ELECTRONICS AND TELECOMMUNICATION ENGINEERING

PAPER - I

Time Allowed: Three Hours *Maximum Marks : 200*

Candidates should attempt any FIVE questions.

Value of the following constants may be used wherever necessary:

Electronic charge = -1.6×10^{-19} Coulomb

Free space permeability $4\pi \times 10^{-7}$ Henry/m.

Free space permittivity $(1/36\pi) \times 10^{-9}$ Farad/m.

Velocity of light in free space 3×10^{8} m/sec.

Boltzmann constant 1.38×10^{-23} Joule/K.

Planck's constant = 6.626×10^{-34} Joule. sec.

1. (a) Pure silicon has an electrical resistivity of 3000 Ωm. If the free carrier density in it is 1.1×10^{6} m^{-3} and the electron mobility is three times that of whole mobility, calculate the mobility values of electrons and holes.

15

(b) Discuss the power loss in the magnetic core of a transformer.

If the total losses in the core of a transformer at 440 V, 50 Hz is 1000 watt and at 220 V, 50 Hz is 400 watt, calculate the eddy current and hysteresis loss separately at 220 V, 50 Hz and 220 V, 60 Hz.

15

(c) What is piezoelectricity ? Explain its application in (i) tweeters and (ii) domestic gas lighters.

The voltage coefficient of a piezoelectric material (PZT), defined as open circuit electric field per unit mechanical stress, is 23×10^{3} Vm/N. Calculate the voltage generated across this PZT of thickness one cm when an impact stress of 10 N per sq m is applied.

10

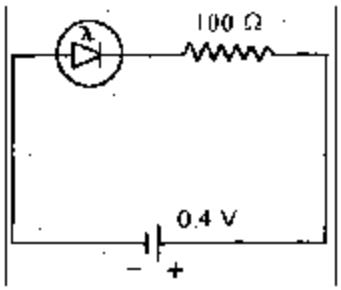
2. (a) Explain the formation of the transition capacitance in a p-n junction diode. Draw the depletion region in a p-n diode if the p-region is heavily doped. The transition capacitance for such a diode having specific value of N_d is given by

$$C_T = 1.4 \times 10^{8} V_B^{-1/2} \text{ pf/m}^2$$

where V_B is the reverse bias voltage. The device is to be used as varactor requiring a capacitance value of 140 pf at 1 volt. Explain how it can be realized.

15

(b) What is a photodiode ? Draw typical I – V characteristic curves at two illumination levels and explain how it works as a photo-resistor and also as a photovoltaic converter.



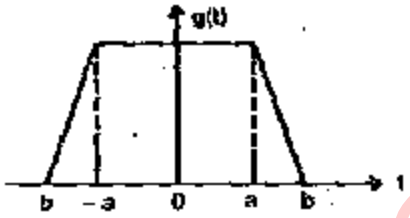
A photodiode is connected as shown in figure. When the device is illuminated with light of intensity 100 lm/cm^2, a current of 1.8 mA flows in the circuit. Calculate the resistance offered by the photodiode. If the illumination is doubled, what happens to the resistance value?

15

(c) Draw and explain the characteristics of an NMOSFET. Calculate the minimum value of V_{DS} required for an NMOSFET to operate in pinchoff condition when $V_{GS} = 1V$, $V_P = -2V$, $I_{DSS} = 10$ mA. Also find the corresponding drain current.

10

3. (a) Using time shifting and time differentiation properties, find the Fourier transform of the trapezoidal signal shown.



What is the condition under which this procedure is valid?

20

(b) If $g(t) * f(t) = h(t)$, show that

$G(t-T_1) * f(t-T_2) = h(t-T_1-T_2)$

10

(c) State and explain Parseval's theorem.

10

4. (a) State sampling theorem. Explain 'flat-top sampling'

(b) Determine the autocorrelation function, power spectral density and mean square value of a sinusoidal process defined by

$$x(t) = A \cos (2 \pi f_c t + \theta)$$

where A is a constant and θ is a uniformly distributed random variable defined by

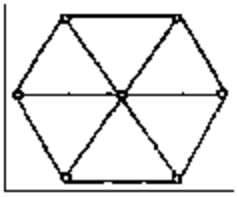
$$f(\theta) = 1/2 \pi, \quad 0 \le \theta \le 2\pi$$
$$= 0, \text{ elsewhere}$$

15

5. (a) Define "tree" of a connected graph. State its properties. How does it aid network analysis?

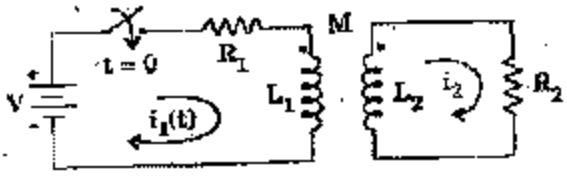
Show at least 4 different trees of the following graph.

10



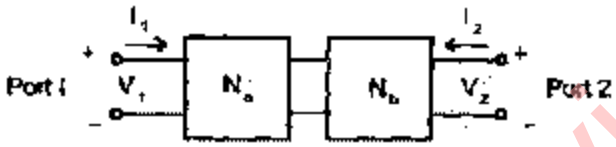
(b) The circuit shown below is unenergized before closing the switch at t = 0. The circuit constants are $L_1 = 1$ H, $L_2 = 4$ H, M = 2 H, $R_1 = 1\Omega$, $R_2 = 1\ \Omega$, V = 5 volts. Find $i_1(t)$ from the instant the switch is closed.

10



(c) For the two two-port networks connected in cascade as shown below find z_{12} and y_{12}.

20



6. (a) What are the four basic rules for the boundary conditions at the interface of two different materials so as to obtain specific solution of Maxwell's equation ?

Derive an expression for the reflection coefficient of a uniform plane Wave incident on a non-lossy medium.

25

(b) Dry ground has a conductivity of 5×10^{-5} mhos/m and a relative dielectric constant of 10 at a frequency of 500 MHz. Calculate the intrinsic impedance and the reflection coefficient of the material of the ground. (Intrinsic impedance of tree space is 377 ohms).

10

(c) Calculate the skin depth for copper at a frequency of 40 MHz if its $\mu = 4\pi \times 10$ H/m and $\sigma = 5.8 \times 10^7$ mho/m.

5

7. (a) Define gauge factor of a strain gauge. A resistant strain gauge having a gauge factor of 2 is fastened to a steel member which is subjected to a strain of 10^{-6}. If the resistance of the unstrained gauge is 120 Ω, calculate the change in resistance of the gauge.

5

(b) A capacitive transducer consists of two circular plates of diameter 3 cm each, separated, by an air gap of 1 mm. Calculate the displacement sensitivity of the transducer for small axial displacements.

10

(c) A platinum resistance thermometer has resistance of 200 Ω at 20° C. Whet is its resistance at 100° C if the temperature coefficient of resistance of the thermometer at 20° C is 0.004?

5

(d) Draw a neat block schematic to show the functional blocks of a successive approximation A/D converter. Explain its operation using timing diagrams. Comment on its conversion speed with respect to the speeds of parallel A/D converter and dual slope A/D converter.

20

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

PAPER – II

Time Allowed: Three Hours *Maximum Marks: 200*

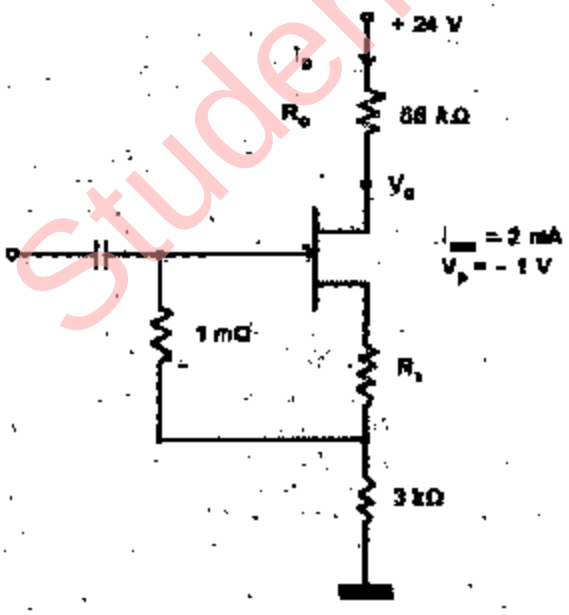
Candidates should attempt Question No. 1 which is compulsory and FOUR more questions taking TWO questions each from Section A and Section B.

Some useful constants are given below :–

Electron charge	: $e = -1.6 \times 10^{-19}$ Coulomb
Electron mass	: $M = 9.1 \times 10^{-31}$ kg
Planck's constant	: $h = 6.625 \times 10^{-34}$ J-s
Velocity of light	: $C = 3 \times 10^{8}$ m/s
Universal constant of gravitation	: $G = 6.668 \times 10^{-11}$ $m^3/kg\text{-}s^2$
Mass of earth	: $M = 5.997 \times 10^{24}$ kg
Radius of earth	: R = 6,378 km
Permeability of vaccum	: $\mu_0 = 4\pi \times 10^{-7}$ H/m
Permittivity of vaccum	: $\varepsilon_0 = 10^{-9}/36\pi$ F/m.

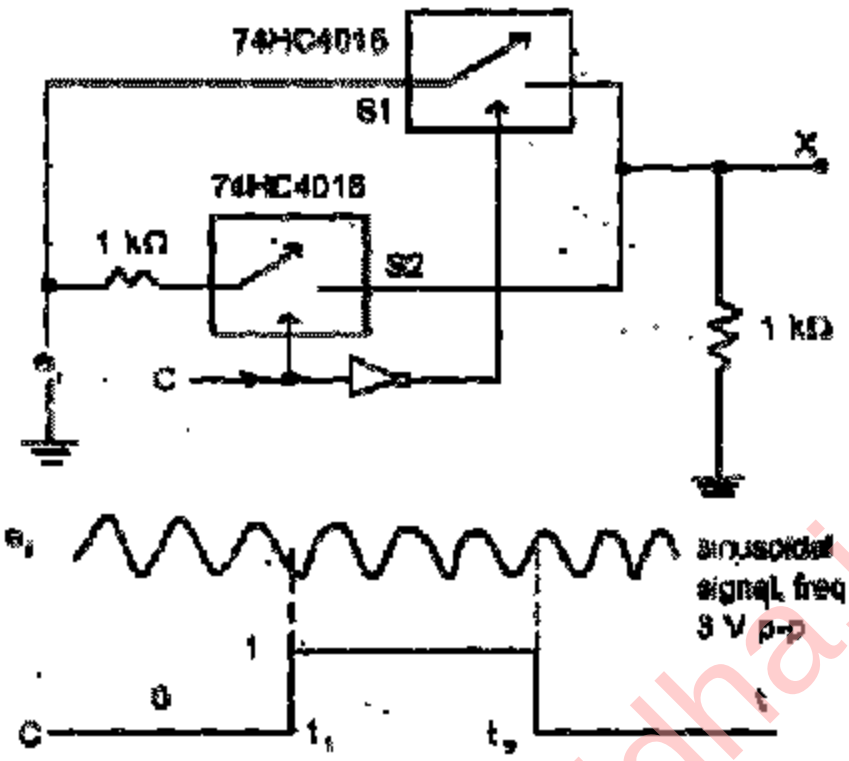
1. (a) Find the value of R in the amplifier circuit shown below such that the quiescent drain to ground voltage becomes 10V.

8



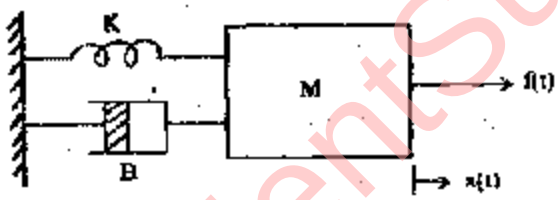
(b) Determine (and sketch) the output waveform (at point X) for the given inputs. The bilateral switch 74 HC 4016 has a resistance of 200 Ω in the ON state. Indicate important values on the sketch.

8



(c) Write the force equation of the mechanical system shown below. Draw the state diagram.

8



(d) Consider a source with three messages having symbol probabilities 0.5, 0.4 and 0.1

(i) Obtain Shannon-Fano code and calculate its efficiency.

4

(ii) Repeat (i) for second-order extension code and determine its efficiency.

4

(e) A step-index fiber in air has a numerical aperture of 0.16, a core-refractive index of 1.45 and a core diameter of 60 μm. Determine the normalized frequency for the fiber when light at a wavelength of 0.9 μm is transmitted Also estimate the number of guided modes propagating sin the fiber.

8

(f) What is the purpose of a taper in a waveguide? The peak valve of a wave at the input of a transmission line with attenuation factor equal to 0.01 N/m is 10 mV. What is the voltage 100 meters down the line?

8

(g) What. three characteristics of waveguides are affected by the addition of a ridge to a rectangular waveguide?

8

(h) Write instructions to read the data at input port 07H and at PORT 08H. Display the input data from PORT 07H at output PORT 00H and store the input data from PORT 08H in register B.

8

(i) For the f_b amplifier shown below determine:

(i) $R_{mf} = V_0/I_s$, where $I_s = V_s/R_s$.

(ii) $A_{vf} = V_0/V_s$ and

(iii) R_{if},

Assume

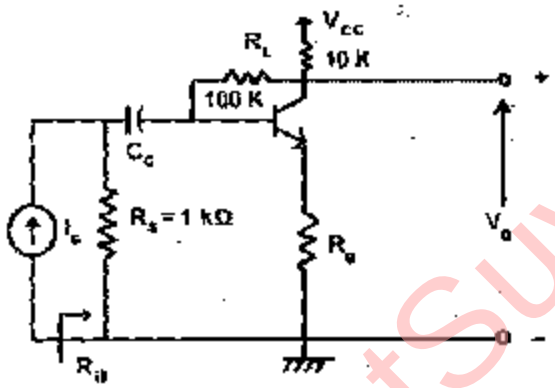
$R_e = 0$

$h_{fe} = 100$

$h_{ie} = 1\ k\Omega$

$h_{re} = h_{oe} = 0$.

8



(j) Solve the following expression by mapping:

$f = \Sigma m\ (0, 2, 3, 6, 7, 8, 9, 10, 13)$.

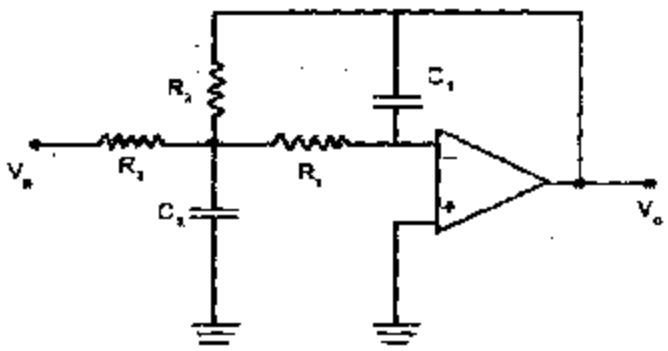
Write the steps involved in solving this problem using Quine-McClusky method.

8

SECTION A

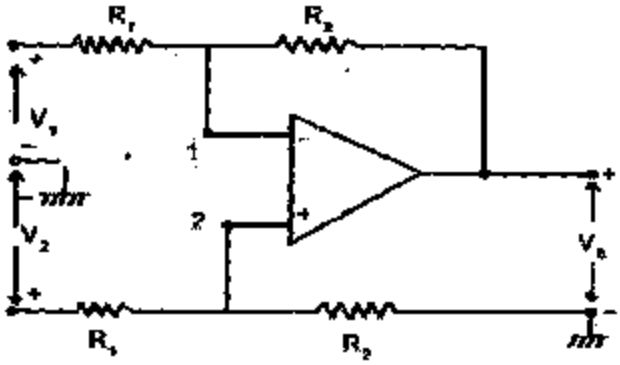
2. (a) For the circuit shown find $A_V = V_0/V_S$, the damping factor and the cut-off frequency.

15



(b) The differential input operational amplifier shown below consists of a base amplifier of infinite gain. Derive an expression for its output voltage, V_0.

15



3. (a) (i) Compare the maximum conversion time of an 8-bit digital ramp ADC with that of a successive approximation ADC both using a clock of 100 kHz. How do these compare with that of a flash type ADC?

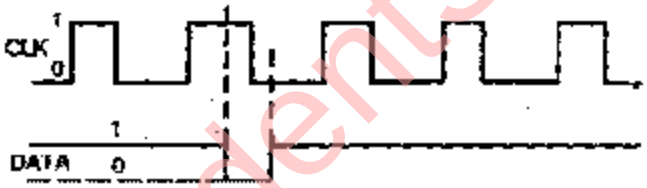
5

(ii) Describe the operation of a 3-bit flash type ADC with the help of a suitable diagram and a table.

10

(b) Draw the diagram of a 4-bit shift register using JK flip-flops. Each flip-flop triggers on the negative going transition. Draw the output waveforms for all flip-flops when the input data and clock signals are as shown.

15



4. (a) Consider a control system with characteristic equation:

$$s(s+4)(s^2+2s+2)+k(s+1)=0$$

Draw the complete root loci labelling important values. Also find the angles of asymptotes arid the intercept of asymptotes.

15

(b) Consider a third order system with characteristic equation

$$s^3+3408.3s^2+1.204\times10^6 s+1.5\times10^7 K=0$$

Find the critical value of K for stability using Routh-Hurwitz criterion. Also find the undamped frequency corresponding to the zero input response and the critical value of K.

15

5. (a) A 4-bit number is represented by ABCD with D as LSB. Design a logic circuit that will produce a 1 whenever the input is greater than 0010 but less than 1000. Use minimum number of gates.

10

(b) For a single loop feedback control system

$$G(s)=\frac{1}{s^2(s+12)} \quad \text{and} \quad H(s)=\frac{5(s+1)}{s+5}$$

Evaluate the steady state errors for three basic types of inputs.

10

(c) A class C transistor amplifier is operating at 150 kHz. The transistor is conducting for 1 μs in each cycle. The saturation values for the transistor are:

$I_{C(SAT)} = 100$ mA ; $V_{CE(SAT)} = 0.2$ V.

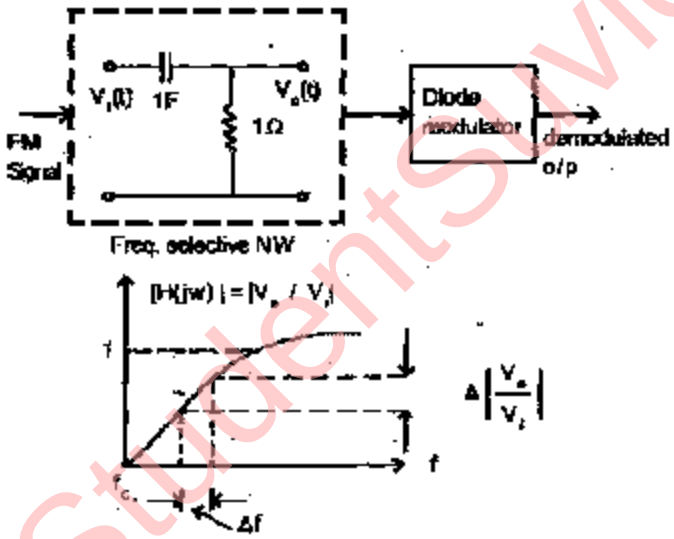
Assuming ideal pulse approximations and the output swinging over the entire load line, find the average power dissipation.

10

SECTION B

6. (a) An FM demodulator is shown- below. The 3 dB frequency of the RC integrating NW is f'. The centre frequency of the FM signal is f_c. Determine tie maximum change of output over change in input frequency (i.e. sensitivity). Using the result obtained, calculate the change in demodulator output, given 1 MHz and change in input frequency is 1 Hz.

15



(b) An analog signal has a 4 kHz BW. The signal is sampled at 2.5 times the Nyquist rate. Each sample is quantised into one of 256 equally likely levels. The successive samples are statistically independent.

(i) What is the information rate of this source ?

(ii) Can the output of this source be transmitted without errors over a Gaussian channel with a bandwidth of 50 kHz and SNR equal to 23 dB ?

(iii) What will be the bandwidth requirements of an analog channel for transmitting the output of the source without errors if the SNR is 10 dB ?

5+5+5

7. (a) An antenna has a power input of 40 π watts and an efficiency of 90%. The radiation intensity has been found to have a max. value of 150 W/unit solid angle. Determine:

(i) Directivity, and

(ii) Gain

of the antenna in dB.

15

(b) Draw the structure, field distribution and doping profile of a $n^+ - p - i - p^+$. Read diode. Explain how an IMPATT diode exhibits a differential negative resistance. Write an expression for the real part of the IMPATT diode terminal resistance and explain.

6+6+3

8. (a) Calculate the delay in the following loop when the system clock period is 0.30 μs.

15

Label	Mnemonics	T-states
	LX1 B, 12FFH	10
DELAY	DCXB	6
	KTHL	16
	NOP	4
	NOP	4
	MOV A,C	4
	DRA, B	4
	JNZ DELAY	10/7.

(b) A set of 16-bit readings is stored in memory locations starting at 2050 H. Each reading occupies two memories locations, the low-order byte is stored first followed by the high-order byte. The number of readings stored is specified by the contents of the register B. Write a program to add all the readings and store the sum in the output-buffer memory. The maximum limit of a sum is 24 bits.

15

9. (a) Recorded orbital measurements for a satellite are : Semi major axis 42,167.911 km, Eccentricity 000033, Mean anomaly = 28.3866°.

(i) Determine the orbital period

(ii) The mean orbital angular velocity

(iii) The maximum and minimum distances of the spacecraft from the centre of the earth during each orbital revolution.

10

(b) In order a material to be useful for negative differential mobility, its band structure must satisfy certain criteria. – State them.

A tunnel diode has

negative resistance = 30 ohms

series resistance = 1 ohm

Jn. capacitance = 4 nF.

Calculate–

(i) resistive cut-off frequency

(ii) the gain of the amplifier when the tunnel diode is connected in parallel with a load of 28 ohms.

5+5

(c) Bring out the differences between a maskable and a non-maskable interrupt. What do you mean by a handshake interrupt? Does it refer to a maskable interrupt?

10

* * * * * * * *