Lecture 18: Photovoltaics

Course: MECH-422 – Power Plants

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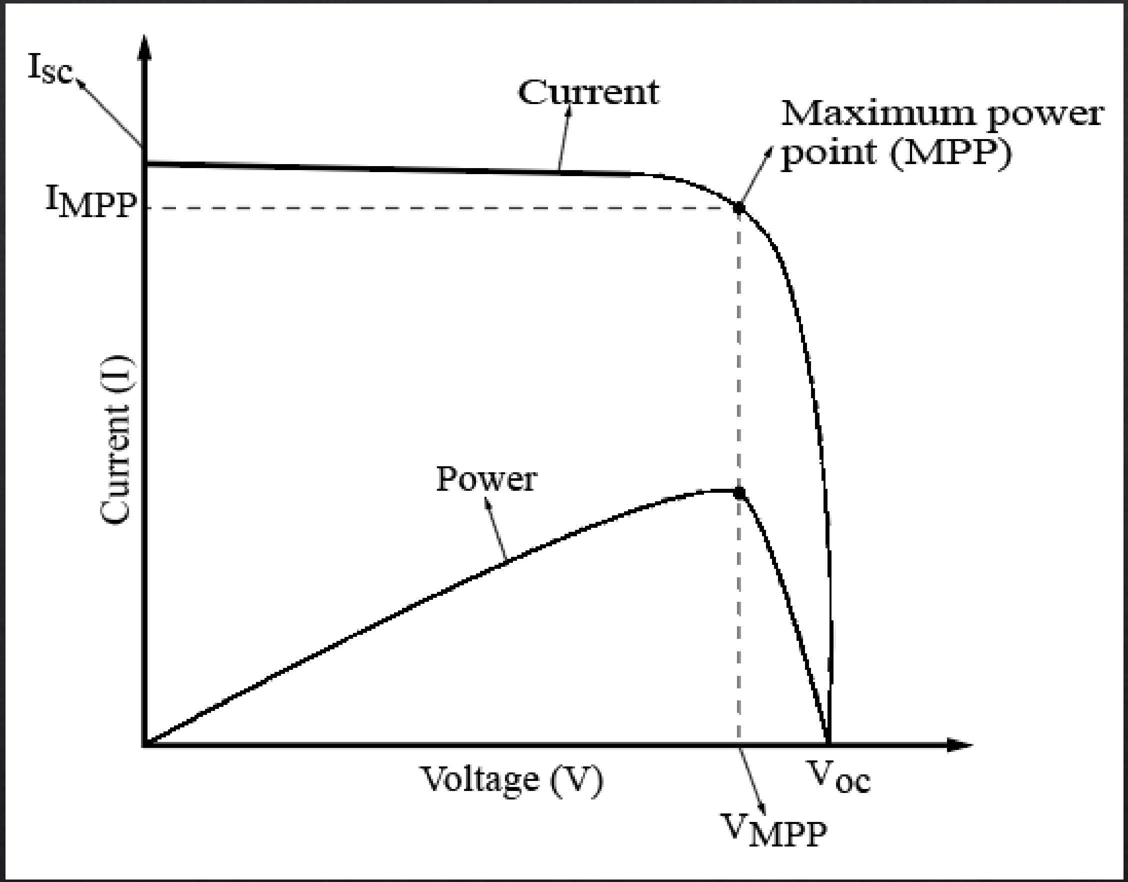
Term: Fall 2021

BUITEMS – DEPARTMENT OF MECHANICAL ENGINEERING

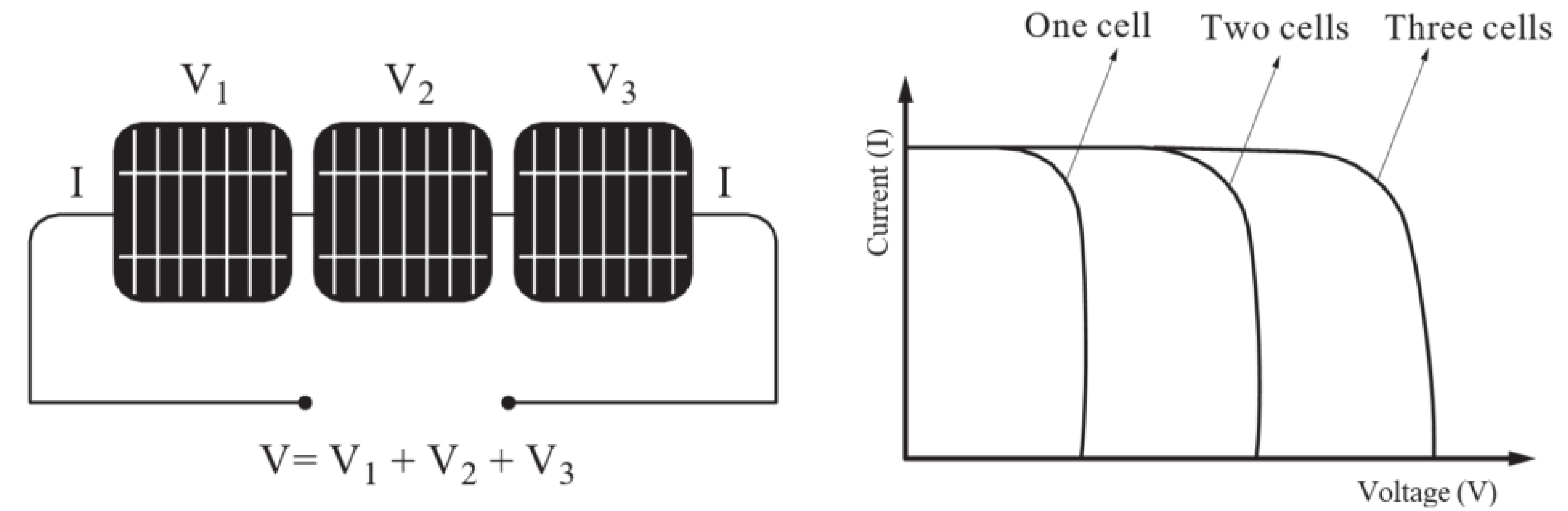
The current when the resistance of the load is reduced to zero so it is called the short-circuit current (ISC)

$$P = \text{Current} \times \text{voltage} = IV$$



Current-voltage (I-V) and power-voltage curves for a solar photovoltaic power generating device showing V_{OC}, I_{SC}, MPP, P_{MPP}, V_{MPP}, and I_{MPP}

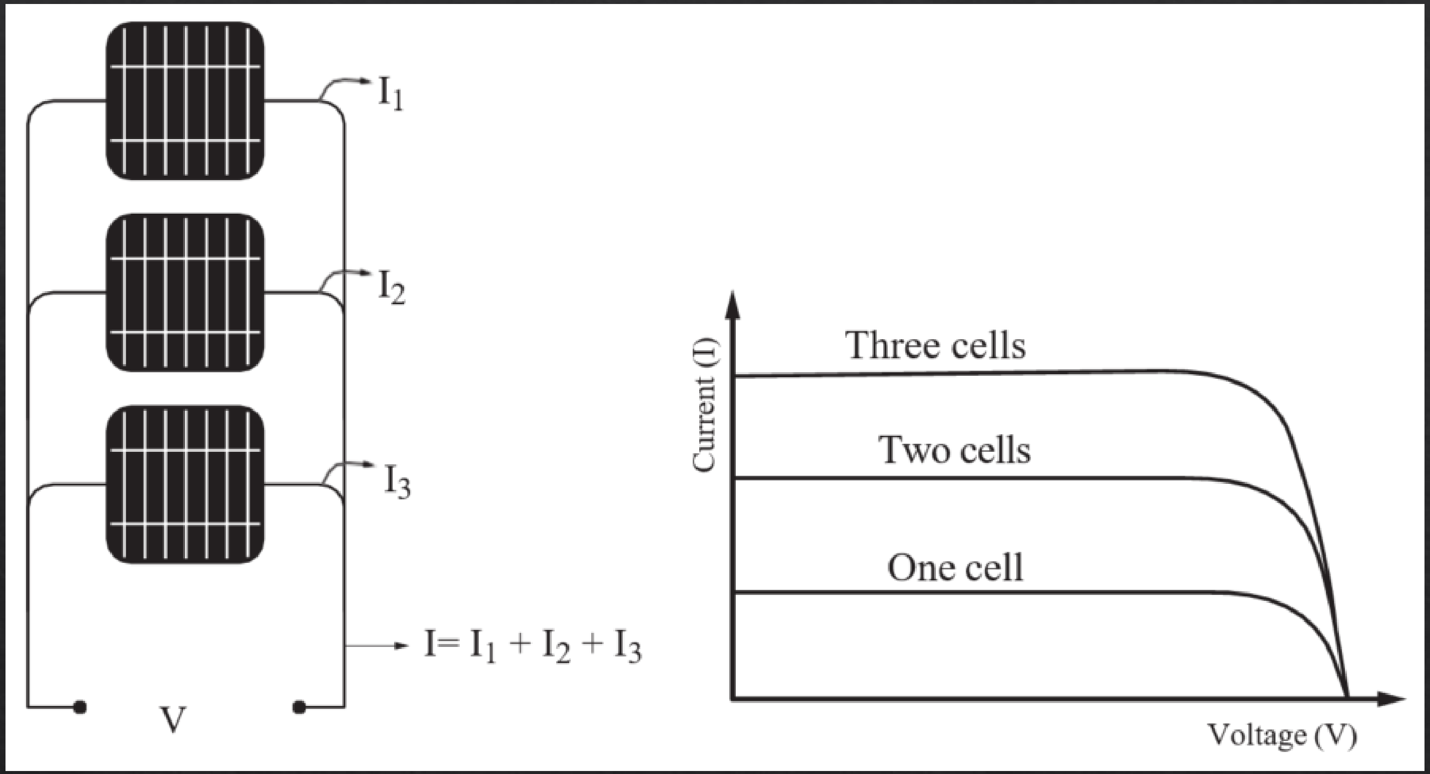
Connecting Solar Cells



Solar cells connected in series and I-V curves of a single cell and when two or three similar cells connected in series

$$I = I_1 = I_2 = \cdots = I_n$$

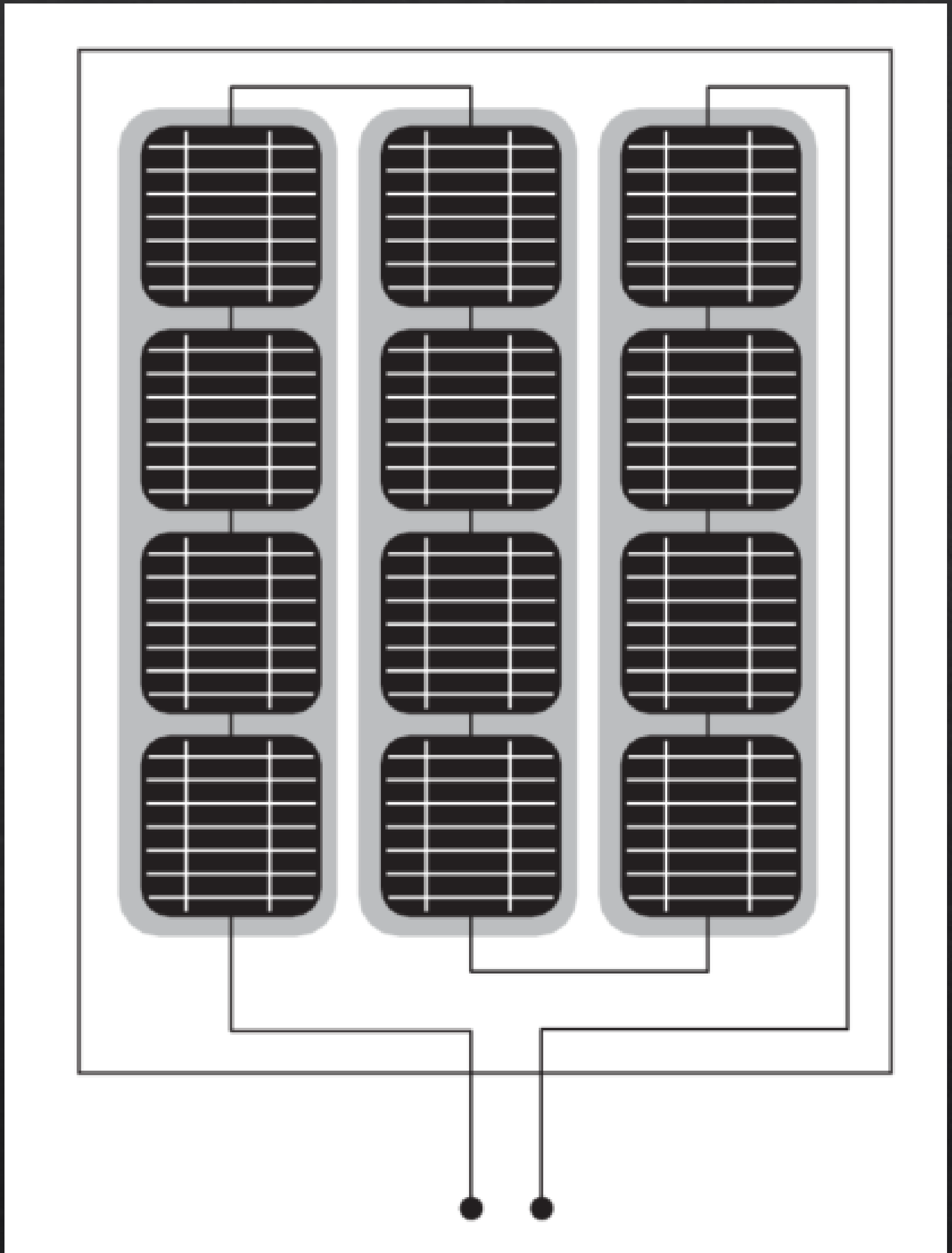
$$V = V_1 + V_2 + \ldots + V_n = \sum_{m=1}^{m=n} V_m$$



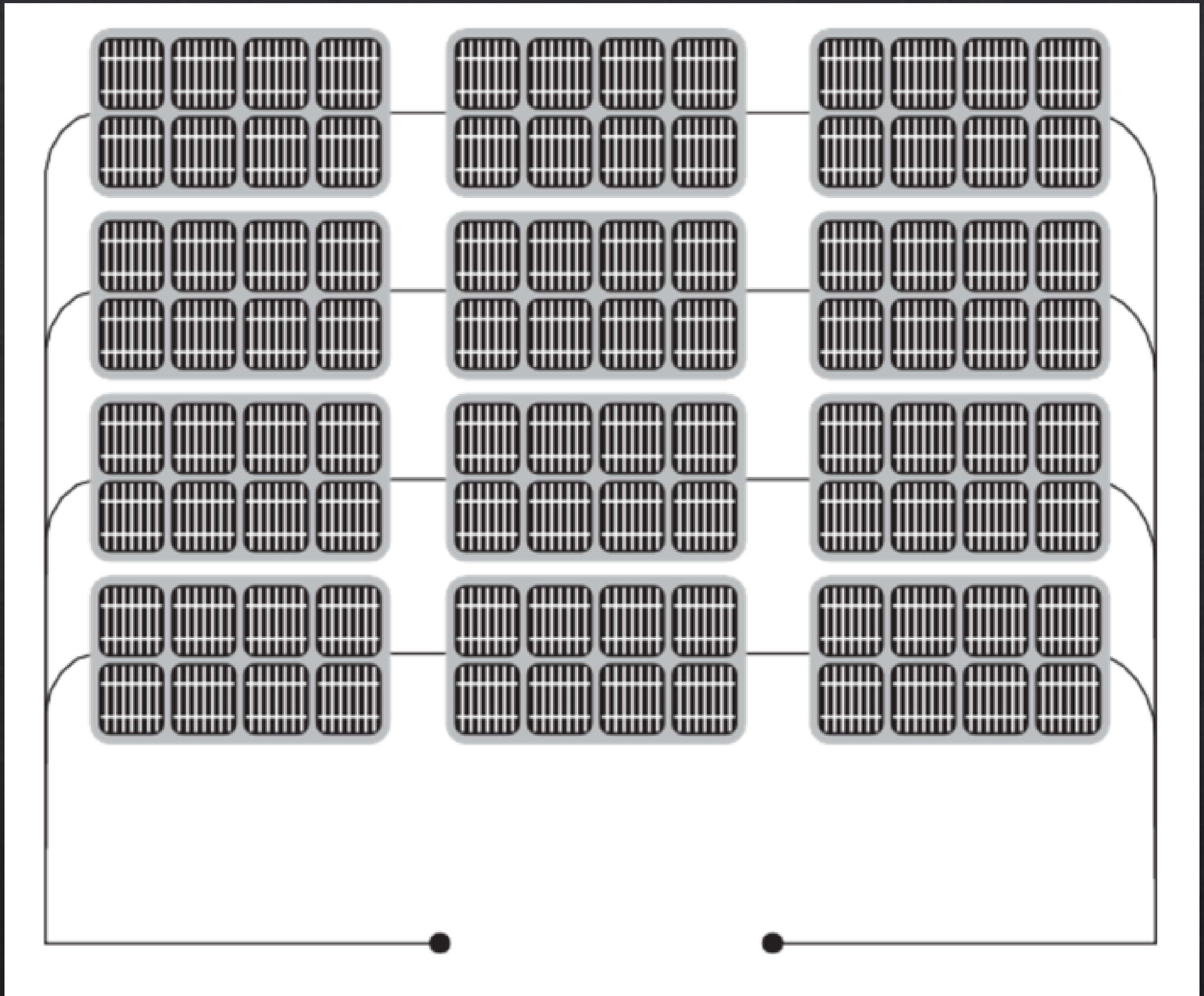
$$V = V_1 = V_2 = \cdots = V_n$$

$$I = I_1 + I_2 + \cdots + I_n = \sum_{m=1}^{m=n} I_m$$

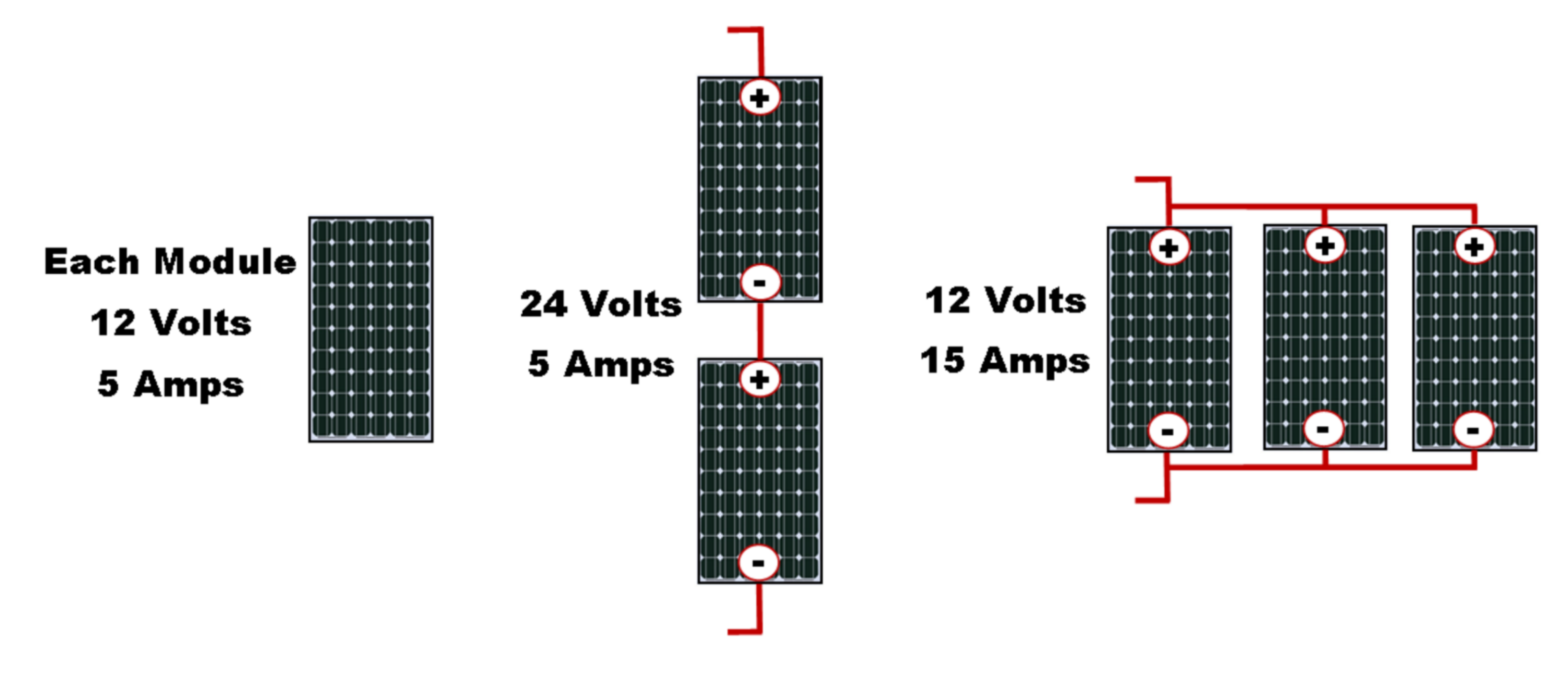
Solar cells connected in parallel and I-V curves of a single cell and when two or three similar cells connected in parallel



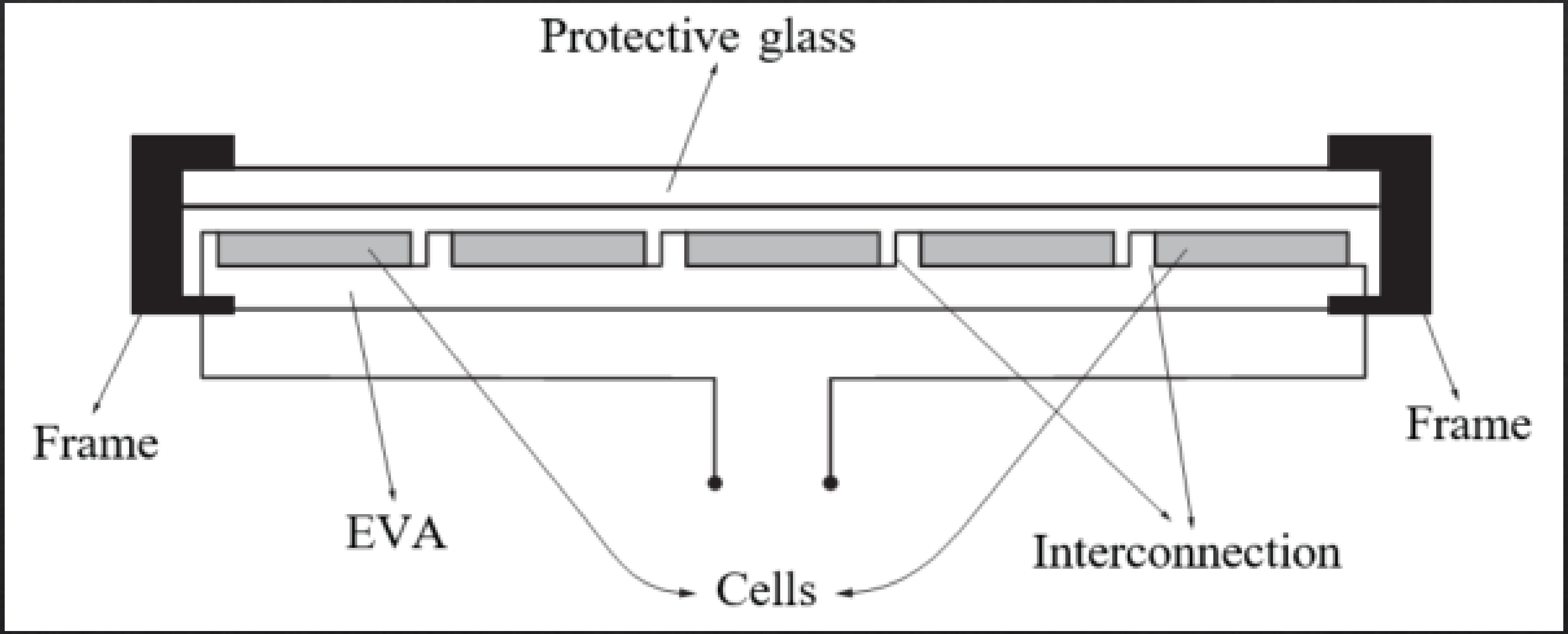
A solar module (panel)



A solar array



Each Module
12 Volts
5 Amps
24 Volts
5 Amps
12 Volts
15 Amps



Schematic of a finished solar PV panel

Example 11.12

Two solar panels are connected once in series and once in parallel. The V_{OC} and I_{SC} of the cells are given as follows. Determine the V_{OC} and I_{SC} when they are connected in series and parallel configurations.

$$V_{OC,1} = 0.55\ \text{V}$$

$$I_{SC,1} = 8\ \text{A}$$

$$V_{OC,2} = 0.5\ \text{V}$$

$$I_{SC,2} = 7\ \text{A}$$

Efficiency of Solar Photovoltaic Units

$$\eta_{\text{Solar unit}} = \frac{\text{Generated electricity}}{\text{Incoming solar energy}} = \frac{I_{\text{MPP}} \times V_{\text{MPP}}}{P_{\text{in}}}$$

standard test conditions (STC)

- **solar irradiance**: 1000 W/m^2
- **operating temperature**: 25°C (77°F)
- **air mass**: AM 1.5 sunlight

Example 11.14

A real-world solar panel manufacturer claims that the efficiency of its solar panels is about 16%. Evaluate this claim if the voltage and current at the maximum power point for the panels are 17.6 V and 7.39 A, respectively. The size of the panel is 0.608 m × 1.367 m. All the given values are at the STC.

Example 11.15

The best efficiency for the commercially available solar panels is about 24%. Determine the required area of solar panels to generate 1 kW peak power using these panels.

Example 11.21

A building energy audit resulted in the following table. Determine the annual electricity consumption of the building.

Device	Number of Device	Rated Power (W)	Usage Hours per Day (h)
Fluorescent lights	6	20	4
Air condition unit	1	250	8
Computer	2	150	5
Microwave	1	450	0.5
Coffee maker	1	900	0.5

Analysis

The annual electricity consumption of each group of appliances can be determined by multiplying their rated power, usage hours, and number, as reflected in the table below.

Device	Number of Device	Rated Power (W)	Usage Hours per Day (h)	Annual Electricity Consumption (kWh/year)
Fluorescent lights	6	20	4	480
Air condition unit	1	250	8	2000
Computer	2	150	5	1500
Microwave	1	450	0.5	225
Coffee maker	1	900	0.5	450
				Total: 4655

Example 11.24

A solar farm with the rated capacity of 3 MW can generate power at this rate for on average 5.5 hours a day. Determine the annual electricity generation of the system in MWh.

Commercial Software Tools to Simulate Performance of Solar PV Units

- System Advisor Model (SAM)[42]
- PVsyst
- HOMER
- RETScreen
- Helioscope

- TRANSYS
- ESP-r
- PV F-Chart
- SolarDesignTool
- PV*SOL
- SOLARGIS
- INSEL

- SolarPro
- PV DesignPro-G
- SOLSIM
- PVLib
- iHOGA
- iGRHYSO

Extra Learning Resources: See page 862 & 863 from Textbook

End of Lecture!