Alternative Energy
Chapter 3 Part 3
Critical Issue about PV module Performance

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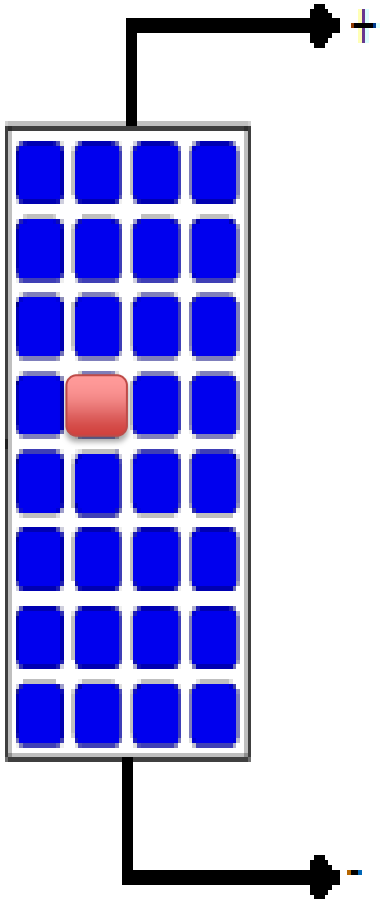
Chapter Description

- Expected Outcomes
  - understand about the critical issue regarding the PV module performance
- References
  - Grid-connected Solar Electric Systems: The Earthscan Expert Handbook by Geoff Stapleton and Susan Neill, 2010.
  - Stand-alone Solar Electric Systems: The Earthscan Expert Handbook for Planning, Design and Installation by Mark Hankins, Earthscan, 2010.

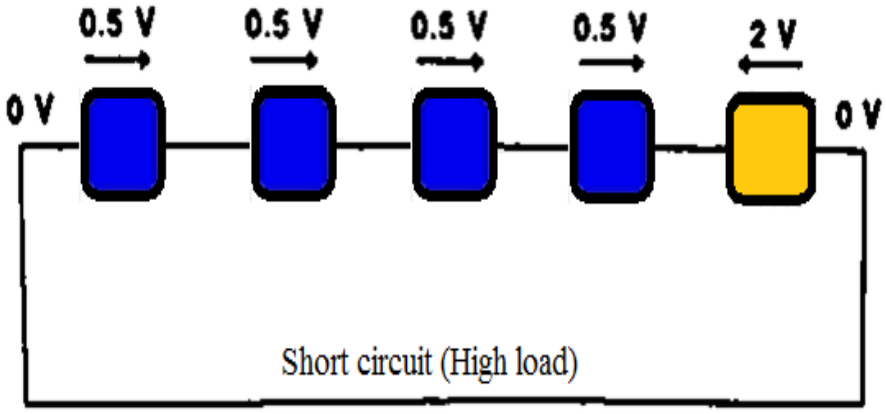
Hot spot

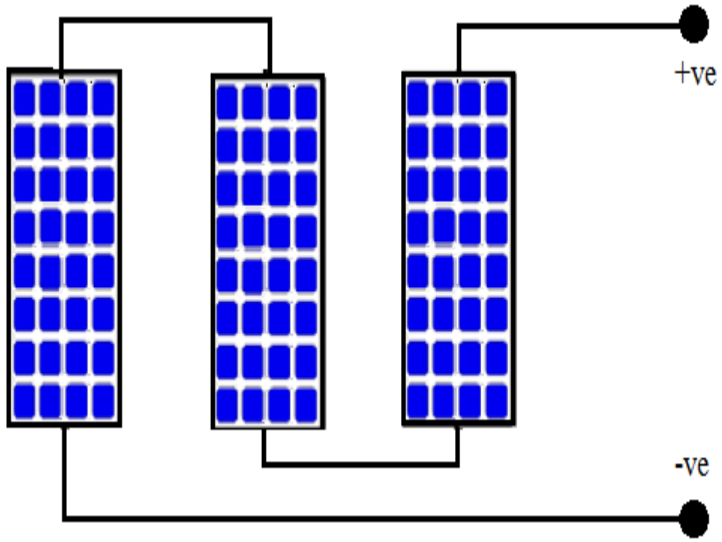
- Consider the scenario where one or several cells in a module or string of modules get shaded and/or faulty
- As a result, the current from the whole module or string will be reduced
- Worse still, the rest of the current in the module or string will force current through the damaged cell/s raising its temperature to further damage
- This is called hot spot formation and it must not be allowed to happen



Hot spot

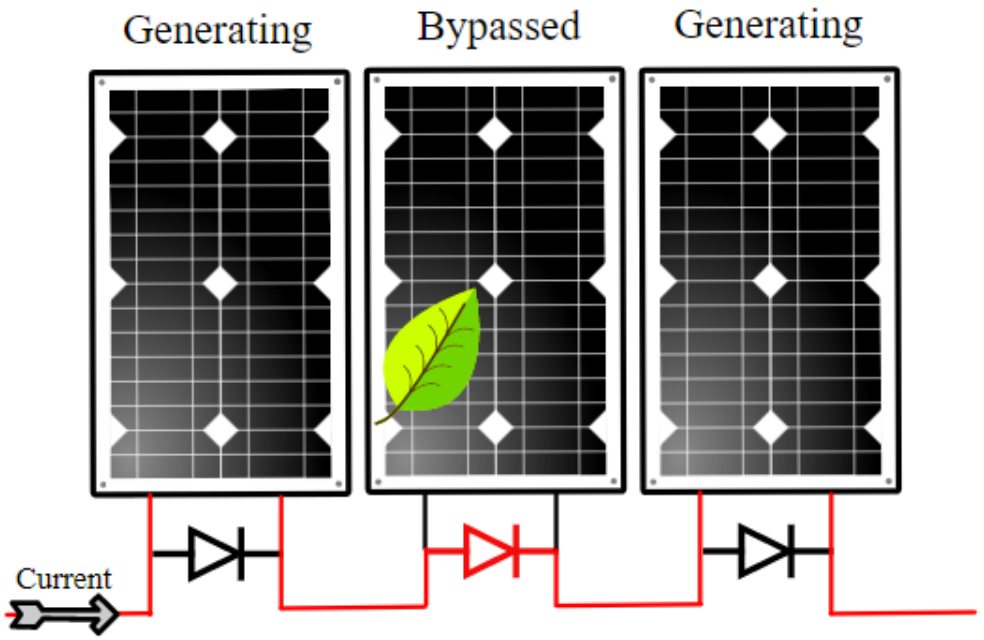
- Because the cells in the module are connected in series and a cell is damaged (or some cells are shaded)
- Then the current from the whole module is reduced. If the same module forms part of an array then the current from the array will be reduced as well





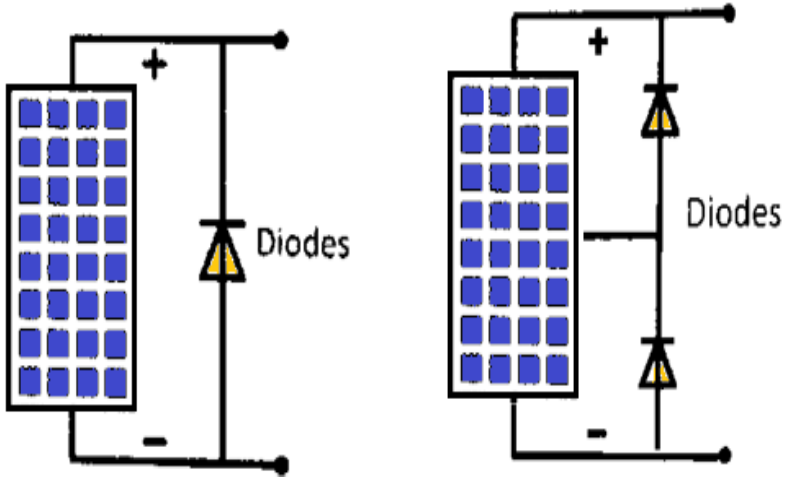
Hot spot: Solution

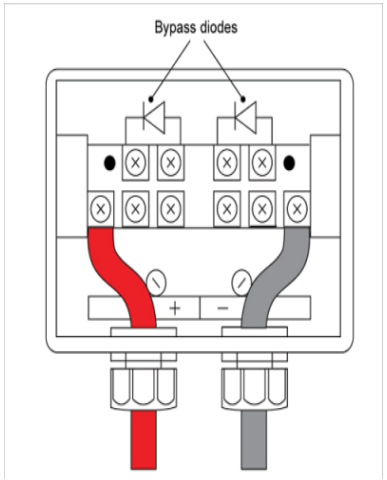
- Bypass diode can be used to minimize or eliminate the formation of hot spots
- If the cell/module is defective/ shaded, the polarity is reversed, causing the diode to conduct (shunt) any current flow



Hot spot: Solution

- Some manufacturers provide a bypass diode across a string of 18 cells, i.e. the module has 2 diodes with a total of 36 cells.
- In series connection, each module should have at least one bypass diode fitted.

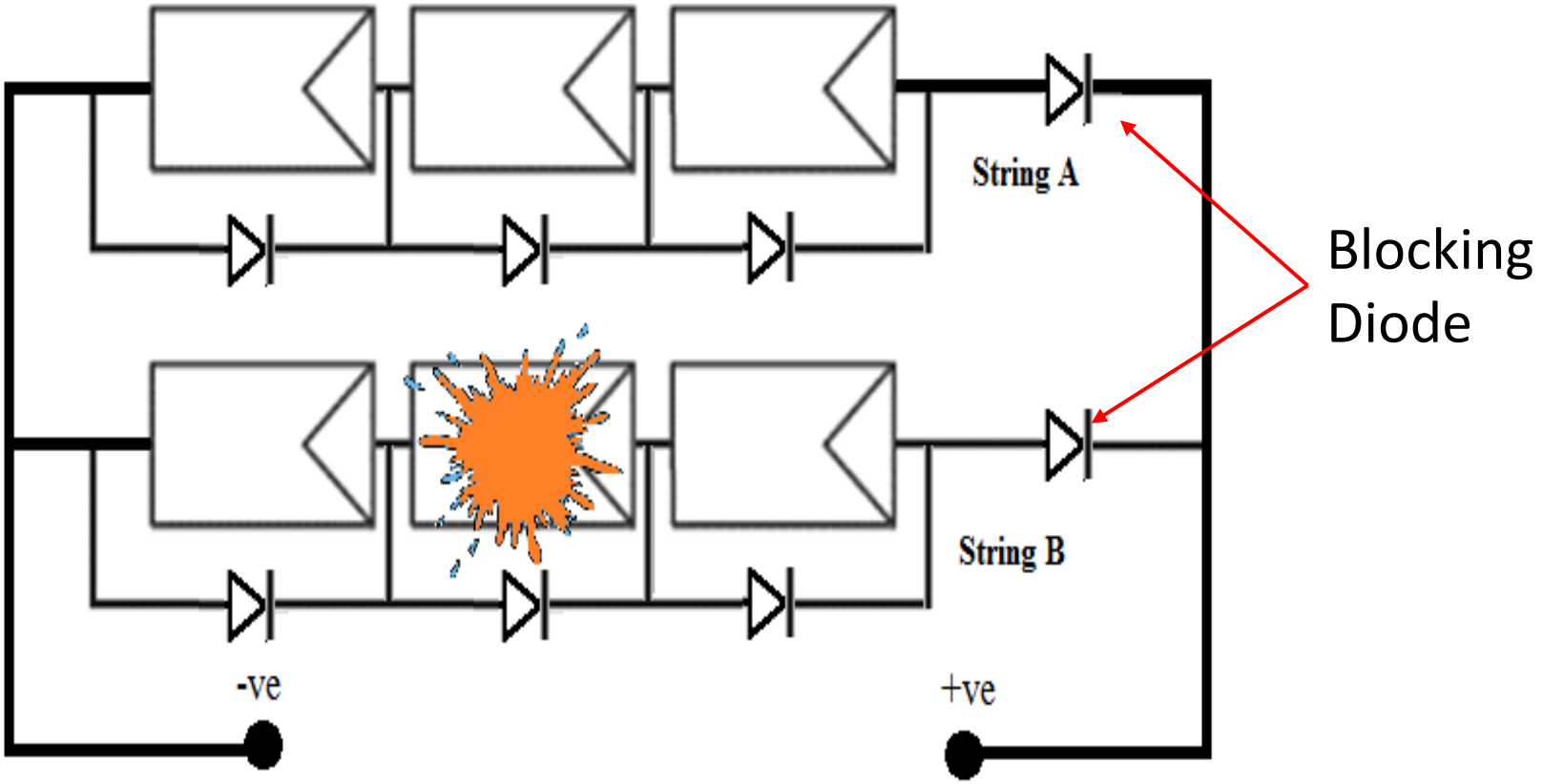




Blocking Diode

- If the PV system uses battery for energy storage, when there is no power generated by the PV module the current from the battery may find its way into the module with adverse effects.
- To prevent this, a blocking diode should be installed to prevent reverse current
- Blocking diodes (also known as series or isolation diodes) conduct current during normal system operation and placed in series with the PV module or PV string
- The main purpose is to prevent current from flowing backwards through the modules at night and to prevent current flowing into the faulty parallel cell/module

Blocking Diode



Placement of blocking diode

Diode selection

- **Two** major parameters in diode selection are:
  - ✓ Maximum continuous forward current (I_R) – The current that the diode will allow in forward direction
  - ✓ Maximum reverse voltage (V_R) – The voltage that the diode will tolerate in reverse direction before failure
- Forward voltage drop across the diode should be considered
- The voltage drop of a silicon diode at its rated current is 0.6 to 0.7 V, so the diode will consumes about 3.6 W at 6 A (6 x 0.6).
- Note: Diodes with ratings of 6 A and 600 V are commonly used as bypass and blocking diodes.

Module reliability

- The solar PV module in operation is exposed to extreme and harsh conditions, especially the weather.
- So, it must be able to withstands the weather variations and perform as expected.
- To meet up to these expectation, the module has to undergo several tests such as:
  - Thermal cycling – which occurs when the module is exposed to the variations in temperature from clay to night
  - Humidity and freezing
  - Cyclic pressure loads – caused by gusting winds
  - Twisting of the mounting surface – caused by mounting the modules on a non-planar surface
  - Hail testing – ice balls are projected at high speed onto the module surface.

Module reliability

- In addition, the PV modules are often constructed with aluminium frame and tempered glass cover over its active surface.
- The cell itself is covered in an encapsulant of ethylene vinyl acetate (EVA) with one or more protective rear surface layers.
- With these, the PV module life is typically more than 25 years.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