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Remote Monitoring of Solar Inverter (An application of IOT)

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Abstract: *In remote areas, there is a need for continuous monitoring of Photovoltaic (PV) system so that stable output is ensured. This paper describes the hardware and software design for Solar Inverter monitoring system in remote area. The monitoring system is equipped with voltage sensor, current sensor and Wi-Fi module for data transmission. The obtained data is displayed on an IOT platform (Cayenne) and relevant triggers are set accordingly.*

Indexterms: *Solar inverter, Wi-Fi Module, Arduino, IOT platform*

I. INTRODUCTION

THE most important resource of human life is Energy which is majorly obtained from Non-Renewable Energy sources and they are on the verge of depletion. Nowadays, Solar Energy is widely used all over world. There is an extensive growth in the solar photovoltaic products in market which reflects the importance of conserving energy and awareness of renewable energy. In order to ensure input to inverter from PV Modules is to suffice levels, the Solar Inverter must be monitored and built.

Traditional monitoring method requires close maintenance from staff for continuous monitoring. Results are taken directly from equipment. Normally, solar power system is placed in remote area. The environment factor can degrade PV power performance.

Various methods are used to monitor solar inverter. Wireless transmission is one of the alternatives to monitor it. The most important factor of Wireless transmission is flexibility function where there is no requirement of staff in actual area where solar panels are located to control and monitor the system.

It is evident from previous work that the systems can be monitored using wireless sensor networks. But it is observed that there are many drawbacks of using wireless sensor network to transmit data. More amount of energy is consumed in case of wireless sensor network. Besides that, there is higher risk of malicious intrusion and attack. These drawbacks are what make it less reliable for data transmission. Many transmission techniques can be used for monitoring purpose such as Ethernet network and Zigbee wireless network.

Ethernet uses a network cable to transmit data. Hence, there are discrepancies due to changing geographical environment. The cost of Zigbee wireless network is also high in comparison of other modules. Also, Zigbee is difficult to develop and has greater complexity. Furthermore, the signal range is limited. In order to overcome these problems, monitoring system using ESP8266 Wi-Fi module is used. The Wi-Fi network has limited error rate, low costs and wide signal coverage. Users can communicate easily using Wi-Fi Module in order to perform monitoring anytime and anywhere. Hence, there is higher reliability in data transmission. In this project, a reliable and stable system is built using microcontroller and Wi-Fi module to monitor performance of solar modules. Attention (AT) commands are used to control functionality of Wi-Fi module. Arduino is connected to internet through Wi-Fi module and furthermore the data from sensors is displayed on html site as well as an IOT platform. There are only a few commands used for this project.

TABLE 1. List of AT Commands

Command	Function
AT	Test AT startup
AT+RST	Reset Module
AT+CIFSR	Get local IP address
AT+CWMODE	Wi-Fi Mode(sta/AP/sta+AP)
AT+CWLAP	List of available AP's
AT+CWJAP	Connect to AP

II. RELATED WORK

Monitoring systems are designed using Zigbee, Raspberry Pi and many other sources. However, design of these systems is quite complex including its higher cost. In order to set triggers as well display results

SCADA systems are also used which provide greater efficiency but then these systems are prominently used on large scale. In a small scale project, installing SCADA maybe expensive. For data interpretation i.e. plotting respective graphs, Telemetry software is used to which data is communicated serially.

III. MAIN BODY OF THE PAPER

The projects architecture consists of two parts. The first part being power electronics, designing of a prototype of solar inverter and the second part being wireless communication, sending the observed data wirelessly over internet. A small prototype of solar inverter is designed using MOSFET's whose DC i/p as well as AC o/p is to be monitored. The MOSFET's are driven by using a CD4047 MOSFET's driver IC. The Solar Inverter is monitored using a Data Acquisition Device. The DAQ consists of an Arduino, Wi-Fi module (ESP8266) ,sensors and HTML or Cayenne platform. The data from the inverter is provided as an analog input to the Arduino. Arduino is connected to internet using ESP8266. The data received by Arduino is displayed and analyzed online by Cayenne.

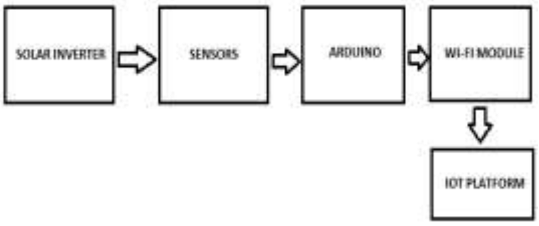

Fig. 1 Block Diagram.

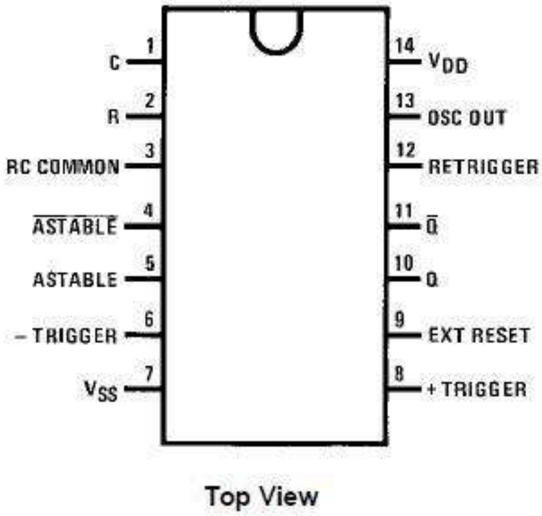

Fig. CD4047 Pin Diagram

Fig. shows pin configuration of MOSFET driver IC CD4047. In order to set the frequency of output pulses to 50Hz, following formula is used to calculate the R & C values.

f= 1/8.8*RC………(1)

where, assume C=0.1µF

Therefore, R= 22kΩ

For IC to be set as Astable Multivibrator,

Function	Terminal Connections			Output Pulse From	Typical Output Period or Pulse Width
	To V_{DD}	To V_{SS}	Input Pulse To		
Astable Multivibrator Free-Running	4, 5, 6, 14	7, 8, 9, 12		10, 11, 13	t_A(10, 11) = 4.40 RC

Output of Solar panels is DC, whereas most of the appliances used in day to day life run on AC power supply. Thus an inverter converts DC into AC. IRFZ44N is a n channel enhancement type which is used as a switch in an Inverter.

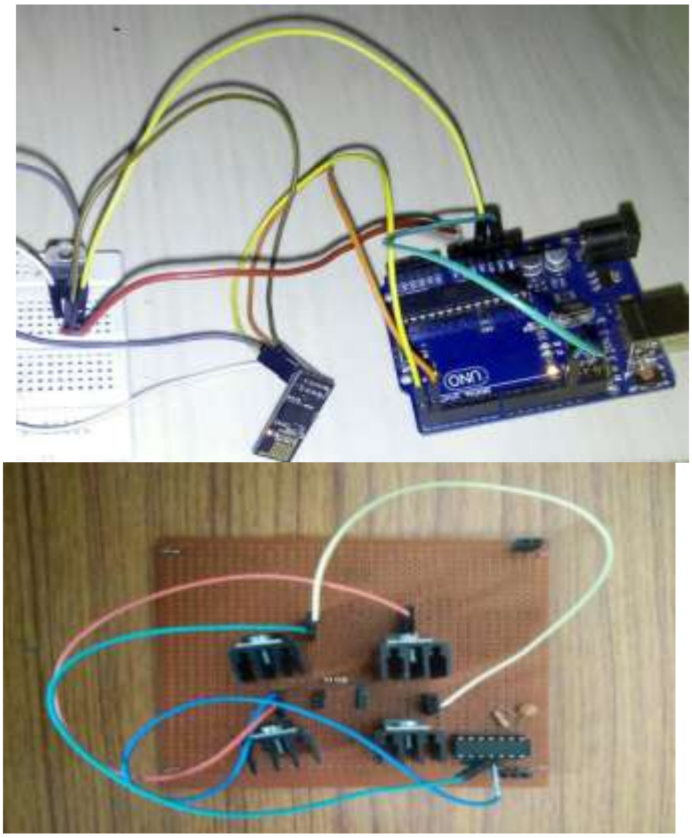

Fig. 2 Project images Above: Interfacing Arduino UNO with Wi-Fi Module (ESP8266) Below: Bridge Inverter

IV. PERFORMANCE AND EXPERIMENTS

The AC output of Inverter is tested on Oscilloscope with input voltage as 12V DC. The waveform observed is a square wave with 12V AC. Fig. 3 shows the output on an oscilloscope.

Fig. 3 Oscilloscope waveform (Output of Inverter)

In order to connect Arduino to the internet Wi-Fi module is being used. Fig. 4 shows the connection diagram for ESP8266.

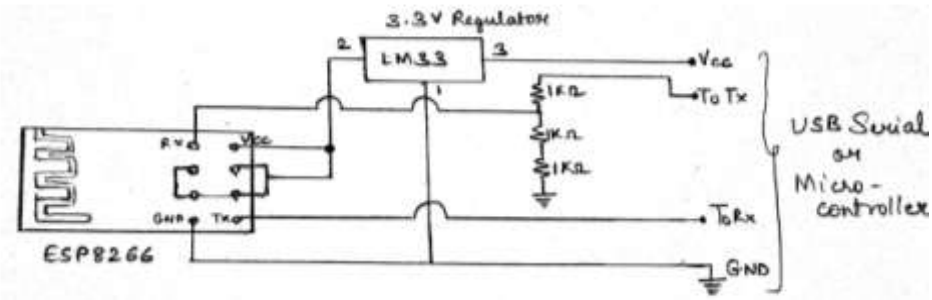

Fig. 4 Connection diagram of ESP8266

ESP8266 communicates serially with Arduino microcontroller. With the use of AT commands it is configured and connected to the known Wi-Fi networks. Fig. 5 shows the output of the respective configuration of ESP8266 AT commands.

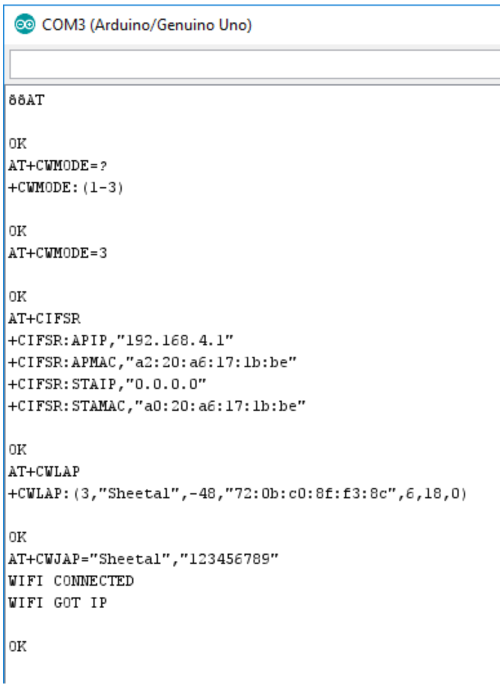

Fig. 5 AT commands output

V. SIMULATION AND SIMULATION RESULTS

The inverter Simulation is carried out in PSim Simulation Software. Simulation circuit and Simulation results are shown in Fig 6.1 and Fig. 6.2 respectively.

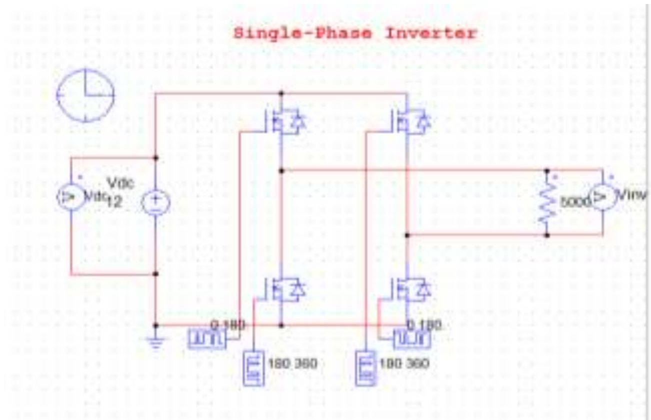

Fig. 6.1 Bridge Inverter.

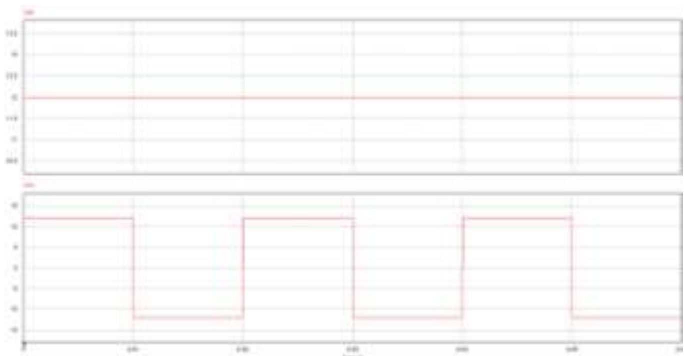

Fig. 6.2 Above (DC i/p of inverter) Below (AC o/p of Inverter)

Cayenne IOT Platform:

For data interpretation, Cayenne is used which displays obtained data graphically as well as gives us the freedom to set triggers accordingly.

Fig 7. Cayenne Platform

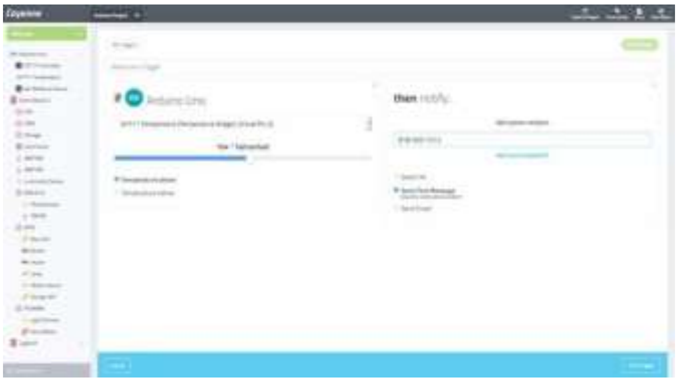

Fig. 8 Setting triggers i.e. sending text messages on provided phone numbers.

VI. CONCLUSION

For implementation of Inverter, Bridge topology is used since it eliminates the use of dual battery source and increases efficiency. IOT is an emerging technology which is providing ease and security. Due to transmission of data over internet human intervention is reduced effectively. Solar systems are installed in remote areas and IOT provides flexibility for their continuous monitoring.

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