VOLTAGE-DIVIDER BIAS

BJT DC BIASING

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TOPIC OUTLINE

Voltage-Divider Bias Circuit

- Base-Emitter Loop
- Collector-Emitter Loop
- Load Line Analysis

VOLTAGE-DIVIDER BIAS CIRCUIT

CURRENT GAIN

The current gain parameters **alpha** (α) and **beta** (β) describe the relationship between currents in the transistor's three terminals (emitter, base, and collector).

Alpha (α) is the ratio of the collector current to the emitter current.

Formula

$$\alpha = \frac{i_C}{i_E}$$

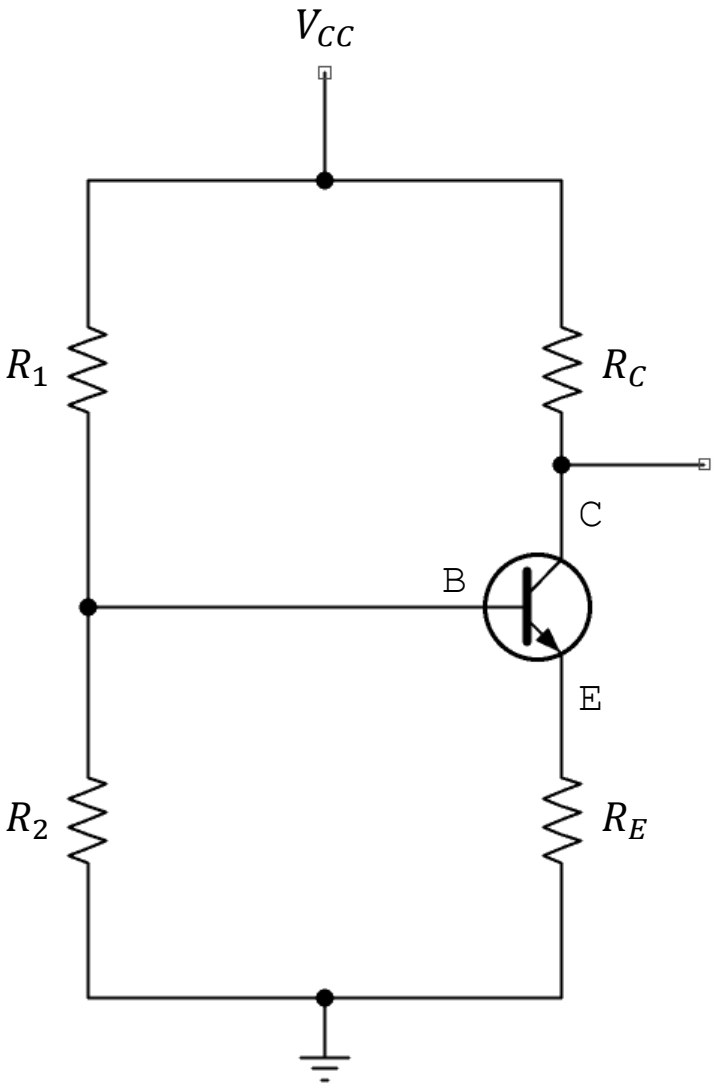
α is always less than 1 (typically 0.95 to 0.995)

Beta (β) is the ratio of the collector current to the base current.

Formula

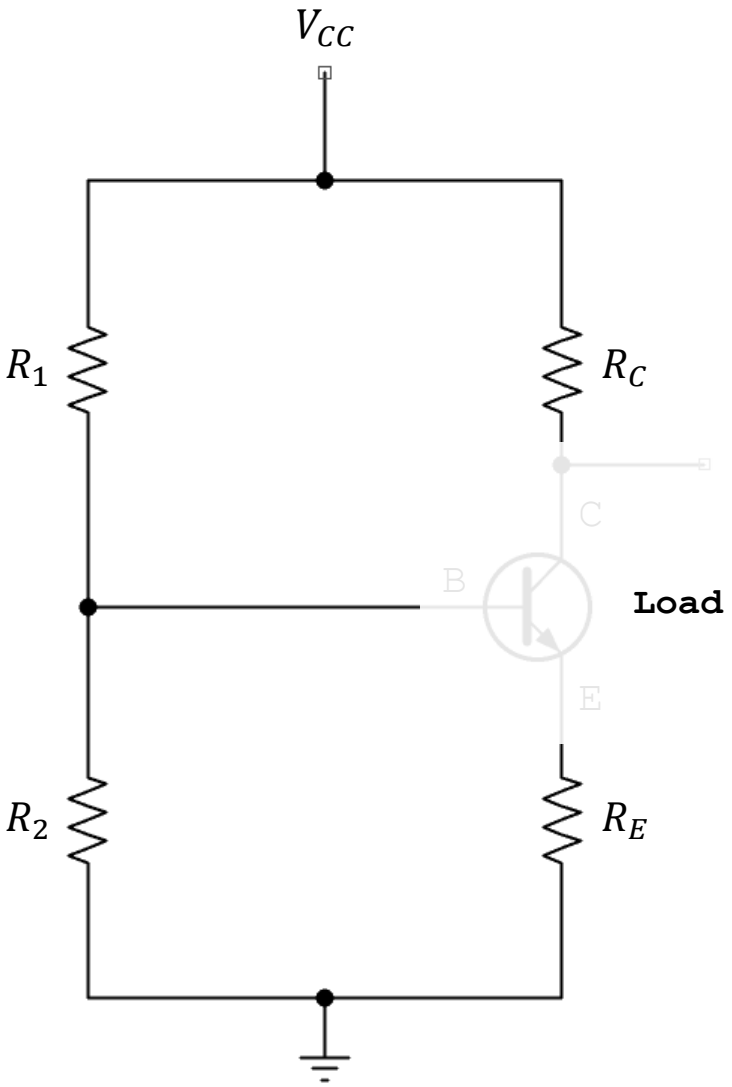
$$\beta = \frac{i_C}{i_B}$$

VOLTAGE-DIVIDER BIAS CIRCUIT



The **voltage-divider bias** uses a pair of resistors (R_1 and R_2) to form a voltage divider that sets the base voltage. This configuration is less sensitive to variations in transistor beta (β) and offers a more **stable operating point**.

THEVENIN EQUIVALENT CIRCUIT



Thevenin Voltage

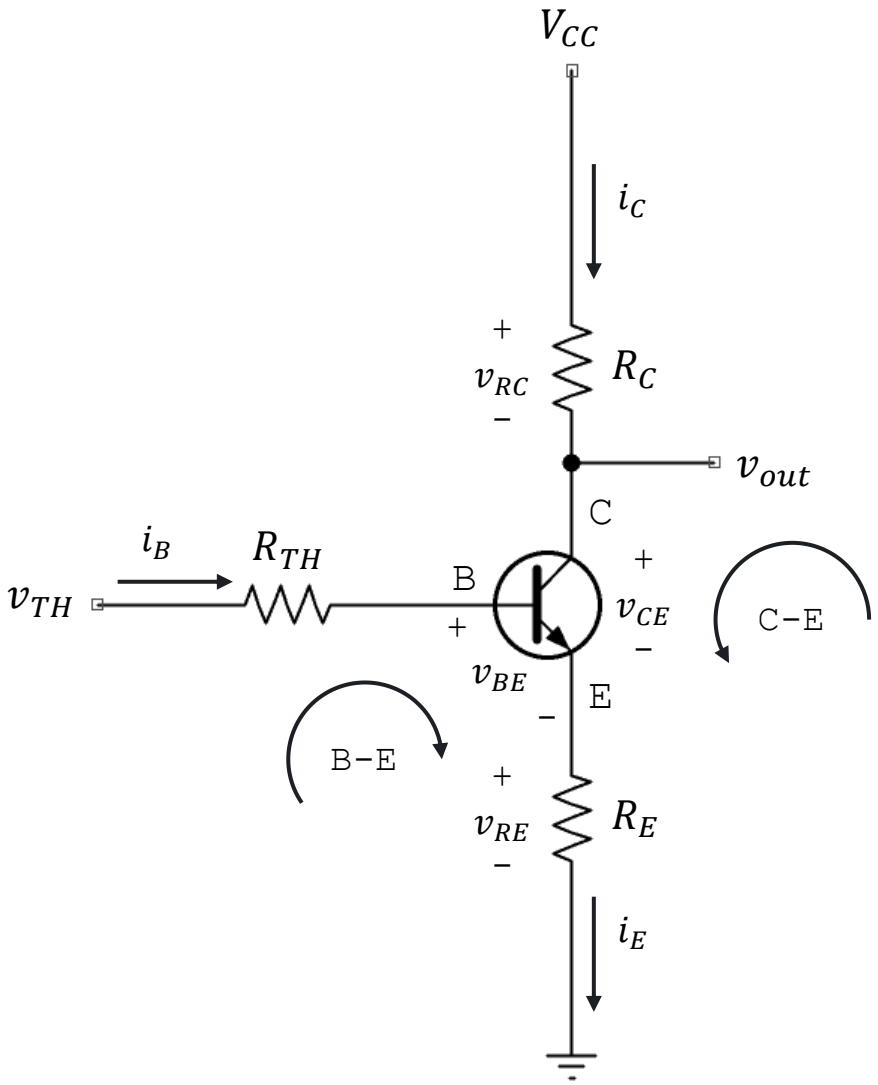
$$v_{TH} = v_{CC}\frac{R_2}{R_1 + R_2}$$

Thevenin Resistance

$$G_o = G_1 + G_2$$

$$\frac{1}{R_{TH}} = \frac{1}{R_1} + \frac{1}{R_2}$$

THEVENIN EQUIVALENT CIRCUIT



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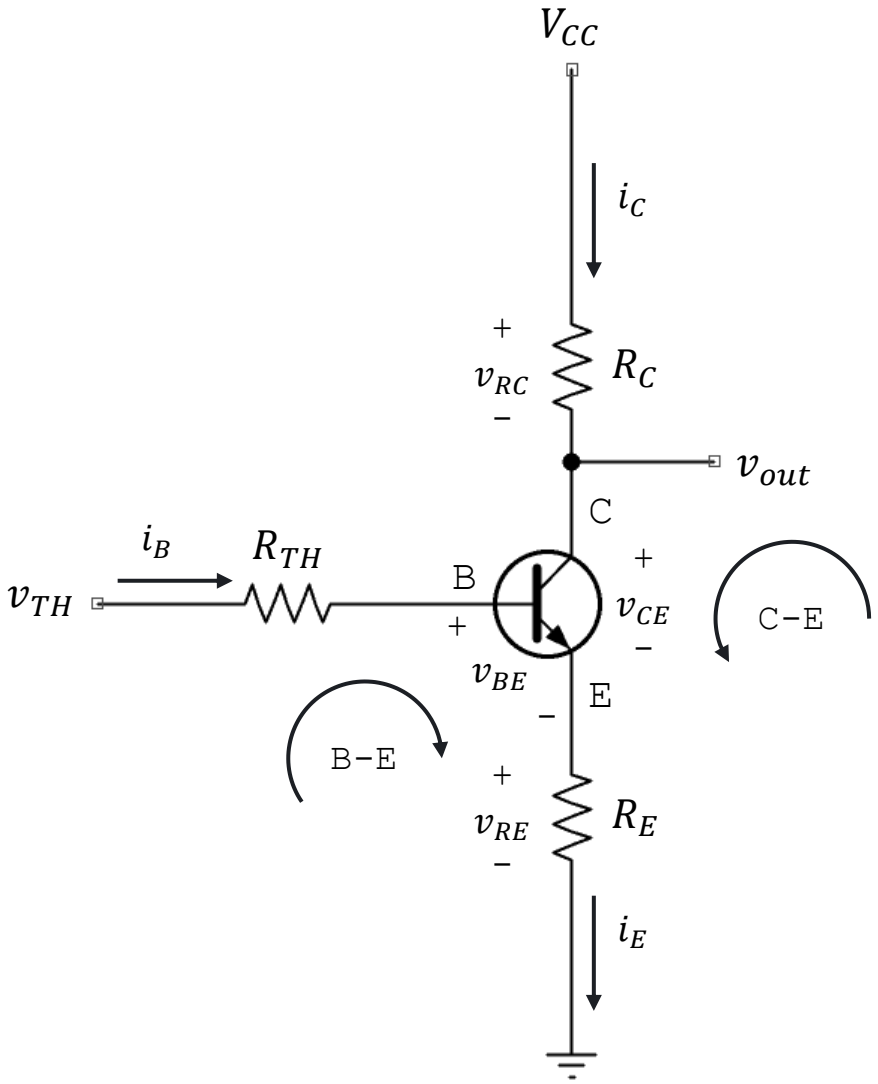
BASE-EMITTER LOOP



KVL @B-E

$$-v_{TH} + v_{RTH} + v_{BE} + v_{RE} = 0$$

$$v_{RTH} + v_{RE} = v_{TH} - v_{BE}$$

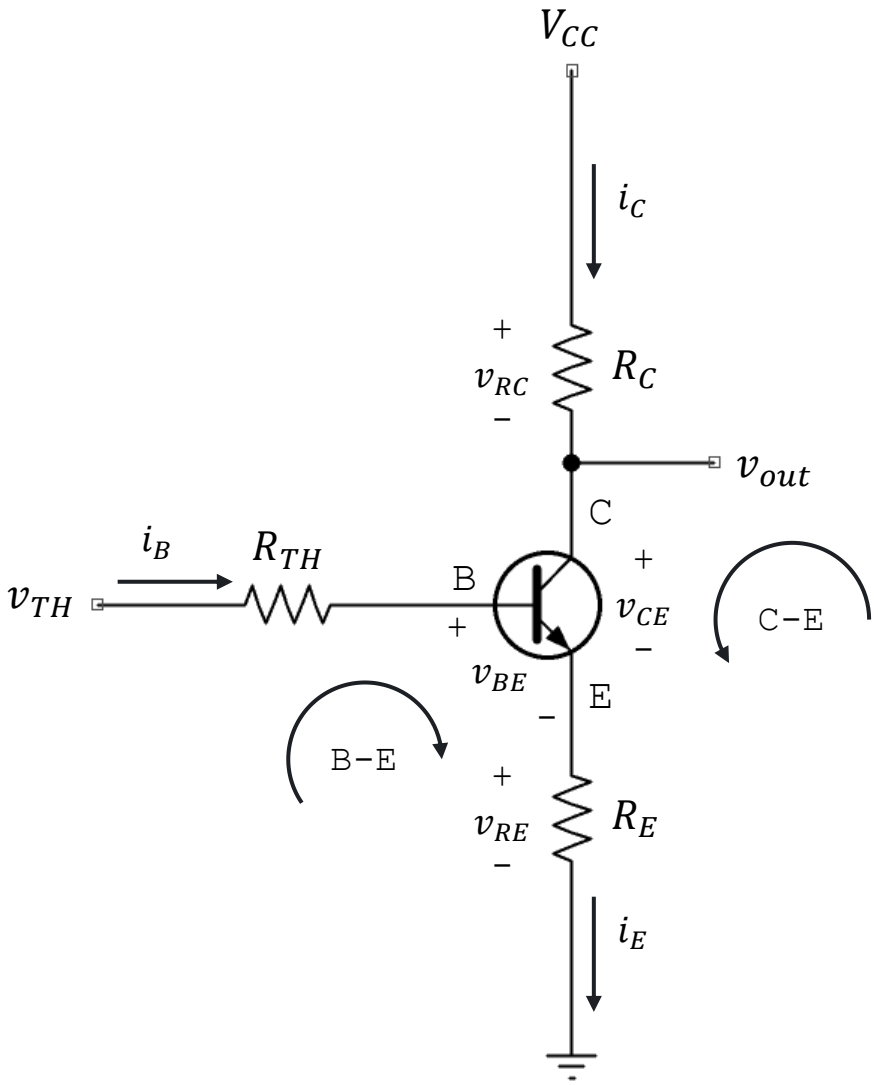
$$i_B R_{TH} + i_E R_E = v_{TH} - v_{BE}$$

$$i_B R_{TH} + i_B(\beta + 1)R_E = v_{TH} - v_{BE}$$

$$i_B(R_{TH} + (\beta + 1)R_E) = v_{TH} - v_{BE}$$

$$i_B = \frac{v_{TH} - v_{BE}}{R_{TH} + (\beta + 1)R_E}$$

COLLECTOR-EMITTER LOOP



KVL @C-E

$$-v_{CC} + v_{RC} + v_{CE} + v_{RE} = 0$$

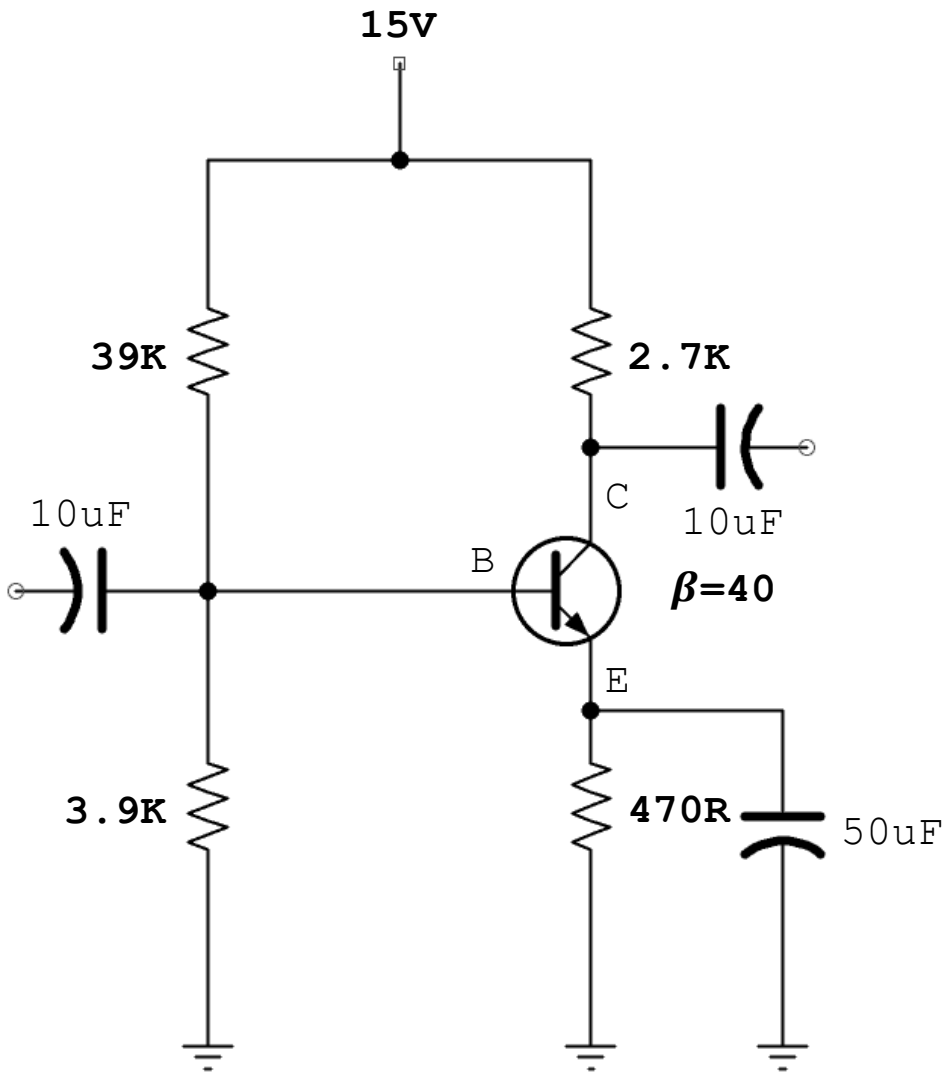
$$v_{CE} = v_{CC} - v_{RC} - v_{RE}$$

$$v_{CE} = v_{CC} - i_C R_C - i_E R_E$$

$$i_E \approx i_C$$

$$v_{CE} = v_{CC} - i_C(R_C + R_E)$$

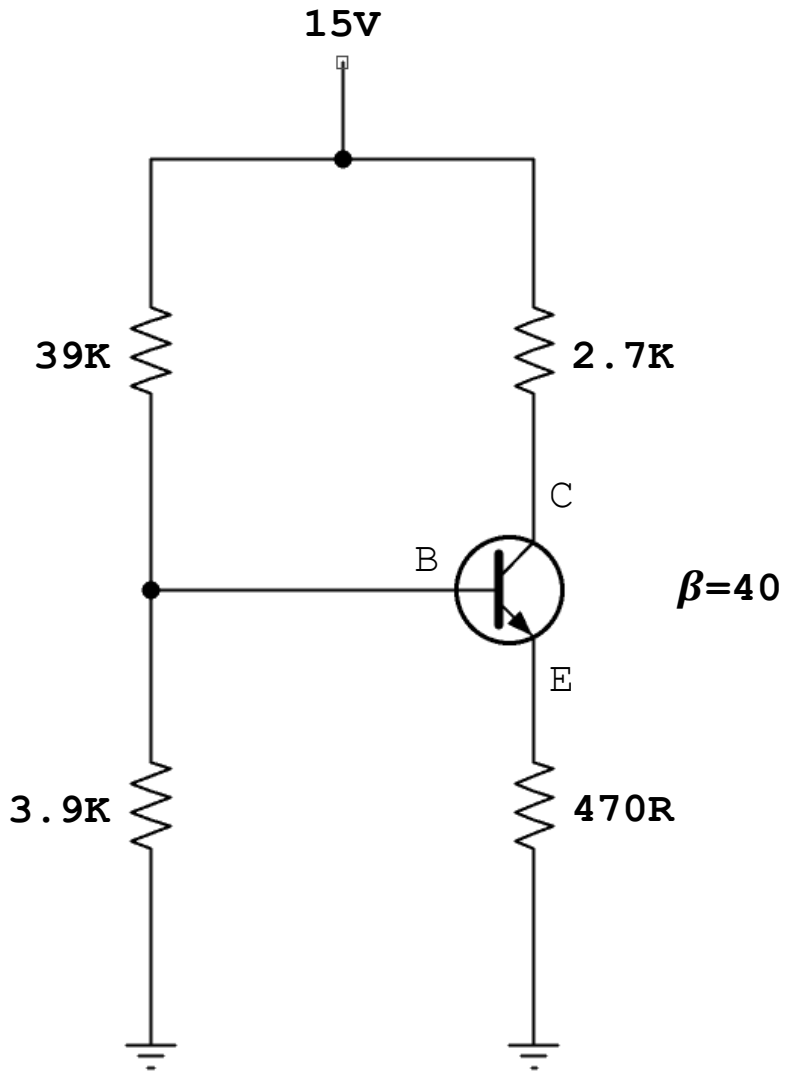
EXERCISE



For the given voltage-divider bias network, determine:

- Base current (i_{BQ})
- Collector current (i_{CQ})
- Collector-Emitter voltage (v_{CEQ})
- Emitter voltage (v_E)
- Collector Voltage (v_C)

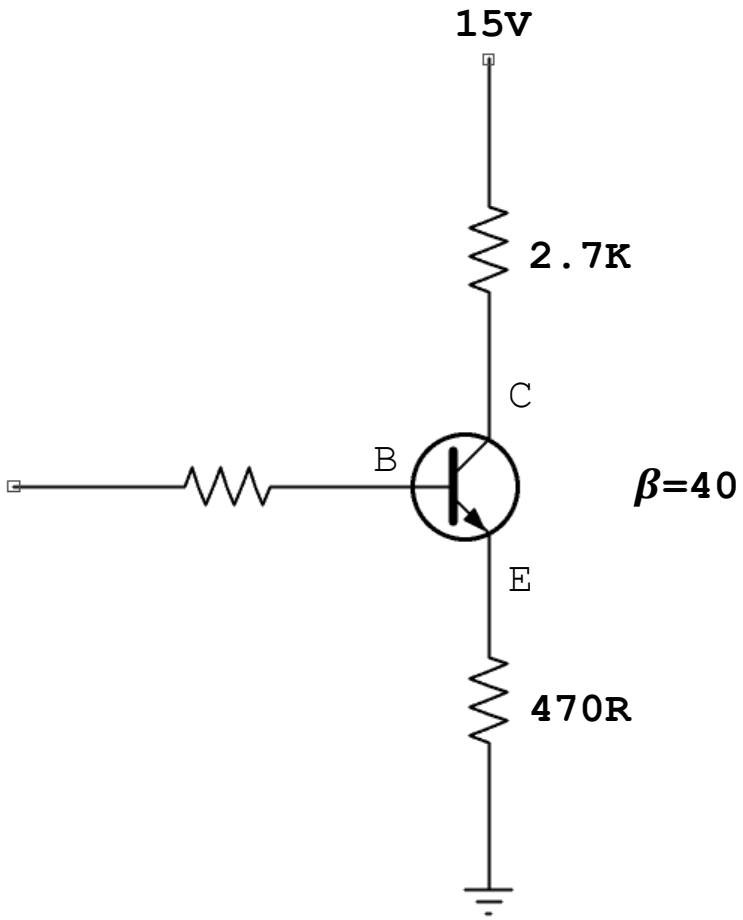
EXERCISE



Solution

EXERCISE

Solution



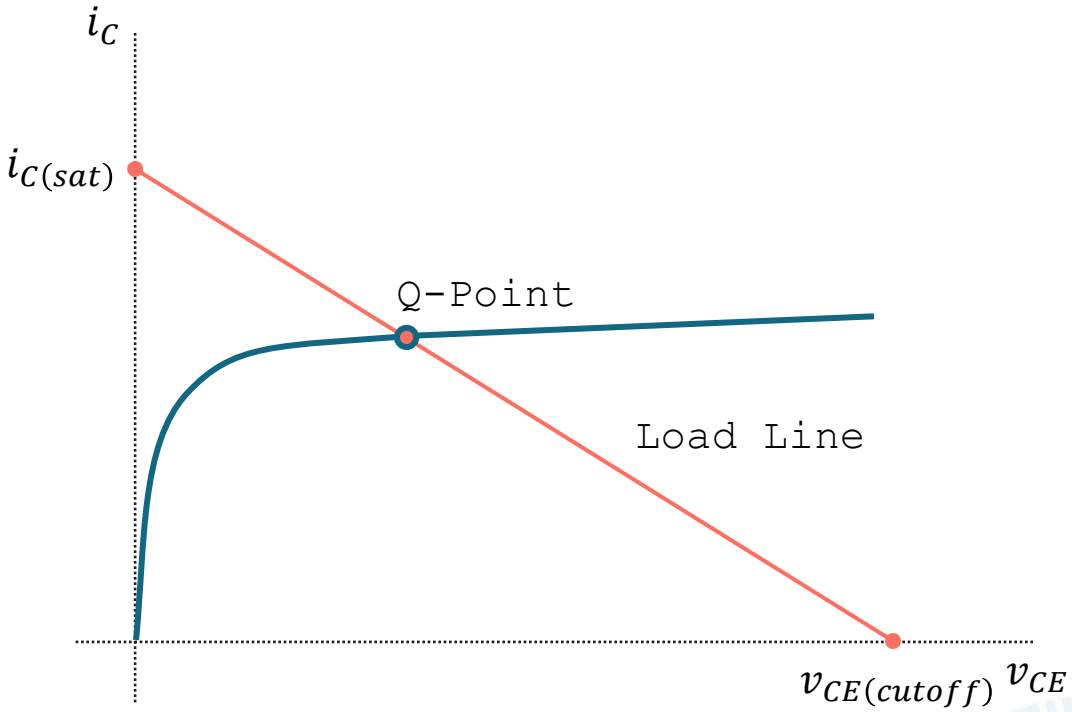
LOAD LINE ANALYSIS

SATURATION POINT

The **saturation point** is the operating state where BJT conducts the **maximum collector current** ($i_{C(sat)}$) with zero collector-emitter voltage ($v_{CE} = 0$).

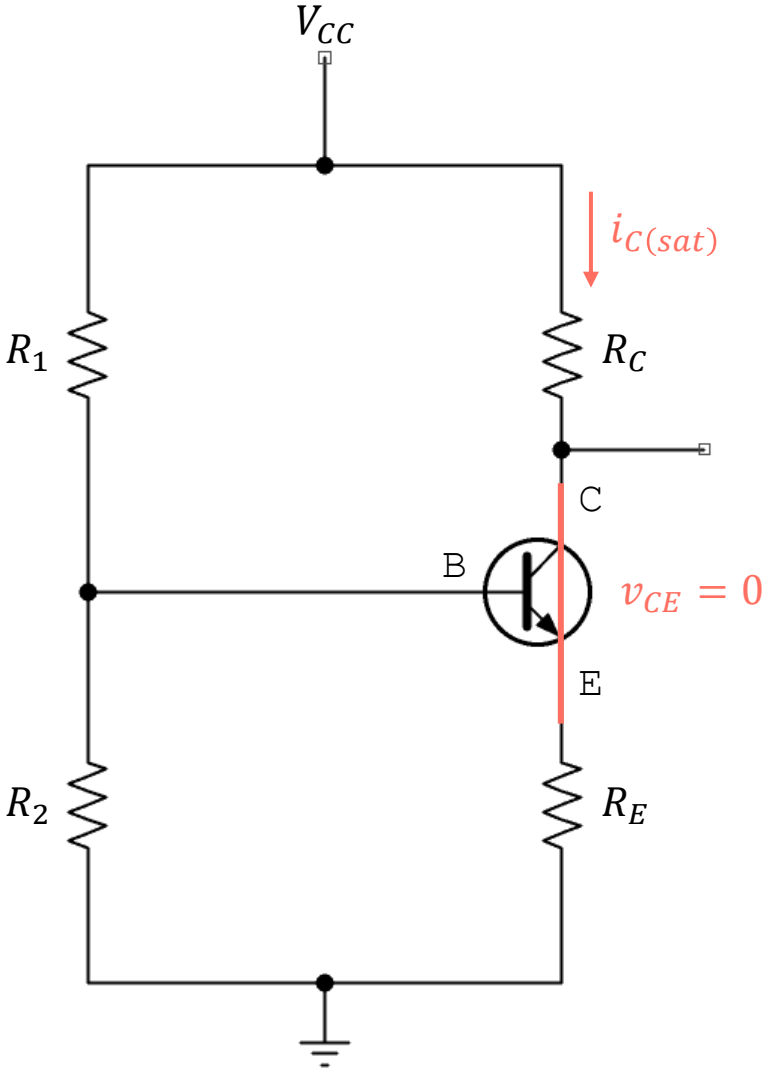
In this region the transistor acts like a **closed switch** (zero resistance between collector-emitter).

Collector Characteristic Curve



SATURATION POINT

Mentally Short



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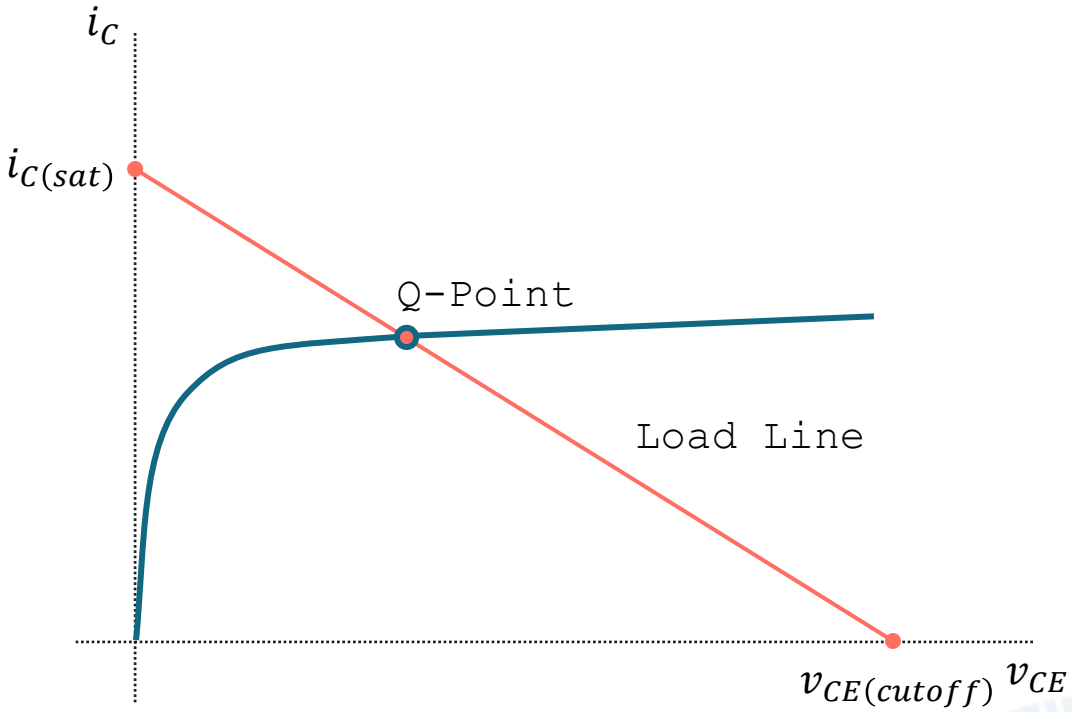
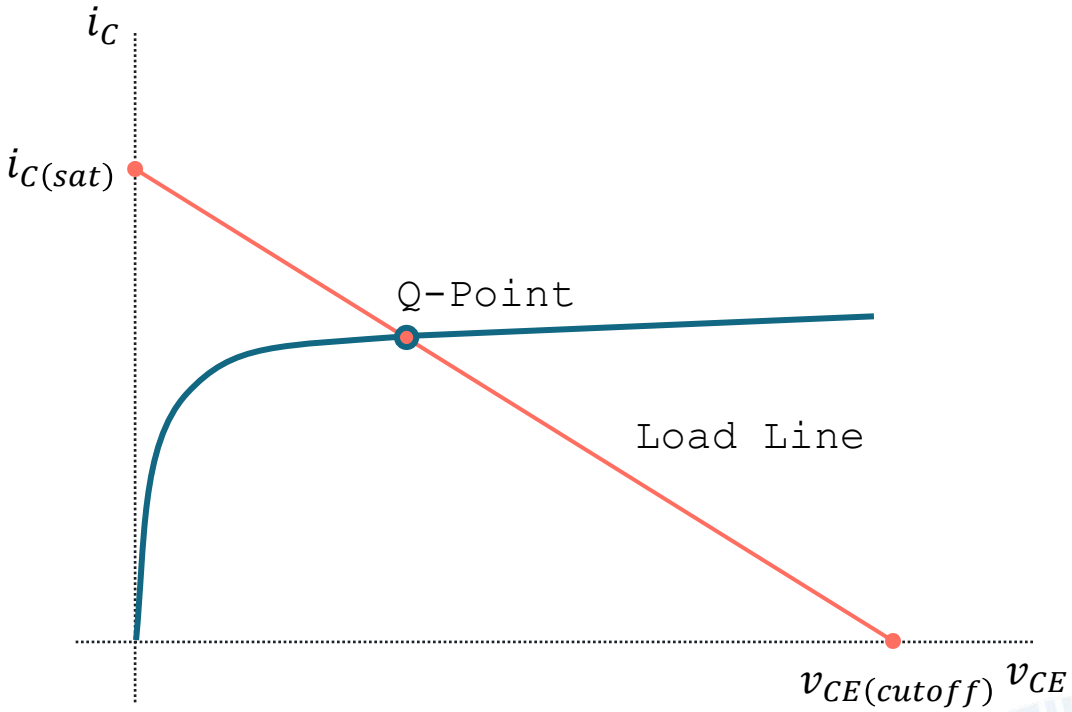


CUTOFF POINT

The **cutoff point** is the operating state where BJT conducts zero collector current ($i_C = 0$) with v_{CE} at its maximum ($v_{CE} = V_{CC}$).

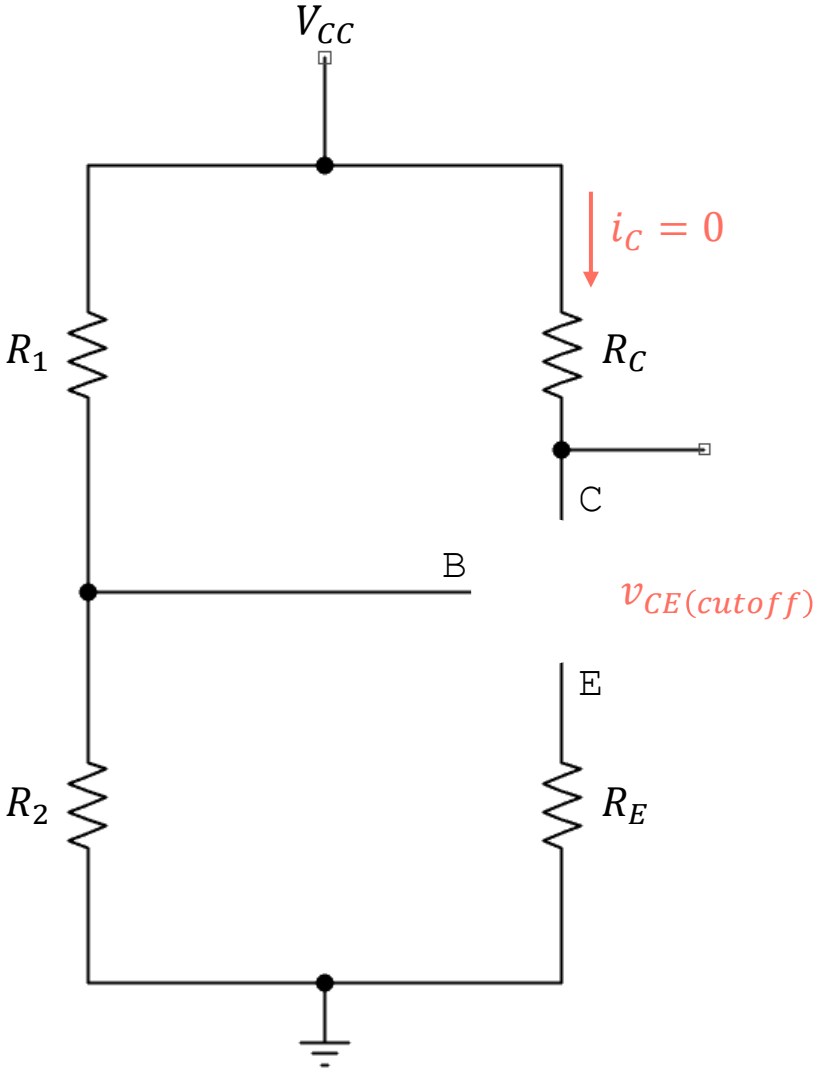
In this region the transistor acts like an **open switch** (infinite resistance between collector-emitter).

Collector Characteristic Curve



CUTOFF POINT

Mentally Open



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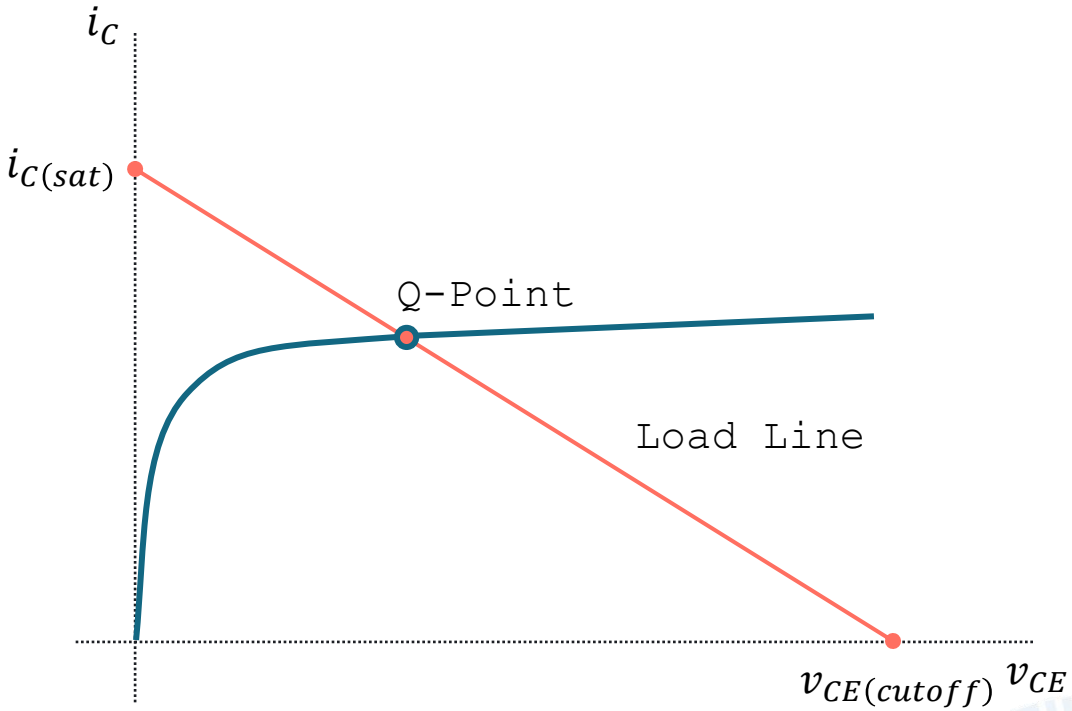
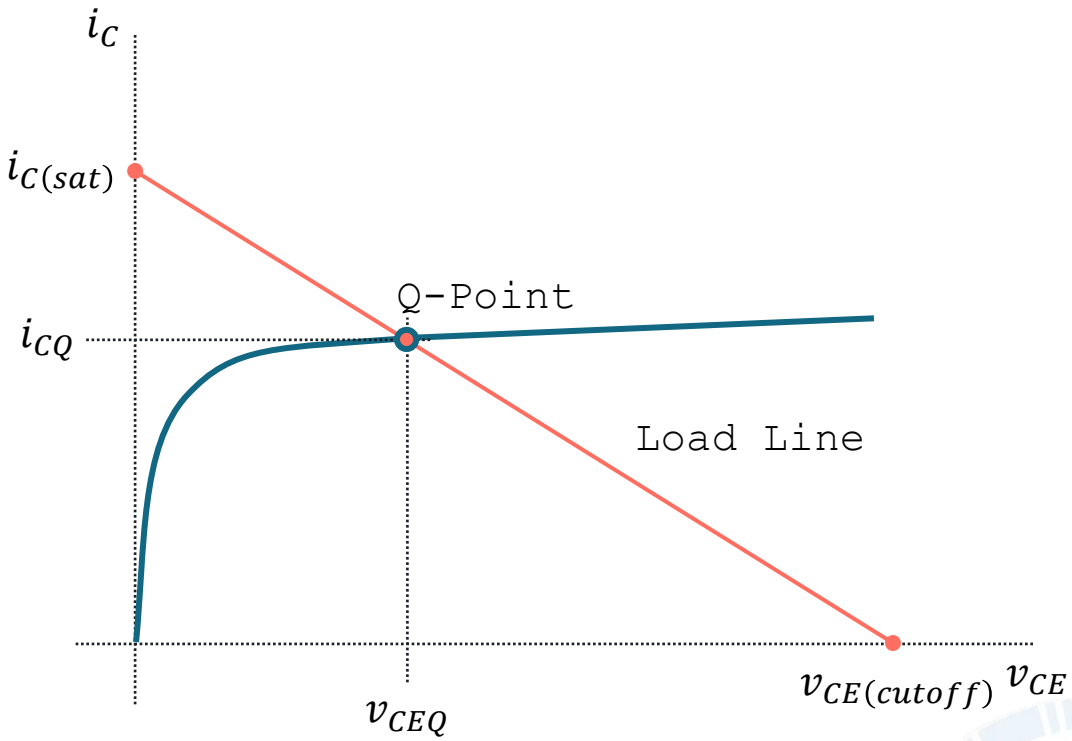


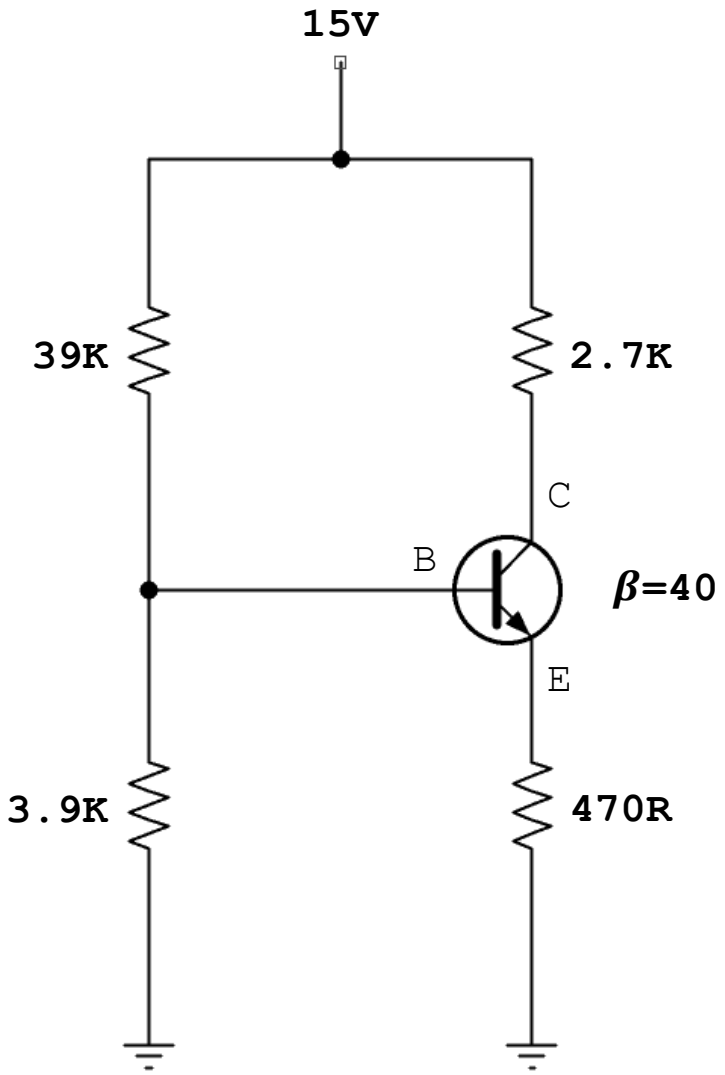
QUIESCENT POINT

The **Q-point** is the stable DC operating condition characterized by specific value of collector current (i_C) and collector-emitter voltage (v_{CE}).

Collector Characteristic Curve



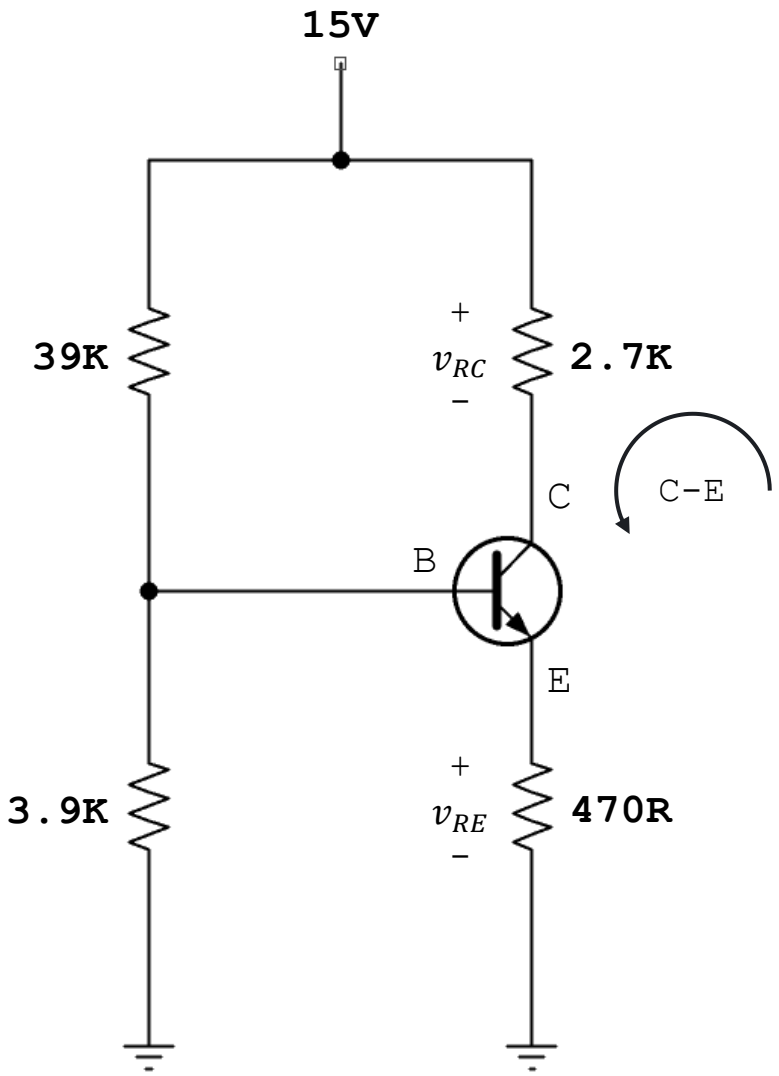
EXERCISE



Plot the DC load line analysis for the voltage-divider bias network, indicating:

- Saturation current ($i_{C(sat)}$)
- Cutoff voltage ($v_{CE(cutoff)}$)
- Operating Point (Q-Point)

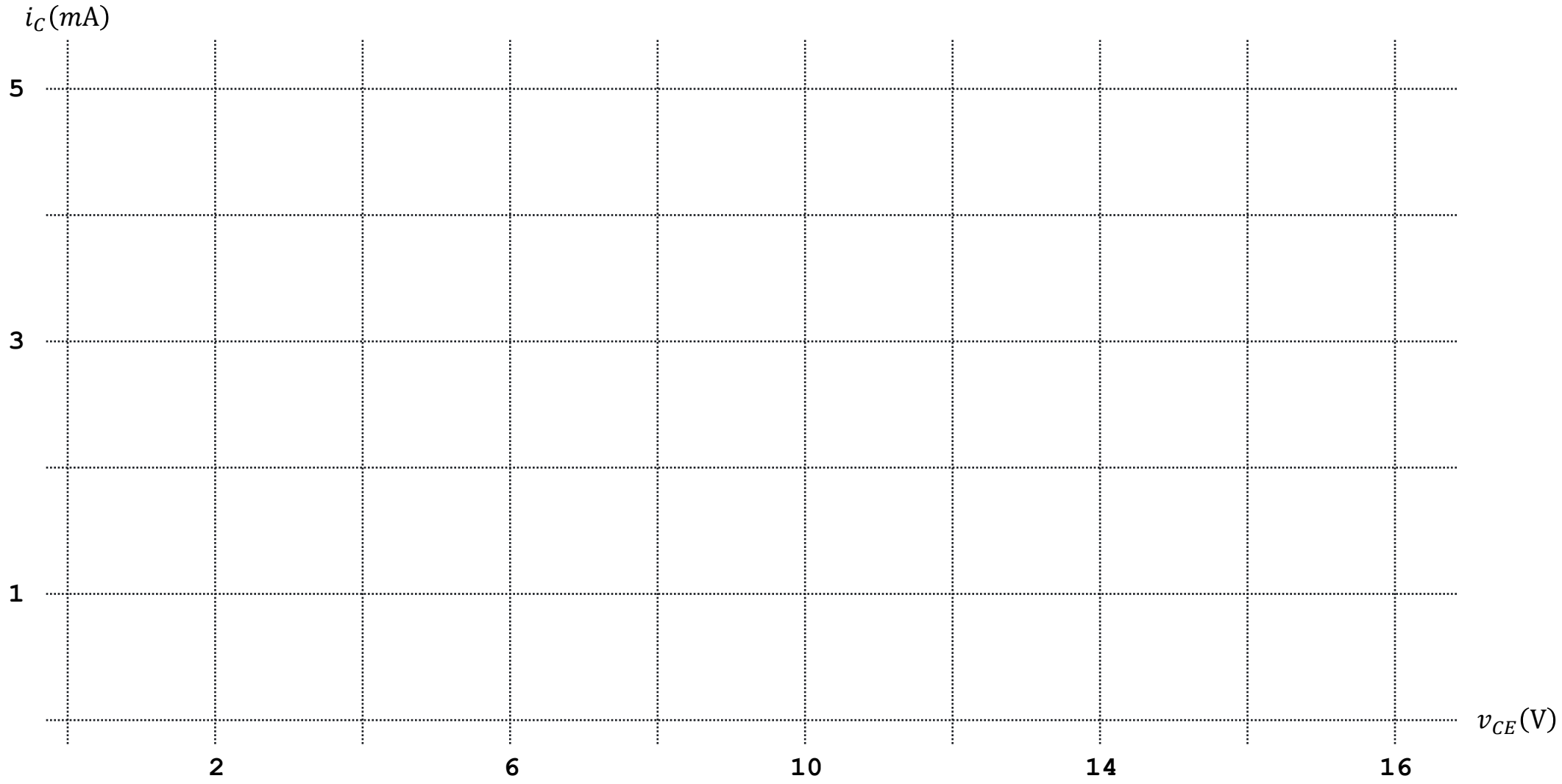
EXERCISE



Solution

EXERCISE

Load Line Analysis



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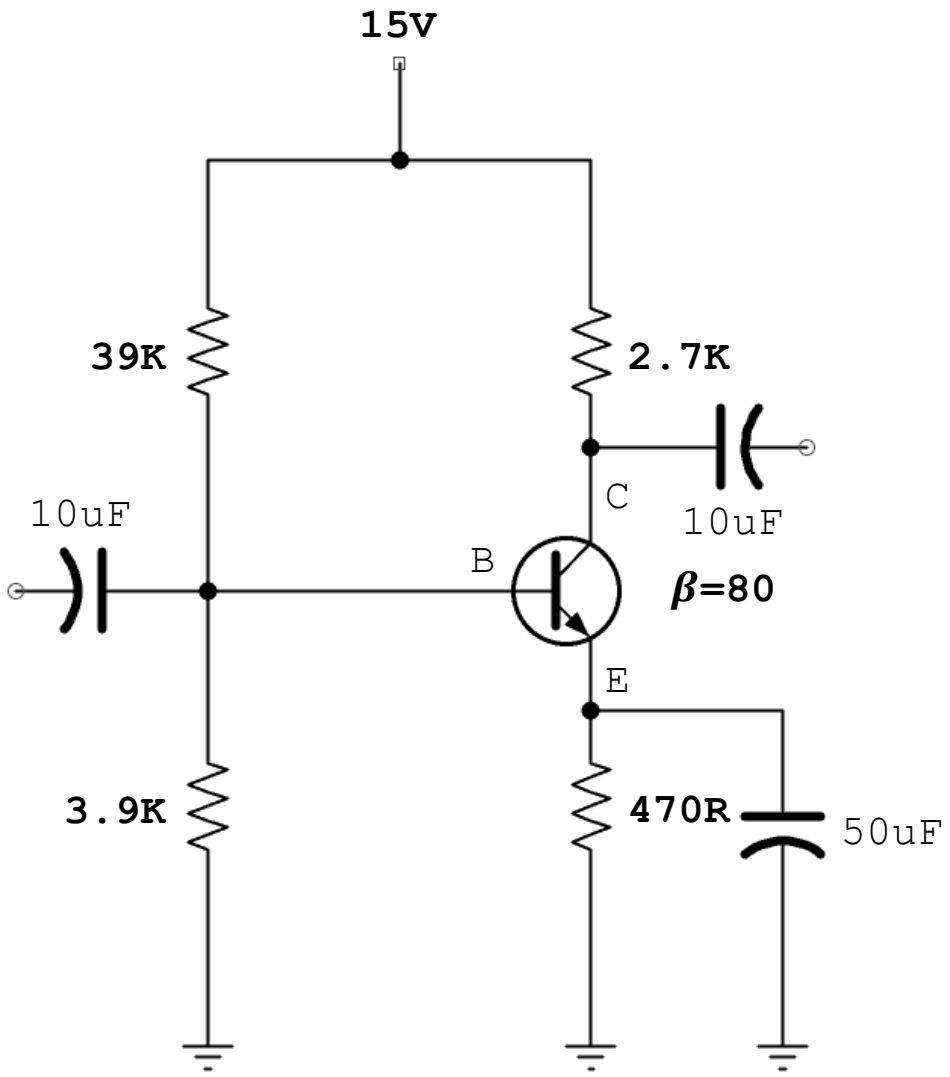

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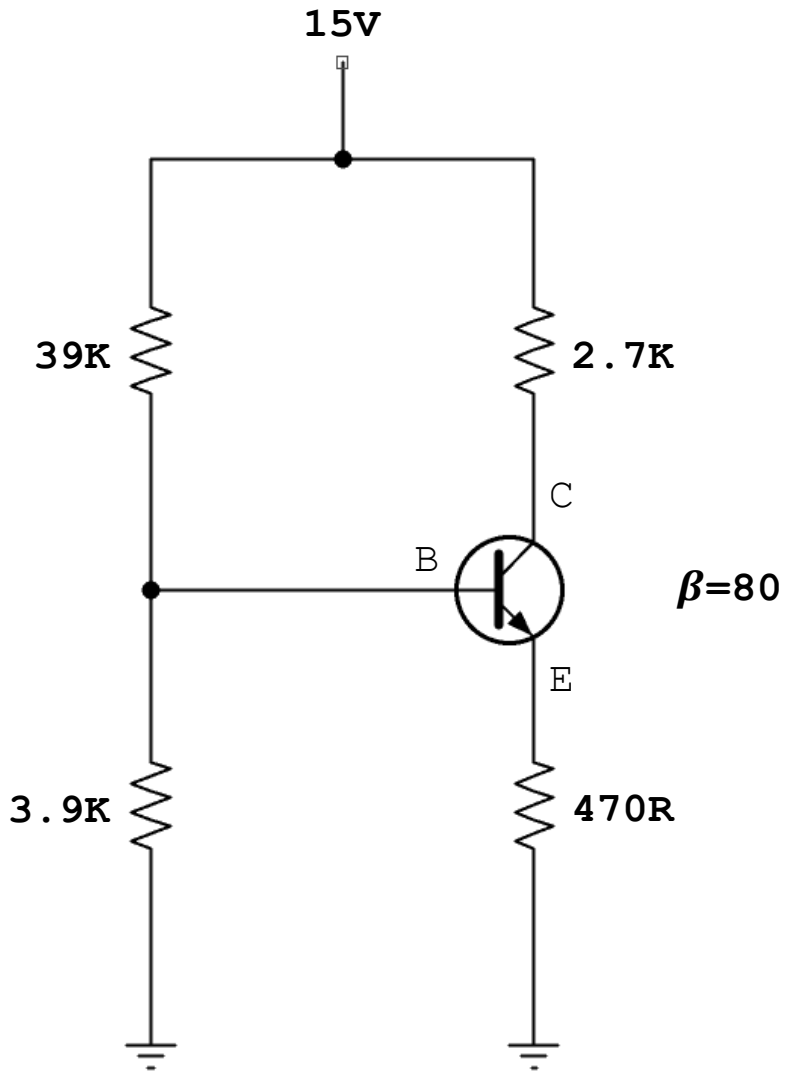
- Collector current (i_{CQ})
- Collector-Emitter voltage (v_{CEQ})

And plot the DC load line analysis indicating:

- Saturation current $(i_{C(sat)})$
- Cutoff voltage $(v_{CE(cutoff)})$
- Operating Point (Q-Point)

EXERCISE



Solution

EXERCISE

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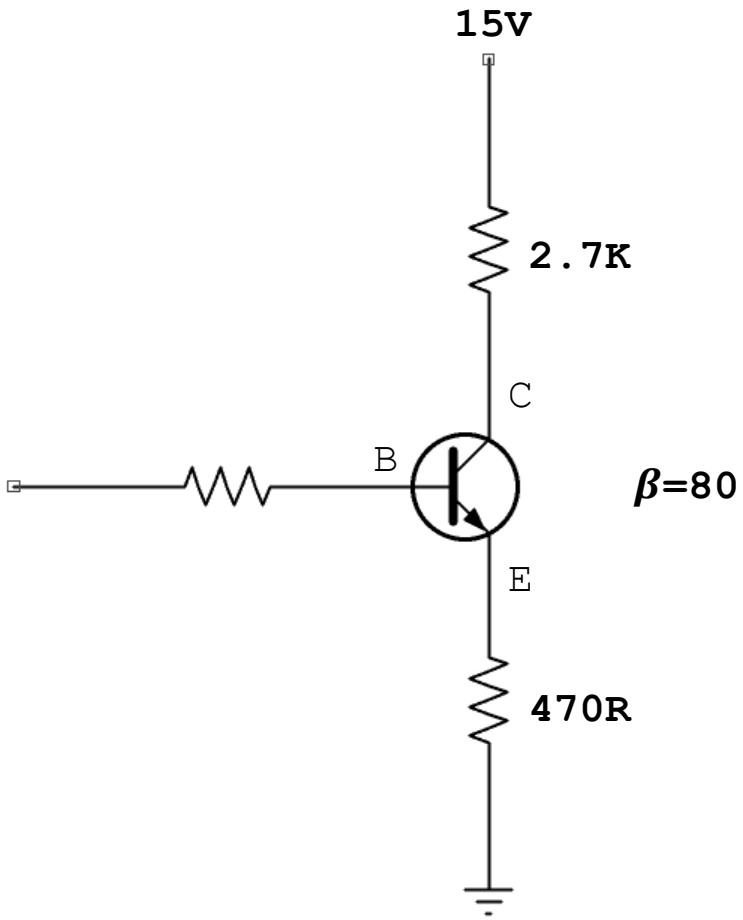

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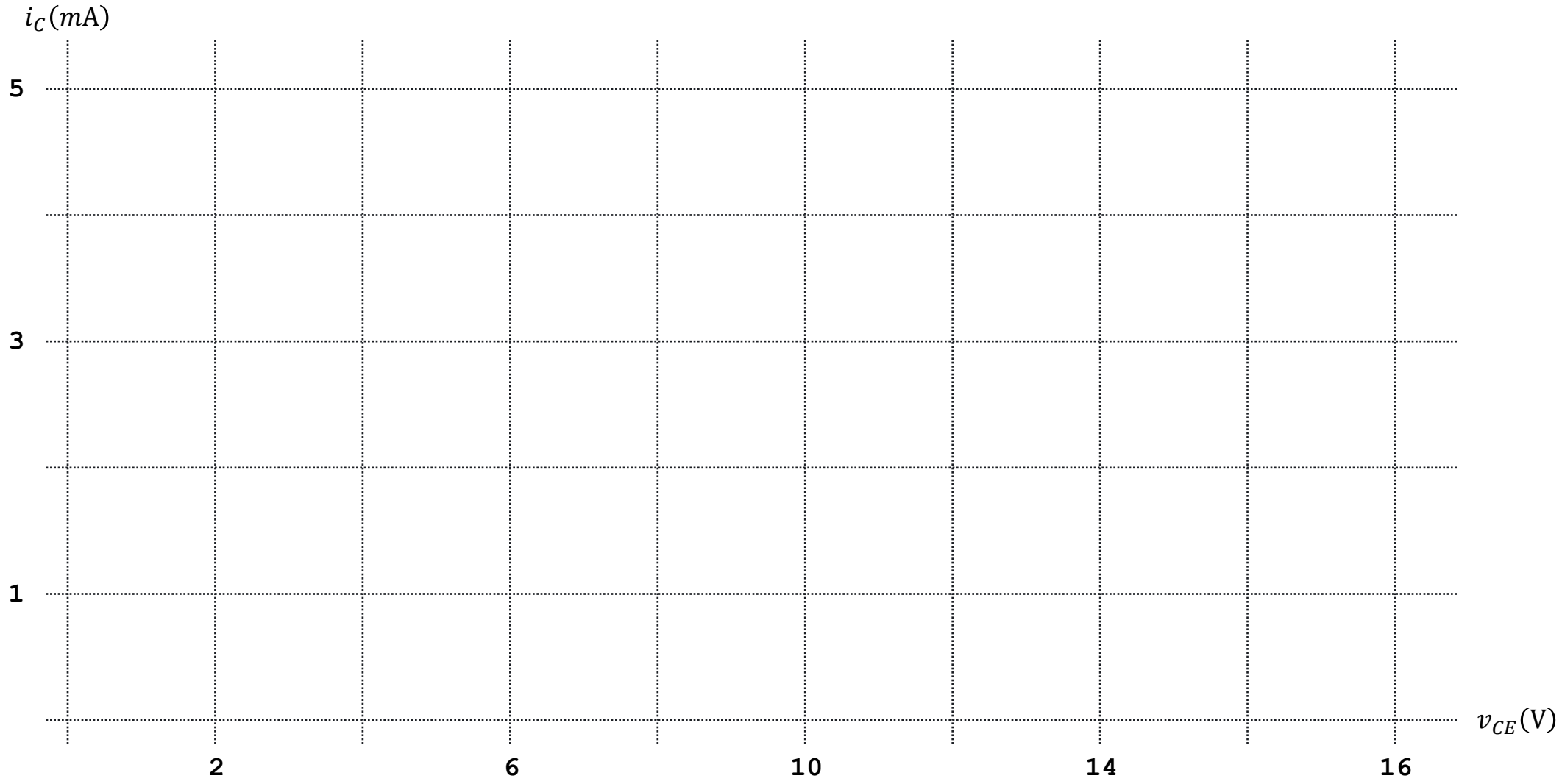

INDEPENDENT OF THE TRANSISTOR BETA

Bias	β	$i_B(\mu A)$	$i_C(mA)$	$v_{CE}(V)$	$\%\Delta v_{CE}$
Fixed-Bias	50	47.08	2.35	6.83	-76%
	100	47.08	4.71	1.64	
Emitter-Stabilized	45	23.74	1.07	14.54	-31.16%
	90	37.04	3.33	10.01	
Voltage-Divider Bias					

LABORATORY