Utilization of power decoupling method in solar system frame to track maximum power using artificial neural networks

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Abstract. In this work, solar PV panel is joined to single phase grid by converters. DC-AC inverter is considered to pass ac output to grid. Due to shading of solar radiation on string, we see irregularities of power. Maximum power is identified at each string with replacement of temperature and irradiance. This discrete power can be corrected by using converters with perturb and observe (P and O) method. Full power processing converters are the available answers where the power is generated directly, and we identify more losses. Boost converter is used to build-up the output of panel, which is very small due to shading and it is the proposed scheme. There are many techniques used to get the power from the system. The entire circuit design, implementation and process is done in MATLAB software. The results show that the used Artificial Neural Network (ANN) scenario is very efficient, very complex and low cost.

Keywords. DC-DC Converter, Partial Shading, Partial Power Processing, Artificial Neural Network(ANN), Maximum power point Tracking(MPPT).

1. Introduction
Day to day, use of renewable energy is remarkably increasing. This type of energy production is seen in hilly, rural areas etc places where the energy requirement is poor. In view of the climatic conditions, it is fuel free, no noise and eco-friendly. Irradiance and temperature play a major role in the PV panel. Transformers are inducted into the converters in applications where a high ratio voltage noticed [1]. Modules are some set of cells, set of modules give array. They perform below one at low voltage. Voltage output, current and power are discovered by grinding of series-parallel of solar cells. PV panels are tied to load by converters. Output of panel is small dc and step-up converter is taken to increase the potential, which is of dc, this generated dc is passed to inverter and converts dc into ac and it is given to load. H-bridge is considered at a less frequency while the two-way switch is used at a
high frequency [2]. Solar photovoltaic has been introduced vastly. In each area, where the necessity of power is high besides the government power, plants are laid. Based on the size, diameter and length of the panel, production price varies. For a DC-AC inverter, a fixed DC voltage is maintained by the Boost converter [3]. MPPT which is simple and efficient is made used and dc-dc converters are located at the output side [4]. PV modules are grinded in series to develop high efficiency and high voltage and power. Power quality obstacles seen at the load are mitigated by the STATCOM system to compensate voltage changes, imbalance and reactive power, STATCOM compensation is used in current control mode[5].

To limit power loss, a bypassing diode surrounded the shaded module is used. To increase the PV value productivity energy and high conversion efficiency, a step- up DC-DC converter has to be used [6]. In PV control system, sun is considered as the major working component to develop 1 w of energy. Two inexhaustible input sources mixed with power matrix with critical electrical communication [7]. The PV block has a quadratic step-up converter connected in between load and PV module as power conditioner. Current and voltage of PV module values are given to the MPPT algorithm to obtain the duty cycle [8]. Power receiving to the system is observed by MPPT controller which incorporates ANFIS. Fly-back based partial converter is used which gives high efficiency when taken similarities with dc-dc. Strings shading and un-shading are put into view by keeping temperature value fixed and change in irradiance value [9]. Various artificial intelligence methods are incorporated in generally available MPPT algorithms to point out the MPP and generation of power in PV array. These are used to track the MPP faster with less no of oscillations. Some other applications of evolutionary optimization techniques may be found in [10-16].

In-order to train ANN there are many inspired algorithms biologically and evolutionary, as another learning form [17]. Neural network training are mainly based on local search, population methods and other models [18-22]. Its design is very complex. Accuracy of the system is tested with different patterns. ANN learn messages in the training process after many iterations. Once process is finished, it is ready to obtain new messages, think about new observations for nonlinear functions.

2. PV panel

Cells of the photovoltaic consist of the P-N link representation. Diode present in the circuit act like a open circuit. Development of power energy takes place by usage of photons in the system. Two individual cells which are pulverized to photovoltaic plate are brought together and give rise to module which has 32 or 36 silicon cells. Materials like gallium arsenide, cadmium telluride, single and multi-crystalline are basically used in silicon cell. Output power obtained from the one-piece module cannot reach the maximum peak value point, so we made an arrangement by connecting them in parallel or series to spread the current and voltage. In this, solar cell is made in touch with the diode and is in parallel. In rare case, we notice usage of two and three diodes in the model circuit. The general circuit network is shown in figure1. It has source which is in parallel with diode and shunt resister are said to be in other opposite side which tells us about the drop in voltage. Taking the temperature and irradiance in point, PV cell is considered to be non-linear.

![Figure1. Equivalent Circuit of a Solar Cell.](image)

Current versus voltage of the cell is shown below which is considered for the rise of MPPT statement.

\[ I_d = I \left[ \exp \left( \frac{q(V+IR_s)}{KT} \right) - 1 \right] \] (1)
\[ I = I_{PV} - I_0 \left[ \exp\left(\frac{V+IR_s}{nV_t}\right) - 1 \right] - \frac{V+IR_s}{R_0} \]

Here, \( I \) = current of solar cell, \( I_d \) = diode current, \( q \) = electron charge, \( K \) = Boltzmann constant, \( T \) = temperature in Kelvin, \( V \) = output voltage, \( R_s \) = series resistor and \( R_{sh} \) = shunt resistor.

**Figure 2.** V-I characteristics.

V-I curves of a PV shown are non-direct so it is very difficult to follow the MPPT. Figure 2 indicates V-I qualities.

**Figure 3.** Describes attributes of P-V under saturate light and temperature conditions.

### 3. Artificial neural networks

ANNs mainly related to the human brain characteristics namely, learning, producing new technology knowledge via learning, new knowledge discovering and skills without any assistance automatically.

**Figure 4.** Feed-forward training layers.
These neurons are connected to each other with weights different to differentiate the ANN which can have storage of memory and invent the data relations. With recognition pattern capability, ANNs are used for MPPT of the uniformly insulated PV systems. Input parameters to the systems are photovoltaic voltage and current or parameters of climatic namely insolation, Celsius degree whereas the outputs are Vmpp and Impp. Based on the data obtained from the experimental and simulation results, and after having the weights determined with intricate training stage, the ANN process of design is being completed. Especially, the ANN based MPPT has the advantage that its performance is dependent on the technical knowledge and designer skills and the characteristics of PV module.

The No of studies are very low based on insolation under non uniform conditions with ANN based MPPT methods because of certain disadvantages. Under this situation, a method with conventional incremental conductance can be combined with ANN to get improved performance which cannot track the global MPP. The process of training is executed with the test values and training from studies after finding the no of hidden layers and neuron at the hidden which has more prominent effect on ANN performance. The mapping between optimum voltage and partially shaded condition is more accurate and can be obtained with ANN and PV array power is obtained.

A series of layers are possessed by the Feed-forward networks and from the network input, the first layer has a connection. From the previous layer, each subsequent layer has a condition and the network output is produced by the final layer.

4. MPPT controller
It is used to trace peak power from the setup. Where voltage is peak at one point, their power tracking is noticed. To gather power there are so many techniques available in MPPT. In this we are using P&O method. The voltage and current are cross-counted, and power is developed from it. The irregular power of other is compared with the new power and maximum power is observed at one particular junction. Based on the algorithm, P and O method is implemented. ANN controller mainly used to reduce and reach the steady state very soon. It has medium speed of response and it has low error tolerance.

The inputs Vpv and Ipv are taken from the PV panel and it is given to MPPT controller. Power is tracked in this and a reference voltage Vpv is obtained, it is given to summing point where dc voltage average is combined to give Vo reference. Vdc is voltage observed across capacitor is given to band pass filter and the obtained ac voltage combines with Vo reference and also Vo is also applied to it and then it is given ANN controller and from it is given to discrete PWM to generate the pulses for the converter used.
5. Simulation results

Case 1: String 1 and string 2 are not under shading
In this temperature and irradiance value is kept constant without any change of 25 degrees and 1000.
In this case, there is no topic of partial shading. We determine voltage, current and power for PV and
also grid voltage, current and power in this. The power obtained in this is same for both the strings.
In this temperature value is 25 while the irradiance value is changed. Here in string 1 we see partial shading and string 2 is not under shading. The power obtained in string 1 will be less than the string 2. We determine voltage, current and power for PV and also grid voltage, current and power.

Figure 8. (a) Voltage (b) Current (c) Power of grids (d) Voltage (e) Current (f) Power of PV

Case 2: String 1 is under shading and string 2 is not shaded.
Specifications of PV module

The parameters of the modules under the standard condition are as shown in Table 1. To study the cases, two conditions are set for this PV system, $G_1 = G_2 = 1000\, \text{W/m}^2$ for case 1, $G_1 = 800\, \text{W/m}^2$, $G_2 = 1000\, \text{W/m}^2$ for case 2 respectively with temperature 25 degrees.

**Table 1.** PV module parameters

| PV panel parameters            | Value |
|-------------------------------|-------|
| No. of series connected cells | 96    |
| Open circuit voltage          | 64.2  |
| Short circuit current         | 5.96  |
| Series resistance             | 5.96  |
| Parallel resistance           | 360   |
| No. of modules in series      | 5     |
| No. of modules in parallel    | 66    |
Table 2. Methods of MPPT comparison under partial shading condition

| Method                  | Variables Sensing | Complexity Implementation | Speed Tracking | Dependency on Module | Tracking capability of Global MPP |
|-------------------------|-------------------|----------------------------|----------------|----------------------|----------------------------------|
| Modified P & O IC       | V,I               | Low                        | Fast           | Yes                  | Medium                           |
| Modified IC             | V,I               | Low                        | Medium         | Yes                  | Medium                           |
| FLC based method        | V,I               | Medium                     | Medium         | Yes                  | High                             |
| ANN based method        | Solar insolation, temperature | Medium to high | Slow to medium | Yes                  | Guaranteed                       |
| PSO                     | V,I               | Medium                     | Medium         | No                   | Guaranteed                       |

6. Conclusion
From the PV system is very important in obtaining man energy. For PV system efficiency improvement, investigation is done with solar tracking systems, highly efficient power electronic converters, and MPPT methods. The performance of the system with ANN is performed and it is noticed under two different conditions to observe the power. We observe the power from the system due to shading by P and O method. Efficiency is observed by using ANN controller. Speed of response is in normal range. From simulation results, ANN is able to track the maximum power from two conditions with changes in temperature and irradiance. Power observed on string 1 and string 2 in case 1 will be same, as there is no shading. In case 2, string power will be less than the string 2 under shading of string 1 and grid power is also obtained under the two cases.

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