Subject Name Solutions

4331101 – Summer 2023

Semester 1 Study Material

Detailed Solutions and Explanations

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

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A((Node A)) {-{-}{-} B((Node B)) {-}{-}{-} C((Node C)) {-}{-}{-} D((Node D)) {-}{-}{-} A}
    A {-{-}{-} C}
    style A fill:\#f9f,stroke:\#333,stroke{-width:2px}
    style B fill:\#bbf,stroke:\#333,stroke{-width:2px}
    style C fill:\#f9f,stroke:\#333,stroke{-width:2px}
    style D fill:\#bbf,stroke:\#333,stroke{-width:2px}
{Highlighting}
{Shaded}
```

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

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[60V] {-{-}{-} B(({}+))}
    B {-{-}{-} C[20Ω] {-}{-}{-} D(({}{-}))}
    B {-{-}{-} E[30Ω] {-}{-}{-} D}
    B {-{-}{-} F[50Ω] {-}{-}{-} D}
    D {-{-}{-} A}
{Highlighting}
{Shaded}
```

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

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    subgraph Series
        direction LR
        A["{+"] {-}{-}{-} B[C_{1}] {-}{-}{-} C[C_{2}] {-}{-}{-} D[C_{3}] {-}{-}{-} E["{}{-}"]}
    end

    subgraph Parallel
        F["{+"] {-}{-}{-} G[C_{1}] {-}{-}{-} H["{}{-}"]}
        F {-{-}{-} I[C_{2}] {-}{-}{-} H}
        F {-{-}{-} J[C_{3}] {-}{-}{-} H}
    end
{Highlighting}
{Shaded}
```

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

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    subgraph Series
        direction LR
        A["{+"] {-}{-}{-} B((L_{1})) {-}{-}{-} C((L_{2})) {-}{-}{-} D((L_{3})) {-}{-}{-} E["{}{-}"]}
    end

    subgraph Parallel
        F["{+"] {-}{-}{-} G((L_{1})) {-}{-}{-} H["{}{-}"]}
        F {-{-}{-} I((L_{2})) {-}{-}{-} H}
        F {-{-}{-} J((L_{3})) {-}{-}{-} H}
    end
{Highlighting}
{Shaded}
```

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

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Input] {-{-}{-} B[Two Port Network] {-}{-}{-} C[Output]}
    D[Z11: Driving point impedance] {-.{-}{} B}
    E[Z21: Transfer impedance] {-.{-}{} B}
    F[Z12: Transfer impedance] {-.{-}{} B}
    G[Z22: Driving point impedance] {-.{-}{} B}
{Highlighting}
{Shaded}
```

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

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A((A)) {-{-}{-} B[R_{1}=30Ω] {-}{-}{-} D((D))}
    B((B)) {-{-}{-} C[R_{2}=50Ω] {-}{-}{-} D}
    C((C)) {-{-}{-} E[R_{3}=90Ω] {-}{-}{-} D}

    subgraph Equivalent Delta
        A {-{-}{-} F[R_{1}_{2}] {-}{-}{-} B}
        B {-{-}{-} G[R_{2}_{3}] {-}{-}{-} C}
        C {-{-}{-} H[R_{3}_{1}] {-}{-}{-} A}
    end
{Highlighting}
{Shaded}
```

Star to Delta Conversion Formula	Calculation	Result
$R_{12} = (R_{12} + R_{23} + R_{31})/R_3$	$(30\times50 + 50 \times 90 + 90 \times 30)/90$	105 Ω
$R_{23} = (R_{12} + R_{23} + R_{31})/R_1$	$(30\times50 + 50 \times 90 + 90 \times 30)/30$	315 Ω
$R_{31} = (R_{12} + R_{23} + R_{31})/R_2$	$(30\times50 + 50 \times 90 + 90 \times 30)/50$	189 Ω

Mnemonic

"PSR: Product over Sum of Resistors"

Question 2(c) [7 marks]

Explain 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

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Input] {-{-}{-} C[Z_{2}] {-}{-}{-} B[Output]}
    A {-{-}{-} D[Z_{1}] {-}{-}{-} E[Common/Ground]}
    B {-{-}{-} F[Z_{3}] {-}{-}{-} E}

    style D fill:\#bbf,stroke:\#333,stroke{-width:2px}
    style C fill:\#f96,stroke:\#333,stroke{-width:2px}
    style F fill:\#bbf,stroke:\#333,stroke{-width:2px}
{Highlighting}
{Shaded}
```

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, -networks, Lattice networks
Based on Ports	One-port networks, Two-port networks, Multi-port networks