Hochschule Karlsruhe
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BRC SOLAR
maximized pv power

SUBSTRING-MPPT FOR 4-TERMINAL MODULES

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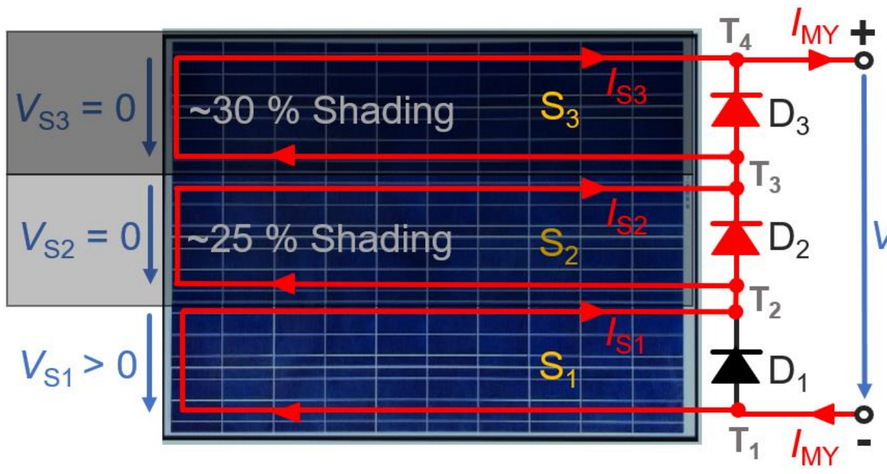


Figure 1: Bypass diodes D_X (X = 1…3) between terminals T_X and T_{X+1} short circuit shaded substring current I_{SX} to $V_{SX,shaded}$ = 0 V to increase string current I_{MY}.

→ No power from shaded substrings

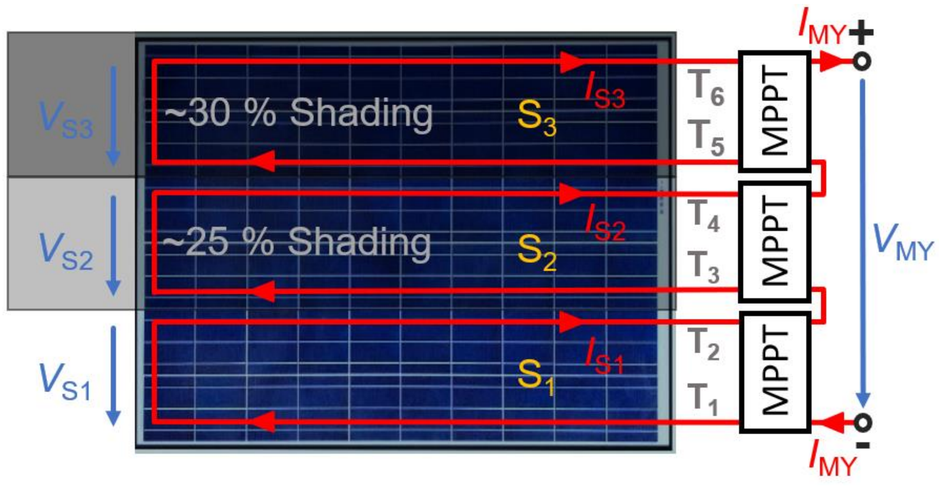
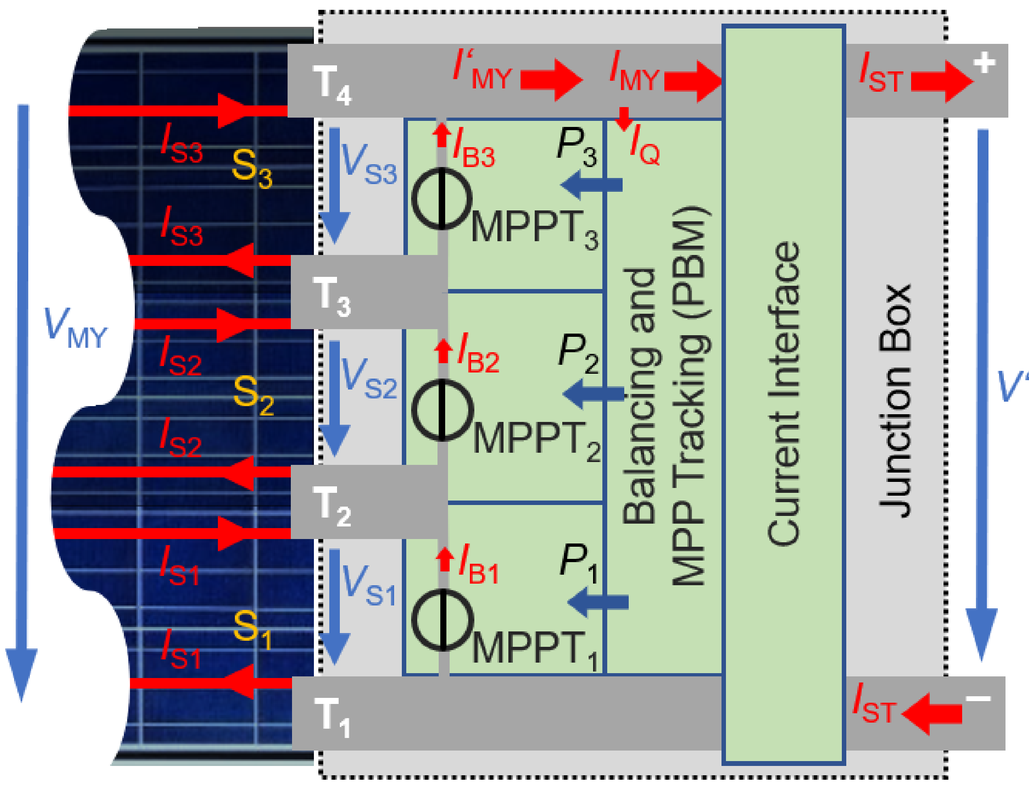


Figure 2: Available 6-terminal substring MPPTs[1)] connected between $T_{2(X-1)+1}$ and $T_{2(X-1)+2}$ incompatible with standard PV-module 4-terminal junction box.

→ Expensive change of module production

<u>Solution:</u> Voltage sources $MPPT_X$ parallel to substring S_X



→ Compatible to modules and junction boxes with 4 terminals

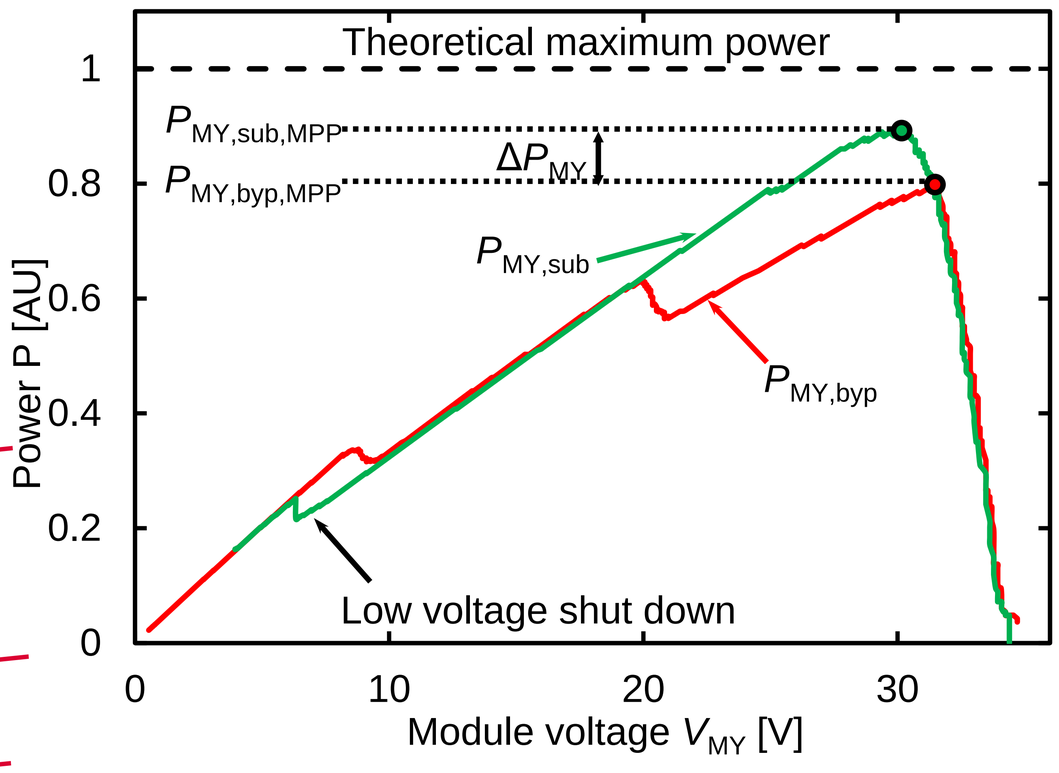
→ Provide bypass current $I_{BX} = I_{MY} - I_{SX}$

→ Balancing and MPP Tracking adjusts V_{SX} to $V_{SX,MPP}$

→ I_Q provides balancing power P_X

→ Current interface adjusts $I_{MY} = I'_{MY} - I_Q$ to I_{ST}

→ Without shading $V_{MY} = V_{MY'}$ and $I_{MY} = I_{ST}$ → no power loss



→ Substring S_2 shaded by ~25 %

→ Substring S_3 shaded by ~30 %

→ Substring MPPT provides power $P_{MY,sub,MPP} > P_{MY,byp,MPP}$ using bypass diodes

→ Substring MPPT increases Module power by ΔP_{MY} = 12 % compared to bypass diode technology

→ Optimizing Substring-MPPT increases power output towards theoretical maximum

Results of unoptimized Substring-MPPT prototype:

- **power performance of shaded module increased by 12 % compared to bypass diodes**
- **Compatible to state of the art 4-terminal PV-modules**
- **No operation means no power loss without shading**

Referemces: [1] maxim integrated, solar cells optimization-1.pdf, https://www.maximintegrated.com/en/markets/solar-energy.html
[2] R. Merz, T. Czarnecki, A. Neumann, EP2018/054159, to be published