भारतीय सूचना प्रौद्योगिकी संस्थान गुवाहाटी

INDIAN INSTITUTE OF INFORMATION TECHNOLOGY GUWAHATI

Mid-Semester Examination

EC 301: Analog Integrated Circuit

Time: 2 Hours, Total Marks: 30, Date: 18^{th} September 2022

Note:

(i) Answer **ALL** questions.

(ii) Write down the assumptions clearly, if any. No queries will be entertained during the exam hours.

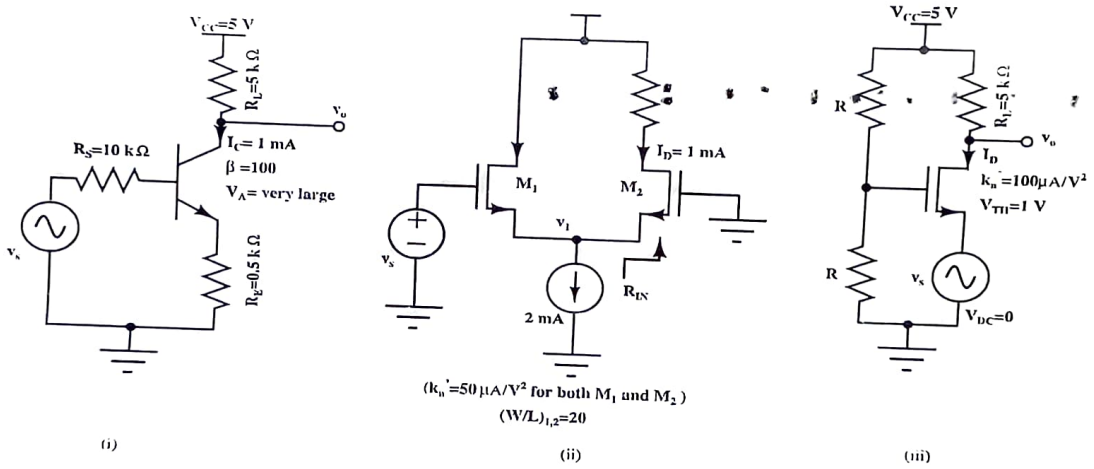


Figure 1: Circuits for Q 1, 2 and 3

1. For the common emitter amplifier with emitter degeneration shown in Fig. 1(i),
   (a) Identify the type of feedback. [1]
   (b) Find the value $\frac{v_o}{v_s}$. [4]
2. For the unbalanced differential amplifier of Fig. 1(ii),
   (a) Find the value of R_{IN} [2.5]
   (b) Find the value $\frac{v_1}{v_s}$. [2.5]
3. For the MOS amplifier shown in Fig. 1(iii),
   (a) Find the value of I_D [2.5]
   (b) Find the value $\frac{v_o}{v_s}$. [2.5]

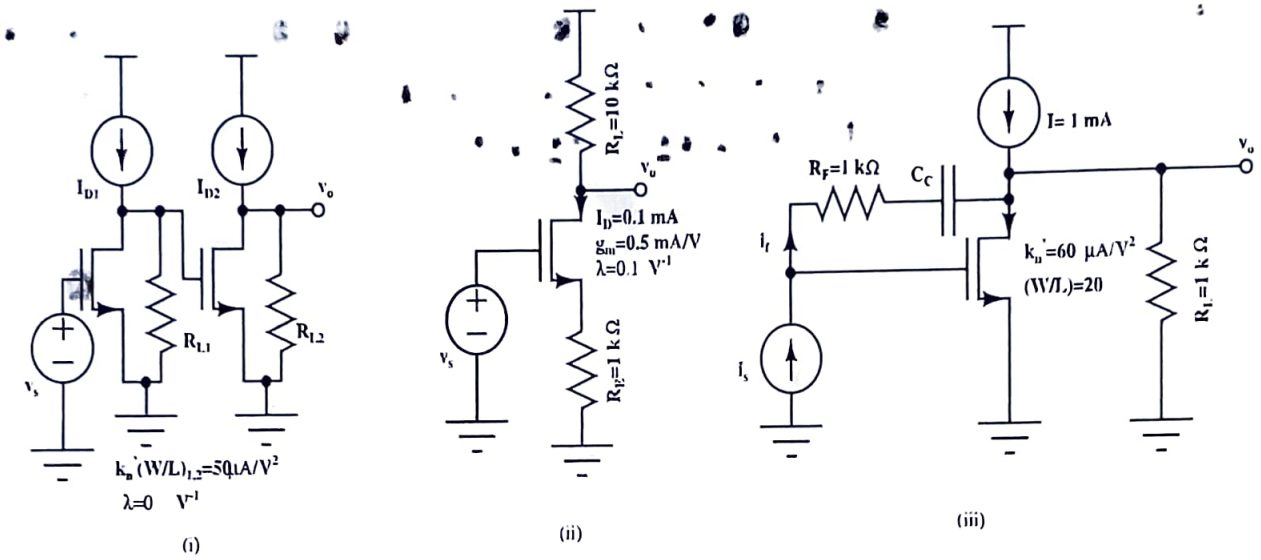


Figure 2: Circuits

4. For the two stage amplifier of Fig. 2(i), $I_{D1} = 1$ mA, $I_{D2} = 0.1$ mA, $R_{L1} = R_{L2}$=1 kΩ, $(f_T)_{1,2} = 500$ MHz and for both transistors, $C_{gs} = 10C_{gd}$.
   (a) Draw the small signal high frequency equivalent circuit of the amplifier, mentioning the values of all the parameters. [5]

5. In Fig. 2(ii),
   (a) Find the value of output resistance appearing at the output node v_o. [5]

6. The common source amplifier circuit shown in Fig. 2(iii) has $C_C \Rightarrow \infty$.
   (a) Identify the type of negative feedback topology used in the circuit. [1]
   (b) Find the feedback factor i_f/v_o. [2]
   (c) Find the closed loop gain v_o/i_s. [2]

INDIAN INSTITUTE OF INFORMATION TECHNOLOGY GUWAHATI

DEPT. OF ELECTRONICS & COMMUNICATION ENGINEERING

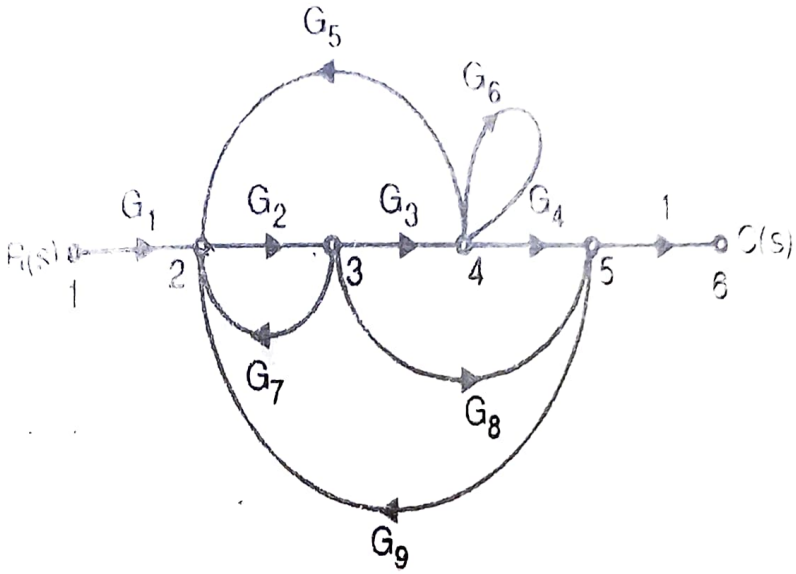
MID SEMESTER EXAMINATION, 21ST SEPTEMBER, 2022

SUBJECT: CONTROL SYSTEMS (EC380)

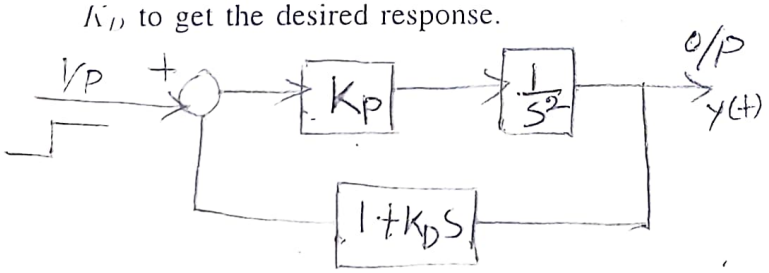
ANSWER ALL QUESTIONS

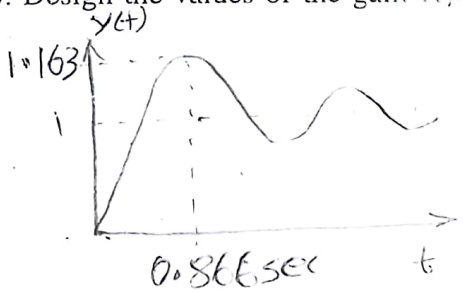
TIME: 2 Hours FULL MARKS: 10

1) Find the transfer function of the following signal-flow graph. (5)

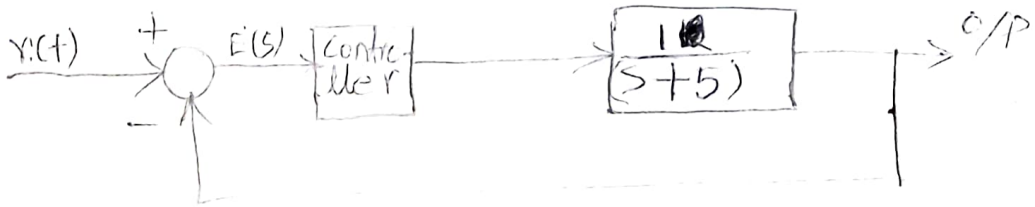


2) The plant shown below has open-loop transfer functions as $G(s) = \frac{1}{s^2}$. The plant is controlled by a forward proportional controller with gain K_P , and a rate controller in its feedback path. It is desired to obtain a response to a step input as shown below. Design the values of the gain K_P and K_D to get the desired response. (5)





3) Consider the feedback control system shown below. The controller is an integrator with a gain of K. Find the value of K for which steady-state error to $r(t) = 0.1tu(t)$ input is less than 0.01. (5)

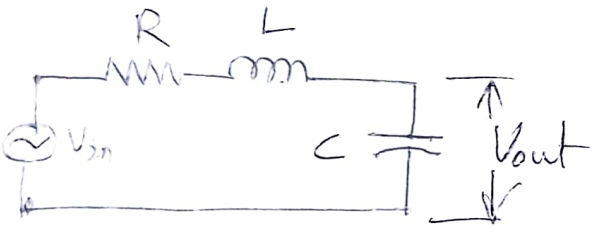


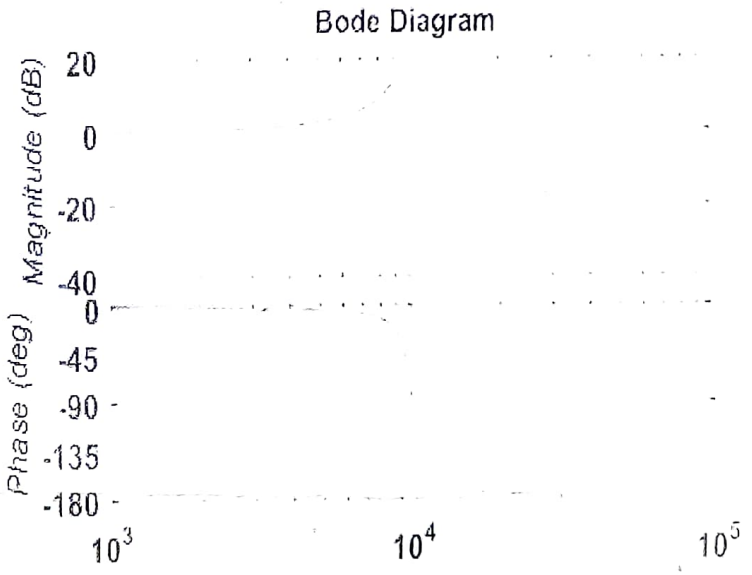
4) Utilizing the Routh-Hurwitz criterion, determine the stability of the polynomial, $s^5 + s^4 + s^3 + s^2 + s + K$.

Determine the number of roots, if any, in the right hand plane. If it is adjustable, determine the range of K that results in a stable system. (5)

5) A unity feedback system has the loop transfer function $L(s) = \frac{k(s+a)}{s(s+b)}$. Sketch the root locus for (i) $a = 4$ & $b = 2$, and (ii) $a = 2$ & $b = 4$. (5)

6) A R-L-C series circuit is shown in Fig. . The Bode diagram obtained by experimental means using a sinusoidal voltage is shown in Fig. . Determine the numerical values of R, L, and C.





(5)

7) For a closed-loop system with loop transfer function, $G(s) = \frac{k}{0.5s^3+1.5s^2+s}$ draw the polar plot. a) From polar plot determine the range of k for which closed-loop system is stable. b) Determine the gain margin(**GM**) and phase margin (**PM**) for $k = 10$ and decide stability. (10)

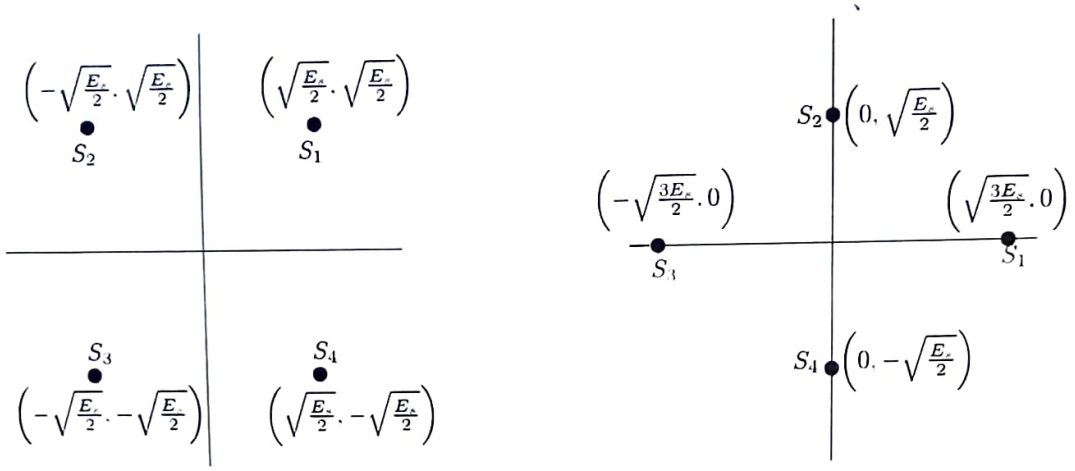
Mid Semester Examination

Digital Communication (EC351)

24 September, 2022 | Duration: 2 Hours | **Total Marks: 50**

Note: Answers without a proper justification carry *zero* marks even if they are correct.

1. Consider the two modulation schemes in the figure below: **[9]**



Modulation scheme - I

a). All symbols are equiprobable

Modulation scheme - II

b). Symbol probabilities are $\Pr(S_1) = \Pr(S_3) = p$ and $\Pr(S_2) = \Pr(S_4)$

Figure: Depiction of two different modulation schemes to transmits 4 symbols

(a) Determine which of the following modulation scheme is energy efficient for the cases below: **[3×2]**

i. For $p = \frac{1}{6}$.

ii. For $p = \frac{1}{12}$.

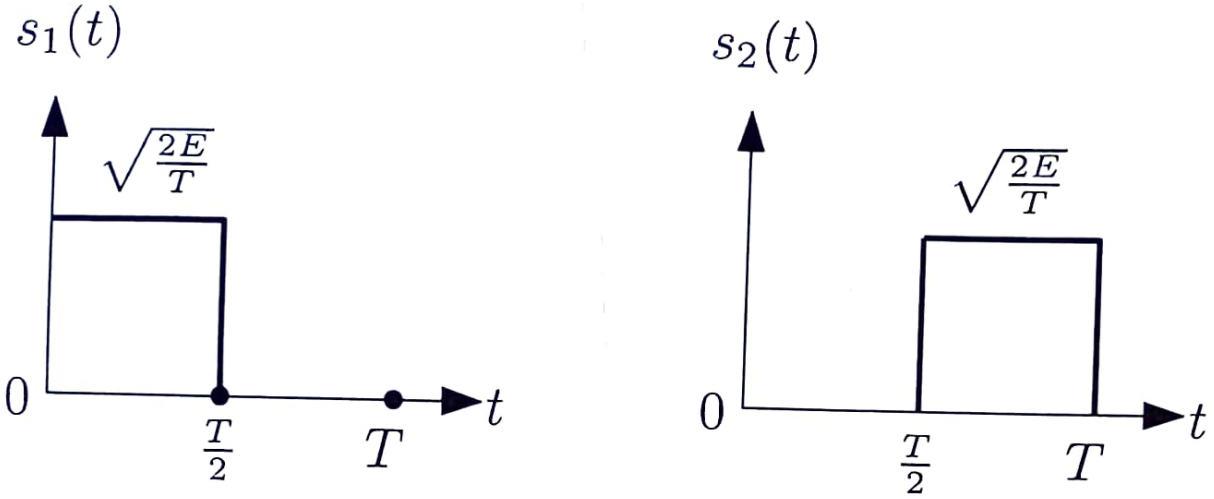
(b) Determine the value of p for which both scheme are equally energy efficient. **[3]**

2. It is given that BASK and BPSK signals have the same probability of error and modulating binary pulses have the same peak amplitude for both modulations. What will be the relation between bit rates? **[4]**

3. Consider a binary signaling scheme where equiprobable bits '1' and '0' are transmitted over an AWGN channel (with mean 0 and variance $\frac{N_o}{2}$) by two signals $s_1(t)$ and $s_o(t)$ respectively. Both the signals have equal energy i.e. $\int_0^T |s_1(t)|^2 dt = \int_0^T |s_o(t)|^2 dt = E$. However, $s_1(t)$ and $s_o(t)$ are not orthogonal to each other, but correlated with a correlation coefficient ρ. Determine the average probability of error in terms of E, ρ and N_o. **[5]**

4. Prove that, in a binary digital communication system average probability of error is upper bounded by $\frac{1}{2}$. **[3]**

5. For a waveform $x(t) = u(t) - 2u(t - \frac{T}{3}) + 2u(t - \frac{2T}{3}) - u(t - T)$, where $u(\cdot)$ is the unit step signal. Is it possible to "fully express" $x(t)$ in terms of $\psi_1(t) = \frac{1}{\sqrt{T}}(u(t) - u(t - T))$, and $\psi_2(t) = \frac{1}{\sqrt{T}}\left(u(t) - 2u(t - \frac{T}{2}) + u(t - T)\right)$? Explain with proper justification. (Note: Here, "fully express" means $x(t) = a_1\psi_1(t) + a_2\psi_2(t)$.) **[5]**



6. The two pulses shown in the figure above are employed in a binary orthogonal signaling scheme to be used in a digital communication system over an AWGN channel with mean 0 and variance $N_o/2$. Evaluate the following:

   (a) Sketch carefully the impulse responses of a pair of matched filters of this system. **[2+2]=[4]**

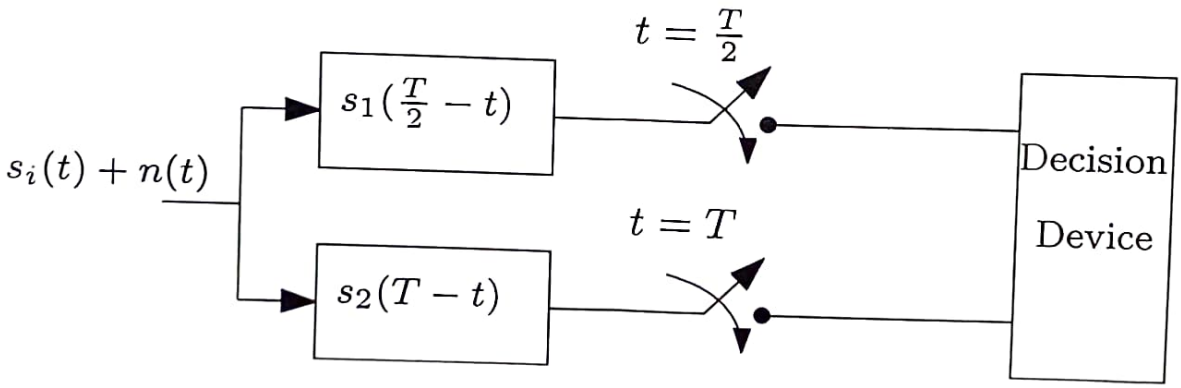
   (b) Find the mean and variance of the output of both the matched filters, sampled at $t = T$, when only $s_1(t)$ is transmitted. **[4]**

   (c) Now, receiver uses a matched filter (MFD) and correlation-based detector (CBD) one by one. However, because of a timing error, the output is incorrectly sampled at t = 0.75T (in both of the detectors).

   What is the relationship between BERs of MFD and CBD? Are they same? Justify. **[3+3]=6**

   How does the BERs of MFD and CBD related to the BER of the ideal detector system (where the signal sampled at t = T) ? **[2+2]=4**

   (d) If receiver employs a detector as shown in below Figure: **[5+1]=6**



How the performance (in terms of BER) of the above receiver is compared to standard matched filter based detector? (Note: The standard matched filters are those which we discussed in the class.)

Indian Institute of Information Technology Guwahati
Mid Semester Examination on Electromagnetics (EC370)
20th September 2022

Time: 2 hours **Full Marks: 65**

Note: All parts of the same question should be answered together.

1. (a) Five equal point charges Q=20 nC are located at x=2, x=3, x=4, x=5 and x=6 (all in m). Find the potential at the origin.
(b) An electric dipole 0.5 $\mathbf{a}_x$ nC-m is situated at the origin. Find the potential at the point (5,0,0).
(c) For a line charge distribution with line charge density 0.5×10^{-9} C/m on Z-axis, find V_{AB}, where A is (2m, pi/2, 0 m) and B (4m, pi, 5 m). (5+5+5 = 15)

2. (a) What net flux crosses the closed surface which contains a charge distribution in the form of a plane disk of radius 4 m with a density $\{(\text{Sin}^2\phi)/2\rho\}$ (C/m^2)?
(b) Determine the torque (N-m) on a square coil of 0.2 m X 0.2 m carrying a current of 3 A in a field of 10 wb/m^2.
(c) A charge of 12 C has velocity of $5a_x+2a_y-3a_z$ m/s. Determine F (in N) on the charge in the field of $B= 4a_x+4a_y+3a_z$ wb/m^2. (5+5+5 = 15)

3. Given that $E = (3x^2 + y)\, a_x + x\, a_y$ kV/m; find the work done in moving a -2μC charge from (0.5,0) to (2, -1, 0) by taking the straight-line path. (10)

4. Given that $\mathbf{H_1} = -2\mathbf{a}_x + 6\mathbf{a}_y + 4\mathbf{a}_z$ A/m in region $y - x - 2 < 0$ where $\mu_1 = 5\mu_0$, calculate
(i) $\mathbf{B_1}$
(ii) $\mathbf{H_2}$ and $\mathbf{B_2}$ in region $y - x - 2 > 0$ where $\mu_2 = 2\mu_0$ (10)

5. (a) For a spherical charge distribution $\rho_v = \rho_0(a^2 - r^2)$, $r < a$;
$= 0$, $r > a$
Find **E** for r> a and r < a and also find the total charge.
(b) Verify whether $V = 4x^2 - 6y^2 + 2z^2$ is the potential for a charge free region.
(7+3 = 10)

6. Fill in the blanks (single word): (1 X 5 = 5)

(a)The electric field inside a conductor is ..... 0 .....

(b) When a dielectric slab is placed between the plates of a charged parallel plate condenser, then the dielectric medium is .....

(c) The total magnetic flux coming out of closed surface is ..... 0 .....

(d) If the particle is at rest in magnetic field, then it will experience ..... forces ..... force.

(e) Surface on which the potential is constant are known as ..... equipotential ..... surface.

.....X.....

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