HOME AUTOMATION

Smart Home Switching Application

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Abstract

This paper describes the implementation of a smart and wirelessly operated switching system. The uniqueness of this system lies in the design of switch and power controlling unit. Wireless control will be established through an android application. This is a highly efficient switching system, as the power delivered to the load is through a low power electronic switching circuit. The use of TRIAC as a main work horse of the circuit makes this system cost effective, modular and dynamic. The microcontroller will communicate with the user by user defined commands sent through the android application. All the loads (fan, air conditioner, refrigerator, etc.) are connected to a sensor.

Hence boosting the compliancy this project is made smart and wirelessly operated.
Keywords: TRIAC, WIFI (Wireless Fidelity), ANDROID, LDR, Modular.

I. INTRODUCTION

This project advances us to the automated world using less human efforts and increasing the efficiency. This is a step towards making the IOT (Internet Of Things) into reality. This will give the disabled and aged persons a helping hand. This will completely change our perspective towards the conventional switches. This system can be installed very easily without changing the existing switches which again adds to its ease of installation and make more versatile than its competitors in the market. The power rating of the Switching module can be scaled from few watts to few kilowatts by just changing the TRIAC. The flow of the main idea goes as follows.

II. COMPONENTS USED

The components used to make this device work are very unique than those used in similar devices which are conventional. The key features and the benefits of using these components are explained in details below.

A. *Microcontroller:*

We have used CC3200 a dual processor with „On-Chip‟ WIFI module a Texas Instruments product as our microcontroller. It handles both the communication by a dedicated ARM CORTEX_M0 processor and other processing by a powerful ARM CORTEX_M4 processor which is needed to realize the system and other general purpose processing of sensor data. This ensures the independent and parallel working of communication and other processing.

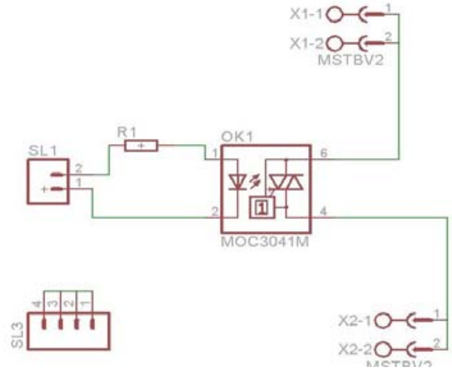
There is a Real Time Operating System (RTOS) which is used to schedule the background tasks and handle the communication and the processing part consonantly. This is a free RTOS provided by Texas Instruments. This increases the processing efficiency of microcontroller. Also priorities can be assigned to the tasks, which ensures the execution of high priority tasks. The high resolution ADC which is 12 bit can be used to sample the data from sensors. The key feature of this microcontroller is that it provides on chip WIFI module which reduces the cost as well as the manufacturing complexities of the system, which may arise due to the RF. Many other peripherals like I2C, UART, SPI etc. are there for value addition. The steps included in programing the controllers are enumerated beneath through an algorithm. The microcontroller acts as a ligament between the load and the android device. It creates an Access point (AP) to which the device connects and communicates using UDP (User Datagram Protocol). Transmission and reception of data with the microcontroller is done using UDP.

Algorithm of the implemented code in CC3200:

1. Initialize the board and the variables with the required values using function “BOARDINIT”.
2. Multiplexing pins for various functions using “PINMUXCONFIG()”.
3. Displaying the current status of the application on UART using “DISPLAYBANNER()”.
4. Creating a “Task” Using OsiTaskCreate() for WlanAP (Access Point mode) application.
5. Starting OSI.
6. Create Hotspot of the desired name entered through the UART.
7. Assure that the client is connected by pinging the client.
8. Start the communication with the client.
9. Take action according to the command.
10. Go back to the listen mode to get command from client.

B. Customary (normal) Switch:

The simple on-off switching operation is done using an OPTO-TRIAC triggered by a microcontroller. The OPTO-TRIAC used is MOC3041. This is the optimal device for switching purpose for load of 100W or below as per its ratings. This was chosen as it has a high dv/dt value of around 2000 V/s this helps in proper triggering of the OPTO-TRIAC. Also the key feature of OPTO-TRIAC is that it has an inbuilt ZCD (Zero Crossing Detector) this ZCD ensures the 0 degree firing angle of the OPTO-TRIAC, which is important for the complete power to reach till the load. The triggering current of the OPTO-TRIAC is 5mA which can be easily sourced from the microcontroller hence reducing the complexity in interfacing the controller with the power circuit and completely eliminates the need of driver circuit. Also the price of MOC3041 is very less as compared to a mechanical switch of good quality (15% – 20 % of mechanical switch). Fig [1a] shows the schematic of this switch.



Fig[1a] Schematic of Normal Switch (Circuit Diagram).

Working:

On turning the GPIO (general purpose input output) of microcontroller high which is connected to the OPTO-TRIAC this drives the optical side of the MOC3041 in series is a resistor to limit the current to 5mA. This triggers the gate of the TRIAC in MOC3041 which turns ON the load at the next zero crossing of the input wave at pin6 of MOC3041. To switch off the load just the GPIO is given a low (zero voltage) which stops the triggering of the TRIAC and stops the current flowing from the load and the load switches OFF.

C. Power controlling switch:

The intent of power control achieved by this switch.

Components:-

1. TRIAC (BT136)
2. OPTO-TRIAC (MOC3041)
3. DIAC (DB3)
4. LDR
5. LED

Working:

This is a regulating switch where the DIAC is a driving device for the TRIAC, which controls the gate current. The power delivered to the load is controlled using a Digitally controlled resistance setup. The digitally controlled resistance setup consists a LED-LDR pair. Intentionally a white color LED is chosen so that it gives light of various wavelengths over the entire spectrum hence maintaining uniformity in the LDR. The resistance control is acquired by a PWM (pulse width modulation) of varying duty cycles sent to the LED which in turn gives light of corresponding intensities to the LDR. This results in the variation of the resistance of the

LDR. This variation of resistance is precisely changed using high resolution timers in CC3200 which are 32 bit timers. The four or five step requirement for controlling the speed of a fan is easily obtained from this setup. The results are given in Table[2a]. Polyester capacitor is used to sustain the high voltage across the LDR and capacitor which controls the firing of TRIAC through DIAC. The PCB of implemented circuit is shown in Fig[2b]. The PCB design is shown in Fig[2c] this design can be optimized by using double layer PCB.

LDR Value (Ohms)	Current	Firing angle	Calculated Firing
53K	20mA	41deg	36deg
42k	22mA	27deg	25deg
33k	25mA	6deg	8deg

Fig[2a] results of the firing angle observed and calculated at various values of LDR and Load current of fan used for speed control (55W, 0.95 Pf).

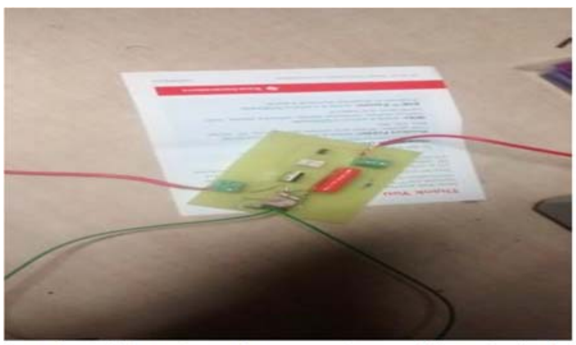


Fig [2b] PCB of Power Controlling Switch.

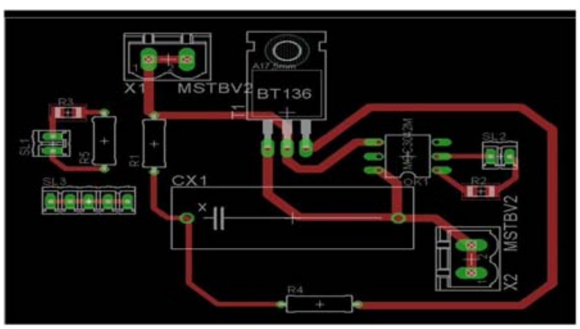


Fig [2c] The PCB layout.

Formulae:

$$I_1 = \frac{230}{r_1+R_L-{}^{j}/_{wC}}$$ (I_1 Where I_1 is the current flowing through the circuit when triac is not fired)

$$V_2 = \frac{230}{r_1+R_L-\frac{j}{wC}} * \left[\frac{-j}{wC}\right] \quad (1)$$

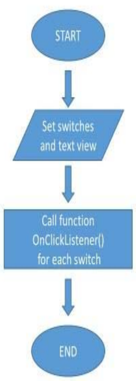
$$\theta = \tan^{-1}\left[\frac{\frac{-j}{wC}}{r_1+R_L}\right]$$

$$V_2 = \left|\frac{230}{\sqrt{(r_1+R_L)^2+(\frac{1}{wC})^2}}\right| \angle -\theta * \left|\frac{1}{wC}\right| \angle -90 \quad (3)$$

(V_2 is the voltage across the capacitor between a DIAC terminal and main terminal 1 of the TRIAC. When V_2 is equal to 30 V, DIAC is fired which results to supply of gate current to the TRIAC and hence TRIAC is fired. By controlling the value of r_1, control the value of θ is achieved, giving us the control of the firing angle of TRIAC.)

D. Android Application:

We created a very basic android application using Android studio to setup the communication between android phone and the controller. Algorithm of it as follows:



User interface of Android Application:

The application send particular data to controller when any one of the buttons is pressed and according to it controller took action for switching on or off of the load.

III. PRACTICAL RESULTS AND TEST SETUP

A. *THD (Total Harmonic Distortion):*

We took THD reading for power controlling switch. According to IEEE standards the tolerable limit for voltage THD is 5% and the obtained values of voltage THDs are less than 2% which is well below the limits. This make our design IEEE compatible. However the total harmonic distortion observed in current is very high. This is due the chopping of sine wave by TRIAC during the changing firing angle of TRIAC. However this can be reduce this harmonics using a filter (ex. LC filter). Fig[3a] shows graph from FLUKE and Fig [3b] and Fig [3c] show the THD values plotted in MS excel.

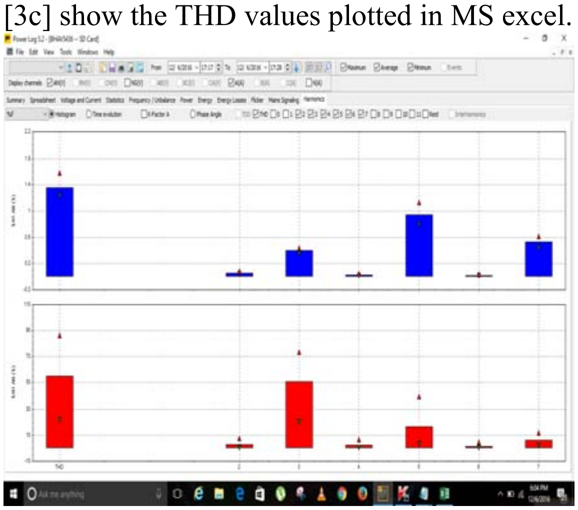


Fig [3a] The values obtained from FLUKE THD measurement device.

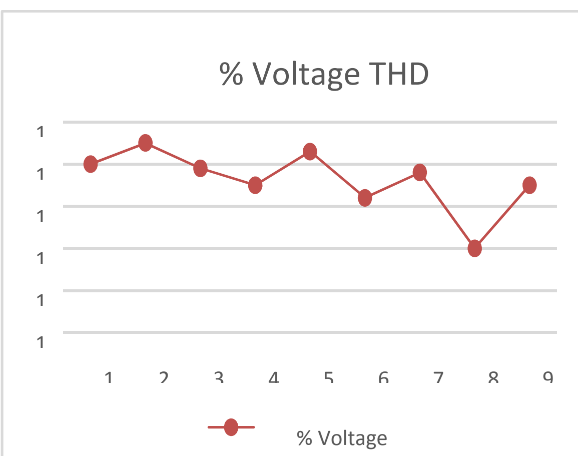


Fig [3b] The values plotted in MS excel of Voltage THD obtained from FLUKE.

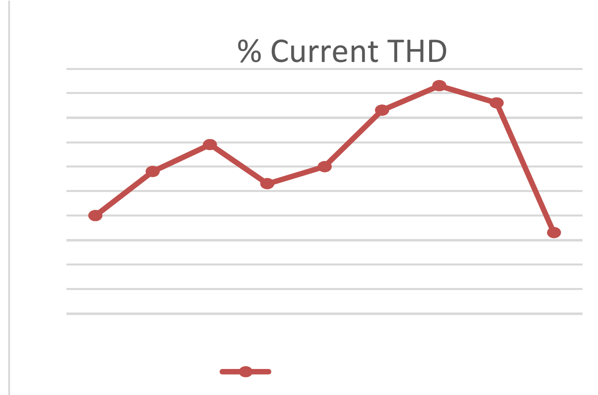


Fig [3c] Current THD obtained from FLUKE.

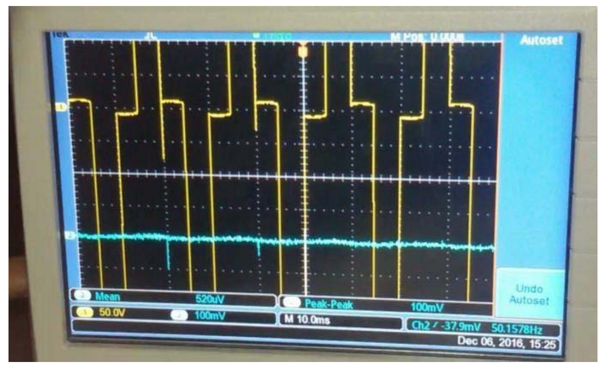


Fig [3d] Firing angle of TRIAC.

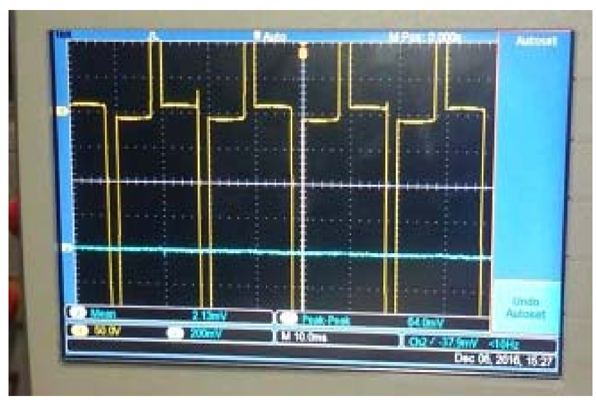


Fig [3e] Firing angle of TRIAC.

IV. CONCLUSION

From this paper we conclude that the wireless switching system has been implemented using the design described in this paper. The wireless switching system designed, is modular and scalable to the rating of device for which it will be used . It is a low cost, driverless switching system which can operate directly by the signals given by micro-controller. This system can be used as retrofit for existing mechanical switch box which increases it's utility, serviceability and practicality.

Guide

1. **Professor Suhas Kakade, Electrical Engineering, COEP.**
2. **Professor Pratap Kumar Kopollu, Electrical Engineering, COEP.**

V. REFERENCES

https://github.com/nqd/cc3200
https://e2e.ti.com/support/wireless_connectivity/simplelink
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