Penguat Diferensial

Elektronika

(TKE 4012)

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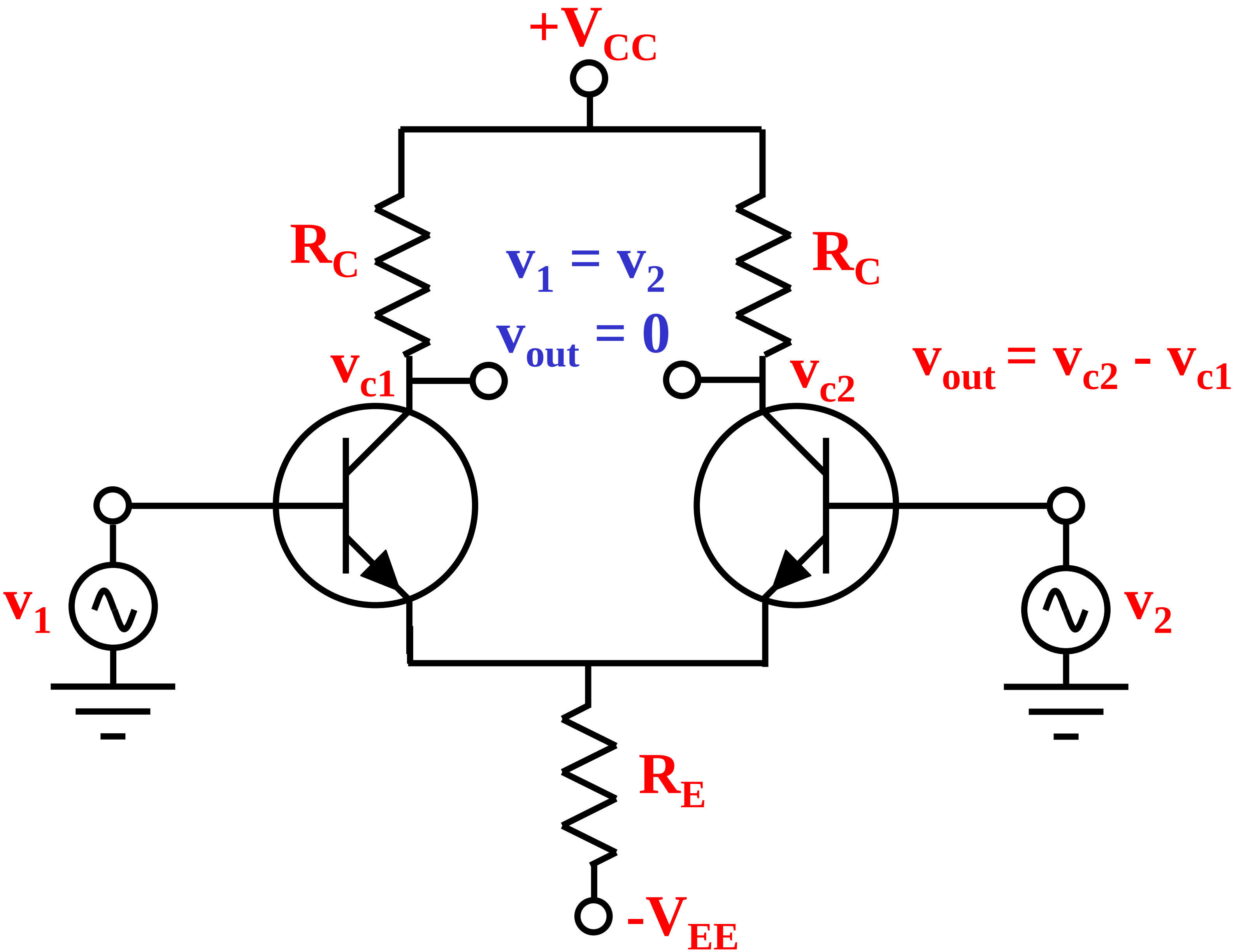
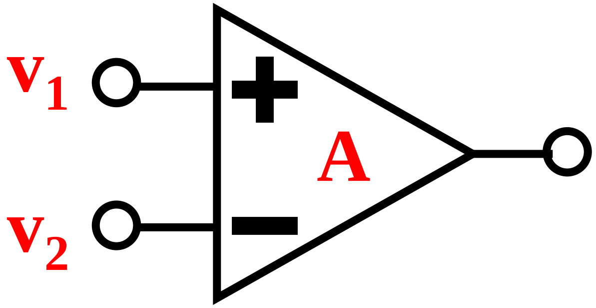
A differential amplifier

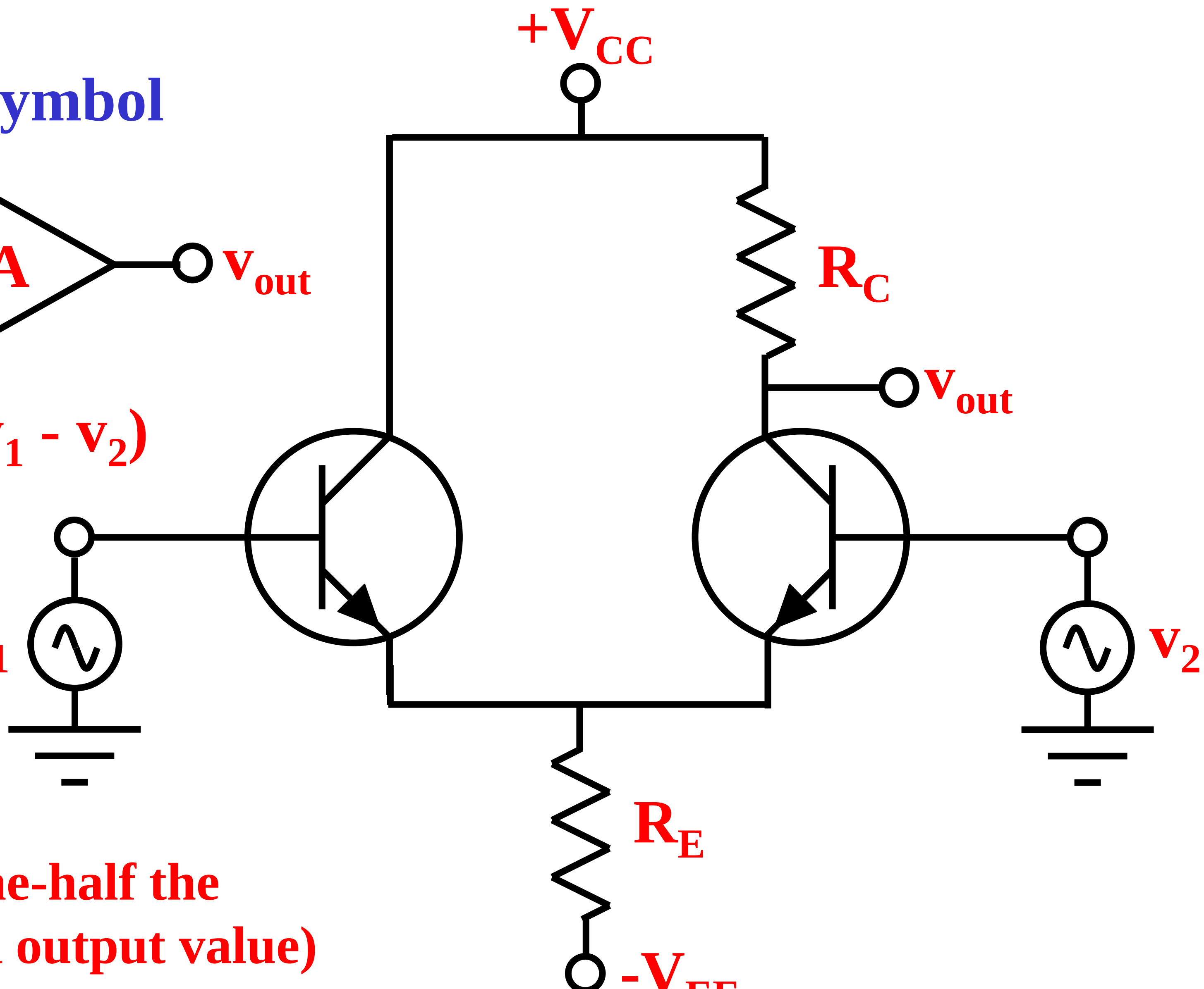


A differential amplifier with single-ended output

Block symbol

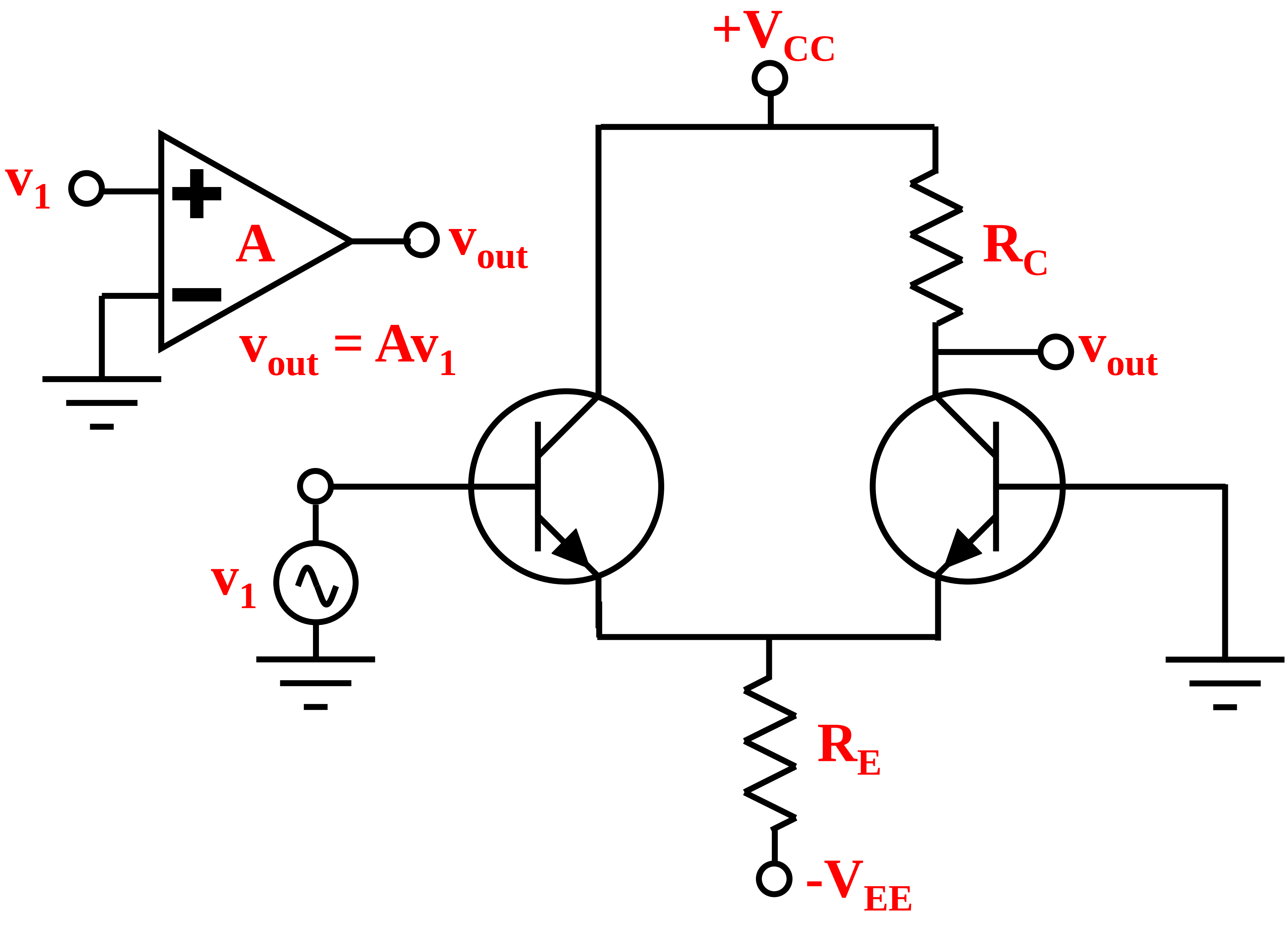


$v_{out} = A(v_1 - v_2)$

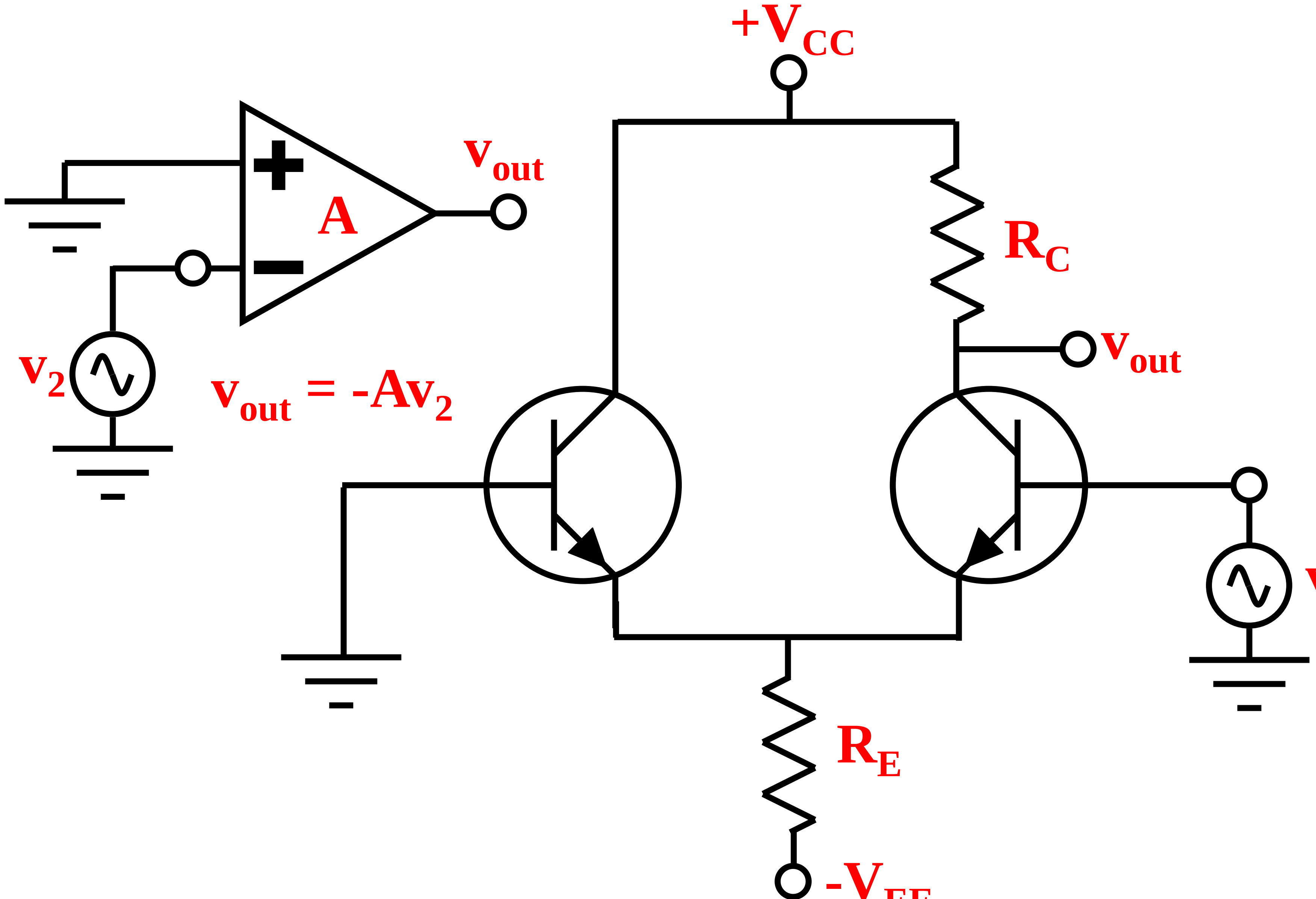


(A is one-half the differential output value)

Single-ended output and single-ended input.



Inverting configuration



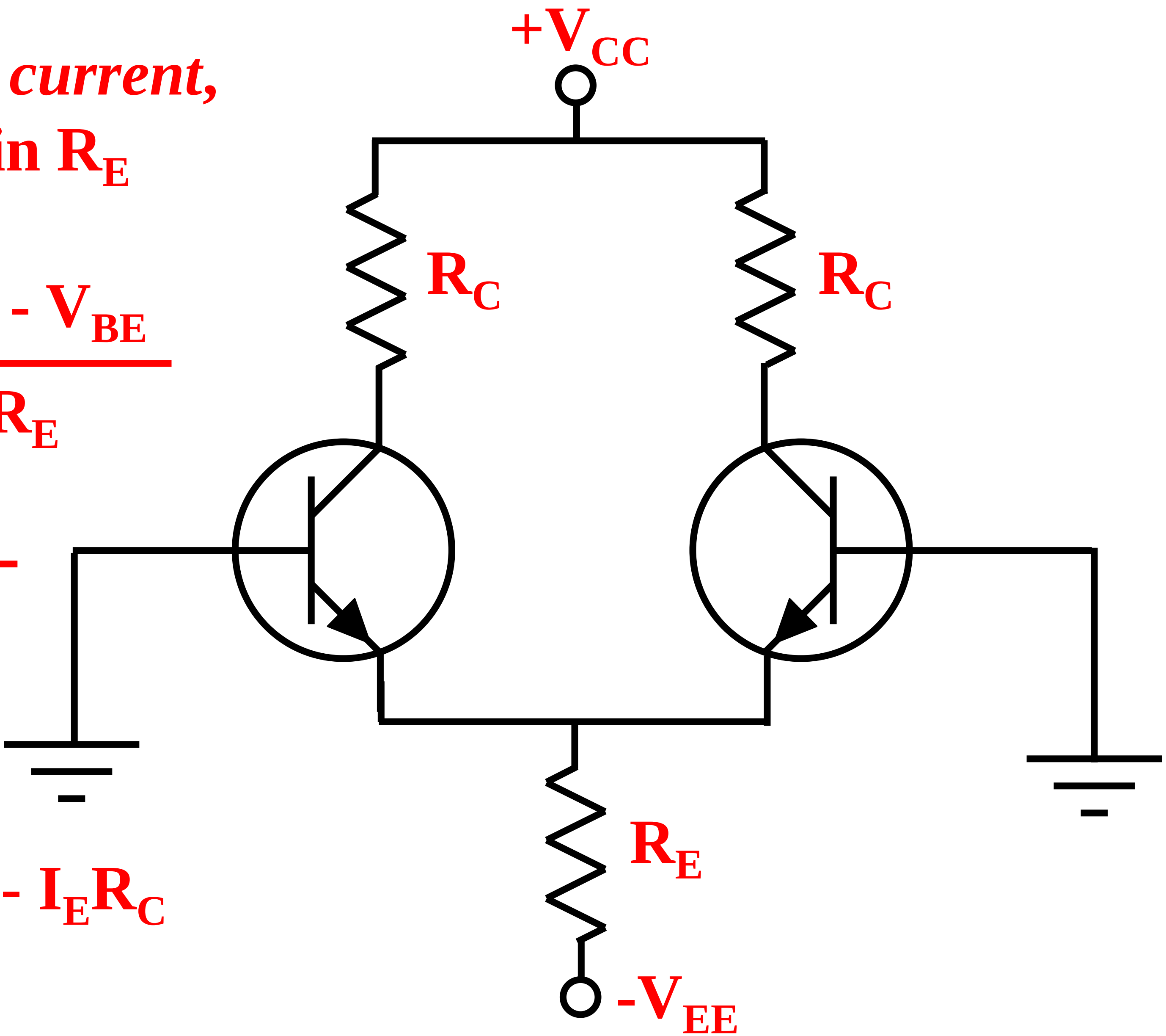
dc analysis

I_T, the *tail current*, flows in R_E

$$I_T = \frac{V_{EE} - V_{BE}}{R_E}$$

$$I_E = \frac{I_T}{2}$$

$$V_C = V_{CC} - I_E R_C$$

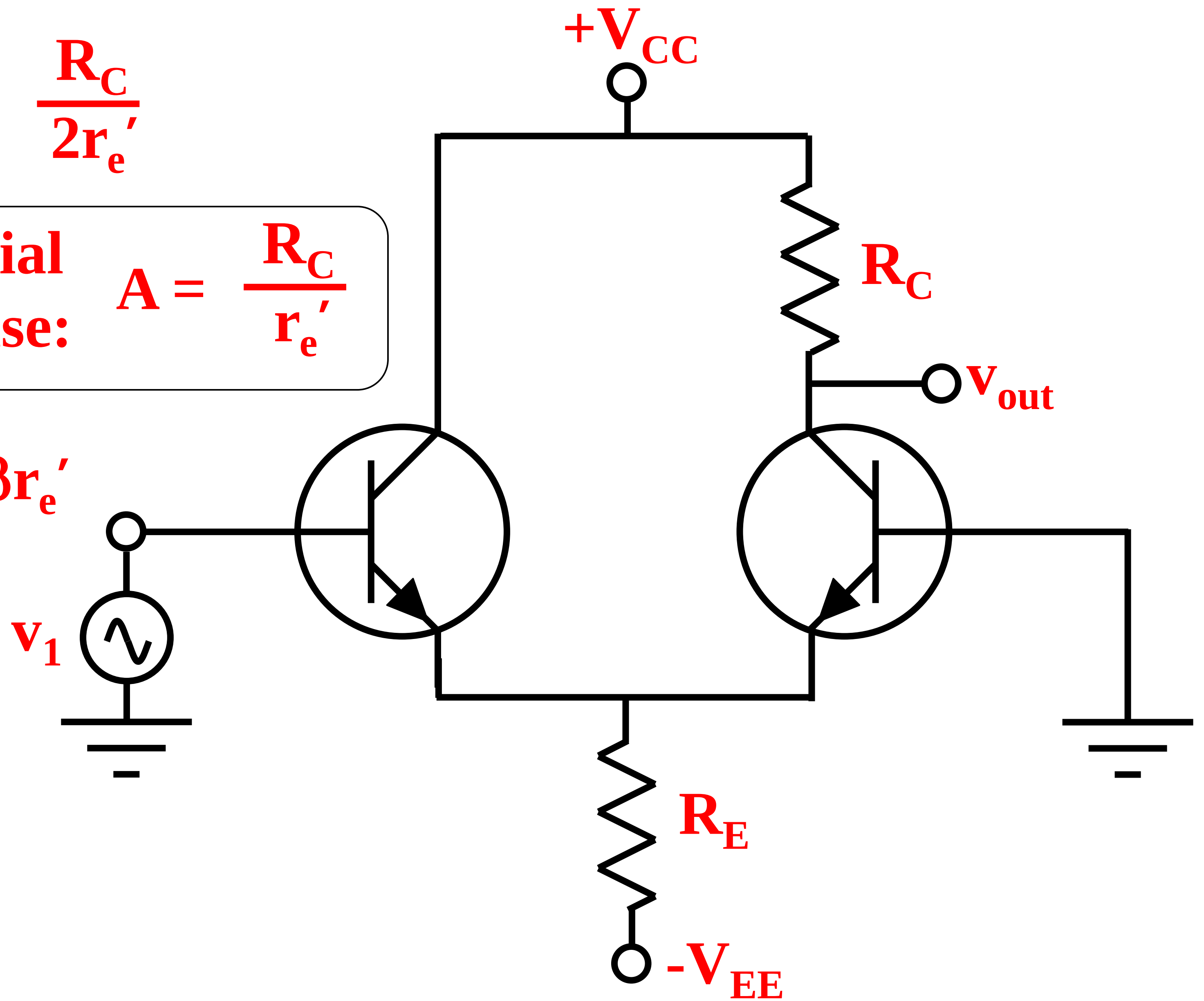


ac analysis

$$A = \frac{R_C}{2r_e'}$$

Differential output case: $A = \frac{R_C}{r_e'}$

$$z_{in} = 2\beta r_e'$$

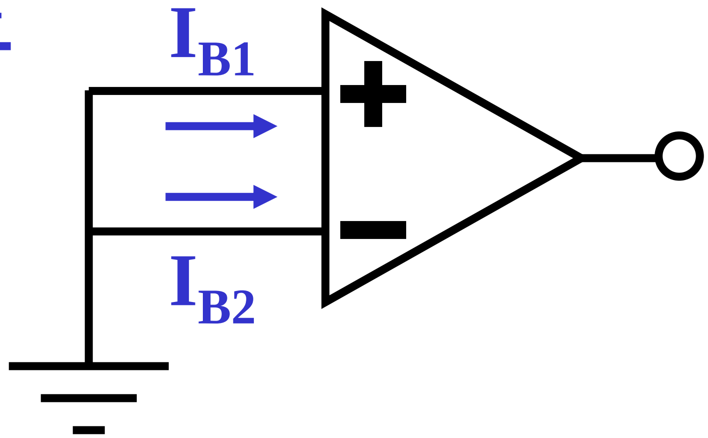


The input transistors are not exactly the same.

$$I_{B1} \neq I_{B2}$$

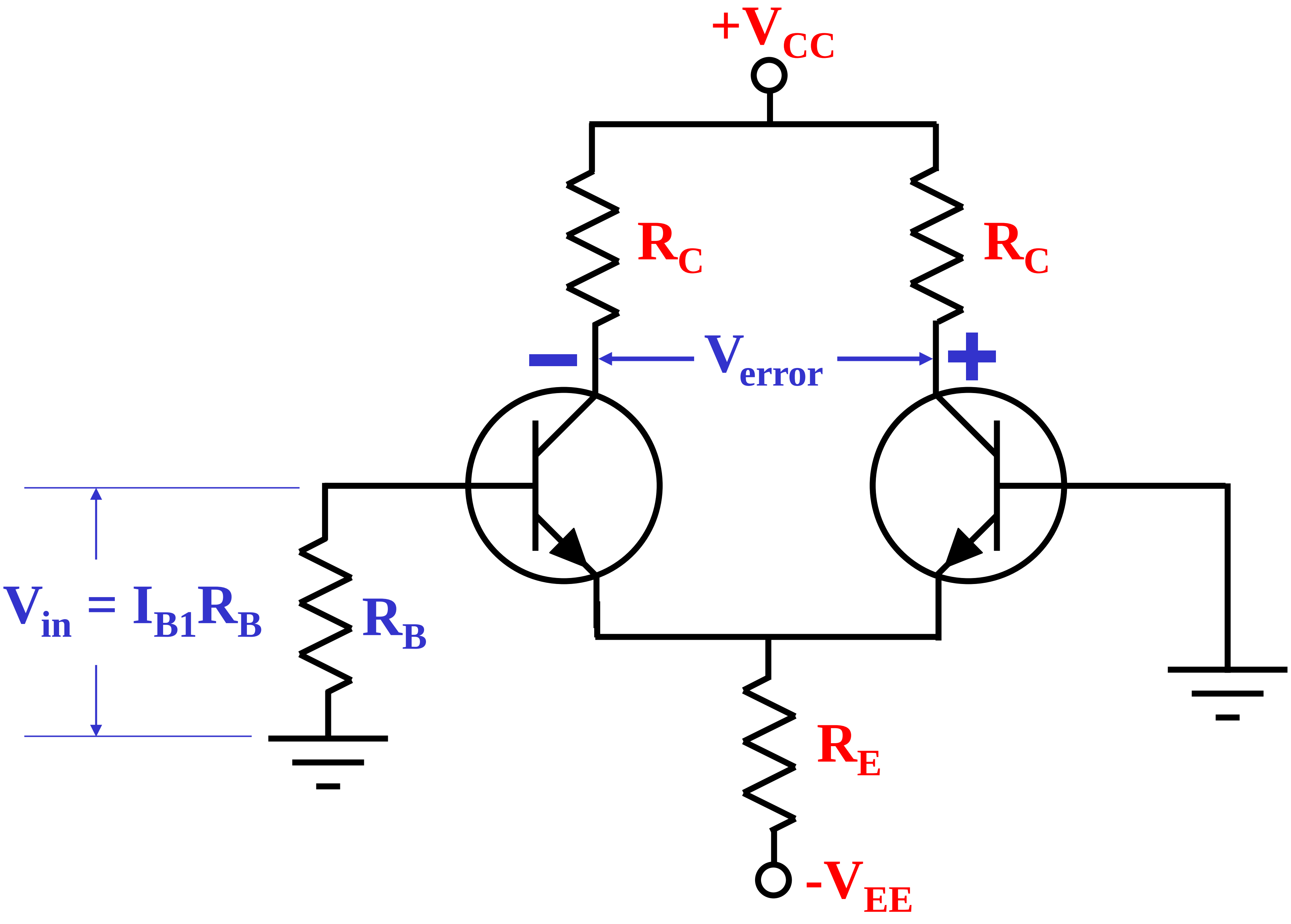
$$I_{in(bias)} = \frac{I_{B1} + I_{B2}}{2}$$

$$I_{in(off)} = I_{B1} - I_{B2}$$



$$I_{B1} = I_{in(bias)} + \frac{I_{in(off)}}{2} \qquad I_{B2} = I_{in(bias)} - \frac{I_{in(off)}}{2}$$

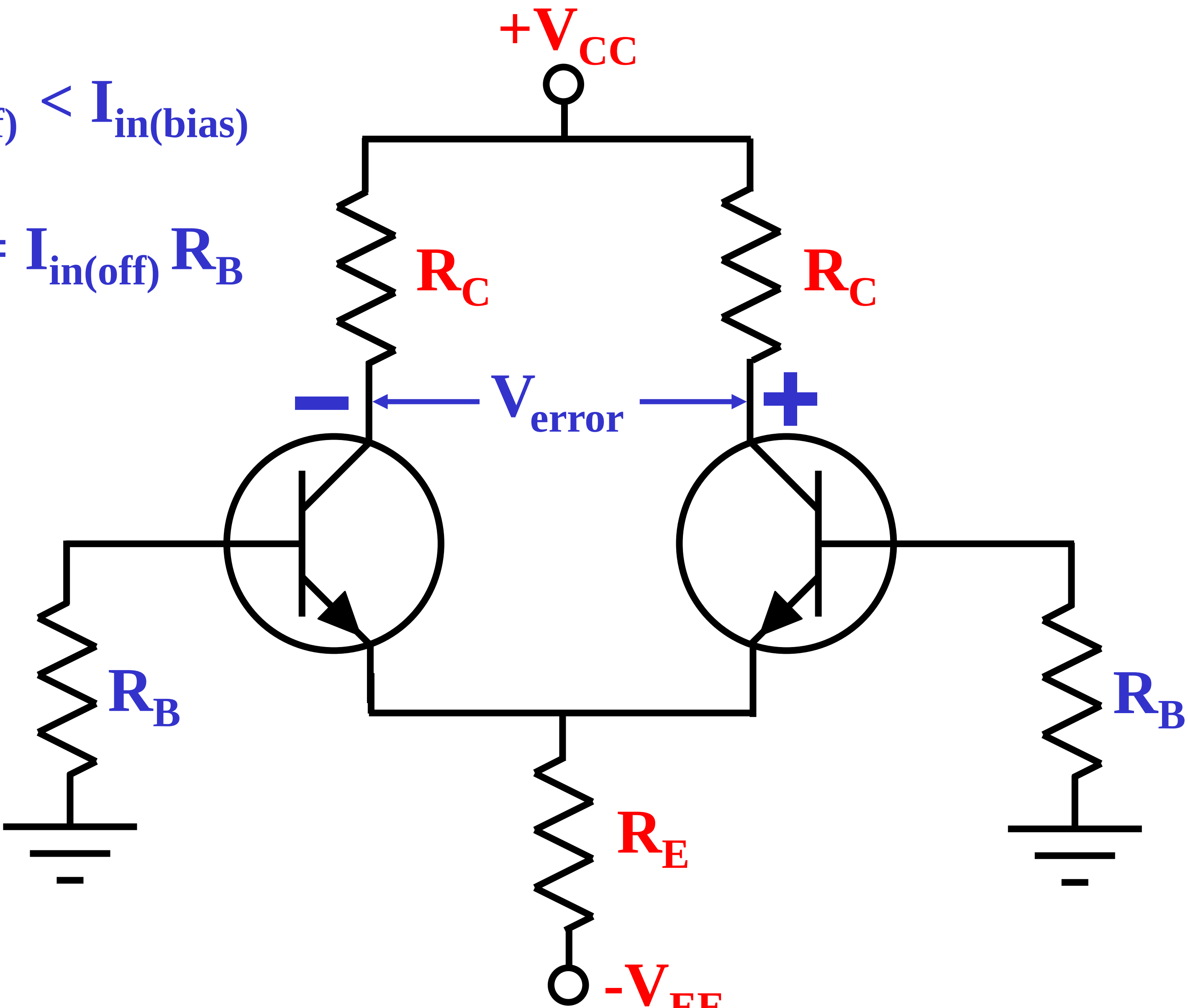
Base current can produce a false signal.



V_{in} and V_{error} are minimized with equal base resistors.

$I_{in(off)} < I_{in(bias)}$

$V_{in} = I_{in(off)} R_B$



Input offset voltage

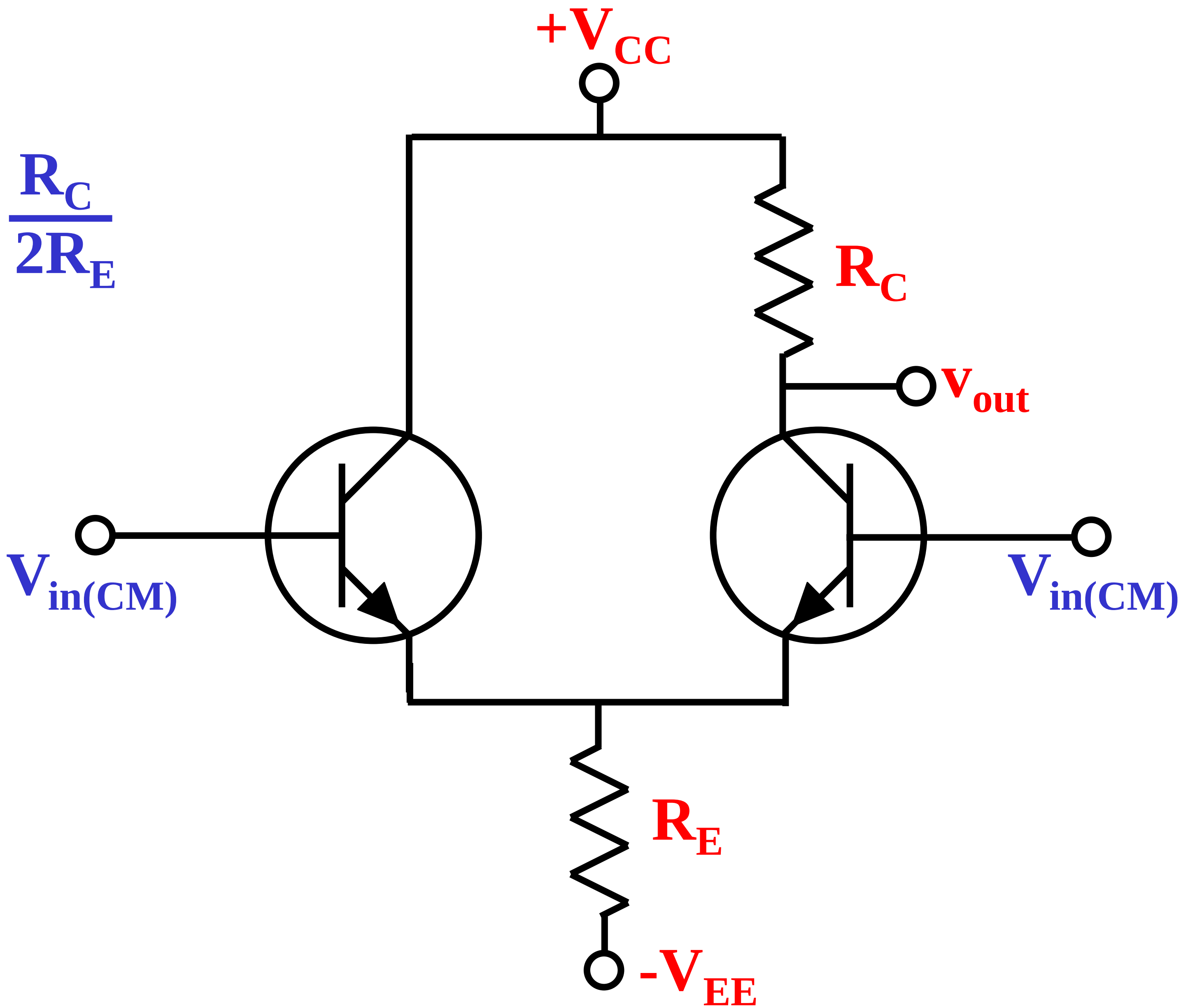
- The R_C values may be different.
- V_{BE} for each transistor may be different.
- Other parameters may differ slightly on each side of the diff amp.
- The input offset voltage would produce the same error in an ideal amplifier.
- $V_{in(off)} = V_{error}/A$
- Both bases are *grounded* when V_{error} is measured.

Combined dc error

- $V_{1err} = (R_{B1} - R_{B2})I_{in(bias)}$
- $V_{2err} = (R_{B1} + R_{B2})I_{in(off)}/2$
- $V_{3err} = V_{in(off)}$
- $V_{error} = A(V_{1err} + V_{2err} + V_{3err})$
- V_{1err} eliminated with equal base resistors
- V_{2err} reduced with smaller base resistors
- V_{3err} reduced with premium op amps

Common-mode gain

$$A_{CM} = \frac{R_C}{2R_E}$$



Common-mode rejection ratio

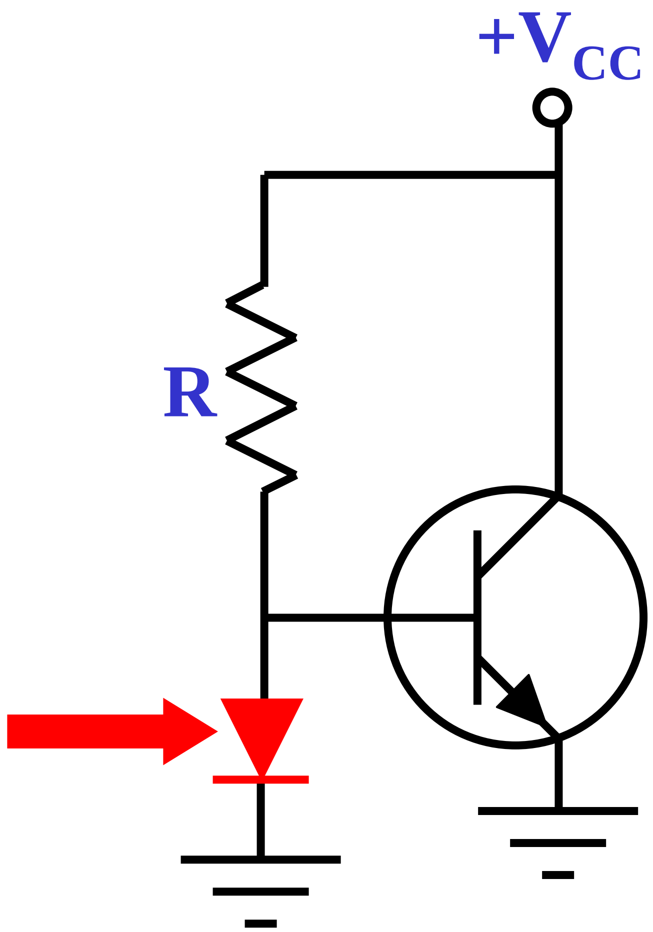
- $CMRR = A/A_{CM}$
- $CMRR_{dB} = 20\log CMRR$
- The higher the CMRR, the better
- A typical op amp has $CMRR_{db} = 90$ dB
- Much interference is common-mode and a high CMRR means an amplifier will be effective in rejecting interference

The current mirror

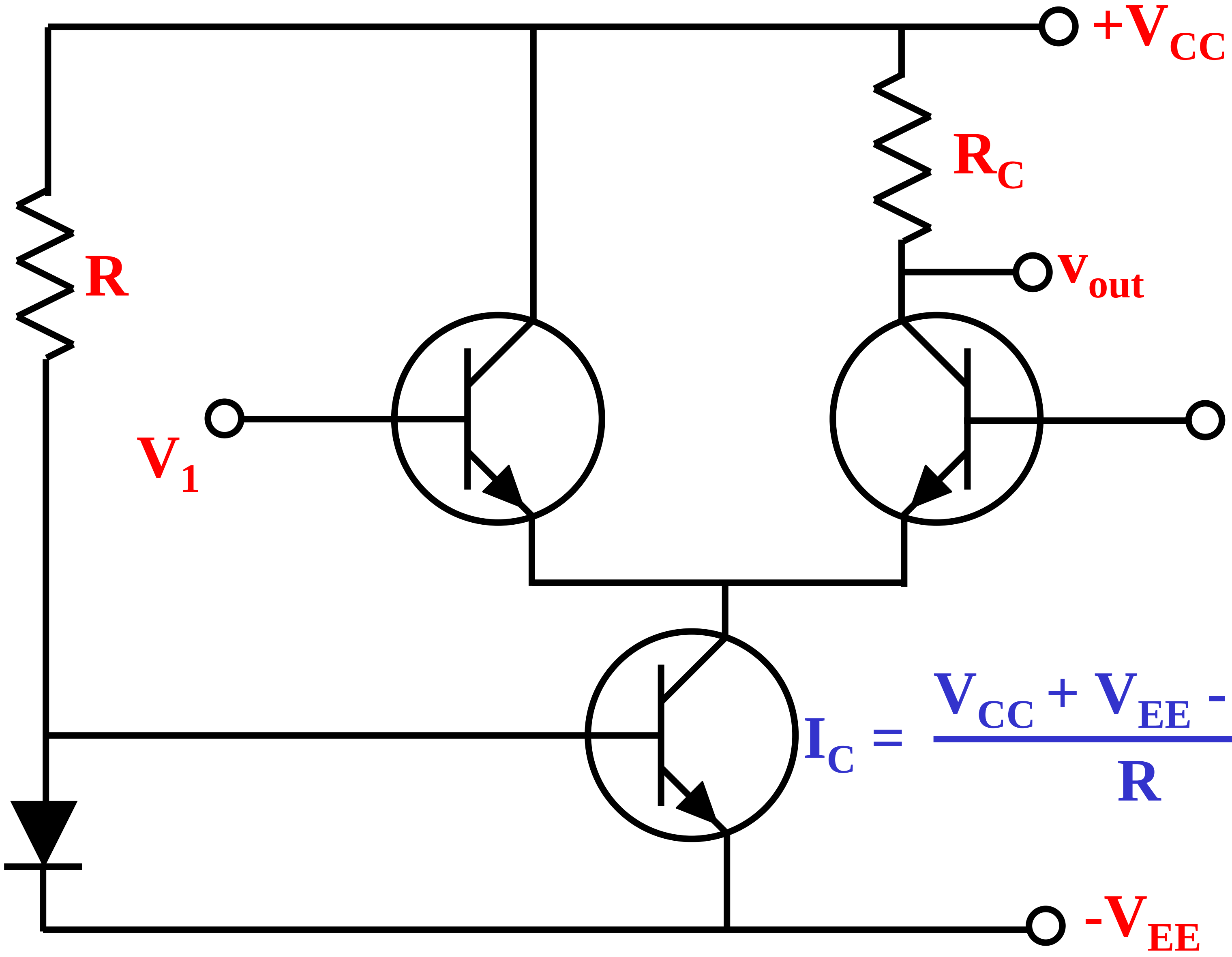
$$I_R = \frac{V_{CC} - V_{BE}}{R}$$

$$I_C = I_R$$

Compensating diode

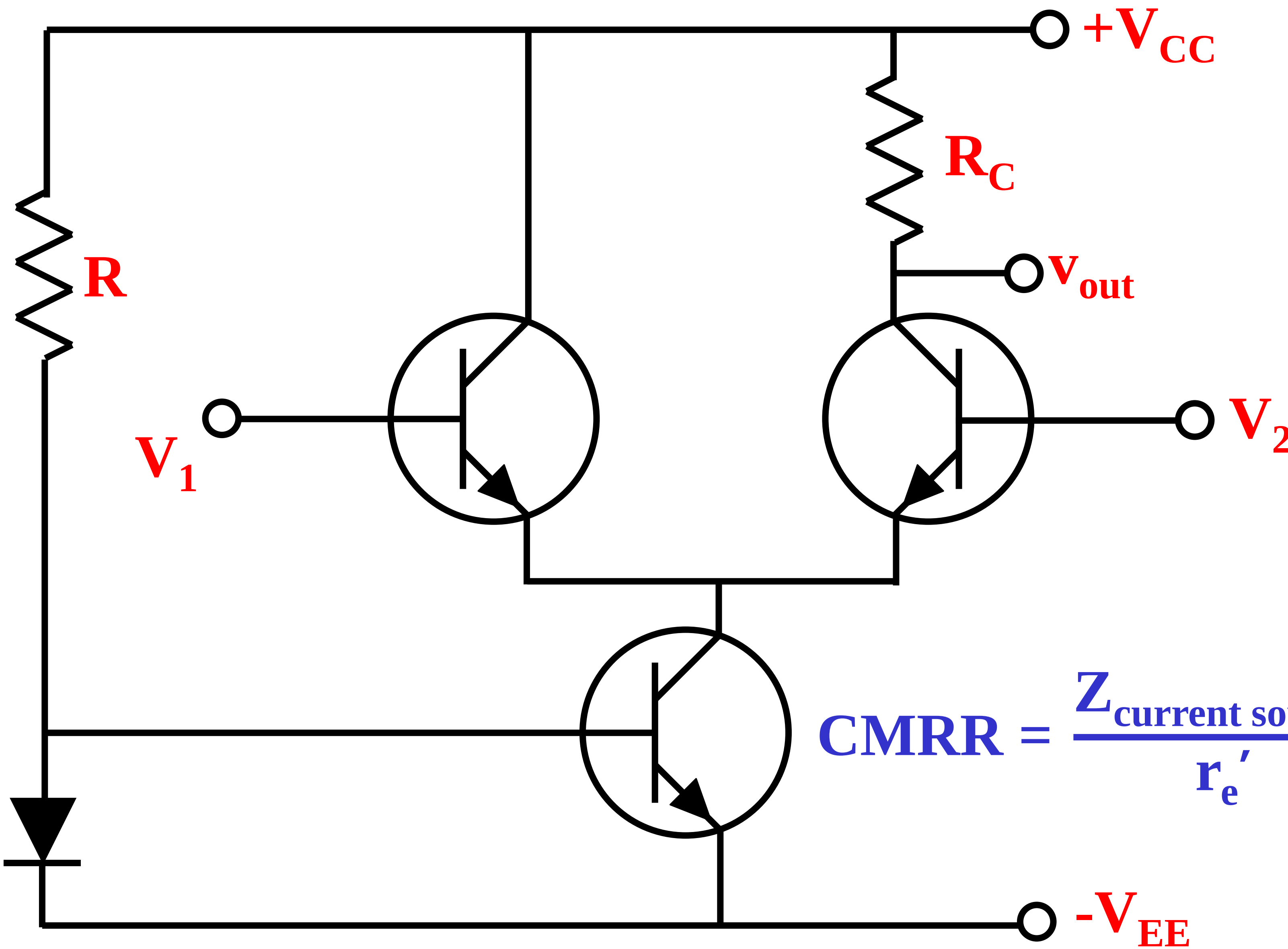


In ICs, a current mirror sources the tail current



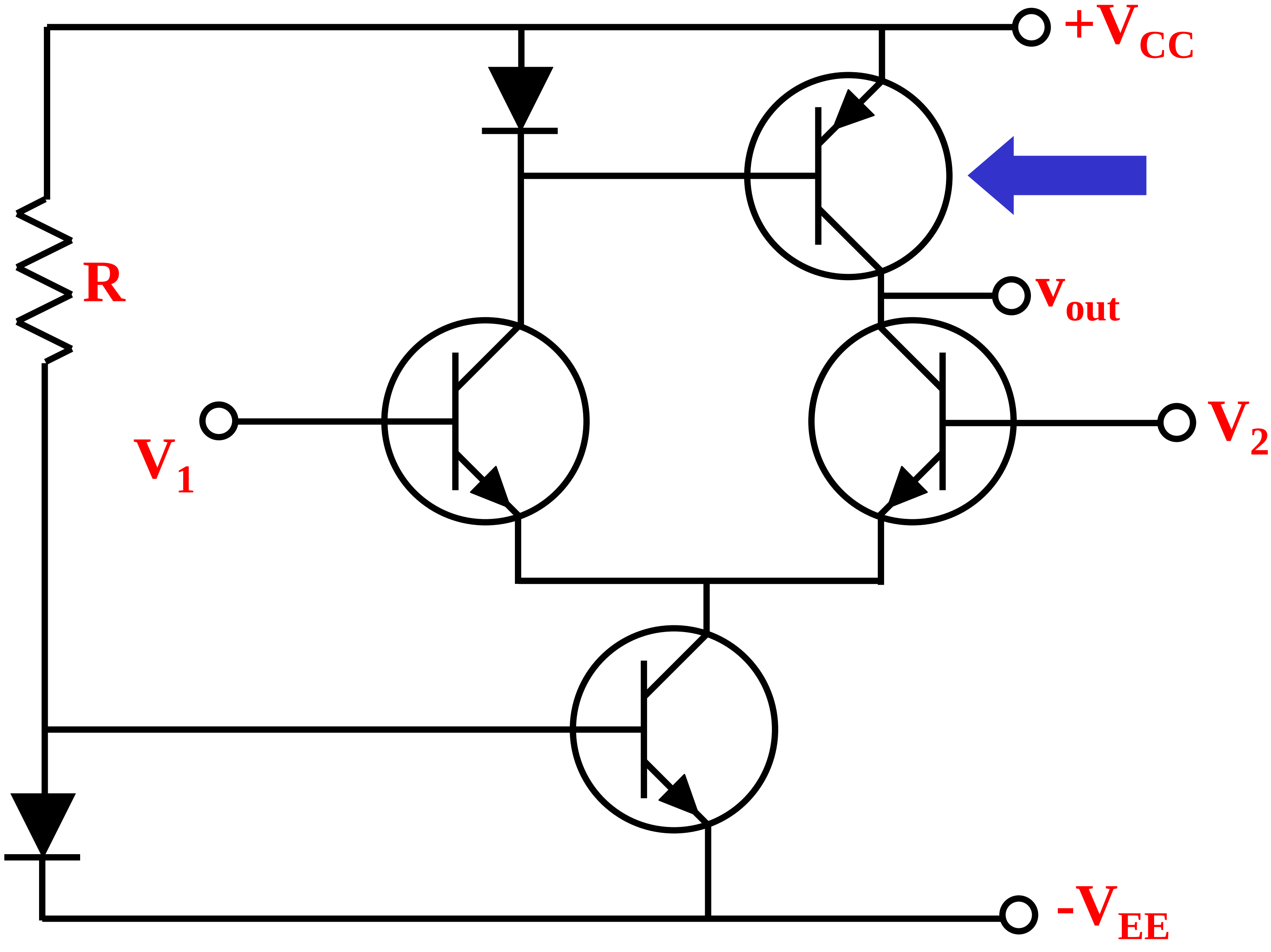
$$I_C = \frac{V_{CC} + V_{EE} - V_{BE}}{R}$$

The impedance of a current source is very high.

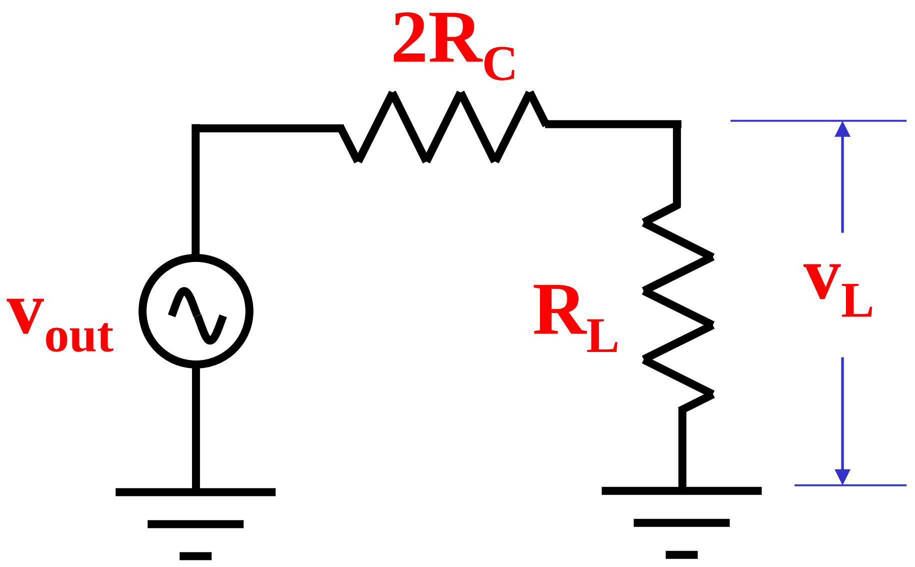


$$CMRR = \frac{Z_{current\ source}}{r_e'}$$

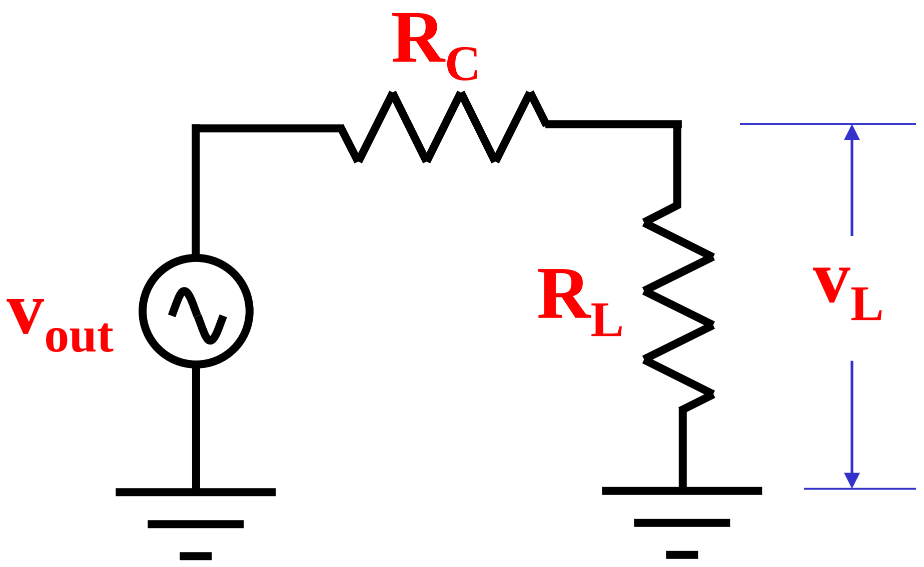
Active loading produces a very high voltage gain.



Loaded diff amps



Thevenin equivalent circuit for differential output



Thevenin equivalent circuit for single-ended output