A COMPARISON OF OBSERVE AND RULE BASED OPTIMIZATION ALGORITHM FOR PHOTOVOLTAIC MAXIMUM POWER POINT TRACKING

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Abstract

The perturb and observe (P&O) in one of a optimization based control that have best operation conditions are investigated in order to identify the edge efficiency performances of this most popular maximum power point tracking (MPPT) technique for photovoltaic (PV) applications. It is shown that P&O may guarantee top-level efficiency. At the other a ruled control such as ANN propose a fast point assignment and a small error the point assignment. It is shown that ruled control may guarantee faster point assignment and a high-level efficiency. This paper compare both method based on the speed to get the maximum point and the efficiency of each algorithm.

Keywords – MPPT; Observe; Predictive; P&O; ANN;

1. INTRODUCTION

Demand of renewable energy as electric source is increased due to the amount of fossil fuel that become more limited. Among several renewable energy sources, photovoltaic (PV) appears to be the most interesting for electric generation because of its clean and quiet operation. Sun produces very large energy that enough to provide electricity for all human population. However, there is a problem with PV as the tool to convert solar energy into electrical power, which is still have low efficiency and high cost [1]. Due to that reason, it is very important to operate PV module in its maximum power to increase system efficiency.

Electric power that provided by PV is a result from PV voltage and current in the same time. The PV voltage and current itself depend on the temperature and sun irradiance. Maximum power point tracking (MMPT) is a technique to extract the possible maximum power of PV module in all condition of temperature and sun irradiance. Many methods have been used to tracking maximum power point of PV module such us perturb and observation (P&O), incremental conductance, artificial neural network (ANN), and . Fractional open-circuit voltage method has problem to determine the optimal operating point in rapid change of sun irradiance [2]. Increment conductance method can overcome this problem but it needs very complex calculation and memory because of differentiation of current and voltage [3]. In the other hand, P&O method has similiar problem with fractional open-circuit voltage method but it is easier and very reliable in normal condition [4].

Maximum power point condition can be achieved by using DC-DC converter as power conditioning. Boost converter is the most common DC-DC converter that used for MPPT of PV. Boost converter is used to maximize energy transfer from PV to the load by regulate PV voltage [5].

Difference used in MPPT control causes the performance difference between the control one another. Observe control the most preferred being able to work on a variety of conditions. This type of control can be used despite the changes in PV characteristics are usually caused by the increasing age the use of PV. On the other side, Observe the use of control looks very slow compared to predictive control.

2. METHOD AND EXPERIMENT

2.1 MPPT System

Fig. 1 presents the overall system. 20 kW PV connected to storage devices. PV is connected to a boost converter is controlled by a controller. Observe the controller can be a control such as perturb and Observe algorithm or a predictive control such as ANN

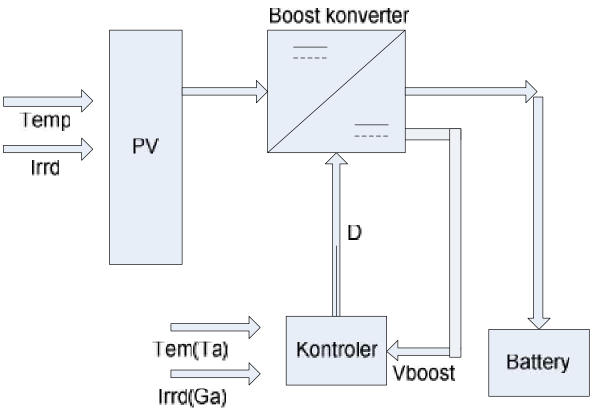


Figure 1. Over all MPPT system

2.2 PV Model

PV equivalent circuit is presented on Fig. 2 and PV characteristics equation presented below.

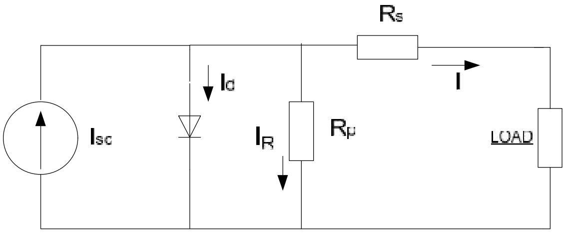


Figure 2. PV equivalent circuit

$$I = I_{sc} - I_0 \left[\exp\left(\frac{e(V + I \cdot Rs)}{\mid kT_c} \right) - 1 \right] \quad (1)$$

$$I^M = I^M{}_{sc} \left[1 - \exp\left(\frac{V^m - V^M_{oc} + R^M_s \cdot I^M}{N_s \cdot V^C_T} \right) \right] \quad (2)$$

$$I^M = Np \cdot I^C_{sc} \left[1 - \exp\left(\frac{V^M - V^C_{oc} + R^M_s \cdot I^M}{N_s \cdot V^C_T} \right) \right] \quad (3)$$

Where :

$$V_t^C = nkT / q \quad (4)$$

$$I^C_{sc} = \frac{I^C_{sc0}}{G_{a0}} \cdot G_a \quad (5)$$

$$V^C_{oc} = V^C_{oc0} + 0.03 \cdot (T_a + 0.03 \cdot G_a - T_{C0}) \quad (6)$$

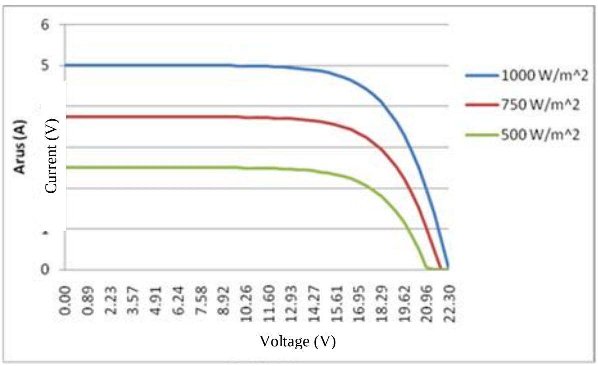


Figure 3. I-V curve for different radiation levels

Fig. 3 presents I-V curve for a different radiation level. In the picture shows that the output voltage Maximum PV decreased if irradiation received by PV reduced. Fig. 4 presents P-V curve for a different radiation level. The figure shows that PV has a maximum power point. Both figures show that PV has a different maximum power point for a different Irradiation.

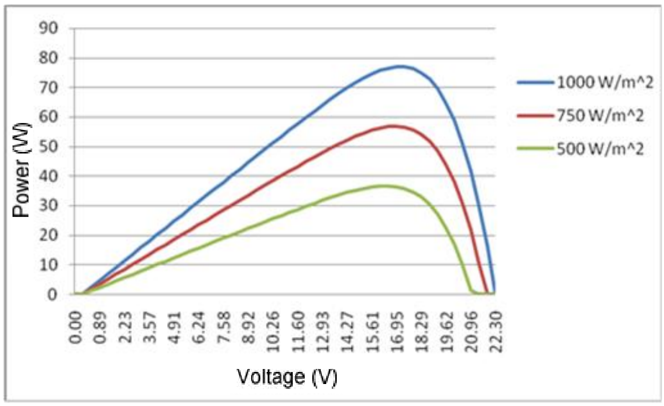


Figure 4. P-V characteristic for different Irradiation

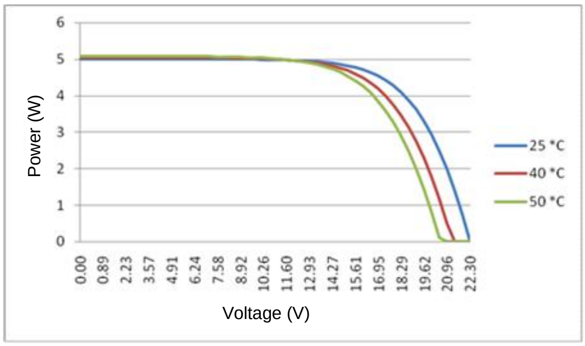


Figure 5. I-V curve for different temperature levels

Fig. 5 and 6 present I-V and P-V curve for a different temperature level. The figure shows that PV has a maximum power point. Both figures show that PV has a different maximum power point for a different temperature.

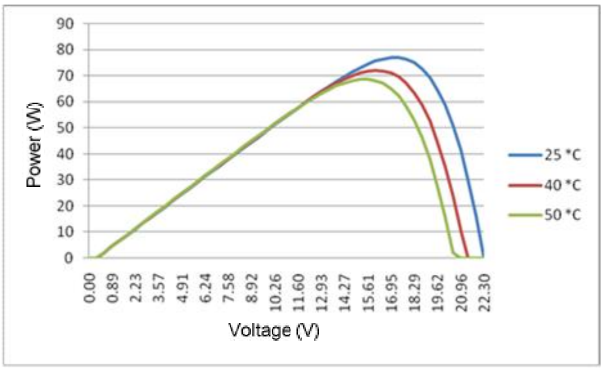


Figure 6. P-V curve for different temperature levels

2.3 P&O MPPT Technique

Basic method of MPPT is to find voltage V_{MPP} or current I_{MPP} where PV arrays delivers maximum power under certain sun irradiance and temperature [1]. Flowchart of P&O MPPT technique given in Fig. 2. Output voltage and current from PV module is measured to calculate PV output power. The change of PV output power is calculated periodically by subtract PV output power in one period with power in previous period. The change of voltage is calculated periodically too by subtract PV output voltage in one period with voltage in previous period. If both of change of power and change of voltage are positive or both of them are negative, module voltage will be increased. If one of them is positive and the other is negative, module voltage will be decreased. The output of MPPT algorithm is duty cycle for DC-DC converter. The duty cycle will be change continously after the maximum power point has been reached. This method will never get the absolute maximum power point, but oscillate around the point with increasing and decreasing module voltage continously. The voltage which PV can deliver maximum power is different for different values of irradiance and temperature. For each condition, PV module has each characteristic curve.

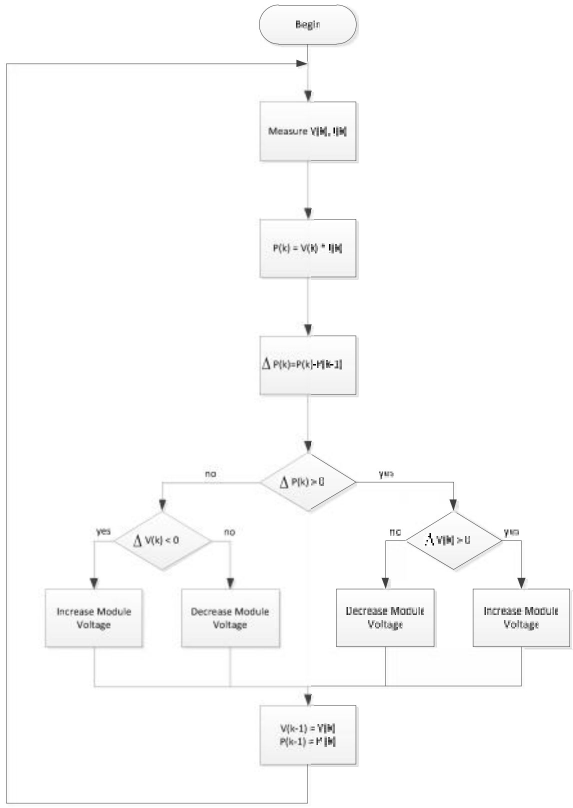


Figure 7. Flowchart of P&O MPPT Technique

2.4 ANN MPPT technique

Artificial neural network (ANN) is an artificial brain tissue that can be learned about the specific patterns. ANN can work quickly and have a relatively high accuracy compared with other artificial intelligent. Fig. 3 presents the topology of an ANN. An ANN consists of input layer, hidden layer can be more than one, and post layer[7].

To obtain an ANN training process is carried out. we can know the quality of the ANN to see the mean square value of the training process. The generated ANN in this paper have 0.612 Volt mean square error . This value is relatively small compared to the optimal nominal voltage range at 250 Volt.

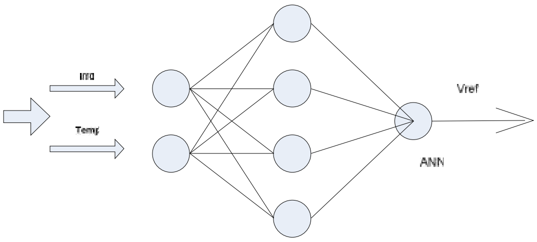


Figure 8. ANN

In the PV MPPT, ANN works as a controller that converts inputs: irradiation and temperature into output (Vref).

Table 1. Parameters Of PV System

Parameters	Value
PV output power (peak) P_{pv}	1250 Watt
Inductor L_1	50 mH
Capacitor C_1	250 μF
Capacitor C_2	1000 μF
Switching frequency	100 kHz

3. SIMULATION RESULT

3.1 P&O MPPT Result

Fig.9. and Fig. 10 present the result of P & O control on PV MPPT. Fig. 9 shows the curve of V versus t for 0.01 Volt on incremental for each step. Figure 10 shows the curve of V versus t for 0.01 Volt on incremental for each step. Figure 9 has a faster rise time than the figure 10, but the ripple in the figure 10 is much smaller than the ripple in Figure 9. The ability of P & O is strongly influenced by the value of increment. At steady state the type of ripple control is still happening.

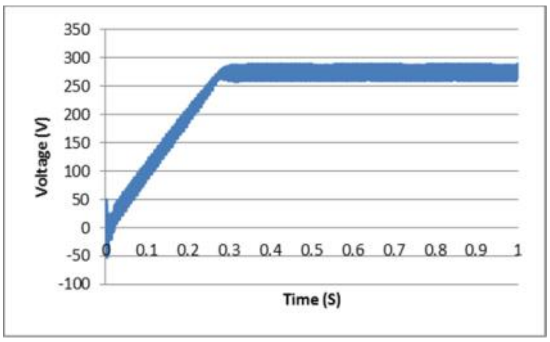


Figure 9. V-t curve for increment = 0.01 at 1000 W/m^2

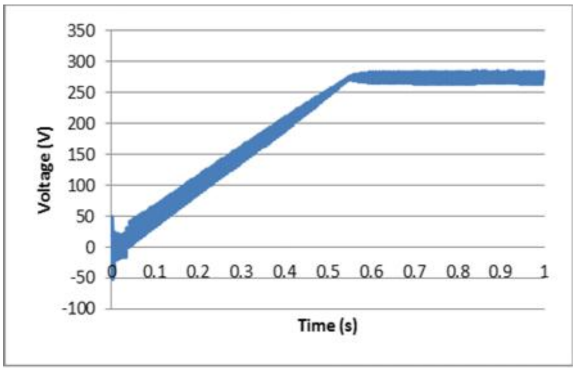


Figure 10. V-t curve for increment = 0.005 at 1000 W/m^2

3.2 ANN MPPT Result

Fig. 11 present the result of ANN control on PV MPPT. MPPT using ANN has a very quick response. This is because the ANN has a direct PV output value of the reference work.

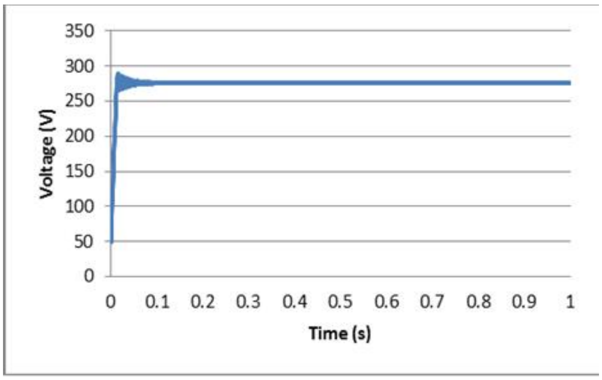
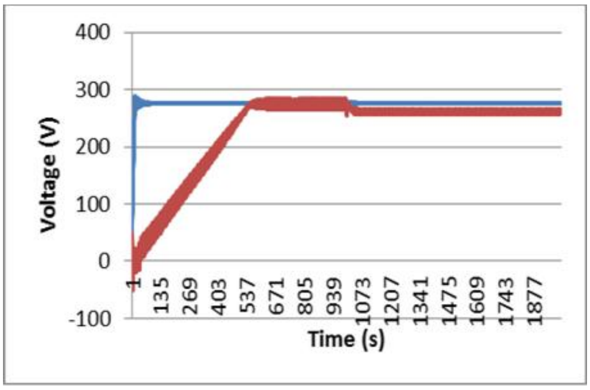


Figure 11. V-t curve for ANN MPPT at 1000 W/m^2

4. COMPARISON OF THE PEFORMANCE

The figure below presents a comparison between P & O and ANN control. From the figure we can conclude that the rise time of the ANN is much smaller than the rise time of P & O. In addition to the ANN control has no ripple which occurs at steady state. In the other hand P & O control ripple is very high and is directly proportional to the increment control P&O.



5. CONCLUSION

P & O and both have their respective advantages. P & O to get the optimum PV power without any training . While ANN can work quickly because the ANN directly determines the reference value. ANN unfortunately can not work directly but must be trained first references.

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