Technical Information

Important Requirements for Medium-Voltage Transformers SUNNY HIGHPOWER PEAK3

Content

This document describes transformer technical requirements and related system design considerations for the following SMA inverters:

- SHP 100-20 (Sunny Highpower PEAK3)
- SHP 150-20 (Sunny Highpower PEAK3)
- SHP 125-US-20 (Sunny Highpower PEAK3-US)
- SHP 150-US-20 (Sunny Highpower PEAK3-US)
- SHP 100-JP-20 (Sunny Highpower PEAK3-JP)
- SHP 143-JP-20 (Sunny Highpower PEAK3-JP)

1 General Technical Properties

The following guidelines must be considered when specifying or evaluating transformers for use with Sunny Highpower inverters:

- Multiple Sunny Highpower inverters connected in parallel can be interconnected to a single transformer.
- Standard distribution or service transformers are acceptable for interconnection to medium-voltage distribution systems.
- Sunny Highpower inverters do not require electrostatic shielding between primary and secondary windings of transformers.
- The nominal voltage at the inverter electrical connection point (ECP) must match the nominal output voltage of the inverter.
- The rated kVA capacity of a transformer must be equal to or greater than the total nominal output power of all inverters connected to the transformer.
- The winding configuration of transformers to which the inverters are connected must be compatible with the inverter. Compatible winding configurations for use with Sunny Highpower inverters are defined in Section 2 Compatible Transformer Winding Configurations (Vector Groups) of this document.
- The total impedance between the inverters and the point of common coupling (PCC) with the grid must not exceed the values specified in Section 3 Allowable Impedance Levels of this document.
- Transformers must be rated for the nominal frequency of the grid voltage at the grid connection point and the tolerances to be expected.
- The expected load (generation) profile and ambient temperature conditions of the PV system and the transformer must be considered when specifying transformer rated kVA capacity, temperature rise and insulation class.
- SMA recommends specifying transformers with multiple connection taps to enable adaption to the local system voltage.
- Transformers should comply with all applicable standards based on the installation location.

2 Compatible Transformer Winding Configurations (Vector Groups)

Sunny Highpower inverters require connection to a grounded Wye transformer winding. A neutral conductor connection is not required between the inverter and the transformer's grounded neutral point.

The phase displacement of transformers does not affect the operation of Sunny Highpower inverters. Transformers with compatible winding configurations can be specified with any available phase displacement.

	Compatible Transformer Winding Configurations* at Inverter ECP			**Inverter type**
	YNyn Wye-grounded : wye-grounded	Dyn Delta : wye-grounded	YNd Wye-grounded : delta	
GRID	Yes	Yes	No	SHP 100-20 SHP 100-JP-20 (400 V)
	Yes	Yes	No	SHP 125-US-20 (480 V)
	Yes	Yes	No	SHP 143-JP-20 (550 V)
	Yes	Yes	No	SHP 150-20 / SHP 150-US-20 / (600 V)

* The second part of the transformer’s vector-group notation gives the inverter-side winding configuration. For example, Dyn is a transformer with a Delta configuration on the grid connection side and a Wye-grounded configuration on the inverter connection side.

Connecting inverters to transformers that do not comply with these guidelines can result in unstable inverter operation, excessive nuisance tripping, and disruption or damage to the inverters or other connected equipment.

3 Allowable Impedance Levels

Impedance (especially resistances of conductors and transformers) between the PV system and the grid cause an increase in voltage measured at the inverter terminals. In order to avoid over-voltage tripping of the inverters and excessive energy losses, AC conductors should be sized to limit the voltage drop between the inverters and the point of common coupling (PCC) to a maximum of 1% of nominal voltage.

In addition, the stability of the inverter control system is affected by the level of impedance (especially inductances of transformers) between the inverters and the point of common coupling (PCC) with the grid.

The maximum allowable impedance level for each Sunny Highpower inverter model is given in the table below.

Inverter type	Maximum allowable impedance (Zmax)
SHP 100-20 / SHP 100-JP-20	50 %
SHP 125-US-20	50 %
SHP 143-JP-20	50 %
SHP 150-20 / SHP 150-US-20	50 %

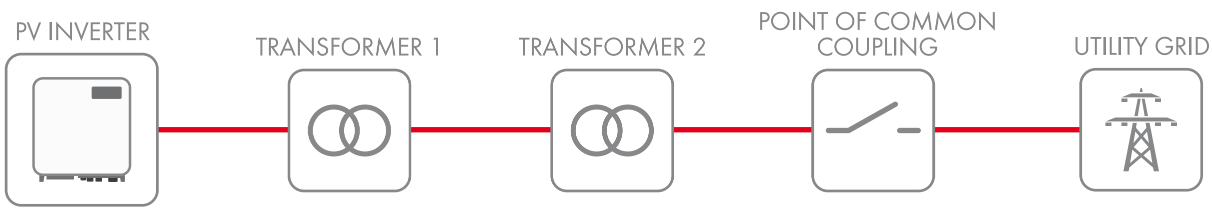

Figure 1: PV system connected to the grid via multiple transformers

The total system impedance for a given inverter in a PV system can be calculated using the equation below:

$$Z_{total} = \sum_{n=1}^{t} \left(\frac{S_{PVn}}{S_{TRn}} \cdot Z_{TRn} \right) + Z_{PCC}$$

- Z_{PCC} is the short-circuit impedance based on the short-circuit power available at the PCC
  - Where the total PV system kVA capacity is insignificant relative to the grid capacity at the PCC, grid impedance will be negligibly small and can be excluded from the calculation.
  - When needed, this value is typically provided by the interconnection utility.
- n is one of one or more transformers connected in series between the inverter and the PCC.
- S_{PVn} is the total nominal output power (in kVA) of all inverters connected to transformer n.
- S_{TRn} is the rated kVA of transformer n.
- Z_{TRn} is the short-circuit impedance of transformer n.

Conductor impedance is assumed to be 2 % and has been deducted from inverter maximum allowable impedance levels.

Use-case example 1: PV system connected through a single distribution transformer

Distribution transformers typically have short-circuit impedances between 4 % and 6 % - well below the lowest maximum allowable impedance of Sunny Highpower inverters. Therefore assuming the transformer kVA rating is equal to or greater than the total nominal output power of all connected inverters (as specified in Section 1 General Technical Properties of this document), system impedance should not be a concern in PV systems connected through a single distribution transformer to the PCC with the grid.

Use-case example 2: Large utility-scale PV system connected to HV transmission system

In this example, a large utility-scale PV system is planned to be interconnected to the high voltage transmission network. The output of the inverters will be stepped up to medium voltage within the PV plant, and then stepped up to high voltage for interconnection.

PV system: 400 x SHP 150-US-20

- S_{PV_total} = 60 MVA
- Z_{max} = 50 %

Z_{PPC} = 60 MVA / 1000 MVA = 6 %

- where 1000 MVA = short-circuit power available at PCC (provided by utility or transmission system operator)

1. MV step-up transformers: 10 inverter per transformer
   - S_{PV1} = 1.5 MVA
   - S_1 = 1.5 MVA
   - Z_1 = 5.75 %

2. HV step-up transformer
   - S_{PV2} = 60 MVA
   - S_2 = 60 MVA
   - Z_2 = 10 %

Total system impedance to the inverters would be calculated as below:

$$Z_{total} = (1.5/1.5)*5.75\ \% + (60/60)*10\ \% + 6\ \% = 21.75\ \%$$

In this example total impedance is less than the 50 % maximum allowable impedance for SHP 150-US-20 inverters. The specified system design is within the impedance limits for the selected Sunny Highpower inverters.