IoT Enabled Solar Smart Inverter

Gopal G Menon[1], Jidhun Das O[2], Sai Kiran[3], Dr. Siny Paul[4]

[1,2,3]Student, Dept. of Electrical and Electronics Engineering, Mar Athanasius College of Engineering, Kothamangalam, Kerala, India
[4]Associate Professor, Dept. of Electrical and Electronics Engineering, Mar Athanasius College of Engineering, Kothamangalam, Kerala, India

---

Abstract - *Inverters and routers are commonly found in most household applications in today's life. In this paper an IOT enabled solar smart inverter is designed and carried out simulations that uses Wi-Fi technology to engage a two way communication with the user and equipments. The battery voltage of the inverter as well as utilization time of the loads which the user chooses to run will be communicated to the user. The user can control the loads wirelessly using mobile phone, thus will enable the efficient utilization of energy and also increases human comfort. An Arduino Uno with Node MCU which runs on the ESP8266 Wi-Fi module can be used to implement the aforementioned objectives. The output power from solar panel can be increased by a solar tracking circuit for absorbing maximum sunlight.*

***Key Words*: IOT, Inverter, Solar Tracking, Arduino, Relay**

1. INTRODUCTION

Pollution due to conventional energy sources are increasing day by day and it's time we utilize renewable energy sources to reduce pressure on power grids. It is extremely important to focus on the concept of energy generation using renewable sources and energy storage in an efficient manner. Solar energy is one of the clean renewable sources of energy that can be utilized to reduce the usage conventional sources for power. Solar powered inverter is an answer for clean energy and a solution to power outages.

In this paper an IOT enabled solar smart inverter is designed in which the battery is charged by the solar panel. This help in reducing the load on the grid and due to its two way communication with the user it helps in saving energy.

In this paper we are using a solar panel to charge the battery and also contains a solar tracking circuit which increases the efficiency of the solar panel. It also uses wifi technology to engage a two way communication with the user and enables the user to control the load by switching it on and off. Home automation is done by using NodeMCU and relay module. So whenever an unwanted load is on or working the user can switch it off wherever he/she is with the help of internet.

1.1 Basic Concept

The block diagram of the IOT based Solar Smart inverter is shown in fig.1. It includes an Arduino Uno microcontroller, a Solar Panel, Battery, Inverter circuit, Charge controller circuit, a Solar tracking circuit, ESP8266 WiFi module and 5V relays.

In-short the whole paper consist of 3 different sections, i.e. solar tracking, Storage and conversion of energy, Distribution of energy to the loads.

(1) Solar tracking: This section contains a LDR module connected to an Arduino microcontroller with a motor with drivers for the gradual movement of the solar panel with respect to reception of maximum solar energy.

(2) Storage and Conversion of Energy: This consist of a charge controller for charging the battery at a nominal voltage and an Inverter for conversion of voltage from DC to AC. It also contains a LCD display coupled with arduino for viewing battery percentage.

(3) Distribution of Energy to the loads: It consist of the IOT module for controlling various loads using Relays, also called Home Automation.

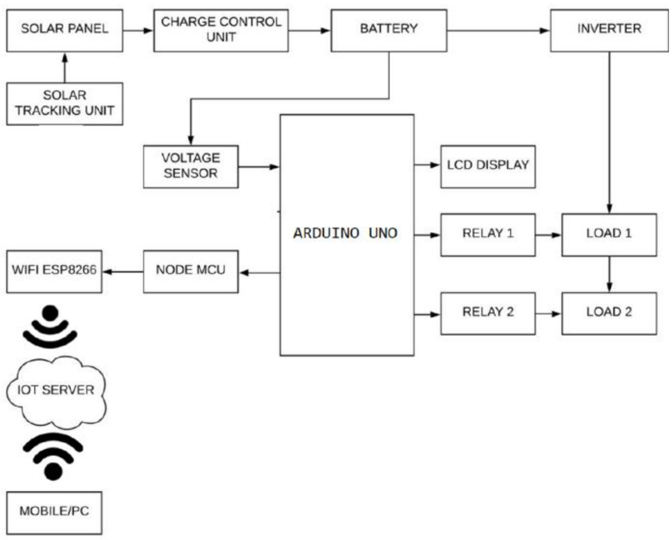

Fig -1: Block Diagram

2. WORKING

When the sunlight falls on the LDR embedded solar panel, it rotates from east to west or vice versa depending upon the direction of sunlight. The rotation is done using a DC motor.Thus maximum solar energy is harvested during different sections of daytime.

This Photovoltaic voltage generated is a variable voltage. This output is then fed to a Charge controller circuit to give a constant DC output voltage of approximately 13 V. The 12V battery is only capable of charging if the input voltage is in the range of 12.7 V to 14 V. The battery percentage is calculated using a potential divider connected to an Arduino and shown in a LCD display.

A 500W 230V inverter converts the DC voltage to AC voltage of frequency 50 Hz. This output is connected to a 5V relay which in turn is connected to NodeMCU based on ESP8266 WiFi module. The user can select which loads to be working with a the help of a mobile app connected to the IOT server. When the User selects the load to be run, the relay works and the load is turned on.

2.1 Solar Tracking mechanism

Solar tracking mechanism directs the PV panel towards the direction of Sunlight to acquire maximum energy. The tracking system we proposed is a single axis tracker. It means that rotation happens only on one axis. The solar tracker consist of 2 LDRs, four resistors, an Arduino and a DC servomotor. The 2 LDRs are placed on opposite sides of the solar panel directing towards east and west. The servomotor's PWM part is connected to the Arduino for controlling the axial rotation.

The potential divider circuit for each LDR gives the corresponding voltage signal to the arduino when sunlight falls on the LDR. The arduino then gives the appropriate voltage of the corresponding LDR to the PWM input of the servo motor and it rotates in the direction of the sunlight.

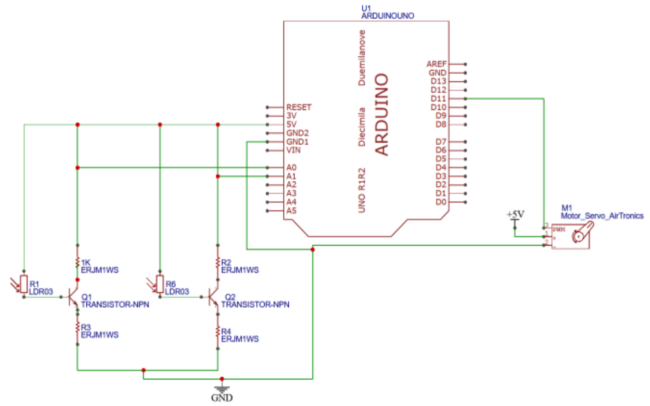

Fig -2: Solar tracking circuit

2.2 Solar charge controller

The charge controller or the Solar battery charger is used to charge the 12V battery at a nominal voltage. It also has an automatic cut-off feature for stop charging the battery after attaining full charge.

The circuit mainly has a voltage regulator IC LM317s to keep a steady output voltage of around 14V as shown in fig.3.

When the solar panel generates current diode D1 conducts and the voltage regulator IC gets the input current. The potential divider circuit which consist of the variable resistance RV1 decides the output voltage for the voltage regulator IC and resistance R1 controls the output current. When the output voltage increases above 14V, the Zener diode D2 conducts and give a stable charging voltage of 13V.When the battery is charged, diode D5 and transistor Q1 gets forward biased. Thus the output current from the voltage regulator drains through Q1 and charging process stops. When the voltage of the battery gets below 12V the Zener diode D5 turns off and charging continues.

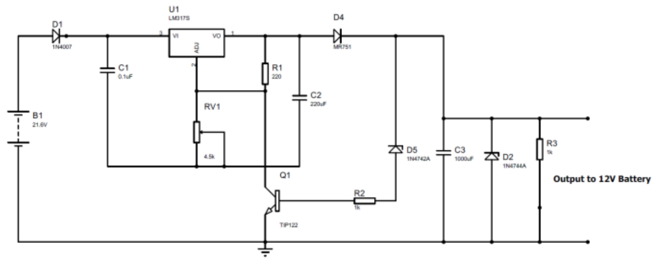

Fig -3: Solar charge controller

2.3 Battery Charge Indicator

The battery charge indicator indicates the state of charge of the battery and shows the percentage of charge remaining in the battery. For a typical 12V battery the range of voltage indicating charge is 11.9V to 12.7V. A fully charged battery should have voltage higher than 12.7V and battery voltage must note go below 11.9V.

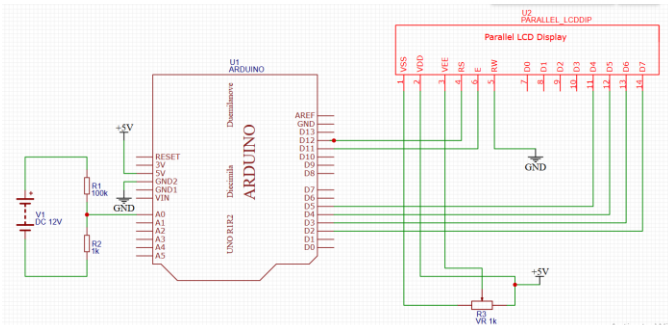

Fig -4: Battery Charge Indicator

Fig 5. shows the circuit for battery charge indicator using Arduino and LCD. The input voltage from the battery is fed to the voltage divider circuit which comprises of a 100k and 1k resistors. This voltage divider circuit decreases the voltage to be measured into a voltage compatible for the arduino analog input. The code in the Arduino then computes the actual value of voltage and using its algorithm the percentage of charge is shown in the LCD display.

2.4 Inverter

The inverter used in this paper is a 500W inverter. It converts 12V DC to 230V AC. The inverter consist of an IC

4047 which works astable multivibrator mode. The output wave obtained is an alternating square wave of frequency 50Hz.The type of wire used in transformer winding is SWG. The inverter, as shown in fig.5, is connected to the 12V battery. This 12V is directly applied to the centre tap of the primary (12-0-12) side of the transformer. IC4047 acts as pulse width modulation circuit. The RC tank circuit connected to the IC is used for setting the desired frequency of the output. In this case the desired frequency is 50Hz. The variable resistor in RC tank circuit is varied for attaining the desired frequency.

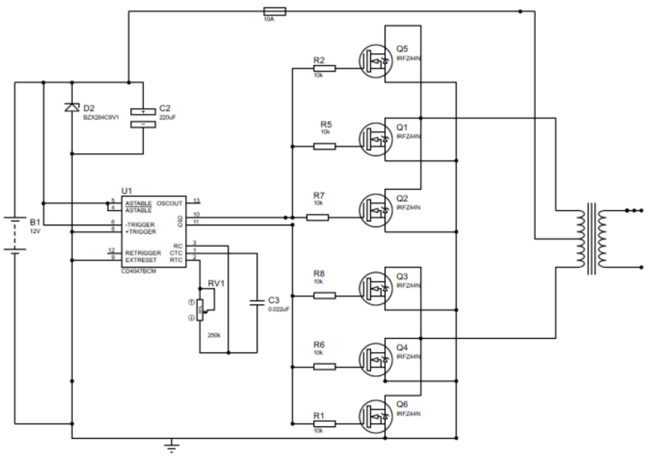

Fig -5: Inverter

The pins 10 and 11 are the outputs Q and Q' of the IC4047.The power mosfets IRFZ44 are directly driven by the outputs of Q and Q'. The mosfets are connected in Push-Pull configuration as they switch according to the pulse from the astable multivibrator IC.

The gates of three mosfets are connected to each output Q and Q'. Each mosfet can be able to withstand a current of 18A.As the power output required is 500W, the number of mosfets to be connected in parallel is calculated as follows:

N=500W/(12V*18A)=2.3= 3 approximately.

Thus 3 IRFZ44 mosfets are connected for efficient operation of the inverter. The mosfets will not be overburdened as the heat produced by the mosfet will be less which will contribute for efficiency for a long period of time.

Thus during each switching of mosfets each half of the primary of the transformer conducts and the output is obtained at the secondary. The square wave obtained will have a peak value of 320V, thus a wave of rms 230V and frequency 50Hz is obtained.

2.5 IOT and Load Switching

One of the most important part of this paper is the IOT part which allows the user to control the loads remotely using his/her smartphone. For this we use NodeMCU which is an open source IOT platform that runs on a WiFi module called ESP8266. A 5V 4 channel Relay module is interfaced with the NodeMCU. This relay module works on opto-coupled isolation for keeping the module optically isolated from the high voltage side for safety. For the user end, we use a mobile application called Blynk that has its own server to process user requests.

The fig.6 shows the diagram for IOT part. At the user end, when one of the load is switched on, the app sends data to the IOT server which is then processed by the NodeMCU. The NodeMCU then sends the signal to the 5V relay module. The high voltage end connected to the load then turns on and thus the required load is operated.

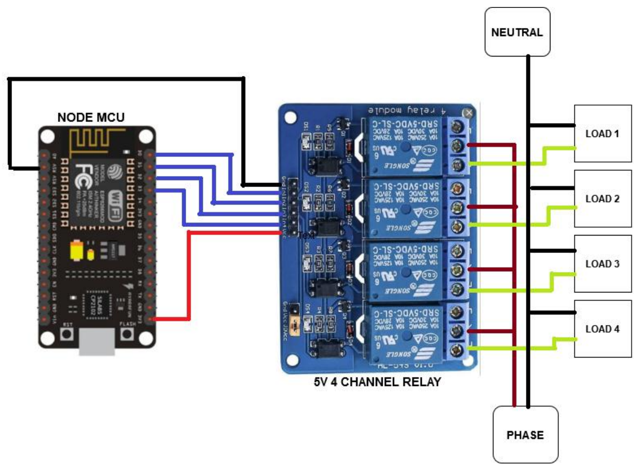

Fig -6: IOT Module

3. SIMULATION AND RESULTS

The inverter and charge controller circuits were simulated in Proteus.
The simulation of inverter is shown in fig.7 .The variable resistance in the RC tank circuit is varied for obtaining the the desired frequency of the output AC voltage. A DSO is connected at the output for attaining a graphical representation of the output.

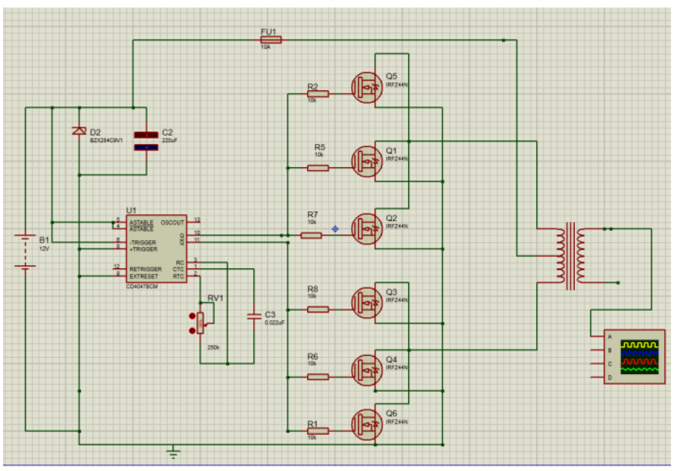

Fig -7: Proteus model of Inverter

The output of The DSO gives an alternating square wave of peak near to 300V and frequency 50Hz as shown in fig.8.

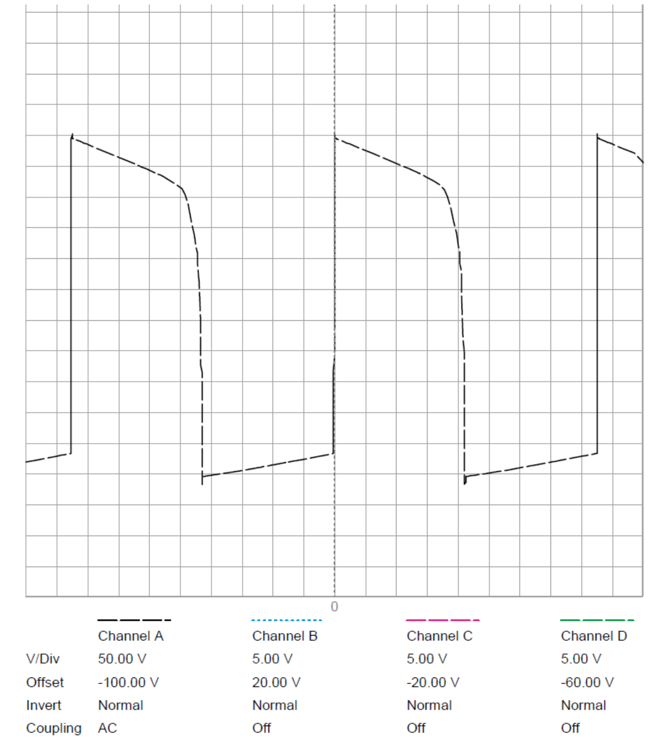

Fig -8: Output waveform of Inverter

The simulation of the charge controller is shown in fig.9. Instead of a solar panel, a DC source of 22V is taken as the input for charge controller. The voltage value of the charge controller that we get in the DC voltmeter connected across the output is 12.7V. The waveform of the charge controller is shown in fig.10.

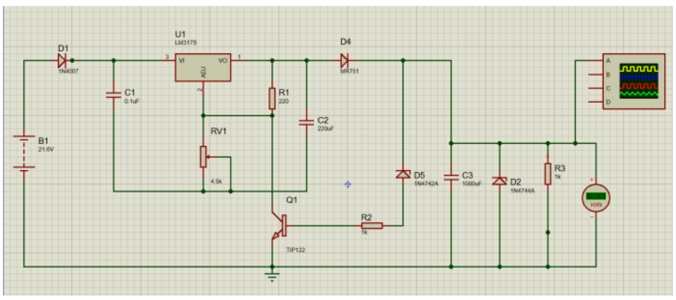

Fig -9: Proteus model of Charge controller

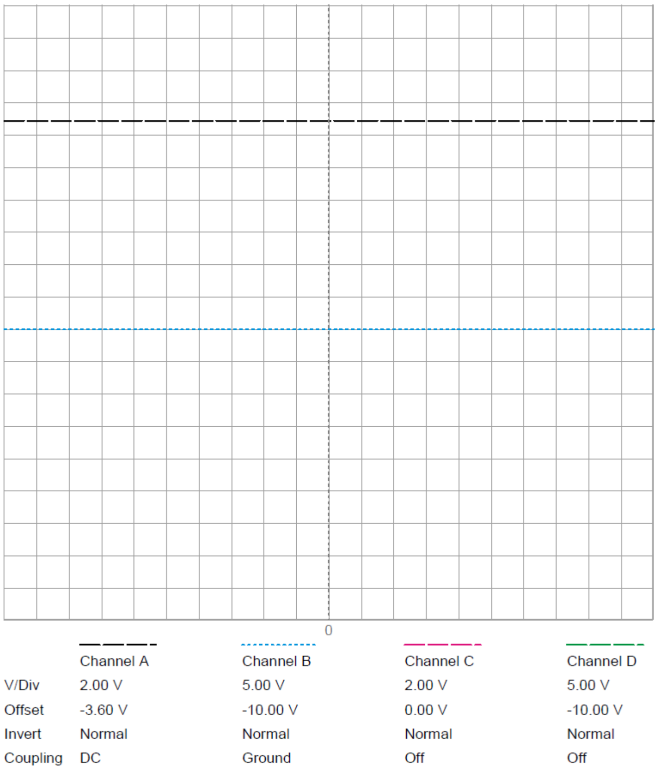

Fig -10: Output waveform of Charge Controller

4. CONCLUSION

In this paper, we successfully simulated a Solar Inverter with load control via IOT. The simulations of the inverter and solar charge controller were accomplished with Proteus. Hence the objectives of energy generation and consumption, which are the two main parts of the proposed system, were achieved efficiently.

REFERENCES

[1] Aishwarya Kumar, Anusha Ashok Bijapur,Charitha B, Kirthi R Kulkarni,K Natarajan ,'An IOT based Smart Inverter', IEEE International Conference On Recent Trends In Electronics Information Communication Technology, May 20-21, 2016, IndiaM. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[2] Aoi Hashizume, Tandanori Mizuno and Hiroshi Mineo, "Energy Monitoring System using Sensor Networks in Residential Houses," 26th IEEE International Conference on Advance Information Networking and Application Workshop, pp. 595-600, June 2012.

[3] Ashok Kumar Saxena, V.Dutta. "A Versatile Microprocessor Based Controller For Solar Tracking".Proc. IEEE, 1990', pp.1105-1109.

[4] Bohora, B., Maharjan, S., and Shrestha, B. R; "IoT Based Smart Home Using Blynk Framework".Zerone Scholar,. (2016). 1(1), 26-30.

[5] J. Chiasson andB. Vairamohan, "Estimating the state of charge of a battery," IEEE Transactions on Control Systems Technology, vol. 13, no. 3, pp. 465–470, 2005.

[6] Krupal Kachhia Patel1, Jignesh Patoliya and Hitesh Patel, "Low Cost Home Automation with ESP8266 and Lightweight protocol MQTT", Transactions on Engineering and Sciences, 3(6), 2015.

[7] Mane, M. A., Pol, M. P., Patil, M. A., and Patil, M;. "IOT based Advanced Home Automation using Node MCU controller and Blynk App."; 13thIntl. Conf. on Recent Innovations in Science, Engineering and Management, Feb. 2018.

[8] Nithin Krishnan, PG Scholar, Dept.of Electronics & Communication, Divya H. Asst. Professor,"Solar smart inverter: A novel design using multi level topology and pulse width modulation with load detection." Dept of Electronics & Communication, Mohandas College of Engineering, Kerala University Trivandrum-695541,Kerala,India.

[9] Prof R. Kameswara Rao ,P. Srinivas,M.V. Suresh Kumar, "Design and Analysis of Various Inverters Using Different PWM Techniques", The International Journal Of Engineering And Science (IJES).