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Analysis of Variation in Solar Panel Parameter with respect to Solar Isolisation and temperature

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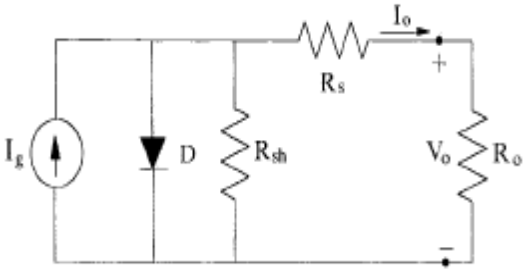
Abstract—
As convetional sources of energy are rapidly depleting and the cost of energy is rising, photovoltaic energy becomes a promising alternative source. Among its advantages are that it is: 1) abundant; 2) pollution free; 3) distributed throughout the earth; and 4) recyclable. The main drawbacks are that the initial installation cost is considerably high nd the energy conversion efficiency is relatively low. To overcome these problems, the following two essential ways can be used: 1) increase the efficiency of conversion for the solar array and 2) maximize the output power from the solar array. With the development of technology, the cost of the solar arrays is expected to decrease continuously in the future, making them attractive for residential and industrial applications.

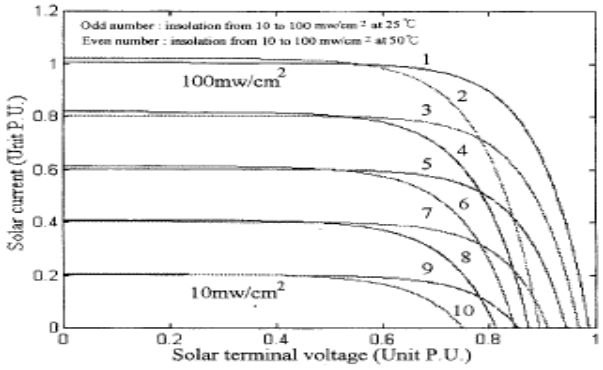
Index Terms— solar array, solar isolation, PV sources, solar irradiation, PSIM simulation, Solar cell, photovoltaic energy

1 INTRODUCTION TO SOLAR ARRAYS CHARACTERISTICS

The electric power generated by a solar array fluctuates depending on the solar radiation value and temperature, as shown in Fig. 1. The solar array characteristics significantly influence the design of the converter and the control system; therefore, these will be briefly reviewed here. The solar array is a nonlinear device and can be represented as a current source model, as shown in Fig. 1(a). The cell structure and parameters involve photocurrent, diode reverse saturation current, diode ideality factor, series resistance and shunt resistance, which need to be identified for every operating condition for the accurate modeling of solar cell behavior [1].



(a)



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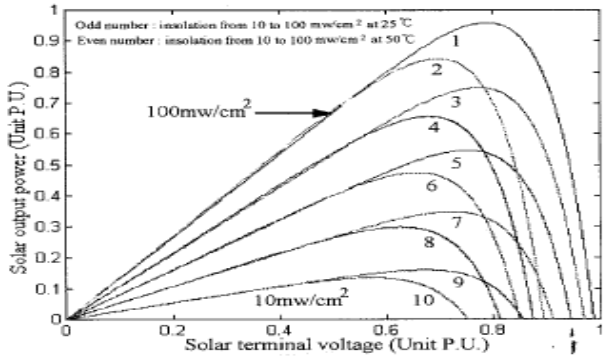

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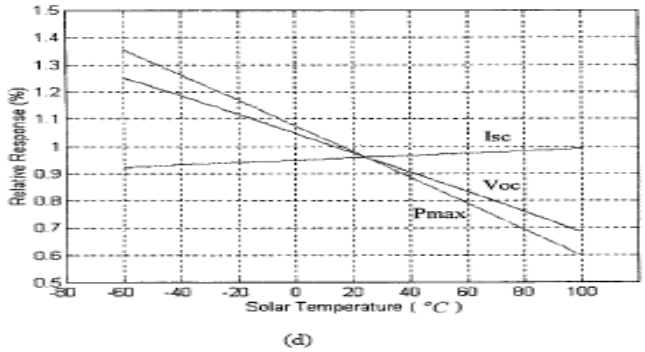

(d)

Fig. 1. Solar array characteristics curves and equivalent circuit.
(a) Equivalent circuit of a solar array. (b) Current–voltage curves.
(c) Power–voltage curves. (d) Temperature characteristics

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2 CURRENT OF SOLAR ARRAY VARIES WITH TEMPERATURE

The current *I* of the solar array varies with temperature according to the following equation [2]:

$$I = Iph - Id$$

$$Iph = \frac{G}{1000} Isc \left(1 + K(T - Tr)\right)$$

$$Id = Io \left(e^{\frac{V}{ns\ Vt}} - 1\right)$$

Iph = photo current directly proportional to solar irradiation

Id = diode current (A)

Io = saturation current of the diode (A)

Ns = number of cell in one panel

G = irradiation (W/m2)

K = boltzman constant (1.3805e-23)

T = cell temperature (K)

Tr= reference tempetature (299K)

3 TRADITIONAL CHARACTERISTICS OF SOLAR ARRAY

The traditional – characteristics of a solar array, when neglecting the internal shunt resistance, is given by the following equation [2]:

$$v = nps\ voc + nps\ ns\ vt\ In\ (1 - \frac{I}{\frac{Isc\ G}{2000}})$$

Voc= open circuit voltage

Vt= cell thermal voltage(25mv)

Isc= short circuit current at stc (A)

G = irradiation (W/m2)

ns = number of cell in one panel

nps = number of panel connected in series

Equations (1)–(2) are used in the development of computer simulations for the solar array. The psim software is used. Fig. 1(b) and (c) Shows the simulated ampere– volt and power–volt curves for the solar array at different insolations and different temperatures. From these curves, it is observed that the output characteristics of the solar array are nonlinear and vitally affected by the solar radiation, temperature, and load condition. Each curve has a maximum power point , which is the optimal operating point for the efficient use of the solar array. When the temperature rises, the open-circuit voltage and the maximum power fall, but the short-circuit current increases slowly, as shown in Fig. 1(d).

The cell temperature in Kelvin can be obtained as in,

T =3.12 + (0.25 X G) + (0.0899 X Ta) – (1.3 X Ws) + 230

G = irradiation (W/m2)

Ta = reference temperature (ºC)

Ws = wind speed (km/h)
T = cell temperature in Kelvin

Approximately power output decreases 0.45% per. ºC increase above rated temperature. From above equation we can find out the effect of wind and solar irradiation on the temperature and then we are able to know the effect of temperature on the output power.

4 MEASUREMENT OF SOLAR IRRADIATION

$$G = Isc[10.033 \cos((360n/365)]$$

$$X\ [\cos \emptyset \cos w \cos \delta + sin \emptyset\ sin \delta]$$

G = irradiation (W/m2)

Isc = solar constant = 1387 w/m2

n = number of total day

w = hour angle

δ = declination angle

ϕ = latitude of location

where δ,

$$\delta = 23.45 \sin\left[\frac{360}{365}(284 + n)\right]$$

5 PSIM CIRCUIT ORIENTED SIMULATOR PV SOURCE

To do the analysis of this solar panel with different conditions, sub circuit implementation has been shown in Fig. In which we can observe the effect of variation of solar irradiation, ambient temperature on the electrical parameter of solar panel.

With above psim circuit simulator model of pv source we can find out the output power of solar panel of different rating manufacture by company as in appendix A, At different location with latitude and longitude angle. And also we are able to observe the effect of inclination angle of solar panel with horizontal plane on solar panel power output.

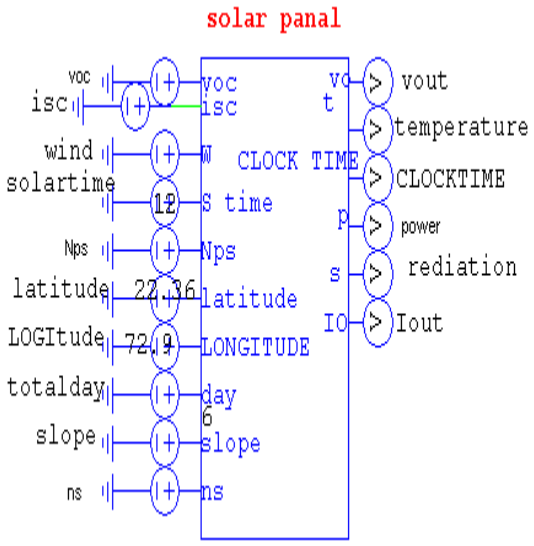

Fig. 2. PSIM circuit oriented simulator PV source

5 POWER OUTPUT OF SOLAR PANEL AT DIFFERENT LOCATIONS AND DELAY TIME

Power output of solar panel at different location at different day time with psim software.

Solar panel rating used for simulation are voc = 21v , Isc = 3.81A

Number of panel connected in series, Nps = 1

Number of cell in one panel connected in parallel, Ns = 36

21ST December ,Total number of day of the year = 355

location - visnagar (23.7 , 73.1) , slope=0

Time (Hour)	Radiation Data using software (w/m2)	Power (watt)	Temperature (Kelvin)	Practically Measured radiation Data (w/m2)
8:00	95.936	-9.6	294.49	
8:30	141.4	-5.9	295.43	
9:00	266.82	3.98	298.766	
9:30	324.64	8.44	300.211	
10:00	455.96	18.46	303.4	478.22
10:30	506.60	22.29	304.76	
11:00	600.64	29.34	307.11	522.19
11:30	627.769	31.415	307.78	
12:00	654.54	33.42	308.45	595.34
12:30	649.57	33.049	308.334	
13:00	600.64	29.37	307.11	580.12
13:30	565.145	26.71	306.22	
14:00	455.96	18.46	303.495	
14:30	401.207	14.305	302.125	
15:00	266.82	3.98	298.766	
15:30	210.655	-0.3	297.364	
16:00	95.3	-9.6	294.49	
16:30	57.76	-12.89	293.53	
17:00	4.74	-18.54	292.214	

21ST December ,Total number of day of the year = 355

location - visnagar (23.7 , 73.1) , slope=45

Time (Hour)	Radiation Data using software (w/m2)	Power (watt)	Temperature (Kelvin)	Practically Measured radiation Data (w/m2)
8:00	461.55	18.88	303.63	
8:30	557.796	26.15	306.04	
9:00	791.78	43.65	311.89	
9:30	891.1	51.61	314.37	
10:00	1105.23	66.70	319.72	460.04
10:30	1184.72	72.44	321.71	
11:00	1334.72	82.44	321.71	545.47
11:30	1384.72	85.44	321.71	
12:00	1410	88.30	327.34	382.66
12:30	1402.57	87.79	327.15	
13:00	1328.97	82.68	325.319	301.09
13:30	1274.98	78.88	323.97	
14:00	1165.23	66.70	319.726	
14:30	1017.53	60.31	317.53	
15:00	791.78	43.61	311.89	
15:30	690.958	36.14	309.36	
16:00	461.55	18.88	303.63	
16:30	370.606	11.9	301.36	
17:00	188.68	-2.1	296.811	

22ST December ,Total number of day of the year = 356

location - visnagar (23.7 , 73.1) , slope=0

Time (Hour)	Radiation Data using software (w/m2)	Power (watt)	Temperature (Kelvin)	Practically Measured radiation Data (w/m2)
10:00	456.61	18.51	303	460.04
11:00	601.44	29.43	307.13	545.47
12:00	655.39	33.48	308.48	382.66
13:00	601.4	29.43	307.1	301.09
14:00	456	18.51	303	
15:00	267.28	4.2	298.7	
16:00	96.17	-9.6	294.4	

23ST December ,Total number of day of the year = 357

location - visnagar (23.7 , 73.1) , slope=0

Time (Hour)	Radiation Data using software (w/m2)	Power (watt)	Temperature (Kelvin)	Practically Measured radiation Data (w/m2)
10:00	457.4	18.57	303.53	501.1
11:00	602.38	29.51	307.55	250.09
12:00	656.4	33.56	308.505	280.11
13:00	602.38	29.51	307.156	208.24
14:00	457.7	18.57	303.53	501.1
15:00	267.828	4.06	298.79	
16:00	96.45	-9.58	294.506	

21ST December ,Total number of day of the year = 355

location - Delhi (28.38 , 73.55) , slope=0

Time (Hour)	Radiation Data using software (w/m2)	Power (watt)	Temperature (Kelvin)
10:00	368.19	11.78	301.3
11:00	492.70	21.32	304.43
12:00	504.72	24.87	305.64
13:00	493.70	21.32	304.43
14:00	368.19	11.78	301.3
15:00	206.38	-0.73	297.255
16:00	65.31	-12.23	293.72

15th May ,Total number of day of the year = 135

location - Delhi (28.38 , 73.55) , slope=0

Time (Hour)	Radiation Data using software (w/m2)	Power (watt)	Temperature (Kelvin)
10:00	1027.47	61.03	317.78
11:00	1230.29	75.70	322.85
12:00	1303.86	80.9	324.64
13:00	1230.29	75.70	322.85
14:00	1027.45	61.036	317.23
15:00	742.34	39.37	310.65
16:00	410.199	17.26	303.1

21ST December ,Total number of day of the year = 355

location - jaipur (26.92 , 72.8) , slope=0

Time (Hour)	Radiation Data using software (w/m2)	Power (watt)	Temperature (Kelvin)
10:00	395.15	13.87	301.97
11:00	526.71	23.81	305.26
12:00	575.92	27.52	306.49
13:00	526.16	23.31	305.25
14:00	395.14	13.84	301.97
15:00	224.73	0.79	297.74
16:00	74.34	-11.454	293.954

15th may ,Total number of day of the year = 135

location - jaipur (26.92 , 72.8) , slope=0

Time (Hour)	Radiation Data using software (w/m2)	Power (watt)	Temperature (Kelvin)
10:00	1032.78	61.38	317.89
11:00	1238.35	76.28	323.09
12:00	1312.96	81.56	324.91
13:00	1238.35	76.24	323.054
14:00	1032.18	61.38	317.89
15:00	742.86	40.01	310.66
16:00	437.067	17.03	303.022

21ST December ,Total number of day of the year = 355

location – banglore (13.01,71.1) , slope=0

Time (Hour)	Radiation Data using software (w/m2)	Power (watt)	Temperature (Kelvin)
10:00	662.7	34.03	308
11:00	846.802	47.74	313.265
12:00	914.75	52.76	314.96
13:00	846.802	46.74	313.26
14:00	662.7	34.03	308.66
15:00	416	15.45	302
16:00	180.72	-2.75	296.61

15th may ,Total number of day of the year = 135

location – banglore (13.01,71.1) , slope=0

Time (Hour)	Radiation Data using software (w/m2)	Power (watt)	Temperature (Kelvin)
10:00	1010.32	59.78	317.353
11:00	1231.2	75.98	322.95
12:00	1315	81.75	314.99
13:00	1234.28	75.98	322.95
14:00	1010.32	59.78	317.352
15:00	700.2	36.83	309.601
16:00	381.16	12.77	301.62

21ST December ,Total number of day of the year = 355

location – Bhuj (23.26,72.74) , slope=0

Time (Hour)	Radiation Data using software (w/m2)	Power (watt)	Temperature (Kelvin)
10:00	464.25	19.94	30.3.7
11:00	610.67	30.13	307.03
12:00	665.19	34.21	308.72
13:00	610.67	30.13	307.3
14:00	464.25	19.09	303.7
15:00	272.63	4.43	298.911
16:00	98.99	-9.37	294.57

15th may ,Total number of day of the year = 135

location – Bhuj (23.26,72.74) , slope=0

Time (Hour)	Radiation Data using software (w/m2)	Power (watt)	Temperature (Kelvin)
10:00	1038.21	61.82	318.05
11:00	1251.52	77.21	323.38
12:00	1328.82	82.67	325.31
13:00	1251.52	77.21	323.38
14:00	1038	61.82	318.03
15:00	739.92	39.79	310.59
16:00	426.82	16.25	302.76

6th january,Total number of day of the year= 6

location – v. v nagar (26.26,73.2) , slope=0

Time (Hour)	Radiation Data using software (w/m2)	Power (watt)	Temperature (Kelvin)	Practically Measured radiation Data (w/m2)
8:00	87	-10.30	294.29	
8:30	131.0	-6.07	295.37	
9	250	2.7	298	256.05
9:30	306	7.05	299	
10:00	432	16.71	302	
10:30	481	20.41	304	
11:00	572	27.25	306.4	
11:30	598	29.22	307.6	
12:00	624	31.02	307.2	
12:30	619.64	30.80	307	
13:00	572	27.2	306.4	
13:30	538	24.67	305.2	
14:00	432	16.71	302	
14:30	380.12	12.69	301	
15:00	250.98	2.7	298	

15th May, Total number of day of the year = 6

Location – v. v nagar (26.26, 73.2), slope=0

Time (Hour)	Radiation Data using software (w/m2)	Power (watt)	Temperature (Kelvin)
10:00	1033	61.50	317.9
11:00	1241	76.49	323.13
12:00	1316	81.81	325
13:00	1241.44	76.48	323.13
14:00	1033	61.50	317.94
15:00	742.77	40.01	310.66
16:00	435.48	16.9	302.982

6 Conclusion

Circuit-oriented model for the PV sources was developed and simulated in the PSIM power electronics simulator. The variation in solar panel parameter with respect to solar isolation and temperature has been analyzed. And we are able to find out the solar irradiation and a solar panel output at different location at different time of the day and at different inclination angle of panel.

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