAM, and 4MB of flash memory which is sufficient to implement web pages, JSON / XML (, JavaScript Objects notation /Extensible Markup Language) data, and everything used in IoT devices.

ESP32 has many multiplexed I/O pins. They are; 1) fifteen ADC channels, 2) two UART interface, 3) twenty-five PWM outputs, 4) two DAC channels, 5) three SPI interface, 6) one I2C interface, 7) one I2S interface, 8) nine touchpads. These pins are multiplexing features, that is; a single GPIO pin can multiplex as PWM / SPI / I2C. There are two built-in sensors- Hall effect sensor and temperature sensor. The pin assignment and block diagram of ESP32 is as shown in figure 1 and figure 2, respectively.
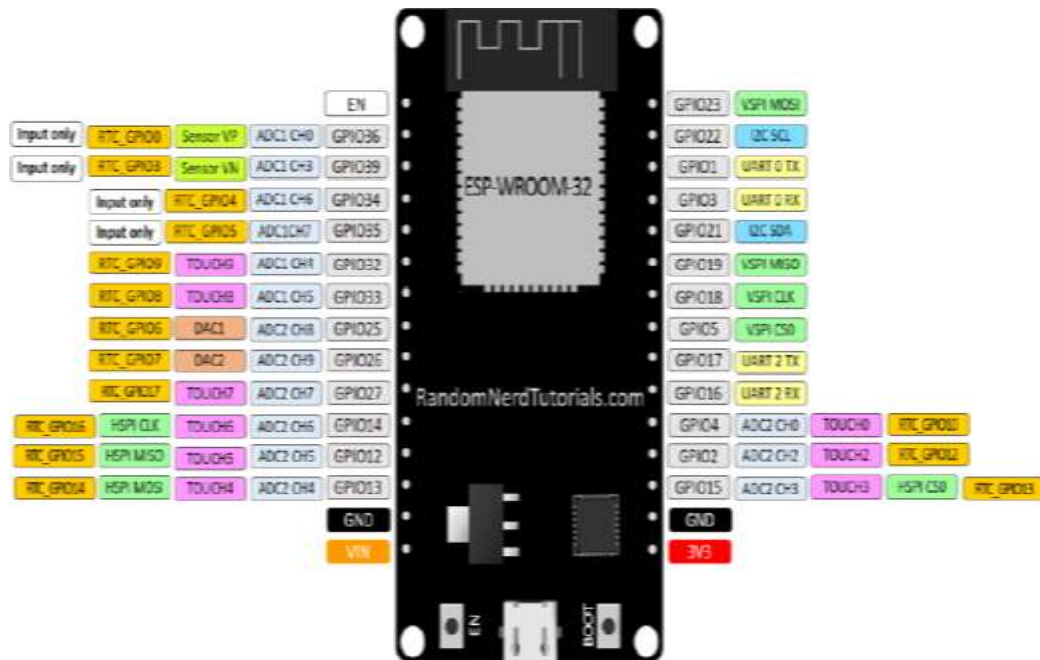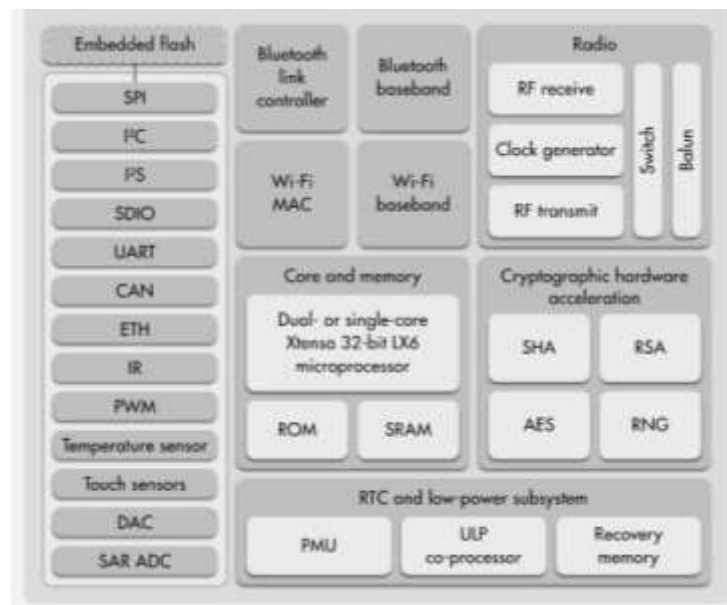

Figure 1 Pin assignment of ESP32

Figure 2 Block diagram of ESP32

Channel Relay

In this research, the relay is used instead of the various appliances to be controlled. The 4-channel relay can be used to control the large voltage and the large current load such as electric motor, stove, air-conditioner, lamp, and ac load. It can be controlled directly by the microcontroller. 5V 4-channel relay interface board needs a 15-20mA driver current in each channel. The 4-channel relay (as shown in figure3) can operate under AC250V 10A or DC30V 10A. There are four LEDs to indicate the status of the output of the relay. The optocoupler is attached to the relay and it is optically isolated from high voltage for electrical safety purposes.

Figure 3   4-channel relay

HTML and CSS

Hypertext markup language (HTML) is a computer language which is making up of a set of instructions and data, for creating a web page. A web page is a document which can be viewed in a web browser. Web page composes of writing, picture, links, sound and video. HTML describes these kinds of content so that the web browser can express them correctly. Cascading style sheets (CSS) are a way to change the appearance of HTML. It is used to style HTML elements. Web server home pages are mostly created by HTML documents CSS.

Web Server and Client

A Web server is a computer that stores, processes, and transfers the web pages which contains HTML documents, CSS style sheets, images and JavaScript files to the clients. The request and response (communication) between the web server and the client takes place using hypertext transfer protocol (HTTP) capability. A client initiates to request the server for a web page using HTTP. The server also responses with the content of that web page or error if it cannot be able to process.

ESP32 can connect to the Wi-Fi network and it can operate in three different modes: station (STA) mode, soft access point (AP) mode, and both at the same time. In this research, the system is implemented in the station (STA) mode.

Ngrok software

To control the system from anywhere with internet access, the system will be run with "ngrok" server software in this research. Ngrok is just a messenger to the server. Ngrok is a cross-platform application that enables developers to expose a local development server to the internet with minimal effort. No public IP or domain name on the local network is needed.

System Operation

ESP32 acts as a web server in station mode. ESP32 gets the internet protocol (IP) address from the wireless router or Wi-Fi hot spot and delivers the web pages to the devices that are requested from anywhere with a Wi-Fi network. The operation of a web server based electrical appliances controlling system is in two sections; hardware interface and software development.

Hardware Interface

The 4- channel relay instead of air-conditioner, electric motor, stove and bedroom lighting operates in the system, GPIO 33, GPIO 25, GPIO 26 and GPIO 27 of ESP32 are connected to the IN1, IN2, IN3 and IN4 of 4- channel relay, respectively, as shown in figure 4. The block diagram of the working principle of the web server based home appliance controlling system is shown in figure 5.
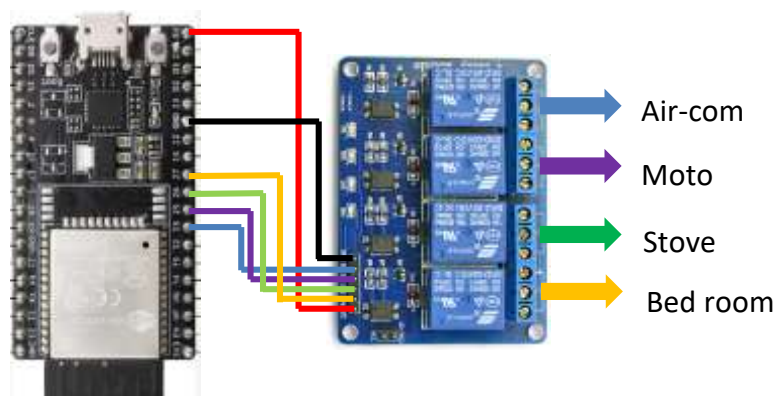
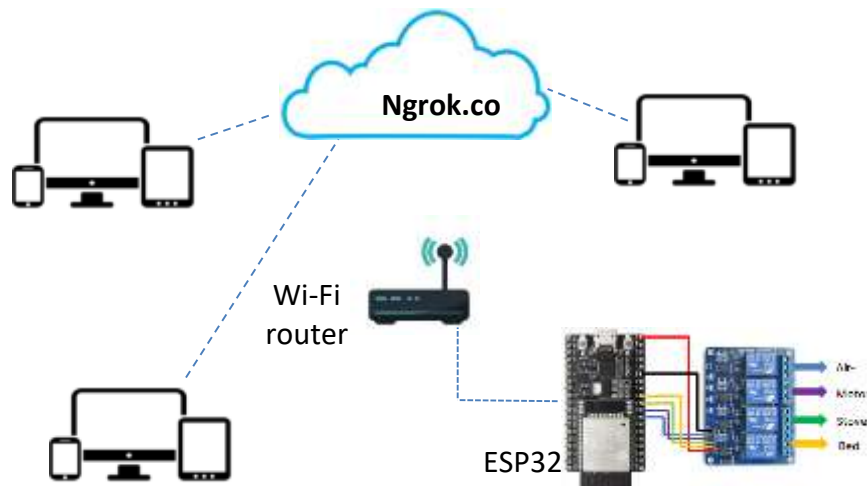**Figure 4** Circuit connection of ESP32 and 4-channel relay

Figure 5 Block diagram of web server based communication

Software Development

ESP32 can run with Arduino IDE. But, the ESP32 board and library are not included in Arduino IDE so that they are needed to install in Arduino IDE. The URL of http://dl.espressif.com/dl/package_esp32_index.json is pasted into the "Additional Board Manager URLs" Field of preference in the IDE window as shown in figure 6. After URL path is defined, ESP32 board can be installed using the board manager, as in figure 7.

Figure 6 Including ESP32 board

Figure 7 Installing ESP32 library

After the program has uploaded, ESP32 will communicate the local Wi-Fi network. It needs to define the network credentials of service set identifier (SSID) and password as;

const char* ssid   = "xxxxxxxxxxx";

   const char* password = "xxxxxxxxxxx";

  Wi-FiServer server (8888);

The web server is at Port 8888 which has assigned to use internet communication with HTTP. While ESP32 is connecting the network, connectivity status is examined with Wi-Fi.status ( ) function. If it is connected, the IP address is obtained by using Wi-Fi.localIP( )function. While the program is uploading, the BOOT push button is pressed. If the connecting dots are seen, the BOOT button is released. After uploading is finished, the serial monitor is open and the IP address is obtained by pressing the reset button as shown in figure 8.
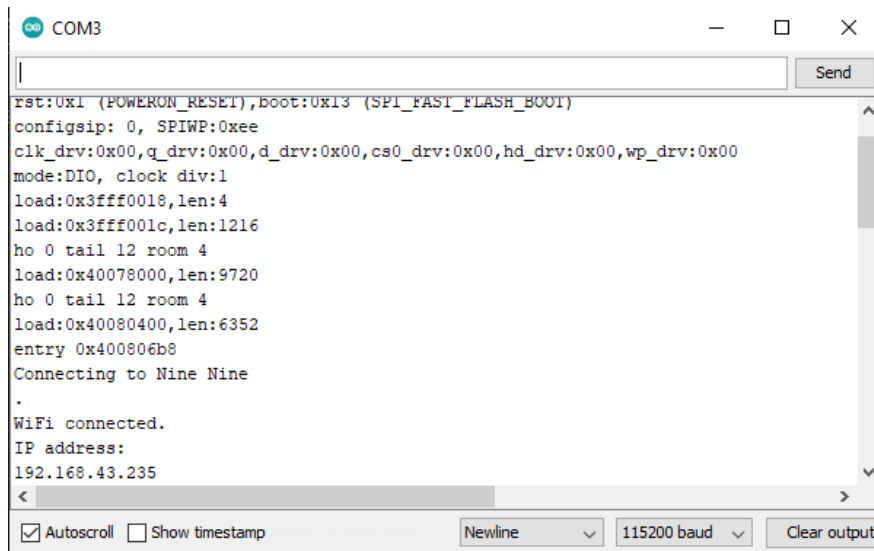
Figure 8 Obtaining IP address on serial monitor
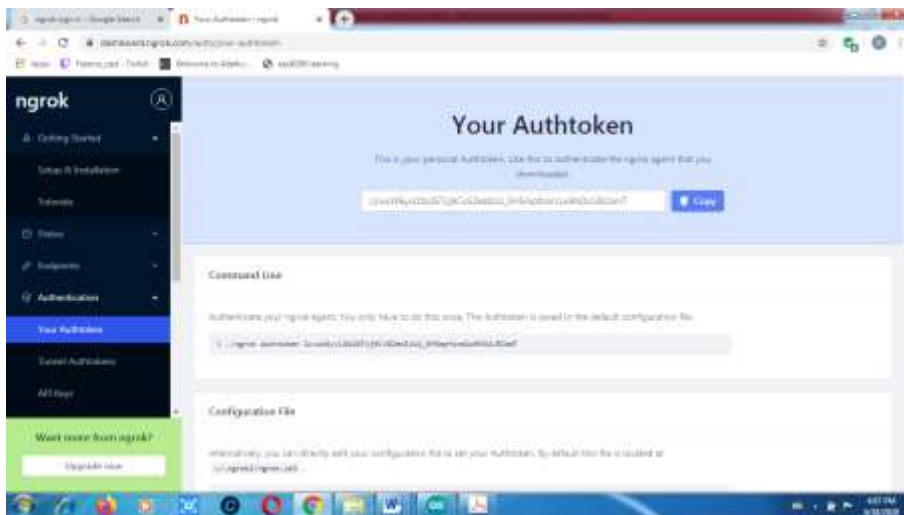
Figure 9 Getting tunnel authtoken from ngrok window

Figure 10 Inserting the Ip address

Figure 11 Obtaining URL from ngrok

Ngrok software is downloaded. The account is created and the "tunnel authtoken" is noted as shown in figure 9. Ngrok.exe file (in figure 10) is open and ESP IP address is filled up in the terminal window like the following format;

ngrok tcp ESP_IP_address:8888 --authtoken tunnel_authtoken .

By pressing "enter", the URL is expressed in the terminal window as illustrated in figure 11. When the URL http:// 2.tcp.ngrok.io.15448 is pasted in a browser, the password security box has appeared as shown in figure 12. If the correct user name (SSID) and password is filled up, the webserver home page is ready to monitor and control the appliances as shown in figure 13. The web server which is accessible from anywhere in the world is ready to serve the appliances controlling.
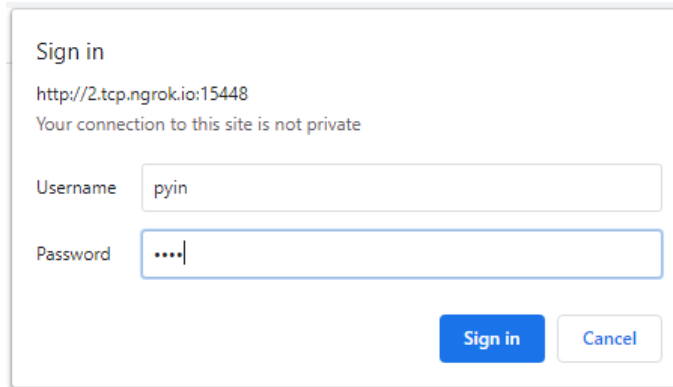
Figure 12 Password protecting the server

Figure 13 Web server being ready to monitor and control appliances

Results and Discussions

Results

The prototype design of home electrical appliances controlling system is implemented by using a 4-channel relay instead of home appliances such as air-conditioner, motor, stove, and lighting. The prototype system and the web server based operation are illustrated in figure 14. In this figure, the states of air-conditioner, motor, stove and lighting are in "off" condition and buttons are ready to be "on" condition. All LEDs are in "off" condition. That means all home appliances switch- off. The home appliances are controlled by the web page on PC as shown in figure15. In figure 15. (b), the air-conditioner is in "on" condition so that the button is ready to be switched off. The remaining appliances are in "off" condition and three LEDs are off. These buttons are ready to be switched on. In figure 15. (e). All home appliances are in "on" condition. All LEDs are switched on while all buttons are ready to be switched off. The home appliances controlling by the web page on a smart phone is illustrated in figure 16. The operation manner by phone is the same as that by PC.
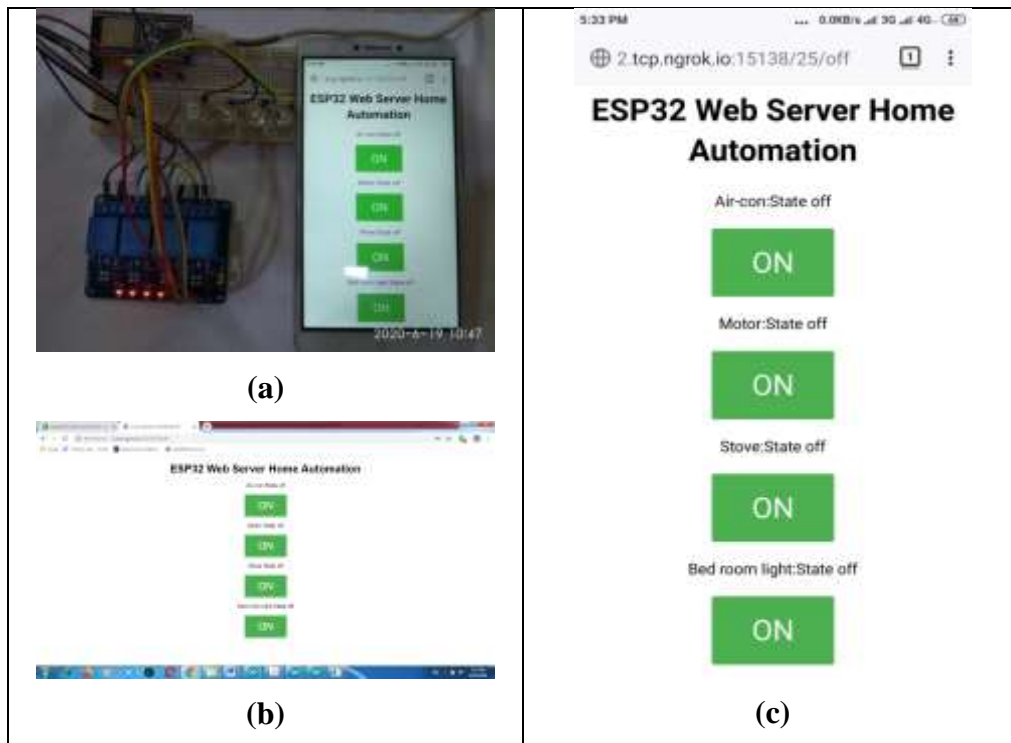
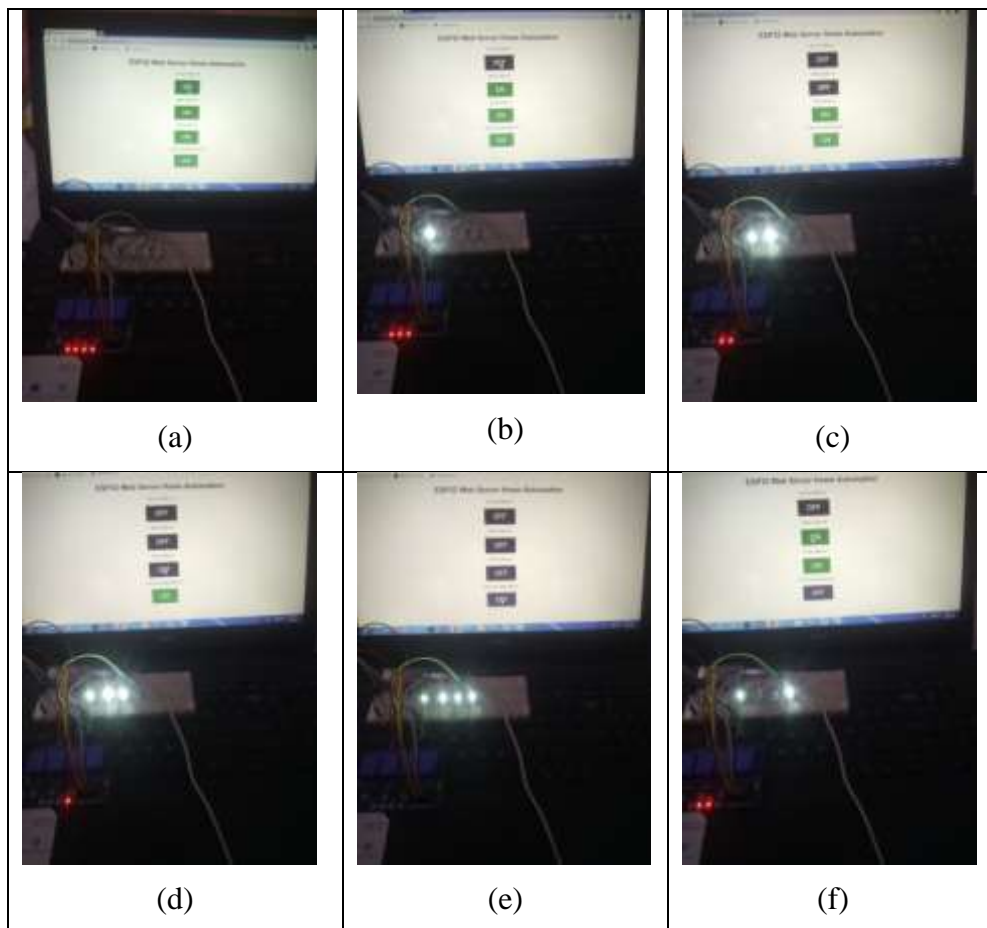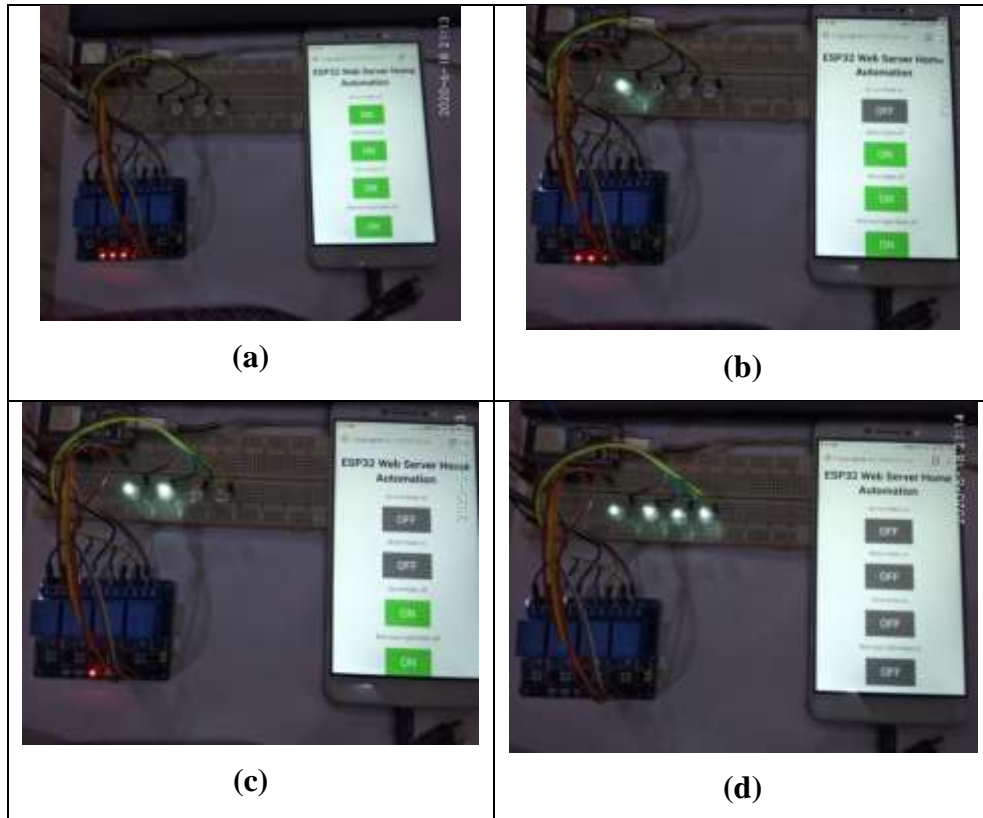**Figure 14** Circuit connection and webpages on PC and phone

Figure 15 Appliances controlling by web page on PC

(a)   **(b)**

(c)   **(d)**

Figure 16 Appliances controlling by web page on phone

Discussions

The typical web server based electrical appliances can control the devices in the Wi-Fi coverage area, not anywhere. The system which is included with ngrok software can control the appliances anywhere with internet access. But, on the free plan, its URLs are randomly generated. One of the disadvantages is ngrok software running always-on PC to control the appliances from anywhere with internet access. When the PC is restarted, the authtoken of ngrok is changed. The program is installed again with different authtoken. The same URL every time can be used if the ngrok is upgraded to a paid plan.

This research demonstrates the prototype's `hardware design by using a 4-channel relay instead of four home appliances. ESP32 consists of thirty-two general-purpose input-output (GPIO) pins. Among them, twenty-eight pins can be used as output pins so that twenty-eight home appliances can be controlled by an ESP32. The heavy-duty appliances can be controlled through the high power switching devices instead of a relay.

A password protected program is developed in this system; no one can control the appliances for the destructed purpose.

Conclusion

The webserver based appliances controlling system can monitor the electrical fixtures such as air-conditioner, motor, stove, and lighting whether they are "on" or "off". And then, they are controlled by using a laptop, tablet, or phone from anywhere with a network. One can check the state of electrical device whether "on" or "off". It can save the electrical cost and it can protect the electrical faults. One can start the air-conditioner or preheat the rice cooker or light on the rooms before you get home from work.

As the future work, the gas sensor, the heat sensor, the light sensor and the motion sensor are attached to this system, and the home automation system can be designed and constructed.

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