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Assessment of 50 kW Grid Connected Solar Power Plant with Experimental Validation

Bansilal Bairwa, Sanjeeva Kumar, Vishal Kaushik S
bansilal.bairwa@reva.edu.in

School of Electrical and Electronics Engineering,REVA University,Bangalore, India 560064

Abstract

The global power sector is witnessing a gradual transition from typical thermal power-generating sources toward clean energy technologies. Non conventional sources of energy are the most appropriate solution to give clean and inexhaustible energy to conquer the worldwide energy emergency. The renewable share was 8.6 percentage within the world energy combine in 2010 and is predicted to extend to 22.5 percentage in 2020 as per a recent thematic analysis report renewable energy by the data collected globally. With the advancement in power electronics technology, photo voltaic system (PV) is getting more popularity in generation of electricity. Inverters connected to grid have developed significantly with high decent variety. Efficiency, estimate, weight, dependable execution have all improved significantly with involvement of technically advanced and innovative electrical converter configurations and these factors have diminished the expenses of inverters. This study deal with investigating the 50 kW with various aspectes.
Keywords: MPPT, Photo-voltaic, Solar, Energy, P& O.

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1.1 Introduction

It is mandatory to observe geographical condition of the locations where we are going to install a solar PV system. And then analyze of climatic conditions. It is must to analyze the climatic condition and the different radiation levels. Primarily it includes selection of components like modules inverters cables combiner box, and others. And the PV array inverter matching is crucial part for design of the grid connected PV system. It is also mandatory to find out the appropriate number of modules, appropriate numbers of inverter support for a particular capacity. Designing a PV system based on the energy balance phenomena. The Energy yield at the DC side is given by the below equation[1, 2, 3].

$$\epsilon_{DC}^{y} = A_{tot} \int G_M \eta(t) dt \tag{1.1}$$

Here A_{tot} is total module area, that is equal to the total area of the cells, mention in below equation.

$$A_{tot} = N_T.A_M \tag{1.2}$$

Where N_T is the total number of cells and A_M is the area of the cell. The energy generated by the PV is equal to the consumed energy for one year. So, these phenomena have been applied for designing a grid connected PV system. This normally global radiation integration for the entire year.

$$N_T = \left[\frac{(\epsilon_L^y .SF}{(A_{tot} \int G_M(t) \eta(t) dt)} \right] \tag{1.3}$$

The required number of modules is calculated by the given equation Solar module can be connected in series and parallel configuration.

$$N_T = N_S.N_P \tag{1.4}$$

The power of the DC side at standard test condition is given in below equation,

$$\rho_{DC}^{STC} = N_T.\rho_{DC}^{mpp} \tag{1.5}$$

Installing a solar PV plant, the ratings of the inverter need to be calculated, for finding out the nominal DC power of the inverter. As the demand for world energy grows because of modern industrialization and population growth, renewable energy technologies are being further developed to improve energy production and energy quality. Since there is many countries with a direct solar density of 1000W/m in tropical and temperate zones, the primary resource is photo-voltaic power. The need for integration of photo-voltaic systems with other energy sources such as battery storage and diesel generators is consequent in major power disruptions due to changing environmental conditions[?]. For estimating the size of solar photo-voltaic cells, the PGF (Panel Generation Factor) play a key role. The maximum watt peak required to meet the electricity demand from solar panels is referred to as the Panel Generation Factor[5]. PGF is dependent on location and climate, hence various locations may have varying PGFs based on the quality of solar insolation and irradiation falling on that location. The PGF is based on empirical relationships. The Panel Generation Factor is an important factor to consider when planning a solar PV plant since it tells us that for every Wp power in the panel, we should expect to get an average of Wh/day, and it varies by location, for Jaipur city considering 5.30 $\frac{W}{m^2}$. Storage of batteries cannot tolerate any variation in load and diesel generators can only provide short periods of backup. As the demand for world energy grows because of modern industrialization and population growth, renewable energy technologies are being further developed to improve energy production and energy quality. Since there is many countries with a direct solar density of 1000W/m in tropical and temperate zones, the primary resource is photo-voltaic power. The need for integration of photo-voltaic systems with other energy sources such as battery storage and diesel generators is consequent in major power disruptions due to changing environmental conditions. Storage of batteries cannot tolerate any variation in load and diesel generators can only provide short periods of backup[6].

1.2 Methodology

In these systems, mono-crystalline silicon cell-based modules were chosen. The cell's efficiency and temperature coefficients were carefully monitored. The typical module capacity of 250Wp was chosen to ensure that the modules are not too small or too large to be affected by wind forces. mono-crystalline silicon modules have been connected in series and parallel configuration. In this work, 15 modules are connected in series to form a string of the plant for every 52.5 kWp power. 14 strings are connected in parallel, and this series-parallel combination is connected to a Junction Box, from which wires are connected to an inverter for DC to AC conversion. The total installed module capacity is calculated up 52.5 kWp, which was achieved to compensate for losses and module rating. Experimental data were collected from

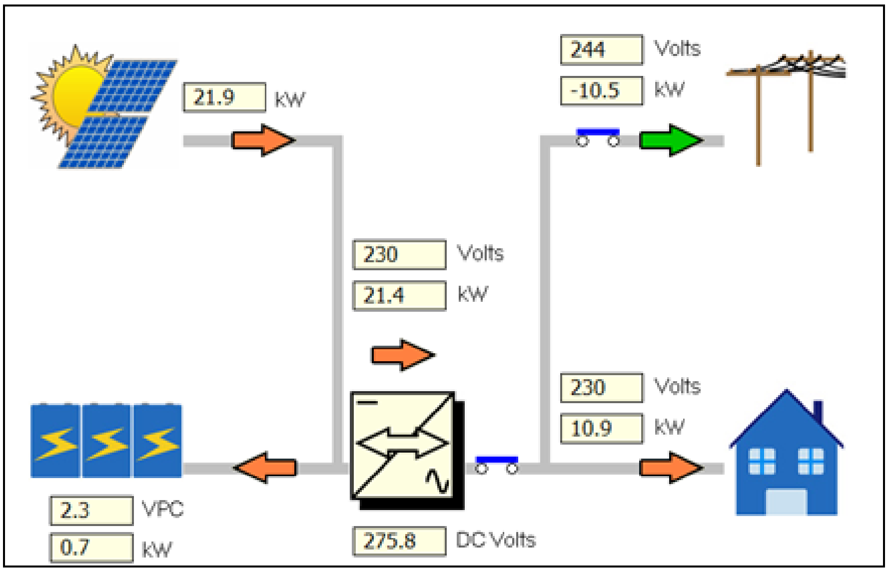

Figure 1.1 Overview of solar power plant with SCADA

grid-connected solar power installed at MNIT Jaipur. The controls of grid-connected solar power plants are mounted with a computerized monitoring system. Figure 1.3 shows the Solar PV control panel desktop view. The 52.5 kW photo-voltaic array is composed of 250 REIL modules. The array is composed of 14 strings of 15 parallel-connected modules (15*14*250 W= 52.5 kW). The PV array block menu enables you to visualize the I-V and P-V characteristics of individual modules or the entire array. The photo-voltaic array block features two inputs for varying sun irradiance $(W/m^2)$and temperature. A Signal Builder block connected to the PV array inputs defines the irradiance and temperature. Inverter Capacity = 50kVA/inverter; efficiency 93% at full load profiles. Figure 1.1 represents the schematic diagram of solar photo voltaic power plant of 52.5 kW full installed capacity. This configuration included 240V, 1000Ah battery bank 50 kVA power conditioning unit, Junction box , AC distribution board , load panel connected to SCADA. The Installed Capacity 52.5 kWp, Number of PV module is taken as 210, Number of Inverters 1 with 50 kVA rating, Efficiency 93% at full load, Number of modules in a string 15 and Number of strings in parallel is taken 14.

Table 1.1 Simulation parameters for solar panel

S.No.	Parameters	Specifications
1.	Parallel strings	15
2.	Series- connected modules per strings	14
3.	Max output current per MPPT (A)	8.3 A
4.	Maximum output power	250 Watt
5.	Maximum output Voltage (V)	30.28 V
6.	Short circuit current I_{sc}	8.8 A
7.	Open circuit voltage V_{ocv}	37 V
8.	Series resistance R_s	0.18
9.	Parallel resistance R_p	360
10.	No. of cells	60
11	Cell technology	Mono-crystalline

1.3 Results and Discussion

Table I. describe the components of the solar power plants have been used in this work.Components, such as PV cells or panel are combining them into arrays with the power electronic converters and inverters.Figure 1.2(a) show the experimental results for the month of January to December for solar power generation,inverter output average load and transferred power to grid, .Figure 1.2(b) shows the imported and exported energy for the month of January to December. The describe the designing control algorithms for solar power plant. In this work maximum power point tracking observed by two MPPT techniques such as perturb and observation and incremental conductance with the help of MATLAB and simulink. Solar irradiance based solar power output has been tracked by the given MPPT techniques at the room temperature. Thermal condition have been included in this work, some heating for voltaic panels photo-voltaic panels convert the sunlight into electricity.DC power has to be converted into AC power through some kind of power inverter, this AC power can be distributed with the load connected to commercial load. This systems include battery storage so this DC power is actually fed into a battery charger, and then the greatest power from the battery. DC DC converter, receiving the power from the array, DC, AC inverter, which is converting the DC power into three phase AC power. It is being connected to a model of the utility grid on the site. The the power obtained from the grid connected solar power plant and the simulink model is limited with the calculation 50kW.The module has been installed by the Rajasthan Electronics Instruments Ltd at the MNIT with the 250 kW rating as

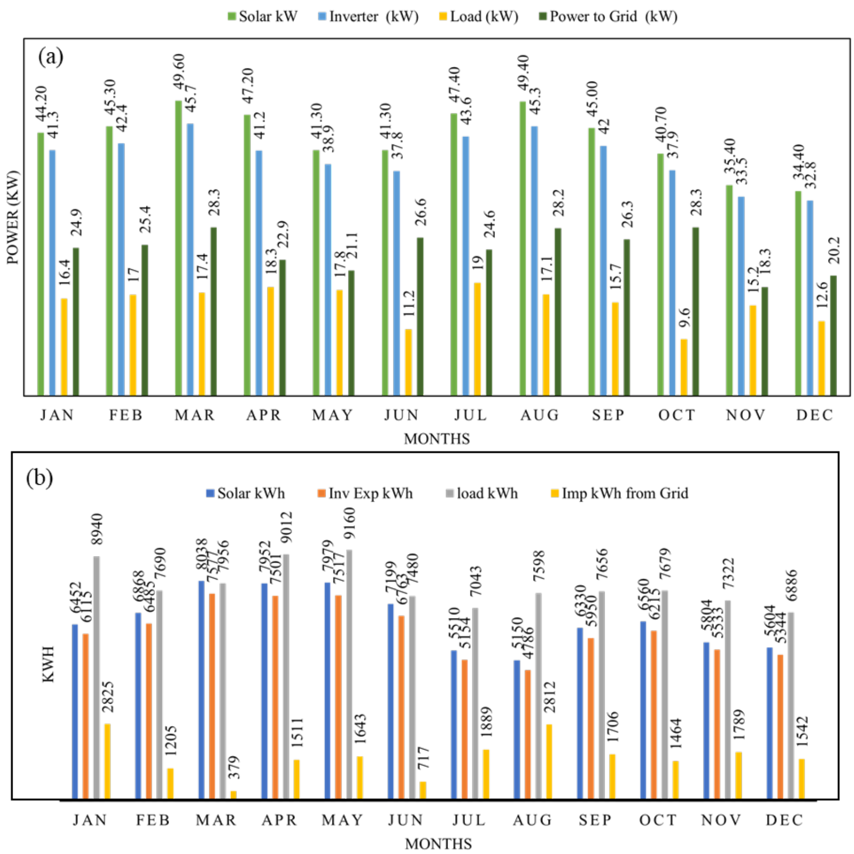

Figure 1.2 experimental results for the month of January to December.

mentioned in the Table 1.1. Figure 1.4 describe the modeling and simulation results for the purturb and observation and incremental conductance MPPT techniques. Simulation results validated with experimental results of the solar power plant at the given instant time.it shows a comparison of the MPPT techniques adopted in this work with experiment output of the solar power plant as represented as bar graph. yellow line represent the solar irradiance from 9:00 AM to 4:00 PM. This work deal with assessment of grid connected PV power plant installed in Malaviya National Institute of Technology Jaipur. Experiments results compared with simulation results. Incremental OCV and P&O maximum power plant tracking have been adapted in this work. Simulation results have good agreement with experimental results extracted from solar optimal power solution installed at prabha bhawan at MNIT Jaipur.

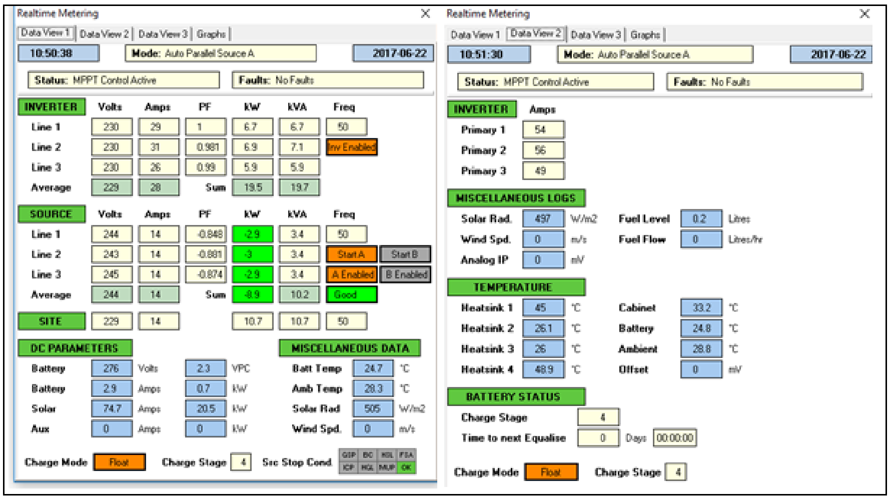

Figure 1.3 Solar PV control panel desktop view

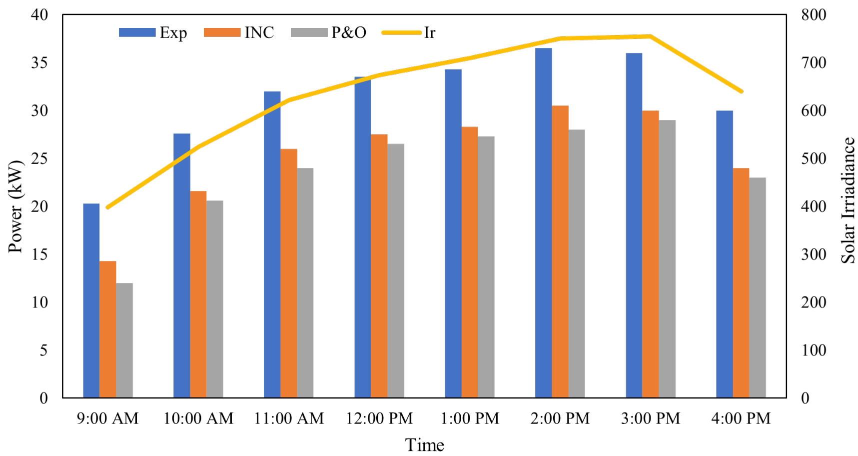

Figure 1.4 Simulated and experimental PV power for 50 kW solar power plant with PO and INC MPPT techniques.

1.4 Conclusion

As the demand for world energy grows because of modern industrialization and population growth, renewable energy technologies are being further developed to improve energy production and energy quality. Since there is many countries with a direct solar density of 1000W/m in tropical and temperate zones, the primary resource is photo-voltaic power. The need for integration of photo-voltaic systems with other energy sources such as battery storage and diesel generators is consequent in major power disruptions due to changing environmental conditions. Storage of batteries cannot tolerate any variation in load and diesel generators can only provide short periods of backup. This research aims to develop a behavioral model of a grid-connected PV system that accurately represents the actual PV system while also addressing the concerns. All photo-voltaic systems provide data loggers that record and store information about operating conditions and performance production. Despite the market's rapid expansion, very few of the numerous monitoring techniques available projected power and energy productions. Forecasting success is critical for all potential future solar energy developers, as it will support their investment decisions.

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