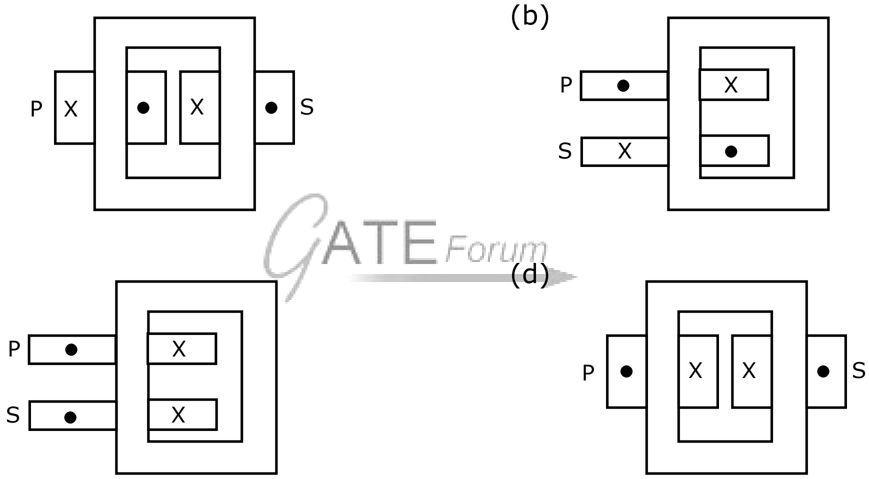
1.1 Level compounded d.c. generator is used for which of the following applications?

(a) Electric Arc Welding (b) Electric Traction
(c) Battery Charging (d) Lighting

1.2 In a polyphase squirrel-cage induction motor, increased starting torque can be obtained by

(a) Increasing the frequency of operation (b) Using deep-bar rotors
(c) Increasing the number of poles (d) Using a double-cage rotor

1.3 The relative current directions through the Primary (P) and Secondary (S) of a single phase transformer connected to a resistive load on the secondary side, are indicated in the various cross-sectional views given in figure. Which of these are correct representations?



1.4 The hysteresis and eddy current losses of a single phase transformer working on 200V, 50 Hz supply are P_h and P_e respectively. The percentage decrease in these, when operated on a 160 V, 40 Hz supply are:

(a) 32, 36 (b) 20, 36 (c) 25, 20 (d) 40, 80

1.5 A prime mover drives a 6 pole, 3-phase induction frequency converter. The converter is connected to 60 Hz, 3-phase supply on the primary. If the prime mover speed is 3,000 rpm, the frequencies of the possible outputs from the converter are

(a) 120 Hz, 60 Hz (b) 90 Hz, 210 Hz
(c) 186 Hz, 86 Hz (d) 180 Hz, 210 Hz

1.6 Damper winding is provided in a polyphase synchronous motor in order to

(a) dampen out the noise of the machine (b) prevent hunting
(c) provide starting torque

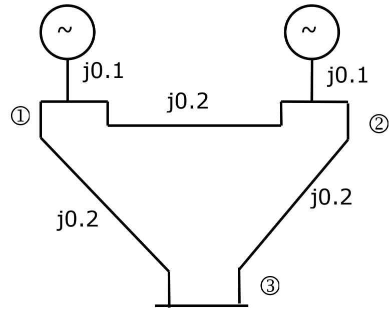
(d) provide a cylindrical structure to reduce wind friction

1.7 A 500 MVA, 11 KV synchronous generator has 0.2 p.u. synchronous reactance. The p.u. synchronous reactance on the base values of 100 MVA and 22 KV is:

(a) 0.16 (b) 0.01 (c) 4.0 (d) 0.25

1.8 A sample power system network is shown in figure. The reactances marked are in p.u. The p.u value of Y_{22} of the Bus Admittance Matrix (Y_{BUS}) is:

(a) j 10.0
(b) j 0.4
(c) -j 0.1
(d) -j 20.0



1.9 When a fixed amount of power is to be transmitted, the efficiency of transmission increases when

(a) voltage decrease, power factor remains constant
(b) voltage increases, power factor increases
(c) voltage decreases, power factor decreases
(d) voltage constant, power factor decreases

1.10 Ring main distribution system is preferred to a radial system, because

(a) it is less expensive
(b) voltage drop in the feeder is less
(c) power factor is higher
(d) supply is more reliable

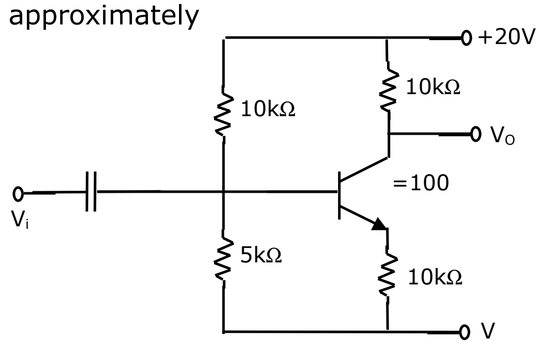
1.11 The mica layer $(\varepsilon_r = 7)$ in a parallel plate capacitor with an effective area of 120 mm^2 has a damaged section equivalent to a hole of 0.5 mm diameter. Which of the following would be significantly affected by the damage?

(a) capacitance
(b) charge
(c) dielectric breakdown strength
(d) tan δ

1.12 The operating state that distinguishes a silicon controlled rectifier (SCR) from a diode is

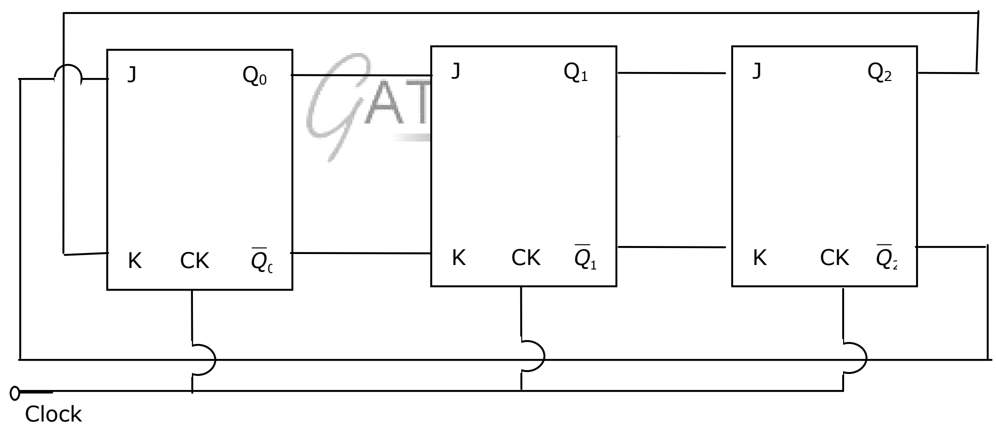
(a) forward conduction state
(b) forward blocking state
(c) reverse conduction state
(d) reverse blocking state

1.13 Figure below shows a common emitter amplifier. The quiescent collector voltage of the circuit is approximately



(a) $\frac{20}{3}V$ (b) 10 V (c) 14 V (d) 20 V

1.14 The three stage Johnson ring counter shown in figure is clock at a constant frequency of f_o from the starting state of $Q_0Q_1Q_2 = 10$. The freqeuency of outputs Q_0, Q_1, Q_2 will be

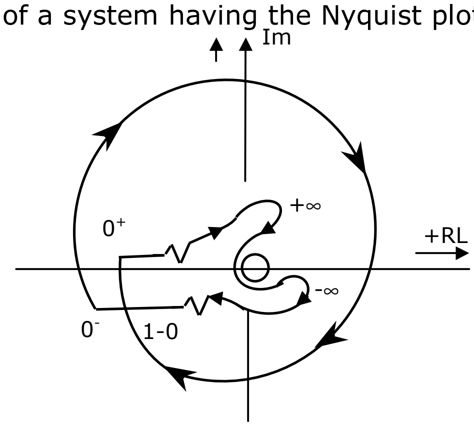


(a) $\frac{f_c}{2}$ (b) $\frac{f_c}{3}$ (c) $\frac{f_c}{6}$ (d) $\frac{f_c}{8}$

1.15 Which of the following is the transfer function of a system having the Nyquist plot in figure?

(a) $\frac{K}{s(s+2)^2(s+5)}$ (b) $\frac{K}{s^2(s+2)(s+5)}$

(c) $\frac{K(s+1)}{s^2(s+2)(s+5)}$ (d) $\frac{K(s+1)(s+3)}{s^2(s+2)(s+5)}$



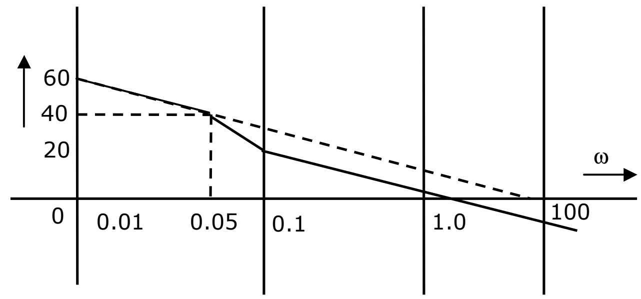
1.16 The system having the Bode magnitude plot shown in figure has the transfer function

(a) $\frac{60(s+0.01)(s+0.1)}{s^2(s+0.05)^2}$

(b) $\frac{10(1+10s)}{s(1+20s)}$

(c) $\frac{3(s+0.05)}{s(s+0.1)(s+1)}$

(d) $\frac{5(s+0.1)}{s(s+0.05)}$



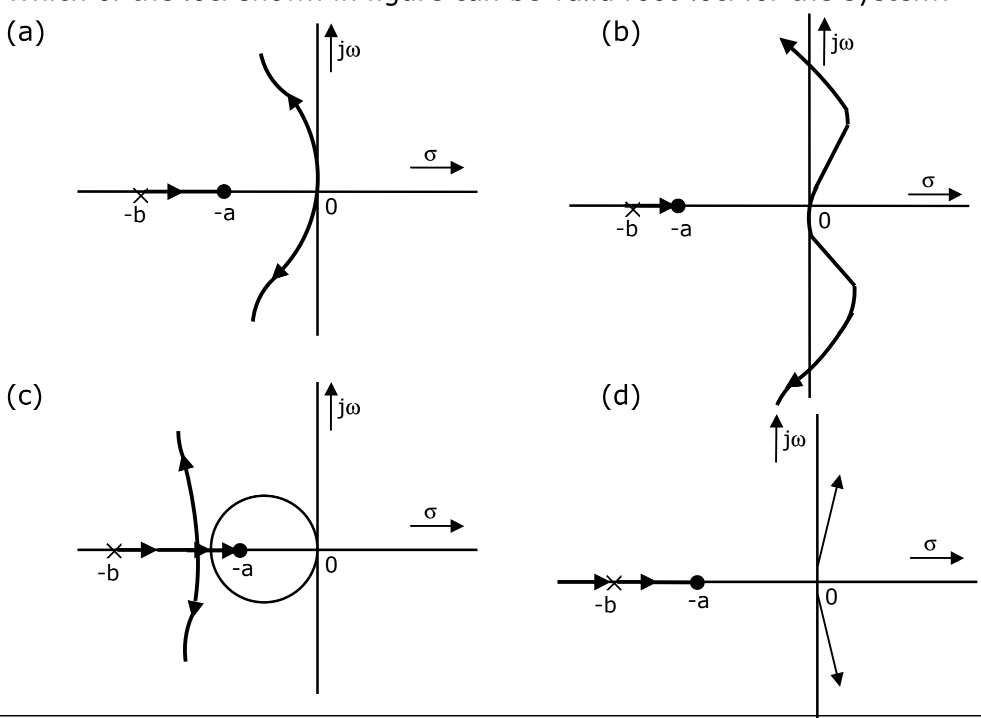
1.17 Two coils having equal resistance but different inductances are connected in series. The time-constant of the series combination is:

(a) sum of the time-constants of the individual coils
(b) average of the time constant of the individual coils
(c) geometric mean of the time constants of the individual coils
(d) product of the time-constants of the individual coils

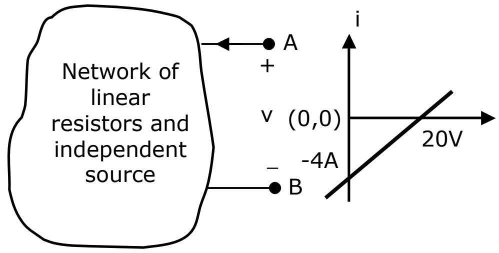
1.18 A unity feedback system has an open-loop transfer function of the form

$$KG(s) = \frac{K(s+a)}{s^2(s+b)}; b > a$$

Which of the loci shown in figure can be valid root-loci for the system?

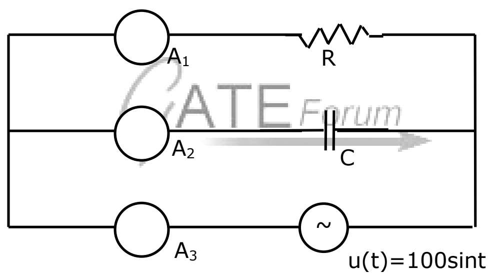


1.19. The V-I characteristic as seen from the terminal pair (A,B) of the network of figure (a) is shown figure (b). if a variable resistance R_L is connected across the terminal pair (A, B), the maximum power that can be supplied to R_L would be



(a) 80 W (b) 40 W (c) 20 W
(d) indeterminate unless the actual network is given.

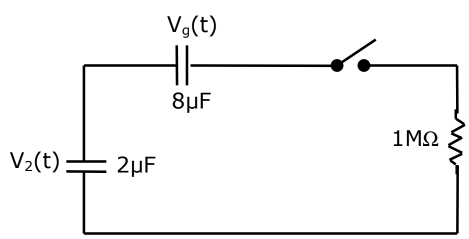
1.20. In the figure shown, A_1, A_2 and A_3 are ideal ammeters. If A_1 and A_3 read 5 and 13 A respectively, reading of A_2 will be



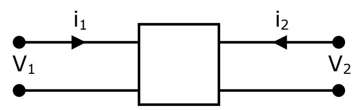
(a) 8 A (b) 12 A (c) 18 A
(d) indeterminate unless the actual values of R, C and ω are specified.

1.21. The switch S in figure is closed at t = 0. If $v_2(0) = 10V$ and $v_g(0) = 0V$ respectively, voltages across the capacitors in steady state will be:

(a) $v_2(\infty) = v_g(\infty) = 0$
(b) $v_2(\infty) = 2V, v_g(\infty) = 8V$
(c) $v_2(\infty) = v_g(\infty) = 8V$
(d) $v_2(\infty) = v_g(\infty) = 2V$



1.22. The terminal voltage and currents of a two-port network are indicated on the figure. If the two-port is reciprocal, then



(a) $\frac{z_{12}}{y_{12}} = z_{12}^2 - z_{11}.z_{22}$ (b) $z_{12} = \frac{1}{y_{22}}$

(c) $h_{12} = -h_{21}$ (d) $AD - BC = 0$

1.23. The ratio and phase angle errors in a well designed current transformer (CT) are kept within specified limits by using

(a) ferrite core (b) strip wound core

(c) some fractional turns (d) in-built compensating capacitors

1.24. Precautions are essential for ensuring that the secondary of a CT is not open circuited when the primary circuit carries a current because

(a) dangerously high voltage might develop across the secondary

(b) the ferromagnetic core may develop residual magnetism

(c) the reflected impedance may prevent the flow of current in the primary circuit

(d) none of the above

2.1 A fault occurring at the terminals of an unloaded synchronous generator operating at its rated voltage has resulted in the following values of current and voltage.

$I_{a0} = j2.37 p.u.$

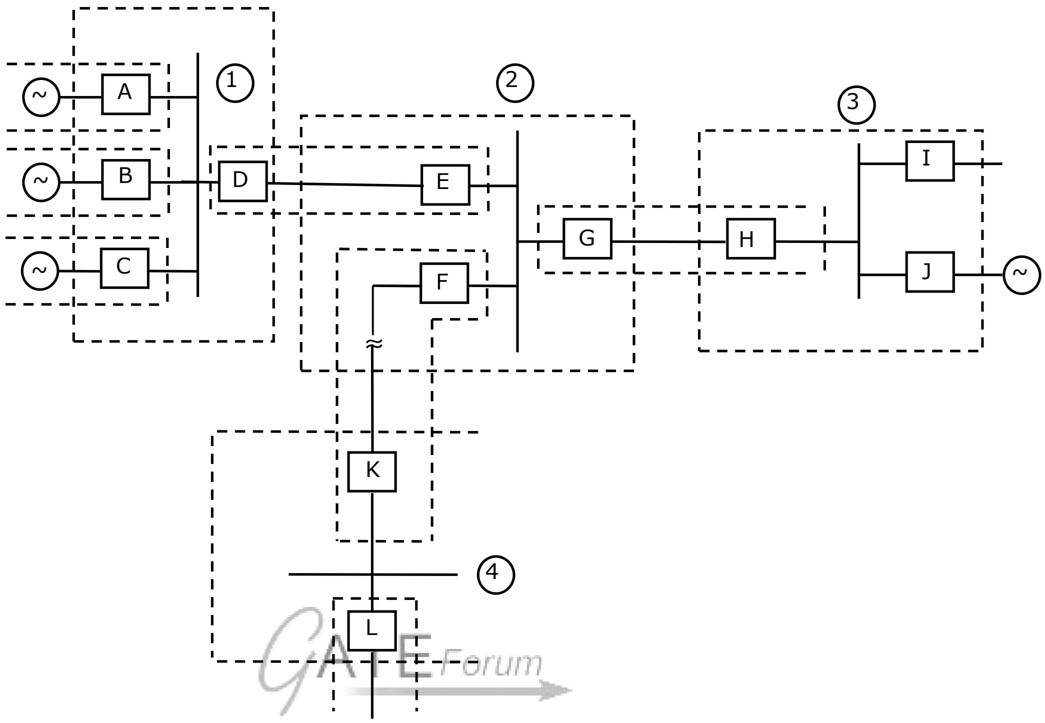
$I_{a1} = j3.05 p.u.$

$I_{a2} = j0.68 p.u.$

$V_{a0} = V_{a1} = V_{a2} = 0.237 p.u.$

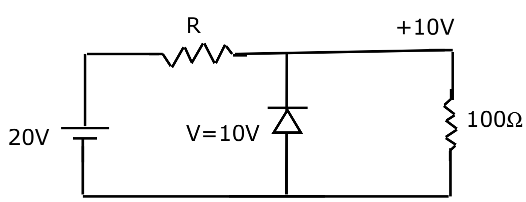
The fault that has occurred is ______________.

2.2. In a 4 bus system the circuit breakers and the various zones of protection are shown in figure. If the circuit breakers E, F and G trip, the location of the fault is on __________.



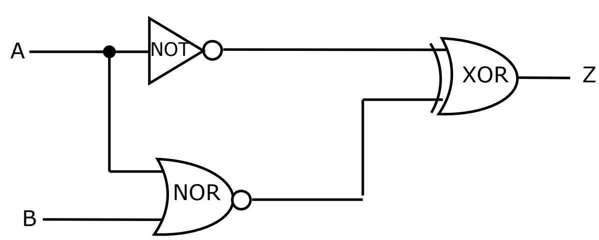
2.3. A separately excited d.c. motor has to be run at 125% of rated speed when delivering 50% torque. The excitation will be __________.

2.4. Figure shows an electronic voltage regulator. The zener diode may be assumed to require a minimum current of 25 mA for satisfactory operations. The value of R required for satisfactory voltage regulation of the circuit is



2.5. Complete the truth table for the combinational circuit shown in figure.

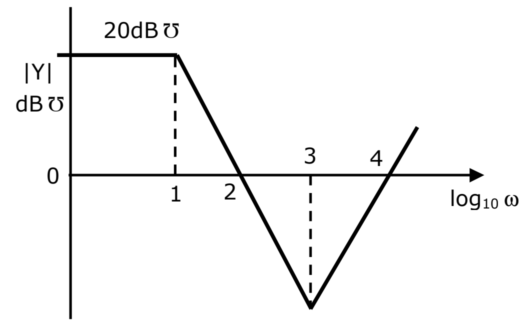
A	B	Z
0	0	
0	1	
1	0	
1	1	



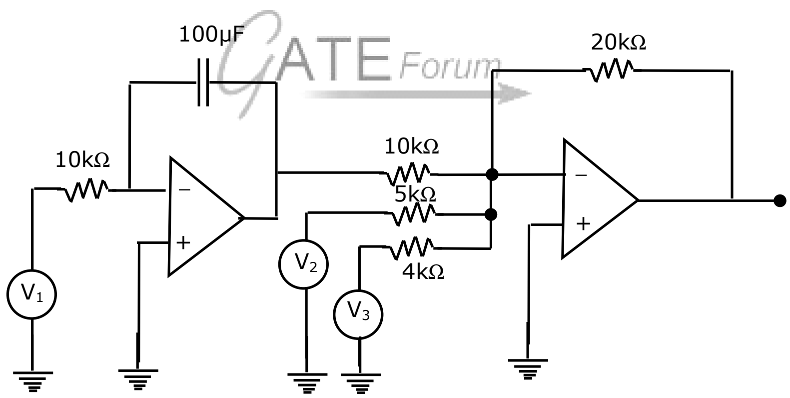
2.6. A one port active network has an input admittance Y, the magnitude of which is shown in figure as a function of frequency. The circuit is resistive or capacitive in different frequency ranges.

Complete the following table:

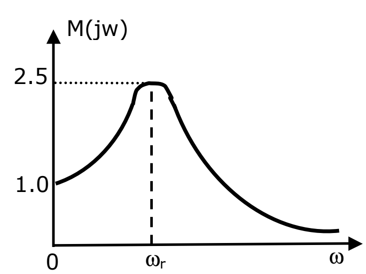
Frequency Range	Type of Impedance	Value (W/H/F)
11000 rad/sec < ω	----	-----
10 rad/sec < ω < 1000 rad/sec	----	-----



2.7. With ideal operational amplifiers, the circuit in figure simulates the equation



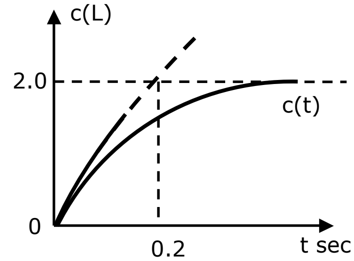
2.8. An underdamped second order system having a transfer function of the form $M(s) = \dfrac{k\omega_n^2}{s^2 + 2\omega_n^s + \omega_n^2}$ has frequency response plot shown in figure. Then the system gain K is ______ and the damping factor is approximately _______.

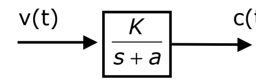


2.9. A first order system and its response to a unit step input are shown in figure. The system parameters are

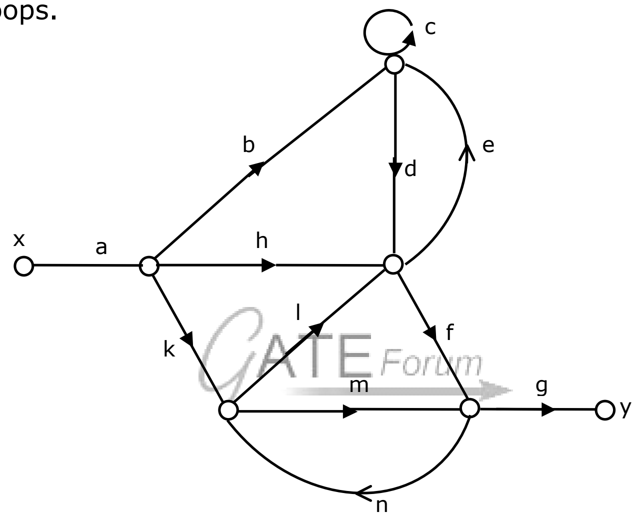
a = ____________

K = ____________

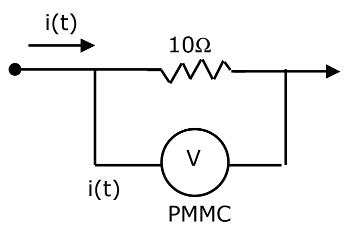




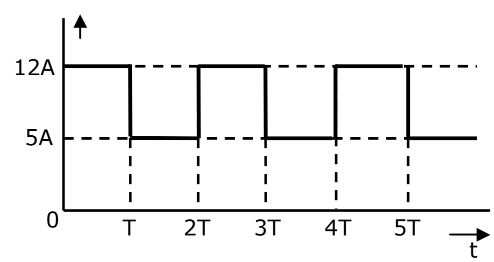
2.10. The signal flow graph of figure has ______ forward paths/and ________ feedback loops.



2.11. The current passing through a 10 Ohm resistor of figure (a) has the waveform in figure (b). The reading of the PMMC voltmeter connected across the resistor



(a)



(b)

2.12. The resolution of an 8 bit A/D converter is __________ %

2.13. Two identical wattmeters are connected to measure power in a 3-phase 3-wire balanced load. What is the load power factor if

(a) $W_1 = W_2$ _______

(b) Either W_1 or W_2 is zero ________

3. This question contains THREE sub-questions, each having two columns. Match every item on the left side with the most appropriate item on the right side. Give your answer as shown the example below:

Example: 3, 5.

(A) --- (P)
(B) --- (Q)
(C) --- (R)
(D) --- (S)

3.1. Match the windings of a large d.c. series motor and their functions:

Windings	Function
(A) series field winding	(P) to avoid field distortion under the pole
(B) shunt field winding	(Q) to avoid sparking
(C) commutating pole winding	(R) to generate working
(D) compensating winding	(S) to avoid runway speeds on no-load

3.2. Match the functions of the following protective elements in SCR applications:

SCR rating	Protective element
(A) di/dt limit	(P) snubber
(B) dυ/dt limit	(Q) heat sink
(C) i^2t limit	(R) series reactor
(D) junction temperature limit	(S) to avoid runway speeds on no-load

3.3. Match the following measuring equipment with their specific application:

(A) Kelvin double bridge	(P) capacitance
(B) Wind bridge	(Q) self inductance
(C) Schering bridge	(R) frequency
(D) Maxwell's bridge	(S) low resistance

4. A 10 kW, 6 pole, d.c. generator develops an e.m.f of 200 V at 1,500 rpm. The armature has a lap connected winding. The average flux density over a pole pitch is 0.9 Tesla. The length and diameter of the armature are 0.25 m and 0.2 m respectively. Calculate

(a) the flux per pole

(b) the total number of active conduction in the armature and

(c) the torque developed by the machine when the armature supplies a current of 50 A.

5. A 5 kW, 400 V, 50 Hz, 4 pole, delta connected three-phase induction motor is supplied by a cable of negligible inductance. On starting the motor using a star-delta starter, it is found that the starting torque is the same on star as well as delta connection, due to the voltage drop in the feeder resistance. The equivalent circuit parameters of the motor are as follows:

$r_1 =$ ohm, $x_1 = 4.5$ ohms, $r_2' = 1.4$ ohms and $x_2 = 4.50$ ohms.

Determine the feeder resistance.

6. A 10 kVA, 380 V, 4-pole, 50 Hz, star-connected cyclindrical rotor alternator has a stator resistance and synchronous reactance of 1 ohm and 15 ohms respectively. It supplies a load of 8 kW at rated voltage and 0.8 power factor lagging.

(a) Draw a phasor diagram of operation

(b) Express the resistance and synchronous reactance in per unit values with the machine rating as the base.

(c) Calculate the percentage regulation

(d) What is the terminal voltage if the load is suddenly removed (with the speed and excitation unaltered)?

7. A toroidal iron ring has a uniform cross-sectional area of 50 mm^2, and a mean magnetic path length of 100 mm. The ring has an airgap of 1 mm. the rign is excited with a dc current of 1 A through a coil of 100 turns wound uniformly along its length. The iron may be assumed to be perfect magnetic material. The effect of fringing at the gap may be assumed to increase the effective area of magnetic flux at the gap by 10%. Evalaute

(a) the exciting mmf of the coil

(b) the effective reductance of magnetic circuit

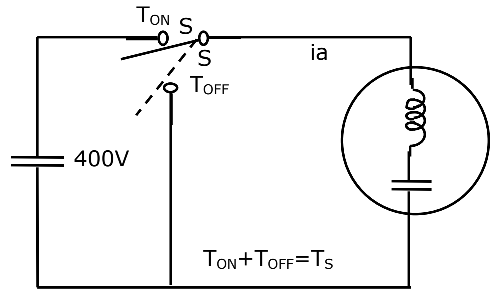
(c) the magnetic flux in the airgap

(d) the inductance of the coil

(e) the energy stored in the magnetic field under the above excitation.

8. Figure shows the circuit schematic of a chopper driven, separately excited d.c. motor. The single-pole double-throw switch operates with a switching period $\left(T_{ON}/T_s\right)$ is 0.2. The motor may be assumed lossless, with an armature inductance

of 10 mH. The motor draws an average current of 20A at a constant back emf of 80 V, under steady state.



(a) Sketch and label the voltage waveform $v_0(t)$ of the chopper for one switching period.

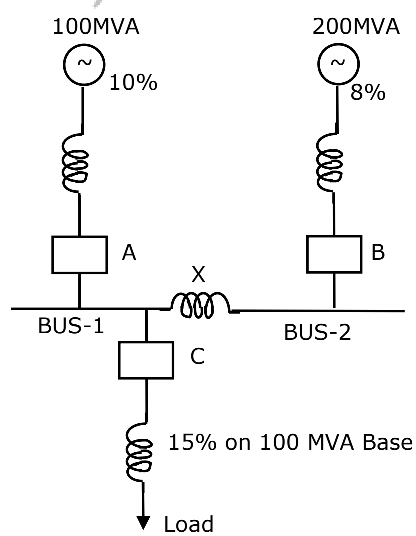
(b) Sketch and label the motor current $i_a(t)$ for one switching period.

(c) Evaluate the peak-to-peak current ripple of the motor.

9. Two transmission lines are connected in cascade, whose ABCD parameters are

$$\begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} = \begin{bmatrix} 1 & 10\angle 30^\circ \\ 0 & 1 \end{bmatrix}; \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0.025\angle -30^\circ & 1 \end{bmatrix}$$

Respectively. Find the resultant ABCD parameters.



(a) a 100 MVA generator with 10% reactance and a 200 mVA generator with 8% reactance (reactances on their own bases) are connected as shown in figure. The fault level on bus 1 is to be restricted to 1500 MVA. Calculate, on 100 MVA base.

(i) the reactance of bus bar reactor X

(ii) fault level of bus 2

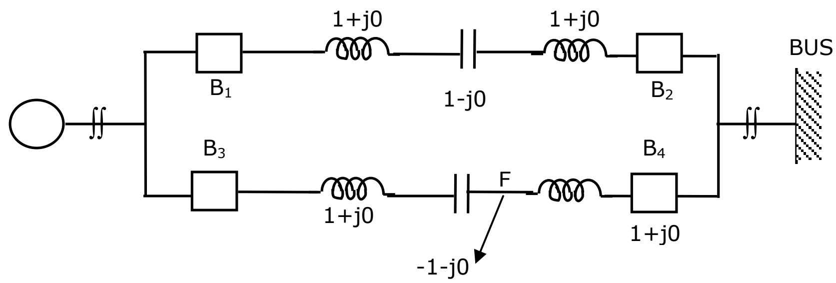
(iii) MVA rating of circuit breaker C

10. A generator is supplying 1 per unit power to an infinite bus through the system shown in figure. Following a fault at F, circuit breakers B_3 and B_4 open simultaneously. The $P-\delta$ relationships in per unit are given by

Pre-fault condition:
p = 2 sinδ

During fault condition:
When B_3, B_4 remain closed :
p = 0.2 sinδ

After B_3, B_4 open: p = 1.5 sinδ



Calculate the critical angel δ before which breakers B_3 and B_4 must open so that synchronism is not lost. Also shown this on a $P-\delta$ diagram.

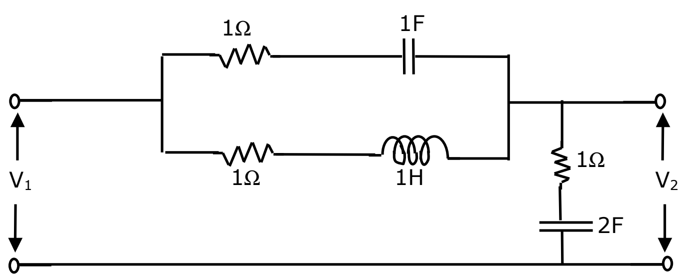
11. A 50 MVA, 132/66 kV, Δ/Y, three phase power transformer is protected by percentage differential relays. If the current transformers (CTs) located on the delta and wye sides of the power transformer are 300/5A and 1200/5A respectively, determine

(a) the output current at full load
(b) the relay current at full load
(c) the minimum relay current setting to permit 25% overload.
(d)

12. (a) Find the transfer function

$$H(s) = \frac{V_2(s)}{V_1(s)}$$

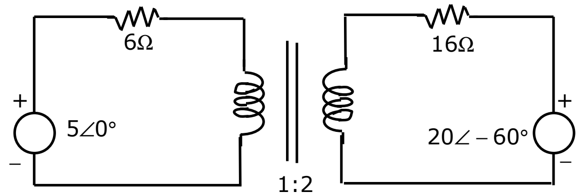
For the network shown in figure.



(b) What is the order of the system?

(c) Now if the inductances value is changed to 2H, what will be the order of the modified network.

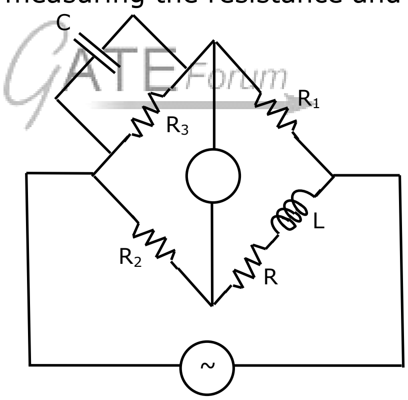
13. In figure, calculate



(a) the power delivered by each source
(b) the power dissipated in each resistor

14. The current coil of a wattmeter is connected in series with the 5H inductance, and its pressure coil is connected across the 8 Ohm resistance as shown in figure. The resistance of the branch AB is negligible and the pressure coil takes negligible current. Calculate the reading of the wattmeter and the energy stored in the inductor.

15. Figure shows a bridge for measuring the resistance and inductance of a choke.



(a) Write down the condition for bridge balance and obtain expressions for R and L.
(b) If the resistors R_1, R_2 and R_3 can have a variation of $\pm 0.2\%$ and C a variation of $\pm 0.1\%$ from their nominal values, estimate the percentage error in the evaluation of R and L.

16. For the system shown in figure, obtain a state variable representation in the form:

$$\dot{X} = Ax + bu$$
$$Y = Cx + du$$

The elements x_1 and x_2 of the state vector are shown in the figure. Making use of the state variable representation, obtain the transfer function $\frac{Y(s)}{X(s)}$ for the system.

17. A unity feedback system has the forward loop transfer function

$$KG(s) = \frac{K(s+2)^2}{s^2(s-1)}$$

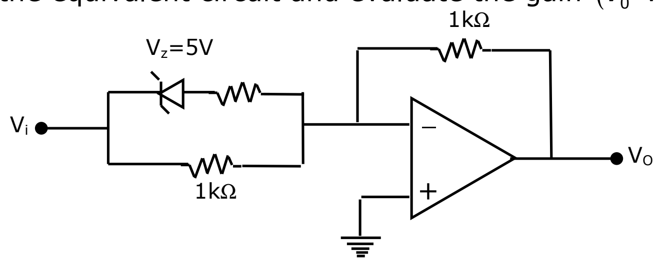
(a) Determine the range of K for stable operation

(b) Determine the imaginary axis crossover points.

(c) Without calculating the real axis break-away points. Sketch the form of root loci for the system.

18. In figure shown, assume the zener diode and the operational amplifier to be ideal.

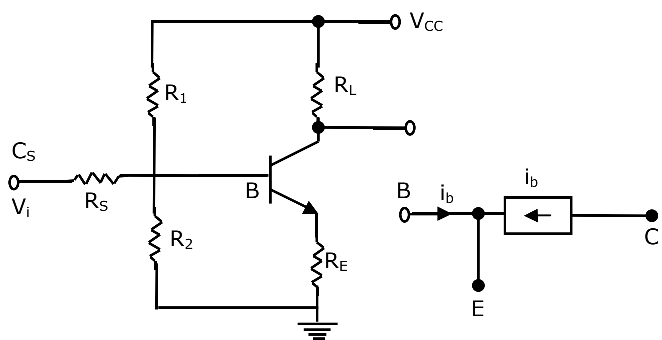
(a) Draw the equivalent circuit and evaluate the gain $(V_0 \text{ vs } V_i)$ of the circuit for



(i) $V_i \le 0$ (ii) $0 < V_i \le 5V$ (iii) $5V < V_i$

(b) Sketch the gain $(V_0 \text{ vs } V)$ characteristics of the above circuit and lable the salient features.

19. Figure shows a common emitter amplifier.



(a) Simplify the circuit by applying Thevenin's theorem to the biasing network R_1, R_2 at the base of the transistor.

(b) Assuming C_s to be a short for the frequency range considered. Draw the small signal a.c. model of the circuit obtained in (a) by using the simple model for the transistor shown in figure.

(c) Evaluate the small signal gain $\left(\frac{V_o}{V_i}\right)$ of the amplifier.