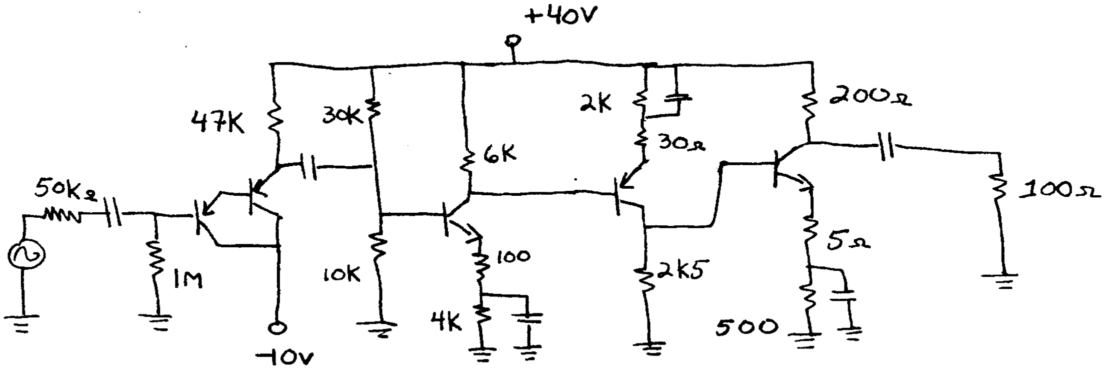
"MONSTERRIFIC" Problem # 1 LINEAR



$h_{fe} = 100$ each for the Darlington Pair, 200 for the remaining 3.
Find: Z_{in} of system, A_v of system.

To find Z_{in} and A_v, we need to find the $Z_{in(base)}$ and r'_e of each stage. This requires us to find I_E. Let's get this stuff out of the way first for later use.

$$I_{E_1} = \frac{40V - 1.4V}{47K} = .821\,ma \qquad r'_{e_1} = 2 \cdot \frac{26mV}{.821ma} = 63.3\Omega$$

$$I_{E_2} = \frac{10V - .7V}{4K1} = 2.27ma \qquad r'_{e_2} = \frac{26mV}{2.27ma} = 11.5\Omega$$

$$I_{E_3} = \frac{40V - (26.4V + .7V)}{2K03} = 6.35ma \quad (\text{note } V_{C_2} = V_{B_3} = 26.4V)$$

$$r'_{e_3} = \frac{26mV}{6.35ma} = 4.10\Omega$$

$$I_{E_4} = \frac{15.88V - .7V}{505\Omega} = 30.1\,ma \quad (\text{note } V_{C_3} = V_{B_4} = 15.88V)$$

$$r'_{e_4} = \frac{26mV}{30.1ma} = .864\Omega$$

$$Z_{in(base)4} = 200(5\Omega + .864) = 1K173\Omega$$
$$Z_{in(base)3} = 200(30\Omega + 4.10) = 6K82\Omega$$
$$Z_{in(base)2} = 200(100 + 11.5) = 22K3\Omega$$
$$Z_{in(base)1} = 100 \cdot 100(63.3 + \underbrace{47K \| 10K \| 30K \| 22K3}_{5K01 = r_{E_1}}) = 50M73\Omega$$

CONTINUED.

NOTE THAT R_{E_1} is in parallel with the Biasing Resistors and $Z_{in(base)}$ of stage 2. This is r_{E_1}.

Zin of system.

this is equal to Z_{in_1}

$$Z_{in_1} = Z_{Bias_1} // Z_{in(base)_1} = 1M\Omega // 50M73 = \underline{981K\Omega}$$

NOTE: IGNORING r'_C of Darlington Pair

A_V of system

there are 5 gains to be considered, first of which is the input loading.

$$A_L = \frac{Z_{in}}{Z_{in}+R_S} = 981K / 50K + 981K = \underline{.952}$$

Note: 50kΩ is quite high for a typical generator impedance, however this could easily represent the internal impedance of a high Z microphone. Note how the Darlington follower minimizes loss.

$$A_{V_1} = \frac{r_{E_1}}{r'_{e_1}+r_{E_1}} = \frac{47K//10K//30K//22K3}{63.3\Omega + 47K//10K//30K//22K3} = \underline{.988}$$

$$A_{V_2} = \frac{r_{C_2}}{r'_{e_2}+r_{E_2}} = \frac{6K // Z_{in(base)_3}}{11.5 + 100} = \frac{3K19}{111.5} = \underline{28.6}$$

$$A_{V_3} = \frac{r_{C_3}}{r'_{e_3}+r_{E_3}} = \frac{2K5 // Z_{in(base)_4}}{30 + 4.1} = \frac{798\Omega}{34.1\Omega} = \underline{23.4}$$

$$A_{V_4} = \frac{r_{C_4}}{r'_{e_4}+r_{E_4}} = \frac{200 // r_L}{.864+5} = \frac{66.7}{5.864} = \underline{11.4}$$

$$A_{V_T} = A_L \cdot A_{V_1} \cdot A_{V_2} \cdot A_{V_3} \cdot A_{V_4} = .952 \cdot .988 \cdot 28.6 \cdot 23.4 \cdot 11.4 = \underline{7176}$$