PHOTOVOLTAIC SYSTEM EMPLOYING ARTIFICIAL INTELLIGENT TECHNIQUE FOR VARIATION OF SOLAR IRRADIATION CONDITION

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ABSTRACT-*Now a days the need for renewable energy sources is in rise due to the fact that the non-renewable energy sources takes into account the fuel costs, which leads to the unit commitment and economic dispatch problem. India plans to produce 20 Gigawatts solar power by the year 2020, whereas it has been realized only less than half a Gigawatt of our potential as of March 2014.The main hindrance for the penetration and reach of solar photovoltaic system is their low efficiency and high capital cost. The main objective of this paper is to track the Maximum Power Point (MPP) continuously of a photovoltaic system under variable temperature and solar irradiation. Traditionally, fast converging MPPT technique was used. Hence ANFIS technique is being proposed. This Artificial Intelligent control method is used for the Maximum Power Point Tracking (MPPT) of a photovoltaic system under variable temperature and solar irradiation conditions. When solar radiation changes slowly correspondingly changes occur in the power angle curve and in this case ANFIS network is beings used in order to track the maximum power point. However if the solar irradiation varies too rapidly, the ANFIS controller tracks the maximum power point rapidly and adjust the duty cycle of the DC-DC converter. In this technique, the input variables of PV array are parameters like voltage in open circuit, current in short circuit and atmospheric data like irradiance and temperature, or any combination of these. Generally, the output is one or several reference signals like a duty cycle signal, which are used to drive the power converter to operate the Maximum power point. The proposed technique is analyzed using MATLAB/Simulink software package 2013a version.*

KEYWORDS- *adaptive neuro and fuzzy inference system (ANFIS), maximum power point tracking (MPPT),photovoltaic (PV) system.*

1 INTRODUCTION

Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human time scale such as wind, sunlight, rain, tide, and wave. Renewable energy replaces conventional fuels in four distinct areas. Electricity generation, air and water heating/cooling, motor fuels, and rural energy services.

Based on ren21's 2014 report, renewable contributed 19 percent to our global energy consumption and 22 percent to our electricity generation in 2012 and 2013, respectively. this energy consumption is divided as 9% coming from traditional biomass,4.2% as heat energy,3.8% hydro electricity and 2%is electricity from wind, solar, geothermal, and biomass. Worldwide investment in renewable technologies amounted to more than14 billion in 2013, with countries like china and the united state heavily investing in wind, hydro, solar and bio fuel.Solar energy, radiant light and heat from the sun, is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaic, concentrated solar power, solar architecture and artificial photosynthesis. Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. A photovoltaic system converts light into electrical direct current (DC) by taking advantage of the photoelectric effect. Solar PV has turned into a multi-billion, fast-growing industry, continues to improve its cost-effectiveness, and has the most potential of any renewable technologies together with CSP. Concentrated solar power (CSP) systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Commercial concentrated solar power plants were first developed in the 1980s. CSP-Stirling has by far the highest efficiency among all solar energy technologies [1].

2 ADAPTIVE NEURO AND FUZZY INFERENCE SYSTEM

The adaptive network based fuzzy inference system (ANFIS) is a data driven procedure representing a neural network approach for the solution of function approximation problems. Data driven procedures for the synthesis of ANFIS networks are typically based on clustering a training set of numerical samples of the unknown function to be approximated. Since introduction, ANFIS networks have been successfully applied to classification tasks, rule-based process control, pattern recognition and similar problems. Here a fuzzy inference system comprises of the fuzzy model proposed by Takagi, Sugeno and Kang to formalize a systematic approach to generate fuzzy rules from an input output data set.

2. 1 ANFIS Structure

Fuzzy model is formed. For a first order two rule Sugeno fuzzy inference system, the two rules may be stated as: Rule 1: If x is A1 and y is B1 then f1 = p1x + q1y + r1

Rule 2: If x is A2 and y is B2 then f2 = p2x + q2y + r2

Here type-3 fuzzy inference system proposed by Takagi and Sugeno is used. In this inference system the output of each rule is a linear combination of input variables added by a constant term.

The final output is the weighted average of each rule's output. The corresponding ANFIS structure is shown in the Figure3

The individual layers of this ANFIS structure are described below :

Layer 1: Every node i in this layer is adaptive with a node function

$$O^1 i = \mu Ai \qquad [1]$$

where,

x is the input to node i, Ai is the linguistic variable associated with this node function and μAi is the membership function of Ai. Usually μAi(x) is chosen as

$$\mu Ai(x) = \frac{1}{1} + [(x - \frac{ci}{ai})^2]^{bi} \qquad [2]$$

Layer 2: Each node in this layer is a fixed node which calculates the firing strength wi of a rule.

The output of each node is the product of all the incoming signals to it and is given by,

$O^2_i = w_i = \mu A_i(x) x \mu bi(y), i=1,2$ [3]

Layer 3: Every node in this layer is a fixed node. Each ith node calculates the ratio of the ith rule's firing strength to the sum of firing strengths of all the rules. The output from the ith node is the normalized firing strength given by,

$O^3_i = w_i = w_i / w_1 + w_2, i=1,2$ [4]

Layer 4: Every node in this layer is an adaptive node with a node function given by,

$O_i^4 = w_i f_i = w_i(p_i x + q_i y + r_i), i=1,2$ [5]

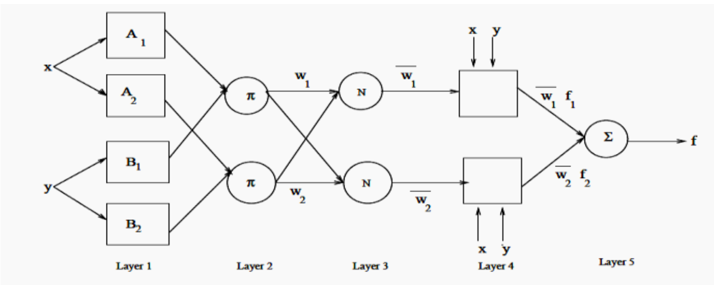

Fig 1 Structure of ANFIS

Where wi is the output of Layer 3 and {pi, qi, ri} is the consequent parameter set.

Layer 5: This layer comprises of only one fixed node that calculates the overall output as the summation of all incoming signals, i.e.

$O_i^5 = \text{over all output} = \sum_i w_i f_i = \sum i w_i f_i / \sum i \; w_i$ [6]

2. 2 Learning Algorithm

In the ANFIS structure, it is observed that given the values of premise parameters, the final output can be expressed as a linear combination of the consequent parameters.

The output F is given by,

$F = w_1/(w_1+w_2) f_1 + w_2/(w_1+w_2) f_2$

$F = w_1 f_1 + w_2 f_2$

$F = (w_1 x) p_1 + (w_1 y) q_1 + (w_1) r_1 + (w_2 y) q_2 + (w_2) r_2$

In the forward pass of the learning algorithm, consequent parameters are identified by the least squares estimate. In the backward pass, the error signals, which are the derivatives of the squared error with respect to each node output, propagate backward from the output layer to the input layer. In this backward pass, the premise parameters are updated by the gradient descent algorithm.

3 SIMULATION RESULT

MATLAB (MATrixLABoratory) is an interactive system for numerical computation. Numerical analysis Clever Moler wrote the initial FORTRAN version of MATLAB in the laten 1970s as a teaching aid. It becomes for both teaching, research, and evolved into a commercial software package written in C. For many years now, MATLAB has been widely used in universities. MATLAB has several advantages over more traditional means of numerical computing.

This section presents the simulation results by using MATLAB/Simulink as shown in Figure 2

An Adaptive Neuro-Fuzzy Inference System (ANFIS) based maximum power point tracker for PV module has been presented. To extract maximum power, a DC–DC boost converter is connected between the PV module and the load by using ANFIS tool box. The duty cycle of DC–DC boost converter is modified with the help of the ANFIS tool model, so that maximum power is transferred to load. Due to the complexity of the tracker mechanism and non-linear nature of photovoltaic system, the artificial intelligence based technique, especially the ANFIS method is used, in order to observe the maximum available power of PV module. It directly takes in operating

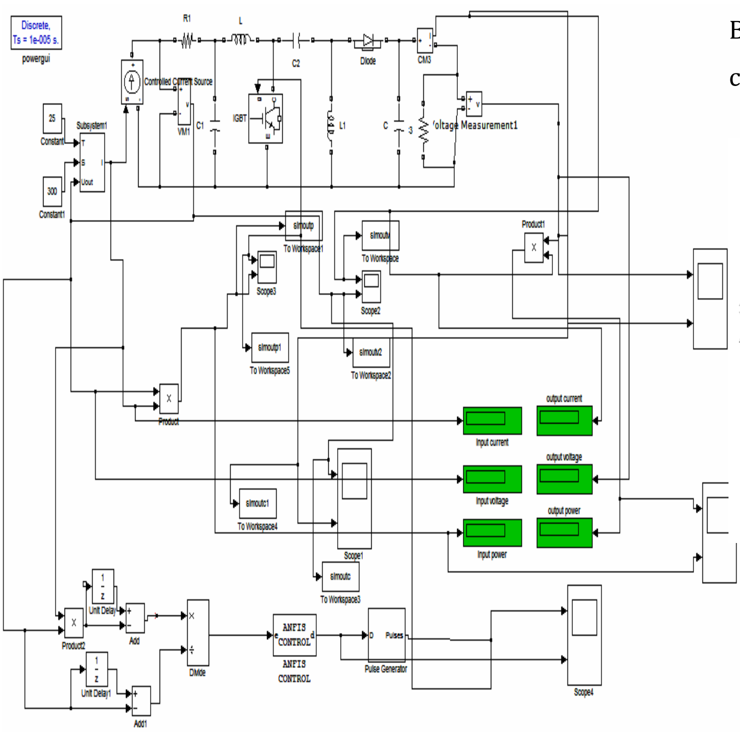

Fig 2 Simulation Diagram of Project Work

Temperature and irradiance level as input. The response of proposed ANFIS based control system gives more accuracy and fast response.

4 ANALYSIS OF RESULTS

The simulation of Photovoltaic system under solar irradiation is done using the ANFIS technique and the resulting waveform for the variation of the photovoltaic voltage, current and power are analyzed.

4.1 PHOTOVOLTAIC VOLTAGE DURING VARIATION IN SOLAR IRRADIATION

Voltage curve for the proposed method, obtained from the simulated Photo Voltaic system for changing solar irradiation is shown in Figure 3. During the solar irradiation, the output voltage of transient response of Boost converter shows the simulation result in the voltage curve.

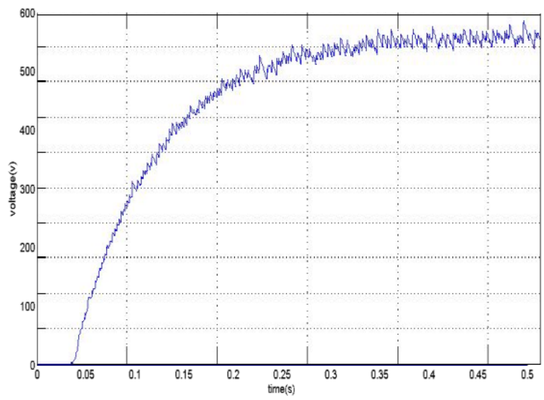

Fig 3 Waveform of Photovoltaic Voltage during Variation in Solar Irradiation

4.2 PHOTOVOLTAIC POWER DURING VARIATION IN SOLAR IRRADIATION

Power curve for the proposed method, obtained from the simulated Photo Voltaic system for changing solar irradiation is shown in Figure 4. During the solar irradiation, the output power of transient response shows the simulation result in the power curve.

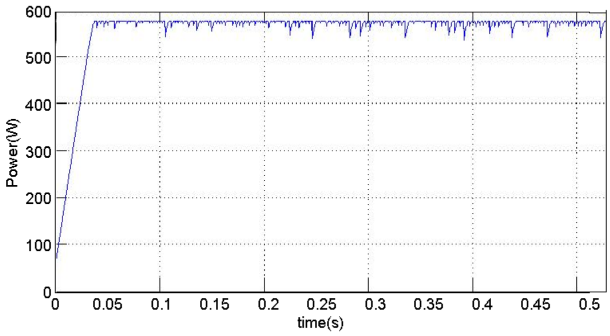

Fig 4 Waveform of Photovoltaic Power during Variation in Solar Irradiation

4.3 PHOTOVOLTAIC CURRENT DURING VARIATION IN SOLAR IRRADIATION

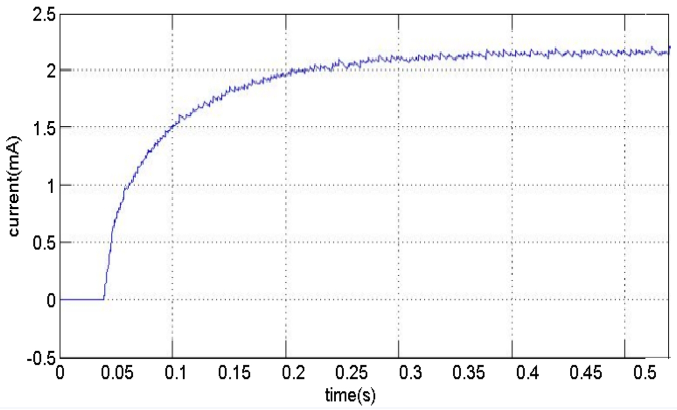

Fig 5 Waveform of photovoltaic current during variation in solar irradiation

Current curve for the proposed method, obtained from the simulated Photo Voltaic system for changing solar irradiation is shown in Figure 5. During the solar irradiation, the output current of transient response shows the simulation result in the characteristic curve of current

5 CONCLUSION

The proposed system only requires a dc–dc converter and is simpler than those which requires extra control loop and intermittent disconnection. Furthermore, the proposed algorithm responds to the variation in solar irradiation and load faster than the conventional algorithm. In addition, there is no steady-state oscillation in the proposed algorithm and thus reduce the power losses. The adaptive neuro and fuzzy inference system becomes popular due to its improved efficiency than conventional algorithm. The performance of the proposed scheme has been validated through simulation studies.

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