# POWER QUALITY ISSUES IN GRID CONNECTED PHOTOVOLTAIC SYSTEM

**[1]Dayanand Gangadhar Patil, [2]Vinodkumar P. Patil**
PG Student GCoE, Nagaon Dist.-Dhule[1], Assistant Professor, GCoE, Nagaon Dist.-Dhule[2]
dgpatil07@gmail.com[1]

## ABSTRACT

In recent decades, solar energy has become one of the most important renewable energy sources. The Photovoltaic (PV) system when connected with the grid proves to be a boon to the modern society. Although various power quality issues arises such as voltage fluctuations, harmonics and flickers. Thus, the integration of solar energy could initiate problems for equipment in power system. In this paper, various power quality issues have been presented. The power quality indicators, such as voltage fluctuations, frequency deviation, non-sinusoidality are studied. Causes of power quality violations have been identified

**Keywords—**PV system, power quality, grid

## I. INTRODUCTION

Increased production of goods per head, increased prosperity and urbanization, rise in per head consumption, and easiness in energy access are the factors that are responsible for the increase in the total demand of electricity by a significant extent. Having a look at the difference of electricity demand and supply, huge quantities of coal and furnace oil are being used. These usages need to be reduced, as these are leading to tremendous costs in the form of subsidies and increment in the country’s dependency on imports. Renewable energy sources have the ability to make a noteworthy contribution in these areas. Due to all of these, renewable energy needs to be studied and utilised to a great extent [1]. Solar power has an exceptionally good potential for providing electrical energy that is free & non-polluting.Its effectiveness as an electricity supply source has encouraged ambitious targets for solar PV system in many countries around the world.

As the government is providing subsidy, more and more people are getting attentive towards the use of solar energy. According to the recent data available, as of 27 November 2020, renewable energy sources generates 136 GW out of total 373 GW. With the increasing demand, solar power installation is presumed to see a raise of approximately 360% by 2021.

Solar PV system can be implemented in two ways: One as “Off Grid” and the other as “Grid Connected”. In the “Off Grid” solar PV, the PV system is stand alone and independent, means it is not associated with the main electric supply line or with the electricity distribution system. On contrary, “Grid Connected” solar Photovoltaic system is connected with main grid or the electricity distribution company. The major distinction between these two is the storage device. Off grid PV system uses batteries to store the extra amount of energy generated during off peak hours, where as with Grid connected Photovoltaic system, surplus amount of energy can be sold to the electricity distribution company. Batteries prove to be a high cost element for the off grid connected system, making it quite expensive to use. Along with high cost, it is inefficient also as the battery loose energy with time. Off-Grid is usually required in more remote areas which are far from any electricity grid. Generation of electricity through photovoltaic-grid system encourages use of solar energy source, on the contrary part, PV generation leads to new initiatives for development and scheming due to several power quality issues [2]. When PV system is tied with the grid, the effect on power quality is being reviewed in this paper.

## II. GRID CONNECTED PV SYSTEM

Photovoltaic (PV) cells also known as solar cells, converts energy of sun light directly into electricity. PV received its name from the action of transforming light energy (photons) to electricity (voltage), which is known to be the PV effect. Figure 1 displays simple illustration of grid connected PV scheme. The various components of the system are briefly described below:

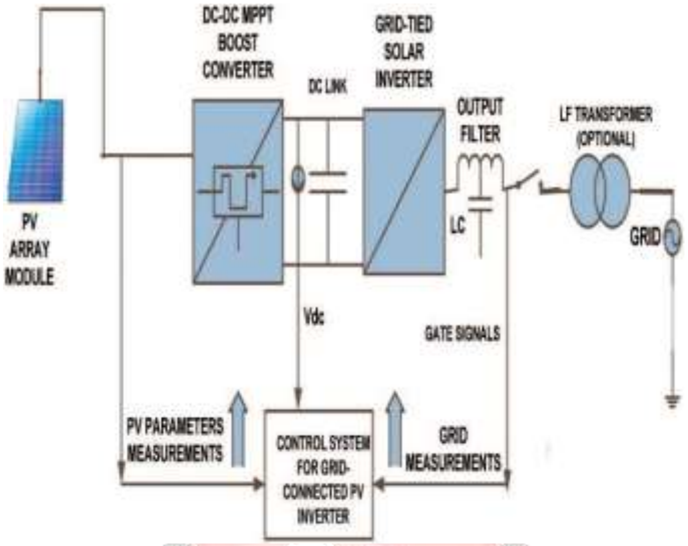


Fig.1.Simple illustration of Grid connected PV scheme

### A. PV ARRAYS

The most important component of the photovoltaic (PV) system is the solar panels that generate electric power by the direct conversion of the sun's energy into electricity. The solar panels are mostly made with semiconductor material, with Silicon (Si) being widely used. Materials like Gallium (Ga) and Aluminium (Al) have better conversion properties and recently they are increasingly finding their application. The components of the PV system includes the electronic devices to interface the PV output and the AC or DC loads. Panels can be used independently, or a number of panels can be connected which forms arrays. Then as element of a complete PV system, more than one array is coupled to the electrical grid. With this modular structure, PV systems can be assembled to meet approximately any electric power requirements whether small or large.

### B. DC - DC BOOST CONVERTER

Because of the unstable nature of the irradiance throughout the day, output voltage of the photovoltaic system varies. Boost converters are therefore needed to get a steady voltage at DC link [3]. By using Maximum power point tracker, operation of DC-DC step up (boost) converter is regulated to draw the highest power from Photovoltaic unit.

### C. DC-AC INVERTER

An inverter is one of the most important pieces of equipment in a solar energy system. Fundamentally, an inverter accomplishes the DC-to-AC conversion by switching the direction of a DC input back and forth very rapidly. As a result, a DC input becomes an AC output. It's the brain of a solar power system and serves primarily two purposes: Firstly, it changes the Direct Current generated from Photovoltaic Panels to Alternating Current in synchronization with grid which is used by the electrical appliances. Secondly, it ensures that solar power generated, is used at priority over grid supply.

## III. POWER QUALITY PROBLEMS IN GRID CONNECTED SYSTEM

While integrating PV system with grid, the most significant parameter is power quality. Electric power quality is the degree to which the voltage, frequency, and waveform of a power supply system conform to established specifications. Good power quality can be defined as a steady supply voltage that stays within the prescribed range, steady a.c. frequency close to the rated value, and smooth voltage curve waveform (resembles a sine wave).Deficient power quality would begin to harm the electrical devices and power distribution elements as frequency variations would cause process in undesired areas [4]. The different power quality problems have been discussed:

### A. HARMONICS

Harmonic distortions is the major power quality issue that is considered in grid connected PV system operations. Harmonics are unwanted higher frequencies which superimposed on the fundamental waveform creating a distorted wave pattern, nature of harmonic currents are as shown in figure. 2.

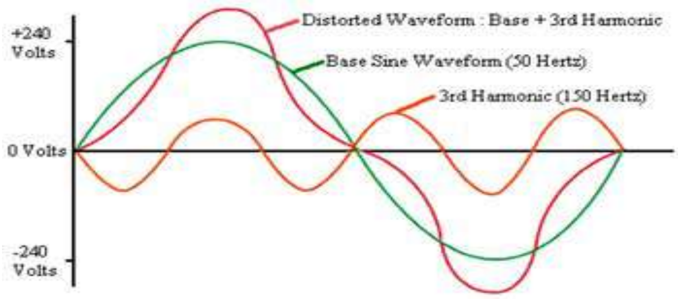


Fig. 2.Harmonic Distortion

Harmonic frequencies are essential multiples of fundamental frequency. The main reasons of harmonics in grid tied systems are existing power electronic mechanism in the PV System. Conversion from Direct Current to Alternating current through inverters; infuse voltage and current harmonic into system thereby resulting in power quality issues. Such phenomenon causes overheating in transformers and capacitor banks, making the system more and more unstable and unreliable [5].



### B.VOLTAGE VARIATION

The primary cause of voltage variations with grid integrated PV system is intermittent nature of the solar irradiance. Uneven solar irradiance is due to transitory clouds and other environmental conditions. All these parameters lead PV system towards unsteadiness via course of voltage variations [5]. Uneven voltage variation leads to:

1. Voltage Sag and Swell*:* When the supply voltage falls for a short time, it is calledas Voltage sag (voltage falls in the magnitude range of 10% - 90% of the RMS voltage). When the supply voltage increases for a short time, it is calledas Voltage swell (voltage increases beyond 110% of the RMS voltage). Figure 3 represents the voltage sag and swells in reference to the normal voltage.

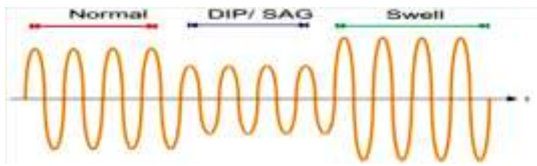


Fig. 3.Voltage sag and swell

2. Short and Long Interruptions: Interruption is defined as the decrease in the voltage supply level to less than 10% of nominal for up to one minute duration. is called voltage interruption. If the interruption occurs for less than one minute, it is defined as short interruption whereas if the time duration is higher than one minute, it is said to be long interruption. However, the term “interruption” is generally used to refer to short-interruption, while the latter is headed by the word “sustained” to indicate a long-duration or long interruption.

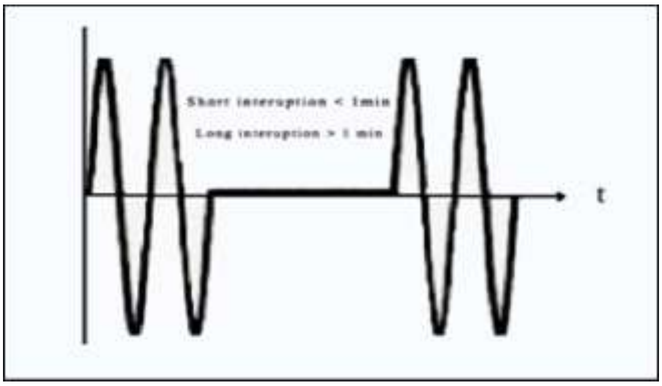


Fig. 4.Voltage Interruption

**C. REACTIVE POWER**

Very Often, Photovoltaic system is intended to work near unity pf, so that it can utilize maximum solar energy. With this instance, electrical grid gets real power from Photovoltaic system that will adjust outflow of reactive power in the PV system. Hence, closeby buses voltage will be improved because of deficient reactive power. Throughout the course of action, system usual power outflow may have undesirable result owing to deficient VAr power. This may reduce the power entail deficient transmission [5].

**D.FREQUENCY VARIATION**

Frequency variation (fluctuation) is variation from standard nominal value (typically 50 or 60Hz) of power system frequency. Frequency variation over tolerance value (± 5%) is not well for PV system and may direct system to collapse [6]. In Photovoltaic system, frequency variation depends on climatic conditions, weather and topographic position which can cause severe troubles.

## IV. STANDARD REGULATIONS FOR POWER QUALITY

Standards on Power Quality are required so that all end consumers (residential, commercial and industrial) and transmission and distribution suppliers converse in similar vernacular when discussing power-quality issues. Standards impart strategy, proposals, restrictions to ensure harmonization among end use apparatus in addition to wherever the scheme will be functional. Standards also describe recommended restriction for instances degrading power quality.

TABLE I: IEEE Std 519-1992 Harmonic Voltage Limits Voltage Distortion Limits

| Bus Voltage at PCC | Individual Voltage Distortion | Total Voltage Distortion sTHD (%) |
|---|---|---|
| 69kV and below | 3.0 | 5.0 |
| 69kV to 161kV | 1.5 | 2.5 |
| Above 161kV | 1.0 | 1.5 |

TABLE II: Voltage Variation Limits and Harmonic Standards as in Central Grid Code

| System Voltage (kV) | Voltage Variation (%) | Voltage Unbalance (%) | Total harmonic Distortion (%) | Individual harmonic Distortion (%) |
|---|---|---|---|---|
| 765 | +-3% | 1.5 | 1.5 | 1.0 |
| 400 | +-3% | 1.5 | 2.0 | 1.5 |
| 220 | +-5% | 2.0 | 2.5 | 2.0 |
| >132 | +-10% | 3.0 | 3.0 | 2.0 |

Out of many, the one most important developments in the field of power quality is the grown significance on commensurating IEEE standards with international standards promoted by the International Electro technical Committee (IEC). Table 1 shows few international standards on particular power quality issues.

TABLE III: IEEE AND IEC STANDARDS REALTED TO POWER QUALITY

| **Power Quality Issue** | **Standards** |
|---|---|
| Harmonics | IEEE-519-1992/2014,IEEE 1346, IEC SC 77A |
| Voltage sag or swell | IEEE P1564,IEC 61000-2-8 , IEC 61000-4-11 |
| Voltage Flicker | IEEE P1453,IEC 61000-2-2,IEC 61000-4-15 |
| Voltage Interruptions | IEEE 1159-95 |



## V. CONCLUSION

Power quality has been a major concern all times, as the disruptions cause great damage to the power system. The paper shows what the power quality is and what are the various power quality issues that occur while integrating PV system with grid. The power quality issues results in overheating, inefficiency, and degrading the service-life of apparatus, process interrupt, insulation breakdown along with the loss of data. It is not possible to entirely get rid of the causes, but measures need to be taken to reduce the power quality issues. The quality or power supply standard needs enhancement, also the persisting outcome of supply requires attenuation.

## REFERENCES

[1] Subhash Kumar, Reinhard Madlener, "CO2 emission reduction potential assessment using renewable energy in India", Energy Volume 97, 15 February 2016

[2] Z Chang and S Tao ,"Power Quality Analysis of Photovoltaic Generation Integrated in User-Side Grid", International Journal of Computer and Electrical Engineering, Vol. 5, No. 2, April 2013.

[3] Majid Taghizadehl , Javad Sadehl and Ebadollah Kamyab,"Protection of grid connected photovoltaic system during voltage sag", The International Conference on Advanced Power System Automation and Protection,2011.

[4] Kow Ken Weng, Wong Yee Wan, Rajparthiban Kumar Rajkumar, "Power Quality Analysis for PV Grid Connected System Using PSCAD-EMTDC", International Journal of Renewable Energy Research, Vol.5, No.1, 2015.

[5] M. A. Eltawil, Z Zhao ,"Grid-connected photovoltaic power systems Technical and potential problems_A Review", Renewable and Sustainable Energy Reviews 14 ,pp 112–129, 2010.

[6] M Farhoodnea ,A Mohamed ,H Shareef ,H Zayandehroodi ,"Power Quality Impact of Grid-Connected Photovoltaic Generation System in Distribution network", IEEE Students Conference on Research and Development,2012.

[7] Filippo Spertino, Paolo Di Leo, Fabio Corona, Fabio Papandrea, "Inverters for grid connection of photovoltaic systems and power quality: Case studies", 3rd IEEE International Symposium on Power Electronics for Distributed Generation Systems (PEDG),2012.

[8] Oana Ceaki, Ramona Vatu, Monica Mancasi, Radu Porumb, George Seritan , "Analysis of electromagnetic disturbances for grid-connected PV plants", Modern Electric Power Systems (MEPS) 2015.

[9] Bincy K. Jose "Grid integration of PV systems-issues and requirements", IEEE International Conference on Circuits and Systems (ICCS),2017.

[10] Pertti Pakonen, Antti Hilden, Teuvo Suntio, Pekka Verho "Gridconnected PV power plant induced power quality problems — Experimental evidence",18th European Conference on Power Electronics and Applications (EPE'16 ECCE Europe),2016.

[11] S. Yasmeena, G. Tulasiram Das, "A Review of Technical Issues for Grid Connected Renewable Energy Sources", International Journal of Energy and Power Engineering 4: pp 22-32, 2015.

[12] Jaan Niitsoo, Marek Jarkovoi, Paul Taklaja, Joni Klüss, Ivo Palu, "Power Quality Issues Concerning Photovoltaic Generation in Distribution Grids", Smart Grid and Renewable Energy, Scientific research Publishing, 6, pp 148-163, June 2015.

[13] Varun Kumar, A.S. Pandey and S.K. Sinha, "Grid Integration and Power Quality Issues of Wind and Solar Energy System A Review", International Conference on Emerging Trends in Electrical, Electronics and Sustainable Energy Systems,pp 72-80,2016.