Bipolar Junction Transistors and Applications

Transistor Physics

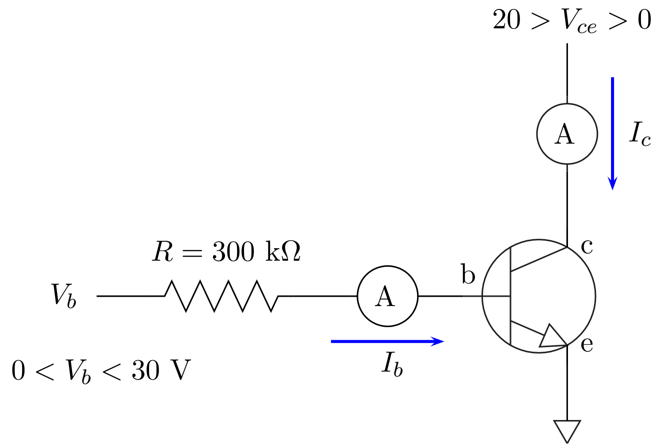

Figure 1: Measurement of $\beta = I_c/I_b$ for an npn bipolar junction transition.

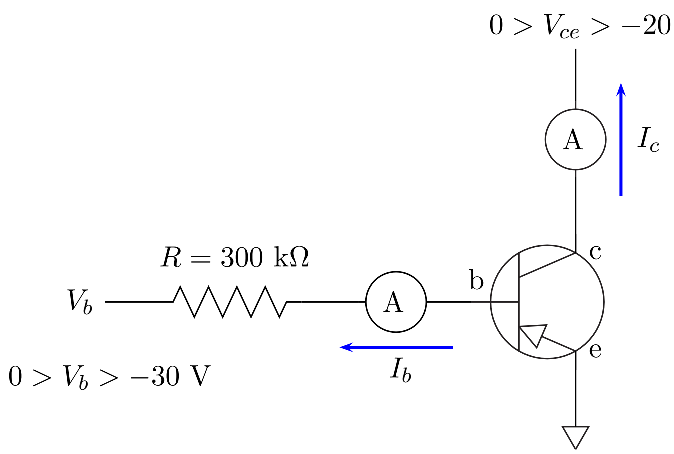

Figure 2: Measurement of $\beta = I_c/I_b$ for a pnp bipolar junction transition.

Common Emitter Amplifier

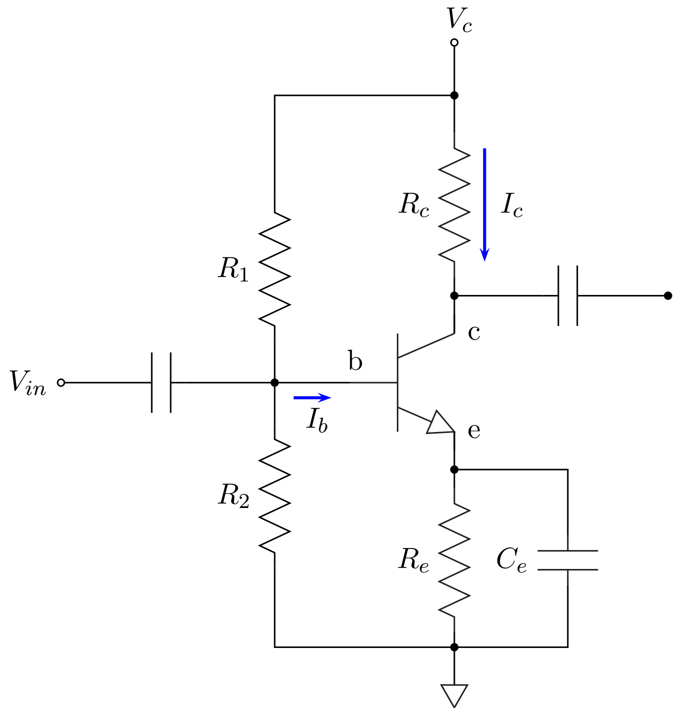

Figure 3: In the common emitter amplifier configuration the DC (zero frequency) operating point is determined by the DC bias current controlled by R_1 and R_2. R_e provides the negative feeback necessary for thermal stability, and C_e provides an AC (finite frequency) path to ground. The high frequency gain is approximately $-R_c/Z_{be}$, where Z_{be} is the base-emitter impedance.

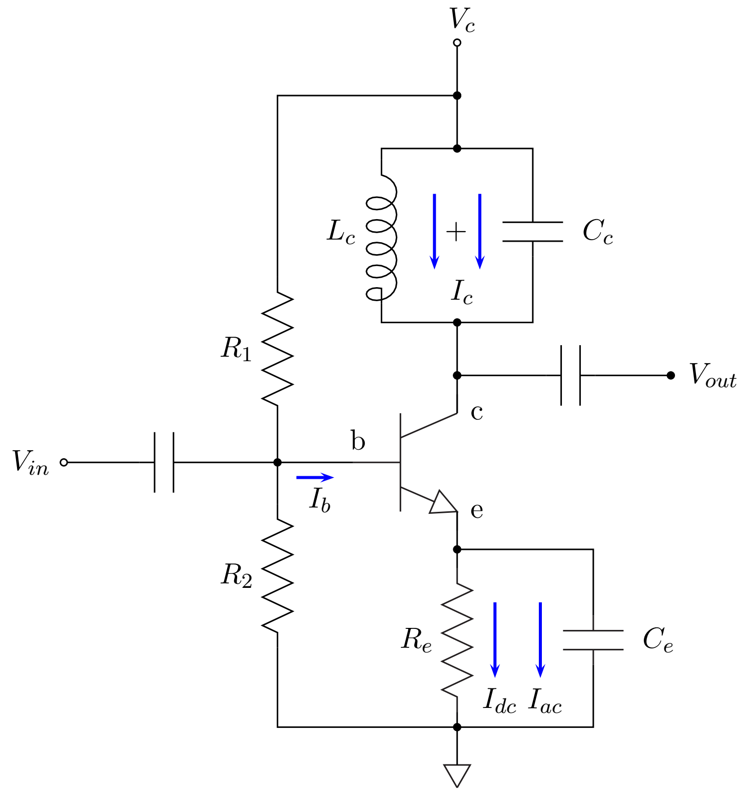

Figure 4: In the bandpass common emitter amplifier, the gain $G(\omega) \simeq -Z_{L||C}/Z_{be}$ becomes large at the LC tank resonance frequency $\omega_\circ = 1/\sqrt(LC)$ because $Z_{L||C}(\omega_\circ)$ is very large.

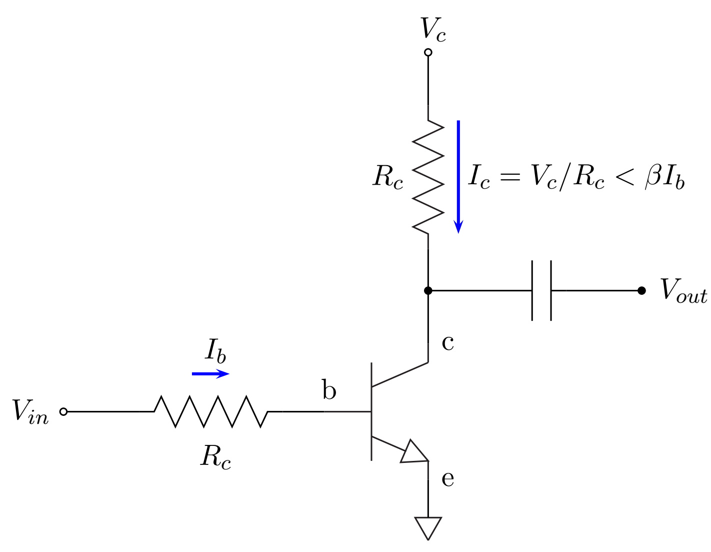

Figure 5: In the saturated common emitter amplifier configuration, known as the *saturated switch*, the base current is either zero or large enough so that the collector current is the maximum value of V_c/R_c.

Common Collector Amplifier

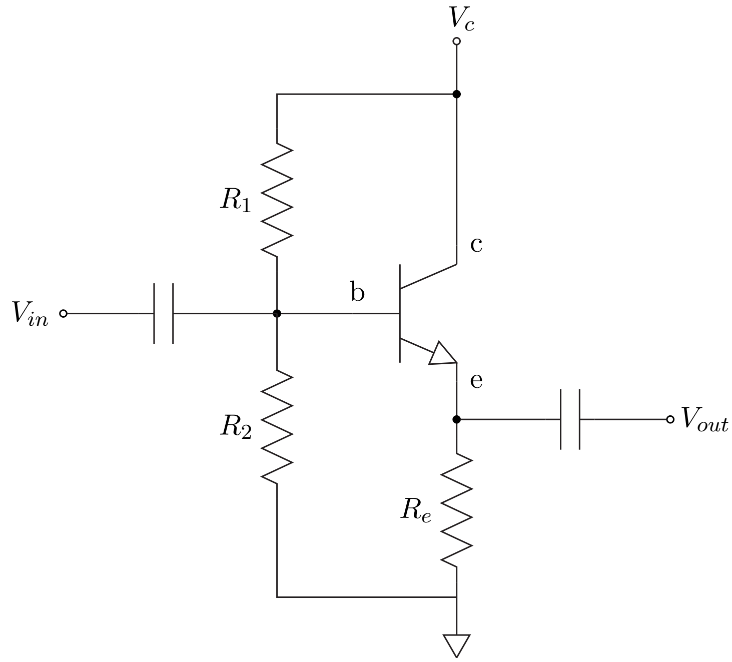

Figure 6: In the common collector amplifier configuration the negative feedback provided by R_e yields a gain of approximately 1, that is, $Vout = V_{in} - 0.6$ V.

Constant Current Source

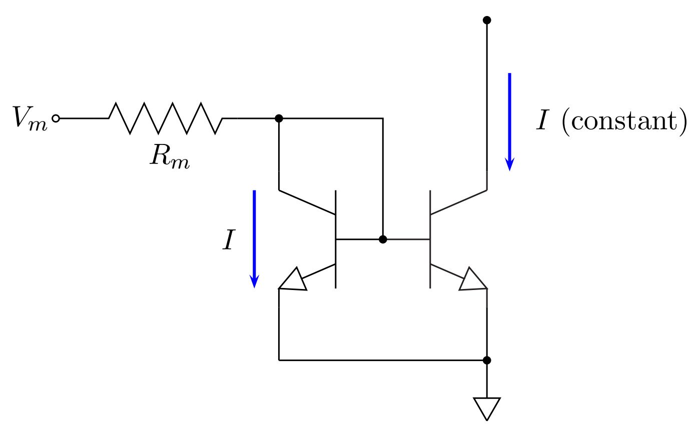

Figure 7: The *current mirror* provides a constant current for another circuit. I is determined by V_m/R_m.

Differential Amplifier

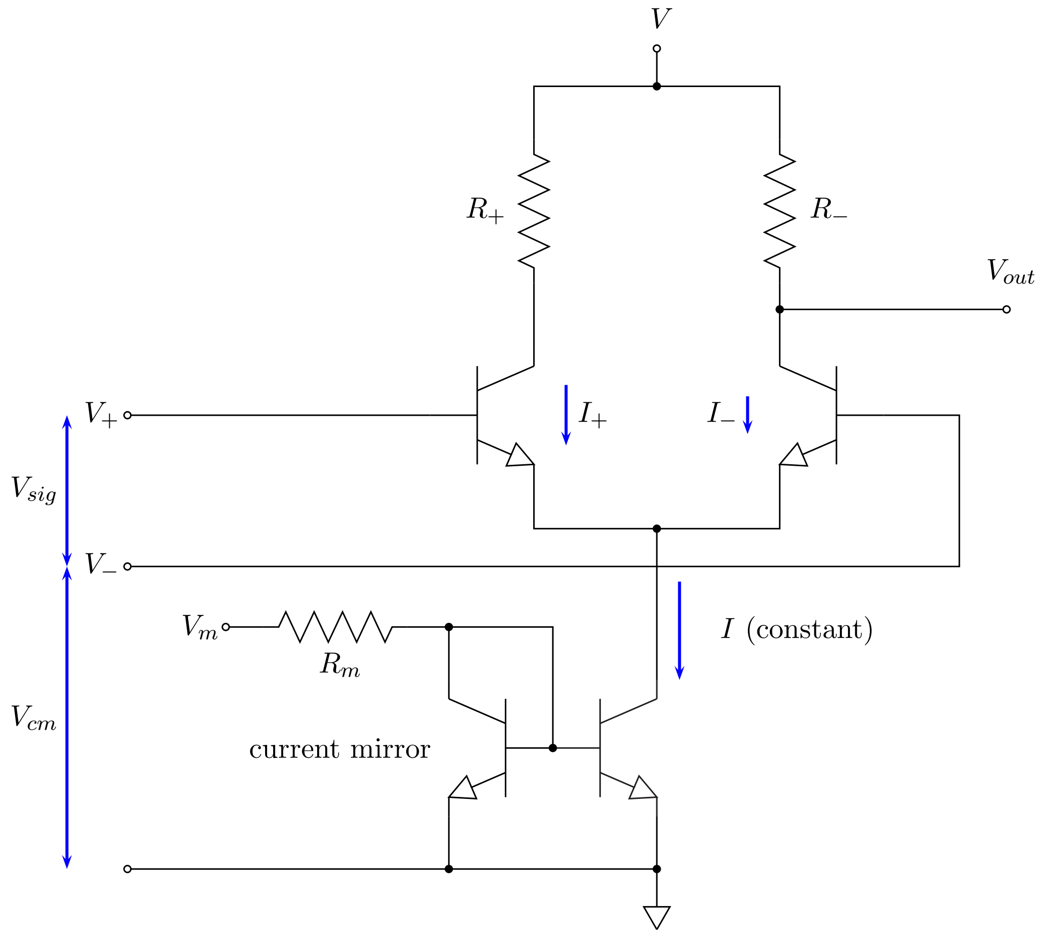

Figure 8: In the differential amplifier, the sum of the currents passing through the two transistors is held constant by the *current mirror*. The output signal is proportional to $-(V_+ - V_-)$, reminiscent of the operational amplifier. This circuit is used to provide gain while eliminating the *common mode* signal V_{cm}.

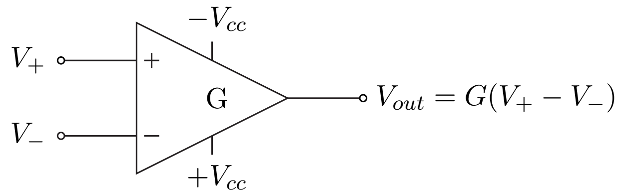

Figure 9: The *operational amplifier* is a differential amplifier with $Vout = G(V_+ - V_-)$.

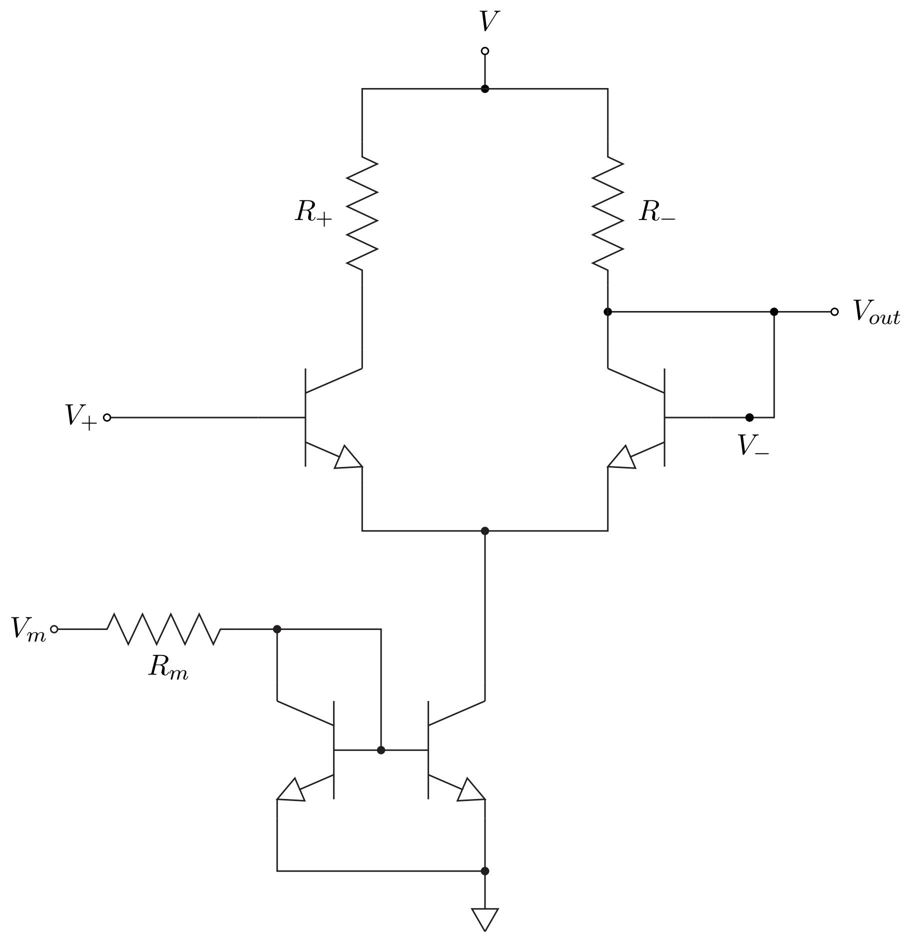

Figure 10: In the differential amplifier, the sum of the currents passing through the two transistors is held constant by the *current mirror*. The output signal is proportional to $-(V_+ - V_-)$, reminiscent of the operational amplifier. This circuit is used to provide gain while eliminating the *common mode* signal V_{cm}.

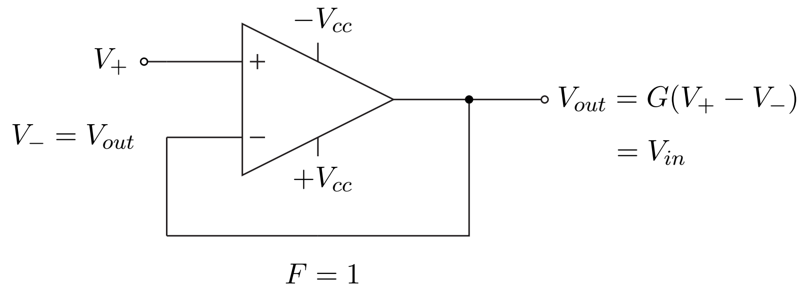

Figure 11: In the *noninverting unity gain configuration*, the output is fed back to the inverting input. The feedback fraction is $F = 1$, and the gain of the circuit is $1/F = 1$.

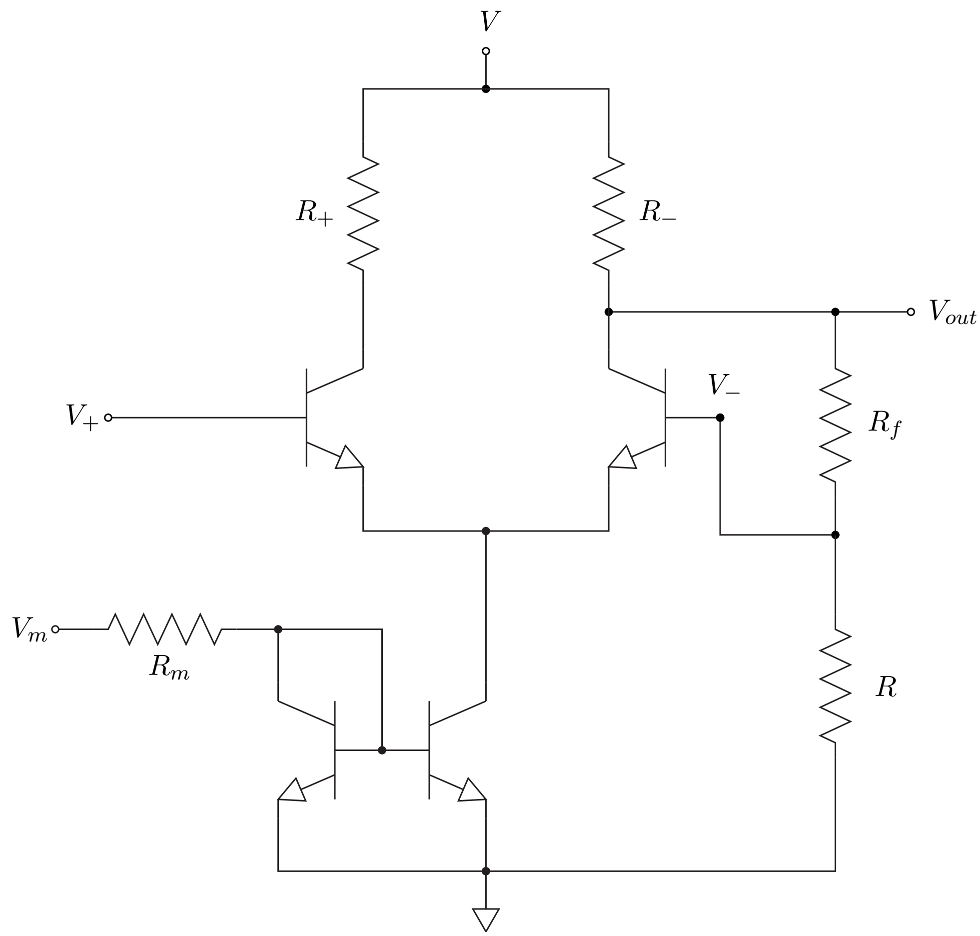

Figure 12: The use of negative feedback, where F is the feedback fraction, limits the gain of the differential amplifier to $-1/F$ when $|GF| >> 1$, where G is the open loop gain.

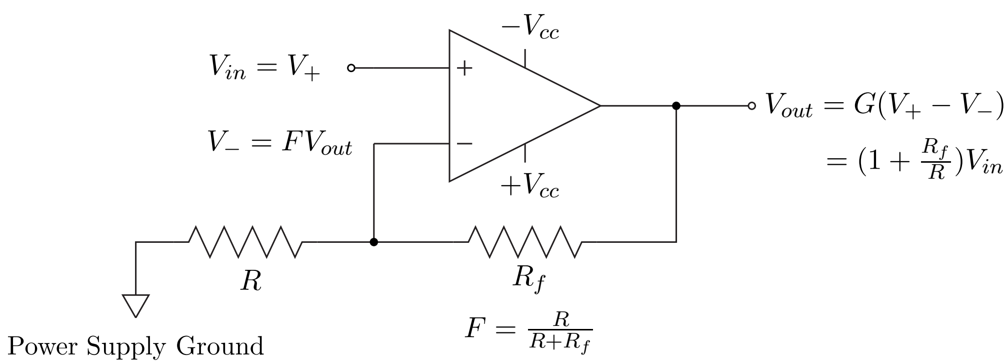

Figure 13: In the *noninverting operational amplifier configuration*, a fraction F of the output is fed back to the inverting input, and the gain of the circuit is $1 + R_f/R$.