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Off Grid Power Supply For Remote Devices Using Solar Photo Voltaic

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Abstract

In Remote areas, communication devices and sensors necessitates the availability of continuous power. It is difficult to supply such loads using conventional power sources. In order to avoid such complexity solar energy may be used to power those devices. The variation of insolation in solar panels induces to store the converted energy and most convenient and suitable method is conversion to chemical fuels for later utilization. In this project power from solar panel is regulated using power electronic converter and microcontroller. The regulated voltage from the converter circuit can be used to charge the battery. An algorithm for tracking maximum power point is developed to achieve the maximum efficiency of the solar panel. The simulation of the project is done using Matlab/Simulink/Simpower.

Keywords: Solar power converter, microcontroller, MPPT, boost converter, input voltage 12-13V, output voltage 18-19V, panel testing, remote loads

Introduction

The usage of solar energy is widely applicable in places where a remote power source is needed and grid is too complicated. Stand alone or remote systems can able to supply the load independent of grid supply [1]. The solar panel, storage devices and inverter combination can able to power electrical appliances all the day [2]. The applications of solar power systems to rural are enormous. They can supply power for irrigation, pest deterrent systems, battery charging, security systems, water pumping, remote lighting, frost warning systems and powering home off the grid[3].

The switching converters play predominant role in the developing area of photovoltaic conversion and plays a key role in balancing the energy flow between a PV source and the load [4]. However, the design constraints switching converters is not an easy task since it has to satisfy certain conditions imposed by the specific application in PV conversion chain [5]. This paper deals with design criteria for supplying timely varying power to unattended remote loads, selecting a solar panel that will supply power to remote load which utilizes maximum power needs to develop an algorithm and design a converter that will supply the load even under low radiation and to regulate the output voltage using suitable feedback control[6].

Maximum Power Point Tracking

The Fig. 1 shows the flow chart explains the operation of this algorithm. It measures the present voltage and current values of PV module. By using the present values and previous values of voltage and current we can calculate the incremental changes of voltage and current, *dV* and *dI* [7].

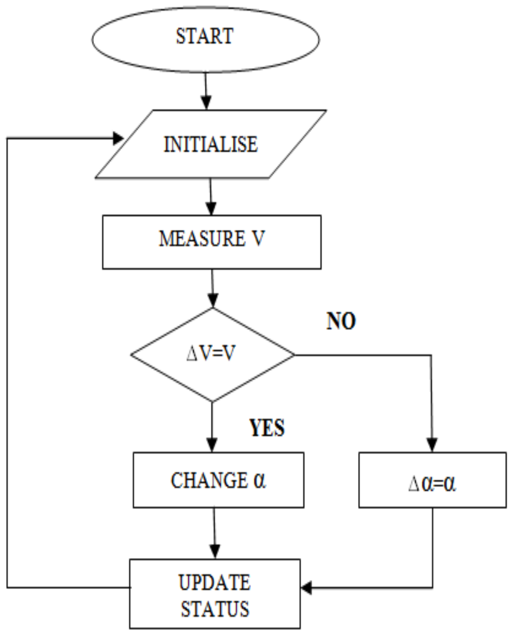

Figure 1: Incremental Conductance Method flow chart

Block Diagram of Solar Converter

The Fig. 2 shows block diagram of Solar Converter. Solar Panel produces voltage depending on illumination of sun. The voltage is regulated by boost converter of about 18 V necessary for battery charging [8]. In between output voltage and input voltage is measured which is given to Microcontroller. The microcontroller varies duty cycle of boost converter according to the incremental conductance algorithm, so that output voltage gets regulated and remains constant.

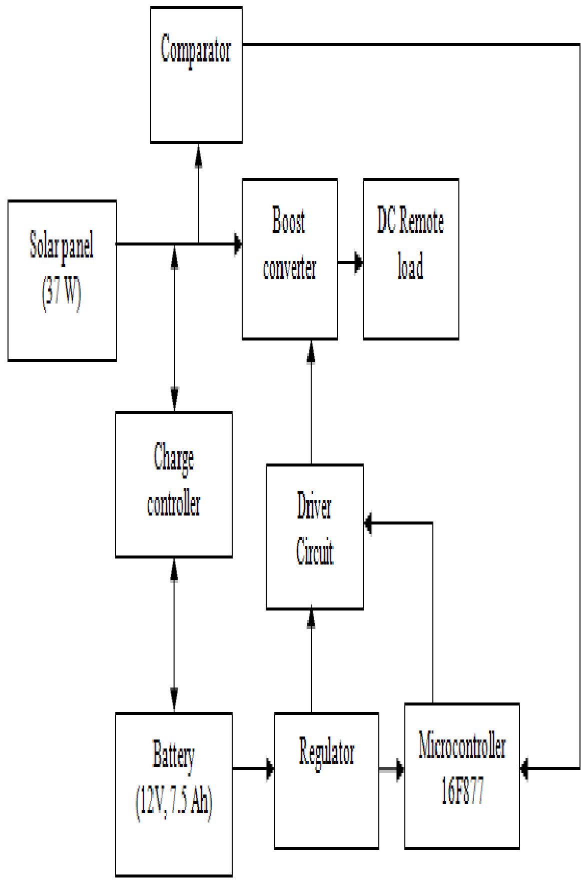

Figure 2: Block diagram of Solar Converter

The solar photovoltaic cells transform the photons of light directly into electricity by photovoltaic effect [9]. Solar panel produces 37W, which is stored in battery and also fed to the boost converter.

The maximum power from solar panel is tracked by the incremental conductance algorithm which is embedded on microcontroller [10]. Microcontroller is preprogrammed by embedded c using PIC C compiler. Charge controller is used to control the power following into the battery and protects the battery from overcharging. Comparator compares the solar panel output voltage gives the feedback to microcontroller.

Microcontroller produce variable duty cycle according to the comparator output and gives to driver circuit. The driver circuit amplifies the signal and gives to the gate of MOSFET. Boost converter produces constant voltage of 18V even though the output voltage of the solar panel varies [11].

Boost Converter Design

The design specifications of boost converter are shown in the table below [12].

Table 1: Boost Converter Design Specifications

Input Voltage (Vs)	12-13V
Input current (Is)	0-2.5A (<5% ripple)
Output voltage (Vo)	18-19V(<5% ripple)
Output current (Io)	0-3A(<5% ripple)
Maximum output power (Pmax)	50W
Switching frequency (f)	40KHz
Duty Cycle (D)	0.385-0.425

Simulation of Solar Converter

Fig. 3 shows the simulation diagram of solar photovoltaic cell with MPPT and boost converter which is connected to resistive load of 40 Ω.

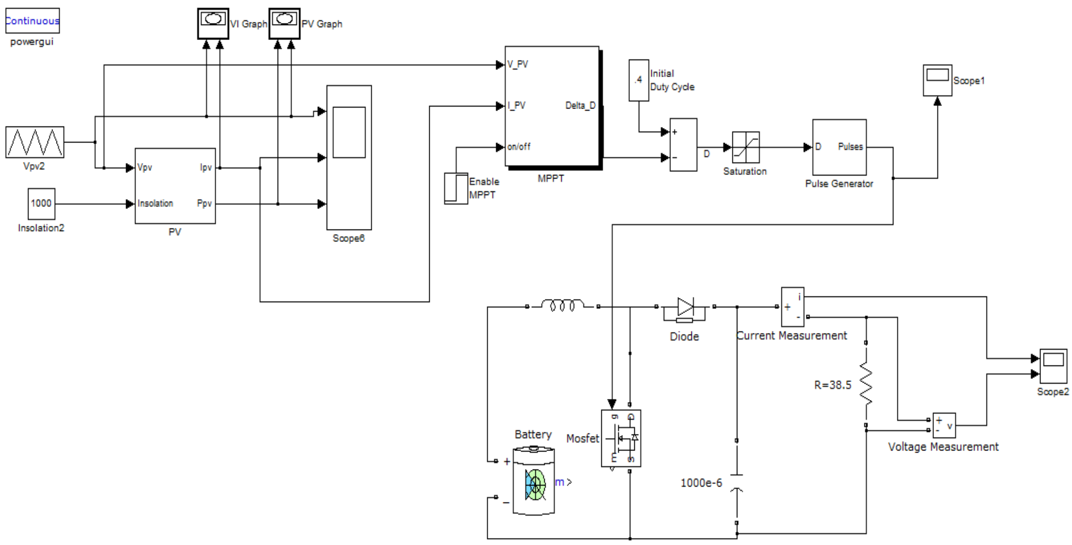

Figure 3: Overall Simulation of the system

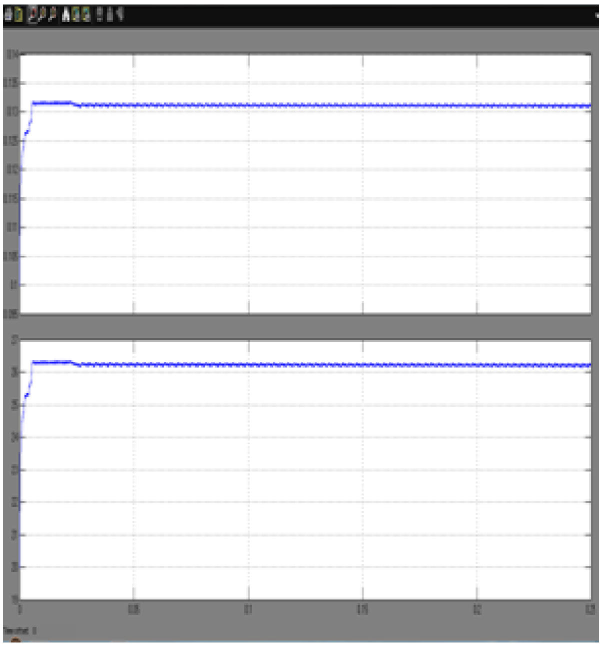

Figure 4: Output of boost converter

Fig. 4 shows the output simulation of boost converter. The output obtained from boost converter is 26 V, 0.13 A.

Solar Panel Testing

When a photovoltaic solar electric panel is exhibit to sunlight it produces DC power. The product of voltage and current gives DC electrical power wattage. The resistance of the electrical load determines the power generated by any solar panel. The current through a resistor is the applied voltage divided by resistance. The method of measuring the power output of a solar panel is to connect various resistor values to the panel and measure the voltage. These measurements calculate the output power [13]. A digital multimeter and assortment of resistors needed to perform the test. In the test execution each power resistor is connected to the panel and voltage is measured with the meter.

Figure 5: Testing of Solar Panel

Fig.5 shows the measurement of voltage and current of solar panel using digital multimeter with the constant load (resistive) of 38.5 Ω.

Test Results

The following are the test results of solar panel under different illumination conditions with a constant resistance value [14]. Table II shows voltage and current readings of solar panel under different illumination conditions connected to the constant load of 38.5 Ω.

Table 2: Voltage And Current Measurement Of Solar Panel With Constant Load Resistance Of 38.5 Ω

TIME	VOLTAGE	CURRENT	LOAD (R LOAD)
10.30	18.60	1.34	38.50
11.00	18.62	1.36	38.50
11.30	18.68	1.36	38.50
12.00	18.77	1.37	38.50
12.30	18.84	1.44	38.50
13.00	18.92	1.58	38.50
13.30	18.97	1.78	38.50
14.00	19.01	1.88	38.50
14.30	19.40	1.92	38.50
15.00	20.50	2.02	38.50
15.30	23.01	1.92	38.50
16.00	23.00	1.90	38.50
16.30	21.33	1.88	38.50
17.00	20.81	1.73	38.50

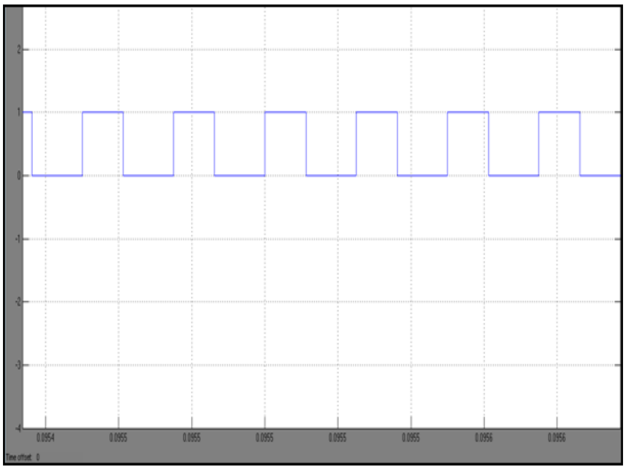

Figure 6: PWM Waveform obtain from MATLAB (input voltage=12V, D=40)

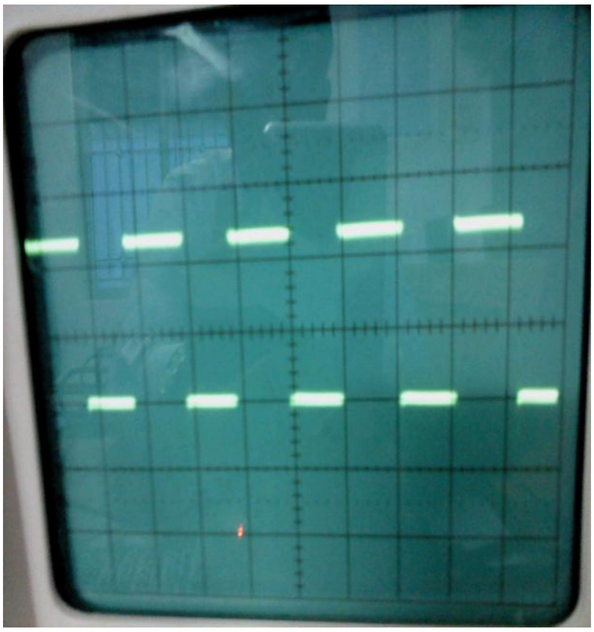

Figure 7: PWM Waveform obtain from CRO (input voltage=12V, D=40)

Figure 8: Testing of Circuit with Solar Panel

Conclusion
In this project a power source for remote low power devices was designed using solar energy. Solar panel of different range was studied and USP37 was selected which is

rated 37 W and 20 V [15]. The panel was tested under different time periods. The test result shows that voltage from panel varies between 10 V to 21 V. The variable voltage from solar panel is regulated using MPPT and boost converter using PIC 16F877 Microcontroller. This system harvests maximum solar energy and stored it in batteries. The stored energy can be used to power the remote devices. This system is suitable to supply the load where conventional power is not available. The boost converter output is 18V so that the system can able to deliver power continuously to the remote load. The main advantage of this system is, it can able to power the devices even under low illumination (At low voltage around 10 V) and also the bidirectional converter used to supply the load and excess energy is stored in battery.

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