UNIVERSITY OF CALIFORNIA AT BERKELEY
College of Engineering
Department of Electrical Engineering and Computer Sciences

EE105 Lab Experiments

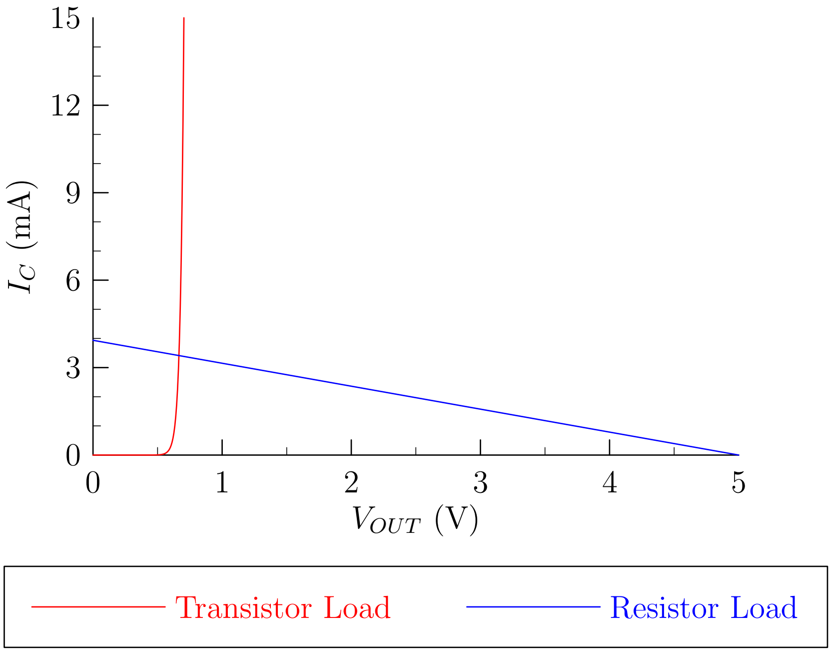
Report 6: Biasing Circuitry

Solutions

3.1.3 What is R_C when $V_{OUT} = 650\,\text{mV}$?

$\boxed{R_C = 1.17\,\text{k}\Omega}$

3.1.4 Roughly sketch I_C vs. V_{OUT} for the transistor and for the resistor, showing the fixed point solution for V_{OUT}. How would we adjust the resistor to increase V_{OUT}?



We should decrease R_C in order to increase V_{OUT}.

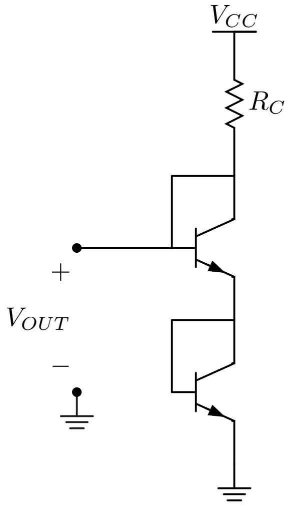
3.1.5 Will the voltage source become better or worse (better as defined by being closer to an ideal source) as the resistor decreases?

It becomes a better voltage source because decreasing R_C decreases output impedance. However, this difference is only marginal, as the output impedance is $R_C \parallel \frac{1}{g_m}$, and $\frac{1}{g_m}$ dominates in most cases.

3.1.6 Find the output impedance of the voltage source.

$\boxed{R_{out} = 9.55\,\Omega}$

3.1.7 Now, suppose you want to make your voltage source output 1.3 V. Clearly, putting 1.3 V on V_{BE} of the diode connected BJT is not a good idea (please, don't even try). Draw a circuit topology to achieve this voltage without requiring a BJT to have an extremely high V_{BE}.



Now each BJT only has half the total output voltage V_{out} across its base-emitter junction.

3.2.2 Short circuit current:

$\boxed{I_{OUT} = 10\text{ mA}}$

3.2.3 Find R_{out} in terms of the small-signal characteristics.

$\boxed{\text{Theoretical } R_{out} = r_o}$

3.2.4 What happens to the output impedance as V_{OUT} nears 5 V?

As V_{OUT} nears 5 V, we will go into deep saturation. This has the effect of greatly reducing r_o, which reduces the output impedance of the current source. This effect is highly undesirable, as we would like to maintain a high output impedance for a current source.

3.2.5 Output impedance at $V_{OUT} = 2.5$ V

$\boxed{\text{Measured } R_{out} = 5.3\text{ k}\Omega}$

3.2.6–8 Transistors in parallel with $V_{OUT} = 2.5$ V:

$\boxed{I_{OUT} = 21.5\text{ mA}}$

$\boxed{R_{out} = 2.6\text{ k}\Omega}$

Explain the effect of the second transistor on the output impedance.

Adding the second transistor results in a smaller output impedance. In the small signal model, we can find that the R_{out} of this current source is $r_{o1} \parallel r_{o2}$. Since both transistor are identical, $R_{out} = \frac{1}{2}r_o$, which our experimental results support.

3.3.2–6 Properties of the CE amp with current mirror:

$\boxed{V_{IN} = 660\text{ mV}}$

$\boxed{A_v = -300}$

$\boxed{I_{C2} = 1\text{ mA}}$

$\boxed{I_{C3} = 1\text{ mA}}$

$\boxed{R_{in} = 2.8\text{ k}\Omega}$

$\boxed{R_{out} = 2.6\text{ k}\Omega}$

3.3.7 How do the impedances and gain compare with a common emitter biased with a resistor instead?

The gain is significantly bigger and our output impedance is also much bigger.

3.3.8 Explain this effect using what you know about BJT temperature effects. How may this be an advantage of BJT biasing over resistive biasing?

In a BJT, I_C is a very strong function of temperature. When we heat up only one side of the current mirror, we destroy a property of the current mirror; the current through both sides is no longer the same and in essense, our circuit is no longer biased properly and we begin to lose output voltage swing in either the high end or the low end. But if both sides are heated up, we maintain the property of the current mirror and keep current through both sides the same, which maintains the bias of our circuit. This property makes BJT biasing superior to resistive biasing; when an integrated circuit chip grows hot, BJT biasing is able to maintain bias. Resistors do not have the same dependence on temperature as BJTs do, so they will not be able to self-adjust and maintain the bias.