Read the following instructions carefully:

(i) This question paper consists of two sections: A & B.
(ii) Section A has NINE questions, Answer all questions in this section.
(iii) Section B has TWENTY questions. Answer any TEN questions in this section.
(iv) Begin answer for this section on a fresh page.
(v) Answer to questions in each section should appear together in the same sequence in which they appear in the question paper.
(vi) There will be no negative marking.

SECTION - A

1. For each of the following (1.1 – 1.19) questions, four possible alternatives (A,B, C and D) are given. Indicate the correct or the best answer by writing the corresponding letter (A,B,C,or D) in each question number.

1.1 The Laplace transform of a unit ramp function starting at t = a, is

(a) $\frac{1}{(s+a)^2}$ (b) $\frac{e^{-as}}{(s+a)^2}$ (c) $\frac{e^{-as}}{s^2}$ (d) $\frac{a}{s^2}$

1.2 The Fourier Series of a odd periodic function, contains only

(a) odd harmonics (b) even harmonics (c) cosine terms (d) sine terms

1.3 A series LCR circuit consisting of R = 10Ω, $|X_L| = 20\Omega$ and $|X_C| = 20\Omega$, is connected across an a.c. supply of 200V rms. The rms voltage across the capacitor is:

(a) $200\angle -90°V$ (b) $200\angle +90°V$ (c) $400\angle -90°V$ (d) $400\angle +90°V$

1.4 A ramp voltage, $v(t) = 100$ volts, is applied to an RC differentiating circuit with R = 5kΩ and C = 4μF. The maximum output voltage is:

(a) 0.2 volts (b) 2.0 volts (c) 10.0 volts (d) 50.0 volts

1.5 The 3-dB bandwidth of a typical second-order system with the transfer function $\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 t + 2x\omega_n s + \omega_n^2}$ is given by

(a) $\omega_n = \sqrt{1-2\xi^2}$ (b) $\omega_n = \sqrt{1-2\xi^2)+\sqrt{\xi^4-\xi^2+1}}$

(c) $\omega_n = \sqrt{1-2\xi^2)+\sqrt{4\xi^4-4\xi^2+2}}$ (d) $\omega_n = \sqrt{1-2\xi^2)+\sqrt{4\xi^4-\xi^2+2}}$

1.6 If the open loop transfer function is a ratio of a numerator polynomial of degree 'm' and a denominator polynomial of degree 'n', then the integer (n-m) represents the number of

(a) breakaway points (b) unstable poles
(c) separate root loci (d) asymtotes

1.7 A small concentration of minority carries is injected into a homogeneous semiconductor crystal at one point. An electric field of 10 V.cm is applied across the crystal and this moves the minority carriers a distance of 1 cm is 20μsec. The mobility (in cm^2/volt.sec) will be

(a) 1,000 (b) 2,000 (c) 5,000 (d) 500,000

1.8 The threshold voltage of an n channel MOSFET can be increased by

(a) increasing the channel dopant concentration

(b) reducing the channel dopant concentration

(c) reducing the gate-oxide thickness

(d) reducing the channel length

1.9 A class – A transformer coupled, transistor power amplifier is required to deliver a power output of 10 watts. The maximum power rating of the transistor should not be less than

(a) 5 W (b) 10 W (c) 20 W (d) 40 W

1.10 Data can be changed from spatial code to temporal code and vice-versa by using

(a) ADCs and DACs (b) shift registers

(c) synchronous counters (d) timers

1.11 The output of a logic gate is '1' when all its inputs are at logic '0'. Then gate is either

(a) a NAND or an EX-OR gate (b) a NOR or an EX-NOR gate

(c) an OR or an EX-NOR gate (d) an AND or an EX-OR gate

1.12 A PLA can be used

(a) as a microprocessor (b) as a dynamic memory

(c) to realize a sequential logic (d) to realize a combinational logic

1.13 A dynamic RAM consists of

(a) 6 transistors (b) 2 transistors and 2 capacitors

(c) 1 transistor and 1 capacitor (d) 2 capacitors only

1.14 $v(t) = 5\left[\cos\left(10^6 \pi t\right) - \sin\left(10^3 \pi t\right) \times \sin\left(10^6 \pi t\right)\right]$ represents

(a) DSB suppressed carrier signal (b) AM signal

(c) SSB upper sideband signal (d) Narrow band FM signal

1.15 Increased pulse-width in the flat-top sampling leads to
(a) attenuation of high frequencies in reproduction
(b) attenuation of low frequencies in reproduction
(c) greater aliasing errors in reproduction
(d) no harmful effects in reproduction

1.16 Medium wave radio signals may be received at far off distances at night because
(a) radio waves travel faster at night
(b) ground wave attenuation is low at night
(c) the sky wave is stronger at night
(d) there is no fading at night

1.17 For a short wave radio link between two stations via the ionosphere, the ratio of the maximum usable frequency to the critical frequency
(a) is always less than 1
(b) is always greater than 1
(c) may be less than or more than 1 depending on the distance between the two stations
(d) does not depend on the distance between the two stations

1.18 A plane electromagnetic wave traveling along +z – direction, has its electric filed given by $E_x = 2\cos(*t)$ and $E_y = 2\cos(*t + 90°)$. The wave is
(a) linearly polarized
(b) right circularly polarized
(c) left circularly polarized
(d) elliptically polarized

1.19. For a dipole antenna
(a) the radiation intensity is maximum along the normal to the dipole axis
(b) the current distribution along its length is uniform irrespective of the length
(c) the effective length equals its physical length
(d) the input impedance is independent of the location of the feed-point

2. In each of the following questions (2.1 – 2.20) fill in the blanks appropriately.

2.1 $f_c \vec{A}.d\vec{t} = \int_s \cdots .d\vec{s}$

2.2. The rank of an $(m \times n)$ matrix $(m < n)$ cannot be more than _____

2.3. The condition that a z-port network is reciprocal, can be expressed in terms of its ABCD parameters as _____

2.4. A generator of internal impedance, Z_G, deliver maximum power to a load impedance, Z_I, only if Z_I =_____

2.5. The open loop frequency response of a system at two particular frequencies are given by: 1.2<180° and 1.0 < -190°.
The closed loop unity feedback control is then _____

2.6. The poles of a continuous time oscillators are _____

2.7. The forward dynamic resistance of a junction diode varies _____ as the forward current.

2.8. The transmit time of the current carriers through the channel of an FET decides its _____ characteristics.

2.9. In order to reduce the harmonic distortion in an amplifier, its dynamic range has to be _____.

2.10. A common emitter transistor amplifier has a collector current of 1.0 mA when its base current is 25μA at the room temperature. It's input resistance is approximately equal to _____

2.11. A pulse having a rise time of 40n sec is displayed on a CRO of 12 MHz bandwidth. The rise time of the pulse as observed on the CRO would be approximately equal to _____.

2.12. For the 2N 338 transistor, the manufacturer specifics $P_{max} = 100mW$ at 25°C free air temperature and the maximum junction temperature $T_{jmax} = 125°C$. Its thermal resistance is _____

2.13. The frequency compensation is used in op-amps to increase its _____

2.14. A 2μ sec pulse can be stretched into a 10 msec pulse by using a _____ circuit.

2.15. Synchronous counters are _____ than the ripple counters.

2.16. A ring oscillator consisting of 5 inverters is running at a frequency of 1.0 MHz. The propagation delay per gate is _____ nsec.

2.17. A 10 MHz carrier is frequency modulated by a sinusoidal signal of 500 Hz, the maximum frequency deviation being 50 KHz. The bandwidth required, as given by the Carson's rule is _____.

2.18. The bandwidth required for the transmission of a PCM signal increases by a factor of _____ when the number of quantization levels is increased from 4 to 64.

2.19. A load impedance, $(200 + j0)\,\Omega$ is to be matched to a 50Ω lossless transmission line by using a quarter wave line transformer (QWT). The characteristic impedance of the QWT required is _____.

2.20. The interior of a $\frac{20}{3}$cm $\times \frac{20}{4}$cm rectangular wave guide is completely filled with a dielectric of $\varepsilon_r = 4$. Waves of free space wave-lengths shorter than _____ can be propagated in the TE_{11} mode.

3. For each of the following questions (3.1 – 3.10) indicate whether the statements is TRUE / FALSE. Give reason for your answer.

3.1. $Z(s) = \frac{5}{s^2 + 4}$ represents the input impedance of a network.

3.2. Tachometer feedback in a d.c. position control system enhances stability.

3.3. If G(s) is a stable transfer function, then $\pi F(s) = \frac{1}{G(s)}$ is always a stable transfer function.

3.4. A p-type silicon sample has a higher conductivity compared to an n-type sample having the same dopant concentration

3.5. Channel current is reduced on application of a more positive voltage to the gate of a depletion mode n-channel MOSFET.

3.6. The look-ahead carry adder is a parallel carry adder where all sum digits are generated directly from the input digits.

3.7. In the output stage of a standard TTL, have a diode between the emitter of the pull-up transistor and the collector of the pull down transistor. The purpose of this diode is to isolate the output node from the power supply V_α.

3.8. Pulse width modulated signals are immune to noise since their amplitude is constant.

3.9. Noise figure of an amplifier is always greater than 1.

3.10. If a pure resistance load, when connected to a lossless 75-ohm line, produces a VSWR of 3 on the line, then the load impedance can only be 25 ohms.

Note: Marks will be given only if all the three items A, B, and C are matched correctly.

4. In each of the following questions (4.1 – 4.8) match each of the items A, B and C with an appropriate item from 1, 2, 3, 4 and 5.

4.1 (a) $a_1 \frac{d^2y}{dx^2} + a_2 y \frac{dy}{dx} + a_3 y = a_4$

(b) $a_1 \frac{d^3y}{dx^3} + a_2 y = a_3$

(c) $a_1 \frac{d^2y}{dx^2} + a_2 x \frac{dy}{dx} + a_3 x^2 y = 0$

(1) Non linear differential equation
(2) Linear differential equation with constant coefficients
(3) Linear homogeneous differential equation
(4) Non-linear homogenous differential equation
(5) Non-linear first order differential equation

4.2 The response of an LCR circuit to a step input is
(a) over damped
(b) critically damped
(c) oscillatory
If the transfer function has
(1) poles on the negative real axis
(2) poles on the imaginary axis
(3) multiple poles on the positive real axis
(4) poles on the positive real axis
(5) multiple poles on the negative real axis

4.3 (a) Very low response at very high frequencies.
(b) Overshoot
(c) Synchro-control transformer output
(1) Low pass systems
(2) Velocity damping
(3) Natural frequency
(4) Phase sensitive modulation
(5) Damping ration

4.4 (a) The current gain of a BJT will be increased if
(b) The current gain of a BJT will be reduced if
(c) The breakdown voltage of a BJT will be reduced if
(1) The collector doping concentration is increased.
(2) The base width is reduced
(3) The emitter doping concentration to base doping concentration ratio is reduced.

(4) The base doping concentration is increased keeping the ratio of the emitter doping concentration to base doping concentration, constant.

(5) The collector doping concentration is reduced.

4.5 (a) Hartley

(b) Wien-bridge

(c) Crystal

(1) Low frequency oscillator

(2) High frequency oscillator

(3) Stable frequency oscillator

(4) Relaxation frequency oscillator

(5) Negative resistance oscillator

4.6 Type of ADC

(a) Successive approximation

(b) Dual slope

(c) Parallel comparator

Maximum conversion for 8 bit ADC in clock cycles.

(1) 1 (2) 8 (3) 16 (4) 256

(5) 512

4.7 (a) Single side band

(b) Amplitude modulation

(c) Binary phase shift keying

(1) Envelope detector

(2) Integrated and dump

(3) Hilbert transform

(4) Ratio detector

(5) Phase locked loop

4.8 (a) $\vec{V} \times \vec{H} = \vec{J}$

(b) $\int_c \vec{E}.\vec{a}_t = -\frac{d}{f}\int_s \vec{B}.\vec{ds}$

(c) $\vec{V}\vec{J} = \frac{\partial_p}{\partial_t}$

(1) Continuity equation (2) Faraday's law

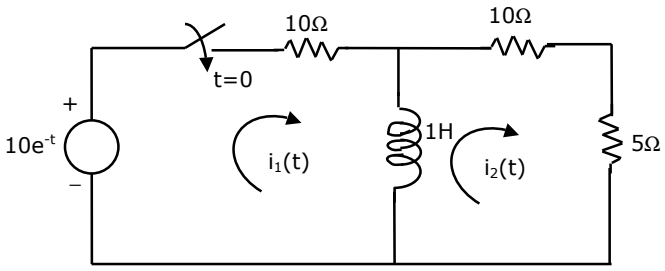
(3) Ampere's law (4) Gauss's law

(5) Biot-Savart law

5. Solve the following equations using Cayley-Hamilton theorem.

$$x + x^2 + x^3 = 3$$
$$x^1 - x^3 = 0$$
$$x^1 - x^2 + x^3 = 1$$

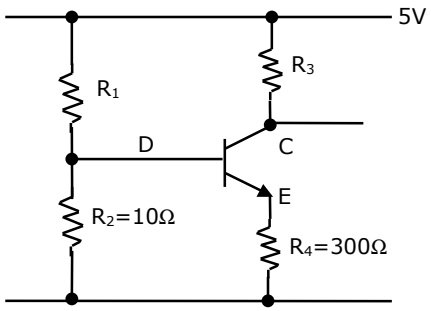
6. Write down the mesh equations of the following network in term of $i_1(t)$ and $i_2(t)$. Derive the differential equation for $i_1(t)$ from these and solve it.



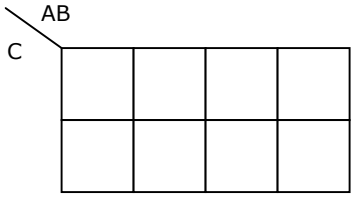
7. Show that the minimum conductivity of an extrinsic silicon sample occurs when it is slightly p-type. Calculate the electron and hole concentrations when the conductivity is minimum.

Given that $\mu_n = 1350$ cm^2 / v sec, $\mu_p = 450$ cm^2 / v sec, and the intrinsic carrier concentration, $n_i = 1.5 \times 100^{100}\ cm^{-3}$.

8. In the common emitter amplifier shown in the figure below, the transistor has a forward current gain of 100, and a base-emitter voltage, $V_{BE} = 0.6$ volt. Assume I_{CO} to be negligible. Choose value of R_1 and R_3 such that the transistor has a collector of 1 mA and a collector to emitter voltage of 2.5V.



9. A Boolean function, F, is given as sum of Product (SOP) terms as P = $\sum m(3,4,5,6)$ with A, B and C as inputs. The function, F can be expressed on the Karnaugh's map shown below.



(1) Implement this function on an 8:1 MUX.

(2) What will be the minimized SOP expression for F^2.

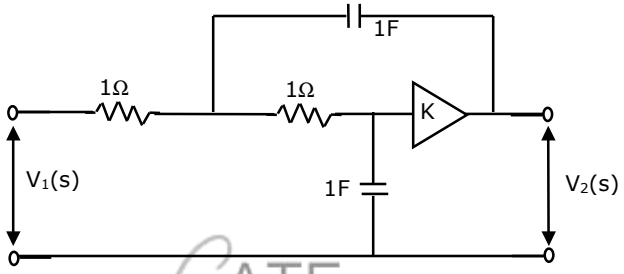
SECTION – B

Attempt any TEN questions in this section.

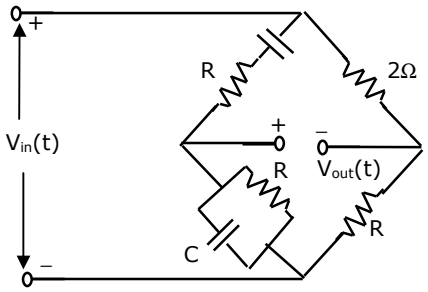
10. Evaluate integral, $\int_C \vec{r}.\vec{dr}$, where C is the helical path described by, $x = \cos t, y = \sin t, z = t$ joining the points given by t = 0 and $t = \frac{\pi}{2}$

11. Assuming that the amplifier shown in the figure below, is a voltage controlled voltage source, show that the voltage transfer function of the network is given by

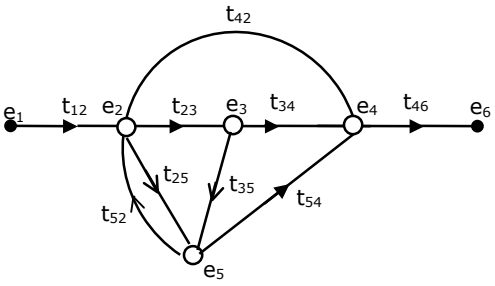
$$T = (s) = \frac{V_2(s)}{V_1(s)} = \frac{K}{2 + (3-k)s + 1}$$

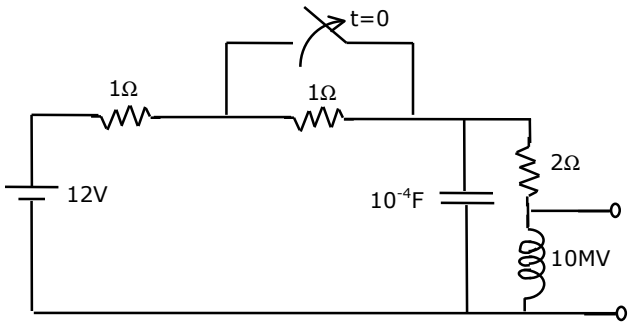


12. Calculate the frequency at which zero-transmission is obtained from the Wien bridge shown in the figure below.



13. The circuit shown in the figure, is initially in its steady state. Switch is opened at t = 0.





(1) Determine the initial voltage, $V_c(0-)$ across the capacitor, and the initial current, it.$(0-)$, through the indicator.

(2) Calculate the voltage, $V_1(t)$, across the inductance for $t > 0$.

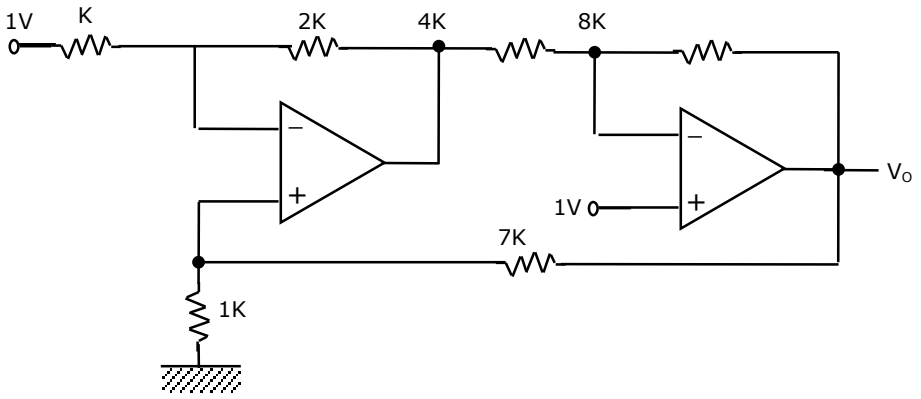
14. Reduce the signal flow graph shown in the figure below, to obtain another graph which does not contain the node e_5. Also, remove any sell loop from the resulting graph.

15. The open loop transfer function of a unity feedback control system, is given by, $G(s) = e^{-25}$. Sketch the output of the feedback system for a unit step input. Assume that the system is initially relaxed.

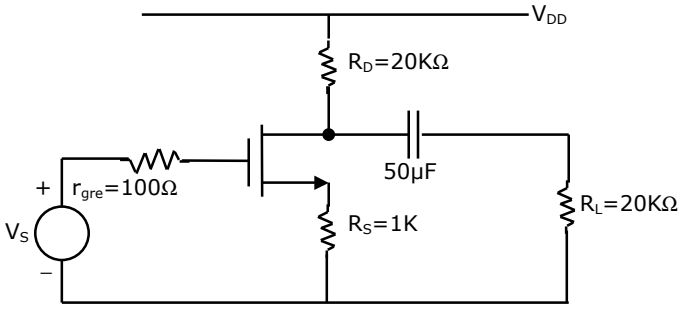
16. A servo mechanism is designed to keep a radar antenna pointed at a flying aero plane. If the aero plane is flying with a velocity of 600 km/hr, at a range of 2 km and the maximum tracking error is to be within 0.1°, determine the required velocity error coefficient.

17. Derive the relation for the maximum electric field in a p^{+n} junction. Assuming that the critical field strength for a avalanche break down is $3\times10^5 V/cm$, what should be the donor dopant concentration if a breakdown voltage greater than 100V is desired? Given: $\in_\sigma = 1\times10^{-12} F/cm$ and $q = 1.6\times10^{-19} C$.

18. Find the output voltage of the following circuit (figure below), assuming ideal op-amp behaviour.



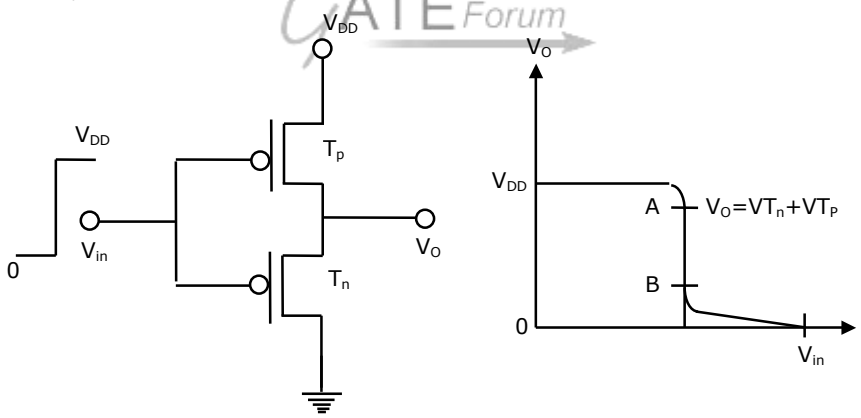
19. In the MOSFET amplifier shown in figure below, the transistor has μ = 50 $r_d = 10k\Omega, C_{gs} = 5pF, C_{gd} = 1pF$ and $C_{ds} = 2pF$. Draw a small signal equivalent circuit for the amplifier for midband frequencies and calculate its midband voltage gain.



20. A typical CMOS interval has the transfer characteristics (VTC) $(V_0 - V_{in})$, as shown in the figure below. Evaluate the value of the Inverter threshold, V_{inx}, which is the value of the input at which V_0 falls abruptly by $\Delta V_0 = V_{Tn} + T_p$.

Given $\beta_n = \mu_n C_{ox}\left(\frac{W}{L}\right)n = \beta_p = \mu_p C_{ox}\left(\frac{W}{L}\right)p$

$V_{Tn} = 1V, V_{Tp} = -1V$ and $V_{DD} = 5V$



21. For the digital circuit shown in the figure below, explain what happens at the nodes N_1, N_2 F and F, when

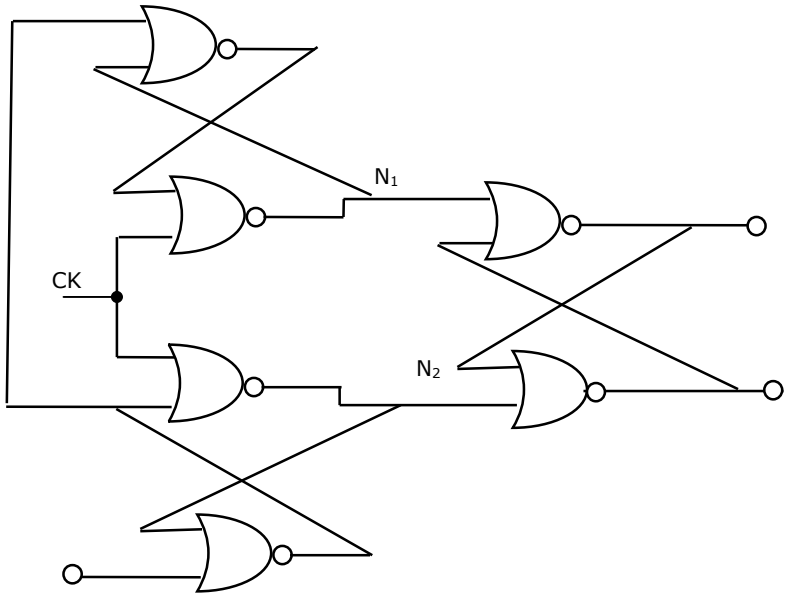
(1) $C_k = 1$ and 'A' changes from '0' to '1'.

(2) A = 1 and 'C_k changes from '1' to '0'.

(3) $C_k = 0$ and 'A' changes from '1' to '0'.

(4) Initially, $C_k = 0$ and 'A' changes from '0' to '1', and then C_k goes to '1'.

(5) What is the circuit performing?



22. Write down the sequence of instructions which are actually executed (till a HLT instruction), if the programme begins with the location 1 FF5 H.

Address (HEX)	8085 Instruction
IFF 5	XRAA
IFF 6	LXI H, 2000 H
IFF 9	PCHL
IFF A	HLT
IFF B	LXI H, 2100 H
IFF E	LXI,H, FFFFH
2000	INXH
2003	JZ 2100 H
2004	HLT
2005	LXIH, IFFFH
2100	MOV A, M
2103	INR A
2104	HLT
2105	

23. A signal, $f(t) = e^{-at}$, where $u(t)$ is the unit step function, is applied to the input of a low-press filter having $|H(\omega)| = \frac{b}{\sqrt{\omega^2 + b^2}}$. Calculate the value of the ratio, $\frac{a}{b}$, for which 50% of the input signal energy is transferred to the output.

24. A given AM broadcast station transmits a total power of 50 kW when the carrier is modulated by a sinusoidal signal with a modulation index of 0.7071. Calculate
    (1) the carrier power
    (2) the transmission efficiency, and
    (3) the peak amplitude of the carrier assuming the antenna to be represented by $(50 + j0)\,\Omega$ load.

25. An FM transmitter delivers a power of 100 W to a load of 50W when non modulation is present. The carrier is now frequency modulated by a single sinusoidal signal and the peak frequency deviation is so adjusted to make the amplitude of the 1st sideband zero in the output. Under this condition, calculate the average power
    (1) at the carrier frequency
    (2) in all the remaining sidebands, and
    (3) in the 2nd order sidebands

    Given:

$$J_0(0.0) = 1.00$$
$$J_0(2.4) = 0.00 \quad J_1(2.4) = 0.52 \quad J_2(2.4) = 0.43$$
$$J_0(3.8) = -0.40 \quad J_1(3.8) = 0.00 \quad J_2(3.8) = 0.41$$
$$J_0(5.1) = -0.16 \quad J_1(5.1) = -0.33 \quad J_2(5.1) = 0.00$$

26. When a radio receiver is tuned to a station of 670 kHz frequency, its local oscillator frequency is 1105 kHz. At the output of the receiver, along with the desired signal another station's output is also present, 20 dB below the level of the desired signal. Determine the frequency of the other station and also its strength, given that the desired stations is producing an antenna signal of 68μV and the antenna coupling coil has a 'Q' of 50.

27. Two spacecrafts are separated by 3000 km. Each has a paraboloidal reflector antenna of 0.85 m diameter operating at a frequency of GHz with an aperture efficiency of 64%. If the spacecraft A's receiver requires 1 pW for a 20 dB signal to noise ratio, what transmitter power is required on the spacecraft B to achieve this signal to noise ratio?

28. A rectangular hollow metal waveguide of internal cross-section, of 7.366 cm × 3.556 cm carries a 3 GHz signal in the TE_{10} mode. Calculate the maximum power handling capability of the waveguide assuming the maximum permissible electric filed inside the waveguide to be 30 kV/cm.

29. A wave traveling in the +Z-direction is the resultant of two linearly polarized components

$$E_x = 3\cos\omega t, \text{ and } E_y = 2\cos(\omega t + 45°)$$

    Determine
    (1) the axial ratio, and
    (2) and angle between the major axis of the polarization ellipse and the +X-axis.