DESIGN AND FABRICATION OF IOT SWITCH WITH MANUAL OVERRIDE

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Abstract: Today internet is the widest platform used by humans which connects people to people, but various researches have been carried out to connect machines to internet on a cloud platform. These are collectively called as Internet of Things (IoT). IoT helps to control and monitor the machines in factory, but later it is also used in home automation to connect household electrical devices like fans and lights. Each device will have their own control medium to access them and monitor them which makes the user, a tedious process to track them. There arises a need of, connecting all the devices and operating them in a common platform. Accessing the main supply of the appliances and turning ON/OFF that supply will be a suitable solution to control any range of applications. Hence, smart switch is becoming more popular now-a-days. But, most of the smart switches replace manual switching and goes for complete software-based switching. This makes the user to rely on the software/application all the time to control the device, even though the user is near the device. In order to solve these problems, in the proposed method a smart switch which follows the manual toggling action of conventional rocking switches to turn them ON/OFF manually and also provide access through remote applications to turn ON/OFF them through a mobile application.

Keywords: Node MCU, Altered relay, IOT, Smart-Home, Blynk server.

1. Introduction

Today in this modern era, either in the business field or in the commercial field, Internet of Things (IoT) is one of the most trending technology which increases the world economy [1]. The main objective of IoT is to improve the quality of livings by providing the safe and secure environment [2]. It has a wide range of applications in the emerging automation world. Apart from all other applications of IoT, smart home is one of the fields which is gaining momentum at a faster rate. It enables the owners to remotely control the devices in the home and configure the time schedules for smart home-enabled devices which helps in controlling the costs and be more energy-efficient. Lots of studies have been conducted on smart home automation using various technologies. Mowad et al [3] has proposed a paper which gives a general overview of how a Smart Home System (SHS) should be and what are the conventional methods to implement those smart devices in common homes. They implemented the system for home automation with a multiplatform control system which combines both hardware and software technologies. Rao et al [4] has proposed a system for smart home control using mobile devices in which a software application will be downloaded in the mobile device of the user of the home and it is configured to control an electrical switch or electrical power outlet. Srivastava et al [5] has developed a
IoT based hybrid energy system by using the ESP8266 which is controlled either by manually or remotely. Durani et al [6] has designed a IoT based automated home application which is monitored and controlled with the help of Node MCU (Micro Controller unit) and the blynk app. Bohara et al [7] has proposed a paper on solving the sundry problem existing in Nepal. They have designed a system to control and monitor home appliances using raspberry pi as a private server and Node MCU chip as a gateway to connect to the server. They have used blynk framework for the operation and control of all the devices and sensors. Yongchuan et al [8] has designed a system in which a retrofit switch apparatus is designed to be attached over the traditional switches. In order to control them remotely, the retrofit switch apparatus will have all the technological support to wirelessly toggle the traditional switch, in order to turn on/off the switches. Habib et al [9] proposed a paper related to IoT robotic switch, which is similar to the above-mentioned retrofit switch apparatus. This device was offering users an extremely easy-to-install home automation solution gives the users the flexibility to implement a phased transition to home automation. They have made the robotic switch in a way that the user can install over the switches without a great deal and gives the greatest feature of allowing the user to automate any existing switches. Also, this robotic switch can be integrated with other home automation solutions with the use of open source platform for programming and monitoring. Somesh et al [10] has designed the IoT based smart home appliance using ALEXA server that its automatically connected to the Wi-Fi network. Karimi et al [11] has proposed a system which automatically monitors the home condition with the use of arduino microcontroller, sensors, actuators and for controlling the household devices using a smartphone. Reddy et al [12] has implemented a system for home automation which uses the HLK-RM04 Wi-Fi module for transferring the date and all data are controlled through an android application.

From the above literature survey, the following research gap is analysed: The remote monitoring and controlling of household appliances need the individual control medium to access them and monitor them which makes the user a tedious process to have a track of them. So, in this novel project, we have made an attempt to control the household devices through a switch which can be turned ON/OFF both wirelessly and by means of manual toggling also which connects all the devices in a common platform. This, low cost automation provides the users of smart home to manually override the controlling devices through remote control methodologies.

1.1. Proposed Methodology

The proposed system consists of two relay coils, one to turn ON the Alternate Current (AC) supplied to the appliances and other will act as a manual switch, which will also use to turn ON/OFF the appliances. The appliance relay can be turned ON/OFF by wire-less means using the Wi-Fi enabled microcontroller (i.e.: Node MCU ESP8266) [15] and also by manual toggling using the other relay coil as the switch. The ESP8266 uses TCP/IP protocol which is developed by Espressif Systems [13]. The relay which acts as manual switch will be in on state whenever the device relay coil is turned ON and will be in OFF position once the appliance is turned OFF.

When the relay acting as a manual switch and it is turned ON, it will pass LOW (ground) signal to the microcontroller and when it is turned OFF it breaks the ground connection, the microcontroller (which is already an active high microcontroller) will take the input as HIGH signal. Thus, when manually pushing the moving coil to ON state it will pass the ground signal and the appliances will be turned ON, and when turned OFF it will pass the high signal which will turn OFF the appliances. The figure 1 depicts the data signal flow, when we turn on the appliance manually.
On the other hand, from any software or application, the user turns on the device wirelessly and the signal will be passed through the cloud to the ESP module connected in the electrical switch hence, both the relay coils will be turned on and vice versa will happen, if the user turns off the device remotely. The blynk provides the platform for exchanging data through cloud between electrical appliances and the user who is connected in internet. The blynk operations are carried out by blynk app, blynk libraries and the blynk servers [14]. Only authorized mobile devices gets the control over the connected device and the blynk user account is secured with the password. Hence, by both remote and manual access of same switch is possible by simple connections and method. Figure 2 depicts the data signal flow from the software platform to the smart switch when the user makes an action in the digital switches.

![Figure 1: Block Diagram of Manual Control](image1)

![Figure 2: Block Diagram of Software Control](image2)

The proposed methodology is depicted in figure 3. The flow is bidirectional from smartphone and also from the Hardware (Here NodeMCU, but any Wi-Fi supported chips can be used). The Wi-Fi medium is used due to its availability and advantage of its range facilities. The hardware receives data from the Blynk server, process them and set the GPIO pins as programmed, which will actuate the device and also toggle the switch to ON position and the device status will be again sent to the server.
2. Feasibility Study

2.1. Economic Feasibility:
The success rate of any device is based on the cost of the device. The average cost of smart switches available in the market range from Rs.1500 to Rs.2500. From Table 1 the cost analysis of our proposed model should be feasible in order to penetrate the market.

Table 1: Bill of Components

| S.No | Item                          | Quantity | Price |
|------|-------------------------------|----------|-------|
| 1    | NodeMCU-ESP8266               | 1        | 300   |
| 2    | MicroSMPS-230V AC to 5V DC    | 1        | 100   |
| 3    | Relay Module                  | 1        | 70    |
| 4    | Electromagnet-12V             | 1        | 60    |
| 5    | Switch Box                    | 1        | 150   |
| 6    | Connecting Wires              | Required | 100   |
|      | Total                         | -        | 780   |

The components of the system are easily available and also the cost of installation will be cheaper in terms of mass production. A single Node MCU have 16 GPIO pins which enable to connect 8 inputs and 8 outputs which is 8 individual switches and hence within Rs.1500 we can control totally 8 devices along with manual override. On the software side Blynk platform is an open source application which can be downloaded/modified easily by all the users. Hence the user needs to pay only for the hardware packages and software is available on windows and android platform for free. Hence in cost wise comparison with the available smart switches in the market, our proposed model performs on par excellent.

2.2. Technical Feasibility
Since it mostly uses the basic components with low maintenance cost. Once fixed on the walls, these switches may perform well until any physical damage or degradation of properties of the integrated circuits. The installation of the device is made simple, since every wiring connection inside will be encapsulated into the switch box and the user need to connect only the line wires and the appliances wires. Since relay is the component mostly used in our system, the failure rate of conventional rate is very low which makes our project reliable. The platform used is an open source platform – blynk which allows the user for further automation by connecting it to other open sourced devices which
may be a master to all these switches.

2.3. Operational Feasibility
This system uses simple circuits and the supply for the device is obtained through Micro SMPS (Switched Mode Power Supply) which converts the live AC into the Direct Current (DC) source suitable for the microcontrollers and DC relays to actuate. The principle used in toggling mechanism is simple electromagnetic principle which leads to low cost automation. The operation and construction of the system is very simple which leads to easy identification, rectification and replacement of the components. Since, all the devices are connected to home Wi-Fi which can be operated from any remote places through cloud-based server application which makes it operational globally.

3. Over All Design Model

3.1. Design Calculations
The magnetic force of a relay is an important parameter to switch the devices. Here, it is calculated by considering the mass of a switch and force applied on the switch.

Mass of Switch = 5 g = 0.049N
Force applied on switch on normal condition = 1N
For the plate movement a normal of 1N is enough. Assuming the relay coil of Omron 12vcoil:

Force produced by the magnetic induction
\[ F = 2 \pi \frac{L}{X} \]
where \( X = \left( \frac{R}{\cos \theta} \right) \sin \theta \)
\[ \theta = \cos^{-1}\left( \frac{W}{VA} \right) \]
For 12V Relay coil standardized values are
\[ R = 288 \ \Omega \]
\[ W = 500 \times 10^{-3} \ \text{V} = 12 \ \text{V} \]
\[ A = 41.7 \times 10^{-3} \]
\[ L = 0.74 \text{H} \]
By calculating
\[ \theta = \cos^{-1}\left( \frac{500 \times 10^{-3}}{12 \times 41.7 \times 10^{-3}} \right) \]
\[ \theta = 0.99920 \]
\[ X = \left( \frac{288}{\cos 0.99920} \right) \sin 0.99920 \]
\[ X = 5.0236 \]
\[ F = 2\pi \times 0.74 / 5.0236 \]
\[ F = 0.92517 \]
Thus, the force calculated will be 0.92517 N.
Hence the same relay coil can be used to move the 5g switch plate between 2mm

4. Modelling and Simulation

The left side view (figure 4a) and right-side view (figure 4b) as shown in shows the structure altered relay and front view (figure 4c) and orthogonal view (figure 4d) of the 2D model of the altered relay depicts the entire structure.
5. Fabrication Process and Working Principle

5.1. Relay Setup Fabrication
A relay is nothing but an electromechanical switch. Mostly switches are manually operated type. It works when a voltage is applied across the relay coil. The contact is moved to new position when voltage is applied to the relay coil. The pole is normally closed contact and the other contact is normally opened contact. When the supply is available across the relay coil, then the normally opened contact is closed and normally closed contact opens. The above explanations are suitable for single pole and double pole relays.

In this proposed method, a slight modification is made in the existing relay, by adding an extra terminal which passes ground signal when the relay coil is turned ON. This setup enables us to identify whether the relay is in ON or OFF state. This ground signal triggering is constantly passed to a microcontroller which is active high. Hence when the ground is not connected, the input will be taken as high signal.

The same altered relay structure can be manually turned ON/OFF, by moving the coil plate manually to touch the ground terminal, which turns on the electromagnet programmatically. Hence, the altered relay as shown in the figure 5 as shown below can act as a switch which can toggle by means of actuation by both electrical and manual methods.
5.2. Entire Fabrication

Figure 6 depicts the simplicity of the project which is completely encapsulated into the switch box. The device attached to the right-side switch box will act as a switch which will toggle into ON/OFF position depending on the commands from the smartphone nearby there. When the switch is pushed manually, the signal will be passed to the microcontroller which will cut the power supply to the apparatus and also updates the device status in the server, so that the user may monitor and control the switch remotely.

Figure 6: Entire fabrication setup

6. Conclusion & Future Scope

A Smart Switch with rocker type manual override is designed and fabricated to control the home appliances both manually and remotely through mobile application. The whole setup is miniaturized as possible it could be, in order to fit in the existing switch boxes size. An open source platform – blynk and its server is used. This allows the user to manipulate the device to connect with other smart devices easily. Micro-SMPS were used to power up the device by converting AC source into DC source which gives conditioned ampere rating for the functioning of hardware chip.

In future, the much-miniaturized power supply converter should be designed, in order to reduce the size of the entire set-up. PCB fabrication of the entire set-up should be made. Fabrication of toggle mechanism incorporated with Integrated circuits may allow us to reduce the size and also to integrate in a better way with any other wireless transfer medium. A mobile application for easy monitoring and control of switches need to be developed for convenient user interface. Study need to be done in the current setup, in perspective of switch board panels consisting of more than 10 switches.

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