LAB MANUAL

Course Name: Basic of Electrical & Electronics Engg.

Course Code:

B.E 1st Year [2017-18]

(Branch: CSE)

FACULTY: Applied Physics Group (BEEE)

Chandigarh University

Gharuan

BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LAB

List of Experiments

Note: Along with the prescribed practical syllabus, every student is required to pursue one Project during the semester. The project report will be submitted & final presentation will be made. The evaluation of the Project will be done as one of the experiments.

Introduction Session

Hands-on session on breadboard, Digital Multimeter, LCR meter, Function generator and CRO.

UNIT-I

1. To verify Kirchhoff's Laws.
2. To study voltage-current relationship in an R-L series circuit and to determine the power factor of the circuit.
3. To measure the power of 3 phase AC Circuits using wattmeter method.

UNIT-II

4. To design Inverting and Non Inverting amplifier using Op-amp.
5. To design adder and subtractor using Op-amp.
6. To design differentiator and Integrator using Op-Amp.

UNIT-III

7. To verify and demonstrate the working of LVDT.
8. To implement stair case and corridor wiring.
9. To interface Analog-to-Digital (ADC) converter with Op-Amp.
10. To interface Digital to Analog convertor with Op-Amp.

<u>**Experiment No.: 1(A)**</u>

1A.1 AIM: To verify Kirchhoff's Current Law (KCL) and study its limitations.

1A.2 APPARATUS REQUIRED:

Table 1A.1: Apparatus required for Kirchhoff's Current Law

Sr. No.	**Equipment name**	**Specifications and range**	**Quantity in No.**
1.	Regulated variable DC supply	0 – 30 *V*, 0 – 2 *A*	1
2.	Digital multimeter	0 – 2 *A*	6
3.	Resistor	Of different values	6
4.	Connecting wires	As per requirement	

1A.3 THEORY:
Kirchhoff's laws are used to determine the current and voltage in different branches of an electric circuit which may not be easily solved by Ohm's law. These laws are applicable to both AC and DC circuits.

1A.3.1 Statement of Kirchhoff's First Law or Kirchhoff's Current Law (KCL) or Point Law:
It states that the algebraic sum of all the currents meeting at a junction or a node in any electric circuit at any instant is zero.

1A.3.2 Explanation:
Consider that few conductors are meeting at point M as in Fig. 1A.1. The arrows indicate the direction of current flow. The currents I_2 and I_4 are coming towards the junction M and currents I_1 and I_3 are going away from the junction. Assume positive sign for incoming currents and negative sign for outgoing currents.

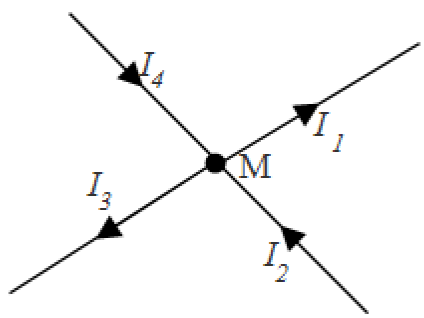


Fig. 1A.1: Currents meeting at a node in Kirchhoff's Current Law

According to KCL,

$$\sum I = 0$$

i.e., $(-I_1)+(I_2)+(-I_3)+(I_4)=0$

$\therefore \quad I_2 + I_4 = I_1 + I_3$ --- (1)

i.e., Incoming currents = Outgoing currents

1A.3.3 Limitations:

1. Not applicable in stray currents environment and in high frequency applications (even KCL is violated at 60 Hz frequency).
2. Not applicable to circuit having distributed elements.

1A.4 PRECAUTIONS:

1. Switch off the supply first and then start making connections.
2. Meters of suitable range should be used as shown in Table 1A.1.

1A.5 CIRCUIT DIAGRAM:

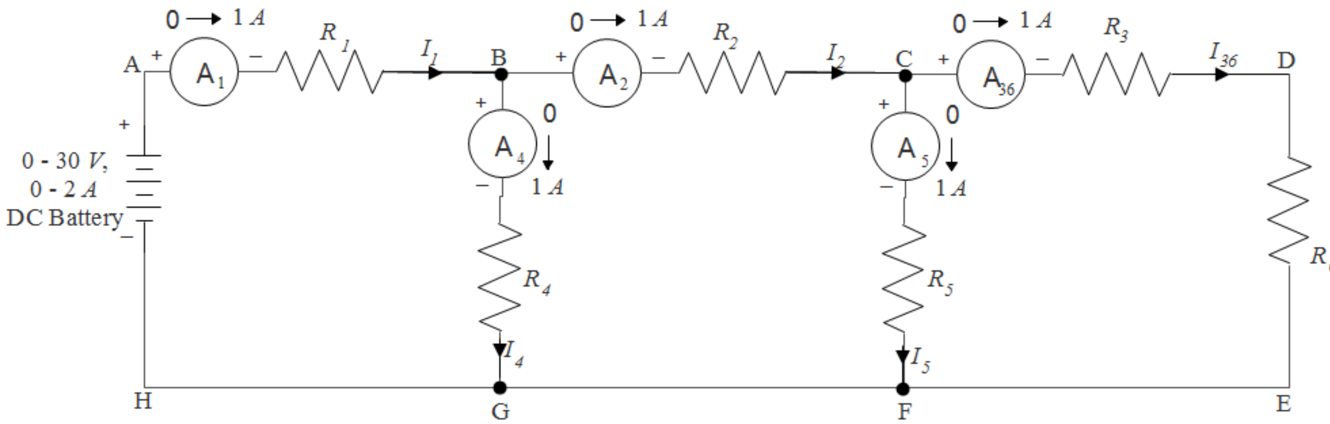


Fig. 1A.2: Circuit Diagram of Kirchhoff's Current Law

1A.6 PROCEDURE:

1. The circuit is connected as shown in Fig. 1A.2.
2. The voltage of DC supply was set at 12 *V*.
3. Different values of R_1 to R_6 were taken and readings of A_1 to A_6 were noted down.
4. Accordingly, only one set of reading was taken at 12 *V* DC supply.
5. The observations were recorded in Table 1A.2.

1A.7 OBSERVATION TABLE:

Table 1A.2: Observation Table for Kirchhoff's Current Law

Sr. No.	Supply Voltage V_{dc} (*V*)	Ammeter I_1 (*A*)	Ammeter I_2 (*A*)	Ammeter I_{36} (*A*)	Ammeter I_4 (*A*)	Ammeter I_5 (*A*)
1.						

1A.8 CALCULATIONS:

Applying KCL at junction B, $I_1 = I_2 + I_4$ (2)

Applying KCL at junction C, $I_2 = I_{36} + I_5$ (3)

Calculations are done for all the readings being taken using Eq. (2) and (3) to be applied at respective junctions.

1A.9 SOURCES OF ERROR:

1. Internal resistance of DC battery.
2. Internal resistance of multimeter viz. voltmeter and ammeter.
3. Internal resistance of connecting wires.
4. Heating effect of rheostat coil (Joule's law of electric heating)
5. All the sources of error related to multimeter.

1A.10 RESULT:

As per Kirchhoff's Current Law, the theoretical and calculated values of algebraic sum of currents are compared as shown in Table 1A.3.

Table 1A.3: Result Table for Kirchhoff's Current Law

Sr. No.	Calculated values of current (A)		Theoretical values of current (A)		Percent Error	
	$I_1 = I_2 + I_4$ **(A)**	$I_2 = I_{36} + I_5$ **(A)**	$I_1 = I_2 + I_4$ **(A)**	$I_2 = I_{36} + I_5$ **(A)**	$I_1 = I_2 + I_4$ **(A)**	$I_2 = I_{36} + I_5$ **(A)**
1.						

1A.11 CONCLUSION:

The difference in comparison of theoretical and calculated values should be analyzed and resulting difference if any, in both sets of readings is likely due to various sources of error mentioned in Section 1A.9. From Table 1A.3, it is seen that error involved is very small and thus, KCL is verified.

1A.12 VIVA VOCE:

1. Give reasons why ammeter is always connected in series with the supply.
2. In what cases, Kirchhoff's laws are not applicable to DC circuits.
3. Can Kirchhoff's laws be applicable to AC circuits?
4. Can we apply Kirchhoff's laws in non-linear circuits?
5. A lamp rated 100 V, 75 W is to be connected across 230 V supply. Find the value of resistance to be connected in series with the lamp and power loss occurred in that resistance. **[173.3 Ω, 97.48 W]**

Prepared By:

Reviewed By:

Approved By:

Experiment No.: 1(B)

1B.1 AIM: To verify Kirchhoff's Voltage Law (KVL) and study its limitations.

1B.2 APPARATUS REQUIRED:

Table 1B.1: Apparatus required for Kirchhoff's Voltage Law

Sr. No.	Equipment name	Specifications and range	Quantity in No.
1.	Regulated variable DC supply	0 – 30 V, 0 – 2 A	1
2.	Digital multimeter	0 – 30 V	6
3.	Resistor	Of different values	6
4.	Connecting wires	As per requirement	

1B.3 THEORY:
Kirchhoff's laws are used to determine the current and voltage in different branches of an electric circuit which may not be easily solved by Ohm's law. These laws are applicable to both AC and DC circuits.

1B.3.1 Statement of Kirchhoff's Second Law or Kirchhoff's Voltage Law (KVL) or Mesh Law:
In any closed path (mesh or loop) of an electric circuit, the algebraic sum of product of current and resistance in each of the conductors plus the algebraic sum of electromotive forces (emfs) in that closed path is zero.

i.e. $\sum IR + \sum emf = 0$ (1)

where, IR = Potential drop across resistor
emf = Potential of battery used in the circuit
$\sum$ = Algebraic sum

Algebraic sum means we have to consider the sign convention. A rise in potential is considered as positive, while a fall in potential is considered as negative. However, if the chosen loop direction is opposite to the flow of branch current as shown in Fig. 1B.1 (b), the fall in potential will be existing due to current flow, but the polarity of voltage across the element will be taken as positive instead of negative.

1B.3.2 Determination of sign for emf source:
1. If we go from positive terminal of emf source to the negative terminal, there is a fall in potential and so emf should be assigned negative sign shown in Fig. 1B.1 (a).
2. On the other hand, if we go from the negative terminal of the emf to the positive terminal, there is rise in potential. Therefore, the emf should be assigned positive sign shown in Fig. 1B.1 (b).

The sign of emf is independent of the direction of current through it.

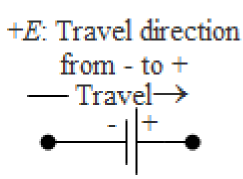


Fig. 1B.1 (a): Fall in Voltage

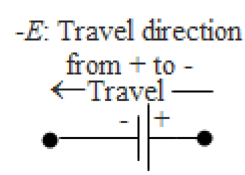


Fig. 1B.1 (b): Rise in Voltage

1B.3.3 Determination of sign for the product of current and resistance:

1. When current flows through a resistor, there is a voltage drop across it which is shown in Fig. 1B.2. If we go through the resistance in the same direction as the current, there is a fall in potential (current always flow from higher to lower potential). Thus, a negative sign should be assigned for the product shown in Fig. 1B.2 (a).
2. On the other hand, if we go through the resistor in the direction opposite to the flow of current, there is a rise in potential. Thus, a positive sign should be assigned to the product shown in Fig. 1B.2 (b).

The sign of product of *IR* terms depend on the direction of current flow and are independent of the polarity of the emf in the circuit under consideration.

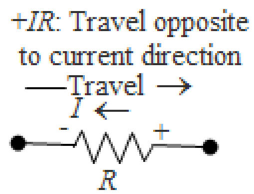


Fig. 1B.2 (a): Fall in Voltage

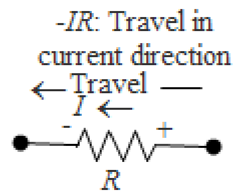


Fig. 1B.2 (b): Rise in Voltage

1B.3.4 Explanation:

Consider the closed path ABCDA in Fig. 1B.3. Different voltage drops will have the following signs:

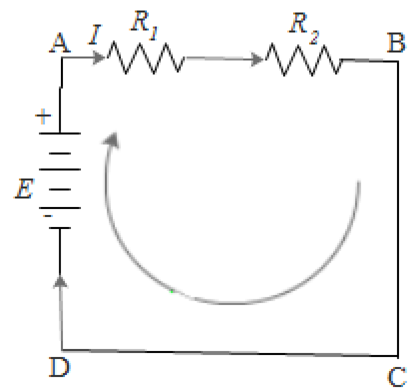


Fig. 1B.3: Electric Circuit

IR_1 is negative (Fall in potential)

IR_2 is negative (Fall in potential)

E is positive (Rise in potential)

Using KVL, we get,

$-IR_1 - IR_2 + E = 0$

or $E = IR_1 + IR_2$ (2)

Voltage rise = Voltage drops

1B.3.5 Limitations:

1. Not applicable in stray currents environment and in high frequency applications (even KCL is violated at 60 Hz frequency).
2.Not applicable to circuit having distributed elements.

1B.4 PRECAUTIONS:
1. Switch off the supply first and then start making connections.
2. Meters of suitable range should be used as shown in Table 1B.1.

1B.5 CIRCUIT DIAGRAM:

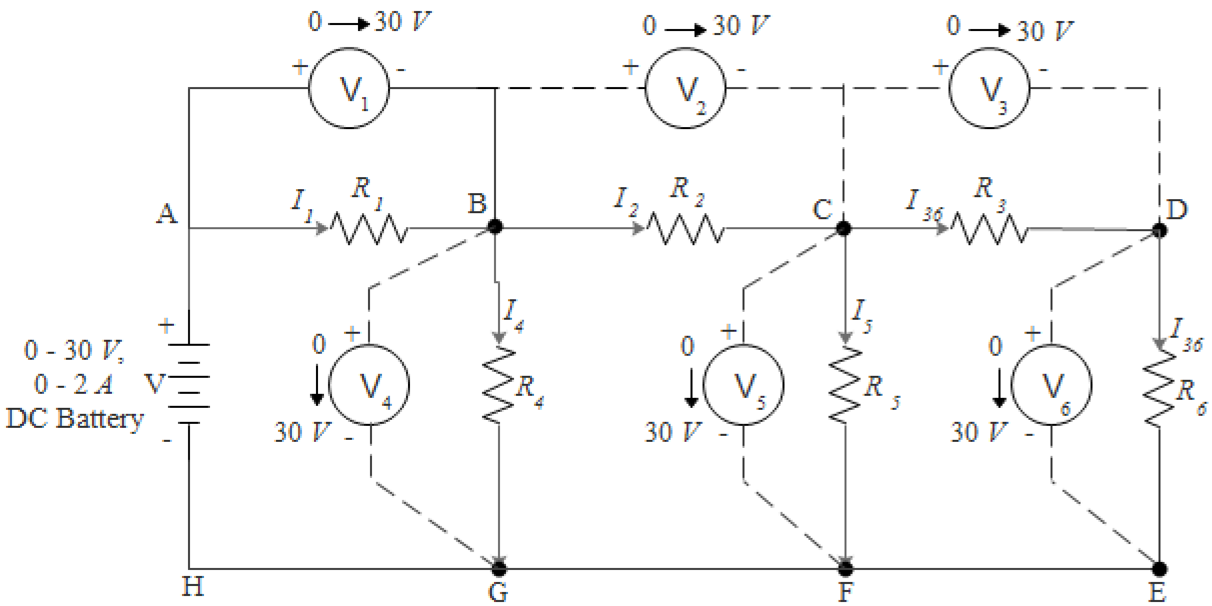


Fig. 1B.4: Circuit Diagram for Kirchhoff's Voltage Law

1B.6 PROCEDURE:
1. The circuit is connected as shown in Fig. 1B.4.
2. The voltage of DC supply was set at 12 *V* DC supply.
3. Different values of R_1 to R_6 were taken and readings of V_1 to V_6 were noted down.
4. Accordingly, only one set of reading was taken at 12 *V* DC supply.
5. The observations were recorded in Table 1B.2.

1B.7 OBSERVATION TABLE:

Table 1B.2: Observation Table for Kirchhoff's Voltage Law

Sr. No.	Voltmeter V_1 (V)	Voltmeter V_2 (V)	Voltmeter V_3 (V)	Voltmeter V_4 (V)	Voltmeter V_5 (V)	Voltmeter V_6 (V)
1.						

1B.8 CALCULATIONS:
Applying KVL in loop ABGH, $V - I_1R_1 - I_4R_4 = 0$ or $V - V_1 - V_4 = 0$ (3)

Applying KVL in loop BCFG, $-I_2R_2 - I_5R_5 + I_4R_4 = 0$ or $-V_2 - V_5 + V_4 = 0$ (4)

Applying KVL in loop CDEF, $-I_{36}R_3 - I_{36}R_6 + I_5R_5 = 0$ or $-V_3 - V_6 + V_5 = 0$ (5)

Calculations are done for all the readings being taken using Eq. (3), (4) and (5) to be applied in respective loops.

1B.9 SOURCES OF ERROR:
1. Internal resistance of DC battery.
2. Internal resistance of multimeter viz. voltmeter and ammeter.
3. Internal resistance of connecting wires.
4. Heating effect of rheostat coil (Joule's law of electric heating)
5. All the sources of error related to multimeter.

1B.10 RESULT:
As per Kirchhoff's Voltage Law, the theoretical and calculated values of algebraic sum of emfs and voltage drops are compared as shown in Table 1B.3.

Table 1B.3: Result Table for Kirchhoff's Voltage Law

Sr. No.	Calculated values of voltages (*V*)			Theoretical values of voltages (*V*)		
	$V-V_1-V_4=0$	$-V_2-V_5+V_4=0$	$-V_3-V_6+V_5=0$	$V-V_1-V_4=0$	$-V_2-V_5+V_4=0$	$-V_3-V_6+V_5=0$
1.						

1B.11 CONCLUSION:
From Table 1B.3, the difference in comparison of theoretical and calculated values should be analyzed and resulting difference if any, in both sets of readings is likely due to various sources of error mentioned in Section 1C.9. The percent error in calculated and theoretical values for $V-V_1-V_4=0$, $-V_2-V_5+V_4=0$ and $-V_3-V_6+V_5=0$ is found to be ____, ______ and ____. From these values, it is seen that error involved is very small and thus, KVL is verified.

1B.12 VIVA VOCE:
1. Define unilateral and non – linear circuits.
2. Give reasons why voltmeter is always connected in parallel to the supply.
3. What do you mean by heating effect of electricity?
4. A Wheatstone bridge consists of AB = 400 Ω, BC = 220 Ω, CD = 225 Ω and DA = 100 Ω. A 2 *V* cell is connected between A and C and a galvanometer of 200 Ω resistance between B and D. Estimate the current through the galvanometer by applying Kirchhoff's laws. **[2/703 A from D to B]**

Prepared By:

Reviewed By:

Approved By:

Experiment No.: 2

2.1 AIM: To study voltage-current relationship in an R-L series circuit and to determine the power factor of the circuit.

2.2 APPARATUS REQUIRED:

Table 2.1: Apparatus required for measuring power and power factor of a choke coil in R – L series circuit

Sr. No.	Equipment name	Specifications and range	Quantity in No.
1.	1-ϕ AC supply	230 *V*	1
2.	1-ϕ Variac	0 – 270 *V*, 15 *A*	1
3.	AC wattmeter	0 – 300 *V*, 5 *A*, 750 *W*	1
4.	AC analog ammeter	0 – 5 *A*	1
5.	AC analog voltmeter	0 – 300 *V*	1
6.	Variable resistive load	230 *V*, 1 *kW*	1
7.	Variable inductive load	230 *V*	1
8.	Connecting wires	As per requirement	

2.3 THEORY:

An AC series circuit consisting of a resistor and an inductor is shown in Fig.2.1. I is the current flowing through the resistor and the inductor. The voltage drop across the resistor and the inductor is V_R and V_L respectively. The phasor sum of these two voltages will be equal to the applied voltage V as shown in Fig.2.2. In a resistive circuit the voltage and current are in phase. In a pure inductive circuit the current lags the voltage by 90 degrees.

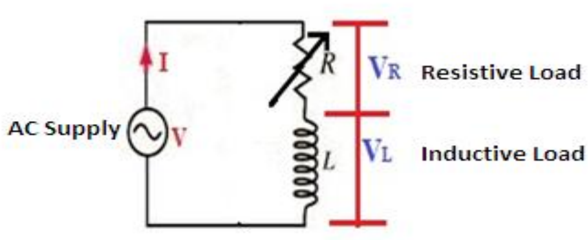


Fig. 2.1: R-L Series circuit

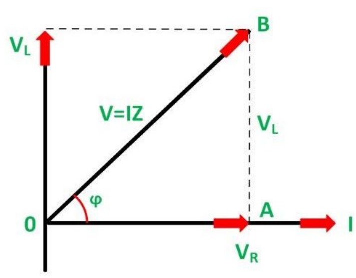


Fig. 2.2: Phasor between voltage and current

As I is common for both the resistor and the inductor in the circuit shown in Fig. 2.1. The current I can be taken as the reference phasor as shown in Fig. 3.2. Voltage drop across the resistor V_R is shown in phase with the current I. Voltage drop across the inductor V_L is shown leading the current phasor by 90 degrees. The phasor sum of V_R and V_L is shown equal to the total applied voltage V. The angle between the applied voltage V and current I is ϕ. The power factor of the circuit is Cosϕ. Current lags the voltage by an angle ϕ as shown in Fig. 2.2. By measuring the power input to the circuit with the help of a wattmeter and hence the power factor angle can also be calculated as:

W =VI Cosϕ ---------------------------------- eq. (i)

Power factor, Cosϕ = [W/(VI)] ---------------- eq. (ii)

Therefore, $\phi = \text{Cos}^{-1}$[W/(VI)] ---------------- eq.(iii)

Fig. 2.3 shows voltage triangle for R – L series connected load.

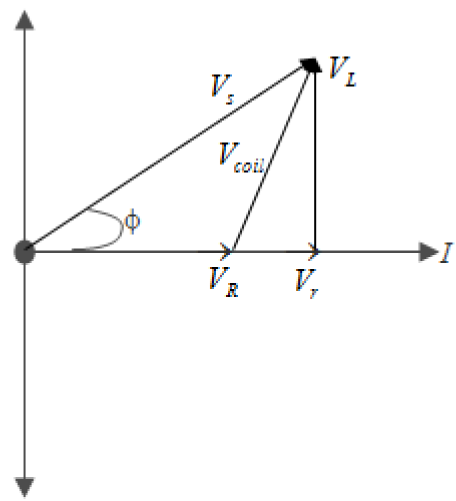


Fig. 2.3: Voltage triangle for R – L series connected load

In Fig. 2.3,
Let, V_s = Supply voltage in volts (V)
V_R = Voltage drop across resistive load (lamp bank) R in volts (V)
V_{coil} = Voltage drop across choke coil in volts (V)
Z_{ckt} = Impedance of the circuit in ohm (Ω)
r = Internal resistance of choke coil in ohm (Ω)
X_L = Inductive reactance of choke coil in ohm (Ω)
L = Inductance of choke coil in henry (H)
Z_{coil} = Impedance of the choke coil in ohm (Ω)
I = Current flowing in the circuit in Amp (A)
P = Power measured in watts (W)
$cos\varphi$ = Power factor of R – L series connected load

From Fig. 2.3,

$$Z_{ckt} = \frac{V_s}{I} \qquad (1)$$

$$Z_{coil} = \frac{V_{coil}}{I} \quad (2)$$

$$R = \frac{V_R}{I} \quad (3)$$

It is evident that, $(R+r)^2 + X^2 = Z_{ckt}^2$ (4)

$$R^2 + 2Rr + r^2 + X^2 = Z_{ckt}^2$$

But, $Z_{coil}^2 = r^2 + X^2$ (5)

$$R^2 + 2Rr + Z_{coil}^2 = Z_{ckt}^2$$

Thus, $r = \frac{Z_{ckt}^2 - Z_{coil}^2 - R^2}{2R}$ (6)

From Eq. (5), $X = \sqrt{Z_{coil}^2 - r^2}$ (7)

But, $\omega L = X$

$$L = \frac{X}{\omega} = \frac{X}{2\pi f}\text{ H} \quad (8)$$

Also, $\cos\phi = \frac{R+r}{Z_{ckt}}$ (9)

Thus, resistance, inductance and power factor of R – L series connected load is calculated using above equations.

2.4 PRECAUTIONS:

1. 1-φ variac should be set at zero potential before switching on 1-φ AC supply.
2. Meters of suitable range should be used as shown in Table 2.1.
3. The current coil (CC) and potential coil (PC) of wattmeter should be shorted externally.

2.5 CIRCUIT DIAGRAM:

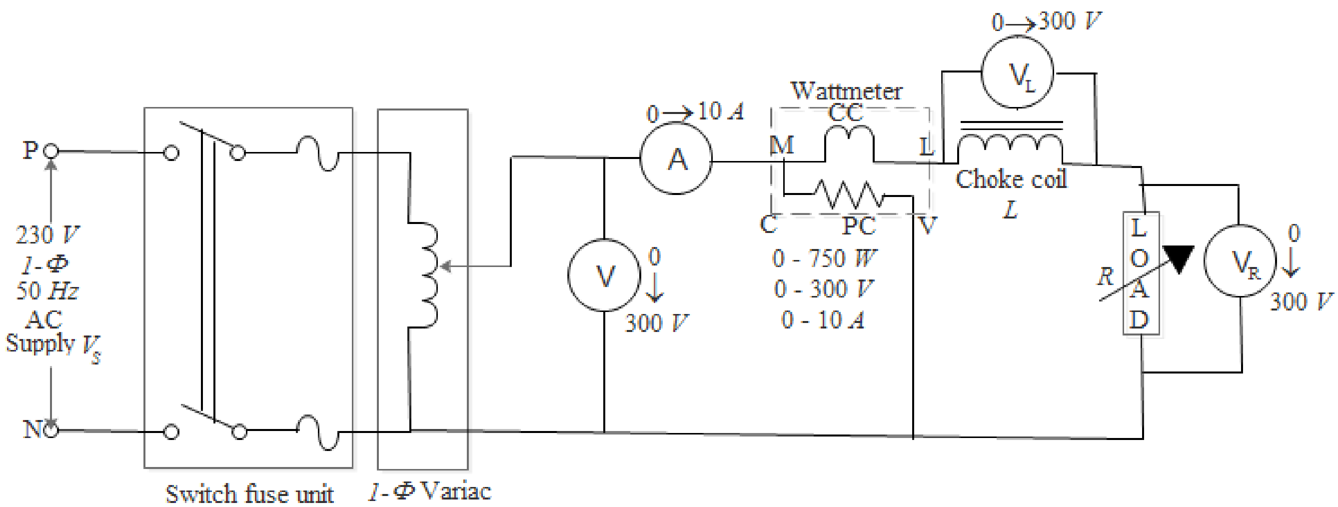


Fig. 2.3: Circuit Diagram for determination of resistance, inductance, power and power factor of R – L series connected load

2.6 PROCEDURE:

1. Connect the circuit as shown in Fig. 2.3.
2. Vary the 1-φ AC supply voltage with the help of 1-ϕ variac shown in Fig. 2.3.
3. Switch on the resistive load by switching various lamps in resistive lamp bank and vary the tappings of choke coil.
4. Take readings of V_s, I, V_L, V_R and P.
5. Increase resistive and inductive load by switching and repeat the procedure as stated in steps 1 to 4.
6. Take at least 5 set of readings and record the readings in Table 2.2.
7. Calculate impedance of circuit, impedance of coil, internal resistance of coil, inductive reactance of coil, inductance of coil and power factor from readings as shown in Eq. (10) to (17).

2.7 PHASOR DIAGRAM:

1. Select the scale 1 cm = ____ V.
2. Draw the current (I) as reference phasor OE as shown in Fig. 2.4.
3. Draw the phasor OB (=V_R) to the scale in phase with the current phasor OE.
4. From point B, draw an arc of radius equal to V_{coil} (to the scale).
5. From point O, draw an arc of radius equal to V_s (to the scale) such that it intersects the previous arc at A.
6. Thus, phasor BA represents the voltage across the coil and phasor OA represents the supply voltage.
7. Draw the perpendicular from point A intersecting the current phasor at D.
8. Phasor BD represents the voltage across the internal resistance of coil. Hence, BD = Ir.
9. Phasor AD represents the voltage across the inductive reactance of the coil. Hence, AD = IX_L.
10. Determine r and L from the phasor diagram. Compare the results with the calculated values for a particular reading.

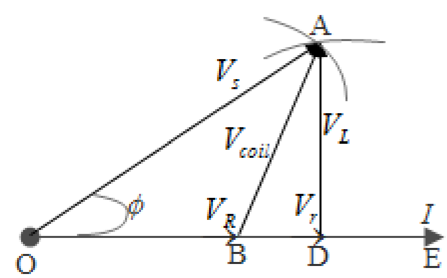


Fig. 2.4: Phasor Diagram of R – L series connected load

2.8 OBSERVATION TABLE:

Table 2.2: Observation Table for determination of resistance, inductance, power and power factor of R – L series connected load

Sr. No.	Supply voltage V_s (V)	Voltage across resistor V_R (V)	Voltage across coil V_{coil} (V)	Current I (A)	Power P (W)
1.					
2.					
3.					
4.					
5.					

2.9 CALCULATIONS:

1. $Z_{ckt} = \dfrac{V_s}{I}$ (10)

2. $Z_{coil} = \dfrac{V_{coil}}{I}$ (11)

3. $R = \dfrac{V_R}{I}$ (12)

4. $r = \dfrac{Z_{ckt}^2 - Z_{coil}^2 - R^2}{2R}$ (13)

5. $X = \sqrt{Z_{coil}^2 - r^2}$ (14)

6. $L = \dfrac{X}{\omega} = \dfrac{X}{2\pi f}$ H (15)

7. $\cos\phi = \dfrac{R + r}{Z_{ckt}}$ (16)

8. $P = V_s I \cos\phi$ (17)

Calculations are done for all the readings being taken using Eq. (10) to Eq. (17) in order to analyze R – L series circuit. All these parameters are recorded in Table 2.3 for all the readings.

2.10 SOURCES OF ERROR:

1. Internal resistance and inductance of autotransformer (or 1-φ variac) coil.
2. Internal resistance of multimeter and wattmeter.
3. Internal resistance of connecting wires.
4. Internal resistance of lamp bank.
5. Internal resistance and inductance of choke coil
6. Analog wattmeter may not be calibrated.

2.11 RESULT:

The calculated and graphical values of phase angle, power and power factor of R – L series connected load are compared in Table 2.4.

Table 2.3: Result table for R – L series connected load

Sr. No.	**Resistance *R* (Ω)**	**Impedance of circuit Z_{ckt} (Ω)**	**Impedance of coil Z_{coil} (Ω)**	**Resistance of coil *r* (Ω)**	**Inductive reactance of coil *X* (Ω)**	**Inductance of coil *L* (*H*)**	**Power *P* (*W*)**	**Power factor *cosφ***
1.								
2.								
3.								
4.								
5.								

The comparison of calculated and graphical values for various parameters is shown in Table 2.4.

Table 2.4: Result Table for phase angle, power factor and power for R – L series connected load

Sr. No.	CALCULATED VALUES			GRAPHICAL VALUES		
	Phase angle ϕ (deg)	Power factor cosϕ	Power P (W)	Phase angle ϕ (deg)	Power factor cosϕ	Power P (W)
1.						
2.						
3.						
4.						
5.						

2.11 CONCLUSION:

The difference in comparison of calculated and graphical values should be analyzed and resulting difference if any, in both sets of readings is likely due to various sources of error mentioned in Section 2.10. Theoretically, for R – L series load, current will always lag behind the applied voltage and thus power factor will always be less than unity.

2.12 VIVA VOCE:

1. What do you mean by choke coil? Why the name is given so?
2. Why power waveform is not symmetrical to X – axis in R – L circuit?
3. Give the significance of active, reactive and apparent power.
4. Why AC meter always measure RMS value of quantity being measured?
5. What is significance of voltage and reactance triangle?
6. Draw vector diagram for R – L series circuit when fed by DC supply.
7. What is significance of Q – factor of choke coil?
8. State applications and significance of average power in purely inductive circuit.
9. Can you draw B – H curve for choke coil? Justify.
10. Define the term power factor in AC circuits. What is meant by lagging and leading power factor?
11. Power in a 1-φ AC circuit is given by _____.
12. What is the power factor of a purely inductive circuit?
13. Draw voltage triangle, impedance triangle and power triangle for R – L series circuit.
14. What is the average power in purely inductive circuit? Justify your answer.
15. Draw simple phasor diagram showing the concept of lagging and leading power factor. Mark the direction of rotation of phasor in the diagram.
16. Why do we need power factor correction? Which equipments are used for it?

Prepared By:

Reviewed By:

Approved By:

Experiment No.: 3

3.1 AIM: To measure the power of 3 phase AC Circuits using wattmeter method.

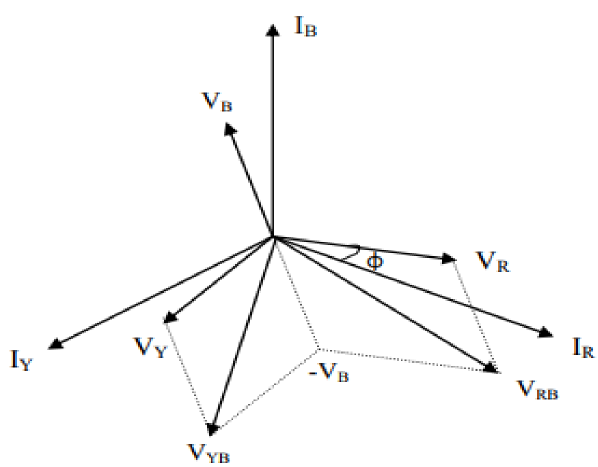
3.2 APPARATUS REQUIRED:

Table 3.1: Apparatus required for the measurement of 3 phase power

Sr. No.	Equipment name	Specifications and range	Quantity in No.
1.	Voltmeter	0 – 440 *V*	1
2.	Ammeter	0-5 A	2
3.	Wattmeter	0-750 W	1
4.	3 Phase Variac	0-415V	1
5.	Balance Load	Lamp Bank	

3.3 THEORY:
At a power generating plant, the windings of a three phase machine are arranged to provide three voltages, each 120° apart in time and, in the common balanced system, usually all of the same magnitude. These three voltage sources may be connected in a wye (Y) or a delta (Δ) configuration. Three phase loads may also be connected in wye or delta connections. The wye connection has a central node to which a neutral wire may be joined, but the delta connection is a three wire system without a node for a neutral or ground) connection. .

If a 3-phase system has four wires, it is necessary to use three wattmeter, unless it is known that the system is balanced and therefore no current is flowing in the neutral wire. For any balanced N wire system it is necessary to use $N-1$ wattmeter to measure the total power.



Phasor Diagram

As it is balance condition $V_a = V_b = V_c$ = Phase voltage

$I_a = I_b = I_c$ = Phase current

For resistive load $\cos\phi = 1$. So, $P_C = 3\, V_{ph}\, I_{ph}$

3.4 PRECAUTIONS:

1. All the connections should be tight and clean.
2. The readings in ammeters should not exceed the current ratings of wattmeter.
3. With negative deflection in wattmeter the connection should be reversed.

3.5 CIRCUIT DIAGRAM:

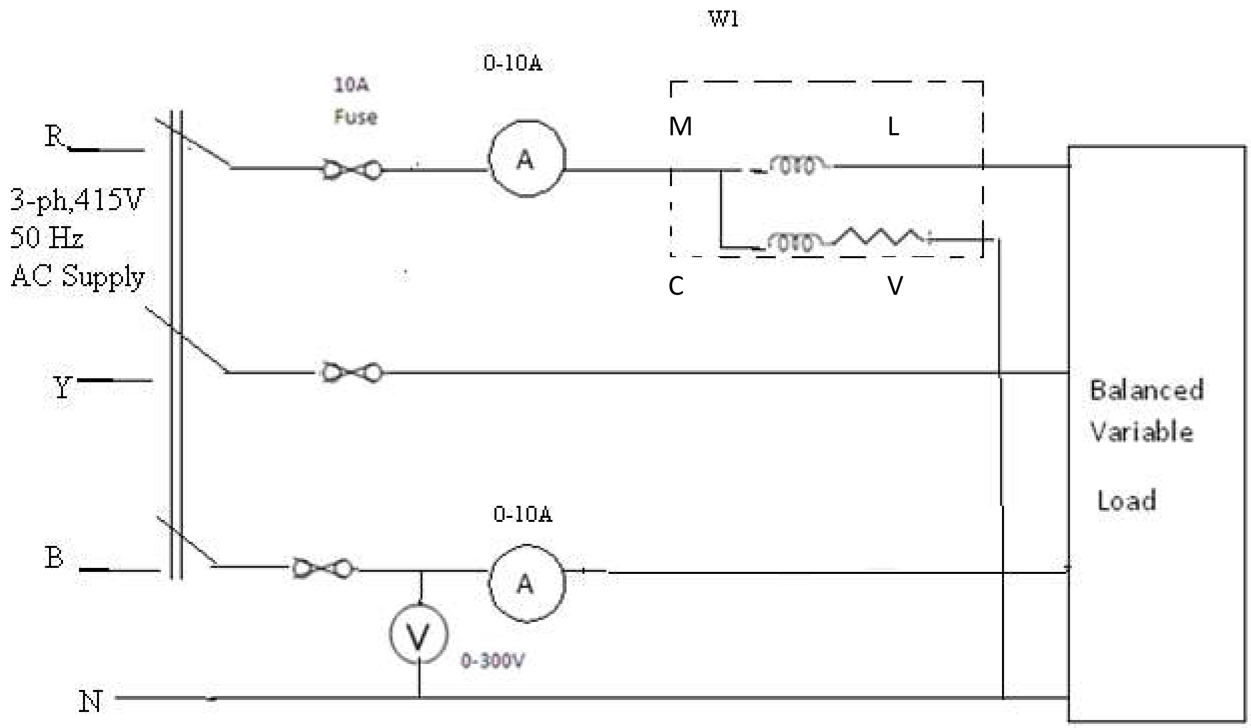


Fig. 3.2: Circuit diagram for active power measurement by Single wattmeter method with balance load

3.6 PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Check and adjust zero indication of wattmeter and note the multiplying factor of wattmeter.
3. Switch on the supply.
4. Adjust required amount of supply voltage with variac.
5. Adjust balanced load.
6. Note voltmeter, ammeter & wattmeter reading W.
7. Take four readings for different current for balanced load.
8. Switch off the supply.
9. Calculate total active power and power factor.

3.7 OBSERVATION TABLE:

Table 3.2: Observation Table for measurement of 3 phase AC power

Sr. No.	Voltmeter reading (V_{ph})	Ammeter reading (I_{ph})	Wattmeter Reading(P_{ph})	Total Active Power (P) = $3 \times P_{ph}$	P_C = 3 Vph Iph
1.					
2.					

3.8 CALCULATION:

Calculate $P = \mathbf{3 \times P_{ph}}$

$$\mathbf{P_C = 3\, V_{ph}\, I_{ph}}$$

$$\%Error= \frac{P_C - P}{P_C}$$

3.9 SOURCES OF ERROR:

1. Internal resistance of DC battery.
2. Internal resistance of multimeter viz. voltmeter and ammeter.
3. Internal resistance of connecting wires.
4. Ripples and harmonics present in DC supply.
5. Forward voltage drop in silicon or germanium diodes.
6. All the sources of error related to multimeter.

3.10 RESULT:

Table 3.2: Observation Table for % error in measurement of 3 phase AC power

Total Active Power (P) = $3 \times P_{ph}$	P_C = 3 Vph Iph	$\%Error= \frac{P_C - P}{P_C}$

3.11 CONCLUSION:

It is analyzed that if there is any value of Error % due to various sources of error mentioned in Section 3.9. Thus, connected load is not a balanced load.

3.12 VIVA VOCE:

1. How many coils are there in a single in a single phase wattmeter?
2. What do you understand by phase sequence in reference to 3-phase circuits?
3. What is the phase sequence of a 3-phase system in general?
4. How the phase sequence of a three phase system can be changed?
5. Is the method used in this experiment applicable to unbalanced loads?
6. Can you measure reactive power in a three phase circuit using this method?
7. Which type of wattmeter is generally used for measuring power in a.c. circuits?

8. How a wattmeter is connected in an a.c. circuit?
9. What is the relation between line voltage and phase voltage in star connected system? .
10. In a star connected 3-phase balanced load with neutral available, how many wattmeters are necessary to measure power?

Prepared By:

Reviewed By:

Approved By:

Experiment No.: 4

4.1 AIM: To design Inverting and Non Inverting amplifier using Op-amp.

4.2 APPARATUS REQUIRED:

Table 4.1: Apparatus required

Sr. No.	Equipment name	Specifications and range	Quantity in No.
1.	Op-amp IC	IC 741 op-amp	1
2.	CRO	0-230V,30 MHz	1
3.	CRO Probes	-------	2
4.	Resistor	10 kΩ, 5 kΩ, 4 kΩ, 2kΩ,	2,1,1,1
5.	Digital Multimeter	--------	1
6.	Function Generator	10Hz to 1MHz	1
7.	Bread Board	--------	
8.	Connecting wires	As per requirement	

4.3 THEORY:

Inverting Amplifier: An amplifier whose O/P is out of phase with the input. It can amplify ac & dc signals. Its gain depends upon the values of feedback resistance (RF) & input resistance (R1). Fig 1 shows inverting amplifier.

$$V_O = V_{IN} (R_F/R_1)$$

Non-Inverting Amplifier: An amplifier whose O/P is in phase with the input. It can amplify ac & dc signals. Its gain depends upon the values of feedback resistance (RF) & input resistance (R1).

$$V_O = V_{IN} (1+ R_F/R_1)$$

4.4 PRECAUTIONS:

1. Connections should be done properly.
2. Check for grounding.
3. Get the circuit checked by the instructor before giving the power supply.
4. Observation should be taken precisely.

4.5 CIRCUIT DIAGRAM:

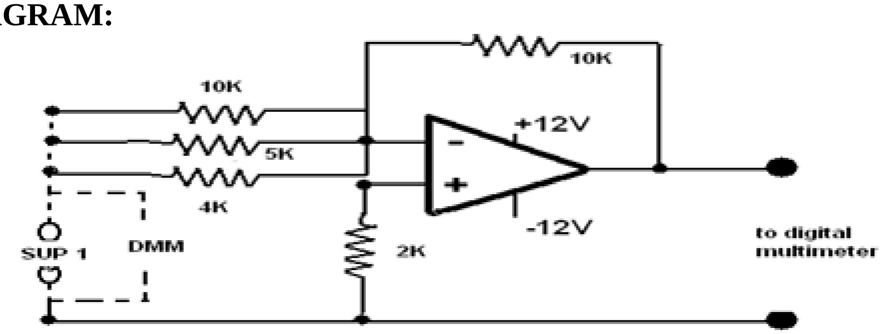


Fig. 4.1(a): Circuit Diagram for Inverting amplifier using Op-amp

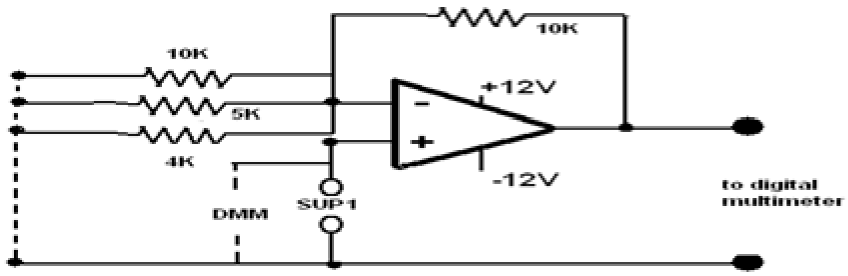


Fig. 4.1(b): Circuit Diagram for Non inverting amplifier using Op-amp.

4.6 PROCEDURE:

4.6.1. Inverting Amplifier:

1. Connect the circuit as shown in the Fig. 4.1(a).
2. Connect 2V supply to I/P
3. Note the values of RF & R1.
4. Note V_{IN} & V_{OUT} with the digital multimeter.
5. Repeat steps 2 & 3 for different values of RF & R1.

4.6.2.Non-Inverting Amplifier:

1. Connect the circuit as shown in the Fig.4.1(b).
2. Connect 2V supply to I/P
3. Note the values of RF & R1.
4. Note V_{IN} & V_{OUT} with the digital multimeter.
5. Repeat steps 2 & 3 for different values of RF & R1.

4.7 OBSERVATION TABLE:

Table 4.2 : Observation Table for Gain of Op-amp

S.No.	R_F	R_1	V_{IN}	V_O	GAIN (V0/VIN)
1					
2					
3					

4.8 RESULT:

In inverting amplifier O/P is out of phase with I/P & in non-inverting amplifier O/P is in phase with I/P. The waveforms for inverting and non-inverting amplifiers are shown in Fig. 4.2(a) and fig. 4.2(b) respectively.

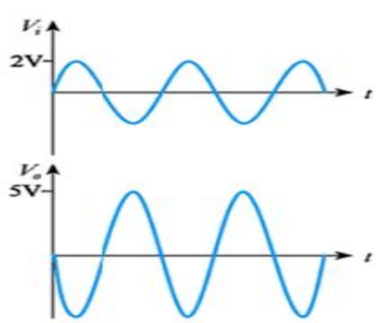


Fig. 4.2(a): waveforms for inverting amplifier

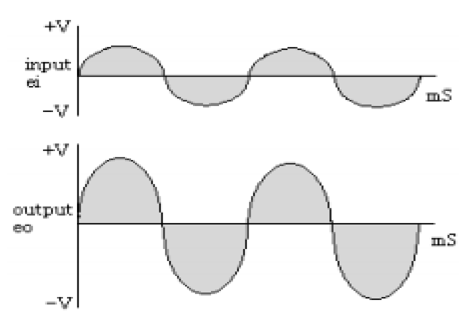


Fig. 4.2(b): waveforms for inverting amplifier

4.9 VIVA VOCE:

1. What do you mean by operational –amplifier?
2. Draw the pin configuration of IC741.
3. How a non-inverting amplifier can be courted into voltage follower?
4. Give the characteristics of an ideal op-amp.
5. What is the difference between inverting and non inverting amplifier?

Prepared By:

Reviewed By:

Approved By:

Experiment No.: 5

5.1 AIM: To design adder and subtractor using Op-amp.

5.2 APPARATUS REQUIRED:

Table 5.1: Apparatus required for adder and subtractor using Op-amp.

Sr. No.	Equipment name	Specifications and range	Quantity in No.
1.	Op-amp IC	IC 741 op-amp	1
2.	CRO	0-230V,30 MHz	1
3.	Resistor	10 kΩ, 2kΩ,	4,1
4.	CRO Probes	-------	2
5.	Function Generator	10Hz to 1MHz	1
6.	Connecting wires	As per requirement	
7.	Bread Board	--------	

5.3 THEORY:

Summing amplifier: It adds the given inputs & can amplify them. Fig 1 shows op-amp as summing amplifier. In this circuit the gain of the amplifier is one as

$$R_F = R_1 = R_2 = R_3$$

So the O/P is function of input voltage & it is summed.

$$-V_O = V_1 + V_2 + V_3$$

Subtractor: The op-amp produces an output potential (relative to circuit ground) that is typically hundreds of thousands of times larger than the potential difference between its input terminals.

$$R_F = R_{in}$$

$$V_O = V_2 - V_1$$

5.5 CIRCUIT DIAGRAM:

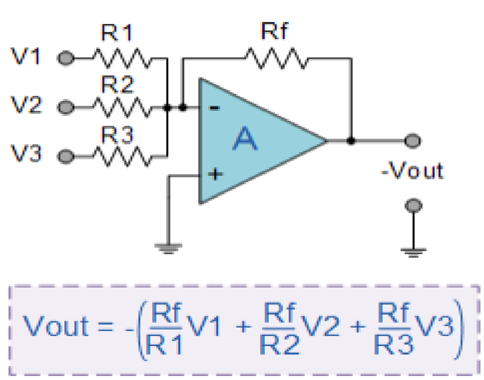


Fig. 5.1: Circuit Diagram for adder using Op-amp.

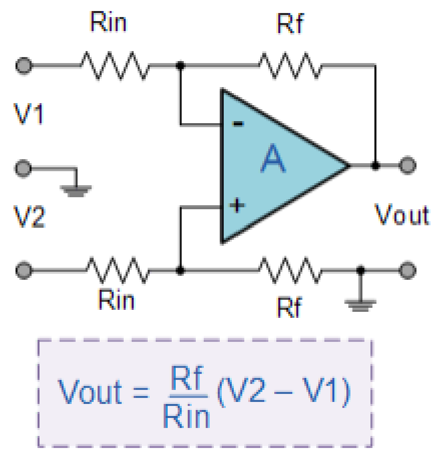


Fig. 5.2 : Circuit Diagram for subtractor using Op-amp.

5.6 PROCEDURE:

5.6.1. Summing Amplifier:

1. Connect the circuit as shown in the Fig. 5.1.
2. Switch on the power supply.
3. Note V_1, V_2, V_3 and V_{OUT} with the digital multimeter.

5.6.2. Subtractor Amplifier:

1. Connect the circuit as shown in the Fig. 5.2.
2. Switch on the power supply.
3. Note V_1, V_2, and V_{OUT} with the digital multimeter.

5.7 OBSERVATION TABLE:

Table 5.2: Observation Table for summing amplifier

S.No.	V_1	V_2	V_3	V_o

Table 5.3: Observation Table for Subtractor:

S.No.	V_1	V_2	V_o

5.8 RESULT:

The result shown in observation table 5.2 and 5.3 shows that op-amp can be used as adder and as a subtractor both.

5.4 PRECAUTIONS:

1. Connections should be done properly.
2. Check for grounding.
3. Get the circuit checked by the instructor before giving the power supply.
4. Observation should be taken precisely.

5.9 VIVA VOCE:

1. What is an adder or summing amplifier?
2. What is Subtractor?
3. What are the assumptions made from ideal op-amp characteristics?
4. Why op-amp is called as operational amplifier?

Prepared By:

Reviewed By:

Approved By:

Experiment No.: 6

6.1 AIM: To design differentiator and Integrator using Op-Amp.

6.2 APPARATUS REQUIRED:

Table 6.1: Apparatus required for designing differentiator and Integrator using Op-Amp.

Sr. No.	Equipment name	Specifications and range	Quantity in No.
1.	Op-amp IC	IC 741 op-amp	1
2.	CRO	0-230V,30 MHz	1
3.	CRO Probes	-------	2
4.	Resistor	10 kΩ	1
5.	Capacitor	0.1µF	1
6.	Digital Multimeter	--------	1
7.	Function Generator	10Hz to 1MHz	1
8.	Bread Board	--------	
9.	Connecting wires	As per requirement	

6.3 THEORY:

Differentiator: Differentiator basically perform the operation of differentiation on the I/P. Fig 1 shows the differentiator circuit, here I/P is applied through the capacitor to inverting I/P & Non Inverting I/P is grounded. So according to kirchoff's current law

$$i_C = i_F \text{ (as } i_B \text{ is negligible)}$$

So

$$C_1 \frac{d}{dt}(V_{IN} - V_2) = \frac{V_2 - V_O}{R_F}$$

But V2 ≅ 0 as amplification factor is very large, so

$$C_1 \frac{d}{dt}(V_{IN}) = \frac{-V_O}{R_F}$$

$$V_O = -R_F C_1 \frac{d}{dt}(V_{IN})$$

so if cosine wave is I/P, O/P will be sine wave & if I/P is triangular wave O/P will be square wave.

Integrator: Integrator basically performs the operation of Integration on I/P. Fig 2 shows the integrator circuit, here feedback is applied through the capacitor (C_F) instead of resistance & Non Inverting I/P is grounded. So according to kirchoff's current law

$$i_1 = i_F \text{ (as } i_B \text{ is negligible)}$$

Relationship between current & voltage through capacitor is

$$i_C = C \frac{dV_c}{dt}$$

But V2 ≅ 0 as amplification factor is very large, so

$$V_O = \frac{-1}{R_F C_F} \int (V_{IN})\, dt + C$$

So if I/P is sine wave is O/P will be cosine wave & if I/P is square wave O/P will be triangular wave.

6.4 PRECAUTIONS:

1. Connections should be done properly.
2. Check for grounding.
3. Get the circuit checked by the instructor before giving the power supply.
4. Observation should be taken precisely.

6.5 CIRCUIT DIAGRAM:

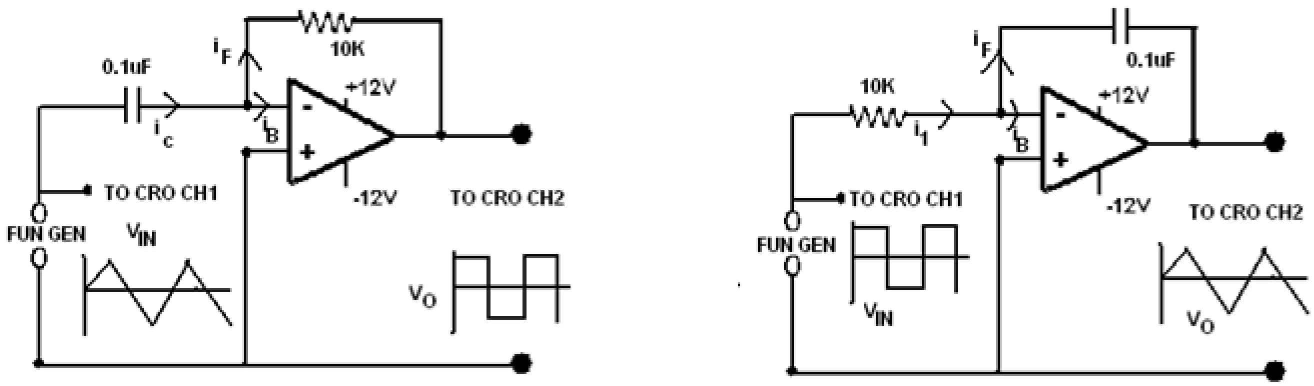


Fig. 6.2 : Circuit Diagram for designing (a) Differentiator and (b)Integrator using Op-Amp.

6.6 PROCEDURE:

6.6.1.Differentiator:

1. Connect the circuit as shown in the Fig6.2(a).
2. Apply I/P of 1VPP, 250Hz triangular wave at the I/P
3. Switch on the power supply.
4. Observe input & O/P wave form on the CRO CH1 & Ch2.

6.6.2.Integrator:

1. Connect the circuit as shown in the Fig6.2(b).
2. Apply input of 1VPP, 250Hz square wave at the input.
3. Switch on the power supply.
4. Observe input & O/P wave form on the CRO CH1 & Ch2.

6.7 RESULT:

Differentiator O/P is square wave & Integrator O/P is triangular wave.

6.8 VIVA VOCE:

1. What are the applications of Differentiator?
2. What are the main applications of the Integrator?
3. Is it possible to design an analog computer using integrator and differentiator?
4. Op-amp is used mostly as an integrator than a differentiator. Why?
5. What are the limitations of basic Differentiator circuit?
6. What are the limitations of basic Integrator circuit?

Prepared By:

Reviewed By:

Approved By:

Experiment No.: 7

7.1 AIM: To study working of Linear Variable Differential Transformer / Linear Variable Displacement Transducer (LVDT).

7.2 APPARATUS REQUIRED:

Table 7.1: Apparatus required for working of LVDT

Sr. No.	Equipment name	Specifications and range	Quantity in No.
1.	LVDT kit	0 – 230 *V*, ±10 *mm*	1
2.	CRO	0 – 230 *V*, 30 *MHz*	1
3.	CRO probes	---	2

7.3 THEORY:
LVDT is an inductive transducer for translating the linear motion into an electrical signal. It is suitable for use in applications where displacements are too large ranging from a fraction of mm to few cm. For example, strain gauge, mechanical displacement greater than 25 *mm* etc.
LVDT can be connected with other transducers in cascade for measurement of other physical quantities such as force, weight, pressure etc.

7.3.1 Construction of LVDT:
LVDT is a differential transformer consisting of one primary winding P and two identical secondary windings S_1 and S_2 wound over a hollow bobbin of non-magnetic and insulating material as shown in Fig. 7.1. The secondary windings S_1 and S_2 have an equal number of turns which are arranged concentrically and placed on either side of primary winding P. A soft iron core, attached to the sensing element of which displacement is to be measured, in the shape of rod or cylinder slides freely in the hollow portion of the bobbing. The eddy current losses are reduced by using nickel iron alloy as core material and are slotted longitudinally. Primary winding is connected to an AC source of voltage varying from 5 – 25 *V* and frequency varying from 50 *Hz* to 20 *kHz*.

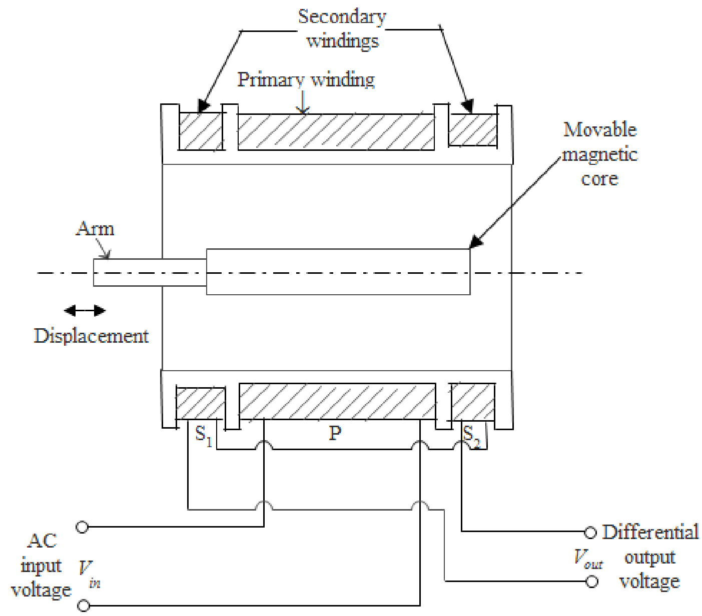


Fig. 7.1: Construction of LVDT

7.3.2 Working of LVDT:
When the core is moved inside the bobbin, coupling of primary to secondary winding is varied.

Case 1: In null position of the core i.e. in central position, coupling of primary winding to both of the secondary windings are equal. Thus, output voltages induced in both of the secondary windings S_1 and S_2 are equal.

Case 2: As the core is moved toward left side from its null position, the magnetic linkages to secondary winding S_1 increases and to secondary winding S_2 decreases. This is because the portion of the core inside S_1 increases and that inside S_2 decreases. Thus, output voltage induced in S_1 increases and output voltage induced in S_2 decreases.

Case 3: As the core is moved toward right side from its null position, the magnetic linkages to secondary winding S_2 increases and to secondary winding S_1 decreases. This is because the portion of the core inside S_2 increases and that inside S_1 decreases. Thus, output voltage induced in S_2 increases and output voltage induced in S_1 decreases. Since, S_1 and S_2 are connected in series opposition, difference in output voltages of secondary windings gives the measurement of displacement.

When an externally applied force moves the iron core to left hand position, more magnetic flux links the left hand coil than the right hand coil. The emf induced in the left hand coil E_{s1} is larger than the induced emf of right hand coil E_{s2}. The magnitude of output voltage is then equal to the difference between the two secondary voltages and it is in phase with voltage of left hand coil.
Similarly, when the core is forced to right hand position, more flux links the right hand coil than the left hand coil. The resulting output voltage, which is the difference of E_{s2} and E_{s1} is now in phase with emf of the right hand coil.

The output voltage of LVDT is a function of core position. The amount of voltage change in either secondary winding is proportional to the amount of movement of the core. The output AC voltage inverts in phase as the core passes through the central null position.

7.4 PRECAUTIONS:
1. Handle LVDT kit and CRO very carefully as stated in Table 7.1.
2. When micrometer scale "0" coincides with "0" of vernier scale, adjust the zero error of displacement in mm if any.
3. The setting of volt/div and time/div in CRO should be kept at 1 *V* and 1 *s* respectively preferably.

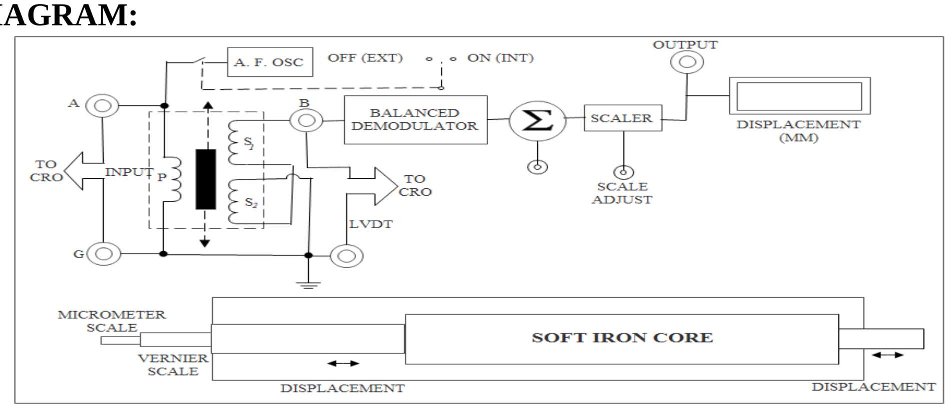
7.5 CIRCUIT DIAGRAM:


Fig. 7.2: Circuit Diagram of LVDT

7.6 PROCEDURE:

1. Connect LVDT kit into mains and switch ON the supply as shown in Fig. 7.2.
2. Connect 'X' channel of CRO to primary winding of LVDT and 'Y' channel of CRO to output of secondary winding in LVDT kit.
3. Adjust micrometer scale at "0" position in order to coincide with "0" of vernier scale.
4. If display of displacement is not showing "0" in LVDT, adjust scale error to have reading equal to zero.
5. Scroll micrometer on either sides to have displacement of soft iron core on right side and left side.
6. Note down the reading of amplitude of voltage by counting number of divisions and multiply it with volt/div from CRO for a particular displacement.
7. Take five set of readings for displacement on right side and left side.
8. Record the readings in Table 7.2.
9. Plot graph of voltage amplitude vs. displacement as shown in Fig. 7.3. Comment on the nature of graph.

7.7 OBSERVATION TABLE:

Table 7.2: Observation Table for LVDT

- **For Positive Displacement:**

Sr. No.	Meter scale reading	Positive displacement (*mm*)	Voltage Amplitude (*V*)
1.			
2.			

- **For Negative Displacement:**

Sr. No.	Meter scale reading	Negative displacement (*mm*)	Voltage Amplitude (*V*)
1.			
2.			

7.8 GRAPH:

The curve for variation of differential output voltage with displacement of core for LVDT is shown in Fig. 7.3. The characteristics of LVDT are linear for limited range of displacement (about 5 *mm* on either side from the null position) and beyond this range, the curve starts flattening out at both ends.

The differential output voltage of LVDT gives the amount of displacement. With the movement of the core in one direction away from the null position, the differential output voltage increases and it is in phase with the input voltage of primary winding. Similarly, the movement of the core in other direction from the null position causes differential output voltage to increase but 180^{o} out of phase with input primary voltage.

By measuring magnitude and comparing the phase of differential output voltage with input primary voltage, amount and direction of displacement of core may be determined.

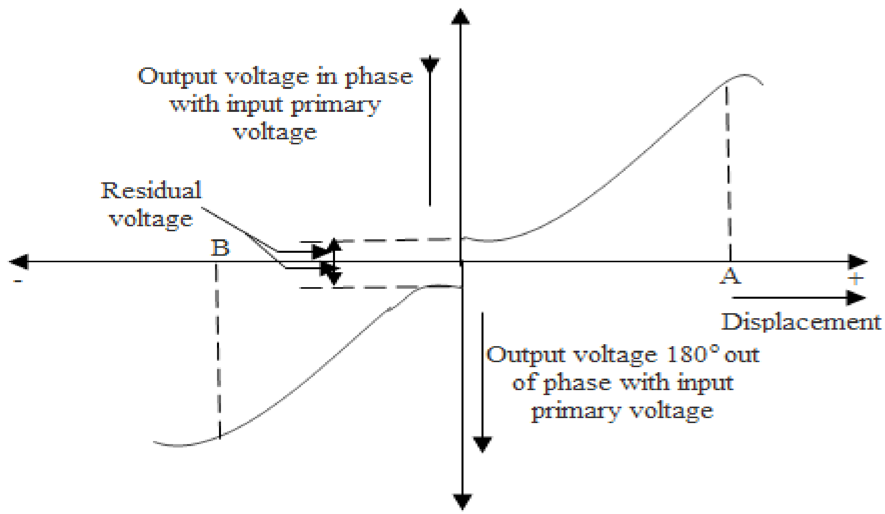


Fig. 7.3: Graph of voltage amplitude vs. displacement for LVDT

7.9 SOURCES OF ERROR:

1. Internal resistance of LVDT kit.
2. Residual magnetism of soft iron core in LVDT.
3. Internal resistance of CRO leads.
4. Effect of magnetic field surrounding the iron core.

7.10 RESULT:

The voltage amplitude at positive and negative displacement is compared in Table 7.3. The graph of voltage amplitude vs. displacement of LVDT is a linear curve but it makes an intercept on Y – axis which signifies the concept of residual magnetism.

Table 7.3: Result Table for Voltage Amplitude of LVDT

Sr. No.	Voltage amplitude at positive displacement (V)	Voltage amplitude at negative displacement (V)
1.		
2.		
3.		

7.11 CONCLUSION:

The difference in comparison of voltage amplitude values at positive and negative displacement should be analyzed and resulting difference if any, in both sets of readings is likely due to various sources of error mentioned in Section 7.9.

7.12 VIVA VOCE:

1. Define LVDT. Why secondary windings of LVDT are connected in phase opposition?
2. On what principle, LVDT works?
3. Why LVDT is known as passive inductive transducer?
4. Why the graph of amplitude vs. displacement is a straight line passing through origin?
5. What do you mean by residual magnetism?
6. Draw B – H curve for soft iron core of LVDT kit.

Prepared By:

Reviewed By:

Approved By:

<u>**Experiment No.: 8A**</u>

8A.1 AIM: To implement Staircase wiring.

8A.2 APPARATUS REQUIRED:

Table 8A.1: Apparatus required for staircase wiring

Sr. No.	Equipment Name	Specification and range	Quantity in No.
1.	Two way switches	230V, 5A	2
2.	Lamp	230V, 60W	1
3.	Holders	5A	1
4.	Fuse	230V, 5A, 50Hz	2
5.	Connecting Wires	---	As per requirement
6.	Multimeter		1

8A.3 THEORY:

Staircase wiring or multiway switching or two way light switch wiring is a commonly using connection to control a load from two different positions. That is from above or below the staircase, from by the side of the bed or door, indoor or outdoor, etc...

Staircase wiring helps to operate a lamp from two frequently using position. And also to off the load after use if the load is a lamp or something that is used for only passage from one position to another. Staircase wiring makes the feasibility for the user to turn ON and OFF the load from two different positions. Its circuit arrangement is in such a way, from common pole we can switch to both 1 & 2 poles, the 1st pole is connected to 1st pole of next and 2nd pole to the 2nd pole of the next, i.e both poles to corresponding pole of the other. The phase of supply is connected to the common pole of one switch and phase supply to the load is taken from the common pole of the next switch.

So in such an arrangement to close the circuit both the switches should be in the same position in order to make the two common poles in contact to achieve a closed circuit. Changing ON & OFF condition of a single switch can determine whether the circuit is closed or open. Thus, in staircase wiring we can control from both positions.

8A.4 PRECAUTIONS:

1. The switches must be in off position before giving supply.
2. Avoid loose connections.
3. Control switch should be connected to the phase only.

8A.5 CIRCUIT DIAGRAM:

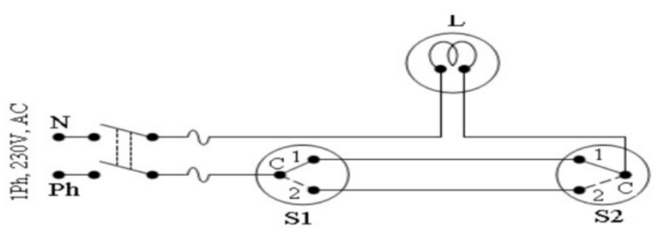


Fig. 8A.1: Circuit Diagram for Staircase wiring

8A.6 PROCEDURE:
1. Collect the required apparatus.
2. Connect the lamp and the switch as shown in the circuit diagram.
3. Check the connections with the help of multimeter.
4. Operate the lamp using the switches.

8A.7 OBSERVATION TABLE:

Table 8A.2: Observation Table for Staircase wiring

Sr. No.	Position of Switch, S1	Position of Switch, S2	Condition of Lamp
1.	Position 1	Position 2	
2.	Position 2	Position 1	
3.	Position 1	Position 1	
4.	Position 2	Position 2	

8A.9 SOURCES OF ERROR:
1. Internal resistance of multimeter.
2. Internal resistance of connecting wires.

8A.10 RESULT:
The ON and OFF status of the lamp is controlled by the two way switches S1 and S2. The observation of the status of lamp with respect to different positions of S1 and S2 are shown in Table 8A.2.

8A.11 CONCLUSION:
This is stair case wiring by which we can control a bulb from two different places. We can switch OFF and Switch ON the bulb from both switches at the same time. In other words, we can control (OFF or ON) the bulb from upper and lower switches.

8A.12 VIVA VOCE:
1. What is two way switch?
2. What is the advantage of using SPDT switch?
3. Mention the type of switches?
4. What are the types of wiring?
5. Which type of wiring is used for domestic purpose nowadays?

Prepared By:

Reviewed By:

Approved By:

Experiment No.: 8B

8B.1 AIM: To implement Corridor wiring.

8B.2 APPARATUS REQUIRED:

Table 8B.1: Apparatus required for Corridor wiring

Sr. No.	Equipment Name	Specification and range	Quantity in No.
1.	Two way switches	230V, 5A	2
2.	One way switch	230V, 5A	1
3.	Lamp	230V, 40W	3
4.	Holders	5A	3
5.	Fuse	230V, 5A, 50hz	2
6.	Connecting Wires	---	As per requirement
7.	Multimeter		1

8B.3 THEORY:

The circuit in a ling corridor or godown meets the requirement of the person.

When the person enters corridor from one end and can put on light L1 from switch S1. When he reaches the switch (S2) in a corridor, he can put on the respective light L2 and simultaneously he can turn off the previous light L1 in that single operation. Similarly this process is continuous up to the end light of the corridor or godown. This process of lighting up the present lamp and putting off the previous lamp is carried from the last light to the first light in the circuit.

The main disadvantage of this system is

1. The operation should be carried in a sequence only i.e. from the beginning switch to the ending switch then from the ending switch to the beginning switch only.

2. Under any circumstances if the switch S1 is kept in off position intermediately, the entire system will be turned into off or the circuit will become dead.

8B.4 PRECAUTIONS:

1. The switches must be in off position before giving supply.
2. Avoid loose connections.
3. Control switch should be connected to the phase only.

8B.5 CIRCUIT DIAGRAM:

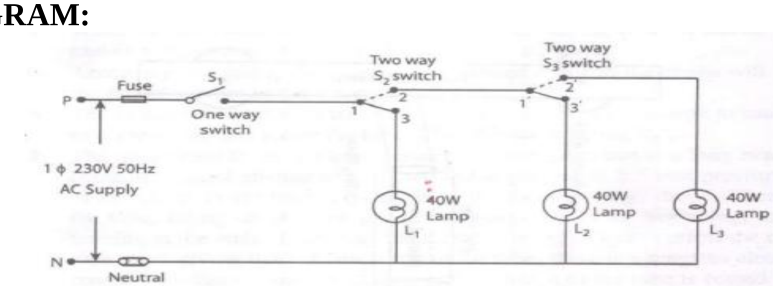


Fig. 8B.1: Circuit Diagram for Corridor wiring

8B.6 PROCEDURE:
1. Collect the required apparatus.
2. Connect the lamp and the switch as shown in the circuit diagram.
3. Check the connections with the help of multimeter.
4. Operate the lamp using the switches.

8B.7 OBSERVATION TABLE:

Table 8B.2: Observation Table for Corridor wiring

Sr. No.	Position of Switch, S1	Position of Switch, S2	Position of Switch, S3	Lamp L1	Lamp L2	Lamp L3
1.	OFF	X	X	OFF	OFF	OFF
2.	ON	1-3	1’-3’	ON	OFF	OFF
3.	ON	1-2	1’-3’	OFF	ON	OFF
4.	ON	1-2	1’-2’	OFF	OFF	ON

8B.9 SOURCES OF ERROR:
1. Internal resistance of multimeter.
2. Internal resistance of connecting wires.

8B.10 RESULT:
The ON and OFF status of the lamps connected in a corridor are controlled by the switches S1, S2 and S3 in such a way that only one lamp is ON at one time. The observation of the status of lamps with respect to different positions of switches is shown in Table 8B.2.

8B.11 CONCLUSION:
In corridor wiring the control of lamps is in such a way that only one bulb is ON at one time in a long corridor. This could be done when the switch S1 is in ON position.

8B.12 VIVA VOCE:
1. What is two way switch?
2. What is the advantage of using SPDT switch?
3. Mention the type of switches?
4. What are the types of wiring?
5. Which type of wiring is used for domestic purpose nowadays?

Prepared By:

Reviewed By:

Approved By:

<u>**Experiment No.: 10**</u>

10.1 AIM: To interface Digital to Analog convertor with Op-Amp.

10.2 APPARATUS REQUIRED:

Table 4.1: Apparatus required for interfacing Digital to Analog convertor with Op-Amp.

Sr. No.	Equipment name	Specifications and range	Quantity in No.
1.	Op-amp IC	IC 741 op-amp	1
2.	CRO	0-230V,30 MHz	1
3.	CRO Probes	-------	2
4.	Capacitor	0.1µF,150pF	1,1
5.	A/D converter	ADC0804	1
6.	D/A converter	DAC0808	1
7.	Temperature Sensor	LM34	1
8.	Resistor	10 kΩ, 20 kΩ,5.1 kΩ	2,1,2
9.	Digital Multimeter	--------	1
10.	Function Generator	10Hz to 1MHz	1
11.	Bread Board	--------	
12.	Connecting wires	As per requirement	

10.3 THEORY:

In order to convert an 8-bit digital value to its respective analog value, we will use a DAC0808 chip. This device utilizes an R-2R ladder network to drive a current summing junction resulting in an appropriate analog value. We will use the circuit of Part One to provide the digital signals for our D/A conversion.

Note that the DAC0808 D/A converter generate a varying analog current at its output, Io, on Pin-4. The full- scale value of this current is determined by the current input at Vref+, on Pin 14, (2.00 mA.) Consequently, this current must be converted back to a voltage to obtain Vo. To do this, an LM741 operational amplifier is configured as a current to voltage converter using the same size current loop (5.1K resistor.)

10.3.1 Ambient Temperature Measurement.

Figure10.2. illustrates the replacement of the 100K potentiometer with an LM34 temperature sensor and an operational amplifier as the voltage source for the A/D converter. The LM34 temperature sensor generates a voltage output equal to 10mV per degree Fahrenheit with an error of less than .1 degrees. Consequently, at room temperature of 72°F, the sensor will generate 200.0mV. In order to measure a voltage that is within the full-scale input of the A/D converter, an LM741 operational amplifier is configured as a non-inverting amplifier with a gain of 2, resulting in a representation of 2.00V for a temperature of 72°F. Note that the pin-out shown for the LM34 is bottom view. Note also that the inputs to the LM741 are configured for non-inverting amplification.

Construct the circuit of Figure 10.2, removing the potentiometer of Figure 10.1, and replacing it with the LM34 temperature sensor and the LM741 operational amplifier circuit. Record in the first line of Table 10.2 the (1) voltage at Pin 2 of the LM34, (2) the corresponding ambient temperature it represents, (3) the voltage at Pin 6 of the ADC0804 verifying the gain of the input amplifier, (4) the digital value at the inputs of the DAC0808, and (5) the voltage at Pin 6 of the LM741 at the output of the circuit. Wait a little while for the temperature to stabilize.

10.4 PRECAUTIONS:

5. Connections should be done properly.
6. Check for grounding.
7. Get the circuit checked by the instructor before giving the power supply.
8. Observation should be taken precisely.

10.5 CIRCUIT DIAGRAM:

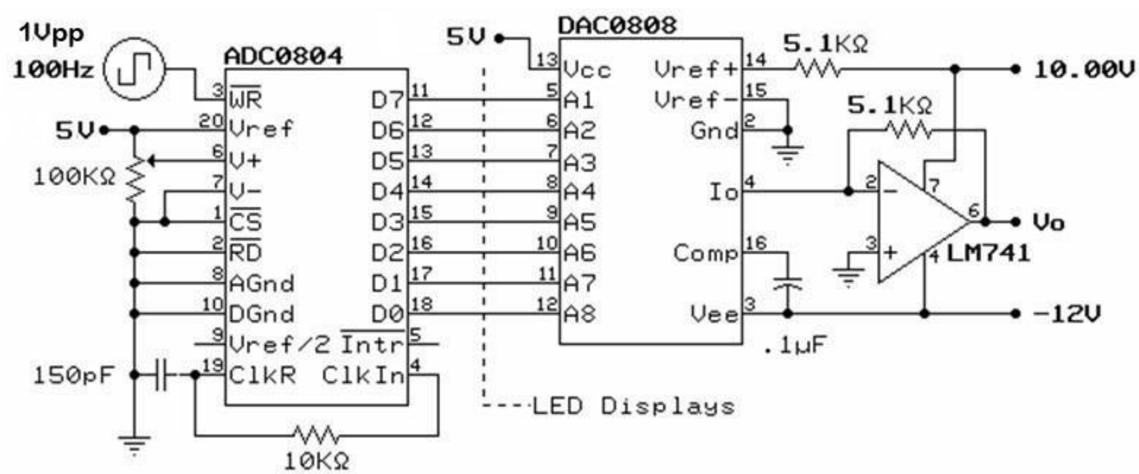


Fig. 10.1: Circuit Diagram for Digital to Analog Conversion.

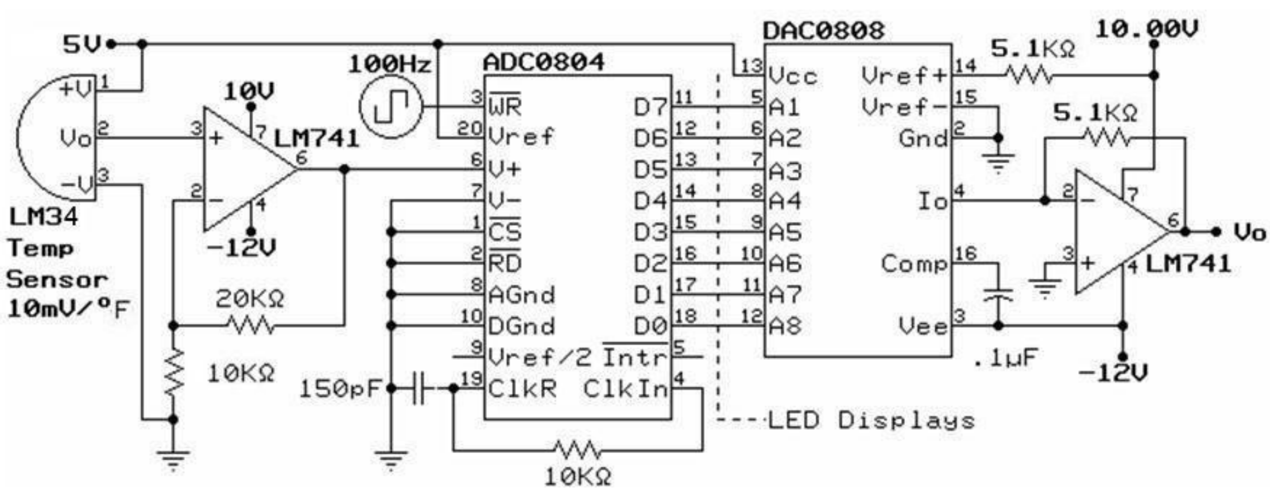


Fig. 10.2: Temperature Sensing Circuit to interface DAC converter with Op-amp.

10.6 PROCEDURE:

Construct the circuit of Figure 10.2, removing the potentiometer of Figure 10.1, and replacing it with the LM34 temperature sensor and the LM741 operational amplifier circuit. Record in the first line of Table 10.2 the (1) voltage at Pin 2 of the LM34, (2) the corresponding ambient temperature it represents, (3) the voltage at Pin 6 of the ADC0804 verifying the gain of the input amplifier, (4) the digital value at the inputs of the DAC0808, and (5) the voltage at Pin 6 of the LM741 at the output of the circuit. Wait a little while for the temperature to stabilize.

10.7 OBSERVATION TABLE:

Table 10.2: Observation Table for DAC

LM34 Output Voltage	Ambient Temperature, °F	A/D Input Voltage	Digital Equivalent	Output Voltage, Vo

10.8 RESULT:

The values of analog signals have been converted to binary signals with the help of Op-amp.

10.9 VIVA VOCE:

1. What is Digital to analog Converter?
2. Which IC is used for temperature sensing?
3. Define resolution.
4. What are the chip numbers for DAC and ADC Converters?

Prepared By:

Reviewed By:

Approved By: