Electronics I * Midterm 1 * November 3, 2009 * 60 minutes

I have neither given nor received any unauthorized help with this exam, nor do I have any reason to believe that anybody else has.

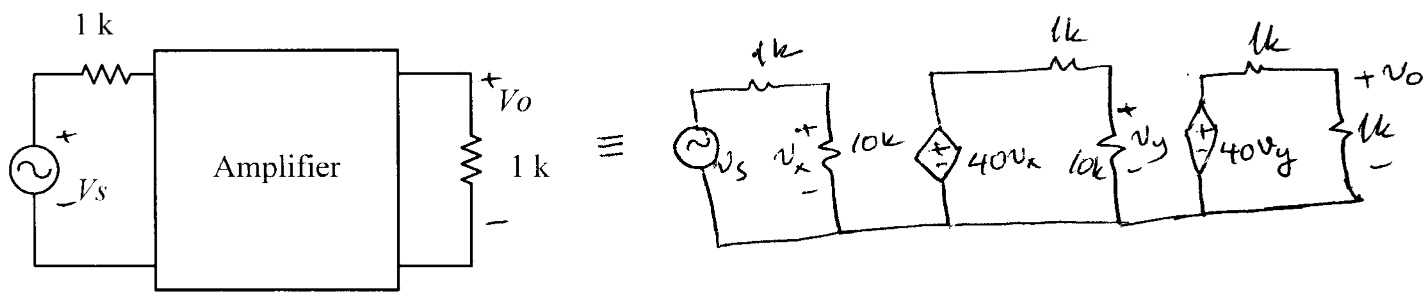
30pts

ID number: ERKAYA Name: SOLUTIONS Signature:______________

1. The amplifier in the circuit below is made of two identical cascaded (one is placed after the other) stages. Each stage has 10 kΩ input resistance, 1 kΩ output resistance, 40 open-circuit voltage gain. Also, each stage draws 5 mA DC current from a 9V power supply. If the signal at the load is $3\ \sin\omega t$ V, what would be the voltage gain and efficiency of the amplifier?

$\eta =$ 5%

$\frac{V_o}{V_s} =$ 661



$$\frac{V_o}{V_s} = 40 \times 40 \times \frac{10}{10+1} \times \frac{10}{10+1} \times \frac{1}{1+1} = 1600\ \frac{100}{242} \cong 661$$

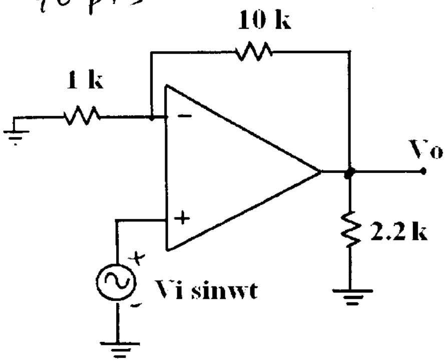
$$P_L = V_{orms}\, I_{orms} \cos\varphi = \frac{3}{\sqrt{2}}\ \frac{3/1k}{\sqrt{2}}\ 1 = 4.5\ mW$$

$$P_{DC} = 2 \times 5m \times 9 = 90\ mW$$

$$\eta = \frac{P_L}{P_{DC}} = \frac{4.5}{90} = \frac{5}{100} = 5\%$$

2. The OPAMP in the circuit below has $f_t = 2$ MHz, $SR = 1$ V/μs, and $V_{omax} = 10$ V
The signal source has a sine-wave with peak amplitude V_i.

40 pts



(a) If $V_i = 0.4$ V, what is the maximum frequency before the output distorts? $f_{max} =$ 36.2 kHz

(b) If $f = 20$ kHz, what is the maximum value of V_i before the output distorts? $V_{i\,max} =$ 0.72 V

(c) If $V_i = 50$ mV, what is the useful frequency range of operation? f range = 0 – 181.8

(d) If $f = 5$ kHz, what is the useful input voltage range? V_i range: 0 – 0.9 V

This is a non-inverting amplifier. gain $= 1 + \frac{10}{1} = 11$

$V_o = 11 \times V_i \sin wt$. Gain-bandwidth product $11 \cdot f_\beta = 2$ MHz

useful frequency range: $0 - \frac{2}{11}$ MHz $= 0 - 181.8$ kHz

a) $|V_o| = 0.4 \times 11 = 4.4$ V

due to SR limitation $f_{max} \le \frac{SR}{2\pi |V_o|} = \frac{1 \times 10^6}{2\pi \times 4.4} = 36.2$ kHz

b) $f = 20$ kHz, $|V_o| \le \frac{1 \times 10^6}{2\pi\, 20 \times 10^3} = 7.95$ V

$V_i \le \frac{7.95}{11} = 0.72$ V

c) $V_i = 50$ mV expected $|V_o| = 0.55$ V expected $f_{max} = \frac{1 \times 10^6}{2\pi \times 0.55}$ Hz $= 289$ kHz

Since $289 > f_\beta$, the gain falls befor SR limitation occurs.

hence $f_{max} = f_\beta = 181.8$ kHz

d) $f = 5$ kHz, $|V_o| \le \frac{SR}{2\pi f} = \frac{10^6}{2\pi \times 5 \times 10^3} = 31.83$ V

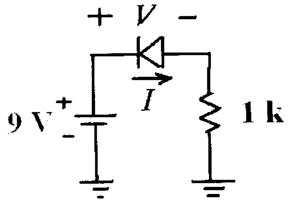
not possible because $V_{omax} = 10$ V

hence $V_{i\,max} = \frac{10}{11} = 0.9$ V

3. Assuming that the diodes in the circuit are made of silicon, find V and I in each circuit below:

30 p.

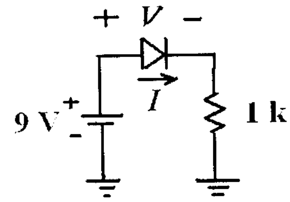
a)



$V =$ 9 V

$I =$ 0 A

b)

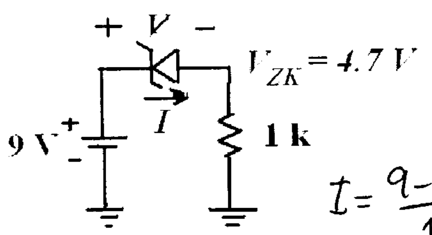


$I = \frac{9-0.7}{1k} = 8.3\ mA$

$V =$ 0.7 V

$I =$ 8.3 mA

c)

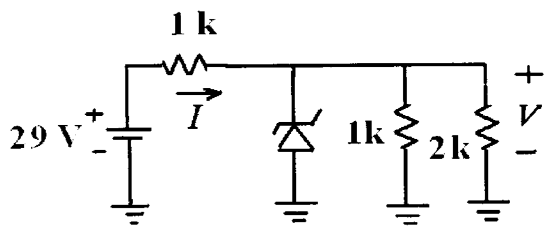


$I = \frac{9-4.7}{1k} = 4.3\ mA$

$V =$ 4.7 V

$I =$ 4.3 mA

d)



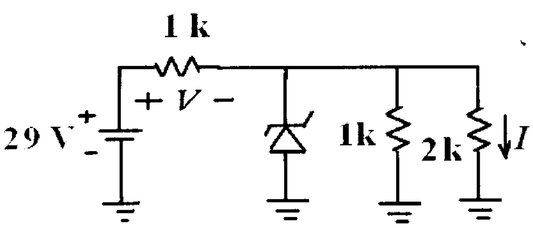
$V_{ZK} = 7\ V$

$I = \frac{29-7}{1k} = 22\ mA$

$V =$ 7 V

$I =$ 22 mA

e)



$V = 29 - 7 = 22V$

$I = \frac{7}{2} = 3.5\ mA$

$V_{ZK} = 7\ V$

$V =$ 22 V

$I =$ 3.5 mA