University of Swaziland
Faculty of Science and Engineering
Department of Electrical and Electronic Engineering

Supplementary Examination 2014

Title of Paper: Analogue Design I

Course Number: EE321

Time Allowed: 3 hrs

Instructions:

1. Answer any four (4) questions.
2. Each question carries 25 marks.

This paper should not be opened until permission has been given by the invigilator.

This paper contains eighty (8) pages including this page.

Question 1

a) Write some notes on the advantages of tuned amplifiers. [6]

b) For the low pass filter in Fig. 1(b), $C_F = 0.01\mu F$, $R_F = 10k\Omega$ and $R_i = 1k\Omega$. Calculate the voltage gain at $1MHz$. [10]

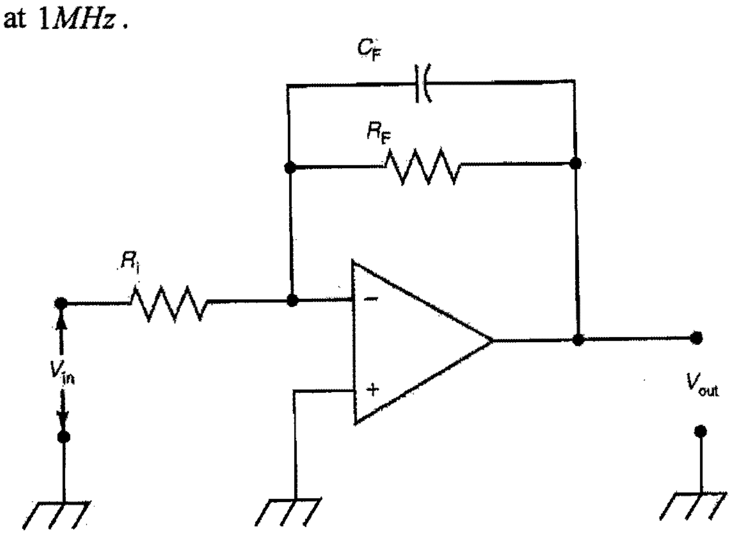

Fig. 1(b)

c) Derive an expression for the voltage gain for the circuit in Fig. 1(c). Assume both transistors are well matched and R_E is very large. [5]

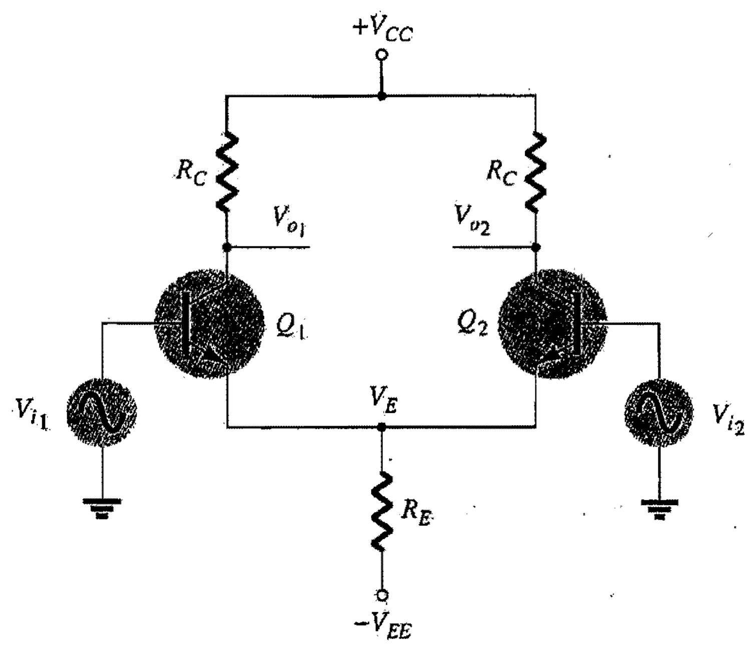

Fig. 1(c)

d) A compensating capacitor of $1000pF$ has a maximum charging current of $1mA$. What is the slew rate? [2]

e) Define f_T. [2]

Question 2

a) For the two-power supply version of the voltage-divider bias circuit shown in Fig. 2(a) derive an expression for the emitter current I_E in terms of β. [3]

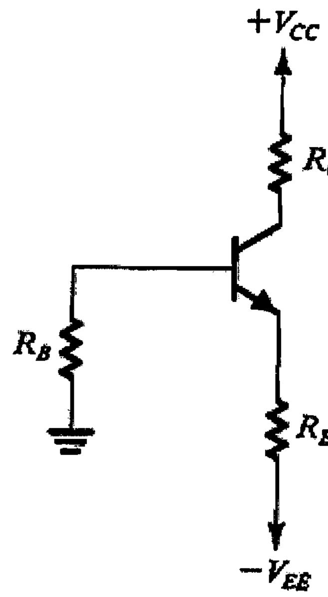

Fig. 2(a)

b) For Fig. 2(b) below, use the following parameters: $R_B = 330k\Omega$, $R_L = 5k\Omega$, $R_{sig} = 5k\Omega$, $I_C = 1.3mA$, $V_T = 25mV$ and $\beta = 100$.

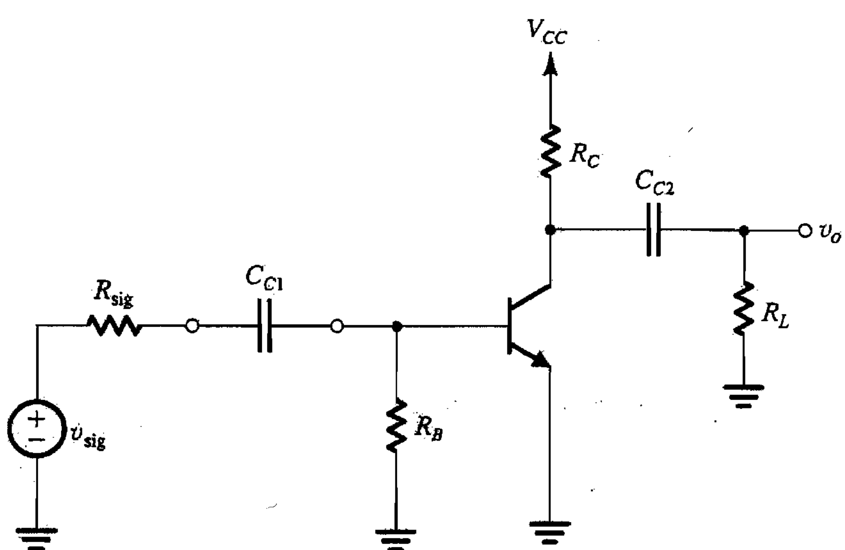

Fig. 2(b)

i) Draw the small signal model of the circuit. [2]

ii) Calculate the value of R_C so that the overall gain, $G_v = \frac{v_o}{v_{sig}} = -27V/V$. [8]

c) What is the frequency of oscillation of the astable multivibrator circuit shown in Fig. 2(c) below, where $V_{CC} = +5V$, $-V_{EE} = -5V$, $R_1 = 6.8k\Omega$, $R_2 = 6.8k\Omega$, $R = 10k\Omega$ and $C = 0.001\mu F$. [6]

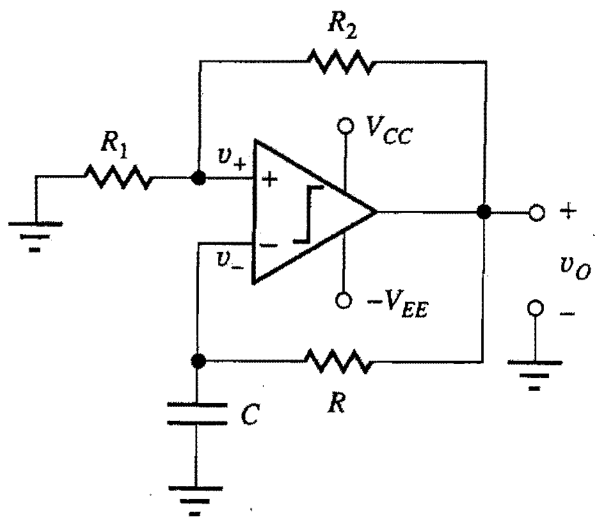

Fig. 2(c)

d) An amplifier has an input power of $2mW$ and an output power of $345mW$. What is its decibel power gain? [2]

e) Differentiate between an ideal and non-ideal op amp. [4]

Question 3

a) Consider the emitter-follower amplifier of Fig. 3(a) for $I = 1mA$, $\beta = 100$, $V_T = 25mV$, $R_B = 100k\Omega$, $R_{sig} = 20k\Omega$ and $R_L = 1k\Omega$.

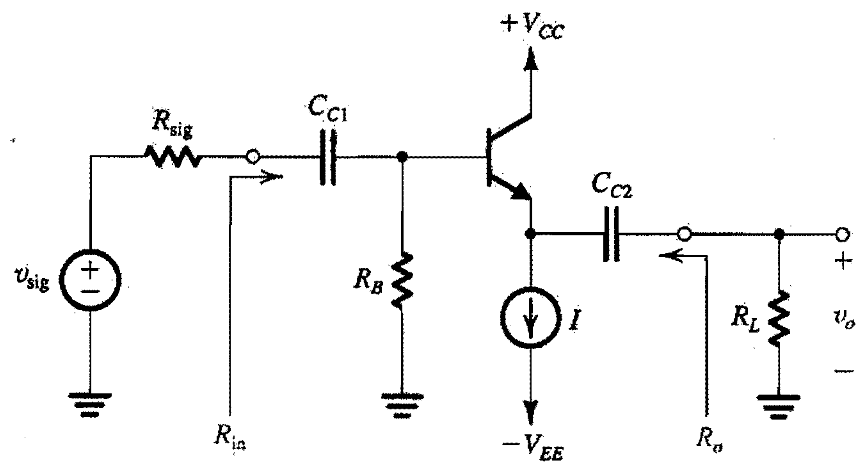

Fig. 3(a)

i) Find R_{in} [5]

ii) Find $\frac{v_o}{v_{sig}}$ [5]

b) A parallel resonant circuit has a capacitor of $100pF$ in one branch and inductance of $100\mu H$ plus a resistance of 10Ω in the parallel branch. If the supply voltage is $10V$, calculate:

i) The resonant frequency [3]
ii) The impedance of the circuit [3]
iii) The line current at resonance [3]
iv) The Q-factor of the circuit. [3]

c) A particular small geometry BJT has $f_T = 5GHz$ and $C_\mu = 0.1pF$ when operated at $I_C = 0.5mA$ and $V_T = 25mV$.

i) Find g_m [1]
ii) When $\beta = 150$, find r_π and f_β. [2]

Question 4

a) Consider the common-emitter amplifier shown in Fig. 4(a) under the following conditions: $R_{sig} = 5k\Omega$, $R_1 = 33k\Omega$, $R_2 = 22k\Omega$, $R_E = 3.9k\Omega$, $R_C = 4.7k\Omega$, $R_L = 5.6k\Omega$, $V_{CC} = 5V$, $r_o = 300k\Omega$, $\beta = 120$, dc collector current, $I_C = 0.3mA$, $V_T = 25mV$, $C_\mu = 1pF$, $f_T = 700MHz$ and $r_x = 50\Omega$. Find:

i) C_π [4]

ii) The upper $3-dB$ frequency, f_H. [10]

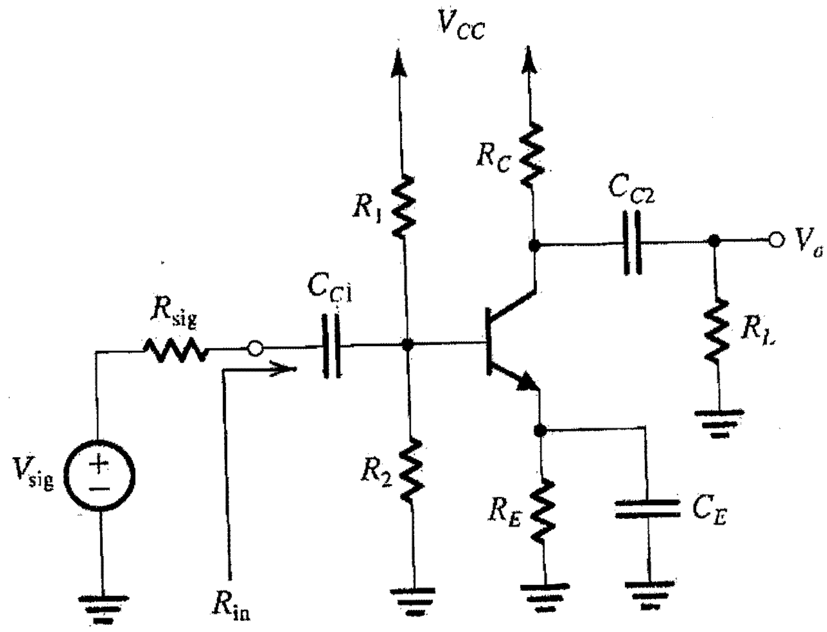

Fig. 4(a)

b) Determine the output voltage of an op amp for input voltages of $V_{i_1} = 150\mu V$ and $V_{i_2} = 140\mu V$. The amplifier has a differential gain of $A_d = 4000$ and the value of Common-Mode Rejection Ratio (CMRR) is 10^5. [4]

c) In Fig. 4(c) below, $V_{sat} = \pm 13V$, $R_1 = 1k\Omega$ and $R_2 = 100k\Omega$. Calculate:
i) The upper threshold point (UTP) [3]
ii) The lower threshold point LTP [2]
iii) The hysteresis voltage (V_H) [2]

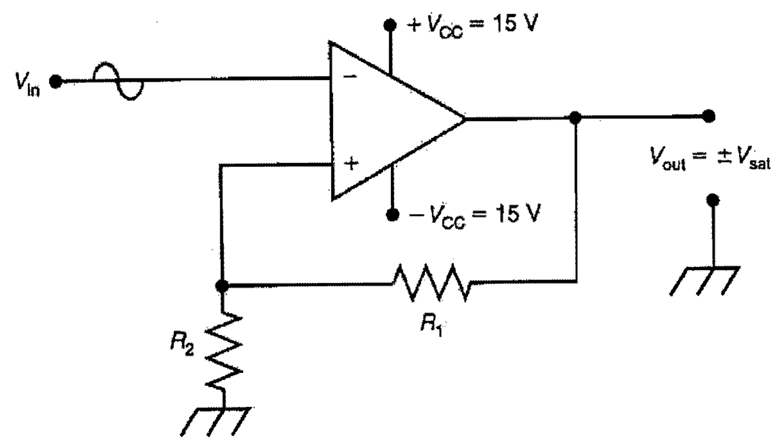

Fig. 4(c)

Question 5

a) The input Miller capacitance in Fig. 5(a) below creates a bypass circuit on the input side. If $A = 300$ and $C = 10pF$, what is the critical frequency of this bypass circuit? [5]

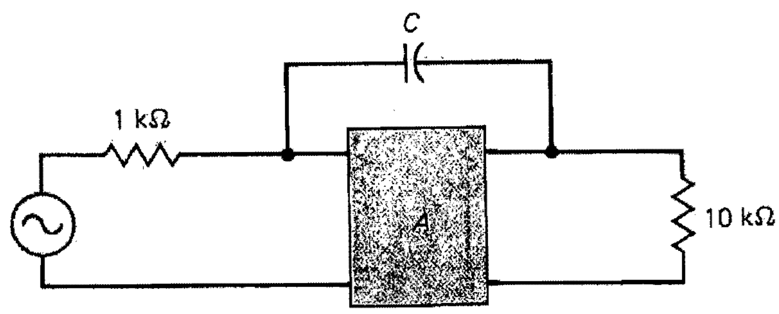

Fig. 5(a)

b) For Fig. 5(b) below, determine f_{L_s}, i.e. low frequency response due to the input coupling capacitor, C_s. $V_T = 26mV$ and $V_{BE} = 0.7V$. [10]

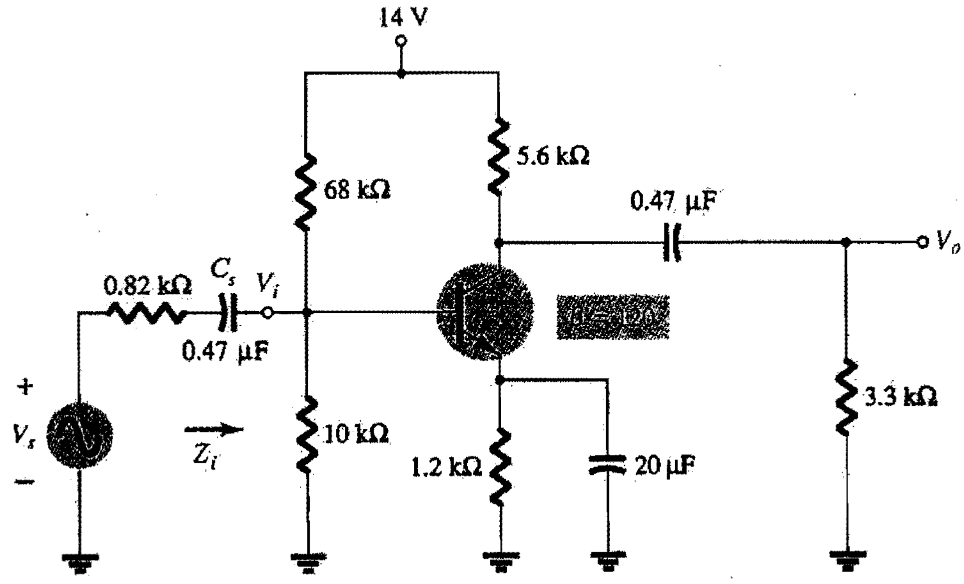

Fig. 5(b)

c) For the noninverting amplifier in Fig. 5(c) derive an expression its open loop gain, $A_v = \frac{V_{out}}{V_{in}}$. [6]

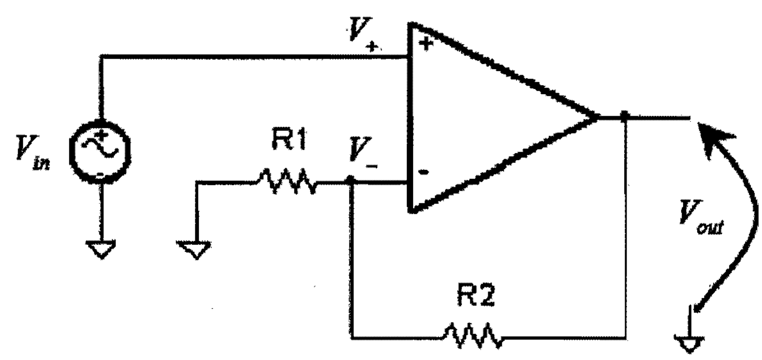

Fig. 5(c)

d) What is Stagger tuning? Sketch the frequency response of this amplifier. [4]