GLASGOW COLLEGE UESTC

MOCK EXAM

Communication Circuits Design (UESTC 3029)

Date: (complete when info available)
Time: (complete when info available)

Attempt all PARTS. Total 100 marks

Use one answer sheet for each of the questions in this exam.
Show all work on the answer sheet.

Make sure that your University of Glasgow and UESTC Student Identification Numbers are on all answer sheets.

An electronic calculator may be used provided that it does not allow text storage or display, or graphical display.

All graphs should be clearly labelled and sufficiently large so that all elements are easy to read.

The numbers in square brackets in the right-hand margin indicate the marks allotted to the part of the question against which the mark is shown. These marks are for guidance only.

DATA/FORMULAE SHEET IS PROVIDED AT THE END OF PAPER

Attempt all PARTS

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Q1

(a) Draw the circuit diagram of a Colpitts oscillator, specifying the role of the components used to implement the amplifier block, the feedback network, and any accessory components for isolating DC and AC signals. [7]

(b) Describe the three main parameters to consider for the design of an oscillator and discuss the Barkhausen criteria for oscillation. [7]

(c) Calculate the oscillation frequency of a Colpitts oscillator if the components in the feedback network have the following values: L=10mH, C1=33nF, C2=1μF. [3]

(d) Design the block diagram of a heterodyne receiver. Comment on the suitability of the oscillator analysed above for usage as the LO in such receiver, and recommend suitable modifications if unsuitable. [8]

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Q2

The circuit shown in the figure below is part of a frequency up-conversion mixing stage within an RF transmitter.

(a) Calculate the frequency of the possible signals at the output of the mixer if the LO can be tuned between 700 kHz and 900 kHz and the IF signal is centered at a carrier frequency of 455 kHz. Ignore 3rd order components and higher. [4]

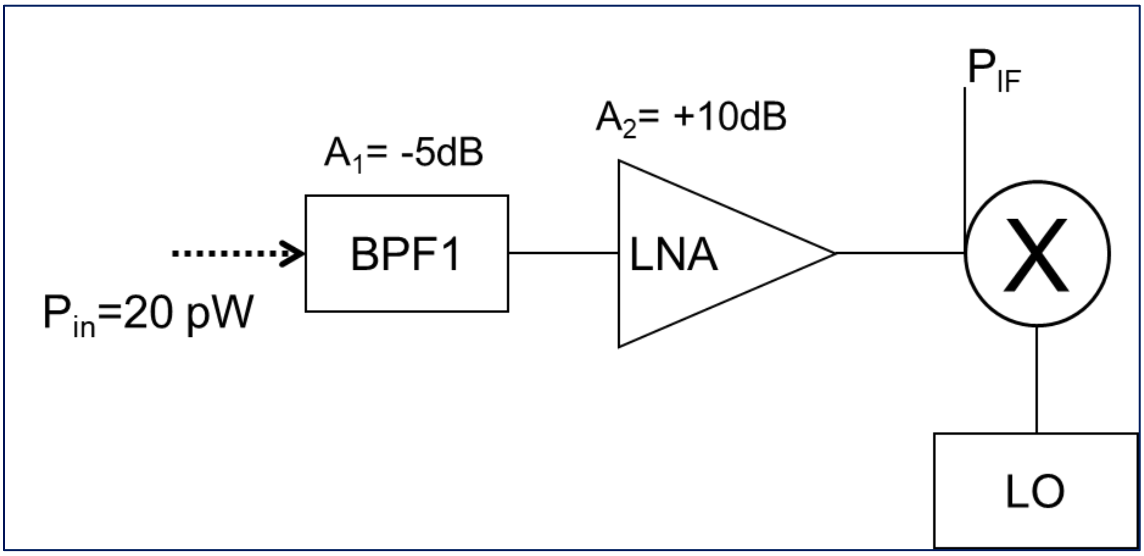
(b) Estimate the necessary Q factor for BPF1 if the bandwidth of the IF signal is 5 kHz. [2]

(c) Calculate the signal power in dBm at the IF port of the mixer, denoted as P_{IF} in the circuit. [3]

(d) Calculate the SNR in dB at the IF port of the mixer if the operating temperature is 300K and the noise factor of the LNA is F=4. [6]

(e) An additional amplifier stage has to be added to the IF branch of this circuit to provide extra +28 dB of gain. Comment on its optimal position if the noise figure of this additional amplifier is +8.5dB and provide justification for your choice. [5]

(f) Explain possible implementation of the mixer component shown in the circuit below, commenting on advantages and disadvantages of using different non-linear components. [5]



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Q3

(a) The antenna current of an AM transmitter is 12A when the unmodulated but increases to 13A when modulated. Calculate the percentage modulation.

[4]

(b) When the input to an ideal non-linear device is a carrier and its sidebands, what will be the output components (frequencies)?

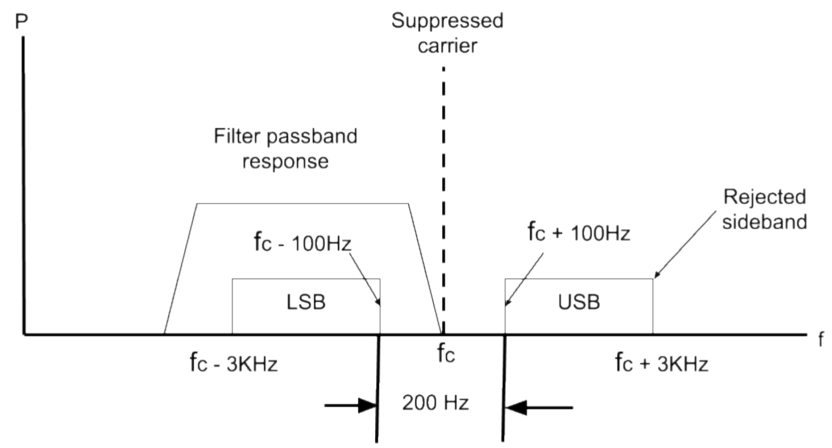
[5]

(c) What are the advantages and disadvantages of diode detector for AM reception?

[6]

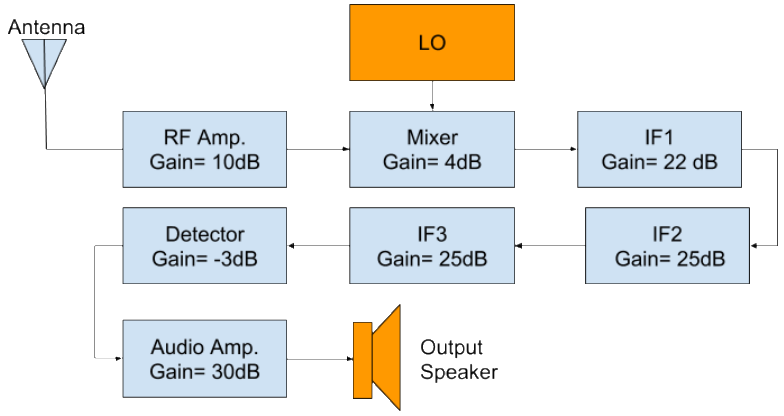
(d) Calculate the required Q for the situation depicted in the following figure for the carrier frequency of 100KHz and 80-dB sideband suppression.

[4]



(e) Consider the radio receiver shown in figure below. The antenna receives a 10-μV signal into its 40 Ω input impedance. Calculate the input power in watts, dBm and dBW, and calculate the power driven into the speaker, in watts.

[6]



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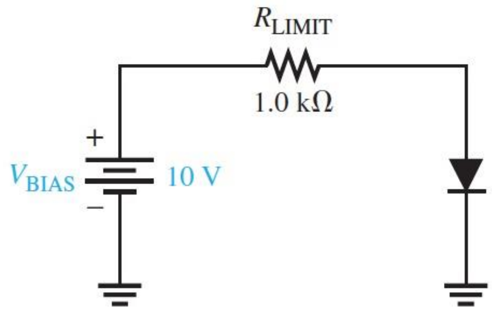
Q4

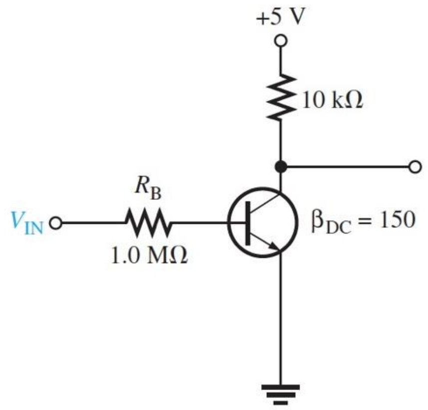
(a) How is the electric field across the *pn* junction created. [5]

The electric field across the *pn* junction of a diode is created by donor atoms in the n region losing free electrons to acceptor atoms in the p region. This creates positive ions in the n region near the junction and negative ions in the p region near the junction. A field is then established between the ions.

(b) Using the complete diode model, determine the forward voltage and forward current of the diode in Fig. 1(b) below with $r'_d = 10\ \Omega$. . Also find the voltage across the limiting resistor. [3+3+3=9]



(c) Determine $I_{C(sat)}$ for the transistor in Fig. 1(c). What is the value of I_B necessary to produce saturation? What minimum value of V_{IN} is necessary for saturation? Assume $V_{CE(sat)} = 0$ V. [3+3+5=11]



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FORMULAE SHEET

$$|A_r| = \frac{|V_0|}{V_0(\omega_0)} = \frac{1}{\sqrt{1+(\delta Q)^2}} \qquad \delta = \frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}$$

$$RL = -20\log_{10}\left|\frac{Vref}{Vinc}\right|; \;\; VSWR = \frac{1+10^{-\frac{RL}{20}}}{1-10^{-\frac{RL}{20}}}$$

$$Q_L = \frac{reactance}{resistance} = \frac{\omega L}{R}; \; Q_C = \frac{susceptance}{conductance} = \frac{\omega C}{G} = \omega CR; \; Q = \frac{f_0}{BW}$$

$$R_P = R_S(1+Q^2); \; X_P = X_S(1+\frac{1}{Q^2})$$

$$C_D = C_{Varactor} \approx \frac{C_0}{\sqrt{1+\frac{|V_D|}{0.5}}} \;\; C_{Miller} = C(A_v + 1)$$

	Input R_I		Output R_o		Gain Av
	Large R_L	Small R_L	Large R_S	Small R_S	
CB	R_E+R_B	R_E	R_c+R_b	$R_c\dfrac{R_e+R_b(1-\alpha)}{R_e+R_b}$	$\dfrac{R_L}{R_S+R_i}$
CE	$r_i = r_b + r_e \approx r_b$	$r_b + \beta r_e$	$r_e + \dfrac{r_c}{\beta}$	$r_c\dfrac{r_e+\dfrac{r_b}{\beta}}{r_b+r_e} \approx r_c$	$\dfrac{R_c}{R_b+R_e}$
CC	$r_i = r_b + r_c \approx r_c$	$r_b + \dfrac{r_e}{1-\alpha} = r_b + \beta r_e$	$r_e + r_c(1-\alpha) \approx \dfrac{r_c}{\beta}$	$r_e + \dfrac{r_b}{\beta} \approx r_e \approx \dfrac{1}{g_m}$	$\dfrac{R_L}{R_L + R_S/\beta}$

$$B_{-1dB} = \sqrt{0.145\left|\frac{a_1}{a_3}\right|}\;; \; B_{IIP3} = \sqrt{4/3\left|\frac{a_1}{a_3}\right|}; \;\; B_{-1dB} = IIP3 - 9.6dB$$

$$DR = 1dB_{point} - S_n; \; S_n = P_n + SNR; \; P_{n,input} = 10log_{10}(kT\Delta f_{eff})$$

$$k = 1.38 \times 10^{-23}$$

End of question paper