Necessity for high speed PV Simulators

The relating standards:
EN 50530
IEC/EN 61683
IEC/EN 61727
IEC/EN 62116
VDE 0126-2
IEEE 1547

The fast response time of PV simulator is required to realistically simulate the I/V characteristic when the inverter produces a ripple on DC voltage and DC current of the PV simulator. Single phase inverters have typically a ripple with twice the grid frequency. A ripple can also occur when the MPP tracker is searching very fast on the I/V characteristic. Real solar cells have a I/V characteristic like shown in Fig. 1:

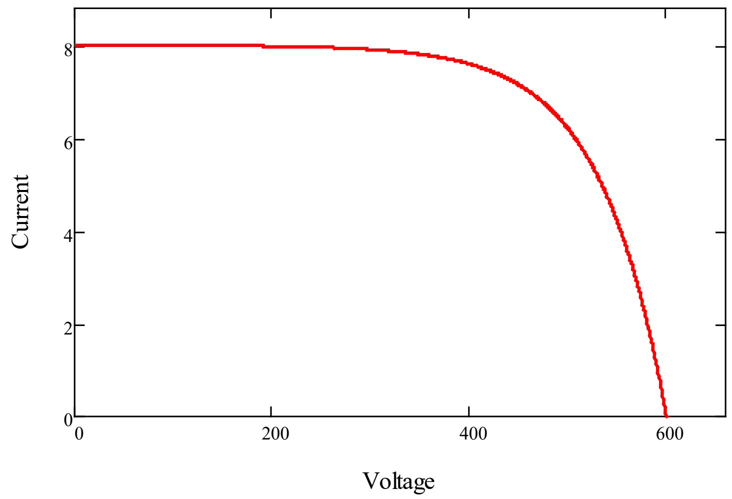

Fig. 1: Current/voltage characteristic of real solar cells

So when the voltage goes up the current goes down and vice versa. The PV simulator has to simulate this characteristic as realistically as possible. To achieve the maximum accuracy to reach the I/V characteristic the PV simulator measures voltage and current and controls its output accordingly.

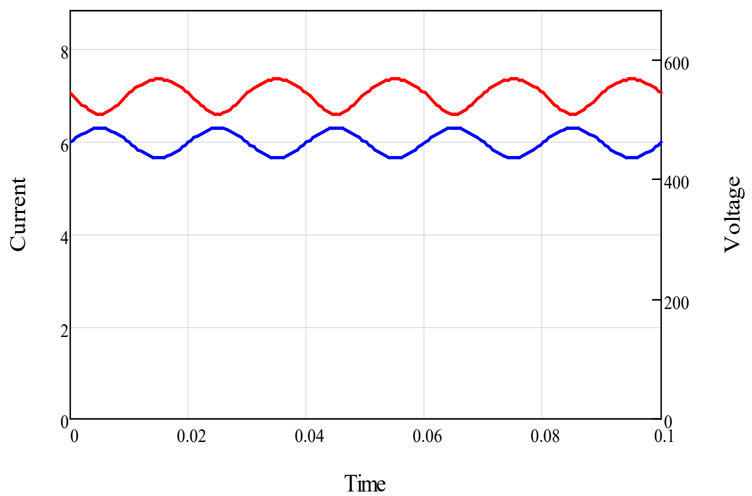

Fig. 2: Phase shift between current and voltage at ripple 50Hz

When there is an abrupt load change it takes typically 100µs with the PV simulator PVS from Spitzenberger & Spies until the output is adjusted according to the I/V characteristic. Switch mode PV Simulators need much longer time (maybe 2ms or more). For example: single phase inverters have a typical ripple with twice the grid frequency. With 50Hz mains frequency this is a 100Hz ripple.

With real solar generators as well as with the linear type PV simulator PVS from Spitzenberger & Spies the voltage and current characteristic look like the following diagram in Fig. 3:.

The operating points are lying all on the desired I/V characteristic. It is very important that the PV simulator is fast enough, to follow and to make as less additional phase shift as possible. The voltage and current ripple are inverse (current goes up => voltage goes down), so phase angle is 180 degrees.

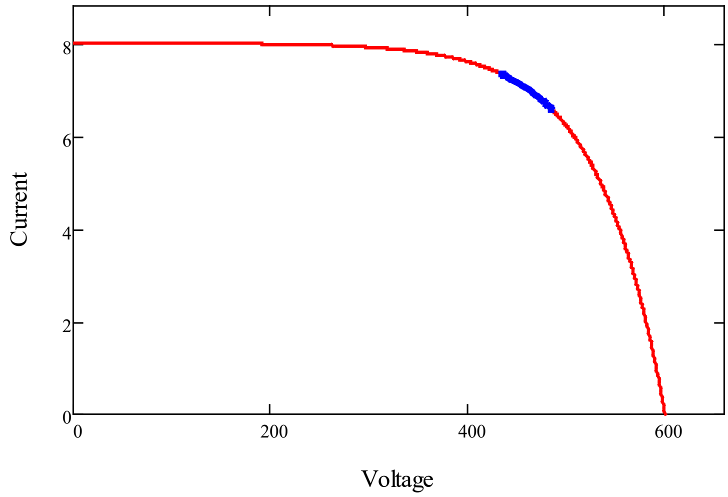

Fig. 3: Operating points (blue) when using PVS

If you take a rise time of 100µs (from 10% to 90%) and assume that the simulator acts like a first order filter,

then the time constant is □calculated as:

$$T = \frac{t\_rise}{ln(9)} = 45\mu s$$

The phase shift can be calculated with the following formula:

$$\varphi = -atan(2 * \pi * f)$$

For the PVS□ (T=45µs) the calculation of the phase shift at 100Hz is -1.6 degrees.

For a switch mode amplifier with a rise time of e.g. 2ms the phase shift would be about 30 degrees which is too much for efficient MPP tracking measurement. When the PV simulator is too slow for the ripple produced by the inverter, the operating points are not on the I/V characteristic. The behaviour is different to the behaviour of real solar cells. Accurate MPP tracking efficiency measurements like described in IEC/EN 50530 wouldn't be possible in such a case.

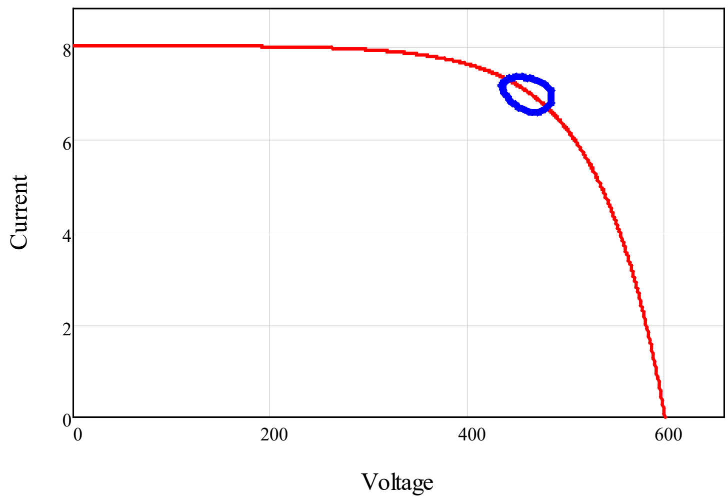

Fig. 4: Operating points (blue) when using switch-mode simulator

In IEC/EN 50530 there is the requirement:
"This requires a sufficient dynamic of the PV simulator in order to follow the dynamic voltage changes that occur in the measurement (e.g. the typical ripple of single phase inverters with twice the grid frequency)"