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CONSTRUCTION AND PERFORMANCE STUDY OF SOLAR LIGHTS USING MICROCONTROLLER

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Abstract: Solar power is produced by collecting sunlight and converting it into electricity. This is done by using solar panels, which are large flat panels made up of many individual solar cells. Here we report the implementation of a solar powered inverter with micro-grid system. The micro-grid system is designed using solar cells, MPPT charge controller, Battery, Inverter and Microcontroller. The microcontroller is programmed to have 15 watts as the fixed output. The output voltages and currents were measured from 9.00a.m to 4.00p.m. The sustainability of the system and efficiencies of the inverter were studied using Time vs Voltage and Current characteristic for CFL and Tungsten bulb and it was compared.

Keywords: Solar cell, Charge controller, Battery, Inverter, Microcontroller.

INTRODUCTION:

Solar energy is both light and radiant heat obtained from the Sun that influences earth's climate and weather, thus it helps in sustaining life. Solar power is produced by collecting sunlight and converting it into electricity. This is done by using solar panels, which are large flat panels made up of many individual solar cells. It is most often used in remote locations, and it is now becoming more popular in urban areas as well [1]. The Photovoltaic (PV), concentrating solar power (CSP), heating and cooling systems are the three primary technologies by which solar energy is harnessed at different levels around the world. Although solar energy refers primarily to the use of solar radiation for practical ends all renewable energies other than geothermal and tidal, derive their energy from the Sun in a direct or indirect way. The aim of this work is to design the solar lights using microcontroller, battery charger and inverter to get a constant output. The present work is based on low-cost micro-grid system prototype of 15W solar system built to develop a low-cost and sustainable renewable source of electrical power. Since renewable energy is weather dependent, energy management is very crucial [2]. Energy management involves monitoring the energy generation and its usage. Hence in short, the uniqueness of this project is about how we have implemented a fully functional micro-grid system with solar cells, MPPT charge controller, Battery, Inverter and Microcontroller in an efficient way. The Microcontroller is programmed to have 15 watts, as the fixed output. The output voltages and currents were measured from 9.00a.m. to 4.00p. m. The sustainability of the system and efficiencies of the inverter were studied using the Time vs Voltage and Current characteristic for CFL and Tungsten bulb and it was compared.

Overview of the micro-grid system:

In general, a micro-grid is a subset of an electric power system [3]. The prototype micro-grid system has four main components:

- Photovoltaic cell
- MPPT charge controller
- Battery
- Inverter

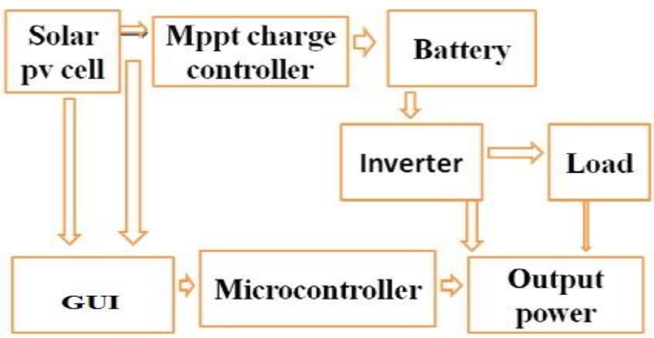

Figure1: Block diagram of micro grid system

Working of Prototype Micro-Grid System:

Construction of the Micro-grid system is shown in Fig. 2. An array of Photovoltaic cells (30 X 30 cms) was exposed to the sunlight to receive the solar energy and convert it into the electrical energy through Photovoltaic effect. It is constructed to obtain 5V Solar voltage as output

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and it was fed into the MPPT charge controller to adjust the battery charging current as 1 A. The input solar power of 5 watts is stored in the inbuilt capacitor (100µF/ 100V) of the charge controller (Refer Fig. 3). Thus it helps in regulating the net flow of current to the battery. The battery which gets charged during the day time stores its energy and discharges to the load through an inverter (Refer Fig.3) during emergency situation like power failures. A Graphical User Interface helps to monitor and process the analog signals from the PV cell array into a digital data using the computer and send it to a highly capable multitasking Microcontroller PIC 16F877A having a large programming memory, from where it was programmed to give a constant output of 15 watts to the load.

Figure 2: Micro-Grid System

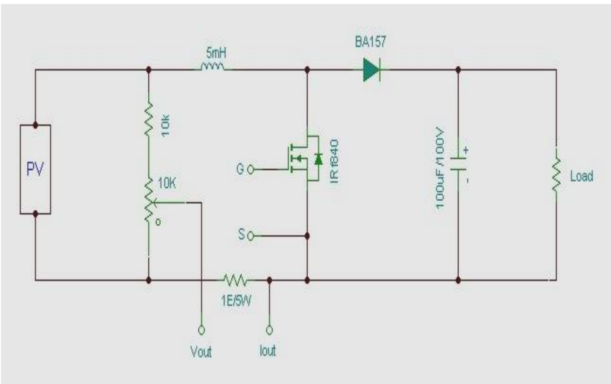


Figure 3: Circuit diagram of MPPT charge controller

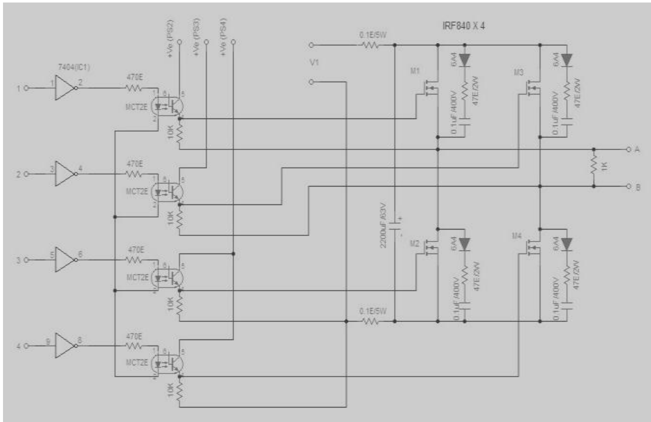


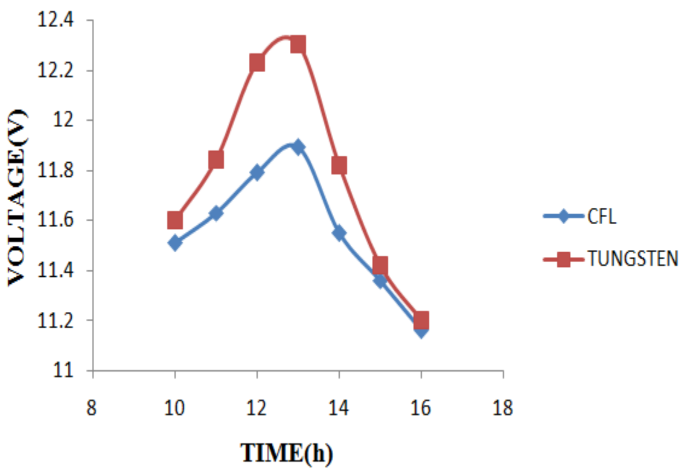
Figure 4: Circuit diagram of the Inverter.

Observation and Analysis:

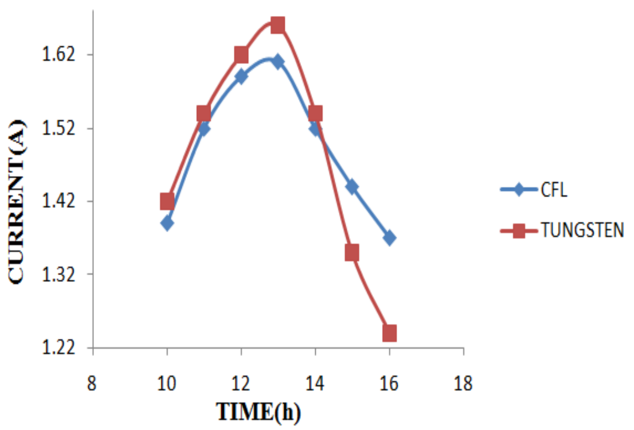
The whole setup is placed in the open sunlight and the maximum intensity of the sunlight was noted as 602 weber/amp/m. on 10/2/2016. The output voltages were measured from 10.00am in the morning to 4.00pm in the evening for every one hour. The corresponding output currents were noted and the graph is plotted between Time Vs Voltage and Time Vs Current to study its characteristics. The same procedure was repeated for different models of bulbs (CFL, Tungsten).

Time Vs Voltage Characteristics of Solar Panel (Using CFL & Tungsten Bulb)

CFL and Tungsten bulbs were used for experimental observations.



Time Vs Current Characteristics of Solar Panel (Using CFL & Tungsten Bulb)



Sustainability of the System:

It is examined and found that by charging the battery for a maximum of 13.60 V and it can able to operate the load for 2 hrs for Tungsten bulb and 2 hrs 25 mts for CFL bulb and hence CFL bulbs are more efficient than Tungsten bulbs.

Table-1: Sustainability of the system

Load	Charging	Discharging
1 Bulb of 15w (Tungsten)	13.60	2 hrs
1 Bulb of 15w (CFL)	13.60	2 hrs 25 mts

Efficiency of the Inverter (CFL):

Efficiency is the ratio of power out to power in, expressed as a percentage. If the efficiency is 90 percent, 10 percent of the power is lost in the inverter. The efficiency of an inverter varies with the load [2].

[Load = 1 bulb, Output = 15W]

Table 2: Efficiency of the inverter (CFL)

Time (Hr)	Input power (W)	Efficiency %
10.00 A.M	11.5V*1.39A=16.0W	93.4
11.00 A.M	11.6V*1.52A=17.6W	85.2
12.00 P.M	11.7V*1.59A=18.7W	80
01.00 P.M	11.8V*1.61A=19.0W	78.8
02.00 P.M	11.5V*1.53A=17.5W	85.7
03.00 P.M	11.3V*1.44A=16.3W	92
04.00 P.M	11.1V*1.37A=15.3W	98

Efficiency of the Inverter (Tungsten):

[Load = 1 bulb, Output = 15W]

Table 3: Efficiency of the inverter (Tungsten)

Time (Hr)	Input power(W)	Efficiency %
10.00 A.M	11.6V*1.42A=16.4W	91.4
11.00 A.M	11.8V*1.54A=18.2W	82.4
12.00 P.M	12.2V*1.62A=19.8W	75.7
01.00 P.M	12.3V*1.66A=20.4W	73.5
02.00 P.M	11.8V*1.56A=18.2W	82.4
03.00 P.M	11.4V*1.35A=15.4W	97.4

CONCLUSION:

The prototype micro-grid system is designed in a simulated environment to manage a photovoltaic based micro-grid during an emergency condition. The solar micro-grid will not only reduce electricity bills but also can provide a sustainable supply of electrical energy. Solar micro-grid will be able to provide light for few weeks if it is completely charged with free energy from the sun, it is a long lasting solution. The circuit can be extended to have any number of loads.

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