

Sl. No.

65201

इन्जिनियरिंग सेवा परीक्षा,

Engineering Service Examination

2019
A-FTF-J-FUA

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

Paper—I

(Conventional)

Time Allowed : Three Hours

Maximum Marks : 200

INSTRUCTIONS

Candidates should attempt FIVE questions.

The number of marks carried by each question is indicated at the end of the question.

Answers must be written in ENGLISH.

Assume suitable data, if necessary and indicate the same clearly.

Values 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 = $\left(\frac{1}{36\pi}\right) \times 10^{-9}$ farad/m.

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

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

Planck constant = 6.626×10^{-34} joule-sec.

Wherever a question is attempted, all its subdivisions must be attempted.

Unless otherwise indicated, symbols and notations have their usual meanings.

1. (a) The mobilities of electron and hole in silicon sample are $0.125 \text{ m}^2/\text{V-s}$ and $0.048 \text{ m}^2/\text{V-s}$ respectively. Determine the conductivity of intrinsic silicon at 27°C , if the intrinsic carrier concentration is $1.6 \times 10^{16} \text{ atoms/m}^2$. When it is doped with 10^{23} phosphorus atoms/ m^2 , determine the equilibrium hole concentration, conductivity and position of the Fermi level relative to the intrinsic level. 15
- (b) Differentiate between Light Emitting Diodes (LEDs) and Laser Diodes (LDs). An LED is made of GaAsP having a band gap of 1.9 eV . Determine the wavelength and colour of the radiation emitted. 15
- (c) Sketch the electron distribution in insulator, intrinsic semiconductor and metal at 0 K . 10
2. (a) Draw the low-frequency small-signal models of FET and bipolar junction transistor, and compare the two models. Justify the statement that FET is a much more ideal amplifier than the bipolar junction transistor at low frequencies. 15

- (b) For the circuit shown in Fig. 1, assume $\beta = h_{FE} = 100$. Find if the transistor is in cutoff, saturation or in the active region. 15

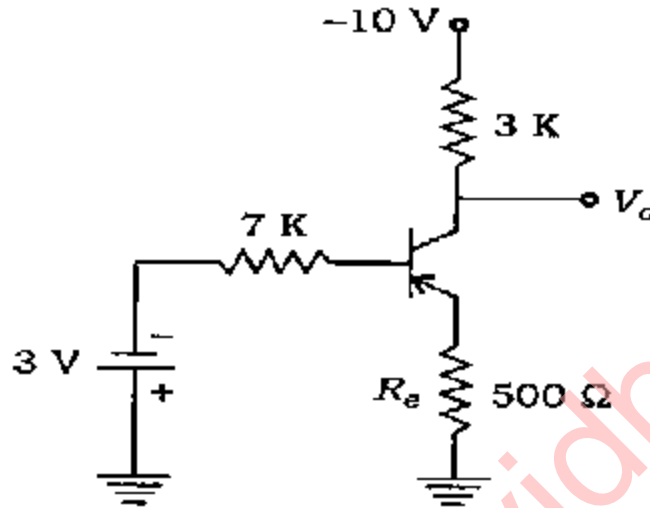


Fig. 1

- (c) Describe how an FET can be used as a Voltage Variable Resistor (VVR). 10

3. (a) The input and output of a causal LTI system is related by the differential equation

$$\frac{d^2 y(t)}{dt^2} + 6 \frac{dy(t)}{dt} + 8y(t) = 2x(t)$$

- (i) Find the impulse response of the system.
- (ii) What is the response of this system, if $x(t) = te^{-2t}u(t)$? 15

(b) Describe the Hall effect in a semiconductor bar. Derive the expression for the Hall voltage. 15

(c) Evaluate the cross-correlation between the following signals : 10

$$x(t) = u(t) - 2u(t-1) + u(t-2)$$

$$y(t) = u(t+1) - u(t)$$

4. (a) (i) Show that if $x(t)$ is an even function, so that $x(t) = x(-t)$, then $X(s) = X(-s)$.

(ii) Determine which, if any, of the pole-zero plots of Fig. 2 could correspond to an even function of time. For those that could, indicate the required ROC. 15

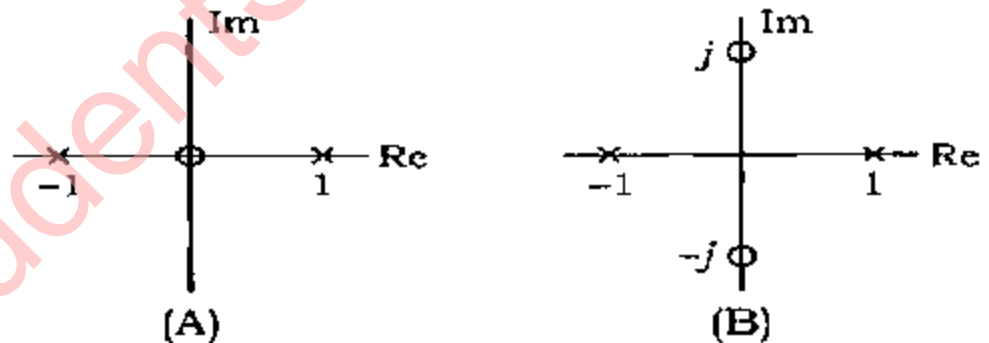


Fig. 2

(b) Realize driving-point impedance

$$\frac{s^2 + 12s + 35}{s^3 + 15s^2 + 62s + 48}$$

in Foster-I and Cauer-I forms. 15

- (c) A certain 2-terminal linear network, including a generator, has an open-circuit voltage of 125 V, and on short circuit produces a current of 5.59 A. When a $10\ \Omega$ resistive load is connected, the load current is 4.41 A. Find Thevenin's equivalent of this network. How could the sign of reactance be determined?

10

5. (a) (i) Determine v_1 and v_2 node voltages in the circuit of Fig. 3.

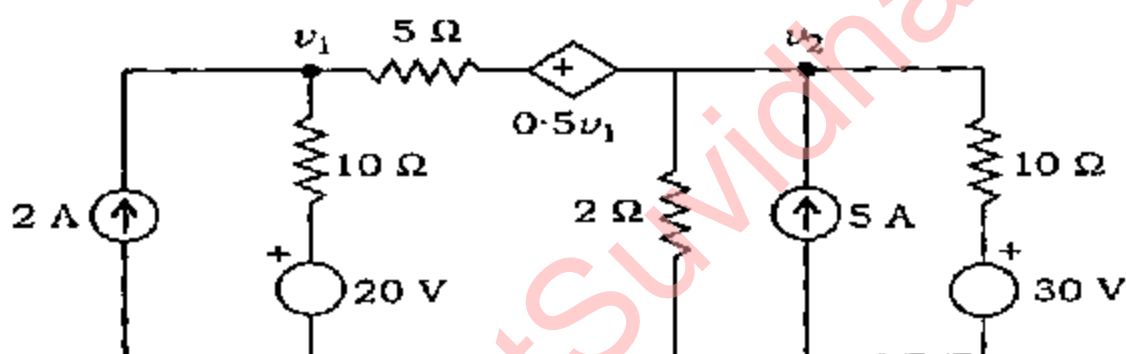


Fig. 3

- (ii) Fundamental circuit (tie-set) matrix for a certain network is given as

$$B_f = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & -1 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & -1 & 1 \end{bmatrix}$$

Determine the corresponding fundamental cutset matrix. State the relationship used.

15

- (b) (i) The switch in the circuit of Fig. 4 has been closed for a very long time. It opens at $t = 0$. Find $v_c(t)$ for $t > 0$.

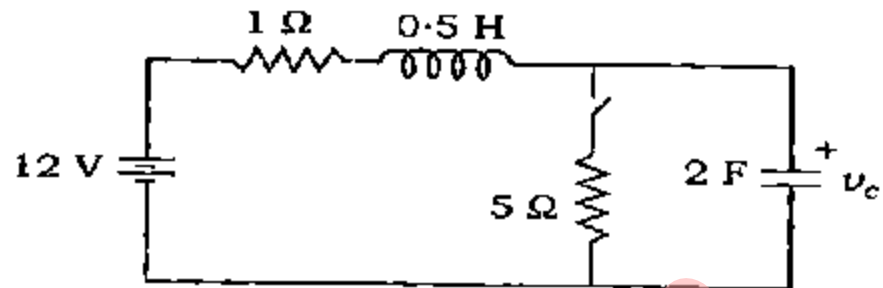


Fig. 4

- (ii) Determine h_{12} , z_{12} and y_{12} parameters for the 2-port network of Fig. 5.

15

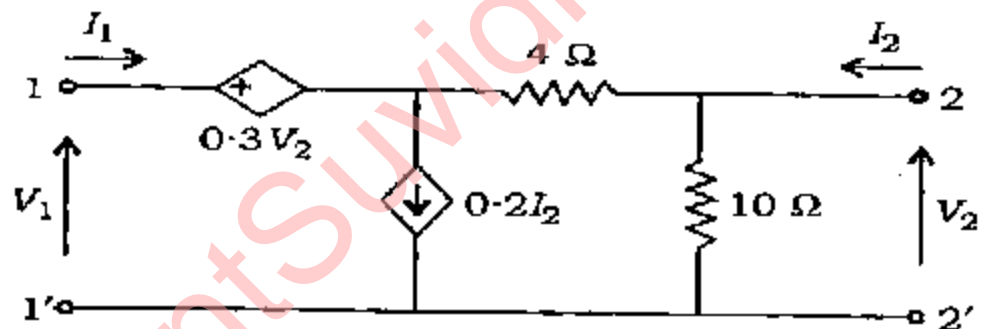


Fig. 5

- (c) The step response of a certain initially relaxed device is $y(t) = (1 - \frac{1}{2}e^{-t/3})u(t)$. Determine the impulse response of the system of two such devices connected in cascade, assuming that the loading effect due to cascading is negligible.

10

6. (a) A plane wave with

$$\vec{E} = 30e^{-\alpha z} \sin(\omega t - z)\hat{X} \text{ V/m}$$

is propagating through a lossy dielectric medium having an intrinsic impedance

of $300 \angle 30^\circ \Omega$ and $\mu_r = 1$. Establish the phasor and instantaneous field expressions for \vec{H} , and find the loss tangent, propagation constant, wave polarization and the dielectric constant of the medium at 15 MHz. Also determine the skin depth and the depth at which the amplitude of the field is 1% of the value at $z = 0$.

15

- (b) A 10 cm long vertical dipole radiates into air at 60 MHz with a peak input current of 100 mA. Find its radiation resistance, radiated power and efficiency, if its loss resistance is 0.1Ω . At what distance its radiated field strength will be 1 mV/m, for a field point at $\theta = \frac{\pi}{2}$? Also find the directivity, if this antenna is used as a monopole.

If a dipole of same length and input current is to radiate at 1500 MHz, find the power radiated and far field strengths at the above-mentioned field point.

15

- (c) A 60Ω half-wavelength lossless line is open circuited at the load end and has a load voltage of 12 V. Find the voltage and current at the middle of the line, listing out the relevant transmission line equations for both lossy and lossless lines.

If this 60Ω line is connected to a load of 100Ω resistance in series with a capacitance of 8.84 pF , find the load

reflection coefficient and VSWR at 100 MHz, and the maximum and minimum impedances along the line, assuming a line length of 5 metres. 10

7. (a) Explain the working of a Resistance Temperature Detector (RTD).

In a load cell, all four strain gauges are connected in a bridge circuit. If a stress of 1050 kg/cm^2 is applied on the top of such a load cell, calculate the change in the resistance $\Delta R/R$. The load cell is made up of steel and the modulus of elasticity of steel is approximately $2.1 \times 10^6 \text{ kg/cm}^2$; the gauge factor of the strain gauge is 2. 15

- (b) Define 'accuracy', 'precision', 'absolute error' and 'relative accuracy' of a measurement. A resistor of value 4.7 K is read as 4.65 kohms in a measurement. Calculate (i) absolute error, (ii) % errors and (iii) accuracy.

Design a universal shunt meter with current range of 0.1 mA , 10 mA and 50 mA ; with a d.c. ammeter of internal resistance 100Ω and full-scale current of $100 \mu\text{A}$. 15

- (c) Determine the binary output of a Successive Approximation Register (SAR) type digital voltmeter with 10-bit output and reference voltage of $+5 \text{ V}$ for an input of 2.567 V . Draw the block diagram for the display in $3\frac{1}{2}$ -digit LCD. 10

Serial No.

65301

A-FTF-J-FUB

**ELECTRONICS AND
TELECOMMUNICATION ENGINEERING**

**Paper—II
(Conventional)**

Time Allowed : Three Hours

Maximum Marks : 200

INSTRUCTIONS

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

The number of marks carried by each question is indicated at the end of the question.

Answers must be written in ENGLISH. Assume any data, if required and indicate the same clearly.

Wherever a question is attempted, all its subdivisions must be attempted.

Unless otherwise indicated, symbols and notations have their usual meaning.

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 : $G = 6.668 \times 10^{-11}$ m³/kg-s²

Mass of Earth : $M = 5.997 \times 10^{24}$ kg

Radius of Earth : $R = 6378$ km

Permeability of vacuum : $\mu_0 = 4\pi \times 10^{-7}$ H/m

Permittivity of vacuum : $\epsilon_0 = \frac{10^{-9}}{36\pi}$ F/m

1. (a) For a fullwave rectifier with a capacitor filter, show that the ripple voltage— V_r is inversely proportional to the capacitor C and is proportional to the load current I_{dc} . Calculate the value of ' V_r ' when $C = 100 \mu\text{F}$ and $I_{dc} = 10$ mA. The a.c. input voltage to the rectifier is given by $v = V_m \sin 314t$. 8
- (b) Obtain the minimal SOP expression for $Y(A, B, C, D) = \sum m(2, 3, 5, 7, 8, 9, 11, 12, 13, 14, 15) + d(2, 4)$ using K-map. Realize the expression using 2 input NAND gates only. 8

- (c) Design a mod-7 asynchronous up counter using JK flip-flops. Write the state diagram and the timing diagram for the same. The counter counts during +ve edges of the clock. 8
- (d) State and explain minimum phase and non-minimum phase transfer functions with examples. 8
- (e) Obtain the overall transfer function of an armature controlled d.c. shunt motor. Explain the difference between armature controlled and field controlled d.c. motor. 8
- (f) An optical fibre has a core refractive index of 1.45 and a cladding refractive index of 1.4. Assuming ray theory of analysis, determine the following :
- (i) Numerical aperture of the fibre.
 - (ii) Acceptance angle in air for fibre.
 - (iii) Critical angle at core-cladding interface. 8
- (g) (i) Assuming a geosynchronous satellite global beam covering all visible earth surface with 100% efficiency, calculate its G/T ratio, if earth radius is 6400 km and altitude of satellite is 6000 km (Noise temp. of satellite antenna is 290° K). 6

(ii) What are the classification of satellites in terms of distance from earth and position from earth ? 2

(h) Microwave signal of 9.2 GHz is propagating in dominant mode through a rectangular waveguide filled with air. If inside dimensions of the waveguide are 2 cm \times 1 cm, calculate the following :

- (i) cut off frequency
- (ii) guide wavelength
- (iii) phase velocity
- (iv) characteristic impedance.

Sketch also the method of excitation of TE_{10} mode and TE_{20} mode in a rectangular waveguide.

6+2

(i) Convert the following :

- (i) decimal number into octal

$$(5621.125)_{10}$$

- (ii) hexadecimal number into octal and into binary

$$(5621)_{16}$$

4+2+2

[4]

(Contd.)

- (j) Write a 'C' program to print first twenty Fibonacci numbers (Fib (i)) using the formula :

$$\text{Fib (i)} = \text{Fib (i - 1)} + \text{Fib (i - 2)}$$

where i is an integer ≥ 0 .

It is given that

$$\text{Fib (0)} = \text{Fib (1)} = 1.$$

8

SECTION—A

2. (a) Design a self bias circuit for a CE amplifier using an npn transistor with $\beta = 100$. The other details are : $V_{CC} = 12 \text{ V}$, $V_{CEQ} = 6 \text{ V}$, $I_{CQ} = 4 \text{ mA}$.

10

- (b) Design an op-amp waveform generating circuit to produce the waveform given in Fig. 2(b). Explain the circuit operation with other relevant waveform.

10

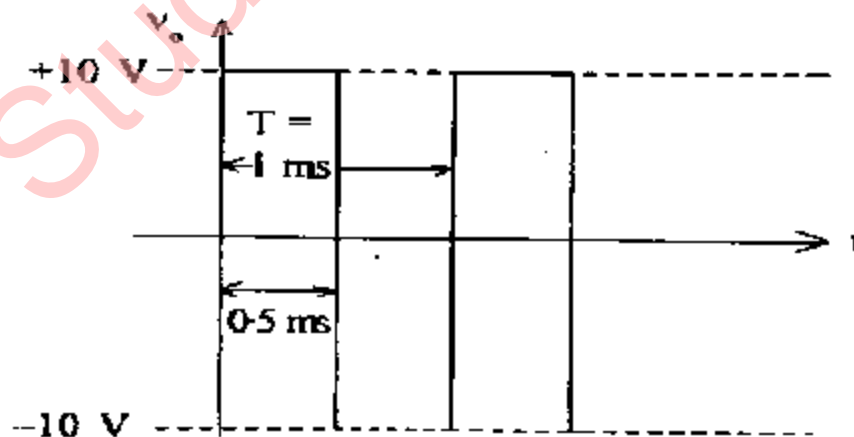


Fig. 2(b)

- (c) Identify the logic gate shown in Fig. 2(c). Explain the operation of the same with the help of truth-table. 10

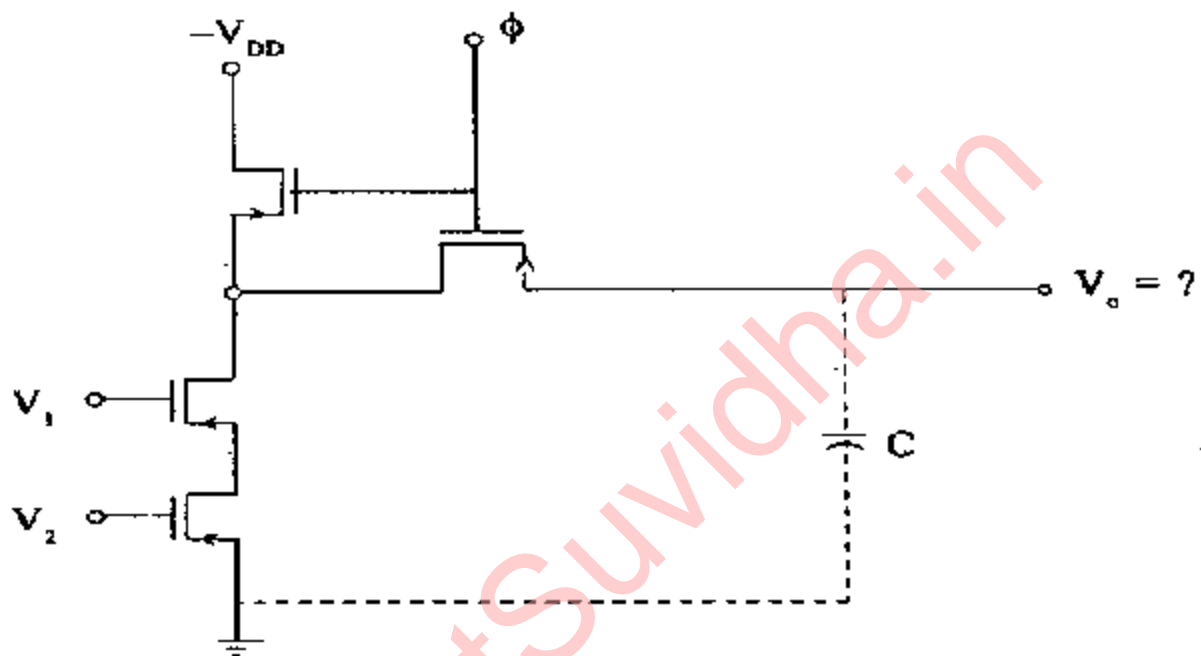


Fig. 2(c)

3. (a) Write the counting sequence of a 4 bit down synchronous counter. Design the same using -ve edge triggered J-K Flip-Flops. 10
- (b) Design a Schmitt trigger circuit using an op-amp which has a maximum output voltage of ± 10 V. The 'hysteresis'— V_H should be $= 0.4$ V. Explain the working of the circuit with the transfer characteristics. Use a reference voltage $V_R = 2$ V. 10

(c) Implement the following expressions using CMOS-AOI logic circuits. Verify the circuit operation with the help of truth table :

(i) $Y = A + BC$

(ii) $Y = \overline{AB + CD}$ 10

4. (a) Explain the difficulties involved in the application of Routh-Hurwitz criterion and also bring out limitations. Find the stability of the control system whose characteristic equation is given by

$$(s - 1)^2 (s + 2) (s + 1) = 0. \quad 10$$

(b) Explain the effect of additional poles and zeros of $G(s) H(s)$ on the shape of the Nyquist plot. Sketch the Nyquist diagram and determine stability of the transfer function :

(i) $G(s) H(s) = \frac{s}{1 - 0.2s}$

(ii) $G(s) H(s) = \frac{s + 2}{(s + 1)(s - 1)}$ 10

- (c) Obtain the overall transfer function C/R from the signal flow graph—Fig. 4(c). 10

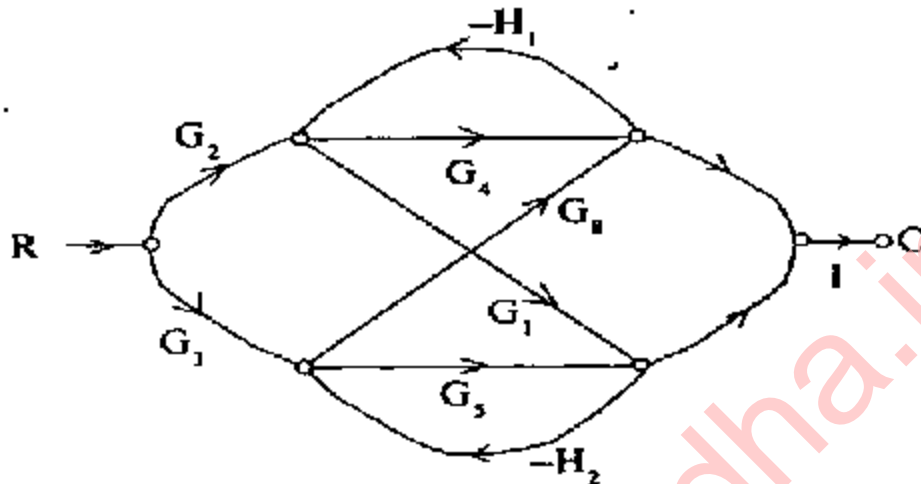


Fig. 4(c)

SECTION—B

5. (a) A voice grade telephone circuit has to transmit audio signal in digital signal form. Suggest and explain the scheme for the same with suitable block diagram. Calculate the data rate if an ADC of 12 bits is used in your scheme. 10
- (b) An optical fiber link has the following details :
 Laser diode output = 3 dBm
 In GaAs APD sensitivity = -32 dBm
 Optical fiber attenuation = 0.25 dB/km
 Connector loss at each end = 1 dB
 Power margin = 6 dB.
 Calculate the link distance. Represent this link loss budget graphically. 10
- (c) With the help of a block diagram explain the working of a superheterodyne AM receiver. 10

6. (a) Sketch the structure, field distribution and doping profile of an IMPATT diode. With the help of appropriate voltage and current plots in IMPATT diode, show how negative resistance is obtained in it. 14

- (b) In the case of an IMPATT having carrier drift velocity $v_d = 4 \times 10^5$ m/sec

Drift region length $L = 12 \mu\text{m}$

Breakdown voltage $V_{bd} = 90$ V

Maximum operating voltage $V_{max} = 100$ V

Maximum operating current $I_{max} = 100$ mA

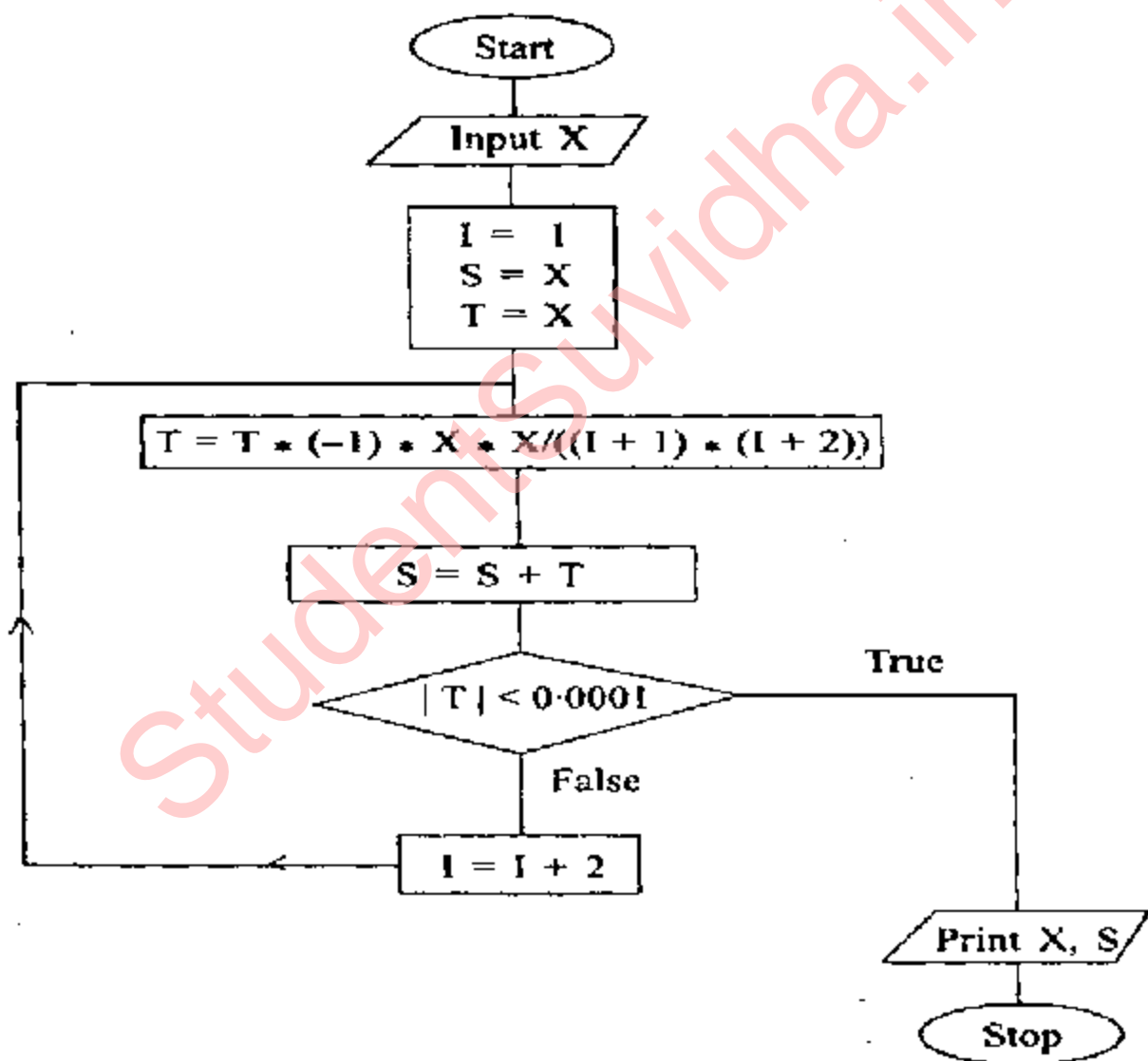
Efficiency $\eta = 10\%$.

Determine the resonant frequency and maximum CW output power. 6

- (c) Sketch an antenna radiation pattern in polar co-ordinates. With reference to the antenna radiation pattern, show side lobe level, half power beam width and null width. Define gain of an antenna. How is it related to effective aperture area? What is difference between isotropic antenna and omnidirectional antenna? 7

- (d) A parabolic antenna is operating at S-band mid frequency. If the frequency is now shifted to X-band mid frequency, determine the approximate increase in gain in dB. 3

7. (a) What is done by the following program flow chart ? Give a trace (print out) of all the variables till $i = 5$ for $X = 0.5$. 10



[10]

(Contd.)

- (b) What is done by the following assembly language program ? Explain. 10

	LXI	H, TABLTOP
	MOV	C, M
LP2	INX	H
	MOV	E, M
	INX	H
	MOV	D, M
	INX	H
	MOV	B, M
	INX	H
	MVI	M, OO
LP1	MOV	A, E
	SUB	B.
	MOV	E, A
	MOV	A, D
	SBI	OO
	JM	LBL1
	INR	M
	MOV	D, A
	JMP	LP1

LBL1 MOV A, E
ADD B
INX H
MOV M, A
DCR C
JNZ LP2
RET

Programme variable :

TABLTOP EQU 1900H.

- (c) How many interrupt lines are there in Intel 8085 ?
Name them in order of priority. Give their restart
location also. 10