Ex/PE/PC/B/T/321/2023

B.E. POWER ENGINEERING THIRD YEAR SECOND SEMESTER - 2023

Measurement and Transducers **Time 3 Hr.** **Full Marks: 100**

1. Answer any three questions (CO1) 3×5
   (a) Derive the expression for the deflection of a PMMC instrument which is spring controlled. How can the potential divider arrangement be used for multipliers in multirange voltmeter?
   (b) Derive the expression for the deflection of a spring controlled electrodynamometer type instrument under ac operation. Comment on the shape of its scale.
   (c) Explain the special features incorporated in an electrodynamometer to make it suitable for Low Power factor applications.
   (d) Derive the expression for deflecting torque in single phase induction type meter. Show that the deflection is maximum when the phase angle between the two fluxes is 90° and the disc is purly non-inductive.

2. Answer any two questions (CO2) 2×8
   (a) Derive the expression for bridge sensitivity for Wheatstone bridge with equal arms. Also find the expression of the current through the galvanometer during unbalance operation of the bridge.
   (b) Draw the equivalent circuit and phasor diagram of a current transformer. Derive the expression for ratio and phase angle error.
   (c) Draw the circuit diagram of an Anderson Bridge? Derive the expression for the unknown inductance and the resistance measured by it.
   (d) How can the insulation resistance be measured using a Megger? Explain with the help of a diagram.

3. Answer any five questions (CO3) 5×8
   (a) The coil of a moving coil galvanometer is wound on a non-magnetic former whose height and width are both 3 cm and 2cm respectively. It moves in a constant field of 0.15 Wb/m^2. The moment of inertia of its moving parts is 0.5×10^{-6} $kg\text{-}m^2$ and the control spring constant is 30×10^{-6} Nm/rad. Calculate (i) the number of turns that must be wound on the coil to produce the deflection of 120° with a current of 10 mA.
   (b) A ring core current transformer, of nominal ratio 500/5 and a bar primary has a secondary resistance of 0.5 Ω. The secondary reactance is negligible. The resultant of the magnetizing and the iron loss component of the primary current for a full load secondary current of 5 A with a burden of 1 Ω is 3A at a power factor of 0.4. Calculate the ratio error at rated primary current.
   (c) The inductance of a moving iron ammeter is given by: $L = (8 + 4\theta - \frac{1}{2}\theta^2)\mu H$ where θ is the deflection from zero position in degrees. Calculate the angular deflections in radian for currents 1, 2, 3, 4 and 5A. Comment on the scale shape thus obtained.
   (d) Hay's AC bridge has the following arms: AB is a coil of unknown impedance, BC is a non-inductive resistor of 1000Ω; CD is non-reactive resistor of 800Ω in series with a standard capacitor of 0.4 μF; DA is a non-reactive resistor of 16000Ω. Determine the unknown resistance and the inductance at the balanced condition if the supply frequency is 50 Hz.
   (e) Four arms of a Wheatstone bridge are as follows:
   $AB = 100\ \Omega$, $BC = 1000\ \Omega$, $CD = 4000\ \Omega$, and $DA = 400\ \Omega$.
   The galvanometer has a resistance of 200 Ω, a sensitivity of 100 mm/μA and is connected across AC. A source of 5 V DC is connected across BD. Calculate the current through the galvanometer and its deflection if the resistance of the arm DA is changed from 400 Ω to 401Ω..
   (f) A moving coil voltmeter having a resistance of 15 Ω gives full scale deflection of 100° with a potential difference of 100mV applied across it. The dimension of the coil is 30 mm×25 mm with 100 turns. Find the flux density in the air gap and the diameter of the coil if the 25% of the instrument resistance

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is due to the coil winding. The control spring constant is 0.4×10^{-6} Nm/deg. The specific resistance of the copper is 1.7×10^{-8} Ωm.

4. Answer any three questions (CO4) 3×8
   (a) What are piezoresistive gauges? Define the gauge factor and derive its expression.
   (b) What is hall voltage? Derive its expression. State the factors which influence the hall coefficient.
   (c) What are thermistors? Discuss the resistance-temperature characteristics of thermistors and the method of measurement of temperature with the use of thermistors.
   (d) Define the following transducer characteristics: Accuracy, Resolution, Repeatability and Noise
   (e) Describe the working principle of the resistance thermometers. Name the materials used for RTDs along with their properties.

5. Answer any one: (CO5) 1×5
   (a) How does a pH meter work? Explain its working with suitable diagram.
   (b) Discuss how a thermocouple can be used for measurement of flame temperature.