Technical Performance Evaluation and Modelling of 150kw PV Array System Installed at NCU

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Abstract -- **This paper represents the technical performance evaluation of 150 kW solar photovoltaic grid tied system installed on the roof at NCU(North cap University) campus located in Gurgaon, Haryana (latitude 28.5043®N and longitude 77.0490® East). The system consists of total 600 PV modules and 60 cells in each module. The installed system is monitored from August 2015 to October 2015 and then simulated with different ambient and module temperatures and irradiance. The simulated results show that the values of power we get from simulations are higher than the power we measured from 150KW system. To match the simulated power with measured power it is recommended to adjust some parameters (N and Rs) during simulations.**

1. INTRODUCTION

For any country's economic growth energy is the primary requirement. People depend on non –renewable resources for energy production. Non-renewable resources are limited and the energy needed by 10 million people around the world is about couple of kilowatt hour. To meet the requirement of common people, renewable resources can be the best solutions [1]. Among various renewable resources available, solar is gaining more attention because of high quality carbon, free energy supply. To produce electricity using solar energy is based on photovoltaic effect .The PV effect means the generation of a potential difference at the junction of two different materials in response to electromagnetic radiation. PV system is widely used to generate the electricity at low cost and it requires less operation and maintenance.
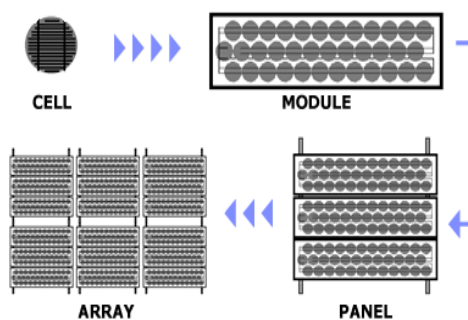

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Fig. 1 . general view of cell, module, array, and panel

Cell is the device that is used to convert sunlight into direct current (DC) electricity. Number of electrons determines the amount of current as the size of cell is limited so it delivers only limited amount of power which is not applicable practically. Thus, In order to use solar electricity PV module is formed by

connecting solar cell together either in series or parallel depending upon either more voltage or current is needed. Then the photovoltaic panel which is formed when one or more PV modules are used together, that is called PV panel, Next is photovoltaic array that contains number of undiscovered PV modules or panels that are used either in series or parallel.

Different methods are used for the simulation of solar system. One method is to use circuit simulator LT-Spice. This is an analog/digital circuit simulator which calculates voltage and current in a circuit. This feature of LT-Spice is already used to model and simulate the circuits of PV cells/arrays [1]. Simulations are done for the single cell and double cell model. Through this temperature and irradiance are observed with the power under the partial shading conditions (PSC) [2]. Simulations and modeling are also done by using Matlab/simulink for the PV system to study the partial shading effects. Partial shading occurs due to the tree leaves falling over system, passing clouds, shade of a neighboring construction etc. under these conditions characteristics gets more complex with multiple peaks like MPPT (maximum power point tracking) points are affected and power from PV array can be reduced [2]. A comparison between these two methods are also done which shows that to increase the output power during PSCs, bypass and blocking diodes are used and their effect on Vm (voltage at maximum power output),Pm (maximum power output), Im (current at maximum power output) and Voc (open circuit voltage) is observed [3].

2. PV SYSTEM AT NCU

The PV system installed at NCU campus Gurgaon, Haryana, India is a grid tie system which does not have battery storage. It is located at 28.5043®N, 77.0490® East. Haryana is having about average 5 hours of sunlight per day [4]. PV systems connected to grid by inverters that convert DC power into AC Electricity. All this is done by the use of an electronic inverter, which is fed to the existing 415V AC system The inverter used in this system is having 93% efficiency , -20degC to 50 deg C ambient temperature and 50Hz output frequency [4]. A single PV cell is very small in size and produce 0.5 to 0.8 watt power depending on cell technology [5]. They are connected in series/parallel to form a module. This system is having 600 modules with 60 cells in each module to produce 150kw power. The main components used in this system are energy meter, SPV module, cables, inverter, and distribution boards [4].

Fig.2. Schematic view of PV system installed in the North Cap University, gurgaon, India.

The installed PV system installed at NCU campus is shown in the fig.2. The model is developed in the STC (standard test conditions i.e. 1000w/m2, 25degree) but the data is driven by the system in the real operating conditions are different [6]. Position of sun is to be kept in mind at the time designing of system to get maximum energy output. Energy obtained from the system is based on seasons, solar position and number of daylight hours available which varies monthly. Technical specification of the system module is shown in the table 1. It covers all the details of the 150KW solar system like number of cells, number and weight of modules, module and system capacity, location and angle of modules, Isc, and Voc of one module which is used to get the Isc and Voc of a single cell for simulations..

TABLE 1
MODULE TECHNICAL SPECIFICATION

ATTRIBUTES	DESCRIPTION
SYSTEM CAPACITY	150KWp
SINGLE PV MODULE CAPACITY	250Wp
PV MODULE TYPE	POLYCRYSTALLINE
TOTAL NO. OF MODULES	600
NO. OF PV CELLS PER MODULE	60
SOLAR INVERTER(DELTA)	TOTAL CAPACITY 300KWp
WEIGHT OF EACH MODULE	17.25KGs
LOCATION	ROOF MOUNTING
PLANT TOPOLOGY	GRID CONNECTED
TILT ANGLE	25 DEGREE
AZIMUTH	TRUE SOUTH
INVERTER TYPE AND RATING	SRTING TYPE, TOTAL 150KW
OUTPUT	415C, 3-PHASE
OPEN CIRCUIT VOLTAGE (Voc)	37.80V
SHORT CIRCUIT CURRENT (Isc)	8.80A
PEAK POWER VOLTAGE (Vmp)	30.60V
PEAK POWER CURRENT (Imp)	8.20A

3. METHODOLOGY

Fig.3. Shows the complete work done during three months. Live data was collected from the solar system installed at NCU i.e. ambient temperature, module temperature, irradiance, and maximum power for august, September and October month. A system simulink model was made up of 600 modules each containing 60 cells (explained below in fig.4). Five cell parameters, short circuit current (Isc = 8.8), open circuit voltage (Voc = 0.63), irradiance (Ir =1000), ideality factor (N = 1.5), series resistance (Rs = 0.001) are taken commonly during all simulations for three months [4]. The value of Isc and Voc took from the system parameters, Ir from the STC (standard test conditions), Rs and N from the default values as the value of N can be lies in between 1 to 2 and Rs should be less than 0.1. Simulations are done with the daily values of ambient temperature and irradiance at 12pm. Maximum power were measured from these simulations and then compared with the measured power. The values of N and Rs can be changed to match the results.
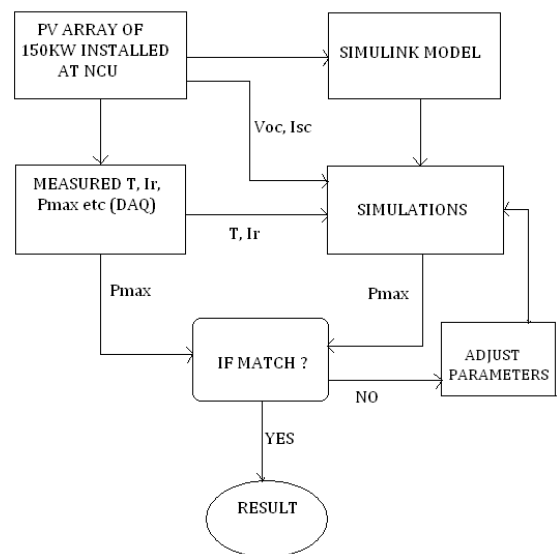

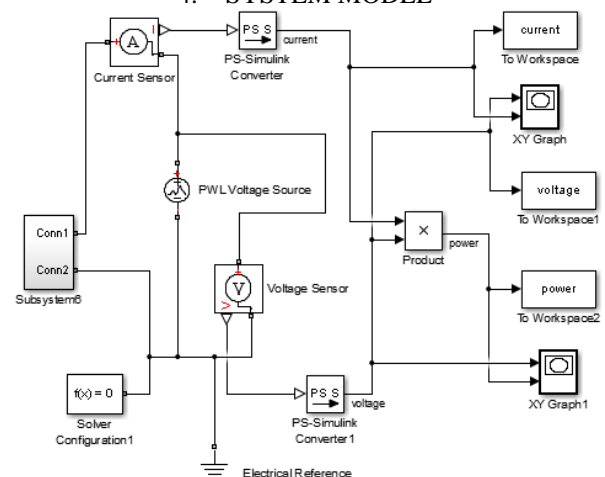Fig.3. Flow chart showing work done.

4. SYSTEM MODEL

Fig.4. block diagram of 150KW solar PV system.

The fig.4 shows the simulink model of 150KW system installed at NCU campus. This model is developed using blocks of simulink/matlab solar cells are connected together in series to form a module and It consists of six subsystems , each subsystem contains 100 modules (i.e. 100 modules * 6 subsystems = 600 modules) and each module contains 60 solar cells. A parallel combination of these subsystems are connected with blocks such as current sensor and voltage sensor to measure current and voltage across solar modules. For varying irradiance level, irradiance blocks are added inside subsystems. Other blocks are the interface between main blocks and these are used for plotting I-V characteristics [5].

5. SIMULATIONS AND RESULTS

Simulations are done for three months. Initial power variations for all months are shown in fig.5. Initial power variations for august month are shown in the fig.5 (a) when the ambient temperature at 12pm is taken during simulations and the values of ideality factor (N) is 1.5 and series resistance (Rs) is 0.001. It can be seen in fig.5 (a) that the simulated power (red line) are much higher than measured power (blue line). Initial power variation for September month is shown in fig.5 (b).
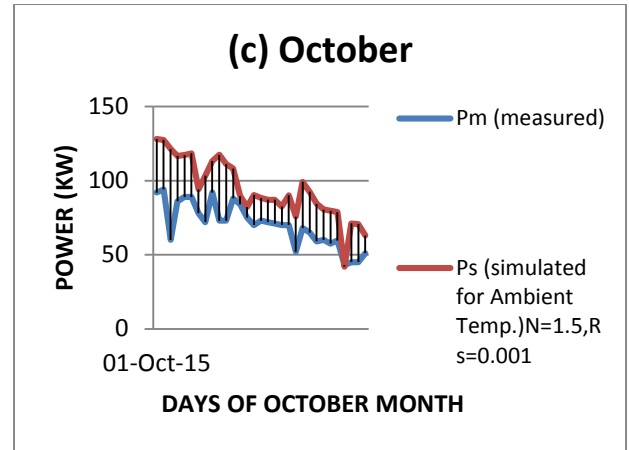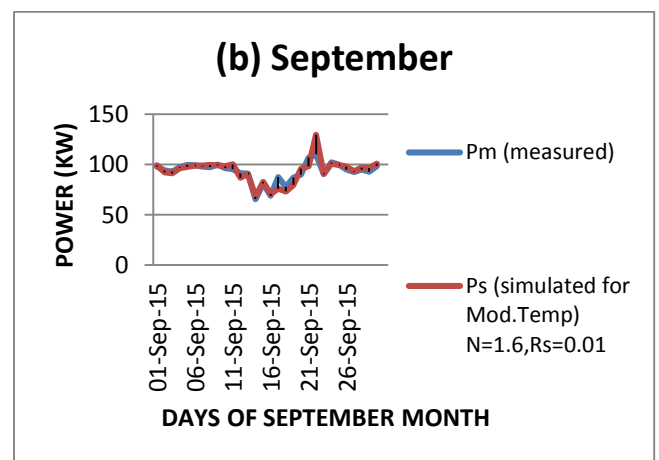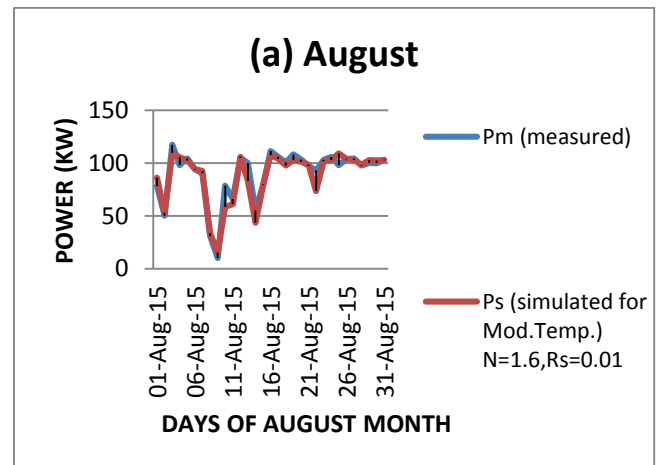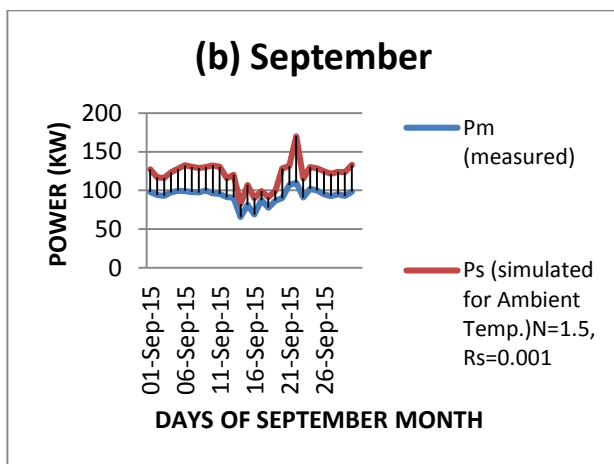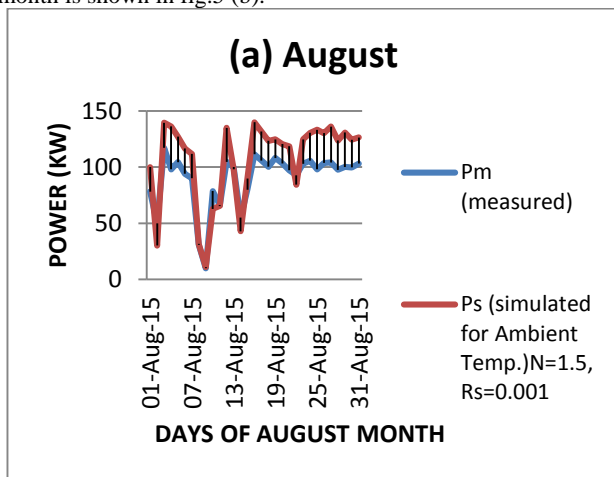

Fig.5. Initial Power variation in (a)-August month (b)-September month (c)-October month for ambient temperature with N=1.5 and Rs=0.001

To match the initial results, simulations are done again by taking module temperature in the place of ambient temperature with N=1.6 and Rs=0.01 shown in fig.6. Module temperature is higher than the ambient temperature and power is inversely proportional to the temperature so by using the module temperature we get the best results.
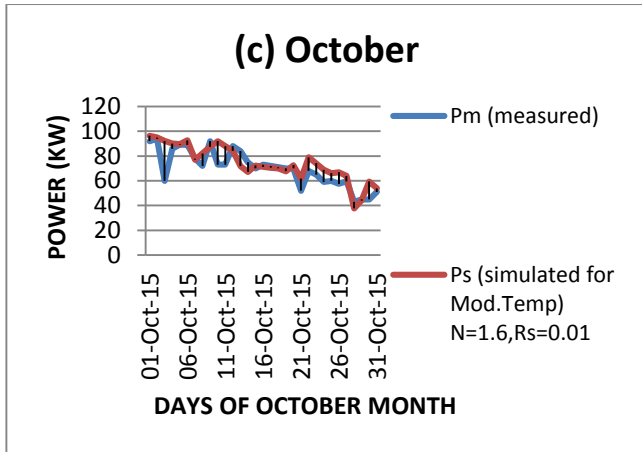
Fig.6. Final Power variation in (a)-August month (b)-September month (c)-October month August month for module temperature with N=1.6 and Rs=0.01

The fig.6 (a) shows the final variation for august month in output power measured directly from the system i.e. solar system live data, and simulated power which we get when the module temperature is taken during simulations. It can be seen that the results with module temperature are quite better as the difference between measured and simulated power value are lesser than with ambient temperature. So these simulations are done with module temperature but with different values of ideality factor (N) and series resistance (Rs), i.e. N = 1.6 and Rs=0.01.

And fig.6 (b) shows the variation in measured power and simulated power when module temperature is taken during simulations for September month. In fig.6 (c) shows the October month variations of both the powers i.e. measured and simulated, in this case simulations are also done with module temperature and increased value of N and Rs i.e. N=1.6 previously it was 1.5 and Rs=0.01 previously it was 0.001. In this case both the powers are matched approximately.

6. CONCLUSION

Simulations are done for three months out of these three months we can see that the best results which we got from simulations are of September month as there is some consistency in the measured and simulated power. Temperature in this month is also consistence as compared to august and October month. As we can see from fig. both the powers are overlapping in most of the days in September. Module temperature is higher than the ambient temperature and power is inversely proportional to the temperature so by using the module temperature we get the best results in September month. The simulink model needed the value of Rs and N, and we didn't get it from sukam manual. So, we tried to find the best values of N and Rs to match the simulated results to measured results.

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