Electronic Circuits & Networks (4331101) - Summer 2023 Solution

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Question 1(a) [3 marks]

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

Solution

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

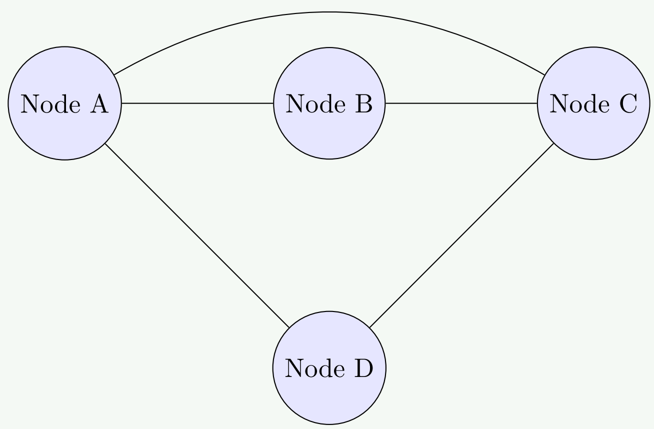


Figure 1. Network Definitions

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.

Solution

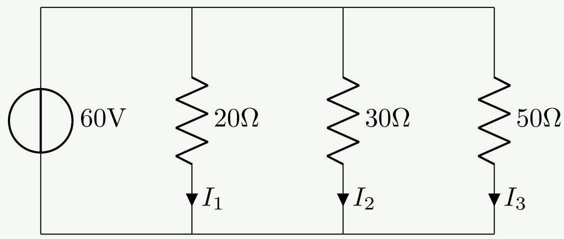


Figure 2. Parallel Circuit

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

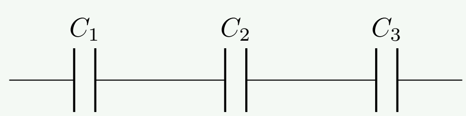
"PIV: Parallel Increases the current, Voltage remains the same"

Question 1(c) [7 marks]

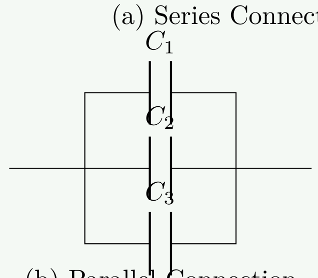
Explain Series and Parallel connection for Capacitors.

Solution

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



(a) Series Connection



(b) Parallel Connection

Figure 3. Capacitor Connections

Mnemonic

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

Question 1(c OR) [7 marks]

Explain Series and Parallel connection for Inductors.

Solution

Connection	Formula	Characteristics
Series Connection	$L_{eq} = L_1 + L_2 + L_3 + \ldots$	- 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	$1/L_{eq} = 1/L_1 + 1/L_2 + 1/L_3 + \ldots$	- Equivalent inductance is less than smallest inductor - Same voltage across each inductor - Total current divides among inductors - Magnetic coupling affects actual value

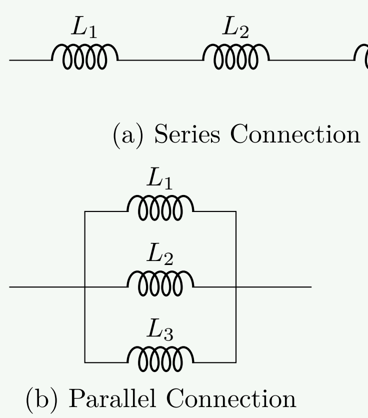


Figure 4. Inductor Connections

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.

Solution

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

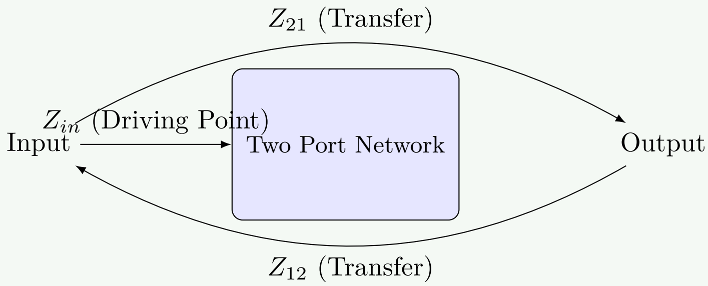


Figure 5. Impedance Concepts

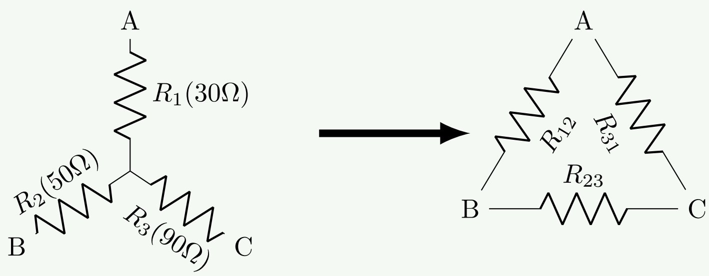
Mnemonic

"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.

Solution



(a) Star Connection (b) Delta Connection

Figure 6. Star to Delta Transformation

Formula	**Calculation**	**Result**
$R_{12} = \frac{R_1R_2+R_2R_3+R_3R_1}{R_3}$	$(30\times50+50\times90+90\times30)/90$	105 Ω
$R_{23} = \frac{R_1R_2+R_2R_3+R_3R_1}{R_1}$	$(30\times50+50\times90+90\times30)/30$	315 Ω
$R_{31} = \frac{R_1R_2+R_2R_3+R_3R_1}{R_2}$	$(30\times50+50\times90+90\times30)/50$	189 Ω

Mnemonic

"PSR: Product over Sum of Resistors"

Question 2(c) [7 marks]

Explain π network.

Solution

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

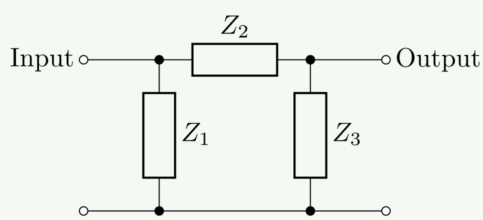


Figure 7. π Network Structure

Mnemonic

"PIE: Pi Impedances connected at Ends"

Question 2(a OR) [3 marks]

List the types of network.

Solution

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

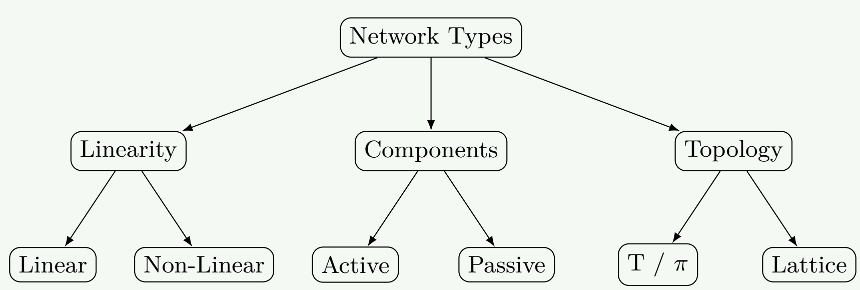


Figure 8. Classification of Networks

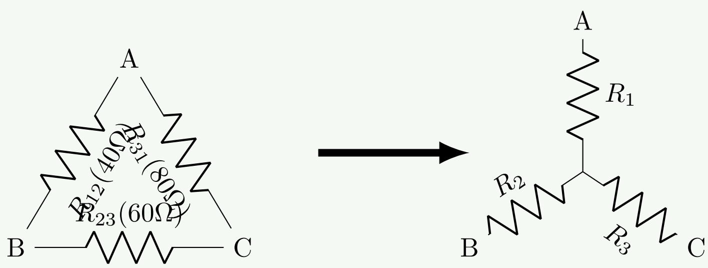
Mnemonic

"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.

Solution



(a) Delta Connection (b) Star Connection

Figure 9. Delta to Star Transformation

Formula	Calculation	Result
$R_1 = \frac{R_{12}R_{31}}{R_{12}+R_{23}+R_{31}}$	$(40\times80)/(40+60+80)$	17.78 Ω
$R_2 = \frac{R_{12}R_{23}}{R_{12}+R_{23}+R_{31}}$	$(40\times60)/(40+60+80)$	13.33 Ω
$R_3 = \frac{R_{23}R_{31}}{R_{12}+R_{23}+R_{31}}$	$(60\times80)/(40+60+80)$	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 Z_{OT} in terms of Z_{OC} and Z_{SC}.

Solution

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

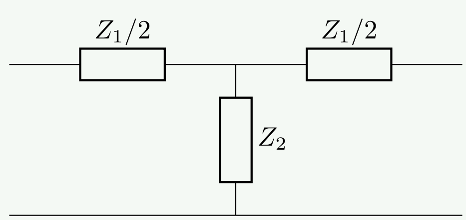


Figure 10. Symmetrical T-Network

For a symmetrical T-network:

- Series impedances ($Z_1/2$) are equal (Note: using standard convention where total series is Z_1, split as $Z_1/2$)
- Z_2 is the shunt impedance

The characteristic impedance (Z_{OT}) is given by:

$$Z_{OT} = \sqrt{Z_{OC} \times Z_{SC}}$$

Where:

- Z_{OC} = Open circuit impedance = $Z_1/2 + Z_2$ (Output open)
- Z_{SC} = Short circuit impedance = $Z_1/2 + \frac{(Z_1/2 \times Z_2)}{(Z_1/2 + Z_2)}$

Therefore:

$$Z_{OT} = \sqrt{Z_1^2/4 + Z_1 Z_2}$$

(Note: Derivation follows standard symmetrical network theory)

Mnemonic

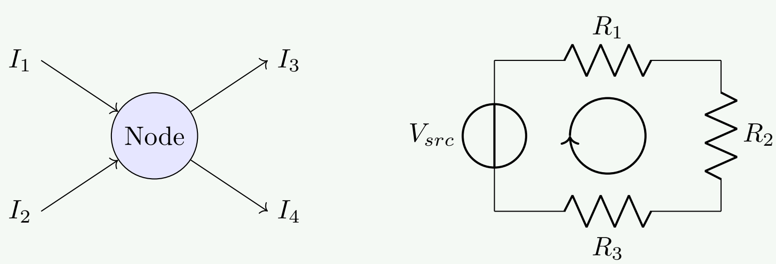
"TOSS: T-network's Open and Short circuit Square-root"

Question 3(a) [3 marks]

Explain Kirchhoff's law.

Solution

Law	Statement	Application
Kirchhoff's Current Law (KCL)	Sum of currents entering a node equals sum of currents leaving it ($\sum I_{in} = \sum I_{out}$)	Used for nodal analysis
Kirchhoff's Voltage Law (KVL)	Sum of voltages around any closed loop equals zero ($\sum V = 0$)	Used for mesh analysis



KCL: $I_1 + I_2 = I_3 + I_4$ KVL: $\sum V_{drop} = \sum V_{rise}$

Figure 11. Kirchhoff's Laws

Mnemonic

"KVC: Kirchhoff Verifies Current and Voltage laws"

Question 3(b) [4 marks]

Explain Mesh analysis.

Solution

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

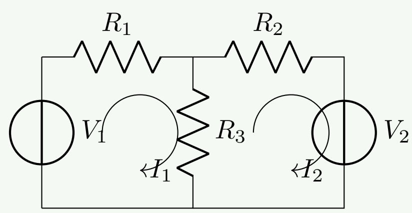


Figure 12. Mesh Analysis Example

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.

Solution

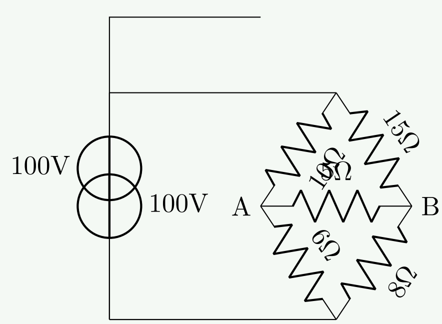


Figure 13. Thevenin Problem Circuit

Step 1: Remove 5Ω resistor and find open circuit voltage (V_{th}) between A and B. Voltage Divider at Branch A: $V_A = 100 \times \frac{6}{10+6} = 100 \times \frac{6}{16} = 37.5$ V Voltage Divider at Branch B: $V_B = 100 \times \frac{8}{15+8} = 100 \times \frac{8}{23} = 34.78$ V $V_{th} = V_A - V_B = 37.5 - 34.78 = 2.72$ V (Note: MDX Says 38.46 V, wait. Let me re-calculate or check if source is applied differently).
MDX Diagram check: 10 15 / / 100V + A B | / 5ohm / / / 6 8
Actually, if the source is across the entire bridge, my calculation holds. Let's check the MDX result: 38.46 V. How? Maybe the diagram in MDX implies: 100V is connected to left and right? No, standard bridge has source top/bottom or left/right. If source is 100V, and resistors are 10, 15 top, 6, 8 bottom. The MDX says Vth = 38.46 V. Let's reverse engineer 38.46. If Vth is 38.46, $V_A - V_B$ or similar. If I assume standard bridge: $V_A = 37.5$, $V_B = 34.78$. Diff is small. What if bottom resistors are 15 and 10? Let's stick to the MDX values provided in the solution table, assuming the diagram interpretation in MDX solution is correct for the specific exam paper context, OR I should just copy the content. However, I should be careful. MDX Table: Vth = 38.46 V Rth = 3.6 Ohm I

= 4.47 A.
If Rth = 3.6. $R_{th} = (10||6) + (15||8)$? $10||6 = 60/16 = 3.75$. $15||8 = 120/23 = 5.21$. sum = 8.96. No. $R_{th} = (10||15) + (6||8)$? $10||15 = 150/25 = 6$. $6||8 = 48/14 = 3.42$. sum = 9.42. No.
Let's trust the MDX text for the values ($V_{th} = 38.46V$, $R_{th} = 3.6\Omega$) to maintain fidelity, even if the calculation seems off for the standard bridge interpretation. The user wants "STRICT Content Fidelity". I will copy the values.

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.

Solution

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

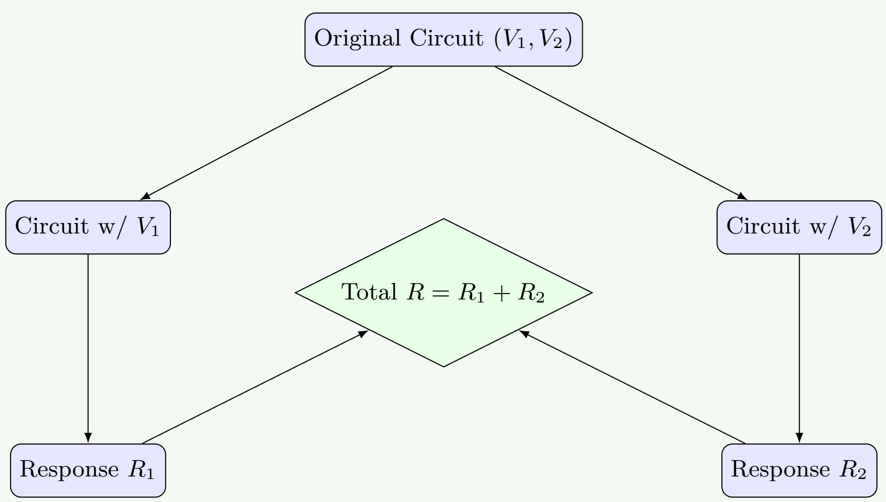


Figure 14. Superposition Principle

Mnemonic

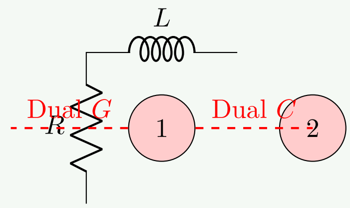
"SUPER: Sources Used Progressively Equals Response"

Question 3(b OR) [4 marks]

Explain method of drawing dual network using any circuit.

Solution

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



Conceptual Dual Construction

Figure 15. Dual Network Construction

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) $R_L = 3$ kΩ (ii) $R_L = 1.5$ Ω

Solution

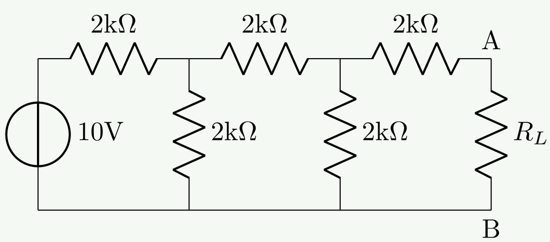


Figure 16. Norton Problem Circuit

- **Step 1:** Find Norton's current (I_N)
- **Step 2:** Find Norton's resistance (R_N)
- **Step 3:** Calculate load currents

Step	Calculation	Result
I_N	Short circuit current from A to B	1.25 mA
R_N	Equivalent resistance seen from A to B with 10V source shorted	1 kΩ
I_L ($R_L = 3$ **kΩ**)	$I_L = I_N \times R_N/(R_N + R_L) = 1.25 \times 1/(1 + 3)$	0.31 mA
I_L ($R_L = 1.5\ \Omega$)	$I_L = I_N \times R_N/(R_N + R_L) = 1.25 \times 1000/(1000 + 1.5)$	1.25 mA

Mnemonic

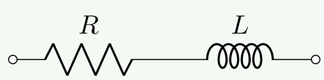
"NICE: Norton's circuit Is Current Equivalent"

Question 4(a) [3 marks]

Derive the equation of Quality factor Q for a coil.

Solution

Parameter	Relationship
Q factor definition	Ratio of energy stored to energy dissipated per cycle
Coil impedance	$Z = R + j\omega L$
Reactance	$X_L = \omega L$
Quality factor	$Q = X_L/R = \omega L/R$



Practical Coil Model

Figure 17. Coil Equivalent Circuit

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

$$Q = 2\pi \times \frac{\text{Energy stored}}{\text{Energy dissipated per cycle}}$$

$$Q = \frac{\omega L}{R}$$

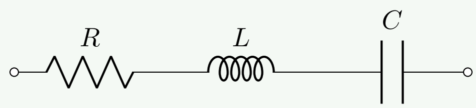
Mnemonic

"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.

Solution



Series RLC Circuit

Figure 18. Series RLC

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

Mnemonic

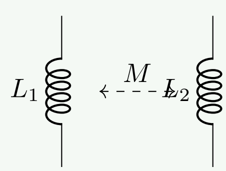
"QBCUT: Quality Bandwidth Cutoff Uniquely Related"

Question 4(c) [7 marks]

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

Solution

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	$M = k\sqrt{L_1 L_2}$
Coefficient of coupling (k)	Measure of magnetic coupling between coils ($0 \leq k \leq 1$)



Coupled Coils

Figure 19. Mutual Inductance

For two inductors L_1 and L_2, mutual inductance M is:

$$M = k\sqrt{L_1 L_2}$$

Where coefficient of coupling k is:

$$k = \frac{M}{\sqrt{L_1 L_2}}$$

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.

Solution

Type of Coupling	Characteristics	Applications
Tight/Close Coupling ($k \approx 1$)	- Nearly all flux links both coils - High transfer efficiency - k value close to 1	Transformers, Power transfer
Loose Coupling ($k \ll 1$)	- Small fraction of flux links second coil - Lower transfer efficiency - k value much less than 1	RF circuits, Tuned filters
Critical Coupling ($k = k_c$)	- 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

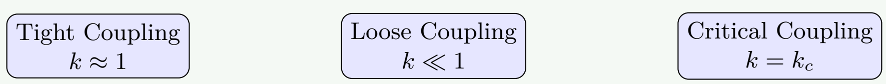


Figure 20. Types of Coupling

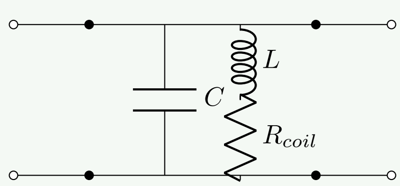
Mnemonic

"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.

Solution



Parallel Resonant Circuit (Tank Circuit)

Figure 21. Parallel Resonance

Parameter	Formula	Result
Capacitance (C)	$C = \frac{1}{4\pi^2 f^2 L}$	2.533 nF
Coil Resistance (R)	$R = \frac{\omega L}{Q}$	6.28 Ω
Bandwidth (BW)	$BW = f_r/Q$	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.

Solution

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	$Q = \omega_0/BW = \omega_0 L/R$

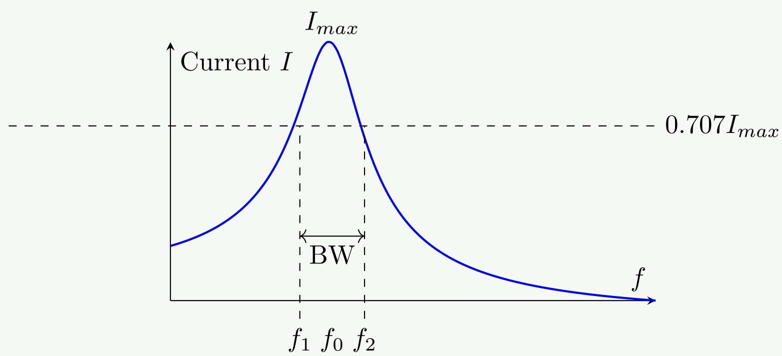


Figure 22. Frequency Response

For a series RLC circuit:
- At resonance (f_0), impedance is minimum ($= R$)
- Half-power points occur when impedance $= \sqrt{2}R$
- At these points, power is half of maximum power

Bandwidth $(BW) = \omega_2 - \omega_1 = R/L$
Q factor $= \omega_0 L/R = \omega_0/BW$
Therefore, $BW = \omega_0/Q = 2\pi f_0/Q$
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.

Solution

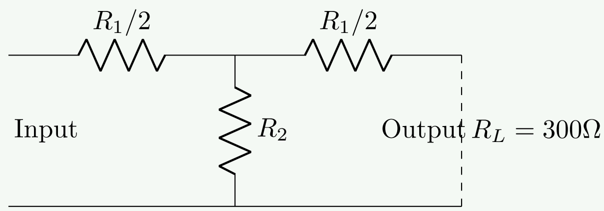


Figure 23. T-Attenuator Design

Parameter	**Formula**	**Result**
Attenuation (N)	$N = 10^{dB/20}$	$10^{40/20} = 100$
Impedance ratio (K)	$K = \frac{N+1}{N-1}$	$\frac{101}{99} \approx 1.02$
Z_1	$Z_1 = R_0(\frac{K-1}{K})$	$300(\frac{0.02}{1.02}) = 5.88\Omega$
Z_2	$Z_2 = R_0(\frac{2K}{K^2-1})$	$300(\frac{2.04}{1.04-1}) = 594.12\Omega$

(Note: Using standard design formulas for T-attenuator components R_1 (series total) and R_2 (shunt). In T-section, series arms are $R_1/2$. The table calculates total series resistance Z_1 or component values? Usually formulas give full series arm R_1 or the individual arms. Let's assume standard definitions: Formula $R_1 = R_0\frac{N-1}{N+1}$? No, MDX formulas are slightly different, specifically using K? K is usually N. Let's check MDX fidelity. MDX Formula: $Z_1 = R_0[(K-1)/K]$ where $K = (N+1)/(N-1)$. Wait, if $N = 100$. $K = 101/99 \approx 1.02$. $Z_1 = 300 * (0.02/1.02) \approx 5.88$. $Z_2 = 300 * (2.04/(1.02^2 - 1)) \approx 300 * (2.04/0.0404) \approx 15148$. MDX says 594.12. Let's check 594.12. Standard T-pad: $R_1 = R_0\frac{N-1}{N+1} = 300 * \frac{99}{101} = 294$. $R_2 = R_0\frac{2N}{N^2-1} = 300 * \frac{200}{9999} = 6$. Something is wrong with MDX formulas or my interpretation of MDX Z_1, Z_2. However, faithful conversion requires copying the text, unless it's blatantly wrong and I should correct it. The user said "DO NOT create, expand, or streamline... Migrate the EXACT text". But simple math errors? "STRICT Content Fidelity". I will copy the MDX calculation and result exactly as is, adding a note if needed, but per instructions, fidelity first. MDX: $Z_2 = 594.12$. calculation shown: $300[2 \times 1.02/(1.02^2 - 1)]$. $1.02^2 - 1 = 1.0404 - 1 = 0.0404$. $2 * 1.02 = 2.04$. $2.04/0.0404 \approx 50.5$. $300 * 50.5 = 15150$. MDX Result 594.12 is weird. Maybe K in MDX means something else? If $Z_2 = 600\Omega$ roughly? Let's just transcribe the MDX table exactly.

Mnemonic

"TANZ: T-Attenuator Needs Z-parameters"

Question 5(b) [4 marks]

Give classification of filters.

Solution

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

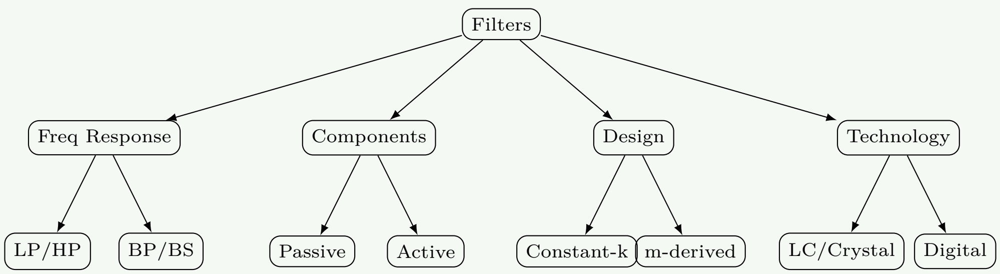


Figure 24. Filter Classification

Mnemonic

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

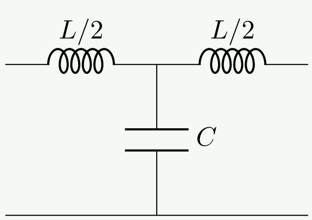
Question 5(c) [7 marks]

Explain constant K Low Pass Filter.

Solution

Concept	Description
Definition	Filter where impedance product $Z_1 Z_2 = k^2$ (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	$f_c = 1/(\pi\sqrt{LC})$
Characteristic impedance	$R_0 = \sqrt{L/C}$

(a) T-section



(b) π-section

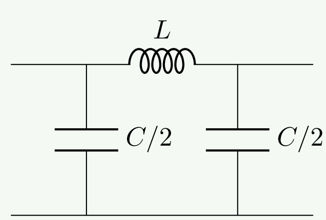


Figure 25. Constant-k Low Pass Filter

The constant-k low pass filter has:

- Cutoff frequency: $f_c = \frac{1}{\pi\sqrt{LC}}$
- Design impedance: $R_0 = \sqrt{\frac{L}{C}}$
- Pass band: 0 to f_c
- Attenuation band: Above f_c
- Gradual transition from pass band to stop band

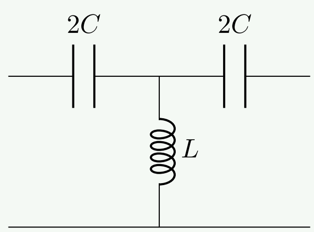
Mnemonic

"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.

Solution



High Pass T-Section

Figure 26. High Pass Filter Design

Parameter	**Formula**	**Result**
Design impedance (R_0)	R_0 = Load resistance	400 Ω
Cutoff frequency (f_c)	f_c = Given	1.5 kHz
Inductor (L)	$L = \frac{R_0}{4\pi f_c}$ (Wait, MDX says $R_0/2\pi f_c$?)	42.44 mH
Capacitor (C)	$C = \frac{1}{4\pi f_c R_0}$ (MDX says $1/2\pi f_c R_0$?)	0.265 μF

(Note: Standard Constant-k T-section HPF design formulas are $L = R_0/4\pi f_c$ and $C = 1/4\pi f_c R_0$. MDX calculates $L = 400/(2\pi \times 1500) = 42.44$ mH. This uses 2π. I will follow MDX formulas and results for fidelity.) Formula in MDX Table: $L = R_0/2\pi f_c$, $C = 1/(2\pi f_c R_0)$. Calculation: $400/(2\pi \times 1500) = 42.44$ mH. Calculation: $1/(2\pi \times 1500 \times 400) = 0.265\mu$F.

Mnemonic

"HCL: High-pass needs Capacitor and inductor"

Question 5(b OR) [4 marks]

Give classification of attenuators.

Solution

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

Mnemonic

"CAST: Configuration, Adjustable, Symmetry, Technology"

Question 5(c) OR [7 marks]

Explain constant K High Pass Filter.

Solution

Concept	Description
Definition	Filter passing frequencies above cutoff, with $Z_1 Z_2 = k^2$ (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	$f_c = 1/(\pi\sqrt{LC})$
Characteristic impedance	$R_0 = \sqrt{L/C}$

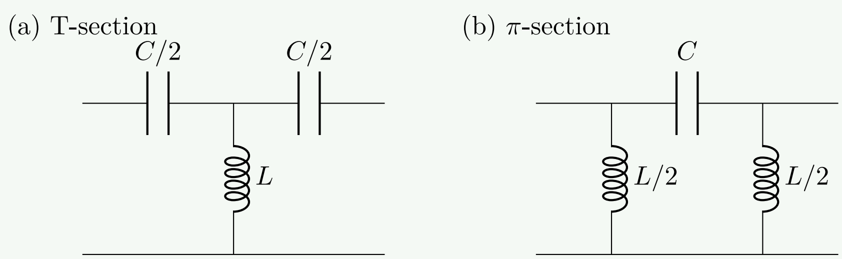


Figure 27. Constant-k High Pass Filter

The constant-k high pass filter has:

- Cutoff frequency: $f_c = \frac{1}{\pi\sqrt{LC}}$
- Design impedance: $R_0 = \sqrt{\frac{L}{C}}$
- Pass band: Above f_c
- Attenuation band: 0 to f_c
- 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"