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 1]**

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

********** **MODULE 1.1** **********

Introduction: Logarithms, Decibels, General frequency consideration.

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

1. Explain the following concepts with examples **[10]**
   a) Log scale
   b) Semi-log scale
   c) Decibels
   d) Cut-off frequency
   e) Bandwidth

2. Given the frequency response of Figure 1 **[05]**
   a) Find the lower cut-off frequency
   b) Find the higher cut-off frequency
   c) Find the mid-band voltage gain in dB
   d) Find the bandwidth of the response
   e) Redraw the frequency response of figure 1 and mark on it the lower and higher cut-off frequencies, mid-band gain in dB and bandwidth.

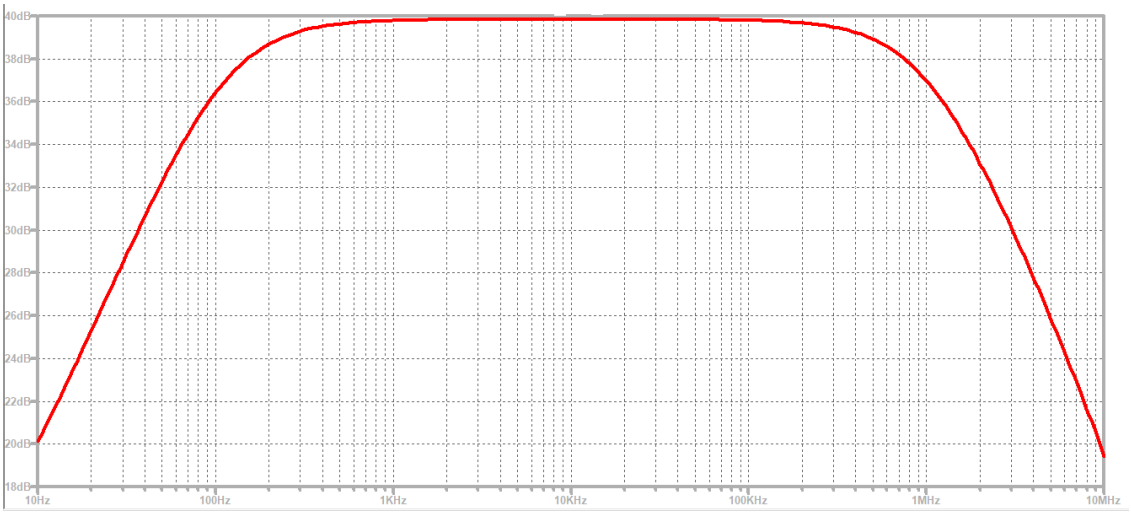

Figure 1: Question 2

3. Given the frequency response of Figure 2 **[05]**

a) Determine the break frequency

b) Sketch the frequency response curve

c) Locate the -3 dB point

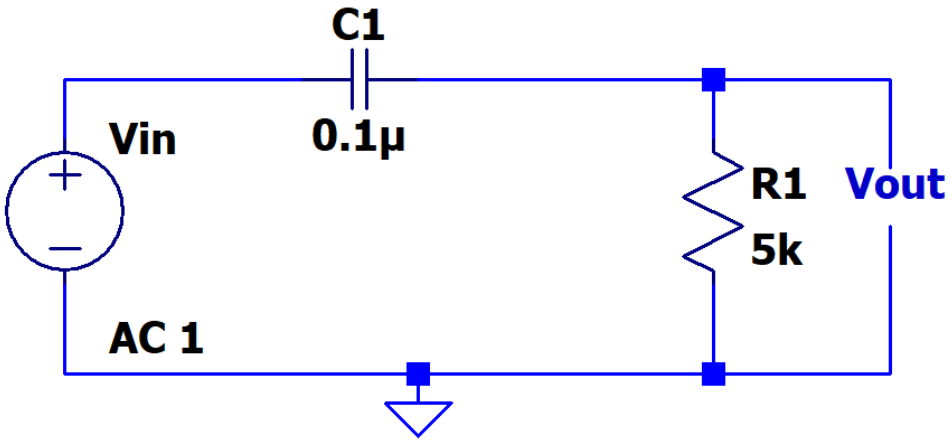

Figure 2: Question 3

********** **MODULE 1.2** **********

Low-frequency Response: Effect of capacitor (coupling, bypass, load) on frequency response of BJT, MOSFET amplifiers.

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

4. Draw the following with respect to Common emitter(CE) BJT amplifier with bypass capacitor C_E, load R_L and source resistance R_{sig} (use hybrid-pi model wherever necessary) **[05]**
   a) Circuit Diagram
   b) Low frequency equivalent circuit
   c) Mid frequency equivalent circuit

5. Explain the effect of coupling and bypass capacitors on frequency response of CE BJT amplifier **[05]**

6. A CE amplifier with transistor parameters $\beta = 100$, $V_{BE} = 0.7V$ is shown in figure 3 **[10]**
   a) Calculate the DC parameters I_{BQ} and I_{CQ}
   b) Calculate the hybrid π model parameters r_π and gm
   c) Calculate the lower cut-off frequency due to C_{C1}, C_{C2}, and C_E
   f) Calculate the overall lower cut-off frequency of the circuit
   g) Calculate the mid-band voltage gain in dB
   h) Plot the frequency response of the circuit

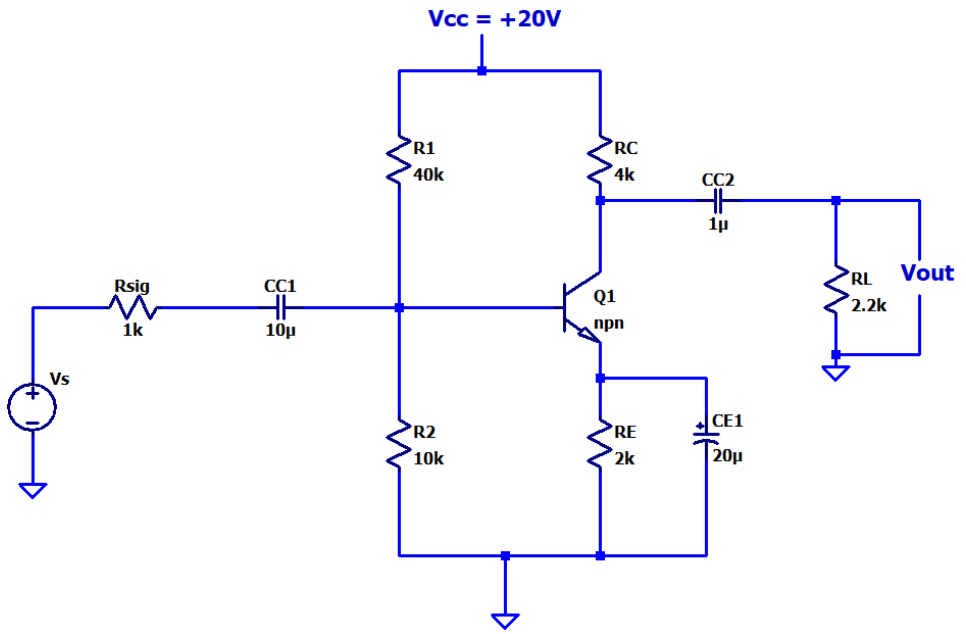

Figure 3: Question 6

Answers: $I_{BQ} = 15.7\mu A \quad I_{CQ} = 1.57mA \quad r_\pi = 1.65k\Omega \quad g_m = 60.4mA/V$
$f_{LCC1} = 6.71Hz \quad f_{LCC2} = 25.67Hz \quad f_{LCE} = 316.8Hz \quad f_L = 316.8Hz$
$A_{VMID} = 33.9dB$

7. Draw the following with respect to Common emitter(CE) BJT amplifier without by-pass capacitor C_E, with load R_L and with source resistance R_{sig} (use hybrid-pi model wherever necessary) **[05]**

   a) Circuit Diagram

   b) Low frequency equivalent circuit

   c) Mid frequency equivalent circuit

8. A CE amplifier with transistor parameters $\beta = 200$, $V_{BE} = 0.7V$ is shown in figure 4 **[10]**

   a) Calculate the lower cut-off frequency of the circuit

   b) Calculate the mid-band voltage gain in dB

   c) Plot the frequency response of the circuit

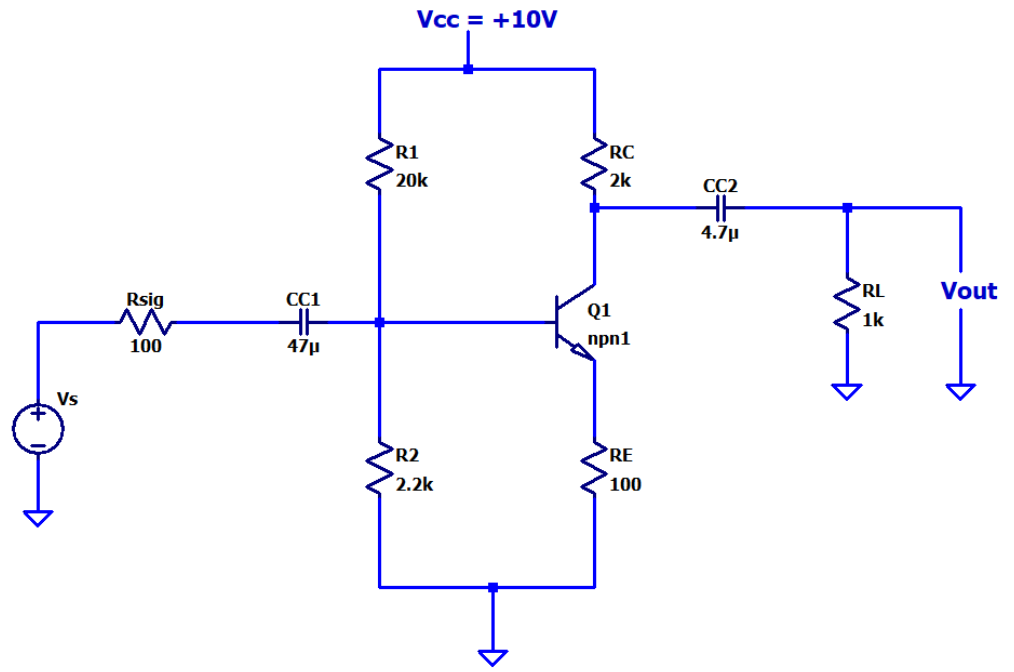

Figure 4: Question 8

Answers: $I_{BQ} = 13.58\mu A \quad I_{CQ} = 2.72mA \quad r_\pi = 1.91k\Omega \quad g_m = 104.61mA/V$
$f_{LCC1} = 1.76Hz \quad f_{LCC2} = 11.287Hz \quad f_L = 11.287Hz \quad A_{VMID} = 15.19dB$

9. A amplifier with transistor parameters $\beta = 100$, $V_{BE} = 0.7V$ is shown in figure 5 **[10]**

   a) Calculate the lower cut-off frequency of the circuit

   b) Calculate the mid-band voltage gain in dB

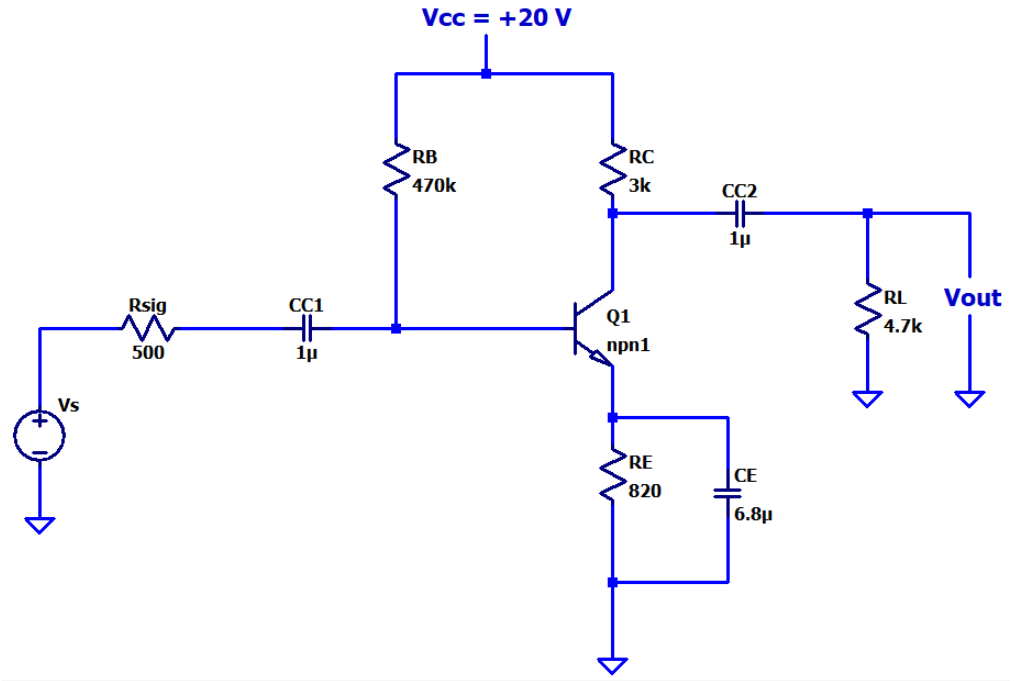

Figure 5: Question 9

Answers: $I_{BQ} = 34.91\mu A$ $I_{CQ} = 3.49mA$ $r_\pi = 744.98\Omega$ $g_m = 134.23mA/V$
$f_{LCC1} = 127.95Hz$ $f_{LCC2} = 20.67Hz$ $f_{LCE} = 1909.99Hz$ $f_L = 1909.99Hz$
$A_{VMID} = 43.34dB$

10. Draw the following with respect to Common collector(CC) BJT amplifier with load R_L and with source resistance R_{sig} (use hybrid-pi model wherever necessary) **[05]**

    a) Circuit Diagram

    b) Low frequency equivalent circuit

    c) Mid frequency equivalent circuit

11. Explain the effect of coupling capacitors on frequency response of CC BJT amplifier **[05]**

12. A amplifier with transistor parameters $\beta = 100$, $V_{BE} = 0.7V$ is shown in figure 6 **[10]**

    a) Calculate the lower cut-off frequency of the circuit

    b) Calculate the mid-band voltage gain

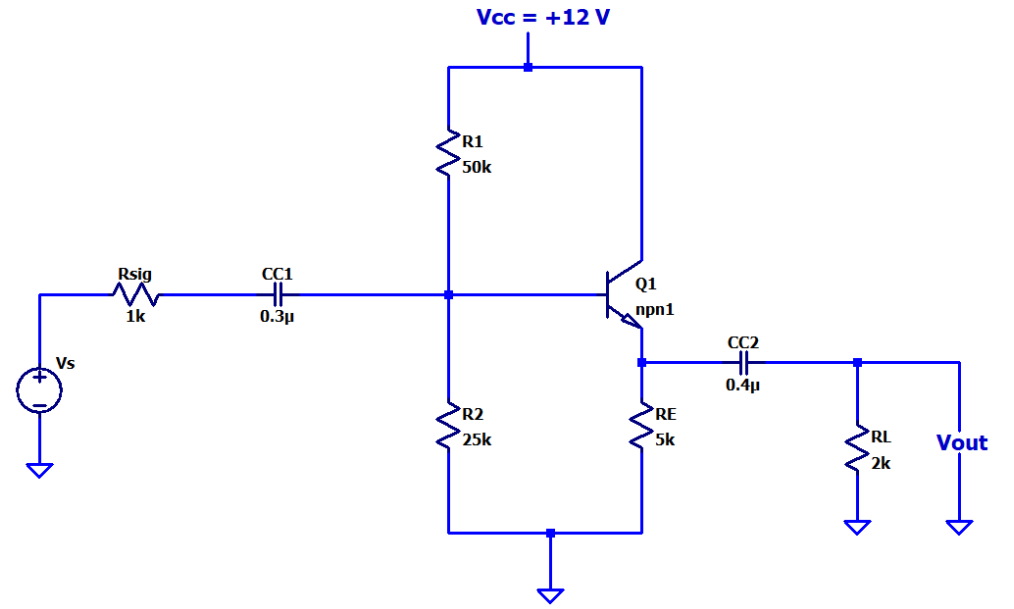

Figure 6: Question 12

Answers: $I_{BQ} = 6.325\mu A \quad I_{CQ} = 0.6325mA \quad r_\pi = 4.11k\Omega \quad g_m = 24.37mA/V$
$f_{LCC1} = 33.2Hz \quad f_{LCC2} = 194.08Hz \quad f_L = 194.08Hz \quad A_{VMID} = 0.911$

13. Draw the following with respect to Common source(CS) E-MOSFET amplifier with bypass capacitor C_S, load R_L and source resistance R_{sig} **[05]**

    a) Circuit Diagram

    b) Low frequency equivalent circuit

    c) Mid frequency equivalent circuit

14. Explain the effect of coupling and bypass capacitors on frequency response of CS E-MOSFET amplifier **[05]**

15. A Common source (CS) E-MOSFET amplifier with transistor parameters $V_{GS(TH)} = 5V$, $V_{GS(ON)} = 10V$, $I_{D(ON)} = 3mA$ is shown in figure 7 **[10]**

a) Calculate the lower cut-off frequency of the circuit

b) Calculate the mid-band voltage gain in dB

c) Plot the frequency response of the circuit

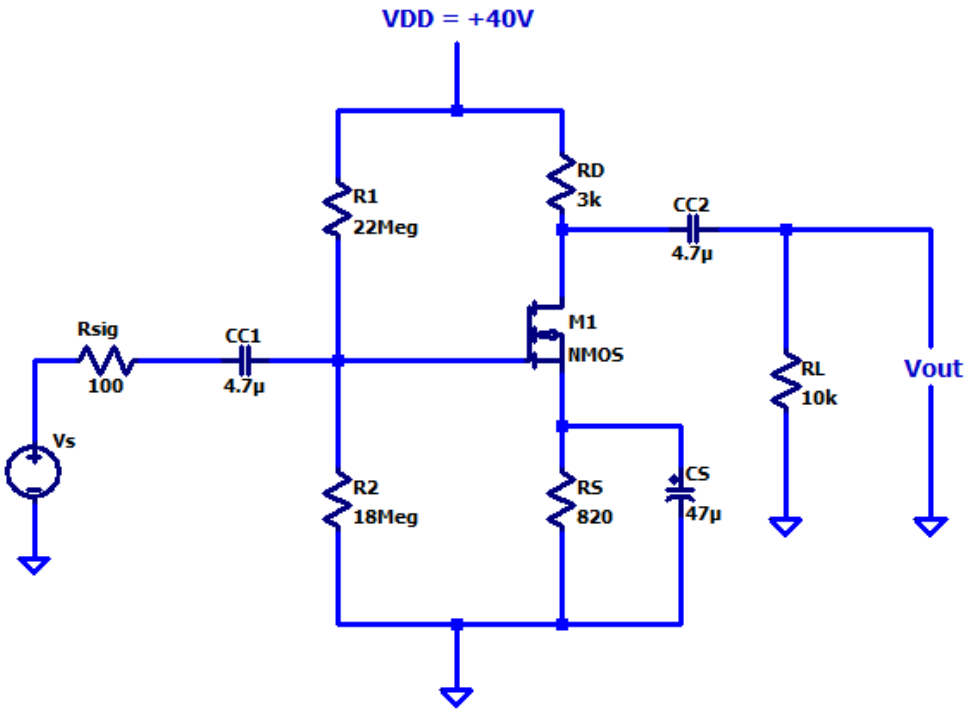

Figure 7: Question 15

Answers: $k_n = 0.12mA/V^2$ $V_{GSQ} = 12.485V$ $I_{DQ} = 6.723mA$ $g_m = 1.796mA/V$
$f_{LCC1} = 0.0034Hz$ $f_{LCC2} = 2.6Hz$ $f_{LCS} = 10.21Hz$ $f_L = 10.21Hz$
$A_{VMID} = -4.146$

16. A E-MOSFET amplifier with transistor parameters $V_{GS(TH)} = 3V$, $V_{GS(ON)} = 8V$, $I_{D(ON)} = 6mA$, $r_d = 50k\Omega$ is shown in figure 8 **[10]**

    a) Calculate the lower cut-off frequency of the circuit

    b) Calculate the mid-band voltage gain in dB

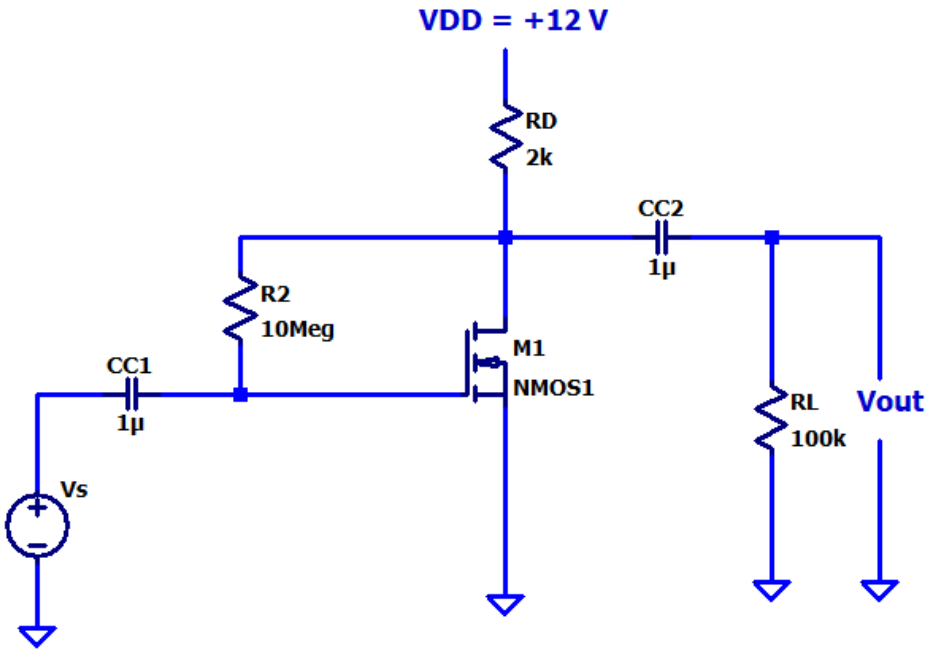

Figure 8: Question 16

Answers: $k_n = 0.24mA/V^2$ $V_{GSQ} = 6.4V$ $I_{DQ} = 2.77mA$ $g_m = 1.63mA/V$
$f_{LCC1} = 15.91mHz$ $f_{LCC2} = 1.57Hz$ $f_L = 1.57Hz$ $A_{VMID} = -3.26$

17. Explain the effect of load capacitor on frequency response of CE BJT amplifier **[05]**

18. Explain the effect of load capacitor on frequency response of CS MOSFET amplifier **[05]**

19. For the circuit shown in figure 9 below, JFET parameters are $I_{DSS} = 8mA$, $V_P = -4V$, $r_d = \infty$ **[05]**

    a) Find the lower cut-off frequency

    b) Plot its frequency response

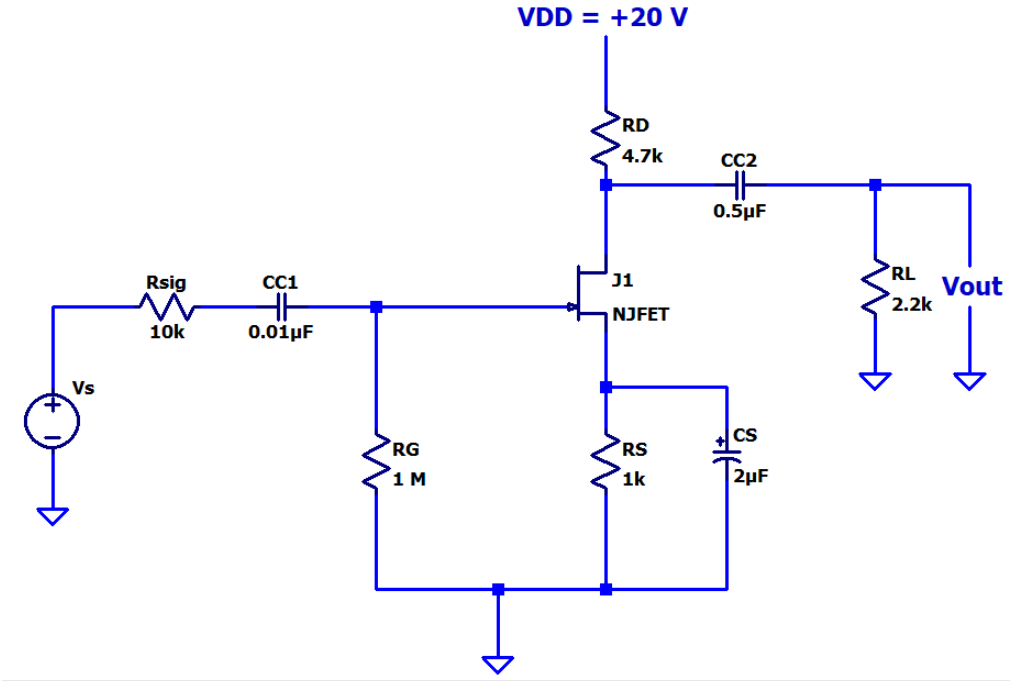

Figure 9: Question 19

Answers: $V_{GSQ} = -2V$ $I_{DQ} = 2mA$ $g_m = 2mA/V$ $f_{LCC1} = 15.76Hz$ $f_{LCC2} = 46.13Hz$ $f_{LCS} = 238.73Hz$ $f_L = 238.73Hz$ $A_{VMID} = -2.96$

20. Why gain of RC coupled amplifier falls in low frequency range **[05]**

********** **MODULE 1.3** **********

High-frequency Response: High frequency equivalent hybrid-pi model, Miller effect and miller capacitance, unity gain bandwidth, high frequency response of BJT and MOSFET amplifiers.

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

21. Draw high frequency model of (npn) Bipolar transistor. Explain the significance of various components in it **[05]**

22. Explain Miller effect. Derive the expressions of input miller capacitance and output miller capacitance for an amplifier with gain A_V **[05]**

23. Draw the following with respect to Common emitter(CE) BJT amplifier , considering various parasitic and wiring capacitance **[05]**
    a) Circuit Diagram
    b) High frequency equivalent circuit

24. Explain the effect of parasitic or inter-electrode capacitance and wiring capacitance on frequency response of CE BJT amplifier **[05]**

25. Explain high frequency response of CE BJT amplifier **[10]**

26. Draw the following with respect to E-MOSFET CS amplifier , considering various parasitic and wiring capacitance **[05]**
    a) Circuit Diagram
    b) High frequency equivalent circuit

27. Explain the effect of parasitic or inter-electrode capacitance and wiring capacitance on frequency response of E-MOSFET CS amplifier **[05]**

28. Explain high frequency response of CS MOSFET amplifier **[10]**

29. A CE amplifier with transistor parameters $\beta = 100$, $V_{BE} = 0.7V$ is shown in figure 10. **[15]** The various parasitic capacitance of the transistor are C_π $(C_{be}) = 36pF$, C_μ $(C_{bc}) = 4pF$, C_{ce} $(C_{cb}) = 1pF$ and the wiring capacitance are $C_{wi} = 6pF$, $C_{wo} = 8pF$

a) Calculate the lower cut-off frequency of the circuit

b) Calculate the higher cut-off frequency of the circuit

c) Calculate the mid-band voltage gain in dB

d) Plot the complete frequency response of the circuit on semi-log paper

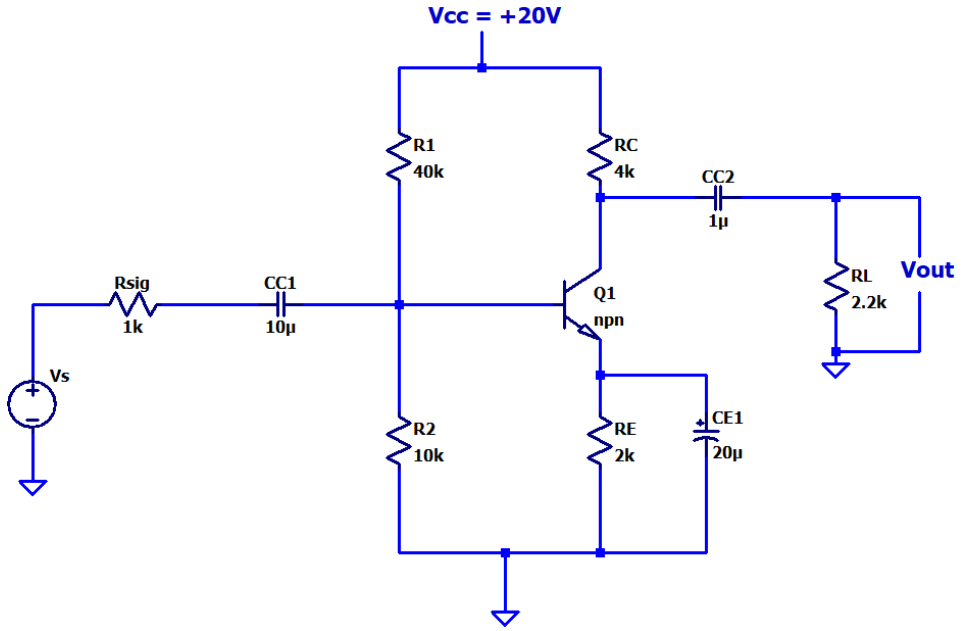

Figure 10: Question 29

Answers: $I_{BQ} = 15.7\mu A$ $I_{CQ} = 1.57mA$ $r_\pi = 1.65k\Omega$ $g_m = 60.4mA/V$
$f_{LCC1} = 6.71Hz$ $f_{LCC2} = 25.67Hz$ $f_{LCE} = 316.8Hz$ $f_L = 316.8Hz$
$A_{VMID} = 33.9dB$ $C_{mi} = 202.24pF$ $C_{mo} = 4.04pF$ $C_i = 244.24pF$
$C_o = 13.04pF$ $f_{Hi} = 1.127MHz$ $f_{Ho} = 8.6MHz$ $f_H = 1.127MHz$

30. A MOSFET CS amplifier with transistor parameters $V_{TN} = 0.8V$, $k_n = 1mA/V^2$ is shown in figure 11. The various parasitic capacitance of the transistor are $C_{gs} = 2pF$ and $C_{gd} = 0.2pF$ **[10]**

a) Calculate the higher cut-off frequency of the circuit

b) Calculate the mid-band voltage gain

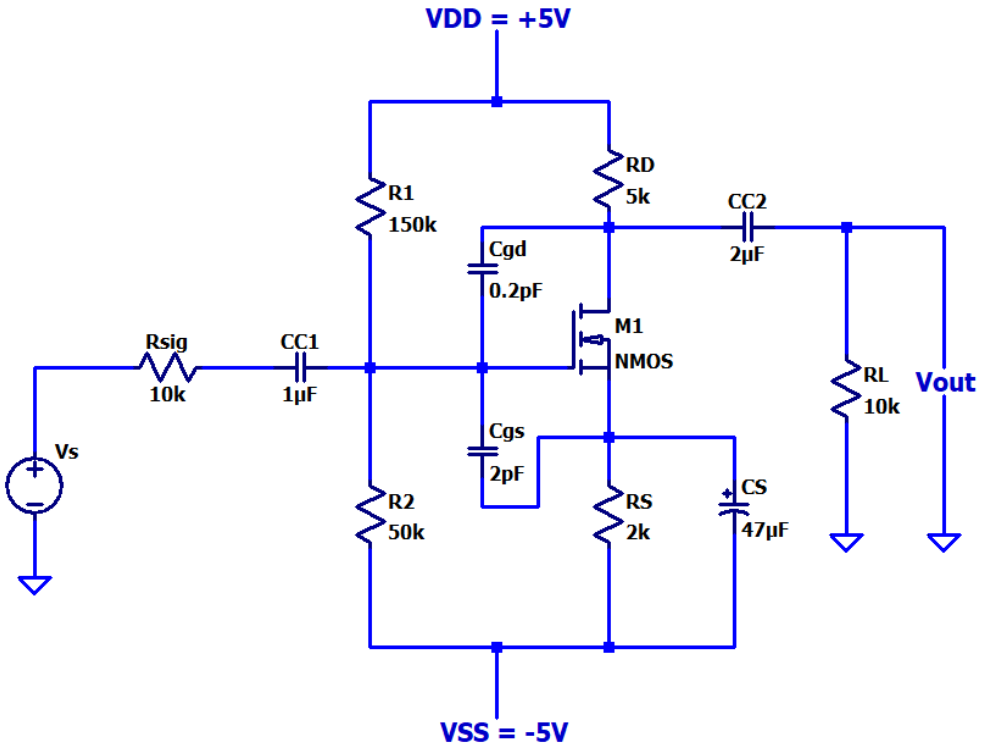

Figure 11: Question 30

Answers: $I_{DQ} = 0.49mA$ $V_{GSQ} = 1.5V$ $g_m = 1.4mA/V$ $A_{VMID} = -3.684$ $C_{mi} = 0.9368pF$ $C_{mo} = 0.254pF$ $C_i = 2.9368pF$ $C_o = 0.254pF$ $f_{Hi} = 6.86MHz$ $f_{Ho} = 187.99MHz$ $f_H = 6.86MHz$

31. Draw high frequency model of N channel MOSFET. Explain the significance of various components in it **[05]**

32. Derive the expression of unity gain bandwidth (f_T) for MOSFET **[05]**

33. Explain how miller capacitance affects the high frequency response of MOSFET amplifier. **[05]**

34. For the circuit shown in figure 12 below, JFET parameters are $I_{DSS} = 8mA$, $V_P = -4V$, $r_d = \infty$. The various parasitic capacitance are $C_{gd} = 2pF$, $C_{ds} = 0.5pF$, $C_{gs} = 4pF$, $C_{wi} = 5pF$, $C_{wo} = 6pF$ **[10]**

a) Find the higher cut-off frequency

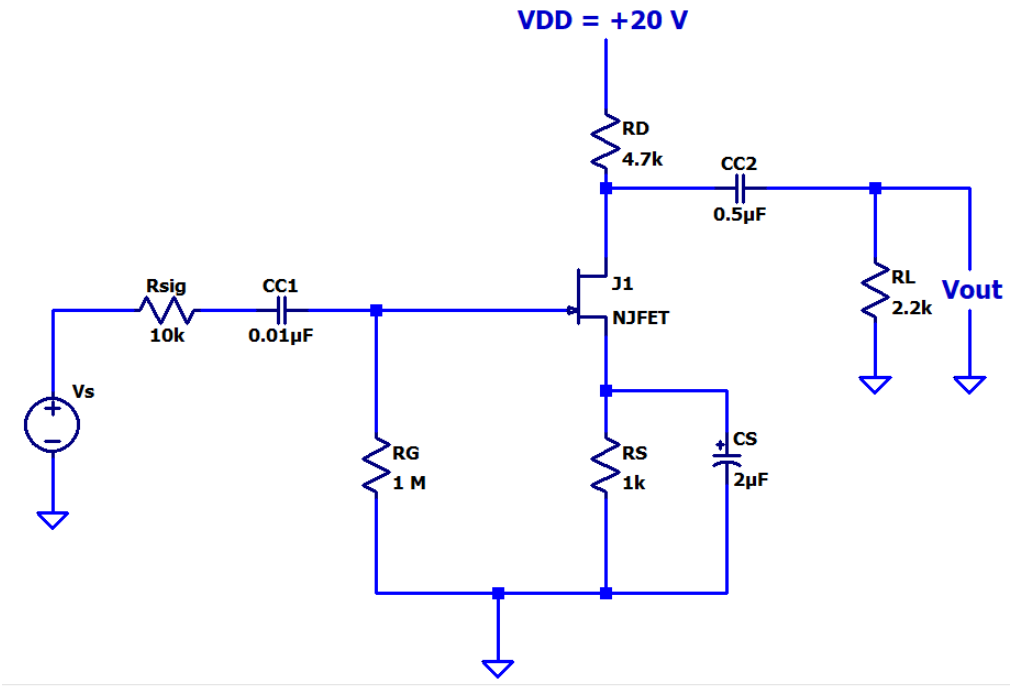

Figure 12: Question 34

Answers: $V_{GSQ} = -2V$ $I_{DQ} = 2mA$ $g_m = 2mA/V$ $A_{VMID} = -2.96$
$C_{mi} = 7.92pF$ $C_{mo} = 2.675pF$ $C_i = 16.92pF$ $C_o = 9.175pF$ $f_{Hi} = 950.13KHz$
$f_{Ho} = 11.579MHz$ $f_H = 11.579MHz$

35. Why gain of RC coupled amplifier falls in high frequency range **[05]**

36. A BJT with $I_c = 1mA$, $C_\pi = 4pF$, $C_\mu = 0.5pF$. Find f_β & f_T **[05]**

Answers: $f_\beta = 9.09MHz$ $f_T = 1.36GHz$

37. Why bandwidth of CB configuration is higher than that of CE configuration **[05]**

38. For NMOS, $k_n = 0.2mA/V^2$, $V_{TN} = 1V$, $C_{gd} = 0.02pF$, $C_{gs} = 0.25pF$, $I_D = 0.4mA$ **[05]**
Find f_T

Answers: $f_T = 335MHz$

********** **MODULE 1** **********

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

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

1. For the Common emitter amplifier shown in figure 13, the parameters of the transistor are $\beta = 100$, $V_{BE} = 0.7V$ and $V_A = \infty$. Internal capacitance of transistors are $C_{be} = 36pF$, $C_{bc} = 4pF$, $C_{ce} = 1pF$ and wiring capacitance are $C_{wi} = 6pF$, $C_{wo} = 8pF$ **[20]** **[IA]**

   a) Draw the three equivalent circuits that represent the amplifier in the low-frequency range, mid-band range, and the high frequency range

   b) Calculate the value of mid band gain in dB

   c) Calculate the value of lower cut-off frequency

   d) Calculate the value of higher cut-off frequency

   e) Sketch the complete frequency response in semi-log paper

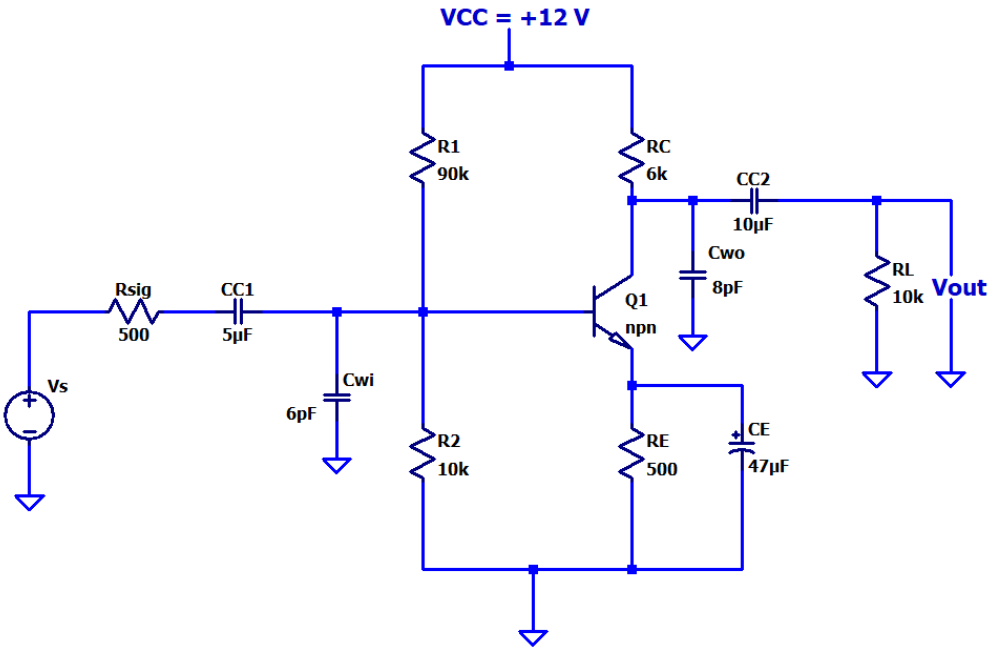

Figure 13: Question 1

2. Derive the expression for lower cut-off frequency of BJT amplifier. Hence explain how the frequency response is affected by different components. **[10]** **[ESE]**

3. Derive the expression for f_β and f_T **[10]** **[ESE]**

4. The parameters of the transistor in the circuit shown in figure 14 are $\beta = 100$, $V_{BE} = 0.7V$ and $V_A = \infty$. Neglect the capacitance effects of the transistor. **[20] [IA]**

   a) Draw the three equivalent circuits that represent the amplifier in the low-frequency range, mid-band range, and the high frequency range

   b) Determine the values of mid band gain in dB, lower cut-off frequency and higher cut-off frequency

   c) Sketch the complete frequency response in semi-log paper

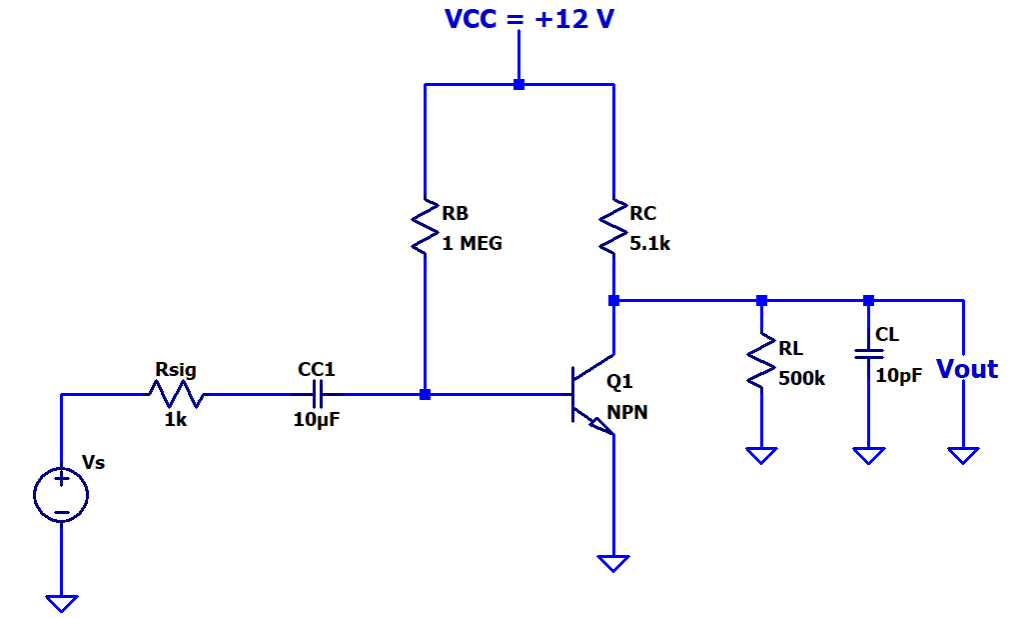

Figure 14: Question 4

5. Explain the procedure to find the lower cut-off frequency for CS amplifier **[05] [ESE]**

6. A MOSFET CS amplifier with transistor parameters $V_{TN} = 0.8V$, $k_n = 1mA/V^2$ is shown in figure 15. The various parasitic capacitance of the transistor are $C_{gs} = 20pF$ and $C_{gd} = 2pF$ **[20]** **[IA]**

   a) Calculate the lower 3 dB frequency

   b) Calculate the mid-band voltage gain

   c) Calculate the higher 3 dB frequency

   d) Sketch the complete frequency response in semi-log paper

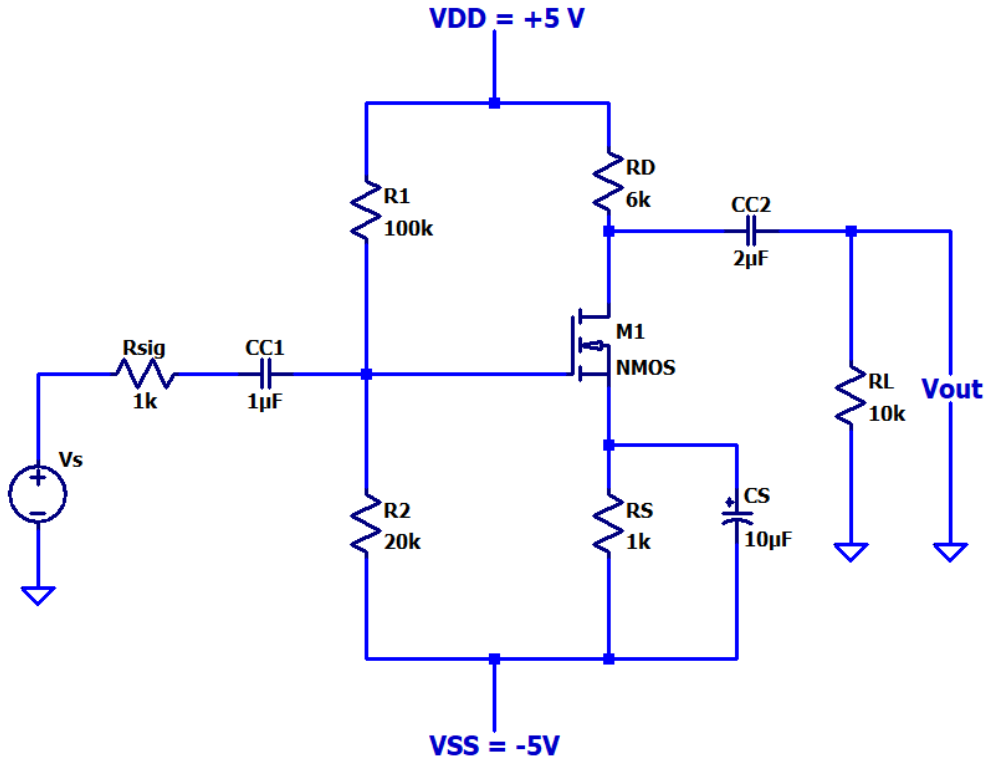

Figure 15: Question 6

7. The parameters of the transistor in the circuit shown in figure 16 are $\beta = 100$, $V_{BE} = 0.7V$ and $V_A = \infty$. **[10]** **[IA]**

   a) Calculate the lower 3 dB frequency

   b) Calculate the mid-band voltage gain

   c) Sketch the low frequency response in semi-log paper

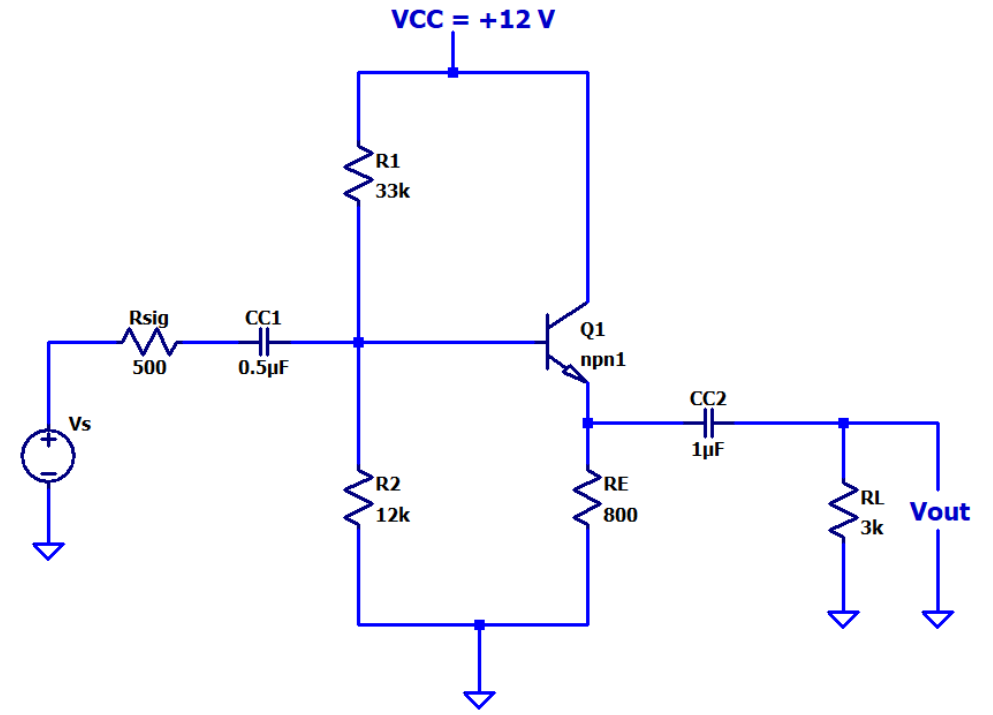

Figure 16: Question 7

8. BJT amplifier given below in figure 17, have $\beta = 120$, $V_{BE} = 0.7V$, $C_{be} = 40pF$, $C_{bc} = 12pF$, $C_{ce} = 8pF$, $C_{wi} = 5pF$, $C_{wo} = 8pF$ **[10]** **[MT]**

a) Determine A_{VMID} and A_{VSMID}

b) Determine lower cut-off frequency

c) Determine higher cut-off frequency

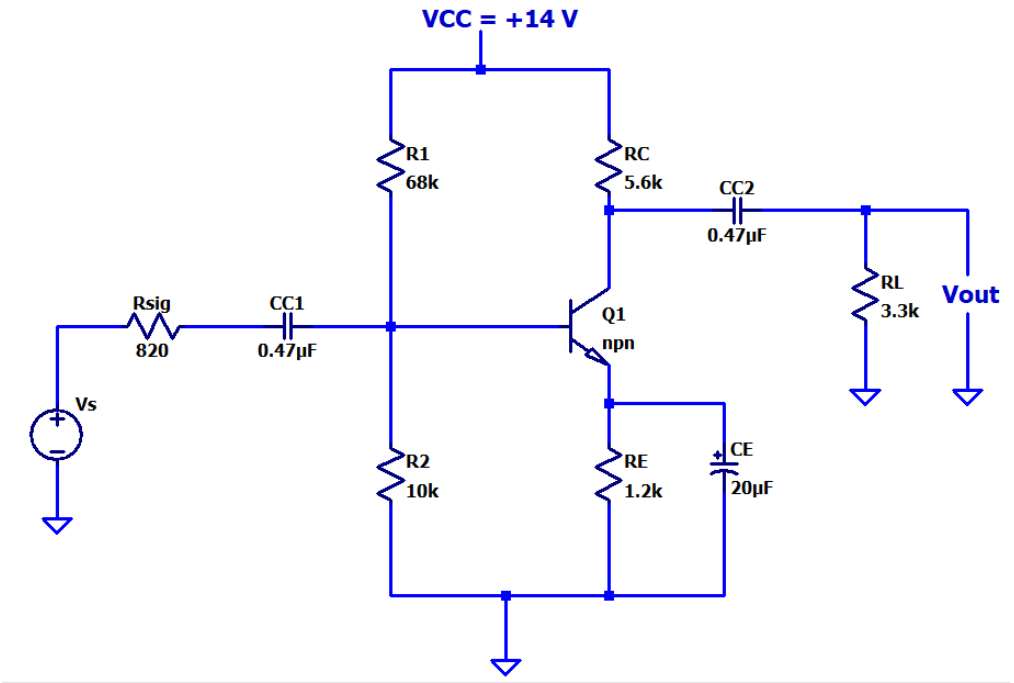

Figure 17: Question 8

9. The circuit given below in figure 18, have $\beta = 100$, $V_{BE} = 0.7V$, $C_{be} = 30pF$, $C_{bc} = 2pF$, $C_{ce} = 5pF$, $C_{wi} = 8pF$, $C_{wo} = 4pF$ **[10]** **[ESE]**

   a) Determine mid frequency voltage gain

   b) Determine f_{Hi}

   c) Determine f_{Ho}

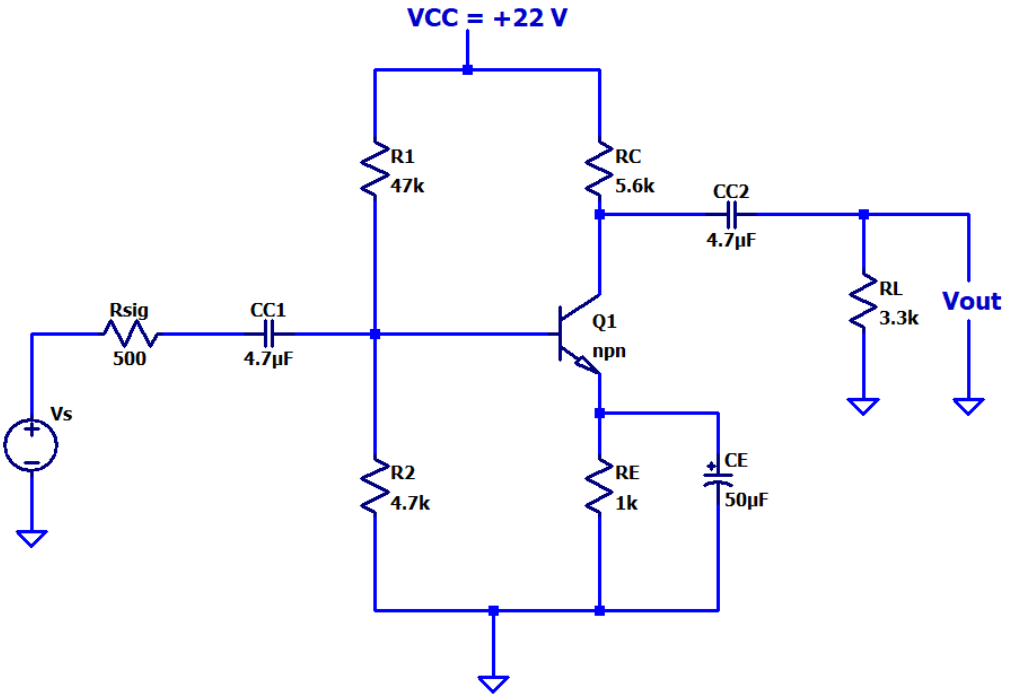

Figure 18: Question 9

Answers: $I_{BQ} = 12.35\mu A$ $I_{CQ} = 1.235mA$ $r_\pi = 2.1k\Omega$ $g_m = 47.5mA/V$
$A_{VMID} = -72.81$ $C_{mi} = 147.62pF$ $C_{mo} = 2.027pF$ $C_i = 185.62pF$
$C_o = 11.027pF$ $f_{Hi} = 2.32MHz$ $f_{Ho} = 6.95MHz$

10. A single stage CS JFET amplifier is shown in figure 19. Given: $I_{DSS} = 8mA$, $V_P = -4V$, $r_d = \infty$, $C_{ds} = 3pF$, $C_{gs} = 10pF$, $C_{gd} = 4pF$, $C_{wi} = 5pF$, $C_{wo} = 6pF$ **[20]** **[ESE]**

    a) Determine and plot complete frequency response(Low and High) of the circuit

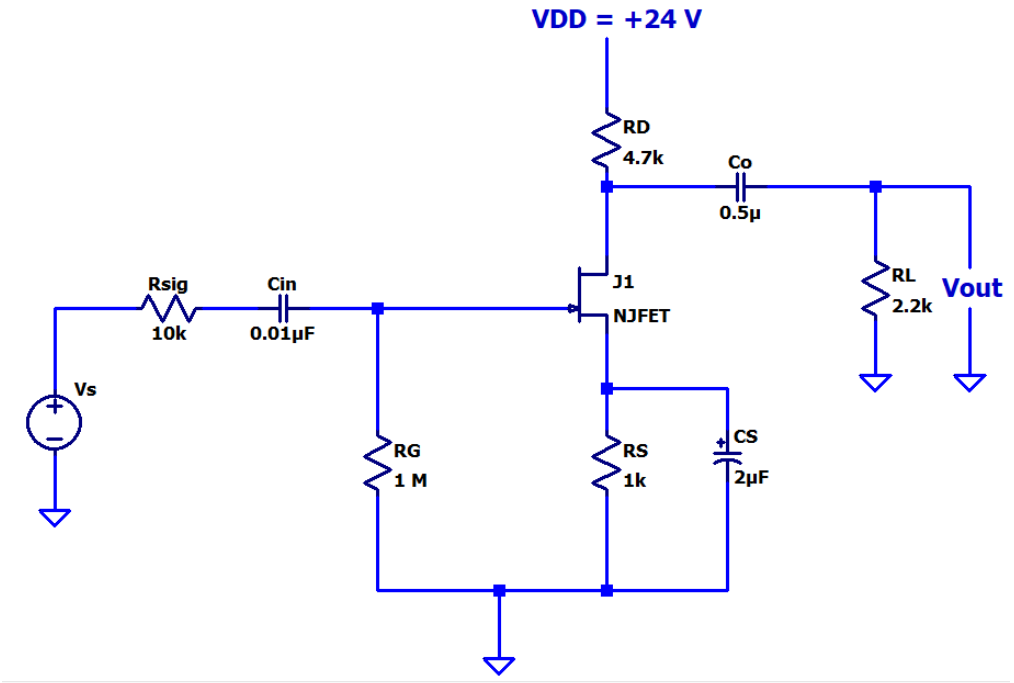

Figure 19: Question 10

Answers: $V_{GSQ} = -2V$ $I_{DQ} = 2mA$ $g_m = 2mA/V$ $A_{VMID} = -2.97$
$f_{LCin} = 15.76Hz$ $f_{LCo} = 46.13Hz$ $f_{LCs} = 238.73Hz$ $f_L = 238.73Hz$
$C_{mi} = 15.88pF$ $C_{mo} = 5.35pF$ $C_i = 30.88pF$ $C_o = 14.35pF$
$f_{Hi} = 520.6KHz$ $f_{Ho} = 7.404MHz$ $f_H = 520.6KHz$

11. Explain how high frequency response of single stage RC coupled JFET CS type amplifier can be determined. **[10]** **[ESE]**

12. For the JFET amplifier shown in figure 20. Given: $I_{DSS} = 6mA$, $V_P = -6V$, $r_d = \infty$, $C_{ds} = 1pF$, $C_{gs} = 6pF$, $C_{gd} = 4pF$, $C_{wi} = 3pF$, $C_{wo} = 5pF$ **[10]** **[MT]**

    a) Determine low cutoff frequency

    b) Determine high cutoff frequency

    c) Determine gain bandwidth product

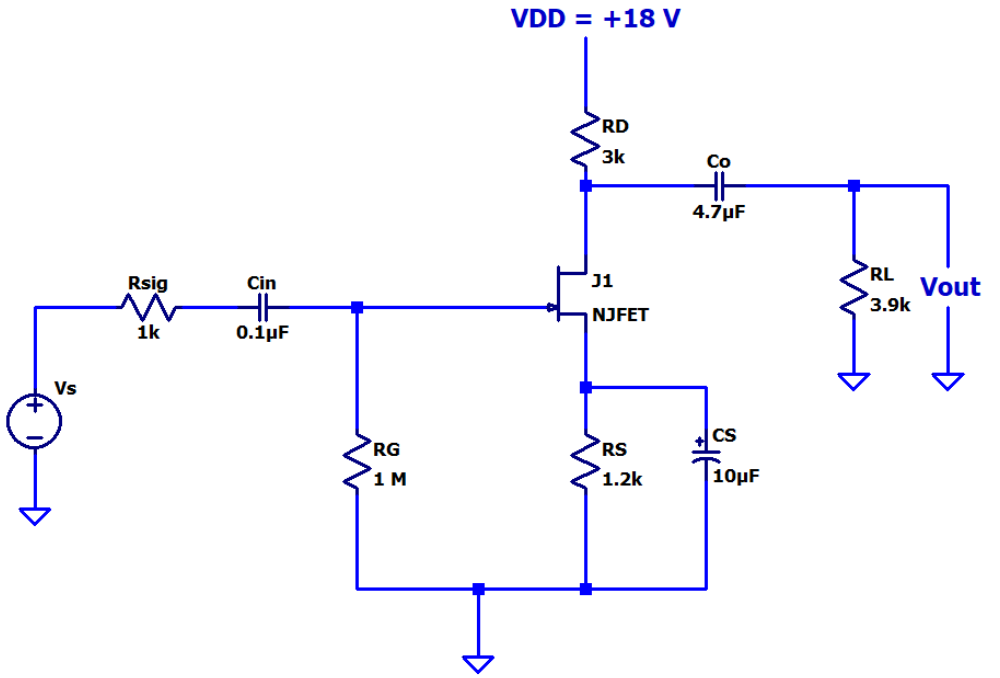

Figure 20: Question 12

Answers: $V_{GSQ} = -2.52V$ $I_{DQ} = 2.1mA$ $g_m = 1.16mA/V$ $A_{VMID} = -2$
$f_{LCin} = 1.59Hz$ $f_{LCo} = 4.91Hz$ $f_{LCs} = 32.04Hz$ $f_L = 32.04Hz$
$C_{mi} = 12pF$ $C_{mo} = 6pF$ $C_i = 21pF$ $C_o = 12pF$
$f_{Hi} = 7.586MHz$ $f_{Ho} = 7.847MHz$ $f_H = 7.586MHz$
$Bandwidth = 7.585MHz$ $GBP = 15.17MHz$

13. For the JFET amplifier shown in figure 21. Given: $I_{DSS} = 8mA$, $V_P = -4V$ **[10]**
    a) Find the lower cut-off frequency **[ESE]**

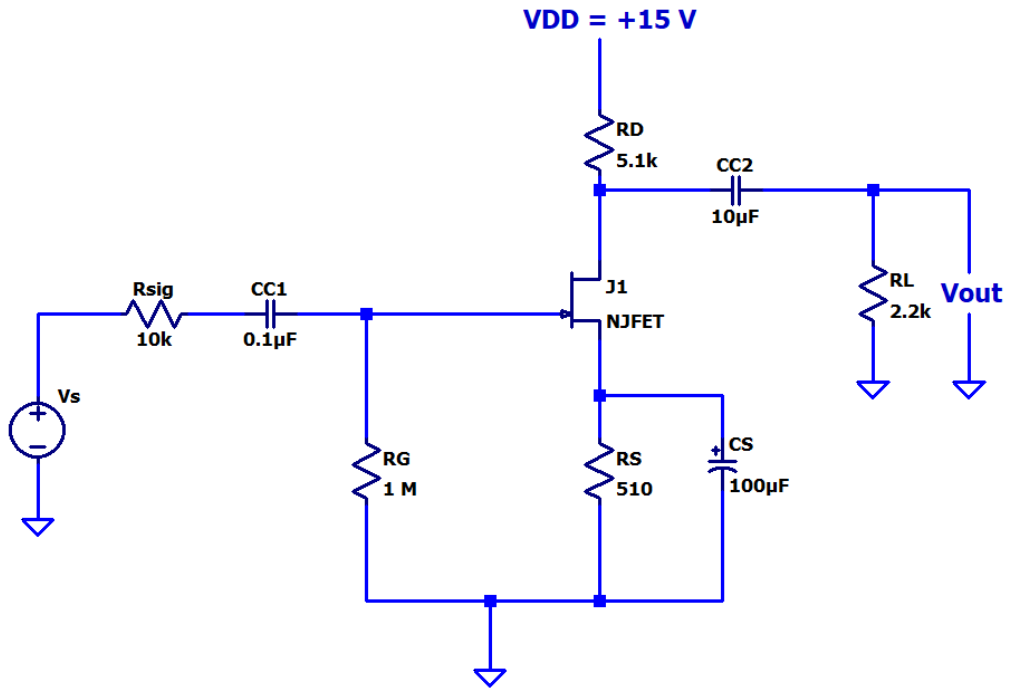

Figure 21: Question 13

Answers: $V_{GSQ} = -1.54V$ $I_{DQ} = 3.026mA$ $g_m = 2.46mA/V$ $f_{LCC1} = 1.576Hz$ $f_{LCC2} = 2.18Hz$ $f_{LCS} = 7.03Hz$ $f_L = 7.03Hz$

14. For the given circuit shown in figure 22, plot DC/AC load line and find the operating point **[10]** **[ESE]**

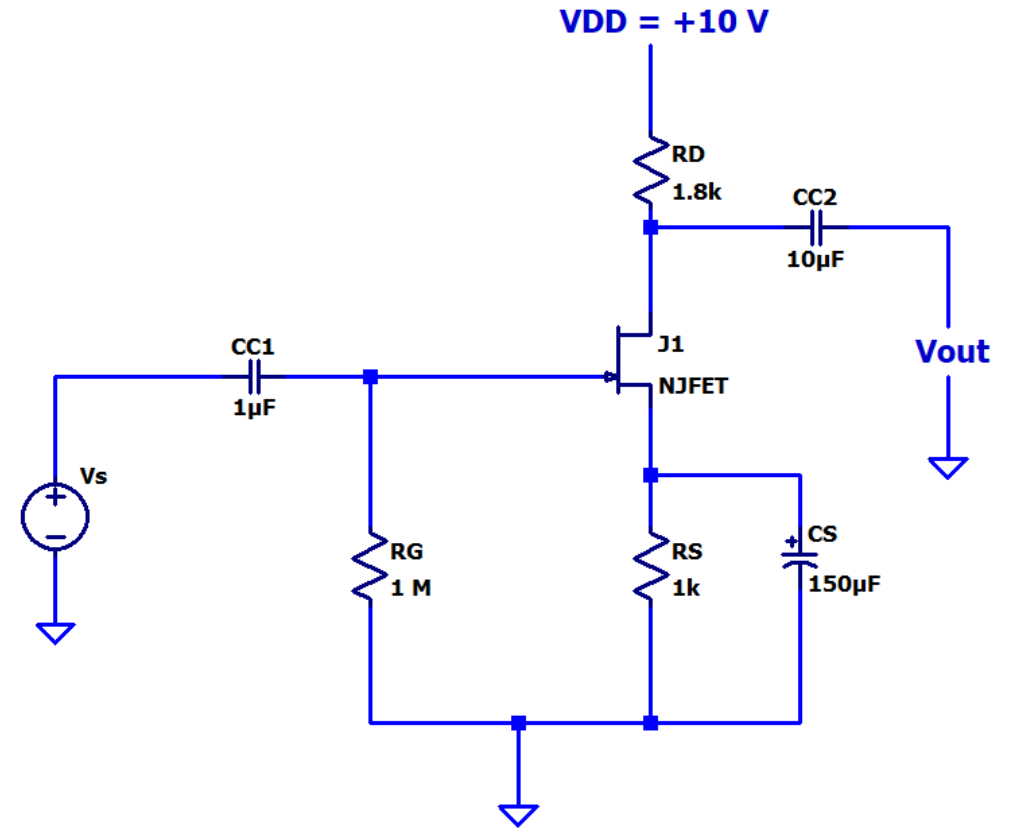

Figure 22: Question 14

Answers: $V_{GSQ} = -1.439V \quad I_{DQ} = 1.44mA$

15. A Common source amplifier circuit using N Channel JFET is given below in figure 23. **[20]**
The transistor parameters are $I_{DSS} = 8mA$ and $V_P = -4V$ **[IA]**

a) Determine the value of mid band gain in dB

b) Lower cut-off frequency

c) Repeat part a) and b) with $r_d = 50K\Omega$

d) Sketch the frequency response for results obtained in part a) and b)

e) What is the effect on the gain of the circuit if R_{sig} is zero.

f) What is the effect on the gain of the circuit if R_L is not connected

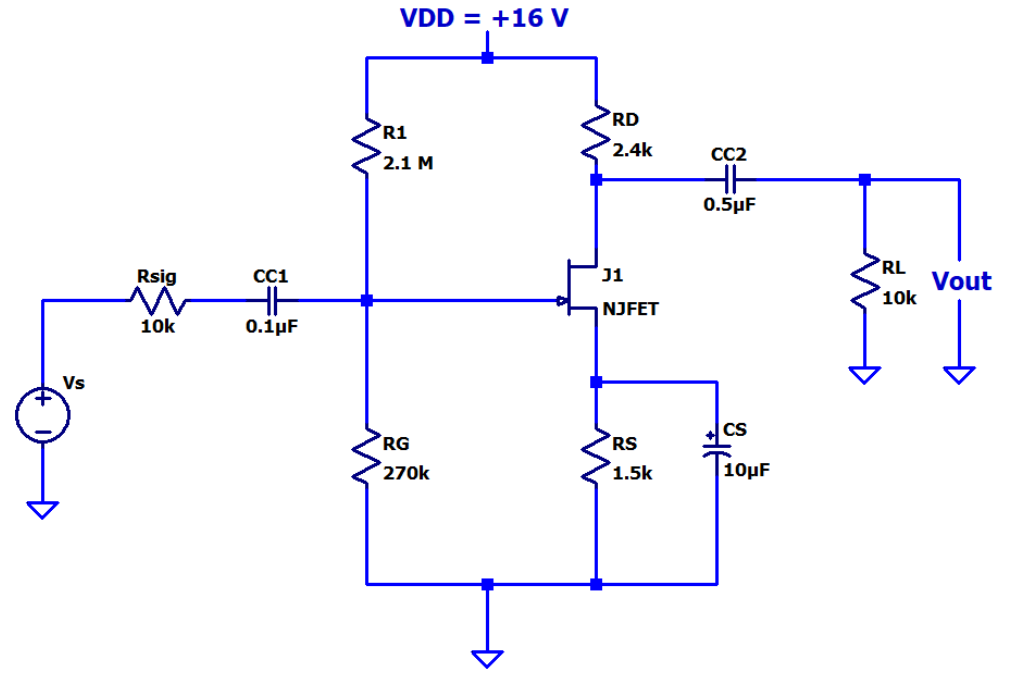

Figure 23: Question 15

16. For the circuit given below in figure 24, find 3 dB frequencies and bandwidth

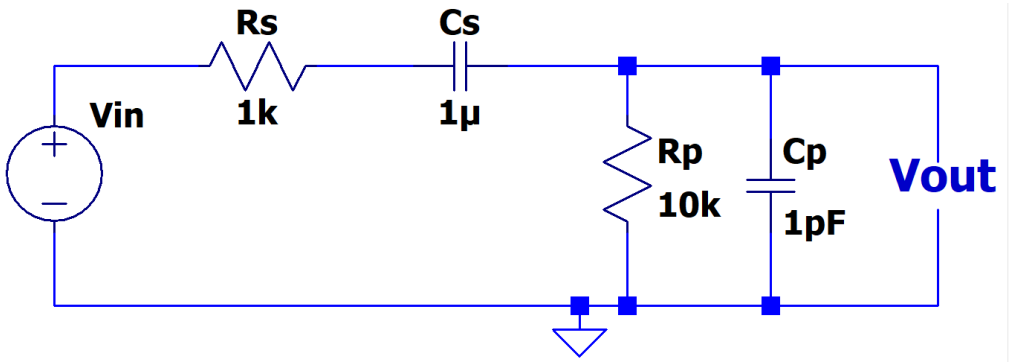

Figure 24: Question 16

Answers: $f_L = 14.47Hz \quad f_H = 175MHz \quad BW = 175MHz$