EEE-2103: Electronic Devices and Circuits

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Coupling and Bypassing Capacitor

dc bias voltage $V_B = \frac{V_{CC} \times R_2}{R_1 + R_2}$

Signal source directly connected to circuit →

bias voltage is altered to $V_B = \frac{V_{CC} \times (r_s \| R_2)}{R_1 + (r_s \| R_2)}$

C_1 is open-circuit to dc →

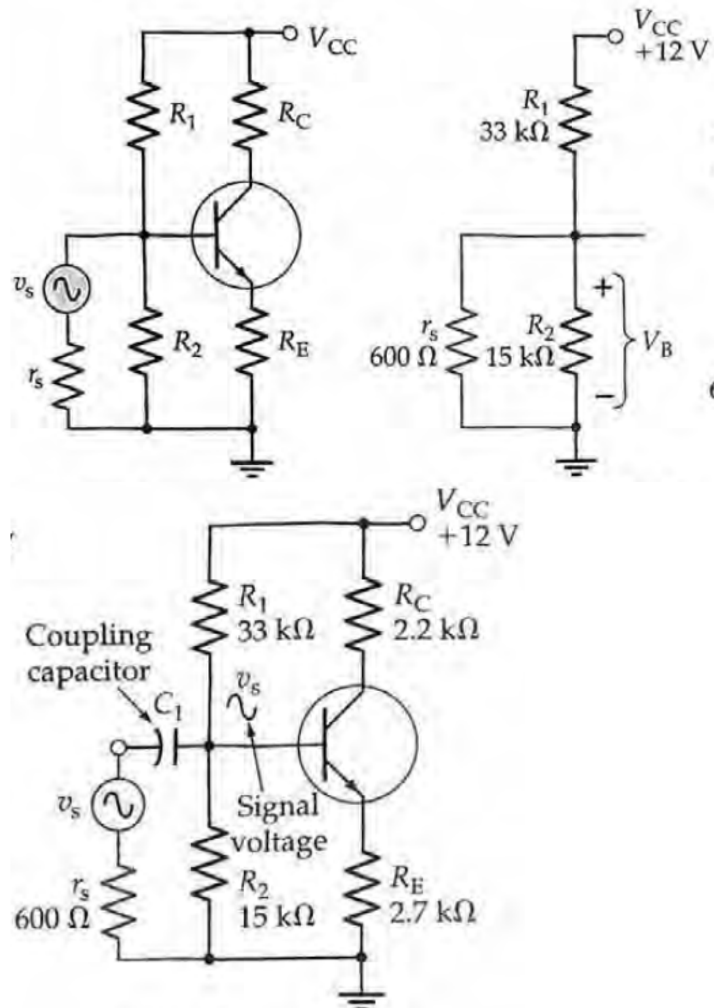
r_s does not effect V_B

C_1 is short-circuit for ac →

v_s appears at transistor base

Signal is ac-coupled to circuit input →

C_1 is called input coupling capacitor



Coupling and Bypassing Capacitor

Directly coupling R_L to circuit output →

supply voltage is reduced to $V = \frac{V_{CC} \times R_L}{R_C + R_L}$

collector resistance becomes $R = R_C || R_L$

C_2 is open-circuit to dc +

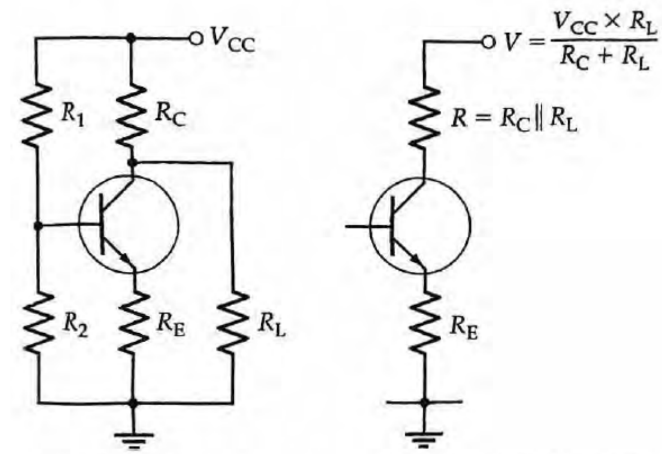
C_2 is short-circuit for ac →

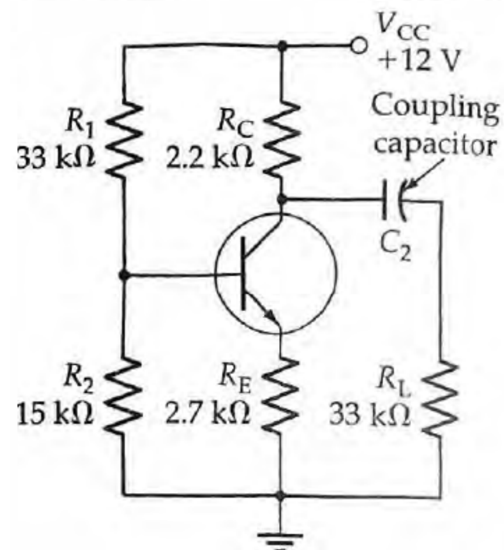
passes ac output waveform to load

does not affect dc bias condition

Signal is ac-coupled to circuit output →

C_2 is called output coupling capacitor





Coupling and Bypassing Capacitor

Emitter bypassing:

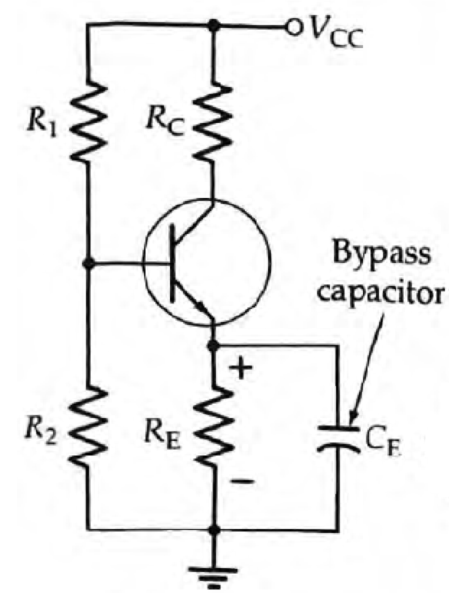
Without C_E →

R_E provides negative feedback to stabilize Q-point
R_E opposes variation in I_E
change in V_{CE} is fed back to base = I_B changes

ac signal sees $r_e + R_E$ → ac gain decreases

With C_E →

C_E provides ac short circuit across R_E
removes ac feedback
ac gain increases
C_E is called emitter bypass capacitor

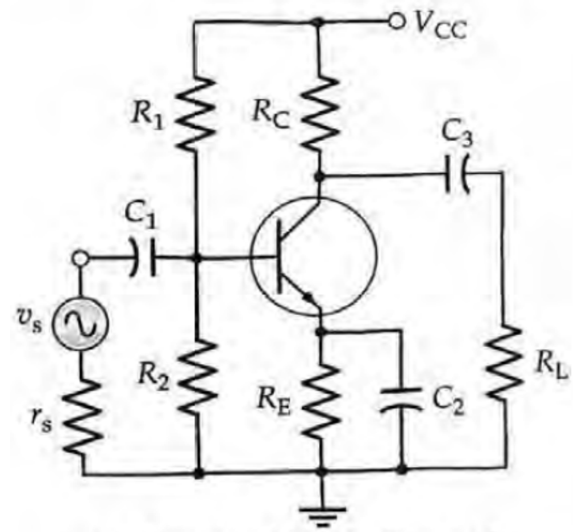


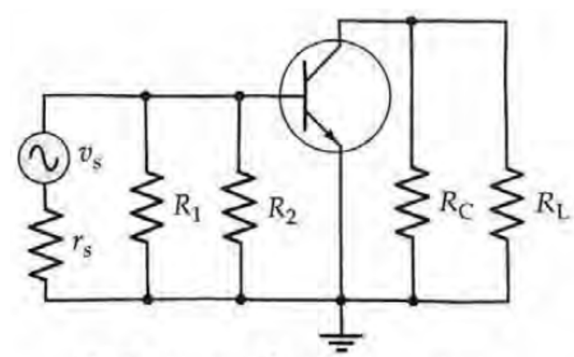
AC Load Lines

<u>AC equivalent circuits:</u>
Capacitors behave short-circuits to ac signals →
all capacitors replaced with short circuits.

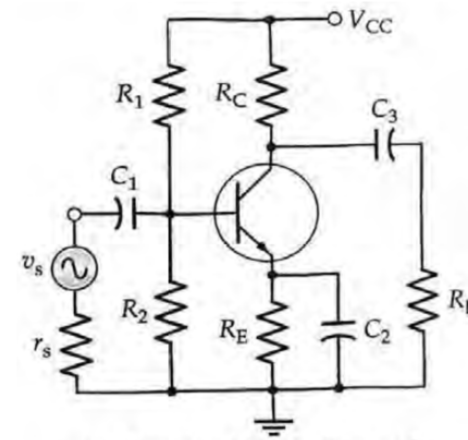
ac signals do not affect dc supply voltage →
power supply behaves as ac short-circuit
replace power supply by short circuit.

<u>AC load lines:</u>
Represent ac performance of circuit.
dc load = $R_C + R_E$
ac load = $R_C \,||\, R_L$



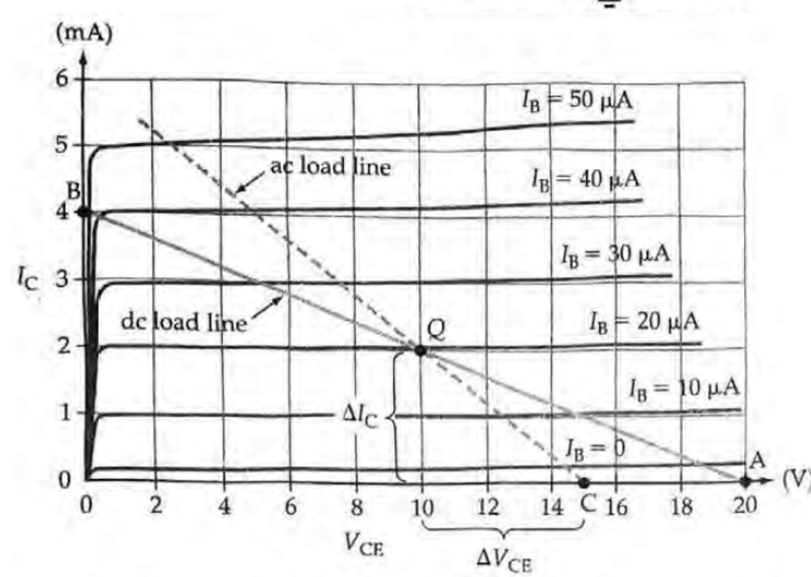


AC Load Lines



AC load lines:
No input signal →
voltage and current condition = Q-point on dc load line
ac input signal →
voltage and current vary above and below Q-point

Q-point is common to both dc and ac load lines

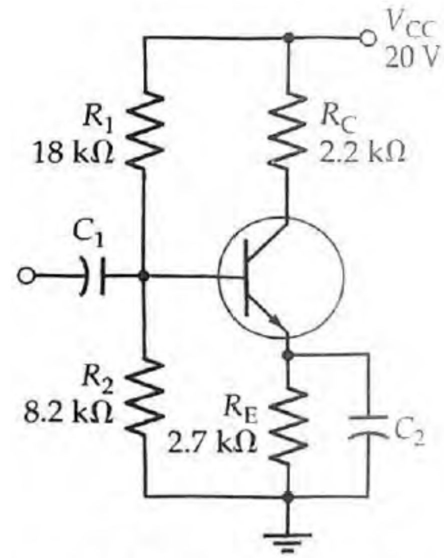


Convenient I_C change → $\Delta I_C = I_{CQ}$
Calculate corresponding V_{CE} change = ΔV_{CE}

Point $C = (V_{CEQ}+\Delta V_{CE}, I_{CQ}-\Delta I_C)$
ac load line = line through points C and Q.

AC Load Lines

Problem-31:
Draw the dc and ac load lines for the transistor circuit in Fig. 31(a), using the transistor common-emitter characteristics in Fig. 31(b).



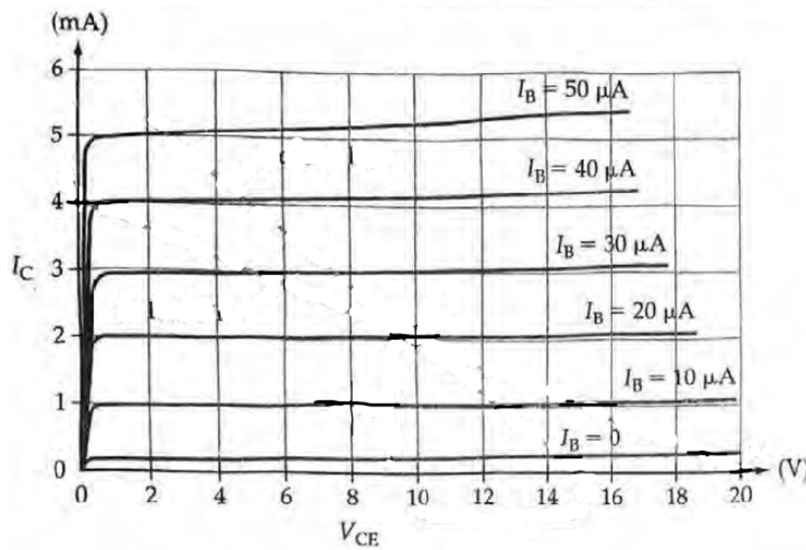
Drawing dc load line →

$R_{L(dc)} = R_C + R_E = 2.2\times10^3 + 2.7\times10^3 = 4.9$ kΩ

$V_{CE} = V_{CC} - I_C(R_C + R_E)$

$I_C = 0 \rightarrow V_{CE} = V_{CC} = 20$ V

Point A = (20 V, 0)

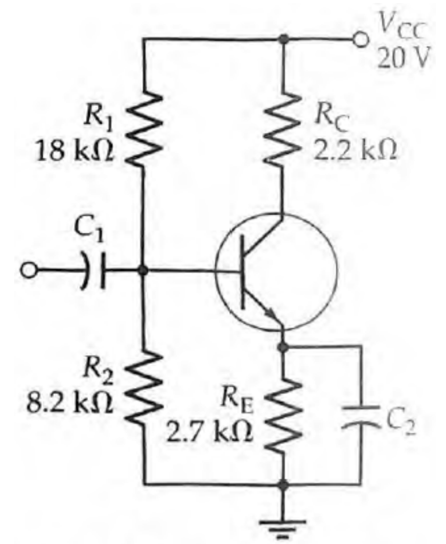


$V_{CE} = 0 \rightarrow I_C = V_{CC}/(R_C + R_E) = 20/4.9\times10^3 = 4.08$ mA

Point B = (0, 4.08 mA)

Draw dc load line through A and B.

AC Load Lines



Problem-31:

$V_B = \frac{V_{CC} \times R_2}{R_1 + R_2} = \frac{20 \times 8.2 \times 10^3}{18 \times 10^3 + 8.2 \times 10^3} = 6.3\ \text{V}$

$V_E = V_B - V_{BE} = 6.3 - 0.7 = 5.6\ \text{V}$

$I_C \approx I_E = V_E / R_E = 5.6 / 2.7 \times 10^3 = 2.07\ \text{mA}$

Mark Q-point on dc load line at $I_C = 2.07$ mA

Drawing ac load line →

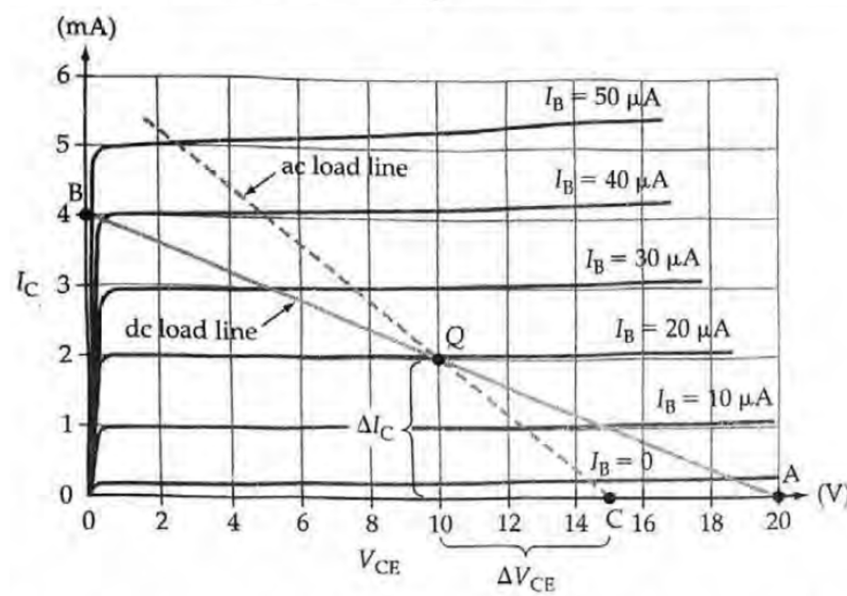
$R_{L(ac)} = R_C = 2.2\ \text{k}\Omega$

I_C changes by $\Delta I_C = I_{CQ} = 2.07$ mA →

$\Delta V_{CE} = \Delta I_C \times R_C = 2.07 \times 10^{-3} \times 2.2 \times 10^3 = 4.55\ \text{V}$

Point $C = (V_{CEQ} + \Delta V_{CE},\ I_{CQ} - \Delta I_C)$

$= (10 + 4.55,\ 2.07 - 2.07) = (14.55,\ 0)$



Draw ac load line through points C and Q.