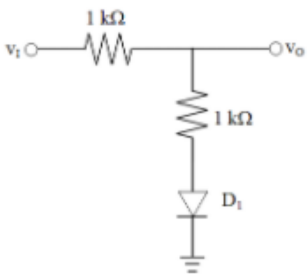
Short Answer Problems

Consider the following circuit that contains an ideal diode.

The source, v_I, is an 10 V peak sinusoid. For what values of v_I is the diode conducting (or on).

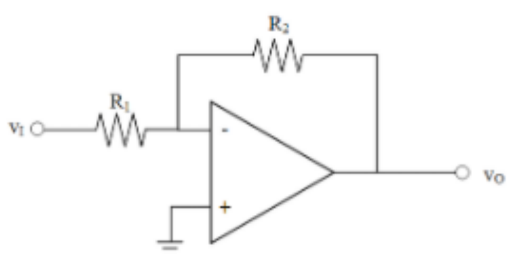


- ○ Diode is on for all values of v_I
- ○ $v_I < 0$
- ○ $v_I > 0$

Consider an inverting configuration using an ideal operational amplifier (see circuit below) that can use resistor values up to 1 MΩ.

If the voltage gain is 40db and you want to maximize the input resistance, what would the values of R_1 [ ] and R_2 be [ ] ?

Note: Your final answers should be in this format (no units). R.RReX (EX. 512.95kΩ is entered as 5.13e5 or 20kΩ is entered as 2.00e4)



R1=10kohm

R2=1Mohm

$$40 = 20\log|A_v|$$

$$2 = \log|A_v|$$

$$A_v = 100\,V/V$$

$$100 = \frac{1\,\text{Mohm}}{R_1}$$

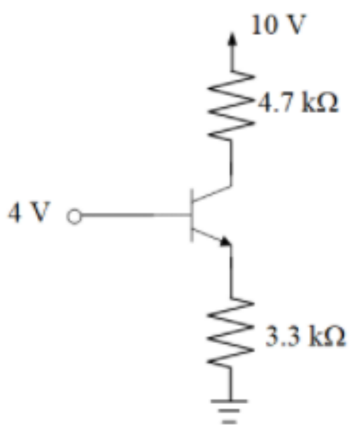
$$R_1 = 10k\Omega$$

$$R_2 = 1\,\text{Mohm}$$

Given the following npn BJT with V_{BE}=0.8 V and α=.98. What are the base | 0.02 mA |,

collector | 0.95 mA |, and emitter | 0.97 mA | currents?

Give your answers in orders of mA and give three decimal places/significant figures (EX: 5.613E-6 A = 0.00563 mA - do not include the units in your answer)



$V_{BE} = .8v \quad \alpha = .98$

$\beta = \frac{.98}{.98-1}$ $\quad V_{BE}$

$i_B = .02mA$

$i_C = 0.95\,mA$

$i_e = 0.97\,mA$

$I_C = .98 \times .97$

$.97 = i_B + .97$

$V_{BE} = V_B - V_E$

$.8v = 4 - V_E$

$V_E = 3.2v$

$V = IR$

$3.2 = i_E(3.3k\Omega)$

You are given a zener diode where it is known that for a zener voltage of 5.6 V, the zener current is 3.2mA. The incremental resistance of the diode is 10Ω. What is V_{ZO}?

Enter your answer with no units an no more than 2 decimal places.

Vzo = 5.57 volts

$V_t = 5.6v$

$I_Z = 3.2mA \qquad .0032A$

$r_Z = 10\Omega$

$5.57v$

- $V_Z = V_{Z0} + I_Z r_Z$ or - $V_{Z0} = V_Z - I_Z r_Z$
- $\Delta V_0 = \frac{r_Z}{R + r_Z}(\Delta v_s)$

A common gate amplifier has the following characteristics: $k'_n=0.5\ \frac{mA}{V^2}$, $\frac{W}{L}=10$, $\lambda=0$, and $V_t=1.1$ V.

The amplifier is biased for $V_{GSQ}=2.2$ V and has a drain resistor of 5.1 kΩ, a load resistor of 8kΩ and a signal resistor of 280 Ω.

What is the input resistance R_{in}? 181.82 in ohms $\quad R_{in} = 1/g_m$

What is the output resistance R_O? 5.1 in kohms $\quad R_D = R_o$

What is the parameter, g_m? 5.5 in mA/V $\quad g_m = k'_n\left(\frac{W}{L}\right)(V_{GSQ}-V_t)$

What is the voltage gain, G_v? 6.74 in V/V $\quad G_v = \dfrac{-g_m(R_D \parallel R_L)}{R_{sig} + 1/g_m}$

All answers should round to two decimal places.

$V_{GSQ} = 2.2v \quad R_D = 5.1k\Omega \quad R_L = 8k\Omega \quad R_{sig} = 280\Omega$

$R_{in} = 1/5.5 = .181 m\Omega \quad G_v = \dfrac{-g_m(R_D \parallel R_L)}{R_{sig} + 1/g_m} \quad \frac{1}{5.1} + \frac{1}{8}$

$R_o = 5.1k\Omega \quad G_v = 6.74\ v/v$

$g_m = k'_n\left(\frac{W}{L}\right)(V_{GSQ} - V_t) = 5.5$

Consider the following circuit that contains diodes that operate in the forward bias region and are identical. It is known that when the diode voltage is 0.8 V, the diode current is 1 mA. If the current source, I_S is 3 mA, what is the voltage V_o. Assume the thermal voltage is 25 mV.

$V_T = 25mV$

$I_d = 1\ mA$

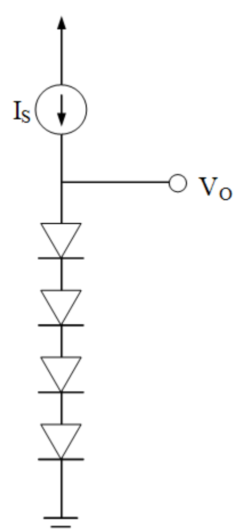
$I_s = 3mA$

$V_d = .8V$

Convert bases!

$V_2 = 4\left(25mV \ln\left(\frac{3mA}{1mA}\right) + .8\right)$

$V_2 = 3.31\ V$



3.31 Volts

$V_2 - V_1 = V_T \ln\left(\frac{I_2}{I_1}\right)$

Long Design Problems:

You have been asked to design an amplifier using the common source configuration :

$k'_n=800\frac{\mu A}{V^2}$, $V_t=1$ V, $\lambda= 0.03\ V^{-1}$ and $\frac{W}{L}=10$

The Q-point is at $I_{DQ}=0.4mA$. There is a drain resistance, $R_D=12k\Omega$ and the amplifier is driven by a signal source, v_{SIG}, in series with a signal resistance, R_{sig}, 500 $k\Omega$.

a. [20 pts] Find V_{GSQ}, r_o, and g_m.

b. [20 pts] Draw the small-signal model. Label and solve for the input resistance, R_{in}, the output resistance, R_o, the open-circuit voltage gain, A_{vo}

c. [15 pts] A variable load, R_L, requires the overall voltage gain, G_V, to be in -5V/V. What should the variable load be set to achieve this overall gain.

Please enter only the load resistor in the box. Show all other work on your submission.

Using an single ideal op-amp, one $100k\Omega$ potentiometer, and one additional resistor (R_1) , design an amplifier that allows a range of closed loop gain from 1 V/V to 20 V/V.

Show all your work including the circuit you designed. The value of R_1 should go in the box.

$100k\Omega$ Pot

R_1

$1 v/v \rightarrow 20 v/v$

$R_2 = 100k\Omega$

$R_1 = ?$

$1 \le G_v \le 20$

$2R1 = RF + \text{pot}$

$AD = \left(1 + \frac{2R_2}{2R_1}\right)$

$1 + \frac{2R_2}{RF + 100k} = 1$

$1 = \frac{2(9.5RF)}{RF + 100k} + 1$

$R_2 = 0$

$1 + \frac{2R_2}{RF} = 20$

$RF\,19 = 2R_2$

$R_2 = 9.5RF$

$RF = 0$