BME 202 Electronics

Lecture 8: BJT – AC Anaysis Part 2

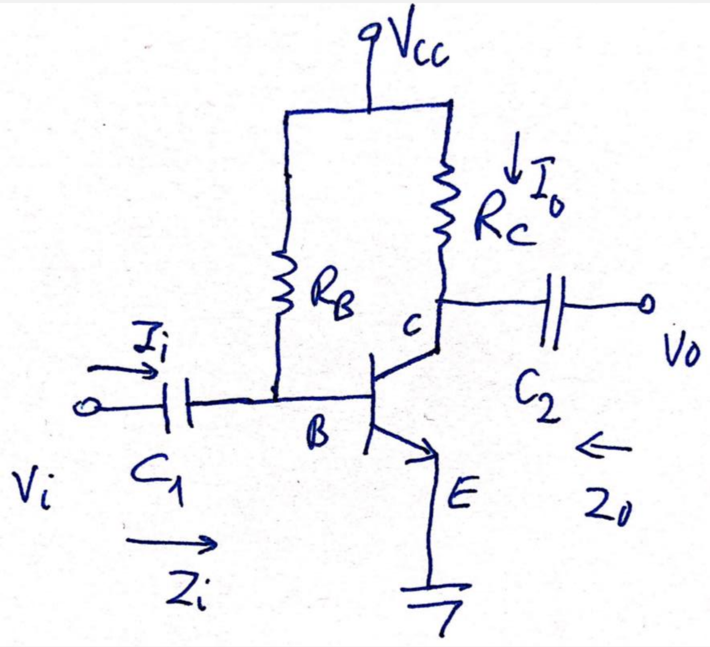
Common-Emitter Fixed-Bias Configuration

- The input is applied to the base
- The output is taken from the collector

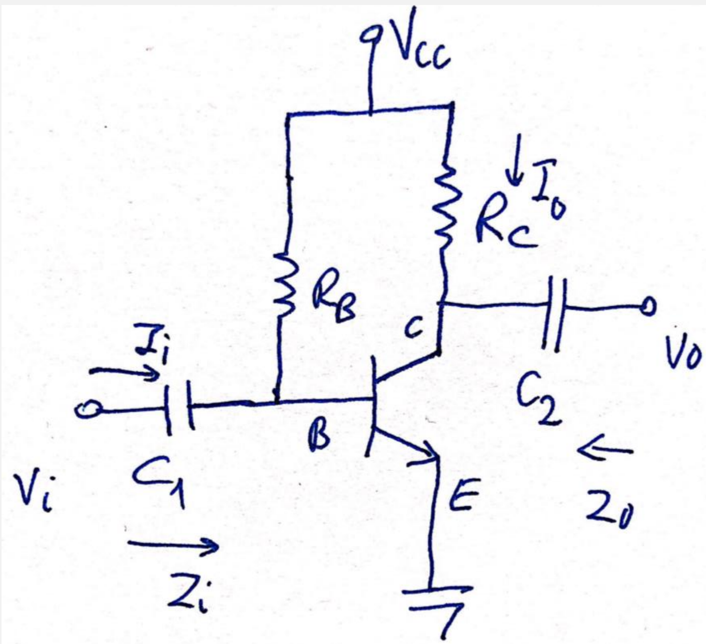
- High input impedance
- Low output impedance

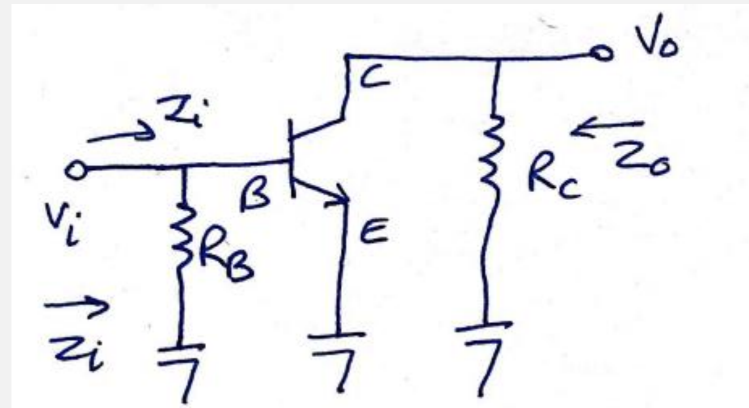
- High voltage and current gain

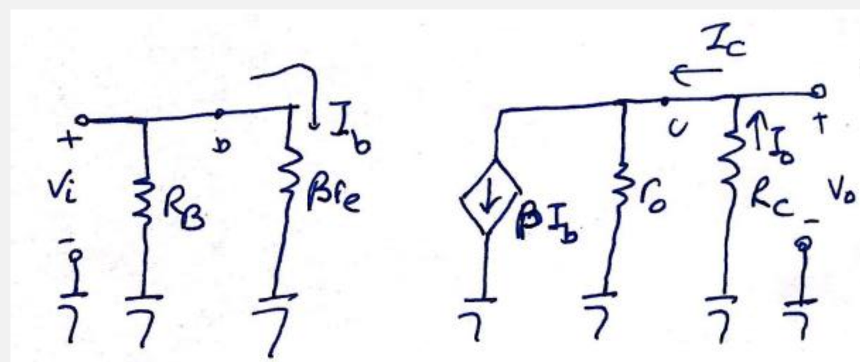
- Phase shift between input and output is 180°



Common-Emitter Fixed-Bias Configuration

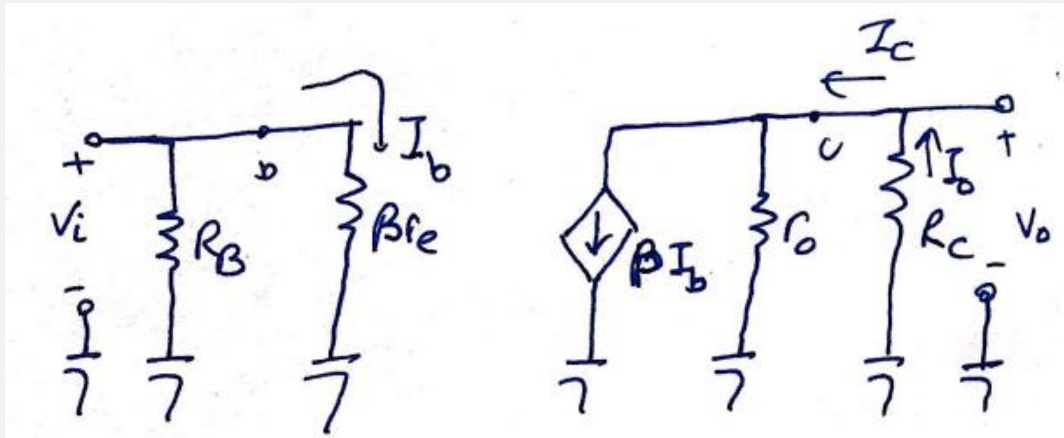






r_e model

Common-Emitter Fixed-Bias Calculations



Input impedance:

$$Z_i = R_B||\beta|_e$$

$$Z_i \cong \beta r_e \Big|_{R_E \geq 10\beta r_e}$$

Output impedance:

$$Z_o = R_C||r_o$$

$$Z_o \cong R_C \Big|_{r_o \geq 10 R_C}$$

Voltage gain:

$$A_v = \frac{V_o}{V_i} = -\frac{(R_C||r_o)}{r_e}$$

$$A_v = -\frac{R_C}{r_e}\Big|_{r_o \geq 10 R_C}$$

Current gain:

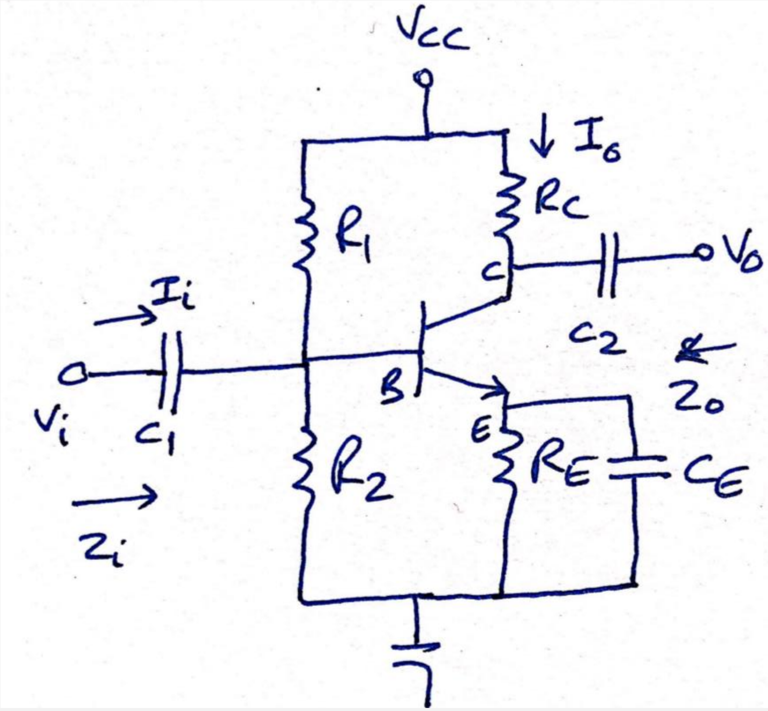
$$A_i = \frac{I_o}{I_i} = \frac{\beta R_B r_o}{(r_o + R_C)(R_B + \beta r_e)}$$

$$A_i \cong \beta \Big|_{r_o \geq 10 R_C,\ R_B \geq 10 \beta r_e}$$

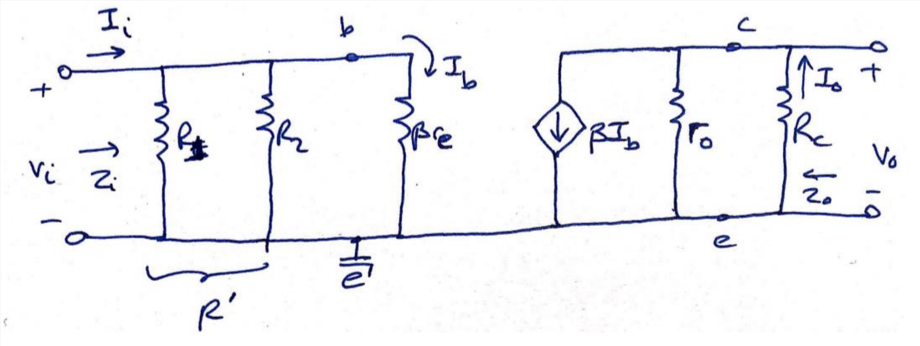
Current gain from voltage gain:

$$A_i = -A_V \frac{Z_i}{R_C}$$

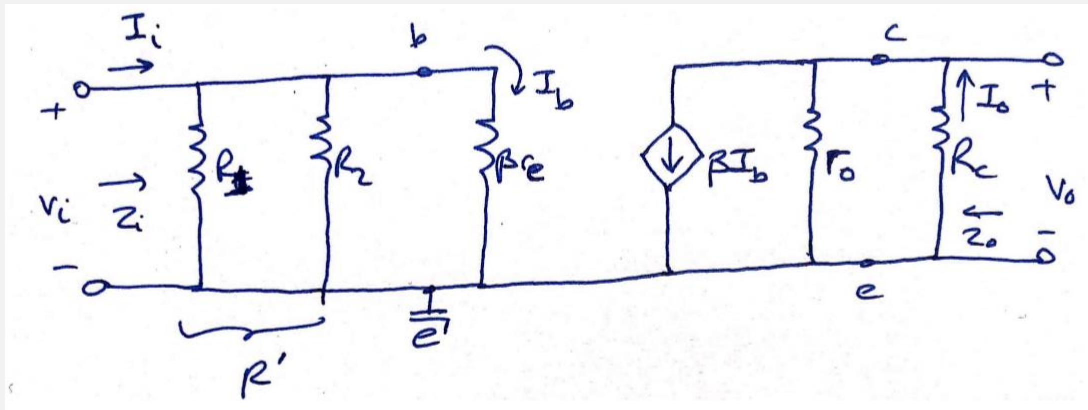
Common-Emitter Voltage-Divider Bias



r_e model requires you to determine β, r_e, and r_o.



Common-Emitter Voltage-Divider Bias Calculations



Input impedance

$$R' = R_1 \,||\, R_2$$
$$Z_i = R' \,||\, \beta r_e$$

Output impedance

$$Z_o = R_C \,||\, r_o$$
$$Z_o \cong R_C \Big|_{r_o \geq 10R_C}$$

Voltage gain

$$A_v = \frac{V_o}{V_i} = \frac{-R_C \,||\, r_o}{r_e}$$
$$A_v = \frac{V_o}{V_i} \cong -\frac{R_C}{r_e}\Big|_{r_o \geq 10R_C}$$

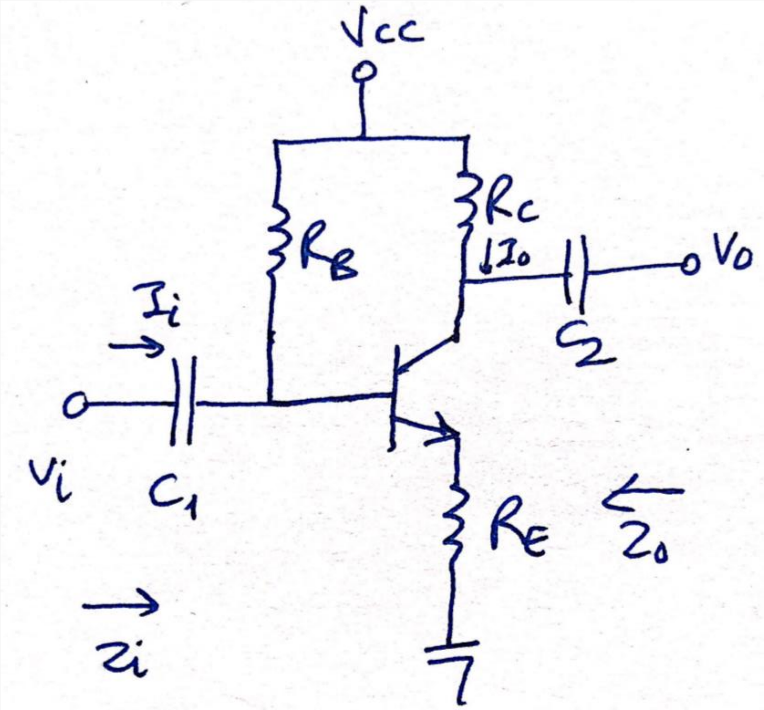
Current gain

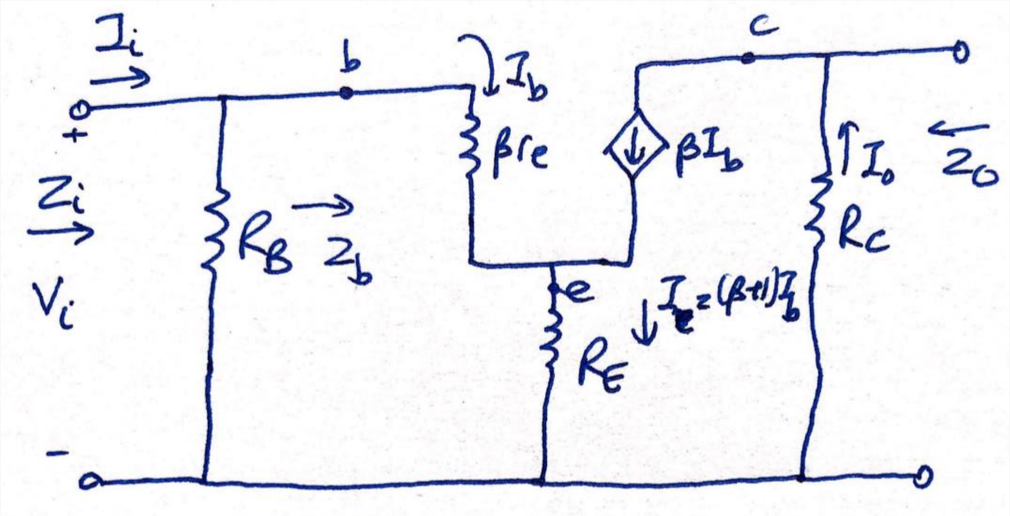
$$A_i = \frac{I_o}{I_i} = \frac{\beta R' r_o}{(r_o + R_C)(R' + \beta r_e)}$$
$$A_i = \frac{I_o}{I_i} \cong \frac{\beta R'}{R' + \beta r_e}\Big|_{r_o \geq 10R_C}$$
$$A_i = \frac{I_o}{I_i} \cong \beta\Big|_{r_o \geq 10R_C,\, R' \geq 10\beta r_e}$$

Current gain from A_v

$$A_i = -A_v \frac{Z_i}{R_C}$$

Common-Emitter Emitter-Bias Configuration





Impedance Calculations

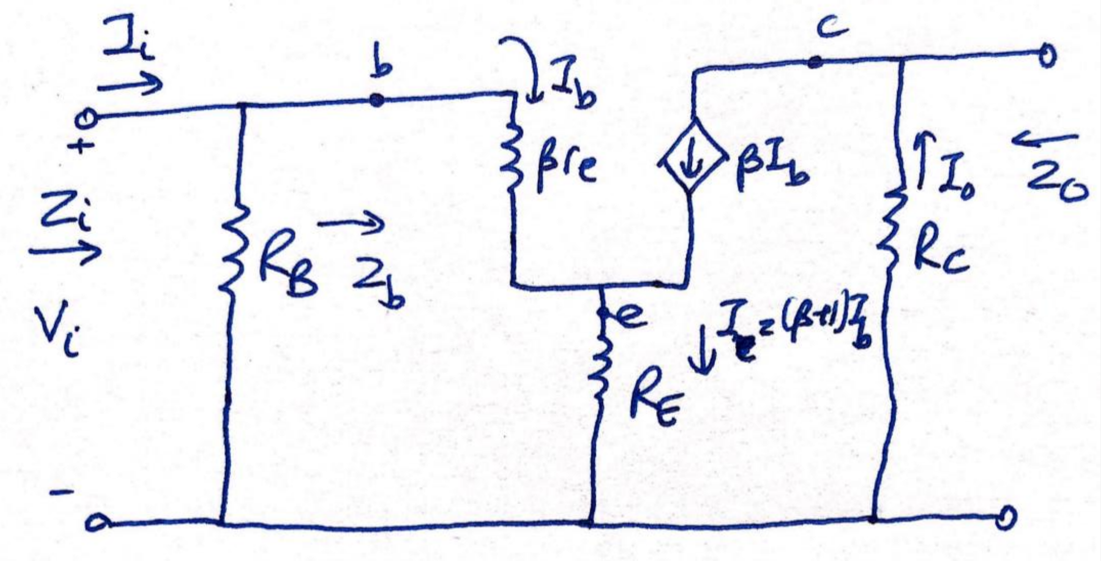
Input impedance:

$$Z_i = R_B || Z_b$$

$$Z_b = \beta r_e + (\beta + 1) R_E$$

$$Z_b \cong \beta (r_e + R_E)$$

$$Z_b \cong \beta R_E$$



Output impedance:

$$Z_o = R_C$$

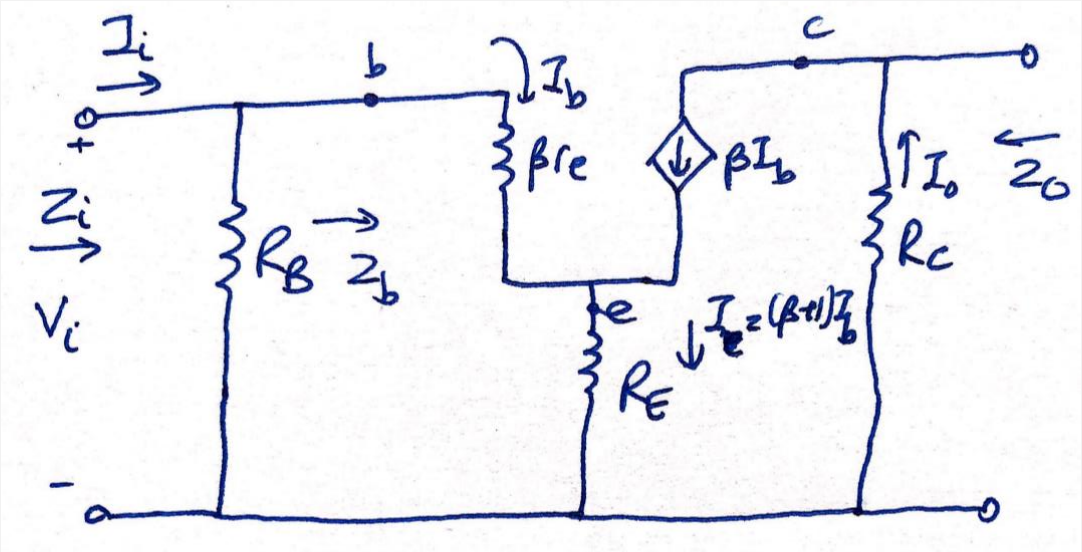
Gain Calculations

Voltage gain:

$$A_v = \frac{V_o}{V_i} = -\frac{\beta R_C}{Z_b}$$

$$A_v = \frac{V_o}{V_i} = -\frac{R_C}{r_e + R_E}\bigg|_{Z_b=\beta(r_e+R_E)}$$

$$A_v = \frac{V_o}{V_i} \cong -\frac{R_C}{R_E}\bigg|_{Z_b\cong\beta R_E}$$



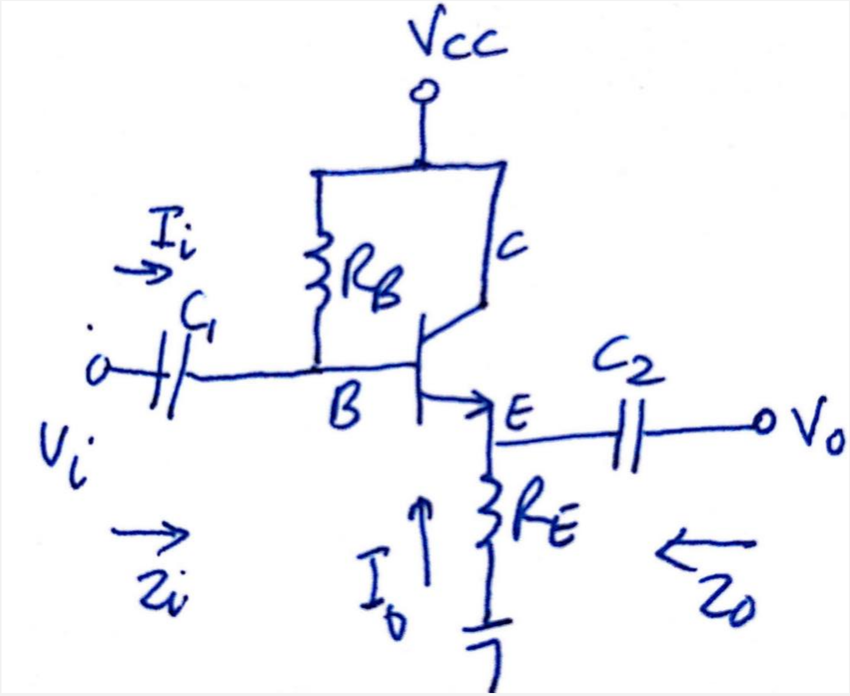
Current gain:

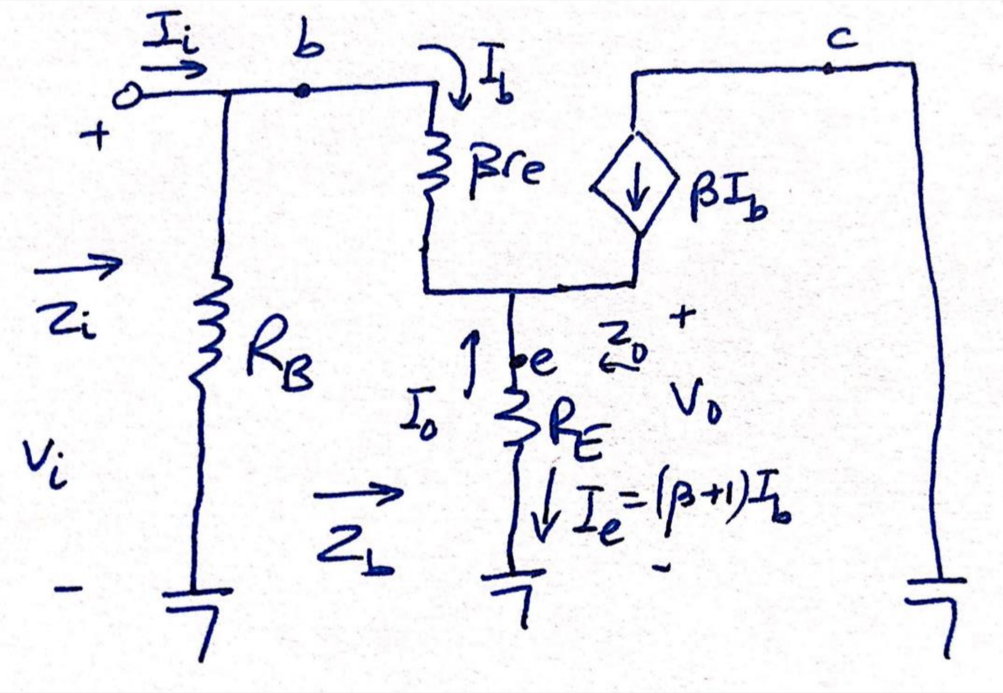
$$A_i = \frac{I_o}{I_i} = \frac{\beta R_B}{R_B + Z_b}$$

Current gain from A_v:

$$A_i = -A_v \frac{Z_i}{R_C}$$

Emitter-Follower Configuration





This is also known as the *common-collector* configuration.

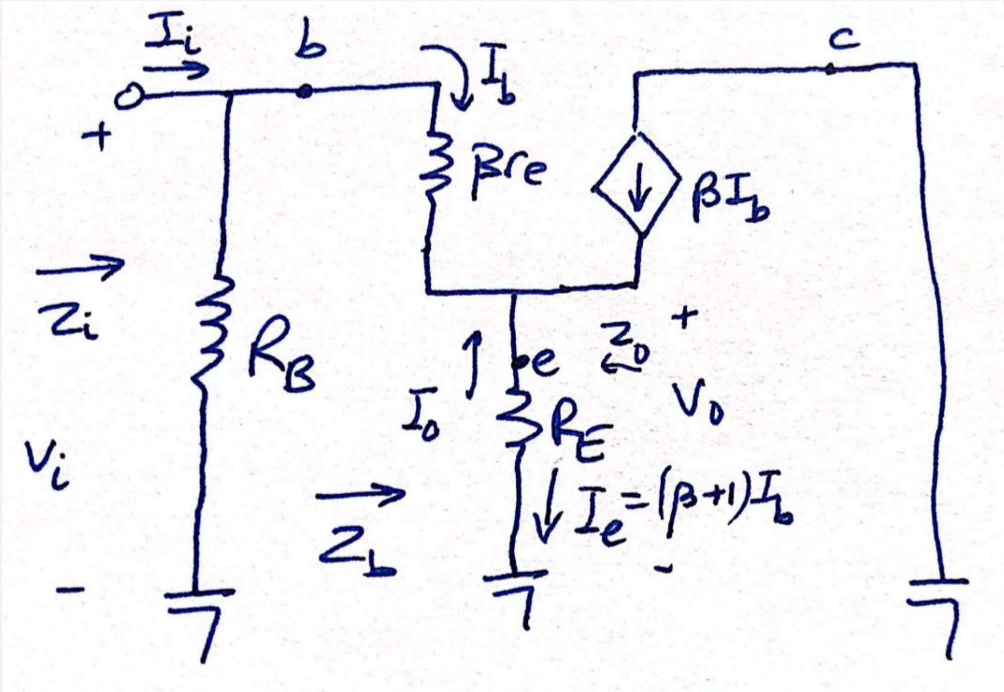
The input is applied to the base and the output is taken from the emitter.

There is no phase shift between input and output.

Impedance Calculations

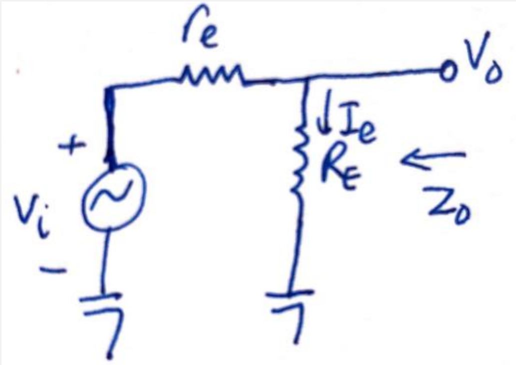
Input impedance:

$$Z_i = R_B || Z_b$$
$$Z_b = \beta r_e + (\beta + 1) R_E$$
$$Z_b \cong \beta (r_e + R_E)$$
$$Z_b \cong \beta R_E$$



Output impedance:

$$Z_o = R_E || r_e$$
$$Z_o \cong r_e \Big|_{R_E >> r_e}$$

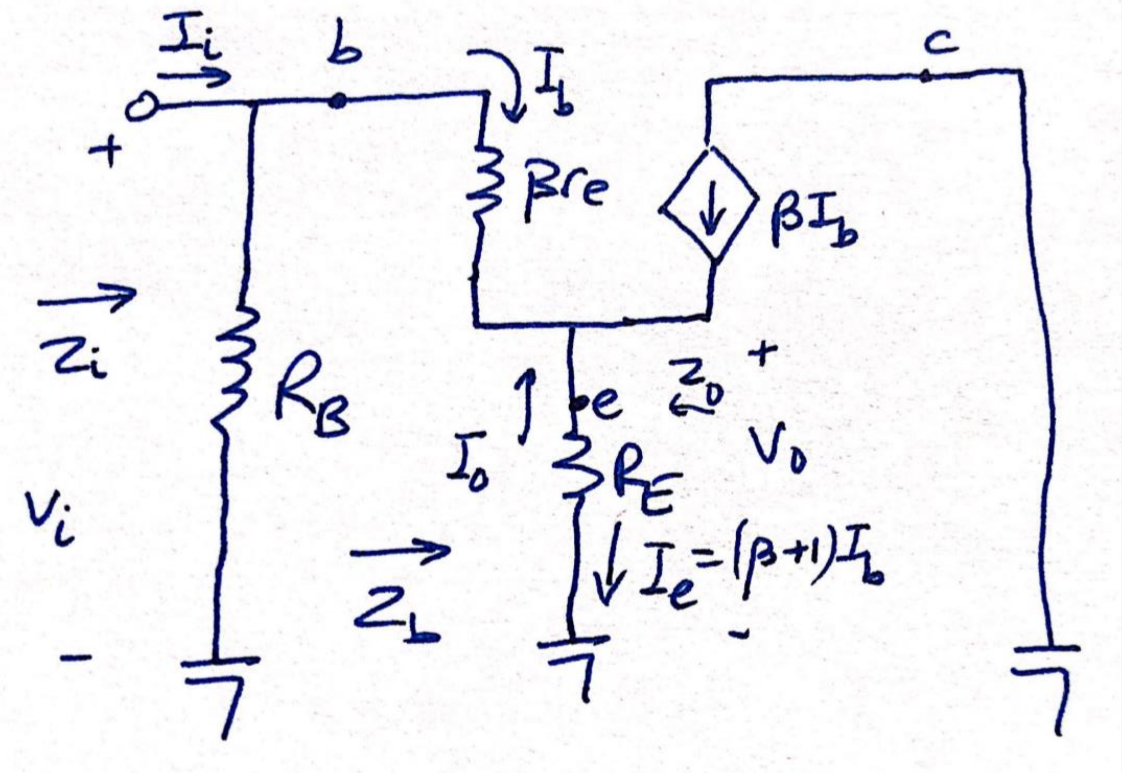


Gain Calculations

Voltage gain:

$$A_v = \frac{V_o}{V_i} = \frac{R_E}{R_E + r_e}$$

$$A_v = \frac{V_o}{V_i} \cong 1 \Big|_{R_E >> r_e,\ R_E + r_e \cong R_E}$$



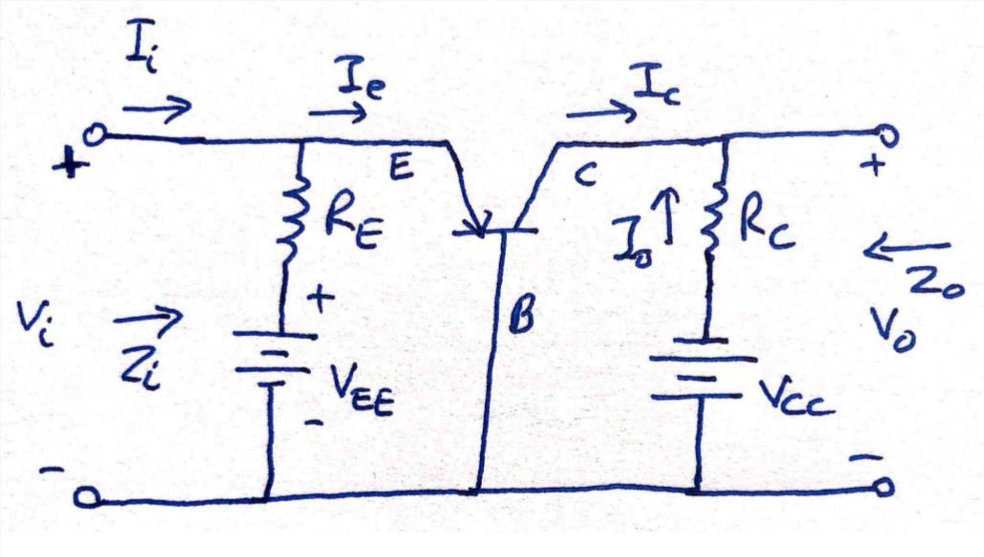
Current gain:

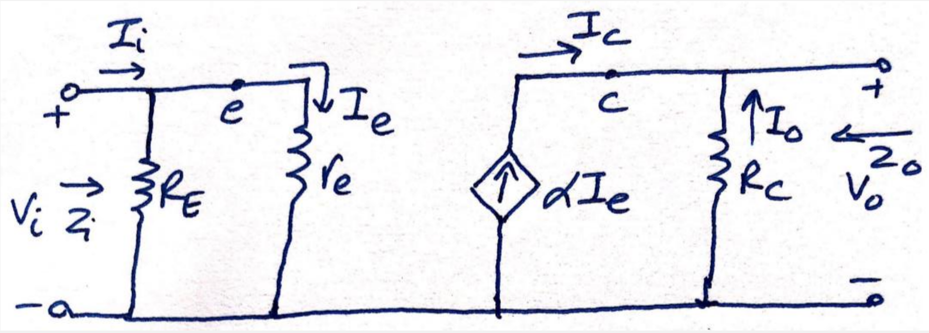
$$A_i \cong -\frac{\beta R_B}{R_B + Z_b}$$

Current gain from voltage gain:

$$A_i = -A_v \frac{Z_i}{R_E}$$

Common-Base Configuration





- The input is applied to the emitter
- The output is taken from the collector
- Low input impedance. High output impedance
- Current gain less than unity
- Very high voltage gain
- No phase shift between input and output

Calculations

Input impedance:

$$Z_i = R_E \,||\, r_e$$

Output impedance:

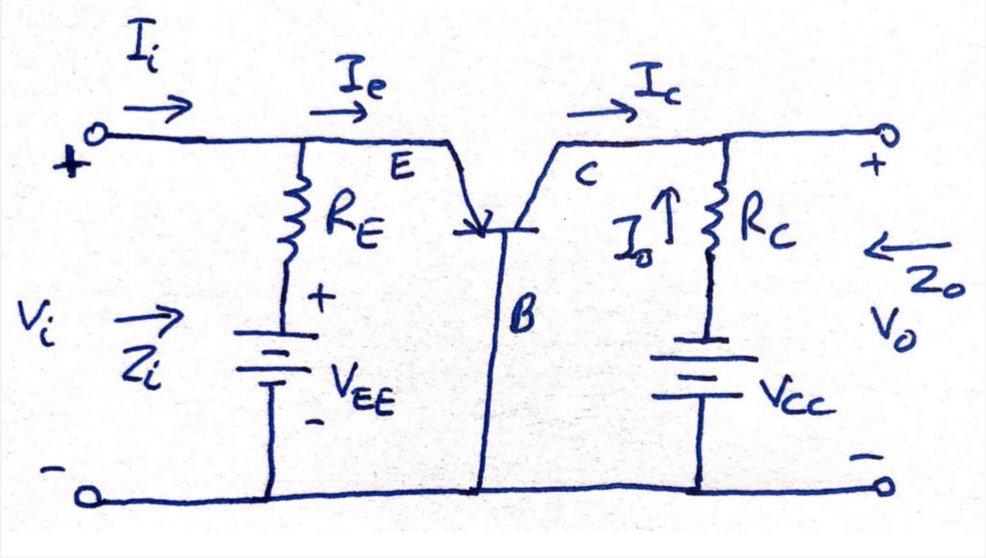
$$Z_o = R_C$$

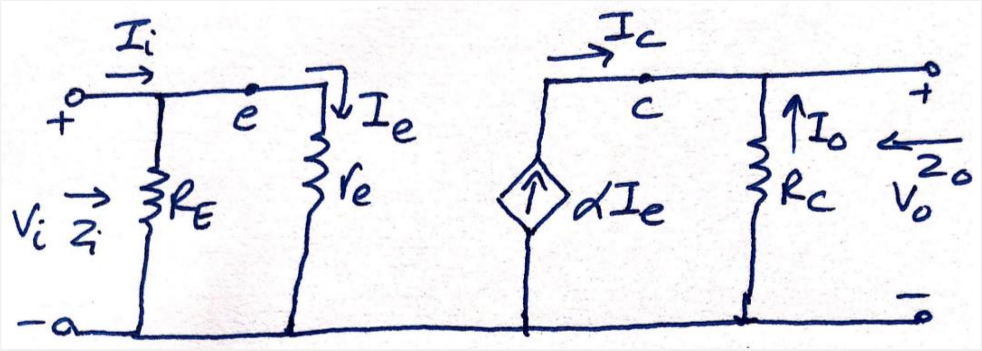
Voltage gain:

$$A_v = \frac{V_o}{V_i} = \frac{\alpha R_C}{r_e} \cong \frac{R_C}{r_e}$$

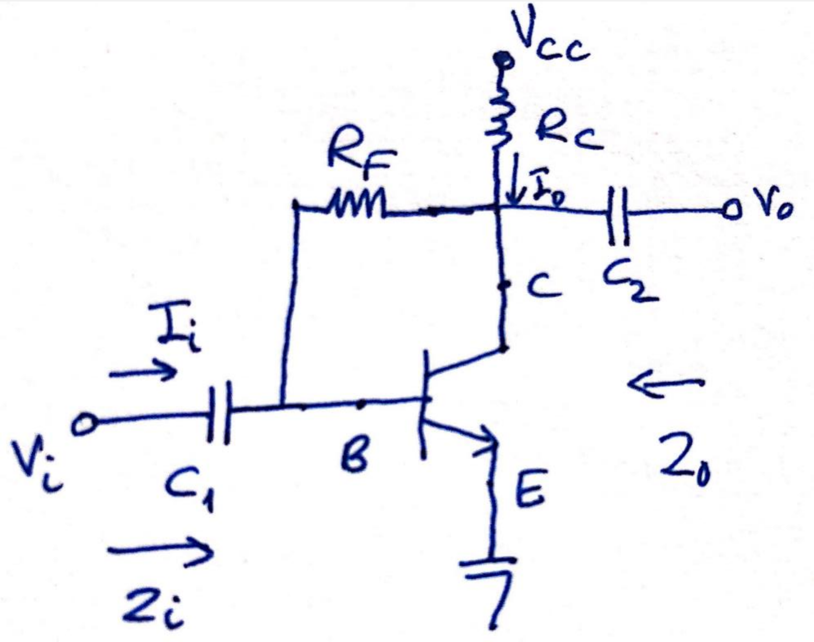
Current gain:

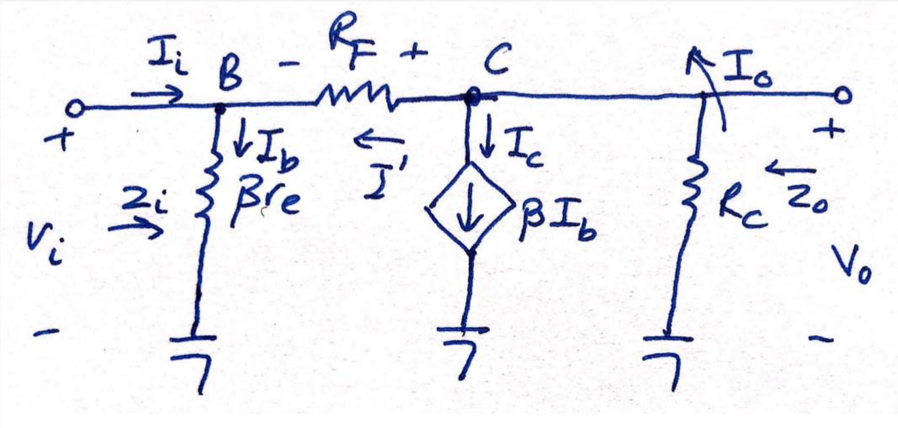
$$A_i = \frac{I_o}{I_i} = -\alpha \cong -1$$





Common-Emitter Collector Feedback Configuration





- A variation of the common-emitter fixed-bias configuration
- Input is applied to the base
- Output is taken from the collector
- There is a 180° phase shift between the input and output

Calculations

Input impedance:

$$Z_i = \frac{r_e}{\frac{1}{\beta} + \frac{R_C}{R_F}}$$

Output impedance:

$$Z_o \cong R_C \parallel R_F$$

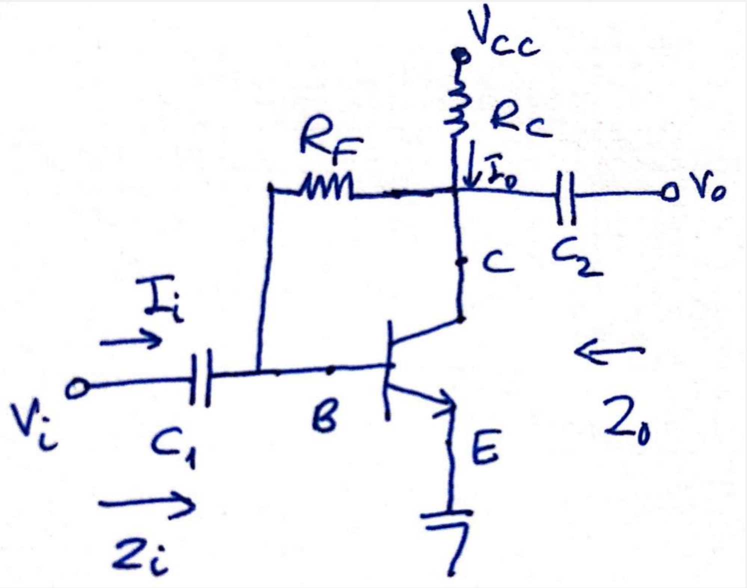
Voltage gain:

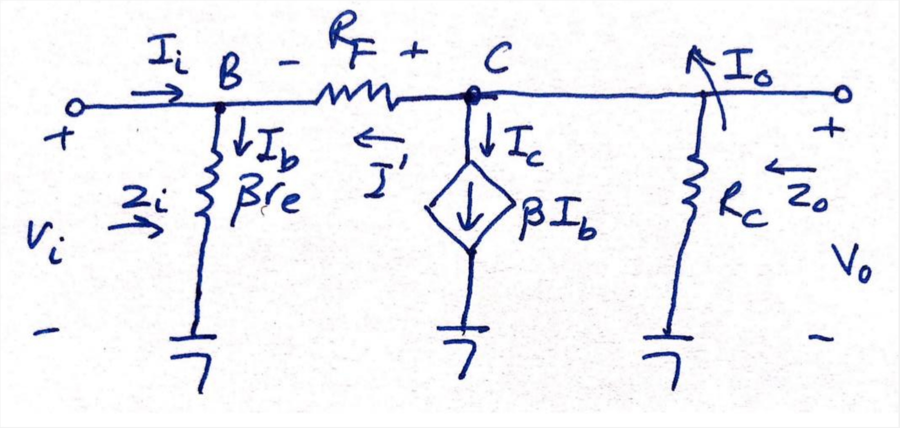
$$A_v = \frac{V_o}{V_i} = -\frac{R_C}{r_e}$$

Current gain:

$$A_i = \frac{I_o}{I_i} = \frac{\beta R_F}{R_F + \beta R_C}$$

$$A_i = \frac{I_o}{I_i} \cong \frac{R_F}{R_C}$$

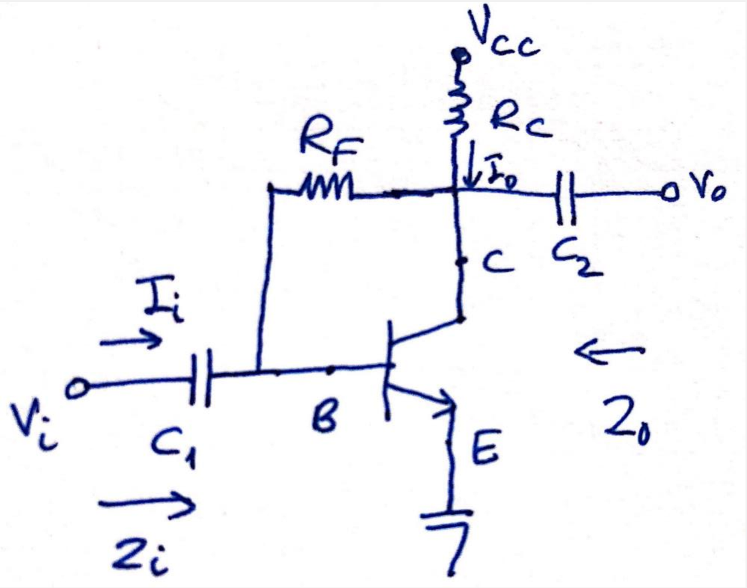


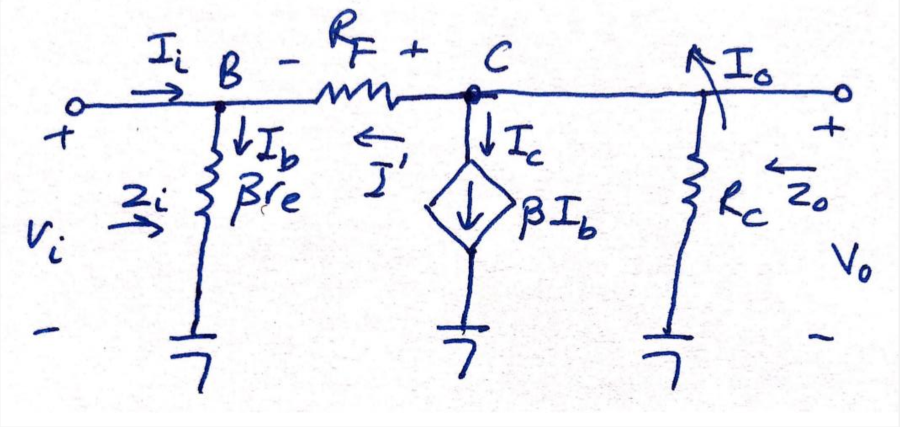


Collector DC Feedback Configuration

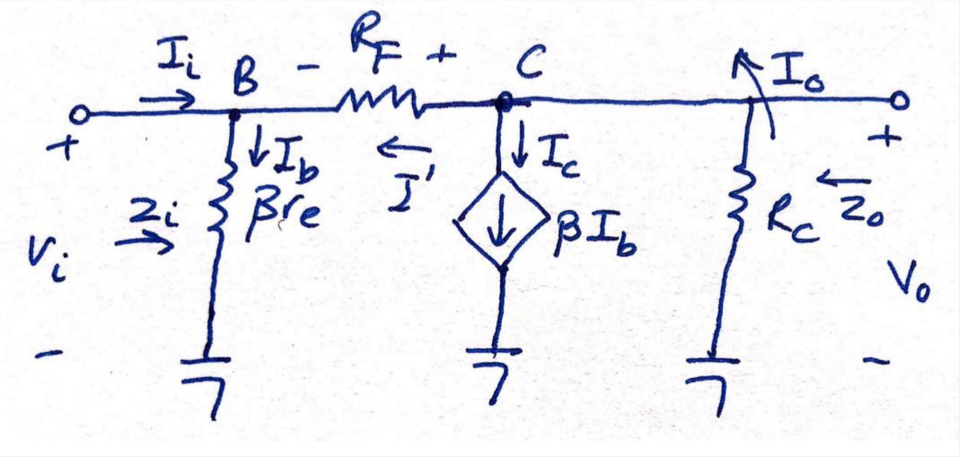
This is a variation of the common-emitter, fixed-bias configuration

- The input is applied to the base
- The output is taken from
- the collector
- There is a 180° phase shift between input and output





Calculations



Input impedance:

$$Z_i = \frac{r_e}{\frac{1}{\beta} + \frac{R_C}{R_F}}$$

Output impedance:

$$Z_o \cong R_C || R_F$$

Voltage gain:

$$A_i = \frac{I_o}{I_i} = \frac{\beta R_F}{R_F + \beta R_C}$$

$$A_i = \frac{I_o}{I_i} \cong \frac{R_F}{R_C}$$

Current gain:

$$A_v = \frac{V_o}{V_i} = -\frac{R_C}{r_e}$$