ELECTRICAL CHARACTERIZATION OF HOT-SPOT-FREE AND STANDARD MODULE

Report on module concept from AE Solar

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Report no V 389/2018

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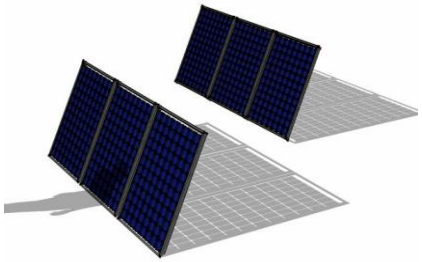
Motivation

- Partial shading in PV module can cause considerable amount of power loss depending on shading direction [1]
- In extreme cases, partial shading can lead to hot spots in PV modules



[1] Hanifi et al. EUPVSEC 2015, Hamburg

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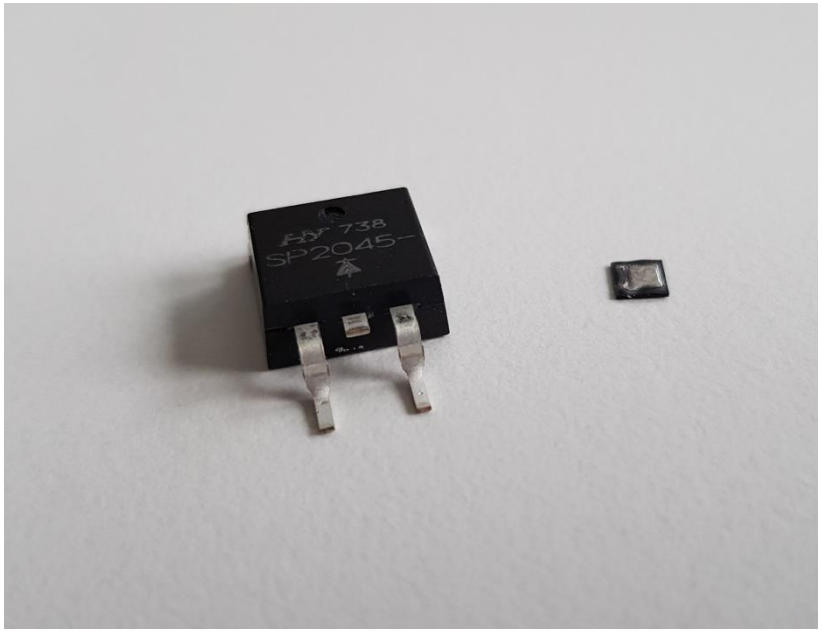
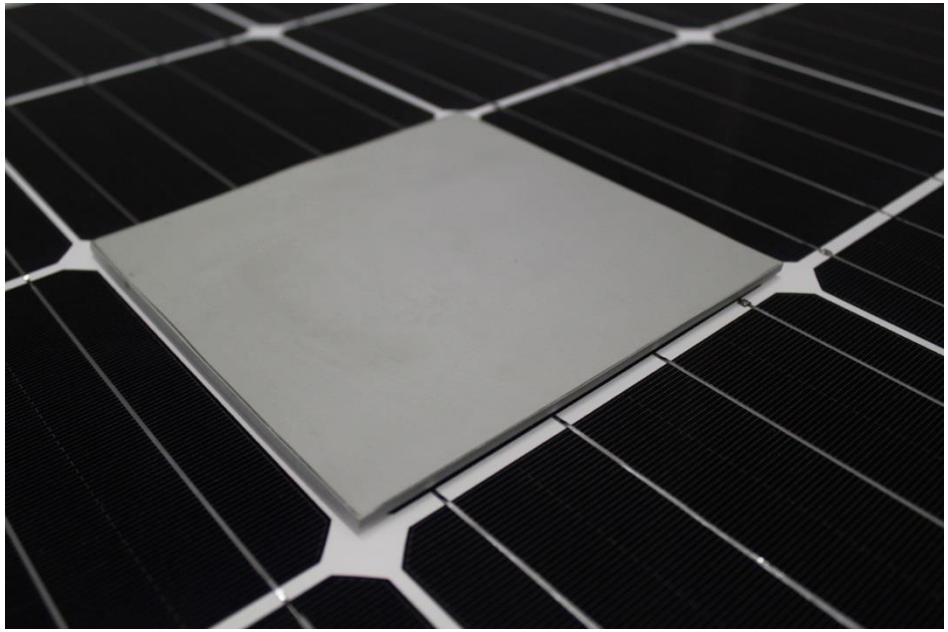
Motivation

- AE Solar has developed a novel module concept by integrating a bypass diode for every single solar cell
- Fraunhofer CSP evaluates the hot-spot-free module by measurement of a standard and hot-spot-free module under static partial shading conditions





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Experimental setup

- Standard module and Hot-spot-free module of AE Solar are measured by Xenon based sun simulator
  The modules are shaded under three different patterns
  - Shading of a single cell
  - Shading of a row
  - Shading of several rows

  Each row is defined as solar cells alliegned in one row but not in the same string

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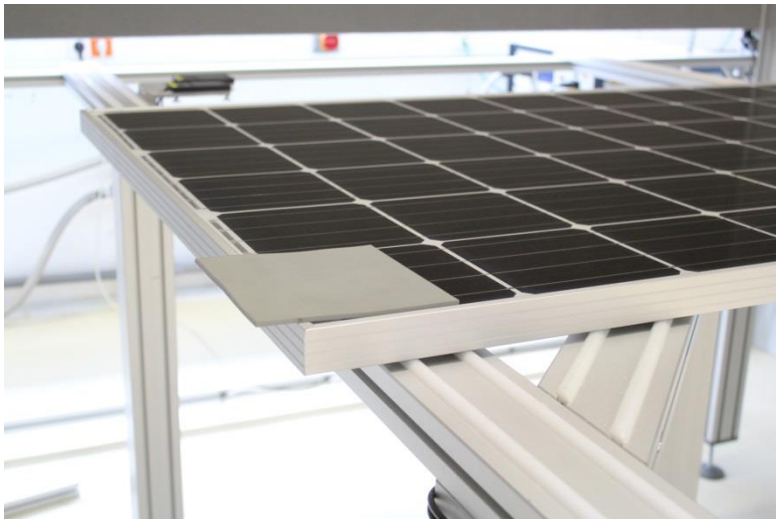
Experimental setup

The shade is moved in different stages for all three mentioned shading patterns



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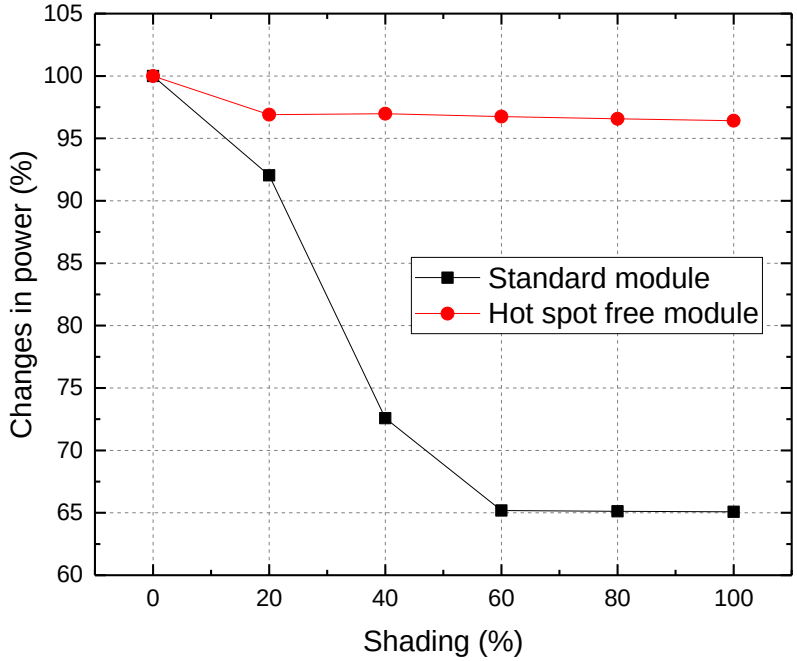
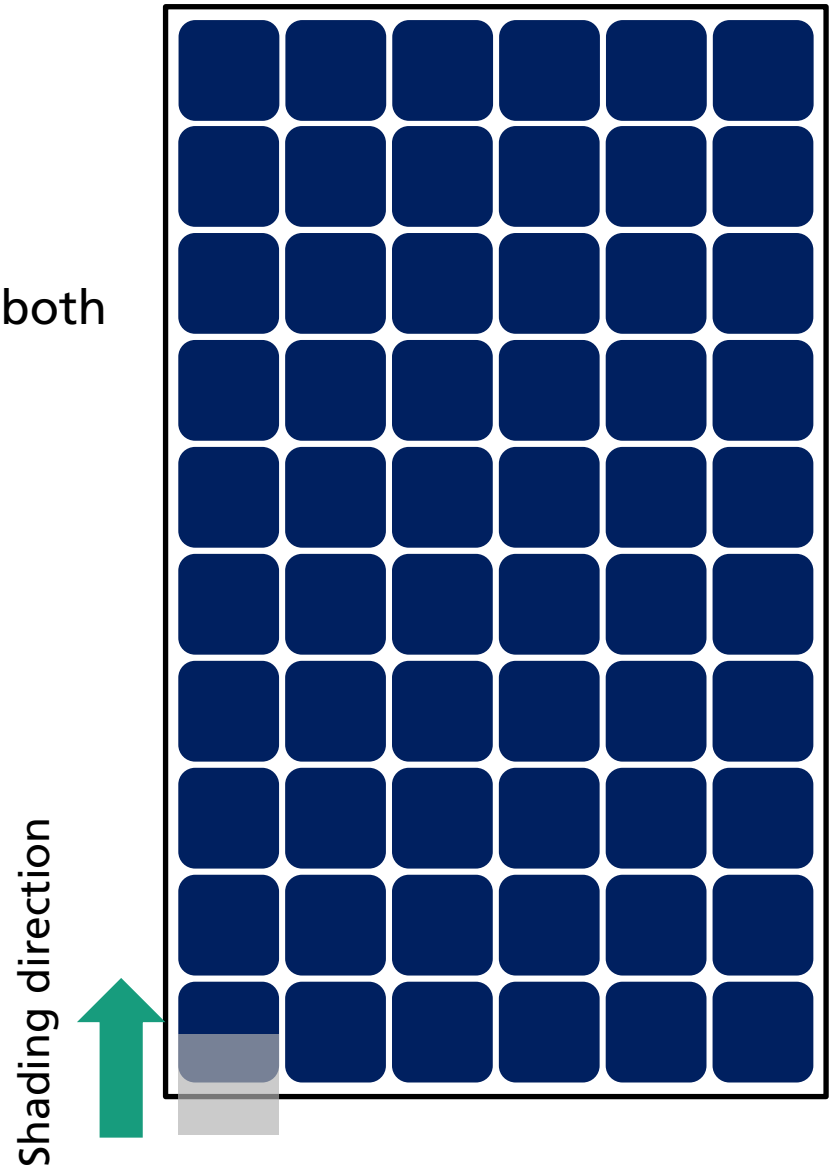
Results
Shading of single cell

- On solar cell is shaded from 0-100% in both modules



*The connecting lines are for eye-guide



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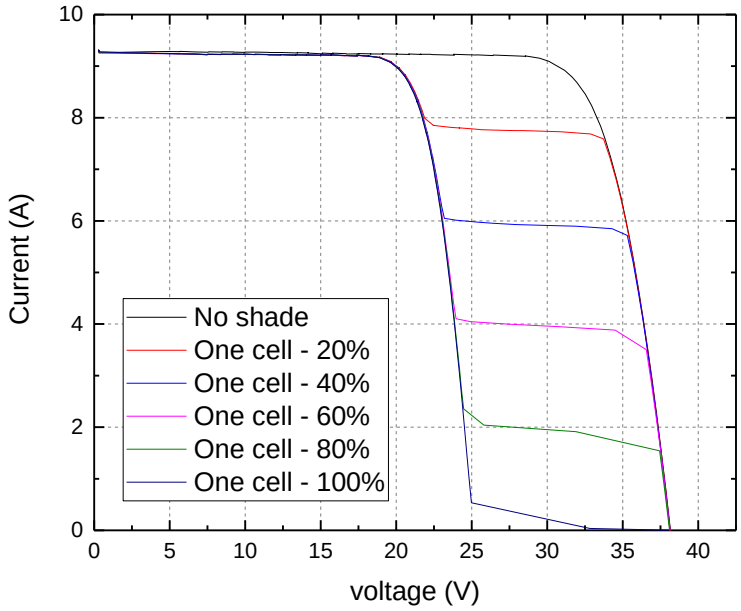
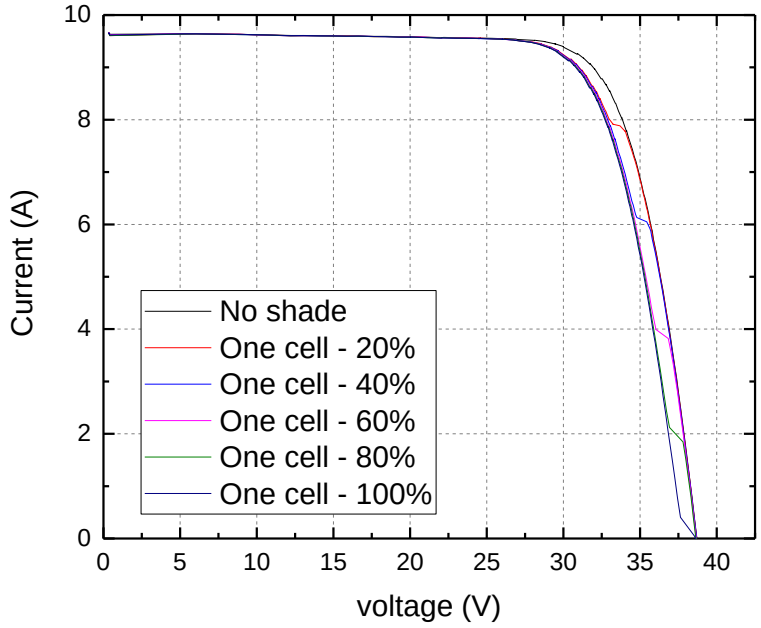
Results
Shading of single cell

Standard module



Hot-Spot-Free module



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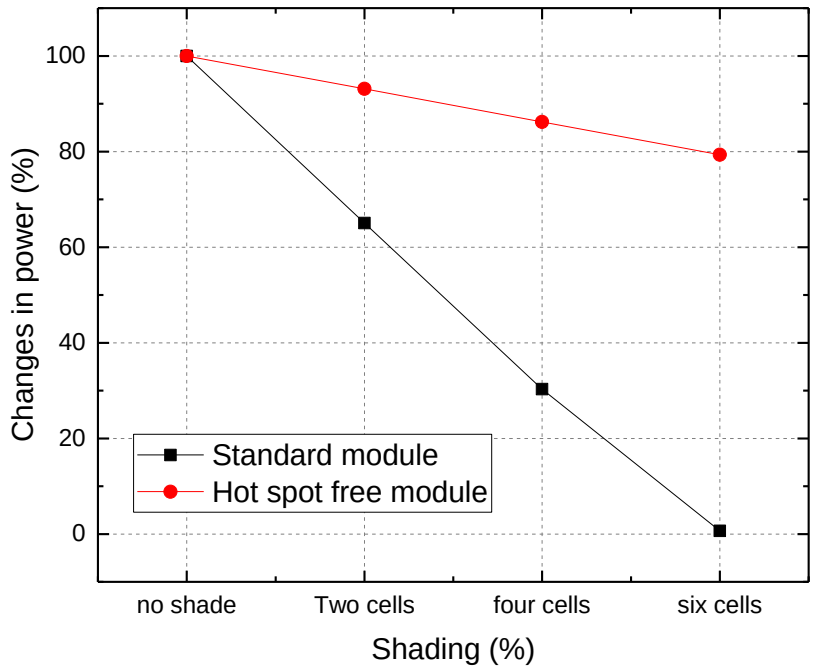
Results
Shading of a row

- On row (three strings) is shaded
- Each step the cells in one string are shaded



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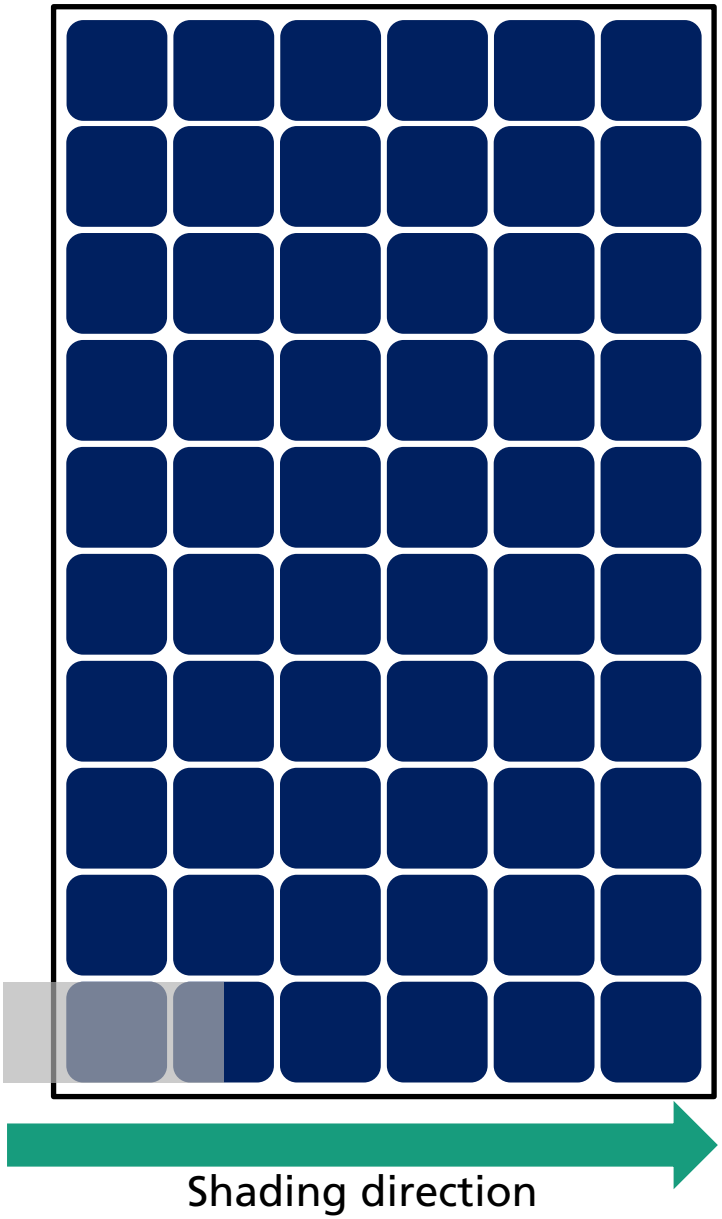

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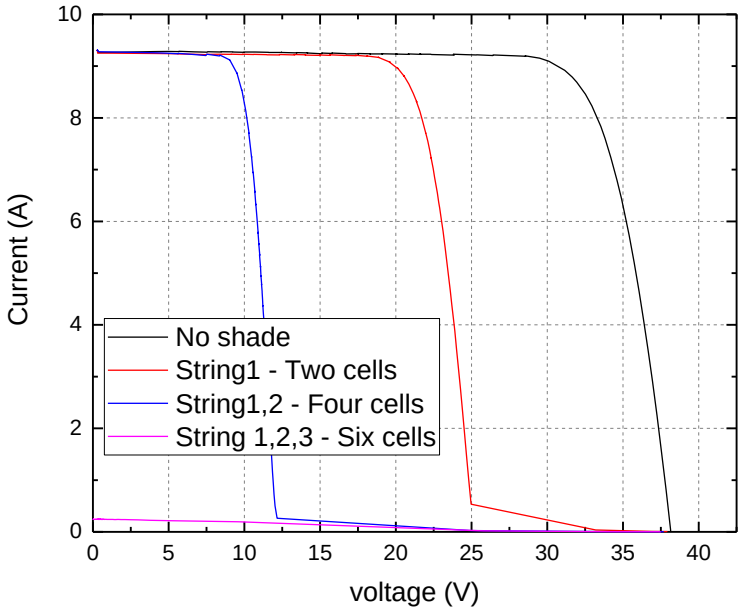
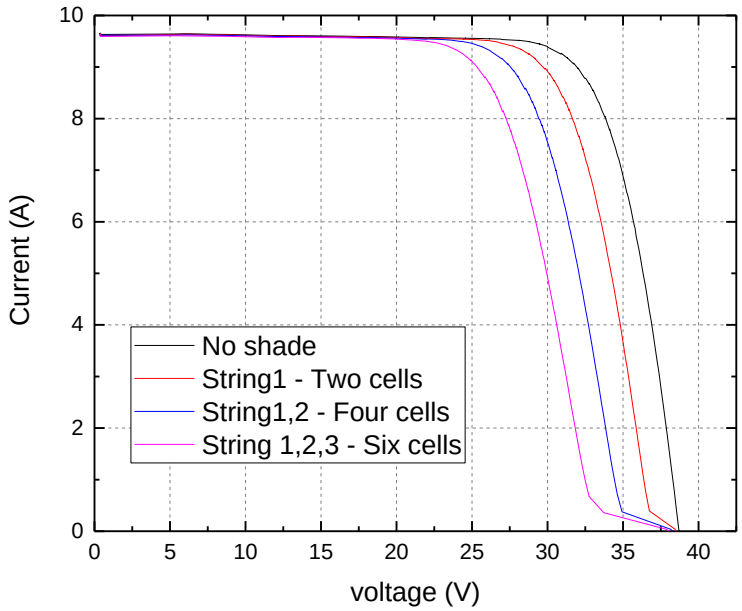
Results
Shading of a row

Standard module



Hot-Spot-Free module



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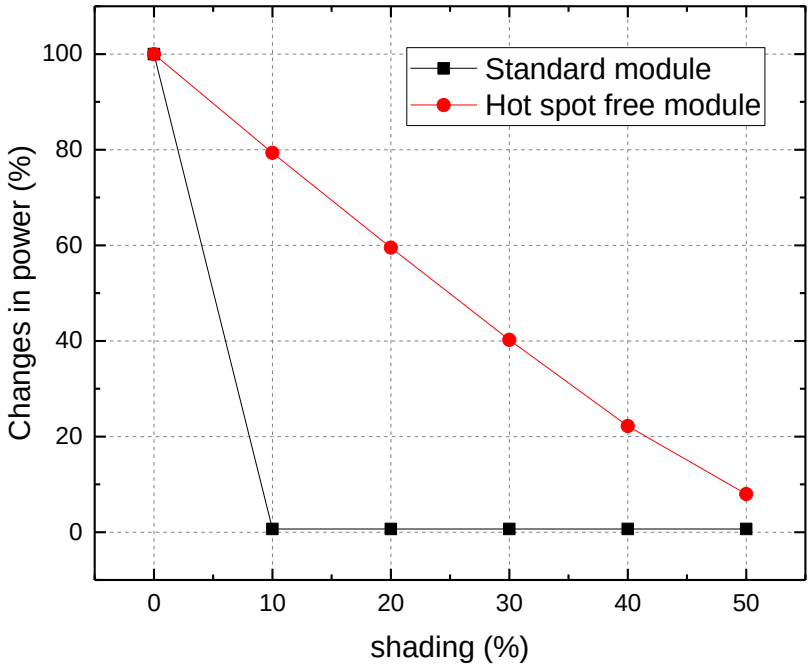
Results
Shading of several rows

- Several rows are shaded
- In each step, one row is added to the shaded area



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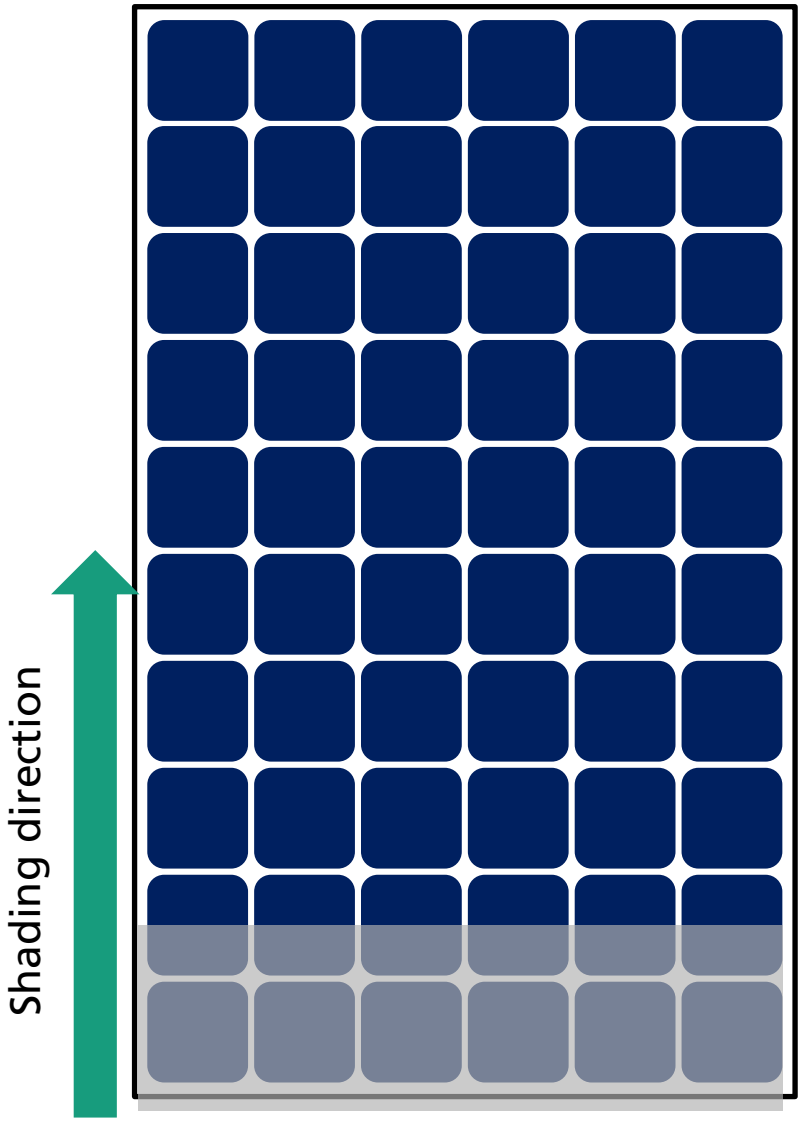

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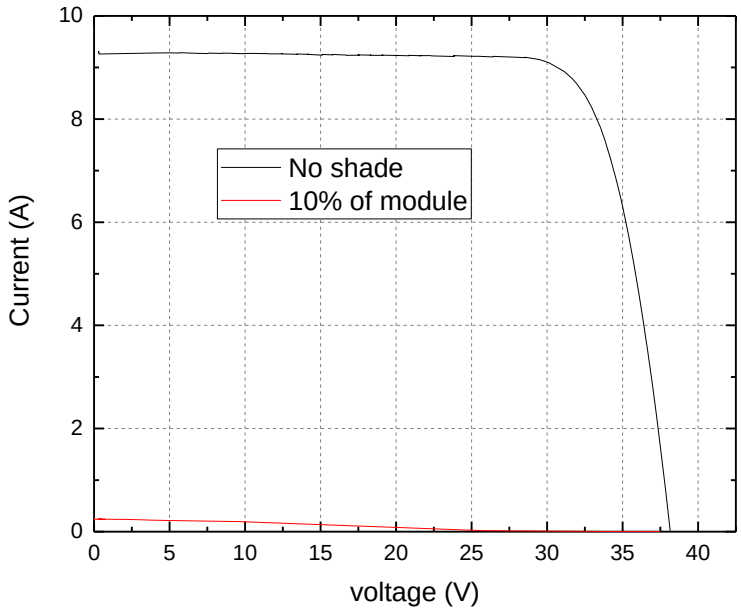
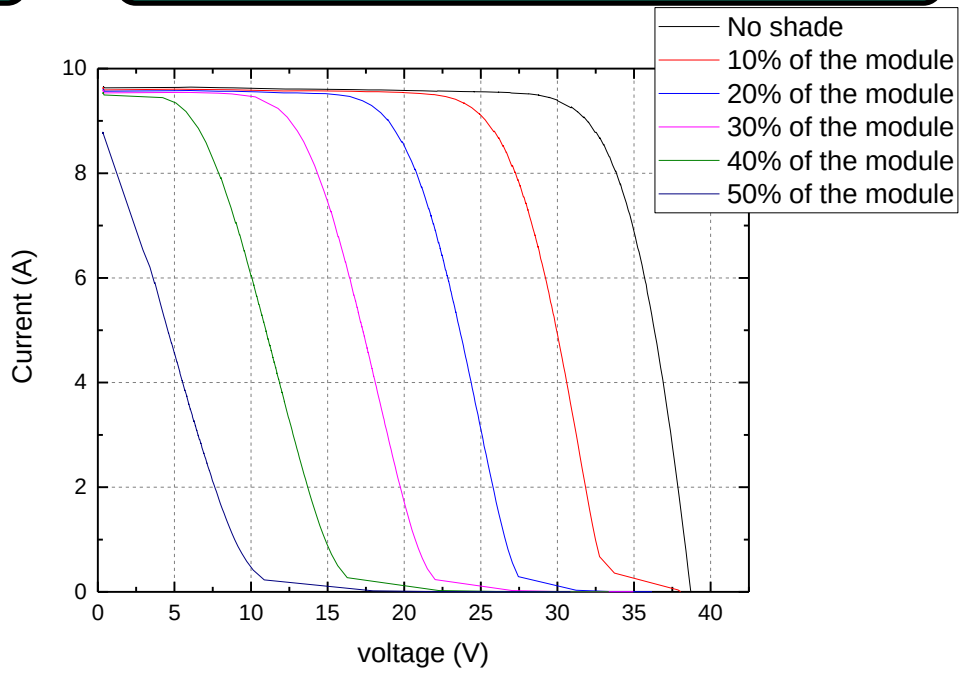
Results
Shading of several rows

Standard module



Hot-Spot-Free module



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Summary and conclusion

- An experimental setup is designed to evaluate the performance of Hot-spot-free module in compared to the standard module design under partial shading conditions
- Different shading patterns are tested on both modules
- Shading of one solar cell
  - After full shading of one solar cell hot-spot-free module loses only 3% of power while standard module loses 35% of its power
- Shading of one row
  - The comparison shows in the worst case of full shading of one row, standard module loses all of ist power while hot-spot-free loses only 20% of the nominal power

Summary and conclusion

- Shading of several rows
  - Hot-spot-free module power decreases linearly with increasing the shading percentage while the standard module loses all of its power after 10% shading of module area
  - After shading of 50% of the area, the hot-spot-free module loses all of its power due to the power dissipations in the diodes.
  - This results is only valid when the shading pattern is from bottom to top. In case of left to right shading pattern, the power dissipation is expected to be considerably higher

Outlook

The following tasks according to the offer are in planning:

- Bypass diode failure detection (WP1)
- Mechanical evaluation of the module under different loading conditions (WP2)
- Simulation of the modules and determination of losses in bypass diodes under partial shading condition (WP3)