Electronic Circuits & Networks (4331101) - Winter 2022 Solution

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February 23, 2023

Question 1(a) [3 marks]

Question Question 1(a) [3 marks]

marks

Define: 1) Branch 2) Junction 3) Mesh

Solution

- **Branch**: A branch is a single circuit element or a combination of elements connected between two nodes of a network.
- **Junction**: A junction (or node) is a point in a circuit where two or more circuit elements are connected together.
- **Mesh**: A mesh is a closed path in a network where no other closed path exists inside it.

Mnemonic

"BJM: Branches Join at junctions to Make meshes"

Question 1(b) [4 marks]

Question Question 1(b) [4 marks]

marks

Write voltage division and current division rule with necessary circuit diagram

Solution

Voltage Division Rule: In a series circuit, voltage across any component is proportional to its resistance.

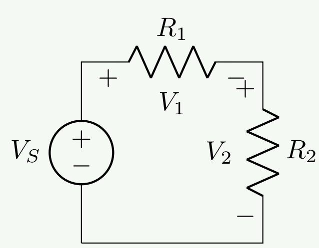


Figure 1. Voltage Division Circuit

- **Formula**: $V_1 = V_S \times \frac{R_1}{R_1+R_2}$
- **Application**: Used to find individual voltage drops across series components

Current Division Rule: In a parallel circuit, current through any branch is inversely proportional to its resistance.

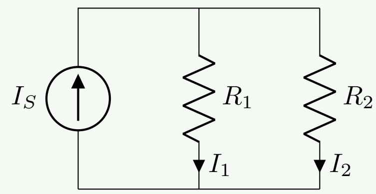


Figure 2. Current Division Circuit

- **Formula**: $I_1 = I_S \times \frac{R_2}{R_1+R_2}$
- **Key concept**: Current takes path of least resistance

Mnemonic

"VoSe CuPa: Voltage divides in Series, Current divides in Parallel"

Question 1(c) [7 marks]

Question Question 1(c) [7 marks]

marks

Draw Graph and Tree for a network shown in fig(1). Show link currents on a graph. Also write Tie-set schedule for a tree of network shown in fig. (1)

Solution

Graph of the Network:

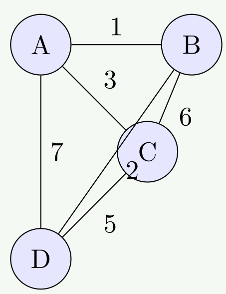


Figure 3. Graph of the Network

Tree of the Network (Twigs in solid, Links in dashed):

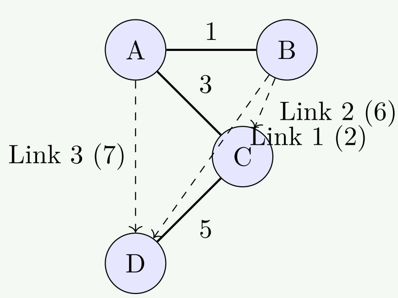


Figure 4. Tree and Links

Tie-set Schedule:

Link/Tree Branch	Br 1 (AB)	Br 3 (AC)	Br 4 (CD)	Br 2 (BD)	Br 6 (BC)	Br 7 (AD)	Br 5 (CD)
Link 1 (BD)	1	0	0	1	0	0	0
Link 2 (BC)	1	1	0	0	1	0	0
Link 3 (AD)	0	0	1	0	0	1	0
Link 4 (CD)	0	0	1	0	0	0	1

Mnemonic

"TGLT: Trees Generate Link-current Tie-sets"

Question 1(c) OR [7 marks]

Question Question 1(c) OR [7 marks]

marks

Draw Graph and Tree for a network shown in fig(1). Show branch voltages on tree. Also write cut-set schedule for a tree of network shown on fig.(1)

Solution

Graph of the Network: Same as above.
Tree of the Network:

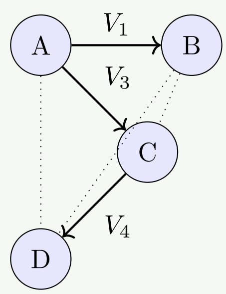


Figure 5. Tree with Branch Voltages

Cut-set Schedule:

Cut-set/Branch	Br 1 (AB)	Br 3 (AC)	Br 4 (CD)	Br 2 (BD)	Br 6 (BC)	Br 7 (AD)	Br 5 (CD)
Cut-set 1 (AB)	1	0	0	-1	-1	0	0
Cut-set 2 (AC)	0	1	0	0	1	-1	0
Cut-set 3 (CD)	0	0	1	1	0	1	1

Mnemonic

"CGVS: Cut-sets Generate Voltage Sources"

Question 2(a) [3 marks]

Question Question 2(a) [3 marks]

marks

Define: 1) Active and passive network 2)Unilateral and Bilateral network.

Solution

- **Active Network**: A network containing one or more sources of EMF (voltage/current sources) that supply energy to the circuit.
- **Passive Network**: A network containing only passive elements like resistors, capacitors, and inductors with no energy sources.
- **Unilateral Network**: A network in which the properties and performance change when input and output terminals are interchanged (e.g., diode circuits).
- **Bilateral Network**: A network in which the properties and performance remain unchanged when input and output terminals are interchanged (e.g., resistor circuits).

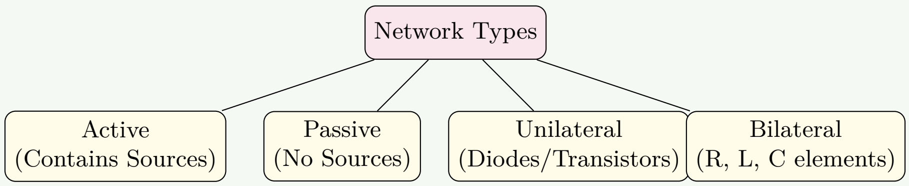


Figure 6. Network Classification

Mnemonic

"APUB: Active Provides energy, Unilateral Blocks reversal"

Question 2(b) [4 marks]

Question Question 2(b) [4 marks]

marks

Write equation for Z parameter and derive Z11, Z12, Z21, Z22 from that equation.

Solution

Z-parameters define the relationship between port voltages and currents in a two-port network:
Equations:

$$V_1 = Z_{11}I_1 + Z_{12}I_2$$
$$V_2 = Z_{21}I_1 + Z_{22}I_2$$

Derivation:

- $Z_{11} = \frac{V_1}{I_1}\Big|_{I_2=0}$: Input impedance with output port open-circuited.
- $Z_{12} = \frac{V_1}{I_2}\Big|_{I_1=0}$: Reverse transfer impedance with input port open-circuited.
- $Z_{21} = \frac{V_2}{I_1}\Big|_{I_2=0}$: Forward transfer impedance with output port open-circuited.
- $Z_{22} = \frac{V_2}{I_2}\Big|_{I_1=0}$: Output impedance with input port open-circuited.

Mnemonic

"Z Impedance: Open circuit gives correct Parameters"

Question 2(c) [7 marks]

Question Question 2(c) [7 marks]

marks

Derive equation of characteristic impedance(ZOT) for a standard T network.

Solution

For a standard T-network:

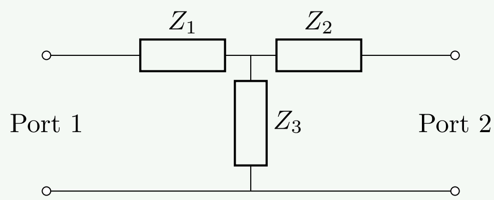


Figure 7. T-Network

Derivation Steps:

1. For a symmetric T-network, $Z_1 = Z_2$.
2. Under matched condition, input impedance equals characteristic impedance.
3. $Z_{0T} = Z_1 + \frac{Z_1 \times Z_3}{Z_1 + Z_3}$
4. For balanced T-network where series arms are $Z/2$ and shunt arm is Z:
5. $Z_{0T} = \frac{Z}{2} + \frac{\frac{Z}{2} \times Z}{\frac{Z}{2} + Z}$
6. $Z_{0T} = \frac{Z}{2} + \frac{Z^2/2}{3Z/2}$
7. $Z_{0T} = \frac{Z}{2} + \frac{Z}{3}$
8. $Z_{0T} = \frac{3Z+2Z}{6}$
9. $Z_{0T} = \sqrt{Z_1(Z_1 + 2Z_3)}$

Final Equation: $Z_{0T} = \sqrt{Z_1(Z_1 + 2Z_3)}$

Mnemonic

"TO Impedance: Two arms Over middle branch"

Question 2(a) OR [3 marks]

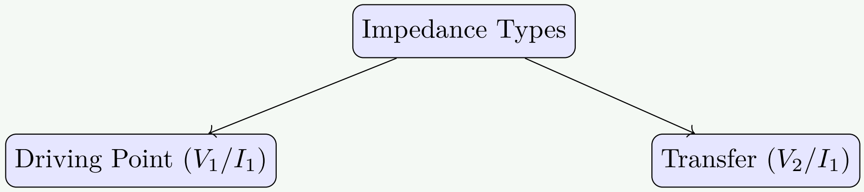
Question Question 2(a) OR [3 marks]

marks

Define: 1)Driving point impedance 2) Transfer impedance

Solution

- **Driving Point Impedance**: The ratio of voltage to current at the same port/pair of terminals when all other independent sources are set to zero ($Z_{11} = V_1/I_1$).
- **Transfer Impedance**: The ratio of voltage at one port to the current at another port when all other independent sources are set to zero ($Z_{21} = V_2/I_1$).



Mnemonic

"DTSS: Driving at Terminal Same, Transfer at Separate"

Question 2(b) OR [4 marks]

Question Question 2(b) OR [4 marks]

marks

Explain Kirchhoff's voltage law with example.

Solution

Kirchhoff's Voltage Law (KVL): The algebraic sum of all voltages around any closed loop in a circuit is zero.
Mathematically: $\sum V = 0$ (around a closed loop)
Circuit Example:

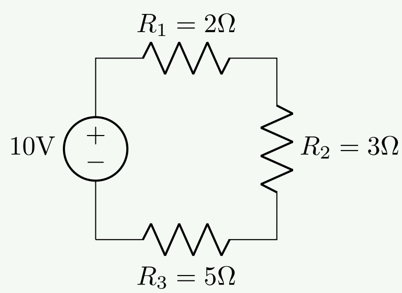


Figure 8. KVL Example Circuit

If $I = 1A$, then:

- $V_1 = 1A \times 2\Omega = 2V$
- $V_2 = 1A \times 3\Omega = 3V$
- $V_3 = 1A \times 5\Omega = 5V$

Applying KVL: $10V - 2V - 3V - 5V = 0$ ✓

Mnemonic

"VACZ: Voltages Around Closed loop are Zero"

Question 2(c) OR [7 marks]

Question Question 2(c) OR [7 marks]

marks

Derive equation to convert π network into T network.

Solution

π Network to T Network Conversion:

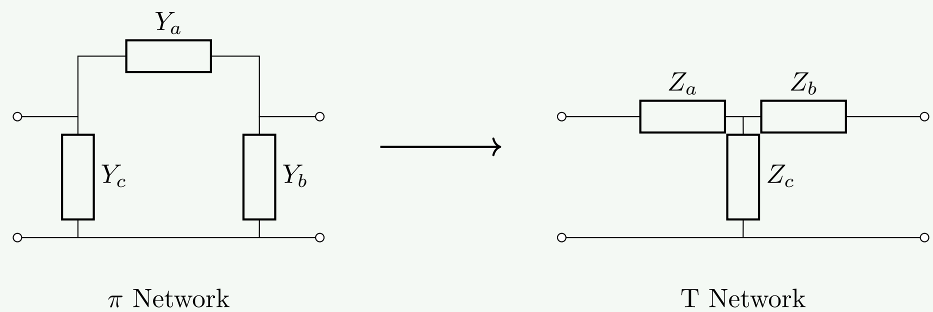


Figure 9. Conversion Diagram

Conversion Equations:
- $Z_a = \frac{Y_a \times Y_c}{Y_\Delta}$
- $Z_b = \frac{Y_b \times Y_c}{Y_\Delta}$
- $Z_c = \frac{Y_a \times Y_b}{Y_\Delta}$

Where $Y_\Delta = Y_a + Y_b + Y_c$

Derivation:
1. Start with Y-parameters of π-network
2. Express Y-parameters in terms of branch admittances
3. Convert to Z-parameters using matrix inversion
4. Express T-network impedances in terms of Z-parameters
5. Simplify to get the conversion formulas above

Mnemonic

"PIE to TEA: Product over sum for opposite branch"

Question 3(a) [3 marks]

Question Question 3(a) [3 marks]

marks

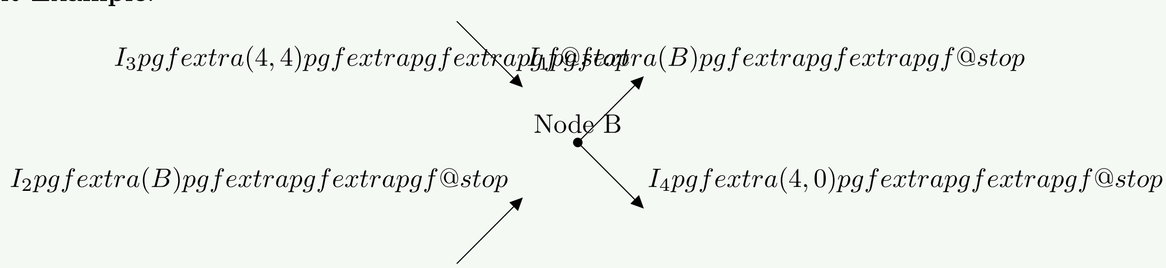
Explain Kirchhoff's current law with example.

Solution

Kirchhoff's Current Law (KCL): The algebraic sum of all currents entering and leaving a node must equal zero.

Mathematically: $\sum I = 0$ (at any node)

Circuit Example:



Applying KCL at node B:
- Currents entering: $I_1 + I_2 = 5A + 2A = 7A$

- Currents leaving: $I_3 + I_4 = 3A + 4A = 7A$
- Therefore: $I_1 + I_2 - I_3 - I_4 = 5 + 2 - 3 - 4 = 0$ ✓

Mnemonic

"CuNoZ: Currents at Node are Zero"

Question 3(b) [4 marks]

Question Question 3(b) [4 marks]

marks

Explain mesh analysis with required equations.

Solution

Mesh Analysis: A circuit analysis technique that uses mesh currents as variables to solve a circuit with multiple loops.
Steps:

1. Identify all meshes (closed loops) in the circuit
2. Assign a mesh current to each mesh
3. Apply KVL to each mesh
4. Solve the resulting system of equations

Example Circuit:

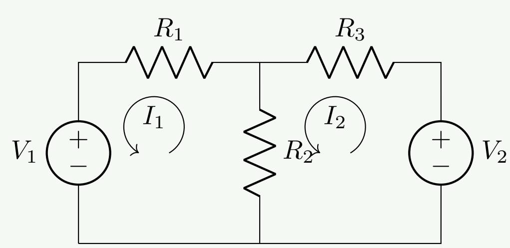


Figure 10. Mesh Analysis Example

Equations:

- Mesh 1: $V_1 = I_1R_1 + (I_1 - I_2)R_2$
- Mesh 2: $V_2 = I_2R_3 + (I_2 - I_1)R_2$

Mnemonic

"MILK: Mesh Is Loop with KVL"

Question 3(c) [7 marks]

Question Question 3(c) [7 marks]

marks

State and explain Thevenin's theorem.

Solution

Thevenin's Theorem: Any linear network with voltage and current sources can be replaced by an equivalent circuit consisting of a voltage source (V_{TH}) in series with a resistance (R_{TH}).

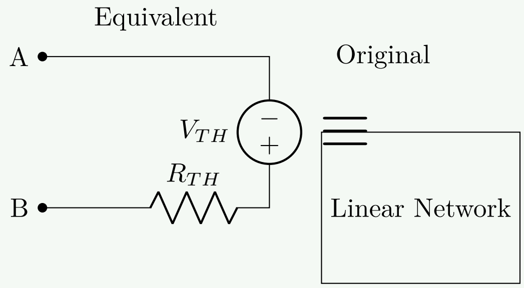


Figure 11. Thevenin Equivalent

Steps to Find Thevenin Equivalent:
1. Remove the load from the terminals of interest
2. Calculate the open-circuit voltage (V_{OC}) across these terminals ($= V_{TH}$)
3. Calculate the resistance looking back into the circuit with all sources replaced by their internal resistances ($= R_{TH}$)
4. The Thevenin equivalent consists of V_{TH} in series with R_{TH}

Mnemonic

"TORV: Thevenin's Open-circuit Resistance and Voltage"

Question 3(a) OR [3 marks]

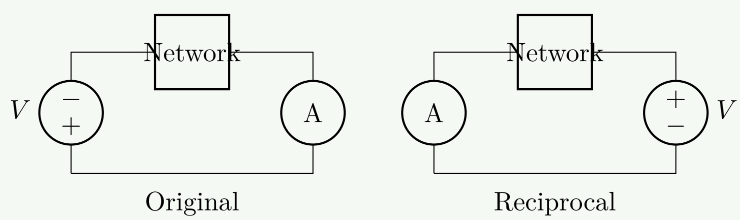
Question Question 3(a) OR [3 marks]

marks

State and explain reciprocity theorem.

Solution

Reciprocity Theorem: In a linear, bilateral network, if a voltage source in one branch produces a current in another branch, then the same voltage source, if placed in the second branch, will produce the same current in the first branch.



Mathematically: If a voltage V_1 in branch 1 produces current I_2 in branch 2, then voltage V_1 in branch 2 will produce current I_2 in branch 1.
Limitations: Applies only to networks with:
- Linear elements
- Bilateral elements (no diodes, transistors)
- Single independent source

Mnemonic

"RESWAP: REciprocity SWAPs Position with identical results"

Question 3(b) OR [4 marks]

Question Question 3(b) OR [4 marks]

marks

Explain nodal analysis with required equations.

Solution

Nodal Analysis: A circuit analysis technique that uses node voltages as variables to solve a circuit.
Steps:

1. Choose a reference node (ground)
2. Assign voltage variables to remaining nodes
3. Apply KCL at each non-reference node
4. Solve the resulting system of equations

Example Circuit:

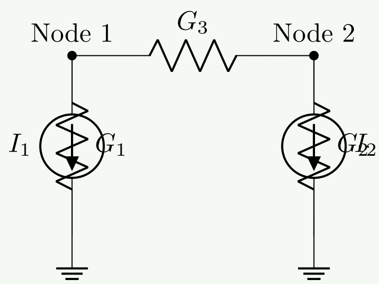


Figure 12. Nodal Analysis

Equations:

- Node 1: $I_1 = V_1G_1 + (V_1 - V_2)G_3$
- Node 2: $I_2 = V_2G_2 + (V_2 - V_1)G_3$

Mnemonic

"NKCV: Nodal uses KCL with Voltage variables"

Question 3(c) OR [7 marks]

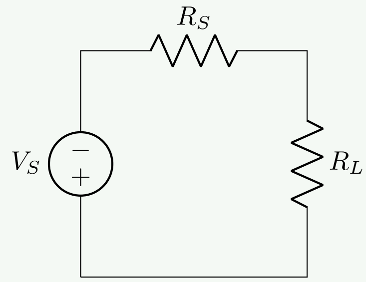
Question Question 3(c) OR [7 marks]

marks

State and prove maximum power transfer theorem.

Solution

Maximum Power Transfer Theorem: A load connected to a source will extract maximum power when its resistance equals the internal resistance of the source.



Proof:

1. Current in the circuit: $I = \frac{V_S}{R_S+R_L}$
2. Power delivered to load: $P = I^2 R_L = \frac{V_S^2 R_L}{(R_S+R_L)^2}$
3. For maximum power, $\frac{dP}{dR_L} = 0$
4. Solving: $\frac{V_S^2(R_S+R_L)^2 - V_S^2 R_L \cdot 2(R_S+R_L)}{(R_S+R_L)^4} = 0$
5. Simplifying: $(R_S + R_L)^2 = 2R_L(R_S + R_L)$
6. Further simplifying: $R_S + R_L = 2R_L$
7. Therefore: $R_S = R_L$

Maximum Power: $P_{max} = \frac{V_S^2}{4R_S}$

Mnemonic

"MaRLRS: Maximum power when load Resistance equals Source Resistance"

Question 4(a) [3 marks]

Question Question 4(a) [3 marks]

marks

Why series resonance circuit act as voltage amplifier and parallel resonance circuit act as current amplifier?

Solution

Series Resonance as Voltage Amplifier:

- At resonance, series circuit impedance is minimum (just R)
- Voltage across L or C can be much larger than source voltage
- Voltage magnification factor = $Q = \frac{X_L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$
- Voltage across L or C = $Q\times$ Source voltage

Parallel Resonance as Current Amplifier:

- At resonance, parallel circuit impedance is maximum
- Current in L or C can be much larger than source current
- Current magnification factor = $Q = \frac{R}{X_L} = R\sqrt{\frac{C}{L}}$
- Current through L or C = $Q\times$ Source current

Table:

Circuit Type	Impedance at Resonance	Amplification
Series	Minimum (R only)	Voltage (V_L or $V_C = Q \times V_S$)
Parallel	Maximum (R^2/r)	Current (I_L or $I_C = Q \times I_S$)

Mnemonic

"SeVoPa: Series Voltage, Parallel current amplification"

Question 4(b) [4 marks]

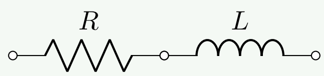
Question Question 4(b) [4 marks]

marks

Derive equation of Q of coil.

Solution

Q-factor of a Coil:



Derivation:

1. Q-factor is defined as: $Q = \frac{\text{Energy stored}}{\text{Energy dissipated per cycle}}$
2. Energy stored in inductor $= \frac{1}{2}LI^2$
3. Power dissipated in resistor $= I^2R$
4. Energy dissipated per cycle = Power × Time period $= I^2R \times \frac{1}{f}$
5. Therefore: $Q = \frac{\frac{1}{2}LI^2}{I^2R\times\frac{1}{f}}$
6. Simplifying: $Q = \frac{2\pi\times\frac{1}{2}LI^2\times f}{I^2R}$
7. $Q = \frac{2\pi f\times L}{R} = \frac{\omega L}{R}$

Final Equation: $Q = \frac{\omega L}{R} = \frac{2\pi f L}{R} = \frac{X_L}{R}$

Mnemonic

"QualityEDR: Quality equals Energy stored Divided by energy lost per Radian"

Question 4(c) [7 marks]

Question Question 4(c) [7 marks]

marks

Derive equation of series resonance frequency for series R-L-C circuit.

Solution

Series R-L-C Circuit:

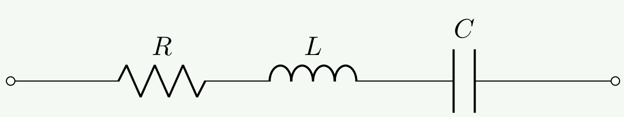


Figure 13. Series RLC Circuit

Derivation:

1. Impedance of series RLC circuit: $Z = R + j(X_L - X_C)$
2. Where: $X_L = \omega L$ and $X_C = \frac{1}{\omega C}$
3. At resonance, $X_L = X_C$ (inductive and capacitive reactances are equal)
4. Therefore: $\omega L = \frac{1}{\omega C}$
5. Solving for ω: $\omega^2 = \frac{1}{LC}$
6. Resonant frequency: $\omega_0 = \frac{1}{\sqrt{LC}}$
7. In terms of frequency f: $f_0 = \frac{1}{2\pi\sqrt{LC}}$

Characteristics at Resonance:

- Impedance is minimum (purely resistive: $Z = R$)
- Current is maximum ($I = V/R$)
- Power factor is unity (circuit appears resistive)
- Voltages across L and C are equal and opposite

Mnemonic

"RES: Reactances Equal at Series resonance"

Question 4(a) OR [3 marks]

Question Question 4(a) OR [3 marks]

marks

What is coupled circuits? Define self-inductance and mutual inductance.

Solution

Coupled Circuits: Two or more circuits that are magnetically linked such that energy can be transferred between them through their mutual magnetic field.

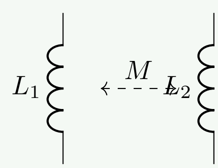


Figure 14. Coupled Coils

Self-inductance (L): The property of a circuit whereby a change in current produces a self-induced EMF in the same circuit. $L = \Phi/I$ (ratio of magnetic flux to the current producing it)
Mutual inductance (M): The property of a circuit whereby a change in current in one circuit induces an EMF in another circuit. $M = \Phi_{21}/I_1$ (ratio of flux in circuit 2 due to current in circuit 1)

Mnemonic

"SiMu: Self in Mine, Mutual in Yours"

Question 4(b) OR [4 marks]

Question Question 4(b) OR [4 marks]

marks

Derive equation for co-efficient of coupling (K).

Solution

Coefficient of Coupling (k):
Derivation:
1. The mutual inductance (M) between two coils depends on:
   - Self-inductances of the coils (L_1 and L_2)
   - Physical arrangement (proximity and orientation)
2. Maximum possible mutual inductance: $M_{max} = \sqrt{L_1 L_2}$

3. Coefficient of coupling is defined as: $k = \frac{M}{M_{max}}$
4. Therefore: $k = \frac{M}{\sqrt{L_1 L_2}}$

Characteristics:

- k ranges from 0 (no coupling) to 1 (perfect coupling)
- k depends on geometry, orientation, and medium
- Typical transformers: $k = 0.95$ to 0.99
- Air-core coils: $k = 0.01$ to 0.5

Mnemonic

"KMutual: K Measures Mutual linkage proportion"

Question 4(c) OR [7 marks]

Question Question 4(c) OR [7 marks]

marks

A series RLC circuit has R=30$\Omega, L = 0.5H, and C = 5\mu$**F. Calculate (i) series resonance frequency (2) Q Factor (3)BW**

Solution

Given:

- Resistance, $R = 30\Omega$
- Inductance, $L = 0.5H$
- Capacitance, $C = 5\mu F = 5 \times 10^{-6} F$

Calculations:

(i) Series Resonance Frequency:

- $f_0 = \frac{1}{2\pi\sqrt{LC}}$
- $f_0 = \frac{1}{2\pi\sqrt{0.5 \times 5 \times 10^{-6}}}$
- $f_0 = 100.76$ Hz ≈ 100 Hz

(ii) Q Factor:

- $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$
- $Q = \frac{1}{30}\sqrt{\frac{0.5}{5 \times 10^{-6}}}$
- $Q = 10.54$

(iii) Bandwidth (BW):

- $BW = \frac{f_0}{Q}$
- $BW = \frac{100.76}{10.54} = 9.56$ Hz

Table:

Parameter	Formula	Value
Resonant Frequency (f_0)	$\frac{1}{2\pi\sqrt{LC}}$	100 Hz
Quality Factor (Q)	$\frac{1}{R}\sqrt{\frac{L}{C}}$	10.54
Bandwidth (BW)	f_0/Q	9.56 Hz

Mnemonic

"RQB: Resonance Quality determines Bandwidth"

Question 5(a) [3 marks]

Question Question 5(a) [3 marks]

marks

Classify various types of attenuators.

Solution

Attenuators: Network of resistors designed to reduce (attenuate) signal level without distortion.
Types of Attenuators:

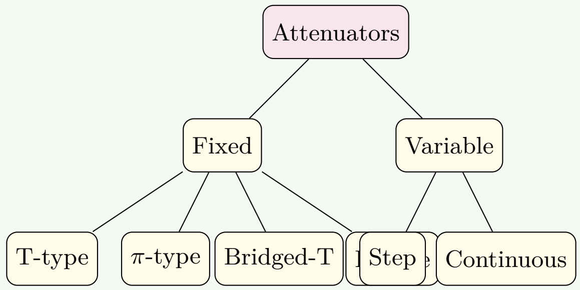


Figure 15. Classification of Attenuators

- **Based on configuration**: T-type, π-type, Bridged-T, Lattice
- **Based on symmetry**: Symmetrical (equal Z in/out), Asymmetrical

Mnemonic

"ATP Fixed: Attenuator Types include Pad, Tee, Lattice"

Question 5(b) [4 marks]

Question Question 5(b) [4 marks]

marks

Derive relation between attenuator and neper.

Solution

Relationship between Attenuation and Neper:
- **Attenuation (α)**: Ratio of input voltage (or current) to output voltage (or current).
- **Neper (Np)**: Natural logarithmic unit of ratios.

Derivation:
1. For a voltage ratio V_1/V_2:
   - Attenuation in Nepers $= \ln(V_1/V_2)$
   - Attenuation in Decibels $= 20\log_{10}(V_1/V_2)$
2. For a power ratio P_1/P_2:
   - Attenuation in Nepers $= \frac{1}{2}\ln(P_1/P_2)$
   - Attenuation in Decibels $= 10\log_{10}(P_1/P_2)$
3. Relationship between dB and Neper:
   - 1 Neper = 8.686 dB
   - 1 dB = 0.115 Neper

Table:

Unit	Voltage Ratio	Power Ratio
Neper (Np)	$\ln(V_1/V_2)$	$\frac{1}{2}\ln(P_1/P_2)$
Decibel (dB)	$20\log_{10}(V_1/V_2)$	$10\log_{10}(P_1/P_2)$

Mnemonic

"NED: Neper Equals Decibel divided by 8.686"

Question 5(c) [7 marks]

Question Question 5(c) [7 marks]

marks

Derive equations of R1 and R2 for symmetrical T attenuator.

Solution

Symmetrical T Attenuator:

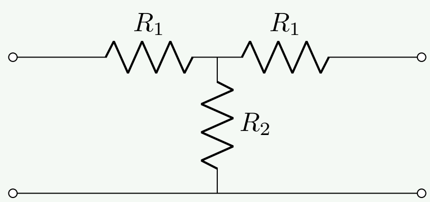


Figure 16. Symmetrical T Attenuator

Derivation:

1. For a symmetrical T-attenuator with characteristic impedance Z_0:
   - Input and output impedance must both equal Z_0
   - Attenuation ratio $N = V_1/V_2 = I_2/I_1$
2. From circuit analysis:
   - $R_1 = Z_0 \frac{N-1}{N+1}$
   - $R_2 = \frac{2Z_0 N}{N^2-1}$
3. For attenuation in dB (α):
   - $N = 10^{\alpha/20}$
   - $R_1 = Z_0 \tanh(\alpha/2)$
   - $R_2 = Z_0/\sinh(\alpha)$

Final Equations:

- $R_1 = Z_0 \frac{N-1}{N+1}$
- $R_2 = \frac{2Z_0 N}{N^2-1}$

Mnemonic

"TSR: T-attenuator Symmetry Requires equal R1 values"

Question 5(a) OR [3 marks]

Question Question 5(a) OR [3 marks]

marks

Draw circuit diagram of symmetrical Bridge T and symmetrical Lattice attenuator.

Solution

Symmetrical Bridge-T Attenuator:

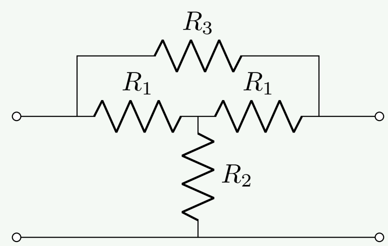


Figure 17. Bridge-T Attenuator

Symmetrical Lattice Attenuator:

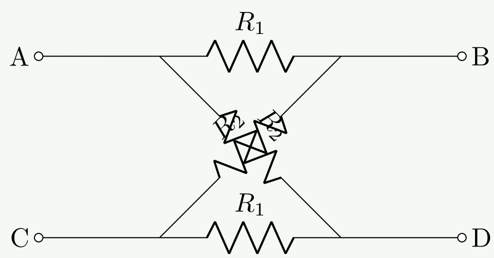


Figure 18. Lattice Attenuator

Characteristics:

- **Bridge-T**: Combines features of T and π attenuators.
- **Lattice**: Balanced configuration with excellent phase/frequency response.

Mnemonic

"BL-BA: Bridge Ladder, Balanced Attenuators"

Question 5(b) OR [4 marks]

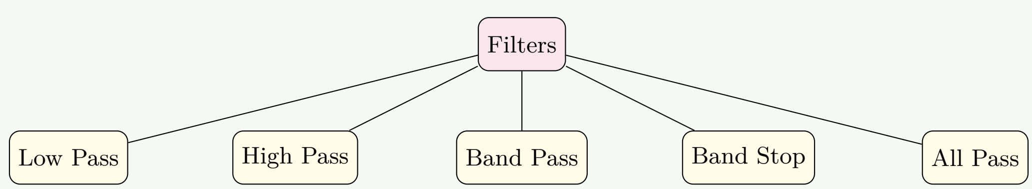
Question Question 5(b) OR [4 marks]

marks

Write classification of filter based on frequency with their frequency responses showing pass band and stop band.

Solution

Classification of Filters Based on Frequency:



Frequency Responses:

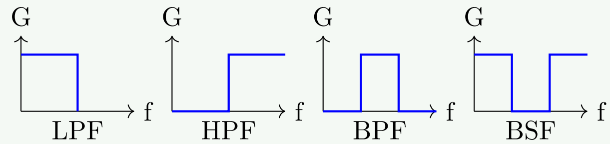


Figure 19. Ideal Frequency Responses

Mnemonic

"LHBBA: Low High Band-pass Band-stop All-pass"

Question 5(c) OR [7 marks]

Question Question 5(c) OR [7 marks]

marks

Draw the circuit for T-section and π-section constant-K low pass filter and Derive equation of cut-off frequency.

Solution

T-section Constant-K Low Pass Filter:

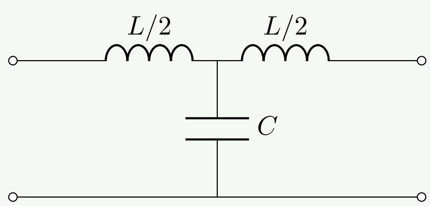


Figure 20. T-section LPF

π-section Constant-K Low Pass Filter:

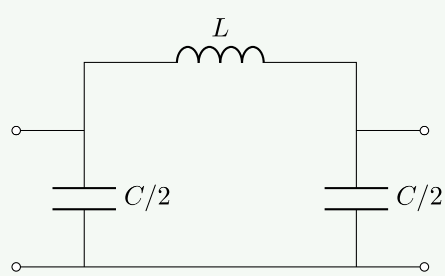


Figure 21. π-section LPF

Derivation of Cutoff Frequency:

1. For a constant-K filter:
   - $Z_1 \times Z_2 = R_0^2$ (characteristic impedance squared)
   - $Z_1 = j\omega L$ (series impedance)
   - $Z_2 = \frac{1}{j\omega C}$ (shunt impedance)
2. $R_0^2 = j\omega L \times \frac{1}{j\omega C} = \frac{L}{C} \implies R_0 = \sqrt{L/C}$
3. Pass band condition: $-1 < \frac{Z_1}{4Z_2} < 0$
4. At cutoff frequency: $\frac{\omega^2 LC}{4} = 1$
5. $\omega_c = \frac{2}{\sqrt{LC}}$
6. $f_c = \frac{1}{\pi\sqrt{LC}}$

Final Equation: $f_c = \frac{1}{\pi\sqrt{LC}}$

Mnemonic

"KCLP: Konstant-k Cutoff in Low Pass depends on L and C product"