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IMPROVED MPPT-MODEL PREDICTIVE CONTROL FOR HIGH GAIN GRID TIED PV SYSTEM USING ANN

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Abstract:

An enhanced maximum power point tracking (MPPT) technique based on the Artificial Neural Network (ANN) for photovoltaic (PV) applications. The system under study is composed of a PV source and resistive load, while a boost converter is used as an interfacing circuit between the PV generator and the resistive load. The operation of the photovoltaic field at the maximum power point is ensured using an algorithm based on a artificial neural network and a predictive control scheme of DC voltage for single-stage three-phase grid-connected PV inverters is proposed based on the analysis of the energy balance relationship in one control period, while AC current is also regulated by ANN control. The proposed scheme provides both good dynamic and steady-state performance. The Proposed topology is able to provide a voltage gain up to 10 times of input-voltage and its measured efficiency is around 93%.

Keywords: ANN, PV, DC voltage, MPPT, High efficiency .

1. INTRODUCTION:

Maximum Power Point Tracking is a technique that Grid Tie Inverters, Solar Battery Chargers, and other similar devices use to get the maximum possible power from one or more solar panels. Solar cells have a complex relationship between solar irradiation, temperature and total resistance that produces a non-linear I-V curve. The MPPT System samples out the output of the cells and applies the proper load to obtain maximum power for any given environmental conditions, ranging from a clear sky to a heavily clouded one, from rainfall to misty, and even foggy. PV cells have a complex relationship between their operating environment and the maximum power they can produce. The fill factor, FF, is a parameter that characterizes the non-linear electrical behaviour of the cell. In tabulated data it is often used to estimate the maximum power that a cell can provide. With an optimal load under given conditions, power P = FF*VOC*ISC; VOC being Open Circuit Voltage and ISC being Short Circuit Current. For most purposes, FF, VOC, and ISC are enough pieces of information to give a useful conclusions on the electrical behaviour of a cell operating under typical conditions[2, 3].For any given set of operating conditions, cells have a single operating point where the values of V &I of each cell result in a maximum power output. These values correspond to a particular load resistance which is equal to V/I as specified by the Ohm's Law. A PV cell has an approximately exponential relationship between current and voltage. From basic circuit theory, the power delivered from or to a device is optimized at the point where the derivative, dI/dV, of the I-V curve is equal and opposite ofI/V ratio (the point where dP/dV=0). This is known as the Maximum Power Point and corresponds to the "Knee" of the curve.A typical solar panel converts only 30 to 40 percent of the incident solar irradiation into electrical energy. Maximum Power Point Tracking technique is used to improve the efficiency of the panel. According to Maximum Power Transfer Theorem, the power output of a circuit is maximum when the Thevenin Impedance of the circuit (source impedance) matches with the load impedance. Hence the problem of tracking the maximum power point reduces to an impedance matching problem.

Since solar cells have a non-linear current-voltage characteristic, with the output power varying in correspondence with the voltage across the cell, it is therefore necessary to design a methodology that can be modelled in such a way that it obtains maximum power from the sun at all times. Thus, a variety of Maximum Power Point Tracking algorithms has been proposed which aim to extract and utilize the maximum portion of the incoming solar radiation.

The Photovoltaic Systems are one of the best direct solar to electrical energy conversion systems. A Photovoltaic System is an array of homogeneously series connected Solar Cells, each of them possessing the typical V-I characteristics. The main purpose of the PV Systems is to absorb radiation from the sun, transfer it to a transducer that converts it to electrical energy, and finally generate electricity. These

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systems are clean, reduce the Greenhouse Gases, and are non-polluting. However, a typical PV System consisting of PV Modules, a DC-AC Inverter, a Charge Controller, and Batteries, the PV modules generate DC Electricity which is used to charge the batteries through a charge controller. Meanwhile, the inverters convert the DC current to AC current. But, here the problems arise; the PV systems are high in the capital cost, largely dependon climate conditions such as solar radiation and ambient temperature, and these factors altogether make electricity generation a difficult process.

It is now that the MPPT system comes into effect, an algorithm which when included in charge controllers, can be used for extracting maximum available power from PV module under these uncertain conditions. MPPTfirst checks PV Array's output, then compares it to battery voltage, and finally fixes the best voltage that theArray can produce to charge the battery and convert it to get maximum current into it. Maximum Power Point Tracking is most effective under the following conditions:

- Cold weather, cloudy or hazy days: Normally, PV Modules work better at hot temperatures and the Maximum Power Point Tracking System on each can thus be utilized to extract maximum power available from them.
- When battery is deeply discharged: The system can extract more current and charge the battery, if the state of charge in the battery is lower.

PROPOSED SYSTEM CONFIGURATION

The problems encountered with basic algorithms for finding the Maximum Power Point Tracking are described here as under:

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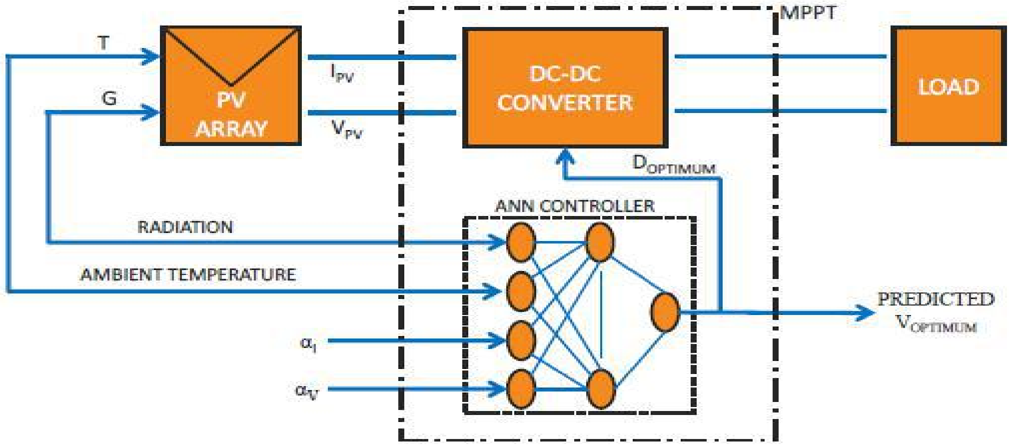

Fig 1: MPPT using ANN's Block Diagram

In the classical Perturb and Observe Algorithm that compares only two points, the Current Operation Point and the Subsequent Perturbation Point to observe their changes in power, the controller increases or decreases the PV array output voltage based on the difference in the output power.If these two points are positive weighted, the duty cycle of the converter should increase, while if they are negative weighted, the duty cycle should decrease[8]. Also in special cases with one positive and one negative weighting, the Maximum Power Point is not reached because the solar radiation changes rapidly and the duty cycle is therefore not able to change itself.

Though the Incremental Conductance Algorithm[7] can perform Maximum Power Point Tracking under rapidly varying irradiation and daylight conditions with an accuracy higher than the Perturb and Observe method, it however lacks behind too as it produces oscillations and can perform erratically under rapidly changing atmospheric conditions. The computational time is thereby increased as the sampling frequency is depressed owing to the higher complexity of the algorithm compared to the classical Perturb and Observe Algorithm.

While Incremental Conductance Algorithm addresses some of the shortcomings of the basic PO Algorithm, a particular situation in which it continues to offer reduced efficiency is in its tracking stage when the operating point fluctuates between two significantly different Maximum Power Points. For example, during cloud cover or when dark clouds hover in the sky, the MPPT system can change rapidly and by large magnitude values. Perturbation and Observation based techniques, including the Incremental Conductance, are limited in their tracking speed because they make fixed-size adjustments to the operating voltage in each of the iterations.

In the Constant Voltage Algorithm[7], the current from the PV Array must be set to zero momentarily to measure the Open Circuit Voltage, and afterwards set to 76 percent or 0.76 of the measured voltage. As a result of this transaction, a considerable amount of energy is pined away in the time duration when the current is set to zero. The approximation in setting the voltage to 76 percent of the measured voltage is therefore not accurate. Although simple and low in cost to implement, the interruptions in this algorithm reduce array efficiency and doesn't ensure a positive result in finding the actual Maximum Power Point.

Considering the obstructions faced while working with the above algorithms, a new design is proposed which works as a prototype for utilizing solar radiation in most of the weather conditions.The objectives of the Maximum Power Point Tracking System can be broadly given under two headings:-

A. Main Idea

Keeping in mind all the negative points of the basic algorithms and the techniques to overcome their drawbacks, the present design is so designed to take head on challenges with the existing algorithms.Some of the highlighting points that support the stated Improved Maximum Power Point using Artificial Neural Network Algorithm are as follows:

Algorithm of three-point weight comparison, an antidote to the two-point weight comparison, which runs periodically perturbing the solar array terminal points of the PV curve, has three distinct points, namely the Current Operation Point A, a point B perturbed from point A, and a point C doubly perturbed in the opposite direction from point B.

The algorithm aims to improve the tracking speed of the PO based techniques by storing current-voltage curves and their maximum power points, and using a classifier based system.

Operation with Batteries

In cases of non-availability of solar radiation for a prolonged time, the solar collectors won't be able to collect the required amount of radiation and that in period of time, will bring plant operations to a halt. The batteries play a vital role; storing a reasonable amount of energy to provide backup.

At night, an Off-Grid PV Power System uses batteries to supply power to its loads. Though the battery, when charged to its full capacity may have its operating voltage close enough to the PV Array's Peak Power Point, but this is unlikely to be true or happen at the time of sunrise when the battery is partially discharged. Charging may begin at a voltage considerably below the Array's Peak Power Point. MPP Tracking, hence, by its sophisticated techniques and well-designed protocols can resolve the mismatch.

When batteries in the Off-Grid system are fully charged and the production exceeds the local loads, the MPP Tracking can no longer operate the PV Array at its Peak Power Point, as the excess power has nowhere to go. The MPP Tracking must then shift the array's operating point away from the Peak Point until production exactly matches the demand. An alternative approach, commonly used in spacecraft is to divert the surplus PV power into a resistive load allowing the array to operate continuously at its Peak Point.

SIMULATION RESULTS

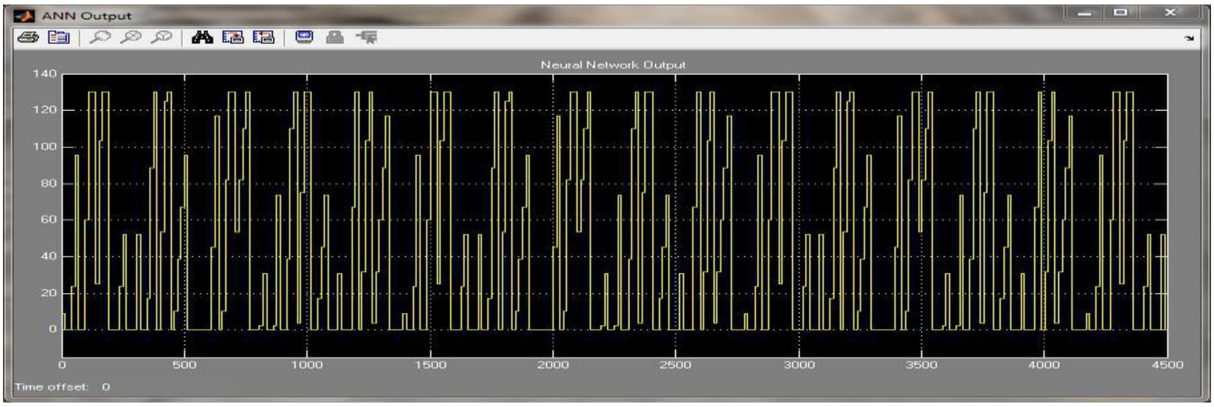

Fig 1: ANN's Predicted Output Waveform

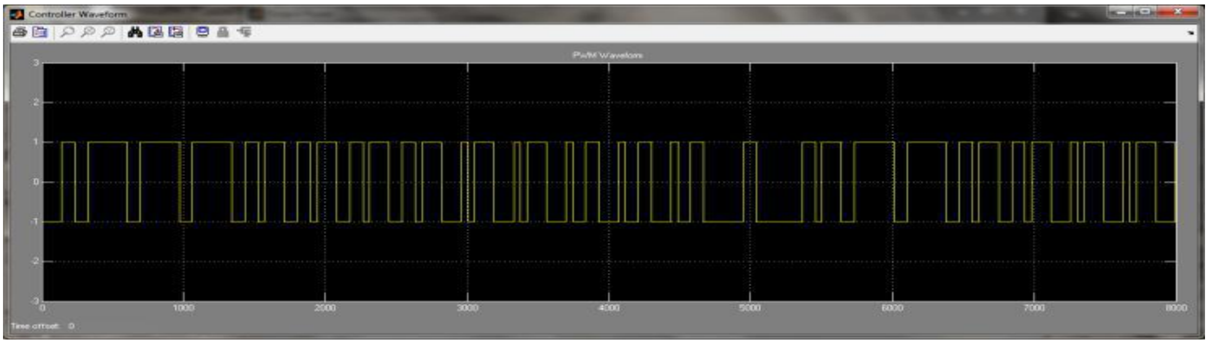

Fig 2:Controller's Waveform

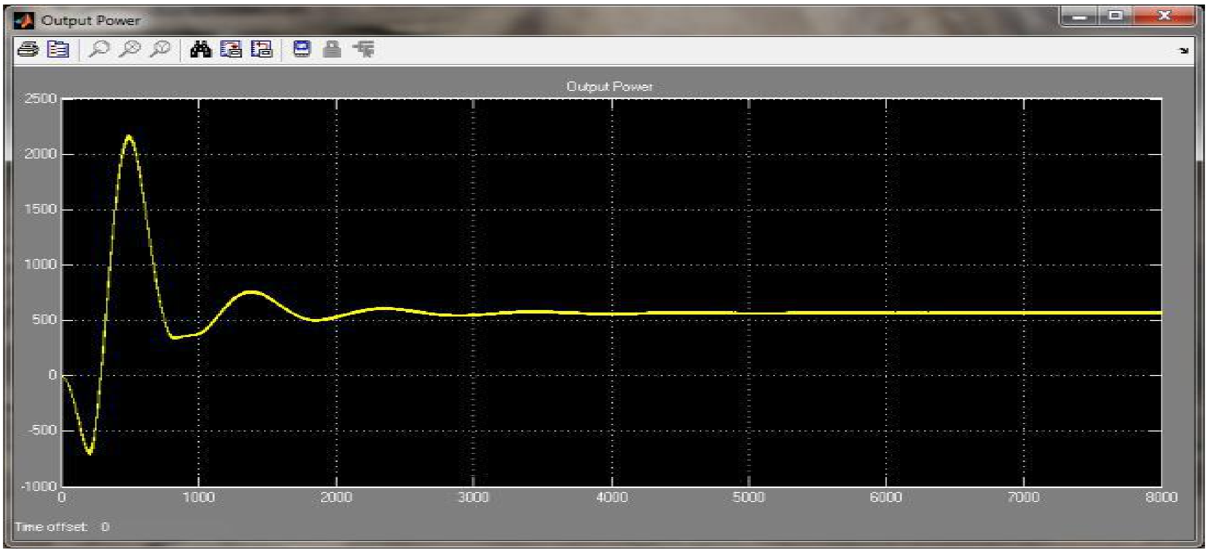

Fig 3:Final Output Power Waveform

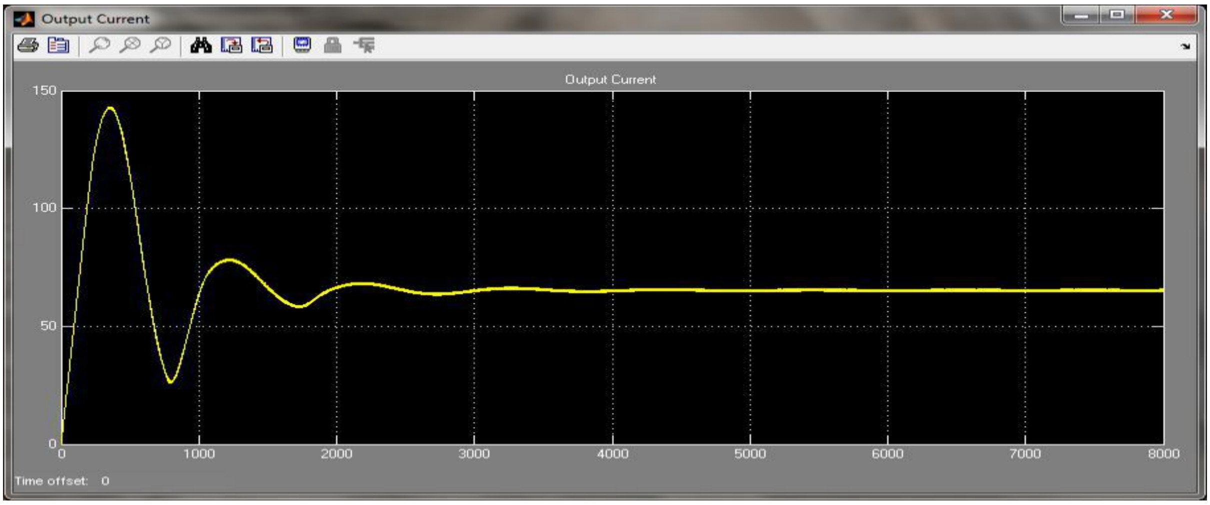

Fig 4: Final Output Current Waveform

CONCLUSION

The operation of the photovoltaic field at the maximum power point is ensured using

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an algorithm based on a artificial neural network and a predictive control scheme of DC voltage for single-stage three-phase grid-connected PV inverters is proposed based on the analysis of the energy balance relationship in one control period, while AC current is also regulated by ANN control. The proposed scheme provides both good dynamic and steady-state performance. The Proposed topology is able to provide a voltage gain up to 10 times of input-voltage and its measured efficiency is around 93%.

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