

**1. Rectifier**

The grid phase voltage (u) and grid current (i) are shown in Fig. 1

- a) What is the used rectifier topology according to the DC voltage waveform shown in Fig. 1?
- b) Draw the used rectifier topology
- c) Sketch the waveform of the DC voltage as a function of time (use template in p. 4)
- d) Calculate the average output voltage value
- e) What should be the maximum peak repetitive reverse voltage rating of the power semiconductor switching components used in the rectifier if 1.5 safety margin is used?
- f) What is the lowest frequency of the produced grid current harmonic component?

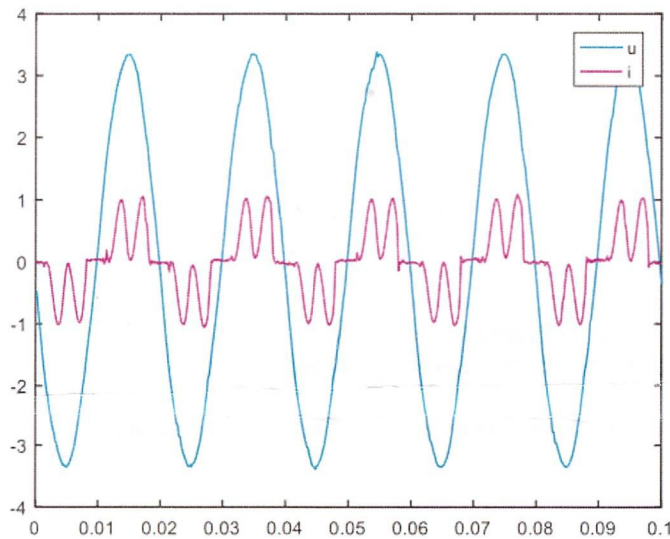
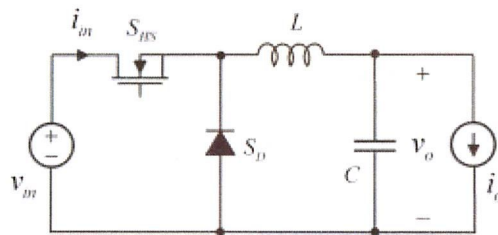
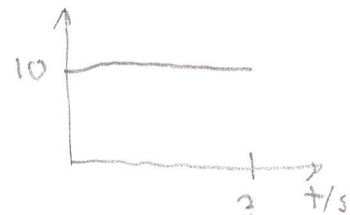


Fig. 1. Measured grid phase voltage (amplitude \*100) and grid current (amplitude\*10)

**2. Ideal boost converter**

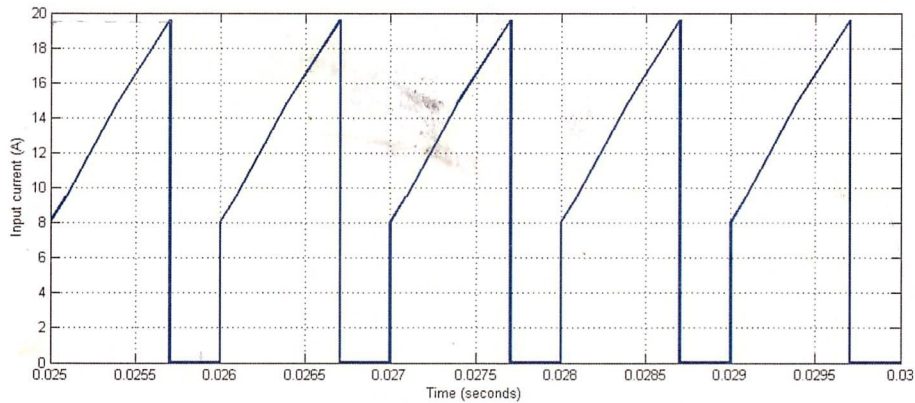
Ideal buck converter is shown in Fig. 2a and the input current waveform is shown in Fig. 2b. Input voltage is 100V. Assume that the capacitor voltage ripple is negligible.

- a) What is the average input current?
- b) What is the average output voltage?
- c) What is the inductance L value?
- d) What is the average capacitor current?
- e) What is the average diode current?
- f) Sketch the diode current waveform



$$\frac{1}{2} \int_0^2 10 dt = 10 \cdot \frac{1}{2} [2-0] = 10$$

Programmable calculator allowed 5 questions/ á 6 p  
 Answers in English or in Finnish allowed  
 Return the waveform template (p.4 of the exam)



b)

Fig 2. a) Ideal buck converter and b) input current

### 3. The frequency converter

The frequency converter of a three-phase synchronous motor is shown in Fig. 3.

- Why the resistor  $R_s$  and the switch  $S_s$  are connected to the circuit?
- Why the capacitor  $C_{dc}$  is connected to the circuit?
- Why the diodes are connected antiparallel with the IGBTs?
- Why the inductance  $L$  is connected in the grid side?
- Is it possible to supply the regenerative power of the motor back to the grid by using this circuit?
- Why the switch  $S_b$  and an external resistor between  $b_+$  and  $b_-$  are connected to the circuit?

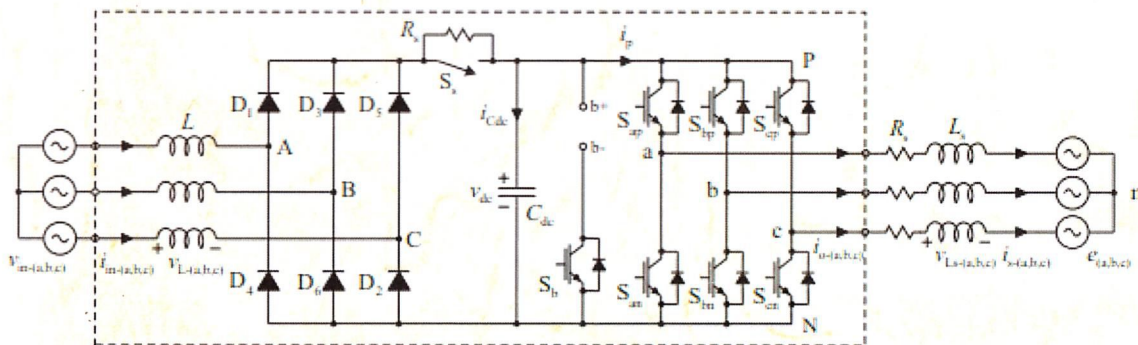


Fig 3. Schematic diagram of a conventional frequency converter

### 4. Single-phase inverter

The single-phase DC/DC converter and inverter is used in the solar power system shown in Fig. 4a. The power-voltage characteristics of a PV module is shown in Fig. 4b.

- What is the minimum DC voltage  $u_{dc-link}$  if the system is grid connected (230 V<sub>rms</sub>, 50Hz) and if two-level half-bridge inverter is used?
- Why DC/DC converter is added between solar power panel and inverter?
- What kind of DC/DC converter is required? Draw the converter.
- What is the duty cycle of the DC/DC converter in the maximum power point in summer? Minimum DC voltage is produced.
- What is MPPT shown in Fig. 4a?