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MPPT CONTROLLER BASED MAXIMUM CONDUCTANCE METHOD FOR ENHANCEMENT OF SOLAR ENERGY

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Abstract-Increase of load and demand factor on power grids has made supply of electric power to rural areas as a big challenge. The idea of increasing the number of power plants could not be much efficient because it increases the emission of carbon and production cost. Hence use of renewable power sources seems to be much more efficient. The main motive of this proposed work is an efficient design of solar panel for constant Current-Voltage (V-I) characteristics of a Photovoltaic array of various environmental conditions like different irradiance and temperature. A proposed model uses constant environmental condition in combination with actual solar radiation and ambient temperature. The new design is developed on Mat lab-Simulink platform for calculating and analyzing the power output from a PV panel by taking the values of current and voltage with constantly varying solar radiation at any geographical location and different day The output power of solar panel is directly given to dc /dc controller in order to reduce circuit complexity. The estimation of MPP (maximum power point) of a Photovoltaic (PV) array is done by calculating the value of both ampere, voltage and power curves for changing environmental conditions.

Keywords: maximum power point tracking, conductance, solar energy, inverter

I. Introduction

Energy consumption tends to grow continuously. Due to this the rapid use and depletion of fossil fuel occurs. These factors lead to the need of renewable energy resources such as wind, fuel stack, photovoltaic etc. Researches were carried out to obtain maximum power with high efficiency from renewable energy. Solar and fuel cell energy play the major role among renewable energy resources and act as major challenges. The conversion of fuel cell and photovoltaic energy in to useful energy such as AC, DC source is increased to meet global energy requirements. High step up DC converter play major role in backup energy for grid system [2] and in many application as shown in Fig.1. The boost converter is used to obtain high output voltage but operate at extreme duty cycle. Theoretically boost converter gain tend to infinite when duty cycle tend to unity. Step up converter with coupled inductor provides high output voltage without using extreme duty cycle and reduce voltage stress across the switch. Single switch topology may reduce switching losses and stress across the switch [5]. The single switch with high gain interleaved DC boost converter is proposed to obtain high output voltage and act as soft switching converter [9]. An interleaved converter with single switch can have low input current ripple and reduced switch current stress due to interleaved operation. The major challenges of renewable energy sources are due to non-linear characteristics. The MPPT (maximum power point tracking) is required to track maximum power from PV panel [1]. Because of safety is uses, the operating output voltage level is very low between 25-50 V. Thus large voltage boosting is required for various applications.

There are two distinctive and only lightly related concepts called tracking. It is important to differentiate between the two. The two concepts are one is Maximum Power Point Tracking (MPPT): an electronic function that regulates voltage current parameters to allow the modules to produce all the power they are capable of out of a solar panel. Additional power harvested from the modules is then made available as increased battery charge current Mechanical Tracking: a method to physically move the solar panels to keep them facing the sun at an angle that changes with time depending on the sun position. Electronics and programming are used in MPPT to change the electrical operating point (usually the voltage) of the modules so that the modules are able to deliver maximum available power. Monitoring the Current (I) vs. Voltage (V) curve also known as the IV curve that is knee shaped, by slightly moving the voltage level a significantly higher current can be achieved

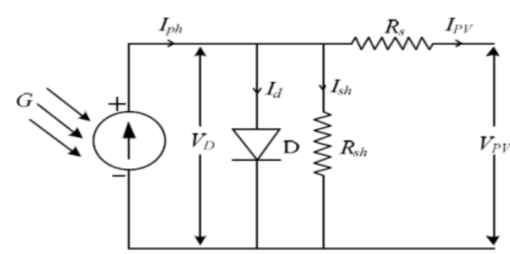

Fig 1: PV cell equivalent circuit

An electrical equivalent circuit of solar cell can be obtained as shown in Fig. 1. The circuit contains a current source with a diode, a shunt resistance and a series resistance. The current Id is mainly responsible for producing the nonlinear I-V characteristics of the PV cell.

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II. Factors To Be Considered Before Constructing Solar Panel

A. Material used for PV panel

The power generated in solar panel depends on the type of material used in construction. CIGS solar cells are very thin solar panel array with 10% thickness. The existing system contains homogeneous junction whereas, CIGS possess heterogeneous junction. Due to high variability in the absorption of incident light radiation, CIGS have more working time than other materials, the absorption spectrum of CIGS changes from 300-1300 nm, whereas in case of other panels it was about 400-700 nm. Due to a thin structure of solar panels, temperature transfer to the surrounding environment was increased. Therefore, temperature coefficient was very much lesser than the existing solar panel [7].

$$I = I_{PV} - I_o\left[exp\left(\frac{V + IR_S}{V_t N}\right) - 1\right] - \frac{V + IR_S}{R_p}$$

$$I_{pv} = \{[1 + a(T - T_{ref})]I_{sc}\}\left[\frac{G}{1000}\right]$$

$$I_o = I_{o(T_{ref})}\frac{T}{T_{ref}}]^{\frac{3}{n_e}}\frac{qE_g}{nk}\left[\frac{1}{T_{ref}} - \frac{1}{T}\right]$$

B. Solar irradiance

Solar irradiance value is calculated by taking power/unit area. The value of irradiance is received from the Sun in the form of visible and electromagnetic spectrum with many wavelength ranges The projected PV panel has ability to absorb deep range of spectrum wavelength and consequently, the operating time of panel upsurges. Irradiance can be measured with the help of intensity meters at the surface of PV panel after atmospheric absorption and scattering of incident light. Irradiance from the sun varies largely in a given year. So by calculating the value of solar irradiance based on the history of irradiance, efficient construction of solar panel is achieved. A PV panel used is more efficient for a varied range of climatic conditions [8].

C. Temperature of solar panel

The temperature in PV panel is inversely proportional to the power from equation (1). In a PV cell, once the material resistance is more, then the electron speed would decline causing subsequent devaluation in the yield. Henceforth, sustaining the temperature to be idle is vital in sun powered board. As the temperature coefficient of existing panel is negative and ranges from 0.4-0.5%, for upsurge in temperature the output power decreases by 0.5% respectively. The coefficient of temperature in our panel is of about 0.1%, so the loss of power is minimized.

D. Efficiency of inverter

PV system is associated with battery backup and inverter circuit for transmitting power to remote places. According to the law of energy conservation, always energy loss may occur [6]. The solar inverters are available in market with 80% - 90% efficiency range. Hence, to obtain better efficiency and eliminate harmonics sine wave inverter is designed. In order to reduce harmonics, STATCOM based power quality enhancement method for the reformed output power factor is used

E. Efficiency of battery

The output from the solar panel will be directly stored in the battery and battery will be connected to the inverter and then to load. The charge stored by the battery will be delivered to an inverter and to the loads [10]. The efficiency of the battery will be fine at the time of installation, but due to aging and sulfation the battery efficiency will be reduced heavily. Hence the efficiency of the battery needs to be cross checked at regular intervals. The power output from the battery will be

$$E_{in} = V_c I_c \Delta T_c$$

B. Design of maximum power point tracking controller MPPT controller working is mainly based on the relationship between the output Power-Voltage (P -V) curve of a solar panel. The main concept behind our proposed model is agitation analysis using average value techniques. The main input needed for this analysis are output current and voltage from the solar PV array. The power output from the solar array are computed by-product of Voltage (V) and current (I). The maximum power and voltage value at the output x terminal are computed from the difference between the present value and the average of the previous value from the PV panel. From instantaneous conductance algorithm, the maximum power of the PV panel is computed by incorporating the average value of previous maximum conductance output to the instant value of conductance.

III. Methodology

A. Conductance calculation

Proposed system works with the concept of taking the conductance value by taking the ratio between values of both current (Isc) and voltage (Vop) [3]. Since short circuit current is the highest possible amount of current that can flow in an electrical circuit, by calculating the amount of short circuit current and open circuit voltage in the circuit maximum value of conductance value of the circuit is obtained.

$$\frac{dI}{dV} = -\frac{I_{sc}}{V_{oc}}$$

Where dI denotes the change of current and dV is the value of change of voltage.I_{sc} denotes the short circuit current of the PV array, V_{op} denotes the open circuit voltage of the PV array

$$I_{sc} = \frac{V_B}{R_{Total}}$$

Thus, the maximum power of PV panel is calculated with the short circuit current and open circuit voltage.

$$V_{OC} = \frac{nT}{q}\log(\frac{I_{\max}}{I_{\min}} + 1)$$

Where n is the ideality factor, T is the room temperature.

$$\frac{dI}{dV} = -\frac{I_{MPP}}{V_{MPP}}$$

This is the formula to evaluate maximum values of current and voltage that remains in the circuit.

IV.Boost Converter

Basic Principle of Boost The boost is a popular non-isolated power stage topology, sometimes called a step-up power stage. Power supply designers choose the boost power stage because the required output is always higher than the input voltage. The input current for a boost power stage is continuous, or non-pulsating, because the output diode conducts only during a portion of the switching cycle. The output capacitor supplies the entire load current for the rest of the switching cycle. Fig.2. shows a simplified schematic of the boost power stage. Inductor L and capacitor C make up the effective output filter. The capacitor equivalent series resistance (ESR), RC, and the inductor dc resistance, RL, are included in the analysis. Resistor R represents the load seen by the power supply output.

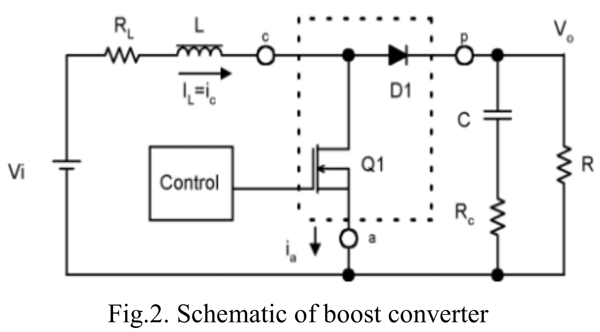

Fig.2. Schematic of boost converter

A power stage can operate in continuous or discontinuous inductor current mode. In continuous inductor current mode, current flows continuously in the inductor during the entire switching cycle in steady-state operation. In discontinuous inductor current mode, inductor current is zero for a portion of the switching cycle. It starts at zero, reaches peak value, and return to zero during each switching cycle. It is desirable for a power stage to stay in only one mode over its expected operating conditions because the power stage frequency response changes significantly between the two modes of operation.

V. Result And Discussion

In this section, time and space simulated responses of the projected framework using Matlab Simulink under various environmental conditions were performed. Under dissimilar environment conditions the response of PV panel were briefly discussed. It is found that proposed MPPT algorithm showed better improvement in the output power of PV panel. While evaluating with P&O method, the maximum conductance technique produces efficient output.

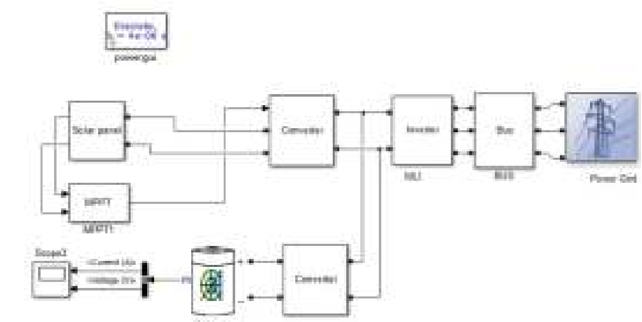

Fig 3. Model of Solar PV array with MPPT

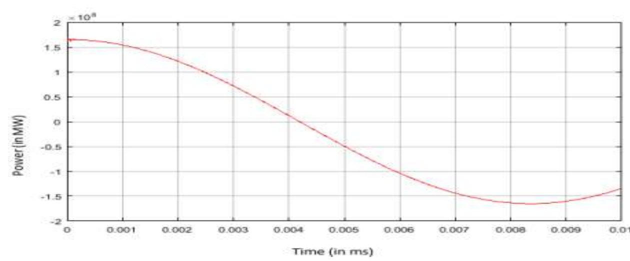

Fig 4. Ideal output characteristics of PV Panel

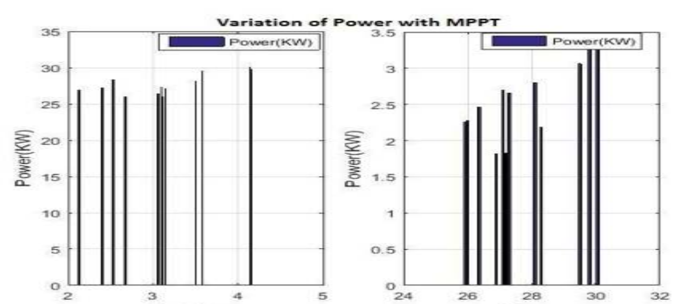

Fig. 5. Change of output power of solar PV array without MPPT regards to the change of both temperature and solar irradiance

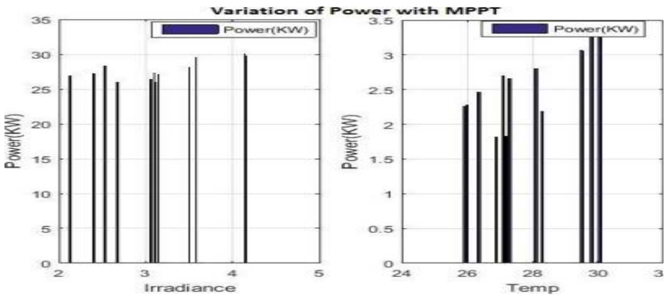

Fig. 6. Change of output power of solar PV array with MPPT regards to the change of both temperature and solar irradiance

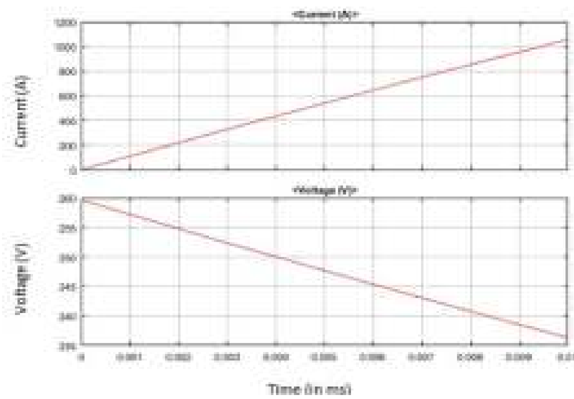

Fig. 7. Variation in current and voltage

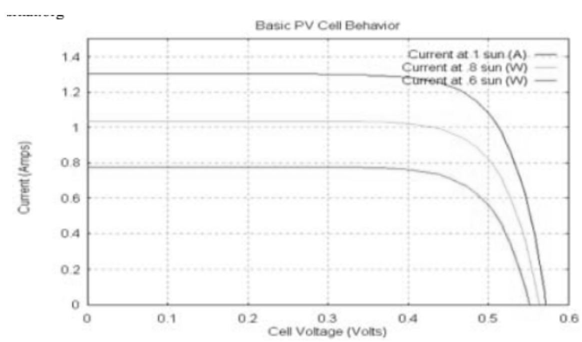

Fig. 8.V-I curves of a PV module for different sun irradiations

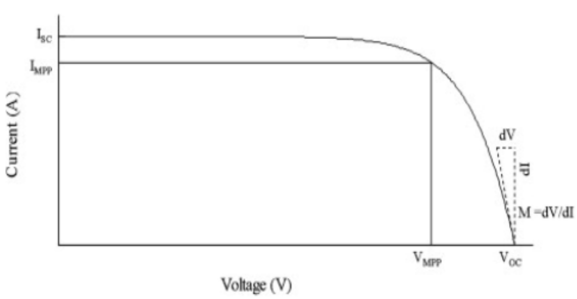

Fig.9. Typical V-I curve of a PV module

VII. Conclusion

The operating point of MPP may not be guaranteed if the computation speed is not contented under varying environmental conditions. In existing (incremental conductance) method, the computation time required by control circuit for analyzing the conductance value is quite higher, which is a major drawback. To overcome the above problem open circuit voltage and short circuit current values are measured for obtaining maximum conductance. In this paper, we have checked our output result with both perturb and observe algorithm, and maximum conductance algorithm. From our comparison, we observed that our model showed 40% efficiency over other existing methods. Hence, we conclude that our proposed maximum conductance method provides better efficiency even for different environmental conditions.

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