

SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF ELECTRONICS AND INSTRUMENTATION ENGINEERING

LAB MANUAL

VII SEMESTER

1907710 – Instrumentation System Design Laboratory

Regulation– 2019

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OBJECTIVES:

To obtain adequate knowledge in design of various signal conditioning circuits, instrumentation Systems, controller and control valve.

LIST OF EXPERIMENTS:

1. Design of Instrumentation amplifier.
2. Design of active filters – LPF, HPF and BPF
3. Design of regulated power supply and design of V/I and I/V converters.
4. Design of linearizing circuits and cold–junction compensation circuit for thermocouples.
5. Design of signal conditioning circuit for Strain gauge and RTD.
6. Design of Orifice plate and Rotameter.
7. Design of Control valve (sizing and flow-lift characteristics)
8. Design of PID controller (using operational amplifier and microprocessor)
9. Design of a multi-channel data acquisition system.
10. Design of multi range DP transmitter.
11. Piping and Instrumentation Diagram – case study.
12. Preparation of documentation of instrumentation project and project scheduling for the above case study. (Process flow sheet, instrument index sheet and instrument specifications sheet, job scheduling, installation procedures and safety regulations).
13. One or two experiments beyond syllabus.

CYCLE 1

1. Design of Instrumentation amplifier.
2. Design of active filters – LPF, HPF and BPF
3. Design of regulated power supply and design of V/I and I/V converters.
4. Design of linearizing circuits and cold–junction compensation circuit for thermocouples.
5. Design of signal conditioning circuit for strain gauge and RTD.
6. Design of orifice plate and rotameter.
7. Design of Control valve (sizing and flow-lift characteristics)

CYCLE 2

8. Design of PID controller.
9. Design of a multi-channel data acquisition system
10. Design of multi range DP transmitter
11. Piping and Instrumentation Diagram – case study.
12. Preparation of documentation of instrumentation project and project scheduling for the above case study. (Process flow sheet, instrument index sheet and instrument specifications sheet, job scheduling, installation procedures and safety regulations).

EXPERIMENTS BEYOND SYLLABUS

13. Design and implementation of signal conditioning circuit for RTD using instrumentation amplifier.

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Exp. No:1(a)

DESIGN OF INSTRUMENTATION AMPLIFIER

Aim:

To design and construct an instrumentation amplifier.

Apparatus Required:

S. No.	Components / Equipments	Specifications	Quantity
1.	Dual RPS	0-30V	1
2.	Operational Amplifier	IC 741	3
3.	Resistors	1K Ω	6
4.	Decade Resistance Box	6 dial	1
5.	Digital Multimeter	-	1
6.	Bread Board & Connecting Wires	-	Sufficient nos.

Theory:

Instrumentation amplifier is an amplifier with high input impedance, very low output impedance, low offset and low drifts voltage. This configuration is better than inverting or non-inverting amplifier because it has minimum non-linearity, stable voltage gain and high common mode rejection ratio (CMRR > 100 dB.). This type of amplifier is used in instrumentation field where the output voltages are very low such as in thermocouples, strain gauges and biological probes.

In this circuit, consider all resistors to be of equal value except for R_g . The negative feedback of the upper-left op-amp causes the voltage at point V_a (top of R_g) to be equal to V_1 . Likewise, the voltage at point V_b (bottom of R_g) is held to a value equal to V_2 . This establishes a voltage drop across R_g equal to the voltage difference between V_1 and V_2 . That voltage drop causes a current through R_g , and since the feedback loops of the two input op-amps draw no current, that same amount of current through R_g must be going through the two "R" resistors above and below it. This produces a voltage drop between points V_1' and V_2' equal to:

$$V_1' - V_2' = (V_2 - V_1) [1 + (R / R_g)]$$

The differential amplifier in the circuit diagram takes the voltage drop between V_1' and V_2' , and amplifies it by a gain of 1 (assuming again that all "R" resistors are of equal value). It possesses extremely high input impedances on V_1 and V_2 inputs (because they connect straight into the non inverting inputs of their respective op-amps). It also provides the same for the input through adjustable gain resistor. Hence the overall voltage gain in the instrumentation amplifier is,

$$A_v = [1 + (2R / R_g)]$$

Circuit Diagram:

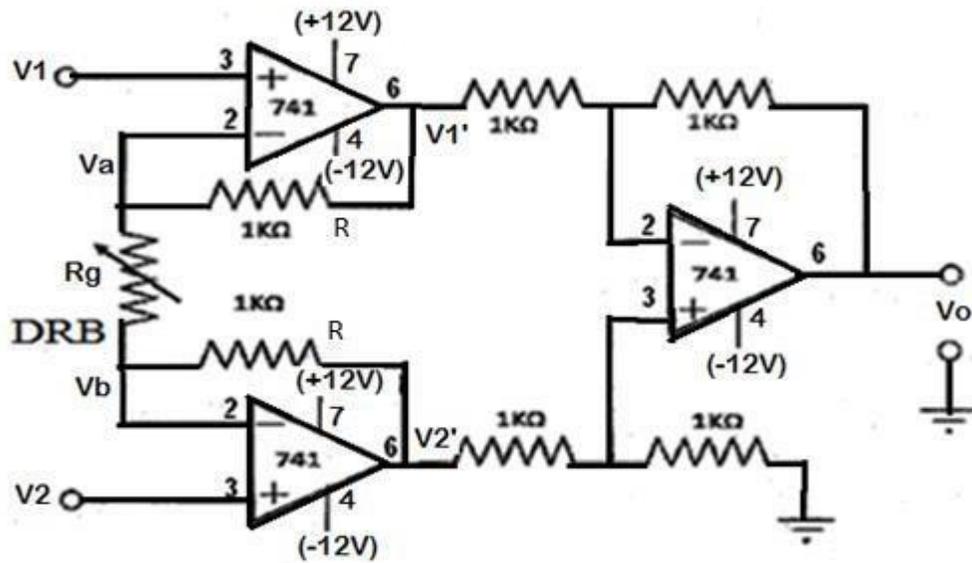


Fig: Instrumentation Amplifier

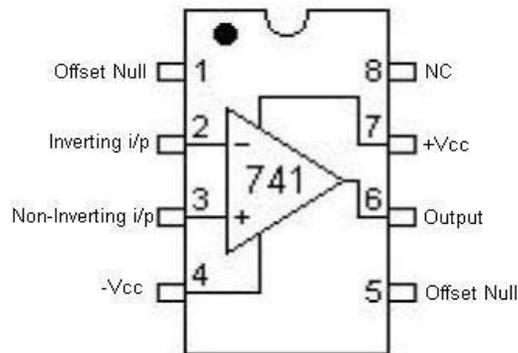


Fig: Pin Diagram of IC 741

Formula used:

$$V_0 = - (R_2/R_1)(1 + 2R_f/R_g)$$

Where,

$$V_d = V_2 - V_1$$

$$V_1' = R/R_g(V_1 - V_2) + V_1$$

$$V_2' = R/R_g(V_1 - V_2) + V_2$$

Design Steps

1. Transfer function of this circuit:

$$V_O = (V_{i2} - V_{i1}) \times G + V_{ref}$$

When $V_{ref} = 0$, the transfer function simplifies to the following equation:

$$V_O = (V_{i2} - V_{i1}) \times G$$

where

$$G = \frac{R_4}{R_3} \times \left(1 + \frac{2 \times R_5}{R_{10}} \right)$$

2. Select the feedback loop resistors R_5 and R_6 :

Choose $R_5 = R_6 = 10 \text{ k}\Omega$ (Standard Value)

3. Select R_1, R_2, R_3, R_4 . To set the V_{ref} gain at 1 V/V and avoid degrading the instrumentation amplifier's CMRR, ratios of R_4/R_3 and R_2/R_1 must be equal.

Choose $R_1 = R_2 = R_3 = R_4 = 10 \text{ k}\Omega$ (Standard Value)

4. Calculate R_{10} to meet the desired gain:

$$G = \frac{R_4}{R_3} \times \left(1 + \frac{2 \times R_5}{R_{10}} \right) = 10 \frac{V}{V}$$

$$R_4 = R_3 = 10 \text{ k}\Omega$$

$$\rightarrow G = \left(1 + \frac{2 \times 10 \text{ k}\Omega}{R_{10}} \right) = 10 \frac{V}{V} \rightarrow \left(1 + \frac{20 \text{ k}\Omega}{R_{10}} \right) = 10 \frac{V}{V}$$

$$\frac{20 \text{ k}\Omega}{R_{10}} = 9 \frac{V}{V} \rightarrow R_{10} = \frac{20 \text{ k}\Omega}{9} = 2222.2 \Omega \rightarrow R_{10} = 2.21 \text{ k}\Omega \text{ (Standard Value)}$$

Procedure:

1. Give the connections as per the circuit diagram.
2. Gain resistance (R_g) is calculated using the design formula and set the value in DRB.
3. Apply the differential input voltage at the input terminals and note the corresponding output value.
4. Repeat the above step for the different values of R_g .

Tabulation:

S. No.	R_g (Ω)	V_1 (Volts)	V_2 (Volts)	$V_d=(V_2-V_1)$ Volts	Output Voltage (Volts)	
					V_{th}	V_p
1.						
2.						
3.						
4.						
5.						

Model Calculations:

Result:

Thus, the Instrumentation Amplifier is designed and tested using 3 Op-amp configuration

Review Questions:

1. What is the difference between instrumentation amplifier and differential amplifier?
2. What are the characteristics of instrumentation amplifier?
3. What is CMRR?
4. What are the applications of instrumentation amplifier?
5. What is the other name of instrumentation amplifier?

Exp. No:1(b) DESIGN OF INSTRUMENTATION AMPLIFIER IN VIRTUAL LAB

AIM: Design of Instrumentation Amplifier in Virtual Lab

APPARATUS REQUIRED:

Virtual Lab

<https://bmsp-coep.vlabs.ac.in/exp/biopotential-amplifier/theory.html>

Procedure

1. To apply input signal from various sources to the biosignal amplifier and observe the output of biosignal amplifier.
2. To change the gain of Amplifier and observe the change in output signal.
3. To record the output of biosignal amplifier with different gains and different inputs.
4. Plot the characteristic of biosignal amplifier.
5. To compare the output of simulated biosignal amplifier with the theoretical value.

Design Steps

1. Transfer function of this circuit:

$$V_O = (V_{i2} - V_{i1}) \times G + V_{ref}$$

When $V_{ref} = 0$, the transfer function simplifies to the following equation:

$$V_O = (V_{i2} - V_{i1}) \times G$$

where

$$G = \frac{R_4}{R_3} \times \left(1 + \frac{2 \times R_5}{R_{10}} \right)$$

2. Select the feedback loop resistors R_5 and R_6 :

Choose $R_5 = R_6 = 10 \text{ k}\Omega$ (Standard Value)

3. Select R_1, R_2, R_3, R_4 . To set the V_{ref} gain at 1 V/V and avoid degrading the instrumentation amplifier's CMRR, ratios of R_4/R_3 and R_2/R_1 must be equal.

Choose $R_1 = R_2 = R_3 = R_4 = 10 \text{ k}\Omega$ (Standard Value)

4. Calculate R_{10} to meet the desired gain:

$$G = \frac{R_4}{R_3} \times \left(1 + \frac{2 \times R_5}{R_{10}} \right) = 10 \frac{V}{V}$$

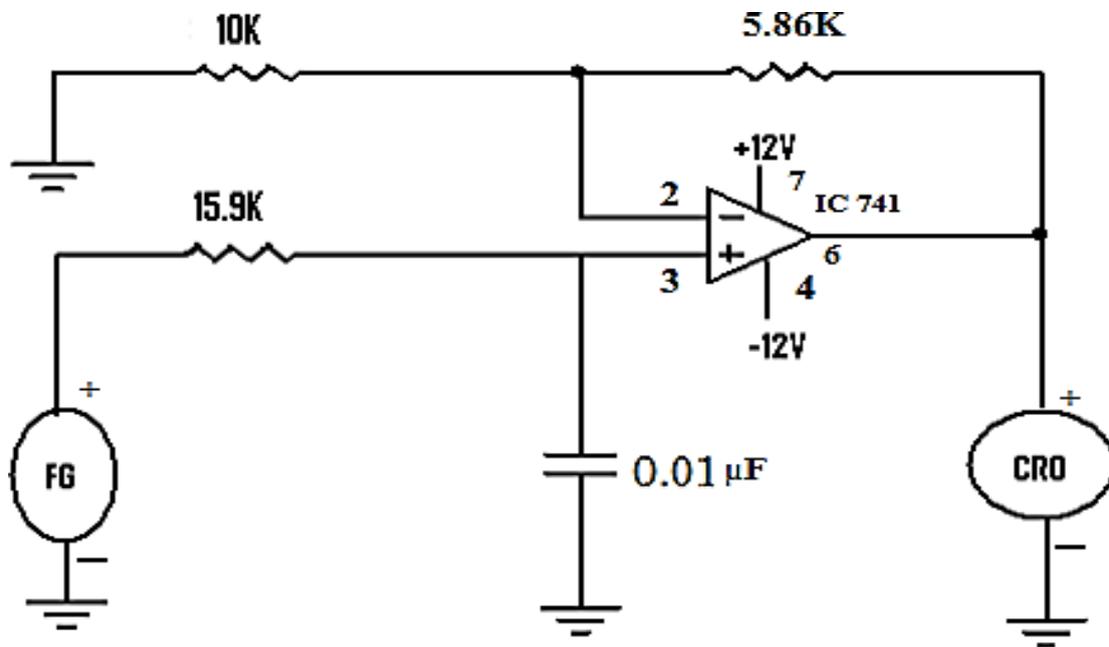
$$R_4 = R_3 = 10 \text{ k}\Omega$$

$$\rightarrow G = \left(1 + \frac{2 \times 10 \text{ k}\Omega}{R_{10}} \right) = 10 \frac{V}{V} \rightarrow \left(1 + \frac{20 \text{ k}\Omega}{R_{10}} \right) = 10 \frac{V}{V}$$

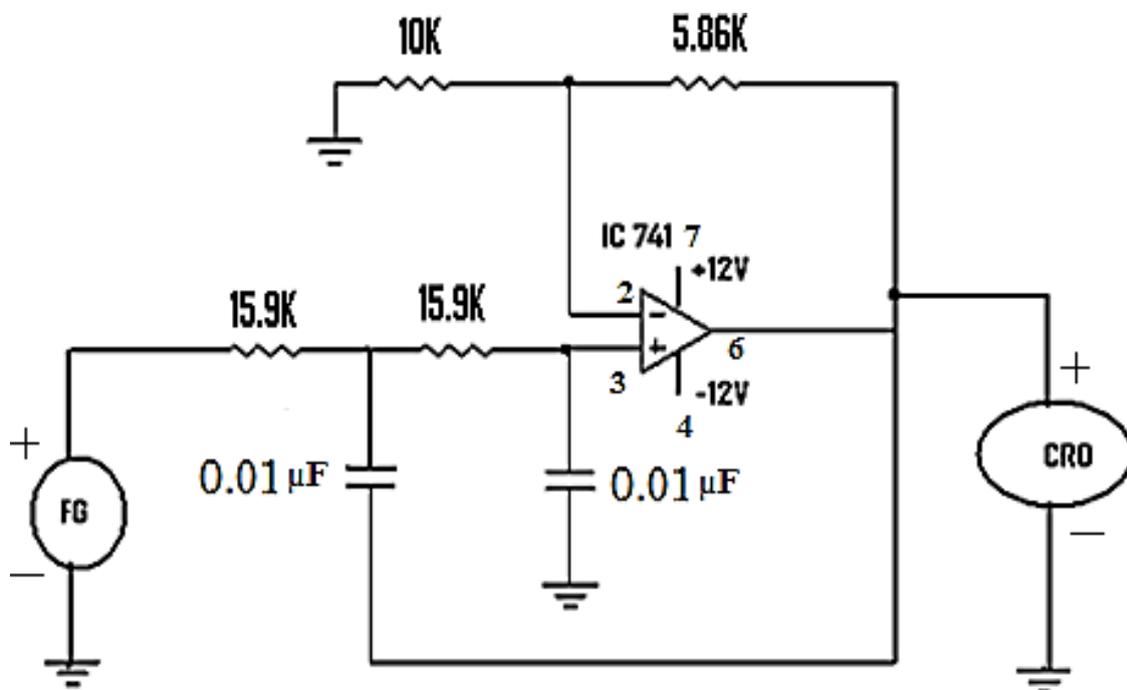
$$\frac{20 \text{ k}\Omega}{R_{10}} = 9 \frac{V}{V} \rightarrow R_{10} = \frac{20 \text{ k}\Omega}{9} = 2222.2\Omega \rightarrow R_{10} = 2.21 \text{ k}\Omega \text{ (Standard Value)}$$

RESULT: Thus, the Instrumentation Amplifier is designed and tested using 3 Op-amp configuration.

**CIRCUIT DIAGRAM:
FIRST ORDER LPF**



SECOND ORDER BUTTERWORTH FILTER LPF



EX.NO:2(a)	DESIGN OF FIRST ORDER & SECOND ORDER ACTIVE LOW PASS FILTER
DATE:	

AIM:

To design an active,

1. First order
2. Second order Butterworth type low pass filter with cut off frequency of 1 KHz.

THEORY:

An electric filter is a frequency selective circuit that passes a specified band of frequencies and blocks (or) attenuates signals of frequencies outside this band. Filters may be classified in a number of way Analog (or) Digital Passive (or) Active Audio (AF) (or) Radio frequency Analog filters are designed to process analog signals, while digital filters process analog signal using digital techniques. Depending on type of elements used in their construction, filters may be classified as active (or) passive.

Elements used in passive filters are resistor, capacitor and inductors. Active filters, on the other hand employ transistor (or) op –Amps in addition to resistors and capacitor. For example, RC filters are commonly used for audio (or) low frequency operation, whereas LC (or) crystal filters are employed at RF (or) high frequencies especially because of their high Q value, the crystals provide more stable operation at high frequencies.

Active filters are mostly used in field of Communication, and Signal processing, Radio, Television, RADAR, space satellites and bio-medical equipment. Each of these filters is using an Op-Amp as the active element and resistors and capacitors as passive elements. The order of filter is determined by gain of the filter. For example first order high pass filter, the gain rolls of at 20dB/decade in stop band. For the second order filter the gain rolls of at 40dB/decade. For first order high pass filter gain increases at a rate of 20dB/decade in stop band for second order, gain increases at rate of 40dB/decade in stop band.

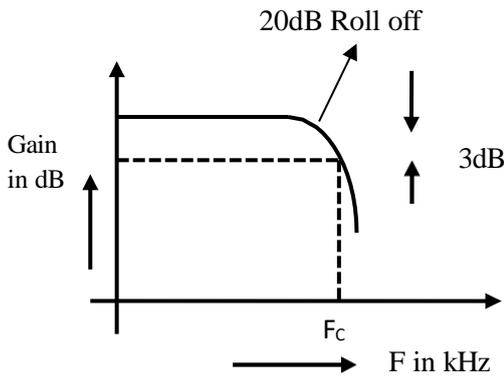
TABULATION AND MODEL GRAPH:**FIRST ORDER LPF** $V_{in} = \underline{\hspace{2cm}} \text{ v}$

S.No	Frequency (Hz)	O/P voltage (V _o)	Gain=20log ₁₀ (V _o /V _{in})
1	200		
2	400		
3	600		
4	800		
5	1K		
6	1.2k		
7	1.4k		
8	1.6k		
9	1.8k		
10	2 K		
11	4 K		
12	5 K		
13	6 K		
14	8k		
15	10k		

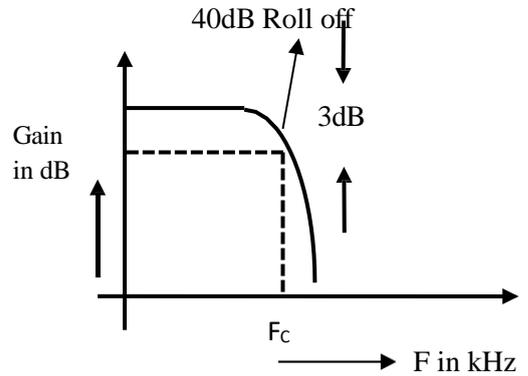
SECOND ORDER LPF $V_{in} = \underline{\hspace{2cm}} \text{ v}$

S.No	Frequency (Hz)	O/P voltage (V _o)	Gain=20log ₁₀ (V _o /V _{in})
1	200		
2	400		
3	600		
4	800		
5	1K		
6	1.2k		
7	1.4k		
8	1.6k		
9	1.8k		
10	2 K		
11	4 K		
12	5 K		
13	6 K		
14	8k		
15	10k		

FIRST ORDER LPF



SECOND ORDER LPF



DESIGN:

FIRST ORDER BUTTERWORTH LPF

The closed loop gain of amplifier (or) gain of filter

$$A_0 = 1 + R_f/R_1$$

$$R_f = 5.86 \text{ K}\Omega,$$

$$R_1 = 10 \text{ K}\Omega$$

$$A_0 = 1 + 5.86 \text{ K}\Omega / 10 \text{ K}\Omega = 1.586$$

The cutoff frequency of first order filter is given by $F_c = 1/2\pi RC$

Assume $C = 0.01 \mu\text{F}$, $R = ?$

$$1 \text{ KHz} = \frac{1}{2\pi \times 0.01 \times 10^{-6} \times R}$$

$$R = 15.9 \text{ K}\Omega$$

SECOND ORDER BUTTERWORTH LPF

The transfer function of second order Low pass Butterworth filter is $A_0 / (s^2 + \alpha s + 1)$, $\alpha =$ damping coefficient $= 1.414$ & $A_0 =$ gain. This is called as Butterworth filter. Audio filters are usually Butterworth.

$$F_c = \frac{1}{2\pi RC} = 1 \text{ KHz}$$

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

Then pass band gain $A_0 = 3 - \alpha = 3 - 1.414 = 1.586$. The transfer function of second

order Low pass Butterworth filter is $= \frac{1.586}{(s^2 + 1.414s + 1)}$

$$A_0 = 1 + R_f/R_1$$

$$R_f = 5.86$$

$$R_1 = 10K\Omega$$

$$\text{So, } A_0 = 1 + \frac{5.86}{10} = 1.586$$

$$\text{Then pass band gain, } 3 - \alpha = 3 - 1.414 = 1.586$$

$$F_c = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}}$$

Assume $R = 15.9 K\Omega$, $C = ?$

$$F = 1 \text{ KHz}$$

$$\text{So, } C = \frac{1}{F_c * 2\pi R} = \frac{1}{1000 * 2 * 3.14 * 15.9k} = 0.01\mu\text{F.}$$

APPARATUS REQUIRED:

1. IC 741-1No.
2. Resistors (5.86K - 1No., 10K - 2Nos.)
3. Capacitor (0.01 μ F - 1No.)
4. AFO & CRO
5. Bread board and Connecting wires.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. The input voltage V_{in} is given, keeping it constant. The input frequency is varied from 100Hz to maximum frequency (10 KHz) and the output voltage is noted.
3. The gain is calculated by using the formula $20\log_{10}(V_o/V_{in})$.
4. The 3dB line is drawn and the cutoff frequency f_c is found, this is compared with theoretical value.

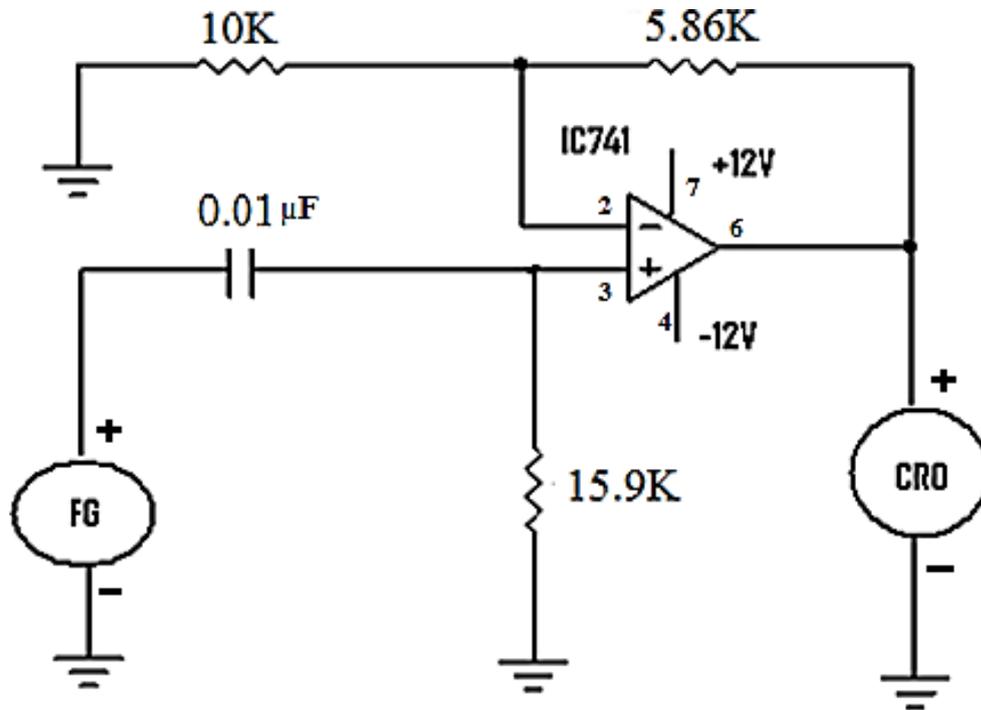
RESULT:

Thus the first order & second order Low pass filter was designed and the cut-off frequency was calculated from the graph.

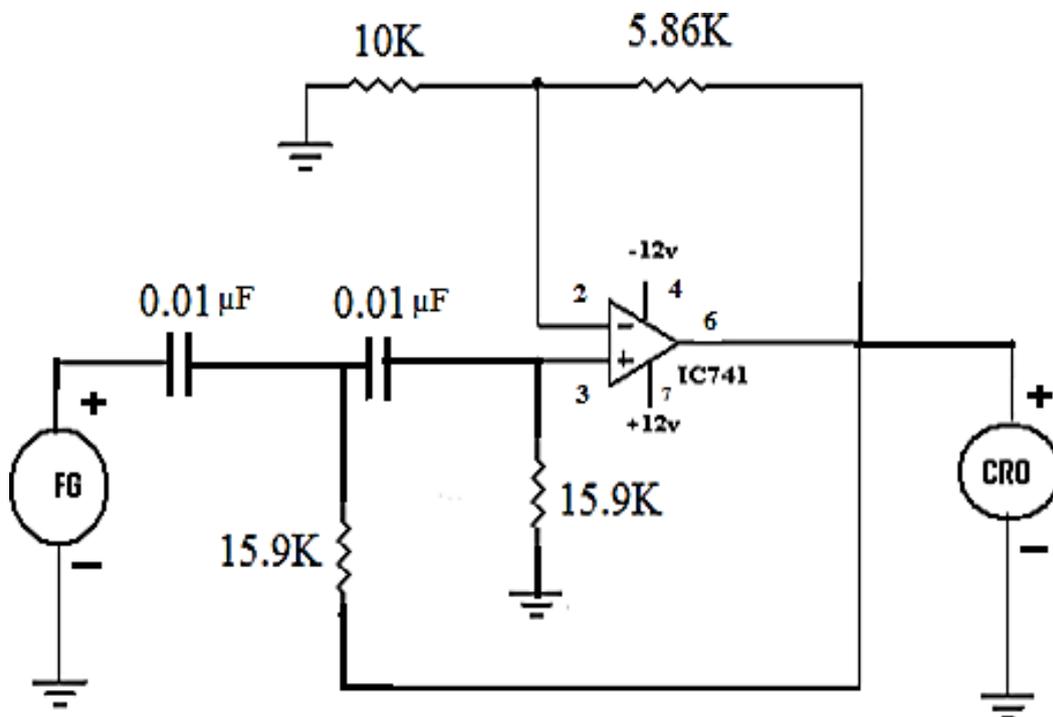
EXERCISE:

1. Design a low pass filter for a cut off frequency of 1.5KHZ.
2. Design a low pass filter for a cut off frequency of 3KHZ.

CIRCUIT DIAGRAM:
FIRST ORDER HPF



SECOND ORDER HPF



EX.NO:2(b)	DESIGN OF FIRST ORDER & SECOND ORDER ACTIVE HIGH PASS FILTER
DATE:	

AIM:

To design an active,

1. First order
2. Second order Butterworth type High-pass pass Filter with cut off frequency of 1 KHz

DESIGN:**FIRST ORDER BUTTERWORTH HPF**

The closed loop gain of amplifier (or) gain of filter

$$A_0 = 1 + R_f/R_1$$

$$R_f = 5.86 \text{ K}\Omega,$$

$$R_1 = 10 \text{ K}\Omega$$

$$A_0 = 1 + 5.86 \text{ K}\Omega / 10 \text{ K}\Omega = 1.586$$

The cutoff frequency of first order filter is given by $F_c = 1/2\pi RC$

Assume $C = 0.01 \mu\text{F}$, $R = ?$

$$1 \text{ KHz} = \frac{1}{2\pi \times 0.01 \times 10^{-6} \times R}$$

$$R = 15.9 \text{ K}\Omega$$

SECOND ORDER BUTTERWORTH HPF

The transfer function of second order High pass Butterworth filter is $A_0/(s^2 + \alpha s + 1)$, $\alpha = \text{damping coefficient} = 1.414$ & $A_0 = \text{gain}$. This is called as Butterworth filter. Audio filters are usually Butterworth.

$$F_c = \frac{1}{2\pi RC} = 1 \text{ KHz}$$

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

Then pass band gain $A_0 = 3 - \alpha = 3 - 1.414 = 1.586$. The transfer function of second order Low pass Butterworth filter is $= \frac{1.586}{(s^2 + 1.414s + 1)}$

$$A_0 = 1 + R_f/R_1$$

$$R_f = 5.86$$

$$R_1 = 10 \text{ K}\Omega$$

$$\text{So, } A_0 = 1 + \frac{5.86}{10} = 1.586$$

Then pass band gain, $3 - \alpha = 3 - 1.414 = 1.586$

$$F_c = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}}$$

Assume $R = 15.9 \text{ K}\Omega$, $C = ?$

$$F_c = 1 \text{ KHz}$$

$$\text{So, } C = \frac{1}{F_c \cdot 2\pi R} = \frac{1}{1000 \times 2 \times 3.14 \times 15.9 \text{ K}} = 0.01 \mu\text{F}.$$

APPARATUS REQUIRED:

1. IC 741-1 No.
2. Resistors (15.9K - 2Nos, 5.86K-2Nos 10K - 2Nos.)
3. Capacitor (0.01 μ F - 2Nos)
4. AFO & CRO
5. Bread board and Connecting wires.

THEORY:

An electric filter is a frequency selective circuit that passes a specified band of frequencies and blocks (or) attenuates signals of frequencies outside this band. Filters may be classified in a number of ways

- i) Analog (or) Digital
- ii) Passive (or) Active
- iii) Audio (AF) (or) Radio frequency (RF)

Analog filters are designed to process analog signals, while digital filters process analog signal using digital techniques. Depending on type of elements used in their construction, filters may be classified as active (or) passive. Elements used in passive filters are resistor, capacitor and inductors. Active filters . For example, RC filters are commonly used for audio (or) low frequency operation, whereas LC (or) crystal filters are employed at RF (or) high frequencies especially because of their high Q value, the crystals provide more stable operation at high frequencies.

Active filters are mostly used in field of Communication, and Signal processing, Radio, Television, RADAR, space satellites and bio-medical equipment. Each of these filters is using an Op-Amp as the active element and resistors and capacitors as passive elements. The order of filter is determined by gain of the filter. For example first order high pass filter, the gain rolls off at 20dB/decade in stop band. For the second order filter the gain rolls off at 40dB/decade. For first order high pass filter gain increases at a rate of 20dB/decade in stop band for second order, gain increases at rate of 40dB/decade in stop band.

TABULATION AND MODEL GRAPH:**FIRST ORDER HPF**

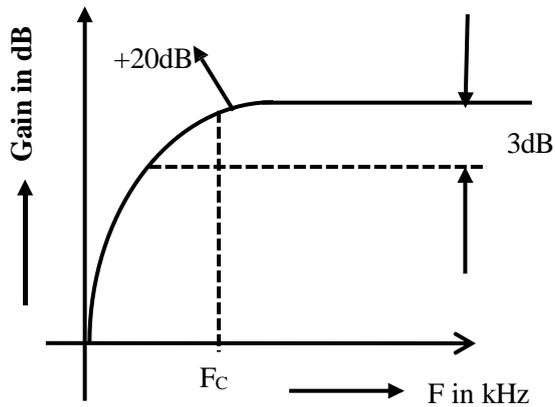
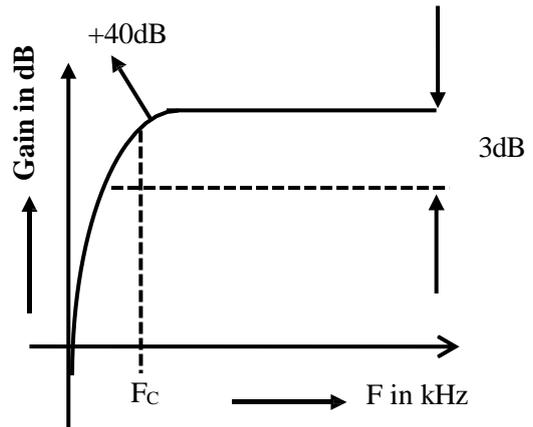
$$V_{in} = \text{_____} \text{ v}$$

S.No	Frequency (Hz)	O/P voltage (V _o)	Gain=20log ₁₀ (V _o /V _{in})
1	200		
2	400		
3	600		
4	800		
5	1K		
6	1.2k		
7	1.4k		
8	1.6k		
9	1.8k		
10	2 K		
11	4 K		
12	5 K		
13	6 K		
14	8k		
15	10k		

SECOND ORDER HPF

$$V_{in} = \text{_____} \text{ v}$$

S.No	Frequency (Hz)	O/P voltage (V _o)	Gain=20log ₁₀ (V _o /V _{in})
1	200		
2	400		
3	600		
4	800		
5	1K		
6	1.2k		
7	1.4k		
8	1.6k		
9	1.8k		
10	2 K		
11	4 K		
12	6 K		
13	8k		
14	10k		

MODEL GRAPH:**FIRST ORDER HPF****SECOND ORDER HPF****PROCEDURE:**

1. Connections are made as per the circuit diagram.
2. The input voltage is applied to the input side of the circuit.
3. The O/P voltage is measured by varying frequency of input signal.
4. The readings are tabulated.
5. The graph is plotted between frequency and voltage gain. Also Cut-off frequency is calculated and verified.

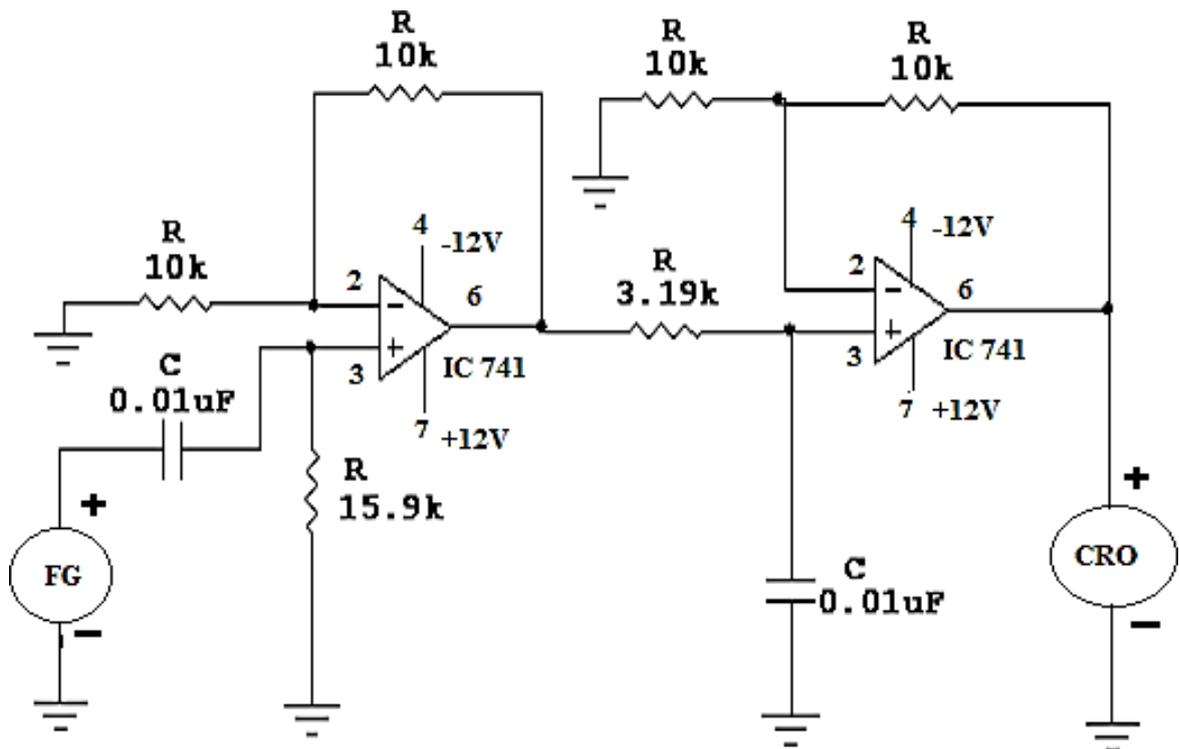
RESULT:

Thus the first order & second order high pass filter was designed and the cut-off frequency was calculated from the graph.

EXERCISE:

1. Design a high pass filter for a cut off frequency of 2.5KHZ.
2. Design a high pass filter for a cut off frequency of 10KHZ.

CIRCUIT DIAGRAM:



TABULATION: $V_{in} = 1.3v$

MODEL GRAPH:

S.N o	Frequenc y(Hz)	O/P voltage (V_o)	Gain= $20\log_{10}$ (V_o/V_{in})
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

EX.NO:2(c)	DESIGN OF BAND PASS FILTER
DATE:	

AIM:

To design an active first order Butterworth type Band-pass filter with cut off frequency (f_c) between 1 KHz and 5 KHz.

DESIGN:

Design of a band pass filter with the upper cut-off frequency of 5 kHz and lower cut-off frequency 1kHz using IC741.

f_L for high pass filter - 1 KHz

$f_L = 1 \text{ kHz}$

Assume $C = 0.01 \mu\text{f}$, $R = ?$

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

$$1 \text{ KHz} = \frac{1}{2\pi \times 0.01 \times 10^{-6} \times R}$$

$$R = 15.9 \text{ K}\Omega$$

f_H for low pass filter - 5 kHz

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

Assume $C = 0.01 \mu\text{f}$, $R = ?$

$$5 \text{ KHz} = \frac{1}{2\pi \times 0.01 \times 10^{-6} \times R}$$

$$R = 3.19 \text{ K}\Omega$$

Overall gain of the first order band pass filter is given by,

For High pass filter

$$A_{02} = 1 + R_f / R_1$$

$$A_{01} = 1 + 10 / 10$$

$$A_{01} = 2$$

For low pass filter

$$A_{01} = 1 + R_f / R_1$$

$$A_{02} = 1 + 10 / 10$$

$$A_{02} = 2$$

$$A_0 = A_{01} + A_{02} = 4$$

Band width = $f_H - f_L$

$$BW = 5 \text{ KHz} - 1 \text{ KHz}$$

$$BW = 4 \text{ kHz}$$

$$Q = \frac{f_0}{BW}$$

$$f_0 = \sqrt{f_H f_L} = \sqrt{5} = 2.236$$

$$Q = \frac{2.236}{4}$$

$$Q = 0.55$$

Q factor is less than 10, so it is a wide band pass filter.

APPARATUS REQUIRED:

1. IC741 - 2 Nos
2. Capacitors (0.01 μ f - 2 Nos)
3. Resistors (10K - 4 Nos, 3.3K, 15.9K - each 1No.)
4. Connecting wires and Bread Board
5. CRO and AFO

THEORY:

A band pass filter has a pass band between two cut off frequencies such that $f_H > f_L$. Basically there are two types of band pass filters,

- 1) Wide band pass filter
- 2) Narrow band pass filter

If the Q factor is less than 10 it is a wide band pass filter. If the Q factor is greater than 10 it is a narrow band pass filter. Q factor is a measure of selectivity, meaning the higher value of Q, the more selective is the filter or the narrower its bandwidth (BW). The relationship between Q, BW and the center frequency f_c is given by

$$Q = \frac{f_c}{BW} = \frac{f_c}{f_H - f_L} \quad ; \quad f_c = \sqrt{f_H f_L}$$

A wide band pass filter can be formed by cascading high pass and low pass filtering sections. To obtain a +/- 20dB / decade band pass, first order high pass and first order low pass sections are cascaded. For a +/- 40dB /decade band pass filter, second order high pass and second order low pass sections are connected in series, and so on. In other words the gain of the band pass filter depends on the order of the high pass and low passes filter sections.

PROCEDURE:

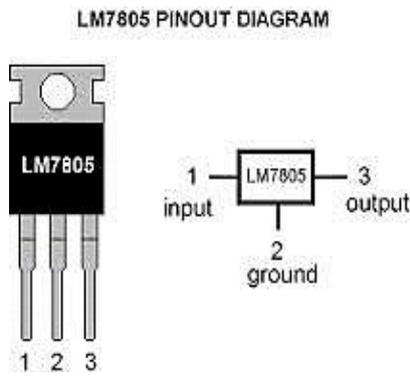
1. Connections are made as per the diagram.
2. The input voltage V_{in} is given, keeping it constant the input frequency is varied from 200 Hz to maximum frequency (10 KHz) and the output voltage is noted down.
3. The gain is calculated by using the formula $20 \log_{10} V_0 / V_{in}$
4. The 3 dB line is drawn and the cut off frequency f_c is found. This is compared with theoretical value.

RESULT:

Thus the first order Band pass filter was designed and the cut-off frequency was calculated from the graph.

EXERCISE:

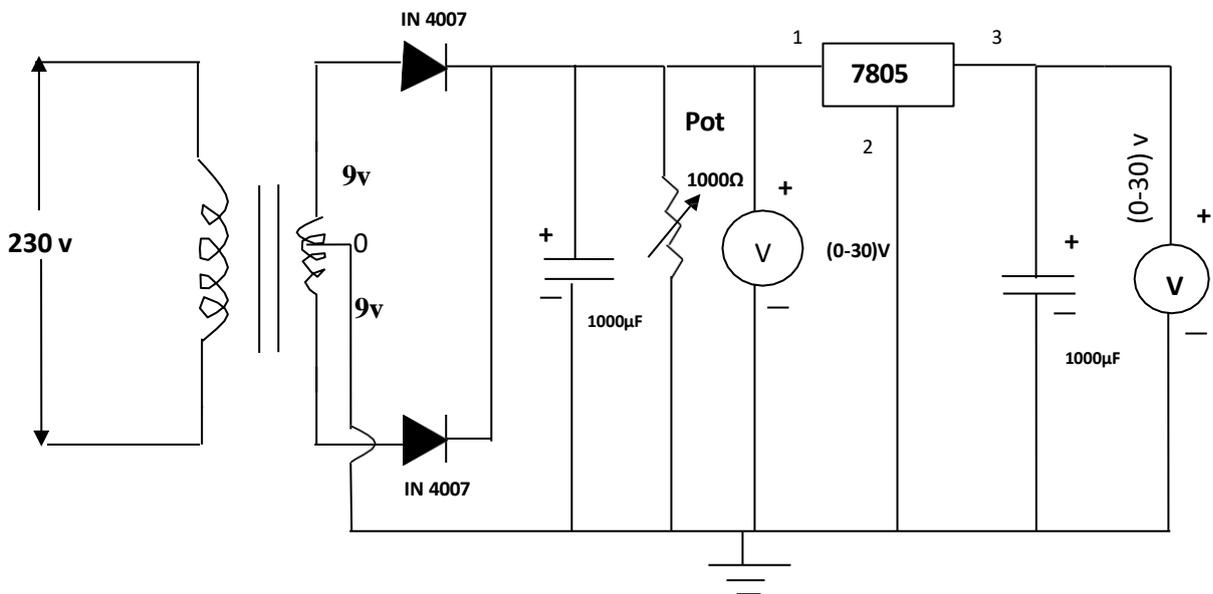
1. To design an active first order Butterworth type Band-pass filter with cut off frequency (f_c) between 2 KHz and 6 KHz.



Pin No	Function	Name
1	Input voltage (5V-18V)	Input
2	Ground (0V)	Ground
3	Regulated output; 5V (4.8V-5.2V)	Output

CIRCUIT DIAGRAM:

LINE REGULATION



TABULATION AND MODEL GRAPH:

LINE REGULATION

Input Voltage V_{in} (V)	Output Voltage V_{out} (V)

EX.NO:3(a)	DESIGN OF REGULATED POWER SUPPLY
DATE:	

AIM:

To design a Regulated Power Supply.

APPARATUS REQUIRED:

1. Diodes IN4007
2. Capacitors (100 μ F, 10 μ F – each 1 No.)
3. IC 7805
4. Potentiometer (1K)
5. Ammeter and Voltmeter

THEORY:

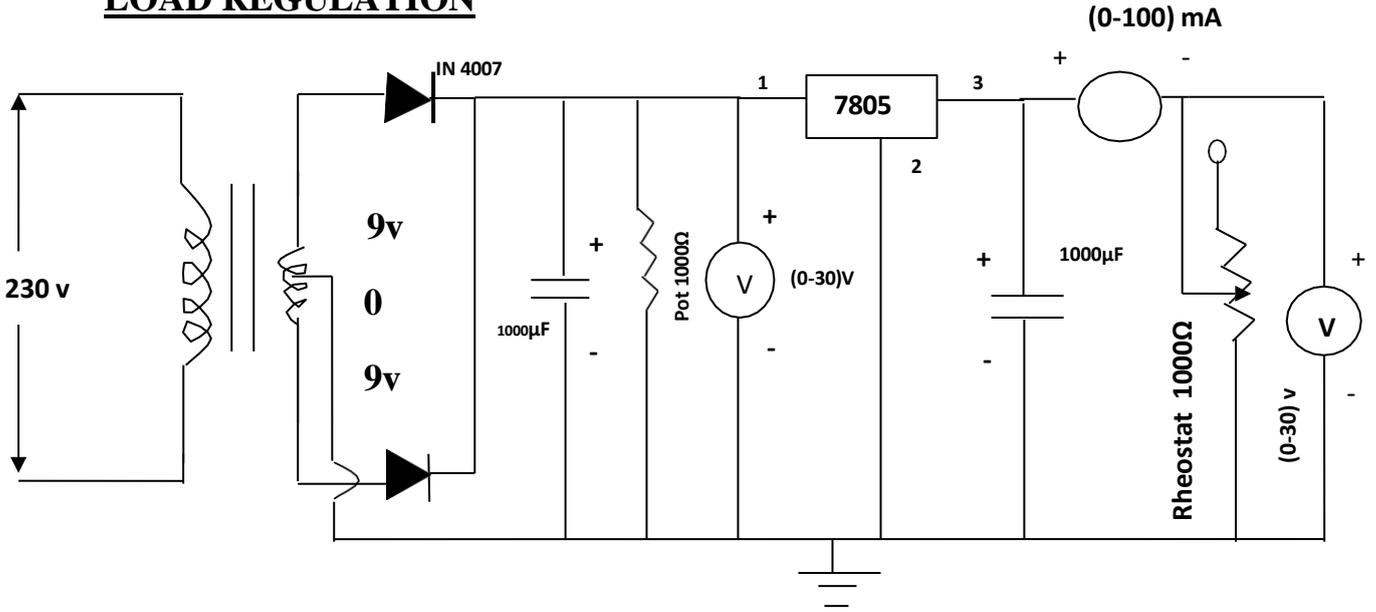
In an unregulated power supply, the o/p voltage changes whenever the i/p voltage (or) load changes. An ideal regulated power supply is an electronic circuit designed to provide predetermined DC voltage V_0 which is independent of the load current and variations in the input voltage. A voltage regulator is an electronic circuit that provides a stable DC voltage independent of the load current, temperature and AC line voltage variations. Although voltage regulators can be designed using op-amps, it is quicker and easier to use IC voltage regulators. Furthermore, the IC voltage regulators are versatile, relatively inexpensive and are available with features such as programmable o/p, current/voltage boosting and floating operation for high voltage application.

Some important types of linear IC voltage regulators are,

1. Fixed positive/negative o/p voltage regulators.
2. Adjustable o/p voltage regulators.

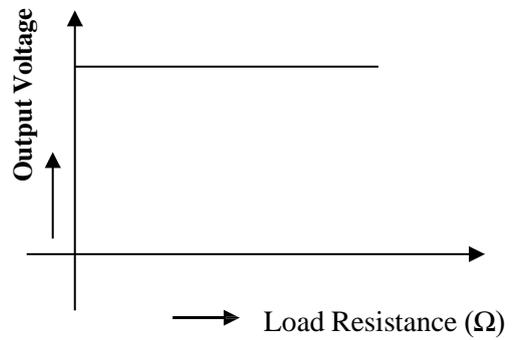
Fixed voltage regulators: 78XX series are three terminal, positive fixed voltage regulators. There are seven o/p voltage options available such as 5, 6, 8,12,15,18 and 24V. In 78XX, the last two numbers (XX) indicate the o/p voltage. 79XX series are negative fixed voltage regulators which are complements to the 78XX series devices. There are two extra voltage options of -2V and -5.2V available in 79XX series. The input capacitor used to eliminate the unwanted ripples present in the input and the output capacitor is used to eliminate oscillations because more oscillations present in the input.

LOAD REGULATION



TABULATION AND MODEL GRAPH:

Resistance (KΩ)	Current (mA)	Output Voltage (V)



A change in the input voltage to a Regulator does cause a change in its output voltage. The line Regulation rating of a voltage regulator indicates the change in the input voltage.

The line regulation of a voltage regulator is found as

$$\text{Line Regulation} = \frac{\Delta V_{\text{out}}}{\Delta V_{\text{in}}}$$

Where,

ΔV_{out} = the change in output voltage (usually in microvolt's (or) millivolts)

ΔV_{in} = the change in input voltage (usually in volts)

LOAD REGULATION

The Load Regulation means the change in regulator output voltage that occurs per unit change in load current.

The load regulation of a voltage regulator is found as,

$$\text{Load Regulation} = \frac{(V_{NL} - V_{FL})}{\Delta I_L}$$

Where,

V_{NL} is the no load output voltage (the output voltage when the load is open)

V_{FL} is the full load output voltage (the output voltage when the load is connected)

ΔI_L is the change in load current,

Another way of expressing is this

$$\text{Load regulation} = \frac{\Delta V_{\text{out}}}{\Delta I_L}$$

PROCEDURE:

LINE REGULATION

1. Connections are made as per the circuit diagram.
2. Varying the input voltage from (0-15) v.
3. Note down the output voltage.
4. Draw the graph of line voltage Vs o/p voltage.

LOAD REGULATION

1. Connect a Variable Potentiometer across the output of the RPS.
2. Vary the Potentiometer from 100 Ω to 1K Ω and note down the corresponding output current and voltage.
3. Draw the graph of current Vs output voltage.

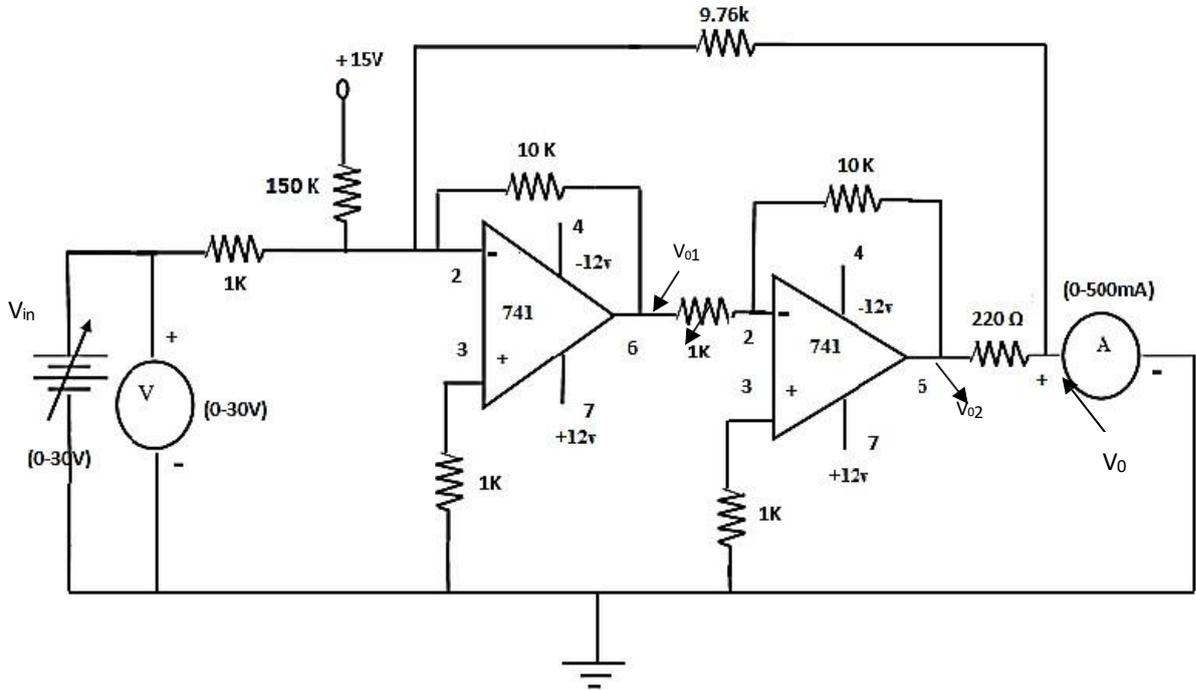
RESULT:

Thus the Load and Line Regulation was performed using regulated IC's.

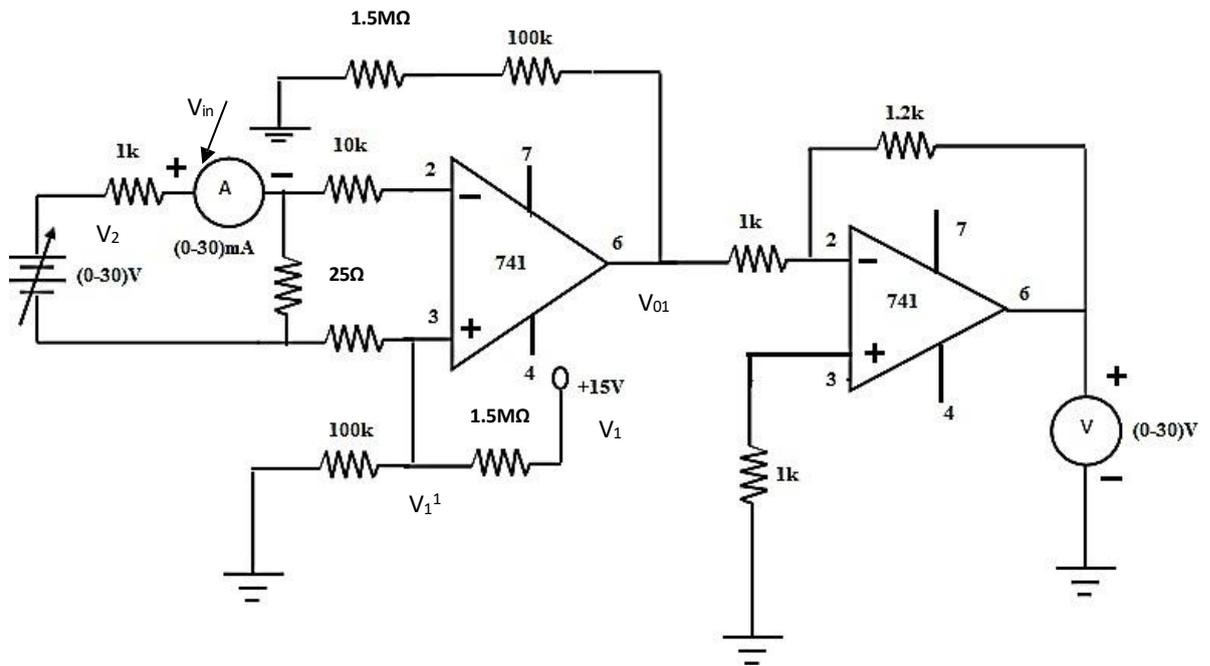
EXERCISE:

1. To design a Regulated Power Supply Using IC 7812 and 7912.

**CIRCUIT DIAGRAM:
V/I CONVERTER**



I/V CONVERTER



EX.NO:3(b)	DESIGN OF V/I AND I/V CONVERTERS
DATE:	

AIM:

To design and verify the characteristics of voltage to current converter and current converter experimentally.

DESIGN:**CIRCUIT ANALYSIS FOR VOLTAGE TO CURRENT CONVERTER**

Apply KCL in node 1

$$\frac{15}{150} + \frac{v_{in}}{12.5} + \frac{v_{01}}{10} + \frac{v_0}{9.76} = 0$$

If V_{01} is +Ve then V_{02} is -Ve ($V_{01} = -V_{02}$)

$$\frac{15}{150} + \frac{v_{in}}{12.5} + \frac{v_0}{9.76} = \frac{V_{02}}{10}$$

$$0.1 + 0.08v_{in} + 0.10245v_0 = \frac{V_{02}}{10}$$

$$1 + 0.80v_{in} + 1.0245v_0 = V_{02}$$

$$V_{02} = 1 + 0.80v_{in} + 1.0245v_0 \dots\dots\dots 1$$

Apply KCL in node 2

$$I_0 = \frac{V_{02} - V_0}{0.249} - \frac{V_0}{9.76} \dots\dots\dots 2$$

Substitute 1 in 2

$$= \frac{1 + 0.80v_{in} + 1.0245v_0 - v_0}{0.249} - \frac{V_0}{9.76}$$

$$= \frac{9.76 + 7.8v_{in} + 9.99v_0 - 9.76v_0 - 0.249v_0}{2.43}$$

$$= 4.016 + 3.2v_{in} + 4.11v_0 - 4.016v_0 - 0.10v_0$$

$$I_0 = 4.016 + 3.2v_{in} + 0.008v_0 \quad (V_0 \text{ is small value so neglect } V_0)$$

When $V_{in} = 0V$

$$I_0 = 4.016mA$$

When $V_{in} = 5V$

$$I_0 = 20.016mA$$

CIRCUIT ANALYSIS FOR CURRENT TO VOLTAGE CONVERTER:Evaluation of V_{01} due to V_1

$$V_{01} = \left[1 + \frac{100k}{1500k} \right] V_1^1$$

$$V_1^1 = \left[\frac{100k}{100K + 1500k} \right] 15v$$

$$= 0.9375v$$

$$= \left[1 + \frac{100k}{1500k} \right] (0.9375V)$$

$$V_{01(V1)} = 1V$$

Evaluation of V_{01} due to V_2

$$V_{01(V2)} = \left[-\frac{R_f}{R_{in}} \right] V_{in} = \left[\frac{-100k}{10k} \right] V_{in} = -10 V_{in}$$

$$V_{01(\text{total})} = V_{01(V1)} + V_{01(V2)}$$

$$V_{01} = 1 - 10 V_{in}$$

When ,

$$I_{in} = 4mA, V_{in} = 4mA \times 25 \Omega = 0.1 V, V_{01} = 1 - 10(0.1) = 0$$

$$I_{in} = 20mA, V_{in} = 20mA \times 25 \Omega = 0.5 V, V_{01} = 1 - 10(0.5) = -4$$

$$(V_{in} = I_{in} \times R; R = 25\Omega)$$

Second stage amplification factor

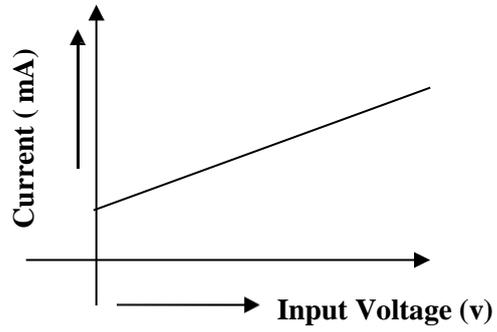
$$V_o = \left(\frac{-R_f}{R_{in}} \right) V_{01} = \left(\frac{-1.2k}{1k} \right) V_{01}$$

$$V_o (\text{when } I = 4mA) = (-1.2) (0) = 0 \text{ volt}$$

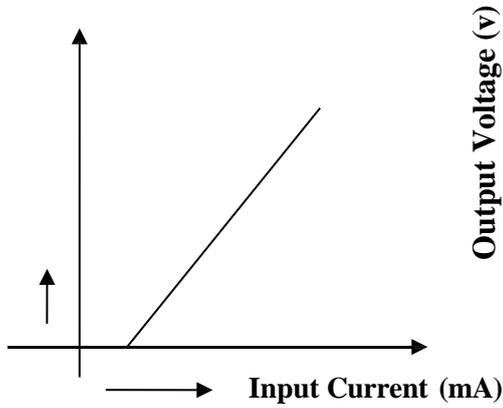
$$V_o (\text{when } I = 20mA) = (-1.2) (-4) = 4.8 \text{ volt}$$

**TABULATION AND MODEL GRAPH:
V/I CONVERTER**

Input voltage (V)	Output Current (mA)



I/V CONVERTER



Input Current (mA)	Output voltage (V)

APPARATUS REQUIRED:

1. IC 741 – 2Nos.
2. Power supply (0-30) V
3. Power supply +/- 12V
4. Resistors (10K,150K,10K,4.7K – each 1 No.)
5. Ammeter (0-30) mA
6. Multimeter

THEORY:

The active current-to-voltage converter is an amplifier with current input and voltage output. The current-to-voltage converter provides an output voltage that is directly proportional to input current and vice versa.

PROCEDURE:

1. Connections are made as per the diagram.
2. By varying the voltage using the power supply corresponding current values in the ammeter are noted.
3. Plot the graph for voltage Vs current.
4. For current to voltage converter initially set the current values in the ammeter and take the voltage using the voltmeter.
5. Plot the graph for current Vs voltage

RESULT:

Thus V/I and I/V converters are designed and their characteristics were obtained.

EX.NO:4	DESIGN OF LINEARIZING CIRCUITS AND COLD-JUNCTION COMPENSATION CIRCUIT FOR THERMOCOUPLES
DATE:	

AIM:

To design and implement the cold-junction compensation circuit for Thermocouple with the following specifications. When the Hot junction temp is 100 °C and reference junction temp is 30 °C the output should be 0V and hot junction maintain 100 °C and reference junction reaches 50 °C the output should be 2 V.

DESIGN FOR COLD JUNCTION COMPENSATION,

RTD – PT -100

$$R_{RTD} = R_o (1 + \alpha t)$$

$$R_o = \text{RTD resistance at } 0^\circ\text{C} = 100\Omega$$

$$\alpha = \text{Temperature co-efficient } (\alpha = 0.0039/^\circ\text{C})$$

$$R_{30^\circ\text{C}} = 100 [1 + 0.0039 (30)] = 111.7 \Omega.$$

$$R_{100^\circ\text{C}} = 100 [1 + 0.0039 (100)] = 139 \Omega.$$

Maximum current through RTD not exceeds 0.01469 A

Find voltage across RTD

$$V_{RTD} = I R_{RTD} = 0.01469\text{A} * 139 \Omega = 2.0419\text{v}.$$

Choose $V_{in} = 5\text{volts}$.

Find R_2

$$V_{in} = V_{R2} + V_{RTD}$$

$$= IR_2 + V_{RTD}$$

$$5\text{V} = 0.01469\text{A} * R_2 + 2.0419\text{V}$$

$$R_2 = 201.3 \Omega. \text{ Let us use } 220 \Omega \text{ (standard value) for } R_2, R_2 = R_1 = 220 \Omega$$

To null the bridge at 30°C

$$\Delta V = \left[\frac{R_{rtd}}{R_{rtd} + R_2} - \frac{R_3}{R_3 + R_1} \right] \times V_{in} = \left[\frac{111.7}{111.7 + 220} - \frac{111.7}{111.7 + 220} \right] (5\text{v}) = 0 \text{ V}$$

Output of the bridge circuit at 100°C

$$\Delta V = \left[\frac{139}{139 + 220} - \frac{111.7}{111.7 + 220} \right] (5\text{v}) = 0.2594 \text{ v}$$

Differential Amplifier Stage

$$V = (V_a - V_b) R_5/R_4$$

$$V = 0.2594 \text{ v}$$

Non Inverting Summer stage:

$$V_o = \left(1 + \frac{R_f}{R} \right) \left(\frac{V_a + V_b}{2} \right) \text{----- } 1$$

$$V_o = 2\text{v}, \text{ Assume } R = 1\text{k}\Omega$$

$$V_a = 3\text{mV}, V_b = 0.252\text{V}$$

To find R_f , Apply this value in Eqn 1

$$2V = \left(1 + \frac{R_f}{1}\right) \frac{(3 \times 10^{-3} + 0.252)}{2}$$

$$4 = (1 + R_f)(0.003 + 0.252)$$

$$4 = 0.255 + 0.255R_f$$

$$R_f = 14.68 \approx 15\text{k}\Omega.$$

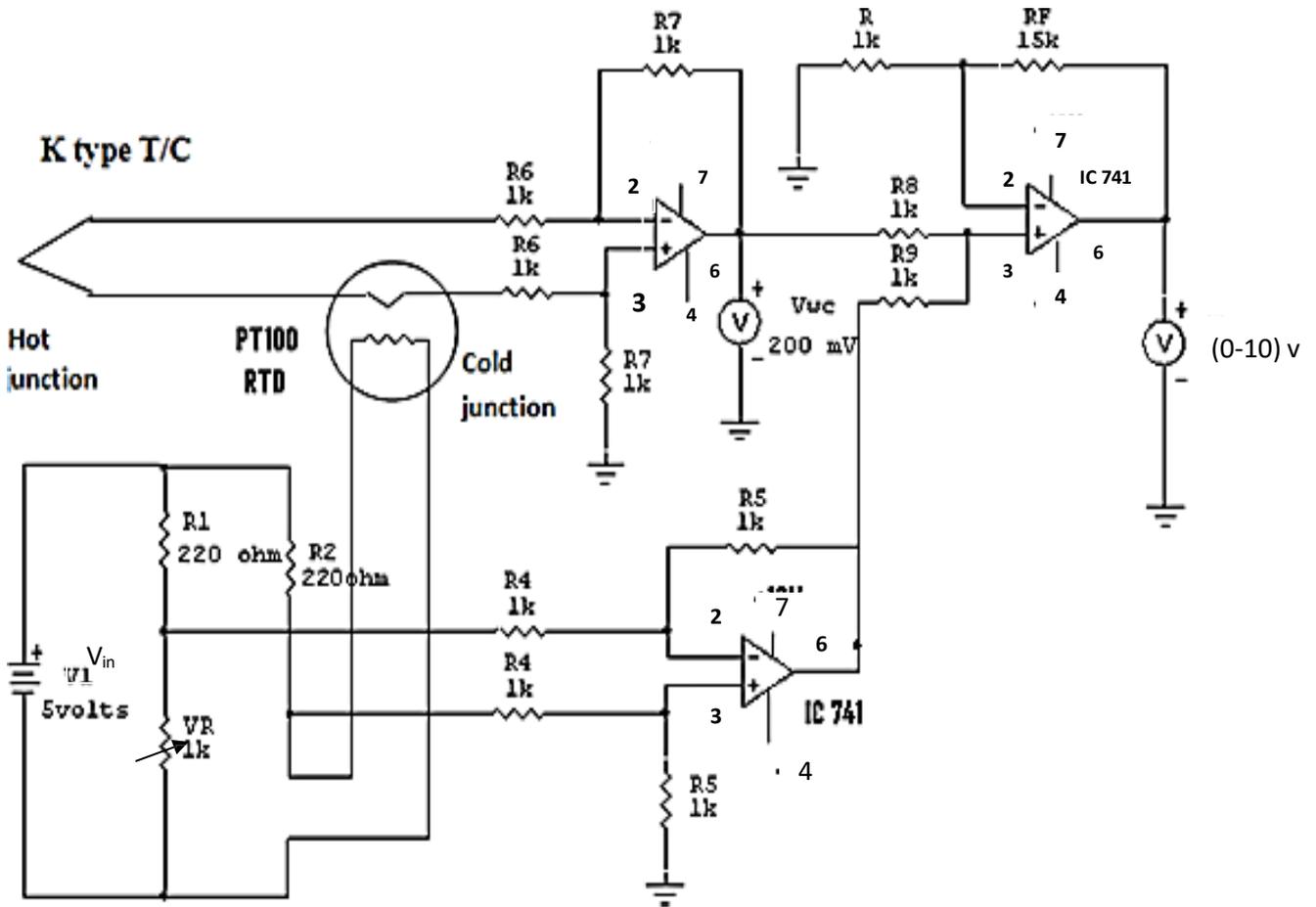
APPARATUS REQUIRED:

1. T/C – K type
2. RTD- PT -100
3. Resistors (15K, 1K -12No., 220 Ω – 2No.)
4. Variable resistor -1K – 1No.
5. Multimeter – 2
6. Op Amp – 741- 3
7. Connecting wires and bread board.

THEORY:

Reference junction compensation: A problem with the practical use of T/C is the necessity of knowing the reference temperature. Because the T/C voltage is proportional to the difference between the measurement and reference junction temperatures, variations of the reference show up as direct errors in the measurement temperature determination. A factor which is important in the use of T/C is the requirement of a known reference junction. This is because when the reference junction is not held at 0°C , the observed value must be corrected by adding to it a voltage that has resulted from a temperature difference equal to the amount by which the reference junction is above 0°C . (This is because the T/C are calibrated with temperature of reference junction as 0°C). Now $E_T = E_t + E_0$ where E_T is the total emf at temperature T, E_t is the emf on account of temperature difference between detecting (hot) and the reference junction and E_0 is the emf due to temperature of the reference junction being above 0°C . Since, there exists a nonlinear relationship between the emf and the temperature, it is important that temperatures are determined by the above process rather than converting an emf to temperature and then adding it to ambient temperature.

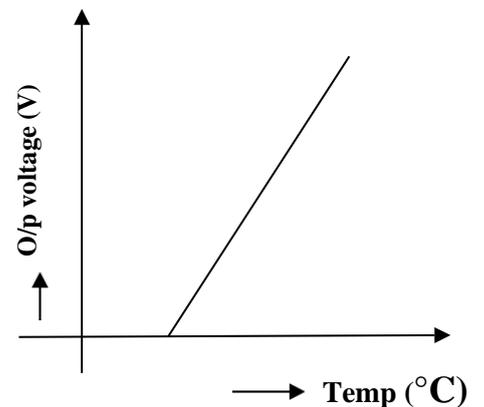
CIRCUIT DIAGRAM:



TABULAR COLUMN:

MODEL GRAPH

With cold junction compensation	
Temperature in °(c)	O/p in Voltage (V)



PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Switch on the heater upto 100 ° C.
3. Notedown the temperature and without compensation o/p voltage readings up to 100°C .
4. Maintain T/C hot junction temp. 100° C constantly.
5. Now switch on the RTD inseterd heater.
6. Note down the cold junction temp and output voltage readings until the temp reaches upto 100° C .
7. Plot the graph for cold junction temp and output voltage.

RESULT:

Thus the cold junction compensation circuit was designed and implemented for the given specification. And also plot the graph of temperature Vs O/p voltage.

Exp. No:5(a)

**DESIGN OF SIGNAL CONDITIONING CIRCUIT
FOR STRAIN GAUGE**

Aim:

To design and construct a signal conditioning circuit for strain gauge.

Apparatus Required:

S. No.	Components / Equipments	Specifications	Quantity
1.	RPS	+/-15V, 5V	1 each
1.	Operational Amplifier	IC 741	2
2.	Strain Gauge (Resistor)	DRB	1
3.	Resistors	1K Ω , 10 K Ω , 47 K Ω	4,4,1
4.	Digital Multimeter	-	1
5.	Bread Board & Connecting	-	Sufficient

Theory:

Signal conditioning circuits normally employ amplifiers, temperature compensation devices etc.

Strain Gauge: Strain gauge is a bridge network which has four arms. Each arm has a resistor. The principle of strain gauge is given by the following formula:

$$R = \frac{\rho L}{A}$$

Where R is the resistance, ρ is the specific resistance or resistivity in ohm-m. L is length in mm and A is area in m². Thus the resistance change according to the stress applied along the horizontal or vertical columns. There are tensile forces acting along vertical and compressive forces along horizontal direction. Initially the bridge will be in a balanced position. Hence no output is obtained. Whenever there is a change in strain values the corresponding change in voltage is measured.

Procedure:

1. Connections are made as per the circuit diagram.
2. Design a signal conditioning circuit for the strain gauge to get the appropriate desired output.
3. Balance the bridge initially so that no output voltage occurs.
4. Gradually increase the strain gauge resistance.
5. Note down voltage value corresponding to the increase in strain.
6. Check the output voltage at each stage of amplification.
7. Observe the final output voltage and tabulate.

Circuit Diagram:

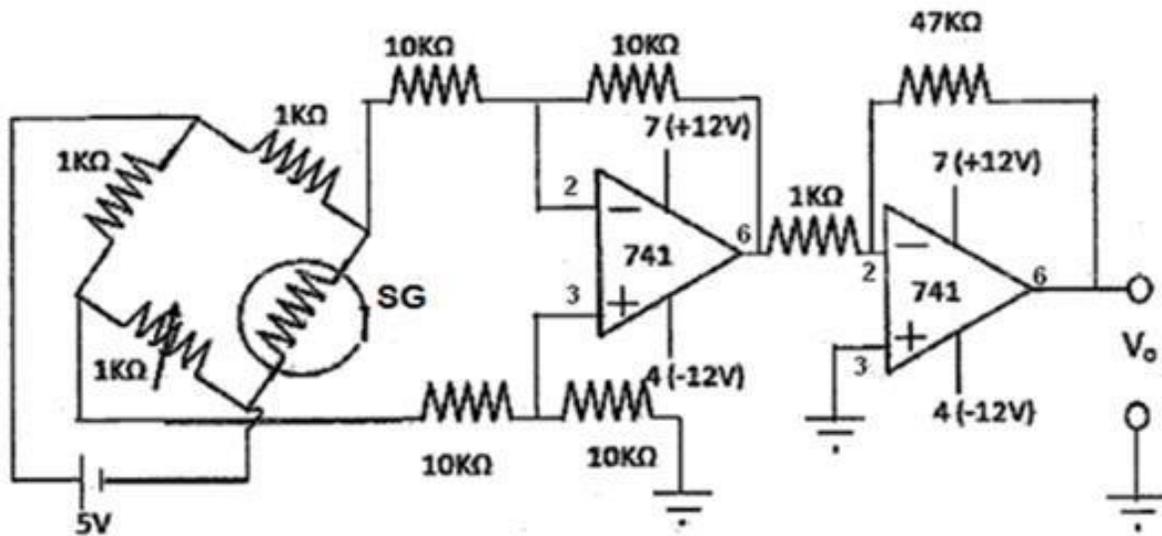


Fig: Signal Conditioning Circuit for Strain Gauge

Tabulation:

S.No.	Resistance (Ω)	Output Voltage (Volts)

Result:

Thus a signal conditioning circuit for strain gauge circuit using operational amplifier was designed and implemented..

Review Questions:

1. What is dummy strain gauge?
2. What is Rossete?
3. What is the need of signal conditioning circuit for strain gauges?
4. What is gauge factor?
5. What is the working principle of strain gauge?

Exp. No:5(b)

DESIGN OF SIGNAL CONDITIONING CIRCUITS FOR RTD

Aim:

To design and construct a signal conditioning circuit for resistance temperature detector .

Apparatus Required:

S. No.	Components / Equipments	Specifications	Quantity
1.	RPS	+/-15V, 5V	1 each
1.	Operational Amplifier	IC 741	2
2.	RTD (Resistor)	DRB	1
3.	Resistors	1K Ω , 10 K Ω , 47 K Ω	4,4,1
4.	Digital Multimeter	-	1
5.	Thermometer & Water bath	-	1 each
6.	Bread Board & Connecting	-	Sufficient

Theory:

Cold junction compensation: Signal conditioning circuits normally employ amplifiers, temperature compensation devices etc.

Resistance Temperature Detector: RTD has a positive temperature coefficient. The principle of RTD is as there is a change in the temperature, the resistance changes, and this change in resistance is measured. As RTD has a positive temperature coefficient i.e as temperature increases, resistance increases, the resistance at any temperature t can be calculated using the formula.

$$R_T = R_0 [1 + \alpha (t - t_0)]$$

Where,

R_T is resistance at $T^{\circ}\text{C}$

R_0 is resistance at 0°C , room temperature.

α - Temperature coefficient of the material 0.04.

Thus the value of resistance can be calculated.

Circuit Diagram:

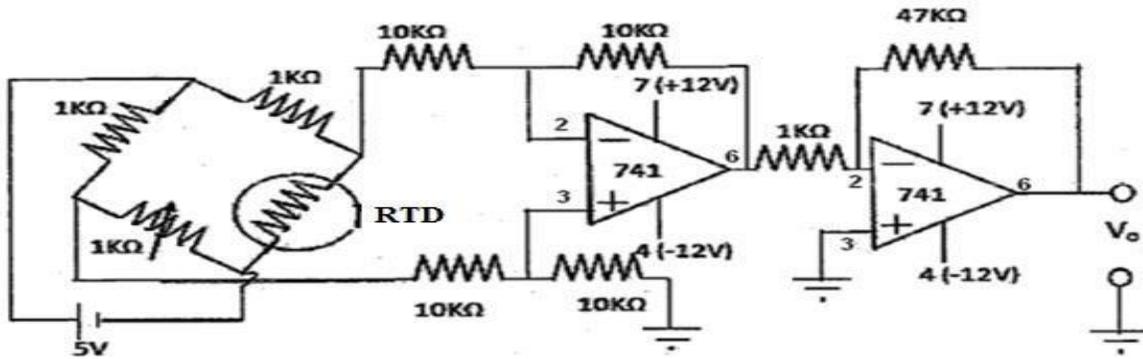


Fig: Signal Conditioning Circuit for Resistance Temperature Detector

Procedure:

1. Connections are made as per the circuit diagram.
2. Design a signal conditioning circuit for the RTD to get the appropriate desired output.
3. Balance the bridge initially so that no output voltage occurs.
4. Increase the temperature of the RTD by using water bath. Note down the change in resistance of RTD and output voltage.
5. Plot the graph between RTD resistance and output voltage.

Tabulation: Resistance of RTD at ambient conditions =

S.No.	Temperature (°C)	Resistance (Ω)	Output Voltage (Volts)

Result:

Thus a signal conditioning circuit for an RTD was designed as per the given specifications and implemented.

Review Questions:

1. What is 3 wire RTD?
2. What is 4 wire RTD?
3. What do you mean by resistance compensation in RTD?
4. What is the working principle of RTD?
5. What is positive temperature coefficient?

Exp. No:6(a)

DESIGN OF ORIFICE PLATE

Aim:

To determine the discharge coefficient (C_d) of Orifice plate for various flow rates.

Apparatus Required:

S. No.	Components / Equipments	Specifications	Quantity
1.	Orifice plate setup	Flat-plate, sharp-edge	1
2.	Mercury manometer	-	1
3.	Stopwatch	-	1

Theory:

An Orifice plate is a device which measures the rate of fluid flow. It uses the same principle as a nozzle, namely Bernoulli's principle which says that there is a relationship between the pressure of the fluid and the velocity of the fluid. When the velocity increases, the pressure decreases and vice versa.

An orifice plate is basically a thin plate with a hole in the middle. It is usually placed in a pipe in which fluid flows. As fluid flows through the pipe, it has a certain velocity and a certain pressure. When the fluid reaches the orifice plate, with the hole in the middle, the fluid is forced to converge to go through the small hole; the point of maximum convergence actually occurs shortly downstream of the physical orifice, at the so-called vena contracta point. As it does so, the velocity and the pressure changes. Beyond the vena contracta, the fluid expands and the velocity and pressure change once again. By measuring the difference in fluid pressure between the normal pipe section and at the vena contracta, the volumetric and mass flow rates can be obtained from equation. It states that in a steady, ideal flow of an incompressible fluid, the total energy at any point of the fluid is constant. The total energy consists of pressure energy, kinetic energy and potential energy or datum energy. Mathematically Bernoulli's theorem is written as

$$\frac{p}{w} + \frac{v^2}{2g} + z = \text{Constant}$$

Coefficient of discharge (C_d): It is defined as the ratio of the actual discharge from an Orifice to the theoretical discharge from the Orifice. Mathematically

$$\text{Coefficient of discharge} = \frac{Q_{Act}}{Q_{The}}$$

Q_{Act} = Volume / time taken for collecting in to the tank. (m^3 / sec)

$$Q_{The} = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} \cdot (\text{m}^3 / \text{sec})$$

C_d = Coefficient of discharge,

a_1 = cross sectional area of inlet ($\pi d_1^2/4$) = x 10^{-6}m^2 ,

a_2 = cross sectional area of outlet ($\pi d_2^2/4$) = x 10^{-6}m^2 ,

d_1 = diameter of inlet section in meter,

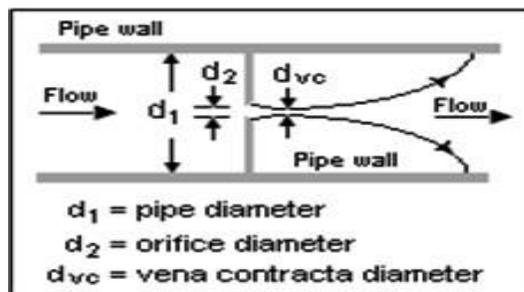
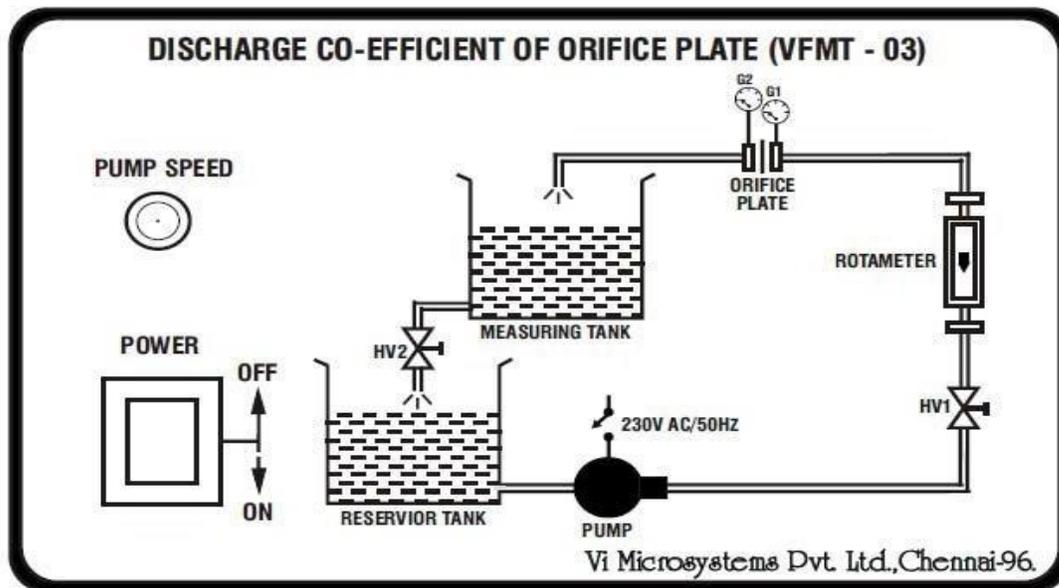
d_2 = diameter of throat section in meter = $0.6 \times d_1$

$$h = \frac{h_1 - h_2}{100} * 12.6$$

$h_1 - h_2$ = difference of mercury level in the manometer.

g = acceleration due to gravity = 9.81 m/sec^2

General Diagram:



Orifice Plate

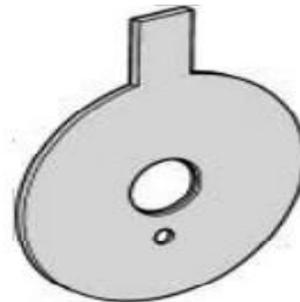


Fig: Discharge coefficient (C_d) of Orifice plate

Precaution:

1. The arrangement of orifice plate is closed type.
2. Water is circulated through the Orifice meter from reservoir to collecting tank by means of a monoblock pump.
3. The collecting tank of the Orifice meter is connected to a mercury manometer.

Procedure:

1. The pump is primed and started.
2. Keeping the gate valve fully open the experiment is started.
3. Pressure gauge reading is set by adjusting the gate valve and the time taken for 100 cm of water (Rotameter reading) are noted.
4. The gate valve is gradually closed; for each valve setting the readings are noted and the values are tabulated.

Tabular column:

S.No.	Pressure Gauge reading (mm.wc)	Rotameter reading (LPH)	Q_{Act} (m^3/sec) $\times 10^{-5}$	Q_{The} (m^3/sec) $\times 10^{-5}$	Discharge coefficient C_d

Model Calculation:

Result:

Thus the orifice plate designed for the given specification for determines the discharge coefficient (C_d) of Orifice plate for various flow rates.

Review Questions:

1. What are the different types of orifice plates?
2. What is vena contracta?
3. What are the advantages and disadvantages of orifice plates?
4. Name some other flow sensors.
5. For slurry type fluids which type of orifice plate is suitable?

Exp. No:6(b)

DESIGN OF ROTAMETER

Aim:

To design the rotameter for measuring the flow rate.

Apparatus Required:

S. No.	Components / Equipments	Specifications	Quantity
1.	Pump and reservoir	-	1
2.	Pipeline with rotameter	-	1
3.	Collecting tank	-	1
4.	Stopwatch	-	1

Theory:

The rotameter operation is based on the variable area principle: fluid flow raises a float in a tapered tube, increasing the area for passage of the fluid. The greater the flow, the higher the float is raised. The height of the float is directly proportional to the flow rate. With liquids, the float is raised by a combination of the buoyancy of the liquid and the velocity head of the fluid. With gases, buoyancy is negligible, and the float responds to the velocity head alone. The float moves up or down in the tube in proportion to the fluid flow rate and the annular area between the float and the tube wall. The float reaches a stable position in the tube when the upward force exerted by the flowing fluid equals the downward gravitational force exerted by the weight of the float. A change in flow rate upsets this balance of forces. The float then moves up or down, changing the annular area until it again reaches a position where the forces are in equilibrium. To satisfy the force equation, the rotameter float assumes a distinct position for every constant flow rate. However, it is important to note that because the float position is gravity dependent, rotameters must be vertically oriented and mounted. Rotameter consists of the vertical tube with tapered tube in which float assumes vertical position corresponding to each flow rate through the tube for the given flow rate. Float remains stationary since the vertical forces of differential pressure, gravity, viscosity and buoyancy are balanced. Downward force is constant, since the pressure drop across the float is constant.

Process Setup:

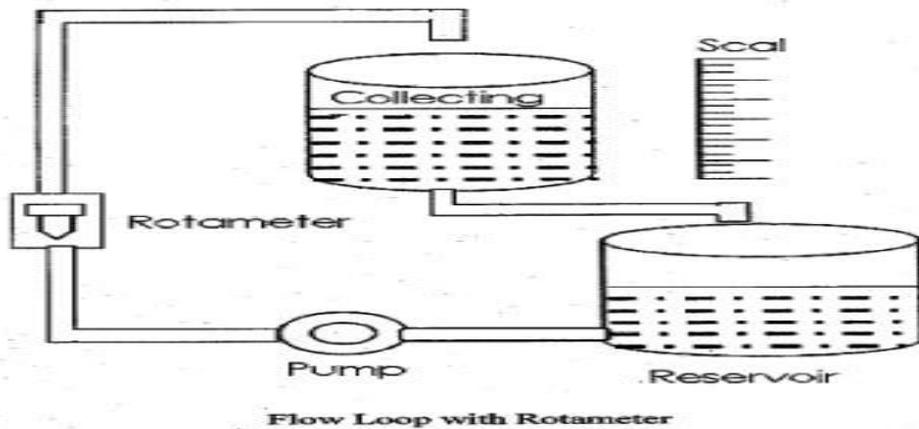


Fig: Flow loop with Rotameter

Procedure:

1. Switch ON the motor.
2. Adjust the rotameter to read the required flow rate.
3. Start the timer.
4. After 5 minutes, note down the head in the tank.
5. Drain the tank.
6. Repeat the procedure & calculate C_d in each case.

Tabular Column:

S. No.	Flow (LPH)	Time (sec)	Head 'h' of water (mm)	Q_{Act} (m^3/sec)	Q_{The} (m^3/sec)	Discharge coefficient C_d	% Error

Formulae used:

$$Q_{Act} = A^2 h / t \text{ (m}^3/\text{sec)}$$

$$Q_{The} = \text{flow rate (lph)} \times 10^{-3} / 3600 \text{ (m}^3/\text{sec)}$$

$$C_d = Q_{Act} / Q_{The}$$

$$\% \text{ Error} = (Q_{The} - Q_{Act}) / Q_{The}$$

Model Calculation:**Result:**

Thus the Rotameter designed for the given specification for measuring flow rate.

Review Questions:

1. Why rotameter is called so?
2. What is discharge coefficient?
3. What is the shape of glass tube in Rotameter?
4. What is the need for mechanical casing in rotameter?
5. What is the other name of rotameter?

Exp. No:7

DESSIGN OF CONTROL VALVE

Aim:

To study the actuator characteristics and control valve characteristics of on – off and equal percentage control valve.

Apparatus Required:

S. No.	Components / Equipments	Specifications	Quantity
1.	Control valve trainer setup	-	1
2.	Air Compressor	(0 – 100)psi	1

Theory:

In most of the industrial process control systems control valve is the final control element.. The control valve consists of two major components, viz. Actuator and Valve. The actuator is made up of flexible diaphragm; spring and spring tension adjustments, plate, stem and lock nut, housing. The valve is made up of body, plug, stem, and pressure tight connection.

The function of a control value is to vary the flow of fluid through the value by means of a change of pressure to the valve top. The relation between the flow through the valve and the valve stem position (or lift) is called the valve characteristic. There are three main types of valve characteristics. The types of valve characteristics can be defined in terms of the sensitivity of the valve, which is simply the fraction change in flow to the fractional change in stem position for fixed upstream and downstream pressures. Mathematically

$$\text{Sensitivity} = \frac{dm}{dx}$$

In terms of valve characteristics, valve can be classified into three types:

1. Linear, 2. Increasing sensitivity, 3. Decreasing sensitivity.

For the **linear type valve** characteristics, the sensitivity is constant and the characteristic curve is a straight line (e.g. linear valve). For increasing sensitivity type, the sensitivity increases with flow. (e.g. Equal percentage or Logarithmic valve). In practice, the ideal characteristics for linear and equal percentage valves are only approximated by commercially available valves. These discrepancies cause no difficulty because the inherent characteristics are changed considerably when the valve is installed in a line having resistance to flow, a situation that usually prevails in practice.

Equal percentage control valve:

Flow changes by a constant percentage of its instantaneous value for each unit of valve lift.

Quick opening control valve:

Flow increases rapidly with initial travel reaching near its maximum at a low lift.

Characteristic of control valve:

Control valve with actuator

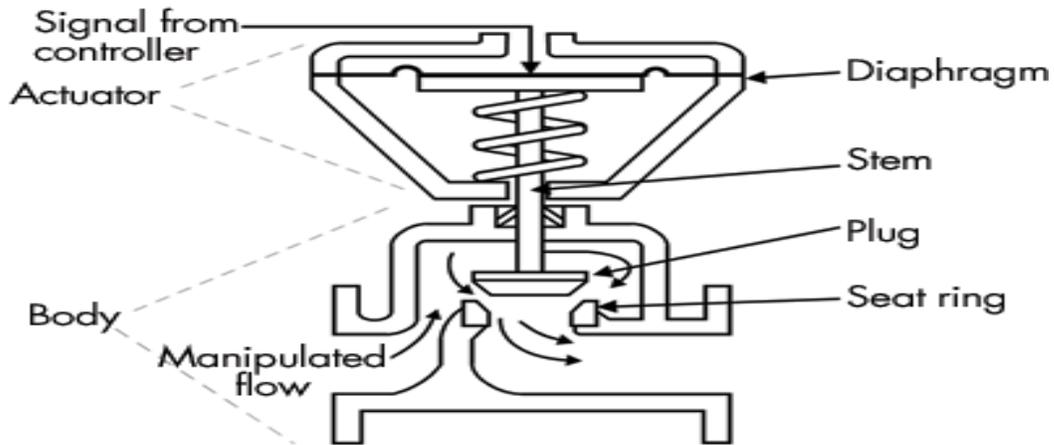


Fig: Control valve with Actuator

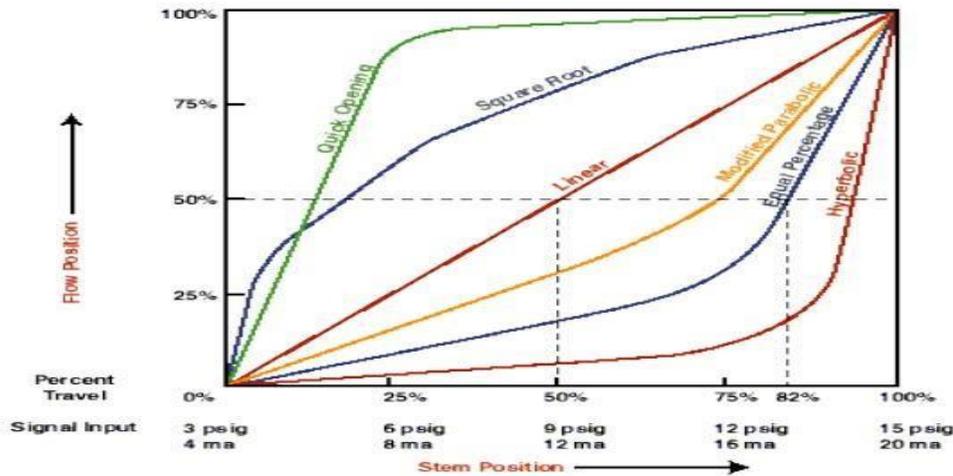


Fig : Control valve characteristics

Precautions:

1. Check the inlet pressure to the air regulator.
2. Don't operate the motor, pump without load
3. Release the air pressure before conducting the experiment.

Procedure:

1. Open the appropriate hand valve for ON/OFF control valve and close all other hand valves.
2. Vary the pressure using the knob provided in the air regulator.
3. Note down the pressure in gauge and corresponding stem movement and flow rate.
4. Reduce the output pressure to zero using the air regulator knob.

5. Release the air in the control valve using the hand valve.
6. Select another control valve and repeat the same procedure.
7. Draw the graph between input pressures to the control valve and stem movement.
8. Draw the graph between input pressures to the control valve and flow rate.
9. Find out the sensitivity of the control valve.

Table 1: ON-OFF control valve (quick opening valve)

S. No.	Input pressure (psi)	Stem movement (mm)	Flow Rate (LPH)	$C_v=Q$

Formula used:

$C_v=Q$ Where, Q-Flow rate in LPH; P-Input pressure in psi;
G- Specific gravity of water.

Table 2: Equal percentage control valve

S. No.	Input pressure (psi)	Stem movement (mm)	Flow Rate (LPH)	$C_v=Q$

Model Calculation:

Result:

Thus the actuator characteristics of the control valves are designed.

Review Questions:

1. What is under sizing of control valve?
2. What is over sizing of control valve?
3. What is the need for monographs in control valve?
4. What is cavitation?
5. What is flashing?

EX.NO:8	DESIGN OF PID CONTROLLER
DATE:	

AIM:

To study the response of P, PI, PD, PID controllers using op amp IC741 and Microprocessor.

DESIGN:**For P controller**

$$G_P = \frac{R_2}{R_1}$$

Assume $R_1 = 1k\Omega$

Given $G_P = 10$

$$10 = \frac{R_2}{1k}$$

$R_2 = 10 k\Omega$

For I controller

$$G_I = \frac{1}{R_1 C_I}$$

Given $G_I = 1000$

Assume $C_I = 0.1\mu F$

$$1000 = \frac{1}{R_I \times 0.1 \times 10^{-6}}$$

$$R_I = \frac{1}{1000 \times 0.1 \times 10^{-6}} = 10K\Omega$$

$R_I = 10K\Omega$

For D controller

$$G_D = R_D C_D$$

Given $G_D = 0.001s$

Assume $C_D = 0.1\mu F$

$$0.001s = R_D \times 0.1 \times 10^{-6}$$

$$R_D = \frac{0.001}{0.1 \times 10^{-6}} = 10K\Omega$$

$R_D = 10K\Omega$

APPARATUS REQUIRED:

1. Op-amp-4no's
2. Resistors -1K Ω (1 no), 10K Ω (7 no's).
3. Capacitors-0.1 μ F(2)
4. Signal generator
5. CRO
6. Connecting wires and Breadboard.

THEORY:**PROPORTIONAL CONTROL**

A controller mode in which the controller output is directly proportional to the error signal.

$$U(t) = MV(t) = K_p * e_p + P_o$$

Where

P is controller output

K_p is proportional gain

e_p is error in percentage of variable range

P_o is controller output with no error (%)

PROPORTIONAL + INTEGRAL CONTROL

This is a control mode that results from a combination of the proportional mode and the integral mode. The analytical expression for this control process is given by

$$U(t) = MV(t) = K_p * e_p + K_p K_i \int_0^t e_p dt + P_i(0)$$

Where

$P_i(0)$ is the integral term

The main advantage of this composite control mode is that the one to one correspondence of the proportional mode is available and the integral mode eliminates the inherent offset.

PROPORTIONAL + DERIVATIVE

Derivative control action combined with proportional gives us a controller which is good on the process having a appreciable lag . Because the process lag can be compensated by the anticipating nature of derivative action, necessary to counteract the time delay associated with such control action.

$$U(t) = MV(t) = k_d * d/dt * e(t) + P_i(0)$$

PROPORTIONAL+INTEGRAL +DERIVATIVE

When all the three effects are combined together we obtain the benefits of each control action of good human operator on a control application. A three mode controller contains the stability of proportional control and ability to eliminate offset, because of reset control and ability to provide immediate correction for the magnitude of disturbance because of rate control. The PID control scheme is named after its three correcting terms, whose sum constitutes the manipulated variable (MV). The proportional, integral, and derivative terms are summed to calculate the output of the PID controller. Defining $u(t)$ as the controller output, the final form of the PID algorithm is:

$$U(t) = MV(t) = K_p * e_p + K_i \int_0^t ep dt + k_d * d/dt * e(t)$$

Where K_p : Proportional gain, a tuning parameter

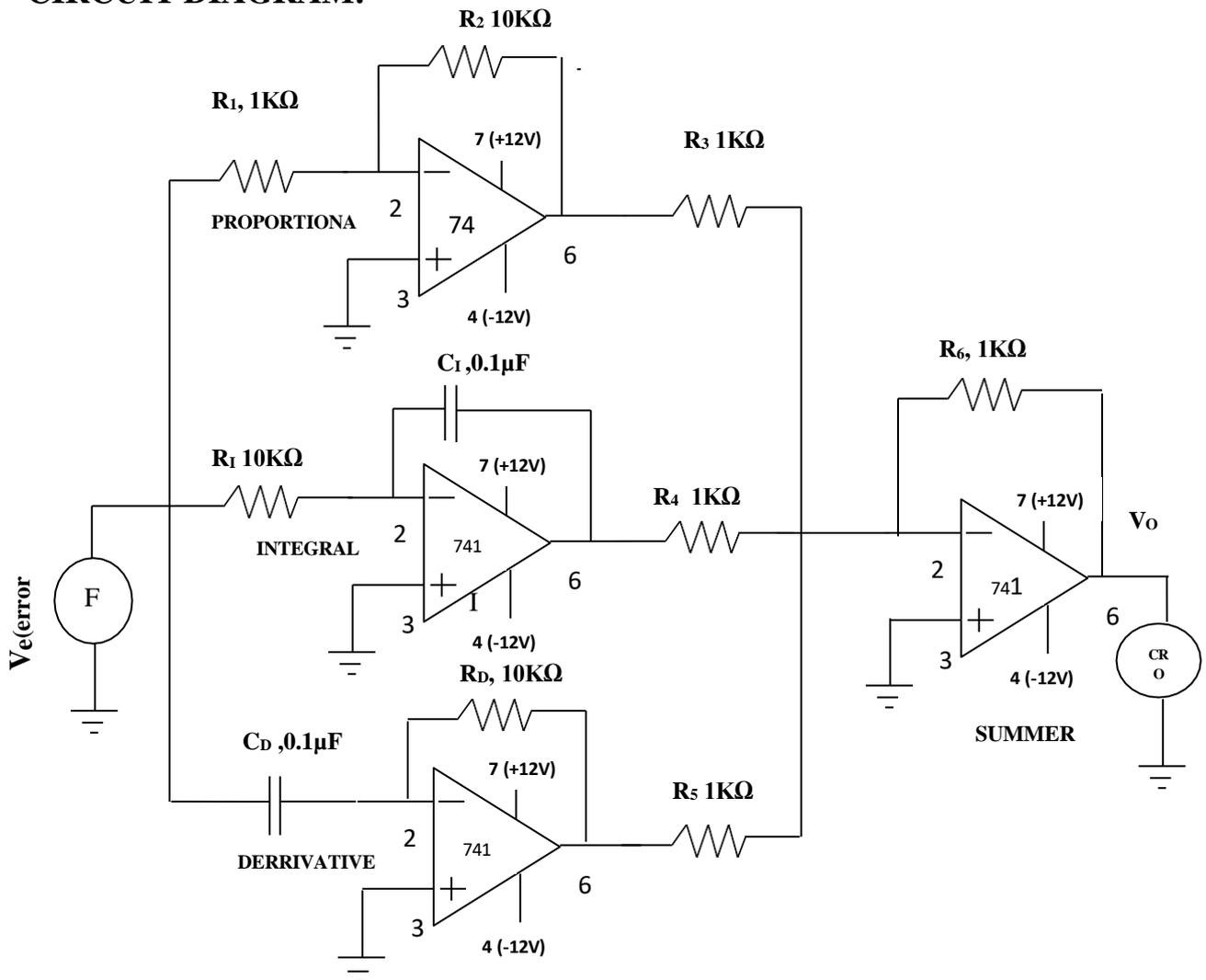
K_i : Integral gain, a tuning parameter

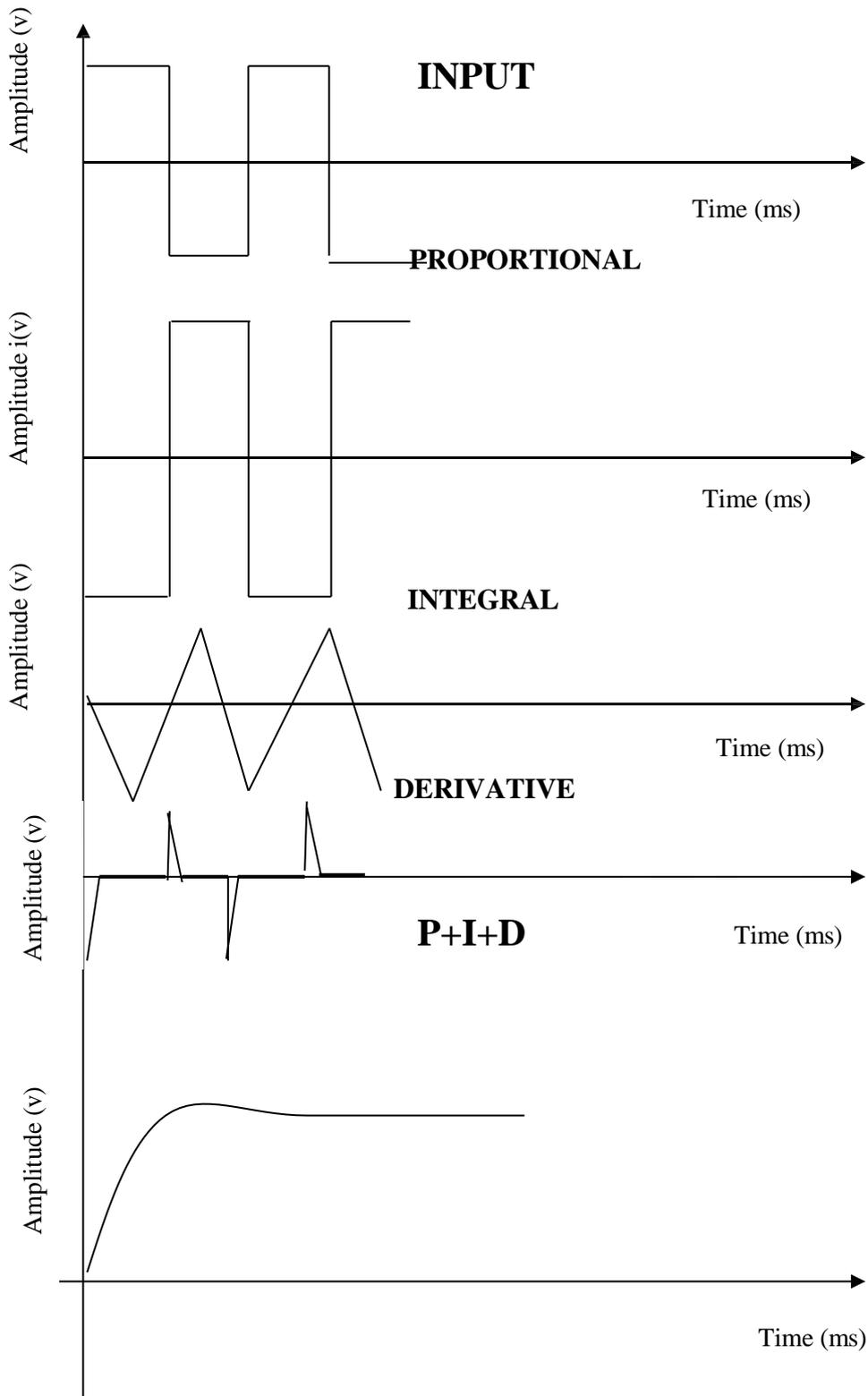
K_d : Derivative gain, a tuning parameter

e : Error = SP – PV

t : Time or instantaneous time (the present)

CIRCUIT DIAGRAM:





TABULATION AND MODEL GRAPH:

Amplitude in volts	I/P	P	I	D	PID
Time period in (ms)					

Procedure:

1. Connections are made as per the circuit diagram.
2. Input error voltage is set in function generator.
3. Output voltage for various modes P,I,D, PID are taken.
4. The output waveforms are traced for various controller modes.
5. Calculations for G_p, G_I, G_D are done using the output voltage obtained practically.
6. Thus the theoretical values of gain G_p, G_I, G_D are verified with practical values of G_p, G_I, G_D .

Using micro controller 8051

Start:

previous_error = error or 0 if undefined

error = setpoint - actual_position

$P = K_p * \text{error}$

$I = I + K_i * \text{error} * dt$

$D = K_d * (\text{error} - \text{previous_error}) / dt$

output = P + I + D

wait(dt)

goto start

Result:

Thus the PID controller was designed for $G_p=10$, $G_I = 1000s^{-1}$, $G_D = 0.001s$ and the controller output was verified for the given error input.

EX.NO:9	DESIGN OF A MULTI-CHANNEL DATA ACQUISITION SYSTEM
DATE:	

AIM

To design a multichannel data acquisition system.

There are two types of DAQ.

1. single channel DAQ
2. Multi channel DAQ

MULTICHANNEL DAQ:

The various subsystem of DAQ system can be time shared by two or more input sources.

The Multichannel analog multiplexed DAQ is shown .It has a single analog to digital converter. This A/D has an input which is selected for multiplexer.

The individual analog signals are applied directly or after amplification and or signal conditioning whenever necessary to multiplexer.

For most efficient utilization of time, multiplexer is made to seek the next channel to be converted. while the previous data stored in sample is converted to digital form.

When the conversion is complete the status line from the converter causes the sample mode and acquires the signal of next channel.

SIGNAL CONDITIONING IN DAQ:

A simple attenuator is used to down the input gains.

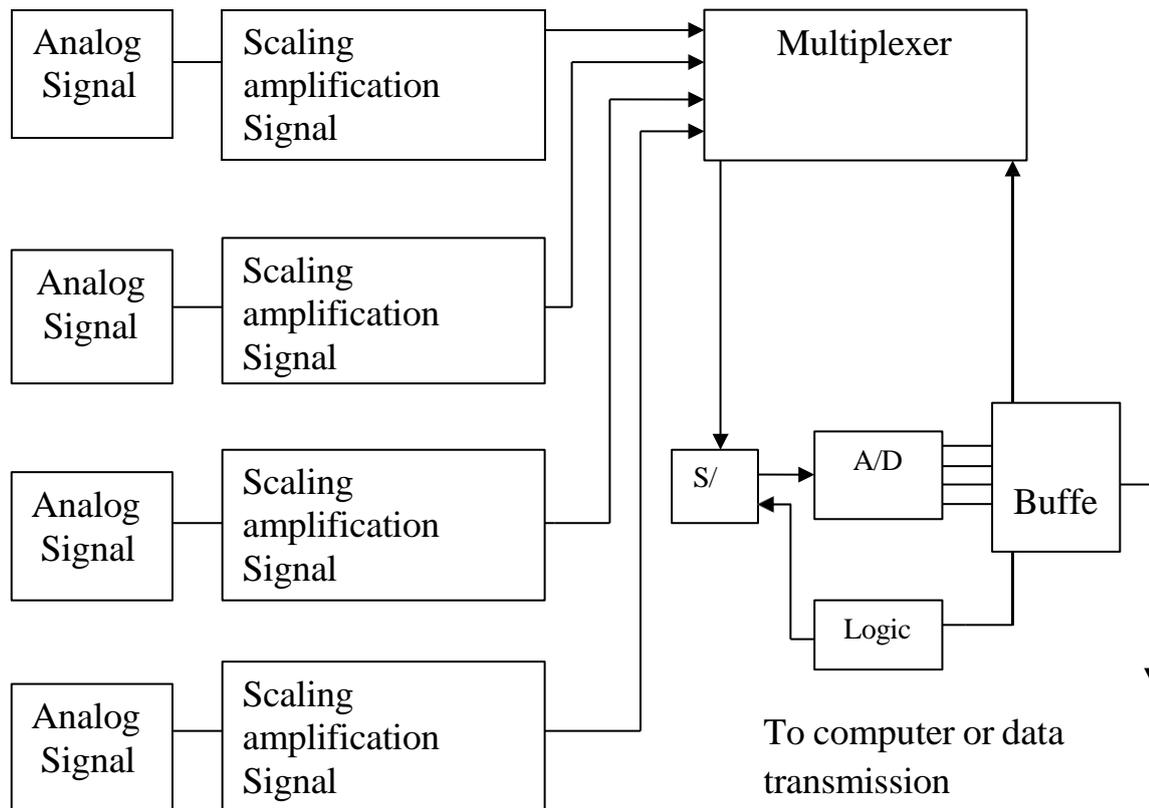
Analog differentiation, precision rectification and averaging, phase detection, log conversion, ratio computing.

There are two methods of signal conditioning are as follows.

- a) Radiometric conversion
- b) Logarithmic conversion

RADIOMETRIC CONVERSION:

If the bridge output is conditioned, in such a way that output of signal amplifier is a voltage proportional to strain only an independent of the excitation voltage, the system accuracy.

CIRCUIT DIAGRAM:**LOGARITHMIC CONVERSION:**

This circuit enables the measurement of a practical change in the input as a percentage of the input magnitude. Consider that a change of 1% (i.e) the input changes from 100mV to 101mV.

Application of DAQ

1. It is used for collecting information.
2. It converts data in to useful form
3. It is used to generate information.
4. It is used in aircraft control system

RESULT:

Thus the design of multichannel data acquisition system is studied.

Exp. No: 10 DESIGN OF MULTIRANGE DP TRANSMITTER

Aim:

To design a multirange Differential Pressure Transmitter.

Apparatus Required:

S. No.	Components / Equipments	Specifications	Quantity
1.	Collecting tank	-	1
2.	DPT setup	-	1
3.	Pump and reservoir	-	1

Theory:

The differential pressure detector method of liquid level measurement uses a differential pressure detector connected to the bottom the tank being monitored. The high pressure, caused by the fluid in the tank, is compared to a lower reference pressure (usually atmosphere).The tank is open to the atmosphere; therefore, it is necessary to use only the high pressure connector on the differential pressure transmitter. With the lower pressure side being open to the atmosphere the differential pressure is the hydrostatic head of the liquid in the tank Most of the tanks are totally enclosed to prevent vapor or steam from escaping, or to allow pressurizing the contents of the tank. In this case both the high pressure and the low pressure sides of the differential pressure transmitter must be connected.

Circuit Diagram:

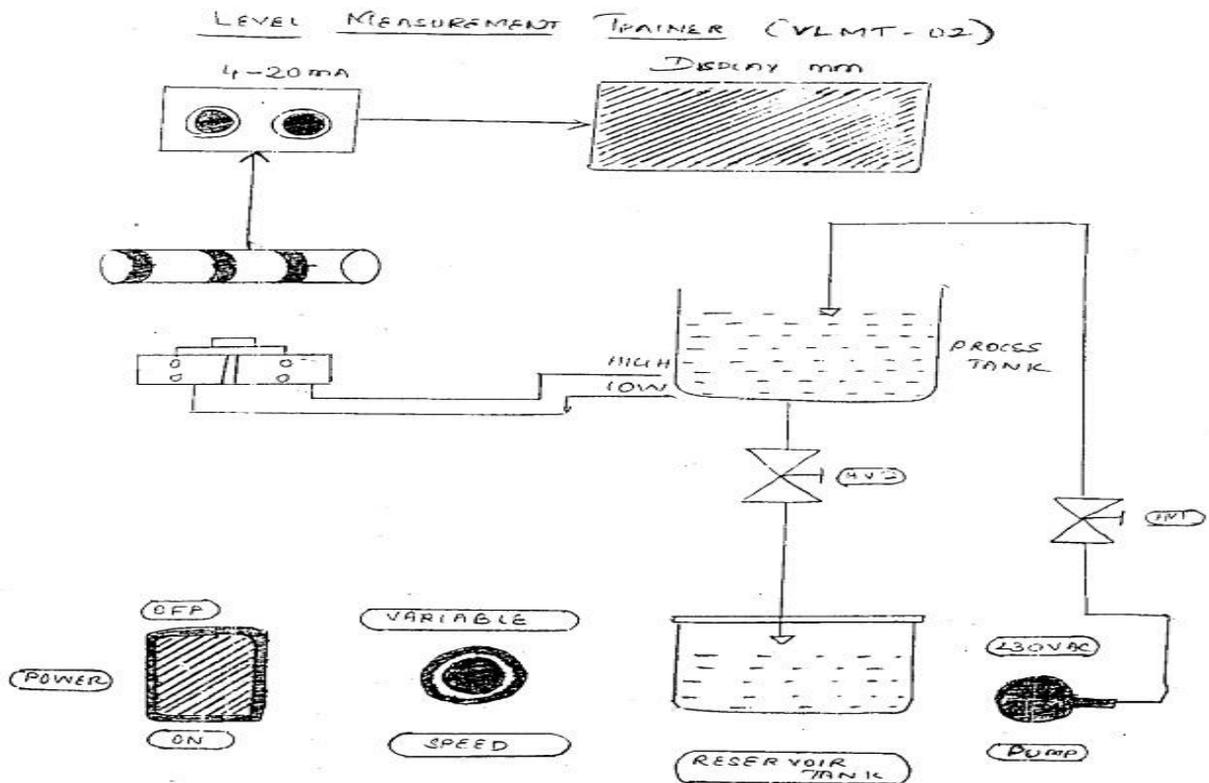


Fig:DPT Trainer Kit Setup

PROCEDURE:

1. Weight the empty container and calibrate the zero level to 4mA.
2. Fill the container with the water and calibrate the full level to 20mA.
3. Now perform the experiment in ascending order in steps of 5cms.
4. Repeat the same procedure for the descending order and tabulate the reading.
5. A graph is plotted between the liquid level and its corresponding current output.

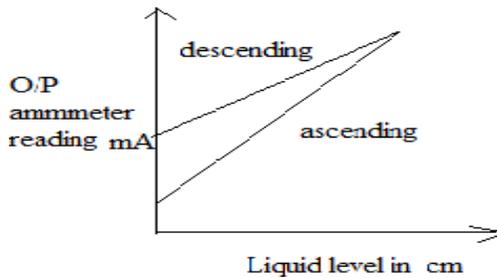
TABULATION:

Table: 1 Ascending Liquid Level Table: 2 Descending Liquid Level

S.No	Liquid level (cm)	DPT output(mA)

S.No	Liquid level (cm)	DPT output(mA)

Model Graph:



Result:

Thus the response of a multirange Differential Pressure Transmitter studied.

Review Questions:

1. What is the principle of DPT?
2. How does DPT measures the liquid level?
3. What is the use of current loop?
4. Why (4-20)mA current loop is mostly preferred?
5. Define differential pressure
6. Name few sensors used for differential pressure measurement.
7. Define (4-20)mA current loop.

EX.NO:11	PIPING AND INSTRUMENTATION DIAGRAM – CASE STUDY.
DATE:	

AIM:

To study the piping and instrumentation diagram.

THEORY:

Process diagrams can be broken down into two major categories: process **flow diagrams** (PFDs) and **process and instrument drawings (P&IDs)**, sometimes called piping and instrumentation drawings. A flow diagram is a simple illustration that uses process symbols to describe the primary flow path through a unit. A process flow diagram provides a quick snapshot of the operating unit. Flow diagrams include all primary equipment and flows. A technician can use this document to trace the primary flow of chemicals through the unit. Secondary or minor flows are not included. Complex control loops and instrumentation are not included. The flow diagram is used for visitor information and new employee training. A process and instrument drawing is more complex. The P&ID includes a graphic representation of the equipment, piping, and instrumentation. Modern process control can be clearly inserted into the drawing to provide a process technician with a complete picture of electronic and instrument systems. Process operators can look at their process and see how the engineering department has automated the unit. Pressure, temperature, flow, and level control loops are all included on the unit P&ID.

Basic Instrument Symbols:

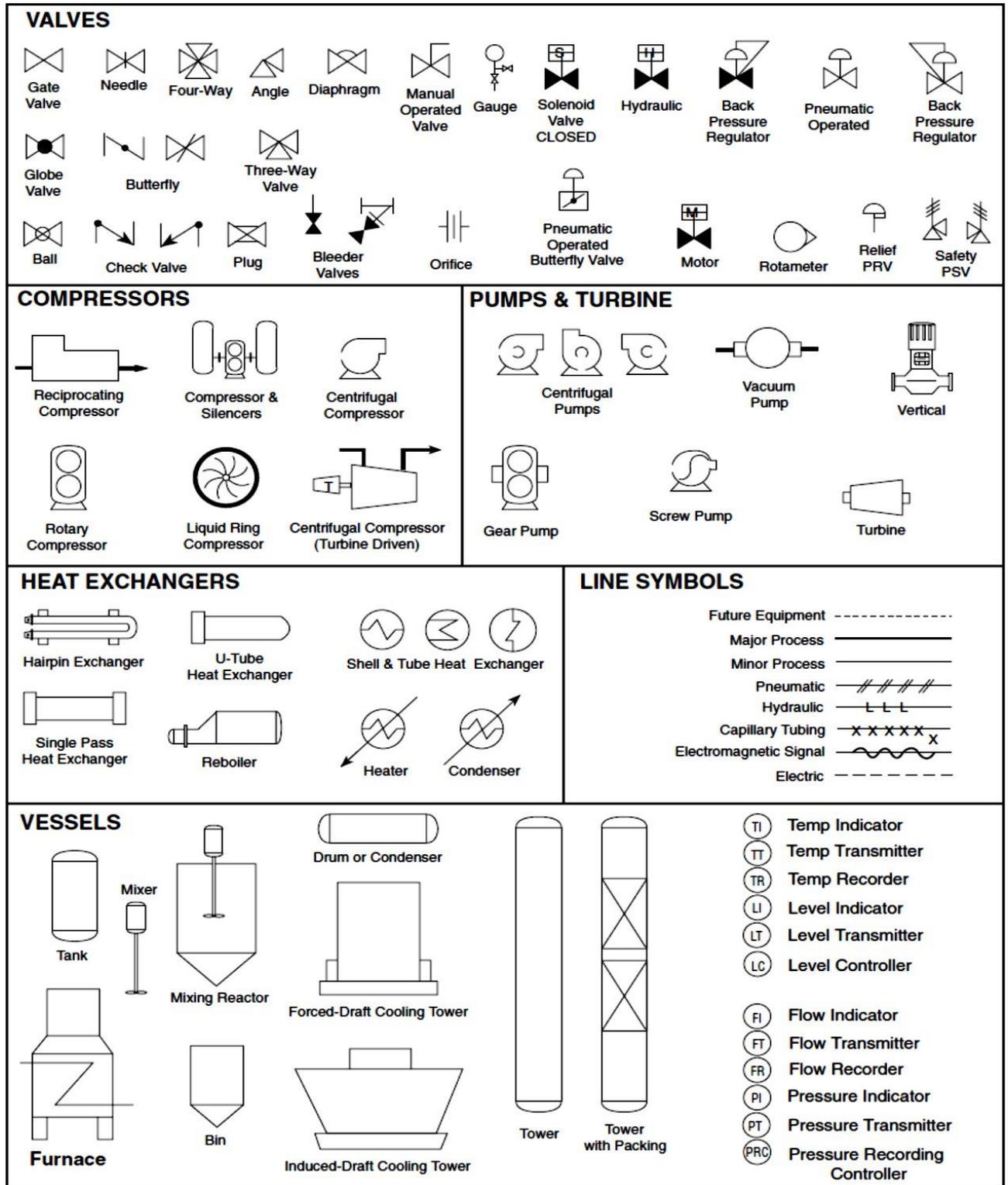


Fig.1 - Process and Instrument Symbols

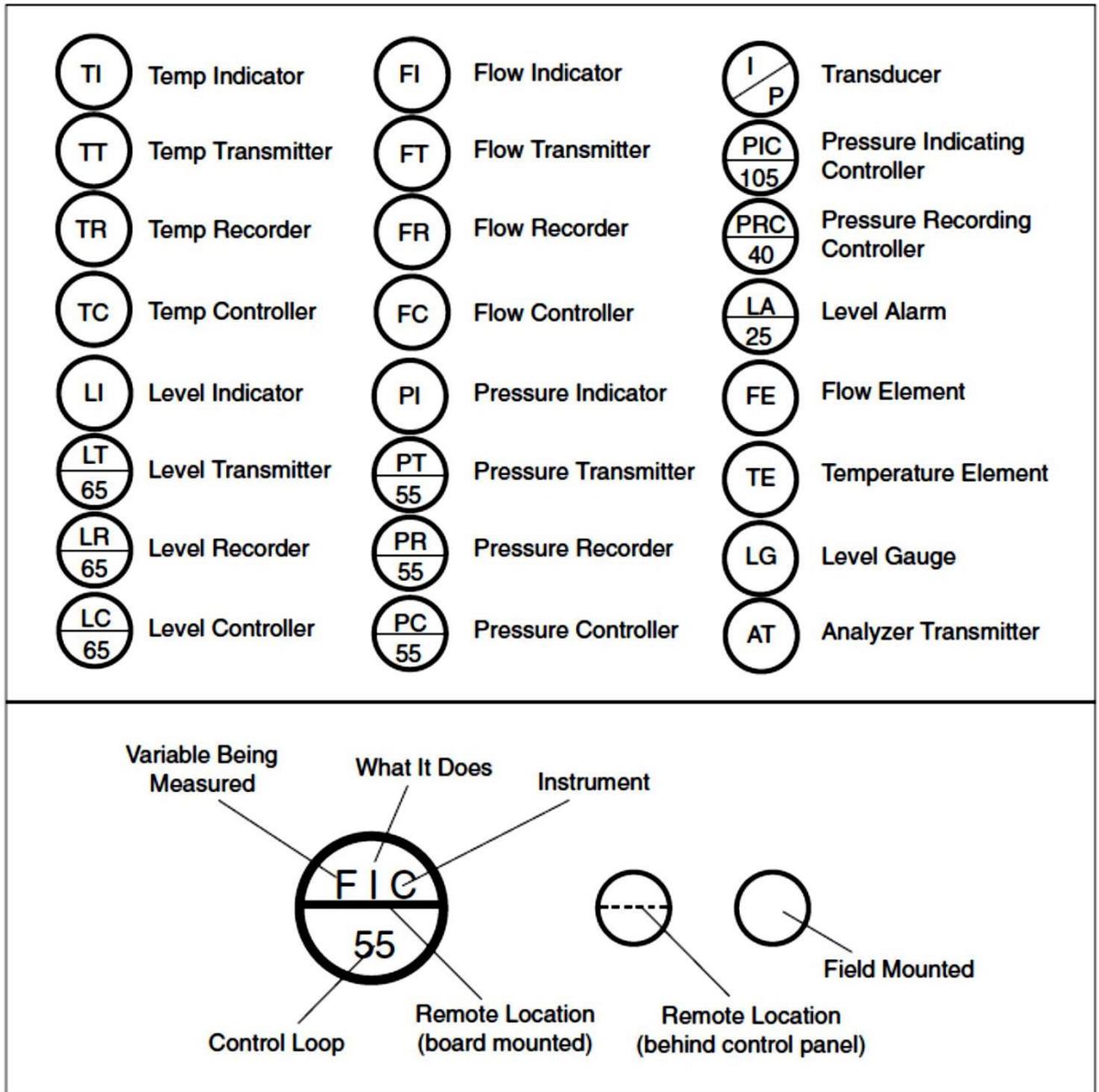


Fig 1 - Process and Instrument Symbols

Process technicians use P&IDs to identify all of the equipment, instruments, and piping found in their units. New technicians use these drawings during their initial training period. Knowing and recognizing these symbols is important for a new technician. The chemical processing industry has assigned a symbol for each type of valve, pump, compressor, steam turbine, heat exchanger, cooling tower, basic instrumentation, reactor, distillation column, furnace, and

boiler. There are symbols to represent major and minor process lines and pneumatic, hydraulic, or electric lines, and there is a wide variety of electrical symbols.

Case Study

Flow Diagrams

New technicians are required to study a simple flow diagram of their assigned operating system. Process flow diagrams typically include the major equipment and piping path the process takes through the unit. As operators learn more about symbols and diagrams, they graduate to the much more complex P&IDs. Some symbols are common among plants; others differ from plant to plant. Some standardization of process symbols and diagrams is taking place. The symbols used in this chapter reflect a wide variety of petrochemical and refinery operations. The PFD that shows the basic relationships and flow paths found in a process unit. It is easier to understand a simple flow diagram if it is broken down into sections: feed, preheating, the process, and the final products. This simple left-to-right approach allows a technician to identify where the process starts and where it will eventually end. The feed section includes the feed tanks, mixers, piping, and valves. In the second step, the process flow is gradually heated for processing. This section includes heat exchangers and furnaces. In the third section, the process is included. Typical examples found in the process section could include distillation columns or reactors. The process area is a complex collection of equipment that works together to produce products that will be sent to the final section.

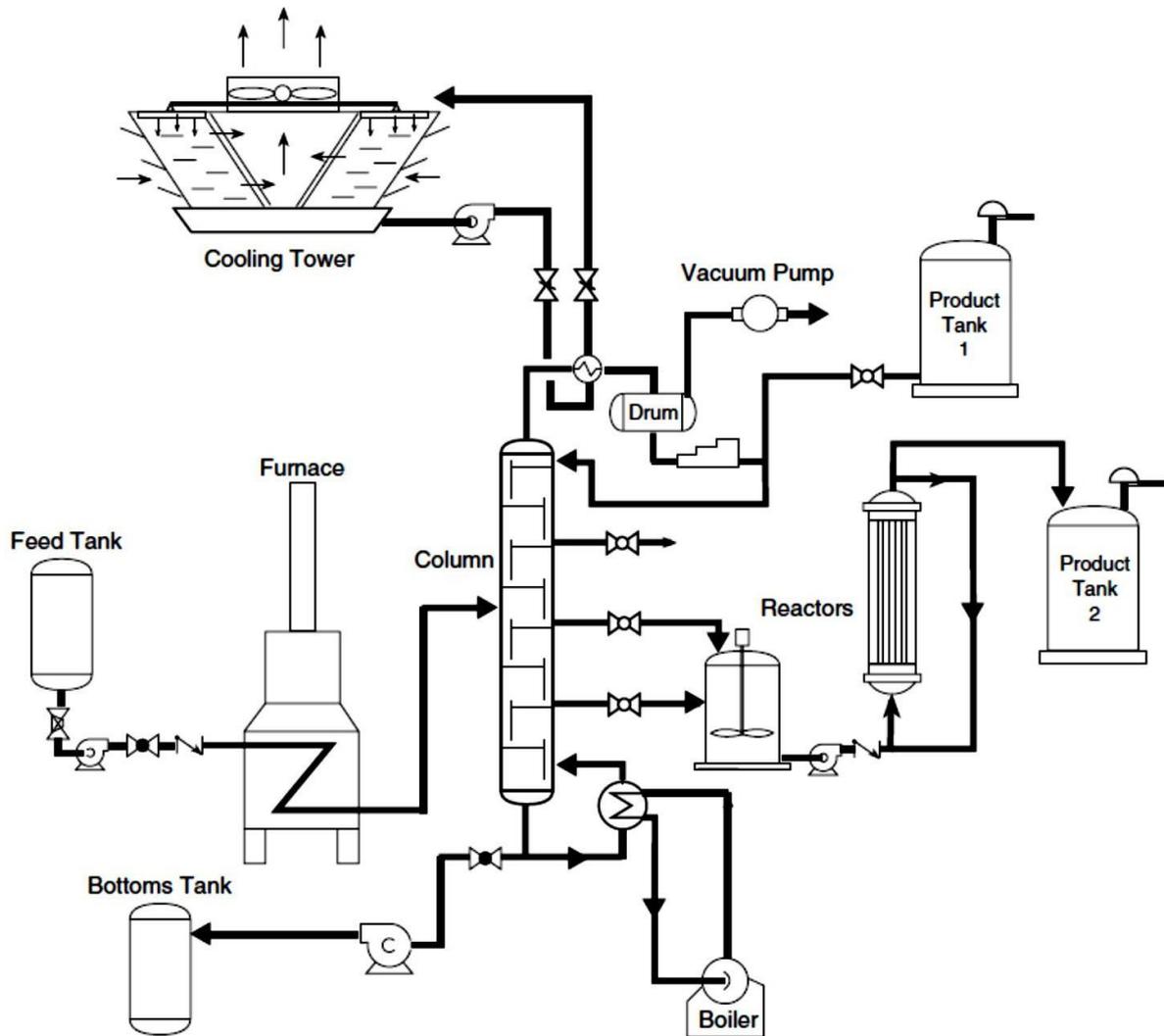


Fig 2 - Process Flow Diagram (PFD)

Process and Instrument Drawings

A P&ID is a complex representation of the various units found in a plant. It is used by people in a variety of crafts. The primary users of the document after plant startup are process technicians and instrument and electrical, mechanical, safety, and engineering personnel. In order to read a P&ID, the technician needs an understanding of the equipment, instrumentation, and technology. The next step in using a P&ID is to memorize your plant's process symbol list. This information can

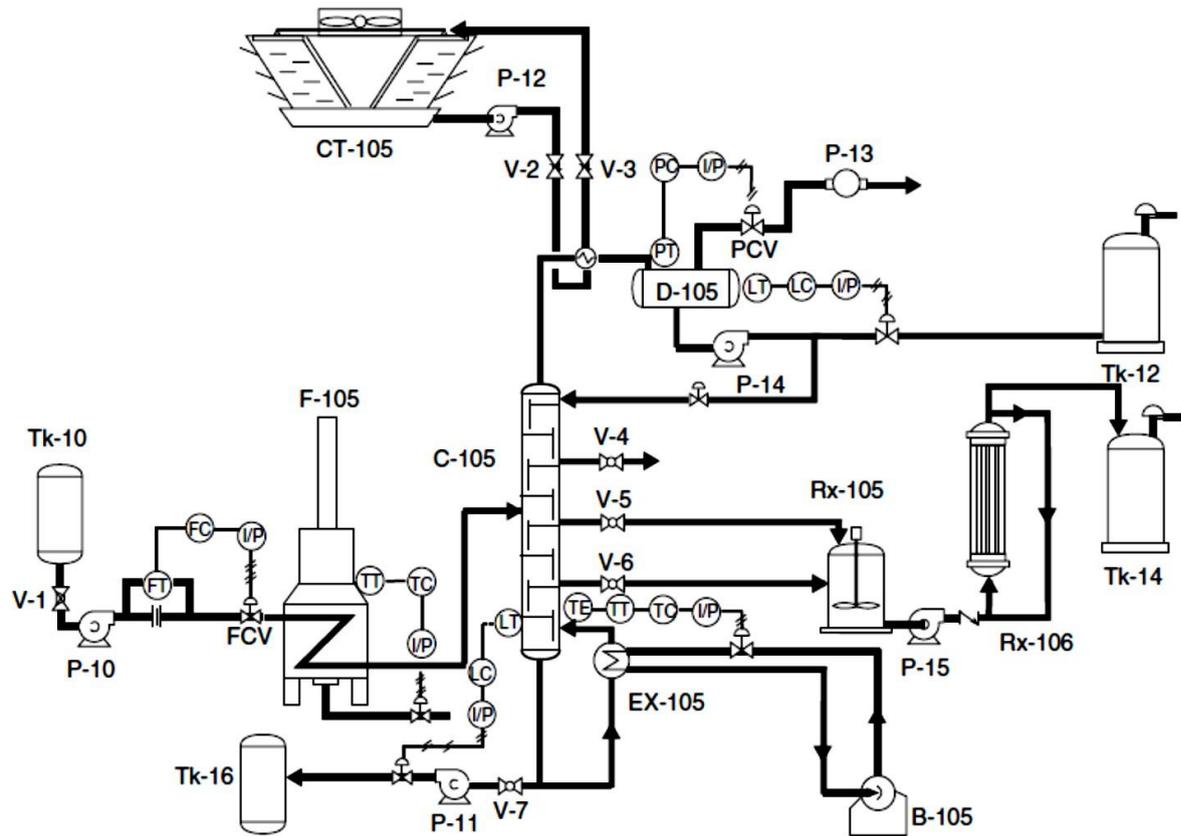


Fig 3 - Process and Instrument Diagram (P&ID)

be found on the process legend. Process and instrument drawings have a variety of elements, including flow diagrams, equipment locations, elevation plans, electrical layouts, loop diagrams, title blocks and **legends**, and **foundation drawings**. The entire P&ID provides a three-dimensional look at the various operating units in a plant.

RESULT:

Thus the piping and instrumentation diagram was drawn and studied.

EX.NO:12	PREPARATION OF DOCUMENTATION OF INSTRUMENTATION PROJECT AND PROJECT SCHEDULING FOR THE ABOVE (CASE STUDY)
DATE:	

AIM:

To steady the steps required to schedule a new project.

THEORY:

Commissioning of a platform of a new plant by one of the following ways.

- Execution and commissioning of a new plant.
- Renovating new plant.

Execution and Commissioning of a new project involves mapping customer needs, working out and fixing a system suitable based on the available fuel, turbine selection, preparation of front end engineering, mass plant layout, control schemes, engineering vendor sourcing, manufacturing inspection plan, project scheduling etc.

In case of old plant renovation, careful study of the excising layout, analysis of operation of log sheets of residual type is required.

Assessment of plant is carried out to enable and conclude necessary, upgrade equipment necessary for renovation.

Renovation and modernization of existing power plant

- Improvement based on change of fuel capacity, enhancement and efficiency improvement.
- Solution based solving system to solve temperature problems, repeated failure in particular ratio to remove ratio limitations.
- Control and instruments modernization consultant and provides servicing in the following sectors.
- Engineering studies:
 - * Conduct product flexibility studies.
 - * Engineering analysis for trouble shooting.
 - * Conductivity assessment and removing type analysis.
 - * Solid modeling of equipment assembly.

Engineering assignment:

- Vendor selection and sourcing of materials, executive follow up for scheduled job completion. Third party inspection for power plant equipment, lower target prize for the plant equipment based on preparation and project specification to be prepared.
- Spare sourcing

Advantages:

Consultant assures the following benefits.

- Proven performance
- Complete solution covered in package.
- Suitable for latest pollution norms
- Faster execution
- Minimum initial instrument.

The consultant studies all the minute details before offering the best suitable option proposed with alternatives and suggestions for customer assessment.

Typical project execution steps conceptualization:

Where design basic operating load causes and I schemes and M requirements, site setup, skilled and semi-skilled labor apart from market situation are assessed and planned.

Engineering:

Where equipment sizing, layout pipeline sizing, engineering equipment generating a valid schedule and foundation and data generation part of the project and assessed.

Project assurance plan:

Working out quality assurance plan for a raw material, inspecting bought out items, test and run witness review of equipment.

Execution:

Deciding execution, sequence identifying, Parallel plants, schedule its man power required.

RESULT:

Thus the steps involved in project scheduling were studied.

ADDITIONAL EXPERIMENT

EX.NO:13	DESIGN AND IMPLEMENTATION OF SIGNAL
DATE:	CONDITIONING CIRCUIT FOR RTD USING INSTRUMENTATION AMPLIFIER

AIM

To design a signal conditioning circuit to RTD. The specifications are as follows:

Temperature range: 30C-100C (approximately)

Output voltage range: 0-5VDC.

Sensor: RTD (Pt 100).

Current through RTD: Not to exceed 0.01469A

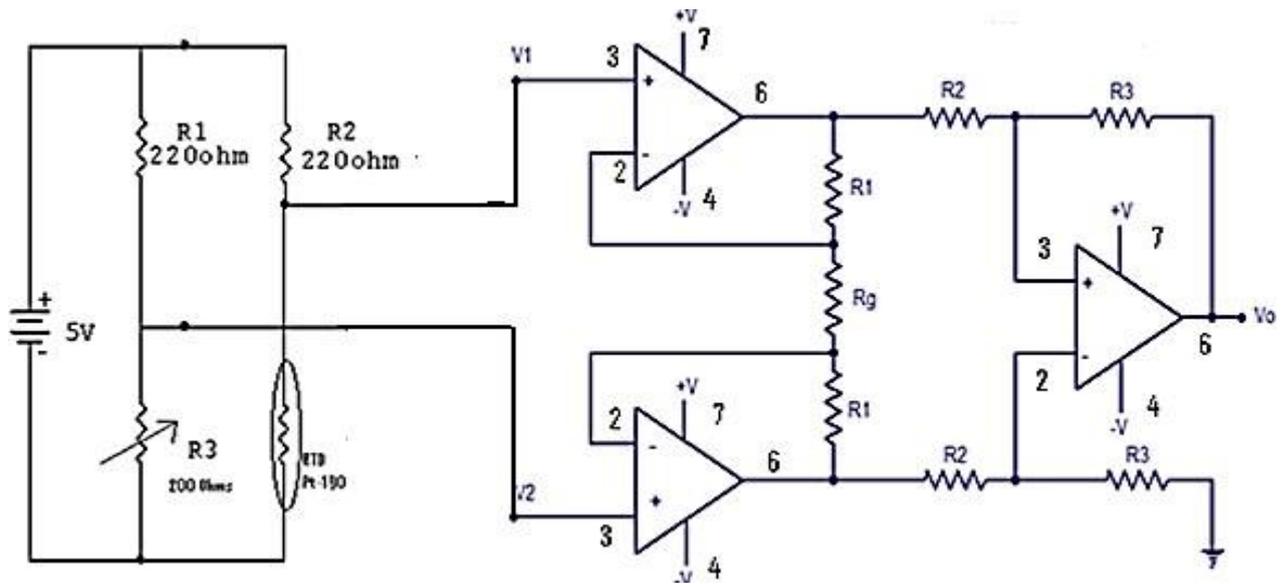
APPARATUS REQUIRED

1. Op-amp-2 No's
2. Resistors-- 220 Ω -4, 1k-5,19.2k-1
3. Variable resistor (1K) -1
4. Power supply 0-30v,+/-12v
5. Voltmeter (0-30)v
6. Bread board and connecting wires.

THEORY

Water flows through a pipe which is immersed in another hot liquid, a control systems is to regulate the water temperature by controlling the flow. For this purpose it is required to measure the temperature in range from 30°C to 100°C using RTD. A control system will regulate the water temperature so a measurement must be provided to convert 30°C to 100 °C into 0 to 5 volts using Pt – 100. The error due to self heating of the RTD should not exceed 1°C. Power dissipation constant(P_D) of RTD is 30 mW/°C.

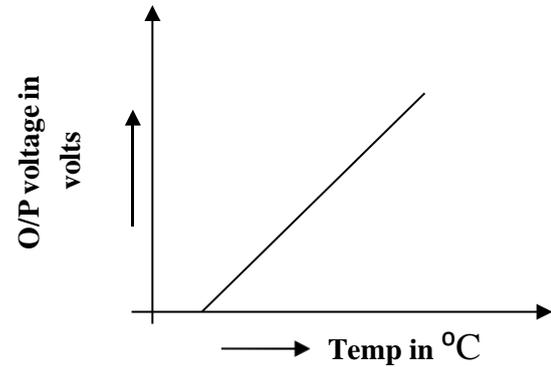
CIRCUIT DIAGRAM:



TABULAR COLUMN

S.No	Temperature in °C	Bridge o/p in volts	Output voltage in volts
1	30		
2	50		
3	60		
4	75		
5	100		

MODEL GRAPH



PROCEDURE

1. Connections are made as per the circuit diagram.
2. Note down the o/p voltage of 0v at 30°C.
3. Note down the bridge o/p voltage and amplifier o/p voltage for every 10°C rise in temperature.
4. Plot the graph for temp Vs o/p voltage.

RESULT

Thus the signal conditioning circuit for RTD using instrumentation amplifier is designed and implemented.

VIVA QUESTIONS AND ANSWERS

EX.NO 1 DESIGN OF INSTRUMENTATION AMPLIFIER.

1. What is the need for an instrumentation amplifier?

In a number of industrial and consumer applications, the measurements of physical Quantities are usually done with the help of transducers. The output of transducer has to be amplified So that it can drive the indicator or display system. This function is performed by an instrumentation amplifier.

2. List the features of instrumentation amplifier:

- High gain accuracy
- High CMRR
- High gain stability with low temperature co-efficient
- Low dc offset
- Low output impedance

3. What is meant by instrumentation amplifier?

The special amplifier which is used for such a low level amplification with high CMRR, high input impedance to avoid loading, low power consumption and some other features is called an instrumentation amplifier. It is also called data amplifier and is basically a difference amplifier.

4. What are the applications of Instrumentation amplifier?

1. Temperature controller.
2. Light intensity meter.
3. Analog weight Scale.
4. Temperature indicator

5. What are the requirements of good instrumentation amplifier?

1. Finite, accurate, and stable gain.
2. Easier gain adjustment.

3. High Input impedance.
4. Low output impedance.
5. High CMRR.
6. Low power consumption.
7. Low thermal and time drifts.
8. High slew rate.

EX.NO 2 DESIGN OF FIRST AND SECOND ORDER FILTER

1. Define Filter.

A filter is a circuit that is designed to pass a specified band of frequencies while attenuating all the signals outside that band. It is a frequency selective circuit.

2. Define cut off frequency.
3. List the application of LPF,HPF and BPF

4. What is a state variable filter?

It uses three or four Op-Amps & provides low pass, high pass, band pass & notch Filter characteristics simultaneously. Problems such as noise, transients, contact bounce, are eliminated.

EX.NO 3 DESIGN OF REGULATED POWER SUPPLY

1. What are the components of a basic voltage regulator?

- (i) Voltage reference
- (ii) Error amplifier
- (iii) Feedback network.
- (iv) Active series or shunt control element.

2. What are the advantages of IC voltage regulators?

- (i) Easy to use.
- (ii) It greatly simplifies power supply design.

- (iii) Due to mass production, low in cost.
- (iv) Versatile.
- (v) Used for local regulation.

3.State some important features of IC 723.

- (i) Input & output short circuit protection is provided.
- (ii) It has good line & load regulation.
- (iii) Low standby current drain.
- (iv) Smaller size, lower cost.
- (v) Low temperature drift & high ripple rejection.

4. What are the important blocks of IC 723?

- (i) Temperature compensated voltage reference source.
- (ii) An OpAmp circuit used as an error amplifier.
- (iii) A series pass transistor capable of 150mA output current.
- (iv) Transistor used to limit output current

5. State any three applications of IC723.

- Basic low voltage regulator.
- Low voltage high current regulator.
- Negative voltage regulator.

6. What is the protection circuits used in regulators?

- Constant current limiting
- Foldback current limiting
- Over voltage protection
- Thermal shutdown.

7. What are the advantages of LM 317 regulator over fixed voltage regulator?

- Improved line & load regulation by a factor of 10 or more.
- Improved reliability for the power supply.
- Improved overload protection i.e., greater load current can be drawn over the given operating temperature range.

8. What are the limitations of LM 317 linear voltage regulators?

- The required input transformer is bulky & expensive.
- Due to low line frequency, large values of filter capacitors are required.
- Input must be greater than output voltage.
- For higher input voltages, efficiency decreases.

9. What are the types of switching regulators?

Switched mode regulator.

Switched mode converter.

10. How the current boosting is achieved in an IC 723?

The maximum load current of IC 723 is 150mA .If the current is to be boosted then external resistor Q1 is connected to the output terminal.

11. Mention some switched capacitor filter IC's.

1. MF5-Universal second order filter
2. MF6-Unity gain sixth order Butterworth LP filter.
3. MF8-Two second order BP filter.
4. MF10- State variable filter IC.

E.NO 3(B)DESIGN AND IMPLEMENTATION OF V/I AND I/V CONVERTERS.

1. What are the types of V/I converter.

1. Floating type.
2. Grounded type.

2. Write the applications of V-I Converter.

1. Low Voltage D.C Voltmeter.
2. Low Voltage A.C Voltmeter.
3. Zener diode tester
4. Diode tester and Match filter.

3. Write the applications of I- V Converter.

4. Why (4-20)mA range is used for conversion?

EX.NO 5 (A)DESIGN OF SIGNAL CONDITIONING CIRCUIT FOR STRAIN GAUGE.

1. Define stress.

When an external force acts on a body, it undergoes deformation. At the same time the body resists deformation. The magnitude of the resisting force is numerically equal to the applied force. This internal resisting force per unit area is called stress.

$$\text{Stress} = \text{Force}/\text{Area}$$

2. Define strain

When a body is subjected to an external force, there is some change of dimension in the body. Numerically the strain is equal to the ratio of change in length to the original length

$$\text{Of the body.} = P/A \text{ unit is } N/\text{mm}^2$$

$$\text{Strain} = \text{Change in length}/\text{Original length}$$

$$e = \Delta L/L$$

3. State Hooke's law.

It states that when a material is loaded, within its elastic limit, the stress is directly proportional to the strain.

4. Define shear stress and shear strain.

The two equal and opposite force act tangentially on any cross sectional plane of the body tending to slide one part of the body over the other part. The stress induced is called shear stress and the corresponding strain is known as shear strain.

5. Define Poisson's ration.

When a body is stressed, within its elastic limit, the ratio of lateral strain to the longitudinal strain is constant for a given material.

Poisson' ratio (μ or $1/m$) = Lateral strain /Longitudinal strain.

6. State the relationship between Young's Modulus and Modulus of Rigidity.

$$E = 2G (1+1/m)$$

Where,

E - Young's Modulus

K - Bulk Modulus

$1/m$ - Poisson's ratio

7. Define strain energy.

Whenever a body is strained, some amount of energy is absorbed in the body. The energy which is absorbed in the body due to straining effect is known as strain energy.

8. What is resilience?

The total strain energy stored in the body is generally known as resilience.

9. State proof resilience.

The maximum strain energy that can be stored in a material within elastic limit is known as proof resilience.

10. Define – Young's modulus.

The ratio of stress and strain is constant within the elastic limit.

$$E = \text{Stress/Strain}$$

11. Define Bulk-modulus.

The ratio of direct stress to volumetric strain.

$$K = \text{Direct stress}$$

Volumetric strain

12. Define- lateral strain.

When a body is subjected to axial load P. The length of the body is increased. The axial deformation of the length of the body is called lateral strain.

13. Define- longitudinal strain.

The strain right angle to the direction of the applied load is called lateral strain.

EX.NO 6 DESIGN OF ORIFICE PLATE AND ROTAMETER.

1. What is Rotameter?

It is an example of variable area flow meter. When fluid enters lopped moves from the Bottom to top. Distance is proportional to the flow rate.

2. List some example of inferential flow meter.

Turbine flow meters

Target flow meters

Ultrasonic flow meters.

3. Mention some temperature sensor.

Thermocouple

Thermistor

RTD

RTD

4. What are the different types of orifice?

Concentric orifice, Eccentric, Segmental, Quadrant edge

5. Define concentric orifice?

It has a circular hole in the middle and is installed in the pipe line with the hole concentric to the pipe. Its thickness depends upon pipe line size.

6. Define eccentric.

It is installed in with the bore tangential to the upper surface of the pipe, it is used where the liquid contains a relatively high % of dissolved gases.

7. Define segmental.

Its hole diameter is 98% of pipe diameter. It is installed with a curved section of the opening coincident with the lower surface of the pipe.

8. Define quadrant.

Edges is rounded to form a quarter circle. Used for the flow of heavy crudes and slurry and Viscous flows.

9. what are the different tapping of orifice?

Flange tap, Pipe tap , Venacontracta tap

10. Give the details about flange tap.

Located one inch either side of orifice plate.

Pressure difference is an integral part of the orifice.

11. Give the details about pipe tap.

Located pipe diameter from the orifice.

Only the permanent pressure difference across the orifice is utilized.

12. Give the details about vena contracta tap.

Downstream pressure tap is located variable distance from the orifice.

Pressure difference is maximum for the given flow.

13. List the advantages of the orifice plate

Used in wide range of pipe sizes

Used with pressure differential device.

Available in many materials

14. List the disadvantages of the orifice plate.

- High permanent pressure loss
- Reduces the use in slurry services
- Accuracy depends on the care during installation.
- It has the square root characteristics.

EX.NO 8 DESIGN OF PID CONTROLLER (USING OPERATIONAL AMPLIFIER AND MICROPROCESSOR).

1. What is a First Order System?

The input and output relationship of a control system can be expressed by a differential equation. The order of the system is given by the order of the differential equation governing the system. If the system is governed by n^{th} order differential equation, then the system is called n^{th} order system. For a first order system the order of the equation is one.

2. What is a second order system?

The input and output relationship of a transfer function is given by a differential equation. The order of the system is given by the order of differential equation governing the system. If the order of the differential equation is two then the system is called second order system.

3. What is damping?

Damping is any effect that tends to reduce the amplitude of oscillations in an oscillatory system.

4. What is damping ratio?

This is defined as the ratio of the actual damping to the critical damping. Output $C(s)$ of a second order system depends on the value of damping ratio (η).

5. What is a transfer function?

Transfer function of a linear time invariant continuous system is defined as ratio of Laplace of output variable / Laplace of input variable with all initial conditions taken to be zero.

6. What is Delay Time?

It is the time taken for the response of a second order system to reach 50% of the final value, for the very first time.

7. What is rise time?

It is the time taken for the response of a second order system to rise from 0 to 100% for the very first time.

8. What is peak time (t_p)?

It is the time taken for the response to reach the peak value for the very first time

9. What is peak overshoot?

It is defined as the ratio of the maximum peak value measured from initial value to final value.

10. What is settling time?

It is defined as the time taken by the response to reach and stay within a specified error.

11. What is time constant?

It is an alternative measure for settling time. It is the time required by the system response decay to 37 % of its initial value or time to reach 63 % of the final value in response to a fixed change in input.

12. What is the use of a controller?

A controller is used to achieve a better control action by modifying the difference signal $E(S)$.

13. What is proportional controller?

Proportional controller produces an actuating output, which is proportional to the error signal.

14. What are the advantages of proportional controller?

(i) Relative stability of the system is improved

(ii) Noise signal rejection is better

(iii) Accuracy of steady state tracking is improved.

(iv) As loop gain increases sensibility of system to parameter variations decreased.

14. What are the disadvantages of proportional controller?

It produces steady state error.

15. What is steady state error?

It is defined as the difference between the ideal and final values of the system output after the transient has expired.

16. What is a PI controller?

A PI controller is one which produces an actuating output, which is proportional to two terms, they are, (i) Error signal (ii) Integral of error signal.

17. What are the drawbacks of PI controller?

PI controller needs special provisions to remove integral wind up.

18. What is a PID controller?

i) Proportional to error

ii) Proportional to Integral of error.

iii) Proportional to derivative of error.

19. what is an anticipatory controller?

The PID controller is also called the anticipatory controller as it can anticipate future errors with the knowledge of the current error

87. what is a Ladder Diagram?

The ladder diagram serves as a basis for writing programs for a PLC. The ladder diagram reflects a conventional wiring diagram which shows the physical arrangement of various components used.

EX.NO 9 DESIGN OF A MULTI-CHANNEL DATA ACQUISITION SYSTEM.

1. What is meant by acquisition?
2. How will you select DAQ for any application?
3. What is interfacing?
4. What is serial and parallel interfacing?
5. What are all the serial communication protocol available ?

EX.NO 10 DESIGN OF MULTI RANGE DP TRANSMITTER.

1. what is DPT?
2. Define pressure
3. What are the devices used for measuring pressure?
4. Name some low and medium pressure measuring devices.
5. Define vacuum.
6. What is meant by absolute pressure?
7. What is meant by gauge pressure?

EX.NO 11 & 12 PIPING AND INSTRUMENTATION DIAGRAM – CASE STUDY**1. what are the four fundamental instructions used in PLC program?**

- i) LD, LDI – input loaded or inverted loaded before it is read in the accumulator.
- ii) AND, ANI – AND & AND inverse instruction
- iii) OR, ORI – OR & OR inverse instruction
- iv) OUT – instruction output A to the output memory register.

2. what is a DCS?

A Distributed control system is one which utilizes microprocessor based Controllers and data acquisition modules housed in cabinets at the process stations which can be controlled at a central place.

3. Advantages of DCS:

- i) Good scalability and expandability

- ii) Control capability is digitized
- iii) Non-occurrence of single point failure.
- iv) Low cost maintenance

4. What is a Process?

A Process denotes an operation or series of operations. A Process can be described by either an Ordinary differential equation (lumped parameter system) or by partial differential equation (Distributed parameter system).

5. Define Set point Variable.

Set point variable is set by the operator, master controller (or) computer as a desired value. It is also sometimes called as 'reference variable'.

6. Define Manipulated Variable.

Manipulated Variable is the one that can be changed in order to maintain the controlled Variable at the set point value.

7. Define Controlled Variable.

Controlled Variable is the one that must be maintaining precisely at the set point.

8. Define Load Variable.

Load Variables (or) Load disturbances are those variables that cause disturbances in the Process, which may change either continuously (or) instantaneously with some function of time.

9. Mention some application areas where there is need for automatic process control.

Automatic Process control devices are used in almost every phase of industrial Operations.

10. Define Proportional Gain.

The adjustable parameter of the proportional mode K_P is called the Proportional gain or proportional sensitivity.

11. Define Proportional Band.

The range of error to cover the 0% to 100% controller output is called the proportional band because the one to one correspondence exists only for errors in this range.

12. Define Integral time.

Integral time is defined as the time of change of manipulated variable caused by a unit change of deviation.

13. Define Derivative time or Define Differential time.

Derivative time (or Differential time) is the time interval by which the rate of action advances the effect of proportional action.