3.10 EFFICIENCY OF SOLAR CELLS:

- Energy conversion efficiency (h) is defined as the ratio of power output of cell (in watts) at its maximum power point (P_{MAX}) and the product of input light power (E, in W/m^2) and the surface area of the solar cell (S in m^2) under standard conditions

  η= maximum output power/(irradiance × area) = $P_{MAX}/(E \times S)$

- The performance of a photovoltaic device defines the prediction of the power thatthe cell will produce. Current–voltage (I–V) relationships, which measure the electrical characteristics of solar cell devices, are represented by I–V curves.

- These I–V curves are obtained by exposing the cell to a constant level of light while maintaining a constant cell temperature, varying the resistance of the load, and measuring the current that is produced.

- By varying the load resistance from zero (a short circuit) to infinity (an open circuit), researchers can determine the highest efficiency as the point at which thecell delivers maximum power.

- The power is the product of voltage and current. Therefore, on the I–V curve, the maximum power point (P_{MAX}) occurs where the product of current and voltage is a maximum. No power is produced at the short- circuit current with no voltage or at open-circuit voltage with no current.

- Therefore, the maximum power generated is expected to be somewhere between these two points. Maximum power is generated at only one place on the power curve, at about the „knee" of the curve. This point represents the maximum efficiency of the solar device at converting sunlight into electricity.

FILL FACTOR

- Another term defining the overall behavior of a solar cell is the fill factor (FF). It isa measure of squareness of the I–V characteristics of the solar cell and is defined as

FF = Maximum output power/(open-circuit voltage × short-circuit current)

- It is the available power at the maximum power point (P_{MAX}) divided by theproduct of open circuit voltage (V_{OC}) and short-circuit current (I_{SC}) as

$$FF = P_{MAX}/(V_{OC} \times I_{SC}) = (V_{MP} \times I_{MP})/(V_{OC} \times I_{SC})$$

- where V_{MP} and I_{MP} are the voltage and current at the maximum power point.The above equation can be redefined as,

$$FF = (h \times S \times E)/(V_{OC} \times I_{SC})$$

3.10.1 Factors Limiting the Efficiency of the Cell:

1. Wavelength of solar spectrum: Cell response to only a portion of wavelength available in the solar spectrum. Photon with wavelength >1.1 μm does not have sufficient energy to create electron–hole pair in silicon cell.

2. Temperature: Normal operating temperature of silicon cells can reach 60°C in peak sunlight and these temperature decreases the efficiency of the cells. Therefore, it is important to provide heat sinks of the best quality available. Gallium arsenide cells are capable of operating at high temperature where focused energy can be used.

3. Mounting of the cells: It should be to a heat sink (usually an aluminium plate) either heat conductive but electrically insulated. This will reduce operating temperatures and make the cell more efficient. In case free water source is available, heat sinks can be water cooled.

4. Arrangement and maintenance of solar cell: The negative side of the cells usually faces the sun and has antireflection coatings. These coatings should be protected from dust, bird dropping, by a clear plastic or glass cover. Accumulated

dust on the cover will reduce the output power by about 10%.

5 Position of the cell: The cell or panel should be positioned either facing southin the north of equator or facing north in the south of equator for maximum power output and fixed panel applications. The angle off the ground should be equal to the latitude of the place for year around average or can be changed monthly to face the sun at noon for more efficiency.