

Maximize Solar Power by Solar Cell Reconfiguration Circuits



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Motivation

- Can terrestrial solar power be more efficiently extracted with innovation in reconfigurable hardware and algorithms?
- Preliminary research in spacecraft solar systems (where array performance can degrade from 20% to 50% over a 15-year mission) shows promise in significantly increasing available power using array reconfiguration.
- This research explores using innovative hardware, including low-loss electronic power switches, to bypass or reconfigure solar cells affected by shading.
- This approach may potentially improve output solar efficiency up to 30% over the system's lifetime.

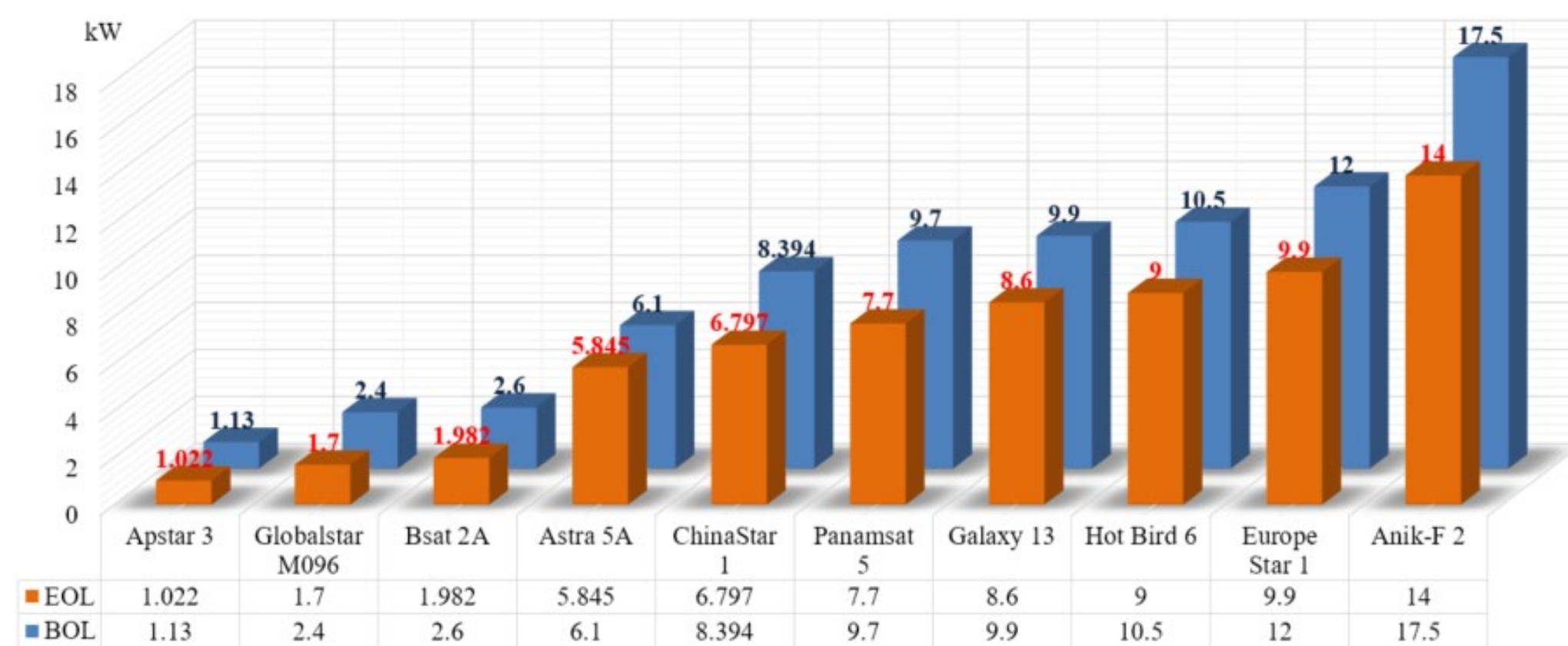
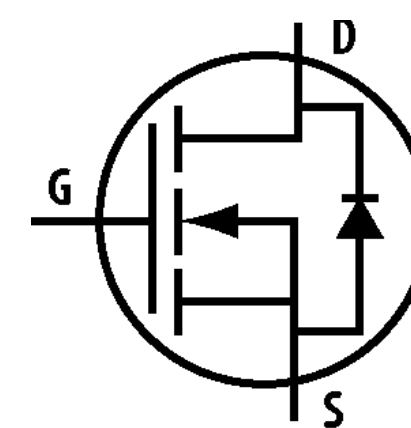


Figure 1: Spacecraft BOL vs EOL

Research Focus

- Optimize switch configuration in a modular 2 x 2 solar array.
- Design Structure Considerations:
 - (1) TCT horizontal
 - (2) TCT vertical
 - (3) Vertical
 - (4) Parallel
- This Design can be Scaled.
- The optimal number of switches can be found by:

$$n [module] + h[8] + v[2] = N$$



$n = \text{Num. of Modules}$

$N = \text{Num. of Switches}$

$v = \text{Num. of Vert. Modules}$

$h = \text{Num. of Horiz. Modules}$

Max Pout vs. Shading

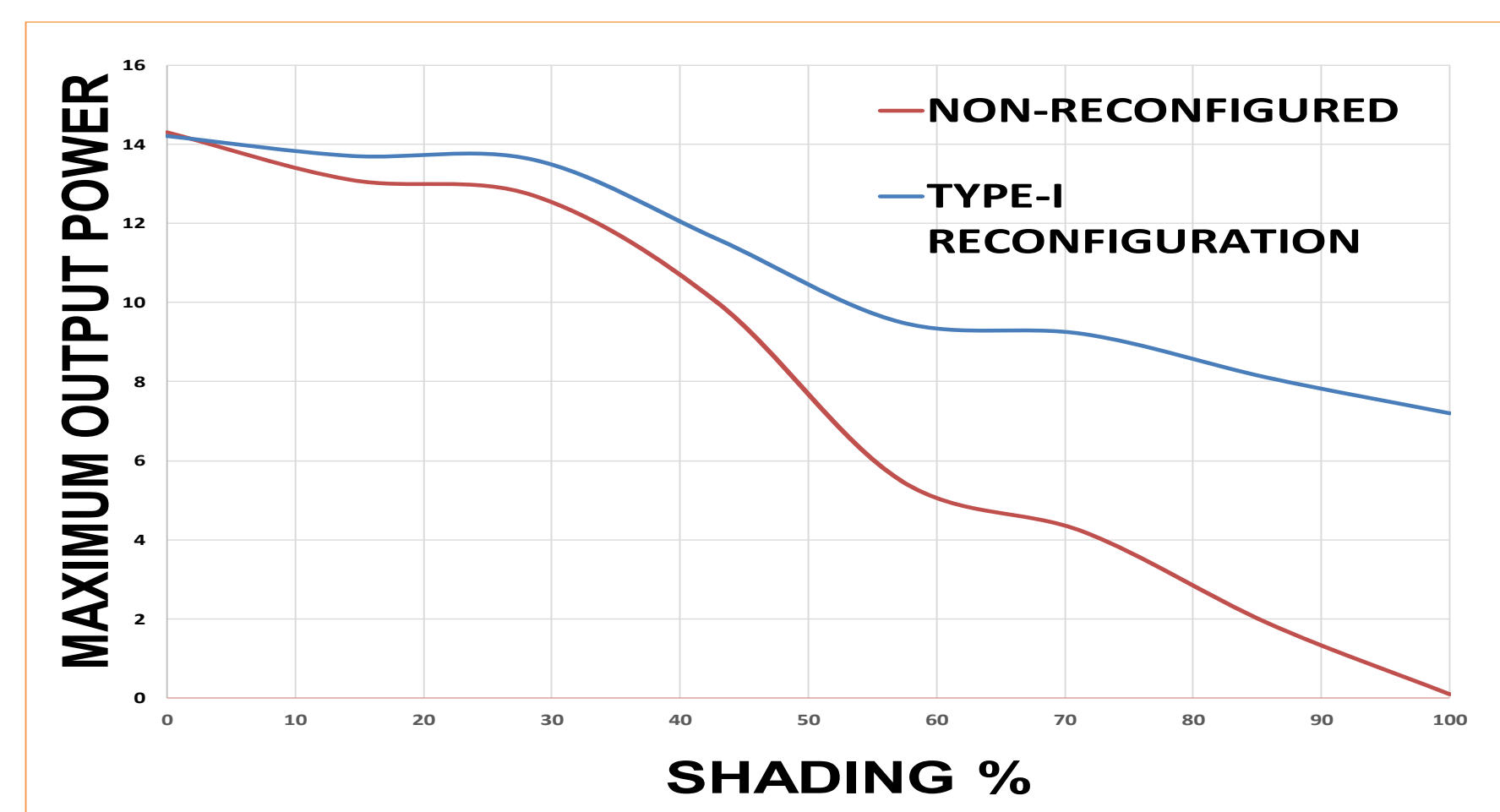


Figure 2: Max Pout vs. Shading

Scalable Modular Design

- 2x2 Design uses 12 switches
- Enables 27 Configurations
 - 15 Series
 - 10 Parallel
 - TCT Vertical
 - TCT Horizontal
- Scaling maintains flexibility

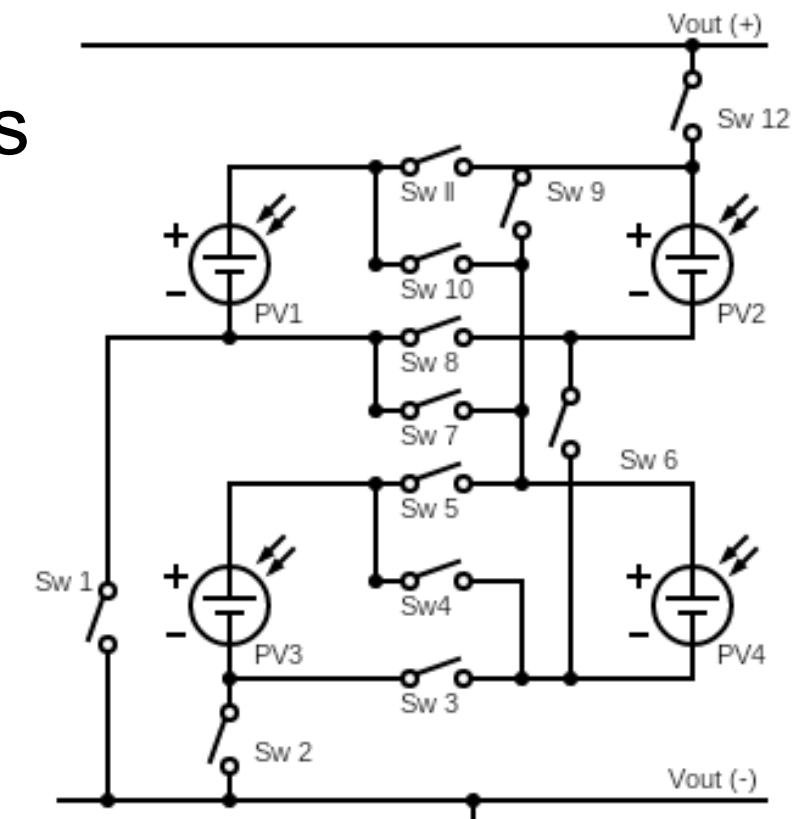


Figure 3: 2 x 2 Module

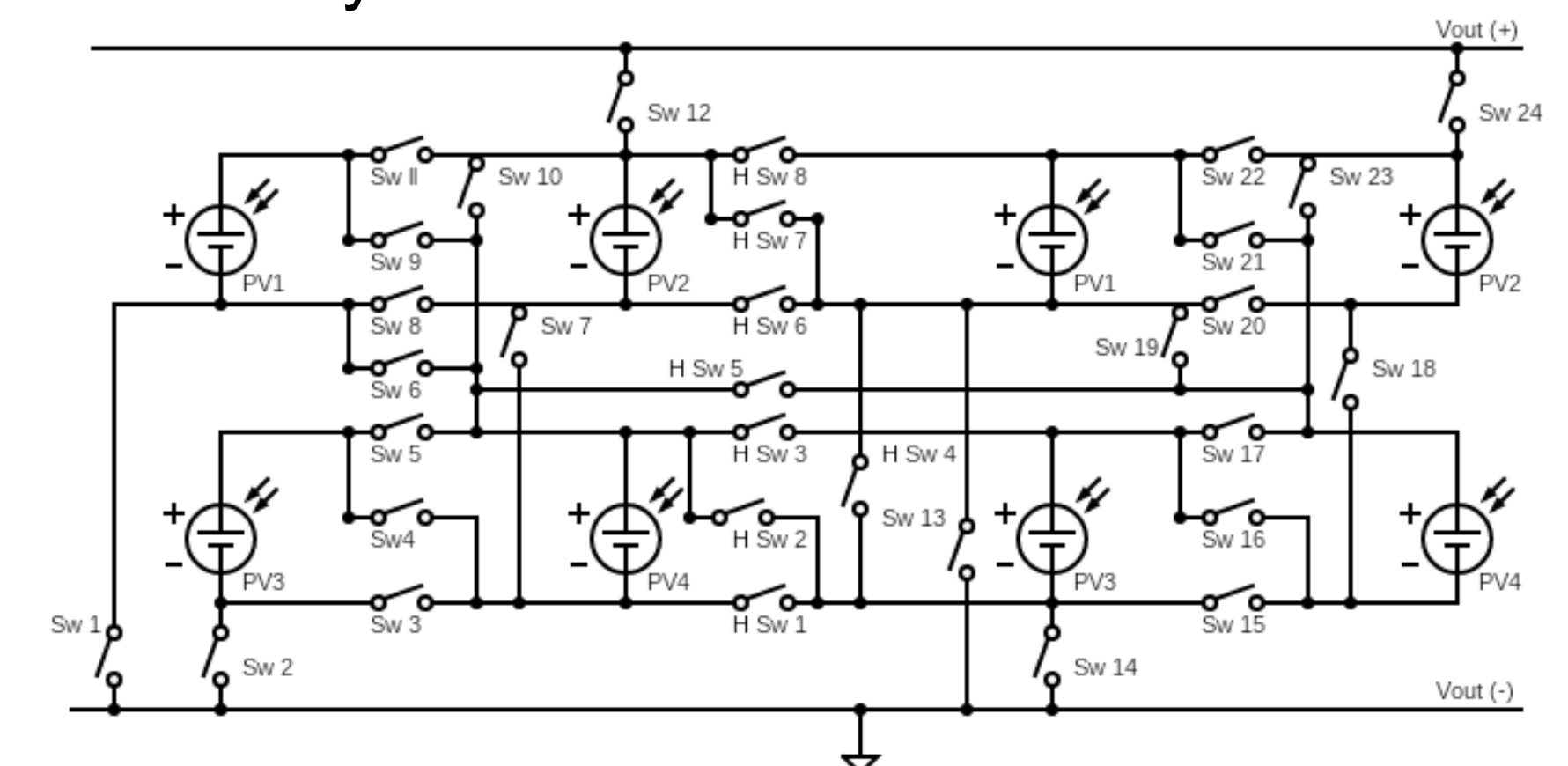


Figure 4: 2 x 4 Scaled Module

Shading Patterns

(a.) Type-I Row Shading.

(b.) Type-II Diagonal shading.

(c.) Type-III Column Shading

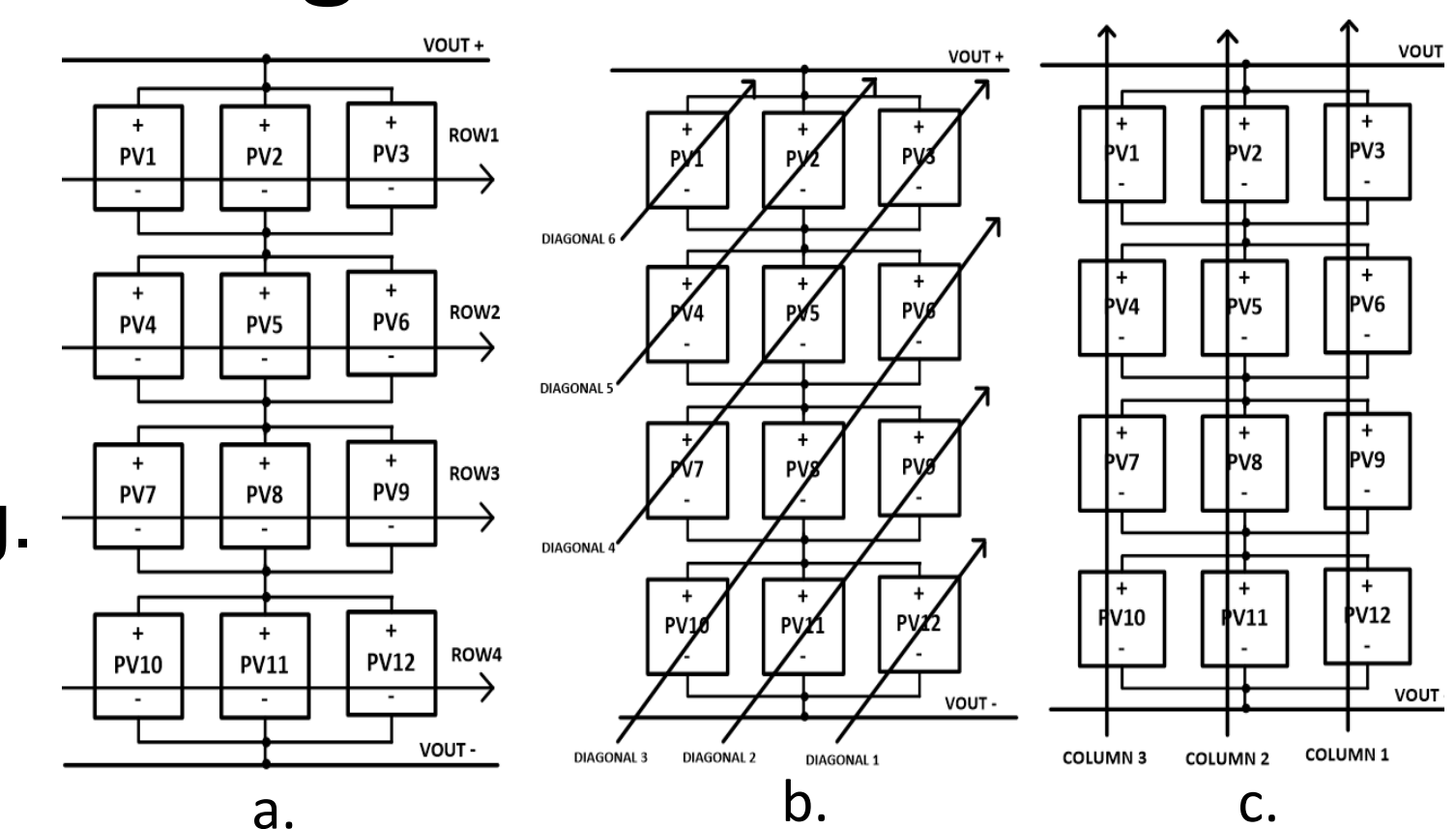


Figure 5: Three Shading Patterns