TUTORIAL CHAPTER 4 (SEEU2012)

1. Explain briefly why the operating point (Q-point) of a BJT small-signal amplifier circuit is chosen to be located at the centre of the load line.

2. Referring to the values of voltage V_{BE} and voltage V_{BC} of the silicon npn BJT for each biasing condition in Table QA.2, state whether the BJT is operates in active, saturation or cut-off region.

Table QA.2

V_{BE} (V)	V_{BC} (V)	Operation region
0.3	0.7	
0.7	-1	
0.7	0.65	

3. Referring to Figure QA.3, assume the BJT is operated in active region.

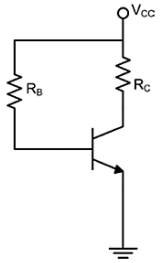


Figure QA.3

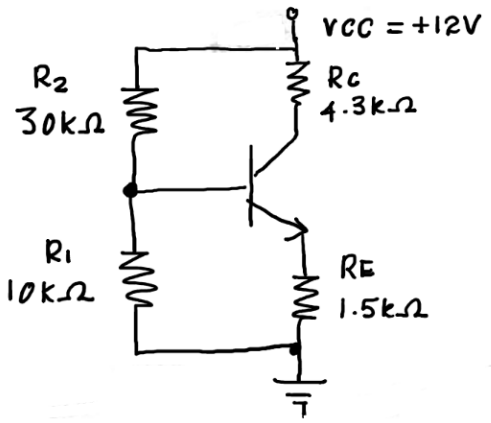
   a. When the value of base resistor RB is increased, current I_C _____.
   b. When the value of collector resistor RC is decreased, current I_C _____ and voltage V_{CE} _____.

4. Referring to the amplifier circuit shown in Figure QB.1, given the BJT parameters: V_{BE} = 0.7 V, $\beta = h_{FE} = h_{fe}$ = 140, V_T = 26 mV and $r_o = \infty$.
   a. By doing DC analysis, prove the collector current IC = 0.76 mA.
   b. Draw and label the small-signal hybrid-π ac equivalent circuit at mid-frequency range.
   c. Calculate the values of parameters g_m and r_π.
      Answer: g_m = 29.23 mS and r_π = 4.79 kΩ.
   d. Calculate the input impedance, Z_i.
      Answer: 3.86 kΩ
   e. Calculate the output impedance, Z_O.
      Answer: 10 kΩ
   f. Calculate the voltage gain, $A_V = V_O / V_i$ at mid-frequency range.
      Answer: –26.57

5. One of the important aspects in designing biasing circuit is the stability of the Q –point. If you want to design a small-signal amplifier using BJT, would you choose a circuit with an emitter resistor, RE? State a reason for your choices.

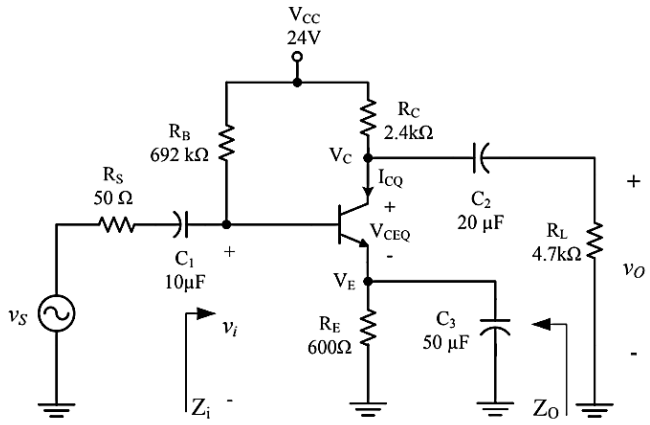
6. The Q – point is best located in the active region. Explain the behaviour of the collector current, IC and VCE when the BJT is operating in the active, saturation and cut – off region.

7. Referring to the BJT DC circuit in Figure Q.1B. Given V_{BE} (ON) = 0.65 V and ß = 100.



   a. Find the Q – point, V_{CEQ} and I_{CQ}.
   Answer: I_{BQ} = 15µA, I_{CQ} = 1.5mA and V_{CE} = 3.3V.
   b. Determine the value for $I_{C(SAT)}$ and $V_{CE(CUT-OFF)}$. Then draw the DC load line and show the position of the Q – point. State if the biasing circuit is suitable to use in small signal amplification.
   Answer: $I_{C(sat)}$ = 2.07mA and V_{CE} = 12V.

8. A bipolar junction transistor (BJT) amplifier circuit as in Figure below has the following specifications: β = 140, V_{BE} = 0.7 V, V_T = 26 mV and r_O = ∞.

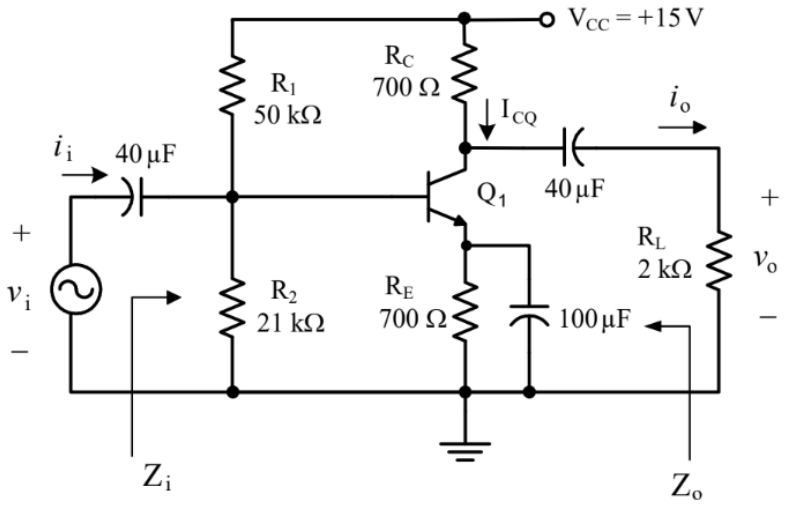


   a. Show that I_{CQ} = 4.2 mA.
   b. Calculate V_{CEQ} and V_c.
   Answer: V_{CEQ} = 11.4V and V_C = 13.92V.

c. Draw the hybrid-π ac equivalent circuit at mid-frequency.
d. Calculate g_m, r_π, input impedance (Z_i) and output impedance (Z_o).
Answer: g_m = 161.5 mS, r_π = 866.7 Ω, Z_i = 0.87 kΩ and Z_o = 2.4 kΩ
e. Determine $A_{vs} = v_o/v_s$.
Answer: –241.7

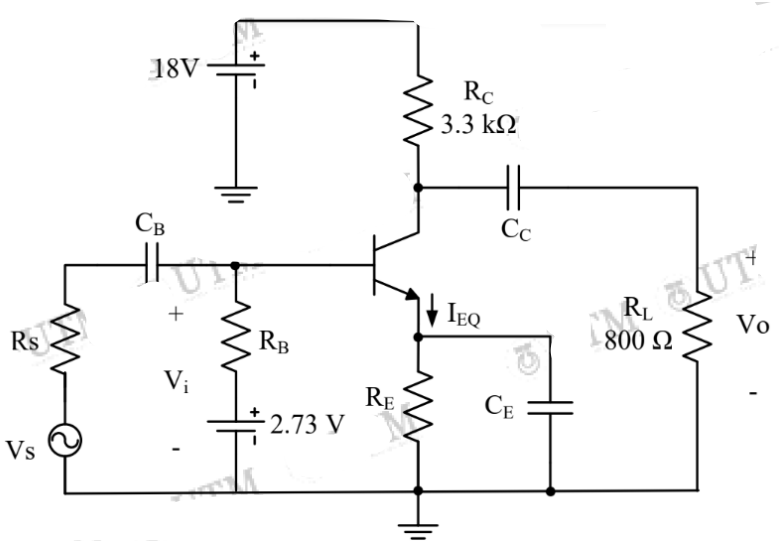
9. State the suitable application for BJT that works in (i) active and (ii) saturation regions.

10. A BJT amplifier circuit in figure below has the following specifications: hFE = hfe = β = 350, VT = 26 mV, and rO = ∞.



a. By doing DC analysis, prove that current ICQ = 5 mA.
b. Draw and label the small-signal hybrid-π AC equivalent circuit at mid-frequency range.
c. Calculate the value of parameter gm and rπ.
Answer: g_m = 192.31 mS and r_π = 1.82 kΩ.
d. Calculate the input impedance, Zi.
Answer: 1.62kΩ.
e. Calculate the output impedance, Z_O.
Answer: 700Ω.
f. Calculate the voltage gain, Av = VO / Vi.
Answer: -99.72
g. If the input voltage Vi = 0.01sin (100πt) (V), draw and label the output voltage, Vo.

11. Figure below represents a common emitter amplifier circuit. Assume the BJT is in the active region. The parameters of the BJT amplifier circuit are: β = 100, V_{BE} = 0.7 V, V_T = 26 mV and I_{EQ} = 2.31 mA.



a. Draw the AC equivalent circuit at mid – frequency using Hybrid-pi model at mid- frequency band.
b. Calculate the value of rπ and gm.
   Answer: g_m = 88.8 mS and r_π = 1.126 kΩ.
c. The input impedance, Zi is 1.07 kΩ, determine the value of resistor RB and the output impedance, Zo.
   Answer: 3.3kΩ.
d. From the AC equivalent circuit, derive an expression for the open circuit voltage gain, Av = Vo/Vi, then calculate the value.
   Answer: -57
e. The source resistance, Rs is very small compared to input impedance, Zi resulting source voltage, VS = Vi. If Vs = 0.15 sin (ωt) V with frequency 50Hz, determine the output voltage Vo. Then draw and the output waveform.
   Answer: -8.6 sin (ωt) V
f. Determine the minimum peak amplitude of the source voltage, Vs(p) to avoid the output signal, Vo from clipping.
   Answer: 0.32V