CALCULATION OF GAIN

Voltage Gain = v_o / v_s

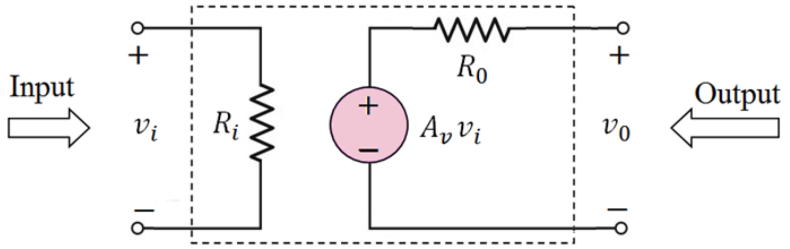
Current Gain = i_o / i_s

- 3 configurations of BJT Amplifiers
  - Common Emitter
  - Common Collector
  - Common Base

Common-Emitter Amplifier

- Remember that for Common Emitter Amplifier,
  - the output is measured at the collector terminal.
  - the gain is a negative value
- Three types of common emitter
  - Emitter grounded
  - With R_E
  - With bypass capacitor C_E

STEPS TO OBTAIN VOLTAGE AMPLIFIER COMPONENTS



Equivalent circuit of a voltage amplifier

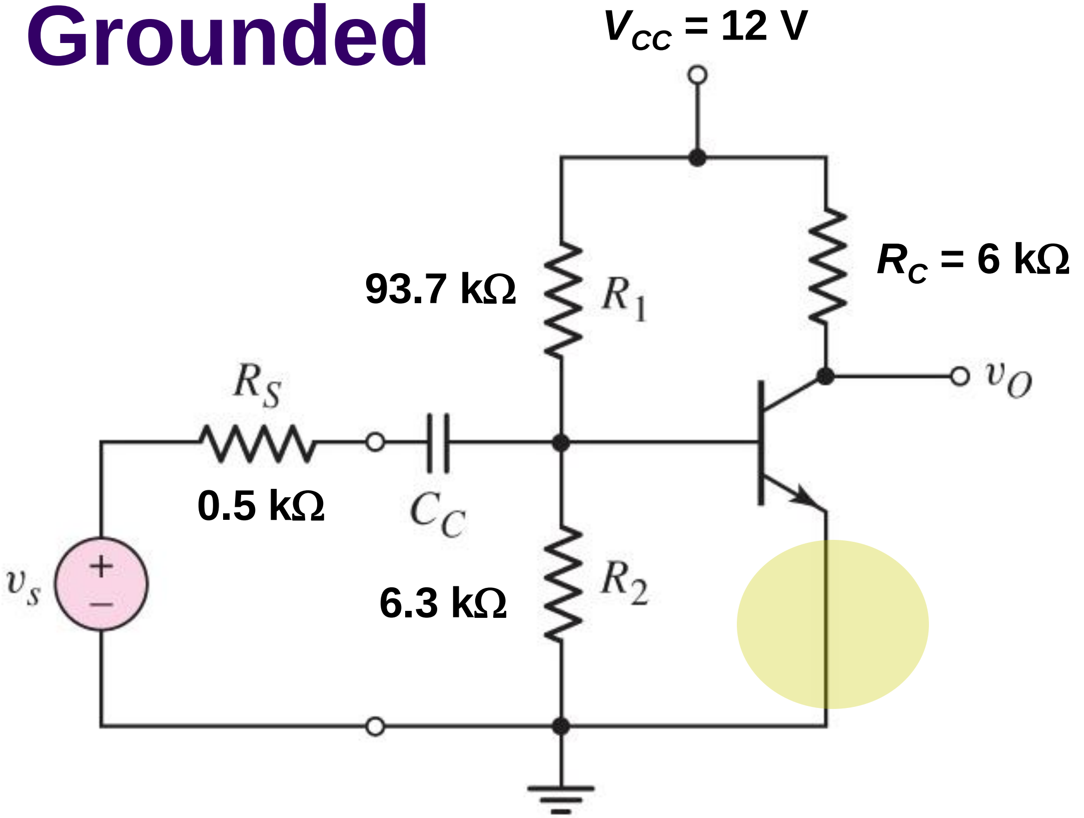
OUTPUT SIDE

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 <u>open circuit</u> voltage gain

Emitter Grounded



$\beta = 100$
$V_{BE} = 0.7V$
$V_A = 100\ V$

Voltage Divider biasing:

Change to Thevenin Equivalent

$R_{TH} = 5.9\ k\Omega$

$V_{TH} = 0.756\ V$

- Perform DC analysis to obtain the value of I_C

  BE loop: $5.9I_B + 0.7 – 0.756 = 0$

  $I_B = 0.00949$

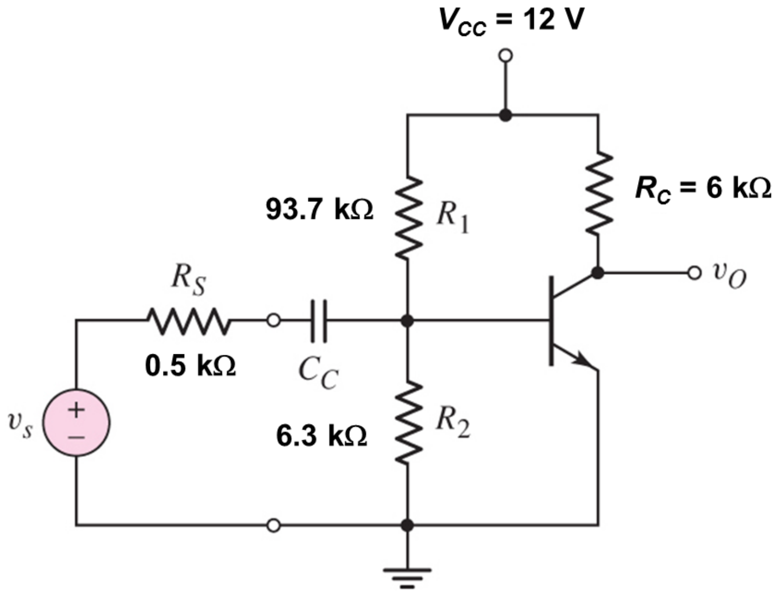
  $I_C = \beta I_B = 0.949$ mA

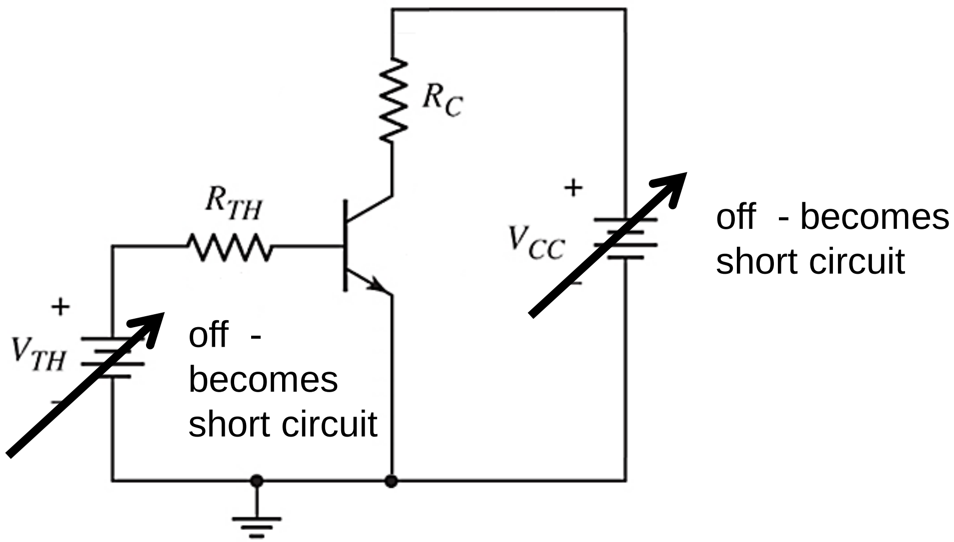
- Calculate the small-signal parameters

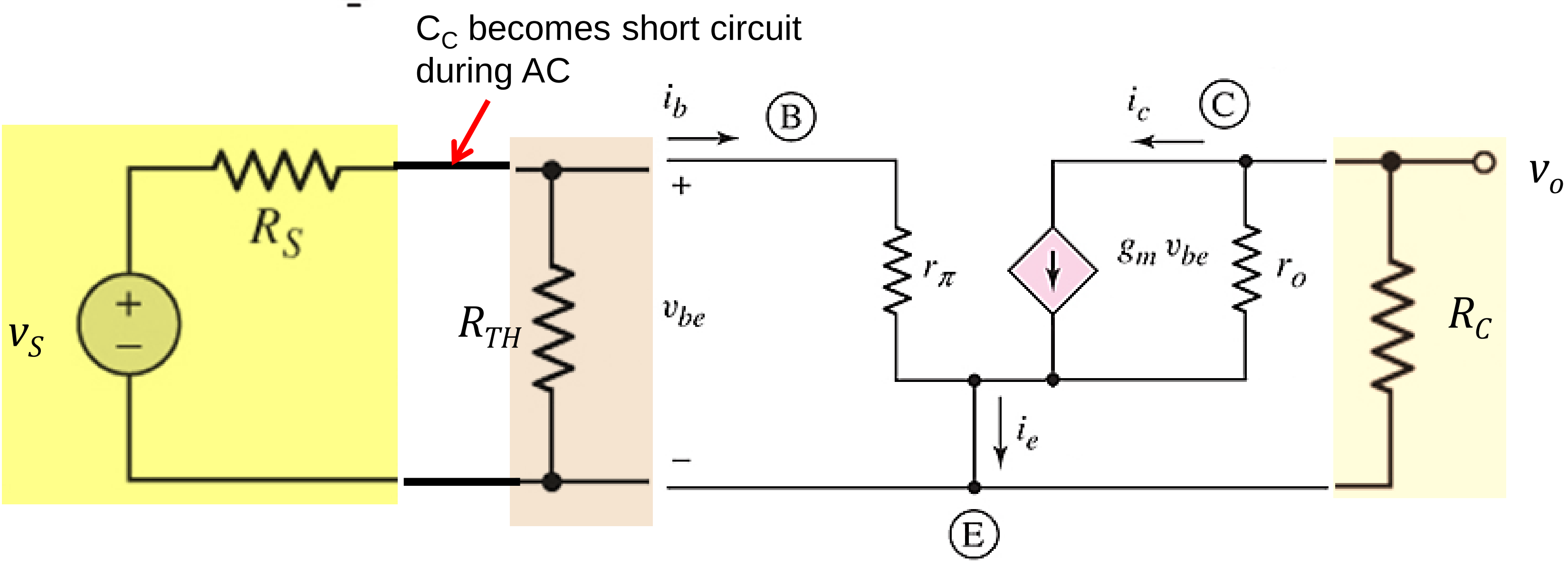
  $r_\pi = 2.74\ k\Omega$, $r_o = 105.37\ k\Omega$ and $g_m = 36.5$ mA/V

Emitter Grounded

β = 100
V_{BE} = 0.7V
V_A = 100 V





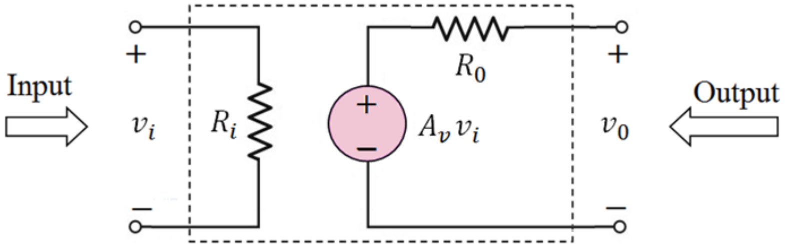


1. $Ro = r_o \parallel R_C$

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

3. Calculate $R_i = R_{TH} \parallel r_\pi$

4. $v_{be} = v_i$

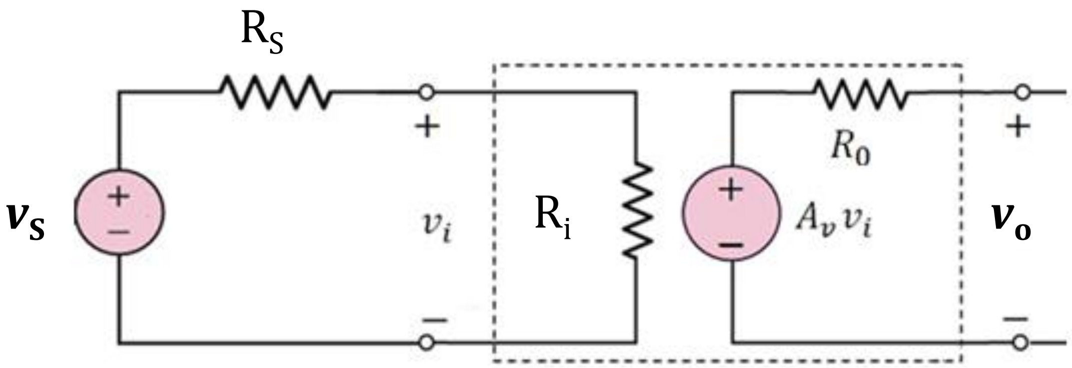


Equivalent circuit of a voltage amplifier

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

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

   $A_v = -(r_o \parallel R_C)\, g_m$ ← 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

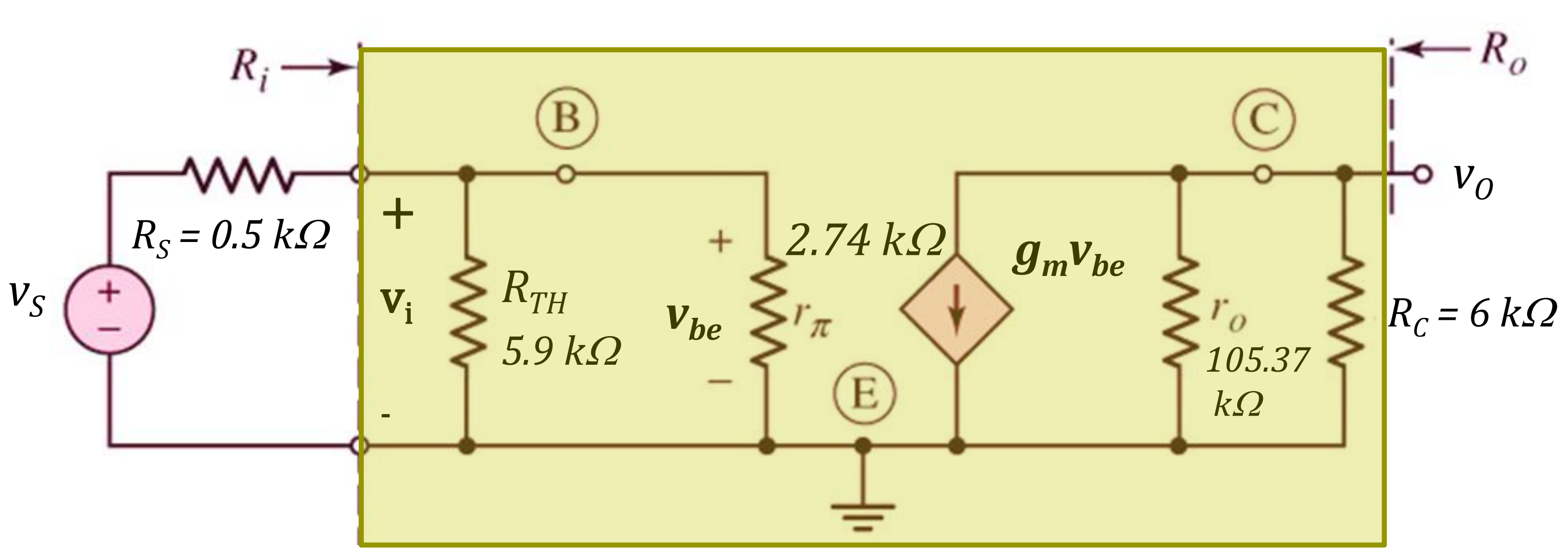
6. v_i in terms of v_s → use voltage divider:

$$v_i = [\, R_i / (R_i + R_s)\,] * v_s = \left(\frac{R_{TH}||r_\pi}{(R_{TH}||r_\pi) + R_S} \right) v_s$$

7. $v_o = A_v v_i$ ← because there is no load resistor

$$v_o = -\,(r_o \,||\, R_C)\, g_m \left(\frac{R_{TH}||r_\pi}{(R_{TH}||r_\pi) + R_S} \right) v_s$$

$$v_o/v_s = -\,(r_o \,||\, R_C)\, g_m \left(\frac{R_{TH}||r_\pi}{(R_{TH}||r_\pi) + R_S} \right)$$



Follow the steps

1. Ro = $r_o \parallel R_C = 5.677\ k\Omega$

2. Equation of v_o : $v_o = -\ (r_o \parallel R_C)\ g_m v_{be} = -\ 36.5\ (5.677)\ v_{be} = -207.21\ v_{be}$

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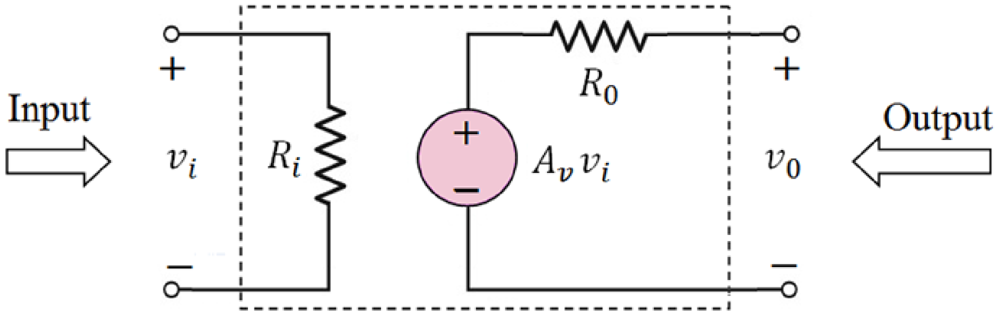
3. Calculate $R_i \rightarrow R_{TH} \| r_\pi = 1.87\ k\Omega$

4. $v_{be} = v_i$



Equivalent circuit of a voltage amplifier

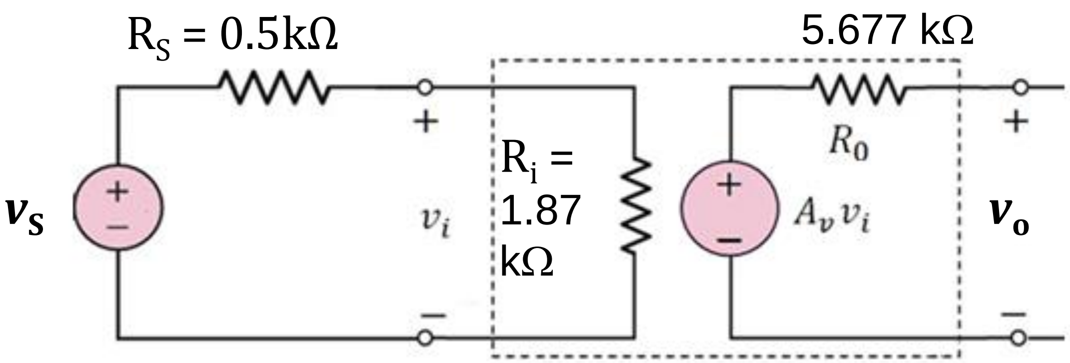
Equation of v_o : $v_o = -\,(r_o \,||\, R_C)\, g_m v_{be} = -\,36.5\,(5.677)\, v_{be} = -207.21\, v_{be}$

$v_{be} = v_i$

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

$A_v \cancel{v_i} = -207.21\, v_{be} = -207.21\, \cancel{v_i}$

$A_v = -207.21$ ← open circuit voltage gain



Equivalent circuit of a voltage amplifier

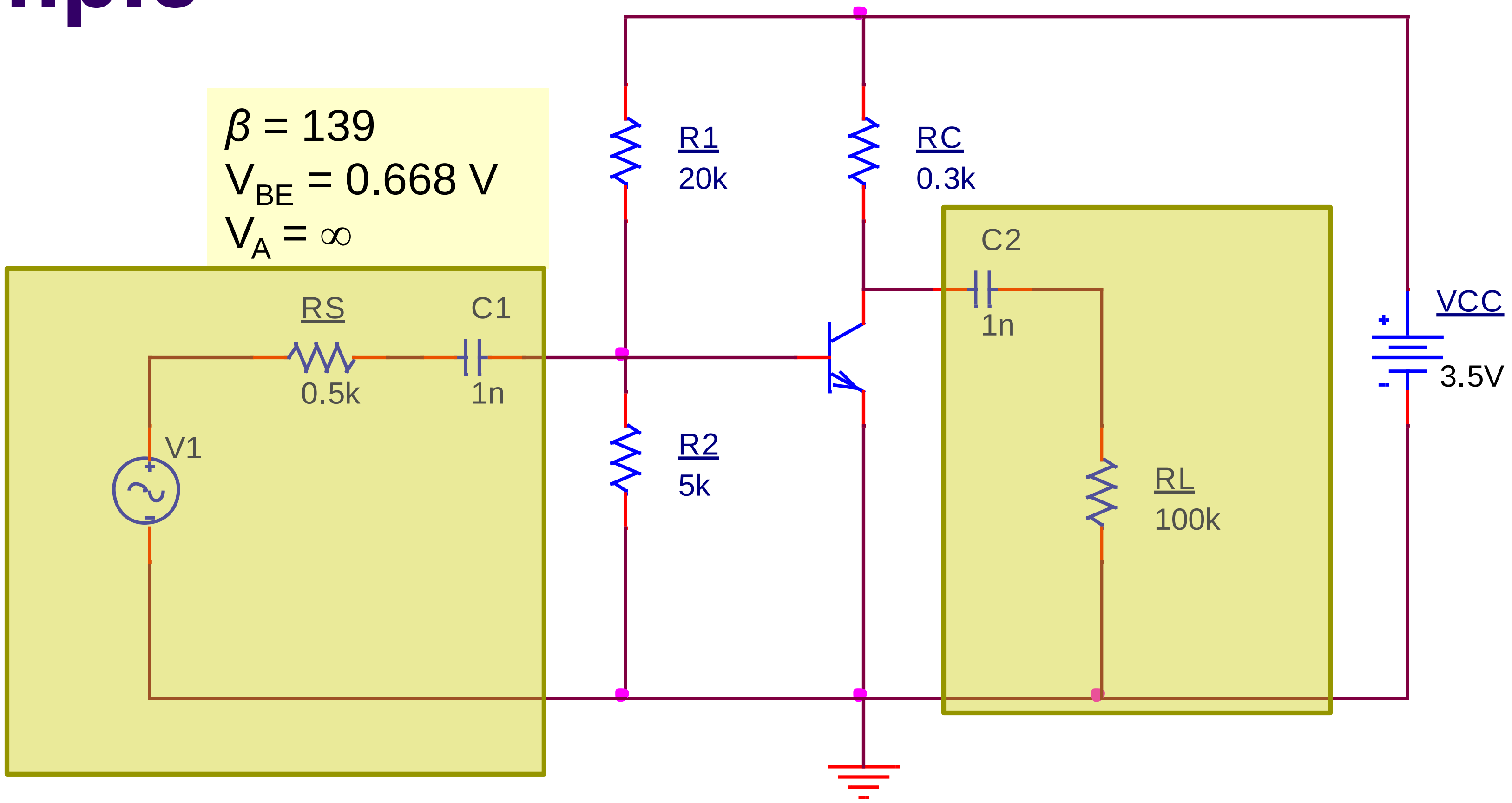
To find new voltage gain, v_o/v_s with input signal voltage source, v_s

6. v_i in terms of v_s → use voltage divider:
$v_i = [\ R_i\ /\ (\ R_i + R_s\ )]\ *\ v_s\ = 0.789\ v_s$

7. $v_o = A_v v_i$ ← because there is no load resistor
$v_o = -207.21\ (0.789\ v_s)$
$v_o/v_s = -163.49$

Example

$\beta = 139$
$V_{BE} = 0.668$ V
$V_A = \infty$



Voltage Divider biasing:

Change to Thevenin Equivalent

R_{TH} = 4 kΩ

V_{TH} = 0.7 V

β = 139
V_{BE} = 0.668 V
$V_A = \infty$

- Perform DC analysis to obtain the value of I_C

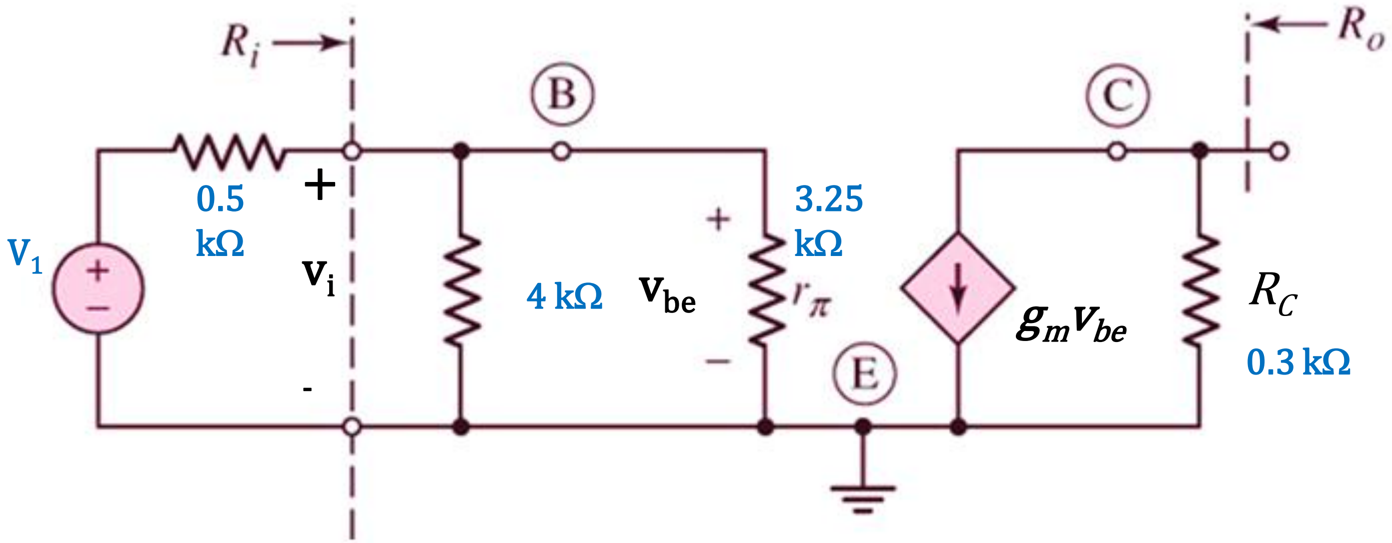
BE loop: $4\ I_B + 0.668 - 0.7 = 0$

$I_B = 0.008$

$I_C = \beta I_B = 1.112$ mA

- Calculate the small-signal parameters

r_π = 3.25 kΩ , $r_o = \infty$ and g_m = 42.77 mA/V



Follow the steps

1. Ro = R_C = 0.3 kΩ

2. Equation of v_o : $v_o = -(R_C)\, g_m v_{be} = -0.3\,(42.77)\, v_{be} = -12.831\, v_{be}$

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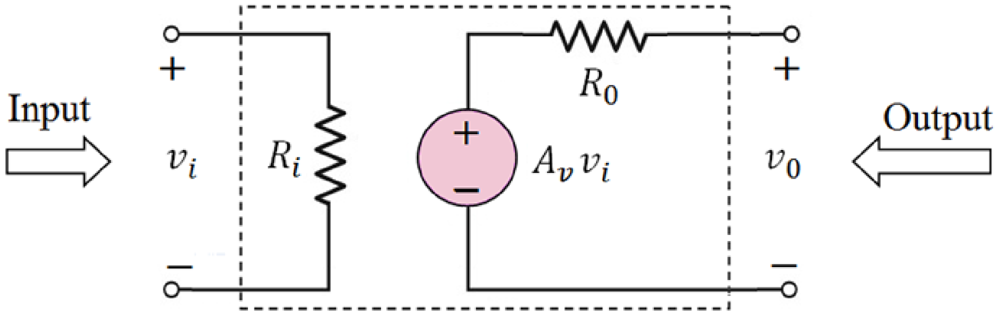
3. Calculate R_i → $R_{TH} || r_\pi = 4 \,||\, 3.25 = 1.793$ kΩ

4. $v_{be} = v_i$



Equivalent circuit of a voltage amplifier

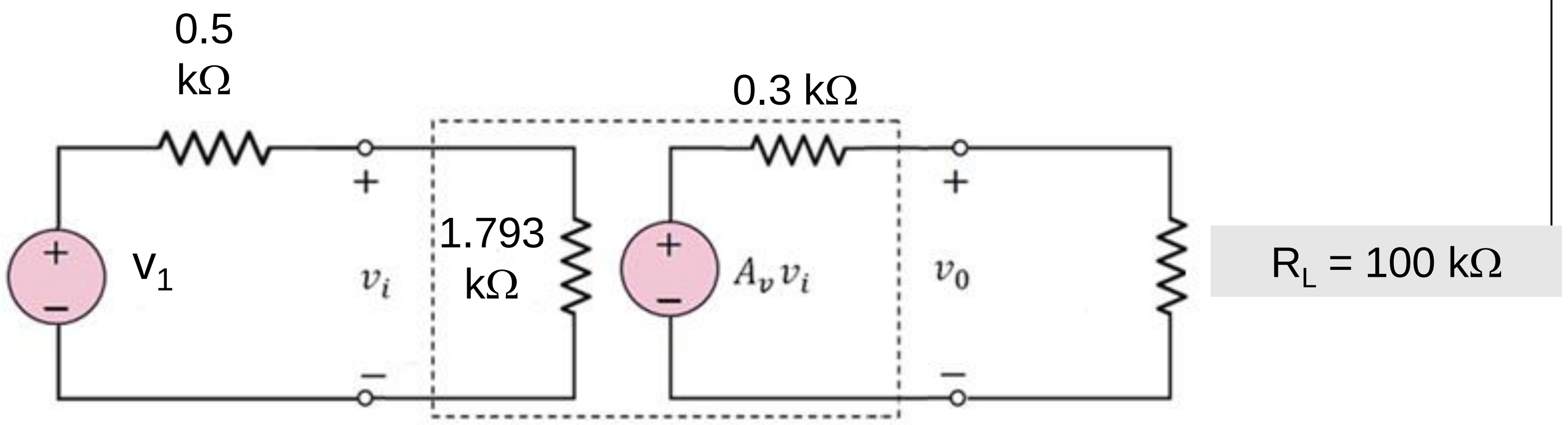
Equation of v_o : $v_o = -(R_C)\, g_m v_{be} = -0.3\,(42.77)\, v_{be} = -12.831\, v_{be}$

$v_{be} = v_i$

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

$A_v \cancel{v_i} = -12.831\, v_{be} = -12.831\, \cancel{v_i}$

$A_v = -12.831$ ← open circuit voltage gain



To find new voltage gain, v_o/v_1 now with signal voltage, v_1 and R_L

6. v_i in terms of v_s → use voltage divider:

$v_i = [\ R_i / (\ R_i + R_s\ )] * v_1 = 0.782\ v_1$

7. $v_o = [\ R_L / (\ R_L + R_o\ )] * A_v v_i$ ← this is because we have load resistor R_L

$v_o = 0.997\ (-12.831\ )\ (0.782\ v_1)$

$v_o/v_1 = -10$