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The Measurement of Solar Electric Power in Form of A.C, D.C. Volt, Current and Power Efficiency (η) of the System Using Inverter (Regulated Voltage)

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Abstract: Solar Electricity, Solar Cell, also refer as photovoltaic cells and devices or bank of devices that use the photovoltaic effect of semi-conductor to generate electricity directly from the sunlight. This paper demonstrates the measurement of solar electric power in the form of AC, DC volt and current and power efficiency of the system using inverter. Installation and calculation have been done at PCSIR Laboratory, Lahore Pakistan. There are 15 modules and each module has 36 photovoltaic cells. Different calculations have been made in terms of AC/DC current, voltage and output power and then efficiency has been measured at different time scale. The system efficiency has been improved and recorded in day time at different temperature.

Key words: Efficiency · Inverter · Solar Energy · Photovoltaic Cell

INTRODUCTION

The intensity of solar energy on a surface oriented perpendicular to the sun's rays above the earth's atmosphere (known as the solar constant) has been measured by satellite to be between 1,365 and 1,367 W/m2 (NASA 2003). This energy is transmitted through the atmosphere and reaches the earth's surface at a rate that varies over time at a particular location because of the angle at which the sun's rays strike the earth (called the zenith angle). This angle establishes the path length through the atmosphere for incoming sunlight and varies with latitude, date and local time of day. Worldwide photovoltaic installations increased by 7.3 GW in 2009, up from 6,080 MW installed during the previous year. In 1985, annual solar installation demand was only 21 MW [1]. A novel Voltage-Based Maximum Power Point Tracking (MPPT) technique, a new and simple tracking algorithm is presented in [2]. The proposed MPPT algorithm is applied to a Buck regulator to regulate the output power at its maximum possible value. The amount of power generated by a PV depends on the operating voltage of the array. A PV's maximum power point (MPP) varies with solar insulation and temperature. It's V-I and V-P characteristic curves specify a unique operating point at which maximum possible power is delivered. At the MPP, the PV operates at its highest efficiency [3]. These features may be incorporated in existing structures but are most effective when integrated in a solar design package which accounts for factor such as glare, heat gain, heat loss and time-of-use. Architectural trends increasingly recognize day lighting as a corner stone of sustainable design.

Hybrid solar lighting (HSL) is an active solar method of using natural light to provide illuminations. Hybrid solar lighting (HSLS) collect sunlight for using systems. The collected light using focusing mirror can be transmitted via optical fibers into building's interior to supplement conventional lighting [4]. Daylight saving time (DST) can be seen as a method of utilizing solar energy (SE) by matching available sunlight to the hours of the day in which it is most useful. In 2001 this was estimated to reduce peak demand in California by 35-70 MW (0.08 % - 0.16%) In June through August, through total electricity use was unaffected [5]. However, there is some question whether these estimates are valid. In 2000 when parts of Australia started DST in late winter, over all electricity consumption did not decrease, but the peak load increased [6].

In this publication, readings in terms of AC, DV voltage, current and power efficiency have been taken at PCSIR labs Complex Lahore where solar radiations depend upon the altitude of the radiations south towards north at 45°.

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Table 1: Description of Solar Modules Installed at PCSIR Laboratory Lahore Pakistan

Sr.#	Specifications	Sr.#	Specifications
1	BP-47A /6077	9	BP-47A /6085
2	BP-47A /6078	10	BP-47A /6086
3	BP-47A /6079	11	BP-47A /6087
4	BP-47A /6080	12	BP-47A /6088
5	BP-47A /6081	13	BP-47A /6089
6	BP-47A /6082	14	BP-47A /6090
7	BP-47A /6083	15	BP-47A /6091
8	BP-47A /6084		

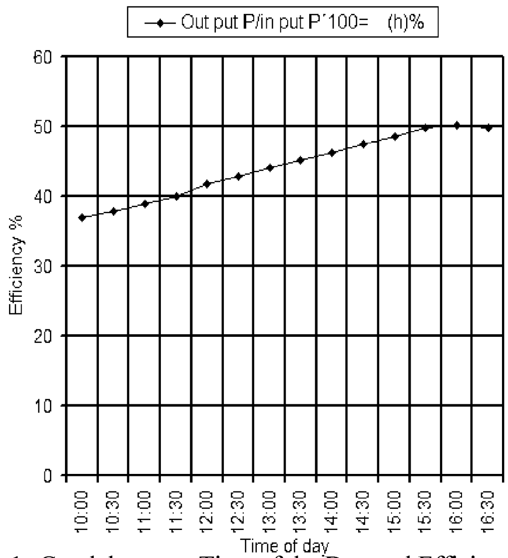

Fig. 1: Graph between Time of the Day and Efficiency for 23rd August

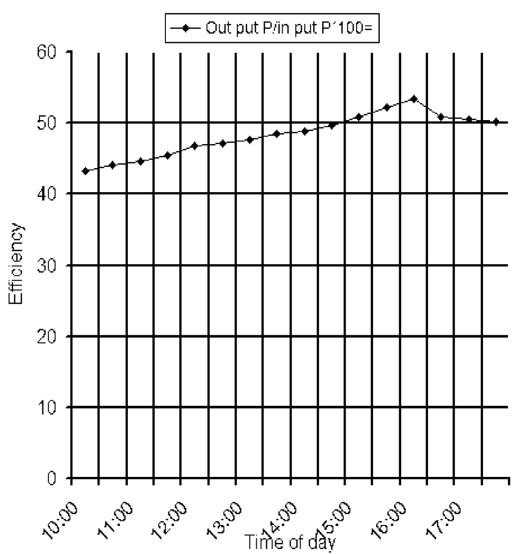

Fig. 2: Graph between Time of the Day and Efficiency for 25th August

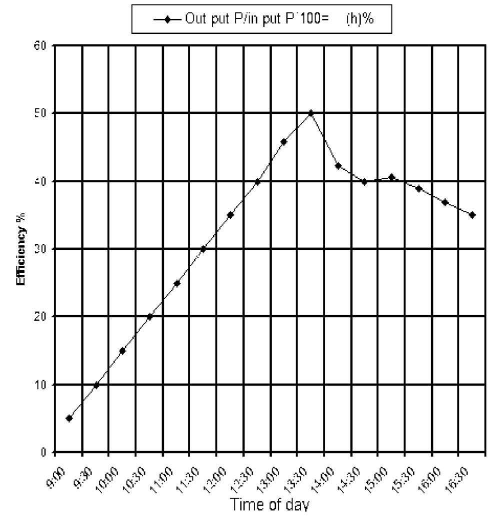

Fig. 3: Graph between Time of the Day and Efficiency for 24th August

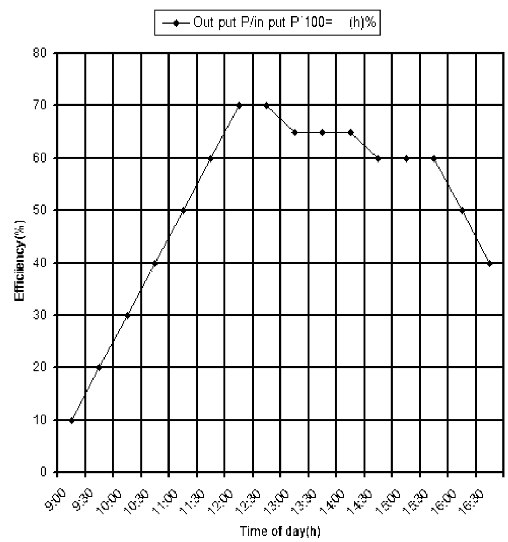

Fig. 4: Graph between Time of the Day and Efficiency on 28th August

Experimental Description and Calculation: There are total 15 solar modules installed on the roof of calibration building of applied physics computer & instrumentation centre in PCSIR labs, Complex Lahore. The techniques of arranging these 15 photovoltaic cells are used in parallel combination. Each cell has voltage capacity equal to 17.5V and then total volt of 15 PV Cells remains same but total power becomes 510 Watt. If these 15 PV cells are connected in series combination then volt becomes equal to 262.50V and power will be remain same. In PV system, battery, charge controller, inverters and solar modules are the major equipments used in demonstration.

Table 2: Different load has been used for the calculation of AC and DC current from 30W to 190W

Sr. #	Time of day	Temp °C	T/K=t+273	DC input volt	DC input current	DC input power	AC Inverted output volt	AC Inverted output current	AC output power	(η)%
1	9:00am	35	308	230	0.132	21.25	220	0.051	7.85	36.96
2	9:30am	35	308	230	0.131	21.09	220	0.052	8.00	37.93
3	10:00am	35	308	230	0.130	20.93	220	0.053	8.16	38.98
4	10:30am	35	308	230	0.129	20.76	220	0.054	8.31	40.02
5	11:00am	35	308	230	0.128	20.60	220	0.056	8.62	41.84
6	11:30am	37	309	230	0.127	20.44	220	0.057	8.77	42.90
7	12:00pm	37	309	230	0.126	20.28	220	0.058	8.93	44.03
8	12:30pm	37	309	230	0.125	20.12	220	0.059	9.08	45.12
9	13:00pm	37	309	230	0.124	19.96	220	0.060	9.24	46.29
10	13:30pm	37	309	230	0.123	19.80	220	0.061	9.39	47.42
11	14:00pm	38	310	230	0.122	19.64	220	0.062	9.54	48.57
12	14:30pm	38	310	230	0.121	19.48	220	0.063	9.70	49.79
13	15:00pm	38	310	230	0.122	19.64	220	0.064	9.85	50.15
14	15:30pm	38	310	230	0.119	19.15	220	0.062	9.54	49.81
15	16:00pm	38	310	230	0.118	18.99	220	0.061	9.39	49.46
16	16:30pm	38	310	230	0.117	18.83	220	0.060	9.24	49.07

Table 3: Different load has been used for the calculation of AC and DC current from 10W to 100W

Sr. #	Time of day	Temp °C	T/K=t+273	DC input volt	DC input current	DC input power	AC Inverted output volt	AC Inverted output current	AC output power	(η)%
1	10:00am	36	309	225	0.115	18.11	220	0.051	7.85	43.34
2	10:30 am	36	309	225	0.115	18.11	220	0.052	8.00	44.17
3	11:00 am	36	309	225	0.116	18.27	220	0.053	8.16	44.66
4	11:30 am	36	309	225	0.116	18.27	220	0.054	8.31	45.48
5	12:00pm	37	310	225	0.117	18.42	220	0.056	8.62	46.79
6	12:30 pm	37	310	225	0.118	18.58	220	0.057	8.77	47.20
7	13:00 pm	37	310	225	0.119	18.74	220	0.058	8.93	47.65
8	13:30 pm	37	310	225	0.119	18.74	220	0.059	9.08	48.45
9	14:00 pm	37	310	225	0.120	18.90	220	0.060	9.24	48.88
10	14:30 pm	37	310	225	0.120	18.90	220	0.061	9.39	49.68
11	15:00 pm	38	311	225	0.119	18.74	220	0.062	9.54	50.90
12	15:30 pm	38	311	225	0.118	18.57	220	0.063	9.70	52.23
13	16:00 pm	38	311	225	0.117	18.42	220	0.064	9.85	53.47
14	16:30 pm	38	311	225	0.119	18.74	220	0.062	9.54	50.90
15	17:00 pm	38	311	225	0.118	18.57	220	0.061	9.39	50.56
16	17:30 pm	38	311	225	0.117	18.42	220	0.060	9.24	50.16

Table 4: Different load has been used for the calculation of AC and DC current from 5W to 100W

Sr. #	Time of day	Temp °C	T/K=t+273	DC input volt	DC input current	DC input power	AC Inverted output volt	AC Inverted output current	AC output power	(η)%
1	9:00am	35	308	220	0.45	100	220	0.220	5.0	5.00
2	9:30am	35	308	220	0.45	100	220	0.045	10.0	10.00
3	10:00am	35	308	220	0.45	100	220	0.060	15.0	15.00
4	10:30am	35	308	220	0.45	100	220	0.090	20.0	20.00
5	11:00am	35	308	220	0.45	100	220	0.110	25.0	25.00
6	11:30am	37	309	220	0.45	100	220	0.130	30.0	30.00
7	12:00pm	37	309	220	0.45	100	220	0.150	35.0	35.00
8	12:30pm	37	309	220	0.45	100	220	0.180	40.0	40.00
9	13:00pm	37	309	220	0.45	100	220	0.200	45.0	45.90
10	13:30pm	37	309	220	0.45	100	220	0.220	50.0	50.00
11	14:00pm	38	310	220	0.59	130	220	0.250	55.0	42.30
12	14:30pm	38	310	220	0.68	150	220	0.270	60.0	40.00
13	15:00pm	38	310	220	0.72	160	220	0.290	65.0	40.62
14	15:30pm	38	310	220	0.72	160	220	0.310	70.0	38.88
15	16:00pm	38	310	220	0.86	190	220	0.310	70.0	36.84
16	16:30pm	38	310	220	0.90	200	220	0.310	70.0	35.00

Table 5: Different load has been used for the calculation of AC and DC current from 10W to 100W

Sr. #	Time of day	Temp °C	T/K=t+273	DC input volt	DC input current	DC input power	AC Inverted output volt	AC Inverted output current	AC output power	(η)%
1	9:00am	35	308	230	0.437	100	220	0.045	10	10.0
2	9:30am	35	308	230	0.437	100	220	0.090	20	20.0
3	10:00am	35	308	230	0.437	100	220	0.136	30	30.0
4	10:30am	35	308	230	0.437	100	220	0.181	40	40.0
5	11:00am	35	308	230	0.437	100	220	0.227	50	50.0
6	11:30am	37	309	230	0.437	100	220	0.272	60	60.0
7	12:00pm	37	309	230	0.437	100	220	0.318	70	70.0
8	12:30pm	37	309	230	0.437	100	220	0.318	70	70.0
9	13:00pm	37	309	230	0.437	100	220	0.295	65	65.0
10	13:30pm	37	309	230	0.437	100	220	0.295	65	65.0
11	14:00pm	38	310	230	0.437	100	220	0.295	65	65.0
12	14:30pm	38	310	230	0.437	100	220	0.272	60	60.0
13	15:00pm	38	310	230	0.437	100	220	0.272	60	60.0
14	15:30pm	38	310	230	0.437	100	220	0.272	60	60.0
15	16:00pm	38	310	230	0.437	100	220	0.227	50	50.0
16	16:30pm	38	310	230	0.437	100	220	0.181	40	40.0

Implementation has been done and observations in terms of efficiency were recorded on different days. Efficiency for the entire system has been calculated using (1) and simulation has been done in MATLAB at different time scales shown in Fig. 1, Fig. 2, Fig. 3 and Fig. 4. It has been observed that total efficiency of solar modules varies at different temperatures.

$$\eta = {P_{out}(AC)} \Big/ {P_{input}(DC)} \times 100 \quad (1)$$

Where η is the symbolic representation of efficiency of solar modules.

The four observation data tables and graphs of 15 photovoltaic cells connected in series and parallel are listed in Table 2.

RESULTS

Different loads have been used for the calculation of AC and Dc current and overall installed photovoltaic system efficiency. Table 2and Table 3 show readings for PV system with regulated voltage using inverter and efficiency is remain constant throughout the day. Without inverter (regulated voltage), system efficiency varies throughout the day as tabulated in Table 4 and Table 5. It has also been shown in Fig. 1, Fig. 2, Fig. 3 and Fig. 4. The detailed results in operating hours are shown in (Table 2, 3, 4, 5).

CONCLUSION

The measurement of solar electric power in the form of AC, DC volt and current and power efficiency of the system using inverter has been discussed. Calculations have been recorded for 15 modules and each module has 36 photovoltaic cells. Different calculations have been made in terms of AC/DC current, voltage and output power efficiency. Using inverter (regulated voltage), overall PV system efficiency has been improved. Proposed methodology is very useful for various applications including solar lighting system for home & business use, solar gardening lights, stand alone solar system e.g. portable kits, solar pumps, solar street lights, solar air conditioning units, solar water heaters, solar cooker, solar dryer, solar dehydrator, solar generator, etc.

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