Question 1(a) [3 marks]

Define (i) Node (ii) Branch and (iii) Loop for electronic network.

Answer:

Node:

- **Junction point** where two or more branches meet in a network
- Points where elements are connected together
- Current sum of all branches at a node equals zero

Branch:

- **Single element** (R, L, or C) or path connecting two nodes
- Each branch has a specific current flowing through it
- Active branches contain sources; passive branches contain R, L, C

Loop:

- **Closed path** in a network formed by connected branches
- No node is encountered more than once
- Used in loop analysis for solving networks

Mnemonic: "NBL: Nodes join, Branches connect, Loops circle"

Question 1(b) [4 marks]

Three resistors of 200 Ω, 300 Ω and 500 Ω are connected in parallel across 100 V supply. Find (i) Current flowing through each resistor and Total current (ii) Equivalent Resistance

Answer:

Table of Calculations:

Parameter	Formula	Calculation	Result
I_1 (200Ω)	I = V/R	100V/200Ω	0.5A
I_2 (300Ω)	I = V/R	100V/300Ω	0.333A
I_3 (500Ω)	I = V/R	100V/500Ω	0.2A
$I_{(total)}$	$I_1+I_2+I_3$	0.5+0.333+0.2	1.033A
$R_{(eq)}$	$1/R_{(eq)} = 1/R_1+1/R_2+1/R_3$	1/200+1/300+1/500	96.77Ω

Mnemonic: "Parallel paths divide current inversely with resistance"

Question 1(c) [7 marks]

Explain Series and Parallel connection for Capacitors

Answer:

Capacitors in Series:

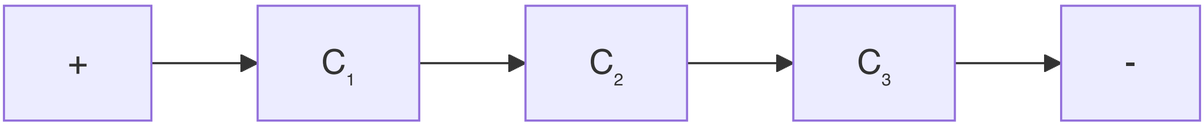


Table: Series Capacitors Properties

Property	Formula	Description
Equivalent Capacitance	$1/C_{(eq)} = 1/C_1 + 1/C_2 + 1/C_3$	Always smaller than smallest capacitor
Charge	$Q = Q_1 = Q_2 = Q_3$	Same on all capacitors
Voltage	$V = V_1 + V_2 + V_3$	Divides according to 1/C ratio
Energy	$E = CV^2/2$	Distributed across capacitors

Capacitors in Parallel:

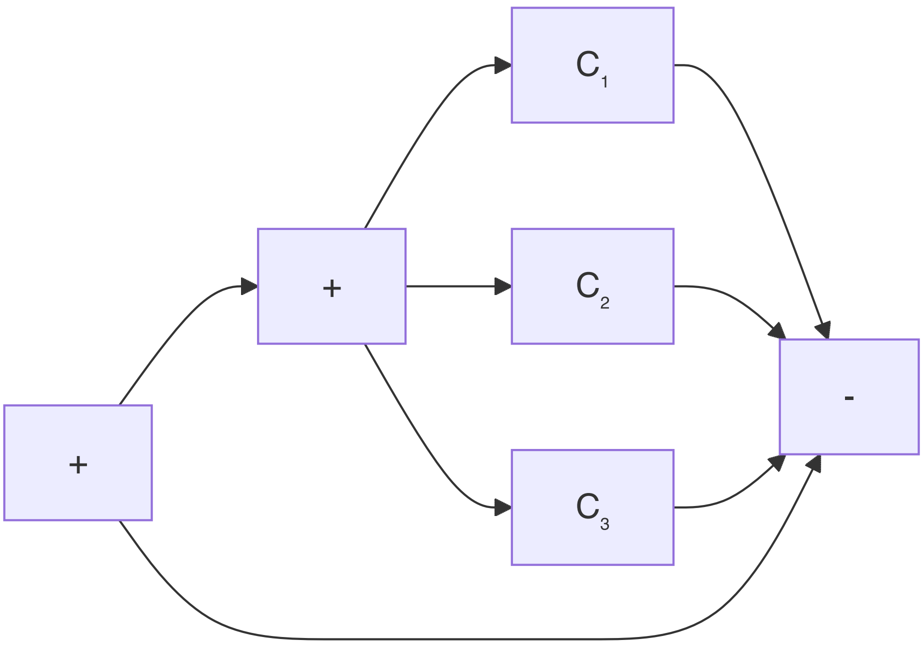


Table: Parallel Capacitors Properties

Property	Formula	Description
Equivalent Capacitance	$C_{(eq)} = C_1 + C_2 + C_3$	Sum of individual capacitances
Charge	$Q = Q_1 + Q_2 + Q_3$	Distributes according to C value
Voltage	$V = V_1 = V_2 = V_3$	Same across all capacitors
Energy	$E = CV^2/2$	Sum of individual energies

Mnemonic: "Series caps add reciprocally, parallel caps add directly"

Question 1(c) OR [7 marks]

Explain Series and Parallel connection for Inductors.

Answer:

Inductors in Series:

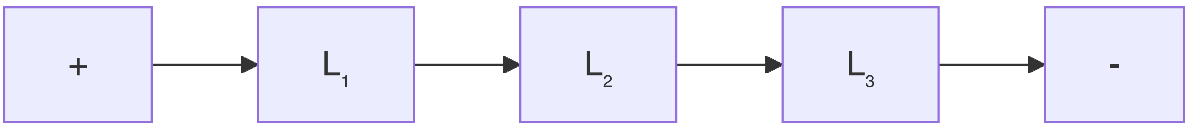


Table: Series Inductors Properties

Property	Formula	Description
Equivalent Inductance	$L_{(eq)} = L_1 + L_2 + L_3$	Sum of individual inductances
Current	$I = I_1 = I_2 = I_3$	Same through all inductors
Voltage	$V = V_1 + V_2 + V_3$	Divides according to L ratio
Energy	$E = LI^2/2$	Sum of individual energies

Inductors in Parallel:

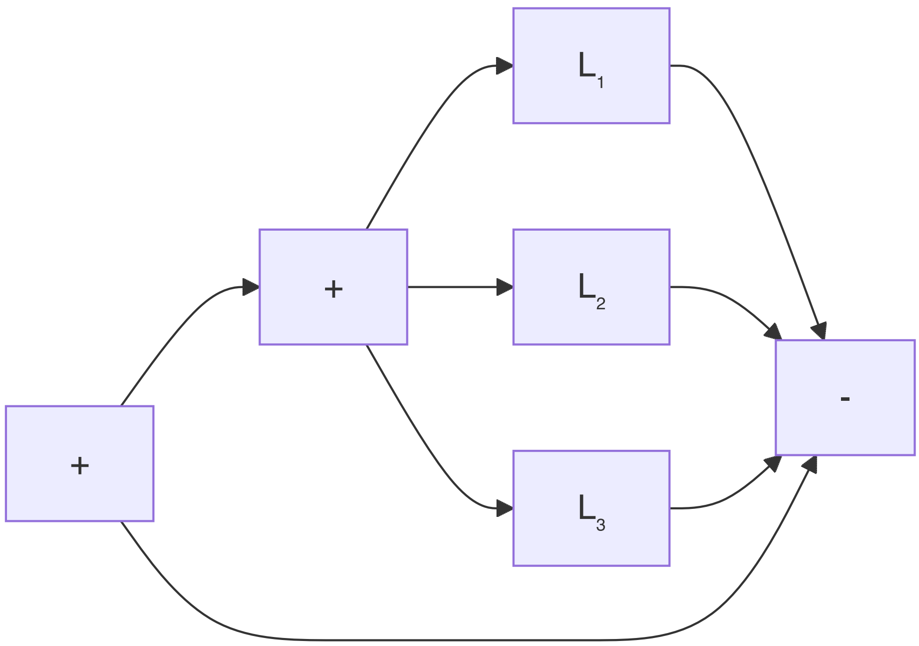


Table: Parallel Inductors Properties

Property	Formula	Description
Equivalent Inductance	$1/L_{(eq)} = 1/L_1 + 1/L_2 + 1/L_3$	Always smaller than smallest inductor
Current	$I = I_1 + I_2 + I_3$	Divides according to 1/L ratio
Voltage	$V = V_1 = V_2 = V_3$	Same across all inductors
Energy	$E = LI^2/2$	Distributed across inductors

Mnemonic: "Series inductors add directly, parallel inductors add reciprocally"

Question 2(a) [3 marks]

Classify network elements.

Answer:

Table: Classification of Network Elements

Category	Types	Examples
Active vs Passive	Active	Voltage/current sources, transistors
	Passive	Resistors, capacitors, inductors
Linear vs Non-linear	Linear	Resistors, ideal sources
	Non-linear	Diodes, transistors
Bilateral vs Unilateral	Bilateral	Resistors, capacitors, inductors
	Unilateral	Diodes, transistors
Lumped vs Distributed	Lumped	Discrete R, L, C components
	Distributed	Transmission lines

Mnemonic: "ALBU: Active/passive, Linear/non-linear, Bilateral/unilateral, lumped/distributed"

Question 2(b) [4 marks]

Three resistances of 10, 30 and 70 ohms are connected in star. Find equivalent resistances in delta connection.

Answer:

Diagram: Star to Delta Conversion

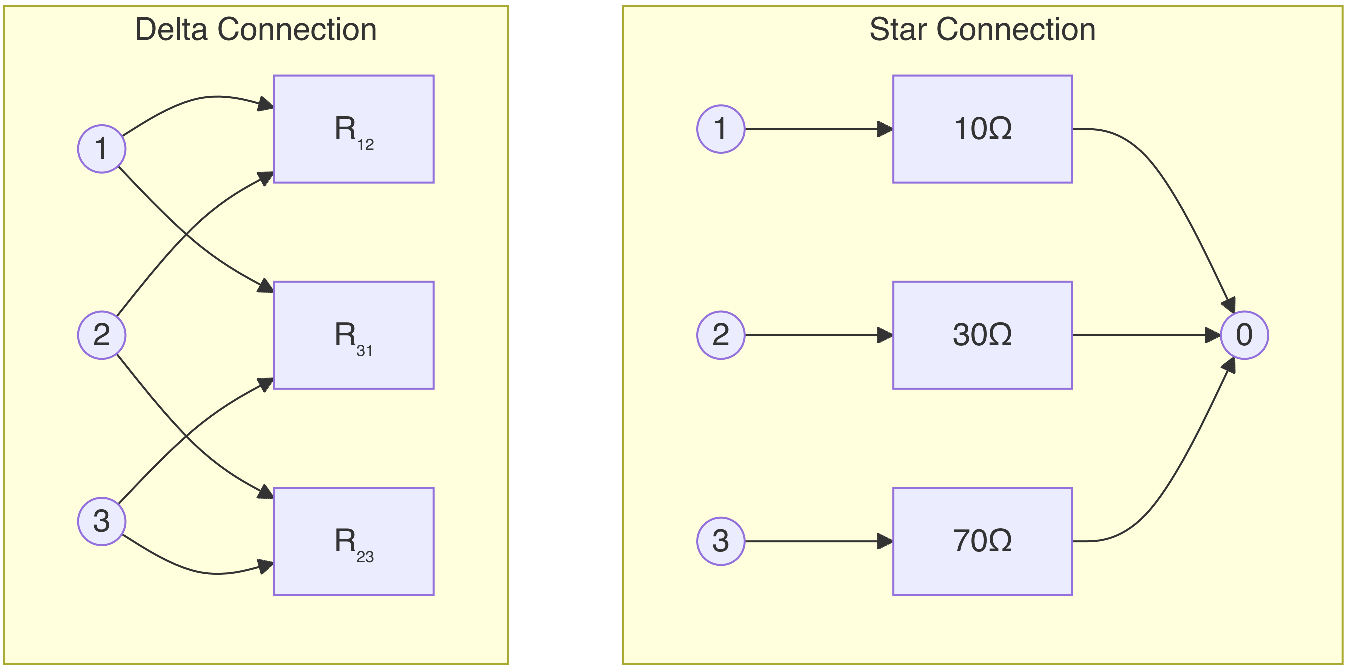


Table: Star-Delta Conversion Formulas and Calculations

Delta Resistance	Formula	Calculation	Result
R_{12}	$(R_1 \times R_2+R_2 \times R_3+R_3 \times R_1)/R_3$	(10×30+30×70+70×10)/70	47.14Ω
R_{23}	$(R_1 \times R_2+R_2 \times R_3+R_3 \times R_1)/R_1$	(10×30+30×70+70×10)/10	330Ω
R_{31}	$(R_1 \times R_2+R_2 \times R_3+R_3 \times R_1)/R_2$	(10×30+30×70+70×10)/30	110Ω

Mnemonic: "Star-Delta: Product sum over opposite resistor"

Question 2(c) [7 marks]

Explain π network.

Answer:

Diagram: π (Pi) Network

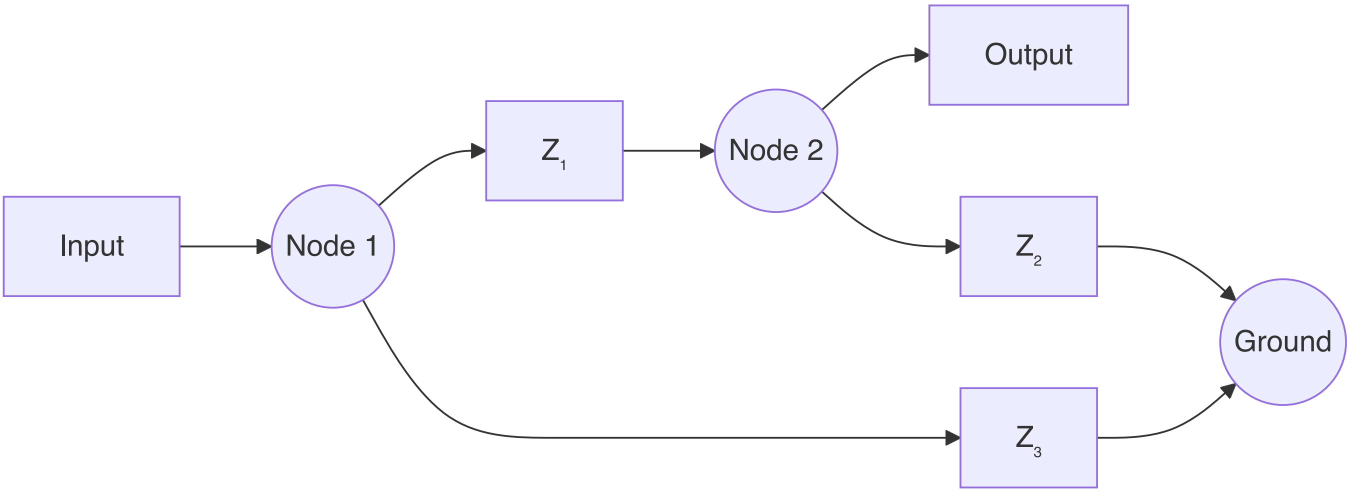


Table: π Network Characteristics

Parameter	Description
Structure	Two shunt impedances (Z_3, Z_2) and one series impedance (Z_1)
Transmission Parameters	$A = 1 + Z_1/Z_2$, $B = Z_1$, $C = 1/Z_2 + 1/Z_3 + Z_1/(Z_2 \times Z_3)$, $D = 1 + Z_1/Z_3$
Impedance Parameters	$Z_{11} = Z_1 + Z_3$, $Z_{12} = Z_1$, $Z_{21} = Z_1$, $Z_{22} = Z_1 + Z_2$
Image Impedance	$Z_0\pi = \sqrt{(Z_1Z_2Z_3/(Z_2+Z_3))}$
Applications	Matching networks, filters, attenuators
Conversion	Can be converted to T-network

Mnemonic: "π has two legs down, one branch across"

Question 2(a) OR [3 marks]

List the types of network.

Answer:

Table: Types of Networks

Category	Types
Based on Linearity	Linear Networks, Non-linear Networks
Based on Elements	Passive Networks, Active Networks
Based on Parameters	Time-variant, Time-invariant Networks
Based on Configuration	T-Network, π-Network, Lattice Network
Based on Ports	One-port, Two-port, Multi-port Networks
Based on Symmetry	Symmetrical, Asymmetrical Networks
Based on Reciprocity	Reciprocal, Non-reciprocal Networks

Mnemonic: "LEPCPS: Linearity, Elements, Parameters, Configuration, Ports, Symmetry"

Question 2(b) OR [4 marks]

Three resistances of 20, 50 and 100 ohms are connected in delta. Find equivalent resistances in star connection.

Answer:

Diagram: Delta to Star Conversion

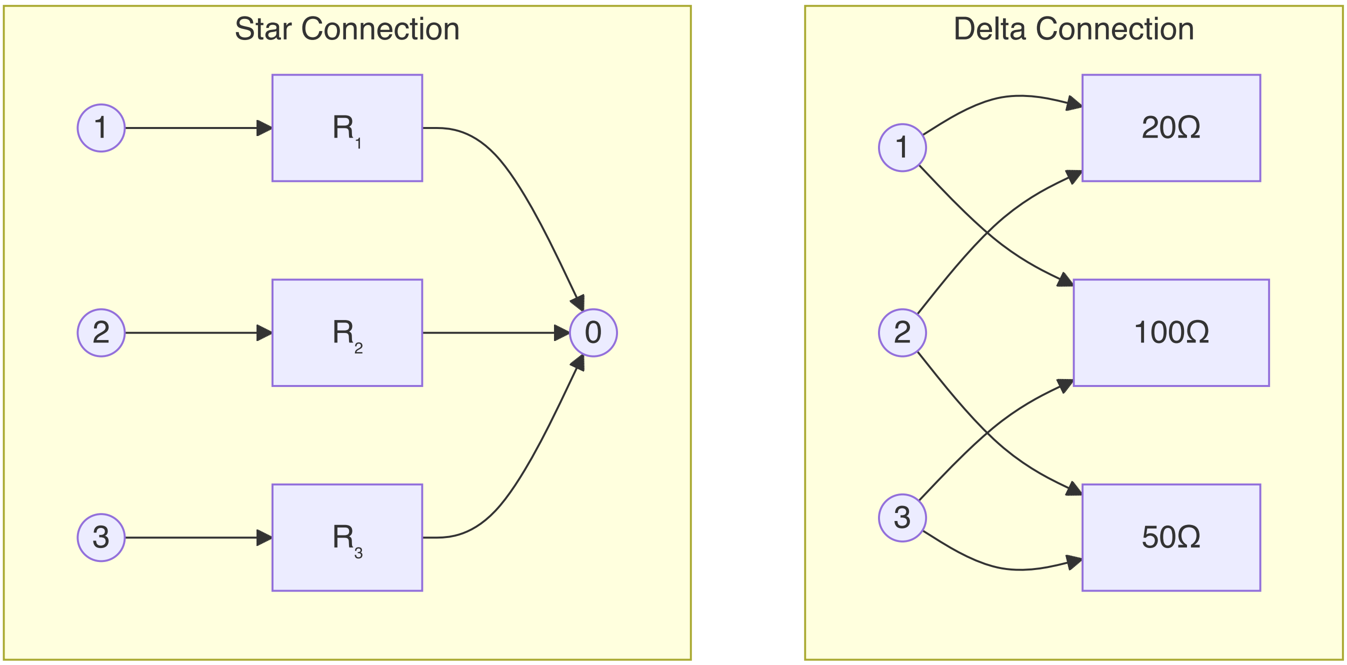


Table: Delta-Star Conversion Formulas and Calculations

Star Resistance	Formula	Calculation	Result
R_1	$(R_{12}\times R_{31})/(R_{12}+R_{23}+R_{31})$	(20×100)/(20+50+100)	11.76Ω
R_2	$(R_{12}\times R_{23})/(R_{12}+R_{23}+R_{31})$	(20×50)/(20+50+100)	5.88Ω
R_3	$(R_{23}\times R_{31})/(R_{12}+R_{23}+R_{31})$	(50×100)/(20+50+100)	29.41Ω

Mnemonic: "Delta-Star: Product of adjacent pairs over sum of all"

Question 2(c) OR [7 marks]

Explain T network.

Answer:

Diagram: T Network

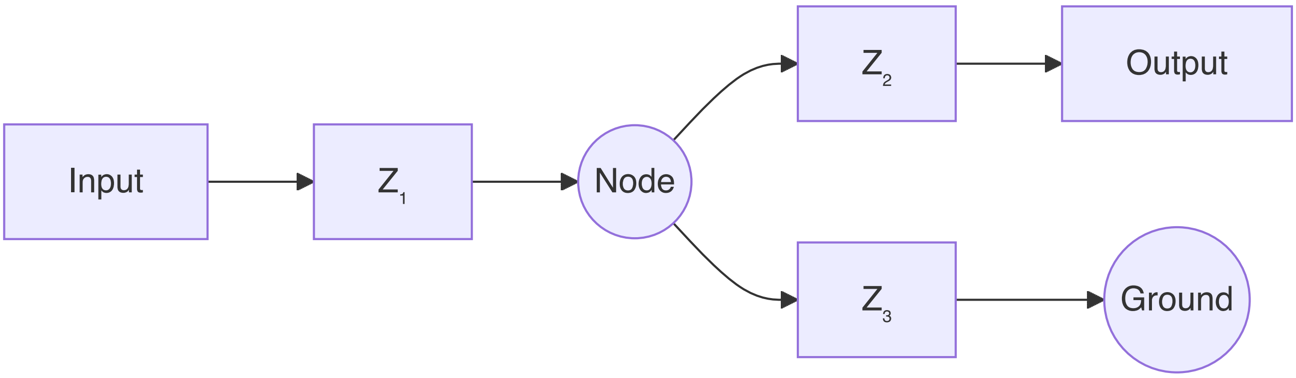


Table: T Network Characteristics

Parameter	Description
Structure	Two series impedances (Z_1, Z_2) and one shunt impedance (Z_3)
Transmission Parameters	$A = 1 + Z_1/Z_3$, $B = Z_1 + Z_2 + Z_1Z_2/Z_3$, $C = 1/Z_3$, $D = 1 + Z_2/Z_3$
Impedance Parameters	$Z_{11} = Z_1 + Z_3$, $Z_{12} = Z_3$, $Z_{21} = Z_3$, $Z_{22} = Z_2 + Z_3$
Image Impedance	$Z_0T = \sqrt{(Z_1Z_2 + Z_1Z_3 + Z_2Z_3)}$
Applications	Matching networks, filters, attenuators
Conversion	Can be converted to π-network

Mnemonic: "T has two arms across, one leg down"

Question 3(a) [3 marks]

Explain Kirchhoff's law.

Answer:

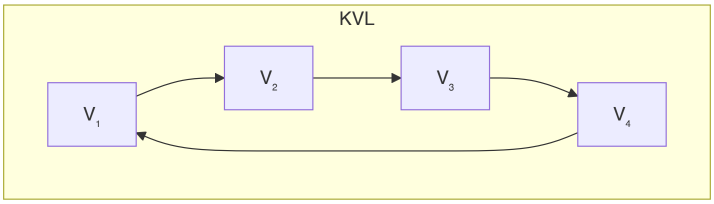
Kirchhoff's Current Law (KCL):

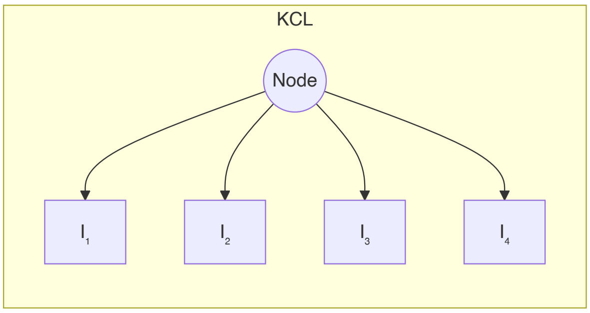
- **Sum of currents** entering a node equals sum of currents leaving it
- Algebraic sum of currents at any node is zero
- ∑I = 0 (currents entering positive, leaving negative)

Kirchhoff's Voltage Law (KVL):

- **Sum of voltage drops** around any closed loop equals zero
- ∑V = 0 (voltage rises positive, drops negative)
- Based on conservation of energy

Diagram of Kirchhoff's Laws:





Mnemonic: "Current converges, Voltage voyages in a loop"

Question 3(b) [4 marks]

Explain Nodal analysis.

Answer:

Diagram: Nodal Analysis Concept

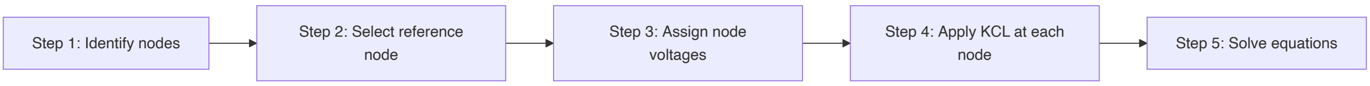


Table: Nodal Analysis Method

Step	Description
1. Select reference node	Usually ground (0V)
2. Assign voltages	Label remaining node voltages (V_1, V_2, etc.)
3. Apply KCL	Write KCL equation at each non-reference node
4. Express currents	Use Ohm's Law to express branch currents
5. Solve equations	Find node voltages using simultaneous equations

Example: For nodes with voltages V_1 and V_2:

- KCL at node 1: $(V_1-0)/R_1 + (V_1-V_2)/R_2 + I_1 = 0$
- KCL at node 2: $(V_2-V_1)/R_2 + (V_2-0)/R_3 + I_2 = 0$

Mnemonic: "Nodal needs KCL to analyze voltage"

Question 3(c) [7 marks]

Use Thevenin's theorem to find current through the 5 Ω resistor for given circuit.

Answer:

Diagram: Original Circuit and Thevenin Equivalent

```
+--+     +--+
|  |     |  |
12V 20Ω  8V 10Ω
|  |     |  |
+--+--+--+--+
    |      |
   +--+---+
      |
      5Ω
      |
     ---
      -
```

Steps to Find Thevenin Equivalent:

Table: Thevenin's Theorem Process and Calculations

Step	Process	Calculation	Result
1. Remove load (5Ω)	Calculate open-circuit voltage (Voc)	Voc = Voltage divider formula	Vth = 9.33V
2. Replace voltage sources with shorts	Calculate equivalent resistance (Req)	Req = 20Ω	
3. Draw Thevenin equivalent	Connect Vth and Rth in series with load		
4. Calculate load current	I = Vth/(Rth+RL)	I = 9.33/(6.67+5)	I = 0.8A

Mnemonic: "Thevenin transforms: Find Voc and Req, then calculate I"

Question 3(a) OR [3 marks]

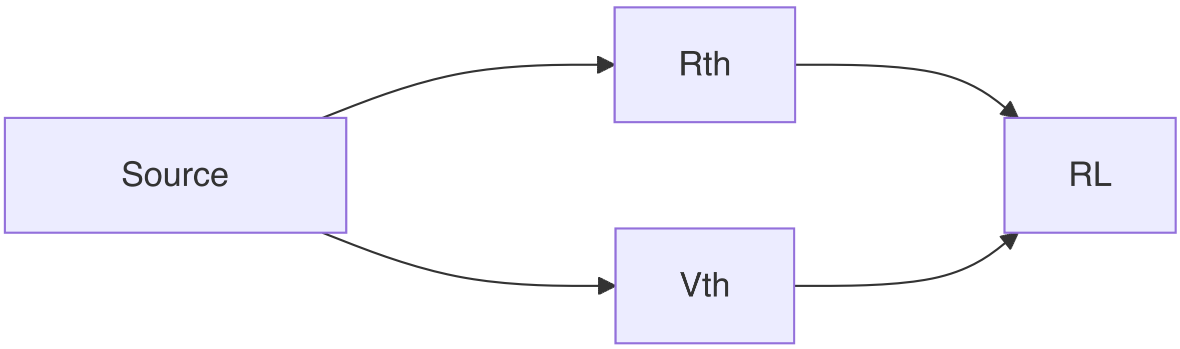
State and explain Maximum Power Transfer Theorem.

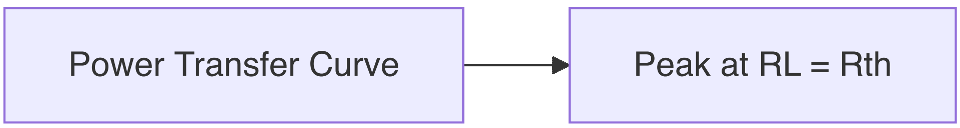
Answer:

Maximum Power Transfer Theorem:

- Maximum power is transferred from source to load when **load resistance equals source internal resistance** (RL = Rth)
- Only 50% efficiency is achieved at maximum power transfer
- Applies to DC and AC circuits (with complex impedances)

Diagram: Maximum Power Transfer





Formula: $P = (Vth^2 \times RL)/(Rth+RL)^2$

Mnemonic: "Match the load to the source for maximum power transfer"

Question 3(b) OR [4 marks]

Explain method of drawing dual network using any circuit.

Answer:

Diagram: Original and Dual Network Example

```
Original:       Dual:
R1              C1
o---www---o     o---||---o
|         |     |        |
C1        R2    L1       L2
|         |     |        |
o---||---o      o---www--o
    L1              R1
```

Table: Dual Network Conversion Rules

Original Element	Dual Element	Example
Series connection	Parallel connection	Series R → Parallel C
Parallel connection	Series connection	Parallel C → Series L
Voltage source	Current source	V source → I source
Current source	Voltage source	I source → V source
Resistor (R)	Conductance (1/R)	R → G (1/R)
Inductor (L)	Capacitor (1/L)	L → C (1/L)
Capacitor (C)	Inductor (1/C)	C → L (1/C)

Duality Process:

1. Redraw network with meshes as nodes and nodes as meshes
2. Replace elements with their duals
3. Interchange series and parallel connections

Mnemonic: "Duality swaps: Series↔Parallel, V↔I, R↔G, L↔C"

Question 3(c) OR [7 marks]

Find out Norton's equivalent circuit for the given network. Find out load current if (i) $R_{(L)}$ = 3 KΩ (ii) $R_{(L)}$ = 1.5 Ω

Answer:

Diagram: Original Circuit and Norton Equivalent

```
         +--+
         |  |
         6V 9KΩ
         |  |
     +---+--+-----+
     |            |
     3KΩ          6KΩ
     |            |
     +-----+------+
           |
          RL
           |
          ---
           -
```

Table: Norton's Theorem Process and Calculations

Step	Process	Calculation	Result
1. Calculate short-circuit current (Isc)	Short load terminals and find current	Isc = Source current through short	In = 0.5mA
2. Calculate Norton resistance (Rn)	Replace sources with internal resistance	Rn = 9KΩ	
3. Draw Norton equivalent	Connect In and Rn in parallel		
4. Calculate load current (RL = 3KΩ)	I = In × Rn/(Rn + RL)	I = 0.5mA × 3KΩ/(3KΩ + 3KΩ)	I = 0.25mA
5. Calculate load current (RL = 1.5Ω)	I = In × Rn/(Rn + RL)	I = 0.5mA × 3KΩ/(3KΩ + 1.5Ω)	I = 0.33mA

Mnemonic: "Norton needs Isc and Req to make a current source"

Question 4(a) [3 marks]

Derive the equation of Quality factor Q for a coil.

Answer:

Diagram: Coil Equivalent Circuit

```
     R        L
o---www---OOOOOO---o
```

Derivation of Q factor for a coil:

Table: Q Factor Derivation for Coil

Step	Expression	Explanation
1. Impedance	$Z = R + j\omega L$	Complex impedance of coil
2. Reactive power	$PX = (\omega L)I^2$	Power stored in inductor
3. Real power	$PR = RI^2$	Power dissipated in resistance
4. Quality factor	$Q = PX/PR$	Ratio of stored to dissipated power
5. Substitution	$Q = (\omega L)I^2/RI^2$	Substitute expressions
6. Final equation	$Q = \omega L/R$	Simplify to get Q factor

Mnemonic: "Quality coils: ωL/R shows energy saving ability"

Question 4(b) [4 marks]

A series RLC circuit has R = 50 Ω, L = 0.2 H and C = 10 μF. Calculate (i) Q factor, (ii) BW, (iii) Upper cut off and lower cut off frequencies.

Answer:

Diagram: Series RLC Circuit

```
     R=50Ω    L=0.2H
o----www------OOOOOO----+
                        |
                        |
                       ---
                       --- C=10μF
                        |
                        |
o-----------------------+
```

Table: Calculations for Series RLC Circuit

Parameter	Formula	Calculation	Result
Resonant frequency (fr)	fr = 1/(2π√LC)	$1/(2\pi\sqrt{(0.2\times10\times10^{-6})})$	112.5 Hz
Quality factor (Q)	Q = (1/R)√(L/C)	$(1/50)\sqrt{(0.2/10\times10^{-6})}$	28.28
Bandwidth (BW)	BW = fr/Q	112.5/28.28	3.98 Hz
Lower cutoff (f_1)	f_1 = fr - BW/2	112.5 - 3.98/2	110.51 Hz
Upper cutoff (f_2)	f_2 = fr + BW/2	112.5 + 3.98/2	114.49 Hz

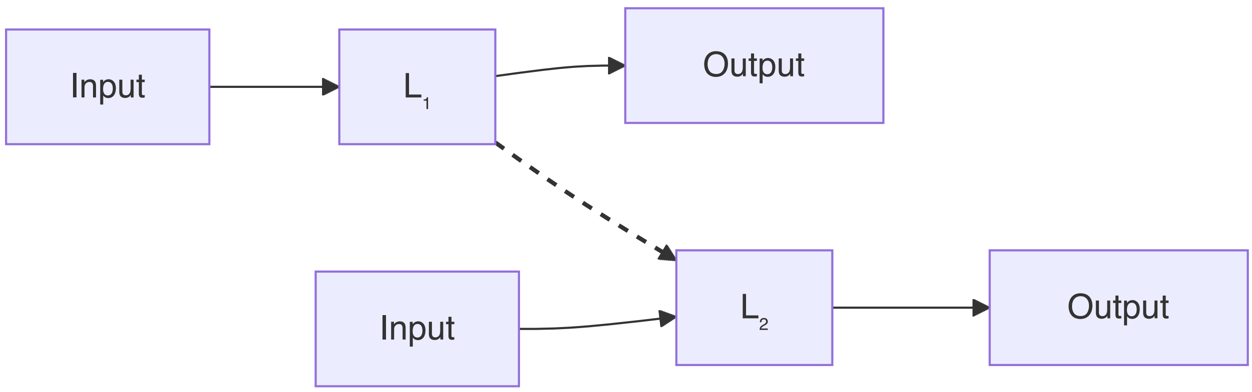
Mnemonic: "Q defines BW, which sets cutoff frequencies"

Question 4(c) [7 marks]

Explain Mutual Inductance along with Co-efficient of mutual inductance. Also derive the equation of K.

Answer:

Diagram: Mutual Inductance Between Two Coils



Mutual Inductance (M):

- When current in one coil induces voltage in nearby coil
- Coupling between coils depends on position, orientation, and medium
- Mutual inductance M in henries (H)

Table: Mutual Inductance Equations

Parameter	Formula	Description
Induced voltage	$v_2 = M(di_1/dt)$	Voltage induced in coil 2 due to current in coil 1
Mutual inductance	$M = k\sqrt{(L_1L_2)}$	Mutual inductance related to self-inductances
Coupling coefficient (k)	$k = M/\sqrt{(L_1L_2)}$	Measure of coupling between coils ($0 \leq k \leq 1$)
Total inductance	$Lt = L_1 + L_2 \pm 2M$	Total inductance depends on direction of coupling

Derivation of Coupling Coefficient (k):

- From $M = k\sqrt{(L_1L_2)}$
- Rearranging: $k = M/\sqrt{(L_1L_2)}$
- k = 1 for perfect coupling
- k = 0 for no coupling
- Typically 0.1 to 0.9 for real circuits

Mnemonic: "M measures magnetic linkage, k shows coupling quality"

Question 4(a) OR [3 marks]

Explain the types of coupling for coupled circuit.

Answer:

Diagram: Types of Coupling

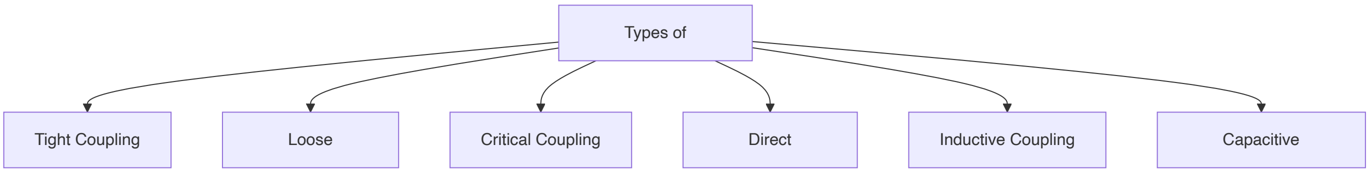


Table: Types of Coupling

Coupling Type	Characteristics	Applications
Tight Coupling	k > 0.5, high energy transfer	Transformers
Loose Coupling	k < 0.5, selective frequency response	RF tuning circuits
Critical Coupling	k adjusted for optimal bandwidth	RF filters
Direct Coupling	Components directly connected	Audio amplifiers
Inductive Coupling	Magnetic field transfers energy	Transformers, wireless charging
Capacitive Coupling	Electric field transfers energy	Signal coupling between stages

Mnemonic: "TLCLIC: Tight, Loose, Critical, Direct, Inductive, Capacitive"

Question 4(b) OR [4 marks]

A parallel resonant circuit having inductance of 10 mH with quality factor Q = 100, resonant frequency Fr = 50 KHz. Find out (i) Required capacitance C, (ii) Resistance R of the coil, (iii) BW.

Answer:

Diagram: Parallel Resonant Circuit

```
        L=10mH
o-------OOOOOO--------+
|                     |
|        R            |
|       WWW           |
|                     |
|                    ---
|                    --- C=?
|                     |
o---------------------+
```

Table: Calculations for Parallel Resonant Circuit

Parameter	Formula	Calculation	Result
Resonant frequency	$f_r = 1/(2\pi\sqrt{LC})$	$50\text{ kHz} = 1/(2\pi\sqrt{(10\times10^{-3}\times C)})$	
Capacitance (C)	$C = 1/(4\pi^2 f_r^2 L)$	$C = 1/(4\pi^2\times(50\times10^3)^2\times10\times10^{-3})$	C = 1.01 nF
Resistance (R)	$Q = \omega L/R$	$100 = 2\pi\times50\times10^3\times10\times10^{-3}/R$	R = 31.4 Ω
Bandwidth (BW)	BW = fr/Q	$BW = 50\times10^3/100$	BW = 500 Hz

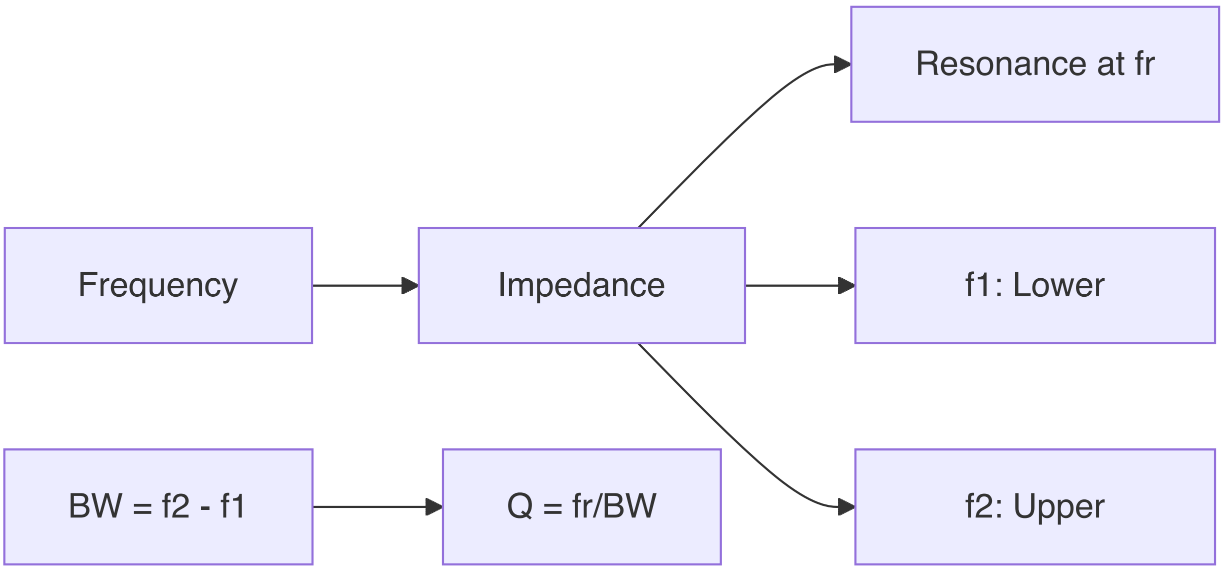
Mnemonic: "Parallel resonance parameters: C from fr, R from Q, BW from fr/Q"

Question 4(c) OR [7 marks]

Explain Band width and Selectivity of a series RLC circuit. Also establish the relation between Q factor and BW for series resonance circuit.

Answer:

Diagram: Frequency Response of Series RLC Circuit



Bandwidth (BW):

- **Frequency range** between half-power points
- At half-power points, impedance is √2 times minimum value
- $BW = f_2 - f_1$, where f_1 and f_2 are lower and upper cutoff frequencies

Selectivity:

- **Ability to reject** frequencies outside the bandwidth
- Higher Q means higher selectivity and narrower bandwidth
- Measured by steepness of response curve

Table: Series RLC Bandwidth Parameters

Parameter	Formula	Description
Bandwidth (BW)	$BW = f_2 - f_1$	Difference between upper and lower cutoff points
Half-power points	$Z = \sqrt{2} \times Z_{min}$	Points where power drops to half of maximum
Resonant frequency	$fr = 1/(2\pi\sqrt{LC})$	Center frequency
Quality factor	$Q = \omega_o L/R$	Energy storage vs. dissipation ratio

Derivation of Q-BW Relationship:

- At resonance, impedance Z = R
- At cutoff frequencies, $Z = \sqrt{2}R$
- This occurs when reactance XL - XC = ±R
- At f_1: $\omega L - 1/\omega C = -R$
- At f_2: $\omega L - 1/\omega C = +R$
- Solving these equations: BW = R/2πL = fr/Q
- Therefore, Q = fr/BW

Mnemonic: "Quality inversely proportional to bandwidth"

Question 5(a) [3 marks]

Design a symmetrical T type attenuator to give attenuation of 60 dB and work in to the load of 500 Ω resistance.

Answer:

Diagram: Symmetrical T-type Attenuator

```
        R1/2          R1/2
   o----www-----o----www----o
   |            |           |
   |            |           |
   |           R2           |
   |            |           |
   |            |           |
  IN           ---         OUT
                -
```

Table: Attenuator Design

Parameter	Formula	Calculation	Result
Attenuation (N)	N = 10^(dB/20)	10^(60/20)	N = 1000
Z_0	Given	500 Ω	500 Ω
R_1	$R_1 = 2Z_0(N-1)/(N+1)$	2×500×(1000-1)/(1000+1)	R_1 = 998 Ω
R_2	$R_2 = Z_0(N+1)/(N-1)$	500×(1000+1)/(1000-1)	R_2 = 0.5 Ω

Mnemonic: "T attenuator: R_1 series divides, R_2 shunts"

Question 5(b) [4 marks]

Compare Band pass and Band stop filters.

Answer:

Diagram: Band Pass vs Band Stop Response

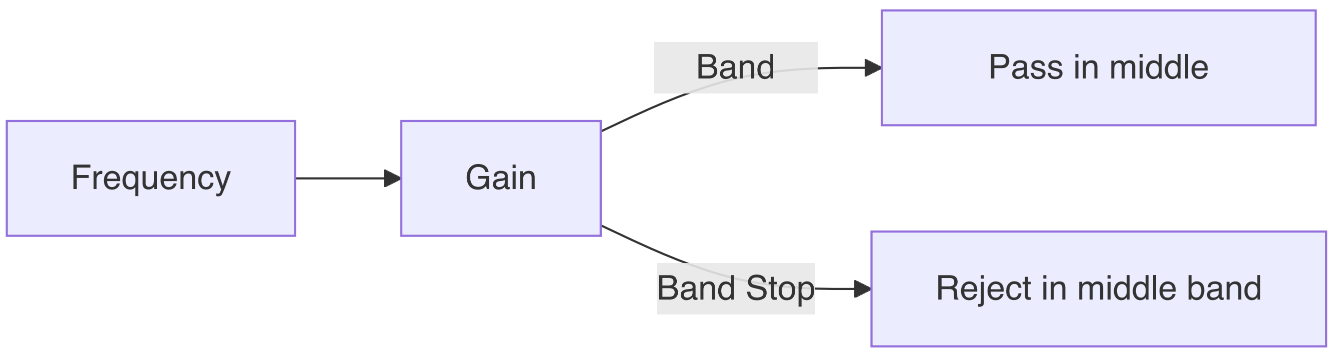


Table: Comparison of Band Pass and Band Stop Filters

Parameter	Band Pass Filter	Band Stop Filter
Frequency Response	Passes frequencies within specific band	Rejects frequencies within specific band
Circuit Structure	Series & parallel resonant circuits	Series & parallel resonant circuits
Cut-off Frequencies	Has lower (f_1) and upper (f_2) cut-offs	Has lower (f_1) and upper (f_2) cut-offs
Bandwidth	BW = $f_2 - f_1$	BW = $f_2 - f_1$
Applications	Radio tuning, audio equalization	Noise elimination, harmonic suppression
Implementation	Series/parallel combination of HPF & LPF	Parallel/series combination of HPF & LPF
Phase Response	0° at resonance	180° at resonance

Mnemonic: "Pass the middle or Stop the middle"

Question 5(c) [7 marks]

Explain constant K Low Pass Filter.

Answer:

Diagram: Constant K Low Pass Filter T and π Sections

```
T-section:                      π-section:
    L/2         L/2                 L
o---0000----o---0000------o  o---0000---o
            |                  |      |
            C                 C/2    C/2
            |                  |      |
            |                  |      |
o-----------o-------------o  o----------o
```

Constant K Low Pass Filter:

- **Passes frequencies** below cutoff frequency (fc)
- Attenuates frequencies above fc
- "Constant K" means product of series and shunt impedances is constant at all frequencies ($Z_1Z_2 = K^2$)

Table: T and π Section Parameters

Parameter	T-section	π-section
Series arm	L/2 at each end	L in center
Shunt arm	C in center	C/2 at each end
Cutoff frequency	$fc = 1/(\pi\sqrt{LC})$	$fc = 1/(\pi\sqrt{LC})$
Characteristic impedance	$Z_0 = \sqrt{(L/C)}$	$Z_0 = \sqrt{(L/C)}$
Design equation for L	$L = Z_0/\pi fc$	$L = Z_0/\pi fc$
Design equation for C	$C = 1/(\pi fcZ_0)$	$C = 1/(\pi fcZ_0)$

Frequency Response:

- Passes DC and low frequencies with minimal attenuation
- Attenuation increases rapidly above cutoff frequency
- Phase shift increases with frequency

Mnemonic: "Constant K LPF: L series blocks high, C shunt shorts high"

Question 5(a) OR [3 marks]

Design a high pass filter with T section having a cut-off frequency of 2 KHz with a load resistance of 500 Ω.

Answer:

Diagram: High Pass T-section Filter

```
     C/2          C/2
  o---||----o---||---o
  |         |        |
  |         L        |
  |        OOO       |
  |         |        |
 IN        ---      OUT
            -
```

Table: High Pass Filter Design

Parameter	Formula	Calculation	Result
Cutoff frequency (fc)	Given	2 kHz	2 kHz
Load resistance (R_0)	Given	500 Ω	500 Ω
Series capacitance (C/2)	$C = 1/(\pi f c R_0)$	$C = 1/(\pi\times2\times10^3\times500)$	C = 0.318 μF
Total capacitance (C)	2 × (C/2)	2 × 0.159 μF	C = 0.318 μF
Shunt inductance (L)	$L = R_0/(\pi fc)$	$L = 500/(\pi\times2\times10^3)$	L = 79.6 mH

Mnemonic: "High pass T: C blocks DC in series, L passes high in shunt"

Question 5(b) OR [4 marks]

Give classification of filters.

Answer:

Diagram: Filter Classification

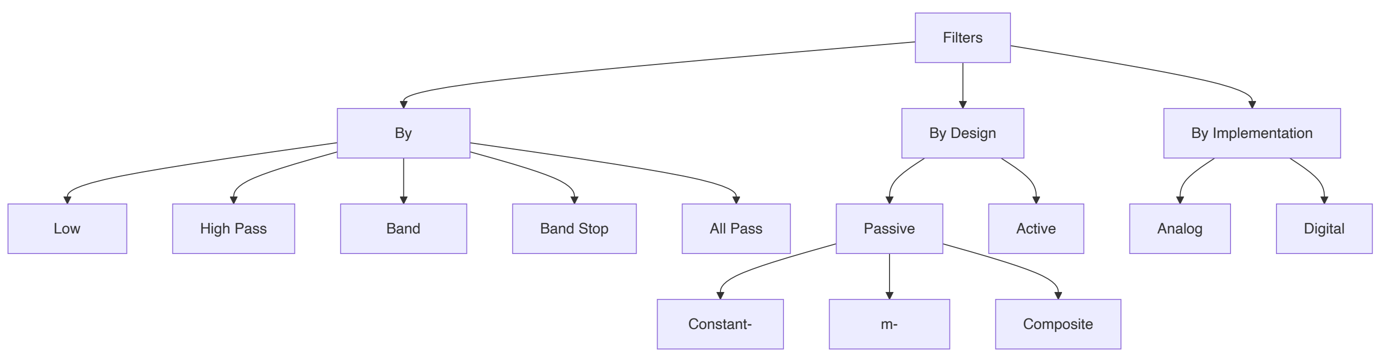


Table: Classification of Filters

Classification By	Types	Characteristics
Function	Low Pass	Passes frequencies below cutoff
	High Pass	Passes frequencies above cutoff
	Band Pass	Passes frequencies within a band
	Band Stop	Rejects frequencies within a band
	All Pass	Passes all frequencies but modifies phase
Design	Passive	Uses passive elements (R, L, C)
	Active	Uses active components (op-amps)
Response	Butterworth	Maximally flat response
	Chebyshev	Ripple in passband, steeper rolloff
	Bessel	Linear phase response
	Elliptic	Ripple in both passband and stopband
Implementation	Passive Filter Types	Constant-k, m-derived, composite

Mnemonic: "FLHBA: Function (Low/High/Band/All-pass), Design, Response, Implementation"

Question 5(c) OR [7 marks]

Explain constant K High Pass Filter.

Answer:

Diagram: Constant K High Pass Filter T and π Sections

```
T-section:                          π-section:
     C/2           C/2                   C
o----||------o----||-------o   o----||----o
             |                   |       |
             L                  L/2     L/2
             |                   |       |
             |                   |       |
o------------o--------------o   o----------o
```

Constant K High Pass Filter:

- **Passes frequencies** above cutoff frequency (fc)
- Attenuates frequencies below fc
- "Constant K" means product of series and shunt impedances is constant at all frequencies ($Z_1Z_2 = K^2$)

Table: T and π Section Parameters

Parameter	T-section	π-section
Series arm	C/2 at each end	C in center
Shunt arm	L in center	L/2 at each end
Cutoff frequency	$f_c = 1/(\pi\sqrt{LC})$	$f_c = 1/(\pi\sqrt{LC})$
Characteristic impedance	$Z_0 = \sqrt{(L/C)}$	$Z_0 = \sqrt{(L/C)}$
Design equation for L	$L = Z_0/(\pi f_c)$	$L = Z_0/(\pi f_c)$
Design equation for C	$C = 1/(\pi f_c Z_0)$	$C = 1/(\pi f_c Z_0)$

Frequency Response:

- Blocks DC and low frequencies
- Passes high frequencies with minimal attenuation
- Attenuation increases as frequency decreases below cutoff
- Phase shift approaches 0° at very high frequencies

Mnemonic: "Constant K HPF: C series blocks low, L shunt passes high"