Electrical Engineering

Q. No. 1 – 25 Carry One Mark Each

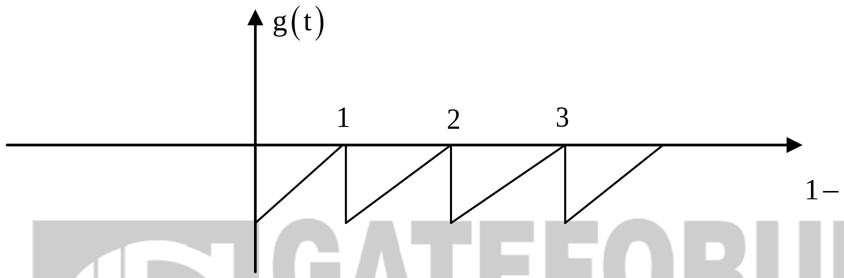
1. Consider $g(t)=\begin{cases} t-\lfloor t \rfloor, & t \ge 0 \\ t-\lceil t \rceil, & \text{otherwise} \end{cases}$, where $t \in \mathbb{R}$

Here, $\lfloor t \rfloor$ represents the largest integer less than or equal to t and $\lceil t \rceil$ denotes the smallest integer greater than or equal to t. The coefficient of the second harmonic component of the Fourier series representing g(t) is _________.

Key: 0 to 0

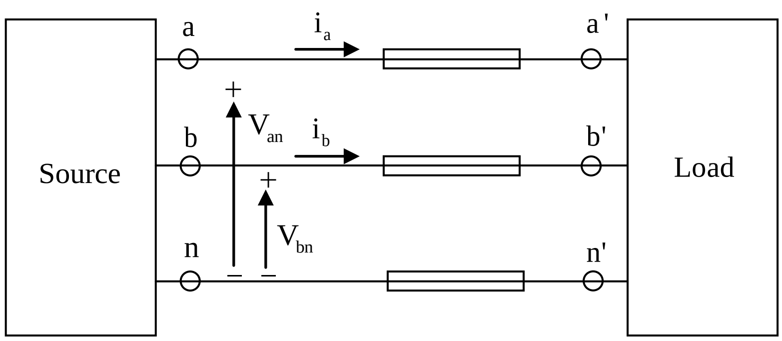
Exp: Given $g(t)=\begin{Bmatrix} t-\lfloor t \rfloor & +\ge 0 \\ t-\lceil t \rceil & \text{otherwise} \end{Bmatrix}$

If we plot the above signal, we get



Since this wave form contain hidden half wave symmetry, even harmonics does not exist. Thus coefficient of second harmonic component of Fourier series will be zero.

2. A source is supplying a load through a 2-phase, 3-wire transmission system as shown in figure below. The instantaneous voltage and current in phase-a are $V_{an}=220\sin(100\pi t)\,V$ and $i_a=10\sin(100\pi t)\,A$, respectively. Similarly for phase-b the instantaneous voltage and current are $V_{bn}=220\cos(100\pi t)\,V$ and $i_b=10\cos(100\pi t)\,A$, respectively.



The total instantaneous power flowing form the source to the load is

(A) 2200 W (B) $2200\sin^2(100\pi t)$ W

(C) 440 W (D) $2200\sin(100\pi t)\cos(100\pi t)$ W

Key: (A)

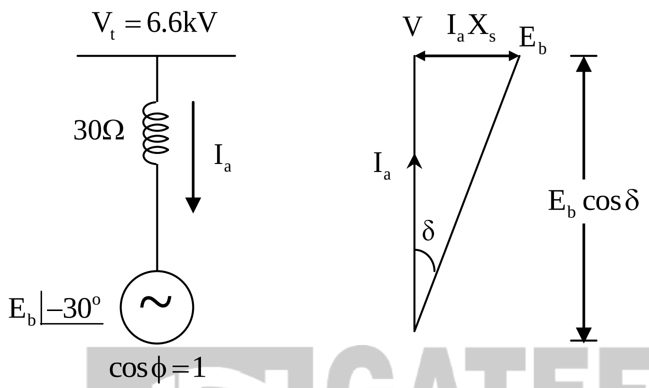
Exp: $P_{instaneous} = V_{an} i_a + V_{bn} i_b$

$$= 220\sin(100\pi t)10\sin(100\pi t)t + 220\cos(100\pi t)10\cos(100\pi t)$$
$$= 2200\sin^2(100\pi t) + 2200\cos^2(100\pi t)$$
$$= 2200W$$

3. A three-phase, 50Hz, star-connected cylindrical-rotor synchronous machine is running as a motor. The machine is operated from a 6.6 kV grid and draws current at unity power factor (UPF). The synchronous reactance of the motor is $30\,\Omega$ per phase. The load angle is 30^o. The power delivered to the motor in kW is _______.

Key: 835 to 842

Exp:



$$E_b \cos\delta = V$$
$$E_b = \frac{V}{\cos\delta} = \frac{6600/\sqrt{3}}{\cos 30^o}$$
$$E_b = 4400 \text{ volts}$$

$$P = 3.\frac{E_b.V}{X_s}\sin\delta = 3.\frac{4400\times 3810.51}{30} = \sin 30^o$$
$$P = 838.31\,kW$$

4. For a complex number z, $\lim\limits_{z\to i}\dfrac{z^2+1}{z^3+2z-i(z^2+2)}$ is

(A) -2i (B) -i (C) i (D) 2i

Key: (D)

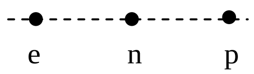
Exp: $\lim\limits_{z\to i}\dfrac{z^2+1}{z^3+2z-i(z^2+2)} = \lim\limits_{z\to i}\dfrac{z+i}{z^2+2} = \dfrac{2i}{-1+2} = 2i$

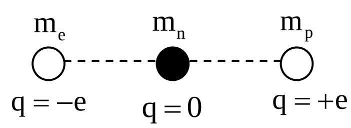
5. Consider an electron, a neutron and a proton initially at rest and placed along a straight line such that the neutron is exactly at the center of the line joining the electron and proton. At t=0, the particles are released but are constrained to move along the same straight line. Which of these will collide first?

(A) The particles will never collide
(B) All will collide together
(C) Proton and Neutron
(D) Electron and Neutron

Key: (D)

Exp:





The Gravitational force of alteration between any two particles shown above is made much negligible when compared to coloumbic force of alteration between electron and proton.

Force of alteration

$$F = \frac{-e^2}{4\pi \in_o r^2}, \text{ accelleration } q = \frac{F}{M}; q_e >> q_p$$

Due to this force, the electron as well as the proton will move towards each other, since $m_e << m_p$, the speed and acceleration of the electron will be much greater than that of proton. This causes electron to collide with the neutron faster when compared to proton.

6. Let $z(t) = x(t) * y(t)$, where "$*$" denotes convolution. Let C be a positive real-valued constant. Choose the correct expression for z (ct).

(A) $c.x(ct) * y(ct)$ (B) $x(ct) * y(ct)$ (C) $c.x(t) * y(ct)$ (D) $c.x(ct) * y(t)$

Key: (A)

Exp: $z(t) = x(t) * y(t)$

$\Rightarrow z(s) = x(s).y(s)$

Converting into Laplace transform and applying time sealing property.

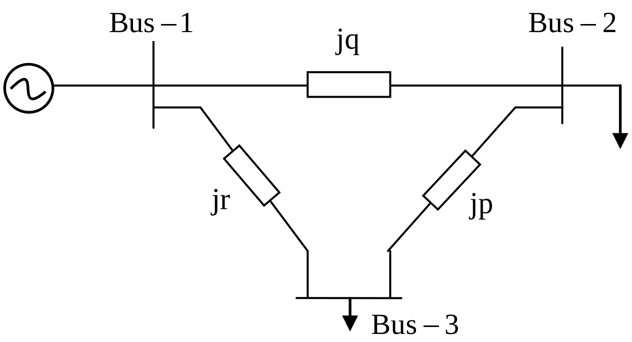
$$z(ct) \leftrightarrow \frac{1}{c} z(s/c)$$

$$= \frac{1}{c} \times (s/c) y(s/c)$$

$$= c\frac{1}{c} \times (s/c) \frac{1}{c} y(s/c)$$

$$z(ct) = c.x(ct) * y(ct)$$

7. A 3-bus power system is shown in the figure below, where the diagonal elements of Y-bus matrix are $Y_{11} = -j12pu$, $Y_{22} = -j15pu$ and $Y_{33} = -j7pu$



The per unit values of the line reactances p, q and r shown in the figure are

(A) $p = -0.2, q = -0.1, r = -0.5$ (B) $p = 0.2, q = 0.1, r = 0.5$

(C) $p = -5, q = -10, r = -2$ (D) $p = 5, q = 10, r = 2$

Key: (B)

Exp: $Y_{11} = y_{10} + y_{12} + y_{13} = -j12 = -(jq^1 + jr^1)$

$\therefore q^1 + r^1 = +12$

$Y_{22} = -j15 = y_{20} + y_{21} + y_{23} = -\left(jq^1 + jp^1\right)$

$\therefore p^1 + q^1 = +15$

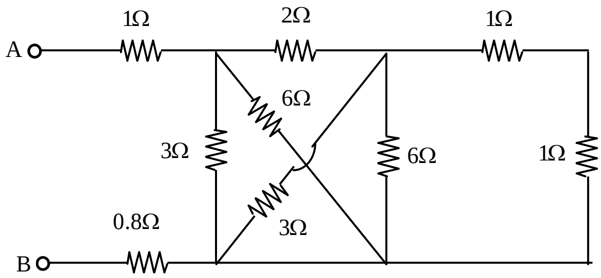
$Y_{33} = -j7 = y_{30} + y_{31} + y_{32} = -\left(jp^1 + jr^1\right)$

$\therefore p^1 + r^1 = +7$

solving $P^1 = +5, q^1 = +10, r^1 = +2$ (admit tan ces)

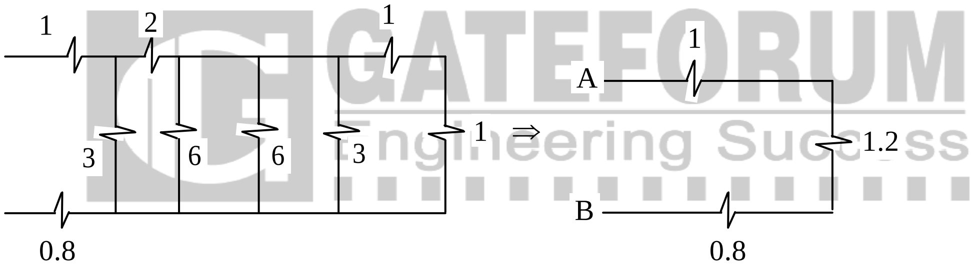
$P = +0.2, q = +0.1, r = +0.5$ (reac tan ces)

8. The equivalent resistance between the terminals A and B is ______ Ω .



Key: 2.9 to 3.1

Exp: The Ckt will become



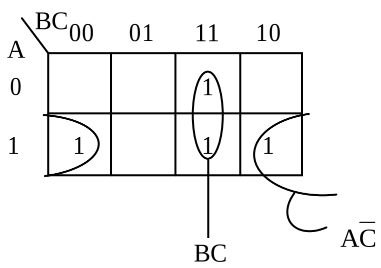
$R_{AB} = 1 + 1.2 + 0.8 = 3\Omega$

9. The Boolean expression $AB + A\bar{C} + BC$ simplifies to

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

Key: (A)

Exp: $AB + A\overline{C} + BC$



$\Rightarrow BC + A\bar{C}$

10. The following measurements are obtained on a single phase load:
$V = 220V \pm 1\%$, $I = 5.0A \pm 1\%$ and $W = 555W \pm 2\%$. If the power factor is calculated using these measurements, the worst case error in the calculated power factor in percent is ________.

Key: **4 to 4**

Exp: $P = VI\cos\phi$

$$\cos\phi = \frac{P}{V.I} = \frac{555 \pm 2\%}{(220 \pm 1\%)(5 \pm 1\%)} = \frac{555 \pm 2\%}{1100 \pm 2\%} = 0.504 \pm 4\%$$

11. The transfer function of a system is given by, $\frac{V_o(s)}{V_i(s)} = \frac{1-s}{1+s}$ Let the output of the system be $v_o(t) = V_m \sin(\omega t + \varphi)$ for the input $v_i(t) = V_m \sin(\omega t)$. Then the minimum and maximum values of φ (in radians) are respectively

(A) $\frac{-\pi}{2}$ and $\frac{\pi}{2}$ (B) $\frac{-\pi}{2}$ and 0 (C) 0 and $\frac{\pi}{2}$ (D) $-\pi$ and 0

Key: **(D)**

Exp: $\frac{V_o(s)}{V_i(s)} = \frac{1-s}{1+s} = H(s)$

$H(\omega) = 1 < -2\text{Tan}^{-1}\omega$, If $\omega = 0, \phi = 0$

If $\omega = \infty, \phi = -\pi$

$V_o(t) = V_m \sin\left(\omega t - 2\text{Tan}^{-1}(\omega)\right)$

12. The matrix $A = \begin{bmatrix} \frac{3}{2} & 0 & \frac{1}{2} \\ 0 & -1 & 0 \\ \frac{1}{2} & 0 & \frac{3}{2} \end{bmatrix}$ has three distinct eigenvalues and one of its eigenvectors is $\begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}$

Which one of the following can be another eigenvector of A?

(A) $\begin{bmatrix} 0 \\ 0 \\ -1 \end{bmatrix}$ (B) $\begin{bmatrix} -1 \\ 0 \\ 0 \end{bmatrix}$ (C) $\begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix}$ (D) $\begin{bmatrix} 1 \\ -1 \\ 1 \end{bmatrix}$

Key: **(C)**

Exp: By the properties of Eigen values and Eigen vectors, another eigen vector of A is $\begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix}$

The eigen vectors corresponding to distinct eigen values of a real symmetric matrix are orthogonal i.e., pair wise dot product is zero.

13. For the power semiconductor devices IGBT, MOSFET, Diode and Thyristor, which one of the following statements is TRUE?

(A) All of the four are majority carrier devices.

(B) All the four are minority carrier devices

(C) IGBT and MOSFET are majority carrier devices, whereas Diode and Thyristor are minority carrier devices.

(D) MOSFET is majority carrier device, whereas IGBT, Diode, Thyristor are minority carrier devices.

Key: (D)

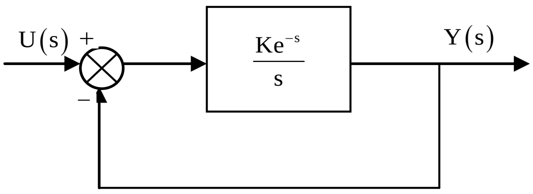
Exp: MOSFET → Majority carrier device (NMOS, PMOS)

Diode → both majority & minority carrier device

Transister → Npn, pnp

IGBT → input is MOSFET, Output is BJT

14. Consider the unity feedback control system shown. The value of K that results in a phase margin of the system to be 30^{o} is ________.



Key: 1.01 to 1.06

Exp: $PM = 180 + \angle G_{\omega=\omega gc}$

$$G(s) = \frac{Ke^{-s}}{s}$$

$$\text{For } \omega gc \Rightarrow |G(s)| \Rightarrow \frac{K}{\omega} = 1$$

$$\omega gc = K \Rightarrow \angle G(s) = -\omega \times \frac{180}{\pi} - 90^{o}$$

$$30^{o} = 180^{o} - K \times \frac{180^{o}}{\pi} - 90^{o}$$

$$K\frac{180^{o}}{\pi} = 60 \Rightarrow K = \frac{\pi}{3} = 1.047$$

15. A solid iron cylinder is placed in a region containing a uniform magnetic field such that the cylinder axis is parallel to the magnetic field direction. The magnetic field lines inside the cylinder will

(A) bend closer to the cylinder axis

(B) bend farther away from the axis

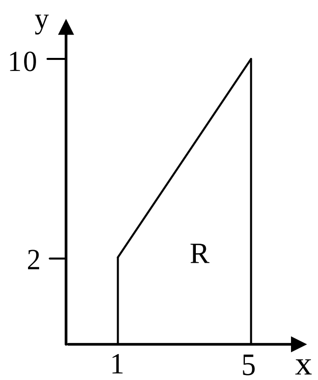
(C) remain uniform as before

(D) cease to exist inside the cylinder

Key: (A)

Exp: Flux always chooses less reluctance path. So flux tried to flow inside the conductor and closer to the axis of the cylinder.

16. Let $I = c\int\int_R xy^2 dxdy$, where R is the region shown in the figure and $c = 6\times10^{-4}$. The value of I equals________.



Key: 0.99 to 1.01

Exp: $\iint_R xy^2dxdy = \int\int_{R_1} xy^2dxdy + \int\int_{R_2} xy^2dxdy$

$$= \int_{x=1}^{5}\int_{y=0}^{2} xy^2dxdy + \int_{x=1}^{5}\int_{y=2}^{2x} xy^2dx = \left(\frac{x^2}{2}\right)_1^5\left(\frac{y^3}{3}\right)_0^2 + \int_1^5 x\left(\frac{y^3}{3}\right)_2^{2x} dx$$

$$= (12)\left(\frac{8}{3}\right) + \frac{1}{3}\int_1^5 x\left(8x^3 - 8\right)dx = 32 + \frac{1}{3}\left[8\left(\frac{x^5}{5}\right)_1^5 - 8\left(\frac{x^2}{2}\right)_1^5\right]$$

$$= 32 + \frac{1}{3}\left(\frac{24992}{5}\right) - 32 = \frac{24992}{15}$$

$$\therefore C\int\int_R xy^2dxdy = \frac{2}{5}(24992)\times10^{-4} = 0.99968 \approx 1$$

OR

$$\iint_R xy^2dxdy = \int_{x=1}^{5}\left(\int_{y=0}^{2x} xy^2dy\right)dx$$

$$= \int_1^5 x\left(\frac{y^3}{3}\right)^{2x} dx = \frac{8}{3}\int_1^5 x\left(x^3\right)dx$$

$$= \frac{8}{3}\left(\frac{x5}{5}\right)_1^5 = \frac{8}{15}(3124) = \frac{24992}{15}$$

$$\therefore C\iint_R xy^2dxdy = \frac{24992}{15}\times10^{-4}\times6 = \frac{2}{5}\times2.4992 = 0.9968 \approx 1$$

17. Consider the system with following input-output relation $y[n] = \left(1+(-1)^n\right)x[n]$

where, x[n] is the input and y[n] is the output. The system is

(A) invertible and time invariant

(B) invertible and time varying

(C) non-invertible and time invariant

(D) non-invertible and time varying

Key: (D)

Exp: Given $y[n] = \left(1+(-1)^n\right)x[n]$

For time invariance

$y'[n] = \left(1+(-1)^n\right)x\left(n-n_o\right) \to (1)$

$y\left(n-n_o\right) = \left(1+(-1)^{n-n_o}\right)x\left(n-n_o\right) \to (2)$

Since (1) is not equal to (2)

System is time variant

For inverse system

For each unique $x[n]$, there should be unique $y[n]$

If $x[n] = \delta[n-1]$

$y[n] = \left[1+(-1)^n\right]\delta[n-1]$

$$\Rightarrow y[1]=0$$
$$\text{if } x[n]=2\delta[n-1]$$
$$y[n]=\left[1+(-1)^n\right]2\delta(n-1)$$
$$y(1)=0$$

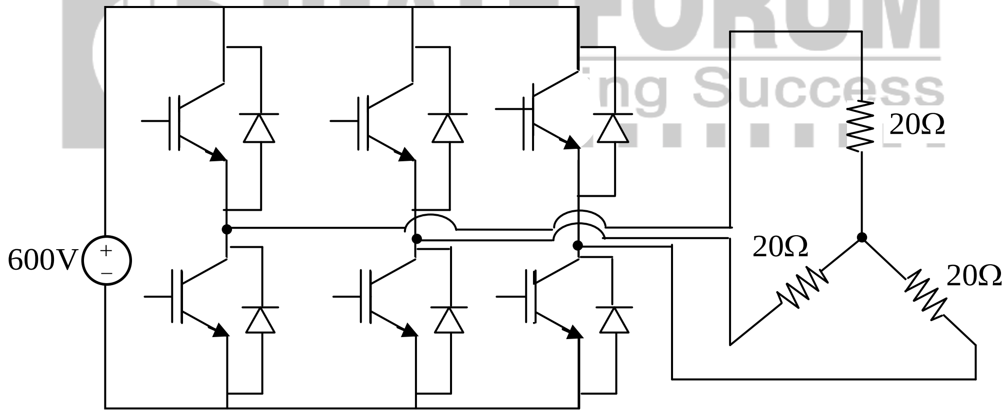
For two different inputs we have same output. Thus one to one mapping is not possible. Hence the systems is non invertible

18. The slope and level detector circuit in a CRO has a delay of 100 ns. The start-stop sweep generator has a response time of 50 ns. In order to display correctly, a delay line of
(A) 150 ns has to be inserted into the y-channel
(B) 150 ns has to be inserted into the x-channel
(C) 150 ns has to be inserted into both x and y channels
(D) 100 ns has to be inserted into both x and y channels

Key: (A)

Exp: The delay line should be inverted in VDP (Y-channel) only.

19. A 3-phase voltage source inverter is supplied from a 600V DC source as shown in the figure below. For a star connected resistive load of $20\,\Omega$ per phase, the load power for 120^o device conduction, in kW is ________.



Key: 8.5 to 9.5

Exp: $V_{dc}=600V$

$R_L=20\Omega/Ph \quad 120^o \text{ mode}$

RMS value of phase voltage $(V_P)=0.4082V_{dc}=244.92V$

$$\text{Load power }=\frac{3Vph^2}{R}=\frac{3\times 244.92^2}{20}=8.99kW\approx 9kW$$

20. A closed loop system has the characteristic equation given by $s^3+Ks^2+(K+2)s+3=0$. For this system to be stable, which one of the following conditions should be satisfied?
(A) $0<K<0.5$ (B) $0.5<K<1$ (C) $0<K<1$ (D) $K>1$

Key: (D)

Exp: Given $CE=s^3+ks^2+(k+2)s+3=0$

For stable

$k(k+2)>3$

$k^2+2k-3>0$

$(k-1)(k+3)>0$

$k>-1 \cap k>-3$

$k>1$

(OR)

By R-H criteria

s^3	1	$k+2$
s^2	k	3
s	$\frac{k(k+2)-3}{k}$	0
s^0	3	

$k>0 \cap (k+3)(k-1)>0$

$K>0 \cap k>1 \cap k>-3 \Rightarrow k>1$

21. A 4 pole induction machine is working as an induction generator. The generator supply frequency is 60 Hz. The rotor current frequency is 5 Hz. The mechanical speed of the rotor in RPM is

(A) 1350 (B) 1650 (C) 1950 (D) 2250

Key: (C)

Exp: $N_s = \frac{120 \times 60}{4} = 1800\text{ rpm}$

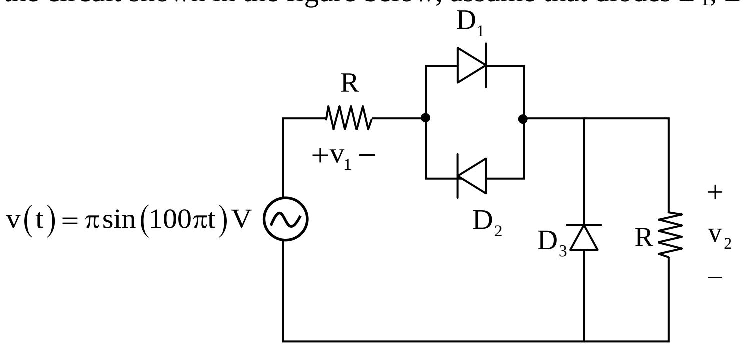
Rotor speed should be greater than syn.speeed, to ge inductance generator mode.

$$S = \frac{N_r - N_S}{N_S}$$

$$\Rightarrow N_r = N_S(1+S) \qquad \left[f_r = sf \Rightarrow s = \frac{f_r}{f} = \frac{5}{60} = \frac{1}{12}\right]$$

$$N_r = 1800\left(1+\frac{1}{12}\right) = 1950\text{ rpm}$$

22. For the circuit shown in the figure below, assume that diodes D_1, D_2 and D_3 are ideal.



The DC components of voltages v_1 and v_2, respectively are

(A) 0 V and 1 V (B) -0.5 V and 0.5 V (C) 1 V and 0.5 V (D) 1 V and 1 V

Key: (B)

Exp: For half wave Rectifier $Vdc = \frac{V_m}{\pi}$

$$V_1 = V_{dc}\text{for} + \text{ve pulse} + V_{dc}\text{for} - \text{ve pulse} = \frac{\pi}{2\pi} + \left(\frac{-\pi}{\pi}\right) = \frac{1}{2} - 1 = -0.5V$$

$$V_2 = \frac{\pi}{2\pi} + 0 = 0.5V$$

23. A 10-bus power system consists of four generator buses indexed as G1, G2, G3, G4 and six load buses indexed as L1, L2, L3, L4, L5, L6. The generator bus G1 is considered as slack bus, and the load buses L3 and L4 are voltage controlled buses. The generator at bus G2 cannot supply the required reactive power demand, and hence it is operating at its maximum reactive power limit. The number of non-linear equations required for solving the load flow problem using Newton-Raphson method in polar form is _______.

Key: 14 to 14

Exp: Total no of buses=10

Given G_1=slack bus, G_2=generator/PQ bus

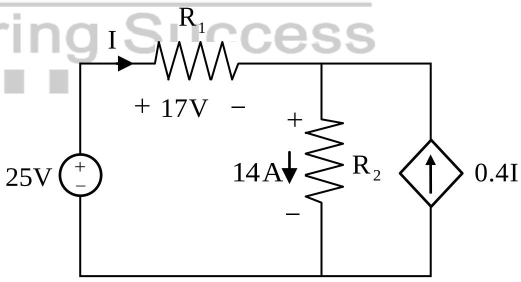
$\therefore G_3, G_4$ are PV buses

PQ buses $\rightarrow L_1, L_2, L_5, L_6$ (4)

Voltage controlled PV buses $\rightarrow L_3, L_4$ (2)

Minimum no of nonlinear equations to be solved $= 2\times10 - 2 - 4 = 14$

24. The power supplied by the 25 V source in the figure shown below is ________W.



Key: 248 to 252

Exp: KCL

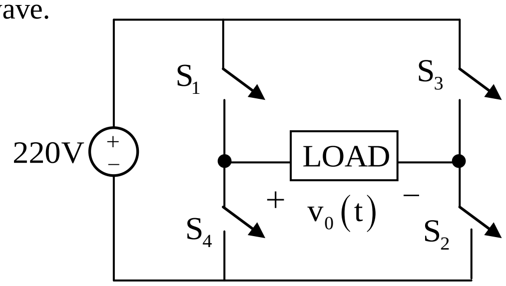
$I + 0.4I = 14$

$\Rightarrow 1.4I = 14$

$\Rightarrow I = 10A$

The power supplied by 25 V = $25\times10 = 250W$

25. In the converter circuit shown below, the switches are controlled such that the load voltage $v_o(t)$ is a 400 Hz square wave.



The RMS value of the fundamental component of $v_o(t)$ in volts is _______.

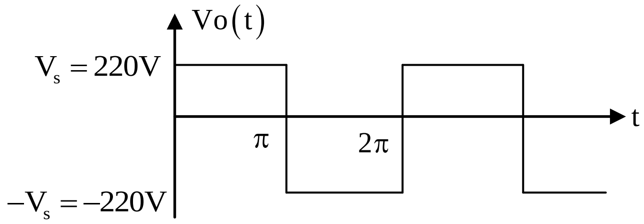
Key : 196 to 200

Exp: $Vo(t)=\dfrac{4V_s}{\pi}\left[\sin\omega t+\dfrac{1}{3}\sin 3\omega t+\dfrac{1}{5}\sin 5\omega t+\right]=\sum\limits_{n=1,3,5}^{\infty}\dfrac{4V_S}{n\pi}\sin(n\omega t)$

$V_{on}=\dfrac{4}{\sqrt{2}}\dfrac{V_S}{n\pi}$

$V_{ol}=\dfrac{4}{\sqrt{2}}\times\dfrac{V_S}{\pi}=0.9V_S$

$=0.9\times 220=198.069V$



Q. No. 26 – 55 Carry Two Marks Each

26. The output expression for the Karnaugh map shown below is

AB \ CD	00	01	11	10
00	0	0	0	0
01	1	0	0	1
11	1	0	1	1
10	0	0	0	0

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

Key: (D)

Exp:

AB \ CD	00	01	11	10
00	0	0	0	0
01	1	0	0	1
11	1	0	1	1
10	0	0	0	0

$B\bar{D}$

ABC

27. A 220 V DC series motor runs drawing a current of 30 A from the supply. Armature and field circuit resistances are $0.4\,\Omega$ and $0.1\,\Omega$ respectively. The load torque varies as the square of the speed. The flux in the motor may be taken as being proportional to the armature current. To reduce the speed of the motor by 50% the resistance in ohms that should be added in series with the armature is __________.

Key: 9.5 to 12

Exp: $E_{b_1}=220-30(0.5)=205$ volts

$E_{b_2}=220-I_{a_2}(0.5+R_X)$

Given $T\propto N^2$ and $\phi\propto I_R$

We know that, in series motor $\Rightarrow T\propto I_a^2$

$T \propto I_a^2 \propto N^2$

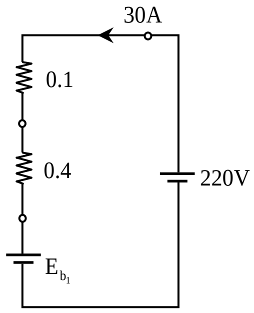
$$\frac{N_2}{N_1} = \frac{I_{a_2}}{I_{a_1}} \Rightarrow I_{a_2} = 0.5\, I_{a_1} = 15 \text{ Amp}$$

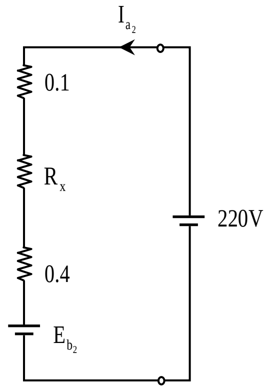
$$N \propto \frac{E_b}{\phi}$$

$$\frac{N_2}{N_1} = \frac{E_{b_2}}{E_{b_1}} = \frac{\phi_1}{\phi_2}$$

$$\frac{0.5N_1}{N_1} = \frac{220 - 15(0.5 + R_x)}{205} \times \frac{30}{15}$$

$$\Rightarrow R_x = 10.75\,\Omega$$





28. The transfer function of the system Y(s)/U(s) whose state-space equations are given below is:

$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 1 & 2 \\ 2 & 0 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u(t)$$

$$y(t) = [10] \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix}$$

(A) $\frac{(s+2)}{(s^2 - 2s - 2)}$ (B) $\frac{(s-2)}{(s^2 + s - 4)}$ (C) $\frac{(s-4)}{(s^2 + s - 4)}$ (D) $\frac{(s+4)}{(s^2 - s - 4)}$

Key: (D)

Exp: Given

$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 1 & 2 \\ 2 & 0 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u(t)$$

$$x(t) = Ax + Bu$$

Transfer function $= C[SI - A]^{-1} B + D$

Here D = 0

$C = [1 \quad 0]$

$$A = \begin{bmatrix} 1 & 2 \\ 2 & 0 \end{bmatrix} B = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$$

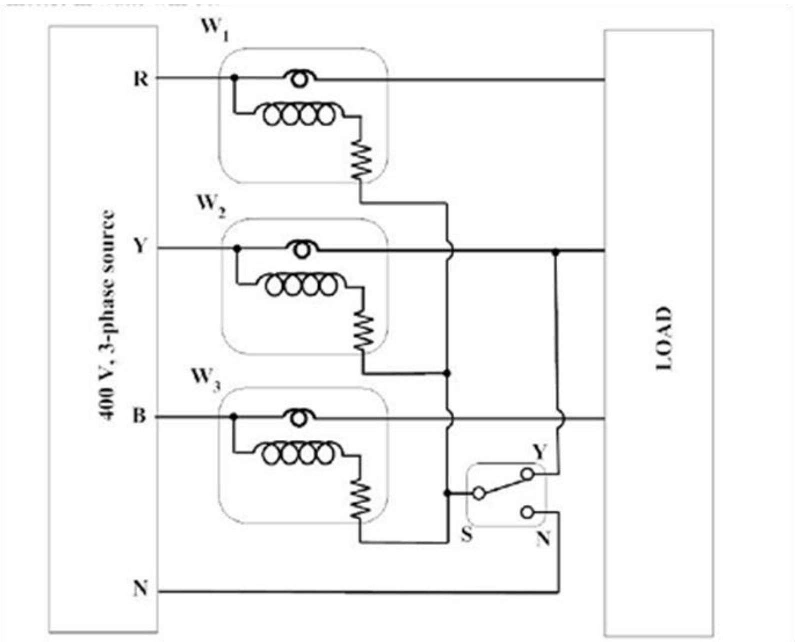
$$T/F = [1 \quad 0] \begin{bmatrix} s-1 & -2 \\ -2 & s \end{bmatrix}^{-1} \begin{bmatrix} 1 \\ 2 \end{bmatrix}$$

$$= [1 \quad 0] \frac{\begin{bmatrix} s & 2 \\ 2 & s-1 \end{bmatrix} \begin{bmatrix} 1 \\ 2 \end{bmatrix}}{s^2 - s - 4}$$

$$= [1 \quad 0] \frac{\begin{bmatrix} s+4 \\ 2+2s-2 \end{bmatrix}}{s^2 - s - 4}$$

$$\Rightarrow T/F = \frac{s+4}{s^2 - s - 4}$$

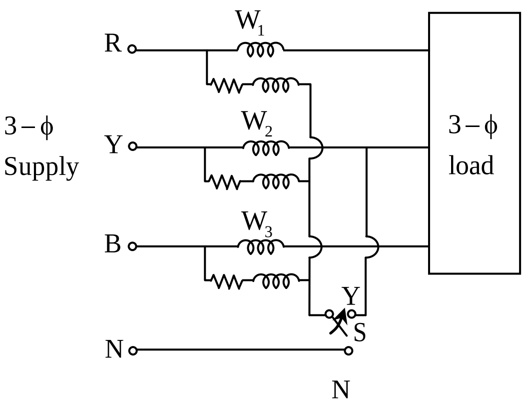
29. The load shown in the figure is supplied by a 400 V (line to line) 3-phase source (RYB sequence). The load is balanced and inductive, drawing 3464 VA. When the switch S is in position N, the three watt-meters W_1, W_2 and W_3 read 577.35 W each. If the switch is moved to position Y, the readings of the watt-meters in watts will be:



(A) $W_1 = 1732 \text{ and } W_2 = W_3 = 0$
(B) $W_1 = 0, W_2 = 1732 \text{ and } W_3 = 0$
(C) $W_1 = 866, W_2 = 0, W_3 = 866$
(D) $W_1 = W_2 = 0 \text{ and } W_3 = 1732$

Key: (D)

Exp:



If the switch is connected to Neutral, then each wattmeter will read $1-\phi$ power.

$W_1 + W_2 + W_3 = 3.V_{ph}.I_{ph} \cos\phi = 1732.05$

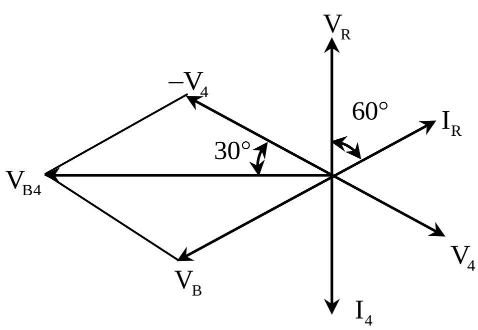
$\Rightarrow \cos\phi = 0.51\text{agg.} \Rightarrow \phi = 60°$

Given that, load drawing Apparent power of 3464 VA.

$\sqrt{3}V_L I_L = 3464$

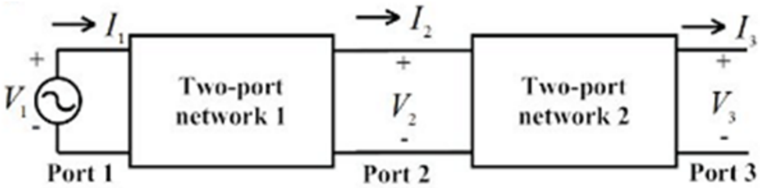
$I_L = \frac{3464}{\sqrt{3} \times 400} = 5A$

If the switch connected to "Y", then $W_2=0$



$$W_1 = V_{pc}\ I_{cc}\ \cos\left(V_{pc}\ \&\ I_{cc}\right) = V_{Ry}\ I_R\ \cos\left(V_{Ry}\ \&\ I_R\right)$$
$$= 400\times 5\cos\left(90°\right) = 0W$$
$$W_3 = V_{By} I_B\ \cos\left(V_{By}\ \&\ I_B\right) = 400\times 5\times\cos 30° = 1732\text{watts}$$

30. Two passive two-port networks are connected in cascade as shown in figure. A voltage source is connected at port 1.



Given $V_1 = A_1V_2 + B_1I_2$
$I_1 = C_1V_2 + D_1I_2$
$V_2 = A_2V_3 + B_2I_3$
$I_2 = C_2V_3 + D_2I_3$

$A_1, B_1, C_1, D_1, A_2, B_2, C_2$ and D_2 are the generalized circuit constants. If the Thevenin equivalent circuit at port 3 consists of a voltage source V_T and impedance Z_T connected in series, then

(A) $V_T = \dfrac{V_1}{A_1A_2}, Z_T = \dfrac{A_1B_2 + B_1D_2}{A_1A_2 + B_1C_2}$ (B) $V_T = \dfrac{V_1}{A_1A_2 + B_1C_2}, Z_T = \dfrac{A_1B_2 + B_1D_2}{A_1A_2}$

(C) $V_T = \dfrac{V_1}{A_1 + A_2}, Z_T = \dfrac{A_1B_2 + B_1D_2}{A_1 + A_2}$ (D) $V_T = \dfrac{V_1}{A_1A_2 + B_1C_2}, Z_T = \dfrac{A_1B_2 + B_1D_2}{A_1A_2 + B_1C_2}$

Key: (D)

Exp: We can write V_1, I_1 in terms of $V_3 + I_3$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix}\begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix}\begin{bmatrix} V_3 \\ I_3 \end{bmatrix}$$
$$\Rightarrow V_1 = \left(A_1A_2 + B_1C_2\right)V_3 + \left(A_1B_2 + B_1D_2\right)I_3$$
$$I_1 = \left(C_1A_2 + D_1C_2\right)V_3 + \left(C_1B_2 + D_1D_2\right)I_3$$

To find V_{th} (or) V_{oc} $I_3 = 0$

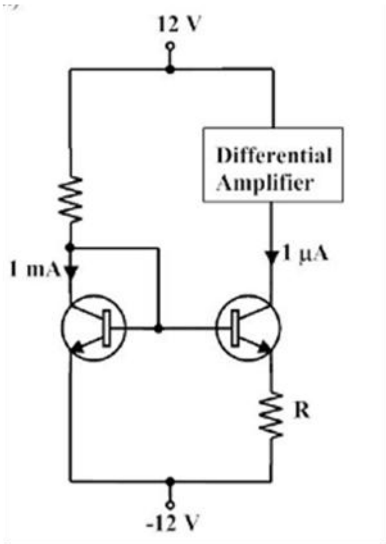
$$V_1 = \left(A_1A_2 + B_1C_2\right)V_{th}$$
$$\Rightarrow V_{th} = V_{oc} = \frac{V_1}{A_1A_2 + B_1C_2}$$

To find I_{SC} $V_3 = 0$

$$V_1 = \left(A_1B_2 + B_1D_2\right)I_{SC} \Rightarrow I_{SC} = \frac{V_1}{A_1B_2 + B_1D_2}$$

To find R_{th} $R_{th} = \dfrac{V_{OC}}{I_{SC}} = \dfrac{A_1B_2 + B_1D_2}{A_1A_2 + B_1C_2}$

31. The circuit shown in the figure uses matched transistors with a thermal voltage $V_T = 25mV$. The base currents of the transistors are negligible. The value of the resistance R in $k\Omega$ that is required to provide $1\,\mu A$ bias current for the differential amplifier block shown is ______.



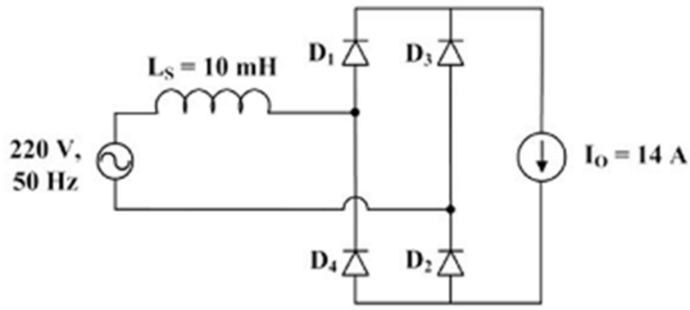
Key: 170 to 174

Exp: $R = \frac{V_T}{I_{C2}} \ln\left(\frac{I_{C1}}{I_{C2}}\right);$

$I_{C1} = 1mA; I_{C2} = 1\mu A$

$R = \frac{25\times10^{-3}}{1\times10^{-6}} \ln\left[\frac{1\times10^{-3}}{1\times10^{-6}}\right] = 172.7k\Omega$

32. The figure below shows an uncontrolled diode bridge rectifier supplied form a 220 V, 50 Hz 1-phase ac source. The load draws a constant current $I_o = 14A$. The conduction angle of the diode D_1 in degrees is___________.



Key: 220 to 230

Exp: Average reduction in output voltage due to L_s

$\Delta V_o = 4f_sL_sI_o = 4\times50\times\left(10\times10^{-3}\right)\times14 = 28V$

$\Delta V_o = \frac{V_m}{\pi}\left[\cos\alpha - \cos\left(\alpha+\mu\right)\right]$

for a diode, $\alpha = 0$

$\therefore \Delta V_o = \frac{V_m}{\pi}\left[1-\cos\mu\right]$

$28 = \frac{220\sqrt{2}}{\pi}\left[1-\cos\mu\right] \Rightarrow \mu = 44.17^o$

$\therefore$ conduction angle of diode $= 180+\mu = 224.17^o$

33. Consider the differential equation $\left(t^2-81\right)\frac{dy}{dt}+5ty=\sin(t)$ with $y(1)=2\pi$. There exists a unique solution for this differential equation when t belongs to the interval

(A) (-2,2) (B) (-10,10) (C) (-10,2) (D) (0,10)

Key: (A)

Exp: D.E is $\frac{dy}{dt}+\frac{5t}{t^2-81}y=\frac{\sin(t)}{t^2-81}$ is a first order linear eq.

$$\text{I.F} = e^{\int\frac{5t}{t^2-81}dt}=e^{\frac{5}{2}\ln\left(t^2-81\right)}=\left(t^2-81\right)^{5/2}$$

$$\therefore \text{ Solution is } y\left(t^2-81\right)^{5/2}=\int\frac{\sin t}{t^2-81}\left(t^2-81\right)^{5/2}=\int\left(t^2-81\right)^{3/2}\sin t\,dt+c$$

$$\Rightarrow y=\frac{\int\left(t^2-81\right)^{3/2}.\sin t\,dt}{\left(t^2-81\right)^{5/2}}+\frac{C}{\left(t^2-81\right)^{5/2}}$$

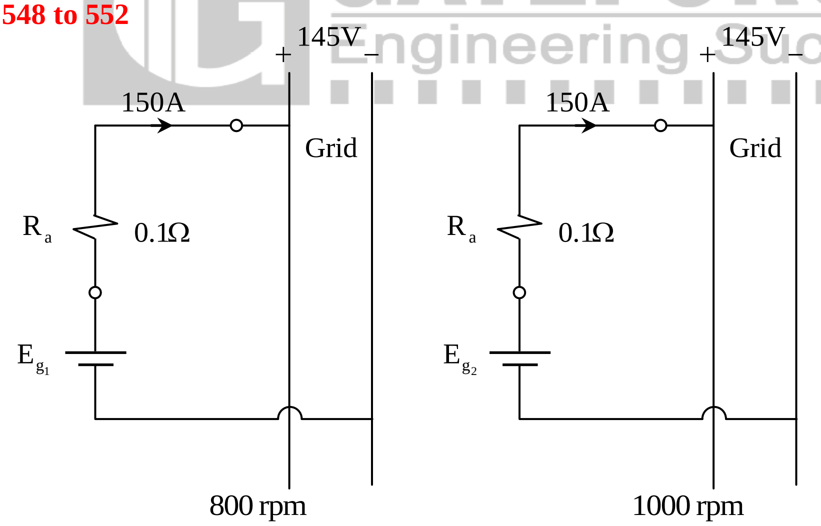
If $t\neq-9,9$ then the solution exists.

Options (b), (c), (d) contain either -9 or 9 or both. So answer is option A

34. A separately excited DC generator supplies 150 A to a 145 V DC grid. The generator is running at 800 RPM. The armature resistance of the generator is 0.1 Ω . If the speed of the generator is increased to 1000 RPM, the current in amperes supplied by the generator to the DC grid is ________.

Key: 548 to 552

Exp:



$E_{g_1}-150\times0.1=145$

$E_{g_1}=160V$

$N\propto E_g\ \left(\because \phi=\text{constant}\right)$

$\frac{N_2}{N_1}=\frac{E_{g_2}}{E_{g_1}}$

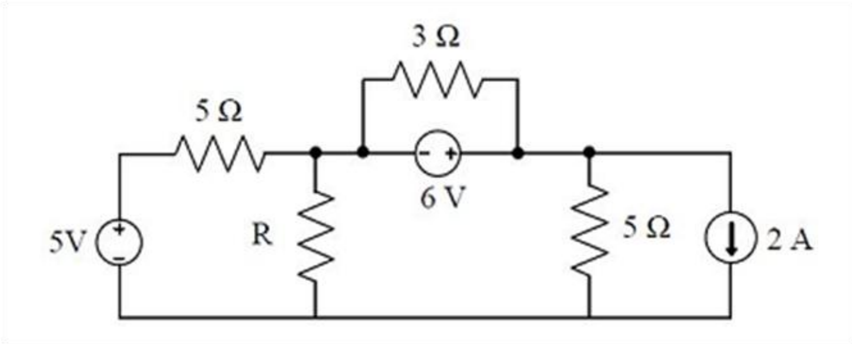
$E_{g_2}=\frac{1000}{800}\times160=200\text{ volts}$

$E_{g_2}-I_{a_2}\times0.1=145$

$200-145=I_{a_2}\times0.1\Rightarrow\frac{55}{0.1}=I_{a_2}$

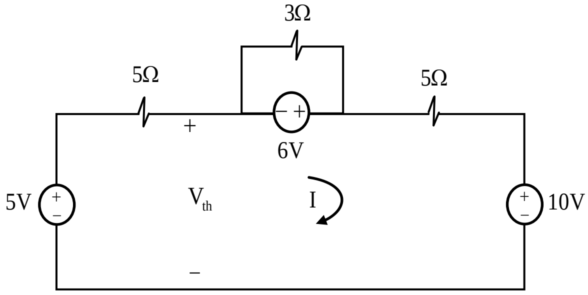
$I_{a_2}=550\text{ amps}$

35. In the circuit shown below, the maximum power transferred to the resistor R is _______ W.



Key: 3 to 3.1

Exp: To find V_{th}

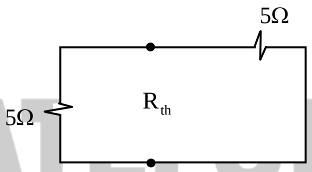


$$I = \frac{5+6+10}{10} = \frac{21}{10} = 2.1A$$

$$V_{th} = 5 - 5 \times 2.1 = -5.5V$$

To find R_{th}

$$\Rightarrow R_{th} = \frac{5 \times 5}{5+5} = 2.5\Omega$$



The maximum power transferred to

$$R = \frac{V_{th}^2}{4R_{th}} = \frac{5.5^2}{4 \times 2.5} = 3.025W$$

36. Let a causal LTI system be characterized by the following differential equation, with initial rest condition

$$\frac{d^2y}{dt^2} + 7\frac{dy}{dt} + 10y(t) = 4x(t) + 5\frac{dx(t)}{dt}$$

Where x(t) and y(t) are the input and output respectively. The impulse response of the system is (u(t) is the unit step function)

(A) $2e^{-2t}u(t) - 7e^{-5t}u(t)$ (B) $-2e^{-2t}u(t) + 7e^{-5t}u(t)$

(C) $7e^{-2t}u(t) - 2e^{-5t}u(t)$ (D) $-7e^{-2t}u(t) + 2e^{-5t}u(t)$

Key: (B)

Exp: Given causal LTI system

$$\frac{d^2y(t)}{dt^2} + \frac{7dy(t)}{dt} + 10y(t) = ux(t) + \frac{5dx(t)}{dt}$$

$$\Rightarrow s^2y(s) + 7sy(s) + 10y(s) = u\,x(s) + 5sx(s)$$

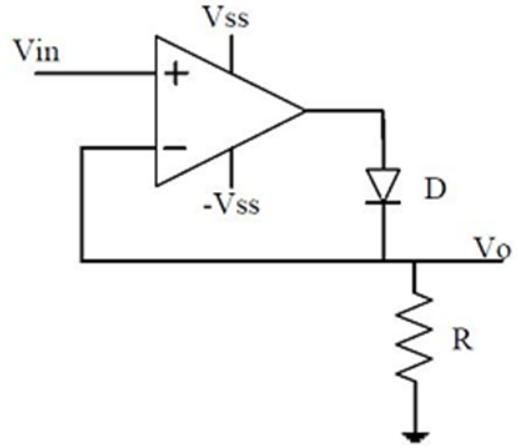
$$\Rightarrow \frac{Y(s)}{X(s)} = \frac{4+5s}{s^2+7s+10} \Rightarrow H(s) = \frac{5s+4}{(s+2)(s+5)}$$

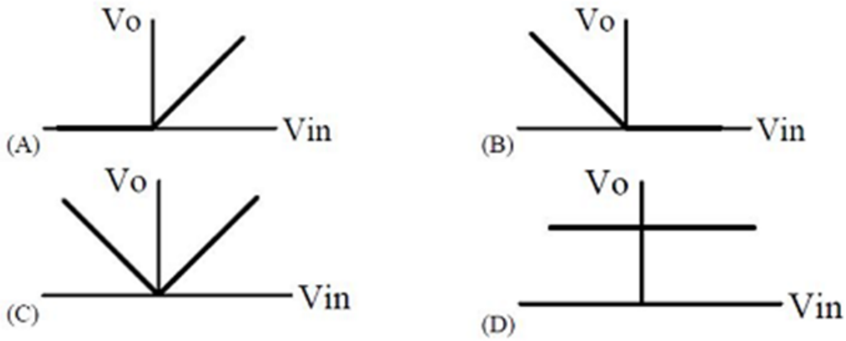
Inverse Laplace transform will give $h(t)$ (impulse response).

$$H(s) = \frac{-2}{s+2} + \frac{7}{s+5}$$

$$h(t) = -2e^{-2t}u(t) + 7e^{-5t}u(t)$$

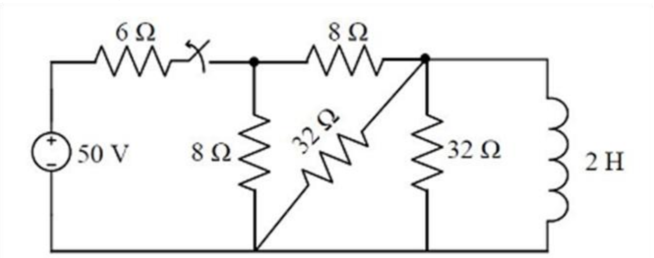
37. The approximate transfer characteristic for the circuit shown below with an ideal operational amplifier and diode will be





Key: (A)

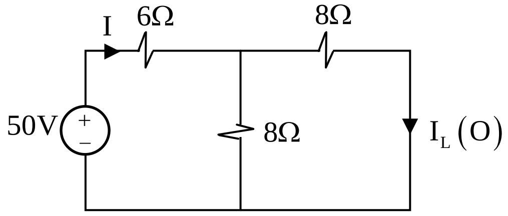
38. The switch in the figure below was closed for a long time. It is opened at t = 0. The current in the inductor of 2 H for $t \geq 0$, is



(A) $2.5e^{-4t}$ (B) $5e^{-4t}$ (C) $2.5e^{-0.25t}$ (D) $5e^{-0.25t}$

Key: (A)

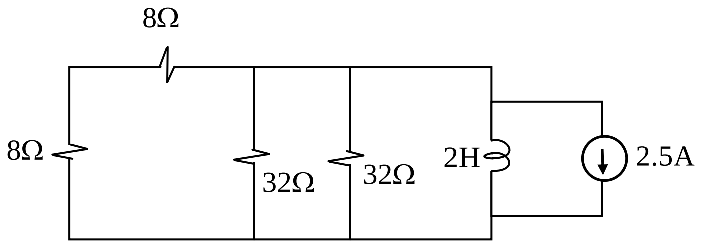
Exp: at $t = 0^{-}$



$$I = \frac{50}{6+4} = 5A$$

$$I_L\left(0^{-}\right) = \frac{5}{2} = 2.5A$$

For $t \geq 0$



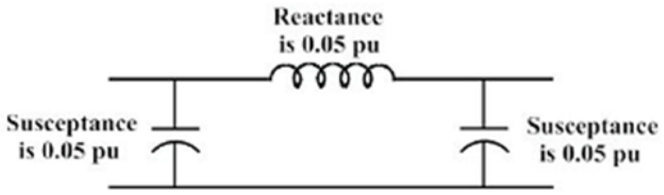
$$T = \frac{L}{Req} = \frac{2}{8} = \frac{1}{4}$$

$$I_L(\infty) = 0 \left(bc_3 \text{ it is a source free ckt}\right)$$

$$i_L(t) = I_L(\infty) + \left[I_L(0) - I_L(\infty)\right]e^{-t/T} = 2.5e^{-4t}$$

39. The bus admittance matrix for a power system network is $\begin{bmatrix} -j39.9 & j20 & j20 \\ j20 & -j39.9 & j20 \\ j20 & j20 & -j39.9 \end{bmatrix}$ pu

There is a transmission line, connected between buses 1 and 3, which is represented by the circuit shown in figure.



If this transmission line is removed from service, What is the modified bus admittance matrix?

(A) $\begin{bmatrix} -j19.9 & j20 & 0 \\ j20 & -j39.9 & j20 \\ 0 & j20 & -j19.9 \end{bmatrix}$ pu

(B) $\begin{bmatrix} -j39.95 & j20 & 0 \\ j20 & -j39.9 & j20 \\ 0 & j20 & -j39.95 \end{bmatrix}$ pu

(C) $\begin{bmatrix} -j19.95 & j20 & 0 \\ j20 & -j39.9 & j20 \\ 0 & j20 & -j19.95 \end{bmatrix}$ pu

(D) $\begin{bmatrix} -j19.95 & j20 & j20 \\ j20 & -j39.9 & j20 \\ j20 & j20 & -j19.95 \end{bmatrix}$ pu

Key: (C)

Exp: When the line 1-3 is removed

$$z_{13} = 0.05 = z_{31}$$

$$y_{13} = \frac{1}{0.05} = -j20, \qquad y_{13} = y_{31} = 0$$

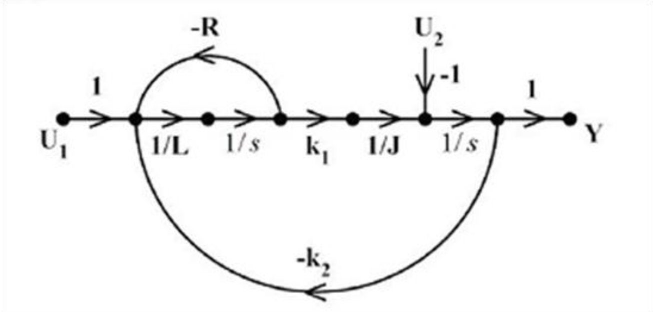
$$\frac{y'_{13}}{2} - \text{Half line shunt susceptance} = j0.05$$

$$y_{11}(\text{new}) = y_{11}(\text{old}) - y_{13} - \frac{y'_{13}}{2} = -j39.9 - (-j20) - j0.05 = -j19.95$$

$$y_{33}(\text{new}) = y_{33}(\text{old}) - y_{13} - \frac{y'_{13}}{2} = -j39.9 - (-j20) - j0.05 = -j19.95$$

Modified Bus admittance matrix: $y_{\text{Bus(new)}} = \begin{bmatrix} -j19.95 & j20 & 0 \\ j20 & -j39.9 & j20 \\ 0 & j20 & -j19.95 \end{bmatrix}_{pu}$

40. In the system whose signal flow graph is shown in the figure, $U_1(s)$ and U_2 (s) are inputs. The transfer function $\frac{Y(s)}{U_1(s)}$ is



(A) $\frac{k_1}{JLs^2 + JRs + k_1k_2}$

(B) $\frac{k_1}{JLs^2 - JRs - k_1k_2}$

(C) $\frac{k_1 - U_2(R + sL)}{JLs^2 + (JR - U_2L)s + k_1k_2 - U_2R}$

(D) $\frac{k_1 - U_2(sL - R)}{JLs^2 - (JR + U_2L)s - k_1k_2 + U_2R}$

Key: (A)

Exp: $\left.\frac{Y(s)}{U_1(s)}\right|_{U_2(s)=0}$

By Masons gain formula

$$\frac{Y(s)}{U_1(s)} = \frac{P_1\Delta_1}{1-[L_1 + L_2]}$$

$$\text{Here } P_1 = \frac{1}{k^2}.\frac{k_1}{LJ}$$

$$\Delta_1 = 1$$

$$L_1 = -\frac{R}{L}\frac{1}{s}$$

$$L_2 = \frac{1}{LJ}.\frac{1}{s^2}(k_2)k_1$$

$$\frac{Y(s)}{U_1(s)} = \frac{\frac{1}{s^2}.\frac{k_1}{LJ}}{1+\frac{R}{L}.\frac{1}{s}+\frac{1}{LJ}.\frac{1}{s^2}k_2k_1}$$

$$T/F = \frac{k_1}{s^2LJ + sRJ + k_1k_2}$$

41. For a system having transfer function $G(s) = \frac{-s+1}{s+1}$, a unit step input is applied at time t=0. The value of the response of the system at t=1.5 sec is __________.

Key: 0.550 to 0.556

Exp: $\frac{Y(s)}{R(s)} = \frac{-s+1}{s+1}$

$$Y(s)=\frac{1-s}{s+1}\cdot\frac{1}{s}$$

$$Y(s)=\frac{1}{s}-\frac{2}{s+1}$$

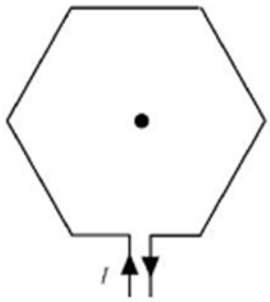
Apply Inverse L.T

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

$$y(1.5)=1-2e^{-1.5}=1-0.44626$$

$$y(1.5)=0.5537$$

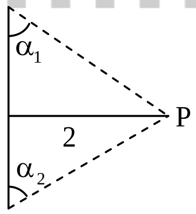
42. The magnitude of magnetic flux density (B) in micro Teslas (μT) at the center of a loop of wire wound as a regular hexagon of side length 1m carrying a current (I=1A), and placed in vacuum as shown in the figure is __________.



Key: 0.65 to 0.75

Exp: For a finite length conductor B at a point P

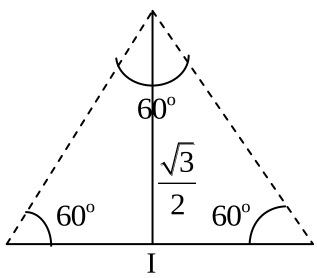
$$B=\frac{\mu_o I}{4\pi r}\left(\cos\alpha_1+\cos\alpha_2\right)$$



For a given hexagon 4 for a side

$$r=\frac{\sqrt{3}}{2}$$

$$\alpha_1=\alpha_2=60^o$$



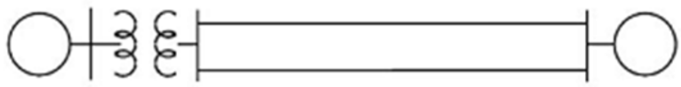
Total flux density $B=6\times\frac{\mu_o I}{4\pi r}\left(\cos\alpha_1+\cos\alpha_2\right)$

$$=6\times\frac{4\pi\times10^{-7}\times1}{4\pi\times\sqrt{3}/2}\left(\cos60^o+\cos60^o\right)$$

$$=6.9\times10^{-7}$$

$$=0.69\times10^{-7}\text{ Tesla}$$

43. The figure shows the single line diagram of a power system with a double circuit transmission line. The expression for electrical power is $1.5\sin\delta$, where δ is the rotor angle. The system is operating at the stable equilibrium point with mechanical power equal to 1 pu. If one of the transmission line circuits is removed, the maximum value of δ as the rotor swings, is 1.221 radian. If the expression for electrical power with one transmission line circuit removed is $P_{max}\sin\delta$, the value of $P_{max,}$ in pu is _________.

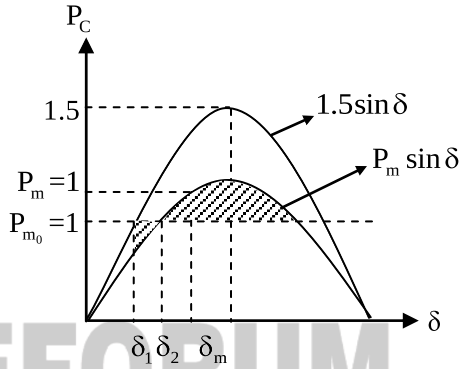


Key: 1.21 to 1.23

Exp: Given $\delta_m = 1.22\text{rad} = 69.958°$

$$\delta_1 = \sin^{-1}\left(\frac{P_m}{1.5}\right)$$

$$= \sin^{-1}\left(\frac{1}{1.5}\right) = 41.81° = 0.729\,\text{rad}$$



Using equal area criterion

$A_1 = A_2$

$$\int_{\delta_1}^{\delta_2}\left(P_{m_0} - P_{m_1}\sin\delta\right)d\delta = \int_{\delta_2}^{\delta_m}\left(P_{max1}\sin\delta - P_{m_0}\right)d\delta$$

By solving above integration

$$P_{max1} = \frac{P_{m_0}\left(\delta_m - \delta_1\right)}{\cos\delta_1 - \cos\delta_m} = \frac{1(1.221 - 0.7297)}{\cos(41.81) - \cos(69.95)} = 1.22\text{pu}$$

44. A 375W, 230 V, 50 Hz capacitor start single-phase induction motor has the following constants for the main and auxiliary windings (at starting): $Z_m = (12.50 + j15.75)\Omega$ (main winding), $Z_a = (24.50 + j12.75)\Omega$ (auxiliary winding). Neglecting the magnetizing branch the value of the capacitance (in μF) to be added in series with the auxiliary winding to obtain maximum torque at starting is _______.

Key: 95 to 100

Exp: $$\tan^{-1}\left(\frac{X_m}{R_m}\right) - \tan^{-1}\left(\frac{x_a - x_e}{R_a}\right) = 90°$$

$$\tan^{-1}\left(\frac{15.75}{12.5}\right) - \tan^{-1}\left(\frac{12.75 - X_c}{24.5}\right) = 90°$$

$$51.562° - \tan^{-1}\left(\frac{12.75 - X_c}{24.5}\right) = 90° \Rightarrow -\tan^{-1}\left(\frac{12.75 - X_c}{24.5}\right) = 38.43°$$

$$\frac{12.75 - X_c}{24.5} = -0.793 \Rightarrow -X_c = 32.194\Omega$$

$$X_c = \frac{1}{2\pi \times 50 \times 32.194} = 98.87\mu F$$

45. A function f(x) is defined as $f(x)=\begin{cases} e^x, & x<1 \\ \ln x+ax^2+bx, & x\ge 1 \end{cases}$ where $x\in\mathbb{R}$. Which one of the following statements is TRUE?

(A) f(x) is **NOT** differentiable at x=1 for any values of a and b.

(B) f(x) is differentiable at x = 1 for the unique values of a and b

(C) f(x) is differentiable at x = 1 for all values of a and b such that a + b = e

(D) f(x) is differentiable at x = 1 for all values of a and b.

Key: (A) Not matching with IIT key

Exp: $Lf^1(1)=\underset{\substack{x\to 1\\ x<1}}{Lt}\dfrac{f(x)-f(1)}{x-1}=\underset{x\to 1}{Lt}\dfrac{e^x-(a+b)}{x-1}$ does not exists, for any values of a and b

$\therefore f(x)$ is not differentiable at $x=1$, for any values of a and b.

46. Consider a causal and stable LTI system with rational transfer function H(z). Whose corresponding impulse response begins at n = 0. Furthermore, $H(1)=\dfrac{5}{4}$. The poles of H(z) are $P_k=\dfrac{1}{\sqrt{2}}\exp\left(j\dfrac{(2k-1)\pi}{4}\right)$ for k = 1,2,3,4. The zeros of H(z) are all at z = 0. Let g[n] = j^nh[n]. The value of g[8] equals ____________.

Key: 0.06 to 0.065

47. Only one of the real roots of $f(x)=x^6-x-1$ lies in the interval $1\le x\le 2$ and bisection method is used to find its value. For achieving an accuracy of 0.001, the required minimum number of iterations is _________.

Key: 10 to 10

Exp: $a=1, b=2$ and $\dfrac{b-a}{2^n}<0.001$ using bisection method

$\Rightarrow 2^n>1000\Rightarrow n=10$ is the minimum number of iterations

48. Two parallel connected, three-phase, 50Hz, 11kV, star-connected synchronous machines A and B, are operating as synchronous condensers. They together supply 50 MVAR to a 11 kV grid. Current supplied by both the machines are equal. Synchronous reactances of machine A and machine B are 1Ω and 3Ω respectively. Assuming the magnetic circuit to be linear, the ratio of excitation current of machine A to that of machine B is _________.

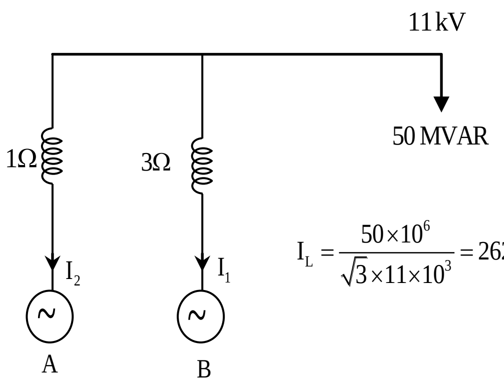
Key: 2.05 to 2.13

Exp: $\rightarrow$ syn. Condencors

$\rightarrow$ current's supplied both the machines are same

$\therefore\ I_1=I_2=\dfrac{2624.31}{2}=1312.159$ Amps

As the two motors, supplying reactive power only, the phasor diagaram will be



$I_L=\dfrac{50\times 10^6}{\sqrt{3}\times 11\times 10^3}=2624.31$

$E + jI_aX_s = V_t$

$E = V - jI_aX_s$

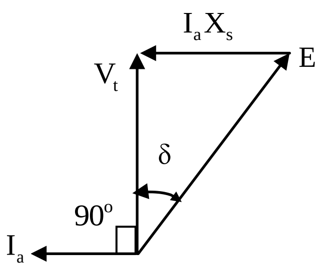
Consider magnitudes $\Rightarrow E^2 = \left(V - I_aX_s\right)^2$

$E = \sqrt{\left(V - I_aX_S\right)^2}$

$E_A = \sqrt{\left(6350.85 - 1312.159 \times 1\right)^2} = 5038.7 \text{ volts}$

$E_B = \sqrt{\left(6350.85 - 1312.159 \times 3\right)^2} = 2414.14 \text{ Volts}$

$\frac{I_{fA}}{I_{fB}} = \frac{E_A}{E_B} = \frac{5038.7}{2414.14} = 2.086$



49. The positive, negative and zero sequence reactances of a wye-connected synchronous generator are 0.2 pu, 0.2 pu, and 0.1 pu, respectively. The generator is on open circuit with a terminal voltage of 1 pu. The minimum value of the inductive reactance, in pu, required to be connected between neutral and ground so that the fault current does not exceed 3.75 pu if a single line to ground fault occurs at the terminals is _______ (assume fault impedance to be zero).

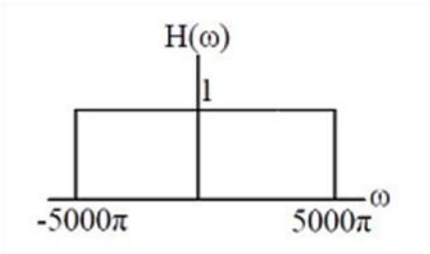
Key: 0.1 to 0.1

Exp: $I_f = \frac{3E_f}{Z_0 + Z_1 + Z_2 + 3Z_n}$

$3.75 = \frac{3 \times 1}{0.1 + 0.2 + 0.2 + 3Zn}$

$Zn = 0.1 P.U$

50. Let the signal $x(t) = \sum_{k=-\infty}^{+\infty} (-1)^k \delta\left(t - \frac{k}{2000}\right)$ be passed through an LTI system with frequency response $H(\omega)$, as given in the figure below



The Fourier series representation of the output is given as

(A) $4000 + 4000\cos(2000\pi t) + 4000\cos(4000\pi t)$

(B) $2000 + 2000\cos(2000\pi t) + 2000\cos(4000\pi t)$

(C) $4000\cos(2000\pi t)$

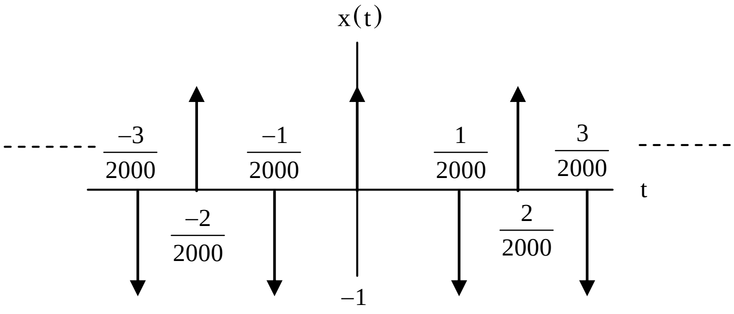
(D) $2000\cos(2000\pi t)$

Key: (C)

Exp: Given $x(t)$ is a periodic signal for which Fourier transform $x(\omega)$ is to be calculated

$$x(\omega)=2\pi\sum_{n=-\infty}^{\infty}D_n\delta(\omega-n\omega)$$

D_n is exponential Fourier series coefficient for x(t)



Define $x(t)$ over one period $\quad x(t)=\delta(t)-\delta\left(t-\frac{1}{2000}\right)$

Where as $T_o=\frac{1}{1000}$ sec; $\omega_o=2000\pi$ rad/sec

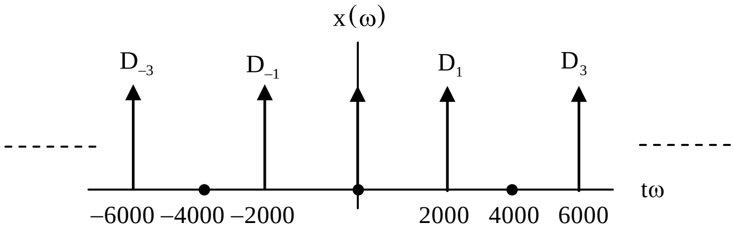
$$\therefore D_n=\frac{1}{T_o}\left[1-e^{-jn\omega_o t_o}\right];\ t_o=\frac{1}{2000}$$

$$D_n=1000\left[1-e_{-j\pi n}\right]\Rightarrow D_n=\left[1-(-1)^n\right]1000$$

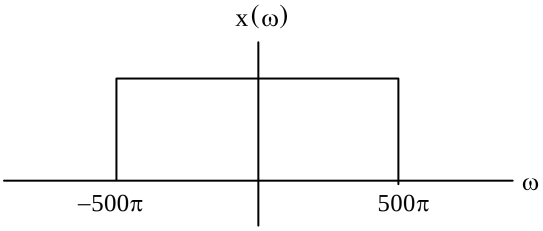
At $n=0,2,4,..........D_n=0$

i.e., $D_n=\begin{cases}0 & \text{for even values of } n\\ 2000 & \text{for odd values of } n\end{cases}$

$$\therefore x(\omega)=2\pi\left[D_0+D_1\right]\delta(\omega-2000\pi)+D_{-1}\delta(\omega+2000\pi)+D_2\delta(\omega-4000\pi)+D_{-2}\delta(\omega+4000\pi)$$
$$+..................]$$



Given $x(\omega)$ is



Thus the filtered output is

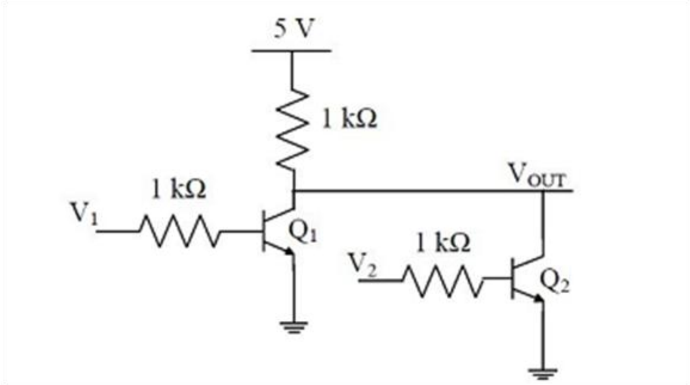
$$y(\omega)=2\pi\left[D_1\delta(\omega-2000\pi)\right]+D_{-1}\delta(\omega+2000\pi)$$

$$\because D_1=D_{-1}=2000$$

$$y(\omega)=4000\left[\pi\left(\delta(\omega-2000\pi)+\delta(\omega+2000\pi)\right)\right]$$

$$\therefore y(t)=4000\cos(2000\pi t)$$

51. The logical gate implemented using the circuit shown below where. V_1 and V_2 are inputs (with 0 V as digital 0 and 5 V as digital 1) and V_{OUT} is the output is



(A) NOT (B) NOR (C) NAND (D) XOR

Key: (B)

Exp:

V_1	V_2	Q_1	Q_2	V_{out}	Logic Level
0	0	OFF	OFF	5V	1
0	1	OFF	ON	0V	0
1	0	ON	OFF	0V	0
1	1	ON	ON	0V	0

So, this logic level o/p is showing the functionality of NOR-gate.

52. A load is supplied by a 230 V, 50 Hz source. The active power P and the reactive power Q consumed by the load are such that $1\text{ kW} \le P \le 2\text{kW}$ and $1\text{kVAR} \le Q \le \text{kVAR}$. A capacitor connected across the load for power factor correction generates 1 kVAR reactive power. The worst case power factor after power factor correction is

(A) 0.447 lag (B) 0.707 lag (C) 0.894 lag (D) 1

Key: (B)

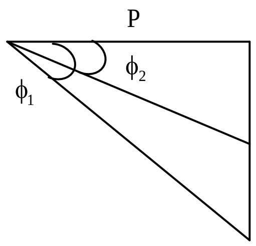
Exp: Under worst case,

$P_{max} = 2\text{kW}$

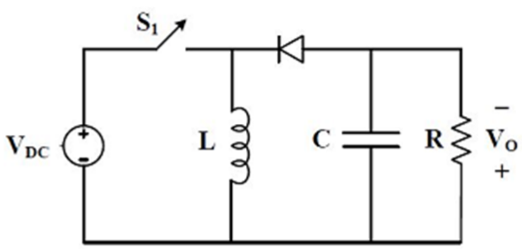
$Q_{max} = 2\text{kVAR}$

$\phi_1 = \tan^{-1}\frac{Q}{P} = 45^o$

$\cos 45 = 0.707\text{lag}$



53. The input voltage V_{DC} of the buck-boost converter shown below varies from 32 V to 72 V. Assume that all components are ideal, inductor current is continuous, and output voltage is ripple free. The range of duty ratio D of the converter for which the magnitude of the steady state output voltage remains constant at 48 V is



(A) $\frac{2}{5} \le D \le \frac{3}{5}$ (B) $\frac{2}{3} \le D \le \frac{3}{4}$ (C) $0 \le D \le 1$ (D) $\frac{1}{3} \le D \le \frac{2}{3}$

Key: (A)

Exp:

$V_{dc} = 32V$	$V_{dc} = 72V$
$V_o = 48V$	$V_o = 48V$
$\frac{V_o}{V_{dc}} = \frac{D}{1-D}$	$\frac{V_o}{V_{dc}} = \frac{D}{1-D}$
$\frac{48}{32} = \frac{D}{1-D}$	$\frac{2}{3} = \frac{D}{1-D}$
$\frac{3}{2} = \frac{D}{1-D}$	$3D = 2-2D$
$3-3D = 2D$	$5D = 2$
$3 = 5D \Rightarrow D = \frac{3}{5}$	$D = \frac{2}{5}$

$$\frac{2}{5} \le D \le \frac{3}{5}$$

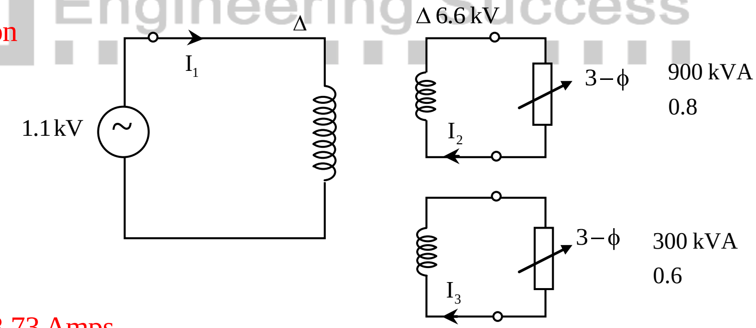
54. A three-phase, three winding $\Delta/\Delta/Y$ (1.1kV/6.6kV/400 V) transformer is energized from AC mains at the 1.1 kV side. It supplies 900 kVA load at 0.8 power factor lag from the 6.6 kV winding and 300 kVA load at 0.6 power factor lag from the 400 V winding. The RMS line current in ampere drawn by the 1.1 kV winding from the mains is ________.

Key: **623 to 627**

Exp: $3-\phi, 3-$winding T/F

$\Delta/\Delta/Y$

per phase representation



$$\gamma = \frac{400}{\sqrt{3}}$$

$$I_2 = \frac{900\times10^3}{\sqrt{3}\times6.6\times10^3} = 78.73 \text{ Amps}$$

$$I_{ph} = \frac{I_2}{\sqrt{3}} = 45.45\underline{|-36.87^o}$$

$$I_2' = KI_2 = \frac{6.6\times10^3}{1.1\times10^3}\times45.45 \Rightarrow I_2' = 272.7\underline{|-36-.87^o}$$

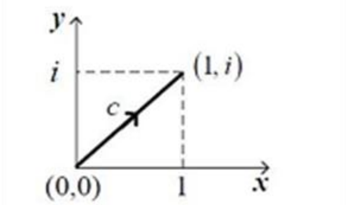
$$I_3 = \frac{300\times10^3}{\sqrt{3}\times400} = 433.01 \text{ Amp}$$

$$I_{ph} = I_L = I_3 = 433.01\underline{|-53.13}$$

$$I_3' = \frac{400/\sqrt{3}}{1.1\times10^3}\times433.01 \Rightarrow I_3'' = 90.91\underline{|-53.13^o}$$

$$I_1 = I_2' + I_3' \Rightarrow I_1 = 360.87\underline{|-40.91} \Rightarrow I_1 = \sqrt{3}\, I_1 = 625.05\underline{|40.91}$$

55. Consider the line integral $I = \int_C \left(x^2 + iy^2\right)dz$ where z = x + iy. The line C is shown in the figure below.



The value of I is

(A) $\frac{1}{2}i$ (B) $\frac{2}{3}i$ (C) $\frac{3}{4}i$ (D) $\frac{4}{5}i$

Key: (B)

Exp: curve ‘C’ is $y = x \Rightarrow dy = dx$

$$\therefore I = \int_0^1 \left(x^2 + i(x)^2\right)(dx + idx) = (1+i)^2 \int_0^1 x^2 dx = (2i)\left(\frac{x^3}{3}\right)_0^1 = \frac{2}{3}i$$

General Aptitude

Q. No. 1 – 5 Carry One Mark Each

1. Research in the workplace reveals that people work for many reasons________.

(A) money beside (B) beside money (C) money besides (D) besides money

Key: (D)

2. The probability that a k-digit number does NOT contain the digits 0.5, or 9 is

(A) 0.3^k (B) 0.6^k (C) 0.7^k (D) 0.9^k

Key: (C)

$$\underbrace{\text{- - - - - - - - - - - - - - - - - - - -}}_{\text{k digits}}$$

Each digit can be filled in 7 ways as 0, 5 and 9 is not allowed, so each of these places can be filled by 1, 2, 3, 4, 6, 7, 8.

So required probability is $\left(\frac{7}{10}\right)^k$ or 0.7^k.

3. Find the smallest number y such that $y \times 162$ is a perfect cube.

(A) 24 (B) 27 (C) 32 (D) 36

Key: (D)

Exp: Factorization of 162 is $2\times3\times3\times3\times3$

$y \times 162$ is a perfect cube

$y \times 2 \times 3 \times 3 \times 3 \times 3 = \text{Perfect cube}$

For perfect cube 2's & 3's are two more required each.

4. After Rajendra Chola returned from his voyage to Indoneisa, he _______ to visit the temple in Thanjavur.

(A) was wishing (B) is wishing (C) wished (D) had wished

Key: (C)

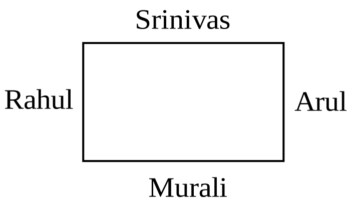
5. Rahul, Murali, Srinivas and Arul are seated around a square table. Rahul is sitting to the left of Murali. Srinivas is sitting to the right of Arul. Which of the following pairs are seated opposite each other?

(A) Rahul and Murali (B) Srinivas and Anil

(C) Srinivas and Murali (D) Srinivas and Rahul

Key: (C)

Exp:



Q. No. 6 – 10 Carry Two Marks Each

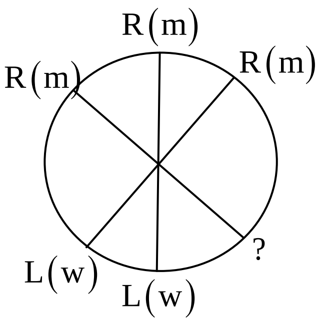
6. Six people are seated around a circular table. There are at least two men and two women. There are at least three right-handed persons. Every woman has a left-handed person to her immediate right. None of the women are right-handed. The number of women at the table is

(A) 2 (B) 3

(C) 4 (D) Cannot be determined

Key: (A)

Exp: Out of six people, 3 place definitely occupied by right handed people as atleast 2 women are there so these two will sit adjacently. Now as only one seat is left it will be occupied by a left handed man because on right side of this seat is sitting an right handed man.



Therefore, answer should be 2 women.

7. The expression $\frac{(x+y)-|x-y|}{2}$ is equal to

(A) the maximum of x and y (B) the minimum of x and y

(C) 1 (D) none of the above

Key: (B)

Exp: If $x > y$

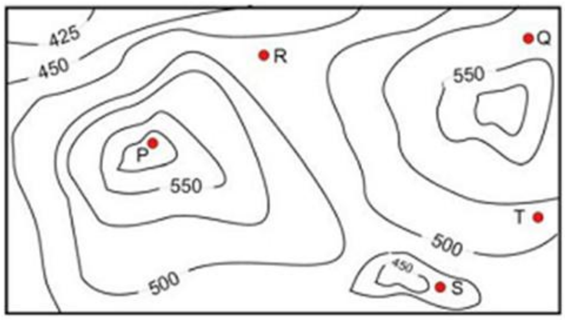
$$Exp = \frac{x + y - (x - y)}{2} = y_{min}$$

If $x < y$

$$Exp = \frac{x + y - (y - x)}{2} = x_{min}$$

$\therefore$ The expression $\frac{(x + y) - |x - y|}{2}$ is equal to minimum of x & y

8. A contour line joins locations having the same height above the mean sea level. The following is a contour plot of a geographical region. Contour lines are shown at 25m intervals in this plot. If in a flood, the water level rises to 525m. Which of the villages P,Q,R,S,T get submerged?



(A) P, Q (B) P,Q,T
(C) R,S,T (D) Q,R,S

Key: (C)

Exp: The given contour is a hill station, the peak point of this hill station is P, it is under a contour of 550. At floods, the water level is 525m. So the village of R, S and T are under a contour of 500. Therefore these villages are submerged.

9. Arun, Gulab, Neel and Shweta must choose one shirt each from a pile of four shirts coloured red, pink, blue and white respectively. Arun dislikes the colour red and Shweta dislikes the colour white, Gulab and Neel like all the colours. In how many different ways can they choose the shirts so that no one has a shirt with a colour he or she dislikes?

(A) 21 (B) 18 (C) 16 (D) 14

Key: (D)

Exp: As there are 4 people A,G,N,S and 4 colours so without any restriction total ways have to be $4 \times 4 = 16$

Now, Arun $\rightarrow$ dislikes Red and

Shweta $\rightarrow$ dislikes white

So 16-2=14 ways

10. "The hold of the nationalist imagination on our colonial past is such that anything inadequately or improperly nationalist is just not history."

Which of the following statements best reflects the author's opinion?

(A) Nationalists are highly imaginative.
(B) History is viewed through the filter of nationalism.
(C) Our colonial past never happened
(D) Nationalism has to be both adequately and properly imagined.

Key: (B)