INSTRUMENTATION

LAB MANUAL

B. Tech IV Year - I Semester

NAME : ____________________________

ROLL NO : ____________________________

BRANCH : ____________________________

DEPARTMENT OF
MECHANICAL ENGINEERING

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CONTENTS

I N T R O D U C T I O N

Introduction to Transducers and Measurement systems:

Transducer: Transducer is a device which converts one form of energy into another form like Electrical to Mechanical, Mechanical to Electrical, Thermal to Electrical and etc.,

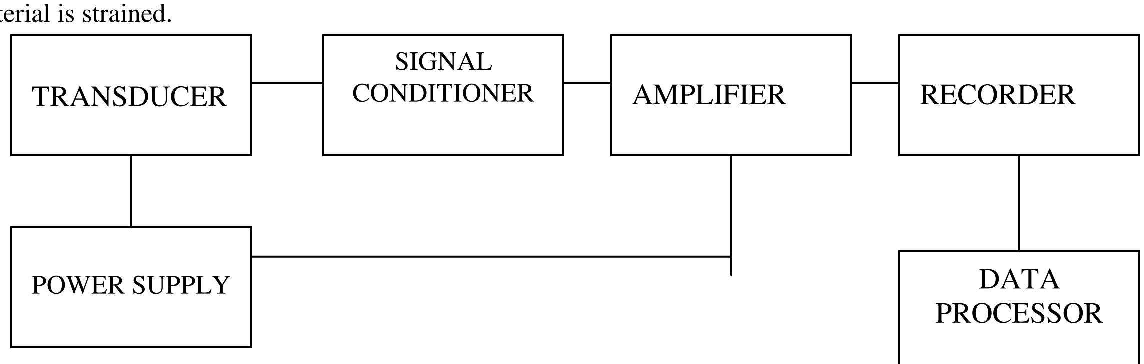
Emphasis in the instrumentation trainers will be directed toward electronic instrumentation systems rather than mechanical systems. In most cases electronic systems provide better data more accurately completely characterize the design or process being experimentally evaluated. Also the electronic system provides an electrical out put signal that can be used for automatic data reduction or for the control of the process. These advantage of the electronic measurement system over the mechanical measurement system have initiated and sustained trend instrumentation toward electronic methods.

An attempt is made through these “Instrumentation trainer kits” to make as easy as possible for the students to learn about the electronic instrumentation system and various transducers used for the measurement of mechanical component. The instrumentation tutor panels are design in such a way that block diagrams of the stages of electronic instrumentation system are clearly pictured on them. This makes the instrumentation tutor self explanatory and also the best teaching aid for engineering students.

Since the instrumentation tutors are not instrument as a whole the accuracy of the measurement cannot be claimed. It is very clear that the instrumentation tutors are only for demonstration purpose and cannot be used for any external measurement other than conducting experiments.

THE ELECTRONIC INSTRUMENTATION SYSTEM.

The complete electronic instrumentation system usually contains six sub systems or elements the TRANSDUCER is a device that convert a change in the mechanical or thermal quantity being measured into a change of an electrical quantity. Example strain gauges bonded in to an specimen, gives out electrical out put by changing its resistance when material is strained.



The POWER SUPPLY provides the energy to drive the Transducers, example differential transformer, which is a transducer used to measure displacement required an AC voltage supply to excite the coil.

SIGNAL CONDITIONERS are electronic circuits the convert, compensate, or manipulate the out put from in to a more usable electronic quantity. Example the whetstone bridge used in the strain transducer converts the change in resistance. AR to a change in the resistance AE.

AMPLIFIERS are required in the system when the voltage out put from the transducer signal conditioner combination is small. Amplifiers with game of 10 to 1000 are used to increase their signals to levels they are compatible with the voltage – measuring devices.

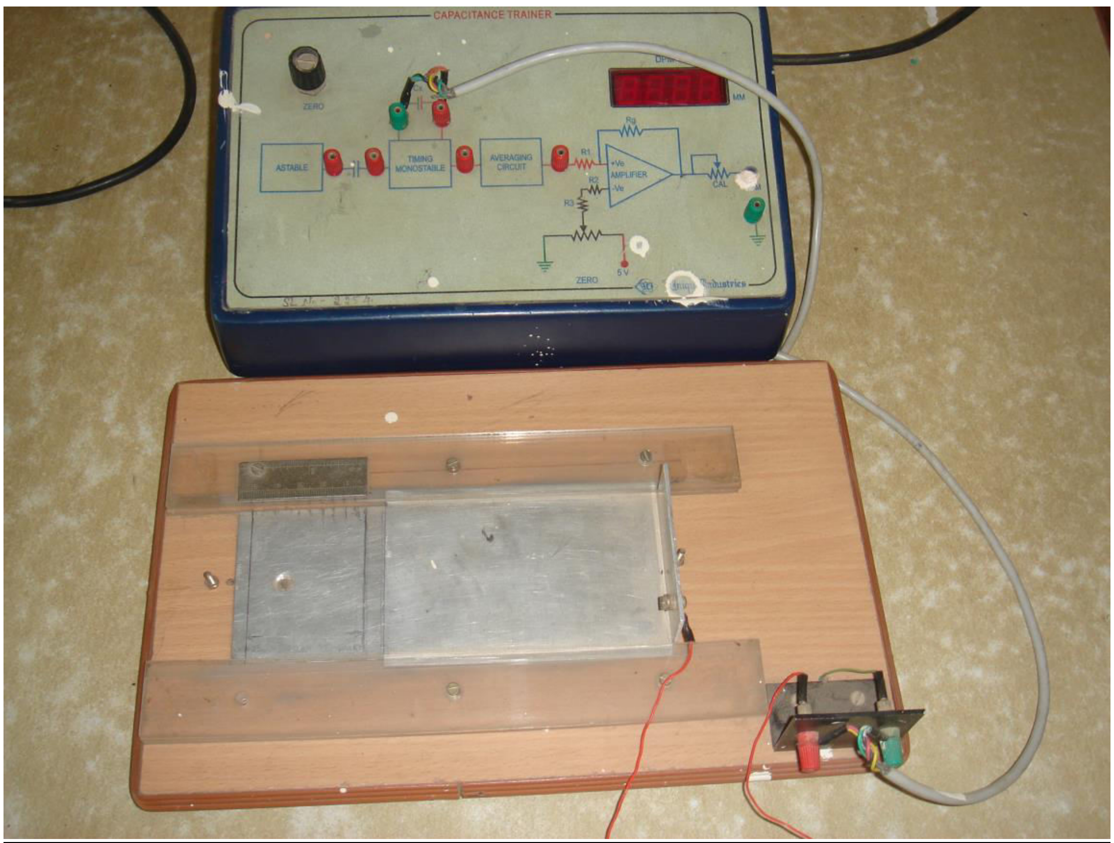
RECORDERS are voltage measuring devices that are used to display the measurement in a form that can be read and interpreted Digital/Analog voltmeters are often used to measure static voltages.

DATA PROCESSORS are used to convert the out put signals from the instrument system into data that can be easily interpreted by the Engineer. Data processors are usually employed where large amount of data are being collected and manual reduction of these data would be too time consuming and costly.

EXPERIMENT NO.1

CALIBRATION OF CAPACITIVE TRANSDUCER FOR ANGULAR DISPLACEMENT.

Displacement measurement by Capacitive Transducer:



INTRODUCTION

Unique Capacitance trainer Module is the best trainer for which demonstrate the use of capacitance as a transducer. Two parallel plates (A1), one fixed to the base and the other moving over the fixed plate parallel with a small gap between the two. The over lapping of the plate will act as a capacitor with air as dielectric media. The parallel capacitor is used as a displacement sensor which measure the displacement.

The instrument is built around an NE556 integrated circuit. The NE556 is a dual 556 times IC. The first timer is connected as a stable multi vibrator while the second time is sued as a mono stable.

At each trigger, the mono stable output a pulse whose width is determined by the Resistance and the Capacitance of the parallel plate capacitor Cx connected across the measuring terminals. Specifically the mono stable duration is given by T=1.1 R range X Cx, where R range is the range resistance across the measurement terminals. From this is is seen that the width of the mono stable pulse is directly proportional to capacitance Cx (parallel plate capacitor).

Since the mono stable duration is itself is proportional to capacitance Cx (parallel plate capacitor) across the measurement terminals, it follows that the meter indicated is directly proportional to the capacitance. The mono stable output is average during averaging circuit and feed to amplified for Zero setting and calibration the instrument to read displacement.

Theory

Capacitive transducer is a device used to measure the displacement by the following equation

$$C = \varepsilon A/d$$

Where c- capacitance,
ε – Dielectric medium,
A- Area of overlapping,
d- Distance between plates
BY capacitive Transducer we have three combinations for measuring Linear and Angular Displacement:

1. Change in the Area of overlapping,
2. Change in the Distance between plates,
3. Change in the Dielectric medium.

Here, in this experiment we are going to use Change in the Area of overlapping for finding the LIneasr displacement measasurement

Aim:

To perform an experiment on Displacement measurement using capacitive transducer

OPERATING PROCEDURE

- Check connection made to the instrument
- Allow the instrument in On position for 10 minutes for initial warm up
- Pull the top plate to Zero position
- Adjust the ZERO potentiometer so that the display reads ‘000’
- Move the plate in step of 5 to 10 mm and note down the reading in the tabular column till 50mm.

S P E C I F I C A T I O N S

Sensor	:	Parallel plate capacitor
Sensor Materia.3	:	Aluminum plates
Dielectric Medium	:	Air
Displacement	:	0 to 50 mm
Accuracy	:	5 to 10%
Display	:	3.5 digit LED display to read +/- 1999 counts for
Power	:	230V +/- 10% 50 HZ

E X P E R I M E N T & T A B U L A R C O L U M N

Measurement of displacement using capacitance is a demo model to demonstrate the use of capacitance as displacement sensor. In measurement Repeatability, Linearity. Accuracy important factors. So the experiment to test the Parallel plate Capacitance for all these factors.

EXPERIMENT

Known displacement is given to the parallel plate and the displacement on the scale can be noted down along with the display readings. Graph of scale reading versus Display reading can be Plotted. Accuracy and the linearity of the Capacitance sensor can be calculated by the graphs, Repeatability can be calculated by repeating the experiment 3 to 4 times and tabulating the readings both for ascending and descending of displacement.

TABULAR COLUMN

A SL. NO.	B ACTUAL SCALE READINGS (MM)	C INDICATOR READINGS (MM)	D ERROR B-0	E % ERROR

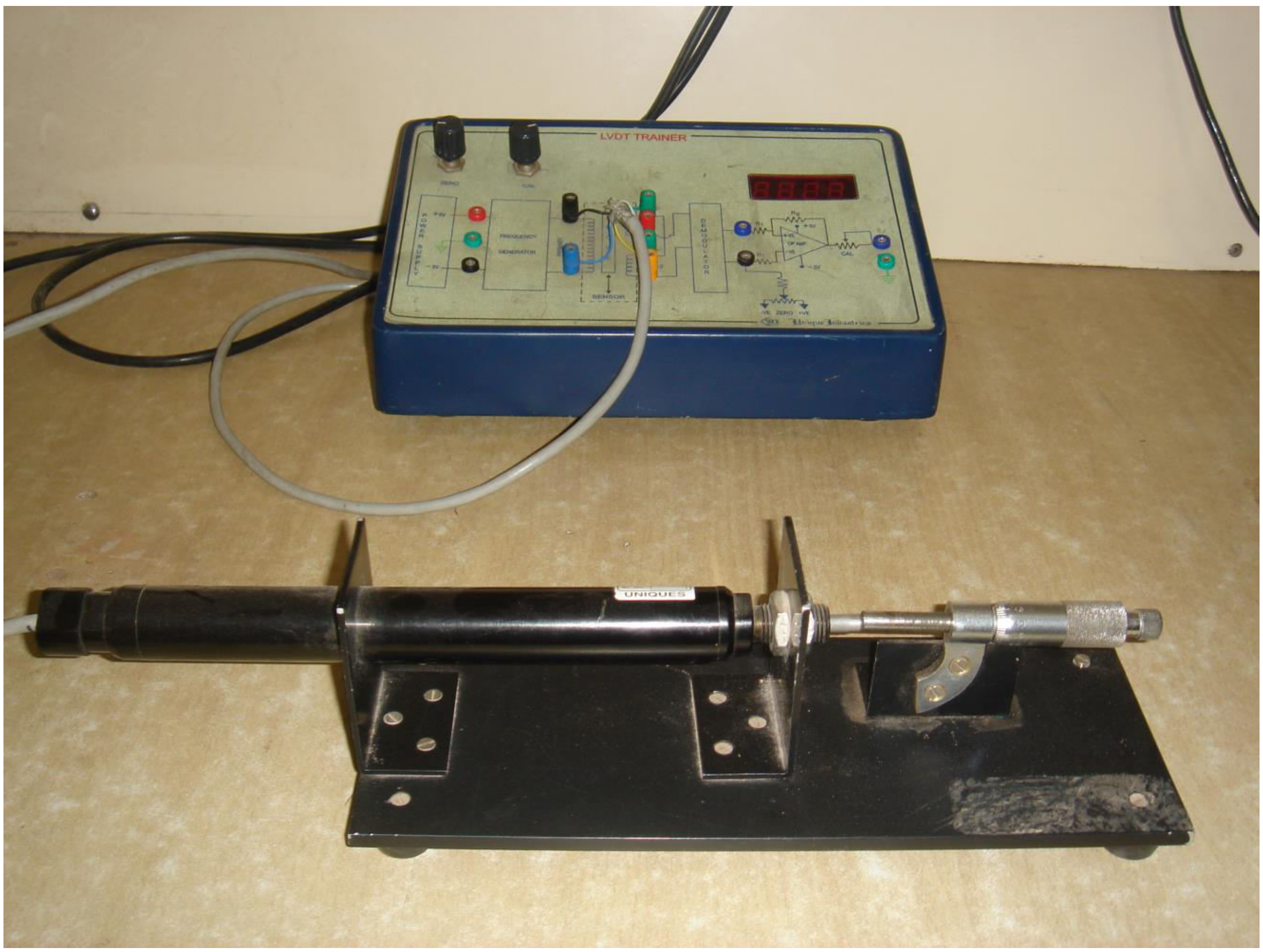
Questions:

1. What is the principle of working of capacitive transducer?
2. What is calibration?
3. How capacitive transducer used for displacement measurement?
4. What are the advantages of capacitive transducer?
5. What is the replacement for displacement measurement if capacitive transducer is not there?

EXPERIMENT NO.2

STUDY AND CALIBRATION OF LVDT TRANSDUCER FOR DISPLACEMENT MEASUREMENT

Displacement Measurement by LVDT



I N T R O D U C T I O N

The primary object of the INSTRUMENTATION TRAINER is to introduce and to educate electronic instrumentation systems in a manner sufficiently complete that the students will acquire proper knowledge and the idea about the transducers and their applications to measure mechanical and terminal quantities. The mechanical quantities include strain, force, pressure torque displacement, acceleration, frequency, etc. The terminal quantities include temperature and heat flux.

It is understood that the students will have a conceptual understand of these quantities through exposure of mechanics or physics courses, such as static's dynamics, strength of materials or thermodynamics. The students experience in actually measuring these quantities by conducting experiments, however, will usually be quit limited. It is an objective of this tutor to introduce methods commonly employed in such measurements and the usage of such electrical components such as capacitance, resistance, inductance, intensity, etc.

Emphasis in the instrumentation trainer will be directed toward electronic instrumentation systems rather than mechanical systems. In most cases electronic systems provide better data more accurately completely characterize the design or process being experimentally evaluated. Also the electronic system provides an electrical out put signal that can be used for automatic data reduction or for the control of the process. These advantage of the electronic measurement system over the mechanical measurement system have initiated and sustained trend instrumentation toward electronic methods.

An attempt is made through these “Instrumentation trainer” to make as easy as possible for the students to learn about the electronic instrumentation system and various transducers used for the measurement of mechanical component. The instrumentation tutor panels are design in such a way that block diagrams of the stages of electronic instrumentation system are clearly pictured on them. This makes the instrumentation tutor self explanatory and also the best teaching aid for Engineering students.

Since the instrumentation tutors are not instrument as a whole the accuracy of the measurement cannot be claimed. It is very clear that the instrumentation tutor are only for demonstration purpose and cannot be used for any external measurement other than conducting experiments.

T H E O R Y

MEASUREMENT OF DISPLACEMENT

Differential transformers on a variable inductance principle, are also used to measure displacement. The most popular variable inductance transducer for linear displacement measurement is the Linear Variable Differential Transformer (LVDT). The LVDT illustrated in the fig. consists of three symmetrically spaced coils would onto an insulated bobbin. A magnetic core moves through thee bobbin without contact, provides a path for magnetic flux linkage between coils. The position of the magnetic core controls the mutual between the center or primary coil and with the two outside of secondary coils.

When an AC carrier excitation is applied to the primary coil, voltages are induced in the two secondary coils that are wires in a series-opposing circuit. When the core is centered between the two secondary coils, the voltage induces between the secondary coils are equal but out of phase by 180^0. The voltage in the two coil cancels and the output voltage will be zero. When the core is moves from the center position, an imbalance in mutual inductance between the primary coil and the secondary coil occurs and an output voltage develops. The output voltage is a linear function of the core position as long as the motion of the core is within the operating range of the LVDT.

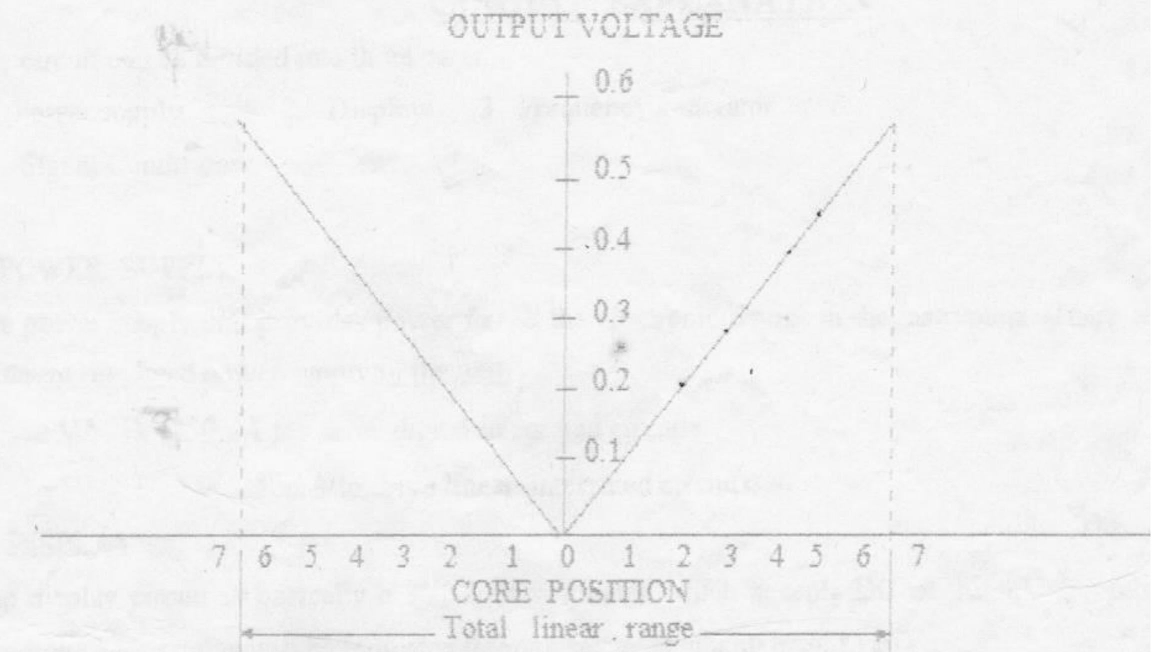


FIG. 1 Magnitude of the output Voltage as a function of LVDT core Position.

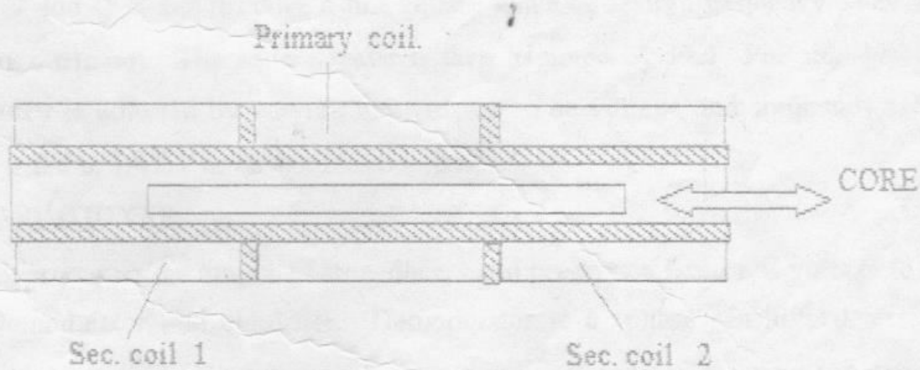


FIG. 2 Diagram to shows schematically the working of LVDT.

CIRCUIT EXPLANATION

The circuit can be divided into three parts.

1. Power supply 2. Display 3. Frequency generator &
4. Signal Conditioner

1. POWER SUPPLY

The power supply unit provides power for all the electronic device in the instrument. There are two differential regulated power supply in the unit.

a) +5V, -5V 250mA too drive digital integrated circuits.
b) +5V, -0 -5V, 250mA to drive linear integrated circuits.

2. DISPLAY

The display circuit is basically a 3 ½ digit voltmeter which accepts DC of 200mV for full scale Reading. The display will be indicated through seven segment bright LED's.

3. FREQUENCY GENERATOR

The circuit is an IC based (OP AMP) used to generate excitation voltage to the LVDT primary coil. The IC's use +5V and -5V and produce a fine square wave of desired frequency. The Voltage can be adjusted using a trim pot. The square wave is then trimmed by FET, PnP and NpN transistor. Then the Frequency is adjusted by varying the trim pot. The voltage and frequency is adjusted to 2khz 2 V which is fed to LVDT as an excitation voltage.

4. SIGNAL CONDITIONER

The circuit which processes the output of transducers and presents a fixed DC voltage to the display constitute the Demodulator and amplifier. Demodulator is a phase sensitive detector and AC amplifier, which gives out DC voltage which is amplified and fed to summing amplifiers. The output of the summing amplifier is fad to the display.

S P E C I F I C I A T I O N S

INDICATOR

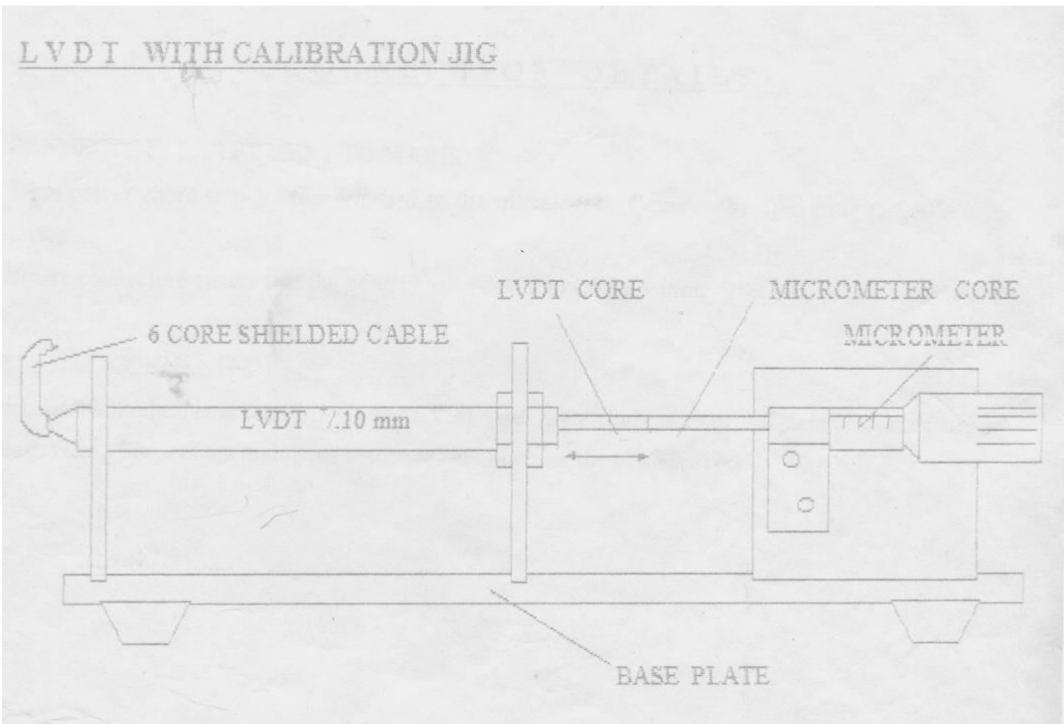
*	DISPLAY	:	3 ½ digit seven segment red LED display of Rage 200mV for full scale deflection to read $^{+}/_{-}$ 1999 counts
*	EXCITATION VOLTAGE	:	1000 Hz at IV
*	OPERATING TEMPERATURE:		$+10^{0}$ c to 55^{0} C
*	ZERO ADJUSTMENT	:	Front panel through Potentiometer
*	SENSTIVITY	:	0.1 mm
*	SYSTEM IN ACCURACY	:	1%
*	REPEATABILITY	:	1%
*	CONNECTION	:	Through 6 core shielded cable with Din connector.
*	FUSE	:	250mA fast glow type.
*	POWER	:	230 V +/- 10%, 50 Hz

SENSOR

*	RANGE	:	+/- 10.0 mm
*	EXCITATION VOLTAGE	:	1 to 4 kHz at 1 to 4V
*	LINEARITY	:	1%
*	OPERATING TEMPERATURE:	:	$+10^{0}$c to 55^{0} C
*	CONNECTION	:	Through 6 core shielded cable provided along with the sensor of 2M length.
*	CALIBRATION JIG	:	Micrometer to 0 to 25 mm length is mounted on the base.

PANEL DETAILS

DISPLAY	:	3 ½ Digit LED display of 200mV FSD to read up to "+/- 1999" counts.
ZERO	:	Single turn potentiometer to adjust "000" when the sensor is connected
CAL	:	Single turn potentiometer to adjust the calibration point.
CIRCUITRY	:	Block diagram of the circuit for displacement indicator. The diagram also shows LVDT block diagram also.



MOUNTING OF L V D T ON THE CALIBRATION JIG

L V D T has to be mounted perfectly on the calibration Jig. Micrometer should be moved till the micrometer reads 20.0 mm. LVDT should be mounted too the center plate by the two nuts provided. The core of the LVDT should be aligned with the core of the micrometer. Adjust the core of the LVDT till it touches the micrometer core and lighten the nut.

C O N N E C T I O N D E T A I L S

CONNECTING INSTRUMENT TO MAINS
3 Pin power chord is provided, attached to the instrument. Connect the 3 pin plug to 230V 50Hz socket.
Before connecting ensure that the power On switch is in OFF position.

SENSOR CONNECTION
6 core shielded cable is connected to the LVDT with male connectors of different colors are fixed to each wire.
Connect the male pins to the socket matching the color correctly.

O P E R A T I N G P R O C E D U R E

1. Connect the power supply chord at the rear panel to the 230V 50Hz supply. Switch on the instrument by pressing down the toggle switch. The display glows to indicate the instrument is ON.
2. Allow the instrument in ON position for 10 minutes for initial warm-up.
3. Rotate the micrometer till it reads "20.0".
4. Adjust the CAL potentiometer at the front panel so that the display reads "10.0"
5. Rotate the core of micrometer till the micrometer reads "10.0" and adjust the ZERO potentiometer till the display reads "00.0".
6. Rotate back the micrometer core upto 20.0 and adjust once again CAL Potentiometer till the display read 10.0. Now the instrument is calibrated for +/- 10.0 mm range. As the core of LVDT moves the display reads the displacement in mm.
7. Rotate the core of the micrometer in steps of 1 or 2 mm and tabulate the readings. The micrometer will show the exact displacement given to the LVDT core the display will read the displacement sensed by the LVDT. Tabulate the readings and Plot the graph Actual V/s indicator readings.

E X P E R I M E N T & T A B U L A R C O L U M N

Measurement of displacement through LVDT is well accepted method in process control instrumentation. In measurement Repeatability, Linearity. Accuracy are important factors. So the experiment to test the LVDT for all these factors.

EXPERIMENT is the known displacement is given to the LVDT core through micrometer and the displacement sensed by the micrometer can be noted down. Graph of Micrometer reading versus LVDT reading can be Plotted. Accuracy and the linearity of the LVDT can be calculated by the graphs. Repeatability can be calculated by repeating the experiment 3 to 4 times and tabulating the readings both for ascending and descending of displacement.

TABULAR COLUMN

A **SL.NO.**	**B** **ACTUAL MICROMETER READINGS (MM)**	**C** **INDICATR READINGS LVDT (MM)**	**D** **ERROR B.C.**	**E** **% ERROR**

Questions:

1. What is the principle of working of LVDT?
2. What is calibration?
3. How LVDT used for displacement measurement?
4. What are the advantages of LVDT?
5. What is the replacement for displacement measurement if LVDT is not there?

EXPERIMENT NO.3

STUDY OF RESISTANCE TEMPERATURE DETECTOR FOR TEMPERATURE MEASUREMENT.

Temperature measurement by RTD

CONTENTS

1. THEORY
2. PANEL DETAILS
3. SPECIFICATIONS
4. OPERATING PROCEDURE

Theory

RESISTANCE TERMPERATURE DETECTORS (RTD)

The change in the resistance of metals with temperature provides the basic for a family of temperature measuring sensors known as resistance temperature detectors. The sensor is simply a conductor fabricated either as a wire would coil or as a film or foil grid. The change in resistance of the conductor with temperature is given by the expression.

$$\Delta R / R_0 = \lambda_1 (T-T_0) + \lambda_2 (T-T_0)^2 + \lambda_n (T-T_0)^n$$

Where T_0 is a reference temperature.
R_0 is the resistance at temperature T_0

$\lambda_1, \lambda_2, \ldots\ldots \lambda_n$ are temperature co-efficient of resistance.

Platinum is widely used for sensor fabrication since it is the most stable of all the metals, is the least sensitive to contamination, and is capable of operating over a very wide range of temperature. The dynamic response of on RTD depends almost entirely on construction details.

CIRCUIT EXPLANATION

The circuit comprises of three parts.

1. POWER SUPPLY
2. SIGNAL CONDITIONING AND AMPLIFYING
3. ANALOG TO DIGITAL CONVERTER.

1. POWER SUPPLY.

Inbuilt power supply use power to all electronic devices inside the circuitry. High stable regulated Power supply is used for better performance.
There are three different power supply inside the unit.

+12-0 012 V 500mA to drive digital integrated circuitry.
+5-0—5V 250mA to drive A to D converter.

2. SIGNAL CONDITIONING AND AMPLIFYING

The circuitry comprises of signal conditioner and amplifier. The output of the sensor is amplified to required level. The Thermocouple gives out directly which is amplified. Thermistor and RTD are connected to the ground through a resister, and the voltage is applied to the other end of the sensor. The resistance change in the sensor will gives the mV out put which is amplified and controlled. Analog out put is fad to the ADC.

3. ANALOG TO DIGITAL CONVERTER.

The output from the amplifier is a linearised analog DC voltage. This analog output is converted into digital output with the help of IC 7107 3.5 digit 200mA. A to D converter. Then it is displayed through seven segmented LEDs.

PANEL DETAILS

DISPLAY	:	3 ½ Digit LED Display of 200 mV FSD.
INITIAL SET	:	Single turn potentiometer to set Initial Temperature (Room Temperature)
FINAL TEST	:	Single turn potentiometer to Calibrate the instrument (Max. Temperature)
SELECT	:	3 Way rotary switch to select RTD, Thermocouple and Thermister.

POWER ON : Rocker switch to control power supply to the instrument.

CONNECTION DETAILS

POWER : 3 pin mains cable is provided with the instrument. Connect the 3 pin socket to the instrument at the rear panel and to the AC mains 230v supply.

NOTE : Before connecting ensure the voltage is 230 V and the Power switch is in off position)

SENSORS : Connect RTD, Thermistor and Thermocouple to the connector on the rear panel.

OPERATING PROCEDURE

Check connection made and Switch ON the instrument by rocker switch at the front panel.
The display glows to indicate the instrument is ON.
Allow the instrument in ON Position for 10 minutes for initial warm-up.
Pore around $3/4^{th}$ full of water to the kettle and place sensors and thermometer inside the kettle.
Note down the Initial water temperature from the thermometer.
Select the sensor on which the experiment to be conducted through selection switch on the front panel.
Adjust the Initial set Potentiometer in the front panel till the display reads initial water temperature.
Switch on the kept and wait till the water boils note down the reading inn the thermometer and set Final set potentiometer till the display reads boiling water temperature.
Remove the sensor from the boiling water immerse it I the cold water. Set the cold water temperature using initial set potentiometer.

Repeat the process till the display reads exact boiling water and cold water temperature. Change the water in the kettle with and re heat the water. Now the display starts showing exact temperature raise in the kettle.

Experiment can be repeated for all the three sensors. Temperature in the thermometer and the indicator readings in steps of 10^0 C can be tabulated.

EXPERIMENTS AND TABULAR COLUMN-1

EXPERIMENT TO MEASURE TEMPERATURE USING RTD:

Experiment can be conducted on the instrument as per the operating instruction given above for the RTD and and various parameters like Linearity. Accuracy, Hysteresis etc, can be calculated. The readings can be tabulated and graphs can be plotted to calculated the above parameters.

TABULAR COLUMN-1

SL. NO	THERMOMETER REARING ^{0}C (Actual Temperature)	RTD ^{0}C

Graphs: Actual reading V/s indicator Reading

EXPERIMENTS AND TABULAR COLUMN – 2

EXPERIMENT TO STUDY THE CHARACTERISTICS OF RTD.

- Remove the YELLOW & GREEN terminals of the sensors from the instrument
- Connect RTD to Ohm-meter to measure ohms.
- Repeat the Experiment 1 but measure the resistance changes of RTD.
- Tabulate the readings in the tabular column given below. Plot the graphs for Temperature change in the thermometer V/s Change in the millivolt/Resistance

TABULAR COLUMN-1

EXPERIMENT-2

SL. NO	THERMOMETER REARING ^{0}C (Actual Temperature)	RTD ^{0}C

Questions:

1. What is the principle of RTD?
2. What is calibration?
3. How RTD used for Temperature measurement?
4. What are the advantages RTD?
5. What is the replacement for temperature measurement if RTD is not there?

EXPERIMENT NO.4

CALIBRATION OF THERMOCOUPLE FOR TEMPERATURE MEASUREMENT.

Temperature measurement by THERMOCOUPLE

CONTENTS

1. INTRODUCTION
2. THEORY
3. PANEL DETAILS
4. SPECIFICATIONS
5. OPERATING PROCEDURE

INTRODUCTION

The primary object of the INSTRUMENTATION TAINERS (TEMPERATURE TRAINER) is to introduce and to educate electronic instrumentation systems in a manner sufficiently complete that the students will acquire proper knowledge and the idea about the transducers and their applications measure mechanical and thermal quantities. The mechanical quantities include strain, force, pressure, torque, displacement, acceleration, frequency, etc. The thermal quantities include temperature and heat flux.

It is understood that the students will have a conceptual understanding of these quantities through exposure of mechanics or physics courses, such as static's, dynamics, strength of materials or thermodynamics. The student's experience in actually measuring these quantities by conducting experiments, however, will usually be quit limited. It is an objective of this tutor to introduce methods commonly employed in such measurements and the usage of such electrical components such as capacitance, resistance, inductance, intensity, etc.,

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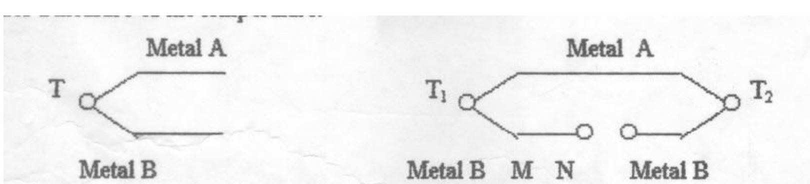
1. THERMOCOUPLE

When two dissimilar materials are brought into contact, a potential develops as a result of an effect known as the "seeback effect". A Thermocouple is a very simple temperature sensor operates based on the seeback effect, which results in the generation of a thermoelectric potential when two dissimilar metals are joined together to a junction. The electric potential of the material accepting electrons becomes negative at the interface, while the potential of the material providing the electrons become positive. Thus an electric field is established by the flow of electrons across the interface. When this electric field becomes sufficient to balance the diffusion forces, a state of equilibrium with respect to electron migration is established. Since the magnitude of the diffusion force is controlled by the temperature of the thermocouple junction, the electric potential developed at the junction provides a measure of the temperature.



The electric potential is usually measured by introducing a special junction in an electric circuit. The voltage across terminals M-N can be represented approximately by an empirical equation having the form.

$$E_0 = C_1 (T_1 - T_2) + C_2 (T_1^2 - T_2^2)$$

When C1 and C2 are thermoelectric constants that depend on the material used to form the junction T1 and T2 are junction temperature.

CIRCUIT EXPLANATION

The circuit comprises of three parts.

1. POWER SUPPLY
2. SIGNAL CONDITIONING AND AMPLIFYING
3. ANALOG TO DIGITAL CONVERTER.

1. POWER SUPPLY.

Inbuilt power supply use power to all electronic devices inside the circuitry. High stable regulated Power supply is used for better performance.
There are three different power supply inside the unit.

+12-0 012 V 500mA to drive digital integrated circuitry.
+5-0—5V 250mA to drive A to D converter.

2. SIGNAL CONDITIONING AND AMPLIFYING

The circuitry comprises of signal conditioner and amplifier. The output of the sensor is amplified to required level. The Thermocouple gives out directly which is amplified. Thermistor and RTD are connected to the ground through a resister, and the voltage is applied to the other end of the sensor. The resistance change in the sensor will gives the mV out put which is amplified and controlled. Analog out put is fad to the ADC.

3. ANALOG TO DIGITAL CONVERTER.

The output from the amplifier is a linearised analog DC voltage. This analog output is converted into digital output with the help of IC 7107 3.5 digit 200mA. A to D converter. Then it is displayed through seven segmented LEDs.

PANEL DETAILS

DISPLAY	:	3 ½ Digit LED Display of 200 mV FSD.
INITIAL SET	:	Single turn potentiometer to set Initial Temperature (Room Temperature)
FINAL TEST	:	Single turn potentiometer to Calibrate the instrument (Max. Temperature)
SELECT	:	3 Way rotary switch to select RTD, Thermocouple and Thermister.
POWER ON	:	Rocker switch to control power supply to the instrument.

CONNECTION DETAILS

POWER	:	3 pin mains cable is provided with the instrument. Connect the 3 pin socket to the instrument at the rear panel and to the AC mains 230v supply.
NOTE	:	Before connecting ensure the voltage is 230 V and the Power switch is in off position)
SENSORS	:	Connect RTD, Thermistor and Thermocouple to the connector on the rear panel.

OPERATING PROCEDURE

Check connection made and Switch ON the instrument by rocker switch at the front panel.
The display glows to indicate the instrument is ON.
Allow the instrument in ON Position for 10 minutes for initial warm-up.
Pore around 3/4th full of water to the kettle and place sensors and thermometer inside the kettle.
Note down the Initial water temperature from the thermometer.
Select the sensor on which the experiment to be conducted through selection switch on the front panel.
Adjust the Initial set Potentiometer in the front panel till the display reads initial water temperature.
Switch on the kept and wait till the water boils note down the reading inn the thermometer and set Final set potentiometer till the display reads boiling water temperature.
Remove the sensor from the boiling water immerse it I the cold water. Set the cold water temperature using initial set potentiometer.
Repeat the process till the display reads exact boiling water and cold water temperature. Change the water in the kettle with and re heat the water. Now the display starts showing exact temperature raise in the kettle.
Experiment can be repeated for all the three sensors. Temperature in the thermometer and the indicator readings in steps of 10^0 C can be tabulated.

EXPERIMENT AND TABULAR COLUMN-1

EXPERIMENT TO MEASURE TEMPERATURE USING THERMOCOUPLE. Experiment can be conducted on the instrument as per the operating instruction given for Thermocouple and various parameters like Linearity. Accuracy, Hysteresis etc, can be calculated. The readings can be tabulated and graphs can be plotted to calculate the above parameters.

TABULAR COLUMN-1

EXPERIMENT-1

SL.NO	THERMOMETER REARING ^{0}C (Actual Temperature)	THERMOCOUPLE ^{0}C

% Error = Column No. 4 X 100
Max. Load

Graphs: Actual reading V/s indicator Reading

EXPERIMENTS AND TABULAR COLUMN – 2

EXPERIMENT TO STUDY THE CHARACTERISTICS OF THERMOCOUPLE

- Remove the YELLOW & GREEN terminals of the sensors from the instrument
- Connect Thermocouple terminals to a Millivolt meter.
- Repeat the Experiment 1 but measure the thermocouple output through millivolt meter.
- Tabulate the readings in the tabular column given below. Plot the graphs for Temperature change in the thermometer V/s Change in the millivolt/Resistance

TABULAR COLUMN-1

EXPERIMENT-2

SL.NO	THERMOMETER REARING ^{0}C (Actual Temperature)	THERMOCOUPLE ^{0}C

Questions:

1. What is the principle of Thermocouple?
2. What is calibration?
3. How Thermocouple used for Temperature measurement and what is the range of thermocouples?
4. What are the advantages of Thermocouple?

EXPERIMENT NO.5

CALIBRATION OF THERMISTOR FOR TEMPERATURE MEASUREMENT.

Temperature measurement by THERMISTOR

CONTENTS

1. THEORY
2. PANEL DETAILS
3. SPECIFICATIONS
4. OPERATING PROCEDURE

Theory

THERMISTORS.

Temperature – measuring sensor based on the fact that the resistance of a material may change with temperature is known as a THERMISTOR. Thermostats differ from resistance temperature detectors in that they are fabricated from semi conducting materials instead of metals. The semi – conducting materials, which include oxides of copper, cobalt, manganese, nickel and titanium, exhibit very large change in resistance with temperature.

Resistance with temperature can be expressed by an equation of the form

$$I_np = A_0 + A_1 / T + A_2 / T^2 + \ldots\ldots\ldots\ldots + A_n / T^n$$

Where P is the specific resistance of the material.

A1, A2, ……………………….An are material constants.

T is the absolute temperature.

Thermistor have many advantage over other temperature sensors and are widely used in industry. They can be small and consequently, permit point sensing and rapid response to temperature change. Their high resistance minimizes lead – wire problems. Their out put is more than 10 times that of a resistance temperature detector. The disadvantages of thermistor includes non linear out put with temperature and limited range.

Since the instrumentation tutors are not instrument as a whole the accuracy of the measurement cannot be claimed. It is very clear that the instrumentation tutor are only for demonstration purpose and cannot be used for any external measurement other than conducting experiments.

CIRCUIT EXPLANATION

The circuit comprises of three parts.

1. POWER SUPPLY
2. SIGNAL CONDITIONING AND AMPLIFYING
3. ANALOG TO DIGITAL CONVERTER.

1. POWER SUPPLY.

Inbuilt power supply use power to all electronic devices inside the circuitry. High stable regulated Power supply is used for better performance.

There are three different power supply inside the unit.

+12-0 012 V 500mA to drive digital integrated circuitry.
+5-0—5V 250mA to drive A to D converter.

2. SIGNAL CONDITIONING AND AMPLIFYING

The circuitry comprises of signal conditioner and amplifier. The output of the sensor is amplified to required level. The Thermocouple gives out directly which is amplified. Thermistor and RTD are connected to the ground through a resister, and the voltage is applied to the other end of the sensor. The resistance change in the sensor will gives the mV out put which is amplified and controlled. Analog out put is fad to the ADC.

3. ANALOG TO DIGITAL CONVERTER.

The output from the amplifier is a linearised analog DC voltage. This analog output is converted into digital output with the help of IC 7107 3.5 digit 200mA. A to D converter. Then it is displayed through seven segmented LEDs.

PANEL DETAILS

DISPLAY	:	3 ½ Digit LED Display of 200 mV FSD.
INITIAL SET	:	Single turn potentiometer to set Initial Temperature (Room Temperature)
FINAL TEST	:	Single turn potentiometer to Calibrate the instrument (Max. Temperature)
SELECT	:	3 Way rotary switch to select Thermister.
POWER ON	:	Rocker switch to control power supply to the instrument.

CONNECTION DETAILS

POWER : 3 pin mains cable is provided with the instrument.
Connect the 3 pin socket to the instrument at the rear panel and to the AC mains 230v supply.

NOTE : Before connecting ensure the voltage is 230 V and the Power switch is in off position)

SENSORS : Connect Thermistor to the connector on the rear panel.

OPERATING PROCEDURE

Check connection made and Switch ON the instrument by rocker switch at the front panel.
The display glows to indicate the instrument is ON.
Allow the instrument in ON Position for 10 minutes for initial warm-up.
Pore around 3/4th full of water to the kettle and place sensors and thermometer inside the kettle.
Note down the Initial water temperature from the thermometer.
Select the sensor on which the experiment to be conducted through selection switch on the front panel.
Adjust the Initial set Potentiometer in the front panel till the display reads initial water temperature.
Switch on the kept and wait till the water boils note down the reading inn the thermometer and set Final set potentiometer till the display reads boiling water temperature.
Remove the sensor from the boiling water immerse it I the cold water. Set the cold water temperature using initial set potentiometer.
Repeat the process till the display reads exact boiling water and cold water temperature. Change the water in the kettle with and re heat the water. Now the display starts showing exact temperature raise in the kettle.
Experiment can be repeated for all the three sensors. Temperature in the thermometer and the indicator readings in steps of 10^0 C can be tabulated.

EXPERIMENTS AND TABULAR COLUMN-1

EXPERIMENT TO MEASURE TEMPERATURE USING THERMISTOR:

Experiment can be conducted on the instrument as per the operating instruction given above for Thnermistor and various parameters like Linearity. Accuracy, Hysteresis etc, can be calculated. The readings can be tabulated and graphs can be plotted to calculated the above parameters.

TABULAR COLUMN-1

SL. NO	THERMOMETER REARING ^{0}C (Actual Temperature)	THERMISTER ^{0}C

Graphs: Actual reading V/s indicator Reading

EXPERIMENTS AND TABULAR COLUMN – 2

EXPERIMENT TO STUDY THE CHARACTERISTICS OF THERMISTER.

- Remove the YELLOW & GREEN terminals of the sensors from the instrument
- Connect Thermistor to Ohm-meter to measure ohms.
- Tabulate the readings in the tabular column given below. Plot the graphs for Temperature change in the thermometer V/s Change in the millivolt/Resistance

TABULAR COLUMN-1

EXPERIMENT-2

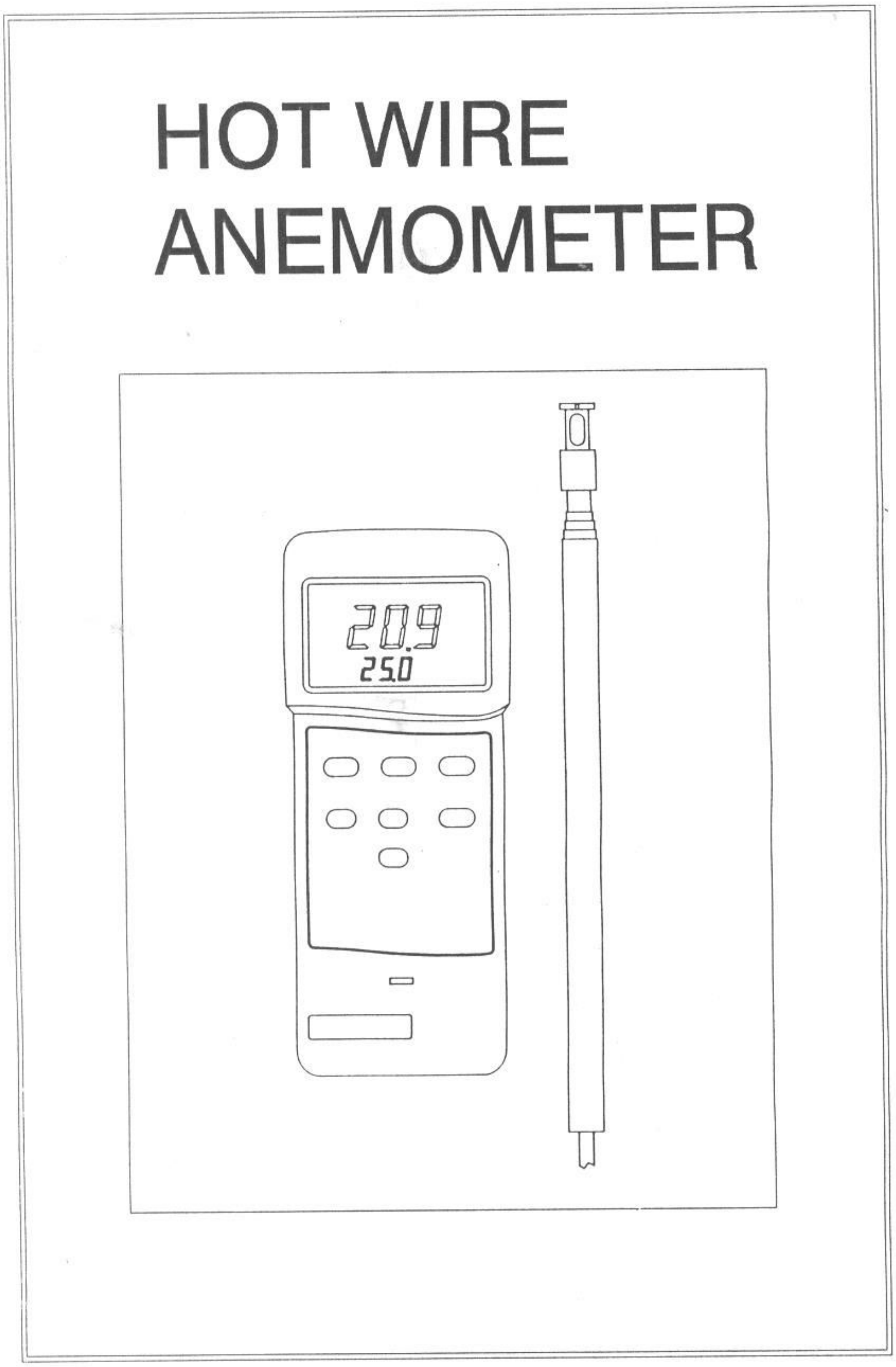
SL. NO	THERMOMETER REARING ^0C (Actual Temperature)	THERMISTER ^0C

Questions:

1. What is the principle of Thermistor?
2. What is calibration?
3. How Thermistor used for Temperature measurement?
4. What are the advantages of Thermistor?
5. What is the replacement for temperature measurement if Thermistor is not there?

EXPERIMENT NO.6

CALIBRATION OF HOT WIRE ANEMOMETER FOR TEMPERATURE MEASUREMENT.



1. FEATURES

- * Thermal anemometer, available for very low air velocity measurement.
- * Slim probe, ideal for grilles & diffusers.
- * Combination of hot wire and standard thermistor, deliver rapid and precise measurements even at low air velocity value.
- * Microprocessor circuit assures maximum possible accuracy, provides special functions and features.
- * Super large LCD with dual function meter's display, read the air velocity & temp. at the same time.
- * Heavy duty & compact housing case.
- * Records Maximum and Minimum readings with recall.
- * Data hold.
- * Operates from 0O6P DC 9V battery.
- * RS 232 PC serial interface.
- * The portable anemometer provides fast, accurate readings, with digital readability and the convenience of a remote probe separately.
- * Multi-functions for air t1ow measurement: m/s, km/h, ft/min, knots. mile/h.
- * Build in temperature °C, °F of measurement.
- * Thermistor sensor for Temp. measurement, fast response time.
- * Used the durable, long-lasting components, including a strong, light weight ABS-plastic housing case.
- * Deluxe hard carrying case.
- * Applications: Environmental testing, Air conveyors, Flow hoods, Clean rooms, Air velocity, Air balancing, Fans/motors/blowers, Furnace velocity, Refrigerated case, Paint spray booths.

2. SPECIFICATIONS

2-1 *General Specifications*

Circuit.	Custom one-chip of micro processor LSI circuit
Display	* 13 mm (0.5”) Super large LCD display * Dual function meter’s display
Measurement	m/s (meters per second) km/h (kilometers per hour) ft/min (feet/per minute) knote (nautical miles per hour) mile/h(miles per hour) Temp – ^{o}C, ^{o}F. Data hold.
Sensor Structure	*Air Velocity:* Tiny glass bead thermistor.
	Temperature: Precision thermistor.
Memory	Maximum and Minimum with recall.
Sampling Time	Approx. 0.8 sec.
Data output	RS 232 PC serial interface.

Operating Temperature	0 ^{0}C to 50 ^{0}C (32 ^{0}F to 122 ^{0}F).
Operating Humidity	Less than 80% RH.
Power Supply	1.5 V AAA (UM-4) battery x 6 PCs. (Alkaline or heavy duty type).
Power Supply	Approx. DC 30 mA.
Weight	355 g/o0.78 LB.
Dimension	Main instrument. 180x72x32 mm (7.1x2.8x1.3 inch)
	Telescope Probe. Round, 12 mm Dia x 280 mm (min. length). Round, 12 mm Dia x 940 mm (max. length)
Accessories included	Instruction manual……………….1 PC. Telescope Probe………………….1 PC. Hard carrying case……………….1 PC.

A. Air Velocity

Measurement	Range	Resolution	Accuracy
m/s	0.2-20.0 m/s	0.1 m/s	± (5% + 1 d) Reading or ± (1%+1d) full scale
km/h	0.7 - 72.0 km/h	0.1 km/h	
ft/min	40-3940 ft/min	1 ft/min	
mile/h	0.5-44.7 mile/h	0.1 mile/h	
knots	0.4-38.8 knots	0.1 knots	

Note: m/s - meters per second km/h - kilometers per hour
ft/min - feet/per minute knots - nautical miles per hour
mile/h - miles per hour (international knot)

Remark:

Spec. tested under the environment RF Field Strength less than 3 *VIM & frequency less than the* 30 *MHz only.*

3. FRONT PANEL DESCRIPTION

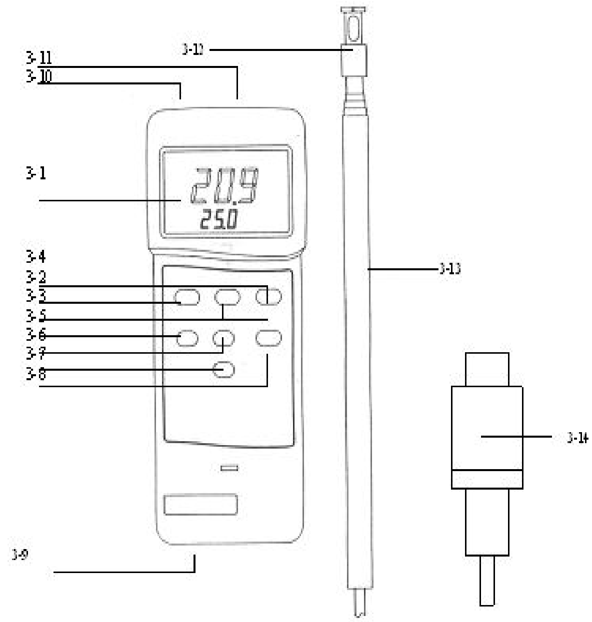


Fig. 1

3-1	Display
3-2	Power Off/On Button
3-3	Data Hold Button
3-4	$^{0}C/^{0}C$
3-5	Memory “Record” Button
3-6	Memory “CALL” Button
3-7	Zero Button
3-8	Unit Button
3-9	Battery Compartment/Cover
3-10	RS232 Output Socket
3-11	Probe Input Socket
3-12	Sensing Head
3-13	Probe Handle 3-14 Probe Plug

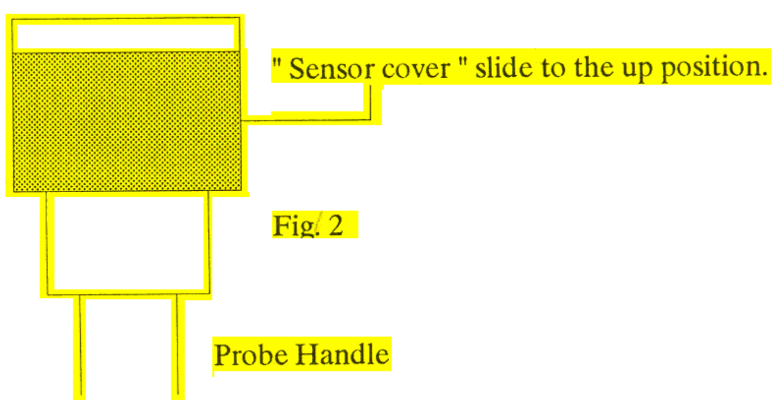


Fig. 2

5) a. Slide the sensor cover to the down position, let the air velocity sensor to contact the air, refer Fig. 3.

b. Extent the telescope probe to the convenient length, refer Fig.4.

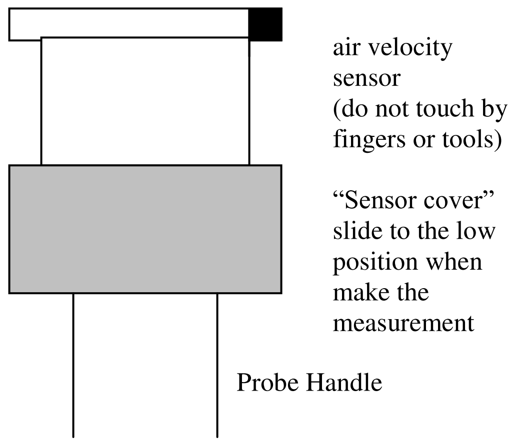


Fig. 3

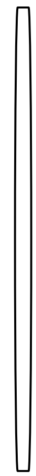


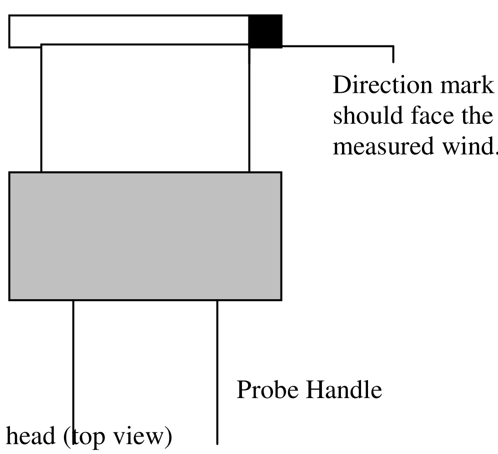
Fig.4

Caution !!!

Do not use the fingers or any tools to touch the air velocity sensor, otherwise the meter may happen the permanent damage.

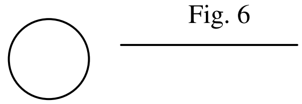
6) Direction of the sensor head:
There is a mark on the top of the "Sensor Head", When make the measurement, then this mark should against the measured wind refer Fig. 6, Fig. 7. When sensor head face against the measurement air, then the upper display will show the air velocity value. The lower display will show the temperature value.

Sensor head (side view)



Sensor head (top view)

Fig. 6



Direction mark should face the measured wind.

Fig. 7

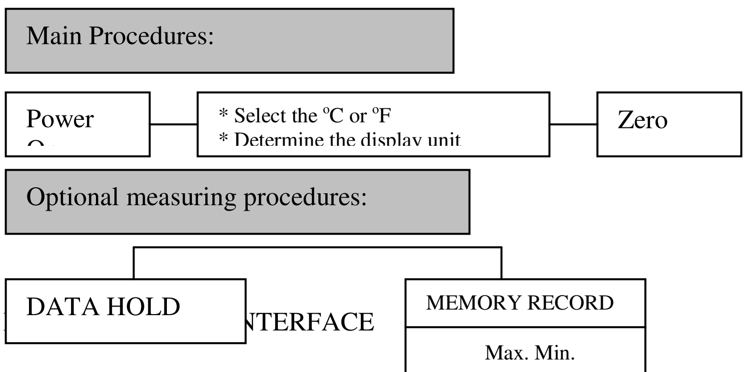
7) **<u>Data Hold:</u>**

a. During measurement, pushing the "Data Hold Button" (3-3, Fig. 1) will hold the display values & the LCD will show the "D.H" symbol
b. To cancel the Data Hold function, Press the Data Hold Button once more.

8) <u>Data Record (Max. & Min. reading)</u>

a. The Data Record function displays the maximum & minimum readings. To start the Data Record function, press the "Record Button" (3-5, Fig. 1) once. "REC" symbol will appear on the LCD display.
b. With the "REC" symbol indicated on the display
   * Push the "CALL Button" (3-6, Fig. 1) once, then the "Max" symbol with the maximum values recorded will appear on the LCD display.
   * Push the "CALL Button" once again, the "Min" symbol with the minimum values recorded will appear on the LCD display.
   * To de-activate the Data Record function, Press the "Record Button" (3-5, Fig. 1) once again. All associated anunciators will disappear from the display.

9) For quick measurement, follow the procedures shown below:



5. NTERFACE

The instrument features an RS232 output via 3.5 mm "RS232 Output Socket" (3-10, Fig. 1).

The connector output is a 16 digit data stream which can be utilized to the users's specific application.

An RS232 lead with the following connection will be required to link the instrument with the PC serial input.

Meter (3.5 mm jack plug)	PC (9W 'D" Connector)
Center Pin……………………………………………………	Pin 2
Ground/Shield……………………………………………..	Pin 5

The 16 digit stream will be displayed in the following format:

D15 D14 D13 D12 D11 D10 D9 D8 D7 D6 D5 D4 D3 D2 D1 D0

Each digit indicate the following status:

D0	End Word
D1 to D4	Upper Display reading, D1=LSD, D4=MSD
D5 to D8	Lower Display reading, D5 = LSD, D8 = MSD
D9	Decimal Point(DP) for Upper display. 0 = No DP, 1= 1 DP, 2 = 2 DP, 3 = 3 DP

D10	Decimal Point (DP) for lower display 0 = No DP, 1 = 1 DP, 2 = 2 DP, 3 = 3 DP		
D11 & D12	Anunuciator for Upper Display		
	00= No Symbol	07 = mg/L	14=mS
	01 = ^{0}C	08 = m/s	15=Lux
	02 = ^{0}F	09 = Knots	16=Ft – cd
	03= %	10=km/h	17= dB
	04= % RH	11=Ft/min	18=mV
	05 = % PH	12=mile/h	
	06=% O 2	13= uS	
D13	Anunuciator for Lower Display 0 =No Symbol 1= ^{0}C 2 = ^{0}F		
D14	Reading Polarity for the Display 0 = Both upper & lower display value are "+", 1= Upper "__" Lower "+" 2= Upper "__" Lower "__+ 3= Both upper & lower display value are "_"		
D15	Start Word		

6. BATTERY REPLACEMENT

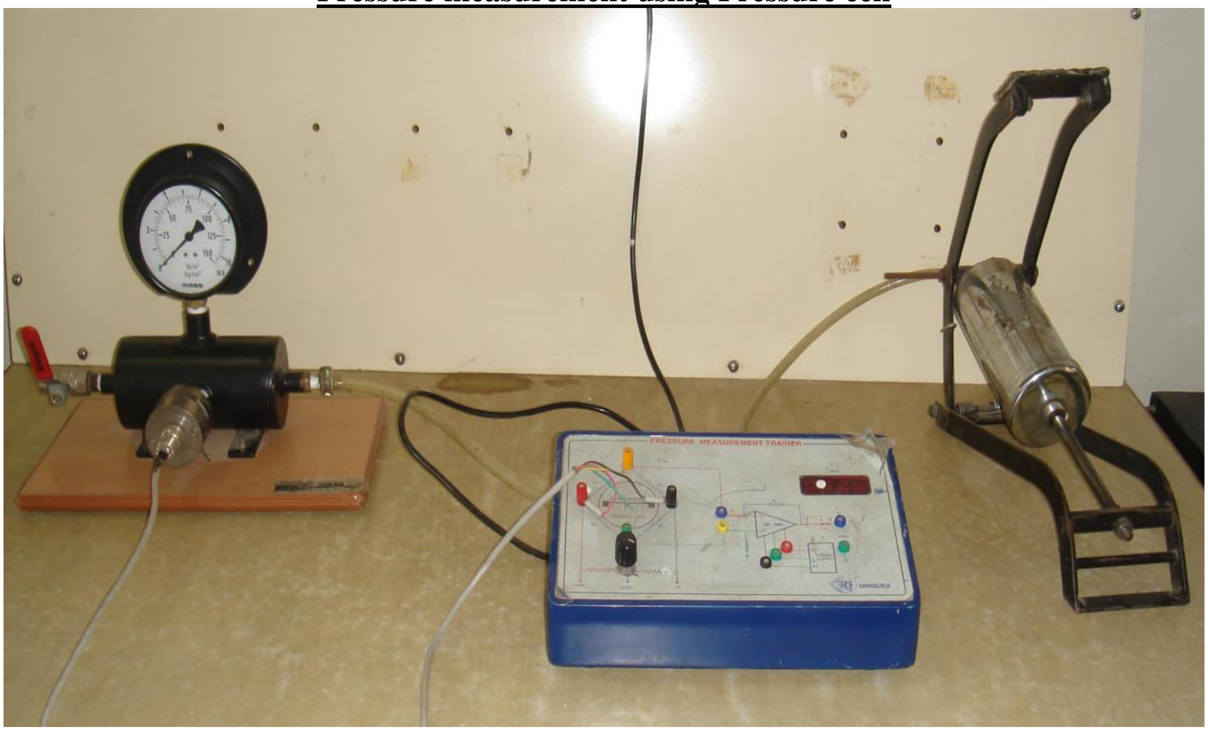
1) When the left corner of LCD display show "LBT", it is necessary to replace the battery. However, in – spec measurement may still be made for several hours after low battery indicator appears before the instrument become inaccurate.

2) Slide the "Battery Cover" (3-9, Fig. 1) away from the instrument and remove the battery.

3) Install the 1.5 V AAA (UM-4) battery x 6 PCs. Please use the Alkaline of heavy duty type battery. When install the batteries, then reinstate the battery cover.

EXPERIMENT NO.7
CALIBRATION OF PRESSURE GAUGES

Pressure measurement using Pressure cell



C O N T E N T S

THE INSTRUMENT

UNIQUE Digital pressure measuring setup comprises of pressure indicator and pressure cell with loading system. Pressure indicator is a strain gauge signal conditioner and amplifier used to measure pressure due to load applied on the pressure cell. The strain gauge are bonded on the diaphragm and are connected in the form of whetstones bridge. A foot pump of capacity 7Kg/cm^2 is provided to load the Pressure cell UNIQUES Pressure measuring setup in a complete system which can be used to conduct measurement of pressure applied on the Pressure cell. The pressure indicator is provided with zero balancing facility through adjustable potentiometer. Digital display will enable to take error free readings.

The digital indicator comprises of four parts.
1. Power supply 2. Signal conditioning 3. Amplifier
4. Analog and digital converter.
The inbuilt regulated power supply used will provide sufficient power to electronic parts and also excitation voltage to the strain gauge bridge transducers. The signal conditioner Buffers the output signals of the transducers. Amplifier will amplifies the buffered output signal to the required level where it is calibrated to required unit. Analog to digital converter will convert the calibrated analog out put to digital signals and display through LED's.

THEORY:

Transducers that measure force, torque or pressure usually contains an elastic member that converts the quantity to be measured to a deflection or strain. A deflection sensor or, alternatively, a set of strain gauges can be used to measure the quantity of interest (force, torque or pressure) indirectly. Characteristics of transducers, such as range, linearity and sensitivity are determined by the size and shape of the elastic member, the material used in its fabrication.
A wide variety of transducers are commercially available for measuring force. Torque and pressure the different elastic member employed in the design of these transducer include link, columns, rings, beams, cylinders, tubes, washers, diaphragms, shear webs and numerous other shapes of special purpose applications. Strain gauges are usually used as sensors; however linear variable differential transformers (LVDT) and linear potentiometers are some time used for static or quasistatic measurement.

PRESSURE MEASUREMENT (PRESSURE CELL).

Pressure cells are divisors that convert pressure into electrical signal through a measurement of either displacement strain or Piezoelectric response. Diaphragm type pressure transducers with strain gauges as sensor is used here for measurement of pressure.

This type of pressure transducers uses diaphragm as the elastic element. Diaphragms are used for low and middle pressure ranges. Strain gauges are bonded on the diaphragm and the pressure force is applied to the specimen the material gets elongated or compressed due to the force applied i.e., the material get strained. The strain incurred by the specimen depends on the material used and its elastic module. This strain is transferred to the strain gauges bonded on the material resulting in change in the resistance of the gauge. Since the strain gauges are connected in the form of whetstones bridge any change in the resistance will imbalance the bridge. The imbalance in the bridge will intern gives out the output in mV proportional to the change in the resistance of the strain gauge.

C I R C U I T E X P L A N A T I O N

The circuit comprises of three parts.

1. POWER SUPPLY
2. SIGNAL CONDITIONING AND AMPLIFYING
3. ANALOG TO DIGITAL CONVERTER.

1. POWER SUPPLY:

Inbuilt power supply use power to all electronic devices inside the circuitry. High stable regulated Power supply is used for better performance
There are two different power supply inside the unit
+12 – 0 -12V 500mA to drive digital integrated circuitary.
+5 – 0 - -5V 250mA to drive A to D converter.

2. SIGNAL CONDITIONING AND AMPLIFYING

Signal conditioner will process the output of transducer and presents a linear DC voltage to the amplifier. This circuit will also buffers the inputs signal given to the differential amplifier. The operations amplifier is used as a differential amplifier where the signal gets amplified to required level. The amplifier gives out the analog output.
This output is controlled and calibrated to get the linear to micro strain. This analog output is sed to the A to D converter.

3. ANALOG TO DIGITAL CONVERTED.

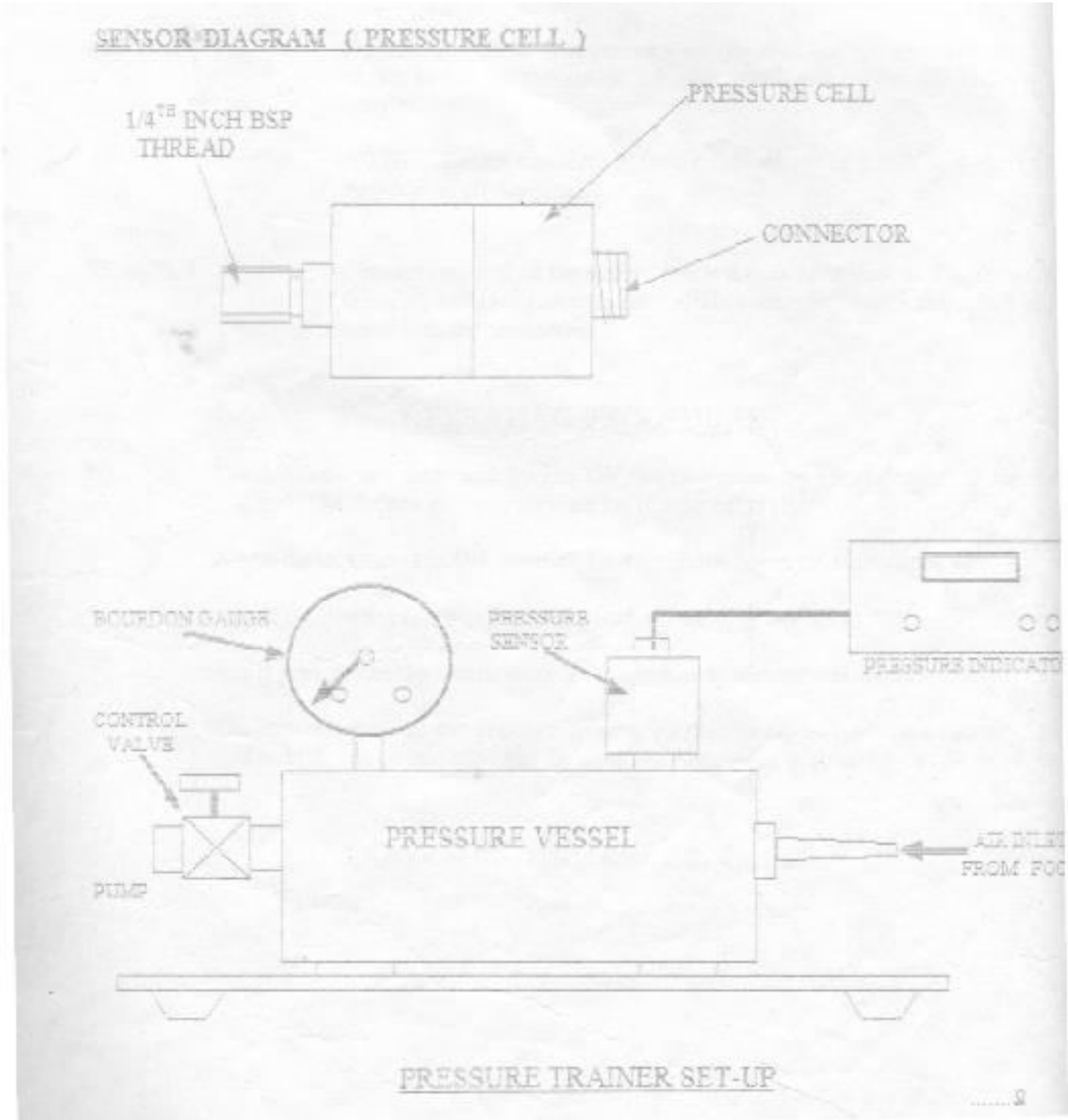
The output from the amplifier is a linearised analog DC voltage. This analog output is converted into digital output with the help of IC 7107 3.5 digit 200mV A to D converter. Then it is displayed through seven segmented LED's.

S P E C I F I C A T I O N S
MEASUREMENT OF PRESSURE

PRESSURE CELL	:	
SENSOR	:	strain gauges bonded on steel diaphragm for pressure measurement.
TYPE	:	Diaphragm
RANGE	:	10 Kg/cm^2
CONNECTION	:	Through four cure shielded cable with the connector Attached
EXCITATION	:	10V DC
ACCURACY	:	1%
LINEARITY	:	1%
MAX OVER LOAD	:	150%
MECHANICAL CONNECTION	:	1/4 INCH BSP thread.

INDICATOR:

DISPLAY	:	3 ½ digit seven segment LED display is used for the indicator of 200mV full scale deflection to read +/- 1999’
EXCITATION	:	10 V DC
ACCURACY	:	1%
TARE	:	Front panel zero adjustment through Potentiometer
POWER SUPPLY	:	230 V +/- 10% 50 Hz



CONNECTION DETAILS

POWER	:	3 pin mains cable is provided with the instrument. Connect the 3 pin socket to the instrument at the rear panel and to the AC mains 230v supply. NOTE : Before connecting ensure the voltage is 230 V and the Power switch is in off position.
SENSOR	:	Connect one end of the cable attached with connector to the sensor and the other end to the instrument. While connecting match the colors of the wires with the connectors.

OPERATING PROCEDURE

* Check connection made and switch ON the instrument by rocker switch at the front panel. The display glows to indicate the instrument is ON.
* Allow the instrument in ON Position for 10 minutes for initial warm-up.
* Adjust the Potentiometer in the front panel till the display reads “000”
* Apply pressure on the sensor using the loading arrangement provided.
* The instrument reads the pressure coming on the sensor and display through LED. Readings can be tabulated and % error of the instrument, linearity can be calculated.

EXPERIMENTS AND TABULAR COLUMN

Experiments can be conducted on the instrument as per the Operating Instruction
given and various parameters like Linearity. Accuracy, Hysteresis etc of the Pressure indicator can be calculated. The readings can be tabulated and graphs can be plotted to calculate the above parameters.

TABULAR COLUMN

EXPERIMENT-1

1 SL.NO.	2 ACTUAL PRESSURE Kg cm^2	3 INDICATOR READING Kg/cm^2	4 3-2 ERROR	5 % ERROR

% Error = $\frac{ColumnNo.4}{MaxLoad} X100$

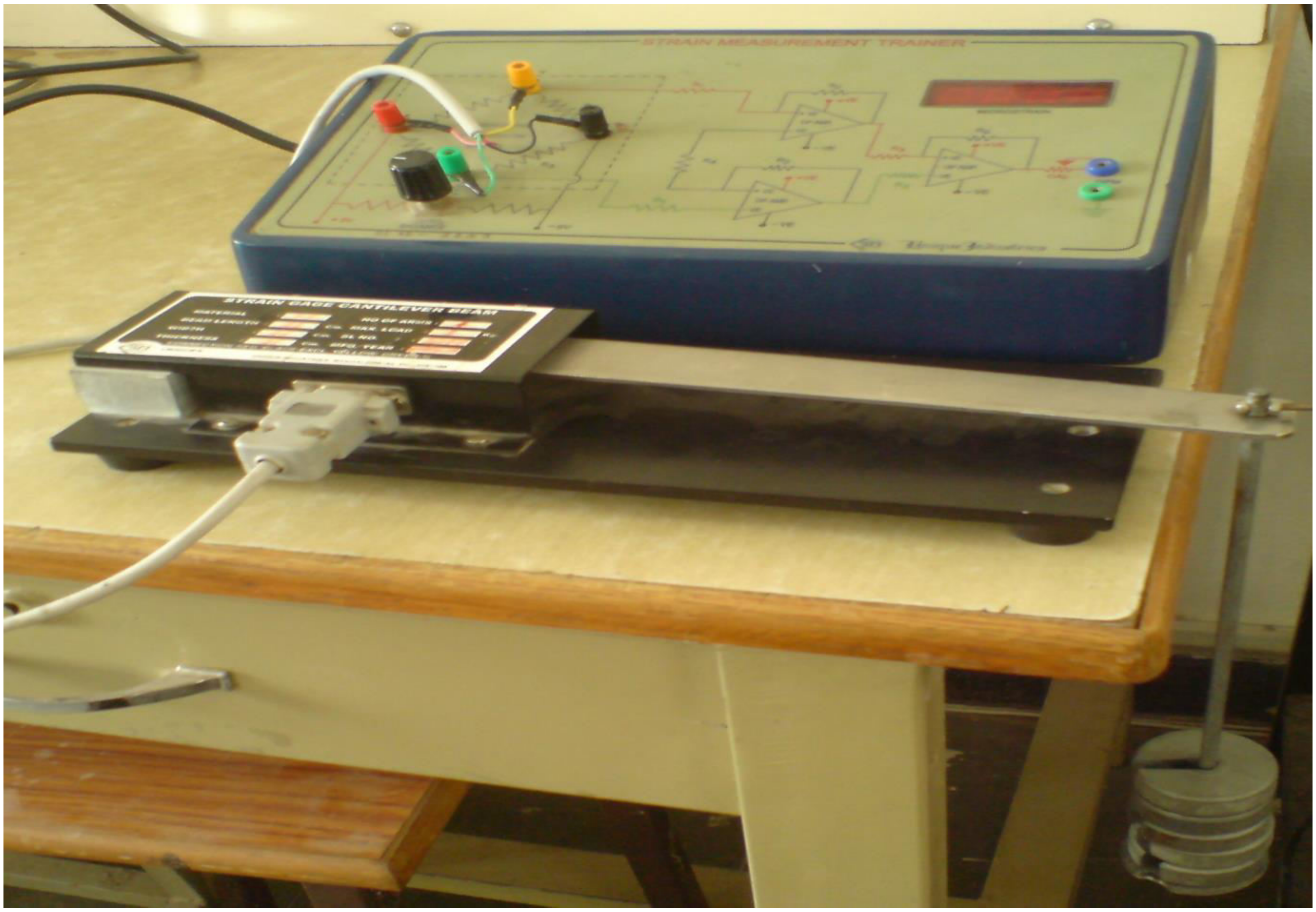
Graphs: Actual reading V/s indicator Reading

SPECIMEN READINGS

EXPERIMENT-1

1 SL.NO.	2 ACTUAL PRESSURE Kg/cm^2	3 INDICATOR READING Kg/cm^2	4 3-2 ERROR	5 % ERROR
1	1.0	0.9	-0.1	
2	2.0	2.0	0	
3	3.0	3.0	0	
4	4.0	4.0	0	
5	5.0	5.1	0.1	
6	6.0	6.1	0.1	
7	7.0	7.1	0.1	

EXPERIMENT NO. 8
CALIBRATION OF STRAIN GAUGE FOR TEMPERATURE MEASUREMENT.



C O N T E N T S

S P E C I F I C A T I O N

DISPLAY RANGE	:	31/2 digit RED LED display of 200 mV FSD to read up to +/- 1999 micro strain.
GAUGE FACTOR SETTING	:	2.1
BALANCE	:	Potentiometer to set zero on the panel
BRIDGE EXCITATION	:	12V DC
BRIDGE CONFIGURATIONS	:	Full Bridge
MAX. LOAD	:	1 Kg
POWER	:	230 V+/- 10% at 50Hz with perfect Grounding

All specification nominal or typical at 23^0 C unless noted.

CANTILEVER BEAM SPECIFICATION

MATERIAL	:	Stainless Steel
BEAM THICKNESS (1)	:	0.25 Cm
BEAM WIDTH (b)	:	2.8 Cms
BEAM LENGTH (Actual)	:	22 Cms
YOUNGS MODULUS (ε)	:	$2X10^6$ Kg / cm^2
STRAIN GAUGE	:	Foil type gauge
GAUGE LENGTH (F)	:	5 mm
GAUGE RESISTANCE (R)	:	300 Ohms
GAUGE FACTOR (g)	:	2.01

INTRODUCTION

The primary object of the INSTRUMENTATION TRAINER is to introduce and to educate electronic instrumentation systems in a manner sufficiently complete that the students will acquire proper knowledge and the idea about the transducers and their applications to measure mechanical and terminal quantities. The mechanical quantities include strain, force, pressure torque, displacement, acceleration frequency, etc. The terminal quantities include temperature and heat flux.

It is understood that the students will have a conceptual understanding of these quantities through exposure of mechanics or physics courses, such as static's, dynamics, strength of materials or thermodynamics. The students experience in actually measuring these quantities by conducting experiments, however, will usually the quit limited. It is an objective of this tutor to introduce methods commonly employed in such measurements and the usage of such electrical components such as capacitance, resistance, intensity, etc.

Emphasis in the instrumentation trainer will be directed toward electronic instrumentation systems rather than mechanical systems. In most cases electronic systems provide better data more accurately and completely characterize the design or process being experimentally evaluation. Also the electronics system provides an electrical out put signal that can be used for automatic data reduction or for the control of the process. These advantage of the electronic measurement system over the mechanical measurement system have initiated and sustained trend in instrumentation toward electronic methods.

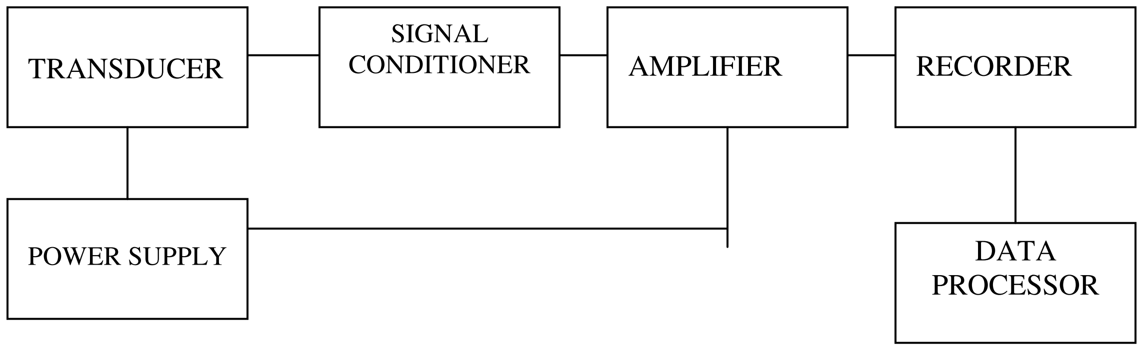
An attempt is made through these “Instrumentation trainer” to make as easy as possible for the students to learn about the electronic instrumentation system and various transducers used for the measurement of mechanical component. The instrumentation tutor panels are design in such a way that the block diagrams of the stages of electronic instrumentation system are clearly pictured on them. This makes the instrumentation tutor self-explanatory and also the best teaching aid for Engineering students.

Since the instrumentation tutors are not instruments as a whole the accuracy of the measurement cannot be claimed. It is very clear that the instrumentation tutor are only for demonstration purpose and cannot be used for any external measurement other than conducting experiments.

THE ELECTRONIC INSTRUMENTATION SYSTEM.

The complete electronic instrumentation system usually contains six sub systems or elements.

The **TRANSDUCER** is a devise that convert a change in the mechanical or thermal quantity being measured into a change of an electrical quantity. Example strain gauges bonded in to an specimen, gives out electrical out put by changing its resistance when material is strained.



The **POWER SUPPLY** provides the energy to drive the Transducers, example differential transformer, which is a transducer used to measure displacement required an AC voltage supply to excite the coil.

SIGNAL CONDITIONERS are electronic circuits the convert, compensate, or manipulate the out put from in to a more usable electronic quantity. Example the whetstone bridge used in the strain transducer converts the change in resistance. AR to a change in the resistance AE.

AMPLIFIERS are required in the system when the voltage out put from the transducer signal conditioner combination is small. Amplifiers with game of 10 to 1000 are used to increase their signals to levels they are compatible with the voltage – measuring devices.

RECORDERS are voltage measuring devices that are used to display the measurement in a form that can be read and interpreted Digital/Analog voltmeters are often used to measure static voltages.

DATA PROCESSORS are used to convert the out put signals from the instrument system into data that can be easily interpreted by the Engineer. Data processors are usually employed where large amount of data are being collected and manual reduction of these data would be too time consuming and costly.

THE INSTRUMENT

UNIQUE Digital strain measuring setup comprises of Strain Indicator and Cantilever Beam setup strain Indicator is a strain gauge signal conditioner and amplifier used to measure strain due to load applied on the cantilever beam. The strain gauge are bonded on the cantilever beam and are connected in the form of whetstones bridge. A pan and weights upto 1 Kg is provided to load the cantilever beam. Unique strain measuring setup is a compete system which can be used to conduct measurement on strain gauge. The strain indicator is provided with zero balancing facility through adjustable potentiometer. Digital display will enable to take error free readings.

The digital indicator comprises of four parts.

1. Power supply
2. Signal conditioning
3. Amplifier
4. Analog and digital converter.

The inbuilt regulated power supply used will provide sufficient power is electronics parts and also excitation voltage to the strain gauge bridge transducers. The signal conditioners Buffers the output signals of the transducers. Amplifier will amplifies the buffered output signal to the required level where it is calibrated to required unit. Analog to digital converter will convert the calibrated analog output to digital signals and display through LED's.

THEORY BEHIND IT

When a material is subjected to any external load, there will be small change in the mechanical properties of the material. The mechanical property may be, change in the thickness of the material or change in the length depending on the nature of load applied to the material. This change in mechanical properties will remain till the load is released. The change in the property is called strain in the material or the material get strained. So the material is mechanically strained this strain is defined as. The ratio between change in the mechanical property to the original property. Suppose a beam of length L is subjected to a tensile load of P Kg the material gets elongated by a length of □1. So according to the definition strain S is give by

$$S = \square 1/L \qquad \text{…………Eq 1}$$

Since the change in the length of the material is very small it is difficult to measure □1. So the strain is always read in terms of micro strain. Since it is difficult to measure the length Resistance strain gauges are used to measure strain in the material directly. Strain gauges are bonded directly on the material using special adhesives. As the material get strained due to load applied, the resistance of the strain changes proportional to the applied. This change in resistance is used to convert mechanical property in to electrical signal which can be easily measured and stored nor analysis.

The change in the resistance of the strain gauge depends on the sensitivity of the strain gauge. The sensitivity of strain gauges is usually expressed in terms of a gauge factor S_g where S_g is given as

$$\Delta R/R = Sg \qquad \text{…………Eq 1}$$

Where □is Strain in the direction of the gauge length.

The output □R / R of a strain gauge is usually converter in to voltage signal with a Whetstones bridge, If a single gauge is used in one arm of whetstones bridge and equal but fixed resistors is used in the other arms, the output voltage is

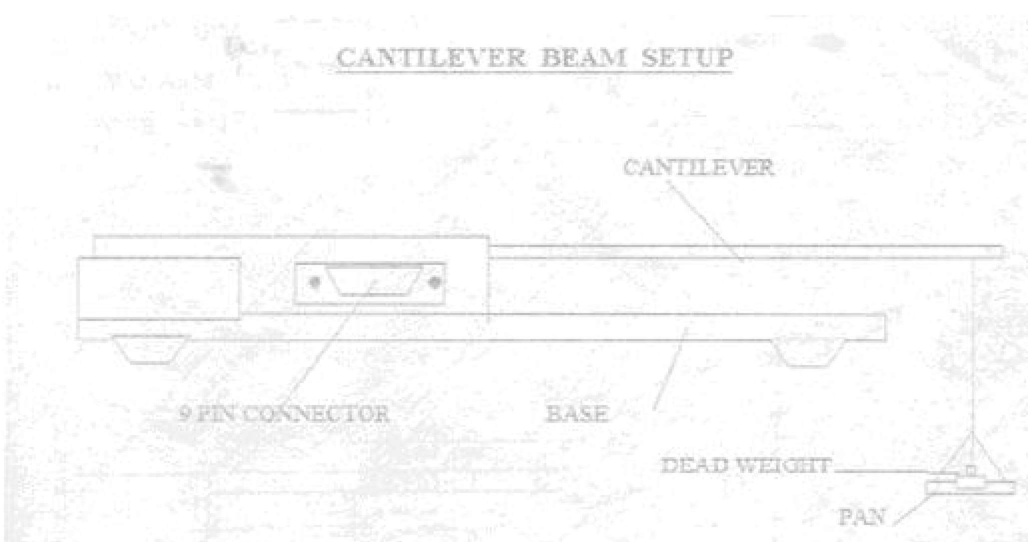
$$Eo = Ei / 4 (\square Rg/Rg) \qquad \text{……………….Eq 3.}$$

Substituting Eq2 into Eq3 gives

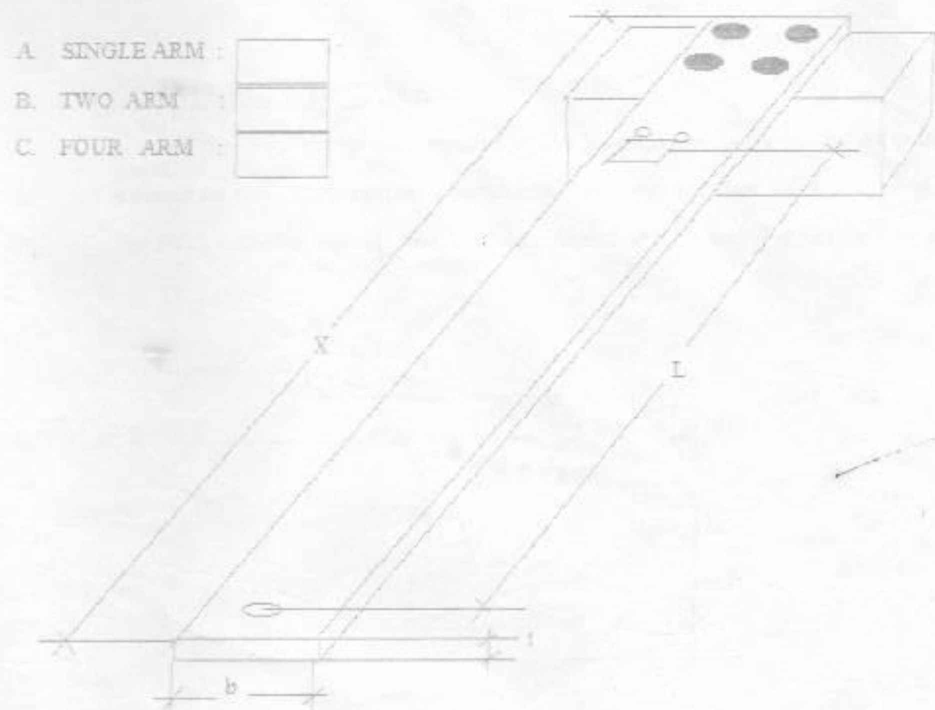
$$Eo = Ei\ 1 / 4 (Ei\ Sg\ \square) \qquad \text{……………….Eq 3.}$$

……. Eq 4

The input voltage is controlled by the gauge size (the power it can dissipate) and the initial resistance of the gauge. As a result, the output voltage Eo usually ranges between 1 to 10 □ V/micro units of strain.

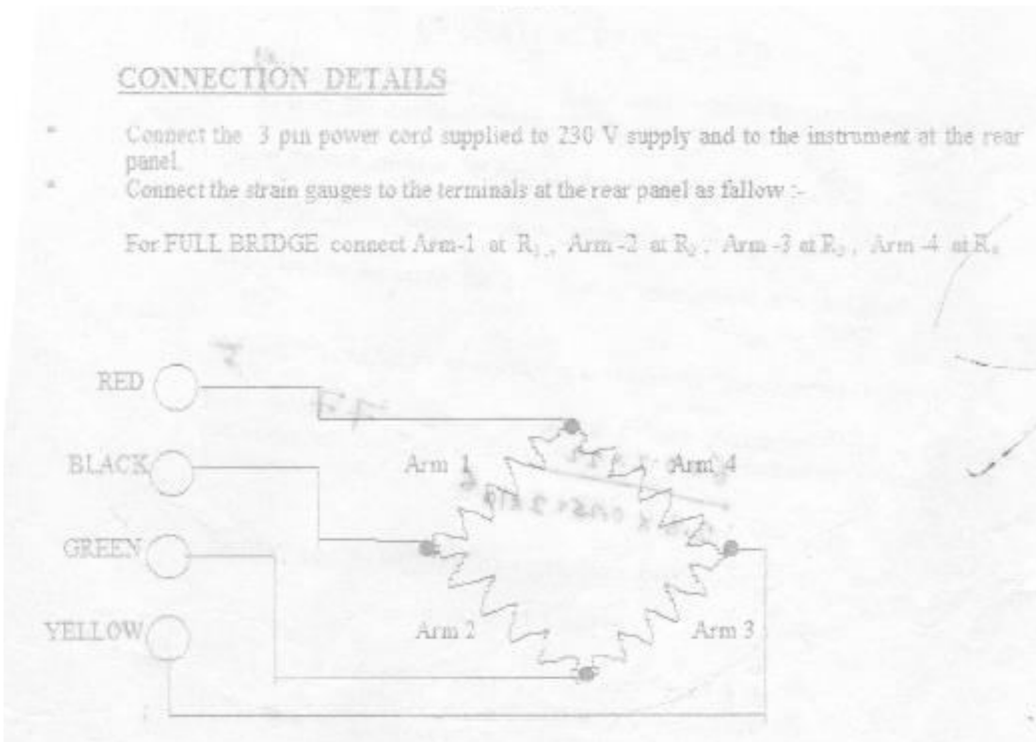


PHYSICAL DIMENSION OF THE CANTILEVER BEAM



PHYSICAL DIMENSIONS

Over all BEAM Length (X)	:	300 mm
Actual Length (L)	:	220.0 mm (Middle of the Strain Gauge Grid to loading point)
Width of the Beam (b)	:	28.0 mm
Thickness of the Beam (t)	:	2.5 mm



CONNECTION DETAILS

- Connect the 3 pin power cord supplied to 230 V supply and to the instrument at the rear panel.
- Connect the strain gauges to the terminals at the rear panel as fallow :-

For FULL BRIDGE connect Arm-1 at R_1, Arm-2 at R_2, Arm-3 at R_3, Arm-4 at R_4

OPERATING PROCEDURE

- Check connection made and Switch ON the instrument by toggle switch at the back of the box. The display glows to indicate the instrument is ON.
- Allow the instrument in ON Position for 10 minutes for initial warm-up.
- Adjust the ZERO Potentiometer on the panel till the display roads ‘ OOP’.
- Apply load on the sensor using the loading arrangement provided in steps of 100g upto 1 Kg.
- The instrument display exact microstrain strained by the cantilever beam.
- Note down the readings in the tabular column. Percentage error in the readings. Hysteresic and Accuracy of the instrument can be calculated by comparing with the theoretical values.

Specimen Calculation For Cantilever Beam

S=(6pl) BT^{2}E

P = Load applied in Kg (1 Kg) – 0.2 kg
L = Effective length of the beam in Cms. (22 Cms)
B = Width of the beam (2.8 Cms)
T = Thickness of the beam (0.25 Cm)
E = Young’s modulus (2X10^6)
S = Micro strain

Then the micro strain for the above can be calculated as follows.

$$S = \frac{6X1X22}{2.8X0.25X(2X10^6)}$$

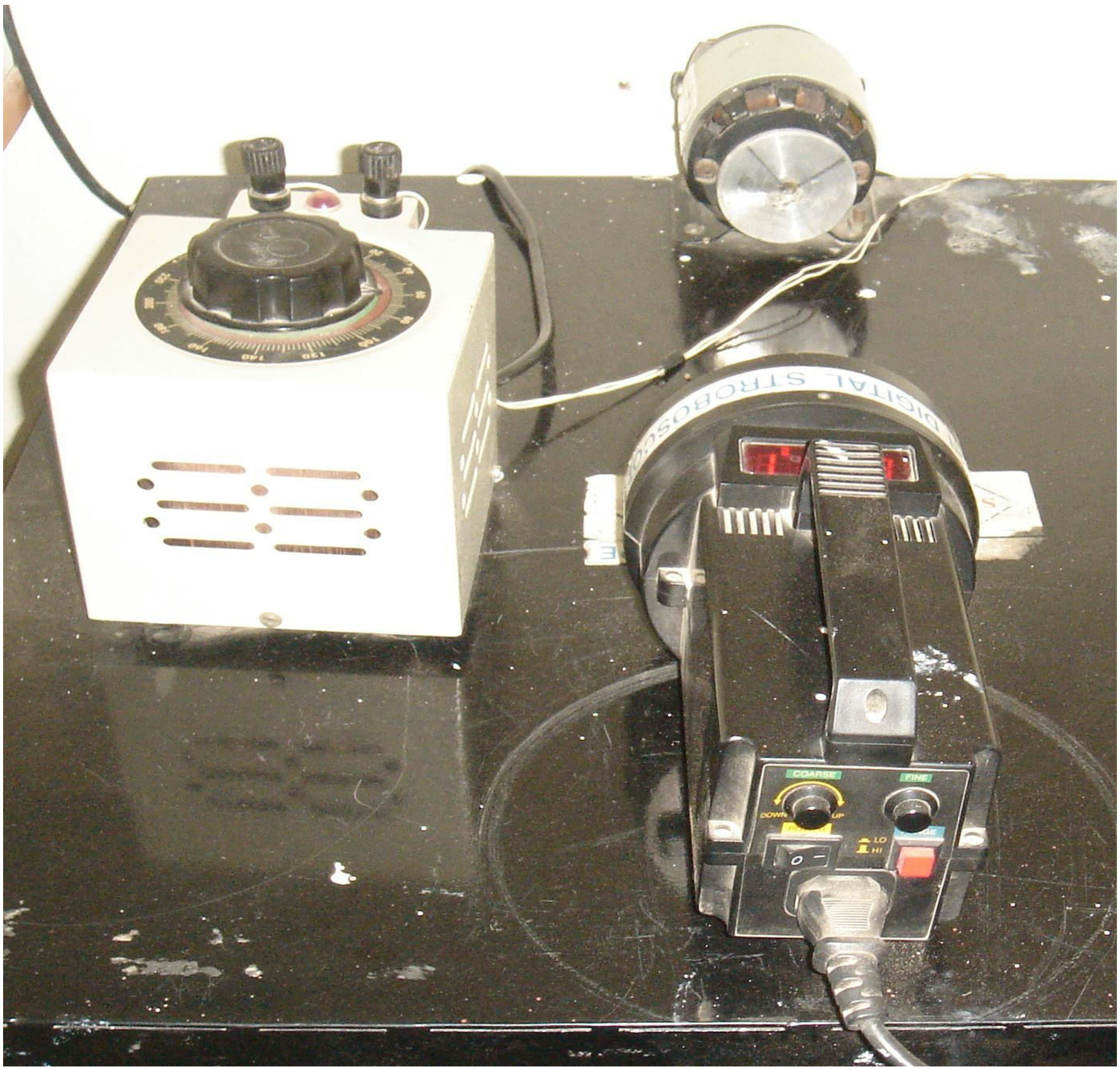
$$S = 3.77X10^4$$

S = 377 micro strain

EXPERIMENT NO.9

STUDY AND CALIBRATION OF PHOTO AND MAGNETIC SPEED PICKUPS FOR THE MEASUREMENT OF SPEED

Speed Measurement by Stroboscope



Aim: To measure the Speed by an optical method called as Stroboscope.

Introduction:
Theory:
Apparatus:

1. Xenon Flash Lamp
2. Adjustable Motor
3. Marked Rotating Wheel
4. Stand for set up
5. Power Supply

Procedure:

1. Check the connections of the equipment.
2. Select the mode of operation on Xenon flash lamp (Hi/lo).
3. Make a mark on the rotating wheel.
4. Now switch on the Xenon flash lamp and adjust that the light exactly projected on the rotating wheel.
5. Adjust the speed of the motor such that ONE STATIONARY mark is visible on the wheel. Note down the reading in the tabular column.
6. Now adjust the sped of the motor such that Two Stationary marks are visible and note the readings.
7. Similarly for Three and more marks and note the readings.

Tabular column:

S.No	**No. of images**	**Reading on the Xenon Flash Lamp**	**Frequency**

Questions:

1. What is the Principle of Stroboscope?
2. What are the applications of Stroboscope?
3. Specifications of Stroboscope?
4. What are the Applications of Stroboscope?
5. What are the advantages and disadvantages of Stroboscope?

EXPERIMENT NO.10
STUDY AND CALIBRATION OF A ROTAOMETER FOR FLOW MEASUREMENT.

ROTAMETER

The obstruction is a float that rises in a vertical tapered column. The lifting force and thus the distance to which the float rises in the column is proportional to the flow rate. The lifting force is produced by the differential pressure that exists across the float, because it is a restriction in the flow. This type of sensor is used for both liquids and gases. A moving vane flow meter has a vane target-immersed in the flow region, which will be roted out of the flow as the flow velocity increases. The angle of the vane is a measure of the flow rate.

FLOW CONTROL SYSTEM

TURBINE METER:

The turbine flow meter consists of a multi-bladed rotor that is supported centrally in the pipe along which the flow occurs. The fluid results in rotation of the rotor. The angular velocity bring approximately proportional to the flow rate. The rate of revolution of the rotor can be determined using a magnetic pick-up. The pulses are counted and so the number of revolutions of the rotor can be determined.

FLOW CONTROL SYSTEM

Control & Operations:

1. Press flow: This is a D.P.D.T Switch to set the required flow rate.
2. Flow Control: This is a potentiometer to set the flow rate.

Operation:

1. Connect the turbine flow sensor with indicator marked as flow sensor input.
2. Connect the two pin of the motor to the instrument.
3. Now vary the flow control potentiometer to any required set level.
   Note: While controlling the flow make sure the pointer in Rotometer floats.
4. Compare the Rotameter reading and digital reading with set reading.
5. Take reading for different set of flows rate.
6. Plot the graph of Rotameter Reading with Digital Indicator Reading.

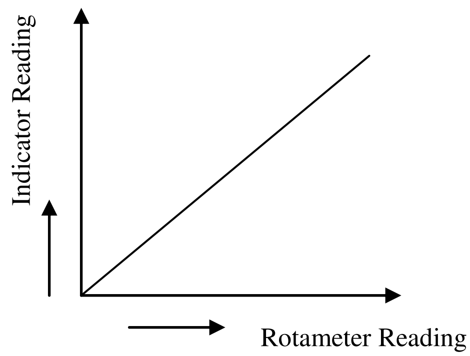
Description Rotometer:

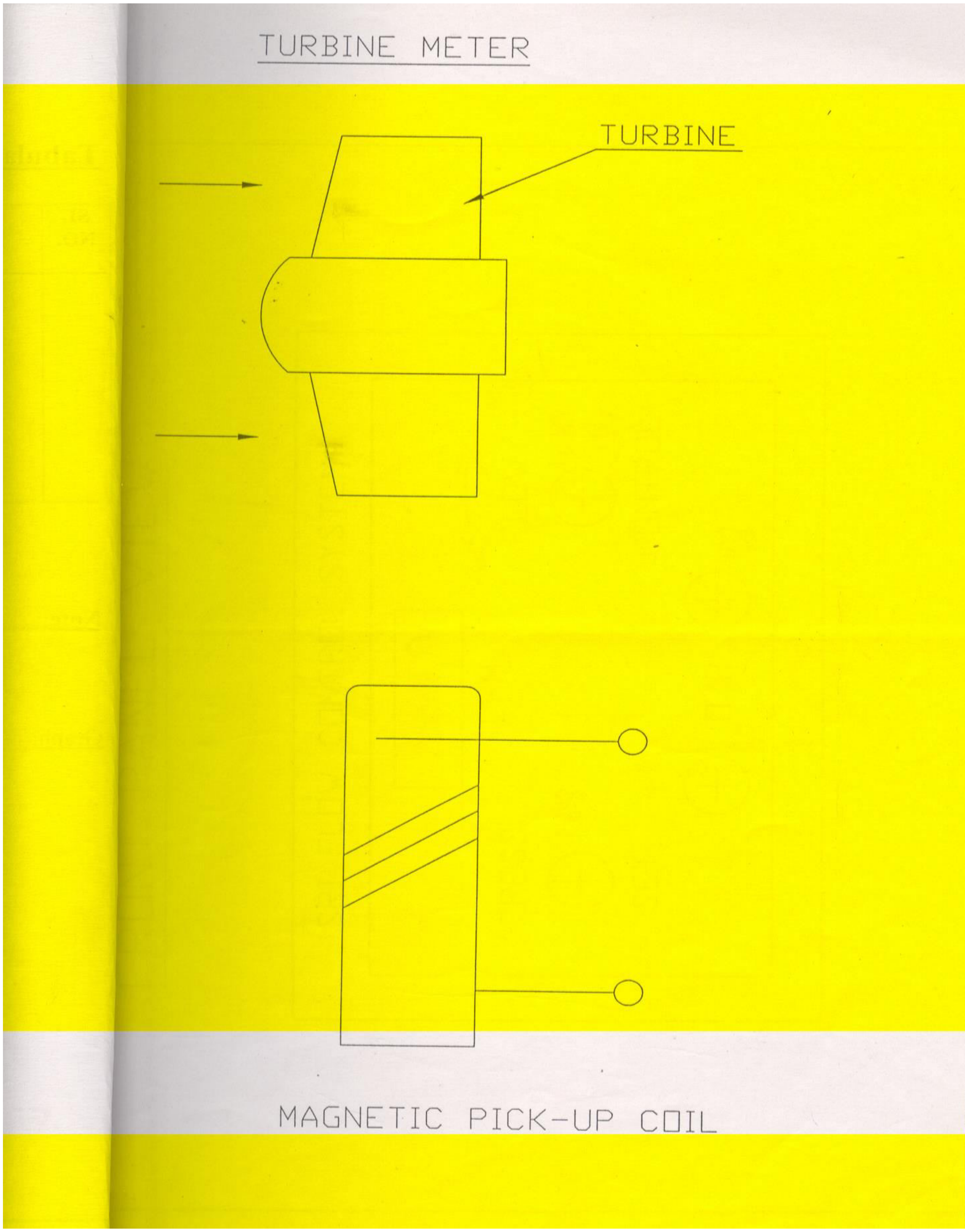
The air source is centrifugal blower which controlled by the set valve of flow of air measured in L.P.M. The flow is measured directly on the rotameter. The turbine flow meter senses the flow rate and through microprocessor based signal conditioner. The flow is measure din digital form and acts us a set point controller also.

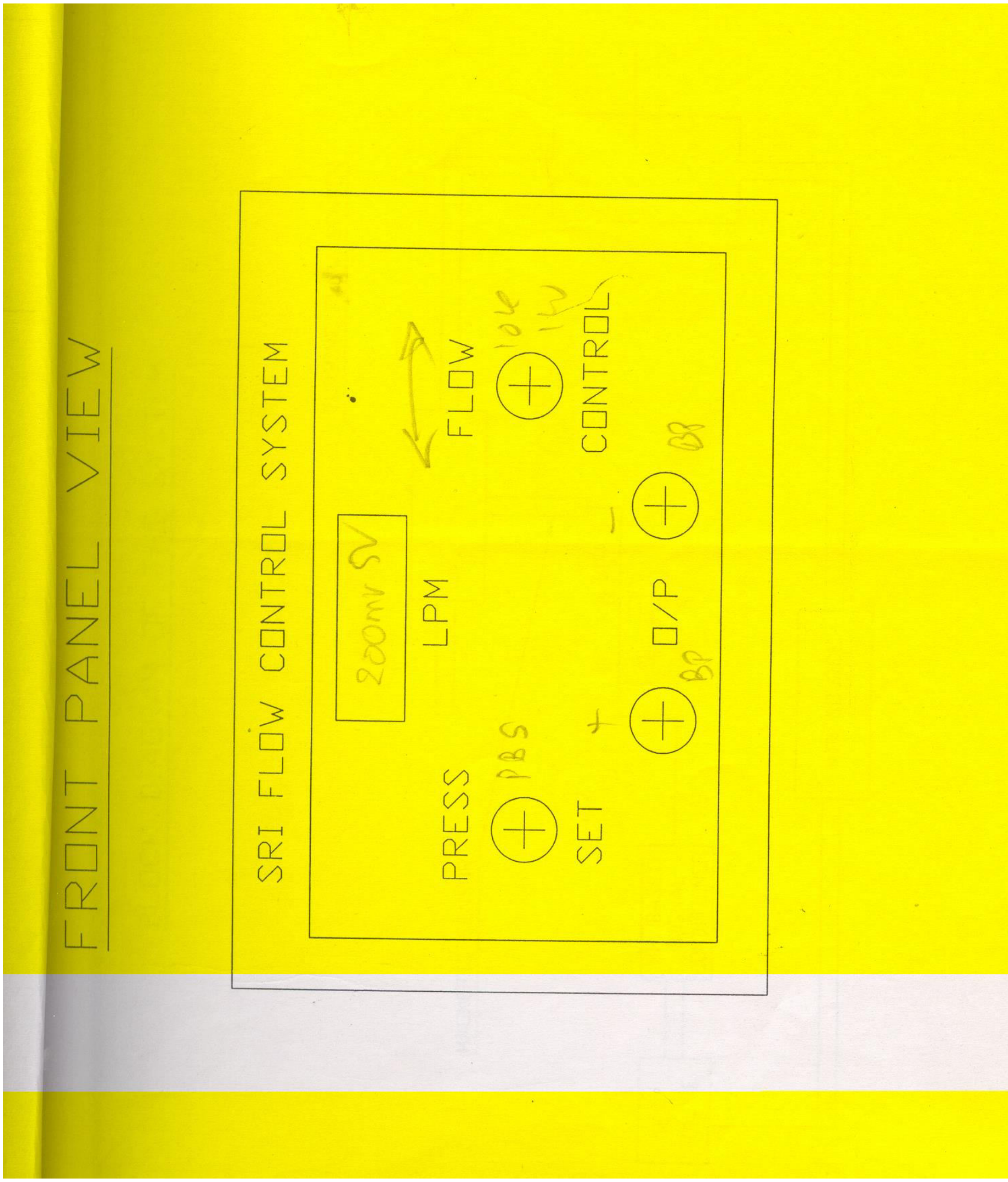
Tabular Column

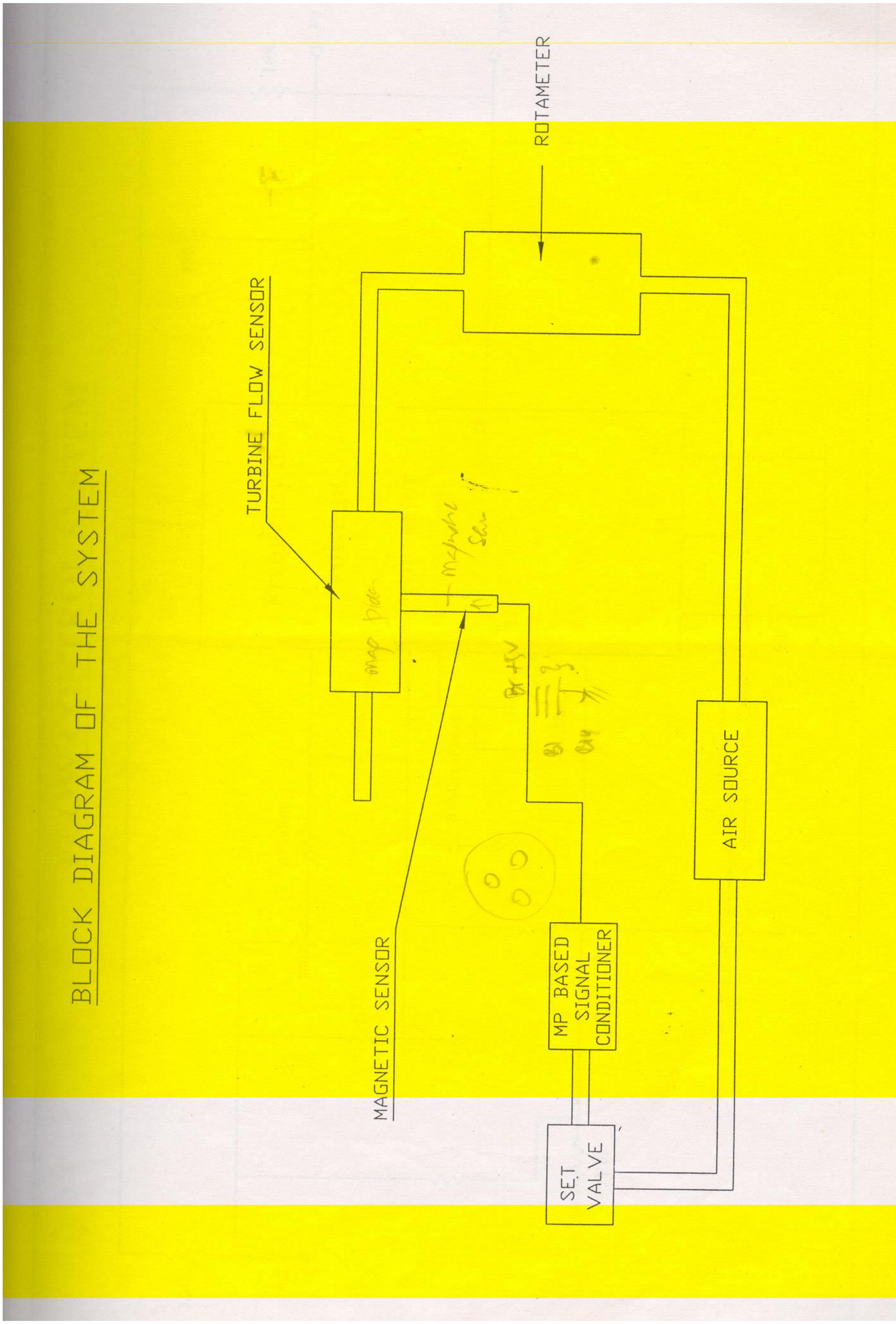
Sl.No.	Set Flow in L.P.M.	Rotameter Reading in L.P.M.	Digital Reading	Error Between Rotameter & Digital reading

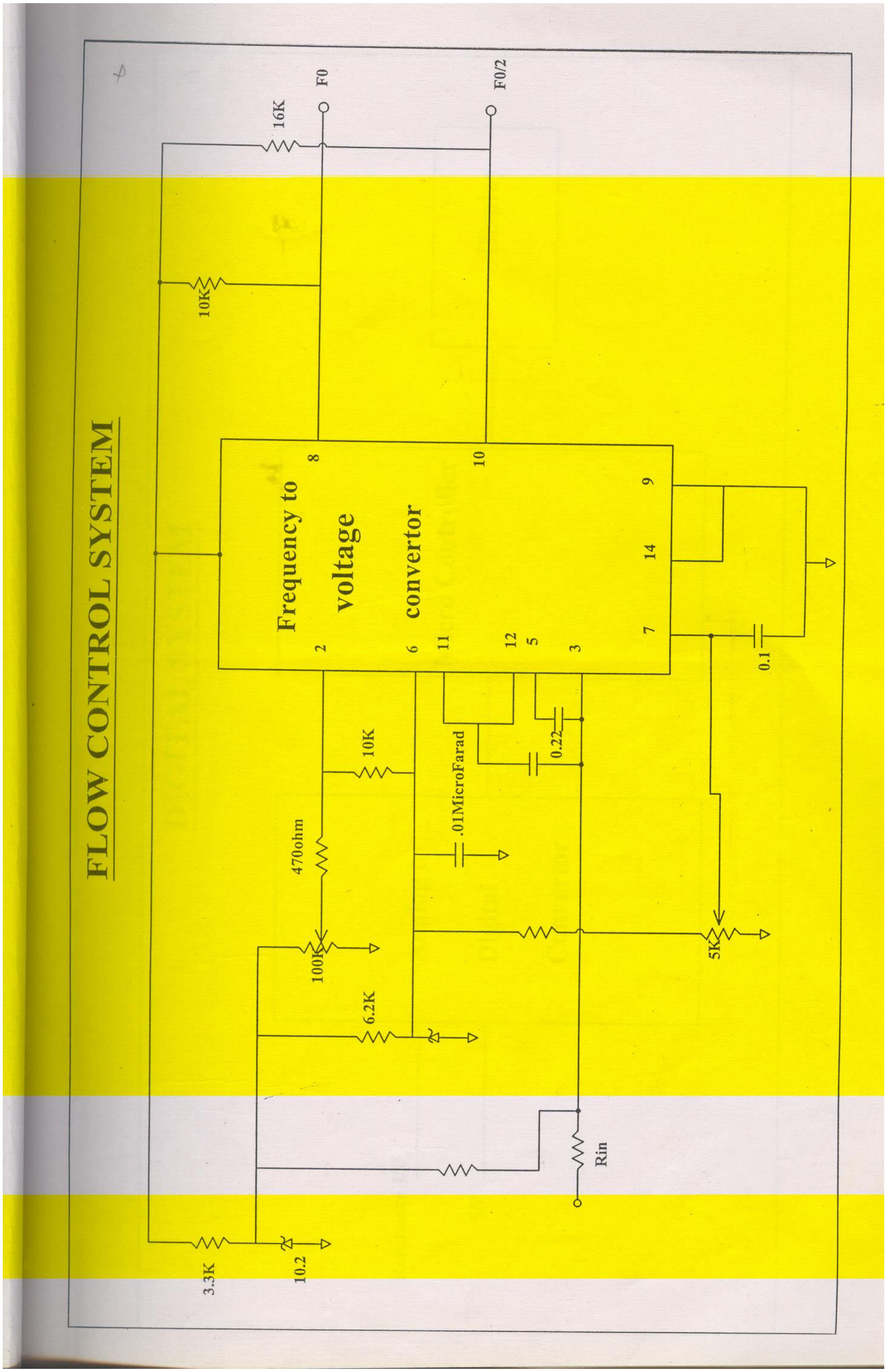
Note: **The range of Flow is 30 L.P.M. to 100 L.P.M.**

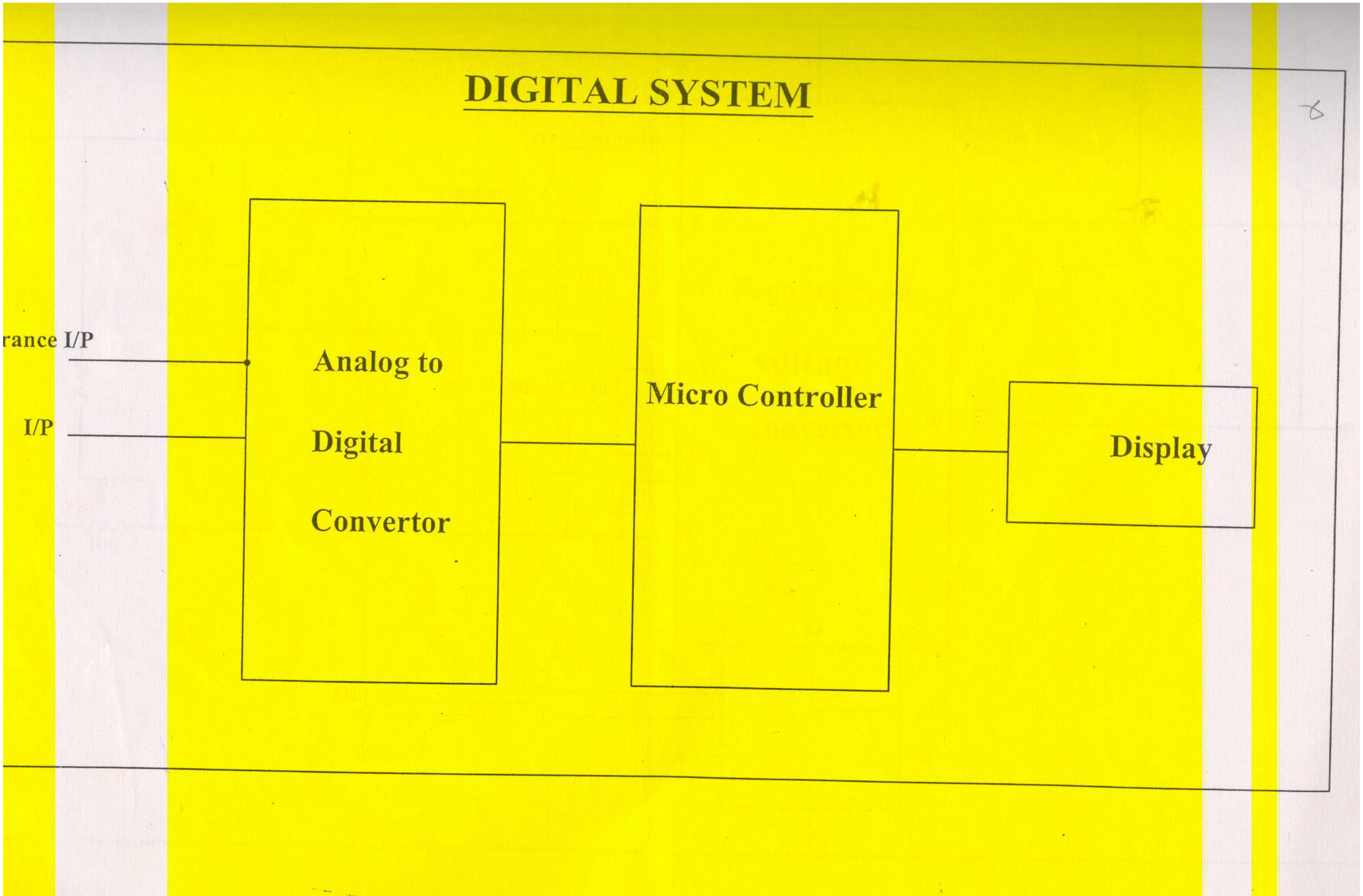



TURBINE METER
TURBINE
MAGNETIC PICK-UP COIL

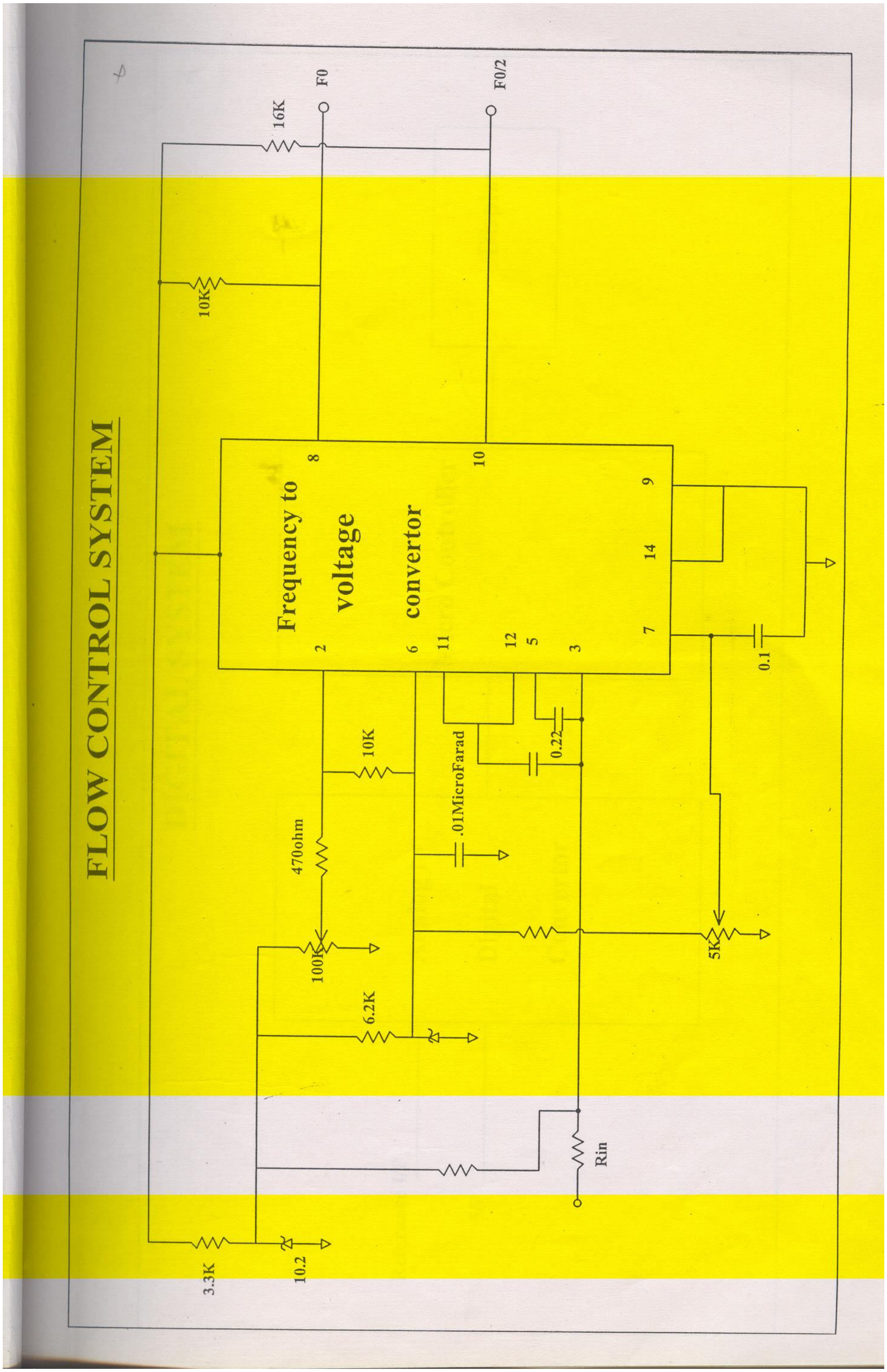

FRONT PANEL VIEW
SRI FLOW CONTROL SYSTEM
LPM
PRESS
SET
O/P
FLOW
CONTROL


BLOCK DIAGRAM OF THE SYSTEM
TURBINE FLOW SENSOR
ROTAMETER
MAGNETIC SENSOR
MP BASED SIGNAL CONDITIONER
AIR SOURCE
SET VALVE

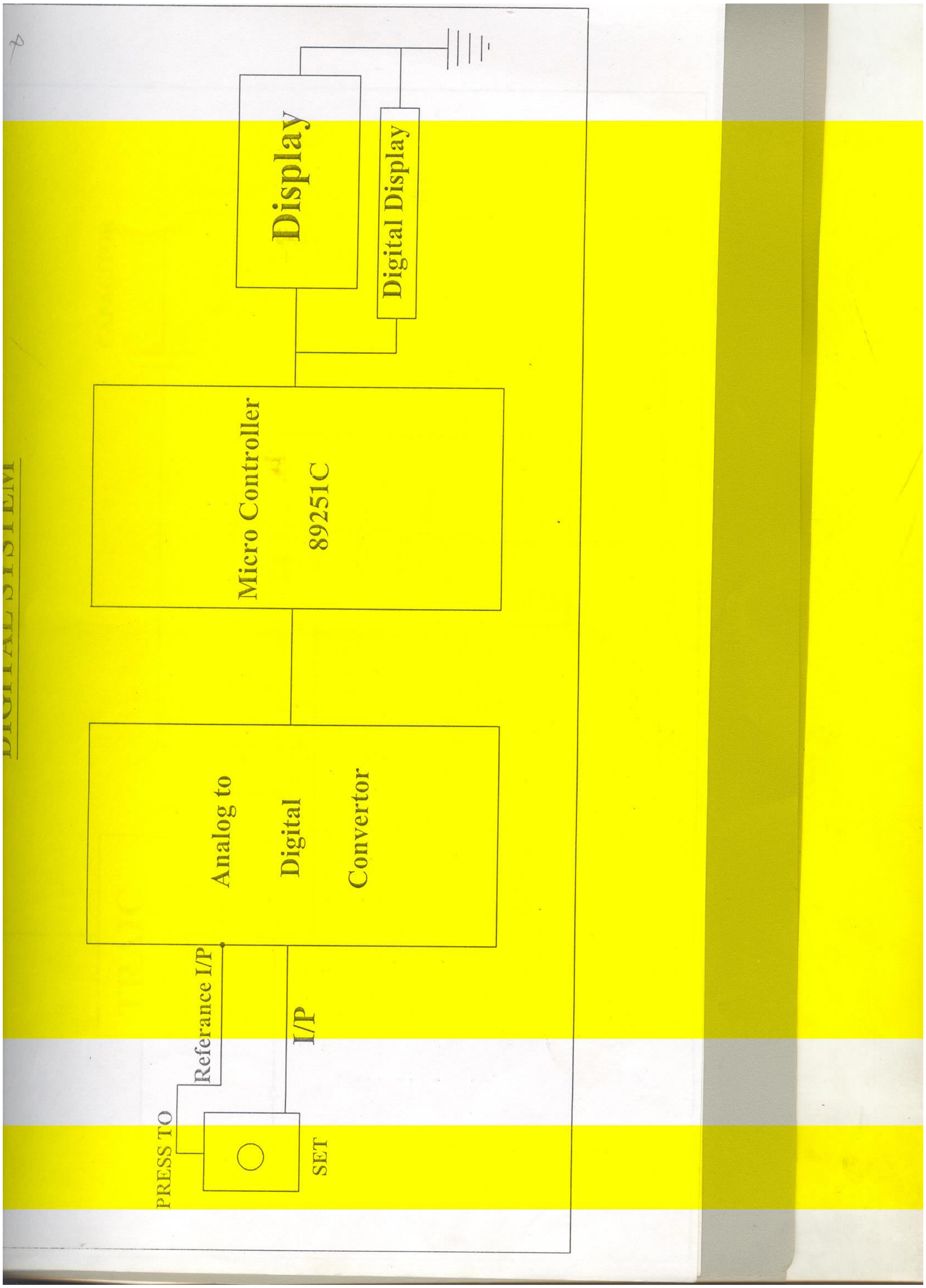

FLOW CONTROL SYSTEM
Frequency to
voltage
convertor
16K
F0
F0/2
10K
8
10
9
14
7
2
6
11
12
5
3
0.1
10K
.01MicroFarad
0.22
470ohm
100K
5K
6.2K
Rin
3.3K
10.2

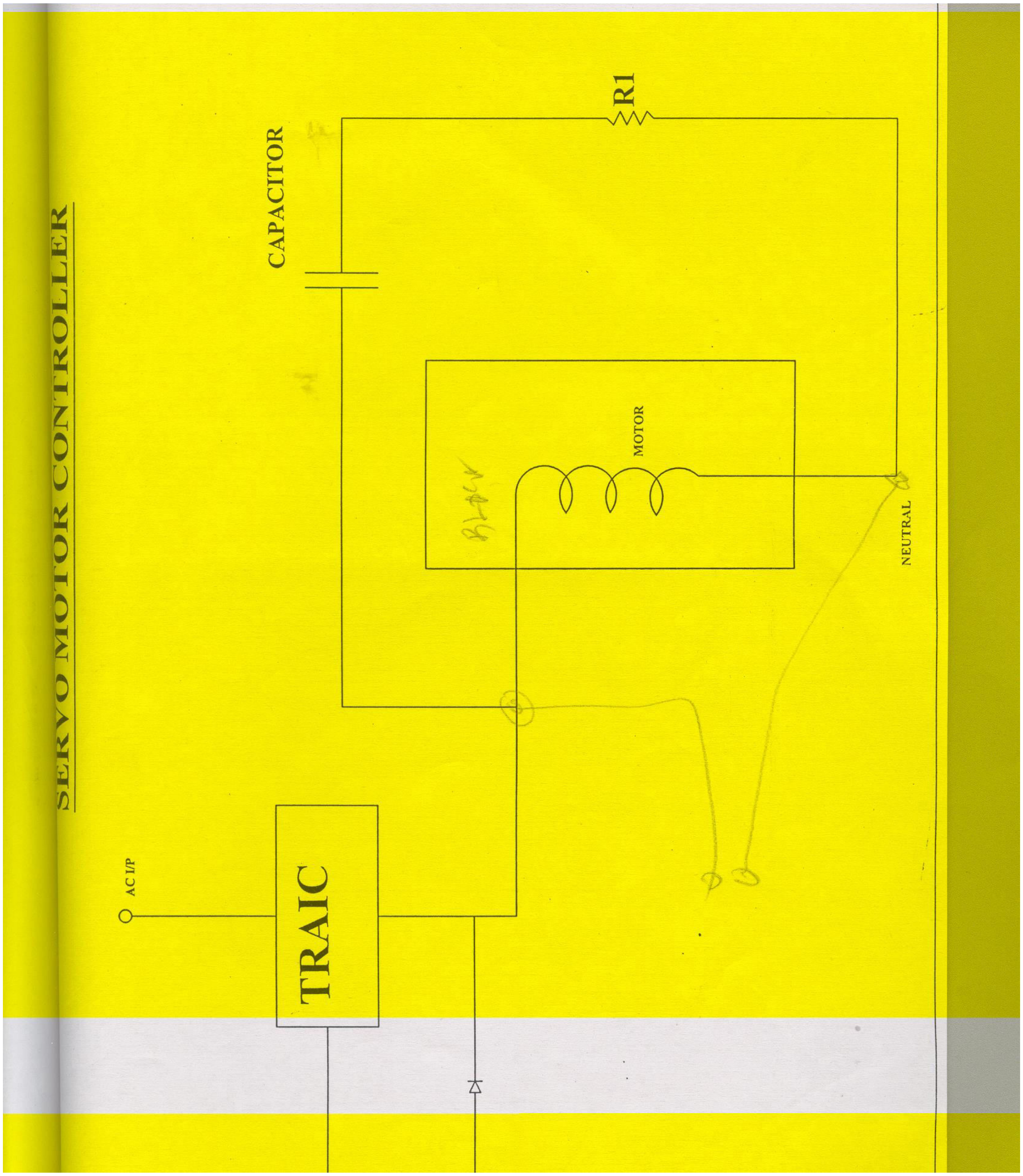


DIGITAL SYSTEM
rance I/P
I/P
Analog to
Digital
Convertor
Micro Controller
Display


FLOW CONTROL SYSTEM
Frequency to
voltage
convertor
2
6
11
12
5
3
7
14
9
8
10
16K
F0
F0/2
10K
10K
470ohm
.01MicroFarad
0.22
0.1
100K
6.2K
5K
Rin
3.3K
10.2

DISPLAY SYSTEM




SERVO MOTOR CONTROLLER
CAPACITOR
R1
MOTOR
NEUTRAL
AC I/P
TRAIC