Experiment-1: Wheatstone’s bridge

Date:__________

1. **Aim:** To study and perform an experiment to measure the unknown Resistance by Wheatstone’s bridge.

2. **Requirements:**
   - Light Spot DC Galvanometer, Various Medium Resistors, Multimeter, Portable Wheatstone bridge

3. **Pre-Experiment Exercise:**
   **Brief Theory**
   
   A bridge circuit in its simplest form consists of network of four resistance arms forming a closed circuit, with a dc source of current applied to two opposite junctions and a current detector connected to the other two junctions.

   Wheatstone’s bridge is used for accurate measurement of resistance. The circuit diagram of a typical Wheatstone’s bridge is given in fig. 1.1

[Diagram of Wheatstone Bridge]

Fig 1.1 Wheatstone Bridge
When SW₁ is closed, current flows and divides into the two arms at point A, i.e. \( I₁ \) and \( I₂ \). The bridge is balanced when there is no current through the galvanometer, or when the potential difference at points C and D is equal, i.e. the potential across the galvanometer is zero.

To obtain the bridge balance equation, we have from the fig. 1.1,

\[
I₁ \, R₁ = I₂ \, R₂ \quad \text{(1.1)}
\]

For the galvanometer current to be zero, the following conditions should be satisfied.

\[
I₁ = I₃ = \frac{E}{(R₁ + R₃)}
\]
\[
I₂ = I₄ = \frac{E}{(R₂ + R₄)}
\]

Substituting in Eq. (1.1)

\[
\frac{(E \cdot R₁)}{(R₁ + R₃)} = \frac{(E \cdot R₂)}{(R₂ + R₄)}
\]

\[
R₄ = \frac{(R₂ \cdot R₃)}{R₁}
\]

This is the equation for bridge to be balanced.

**Circuit Diagram:**

![Circuit Diagram](image)

**Fig 1.2: Wheatstone's Bridge**
4. Laboratory Exercise:

Procedure
1) Take The Trainer kit. Measure resistors A, B, C, D, E, F, R1 and the variable pot R3 by adjusting “ADJ R3”. Note down the values of each resistors.
2) Now insert its mains cord in mains 230 V supply plug and switch it 'ON’. Measure the DC supply voltage. (It should be 12V DC)
3) Select the unknown resistor and measure its resistance Rx and note it down.
4) Connect the resistor to the terminal (Rx), and connect the power supply into the circuit. Connect the galvanometer to M of the bridge with the help of jumper.
5) Connect the S1 terminal to any resistor A, B, C, D, E, F. Adjust pot ‘R3’ to get a null reading on the galvanometer.
6) Once the ‘Null, reading is found, remove all the jumpers and measure the value of R3. Put the value of R3 in the formula given below and calculate Rx practically.

\[ \text{Rx} = \frac{R_2 \times R_3}{R_1} \quad (R_2=A \text{ or } B \text{ or } C \text{..... or } F) \]

7) Match the practical ‘Rx’ with that of the Rx directly measured on multimeter.
8) Take four to five reading to find the unknown resistance i.e. Rx with different resistors.

Note: Use unknown resistors of values between 10 Ω to 10 KΩ for the better sensitivity.

<table>
<thead>
<tr>
<th>Resistor R2</th>
<th>Rx Range which can be measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-10 Ω</td>
<td>10 Ω to 100 Ω</td>
</tr>
<tr>
<td>B-100 Ω</td>
<td>100 Ω to 1 KΩ</td>
</tr>
<tr>
<td>C-1 KΩ</td>
<td>1 KΩ to 10 KΩ</td>
</tr>
<tr>
<td>D-10 KΩ</td>
<td>10 KΩ to 100 KΩ</td>
</tr>
<tr>
<td>E-100 KΩ</td>
<td>100 KΩ to 500 KΩ</td>
</tr>
<tr>
<td>F-500 KΩ</td>
<td>500 KΩ to 1 MΩ</td>
</tr>
</tbody>
</table>

Conclusion:
Experiment-2: Maxwell’s Bridge

Date: __________

1. Aim: To study and perform an experiment to measure the unknown inductance and capacitance by Maxwell’s Bridge.

2. Requirements:

   Head Phone (provided), L.C. Meter, Digital Multimeter, Few coils and capacitors of standard values, Trainer kit, Patch Cords

3. Pre-Experiment Exercise:
   Brief Theory

   Maxwell’s bridge which is shown in fig. 2.1, measures an unknown inductance in terms of a known capacitor. The use of standard arm offers the advantage of compactness and easy shielding. The capacitor is almost a loss-less component. One arm has a resistance $R_1$ in parallel with $C_1$, and hence it is easier to write the balance equation using the admittance of arm 1 instead of the impedance.

   The general equation for bridge balance is,

   \[ Z_1 Z_X = Z_2 Z_3 \]

   i.e. \[ Z_X = Z_2 Z_3 / Z_1 = Z_2 Z_3 Y_1 \] (2.1)

   where \( Z_1 = R_1 \) in parallel with \( C_1 \)

   \[ Y_1 = 1/R_1 + j\omega C_1 \]

   \[ Y_1 = 1/R_1 + j\omega C_1 \]

   \[ Z_2 = R_2 \]

   \[ Z_3 = R_3 \]

   \[ Z_X = R_x \text{ in series with } L_x = R_x + j\omega L_x \]

   From Eq. 2.1 we have

   \[ R_x + j\omega L_x = R_2 R_3 (1/R_1 + j\omega C_1) \]

   \[ R_x + j\omega L_x = R_2 R_3 / R_1 + j\omega C_1 R_2 R_3 \]
EQUATING real terms and imaginary terms we have

\[ R_x = \frac{R_2 R_3}{R_1} \]

\[ L_x = C_1 R_2 R_3 \]

\[ Q = \frac{\omega L_x}{R_x} = \omega C_1 R_1 \]

The Maxwell's Bridge using a fixed capacitor has the disadvantage that there is interaction between the resistance and reactance balances. This can be avoided by varying the capacitances, instead of \( R_2 \) and \( R_3 \), to obtain a reactance balance.
**Circuit Diagram:**

![Circuit Diagram](image)

Fig. 2.2 Maxwell's Bridge

**4. Laboratory Exercise:**

**Procedure**

1) Take the trainer kit and insert its mains cord in mains supply plug, switch it 'ON'.

2) Observe the output of built in oscillator on CRO. Measure the frequency band of the oscillator.

3) For finding inductance value, connect a standard 1 micro-farad capacitor at $C_1$, short $R_x$, and select $R_{C1}$, with the patch cord and inductor at $L_x$.

4) Connect headphone to the Headphone socket. Apply the Audio Signal to the bridge input shown by dotted line. Listen to the audio output of the Headphone, and adjust $R_A$ till you do not hear
any audio sound. If audio sound continues for all the position of R_A, try with R_C2 and R_C3, in place of R_C1.

5) The bridge is balanced when you don't get any sound from the headphone with the adjustment of R_A.

6) Note the value of R_A & R_C after separating them from the bridge using Digital Multimeter. Remove all the connections of Headphone, Audio Signal & R_C while measuring the values.

7) Apply the formula of equation given below for finding L_x.

\[ L_x = R_A \times R_C \times C_1 \]

8) Note the value of inductor and verify your result with the value measured by LC meter.

NOTE: The components, values of the kit are designed to measure the inductance value from 1 mH to 100 mH.

**Experimental procedure for measuring the value of unknown capacitor:**

1) For finding unknown capacitor value, connect a 10 mH standard inductor at L_x. Short Rx, select R_C, and Connect unknown capacitor at C_1 and headphone at the output.

2) Adjust R_A for getting null condition as performed in previous procedure of inductance measurement.

3) Apply the formula of equation given below for finding C_1.

\[ C_1 = \frac{L_x}{R_A \times R_C} \]

4) Verify your result by measuring the value on capacitance meter.

**Experimental procedure for measuring the value of unknown resistance:**

1) Short L_x, remove C_1, select R_C and connect the unknown resistor at Rx.

2) Adjust R_A for null point and apply the formula of Wheatstone bridge.

3) Verify your result with the value observed from the ohmmeter.

**Conclusion:**
Experiment 3: Wien Bridge

1. Aim: To study and perform an experiment to measure the frequency by Wien’s bridge.

2. Requirements:
   Sine wave generator, CRO, digital multimeter, CRO probes.

3. Pre-Experiment Exercise:
   Brief Theory

   The Wien Bridge, shown in fig., has a series RC combination in one arm and a parallel combination in the adjoining arm. Wien Bridge in its basic form is designed to measure frequency. It can also be used for the measurement of unknown capacitor with great accuracy.

   The impedance of one arm is
   \[ Z_1 = R_1 - j \omega C_1. \]

   The admittance of the parallel arm is
   \[ Y_3 = (1/R_3) + j \omega C_3. \]

   Using the Bridge balance equation, we have
   \[ Z_1 Z_4 = Z_2 Z_3. \]

   Therefore
   \[ Z_1 Z_4 = Z_2 / Y_3, \text{ i.e.} Z_2 = Z_1 Z_4 Y_3 \]

   \[ R_2 = R_4 \left( R_1 - j / \omega C_1 \right) \left[ (1/R_3) + j \omega C_3 \right] \]

   \[ R_2 = (R_1 R_4 / R_3) - j R_4 / \omega \left( C_1 R_3 \right) + j \omega C_3 R_1 R_4 + C_3 R_4 / C_1 \]

   \[ R_2 = (R_1 R_4 / R_3) + (C_3 R_4 / C_1) - j [(R_4 / \omega \left( C_1 R_3 \right)) - (\omega C_3 R_1 R_4)] \]

   Equating the real and imaginary terms we have
   \[ R_2 = (R_1 R_4 / R_3) + (C_3 R_4 / C_1) \text{ and } (R_4 / \omega \left( C_1 R_3 \right)) - (\omega C_3 R_1 R_4) = 0 \]
\[
\frac{R_2}{R_4} = \frac{R_1}{R_3} + \frac{C_3}{C_1}
\]

Therefore
\[
\frac{R_2}{R_4} = \frac{R_1}{R_3} + \frac{C_3}{C_1}
\]

and
\[
\frac{1}{\omega C_1 R_3} = \omega C_3 R_1
\]

\[
\omega^2 = \frac{1}{(C_1 R_1 C_3 R_3)}
\]

\[
\omega = \frac{1}{(C_1 R_1 C_3 R_3)^{1/2}}
\]

\[
\omega = 2 \prod f
\]

\[
f = \frac{1}{2 \prod (C_1 R_1 C_3 R_3)^{1/2}}
\]

The Bridge is used for measuring frequency in the audio range. Resistance R1 and R3 can be ganged together to have identical values. Capacitors C1 & C3 are normally of fixed values.

The audio range is normally divided in to 20 – 200 – 2K – 20KHz ranges. In this case, the resistance can be used for range changing and capacitor C1 & C3 for fine frequency control within the range. The Bridge can also be used measuring capacitances. In that case, the frequency of operation must be known.

An accuracy of 0.5% - 1% can be readily obtained using this bridge. Because it is frequency sensitive, it is difficult to balance unless the waveform of applied voltage is purely sinusoidal.

4. Laboratory Exercise:

Procedure

1) Make connections as shown in Fig.3.1
2) Connect unknown sine wave frequency (1 kHz) across the input terminal marked as ‘input’ variable frequency.
3) Connect capacitor C1 and C3 as indicated by dotted line through patch cords. Note that C1 and C3 should be of equal value.
4) Now connect resistor R2 and R4 so that \( \frac{R_4}{R_2} = 2 \).
5) Now adjust R control so that indicator shows null.
6) After balance condition disconnect the connection of arm A - D of A-B and measure the value of port R by multimeter.
7) With the help of formula given. Find out output frequency.
8) Repeat the above procedure for other values of capacitor.

FORMULA:

\[
\omega = 2 \prod f
\]

\[
f = \frac{1}{2 \prod (C_1 R_1 C_3 R_3)^{1/2}}
\]
Figure 3.1 Wien Bridge

B. Observation Table

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Value of capacitor ‘c’</th>
<th>Measured Frequency ‘f’</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclusion:
Experiment 4: Lissajous Patterns

1. **Aim:** To study and perform an experiment to measure unknown frequency using Lissajous method.

2. **Requirements:**
   - C.R.O, Function generators, Patch cords, CRO probes etc.

3. **Pre-Experiment Exercise:**
   **Brief Theory**

   The oscilloscope is a sensitive indicator for frequency and phase measurements. The techniques used are simple and dependable, and measurement may be made at any frequency in the response range of the oscilloscope.

   One of the quickest methods of determining frequency is by using Lissajous patterns produced on a screen. This particular pattern results when sine waves are applied simultaneously to both pair of the deflection plats. If one frequency is an integral multiple of the other, the pattern will be stationary, and is called a Lissajous figure.

   In method of measurement a standard frequency is applied to one set of deflection plates of the CRT tube while the unknown frequency is simultaneously applied to other set of plates which is shown in the figure 4.1. However the unknown frequency is presented to vertical plates and the known frequency to the horizontal plates. The resulting patterns depend on the integral and phase relationship between the two frequencies. (The horizontal signal is designated as \( f_h \) and the vertical signal as \( f_v \)).
4. Laboratory exercise

Fig 4.1 Set-up for frequency measurement by Lissajous method.

A. Procedure:

1) Connect two Function Generators to the channel 1 and 2 as shown in Fig 4.1.
2) Consider channel-1 as unknown frequency channel and channel-2 as known frequency channel.
3) Press XY mode switch of C.R.O, so that channel-1 signal is connected to the vertical plate and channel-1 signal is connected to horizontal plate.
4) Set the frequency as given in observation table and very the unknown freq as given pattern.

FORMULA

\[
\frac{F_v}{F_h} = \frac{\text{No. of horizontal tangentes}}{\text{No. of vertical tangentes}}
\]

Where \( F_v = \text{Unknown Frequency} \)
\( F_h = \text{Known frequency} \)
B. Observation table:

<table>
<thead>
<tr>
<th>Known Frequency $I_r$</th>
<th>Pattern</th>
<th>Unknown Frequency $F_v$</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 Hz</td>
<td><img src="#" alt="Pattern 1" /></td>
<td></td>
</tr>
<tr>
<td>100 Hz</td>
<td><img src="#" alt="Pattern 2" /></td>
<td></td>
</tr>
<tr>
<td>100 Hz</td>
<td><img src="#" alt="Pattern 3" /></td>
<td></td>
</tr>
<tr>
<td>100 Hz</td>
<td><img src="#" alt="Pattern 4" /></td>
<td></td>
</tr>
<tr>
<td>100 Hz</td>
<td><img src="#" alt="Pattern 5" /></td>
<td></td>
</tr>
<tr>
<td>100 Hz</td>
<td><img src="#" alt="Pattern 6" /></td>
<td></td>
</tr>
</tbody>
</table>

Conclusion:
Experiment-5: Strain Gauge

Date: ______

1. Aim: To study and perform an experiment on strain gauge amplifier and strain gauge transducer.

2. Requirements:

   Digital Multimeter, Patch Cords, Different Weights (From 100gm.to 1 Kg.), Strain Gauge Kit

3. Pre-Experiment Exercise:

   Brief Theory

   The strain gauge is an example of a passive transducer that uses the variation in electrical resistance in wires to sense the strain produced by a force on the wires. Generally, displacement is thought of in terms of a motion of a few millimeters (mm) or less. The measurement of displacement is made frequently to relate to some other measured, and hence displacement transducers are fundamental components of any instrumentation system. Displacement is closely associated with motion, i.e. from one point to another, and position, i.e. a change from one position to the next. Displacement can be measured by both mechanical and electrical methods, but only electrical methods which are common in industries.

   Resistance Strain Gauge:

   Strain gauge is a positive type resistance transducer which converts a mechanical displacement into a change of resistance. It is the most commonly used transducer for the measurement of displacement. The resistance gauge is essentially a fine wire which changes its resistance, when mechanically strained, due to physical effects. Its length and cross sectional area vary and a change of electrical resistivity also occurs. The strain gauge is mounted to the measured surface so that it elongates or contracts with that surface. This deformation of the sensing material causes it to undergo a change in resistance. The resistance change of the strain gauge is usually converted into voltage by connecting one, two, or four similar gauges as arms of a Wheatstone bridge (known as strain gauge bridge) and applying excitation to the bridge. The bridge output voltage is then a measure of the strain, sensed by each strain gauge.
Circuit Diagram:

Fig. 5.1 Set Up for Strain Gauge Amplifier and Transducer

4. Laboratory Exercise:

Procedure

1. Connect the trainer Kit to the mains supply and Switch it ON.

2. Connect the Strain Gauge Transducers to the input Socket of the Kit.
3. Connect the output of instrumentation Amplifier to the Digital indicator.

4. Now adjust the' Zero Adj.' Potentiometer to get Zero reading on the indicator.

5. Now place the Weight of 100-gm at the centre or near the border of the pan fitted on the strain Gauge Cantilever arrangement.

6. Observe and note down the reading.

7. Place the Weights from 100-gm to 500-gm (1 Kg. Maximum) in such a way that maximum stress is applied at the cantilever arrangement. Put the Weights near the border of the Pan. Note the reading of Amplifier output for each increment of 100-gm.

8. Draw the graph of Weight V/S. Output in micro volts.

**Conclusion:**
Experiment 5: Linear Variable Differential Transducer (L.V.D.T)  

Date: ________

1. Aim: To study and perform an experiment on Linear Variable Differential Transducer (L.V.D.T)

2. Requirements:  
   - Dual Trace CRO, Patch cords, L.V.D.T. Trainer Kit, Digital Multimeter.

3. Pre-Experimental Exercise:  
   Brief Theory

   The differential transformer is a passive inductive transformer. The transformer consists of a single primary winding $P_1$ and two secondary windings $S_1$ and $S_2$ wound on a hollow cylindrical former. The secondary windings have an equal number of turns and are identically placed on either side of the primary windings. The primary winding is connected to an AC source. A movable soft iron core slides within the hollow former and therefore affects the magnetic coupling between the primary and two secondaries. The displacement to be measured is applied to an arm attached to the soft iron core. In order to convert the output from $S_1$ to $S_2$ into a single voltage signal, the two secondaries $S_1$ and $S_2$ are connected in series oppositions. Hence the output voltage of the transducer is the difference of the two voltages. Therefore the differential output voltage $E_0 = E_{S_1} - E_{S_2}$. The output voltage of an LVDT is a linear function of the core displacement.

4. Laboratory Exercise:

   A. Procedure
   1) Connect the Trainer Kit to the mains supply and switch it ‘ON’.

   2) Now observe the output of the sine wave of approx.4-kHz with adjustable output of 10-volt Peak to Peak.

   3) Set the amplitude of the 4-khz oscillator to get maximum output.

   4) Connect the output signal to the input of the LVDT Transducer Primary.

   5) Short the secondary terminals of LVDT shown by dotted lines.

   6) Refer to Figure 6.1 & observe the output of LVDT on the second channel of the CRO (Between A & C) You should observe the same signal with 180 degree out of phase. Note the amplitude of this output signal. This is the output observe when LVDT shaft is not displaced.
7) Now slowly shift the position of LVDT shaft as per the observation table and record the output for all the position. Observe Null Point and 180degree phase shift of the input signal between A & C terminals.

8) Now connect the output of LVDT point A, B and C at the LVDT Detector circuit with the help of patch cords. Refer to Fig. 6.1 calibrate the output of LVDT to 10 mm by adjusting the output potentiometer of the displacement indicator digital meter.

9) Connect the output of LVDT detector circuit to the displacement indicator digital meter.

10) Observe and record the output of LVDT and plot the graph of displacement in mm v/s output in D.C millivolts verify the linearity of the LVDT.

B. Observation Table

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Input displacement in mm</th>
<th>Meter reading in mv</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Note:
In right side direction consider displacement reading as +ve.
In left side direction consider displacement reading as –ve.
Conclusion:
Experiment-6: RTD as a Transducer

1. Aim: To study and perform an experiment on the principle and working of a temperature Controlling RTD as a transducer.

2. Requirements:

Trainer Kit, PT-100 Sensor, Water Heater, Patch cords, Thermometer, Digital Multimeter

1. Pre-Experiment Exercise

Brief Theory

The circuit of the RTD Temperature Indicator & Controller is basically an ON-OFF type temperature controller with water heater as process. We can control the temperature of water kept in a Water Heater. The RTD sensor (PT-100) is kept in water heater. The Heater gets its mains supply from the controller circuit. Suppose the set point of the water is kept at 70° C, then the temperature indicator circuit will produce approx. 70 mV at the A2 output. The comparator A3 compress the 70 mV process value and the 70 mV reference value. As soon as the temperature crosses 70° C, the Op amp A3 i.e. comparator switches of relay hence no supply to the water heater.

Resistance temperature detectors are thermally sensitive resistive elements that exhibit an increase in resistance as that temperature of their environment increases. Thus, these devices have a positive temperature coefficient, and they constructed of platinum, nickel, copper, tungsten, or nickel-iron. Since the RTD will increase its resistance when the temperature of its environment increases, its resistance is a function of temperature and it's usually determined at O'C. Thus a 100-Q RTD will exhibit 100-Q of resistance when its temperature is 0° C, or 32° F. As its temperature increases, like-wise its resistance increases. To determine the resistance of an RTD at any temperature within its range, the RTD's temperature coefficient must be used. The positive temperature coefficient of resistance is stated as 'alpha' and represents the percent of change in resistance for each-Celsius change in temperature.
Fig. 7.1 Circuit of temperature indicator using R.T.D. and Thermistor
4. Laboratory Exercise:

Procedure

(A) To study indicator action

1. Connect the given temperature sensor (PT 100) to the socket provided for sensor.

2. Observe the output of bridge on Voltmeter.

3. Adjust the Ten Turns potentiometer of bridge to the room temperature, i.e. the voltage reading in millivolts. Suppose the room temperature is 30° adjust the potentiometer to get 30.0 on meter in 200 millivolts range.

4. Now connect the digital indicator at the final amplifier output & calibrate the system by the potentiometer provided in the amplifier circuit. The system can be calibrated at 100’ C by boiling the water in water heater.

5. Now switch off the water heater and remove thermometer and sensor from the water. Insert the sensor in normal water to cool it at room temperature.

6. Now place the sensor near the kit and observe the reading on digital panel meter. This is the room temperature. Verify it with the reading on thermometer.

(B) To study controller action

7. Now connect the heater at "Connect Heater" socket of the Kit.

8. Connect Ref. Input (set point) to the controller circuit & A₂ to the input of controller circuit.

9. Set the Value of reference between 40° to 80°C.

10. Verify that comparator makes the heater ON & OFF when the water temperature reaches above the set or below the set point.

Note: Temperature of Water can be set by pressing the Set Point switch. The Indicator now showed the set value.
Conclusion:
Experiment-8: CRO Demonstrator

Date: ______

1. Aim: To study and perform an experiment on CRO demonstrator.

2. Requirements:

C.R.O Demonstrator trainer, Patch cords, Multimeter, Function generator, Connectors

3. Pre-Experiment Exercise:

Brief Theory

The Cathode Ray Oscilloscope (CRO) is probably the most versatile tool for the development of electronic circuits and systems. It allows the amplitude of electronic signals, whether they are voltage, current or power to be displayed as a function of time. The depends on the movement of an electron beam, which is bombarded on a screen coated with a fluorescent material, to produce a visible spot. If the electron beam is deflected on both the conventional axes, i.e. X-axis and Y-axis, a two dimensional pattern is produced.

Block Diagram of CRO:

The block diagram of CRO is shown in fig 8.1. It contains following major blocks.

1. Signal input (panel p1)
2. Beam switch & XY amplifier (panel p2)
3. Trace & Trigger control (panel p3)
4. Time base (panel p4)
5. CRT & Beam control (panel p5)
6. Power supply (panel p6)
7. Fault generation trouble shooting panel (panel p7)
Fig 8.1 Block Diagram of CRO
The functions of the various blocks are as follows:

1. **Signal input (panel-p1)**

   Fig 8.2 shows the block diagram of signal input. It contains attenuator and pre-amplifier and component tester circuit.
   
   Attenuator is the main block which attenuates the signal to a specified level. The pre-amplifier generates a differential output from single ended input.
   
   Component tester mode disables regular working by disabling sweep and controls the circuit through CTx and CTy for observing the patterns of any component.

2. **Beam switch and X-Y amplifier (panel-p2)**

   Fig 8.3 shows the block diagram of beam switch and X-Y amplifier. The differential signal obtaining from pre-amplifier stage is supplied to the input stage of Y final amplifier. This amplifier consists of several differential pairs for obtaining high gain at the final stage. This high gain output is directly fed to Y plates of tube.
   
   A sweep signal and X-Position control is applied as an input to the X final amplifier which also includes several differential amplifiers for proper shaping and high gain at final stage. This amplified signal is directly fed to X deflection plates of cathode ray tube.
   
   In XY mode of operation, the sweep generator is disconnected and CH-2 is connected to horizontal amplifier. Since both the pre-amplifiers are identical and have a same delay time, accurate X-Y measurement can be made.

3. **Trace and Trigger control (panel-p3)**

   Fig 8.4 shows the block diagram of trace and trigger control circuit. The trigger circuit is activated by signals of variety of shapes and amplitudes, which are converted to trigger pulses of uniform amplitude for the precision sweep operation.
   
   The trigger comparator is used to trigger the shortest signal just by setting proper trigger level to one input and the signal is applied to the another input.

4. **Time base (panel-p4)**

   Fig 8.5 shows the block diagram of time base panel. It is used to delay the signal for some time in the vertical sections. It is used to generate the saw tooth voltage required to deflect the beam in the horizontal section.
5. CRT & Beam control (panel-p5)

The oscilloscope is basically an electron beam voltmeter. It is more versatile tool for the development of electronic circuits and systems. The heart of the oscilloscope is the Cathode Ray Tube which makes the applied voltage visible by the deflection of a thin beam of electrons. The electron beam faithfully follows rapid variations in signal voltage and traces a visible path on the CRT screen.

Since it is electronic in nature, the oscilloscope can reproduce HF waves which are too fast for electro mechanical devices to follow.

The electron gun is the source of electrons which fires electrons strikes on the flat wall of tube which is chemically coated to form a fluorescent screen generates a spot on the screen. The control grid in CRT is cylindrical, with a small aperture in line with the cathode. The electrons emitted from the cathode emerge from this aperture as a slightly divergent beam. The negative bias voltage is applied to grid, controls the beam current. The intensity of phosphorescent spot depends on the beam current. Hence this control bias is called as intensity.

The divergent beam of electron is converged and focused on the screen by 2 accelerating anodes, which forms an electronic lens. The combination of the first anode cylinder and the wider second anode cylinder operated at higher positive potentials produces an electric field that focuses the electron beam on the screen. The electronic lens action is control by the focus control.

6. Power supply (panel-p6)

There are two power supplies, a –ve High Voltage (HV) supply and a +ve Low Voltage (LV) supply. Two voltages are generated in the CRO. The +ve voltage supply is from+300 to 400V. The –ve high volt supply is –1000 to –1500 V. This voltage is passed through a bleeder resistor at a few mA.

The intermediate voltages are obtained from the bleeder resistor for intensity, focus and positioning controls.
Fig. 8.2 Signal Input Panel - p1
Fig. 8.3 Beam switch and X-Y amplifier - p2
Fig. 8.4 Trace and Trigger Control-p3
Fig. 8.5 Time Base Panel- p4
Fig. 8.6 CRT and Beam control-p5
Fig. 8.7 Power Supply - p6
Fig. 8.8 Fault generation trouble shooting panel - p7
4. Laboratory Exercise:

To study all the blocks of CRO Demonstrator kit.

Conclusion:
Experiment 9: Digital Multimeter Demonstrator

Date: __________

1. Aim: To study and perform an experiment on Digital Multimeter Demonstrator.

2. Requirements:
   Digital multimeter demonstrator, patch cords.

3. Pre-experimental Exercise:
   Brief-Theory
   The heart of measurement of DMM trainer is a 3 ½ digit digital panel meter (DPM) with a sensitivity of 199.9 mV D.C. The DPM is designed on intersil 7107 high performance, low power 3 ½ digit A/D converter containing all the necessary active devices on a single CMOS i.e. included in this IC are seven segment decoder, display drivers, references source and a clock. This IC 7107 can directly drive seven segment diode (LED) displays. This DPM based on 7107 IC can read D.C. voltages from 0 to 199.9 mV with an accuracy of 1%. For measurement of higher voltage, the input voltage has to be divided by using voltage divider network. The four decimal points corresponding to four LED displays are provided on front panel. The decimal points are to be manually selected depending upon the range of input voltage or current to be measured. The DPM works on built in stabilized voltage of 5 V D.C.

4. Laboratory Exercise:
   Any voltage which is higher than 199.9 mV, we have to use voltage divider network.
   Following FSD ranges are provided
   a) 200 m V
   b) 2 V.
   c) 20 V.
   d) 200 V.

   A. Procedure:
   1) Connect 199.9 mV. D.C. to input of DPM Trainer marked as INPUT 199.9 V DC. Observe the display reading. Reverse the polarity of input supply the display will show same reading but with negative polarity. Select the proper decimal point by shorting common with corresponding DP terminal as shown by dashed lines.

   2) Now increase the voltage more than 200 m V and observe the display. It will not show proper reading.
3) Now connect input to voltage divider network, select 2V.D.C. range. Connect output of voltage divider network to input of DPM. Select corresponding decimal point. Now you can read Voltages correctly up to 2V, for higher ranges say 20V and 200 V D.C. select the proper voltage divider range.

**D.C.Current Measurement:**

The input d.c. currents are connected to a resistance network. The output which is in mV is connected to input of DPM. The network can measure current for 2mA FSD to 200mA in the following three ranges.

a) 2 mA.  
b) 20 mA.  
c) 200 mA.  

**Procedure:**

1) Connect 2mA (DC) current to input of resistance network. Connect output of network to input of DPM. Short the corresponding (2mA) terminal with input. Select the proper DP point on display (1.999mA).
2) Change the polarity of input current observe the (-ve) indication on display.  
3) For higher currents up to 200mA select the proper network in the panel.

**Resistance Measurement:**

For resistance measurement a constant current of 10 Micro Amps is passed through unknown resistance. The voltage developed across the resistance is then connected to input of DPM.

Maximum resistance to be measured = $10 \times 10^{-6} \times 20 \times 10^3$.  

= 200 milli $1/\Omega$.  

= 20K $\Omega$.  

So any resistance up to 20K $\Omega$ can be measured.

**Procedure:**

1) Connect any unknown resistance upto 20K$\Omega$. Across the terminals make R (dashed) connect output terminal to input of DPM. Select proper decimal point (19.99K$\Omega$). The display will directly read resistance in Kilo ohms.
**AC Voltage Measurement:**

The complete circuit diagram of AC/DC converter is engraved on front with an input of 200mV A.C. the output will be 200mV d.c for higher A.C voltage measurement use voltage divided network.

**Procedure:**

1) Connect the input of 200 mV (1kHz) to AC/DC converter. Connect output of A.C / D.C converter the DPM. Select the proper point (199.9).

2) For measurement of higher A.C voltage, connect the input to voltage divider network. The output of voltage divided network should be connected to AC/ DC converter. The output of AC/DC converter should be connected to input terminal of DPM. Use the voltage divider network, for measurement of higher A.C. voltage.

**Conclusion:**
Experiment: 10 Function Generator Demonstrator

Date: __________

1. Aim: To study and perform an experiment on the operation of function generator using IC 8038.

2. Requirements:
   Function generator trainer kit, CRO, Digital Millimeter, CRO probes.

3. Pre-Experimental Exercise:
   Brief Theory

   The function generator trainer kit demonstrated is based on the generator IC 8038. The ICL 8038 waveform generator is a monolithic integrated circuit capable of producing high accuracy sine, square, triangular, saw tooth and pulse waveforms with minimum of external components. The frequency can be selected externally from 0.001 Hz to more than 300 kHz using either resistor of capacitors and frequency modulation and sweeping can be accomplished with an external voltage. These devices may be interfaced with phase locked loop circuitry to reduce temperature drift to less than 250ppm/°C.

   The various output of the generator can be made available at the same time. For example, the generator can provide a square wave to test the linearity of an amplifier and simultaneously provide a saw tooth to drive the horizontal deflection amplifier of the CRO to provide a visual display.
4. Laboratory Exercise:

A. Procedure:
1) Connect the required supply and switch ON the unit. See that the supply indicator glows.
2) Connect the CRO at the terminal marked output and observe the waveform.
3) Keep the function switch ON sine wave and frequency switch on 10Hz and amplitude control pot maximum.
4) Vary the fine frequency pot from minimum to maximum and note the minimum and maximum frequency and amplitude.
5) Repeat the above procedure for each frequency range selected.
6) Repeat the above procedure for different waveforms selected by the function switch.
7) Observe the waveform at various stages in the circuit.

B. Observation:
   Draw the observed waveforms.

Conclusion: