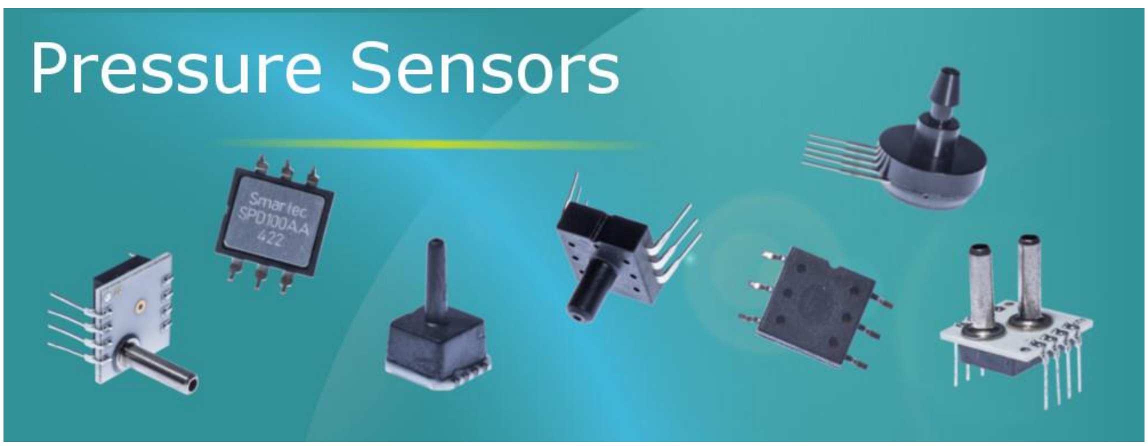
EXPERIMENT – 1

AIM: To study performance characteristics Pressure sensor.

- **Definition of a sensor:-**

  A sensor is a device that measures a physical quantity and translates it to a signal. The quantity can be for instance temperature, length, force, or pressure. The signal is in most cases electrical but can also be optical.



- **Working Principle of a Pressure Sensor:-**

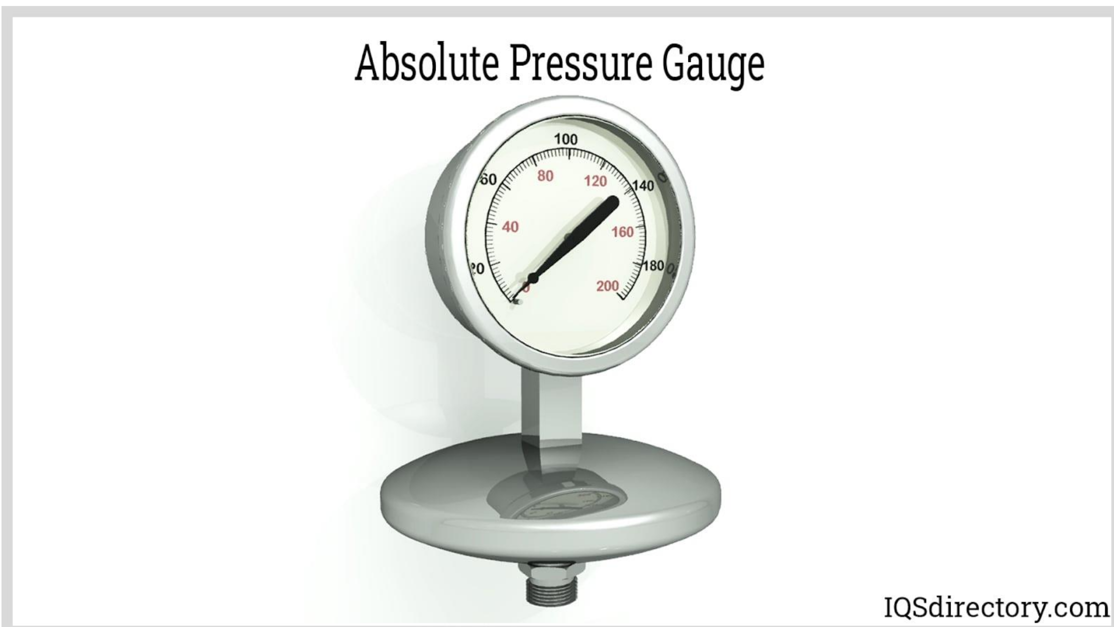
  Pressure transducers have a sensing element of constant area and respond to force applied to this area by fluid pressure. The force applied will deflect the diaphragm inside the pressure transducer. The deflection of the internal diaphragm is measured and converted into an electrical output. This allows the pressure to be monitored by microprocessors, programmable controllers and computers along with similar electronic instruments.

- **Types of Pressure Gauges:-**

1. Absolute Pressure Gauge

Absolute pressure gauges are used to measure pressure independent of the natural fluctuations in atmospheric pressure. A reference vacuum is attached to the side of the measuring element, which is not subject to pressure; it has zero pressure with no variation. A diaphragm separates the media chamber from the vacuum chamber and deforms into the vacuum chamber as pressure rises. The deformation and change is converted into a pressure value.

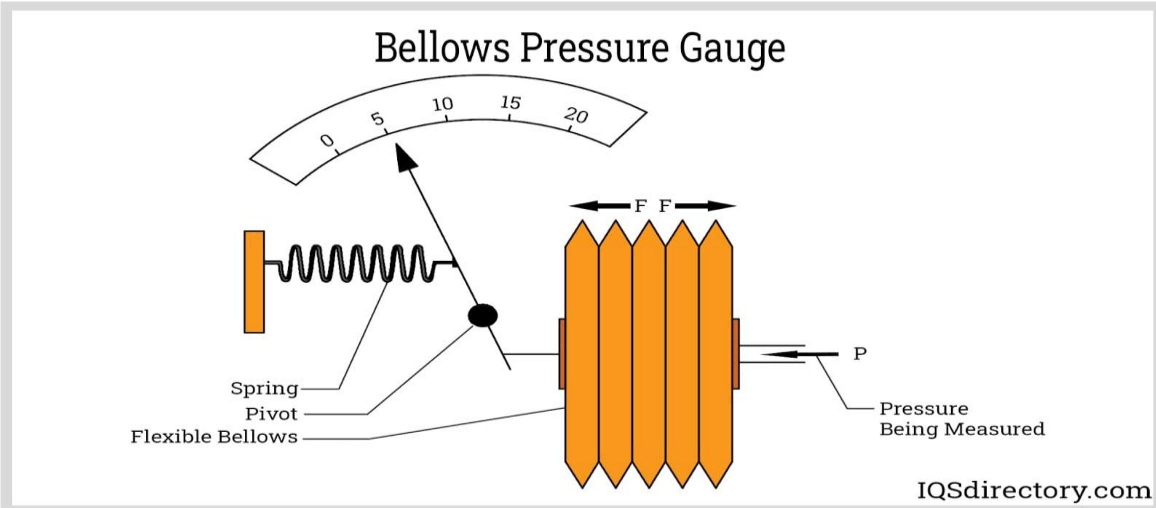
Unlike other pressure gauges, absolute pressure gauges are not influenced by changes in altitude, which makes them ideal for use in aeronautics, HVAC systems, and distillation processes.



2. Bellows Pressure Gauge

The bellows in a bellows pressure gauge is made of thin walled springy metal connected tubes that form a shape similar to an accordion; this is sealed in the free end of the gauge. As pressure is applied, it acts on the bellows on the free end, causing it to expand and produce movement. Bellows pressure gauges are very sensitive and used for low pressure applications.

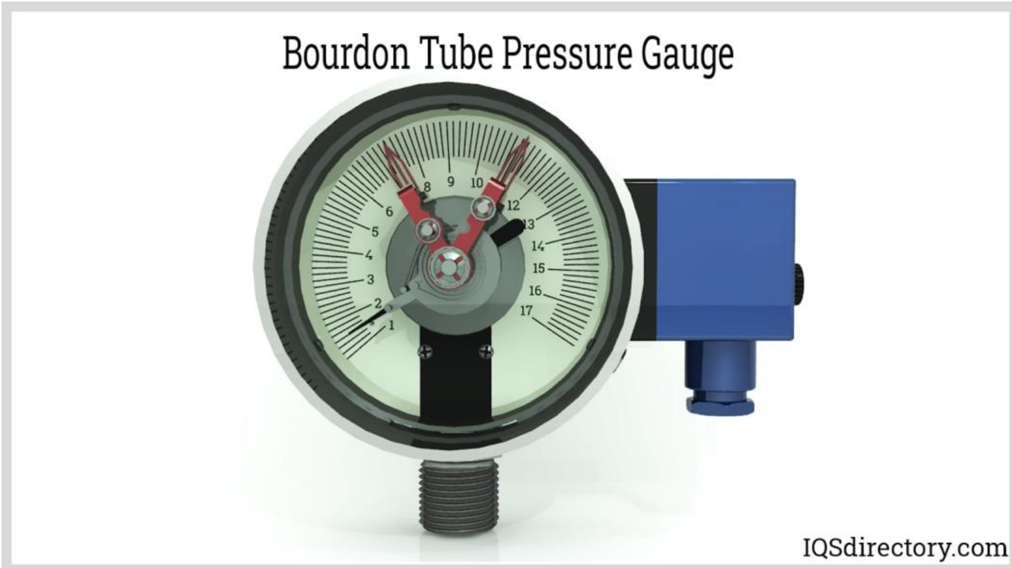
There are two forms of bellows gauges. In one form, pressure is applied to the bellows, resulting in a deformation on a counterbalanced spring. Another form uses the differential pressure principle with the bellows sealed between the two chambers of differing pressure.



3. Bourdon Tube Pressure Gauge

A Bourdon tube pressure gauge has an elastic tube that is soldered or welded on one end into a socket. A change in pressure causes deflection in the tube; this is proportional to the applied pressure and is sent to a rotary gear with a pointer. The operating principle of a Bourdon pressure gauge is that a curved tube will straighten when pressure is applied; this is indicated by a dial or digital readout.

Bourdon tube pressure gauges are used to measure pressure up to 1000 bar and down to -1 bar of gas, steam, or fluids. They have accuracy between ± 0.1% and ± 2.5% of full scale deflection and are made of brass, stainless steel, or monel, a nickel alloy.

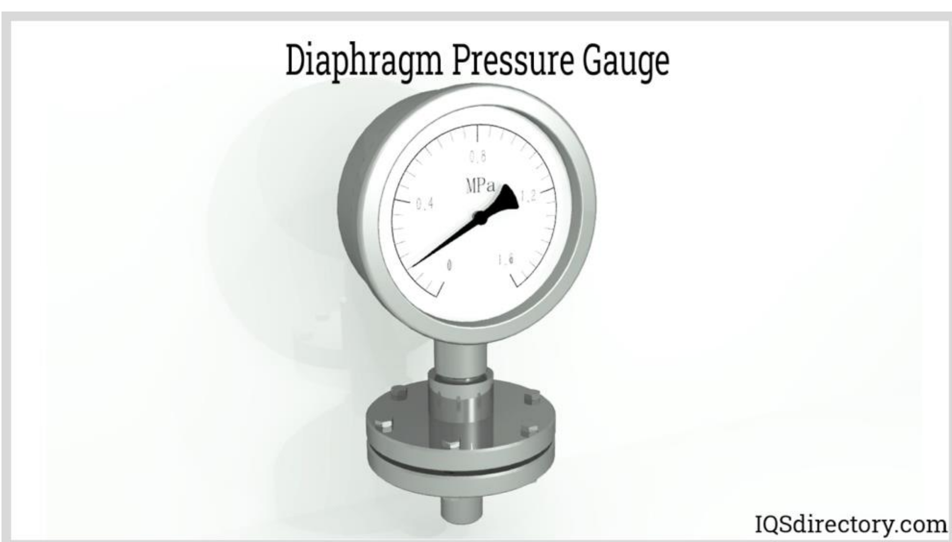


4. Capsule Pressure Gauge

A capsule pressure gauge has two thin, concentric corrugated diaphragms that are sealed tightly together around their circumferences. One of the diaphragms has a hole in the center that allows the medium to enter. When pressure is applied, the diaphragms expand or contract. This change in shape creates rotary movement that appears on the face of the gauge. Capsule pressure gauges are used for the measurement of substances with pressures up to 600 mbar with an accuracy of ± 1.6%, and they are used exclusively for measuring the pressure of gases.

5. Diaphragm Pressure Gauge

A diaphragm pressure gauge is elastic and becomes displaced when pressure is applied. This type of pressure gauge works on the same principle as a Bourdon pressure gauge but measures pressure using a diaphragm instead of a flexible tube. The diaphragm, which is placed between two flanges, is used to determine the difference between the applied pressure and the reference pressure. It can measure pressure as high as 40 bar to -1 bar of gas, steam, and fluids. The main use of a diaphragm pressure gauge is for measurement of low level pressure.



- **Characteristics of Pressure Sensors**

Today many measuring principles are used in electrical pressure measuring instruments. Most methods are based on the measurement of a displacement or force. In other words, the physical variable "pressure" has to be converted into an electrically quantifiable variable. Unlike mechanical pressure measuring methods, this conversion requires an external power source for the pressure sensor.

This pressure sensor is the basis of electrical pressure measuring systems. While mechanical gauge element displacements of between 0.004 and 0.012 inches are standard, the deformations in electrical pressure sensors amount to no more than a few microns.

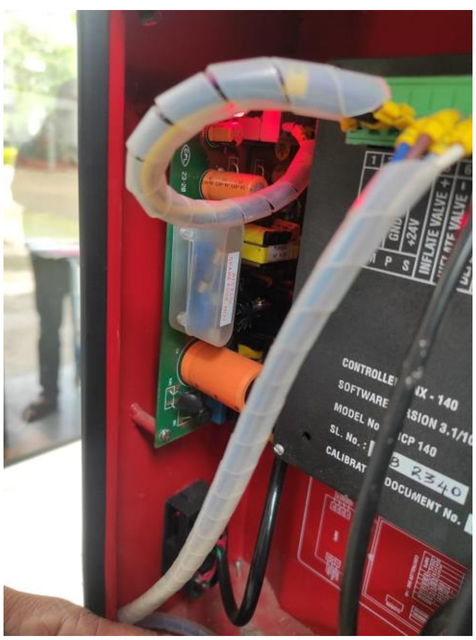
Thanks to this minimal deformation, electrical pressure measuring instruments have excellent dynamic characteristics and low material strain resulting in high resistance to alternating loads and long-term durability.

Listed below some of the sensor elements used by WIKA in its electronic pressure measurement instrumentation:

- Capacitive Polymer Sensor
- Ceramic Thick Film Sensor (top left and top middle images)
- Chilled Mirror Sensor
- Electrochemical Sensor
- Infrared Spectroscopy Sensor
- LVDT (Linear Variable Differential Transformer) Sensor
- Piezoresistive (Piezo) Sensor (center and center right images)
- Sound Velocity Sensor.

- **Example of Pressure in Real Life.**

Above and below are shown figure of pressure sensors with its whole mechanism for Tyre Inflators.



- **Conclusion**
  In this experiment, we have studied a brief of pressure sensors and explored more of practically by visualizing pressure sensors in tyre inflators with its working.

EXPERIMENT – 2

AIM: To study the working of Photovoltaic sensor.

- **Introduction**

  An important type of photodetector is the photovoltaic cell, which generates a voltage that is proportional to the incident EM radiation intensity. These sensors are called photovoltaic cells because of their voltage-generating capacity, but the cells actually convert EM energy into electrical energy. Photovoltaic cells are very important in instrumentation and control applications because they are used both as light detectors and in power sources that convert solar radiation into electrical power for remote-measuring systems. Our emphasis here is on their use in analytical instruments.

- **Working principle**

  The operating principle of the photovoltaic cell is illustrated in Figure above. The cell is a large exposed diode that is constructed using a pn junction between appropriately doped semiconductors. Photons hitting the cell pass through the thin p-doped upper and are absorbed by electrons in the n-doped layer. This causes conduction electrons and holes to be created.

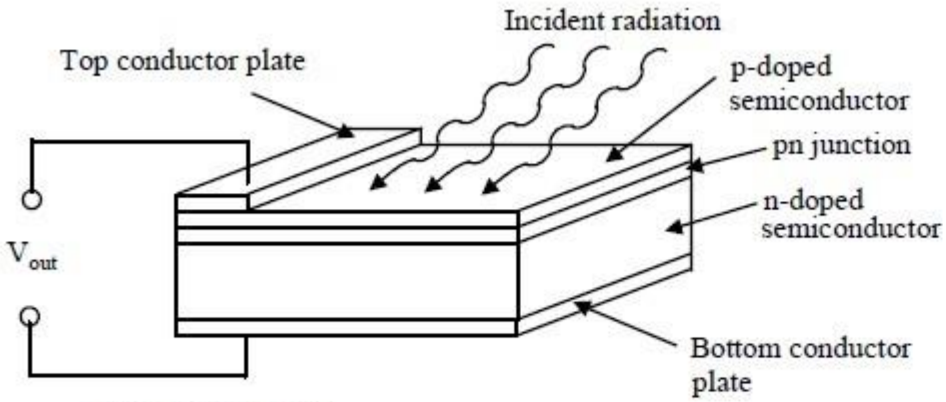
  The upper terminal is positive and the lower negative. In general, the open-circuit voltage V that is developed on a photovoltaic cell varies logarithmically with the incident radiation intensity according to the following equation:

  $V = V_o \ln(I_r)$, where

  I_r = the radiation intensity in W/m2

  V_o = the calibration voltage in volts

  V = the unloaded output voltage in volts



Photovoltaic cell

- **Advantages**

1. The electricity produced by the solar cells is clean and silent. Because they do not use fuel other than sunlight, PV systems do not release any harmful contamination of air or water into the environment, deplete natural resources or endanger human or animal health.

2. Photovoltaic systems are silent and visually discrete.

3. Small-scale solar plants can take advantage of unused space on the roofs of existing buildings.

4. Photovoltaic cells were originally developed for use in space, where repair is extremely expensive, if not impossible. Photovoltaic energy still feeds almost all satellites that circulate through the earth, since it works reliably for long periods of time with little maintenance.

- **Disadvantages**

1. Some toxic chemicals, such as cadmium and arsenic, are used in the photovoltaic production process. These environmental impacts are minor and can be easily controlled by recycling and proper disposal.

2. Solar energy is somewhat more expensive to produce than conventional energy sources due in part to the cost of manufacturing photovoltaic devices and partly to the conversion efficiencies of the equipment. As conversion efficiencies continue to increase and manufacturing costs continue to decline, PV will become increasingly cost competitive with conventional fuels.

- **Procedure**

1. Connecting power supply from the external source to the kit
2. Connecting voltmeters between the test point name as lamp input voltage and ground.
3. Connect the voltmeter between photovoltaic output and GND(Ground).
4. Rotate 10kohm potentiometer fully in counter clock-wise direction
5. Place the Op-amp box over plastic, enclosure to exclude the light
6. Switch on the supply.
7. Take the readings after 1 V each step
8. Plot the graph of photovoltaic o/p voltage against lamp voltage.

- **Observation Table**

Sr.No	Lamp Input voltage	Output Voltage
1	10.8	1.62
2	9.96	1.55
3	7.82	1.34
4	7.06	1.22
5	6.02	1.12
6	4.88	0.975
7	3.95	0.956

8	2.68	0.824
9	1.05	0.780
10	0.3	0.765

- **Conclusion**

In this experiment, we have discussed about the photovoltaic cell , how it can act as a sensor and performed practical experiment in the laboratory.

<u>EXPERIMENT – 3</u>

AIM: To study about sensors used in Automobile system

- **Introduction**

    - At present, the modern automobile designing can be done using different types of sensors.
    - These are arranged into the car engine to recognize & solve possible problems like repairs, servicing, etc.
    - The sensors used in automobiles will check the function of the vehicle. An owner of a vehicle doesn't know the status of how many sensors are used in their vehicles.
    - There are several largest sensor organizations available worldwide, which can offer an innovative solution to the customers.
    - In recent automobiles, sensors are used for detecting as well as responding to change the conditions inside & outside of the car. So that travelers in the vehicle can move efficiently and safely.
    - By using these sensors data we can increase comfort, efficiency and safety.

- **Types of sensors used in Automobiles**

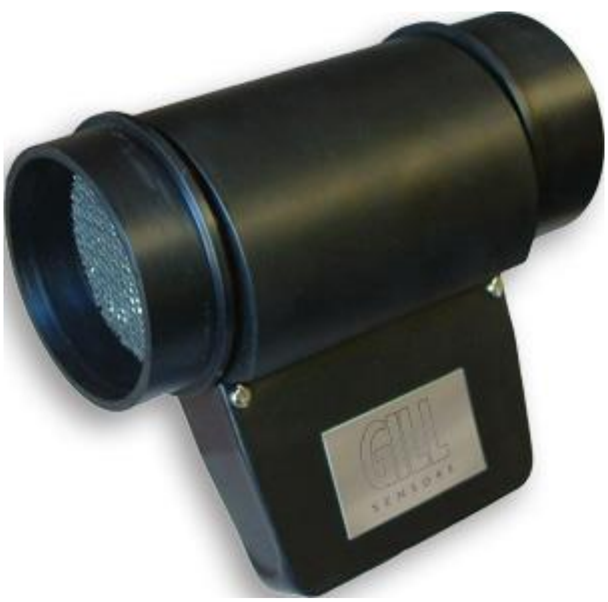
  Automobile sensors are intelligent sensors which can be used to control and process the pressure of oil, temperature, level of emission, coolant levels, etc. There are different types of sensors used in automobiles, but knowing the working of these sensors is essential. In order to the function of these sensors, here we have listed some popular sensors used in automobiles which include the following.

- Mass airflow sensor
- Engine Speed Sensor
- Oxygen Sensor
- Spark Knock Sensor
- Coolant Sensor

- Manifold Absolute Pressure (MAF) Sensor
- Fuel Temperature Sensor
- Voltage sensor
- Camshaft Position Sensor
- Throttle Position Sensor
- Vehicle Speed Sensor

1. Mass Air Flow Sensor

The MAF or Mass airflow sensor is one of the essential sensor used in automobiles. This sensor is used in an engine of the car. This sensor can be controlled by a computer and can calculate the air density in the engine. If the working of this sensor halts, then the running of the vehicle will be stopped. In addition, the usage of petroleum will be high. These sensors are classified into two types namely vane meter & hot wire.



2. Engine Speed Sensor

The engine speed sensor in the automobile can be connected to the crankshaft. The main purpose of this sensor is to monitor the crankshaft's rotating speed. So that fuel injection & the engine timing can be controlled. There are different ways for the vehicle engine to stop unexpectedly. So this sensor will stop that for car drivers.

3. Oxygen Sensor

Located in the exhaust stream, usually near the exhaust manifold and after the catalytic converter, the oxygen sensor (or O2 sensor) monitors the content of exhaust gases for the proportion of oxygen. The information is compared to the oxygen content of ambient air and is used to detect whether the engine is running a rich fuel ratio or a lean one. The engine computer uses this information to determine fuel metering strategy and emission controls.

4. Spark Knock Sensor

The spark knock sensor is used to ensure whether the fuel is burning smoothly, otherwise, it will cause an unexpected ignition. This ignition is very dangerous which will cause damage in the engine of the car like damage of rings, head gasket, and rod bearings. Fitting these parts can be costly. So this sensor is used to save all the troubles occurred in an engine of the car.

spark-knock-sensor

5. Coolant Sensor

The coolant sensor is the most significant sensor used in automobiles. Because the computer depends on the sensor inputs to control all the functions. For instance, turn ON/OFF the EFE system (Early Fuel Evaporation), retard, spark advance, the flow of EGR, and canister purge.

coolant-sensor

Generally, this sensor can be connected on the board. If the sensor is failed, then there will be some indications stalling, like poor fuel mileage, etc. So, the status of the sensor should be checked whether it is defective or not. If it is damaged, then it will be a problem.

6. Manifold Absolute Pressure Sensor

The short term of the manifold absolute pressure is MAP. The main function of this sensor in an automobile is to monitor the load of an engine. Mostly, it measures the dissimilarity among manifold pressure. This can be received from the outside pressure by the car to make sure that the car engine is capable to receive petroleum depending on the changes within the pressure.

manifold-absolute-pressure-sensor

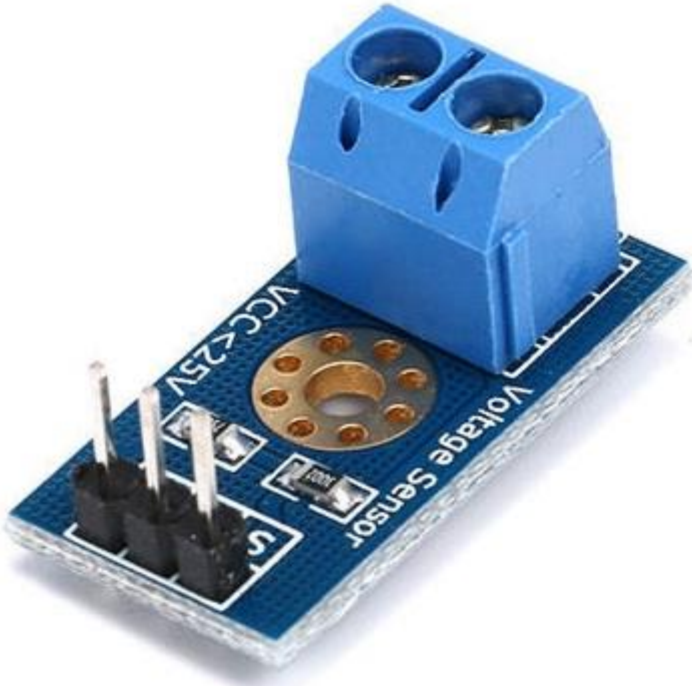
7. Fuel Temperature Sensor

The fuel sensor is used to check the temperature of the fuel continually whether the fuel utilization is optimum or not. If the fuel of the engine is cold, then it will take much time to burn due to its high density. Similarly, if the fuel is warm then it will take less time to burn. Here, the main problem is the inflow varying levels. So this can injure other parts of an automobile. This sensor will monitor the petroleum is injected at the right speed and temperature. So that engine of the automobile works properly.

fuel-temperature-sensor

8. Voltage Sensor

Voltage Sensor is one type of sensor used in automobiles. The main function of this sensor is to manage the car speed and to make sure the speed of is increased (or) decreased as required. So it is essential to have in your car.



voltage-sensor

9. Throttle Position Sensor

The throttle position sensor in automobile mainly uses feedback carburetion & electronic fuel injection (EFI). It informs the computer regarding the throttle opening rate as well as the position of the relative throttle. This sensor is a variable resistor, which is used to change the resistance as the throttle opens.

throttle-position-sensor

It is not complex to identify the faulty throttle position sensor symptoms. As there is a fall while speeding up, then you can identify the faulty of the sensor. It is the major sign of a faulty throttle position sensor. Whenever you change this sensor, you cannot adjust it properly.

10. Vehicle Speed Sensor

As the name suggests, this VSS sensor has the capability to verify the speed of the car wheels. It is a type of tachometer. This sensor is arranged within the anti braking system which is known as ABS. Additionally, the output of this sensor is also utilized for the odometer to read the speed of the vehicle to control gears depending on the vehicle speed.

vehicle-speed-sensor

Thus, this is all about the different types of sensors used in automobiles. These sensors are smart systems which are used for controlling different parts like coolant levels, temperature, the pressure of oil, levels of emission, etc. These automobile sensors are complex to allow a variety of values, decide and process the accurate combination.

- **Conclusion**

In this experiment, we studied the various different types of sensors used in practical life in automobile systems along with their working principle.

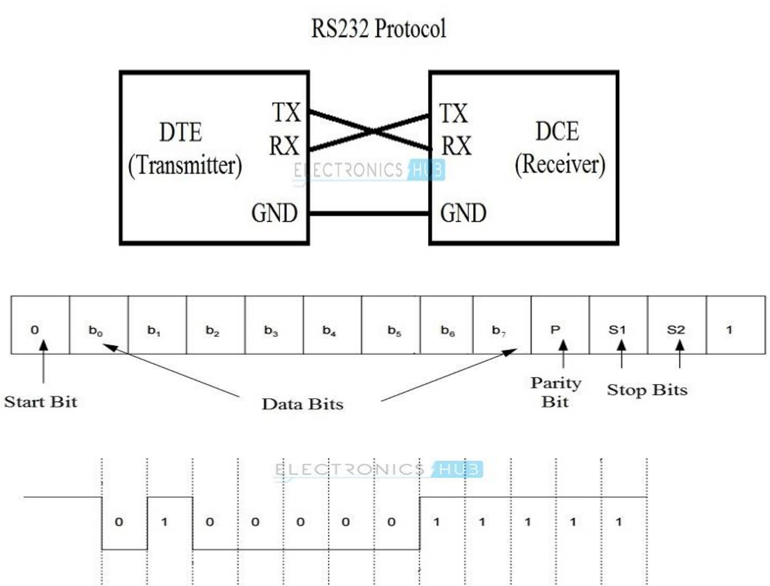
EXPERIMENT – 4

AIM: To study Industry standard RS232

- ### Introduction

A popular way to transfer commands and data between a personal computer and a microcontroller is the use of standard interface, like the one described by protocols RS232 (older) or USB (newer). It formally defines signals connecting between a DTE (data terminal equipment) such as a computer terminal, and a DCE (data circuit-terminating equipment or data communication equipment), such as a modem

The protocol RS232 defines the signals used in communication, and the hardware to transfer signals between devices.



A serial port complying with the RS-232 standard was once a standard feature of many types of computers. Personal computers used them for connections not only to modems, but also to printers, computer mice, data storage, uninterruptible power supplies, and other peripheral devices.

Compared with later interfaces such as RS-422, RS-485 and Ethernet, RS-232 has lower transmission speed, shorter maximum cable length, larger voltage swing, larger standard connectors, no multipoint capability and limited multidrop capability. In modern personal computers, USB has displaced RS-232 from most of its peripheral interface roles. However, RS-232 interfaces are still used—particularly in industrial machines, networking equipment, and scientific instruments where a short-range, point-to-point, low-speed wired data connection is fully adequate.

- **Role of RS232 In Modern Personal Computer**

Today, RS-232 has mostly been replaced in personal computers by USB for local communications. Advantages compared to RS-232 are that USB is faster, uses lower voltages, and has connectors that are simpler to connect and use. Disadvantages of USB compared to RS-232 are that USB is far less immune to electromagnetic interference (EMI) and that maximum cable length is much shorter (15 meters for RS-232 versus 3–5 meters for USB)

In fields such as laboratory automation or surveying, RS-232 devices continue to be used. Some types of programmable logic controllers, variable-frequency drives, servo drives, and computerized numerical control equipment are programmable via RS-232.

RS-232 ports are also commonly used to communicate to headless systems such as servers, where no monitor or keyboard is installed, during boot when operating system is not running yet and therefore no network connection is possible. A computer with an RS-232 serial port can communicate with the serial port of an embedded system (such as a router) as an alternative to monitoring over Ethernet.

- **Physical Interface**

In RS-232, user data is sent as a time-series of bits. Both synchronous and asynchronous transmissions are supported by the standard. In addition to the data circuits, the standard defines a number of control circuits used to manage the connection between the DTE and DCE. Each data or control circuit only operates in one direction, that is, signalling from a DTE to the attached DCE or the reverse. Because transmit data and receive data are separate circuits, the interface can operate in a full duplex manner, supporting concurrent data flow in both directions. The standard does not define character framing within the data stream or character encoding.

- ## Voltage levels

The RS-232 standard defines the voltage levels that correspond to logical one and logical zero levels for the data transmission and the control signal lines. Valid signals are either in the range of +3 to +25 volts or the range −3 to −25 volts with respect to the "Common Ground" (GND) pin; consequently, the range between −3 to +3 volts is not a valid RS-232 level. For data transmission lines, logic one is represented as a negative voltage and the signal condition is called "mark". Logic zero is signalled with a positive voltage and the signal condition is termed "space". Control signals have the opposite polarity: the asserted or active state is positive voltage and the de-asserted or inactive state is negative voltage.

- ## Scope of RS232

The Electronic Industries Association (EIA) standard RS-232-C as of 1969 defines:

- Electrical signal characteristics such as voltage levels, signalling rate, timing, and slew-rate of signals, voltage withstand level, short-circuit behaviour, and maximum load capacitance.
- Interface mechanical characteristics, pluggable connectors and pin identification.
- Functions of each circuit in the interface connector.
- Standard subsets of interface circuits for selected telecom applications.

The standard does not define such elements as the character encoding (i.e. ASCII, EBCDIC, or others), the framing of characters (start or stop bits, etc.), transmission order of bits, or error detection protocols. The character format and transmission bit rate are set by the serial port hardware, typically a UART, which may also contain circuits to convert the internal logic levels to RS-232 compatible signal levels. The standard does not define bit rates for transmission, except that it says it is intended for bit rates lower than 20,000 bits per second.

- ## Limitation of RS232

Because RS-232 is used beyond the original purpose of interconnecting a terminal with a modem, successor standards have been developed to address the limitations. Issues with the RS-232 standard include:

- The large voltage swings and requirement for positive and negative supplies increases power consumption of the interface and complicates power supply design. The voltage swing requirement also limits the upper speed of a compatible interface.
- Single-ended signalling referred to a common signal ground limits the noise immunity and transmission distance.
- Multi-drop connection among more than two devices is not defined. While multi-drop "work-arounds" have been devised, they have limitations in speed and compatibility.
- The standard does not address the possibility of connecting a DTE directly to a DTE, or a DCE to a DCE. Null modem cables can be used to achieve these connections, but these are not defined by the standard, and some such cables use different connections than others.
- The definitions of the two ends of the link are asymmetric. This makes the assignment of the role of a newly developed device problematic; the designer must decide on either a DTE-like or DCE-like interface and which connector pin assignments to use.
- The Handshaking and control lines of the interface are intended for the setup and takedown of a dial-up communication circuit; in particular, the use of handshake lines for flow control is not reliably implemented in many devices.
- No method is specified for sending power to a device. While a small amount of current can be extracted from the DTR and RTS lines, this is only suitable for low-power devices such as mice.
- The 25-pin D-sub connector recommended in the standard is large compared to current practice.

- ## Conclusion

In this experiment, we have briefly discussed the general idea, features, scope and pros and cons of the industry standard RS232.

EXPERIMENT – 5

AIM: To study Industry standard OSI model.

- **Introduction:**

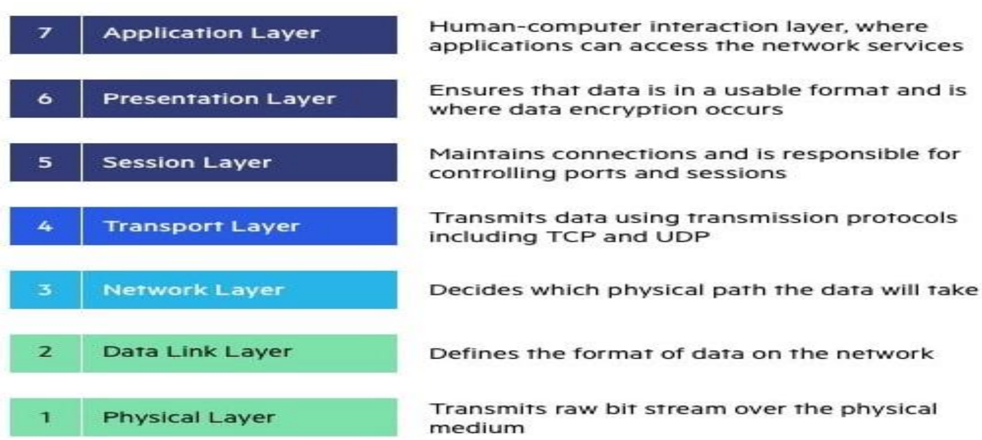
  • The Open Systems Interconnection (OSI) model describes seven layers that computer systems use to communicate over a network. It was the first standard model for network communications, adopted by all major computer and telecommunication companies in the early 1980s.

  • The modern Internet is not based on OSI, but on the simpler TCP/IP model. However, the OSI 7-layer model is still widely used, as it helps visualize and communicate how networks operate, and helps isolate and troubleshoot networking problems.

  • OSI was introduced in 1983 by representatives of the major computer and telecom companies, and was adopted by ISO as an international standard in 1984.

  • The Open Systems Interconnection (OSI) model is a reference tool for understanding data communications between any two networked systems. It divides the communications processes into seven layers. Each layer both performs specific functions to support the layers above it and offers services to the layers below it. The three lowest layers focus on passing traffic through the network to an end system. The top four layers come into play in the end system to complete the process.

- **OSI Model Explained: The OSI 7 Layers**



1. Physical

• The lowest layer of the OSI model is concerned with data communication in the form of electrical, optic, or electromagnetic signals physically transmitting information between networking devices and infrastructure.

• The physical layer is responsible for the communication of unstructured raw data streams over a physical medium. It defines a range of aspects, including:

1. Electrical, mechanical, and physical systems and networking devices that include specifications such as cable size, signal frequency, voltages, etc.

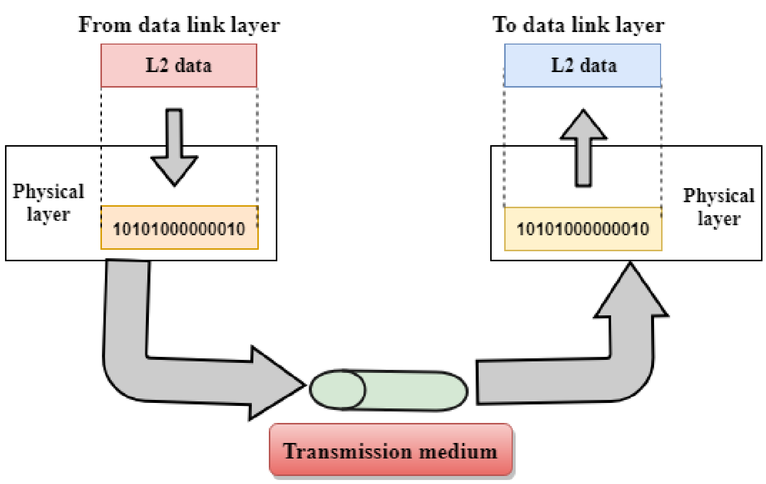
2. Topologies such as Bus, Star, Ring, and Mesh

3. Communication modes such as Simplex, Half Duplex, and Full Duplex

4. Data transmission performance, such as Bit Rate and Bit Synchronization.

5. Modulation, switching, and interfacing with the physical transmission medium.

6. Common protocols including Wi-Fi, Ethernet, and others.



2. Data Link

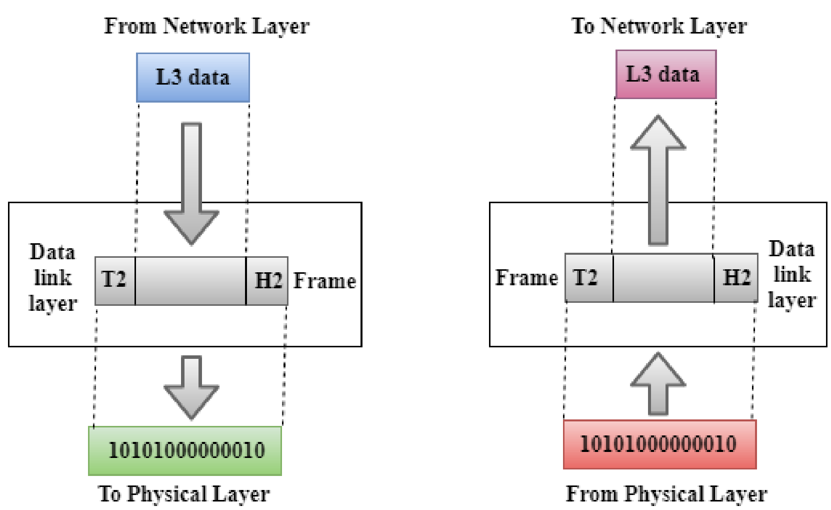
• The second layer of the OSI model concerns data transmission between the nodes within a network and manages the connections between physically connected devices such as switches.

•The raw data received from the physical layer is synchronized and packaged into data frames that contain the necessary protocols to route information between appropriate nodes.

The data link layer is further divided into two sublayers:

• The Logical Link Control (LLC) sublayer is responsible for flow controls and error controls that ensure error-free and accurate data transmission between the network nodes.

• The Media Access Control (MAC) sublayer is responsible for managing access and permissions to transmit data between the network nodes. The data is transmitted sequentially and the layer expects acknowledgement for the encapsulated raw data sent between the nodes.



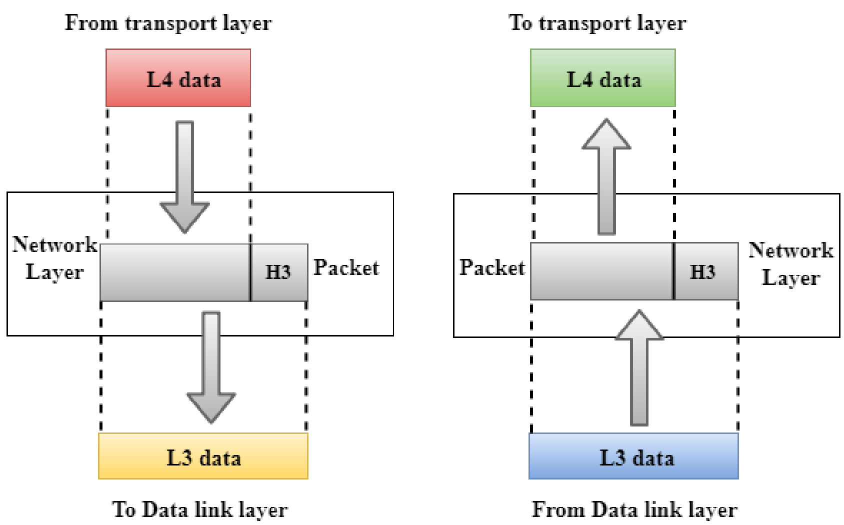
3. Network

• The third layer of the OSI model organizes and transmits data between multiple networks.

• The network layer is responsible for routing the data via the best physical path based on a range of factors including network characteristics, best available path, traffic controls, congestion of data packets, and priority of service, among others.

• The network layer implements logical addressing for data packets to distinguish between the source and destination networks.

• Network layer hardware includes routes, bridge routers, 3-layer switches, and protocols such as Internet (IPv4) Protocol version 4 and Internet Protocol version 6 (IPv6).

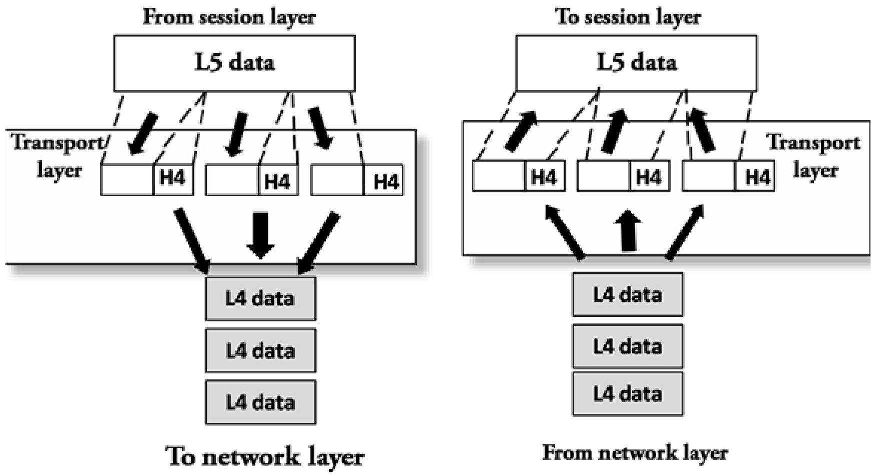


4. Transport

The fourth layer of the OSI model ensures complete and reliable delivery of data packets.

• The transport layer provides mechanisms such as error control, flow control, and congestion control to keep track of the data packets, check for errors and duplication, and resend the information that fails delivery. It involves the service-point addressing function to ensure that the packet is sent in response to a specific process (via a port address).

• Packet Segmentation and reassembly ensure that the data is divided and sequentially sent to the destination where it is rechecked for integrity and accuracy based on the receiving sequence.



5. Session

• As the first of three layers that deal with the software level, the session layer manages sessions between servers to coordinate communication.

• Session refers to any interactive data exchange between two entities within a network.

• Common examples include HTTPS sessions that allow Internet users to visit and browse websites for a specific time period.

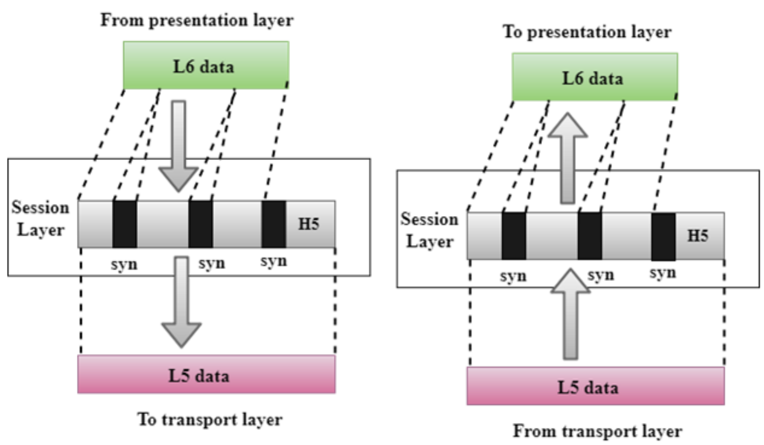
• The Session Layer is responsible for a range of functions including opening, closing, and re-establishing session activities, authentication and authorization of communication between specific apps and servers, identifying full-duplex or half-duplex operations, and synchronizing data streams.

Common Session Layer protocols include:

• Remote procedure call protocol (RPC)

• Point-to-Point Tunneling Protocol (PPTP)

• Session Control Protocol (SCP)



6. Presentation

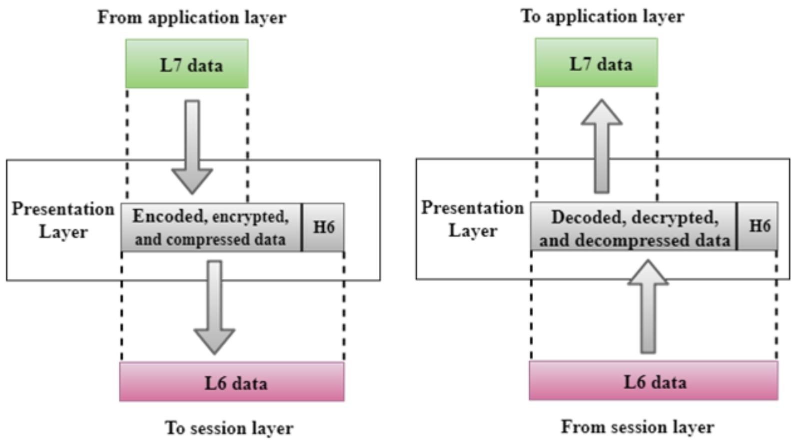
• The sixth layer of the OSI model converts data formats between applications and the networks.

Responsibilities of the presentation layer include:

1. Data conversion
2. Character code translation
3. Data compression
4. Encryption and decryption

• The presentation layer, also called the syntax layer, maps the semantics and syntax of the data such that the received information is consumable for every distinct network entity. For example, the data we transfer from our encryption-based communication app is formatted and encrypted at this layer before it is sent across the network.

• At the receiving end, the data is decrypted and formatted into text or media information as originally intended. The presentation layer also serializes complex information into transportable formats. The data streams are then deserialized and reassembled into original object format at the destination.

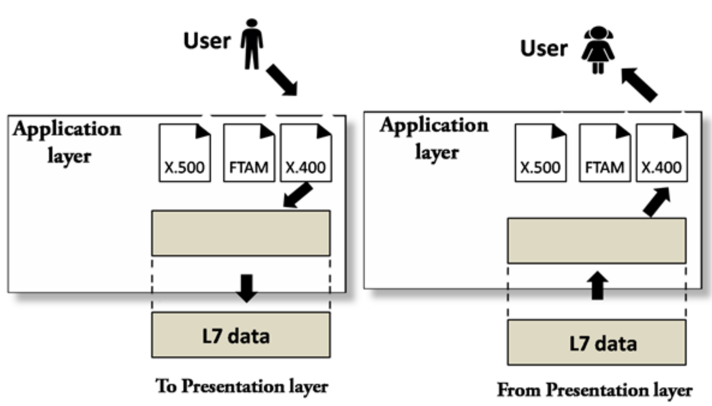


7. **Application**

The application layer concerns the networking processes at the application level. This layer interacts directly with end-users to provide support for email, network data sharing, file transfers, and directory services, among other distributed information services. T

Common application layer protocols include:

- File Transfer Protocol (FTP)
- Simple Mail Transfer Protocol (SMTP)
- Domain Name System (DNS)



- **Conclusion:**

From this practical, we have learnt the structure of OSI model and application of each layer of model.

EXPERIMENT – 6

AIM: TO STUDY THE ARCHITECTURE OF RASPBERRY PI.

APPARATUS: RASPBERRY PI(ANY MODEL)

OVERVIEW OF CONTENTS:-

1) INTRODUCTION
2) HISTORY
3) TYPES OF MODELS
4) CLASSIFICATION
5) FEATURES

THEORY:-

- **INTRODUCTION**

Raspberry Pi is a small single board computer. By connecting peripherals like Keyboard, mouse, display to the Raspberry Pi, it will act as a mini personal computer.

Raspberry Pi is popularly used for real time Image/Video Processing, IoT based applications and Robotics applications.

Raspberry Pi is slower than laptop or desktop but is still a computer which can provide all the expected features or abilities, at a low power consumption.

Raspberry Pi Foundation officially provides Debian based Raspbian OS. Also, they provide NOOBS OS for Raspberry Pi. We can install several Third-Party versions of OS like Ubuntu, Archlinux, RISC OS, Windows 10 IOT Core, etc.

Raspbian OS is official Operating System available for free to use. This OS is efficiently optimized to use with Raspberry Pi. Raspbian have GUI which includes tools for Browsing, Python programming, office, games, etc.

We should use SD card (minimum 8 GB recommended) to store the OS (operating System).

Raspberry Pi is more than computer as it provides access to the on-chip hardware i.e. GPIOs for developing an application. By accessing GPIO, we can connect devices like LED, motors, sensors, etc and can control them too.

- **HISTORY**

  - Back in 2006, while Eben Upton, his colleagues at University of Cambridge, in conjunction with Pete Lomas and David Braben, formed the Raspberry Pi Foundation.
  - Early prototypes of the Raspberry Pi were based on the 8-bit Atmel ATMega644 in order to reduce cost. Following prototypes utilized an ARM processor similar to what was used in the release version of the Raspberry Pi.
  - In 2012, the team started its first production run consisted of 10,000 Raspberry Pi unites manufactured by foundries in China and Taiwan.
  - Unfortunately, there was a manufacturing issue where the ethernet jack on the Raspberry Pi. This incident caused some minor shipping delays.
  - It took the team six years of hardware development to create the Raspberry Pi makers and electronics enthusiasts adore today

- **TYPES OF MODELS**

  Model A:

  - The cheaper and simpler of the two as a general rule.
  - It only has one USB port and no Ethernet connector. With that being said, it's still a great educational tool.

  Model B:

  - Generall**y** more expensive and advanced model of the two.
  - It contains 2 USB ports as well as Ethernet connectivity support.
  - Although marginally more expensive, for personal use, the Model B tends to outperform its cousin by a significant margin.
  - The first generation (Raspberry Pi 1 Model B) was released in February 2012. It was followed by a simpler and inexpensive model Model A.
  - In 2014, the foundation released a board with an improved design in Raspberry Pi 1.

  Model B+.

  - These boards are approximately credit-card sized and represent the standard mainline form-factor. Improved A+ and B+ models were released a year later.
  - A "compute module" was released in April 2014 for embedded applications, and a
  - **Raspberry Pi Zero** with smaller size and reduced input/output (I/O) and general-purpose input/output (GPIO) capabilities was released in November 2015 for US$5.

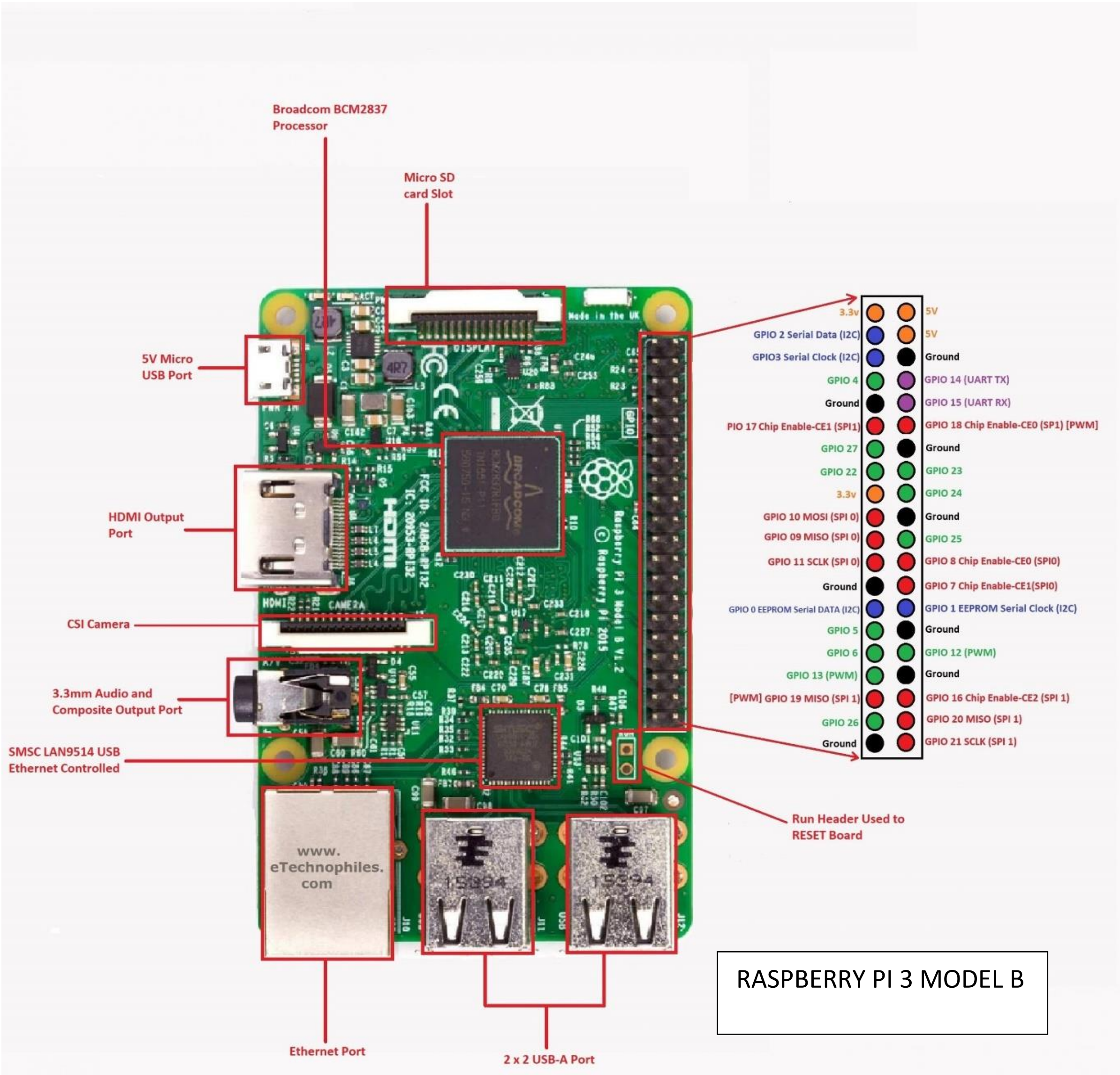
  - The **Raspberry Pi 2** which added more RAM was released in February 2015.
  - **Raspberry Pi 3 Model B** released in February 2016, is bundled with on-board WiFi, Bluetooth and USB boot capabilities.
  - As of January 2017, Raspberry Pi 3 Model B is the newest mainline Raspberry Pi.
  - As of 28 February 2017, **the Raspberry Pi Zero W** was launched, which is identical to the Raspberry Pi Zero, but has the Wi-Fi and Bluetooth functionality of the Raspberry Pi.

- All models feature a Broadcom system on a chip (SoC), which includes an ARM compatible central processing unit (CPU) and an on-chip graphics processing unit (GPU, a Video Core IV).
- CPU speed ranges from 700 MHz to 1.2 GHz for the Pi 3 and on board memory range from 256 MB to 1 GB RAM. Secure Digital (SD) cards are used to store the operating system and program memory in either the SDHC or Micro SDHC sizes.
- Most boards have between one and four USB slots, HDMI and composite video output, and a 3.5 mm phono jack for audio.
- Lower-level output is provided by a number of GPIO pins which support common protocols like I²C.
- The B-models have an 8P8C Ethernet port and the Pi 3 and Pi Zero W have on board Wi-Fi 802.11n and Bluetooth.
- The Foundation provides Raspbian, a Debianbased Linux distribution for download, as well as third party Ubuntu, Windows 10 IOT Core, RISC OS, and specialized media center distributions.
- It promotes Python and Scratch as the main programming language, with support for many other languages.
- The default firmware is closed source, while an unofficial open source is available.

- **CLASSIFICATION**

	Raspberry Pi 1 Model A	Raspberry Pi 1 Model A+	Raspberry Pi 1 Model B	Raspberry Pi 1 Model B+	Raspberry Pi 2 Model B	Raspberry Pi 3 Model B	Raspberry Pi Zero
USB 2.0 Ports	1	1	2	4	4	4	1 (Micro-USB)
Ethernet	None	None	10/100 Mbit/s	10/100 Mbit/s	10/100 Mbit/s	10/100 Mbit/s	None
Bluetooth	None	None	None	None	None	4.1	None
WiFi	None	None	None	None	None	802.11n	None
Audio In	I²S	I²S	I²S	I²S	I²S	I²S	I²S
Audio Out	I²S, analog (3.5mm jack), digital (HDMI)	I²S, analog (3.5mm jack), digital (HDMI)	I²S, analog (3.5mm jack), digital (HDMI)	I²S, analog (3.5mm jack), digital (HDMI)	I²S, analog (3.5mm jack), digital (HDMI)	I²S, analog (3.5mm jack), digital (HDMI)	Digital (mini-HDMI), analog GPIO PWM
Video In	CSI Camera Connector	CSI Camera Connector	CSI Camera Connector	CSI Camera Connector	CSI Camera Connector	CSI Camera Connector	None
Video Out	HDMI, Composite (RCA)	HDMI, Composite (TRRS)	HDMI, Composite (RCA)	HDMI, Composite (TRRS)	HDMI, Composite (TRRS)	HDMI, Composite (TRRS)	Mini-HDMI, GPIO Composite
External Storage	SD	MicroSD	SD	MicroSD	MicroSD	MicroSD	MicroSD

- **RASPBERRY PI 3 MODEL B FEATURES**



RASPBERRY PI 3 MODEL B

1. **CPU:** Raspberry Pi 3 uses Broadcom BCM2837 SOC 64-bit quad-core ARM Cortex A53 (ARMv8 CPU) with 512KB shared L2 cache.

2. **Memory:** Provided with 1 GB of RAM

3. **Wi-Fi Support:** 802.11n Wireless LAN

4. **Bluetooth:** Supports Bluetooth 4.1 Bluetooth Low Energy (BLE)

5. **USB Ports:** 4-USB ports which allow attaching four different USB devices like keyboard, mouse, etc.

6. **Ethernet Port:** Standard Ethernet port to quickly setup and access internet. This can be very useful when we want to setup raspberry pi for the first time without a monitor.

7. **GPIO Pins:** Raspberry Pi 3 supports 40 GPIO Pins General Purpose Input Output. These digital input/output pins can be used to drive LED, Switches, and Sensors etc.

8. **Full HDMI Port:** Support HDMI port (High-Definition Multimedia Interface) which can be used to quickly connect raspberry pi to HDMI Monitor. With HDMI Cable and Monitor we can add Screen to Raspberry Pi.

9. **Micro SD card slot:** The Micro SD Card will hold the operating system which will boot while we power on Raspberry Pi 3.

10. **Audio/Video:** Combined 3.5mm audio jack and composite video.

11. **Display interface (DSI):** To interface Display Module

12. **Camera interface (CSI):** To interface Camera Module.

13. **Graphics Support:** Video Core IV 3D graphics core for advance graphics capabilities.

- **CONCLUSION:**

  In this experiment, we have studied introduction to Raspberry Pi, it's various classification, types of models and briefly studied the architecture of Raspberry Pi 3 Model B.

<u>EXPERIMENT – 7</u>

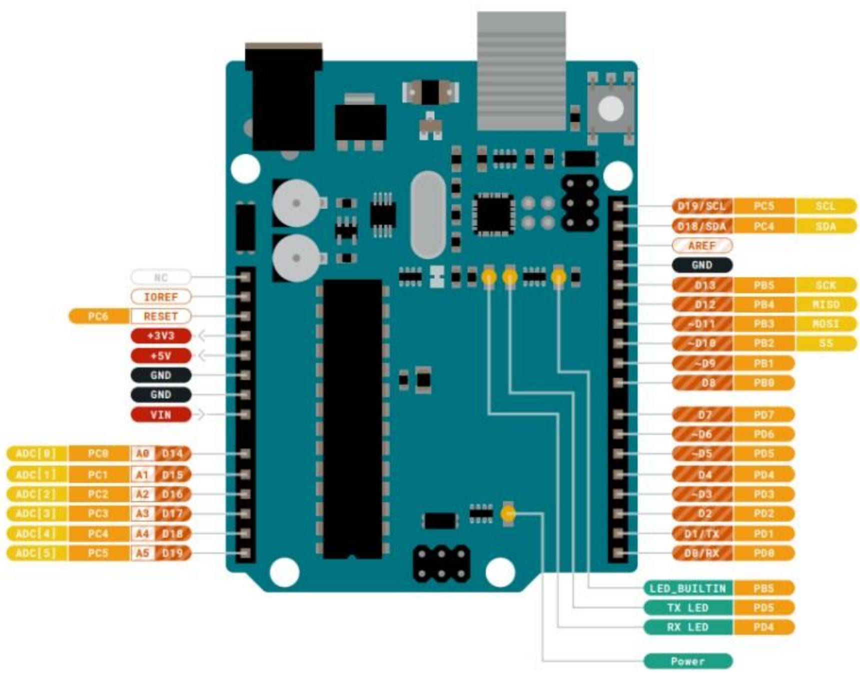
AIM: To study the programming of Arduino and to write a simple program to blink LED using Arduino.

APPARATUS: Arduino Uno , led , jumper wire , Breadboard,resistor

- **Theory:**

Arduino Uno:

- The Arduino UNO R3 is the perfect board to get familiar with electronics and coding. This versatile microcontroller is equipped with the well-known ATmega328P and the ATMega 16U2 Processor.

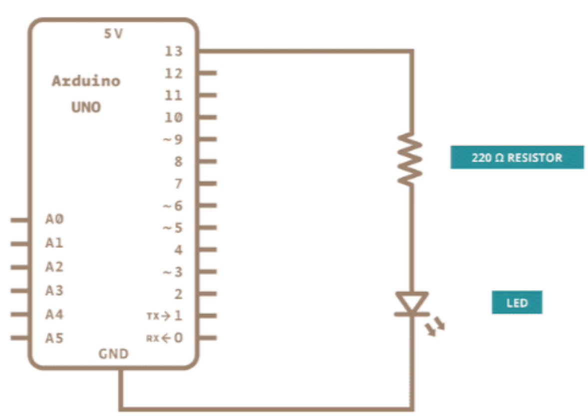


Pinout

- Arduino UNO is a microcontroller board based on the **ATmega328P**.
- It has 14 digital input/output pins, 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button.
- It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.
- Arduino programs are written in the Arduino Integrated Development Environment (IDE).
- Arduino IDE is a special software running on your system that allows you to write sketches (synonym for program in Arduino language) for different Arduino boards.
- The Arduino programming language is based on a very simple hardware programming language called processing, which is similar to the C language.
- After the sketch is written in the Arduino IDE, it should be uploadedon the Arduino board for execution.

- **Simple Program to blink led using Arduino.**

Circuit:



Procedure:

1. Take a Led and determine positive and negative leg.
   Long leg = Positive
   Short leg= Negative
2. Make a circuit like shown in schematic.
3. Arduino's pin 13 connected to positive leg of LED through resister.Arduino's GND connected to negative leg of LED.
4. Write code and upload it on arduino. To upload code into arduino, need to attach arduino with pc using USB cable which is come with arduino board.

Code:

```
void setup()

{
 // initialize digital pin 13 as an output.
 pinMode(2, OUTPUT);
}

void loop()
{
         digitalWrite(2, HIGH);
         // turn the LED on (HIGH is the voltage level)

         delay(1000);
          // wait for a second

         digitalWrite(2, LOW);
         // turn the LED off by making the voltage LOW


           delay(1000);
         // wait for a second
}
```

Conclusion:

From this experiment we learnt about Arduino Uno , how to do programming along with writing a program to blink LED.

EXPERIMENT – 8

AIM: Interface Temperature sensor with Arduino kit.

APPARATUS:

- Arduino Board
- Ggeneral Purpose Board
- USB cable
- 20 pin Flat cable
- Temperature Sensor
- PC
- Arduino Software
- Connecting Wires

- **Hardware Connection:**

  Connect 20pin flat cable between PL1 connector of Daughter board 2 and PL3 connector of ASK25.

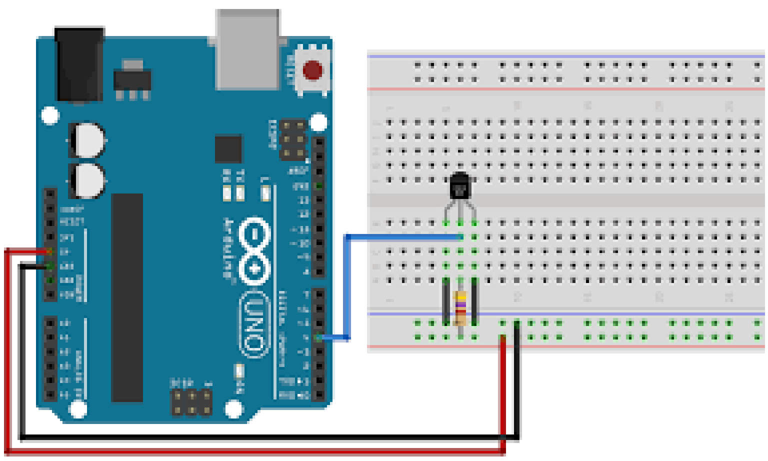


Fig.1

LM35 temperature sensor

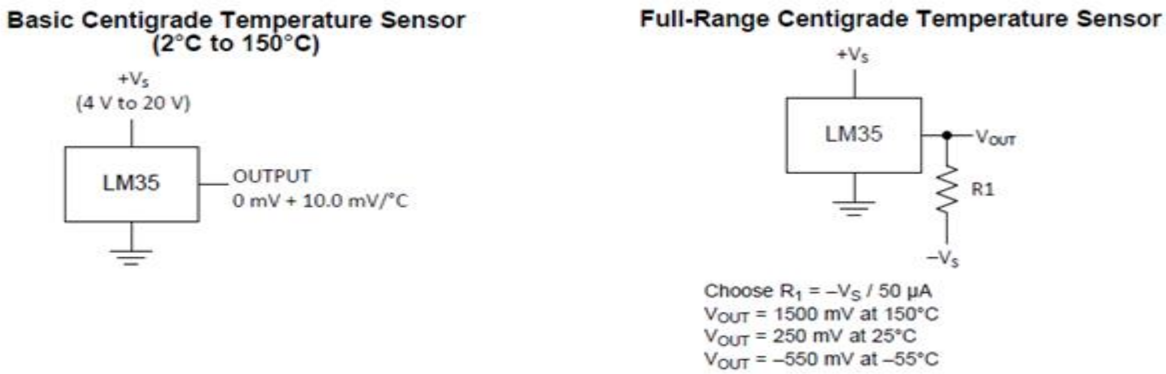


Fig.2

LM35 can be used in two circuit configurations. Both yield different results. In the first configuration, you can only measure the positive temperature from 2 degrees Celsius to 150 degrees Celsius. In this first configuration, we simply power lm35 and connect the output directly to analog to digital converters. In the second configuration, we can utilize all the sensor resources and can measure the full range temperature from -55 degree centigrade to 150-degree centigrade. This configuration is a little complex but yields high results. We have to connect an external resistor, in this case, to switch the level of negative voltage upwards. The external resistor value can be calculated from the formula given below the configuration circuit. The second configuration circuit can be made in various ways. To see about the second configuration circuits visit the LM35 **datasheet** by Texas Instruments. Texas Instruments **data sheet** enlists the circuit with clear component values.

Although the first configuration did not need a resistor at the output side, I recommend connecting an 80 k to 100 k resistor between Vout and GND pin. When I performed several experiments I noticed that the readings some time fluctuate and the Vout pin floats. So a resistor between Vout and GND tights the Vout pin low and prevents the pin from floating.

PARAMETER	VALUE
Accuracy at 25°C	±0.5°C
Accuracy from –55 °C to 150°C	±1°C
Temperature Slope	10 mV/°C

LM35 accuracy level

The accuracy parameters for both configurations are different. The average accuracy level is +- 1 degree Celsius for both configurations. But the accuracy level decreases for temperature between 2 degrees to 25-degree centigrade. Now that we have discussed the LM35 temperature sensor pin out, structure, linear scale factor and accuracy level its time to list down the steps on how to measure temperature using LM35 temperature Sensor.

- **CODE**

```
#define sensorPin 0
float Celsius, Fahrenheit, Kelvin;
int sensorValue;
void setup()
{
	Serial.begin(9600);
	Serial.println("Initialising.....");
}
void loop()
{
	GetTemp();
	Serial.print("Celsius: ");
	Serial.println(Celsius);
	Serial.print("Fahrenheit: ");
	Serial.println(Fahrenheit);
	Serial.println();
	delay(2000);
}
void GetTemp()
{
		sensorValue = analogRead(sensorPin); // read the
		sensor
```

```
        Kelvin = (((float(sensorValue) / 1023) * 5) * 100); // convert to
        Kelvin
        Celsius = Kelvin - 273.15; // convert to
        Celsius
        Fahrenheit = (Celsius * 1.8) +32; // convert to
        Fahrenheit
}
```

- ## Steps to create project and program compilation:

Steps:

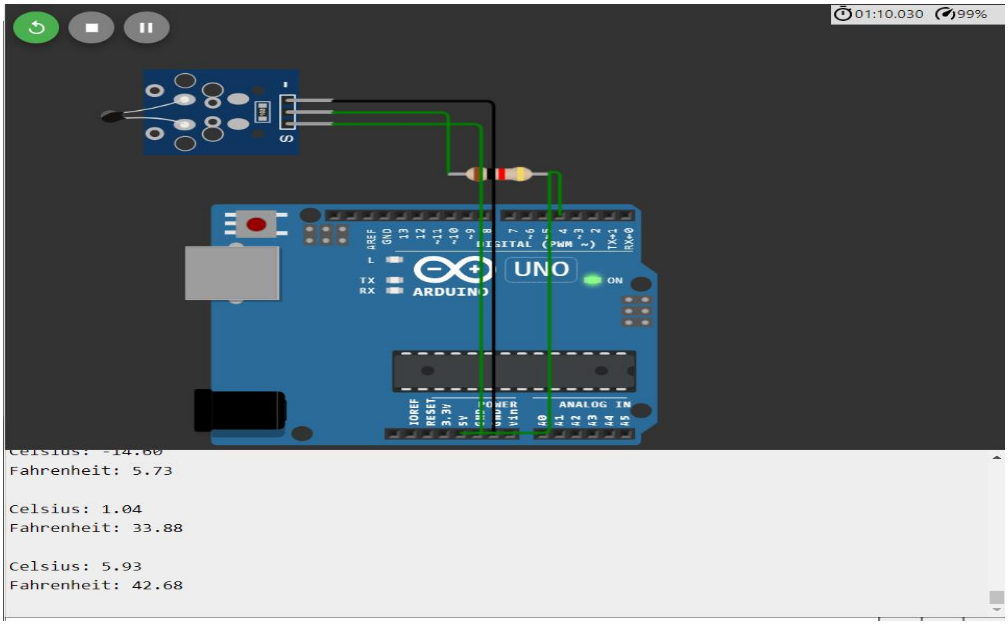
- Open Arduino Software.
- To create a new project click on **File > New**.
- Write a program in new file.
- To save your file click **“File > Save”.**
- Enter project name and project path where you want to create a project.
- To verify your program click on **“Sketch > Verify/Compile”** or click on the verify icon.
- After successful compilation, **“Done Compiling”** message will be displayed.
- To upload the program click on **“File > Upload”** or click on Upload icon.
- If program uploaded successfully **“Done Uploading”** message will be displayed.

- ## Procedure:

- Connect USB cable between USB connector of Arduino board and USB connector of PC.
- Upload the program in your board.
- Connect the temperature sensor and resister as shown in figure.
- Short Pin 1 and 2 o JP4 jumper.
- Apply reset to execute the program.

- ## Result:

Temprature will be displayed on Com. port.



- ## Conclusion:

A simple project called Arduino LM35 Temperature Sensor is built here. You learned about the classic LM35 Temperature Sensor, how to measure temperature from LM35 without any Microcontroller.

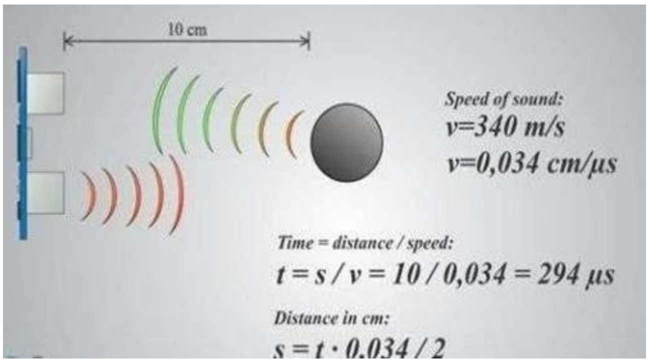
EXPERIMENT – 9

AIM: Interface Ultrasonic sensor with Arduino.

Apparatus: Arduino UNO, Ultrasonic Sensor – HC SR04(Generic), JumperWire (Generic), Arduino IDE, Bread Board, USB Cable, Resistor.

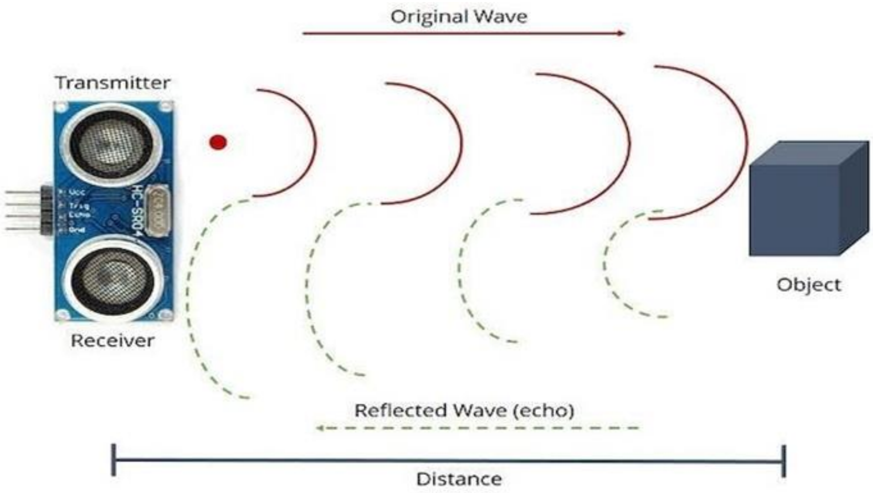
- **Introduction**

HC-SR04 Ultrasonic Sensor for Detecting Distance Of The Object

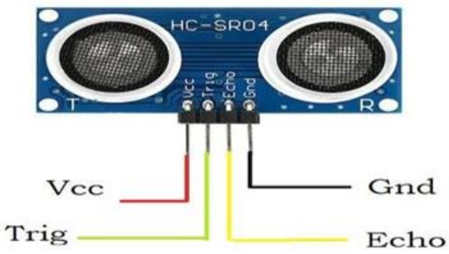


This sensor measures the distance of a target object by emitting ultrasonic sound waves and converts the reflected sound into an electrical signal. Ultrasonic waves travel faster than audible sound (ultrasonic is the sound that humans cannot hear).

Ultrasonic sensing is one of the best ways to sense proximity of obstacle and detect levels of substance or liquid with high reliability. An ultrasonic sensor module uses a transducer to send and receive ultrasonic pulses. The working principle of this module is simple. It sends an ultrasonic pulse out of trigger pin at 40kHz which travels through the air and if there is an obstacle or object, it will bounce back to the sensor at echo pin. By calculating the time travelled by wave and the speed of sound, the distance of the object is calculated.



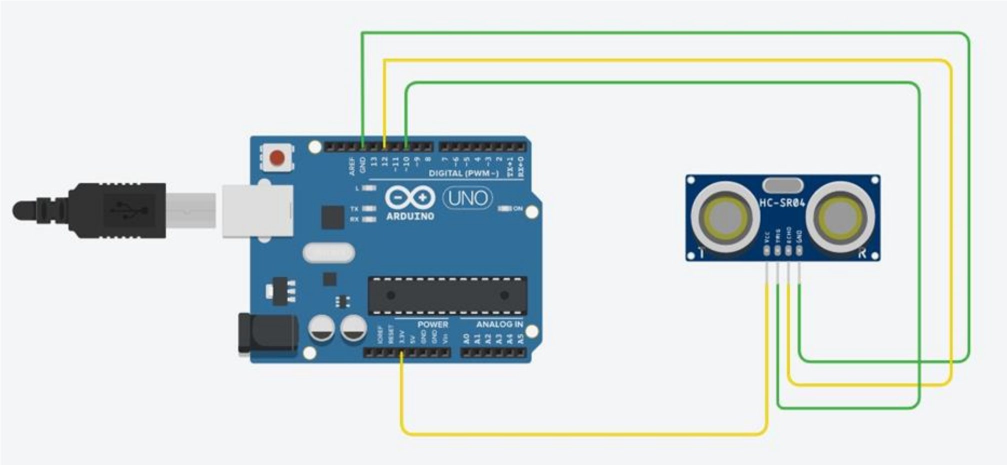
Ultrasonic sensor module has four pins namely Gnd, Vcc, Echo and Trigger. Gnd is considered as the negative pin and it is connected to the ground of the system. Vcc powers the sensor. It typically requires 3.3V. Trig (Trigger) pin is used to trigger the ultrasonic sound pulses. Echo pin produces a pulse when the reflected signal is received.



Arduino Uno is the brain of this system. It is microcontroller board based on the microcontroller ATmega328P. Arduino is capable of reading inputs, processing them and generating outputs. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a USB connection, a power jack, an ICSP header and a reset button.

Now as we know about ultrasonic sensor, we can start building up our circuit. Connections are as follows: Gnd to Gnd of Arduino Echo to D12 of Arduino Trig to D10 of Arduino Vcc to 3.3v of Arduino.

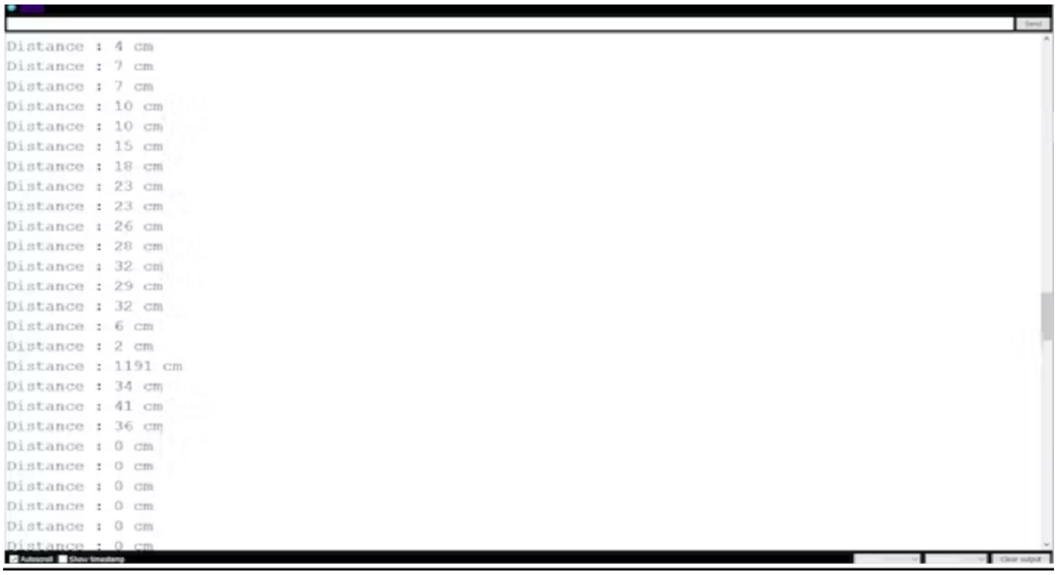
- **Circuit Diagram**



- **Source Code**

```
#define echoPin 6
#define trigPin 7

long duration;
int distance;

void setup() {
  Serial.begin(9600);
  pinMode(trigPin,OUTPUT);
  pinMode(echoPin,INPUT);
  // put your setup code here, to run once:

}

void loop() {
  digitalWrite(trigPin,LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin,HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin,LOW);
  // put your main code here, to run repeatedly:

  duration=pulseIn(echoPin,HIGH);
  distance=(duration*0.034/2);
  Serial.print("Distance:");
  Serial.print(distance);
  Serial.println("cm");
  delay(1000);
}
```

After uploading the code check the right corner of the software you will find a magnifying glass icon and. Click on that option and you will get the values of ultrasonic sensor. E.g.: Distance: 3 cm that means the object is 3 cm away from the sensor. This is called a serial monitor mainly used to display the values of sensors.



- **Conclusion**

  It sends an ultrasonic pulse out of trigger pin at 40kHz which travels through the air and if there is an obstacle or object, it will bounce back to the sensor at echo pin. By calculating the time travelled by wave and the speed of sound, the distance of the object is calculated.

EXPERIMENT – 10

AIM: Interface DHT11 with Arduino

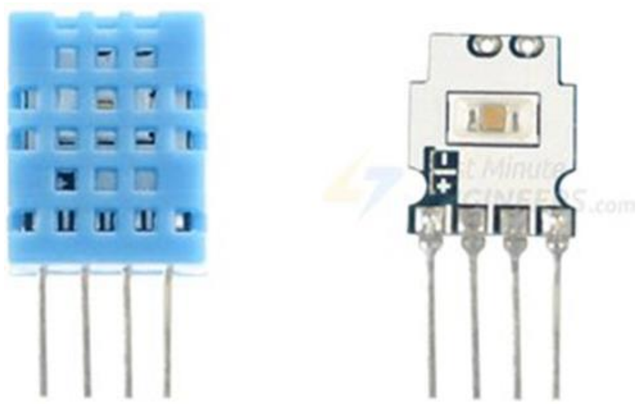
- **Interface DHT11 Module With Arduino**

Give your next Arduino project the ability to sense the world around it with the inexpensive DHT11 digital temperature & humidity sensor module from AOSONG.

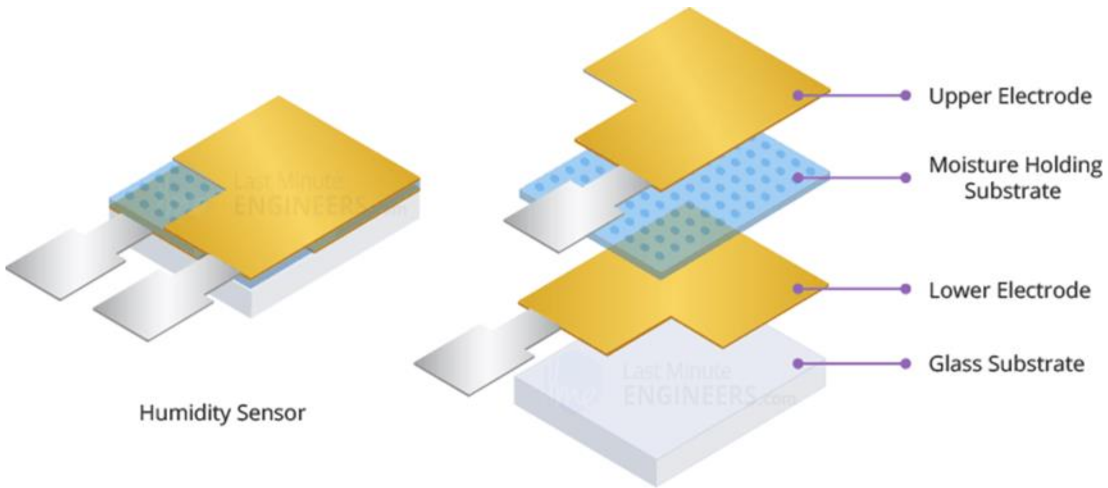
This sensor is pre-calibrated and don't require extra components so you can start measuring relative humidity and temperature right away.

- **How DHT11 Measures Temperature and Humidity**

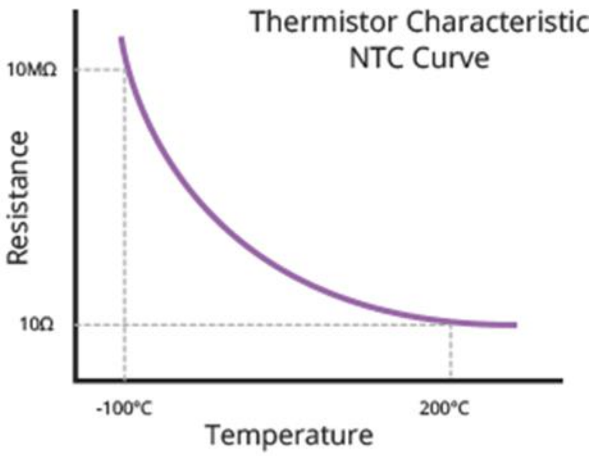
Inside the DHT11, there is a humidity sensing component along with a Thermistor.



- Humidity sensing component has two electrodes with moisture holding substrate sandwiched between them.
- The ions are released by the substrate as water vapor is absorbed by it, which in turn increases the conductivity between the electrodes.
- The change in resistance between the two electrodes is proportional to the relative humidity. Higher relative humidity decreases the resistance between the electrodes, while lower relative humidity increases the resistance between the electrodes.

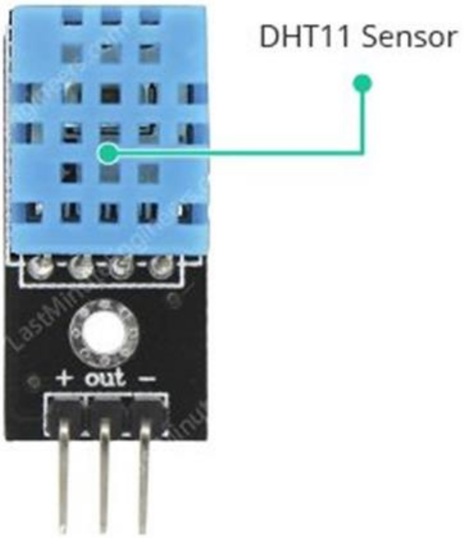


- DHt11 also contains a NTC/Thermistor to measure temperature. A thermistor is a thermal resistor whose resistance changes drastically with temperature. The term “NTC” means “Negative Temperature Coefficient”, which means that the resistance decreases with increase of the temperature.



- On the other side, there is a small PCB with an 8-bit SOIC-14 packaged IC. This IC measures and processes the analog signal with stored calibration coefficients, does analog to digital conversion and spits out a digital signal with the temperature and humidity.

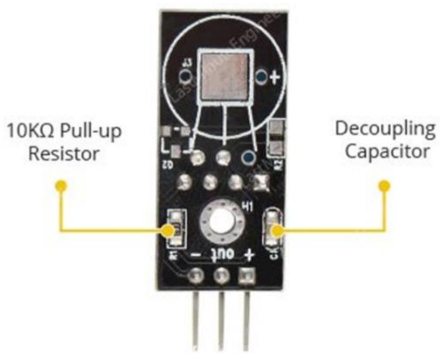
- **DHT11 Module Hardware Overview**
- At the heart of the module is the digital temperature & humidity sensor manufactured by AOSONG – DHT11.
- DHT11 Sensor
- DHT11 can measure temperature from 0°C to 50°C with ±2.0°C accuracy, and humidity from 20 to 80% with 5% accuracy.



Note that the sampling rate of the DHT11 is 1Hz, meaning you can get new data from it once every second.

Supporting Circuitry

The module comes with all the essential supporting circuitry, so it should be ready to run without any extra components.

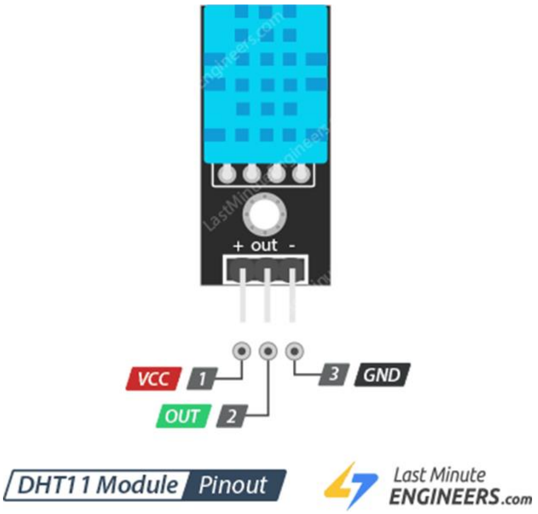


The DHT11 sensors usually require external pull-up resistor of 10KΩ between VCC and Out pin for proper communication between sensor and the Arduino. However, the module has a built-in pull-up resistor, so you need not add it.

The module also has a decoupling capacitor for filtering noise on the power supply.

DHT11 Module Pinout

The DHT11 module is fairly easy to connect. It has only three pins:



+ (VCC) pin supplies power for the sensor. 5V supply is recommended, although the supply voltage ranges from 3.3V to 5.5V. In case of 5V power supply, you can keep the sensor as long as 20 meters. However, with 3.3V supply voltage, cable length shall not be greater than 1 meter. Otherwise, the line voltage drop will lead to errors in measurement.

Out pin is used to communication between the sensor and the Arduino.

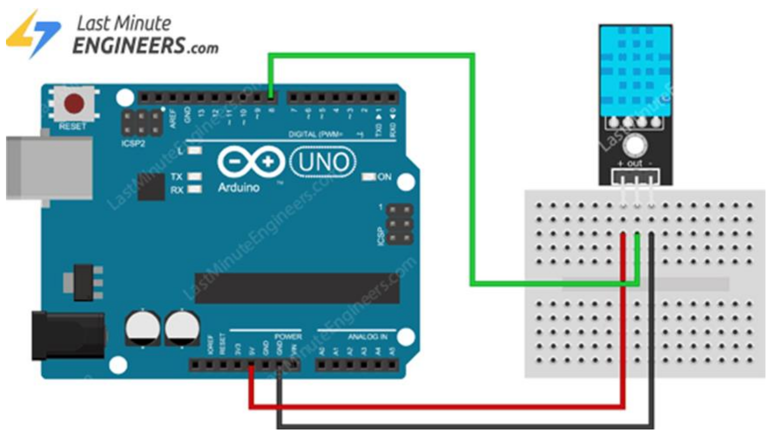
– (GND) should be connected to the ground of Arduino.

Wiring DHT11 Module to Arduino

Let’s hook the DHT11 module up to the Arduino.

Connections are fairly simple. Start by connecting + (VCC) pin to the 5V output on the Arduino and connect – (GND) to ground. Finally, connect the Out pin to the digital pin #8.

The following diagram shows you how to wire everything.



Installing DHT library

DHT11 sensors have their own single wire protocol for transferring the data. This protocol requires precise timing. Fortunately, DHT Library was written to hide away all the complexities so that we can issue simple commands to read the temperature and humidity data.

Download the library first, by visiting the GitHub repo

To install it, open the Arduino IDE, go to Sketch > Include Library > Add .ZIP Library, and then select the DHTlib ZIP file that you just downloaded.

Arduino Code – Basic Example

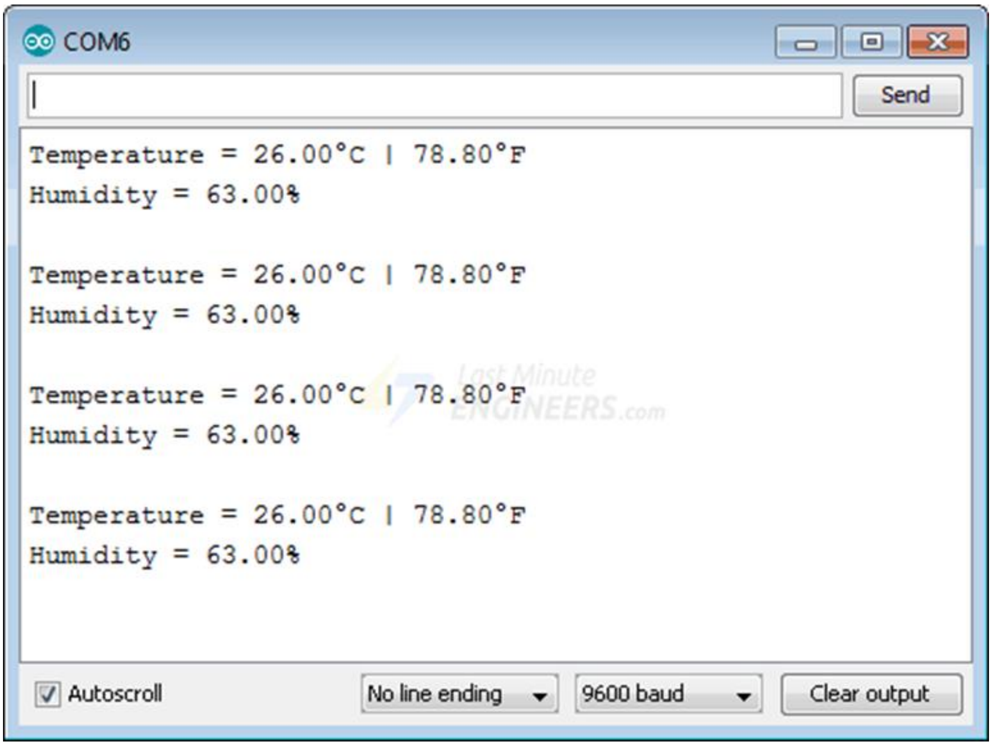
Once you have the library installed, you can copy this sketch into the Arduino IDE.

The following test sketch will print the temperature and relative humidity values on the serial monitor. Try the sketch out; and then we will explain it in some detail.

```
#include<dht.h>     // Include library

#define outPin 8    // Defines pin number to which the sensor is connected


dht DHT;                        // Creates a DHT object


void setup() {

Serial.begin(9600);

}

void loop() {

int readData = DHT.read11(outPin);


float t = DHT.temperature;        // Read temperature

float h = DHT.humidity;           // Read humidity


Serial.print("Temperature = ");

Serial.print(t);

Serial.print("°C | ");

Serial.print((t*9.0)/5.0+32.0);    // Convert celsius to fahrenheit

Serial.println("°F ");

Serial.print("Humidity = ");

Serial.print(h);

Serial.println("% ");
```

```
Serial.println("");

delay(2000); // wait two seconds
}
```

Once the sketch is uploaded, open a Serial Monitor window to see the output from the Arduino.



- **Conclusion**

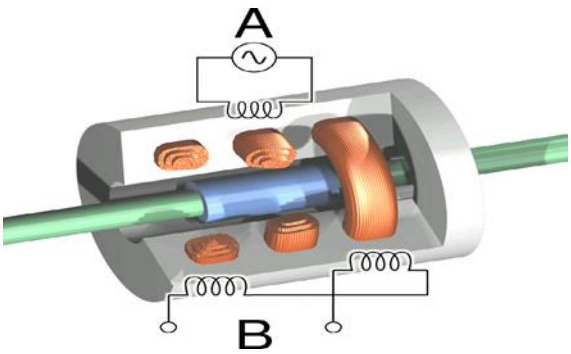
In this experiment, we have done interfacing of DHT11 with Arduino and also implementing a sample program.

EXPERIMENT – 11

AIM: To study the characteristics of LVDT sensor.

- **Theory:**

The LVDT, Linear Variable Differential Transformer is a well established transducer design which has been used throughout many decades for the accurate measurement of displacement and within closed loops for the control of positioning. The LVDT is a type of electrical transformer used for measuring linear displacement. The transformer has three solenoidal coils placed end-to-end around a tube. The centre coil is the primary, and the two outer coils are the secondaries.



A cylindrical ferromagnetic core, attached to the object whose position is to be measured, slides along the axis of the tube. An alternating current is driven through the primary, causing a voltage to be induced in each secondary proportional to its mutual inductance with the primary. The frequency is usually in the range 1 to 10 kHz.

Fig. 1 Cutaway view of an LVDT. Current is driven through the primary coil at A, causing an induction current to be generated through the secondary coils at B.

As the core moves, these mutual inductances change, causing the voltages induced in the secondaries to change. The coils are connected in reverse series, so that the output voltage is the difference (hence "differential") between the two secondary voltages. When the core is in its central position, equidistant between the two secondary’s, equal but opposite voltages are induced in these two coils, so the output voltage is zero.

When the core is displaced in one direction, the voltage in one coil increases as the other decreases, causing the output voltage to increase from zero to a maximum. This voltage is in phase with the primary voltage. When the core moves in the other direction, the output voltage also increases from zero to a maximum, but its phase is opposite to that of the primary. The magnitude of the output voltage is proportional to the distance moved by the core (up to its limit of travel), which is why the device is described as "linear". The phase of the voltage indicates the direction of the displacement.

Because the sliding core does not touch the inside of the tube, it can move without friction, making the LVDT a highly reliable device. The absence of any sliding or rotating contacts allows the LVDT to be completely sealed against the environment. Movement of the core within this area causes the secondary signal to change. As the two secondary windings are positioned and connected in a set arrangement (push-pull mode), when the core is positioned at the centre, a zero signal is derived.

The secondary output signal is then processed by a phase-sensitive demodulator which is switched at the same frequency as the primary energizing supply. This results in a final output which, after rectification and filtering, gives D.C. or 4-20mA output proportional to the core movement and also indicates its direction, positive or negative from the central zero point.

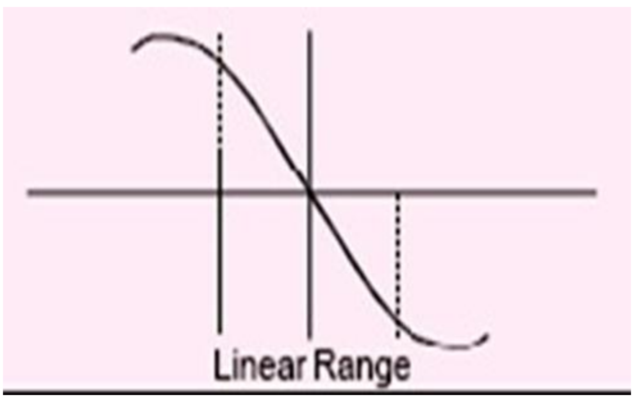
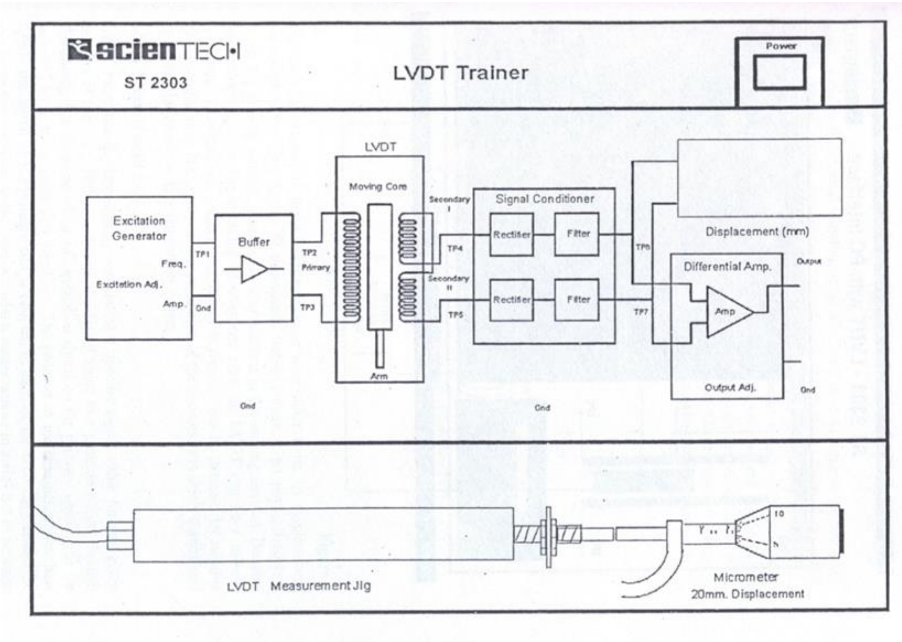


Fig. 2 Linear Range

The distinct advantage of using an LVDT displacement transducer is that the moving core does not make contact with other electrical components of the assembly, as with resistive types, as so offers high reliability and long life. Further, the core can be so aligned that an air gap exists around it, ideal for applications where minimum mechanical friction is required. LVDTs are commonly used for position feedback in servomechanisms, and for automated measurement in machine tools and many other industrial and scientific applications.



Functional Description of blocks:

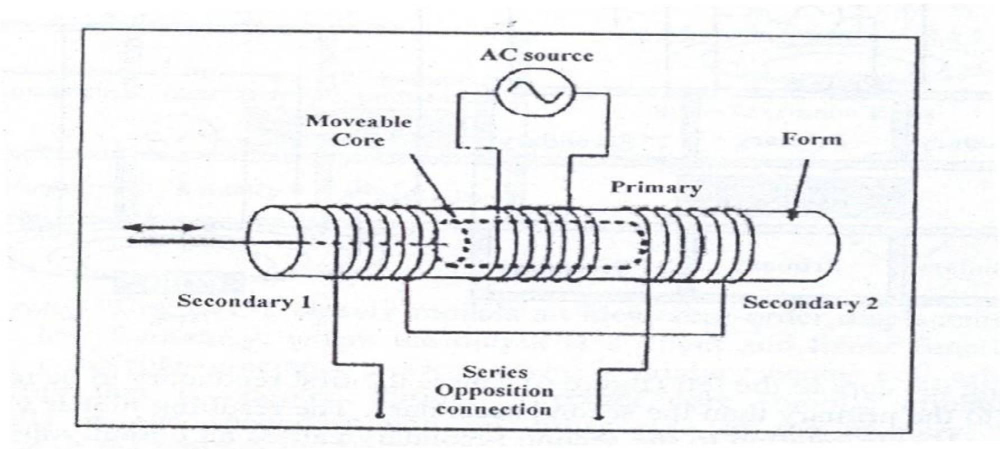
1. LVDT: It is enclosed in mild steel enclosure with arrangement of two hexagonal nuts that can be rotated clockwise or anticlockwise to set reading on display to 0.0 at 10 mm position on micrometer. LVDT core is attached to the micrometer spindle as shown in diagram.

2. Micrometer: it provides displacement to the LVDT core. The displacement suffered by core is indicated by 31/2 digit LED display in mm. it will be same as read on micrometer. The main scale of micrometer is of 25 mm. least count of main scale is 1 mm. circular scale on thimble is of 1 mm with least count 0.01 mm. on one circular rotation of thimble, the spindle will displace LVDT core is 1 mm. the maximum displacement that can be measured and given to LVDT core is: ± 10 mm

i.e. 10 mm to the right or to the left from the mean position. Mean position is 10 mm.

3. Excitation generator: the output of excitation generator is 4 K Hz sine wave of variable amplitude. It is used to excite primary coil of LVDT. The maximum input. Given to primary of LVDT is 4 V p –p which can be set by amp preset given in the excitation generator block.

4. Buffer: it is used to improve current driving capacity of excitation generator so that excitation generator can drive low impedance primary coil of LVDT.



5. LVDT: it consists of one primary coil, two secondary coils (in phase opposition) movable core. The output of secondary is input to the signal conditioner block.

6. Signal conditioner: it is used to process the form or mode of a signal so as to make it intelligible to or compatible with, a given device, including such manipulation as pulse shaping, pulse clipping, compensating, digitizing and Linearizing. It consists of rectifier and filter section for each secondary coil; rectifier is used to rectify output of secondary and then filtered out by filter to give DC voltage.

7. Differential Amplifier: it is based on differential amplifier block. It converts the differential output of signal conditioner block to single ended output, which can be used as input to some recording stage to record the data. The output is same as indicated by display.

8. Display: it is 31/2 digit LED display. It shows displacement of core in mm with polarity indication. + sign shows core is moved inside and – sign shows it is moved outside the LVDT.

Advantages:

1. Friction free operation: in normal use, there is no mechanical contact between the LVDT's core and coil assembly, so there is no rubbing, dragging or other source of friction.

2. Infinite resolution: since LVDT operates on electromagnetic coupling principles in a friction free structure, it can be measured infinitesimally small changes in core position.

3. Unlimited mechanical life: because there is normally no contact between the LVDTs core and coil structure, no parts can rub together or wear out.

- **Procedure**

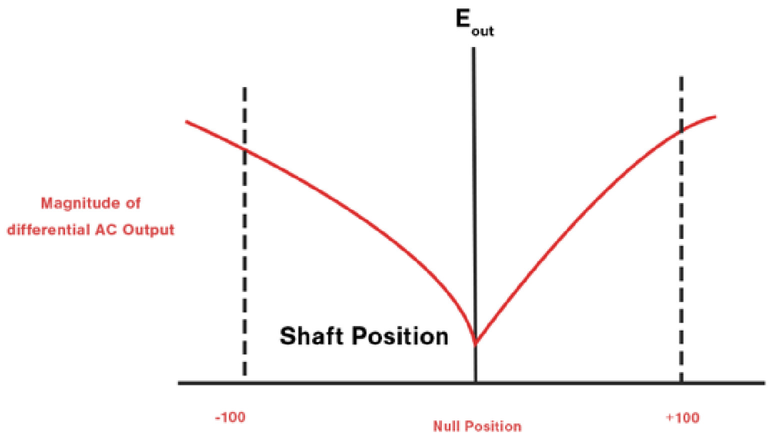
1. Switch on the Trainer.
2. Make the micrometer to read 10mm.
3. Rotate the rod till 0 coincides with 10 of the Main Scale.
4. Display will indicate 0 i.e., this is the position where the core is at the center that means equal flux to both the secondary windings.
5. Rotate the rod and change the position and put the result in the observation table.
6. Plot the graph between displacement in mm and the display reading. (Graph should be linear)

- **Observation Table**

Sr.No.	Displacement (mm)	Display Reading
1	20	-10.4
2	19	-9.4
3	18	-8.4
4	17	-7.4

5	16	-6.4
6	15	-5.3
7	14	-4.3
8	13	-3.2
9	12	-2.1
10	11	-1
11	10	0
12	9	1.1
13	8	2.1
14	7	3.2
15	6	4.3
16	5	5.3
17	4	6.3
18	3	7.4
19	2	8.5
20	1	9.5

- **Graph**



- **Conclusion**

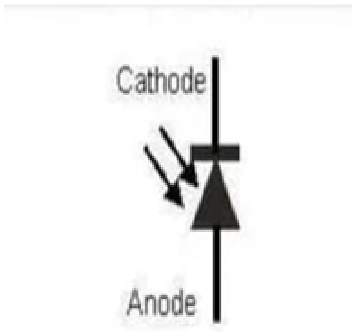
In this experiment, we discussed about LVDT sensor, saw it's characteristics, advantages, applications and performed experiment in the laboratory along with plotting its graph.

EXPERIMENT – 12

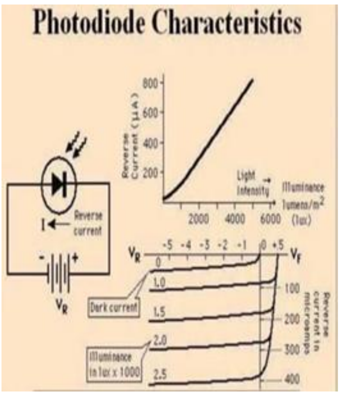
AIM: To study the working of Photodiode as a sensor.

- **Introduction**
  - Photodiodes are semiconductor light sensors that produce a current or voltage when light illuminates the P-N junction within the semiconductor.
  - It comprises of optical filters, built-in lenses and also surface areas. These diodes have a slow response time when the surface area of the
  - Photodiode increases.
  - Photodiodes are alike to regular semiconductor diodes.
  - A PIN junction, as opposed to the more common PN junction, is also used in certain diodes designed specifically for use as photodiodes.

- **Operation:**
  - Photodiode is designed to operate in reverse bias.
  - Photoelectric effect The photoelectric effect is the observation that many metals emit electrons when light shines upon them.
  - Electrons emitted in this manner can be called photoelectrons.



- **Characteristics:**
    - Similar to conventional semiconductor diodes, photodiodes can be packed with a window or optical fibre to enable light to reach the sensitive area of the device or exposed (to detect UV or X-rays).
    - PIN junctions, as opposed to p-n junctions, are frequently used in photodiodes because they speed up reaction time



- **Types of photodiode:**

1. Pin photodiode
2. P-N phothodiode
3. Avalanche photodiode
4. Schottky photodiode

- **Features:**

1. Excellent linearity with respect to incident light
2. Low noise
3. Wide spectral response
4. Mechanically rugged Compact and lightweight
5. Long life

- **Construction:**
  - N type silicon is the starting material. A thin "p" layer is formed on the front surface of the device by thermal diffusion or ion implantation of the appropriate doping material (usually boron)
  - The interface between the "p" layer and the "n" silicon is known as a p-n junction. Small metal contacts are applied.
  - To the front surface of the device and the entire back is coated with a contact metal.
  - The back contact is the cathode, the front contact is the anode. The active area is coated with either silicon nitride, silicon monoxide or silicon dioxide for protection and to serve as an anti-reflection coating.
  - The thickness of this coating is optimized for particular
  - Irradiation wavelengths. As an example, a Centro Vision
  - Series 5-T photodiode has a coating which enhances it
  - At the PN junction there will a concentration gradient that causes electrons to diffuse into the p-layer and holes to diffuse into the n-layer.
  - This diffusion results in an opposing electrical potential, often referred to as an internal bias (depletion region).
  - In a generic p-n photodiode, light enters the
  - Device through the thin p-type layer. Absorption causes light intensity to drop exponentially with penetration depth.
  - Any photons absorbed in the depletion region produce charge carriers that are immediately separated and swept across the junction by the natural internal bias. Eventually there will be the movement of the charge carriers.

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  - Any photons absorbed in the depletion region produce charge carriers that are immediately separated and swept across the junction by the natural internal bias. Eventually there will be the movement of the charge carriers.

- **Applications:**
- Photodiode are used in consumer electronics Photodiodes devices such as CD players, smoke detectors, and the receivers for infrared remote control devices used to control equipment from televisions to air conditioners.
- Photodiodes are used as a light sensors.
- Photodiodes are often used for accurate measurement of light intensity in science and industry.
- They are also widely used in various medical applications, such as detectors for computer tomography, instruments to analyze samples, and pulse oximeters.
- **Procedure**

1. Connecting power supply from the external source to the kit
2. Connecting voltmeters between the test point name as lamp input voltage and ground.
3. Connect the voltmeter between photovoltaic output and GND(Ground).
4. Rotate 10kohm potentiometer fully in counter clock-wise direction
5. Place the Op-amp box over plastic, enclosure to exclude the light
6. Switch on the supply.
7. Take the readings after 1 V each step
8. Plot the graph of photovoltaic o/p voltage against lamp voltage.

- **Observation Table**

Sr.No	Lamp Input voltage	Output Voltage
1	11	0.691
2	10	0.702
3	9	0.715

4	8	0.737
5	7	0.785
6	6	1.856
7	5	2.610
8	4	2.865
9	3	2.962
10	2.018	2.985
11	1.017	2.950

- **Conclusion**

In this experiment, we have learnt about photodiodes and photo transistors, it's characteristics ,graph, performed experiment based on that and visualized its characteristics