The Bipolar Junction Transistor Current Mirror

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The current mirror is a device for generating a copy of a current. It is widely used in common amplifiers as well as in operational amplifiers. The basic circuit is shown in Figure 1.

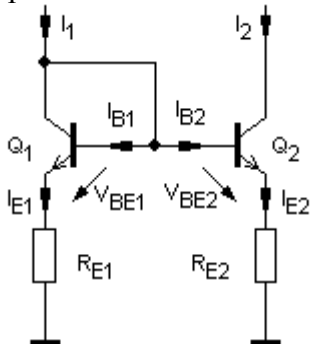

Figure 1: Basic circuit of current mirror

The primary goal of this circuit is the control of the current I_2 by the current I_1.
The DC-analysis can be done easily by using the Kirchoff's first law, the equation

$$I_{B2} = I_1 - I_{E1} \quad . \tag{1}$$

Using Kirchhoff's second law results in the equation

$$V_{BE1} + I_{E1} R_{E1} = V_{BE2} + I_{E2} R_{E2} \tag{2}$$

Substitution of (1) into (2) shows the relation between the currents I_1 and I_2.

$$V_{BE1} + I_1 R_{E1} = V_{BE2} + I_2 R_{E2} + I_{B2}(R_{E1} + R_{E2}) \tag{3}$$

taking the current gain B_2 of transistor Q_2 into account, one derives with $I_2 = I_{B2} B_2$

$$V_{BE1} - V_{BE2} + I_1 R_{E1} = I_2 \frac{R_{E2}(B_2+1) + R_{E1}}{B_2} \tag{4}$$

as final result. It is an interesting fact, that the current gain B_1 of the transistor Q_1 does not affect the relation between I_1 and I_2. For large B_2 the factor $\frac{B_2+1}{B_2}$ tends to unity and (4) reduces to

$$V_{BE1} - V_{BE2} + I_1 R_{E1} = I_2 R_{E2} \tag{5}$$

If Q_1 and Q_2 have equal properties, $V_{BE1} = V_{BE2}$ holds and the relation between I_1 and I_2 becomes

$$I_1 R_{E1} = I_2 R_{E2} \tag{6}$$

I_2 is proportional to the impressed current I_1 and one gets

$$I_2 = I_1 \frac{R_{E1}}{R_{E2}} \tag{7}$$