K. J. SOMAIYA COLLEGE OF ENGINEERING
DEPARTMENT OF ELECTRONICS ENGINEERING
2UXC402: ELECTRONIC CIRCUITS ANALYSIS AND DESIGN SEM IV
SET OF QUESTIONS

7^{th} **January, 2020** [**MODULE 2**]

1. **Assume any suitable data if necessary**
2. **Read the questions carefully before attempting**

********** **MODULE 2.1** **********

Analysis: DC & AC analysis of cascade, cascode amplifier and Darlington pair

********** **********

1. Explain the need of multistage amplifiers **[05]**

2. Explain the effect of cascading two or more stages on the following **[10]**
   a) Voltage gain
   b) Lower cut-off frequency
   c) Higher cut-off frequency
   d) Gain Bandwidth product

3. Explain various coupling mechanisms used in multistage amplifiers **[05]**

4. Compare RC coupling and Direct coupling mechanism (any 5 distinct points) **[05]**

5. Name the various types of Multi-stage amplifiers **[05]**

6. Draw the following for CE−CE RC coupled BJT amplifier **[05]**
   a) Circuit diagram
   b) Mid-frequency equivalent circuit

7. Derive the expression of overall voltage gain, input impedance and output impedance for a CE−CE RC coupled BJT amplifier **[10]**

8. A two stage circuit is shown in Figure 1. Given $\beta_1 = \beta_2 = 220$, $V_{BE1} = V_{BE2} = 0.7V$ **[10]**

   a) Calculate input impedance of the circuit

   b) Calculate output impedance of the circuit

   c) Calculate voltage gain of the circuit

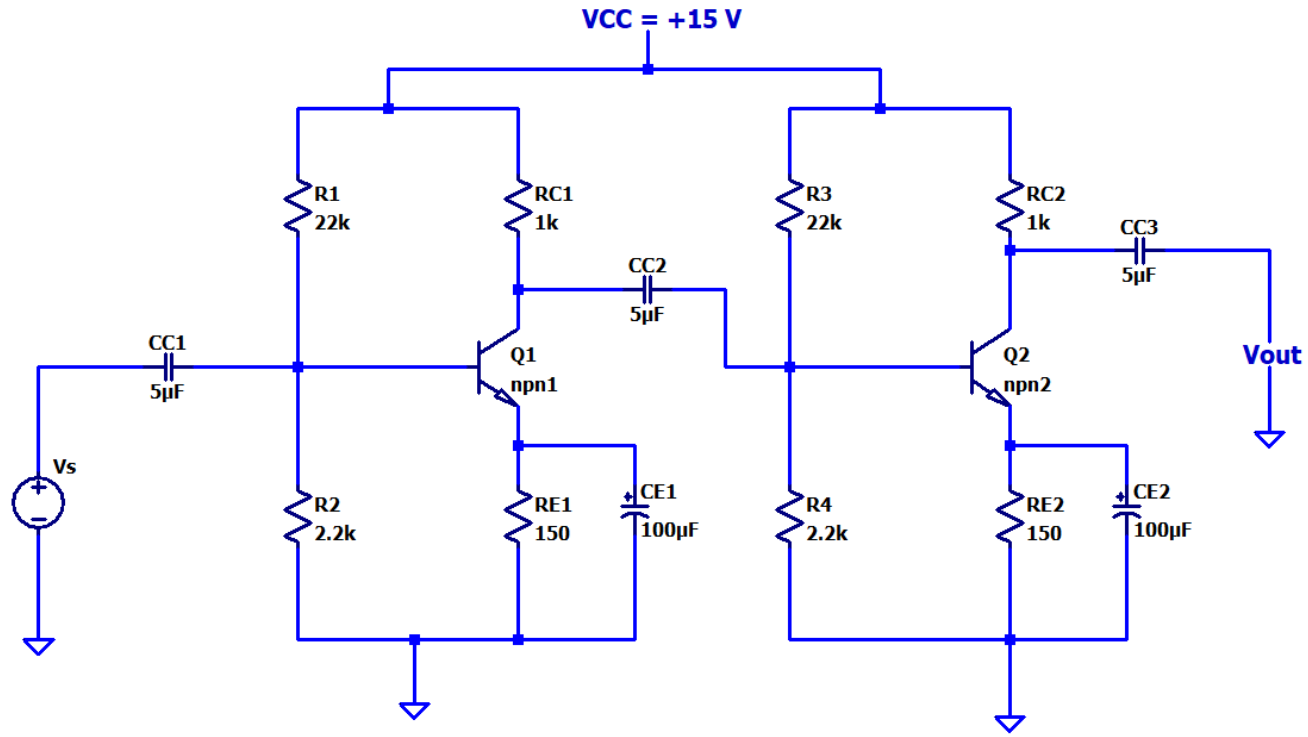

Figure 1: Question 8

Answers: $I_{BQ1} = I_{BQ2} = 18.89\mu A$ $I_{CQ1} = I_{CQ2} = 4.156mA$ $r_{\pi 1} = r_{\pi 2} = 1.376k\Omega$ $g_{m1} = g_{m2} = 159.85mA/V$ $A_{V1} = -71.78$ $A_{V2} = -159.85$ $A_{VT} = 81.19dB$ $Z_i = 815.16\Omega$ $Z_o = 1k\Omega$

9. Draw the following for CS−CS RC coupled JFET amplifier **[05]**

   a) Circuit diagram

   b) Mid-frequency equivalent circuit

10. Derive the expression of overall voltage gain, input impedance and output impedance for a CS−CS RC coupled JFET amplifier **[10]**

11. A two stage RC coupled circuit is shown in Figure 2. Given $I_{DSS1} = I_{DSS2} = 7mA$, $V_{P1} = V_{P2} = -2.5V$ and $r_{d1} = r_{d2} = 50k\Omega$ **[10]**

    a) Calculate input impedance of the circuit

    b) Calculate output impedance of the circuit

    c) Calculate mid band voltage gain of the circuit

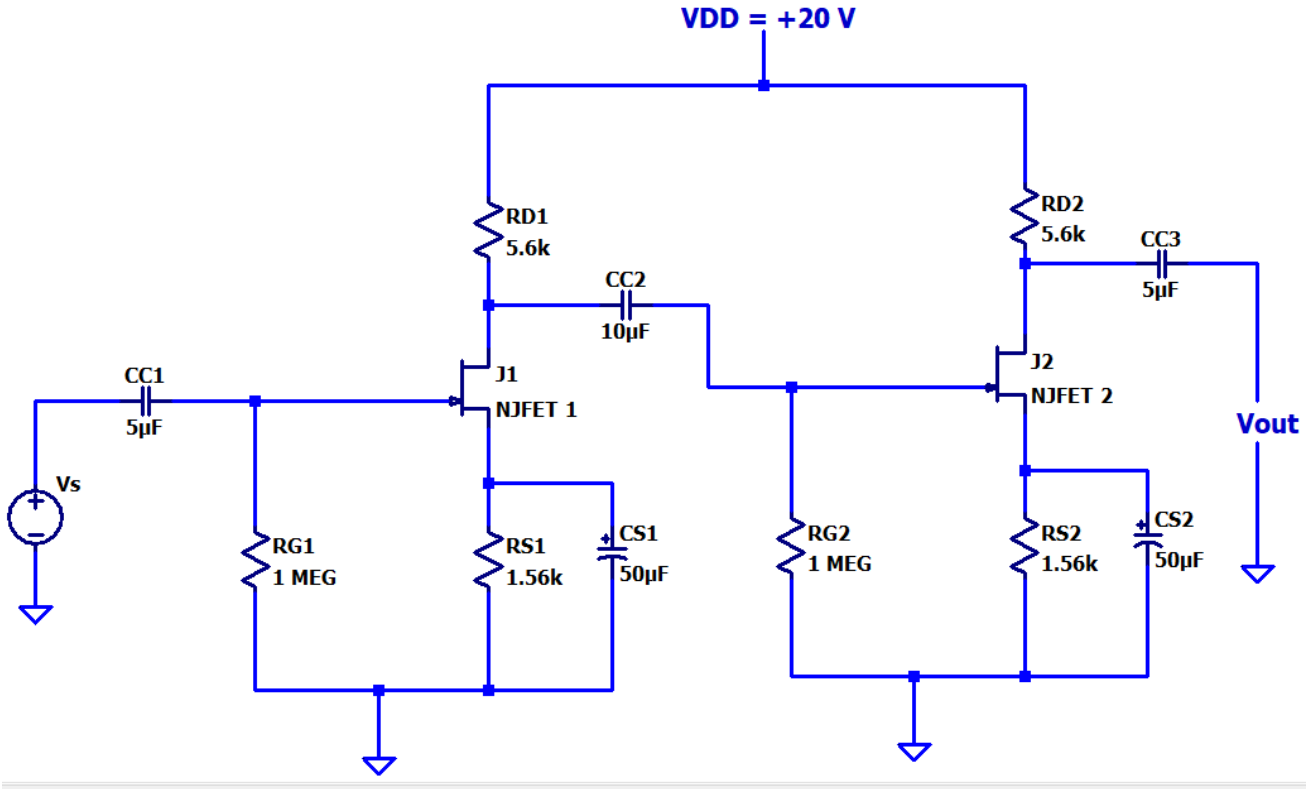

Figure 2: Question 11

Answers: $I_{DQ1} = I_{DQ2} = 1mA$ $V_{GSQ1} = V_{GSQ2} = -1.556V$ $Z_i = 1M\Omega$
$Z_o = 5.036k\Omega$ $g_{m1} = g_{m2} = 2.11mA/V$ $A_{V1} = -10.57$ $A_{V2} = -10.62$
$A_{VT} = 112.25$

12. Draw the following for CS−CS RC coupled E-MOSFET amplifier **[05]**

    a) Circuit diagram

    b) Mid-frequency equivalent circuit

13. Derive the expression of overall voltage gain, input impedance and output impedance for a CS−CS RC coupled E-MOSFET amplifier **[10]**

14. Draw the following for CS−CE two stage RC coupled cascade amplifier **[05]**

    a) Circuit diagram

    b) Mid-frequency equivalent circuit

15. Derive the expression of overall voltage gain, input impedance and output impedance for a CS−CE two stage RC coupled cascade amplifier **[10]**

16. A two stage RC coupled circuit is shown in Figure 3. JFET parameters are $I_{DSS} = 7mA$, $V_P = -2.5V$ & $r_d = 50k\Omega$ and BJT parameters are $\beta = 220$, $V_{BE} = 0.7V$ **[10]**

    a) Calculate input impedance of the circuit

    b) Calculate output impedance of the circuit

    c) Calculate output voltage for the circuit

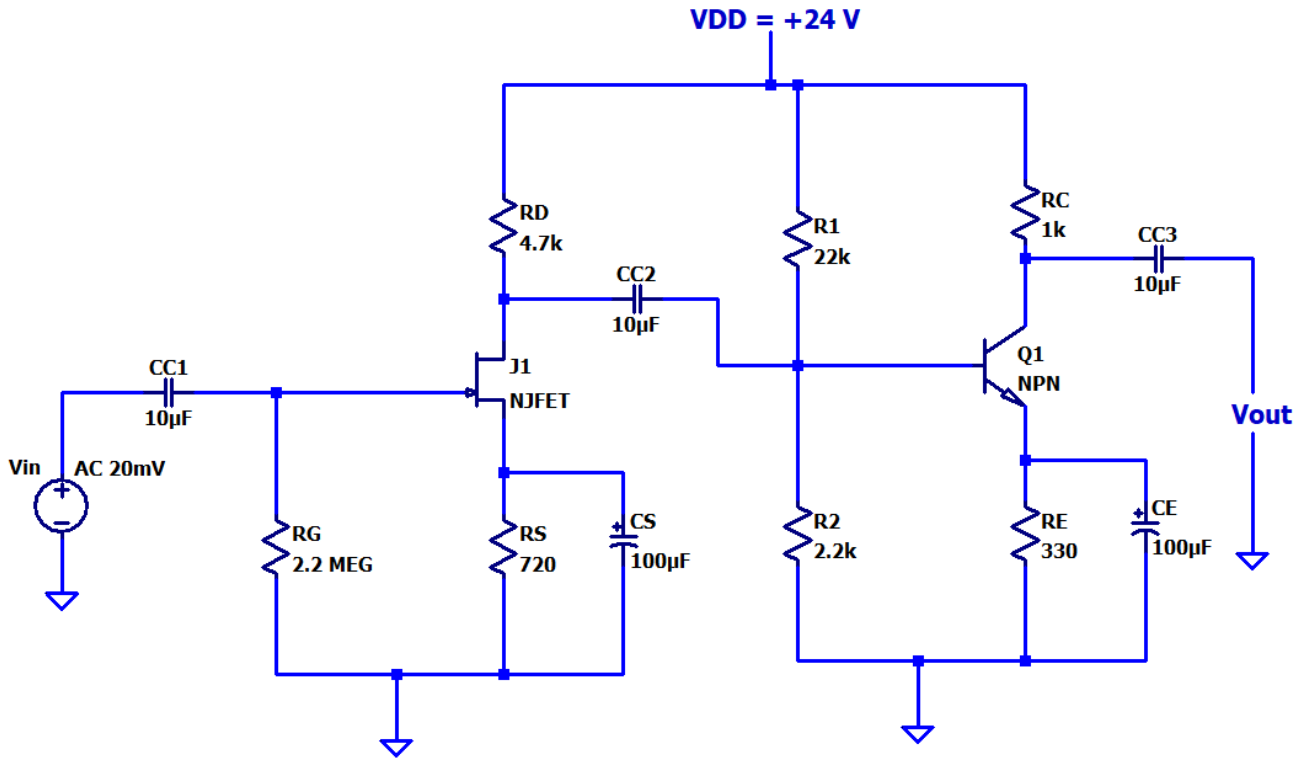

Figure 3: Question 16

Answers: $I_{DQ} = 1.74mA$ $V_{GSQ} = -1.253V$ $g_{m1} = 2.793mA/V$ $I_{BQ} = 19.75\mu A$ $I_{CQ} = 4.345mA$ $g_{m2} = 167.11mA/V$ $r_\pi = 1.32k\Omega$ $Z_i = 2.2M\Omega$ $Z_o = 1k\Omega$ $A_{V1} = -1.874$ $A_{V2} = -167.11$ $A_{VT} = 313.16$ $V_{out} = 6.263V$

17. Write short note on Cascode Amplifier **[10]**

18. Draw the following for CE−CB two stage direct coupled cascode amplifier **[05]**

    a) Circuit diagram

    b) DC equivalent circuit

    b) Mid-frequency equivalent circuit

19. Derive the expression of overall voltage gain, input impedance, output impedance & current gain for CE−CB two stage direct coupled cascode amplifier **[10]**

20. A two stage circuit is shown in Figure 4. It's BJT parameters are $\beta_1 = \beta_1 = 150$, $V_{BE1} = V_{BE2} = 0.7V$ **[10]**

    a) Calculate the DC parameters of the circuits i.e V_{B1}, V_{B2}, V_{E1}, I_{E1}, I_{C1}, I_{C2}, I_{E2}, V_{C1}, V_{C2}, V_{E2}, V_{CE1} & V_{CE2}

    b) Calculate input impedance of the circuit

    c) Calculate output impedance of the circuit

    d) Calculate voltage gain for the circuit

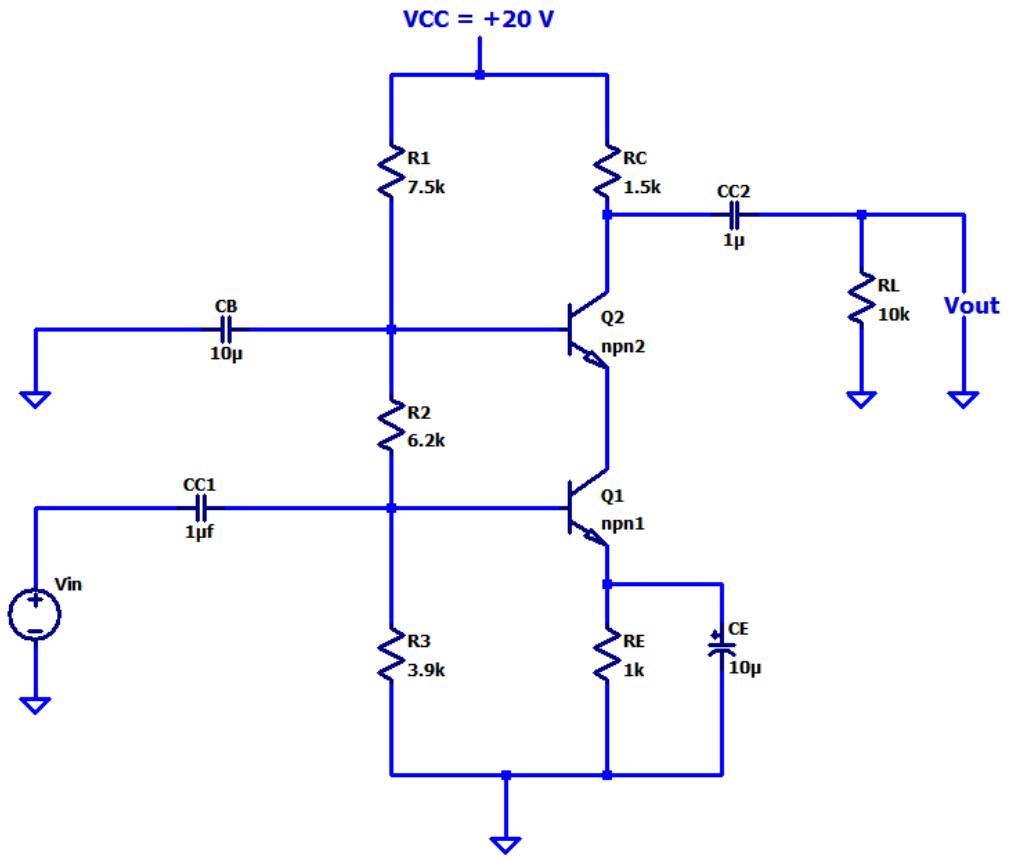

Figure 4: Question 20

Answers: $V_{B1} = 4.4318V$ $V_{B2} = 11.477V$ $V_{E1} = 3.73V$ $I_{E1} = 3.73mA$ $I_{C1} = 3.73mA$ $I_{C2} = 3.73mA$ $I_{E2} = 3.73mA$ $V_{C1} = 10.777V$ $V_{C2} = 14.4V$ $V_{E2} = 10.777V$ $V_{CE1} = 7.045V$ $V_{CE2} = 3.625V$ $g_{m1} = g_{m2} = 143.53mA/V$ $r_{\pi 1} = r_{\pi 2} = 1.045k\Omega$ $Z_i = 727.458\Omega$ $Z_o = 1.3k\Omega$ $A_{V1} = -0.9933$ $A_{V2} = 186.59$ $A_{VT} = -185.34$

21. Justify that cascode amplifier biggest advantage is its high bandwidth. **[05]**

22. A two stage circuit is shown in Figure 5. It's BJT parameters are $\beta_1 = \beta_1 = 200$, $V_{BE1} = V_{BE2} = 0.7V$ **[10]**

    a) Calculate the DC parameters of the circuits i.e V_{B1}, V_{B2}, V_{E1}, I_{E1}, I_{C1}, I_{C2}, I_{E2}, V_{C1}, V_{C2}, V_{E2}, V_{CE1} & V_{CE2}

    b) Calculate input impedance of the circuit

    c) Calculate output impedance of the circuit

    d) Calculate voltage gain for the circuit

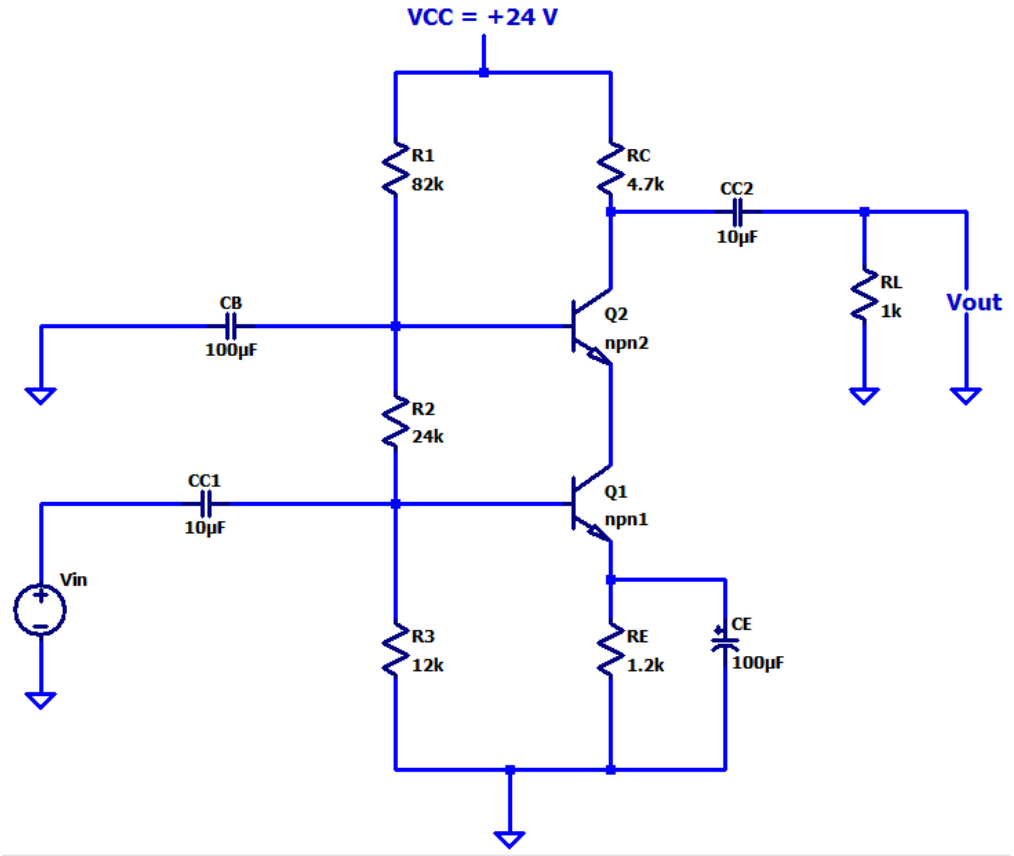

Figure 5: Question 22

Answers: $V_{B1} = 2.44V$ $V_{B2} = 7.32V$ $V_{E1} = 1.74V$ $I_{E1} = 1.45mA$
$I_{C1} = 1.45mA$ $I_{C2} = 1.45mA$ $I_{E2} = 1.45mA$ $V_{C1} = 6.62V$ $V_{C2} = 17.18V$
$V_{E2} = 6.62V$ $V_{CE1} = 4.88V$ $V_{CE2} = 10.56V$ $g_{m1} = g_{m2} = 55.77mA/V$
$r_{\pi 1} = r_{\pi 2} = 3.586k\Omega$ $Z_i = 2.476k\Omega$ $Z_o = 824.56\Omega$ $A_{V1} = -0.9949$
$A_{V2} = 45.98$ $A_{VT} = -45.75$

23. Draw the following for CS−CG two stage direct coupled cascode amplifier **[05]**

    a) Circuit diagram, DC equivalent circuit & Mid-frequency equivalent circuit

24. Derive the expression of overall voltage gain, input impedance & output impedance for CS−CG two stage direct coupled cascode amplifier **[10]**

25. A two stage circuit is shown in Figure 6. It's E-MOSFET parameters are **[10]**
    $k_{n1} = k_{n2} = 0.8mA/V^2$ & $V_{TN1} = V_{TN2} = 0.8V$

    a) Calculate the DC parameters of the circuits i.e V_{G1}, V_{G2}, V_{GS1}, I_{D1}, I_{D2}, V_{D2}, V_{S1}, V_{S2}, V_{DS2}, V_{D1}, V_{DS1} & V_{GS2}

    b) Calculate input impedance of the circuit

    c) Calculate output impedance of the circuit

    d) Calculate voltage gain for the circuit

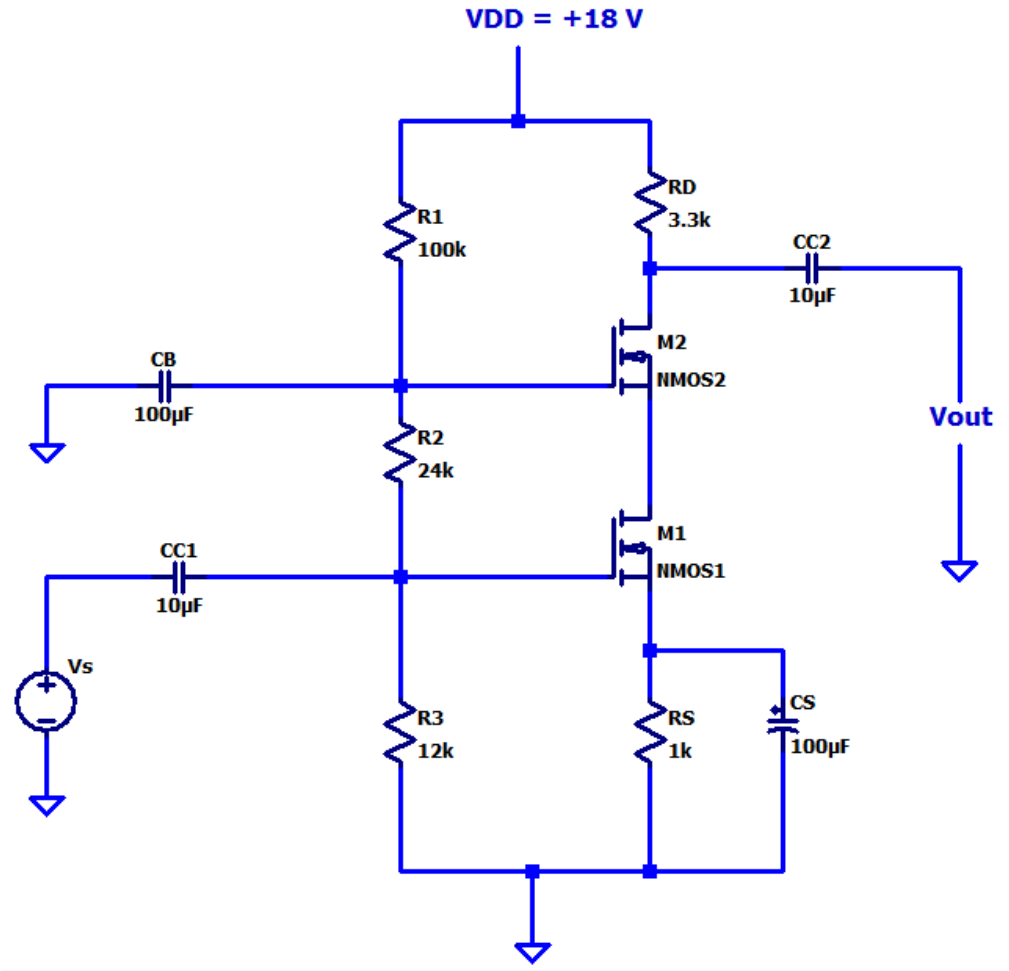

Figure 6: Question 25

Answers: $V_{G1} = 1.588V$ $V_{G2} = 4.76V$ $V_{GS1} = 1.348V$ $I_{D1} = 0.24mA$
$I_{D2} = 0.24mA$ $V_{D2} = 17.2V$ $V_{S1} = 0.24V$ $V_{S2} = 3.416V$ $V_{DS2} = 13.78V$
$V_{D1} = 3.416V$ $V_{DS1} = 3.176V$ $V_{GS2} = 1.348V$ $g_{m1} = g_{m2} = 0.876mA/V$
$Z_i = 8k\Omega$ $Z_o = 3.3k\Omega$ $A_{V1} = -1$ $A_{V2} = 2.89$ $A_{VT} = -2.89$

26. Draw Darlington pair and show that the current gain of individual transistors are the products of individual transistor current gains **[05]**

27. Explain various features of Darlington pair **[05]**

28. Draw circuit of Darlington amplifier in emitter follower configuration and derive the following: **[10]**

    a) Expression for DC output current, input impedance and output impedance

    b) Expression for Current gain and voltage gain

29. A two stage circuit is shown in Figure 7. It's BJT parameters are $\beta_1 = \beta_1 = 100$, $V_{BE1} = V_{BE2} = 0.7V$. Calculate the Q point, input impedance, output impedance, voltage gain and current gain of the circuit **[10]**

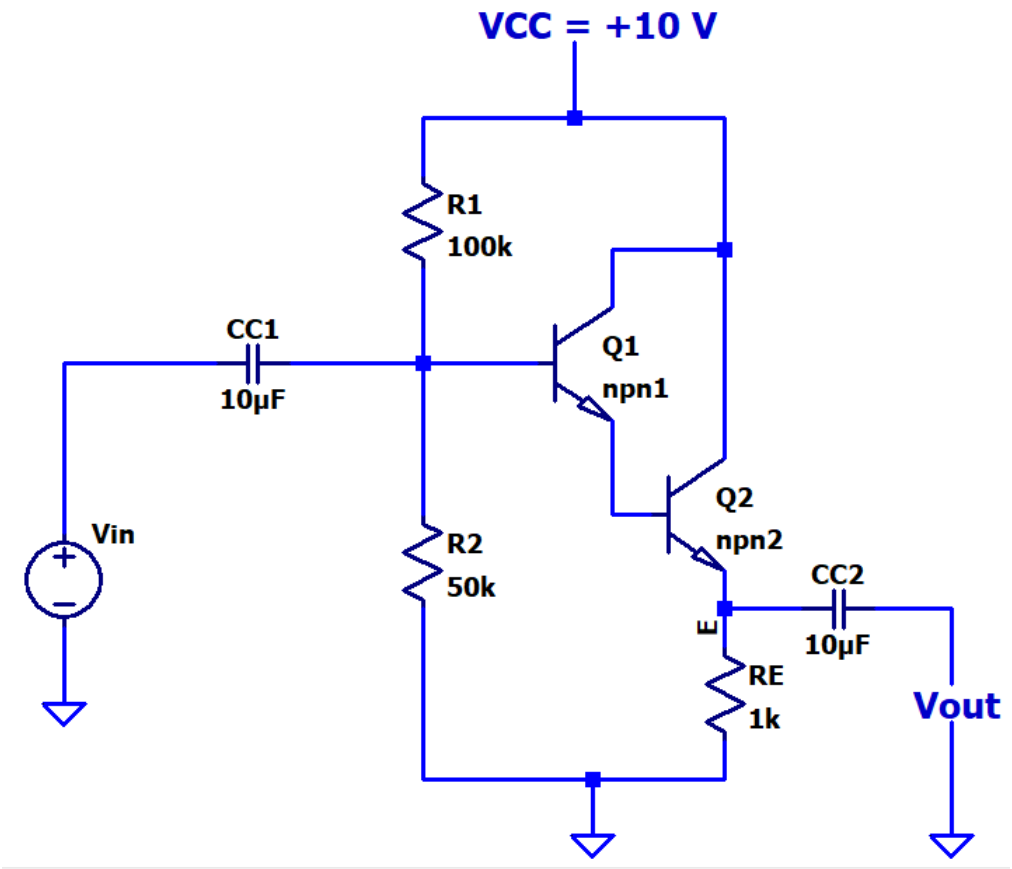

Figure 7: Question 29

Answers: $I_{B1} = 0.1889\mu A$ $I_{C1} = 0.01889mA$ $I_{E1} = I_{B2} = 0.01908mA$
$I_{C2} = 1.9079mA$ $I_{E2} = 1.927mA$ $V_{E2} = 1.927V$ $V_{C2} = 10V$ $V_{CE2} = 8.073V$
$r_{\pi 1} = 137.64k\Omega$ $r_{\pi 2} = 1.363k\Omega$ $Z_i = 33.22k\Omega$ $Z_o = 29.366\Omega$ $A_{i1} = 101$
$A_{i2} = 101$ $A_{iT} = 32.35$ $A_{V1} = 0.9868$ $A_{V2} = 0.9867$ $A_{VT} = 0.9737$

30. A two stage circuit is shown in Figure 8. It's BJT parameters are $\beta_1 = \beta_1 = 20$, $V_{BE1} = V_{BE2} = 0.6V$. **[10]**

a) Determine all node voltages and terminal currents under DC analysis

b) Determine overall voltage gain of the circuit

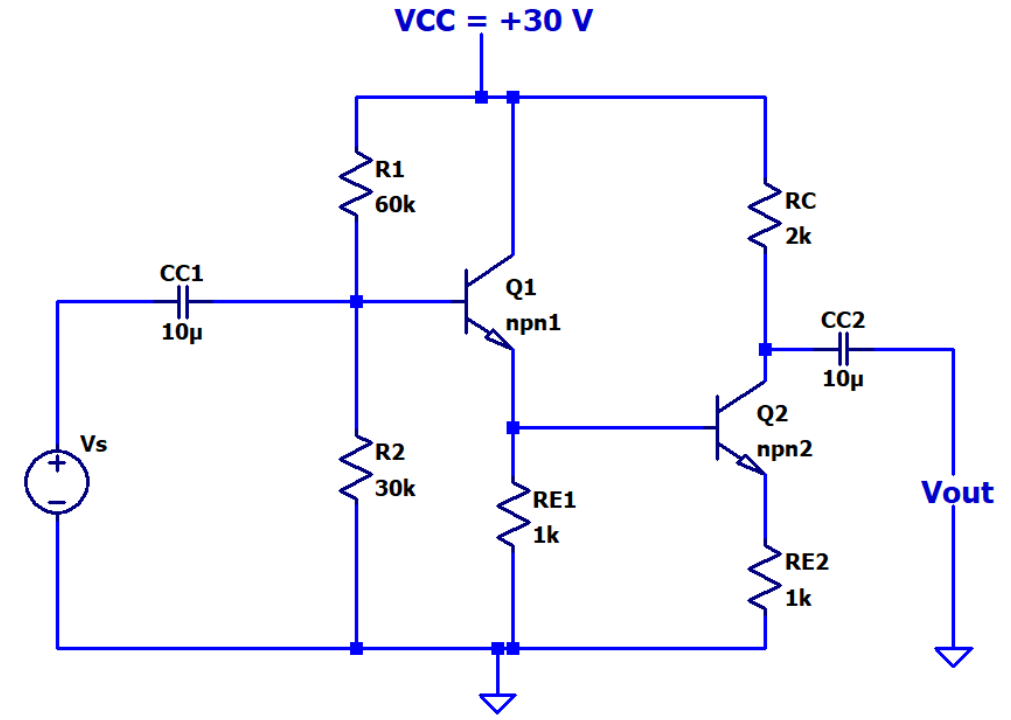

Figure 8: Question 30

Answers:
Node currents: $I_{B1} = 229.27\mu A$ $I_{C1} = 4.585mA$ $I_{E1} = 4.81mA$ $I_{B2} = 191.095\mu A$ $I_{C2} = 3.822mA$ $I_{E2} = 4.013mA$
Node voltages: $V_{B1} = 5.414V$ $V_{E1} = V_{B2} = 4.613V$ $V_{E2} = 4.013V$ $V_{C2} = 22.356V$ $V_{C1} = 30V$
Small signal parameters: $r_{\pi 1} = 113.41\Omega$ $r_{\pi 2} = 136.05\Omega$ $g_{m1} = 176.35mA/V$ $g_{m2} = 147mA/V$
Voltage gain: $A_{V1} = 0.9473$ $A_{V2} = -1.8925$ $A_{VT} = -1.7927$

31. A two stage circuit is shown in Figure 9. It's BJT parameters are $\beta_1 = \beta_1 = 100$, $V_{BE1} = V_{BE2} = 0.7V$. **[10]**

a) Determine all node voltages and terminal currents under DC analysis

b) Determine overall voltage gain of the circuit

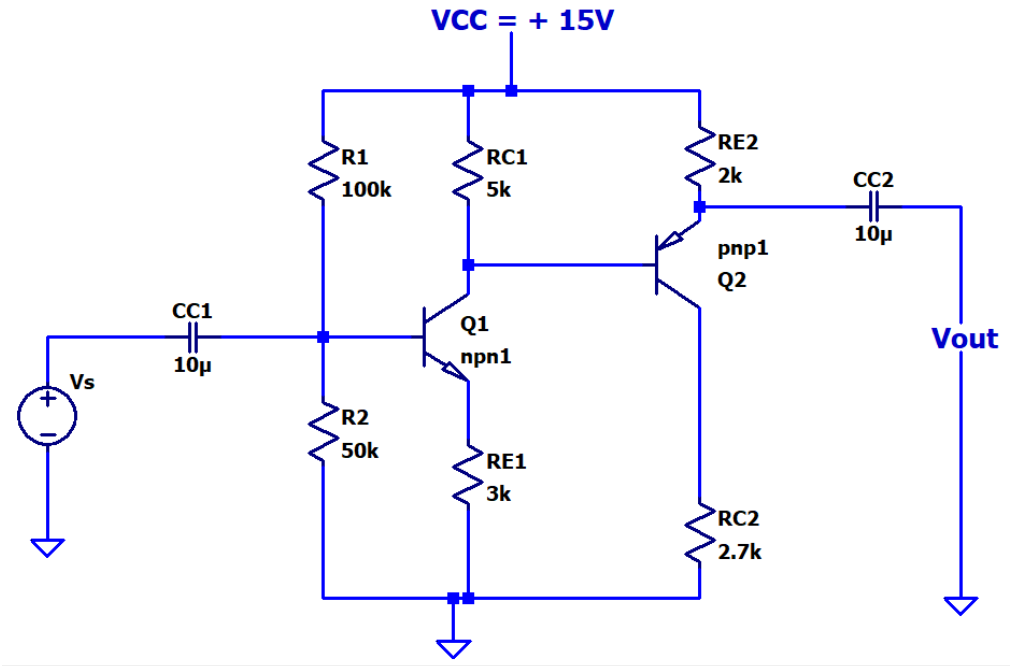

Figure 9: Question 31

Answers:
Node currents: $I_{B1} = 12.785\mu A$ $I_{C1} = 1.2785mA$ $I_{E1} = 1.29mA$ $I_{B2} = 27.47\mu A$ $I_{C2} = 2.743mA$ $I_{E2} = 2.775mA$
Node voltages: $V_{B1} = 4.573V$ $V_{C1} = V_{B2} = 8.75V$ $V_{E2} = 9.45V$ $V_{C2} = 7.4V$ $V_{E1} = 3.873V$
Small signal parameters: $r_{\pi 1} = 2.033k\Omega$ $r_{\pi 2} = 947.867\Omega$
Voltage gain: $A_{V1} = -1.639$ $A_{V2} = 0.985$ $A_{VT} = -1.614$

32. A three stage RC coupled amplifier shown in figure 10 uses FET with following parameters: $g_m = 26mA/V$, $r_d = 7.7K\Omega$, $R_D = 10k\Omega$, $R_G = 100k\Omega$, $C_C = 0.005\mu F$. The total shunting capacitance C_P per stage is $100pF$. Find the overall midband voltage gain in decibels, and overall F_H and F_L for the three stages. Kindly note that C_C is coupling capacitor between two stages and C_P includes miller and parasitic capacitance. **[10]**

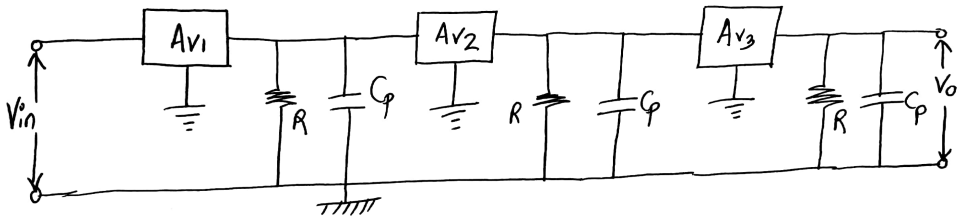

Figure 10: Question 32

Answers: $A_{VMID} = -108.39$ Overall $A_{VMID} = 122.09dB$ $f_L = 305.04Hz$ Overall $f_L = 598.3Hz$ $f_H = 381.76KHz$ Overall $f_H = 194.67KHz$

********** **MODULE 2.2** **********

Design of Cascade amplifiers

********** **********

33. Design a two stage RC coupled cascade amplifier for following specifications $A_V \geq 1600$ $V_{ORMS} = 2V$, $S \leq 8$, $f_L \geq 15Hz$. Use transistor BC 147A from data-sheet **[20]**

34. Design a two stage RC coupled cascade amplifier to meet the following specifications $A_V \geq 120$, $V_{ORMS} = 3V$, $I_{DSQ} = 1mA$, $R_i \geq 1M\Omega$. Select a suitable transistor from data-sheet **[20]**

35. Design a two stage RC coupled cascade amplifier for following specifications $A_V \geq 450$ $V_{CC} = 20V$, $S \leq 8$, $R_i \geq 1M\Omega$. Select a suitable transistor from data-sheet **[20]**

********** **MODULE 2** **********

Previous years Exam questions (ESE exam, IA, Mid term test)

********** **********

1. A two stage RC coupled amplifier circuit shown in figure 11, uses FET with following parameters: $g_m = 26mA/V$, $r_d = 7.7K\Omega$, $R_D = 10k\Omega$, $R_G = 100k\Omega$, $C_C = 0.005\mu F$. The total shunting capacitance C_P per stage is $100pF$. Find the overall midband voltage gain in decibels, and overall F_H and F_L for the two stages. Kindly note that C_C is coupling capacitor between two stages and C_P includes miller and parasitic capacitance **[10] [ESE]**

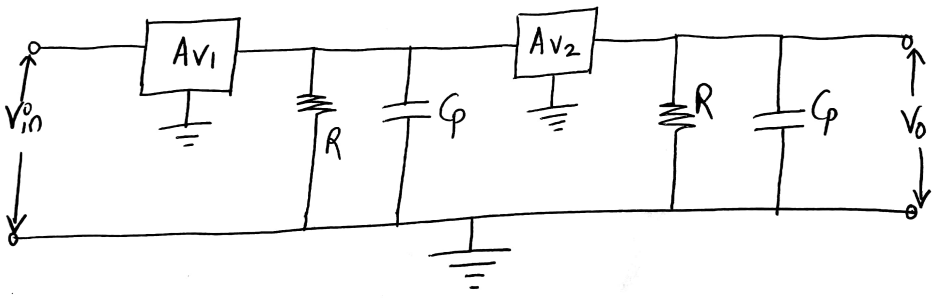

Figure 11: Question 1

Answers: $A_{VMID} = -108.39$ Overall $A_{VMID} = 81.4dB$ $f_L = 305.04Hz$
Overall $f_L = 473.95Hz$ $f_H = 381.76KHz$ Overall $f_H = 245.7KHz$

2. What is the significance of operating point and load line(DC/AC) in amplifiers. Give procedure to locate operating point of Cascade amplifier using its analysis. **[10] [ESE]**

3. Draw neat circuit diagram of Cascode amplifier. Derive expression for its A_V, Z_i & Z_o **[10] [ESE]**

4. Design a two stage CE-CE RC coupled amplifier having overall gain of 6000, lower cut-off frequency of 40 Hz and output voltage as 2.5 V (peak). Use transistor BC 147A **[20] [ESE]**

5. State and explain Darlington amplifier. Derive expressions for voltage gain, input and output impedance. State it's application **[10] [ESE]**

6. State the need of multistage amplifiers. Draw circuit diagram of two stage CE-CE BJT amplifier and derive expressions for R_i, R_o and A_V **[10] [ESE]**

7. For the circuit shown in figure 12. Determine V_{B1}, I_{C1}, A_V, Z_{in} & Z_o **[10]**
Given: $\beta 1 = \beta 2 = 100$, $V_{BE1} = V_{BE2} = 0.6V$ **[MT]**

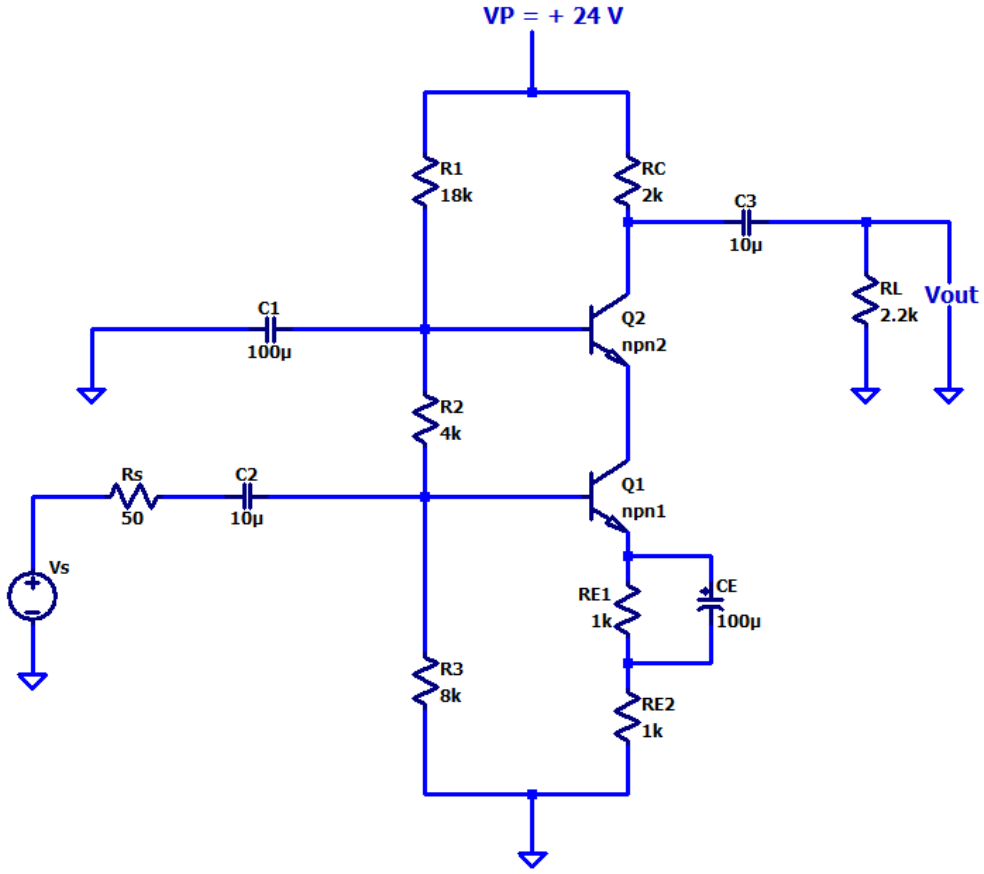

Figure 12: Question 7

Answers: $V_{B1} = 6.4V$ $V_{B2} = 9.6V$ $V_{E1} = 5.8V$ $I_{C1} = I_{E1} = 2.9mA$
$r_{\pi 1} = r_{\pi 2} = 896.55\Omega$ $g_{m1} = g_{m2} = 111.538mA/V$ $Z_{in} = 2.649k\Omega$ $Z_o = 1.047k\Omega$
$A_V = -1.017$

8. State advantages of Cascode amplifier and calculate the values of resistances R_C, R_1 and R_2 for circuit shown in figure 13. Assume $V_{CC} = 9V$, $R_3 = 18k\Omega$, $V_{C1} = 3V$, $V_{C2} = 6V$, $I_C = 1mA$, $R_E = 200\Omega$ **[10]** **[ESE]**

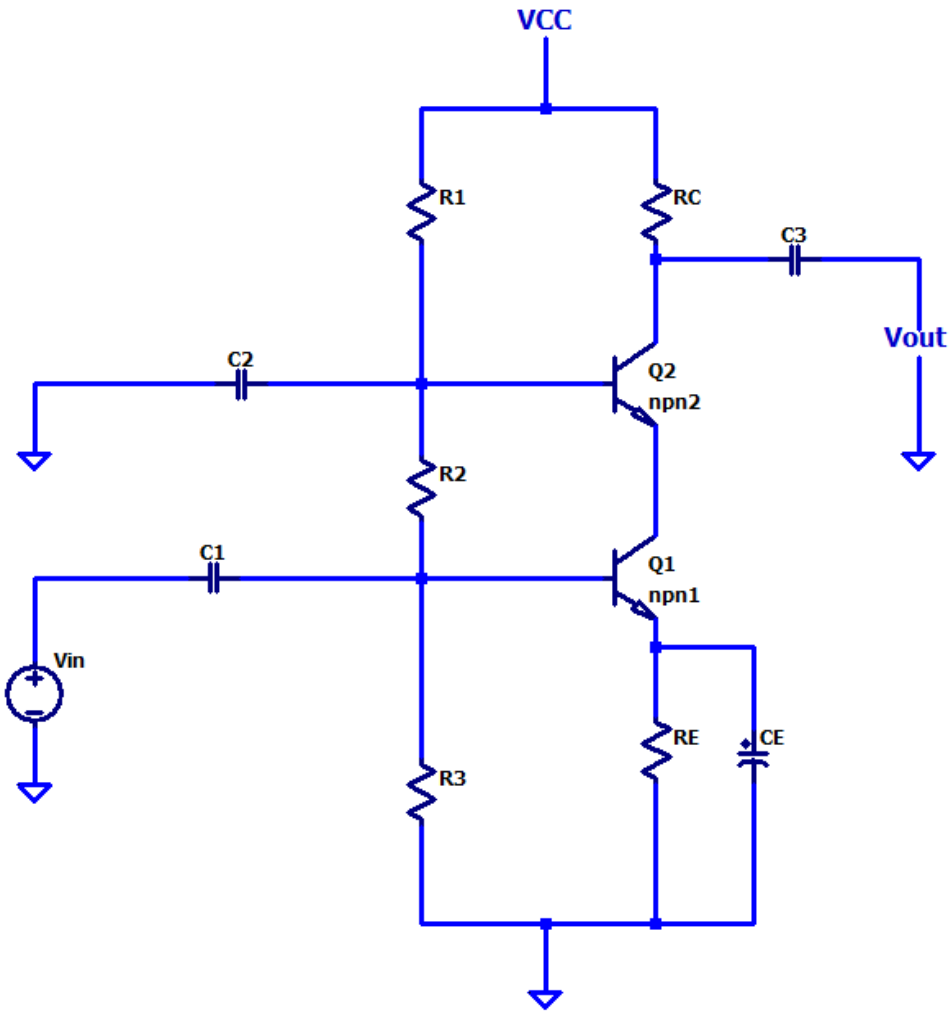

Figure 13: Question 8

Answers: $R_C = 3k\Omega$ $V_{E1} = 0.2V$ $V_{B1} = 0.9V$ $R_1 + R_2 = 162k\Omega$
$V_{E2} = V_{C1} = 3V$ $V_{B2} = 3.7V$ $R_2 = 56k\Omega$ $R_1 = 106k\Omega$

9. A two stage circuit is shown in figure 14, MOSFET parameters are $V_{TN1} = V_{TN2} = 5V$, **[10]**
$k_{n1} = k_{n2} = 0.12mA/V^2$, & $\lambda_1 = \lambda_2 = 0$ **[IA]**

a) Determine the Q point for both stages

b) Draw mid-frequency equivalent circuit

c) Calculate A_{V1} and A_{V2}

d) Calculate A_{VT} in dB

e) Calculate V_{out} if $V_s = 20mV$

f) Calculate Z_i and Z_o

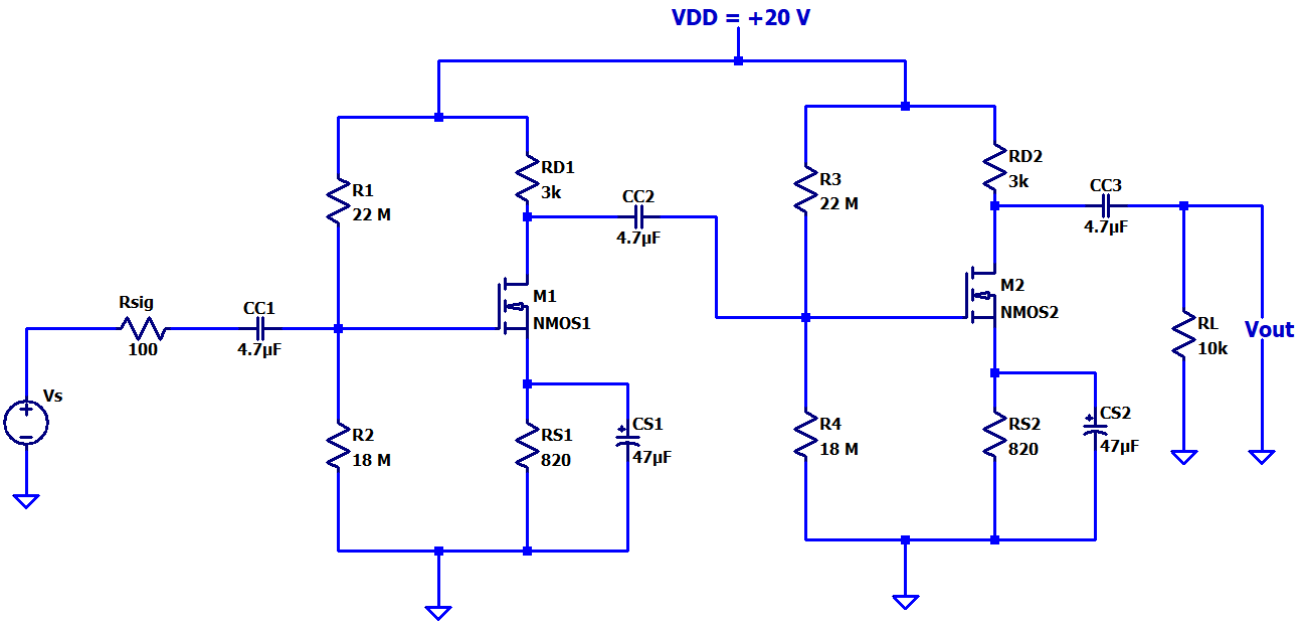

Figure 14: Question 9

10. A two stage circuit is shown in figure 15, BJT parameters are $V_{BE1} = V_{BE2} = 0.7V$, $\beta_1 = 250$, $\beta_2 = 220$ **[10]** **[IA]**

a) Determine the Q point for both stages

b) Draw mid-frequency equivalent circuit

c) Calculate A_{V1} and A_{V2}

d) Calculate A_{VT} in dB

e) Calculate V_{out} if $V_s = 2mV$

f) Calculate Z_i and Z_o

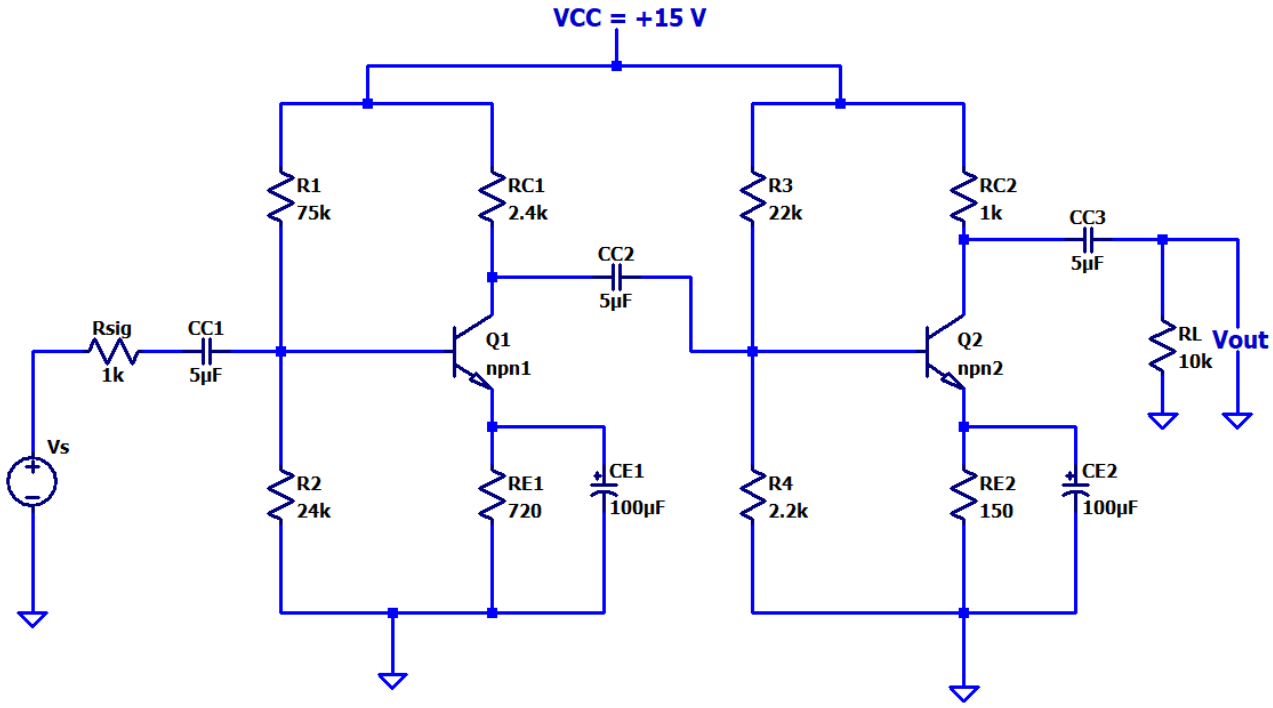

Figure 15: Question 10

11. A two stage circuit is shown in figure 16, BJT parameters are $V_{BE} = 0.7V$, $\beta = 200$, JFET parameters are $I_{DSS} = 10mA$, $V_P = -4V$ **[10]** **[IA]**

a) Determine the Q point for both stages **[MT]**

b) Draw mid-frequency equivalent circuit

c) Calculate A_{V1} and A_{V2}

d) Calculate A_{VT} in dB

e) Calculate V_{out} if $V_s = 1mV$

f) Calculate Z_i and Z_o

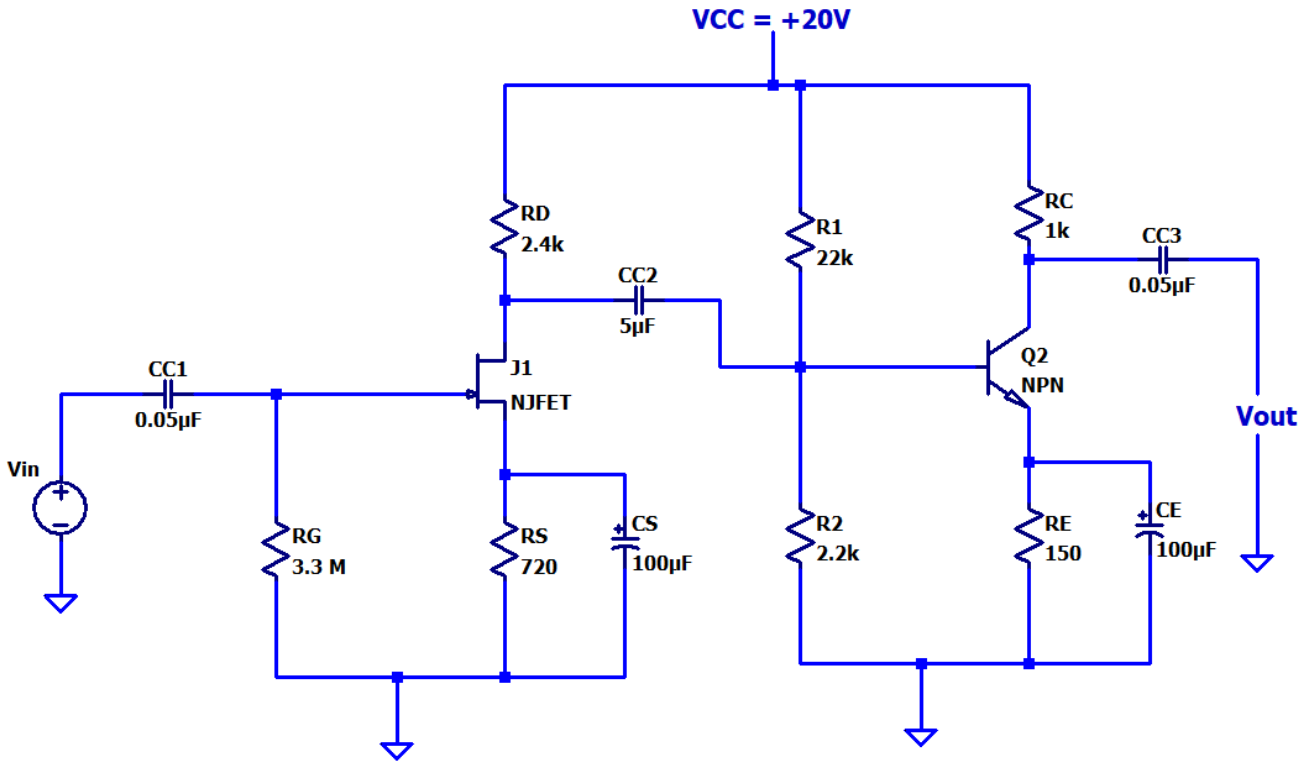

Figure 16: Question 11

12. Compare CE-CE and CS-CE cascade amplifier on the basis of **[05]** **[MT]**

a) Voltage gain

b) Input impedance

c) Bandwidth

d) Output impedance

13. A two stage circuit is shown in figure 17, BJT parameters are $V_{BE1} = V_{BE2} = 0.7V$, $\beta_1 = \beta_2 = 150$ **[10]** **[MT]**

a) Determine DC bias for each stages

b) Calculate A_{V1} and A_{V2}

c) Calculate A_{VT} in dB

d) Calculate V_{out} if $V_s = 25\mu V$

e) Calculate Z_i and Z_o

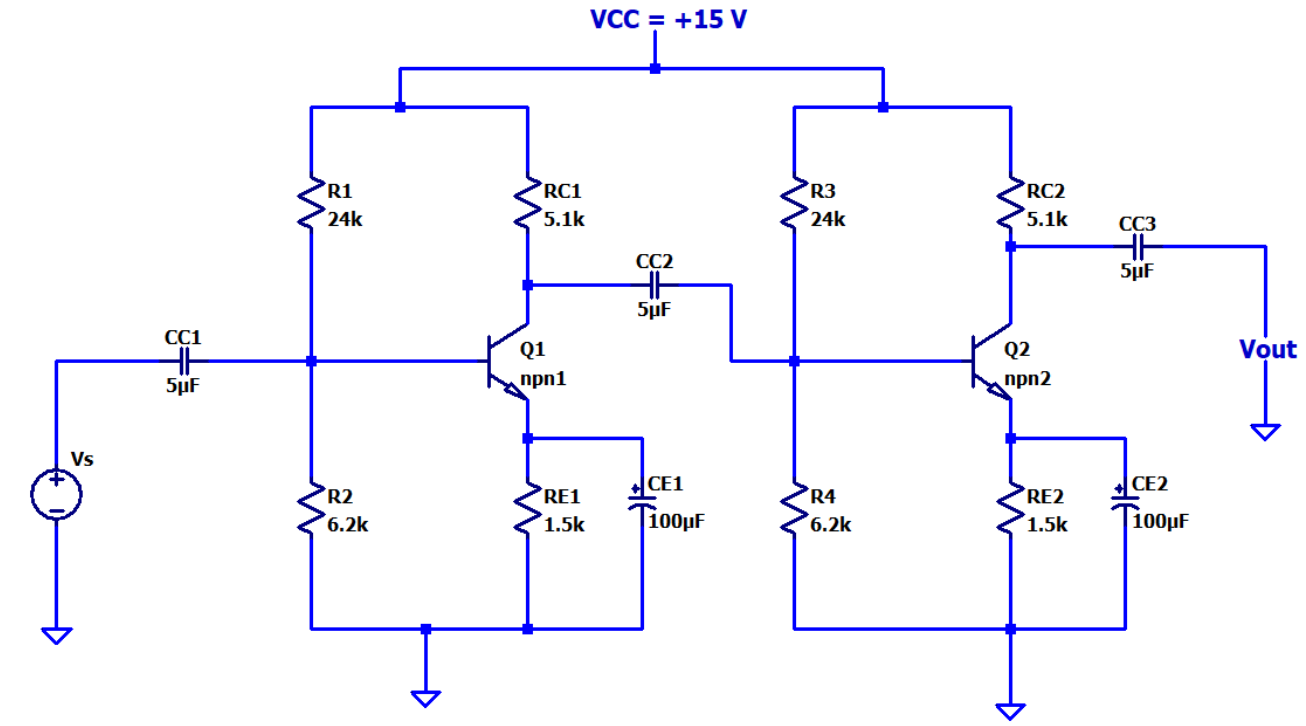

Figure 17: Question 13