Range Forest Officer (Main / Written) Examination, 2021

ELECTRONICS ENGINEERING

Time Allowed: Three Hours | Maximum Marks: 200

QUESTION PAPER SPECIFIC INSTRUCTIONS

Please read each of the following instructions carefully before attempting questions.

1. There are 08 (eight) questions in all, out of which FIVE are to be attempted.
2. Question Nos.1 and 5 are compulsory. Out of the remaining SIX questions, THREE are to be attempted selecting at least ONE question from each of the two Sections I and II.
3. All questions carry equal marks. The number of marks carried by a question / part is indicated against it.
4. Answers must be written in legible handwriting. Each part of the question must be answered in sequence and in the same continuation.
5. Neat sketches may be drawn, wherever required.
7. Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Answer Booklet must be clearly struck off.
8. Re-evaluation / Re-checking of answer book of candidate is not allowed.

SECTION-I

1. (i) A Si solar has a short-circuit current of 100mA and an open-circuit voltage of 0.8V under full solar illumination. The fill factor is 0.7. What is the maximum power delivered to the load by this cell? (5)

   (ii) An intrinsic Si sample is doped with donors from one side such that $N_d=N_0exp(-ax)$. (15)

   (a) Find an expression for the build-in electric field at the equilibrium over the range for which $N_d >> n_i$.

   (b) Evaluate the field when a=1 $(\mu m)^{-1}$.

   (c) Sketch a band diagram and indicate the direction of the field.

   (iii) Consider a CMOS inverter with the following parameters: (20)

nMOS	$V_{T0}, n = 0.6\ V$	$\mu_n C_{ox} = 60\ \mu A/V^2$
pMOS	$V_{T0}, p = -0.8\ V$	$\mu_p C_{ox} = 20\ \mu A/V^2$

with λ = 0.1 V^{-1}. Now consider a cascade connection of four identical inverters, as shown Figure 1.

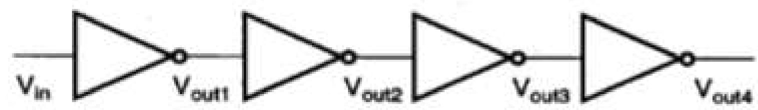


Figure 1

Then find:

(a) If the input voltage $Vin = 1.55V$, find V_{out1}, V_{out2}, V_{out3}, and, V_{out4}.

(b) How many stages are necessary for true logic output level?

2. (i) In the circuit shown in Figure 2 find the indicated currents a long time after the switch has been in position 1. (10)

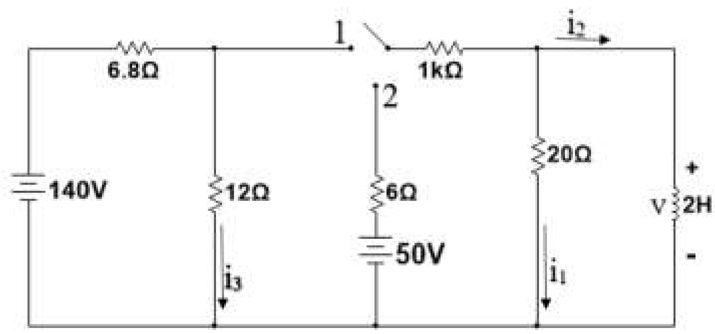


Figure 2

(ii) The voltage v = 30 sin(200πt+30) V is across an inductor that has a reactance of 62Ω.Find the inductor current. Plot one cycle of voltage and current on the same graph also obtained the reading of an ammeter if it is connected in series with the series RL circuit. (15)

(iii) The mean optical power launched into an 8km length fiber is 120μW, the mean optical power at the output of the fiber is 3μW. (15)

Determine:

(a) The overall signal attenuation or loss in decibels through the fiber assuming there are no connectors or splices.

(b) The signal attenuation per Km for the fiber.

(c) The overall signal attenuation for a 10Km optical link using the same fiber with splices at every 1Km intervals, each giving an attenuation of 1dB.

3. (i) The PDF of a Cauchy distributed random variable X is: (15)

$$p(x) = \frac{a/\pi}{x^2 + a^2} \qquad -\infty < x < \infty$$

Determine the mean and variance of X.

(ii) Let $m_1(t)$ and $m_2(t)$ be two message signals, and let $x_{c1}(t)$ and $x_{c2}(t)$ be the modulated signals corresponding to $m_1(t)$ and $m_2(t)$, respectively. (10)

(a) Show that if the modulation is DSB (AM), then $m_1(t)+m_2(t)$ will produce a modulated signal equal to $x_{c1}(t)+x_{c2}(t)$.

(b) Show that if the modulation is PM, then the modulated signal produced by $m_1(t)+m_2(t)$ will not be $x_{c1}(t)+x_{c2}(t)$.

(iii) Determine the autocorrelation function of the stochastic process $X(t)=A\sin(2\pi fct+\theta)$. (15)
Where fc is a constant and is a uniformly distributed phase, i.e. $P(\theta) = 1/(2\pi)$, $0 \le \theta \le 2\pi$

4. (i) For what values of K does the polynomial s4 + 8s3 + 24s2 + 32s +K have roots with zero real parts? What are these roots? (10)

(ii) Sketch the branches of the root-locus for the transfer function

$$GH(jw) = \frac{K(s+2)}{(s+1)(s+3+j)(s+3-j)} \qquad K > 0 \qquad (10)$$

(iii) Construct the Bode plots and determine the gain and phase margins for the system with frequency response function (20)

$$GH(jw) = \frac{4}{(1+jw)(1+jw/3)^2}$$

SECTION-II

5. (i) Simplify the following Boolean functions by first finding the essential prime implicants: (10)

(a) F (w, x, y, z) = ∑ (0,2,5,7,8,10,13,14,15)

(b) F (A, B, C, D) = ∑ (1,3,4,5,10,11,12,13,14,15)

(ii) Draw the multiple-level NOR circuit for CD(B+C)A+(BC′+DE′) and multiple-level NAND circuit for w(x+y+z) +xyz expression. (10)

(iii) A sequential circuit has two JK flip-flops A and B, two inputs x and y, and one output z. the flip-flop input equations and circuit output equation are : (15)

$J_A = Bx + B'y'$ $\qquad K_A = B'xy'$

$J_B = A'x$ $\qquad K_B = A+xy'$

$Z = Ax'y'+Bx'y'$

(a) Draw the logic diagram of the circuit

(b) Tabulate the state table

(c) Derive the state equations for A and B

(iv) A magnetic levitated train travels between the city centre and the airport in, China. Which peculiar property of superconductivity is taken advantage of in this application? (5)

6. (i) Consider the following circuit shown in Figure 3: (10)

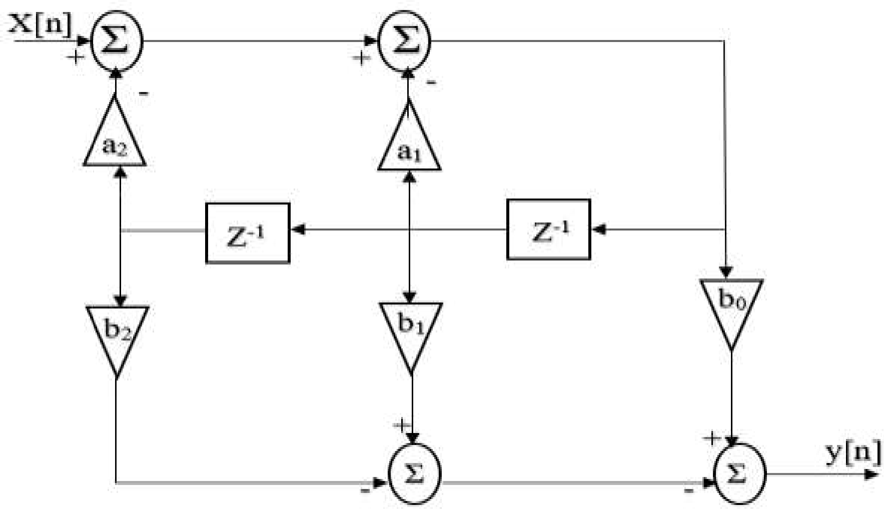


Figure 3

(a) Find the system function H(z).

(b) Find the difference equation relating the output y[n] and x[n].

(ii) Consider the RC circuit in fig.4. The switch is closed at t = 0. Before the switch closing, the capacitor C_1 is charged to v_0 V and the capacitor C_2 is not charged. (15)

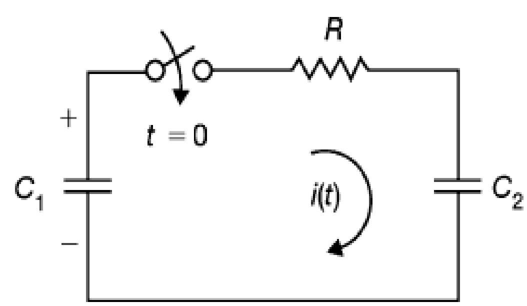


Figure 4

Assuming $C_1 = C_2 = C$,

(a) Find the current i(t) for $t \geq 0$.

(b) Find the total energy E dissipated by the resistor R, and show that E is independent of R and is equal to half of the initial energy stored in C_1.

(c) Assume that $R = 0$ and $C_1 = C_2 = C$. Find the current i(t) for $t \geq 0$ and voltage $v_{c1}(0^+)$ and $v_{c2}(0^+)$.

(iii) Consider the RL circuit shown in Figure 5. (15)

(a) Find the differential equation relating the output voltage y(t) across R and the input voltage x(t).

(b) Find the impulse response h(t) of the circuit.

(c) Find the step response s(t) of the circuit.

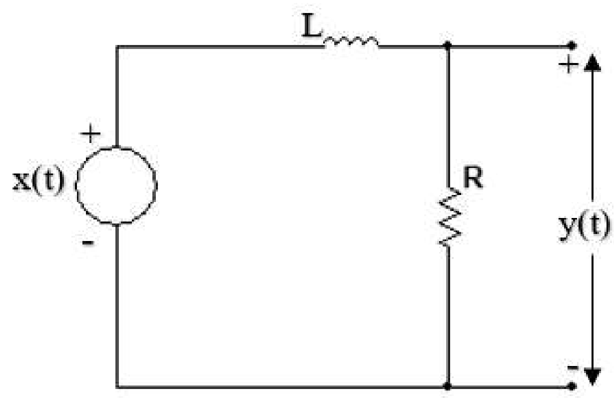
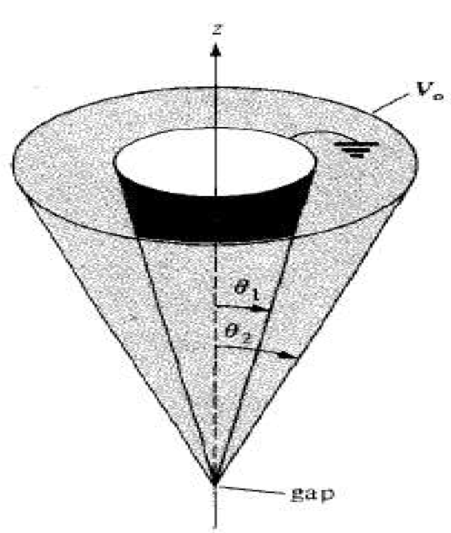


Figure 5

7. (i) In free space ($z \leq 0$), a plane wave with H = 10 cos(108t-βz) ax mA/m is incident normally on a lossless medium (Ɛ = 2Ɛ0, μ = 8μ0) in region $z \geq 0$. Determine the reflected wave Hr, Er and the transmitted wave Ht, Et. (20)

(ii) Two conducting cones (θ=π/10 and θ=π/6) of infinite extent are separated by an infinitesimal gap at r = 0 as shown in following figure. If V(θ=π/10) =0 and V(θ=π/6) =50 V, find V and E between the cones. (20)



8. (i) The varactor diode is designed to operate reverse-biased and is manufactured by a process that increase the voltage-dependent depletion capacitance or junction capacitance Cj. A varactor diode is frequently connected in parallel with an inductor L to form a resonant circuit for which the resonant frequency, $f_R = 1/2\pi\sqrt{(LCj)}$, is voltage-dependent. Such a circuit can form the basis of a frequency modulation (FM) transmitter. A varactor diode whose depletion capacitance is $Cj=10^{-11}/(1-0.75v_D)^{1/2}$F is connected in parallel with a 0.8μH inductor; find the value of v_D required to establish resonance at a frequency of 100 MHz. (20)

(ii) In the circuit of Figure 6, the thyristor is gated with a pulse width of 40 microsec. The latching current of thyristor is 36mA. For a load of 60Ω and 2 H, will this difficulty can be overcome for the the given load. Find the maximum value of the remedial parameter of LOAD. (20)

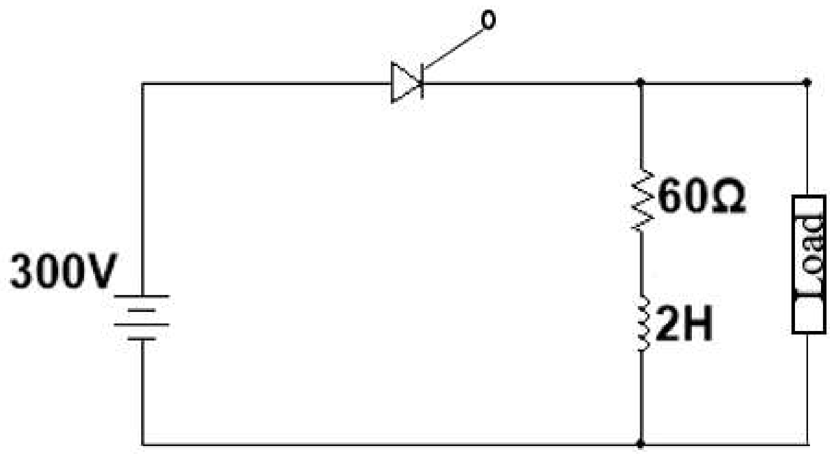


Figure 6

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