NA4.2 – Overview of methods for HW Simulation for PVs

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Use of Hardware PV simulators

- Efficiency measurement of PV inverters
- Measurements of harmonics injection to the AC grid
- Measurements of the DC current injection to the AC grid
- Evaluation of the anti-islanding performance
- Evaluation of the protection performance
- Evaluation of the MPPT performance

Test requirements for grid-connected PV inverters-why PV simulators

- Testing usually under steady-state conditions
- Variation of solar irradiance and ambient temperature
- Specific tests that require dynamic variations of irrariance on the PVs
- Massive measurement data
- Limited availability of time
- Different characteristics for different inverters

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Use of real PV modules

- Exact representation of the real system's behaviour
- The operating conditions are not controllable and usually unpredictable
- The PV array may not meet the nominal current/voltage requirements for the test
- A large surface must be available for their installation
- The testing process is feasible only when conditions allow it (e.g. during the day)
- It is almost impossible to run several experiments in short time

Use of HW PV simulators

Power converters that operate as PV panels producing an I-V curve similar to PVs

Benefits:

- Controllable test conditions with regard to irradiance and temperature
- Flexibility in the use of the PV models. Use of different types of modules.
- Ability to rapidly vary solar irradiance
- Coverage of a wide voltage/current range

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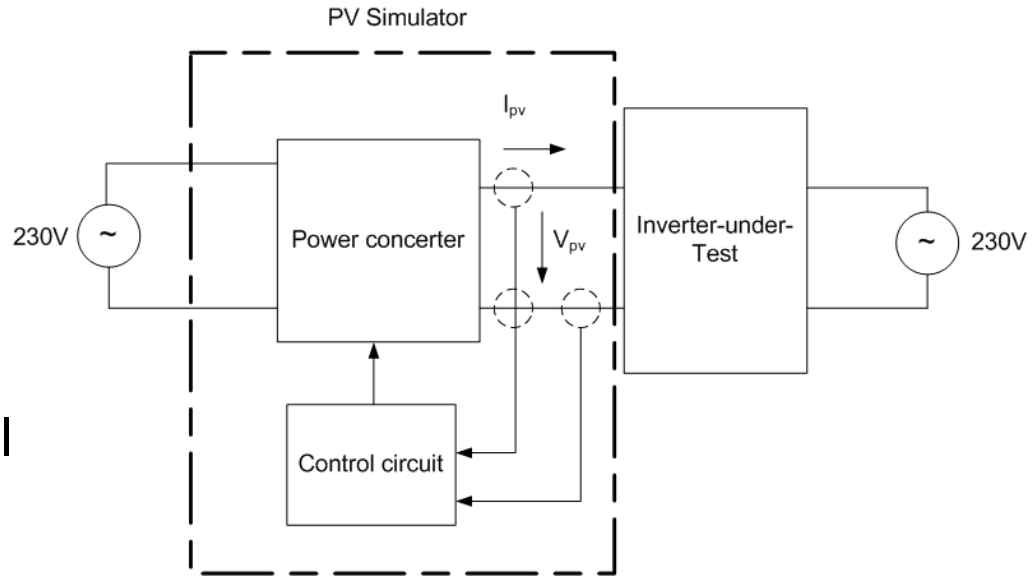
Basic structure of a PV simulator

- AC power supply
- Power converter stage
- Control stage
- Voltage and/or current control in order to behave as a PV



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PV simulators classification

Power:

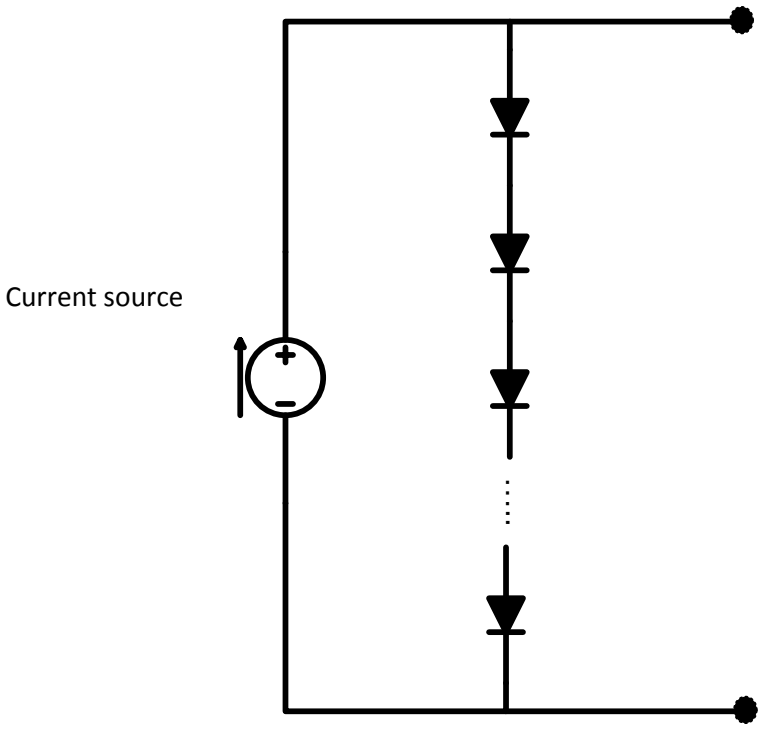
- Small simulators (up to some tenths of Watt)
- Large simulators (up to 100kW)

Topology:

- Simulators based on the diode characteristic (small power levels)
- Simulators based on linear electronic regulators (e.g. bi-polar transistors)
- Simulators based on Switch-Mode Power Supplies

Diode-base simulators

- Use of a combination of diodes in order to approximate the I-V characteristic
- Advantage: Good approximation of the operation under dynamic conditions
- Disadvantages:
  - Increased power losses
  - Inflexible I-V curves
  - Sensitivity to temperature variations



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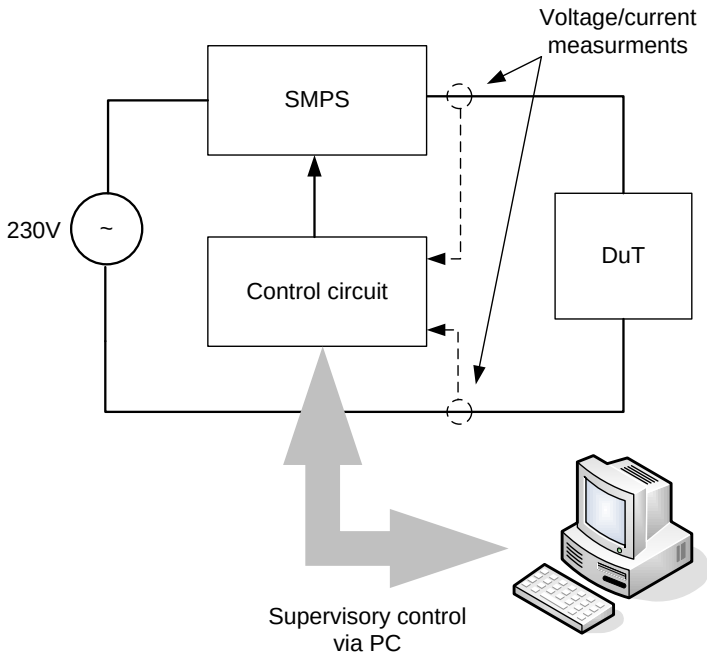
Switch-mode simulators

- Use of a switch-mode converter
- AC power supply
- Advantages:
  - Low losses
  - Flexibility in the operating behaviour

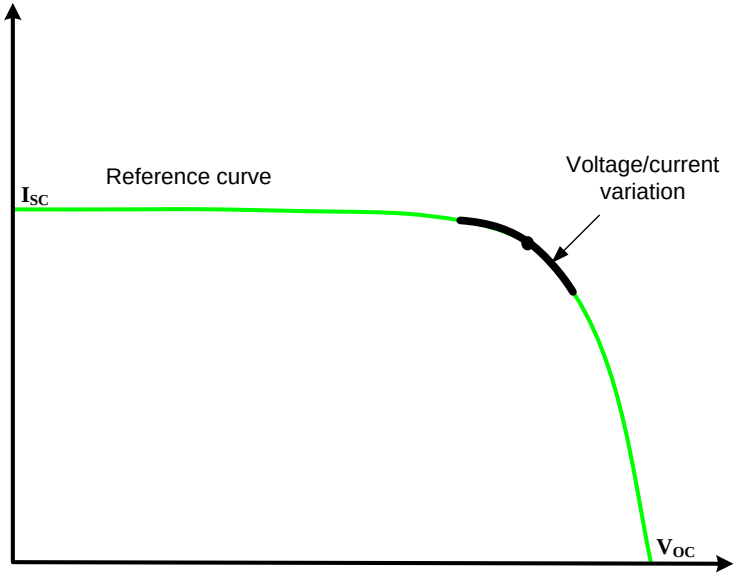
Disadvantages:

  - Usually poor dynamic response
  - Potential Electromagnetic Interference (EMI) problems

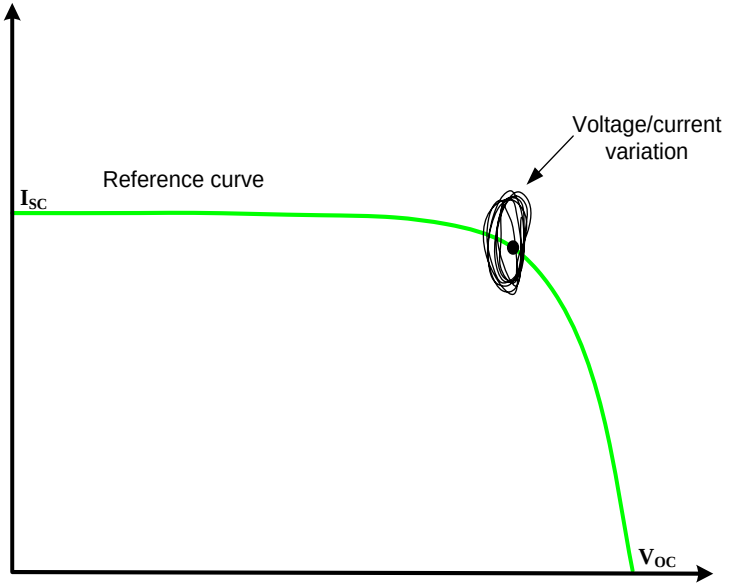


Dynamic response of SMPS simulators

Ideal response to MPPT



Actual response to MPPT-Oscillation



Switch-mode simulators (cont'd)

Improvements:

- Use of a small output capacitor
  - However, too small a capacitor can lead to voltage ripples at the DC side
- Use of a parallel discharging circuit for the rapid voltage reduction
  - The power of the parallel circuit should be carefully selected
- Use of proper voltage/current control
  - Fast acting control is necessary

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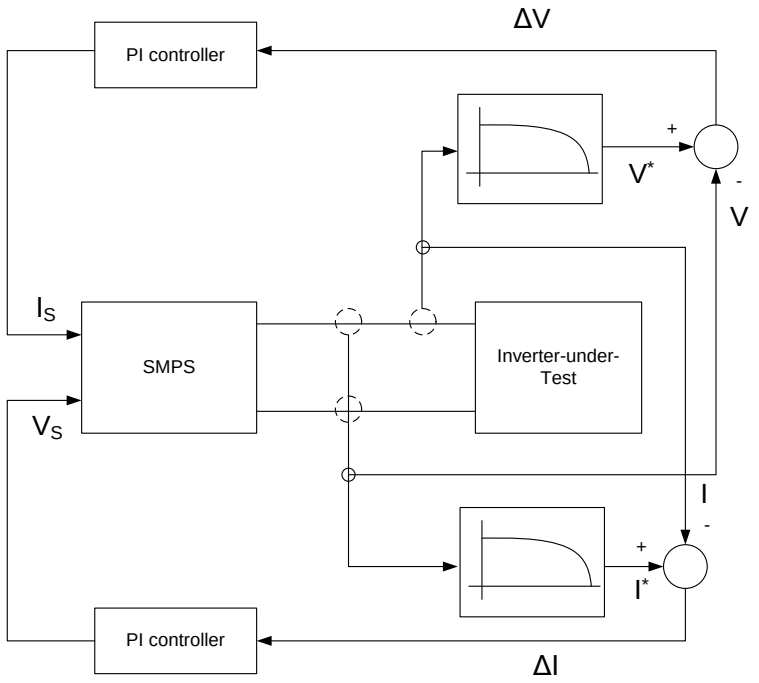
Switch-mode simulators (cont'd)

- Block diagram of a PV simulator that uses two controllers for voltage and current
- Voltage and current measurement and calculation of reference values
- Implementation by means of a DSP



Linear-mode simulators

•They combine an array of transistors in linear mode

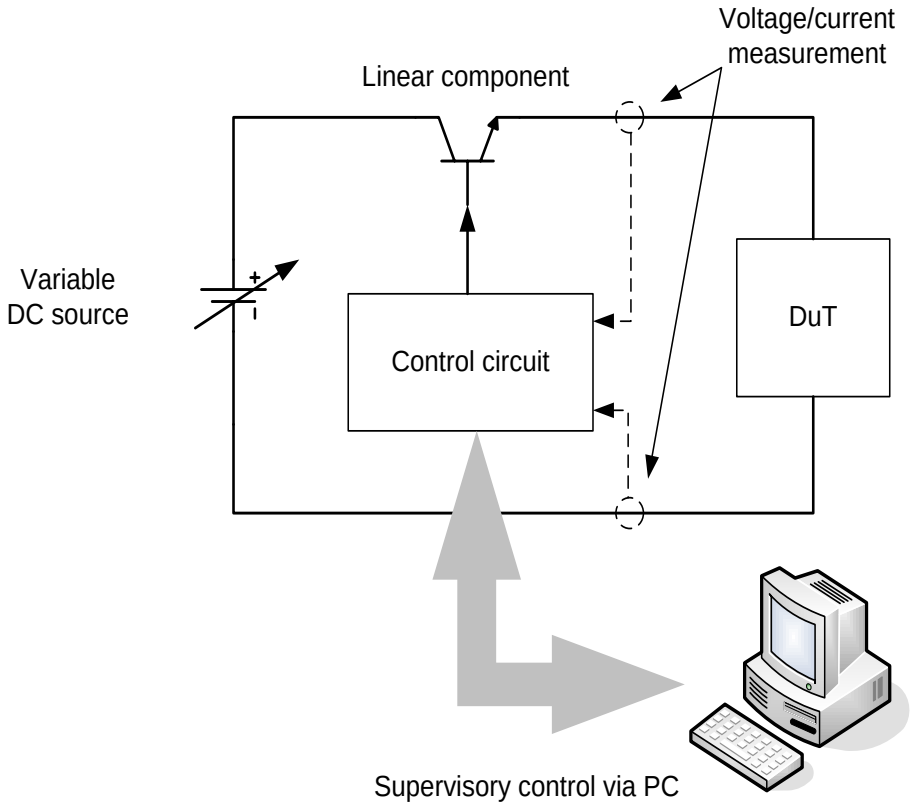
• DC power supply (e.g. from a rectifier)

Advantages:

- Flexible operating characteristics
- Improved dynamic response

Disadvantages:

- Increased losses



Control of the simulator

- Analog circuits
  - Reproduction of reference I-V:
    - With the use of a diode
    - With the use of a reference cell
  - 👌 Fast response
  - 👎 Noise sensitivity
  - 👎 Limited flexibility

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Control of the simulator

- Digital circuits(DSP or microcontroller)
  - Reproduction of the reference I-V:
    - Mathematical calculation of the PV model
    - Use of look-up tables
  - 👎 Slower response depending on the code's size
  - 👌 Noise immunity
  - 👌 Flexibility in terms of parameters variability
  - 👌 Complex control techniques are feasible
  - 👌 Communication with PC and other devices

References

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