Experiment 3
Active Loading

Laboratory Report for ENGE 312
Applications of Electronic Devices
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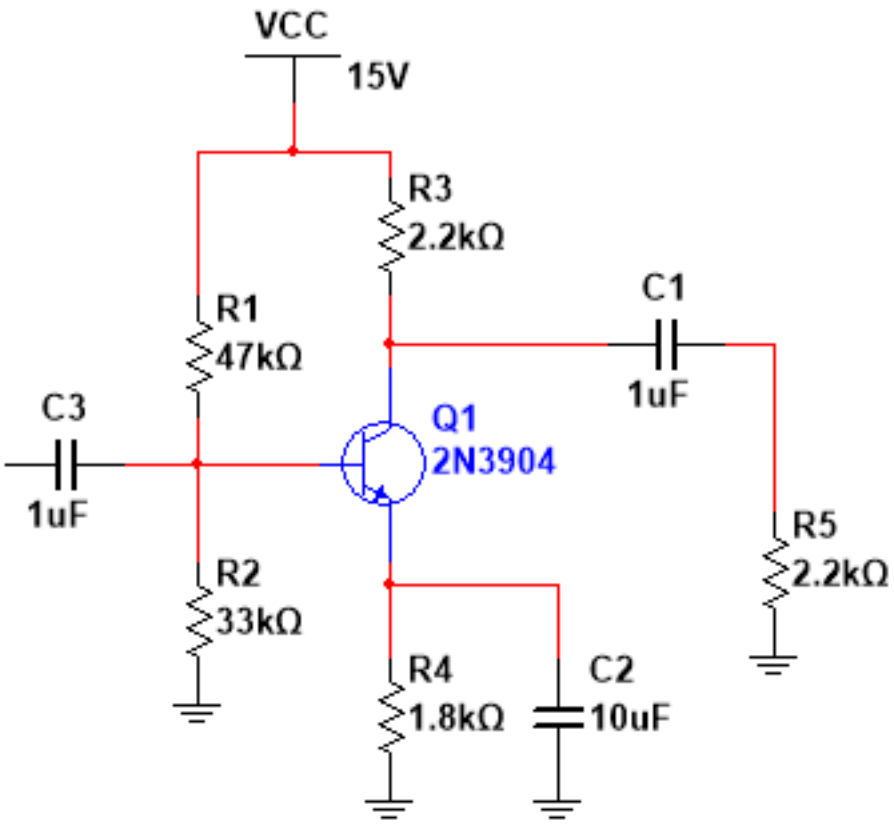

Fig. 1. CE amplifier without active loading.

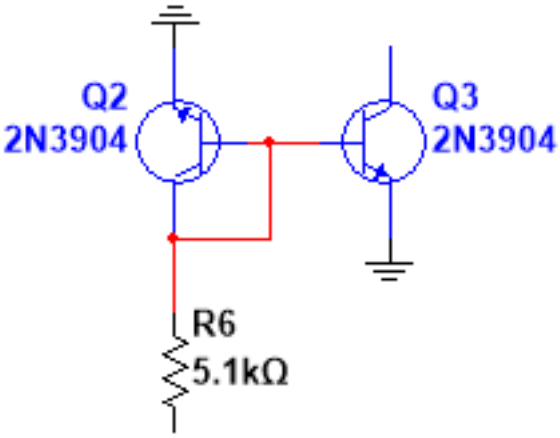

Fig. 2. Current Mirror

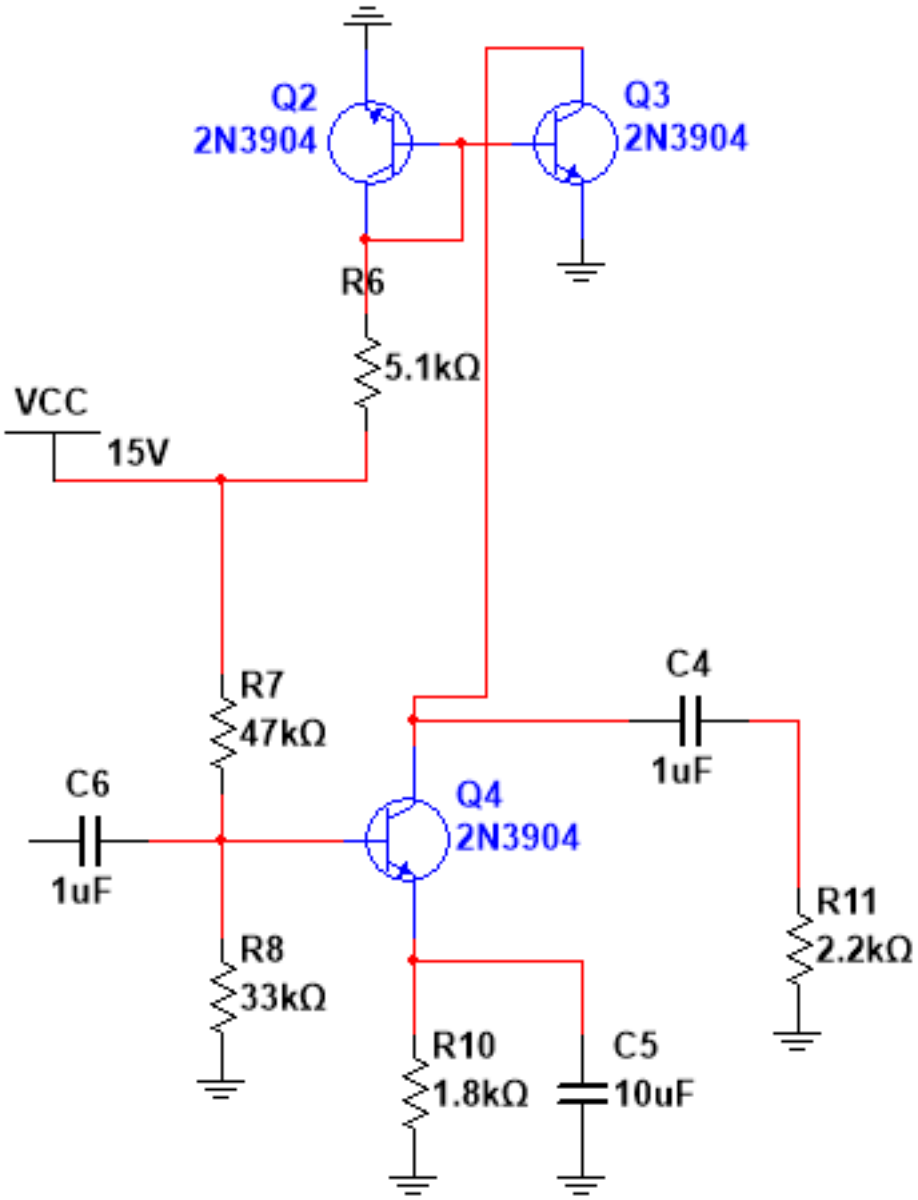

Fig. 3. CE Amplifier with active loading from the current mirror

I. RESULTS

Fig. 1. DC Operating Point Comparison across all circuits.

	(Resistor)			(Current Mirror)			(Active Load)		
Param	**Meas**	**Theo**	**% Diff**	**Meas**	**Theo**	**% Diff**	**Meas**	**Theo**	**% Diff**
I_C / I_O	2.80 mA	2.81 mA	0.13%	2.80 mA	2.81 mA	0.13%	2.88 mA	2.81 mA	0.62%
V_{CE} / V_O	3.78 V	3.76 V	0.13%	14.30 V	10.92 V	6.70%	4.63 V	3.76 V	5.18%

Fig. 2. Voltage Gain Comparison

Configuration	Measured A_v	Theoretical A_v	% Difference
Resistor Bias	−107 V/V	−122 V/V	−3.28%
Active Load	−244 V/V	−204 V/V	−4.46%

Fig. 3. Output Voltage Swing Analysis (Clipping Limits).

Parameter	Measured (V)	Theoretical (V)	% Difference
$v_{o,\max}$	2.56 V	3.56 V	8.17%
$v_{o,\min}$	3.72 V	3.09 V	4.62%
$v_{o,p-p}$	6.28 V	6.18 V	0.39%

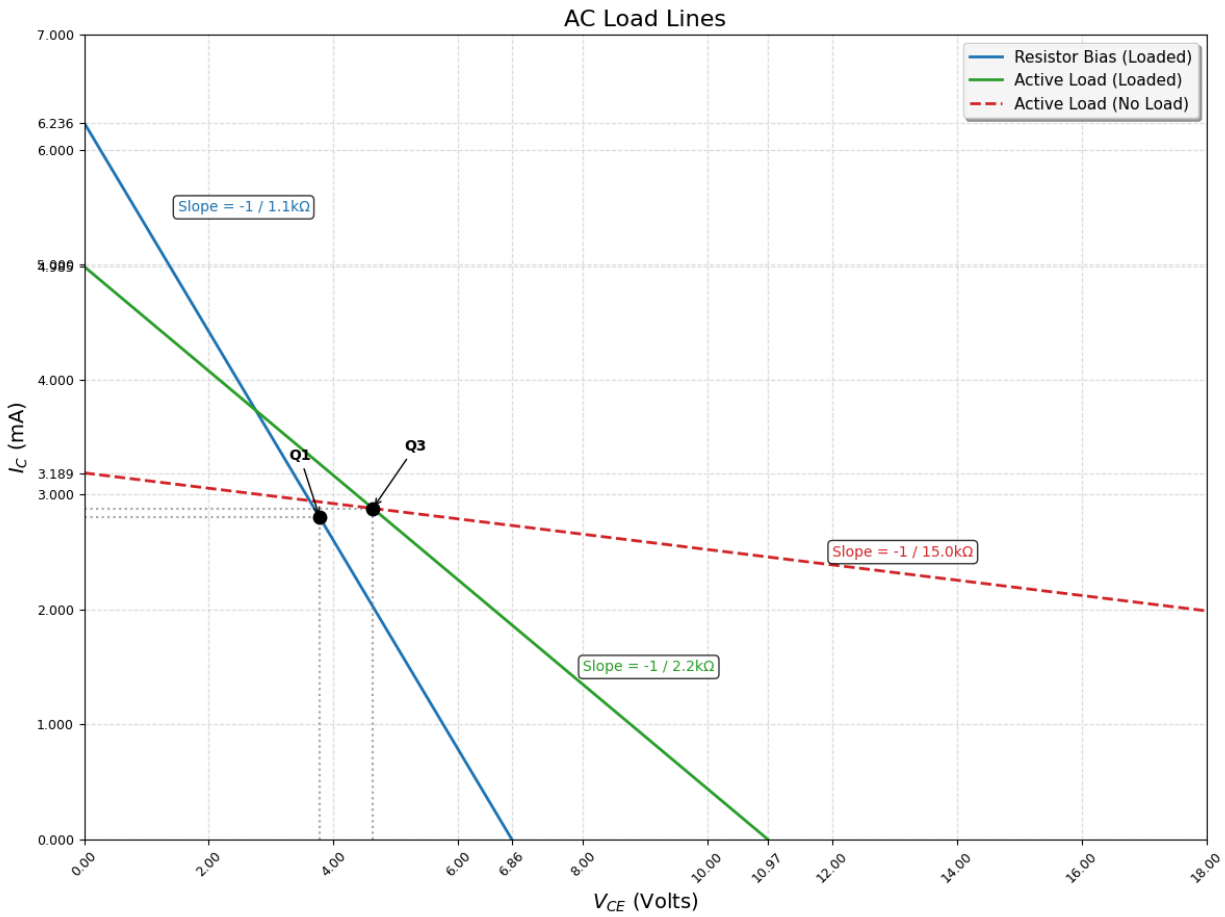

Fig. 4. Graph of AC Load Lines of the two amplifiers used in the experiment. The dotted line is the current mirrored active load amplifier with no load resistor.

II. DISCUSSION

The percent differences between lab measurements and hand calculations seemed to be fairly small; for most, the difference is 5%, with a couple of outliers like $V_{\text{o,max}}$ and V_O. This is probably due to some human error. Of course, for some of the calculations, lab measurements had to be used, since for the current meter, the ideal is that it would match the measured current in the lab when looking at the analysis. The current meter seemed to shift the Q point of the amplifier a little bit when added, at least experimentally, since it shouldn't change the Q point, or increase the gain. The change to a current mirror at the emitter did bring a very similar calculated gain increase. The load resistor decreases the amount of gain possible..

III. SAMPLE CALCULATIONS

$$\begin{aligned} I_{\mathrm{CQ}} &= \frac{V_{\mathrm{BB}} - V_{\mathrm{BE}}}{\left(\frac{R_E}{\alpha}\right) + \left(\frac{R_B}{\beta}\right)} \\ &= \frac{8.13V - 0.7V}{\left(\left(\frac{1.8k\Omega}{\alpha}\right) + \left(\frac{19k\Omega}{130}\right)\right.} \\ I_{\mathrm{CQ}} &= 2.8\ \mathrm{mA} \end{aligned} \tag{1}$$

$$\begin{aligned} V_{\mathrm{CE}} &= V_{\mathrm{CC}} - \left(R_{\mathrm{CC}} + \frac{R_E}{\alpha}\right) I_{\mathrm{CQ}} \\ &= 15V - \left(2.2k\Omega + \frac{1.8k\omega}{0.99}\right)(2.8\ \mathrm{mA}) \\ V_{\mathrm{CE}} &= 3.76V \end{aligned} \tag{2}$$

$$\begin{aligned} A_V &= -\frac{\beta V_T}{I_{\mathrm{CQ}}}(R_o \parallel R_c \parallel R_L) \\ &= -\frac{130 * 25\ \mathrm{mV}}{2.8\ \mathrm{mA}}(30k\Omega \parallel 30k\Omega \parallel 2.2k\Omega) \\ A_V &= -122\frac{V}{V} \end{aligned} \tag{3}$$

$$\begin{aligned} V_{\mathrm{o,max}} &= V_{\mathrm{CE}} - v_{\mathrm{CE,sat}} \\ &= 3.76V - 0.2V \\ &= 3.56V \end{aligned} \tag{4}$$

$$\begin{aligned} V_{\mathrm{o,min}} &= (R_C \parallel R_L) I_{\mathrm{CQ}} \\ &= (2.2k\Omega \parallel 2.2k\Omega) * 2.8\ \mathrm{mA} \\ &= 3.09V \end{aligned} \tag{5}$$

$$\begin{aligned} I_{\text{ref}} &= \frac{V_{\text{CC}} - V_{\text{BE}}}{I_{\text{REF}}} \\ &= \frac{15 - 0.7V}{2.8\ \text{mA}} \\ &= 5.1k\Omega \end{aligned} \tag{6}$$

$$\begin{aligned} I_o &= \frac{I_{\text{ref}}}{1 + \frac{2}{\beta}} \\ &= \frac{5.1k\Omega}{1 + \frac{2}{150}} \\ &= 2.80\ \text{mA} \end{aligned} \tag{7}$$

$$\begin{aligned} V_{\text{o}} &= I_o * R_X \\ &= 2.8\ \text{mA} * 3.9k\Omega \\ &= 10.92V \end{aligned} \tag{8}$$