Solar power generation system with IOT based monitoring and controlling using different sensors and protection devices to continuous power supply

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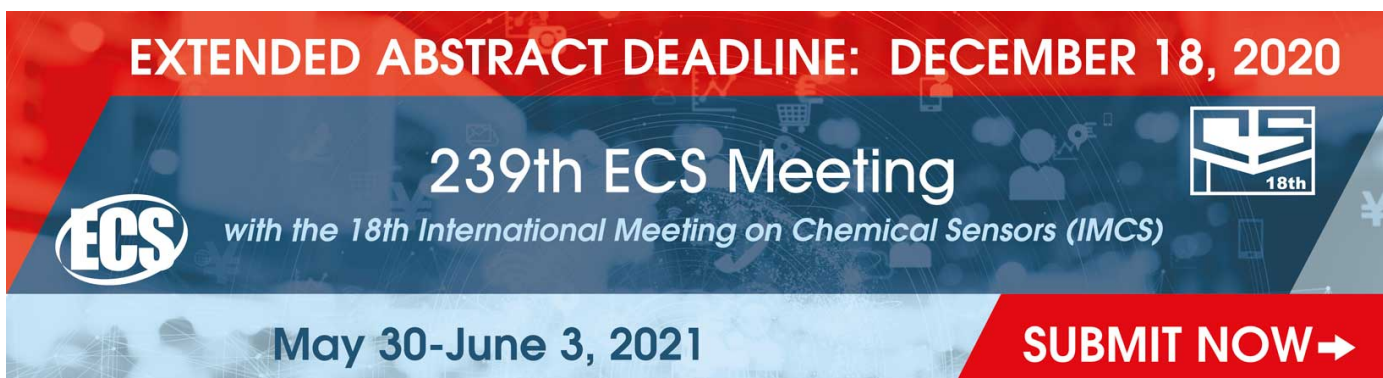**Some of the authors of this publication are also working on these related projects:**

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Solar power generation system with IOT based monitoring and controlling using different sensors and protection devices to continuous power supply

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Abstract.IOT technology, now a day performs very crucial role in industrial aspects related to safety, cost, production and maintains. The cost of renewable energy equipment is much lower, and large-scale industries are encouraged to set up solar photovoltaic systems and maintainers objects that are very useful for high power consumption. This solar photovoltaic system requires a better automation of the equipments, controlling, monitoring plants using remotely with different types of sensors that are interfaced with the system equipments and then have to identify the problems related to inaccessible locations in the industry. Using IOT technology for controlling and generating solar photovoltaic power can have a significant impact on the performance, monitoring and control of the plant using various wireless communication technology methods and then eliminating interrupting problems in a very short time. In this paper, we have implemented a solar power generation and tracking system with IOT sensors and produced continuous power.

Keywords. Micro controller, DC generator, Relay, voltage sensor, current sensor

1. Introduction

In general, previous days IOT is used with wired model networks that can be transmitted and received the information through wire networks only. Recent IOT technology modified and well developed having modern sensors and protective elements with this we can transmit the information using wireless communications. Thus resulting in a new concept of IOT technology was introduced earlier and received the more benefits over the last few years[1]. In every day human life is related to the advancement technology devices like smart phones and tablets are wide spreading over the world so

we are going to interfacing the IOT technology with these devices then having the more benefits and those are saving of time and easy to control[3]-[4]. Use of IOT not only in the home appliances but also in other major fields such as a smart city, smart health care, smart car, smart energy systems.

Solar energy is becoming a significant solution to renewable energy supply for future needs. Increased rooftop solar systems are integrated into networks such as grids and industrial locations, and there is a growing need to track the real-time generation of power from solar power plants and locate fault points, and to improve the overall output of solar systems to achieve good grid stability. Power generation from solar panels is variable due to variations in solar irradiance, temperature and other components[7]-[8]. So that we can assemble the machines automatically and then use advanced IOT technology systems. Based on various sensors and microcontroller devices with these components, we can easily track wireless networks and eliminate the faults and hazards associated with modern technology approaches. So that the cost functions of the device are therefore much smaller than those of the previous control systems[5]-[6].

A predictive analysis that provides information on the faults and maintenance conditions of pv systems is very relevant. What type of devices are the measurement devices and protective equipment are most appropriate for solar photovoltaic systems. Remote monitoring and control of pv systems focused on wireless networking devices such as Zigbee technology and wi-fi technology [2]-[10]. There's a gap in the distance between these units. Zigbee has a smaller range related to Wi-Fi. The Wi-Fi technology is used to run the region below 2.4GHz and to have a fast data rate. This technology operates under the micro grid architecture, and if we need a high level of infrastructure then we need cloud computing technology that is really useful.

At present, a number of solar photovoltaic systems has been set up to operate this system, and we are using wireless communication devices such as GSM and Bluetooth, and Zigbee maintains these communication networks for data transmission and data reception, but there are some disadvantages associated with high operation and maintenances costs which restrict the improvement of home appliances. In order to reduce these impacts, PV systems based on IOT can be changed by monitoring and controlling. The power generation system with its various parts, such as solar panels, temperature sensors, voltage measurement devices, relays, current measurement devices and diesel generators, and these devices communicate with the microcontroller[9]-[22]. Analysis of the data obtained using the database built for these various measuring control devices.

This paper includes section II presents implementation of the IOT based power flow diagram system. Section III presents the over all design and communication devices. Power measuring unit presented by section IV. Overall operation of the system section V. Results are analysed in section VI, and conclusion part in section VII.

1.1 Contribution of the paper
- The hardware prototype voltage and current measurement circuits are designed
- Analysed the Electrical load consumption

2. IOT based power flow system

The schematic diagram of the system used to manage and monitor the solar photovoltaic system with IOT technology is shown in the figure 1. The developed system can be divided into three main parts: they are power supply unit, sensing unit and the last one is communication unit. The first unit power supply is very necessary for any system to supply continuous power to the operating device. The temperature sensor, the voltage sensor and the current sensor are used for detecting the signals from various sensors. The next unit is the communication component, which receives the signal from other devices after it is transmitted to the appropriate devices. In This stage we use micro controllers and wireless modules to transfer data to server systems and this section is sophisticated to web-based applications built with data collection, data storage and processing elements. Using monitoring and

controlling systems are very important for construction and maintains of the system performance is in easy mode.
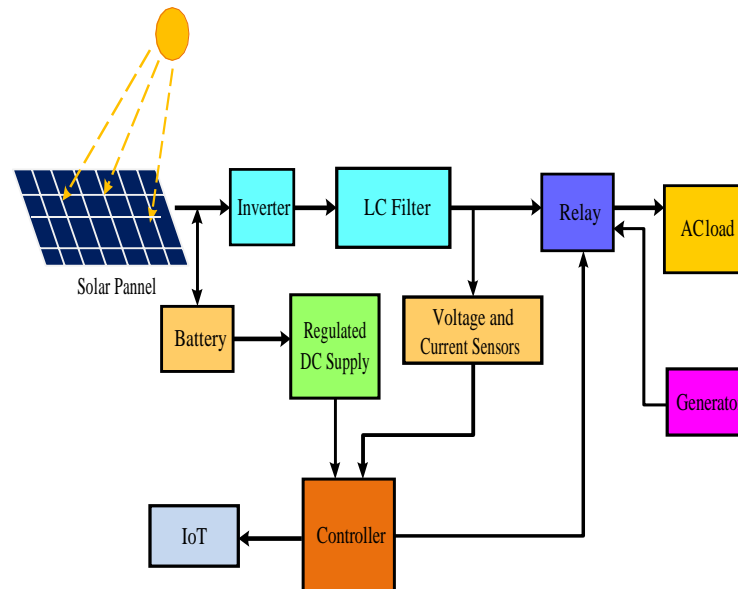

Figure 1. Schematic diagram of proposed system.

## 3. System description

3.1. Power measuring unit

Essentially, the power unit is very important for electrical circuits to operate the system efficiently and is configured to convert AC to DC, which is very important for electronic devices. This power unit can be a series of blocks each part will perform an individual power supply function for other devices. In this developed system with a power supply unit, the 230v ac supply to the rectifier unit can be carried out and this rectifier unit converts the ac supply to the DC supply, which is a constant supply mode to the electronic devices so that we can arrange one voltage regulator part. This factor reduces the voltage ranges 5V,9V,10V and 15V. It is necessary for the system to operate if the voltage value is high in that mode electronic devices are short circuited so that we need to minimize this type of problems to make the voltage regulator better for the electrical circuit. After tracking the sensing stage the power can be described by two measuring systems, 1.voltage measuring system 2. current measuring system.

3.1.1. Voltage measurement system
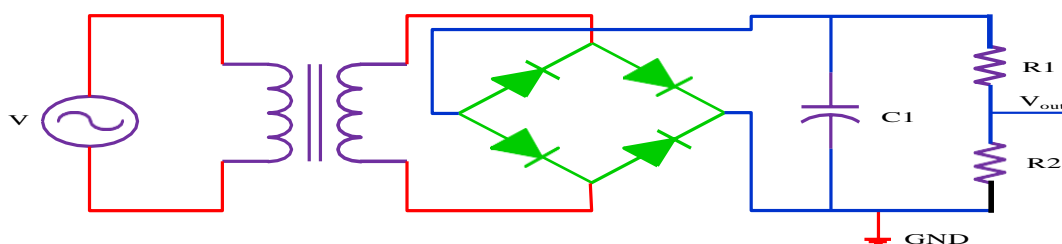
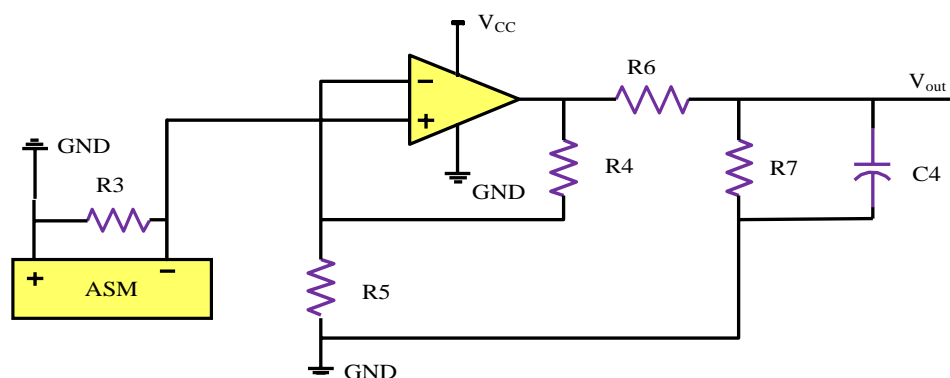**Figure 2.** Voltage measurement circuit.

The voltage measurement device plays a key role in the IOT system, since certain electronic devices are operating with less voltage if we unexpectedly give high voltage to the system, so it is very important to minimize this voltage so that we can built this type of voltage sensing device can arrange some form of DC voltage to the system for the operation purpose. First we use the step down transformer system which reduces the voltage from 230 V to 9V. Then we use the bridge rectifier which converts from AC to DC supply and sends it to the wireless modules. When using wireless devices it should have a minimum voltage value in that case, the voltage regulator is used to controls the voltage value less than 5V which is easier for the wireless modules to operate and works to minimize the overload current values. The hardware circuit shown in below figure 3.
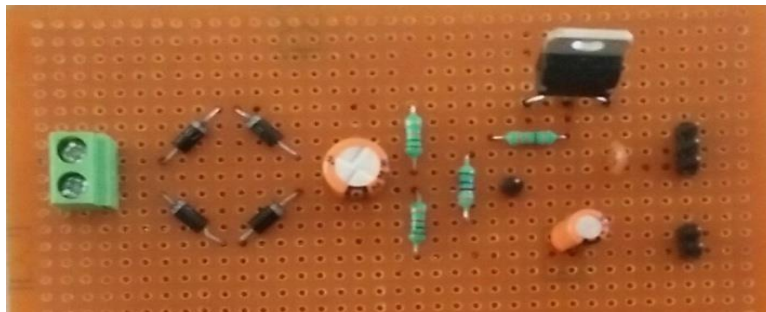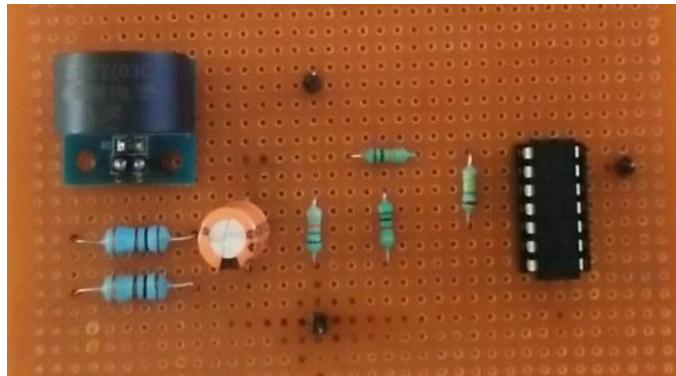

Figure3. Hardware voltage measurement device.

3.1.2. *Current measurement system*

In this current measuring unit, we use two current sensing transformers ASM010 and the necessary load resistors, IC 234, capacitor and normal resistors. These current sensors are used to calculate the current value around the load resistor with respect to the voltage value. Present sensors are small in size and are made of talema working from 1amp to 100A. In this established method, the current measuring device is connected to the machine with one electrical wire and then, if any loads relevant to the home appliances are applied, the current value is easily calculated using this current measuring device , the low power consumption device and the temperature values are worked from-40 degrees to +120 degrees. The developed hardware of the current measuring system is shown in the diagram below figure 4.

Figure 4. Current measurement circuit.

Figure 5. Hardware developed current measurement device.

3.2. LDR Unit
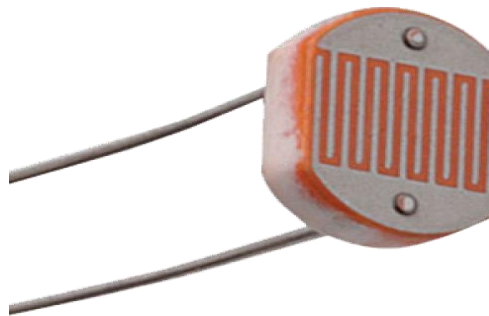
Figure 6. LDR component.

This LDR is also called solar photocells and solar photoconductors, and they are light sensing instruments. The LDR or photo resistor is a system whose resistance depends on the electromagnetic radiation incident or, in other words, the LDR function, which tests the light intensity of the presence or absence of light.

3.3. Relay

Figure 7. Relay component.

The relays will function like a switch that is ON and OFF without a human interface. The Relay is used to monitor the movement of high currents with low power consumption such that they are commonly used for the safety of overloads. These relays are used to isolate and classify problems during transmitting and receiving phases.

3.4. Inverter

Inverter is used to convert the DC supply to AC supply. Inverter is used to home appliances, industry and grid mode. Inverter can generated DC supply from solar panels of the system and if we need DC voltage increases automatically AC voltage increasing the before sending to the power supply system.

3.5. LC Filter

LC Filter is a combination of inductance and capacitances elements. Which is used to reduce the unwanted harmonics and the noise functions. The basic function of filter circuit is remove the AC components from the rectified output and it allows the DC components to reach the load demand.

3.6. Communication system IOT

The figure 8.belowshow the different modules used in IOT technology for moving data from the device to the application and vice versa to the server. In this communication device, which has an interface to the microcontroller, the signals are obtained from various sensor elements in the system. If we assume that the first communication module is Xbee, which has two parts, the transmission is xbee, and the second component is receiving xbee. The transmission xbee collects the information from the sensors and transmits the signals to the receiver xbee device and this device receives the signals from the transmission xbee and sends these signals to the display system, then we can evaluate the output of the system under different conditions so that we have implemented the two-way communication system for the user to the application that is most relevant for IOT. One of the drawbacks of this xbee system is that it operates less area and less bandwidth compared to Bluetooth and wi-fi modules.

The ESP32 Wi-Fi module is a good network that can be easily linked to the micro controller and functions as a wi-fi adapter, a wireless interface to any device with easy networking through serial communication and a UART interface to the system .This system primarily used as three types of large-scale modules ,medium and small-scale modules for the necessary areas. By using these wi-fi modules, we can create wi-fi hot spots that are easily interfaced with the more users function at a time that is optimal device prediction.

The third communication component of the Bluetooth system is a wireless communication channel. In this unit, two modules can be used to transmit and receive signals at a time. The transmission system can take data from the user interface system with different sensors and sends to the receiving device that device also receives signals with the aid of the microcontroller device and displays the information that is important to the system on the basis of the information that we have made available for monitoring and controlling objects using this type of process.
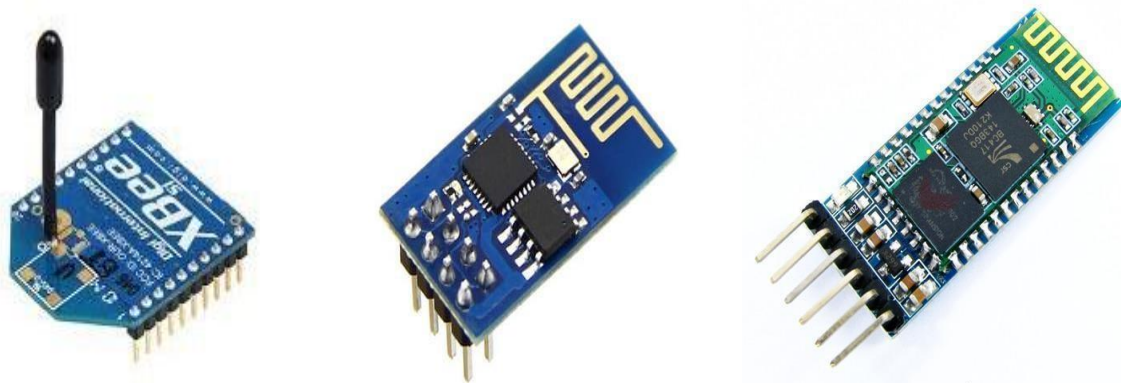
Figure 8. Communication devices(XBee, Wi-fi, Bluetooth)

4. Operation of working

First of all, we need to connect the solar panels in a series formation after the DC motor connected below on the solar panels. From these solar panels generated the DC supply and it is send to the inverter system. Inverter system can convert the DC supply to AC supply. This AC supply system can used to home purpose, industries and grid functions. In the system any unwanted or higher frequency harmonics and noise component scan be eliminated by LC Filter. The proper voltage and current value of the electronic devices can be produced from the power circuit unit. After that, the necessary signals pass through the ADC to the 8051 microcontroller and this controller is connected to the MAX232 IC and 555 IC timer and the engine driver circuit. In these solar panels, on either side of the east and west, two LDR devices are used to absorb solar radiation as the LDR works in that case, the dc engine will rotate in the direction of the LDRs with the engine driver circuit. Various values related to the east and west directions can be established by using this method and these values are shown on the screen. In this way, we can generate and track the solar photovoltaic system, and if there is any issue that can be easily detected by using the connected LED. These LEDs are ON and OFF mode and can quickly locate the location of the solar panel failure. This system having any overload currents passes through the system at the time we are using the relays that can be worked automatically and gives the buzzer then easily detectthe overload currents in the system.
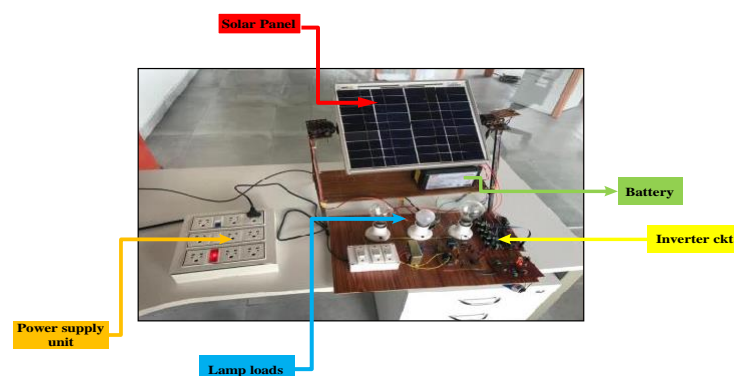
Figure 9. Hardware Solar tracking system

5. Results analysis

In this figure 10 shows the developed power using solar photo voltaic system. The solar system developed power 15 W as well as 40 W with the help of sun energy. IOT technology can helps the systems to monitoring and controlling by using different sensors devices. In this developed system we are using relay, buzzer, LED devices for fault identification process and protection from the high overload conditions. The system can generated the different powers at various loads are using in home appliances so that easily analyzed the power values and cost of the units. The developed system can automatically we are switching off the loads using the IOT technology.


Figure 10. Experimental Solar power generation system with Lamp loads 15W& 100 W.

Table 1. Electric power measured at different loads

Different Home appliances	Reference Power(W)	Measured Power(W)	Measured Voltage(V)	Measured Current (A)
Lamp load1	15	15.21	230	0.066
Lamp load2	60	63.14	230	0.279
Lamp load3	100	104.54	230	0.51
Electric Heater1	400	406.32	230	1.77
Electric Heater2	750	763.26	230	3.31

In this table 1 shows different lamp loads generated various power values with the help of solar panel system. The IOT technology have been implemented using voltage measurement device and current measurement device for measuring the voltage and current values. When we are connected different loads ,we observed the change of current values and these currents can measured by current coil. The observation of current values, we can analyzed the consumption of power .

5.1 Implementation results
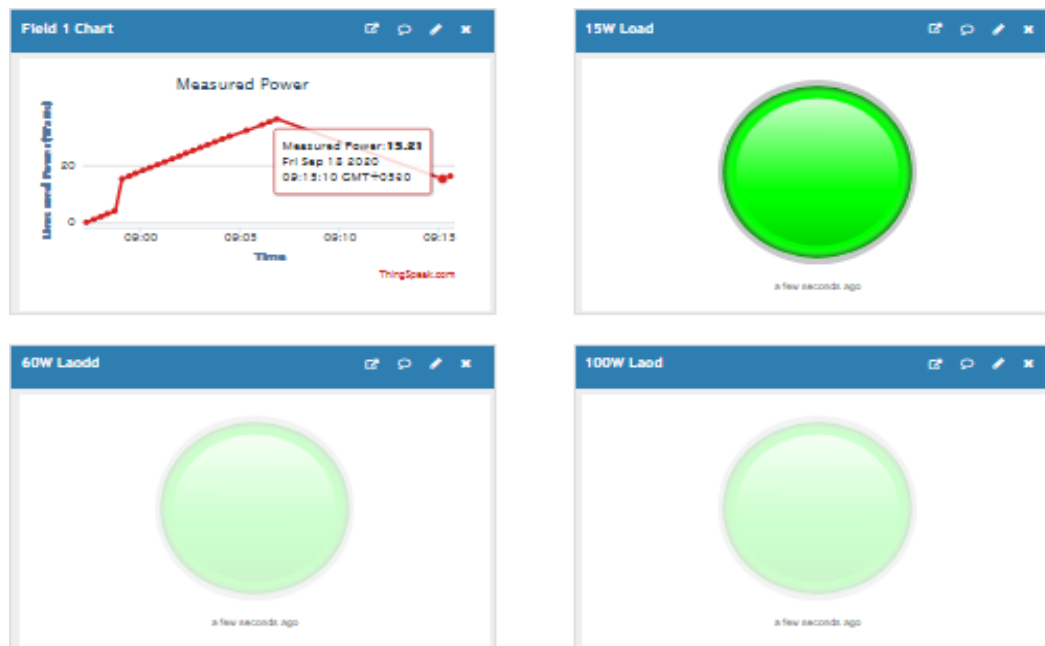
Figure 11. Power monitoring in case of Lamp load 15W connected system.
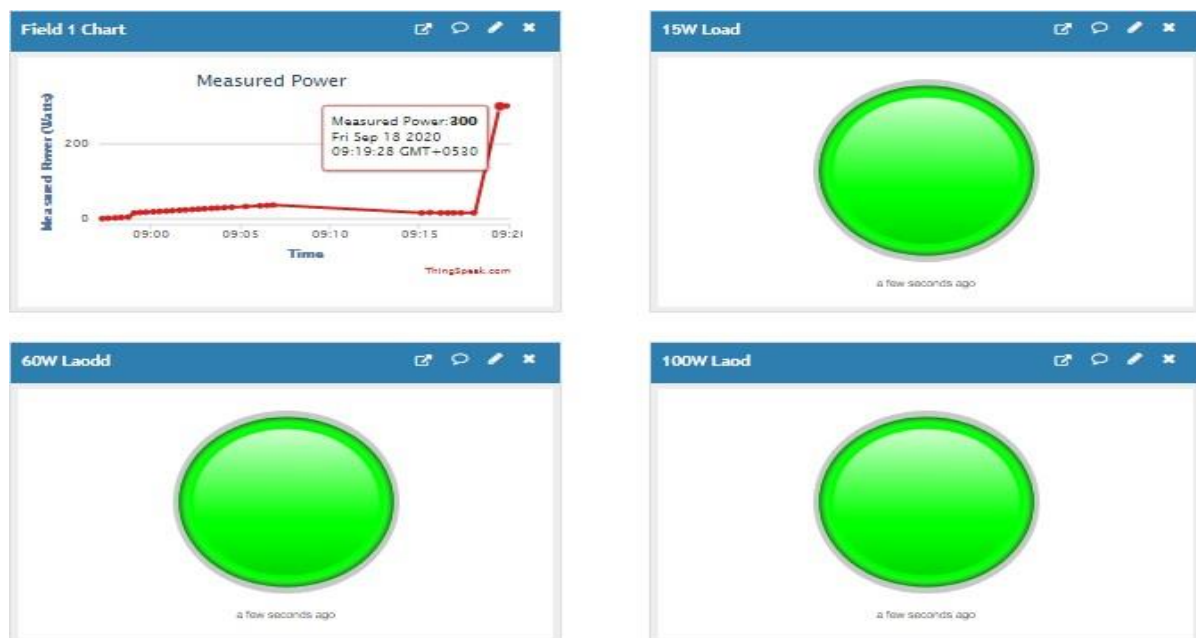
Figure 12.Power monitoring in case of all the Lamp loads connected system.

In the figure 11 & 12 shows the implementation results in case of 15W and 300 W connected to the system as per the available power. If the measuring power is greater than 15 W only one lamp load 15 W is connected to the system. Based on the availability of the power loads automatically connected or disconnected with the help of relay circuit

6. Conclusion

Now a days producing and regulating power is an important task in the study of the power system. In this paper introduces a solar power generation system with IOT technology. The proposed system is used to regulate the load as per the availability of the power with the help of controller and online data monitoring system is IOT, sensors and relay devices. The measurement of voltage and current circuits are important for the consumption of load values. In this developed system, the wireless devices are used to send and receive information from IOT devices, which primarily measure power and recognize faults in the system with safety precautions.

7. References

[1]   Sai Kumar M, Rajender B, Kothapalli B, Rajeshwar Reddy K 2019 Instability evaluation of the temperature tracking and transmission corridors *Int. J. Eng. Adv.Technol.***8**(6) 2986-2989

[2]   Chinthamalla R, Karampuri R, Jain S, Sanjeevikumar P and Blaabjerg F 2018 Dual solarphotovoltaic fed three-phase open-end winding inductionmotor drive for water pumpingsystem application*Electric Power Components andSystems***1**1-16

[3]   Sangeetha Sadu,RajeshwarRao A2018 IoT based monitoring and control system for appliances*Advances in computational Sciences and Technology***11** 0973-6107

[4]   Ali Al-Dahoud, Mohamed Fezari, FatmaZohra Belhouchet and ThamerA,Al-RawashdehRawashdeh2016Remote monitoring system for solar power panels using intelligent sensors network*24th Telecommunications forum*10.1109/TELFOR.2016.7818739

[5]   Andreas and Spanias S2017Solar energy management as an internet of things (IoT)application*8th International Conference on Information, Intelligence, Systems &Applications*DOI:10.1109/IISA.2017.8316460

[6]   Sudhakar A V V,Umendar A, Thirupathi E and Rajeshwar Reddy K 2018A review onpower quality monitoring and power management using developed applications*International journal of engineering and technology***7**(3.34) 972-974

[7]   Ramchandar Rao P, Srinivas S and Ramesh E 2019 A report on designing of wirelesssensor networks for IOT applications *Int. J. Eng. Adv. Technol.***8** 2005-2009

[8]   Arabelli RR and Rajababu D 2019 Transformer optimal protection using internet of things*Int. J.Innov. Technol.Explor. Eng.***8**(11) 2169-2172

[9]   Rajeshwar Reddy K and Rajababu D2020 Smart power monitoring and controllingusingIOT technology*International Journal of Advanced Science and Technology***29**(6)5890-5899

[10]   Subba Rao A and Vidya Garige S 2019IOT based smart energy meter billing monitoringand controlling the loads *Int. J.Innov. Technol.Explor. Eng.***8**(4S2) 340-344

[11]   Seena Naik K and Sudarshan E 2019 Smart healthcare monitoring system using raspberry Pi on IOT platformARPN *J. Eng. Appl. Sci.***14**(4) 872-876

[12]   Vedik B, Shiva C K and Harish P 2020 Reverse harmonic load flow analysis using an evolutionary technique *SN Appl. Sci.* **2,** 1584 https://doi.org/10.1007/s42452-020-03408-4

[13]   Vedik B, Ritesh K, Deshmukh R and Shiva C K 2020 Renewable energy based load frequency stabilization of interconnected power systems using quasi-oppositional dragonfly algorithm *J Control AutomElectr Syst.* https://doi.org/10.1007/s40313-020-00643-3

[14]   Vedik B, Naveen P and Shiva C K 2020 A novel disruption based symbiotic organisms search to solve economic dispatch *Evol. Intel.* https://doi.org/10.1007/s12065-020-00506-5

[15]   Kumar R, Sahu B, Shiva C K and Rajender B 2020 A control topology for frequency regulation capability in a grid integrated PV system *Archives of Electrical Engineering***69**(2)389–401

[16]   Basetti V, Chandel A K and Subramanyam K B 2018 Power system static state estimation using JADE-adaptive differential evolution technique *Soft Computing* **22**(21) 7157-76https://doi.org/10.1007/s00500-017-2715-3

[17]   Shiva C K, Vedik B and Kumar R 2019 Integration of distributed power sources to hydro-hydro power system subjected to load frequency stabilization *International Journal of Engineering and Advanced Technology***8**(2) 128-32

[18]   Pasha SN, Harshavardhan A, Ramesh D and Md S Shabana 2019 Variation analysis of artificial intelligence machine learning and advantages of deep architectures *International Journal of Advanced Science and Technology***28**(17) 488-495

[19]   Swathi N, Padmaja Ch and Navya Jyothi G 2020 Audio assistive for blind people to identify the cloth patterns and colors*Journal of Critical Reviews***7**(17) 154-158 10.31838/jcr.07.17.23

[20]   Prakash TC, Mamatha M and Samala S 2020 An IoT based under weather monitoring system *Journal of Critical Reviews***7**(17) 148-153 10.31838/jcr.07.17.22

[21]   Kumar CN and Satyanarayana N 2015 Hybrid loss recovery technique for multipath load balancing in MANETs *2nd International Conference on Electronics and Communication SystemsICECS 2015* 1294-1301 10.1109/ECS.2015.7124793

[22]   Sekhar VM Rao, KVG Rao NS and Chand MG 2016 Comparing the capacity NCC and fidelity of various quantization intervals on DWT *Advances in Intelligent Systems and Computing***413** 45-55 10.1007/978-981-10-0419-3_6