GLASGOW COLLEGE UESTC

Exam paper

Communication Circuits Design (UESTC 3029)

Date: 26th August 2020
Time: 14:00-16:00pm

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

Continued overleaf

Q1 A radio system is using a heterodyne AM receiver.

(a) Sketch a block diagram of the receiver. [4]

(b) Illustrate waveform shapes at output of each stage for the transmitted message waveform shown in Figure Q4(a). [6]

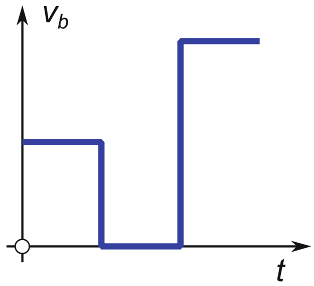

Figure Q4(a)

(c) This AM receiver is designed to receive RF signals in the 500kHz to 1600kHz frequency range with the required bandwidth of B = 10kHz at the resonant frequency f_0 = 1050kHz. The RF amplifier uses an inductor of L = 1μH. Calculate:

i. Q factor [2]

ii. Bandwidth and capacitance at f_{max} = 1600kHz [6]

iii. Bandwidth and capacitance at f_{min} = 500kHz [2]

iv. The minimum channel spacing Δf between adjacent AM channels to prevent inter-channel interference. [1]

v. If all incoming RF signals are shifted to intermediate frequency of f_{IF} = 465kHz by tuning the receiver through a knob that simultaneously tunes resonating capacitors in the RF amplifier and LO oscillator sections, find the local oscillator's frequency tuneability ratio if $f_{LO} > f_{RF}$. [4]

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Q2 (a) A radio receiver is tuned to receive an AM signal transmitted at a carrier frequency of f_{RF} = 970kHz. The Local Oscillator (LO) inside the receiver is tuned at 1.43MHz. Find:

i. The frequencies at the output of the receiver mixer [4]

ii. What frequency is the IF (intermediate filter) frequency [2]

iii. The frequency of a radio station that would represent an image frequency to the desired radio station [4]

iv. The representative frequency graph (spectrum) of the frequencies involved. [5]

(b) Consider an ideal single-stage CE amplifier with Miller capacitance caused by additional capacitance present between base and collector (C_{CB} = 2pF) as shown in the figure below, with infinite input resistance and voltage gain of 49 (its absolute value). The amplifier is driven by a voltage source with output resistance R_s = 75Ω.

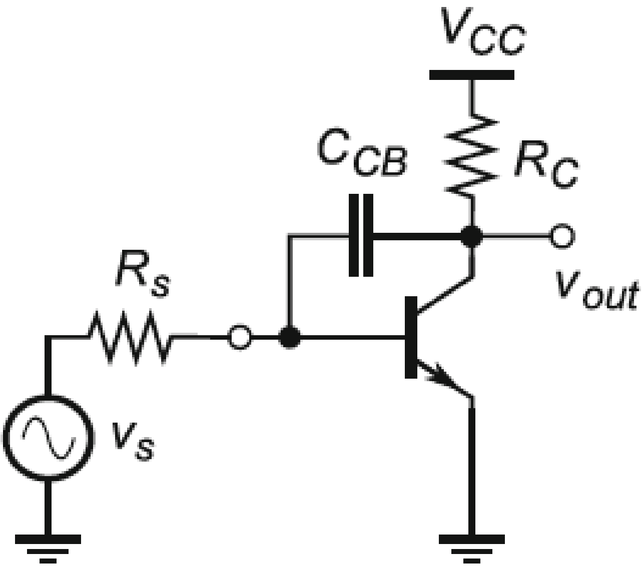

Figure Q2(b)

i. Draw the equivalent low pass filter network with miller capacitance. [3]

ii. Estimate the useful range of input frequencies for the amplifier with and without considering Miller capacitance effect. [5]

(c) What is 'near field' of an antenna? [2]

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Q3 (a) A tuned radio receiver is to be designed with a single tuned circuit using a 10μH inductor.

i. Calculate the capacitance range of the variable capacitor required to tune from 550kHz to 1550kHz. [5]

ii. The ideal 10kHz BW is to occur at 1100kHz. Determine the required Q. [2]

iii. Calculate the BW of this receiver at 550kHz and 1550kHz. [4]

(b) An AM transmitter has a 1kW carrier and is modulated by three different sine waves having equal amplitudes. If $m_{eff} = 0.8$, calculate the individual values of m and the total transmitted power. [4]

(c) An unmodulated carrier is $560V_{p\text{-}p}$. Calculate $\%m$ when its maximum p-p value reaches 700V. [6]

(d) Calculate the required Q for the situation depicted in the Figure 3(d) for the carrier frequency of 100kHz and 80dB sideband suppression. [4]

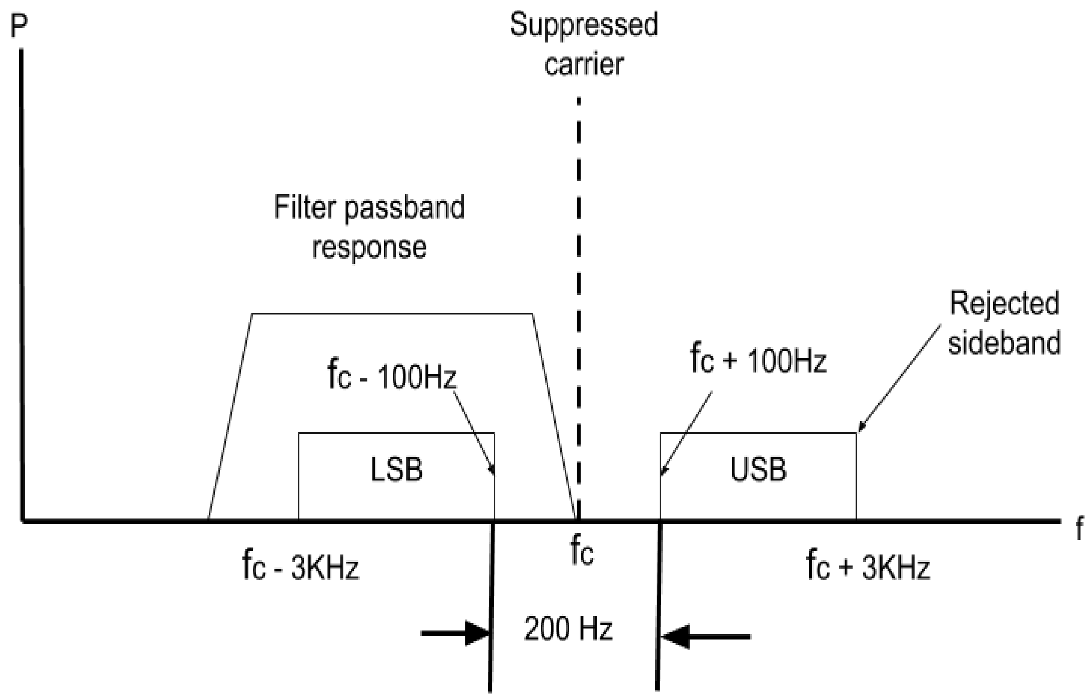

Figure Q3(d)

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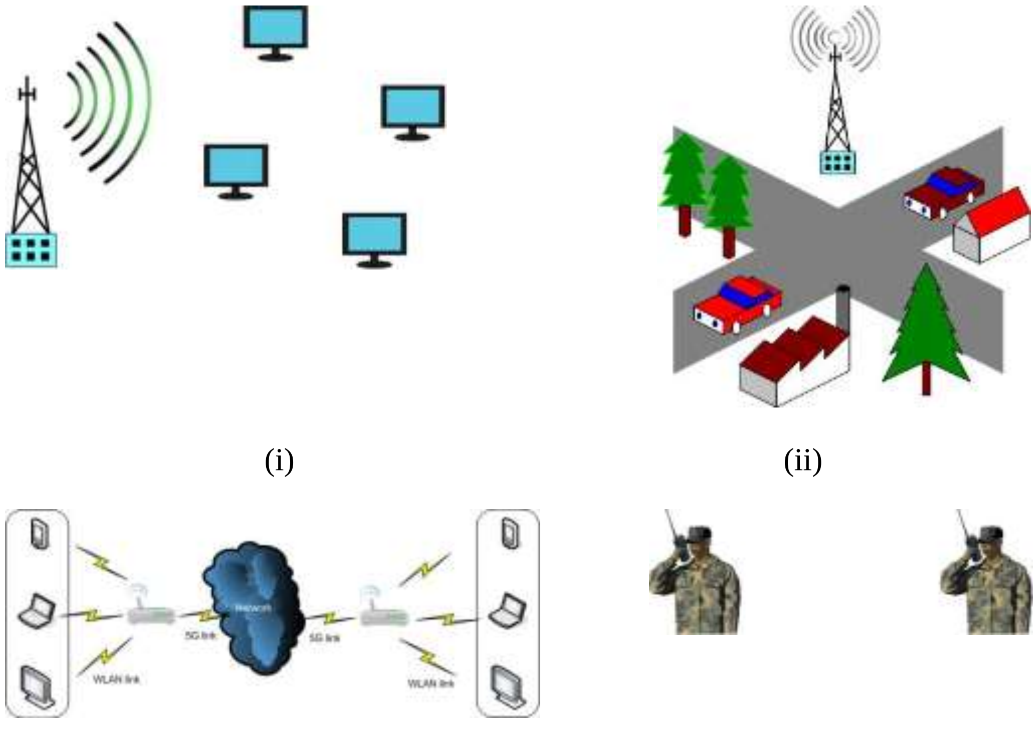
Q4 (a) Analyse the following communication scenarios and identify the type of communication in terms of simplex, half duplex and duplex. [4]



(i) (ii)

(iii) (iv)

Figure Q4(a)

(b) The signal power at the input to a receiver is 6.2nW and the noise power at the input to that receiver is 1.8nW. Find SNR and SNR_{dB}. [6]

(c) Multiplexing is an important technique in modern communication systems.

i. Define the process of multiplexing. [2]

ii. Three radio stations are each allocated a bandwidth of 8kHz respectively. They broadcast radio waves into free space at carrier frequencies of 80, 90 and 100kHz respectively. The guard band between each channel is 2kHz. Determine the type of multiplexing.[1]

iii. Find frequency allocation (band) for each station given in Part (ii) and represent this information on a frequency spectrum graph. [3]

iv. Represent the frequency allocation information of Part (iii) on a frequency spectrum graph. [3]

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(d) The receiver of a communication system uses the amplifier circuit of Figure Q4(d). Determine the values of V_{DS} and V_{GS}. [6]

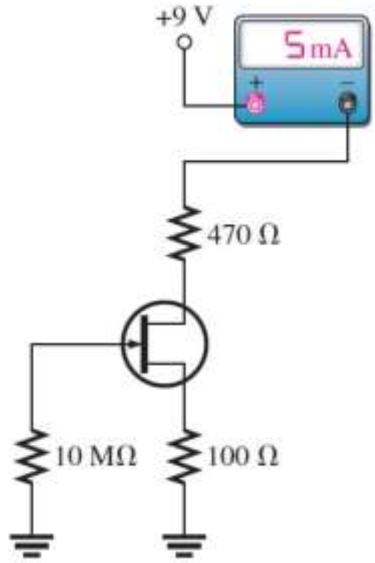

Figure Q4(d)

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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	$R_c\frac{R_e+R_b(1-\alpha)}{R_e+R_b}$	$\frac{R_L}{R_S+R_i}$
CE	$r_i = r_b + r_e \approx r_b$	$r_b + \beta r_e$	$r_e + \frac{r_c}{\beta}$	$r_c\frac{r_e+\frac{r_b}{\beta}}{r_b+r_e} \approx r_c$	$\frac{R_c}{R_b+R_e}$
CC	$r_i = r_b + r_c \approx r_c$	$r_b + \frac{r_c}{1-\alpha} = r_b + \beta r_e$	$r_e + r_c(1-\alpha) \approx \frac{r_c}{\beta}$	$r_e + \frac{r_b}{\beta} \approx r_e \approx \frac{1}{g_m}$	$\frac{R_L}{R_L+R_S/\beta}$

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

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

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

End of question paper