Inspection and compliance checks for Solar PV Systems (AS/NZS / NEC)

Session 2A: PV Cells and Modules

ARRAY CONFIGURATION

- Connecting PV cells in series make up a PV module and PV modules connected in series form a PV string. Large Scale PV systems have large number of PV strings that are typically connected in parallel to form a PV array as shown in figure.

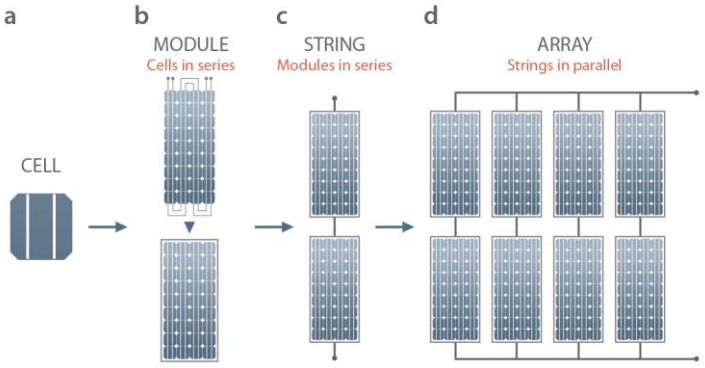


Figure : Arrangement of a PV Array

ARRAY CONFIGURATION 2

- The voltage output of a PV string is defined by the sum of the voltage output of all the modules connected in series. But the current output of a PV string is set by the lowest current generated by a single module in the string.

String (modules in series):

  - Voltage = sum of module voltage outputs
  - Current = smallest module current output.

- Similarly, the voltage output of a PV array consisting of multiple PV strings in parallel will be equal to the lowest string voltage in the array and the array output current is given by the sum of output currents of all the individual PV strings.

ARRAY CONFIGURATION 3

Array (strings in parallel):

- Voltage = lowest string maximum power point voltage output (Note: it does depend on what voltage the Maximum Power Point tracker in the inverter selects for maximum power output)
- Current = sum of current outputs of all the strings that are connected in parallel.

- The number of PV modules connected in series and the number of PV strings connected in parallel are determined based on the current and voltage requirements for the inverter system.

TYPES OF MODULES

Traditional Solar Modules:

- Monocrystalline and Polycrystalline are the traditional types of solar panels made of monocrystalline silicon or polysilicon.
- Both monocrystalline and polycrystalline solar modules serve the same function in the solar PV system: they capture energy from the sun and turn it into electric energy. They are both made from silicon.
- Both mono and poly solar modules can be good choices for your household and commercial purposes, but there are key differences between the two types of solar modules that you should understand.

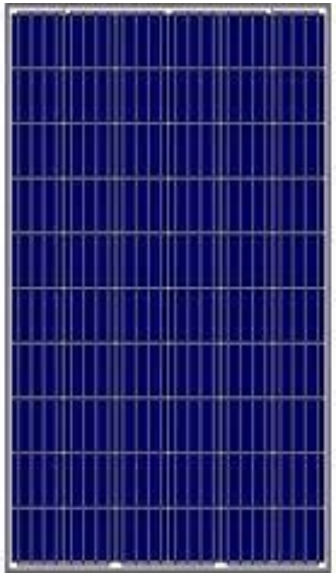
MONO-CRYSTALLINE MODULES

- While making solar cells for monocrystalline solar modules, silicon is formed into bars and cut into wafers. These sorts of modules are called “monocrystalline” because the cell is made out of a single crystal of silicon, and thus the electrons that create a stream of power have more space to move.
- Thus, monocrystalline modules are more efficient than polycrystalline modules. Monocrystalline cells are more expensive to manufacture and typically have a slightly higher efficiency of 15–22% than conventional polycrystalline cells.

mono-crystalline module

POLYCRYSTALLINE MODULES

- Polycrystalline Modules are also made from silicon. In any case, rather than utilizing a single crystal of silicon, producers soften many pieces of silicon out and out to frame the wafers for the board.
- Polycrystalline solar modules are alluded to as “multi-crystalline,” Because there are many crystals in a single cell, there is to less freedom for the electrons to move.
- As a result, polycrystalline solar modules have lower efficiency ratings than monocrystalline counterparts. Polycrystalline solar cells typically have an efficiency of around 13–15% resulting in larger individual cells and thus typically a slightly larger module.



poly-crystalline module

HIGH EFFICIENCY SOLAR CELLS: PERC AND HALF CUT

- Nowadays, high efficiency solar cells that were once only seen in labs are installed on a global scale. PERC cells have become the standard technology type amongst many module manufacturers such as Jinko, Yingli, and Trina, superseding older cell structures such as aluminium Back Surface Field (Al-BSF).
- Half cut cells are another advancement in solar technology which has recently penetrated commercial solar applications and are rapidly becoming standard. Half cut cell modules are made of cells that have been cut in half, resulting in a total of 120 or 144 cells in a single module – doubling the total count in comparison to a traditional solar module.

HIGH EFFICIENCY SOLAR CELLS: PERC AND HALF CUT 2

- Each half-cut cell produces the same voltage as a standard cell but only half the current, thus they are arranged in parallel strings (Figure 6) to mimic the voltage and current ratings of a conventional module. There are many benefits to this type of cell, many of which use PERC technology. The most prominent benefit is the reduction in current per individual cell, lowering resistive losses, which results in a gain in power per square metre.

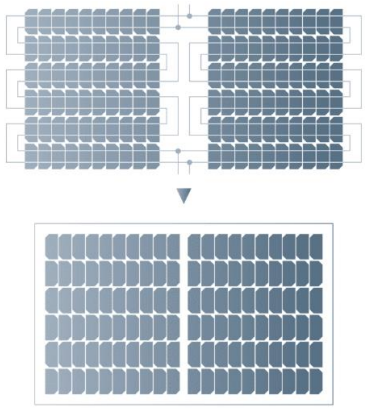
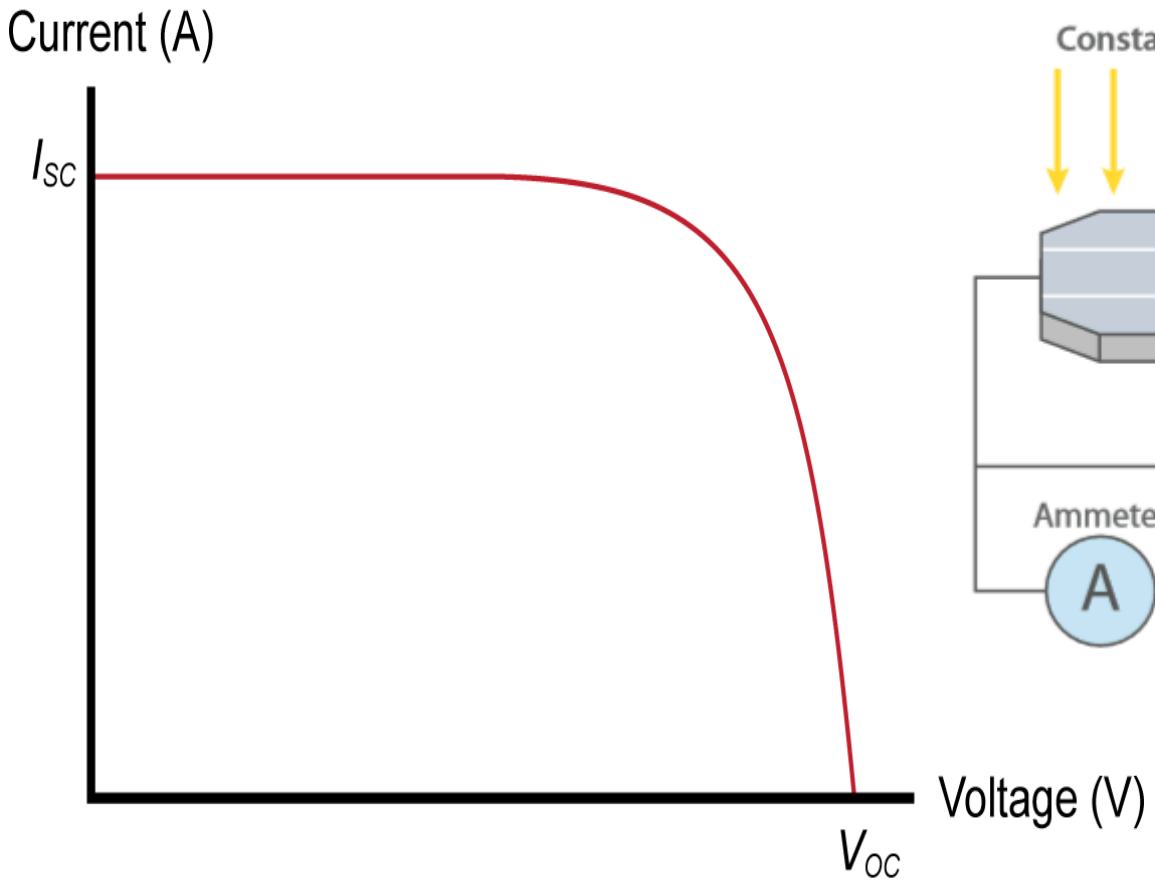
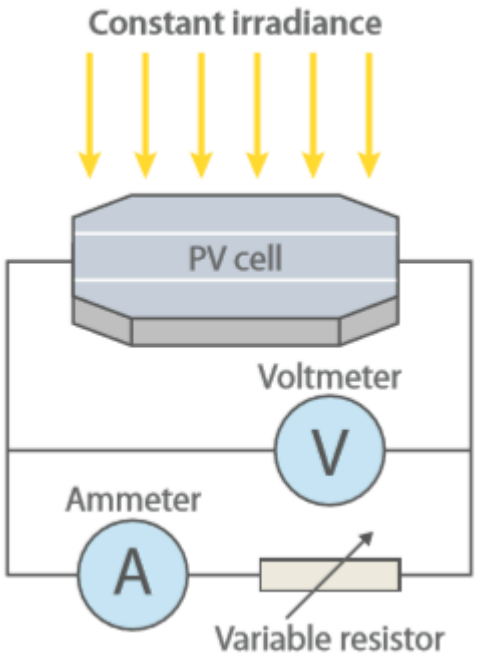


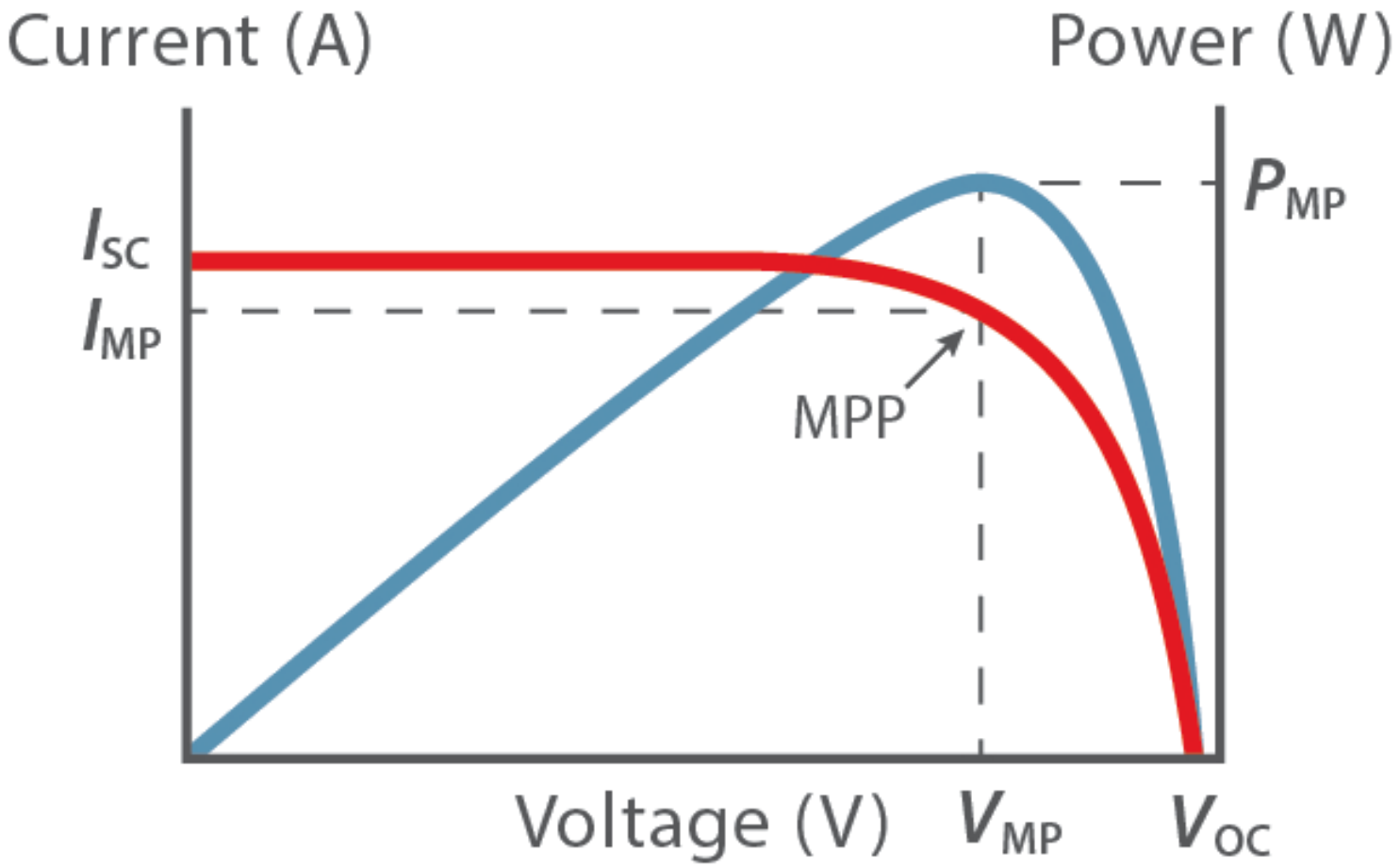
Figure 6 Arrangement of cells in a half-cut cell module

Typical I-V Curve for a Solar Cell



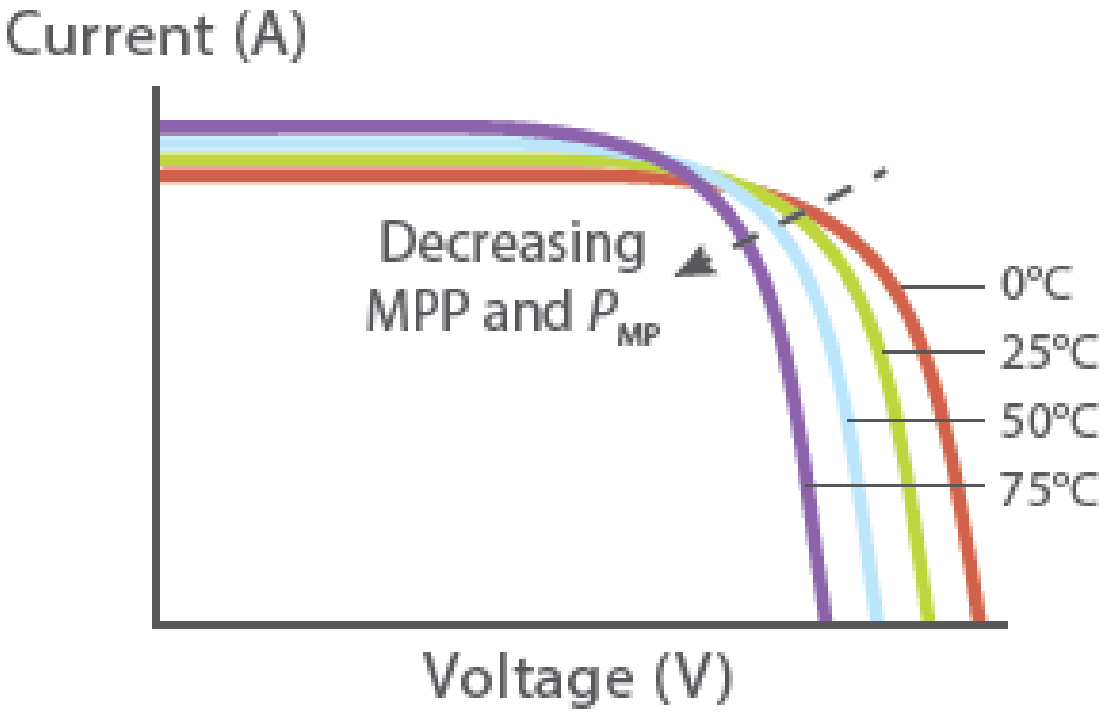


Power Curve for a Solar Cell



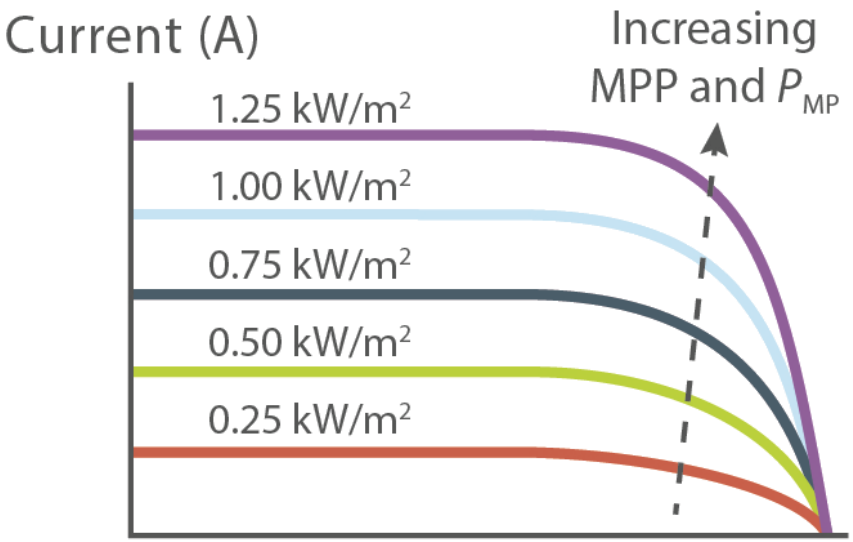
Factors Which Affect the Performance of Solar Cells: Temperature

- Crystalline cells affected more than Thin Film
- As Temperature increases, voltage decreases and vice versa

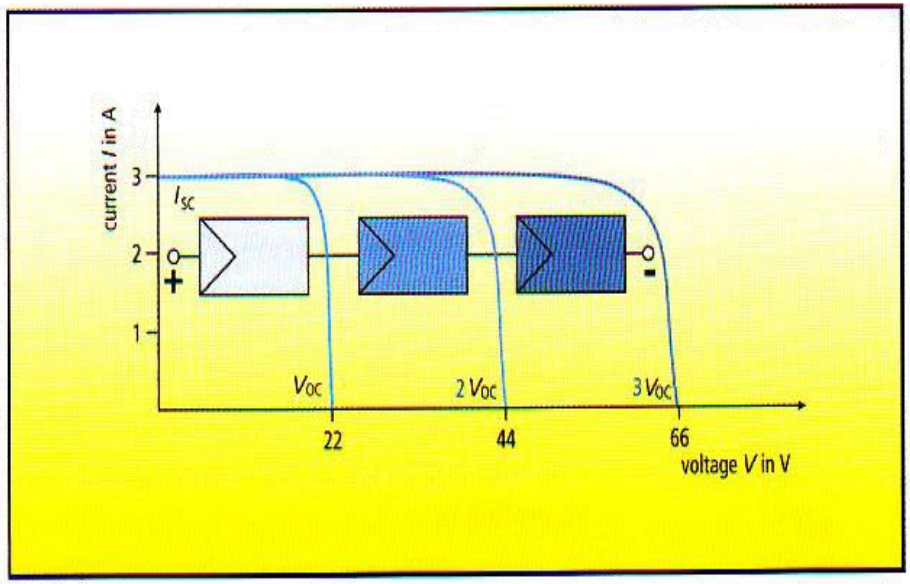


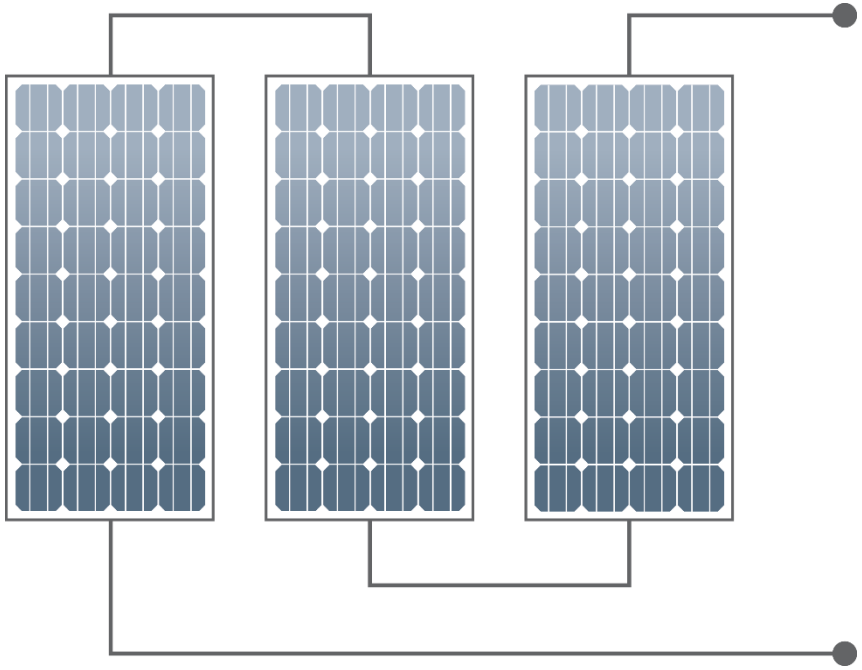
Temperature

Factors Which Affect the Performance of Solar Cells: Irradiance Increases Current

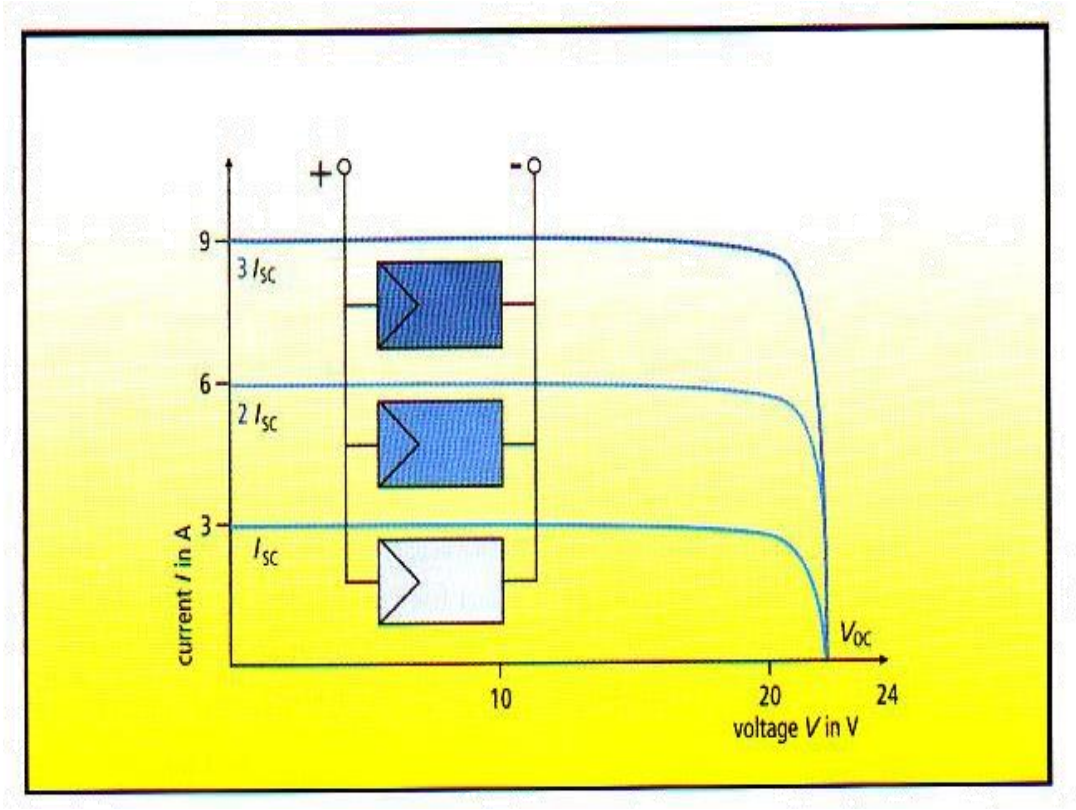


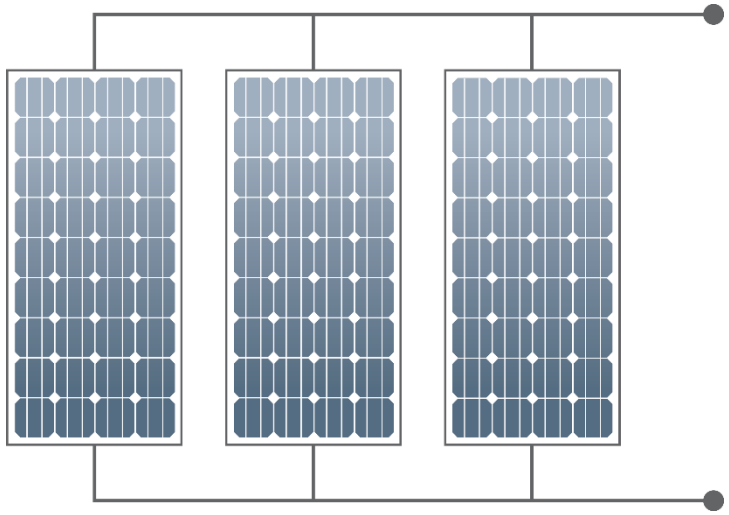
PV Array: Modules Connected in Series



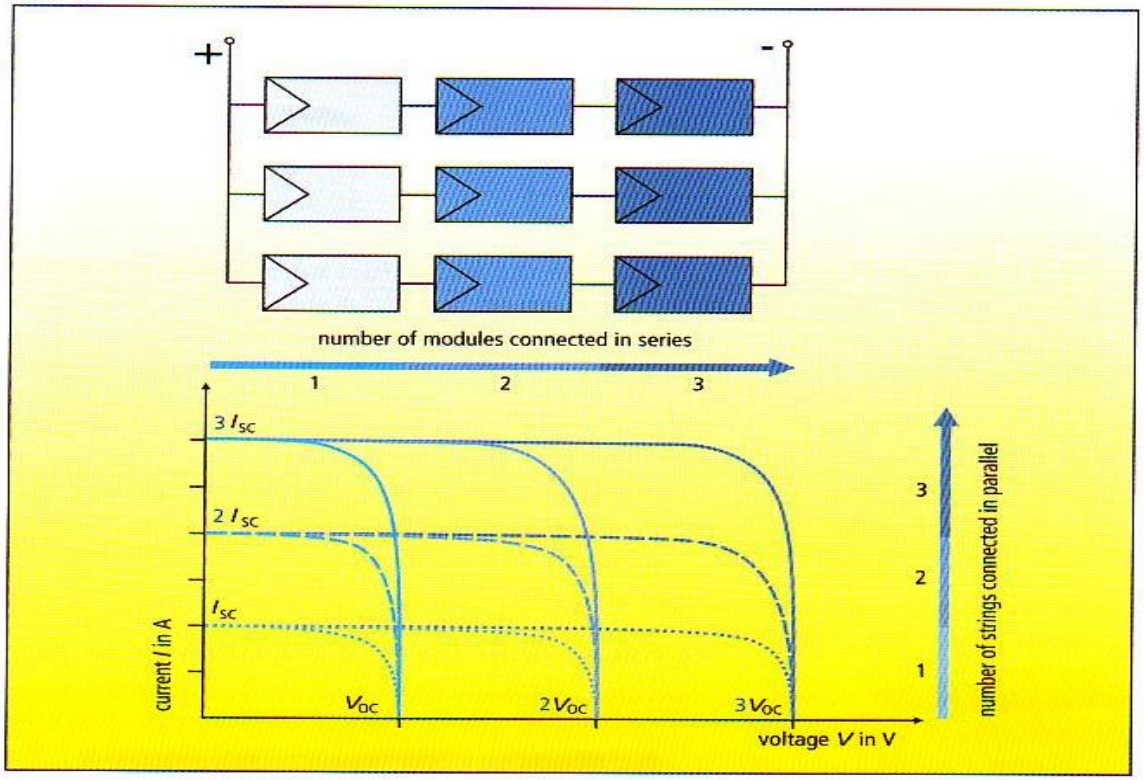


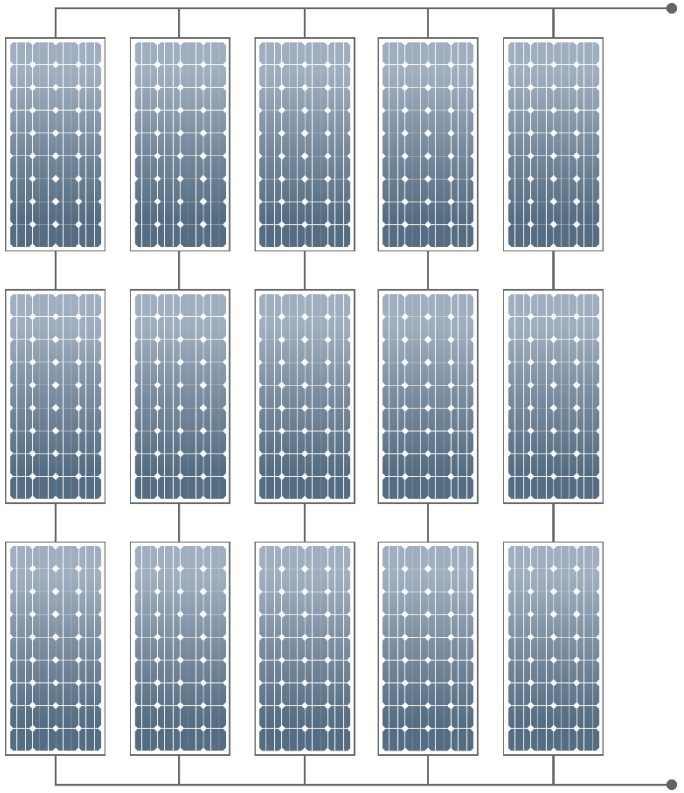
PV Array Modules Connected in Parallel



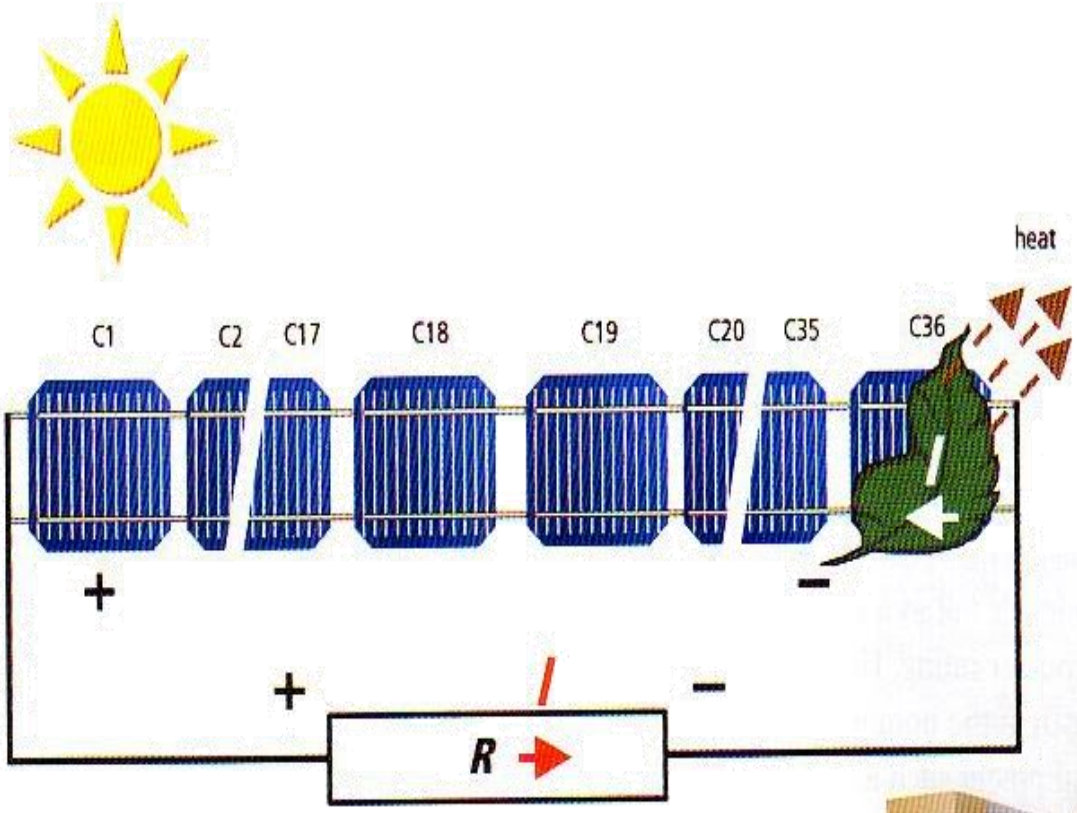


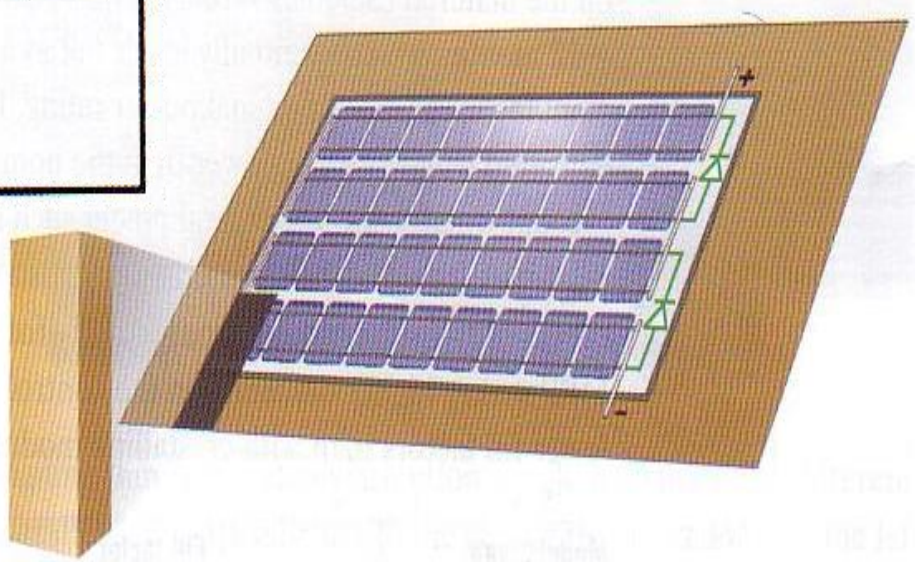
PV Array Modules Connected in Series & Parallel



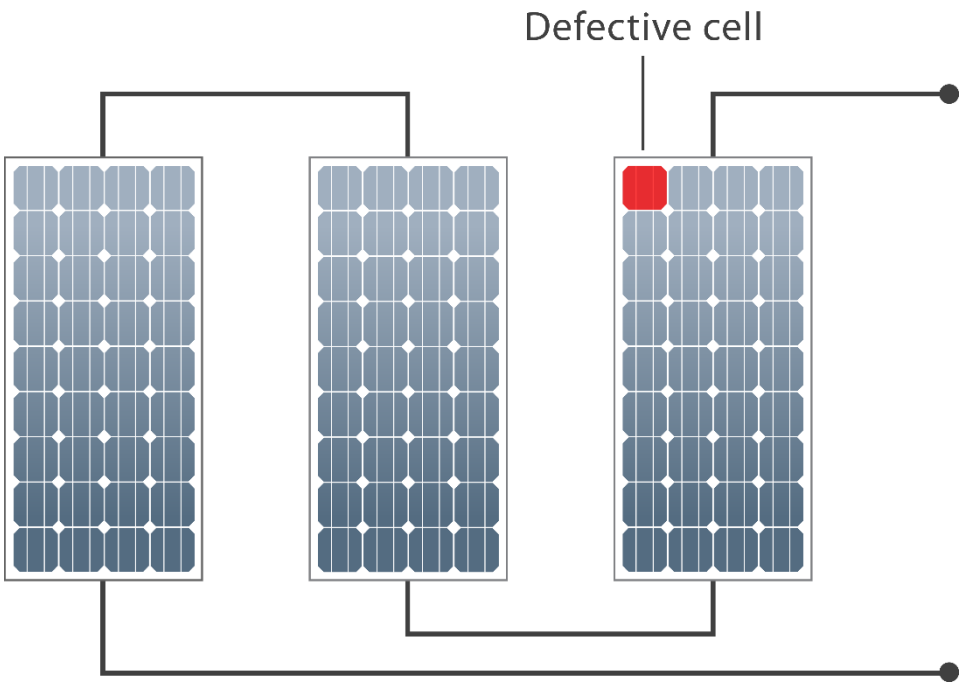


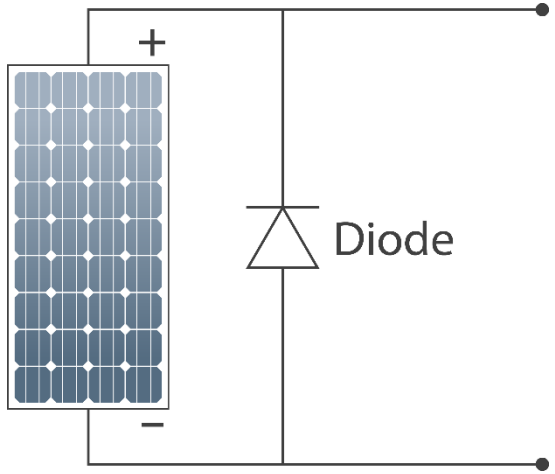
Critical Problem for PV Modules: Shading

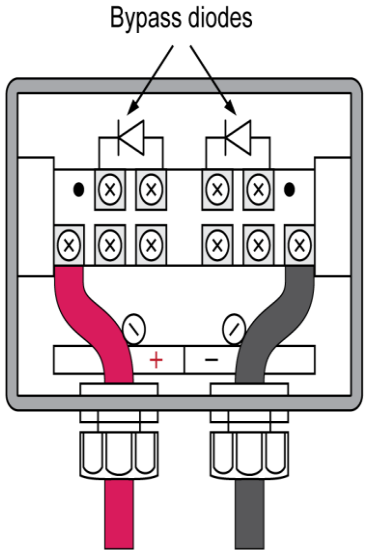




How to Overcome Problem: Use of Bypass Diode

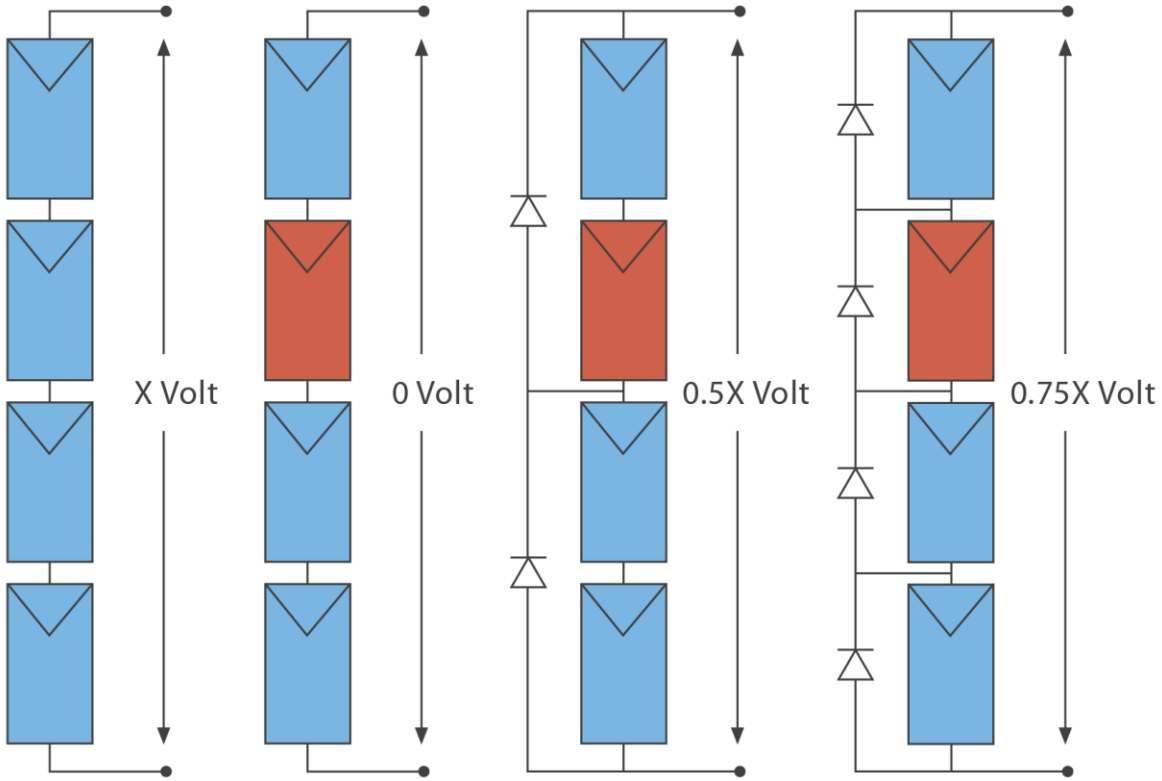






Bypass Diodes

Bypass diodes are found inside solar panels. If a panel is shaded the bypass diode allows current to flow.



BYPASS DIODES 6

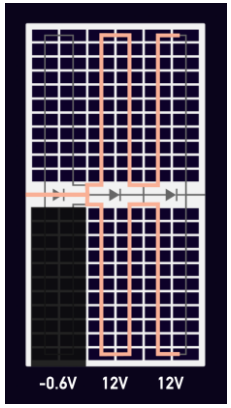
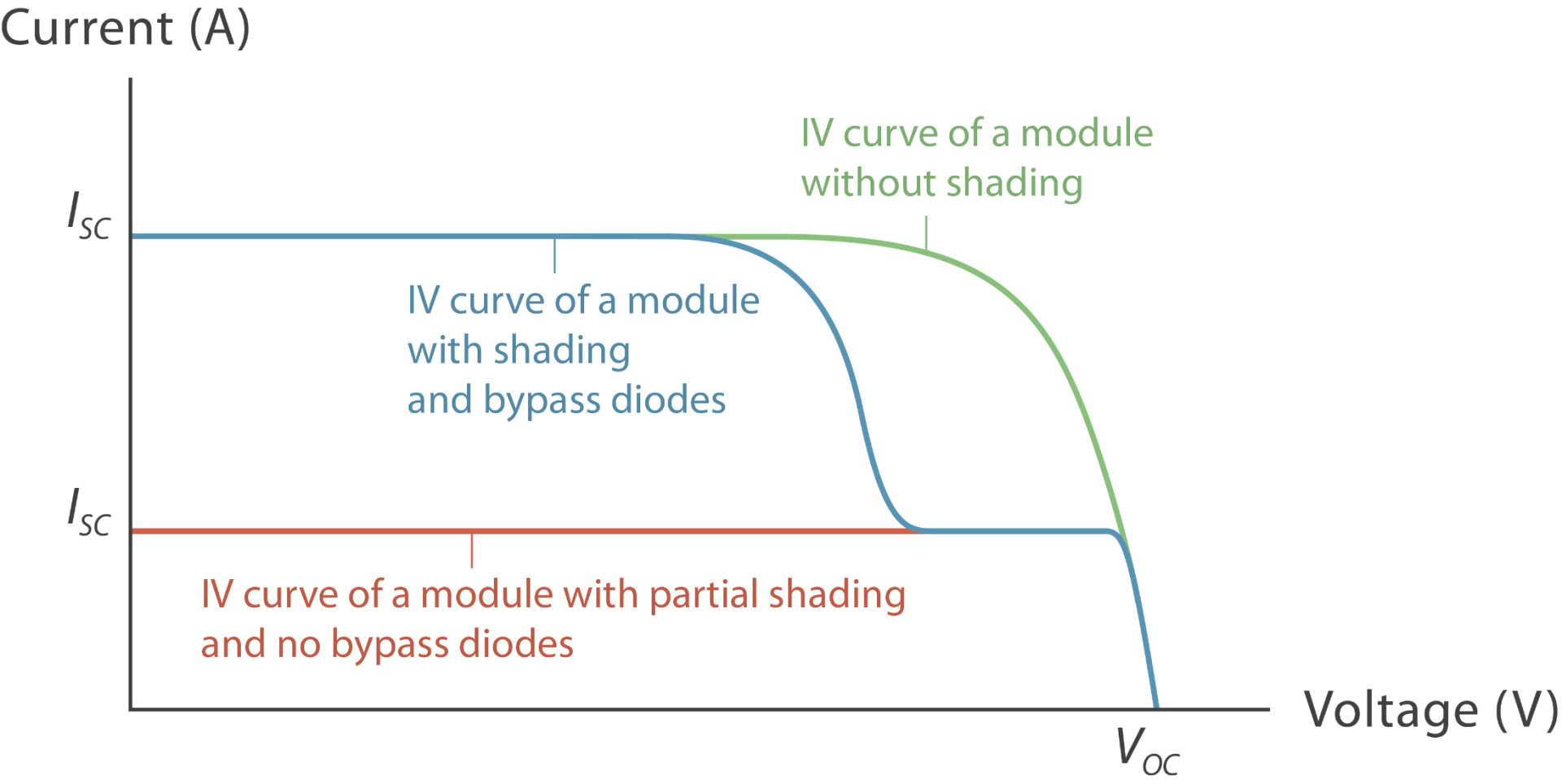


Figure 11 Bypass diode arrangement in half-cut cell module

Half cut cells are configured in such a way that there are 6 substrings, with the cells in each half connected in series, and then each half is connected in parallel. The 3 bypass diodes are situated between each pair of substrings

Effect of Shading



Effect of Shading: Modules in Series