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Low Cost Smart Automation System with Energy Meter

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Abstract

Automation and the Internet of Things (IoT) has become a hot topic in the present tech-driven world. Smart security solutions, smart home automation, smart health care, smart wearable's etc. are in-trend applications of IoT, and by the near future we expect to see its application to a city's transportation system or smart power grids.. Nowadays there are lots of automation products that are available in the market but the cost of which is not affordable to the common man to use it at home or office. Home automation have various applications such as: Lighting control system, Appliance control and integration, Security, Leak and smoke detection, Home automation for the elderly and disabled etc[2]. Mostly all automation products needs special wiring and is not retro fit to their current switches. Automation for both smart and those who are not that smart should also be able to use automation. The research aims at finding sensors and IC's that are cheap and with little modification on the software will reduce cost and making it small enough to fit into the current switch box so the little wiring will convert the current system to smart automatic system. It works on the principle of IOT with a central server to allow access from outside the premises of the system using mobile with internet connectivity. The energy meter also provides all the active and reactive power components of the equipment's connected to the system. In this project most of the objectives were achieved including features and cost optimization. Further research needs to incorporate camera and other security features.

Keywords: IOT; Cost; Retro; Energy Meter.

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1. Introduction

Now a days because of modern technology automation has become very useful to access and monitor appliances, Not only at home but also at offices, malls, farms, etc. Automation has various applications such as: Lighting control system, Appliance control and integration, Security, Leak and smoke detection, Home automation for the elderly and disabled etc. In the present day, automation has become one of the eminently attractive areas that play an important role in day to day life [4].

By using of the Internet of Things (loT), the development of low cost smart automation are going to become simpler and more popular. Internet of Things (IoT) is nothing but connecting different real world objects to provide proper communication, synchronization, and inter-connecting between various devices or physical appliances is also known as "Things". The basic Principle behind the project is using “IOT” and sending the data to a central server which then checks the parameters and responds accordingly. This has gained a lot of popularity in farms as the electrical appliances are placed far away and accessing the appliance becomes difficult without automation. Similarly to monitor soil temperature, moisture, etc which helps in better yield.In the proposed architecture we have tried to try to develop a Smart automation system that can perform similar operations to the existing products at significantly low cost and is retro fit (it fits directly into the existing wall plate). The system can also be extended by joining and multiplying in numbers of six. The system uses WIFI technology which is in built feature of a smart phone and provides a better wireless communication medium. An android application is developed to control the appliances and transmit the data over network. Home appliances are controlled from anywhere by using IoT technology[3].

Features

- Retro Fit in any gang box
- Variable control on any port
- Occupancy Detection
- LPG and smoke detection
- Temperature and humidity indication
- Save IR remote buttons for quick access
- Tap to switch On/Off all Loads
- Child Lock
- IR remote for switch control
- Timed On/Off
- Relay output for Door Magnet
- Energy Meter
- Android and IOS compatible Applications

The system has artificial Intelligence which records the switch sequence and stores the pattern so that the system can set the moods accordingly. The user can also check the energy meter value and control their equipment's and save electricity. In architecture for home control and monitoring system using Android based smart phone is

proposed and implemented. This architecture utilizes a micro web server communication as an application layer for communicating the remote user and the home devices is proposed [4].

1.1 System Design

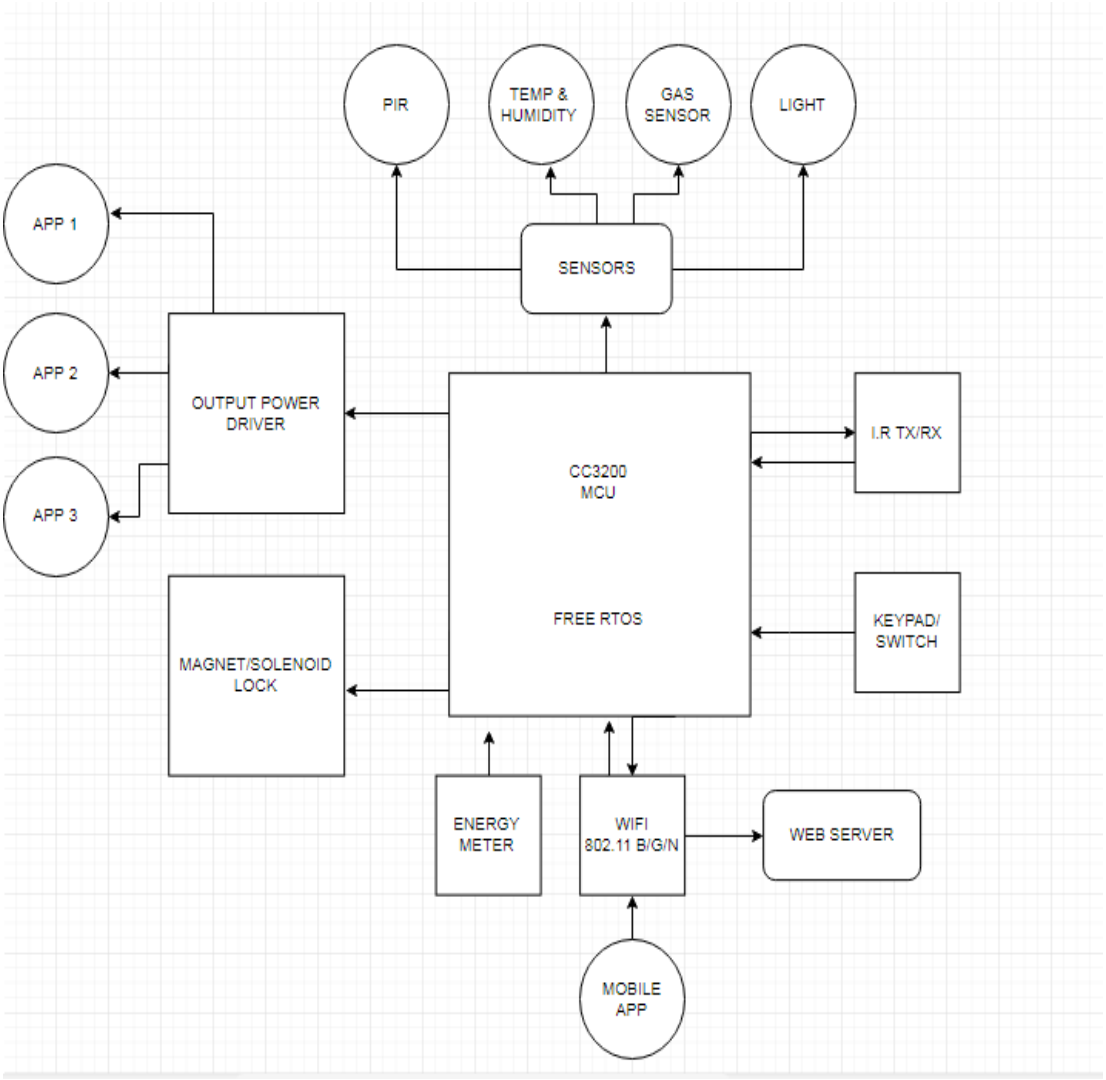

Figure 1

Block Diagram

The above diagram shows how the pheripherals are connected to the controller (CC3200) . The controller runs Free RTOS and mostly all the connunication protocols including the WIFI is inbuit the controller. The sensors like PIR uses the digital input and temperature and humidity uses I2C to communicate, Gas sensor and light uses ADC. The output driver has an opto triac to drive the load , IR receiver using TSOP and Transmijtter using photo LED.

A Full WIFi Stack is implemented into the controller which sends and receives data both form the android device and the server. The system works on both Access Point mode and WIFI mode. If there is no WIFI the

system can be used in AP mode where the user sends data directly to the system and as soon as the request is received it processes it and disconnects it for other android to be connected. The AC On/Off switch is connected to the controller using optocoupler to detect the state of switch Similarly Energy Meter (AT90E26) implements all the power related parameters like Active and recative power and communicated using SPI.

1.2 IR Receiver

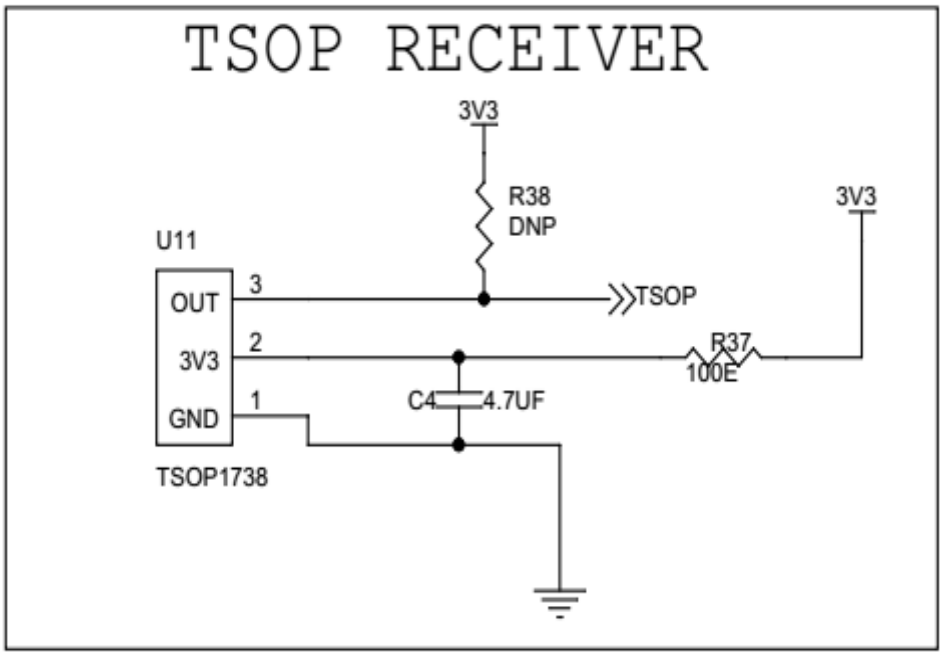

Figure 2

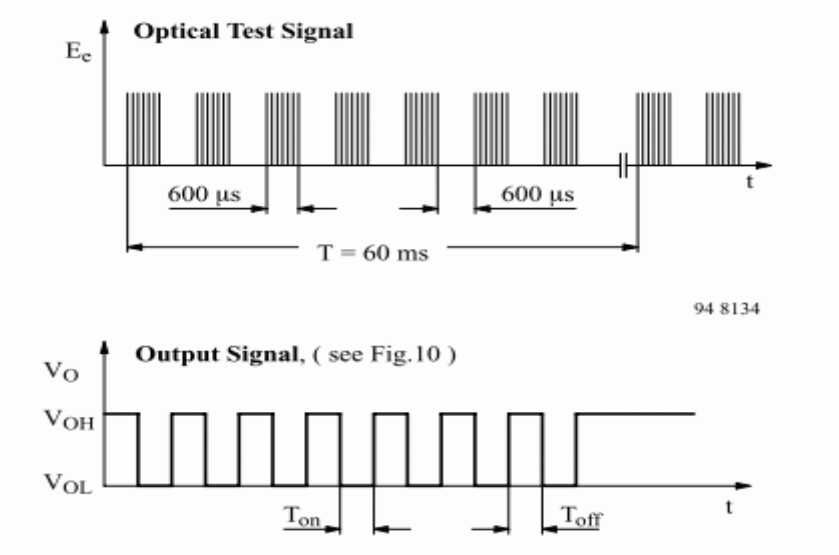

Figure 3

The IR receiver is used to copy any IR remote buttons and save them to be used with the system, ALL saved buttons can be transmitted when required from the Android Device.The output is inverted sequence of the IR transmitter which is filtered form the TSOP and digital output is sent to the microcontoller which is then detected and saved in the controller as button into the flash.

Total Timer Time =1.2mS

Timer Time=600uS

Total Time=60mS

when High is detected consider ‘0’ and when low is detected consider ‘1’.

1.3 IR Trans

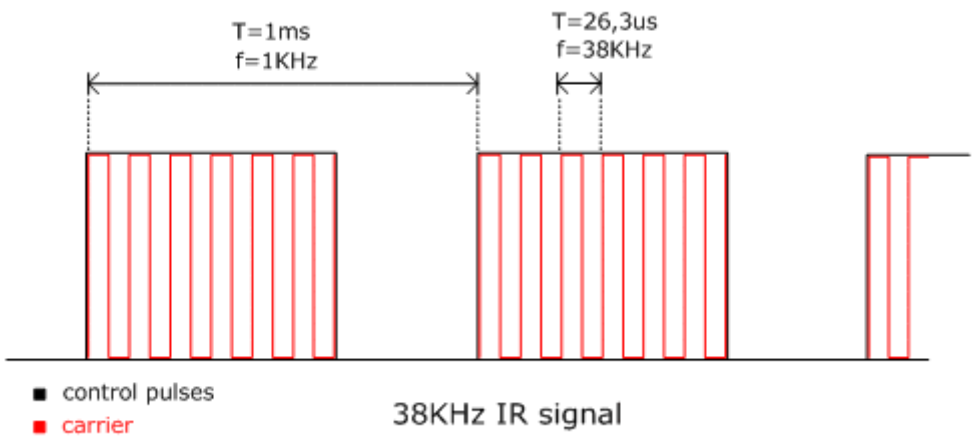

Figure 4

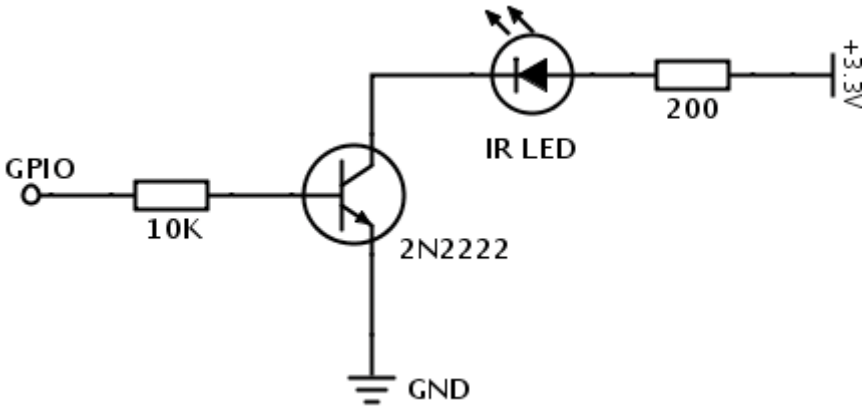

Figure 5

The IR transmitter uses IR photo LED which sends the button data in the form of 38khz packed stream.When the High is to be transmitted the controller sends 38khz pulses within a period of 600uS On/OffTimer 2 is used to transmit the IR data at 38KHZ and timer 1 swithes it on /off at interval of 600uS until the complete data stored is transmitted.

Total Timer = 60mS

Timer 2 toggle =26.3uS

1.4 Energy Meter

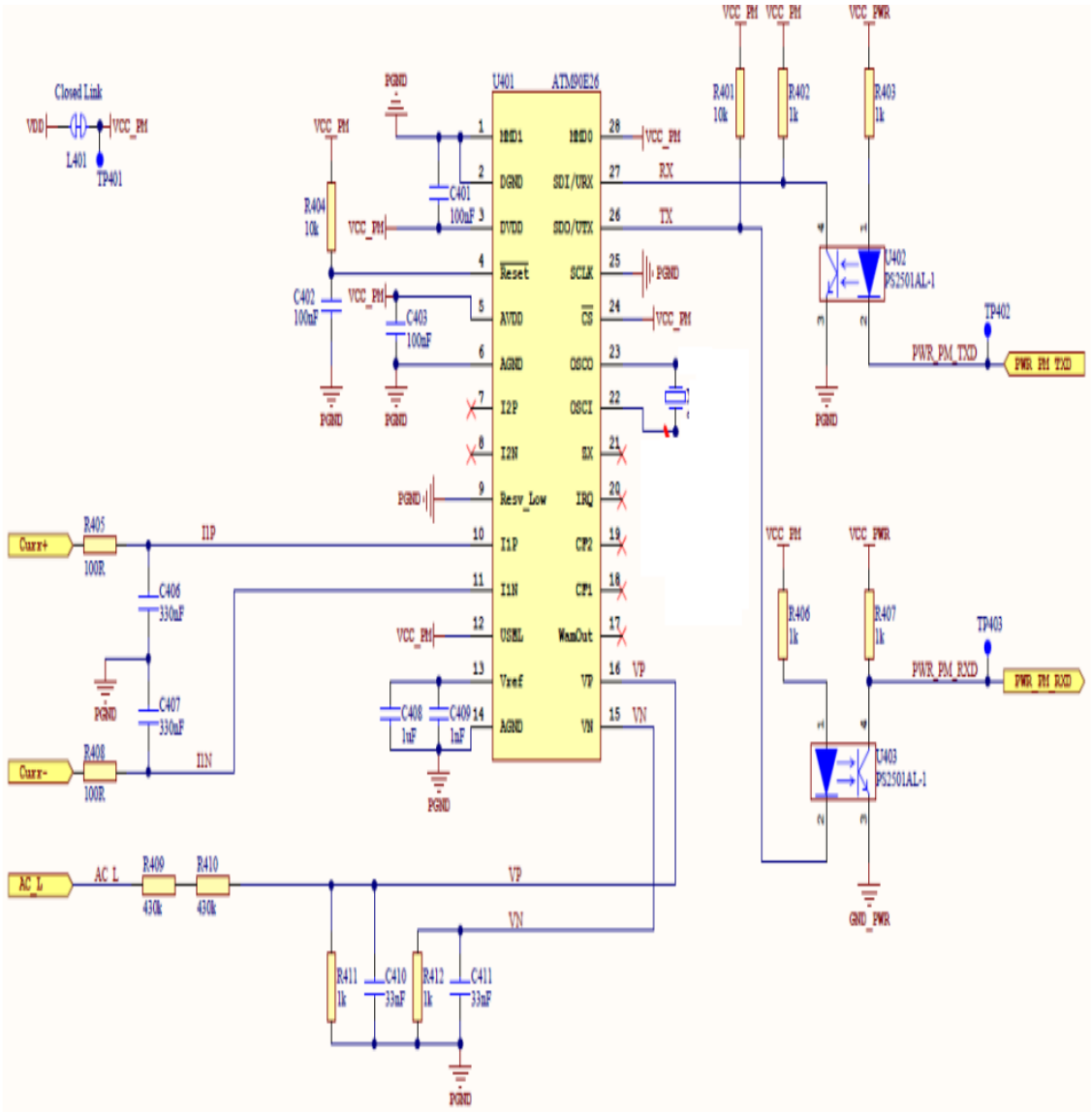

Figure 6

Energy Meter monitors the Voltage and current using Resistor Divider and Current Transformer respectively. The Completer parameters are included into the Energy Meter IC ATM90E26.The Active and reactive Power of

both Line and neural is computed and saved in the registor , Contoller reads the register and sends the data to the server and the android device for further processing.

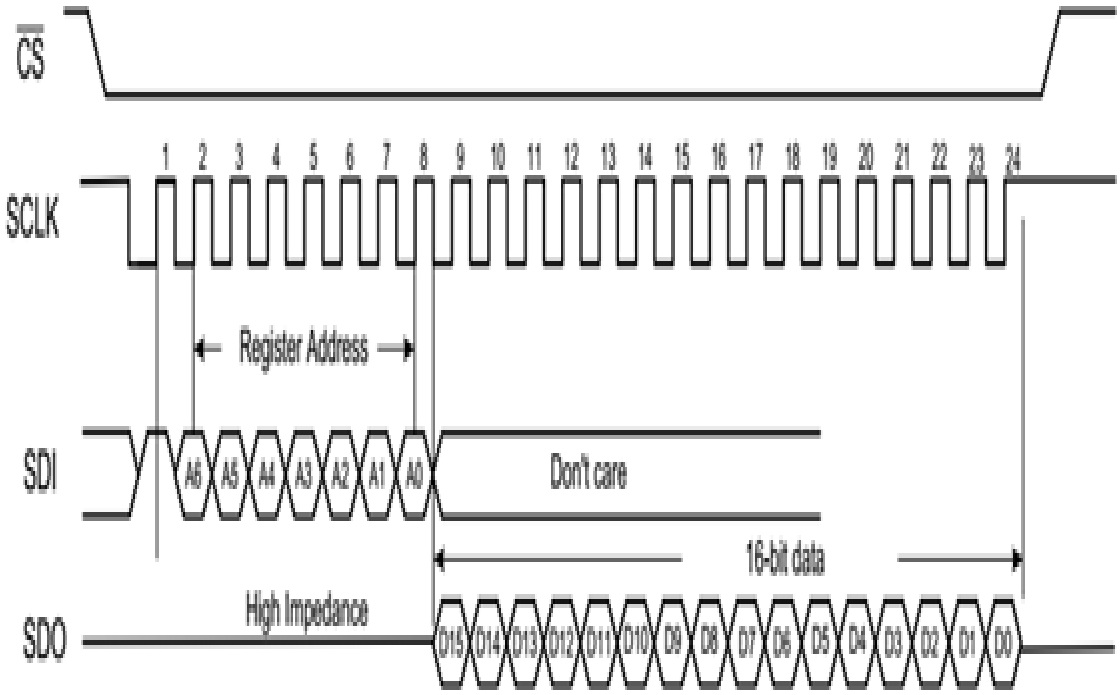

Figure 7: Read Sequence in four-wire mode

In anti-tampering mode, the compare method is as follows:

If current metering line is L line and

$$\frac{\text{N Line Active Power} - \text{L Line Active Power}}{\text{L Line Active Power}} * 100\% > \text{Threshold}$$

N line is switched as the metering line, otherwise L line keeps as the metering line.

If current metering line is N line and

$$\frac{\text{L Line Active Power} - \text{N Line Active Power}}{\text{N Line Active Power}} * 100\% > \text{Threshold}$$

Figure 8

1.5 Switching Circuit (Output Control)

The controller pins are directly connected to the Opto triac which can switch load upto 1500W using output traic. In can switch both stable as well as varying load for fan and light for power control. Loads more than 1500W is controller using relay(AC's, Geyser's,etc)

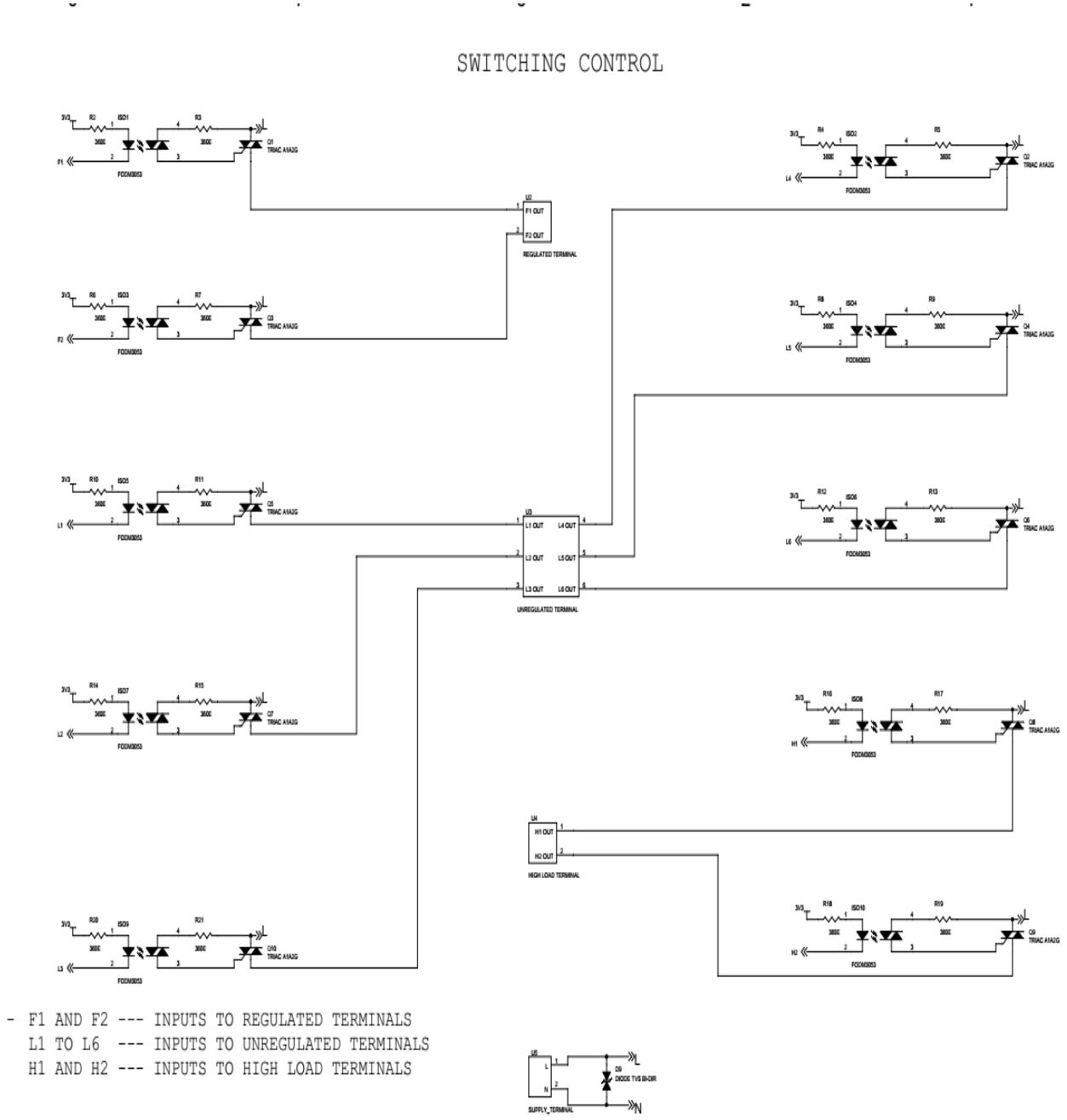

Figure 9

2. Implementation

In CC3200 we are using FreeRTOS which implements most of the drivers on the controllers only the user interfaced devices and functions need to be implemented. The Device is a central controller which connects all the peripherals and acts as a link between the user and the peripherals. The controller connects all other sensors as well and process the data and sends it to the user and the server. The concept of IoT is closely related with the popularization of smart home system. By employing the network structure of IoT and utilizing standard IoT protocols, the household appliances can be monitored and controlled remotely using android application through internet. A home that is equipped with such a wireless system can be called Smart Home in context of IoT[1].

The device works in two modes i.e. AP mode and WIFI mode.

AP mode:- Access point mode which connects to the mobile and only one user can access the device at a time

WIFi mode:- In this mode multiple user connects to the device and process the commands also the server remains connected in this mode and external commands also can be processed.

Figure 10

1)Initial setup is required to use the device.

2)After the setup the mobile sends encrypted data to the device directly in AP mode using wifi .

3)The device checks the user data ,send ack and process the request.

4)After the setup is complete the device connects to the wifi router and broadcast the status continuously to the mobile device and the server.

5)The server stores the temporary data and relays it to the user when required .

6)All the data strings are sent in raw TCP format with proper username and password.

7)The broadcast data received by the mobile is procesed and update the user interface screen.

8)Mobile app for both android and IOS

9)Server data with username registered and stored in Sql database.

10)The data string format is given as follows

2.1 Commands sent from APK to device

2.1.1 To configure Router and Module name

@INFOCFG#APN<AP-NAME>#SKEY<AP-PASSWORD>#STYPEWPA2

#MNAME<MODULE-NAME>

Example:-

@INFOCFG#APNtechsol#SKEYtechsol@123#STYPEWPA2#MNAMEhall

@INFOCFG#APNtechsol#SKEYtechsol@123#STYPEWPA2

@INFOCFG#MNAMEBedroom

2.1.2 To configure image, pir and device name

@INFODEVICE#<PORT-ID><IMAGE-INDEX><PORT-PIR-ENABLE><PORT-NAME>

Example:-

@INFODEVICE#805Fan // if Module-Pir-Enable = 1

@INFODEVICE#830Light // then valid value for

// PORT-PIR-ENABLE is 0[OFF], 5[ON]

@INFODEVICE#830Bulb // if Module-Pir-Enable = 0

// then valid value for

// PORT-PIR-ENABLE is always 0[OFF]

2.1.3 To configure image

@IMG#<PORT-INDEX><IMAGE-INDEX>

Example:-

@IMG#02 // set image2 to port0

@IMG#95 // set image5 to port9

2.1.4 To turn port on/off

@SET#<PORT-INDEX><PORT-STATUS>

Example:-

@SET#14 // Only PORT0 and PORT1 can be varied (0-5)

@SET#34 // PORT2 to PORT9 can be set to 0[OFF] or 5[ON]

@SET#A5 // All port ON

@SET#A0 // All port OFF

2.1.5 To enable PIR on port

@PIR#<PORT-INDEX><PORT-PIR-ENABLE> //Module-Pir-Enable = 0, PIR feature Absent

//Module-Pir-Enable = 1, PIR feature Present, but deactivated

//Module-Pir-Enable = 2, PIR feature Present, but activated

Example:-

@PIR#05,10,25,30,40,55,60,75,80,95

// enable PIR on PORT0, PORT2, PORT5, PORT7, PORT9

// disable PIR on PORT1, PORT3, PORT4, PORT6, PORT8

@PIR#D // deactivated PIR

@PIRTIME#10 // to set amount of time the ports are turned ON, after

// timeout ports will be turned OFF

2.2 Broadcast Data

#Module-Mac-Address#Max-Port#Module-Name#Module-Power#Module-Pir-Enable

#Port-Id,Port-Image,Port-Status,Port-Name,Port-PirEnable

// if Module-Power == NA, energy meter is disabled

Example- Single Port

#11:22:33:44:55:66#1#Hall#123,444,667#0

#0,-1,-1,-1,-1

#1,-1,-1,-1,-1

#2,-1,-1,-1,-1

#3,-1,-1,-1,-1

#4,-1,-1,-1,-1

#5,-1,-1,-1,-1

#6,-1,-1,-1,-1

#7,-1,-1,-1,-1

#8,0,0,AC,0

#9,-1,-1,-1,-1

Example- Six Port

#11:22:33:44:55:66#5#Hall#NA#1

#0,7,3,Fan1,0

#1,-1,-1,-1,-1

#2,9,5,Light,5

#3,0,5,Lamp,0

#4,1,0,Lamp2,5

#5,-1,-1,-1,-1

#6,-1,-1,-1,-1

#7,-1,-1,-1,-1

#8,5,0,AC,5

#9,-1,-1,-1,-1

2.3 Andriod Application and Device Communication

Android Application lists down all the smart automation devices as shown below:

Figure 11

Andriod Application Screenshot

Android Studio is used to develop an android application with user interface options. Application named smart which including layout of each room with corresponding buttons for each device. The visual part of android application is UI/UX which is written in the XML file. The application programming interface(API)of android application is written from java[1]. Application developed for both Android and IOS which used fixed set of commands to send data to the server and the device. The string format as described earlier is used and stored in the database of SQL server. All the String formats are filtered and entered in the respective column of the database and pulled when required. It used Wifi hardware with standard TCP/IP to send data encrypted with username and password.

3. Result & Analysis

This part deals with the outcome of the work that is done above, it deals with what is finally the working model. Going ahead to test the result we first do an analysis of the details of work we did in a step by step manner. Firstly the peripherals are tested with the firmware by trigger the driver manually then later firmware is tested module wise. For example the diver to trigger the relay is tested then the module is confirmed working similarly other communication modules are also tested. Then the hardware is powered on with the complete firmware and the test points are checked using multi meter and oscilloscope for any flaw.

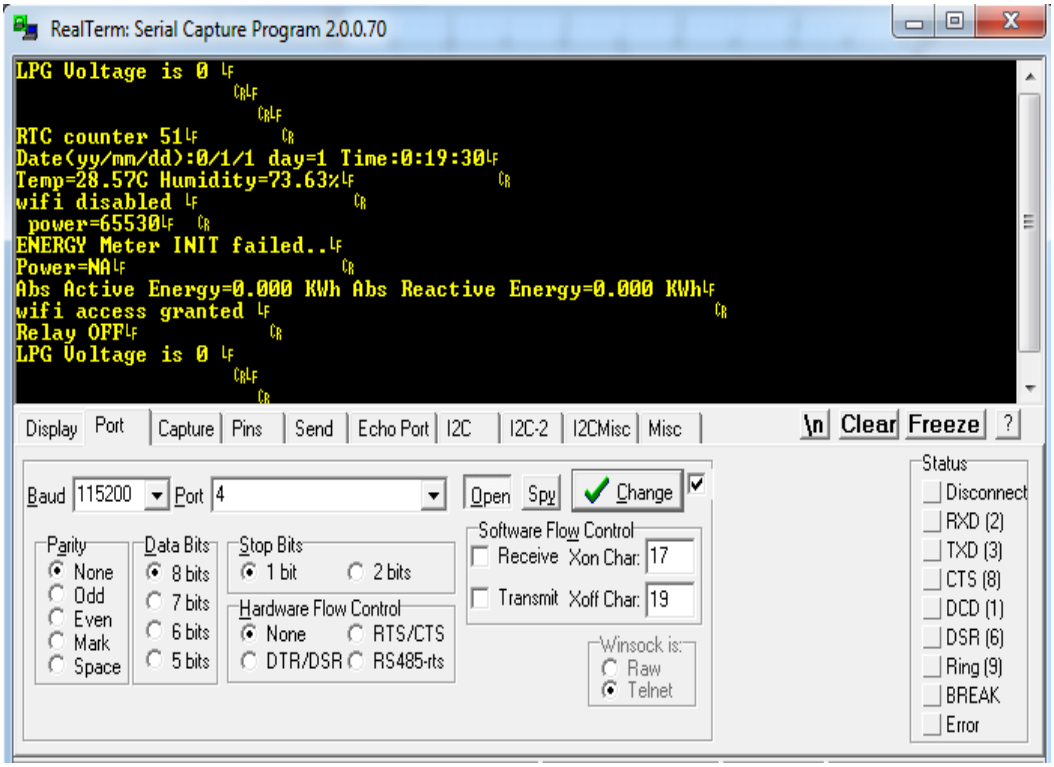

Figure 12

Debug Screenshot

3.1 Budget Analysis (Cost Estimation)

HARDWARE COST

Table 1

MATERIALS	QUANTITY	PRICE/PC
MICROCONTROLLER (CC3200)	1	$ 4.29
ATM90E26	1	$ 0.86
OPTOCOUPLER	6	$ 0.14
TRIAC	6	$ 0.43
RTC	1	$ 0.86
RELAYS	2	$ 0.71
PTR CONNECTORS	6	$ 0.21
DIODES, CAPACITORS AND RESISTORS	6 SETS	$ 0.43
LDO	1	$ 0.57
CURRENT TRANSFORMER	1	$ 1.43
PCB	2	$ 4.29
LABOUR	APPROX	$ 4.29

TOTAL COST OF PRODUCTION OF 1 UNIT = $ 26.74 (1K UNIT)

4. Conclusion

Initially we had issues to procure and finalize low cost chip with WIFI from the market. The initial product needs to be cheap as well as implement all the features without any flaw. As a result we tried few Chinese WIFI modules with atmel controller but there was no reliability, So we finally chose Texas Instrument CC3200 which they said will be cheaper and reliable on a mass production. The system is designed on TI controller and we finally achieved what we were expecting, Further some security features can also be implemented but due to limitation of ports some features needs to be reduced.

Present studies examine the solid grasp of essential IoT concepts and will achieve intermediate expertise in IoT and a high level of comfort with IoT concepts and systems. IoT enables companies to blaze new trails in IoT and scale their IoT strategies by providing the tools they need to turn the billions of data points from the millions of connected devices into engaging customer experiences

It also shows how the internet of things is growing up and reducing the gap between the user and the machine with the help of machine learning and artificial intelligence. Thus the report helps us understand the emerging technologies and future scope of internet of things.

Final Working Model

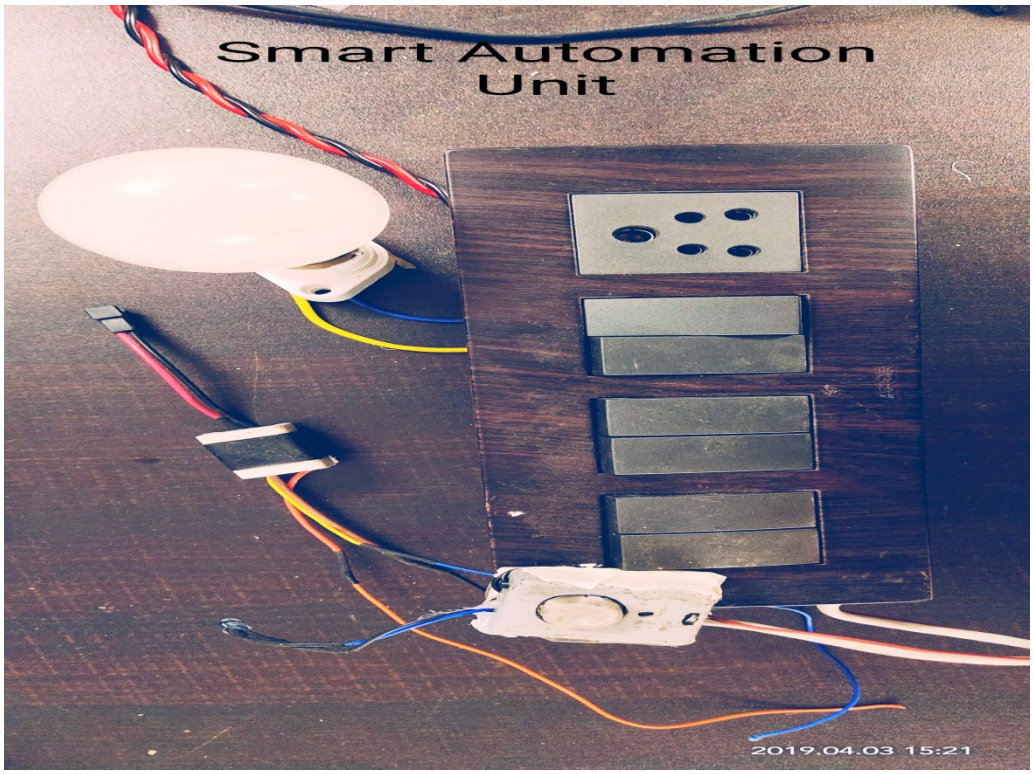

Figure 13

Finally the concept turns into reality and works as per specification stated above with all other peripherals working seamlessly.

Acknowledgements

I sincerely feel that the credit of this thesis could not be narrowed down to only one individual. It gives me great pleasure to express my deep sense of gratitude to my project guide Dr. V.C.Kotak for his resourceful & able guidance which lead to timely completion. It was really his insight and obsession for innovative ideas that motivated me to consider the idea seriously. Special thanks to Mrs. Vidya Gogate for her patience and kindness during the initial period.

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References

[1] Raihanath P.P, Haripriya P “An ARM Based Smart Home System Using ESP8266”, International Journal for Research in Engineering Application & Management, Volume 4, Issue 4, 2018,ISSN 2454-9150

[2] Naresh Kumar, Praveer Singh “Economical Home Automation System using Arduino UNO”, Advances in Computational Sciences and Technology, Volume 10, Number 6 (2017), ISSN 0973-6107

[3] S. Hong, D. Kim, M. Ha, S. Bae, S. Park, W. Jung and J. E. Kim,"SNAIL: An IP-based wireless sensor network approach to the internet of things", IEEE Wireless Commun., vol. 17, no. 6, pp. 34-42, 2010

[4] David N. et al., “Design of Home Automation”, International Journal of Scientific & Engineering Research, Volume 6, Issue 6, 2015, ISSN 2229-5518