SECTION A

1. This question consists of TWENTY FIVE sub-questions (1.1 – 1.25) of ONE mark each. For each of these sub – questions, four possible answers (A, B, C and D) are given, out of which only one is correct. Answer each sub – question by darkening the appropriate bubble on the OBJECTIVE RESPONSE SHEET (ORS) using a soft HB pencil. Do not use the ORS for any rough work. You may like to use the Answer Book for any rough work, if needed.

1.1. Threshold of a measurement system is
   (A) the smallest change in input which can be detected
   (B) a measure of linearity of the system
   (C) the smallest input which can be detected
   (D) a measure of precision of the system.

1.2. International temperature scale in the range 0-630°C is defined by means of a
   (A) mercury pressure spring thermometer
   (B) platinum – platinum. 10% rhodium thermocouple
   (C) platinum resistance thermometer
   (D) total radiation pyrometer.

1.3. A sound intensity level of 60 dB corresponds to
   (A) 10^{-6} W/cm^2
   (B) 10^{-10} W/cm^2
   (C) 10^{-16} W/cm^2
   (D) 10^{-63} W/cm^2

1.4. Linear variable differential transformer has
   (A) two primary coils connected in phase and a secondary coil
   (B) two primary coils connected in opposition and a secondary coil
   (C) one primary coil and two secondary coils connected in phase
   (D) one primary coil and two secondary coils connected in opposition.

1.5. Value of pH of a solution is 4. It indicates that concentration of hydrogen ions is
   (A) 10^{-4} g/litre and the solution is acidic
   (B) 10^{-4} g/litre and the solution is alkaline
   (C) 10^{-4} mg/litre and the solution is acidic
   (D) 10^{-4} mg/litre and the solution is alkaline

1.6. For flow measurement, a rotameter can be installed in a pipe line
   (A) horizontally with flow inlet in a specific direction
   (B) horizontally with flow inlet in any direction

(C) vertically with flow inlet at the bottom and the outlet at the top
(D) vertically with flow inlet at the top and outlet at the bottom.

1.7. An example of a positive displacement flow meter is
(A) orifice meter
(B) rotary vane type meter
(C) turbine type meter
(D) ultrasonic flow meter.

1.8. In a differential micrometer, the main screw has pitch of 0.48 mm and the smaller screw has a pitch of 0.40 mm. The thimble has 50 divisions marked on it. The movement of the spindle per divisions is
(A) 0.0016 mm
(B) 0.0176 mm
(C) 0.08 mm
(D) 0.88 mm

1.9. The refractive indices of glass and water are 1.50 and 1.33, respectively. If the glass is immersed in water, its relative refractive index is
(A) 0.89
(B) 1.13
(C) 1.99
(D) 2.83

1.10. Light is incident on a glass plate of refractive index 1.732. It is plane polarized on reflection when the incidence angle is
(A) 30°
(B) 45°
(C) 60°
(D) 75°

1.11. A gas chromatograph is used for
(A) measuring flow rate of a gas
(B) measuring the temperature of a gas
(C) measuring the pressure of a gas
(D) analyzing the composition of a gas

1.12. A vector normal to $i + 2j - k$ is
(A) $i - j - k$
(B) $-i - 2j + k$
(C) $-i + 2j + k$
(D) $2i + j - 2k$

1.13. The necessary condition to diagonalise a matrix is that
(A) its Eigen values should be distinct
(B) its Eigen vectors should be independent
(C) its Eingen values should be real
(D) the matrix is non-singular.

1.14. Which one of the following sequences is NOT a power signal.

(A) unit step sequence
(B) $e^{j\omega_0 n}$
(C) a periodic sequence
(D) unit ramp sequence

1.15. The final value of a function y (t) whose Laplace transform Y (s) = $\frac{4}{s^2+2s+2}$ is

(A) 4
(B) 2
(C) 1
(D) 0

1.16. A second order feedback system is found to be oscillating with a high frequency .The oscillations

(A) can be reduced by increasing the proportional action
(B) can be reduced by increasing the integral action
(C) can be reduced by increasing the derivative action
(D) cannot be reduced.

1.17. The discrete LTI system with the following impulse response is non-causal.

(A) a^n u (n-2)
(B) a^{n-2} u (n)
(C) a^{n+2} u(n)
(D) a^n u (n+2)

1.18. In The circuit shown in Fig. 1.18, current through the 5 Ω resistor is

(A) 0A
(B) 2 A
(C) 3 A
(D) 7 A

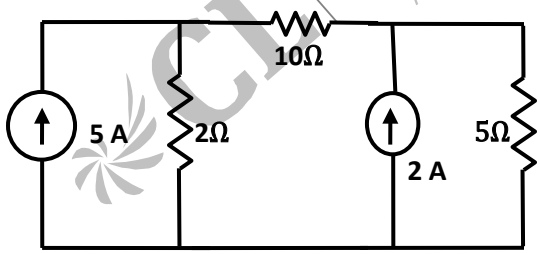


Fig. 1.18

1.19. Two identical 2-port networks with y-parameters $y_{11} = -y_{12} = -y_{21} = y_{22}$ I S are connect in cascade The Overall y - parameters will satisfy the condition

(A) $y_{11} = 1$ S
(B) $y_{12} = -\frac{1}{2}S$
(C) $y_{21} = -2$S
(D) $y_{22} = 1$ S

1.20. A sample and hold circuit has two buffers, one at the input and the other at the output. The primary requirements for the buffers are
(A) The input buffer should have high slew rate and the output buffer should have low bias current
(B) The input buffer should have low bias current and the output buffer should have high slew rate
(C) Both the buffers should have low bias currents
(D) Both the buffers should have high slew rate

1.21. A twisted pair of wires is used for connecting the signal source with the instrumentation amplifier, as it helps reducing
(A) the effect of external interference
(B) the error due to bias currents in the amplifier
(C) the loading of the source by the amplifier
(D) the common mode voltage.

1.22. In a microprocessor with 16 address and 12 data lines, the maximum number of opcodes is
(A) 2^6 (C) 2^{12}
(B) 2^8 (D) 2^{16}

1.23. An *m*-bit microprocessor has an *m*-bit
(A) flag register (C) data counter
(B) instruction register (D) program counter

1.24. In 8085 microprocessor, CY flag may be set by the instruction
(A) SUB (C) CMA
(B) INX (D) ANA

1.25. Microprocessor 8085 regains control of the bus
(A) immediately after HOLD goes low
(B) immediately after HOLD goes high
(C) after half-clock cycle after HLDA goes low
(D) after half-clock cycle after HLDA goes high

2. This questions consists of TWENTY FIVE sub-questions (2.1 – 2.25) of TWO marks each. For each of these sub-questions, four possible answers (a), (b), (c) and (d) are given, out of which only one is correct. Answer each sub-question by darkening the appropriate bubble on the OBJECTIVE RESPONSE SHEET (ORS) using a soft HB pencil. Do not use the ORS for any rough work. You may like to use the Answer Book for any rough work, if needed.

2.1. A strain gauge is attached to a bar of length 20 cm which is subjected to a tensile force. The nominal resistance of strain gauge is 100Ω. The changes in resistance and elongation in the bar measured are 0.35 Ω and 0.2 mm, respectively. The gauge factor of the strain gauge is

(A) 2 (C) 10
(B) 3.5 (D) 100

2.2. In the context of transducers, identify the correct matches :

(a) mean free path	(p) optical pyrometer
(b) humdity	(q) Knudsen gauge
(c) heat transfer co-efficient	(r) sling psychrometer
(c) intensity of radiation	(s) hot wire anemometer

(A) a-p, b-q, c-r, d-s (C) a-r, b-s, c-p, d-q
(B) a-q, b-p, c-s, d-r (D) a-q, b-r, c-s, d-p

2.3. A seismic vibration sensor, having natural frequency ω_n and damping ratio ζ, used for measuring amplitude of vibration with frequency ω, should have

(A) $\omega_n << \omega$ and ζ much greater than 1
(B) $\omega_n = \omega$ and ζ slightly less than 1
(C) $\omega_n >> \omega$ and ζ slightly less than 1
(D) $\omega_n << \omega$ and ζ slightly less than 1

2.4. In a spirit level, 2.5 mm of movement of the bubble corresponds to a tilt angle of 25 seconds. The radius of curvature of the tube of the spirit level is

(A) 52.1 m (C) 26.3 m
(B) 34.4 m (D) 15.6 m

2.5. An optical flat is tested against a standard reference flat in a Newton's interferoscope. If the optical flat is as good as the reference, the fringes observed are a set of

(A) Concentric rings (C) Hyperbolic fringes
(B) Elliptical rings (D) Straight and parallel fringes

2.6. Identify the correct matches:

(a) Spirometer (b) Sphygmomanometer (c) Plethysmograph (d) Electrocardiograph	(p) electricity activity of the heart (q) respiratory volume measurement (r) measurement of change in volume of body part (s) blood pressure measurement

(A) a-p, b-s, c-r, d-q
(B) a-q, b-r, c-s, d-p
(C) a-s, b-p, c-q, d-r
(D) a-q, b-s, c-r, d-p

2.7. The typical maximum output powers associated with the lasers are given below. Indentify the correct matches

(a) He- Ne laser	(p) 10mW
(b) Argon ion laser	(q) 100mW
(c) Carbon dioxide laser	(r) 10W
(d) Diode laser	(s) 500W

(A) a-p, b-q, c-r, d-s
(B) a-q, b-p, c-s, d-r
(C) a-r, b-s, c-p, d-q
(D) a-q, b-r, c-s, d-p

2.8. $\lim_{x \to \frac{\pi}{4}} \left(\frac{sin2\left(x-\frac{\pi}{4}\right)}{x-\frac{\pi}{4}} \right)$ equals

(A) 0
(B) ½
(C) 1
(D) 2

2.9. For an input
$v(t) = 5 - 2\,(100\pi t) - \cos\,(200\pi t)$,
the output of a full-wave rectifier average is
(A) 2
(B) 4
(C) 5
(D) 8

2.10. The 3-dB cut-off frequency of a first order analog high pass filter is ω_c. For a signal 0.5 sin $\omega_c t$, the output will have a phase shift of
(A) $-\pi/2$
(B) $-\pi/4$
(C) $\pi/4$
(D) $\pi/2$

2.11. For a suppressed carrier amplitude modulator (AM-SC) system, the carrier and the modulating inputs are $x_c(t) = \cos \omega_c{}^t$ and $x_m(t) = 0.5 \sin \omega_m{}^t$, respectively. The output of the system is proportional to
(A) $\sin(\omega_c + \omega_m)t - \sin(\omega_c - \omega_m)t$

(B) $\sin(\omega_c + \omega_m)t + \cos(\omega_c - \omega_m)t$
(C) $(1 + 0.5 \sin \omega_m t) \cos \omega_c t$
(D) $(1 - 0.5 \sin \omega_m t) \cos \omega_c t$

2.12. In a frequency modulated system, the carrier and the output signals are $x_c(t) = \cos \omega_c t$ and $y(t) = \cos(\omega_c t + \sin 2t - \cos t)$, respectively. The modulating input $x_m(t)$ is proportional to
(A) 2 cos 2t + sin t
(B) sin 2t – cos t
(C) cos 2t + sin t
(D) 2 cos 2t – sin t

2.13. An analog LTI system has a negative phase shift which varies linearly with frequency. Its magnitude response is frequency independent. The system transfer function is
(A) $\frac{1-s\tau}{1+s\tau}$
(B) $e^{-s\tau}$
(C) $\frac{1-s^2\tau^2}{1+s^2\tau^2}$
(D) $\frac{1-s\tau}{1+s\tau} e^{-s\tau}$

2.14. A process in a feedback loop with a proportional controller with ultimate gain $K_u = 10$ is oscillating at a frequency of $P_u = 8$Hz. The Ziegler-Nichols setting for the proportional controller is
(A) 8
(B) 5
(C) 1.25
(D) 10

2.15. The impulse response of a discrete LTI system is u (n). The system
(A) Is unstable in the sense of bounded input bounded output
(B) Produces bounded outputs for all bounded inputs
(C) Produces bounded outputs for all bounded inputs
(D) Stability properties cannot be commented upon

2.16. A discrete time transfer function has a pole-zero plot as shown in Fig. 2.16. It is a
(A) low pass filter
(B) high pass filter
(C) band pass filter
(D) notch filter

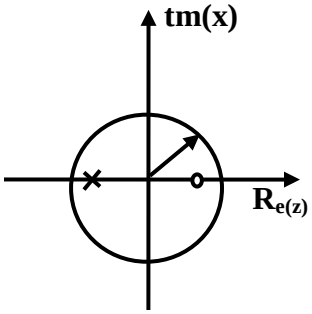


Fig. 2.16

2.17. The impulse response of a discrete LTI system is $a^n u(n)$. Its response is given by

(A) $\sum_{j=0}^{n} a^j$

(B) $\sum_{j=0}^{\infty} a^j$

(C) $\frac{1}{1-a}$

(D) $\sum_{j=-\infty}^{\infty} a^j$

2.18. In Fig. 2.18, input offset voltage of the operational amplifier is 2 mV. The output dc-error voltage is

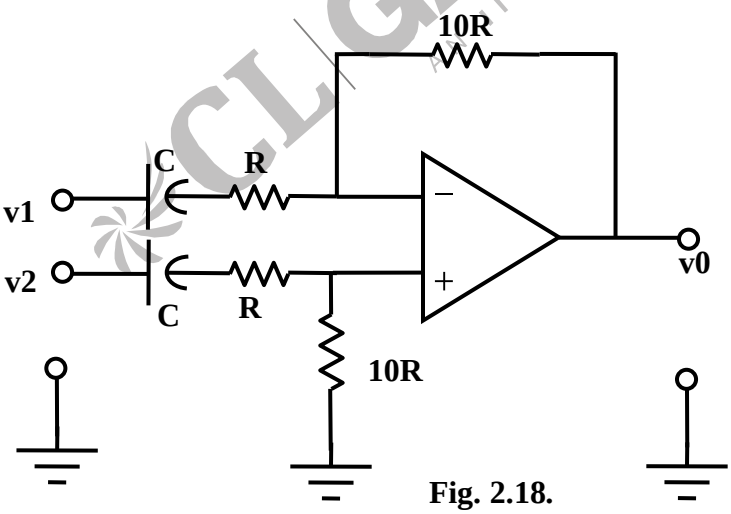


Fig. 2.18.

(A) 0
(B) 2 mV
(C) 11 mV
(D) 22 mV

2.19. In the context of low resistances, identify the INCORRECT statement.

(A) Standard low resistances have four terminal construction

(B) In Kelvin bridge for measuring low resistance, precision depends on the detector sensitivity

(C) A pair of ratio arms in Kelvin bridge for measuring the low resistance eliminates the error due to thermo emf.

(D) Low resistances used for ammeter shunts are usually made with a suitable number of plates of large area and all the plates connected in parallel.

2.20. In the context of a PMMC instrument, identify the correct matches

(a) a pair of springs	(p) to provide controlling torque
(b) aluminium former	(q) to provide damping torque
	(r) to act as a base for the coil
	(s) to provide current into and out of the moving coil

(A) a-p and q, b-r and s

(B) a-r and s, b-p and q

(C) a-p and s, b-q and r

(D) b-q and r, b-p and s

2.21. In a dual-slope type digital voltmeter, an unknown signal voltage is integrated over 100 cycles of the clock. If the signal has a 50 Hz pick up, the maximum clock frequency can be

(A) 50 Hz

(B) 5 kHz

(C) 10 kHz

(D) 50 kHz

2.22. In the circuit shown in Fig. 2.22 when inputs A=B=0 the possible logic states of C and D are

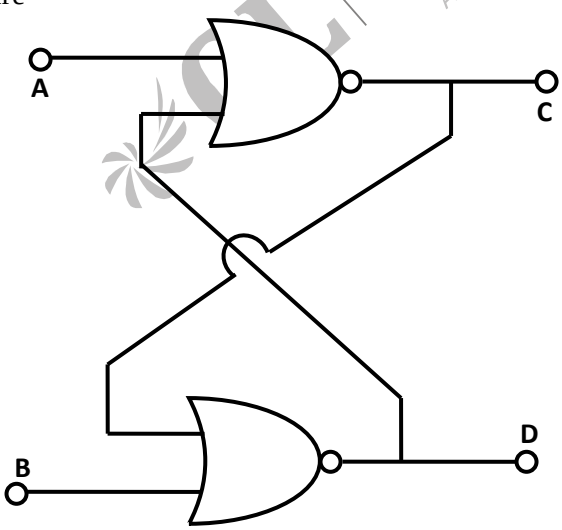


Fig. 2.22

(A) C = 0, D = 1 or C = 1, D = 0
(B) C = 1, D =1 or C = 0, D = 0
(C) C = 1, D = 0
(D) C = 0, D = 1

2.23. In the logic circuit shown in Fig 2.23, the output x is

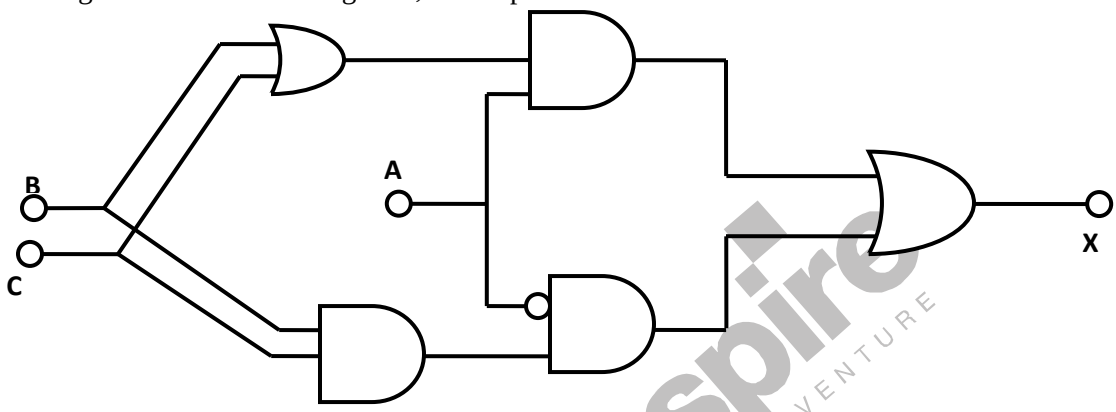
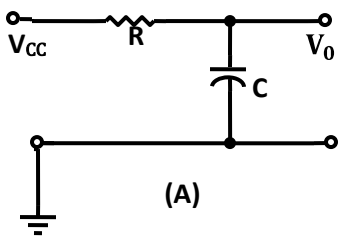


Fig. 2.23

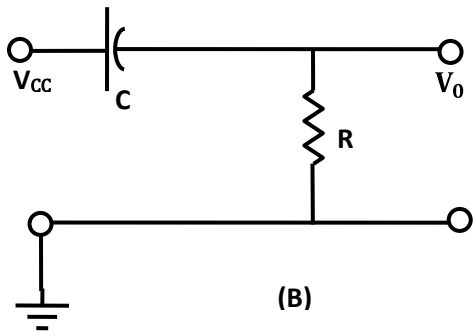
(A) $A\overline{B} + B\overline{C} + C\overline{A}$
(B) A + B + C
(C) AB + BC + CA
(D) $\overline{AB} + \overline{BC} + \overline{CA}$

2.24. A double beam CRO has a band-width of 10 MHz. Two signals
$v_1(t) = 10 \sin (2\pi \times 20 \times 10^3 t)$
and $v_2(t) = 10 \sin (2\pi \times 20 \times 10^6 t)$
are applied to the two channels . If P_1 and P_2 are the peak-to-peak values of the signals displayed, then
(A) $P_1 = 20, P_2 = 20$
(B) $P_1 < 20, P_2 > 20$
(C) $P_1 = 20, P_2 < 20$
(D) $P_1 > 20, P_2 < 20$

2.25. In Fig. 2.25, identify the circuit which is appropriate for use as a power-on reset for a microprocessor.



(A)



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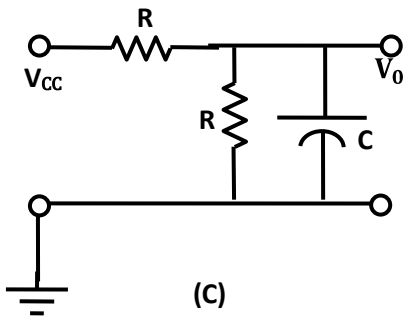
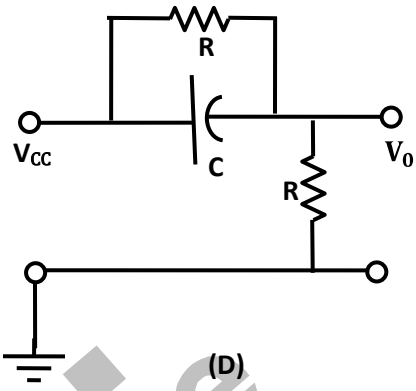


(C)



(D)

SECTION B

This section consists of Twenty questions of Five marks each. Any Fifteen out of these questions have to be answered on the Answer Book provided.

3. A random variable x has a probability density function p (x) = $ae^{-|x-10|}$
   (A) Sketch p (x)
   (B) Find the value of a.
   (C) Find the probability of 9 being in the range [5, 15].

4. Viscosity, μ, is given by

$$\mu = \frac{\pi r^4 (p_1 - p_2)}{8QL}$$

   Where

r (radius of capillary tube)	=	0.5 ± 0.01 mm
p_1 (pressure at the inlet)	=	200 ± 3 kPa
p_2 (pressure at the exit)	=	150 ± 2 kPa
L (length of the capillary tube)	=	3m
Q (volume flow rate)	=	4 x 10^{-7} m^3/s

   (A) Calculate the viscosity and specify the unit.
   (B) Calculate absolute error.
   (C) Calculate root sum square error.

5. During measurement of pressure by an elastic transducer, pressure is instantaneously changed in a stepwise manner from 5 bar to 30 bar. The transducer indicates a value of 20 bar after 30 secs. Assume that the transducer is a first order instrument.
   (A) Determine the time constant of the transducer.

(B) How much time will the transducer take to indicate the pressure within 5% of the final value?
(C) On what factors does the time constant of the elastic transducer depend?

6. A piezoelectric transducer having diameter = 8mm thickness = 4 charge sensitivity = 2×10^{-12} C/N, dielectric constant = 4×10^{-11} F/m and modulus of elasticity = 8.6×10^{10} N/M^2 is used for the measurement of small displacement. For an input displacement of 10^{-9}m, determine
(A) the force to which it is subjected,
(B) the capacitance of the transducer,
(C) the charge generated
(D) the voltage developed.

7. A thermopile having a resistance of 100Ω and consisting of 20 copper-constantan thermocouples is used to measure temperature difference between two points. The temperature of the first point measured separately is 25^0 C. EMF generated measured by a voltage measuring device having an internal resistance of 1000 Ω is 1.47 m V.
EMF - temperature relationship for copper-constantan thermocouple with reference junction at 0^0 is as follows.

Temperature (°C)	EMF (mV)
0	0
10	0.389
20	0.787
25	0.990
27	1.071
29	1.153
31	1.235
33	1.318
35	1.401
37	1.485
39	1.568
41	1.652
43	1.737
45	1.821

Determine the temperature difference between the two points after applying correction for loading effect in the measurement of the EMF

8. A certain pressure transducer measures the stagnation pressure (the total pressure). The density of the fluid is 1.03 g/cm^3 and the velocity of flow is 100 cm/s
   (A) Calculate the dynamic pressure (pressure due to the velocity of flow) in N/m^2
   (B) If the total pressure measured by the transducer is 10000 N/m^2 , find the static pressure in mm of Hg

9. Light of wavelength 546 nm is used to view an object under the microscope. The aperture of the objective is 0.9 cm.
   (A) Calculate the limiting angle of resolution.
   (B) Using visible light, what is the maximum limit of resolution for this microscope?

10. For a narrow beam of X-ray radiation of wavelength 62 pm, the mass absorption co-efficients for aluminium and lead are 3.48 cm^2/g and 72 cm^2/g respectively. The densities of aluminium and lead are 2.7 g/cm^3 and 11.3 g/cm^3, respectively
    (A) By how much is the beam attenuated in an aluminium screen 2.6 cm thick?
    (B) How thick must a lead screen be to attenuate the beam just as much?

11. The width of a V-groove shown in Fig. 11 is determined using a standard steel ball of diameter d and a vernier height gauge.
    (A) If the angle of the groove is A, derive an expression for the width *w* of the V-groove.
    (B) Given: d = 30 mm, H = 50 mm, h = 45 mm and a = 60°, calculate w.

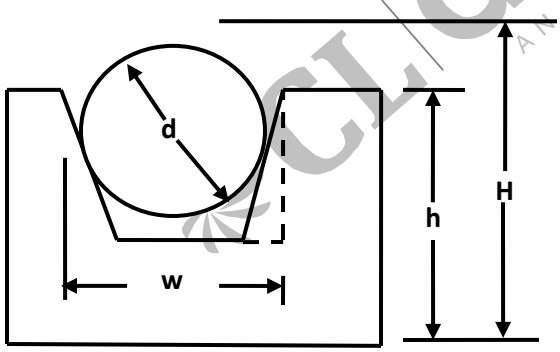


Fig. 11.

12.
    (A) Draw the Nyquist plot for the system $G(s) = \frac{s+1}{s(s-1)}$ by plotting G along the closed contour C shown in Fig. 12. Note the indentation of this contour at the origin is to the left.

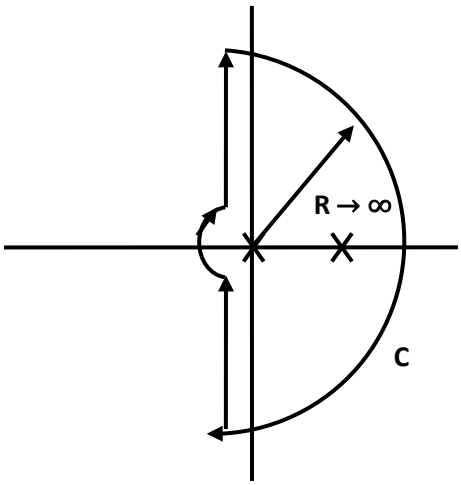


Fig. 12.

(B) What is the encirclement criterion for stability of this system with the type of contour chosen ?

(C) Using this criterion determine the range of the gain K of the proportional controller over which the closed loop system will be stable.

13. The relation between the input x (n) and the output y (n) of a system is given by

$$y(n) - \frac{1}{2}y(n-1) = x(n)$$

$$y(n) = 0$$

(A) Evaluate the outputs for the inputs

(i) x (n) = 0 for all n

(ii) $x(n)\begin{cases}1, & n \geq -2\\ 0, & n < -2\end{cases}$

(B) Is this system causal? Justify your answer.

14. In the circuit shown in Fig. 14, $C_1 = C_2 = 2$ F and L = 1 H. Initially C_1 and C_2 are charged to voltages 20 and 0 volts, respectively. If the switch is closed at t = 0, determine v_{C1} (t) and v_{C2} (t). Use the Laplace transform approach.

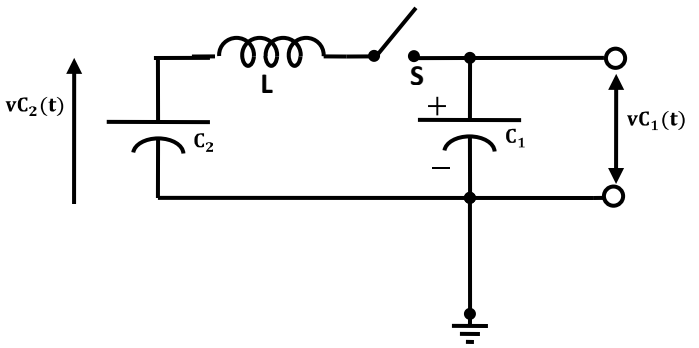


Fig. 14.

15. A small-signal approximate equivalent circuit of an amplifier is shown in Fig. 15, where $h_{ie} = R_L = 4\ k\Omega$, $h_{fe} = 100$
    (A) Draw the actual amplifier circuit using a pnp transistor
    (B) Find input resistance R_i and gain V_o/V_b
    (C) From the result obtained in (b), suggest a possible application for the amplifier.

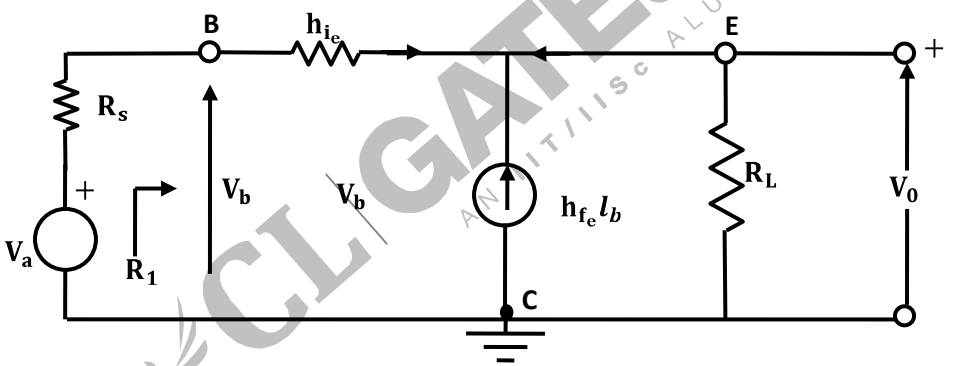


Fig.15.

16. In the circuit shown in Fig. 16, transistors Q_1 and Q_2 have $\beta = 100$. Zener diode has $V_z = 4V$. Given $I_L = 2$ mA, $I_z = 5$mA, $V_{EB1} = V_{EB2} = 0.7$ V, Find
    (A) R_1
    (B) R_2
    (C) the range of R_L

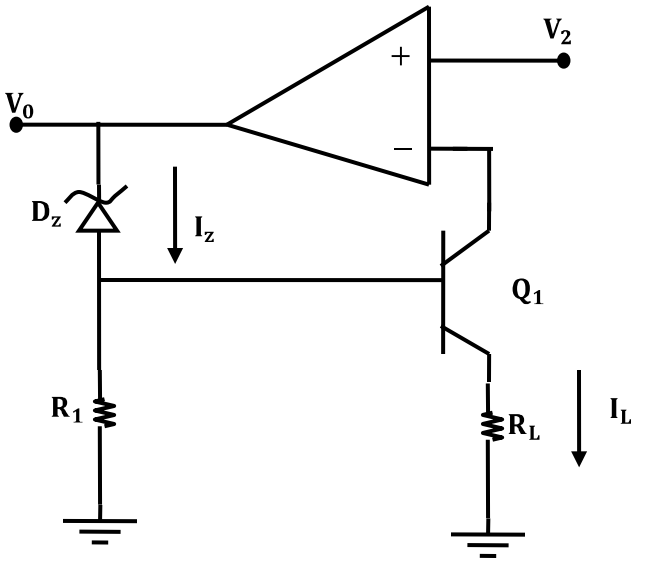


Fig. 16.

17. In the circuit shown in Fig. 17, assume R = 10 kΩ, C = 0.1 μF.
    (A) Find the transfer function $V_0(s)$i $V_i(s)$.
    (B) If $v_i = \sqrt{2}\sin(1000t)$, find $v_0(t)$.
    (C) If a similar circuit is connected in cascade, find Q of the composite circuit.

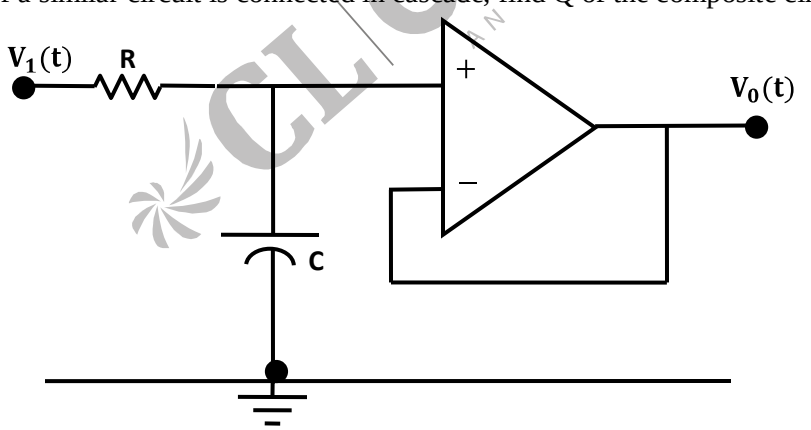


Fig. 17.

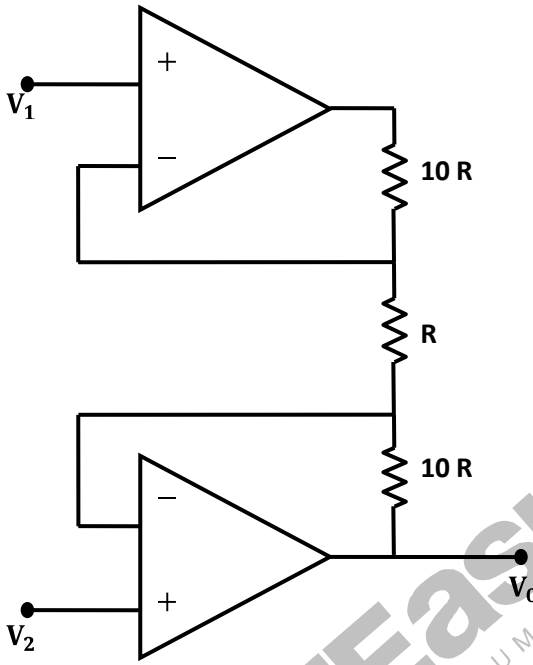


Fig. 18.

18. In the circuit shown in Fig. 18. V_1 and V_2 are the input signals.
    (A) Find V_0 in terms of V_1 and V_2
    (B) Express V_0 in terms of the common mode voltage V_c and the difference mode voltage V_d of the two input voltages.
    (C) Find CMRR (Common mode rejection ratio) at the output V_0.

19. In the circuits shown in Fig. 19, $R_1 = R_2 = 220\ k\Omega, R_3 = 100\ k\Omega, C = 0.1\ \mu F$. Find
    (A) The output voltage, if $v_i = 1$ V dc,
    (B) The transfer function $V_0(s)/V_i(s)$,
    (C) The impulse response.

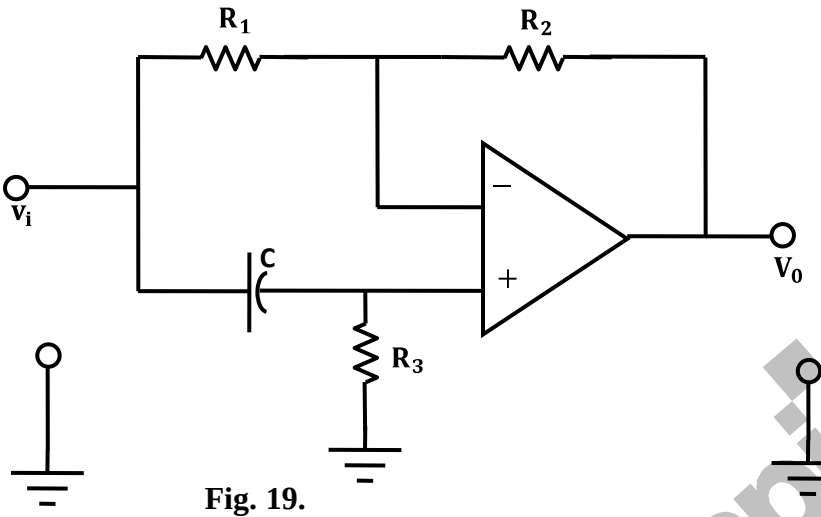


Fig. 19.

20. Determine the value of r such that the circuit shown in Fig. 20 acts as a 4 – bit digital – to - analog converter.

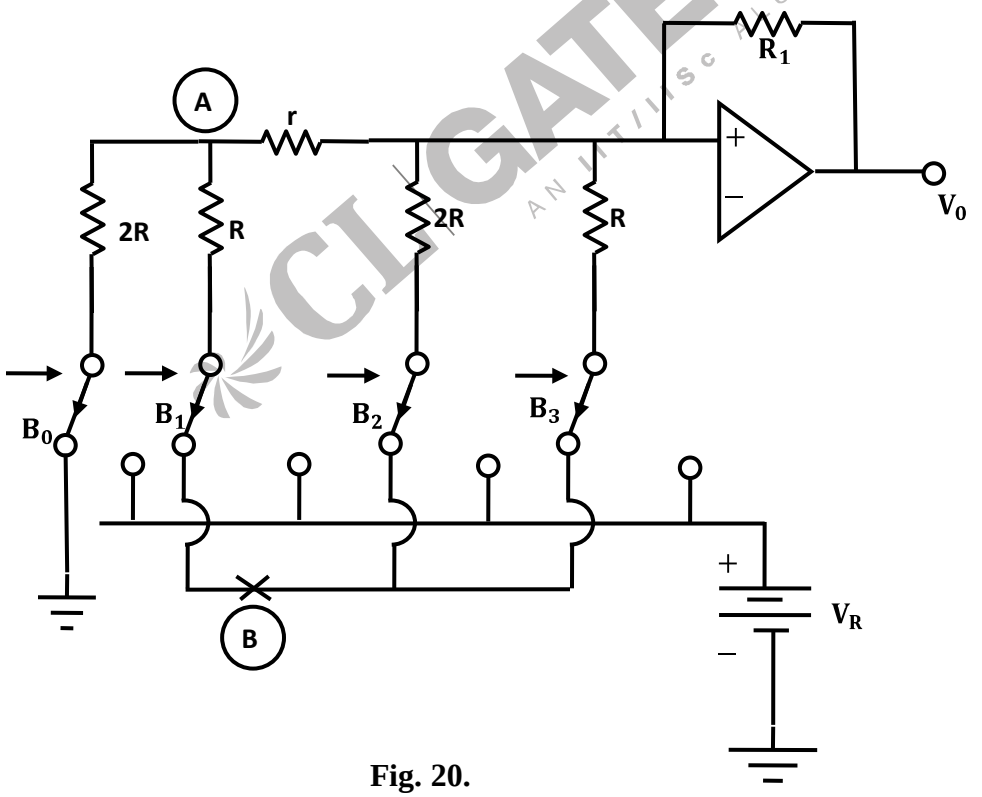


Fig. 20.

21. In the circuit shown in Fig. 21, C is a capacitor formed by two parallel plates each of area A, with air as the dielectric separating the two plates by a distance x. One of the plates is fixed while the other is free to move. Derive an expression for output v_0 in terms of the velocity, dx/dt, of the moving plate.

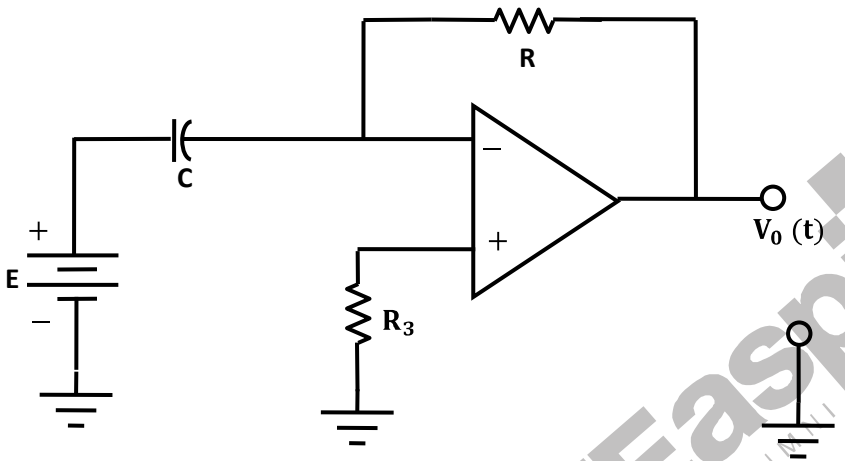


Fig. 21.

22. A block diagram for measuring the power frequency f based on the period measurement is shown in Fig. 22 (a). The detailed circuit diagram for the block Y is shown in Fig. 22 (b) where T-FF, SR-FF and monostables M_1 and M_2 operate on the negative going edges and V_{start} is a narrow pulse. The clock frequency f_c is adjusted such that the display is 50.00 for $f = 50.00\ Hz$.
    (A) Draw the waveforms appearing at A, B, C, D,E and F.
    (B) Determine f_c
    (C) What would be the reading displayed when $f = 49.00\ Hz$?

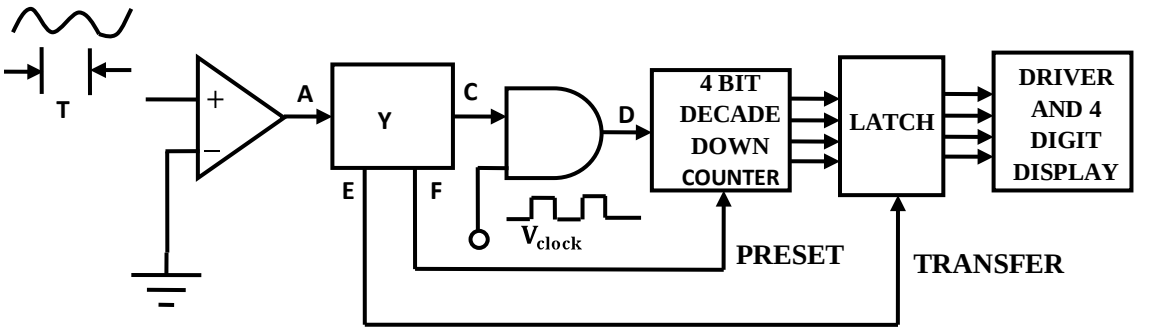


Fig. 22 (a)

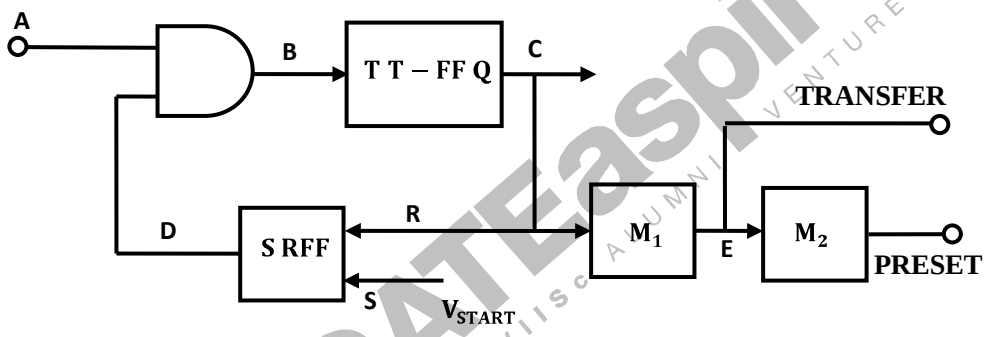


Fig. 22 (b)