3.11 PHOTOVOLTAIC PANELS (SERIES AND PARALLEL ARRAYS):

- As single solar cell has a working voltage and current of about 0.5 V and 50 mA, respectively, they are usually connected together in series (positive to negative) to provide larger voltages. Parallel connection of several strings of cells will give rise to higher current output compared with single series string of cells.
- Photovoltaic panels (as shown in Fig) are made in a wide range of sizes for different purposes. They generally fall into one of three basic categories:
- Low voltage or low power panels are made by connecting between 3 and 12 small segments of amorphous silicon photovoltaic with a total area of a few square centimetres for voltages between 1.5 and 6 V and outputs of a few milliwatts. Although each of these panels is very small, the total production is large. Theyare used mainly in watches, clocks and calculators, cameras, and devices for sensing light and dark, such as night lights.
- Small panels of 1–10 W and 3–12 V, with areas from 100 cm^2 to 1,000 cm^2 are made by either cutting 100 cm^2 single or polycrystalline cells into pieces and joining them in series, or by using amorphous silicon panels. The main uses arefor radios, toys, small pumps, electric fences, and trickle charging of batteries.
- Large panels, ranging from 10 to 60 W, and generally either 6 or 12 V, with areas of 1,000 cm^2 to 5,000 cm^2 are usually made by connecting from 10 to 36 full-sizedcells in series. They are used either separately for small pumps and caravan power (lights and refrigeration) or in arrays to provide power for houses, communications, pumping, and remote area power supplies (RAPS).
- If the load resistance is very low, the cell acts as if it is shortened at the output oflight falling on it. If the load resistance is very high, the cell acts as if it is open- circuited and the voltage rises very rapidly to maximum voltage. The current at a voltage is limited by the amount of sunlight and load resistance. This characteristic is ideal for charging battery.
- For charging, a 12 V battery by a 2 cm × 2 cm (0.3 V battery charging voltage),silicon

cells required = 12/0.3 = 40 cells in series string.

- A number of optimal solar array designs are available. However, the arrangement of series–parallel array has been most preferable, as it results in optimal performance characteristic under many conditions including shading, cell failure, non-uniform illumination, and unequal I–V characteristics.
- A diode is placed in series with the positive terminal of battery as shown in Figure. This will prevent reverse current flow (a small battery drain) when the cells are not receiving sufficient light to chary battery.

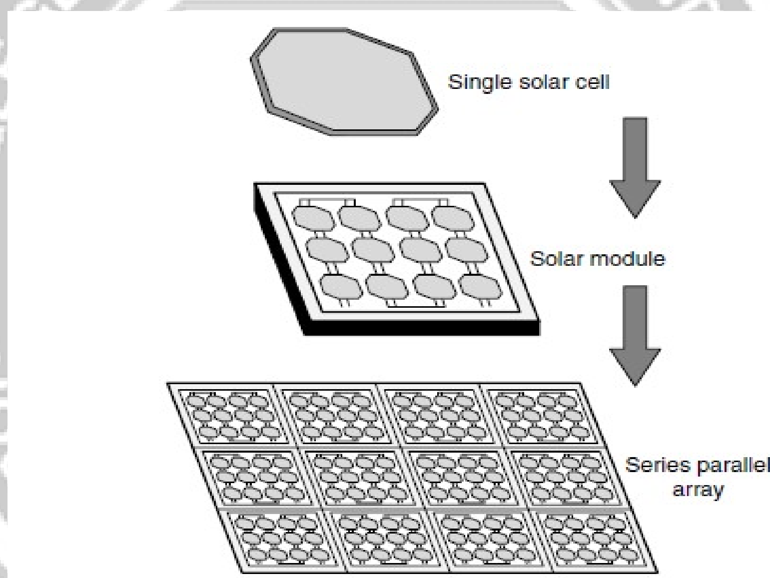

Figure 3.11.1

[Source: "Solar Photovoltaics: Fundamentals,Technologies andApplications" by ChetanSingh Solanki, Page: 285]

3.11.1 Number of Solar Cell Required in Series:

Solar cells must be electrically connected in series to provide the bus voltage (V_B)to the space craft load or batteries and any voltage drops in the blocking diodes (V_D) and in the wiring (Vw).

The required number of cells (N_S) in series is calculated as

$N_S = (V_B + V_D + Vw) / V_{MP}$

V_{MP} = solar cell voltage at maximum power (or battery charging voltage) under operating temperature and intensity. For silicon diode, $V_D = 0.7$ V

3.11.2. Number of Solar Cell in Parallel Strings:

Let NP be the number of parallel strings; I_L is the load current; and I_{MP} is the current corresponding to maximum power point on I–V plot. Therefore,

N_P = (the load current)/(current corresponding to maximum power point on I–V plot.

$$N_P = I_L / I_{MP}$$