

Subject Name Solutions

4331101 – Summer 2025

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

Define following terms. (i) Active elements (ii) Bilateral elements (iii) Linear elements

Solution

| Term | Definition |
|---------------------------|---|
| Active elements | Electronic components that can supply energy or power to a circuit (like batteries, generators, op-amps) |
| Bilateral elements | Components that allow current flow equally in both directions with same characteristics (like resistors, capacitors, inductors) |
| Linear elements | Components whose current-voltage relationship follows a straight line and obeys the principle of superposition (like resistors following Ohm's law) |

Mnemonic

“ABL: Active powers Batteries, Bilateral flows Both ways, Linear stays Lawful”

Question 1(b) [4 marks]

Capacitors of $10\mu F$, $20\mu F$ and $30\mu F$ are connected in series and supply of 200V DC is given. Find voltage across each capacitor.

Solution

For series-connected capacitors:

1. Find equivalent capacitance: $1/C_{eq} = 1/C_1 + 1/C_2 + 1/C_3$

1. Voltage division: $V_C = (C_1/C) \times V$

Calculation: $1/C_{eq} = 1/10 + 1/20 + 1/30 = 0.1 + 0.05 + 0.033 = 0.183$ $C_{eq} = 5.46 \text{ F}$

| Capacitor | Formula | Calculation | Voltage |
|-------------|-------------------------------|---------------------------------|---------|
| $C_1 = 10F$ | $V_1 = (C_{eq}/C_1) \times V$ | $(5.46/10) \times 200 = 109.2V$ | 109.2V |
| $C_2 = 20F$ | $V_2 = (C_{eq}/C_2) \times V$ | $(5.46/20) \times 200 = 54.6V$ | 54.6V |
| $C_3 = 30F$ | $V_3 = (C_{eq}/C_3) \times V$ | $(5.46/30) \times 200 = 36.4V$ | 36.4V |

Mnemonic

“Smaller Capacitors get Larger Voltages”

Question 1(c) [7 marks]

Explain Node pair voltage method for graph theory.

Solution

Node pair voltage method is a systematic approach to analyze electrical networks.

Procedure:

1. Select a reference node (ground)
2. Identify the node voltages (N-1 unknowns for N nodes)

3. Apply KCL at each non-reference node
4. Express branch currents in terms of node voltages
5. Solve the equations for node voltages

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting} []
graph LR
    A[Select reference node] --> B[Identify node voltages]
    B --> C[Apply KCL at each node]
    C --> D[Express branch currents using node voltages]
    D --> E[Solve equations for node voltages]
    E --> F[Calculate branch currents]
{Highlighting}
{Shaded}
```

Key advantages:

- **Fewer equations:** Only $(n-1)$ equations for n nodes
- **Computational efficiency:** Reduces system complexity
- **Direct voltage solutions:** Provides node voltages directly
- **Systematic approach:** Works for any network topology

Mnemonic

“GARCS: Ground, Assign voltages, Relate with KCL, Calculate currents, Solve equations”

Question 1(c) OR [7 marks]

Explain voltage division method with necessary equations.

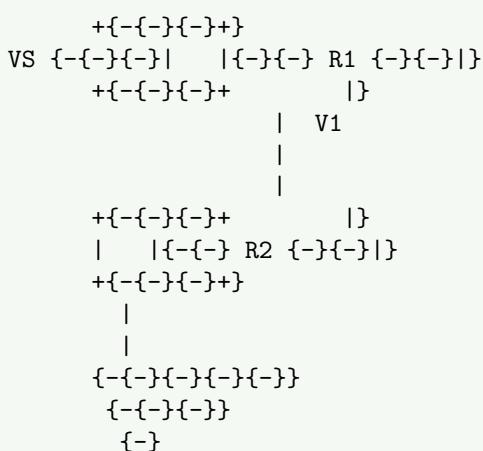
Solution

Voltage division is a method to calculate how voltage distributes across series components.

Principle: In a series circuit, voltage divides proportionally to component resistances/impedances.

Formula: For a resistor R_1 in a series circuit with total resistance RT : $V_1 = (R_1/RT) \times VS$

Diagram:



Mathematical explanation:

- For resistors: $V_1 = (R_1/RT) \times VS$
- For capacitors: $V_1 = (1/C_1)/(1/CT) \times VS = (CT/C_1) \times VS$
- For inductors: $V_1 = (L_1/LT) \times VS$
- For complex impedances: $V_1 = (Z_1/ZT) \times VS$

Examples:

1. Voltage across a $1\text{k}\Omega$ resistor in series with $4\text{k}\Omega$ with 5V source = $(1/5) \times 5\text{V} = 1\text{V}$
1. Voltage across a 10 F capacitor in series with 40 F with 10V source = $(1/10)/(1/8) \times 10\text{V} = 8\text{V}$