GLASGOW COLLEGE UESTC

Exam paper

Communication Circuit Design (UESTC 3029)

Date: 27th June 2021
Time: 14:30-16:30

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.

A FORMULAE SHEET IS PROVIDED AT THE END OF PAPER

Continued overleaf

Q1 (a) A power amplifier has an input of 90 mV across 10 k-ohm. The output is 7.8 V across an 8 Ω speaker. What is the power gain, in decibels? [5]

(b) A common emitter (CE) amplifier circuit is shown in the Figure Q1. Following parameters are given: ac internal resistance $r_e' = 7.3\,\Omega\ \ at\ 20^0$C, $\beta_{ac} = 150$, $\beta_{DC} = 160$. Answer the following questions:

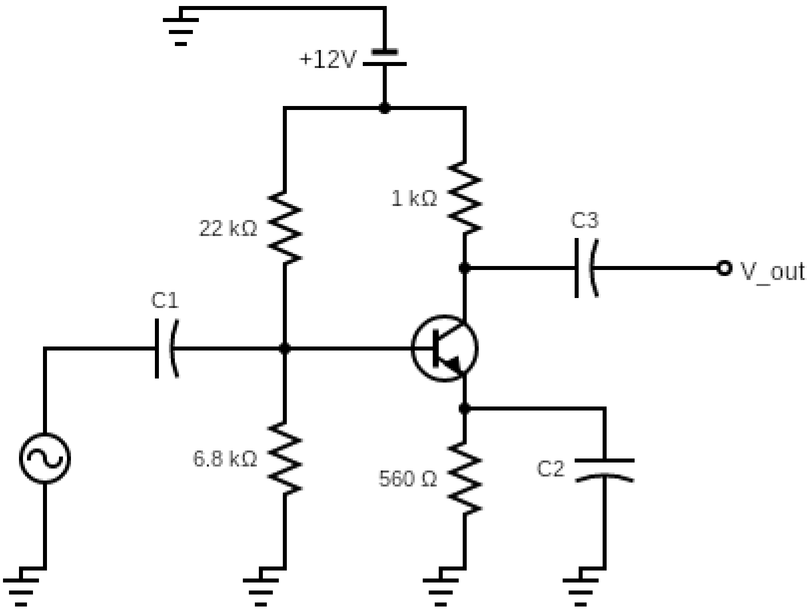

Figure Q1: A common emitter amplifier circuit.

(i) Draw the AC equivalent circuit (Ignore the capacitive reactance and consider it a short circuit). [3]

(ii) Draw the DC equivalent circuit. [3]

(iii) Calculate the DC emitter current I_E and voltage drop across collector to emitter junction, V_{CE}. Given $V_{BE} = 0.7V$. [11]

(iv) What is the base-to-collector voltage gain of the amplifier with and without bypass capacitor C_2 at the emitter? (Ignore the capacitive reactance and consider it a short circuit) [3]

Continued overleaf

Q2 (a) A circuit with mismatched source and load resistance is shown in Figure Q2.

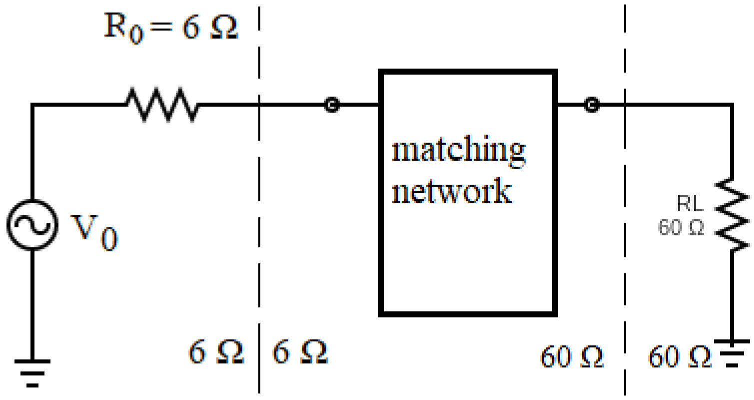

Figure Q2: A typical case of mismatched source and load resistances

(i) Design a matched circuit when the frequency of operation is 100 MHz. [10]

(ii) Using the matched circuit parameters obtained in (i), verify and show that the source and load impedance are matched. [5]

(b) Many radio stations transmit their programs at various carrier frequencies across the Medium Wave band using Amplitude Modulation (AM). A radio receiver is tuned to receive an AM signal transmitted at a carrier frequency of $f_{RF} = 1.5\ MHz$. The Local Oscillator inside the receiver is tuned at 2000 KHz. Find:

(i) What frequency is the intermediate frequency (IF)? [3]

(ii) The frequency of a radio station that would represent an image frequency to the desired radio station. [3]

(iii) The frequency graph (spectrum) of the frequencies involved. [4]

Continued overleaf

Q3 (a) Find the %m for the conditions (i) and (ii) of an unmodulated carrier of 79 V peak to peak (p-p).

(i) Minimum p-p carrier= 34 V, and Maximum p-p carrier =124 V, [2]

(ii) Minimum p-p carrier= 0 V, and Maximum p-p carrier =179 V, [2]

(b) Design a tuned radio frequency (TRF) receiver with a single tuned circuit using a 9.9 μH inductance. Calculate the following:

(i) Find the capacitance range of a variable capacitor required to tune from 600 kHz to 1600 kHz. [3]

(ii) Find the desired signal bandwidth BW if the approximate center is at 1100 kHz with *Q*= 110 and hence find the BW of the receiver at both 600 kHz and 1600 kHz. [3]

(c) 1 kHz and 3 kHz SSB signals received at the antenna are amplified by the RF amplifier and applied to the first mixer (see Figure Q3). The signal then passes to the IF amplifier before entering the 2nd mixer/demodulator to recover the audio signal. The carrier used and suppressed at the transmitter was 2 MHz and only the upper sideband was utilized. Determine the exact frequencies appearing in the following stages if a 445 kHz IF frequency is assumed: [10]

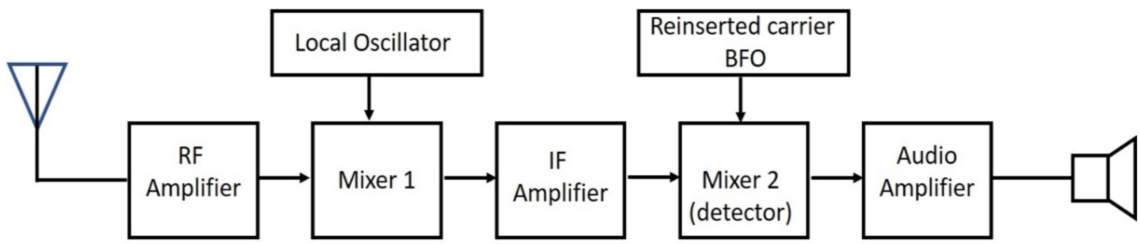

Figure Q3

(i) at the RF Amplifier and mixer 1 input

(ii) generated by the Local Oscillator

(iii) at the IF Amplifier output / mixer 2 input

(iv) generated by the BFO

(d) Determine the possible range and maximum modulation index for a commercial (wideband) FM signal that has 40 Hz to 20 kHz modulating frequencies. [5]

Continued overleaf

Q4 (a) Explain the terms when applied to radio receivers: (i) Sensitivity and (ii) Selectivity. [6]

(b) Determine the sensitivity of the receiver in Figure Q4 below if it operates at room temperature with a bandwidth of 5 MHz and desired SNR of 10 dB [7]

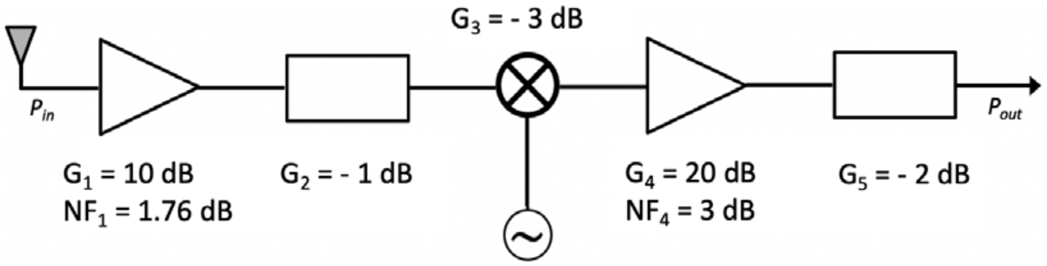

Figure Q4: Receiver block diagram.

(c) A communication link consisting of perfectly aligned half wave dipole antennas has a distance of 10 km. If the transmitter operates at 180 MHz with 9 W transmit power, calculate the received power and voltage into a 73 Ohm receiver. (Hint: the gain of a half-wave dipole is 2.15 dB). [6]

(d) Compare and contrast between Tuned Frequency Receivers and Superheterodyne Receivers. [6]

FORMULAE SHEET

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

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

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

$$C_D = C_{Varactor} \approx \frac{C_0}{\sqrt{1+\frac{|V_D|}{0.5}}}$$

End of question paper