

# Harmonics in Solar PV System: Effects & Mitigation Techniques

## Let's know what is Harmonic...

Harmonics are nothing but distortion in voltage and current waveform relative to its fundamental frequency. Ideally it is defined as multiple integral of fundamental frequency which causes distortion in the voltage and current waveform.

A non-linear load (inductive or capacitive in nature) in any electrical system induces harmonic distortion. These non-linear loads comprises of power electronic components that engender harmonic distortion.

## Harmonics in Solar PV System...

Solar PV System comprises of PV modules, charge controllers, solar inverters, battery bank, utility meter and grid system.

PV modules convert the solar power into electrical (DC) power. This electrical DC power is converted into electrical AC power by the solar inverters. Solar inverters utilize semiconductor devices like IGBT/Thyristors to meet the purpose of power conversion. During power conversion, switching of these semiconductor devices causes distortion in waveform.

Generally, the solar inverters are limited to generate the current harmonics distortion less than 3% but practically, total harmonic distortion at solar inverter comes around less than 8%. Dominant order harmonics are 2<sup>nd</sup>, 3<sup>rd</sup>, 5<sup>th</sup>, 7<sup>th</sup> and 9<sup>th</sup> order harmonics.

## Pros & Cons of Harmonics:

- Overvoltage
- Reduced system efficiency
- Insulation Failure & Frequent tripping of inverters
- Heating issues in equipment(s)
- Interference in communication lines
- Increase in losses at higher frequency

- Existence of 3<sup>rd</sup> order harmonics causes zero sequence currents leading to current flow in neutral phase

## How to Address Harmonics in Solar PV System

Before jumping to the harmonic mitigation techniques, one should be aware of the harmonic distortion level present in the system. This can be achieved by conducting **power quality audit** of the electrical network at any site. Let's have a look on the methodology and correction technique for addressing issue of harmonic distortion in solar PV system:

- ✓ **Audit Analysis:** *Power Quality Audit* will help to analyse the level of harmonics present in the system along with the other power quality parameters that will in turn help to design the effective capacity of filter unit required.
- ✓ **Active Power Filters:** *Advanced IGBT based active power filters* are responsible for mitigation high harmonic distortion. These active filters target the higher order harmonics and reduce the overall harmonic distortion level in the system.
- ✓ **Line Reactors:** Addition of sufficient input line impedance suppress the high harmonic content present in a system
- ✓ **LC Circuit:** Using LC Circuit in a system reduces harmonic problem. It not only reduces the zero-sequence harmonics but the other harmonics as well
- ✓ **K Transformers:** K-rated transformers increase the size of the core, increase the size of the neutral conductor, and use special winding techniques to reduce eddy current and skin effect losses.
- ✓ **Conductor Spacing & Over-Sizing**

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