Charles Darwin University

Final Examination

Family Name	
Given Name/s	
Student Number	
Teaching Period	Semester 1, 2019

ENG221 – Analogue Electronics	DURATION	
	Reading Time:	10 minutes
	Writing Time:	180 minutes

INSTRUCTIONS TO CANDIDATES

- Exam has five questions.
- Answer all questions of the exam.
- Exam has 60 marks.

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
No additional printed material is permitted	1 x 20 Page Book 1 x Scrap Paper Formula Sheet/s

THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

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Question 1 (14 marks)

For the amplifier shown in Figure 1, answer the following questions:

a) Determine the DC Drain current value of the circuit. (3 marks)
b) Determine the input resistance of the amplifier (R_{in}).(2 marks)
c) Determine the output resistance of the amplifier (R_{out}). (4 marks)
d) Determine the overall voltage gain of the amplifier (V_o/V_{sig}). (5 marks)

Assume,

R_{sig}=100KΩ, R_G=1MΩ, R_S=4KΩ, R_L=4KΩ, V_t=1V, $K'_n(W/L)$=2 mA/V^2 and $|V_A|$=50 V.

V_{DD}=10 V, V_{SS}=-10V.

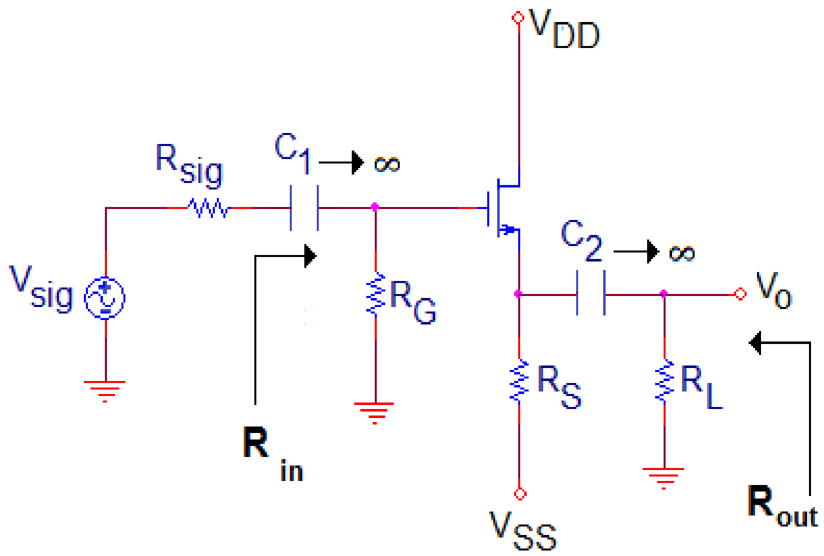

Figure 1.

Question 2 (9 marks)

For the NMOS-based amplifier shown in Figure 2, answer the following questions:

a) Determine the input resistance of the amplifier (R_{in}). (1 marks)
b) Determine the output resistance of the amplifier (R_{out}). (2 marks)
c) Determine the overall voltage gain of the amplifier (V_o/V_{sig}) . (4 marks)
d) By what factor should the bias current (I_D) of the MOSFET be changed to have $R_{in}=R_{sig}$? (2 marks)

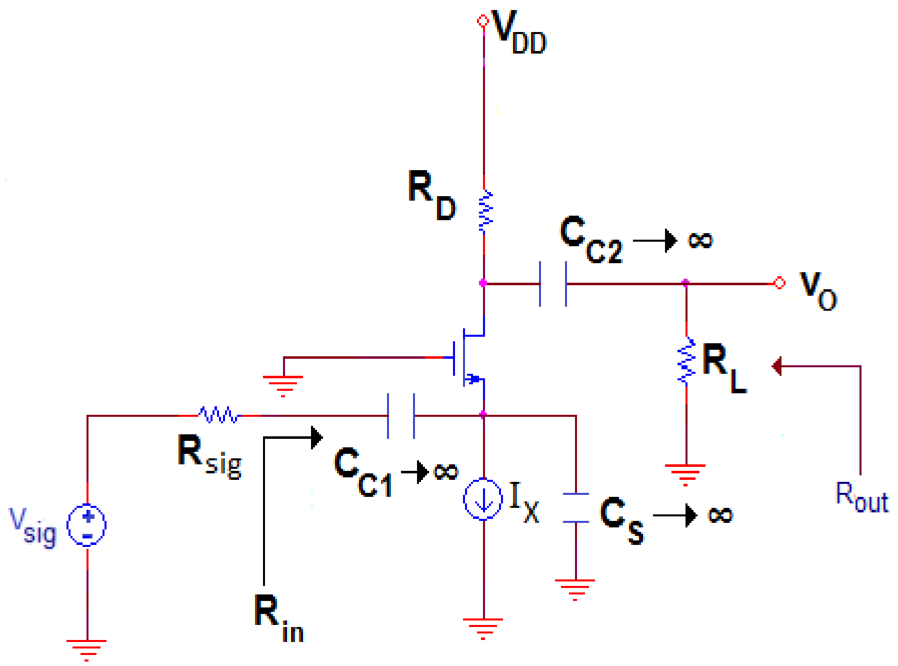

Figure 2.

Assume,

R_{sig}=500Ω,R_D=10 KΩ,R_L=10 KΩ, g_m=1 mA/V^2.

Ignore the Early effect.

Question 3 (5 marks)

For the circuit shown in Figure 3, determine the minimum value of R_E to maintain the transistor in the active region.

Assume, R_B=7KΩ, R_C=3KΩ, V_{CC}= -10V, β=100, $V_{EC}(sat)$=0.2V.

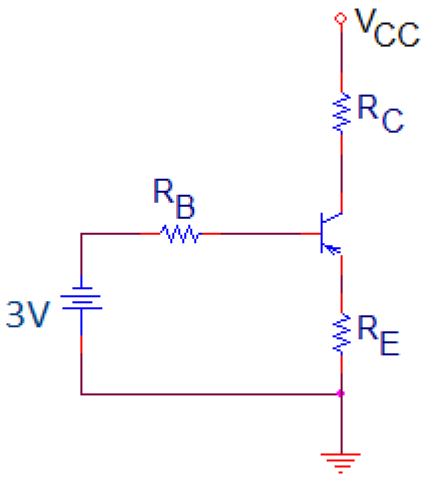

Figure 3.

Question 4 (17 marks)

For the circuit shown in Figure 4, answer the following questions:

a) Determine the DC emitter current value of the circuit. (4 marks)
b) Draw the small-signal model of the circuit (based on π or T model of transistor equivalent circuit). (4marks)
c) Based on the circuit drawn in part (b), determine the overall voltage gain (V_o/V_{sig}) of the amplifier. (6 marks)
d) Based on the circuit drawn in part (b), determine the input resistance of the amplifier. (3 marks)

Assume, R_1=120 KΩ, R_2=500 KΩ, R_3=500KΩ, R_4=3 KΩ, R_5=R_L=1KΩ and β=100.

Ignore the Early effect.

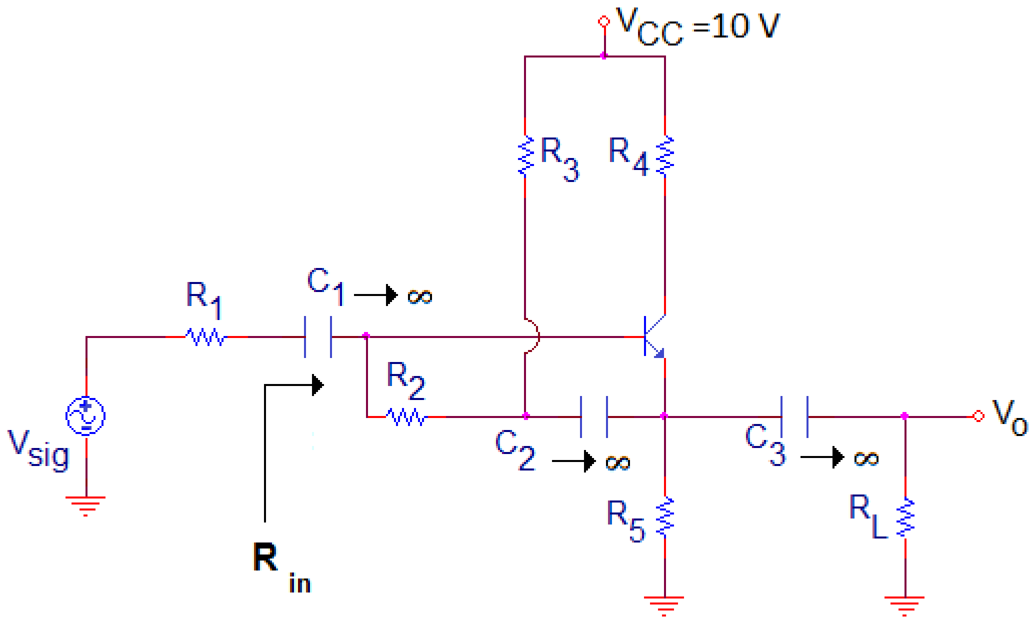

Figure 4.

Question 5 (15 marks)

For the circuit shown in Figure 5, answer the following questions:

a) Determin the DC emitter current value of the circuit.(4 marks)
b) Draw the small-signal model of the circuit (based on π or T model of transistor equivalent circuit). (3 marks)
c) Based on the circuit drawn in part (b), determine the overall voltage gain of the amplifier (V_o/V_{sig}). (8 marks)

Assume V_{CC}=10V, R_1=300KΩ, R_2=10KΩ, R_E=100Ω, R_{sig}=15KΩ, β=100.

Ignore the Early effect.

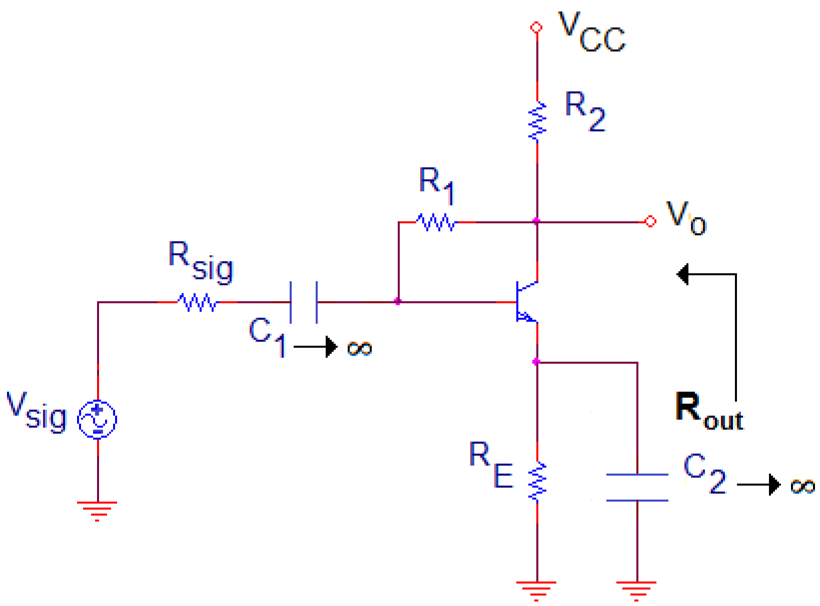

Figure 5.

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