

DESIGN AND ASSEMBLY OF COMPACT PCB FOR HOME AUTOMATION

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Abstract - This paper presents an idea or concept to develop a PCB that is compact, lightweight, and uses less space. Usually, we prefer to go for automation by having various components in the system and it increases the number of components which is proportional to the increase in size and weight of the total system. In this paper, I want to introduce a PCB that is designed, assembled, and tested and that performs various tasks on IoT platforms and mainly focuses on home automation systems. The future is all about home automation and to make a device more classic and special, its size should be decreased and has much more technology embedded in less space. These days, the home automation industry is growing rapidly this is powered by the need to provide systems that provide support for aged and physically handicapped people, especially people who live alone. Smart home or home automation can be said as the domestic extension of building automation, it also involves the automation and controlling of lightings, ACs, Fans, heater, tv, etc. The home automation system allows a user to control their electronic appliances and gadgets from anywhere in the world and causes a quick response to inputs and outputs.

Key Words: IoT devices, PCB design, Home Automation systems, User-friendly, Less space, etc.

1. INTRODUCTION

The word "things" is an embedded or a non-embedded device that is not previously added with WI-FI and the extension of internet to that particular thing is called the Internet of things. For example, the watch is an embedded device which is not equipped with Bluetooth and WI-FI in the past. but today they are so much advanced and it measures the heartbeat, percentage of oxygen dissolved in the blood (spO2 levels) and it keeps tracking about running, workouts, skipping, sleep quality and now in 2021 they are even measuring menstrual cycle which is highly appreciated and helps women keep tracking of their irregular cycles and how to prevent it. Home automation is a process of building smart features for a home, called a smart home. It includes the control and monitoring of lighting, warming, ventilation, aerating and cooling (HVAC), and security. The home appliances, for example, washer/dryers, stoves, or fridges/coolers are added with internet extensions and their functioning is monitored by the system and that can be seen in the mobile phone. IoT is the technology that connects all things. The linked devices together allow new forms of communication between living organisms and non-living organisms, and among things themselves.

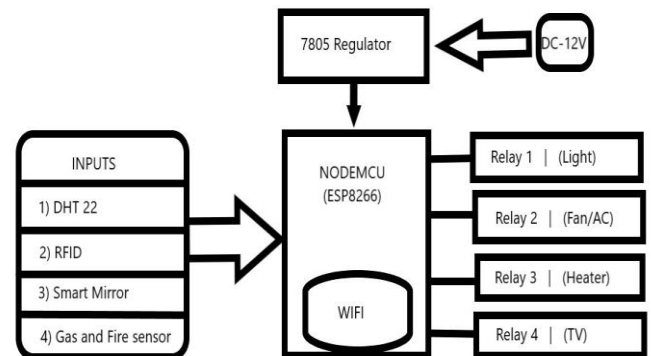


Fig -1: Block diagram

2. DESIGN PROCEDURE

There are two steps involved in designing this prototype, they are,

2.1) PCB design

A printed circuit board (PCB), is used to mechanically support and electrically connect electronic components using conductive pathways, or signal traces etched from copper sheets laminated onto a non-conductive substrate and it is also non-conductive for undefined paths. The below PCB is fabricated with FR4 base material that is flame retardant up to 140c. Easy EDA software is used to design PCB that combines component placement and routing to define electrical conductivity on a manufactured circuit board.

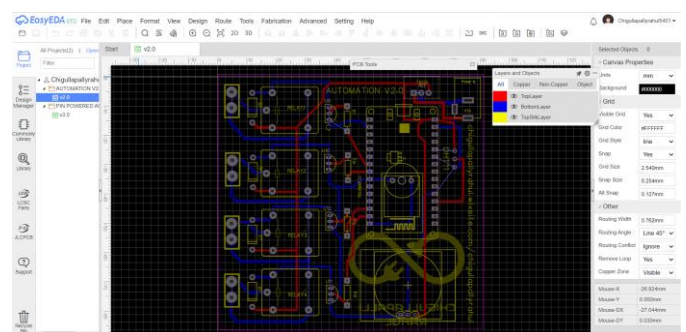


Fig -2: PCB design software - Easy EDA

The above image shows the design of a compact PCB. There are several components used while designing this PCB such as LM7805 Voltage regulator, 7A 250V Relay, 1N4004 Diode,

BC547 Transistors, Multiplexer, ESP8266, and a DC 12V socket for power supply. The designed PCB is given to manufacturing and it is fabricated with FR4 base material which is a glass fiber epoxy laminate. It is the most commonly used PCB material. FR-4 is used widely for printed circuit boards. A thin layer of copper foil is usually laminated to one or both sides of an FR-4 glass epoxy panel. These are commonly referred to as copper-clad laminates. The copper thickness or copper weight is variable.

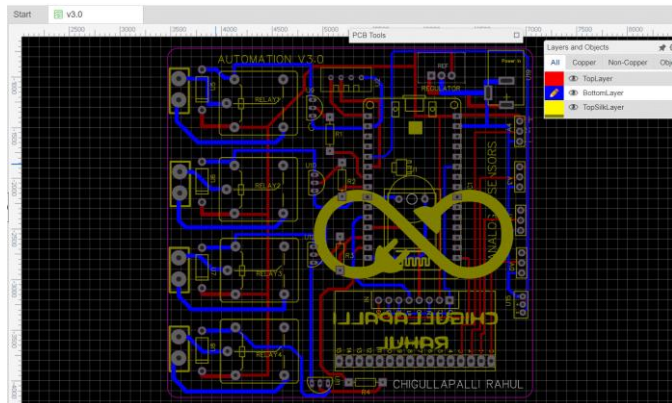


Fig -3: PCB design describing slots to different sensors

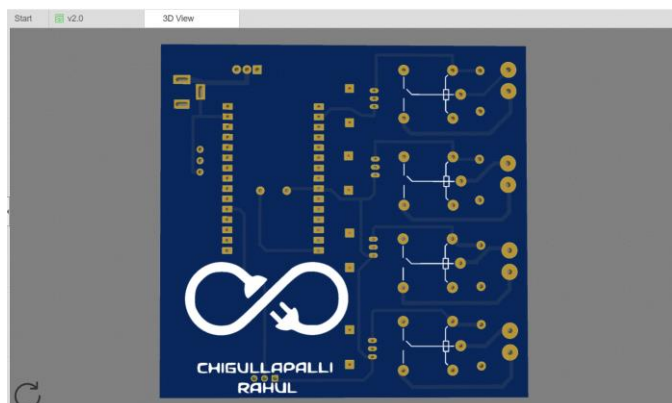


Fig -4: 3D simulation

The software shows the simulation of the design and it gives an accurate output of the part that has to be manufactured. PCB simulations are the capture phase of a design and that process helps in designing and verifying the mechanical and electrical aspects of the present design. They are useful for checking clearances and the alignment of the connectors. Most importantly, we can able to see the overlapping of top and bottom layers which may cause the failure of PCB, and sometimes it may also result in connecting the positive and negative voltages as well. So, it is important to verify all the layers and their role in overlapping before it is given to the production and fabrication process. Easy EDA is a web-based tool that enables engineers to design and develop the PCB.

A) The PCB is manufactured and the below picture shows the model before assembling.

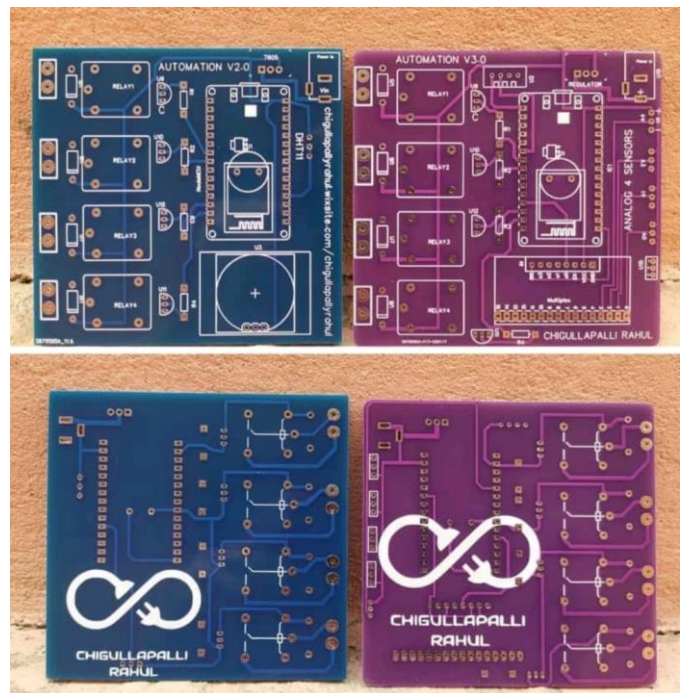


Fig -5: Manufactured model

B) The PCB is assembled with the required components involved in the design software.

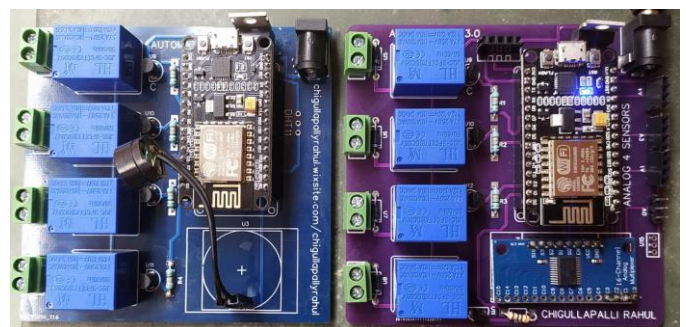


Fig -6: Assembled model

The left PCB is only used for turning on the electrical appliances. Meanwhile, the PCB on right is used to access different types of input data provided by the digital and analog sensors provided on the PCB. ESP8266 contains only one analog input, so it does not take many analog inputs and process the data. A multiplexer is used to process different kinds of analog signals and sends the information to the analog pin on the Node-MCU board. Some of the resistors are soldered on the top layer of the PCB and other components are soldered under the bottom layer. Every component is electrically tested before assembling them onto the PCB board.

2.2) Outer case design using Fusion 360

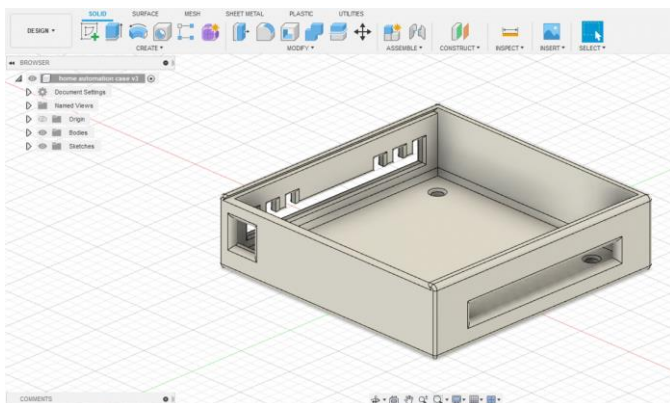


Fig -7: CAD model (bottom part)

The dimensions and requirements are taken into consideration. It's a 90*90 mm PCB. So, it should have a spacing of 10mm on both sides which results in 110mm of the plastic case layer. The 20mm gap is given to have adequate airflow to the PCB and thereby it exchanges the heat to surrounding air. To avail more airflow into the box, the design is given with holes and slots. I used Fusion 360 CAD software to design the outer case(box) and simulated it inside the software with the help of the render feature.

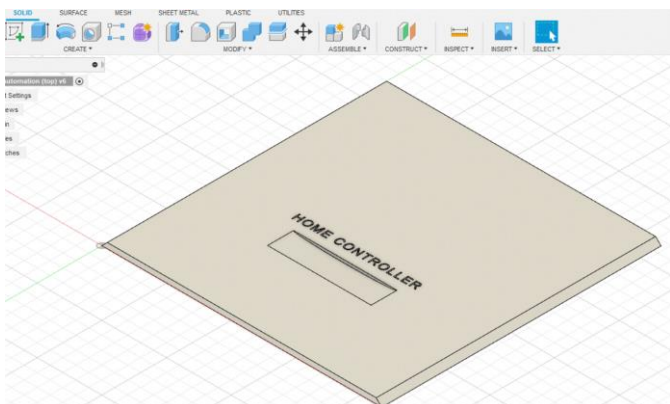


Fig -8: CAD model (Top part)

The top part is given with an ellipse cut to slide it during opening and closing the lid.

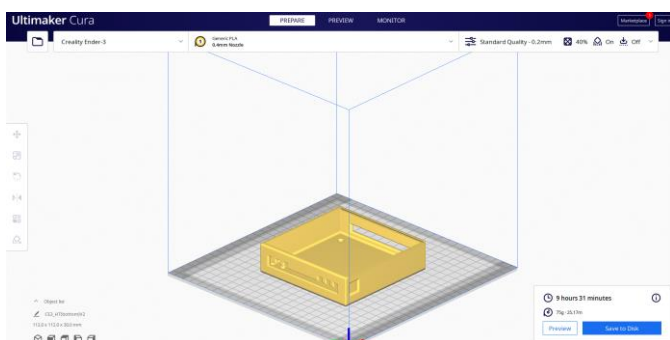


Fig -9: Slicing the CAD model

The slicing software is a computer software used in many 3D processes. It is useful in converting the information to something which is understandable to the 3D printer. Cura slicing is a powerful, open-source slicing engine, this software is built with the help of user contributions. slicer software initially divides the object as a bunch of flat layers, and these layers are linear movements of the 3D printer extruder. All these movements, together with some specific printer commands like the ones to control the extruder temperature or bed temperature, are finally written in the g-code file that is understood only by the 3d printer.

Infill: solid objects need a large amount of material which is called filament. A filament can be in solid form, liquid form and powder form depending upon the process performing for the particular task. For toys, ABS (acrylonitrile butadiene styrene) plastic can be used which is a plastic wire solid material and print time increases with the increase of infill percentages. In this project 40% of infill is used, which is enough to build beautiful and strong layers of the model. Also, polylactic acid (PLA) is widely used because it is biodegradable in nature. The slicer has the inbuilt capability to convert solid volumes to hollow ones automatically, that saves costs and time.

Support structures: A support structure is a technique done during the slicing process that helps in supporting the build part of material. In absence of this feature, the next layer will not be deposited over the previous layer which results in the error. The layer will not build on the adjacent layer and the extruder keeps on ejecting the material in the air. Many 3D printing processes create the object layer by consecutive layer, down to up in ascending order of layer numbers, with the layer under construction being deposited over the previous one.



Fig -10: 3D printed sliding case

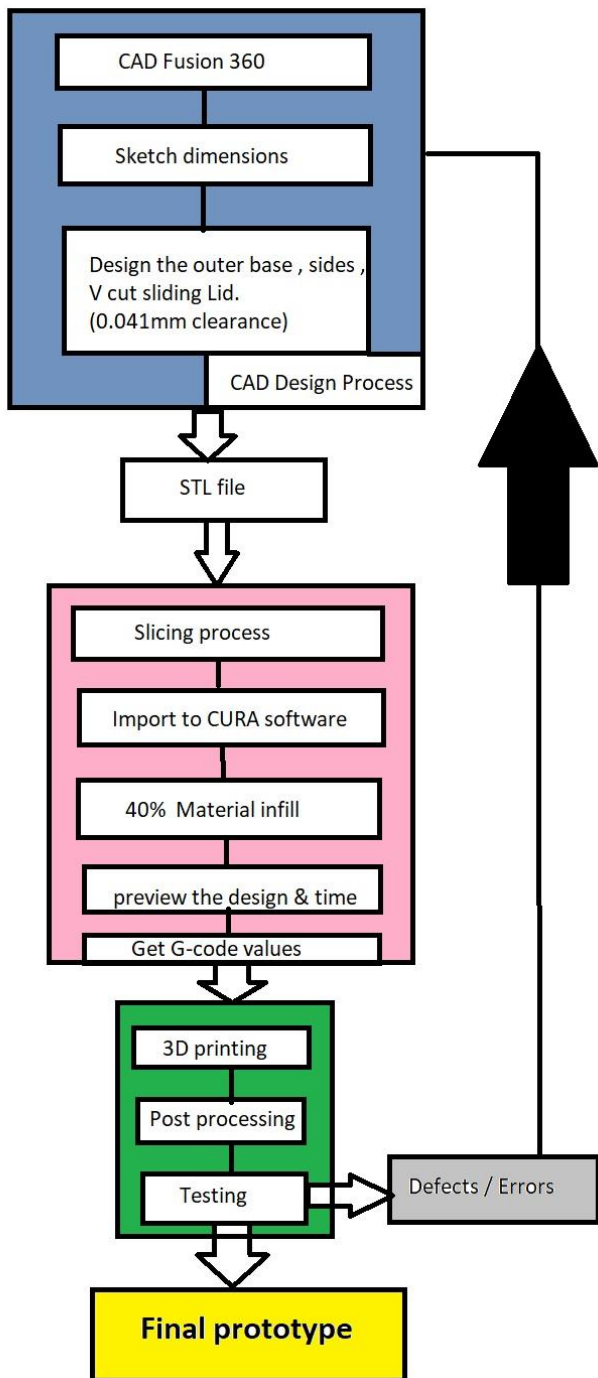


Fig -11: Process for 3D printing

As soon as the material is printed, it will be sent to post processing which makes the process simpler for removing the unwanted materials and giving the prototype a good surface finish. If there are any errors found, some of them can be minimized and other errors cannot be accepted, which in turn, the cycle repeats until it achieves a final prototype without any scalable errors and defects.

3. IMPLEMENTATION

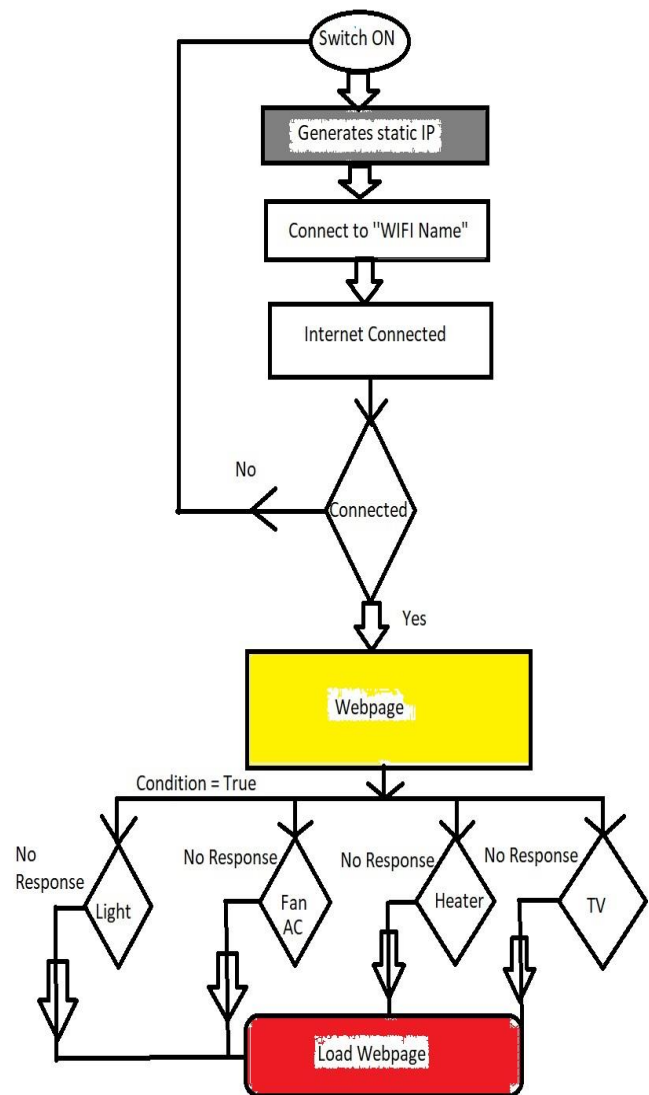


Fig -12: Activity chart

Figure 12 illustrates the sequence of activities taking place in between the ESP8266 and its webserver. Initially, the Node-MCU generates a static IP address which is mandatory to access the webpage contents. Once it is connected to the WIFI, it will load the webpage containing the relays. Those relays get activated when the corresponding button is pressed and the html request is accepted by the board and it sends a command to the associated relay. The microcontroller sends the current and it turns on the electromagnetic relay. Any electronic appliance connected to the relay gets turned on. For example, if the heater is connected to an activated relay, then heater gets switched on and heats the water beyond room temperature and it will automatically cut-off its power supply when a certain temperature constraint is reached.

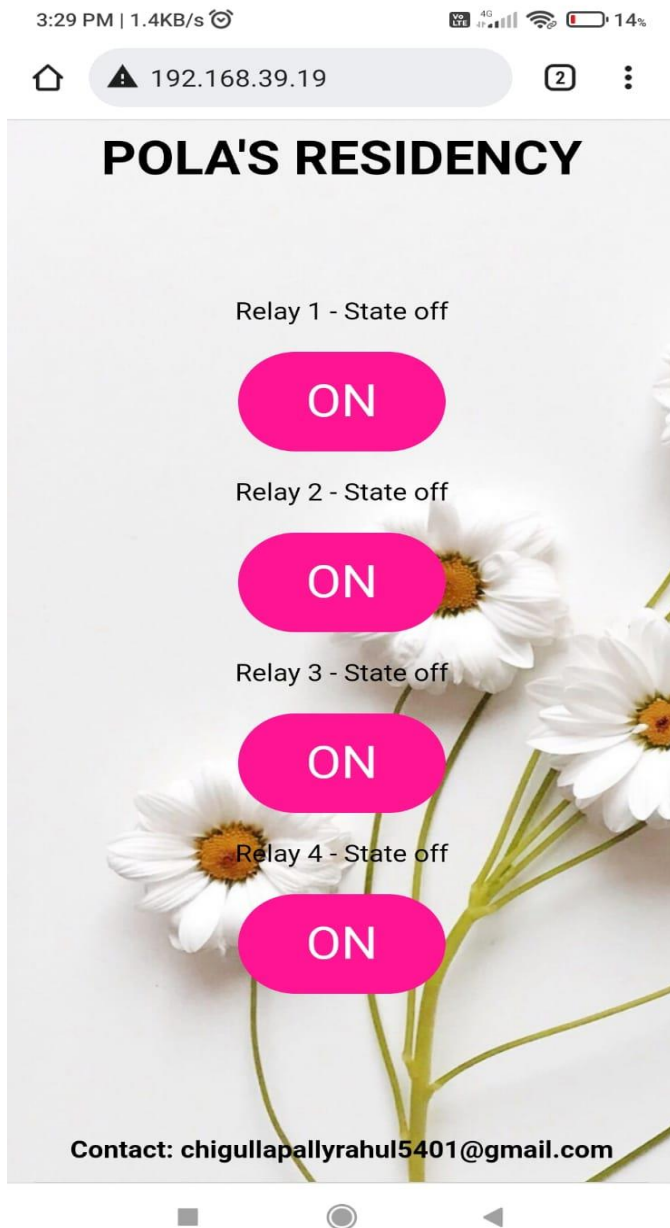


Fig -13: Accessing the webpage in Mobile

The webpage displays the current state of the relay and its working condition with the electrical appliances. The webpage is made with html and added some of the CSS features to make it look beautiful and glossy. It is an embedded system especially made for accessing the home contents and it can work around the WIFI range. An MDNS Server is also established and it is named as "HomeAutomation.local/". This is the process of giving a webpage a name from its static IP address.

4. SOFTWARE



Fig -14: Arduino IDE

Arduino software is used to code ESP8266 Board. Basically, this board does not have any programmer/ software to upload the code. Due to this reason, Arduino is used to write the sketch and upload the code to ESP8266. But, before writing the sketch, one should be able to paste the reference link of ESP in the file preferences bar and continue to download Node-MCU boards from the boards manager and other sufficient libraries that need to be installed in order to compile the code. Without sufficient libraries and header files, the program will not compile.

The HTML file format is understandable to computers to create webpages and get responses. These files must contain an extension like file.htm or file.html. For example, to access my program file which is stored in a local computer. Then it is required to open Homeautomation.html to display the webpage of this project. These markups contain instructions to redirect itself to a browser and perform its task as written in the HTML.

This platform also includes many features such as include preferences, add libraries, create your own sketch, cut, copy, paste, modify, showing braces etc. Only one button is enough to compile the whole code and a single click is required to upload the code to the board. The Node-MCU board is a low cost and powerful device, It connects to the WIFI in a second and response time is very less and efficient in delivering the output.

5. RESULTS

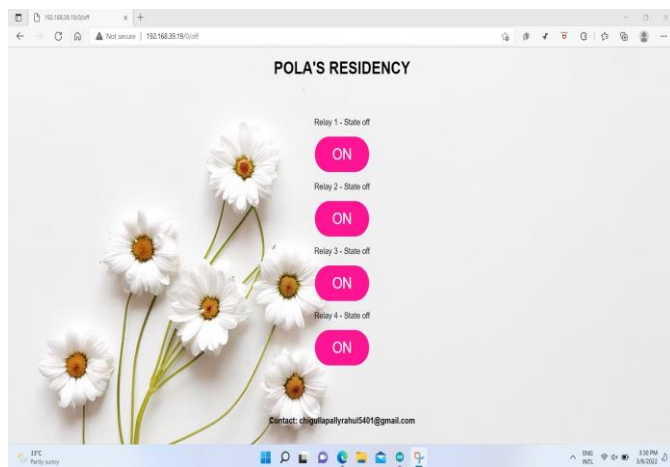


Fig -15: Access in PC (CSS)

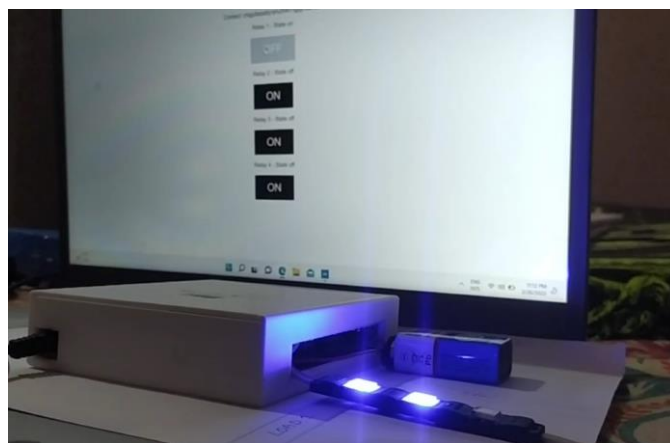


Fig -16: Access in PC (HTML)

Using ESP8266 as the microcontroller and its capability to connect over the internet is really fascinating for the developers who work on WIFI extensions to change a thing from Non IoT to IoT background. Successfully controlled the home appliances using "Compact PCB" which is only 11*11cm(110*110mm) in size and fits everywhere.

6. CONCLUSION

In this paper, it is mainly focused on the design and assembly of the various components onto the PCB. The prototype size has decreased rapidly when compared to all other home automation wired devices. There are no wires at all in this device and it is fully operated on WIFI. The home automation made out of "Compact PCB design" has been experimentally proven to work satisfactorily by connecting various electrical appliances to it.

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BIOGRAPHY

Chigullapalli Rahul, B.Tech Final year student.



Having interested in Electronics, Electromechanics and Automation I've done more than 50 projects on the Arduino platform by myself. My interests are taking a problem statement and finding suitable solutions in a low-cost method approach.

Watch this project on YouTube : https://youtu.be/d1_4wOmTTes