Modeling of an Optimized Standalone Solar PV Plant by using ANN

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Abstract— In this paper Simulink model is made with an energy storing element (battery) which provides energy during unavailability of solar irradiation. MATLAB /Simulink software is used for developing the model. The proposed system consist a PV-array of 100KW, a DC-DC boost Converter for MPPT which is controlled by ANN, a bi-directional dc-dc converter for charging and discharging the battery, a battery, a three phase PWM inverter and a variable load. The battery used has characteristic of fast charging and slow discharging to provide reliable power supply for a standalone system. Three types of control are proposed in this paper namely the MPPT control for getting maximum and constant power output from PV array and the second control is proposed in bi-directional dc- dc converter to ensure the charging and discharging of the battery and last but not least is control of inverter to get constant voltage and constant frequency output with variable load.

Key words: MPPT; Bi-Directional DC-DC Converter; P&O Method; IC Method; ANN; PWM Inverter

I. INTRODUCTION

The energy demand is tremendously growing every year. Fossil fuels like coal, oil, and gas are dominant sources of energy from past decades and hence are called the traditional energy sources. Due to massive consumption of fossil fuels in order to fulfill the present energy demand, the environment has got affected negatively and thus this is an alarming status for sustainable human progress. The urge of this challenge is underlined by limited resources of the fossil fuels on the Earth and increasing demand for energy production and for sustainable development we have to look for environmentally friendly energy sources, known as renewable or sustainable energy sources. This is the reason why the attention is turning to the renewable energy sources. The renewable energy has been framed because it is considered inexhaustible from the point of view of human civilization and is based on the continuing flows of energy. One of these is solar radiation from the sun which is an infinite source of energy for the Earth. The solar energy received by earth from the sun in just one hour is equal to the total amount of energy consumed by humans in one year. Solar radiation utilization can be of two viz. direct utilization and indirect utilization of solar radiation. Direct utilization of solar radiation employs solar cell which directly converts sun light into electricity, for solar power generation. In indirect utilization of solar radiation, solar radiation is concentrated to heat the working fluid which is used as water heater for solar collectors. Power generated from solar energy can be used either as off-grid (stand-alone) or grid connected. Both applications have own importance in power system. In off-grid the required power is generated by the solar farm itself. In grid connected it can be used in two ways, either to supply continuous power to particular defined loads or to supply power to loads during peak load hours only. Diego R proposes a simple and robust MPPT model-based strategy, the control strategy of which is based on IOL (input output linearization) controller. H Ong Wang speaks to the outline of the standalone PV system with battery backup. For expansions the effectiveness of the PV system the planned MPPT control of parallel system is utilized.

II. STANDALONE SOLAR SYSTEM

The standalone Solar system is very beneficial and cost effective in compare to on grid system for Remote areas. The main components of the standalone solar system are following- 1) PV Cell Array (Solar Panel) 2) DC to DC Step-Up Boost Converter 3) PWM Inverter 4) Controller 5) Storage System (Battery Bank)

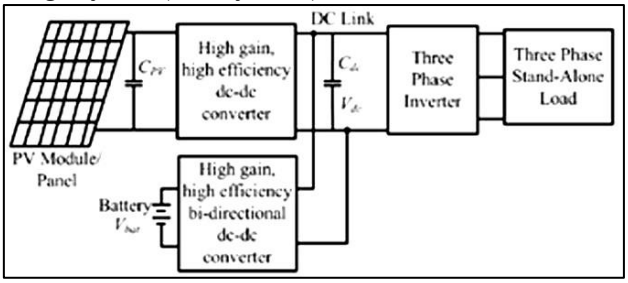

Fig. 1:

III. MAXIMUM POWER POINT TRACKING (MPPT)

The Maximum Power Tracking (MPPT) is basically an algorithm which is used for extracting the maximum available power from the solar system and increases the capacity of the PV array. For extracting the maximum power of the PV array is accomplished by the series connection of DC to DC step up converter between PV array and the energy storage system or load. In order to obtain a good dynamic performance of the MPPT control system, various algorithms are used and these algorithms changes the converter duty cycle in order to achieve the maximum power point. There are two different methods for achieving the MPPT; the first method is direct method which is mainly based on the MPP searching by sensing the input and output of the dc to dc converter and by adjusting the duty cycle of that converter, while second method is searching techniques in conjunction with the closed loop strategy.

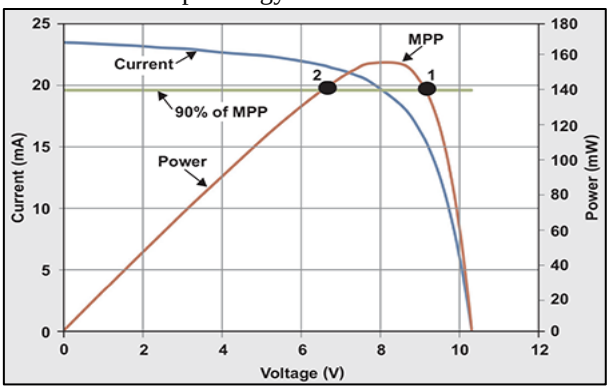

Fig. 2: Voltage (V)

IV. MPPT CONTROL TECHNIQUES

A. Voltage Control Technique

The o/p voltage is regulated to a constant value in all conditions and one in which o/p voltage is regulated based on a constant ratio to measured open circuit voltage. Means the operating point of the PV array is reached near the maximum power point by changing the array voltage and compare to the predefined reference voltage , this reference voltage value chosen in such way that it give the optimal performance and MPP as well as this is also the ratio of open circuit voltage.

B. Current Control Technique

The current control method uses the sweep waveform for the PV array current "I" in such a way the "I-V" characteristics is obtained and updated at fixed time interval in which the MPPT voltage is calculated.

C. Perturbation & Observation Technique

The PV array voltage is adjusted by the controller with a small amount from the array and measured the power. Hill Climbing control Technique- If P & O technique gives the oscillation in the power output so i t is call Hill climb technique because it depends on the rate of rice of curve of power verses voltage under the PPM.

D. Incremental Conductance Technique

In this technique the controller measures the incremental change in PV array voltage and current to determine the effect of voltage change. dI/dV =incremental conductance of the PV array and dP/dV is the change of power with respect to change in voltage. These two factors are use in this MPPT technique.

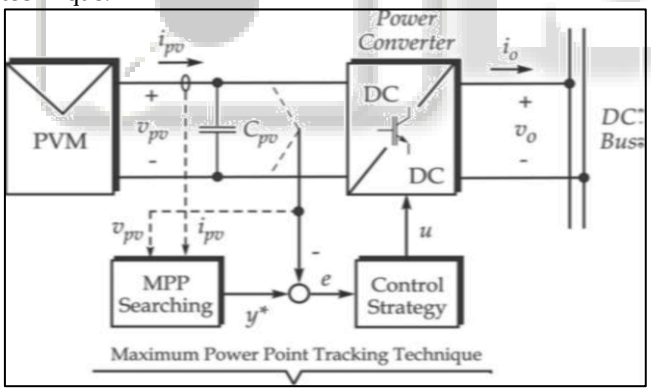

Fig. 3:

V. P-V ARRAY MODELING

The of single diode model characteristic equations are-

$$I = I_{lg} - I_{os} * \left[\exp\left\{q * \frac{V+I*R_s}{A*k*T}\right\} - 1\right] - \frac{V+I*R_s}{R_{sh}} \quad [1]$$

$$I_{os} = I_{or} * \left(\frac{T}{T_r}\right)^3 * \left[\exp\left\{q * E_g * \frac{\frac{1}{T_r}-\frac{1}{T}}{A*k}\right\}\right] \quad [2]$$

$$I_{lg} = \{I_{scr} + Ki\,(T-25)\} * \lambda \quad [3]$$

The number of cell connected in series is called the string and the number of string connected in parallel is called module, and these number of series and parallel cell decides the characteristic equation of the PV array.

$$I = Np * Ilg - NpIos\left[\exp\left\{q\,\frac{\frac{V}{Ns}+I\,\frac{Rs}{Np}}{AkT}\right\} - 1\right] - \frac{V\left(\frac{Np}{Ns}\right)+IRs}{Rsh}$$

Where

I_{lg}	Light – Generated Current
A	Ideality Factor
R_s	Series Resistance
R_{sh}	Shunt Resistance
γ	Solar Irradiance In W/M^2
K_i	S/C Current Temp Coefficient At I_{scr}
Q	Electron Charge .1.6*10^{-23} C
I_{scr}	Short Circuit Current At 25^0 Celsius
I	Cell Output Current
T	Cell Temperature In Celsius
E_g	Band Gap For Silicon
K	Botlzmann's Constatnt, 1.38*10^{-19} J/K
T_r	Reference Temperature
I_{or}	Cell Saturation Current At Tr
I_{os}	Cell Reverse Saturation Current
V	Cell Output Voltage

A. Boost Converter

The PV array produces dc voltage under all state of irradiation. The produced voltage is low in addition; it must be consistent at the primary level of inverter [7]. So we require a support converter which helps to keep up consistent dc output voltage with maximum power output. BJT, MOSFET or IGBT are used as a switching device in these converters. The base oscillator frequency ought to be around 100 times more than the transistor switching period to augment proficiency [10].

B. Neural Network

A neural network (NN), is a computational model that is enlivened by the structure and practical parts of organic neural networks. Normally ANN is a versatile system that changes its structure taking into accounts outside or inside data those passes through the system during the learning stage. Neural networks are typically used to model complex relationship in the middle of inputs and output or to find the patterns of the information [11].

Commonly, neural networks are balanced, or prepared, so that specific information prompts a particular desired output. There, the system is balanced by doing comparison of actual output and desired output, until the system output equals to desired output. Regularly, numerous such data/target sets are expected to prepare a neural network.

VI. SIMULATION RESULT & DISCUSSION

The overall model of proposed system is shown in figure-3. The specified parameter of the Solar system and Battery is mentioned in the appendix. For testing the performance of the MPPT and the voltage regulator used in the system, the simulation is carried out under the variable load condition as well as changing climate conditions. The output wave forms are shown in following waveforms.

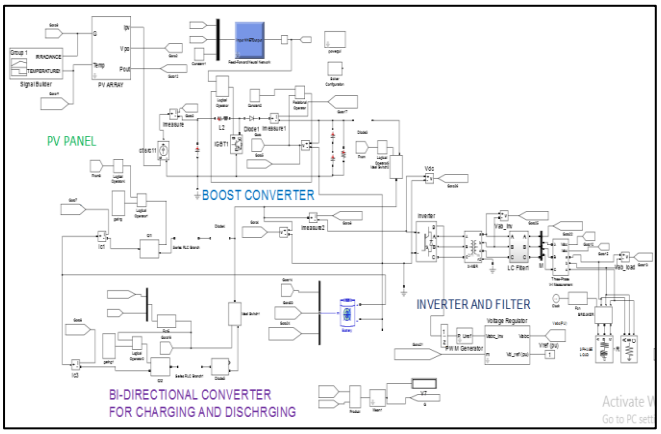

Fig. 4:

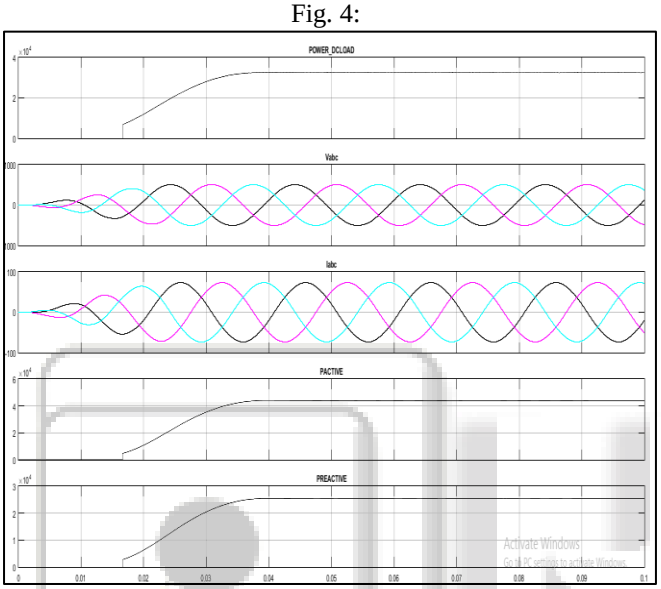

Fig. 5: Voltage, Current & Power Output Waveform of Boost Converter (MPPT)

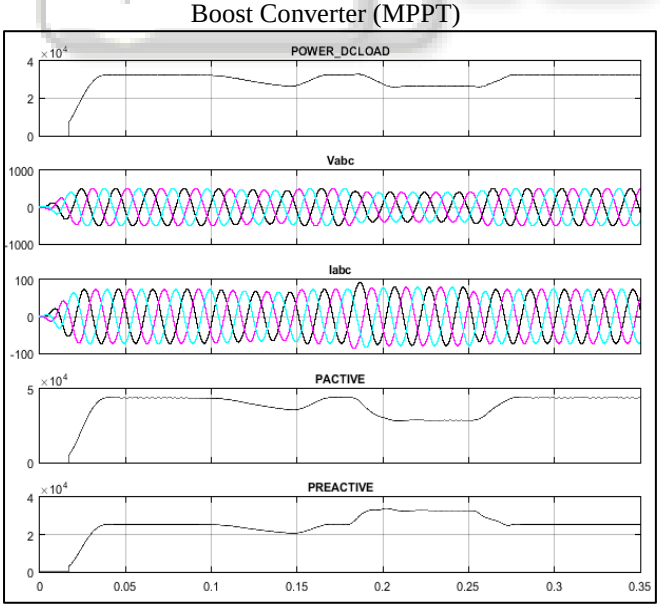

Fig. 6: Three Phase Load Voltage & Current & Active & Reactive Power

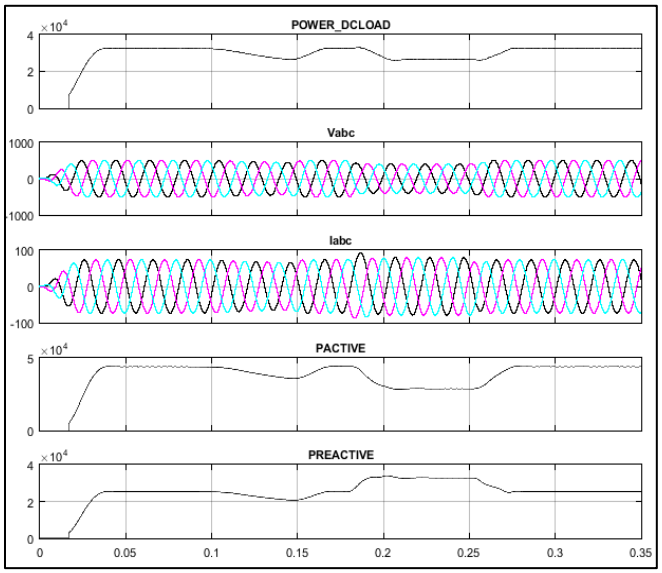

Fig. 7: Three Phase Load Voltage & Current & Active & Reactive Power

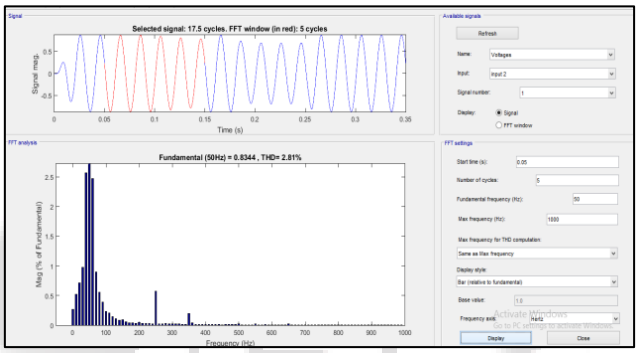

Fig. 8: THD during Variation of Irradiance

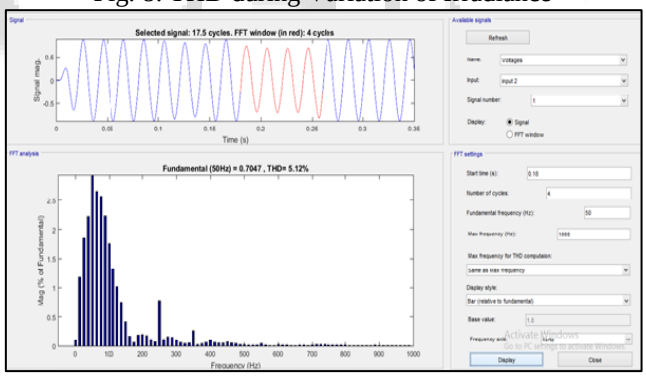

Fig. 9: THD during Variation of load

VII. CONCLUSION

Due to be harmful for environment and its limited stock, the fusil fuel based electricity generation has to be limited and an alternative non-conventional power resource is needed. Solar power is a versatile power and available everywhere, but to extract the maximum power from solar energy and convert in to electrical power with maximum efficiency is still a challenge. In this paper, it is shown that a standalone power system is continuously powered with PV generation system by using a battery of sufficient capacity. Artificial neural network keeps the dc bus voltage constant and make it more efficient system during the sufficient availability of solar irradiant. The result shows that the output of the system is

remain almost constant and the THD is under considerable value in all conditions.

VIII. FUTURE SCOPE

The voltage unbalance occurs on the load variation as well as variation in solar irradiation due to redistribution of reactive power. This problem can be solved by using an appropriate SVC (static VAr Compensator) and required reactive power is provided by the compensator so as to avoid the redistribution of reactive power in the circuit and hence voltage unbalance can be avoided.

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