Global Research Review

ISSN: 2737-8551

Review homepage: http://www.grrjournal.org

Design and Implementation of AC Microgrid for AC loads

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Abstract

As per the history point of view, AC power network has been the standard decision for commercial energy to control the radiant lights in our residence and motors in our processing plants since the late of nineteenth century. To this point, the AC control systems have existed for over one century back alongside the AC loads ruled in the market. AC microgrid system for AC loads is proposed which controls and monitors the power generation, distribution installed in the building. The system electronically controls and monitors the renewable resources and variable loads simultaneously with the microcontroller. The designed system includes solar panels and wind turbine energy sources and also K.E energy source. The solar panel directly links to the specially designed hybrid charge regulator in order to charge the battery as well as supply power to the load. Similarly, the wind turbine is also directly connected to the hybrid charge controller in order to charge a battery and supply the power to the load when there is no other source. The K.E backup makes energy from the available grid inside the building and also connected to the charger controller to have provision for charging from solar, wind and K.E sources. The microcontroller used to protects the power network from the outages and faults due to low voltage and overvoltage.

Introduction

Expanding energy demand led to shifting concentration to the utilization of the renewable and sustainable energy sources. Microgrids (MGs), mainly inverter based, are gaining more significance as they can accommodate various types of renewable energy effectively. Their control is one of the most challenging research areas. In the last few years, many control strategies have been developed. Pakistan has four seasons summer, winter, autumn, and spring. In summer season, the electricity consumption is more because of usage of many loads such as Air cooler, Air Conditioner, and Refrigerator when contrasted with different seasons. Different renewable energy resources are available in Pakistan such as solar, wind, biomass and others. These different renewable energy resources can be converted into electricity. This project aims to design and implement the project with micro controller for the control and assessment of energy for AC Loads and conducts the MATLAB simulation and hardware implementation and also compares characteristics of energy sources used solar, wind and K.E energy sources. Further, the development of renewable energies globally and their increased use have created the need to modernize the existing electricity system. These changes lead to the control and management of energy systems due to the consistent nature of the change in the consumption of electricity. The generated electricity is controlled and monitored from both the sides (i.e. generated and load side) with microcontroller which manages and controls the renewable energy resources for electricity production. Hence, if the wind speed is slow, microcontroller initiates control action to get the energy from the solar. When sunlight is not reliable then load will get the energy from wind and when wind speed is slow and sunlight is also not reliable than K.E will carry the load. Battery backups are used in case of increased demand during a higher level of consumer requirements [3]. Therefore, there is always the need for an energy that will never vanish all the time.

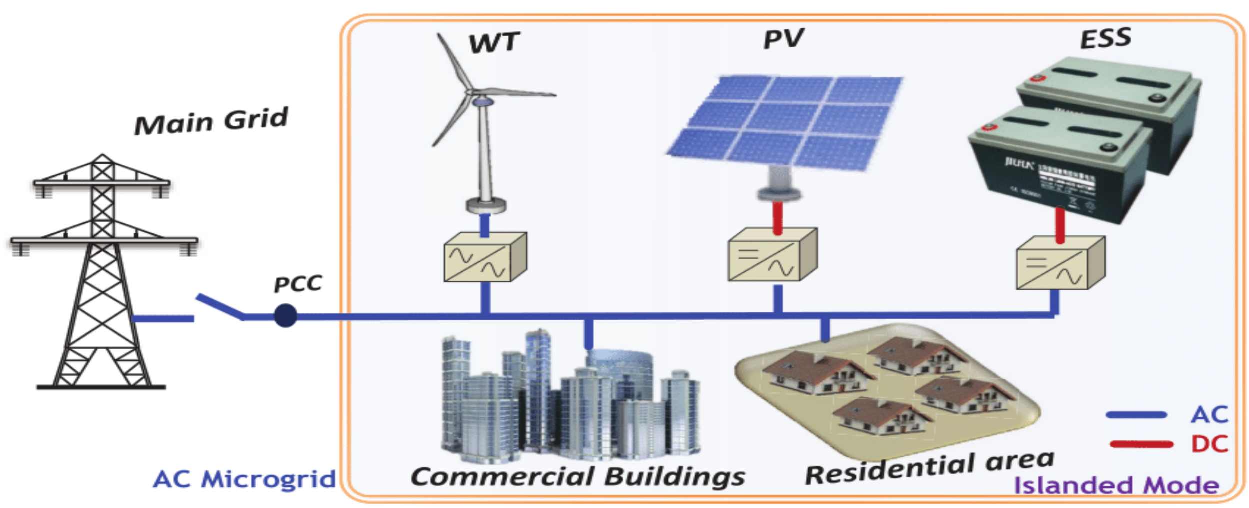


Fig. 1.1: The solar and wind power systems in AC load system

While shifting from one energy source to another energy source it may cause the burning of sensitive AC loads so it's important to analyze effects of these energy sources and the effectiveness of this proposed system is performed using MATLAB simulation. By analyzing the simulation results we can improve the characteristics such as voltage variation, power factor and power efficiency in proposed system. This technique utilizes a smaller amount of renewable resources into large output power gain. We control and manage power inside the building as well as renewable resources outside the building to fill the gap of increasing energy demand and reducing the shortage of energy from all over the world so it is time to convert energy sufficient problem in to a feasible mechanism coupled with the solution by applying the instrument of proper management, assessment, and control of energy [4]. Existing solutions advocate the stoppage of the energy wastage problem by using different sensors and microcontroller. These ways will generate global benefit to the country economy. The wastage of energy will create an excessive shortage until and unless.

Problem Statement

The proposed system includes energy sources such as renewable (solar, wind) and non-renewable (K.E). The three defined energy sources have different characteristics such as voltage variation, power factor and Power efficiency. The generated electricity is controlled and monitored with microcontroller which manages and controls the renewable energy resources for electricity production. Hence, if the wind speed is slow, microcontroller initiates control action to get the energy from the solar. When sunlight is not reliable then loads will get the energy from wind and when wind speed is slow and sunlight is not reliable than K.E will carry the load. While shifting from one energy source to another energy source it may cause the burning of sensitive AC loads so it's important to analyze effects of these energy sources and the effectiveness of this proposed system is performed using MATLAB simulation. By analyzing the simulation results we will improve the characteristics such as voltage variation, power factor and power efficiency in proposed system.

PROPOSED THEORETICAL MODEL DESIGN

The project model contains the three sections. All the section is interlinked with each other. In these sections, the microcontroller has an important advanced role to control and manage the generation as well as load section. Block diagram contains renewable sources (solar, wind) non-renewable (K.E), charge controller, battery for Storage, and various AC loads as refer fig

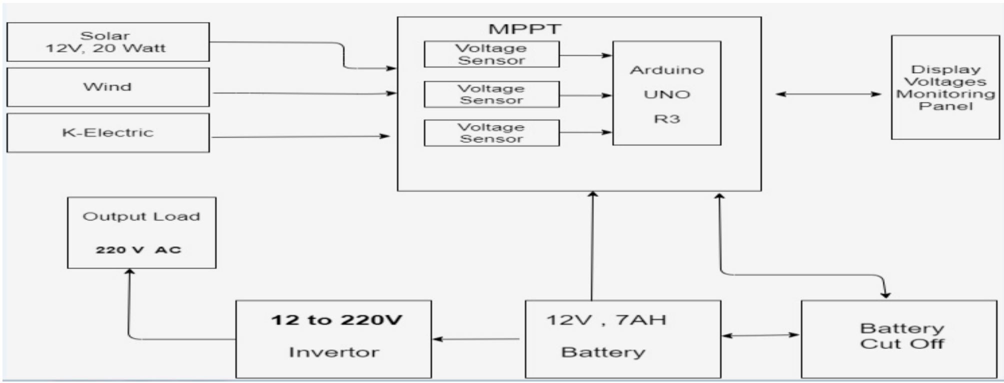


Fig. Block diagram of the proposed system

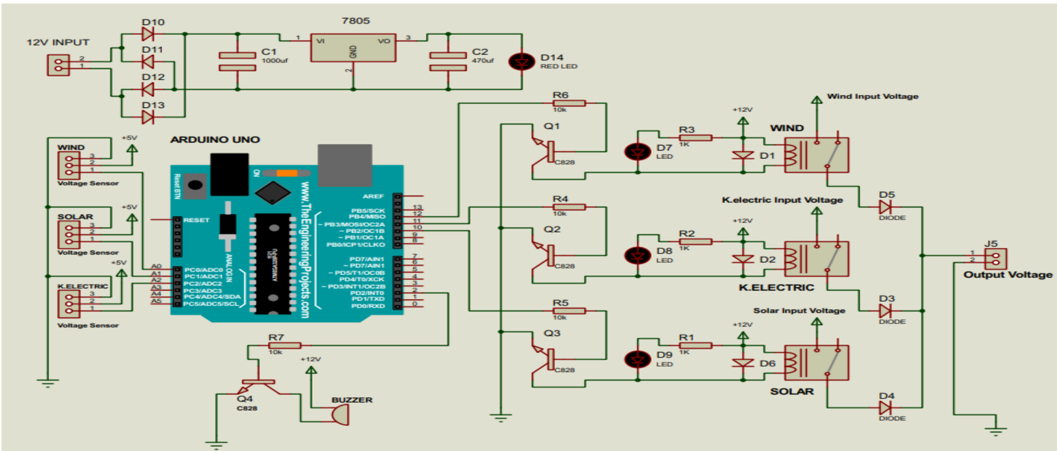
Fig. The Proposed real time diagram AC Microgrid with AC Load system

Energy Generation Section

The generation section is the most important part of the AC Microgrid. Microcontroller plays an important role that will manage and control the renewable resource like wind and solar. If the wind speed is slow, load gets energy from solar. When sun light is sufficient then load will get the energy from wind We have battery backup if our demand is increased from requirement. Hence, we have such level of energy that will never vanish .

Charge controller section

MPPT control the renewable resources at energy generation section that optimize the power gain. MPPT are so different and efficient than traditional PWM controller. The microcontroller choose the renewable sources for effective power generation with the help of MPPT in such a manner that when the voltage of solar panel is 12V or more than 12 volts then whole load will shift to the solar. When sun Light is not reliable or solar panel voltage is less than 12 volts after that 2nd priority is given to the wind. When wind voltage is 12V or greater than 12 volts then whole load would shift to the wind and at last priority is given to K.Electric. The design charge controller manages the overall control of the design system. It provides satisfactory solution to generation section. At generation section it will manage and control the renewable resources for electricity production.



Load Section Design System

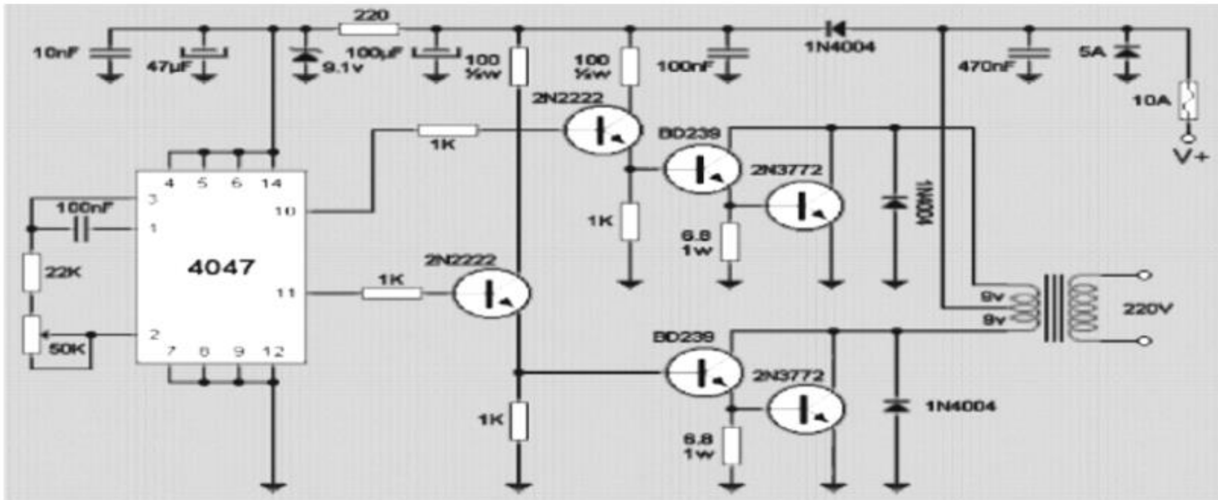
Microcontroller is a future technology that will accommodate control analysis. We propose a microcontroller based system by using this technology that will automate, assess and control our homes appliances. Our project consists of a microcontroller based circuit that will connect lights, fan and complete load along with the sensor. The main aim of the system design is that the user can control the appliances. A sensor is used to control the appliances and to get the current status (i.e., off or on) of the appliances [10].

AC loads

S.NO	Load Type	Rating of item used	Total item used	Units	Total Item
1	Tungsten bulb	100W	1	Watt	100W
1	LED Bulb	13W	1	Watt	13W

Inverter

Inverter is a power electronic device that converts the direct current DC into Alternating current AC. The input, output voltage and frequency, and overall handling of power depend on the design of the specific device or circuitry. The inverter does not produce any power by itself but the power is provided by the DC source which inverters convert it into AC source. In this purposed system the output of solar and battery is in DC current.



RESULTS AND DISCUSSION

The proposed model is designed in such a manner that when the voltage of solar panel is 12v or more than 12 volts then whole load will shift to the solar. When sun Light is not reliable or solar panel voltage is less than 12 volts after that 2nd priority is given to the wind. When wind voltage is 12v or greater than 12 volts then whole load would shift to the wind and at last priority is given to K.Electric. The design project “AC Microgrid for AC Loads” was experiment and observed in three days, from 12 to 14 March 2020. The real time experimental setup gives the voltage, power and current results as shown in fig.4.1 to 4.6.

Voltage Measurement

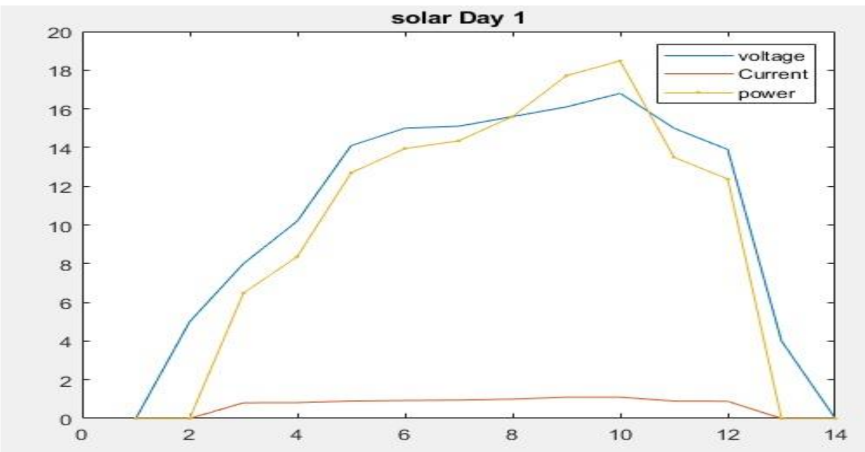
The voltage measurement of the design system is observed for the selected three days Thursday, Friday, and Saturday under the time allotment of 6:00 AM to 7:00 PM. The specific days of the estimation are from Thursday, Mar 12, 2020, to Saturday, March 14, 2020. It is seen that the voltage is most extreme during 1:00 PM and 2:00 PM and minimum at the 6:00 AM and 7:00 PM as shown in the figure. The voltage measurement of solar PV for the three days are observed in fig.8. From the trial, it is clearly observed that there is a little bit of output voltage discrimination between the first, second, and third day. The voltage of solar penal is due to the direct and scattered fall of solar irradiation as shown in the fig.4.1 to fig.4.6

Current Measurement

The current measurement of the design system is observed for the selected days Thursday, Friday, and Saturday under the time allotment of 6:00 AM to 7:00 PM. The designed solar system, it is observed that the current is maximum during 12:00AM to 1:00 PM and minimum at the 6:00AM and 7:00PM as shown in the figure.10. The current measurement of solar PV for the three Days experiment is observed as shown in the figure.11. From the experiment it is clearly observed that the current is due to direct scatter of irradiation. The observed current output as shown in the fig.4.1 to fig.4.6

Power Measurement

The Solar Panel is used in this proposed system is of 20W power. The power measurement of the design system is observed for the selected days Thursday, Friday and Saturday under the time allotment of 6:00AM to 7:00PM. It is observed that the power is maximum during 1:00 PM and minimum at the 6:00AM and 7:00PM as shown in the figure.13. The Power measurement of solar PV for the three days experiment is observed as shown in the figure.14. From the experiment it is clearly observed that there is little bit output power discrimination between the 1st, 2nd and 3rd day of the solar penal. The direct irradiation fall at the solar penal make the difference in observed output power values as shown in the fig.4.1 to fig.4.6.



Hourly solar measurement variation of proposed real time System for Thursday
Mar 12th, 2020. The horizontal line shows the time from 6:00 am to 7:00 pm, the time frame of 14 hour

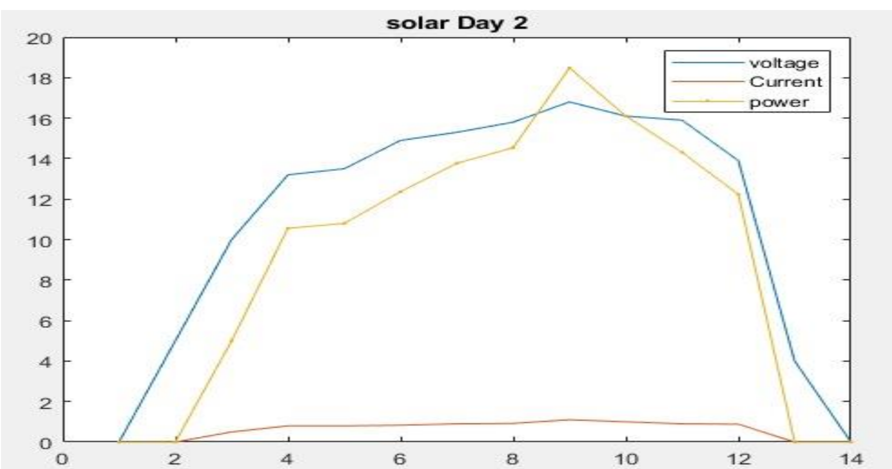


Fig.4.2. Hourly solar measurement variation

Fig. Hourly solar measurement variation of proposed real time System for Friday, Mar 13th, 2020. The horizontal line shows the time from 6:00 am to 7:00 pm the time frame of 14 hours

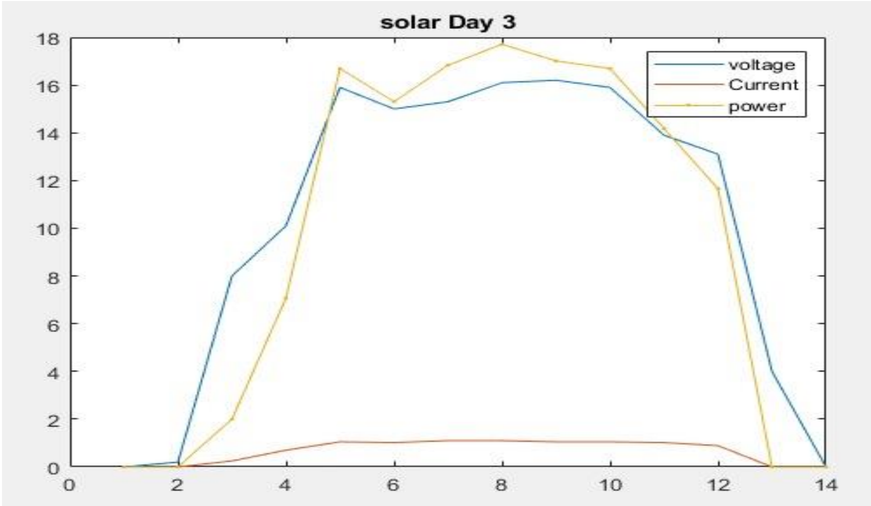


Fig.4.3. Hourly solar measurement variation

Fig.4.3. Hourly solar measurement variation of proposed real time System for Saturday Mar 14th, 2020. The horizontal line shows the time from 6:00 am to 7:00 pm the time frame of 14 hours.

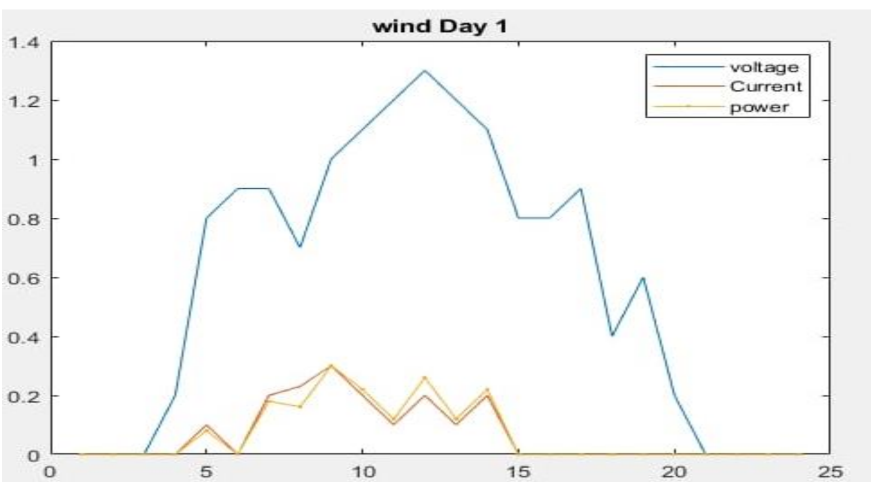


Fig4.5. Hourly wind measurement variation

Fig.4.5. Hourly wind measurement variation of proposed real time System for Thursday Mar 12th, 2020. The horizontal line shows the time from 7:00 am to 6:00 am the time frame of 24 hours.

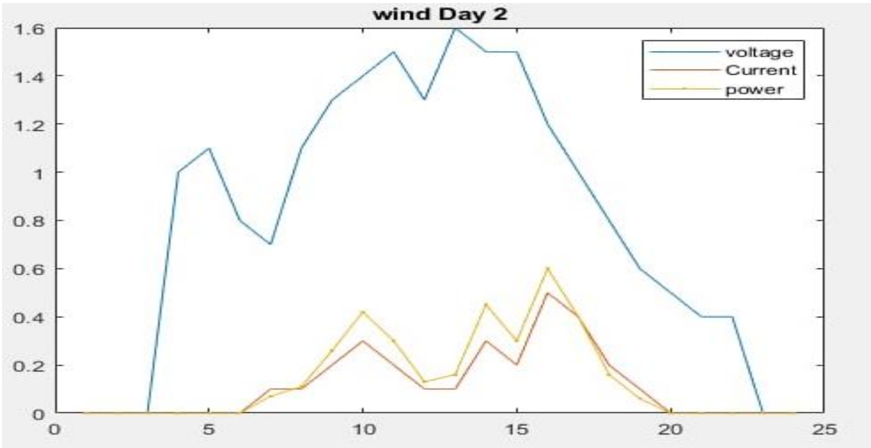


Fig4.6. Hourly wind measurement variation

Fig.4.6. Hourly wind measurement variation of proposed real time System for Friday Mar 13th, 2020. The horizontal line shows the time from 7:00 am to 6:00 am the time frame of 24 hours.

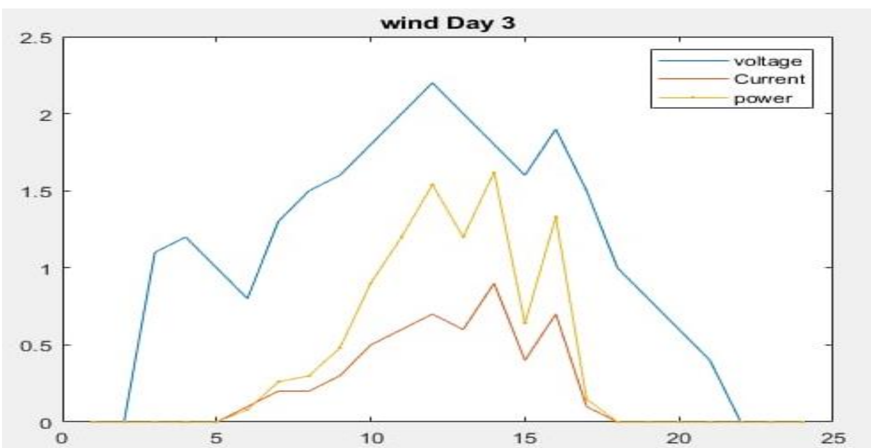


Fig4.7. Hourly wind measurement variation

Fig.4.7. Hourly wind measurement variation of proposed real time System for Saturday Mar 14th, 2020. The horizontal line shows the time from 7:00 am to 6:00 am the time frame of 24 hours.

The power capabilities of the proposed design system had been experimentally tested with 20W solar panel at different rotations of the time frame under standard test conditions. Hence solar panel was connected with the different loads and checked one by one in series and in parallel. The 12 V battery keep in closed circuit voltage at constant level throughout the experiment. The current and voltages have been measured at various time frames throughout the day as sun moved. To keep the system simple for experimental purpose, the designed system can be rotated manually with the help itself. The require voltage level maintain the system and the standard alignment of tracker was kept at 45°. The designed system can extract maximum amount of solar power from the available radiation throughout the day as sun kept moving from east to west. To analyses the performance of the tracker, the measurements take place at different selected days after every hour from 6:00 AM to 7:00 PM. The voltage level was very good while taking reading in series connection. On the other hand, while connected in parallel the maximum current and power was too good for our experiment and had good result. We took the readings of 3 days and got the results which were very successful in our study of this project design to provide the optimal require value.

Results of Voltage and Current with different Loads

Result 1: When load is 100 watt one bulb then
220 V-0.45 A
Result 2: When load is 20 watt one bulb then
220 V-0.068 A
Result 3: When load is 20 watt and 100 watt two bulbs then
220V-0.5454 A

CONCLUSION

This AC Microgrid aims to design and implement with microcontroller for the control and assessment of energy for AC Loads and conducts the MATLAB simulation and hardware implementation and also compares characteristics of energy sources used solar and wind. The proposed system which controls and monitors the power generation, distribution installed in the building. The system electronically controls and monitors the generation resources and variable loads simultaneously with the designed controller system. The AC Microgrid with the electronic control system will generate the energy from renewable resources and save the energy by managing the loads. The energy saving, controlling and managing is achieved from either side, that is, generation and load simultaneously. The designed system includes solar panels, wind turbine and K.E sources. Solar panel directly links to the specially designed charge controller in order to charge the battery as well as supply power to the load. Similarly, the wind turbine is also directly connected to the same charge controller in order to charge battery and supply the power to the load when there is no other source. The K.E backup makes energy from the grid collected inside the building and also connected to the charger controller to have provision for charging from solar, wind and solid K.E sources. By making the system automatic through Ardiuno microcontroller we got the less voltage variation of the three sources (Solar, Wind and K.Electric) The microcontroller protects the power network from the outages and faults due to low voltage and overvoltage. The Results of the proposed system are gotten through MATLAB by interfacing the hardware with MATLAB software. The proposed system increases the energy saving mechanism, stability, and efficiency of the system.

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