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.

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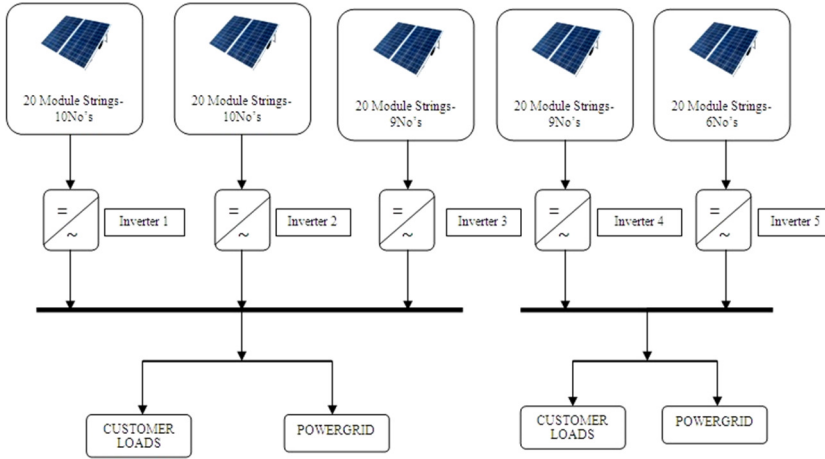
Fig.1. Proposed approach for Designing PV Solar Plant

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) publishedthe 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	4mm^2
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

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 (Voc)[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 (Isc) [Amps]	8.92	9.01	9.09	9.17	9.28
Maximum power current (IMP) [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_I_{SC})	+0.058%/°C				
Temperature Coefficient of(βV_{oc})	-0.330%/°C				
Temperature Coefficient of Pmax(γ_P_{mp})	-0.410%/°C				
Standard Test Condition (STC)	Irradiance 1000w/m², cell temperature 25°c AM1,5G				

Table 3. Electrical Parameters at NOCT

| TYPE	JAP72S01- 310/SC	JAP72S01- 315/SC	JAP72S01- 320/SC	JAP72SC01- 325/SC	JAP72SC01- 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,Am,1.5g				

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.
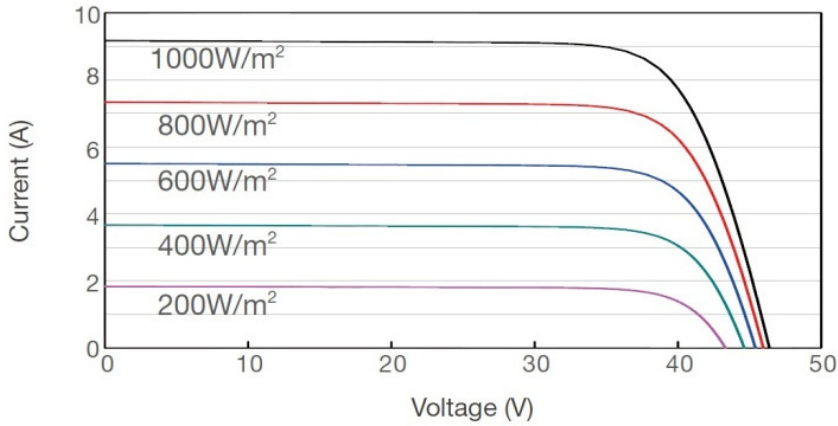
Fig. 2.Current – Voltage Curve (JAP72S01-325/SC)[13-14]
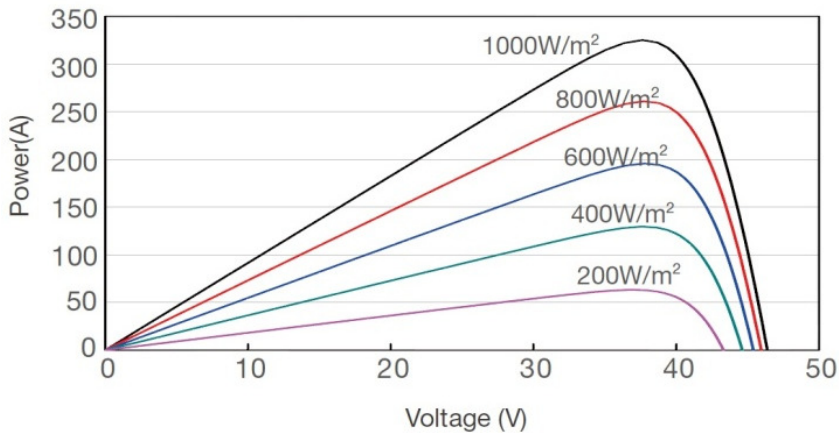
Fig. 3. Power – Voltage Curve (JAP72S01-325/SC) [13-14]

This graphical representation Fig 2 & Fig 3 shows the performance characteristics which is of 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 relationshipbetween current (I)-voltage(V) and Power (P) – Voltage (V) under prevailingconditions of temperature and sunlight. There exists mutiple 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

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	60A / 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

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)

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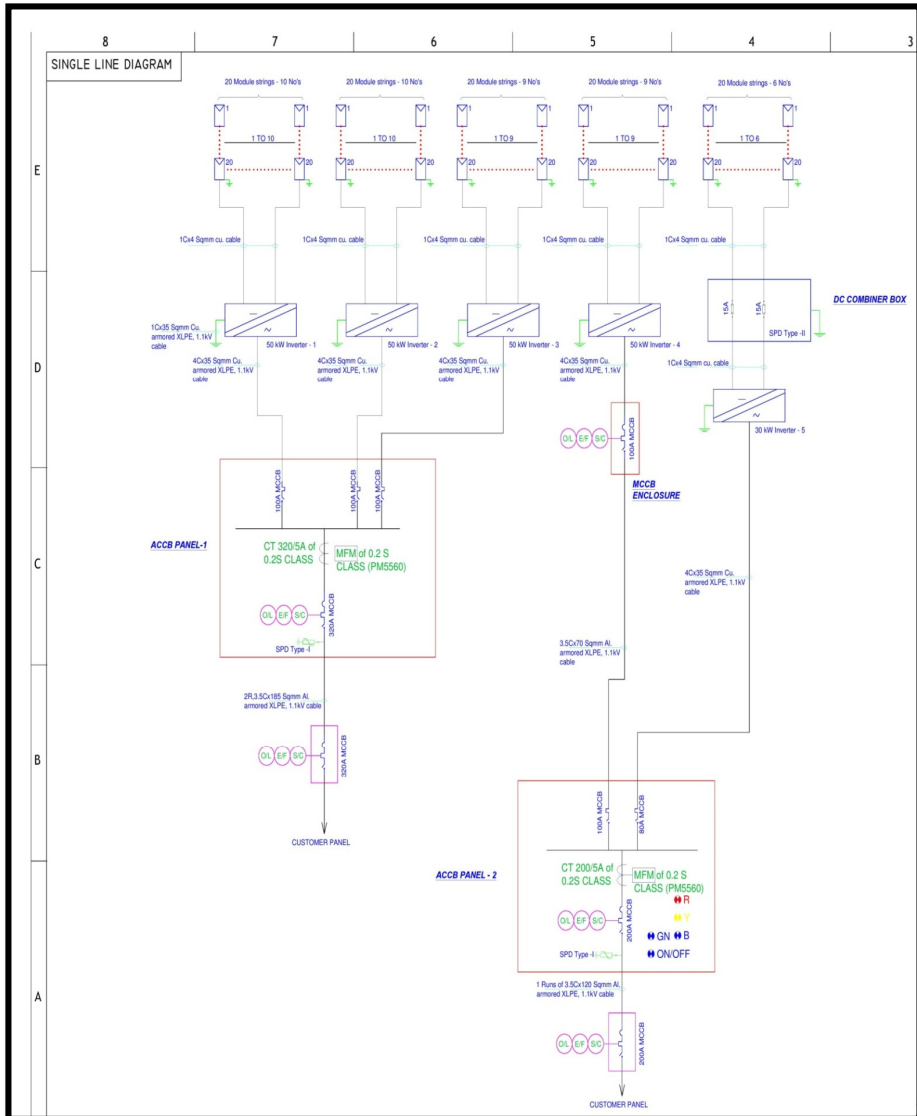
Fig. 4. Single Line Diagram of grid tied 281.6KW Solar Power Generation with inverter modules.

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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