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UNIVERSITÉ Concordia UNIVERSITY

Examination Cover Sheet

COURSE: ELEC	**NUMBER: 311**	**SECTION(S): 2/F**	
EXAMINATION: **_X_ FINAL** ___ **ALTERNATE** ___ **DEFERRED** **VERSION**: ________	**DATE: December 11, 2015**	**TIME: 14:00-17:00** **Exam Length: 3 hours**	**PAGES: 5** Including cover
INSTRUCTOR(S): Dr. R. Raut		**DIVISION**:	
MATERIALS ALLOWED: _**X**_ Booklets ____ IBM (Scantron) ___ Blue ___ Green ____ Printed Translation Dictionary Other________ _**X**_ Calculator _**X**_ENCS Approved ____ Other ______________________________		**INSTRUCTIONS:** _**X**_ Return all ___ Answer on Exam ___ Open book ___ Crib sheet Details________	

SPECIAL INSTRUCTIONS:

You are required to *answer* SIX questions

You MUST attempt **Q.1** : **10 marks**

From **Q.2-Q.7**, answer any **FIVE** questions.: **10 marks** (each)

Before submitting your answer book, **fill in the Table below** indicating the answers you want to be graded.

(If you **do not** *fill in the Table*, the instructor will mark your answers *as they appear one after another in the answer book)*

Table

Answers to be graded	**Q.1 (compulsory)**					
Marks						

Show all steps clearly in **neat** and **legible** handwriting.

(Some important formulae)

$I_C = \beta I_B$, $I_E = (\beta+1)I_B$	$g_m = \frac{I_C}{V_T}$, $r_\pi = \frac{\beta}{g_m}$, $\alpha = \frac{\beta}{\beta+1}$	$r_o = \frac{V_A}{I_C}$, $r_e = \frac{r_\pi}{\beta+1}$, $I_C = I_S \exp(V_{BE}/V_T)$
$I_D = k\left(\frac{W}{L}\right)\left((V_{GS}-V_t)V_{DS} - \frac{V_{DS}^2}{2}\right)$ (linear region)	$I_D = k\left(\frac{W}{2L}\right)(V_{GS}-V_{TH})^2(1+\lambda V_{DS})$ (saturation region)	$g_m = k\left(\frac{W}{L}\right)(V_{Gs}-V_{TH}) = \sqrt{\frac{2kI_DW}{L}}$ $r_o = \frac{V_A}{I_D}$

Part I: *The student MUST answer this question* **(10 marks)**

Q.1: A semiconductor junction diode **D** is used in an automatic gain control system as shown in **figure 1.** The ac resistance of the diode is dependent on the amplitude V_p of the input signal. The capacitance acts as a *short circuit* and the inductor acts as an *open circuit* for the *ac* signal.

The input signal is full-wave rectified to generate a DC voltage which drives the DC current through the diode. This DC voltage is given by $2V_p/\pi$. The diode is a 1 mA diode. For the diode you may use the relation: $V_2 = V_1 + 2.303nV_T \log_{10}(I_2/I_1)$, where V_T is the thermal voltage (=25 mV). You may use n =1. The DC resistance of the diode can be neglected.

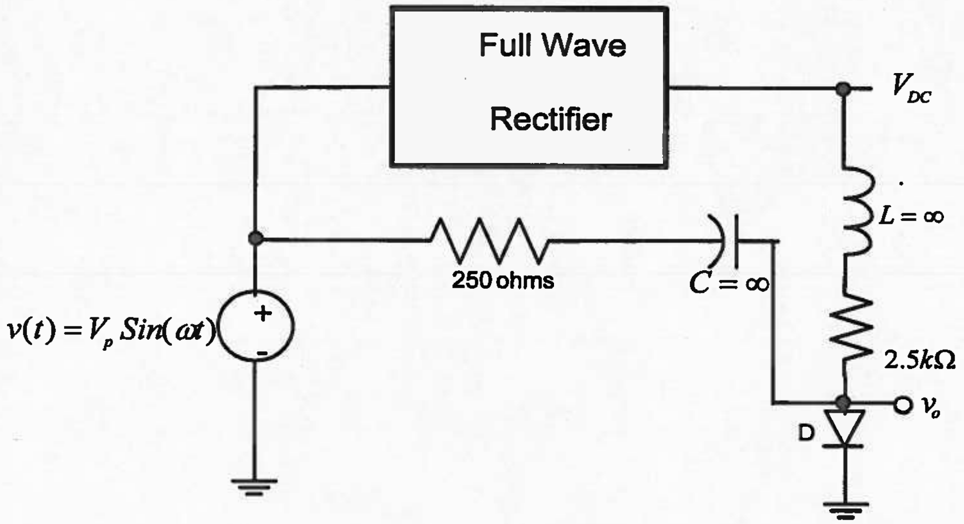


Figure 1:

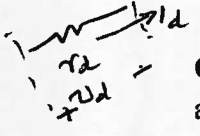
You are required to find the amplitude of the *ac* output voltage v_o for a given amplitude V_p of the input signal. Please address the following questions.

ac resistance

$r_d = \left(\frac{I_D}{nV_T}\right)^{-1}$

$i_D = I_S \exp\left(\frac{v_D}{nV_T}\right)$

$\left.\frac{\partial i_D}{\partial v_D}\right|_{I_{DO}} = \frac{1}{r_d} = \frac{I_D}{nV_T}$

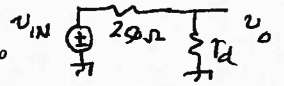


(a) How will you represent the diode to calculate the signal v_o? (1.0 point: **KB 3**)

(b) Show/derive the equivalent circuit model of the diode to do your work (3.0 points: **PA1**)

(c) Show the overall equivalent circuit containing the diode for calculating v_o (4.0 points: **PA2**)

(d) Find the value of the *ac* signal v_o (2.0 point: **PA3**)



V_p need be given.

(Total: **10 marks**)

Part II: Answer any **FIVE** questions (Each question has **10 marks**)

Q.2: An implanted bio-electronic device requires +3 and -3 volts for its operation. This is to be arranged by inductive coupling (i.e. a transformer) of a radio signal through the skin of the person. The magnitude of the radio signal is 1.5 volts at 1MHz.

(a) Provide a schematic of the system which can deliver the required voltages of +3 and -3 volts. You can use transformer, diodes, capacitors and resistors. (Two voltage doubler systems will be needed. explain in words from text-book/course pack.)

(b) Explain the operation of the circuit. If the capacitors used are 10pF (pF=10^{-12} Farad) each, what value of resistors will be desirable for smooth DC voltages of +3 and -3 volts? $R_L \geq 500\,k\Omega$, assuming $CR_L \geq 5T$, $T = 10^{-6}$ s

Q.3: The circuit in **Fig.3** depicts a BJT configured as *common collector* amplifier. Find and use the *ac* parameter values of the transistor (β=49) to calculate the R_{in}, and R_{out} as shown on the schematic. Given V_A =100 Volts.

$I_E = 1.17\,mA$; $I_C = 1.15\,mA$

$g_m = .046$ mho

$r_o \cong 87\,k\Omega$

$r_\pi \cong 1065\,\Omega$

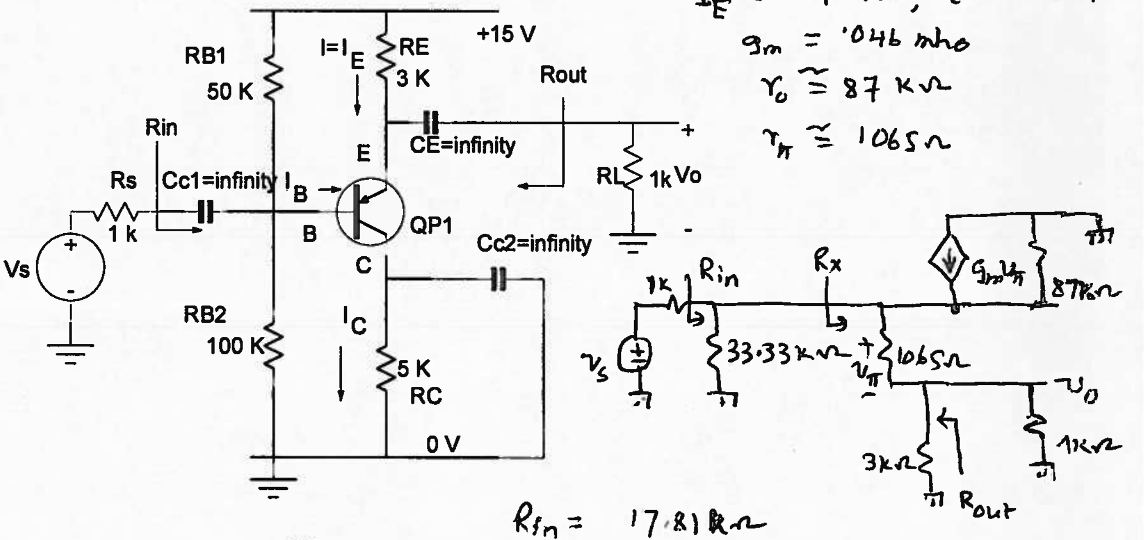


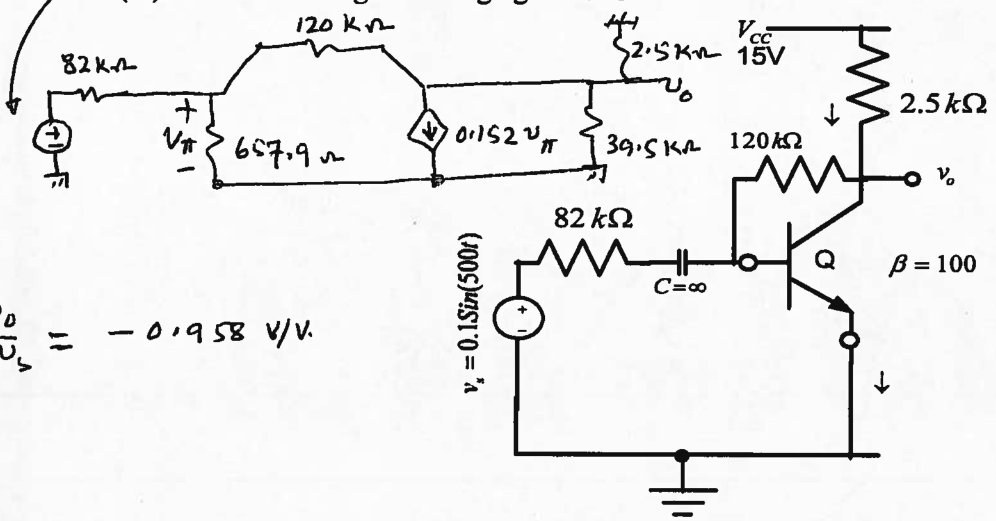
Figure 3:

$R_{in} = 17.81\,k\Omega$

$R_{out} = 40.17\,\Omega$

Q.4: **Figure 4** shows a BJT amplifier operating in *common emitter* configuration. The transistor has β=100, and V_A (i.e., *Early* voltage)=150 Volts. Find

(i) The DC operating point $\longrightarrow I_C = 3.8\,mA,\ V_o = 5.4V$
(ii) The *ac* equivalent circuit $\longrightarrow g_m = 0.152\,mho,\ r_\pi = 657.9\Omega,\ r_o = 39.5\,k\Omega$
(iii) The *small signal* voltage gain v_o/v_s.



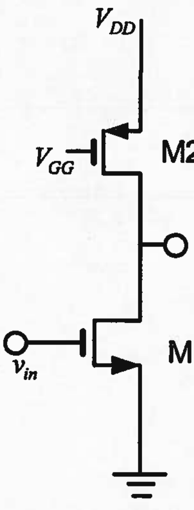
(iii) $\frac{v_o}{v_s} = -0.958$ V/V.

Figure: 4

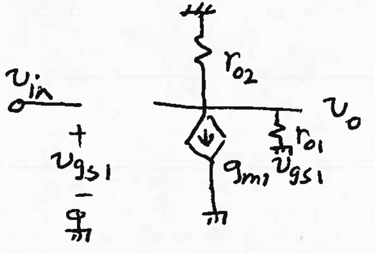
Q.5: For a particular MOSFET operating in the saturation region at a constant v_{GS}, *the* i_D is found to be 0.5 mA for v_{DS} =1 V, and 0.52 mA or v_{DS} =2 V.

(a) What are the values of r_o, V_A, and λ for this transistor? $r_o = 49.6\,k\Omega,\ V_A = 23.8\,V,\ \lambda = 0.042\,V^{-1}$

(b) The transistors M1, M2 in **Fig.5** have same r_o as in (a) above. For I_D=0.1mA, V_{DD} =5V, V_{THN} =0.7V, K_n =100μA/V², and W/L =5 for each transistor, what voltage gain v_o/v_{in} will be realized?



AC equiv. ckt.



$g_{m1} = 316.23\,\mu℧$
$r_{o1} = r_{o2} = 49.6\,k\Omega$

$\frac{v_o}{v_{in}} = -7.84$ V/V

Figure 5:

Q.6: In the circuit of **Fig. 6**, the NMOS transistor has $|V_{TH}| = 0.6$ V, $V_A = 75$ V and operates with $V_D = 1$ V.

(a) What is the voltage gain v_o/v_i of this amplifier stage?

$\frac{v_o}{v_i} = -2.482$ V/V

(b) What will V_D become if I is increased to 750 μA?

$V_D = 1.09$ V.

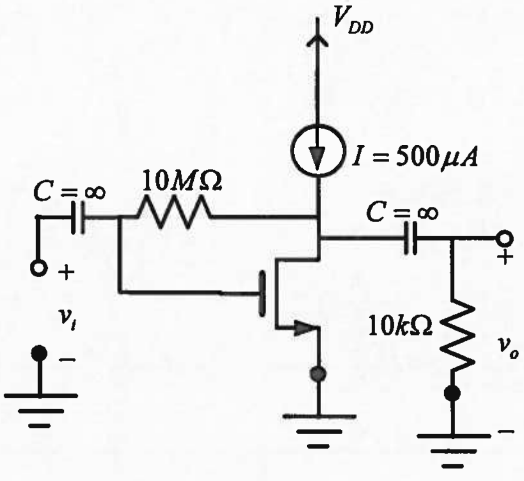
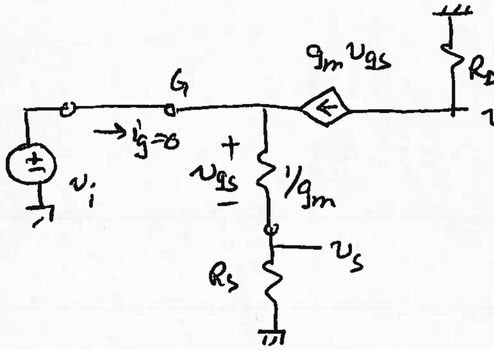


Figure 6:

Q.7: For the NMOS amplifier in **Fig. 7**, draw the *ac* equivalent circuit using T-model for the transistor, and assuming r_o =infinity. Derive expressions for the voltage gain v_s/v_i and v_d/v_i.



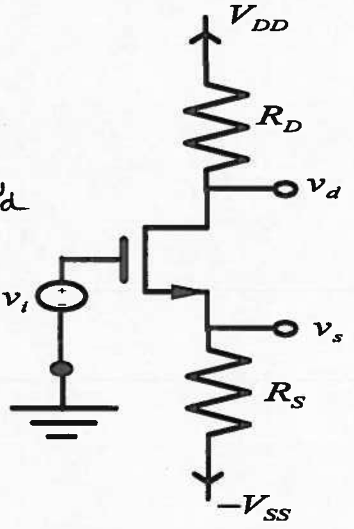


Figure 7:

$$\frac{v_s}{v_i} = \frac{g_m R_s}{1+g_m R_s}$$

$$\frac{v_d}{v_i} = -\frac{g_m R_D}{1+g_m R_s}$$