Inverter Compatibility with Ultra High-Power Modules
A Technical Overview

Presented by Omar al-Darwish, Applications Engineer SMA MEA

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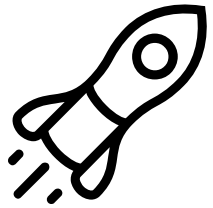
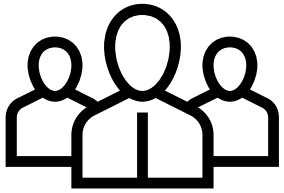
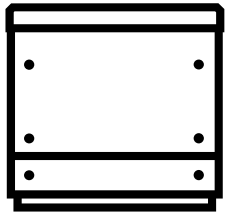
Key Figures



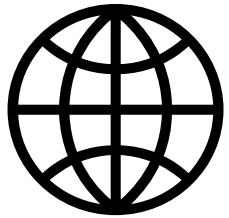
35+
Years



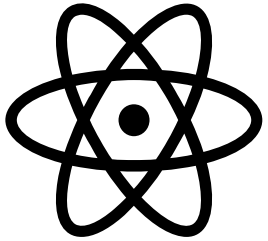
3,000
Employees



95+
GW



190
countries



1,200
Patents

Key Financials

	Sales	EBITDA	Inverter Capacity
2019 (Actual)	€915 million	€34 million	11.4 GW
2020 (Guidance)	€1.0 – 1.1 billion	€50 – 80 million	7.1GW (H1 2020)

SMA Solar Technologies AG
Product Portfolio

HOME

USE CASES	Generate solar power	Store solar power	Manage energy	Refuel with solar power	Be your own grid
HARDWARE	TS4-R MODULTECHNIK SUNNY BOY 1.5/2.0/2.5 SUNNY BOY 3.0/3.6/4.0/5.0/6.0 SUNNY TRIPOWER 3.0/4.0/5.0/6.0 SUNNY TRIPOWER 8.0/10.0	SUNNY BOY STORAGE 2.5 SUNNY BOY STORAGE 3.7/5.0/6.0 SUNNY ISLAND 4.4M/6.0H/8.0H	SUNNY HOME MANAGER 2.0 ENERGY METER	SMA EV CHARGER	SUNNY ISLAND 4.4M/6.0H/8.0H

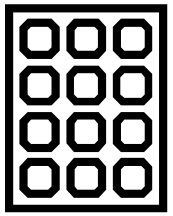
BUSINESS

USE CASES	Generate solar power	Store solar power	Manage energy	Be your own grid
HARDWARE	SUNNY TRIPOWER 15/20/25000TL (15/20/25kW) SUNNY TRIPOWER CORE1 (50kW)	SUNNY TRIPOWER STORAGE 60 SMA STORAGE BUSINESS (76kWh)	SMA DATA MANAGER M ENERGY METER	SUNNY ISLAND 4.4M/6.0H/8.0H MULTICLUSTER 6/12/36
SOFTWARE	SUNNY DESIGN SUNNY PORTAL SMA 360° APP SMA ENERGY APP			
SERVICES	Smart Connected Commissioning Support Extended Warranty Operation & Maintenance Repowering Solar Academy Training SMA SPOT			

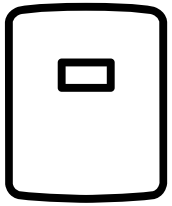
LARGE SCALE

USE CASES	Generate solar power	Store power	Manage energy
HARDWARE	SUNNY HIGHPOWER PEAK3 (100kW/1000V + 150kW/1500V) SUNNY CENTRAL (1850 – 4600 kW) MEDIUM VOLTAGE POWER STATION	SMA DC-DC CONVERTER SUNNY CENTRAL STORAGE STORAGE UP (2200 – 4600kW) MEDIUM VOLTAGE POWER STATION	SMA DATA MANAGER L HYBRID CONTROLLER POWER PLANT MANAGER

Inverter Compatibility with Ultra High-Power Modules
Topics for Today



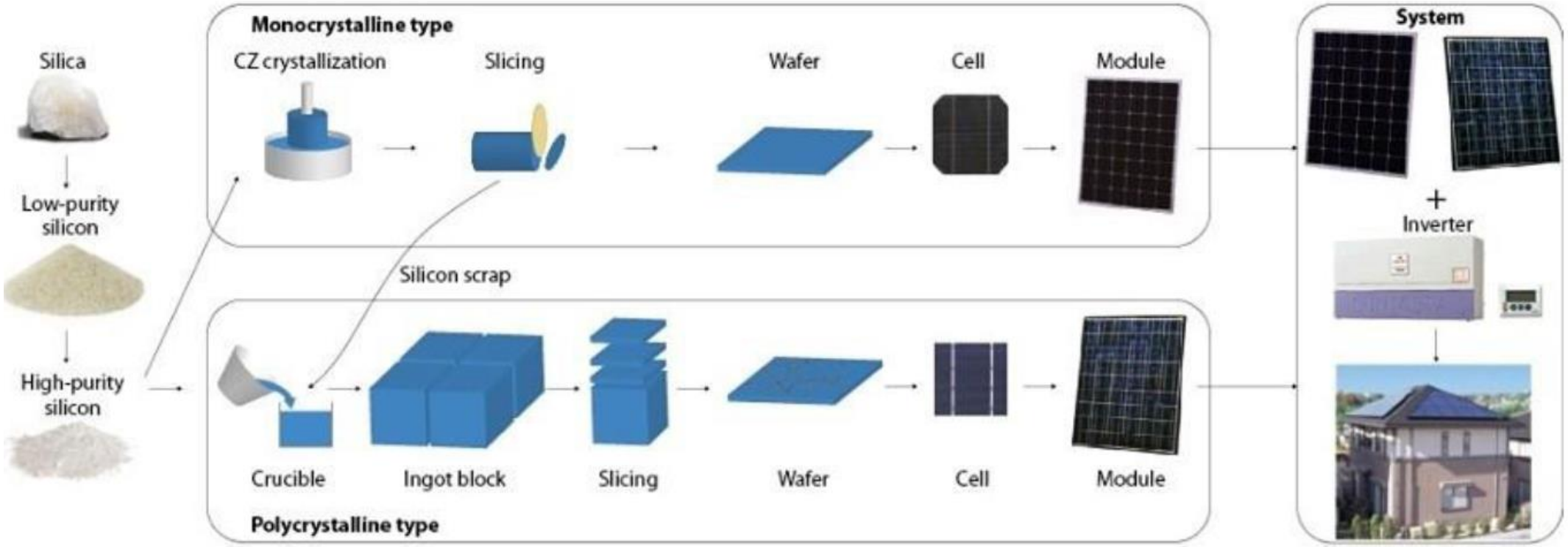
Fundamentals behind ultra high-power modules and their electrical characteristics (Mainly Isc / Imp)



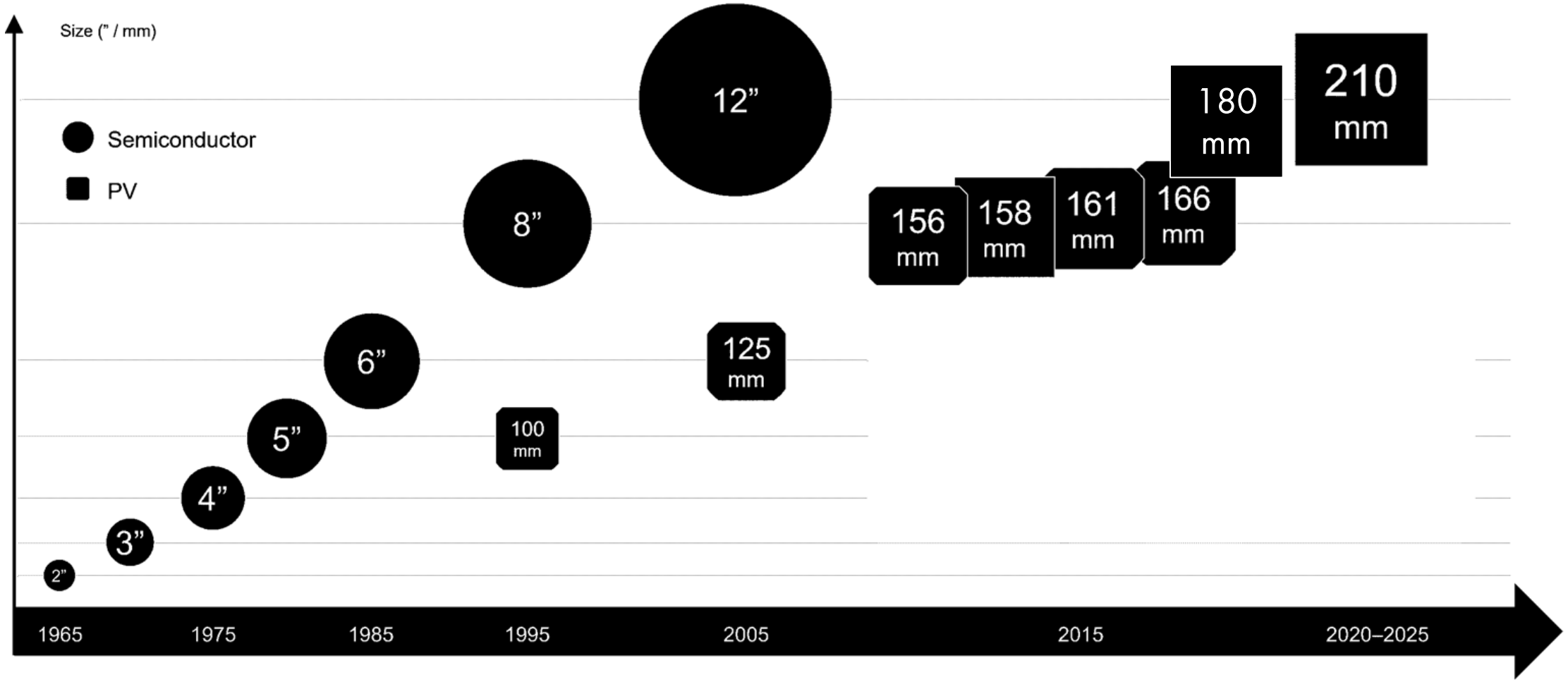
Implications of higher power modules on inverter/module interface

Compatibility of high current modules with SMA inverters

Solar Cell Basics
From Silicon to Wafers

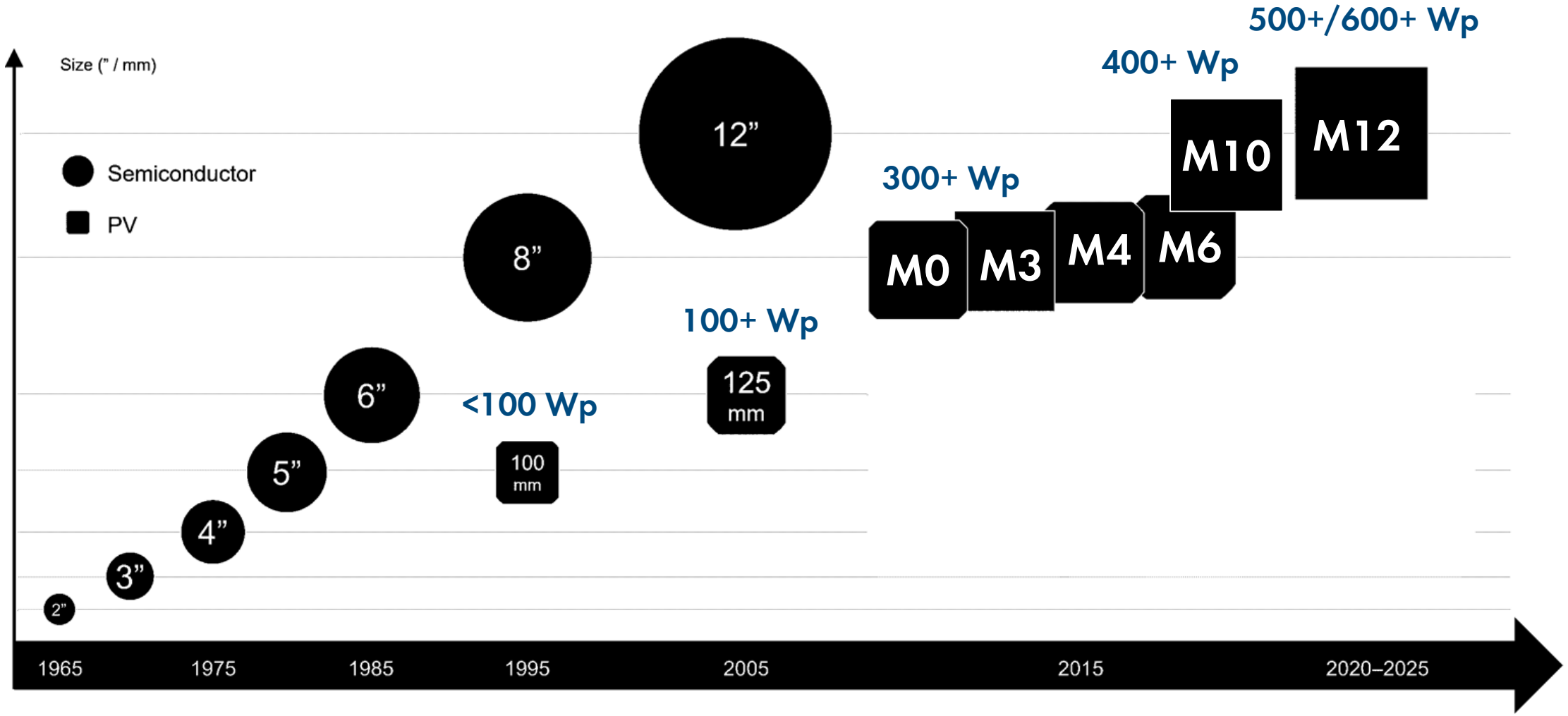


Solar Cell Basics
From M0 to M12 Wafers



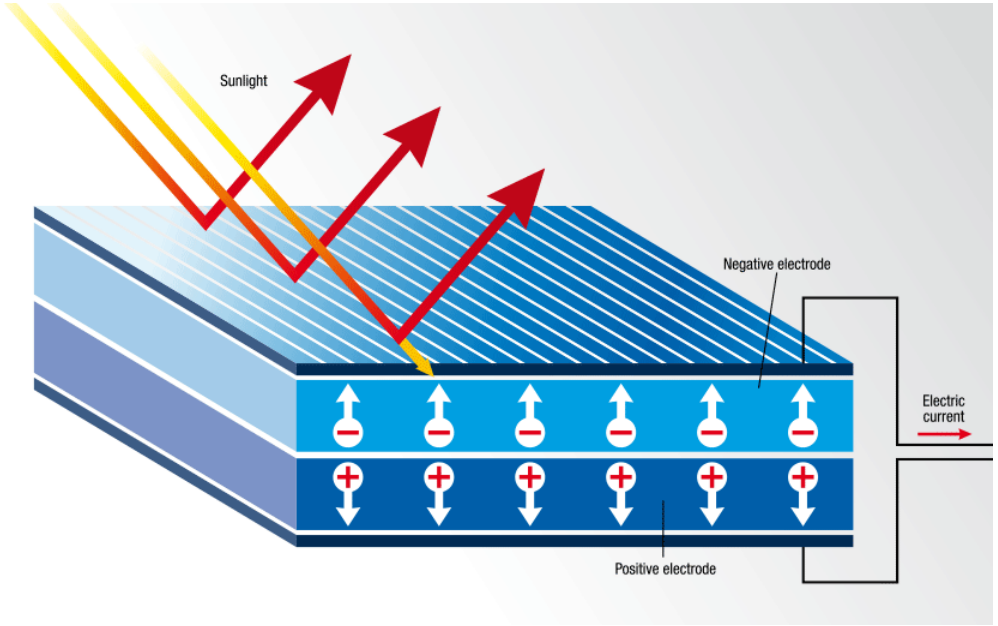
Source:

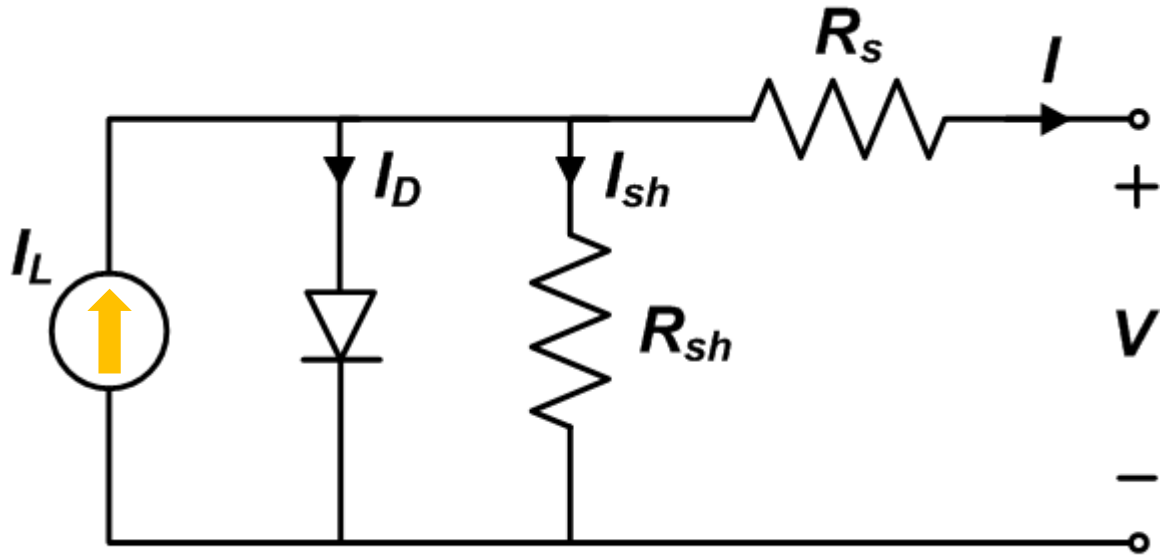
Solar Cell Basics
From M0 to M12 Wafers



Source: Trina Vertex Series Event, Dr. Feng.

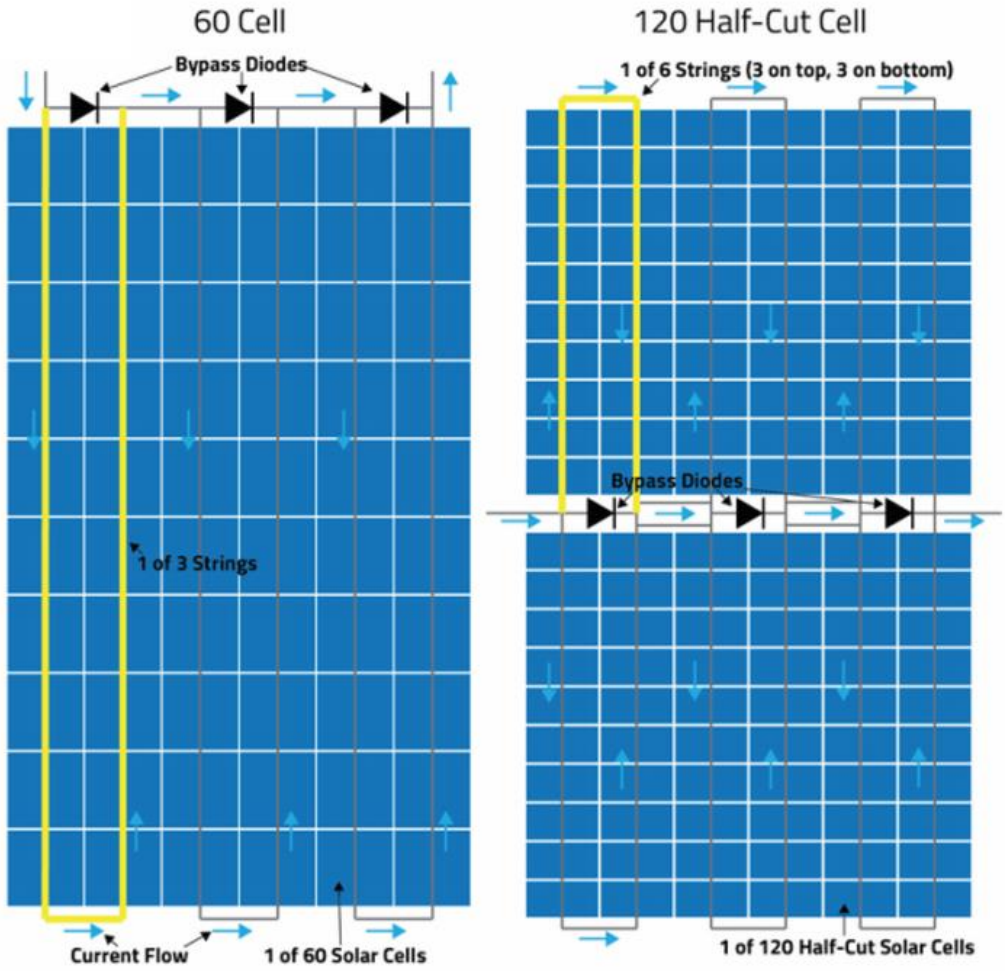
Solar Cell Basics
From M0 to M12 Wafers | implications of bigger cells?

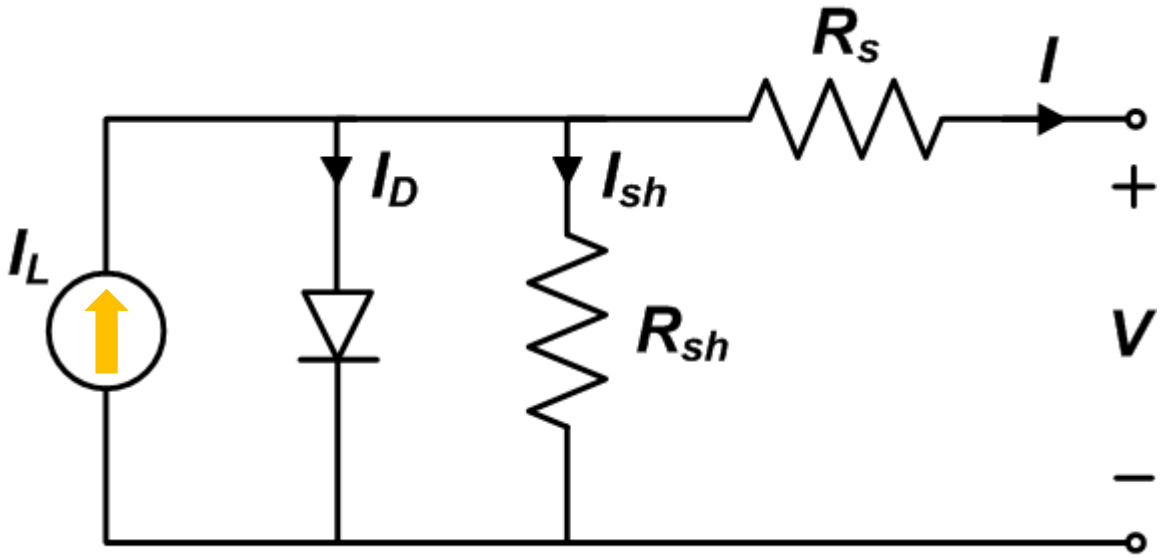




$$I \propto I_L \propto Irradiance \propto Cell\ Area$$
$$V \propto V_D \propto Temperature$$

Solar Cell Basics
From M0 to M12 Wafers | Module Level





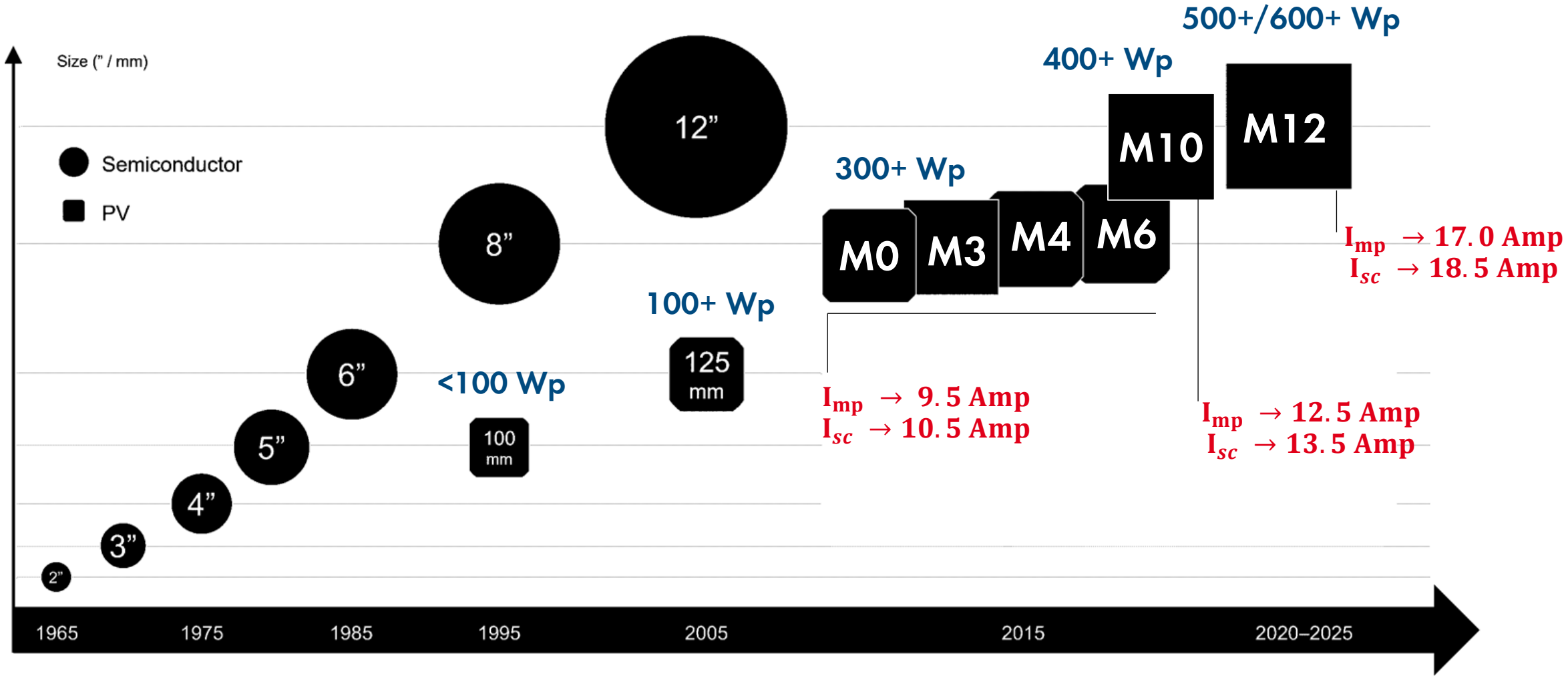
$$I \propto I_L \propto Irradiance \propto Cell\ Area$$

$$V \propto V_D \propto Temperature$$

Solar Cell Basics
From M0 to M12 Wafers | What about bifacial?

Source: LG Technolgoies, Bifacial Modules.

Solar Cell Basics
From M0 to M12 Wafers

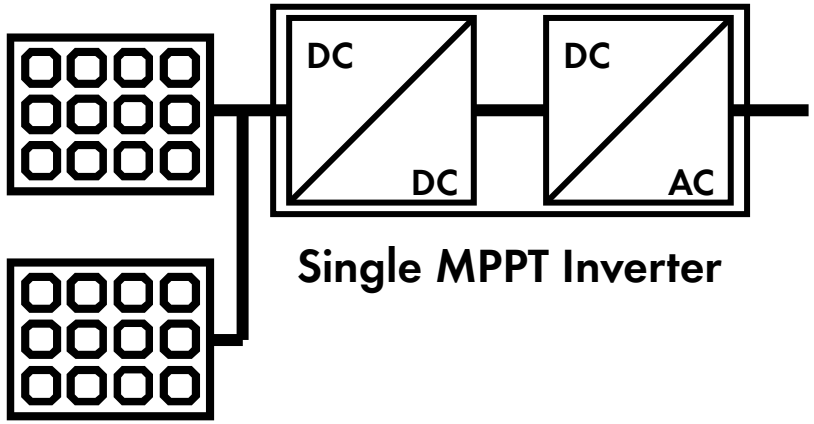


Source: Trina Vertex Series Event, Dr. Feng.

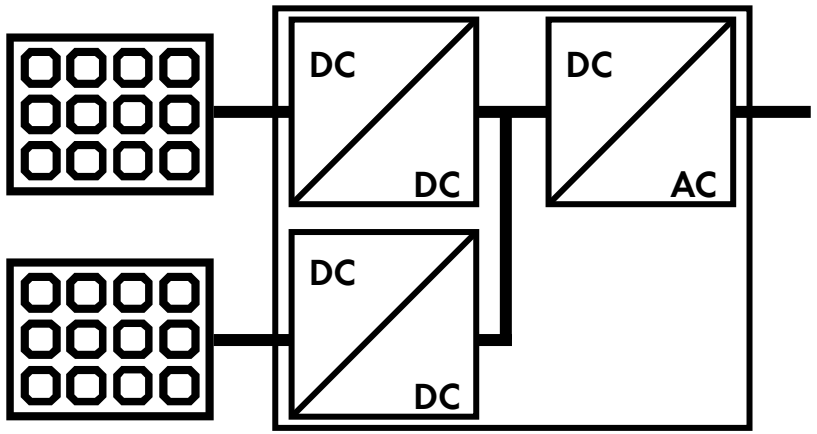
PV inverter Basics
How does cell size affect down-stream system components?

$I_{max\ power}$

$I_{short\ circuit}$



Single MPPT Inverter

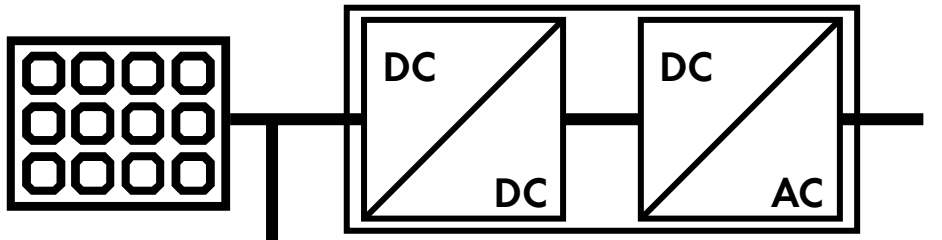


Mutli-MPPT Inverter

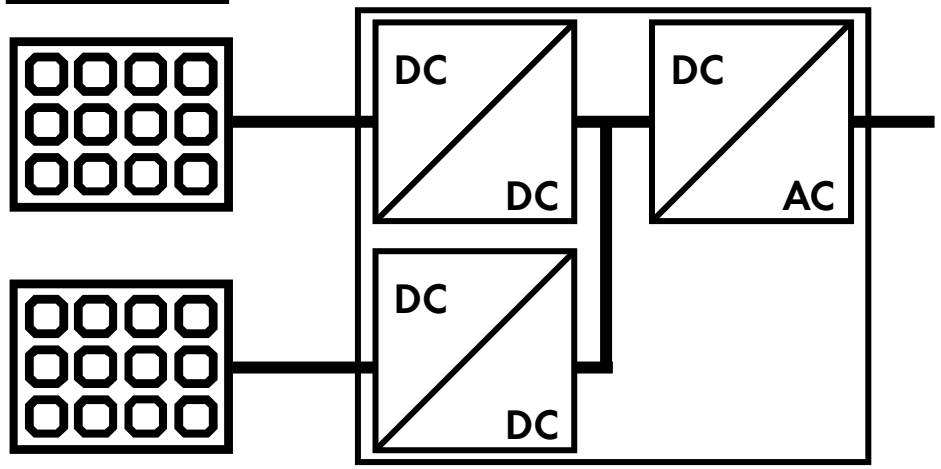
$I_{operating}$

$I_{short\ circuit\ DC}$

PV inverter Basics
Inverter DC Short Circuit Current 1

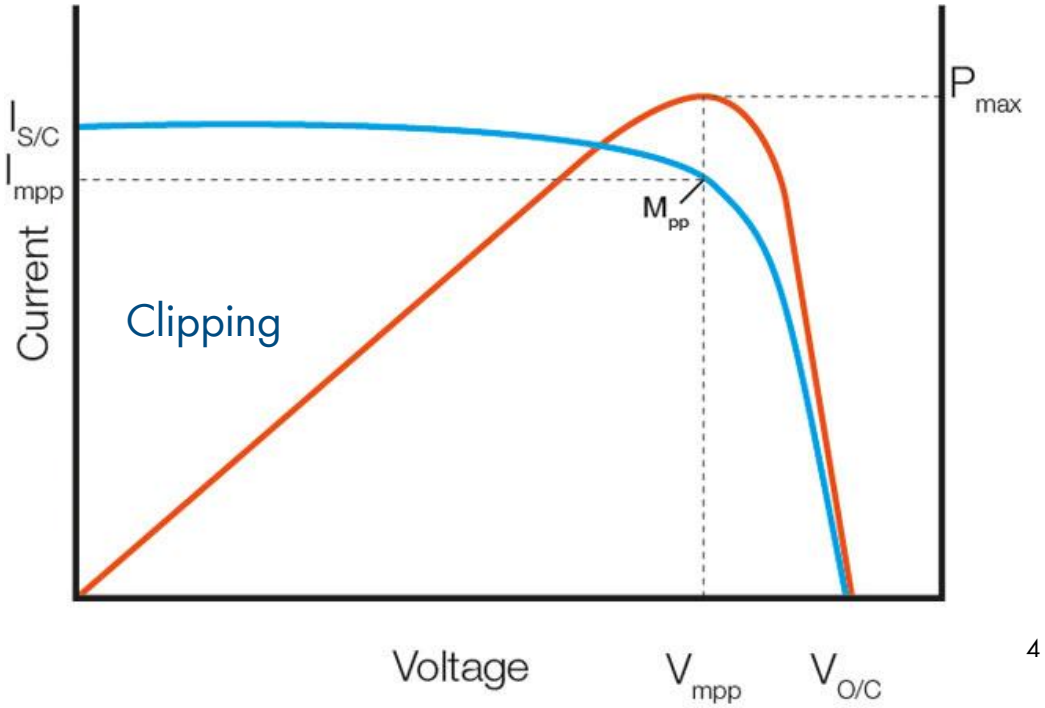


Single MPPT Inverter

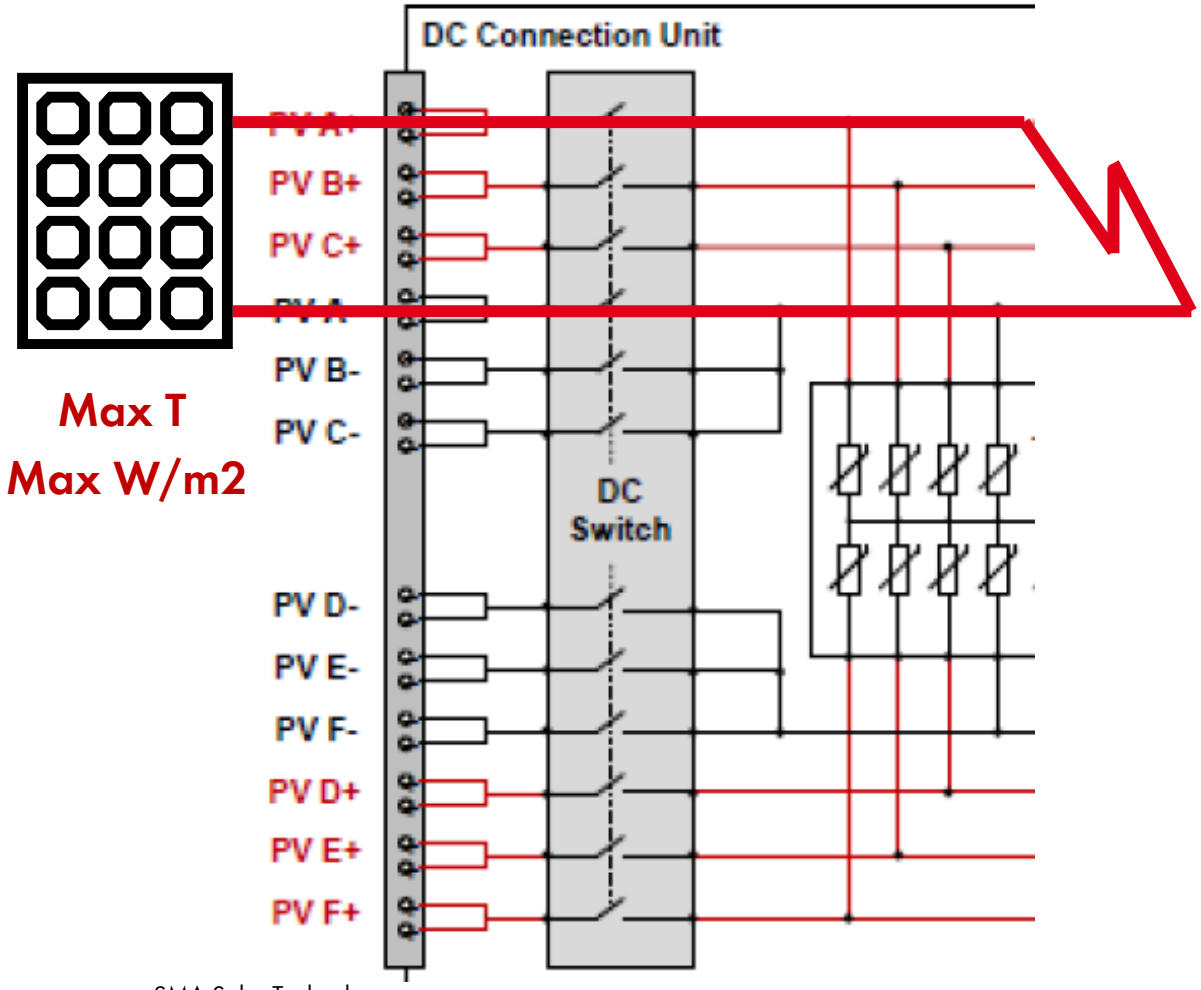


Mutli-MPPT Inverter

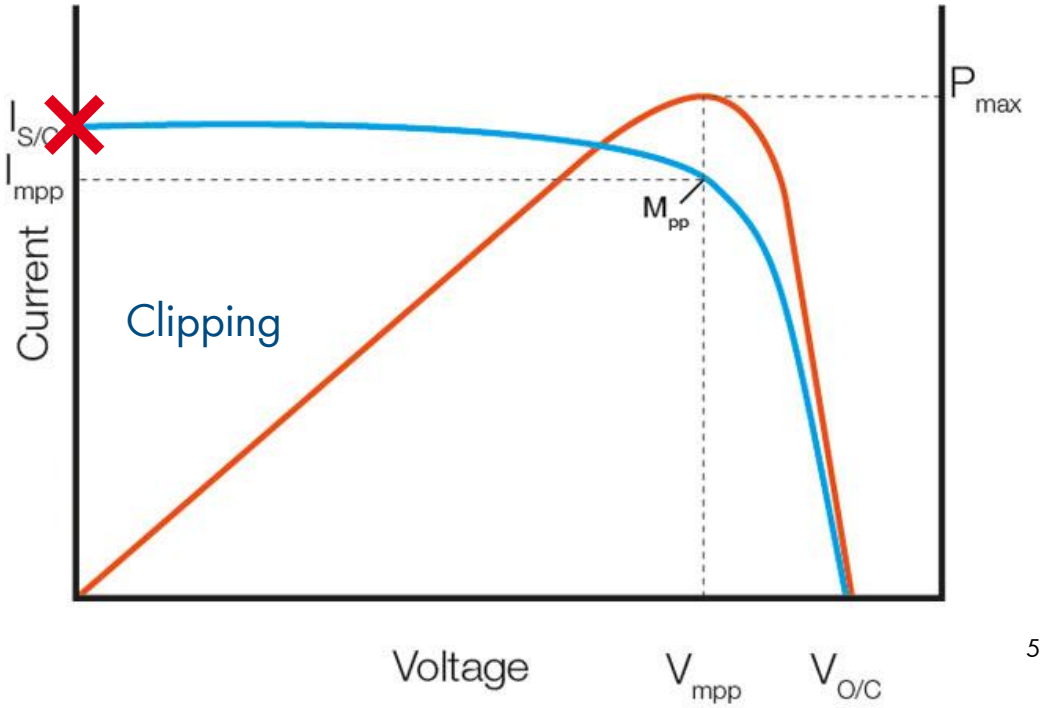
Sum of short circuit current of all strings connected to an MPPT <= short circuit current of MPPT **at worst case** temperature / irradiance combination



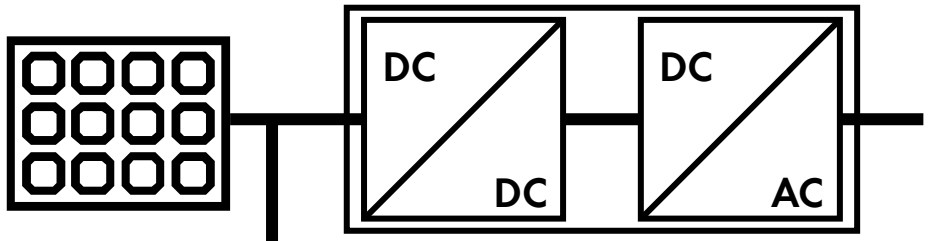
PV inverter Basics
Inverter DC Short Circuit Current 2



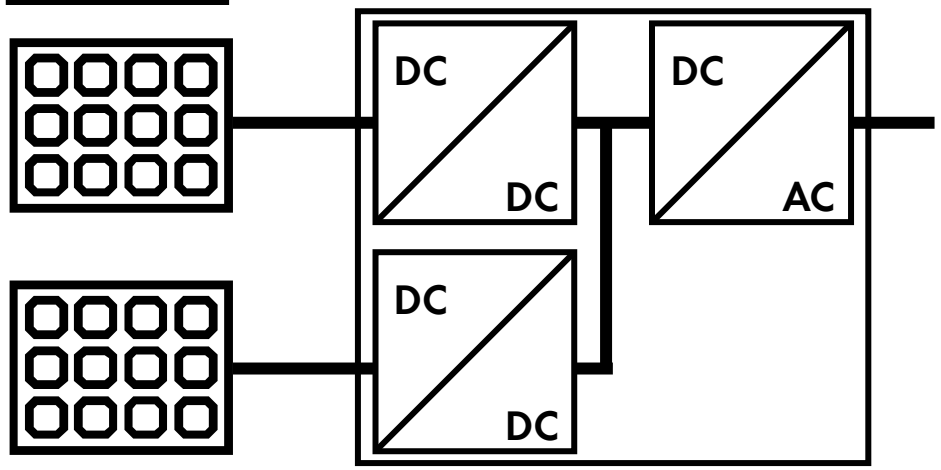
Sum of short circuit current of all strings connected to an MPPT <= short circuit current of MPPT **at worst case** temperature / irradiance combination



PV inverter Basics
Inverter Operating Current 1

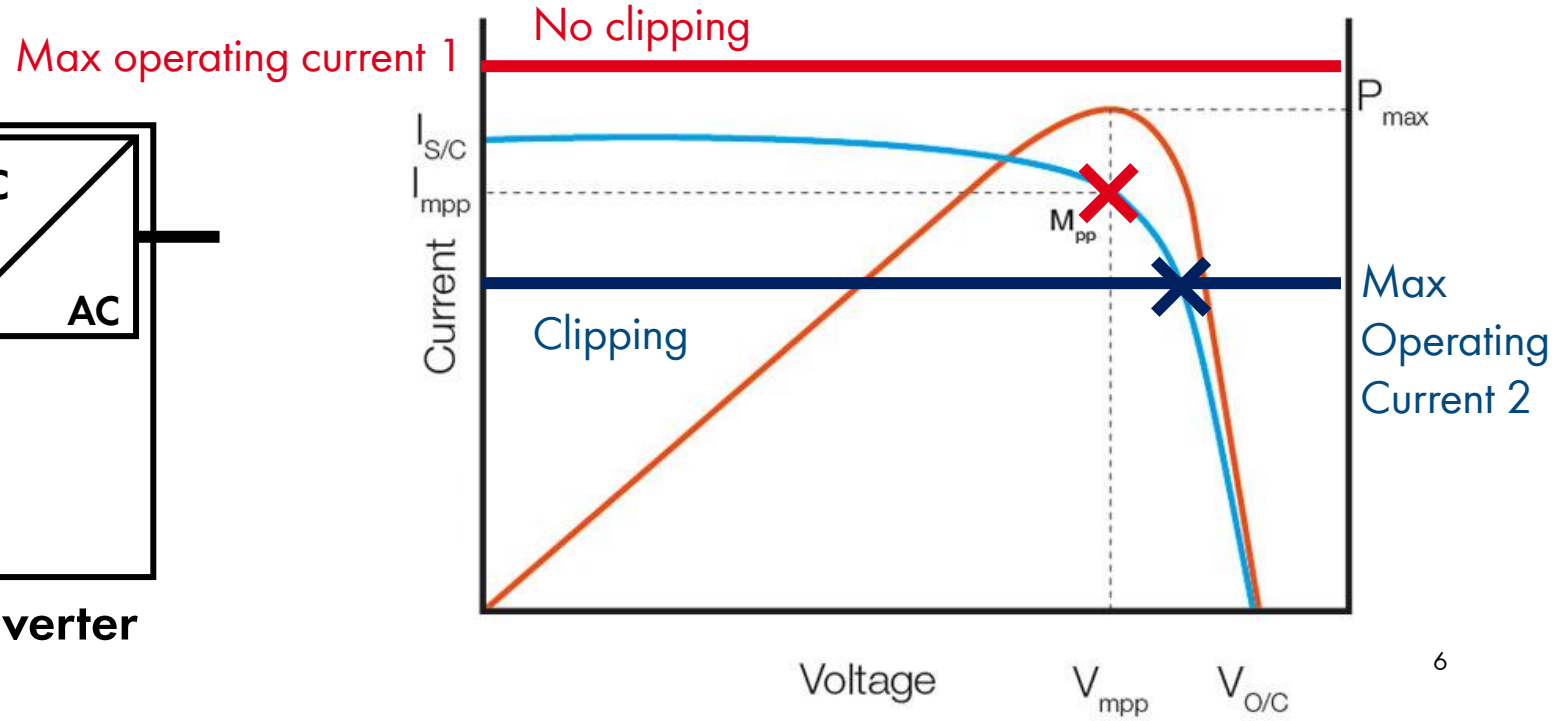


Single MPPT Inverter



Mutli-MPPT Inverter

Operating Current is controlled by the MPP Tracking by varying the load as seen by the string from 0 (short circuit) to infinity (open circuit) - i.e. “controlling” DC Voltage.

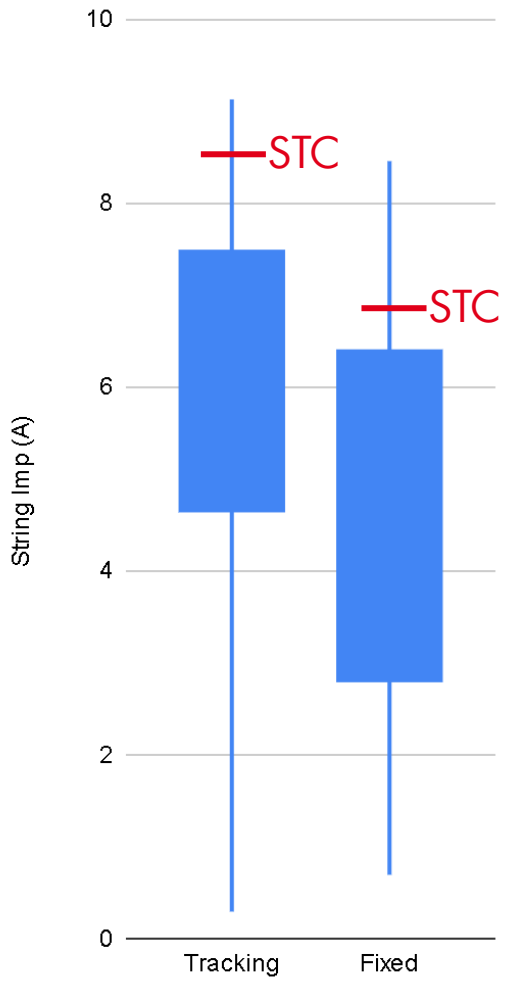


PV inverter Basics
Inverter Operating Current 2

Operating current shouldn't necessarily match to Imp current of your string/array. Unlike short-circuit current this is generally a stochastic rather than a worst-case scenario sizing exercise.

Factors to consider:

- LID
- Soiling
- Airmass
- Irradiation (Azimuth/Tilt)
- Shadowing



1st year field data from two plants in Jordan to show distribution of Imp across the year in comparison to STC Imp current

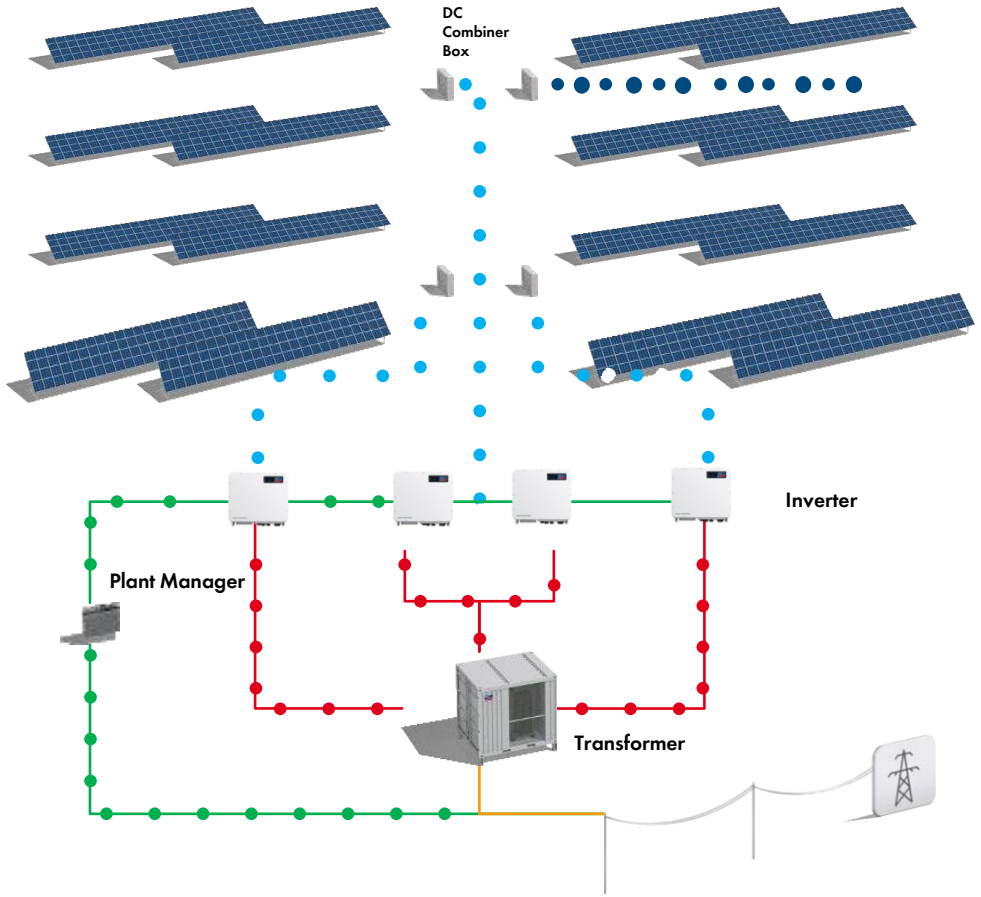
Field Data Courtesy of mustakbal clean tech

Are inverters ready for high current modules?
SMA Inverters | Single-MPPT / Fused

Conditions: 0°C/70°C | 1,000W/m² | 20% rearside Irradiance

Inverter Model	Rated Capacity (kVA)	MPPT	Theoretical DC/AC Ratio Monofacial (550Wp)	Theoretical DC/AC Ratio Bifacial (600Wp)
SHP100-20 (1,000V)	100	1	2.24	2.40
SHP150-20 (1,500V)	150	1	2.30	2.26

- Larger Size Fuses must be used in combiner boxes depending on temperature profile
- Larger currents create better opportunity for combiner box type inverter due to 1 larger cable rather than multiple ones.
- Decentral Architecture Enables compensation of DC losses by oversizing whilst minimizing AC losses.
- Mismatch losses negligible (Vmp function of temperature)

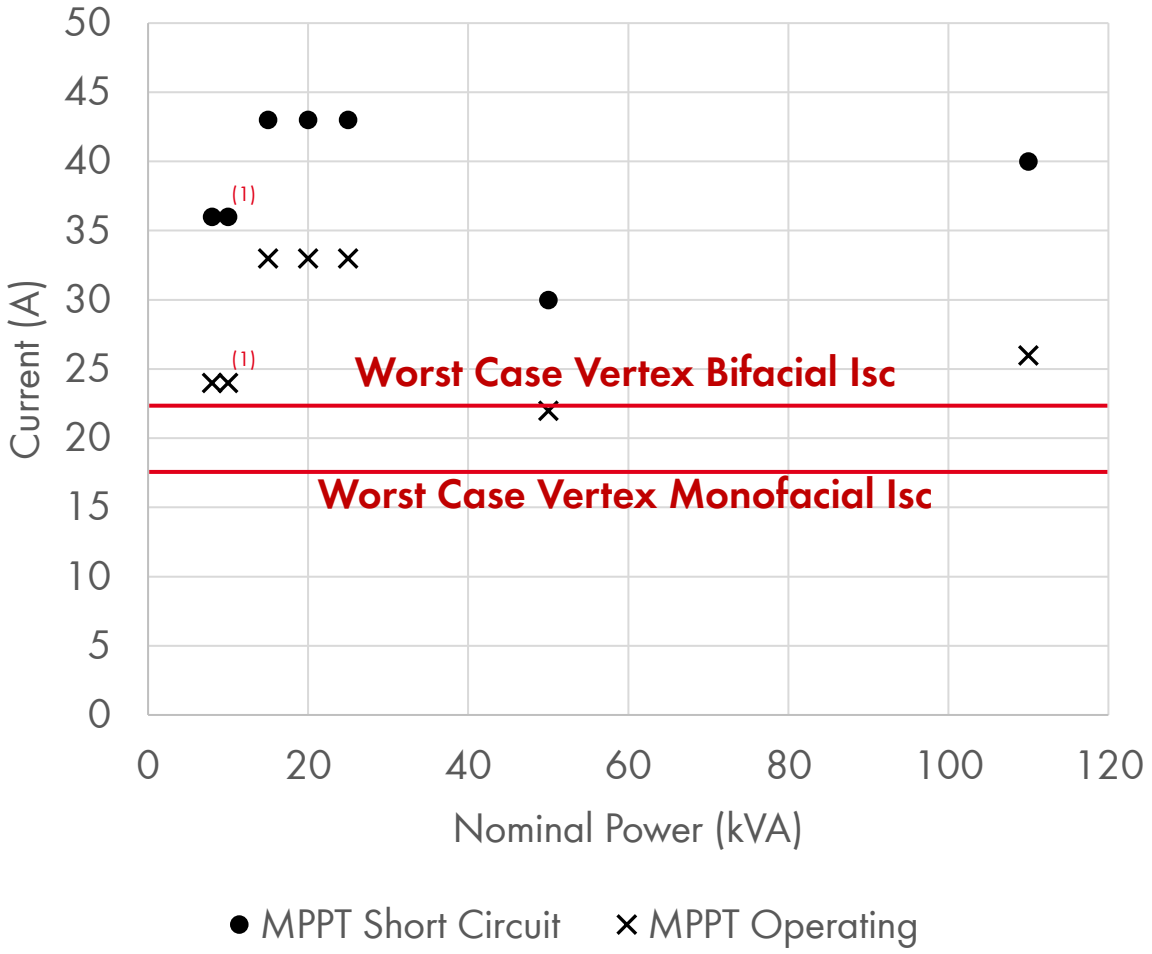


Are inverters ready for high current modules?
SMA Inverters | Multi-MPPT / Fuseless

Conditions: 0°C/70°C | 1,000W/m² | 20% rearside Irradiance

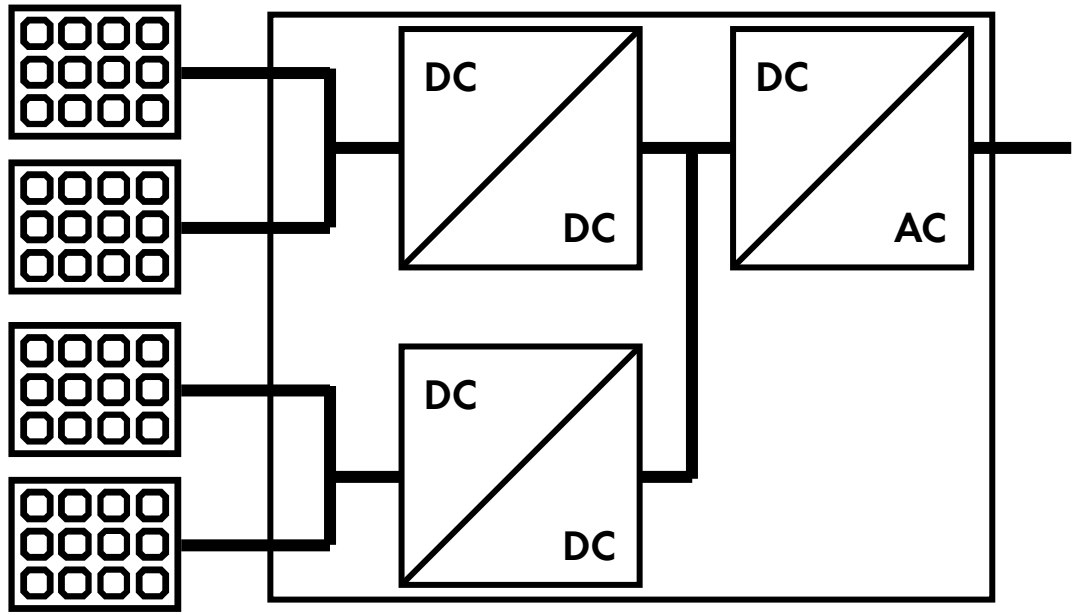
Inverter Model (1,000V)	Rated Capacity (kVA)	MPPT	Theoretical DC/AC Ratio Monofacial (550Wp)	Theoretical DC/AC Ratio Bifacial (600Wp)
STP8.0-3AV-40	8	1(1)	3.3	2
STP10.0-3AV-40	10	1(1)	2.6	1.6
STP15000TL30	15	2	3.5	4.3
STP20000TL30	20	2	2.6	3.2
STP25000TL30	25	2	2.1	2.6
STP50-40	50	6	1.6	1.9
STP110-60	110	12	1.5	1.8

(1) Use of parallel MPPT operation is required.



Are inverters ready for high current modules?
General hints for multi-mppt inverters 1

1) String vs. MPPT ratings
2) Power Limitation per MPPT
3) Voltage dependent current ratings



Mutli-MPPT Inverter

Are inverters ready for high current modules? General hints for multi-mppt inverters 2

Excerpt From PVSyst Documentation:

"By default, PVsyst assumes ***that an inverter with 2 MPPT inputs behaves as 2 identical inverters of half the power.*** *That is, each MPPT input will have a "nominal power" of half the power of the full inverter.*

If you check the option "Use Multi-MPPT feature", each MPPT input will be considered as an individual inverter with fixed PNom(MPPT) = PNom(Inv) / NbMppt.

Be careful: *as in the PVsyst inverter database, there is no information about the maximum power (or current) for each individual MPPT input,* ***it is your responsibility to check in the data sheets whether the allocated power is compatible with the manufacturer's specifications."***

Thank you!

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