DC Analysis of Four-Resistor Biasing Circuit

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EE2002 Analog Electronics

Lesson Objectives

At the end of this lesson, you should be able to:

- Draw DC equivalent circuits for four-resistor biasing BJT and MOSFET amplifiers
- Calculate the Q-points from the DC equivalent circuits of BJT and MOSFET amplifiers by using appropriate circuit analysis techniques

DC and AC Analyses

DC Analysis

- Obtain DC equivalent circuit by replacing all capacitors by open circuits, inductors by short circuit, AC voltage sources by ground connections, and AC current sources by open circuits.

- Find Q-point from DC equivalent circuit by using appropriate circuit analysis techniques, such as Thevenin equivalent circuit, KVL, and KCL.

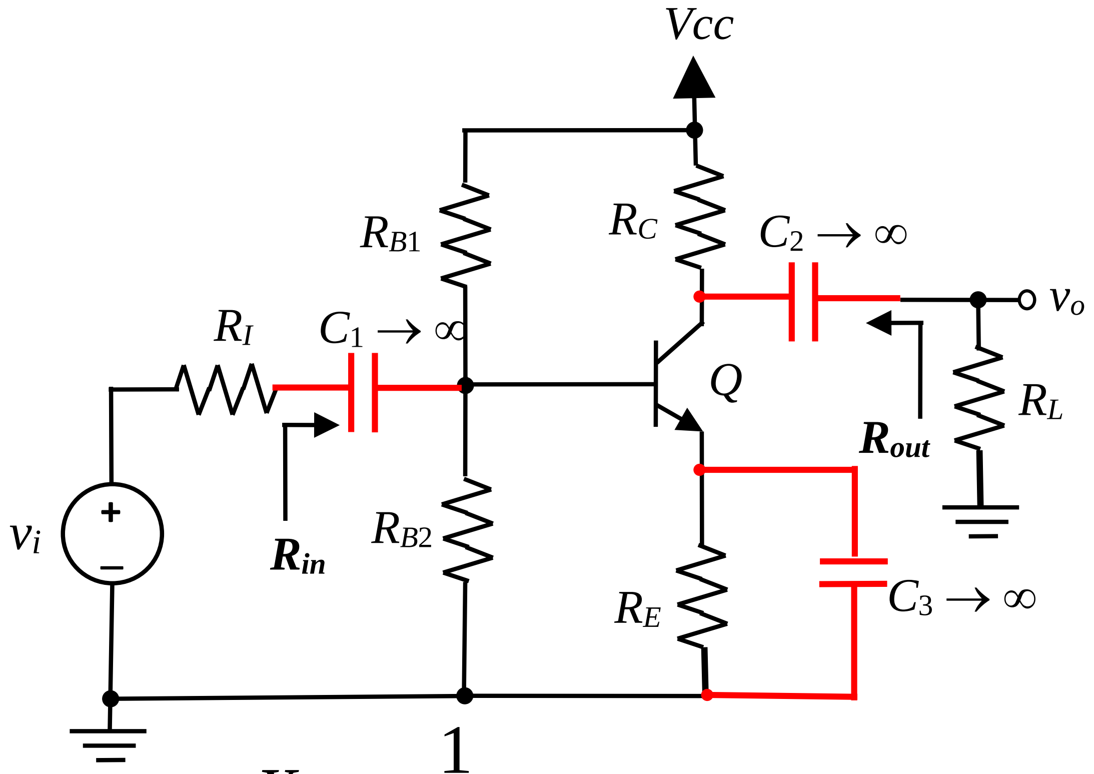
DC and AC Analyses

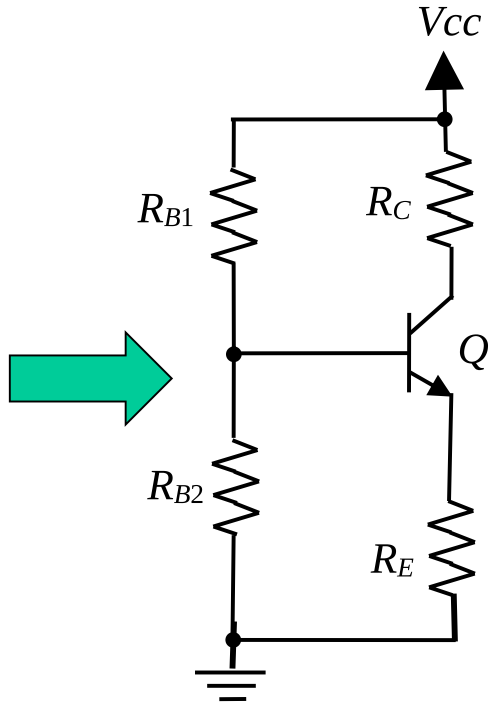
AC Analysis

- Obtain AC equivalent circuit by replacing all capacitors by short circuits, inductors by open circuits, DC voltage sources by ground connections, and DC current sources by open circuits.
- Replace transistor by its small signal model.
- Use small signal AC equivalent to analyse AC characteristics of amplifier.

Combine end results of DC and AC analyses to yield total voltages and currents in the network.

DC Equivalent Circuit for BJT Amplifier



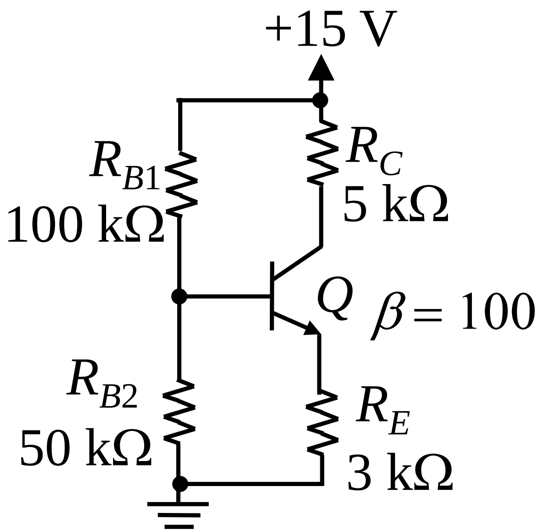


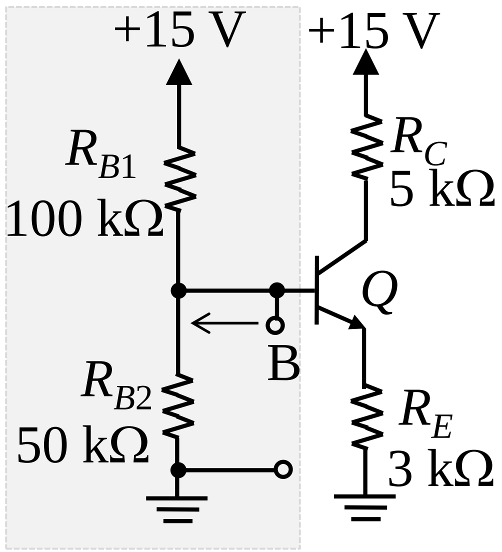
$$X_C = \frac{1}{\omega C} \qquad \omega = 0 \text{ rad/s (DC)}, X_C = \infty \text{ (open circuit)}$$

All capacitors in original amplifier circuits are replaced by open circuits, disconnecting v_i, R_I, and R_L from circuit.

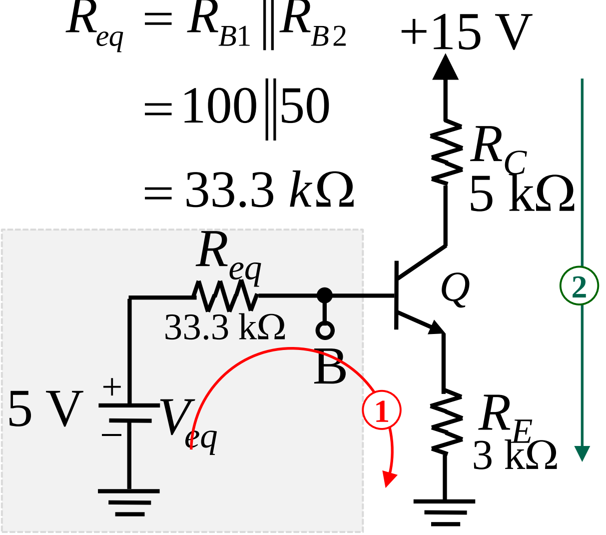
DC Analysis Example: Four-Resistor BJT Biasing Circuit

Equi Resistance how???





$$R_{eq} = R_{B1} \| R_{B2}$$
$$= 100 \| 50$$
$$= 33.3\ k\Omega$$



KVL 1: $V_{eq} = I_B R_{eq} + V_{BE} + I_E R_E$

$$5 = 33.3 I_B + 0.7 + 101 \times I_B \times 3$$

$$I_B = 0.0128\ \text{mA}$$

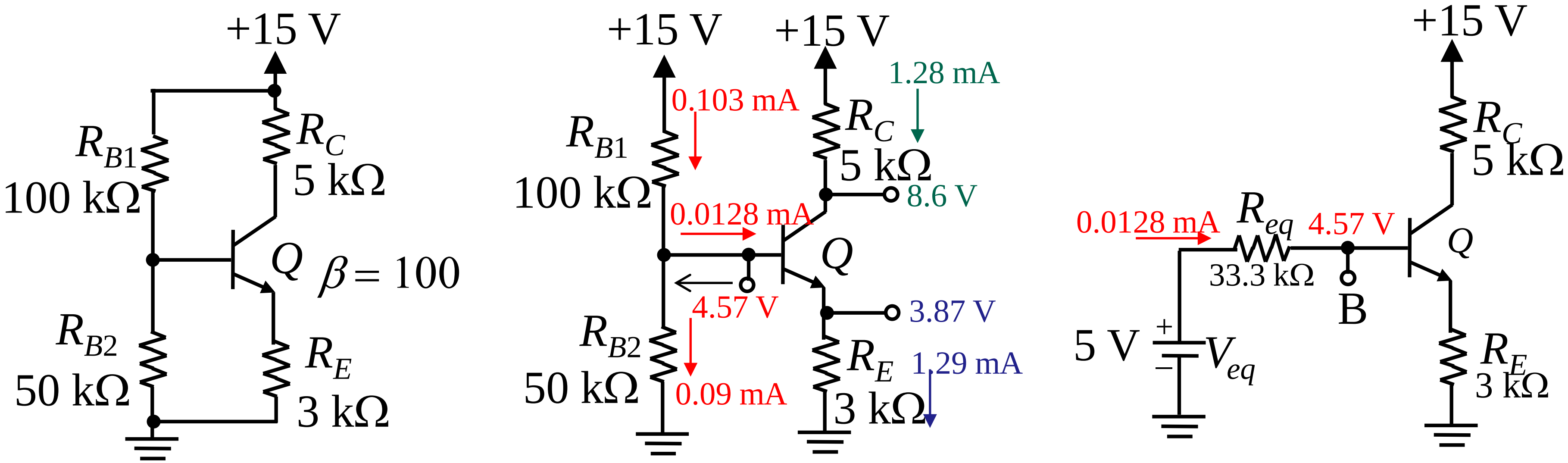
$$V_{eq} = \left(\frac{R_{B2}}{R_{B1} + R_{B2}}\right) V_{CC}$$

$$= \frac{50}{100+50} \times 15 = 5\ \text{V}$$

$I_C = \beta\, I_B =$ **1.28 mA**, $I_E = (\beta+1)\, I_B = 1.29$ mA

KVL 2: $V_{CE} = 15 - I_C R_C - I_E R_E = 15 - 1.28 \times 5 - 1.29 \times 3 =$ **4.73 V**

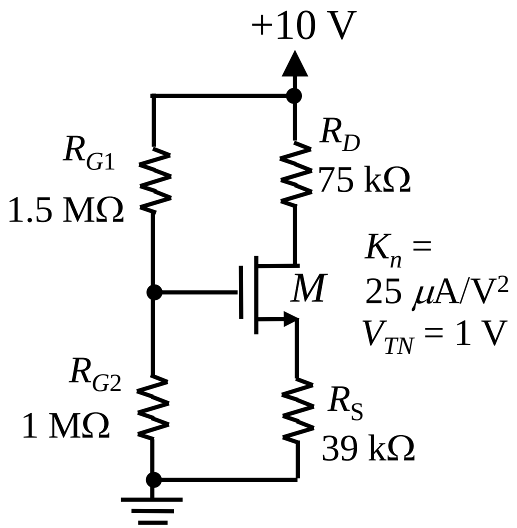
DC Analysis Example: Four-Resistor BJT Biasing Circuit

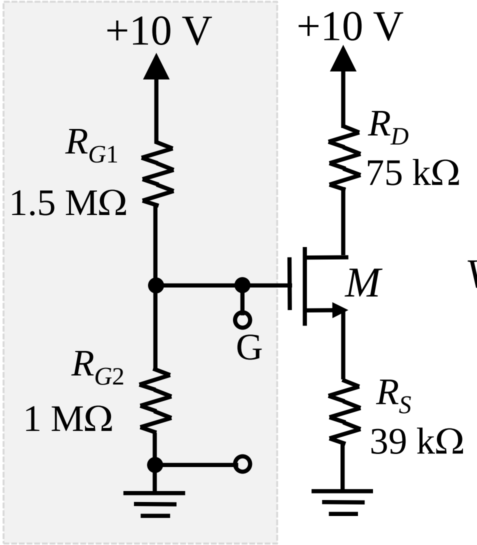


$$V_B = V_{BE} + I_E R_E = 0.7 + 3.87 = 4.57 \text{ V}$$
$$V_C = V_{CC} - I_C R_C = 15 - 1.28 \times 5 = 8.6 \text{ V}$$
$$V_{BC} = V_B - V_C = 4.57 - 8.6 = -4.03 \text{ V}$$

BCJ is reverse biased, Q is indeed in active mode as had been assumed.

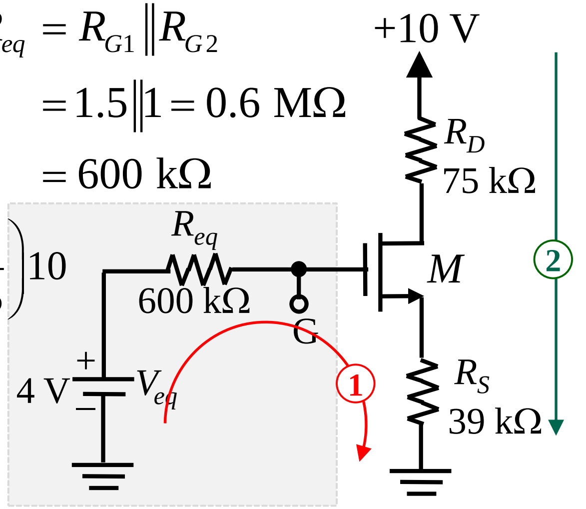
DC Analysis Example: Four-Resistor MOSFET Biasing Circuit





$$R_{eq} = R_{G1} \| R_{G2} = 1.5 \| 1 = 0.6\ \text{M}\Omega = 600\ \text{k}\Omega$$

$$V_{eq} = \left(\frac{1}{1+1.5}\right)10 = 4\ \text{V}$$



KVL 1: Since $I_G = 0$, $V_{eq} = V_{GS} + I_D R_S$

$4 = V_{GS} + 0.5 \times 25\mu\,(V_{GS} - 1)^2 \times 39\ \text{k}$

$V_{GS}^2 + 0.05\,V_{GS} - 7.21 = 0$

$V_{GS} = -2.71$ or 2.66 V

Since $V_{GS} = -2.71 < V_{TN} = 1$, $V_{GS} = 2.66$ V.

$\boldsymbol{I_D}$ = (4 – 2.66)/39k = **34.4 µA**

KVL 2: $V_{DS} = 10 - I_D R_D - I_D R_S$

$\boldsymbol{V_{DS}}$ = 10 – 0.0344×(75 +39) = **6.08 V**

Since $V_{DS} > V_{GS} - V_{TN} = 1.66$,

***M* is in saturation region.**