# EE335 Electronics

FINAL Exam, June 1, 2018

| Name, Surname: | Student No: |
|---|---|
| Instructor: R. Kopru | |

**Q1.** (18) For the DC analysis of a BJT amplifier seen in Fig. 1, determine the followings:

- **a)** (4) $I_{BQ}$
- **b)** (6) $I_{CQ}, V_{CEQ}$
- **c)** (2) operating point $Q$
- **d)** (6) $V_E, V_C, V_B$.

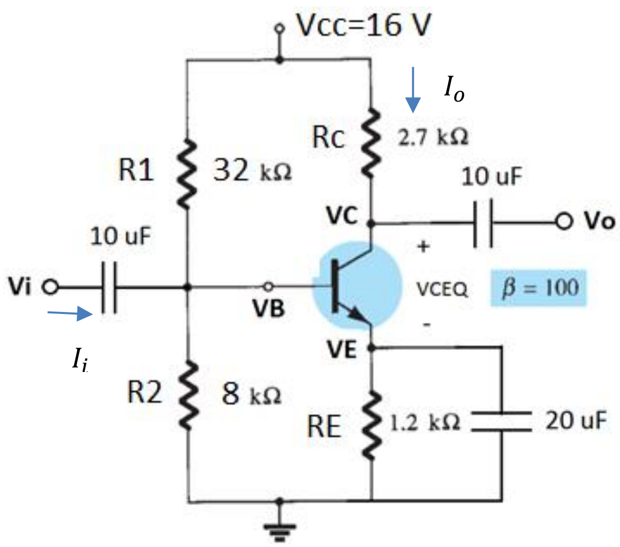



Fig. 1.

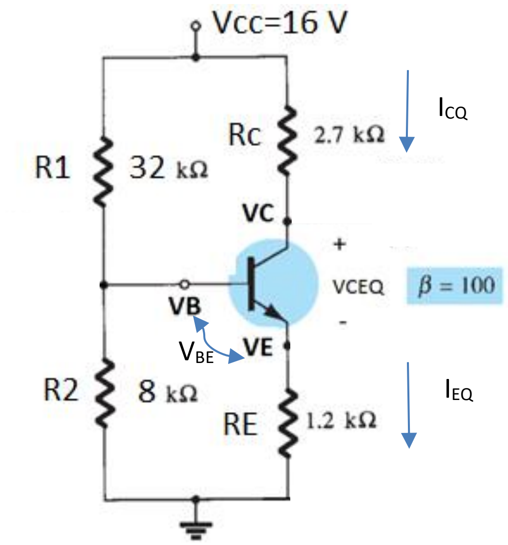
**Q2.** (22) Consider again the same BJT amplifier of Fig. 1.
For the AC analysis, determine the followings:

- **a)** (03) $r_e$.
- **b)** (04) calculate $Z_i$ and $Z_o$.
- **c)** (08) derive the expression of $A_v$
- **d)** (03) calculate the value of $A_v$.
- **e)** (04) Write the output voltage expression $v_o(t)$ if the input voltage is $v_i(t) = 10\sin(2\pi 1000t), mV$.

**SOLUTIONS**

**Q1.** We have VBE=0.7 V, VCC=16 V, R1=32.0 k, R2=8.0 k, RE=1.2 k, RC=2.7 k, $\beta$ =100.

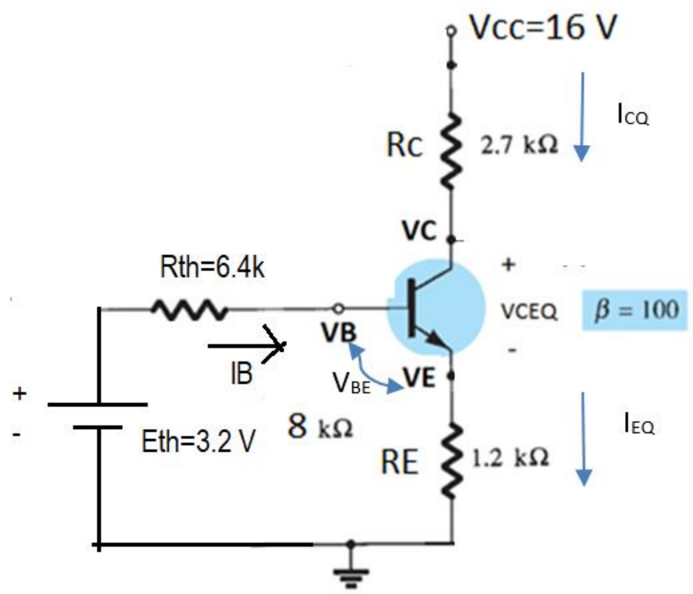
a) **DC ANALYSIS:** We should draw the DC eqvn. circuit. For this; we do the following:
- all caps. should be “open-circuited”.




DC. eqvn. circuit.

Using Thevenin’s method we have,

RTH=R1||R2=R1*R2/(R1+R2)=6.4 k
ETH=VCC*R2/(R1+R2)=3.2 V
IBQ=(ETH-VBE)/(RTH+( $\beta$ +1)*RE)=0.0196 mA=19.6 uA



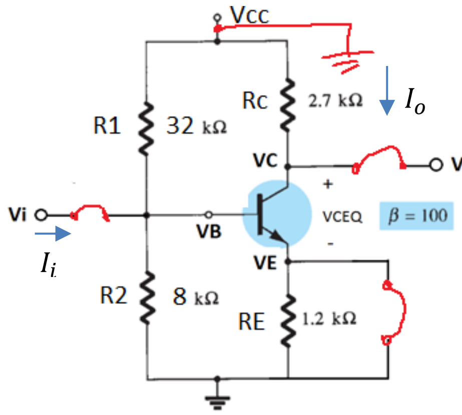

b)
ICQ= $\beta$ *IB=1.9592 mA
IEQ=( $\beta$ +1)*IB=1.9788 mA
KVL for the output: VCC=IC*RC+VCE+IE*RE, so we have VCEQ=VCC-IC*RC-IE*RE=8.3354 V

c) Q(VCEQ, ICQ)=Q(8.3354V, 1.9592mA)
d)
VE=IE*RE=2.3746 V
Since VCE=VC-VE, so we have VC=VCE+VE=10.71 V
Since VBE=VB-VE, so we have VB=VBE+VE=3.0746 V

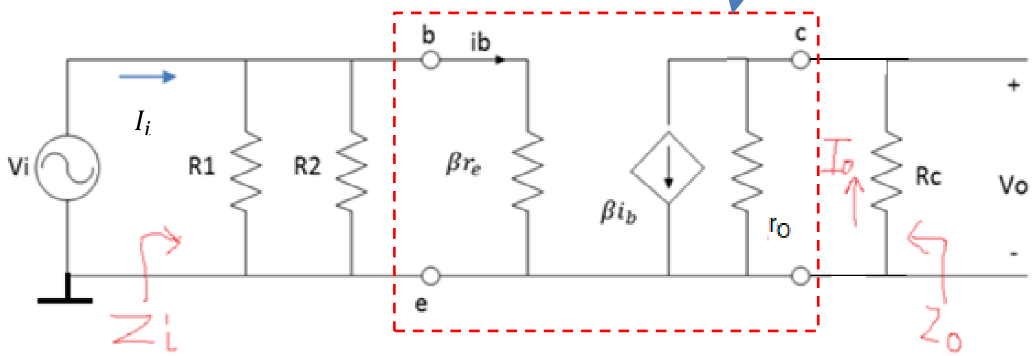
**Q2.**

a) re=VT/IEQ=26 mV/1.9788mA=13.1 Ohm.
b) **AC ANALYSIS:** The AC equivalent circuit is to be drawn. For this, we need to make the followings:
   - All caps. are to be "short-circuited".
   - Supply source is to be grounded.

   The resulting circuit would be as follows:




If the transistor in the above circuit is replaced by its **AC eqvn. circuit** and the circuit is rearranged, the **"complete AC eqvn. circuit of the BJT amplifier"** would be as follows:




**Finding input impedance (Zi)**: from the AC eqvn. circuit we write;

Zi= $V_i/I_i$=R1||R2||($\beta r_e$)= 32 k || 8 k || (100*0.0131 k)     CORRECTION

= 32 k || 8 k || 1.31 k

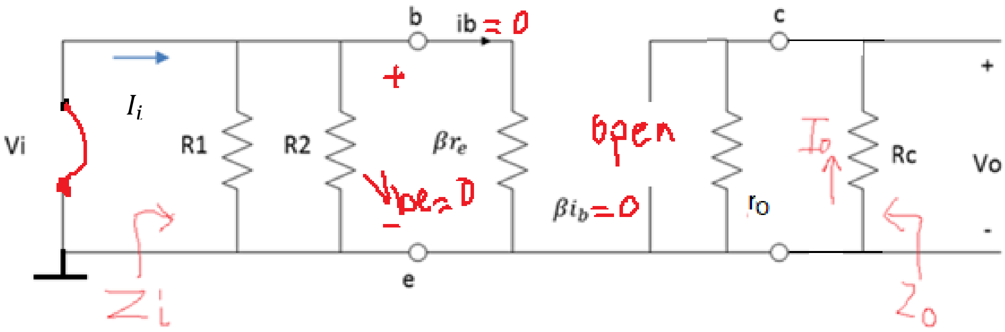
= $\left(\frac{1}{32}+\frac{1}{8}+\frac{1}{1.31}\right)^{-1}$ (Note: since we know the result will be in kOhm, we do not put "k" near 32, 8 and 1.31).

=$(0.0313 + 0.125 + 0.7634)^{-1}$

=$(0.9197)^{-1}$

=**1.0873 kOhm**

**Finding output impedance (Zo)**: $Z_o = \frac{v_o}{i_o}|_{Vi\to 0}$. This expression tell us, first Vi input voltage must be set to zero volt (i.e. it should be connected to ground.) therefore, the circuit can further be drawn as follows to find Zo. Notice that since Vi is grounded (i.e. Vi->0 V), Vbe is also become 0 V. Therefore the current source of $\beta i_b$ has become zero amper source which means that it can be assumed as "**open**" (see the figüre below).




Therefore Zo=RC||ro ≅ RC=2.7 k (since we assume ro->∞) is seen immediately from the circuit above.

c) From the **"complete AC eqvn. circuit of the BJT amplifier"** drawn in part b, we can write;

$$A_v = \frac{v_o}{v_i} = \frac{-\beta i_b R_c}{i_b \beta r_e} = -\frac{R_c}{r_e}$$

d)

$$A_v = -\frac{R_c}{r_e} = -\frac{2.7k}{13.1\ Ohm} = -205.495$$

e)

$$v_o = A_v v_i = (-205.495)(10\sin(2\pi 1000t)\,, mV) = -2.055\sin(2\pi 1000t)\,, V$$