Capabilities of modern bi-directional inverters

Using battery energy storage systems in local PV installations and testing the performance of the connected solar inverters. A discussion, courtesy of Spitzenberger & Spies GmbH & Co. KG.

The longstanding problem when using photovoltaic energy harvesting is the night, when no energy production is available. Yet, several ways are currently being discussed to supply energy even during night-time with renewable energy.

One application for avoiding the nightly energy gap is an energy storage system. Centralised storage systems are already on the market, and are mainly driven by the power generating and distributing industry. For the storage medium, heat, gas, air, water is used and for smaller installations like family houses, new battery based storage systems are entering the market.

The functional idea behind battery energy storage systems is shown in **Fig.1** (overleaf).

In this idea the solar inverter acts as a bi-directional gateway between the local installation and the public grid. In the above diagram, the optimum battery energy storage system is connected on the DC side of the solar inverter to the PV installation. The battery storage system can be charged either by using the DC generated from the PV installation or by using the AC/DC path of the inverter connected to the public grid.

Secondly, the battery storage system can also supply the public grid with internally stored energy.

In installations with a unidirectional inverter – most of the existing installations – the battery storage system could be connected (as an option) on the AC side of the solar inverter. This installation is made easier, but

Overall test system for bi-directional solar inverters – BESS test system

SPITZENBERGER SPIES

PHOTOVOLTAIC

Photovoltaic Simulators
Testing of solar inverters according to EN 50530

V: 0 ... 950 V / I: 0 ... 1250 A
P: 0 ... 400 kW / $t_{transient:}$ < 100 µs

AUTOMOTIVE

2-/4-Quadrant Amplifiers
Testing of drive systems / battery simulations

V: 0 ... 800 V / I: 0 ... 1000 A
P: 0 ... 30 kW / f: DC ... 150 kHz

POWER AMPLIFIER

AC/DC 4-Quadrant Amplifiers
Current and voltage sources / power system simulation

V: 0 ... 1000 V / I: 0 ... 10000 A
P: 0 ... 300 kW / f: DC ... 300 kHz / t_r: < 5 µs

EMC TESTING

Basic EMC System
Fully compliant emission and immunity tests

IEC/EN 61000-3-2 / -3-3 / -3-11 / -3-12
IEC/EN 61000-4-xx

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then needs a second, bi-directional inverter for the charge/discharge capability of the battery energy storage system.

In both cases the optimum performance of the solar inverter is the main point talking about efficiency of the overall system.

Due to the changing load condition during the charge cycle, the inverters need to adjust the maximum power point to gain maximum performance.

How can this inverter efficiency be tested?

The Spitzenberger & Spies BESS test system is an optional extension of an existing solar inverter test system. The functional principle of the BESS system is based on the battery model of Rincon-Mora.

See Fig. 2

The normal operation mode of the PV simulator is shown in the figure above. The solar inverter's input is connected to the PV simulator PVS and the AC output of the inverter is feeding energy into the grid simulator. The inverter converts DC to AC.

See Fig.3

The multi-function PV Simulator PVS can operate either as a generator / simulator of the PV installation or as battery simulator. Due to different types of solar generators, the PVS/BESS series has five voltage ranges: 400V / 500V / 600V / 800V / 950V.

Operating as a battery simulation system the solar inverter is converting AC to DC. The inverter's efficiency is depending on the battery characteristic of the connected battery system.

The simulation part of the software allows specifying the battery model parameters which are the input parameters of the battery characteristic in relation to the percentage of charge:

* U0: the battery voltage
* RS: the serial impedance
* R1: the parallel impedance 1
* C1: the parallel capacitance 1
* R2: the parallel impedance 2
* C2: the parallel capacitance 2

The PVS simulator acts during the test as a sink, consuming the energy produced by the solar inverter. Furthermore the technical specification of the battery storage system can be specified:

"One application for avoiding the nightly energy gap is an energy storage system"

* Capacity (Ah)
* Charging percentage at system startup (%)
* Maximum current capability (A)
* Maximum voltage capability (V)

As a result, the software prints the voltage / current curve of the battery storage system during the charging cycle from 0-100%.

All manufacturers of bi-directional inverters can easily optimise their inverter characteristic for different battery types using the SPS battery simulation system. ■

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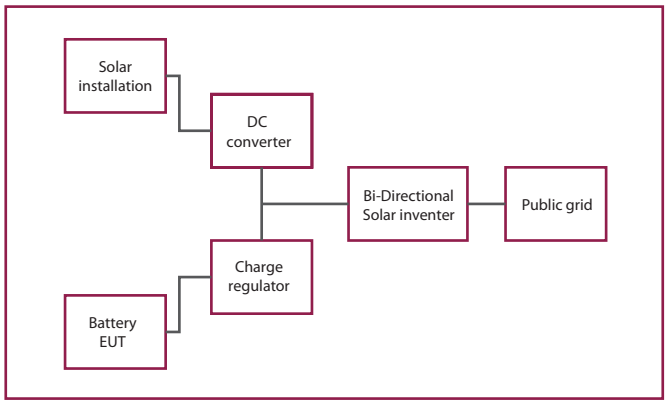

Fig.1 DC connected PV battery systems diagram

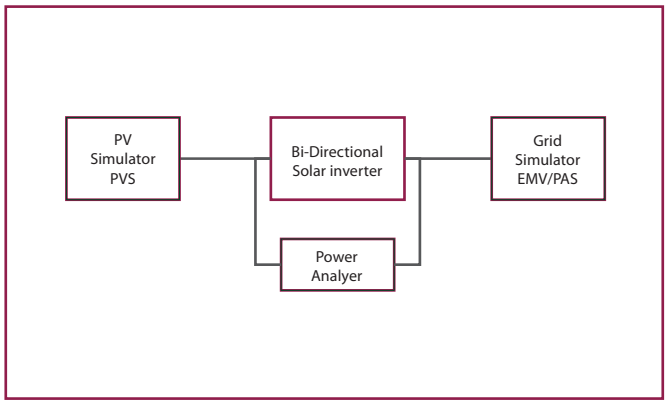

Fig.3 Inverter test system (discharging test)

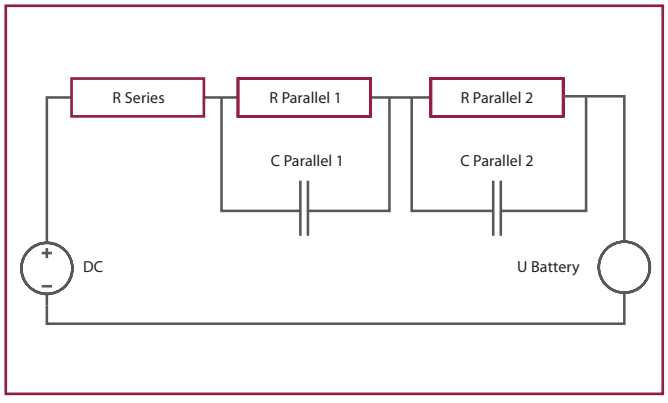

Fig.2 Battery model according to Rincon-Mora

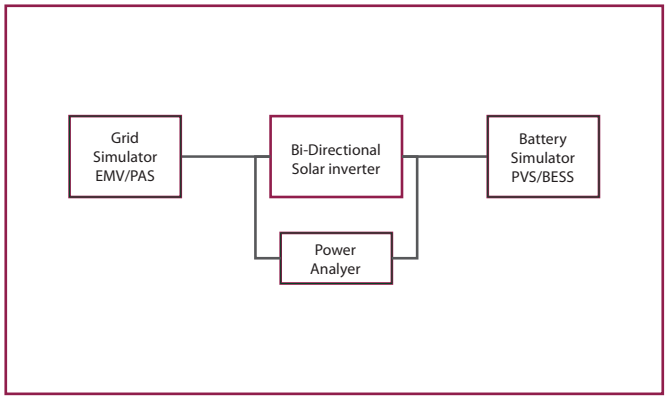

Fig.4 Inverter test system (charging test) diagram