Basic Electronics Solutions

DI01000101 – Winter 2024

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

Explain ohm's law with its limitation and application.

Solution

Table 1: Ohm's Law Summary

Aspect	Description
Statement	Current through conductor is directly proportional to voltage
Formula	$V = I \times R$
Units	V (Volts), I (Amperes), R (Ohms)

Limitations:
- **Temperature dependency**: Resistance changes with temperature
- **Non-linear materials**: Does not apply to semiconductors, diodes
- **AC circuits**: Modified form needed for reactive components

Applications:
- **Circuit analysis**: Calculate unknown voltage, current, or resistance
- **Power calculations**: $P = V^2/R, P = I^2R$

Mnemonic

"Voltage Is Really Important" ($V = I \times R$)

Question 1(b) [4 marks]

Explain faraday's law of electromagnetic induction with necessary figure.

Solution

Faraday's Laws:
- **First Law**: EMF is induced when magnetic flux changes through conductor
- **Second Law**: Magnitude of EMF equals rate of flux change

Mathematical Expression:

```
e = -N \times (dΦ/dt)
```

Diagram:

```
    +{-{-}{-}{-}{-}{-}{-}+}
    |   N   |  Coil with N turns
    |       |
    +{-{-}{-}+{-}{-}{-}+}
        |
        |  Moving magnet
    +{-{-}{-}v{-}{-}{-}+}
    | S | N |
    +{-{-}{-}{-}{-}{-}{-}+}

   Motion direction
```

Applications:
- **Transformers**: Mutual induction principle

- **Generators**: Mechanical to electrical energy conversion
- **Inductors**: Self-induced EMF opposes current changes

Mnemonic

"Flux Change Generates EMF" ($d\Phi/dt$ = EMF)

Question 1(c) [7 marks]

Explain kirchhoff's voltage law and kirchhoff's current law with necessary diagram.

Solution

Table 3: Kirchhoff's Laws Comparison

Law	Statement	Mathematical Form	Application
KVL	Sum of voltages in closed loop = 0	$\Sigma V = 0$	Series circuits
KCL	Sum of currents at node = 0	$\Sigma I = 0$	Parallel circuits

KVL Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A["{+"] {-}{-}{} B[V1]}
    B {-{-}{} C[R1]}
    C {-{-}{} D[V2]}
    D {-{-}{} E[R2]}
    E {-{-}{} A}

    style A fill:\#f9f,stroke:\#333,stroke{-width:2px}
    style C fill:\#bbf,stroke:\#333,stroke{-width:2px}
    style E fill:\#bbf,stroke:\#333,stroke{-width:2px}
{Highlighting}
{Shaded}
```

KCL Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[I1] {-{-}{} B((Node))}
    C[I2] {-{-}{} B}
    B {-{-}{} D[I3]}
    B {-{-}{} E[I4]}

    style B fill:\#f96,stroke:\#333,stroke{-width:4px}
{Highlighting}
{Shaded}
```

Key Points:

- **KVL**: Algebraic sum considers voltage polarities
- **KCL**: Considers current directions (incoming vs outgoing)
- **Applications**: Circuit analysis, finding unknown values

Mnemonic

"Voltage Loops, Current Nodes" (KVL for loops, KCL for nodes)

Question 1(c OR) [7 marks]

Differentiate statically induced emf and dynamically induced emf

Solution

Table 5: Static vs Dynamic EMF

Parameter	Statically Induced EMF	Dynamically Induced EMF
Cause	Changing magnetic field	Relative motion between conductor and field
Field	Time-varying, conductor stationary	Steady field, conductor moving
Examples	Transformer, inductor	Generator, motor
Formula	e = -N(dΦ/dt)	e = BLv
Applications	AC circuits, power supplies	Power generation, motors

Static EMF Types:

- **Self-induced**: Same coil creates and experiences flux change
- **Mutually induced**: One coil affects another coil

Dynamic EMF Factors:

- **Magnetic field strength (B)**: Tesla
- **Conductor length (L)**: Meters
- **Velocity (v)**: m/s

Mnemonic

"Static Stays, Dynamic Dances" (Static = stationary, Dynamic = motion)

Question 2(a) [3 marks]

Explain various types of losses in transformer.

Solution

Table 7: Transformer Losses

Loss Type	Cause	Location	Characteristics
Iron Loss	Hysteresis + Eddy currents	Core	Constant, frequency dependent
Copper Loss	I^2*Rheating*	Windings	Variable with load
Stray Loss	Leakage flux	Overall	Minimal

Iron Losses:

- **Hysteresis loss**: Magnetic domain reversal energy
- **Eddy current loss**: Circulating currents in core

Copper Losses:

- **Primary winding**: $I_1^2 R_1$
- **Secondary winding**: $I_2^2 R_2$

Mnemonic

"Iron Core, Copper Coil" (Location of main losses)