A Neuro-Fuzzy Approach to Grid connected Multi-Junction PV Array using PWM Inverter

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***Abstract* - In this paper a novel Adaptive Neuro-fuzzy algorithm is proposed based on Inference System for Maximum Peak Power Transfer technique for multi-junction solar cells connected to a grid. The multi-junction solar cells can be supposed to provide better efficiency as opposed to their single junction counterparts. ANFIS based algorithm is designed utilizing neural network and fuzzy logic. The membership functions are formulated using an initial inference and then the weights of the common membership functions are found by using Neural Network. Gradient Learning is utilized for tuning. The firing angle's optimal value is calculated and fed to the Boost converter. The converter output is given to a three phase inverter and the inverter output is connected to a grid. The inverter is controlled using a PWM regulator. The results are compared to that of an incremental conductance technique and it is found that the ANFIS based MPPT performs quite better than its other counterparts in terms of transient state and the magnitude of voltage obtained.**

***Keywords* - ANFIS, MPPT, PV cell, multi-junction solar cell.**

I. INTRODUCTION

Nowadays, consumption of energy is increasing, idea of exploring renewable energy sources are also growing. Due to our limited energy sources, renewable energy sources are the future. Significant processes are made over the later years in development and research of the renewable power systems such as sea, wind, solar energy and wave systems. With these resources, the sun power energy can be used nowadays as most reliable, and environmental friendly energy source. Although sun power energy systems can be suffer with high costs and low efficiencies. To control these problems, maximum power can be extracted from PV panel while using the MPPT methods to optimize an efficiency of all the PV system. The photovoltaic technology can be made attractive option because the features various merits like as low maintenance requirement, environmental friendliness and absence of fuel cost. The efficiency of energy conversion a PV generation system may low because sun power cell exhibits to the nonlinear voltage and current and power versus voltage characteristics. These nonlinear characteristics contain weather functions conditions like as panel temperature and solar insolation. This is used to maintain the maximum power point tracking algorithm, efficient operation which can quick response and extract the maximum power from PV arrays in the real time becomes important in PGSs.

Maximum Power Point Tracking, frequently referred to as MPPT, is an electronic system that operates the Photovoltaic (PV) modules in a manner that allows the modules to produce all the power they are capable of. MPPT is not a mechanical tracking system that "physically moves" the modules to make them point more directly at the sun. MPPT is a fully electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power. Additional power harvested from the modules is then made available as increased battery charge current. MPPT can be used in conjunction with a mechanical tracking system, but the two systems are completely different

All types of solar installations will benefit by using MPPT technology. The higher the module operating voltage (Vmp) the more benefit you will gain by using MPPT. Recreational Vehicles (RV) have very limited roof space for solar modules. If you do not tilt the modules, considerable power is lost in the winter months due to the low angle of the sun. Because of these limitations, it is very important to transfer all the power you can by using MPPT technology. For off-grid systems, MPPT will allow you to wire the PV modules in series for high voltage, even up to 600 volts DC! This is extremely beneficial for long wire runs as the higher the operating voltage, the smaller the wire can be for a given length. Several MPPT techniques can be projected and enforced. These strategies are observe and perturb, third open-circuit voltage, progressive conductance, fuzzy logic management, third short-circuit current and ripple correlation management app roaches. Some techniques are aim to attenuate hardware demand that is used to enhance performance which are additionally been projected. Perturb and Observe technique can be displayed to trace the wrong direction beneath for abrupt increase/decrease of the irradiance the result of the irradiance modification can be higher than the [9] perturbation step applied. Moreover, if MPPT algorithmic rule can be slower than speed of the irradiation changes, then most general electrical outlet trailing potency may become lower MPP .Thus, a quick and correct MPPT technique is needed. The wealthy with the numerous MPPT techniques can be supported completely different topologies with various cost, complexness and overall made potency. The hill climbing is Perturb and Observe area unit which is the best-known and commercially used techniques. In HC-MPPT technique, duty cycle can be directly increased or decreased in the fastened steps counting on panel voltage and power values till utmost electrical outlet has been reached.

The organization of paper is as following. In section II literature review is presented. Proposed methodology is described in section III. The simulation results are seen in section IV. Finally, section V concludes this paper.

II. LITERATURE REVIEW

In voltage-based MPPT current-based MPPT approaches unit of the measurement is presented. Every unit of measurement can be simple and fast. Hence, these ways can track the low efficiencies for low irradiation levels. In this, **Jain andAgarwal** et al. [3], a strategy has been projected supported to the analysis and derivation of the I–V characteristics of photo voltaic panel by natural exponent index. This method offers the faster track speed than quality of hill-climbing methodology, the used index is solely to complicate for amount calculation exploitation in an inexpensive 8- or 16-bit lC. In MPPT management rules unit of the measurement can be supported the prediction line which associates the maximum power point and optimum current. One of the parameter got to be non-inheritable through hill-climbing methodology that generates commercially impractical. **Kimball and Krein** et. al [1]extended previous analog RCC method to the digital domain for MPP track. The projected digital implementation could be plenty of versatile, smaller quantity expensive; ton of durable quite such as analog RCC methodology, inductive and physical phenomenon parasitic elements may have impact on the facility of RCC to drive system toward being MPP. To subsume the exchange between the steady-state performance and so the speed of track, steepest descent methodology, variable step-size ways, parabolic prediction technique measure projected for MPP.The link between the values of panel current and voltage at MPP can be used to accelerate speed of the MPPT algorithmic rule. **Panom Petchjatuporn et** al [7] introduced most electric receptacle track algorithmic rule exploitation an artificial neural network for energy system. By applying a three layers neural network and few easy activation functions, most electric receptacle of an electrical device is expeditiously tracked.**Yuvarajan** et al [8] projected proper and fast most electric receptacle track the algorithmic rule for physical phenomenon panel uses electrical circuit voltage and so tangency current of photovoltaic panel. **Prof. Dr. IlhamiColak**et al. [9] have curvy three separate farms that supply fifteen emu power for each farm exploitation Mat work Simulink amount analysis code [9]. Energy conversion is performed with the most electric receptacle track algorithms in every device exploitation Perturb and Observe structure **S. G. Tesfahunegn** et al. [10]designed solar/battery charge controller that mixes every MPPT and over-voltage controls as single operation. **Yuncong Jiang** et al. [11] has proposed Associate in the analogue most electric receptacle track the controller for physical phenomenon theme that utilized the load current to output power from device [11]. **ArashShafie** et al. [12] projected distinctive MPPT algorithmic rule in main for battery charging applications that were thought of the constant voltage kind lots. It is achieved in main with the output current maximization [12]. This method edges from the blessings just like easy current controller and to boot circuit topology independence. **Ali F Murtaza** et al. [13] addresses the problematic behavior of Perturb & Observe technique and so displays complete distinctive MPPT hybrid technique has combination of the two basic techniques i.e. Perturb & Observe (P&O) [13] and halfway electrical circuit Voltage method therefore transmissible deficiencies found in P&O technique.**Ko, S.H. et al. [2]**presented Associate in intelligent management methodology for several electric receptacles trailing of physical phenomenon power-driven pump system for long boat within Asian country by exploitation DC-DC boost convertor as shift charger. This method consist the electrical device, a charger supported to the boost, battery, DC-DC converter, small pump. The electrical device has the specification of 75 watts of output power, and 3A of output DC current, 14-18 volts of output DC voltage. The output power of the electrical device uses input power to boost the DC-DC converters the shift charger. To manage the boost convertor heartbeat dimension [2] of the modulation can be applied. **B.R.Sanjeeva Reddy** et al [14] projected the PWM methods to regulate the output power of boost at the foremost possible price and at controls charging technique of battery. Parameter extraction, model analysis and analysis of boost device square measure incontestable exploitation MATLAB/Simulink model the recent development of the inverters for physical phenomenon AC-modules [4] has been targeted by **Soeren** et al. [4] The technology can be supported Centralized the Inverters on String Inverters and future on AC-Modules and AC-Cells. In this, target on DC to AC Inverter; power shift system; ability to induce drive voltage and shift power gives between electrical system and energy system.

III. PROPOSED METHOD

It is proposed to use a Neuro-Fuzzy model for improvement of the MPPT technique. A model will be simulated in which the algorithm will be implemented and the controller will be included with the load.To simplify the design procedure, numerical method instead of analytical technique is employed to obtain the EML in this paper. For PV panels, the MPP locus can be defined as the point (VMP, IMP), which expresses a function of panel irradiation at a given operating temperature. When the PGS is subjected to a step change in irradiation level, conventional P&O methods require a few perturbation steps to reach the MPPT value. On the other hand, the operation along the EML is carried out by the fast voltage regulating loop. Thus, the tracking time of the proposed method can be greatly reduced. In addition, this voltage regulating loop is commonly utilized in switching power converters and can simply be implemented using a commercially available pulse-width modulated (PWM) IC in analog form. This paper aims at developing a novel technique based on Neural Network for improved performance of MPPT method for solar cells connected to a grid. The design will be made on SIMULINK of MATLAB and algorithm codes will be written in editor of MATLAB. The Neural Network will be designed using NN-toolbox of MATLAB.

IV. RESULTS

This section presents the various results which are obtained using the proposed methodology as given in the previous section. The problem at hand was to develop an MPPT model using ANFIS for multi-junction solar cell connected to a grid. All the simulations have been done in MATLAB R =2013b in a computer having 2.7 GHz processor and 4 GB RAM.

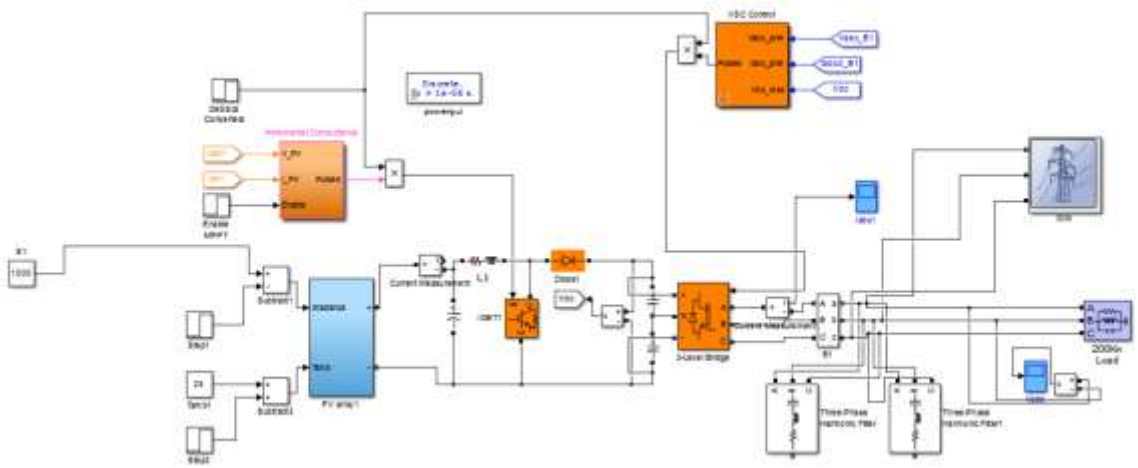

Fig. 1: Representing the overall proposed model

The voltage output is found to be quite close to sine wave as shown in figure 2

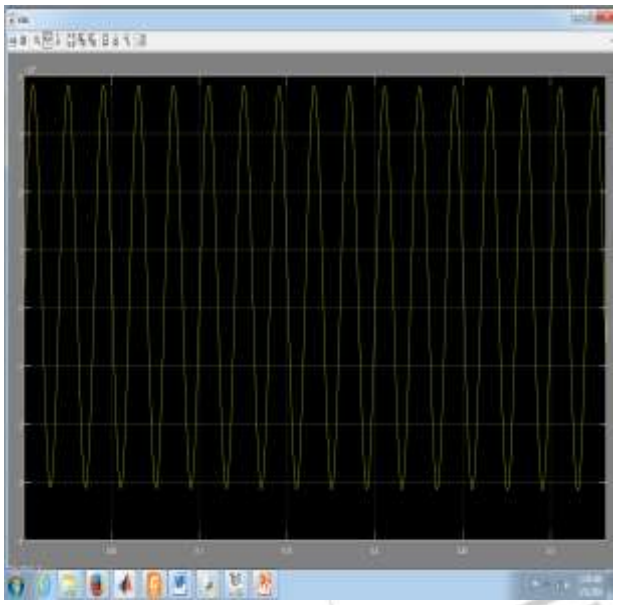

Fig. 2: Voltage output of ANFIS based MPPT

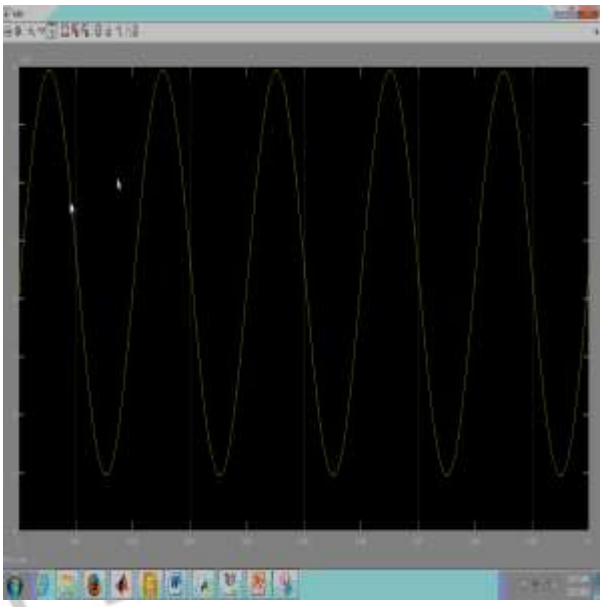

Fig. 3: The voltage output of I&C based approach

The voltage obtained using I&C is also analysed using FFT and it is found that the THD content of I&C approach is 0.35% which is more than ANFIS based approach as given in figure 3.

Table1: Showing Comparison of THD

	ANFIS	I&C
THD	0.17%	0.35%

V. CONCLUSION AND FUTURE SCOPE

This paper proposed a novel approach of utilising a neuro-fuzzy approach to solve the MPPT problem in multi-junction photo-voltaic cell connected to a grid using three phase inverter. The multi-junction photovoltaic cell was assumed to provide better output in terms of voltage. The model for adaptive neuro-fuzzy inference system was designed was designed and developed. The neuro-fuzzy model is used to train itself and track the voltage output based on the THD values of the output. The THD of the voltage was fed as input to the neuro-fuzzy model and as it is trained the firing angle of the boost converter connected to it is computed. The solar cell model was designed and given to boost converter. The converter output was analysed. An incremental conductance technique was also implemented for comparison purpose. The result of ANFIS algorithm was found to be quite better than the incremental conductance technique in terms of output voltage magnitude and THD content. The THD content reduces using our proposed approach. Also when the current is compared, the oscillations die out very fast in case of ANFIS algorithm while in I&C approach it is more or less sustained.

In future this algorithm can be improved using other techniques and approaches. Also real time implementation of the algorithms can be done and hardware testing can be done. Hybrid with other algorithms can be utilised and the performances can be compared. Also clustering and other gradient learning methods can be utilised and the model can be tested for grid connection.

VI. REFERENCES

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