Design Approach of Grid Coupled Solar Inverter

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Abstract. In novel times, more demands are gained by grid connected solar inverters along with the upgrading of the solar energy generation. In grid connected solar power generation, if there is increase in placing more number of solar inverters it may result in effecting the power quality issues. Solar Grid Tied Inverter system is a electrical power generating system that is coupled to the functioning power grid. This power generating system unit consists of elements like Photovoltaic array, DC to DC converter, DC to AC converter, single phase/three phase converter, and AC Source. The inverter converts DC power generated by the array of photovoltaic cells into AC power and this generated AC power is fed to the connected AC loads. If the amount power generation is exceeding the power demanded, excess AC power is supplied to the grid. With this novel approach we can minimize the use of the AC power from the power grid and also even make a generation to the power grid and this is measured with help of net metering. In this paper designing of 281.6Kw grid tied solar power generation and technical specifications required for them are proposed.

1 Introduction

Indian government has a quest to install hundred Giga Watts of solar power energy by the end of 2022[1-3]. Due to the increase in energy demands for the last few decades; there is increase in natural problems and reduction of fossil fuel assets. This leads to think about for another sources i.e., renewable energy sources especially Solar Energy. With thereduction in solar cells cost, it is economically feasible for solar energy conversion to electric energy [4-7]. The solar electric power generation system includes PV panels, DC to DC converter, DC to AC inverter, DC cabling. Maximum power point tracking (MPPT) is a technique preferred to increase the overall efficiency of photovoltaic systems by drawing maximum power available at all times irrespective of irradiation and temperature conditions. Without MPPT technique when the power generated by PV systems connected directly it results in poor efficiency of the system. Grid tied inverter is different from a traditional inverter which is available. The following requirements are a must and need to be fulfilled before getting connected with the grid[8-11]. Inverter output voltage magnitude must be same as functioning grid voltage, phase and phase sequence of inverter output must be same as functioning grid phase and phase sequence, the inverter output frequency must be same as functioning grid frequency which is shown in Fig 1 shown below.
2 Design considérations

2.1 PV Panel

To test the performance of Solar PV cells, there are various standards testing conditions of PV segments. Majority of the test conditions includes Standard Test Conditions (STC) as shown in Table 2, Normal Operating Cell Temperature (NOCT) as shown in Table 3 Low Irradiance Conditions (LIC), High Temperature Conditions (HTC) and Low Temperature Conditions (LTC). The International Electrotechnical Commission (IEC) published the IEC 61853 standard “Photovoltaic Module. Power Rating” which requires testing based on a variety of climatic and geographic conditions and includes HTC, LIC, HTC, NOCT and STC.[12-13]

| Table 1. PV Panel Specifications |
|----------------------------------|
| cell | Poly 156.75*156.75mm |
| weight | 222.5kg±3% |
| Dimensions | 1960*991*40mm |
| Cable cross section size | 4mm² |
| No of cells | 72(6*12) |
| Junction Box | IP67, 3 diodes |
| connector | MC4 Compatible |
| Packaging configuration | 27 per pallet |

Table 2. Electrical Parameters at STC
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Table 1. PV Panel Specifications

| TYPE | JAP72S01 .310/SC | JAP72S01 .315/SC | JAP72S01 .320/SC | JAP72S01 .325/SC | JAP72S01 .330/SC |
|------|------------------|------------------|------------------|------------------|------------------|
| Rated Maximum power (P_{max}) [Watts] | 310 | 315 | 320 | 325 | 330 |
| Open circuit voltage (V_{oc}) [Volts] | 45.56 | 45.85 | 46.12 | 46.78 | 46.40 |
| Maximum power voltage (V_{mp}) [Volts] | 36.89 | 37.09 | 37.28 | 37.39 | 37.65 |
| Short circuit current (I_{sc}) [Amps] | 8.92 | 9.01 | 9.09 | 9.17 | 9.28 |
| Maximum power current (I_{mp}) [Amps] | 8.40 | 8.49 | 8.69 | 8.69 | 8.77 |
| Module Efficiency [%] | 15.96 | 16.22 | 16.73 | 16.47 | 16.99 |
| Power Tolerance | 0±5W |
| Temperature Coefficient of Isc (α_{Isc}) | +0.058%/°C |
| Temperature Coefficient of V_{oc} (α_{V_{oc}}) | -0.330%/°C |
| Temperature Coefficient of P_{max} (α_{P_{max}}) | -0.410%/°C |
| Standard Test Condition (STC) | Irradiance 1000 w/m², cell temperature 25°C AM1.5G |

Table 3. Electrical Parameters at NOCT

| TYPE | JAP72S01 .310/SC | JAP72S01 .315/SC | JAP72S01 .320/SC | JAP72S01 .325/SC | JAP72S01 .330/SC |
|------|------------------|------------------|------------------|------------------|------------------|
| Max Power (P_{max}) [Watts] | 229 | 233 | 237 | 241 | 244 |
| Open circuit voltage (V_{oc}) [Volts] | 42.63 | 42.84 | 43.04 | 43.24 | 43.41 |
| Max Power voltage (V_{mp}) [Volts] | 34.32 | 34.45 | 34.64 | 34.82 | 35.03 |
| Short circuit current (I_{sc}) [Amps] | 7.18 | 7.35 | 7.29 | 7.35 | 7.40 |
| Max power current (I_{mp}) [Amps] | 6.68 | 6.91 | 6.84 | 6.91 | 6.97 |
| Normal Operating Cell Temperature (NOCT) | Irradiance 800 w/m², ambient temperature 20°C, Wind Speed 1m/S, Am1.5g |

Table 4. Operating conditions

| Maximum system voltage | 1000vDC (IEC) |
| Operating temperature | -40°C ~ +85°C |
| Maximum series fuse | 20A |
| Maximum Static Load, Front | 5400pa |
| Maximum Static Load, Back | 2400pa |
| NOCT | 45±2°C |
| Application class | Class A |

2.2 PV Panel Characteristics
When designing a PV system, four factors namely operating temperature, solar intensity, sun’s incident angle and I-V (Fig 2) & P-V (Fig 3) performance characteristics are considered.

![Current – Voltage Curve](image1)

**Fig. 2.** Current – Voltage Curve (JAP72S01-325/SC) [13-14]

![Power – Voltage Curve](image2)

**Fig. 3.** Power – Voltage Curve (JAP72S01-325/SC) [13-14]

This graphical representation Fig 2 & Fig 3 shows the performance characteristics which is unique to each and every model of solar panel and this graph is termed as the “I-V” curve(Fig 2) and “P-V” curve(Fig 3) which gives the relationship between current (I)-voltage(V) and Power (P) – Voltage (V) under prevailing conditions of temperature and sunlight. There exists multiple number of I-V & P-V curves for one particular module which is shown in Fig 2 & Fig 3 is due to the different operating conditions that would affect the STC rating parameters such as the temperature, air mass, irradiance, etc., and that’s a lot of possible graphs. [12-13]

### 2.3 PV Inverter

“RPI-M50A” transformer less Photovoltaic inverter is the glossy, least possible and first wall mutable 50Kw string inverter in the present world. With such compressed size and less
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2.3 PV Inverter

"RPI-M50A" transformer less Photovoltaic inverter is the glossy, least possible and first wall mutable 50Kw string inverter in the present world. With such compressed size and less weight, RPI-M50A tenders high design tractability for different capacities of Photovoltaic plants. Higher level of protection and enhanced durability in a severe outdoor environment provided by IP65 enclosure. The DC Specifications and obtained AC parameters are given in Table 5 & Table 6 respectively [13-16].

Table 5. DC Input to the Inverter

| Input (DC)               | RPI-M50A          |
|--------------------------|-------------------|
| Recommended max. Dc power| 63kWP             |
| Max. Input voltage       | 1000V             |
| Dc voltage range         | 200-1000V         |
| Start-up voltage         | >250V             |
| Start-up power           | 40W               |
| MPPT voltage range       | 200-1000V         |
| MPP voltage range, full power | 520-800        |
| Nominal dc voltage       | 600V              |
| Max. Input current per MPPT | 50A               |
| Total input current      | 100A              |
| Maximum short circuit current | 50A / 60A        |
| No. Of independent MPP trackers | 2                 |
| Unbalanced input (%)     | 33 / 67           |
| Input connection type    | 12 pair MC4       |
| Dc disconnection switch  | Yes (inbuilt)     |

Table 6. AC Output of the Inverter

| Parameter                          | Value            |
|------------------------------------|------------------|
| Rated output power                 | 50KVA            |
| Maximum output power               | 55KVA            |
| Rated output current               | 76A              |
| Max. output current                | 80A              |
| Inrush current                     | 200A/100µs       |
| Nominal AC voltage                 | 3 Ph,400 V       |
| AC voltage range                   | 400V ± 20% (320-480) |
| Nominal frequency                  | 50HZ             |
| Frequency range                    | 45HZ-55HZ        |
| Power factor at rated power        | UNITY            |
| Reactive power (Adjustable)        | 0.8 Lagging ~0.8 leading |
| Harmonics                          | <3% at Rated Power |
| DC injection                       | <0.5% at Rated Output Current |
| No. of conductors (user settable)  | 4/5 Wire (L1,L2,L3,N,PE) |
Fig. 4. Single Line Diagram of grid tied 281.6KW Solar Power Generation with inverter modules.
3 Conclusion

In this, a photovoltaic system for interconnection to the functioning electrical power grid is designed. Validity of the designed Photovoltaic system with the grid coupled can be verified through the experimental results. The relative cost of this solar inverter will also be less as there is minimal number of power devices and dual MPPT is used to execute this composition. It will be also clear from the result, that the obtained output of the inverter modules at different solar panel voltages levels can be prolonged within the particular regulation limits of the functioning electrical power grid. Grid tied photovoltaic systems, with all the above benefits made the inverter composition highly feasible.

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