INDIAN INSTITUTE OF TECHNOLOGY, KANPUR

MANUAL

EXPERIMENT NO: - 3

STUDY OF AC AND DC BRIDGES

TRANSDUCERS AND INSTRUMENTATION

VIRTUAL LAB

Experiment No:- 3

Aim: - To study the AC and DC Bridges

Requirement: -

- Computer Facility
- Lab view 2009 Runtime engine
- Internet facility for performing (on-line experiment)
  For (off- line experiment) executable file of the experiment can be downloaded through the download link given on the website.

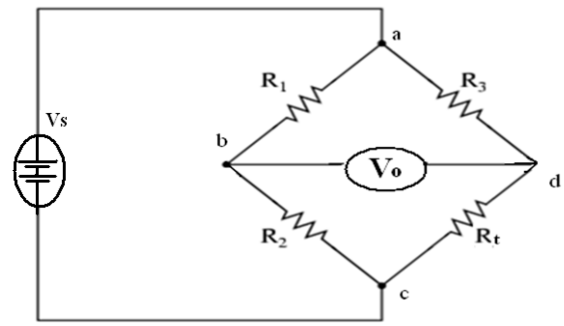
Theory: -

There are many different ways in which physical variables like temperature, light intensity, pressure and numerous other physical variables can be measured electrically. Devices used to measure a physical variable are called sensors. Some different kinds of sensors include the following. • Sensors which change resistance as the physical variable changes. • Thermistors for temperature measurement • Photo-resistors for light measurement • Strain gages for measurement of mechanical strain • Sensors which produce a voltage change for a change in a physical variable. • Thermocouples for temperature • Solar cells for light.

The point here is that it is common to want a zero output signal under certain, known conditions. There are several ways you could subtract out that pesky DC voltage. Bridge circuits are simple circuits that permit us to solve the pesky voltage without complication.

. To review, the bridge circuit works as a pair of two-component voltage dividers connected across the same source voltage, with a null-detector meter movement connected between them to indicate a condition of “balance” at zero volts.

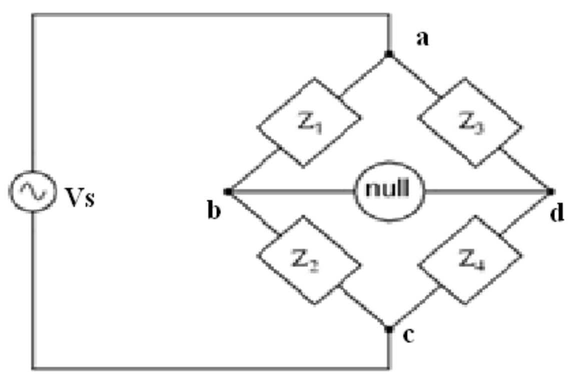
DC BRIDGE: - Branches with resistance as shown below in circuit diagram.



DC BRIDGE

Each arm is composed of two resistors in series, and you may want to think of each arm as a voltage divider. The output is the difference between the outputs of the two voltage dividers.

AC BRIDGE: - When describing general AC bridges, where impedances and not just resistances must be in proper ratio for balance, it is sometimes helpful to draw the respective bridge legs in the form of box-shaped components, each one with certain impedance i.e. with resistors, inductors and capacitors are also there, (Figure below).



AC BRIDGE

Objectives covered

1) <u>Types of DC Bridges covered:-</u>

- (a) **Wheat stone Bridge.**
- (b) **Carey Foster Bridge.**

2) <u>Types of AC Bridges covered:-</u>

- (a) **Maxwell Bridge**
- (b) **Wien Bridge**
- (c) **Hay Bridge**
- (d) **De Shauty Bridge**
- (e) **Schering Bridge**

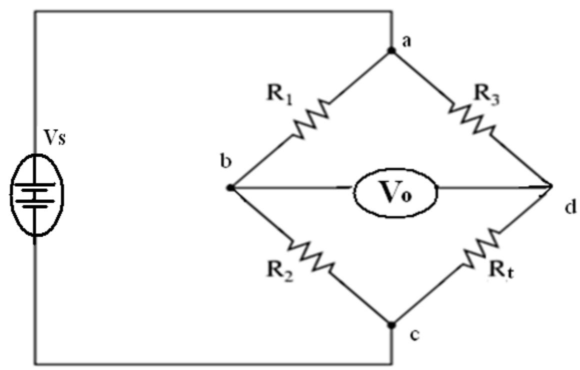
DC Bridge (Wheatstone Bridge)

Aim:-

(a) To study of Wheatstone Bridge.

Theory:-

Any one of the four resistors in the bridge shown below, can be the resistor of unknown value, and its value can be determined by a ratio of the other three, which are "calibrated," or whose resistances are known to a precise degree.



Wheatstone Bridge

When the bridge is in a **balanced condition** (zero voltage as indicated by the null detector), Voltage output is zero indicated as $V_{db}(V_O)$.

$$V_{db} = V_{dc} - V_{bc} = 0; \left(\frac{R_t}{R_t + R_3} = \frac{R_2}{R_2 + R_1} \right)$$

Formula Used:-

Apply voltage divider rule in both the branches and we get for branch (abc)

$$V_{bc} = (\frac{R_2}{R_2 + R_1})V_S$$

And for other branch, (adc)

$$V_{dc} = (\frac{R_t}{R_t + R_3})V_S$$

Now on subtracting V_{bc} from V_{dc} and we get $V_{db}(V_O)$,

$$V_{db} = V_{dc} - V_{bc} = \left(\frac{R_t}{R_t + R_3} - \frac{R_2}{R_2 + R_1} \right) V_s$$

R_t can be any of the resistors among the other four, thus by keeping any three resistor constant, We can get the value of other resistor at which the bridge will be at the balanced position, as in the experiment one by one calibration of every resistors of four arms.

Procedure:-

- Select input voltage as abbreviated Vs in the experiment.
- Now you can calibrate any one of the four resistors(R1,R2,R3,R4) by keeping other three at fix value, and change the value of the fourth resistor through slider, till Bridge be at balanced i.e. below condition is satisfied.

$$\left(\frac{R_t}{R_t + R_3} = \frac{R_2}{R_2 + R_1}\right)$$

  R_t can be any one among the four resistors (R_1, R_2, R_3, R_t) which is variable.
- As you change the value of resistor which is to be calibrated, correspondingly you will get the output as $V_{db}(V_O)$.
- As the bridge will attain balanced state, the $V_{db}(V_O)$ will be zero.

Observational table:-

S. No.	Vs(V)	R1(ohm)	R2(ohm)	R3(ohm)	R4(ohm)	Vo (Vdb)
1.						
2.						
3.						
4.						
5.						

Result:-

Through the above process, voltage output is calculated. When the bridge is at balanced state then voltage output is zero, thus on that balanced state resistor value can be calibrated.

Precaution:-

- Follow instructions carefully.
- For fetching correct value, wait until the process gets complete.
- Runtime engine should be properly installed.

DC Bridge (Carey Foster Bridge)

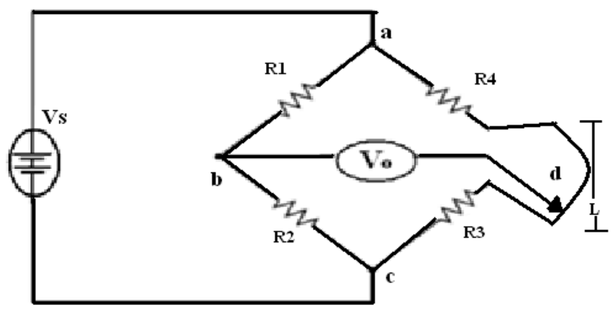
Aim:-

(b) To study the Carey Foster Bridge

Theory:-

Carey Foster Bridge is an electrical circuit that can be used to measure very small resistances. It works on the same principle as Wheatstone bridge. The Carey Foster Bridge is a modified form of the meter bridge in which the effective length of the wire is considerably increased by connecting a resistance in series with each end of the wire and then the voltage output is calculated correspondingly. This increases the accuracy of the bridge.

While performing this experiment you will balance the Carey Foster Bridge by a null deflection method using a galvanometer. You will first determine the resistance per unit length of the material used for the bridge wire, and will then determine the value of an unknown resistance. Circuit diagram is shown below,



Carey Foster Bridge

Formula:-

Applying the voltage divider rule, we get V_{bc} in first branch as shown below,

$$V_{bc} = \left(\frac{R_2}{R_2 + R_1}\right) V_S$$

$$V_{dc} = \left(\frac{R_4 + (x \times r)}{R_4 + (x \times r) + R_3 + (L - x) \times r}\right) V_s$$

Thus on subtracting both the above equations we get,

$$V_{db} = V_{dc} - V_{bc} = \left(\frac{R_4 + (x \times r)}{R_4 + (x \times r) + R_3 + (L - x) \times r} - \frac{R_2}{R_2 + R_1}\right) V$$

When below condition is satisfied, then Bridge is at balance;-

$$V_{db} = V_{dc} - V_{bc} = 0$$

Procedure:-

- Set the input voltage as desired.
- Now there are four controls given as R_1, R_2, R_3, R_4, set these value to some constant, then slide jockey on the wire whose per unit resistance is 2ohm , and Calculate the value of (V_O) as output.

Observational Table:-

Per unit resistance of wire length (L) is 2ohm.

S. No.	Vs(input Voltage)	R1(ohm)	R2(ohm)	R3(ohm)	R4(ohm)	x(in cm)	(L-x)in cm	Vo(V)
1.								
2.								
3.								
4.								
5.								

Result:-Through the above process, voltage output is calculated.

Precaution:-

- Follow instructions carefully.
- For fetching correct value, wait until the process gets complete.
- Runtime engine should be properly installed.

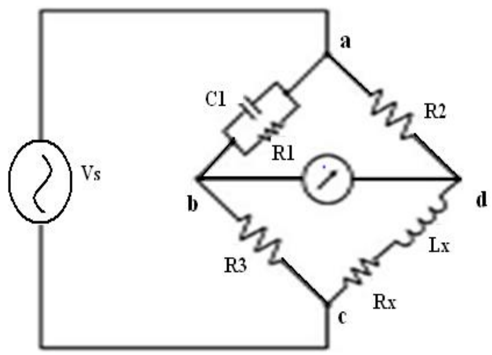
<u>AC Bridges</u> (<u>Maxwell Bridge</u>)

<u>Aim</u>:-

(a) To study Maxwell Bridge.

<u>Theory</u>:-

- Maxwell Bridge measures an inductor in terms of a capacitor standard.
- Maxwell Bridge measure unknown inductances in terms of calibrated resistance and capacitance.
- Calibration-grade inductors are more difficult to manufacture than capacitors of similar precision.
- The circuit diagram of the Maxwell Bridge is shown below,



<u>Maxwell Bridge</u>

<u>Formula used</u>:-

$$Z_1 = \frac{R_1}{1 + jwR_1C_1};$$

$$Z_2 = R_2;$$

$$Z_3 = R_3$$

$$Z_X = R_X + jwL_X$$

At balanced condition;

$$Z_X = \frac{Z_2 \times Z_3}{Z_1}$$

Thus on calculation, and comparing the coefficient we get

$$L_x = C_1 \times R_2 \times R_3$$

And,
$$R_X = \frac{R_2 \times R_3}{R_1}$$

Procedure:-

- Select the Maxwell Bridge.
- Now fix the value of R_2, R_3 to some particular value.
- Then vary the value of C_1, R_1, to get the value of unknown inductance of an inductor and unknown resistor values.

Observation Table:-

S. No.	R1(ohm)	R2(ohm)	R3(ohm)	C1(farad)	Lx(h)	Rx(ohm)
1.						
2.						
3.						
4.						
5.						

Result:-

Thus on inserting the values of R_1, R_2, R_3 and C_1, you will get the values of L_X (unknown inductance) and R_X (unknown resistance).

Precaution:-

- Follow instructions carefully.
- For fetching correct value, wait until the process gets complete.
- Runtime engine should be properly installed.

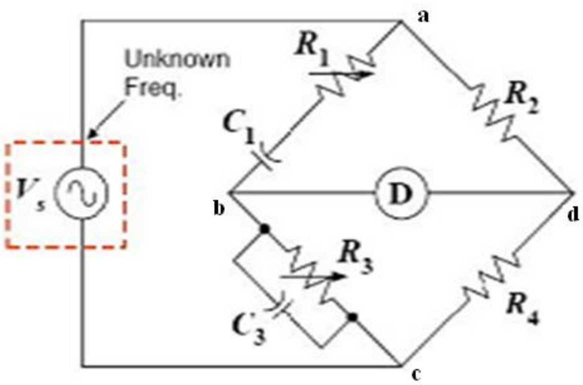
AC Bridges (Wien Bridge)

Aim:-

(**b**) To study of Wien Bridge.

Theory:-

- Wien Bridge measures the unknown frequency of the voltage source through the help of resistors and the capacitors of the bridge.
- Figure of the Wien Bridge is given below,



Wien Bridge

Formula Used:-

$$Z_1 = \frac{1 + jwR_1C_1}{jwC_1}; Z_2 = R_2$$

$$Z_3 = \frac{R_3}{1 + jwR_3C_3}; Z_4 = R_4$$

At balanced condition;

$$Z_4 = \frac{Z_2 \times Z_3}{Z_1}$$

Hence,

$$f = \frac{1}{2\prod\sqrt{R_1 \times R_3 \times C_1 \times C_3}}$$

Procedure:-

- Select the Wien Bridge.
- Fix resistors values for R_1, R_2, R_3 and R_4 are been used, and the controls are given to C_1 And C_3.
- Now on changing the value C_1 and C_3, you will get the different values of **frequency**.

Observation Table:-

S. No.	R1(ohm)	R3(ohm)	C1(farad)	C3(farad)	Frequency(Hz)
1.	4	2			
2.	4	2			
3.	4	2			
4.	4	2			
5.	4	2			

Result:-

As you will insert the different values for C_1, C_3 you will get the corresponding value of frequency.

Precaution:-

- Follow instructions carefully.
- For fetching correct value, wait until the process gets complete.
- Runtime engine should be properly installed.

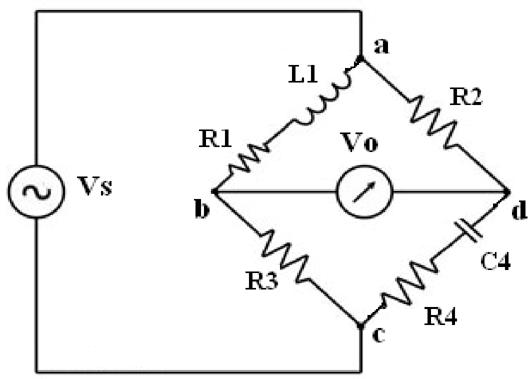
<u>AC Bridges (Hay Bridge)</u>

<u>Aim</u>:-

(c) To study of Hay Bridge.

<u>Theory</u>:-

- Hay Bridge is an AC Bridge used for measuring an unknown inductance by balancing the loads of its four arms, one of which contains the unknown inductance.
- One of the arms of a Hay Bridge has a capacitor of known characteristics, which is the principal component used for determining the unknown inductance value.
- Figure below shows a diagram of the Hay Bridge.



<u>Hay Bridge</u>

<u>Formula used</u>:-

$$Z_1 = R_1 + jwL_1;$$

$$Z_2 = R_2;$$

$$Z_3 = R_3,$$

$$Z_4 = R_4 + \frac{1}{jwC_4}$$

At balanced condition;

$$Z_1 = \frac{Z_2 \times Z_3}{Z_4}$$

On solving through above equation and comparing the coefficient we get,

$$L_1 = C_4 \times R_2 \times R_3$$

Note- For the above calculation it is been considered that Quality factor of the bridge is greater than 10.

Procedure:-

- Select the Hay Bridge.
- Fix different values for R_2, R_3 and change the value of C_4 thus you will get the value of L_1 (unknown value inductor).

Observation Table:-

S. No.	R2(ohm)	R3(ohm)	C4(farad)	L1(h)
1.				
2.				
3.				
4.				
5.				

Result:-

As the values of R_2, R_3 and C_4 are given, correspondingly we will get the value of the unknown inductor L_1 .

Precaution

- Follow instructions carefully.
- For fetching correct value, wait until the process gets complete.
- Runtime engine should be properly installed.

AC Bridges (De Sauty Bridge)

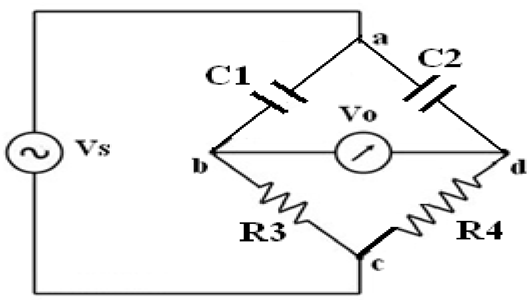
Aim:-

(d) To study De Sauty Bridge**.**

Theory:-

- The De Sauty Bridge is an A.C Bridge works on the principle of Wheat stone's bridge.
- This bridge is used to determine the capacity of an unknown capacitor C2 in terms of the capacity of a standard known capacitor C1.
- Here R1 and R2 are non - inductive resistors.

Figure of De Sauty Bridge is given below,



De Sauty Bridge

Formula Used:-

$$Z_1 = \frac{1}{jwC_1}$$

$$Z_2 = \frac{1}{jwC_2}$$

$$Z_3 = R_3; Z_4 = R_4$$

At balanced condition**;** $$Z_1 = \frac{Z_2 \times Z_3}{Z_4}$$

Thus after calculation we get

$$C_2 = \frac{C_1 \times R_3}{R_4}$$

Procedure:-

- Select the De Sauty Bridge.
- Now give the value of R_3, R_4 and C_1, correspondingly we will get the value of unknown capacitance of C_2.

Observation Table:-

S. No.	R3(ohm)	R4(ohm)	C1(farad)	C2(farad)
1.				
2.				
3.				
4.				
5.				

Result:-

Thus on inserting the value R_3, R_4 and C_1 we will get the value of unknown value of the Capacitor (C_2).

Precaution:-

- Follow instructions carefully.
- For fetching correct value, wait until the process gets complete.
- Runtime engine should be properly installed.

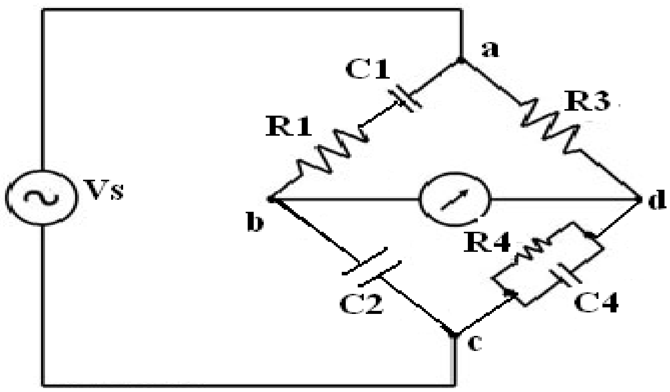
AC Bridges (Schering Bridge)

Aim:-

(**e**) To study Schering Bridge.

Theory;-

- This Bridge is used for measuring an unknown electrical capacitance and its dissipation factor.
- The dissipation factor of a capacitor is the ratio of its resistance to its capacitive reactance.
- The Schering Bridge is basically a four-arm alternating-current (AC) bridge circuit whose measurement depends on balancing the loads on its arms.
- Figure below shows a diagram of the Schering Bridge.



Schering Bridge

Formula;-

$$Z_1 = \frac{1 + jwR_1C_1}{jwC_1};$$

$$Z_2 = \frac{1}{jwC_2}$$

$$Z_3 = R_3;$$

$$Z_4 = \frac{R_4}{1 + jwR_4C_4}$$

At balanced condition;

$$Z_4 = \frac{Z_2 \times Z_3}{Z_1}$$

Thus on calculation and comparing the coefficient we get C1 and R1 as

$$C_1 = \frac{C_2 \times R_4}{R_3} \qquad R_1 = \frac{C_4 \times R_3}{C_2}$$

Procedure-

- Select the Schering Bridge.
- Now insert the value of C_2, C_4, R_3 and R_4 correspondingly we will get the unknown value of R1 and C1.

Observation Table-

S. No.	R3(ohm)	R4(ohm)	C2(farad)	C4(farad)	C1(farad)	R1(ohm)
1.						
2.						
3.						
4.						
5.						

Result:-

As the values C_2, C_4, R_3 and R_4 are inserted we will get the corresponding unknown value of C_1 and R_1.

Precaution:-

- Follow instructions carefully.
- For fetching correct value, wait until the process gets complete.
- Runtime engine should be properly installed.