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Maximum Power Point Voltage Prediction for Solar Photo Voltaic Panel Using Artificial Neural Network

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ABSTRACT:
solar energy is the most rapidly growing renewable energy resource. in the past five years, it is gaining very much popularity in India as well as in many developing countries. Much research work is going on to increase the efficiency of the solar panels as well as to extract the maximum power from the solar panels as much as possible. The difficulty with the solar panel is that it is having non-linear characteristics that means its operating point gets shifted with the change in irradiation level and temperature. This research is dedicated to modeling a photovoltaic panel and understanding its non-linear characteristics with various irradiation levels and temperatures. Along with that maximum power point voltage prediction by using artificial neural networks is done. The simulation model is made on MatLab Simulink and by collecting various data from the Simulink model an artificial neural network-based network is modeled which is having the ability to predict the value of the voltage at which maximum power can be extracted from solar PV panel and maximize the efficiency of the solar PV panel.

Keywords: photovoltaic modeling, artificial neural network, maximum power point voltage, solar panel characteristics

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I. INTRODUCTION :

solar energy is an everlasting source of energy and in the field of the energy sector, it is gaining very much importance. The demand for energy has increased rapidly in recent years especially in developing countries like India. Due to the large electrification of rural areas of India the need to have a vast source of energy has increased. To cope up with this problem the Indian government is going towards solar solutions. Solar energy is converted into electricity by using solar cells. Solar cells are connected in a series-parallel combination as per the requirement for voltage and power. Voltage ratings are increased by series connection and power ratings are increased by parallel connection. A combination of solar cells are termed as solar panels.

Problems associated with the solar panels are that they are having very low efficiency(around 20%) along with that with the change in irradiation level and temperature its operating point gets shifted. For a particular voltage, only maximum power from the solar panel can be extracted. So this buck converter is connected between the load and the solar panel so that the panel voltage can be adjusted so as to extract maximum power.

Many algorithms are there in the literature like perturb and observe method, incremental conductance method, etc that tracks the maximum power point of the solar panel. This paper is emphasized on creating an artificial neural network that will be having the capability to predict the maximum power point voltage of the solar panel so that the maximum power point can be tracked more effectively.

II. MODELLING OF PV PANEL

PV panel can be modelled by using the following governing equation

The phase current of the PV panel as a function of short circuit current, temperature and irradiance level is given by equation 1

$$I_{ph} = \left[I_{sc} + k_i (T - 298) \right] \frac{G}{1000} \text{ --------------(1)}$$

Where I_{sc} is the short circuit current of the PV panel, K_i is the short circuit current temperature coefficient, T is the panel temperature in kelvin scale and G is the irradiance level.

The reverse saturation current of the PV module is obtained by the following equation 2

$$I_{rs} = \frac{Isc}{\left[e^{\frac{qVoc}{NsKAT}} - 1 \right]} \quad \text{----------------(2)}$$

Where q is charge of 1 electron $=1.6*10^{-19}$ coulomb, Voc is the open circuit voltage of the PV panel, N_s is the number of cells connected in series,K is the boltzman constant $=1.3806*10^{-23} m^2 kg s^{-2} K^{-1}$, A is the ideality factor =1.3

Panel saturation current is given by equation 3

$$I_o = I_{rs} \left[\frac{T}{T_r} \right]^3 \left(e^{\frac{qEgo}{AK}} \right) \left(\frac{1}{T_r} - \frac{1}{T} \right) \quad \text{--------------(3)}$$

Here Ego is the band gap for silicon =1.12 eV and Tr is the reference temperature in kelvin=298 K

The PV output current I_{PV} is calculated by equation 4

$$I_{PV} = N_p I_{ph} - N_p I_o \left[e^{q \frac{(V_{pv} + I_{pv} R_s)}{N_s AKT}} - 1 \right] \quad \text{-----------(4)}$$

Rs is the series resistance connected with panel, Vpv is the panel output voltage Np is the number of cells connected in parallel.

Various value of parameters taken for modelling are ki=0.0032,q=1.6e-19,k=1.38e-23, A=1.3,Ego=1.1,Rs=0.221,Tn=298,Voc=32.9,Isc=8.21,

Ns=54

III. PV CHARACTERISTICS

The P-V curve of the photovoltaic panel modeled for T=25 celcius and G=1000 is shown in figure 1. Figure 2 gives the I-V curve of PV panel at T=25 degree celcius and G=1000. It is clear that maximum power point is obtained at voltage of 26.65 Volt for the temperature of 25 degree celcius and irradiance of 1000. Variation of the P-V curve with the variation in irradiance level keeping temperature constant is shown in figure 3.

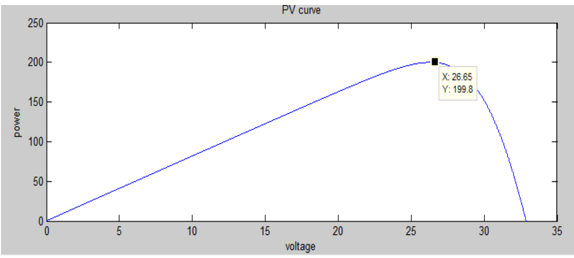

Fig 1 P-V curve for T=25 celcius and G=1000.

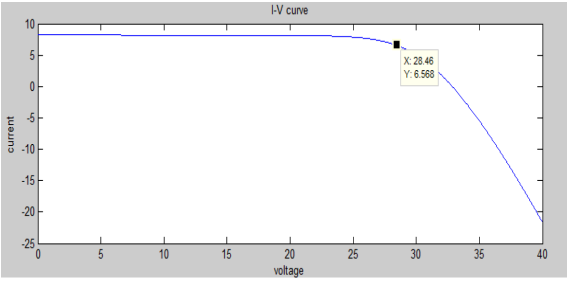

Fig 2 I-V curve for T=25 celcius and G=1000.

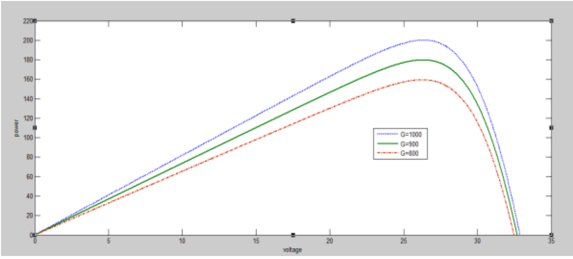

Fig 3 variation of P-V curve with variation of G

As it is seen from fig 3 the variation in irradiance level cause change in maximum power point voltage .

Figure 4 gives the variation in P-V curve with the variation of temperature keeping irradiance level constant

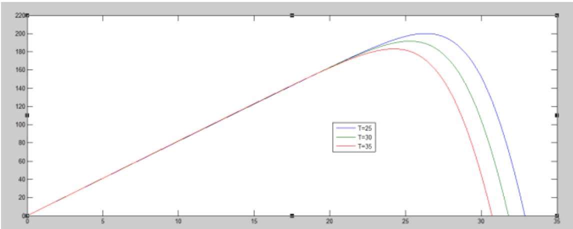

Fig 4 variation of P-V curve with variation of temperature

From figure 4 it is clear that maximum power point voltage also changes with the change in temperature.

From the various characteristics shown it is clear that maximum power point voltage gets changed everytime when there is change in temperature or the change of irradiance level. Maximum power point voltage data is obtained with various value of temperature and irradiance. Some of the obtained data is shown in table 1. Here Vm is maximum power point voltage.

s.no	G	T	Vm
1	1000	25	26.55
2	900	25	26.52
3	800	25	26.51
4	700	25	26.48

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5	600	25	26.33
6	1000	30	25.36
7	1000	35	24.26
8	900	35	24.47
9	800	35	24.41
10	40	1000	24.41

Table 1 value of mppt voltage for various values of G and T

IV. MODELING OF ANN NETWORK

Artificial neural network modeling is a method by which an input-output relationship can be established for any system using networks. ANN modeling is done by using many input-output data and that network can be used to predict the unknown output data from the given input data. The temperature and irradiance level data are taken as input data and the maximum power point voltage data is taken as output. A total of 50 data is collected and its neural network model is obtained. Figure 5 shows the neural network model to calculate the maximum power point voltage.

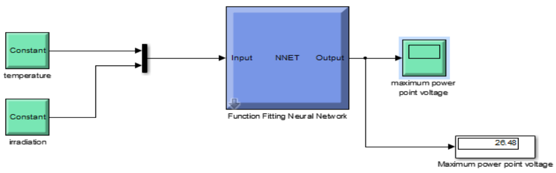

Fig 5 ANN model to calculate MPPT voltage

From the ANN model 10 data is obtained and it is compared with the data obtained in actual solar PV model to validate the ANN model. Table 2 gives the comparison between the maximum power point voltage by ANN network and PV model. Here T represents the input temperature, G represents the irradiation level, Vs represents maximum power point voltage obtained from PV characteristics and Va represents maximum power point voltage obtained by ANN model.

T	G	Vs	Va
24	700	26.61	26.62
24	1000	26.58	26.64
25	900	26.45	26.46
25	950	26.51	26.45
25	1000	26.45	26.44
34	1000	24.48	24.48
40	1100	23.32	23.29
42	1200	22.89	22.81
44	1200	22.54	22.53
25	1200	26.45	26.5

Table 2 comparison analysis between actual data and ANN data

V. RESULT

From table 2 plot between the two maximum power point voltage data is done. The plot is shown in figure 6

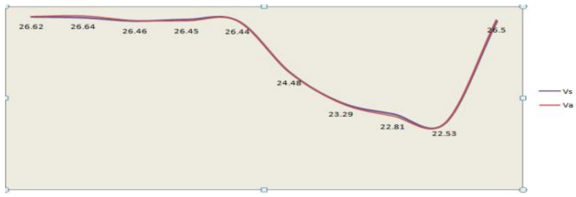

Fig 6 plot between Vs and Va

As it is seen from the plot that the two curves are approximately overlapping which means the data obtained from the neural network model is approximately equal to the maximum power point voltage. this validates the ANN model to be useful in obtaining maximum power point voltage.

VI. CONCLUSION

The solar PV panel is modeled and the characteristics of the PV panel are discussed. To obtain the maximum power point voltage artificial neural network model is obtained and its effectivity is validated by the plot between the actual mppt voltage and mppt voltage obtained from the ANN network. The result shows the accuracy of the obtained ANN model. The obtained ANN model can be used to track the maximum power point of the PV panel very much effectively.

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