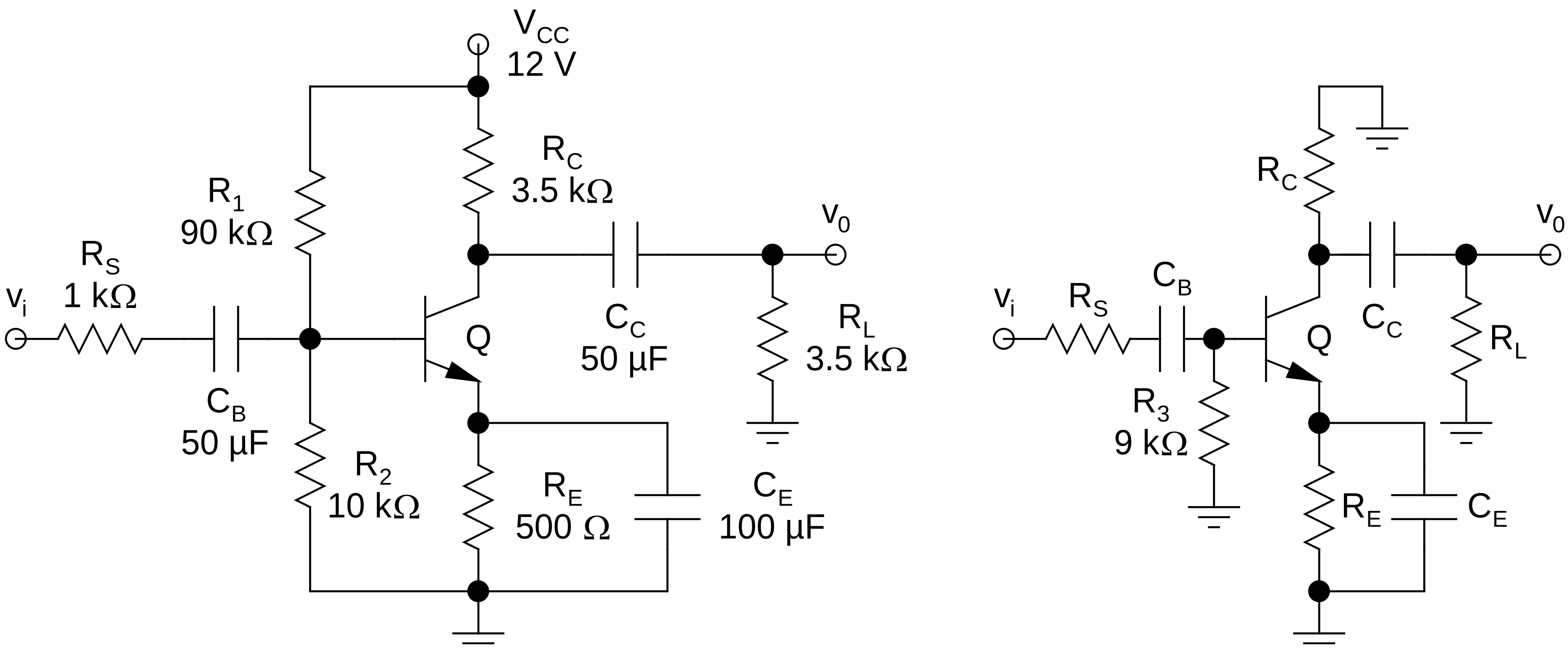
- ***Low-Frequency Response of RC-Coupled Amplifier***:



Complete Circuit **ac Schematic**

- ***DC analysis*** gives $I_C = 1$ mA and $V_{CE} = 4$ V

  $\Rightarrow r_E = 26\ \Omega$ and $r_\pi = 2.6\ k\Omega$ (assuming $\beta = 100$)
- ***Neglect Early effect***

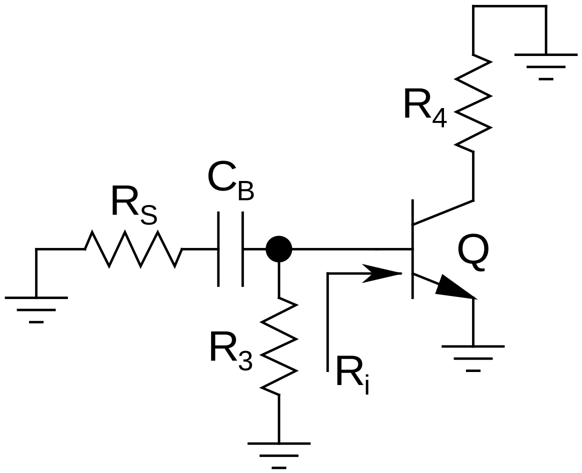
  $\Rightarrow r_0 \rightarrow \infty$
- 3 ***capacitors*** (C_B, C_E, C_C) with ***time constants*** τ_1, τ_2, τ_3, and corresponding ***cutoff frequencies*** f_1, f_2, f_3
- To apply the ***IVTC technique***, we have to take ***one capacitor at a time*** and ***treat other capacitors as short circuits***
- ***The analysis can be done by inspection***!

- ***C_B***:
  - ***Short C_C and C_E***
  - $R_3 = R_1 || R_2 = 9\ k\Omega$
  - $R_4 = R_C || R_L = 1.75\ k\Omega$
  - $R_i = r_\pi = 2.6\ k\Omega$
  - By inspection, the ***Thevenin resistance*** seen by C_B:

    $$R_B^\infty = R_S + \left(R_3 \,||\, R_i\right) = 3\ k\Omega$$

    $$\Rightarrow \tau_1 = R_B^\infty C_B = 150\ ms$$

    $$\Rightarrow f_1 = 1/(2\pi\tau_1) = 1.06\ Hz$$



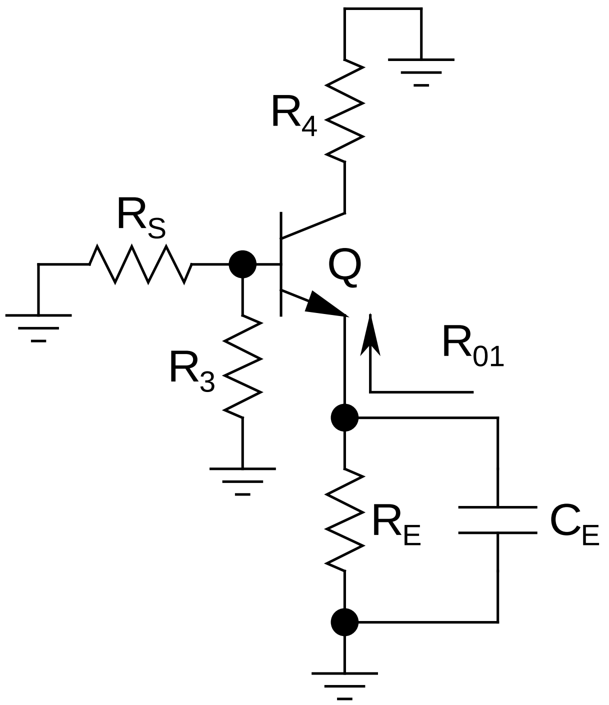
- ***C_E***:
  - ***Short C_C and C_B***
  - $R_{01} = r_E + (R_S \| R_3)/(\beta + 1)$

    $= 34.9\ \Omega$
  - By inspection, the ***Thevenin resistance*** seen by C_E:

    $R_E^{\infty} = R_E \,\|\, R_{01} = 32.6\ \Omega$

    $\Rightarrow \tau_2 = R_E^{\infty} C_E = 3.26\ \text{ms}$

    $\Rightarrow f_2 = 1/(2\pi\tau_2) = 48.8\ \text{Hz}$



- ***C_C***:
  - ***Short C_E and C_B***
  - By inspection, the ***Thevenin resistance*** seen by C_C:

$$R_C^{\infty} = R_C + R_L = 7\ \text{k}\Omega$$

$$\Rightarrow \tau_3 = R_C^{\infty} C_C = 350\ \text{ms}$$

$$\Rightarrow f_3 = 1/(2\pi\tau_3) = 0.45\ \text{Hz}$$

  - Thus, the ***lower cutoff frequency*** of the circuit:

$$f_L = \left[f_1^2 + f_2^2 + f_3^2\right]^{1/2} = 48.8\ \text{Hz}$$

- Note that ***f_L is equal to f_2*** (***contributed by C_E***)
- Now let's attempt to ***minimize*** the ***total capacitance requirement*** of the circuit

➢ *Minimization of the Total Capacitance*:

- From the previous analysis, we note that ***C_E sees the least Thevenin resistance across its two terminals***

  $\Rightarrow$ ***Let's choose C_E to contribute the DP f_d***, and let ***C_C and C_B each contribute poles at $f_d/10$***

  $$\Rightarrow 48.8 = \sqrt{f_d^2 + 2\left(f_d/10\right)^2}$$

  $$\Rightarrow f_d = 48.3 \text{ Hz and } f_d/10 = 4.83 \text{ Hz}$$

- Thus:

  $$C_E = 1\Big/\left(2\pi f_d R_E^\infty\right) = 101.1\ \mu\text{F}$$

  $$C_B = 1\Big/\left[2\pi\left(f_d/10\right)R_B^\infty\right] = 11\ \mu\text{F}$$

  $$C_C = 1\Big/\left[2\pi\left(f_d/10\right)R_C^\infty\right] = 4.7\ \mu\text{F}$$