

You can use tables of mathematic equations during the exam. You can answer in English, Finnish or Swedish. Filling in the attached feedback form is rewarded by two bonus points!

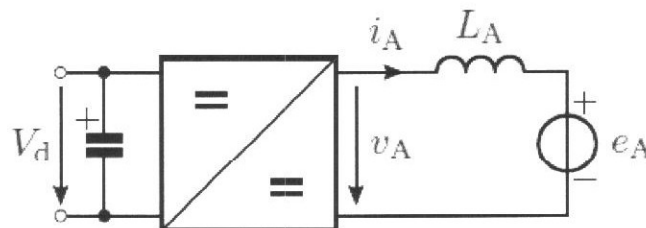
### Question 1

In Buck (step-down) converter the input voltage  $V_{in} = 10$  V, switching frequency  $f_s = 100$  kHz, and the switch duty ratio  $D = 0.75$ . Draw the circuit diagram of the converter and the waveform of the unfiltered output voltage. Calculate its average value and the rms magnitudes of its harmonic components up to 500 kHz.

### Question 2

A dc-motor drive shown in the figure below is considered. The motor is fed by a dc-dc converter, which is implemented with IGBTs and a diodes. The dc source voltage is  $V_d$ . Draw a circuit diagram of a converter topology in the following cases:

- Current  $i_A \geq 0$  and switching-cycle averaged voltage  $0 \leq v_A \leq V_d$ .
- Current  $i_A$  is allowed to reverse and voltage  $0 \leq v_A \leq V_d$ .
- Current  $i_A$  is allowed to reverse and voltage  $-V_d \leq v_A \leq V_d$ .
- Current  $i_A \geq 0$  and voltage  $-V_d \leq v_A \leq V_d$ .



### Question 3

A full-bridge single-phase thyristor converter is connected to a 50-Hz 230-V (rms) utility voltage. The control angle is 100 degrees and the load is a 20 A dc-current source. The rms magnitude of the fundamental component of the ac-side current is  $I_{a1} = (2\sqrt{2}/\pi)I_d$ .

- Draw the waveforms of the voltages and currents on the ac-side and dc-side.
- Derive the equation for the average value of the dc-side voltage and calculate its value.
- Calculate the power and the reactive power drawn by the converter, the power factor, and the displacement power factor.

### Question 4

Draw the circuit of a three-phase voltage source inverter. Derive the equations for its line-to-line and phase voltages and draw the switching functions and the waveforms of the line-to-line and phase voltages, when the inverter operates in square-wave (six-step) mode. Assume balanced load and sinusoidal output current, which lags the fundamental of the phase voltage by  $60^\circ$ . Mark the conducting devices (IGBTs and diodes) for one period of the output voltage.

### Question 5

Why power electronics is needed? What are the main advantages and disadvantages when power electronics is used in different kind of applications?