Scope International Journal of Science, Humanities, Management and Technology. ISSN : 2455-068X
Vol.2 Issue 2 (2016) 125-129. Submitted 28/03/2016. Published 05/04/2016

HIGH STEP UP CONVERTER FOR SOLAR POWER USING FLC

[1]Priya.M, [2]Padmashri.A, [3]Muthuselvi.G, [4]Sudhakaran.M,
[1,2]Student, Dept of EEE, GTEC Engineering college, vellore,
[3]Asst prof, Dept of EEE, GTEC Engineering college, vellore.
[4]Asso prof, Dept of EEE, GTEC Engineering college, vellore.

Abstract:
In this paper, the conventional DC-DC converter is replaced with a High Step-up Converter for the Maximum Power Point Tracking (MPPT) in solar power applications. The performance of converter-inverter technology to drive a brushless DC motor is analysed. The converter switching power losses is eliminated by zero-voltage method in this proposed converter. The fuzzy controlled high step-up converter increases the output voltage from the panel compared to the conventional type. The DC to DC converter is operated at an adjustable duty cycle by the fuzzy logic controller. The advantage of the proposed high step-up converter for the MPPT compared to the conventional type are, the output is efficiently increased and regulated by the boost operation. This avoids the parallel buck operation. The ZVS technique further reduces the power loss due to frequent switching. The proposed fuzzy controlled unidirectional operation of the high-step up MPPT converter is analysed. The experimental results are compared for different inputs and analysed.
Keywords:Brushless DC Motor, Fuzzy Logic Controller, High Step-up Converter, Maximum Power Point Tracking, Zero-voltage switching.

1. INTRODUCTON

The years of research in solar power applications have reached to a greater extent in the field of power generation and utilization. Problems caused due to non-renewable resources are being explained for years which introduced the renewable energy resources using wind, solar, tidal, water as its major source of power generation. The influence of these renewable resources requires a higher power generation compared to the non- renewable resources. This is being a major problem for years, in comparison to the existing non-renewable energy units.

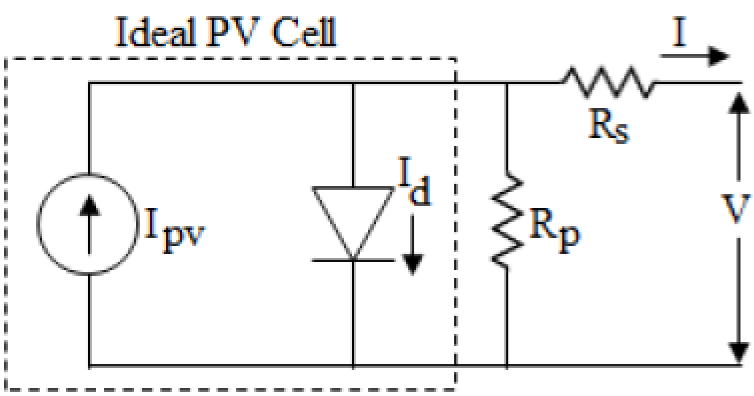

Fig.1. Equivalent Circuit of PV Cell

In developed counties, the problem is solved by introducing the advanced control units for the renewable energy resources to compete the production capacity of the non-renewable energy resources. However the research and developments have a challenging environment in producing high power generation units using renewable energy. The use of the solar is widely seen in many applications. However the power conversion from the renewable energy is the challenging task. It is well known that the power extraction from the renewable energy is not possible for 100% extraction. This challenging task over years has developed various power electronics techniques to extract the maximum power from the renewable source. In solar, the solar panels require the maximum power point tracing system (MPPT) to obtain the maximum power. In conventional methods the MPPT is performed using the DC-DC converter through the controllers. This DC-DC converter is operated both in buck and boost operation to obtain the wide range of voltage values. There are various methods to obtaining the maximum power from the solar energy. Each method has its own significance. The solar energy form the solar power is converted to electrical form using the solar PV panel. The solar radiations are not the constant source so the output of the solar panel is also variable [4]. The power constancy is obtained by using the DC-DC converters. The different DC-DC converters are the buck, boost and cuk converters are used based on the application requirements. The implementation of cuk converter for the power constancy which is also referred to maximum power tracking method is used in direct control of power extraction [1]. The MPPT techniques have various advantages which is discussed and compared and the significance are studied [2]. The implementation of boost converter is more common among the MPPT technique. The boost converter output is comparatively efficient however; the extraction of power from the panel is considerable limited [3]. In some applications it is necessary to have the buck and the boost converter to obtain the various level of the power output, but the cost of two converters in a single system is not much efficient for the power generation [5]. Further discussions have turned another new method of MPPT for the lower power solar PV panels [6]. In the proposed method, the MPPT involved uses the boost converter which is controlled using the fuzzy logic controller. This fuzzy logic controller efficiently controls the boost converter operation in obtaining the maximum power from the solar PV panel.

2. MODELLING

The solar PV can be modeled by a current source acting as the PV panel current (Ipv) connected to the parallel diode. The equivalent structure implies the photo-diode operation producing the current (I). The combination of the series resistance (Rs) and the parallel resistance (Rp) refers to the solar array consisting of the

$$I = I_{pv,cell} - I_d \quad (1)$$

Where, $$I_d = I_{0,cell}\left[\exp \frac{qV}{akT} - 1\right] \quad (2)$$

Therefore, $$I = I_{pv,cell} - I_{0,cell}\left[\exp \frac{qV}{akT} - 1\right] \quad (3)$$

Where, $I_{pv,cell}$is the current generated by the incident light (it is directly proportional to the Sun irradiation), I_d is the Shockley diode equation, $I_{0,cell}$is the reverse saturation or leakage current of the diode, q is the electron charge ($1.60217646 \times 10^{-19}$ C), kis the Boltzmann constant ($1.3806503 \times 10^{-23}$ J/K), T (in Kelvin) is the temperature of the p–n junction, and ais the diode ideality constant. The figure 2 shows the origination of the I – V curve for the equation (2). Practical arrays are composed of several connected PV cells and the observation of the PV array requires the inclusion of additional parameters to the basic equation. The output voltage is increased by increasing the number of the series cells because the voltage gets added up in series combination. Similarly, the current is increased on parallel connection of the solar cells as the current gets added up in parallel combination under same direction. If the array is composed of Np parallel connections of cells the photovoltaic and saturated currents may be written as,

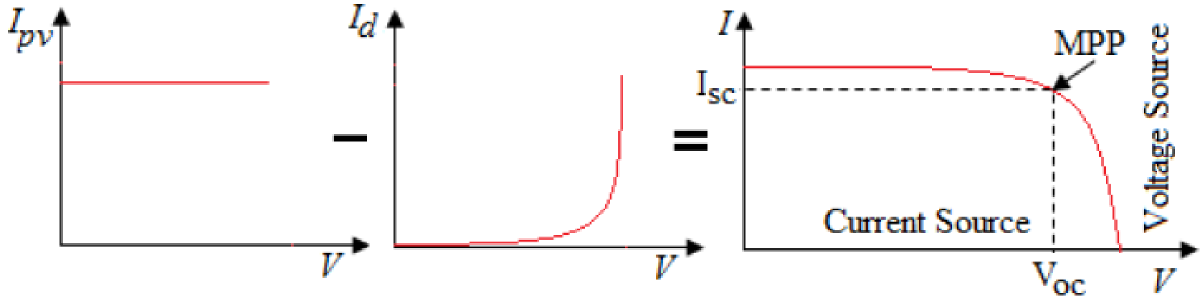

Fig.2. Origin of I-V equation of an Ideal PV cell curve of a practical PV module and Characteristic I-V curve of a practical PV module

The mathematical modeling equations of the PV panel are modeled using suitable equations programmed in the MATALB. This simulation is done for standard test condition (STC) when temperature is 35°C and Irradiation is 3000 W/m2. The modeling is done for a 500W solar panel.

3. MODELLING OF MPPT

DC-DC Converters are prominently used to obtain the Maximum Power output from the PV panel. The conventional DC-DC are operated both in buck and boost condition. The optimized output value is set such that if the output from the panel when comparatively less to that of the desired out is boosted and when comparatively greater than the desired output it is bucked. This double operation minimizes the output level due to the frequent operation of the converter both in buck and boost operation. In the proposed method, a high step up converter is used such that for any output obtained from the panel can be boosted to a maximum constant value to attain the maximum power.

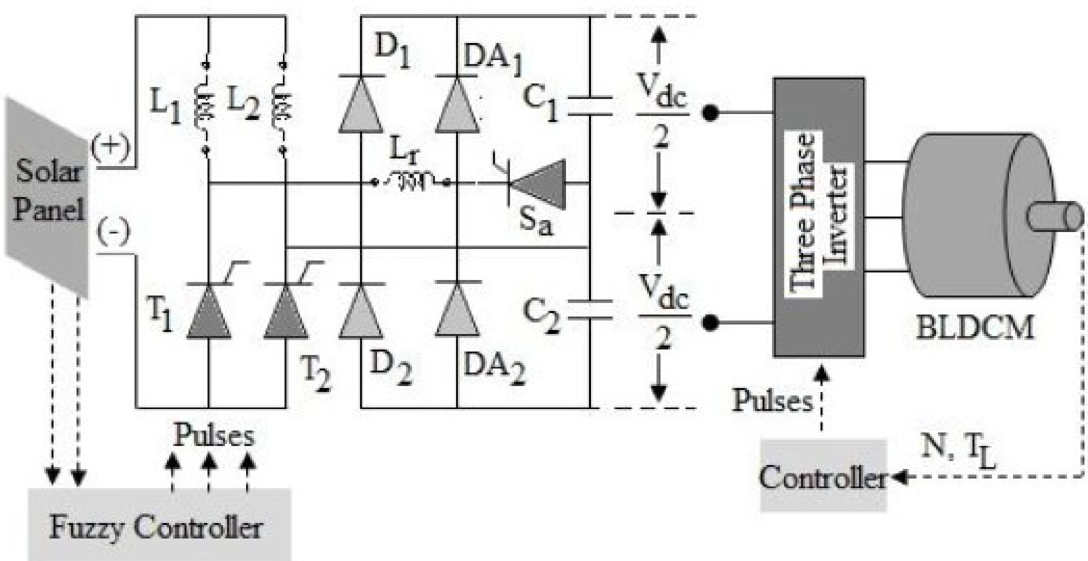

Fig.2. Proposed High Step-up Converter Driven BLDC Motor

This can be done by selecting the duty cycle of the converter such that the voltage is boosted to a constant value. This can be performed using a controller to convert feedback signals to a desired output pulse for the converter. In this proposed technique fuzzy logic controller is used to select the desired duty cycle. Due to this the limitation in the linear voltage output is eliminated. The switching losses are reduced as the converter operates only in boost condition. The figure 3shows that high step-up converter for the MPPT technique. The circuit diagram consists of the Solar PV Panel connected to the proposed converter. The output of the panel is controlled by the step-up DC-DC boost converter. The converter produces a constant boosted output for the load. The stepped voltage is inverted using an inverter to supply the brushless DC Motor. The power drop during the inversion process is compensated by stepping up to a higher value at the input level so as the losses is reduced during the power conversion and drive operation. The proposed high step up DC-DC boost converter is constructed using two thyristor switches T1 and T2 connected in series to the inductor L1 and L2 respectively. The gate pulses are signaled to switch ON and OFF the thyristor switch T1 and T2. A resonant inductor is connected to this boost circuit which consists of the series combination of diodes D1 and D2and additionally a parallel combination of auxiliary diodes DA1 and DA2. The stress in the switching of the thysistor is reduced by soft switching using the Auxiliary thyristor switch Sa which is turned ON and OFF using separate gate pulses. This is due to the zero voltage switching (ZVS) technique followed in the proposed converter circuit. The output of the converter is maintained constant by the capacitors C1 and C2. The output is maintained constant thereby to supply as a source to the three phase inverter. The boosting nature of the circuit produces the voltage step up level at the motor rated voltage thus driving the motor. The input current is constant and is greater than the resonant inductor is observed during the cycle and a large value is assumed for the power factor pre-regulator inductor L1 and L2. The constant and ripple free values are obtained in the voltage Vdc by the capacitor C1 and C2. The lossless switching operation is obtained using the zero voltage switching of the proposed converter. The inductor and capacitor values and the switching pulses for both the thyristor switches are mathematically calculated. During the ON and OFF condition the auxiliary switches perform the ZVS operation.

4. RESULT ANALYSIS

The prototype model of the proposed method is developed for a 500W solar panel. The solar panel is regulated using fuzzy logic controlled to track the maximum power using high step up DC-DC converter.

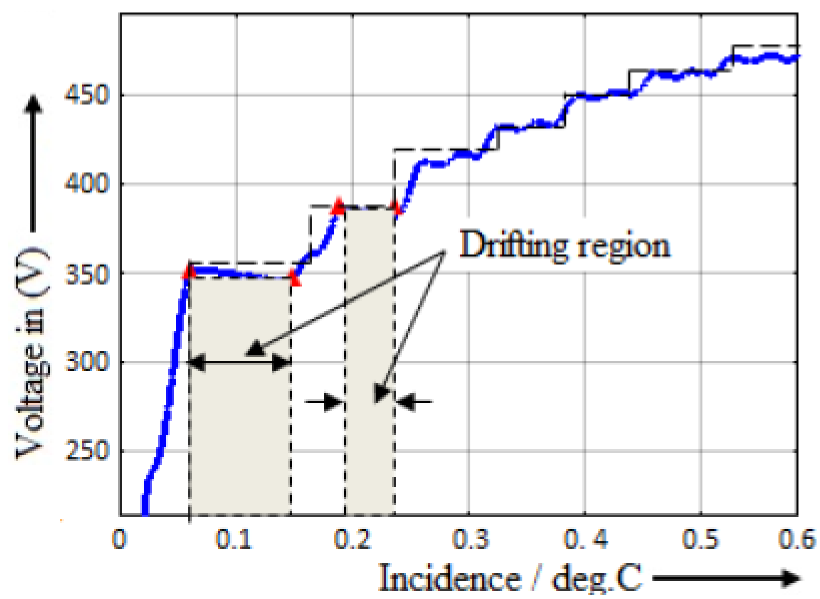

Fig.3. Voltage vs. Incidence/deg.C

The high DC-DC step up converter acts as the MPPT controller to track the solar power. The SVM is

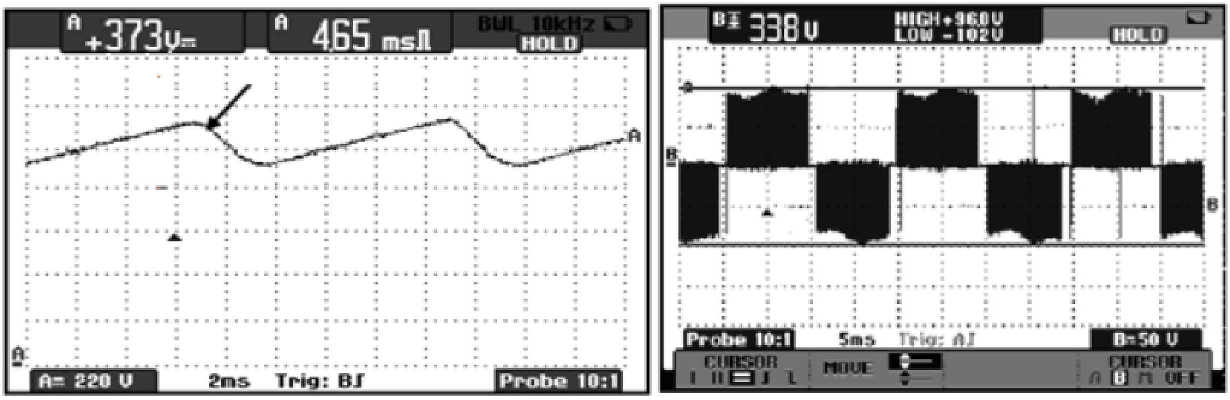

Fig.4. Voltage output (a) from the panel (b) from the inverter

CONCLUSON:
The proposed high step-up DC-DC converter replaces the conventional DC-DC converter for the MPPT technique. The proposed technique involves boost conversion of the input power produced by the solar panel. The high step up converter steps up to the maximum value and regulates the value of the voltage to a constant value irrespective to the change in the input voltage. The conventional MPPT using the DC-DC converter involves the buck boost conversion which is limits the voltage output. The power extracted from the panel is inverted using the space vector controlled three phase inverter with minimum power loss. The proposed method provides a high step up power output for the drive application. Here the BLDC motor drive is used to study the performance. Extending its scope, the proposed method can be implemented in hybrid power generation.

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