Inverter in pv system

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Inverters belong to a large group of static converters, which include many of today’s devices able to “convert” electrical parameters in input, such as voltage and frequency, so as to produce an output that is compatible with the requirements of the load.

Generally speaking, inverters are the devices capable of converting direct current into alternating current and are quite common in industrial automation applications and electric drives. The architecture and the design of different inverter types changes according to each specific application, even if the core of their main purpose is the same (DC to AC conversion).

Standalone inverters are for the applications where the PV plant is not connected to the main energy distribution network. The inverter is able to supply electrical energy to the connected loads, ensuring the stability of the main electrical parameters (voltage and frequency). This keeps them within predefined limits, able to withstand temporary overloading situations. In this situation, the inverter is coupled with a battery storage system in order to ensure a consistent energy supply.

Grid-connected inverters, on the other hand, are able to synchronize with the electrical grid to which they are connected because, in this case, voltage and frequency are “imposed” by the main grid. These inverters must be able to disconnect if the main grid fails in order to avoid any possible reverse supply of the main grid, which could represent a serious danger.

Nowadays, the difference between standalone and grid-connected inverters is not as evident because many solar inverter are designed to work in both standalone or grid-connected conditions. In fact, some distribution system operators (DSO) allow, or even require, specific generators to stay active in the case of grid failure in order to supply energy to a specific area or load. This situation is called “island operation mode” and actually falls in the conditions described for the standalone application.

Let’s now focus on the particular architecture of the photovoltaic inverters. There are a lot of different design choices made by manufacturers that create huge differences between the several inverters models. Knowing this, we will present the main characteristics and common components in all PV inverters.

The input section of the inverter is represented by the DC side where the strings from the PV plant connect. The number of input channels depends on the inverter model and its power, but even if this choice is important in the plant design, it does not affect the inverter operation. So let’s suppose, for the moment, that all the strings are coupled before the inverter with a pre-parallel box and the inverter has just two inputs: + and -.

Each PV module (or string) can be characterized by an I-V curve (seen in Figure 3) where it is possible to determine the maximum power conditions (Imp, Vmp). As a standard rule, this curve is available in each PV module’s datasheet and is calculated according to the Standard Test Condition, STC: (1000 W/m2, 25 °C, IAM 1.5). To better understand IAM, read How Radiation and Energy Distribution Work in Solar PV.

As soon as temperature and irradiance differ from those of the STC, voltage and current change, resulting in I-V curves different from those of the STC. Figures 4 and 5 show how the I-V change according to temperature and irradiance. Obviously the maximum power point will also change, so the MPPT algorithm always looks for this point in order to maximize the power output.

Next, we find the “core” of the inverter which is the conversion bridge itself. There are many types of conversion bridges, so I won’t cover different bridge solutions, but focus instead on the bridge’s general workings.

In Figure 2, a three-phase inverter is represented, and from each “leg” of the bridge are two switching devices, commonly MOSFET or IGBT — nowadays, 3 IGBT is the most popular solution for solar inverters. Control logic governs the switching behavior of the IGBT in such a way as to produce DC to AC conversion. The most common switching strategy for producing a sinusoidal waveform from a DC signal is pulse width modulation (PWM).

The last section of the inverter is the filter section, designed to compensate for the harmonic content produced by all the previous sections and clean up the output waveform. The switching of the IGBT is the main source of harmonics. It introduces waveforms at a higher frequency than the fundamental.