Solutions to Chapter 6:

Exercise 6.1: Short Circuit Current and Open Circuit Voltage for a Variation of the Irradiance

a) $$n_{\text{Cells}} \approx \frac{V_{\text{OC\_Module}}}{V_{\text{OC\_Cell\_typical}}} = \frac{43.2\ \text{V}}{0.6\ \text{V}} = \underline{72\ \text{cells}}$$

b) $$I'_{\text{SC}} \approx \frac{E'}{E} \cdot I_{\text{SC}} = \frac{500}{1000} \cdot 10\ \text{A} = \underline{5\ \text{A}}$$

c) With Equation (4.16): $V_{\text{OC}} = n_{\text{Cells}} \cdot m \cdot V_{\text{T}} \cdot \ln \frac{I_{\text{SC}}}{I_{\text{S}}}$

$$\Rightarrow V'_{\text{OC}} = n_{\text{Cells}} \cdot m \cdot V_{\text{T}} \cdot \ln \frac{I'_{\text{SC}}}{I_{\text{S}}} = n_{\text{Cells}} \cdot m \cdot V_{\text{T}} \cdot \ln \frac{I_{\text{SC}}}{I_{\text{S}}} \cdot \frac{E'}{E}$$

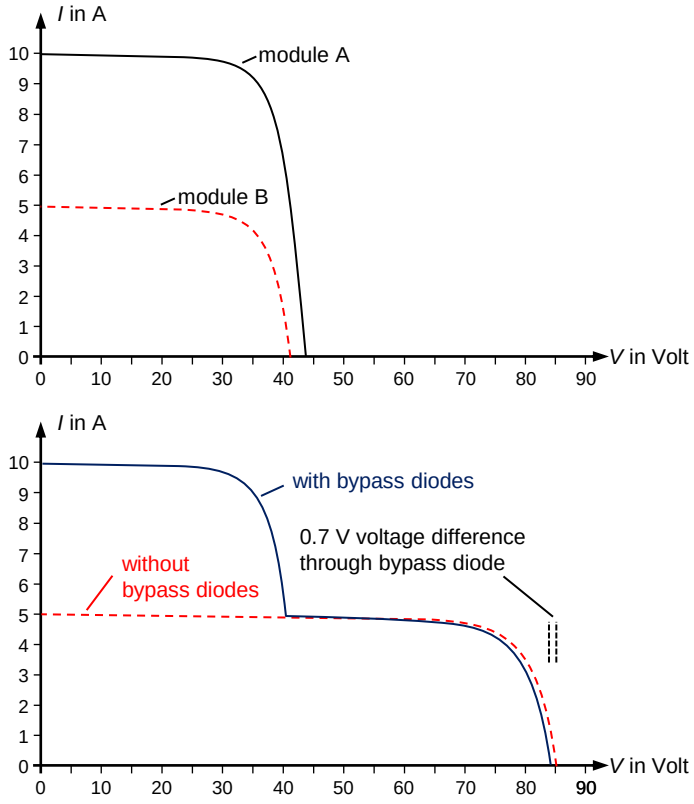
$$\Rightarrow V'_{\text{OC}} = n_{\text{Cells}} \cdot m \cdot V_{\text{T}} \cdot \ln \frac{I_{\text{SC}}}{I_{\text{S}}} + n_{\text{Cells}} \cdot m \cdot V_{\text{T}} \cdot \ln \frac{E'}{E} = V_{\text{OC}} + n_{\text{Cells}} \cdot m \cdot V_{\text{T}} \cdot \ln \frac{E'}{E}$$

$$\Rightarrow V'_{\text{OC}} = 43.2\ \text{V} + 72 \cdot 1.5 \cdot 26\ \text{mV} \cdot \ln(0.5) = 43.2\ \text{V} - 1.9\ \text{V} = \underline{41.3\ \text{V}}$$

Exercise 6.2: Series Connection of Modules

a) 1. Prevention of overheating of shaded cells (hotspots)
2. Securing that in case of shading of a module not the whole string turns out

b) Characteristic curves:



Exercise 6.3: *NOCT*

a) Nominal Operating Cell Temperature.
This is the cell temperature which sets up under the following conditions:
E = 800 W/m^2; ϑ_A = 20 °C; v_{Wind} = 1 m/s.

b) Given: P_{STC} =102.5 Wp, *NOCT* = 45 °C.

With Equation (6.8): $\vartheta_{Cell} = \vartheta_A + (NOCT - 20\ °C) \cdot \frac{E}{E_{NOCT}} = 30\ °C + (45\ °C - 20\ °C) \cdot \frac{900}{800}$

$\Rightarrow \vartheta_{Cell} = 30\ °C + (25\ K) \times 1.125 = \underline{58.125\ °C}$

$$P' = P_{STC} \cdot \left[1 + TC_P \cdot (\vartheta - \vartheta_{STC})\right] = 102.5\ W \cdot \left[1 - 0.25\ \%/K \cdot (58.125\ °C - 25\ °C)\right] = \underline{94.01\ W}$$

Exercise 6.4: Mismatching

a) Mismatching means „wrongly put together“. This always arises when modules of different voltages are connected in parallel of modules of different currents are connected in series. The total power of the solar generator then is always smaller than the sum of the single module powers:

b) See figures 6.20 and 6.21 and accompanying text.