Electrical Engineering - Optional For IAS (UPSC)

Measurements & Instrumentation - 2015-2021

UPSC – ELECTRICAL Engineering optional – 2015 Questions

1. Name the different types of CROs and mention their applications. Find the velocity of electrons that have been accelerated through a potential of 2000 V in a CRO. **[10M]**

2. Explain the working of an LVDT with a Bourdon tube for the measurement of pressure. **[10M]**

3. Explain the working of a successive-approximation type digital voltmeter using a block diagram. **[10M]**

4. Explain the direct connection method of measurement of Q of a coil. Name the sources of error in such measurements. Compute the value of self-capacitance and inductance of a coil when the following measurements are made:

At frequency 2 MHz, the tuning capacitor is set at 450 pF

When the frequency is measured to 5 MHz, the tuning capacitor is tuned at 60 pF **[10M]**

5. What are the sources of errors in an electrodynamometer type wattmeter? A dynamometer type wattmeter connected normally to read power in a 1-phase circuit indicates the value P_1. A second reading P_2 is obtained when a capacitor of reactance equal to the pressure coil resistance is connected in series with the pressure coil. Show that the phase angle of the load can be obtained from the expression $\tan \emptyset = 1 - \frac{2P_2}{P_1}$. **[20M]**

UPSC – ELECTRICAL Engineering optional – 2016 Questions

1. An 820 Ω resistance with an accuracy of $\pm 10\%$ carries a current of 10 mA. The current was measured by an analog meter of 25 mA range with an accuracy of $\pm 2\%$ of full scale. Compute the power dissipated in the resistor and determine the accuracy of the result. **[10M]**

2. Show that the maximum non-linearity on account of loading of a linear potentiometer can be expressed as $\frac{400}{27}\frac{R_p}{R_m}\%$ of f.s.d. for $\frac{R_p}{R_m} << 1$. **[20M]**

3. An accelerometer has an input range of $0 - 100\ m/s^2$. It has a mass of 10 g and works on a frequency of 10 Hz. Find the range for the displacement transducer used to measure the displacement of the accelerometer. **[05M]**

4. (i) With the help of a neat diagram, explain the working of an LVDT. Give its characteristics, advantages and applications. Explain the role of phase sensitive detector used for signal conditioning of LVDT. **[15M]**

5. An LVDT is connected to a 10V voltmeter through an amplifier of gain 100. An output of 2 mV appears across the terminals of the LVDT when the core crosses a distance of 0.5 mm. Find the sensitivity of the LVDT and that of the whole set-up. The used voltmeter has 100 divisions and $\frac{1}{5}th$ of a division can be read accurately. Find the resolution of the instrument in mm. **[05M]**

6. A 500 Hz triangular wave with a peak amplitude of 40 V is applied to the vertical deflecting plates of a CRO having a vertical deflection sensitivity of 0.1 cm/V. Another 250 Hz sawtooth wave of 50 V is applied to the horizontal plates having a horizontal deflection sensitivity of 0.08 cm/V. Assuming the two inputs are synchronized, sketch the waveform displayed on the CRO. **[10M]**

UPSC – ELECTRICAL Engineering optional – 2017 Questions

1. (i) Why low resistances are usually constructed as four-terminal resistances ?

(ii) How can surface resistivity of insulating material be measured using direct deflection method? **[10M]**

2. A single phase, 240 V, 20 A, induction type watt-hour meter is working correctly. When tested at half load, rated voltage, and unity power factor, the disc rotates at 32 rpm. Determine the meter constant of the meter. Then, due to the alteration of the lag adjustment of the meter, the meter reads with -6.7% error at 0.8 p.f. lagging. What is the new phase angle between the supply voltage and the pressure coil flux because of this incorrect lag adjustment? **[15M]**

3. A Schering bridge, used to test a specimen, has the following bridge arms:

arm ab contains the unknown capacitance (C_1) whose loss part is represented by a series resistance (r_1), arm bc contains a non-inductive resistance (R_3) of 315 Ω, arm cd contains a variable capacitor (C_4) in parallel with a variable $\text{non}-\text{inductive}$ resistance (R_4) and arm da contains a standard capacitor (C_2) of 150 pF. The supply is connected between $a\ and\ c$ and the detector is connected between b and d. The specimen is tested at a frequency of 50 Hz, it is having a thickness of 6.3 mm and it is tested between electrodes each having a dimension of $0.15\,m \times 0.18\,m$. At balance, $C_4 = 0.375\,\mu F$ and $R_4 = 423\Omega$. Find the capacitance, dissipation factor and relative permittivity of the specimen. Given: Permittivity of free space $= 8.854 \times 10^{-12} F/m$. **[15M]**

4. How a compensating coil can be utilized in reducing connection errors in an electrodynamometer type wattmeter? **[10M]**

5. Explain in detail different types of frequency instabilities that cause difficulties in spectrum analyzers for display of narrow frequency ranges. A spectrum analyzer is designed using a $10-$ kHz,3 dB filter and with a noise figure of 25 dB. What is the minimum detectable signal of this spectrum analyzer? What will be the power-level of the third-order intercept point, if this spectrum analyzer possesses a dynamic range of 86 dB ? **[15M]**

6. Why temperature compensation is needed in strain gauges ? A four arm DC Wheatstone bridge is designed using a single active gauge. How can a dummy gauge be employed here to achieve temperature compensation? **[10M]**

7. A resistance wire strain gauge with nominal resistance 350Ω and gauge factor 2 is fastened to a steel bar. The modulus of elasticity of steel is 2.1×10^6 kg/cm^2. What is the stress applied to the steel bar if strain gauge resistance becomes 350.5Ω? **[05M]**

UPSC – ELECTRICAL Engineering optional – 2018 Questions

1. The magnetizing and loss component of exciting current of a current transformer rated $1000/5$ A, are 15 A and 9 A respectively. The phase angle between secondary winding induced voltage and current is 40 degree. Determine the phase angle error of the transformer. **[10M]**

2. An energy meter is designed to have 80 revolutions of the disc per unit of energy consumed. Calculate the number of revolutions made by the disc when measuring the energy consumed by the load carrying 30 A at 230 V and 0.6 power factor. Find the percentage error if the meter actually makes 330 revolutions. Also specify whether the meter runs slower or faster. **[10M]**

3. Explain how the spectra of amplitude-modulated signal are displayed on a spectrum analyzer. **[10M]**

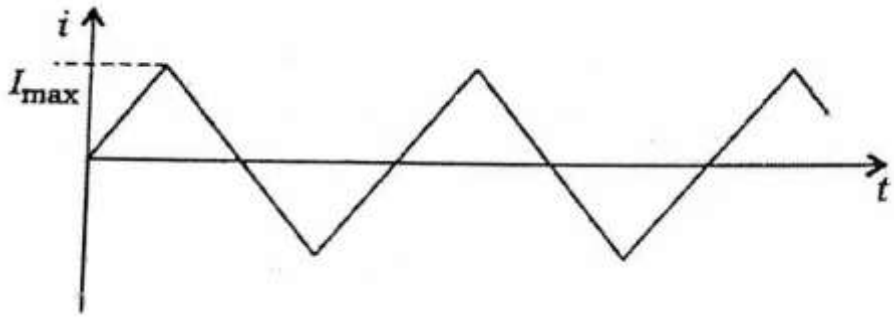
4. A wattmeter reads 5 kW when its current coil is connected in red phase and its voltage coil is connected between neutral and red phase of a symmetrical three-phase star-connected system supplying a balanced three-phase inductive load of 25 A at 440 V. What will be the reading of the wattmeter if the connection of the current coil remains unchanged and voltage coil is connected between blue and yellow phase? Hence determine the total reactive power in the circuit. **[10M]**

5. Which method is used to eliminate the effect of stray capacitances in a four-arm AC bridges? Describe with circuit diagram. **[20M]**

UPSC – ELECTRICAL Engineering optional – 2019 Questions

1. (i) Due to some errors in the internal circuit of a differential amplifier, its differential mode gain is halved, while its common-mode gain does not change. Find the reduction in the CMRR of amplifier in decibels. **[05M]**

(ii) A full-wave rectifier type ammeter displays a current reading of $5.55\ \text{mA}$ r. m. s. when measuring the current waveform shown in the figure given below: **[05M]**



Determine the true r. m. s. value of the current waveform and the error in the meter.

2. With the help of suitable circuit diagram and related equations, explain the principle of measurement of the unknown parameters of a low-impedance coil using a Q meter in series connection mode. **[10M]**

3. Draw the circuit diagram of an instrumentation amplifier and derive an expression for the voltage gain of this amplifier. How can this gain be varied? **[10M]**

4. With the help of a suitable diagram and equations, describe the principle of operation of a differential capacitive displacement transducer. In what way is it better than a normal capacitive displacement transducer? Determine the output voltage of this differential transducer when it is connected in an AC bridge. **[20M]**

UPSC – ELECTRICAL Engineering optional – 2020 Questions

1. Why are strain gauges made with high value of gauge factor (G_f)? Write the expression for gauge factor in terms of change in resistance and strain. If a strain gauge with a gauge factor of 2 is bonded on a steel structure which is subjected to a stress of 100 MN/m^2 and the modulus of elasticity of steel is 200 GN/m^2, then what is the percentage change in the value of the strain gauge resistance due to this applied stress? [**10M**]

2. Draw the circuit arrangement for power measurement in a 3-phase, 3-wire balanced supply and load using two-wattmeter method, and show that the power factor of the load is given by

$$\cos\phi = \frac{1}{\sqrt{1+3\left(\frac{P_1-P_2}{P_1+P_2}\right)^2}}$$

where P_1 and P_2 are powers indicated by Wattmeter 1 and Wattmeter 2, respectively.

[20M]

3. The resistance-temperature characteristic of a thermistor is given by

$$R_T = R_0 e^{\left(\frac{1}{T}-\frac{1}{T_O}\right)}$$

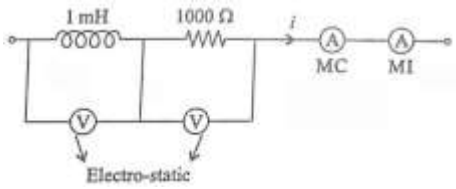
Where R_o is the resistance of the thermistor at reference temperature, T_O and R_T is the resistance at the measured temperature, T. If the value of β is 4000 K and the resistance of the thermistor is $200\ k\Omega$ at $-100\ °C$, find the value of resistance at $400\ °C$. Also find the ratio of two resistances. If platinum resistance temperature detector (RTD) is used over the same temperature range, then what will be the ratio of RTD resistances on the above-referred two temperatures? **[20M]**

4. An insulating material specimen is connected to arm AB of a Schering bridge. The arm BC has a non-inductive resistance R_2 of $140\ \Omega$ and arm CD has a non-inductive resistance R_4 of $208\ \Omega$ in parallel with a capacitor C_4 of $0.5\ \mu F$ (loss-free). The arm DA has a loss-free capacitor $C_3$of $150 \times 10^{-6}\ \mu F$. If the bridge is supplied with 50 Hz a. c. voltage connected between terminals A and C, then draw a neat circuit diagram of the bridge and derive the balance condition of the bridge, and calculate the parameters C_1, r_1 of the specimen and its loss angle (δ). **[10M]**

5. Which the help of a neat diagram, explain the working principle and characteristics of a linear variable differential transformer (LVDT). Why is the frequency of excitation in primary winding kept very high as compared to frequency of the signal detected? Write three advantages and disadvantages of LVDT also. **[20M]**

UPSC – ELECTRICAL Engineering optional – 2021 Questions

1. A current of $(0.5 + 0.3 \sin \omega t - 0.2 \sin 2\omega t)$ amps is passed through the circuit shown in figure. Determine the reading of each instrument if $\omega = 10^6\, rad/sec$. [**10M**]



2. A coil of 300 V moving iron voltmeter has a resistance of 500 ohms and an inductance of 0.8 H. The instrument reads correctly at 50 Hz AC supply and takes 100 mA at full scale deflection. What is the percentage error in the instrument reading, when it is connected to 200 V DC supply. [**10M**]

3. Derive the conditions of balance of an Anderson's bridge and also draw the phasor diagram of the bridge under balanced condition. Determine the unknown quantities in terms of known parameters and comment on easy convergence of balance of the bridge. [**20M**]

4. Explain the ratio error and phase angle error of current transformer. [**10M**]

5. A pulse is applied to a piezo-electric transducer for a time T. Prove that in order to keep the undershoot of the response to a value within 5%, the value of time constant should be approximately $20T$. [**10M**]

6. Write advantages, disadvantages and application of spectrum analyzer. [**10M**]