Electronics
Ch 2 2, 10, 15, 18, 22, 25, 35, 37

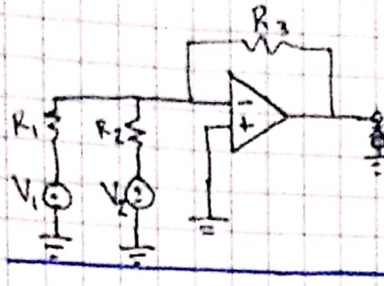
32

4/4/4/4/4 4/4/4

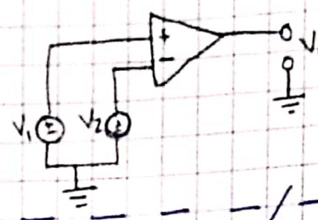
Adam Stammer

2.2) $v_1(t) = .1\cos(20\pi t) + 20\sin(120\pi t)$ $v_2(t) = -0.1\cos(20\pi t) + 20\sin(120\pi t)$

Common mode: $\frac{1}{2}(v_1+v_2) = \frac{1}{2}(40\sin\pi t) = \boxed{\cancel{20\sin(\pi t)}}$ $\boxed{20\sin(20\pi t)}$



where $R_3 = 2R_1$
and $R_1 = R_2$
$V_o = \frac{1}{2}(V_1+V_2)$

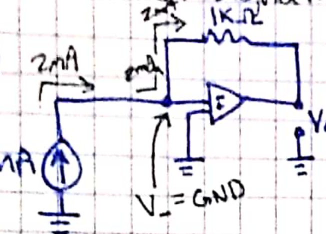


$V_o = V_1 - V_2$

differential signal: $(v_1 - v_2) = \boxed{.2\cos(120\pi t)}$

2.10)

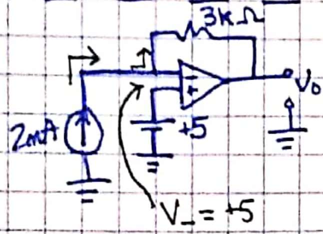
Find V_o



$\frac{V_o - V_-}{R_F} = I_F$ | $\frac{V_o - 0}{1000\Omega} = 2mA$ | $V_o = 1000(2mA) = \boxed{\cancel{2}\text{Volts}}$

and the signal goes into the neg pin → Since the feedback is negative, it should be negating

Find V_o

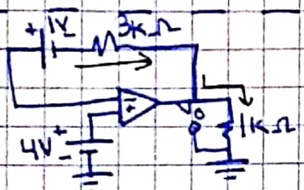


$\frac{V_o - V_-}{R_F} = I_F$ | $\frac{V_o - 5V}{3000\Omega} = 2mA$ | $V_o = 3000(2mA) + 5V = \boxed{6+5 = 11\text{ Volts}}$

$\frac{V_- - V_o}{R_F}$

$= -1$

Find V_o



$V_- - 1\text{Volt} - 3k\Omega I_F \cancel{- 1k\Omega I_F = 0} = V_o$ $I_F = \frac{V_o - 0}{1k\Omega} = \frac{V_o}{1k\Omega}$

$\cancel{V_- - 1\text{Volt} - 3V_o - V_o = 0}$

$\cancel{V_- - 4V_o = 1}$

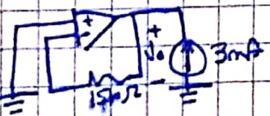
$\cancel{4 - 1 = 4V_o}$

$\boxed{\cancel{V_o = 3/4\text{ Volt}}}$

$4 - 1 - 3k(0) = V_o = \boxed{3\text{ Volts}}$

~~but current shouldn't flow through the top or bottom branch so I don't like my answer~~

Find V_o

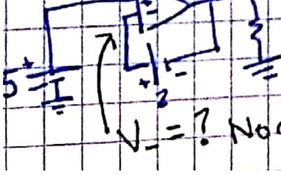


$\cancel{\frac{V_o - 0}{15k\Omega} = 3mA}$ | $\cancel{V_o = 3mA(15k\Omega)} = \boxed{\cancel{45\text{ Volts}}}$

~~Again, current shouldn't be flowing through the 15kΩ resistor so I don't like this answer either.~~

$V = IR$
$R = 0$ so $\boxed{V_o = 0\text{ Volts}}$

$+5 - 2 = \boxed{3\text{ Volts}}$



Again our only flowing current is that of the load resistor so I'm not sure where to start even.

$V_- = ?$ No clue

15.) R_1 and R_2 have tolerances of ±1%. What is the gain tolerance of this inverting amplifier.

We've already solved an inverting amplifier to be $A = \frac{R_2}{R_1}$
So let's look at the extremes.

an increased R_1 with a decreased R_2

$$\frac{R_2(.99)}{R_1(1.01)} \cong A(.98)$$

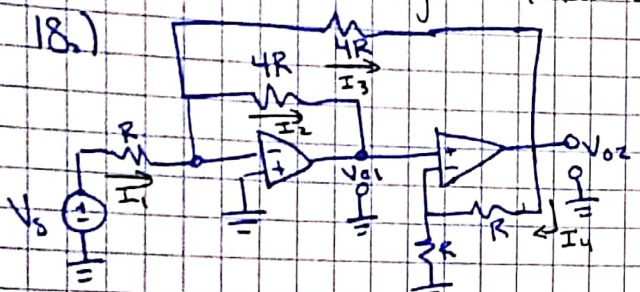
a decreased R_1 with an increased R_2

$$\frac{R_2(1.01)}{R_1(.99)} \cong A(1.02)$$

✓

So we see a gain tolerance range of roughly ±2%.
I would guess that the resistance tolerances add together.

18.)



Since no current goes in V_- or V_+ we can say that $I_1 = I_2 + I_3$

Sub in variables and values to see that

$$\frac{V_- - V_s}{R} = \frac{V_{o1} - V_-}{4R} + \frac{V_{o2} - V_-}{4R} \Rightarrow -4V_s = V_{o1} + V_{o2}$$

Now we can also make a statement regarding I_4. Since no current is going through the op amp's V_{-2} we can say that I_4 is constant through both of those final resistors. So,

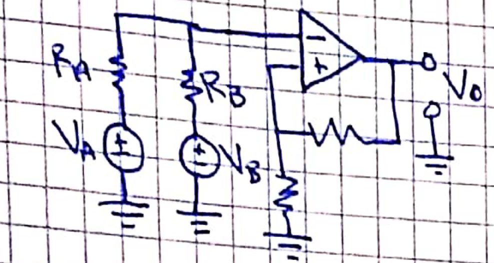
$$\frac{V_{o2} - V_{o1}}{R} = \frac{V_{o1} - 0}{R} \Rightarrow V_{o2} - V_{o1} = V_{o1} \Rightarrow V_{o2} = 2V_{o1}$$

2 equations and 2 unknowns. Simple substitution.

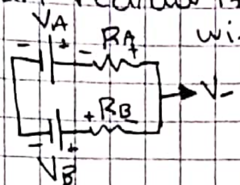
$$-4V_s = V_{o1} + 2V_{o1} = 3V_{o1} \Rightarrow \boxed{V_{o1} = (-4/3)V_s}$$

$$V_{o2} = 2(-4/3)V_s = \boxed{V_{o2} = (-8/3)V_s}$$ ✓

22.) Find V_o



First lets look at the voltage coming into V_-
we can redraw it as follows



with no current flowing to V_-

so lets nodally analyze it

$$\frac{V_- - V_A}{R_A} = \frac{V_B - V_-}{R_B}$$

$$R_A V_B - R_A V_- = R_B V_- - R_B V_A$$

$$R_A V_B + R_B V_A = R_B V_- + R_A V_-$$

$$V_- = V_B\left(\frac{R_A}{R_A+R_B}\right) + V_A\left(\frac{R_B}{R_A+R_B}\right)$$

so the input on V_- is an adding voltage divider. neat.

Now lets look at the output using what we found at the input.

$$\frac{V_o - V_-}{R_2} = \frac{V_- - 0}{R_1}$$

$$V_o = \frac{(V_-)R_2}{R_1} + V_- = V_-\left(\frac{R_2}{R_1}+1\right)$$

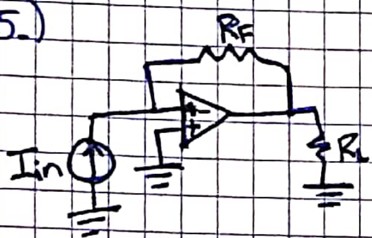
$$= V_-\left(\frac{R_2+R_1}{R_1}\right)$$

$$\boxed{V_o = \left(\frac{R_2+R_1}{R_1}\right)\left(V_A\left(\frac{R_B}{R_A+R_B}\right) + V_B\left(\frac{R_A}{R_A+R_B}\right)\right)}$$

which to me looks like a weighted summer with amplification that is non-inverting. With the right resistors we could find averages with this circuit I do believe.

✓

25.)



a) Find V_o

↳ all current from I_{in} must be going through R_F

so

$$V_o = -I_{in} * R_F$$

b) Output Impedance: 0

c) Input Impedance: 0

d) Transresistance since it puts out a V_o base on a I_{in}. It also has $0 R_{in}$ and R_o

✓

35.) Design a single op amp with a gain of −100 and no resistor smaller than 1kΩ. Try to minimize resistance

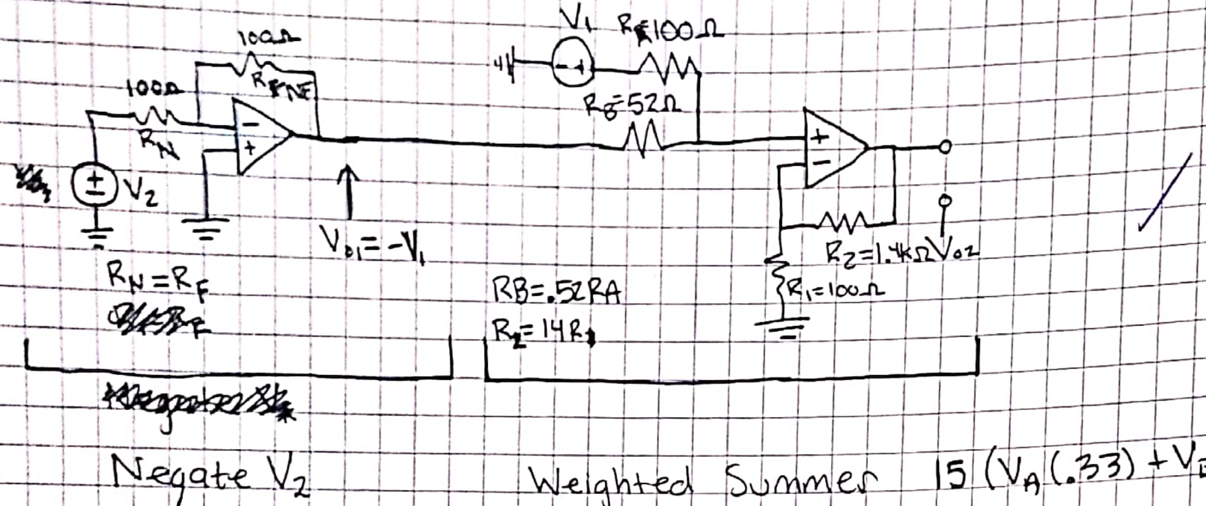
The most basic of inverting amplifiers follow $V_o = -V_s\left(\frac{R_F}{R_1}\right)$ so if $R_F = 100{,}000\,\Omega$ and $R_1 = 1{,}000\,\Omega$, we would achieve our goal of −100 gain and have big enough resistors. 100,000 Ω is a pretty large resistance though.

$$A_v = \frac{V_o}{V_{in}} = -\left(\frac{R_2}{R_1} + \frac{R_4}{R_1} + \frac{R_4 R_2}{R_1 R_3}\right)$$

✓

35.) Design circuit such that $V_o = A_1 V_1 + A_2 V_2$ and $A_1 = 5$ and $A_2 = -10$.

So lets use a summing op amp circuit combined with an inverter.



Accepting that V_2 has been negated already, lets focus on the weighted summer

we already solved this summing circuit to be $V_o = \left(\frac{R_2+R_1}{R_1}\right)\left(V_A\left(\frac{R_B}{R_A+R_B}\right) + V_B\left(\frac{R_A}{R_A+R_B}\right)\right)$

we'll simplify the notation such that

$X = \left(\frac{R_2+R_1}{R_1}\right)$, $Y = \left(\frac{R_B}{R_A+R_B}\right)$, and $Z = \left(\frac{R_A}{R_A+R_B}\right)$

To achieve gains of 5 on A and 10 on B (since it's already negated), we just need XY to equal 5 and XZ to equal 10.

Looking at the equations, Y and Z will never be greater than 1 so let's work the other way and find those proportions based on X. $5+10=15$ so I'll keep it simple and say that $X=15$. With this we can say that $Y = \frac{5}{15} = .33$ and $Z = \frac{10}{15} = .66$.

Now all we need to do is select on resistor in the R_1, R_2 set and another in the R_A, R_B set and solve based on our X, Y, Z equations.

See back of page for work.

$R_A = 100Ω$	$R_B = 52Ω$
$R_1 = 100Ω$	$R_2 = 1.4kΩ$
$R_N = 100Ω$	$R_F = 100Ω$

For convenience I'll choose R_1 and R_A to both be 100Ω

We know that

$$X = \frac{R_2+R_1}{R_1} = \frac{R_2+100}{100}$$ and we need it to equal 15

so $\frac{R_2+100}{100} = 15 \quad R_2 = 1500-100 = \boxed{1.4k\Omega}$

Thus $\cancel{R_A}$ $R_1 = 100\Omega$ and $R_2 = 1.4k\Omega$

We also know that

$$Z = \frac{R_A}{R_A+R_B} = \frac{100}{100+R_B}$$ and we need it to equal .66

so $\frac{100}{100+R_B} = .66 \quad R_B = \frac{100}{.66} - 100 \cong \boxed{52\Omega}$

Thus $R_A = 100\Omega$ and $R_B \doteq 52\Omega$

✓

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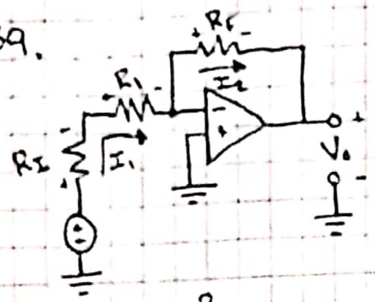
4/4/4/4 4 (20)

Electronics
Homework 4
Ch 2: 39, 47, 51, 75, 77

Adam Stammer

39.



$R_I = [1000\,\Omega, 1M\Omega]$ Design this circuit (R_1 and R_F) such that $A_v = -20 \pm 15\%$. Assume resistor tolerances of $\pm 5\%$.

A_v

Start by solving for V_o.

$I_1 = I_2 \rightarrow \frac{V_S - V_-}{R_I + R_1} = \frac{V_- - V_o}{R_F} \rightarrow \boxed{V_o = -V_S\left(\frac{R_F}{R_1 + R_I}\right)}$

So, $\left(\frac{R_F}{R_1 + R_I}\right) = 20 \pm 15\%$. ~~Add in~~

$\left(\frac{R_F}{R_1 + 1000}\right) = 20(1.15)$ and $\left(\frac{R_F}{R_1 + 1M}\right) = 20(.85)$

now add in our resistor tolerances,

$\left(\frac{R_F(1.05)}{R_1(.99) + 1000}\right) = 20(1.15)$, $\left(\frac{R_F(.99)}{R_1(1.05) + \cancel{1000}\,1M}\right) = 20(.85)$

With two equations and two unknowns we can solve via substitution.

$R_F = 17(R_1(.99) + 1000)/1.05$

$= \frac{17(.99)R_1 + 17{,}000}{1.05}$

$R_1 = \left(\frac{R_F(.99)}{23} - 1M\right)/1.05$

$= R_F\left(\frac{.99}{23(1.05)}\right) - \frac{1M}{1.05}$

$R_1 = \left(\frac{17(.99)R_1 + 17000}{1.05}\right)\left(\frac{.99}{23(1.05)}\right) - \frac{1M}{1.05}$

$R_1 = (16.029R_1 + 16190.48)(0.040994) - \frac{1M}{1.05}$

$R_1 = .657098R_1 + 663.71 - \frac{1M}{1.05}$

$R_1 = \frac{663.71 - \frac{1M}{1.05}}{.34291}$

$\boxed{|R_1| \cong 277414.08061 \approx 2.77414\,M\Omega}$

$R_F \cong 44502113.31106$

$\boxed{R_F \cong 44502113\,M\Omega}$

checking this answer we expect $\left(\frac{R_F}{R_1 + 499500}\right)$ to equal our exact 20 gain goal. I actually found these resistor values to achieve a $\pm 15.2\%$ tolerance around a gain of ~13.9 which is significantly lower than our design requirements.

✓

New Answer:

$\boxed{R_1 = 9.48595\,M\Omega \quad R_2 = 199.3005\,M\Omega}$

47.) DC Gain of 100

Cascading amps with gain of 10

$A_{CL} = A_v = 100$ $GBP = A_{OCL} \cdot f_{BOL} = 10^4$

$\boxed{f_{BCL} = \frac{10^6}{100} = 10^4 Hz}$

$A_{CL}(f) = \frac{A_{OOL}}{1+j\left(\frac{f}{f_{BOL}}\right)} = \frac{A_{OOL}}{1+j\left(\frac{f}{10^4}\right)}$

$f_{BOL} = \frac{10^6}{10} = 10^5 Hz$ $A_{O}(f) = \frac{A_{OOL}}{1+j\left(\frac{f}{10^5}\right)}$

$A_{OL}(f) = \left(\frac{A_{OOL}}{1+j\left(\frac{f}{10^5}\right)}\right)\left(\frac{A_{OOL}}{1+j\left(\frac{f}{10^5}\right)}\right)$

$= \left(\frac{10}{1+j\left(\frac{f}{10^5}\right)}\right)\left(\frac{10}{1+j\left(\frac{f}{10^5}\right)}\right) = \frac{100}{\left(1+j\left(\frac{f}{10^5}\right)\right)^2} = \frac{100}{1+2j\left(\frac{f}{10^5}\right)-\left(\frac{f}{10^5}\right)^2}$

$= \frac{100}{-\frac{f^2+10^{10}}{10^{10}}+2j\left(\frac{f}{10^5}\right)}$ Complex conjugate to take further?

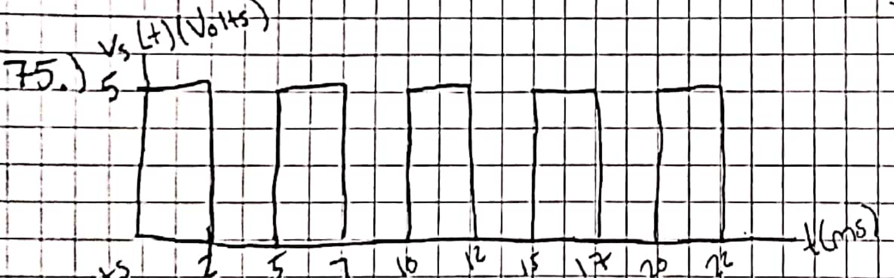
yup.

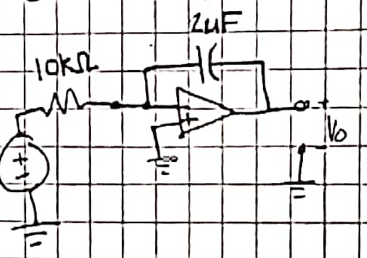
51.) Slew rate at 100kHz sin wave, amplitude of 5 Volts

$SR = 2\pi f V_{OMAX} = 2\pi(100000)(5) = 3.14 * 10^6 \ V/S$

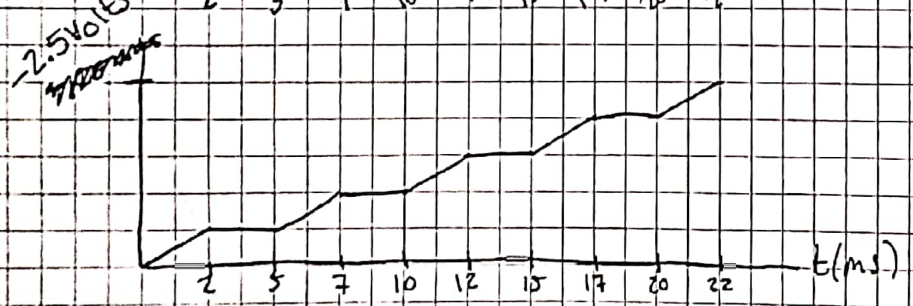
$= 3.14 \ V/\mu S$

75.)





Sketch Vo over time (ms=0, ms=22)



What if $V_o = -10$?

→ How many pulses have gone through?

$\frac{1}{10k(2\mu)}\int_0^{2ms} 5 \, Volts \, dt$ ~~.01Volts per pulse~~ .5 Volts per pulse

$10/.5 = 20$ pulses

~~10/.01 = 1000 pulses~~ ← too many

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Robotic Arm Displacement

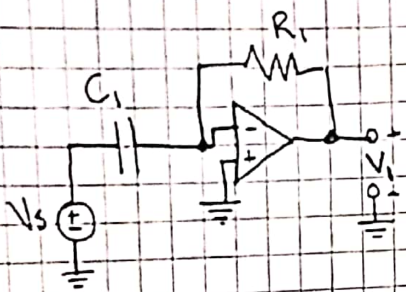
10cm → 1 Volt

Design Circuit such that 1m/s → 1Volt, and another circuit such that $1m/s^2$ → 1Volt

$$\frac{1\text{ Volt}}{.1\text{meter}} = \frac{x\text{ Volts}}{1\text{meter}} \qquad x = \frac{1}{.1} * 1 = 10$$

so 1 meter of displacement corresponds to 10 Volts.

Velocity is the derivative of displacement so let's use a differentiator



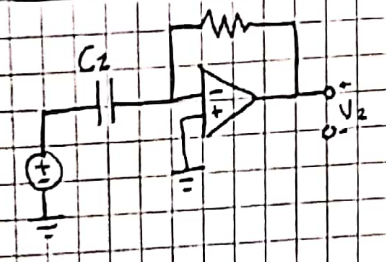
$$V_1 = R_1C_1\frac{d(V_s)}{dt} \qquad V_s = \text{displacement (In meters)} * \frac{\text{Volts}}{\text{meter}}$$

$$V_1 = R_1C_1\frac{d(10x)}{dt} \leftarrow V_s = x\left(\frac{10}{1}\right) = 10x$$

$$1m/s = R_1C_1\frac{d(10x)}{dt} \rightarrow 1 = R_1C_1 10$$

$$R_1C_1 = \frac{1}{10}$$

So let's choose $\boxed{C = .1\mu F}$ → $R_1(.1*10^{-6}) = \frac{1}{10}$ → $\boxed{R_1 = \frac{\frac{1}{10}}{(.1*10^{-6})} = 1M\Omega}$



Now if we differentiate again we will have acceleration

Keep goin'

4/4/4/4/4/4 (24) Adam Stammer

Electronics HW #1

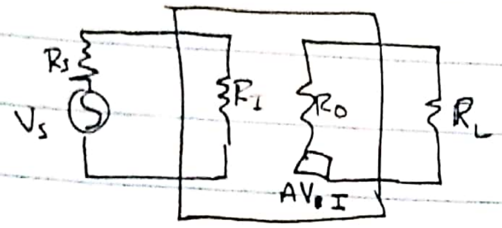
1.6 44.1kHz @ 16 bits

$44.1k * 16 \cong 705{,}600$ bits/s $\cong 86.13$MB/s

$2^{16} = 65{,}536$ amplitude zones

$\frac{5-(-5)}{2^{16}} \cong 152.6\mu V$ ✓

1.15 $V_s = 2mV$ $R_s = 50k\Omega$ $A_{voc} = 100$ $R_I = 100k\Omega$ $R_o = 4\Omega = R_L$



$V_I = \left(\frac{R_I}{R_I+R_S}\right)V_S$ $\quad V_o = \left(\frac{R_L}{R_L+R_O}\right)AV_I$

$V_o = \left(\frac{R_L}{R_L+R_O}\right)A_{voc}\left(\frac{R_I}{R_I+R_S}\right)V_S = \left(\frac{4}{4+4}\right)(100)\left(\frac{100k}{100k+50k}\right)(.002)$

$= \left(\frac{1}{2}\right)(100)\left(\frac{2}{3}\right)(.002)$

$= \frac{100}{3}(.002) = \frac{200}{3}mV$

$\boxed{A_{VS}} = \frac{V_o}{V_s} = \frac{(200/3)mV}{2mV} = 33.\overline{33}$ ✓

$\boxed{A_V} = \frac{V_o}{V_I} = \frac{(200/3)mV}{(200/150)mV} = 50$ ✓

$I_I = \frac{V_S}{R_S+R_I} = \frac{2mV}{50K+100K} \cong \frac{4}{3}*10^{-8}$

$I_L = \frac{V_o}{R_L} = \frac{200/3}{4} = \frac{50}{3}mA = \frac{50}{3}*10^{-3}$

$\boxed{A_I} = I_L/I_I = \frac{50/3}{4/3} * \frac{10^{-3}}{10^{-8}} = 12.5*10^5$ ✓

$\boxed{A_P} = A_V * A_I = 50(12.5*10^5) = 625*10^5 = 6.25*10^7$

✓

Adam Stammer
HW#1 Cont.

1.16

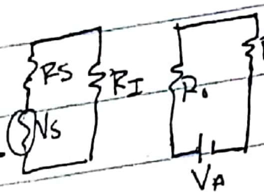
$A_{voc} = 1$, $V_s = 5\text{Volts}$, $R_s = 100k\Omega$, $R_I = 1M\Omega$, $R_o = 100\Omega$, $R_L = 50\Omega$

$V_I = V_s\left(\frac{R_i}{R_i+R_s}\right) = 5\left(\frac{1m}{1m+100k}\right) = 5(.90909) \doteq 4.5455\text{ Volts}$

$V_A = G_{oc}V_I = 1(4.5455) = 4.5455\text{ Volts}$ ✓

$V_o = V_A\left(\frac{R_L}{R_L+R_o}\right) = 4.5455\left(\frac{50}{100+50}\right) \doteq 1.5152\text{ Volts}$

$P_o = \frac{V_o^2}{R_L} = \frac{1.5152^2\text{ Volts}}{50\Omega} \doteq .045917\text{ Watts}$ ✓



$V_{L2} = V_s\left(\frac{R_L}{R_L+R_s}\right) = \cancel{9.998*10^{-3}} = \cancel{\doteq 10mV}$ .002499 Volts ✓

$P_{o2} = \frac{\cancel{10mV}^2}{50} \doteq \cancel{1.9992*10^{-8}\text{ Watts}}$ $3.122*10^{-6}$ Watts

So even with ~~a~~ a voltage gain of unity, the power increases substantially. It seems especially helpful when the signal resistance is much larger than the load resistance. ✓

this isn't valid b/c 2 Resistors in series. Not parallel

1.17 $R_I = 75\Omega$, $V_s = 5\mu V$, $V_o = 5V$ $R_L = 8\Omega$

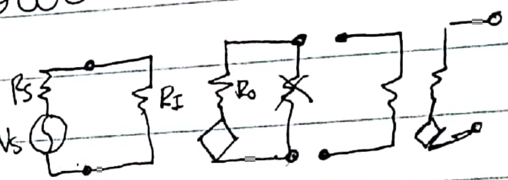
$P = V^2/R$ so,

$P_I = (5\mu V)^2/75\Omega$ $3.3\times10^{-13}W$? ok and $P_o = \frac{5^2\text{ Volts}}{8\Omega}$ ✓

$\doteq \cancel{6.6667*10^{-8}}$ Watts $= \frac{25}{8} = 3.125\text{ Watts}$

$A_p = P_o/P_I = 3.125/6.667*10^{-8} \doteq \cancel{46875000}$

		A_{voc}	*R_I	R_o
1.21	A	100	$3k\Omega$	400Ω
	B	500	$1M\Omega$	20Ω



$V_{i1} = \frac{R_{I1}}{R_{I1}+R_{S1}}V_s$ $V_{o1} = A_1V_{i1}\left(\frac{R_{i2}}{R_{o1}+R_{i2}}\right) = V_{i2}$ ✓

$V_{o2} = A_2V_{i2} = A_2A_1\left(\frac{R_{I1}}{R_{I1}+R_{S1}}\right)V_s\left(\frac{R_{i2}}{R_{o1}+R_{i2}}\right)$

A→B $= 50000\left(\frac{3k}{3k+R_{S1}}\right)V_s\left(\frac{1m}{400+1m}\right) \doteq \boxed{49980.008\left(\frac{3k}{3k+R_{S1}}\right)V_s}$

✓

B→A $= 50000\left(\frac{1m}{1m+R_{S1}}\right)V_s\left(\frac{3k}{3k+20}\right)$

$\boxed{\doteq 49668.87417\left(\frac{1m}{1m+R_{S1}}\right)V_s}$ ✓

~~Be specific~~ Be specific about in/out Impedances

24D.	A_{voc}	Input Resistance	Output Resistance
A	1	$10M\Omega$	$4k\Omega$
B	5	$1k\Omega$	1Ω
C	10	$20k\Omega$	100Ω

$V_s = 20mV$
$R_s = 2M\Omega$
$R_L = 20\Omega$

1 Watt $\quad 20\Omega$ Load $\quad P = \frac{V^2}{R}$ $\quad 1 = \frac{V^2}{20}$
$V = \sqrt{20} = 2\sqrt{5}$
≈ 4.47 Volts output

$A_{vo}\ \frac{4.47}{20mV} = 223.5$

1. We want an input resistance much higher than our source resistance and only A is higher at $10M\Omega$. So let's start with A.
2. We want our last amplifier to do the opposite and have an internal resistance smaller than the load resistance. B is the closest we can get to that so lets end with B.
3. For the intermediary amplifier we want something with a high voltage gain so lets use C. But, how many? If we temporarily forget power loss of internal resistance and look simply at our open circuit gain of 10, then $V_{ocn} = .02 * 10^n$, n being the number of class C amplifiers. Our goal is 4.47 Volts or higher an when $n = 3$, $V_{ocn} = 20$. We also disregarded the first and last amplifier so I'm going to estimate a need for 3 intermediate C amplifiers. Thus A-C-C-C-B

good

Small Signal Analysis

Adam Stammer

Ch4 #42, 45, 51, 56

42) $\beta = 100$ $I_{CQ} = 1mA, .1mA, 1\mu A$ npn in active region

Find g_m and r_π

$I_{CQ} = \beta I_{BQ} \rightarrow I_{BQ} = \frac{I_{CQ}}{\beta}$

$g_m = \frac{I_{EQ}}{V_T}$ $I_{EQ} = I_{BQ} + I_{CQ}$

$I_{EQ} = \frac{I_{CQ}}{\beta} + I_{CQ}$

$g_m = \frac{\frac{I_{CQ} + \beta I_{CQ}}{\beta}}{V_T} = \frac{I_{CQ}(1+\beta)}{\beta V_T}$

$r_\pi = (\beta+1)\frac{V_T}{I_{EQ}} = (\beta+1)/g_m$

$g_m = .03885$ @ $I_{CQ} = 1mA$

$= .003885$ @ $I_{CQ} = .1mA$

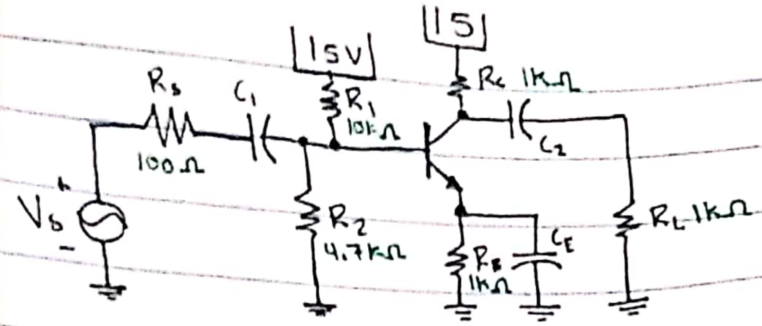
$= .00003885$ @ $I_{CQ} = 1\mu A$

$r_\pi = 67.6\ \Omega$ @ $I_{CQ} = 1mA$

$= 676\ \Omega$ @ $I_{CQ} = .1mA$

$= 67600\ \Omega$ @ $I_{CQ} = 1\mu A$

45)



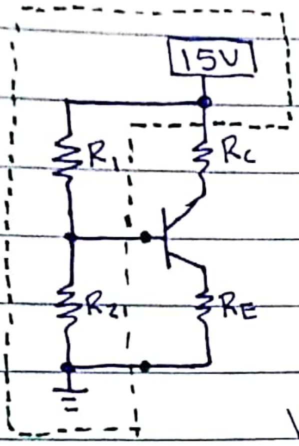
$\beta = 100$

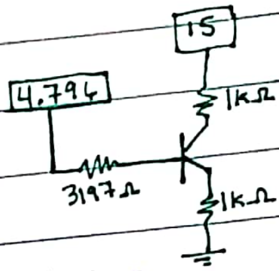
$V_{BEQ} = .7$ Volt

$R_s = 100\Omega$ $R_1 = 10k\Omega$ $R_2 = 4.7k\Omega$ $R_c = 1k\Omega$ $R_E = 1k\Omega$ $R_L = 1k\Omega$

Find I_{CQ}, then r_π Find A_v, A_{vo}, Z_{in}, A_i, G, and Z_o

DC capacitors open circuit





Find V_{TH} and R_{TH}

$V_{TH} = V_{cc}\frac{R_2}{R_1+R_2} \doteq 4.796$ Volts

$R_{TH} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} \doteq 3197\Omega$

$I_{BQ} \Longrightarrow$ $4.796 - 3197 I_{BQ} - .7 - 1k(I_{EQ}) = 0$

$I_{EQ} = I_{BQ} + I_{CQ} = I_{BQ}(1+\beta)$, $V_{TH} - R_{TH}I_{BQ} - .7 - R_E I_{BQ}(1+\beta) = 0$

$V_{TH} - .7 - I_{BQ}(R_{TH} + R_E(1+\beta)) = 0$

$I_{BQ} = \frac{V_{TH} - .7}{R_{TH} + R_E(1+\beta)} = \frac{4.796 - .7}{3197 + 1000(1+\beta)} = 39.31\mu A$

$\cancel{V_{TH} - 3197 I_{BQ}}$

$\cancel{V_{TH} - R_{TH}I_{BQ} - .7 - 1kI_{EQ} = 0}$ $\cancel{15 - 1kI_c - V_{CE} - 1kI_E = 0}$

$I_{CQ} = \frac{I_{BQ}}{\beta} = \frac{39.31\mu A}{100} = 3.93mA$

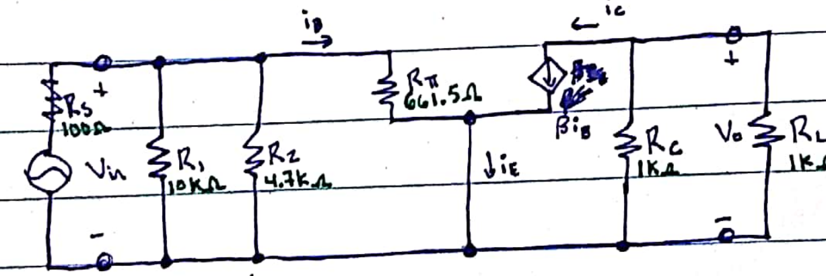
$I_{EQ} = I_{CQ} + I_{BQ} \doteq 3.97mA$

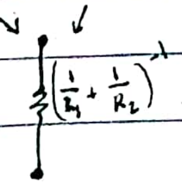
$15 - 1000I_{CQ} - V_{CE} - 1000I_{EQ} = 0$

$V_{CE} = 15 - 1000(I_{CQ} + I_{EQ}) = 7.1$ Volts

$r_\pi = (\beta+1)\frac{V_T}{I_{EQ}}$

$= (101)\left(\frac{.026}{3.97mA}\right) \doteq 661.46\Omega$ so yeah probably active mode



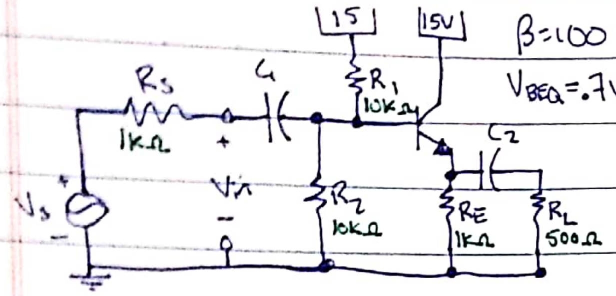


$-V_{in} - R_\pi i_B + V_{CE} + R_c i_c = 0$

$$A_v = \frac{V_o}{V_i} = \frac{\beta i_B R_L'}{i_B R_T} = \frac{\beta R_L'}{R_T} = \frac{100\left(\frac{1}{1000}+\frac{1}{1000}\right)^{-1}}{661.5} = \frac{50000}{661.5} = 75.5858$$

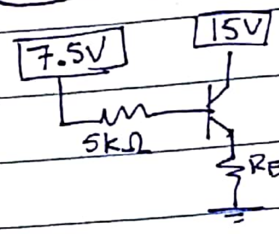
$$A_{vo} = \frac{V_o}{V_i} = \frac{\beta R_c}{R_T} = \frac{100(1000)}{661.5} \doteq 151.1716$$

51.



$$V_{TH} = V_{CC}\left(\frac{R_2}{R_1+R_2}\right) = 7.5\text{Volts}$$

$$R_{TH} = \left(\frac{1}{R_1}+\frac{1}{R_2}\right)^{-1} = 5000\,\Omega$$



$$7.5 - 5000 I_{BQ} - .7 - R_E I_{EQ} = 0$$

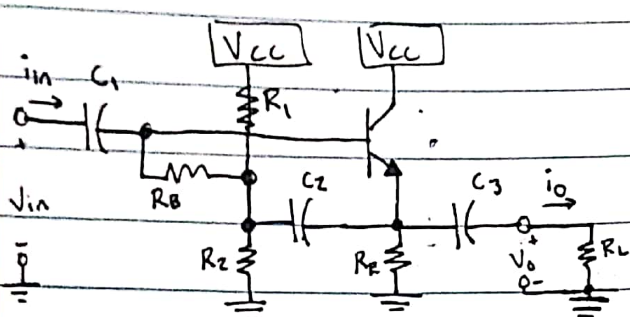
$$6.8 - 5000 I_{BQ} - 1000(I_B(\beta+1)) = 0$$

$$6.8 - I_{BQ}(5000 - 1000(100+1)) = 0$$

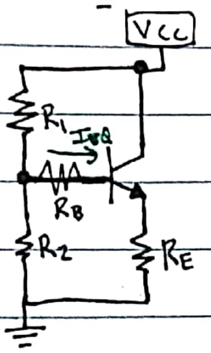
$$I_{BQ} = \frac{6.8}{5000-1000(100+1)} = -70.8\bar{3}\,\mu A$$

so not in active mode?

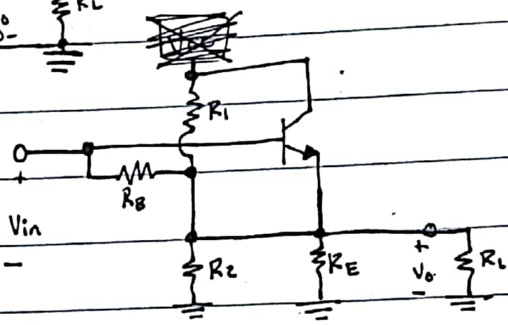
56.)



in
C1
Vcc
Vcc
R1
RB
C2
C3
io
Vin
R2
RE
Vo
RL



Vcc
R1
RB
R2
RE



R1
RB
Vin
R2
RE
Vo
RL