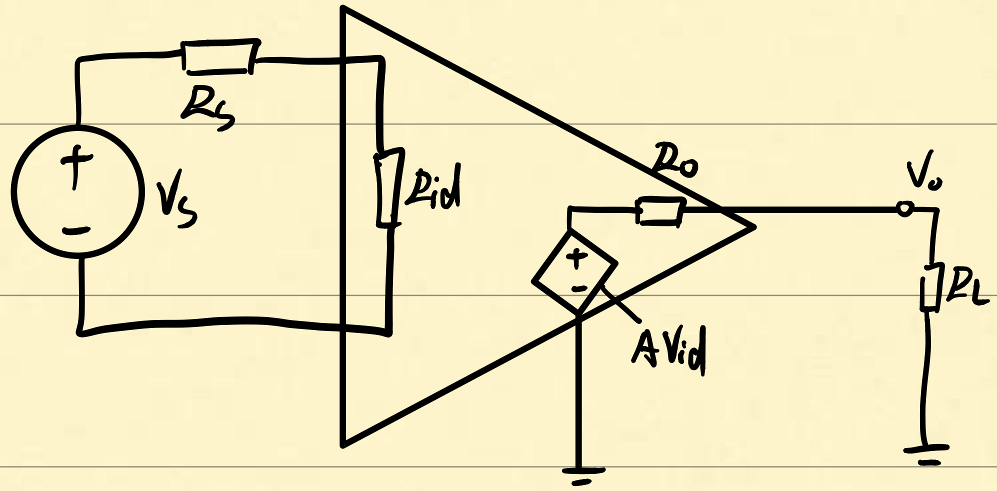
Q1: A differential amplifier, connected in the circuit.

$A = 84\,dB$, $R_{id} = 2M\Omega$, $R_o = 50\Omega$

sinusoidal signal $V_s(t) = V_s \cdot \sin(\omega_s \cdot t)$, $R_s = 10k\Omega$, $R_L = 500\Omega$



a) Find the overall votage A_v, current A_i, and power gain A_p for the amplifier and express it in dB.

	A_v	A_i	A_p
Gain ratio[1]	14336.5	5.73×10^{7}	8.26×10^{11}
Gain [dB]	83.13	155.2	119.17

$$A_v = \frac{V_o}{V_s} = \frac{AV_{id}\cdot\frac{R_L}{R_o+R_L}}{V_s} = \frac{A\cdot V_s\cdot\frac{R_{id}}{R_s+R_{id}}\cdot\frac{R_L}{R_o+R_L}}{V_s} = A\cdot\frac{R_{id}}{R_s+R_{id}}\cdot\frac{R_L}{R_o+R_L}$$

$$= 10^{\left(\frac{84}{20}\right)}\cdot\frac{2M}{10k+2M}\cdot\frac{500}{50+500} = 14336.5$$

$$A_{v\_dB} = 20\lg|A_v| = 83.13$$

$$A_i = \frac{I_{out}}{I_{in}} = \frac{\frac{V_o}{R_L}}{\frac{V_s}{R_s+R_{id}}} = \frac{V_o}{V_s}\cdot\frac{R_s+R_{id}}{R_L} = 143365\cdot\frac{10K+2M}{500}$$

$$=5.73\times10^7$$

$$A_{i\_dB} = 20\lg|A_i| = 155.2$$

$$A_p = A_i\cdot A_v = 8.26\times10^{11}$$

$$A_{p\_dB} = 10\lg A_p = 119.17$$

b) 已知 peak to peak is 10V in $V_o(t)$

$A = 5V$

	$V_s(t)$	$A_v=V_o/V_s$	$V_o(t)$
differential amp	$0.348\sin(\omega st)$ mV	143365	$5\sin(\omega st)$ V

c) power, peak to peak is 10V in $V_o(t)$

	input power	output power	dissipated power
differential amp	3.01×10^{-14} W	0.025 W	2.5 mW

★RMS有效值

$$P_s = \frac{(\frac{V_s}{\sqrt{2}})^2}{R_s+R_{id}} = 3.01\times10^{-14}\,W$$

$$P_o = \frac{(\frac{V_o}{\sqrt{2}})^2}{R_L} = 0.025\,W = 25\,mV$$

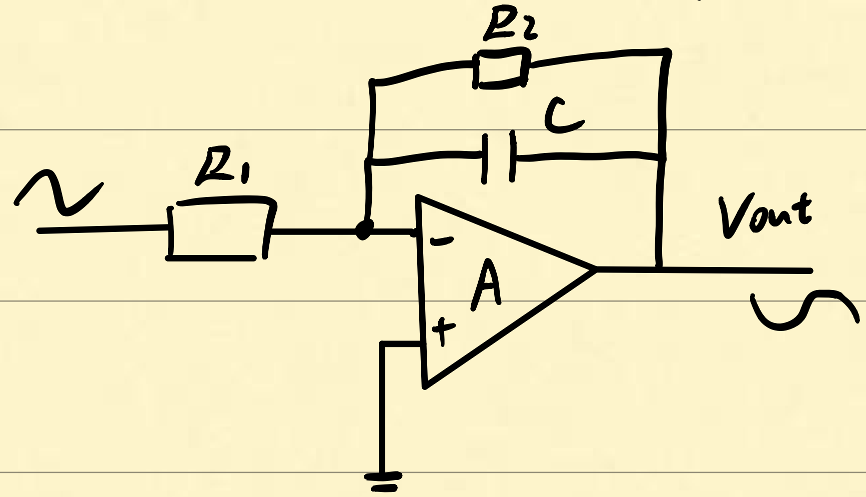
$$P_{dissipated} = P_{R_{id}} + P_{R_o}$$

$$= \frac{(\frac{V_s}{\sqrt{2}})^2}{R_{id}} + \left(\frac{\frac{V_o}{\sqrt{2}}}{R_L}\right)^2\cdot R_o$$

$$= 3.0276\times10^{-14} + 0.0025$$

$$\approx 2.5\,mW$$

Q2: Consider the amp circuit



a) what is the transfer function $A_v(s) = V_o(s)/V_i(s)$?
what is the circuit bandwidth frequency ω_B? and
unity gain frequency ω_T?

$$A_v = \frac{V_{out}}{V_{in}} = -\frac{R_2 // \frac{1}{sC}}{R_1} = -\frac{R_2}{R_1} \cdot \frac{1}{1+sCR_2}$$

$$\omega_B = \frac{1}{R_2 C}$$

让A_v为$\frac{1}{\sqrt{2}}$倍 则 $sCR_2 = 1j$ ($s = j\omega_B$)
$\Rightarrow \omega_B = \frac{1}{R_2 C}$

$$\omega_T = \underline{A_v(0)} \cdot \omega_B = -\frac{1}{R_1 C}$$

☆

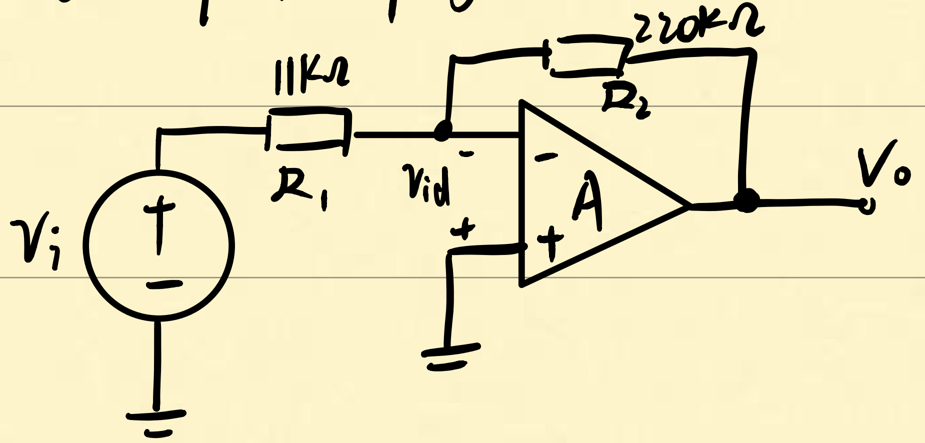
when $R_1 = 3.3k\Omega$, $R_2 = 390k\Omega$, $C = 10pF$ ...

so $A_v(0) = 118.18$, $A_{v\text{-}dB} = 20\lg|A_v(0)| = 41.45$

$\omega_B = 256.41\,K$ rad/s $\Rightarrow f_B = 40.81\,kHz$

$\omega_T = 3.03\times10^7$ rad/s $\Rightarrow f_T = 4.822\,MHz$

Q3: An inverting amp is built using an op-amp with an open loop gain of 60dB.



a) What are the ideal closed loop gain, loop gain, and actual closed loop gain for this amp if $R_1 = 1k\Omega$, $R_2 = 220k\Omega$.

$A = 10^{(\frac{60}{20})} = 1000$

ideal closed loop gain $A_v^{ideal} = -\frac{R_2}{R_1} = -20$

feedback $\beta = \frac{R_1}{R_1 + R_2} = 0.04762$

loop gain $T = A \cdot \beta = 47.619$

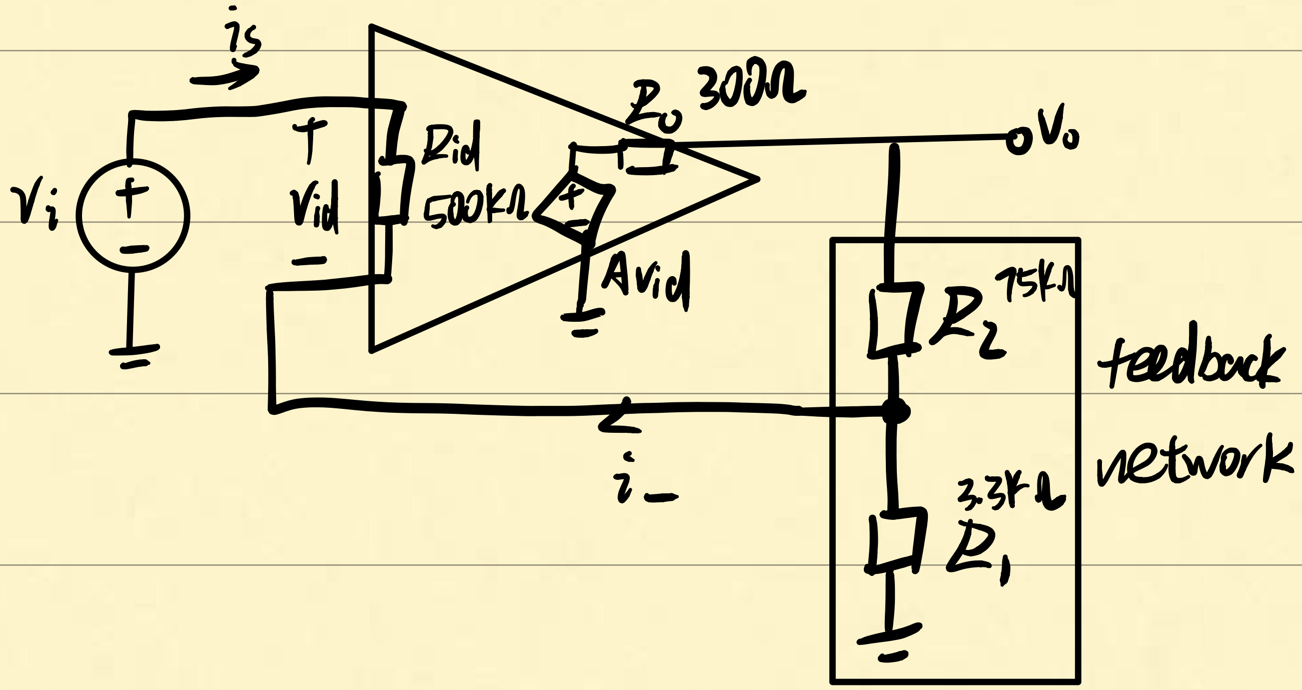
actual closed loop gain A_v^{actual} (A_v) $= A_v^{ideal} \cdot \frac{T}{1+T}$

$= -19.589$

when $R_1 = 3.3k\Omega$, $R_2 = 390k\Omega$

$A_v^{ideal} = -118.182$, $T = A\beta = 8.391$, $A_v = -105.597$

Q4: A non-inverting amp is built using an op-amp with input resistance $R_{id} = 500k\Omega$ and output resistances $R_o = 300\Omega$. The resistances $R_1 = 3.3k\Omega$
$R_2 = 75k\Omega$



	Amp		
	Actual CL gain A_v	Input resistance R_{in}	Output resistance R_{out}
A=60dB	23.18	$2.157 \times 10^7 \Omega$	0.953Ω
A=40dB	19.18	$2.61 \times 10^6 \Omega$	57.526Ω

$$\text{feedback } \beta = \frac{R_1}{R_1+R_2} = 0.0422$$

① when $A = 60\,\text{dB}$

$$= 10^{(\frac{60}{20})} = 1000 \;,\; A_v^{ideal} = \frac{1}{\beta} = 1 + \frac{R_2}{R_1} = 23.73$$

$$\text{loop gain } T = A\beta = 42.146$$

$$A_v^{actual} = A_v^{ideal} \cdot \left(\frac{T}{1+T}\right) = 23.18$$

$$R_{in} = R_{id}(1+T) = 2.157 \times 10^7\,\Omega$$

$$R_{out} = \frac{R_o}{1+T} = 6.953\,\Omega$$

② when $A = 40\,\text{dB}$

$$= 10^{(\frac{40}{20})} = 100 \;,\; A_v^{ideal} = 23.73$$

$$\text{loop gain } T = A\beta = 4.215$$

$$A_v^{actual} = A_v^{ideal}\left(\frac{T}{1+T}\right) = 19.18$$

$$R_{in} = R_{id}(1+T) = 2.61 \times 10^6\,\Omega$$

$$R_{out} = \frac{R_o}{1+T} = 57.526\,\Omega$$