GATE 2015 – A Brief Analysis
(Based on student test experiences in the stream of EE on 7th February, 2015 – (Forenoon Session)

Section wise analysis of the paper

Section Classification	1 Mark	2 Marks	Total Number of Questions
Engineering Mathematics	3	3	6
Networks	3	3	6
Analog Circuits	3	1	4
Digital Circuits	1	3	4
Signals and Systems	2	2	4
Control Systems	2	4	6
Electrical Machines	3	5	8
Power Systems	2	3	5
Measurements	2	1	3
Power Electronics	1	4	5
Field Theory	3	1	4
Verbal Ability	3	2	5
Numerical Ability	2	3	5
	30	35	65

Questions from the Paper

1. Didn't you buy _____ when you went shopping?

    (A) any paper   (B) much paper   (C) no paper   (D) a few paper

Key: (A)

2. A moving average function is given by $y(t) = \dfrac{1}{T}\int_{t-T}^{t} u(\tau)\,d\tau$. If input u is sinusoidal signal of frequency $f(a)/f(b) \le 0$ then the steady state output y will lag u (in degrees) by _____.

Key: 90

Exp: $u(\tau) = \sin(\omega\tau)$

$$\omega = 2\pi f = 2\pi.\dfrac{1}{2T} = \dfrac{\pi}{T}$$

$$\omega T = \pi$$

$$y(t) = \dfrac{1}{T}\int_{t-T}^{t} \sin(\omega\tau)d\tau = \dfrac{\cos(\omega\tau)}{\omega T}\Bigg|_{t}^{t-T}$$

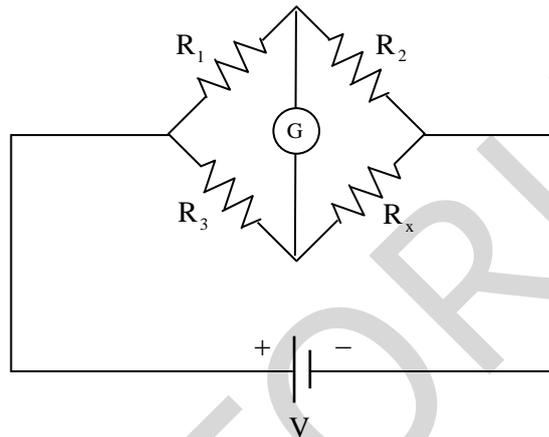$$= \dfrac{1}{\pi}\Big[\cos\omega(t-T) - \cos\omega t\Big]$$

$$= \frac{1}{\pi} \left[\cos \omega t \cos \omega T + \sin \omega t \sin \omega T - \cos \omega t \right]$$

$$y(t) = -\frac{2}{\pi} \cos \omega t = \frac{2}{\pi} \sin(90 + \omega t)$$

$$x(t) = \sin \omega t$$

$$\phi = 90°$$

3. Wheatstone bridge shown is used to find value of resistance R_x. The Galvanometer G indicates zero current when $R_1 = 50\Omega, R_L = 65\Omega \ \& \ R_3 = 100\Omega$. If R_3 is known with $\pm 5\%$ tolerance on its nominal value of 100Ω, what is range of R_x in ohms?

(A) 123.5, 136.5   (B) 125.898, 134.12   (C) 117, 143   (D) 120.25, 139.75

Key: (A)

Exp: Weinbridge is balanced, $R_1, R_x = R_2R_3$

$50 \times R_x = 65 \times 100$

$R_x = 130\Omega$

Now $R_3 = 100 \pm 100 \times 0.05 = 100 \pm 5 = 95/105\Omega$

$R_x = \dfrac{R_2R_3}{R_1} = \dfrac{65 \times 105}{50} = 136.5\Omega$

$R_x = \dfrac{65 \times 95}{50} = 123.5\Omega$

Range of R_x is 123.5Ω to 136.5Ω

4. If the sum of diagonal elements of a 2×2 matrix is -6 then maximum possible value of determinant of matrix is _____.

Key: 9

Exp: Sum of the diagonals elements is -6 for 2×2 matrix
The possible eigen value are

$$\rightarrow \quad -1,-5 \quad -5,-1, \quad -8,2$$
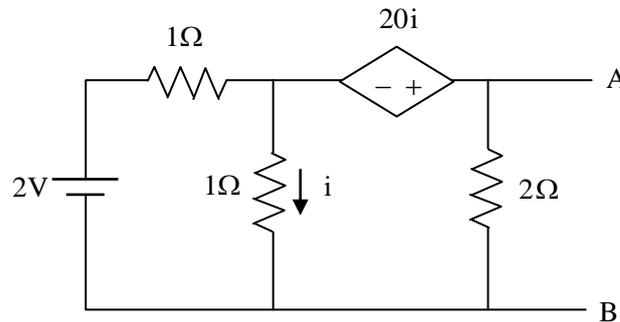$$-2,-3 \quad -4,-2 \quad -9,3 \quad ----$$
$$-3,-1 \quad -3,-3 \quad -10,4$$

Maximum possible value of determinant is $-3 \times -3 = 9$.

5. For a given circuit the thevenin equivalent is to be determined. The thevenin voltage V_{Th} (in volts) seen from terminal AB is _____.

Key: 3.36

Exp: $V_{th} = 2i_1$

$2 = 1[i+i_1]+i = 2i+i_1$

$i(1) = -20i + 2i_1$

$\therefore 21i = 2i_1$

$i = \left(\dfrac{2}{21}\right)i_1$

$2 = 2i + i_1 = 2\left(\dfrac{2}{21}\right)i_1 + i_1 = \left(\dfrac{4}{21}+1\right)i_1 = \dfrac{25}{21}i_1$

$i_1 = \dfrac{42}{25} = 1.68$

$V_{th} = 2i_1 = 3.36V$

6. Base load plants are

$P \rightarrow$ wind farms

$Q \rightarrow$ run off river plants

$R \rightarrow$ Nuclear power plants

$S \rightarrow$ Diesel power plants

(A) P, Q & S only

(B) P, R & S only

(C) P, Q & R only

(D) Q, R only

Key: D

7. A random variable X has probability density function f(x) as given below.

$f(x) = \begin{cases} a + bx & 0 < x < 1 \\ 0 & \text{otherwiese} \end{cases}$

If the exp value $E[x] = \dfrac{2}{3}$. then $Pr[X < 0.5]$ is _____.

Key: 0.25

Exp: $\int_{-\infty}^{\infty} f(x)dx = 1$

so $\int_0^1 (a + bx)dx = 1$

$a + \dfrac{b}{2} = 1$

$2a + b = 2$ _____ (1)

given $E[X] = 2/3 = \int_0^1 x[a + bx]dx$

$\dfrac{2}{3} = \dfrac{a}{2} + \dfrac{b}{3}$

$3a + 2b = 4$ _____ (2)

from (1) and (2)

$a = 0$

$b = 2$

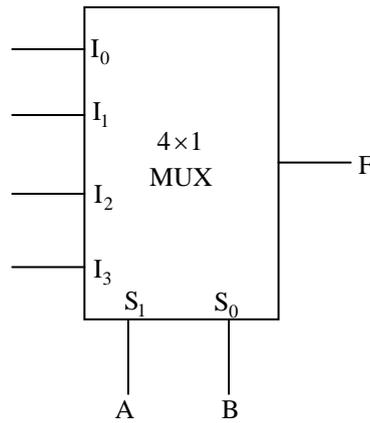$p_r[X < 0.5] = \int_0^{0.5} f(x)dx = 2\int_0^{0.5} x\,dx = 0.25$

8. Consider a function $\overline{F} = \dfrac{1}{r^2}\hat{r}$, where r is distance from origin and $\hat{r}$ is is unit vector. The divergence of this function over a sphere of radius R, which includes origin is.

   (A) 0   (B) 2π (C) 4π (D) $R\pi$.

9. A separately excited DC generator has an armature resistance of 0.1Ω & negligible armature inductance. At rated field current & rated rotor speed its open circuit voltage is 200V. When the generator is operated at half of rated speed, with half the rated field current, an uncharged $1000\mu F$ capacitor is suddenly connected across armature terminals. Assume that speed remains unchanged during the transient. At what time (in μs) after the capacitor is connected will the voltage across it reach 25V?

   (A) 62.25   (B) 69.3   (C) 73.25   (D) 77.3

10. Of the four characteristics given below, what are major requirements for an instrument amplifier?

    P: high common mode rejection ratio

    Q: high input impedance

    R: high linearity

    S: high output impedance

    (A) P,Q & R only   (B) P & R only

    (C) P, Q & S only   (D) Q, R & S only

Key: (A)

Exp: Additional characteristics include very low DC offset, low drift, low noise, very high open-loop gain, very high common-mode rejection ratio, and very high input impedances. Instrumentation amplifiers are used where great accuracy and stability of the circuit both short and long-term are required.

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11. In chopper duty ratio of switch S is 0.4. If the inductor & capacitor are sufficiently large to ensure continuous inductor current & ripple free capacitive voltage, the charging current (in amp) of 5V battery, under steady-state is _____.

12. If a continuous function f(x) does not have a root in the interval [a, b]. Then which one of the following statement is true.

(A) $f(a).f(b)=0$ (B) $f(a).f(b)<0$ (C) $f(a).f(b)>0$ (D) $f(a)/f(b)\leq 0$

13. The primary mmf is least affected by the secondary load variation in a

(A) Power transformer   (B) Potential transformer

(C) Current transformer   (D) Distribution transformer.

14. The voltage divided across $3\Omega \& 2\Omega$ resistance shown in figure are 6V & 2V respectively, with polarity as marked. What is the power (in W) delivered by 5V voltage source.

Key: 5

Exp: $I = \dfrac{6V}{3\Omega} = 2A$

$I = \dfrac{2V}{2\Omega} = 1A$

$I + 1 = 2$

$I = 1A$

$P = 5 \times 1 = 5W$

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15. In the 4×1 multiplexer, the output F is given by $F = A \oplus B$. Find required inputs $I_3 I_2 I_1 I_0$.

(A) 1010   (B) 0110   (C) 1000   (D) 1110

Key: (B)

Exp: $F = A \oplus B = AB' + A'B$

AB $S_1 S_0$			
00	A'B'	I_0 0	$I_0 = 0$
01	A'B	I_1 1	$I_1 = 1$
10	AB'	I_2 1	$I_2 = 1$
11	AB	I_3 0	$I_3 = 0$

16. In given circuit the silicon transistor has $\beta = 75$ collector voltage $V_C = 9V$. The ratio of $R_B \& R_C$ is _____..

Key: 105.1

Exp: $I_C + I_B = \dfrac{6}{R_C}$

$I_B = \dfrac{8.3}{R_B}$,

$\Rightarrow \beta = 75, \ I_C = \beta I_B$

$(76) I_B = \dfrac{6}{R_C}, \ I_B = \dfrac{8.3}{R_B}$

$76 \times \dfrac{8.3}{R_B} = \dfrac{6}{R_C}$

$\dfrac{R_B}{R_C} = \dfrac{76 \times 8.3}{6} = 105.1$

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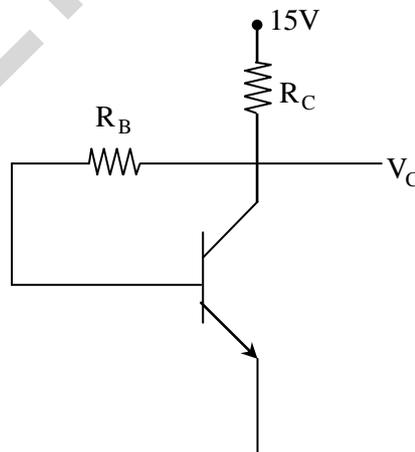
17. A(0 – 50A) moving coil ammeter has a voltage drop of 0.1V across its terminals at full scale deflection. The external shunt resistance $(in\ m\Omega)$ needed to extend its range to (0 – 500A) is _____.

18. Two players A & B alternatively keep rolling a fair dice. The person to get a 'six' first wins the game. Given that player A starts the game, the probability that A wins the game is _____.

    (A) $\dfrac{5}{11}$ (B) $\dfrac{1}{2}$ (C) $\dfrac{7}{13}$ (D) $\dfrac{6}{11}$

19. In the given circuit parameter k is positive and power dissipated in 2Ω resistor is 12.5W. The value of k is _____.
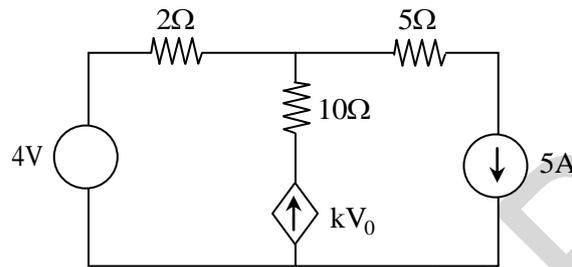
Key: 1.5

Exp: Power dissipated across

$R = \dfrac{V_0^2}{R} = 12.5$

$V_0 = \pm 5V,$

If $V_0 = \pm 5V,$ By nodal analysis at node x,

$kV_0 = I + 5, (I = 2.5A)$

$kV_0 = 7.5$

$k = \dfrac{7.5}{5} = 1.5$
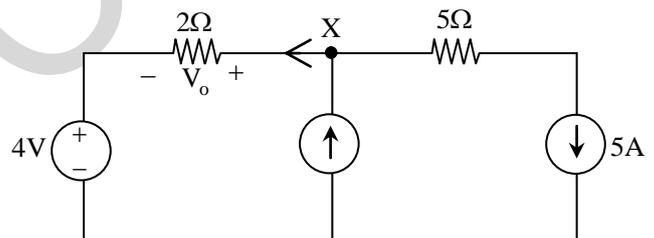
20. Two single phase transformers T_1 & T_2 each rated at 500 kVA are operated in parallel. Percentage impedance of T_1 & T_2 are (1 + j6) and (0.8 + j4.8) respectively. To share a load of 1000 kVA at 0.8 lagging power factor the contribution of T_2 (in kVA) is _____.

21. A solution of ordinary differential equation $\dfrac{d^2y}{dt^2} + \dfrac{5dy}{dt} + 6y = 0$ is such that $y(0) = 2\ \&\ y(1) = -\dfrac{1 - 3e}{e^3}$ The value of $\dfrac{dy}{dt}(0)$ is _____.

Key: -3

Exp: Roots, $-3, -2$

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7

$$y(t) = C_1 e^{-3t} + C_2 e^{-2t}$$

$$y(0) = C_1 + C_2 = 2$$

$$y(1) = -\left(\frac{1-3e}{e^3}\right) = -e^{-3} + 3e^{-2} = C_1 e^{-3} + C_2 e^{-2}$$

So, $C_1 = -1, C_2 = -3$

So,

$$y(t) = -e^{-3t} + 3e^{-2t}$$

$$\frac{dy(t)}{dt} = 3e^{-3t} - 6e^{-2t}, \frac{dy(0)}{dt} = 3 - 6 = -3$$

22. An 8 bit unipolar successive approximation register type ADC is used to convert 3.5V to digital equal output. The reference voltage is +5V. The output of ADC at end of 3rd clock pulse after the start of conversion is _____.

(A) 1010 0000   (B) 1000 0000   (C) 0000 0001   (D) 0000 0011

23. The circuit shown in figure has two sources connected in series. The instantaneous voltage of AC source (in V) is given by $v(t) = 12\sin t$. If the circuit is in steady state, then the value of current (in amp) flowing in circuit is _____.
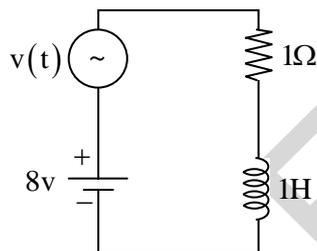
Key: 10

Exp: $V(t) = 8 + 12\sin t$

$z = 1 + j\omega L$, Here $(\omega = 0, \text{ and } \omega = 1)$

$i(t) = 8 + 6\sqrt{2}\sin(t - 45^\circ)$

$i_{rms} = \sqrt{64 + 36} = 10A$

24. Given $Sgn(x) = \frac{|x|}{x}$. The fourier series expansion of sgn[cost] contains

(A) sin t, all harmonics   (B) cos t, all harmonics

(C) sin t, all even harmonics   (D) cos t, all odd harmonics

25.
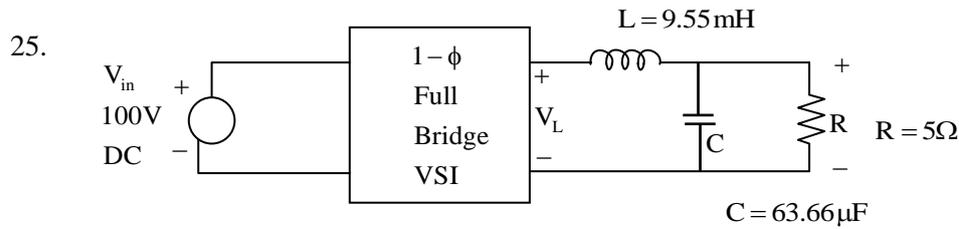
For the given 1-phase, full bridge VSI, switching frequency is 50 kHz and single pulse modulated with modulation index m = 0.7. The fundamental output voltage is _____.

26.
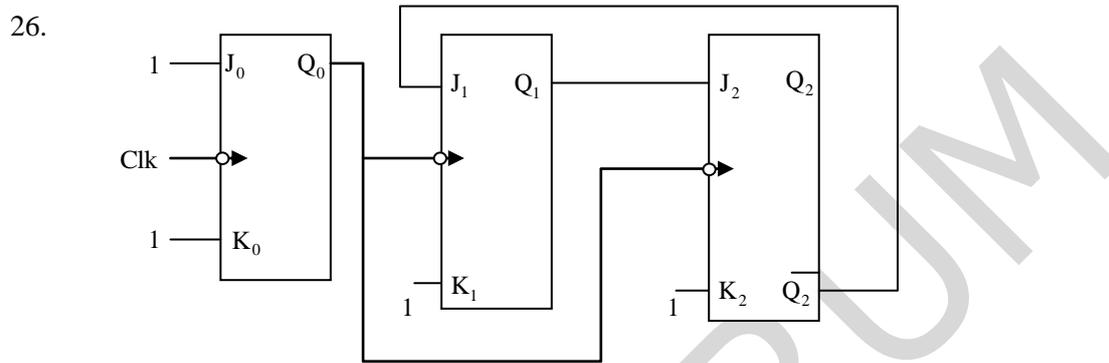
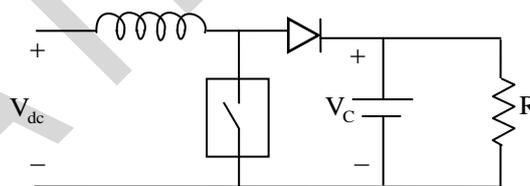Initially $Q_2Q_1Q_0 = 000$, after how many clock cycles, $Q_2Q_1Q_1 = 000$ will be appeared.

Key: 6

Exp: First flip flop acts as mod-2 counter

Second 2 flip flops from mod (2n-1) Johnson counter = mod counter

∴ overall modulus = mod – 6 counter

27. Consider the following power electronic network. The switch is operating at a duty cycle D. Under steady state V_L and V_C are

(A) $0, \dfrac{D}{1-D}V_{DC}$

(B) $\dfrac{D}{2}V_{DC}, \dfrac{D}{1-D}V_{DC}$

(C) $0, \dfrac{1}{1-D}V_{DC}$

(D) $\dfrac{D}{2}V_{DC}, \dfrac{1}{1-D}V_{DC}$

28. The incremental fuel costs of two generators are given by

$C_1 = 0.01P_1^2 + 30P_1 + 10$

$C_2 = 0.05P_2^2 + 10P_2 + 10$

The incremental fuel cost in Rs/MW for a total load of 200 MW is _____.

Key: 30

Exp: $\dfrac{dC_1}{dP_1} = 2 \times 0.01P_1 + 30 = 0.02\,P_1 + 30$

$\dfrac{dC_2}{dP_2} = 2 \times 0.05P_2 + 10 = 0.1P_2 + 10$

$\dfrac{dC_1}{dP_1} = \dfrac{dC_2}{dP_2}$

$0.02P_1 + 30 = 30 = 0.1P_2 + 10$

$2P_1 + 3000 = 10P_2 + 1000$

$2P_1 + 2000 = 10P_2$

$P_1 + P_2 = 200$

$P_2 = 200$

$P_1 = 0$

$\dfrac{dC_1}{dP_1} = 30\,Rs\,/\,Mwh$

29. A DC motor has 10 hp, 37.5 A, 230V, 0.01 Wb, 4 poles, 666 conductors, 2 parallel paths Armature resistance is 0.267Ω, rotational loses are 600 W. At 1000 rpm, the output torque is _____N-m.

Key: 14.14

Exp: $E = \dfrac{\phi 2Np}{60A} = \dfrac{0.01 \times 666 \times 4 \times 1000}{60 \times 2} = 55.5$

Internal power $= EI = 55.5 \times 37.5 = 2081.25$

Pout $= 2081.25 - 600 = 1481.25$

$T = \dfrac{Pout}{w} = \dfrac{1481.25}{2\pi \times \dfrac{1000}{60}} = 14.14 \text{ Nm}$

30.
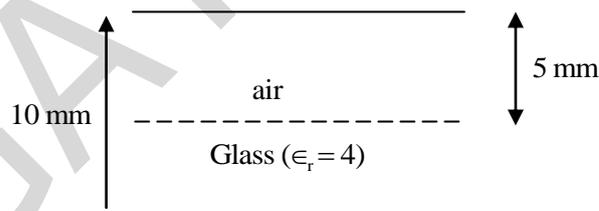
A parallel plate capacitor is separated by air and glass as shown in figure. If the dielectric strength of air and glass is 30 kV/cm and 300 kV/cm, the max voltage applied across the capacitor is _____ without breaking.

31. A synchronous generator has H=2 MJ/MVA and operating at synchronous speed; f=50 Hz, delivering real power = 1 p.u; $\delta_{initial} = 5^{o}$. The value of δ after 0.02 sec. for a $3-\phi$ fault at the generator terminals is _____. Assuming mechanical inputs is maintaining constant at 1 p.u.

32. A 200/400 V transformer is reconnected as auto transformer 200/600V. If a 12Ω resistance is connected across 600V side, the equivalent resistance at the LV terminals is
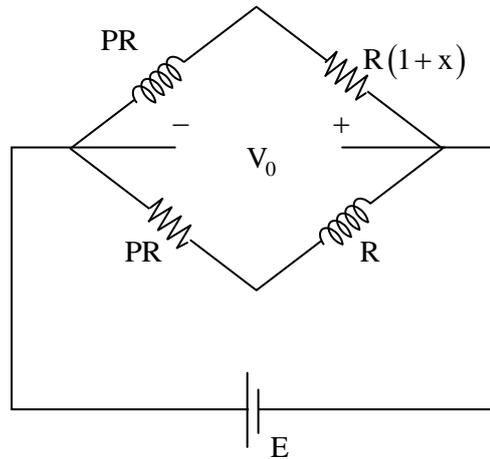
33.
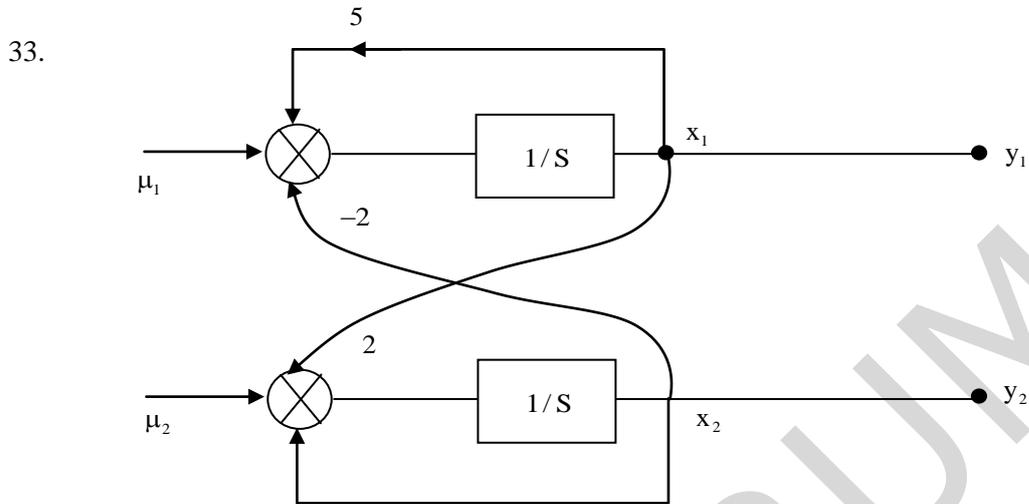
The system is controllable and observable if

(A) μ_1 is input, y_1 is output

(B) μ_2 is input, y_1 is output

(C) μ_1 is input, y_2 is output

(D) μ_2 is input, y_2 is output

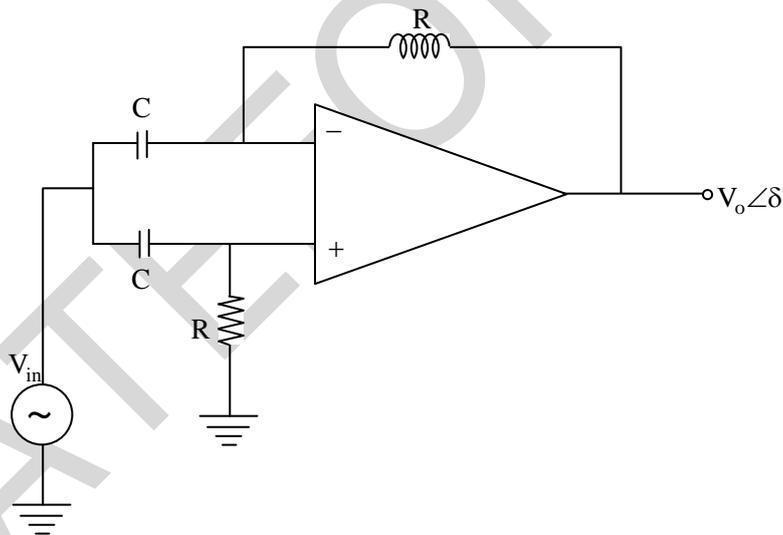34. If the frequency of current is increased, then the impedance of the parallel LC network is
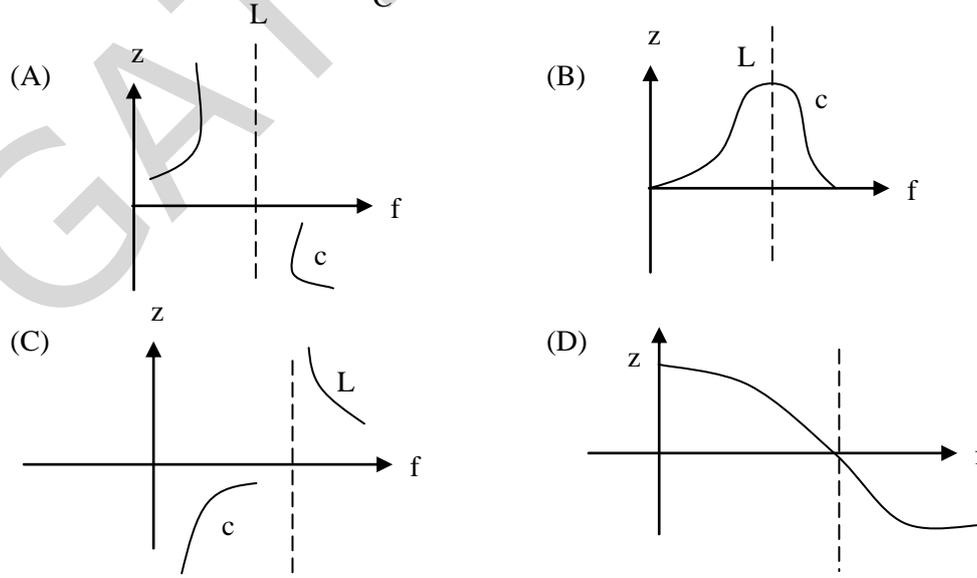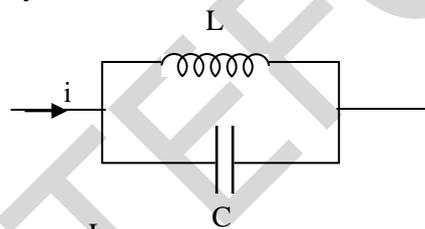
(A)

(B)

(C)

(D)

Key: (A)

35. For the Bridge shown, the value of p is _____ so that V_o is maximum

(A) $\sqrt{1+x}$ (B) $1/\sqrt{1+x}$ (C) $\dfrac{1}{1+x}$ (D) $1+x$

36. In the ideal op-amp, the value of δ is _____.

Key: 0

Exp: $\dfrac{V_t}{V_n} = \dfrac{SCR}{1+SCR} \rightarrow V_t \left(\dfrac{SCR}{1+SCR} \right) V_{in}$

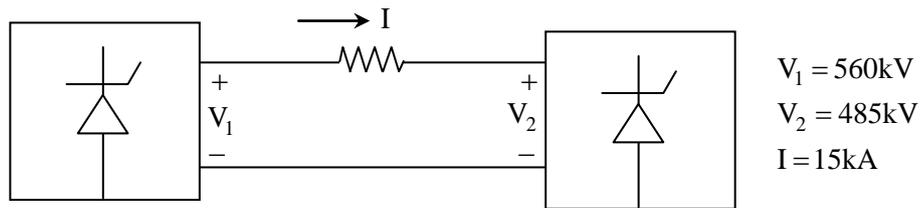$\dfrac{V_{Cn} - V}{\dfrac{1}{SC}} = \dfrac{V - V_o}{R}$

$SCR \left[V_{in} - \dfrac{SCR}{1+SCR} V_{in} \right] = \dfrac{SCR\ V_{in}}{1+SCR} - V_o$

$V_o = 0$

$\delta = 0$

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37. Consider the following HVDC network. With

$V_1 = 560kV$

$V_2 = 485kV$

$I = 15kA$

If power is to be reversed

(A) $V_1 = 500kV, V_2 = 485kV, I = -15kA$

(B) $V_1 = -500kV, V_2 = -485kV, I = -15kA$

(C) $V_1 = 500kV, V_2 = -485kV, I = -15kA$

(D) $V_1 = -500kV, V_2 = -485kV, I = 15kA$

Key: D

Exp: $I = \dfrac{V_1 - V_2}{R}$
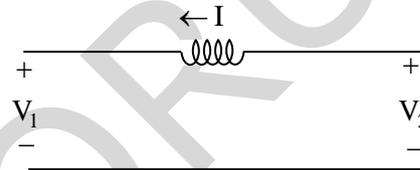
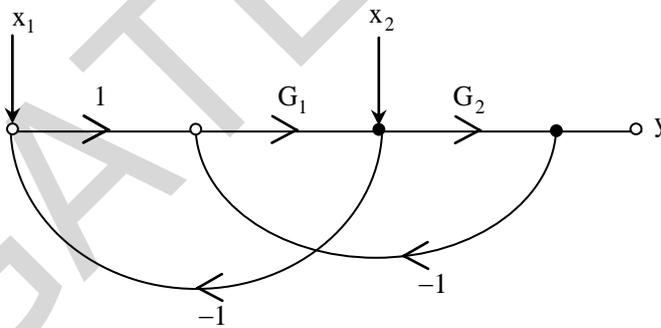For power to be reversed

$I = \dfrac{V_2 - V_1}{R}(+Ve)$

$V_1 = -500kV$

$V_2 = -485kV$

$I = 15kA$

38. If x_1 is zero, then the transfer function $\dfrac{y}{x_2}$ is _____.

(A) $\dfrac{G_2}{1 + G_1(1 + G_2)}$ (B) $\dfrac{G_1}{1 + G_1(1 + G_2)}$ (C) $\dfrac{G_2}{1 + G_1 + G_2}$ (D) $\dfrac{G_1}{1 + G_1} + \dfrac{G_2}{1 + G_2}$

Key: (A)

Exp: $P_1 = G_2$

$\Delta = 1 - \left[-G_1G_2 - G_1\right] = 1 + G_1(1 + G_2)$

$TF = \dfrac{P_1\Delta_1}{\Delta} = \dfrac{G_2}{1 + G_1[1 + G_2]}$

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39. A two port network when 10V applied at input, 4A flows in output port which is shorted. When 5V is applied, 1.25A flows into a resistance of 1Ω when 3V is applied, the current flowing into a 2Ω resistor at port 2 is,

Key: 0.545

Exp:

$I_1 = y_{11}v_1 + y_{12}v_1$ $\qquad I_2 = 0.4 \times 3 - 0.6[2I_2]$

$I_2 = y_{21}v_1 + y_{22}v_2$ $\qquad = 1.2 - 1.2I_2$

$4 = 10y_{21} \rightarrow y_{21} = 0.4$ $\quad I_2 = 0.545A.$

$1.25 = 0.4v_1 + 1.25y_{22}$

$\qquad = 0.4$

$y_{22} = -0.6$