

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

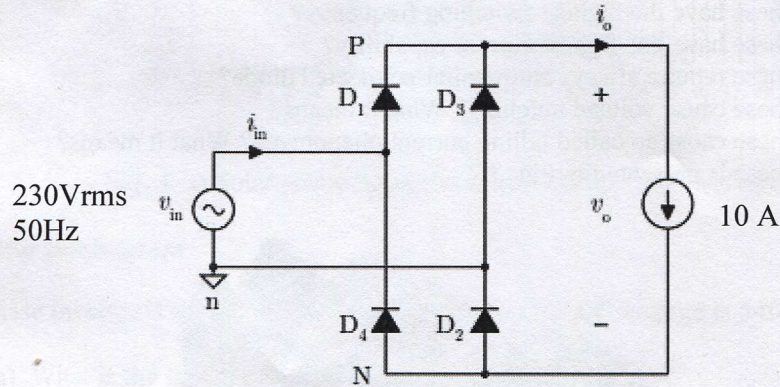


Fig. 1. Full-bridge diode rectifier loaded by a current sink

- Sketch the waveform of the output voltage v_o as a function of time
- Calculate the average output voltage value
- Sketch the waveform of the input current as a function of time
- Calculate the rms-value of the input current
- What should be the maximum peak repetitive reverse voltage rating of the diode if 1.5 safety margin is used?
- What is the power factor of the rectifier? Hint: in the ideal converter $P_{in} = P_{out}$

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

Output voltage is 32V and input voltage is 12V. The power is 200W and the inductance value is 0.5mH. Assume that the capacitor voltage ripple is negligible.

- What is the duty ratio of the converter?
- What is the average inductor current?
- Sketch the inductor current waveform
- What is the average capacitor current?
- What is the average transistor current?
- What should be the switching frequency that the peak-to-peak ripple in the inductor current would be 20 %?

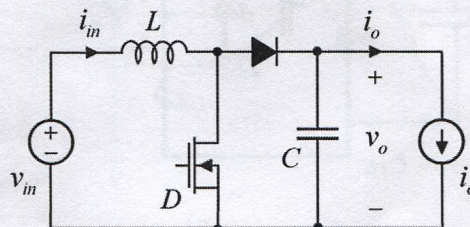


Fig 2. Ideal boost converter

3. Compare the characteristics of thyristor (SCR), MOSFET and IGBT

- a) Which of these have the highest switching frequency?
- b) Which of these have the highest current capability?
- c) Which of these require always antiparallel-connected diode?
- d) Which of these cause voltage notching? What it means?
- e) Which of these cause so called tailing current phenomena? What it means?
- f) Which of these is presented in Fig. 3.?

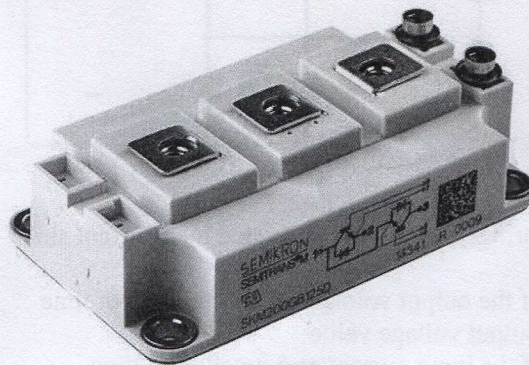
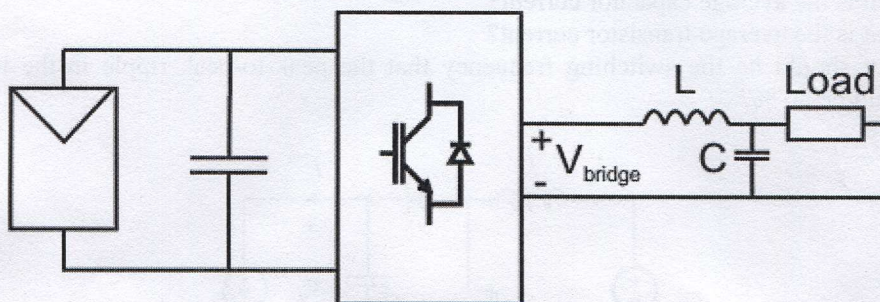


Fig 3. Transistor

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

- a) What is the inverter bridge topology used in the solar power system according to the output voltage waveform?
- b) Draw the inverter bridge
- c) What is the switching frequency of the transistors?
- d) How large DC voltage is produced by the solar power plant?
- e) Why inductor and capacitor are connected between the inverter bridge and the load?
- f) Why the DC capacitor is connected in front of the inverter?



a)

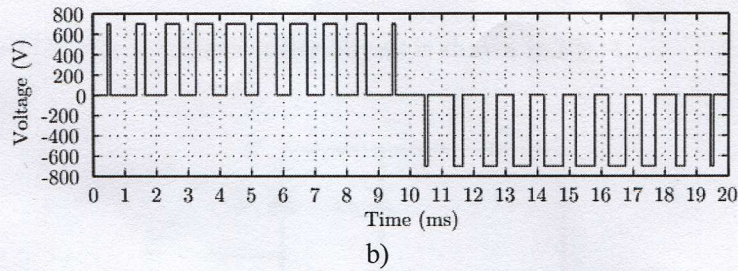


Fig. 4. a) Solar power system and b) inverter bridge voltage v_{bridge}

5. Space-vector modulation

Three-phase inverter is shown in Fig. 5a. Suppose, that the DC voltage is 540V.

- a) What is the length of the active vectors (Fig. 6b)? (1p)
- b) The instantaneous reference voltage of the inverter is $v^{ref} = 150 \text{ V} \cdot e^{j\frac{5\pi}{4}}$. Which active vectors are used to produce the required output voltage (vectors shown in Fig. 6b)? (1p)
- c) Present the switching sequence required to produce the above mentioned reference voltage. The conventional space-vector pulse-width modulation SV-PWM method is used. (2p)
- d) What is the maximum output voltage with the analyzed inverter in the linear modulation region when SV-PWM modulation method is used? (2p)

The complex space vector of three-phase variable is defined as

$$\underline{x} = \frac{2}{3}(x_a + \underline{a}x_b + \underline{a}^2x_c), \quad \text{where} \quad \underline{a} = e^{j\frac{2\pi}{3}}. \quad (1)$$

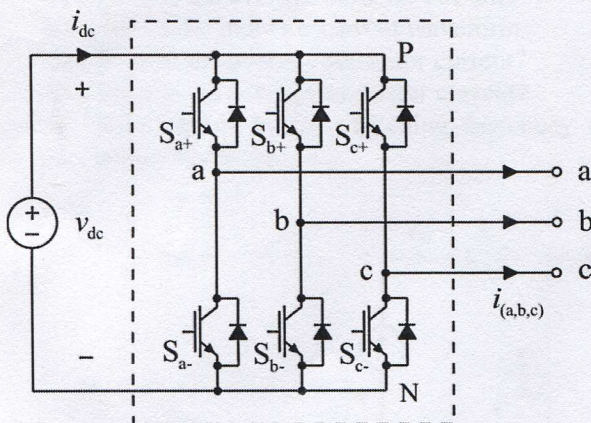
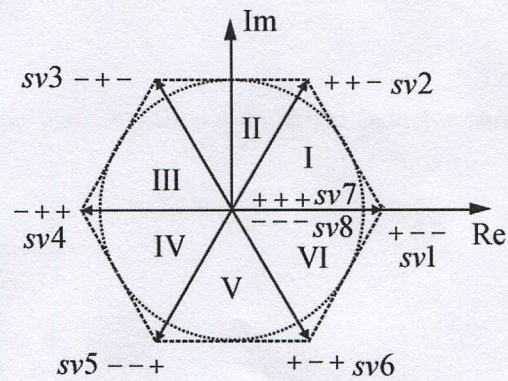


Fig. 5. a) Three-phase inverter



b) vector diagram