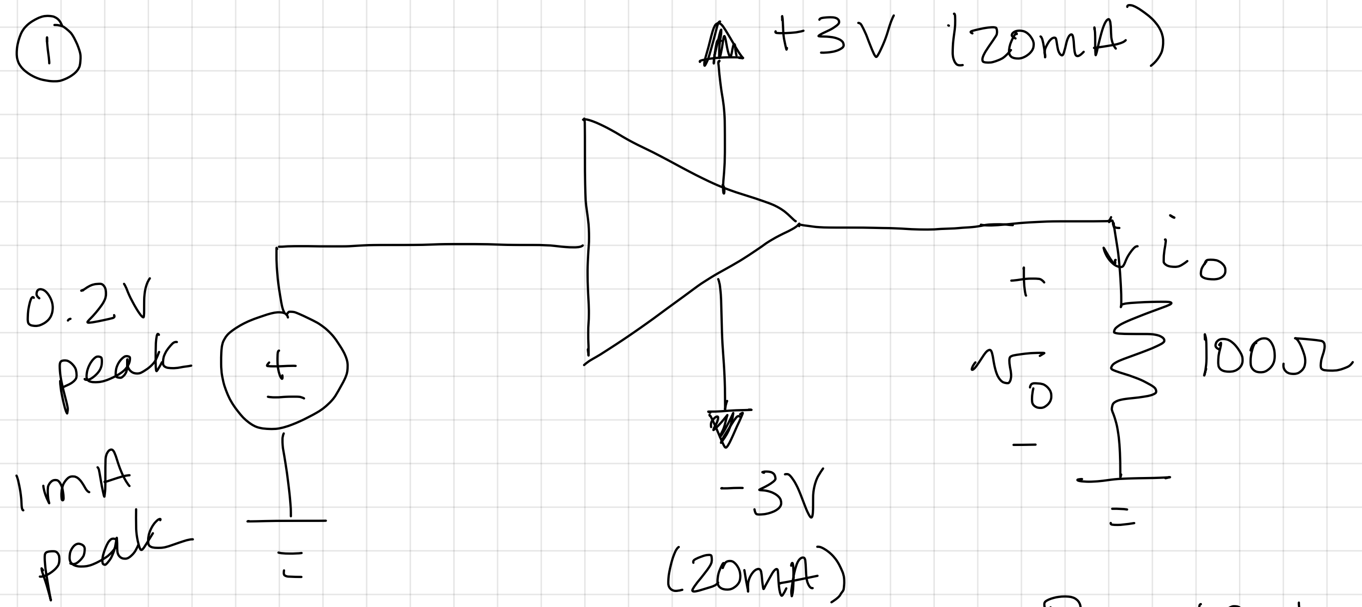
EE 315 HW #1 Solutions

(1)




$P_o = 48.4\,mW$

$$P_o = \frac{v_o^2}{100}$$

$$v_o^2 = 100(48.4 \times 10^{-3})$$

$$v_o = 2.2\,V$$

$$i_o = \frac{v_o}{100} = 22.0\,mA$$

a) $$A_v = \frac{v_o}{v_i} = \frac{2.2}{0.2} = 11\,\frac{V}{V} \text{ or } 20.83\,dB$$

$$A_i = \frac{i_o}{i_i} = \frac{22 \times 10^{-3}}{1 \times 10^{-3}} = 22\,\frac{A}{A}$$

or 26.85 dB

$$A_p = \frac{P_o}{P_i} = \frac{v_o i_o}{v_i i_i} = \frac{(2.2)(22\times10^{-3})}{(.2)(1\times10^{-3})}$$

$$A_p = 242 \ \frac{W}{W} \text{ or } 23.84\,dB$$

b) * now we have to deal w/ rms units or remember that average power is $\frac{1}{2}VI$.

$$P_{dc} + P_i = P_L + P_{diss}$$

same as $P_o$

$$P_{dc} = 3(20\times10^{-3})(2)$$

assume average values

there are 2 supplies

$$P_{dc} = 120\,mW$$

$$P_o = \frac{1}{2}\left(\frac{v_o^2}{100}\right) = 24.2\,mW$$

$$P_i = \frac{P_o}{A_p} = \frac{24.2}{242} = 0.1\,mW$$

$$\eta = \frac{P_o}{P_{dc}}\times100 = \frac{24.2}{120}\times100$$

$\eta = 20.17\%$

c) $P_{diss} = P_{dc} + P_i - P_o$

$$\boxed{P_{diss} = 95.9\ mW}$$

(2)

$v_O = A v_I$
$A = 200\ V/V$

| DC supplies | input at clipping | output at clipping |
|---|---|---|
| $\pm 2V$ | $\pm 8.5mV$ | $v_O = \pm 200(8.5\times10^{-3})$ <br> $\boxed{v_O = \pm 1.7\ V}$ |
| $\pm 5V$ | $\pm 21.5mV$ | $v_O = \pm 200(21.5\times10^{-3})$ <br> $\boxed{v_O = \pm 4.3V}$ |
| $\pm 10V$ | $\pm 42.5mV$ | $v_O = \pm 200(42.5\times10^{-3})$ <br> $\boxed{v_O = \pm 8.5V}$ |

so: for $\pm 2V$, $-1.7\ V \le v_O \le 1.7\ V$

$\pm 5V$, $-4.3\ V \le v_O \le 4.3\ V$

$\pm 10V$, $-8.5\ V \le v_O \le 8.5\ V$

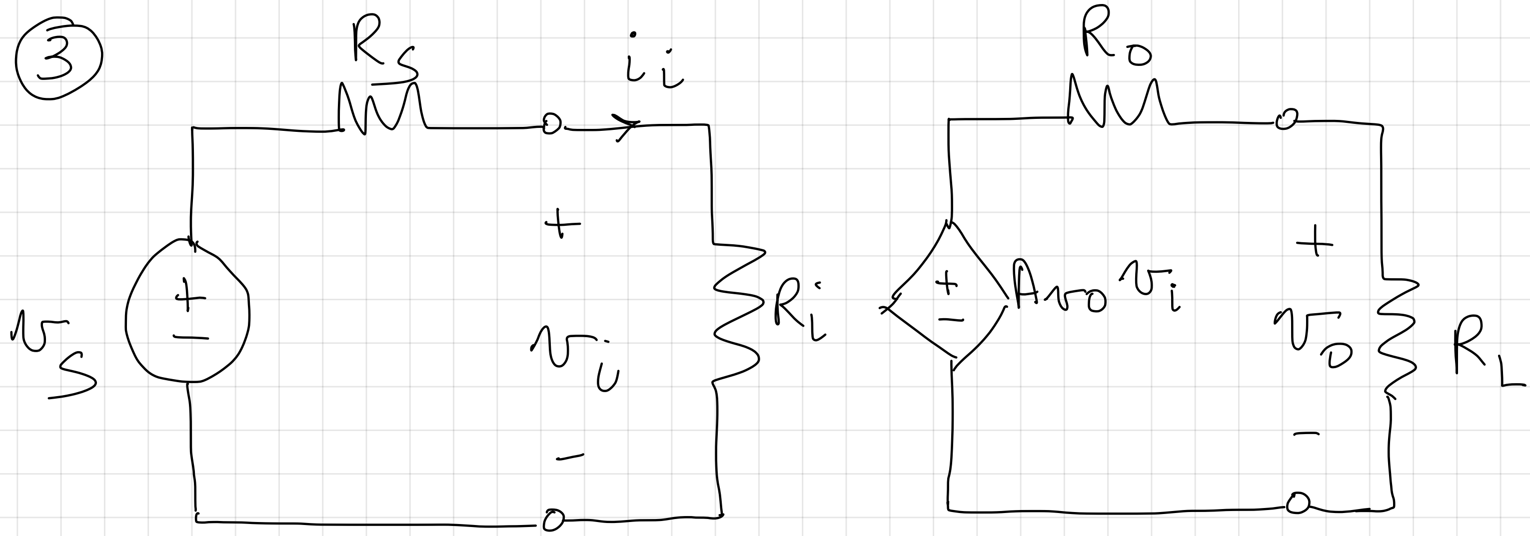
clipping occurs at : ~85% of DC supply

$$\frac{1.7}{2} = 0.85 \quad ; \quad \frac{4.3}{5} = 0.86$$

$$\frac{8.5}{10} = 0.85$$

---

③




$R_S = 200\,k\Omega$ $\quad R_i = 1\,M\Omega$ $\quad R_L = 150\,\Omega$

$v_S = 2\,V$ peak $\quad R_o = 40\,\Omega$ $\quad A_{vo} = 1\,V/V$

$$v_o = \frac{R_L}{R_L + R_o}\left(A_{vo} v_i\right)$$

$$v_i = \frac{R_i}{R_i + R_s} v_S$$

$$v_o = \left(\frac{R_L}{R_L+R_o}\right)(A_{vo})\left(\frac{R_i}{R_i+R_s}\right)v_s$$

$$\frac{v_o}{v_s} = \left(\frac{150}{150+40}\right)(1)\left(\frac{1\times10^6}{1\times10^6+200\times10^3}\right)$$

$$\frac{v_o}{v_s} = (0.789)(1)(0.833)$$

$$\boxed{A_v = \frac{v_o}{v_s} = 0.6575 \text{ V/V or } -3.64\,\text{dB}}$$

means attenuation

$$v_o = 0.6575 \cdot (2) = 1.315$$

$$i_o = \frac{v_o}{R_L} = \frac{1.315}{150} = 8.77\,\text{mA}$$

$$i_i = \frac{v_s}{R_i+R_s} = \frac{2}{1.2\times10^6} = 1.67\,\mu\text{A}$$

$$\boxed{A_i = \frac{i_o}{i_i} = 5.25\times10^3 \text{ A/A or } 74.4\,\text{dB}}$$

$$A_p = \frac{P_o}{P_s} = \frac{v_o i_o}{v_s i_s} = \frac{(1.315)(8.77 \times 10^{-3})}{(2)(1.67 \times 10^{-6})}$$

$$A_p = 3.45 \times 10^{3} \; \frac{W}{W}$$

or 35.38 dB

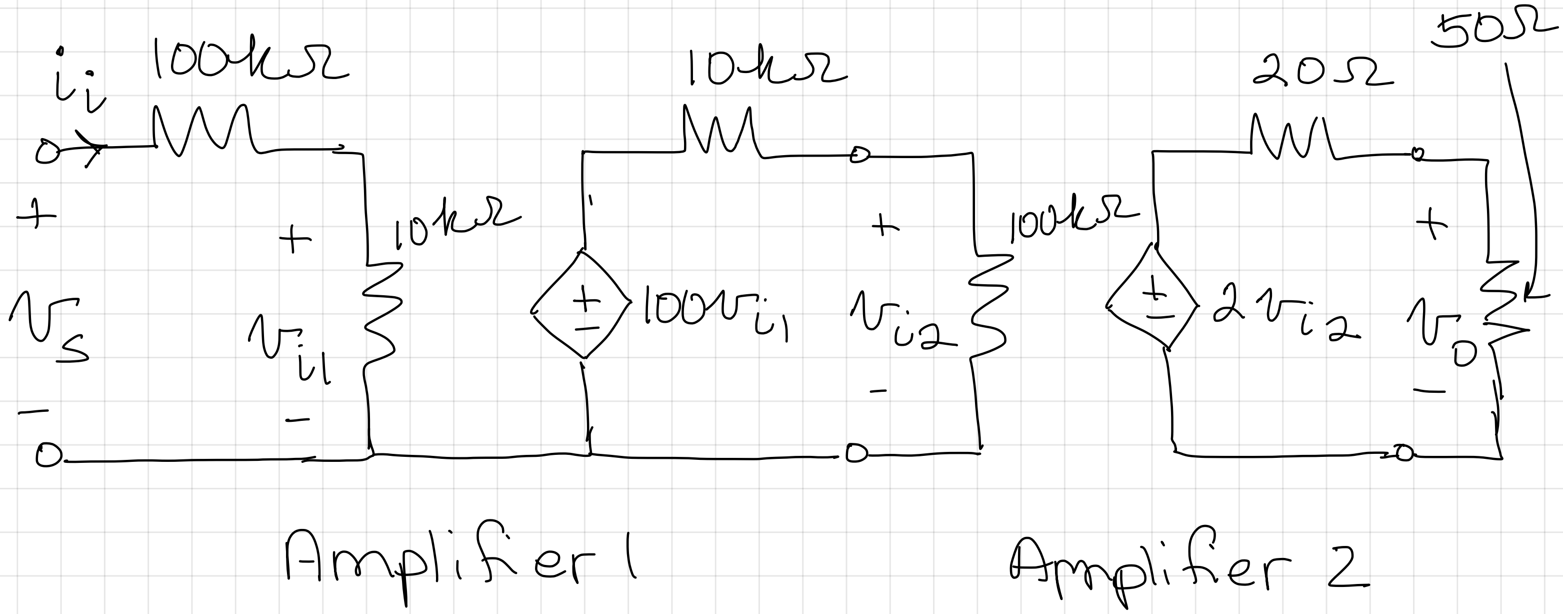
I would also except:

$$A_p = \frac{P_o}{P_i} = \frac{v_o i_o}{i_i^2 (R_i)} = \frac{(1.315)(8.77 \times 10^{-3})}{(1.67 \times 10^{-6})^2 (1 \times 10^{6})}$$

$$A_p = 4.14 \times 10^{3} \; \frac{W}{W} \quad \text{or} \quad 36.16 \text{ dB}$$

does not take into account the source resistance - it is pretty minimal.

(4) $v_s = 10\,mV$ $\quad 40\,dB = 100\,V/V \quad 6\,dB = 2\,V/V$




solve for $A_v$, $A_i$, $A_p$

$$\frac{v_o}{v_s} = \left(\frac{50}{50+20}\right)(2)\left(\frac{100\times10^3}{110\times10^3}\right)(100)\left(\frac{10\times10^3}{110\times10^3}\right)$$

$$= (0.714)(2)(0.909)(100)(0.0909)$$

$$\frac{v_o}{v_s} = 23.14\ \frac{V}{V}$$

$A_v$

$$v_o = 23.14(10\times10^{-3}) = 231.47\,mV$$

$$i_o = \frac{v_o}{50} = 4.63\,mA$$

$$i_i = \frac{v_s}{110\times10^3} = \frac{10\times10^{-3}}{110\times10^3}$$

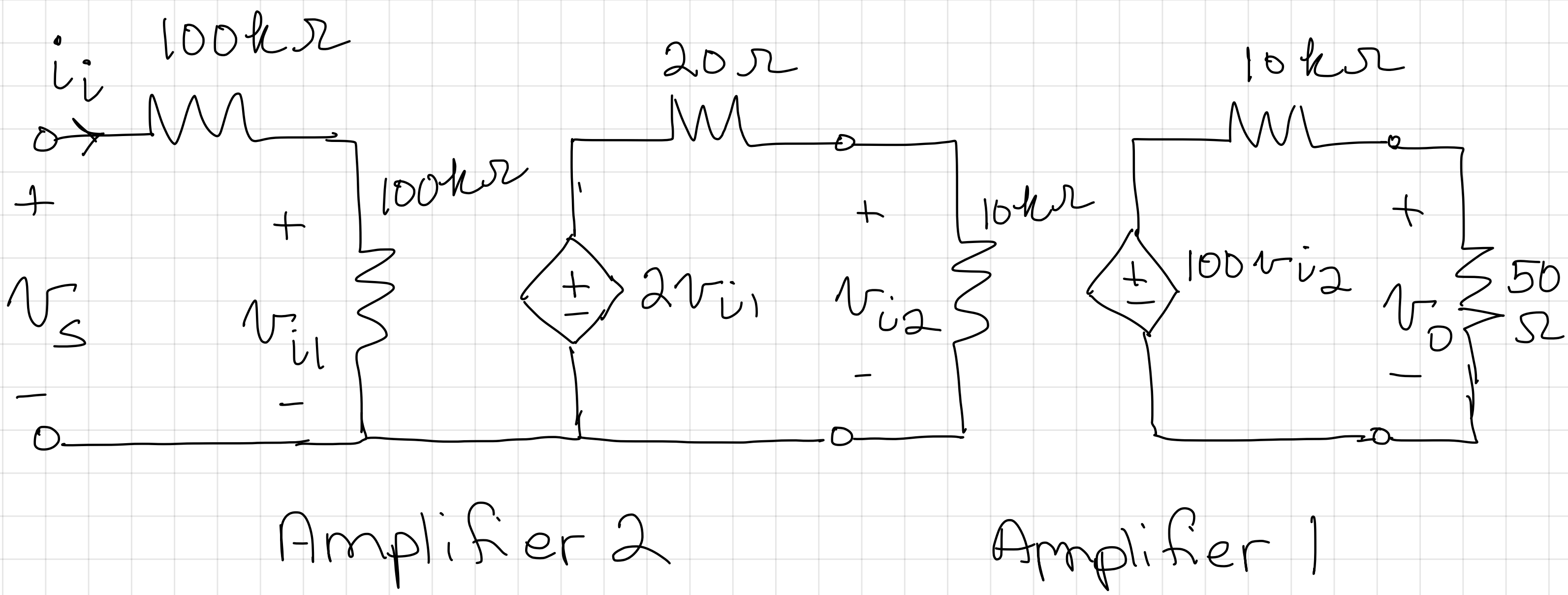
$$i_i = 9.09\times10^{-8}\,A$$

$$A_i = \frac{i_o}{i_i} = \frac{4.63 \times 10^{-3}}{9.09 \times 10^{-8}}$$

$$= 5.09 \times 10^{4} \ A/A$$

$$A_p = \frac{P_o}{P_s} = \frac{v_o i_o}{v_s i_i} = 1.18 \times 10^{6} \ \frac{W}{W}$$

Now, let's switch the order:




$$\frac{v_o}{v_s} = \left(\frac{50}{50+10\times10^3}\right)(100)\left(\frac{10\times10^3}{10\times10^3+20}\right)(2)\left(\frac{100\times10^3}{200\times10^3}\right)$$

$$= (0.005)(100)(0.998)(2)(0.5)$$

$$\frac{v_o}{v_s} = 0.5 \ \frac{V}{V}$$ $A_v$

$$v_o = 0.5(10\times10^{-3})$$

$$v_o = 5\ mV$$

$$i_o = \frac{v_o}{50} = 0.1mA$$

$$i_i = \frac{v_s}{200\times10^3} = 5\times10^{-8}A$$

$$A_i = \frac{i_o}{i_i} = 2{,}000\ A/A$$

$$A_p = \frac{v_o i_o}{v_s i_i} = 1{,}000\ W/W$$

<u>Compare</u>

| order | $A_v$ | $A_i$ | $A_p$ |
|---|---|---|---|
| Amp1, Amp2 | 23.14 V/V | $5.09\times10^4$ A/A | $1.18\times10^6$ W/W |
| Amp2, Amp1 | 0.5 V/V | 2000 A/A | 1000 W/W |

which is better?

It depends, I could make an argument for both.

Amp1, Amp2 : good $A_v$ but very high $A_i$ & $A_p$ – can the load handle it?

Amp2, Amp1 : $A_v$ is small - maybe too small depending on the application but $A_i$ + $A_p$ are pretty good.

My point here is that there is no "right" answer – it depends on the application and what is needed at the load.

And - don't simply pick a stage based on one factor. Based on lectures, you might have been tempted to just go w/ the high $R_i$ as Amp stage 1 and low $R_o$ as Amp ~~stage~~ 2, that design plan is never a good one!

Get used to this!

We are not in EE 213 land anymore!