Asia-Pacific Economic Cooperation

Rooftop Solar PV System Designers and Installers

Training Curriculum

APEC Secretariat

March 2015


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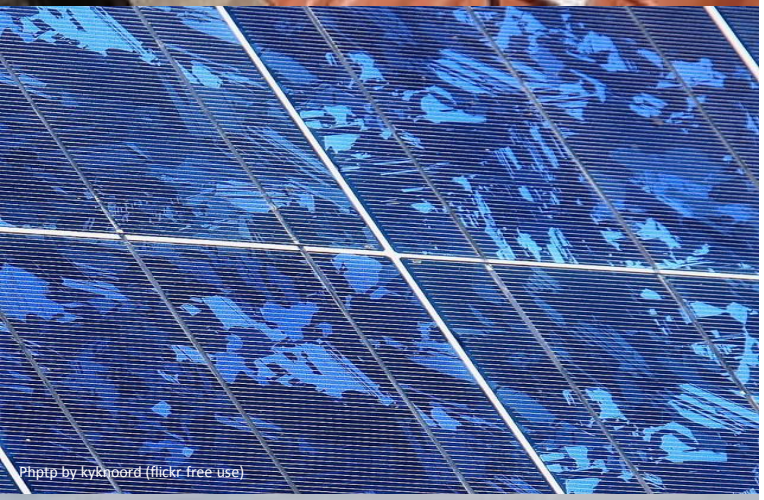
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INVERTER - GRID

Training of PV Designer and Installer

APEC
Asia-Pacific
Economic Cooperation

Cu International Copper Association
Copper Alliance

castlerock consulting

Contents

A. How PV generate electricity?

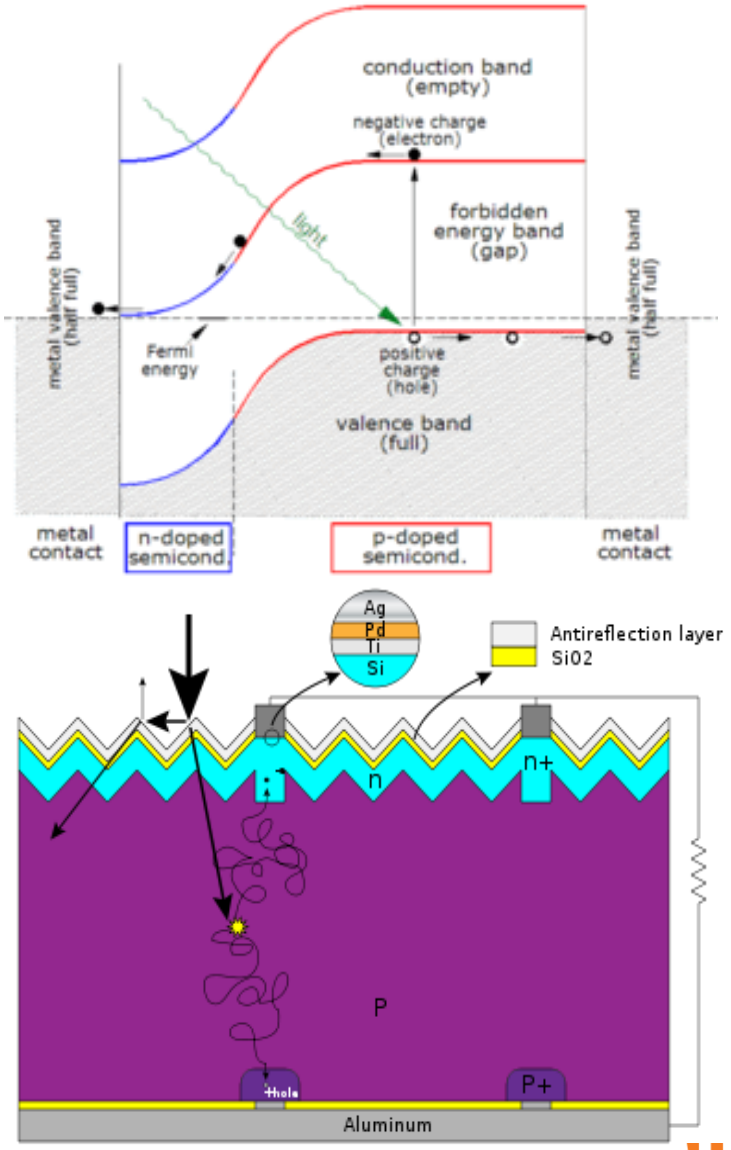
B. Solar cell characteristics

C. Inverter – grid structure

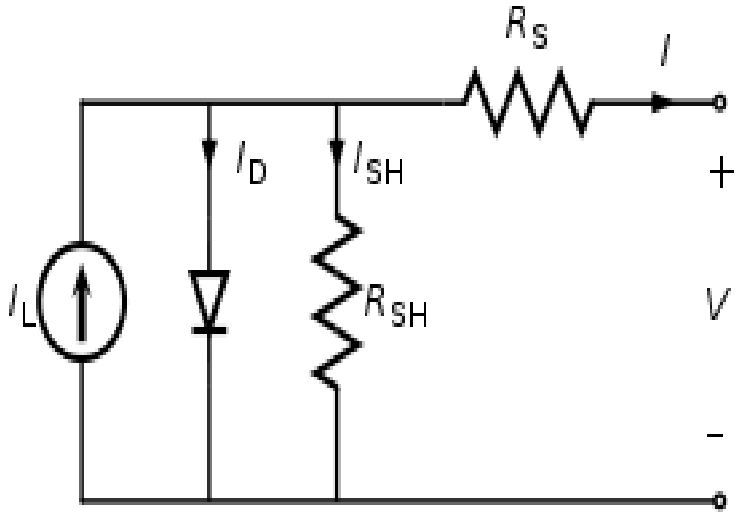
Questions

A. How PV generate electricity

- Photons in sunlight hit the solar panel and are absorbed by semiconductor material – silicon.
- Electrons (negatively charged) are knocked loose from their atoms, allowing them to flow through the material to produce electricity. Due to special composition of solar cell, the electrons are only allowed to move in a single direction.
- An array of the solar cells converts solar energy into a usable amount of direct current (DC) electricity.

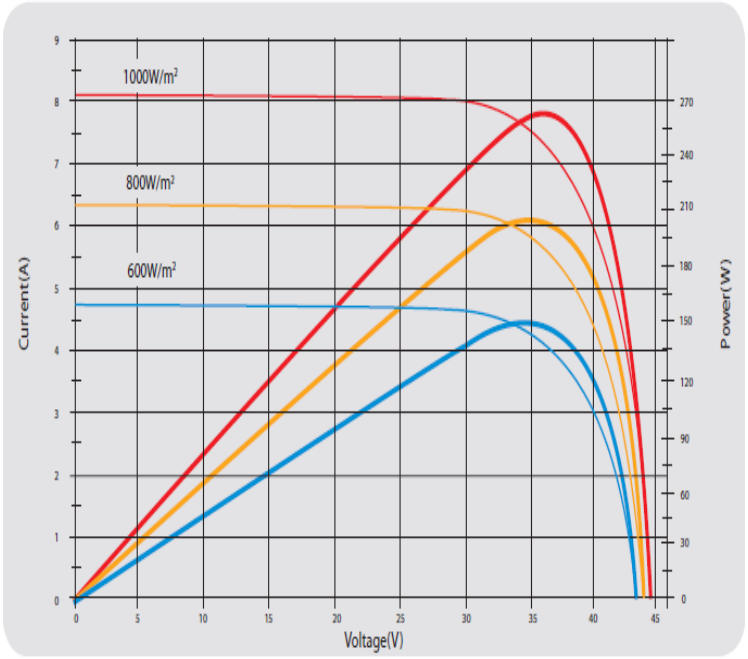


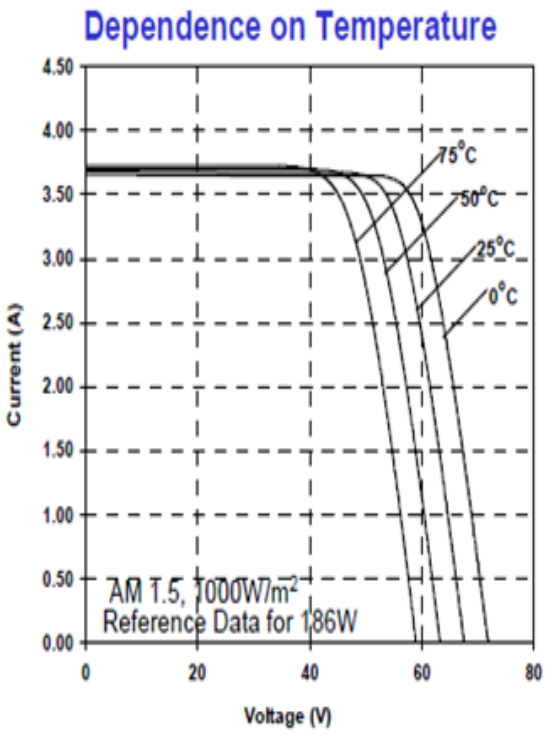
B. Solar cell characteristics

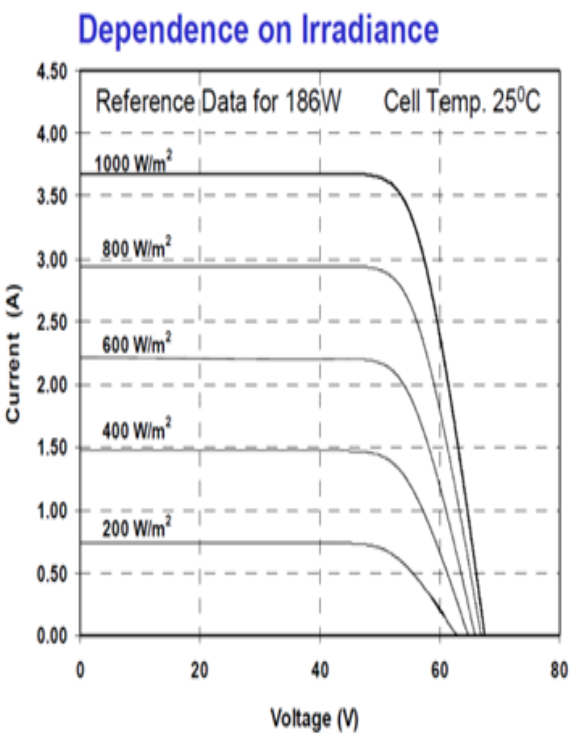


- PV can be modeled by a current source in parallel with a diode, shunt and series resistances
- ILoad represents the max current of the solar panel (short current)
- Diode forms the I-V characteristic
- Shunt resistor (R_{SH}) represents the leakage currents (very small)
- Series resistance (RS) represents the wiring losses

B. Solar cell characteristics: example

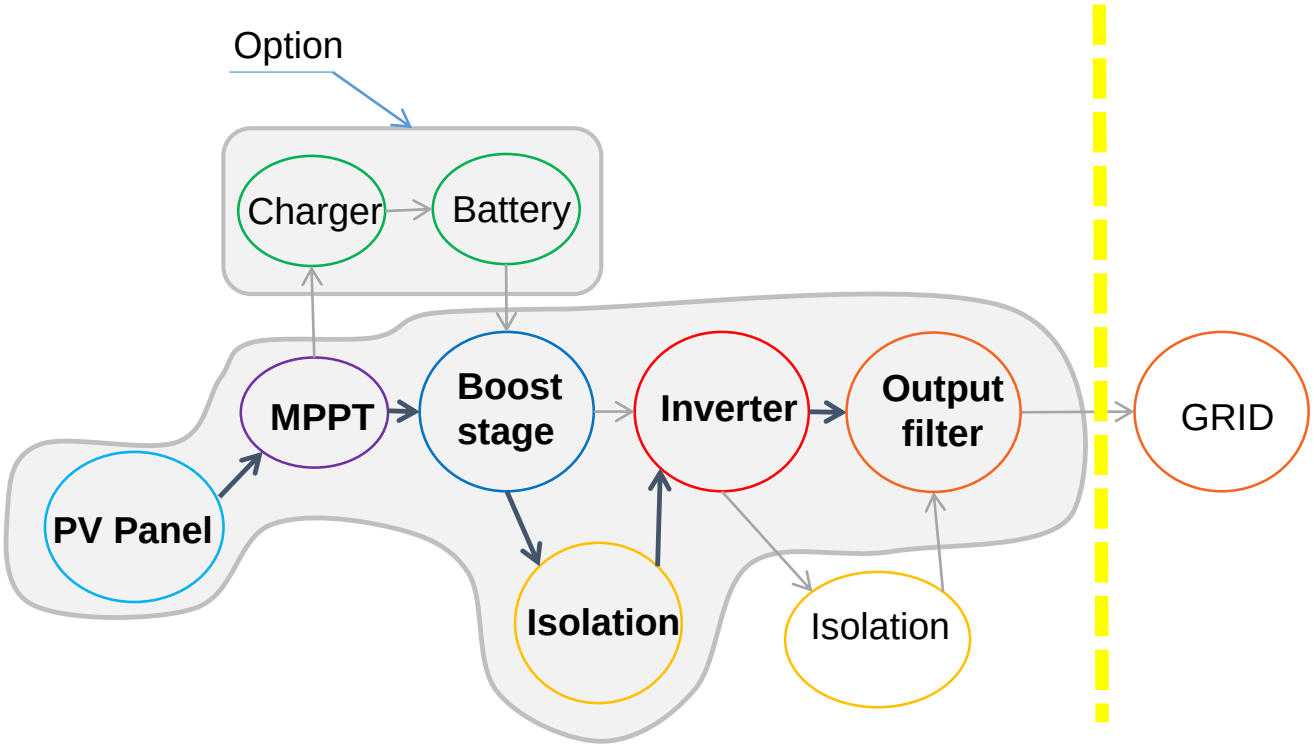






I-V curve varies with real working conditions – high dependency on the irradiance and lower dependency on the temperature. This mean an inverter-grid should have MPPT technology to get maximum power during real conditions.

C. Inverter – grid structure



Questions:

- What is a solar inverter?
- What are the types of solar inverters?
- What are grid-tied solar inverters?
- Where are grid-tied solar inverters used?

Grid Tie PV System

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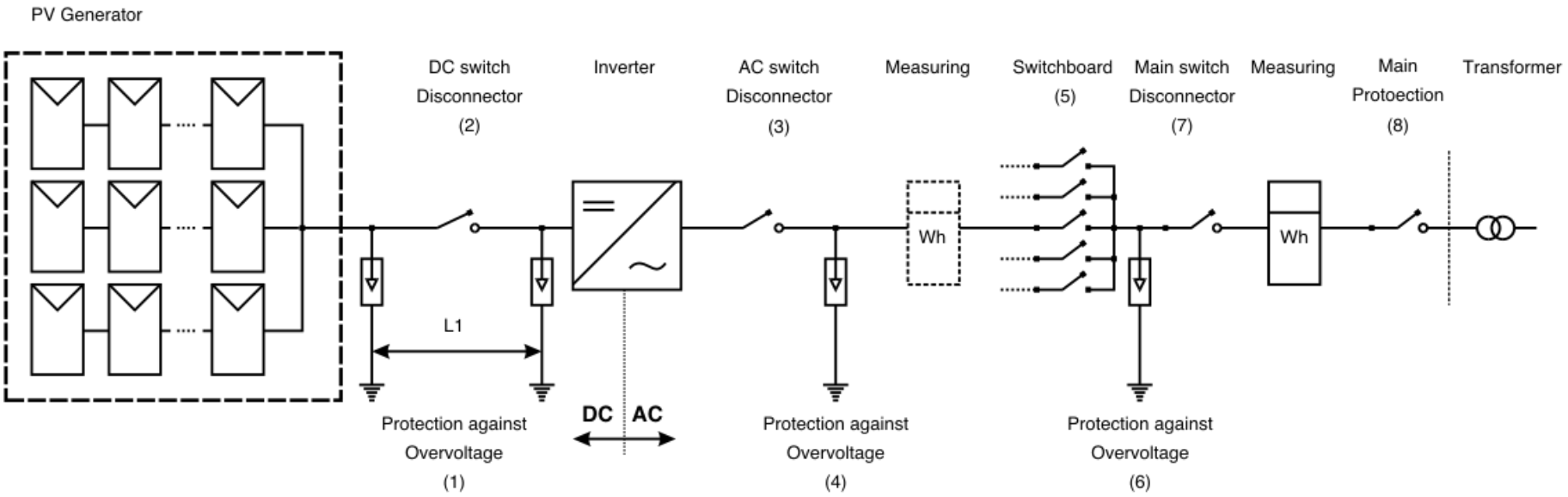
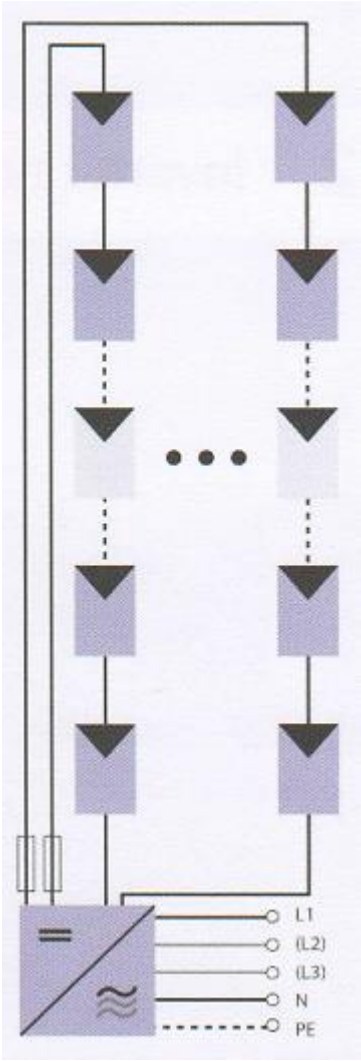
Grid Tie Without Battery Backup



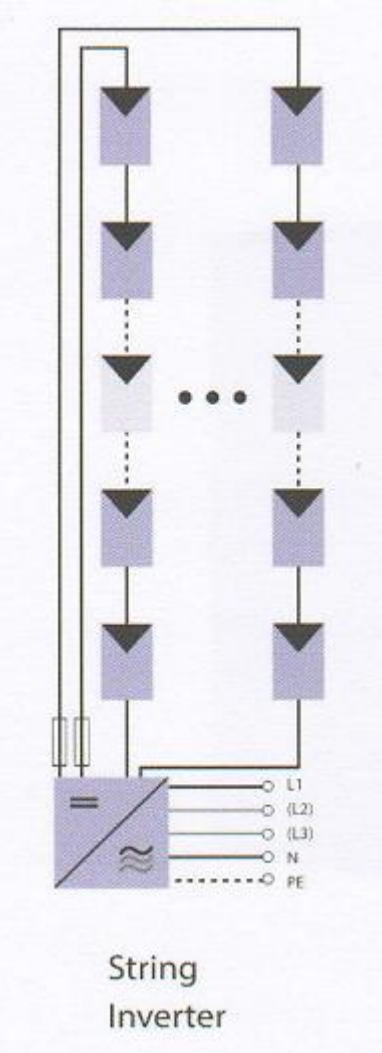
String inverter

- Each inverter works at its individual maximum power point , one MPPT for one string or multiple strings
- Different conditions (e.g. irradiation, orientation, temperature, shading) are acceptable
- High voltage and less current



String inverter

- No generator connection box
- Short cable lengths
- Simple generator design
- Similar MPPT current for all required modules → put similar modules into one string

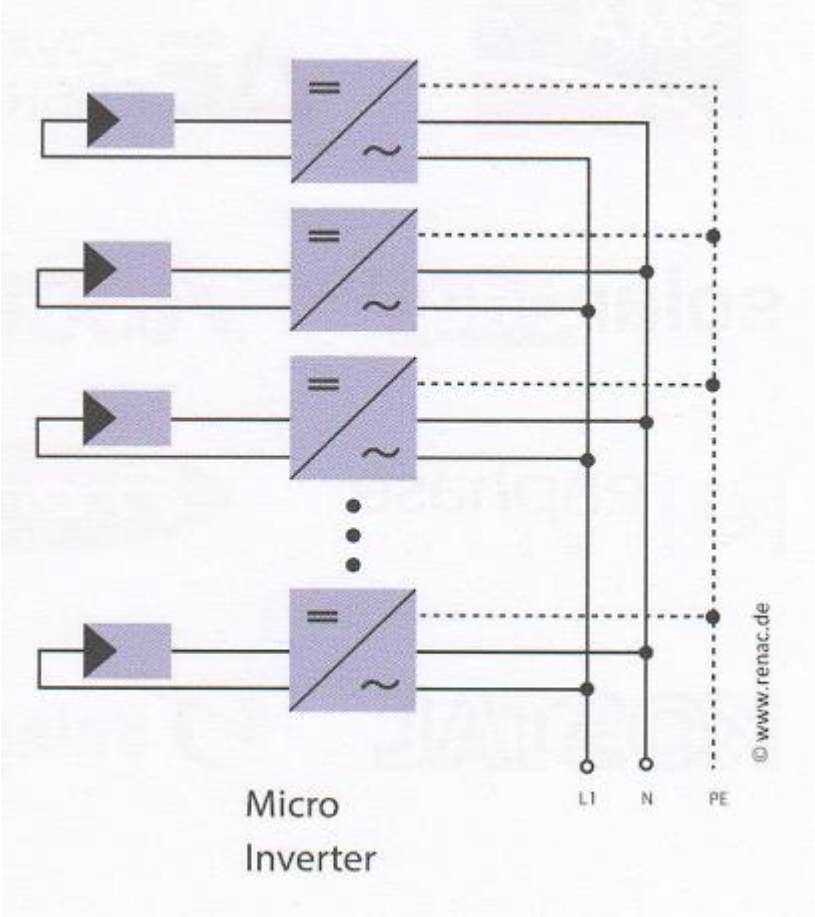


String inverter

Source: Berlin water treatment plant

Micro ("module") inverter

- No DC cabling
- Monitoring on module level is possible
- Shade on a module or faulty inverter does not affect the other strings, individual MPPT-tracking possible
- Fits for modules with high power tolerances
- Safety extra-low voltage possible



Micro ("module") inverter

http://i01.i.aliimg.com/img/pb/026/793/069/1069793026_749.jpg

Micro (“module”) inverter

http://pvshop.eu/userdata/gfx/81e6faa756f321b60b98feedf00b6ba2.jpg

Inverter Types

Typical values	Micro Inverter	String Inverter
DC-Input power	200…300 Wp	1…100 kWp
DC-Voltage range	≤ 50 V	≤ 1000 V
DC-Current range	≤ 10 Amps	≤ 100 Amps
Efficiency	≤ 97%	≤ 98%
MPPTs	1	1…5
Phases	1	1 or 3
Voltage level	Lov voltage grid	Low voltage grid

Inverter Manufacturers

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SMA

ADVANCED ENERGY

KACO new energy.

solaredge

steca

power-one® A MEMBER OF THE ABB GROUP

[e] enphase ENERGY

Fronius

SUNGROW

KOSTAL

SolarMax

sunways Photovoltaic Technology

Relevant Specifications

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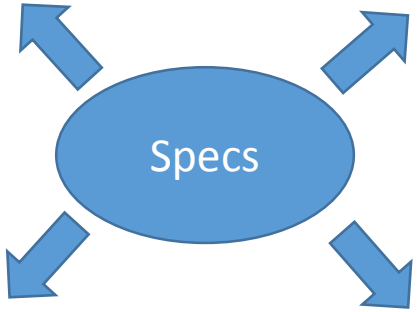
Monitoring and communications

- Available communication interfaces?
- Monitoring system integrated?
- Sampling rate and storage time of data recorded
- Data logging features
- Fault signaling



Electromagnetic compatibility (EMC)

- CE certification is a must!
- Adhere to manufacture's recommendations on earthing and wiring

Overload protection

- Operation above rated power stresses electronic components should be avoided through adequate system design.
- Above the critical operating temperature, the inverter shall derate its power automatically

Reverse polarity protection

- Inverters usually do NOT have reverse DC polarity protection
- Connecting wires with reverse polarity can lead inverter destruction and void guarantee

Inverter efficiency

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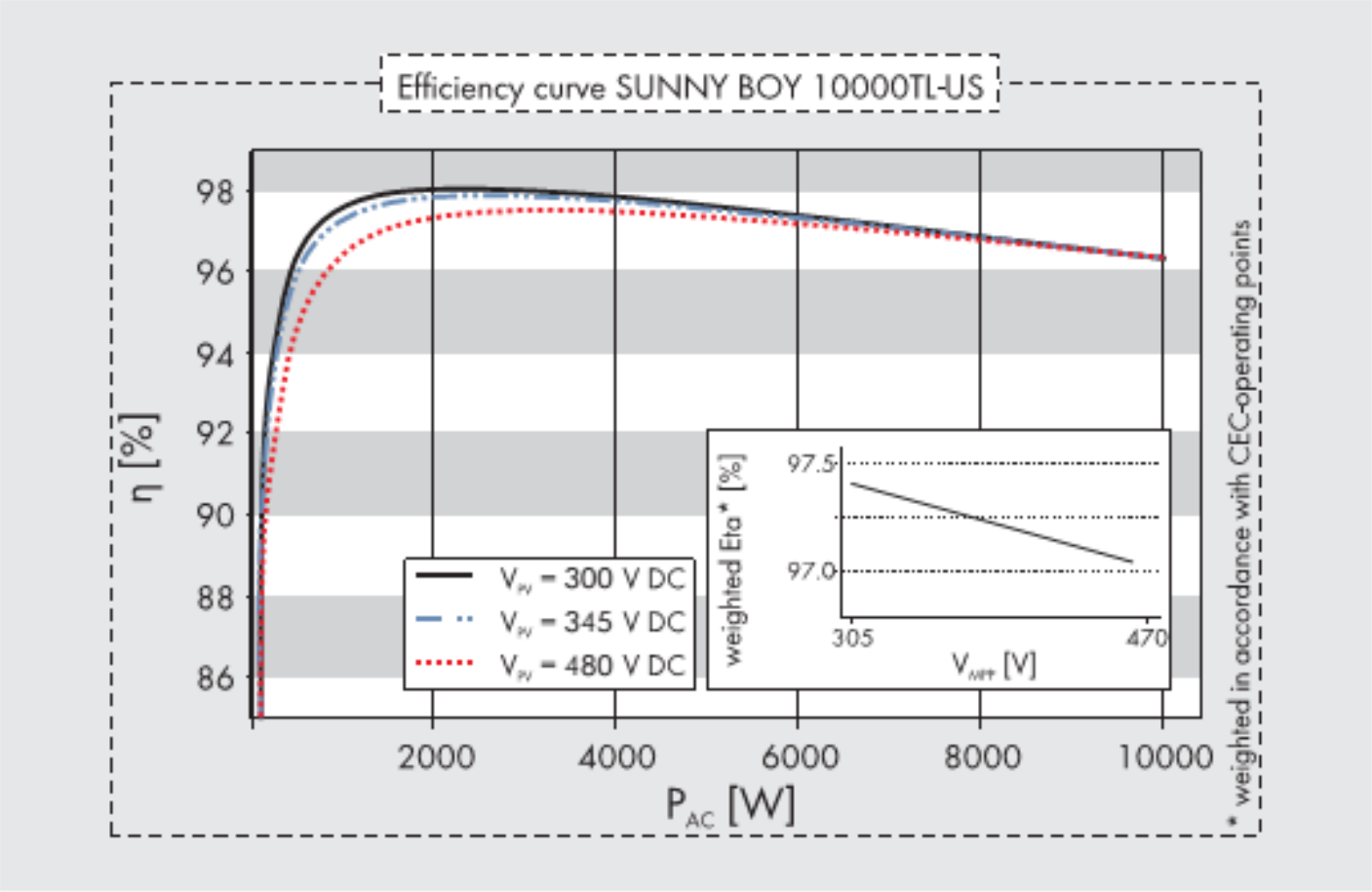
Sample efficiency curve for a grid-connected inverter



www.SMA-America.com

Peak efficiency

- Peak efficiency represent the highest efficiency that the inverter can achieve
- Most of grid-tie inverter have peak efficiencies of over 94%
- The energy lost during inversion is for the most part converted into heat
- This means that in order for an inverter to put out the rated amount of power it will need to have a power input that exceeds the output.
- a 5000 W inverter operating at full power at 95% efficiency will require an input of 5,263 W (rated power divided by efficiency).

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