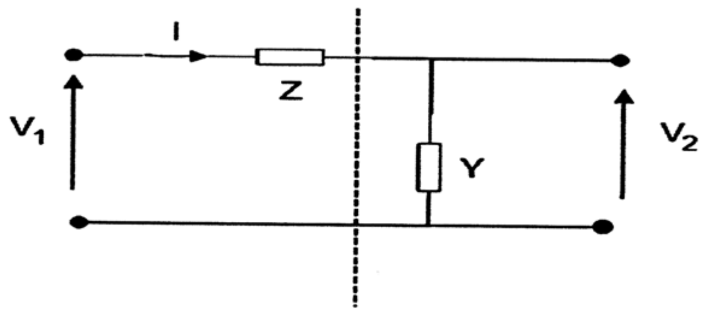
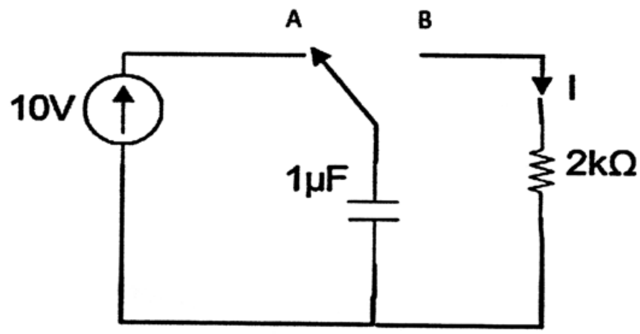
1. Define the T-parameter of a two-port network. Determine the T-parameters of the half T-network shown in the figure below. (5 Marks)

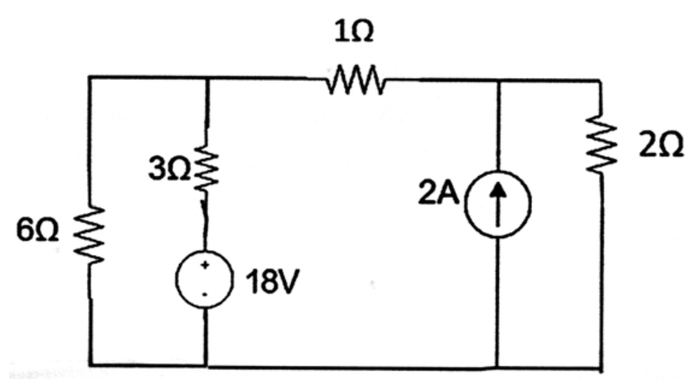


2. The switch in the circuit shown in the figure below has been in position A for a long time. Derive the equation describing how the current I through the resistor will vary with time when the switch is moved from A to B. Sketch the current responses. (5 Marks)



3. Explain why, at resonance in a series RLC circuit, the voltage across the capacitor may significantly exceed the source voltage. Determine the critical frequency at which the capacitor voltage reaches its maximum value. (5 Marks)

4. Determine the power dissipated in the 2 Ω resistor of the figure by applying the superposition principle. The voltage and current sources are treated as ideal sources. (5 Marks)



5. A point charge of 10 μC is shifted from infinity to a point P in an electric field with zero acceleration. If the electric potential at point P is 600 V, then : (5 Marks)

(a) Find the work done by the external agent against the electric field.

(b) Find the work done by the electric field.

(c) If the kinetic energy of the charge increases by 5 mJ when it is brought from infinity to point P, find the total work done by the external agent.

(d) If a point charge of 25 μC is released from rest at point P, find its kinetic energy at a large distance.

6. A parallel-plate capacitor with plate area A and separation d is connected to a DC voltage source V and initially contains air between its plates. The capacitor is then disconnected from the supply, and a dielectric material of relative permittivity εr is completely inserted between the plates.

Explain qualitatively and mathematically how the insertion of the dielectric affects the following quantities :

(a) Capacitance of the capacitor

(b) Charge on the capacitor plates

(c) Electric field intensity between the plates

(d) Potential difference across the plates

(e) Energy stored in the capacitor (5 Marks)

7. A long straight current-carrying conductor lies along the x-axis and carries a steady current I. A small circular conducting loop of radius r is placed near the wire such that its centre lies at a distance d from the wire, and the plane of the loop is perpendicular to the wire.

Using Biot-Savart's law, prove how the magnetic field from a straight conductor varies across the area of a loop. Is the magnetic field over the loop uniform or non-uniform? Discuss with justification. (5 Marks)

8. Examine the benefits of a transformer-coupled class A power amplifier. Consider RL as the load resistance connected to the secondary of the transformer. Derive the expression for the effective resistance observed from the primary side of the transformer. (5 Marks)

9. Will oscillations occur if the bridge is balanced in a Wien bridge oscillator? Derive the frequency of oscillation under the conditions necessary for oscillation in the Wien bridge oscillator. (5 Marks)

10. Why is the control terminal of a 555 timer connected to ground through a 0.01 microfarad bypass capacitor? What must be the relationship between the pulse width tp and the period T of the input trigger signal if 555 is to be used as a divide-by-4 network. (5 Marks)

11. Design an op-amp circuit to provide an output voltage proportional to the rate of change of the input voltage. Explain the method used to overcome the problem of instability and susceptibility to high-frequency noise. (5 Marks)

12. Compare RTL, TTL, ECL, NMOS and CMOS logic families with reference to speed power dissipation and noise immunity. (5 Marks)

13. Draw the truth tables of two input OR, AND, NAND and NOR gates. Which of them are called universal gates? Why they are called so? (5 Marks)

14. What are the main elements of a successive approximation register A/D convertor? Briefly explain the function of each element and mention the advantages of SAR A/D convertor. (5 Marks)

15. A single-phase half-controlled bridge rectifier feeds a purely resistive load from a 240 V (rms) AC supply. When the firing angle is $\alpha = 0°$, the average load current is found to be 12 A. The average current through each controlled switch is half of the average load current. Switching losses are neglected.

    (a) The bridge uses two thyristors (each with on-state voltage drop = 1.2 V) and two diodes. Calculate the total average conduction loss in the two thyristors. (2.5 Marks)

    (b) If the thyristors are replaced by IGBTs having $V_{CE(sat)}$ = 2.4 V, determine the total average conduction loss in the two IGBTs. (2.5 Marks)

16. An ideal inverting buck–boost converter operates from a 24 V DC input and produces an output of 48 V. The converter has L = 100 μH, switching frequency f = 100 kHz, and load resistance R = 10 Ω.

(a) Assuming continuous conduction mode (CCM), determine the duty cycle D. (2.5 Marks)

(b) Using the given parameters, verify whether the converter operates in CCM or DCM. (2.5 Marks)

17. A three-phase Voltage Source Inverter (VSI) feeds a star-connected pure resistive load with per-phase resistance R = 10 Ω from a DC source of V_{dc} = 600 V.

(a) The inverter operates in 180° square-wave conduction mode. Calculate the RMS value of the phase current and the total power delivered to the load (P). (2.5 Marks)

(b) The inverter is now switched to Sinusoidal Pulse Width Modulation (SPWM) with modulation index m_a = 0.6. Calculate the RMS value of the fundamental phase voltage. (Given $\sqrt{2} \approx 1.414$) (2.5 Marks)

18. A single-phase full-wave uncontrolled diode bridge rectifier is supplied from a 230V (rms), 50 Hz sinusoidal AC source. Assume ideal diodes and neglect source impedance.

(a) For a purely resistive load R = 20 Ω, determine the RMS value of the input current I_s, and the RMS value of its fundamental component I_1. (2.5 Marks)

(b) For a highly inductive load with perfectly constant output current I_o, determine :

(i) the RMS value of the input current I_s.

(ii) the RMS value of the fundamental component I_1.

(iii) the total harmonic distortion (THD) of the input current.

(Given $\sqrt{2} \approx 1.414$ and $\sqrt{\pi^2 - 8} \approx 1.367$) (2.5 Marks)

19. Given $x(t) = (t-1)[u(t-1) - u(t-3)]$. Find the signal $y(t) = x(2-t)$ and sketch both signals. (5 Marks)

20. For the system give by the difference equation $y[n]-0.4y[n-1]=x[n]$.

(a) Determine transfer function. (2 Marks)

(b) Find impulse response (2 Marks)

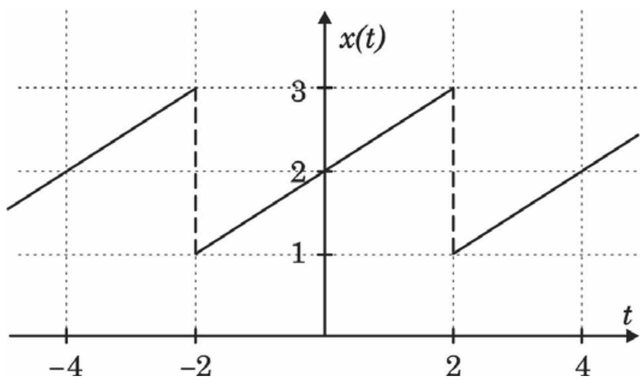
(c) Test stability. (1 Mark)

21. A periodic signal is given by $x(t)=2+\frac{1}{2}t, -2<t<2$, with period $T=4$ and $y(t+T)=y(t)$.

(a) Determine fundamental frequency (1 Mark)

(b) Find complex Fourier coefficients. (3 Marks)

(c) Compute the average power. (1 Mark)



22. Given $x(t)=4\cos(40\pi t)+3\sin(80\pi t)$

(a) Determine Nyquist rate of the signal $x(t)$. (2 Marks)

(b) Compute the RMS value of the signal $x(t)$. (1 Mark)

(c) Find Laplace transform of the signal $x(t)$. (2 Marks)

23. Consider the feedback control system with forward path transfer function $G(s)=\frac{10(s+2)}{s(s+1)(s+4)}$ and feedback path $H(s)=1+\frac{2}{s}$. Using block diagram reduction technique, obtain the closed-loop transfer function $T(s)=\frac{C(s)}{R(s)}$. Also, determine the steady-state error to a unit step input. (5 Marks)

24. A unity feedback control system has the open-loop transfer function $G(s) = \dfrac{K}{s(s+3)(s^2+4s+5)}$.

(a) Apply the Routh-Hurwitz stability criterion to determine the range of gain K for which the closed-loop system is stable. (2.5 Marks)

(b) For $K = 12$, state how many roots of the characteristic equation lie in the right half of the s-plane (if any). (2.5 Marks)

25. For the open-loop transfer function $G(s)\ H(s) = \dfrac{10}{s(s+2)}$, determine using basic Bode approximation rules (no plots required) :

(a) The system type. (1 Mark)

(b) The low-frequency magnitude slope. (1 Mark)

(c) The corner (break) frequency. (1 Mark)

(d) The high-frequency magnitude slope. (1 Mark)

(e) The approximate phase at very low and very high frequencies. (1 Mark)

26. A unity feedback system has open-loop transfer function $G(s) = \dfrac{K}{s(s+2)}$.

Design a lead compensator $G_c(s) = K_c \dfrac{s+z}{s+p}$, $p > z$ so that the dominant closed-loop pole lies approximately at $s = -1 \pm 1j$. Assume only a small practical lead compensation is required. Determine approximate values of the compensator zero z and pole p. (5 Marks)

27. Three resistors have the following ratings : $R_1 = 5\ \Omega \pm 5\%$, $R_2 = 10\ \Omega \pm 5\%$, $R_3 = 50\,\Omega \pm 5\%$. Determine the magnitude and limiting error in ohm and in percent of the resistance if these resistances are connected in series. (5 Marks)

28. Draw the equivalent circuit and phasor diagram of a potential transformer. (5 Marks)

29. (a) Draw the circuit diagram of a basic slide wire potentiometer.

(b) A simple slide wire is used for measurement of current in a circuit. The voltage drop across a standard resistor of 0.1 Ω is balanced at 20 cm. Find the magnitude of current if the standard cell emf of 1.5 V in balanced at 10 cm. (5 Marks)

30. Explain how wien's bridge can be used for experimental determination of frequency. Derive the expression for frequency in fams of bridge parameters. (5 Marks)

31. Deduce ABCD constants for normal T model of a medium transmission line. (5 Marks)

32. Show that per unit equivalent impedance of a two winding transformer is the same whether the calculation is made from high voltage side or low voltage side. (5 Marks)

33. What are the advantages of series compensation? List any two problems associated with series capacitors. (5 Marks)

34. Two generating units are supplying a total load of 200 MW. The cost characteristics of units are

$C1 = 100 + 2P_1 + 0.05_1^2$ z/h

$C_2 = 150 + 1.5P_2 + 0.04P_2^2$ z/h. where P_1 and P_2 are the power outputs in MW. Find the optimal power outputs of the units to minimize the total cost, assuming no transmission losses. Given $0 \le P_1 \le 100$ MW and $0 \le P_2 \le 150$ MW. (5 Marks)

35. Explain equal area criterion and how it may be used to study the stability of a two-machine system. (5 Marks)

36. The primary and secondary windings of a 40 kVA, 3300/250 V single phase transformer have resistances of 10 Ω and 0.02 Ω respectively. The leakage reactance of the transformer referred to the primary side is 30 Ω. Calculate the percentage voltage regulation of the transformer when supplying full load current at a pf of 0.8 lagging. (5 Marks)

37. A shunt generator supplies 98 A at a terminal voltage of 200 V. The armature and shunt field resistances are 0.1 Ω and 100 Ω respectively. The iron and frictional losses are 2800 W. Find (a) emf generated (b) Copper losses (c) Commercial efficiency. (5 Marks)

38. A dc series motor having a resistance of 1 Ω drives a fan for which the torque varies as the square of the speed. At 230 V, the set suns at 320 rpm and takes 28 A. The speed is to be raised to 480 rpm by increasing the voltage. Determine the necessary voltage and the corresponding current assuming the field to be unsaturated. (5 Marks)

39. The ratio of maximum torque to full load torque in a 3-phase squirrel cage induction motor is 2.5. Calculate the ratio of starting torque to full load torque for direct on line starting. The rotor resistance is 0.1 Ω/phase and rotor standstill reactance is 1 Ω/phase. (5 Marks)

40. (a) List any four advantages of parallel operation of alternator.

(b) What are the conditions for paralleling alternator with infinite busbars? (5 Marks)