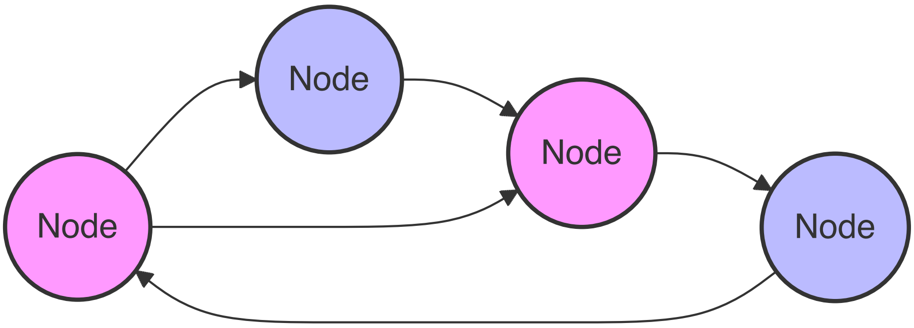
Question 1(a) [3 marks]

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

Answer:

Term	Definition
Node	A point where two or more elements are connected together
Branch	A single element or path between two nodes
Loop	A closed path in a network where no node is traversed more than once

Diagram:



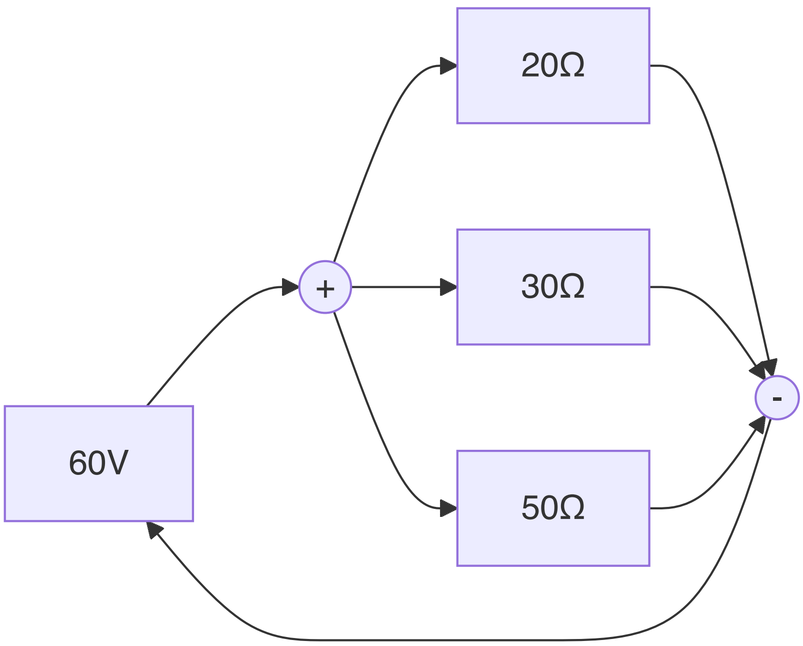
Mnemonic: "NBL: Networks Begin with Loops"

Question 1(b) [4 marks]

Three resistors of 20 Ω, 30 Ω and 50 Ω are connected in parallel across 60 V supply. Find (i) Current flowing through each resistor and Total current (ii) Equivalent Resistance.

Answer:

Diagram:



Calculation	Value
Current through 20 Ω resistor: $I_1 = V/R_1 = 60/20$	3 A
Current through 30 Ω resistor: $I_2 = V/R_2 = 60/30$	2 A
Current through 50 Ω resistor: $I_3 = V/R_3 = 60/50$	1.2 A
Total current: $I = I_1 + I_2 + I_3 = 3 + 2 + 1.2$	6.2 A
Equivalent resistance: Req = V/I = 60/6.2	9.68 Ω

Mnemonic: "PIV: Parallel Increases the current, Voltage remains the same"

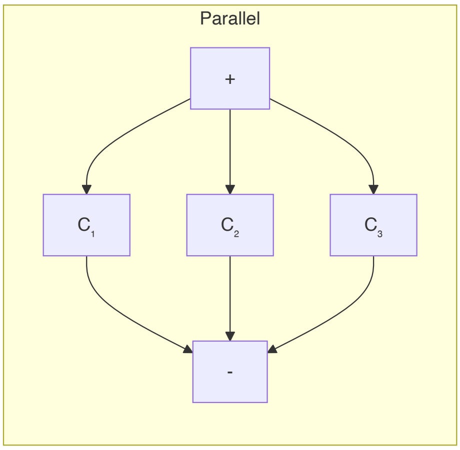
Question 1(c) [7 marks]

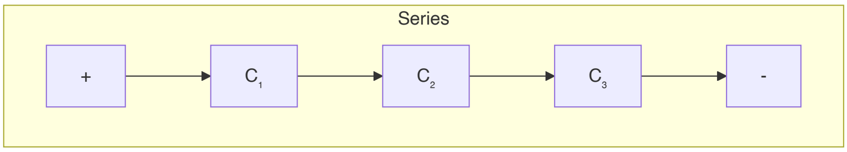
Explain Series and Parallel connection for Capacitors.

Answer:

Connection	Formula	Characteristics
Series Connection	$1/C\_eq = 1/C_1 + 1/C_2 + 1/C_3 + ...$	- Equivalent capacitance is less than smallest capacitor - Same current in each capacitor - Total voltage divides across capacitors - Increases effective dielectric strength
Parallel Connection	$C\_eq = C_1 + C_2 + C_3 + ...$	- Equivalent capacitance is sum of all capacitors - Same voltage across each capacitor - Total charge is sum of individual charges - Increases effective plate area

Diagram:





Mnemonic: "CAPE: Capacitors Add in Parallel, Eliminate in Series"

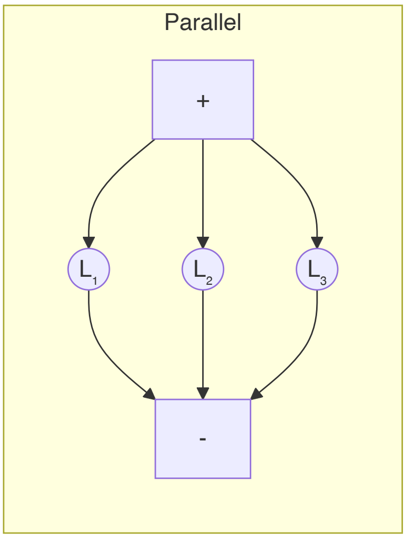
Question 1(c) OR [7 marks]

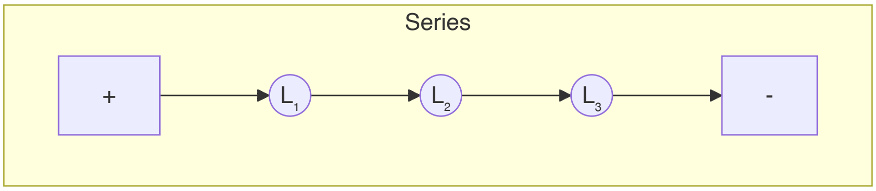
Explain Series and Parallel connection for Inductors.

Answer:

Connection	Formula	Characteristics
Series Connection	$L\_eq = L_1 + L_2 + L_3 + ...$	- Equivalent inductance is sum of all inductors - Same current flows through each inductor - Total voltage is sum of individual voltages - Flux linkage adds
Parallel Connection	$1/L\_eq = 1/L_1 + 1/L_2 + 1/L_3 + ...$	- Equivalent inductance is less than smallest inductor - Same voltage across each inductor - Total current divides among inductors - Magnetic coupling affects actual value

Diagram:





Mnemonic: "LIPS: inductors Link in Series, Partition in Parallel"

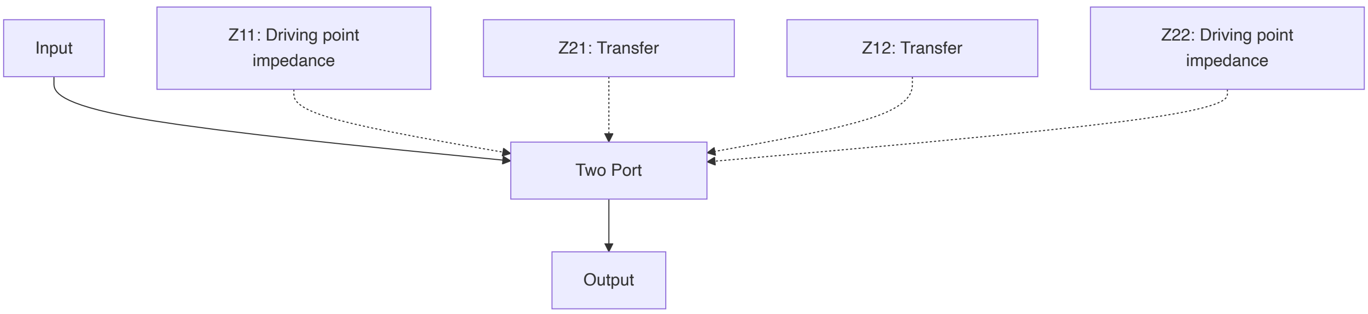
Question 2(a) [3 marks]

Define (i) Transform impedance, (ii) Driving point impedance, (iii) Transfer impedance.

Answer:

Term	Definition
Transform impedance	Impedance seen by signal passing from primary to secondary of a transformer
Driving point impedance	Ratio of voltage to current at the same pair of terminals or port
Transfer impedance	Ratio of voltage at one port to the current at another port

Diagram:



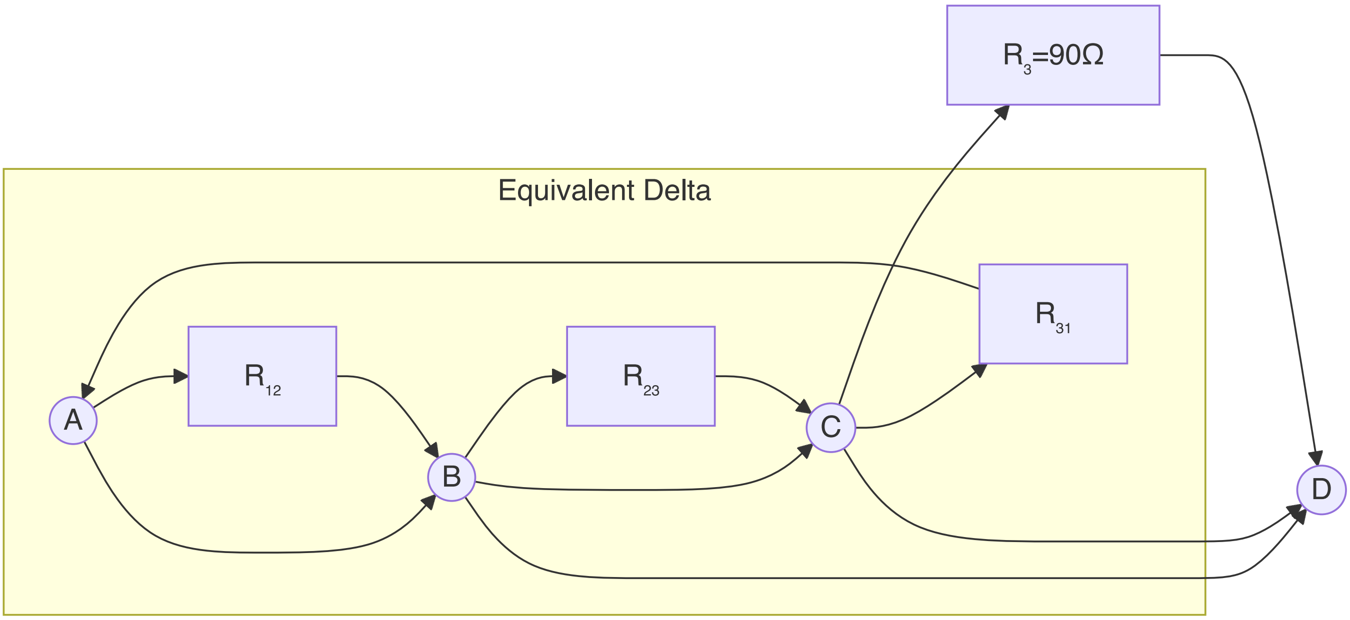
Mnemonic: "TDT: Transformers Drive Transfers"

Question 2(b) [4 marks]

Three resistances of 30, 50 and 90 ohms are connected in star. Find equivalent resistances in delta connection.

Answer:

Diagram:



Star to Delta Conversion Formula	Calculation	Result
$R_{12} = (R_1 \times R_2 + R_2 \times R_3 + R_3 \times R_1)/R_3$	(30×50 + 50×90 + 90×30)/90	105 Ω
$R_{23} = (R_1 \times R_2 + R_2 \times R_3 + R_3 \times R_1)/R_1$	(30×50 + 50×90 + 90×30)/30	315 Ω
$R_{31} = (R_1 \times R_2 + R_2 \times R_3 + R_3 \times R_1)/R_2$	(30×50 + 50×90 + 90×30)/50	189 Ω

Mnemonic: "PSR: Product over Sum of Resistors"

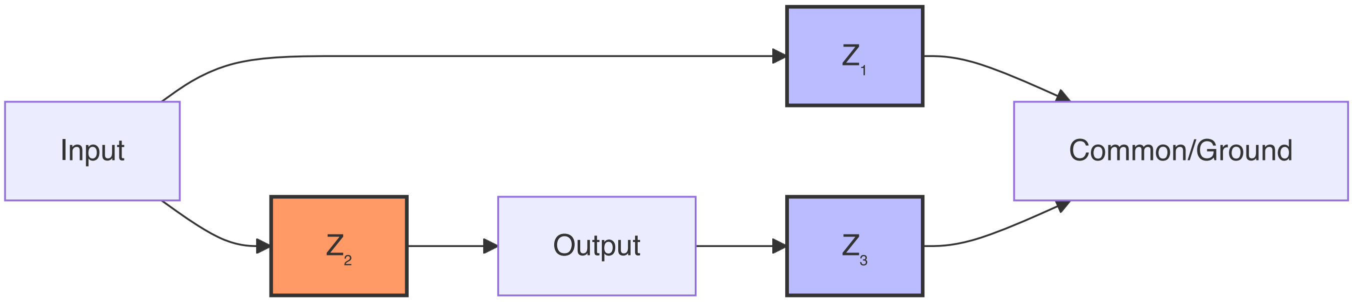
Question 2(c) [7 marks]

Explain π network.

Answer:

Concept	Description
Definition	A three-terminal network formed by three impedances - one in series and two in parallel
Structure	Two impedances connected from input and output to common point, one between input and output
Parameters	Can be defined using Z, Y, h, or ABCD parameters
Applications	Matching networks, filters, attenuators, phase shifters

Diagram:



Mnemonic: "PIE: Pi Impedances connected at Ends"

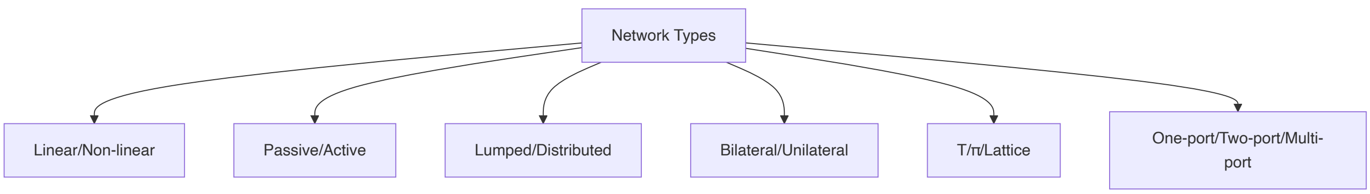
Question 2(a) OR [3 marks]

List the types of network.

Answer:

Network Types	Examples
Based on Linearity	Linear networks, Non-linear networks
Based on Components	Passive networks, Active networks
Based on Structure	Lumped networks, Distributed networks
Based on Behavior	Bilateral networks, Unilateral networks
Based on Topology	T-networks, π-networks, Lattice networks
Based on Ports	One-port networks, Two-port networks, Multi-port networks

Diagram:



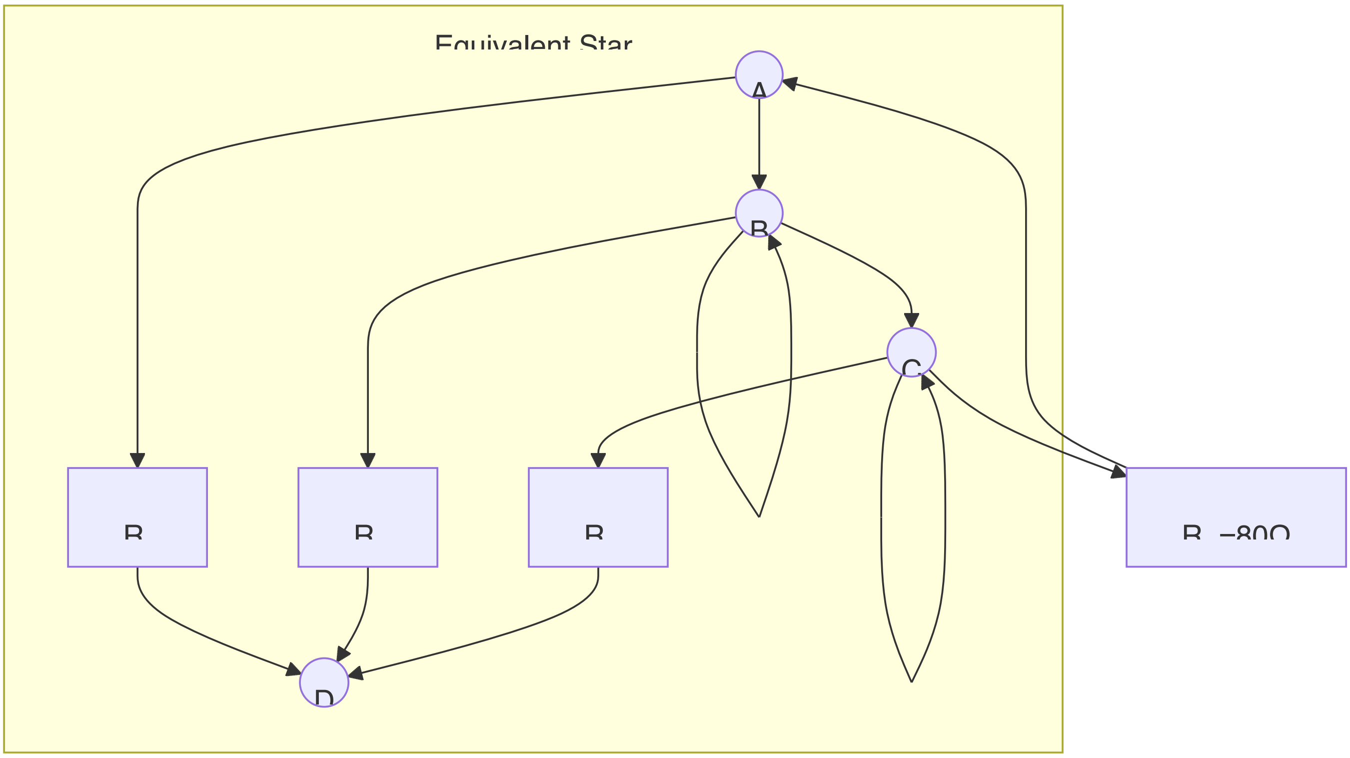
Mnemonic: "PLAN-TB: Passive-Linear-Active-Network-Topology-Bilateral"

Question 2(b) OR [4 marks]

Three resistances of 40, 60 and 80 ohms are connected in delta. Find equivalent resistances in star connection.

Answer:

Diagram:



Delta to Star Conversion Formula	Calculation	Result
$R_1 = (R_{12} \times R_{31})/(R_{12}+R_{23}+R_{31})$	(40×80)/(40+60+80)	17.78 Ω
$R_2 = (R_{12} \times R_{23})/(R_{12}+R_{23}+R_{31})$	(40×60)/(40+60+80)	13.33 Ω
$R_3 = (R_{23} \times R_{31})/(R_{12}+R_{23}+R_{31})$	(60×80)/(40+60+80)	26.67 Ω

Mnemonic: "DPS: Delta Product over Sum"

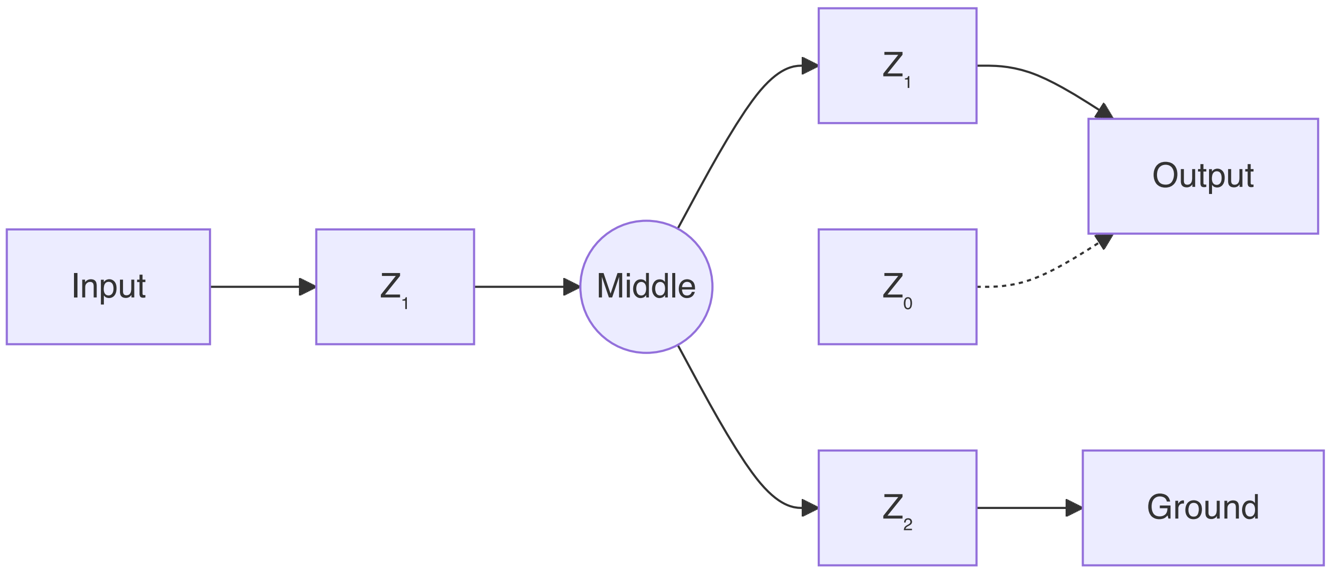
Question 2(c) OR [7 marks]

Explain characteristic impedance of symmetrical T – network. Also derive the equation of ZOT in terms of ZOC and ZSC.

Answer:

Concept	Description
Characteristic impedance (Z_0)	Impedance that when connected at output port causes input impedance to equal Z_0
Symmetrical T-network	T-network where the series impedances on both sides are equal
ZOC and ZSC	Open-circuit and short-circuit impedances of the network

Diagram:



For a symmetrical T-network:

- Series impedances (Z_1) are equal
- Z_2 is the shunt impedance

The characteristic impedance (Z_0^T) is given by:
$Z_0^T = \sqrt{(Z_0^c \times Z_0^{sc})}$

Where:

- Z_0^c = Open circuit impedance = $Z_1 + Z_2 + (Z_1 \times Z_2)/Z_1 = Z_1 + Z_2$
- Z_0^{sc} = Short circuit impedance = Z_1^2/Z_2

Therefore:
$Z_0^T = \sqrt{[(Z_1 + Z_2) \times Z_1^2/Z_2]} = \sqrt{[Z_1^2 + Z_1 \times Z_2]}$

Mnemonic: "TOSS: T-network's Open and Short circuit Square-root"

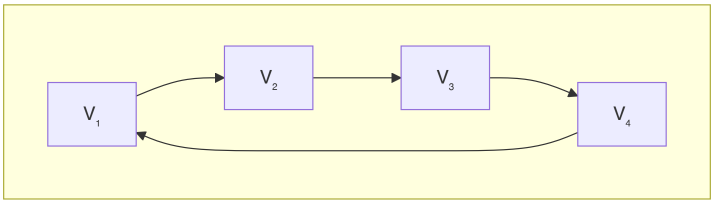
Question 3(a) [3 marks]

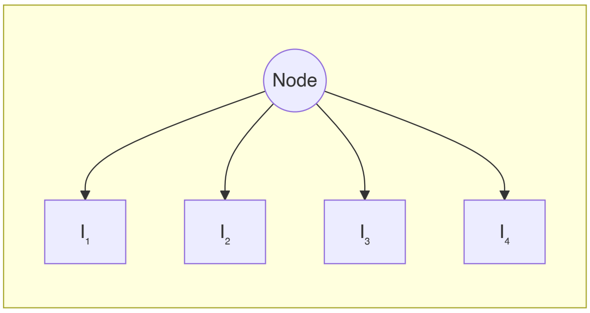
Explain Kirchhoff's law.

Answer:

Law	Statement	Application
Kirchhoff's Current Law (KCL)	Sum of currents entering a node equals sum of currents leaving it	Used for nodal analysis
Kirchhoff's Voltage Law (KVL)	Sum of voltages around any closed loop equals zero	Used for mesh analysis

Diagram:





Mnemonic: "KVC: Kirchhoff Verifies Current and Voltage laws"

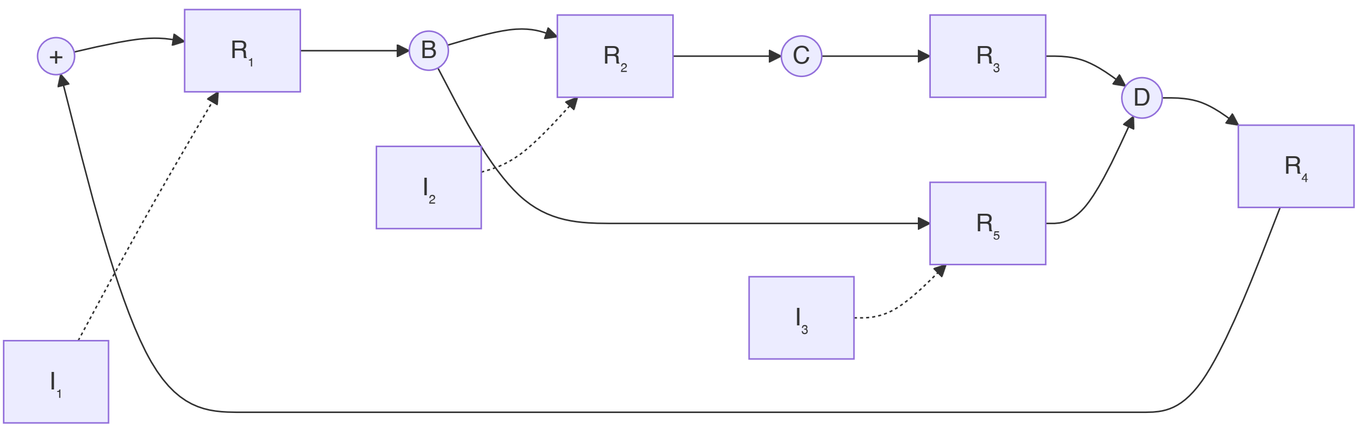
Question 3(b) [4 marks]

Explain Mesh analysis.

Answer:

Concept	Description
Definition	Method to solve circuit problems by applying KVL to each independent closed loop (mesh)
Procedure	1. Assign mesh currents to each loop 2. Write KVL equations for each mesh 3. Solve the resulting system of equations
Advantages	- Reduces number of equations - Works well with circuits having many branches - Suitable for problems with voltage sources

Diagram:



Mnemonic: "MAIL: Mesh Analysis uses Independent Loops"

Question 3(c) [7 marks]

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

Answer:

Diagram:

```
         10Ω        15Ω
         ----      ----
        /    \    /    \
       /      \  /      \
  100V +        A        B
       \        |        /
        \      ---      /
         \    | 5Ω|    /
          \   |   |   /
           \ ---    /
            \|   |/
             6Ω  8Ω
```

Step 1: Remove 5Ω resistor and find open circuit voltage (V_{th})
Step 2: Find Thevenin's equivalent resistance (R_{th})
Step 3: Calculate current through 5Ω resistor

Step	Calculation	Result
V_{th}	Voltage between A and B with 5Ω removed	38.46 V
R_{th}	Equivalent resistance seen from A and B with 100V source shorted	3.6 Ω
Current	$I = V_{th}/(R_{th} + 5) = 38.46/(3.6 + 5)$	4.47 A

Mnemonic: "TVR: Thevenin replaces Voltage and Resistance"

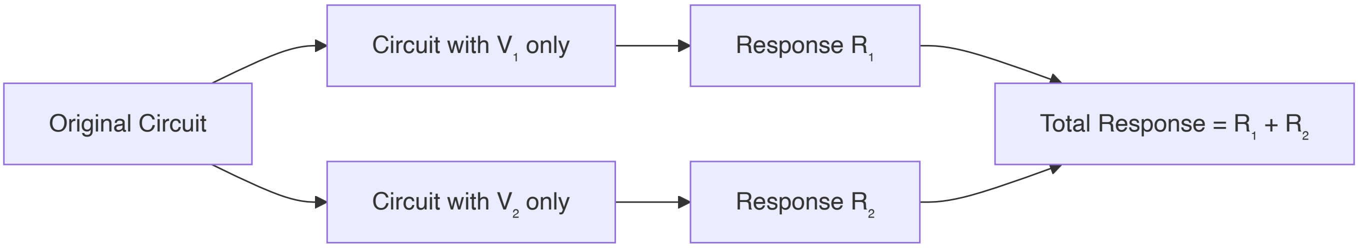
Question 3(a) OR [3 marks]

State and explain Superposition Theorem.

Answer:

Concept	Description
Statement	In a linear circuit with multiple sources, the response at any point equals the sum of responses caused by each source acting alone
Procedure	1. Consider one source at a time 2. Replace other voltage sources with short circuits 3. Replace other current sources with open circuits 4. Find individual responses 5. Add all responses algebraically
Limitation	Only applicable to linear circuits and for voltage/current responses

Diagram:



Mnemonic: "SUPER: Sources Used Progressively Equals Response"

Question 3(b) OR [4 marks]

Explain method of drawing dual network using any circuit.

Answer:

Step	Description
Convert to graph	Draw the circuit as a planar graph
Draw dual graph	Place a node in each region of original graph
Connect nodes	Draw edges crossing each edge of original graph
Replace elements	- Resistance R becomes conductance 1/R - Voltage source becomes current source - Series becomes parallel - Impedance Z becomes admittance 1/Z

Diagram:

```
Original Circuit     Dual Circuit
   +---R1---+          +---G1---+
   |        |          |        |
  V1       R2         I1       G2
   |        |          |        |
   +---R3---+          +---G3---+
```

Mnemonic: "DVSG: Dual transforms Voltage to Series to Graphs"

Question 3(c) OR [7 marks]

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

Answer:

Diagram:

```
          2kΩ          2kΩ          2kΩ
         -----        -----        -----
        /     \      /     \      /     \
       /       \    /       \    /       \
    C +         D  +         E  +         A
       \         \  \         \  \         \
        \         \  \         \  \         \
         \         \ |         | |         |
         |         | |         | |         |
        10V         2kΩ         2kΩ         RL
         |         | |         | |         |
         |         | |         | |         |
         +         + +         + +         +
         B         B B         B B         B
```

Step 1: Find Norton's current (IN)
Step 2: Find Norton's resistance (RN)
Step 3: Calculate load currents

Step	Calculation	Result
IN	Short circuit current from A to B	1.25 mA
RN	Equivalent resistance seen from A to B with 10V source shorted	1 kΩ
IL (RL = 3 KΩ)	IL = IN × RN/(RN + RL) = 1.25 × 1/(1 + 3)	0.31 mA
IL (RL = 1.5 Ω)	IL = IN × RN/(RN + RL) = 1.25 × 1000/(1000 + 1.5)	1.25 mA

Mnemonic: "NICE: Norton's circuit Is Current Equivalent"

Question 4(a) [3 marks]

Derive the equation of Quality factor Q for a coil.

Answer:

Parameter	Relationship
Q factor definition	Ratio of energy stored to energy dissipated per cycle
Coil impedance	Z = R + jωL
Reactance	XL = ωL
Quality factor	Q = XL/R = ωL/R

Diagram:

```
+---R---+
|       |
+--L----+
```

For a coil, the energy stored is in the magnetic field (in the inductor), while energy dissipated is in the resistance. From this:

$Q = 2\pi \times$ (Energy stored)/(Energy dissipated per cycle)
$Q = \omega L/R$

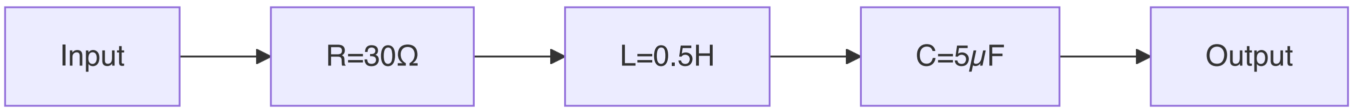
Mnemonic: "QREL: Quality Relates Energy to Loss"

Question 4(b) [4 marks]

A series RLC circuit has R = 30 Ω, L = 0.5 H and C = 5 μF. Calculate (i) Q factor, (ii) BW, (iii) Upper cut off and lower cut off frequencies.

Answer:

Diagram:



Parameter	Formula	Calculation	Result
Resonant frequency (f_0)	$f_0 = 1/(2\pi\sqrt{LC})$	$1/(2\pi\sqrt{(0.5\times5\times10^{-6})})$	100.53 Hz
Q factor	$Q = (1/R)\sqrt{(L/C)}$	$(1/30)\sqrt{(0.5/(5\times10^{-6}))}$	105.57
Bandwidth (BW)	$BW = f_0/Q$	100.53/105.57	0.952 Hz
Lower cutoff (f_1)	$f_1 = f_0 - BW/2$	100.53 - 0.952/2	100.05 Hz
Upper cutoff (f_2)	$f_2 = f_0 + BW/2$	100.53 + 0.952/2	101.01 Hz

Mnemonic: "QBCUT: Quality Bandwidth Cutoff Uniquely Related"

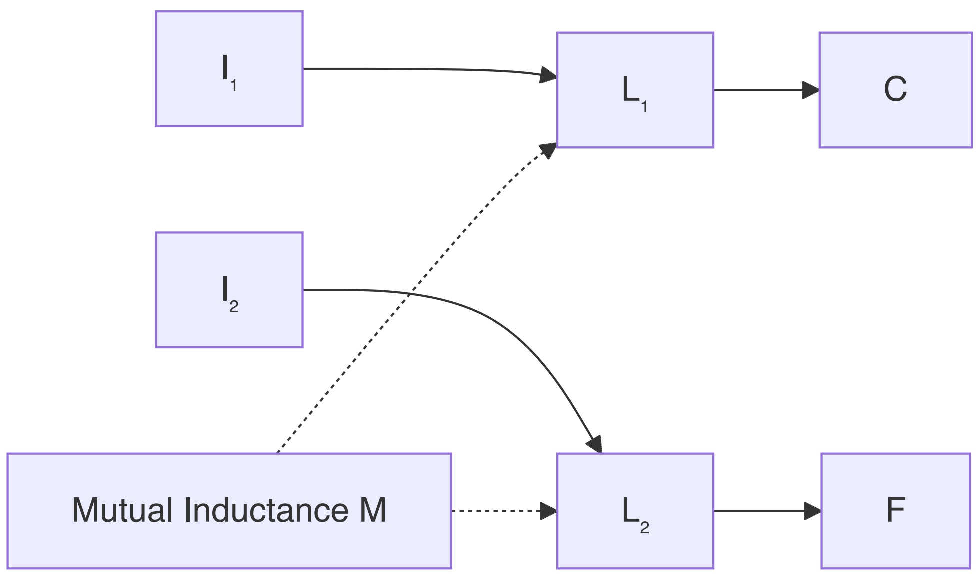
Question 4(c) [7 marks]

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

Answer:

Concept	Description
Mutual Inductance (M)	Property where current change in one coil induces voltage in adjacent coil
Definition	Ratio of induced voltage in secondary to rate of change of current in primary
Formula	$M = k\sqrt{(L_1L_2)}$
Coefficient of coupling (k)	Measure of magnetic coupling between coils ($0 \leq k \leq 1$)

Diagram:



For two inductors L_1 and L_2, mutual inductance M is:
$M = k\sqrt{(L_1L_2)}$

Where coefficient of coupling k is:
$k = M/\sqrt{(L_1L_2)}$

k represents fraction of magnetic flux from one coil linking with another coil.
For perfectly coupled coils, k = 1
For no coupling, k = 0

Mnemonic: "MKL: Mutual coupling K Links inductors"

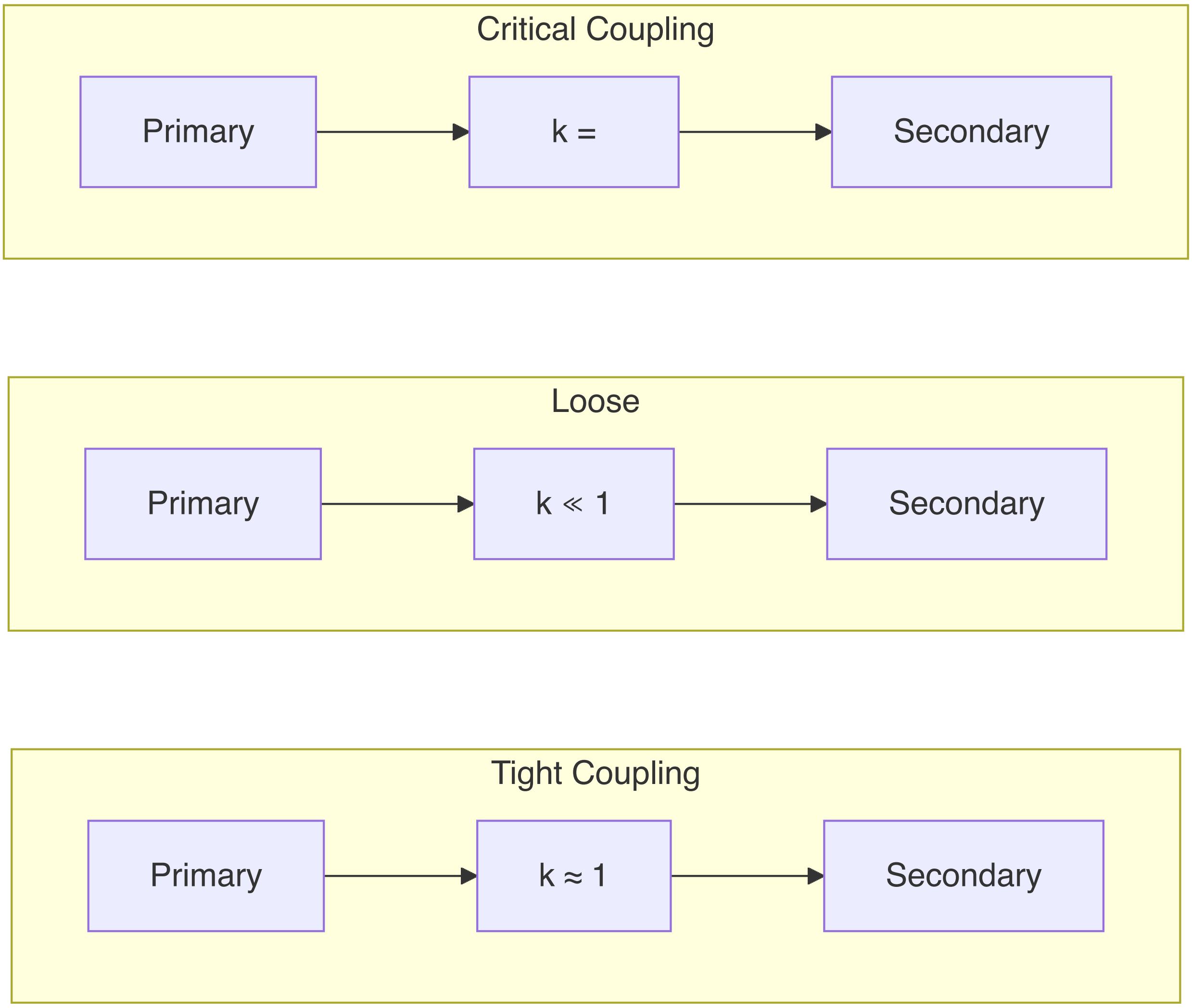
Question 4(a) OR [3 marks]

Explain the types of coupling for coupled circuit.

Answer:

Type of Coupling	Characteristics	Applications
Tight/Close Coupling (k≈1)	- Nearly all flux links both coils - High transfer efficiency - k value close to 1	Transformers, Power transfer
Loose Coupling (k≪1)	- Small fraction of flux links second coil - Lower transfer efficiency - k value much less than 1	RF circuits, Tuned filters
Critical Coupling (k=kc)	- Optimum coupling for bandpass response - Maximum power transfer at resonance	Bandpass filters, IF transformers
Inductive Coupling	- Coupling via magnetic field	Transformers, Wireless charging
Capacitive Coupling	- Coupling via electric field	Signal coupling, Capacitive sensors

Diagram:



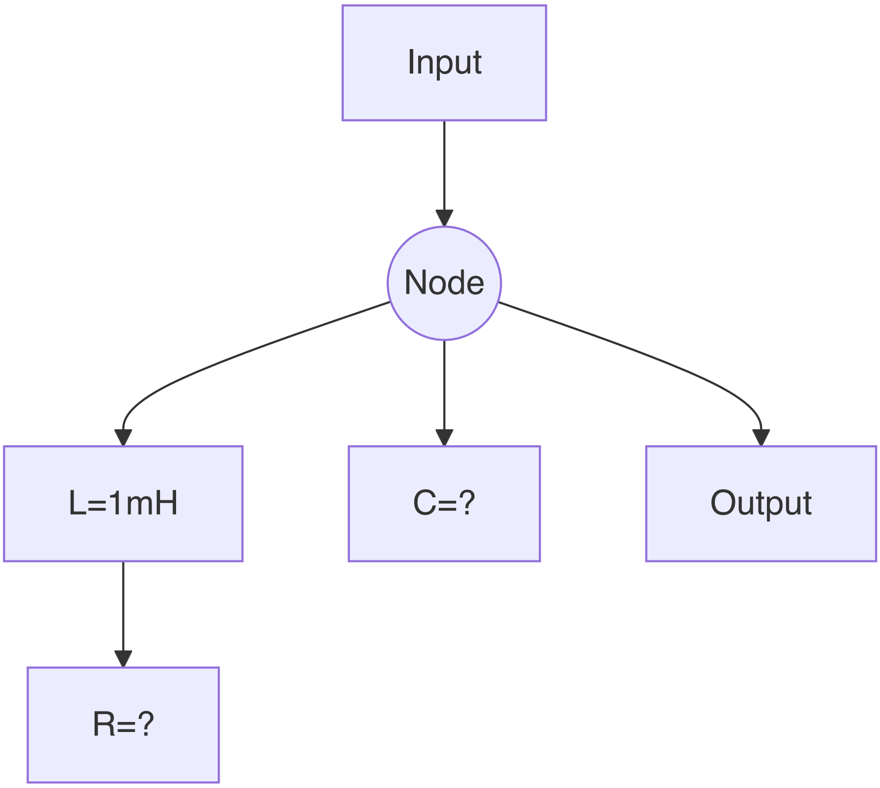
Mnemonic: "TLC: Tight, Loose, Critical couplings"

Question 4(b) OR [4 marks]

A parallel resonant circuit having inductance of 1 mH with quality factor Q = 100, resonant frequency Fr = 100 KHz. Find out (i) Required capacitance C, (ii) Resistance R of the coil, (iii) BW.

Answer:

Diagram:



Parameter	Formula	Calculation	Result
Capacitance (C)	$C = 1/(4\pi^2 f^2 L)$	$1/(4\pi^2 \times (100\times10^3)^2 \times 1\times10^{-3})$	2.533 nF
Coil Resistance (R)	$R = \omega L/Q$	$2\pi \times 100\times10^3 \times 1\times10^{-3}/100$	6.28 Ω
Bandwidth (BW)	$BW = f_r/Q$	$100\times10^3/100$	1 kHz

Mnemonic: "RCB: Resonance needs Capacitance and Bandwidth"

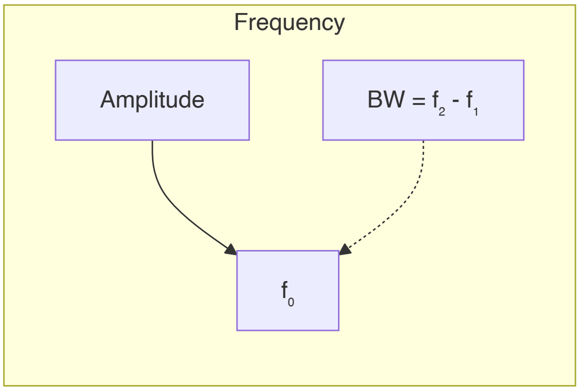
Question 4(c) OR [7 marks]

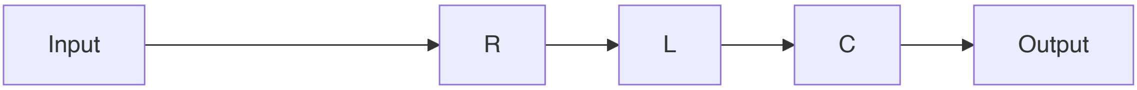
Explain Band width and Selectivity of a series RLC circuit. Also establish the relation between Q factor and BW for series resonance circuit.

Answer:

Parameter	Definition	Relationship
Bandwidth (BW)	Frequency range between half-power points	BW = $f_2 - f_1 = \omega_2 - \omega_1$ = R/L
Selectivity	Ability to differentiate between signals of different frequencies	Inversely proportional to BW
Q factor	Ratio of resonant frequency to bandwidth	Q = ω_0/BW = ω_0L/R

Diagram:





For a series RLC circuit:

- At resonance (f_0), impedance is minimum (= R)
- Half-power points occur when impedance = √2×R
- At these points, power is half of maximum power

Bandwidth (BW) = $\omega_2 - \omega_1$ = R/L
Q factor = ω_0L/R = ω_0/BW

Therefore, BW = ω_0/Q = $2\pi f_0$/Q

This shows Q factor and bandwidth are inversely related:
Higher Q → Narrower bandwidth → Better selectivity

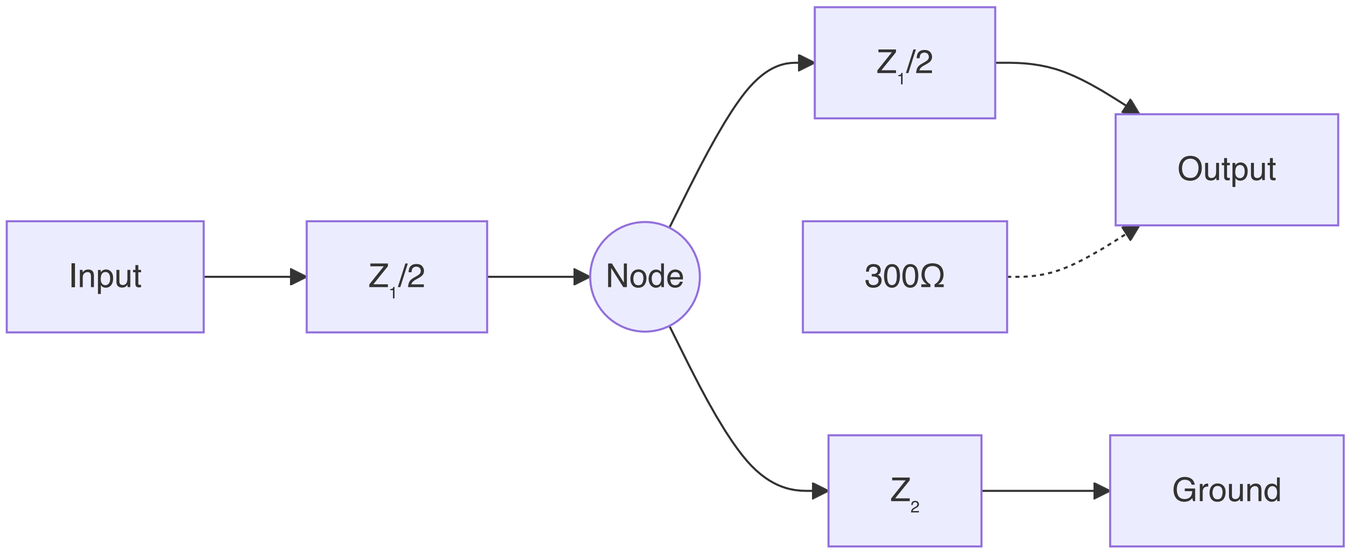
Mnemonic: "BQS: Bandwidth and Q determine Selectivity"

Question 5(a) [3 marks]

Design a symmetrical T type attenuator to give attenuation of 40 dB and work in to the load of 300 Ω resistance.

Answer:

Diagram:



Parameter	Formula	Calculation	Result
Attenuation (N)	N = 10^(dB/20)	10^(40/20)	100
Impedance ratio (K)	K = (N+1)/(N-1)	(100+1)/(100-1)	1.02
Z_1	$Z_1 = R_0[(K-1)/K]$	300[(1.02-1)/1.02]	5.88 Ω
Z_2	$Z_2 = R_0[2K/(K^2-1)]$	$300[2×1.02/(1.02^2-1)]$	594.12 Ω

Mnemonic: "TANZ: T-Attenuator Needs Z-parameters"

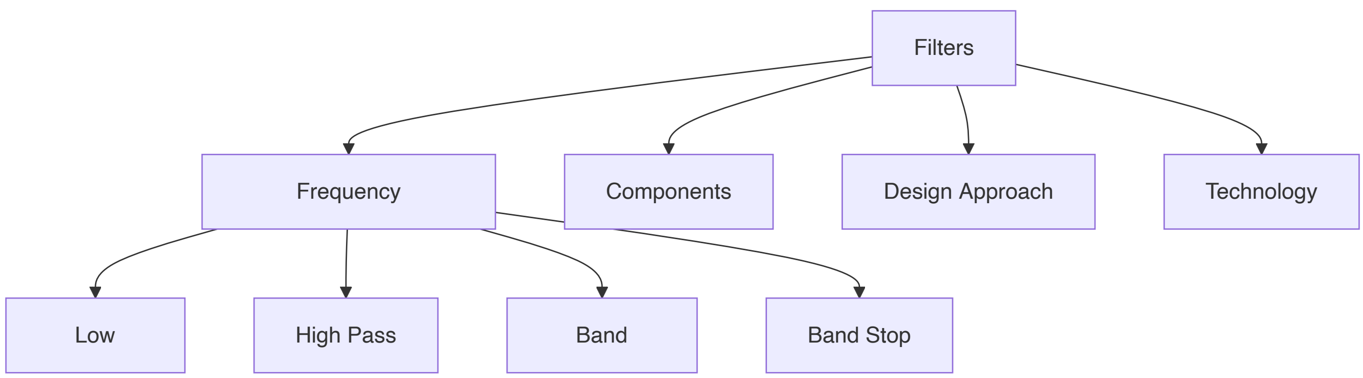
Question 5(b) [4 marks]

Give classification of filters.

Answer:

Classification	Types	Characteristics
Based on Frequency Response	- Low Pass - High Pass - Band Pass - Band Stop	- Passes frequencies below cutoff - Passes frequencies above cutoff - Passes frequencies within a band - Blocks frequencies within a band
Based on Components	- Passive Filters - Active Filters	- Uses R, L, C elements - Uses active devices with RC
Based on Design Approach	- Constant-k Filters - m-derived Filters - Composite Filters	- Simplest design - Better cutoff characteristics - Combines advantages
Based on Technology	- LC Filters - Crystal Filters - Ceramic Filters - Digital Filters	- Uses inductors and capacitors - Uses piezoelectric crystals - Uses piezoelectric ceramics - Implemented in software

Diagram:



Mnemonic: "FLAC: Filters: Low-pass, Active, Constant-k"

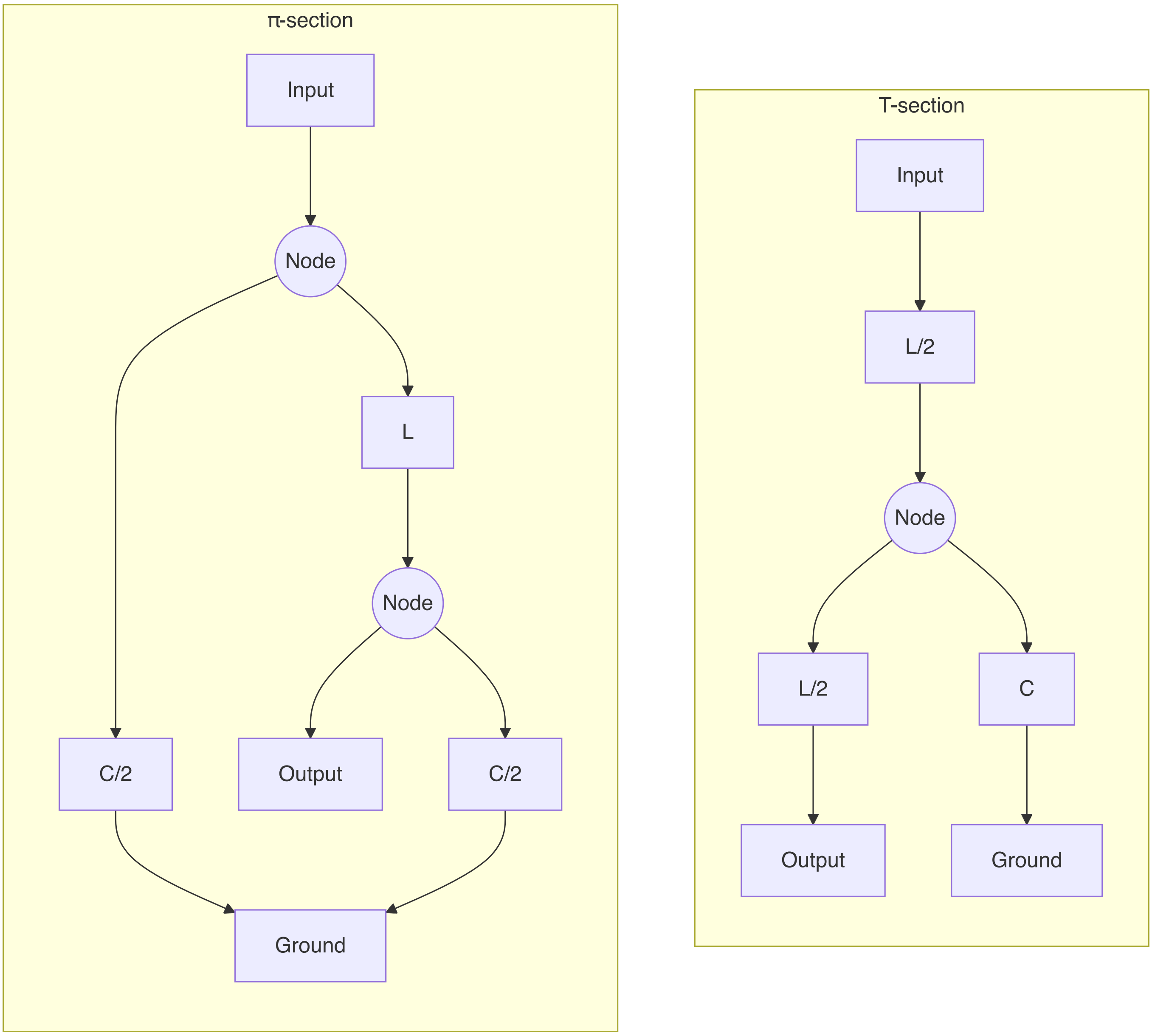
Question 5(c) [7 marks]

Explain constant K Low Pass Filter.

Answer:

Concept	Description
Definition	Filter where impedance product $Z_1Z_2 = k^2$ (constant) at all frequencies
Circuit Types	T-section and π-section
T-section components	Series inductors (L/2) and shunt capacitor (C)
π-section components	Series inductor (L) and shunt capacitors (C/2)
Cutoff frequency	fc = 1/π√(LC)
Characteristic impedance	R_0 = √(L/C)

Diagram:



The constant-k low pass filter has:

- Cutoff frequency: fc = 1/π√(LC)

- Design impedance: $R_0 = \sqrt{(L/C)}$
- Pass band: 0 to fc
- Attenuation band: Above fc
- Gradual transition from pass band to stop band

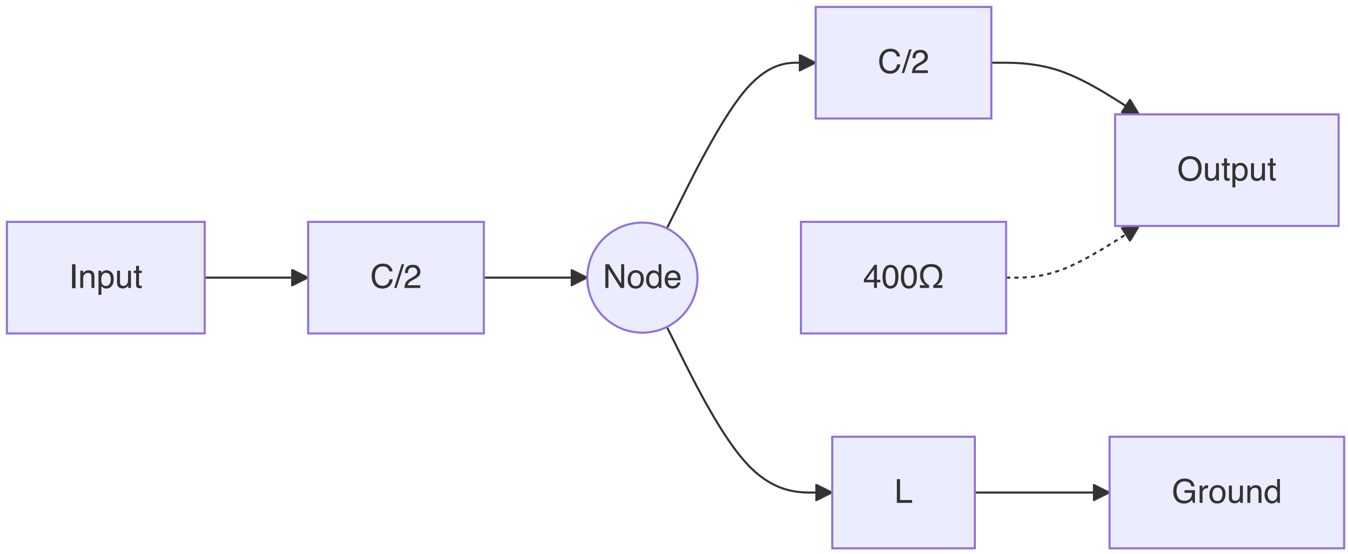
Mnemonic: "CLPT: Constant-k Low Pass needs T-section"

Question 5(a) OR [3 marks]

Design a high pass filter with T section having a cut-off frequency of 1.5 KHz with a load resistance of 400 Ω.

Answer:

Diagram:



Parameter	Formula	Calculation	Result
Design impedance (R_0)	R_0 = Load resistance	Given	400 Ω
Cutoff frequency (fc)	fc = Given	Given	1.5 kHz
Inductor (L)	$L = R_0/2\pi fc$	400/(2π×1500)	42.44 mH
Capacitor (C)	$C = 1/(2\pi fcR_0)$	1/(2π×1500×400)	0.265 μF

Mnemonic: "HCL: High-pass needs Capacitor and inductor"

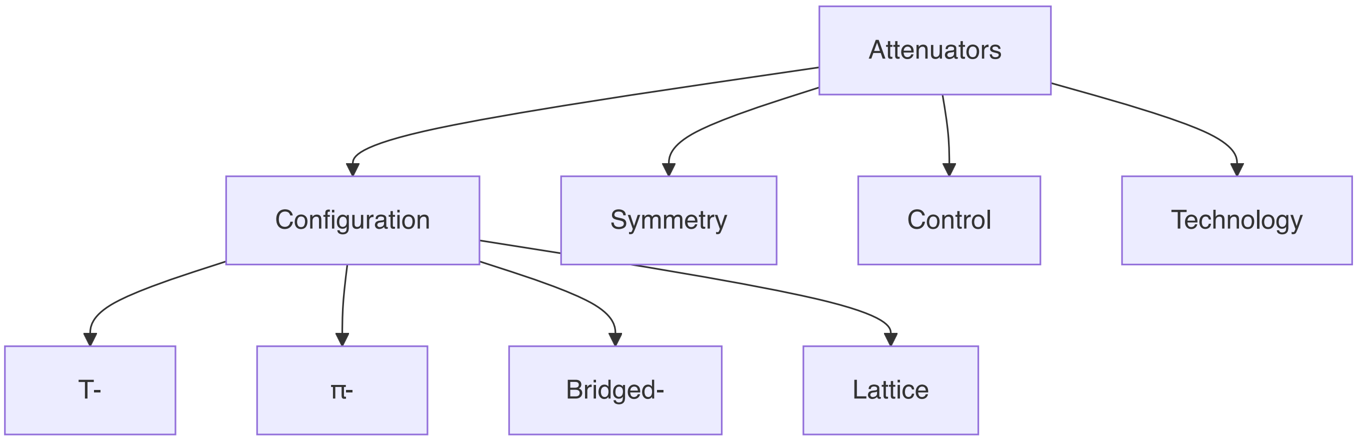
Question 5(b) OR [4 marks]

Give classification of attenuators.

Answer:

Classification	Types	Characteristics
Based on Configuration	- T-attenuator - π-attenuator - Bridged-T - Lattice	- Series-shunt-series - Shunt-series-shunt - Balanced bridge - Balanced network
Based on Symmetry	- Symmetrical - Asymmetrical	- Equal impedance - Unequal impedance
Based on Control	- Fixed - Variable - Programmable	- Constant attenuation - Adjustable attenuation - Digitally controlled
Based on Technology	- Resistive - Reactive - Active	- Uses resistors - Uses reactances - Uses active devices

Diagram:



Mnemonic: "CAST: Configuration, Adjustable, Symmetry, Technology"

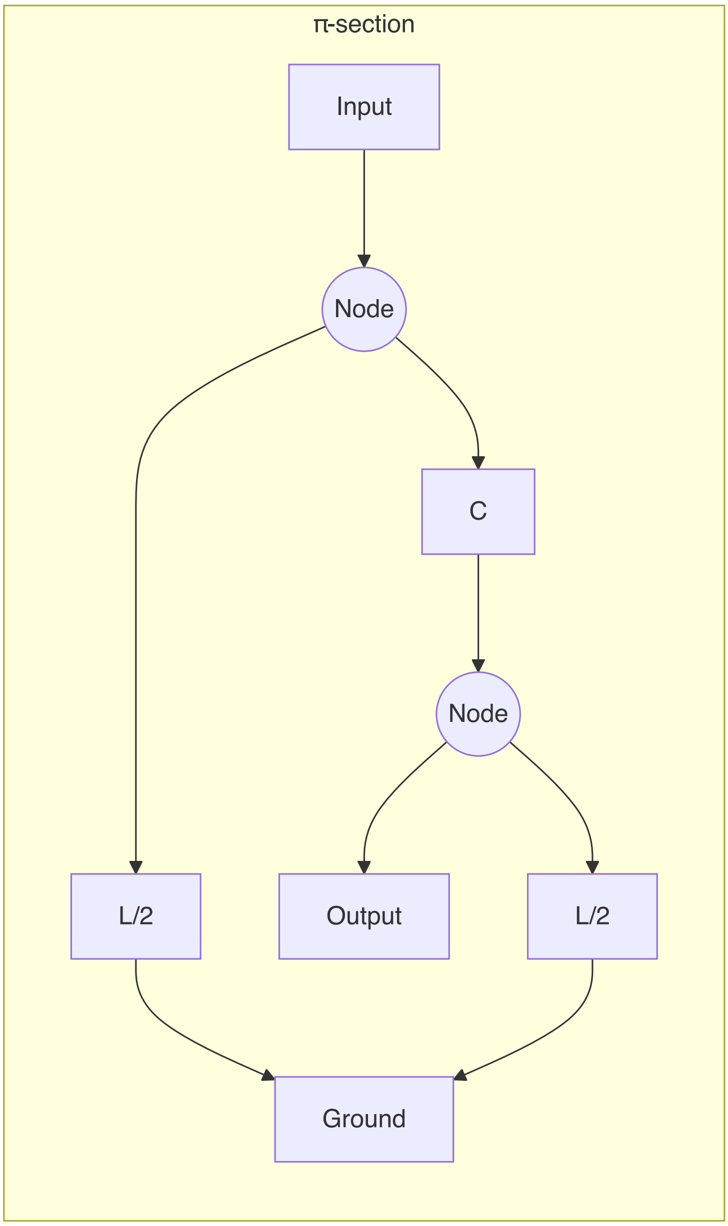
Question 5(c) OR [7 marks]

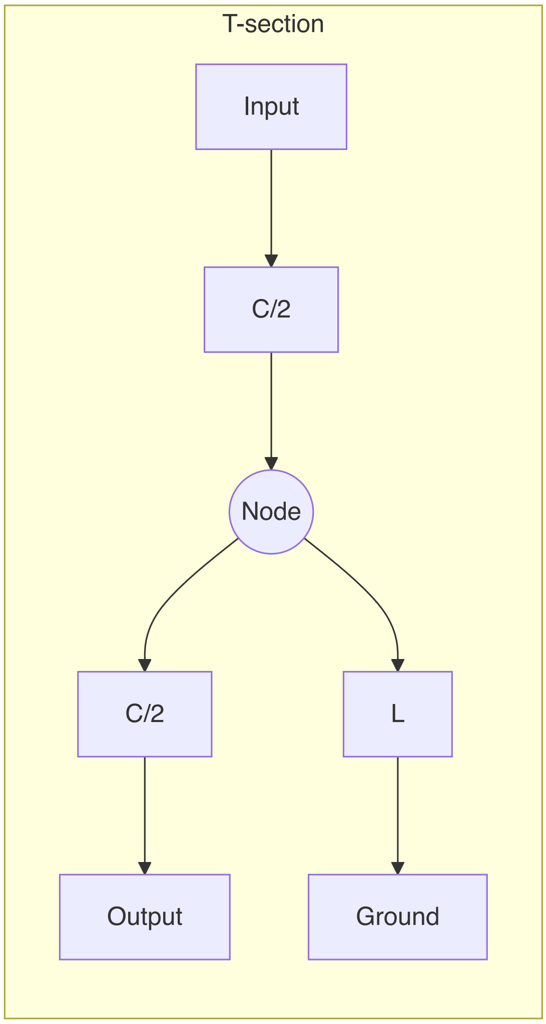
Explain constant K High Pass Filter.

Answer:

Concept	Description
Definition	Filter passing frequencies above cutoff, with $Z_1Z_2 = k^2$ (constant)
Circuit Types	T-section and π-section
T-section components	Series capacitors (C/2) and shunt inductor (L)
π-section components	Series capacitor (C) and shunt inductors (L/2)
Cutoff frequency	$fc = 1/\pi\sqrt{(LC)}$
Characteristic impedance	$R_0 = \sqrt{(L/C)}$

Diagram:





The constant-k high pass filter has:

- Cutoff frequency: $fc = 1/\pi\sqrt{(LC)}$

- Design impedance: $R_0 = \sqrt{(L/C)}$
- Pass band: Above fc
- Attenuation band: 0 to fc
- Gradual transition from pass band to stop band
- Component values are dual of low pass filter (L and C swap places)

Mnemonic: "CHTS: Constant-k High-pass uses T-Section"