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Monitoring & Improving Efficiency of Multiple PV Array using Boost Converter

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Abstract - *The main aim of the project is to create real-time photovoltaic monitoring system and also improving the efficiency of PV array system using the power electronics circuit named as Boost converter. This is created by designing the PV array system with proper solar radiation, current, voltage and temperature values by connecting the boost converter circuit to the photovoltaic array to achieve proper efficiency, and generating an analysed data. This user-friendly data can be shown on the display. This system can be used in many industries which generates electrical energy where the constant voltage source is required for proper efficiency and solar panels monitoring and maintenance.*

1. INTRODUCTION

Nowadays, Humans are more dependent on energy related resources thus energy harvesting has now become main focus in the industries. The main component for generating energy are fossil fuels such as coal, crude oil, petrol, diesel, natural gas etc which are Non-Renewable energy sources. With increasing energy demand these Non-Renewable sources will soon dry out in future. Due to which the prices of non-renewable resources increase daily. Non-Renewable energy are very harmful as they radiate dangerous gases in the atmosphere and its harmful for nature.

To overcome these problems, scientists chose the effective renewable energy. Renewable energy was firstly used in industries but now due to public awareness the renewable energy resources are widely used in small sectors such as household devices, schools, colleges, hospitals. Renewable energy is available in abundance, pollution free and can be recycled.

Solar energy is one of the best renewable energy which can be obtained from nature. Earth receives enough solar energy to power all the industries and household equipment's but humans are not using its maximum potential to extract this energy from the nature. Solar Panels absorbs the radiations from the sun and the convert light energy into electrical energy. For this process it requires continuous light radiation for maximum efficiency. Solar panel is only capable of converting 15% - 25% of light energy to electrical energy. Therefore, it is important to connect multiple solar panels in series to achieve maximum efficiency.

Many factors can reduce the efficiency of multiple solar panels such as dust and bad weather conditions. This could significantly reduce the overall output capacity of the PV array system.

There are many products used in market to monitor the generation of energy from photovoltaic panels. These products is mainly classified into two categories i.e smart micro-inverter and string inverter power sensor.

The string inverter power sensor suffer from lack of accuracy and it does not provide the proper health condition of individual solar panel. Due to which it does not provide a information of total array. Whereas, smart micro-inverter is the new technology in the market and offreach from most industries and this is very much costly product. The price of smart micro-inverter is high due to the complex software used in these techniques and also it is required to be used for individual panels.

1.1 Photovoltaic Cell

Photovoltaic cell are composition of semiconductor compounds like arsenide, telluride and silicon(Si). Small semiconductor of biscuit like structure is treated to create an E-field in solar cells. It consists of two terminals one is positive terminal and another negative terminal which are p-type and n-type respectively. When sunlight hits the solar cell the electrons from semiconductor compounds gets multiplied and then settled in the positive and negative terminals of photovoltaic cells which creates and electricity.

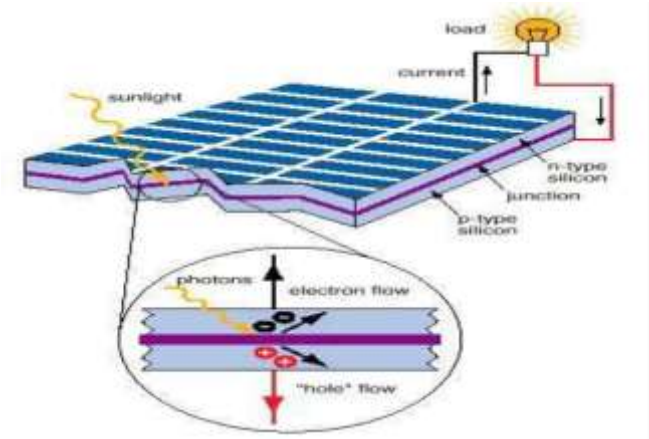

Figure 1: Basic Structure of PV Cell [5]

1.2 Photovoltaic Module

The voltage generated by single PV cell is very low that is around 0.5 volt. Hence, to obtain high voltage and high current. These PV cells are connected in series and parallel respectively. which is termed as PV module. The reverse current which is generated because of partial or total shading, or during nights are avoided by using special diodes.

1.3 Photovoltaic array

The power requirement of home and industries are very high which cannot be satisfied by one PV module hence to fullfill the requirement of high power number of PV modules are attached with each other in series and parallel to obtain high voltage and current respectively.

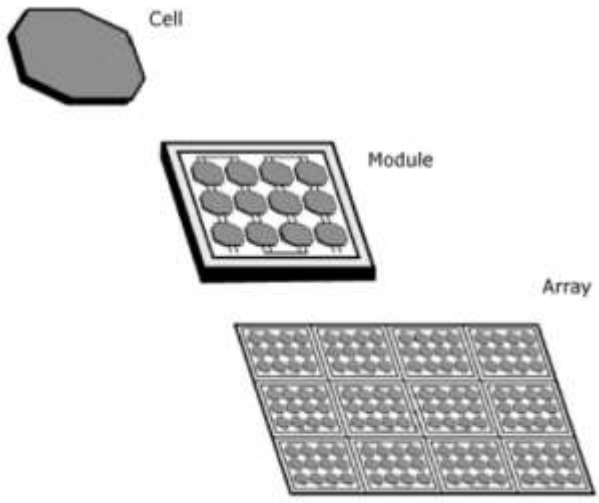

Figure 2: Photovoltaic system

1.4 Efficiency of PV Cell

The efficiency of a PV cell is outlined because the quantitative relation of peak power to input alternative energy and is given by

$$\eta = V(peak)*I(peak) / Int*Area$$

where,
V(peak) = voltage at peak power,
I(peak)= current at peak power,
Int= solar intensity per square metre,
Area = area on which solar radiation fall.

1.5 Boost Converter

Below figure shows the boost converter circuit consists of various analog components such as Dc input voltage source(Vg), diode(D), switch(S), Inductor(L), capacitor(C) and Load resistance(R).

When the Switch(S) is in ON state then the current in the circuit increases linearly and the inductor(L) gets charge during that time and diode(D) is OFF at that time.

When the Switch(S) is in OFF state then the energy stored in inductor is drained from the diode to the output boost converter circuit.

Thus this switching helps the boost converter circuit to boost up the voltage at output for variable input voltage.

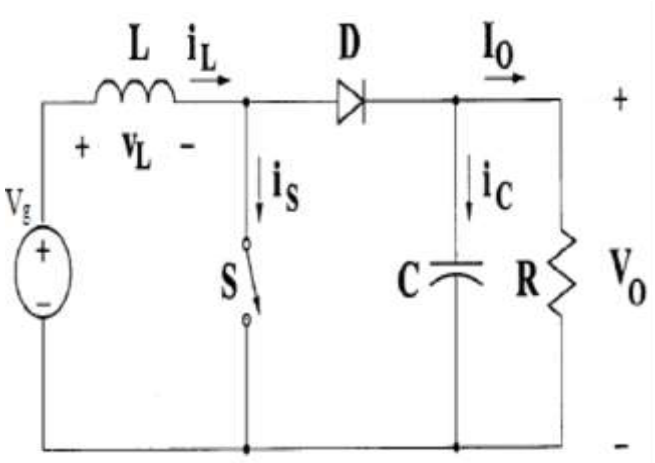

Figure 3: Circuit Diagram of boost converter

So with the help of all this knowledge and their software setup we created a hardware set up for improving the efficiency of PV array using boost converter and also added an analog circuit to provide data of voltage, current and to display the maintenance when required for PV array. With the help of this technique it not only increases the efficiency of PV cell but also reduces the human effort for monitoring the panels and also helps in well maintaining of solar panels.

2. LITERATURE REVIEW

Debashis Das and Shishir Kumar Pradhan students of NIT, Rourkela studied on "Modelling and Simulation of PV array with boost device". The complete energy conversion system has been designed and tested in MATLAB-SIMULINK settings.[1]

During this literature survey and with the help of other sources we have gained a good knowledge about solar energy, photovoltaic system which includes photovoltaic cell, photovoltaic array, and efficiency of PV array cell and characteristics of PV array. So, in this paper we would like to share the brief information about the solar energy and PV system.

3. METHODOLOGY

So firstly as Debashish Das and Shishir Kumar Pradhan did MATLAB simulation we also performed simulation of boost converter on MATLAB and we got the desired output as voltage was increased.

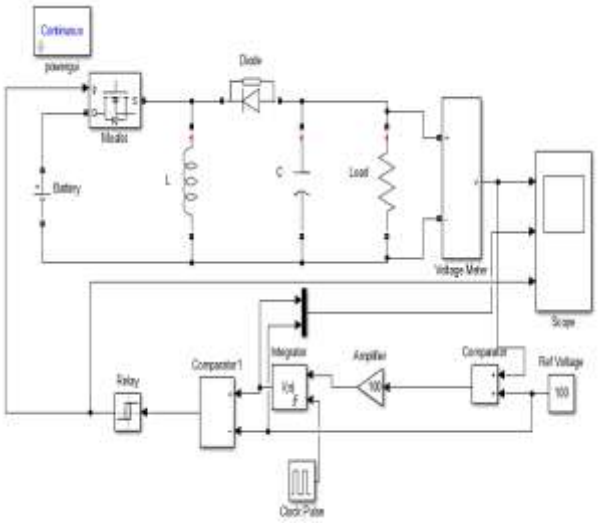

Figure 4: Boost Converter circuit implemented on MATLAB

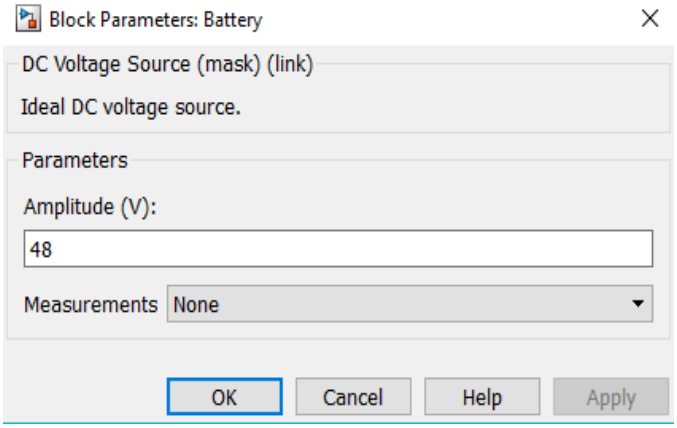

Figure 5: Voltage Parameters

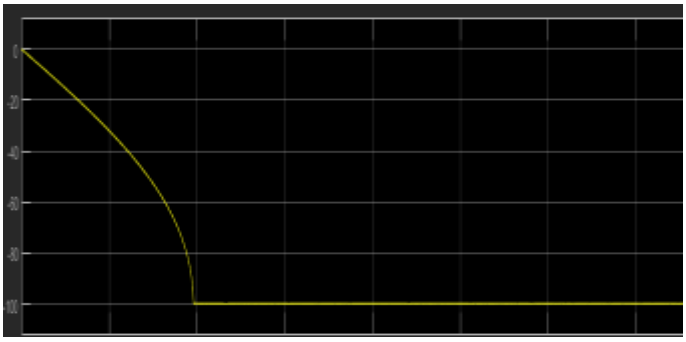

Figure 6: Voltage output on the CRO block

As we are able to see in on top of MATLAB simulation, as the reference voltage was set at 100 V the boost converter device circuit improve the voltage to the reference voltage and as the figure.6 shows the output on CRO as the voltage increase to reference voltage i.e 100 V.

Secondly we have a designed a diagram for analog and digital circuit. The overall idea of this circuit is to connect the PV module to the reference testing load and note the output voltage levels of individual PV cells and also the current flowing through the load. PIC microcontroller is used as main microcontroller unit which is used to analysed the data and process on them.

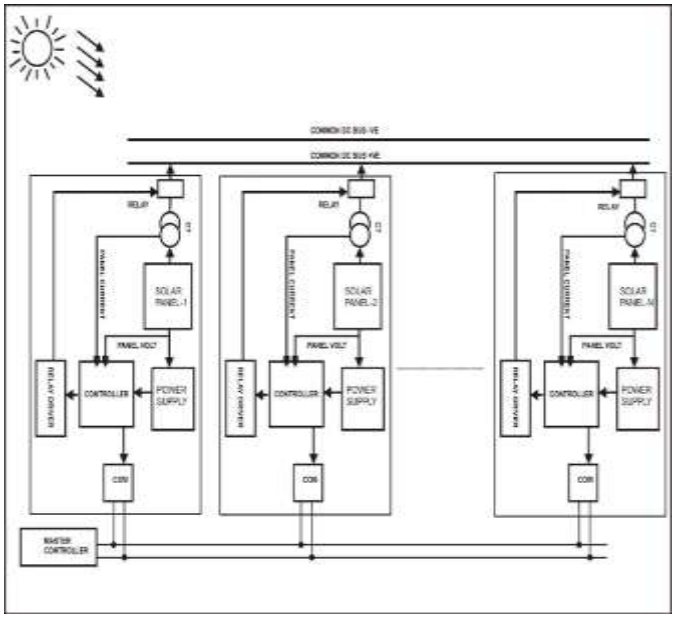

Figure 7: Basic Block diagram of multi PV array using boost converter

Then with the assistance of boost converter circuit and above block diagram we have designed a circuit diagram for hardware implementation.

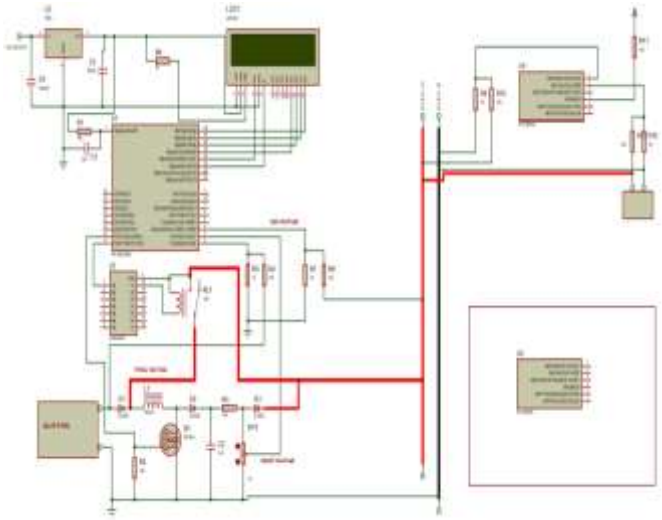

Figure 8: Circuit Diagram of multi PV array using boost converter on Diptrace

The circuit diagram was then designed in DIPTRACE software and this design was then converted in PCB module with the help of laser printing. LCD was interfaced with PIC microcontroller and all the programming in PIC microcontroller was done. with the assistance of MPLAB IDE software and the programming was based on Embedded C language.

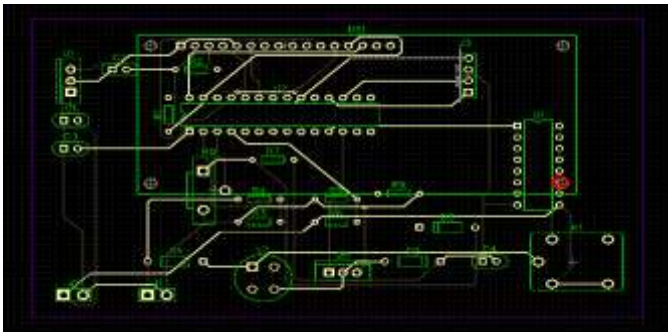

Figure 9: PCB design layout on Diptrace

Then we finally mounted all the components on PCB module as per circuit diagram.

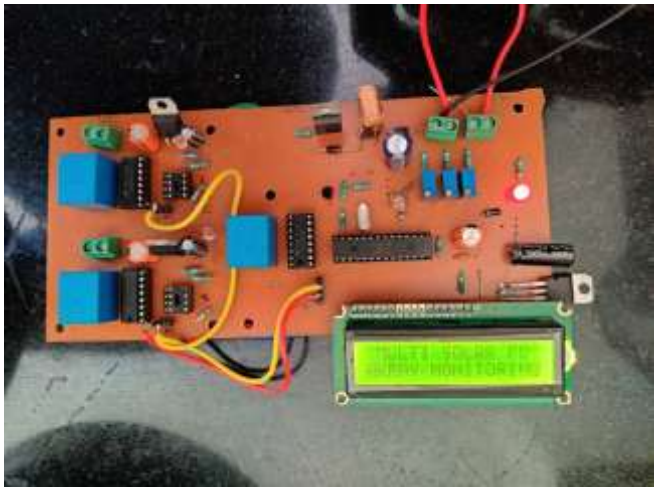

Figure 10: Hardware module of multi PV array using boost converter

Our desired model was finally created with the help of hardware and software which is capable of increasing the efficiency of PV array when required and reduces the human effort of regular monitoring and also reduces the maintenance cost.

4. CONCLUSIONS

With the help of hardware and software which is capable of increasing the efficiency of PV array when required and reduces the human effort of regular monitoring and also reduces the maintenance cost including following parameters.

1. Constant Equivalent Voltage for multiple solar panels.
2. Real time monitoring of Voltage, Current, Intensity and Temperature.
3. Defective Panels are detected and maintenance of panels are suggested on LCD.

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