

SECTION A

1. This question contains THIRTY sub-questions of multiple choice type. Each sub-question has only ONE correct answer.

1.1 The rank of the matrix $A = \begin{bmatrix} 1 & 2 & 3 \\ 3 & 4 & 5 \\ 4 & 6 & 8 \end{bmatrix}$, is

- (A) 0 (C) 2
(B) 1 (D) 3

1.2. A real valued random variable lying between 0 and 100 has a uniform probability density function. The probability that the value of the variable is greater than 20 is,

- (A) $\frac{1}{5}$ (C) $\frac{4}{5}$
(B) $\frac{1}{2}$ (D) 1

1.3. For a unity feedback system with open loop transfer function $G(s) = \frac{9}{s(s+2)}$, the damping ratio is

- (A) 1/3 (C) 1
(B) 1/2 (D) 2

1.4. The asymptotic Bode plot for the gain magnitude of a minimum phase system $G(s)$ is shown in Fig. 1.4.

The transfer function is $G(s) =$

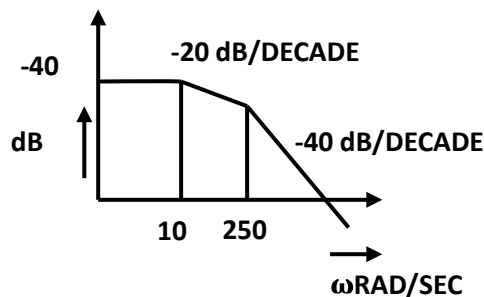


Fig. 1.4.

(A) $\frac{100}{(1+s/10)(1+s/250)}$

(C) $\frac{100}{(s+10)(s+250)}$

(B) $\frac{40}{s(s+250)}$

(D) $\frac{100s}{(s+10)(s+250)}$

1.5. The transfer function of a second order all pass filter is

(A) $\frac{s^2}{s^2+as+b}$

(C) $\frac{s^2+d}{s^2+as+b}$

(B) $\frac{cs}{s^2+as+b}$

(D) $\frac{s^2-as+b}{s^2+as+b}$

1.6. For the circuit shown in Fig. 1.6, $V_R = 20$ V when $R = 10 \Omega$ and $V_R = 30$ V when $R = 20 \Omega$. For $R = 80 \Omega$ V_R will read as

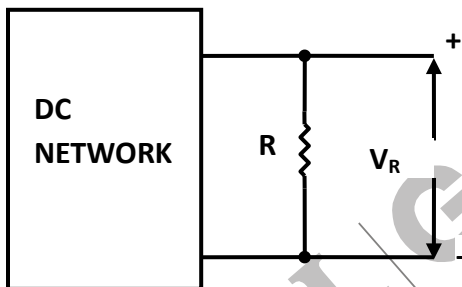


Fig 1.6

(A) 48 V

(C) 120 V

(B) 60 V

(D) 160 V

1.7. For the circuit shown in Fig. 1.7. R is adjusted to have maximum power transferred to it. The maximum power transferred is

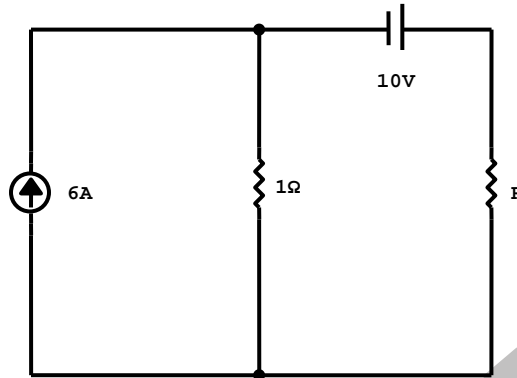


Fig. 1.7.

- (A) 16 W
(B) 32 W

- (C) 64 W
(D) 100 W

1.8. The resistance temperature characteristics of a temperature transducer is shown in Fig. 1.8.

The transducer is,

- (A) Nickel RTD
(B) Platinum RTD

- (C) NTC thermistor
(D) PTC thermistor

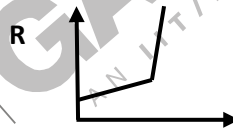


Fig. 1.8.

1.9. The elliptical Lissajous pattern shown in fig. 1.9 was observed from two sinusoidal signal sources of same frequency on a CRO.

The phase angle between the signals is

- (A) $\cos^{-1}(A/B)$
(B) $\tan^{-1}(A/B)$

- (C) $\sin^{-1}(A/B)$
(D) (A/B)

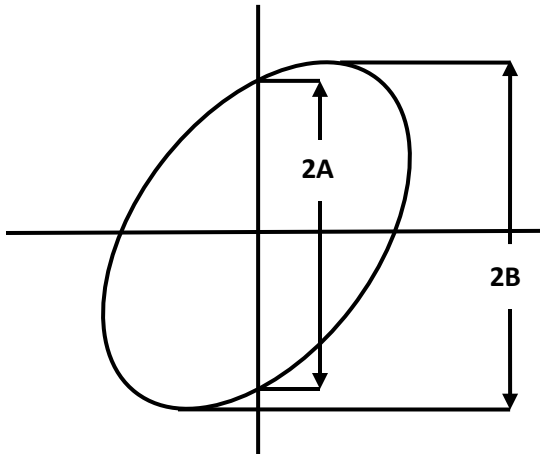


Fig 1.9

- 1.10. The scale of a full wave rectifier type average sensing meter is calibrated to read the r. m.s for ideal sine wave signal (form factor 1.11) Determine the multiplying factor of the meter if it is used to measure the r.m.s. value of square waves.
- (A) 1.11
 (B) 1/1.11
 (C) 1.0
 (D) Depends on the frequency of the square wave.
- 1.11. In an FM broadcast, the maximum frequency deviation allowed is 75 kHz and the maximum modulation frequency is 15 kHz. The bandwidth is closest to
- (A) 180 kHz
 (B) 60 kHz
 (C) 105kHz
 (D) 120kHz
- 1.12. The transfer function $T(z) = \frac{1-0.8z^{-1}}{1+0.8z^{-1}}$ represents
- (A) Auto regressive Filter
 (B) Moving average Filter
 (C) Auto regressive moving average filter
 (D) FIR filter
- 1.13. An op- amp with a slew rate of 1 V/ μ sec has been used to build an amplifier of gain +10 . If the input to the amplifier is a sinusoidal voltage with peak amplitude of 1 V, the maximum allowable frequency of the input signal for undistorted output is
- (A) 830 Hz
 (B) 15.92 Hz
 (C) 31.84 kHz
 (D) 1.0 MHz

1.14. For a sinusoidal input of 50 V amplitude, the circuit shown in Fig. 1.14 can be used as

- (A) Regulated dc power supply
 (B) Square wave generator
 (C) Half wave rectifier
 (D) Full wave rectifier

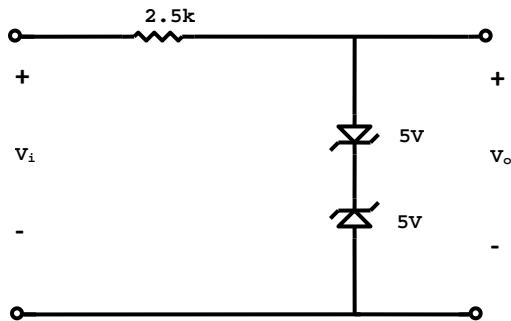


Fig 1.14

1.15. The expression $A + \bar{A}B$ is equivalent to

- (A) $A + B$
 (B) $AB + A$
 (C) $A + \bar{B}$
 (D) AB

1.16. Find the correct match among the following pair in the context of an 8085 microprocessor :

(a) DAA	(e) Program control instruction
(b) LXI	(f) Data movement Instruction
(c) RST	(g) Interrupt instruction
(d) JMP	(h) Arithmetic instruction

(A) a-e, b-f, c-g, d-h

(C) a-h, b-g, c-f, d-e

(B) a-h, b-f, c-g, d-e

(D) a-f, b-h, c-g, d-e

1.17. Indicate which one of the following statements is correct :

- (A) Static RAMs are faster than dynamic RAMs
 (B) RAMs cannot be used to realise Read Write Memory (RWM)
 (C) ROMs are not Random access Devices
 (D) RAMs are generally non-volatile.

1.18. For an 8085 microprocessor, the Stack Pointer (SP) and Program Counter (PC) registers contain the number F000 and 2400 in Hex respectively. The contents of the register after execution of the instruction CALL E000 would be

- (A) PC : F003 SP : 2400
 (B) PC : E000 SP : 2400

(C) PC : E000

SP : 2401

(D) PC : E000

SP : 23 FE.

A	0	0	0	0	1	1	1	1
B	0	0	1	1	0	0	1	1
C	0	1	0	1	0	1	0	1
D	0	0	0	1	0	1	1	1

1.19. From the above truth table, choose the correct logical expression for Q.

(A) $AB + BC + CA$ (C) $A\bar{B} + B\bar{C} + C\bar{A}$ (B) $A + B + C$ (D) $\bar{A}\bar{B} + \bar{B}\bar{C} + \bar{C}\bar{A}$

1.20. The relative permittivity (ϵ_r) to an optical medium is 2.5 Its refractive index is

(A) 0.4

(B) 1.25

(C) 1.58

(D) There is no interrelation between the two parameters.

1.21. An interference filter has been made with a dielectric of magnesium fluoride (refractive index $\eta = 1.38$) for a nominal wavelength of 455 nm. The required thickness of the dielectric for first order interference is

(A) 8.2 nm

(C) 82 nm

(B) 16.5 nm

(D) 165 nm

1.22. The transmittance of a coloured solution is 0.5 The absorbance of the solution is ,

(A) 0.3

(C) 3.16

(B) 0.69

(D) -1.5

1.23. Identify the correct set of matches from the following:

(a) Beer's law	(e) X- ray diffraction
(b) Bragg's law	(f) Thermo – emf
(c) Peltier effect	(g) Electro – chemical cell
(d) Nernst equation	(h) Absorption of light

- (A) a-h , b-e , c-g ,d-f
 (B) a-g , b-f , c-e ,d-h

- (C) a-h , b-e , c-f ,d-g
 (D) None of the above

1.24. Identify the correct set of matches from the following:

(a) Electron capture detector	(e) IR Spectroscopy
(b) Scintillation counter	(f) Oxygen analyser
(c) Thermopile	(g) Gas chromatography
(d) Zirconia probe	(h) Nuclear radiation spectroscopy

- (A) a-h, b-e, c-f, d-g
 (B) a-f, b-h, c-e, d-g

- (C) a-g, b-e, c-h, d-g
 (D) None of the above

1.25. Identify the correct set of matches from the following:

(a) LVDT	(e) Reference junction compensation
(b) Piezoelectric crystal	(f) Charge amplifier
(c) pH probe	(g) Phase sensitive detector
(d) Thermocouple	(h) High input impedance amplifier

- (A) a-e, b-g, c-h, d-f
 (B) a-g, b-f, c-h, d-e

- (C) a-h, b-e, c-f, d-e
 (D) None of the above

1.26. Identify the correct set of matches from the following:

(a) Pirani gauge	(e) Temperature measurement
(b) Venturi meter	(f) Vacuum pressure measurement
(c) Radiation pyrometer	(g) Force measurement
(d) Load cell	(h) Flow measurement

- (A) a-f, b-e, c-h, d-g
- (B) a-h, b-g, c-f, d-e

- (C) a-f, b-h, c-e, d-g
- (D) None of the above

1.27. The value of the impedance $Z_d(s)$ between 1-1 of the circuit shown in Fig 1.27 as $s \rightarrow \infty$ is

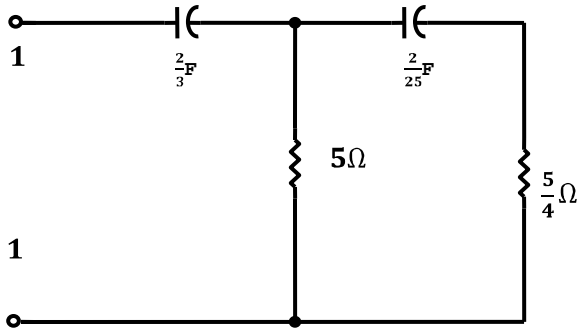


Fig 1.27

- (A) 0
- (B) 1

- (C) $5/4$
- (D) 5

1.28. In the dc millivoltmeter circuit shown in Fig. 1.28, the input voltage for full scale deflection is

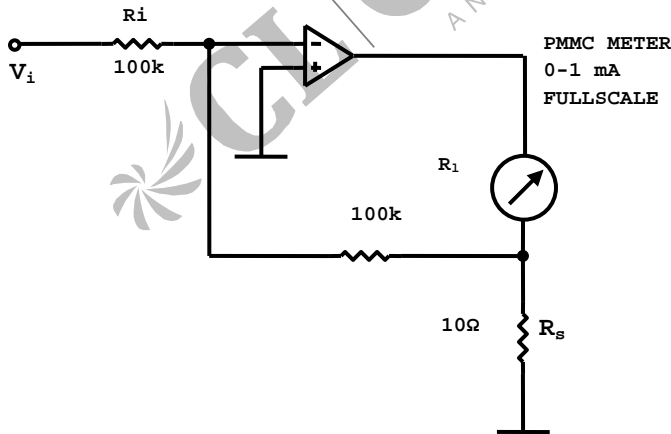


Fig. 1.28.

- (A) 10 V
- (B) 1 V

- (C) 100 mV
- (D) 10 mV

- 1.29. A Hall probe of thickness 2×10^{-3} m carrying a current of 0.2 A is placed in voltage of 0.4 V. The Hall co-efficient of the probe in terms of consistent unit is
(A) 1×10^{-3} (C) 0.5×10^{-2}
(B) 8×10^{-3} (D) 4×10^{-2}
- 1.30. A sinusoidal signal of amplitude $\sqrt{2}$ mV and frequency 5 kHz is buried in Gaussian noise with zero mean value. The noise has a uniform power spectral density of 100 pW/Hz upto a cut-off frequency of 1 MHz. For this system, the signal to noise ratio in dB is
(A) 20 (C) -20
(B) 100 (D) -40
2. *This question contains FIFTEEN sub-question of multiple choice type.*
- 2.1. Which of the following gauges can measure the lowest vacuum pressure ?
(A) McLeod gauge (C) Ionisation gauge
(B) Pirani gauge
- 2.2. Among the bonded metal strain gauges, the foil type is more popular than the wire type because
(A) Error due to transverse strain is much less in foil type
(B) Gauge factor is much higher in foil type
(C) The foil type is much more insensitive to temperature variation.
- 2.3. In a Gas Chromatograph, the gas which can not be used as a carrier gas is,
(A) Helium (C) Ammonia
(B) Nitrogen
- 2.4. Which of the following restrictors has the highest discharge co-efficient?
(A) Orifice plate (C) Venturi tube
(B) Flow nozzle
- 2.5. The characteristics of a control valve is shown in Fig 2.5. The type of the valve is
(A) Equal percentage (C) Quick opening
(B) Linear

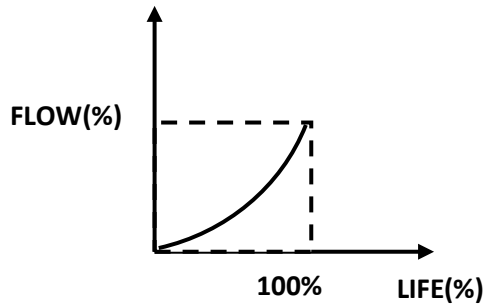


Fig. 2.5.

- 2.6. Brewster angle is the angle of incidence of monochromatic light at the interface of two media, for which
- (A) The incidence beam would be totally internally reflected
 (B) A polarized beam would become unpolarised after reflection
 (C) An unpolarised beam would become polarized after reflection.
- 2.7. Which of the following instruments uses an ultrasonic transducer?
- (A) Echo-cardiograph
 (B) Electro - cardiograph
 (C) Electro- encephalograph.
- 2.8. Among the electrodes which are used to record ECG signals, the one used for ground referencing is placed at,
- (A) left arm
 (B) right leg
 (C) left leg
- 2.9. The characteristic roots of the system described as $\frac{dx}{dt} = y, \frac{dy}{dt} = -x$ are at
- (A) +1, +1
 (B) -1, +1
 (C) -j, +j
- 2.10. The proportional gain of a PID controller can be expressed in terms of its proportional band (PB) as,
- (A) PB
 (B) 100/PB
 (C) PB/100
- 2.11. If both the junctions of a transistor are forward biased, it will be in
- (A) Saturation mode
 (B) Action mode
 (C) Cut off mode

- 2.12. Superposition theorem does not hold for
(A) R-L-C networks (C) Linear op-amp circuits.
(B) Networks containing diodes and R-C elements
- 2.13. For a singular matrix.
(A) Atleast one eigen value would be at the origin
(B) All eigen values would be at the origin
(C) No eigen value would be at the origin.
- 2.14. Which one of the following conditions must be satisfied for the two wattmeter method of three phase power measurement?
(A) Load must be balanced
(B) Source must be balanced
(C) System should be 3-phase 3-wire type.
- 2.15. For a Phase locked loop identify the correct relationship between the Lock Range (LR) and Capture Range (CR)
(A) $LR = CR$
(B) $LR < CR$
(C) $LR > CR$.

SECTION B

Answer any FIFTEEN questions in this section. Each question carries FIVE marks.

3. By dc analysis of the circuit shown in Fig. 3, find I_{FQ} , V_{CEQ} . Assume $V_{BF} = 0.7 \text{ V}$, $\beta_{dc} = 100$, and the capacitors are ideal.

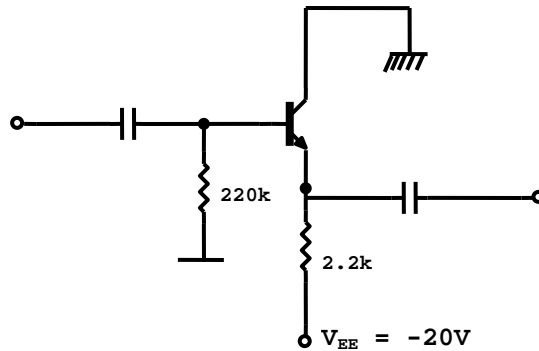


Fig. 3.

4. Applying Superposition theorem, find V_0 for the circuit of Fig. 4.

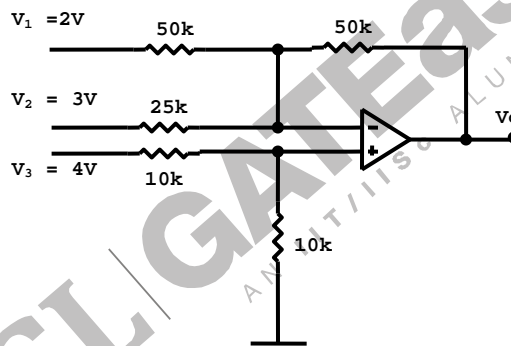


Fig. 4.

5. The bridge circuit shown in Fig 5 is balanced at a supply frequency $\omega = 1000$ rad/sec for the values:

$$R_1 = 1 \text{ k}\Omega \quad R_2 = 2 \text{ k}\Omega \quad C_2 = 0.1 \text{ }\mu\text{F}, \quad C_3 = 0.05 \text{ }\mu\text{F},$$

The unknown element X may be a pure inductance, a pure capacitance or a pure resistance.

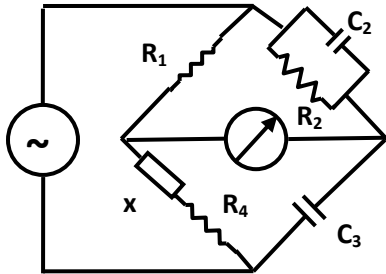


Fig. 5.

- (A) Identify the element X.
 (B) Find the values of X and R_4
6. A direct method of capacitance measurement is shown in Fig. 6, where the phase difference between the voltage across the capacitor and the supply ($\theta_i - \theta_0$) is measured.

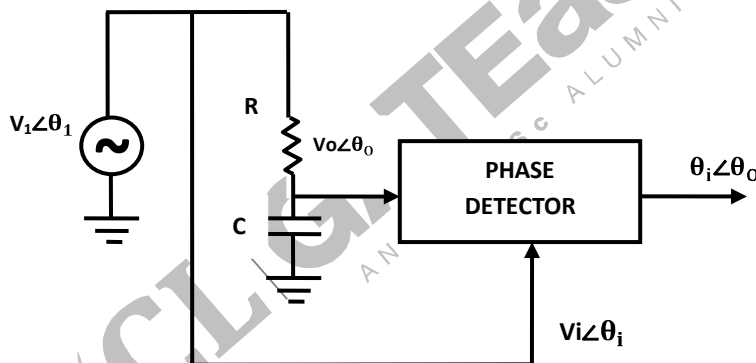


Fig. 6.

- (A) Show that for small values of $(\theta_i - \theta_0)$, the capacitance value can be expressed as ,

$$C = (\theta_i - \theta_0) / (2\pi f R)$$
 Where f is the frequency of the supply in Hz.
- (B) Select the maximum value of R , so that for a 1 MHz signal, the phase shift is kept below 5.7° for full scale capacitance measurement of 100 pF.
7. An RTD has a resistance of 500Ω at 20°C and a temperature coefficient of 0.005°C at 0°C . The RTD is used in a wheatstone bridge circuit with $R_1 = R_2 = 500 \Omega$. The variable resistor R_3 to nulls the bridge. If the bridge supply is 10 V and the RTD is in the batch of 0°C , find the values of R_3 to null the bridge when,
- (A) No self-heating of RTD is considered

(B) Self-heating of RTD is considered and the dissipation constant of the RTD is 20 m W/°C.

8. Two identical strain gauges of resistance 120 Ω and gauge factor +2.0 each, are attached to a steel block of poisson's ratio $\nu=0.3$ as shown

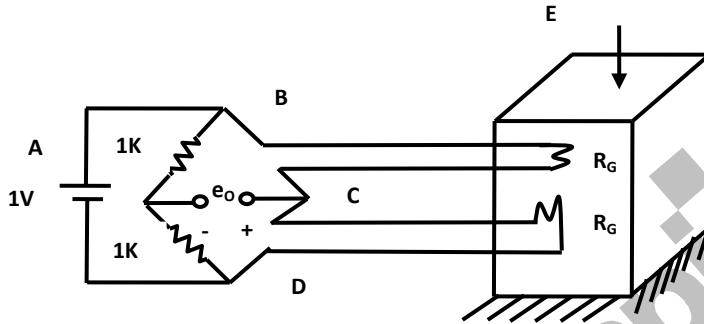


Fig. 8.

in Fig. 8. Find the unbalance voltage per unit microstrain applied to the steelblock as shown.

9. A pH electrode is connected through a shielded cable to a non-inverting amplifier as shown in Fig. 9. The resistance of the electrode is $10^9 \Omega$ and the leakage resistance of the shielded cable is also $10^9 \Omega$. Given that the input resistance of the non-inverting amplifier is,

$$R = R_i \left(1 + A_0 \frac{R_F}{R_l} \right)$$

Where A_0 is the open loop gain and R_i is the input resistance of the op-amp, find the output voltage v_0 when a 100 mV signal is generated at the electrode. Assume $R_i = 10^6 \Omega$ and $A_0 = 10^5$ for the op-amp used.

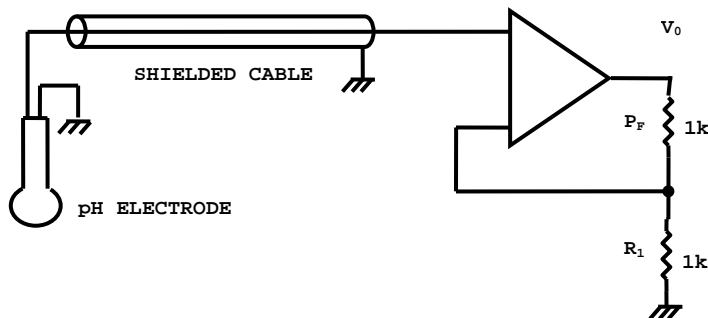


Fig. 9.

10. The e.m.f. developed by a photovoltaic cell can be taken as proportional to the logarithm of the intensity of radiation impinging on it. For 10 W/m^2 radiation, a cell develops an e.m.f. of 0.33 V and drives a current of 2.2 mA into a 100Ω load.

Calculate :

- (A) The open circuit voltage at 25 W/m^2 .
 (B) The internal resistance of the cell.

11. Consider the plant shown in Fig. 11 with a proportional controller with a positive gain.

- (A) Sketch the open loop unit step response of the plant.
 (B) Show that the steady gain of the above

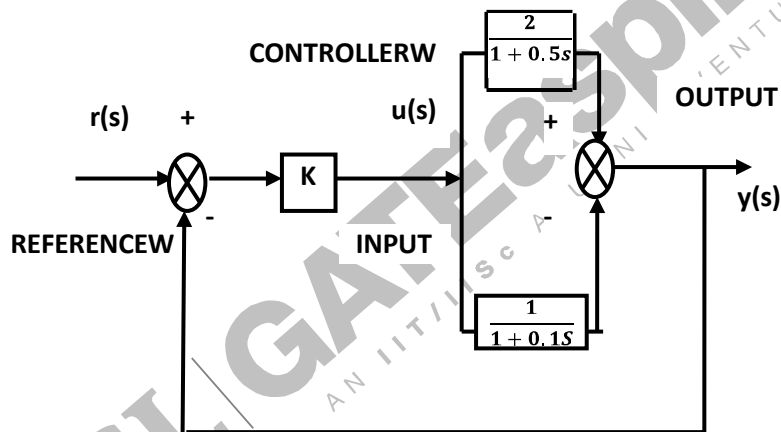


Fig. 11.

Closed loop controlled system is limited to $2/3$ for stable operation.

12. Fig. 12 shows the block diagram for a system with feed forward control.

- (A) Find the transfer function between the output y and the disturbance input w .
 (B) What would be the transfer function of the feed forward controller $G_f(s)$ to eliminate completely the effect of the disturbance input w ?

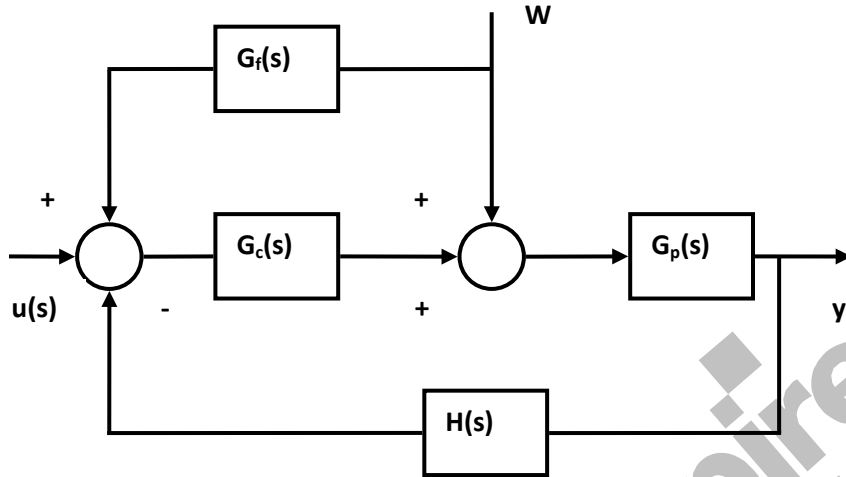


Fig. 12.

13. Assuming an ideal op –amp, obtain the complete state variable model of the circuit shown in Fig.13 Choose the voltages across the capacitors as state variables as shown

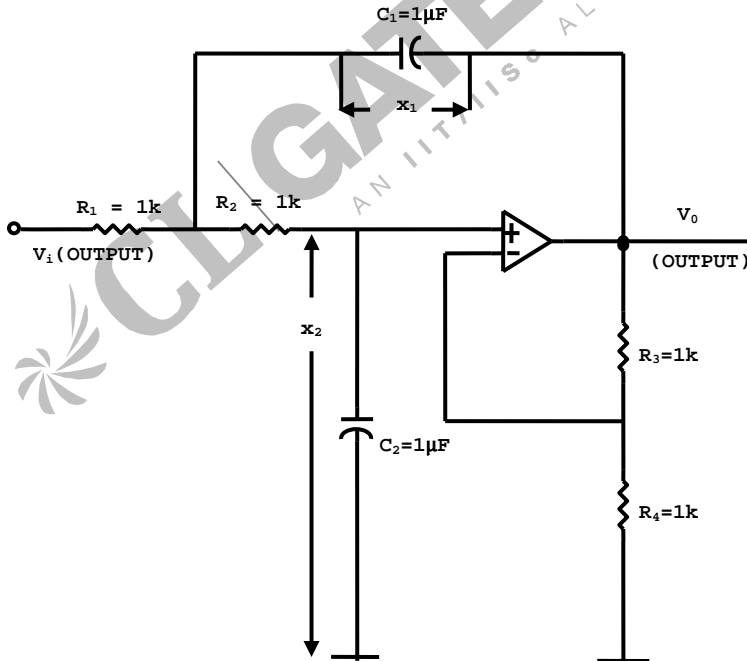


Fig. 13.

14. An inverting Schmitt Trigger, with an upper trip point (V_{UTP}) of 0 V (when the output changes from 1 to 0) and hysteresis (V_H) of 0.3 V, converts a 1KHz sine wave of amplitude 5 V (peak – to-peak) into a square wave. Calculate the “mark –to-space” (T_{HIGH}/T_{LOW})ratio of the output voltage waveform.
15. A dual slope ADC uses a 16 bit counter with a 5 MHz clock. The maximum input voltage is +12 V and the maximum integrator output voltage for maximum count is -10 V. If the resistor in the integrator is $100\text{ k}\Omega$, find the value of the capacitor.
16. (A) Realize a clocked SR flip –flop with NAND gates and write its truth table.
 (B) Using the above, write the state transition table of the circuit shown in Fig.16.

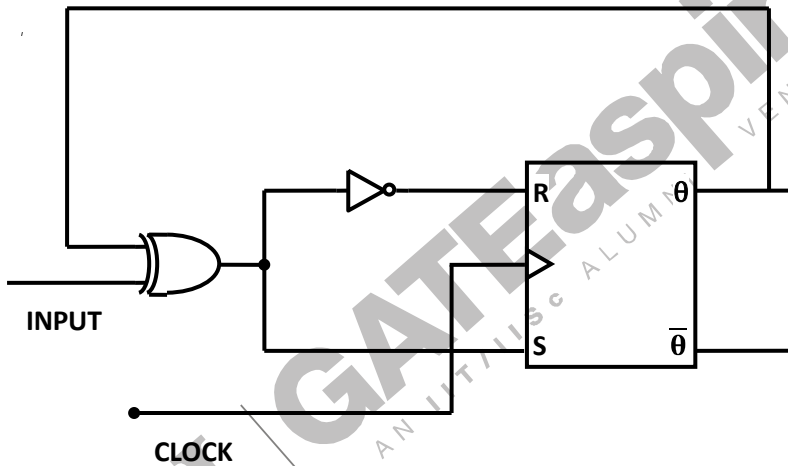


Fig. 16.

17. 2K bytes of ROM have to be interfaced to an 8085 microprocessor using one E^2 PROM chip. The relevant pins of the E^2 PROM are shown in Fig. 17. The address space assigned to the ROM chip in hex is C000-C7FF.

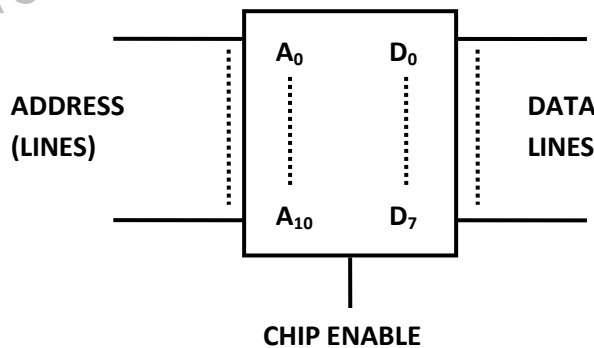


Fig. 17.

- (A) Show how the address and data lines of the 8085 are to be connected to those of the E² PROM chip.
- (B) Design the address decoding circuit whose output is to be connected to the Chip Enable pin of the E²PROM chip using only 2-input AND gates and inverters.
18. The input-output relationship for a causal system is given by the difference equation,

$$y(k+1) - \frac{1}{4}y(k) = x(k)$$

Where $y(k)$ is the output and $x(k)$ is the input.

- (A) Find the Pulse transfer function of the system.
- (B) Find the response of the system for an input,
 $x(k) = 1$ for $k = 0$ and
 $x(k) = 0$ otherwise.
19. For an Amplitude Modulated Double Side Band Full Carrier wave, with a peak unmodulated carrier voltage of 10 V and load resistance of 10 Ω , the modulation index is 0.5. Assume that both the carrier and the modulating signals are sinusoidal.
- (A) Write the time-equation for the modulated signal.
- (B) Find the r.m.s. power of the carrier, the upper sideband frequency, the lower side band frequency and the total r.m.s. power of the modulated wave.
20. A method for measuring a large bore diameter (D) is to place a pin of length L and measure the swing (S) of the pin across the bore, as shown in Fig. 20.

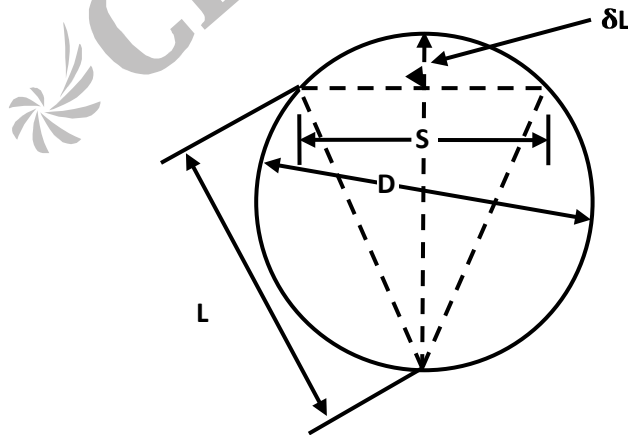


Fig. 20.

(A) By approximating $D = L + \delta L$.

Show that, $D = L + \frac{S^2}{8L}$

(B) If $L = 500 \text{ mm} \pm 0.02 \text{ mm}$ and $S = 30 \text{ mm} \pm 1.0 \text{ mm}$, where the uncertainties denote the standard deviations, determine the uncertainty for the diameter (D).

21. Cobalt -60 is a gamma ray source whose half -life is 5 years. The intensity of such a source was measured one year back and found to be 100 units.

(A) What will be the intensity of the source if it is measured today?

(B) The same source is now used to measure the thickness of a steel block whose absorption coefficient is $0.46/\text{cm}$. The radiation from the source is passed through the steel block and its intensity after attenuation is measured today and is found to be 40 units. What is the thickness of the block?

22.

(A) Derive the relationship for the time of flight of a mass spectrometer.

(B) A time -of- flight mass spectrometer has a drift tube 85 cm long. If the accelerating potential is 2.0 kV, calculate the difference in arrival times of two ions with mass number 200 and 300. Take the charge of an electron to be $1.6 \times 10^{-19} \text{ C}$ and the mass of a proton to be $1.66 \times 10^{-27} \text{ kg}$.

