

1. A simplified ideal single-phase diode rectifier circuit is shown in Fig. 1.

Assume that the supply voltage is sinusoidal (RMS value 230V at 50 Hz). Suppose the components to be ideal (power losses are not taken into account).  $I_d = 10A$ .

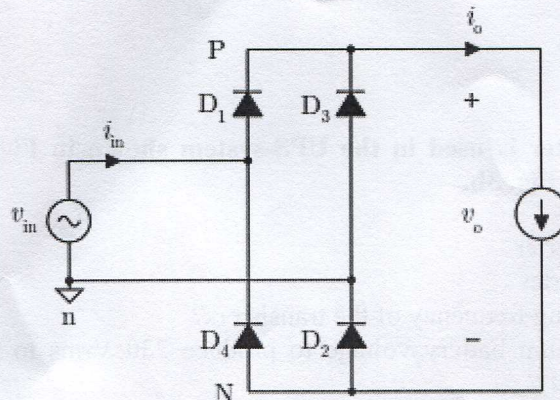


Fig. 1. Full-bridge diode rectifier loaded by a current sink

- Sketch the waveform of the output voltage as a function of the supply voltage electrical angle  $\omega t$
- Calculate the average output voltage value
- Sketch the waveform of the input current as a function of the supply voltage electrical angle  $\omega t$
- Calculate the rms-value of the input current
- What should be the voltage rating of the diode if 1.5 safety margin is supposed to be used?
- What is the power factor of the diode rectifier? Hint: in the ideal converter  $P_{in} = P_{out}$

2. Ideal buck converter is shown in Fig. 2.

Input voltage is 24V and output voltage is 12V. The power is 100W and the inductance value is 1mH. Assume that the capacitor voltage ripple is negligible.

- What is the average inductor current?
- What is the average diode current?
- What is the average transistor current?
- What is the average input current?
- What should be the switching frequency that the peak-to-peak ripple in the inductor current would be 20 %?
- Sketch the diode current waveform with maximum and minimum values. The switching frequency is 10 kHz.

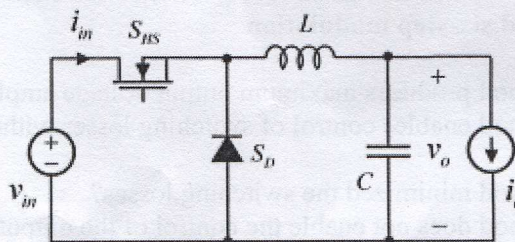


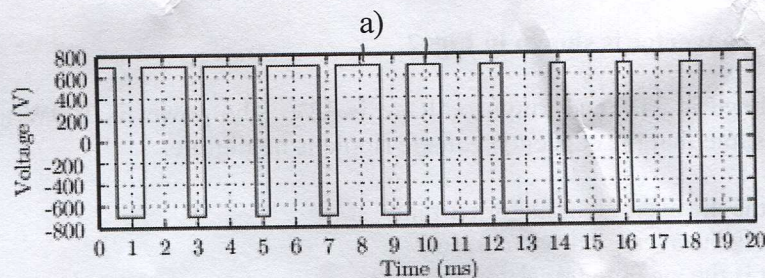
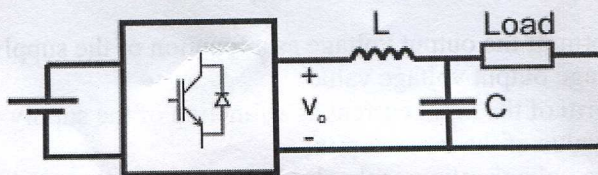
Fig 2. Ideal buck-converter

3. Explain shortly the meaning of the following terms

- a) As-balance
- b) Vs-balance
- c) dead time
- d) reverse recovery
- e) Distortion power D
- f) tail current

4. The single-phase inverter is used in the UPS-system shown in Fig. 3a and the output voltage waveform is shown in Fig. 3b.

- a) Name the used inverter
- b) Draw the used inverter
- c) What is the switching frequency of the transistors?
- d) What is the minimum battery voltage to produce 230 Vrms to the load (all components are supposed to be ideal)?
- e) Why inductor and capacitor are connected between the inverter and the load?
- f) How the value of the required inductor and capacitor can be defined? (Answer shortly)



b)

Fig. 3. a) UPS and b) output voltage  $v_o$

5. Compare the following modulation methods: PWM, PWM with 3<sup>rd</sup> harmonic injection, space vector modulation and six-step modulation

- a) Which method produces maximum output voltage amplitude?
- b) Which method enables control of switching losses without changing the switching frequency?
- c) Which method minimized the switching losses?
- d) Which method does not enable the control of the output voltage amplitude?
- e) Which method is possible to use with three-phase inverters?
- f) Which method produces harmonics to the output voltage at the lowest frequencies?

Multiple modulation methods might be a correct answer to one question. In this case, mention all of them.