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 10µF, 20µF and 30µF 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: $1/\text{Ceq} = 1/\text{C}_1 + 1/C_2 + 1/C_3$
1. Voltage division: $\text{VC} = (\text{C}_1/C) \times V$

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

Capacitor	Formula	Calculation	Voltage
$\text{C}_1 = 10F$	$\text{V}_1 = (Ceq/C_1) \times V$	$(5.46/10)\ \times 200 = 109.2V$	109.2V
$\text{C}_2 = 20F$	$\text{V}_2 = (Ceq/C_2) \times V$	$(5.46/20)\ \times 200 = 54.6V$	54.6V
$\text{C}_3 = 30F$	$\text{V}_3 = (Ceq/C_3) \times V$	$(5.46/30)\ \times 200 = 36.4V$	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:

```
      +{-{-}{-}+}
VS {-{-}{-}|   |{-}{-} R1 {-}{-}|}
      +{-{-}{-}+        |}
                   |  V1
                   |
                   |
      +{-{-}{-}+        |}
      |   |{-{-} R2 {-}{-}|}
      +{-{-}{-}+}
        |
        |
      {-{-}{-}{-}{-}}
       {-{-}{-}}
        {-}
```

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 1kΩ resistor in series with 4kΩ with 5V source = (1/5)×$5V = 1V$
1. Voltage across a 10 F capacitor in series with 40 F with 10V source = (1/10)/(1/8)×$10V = 8V$