Problem: CM5 **Area: Integrated Circuits and Logic Design** **Code #_____**

Design a 2-bit down counter 32103210... using JK flip-flops. Show your design steps for full credit.

Problem: CM6 **Area: Integrated Circuits and Logic Design** **Code #_____**

Given the function F(A,B,C,D) below. Answer the following questions.

$$F = \sum_{ABCD} m(1,3,4,6,7,9,11,13) + dc(0,12)$$

(a) Write the canonical SOP expression for F.

(b) Determine the minimal SOP expression for F.

(c) Draw the logic network for the minimal SOP expression for F found in part (b). You may use any combination of logic gates.

Problem: CM7 **Area: Integrated Circuits and Logic Design** **Code #_____**

Design/draw the CMOS logic array logic for the function $F = \bar{A}B + \bar{B}C$. Include both the pFET and nFET arrays in your design.

Problem: CM8 **Area: Integrated Circuits and Logic Design** **Code #_____**

Given the following Boolean expression:

$$Z(A,B,C,D) = A\overline{\overline{C}} + \overline{B}C + AD + A\overline{\overline{B}} + CD$$

Out of the five product terms, one is redundant (i.e., can be eliminated without affecting the function). Please identify the term and explain your answer.

Problem: CM17 **Area: Networking and Software Engineering** **Code #_____**

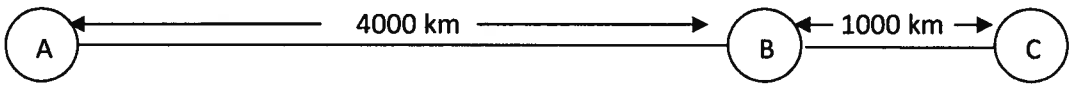
Answer <u>all three</u> questions below:

a. In the context of communication networks, what is the purpose of flow control?

b. In which layer(s) of the OSI network model is flow control carried out? Explain your answer.

c. In the figure below, frames are generated at node A and sent to node C through node B. Determine the minimum data rate required between nodes B and C so that the buffers of node B are not flooded, based on the following information. <u>Show every step of your work.</u>

- The data rate between A and B is 50 kbps.
- The propagation delay is 5 μsec/km for both lines.
- There are full duplex lines between the nodes.
- All data frames are 1000 bits long; ACK frames are separate frames of negligible length.
- Between A and B, a sliding window protocol with a window size of three is used.
- Between B and C, stop-and-wait is used.
- There are no errors.

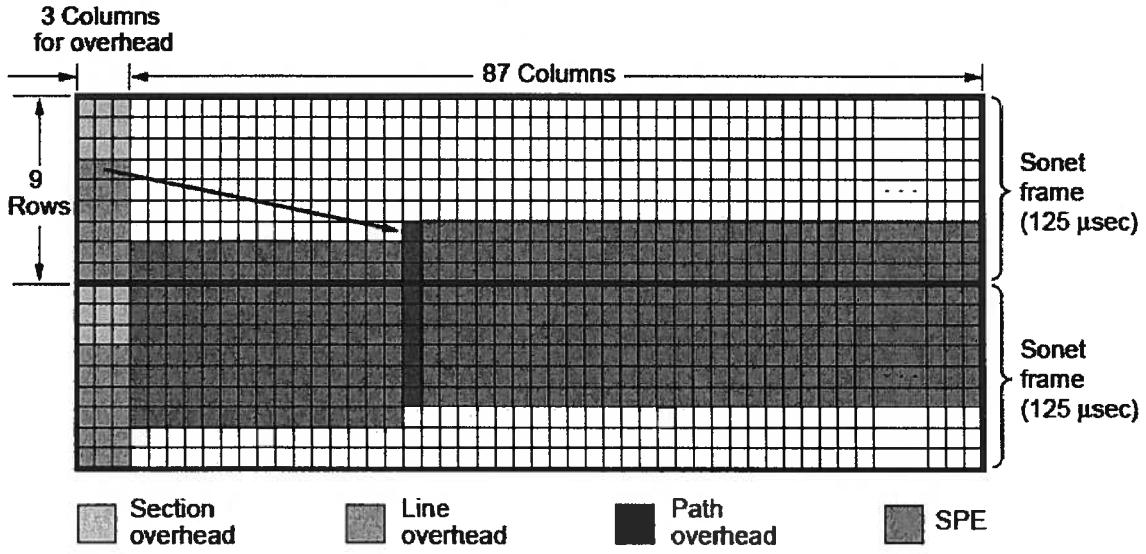


Problem: CM18 **Area: Networking and Software Engineering** **Code #_____**

Answer <u>both</u> questions below.

a. In which layer(s) of the OSI model is the OC-n standard applied?

b. The user data rate for OC-3 is stated to be 148.608 Mbps. Show how this number is derived from the SONET OC-3 parameters. For your reference, the figure below depicts two back-to-back OC-3 frames. Note that the numerical calculation is not the point of this question, so it is important that you identify each number (from the figure) that contributes to the user data rate. You can leave your answer as a product of several numbers, but the source of each number needs to be clear.



Problem: CM19 **Area: Networking and Software Engineering** **Code #_____**

Answer <u>all four</u> questions below.

a. In IP, the checksum covers only the header and not the data. Why do you suppose this design was chosen?

b. A router has just received the following new IP addresses: 57.6.96.0/21, 57.6.104.0/21, 57.6.112.0/21, and 57.6.120.0/21. If all of them use the same outgoing line, can they be aggregated? If so, to what? If not, why not? Explain your answer by showing your work.

c. Which of the following is a Class C IP address? Why?
   i. 10.10.14.118
   ii. 135.23.112.57
   iii. 191.200.199.199
   iv. 204.67.118.54

d. What is the difference between classless and classful routing? Which came later? Which shortcomings of the former was it intended to address?

Problem: CM20 **Area: Networking and Software Engineering** **Code #_____**

Answer both questions below. Show your work.

a. Suppose that data are transmitted in blocks of 1000 bits. What is the maximum error rate under which error detection and retransmission mechanism (one parity bit per block) is better than using Hamming code? Assume that bit errors are independent of one another and no bit error occurs during retransmission.

b. A disadvantage of the contention approach for LANs, such as CSMA/CD, is the capacity wasted due to multiple stations attempting to access the channel at the same time.
Suppose that time is divided into discrete slots, with each of N stations independently attempting to transmit with probability p during each slot.
What fraction of slots is wasted due to multiple simultaneous transmission attempts?

Problem: CM21 **Area: Security and Reliability** **Code #_____**

What are the key differences between symmetric key cryptographic algorithms and asymmetric key cryptographic algorithms?

Problem: CM22 **Area: Security and Reliability** **Code #_____**

A Cyclic Code word is received as 1011110 which may or may not be erroneous. Determine if the received Cyclic code word is valid or invalid using $G(X) = x^3 + x + 1$.

Problem: CM23 **Area: Security and Reliability** **Code #_____**

Use output encoding to eliminate bi-directional errors on the outputs due to single primary input faults. For the 3-input and 2-output circuit represented by the two Boolean equations below, determine the following.

$F_1 = B \cdot C$ and $F_2 = A$

a. Construct a truth table for the given circuit and draw a graph representation G and G_m.

c. Find one possible output encoding from G_m.

Problem: CM24 **Area: Security and Reliability** **Code #_____**

An NMR system consists of five identical computing modules and a voter. Assume the reliability of the voter is much more reliable than the modules and can be neglected. Determine the following.

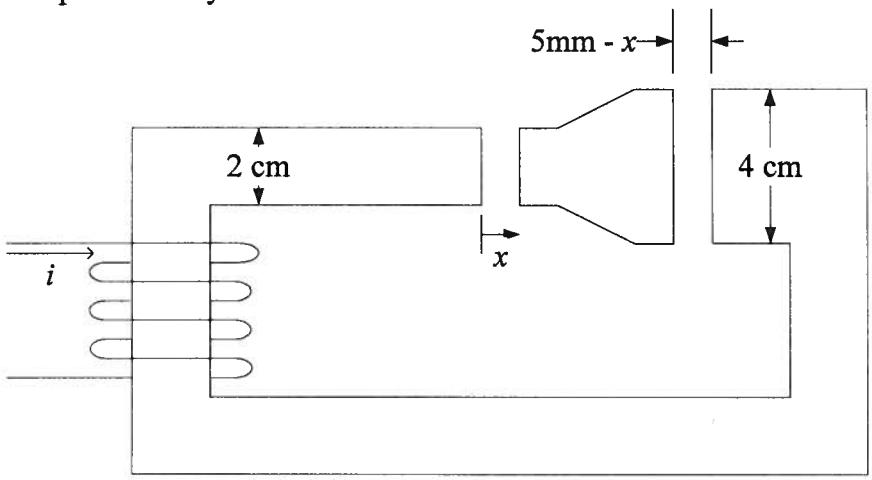
a. Find the reliability of the module RM and the reliability of the NMR system RNMR using the exponential failure law.

b. Assume that an individual module fails every 10,000 hours. Find the Reliability Improvement Factor (RIF) at t = 5,000 hours.

c. Consider a Hybrid Redundancy system consists of a TMR system with two dynamic spares (e.g, (3,2) system). Compare R_{NMR} and R_{HYBRID}, assuming that an individual module fails every 10,000 hours and t=5,000. Which one is better in terms of the reliability?

Problem M.1 **Power/Machinery** **Code #**_____

Consider the figure below. Dimensions are as shown. The total air path is 5 mm, split into two parts of lengths x and (5mm-x). Depth into the page is 4 cm. The coil has 150 turns. The steel has infinite permeability.



a. Draw the magnetic equivalent circuit.
b. Solve the circuit for flux and flux-linkage.
c. Determine the co-energy.
d. Determine the force of electric origin acting on the moving member in the $+x$ direction, as a function of current i. The only variables allowed to remain in your answer are x and i.

Problem M.2 **Power/Machinery** **Code #_____**

A three-phase, 4-pole induction motor is rated for 575 V, 60 Hz. Its parameters are: $R_1 = 0.75\ \Omega$, $R_2 = 1.2\ \Omega$, $X_1 = 3\ \Omega$, $X_2 = 3\ \Omega$, $X_m = 25\ \Omega$. It will be operated from an adjustable speed drive, which has a bus voltage of 810 V.

a. If third harmonic injection is used, what is the maximum possible voltage applied to the motor without saturating the PWM process?
b. The motor is now operated at 35 Hz. The ASD uses a linear V/Hz profile with 50 V of boost. What is the applied voltage?
c. For the conditions of (b), draw the equivalent circuit of the motor. Label all impedances NUMERICALLY. Also label the source voltage NUMERICALLY.
d. For the conditions of (b), the speed is 975 RPM. Determine the slip and the total power consumption of the motor.

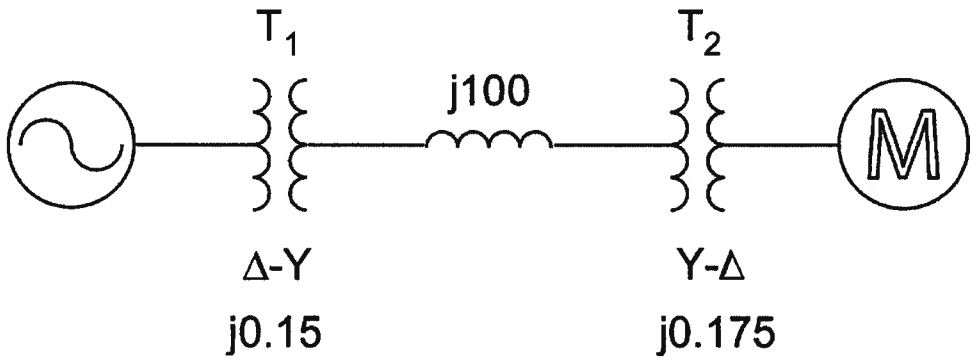
Problem M.3 **Power/Machinery** **Code #_____**

A 13.8 kV line serves a three-phase load rated 800 kW at 0.92 power factor lagging. What is the three-phase rating of a capacitor bank required to correct the power factor to 0.98 lagging?

Problem M.4 **Power/Machinery** **Code #_____**

In the following system, the generator, motor, and transformers are all solidly grounded.

Generator: 1 MVA, 13.8 kV, $x_d=x_2=0.1$ per unit, $x_0=0.05$ per unit
Motor: 1 MVA, 12.5 kV, $x_d=x_2=0.1$ per unit, $x_0=0.05$ per unit
Transformer 1: 1 MVA, 138 kV Y/ 13.8 kV Δ
Transformer 2: 0.5 MVA, 138 kV Y/ 13.8 kV Δ

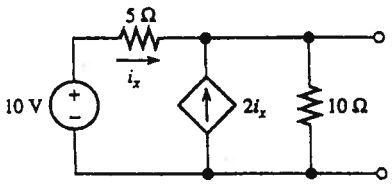


Draw the per-unit positive sequence equivalent circuit.

PROBLEM M5 CIRCUITS AND ELECTRONICS AREA Code #_____

Thevenin Equivalent Circuit

Determine *Thevenin Equivalent Voltage,* V_{th} and *Thevenin Equivalent Resistance,* R_{th} for the circuit shown below.



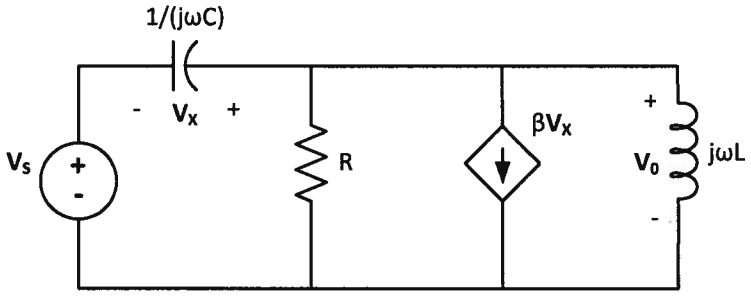
Answer

V_{th} =

R_{th} =

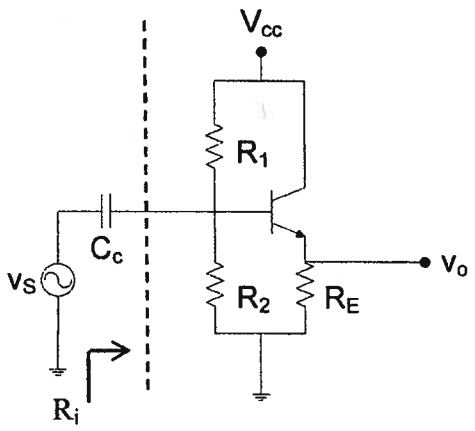
PROBLEM M6 CIRCUITS AND ELECTRONICS AREA Code #_____

For the following circuit, find the transfer function: $H(j\omega) = \frac{V_0}{V_S}$.

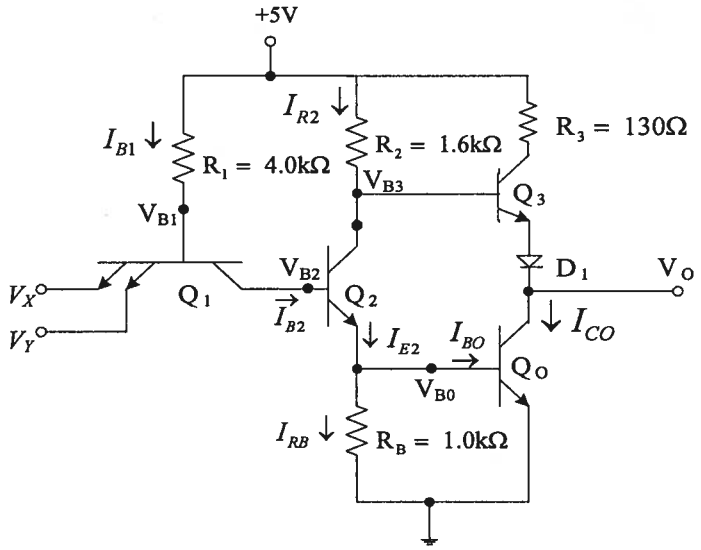


Problem: M7 Area: Circuits and Electronics Code #:_____

For the following amplifier circuit, $\beta = 100$, $R_1 = 20\ k\Omega$, $R_2 = 10\ k\Omega$, $R_E = 3\ k\Omega$, and $V_A = 100$ V. Assume V_{CC} has been adjusted such that $I_{CQ} = .75$ mA. Find the input resistance, Ri, as shown, and the small-signal voltage gain, $A_v = v_o / v_s$. Assume the transistor is in the forward active mode, and recall that $r_\pi = V_T \beta / I_{CQ}$, $g_m = I_{CQ} / V_T$, and $r_o = V_A / I_{CQ}$.



Consider the TTL gate shown. The parameters for the diodes and transistors are shown in the table to the right.



$V_\gamma = 0.7V$
$V_{BE}(on) = 0.7V$
$V_{BE}(sat) = 0.8V$
$V_{CE}(sat) = 0.1V$
$\beta_F = 25$
$\beta_R = 0.1$

Let $V_X = V_Y$ = 5V. Find V_{B0}, V_{B2}, V_{B1}, I_{B1}, I_{B2}, V_{B3}, I_{R2}, I_{E2}, I_{RB}, and I_{B0}.

Answers: V_{B0} = _____, V_{B2} = _____, V_{B1} = _____, I_{B1} = _____, I_{B2} = _____,

V_{B3} = _____, I_{R2} = _____, I_{E2} = _____, I_{RB} = _____, I_{B0} = _____,

Problem M14 Area: Control Code #_____

Consider the following discrete-time system

$$x(k+1)=\begin{bmatrix}1 & T\\ 0 & 1\end{bmatrix}x(k)+\begin{bmatrix}\frac{T^2}{2}\\ T\end{bmatrix}u(k)$$

where T is the sampling interval. Determine a state feedback gain matrix K such that the response to an arbitrary initial condition is deadbeat.

Problem M16 Area: Control Code#_____

Use the Routh-Hurwitz test to find the range of K for which the following characteristic equation is stable.

$$s + 2s^4 + 2s^3 + 4s^2 + Ks + 4 = 0$$

Problem M-21 Communications / Signal Processing Code# ___

Find the complex exponential Fourier Series coefficients for

$$x(t) = sgn\{sgn[20\ cos(2\pi 10t) + 10\sqrt{2}]\} + 20$$

Where sgn() is the signum function, defined as

$$sgn(y) = \begin{cases} -1 & for\ y < 0 \\ 0 & for\ y = 0 \\ +1 & for\ y > 0 \end{cases}$$

Show your work for full credit. If you think it is impossible to find the Fourier Series coefficients for x(t), explain why it is impossible.

Problem M22 **Communications** **Code #_____**

Prove that the impulse response, $h(n)$ of a causal, linear, time invariant, discrete-time system has no non-zero values for $n < 0$.

Prob. M23 **Area: Communications/Signal Processing** **Code #:** _____

A standard (non-adaptive) delta modulator is to be used to transmit the message signal $m(t) = 3\cos 500\pi t$ volts.

(20%) a) From the choices below, select an appropriate sampling interval. (Circle one.) Explain the reason for your choice.

Answer (Circle one): $T_S = 0.15$ ms $T_S = 1.5$ ms $T_S = 15$ ms

Explain your answer_____

(20%) b) Find the maximum slope of $m(t)$.

Answer: $\left|\frac{dm(t)}{dt}\right|_{\max}$ = _____

(15%) c) Using the T_S you selected in a), find the smallest step size, δ_0, that will prevent slope overload.

Answer: δ_0 = _____

(15%) d) What is the bit rate of this design?

Answer: R = _____

(15%) e) If this design results in quantization levels that are too coarse then you must make δ_0 smaller. What effect will this have on T_s (still preventing slope overload)?
(Circle the best answer.)

1) T_S will have to become larger.
2) T_S can stay the same.
3) T_S will have to become smaller.

(15%) f) Based on your answer to e), how will the bit rate change?
(Circle the best answer.)

1) The bit rate will be lower.
2) The bit rate will not change.
3) The bit rate will be higher.

A set of symbols $S = \{a, b, c, d, e\}$ is found in a discrete source with the probability of occurrence being $P = \{0.1, 0.15, 0.30, 0.16, 0.29\}$.

1. What is the self-information of each symbol?
2. What is the entropy of the discrete source?
3. Use Huffman Coding to encode the symbols.
4. Compute the average coding length of the resulting Huffman code and compare it with the entropy.