Solutions to Chapter 7:

Exercise 7.1: Buck Converter

a) See Figure 7.4.

- Capacitor C_1: In case of a solar module at the input the capacitor serves as a buffer storage for the solar energy.
- Mosfet: Serves as a fast, wear-free and controllable switch
- Choke coil L: Ensures a continuous current at the output
- Capacitor C_2: Serves to smooth the output voltage
- Diode D: Flyback diode, which enables that the current an continuously flow even when the Mosfet is switched off

b) In case of a high switching frequency small inductors and capacitors can be used without running into the undesired discontinuous mode.

c) High switching frequencies cause higher switching losses. Therefore suitable fast, low-loss switches (e.g. of silicon-carbide) should be used.

Exercise 7.2: Feed-In Variations

See Figures 7.8 und 7.9.

Exercise 7.3: Inverter Variations

a) See Section 7.2.2.

b) The Current curve is almost exactly sinusoidal and therefore enhances the quality of the grid voltage.

c) i) In the case of thin film modules.
ii) In the case of special c-Si modules (e.g. Sunpower, Evergreen) that can be prone to PID.
iii) In the case of all modules, which are not explicitly approved for the operation with inverters without transformers.

d) It is used when a galvanic isolation is desired and one simultaneously wants to prevent the disadvantages of an inverter with mains transformer (poor efficiency, high weight etc.).

e) i) The grid is symmetrically supplied.
ii) The momentary value of the fed-in power is nearly constant so that only small storage capacitors are necessary in the inverter.
iii) Two additional switching elements (50 % more) facilitate 200 % more power.

Exercise 7.4: Inverter Dimensioning

Data from Table 6.1 and 7.2 as well from Figure 7.22:

Solar module:		Inverter:	
V_{OC} = 29.7 V,	V_N = 24.4 V	V_{DC_N} = 350 V,	V_{MPP} = 333 to 500 V
I_{SC} = 8.7 A,	I_N = 8.1 A	V_{Inv_Max} = 700 V,	I_{Inv_Max} = 25 A
P_N = 200 Wp	TC_U = -0.34 %/K	P_{DC_N} = 8.25 kW,	P_{AC_N} = 8 kW

a) $V_{OC\_(-10°C)} \approx V_{OC} \cdot [1 + TC_U \cdot (\vartheta - \vartheta_{STC})] = 29.7\text{ V} \cdot [1 - 0.34\text{ \%/K} \cdot (-10\text{ °C} - 25\text{ °C})] = \underline{33.2\text{ V}}$

$$n_{Max} = \frac{U_{Inv\_Max}}{V_{OC\_(-10°C)}} = \frac{700\text{ V}}{33.2\text{ V}} = 21.1 = \underline{21\text{ modules}}$$

b) $V_{MPP\_Modul(70°C)} \approx V_{MPP} \cdot [1 + TC_U \cdot (\vartheta - \vartheta_{STC})] = 24.4\text{ V} \cdot [1 - 0.34\text{ \%/K} \cdot (70\text{ °C} - 25\text{ °C})] = \underline{20.7\text{ V}}$

$$n_{Min} = \frac{V_{MPP\_Min}}{V_{MPP\_Modul(70°C)}} = \frac{333\text{ V}}{20.7\text{ V}} = 16.1 = \underline{17\text{ modules}}$$

c) $n_{String\_Max} = \frac{I_{Inv\_Max}}{I_{String\_Max}} = \frac{I_{Inv\_Max}}{1.25 \cdot I_{MPP}} = \frac{25\text{ A}}{1.25 \cdot 8.1\text{ A}} = 2.5 = \underline{2\text{ strings}}$

Thus, minimum 1 x 17 modules and maximum 2 x 21 = 42 modules can be installed.

d) With regard to the power dimensioning a design factor of maximum 1 is recommended. With Equation (7.21) this leads to:

$\Rightarrow P_{STC} \leq 1 \cdot P_{AC\_N} = 8\text{ kW}$

Therefore, the optimal plant configuration comprises tow strings with 20 modules each. Possible were also 19 per string or - if necessary - 21 modules per string.