Question 3 (Power Electronics):

A single-phase single-pulse diode rectifier (Fig. 3.1), with a resistive load (R=100 Ω), is fed from an AC voltage source $v_s(t) = Vs \cdot \sqrt{2} \cdot \sin(\omega t)$, where Vs=240 V, f=50 Hz.

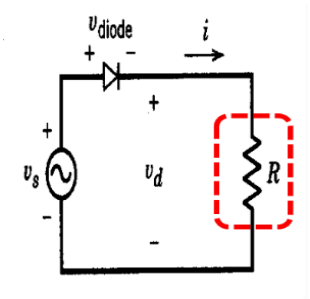

Fig. 3.1. A single-phase single-pulse diode rectifier with a resistive load

a) Calculate the average and RMS values of the current and power dissipation in the load resistor;
b) To evaluate the performance of the rectifier, calculate the efficiency of the rectification and the power factor;
c) Calculate the load voltage ripple factor or distortion factor in terms of average and RMS values and explain the result (the value obtained);
d) Replace the resistive load with an inductive-resistive one (R-L load), having R=100 Ω, L=0.06 H. Sketch the load voltage and current waveforms for this case and explain the four distinct regions for each supply period (cycle);
e) Calculate the average DC output voltage for the topology from the previous case (3d).

Question 4 (Power Electronics):

For a single-phase one-quadrant boost rectifier with power factor correction, the input AC voltage source Vin=220 V (RMS value), f=50 Hz and the output DC voltage is kept constant at Vd=350 V. The converter is supplying a DC motor drive

(DC-DC converter + DC motor) having the following parameters: the nominal voltage, power and speed of the motor V_N=500 V, P_N=2500 W, n_N=2000 rpm.

a) Draw the entire power electronic equipment (converter) highlighting the DC-DC converter type (topology) as part of the DC motor drive;
b) Design the DC-DC converter of the DC motor drive, finding the key parameters, such that the converter is able to modify the motor speed in the range n=(0.5 ÷ 1) n_N . Assume that the converter is working at the switching frequency fs=100 kHz, the inductor current ripple is Δi_L=10%, the voltage output ripple is Δvo=± 2%. The motor is a PM DC motor working with a constant mechanical torque over the speed range. Neglect the losses and consider the efficiency 100%.
c) Draw the entire power electronic equipment / converter such that to assure the bidirectional power flow considering the DC machine working as motor and generator as well. Explain the differences with the previous case;
d) Describe the control strategy of the DC-DC converter topology used in the previous case (4c) for driving the DC machine accordingly.