Name of Student: ______________________________

Enrollment No.: ______________________________

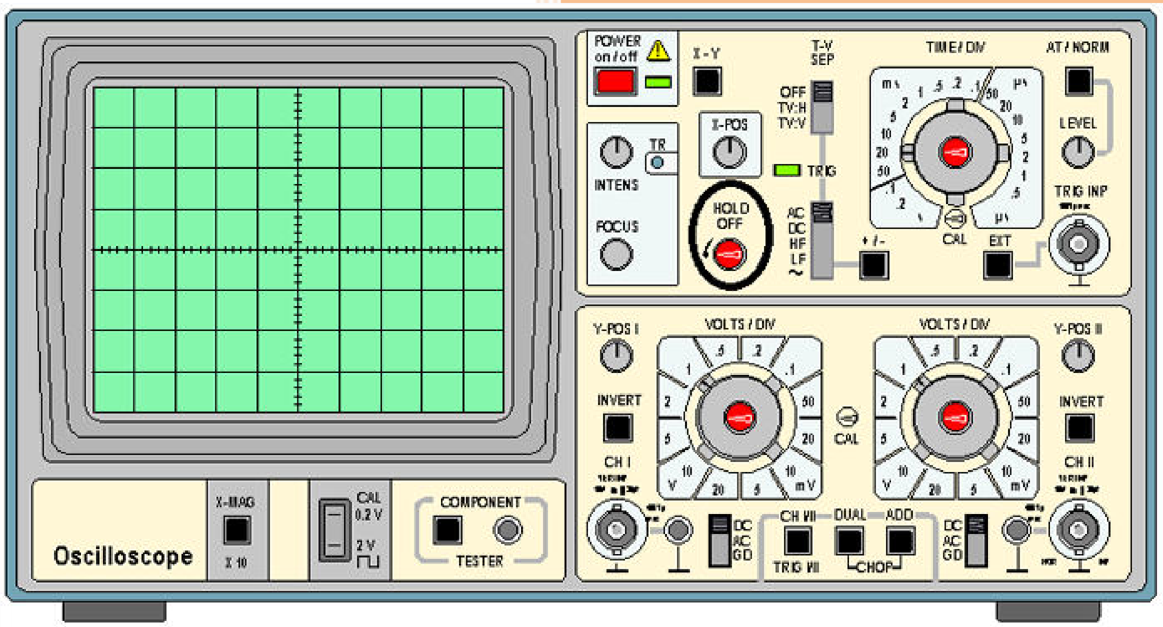
Class: ______________________________

Section: ______________________________

Session: ______________________________

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

EMI [EC-306] Lab Manual



Prepared By: Dr. Aparna Gupta

LAKSHMI NARAIN COLLEGE OF TECHNOLOGY & SCIENCE

Kalchuri Nagar, Raisen Road Bhopal (MP) 462023

Vision and Mission of the Department

Vision

To be world-wide recognized for adopting and keeping innovation and entrepreneurship mindset as abreast of learning to produce professionals as valuable, ethical and moral resource for industry and society.

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Mission

- To establish an ecosystem where students could grow with innovative practices followed in communication engineering.
- Adopt the global approaches to transform the young aspirant into engineering professional catering the society with ethical and patriotic zeal.
- Facilitate and felicitate the learners to have close interactions with the industry experts and researchers for keeping them updated of the current and future needs of the society.
- To develop the mindset of learners for being innovative and entrepreneurial in becoming successful professional.

PROGRAM SPECIFIC OUTCOME (PSO)

PSO1: To analyze, design and develop solutions of real time problems and industry needs.

PSO2: Ability of effectively communicating with the professionals and preparation of reports, documents and presentation while working in teams.

PSO3: Knowledge and understanding of latest developments in the field of VLSI, Embedded system, Networking, Matlab and other major tools necessary for keeping pace with the industry.

PSO4: Ability of solving complex engineering problems with ethical and law full approach to prevent the society and environment from adverse impacts.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: The graduate will have the knowledge and skills of analog and digital communication in providing necessary solutions to the real world problems.

PEO2: The graduate will be able to design, develop, analyze and implement the modern tools and systems involving principles of electronics and telecommunication engineering.

PEO3: The graduate will be following the ethical practices of the core industry and supporting software industry in providing most acceptable solution to the society.

PEO4: The graduate will have the innovative mindset of learning and implementing the latest technological advancements and research outcomes in the electronic hardware and software to keep pace with the rapid developments in socio economic world

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Name of Student:____________________**Enrollment No.:** _________________

S. No.	Title of the Experiment	Date of Experiment	Date of Experiment	Remark
1	Measurement of Amplitude and frequency of various waveforms using CRO.			
2	To measure unknown frequency with comparison of known frequency using Lissajous Patterns of Cathode Ray Oscilloscope.			
3	Measurement of self-inductance of an inductor using Maxwell's Bridge.			
4	Measurement of unknown inductance of an inductor using Hay's Bridge.			
5	Measurement of unknown capacitance of a capacitor using Schering Bridge.			
6	Measurement of frequency using Wien Bridge.			

7	Displacement measurement by LVDT.			
8	Force measurement by strain gauge.			
9	To convert analog voltage into equivalent digital voltage using Analog-to-Digital convertor.			
10	To convert digital voltage into equivalent analog voltage using Digital-to-Analog convertor.			

Code of Conducts for the Laboratory

- All bags must be left at the indicated place.
- The lab timetable must be strictly followed.
- Be **PUNCTUAL** for your laboratory session.
- Noise must be kept to a minimum.
- Workspace must be kept clean and tidy at all time.
- Handle the experiment kit and interfacing kits with care.
- All students are liable for any damage to the accessories due to their own negligence.
- Students are strictly **PROHIBITED** from taking out any items from the laboratory.
- Students are **NOT** allowed to work alone in the laboratory without the Lab Supervisor
- Report immediately to the Lab Supervisor if any malfunction of the accessories, is there.
- Before leaving the lab Place the stools properly.
- Please check the laboratory notice board regularly for updates.

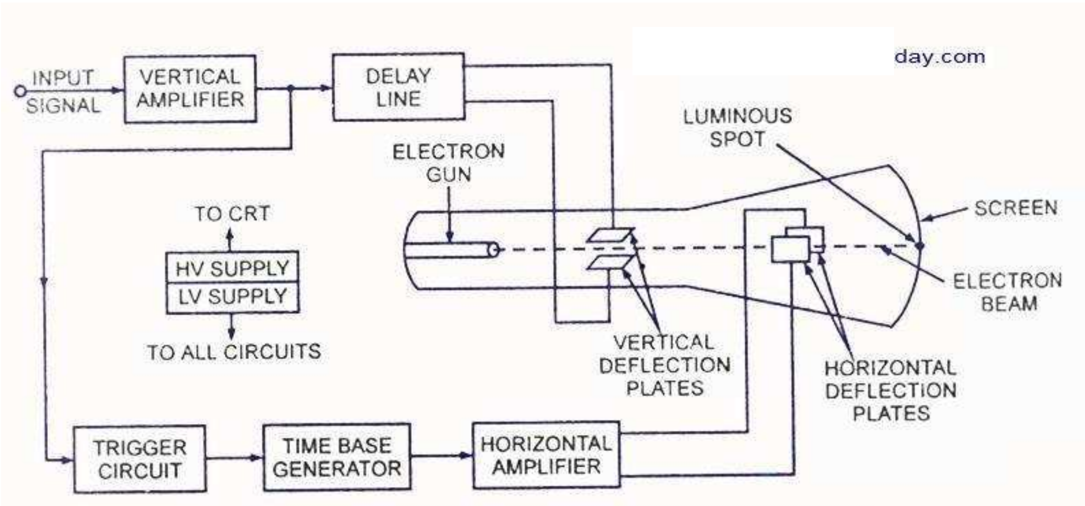
Date of Experiment _____________

EXPERIMENT NO: 1

Aim: Measurement of Amplitude and frequency of various waveforms using CRO.

Apparatus Required: Function generator, CRO, Patch chord.

Circuit Diagram:



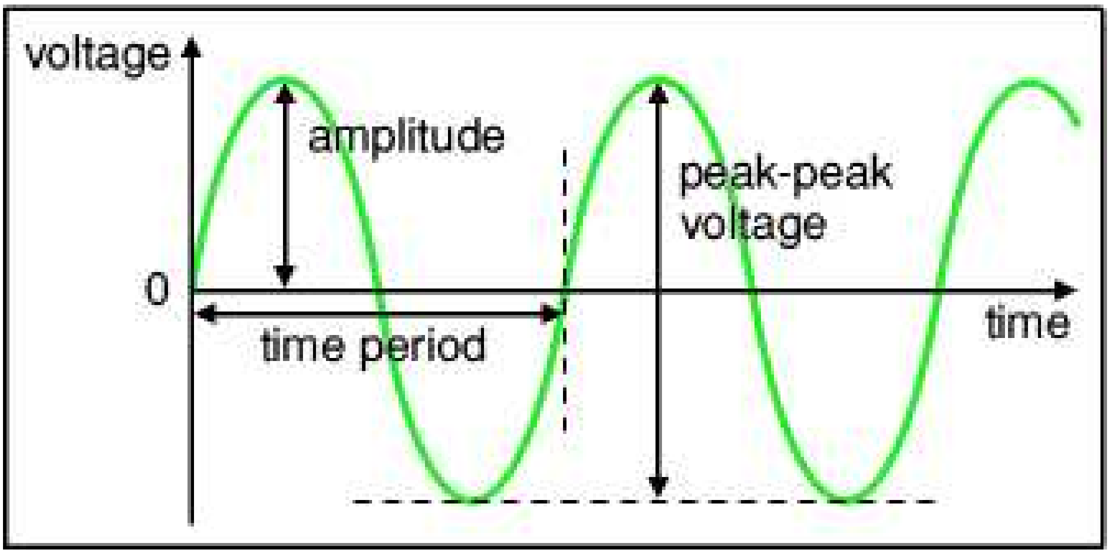
Block Diagram of a General Purpose CRO

Theory: The Cathode Ray Oscilloscope is a very useful and versatile laboratory instrument used for display, measurement and analysis of waveforms and other phenomena in electrical and electronics circuit.

CRO is a fast X-Y plotter, displaying an input signal versus another signal or versus time. The "stylus" of this plotter is a luminous spot which moves over the display area in response to the input signal. The luminous spot is produced by a beam of electrons striking a fluorescent screen.

The signal to be analysed is applied to the ***vertical amplifier*** which contains amplifier and attenuator to provide desired output voltage for vertical deflection plate. The vertical signal applied to vertical deflection plate passes through ***delay line***, which delays input signal for few times until the time base start sweep of the beam. A sample of input waveform is fed to the ***trigger circuit*** which produce a trigger pulse synchronize to the input frequency, this trigger pulse is used to start time base generator. ***Time base generator*** generates a saw tooth waveform that is used as horizontal deflecting signal of CRT. Saw tooth wave form of time base generator amplified by ***horizontal amplifier***, which amplifies the horizontal signal and make suitable to deflect the horizontal deflection plate.

Measurement of Voltage and frequency:



Voltage Measurement: Peak-to-peak voltage of unknown signal can be measured as:

$$V_{pp} = No. of\ division\ on\ Y\ axis\ \times \frac{Volt}{div} Multiplier$$

$$V_m = \frac{V_{pp}}{2}$$

$$V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{V_{pp}}{2\sqrt{2}}$$

Frequency Measurement: Time period of unknown signal can be measured as

$$T = No. of\ division\ on\ X\ axis \times \frac{Time}{div} Multiplier$$

$$Frequency\ is\ given\ by\ f = \frac{1}{T} Hz$$

Observation Table:

Sr. No	Type of Waveform	Signal Frequency (Hz)	**Amplitude Measurement**			**Frequency Measurement**			
			No. of division on Y Axis	Volt/Div Multiplier	Amplitude (Volt)	No. of division on X Axis	Time/ Div Multiplier	Time T (Sec.)	Frequency f = 1/T (Hz)
1	Sine Wave								
2	Square Wave								
3	Triangular Wave								

Result: Various waveforms are plotted in graph paper.

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Date of Experiment ______________

EXPERIMENT NO: 2

Aim: To measure unknown frequency with comparison of known frequency using Lissajous Patterns of Cathode Ray Oscilloscope.

Apparatus Required:

Sr. No	Apparatus	Quantity
1	Cathode ray Oscilloscope	1
2	Function Generator	2
3	CRO Probes	2

Theory:

It is interesting to consider the characteristics of the patterns that appear on the screen of a CRT when sinusoidal voltages are simultaneously applied to horizontal & vertical plates. These patterns are called 'Lissajous Patterns'. A Lissajous figure is produced by taking two sine waves of the same frequency produce a Lissajous pattern which may be a straight line, a circle or an ellipse depending upon the phase and magnitude of voltages. This is easily done on an oscilloscope in XY mode. In the following examples the two sine waves have equal amplitudes.

- When the two voltages are of equal frequency and in-phase, you get a diagonal line to the right.
- When the two voltages are of equal frequency and 180 degrees out-of-phase you get a diagonal line to the left.

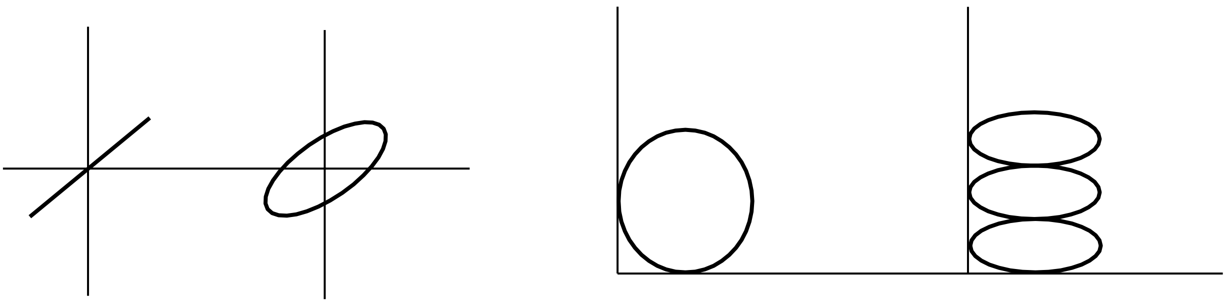
- When the two voltages are of equal frequency and phase angle of φ (not equal to 0 or 90 degrees) you get an ellipse.
- When the two voltages are of equal frequency and 90 degrees out-of-phase you get a circle see figure1.

Two lines are drawn, one horizontal and the other vertical so that they do not pass through any intersections of different parts of the Lissajous curve. The number of intersections (or touches) of the horizontal and the vertical lines with the Lissajous curve are individually counted (see Figure2). The frequency ratio is given by

$$\frac{f_V}{f_H} = \frac{No. of\ intersections\ of\ the\ horizontal\ line\ with\ the\ curve}{No. of\ intersections\ of\ the\ vertical\ line\ with\ the\ curve}$$

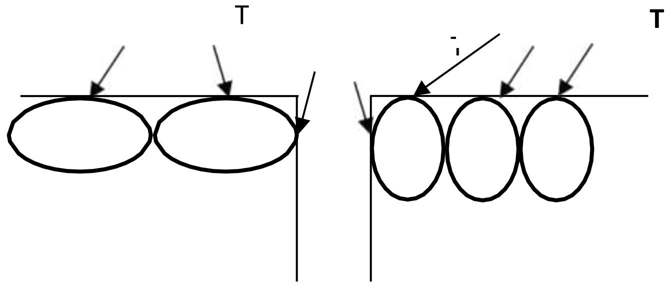
or

$$\frac{f_V}{f_H} = \frac{No. of\ Horizontal\ Tangencies}{No. of\ Vertical\ Tangencies}$$



$\frac{f_V}{f_H} = 1$ $\frac{f_V}{f_H} = \frac{1}{3}$

Figure1: Lissajous Patterns



$$\frac{f_V}{f_H} = \frac{2}{1} \qquad \frac{f_V}{f_H} = \frac{3}{1}$$

Figure 2: **Lissajous Patterns**

Procedure:

1. Switch on the CRO. Rotate the intensity control clockwise. After some time either a bright spot or a line will be appeared on the screen. If you see none, adjust X-POS and Y-POS controls to get the display in the centre of the screen.

2. . Operate the INTEN and FOCUS controls and observe the effect on the spot (or line). Adjust them suitably.

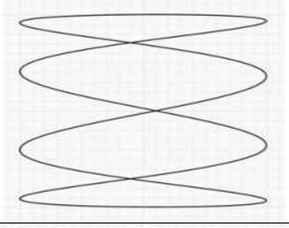
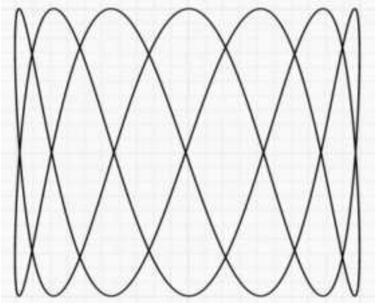
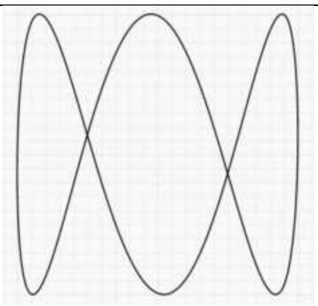
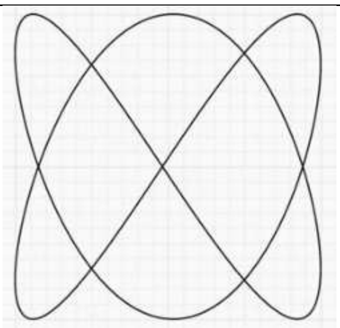
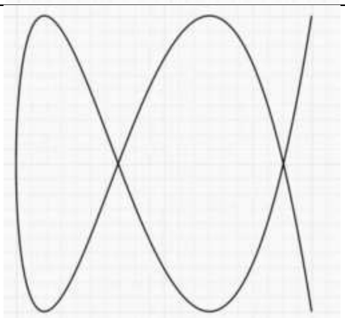
3. For measuring the frequency of the signal feed the unknown signal (taken from the signal generator) to the Y-INPUT terminals. Take a standard signal generator, and connect its output to the X-INPUT terminals of the CRO. Put the TIME-BASE or HORIZONTAL-AMPLIFIER knob at EXT position. Change the frequency of the standard signal generator till you get a stable Lissajous pattern. For the various frequency ratios, f_H/f_V, the Lissajous patterns are shown in Fig. The unknown frequency can thus be determined using the relationship.

$$\frac{f_V}{f_H} = \frac{No.of\ Horizontal\ Tangencies}{No.of\ Vertical\ Tangencies}$$

Table 1 Phase Measurement

Sr. No	Phase Difference	Pattern Observed
1	0°	
2	30°	
3	60°	
4	90°	
5	120°	
6	150°	
7	180°	

Table 1 Frequency Measurement

Sr. No	Known Freq.	Pattern Observed	Unknown Freq.
1	1000 Hz		
2	1000 Hz		
3	1000 Hz		
4	2000 Hz		
5	2000 Hz		

Result: Thus, obtained unknown frequency of given signal using Lissajous pattern on cathode ray oscilloscope.

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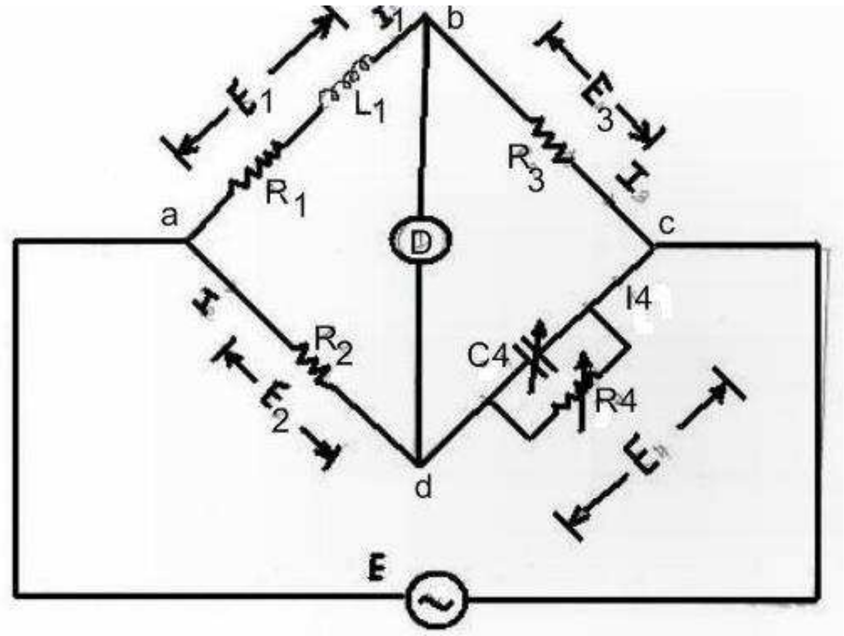
Date of Experiment ______________

EXPERIMENT NO: 3

Aim: Measurement of Inductance of coil using Maxwell's inductance capacitance Bridge.

Apparatus Required: Maxwell's Bridge kit, LCRQ meter, Patch chord etc.

Circuit Diagram:



Introduction: Bridges are used for accurate measurement of electrical quantities viz; Resistances, inductances, capacitances, frequency etc.

Maxwell's inductance-capacitance bridge is used for measurement of inductance of coil having low Q factor (1-10).

Theory: Let

L1 = unknown inductance,

R1 = effective resistance of inductor L1,

R2, R3, R4 = known non-inductive resistances,

C4 = variable standard capacitor.

Writing the equation for balance

$$(R_1 + jwL_1)\left(\frac{R_4}{1 + jwC_4R_4}\right) = R_2R_3$$

$$R_1R_4 + jwL_1R_4 = R_2R_3 + jwR_2R_3C_4R_4$$

Separating the real and imaginary terms, we have

$$R_1 = \frac{R_2R_3}{R_4}$$

And

$$L_1 = R_2R_3C_4$$

Thus we have two variables R4 and C4 which appear in one of the two balance equations and hence the two equations are independent.

The expression for **Q factor**

$$Q = \frac{wL_1}{R_1} = wC_4R_4$$

Observation Table:

Sr. No	Unknown Inductance L_1	R_2 (ohm)	R_3 (ohm)	C_4 (Farad)	$L_1=R_2R_3C_4$ (Henry)	True value of L (Henry)	% Error
1	L_{11}						
2	L_{12}						

Result: The inductance of coils is measured using Maxwell's bridge and their inductances are

L_{11} = ………………H Q_1 = ……………..

L_{12} = ………………H Q_2 = ……………..

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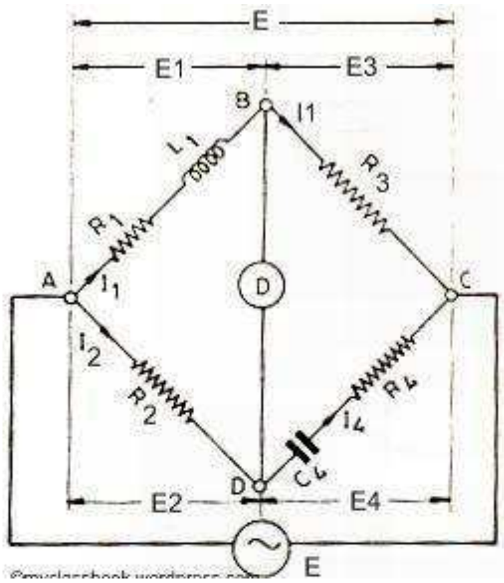
Date of Experiment ____________

EXPERIMENT NO: 4

Aim: Measurement of Inductance of coil using Hay's bridge.

Apparatus Required: Hay's bridge kit, LCRQ meter, multimeter, Patch chord etc.

Circuit Diagram:



Theory: The Hay's bridge is the modification of the Maxwell Bridge. This bridge uses a resistance in series with the standard capacitor. The bridge has four resistive arms in which the arms 1 consists of the resister R_1, in series with unknown inductor $L_1(L_x)$.The arm 2 and arm 3 consists of the variable resistance R_2 and R_3. Arm 4 has a standard capacitoC_4 in series with resistor R_4.

By using the unknown inductance having a resistance R_1. R_2, R_3, R_4 is the known non-inductive resistance and C_4 is standard value of the capacitor. The unknown value of inductance and Quality factor of the Bridge is obtained by formula.

$$L_x = \frac{R_2R_3C_4}{1+\omega^2R_4^2C_4^2}$$

Quality factor

$$Q = \frac{1}{\omega R_4 C_4}$$

Procedure:-

- Study the circuit provided on the front panel of the kit.
- Connect unknown inductance L_{X1} in the circuit. Make all connections to complete the bridge.
- Put the supply ON
- Set the null point of galvanometer by adjusting variable resistance R3.
- Note value of R_2, R_3, and C_4 by removing connection by patch cords.
- Calculate theoretical value of L_{X1}.
- Measure value of L_{X1} by LCRQ meter and compare it.
- Repeat process for L_{X2}.

Observation Table:

Sr. No	**Unknown Inductance L_x**	**R_2 (ohm)**	**R_3 (ohm)**	**C_4 (Farad)**	**$L_x=R_2R_3C_4$ (Henry)**	**True value of L (Henry)**	**% Error**
1	L_{x1}						
2	L_{x2}						

Result: - The unknown inductance is measured using Hay's bridge and is found to be:

L_{x1} = -------- Henry, Q_1 = ---------

L_{x2} = -------- Henry, Q_2 = ---------

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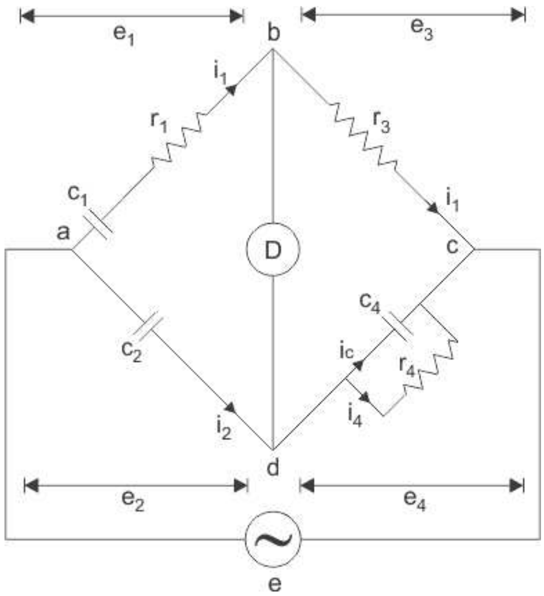
Date of Experiment ____________

EXPERIMENT NO: 5

Aim: Measurement of Capacitance of a capacitor using Schering Bridge.

Apparatus Required: Schering bridge kit, LCRQ meter, Multimeter, Patch chord etc.

Circuit Diagram:



Theory:

Schering bridge is used to measure to the capacitance of the capacitor, dissipation factor and measurement of relative permittivity. Let us consider the circuit of Schering bridge as shown above:

Here, c_1 is the unknown capacitance whose value is to be determined with series electrical resistance r_1.

c_2 is a standard capacitor.
c_4 is a variable capacitor.
r_3 is a pure resistor (i.e. non inductive in nature).
And r_4 is a variable non inductive resistor connected in parallel with variable capacitor c_4.

Now the supply is given to the bridge between the points a and c. The detector is connected between b and d.

At balanced condition the value of unknown capacitance C1 and series resistance r1 is given as:

$$c_1 = c_2 \frac{r_4}{r_3} \qquad r_1 = r_3 \frac{c_4}{c_2}$$

The dissipation factor is given by

$$D = \omega r_1 c_1$$

Observation Table:

Sr. No	Unknown Inductance C_x	R_3 (ohm)	R_4 (ohm)	C_2 (Farad)	$c_x = c_2 \frac{r_4}{r_3}$ (Farad)	True value of C (Farad)	% Error
1	C_{x1}						
2	C_{x2}						

Result: - The unknown capacitance and dissipation factor is measured using Schering bridge and is found to be:

C_{x1} = -------- Farad, D_1 = ---------

C_{x2} = -------- Farad, D_2 = ---------

Signature of Faculty

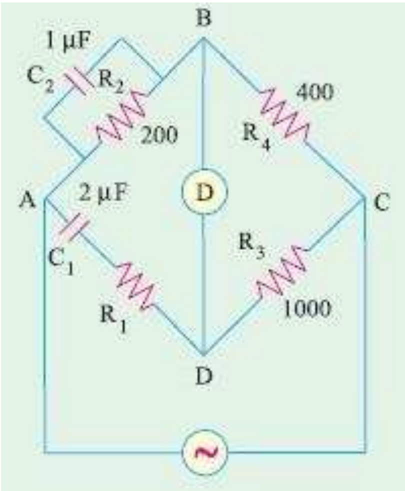
Date of Experiment ______________

EXPERIMENT NO: 6

Aim: Measurement of Frequency of signal using Wien Bridge.

Apparatus Required: Wien bridge kit, LCRQ meter, Multimeter, Patch chord etc.

Circuit Diagram:



Wien Bridge is commonly used for the measurement of frequency in audio frequency (20 Hz – 20 kilo Hz) range. It consist a series RC combination in one and a parallel combination in the adjoining arm.

At balance condition

$$Z_1Z_4 = Z_2Z_3$$

Where

$$Z_1 = R_1 - \frac{j}{\omega C_1},\ Y_2 = \frac{1}{R_2} + j\omega C_2,\ Z_3 = R_3,\ and\ Z_4 = R_4$$

$$Z_3 = \frac{Z_1Z_4}{Z_2} = Z_1 Z_4 Y_2$$

$$R_3 = (R_1 - \frac{j}{\omega C_1})\, R_4\, (\frac{1}{R_2} + j\omega C_2)$$

Equating real parts we have

$$\frac{R_3}{R_4} = \frac{R_1}{R_2} + \frac{C_2}{C_1}$$

If $R_1 = R_1 \ and \ C_1 = C_2$

$$R_3 = 2R_4$$

Equating imaginary parts we have

$$\omega C_2 R_1 = \frac{1}{\omega C_1 R_2}$$

This gives

$$f = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$$

If $R_1 = R_1 = R \ and \ C_1 = C_2 = C$

$$f = \frac{1}{2\pi RC}$$

Measurement:

1. Value of Resistance R_1 =................. Ohm
2. Value of Resistance R_2 =................. Ohm
3. Value of Capacitance C_1 = ...Farad
4. Value of Capacitance C_2 = ...Farad

Result : Frequency of signal is .... Hz

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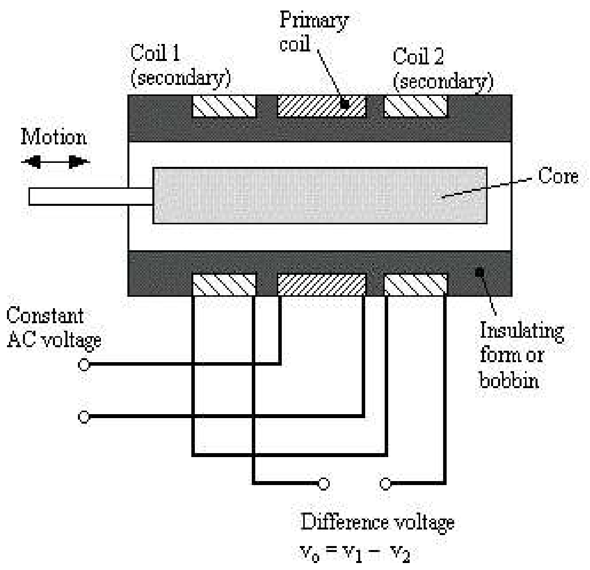
Date of Experiment _____________

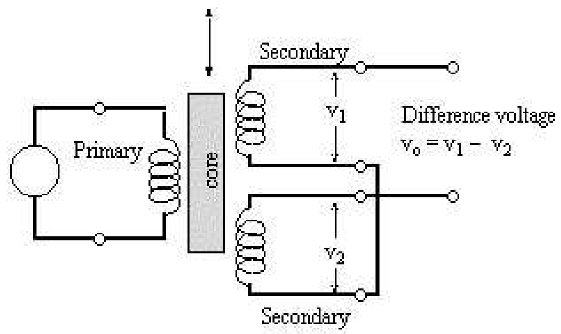
EXPERIMENT NO: 7

Aim: Displacement measurement using LVDT.

Apparatus Required: LVDT kit, Screw gauge, connecting chords etc.

Circuit Diagram:





Theory:

LVDT stands for linear variable differential transformer. It works on the principle of mutual induction LVDT illustrated in figure consist of three symmetrically spaced coils bound out and illustrated bobbin. A magnetic core, which moves through the bobbin, provides a path for magnetic flux linkage between coils. The position of the magnetic core control the mutual inductance between the primary coils and two secondary coils. When a carrier excitation is applied to the primary coil, voltage is induced in the two secondary coils that are wired in series opposing circuit. When the core is centred between the two secondary coils, the voltage induced in secondary coils are equal but cut of phase by 180° with series opposing circuit, the voltage in two secondary coils contact cancel each other and the O/P voltage is zero. When the core is moved from the centre position, an in-balance in the mutual inductance between the primary and secondary coils occurs and an o/p voltage develops. The o/p voltage is linear function of core position as long as the motion of the core is within the operating range of LVDT. The direction of motion can be determined from the phase of o/p voltage.

Features :

1. The frequency of voltage applied to the primary winding can range from 50-25000 kHz.

2. Dynamic measurement is possible is the carrier frequency is 10 times greater than the highest frequency component in dynamic signal.

3. The I/P ranges from 5 – 15 watts / amp i.e. volts.

4. The power required is less than 1 watt.

5. Range of sensitivity is from 0.02 – 0.2 V / nm.

6. Available in operating range ± 2 to ± 150 mm.

Procedure:

Make the connection between LVDT sensor and the digital display unit as directed in manual. Switch 'ON' the circuit. Advance the LVDT core on one side with screw gauge. Record the o/p, repeat the procedure for possible range of i/p in regular steps on one side. Withdraw the LVDT core to the null position in same steps it was advanced. Take o/p while drawing i/p. Repeat same on other side of null. Plot I/P v/s O/P graph using least square fit method. Calculate linearity of instrument.

Observation Table:

Correction Factor (if any): ……………..

Sr. No	Displacement (in mm)	Output Voltage (in Volts)	Corrected Output Voltage (in Volts)
1	10 mm		
2	8 mm		
3	6 mm		
4	4 mm		
5	2 mm		
6	0 mm		
7	-2 mm		
8	-4 mm		
9	-6 mm		
10	-8 mm		
11	-10 mm		

Result: 1.The graph between displacement and output voltage is plotted in the graph paper.

2. The graph shows that output voltage is linearly related with the displacement.

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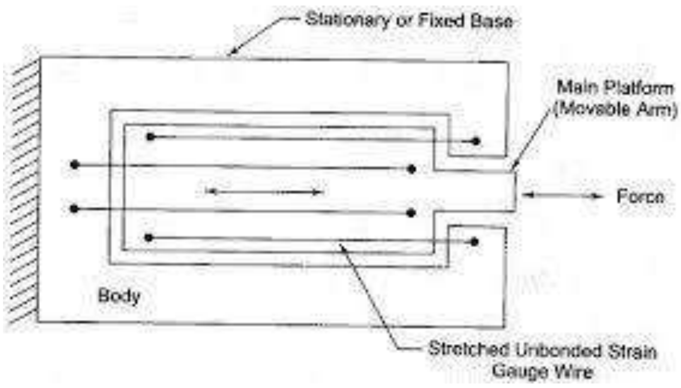
Date of Experiment ____________

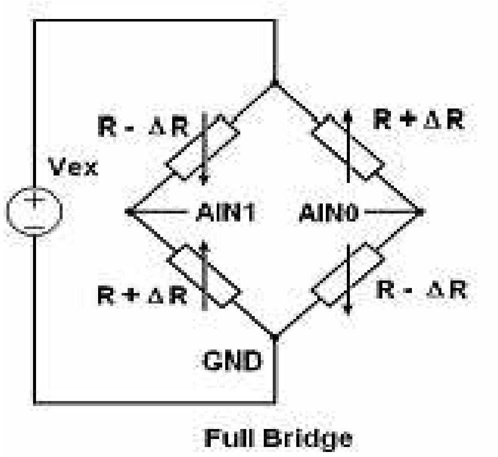
EXPERIMENT NO: 8

Aim: Force measurement using strain gauge.

Apparatus Required: Strain measurement kit, load cell, weights of various value, connecting chords etc.

Circuit Diagram:





Theory: The strain gauge is an example of a primary passive analog transducer that converts force or small displacement into a change of resistance. Since many other quantities such as torque, pressure, weight, and tension also involve force or displacement effects, they can also be measured by strain gauges. Strain gauges are so named because when they undergo a strain (defined to be a fractional change in linear dimension tension or compression caused by an applied force);

they also undergo a change in electrical resistance. The strain takes the form of a lengthening of the special wire from which the gauge is constructed. The change in resistance is proportional to the applied strain and is measured with a specially adopted Wheatstone bridge.

The gauge factor (k) is given by:

$$k = \frac{\Delta R/R}{\Delta l/l}$$

Where $R = \rho \frac{l}{A}$

Since strain is given as $\sigma = \frac{\Delta l}{l}$

Hence $\Delta R = kR\sigma$

Or ΔR a σ

Observation Table:

Sr. No	Weight (in Gram)	DPM Reading (in Volts)
1		
2		
3		
4		
5		
6		
7		
8		

Result: The graph between weight and output voltage is plotted in graph paper, and found linear.

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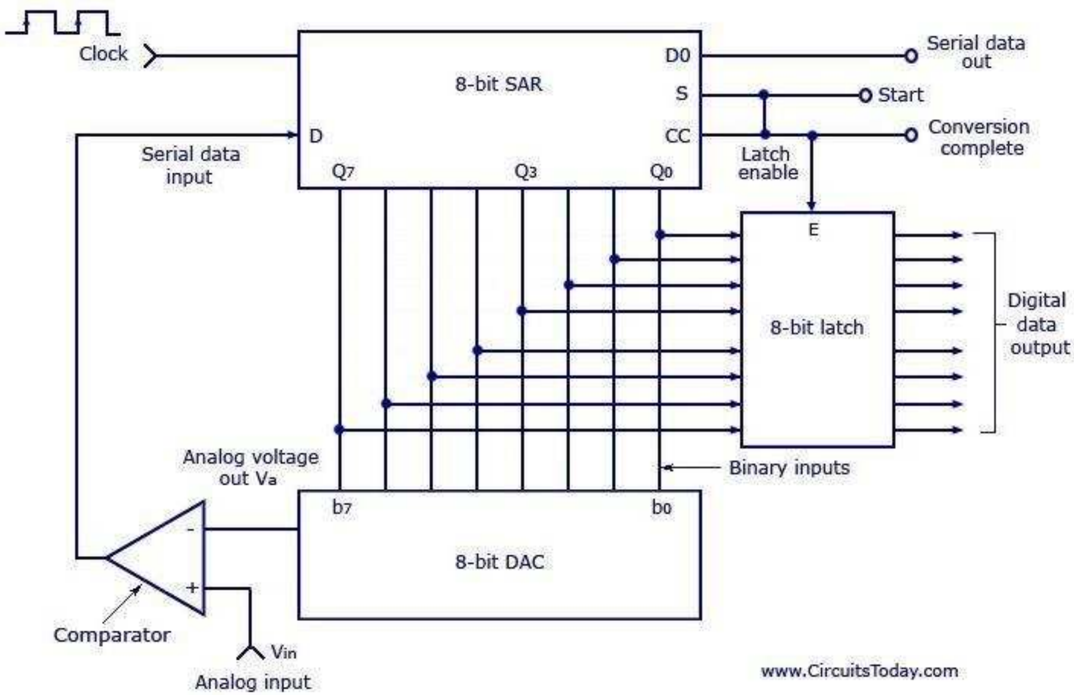
Date of Experiment ____________

EXPERIMENT NO: 9

Aim: To convert Analog voltage into equivalent Digital voltage using Analog-to-Digital converter.

Apparatus Required: A/D Converter kit, connecting chords etc.

Circuit Diagram:



Principle & Working: A successive approximation A/D converter consists of a comparator, a successive approximation register (SAR), output latches, and a D/A converter. The main part of the circuit is the 8-bit SAR, whose output is given to an 8-bit D/A converter. The analog output V_a of the D/A converter is then compared to an analog signal V_{in} by the comparator. The output of the comparator is a serial data input to the SAR. Till the digital output (8 bits) of the SAR is equivalent to the analog input V_{in}, the SAR adjusts itself. The 8-bit latch at the end of conversation holds onto the resultant digital data output.

At the start of a conversion cycle, the SAR is reset by making the start signal (S) high. The MSB of the SAR (Q7) is set as soon as the first transition from LOW to HIGH is introduced. The output is given to the D/A converter which produces an analog equivalent of the MSB and is compared with the analog input V_{in}.

If comparator output is LOW, D/A output will be greater than V_{in} and the MSB will be cleared by the SAR. If comparator output is HIGH, D/A output will be less than V_{in} and the MSB will be set to the next position (Q7 to Q6) by the SAR.

According to the comparator output, the SAR will either keep or reset the Q6 bit. This process goes on until all the bits are tried. After Q0 is tried, the SAR makes the conversion complete (CC) signal HIGH to show that the parallel output lines contain valid data. The CC signal in turn enables the latch, and digital data appear at the output of the latch. As the SAR determines each bit, digital data is also available serially. As shown in the figure above, the CC signal is connected to the start conversion input in order to convert the cycle continuously.

The biggest advantage of such a circuit is its high speed. It may be more complex than an A/D converter, but it offers better resolution.

Observation Table:

Sr. No.	Analog I/P Voltage	Digital O/P Voltage
1		
2		
3		
4		
5		
6		
7		
8		
9		

Result & Discussion:

Signature of Faculty

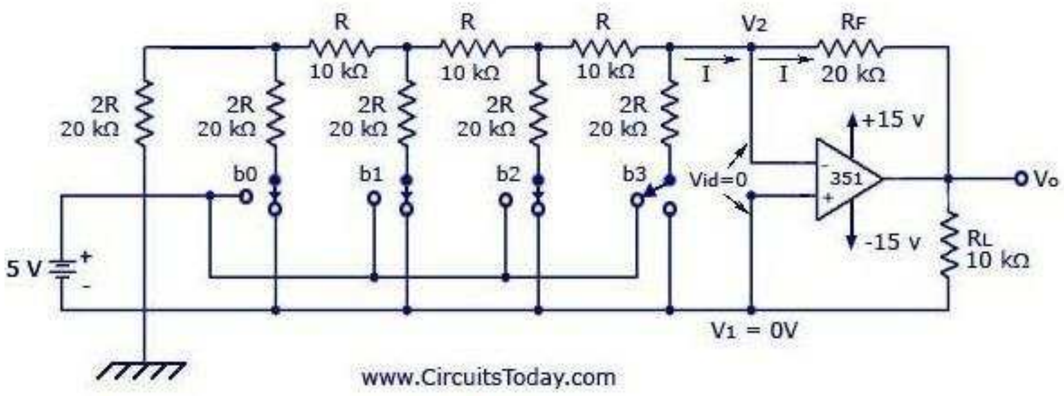
Date of Experiment _____________

EXPERIMENT NO: 10

Aim: To convert Digital voltage into equivalent Analog voltage using Digital-to-Analog converter.

Apparatus Required: D/A Converter kit, connecting chords etc.

Circuit Diagram:



Principle: A R-2R ladder type D/A Converter is designed by resistors having two values and thus overcome the disadvantage of Binary Weighted resistor DAC.

From the above circuit we can calculate the value of voltage on different nodes as $V_R/2$, $V_R/4$, $V_R/8$ and $V_R/16$. The total current entering on current to voltage converter is given by

$$I = I_1 + I_2 + I_3 + I_4$$

$$I = \frac{V_R}{4R} + \frac{V_R}{8R} + \frac{V_R}{16R} + \frac{V_R}{32R} = \frac{V_R}{2R}\left[\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16}\right]$$

The output voltage of digital to analog converter is given by

$V_o = -IR_F$ (Since $R_F = 2R$)

$$V_o = V_R[D_{n-1}2^{-1} + D_{n-2}2^{-2} + \cdots \ldots .. D_1 2^{-(n-1)} + D_0 2^{-n}]$$

Which can be written as

$$V_o = \frac{V_{ref} \times Digital\ bit\ value}{2^n}$$

Observation Table: Reference voltage V_{Ref} = …..Volts

Sr. No.	Digital Input (Binary Bits)	Analog Output (Measured)	Analog Output (Calculated)
1	00000001		
2	00000010		
3	00000100		
4	00001000		
5	00010000		
6	00100000		
7	01000000		
8	10000000		
9	11111111		

Result and Discussion:

Signature of Faculty