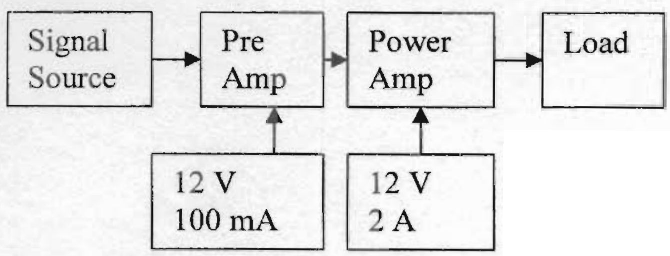
Electronics I * Midterm 1 * October 23, 2007 * 60 minutes

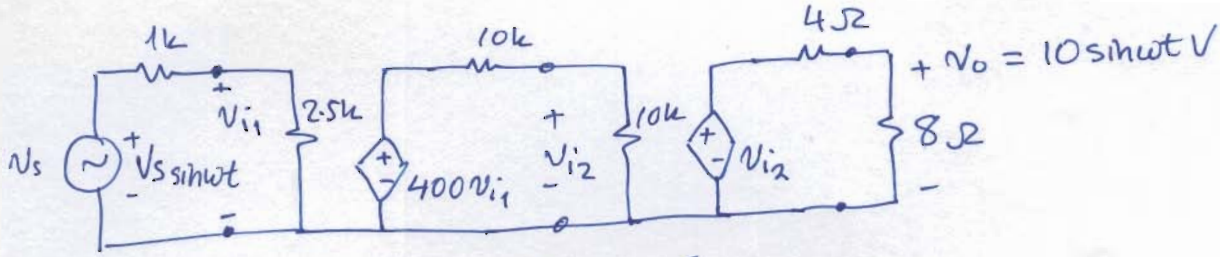
I have neither given nor received any unauthorized help with this exam.

ID number: ______________ Name: ERKAYA______________ Signature: ______________

30p 1) A sinusoidal signal source which has a 1-kohm output resistance is connected to an amplifier set which is made of a pre amplifier and a power amplifier cascade as shown below. The preamplifier has 2.5 kohm input resistance, 10 kohm output resistance and an open-circuit voltage gain of 400 whereas the power amplifier has 10 kohm input resistance, 4 ohm output resistance and an open-circuit voltage gain of 1. An 8-ohm load is connected to the output of the power amplifier. The output voltage across the load is 10 *sinωt* V.

a) Find the signal amplitude when the source is open-circuit. $V_s =$ 0.105 V
b) Find the power delivered to the load. $P_L =$ 6.25W
c) Find the total power dissipated in the amplifiers $P_{diss} =$ 18.95 W
d) Find the overall efficiency of the system $\eta =$ 24.8%





$$\frac{v_o}{v_s} = (400)(1)\frac{2.5}{1+2.5}\;\frac{10}{10+10}\;\frac{8}{4+8} = 95.24$$

a) $V_s = \frac{10}{95.24} = 0.105 \text{ V}$

b) $P_L = \frac{V_{orms}^2}{R_L} = \frac{(10/\sqrt{2})^2}{8} = \frac{100}{16} = 6.25\text{W}$

c) The power supplied to the amplifiers $P_{DC} = 12(2+0.1) = 25.20$ W

Out of this power 6.25W is supplied to the load. The rest is dissipated in the amplifiers $P_{diss} = P_{DC} - P_L = 25.20 - 6.25 = 18.95$ W

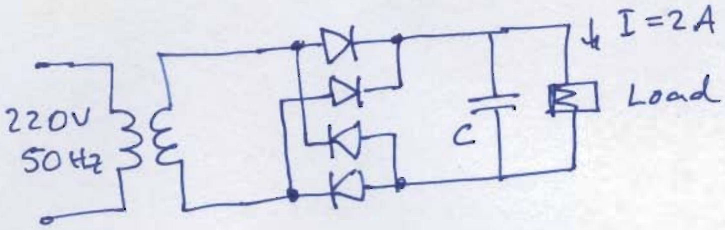
(The signal power at the input is ignored)

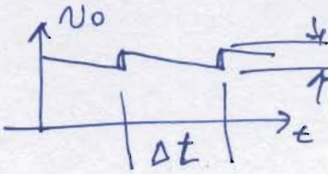
d) $\eta = \frac{P_L}{P_{DC}} = \frac{6.25}{25.20} = 0.248 = 24.8\%$

30p 2) A full-wave rectifier circuit operates at 50 Hz and rectifies the ac voltage at the output of a transformer. The rectifier produces a peak voltage of 12 V at a constant load current of 2A. The ripple voltage at the output is desired to be less than 0.2 V. Each diode in the circuit has a voltage drop of 0.7 V when it is on.

a) Draw a circuit diagram for such a rectifier circuit
b) Find the minimum value of the filter capacitor — min C = 0.1 F
c) Estimate the average power dissipation in each diode — P_{diode} = 0.7 W
d) If the transformer has 80% efficiency, what should be the power-rating of the transformer. (Explain briefly) — min 33.25 W

a)





b) The current in the capacitor equals the load current (in amplitude)

$$i_c = C\frac{dv_c}{dt} = C\frac{\Delta V}{\Delta t}$$

ΔV = ripple voltage = 0.2V

$\Delta T = \frac{T}{2} = \frac{1}{100}$ s

$$C = I\frac{\Delta t}{\Delta V} = 2\,\frac{\frac{1}{100}}{0.2} = 0.1\ F$$

c) Two diodes are ON over half the period. The diodes are on over a very short time. The voltage of the diodes are constant when the diodes are on.

$$P_{diode} = \frac{1}{T}\int_0^{T/2} v_d i_d\,dt = V_d\,\frac{1}{T}\int_0^{T/2} i_d\,dt = V_d\,\frac{1}{2}\,\underbrace{\frac{1}{T/2}\int_0^{T/2} i_d\,dt}_{I \text{ average load current}}$$

$$P_{diode} = \frac{V_d I}{2} = 0.7\times\frac{2}{2} = 0.7\,W$$

d) The transformer must provide power for the load and for the dissipation on diodes.

$$P_{out} = 4\times P_{diode} + P_L = 4\times 0.7 + 2\times(12-0.1) = 26.60\ W$$

$$\eta = \frac{P_{out}}{P_{in}} = 0.8 \qquad P_{in} = \frac{P_{out}}{\eta} = \frac{26.60}{0.8} = \underline{33.25\ W}$$

Note: The transformer output voltage (rms) may be found as follows:

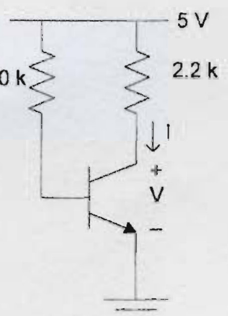
$$\frac{V_{opeak} + 2\times 0.7}{\sqrt{2}} = \frac{12+1.4}{\sqrt{2}} = 9.48\ V\ rms$$

40p

3) Find I and V in the circuits below. Assume silicon BJTs with a common emitter current gain of 300.

I = 0.99mA

V = 2.82V



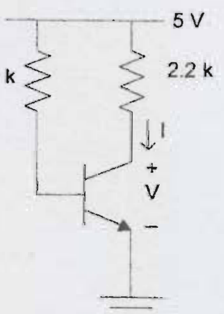
$$I_B = \frac{5-0.7}{1300k} = 0.0033\,mA$$

$$I_C = 300 \times 0.0033 = 0.99\,mA$$

$$V = 5 - 2.2 \times 0.99 = 2.82V$$

I = 2.18mA

V = 0.2V



$$I_B = \frac{5-0.7}{100} = 0.43\,mA$$

$$I_c = 300 \times 0.43 = 129\,mA \text{ (expected)}$$

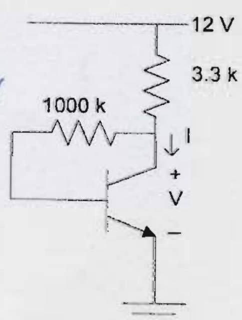
$$V = 5 - 129 \times 2.2 = -278.8\ V \quad \text{not possible}$$

Saturation $\rightarrow V = 0.2V$

$$I = \frac{5-0.2}{2.2} = 2.18\,mA$$

I = 1.7mA

V = 6.39V



$$V_{BE} + I_B 1000 + 3.3(\beta+1) I_B = 12$$

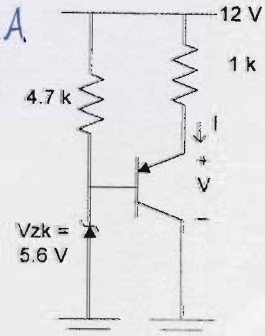
$$I_B = \frac{12-0.7}{1000 + 301 \times 3.3} = 0.0057\,mA$$

$$I_c = 300 \times 0.0057 = 1.7\,mA$$

$$V \cong 12 - 3.3 \times 1.7 = 6.39V$$

I = 5.7mA

V = 6.3V



$$V = 5.6 + 0.7 = 6.3\ V$$

$$I = \frac{12-6.3}{1} = 5.7\,mA$$