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MATLAB/Simulink of a Solar Photovoltaic System through Cuk Converter

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Abstract: ***In parallel to developing technology, demand for more energy makes us seek new energy sources. The most important application field of this research is renewable energy resources. Solar energy is being popular ones owing to abundant, ease of availability and convertibility to the electric energy. This paper covers a detailed analysis of solar PV system with Cuk converter such that it gives constant and stepped up dc voltage to the load. A Cuk Converter is used for examine the performance of solar PV system. Simulink of cuk converter in PV system and analyzing output voltage through MATLAB.***

Keywords: Renewable energy System, Photovoltaic System, Cuk converter, MATLAB/Simulink.

1. Introduction

One of the major concerns in the power sector is the day-to-day increasing power demand but the unavailability of enough resources to meet the power demand using the conventional energy sources. Energy is the prime mover of economic growth and is vital to the sustenance of a modern economy. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible and environment. Demand has increased for renewable sources of energy to be utilized along with conventional systems to meet the energy demand [3]. Solar energy is abundantly available that has made it possible to harvest it and utilize it properly. Solar energy can be a standalone generating unit or can be a grid connected generating unit depending on the availability of a grid nearby[4]. The power conversion mechanisms have been greatly reduced in size in the past few years. The development in power electronics and material science has helped engineers to come up very small but powerful systems to withstand the high power demand. They can hardly compete in the competitive markets as a prime power generation source. The PV module represents the fundamental power conversion unit of PV generator system [4].

1.1 PV Module

A solar cell is the building block of a solar panel [1]. A photovoltaic module is formed by connecting many solar cells in series and parallel. Considering only a single solar cell; it can be modeled by utilizing a current source, a diode and two resistors. This model is known as a single diode model of solar cell. Two diode models are also available but only single diode model is considered here in fig. 1 [3]

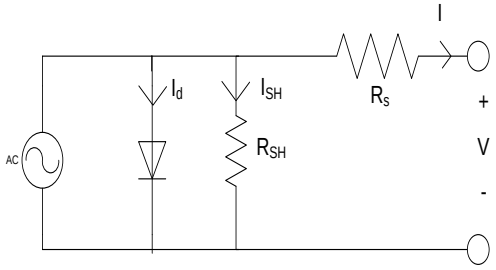

Fig.1 Single PV cell module

1.2 Principal of Operation

PV Cells are basically made up of a PN junction fabricated in a thin wafer or layer of semiconductor [2] (usually silicon). Fig. 2 shows the photocurrent generation principle of PV cells. In fact, when sunlight hits the cell, the photons are absorbed by the semiconductor atoms, freeing electrons from the negative layer. These free electrons find its path towards the positive layer through an external circuit, resulting in an electric current from the positive layer to the negative layer. [5]

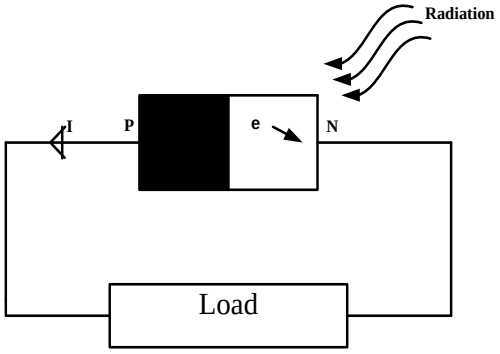

Fig:2 Photocurrent generation principle

1.3 Maximum Power Point

For maximum utilization of the energy available from the solar generator, it is essential to match the load to solar generator. It can be seen from the figure 3 that the maximum power point at

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different solar insolation varies in such a way that the optimum voltage of operation keeps decreasing with increasing insolation. Hence, a Maximum Power Point Tracking (MPPT) charge controller which automatically permits the PV array to operate the voltage that produces maximum power output is utilized. [4]

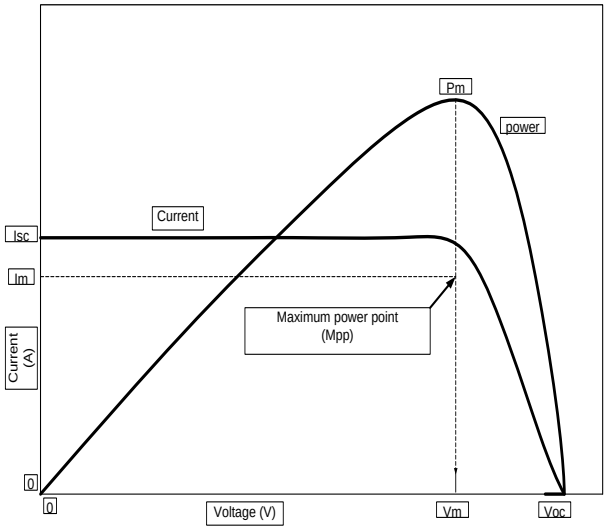

Fig: 3 Maximum power point tracking

1.4 Cuk Converter

For storage or other DC components to be used in conjunction with AC loads, some type of power conversion capability is required. Considering that the output characteristic of a photovoltaic cell has a wide voltage range, depending on the operating conditions of a photovoltaic cell, the DC/DC converter needs to have a wide input voltage range to regulate the constant output voltage. To achieve high step-up and high efficiency DC/DC converters is the major consideration in the renewable power applications due to the low voltage of PV arrays and fuel cells. The purpose of dc-dc converter is insure the impedance adaptation between the PV source generation and the main utility by tracking the reference voltage required by the grid. The DC-DC converter converts a DC input voltage, to a DC output voltage, with a magnitude lower or higher than the input voltage. [5]

There are several different types of dc-dc converters, buck, boost, buck-boost and cuk topologies, have been developed and reported in the literature to meet variety of application specific demands. [6] There is a synchronous DC-DC cuk converter design and implement for photovoltaic application. [7] Synchronous cuk converter has a significant advantage over other inverting topologies since they enable low voltage ripple on both the input and the output sides of the converter. So, the performance of photovoltaic system and the output efficiency of converter is improved. [8] [9] [10]

2. Proposed PV Module: IV curve & PV curve

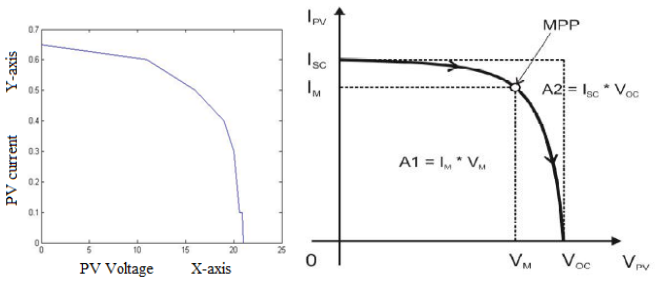

Fig. 4 (a) IV curve

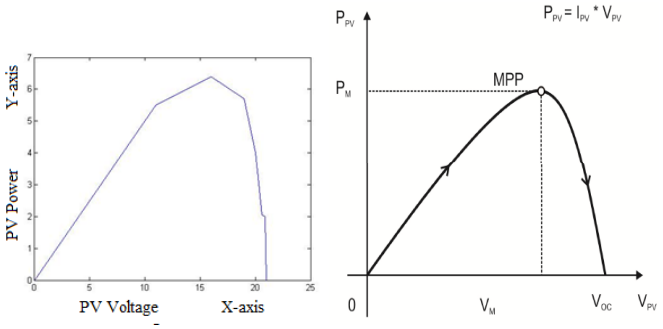

Fig. 4 (b) PV curve

3. Simulink Model of PV System with Cuk Converter

Cuk converter based photovoltaic energy system used for mathematical modelling as simulink using MATLAB software for analysing of voltage and current. For PV module function is simulink with the help of programming and another part such as converter, voltage regulator and filter with simulink. Solar energy is essential for generating voltage at minimum maintenance cost because it's a natural source of energy. Cuk converter is also simulink for uplifting the voltage level as per requirement of load. As shown in figure the output of PV module gives as input to the Cuk converter and another fig shows the optimized output of PV module using Cuk converter.[11]

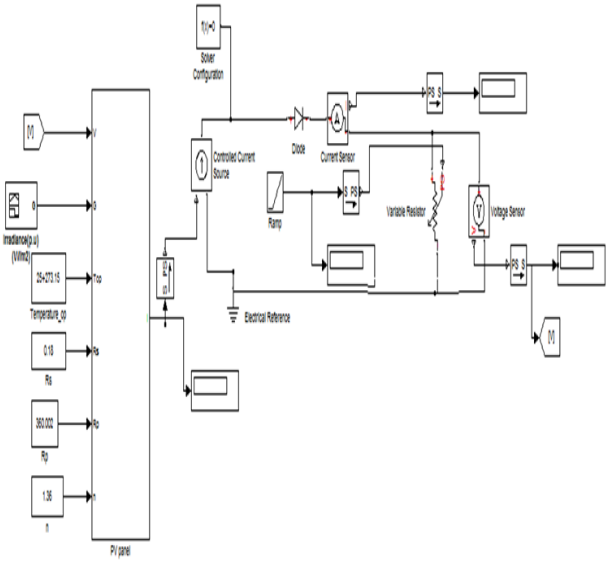

Fig.5 Simulink of PV Module

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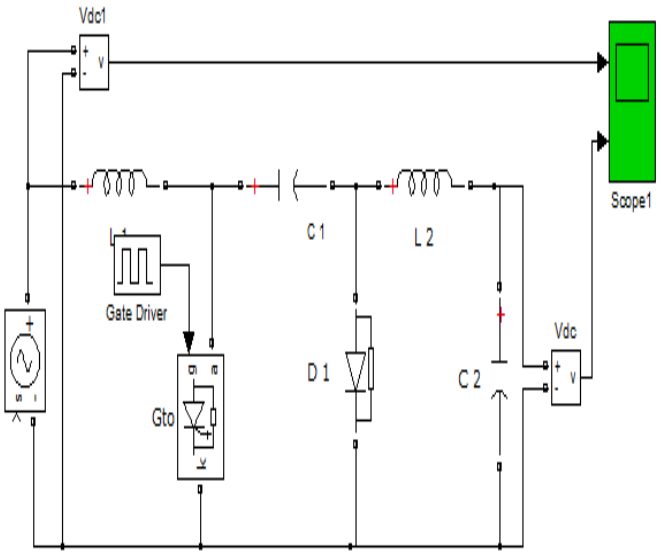

Fig. Simulink of Cuk Converter

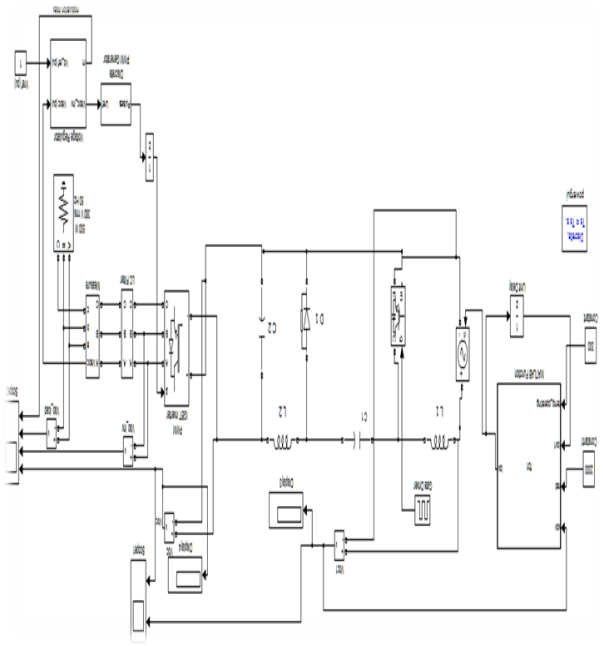

Fig. 6 Simulink of PV Module with Cuk converter

4. Results Analysis

Cuk converter simulation is done using MATLAB. The duty cycle is deviated and compatible voltage and current is analyzed in the Cuk converter. It is observed that the operation of Cuk converter is better as compare to converter. According to this analysis, the output power of Cuk converter is maximum.

From the relative examination, it is unveiled that the proposed Cuk converter is better when analyzed to other converter. The proposed converter efficiency is varied more. Hence, the proposed Cuk converter used with PV system is better than the PV system used without cuk converter application.

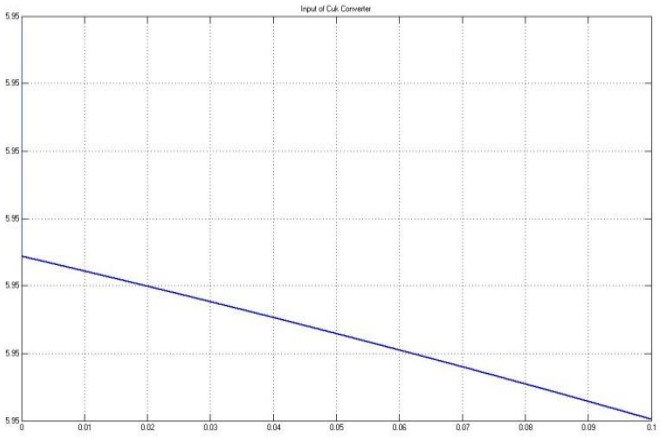

Fig. 7 Input Voltage of Cuk Converter

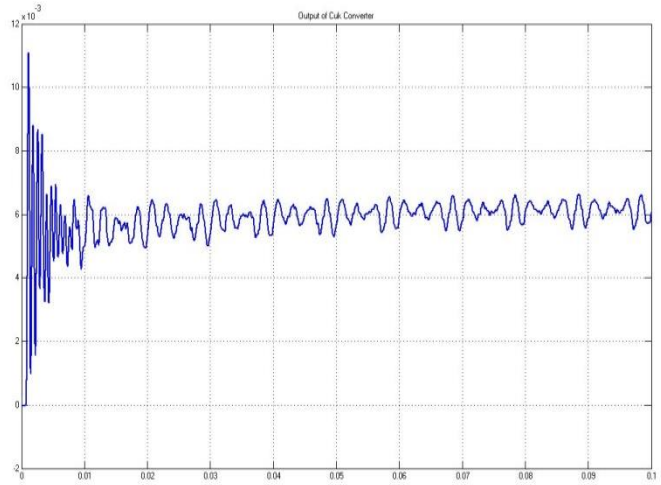

Fig.8 Output Voltage of Cuk Converter

5. Conclusion

The Cuk converter based solar PV system was considered for Simulink through programming in MATLAB. It is based on the electrical equations of the solar PV module. A MATLAB/Simulink model was designed to validate. The solar PV module was used to analyze the Cuk converter based PV system. The input voltage (Output voltage of the solar PV module) of the Cuk converter-based solar `PV system was regulated for the change in irradiation using a voltage controller. Also the DC-DC Cuk converter used in solar PV system was stable and the input voltage was kept within the specified range under disturbances at the source voltage and the change in irradiation.

At first output PV system is observed without Cuk converter and after that a Cuk converter is used with systems which optimize its output.

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