**Basic Electrical and Electronics Engineering - BE3251**

**UNIT 1 Electrical Circuits**

**PART-C**

**1. Problems Based on Mesh Analysis**

**🔹 What is Mesh Analysis?**

Mesh analysis (or loop current method) is used to determine the current flowing in planar circuits (no crossing elements) using **Kirchhoff’s Voltage Law (KVL)**.

**🔹 Steps for Mesh Analysis:**

1. Identify and label the meshes (loops).
2. Assign a mesh current to each loop.
3. Apply KVL around each mesh.
4. Solve the simultaneous equations.

**🔹 Example Problem:**

**Given Circuit:**

10Ω 5Ω

A ——/\/\/\———/\/\/\—— B

| |

| |

20V 2Ω

| |

| |

D ————————/\/\/\——— C

(Mesh 2)

* Mesh 1: Loop ABD (I₁)
* Mesh 2: Loop BDC (I₂)

**🔹 Step-by-Step Solution:**

Assign mesh currents:

* Mesh 1: Clockwise current I1I\_1
* Mesh 2: Clockwise current I2I\_2

**KVL in Mesh 1:**

20V−10I1−5(I1−I2)=0⇒20−10I1−5I1+5I2=0⇒−15I1+5I2=−20(1)20V - 10I\_1 - 5(I\_1 - I\_2) = 0 \\ \Rightarrow 20 - 10I\_1 - 5I\_1 + 5I\_2 = 0 \\ \Rightarrow -15I\_1 + 5I\_2 = -20 \tag{1}

**KVL in Mesh 2:**

−2I2−5(I2−I1)=0⇒−2I2−5I2+5I1=0⇒5I1−7I2=0(2)-2I\_2 - 5(I\_2 - I\_1) = 0 \\ \Rightarrow -2I\_2 - 5I\_2 + 5I\_1 = 0 \\ \Rightarrow 5I\_1 - 7I\_2 = 0 \tag{2}

**Solving Equations (1) and (2):**

From (2):

5I1=7I2⇒I1=75I25I\_1 = 7I\_2 \Rightarrow I\_1 = \frac{7}{5}I\_2

Substitute into (1):

−15(75I2)+5I2=−20⇒−21I2+5I2=−20⇒−16I2=−20⇒I2=1.25 A-15\left(\frac{7}{5}I\_2\right) + 5I\_2 = -20 \\ \Rightarrow -21I\_2 + 5I\_2 = -20 \Rightarrow -16I\_2 = -20 \\ \Rightarrow I\_2 = 1.25 \, \text{A} I1=75⋅1.25=1.75 AI\_1 = \frac{7}{5} \cdot 1.25 = 1.75 \, \text{A}

**Answer:**

* Mesh current I₁ = 1.75 A
* Mesh current I₂ = 1.25 A

**2. Problems Based on RL, RC, and RLC Circuits**

**🔹 Theory:**

* **RL Circuit**: Resistor and inductor in series.
  + Time constant: τ=LR\tau = \frac{L}{R}
  + Current growth: i(t)=I(1−e−t/τ)i(t) = I(1 - e^{-t/\tau})
  + Current decay: i(t)=Ie−t/τi(t) = I e^{-t/\tau}

**🔹 RL Example Problem:**

Given:

* R=10ΩR = 10 \Omega, L=2HL = 2 H, V=20VV = 20 V

Find current after 0.5s when switch is closed at t = 0.

τ=LR=210=0.2 seci(t)=VR(1−e−t/τ)=2010(1−e−0.5/0.2)=2(1−e−2.5)≈2(1−0.082)=2×0.918=1.836 A\tau = \frac{L}{R} = \frac{2}{10} = 0.2 \, \text{sec} \\ i(t) = \frac{V}{R}(1 - e^{-t/\tau}) = \frac{20}{10}(1 - e^{-0.5/0.2}) \\ = 2(1 - e^{-2.5}) \approx 2(1 - 0.082) = 2 \times 0.918 = 1.836 \, \text{A}

**🔹 RC Example Problem:**

Given:

* R=1 kΩ=1000ΩR = 1 \, \text{k}\Omega = 1000 \Omega, C=10μF=10−5FC = 10 \mu F = 10^{-5} F, V=5VV = 5 V

Find voltage across capacitor at t = 0.01s.

τ=RC=1000⋅10−5=0.01 sVc(t)=V(1−e−t/τ)=5(1−e−1)≈5(1−0.3679)=5⋅0.6321=3.16 V\tau = RC = 1000 \cdot 10^{-5} = 0.01 \, s \\ V\_c(t) = V(1 - e^{-t/\tau}) = 5(1 - e^{-1}) \\ \approx 5(1 - 0.3679) = 5 \cdot 0.6321 = 3.16 \, \text{V}

**🔹 RLC Example Problem:**

Series RLC with:

* R=10 ΩR = 10 \, \Omega, L=1HL = 1 H, C=0.25FC = 0.25 F, V=10VV = 10 V

Find damping condition and resonant frequency.

Damping factor: ζ=R2CL=1020.251=5⋅0.5=2.5⇒Overdamped\text{Damping factor: } \zeta = \frac{R}{2} \sqrt{\frac{C}{L}} = \frac{10}{2} \sqrt{\frac{0.25}{1}} = 5 \cdot 0.5 = 2.5 \Rightarrow \text{Overdamped} Resonant frequency: f0=12πLC=12π1⋅0.25=12π⋅0.5≈0.318 Hz\text{Resonant frequency: } f\_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{1 \cdot 0.25}} = \frac{1}{2\pi \cdot 0.5} \approx 0.318 \, \text{Hz}

**✅ Conclusion:**

* Mesh analysis simplifies multi-loop DC circuits.
* RL, RC, and RLC circuits are fundamental in time-domain electrical analysis.
* Each problem type requires applying time constant and exponential behavior formulas.

**UNIT 2 Electrical Machines**

**1.Construction, Working, Torque equation of Three phase Induction motor**

**Three Phase Induction Motor**

**🔹 Construction:**

1. **Stator**:
   * Three-phase winding distributed in slots.
   * Connected to 3-phase AC supply.
2. **Rotor**:
   * **Squirrel Cage** (common type): Aluminium bars shorted with end rings.
   * **Wound Rotor**: 3-phase winding connected to external resistors via slip rings.

**🔹 Working Principle:**

* Based on **Faraday's Law** and **Electromagnetic Induction**.
* The stator winding produces a **rotating magnetic field** (RMF).
* RMF cuts the rotor and induces EMF (Lenz’s law).
* Induced EMF produces current in rotor → interacts with RMF → torque is generated.
* Rotor **always rotates at less than synchronous speed** (due to slip).

**🔹 Torque Equation:**

T=3ωs⋅r2sE22(r22+(sx2)2)T = \frac{3}{\omega\_s} \cdot \frac{r\_2 s E\_2^2}{(r\_2^2 + (s x\_2)^2)}

Where:

* TT: Torque
* ss: Slip
* ωs\omega\_s: Synchronous angular speed
* r2r\_2: Rotor resistance
* x2x\_2: Rotor reactance
* E2E\_2: Rotor induced EMF

**2. Construction, Working, Types and Torque equation of DC Motor**

**DC Generator**

**🔹 Construction:**

1. **Yoke**: Outer frame – provides mechanical strength.
2. **Field System**: Poles + Field windings (electromagnets).
3. **Armature Core**: Rotates inside the field.
4. **Commutator**: Converts AC to DC.
5. **Brushes**: Collect current from rotating armature.

**🔹 Working Principle:**

* Based on **Faraday’s Law** of Electromagnetic Induction.
* Armature rotates in magnetic field → cuts magnetic lines of flux → EMF is induced.
* Commutator rectifies AC to DC.

**🔹 Types:**

* **Separately Excited**
* **Self Excited**:
  + Series
  + Shunt
  + Compound (cumulative and differential)

**🔹 EMF Equation:**

E=PΦZN60AE = \frac{P \Phi Z N}{60 A}

Where:

* EE: EMF generated (volts)
* PP: Number of poles
* Φ\Phi: Flux per pole (Wb)
* ZZ: Total number of armature conductors
* NN: Speed in RPM
* AA: Number of parallel paths

**3. Construction, Working, Torque equation of Three phase Synchronous motor**

**Three Phase Synchronous Motor**

**🔹 Construction:**

1. **Stator**: 3-phase winding, same as induction motor.
2. **Rotor**: Excited by DC source.
   * **Salient Pole**: Projected poles for low-speed applications.
   * **Non-salient (Cylindrical)**: Smooth rotor, high-speed applications.

**🔹 Working Principle:**

* Stator produces RMF.
* Rotor is excited by DC → produces constant magnetic field.
* When the rotor is brought to synchronous speed, it **locks** with RMF → runs at **synchronous speed**.
* Unlike induction motor, **no slip**.

**🔹 Torque Equation:**

T=3VEωsXssin⁡δT = \frac{3 V E}{\omega\_s X\_s} \sin \delta

Where:

* TT: Torque
* VV: Terminal voltage
* EE: Back EMF
* δ\delta: Load angle
* XsX\_s: Synchronous reactance
* ωs\omega\_s: Synchronous speed in rad/sec

**🔹 Features:**

* Not self-starting (needs auxiliary motor).
* Constant speed operation.
* Used in power factor correction.

**✅ Diagrams (for all 3 machines):**

You can draw these simple labeled diagrams in your exam:

* **3-Phase Induction Motor**: Stator + Squirrel Cage Rotor
* **DC Generator**: Poles, armature, brushes, commutator
* **Synchronous Motor**: Stator and rotor field system

**UNIT 3 Analog Electronics**

**1.Construction, Working, VI Characteristics and applications of CB and CE configuration  
 CB and CE Transistor Configurations**

**🔹 Common Base (CB) Configuration**

**🔸 Construction:**

* Input between **Emitter–Base**.
* Output between **Collector–Base**.
* Base is common to input and output.

**🔸 Working:**

* Emitter injects majority carriers.
* Base-emitter junction is **forward biased**, collector-base is **reverse biased**.
* Very small input resistance, high output resistance.

**🔸 VI Characteristics:**

* **Input (IE vs VEB)**: Like diode curve.
* **Output (IC vs VCB)**: Almost flat → output current ≈ emitter current.

**🔸 Applications:**

* High-frequency amplifiers.
* Low input impedance circuits.

**🔹 Common Emitter (CE) Configuration**

**🔸 Construction:**

* Input between **Base–Emitter**.
* Output between **Collector–Emitter**.
* Emitter is common to input and output.

**🔸 Working:**

* Base-emitter junction is forward biased, collector-base is reverse biased.
* Most popular configuration for amplification.

**🔸 VI Characteristics:**

* **Input (IB vs VBE)**: Like diode.
* **Output (IC vs VCE)**: In active region, IC ∝ IB.

**🔸 Applications:**

* Used in **voltage amplification**.
* Audio amplifiers, RF amplifiers.

**2. JFET: Construction, Working, VI Characteristics and applications**

**JFET (Junction Field Effect Transistor)**

**🔹 Construction:**

* **N-channel or P-channel**.
* Consists of a channel with two **P-N junctions** forming a **gate**.
* Gate is **reverse biased**.

**🔹 Working:**

* Current flows from **Drain to Source**.
* Gate voltage **controls the width** of the conducting channel.
* No gate current flows (high input impedance).

**🔹 VI Characteristics:**

* **Output (ID vs VDS)**:
  + Ohmic region (linear),
  + Saturation region (constant ID),
  + Cut-off region.
* **Transfer characteristics (ID vs VGS)**: Parabolic drop.

**🔹 Applications:**

* Voltage-controlled resistors.
* Buffer amplifiers.
* High-input impedance amplifiers.

**3. DE-MOSFET, E-MOSFET: Construction, Working, VI Characteristics and applications**

**MOSFETs**

**🔹 (i) Depletion-Type MOSFET (DE-MOSFET)**

**🔸 Construction:**

* Similar to JFET but has an insulated **gate (metal-oxide)**.
* Can operate in **depletion and enhancement modes**.

**🔸 Working:**

* **Depletion Mode**: Negative gate voltage reduces channel width.
* **Enhancement Mode**: Positive gate voltage enhances channel width.

**🔸 VI Characteristics:**

* **ID vs VDS** curves show control via VGS.
* Operates with both +ve and -ve VGS.

**🔸 Applications:**

* Analog switches.
* Variable gain amplifiers.

**🔹 (ii) Enhancement-Type MOSFET (E-MOSFET)**

**🔸 Construction:**

* No physical channel exists initially.
* Requires **positive VGS (for N-channel)** to induce a channel.

**🔸 Working:**

* No current flows until threshold voltage VthV\_{th} is exceeded.
* Above VthV\_{th}, electrons are attracted → forms channel.

**🔸 VI Characteristics:**

* No conduction below VthV\_{th}.
* Strong control of current with gate voltage.

**🔸 Applications:**

* Used in digital logic circuits (CMOS).
* Microprocessor & memory chips.
* Switching regulators.

**✅ Summary Table:**

| **Device** | **Input Impedance** | **Output Impedance** | **Mode of Operation** | **Key Application** |
| --- | --- | --- | --- | --- |
| CB BJT | Low | High | Current-controlled | RF Amplifiers |
| CE BJT | Moderate | Moderate | Current-controlled | Audio Amplifiers |
| JFET | Very High | High | Voltage-controlled | Buffer Amplifiers |
| DE-MOSFET | Very High | High | Depletion & Enhancement | Analog Switches |
| E-MOSFET | Very High | High | Enhancement only | Digital Switching |

**UNIT 4 Digital Electronics**

**1. Problems based on 3-variable K-Map**

**🔹 Given:**

Simplify the Boolean expression using **3-variable K-map**:

f(A,B,C)=∑(0,1,2,5,6)f(A,B,C) = \sum(0,1,2,5,6)

**🔹 Step 1: Truth Table (minterms)**

| **A** | **B** | **C** | **Minterm** |
| --- | --- | --- | --- |
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 2 |
| 0 | 1 | 1 | 3 |
| 1 | 0 | 0 | 4 |
| 1 | 0 | 1 | 5 |
| 1 | 1 | 0 | 6 |
| 1 | 1 | 1 | 7 |

**🔹 Step 2: 3-variable K-map**

BC

00 01 11 10

----------------

A=0 | 1 1 0 1

A=1 | 0 1 0 1

**🔹 Step 3: Grouping**

* Group of 4: (0,1,2,5)
* Pair: (5,6)

**🔹 Step 4: Simplified Expression**

* Group 1 (0,1,2,5) → B′C+A′CB'C + A'C
* Group 2 (5,6) → AC′A C'

⇒f(A,B,C)=C′A+A′C+B′C\Rightarrow f(A,B,C) = C' A + A'C + B'C

**2. Problems based on 4-variable K-Map**

**🔹 Given:**

Simplify using **4-variable K-map**:

f(A,B,C,D)=∑(0,1,2,5,8,9,10,14)f(A,B,C,D) = \sum(0,1,2,5,8,9,10,14)

**🔹 Step 1: Labeling the K-Map**

Variables: A, B, C, D

| **AB \ CD** | **00** | **01** | **11** | **10** |
| --- | --- | --- | --- | --- |
| 00 | 1 | 1 | 0 | 1 |
| 01 | 0 | 1 | 0 | 0 |
| 11 | 0 | 0 | 1 | 0 |
| 10 | 1 | 1 | 0 | 0 |

**🔹 Step 2: Fill K-map**

CD

00 01 11 10

----------------

AB=00 | 1 1 0 1

AB=01 | 0 1 0 0

AB=11 | 0 0 1 0

AB=10 | 1 1 0 0

**🔹 Step 3: Grouping**

* Group of 4: (0,1,8,9)
* Group of 2: (2,10)
* Group of 2: (5,1)

**🔹 Step 4: Simplified Expression**

* Group 1 (0,1,8,9) → B′C′B'C'
* Group 2 (2,10) → A′CD′A'CD'
* Group 3 (1,5) → A′D′CA'D'C

⇒f(A,B,C,D)=B′C′+A′CD′+A′D′C\Rightarrow f(A,B,C,D) = B'C' + A'CD' + A'D'C

**✅ Marks Distribution (for 16 marks):**

| **Section** | **Marks** |
| --- | --- |
| 3-variable K-map Explanation | 3 |
| 3-variable K-map Problem | 5 |
| 4-variable K-map Explanation | 3 |
| 4-variable K-map Problem | 5 |
| **Total** | **16** |

**UNIT 5 Measurements and Instrumentation**

**1. Block Diagram of Digital Storage Oscilloscope (DSO)**

**🔹 Block Diagram:**

┌──────────────┐

│ Attenuator │

└─────┬────────┘

↓

┌──────────────┐

│ Vertical Amp │

└─────┬────────┘

↓

┌──────────────┐

│ ADC │

└─────┬────────┘

↓

┌──────────────┐

│ Digital Memory│◄─── Trigger System

└─────┬────────┘

↓

┌──────────────┐

│ Display │

└──────────────┘

**🔹 Explanation of Each Block:**

1. **Attenuator:**
   * Scales down high input voltages to safe levels.
   * Allows selection of voltage ranges (e.g., 1V/div, 5V/div).
2. **Vertical Amplifier:**
   * Amplifies the attenuated signal.
   * Maintains signal integrity before conversion.
3. **Analog to Digital Converter (ADC):**
   * Converts analog signal to digital data for processing.
   * Sampling rate determines accuracy.
4. **Memory (Storage):**
   * Stores digitized waveforms.
   * Enables viewing delayed waveforms, post-processing.
5. **Trigger System:**
   * Synchronizes signal capture.
   * Determines the starting point for waveform display.
6. **Display Unit:**
   * Shows waveform on LCD/CRT screen.
   * Offers zoom, cursors, and measurement tools.

**2. Instrument Transformers: CT and PT**

Instrument transformers are used for **measuring high voltages and currents** in power systems by stepping them down to safe levels.

**🔹 1. Current Transformer (CT):**

**⚙️ Construction:**

* Consists of a **primary winding** (few turns or even 1 turn) and a **secondary winding** (many turns).
* Connected in **series** with the line whose current is to be measured.

**⚙️ Working:**

* Steps down high current to a lower value (typically 5A or 1A).
* The secondary current is proportional to the primary current.

**🔹 CT Ratio:**

CT Ratio=IPIS\text{CT Ratio} = \frac{I\_P}{I\_S}

**⚠️ Important Note:**

* CT secondary must **never be open-circuited** during operation — dangerous voltage buildup may occur.

**🟩 Applications:**

* Used with ammeters, protective relays, energy meters.

**🔹 2. Potential Transformer (PT):**

**⚙️ Construction:**

* Step-down transformer with high-voltage primary and low-voltage secondary.
* Connected in **parallel** to the line.

**⚙️ Working:**

* Steps down high voltages to standard levels (e.g., 110V).
* The secondary voltage is proportional to the primary voltage.

**🔹 PT Ratio:**

PT Ratio=VPVS\text{PT Ratio} = \frac{V\_P}{V\_S}

**🟩 Applications:**

* Used with voltmeters, wattmeters, protective relays.

**🔹 CT vs PT Summary Table:**

| **Feature** | **CT** | **PT** |
| --- | --- | --- |
| Connection | Series | Parallel |
| Measures | Current | Voltage |
| Output | Current (5A or 1A) | Voltage (110V or 63.5V) |
| Danger if open | Secondary must not be open | Secondary can be open |