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|---|---|
| **Family Name** | |
| **Given Names** | |
| **Student Number** | |
| **Teaching Period** | Semester 1, 2017 |

| FINAL EXAMINATION | DURATION |
|---|---|
| **ENG221 – Analogue Electronics** | Reading Time: **10** minutes<br>Writing Time: **180** minutes |

## INSTRUCTIONS TO CANDIDATES

## EXAM CONDITIONS

**<u>You may begin writing from the commencement of the examination session.</u>** The reading time indicated above is provided as a guide only.

This is a CLOSED BOOK examination

Any non-programmable calculator is permitted

No handwritten notes are permitted

No dictionaries are permitted

| ADDITIONAL AUTHORISED MATERIALS | EXAMINATION MATERIALS TO BE SUPPLIED |
|---|---|
| none | 1 x 20 Page Book<br>1 x Scrap Paper<br>Formula Sheet/s |

**THIS EXAMINATION IS PRINTED DOUBLE-SIDED.**

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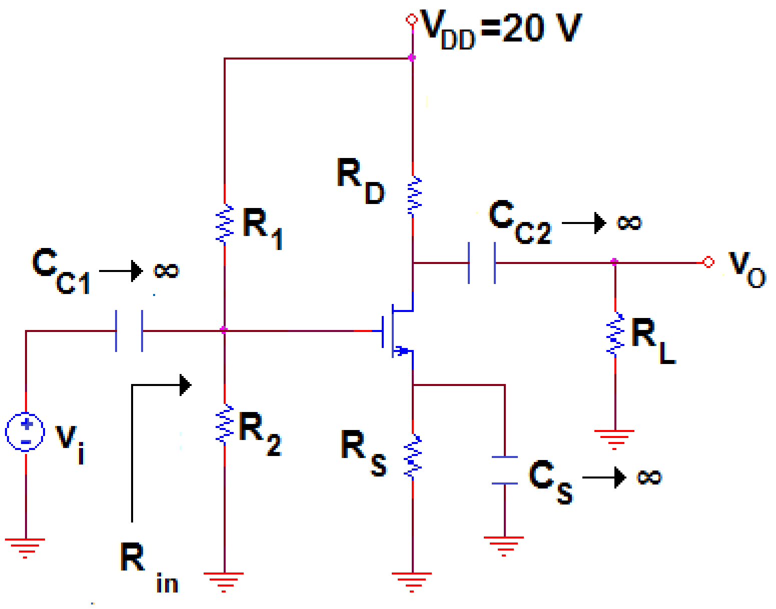
## Question 1 (20 marks)

For the amplifier shown in Figure 1, design the circuit (by determining values of $R_1$, $R_2$, $R_D$ and $R_S$) to achieve a small-signal voltage gain of at least $A_v$=-10 V/V for $R_L$=20 KΩ and $R_{in}$=200 KΩ. Assume that the transistor operates at $I_D$=1mA and $V_{DS}$=10 V. Let $V_t$=2 V and λ=0.




Neamen, 3rd edition, 978-0073285962

Figure 1.

## Question 2 (15 marks)

For the circuit shown in Figure 2, answer the following questions:

a) Determine the value of $R_S$ such that $I_D$=5 mA. (4 marks)
b) Based on the results obtained from part (a), determine the small-signal voltage gain ($A_v=v_o/v_i$). (8 marks)
c) Based on the results obtained from part (a), determine the output resistance ($R_o$). (3 marks)

Assume $R_L$=2 KΩ. The transistor's parameters are $V_t$=2 V, $K'_n(W/L)$=2 mA/$V^2$ and $\lambda$=0.01 $V^{-1}$.

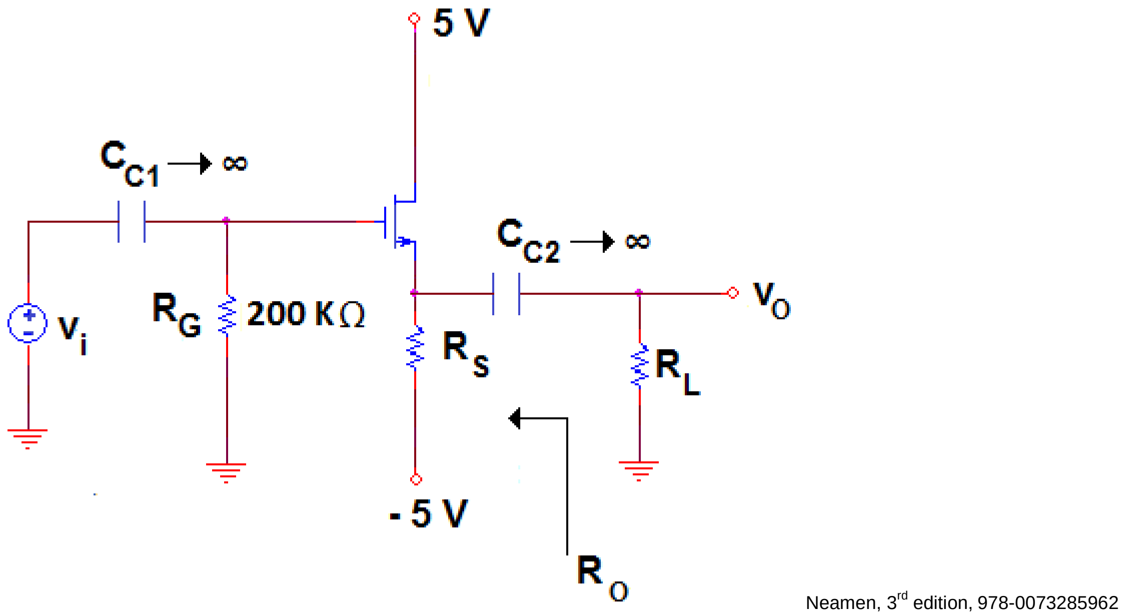
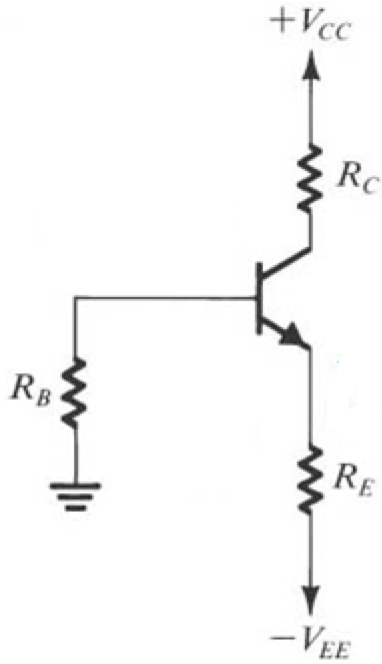



Figure 2.

## Question 3 (15 marks)

Consider the circuit shown in Figure 3, which is supplied by ±3 Volts. It is required to design the circuit so that $I_C$=3 mA and $V_C$ is placed midway between $V_{CC}$ and $V_E$.

a) For β=∞, what values of $R_E$ and $R_C$ are required? (5 marks)
b) If the transistor is specified to have a minimum β of 90, determine the largest value for $R_B$ consistent with the need to limit the voltage drop across it to one-tenth the voltage drop across $R_E$. (5 marks)
c) Based on results obtained from part (b), what are values of $R_E$ and $R_C$? (5 marks)




Sedra,6th edition,ISBN:9780199738519

Figure 3.

## Question 4 (15 marks)

For the circuit shown in Figure 4, let $V_{EE}$=5 V, $R_L$=4 KΩ, $R_E$=3 KΩ, $R_1$=60 KΩ, and $R_2$=40 KΩ. The transistor's parameters are β=50 and $V_A$=80 V.

a) Determine the quiescent point of the transistor ($I_E$ and $V_{EC}$). (5 marks)
b) Determine the overall voltage gain $A_v=v_o/v_{sig}$. (4 marks)
c) Determine the input resistance ($R_{in}$). (3 marks)
d) Determine the output resistance ($R_{out}$). (3marks)

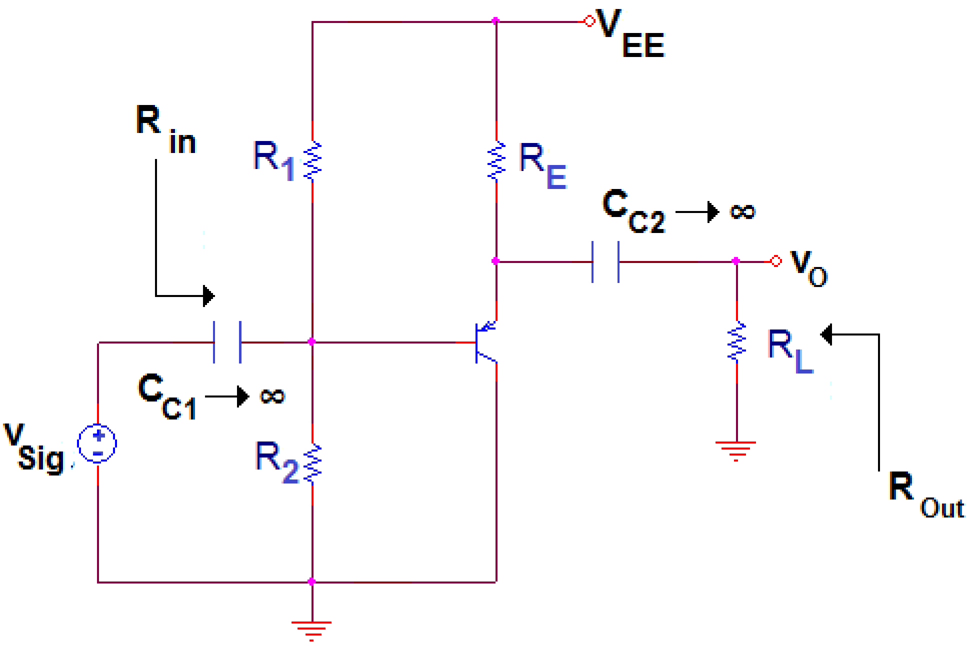



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Figure 4.

## Question 5 (25 marks)

In the circuit shown in Figure 5,

a) Determine the collector current of the transistor. (6 marks)
b) Using the either π or the T model, determine the overall voltage gain ($v_o/v_{sig}$). (8 marks)
c) Using either the π or the T model, determine the input resistance ($R_i$). (6 marks)
d) Using either the π or the T model, determine the output resistance ($R_{out}$). (5 marks)

Assume that β=80 and λ=0.

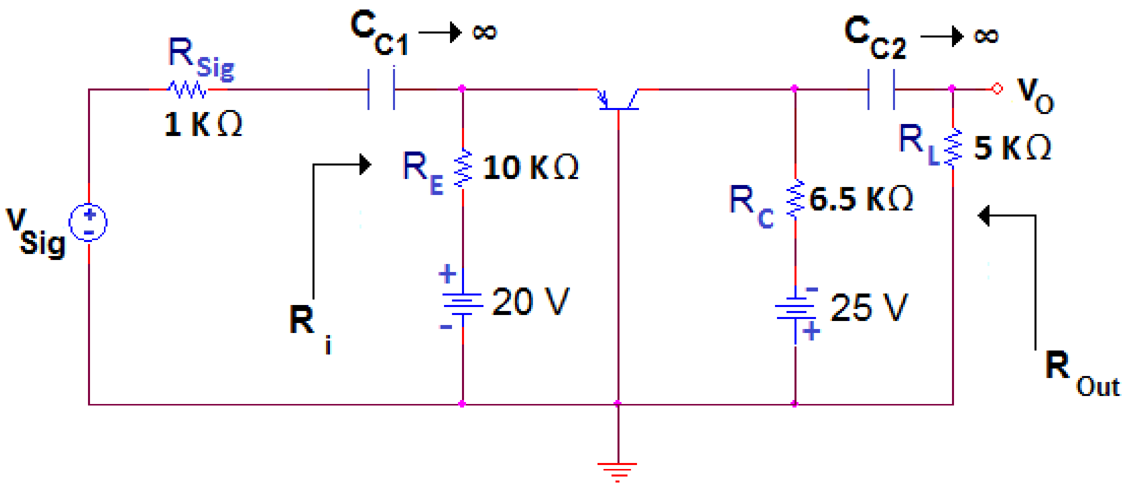


Figure 5.

## Formula sheet

**NMOSET**

$$i_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(v_{GS}-V_t)^2(1+\frac{v_{DS}}{V_A}) = \frac{1}{2}k'_n\frac{W}{L}(v_{GS}-V_t)^2(1+\frac{v_{DS}}{V_A})$$

$$g_m = (\mu_n C_{ox})\left(\frac{W}{L}\right)V_{OV} = \sqrt{2(\mu_n C_{ox})\left(\frac{W}{L}\right)I_D}$$

$$r_o = \frac{V_A}{I_D}$$

$$V_A = \frac{1}{\lambda} \qquad g_m = \frac{I}{V_{OV}/2}$$

**PMOSFET**

$$i_D = \frac{1}{2}\mu_p C_{ox}\frac{W}{L}(v_{SG}-|V_t|)^2(1+\frac{v_{SD}}{V_A}) = \frac{1}{2}k'_p\frac{W}{L}(v_{SG}-|V_t|)^2(1+\frac{v_{SD}}{V_A})$$

$$g_m = (\mu_p C_{ox})\left(\frac{W}{L}\right)V_{OV} = \sqrt{2(\mu_p C_{ox})\left(\frac{W}{L}\right)I_D}$$

$$r_o = \frac{|V_A|}{I_D}$$

$$V_A = \frac{1}{\lambda}$$

**BJT**

$$i_C = I_S e^{v_{BE}/V_T}(1+\frac{v_{CE}}{V_A})$$

$$i_B = \frac{i_C}{\beta} \qquad \Delta I_B = \frac{\Delta I_C}{\beta}$$

$$g_m = \frac{I_C}{V_T}$$

$$g_m r_e = \alpha$$

$$\alpha = \frac{\beta}{\beta+1}$$

$$r_\pi = \frac{\beta}{g_m}$$

$$r_o = \frac{V_A}{I_C}$$

$V_T$=25 mV  $V_{BE}$=0.7 V