ECEN326: Electronic Circuits
Spring 2022

Lab 10: Design of a BJT Shunt-Series Feedback Amp

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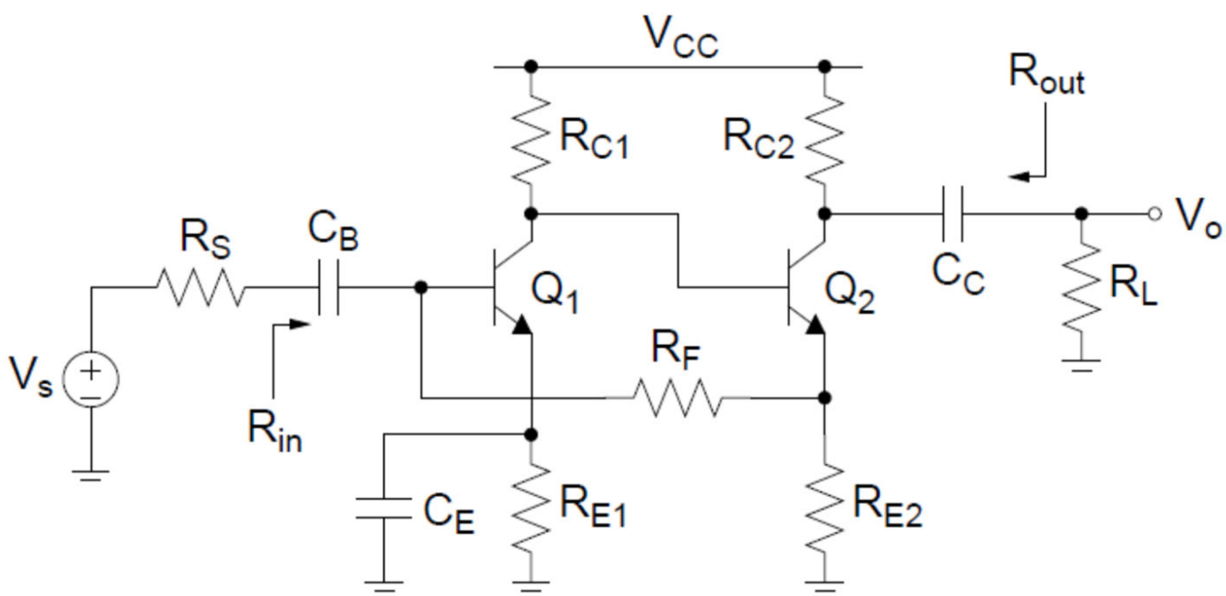
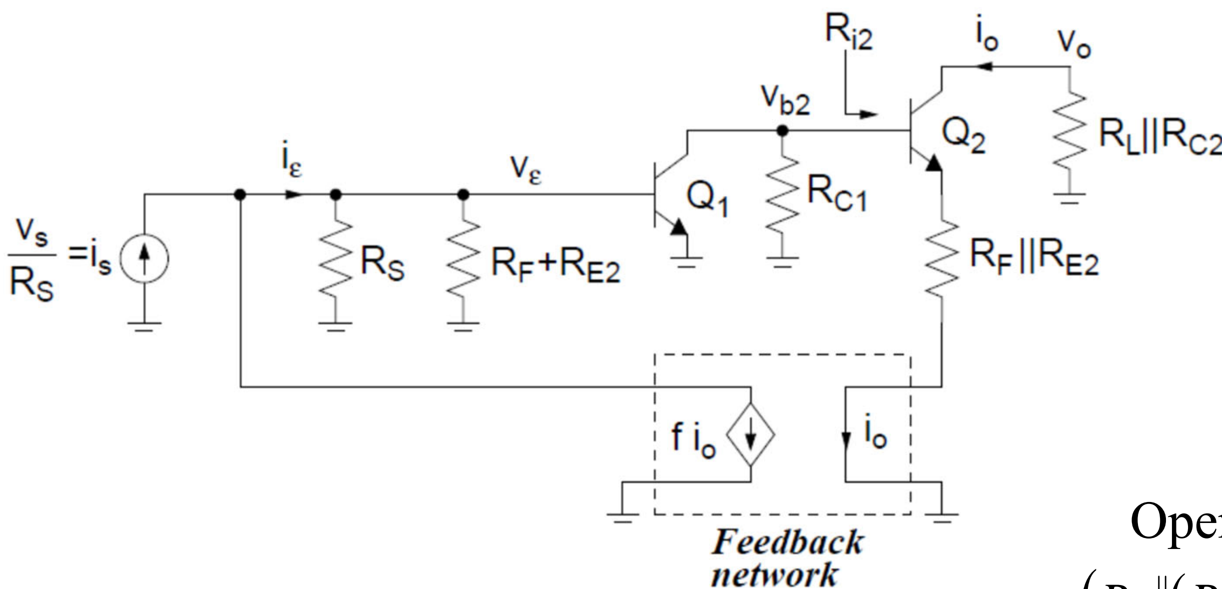
BJT Shunt-Series Feedback Amplifier



- From a feedback perspective, this circuit can be viewed as a current amplifier with the source current amplified to form the signal current through Q2
- Thus, we have **current-current feedback** with a parallel or "shunt" feedback resistor R_F and a "series" sensor resistor R_{E2}
- In the lab, it is easiest to measure this as a voltage amplifier with a standard voltage source input and taking the output as the Q_2 collector

Feedback Equivalent Circuit – Open Loop



$$\text{Assuming } \alpha = 1$$

Open - Loop Current Gain :

$$a = \frac{i_o}{i_\varepsilon} = -\frac{\left(R_S \| (R_F + R_{E2}) \| r_{\pi 1}\right)\left(R_{C1} \| R_{i2}\right)}{r_{e1}\left(r_{e2} + \left(R_F \| R_{E2}\right)\right)} \approx -\frac{R_S g_{m1} R_{C1}}{R_{E2}}$$

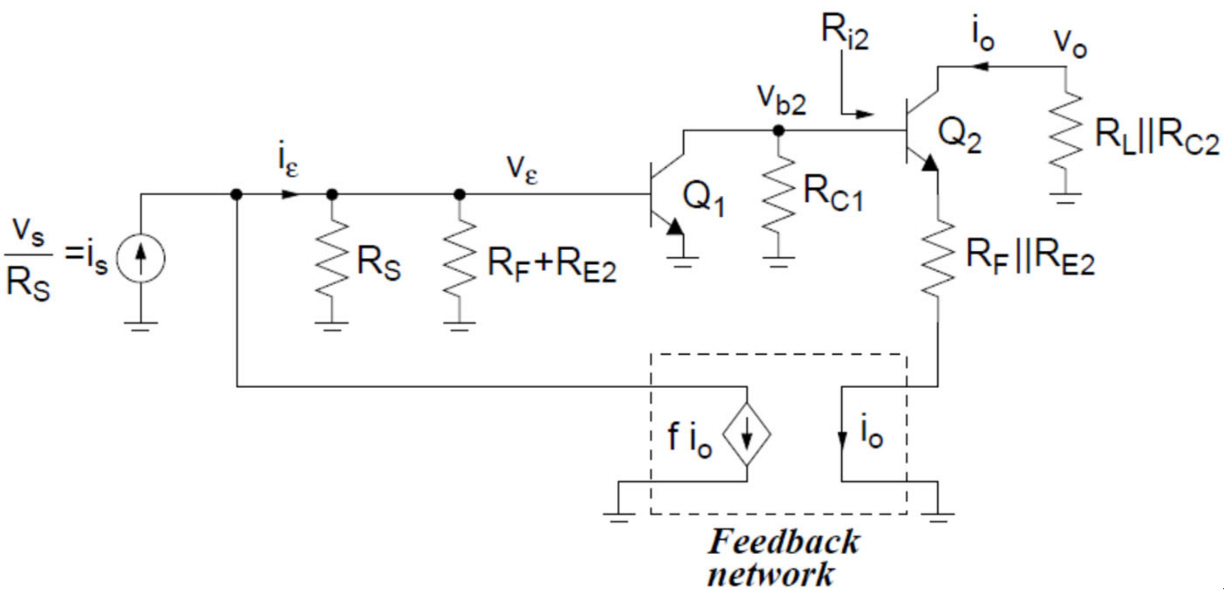
$$\text{Feedback Factor}: \; f = -\frac{R_{E2}}{R_{E2} + R_F} \approx -\frac{R_{E2}}{R_F}$$

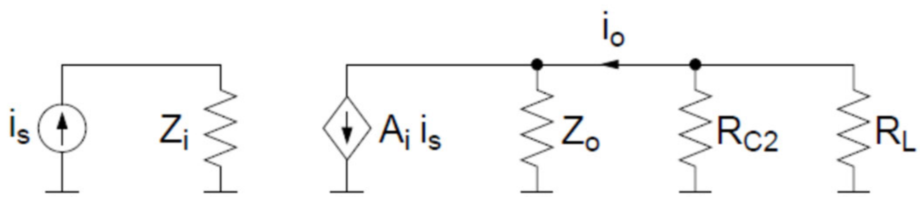
$$z_i = R_S \| (R_F + R_{E2}) \| r_{\pi 1} \approx R_S$$

$$z_o = R_T + r_{o2} + g_{m2}\frac{r_{\pi 2}}{r_{\pi 2} + \left(r_{o1} \| R_{C1}\right)} r_{o2} R_T \approx g_{m2} r_{o2} R_{E2}$$

$$R_T = R_F \| R_{E2} \| \left(r_{\pi 2} + \left(r_{o1} \| R_{C1}\right)\right) \approx R_{E2}$$

Feedback Equivalent Circuit – Closed Loop



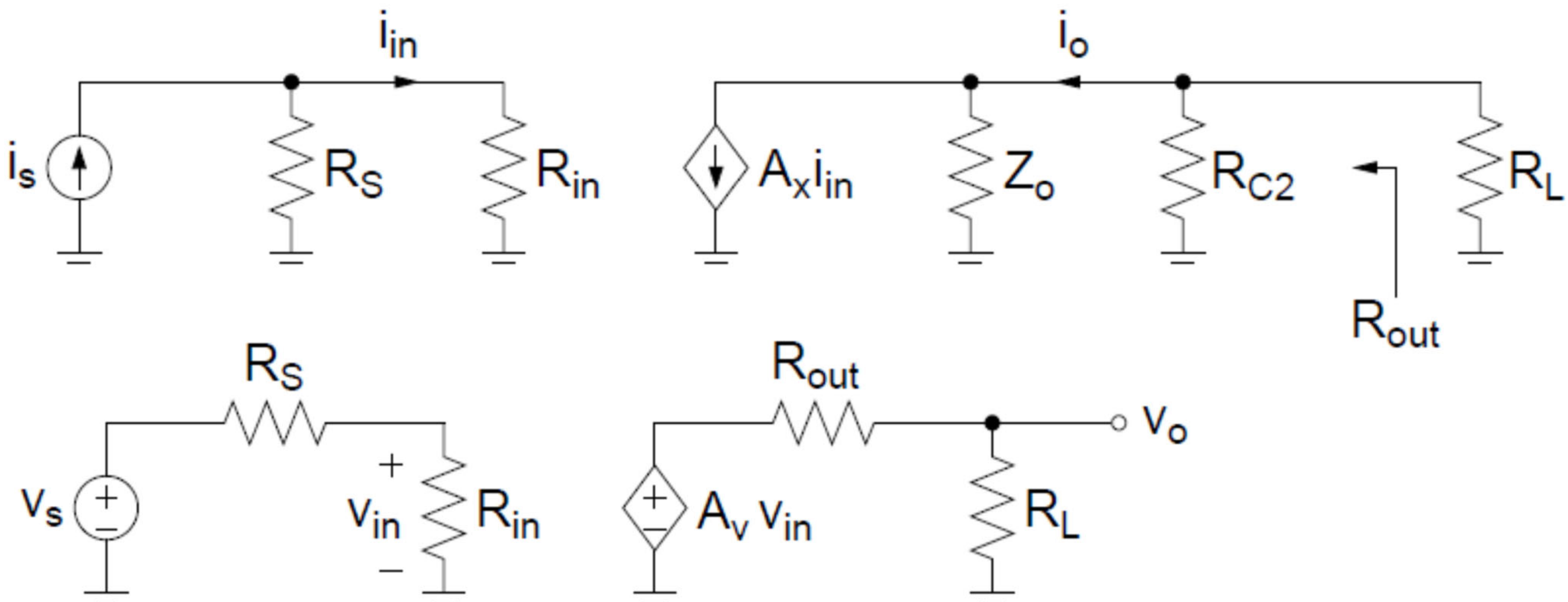


$$A_i = \frac{i_o}{i_s} = \frac{a}{1+af} \approx -\frac{R_F}{R_{E2}}$$

$$Z_i = \frac{z_i}{1+af} \approx \frac{R_F}{g_{m1}R_{C1}}$$

$$Z_o = z_o(1+af) \approx g_{m2}r_{o2}R_{E2}\left(1+\frac{R_S g_{m1} R_{C1}}{R_F}\right)$$

Converting to a Voltage-Mode Amplifier



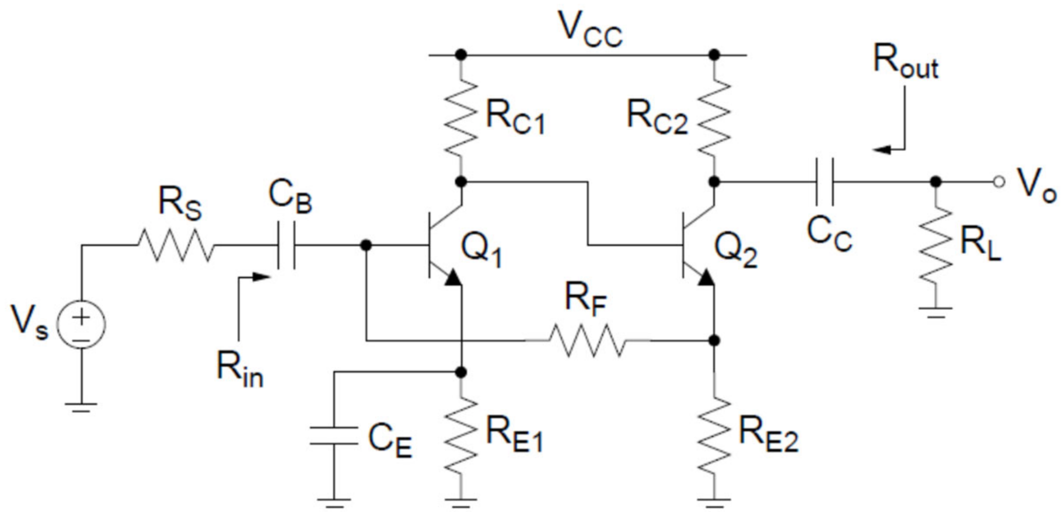
See details in lab manual

$$A_v \approx \frac{R_F R_{C2}}{R_{E2} R_S}$$

$$R_{in} \approx \frac{R_F}{g_{m1} R_{C1}}$$

$$R_{out} \approx R_{C2}$$

Design Procedure



1. Using Isupply spec, apply most of the current to the output stage (7-8mA) for good distortion performance
2. The first stage should work well with 0.5-1mA
3. From DC conditions, set RE1, RE2, and RC1
4. Using load line analysis (Eq 7), calculate RC2
5. Set RF to meet the voltage gain spec
6. Verify that you meet the af spec (Eq 19 & 20)