COMMON EMITTER WITH BYPASS CAPACITOR C_E

TYPE 3: With Emitter Bypass Capacitor, C_E

- **Circuit with Emitter Bypass Capacitor**
  - **There may be times when the emitter resistor must be large for the purpose of DC design, but degrades the small-signal gain too severely.**
  - An **emitter bypass capacitor** can be used to effectively create a short circuit path during AC analysis hence avoiding the effect R_E

TYPE 2: Emitter terminal connected with R_E – normally $r_o = \infty$ in this type

New parameter: input resistance seen from the base, $R_{ib} = v_b / i_b$

$\beta = 120$
$V_{BE} = 0.7V$
$V_A = \infty$

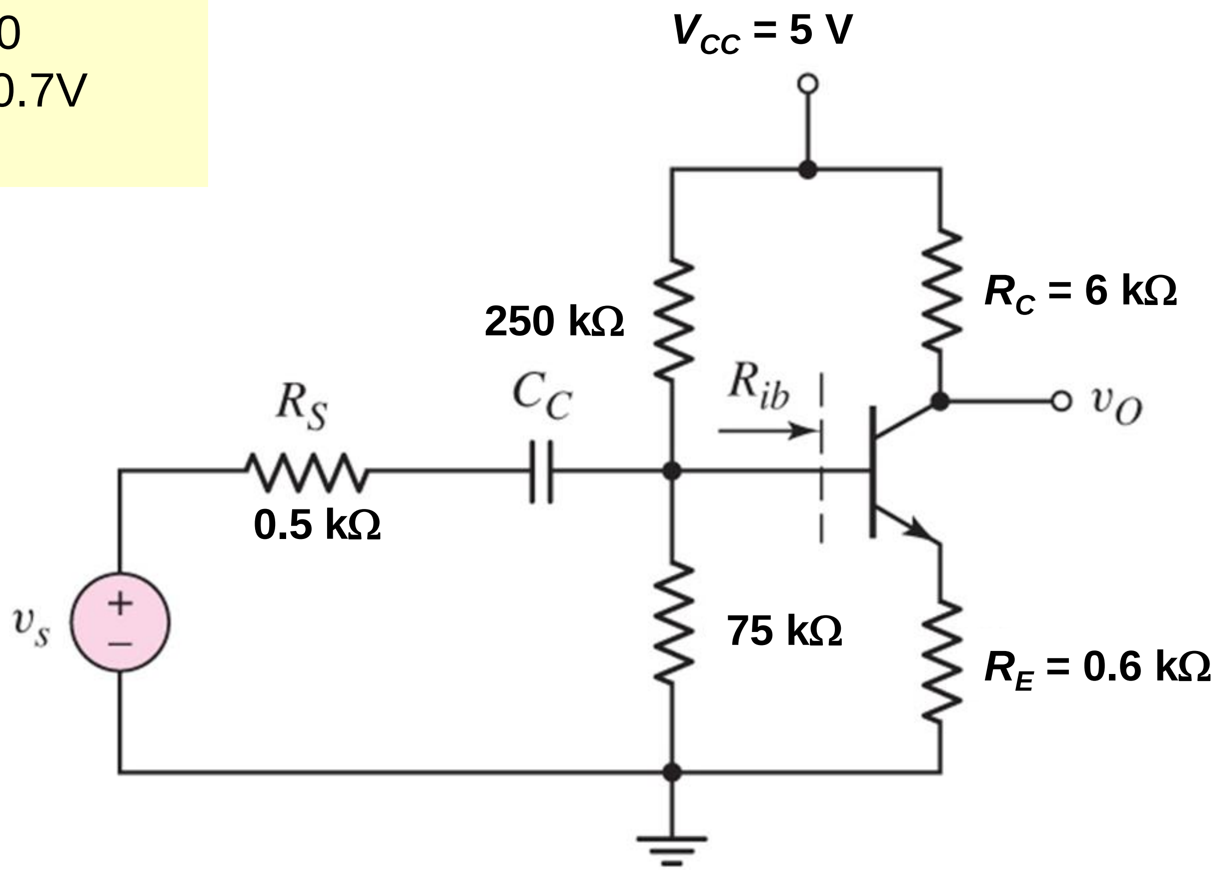
Voltage Divider biasing:

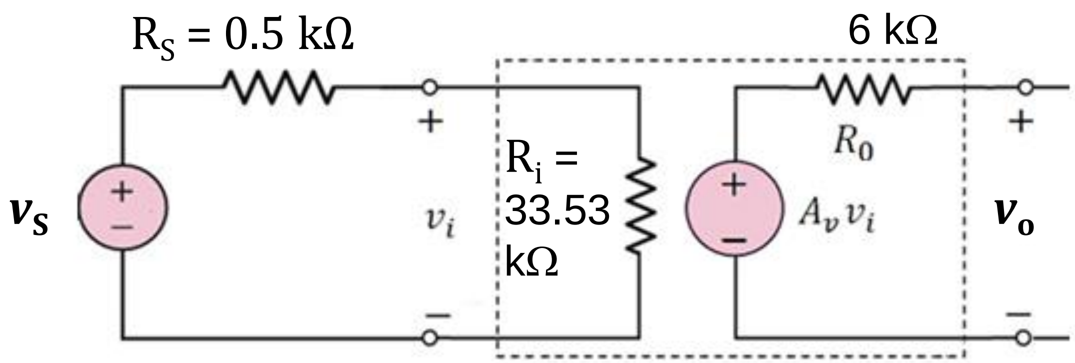
Change to Thevenin

Equivalent

$R_{TH} = 57.7\ k\Omega$

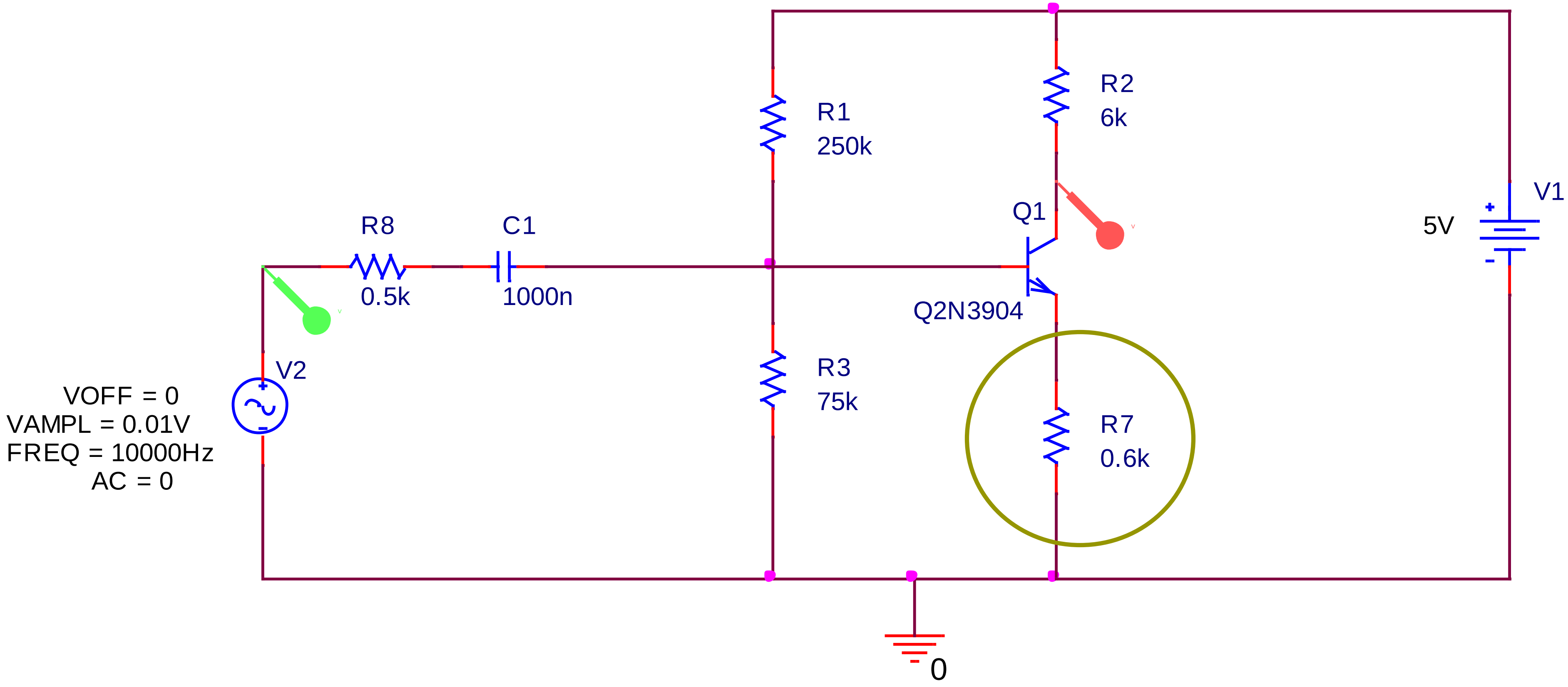
$V_{TH} = 1.154\ V$



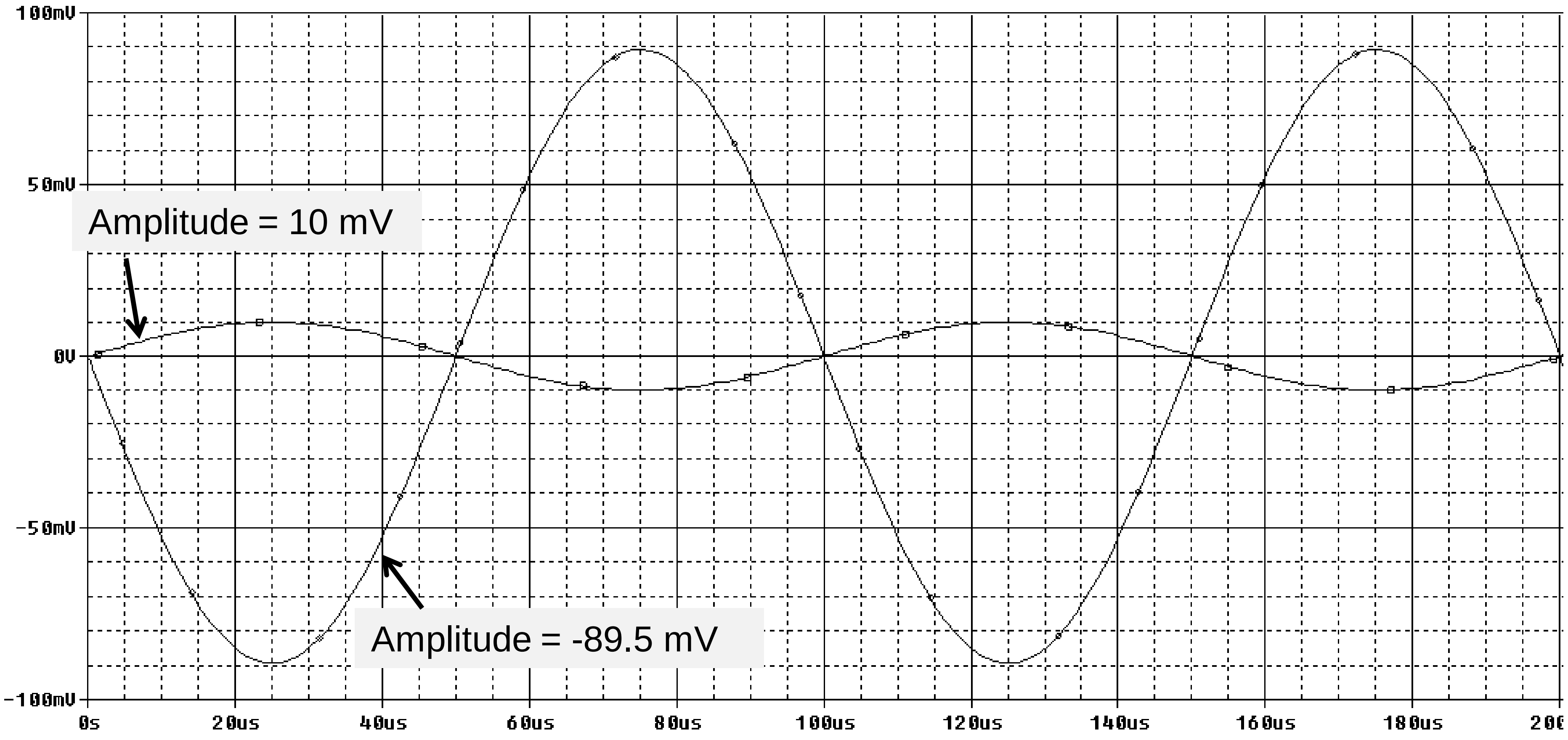


Equivalent circuit of a voltage amplifier

$$v_o/v_s = -8.85$$

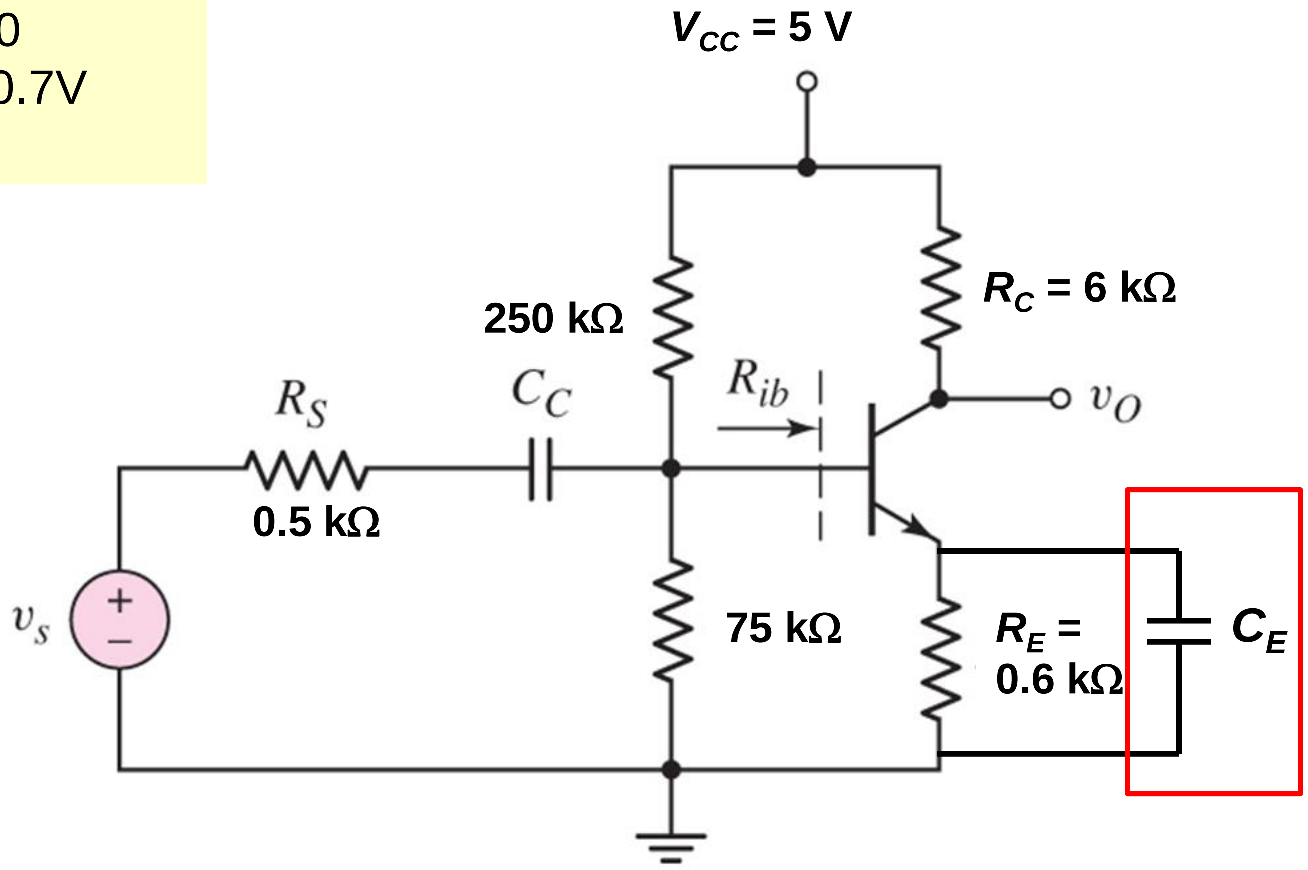


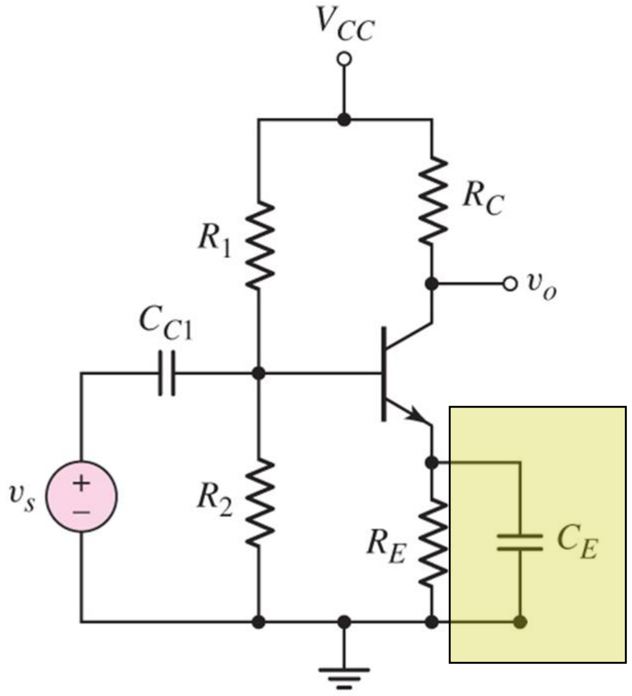
R1
250k
R2
6k
V1
5V
Q1
Q2N3904
R8
0.5k
C1
1000n
V2
VOFF = 0
VAMPL = 0.01V
FREQ = 10000Hz
AC = 0
R3
75k
R7
0.6k
0

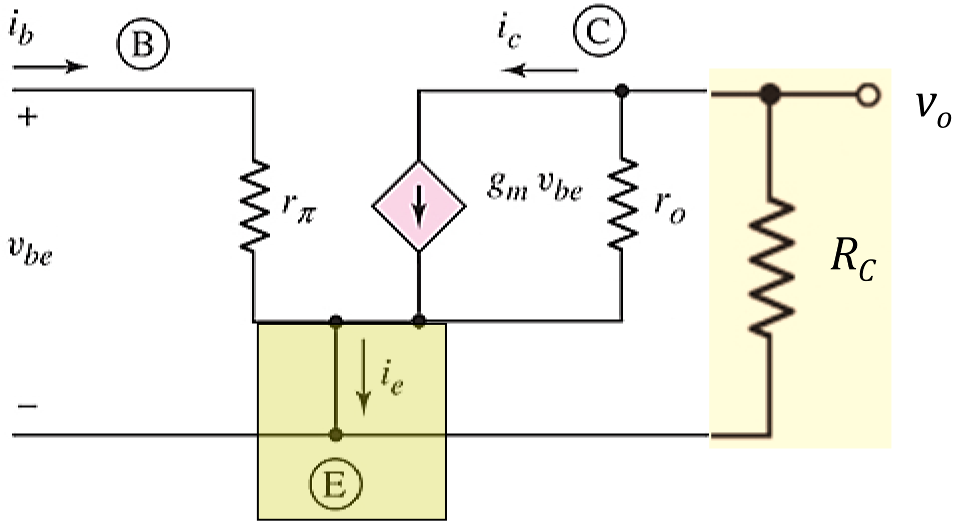


Gain = - (89.5 / 10) = -8.95

$\beta = 120$
$V_{BE} = 0.7V$
$V_A = \infty$

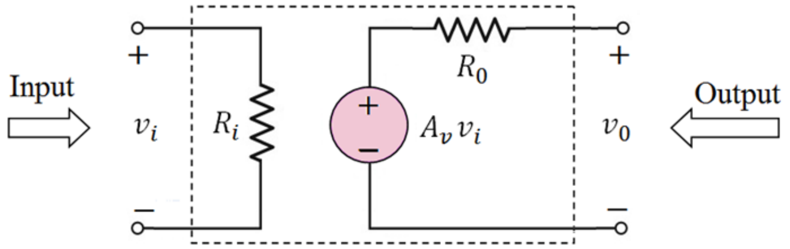






C_E becomes a short circuit path – bypass R_E; hence similar to Type 1

STEPS TO OBTAIN VOLTAGE AMPLIFIER COMPONENTS – SAME WITH EMITTER GROUNDED



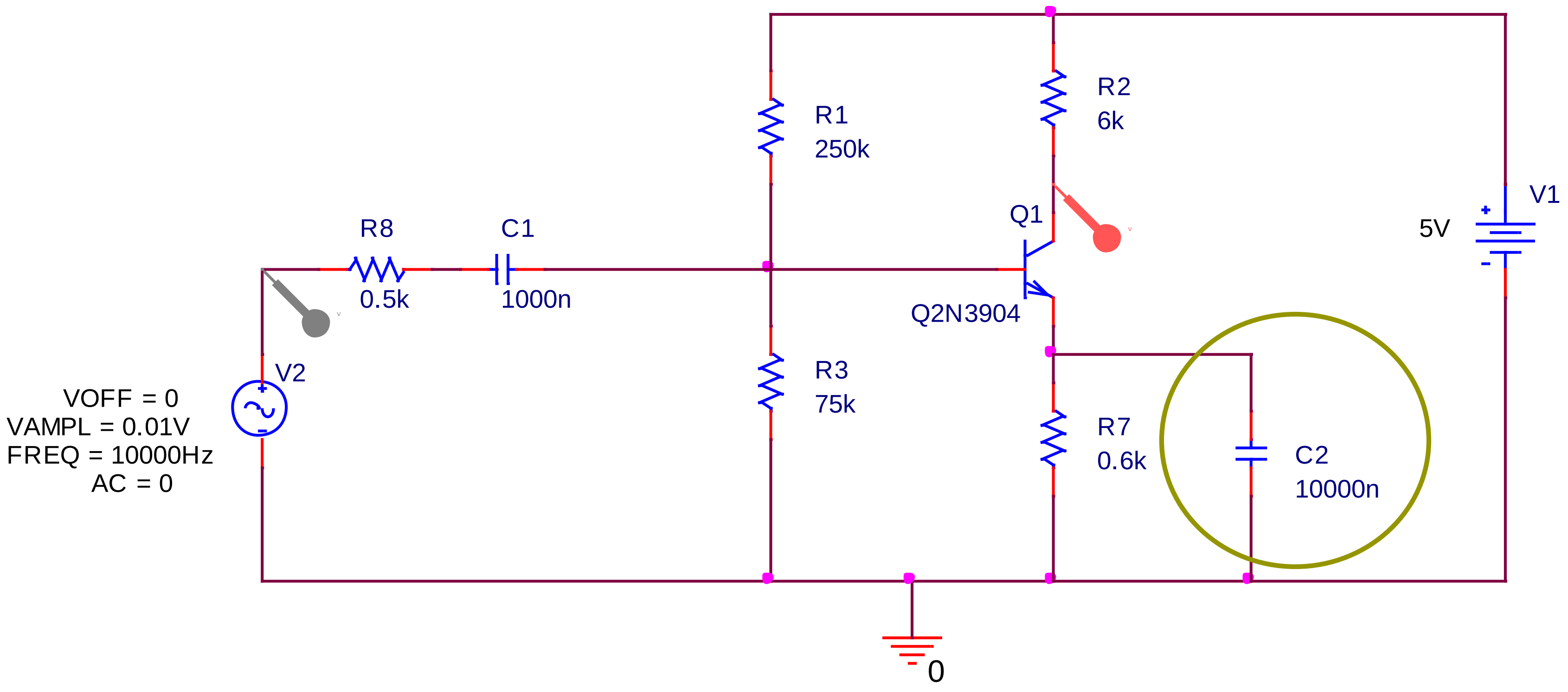
Equivalent circuit of a voltage amplifier

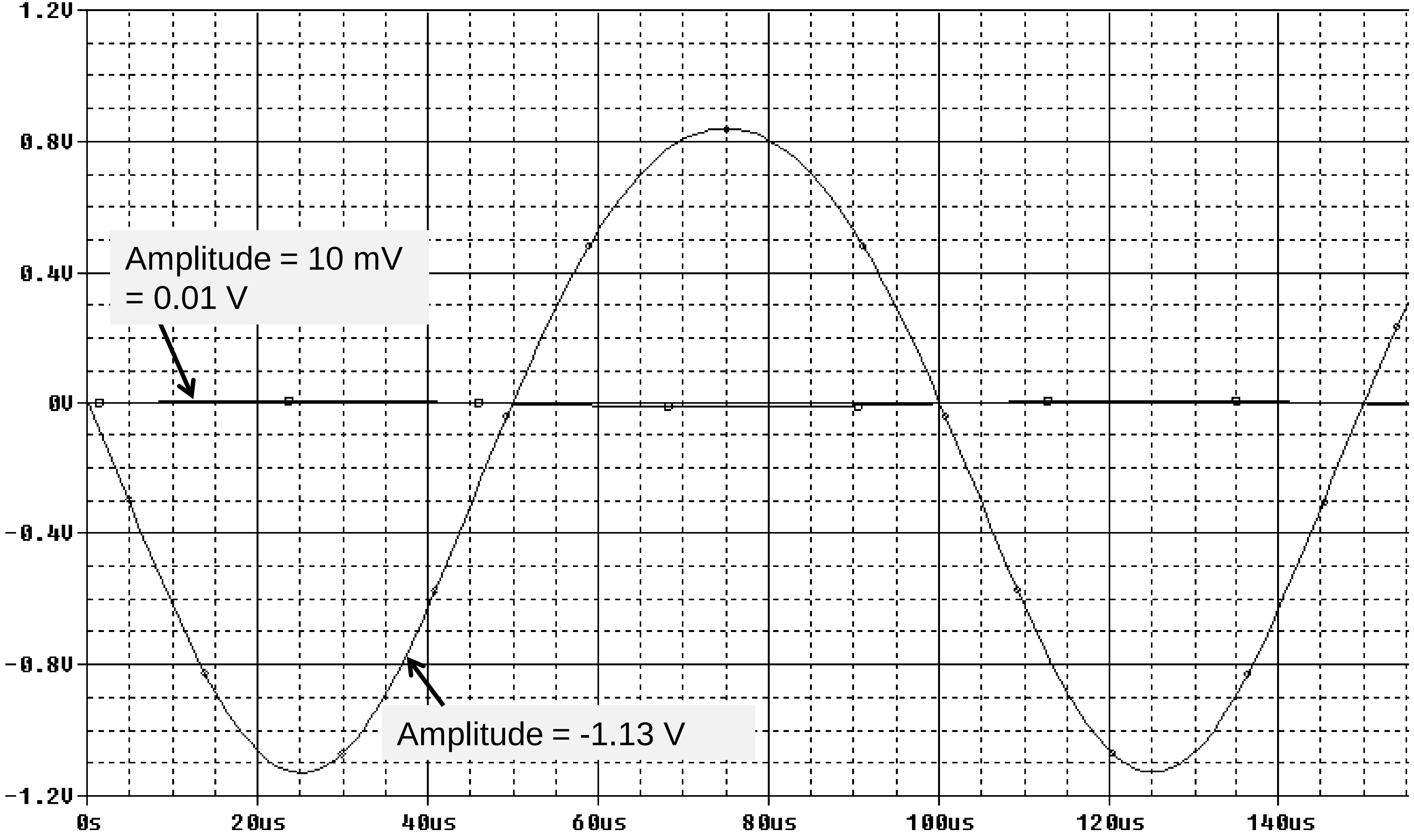
OUTPUT SIDE

1. Get the equivalent resistance at the output side, R_O
2. Get the v_o equation where $v_o = - g_m v_{be} R_O$

INPUT SIDE

3. Calculate R_i
4. Get v_{be} in terms of v_i
5. Get the open circuit voltage gain


R1
250k
R2
6k
V1
5V
Q1
R8
C1
0.5k
1000n
Q2N3904
V2
R3
75k
VOFF = 0
VAMPL = 0.01V
FREQ = 10000Hz
AC = 0
R7
0.6k
C2
10000n
0



Gain = - (1.13 / 0.01) = - 113

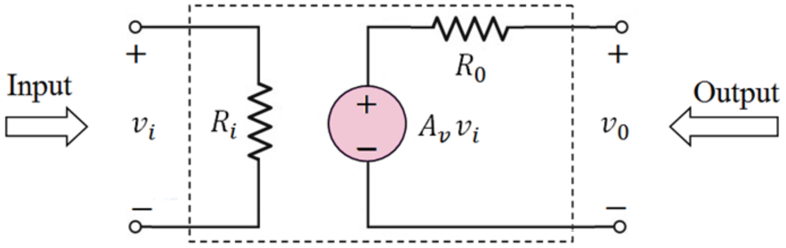
- Hence, from the calculation and the simulation, you can observe the improvement in terms of the voltage gain
  - Based on the simulation:
    - From –8.95 (with R_E) to -113 (with bypass capacitor C_E)

1. $Ro = R_C = 6\ k\Omega$

2. Equation of v_o : $v_o = -(R_C)\, g_m v_{be} = -96.36$ vbe

3. Calculate $R_i = R_{TH} || r_\pi = 57.7\ ||\ 7.46 = 6.6\ k\Omega$

4. $v_{be} = v_i$

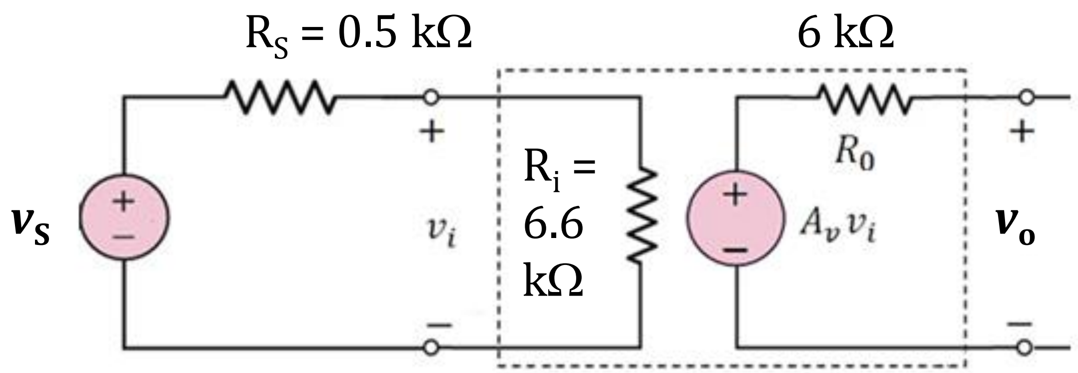


Equivalent circuit of a voltage amplifier

5. $A_v v_i = v_o = -(R_C)\, g_m v_{be}$ ← open circuit voltage

$A_v v_i = -(R_C)\, g_m v_{be}$ because $v_i = v_{be}$

$A_v = -(R_C)\, g_m = -96.36$ ← open circuit voltage gain



Equivalent circuit of a voltage amplifier

To find new voltage gain, v_o/v_s with input signal voltage source, v_s

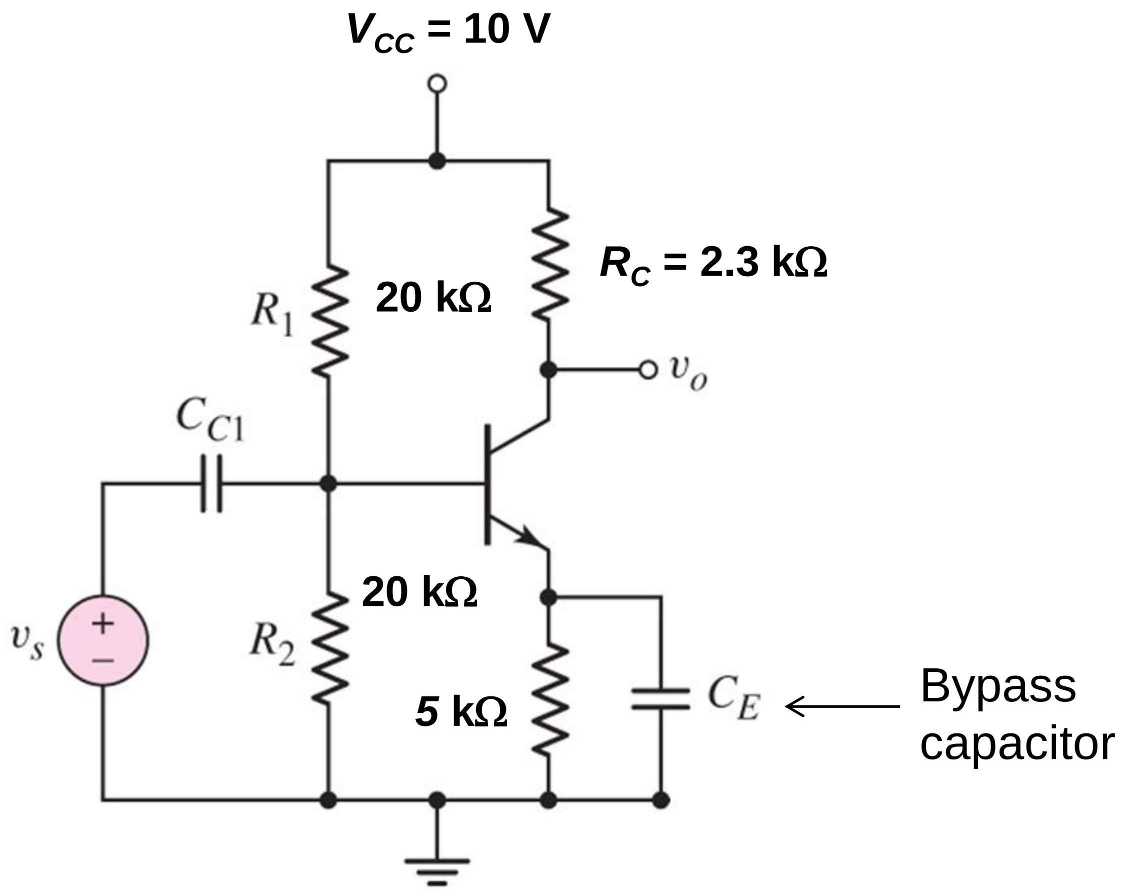
6. v_i in terms of v_s → use voltage divider:
$v_i = [\, R_i / (\, R_i + R_s\,)] * v_s \;=\; [6.6 / 7.1]\, v_s = 0.9296\, v_s$

7. $v_o = A_v v_i$ ← because there is no load resistor
$v_o = -96.36\,(0.9296 v_s)$

$v_o/v_s = -\,89.6$

EXAMPLE TYPE 3

$\beta = 125$
$V_{BE} = 0.7V$
$V_A = \infty$



Voltage Divider biasing:

Change to Thevenin Equivalent

$R_{TH} = 10\ k\Omega$

$V_{TH} = 5\ V$

$\beta = 125$
$V_{BE} = 0.7V$
$V_A = \infty$

- Perform DC analysis to obtain the value of I_C

BE loop: $10\ I_B + 0.7 + 5\ I_E - 5 = 0$

$I_E = 126\ I_B$

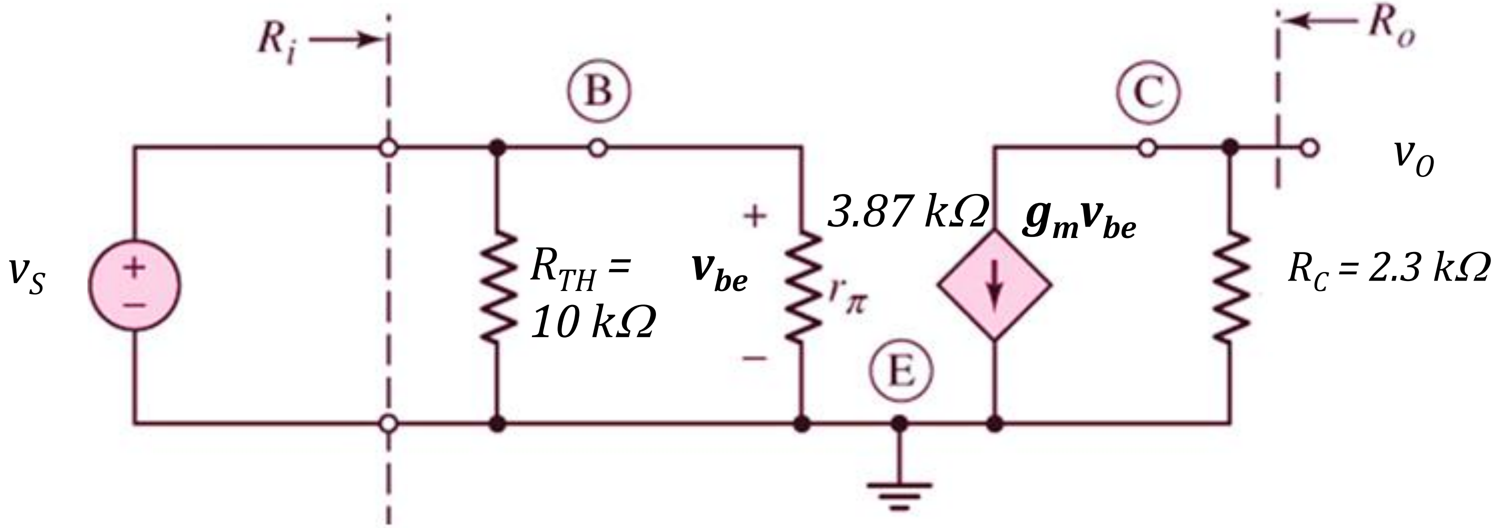
$10\ I_B + 0.7 + 5\ (126\ I_B) - 5 = 0$

$I_B = 4.3\ /\ (10 + 630) = 0.00672\text{mA}$

$I_C = \beta I_B = 0.84\ \text{mA}$

- Calculate the small-signal parameters

$r_\pi = 3.87\ k\Omega$, $r_o = \infty\ k\Omega$ and $g_m = 32.3\ \text{mA/V}$



Follow the steps

1. Ro = R_C = 2.3 kΩ

2. Equation of v_o : $v_o = -(R_C)\, g_m v_{be} = -74.29\, v_{be}$

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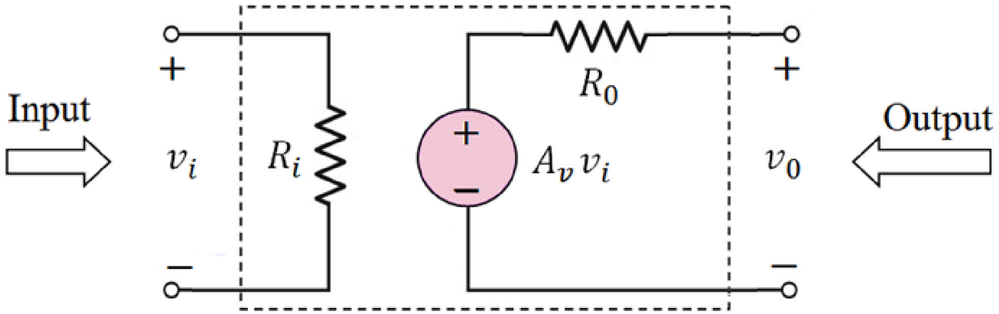
3. Calculate R_i → $R_{TH} || r_\pi$ = 2.79 kΩ

4. $v_{be} = v_i$



Equivalent circuit of a voltage amplifier

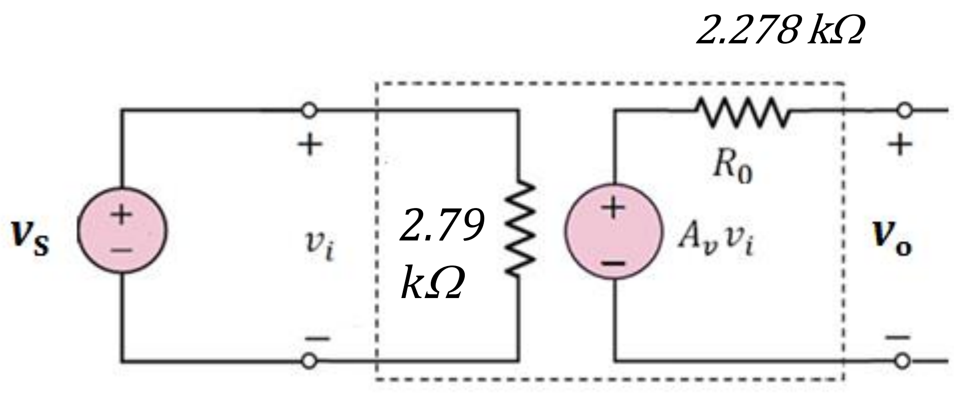
Equation of v_o : $v_o = - 74.29\ v_{be}$

$v_{be} = v_i$

5. $A_v v_i = v_o$ ← open circuit voltage

$A_v\ v_i = -74.29\ v_{be} = -74.29\ v_i$

$A_v = -74.29$ ← open circuit voltage gain



Equivalent circuit of a voltage amplifier

To find new voltage gain, v_o/v_s with input signal voltage source, v_s

6. $v_i = v_s$ → in parallel

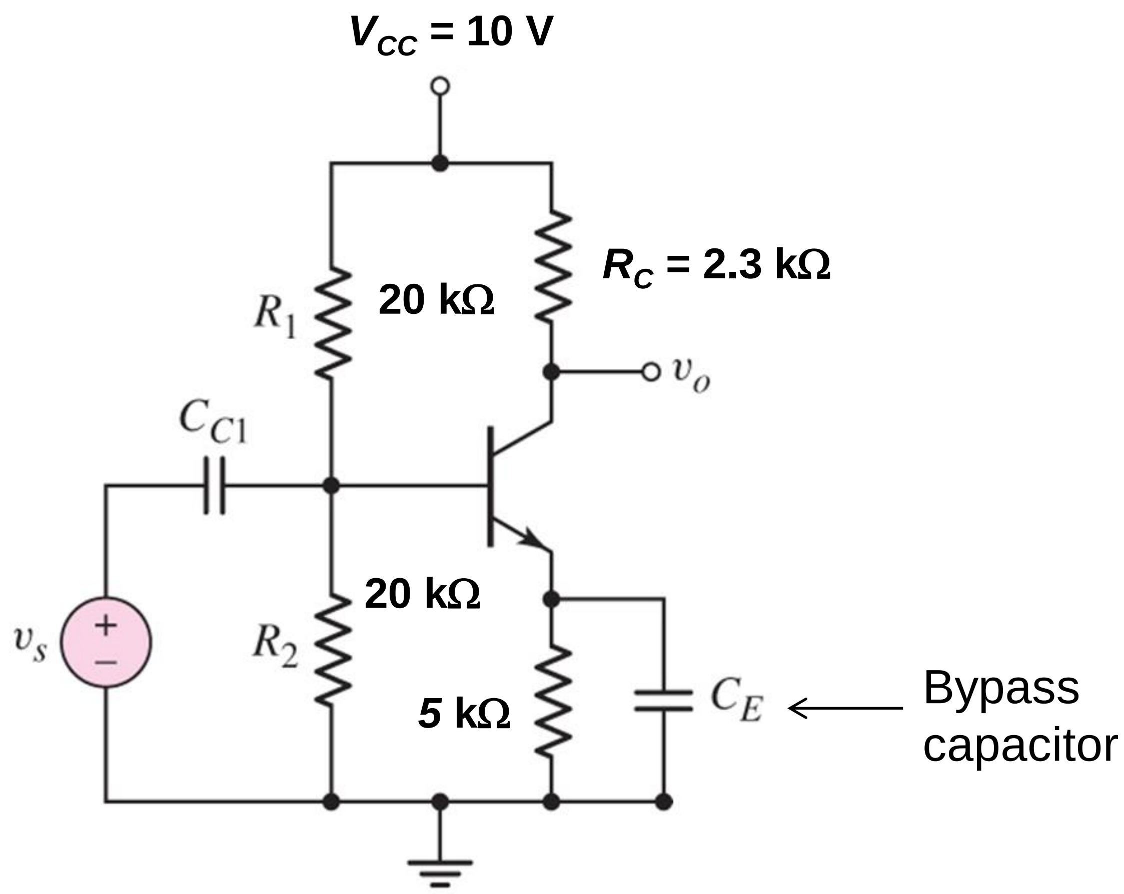
7. $v_o = A_v v_i$

$v_o = -74.29\ (v_s)$

$v_o/v_s = -74.29$

EXAMPLE TYPE 3 – with r_o

$\beta = 125$
$V_{BE} = 0.7V$
$V_A = 200$ V



Voltage Divider biasing:

Change to Thevenin Equivalent

$R_{TH} = 10\ k\Omega$

$V_{TH} = 5$ V

$\beta = 125$
$V_{BE} = 0.7V$
$V_A = 200\ V$

- Perform DC analysis to obtain the value of I_C

BE loop: $10\ I_B + 0.7 + 5\ I_E - 5 = 0$

$I_E = 126\ I_B$

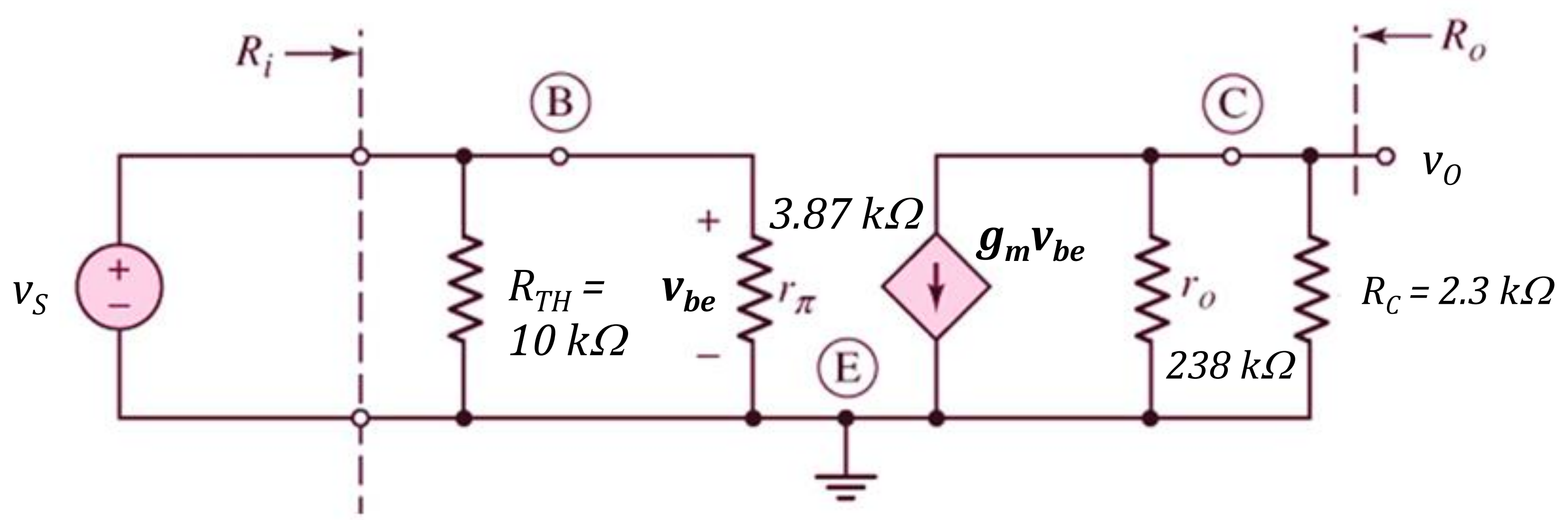
$10\ I_B + 0.7 + 5\ (126\ I_B) - 5 = 0$

$I_B = 4.3\ /\ (10 + 630) = 0.00672mA$

$I_C = \beta I_B\ = 0.84\ mA$

- Calculate the small-signal parameters

$r_\pi = 3.87\ k\Omega$, $\mathbf{r_o = 238\ k\Omega}$ and $g_m = 32.3\ mA/V$



Follow the steps

1. Rout = $r_o \| R_C = 2.278\ k\Omega$

2. Equation of v_o : $v_o = -\ (r_o \| R_C)\ g_m v_{be} = -73.58\ v_{be}$

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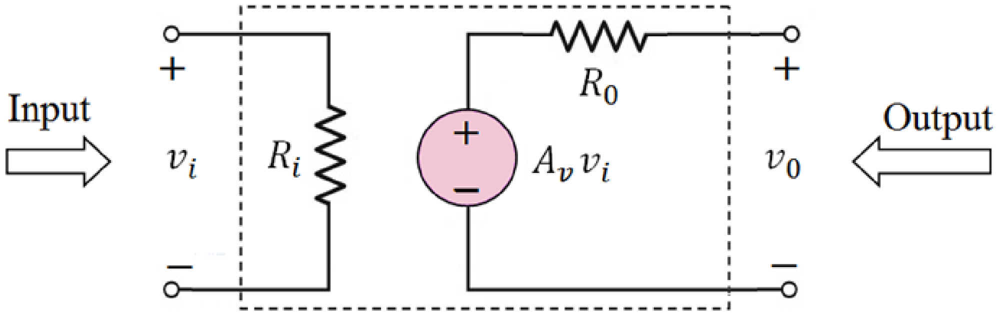
3. Calculate $R_i \rightarrow R_{TH} \| r_\pi = 2.79\ k\Omega$

4. $v_{be} = v_i$



Equivalent circuit of a voltage amplifier

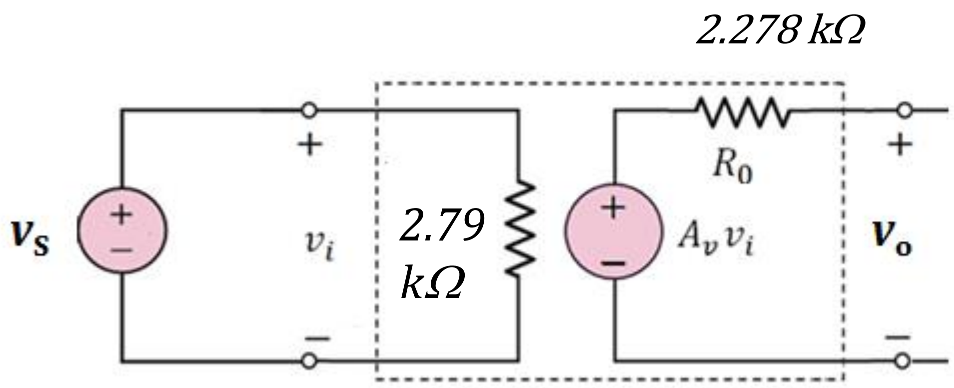
Equation of v_o : $v_o = -\,(r_o \parallel R_C)\, g_m v_{be} = -73.58\, v_{be}$

$v_{be} = v_i$

5. $A_v v_i = v_o$ ← open circuit voltage

$A_v \cancel{v_i} = -73.58\, v_{be} = -73.58 \cancel{v_i}$

$A_v = -73.58$ ← open circuit voltage gain



Equivalent circuit of a voltage amplifier

To find new voltage gain, v_o/v_s with input signal voltage source, v_s

6. $v_i = v_s$ → in parallel

7. $v_o = A_v v_i$

$v_o = -73.58\ (v_s)$

$v_o/v_s = -73.58$