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Semester I, 2022-23

INSTR F311 - ELECTRONIC INSTRUMENTS AND INSTRUMENTATION TECHNOLOGY

Midsemester examination, Regular [Closed Book] Date: 31/10/2022

Maximum Marks: 50 Duration: 90 min

Part A (10 questions X 2 marks = 20 marks, First 40 minutes)

- **Write the answers to the questions in Part-A on a separate, printed answersheet provided. Write only the final answers.**
- **Rough-work for Part A can be done only on the last two pages of the Main Answersheet.**
- **Use the Main Answersheet to write the answers to the questions in Part B.**
- **Prepare an index behind the cover page of the Main Answersheet.**

Q 1: To provide temperature compensation for a PMMC meter, swamping resistors are added in series with the coil. (i) Which material property is considered while choosing the material for the swamping resistors? (ii) Name a candidate material for swamping resistors, as discussed during the lecture.

Q 2: A digital ammeter with a 4 ½ digit LED display was configured to measure DC currents of range 0-1.5 mA. The accuracy of the meter is specified to be ±(0.1% + 2) in that range. Determine the maximum error Δi_{meas} (in μA) while measuring a current of 1 mA with this meter.

Q 3: The internal resistance of the ammeter in Q 2 above is 5Ω when connected in series with the circuit. What is the maximum Burden Voltage V_{burd} (in mV) that it offers in the measurement range of 0-1.5 mA?

Q 4: The crest factor is defined as the ratio of the peak value to the rms value of a waveform. Determine the crest factor CF of a pulse waveform of 25% duty cycle with the high and low levels at 5V and 0V respectively.

Q 5: A ceramic capacitor C_P of 50 nF in parallel with a resistance R_P of 8 kΩ, together is represented as a complex impedance Z_P with the notation $Z_P = |Z_P|e^{j\theta}$. At a frequency of 400 Hz, what is the magnitude $|Z_P|$ (in Ω)?

Q 6: What is the value of the phase angle θ (with sign, in degrees) in Q 5 above, at a frequency of 400 Hz?

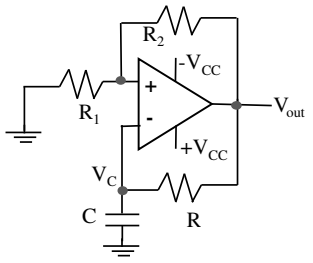

Fig. 1: Astable Multivibrator

Q 7: The circuit of an astable multivibrator is given in Fig. 1. The voltage across the capacitor C is V_C. The saturation voltages V_{sat} of the opamp is ±12V. The components R_1=5 kΩ and R_2=10 kΩ. What are the (i) upper and (ii) lower threshold voltage levels V_{UT} and V_{LT} to which the capacitor voltage V_C would be bounded?

Q 8: If the capacitor C in Q7 is specified as 50 nF, what is the value of resistor R (in Ω) required to generate at the output V_{out}, a square wave of frequency 2 kHz ?

Q 9: An arbitrary waveform generator (AWG) has a memory depth of 16,000 points that are used to store 8 cycles of a periodic waveform. A 100 MHz clock frequency is used to retrieve the samples and output the waveform using a DAC. What is the frequency f_{wave} of the waveform (in Hz)?

Q 10: If the DAC resolution in Q9 is specified as 10 bits with a range of 10 V, what is the Quantization Error $\pm\Delta V_{QE}$ in mV?

Part B (30 marks, 50 minutes)

Instructions:

- **Write all the steps clearly and give explanations for complete credit.**
- **Overwritten answers will not be rechecked.**
- **Make suitable assumptions wherever necessary and mention them clearly.**

Question 1:

a) A PMMC instrument with a 600-turn coil has a magnetic flux density in its air gaps of *B*=125 mT. The coil dimensions are given by height=5 cm and diameter= 6 cm. The torsional stiffness of the spiral spring is c=50×10^{-6} Nm rad^{-1}. Determine the deflection θ_{def} of pointer (in degrees) for meter current of 1 mA. [3]

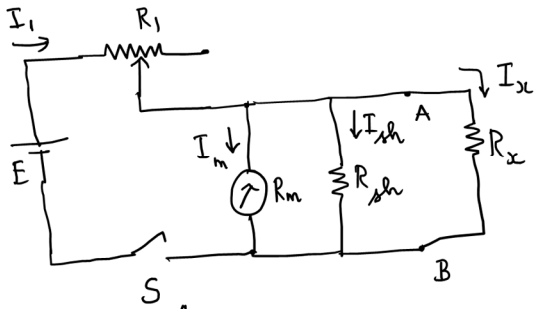

Fig. 2: Shunt-type Ohmmeter

b) The circuit diagram of a Shunt type Ohmmeter is shown in Fig. 2. For a specified meter resistance R_m and meter full-scale current I_{fsd}, derive the expressions for the resistance values R_1 and R_{sh} for a design half-scale deflection reading R_h of the Ohmmeter.

Assume an internal resistance of the meter to be 50 Ω with a full scale deflection current of 1 mA. The battery voltage is 9V. The Half-scale deflection should be for 0.5Ω. Calculate the suitable resistance values R_1 and R_{sh}. [6]

c) A peak reading AC Voltmeter, the input waveform is connected in series through an ideal diode to the parallel combination of a resistor R_p and a capacitor C_p , the voltage V_o across which is measured by a DC voltmeter. If R_p is specified as 1 MΩ, what is the minimum value of C_p so that the steady-state value of V_o decays no more than 1%, in the frequency range of 500 Hz to 50 kHz.
[3]

Question 2: The circuit shown in Fig. 3 is that of an Owen's bridge used to measure inductance values.

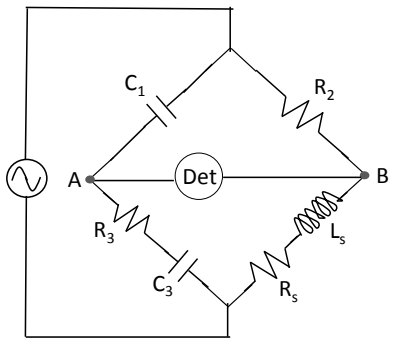

Fig. 3: Owen's bridge

a) Under the condition of bridge balance, find the expressions for the unknown inductance L_S, resistance R_S and the corresponding Q-factor in terms of the standard capacitor C_1, and the variable components R_2, R_3 and C_3. Are these expressions dependent on the frequency of excitation? [6]

b) Determine suitable values for R_3 and C_3 if the bridge has to be used to measure a 150 mH inductor in series with a 50 Ω resistor. The standard components are given by C_1= 1 μF and R_2=150 Ω. The frequency of excitation is 1 kHz. [4]

Question 3:

a) Draw the circuit of an Opamp-based Wien-bridge Oscillator.
In an opamp based Wien-bridge oscillator, the resistors in the tank circuit are given by R_A=R_B=1kΩ. The resistor R_1 between the inverting input pin and the ground is 5 kΩ. Find the values for (i) the feedback resistor R_2 between the output pin and inverting input pin, (ii) the capacitor C=C_A=C_B to generate a sinusoidal output waveform of 1 MHz frequency.
[3]

b) A Programmable Decade Indirect Synthesizer consists of several interacting multiplier phase-locked loops (PLL), one to determine each significant digit in the designed output frequency. Mixers, dividers and bandpass filters are used to combine frequencies from each PLL to generate the final output frequency.
Design a Programmable Decade Indirect Synthesizer to generate a frequency of 7.45 MHz from a given reference of 1 MHz from the oscillator in a). [5]