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Efficiency Improvement of Photovoltaic System by using Maximum Power Point Tracking

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Abstract: ***Photovoltaic system is growing rapidly in today's world. In the recent trend PV industries are gaining more importance but due to its dependence on several factors the actual power supplied from the PV to the load is not sufficient. Thus in order to make full utilization of PV system effective tracking is very necessary. In this paper an improved detail MPPT technique is demonstrated. The duty cycles obtained from this method are analyzed to get a better duty ratio so that the system can operate at peak power point irrespective of any load condition. The detailed work is carried out in MATLAB for resistive load. Therefore MPPT controller with DC-DC converter is considered to carry out effective load matching and make the PV system operate at MPP point. There are various MPPT methods for PV system using soft computing techniques. The results found in this work shows that the PV standalone system using the improved MPPT technique give better performance and higher efficiency i.e 98.88% in comparison to other existing methods.***

Keywords **:** ***Photovoltaic, MPPT, Matlab, Boost converter***

I. INTRODUCTION

In the recent days Renewable energy sources have been attracting energy users due to its easy availability [1]. A much concern has made to the world energy crisis , problem of oil shortage , environmental effects, health hazards are mostly due to the use of conventional source of energy like fossil fuels and nuclear[2]. Among the various renewable sources energy from sun is most preferred source as it is clean, pollution free and highly efficient. But then again the conversion efficiency of solar energy is very less i.e 12-25% [3-4]. It drops with changing solar irradiance, temperature and load. Hence in order to get the required output PV system must be oversized to meet the demand which increases the overall cost of the system[5]. Therefore by using tracking system the problem of over sizing the PV system can be reduced and the system can be made more efficient. MPPT helps in load matching between pv array and the dc-dc converter [6]-[7].

In solar photovoltaic system maximum power point trackers are used to find a point called knee point where PV module peak power can be extracted irrespective of any change in weather conditions[8]. Mechanical tracking by using one axis tracker or dual axis tracker is commonly in use nowadays but simultaneously cost and complicacy increase. Hence electronic tracking are mostly preferred [9]. Studies shows that there are various MPPT Techniques used so far and some are classified as online tracking technique and offline tracking technique [10]. Some of the methods are like Perturb and Observance method, Incremental Conductance , Fuzzy logic, constant voltage , sliding mode control, artificial intelligence method etc. These all methods vary in tracking speed, tracking time, accuracy, efficiency, complexity [11]. Among various applications of standalone solar system water pumping application for rural areas in developing countries is very common as these areas have very less access to power grids [12].

In this paper an improved MPPT technique in developed to generate the best duty pulses so that the system can be utilized at maximum power point irrespective of any weather conditions.

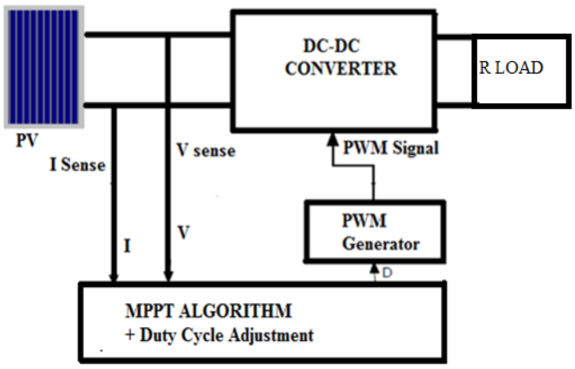

Fig. 1.Shows the layout of the proposed System

The layout in figure 1 represents overall diagram of PV array connected with converter (DC-DC, Boost in this case) for a resistive load. MPPT controller is used to provide necessary duty pulse to the converter. Several techniques of MPPT are compared with the improved method to give the best duty pulse to the converter.

II. PHOTOVOLTAIC SYSTEM

The basic unit of Photovoltaic System is a solar cell which is represented as a p-n junction diode with a current source connected in parallel to it. The photocurrent produced by sunlight is represented by the current source.

The I-V curve determines the solar energy conversion ability and efficiency. Current is controlled by the amount of solar irradiance reaching the panel while change in temperature controls voltage [13].The basic PV module is modeled using fundamental equations.

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The P-V curve represents the power versus voltage curve .here in this curve there is a point called knee point corresponds to maximum power point. At this point the voltage and current drawn from the PV are maximum [14]. In the proposed work a solar array is considered consisting of PV module of 180 watt connected 5 in series and 20 in parallel. Table I shows the details of electrical parameters for the single PV module SANYOHIT 180 W.

Table- I: Module specifications of SANYOHIT 180 W

Parameters	Data
Maximum power (Pmax)	180 W
Voltage at maximum point (Vmax)	540 volt
Current at maximum point (I max)	3.33 amp
Open circuit voltage(Voc)	66.4 volt
Short circuit current (I sc)	3.65 amp
Temperature co-efficient (voltage)	-0.173V/ ^{0}C
Temperature co-efficient(current)	1.10mA/^{0}C
Series Resistance	1.33 ohm

III. MAXIMUM POWER POINT TRACKING METHODS

A. Perturb and Observance method

Perturb and Observance method is most traditional method and is the most simplest among all MPPT algorithms. It is based on the concept that at MPP point change in power is zero. Towards the right of the MPP point change in power is negative and hence the voltage is decremented in order to reach the MPP point. But to the left of this point delta p is positive and hence the voltage in incremented to reach MPP. MPP or knee point is the point where the system operates at highest efficiency. Hence P and O method works by pertubating the PV voltage. But during rapidly changing weather condition the P and O method will oscillate around the MPP point and cause loss in power [15]. Hence the P and O algorithm is controlled by two ways one is my directly controlling the duty ratio and other is by controlling the reference voltage using a PI controller.

B. Incremental Conductance method

Incremental Conductance method uses the derivative of power w.r.t derivative of voltage for tracking the MPP point. At MPP point the incremental conductance is equal to the instantaneous conductance whereas towards the right of the MPP point the incremental conductance is less then instantaneous conductance and vice versa. This method is also used for changing weather condition i.e. if the MPPT is operating at MPP (dV=0) and there is no change in irradiance (dI=0) then there is no action but if the irradiance increases (dI>0) the voltage at peak point is raised up. When the irradiance has decreased (dI<0) the operating voltage is reduced. In this method the algorithm goes for two round checking i.e. finds the MPP point and detects the weather condition

C. Fuzzy logic method

The Fuzzy logic method is one of the MPPT method. The various components of the controller are as follows. These are Fuzzification unit, Inference unit, Rule base and Defuzzification unit. For performing the fuzzy interface process there are various methods. But most commonly used is the Mamdani method. Here two or more inputs are given to the fuzzification interface i.e PV power and current in terms of error and variation in error and the output obtained in this case is the duty cycle which is fed to the converter. In this case triangular function is used with a rule base made of 25 rules. The five fuzzy subsets used are denoted as NL: Negative Large, NLe : Negative less , ZE: Zero, PL: Positive Large, PLe: Positive Less. The crisp output value is calculated in the Defuzzification stage by using centre of gravity method**.** Table II shows the rule base designed for fuzzy logic system.

Table- II: Rule base of Fuzzy system

CE/E	NL	NLe	ZE	PLe	PL
NL	ZE	ZE	PL	PL	PL
NLe	NLe	ZE	ZE	ZE	PLe
ZE	PLe	ZE	ZE	ZE	NLe
PLe	NLe	NLe	NLe	ZE	ZE
PL	NL	NL	NL	ZE	ZE

D. ANN method

Artificial network works like a black box model. It works without knowing the complete information about the system. In this method, the input and output relation is decided by the pattern of data recorded previously. The building block is called as neuron with two parts called as net function and activation function The ANN method used in this work is the feedforward neural network. It consists of mainly three layers. PV voltage, current, irradiance, and temperature are used as input to determine the outputi.e. duty ratio. The input data i.e.voltage and current have been obtained from MATLAB workspace, irradiance is taken as 1000 W/m^2 and temperature at 25 ^{0}C for each value of voltage and current. The feedforward neural network consists of three layers where the output of the input layer are measured and to it bias is inserted. To evaluate the output a hyperbolic tangent sigmoid transfer function is used as the activation function.

E. Modified INC and Fuzzy method

In the modified Incremental Conductance and fuzzy method the duty cycle is selected in a double round checking. Here both incremental conductance and fuzzy logic method are operated simultaneously. The duty cycle obtained from fuzzy logic method is taken into account along with the duty cycle obtained by InC method with the help of selector switches to obtain best duty ratio for tracking MPP point. In this method Voltage and current of the PV module are measured. Delta V and Delta I are calculated based on present value and previous value.

Then the checking of InC condition is done i.e. at peak point incremental conductance is same as negative of instantaneous conductance. Towards the right of peak the incremental value is less then instantaneous value, hence the new duty ratio is obtained by subtracting the fuzzy duty cycle from the exiting value.

Towards the left of the MPP the incremental conductance is more than instantaneous conductance, hence the new duty ratio is obtained by adding the fuzzy duty cycle from the exiting value.

F. Proposed method

In the proposed method an improved algorithm for MPPT is explained by flowchart. The new technique used basically is a modified version of P and O technique giving better results in comparison to other methods. Tracking the peak point is operating PV system at the maximum power point irrespective of any weather and load conditions.

In the proposed technique, the Maximum power is taken as fishes (function of voltage and current of PV) and aims to find out the prey i.e. the knee point. The fixed step size significantly affects the overall system reducing the system performance and efficiency. Instead of using step size whose values do not vary as in traditional P and O method here we use six sets of values for duty cycle (fitness value). Initially, the fishes are set with a fixed fitness value. Then the present value of power and previous power are evaluated and checked for the best power (prey). The iterations proceeds for six cycles and hence the prey (maximum power) with the best fitness value (duty cycle) is fixed. Hence this duty cycle is given to the gate signal of the converter switch to operate at the maximum power point.

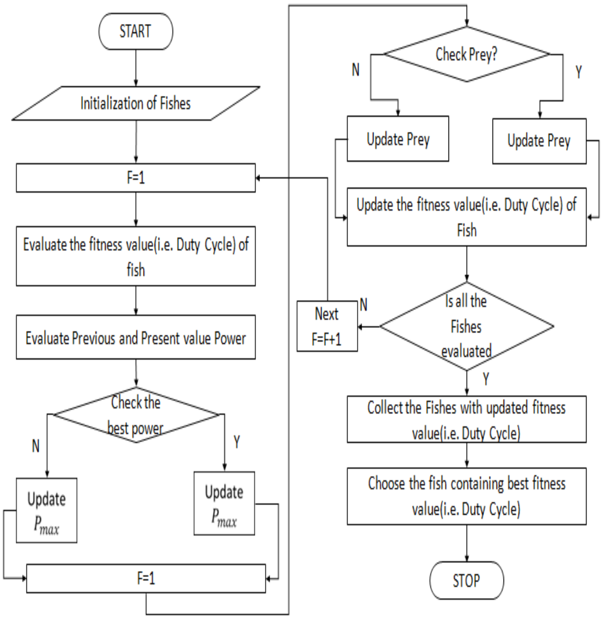

Fig. 2.Algorithm of proposed mppt method

Figure 2 describes the algorithm of the proposed technique. The algorithm begins with initialization of maximum power.

IV. DC-DC CONVERTER

Studies show that DC-DC converters are applied for MPPT stage of PV System. Among the basic classification single inductor type includes buck, boost, Buck-Boost where as double inductor types like cuk converters. However for design of rural pumping system buck and boost are the most simplest type . As ac motor is used for pumping application a higher voltage is required hence step up converters buck-boost, cuk, sepic, Boost are good choice. Even though the input current is continuous and ripple free in case of cuk and sepic converter the presence of high number of passive components create switched power stresses due to high voltage and current. Therefore boost converter is considered as it is having less components, reduced power stresses and simple circuit and high efficiency. Table III shows the parameters calculated for Boost converter.

Table- III: Values of Calculated parameters of Boost converter

Parameters	***Values***
Voltage Input	540 volt
Input current	133.3 amp
Value of Inductance	7.3mH
Capacitance	100µF
Resistance	12 ohm

V. MATLAB AND SIMULATION ANALYSIS

The simulation of the entire work is carried in MATLAB/Simulink platform using the components of sim power systems. The simulation in figure 3 consists of PV array connected with boost converter with resistive load. MPPT controller provides switching pulse to the converter.

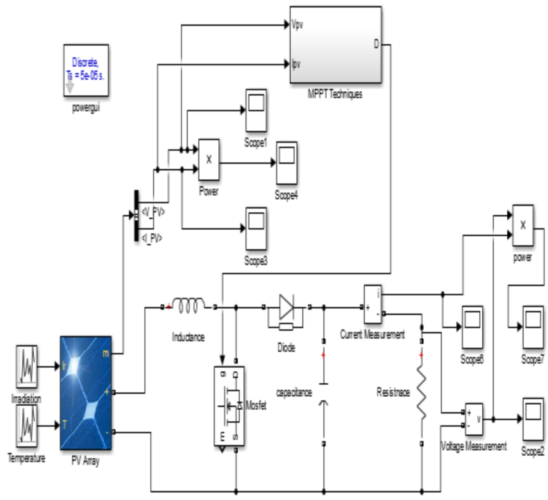

Fig. 3.Shows the layout of the proposed system

VI. RESULTS AND DISCUSSIONS

The output of the Matlab simulation is shown as below. Figure 4 and 5 shows the I-V curve and P-V curve of the solar array considering various irradiance i.e. 1000 Watt/m^2, 800 Watt/m^2, 600 Watt/m^2, 400 Watt/m^2, 200 Watt/m^2. Figure 6 and 7 depicts the I-V, P-V graph of the solar system at various temperature 0 deg, 25 deg, 50 deg, 75 degree. At MPP point power input to the converter is same as the power output from solar array at MPP condition. Figure 8 represents voltage obtained at output, figure 9 output current and figure 10 power obtained as output from the converter using various MPPT methods. Figure 11 shows the efficiency using various MPPT methods.

Hence the proposed method gives more power output, better voltage profile and high efficiency in comparison to other methods.

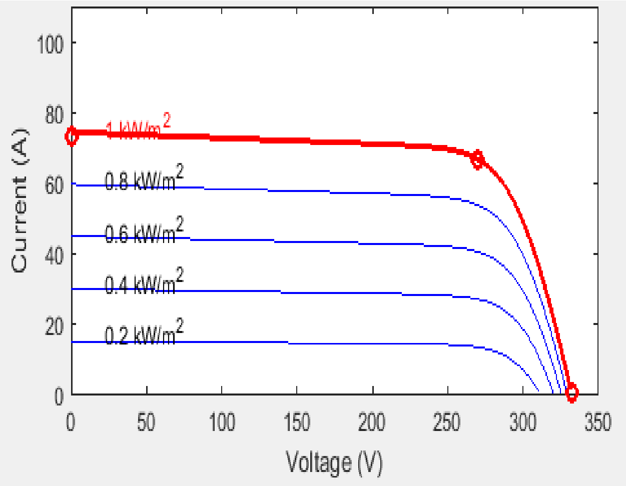

Fig. 4.Shows the IV curve of the solar array at various irradiance

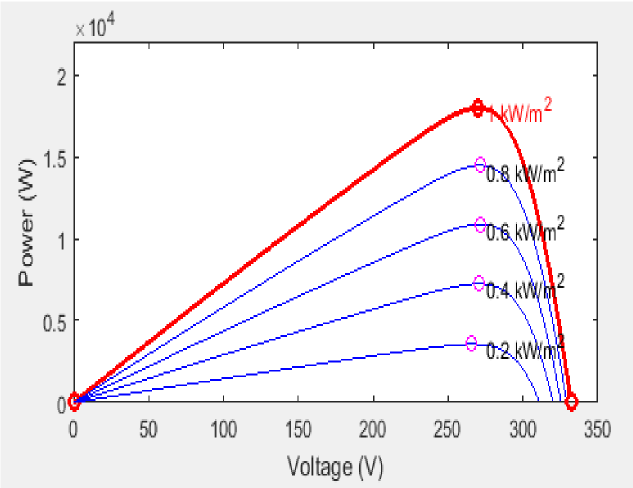

Fig. 5.Shows the PV curve of the solar array at various irradiance

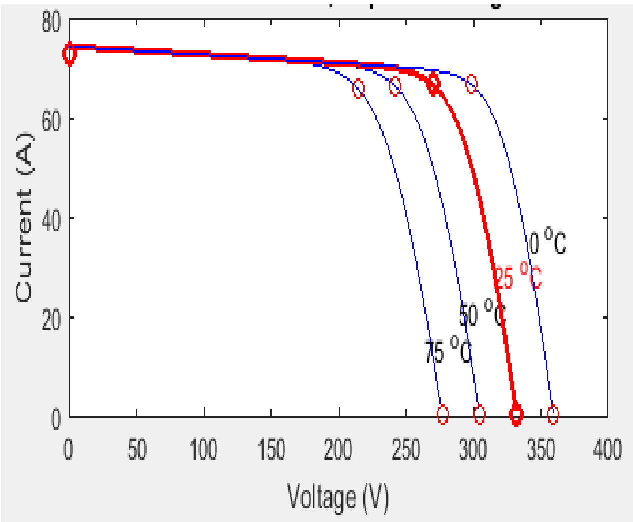

Fig. 6.Shows the IV curve of the solar array for different temperature

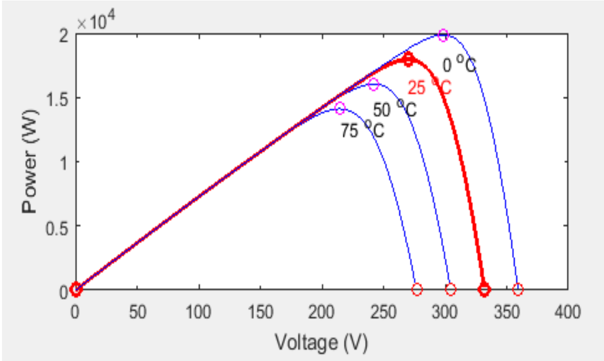

Fig. 7.Shows the PV curve of the array for different values of temperature

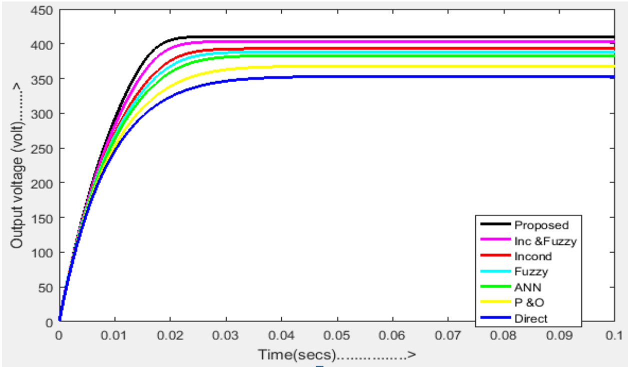

Fig. 8.Shows output voltage of the converter using various MPPT techniques

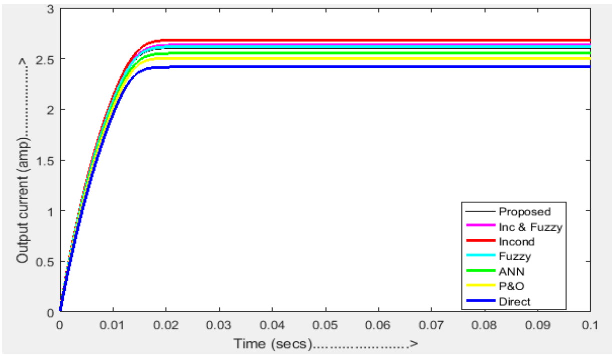

Fig. 9.Shows output current of the converter using various MPPT techniques

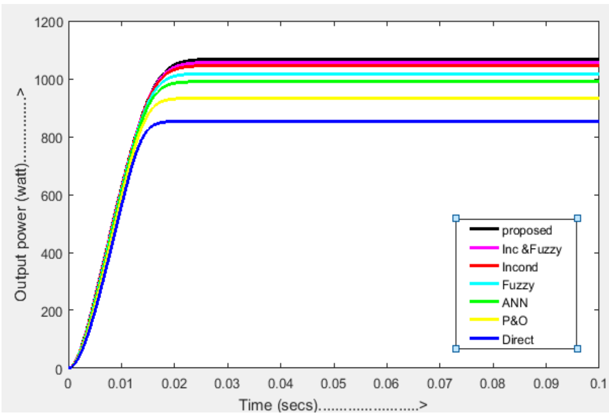

Fig. 10. Shows output power of the converter using various MPPT techniques

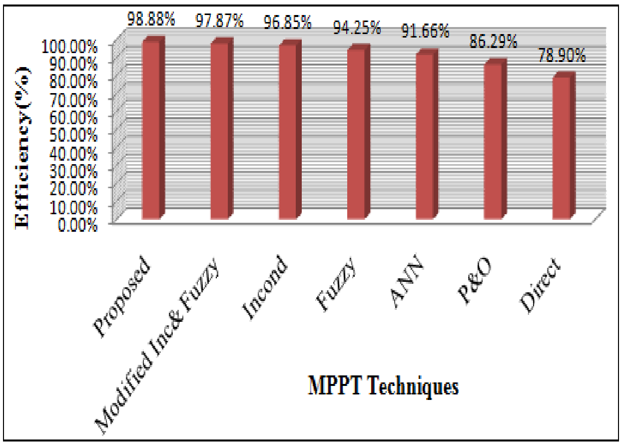

Fig. 11. Shows efficiency of the system using various MPPT techniques at 1000 Watt/m^2 irradiance.

VII. CONCLUSION

The power obtained from the PV system is affected by amount of irradiance falling on the panel, change in temperature and load condition. Therefore maximum power point tracking control circuitry is used to track the peak point and ensures load matching between PV system and the converter. In this work PV array is simulated along with boost converter for a resistive load. Several MPPT techniques are implemented to get the best duty cycle so that output power obtained from the converter can be maximum. Investigation of the effectiveness of the proposed technique implemented in simulink using resistive load. The simulated result shows that the proposed technique have higher efficiency i.e. 98.88% at standard irradiance condition in comparison to other conventional methods like P and O, Incremental Conductance method, Fuzzy logic, ANN, combined fuzzy and InC , direct method. At various irradiance level also the proposed MPPT method shows better result in comparison to other methods. Hence this technique improves both dynamic and steady state responses of the Photovoltaic system.

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