We can make the weather

Introducing the high-level photovoltaic simulator PVS from Spitzenberger & Spies.

The amount of generated energy of a solar panel field (and therefore the profitable efficiency) mainly depends on varying weather conditions such as cloudiness and adverse weather situations. To achieve the maximum energy rate at heavily varying irradiation, modern intelligent solar inverters are used. The overall efficiency of solar inverters is tested according to IEC/EN 50530. Compliance testing requires powerful voltage and current sources, together with analyser units operating in excellent harmony.

The testing of modern solar inverters requires three main functions of the testing equipment:

1. Simulation of solar panels for testing solar inverters according to IEC/EN 50530
2. Generation of typical loads for the anti-islanding tests according to IEC/EN 62116
3. Simulation of the connected grid

Grid-connected photovoltaic systems feed the generated energy into the power distribution grid network, and the amount of power fed into the grid defines the profitability of the whole solar site. The IEC/EN 50530 describes in detail the necessary calculation formulae and testing routines to evaluate the overall efficiency of solar inverters.

Solar inverters must be designed to be able to deal with many different operating conditions. Intensive testing during the development process of inverters as well as during their production is requested.

In the future, a new type of inverter – the micro-inverter – will conquer the market. These micro-inverters are designed to be placed directly at the solar panel, and will operate at much lower voltages and lower power ranges.

As a good strategy for a complete test of solar inverters' three main tasks have to be carried out:

- Simulation of a solar generator and operating the inverter in the MPP (maximum power point), testing of the MPP tracking function, evaluation and calculation of the overall efficiency
- Simulation of varying load conditions and different disturbances like transients, harmonics, ripple, Cos Phi, etc.
- Simulation of the connection to the public grid during normal operating conditions as well as during irregular conditions such as during voltage interruptions, variations and drops

Simulation of the energy generation

The generated energy of a solar site varies depending of the intensity of the solar irradiation, level of cloudiness or shading, as well as the ambient temperature and pollution of the panel surface. The conversion of the panel-power through the solar inverter should be carried out in the Maximum Power Point (MPP).

To convert the maximum available energy generated by the solar panels, many inverters use a MPP tracking algorithm. This algorithm changes the load condition of the inverter so that the panel field always sees an ideal load and can transfer the maximum available energy.

The Photovoltaic-Simulator series PVS from Spitzenberger & Spies is the perfect designed DC Source to reproduce the I/V characteristic curves as required according to IEC/EN 50530.

Two different versions of the PVS simulator are available. On the one hand, the powerful PVS series for testing inverters up to 400kW, and on the other, the PVS 1000/LV is for testing micro inverters below 1000W power and low DC voltages.

Using the PVS simulator, solar panels with different technologies can be recreated (mono-/poly-crystalline). The provided software package SPS_PVS offers an easy automated calculation of the necessary I/V characteristic. In addition, externally-measured and stored characteristics can be imported if they have a CSV-Format.

It is very important that the simulator power supply does not suppress this ripple as a result of the voltage adjustment. More and more inverters use the amplitude and phase shift of the ripple voltage and current to achieve a very fast MPP tracking. This method is much faster than the conventional method 'disturb and perturbate'.

Especially during cloudy weather conditions, where the solar irradiation is changing rapidly, a fast MPP tracking algorithm gives a much higher overall efficiency. The number of inverters using this ripple-based MPP algorithm will increase steadily. PV simulators have to

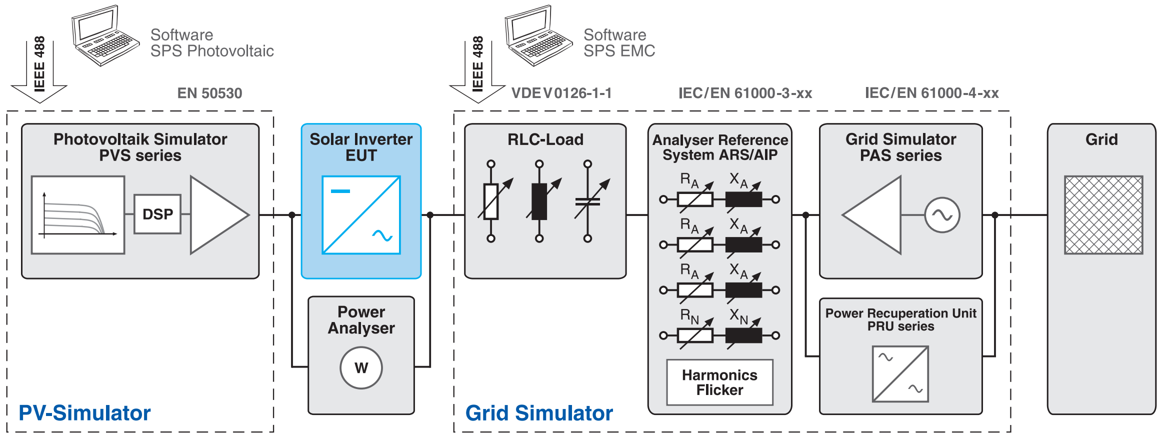

Fig. 1: Function diagram, Spitzenberger & Spies PV-Simulator series PVS and connected grid simulator.

have the ability, to reproduce the according current/voltage characteristic curves at ripple condition very precisely.

For a very precise simulation of the current/voltage characteristic, a very fast PV simulator response time is essential

While switch-mode amplifiers as the simulator source have a response time of typically 2-3ms, linear working transistor amplifiers have a response time in µs area. When the PV simulator's response time is too slow, the I/V-operating points are no longer located on the I/V-characteristic curve; they circle around the desired MPP area on the characteristic curve (See Spitzenberger & Spies application note: 'Necessity for high-speed PV simulators'). The correct testing and evaluation of the solar inverter compliant to the IEC/EN 50530 is not possible with switch-mode amplifiers.

Solar generators and islanding

During normal operation the solar inverter supplies the load which is regularly supplied by the public network. Depending on the amount of generated energy either the solar inverter delivers energy into the public network or the public network delivers energy to the connected loads.

A desired simulator like the combination of the PVS Series and the Basic EMC System from Spitzenberger & Spies must be able to generate irregular interconnection situations and conditions for testing the inverters according to realistic conditions and to verify their conformity.

Islanding is a situation when the connection to the public network is interrupted or the public network has been switched off. Interaction between the local generators and the connected loads causes then the islanding effect and affects the solar inverter a running public grid.

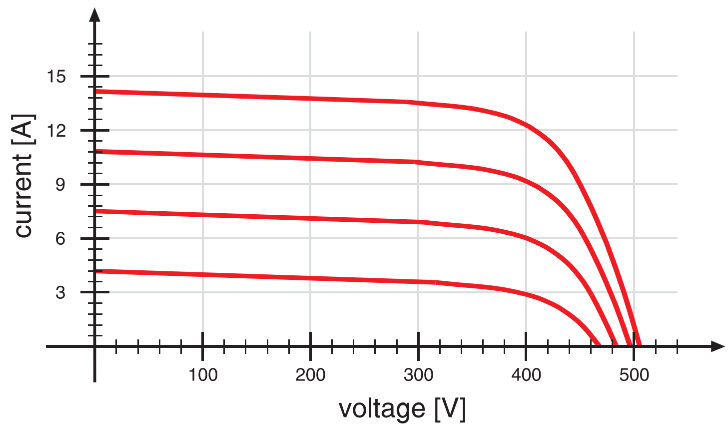

Fig. 2: Different I/V characteristics. The sequence of different characteristics, their duration and transition time is free adjustable. Complete test cycles can be set up easily. The evaluation of measured date can be done graphically as well as in a numeric format. The evaluation can be stored for documentation. Many (single-phase) inverters are generating a type depending AC ripple on their DC input.

The two main problems during islanding are:

1. The public power distributors can no longer control and influence voltage and frequency in the distribution network. Inside the islanding system deviation of voltage and frequency can cause malfunction and/or damage of the local connected loads
2. Injury of operating personnel can be caused when the public grid is cut off for maintenance. The personnel has the opinion of a voltage free network whilst the solar generator still delivers energy and is setting the local islanding grid still under voltage.

The IEC/EN 62116 prevents humans and machines from injury and damage. It defines test specifications and methods for solar inverters to check their ability to detect and avoid the islanding effect.

Practically every solar inverter must have an anti-islanding function which cuts off the connection between inverter and the local grid on error condition. The local grid status is set voltage free.

Testing equipment according to IEC/EN 62116

1. Waveform recorder and power analyser
2. DC source simulating a realistic photovoltaic source
3. AC source simulating the public grid

AC loads – combined RLC load

The IEC/EN 62116 defines an explicit test of this anti-islanding function.

The PV Simulator series PVS from Spitzenberger & Spies complies to all necessary requirements for the DC source as defined in the IEC/EN 50530 and also in the IEC/EN 62116.

RLC load as a power resonant circuit

To establish a realistic environment for this testing a typical AC load as a combination of R, L and C is defined in the standard. The RLC load shall be adjusted according to the output power capability of the respective inverter and shall be in resonance condition at the nominal frequency.

Taking all the requirements for the RLC load according to IEC/EN 62116 into consideration a complex profile of necessities for the test system arises.

Spitzenberger & Spies has developed an optional RLC load unit for the overall test system consisting of the PV simulator series PVS and the Basic EMC test system. This RLC unit complies to all requirements according to IEC/EN 62116. In conjunction with complying measurement units like digital oscilloscopes and power analyzers a complete test according to IEC/EN 50530 and IEC/EN 62116 can be carried out. A convenient software package for running the tests and for documentation completes the PVS simulator system

Many possibilities far beyond the standards

Looking at the PV simulator side, the input of the solar inverter can be supplied with arbitrary solar panel characteristics and irradiation changes from any point of the earth. The PVS simulator just has to be programmed with this data files with the Spitzenberger & Spies software. Realistic weather and panel situations from any place on the earth can be simulated easily in laboratory environment.

On the other hand, the solar inverter's output is connected to the Spitzenberger & Spies Basic EMC system, a grid-simulator with arbitrary functions, which is able to simulate each local grid from any power distributor worldwide. This grid-simulator can not only simulate a stable network, it can perform also many disturbances like voltage drops and voltage variations, frequency variations, unbalances and many more, as described in the IEC/EN 61000-4 series standards. ■

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The relating standards:

IEC/EN 50530
IEC/EN 62116
VDE 0126-2
IEEE 1547
and many manufacturers' test specifications

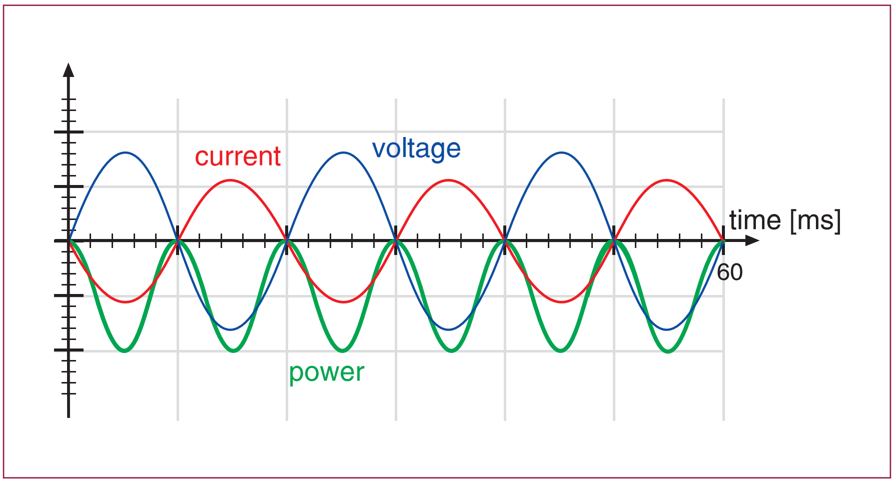

Fig. 3: Phase relation at Ripple. The power fed into the grid has a pulse frequency of double the mains frequency (100Hz in Europe). The inverter consumed power is fluctuating therefore with the same frequency (100Hz in Europe) and produces the described ripple. This ripple is very close to reality conditions, if the dynamic response of the PV simulator is very high.

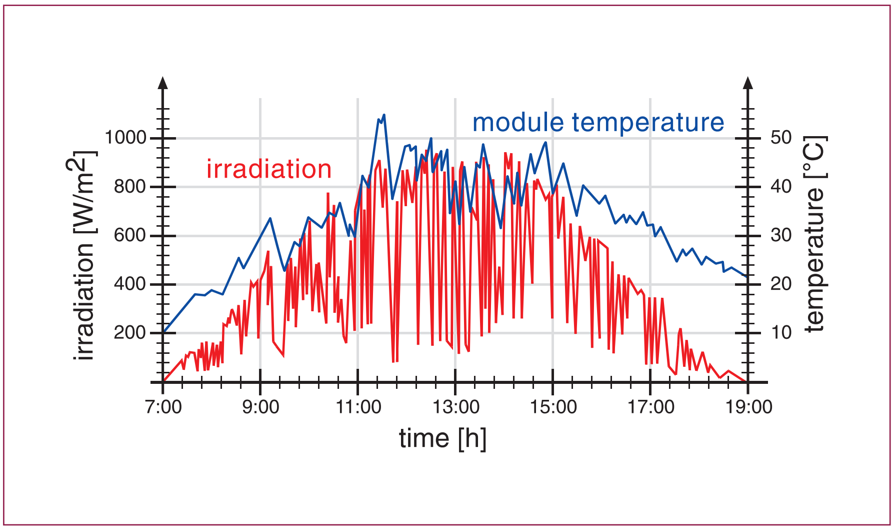

Fig. 4: Daily variation of irradiation intensity and temperature of the solar panel. Above and beyond the IEC/EN 50530 the Spitzenberger & Spies software package offers the possibility to store panel values of solar irradiation and temperature variation in the course of the day for testing the long term behavior of solar inverters. External data values can be imported, if they have CSV-Format.

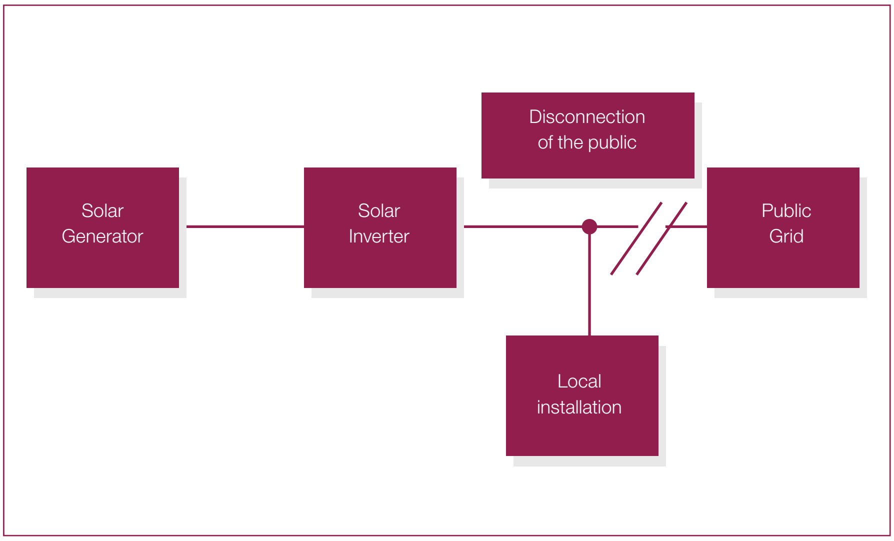

Fig. 5: Schematic diagram of islanding.

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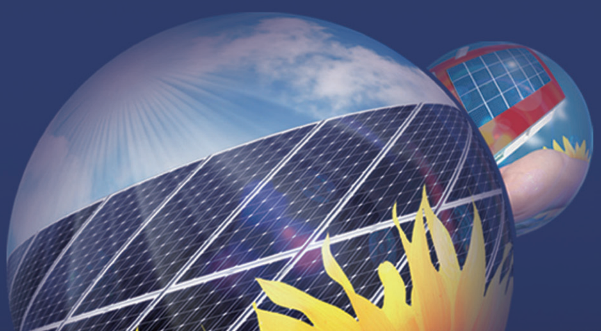

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