KCL: $i_E = i_B + i_C$

KVL: $v_{CE} = v_{CB} + v_{BE}$
Sketch of the emitter-follower, a unity gain impedance buffer.

This circuit can be understood by applying Kirchhoff's voltage law to the left-hand loop. We have:

\[-V_{\text{in}} + I_B R_B + V_{\text{BE}} + I_E R_E = 0.\]

In the linear regime, \(I_E = (1+\beta)I_B\) so:

\[V_{\text{out}} = I_E R_E = (V_{\text{in}} - V_{\text{BE}}) \frac{R_E}{[R_E + R_B / (1+\beta)]} \approx V_{\text{in}} - V_{\text{BE}}\]

since \(\beta \gg 1\). To within an offset of \(V_{\text{BE}}\), the magnitude of output is the same as the input.

The input impedance, found by opening the current source \(I_c\) and shorting the voltage drop \(V_{\text{BE}}\) is just:

\[Z_{\text{in}} = \frac{V_B}{I_B} = \frac{I_E R_E}{[I_E / (1+\beta)]} = (1+\beta) R_E.\]

So we see that the emitter-follower functions as a high impedance input.

The output impedance is approximated by \(Z_{\text{out}} \approx V_{\text{source}}/\beta\).

Can you show this?