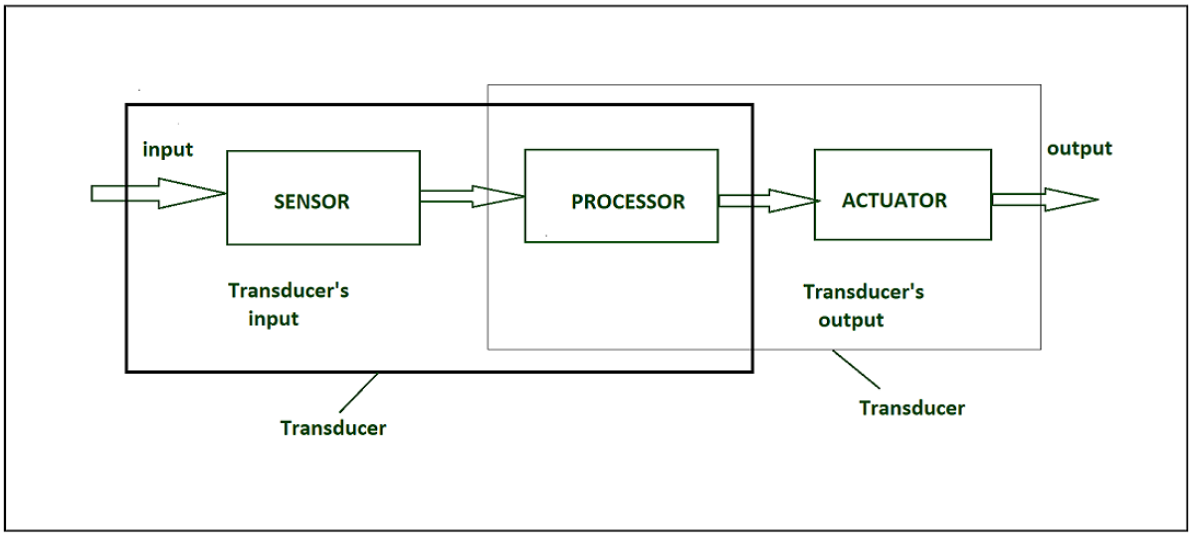
UNIT-II

Principles of Sensors

- A sensor or transducer is a device that gives a usable output (preferably, an electrical quantity) in response to a specified measurand (physical quantity such as light, sound, temperature…etc)
- Daily life examples of sensors include microphones, thermometer, accelerometers, infrared sensors, speakers…etc
- Sensor produces a usable output in response to a specified quantity. it uses the sensing principle, that is it senses or detects a physical phenomenon.
- A transducer converts one form of energy to another form. The process of conversion of energy from one form to another is called transduction.

Not all sensors are transducers, but all transducers contain sensors. Sensing is the first stage of transduction.



Sensors characteristics :

1. Static
2. Dynamic

1. Static characteristics :

It is about how the output of a sensor changes in response to an input change after steady state condition.

- **Accuracy:** Accuracy is the capability of measuring instruments to give a result close to the true value of the measured quantity. It measures errors. It is measured by absolute and relative errors. Express the correctness of the output compared to a higher prior system. Absolute error = Measured value – True value

  Relative error = Measured value/True value
- **Range:** Gives the highest and the lowest value of the physical quantity within which the sensor can actually sense. Beyond these values, there is no sense or no kind of response.

  e.g. RTD for measurement of temperature has a range of -200`c to 800`c.
- **Resolution:** Resolution is an important specification for selection of sensors. The higher the resolution, better the precision. When the accretion is zero to, it

is called the threshold.
Provide the smallest changes in the input that a sensor is able to sense.

- **Precision:** It is the capacity of a measuring instrument to give the same reading when repetitively measuring the same quantity under the same prescribed conditions.

It implies agreement between successive readings, NOT closeness to the true value.
It is related to the variance of a set of measurements.
It is a necessary but not sufficient condition for accuracy.

- **Sensitivity:** Sensitivity indicates the ratio of incremental change in the response of the system with respect to incremental change in input parameters. It can be found from the slope of the output characteristics curve of a sensor. It is the smallest amount of difference in quantity that will change the instrument's reading.
- **Linearity:** The deviation of the sensor value curve from a particularly straight line. Linearity is determined by the calibration curve. The static calibration curve plots the output amplitude versus the input amplitude under static conditions.

A curve's slope resemblance to a straight line describes linearity.

- **Drift:** The difference in the measurement of the sensor from a specific reading when kept at that value for a long period of time.
- **Repeatability:** The deviation between measurements in a sequence under the same conditions. The measurements have to be made under a short enough time duration so as not to allow significant long-term drift.

Dynamic Characteristics :

Properties of the systems

- **Zero-order system:** The output shows a response to the input signal with no delay. It does not include energy-storing elements.

Ex. potentiometer measure, linear and rotary displacements.

- **First-order system:** When the output approaches its final value gradually. Consists of an energy storage and dissipation element.
- **Second-order system:** Complex output response. The output response of the sensor oscillates before steady state.

Sensor Classification :

- Passive & Active
- Analog & digital
- Scalar & vector

1. **Passive Sensor –**

Can not independently sense the input. Ex- Accelerometer, soil moisture, water level and temperature sensors.

2. **Active Sensor –**

Independently sense the input. Example- Radar, sounder and laser altimeter sensors.

3. **Analog Sensor –**

The response or output of the sensor is some continuous function of its input parameter. Ex- Temperature sensor, LDR, analog pressure sensor and analog hall effect.

4. **Digital sensor –**

Response in binary nature. Design to overcome the disadvantages of analog sensors. Along with the analog sensor, it also comprises extra electronics for bit

conversion. Example – Passive infrared (PIR) sensor and digital temperature sensor(DS1620).

5. **Scalar sensor –**

Detects the input parameter only based on its magnitude. The answer for the sensor is a function of magnitude of some input parameter. Not affected by the direction of input parameters.

Example – temperature, gas, strain, color and smoke sensor.

6. **Vector sensor –**

The response of the sensor depends on the magnitude of the direction and orientation of input parameter. Example – Accelerometer, gyroscope, magnetic field and motion detector sensors.

The input/output signals (in the form of energy) in a sensor can be divided into six. They are,

1.Mechanical

2.Thermal

3.Electrical

4.Magnetic

5.Radiant

6.Chemical

Some of the physical and chemical transduction principles can be grouped according to the form of energy in which signals are received and generated.

Mechanical input signal

Triggered by a mechanical force like stress or a push/pull

- May cause change in temperature (Friction effect, cooling effects)
- May cause change in magnetic intensity (Piezomagnetic effect)
- May cause change in electricity (piezoelectric effect, resistive, capacitive and inductive changes)
- May cause change in radiant energy (Photoelasticity, Doppler effect)

Thermal input signal

- May cause change in mechanical energy (Thermal expansion)
- May cause change in electricity (Seebeck effect, thermoresistance)
- May cause change in radiant energy (Thermo optical effects)
- May cause change chemical reaction (Thermal dissociation)

Electrical input signal

- May cause change in mechanical energy (Electrokinetic effects)
- May cause change in temperature (Peltier effect)
- May cause change in electricity (Charge controlled devices)
- May cause change in magnetic intensity (Biot-Savart's electromagnetic law)

- May cause change in radiant energy (Kerr effect)
- May cause change chemical reaction (Electrolysis)

Magnetic input signal

- May cause change in mechanical energy (Magnetometers)
- May cause change in temperature (Magnothermal effects)
- May cause change in electricity (Galvanomagnetic effect)
- May cause change in radiant energy (Magneto-optical effect)

Radiant input signal

- May cause change in mechanical energy (Radiation Pressure)
- May cause change in temperature (Bolometer)
- May cause change in electricity (Photoelectric effect)
- May cause change in radiant energy (Photorefractivity)
- May cause change chemical reaction (Photosynthesis)

Chemical input signal

- May cause change in mechanical energy (Photoacoustic effect)
- May cause change in temperature (Thermal conductivity)
- May cause change in electricity (Potentiometry, conductimetry)
- May cause change in magnetic intensity (Nuclear magnetic resonance)
- May cause change in radiant energy (Spectroscopy)

Working Principle of Sensors

The working principle of each sensor is different, as it is designed to measure a specific quantity. The principle of a few basic sensors is as follows:

Temperature sensor:

The temperature sensor measures the environmental temperature and converts it to an electrical signal. The principle of the thermometer is the expansion and contraction of mercury in glass. With an alteration in temperature, mercury expands and contracts proportionally.

Contact sensor: The sensor that needs to be in physical contact with the object, temperature of which is to be sensed, is known as a contact sensor.

Noncontact sensor: The sensor that needn't to be in physical contact with the object, temperature of which is to be sensed, is known as a non-contact sensor. This type of sensor uses Plank's Law to measure temperature, which senses the heat radiated from the source to measure the temperature.

Thermocouple: Thermocouple is made of two wires, each with different metals. A junction is formed by joining the ends. This junction is open to the object for which temperature needs to be measured; the other end is connected to a measuring device. The current will flow through the metal, due to a difference in temperature of two junctions.

Resistance temperature detectors (RTDs): An RTD is type of thermal resistor that is designed to alter the electrical resistance with a change in temperature.

Thermistors: It is type of thermal resistor that changes the resistance in proportion with small changes in temperature.

IR Sensor:

- An IR sensor emits and detects the infrared rays to sense a specific environment. It is easily available in the market, but it is sensitive toward noise and light.
- The application of an IR sensor includes thermography, heating, meteorology, climatology, spectroscopy, and communications.

UV Sensor:

- A UV sensor measures the intensity or the power of an incident ultraviolet radiation. This electromagnetic radiation has longer a wavelength than x-rays but smaller than visible radiation. Polycrystalline diamond material is used for ultraviolet sensing. It can transmit different types of energy signals but can accept only one type of signal.
- The electrical meter is used to read the output signals and processed to the computer through analog-to-digital converters. The UV sensor is used in UV water treatment, light sensors, UV spectrum detectors, etc.

Touch Sensor:

- A touch sensor is a variable resistor that changes its resistance as per the location where it gets touched. It is made of a conductive and a partially conductive substance and insulated in a plastic cover.
- The flow of current is due to a conductive material that allows current partially. The touch sensor is a cost-effective solution for many applications, such as washing machines, fluid-level sensors, and dishwashers.

Proximity Sensor:

- A proximity sensor can detect the presence of an object without any contact point. The working principle is electromagnetic waves that are emitted by the sensor and return when the object is in range of the waves.
- The presence of the object is detected with the change in filed radiation.
- The proximity sensors working are of different types, like inductive, capacitive, photoelectric sensor, ultrasonic, and Hall-effect.

Proximity Sensor Examples:

Inductive proximity sensor: This type of sensor has an oscillator as an input, which changes the loss resistance by the proximity of an electrically conductive medium. For metal detection, these types of sensors are used.

Capacitive proximity sensor: This type of sensor converts capacitance by changing electrode displacement. It can be done by bringing the object within the variable frequencies. The object is detected with the help of the oscillated frequency, which is converted into a DC voltage. This current is compared with a fixed value to detect the object. For plastic targets, these types of sensors are used.

Ultrasonic Sensor

An ultrasonic sensor is used to detect the distance of an object. The working principle is the time duration between the emission and receiving of the waves after reflecting from the object. Ultrasonic sensors use sound waves to measure the distance of an object.

Principles of Actuators

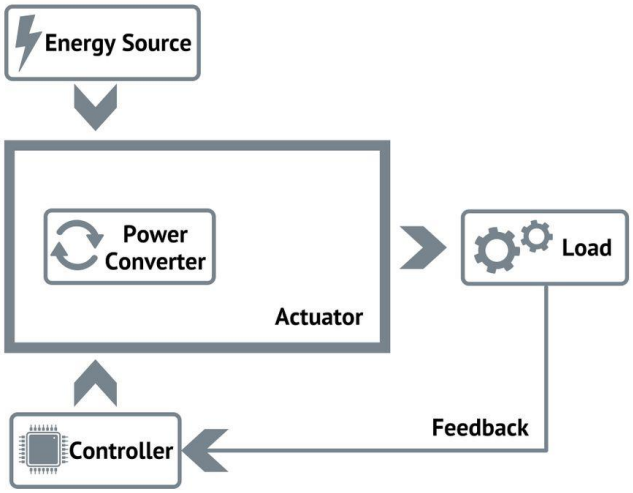
An actuator is a machine, or rather a part of a machine used to convert externally available energy into motion based on the control signals. Much like how hands and legs enable humans to move around and perform actions, actuators let machines perform various mechanical movements.

From the perspective of systems engineering, functions of any engineering product can be classified into three distinct categories; the collection of input, processing and producing an output.

For electromechanical systems, the input is detected and measured by a device called a sensor. The task of a sensor is to sample the signals available to it and convert them into a form understandable by the system. The system then processes the information and decides how to respond. But how exactly does a system respond?

The answer is, with the help of an Actuator. Typically, an actuator consists of:

- **Energy source:** Energy sources provide actuators with the ability to do work. Actuators draw electrical or mechanical energy from external sources for carrying out their operation. The energy available to the actuator can be regulated or unregulated depending on the system that it is a part of.
- **Power converter:** If the energy source attached to the actuators is unregulated, it requires some additional apparatus to regulate it and convert it into a form suitable for the actuation action. Hydraulic valves or solid-state power electronic converters are examples of converters used in industrial actuators.



Functional block diagram of an actuator

- **Controller:** In addition to enabling the operation of the power converter, a control unit is responsible for generating actuating signals. In some systems, it provides the user with an interface to provide inputs or check the system's status.
- **Load:** The mechanical system attached to the actuator that uses the motion of the actuator is called the load. Characteristics like Force/Torque and Speed are carefully tuned before interfacing an actuator with the load.

Classification of actuators based on the motion

The most apparent and basic classification of actuators is based on the type of motion that it produces.

Rotary Actuator

The actuators that can provide a circular motion at their output can be classified under the category of rotary actuators. When it comes to rotational motion, it is hard to think of any other device than the motors, which we shall discuss in the next section of this article.

Linear Actuators

The actuators that can provide motion in a straight line at their output can be classified under the category of linear actuators. Hydraulic or Pneumatic actuators are the most common linear actuators used in the industry. We will also discuss these devices in detail.

Classification of actuators based on the energy source

The energy source can be another means of classification for the actuators.

Electromagnetic Actuators

Electromagnetic actuators make use of electricity and magnetism to perform actuation. These actuators are among the most commonly used actuators in the industries.

AC and DC Servo Motor actuators

Servo drives can be powered by an AC or DC power supply and consist of a motor, feedback unit, control unit, and sometimes a gearbox. The working of a servo motor greatly differs from that of ordinary AC or DC motors. To operate a servo motor, a control signal is required in addition to the power.

Initially, when a voltage is applied to the terminals of a servo motor, it begins to rotate. The position of the shaft is continuously monitored by a rotary encoder, and the voltage-current levels are kept in check by the voltmeter-ammeter combination. The controller then computes the motor's actual speed, compares it with the target speed, and adjusts the voltage and current levels to reduce the error between the target speed and actual speed.

Stepper Motor Actuators

Stepper motors are used for applications where the angular position of the shaft needs to be accurately controlled. The control scheme of the stepper motor is simple, accurate and doesn't require any feedback. This is the reason why they are often more affordable.

The stator of the stepper motor contains multiple teeth, each acting as a pole for the rotor. When a particular pole or a set of poles are energised, the rotor reorients itself to allow maximum MMF to pass through it. When the next step of the poles is energised, the rotor shifts its position. This allows the rotor to complete a revolution in several distinct steps, and that's how the motor gets its name.

Solenoid Actuators

A solenoid actuator consists of a conducting coil wound on a ferromagnetic core with a flat head on one side and a spring connected on the other. The whole apparatus is placed in a hollow cylindrical body. Whenever current flows through the wire, the coil acts as an electromagnet, attracting the ferromagnetic core in one direction and compressing the spring during the process.

Once the power supply is removed, the spring pushes the core back to the original position. The strength of the actuator depends upon the number of turns in the coil. The setup looks and acts a lot like a piston.

Fluid Power Actuators

The actuators that make use of liquids or gasses are called fluid power actuators. On a very superficial level, we can think of a fluid power actuator as a moving disk inside a hollow cylinder filled with fluid forming a piston. The movement of the disk appears as the motion of the actuator. Advanced fluid actuators with dual-acting cylinders make use of fluid for both extension and retracement strokes.

Hydraulic Actuators

These actuators make use of liquids as a driving force to produce mechanical work. Hydraulic Actuators are probably the most widely used linear actuators in real-life applications. These devices are used when stable, but high actuating thrust/forces are required in a small region.

Pneumatic Actuators

The design and construction of pneumatic actuators are very similar to that of hydraulic actuators. The difference is that instead of using a liquid, energy from compressed gases or vacuum is used to facilitate the actuation process.

Mechanical Actuators

These actuators are used to interconvert rotary and linear motion in machines. Some examples of mechanical actuators are rack and pinion arrangements, crankshafts, gears, pulleys, and chains.

Thermal Actuators

Thermal actuators make use of materials that expand or contract by the application of heat. These actuators can be used to sense temperatures and shut off a supply to the system they are a part of. Thermal actuators combine the functions of a temperature switch and an actuator in a single package.

Special Actuators

Apart from the commonly used actuators, some actuators are still under research and find their application in limited fields.

Piezoelectric Actuators

Piezoelectric materials exhibit a contraction/expansion whenever a voltage is applied to them. By applying a controlled signal, this property of piezoelectric materials can be used to build actuators for small but highly precise and rapid positioning mechanisms.

Shape Memory Alloy Actuators

Shape Memory Alloys (SMAs) undergo a change in their molecular arrangement when they are heated or cooled. When a force is applied to alloys like Nitinol (Nickel-Titanium), they experience a deformation that can be reversed with heating.

Supercoiled Polymer Actuators

It gets challenging to downsize conventional actuators like electric motors beyond a certain limit, making them unsuitable for miniature machines. This is where Supercoiled Polymer Actuators (SPAs) come in. Supercoiling is a property of DNA strands that makes it possible for them to relieve stress by twisting around themselves. SPAs are inspired by a similar design that lets them reversibly change their shape and size when stimulated. These structures respond quickly and can last for millions of cycles. [4]

Hydrogel actuators

Hydrogel actuators demonstrate a change in their shape with changes in the temperature, light, pH and concentration of certain substances. The fact that hydrogels can be effective only in aqueous medium limits their applications to some specific specialised fields.

Applications of Actuators

An actuator that can generate sufficient force has suitable load-speed characteristics, works in the operating range with high efficiency, and comes with a robust design is considered ideal for a given application.

Industrial automation and robotics are the two fields where it is just impossible to imagine getting anything done without actuators. These parts enable production machines to move from one place to another and grab objects. Actuators are also widely used in heavy construction equipment and agricultural machinery to enable several different sets of movements. Another beautiful application of actuators can be in solar panels. As the sun rises and sets during the day, the solar panels equipped with actuators keep changing their angle to harness maximum solar energy.

Coming to household applications, actuators can be found in almost every smart home appliance, from furniture to robotic vacuum cleaners that require any sort of manoeuvre. A lot of toys too contain some small actuators built-in them. The applications are endless.

IOT Boards

Internet of Things has a never-ending scope in real-world applications and has been widely considered by organizations and governments all over the world. The number of design boards available for IoT is also overwhelming with large industrial involvement. Many microcontroller panels, daughter boards, chipboard devices, and application-specific ICs are available with onboard Wi-Fi routers, infrared, other communication protocols and many General-Purpose Input/output pins for sensor interface. IoT boards are essentially hardware structures used to build models of the inventions of the designer. There's a wide range of IoT boards available in the market today.

Classification of IoT Boards

In today's market, one can find a large number of boards with different specifications. IoT boards can be broadly classified into three segments:

- Microcontroller Boards
- Single board Computer
- System on Chipboards

1. Microcontroller Boards

Some of the popular open-source hardware used for development and for providing software programming are mentioned below:

a. Arduino Uno Rev

It is an ATmega328P microchip-based open-source **microcontroller board** produced by Arduino, a tech company. The board has arrays of digital and analog input/output pins that can be interfaced with different boards for expansion and other circuits.

Arduino Uno Rev consists of 6 analog inputs, 15 Input/output connectors, 15MHz quartz crystal, reset option and ICSP header. Since the microcontroller is fully supported by this board, it can simply be connected to a device with a USB cable or power it to start with an AC-to-DC converter or battery.

Given below are advantages and disadvantages:

Advantages:

- Arduino Uno is very simple to learn and implement.
- Low-cost IoT board with high standards.
- A wide range of third-party libraries and sensors are available for Arduino Uno.
- A huge community of users along with easily available resources.

Disadvantages:

- Processing and task performance speed are lower when compared with other competitors.
- Arduino Uno has a big structure which requires large sized PCB, other competitors like ATmega works well for IoT development.

b. ESP8266

ESP8266 is a low-cost IoT board with an embedded WIFI system that allows for rapid prototyping of IoT applications. This comes with multiple variants and specific features such as memory capacity and number pins. Arduino IDE can be used to develop alternative IoT IDE or IoT applications.

Given below are advantages and disadvantages:

Advantages:

- ESP8266 IoT board is a cost-friendly. IoT solution in real-time implementation.
- This segment is very reliable and easily available in the market.

Disadvantages:

- Most of the document is available in only Mandarin language, which makes it inaccessible to the rest of the world.

2. Single Board Computer

Single board computers are mostly used to provide command and interfacing within several devices in industrial situations for process control. Some of the widely used computers are:

a. Beagle Board

The Beagle-Board together with Digi-Key is a low-power open-source single-board computer developed by Texas Instruments. **It runs on Linux distribution** and was designed as an instructional board by a small team of engineers to teach open-source hardware and software skills in colleges around the world. This board is very similar to Raspberry Pi.

Given below are advantages and disadvantages:

Advantages:

- The beagle board is very convenient and reliable in usage.
- The board is inexpensive when compared to its competitors.
- The board doesn't require additional cooling equipment and has low power consumption.

Disadvantages:

- It has a basic structure suitable for beginners in electronic programming.
- Lacks audio and graphical capabilities.

b. Raspberry Pi3

Raspberry Pi 3 was developed in the United Kingdom to promote basic computer science teaching in schools, **Raspberry Pi includes** a series of small single-board computers which run on Raspbian operating system created for Raspberry Pi. Raspberry Pi3 is powered by a quad-core 64-bit ARM v8 processor and runs at 1.2 GHz. It further comprises a power unit, 4 USB ports, and an extendable board.

Given below are advantages and disadvantages:

Advantages:

1. Cost friendly and the board category is largely available in the market.
2. Consists of General-purpose Input-Output pins.

Disadvantages:

1. Raspberry Pi 3 isn't as fast when it comes to CPU processing speed and has less memory than a Mac or a laptop.
2. Low fault tolerance, the board is prone to damage in case pins are inserted incorrectly.

3. System on Chipboards

System on Chipboards consists of various functional units such as:

a. Tessel 2

The Tessel 2 runs on JavaScript and is an open-source development board designed to generate the scripts using Node. It is a platform designed for the Internet of Things (IoT) to play, tinker, design and create integrated hardware. Tessel has a collection of Command Line Interface devices to set up the Tessel 2 panel and work with it. One must download these tools and use the terminal command line to execute the script.

Given below are advantages and disadvantages:

Advantages:

1. Javascript development environment makes Tessel 2 a worthy choice.
2. Low maintenance and optimum speed.

Disadvantages:

- The Tessel 2 is quite decent, but it is not as cost-effective as Raspberry Pi, nor does it provide much extra value over the latter.

b. Particle Photon

Particle Photon is a very tiny IoT board with an integrated WIFI module. This is an IoT ready board which has a range of expansion kits to make the process of design quicker.

Advantages:

The Particle Photon is a very useful tool for IoT prototyping which facilitates remote coding, quick application migration, and fast project turnaround. With the platform's built-in factory models, you can be certain that bricking the Photon is impossible and charging the device from a standard phone charger is easy with the use of the micro USB cable.

c. Intel Edison Board

The Intel Edison is an incredibly small computer, it's about the size of a memory card at 35 x 25 x 3.8 mm. But this little chip, despite its tiny size, boasts some great power. The Intel Edison has no problem running Linux 1.6 with a dual-core, multi-threaded Intel Atom CPU operating at 600mhz and 2 GB of RAM.

Given below are advantages and disadvantages:

Advantages:

1. Small yet powerful board for IoT integration.
2. Widely used across the industry with full support provided by Microsoft.

Disadvantages:

1. Limited potential when compared to present-day boards.
2. Expensive when compared to its competitors.

Communication through Bluetooth

Bluetooth wireless technology is a short range communications technology intended to replace the cables connecting portable unit and maintaining high levels of security. Bluetooth technology is based on **Ad-hoc technology** also known as **Ad-hoc Pico nets**, which is a local area network with a very limited coverage.

Bluetooth was developed by Ericsson in 1994 uses short-wavelength UHF waves between 2402 and 2480 MHz. Widely known as the best wireless transmission technology for audio and the ubiquitous solution for hands-free calling in automobiles. Bluetooth is making waves in consumer and business IoT where device-to-device communication needs to be fast, easy, and wireless.

Bluetooth Architecture

The Bluetooth architecture uses two networks like Piconet and Scatternet

Piconet Network

Piconet is one kind of wireless network that includes one main node namely the master node as well as seven energetic secondary nodes are known as slave nodes. So, we can declare that there are eight active nodes totally which are arranged at a10 meters distance. The message between these two nodes can be done one-to-one otherwise one-to-many.

Communication can be possible only among the master and slave but the communication like Slave-slave cannot be possible. It also includes 255 parked nodes which are known as secondary nodes. These cannot communicate until it gets altered to the active condition.

Scatternet Network

The formation of the Scatternet Network can be done through various piconets. On one piconet, a slave is present which acts as a master otherwise it can be called primary within other piconets. So, this type of node gets a message from the master within one piconet & transmits the message toward its slave in another piconet wherever it works like a slave. So, this kind of node is called a bridge-node. In two piconets, a station cannot be master.

Bluetooth(BLE) for IoT

Despite its name, the Internet of Things (IoT) is not constricted to purely internet-based connectivity. In fact, Bluetooth Low Energy (BLE) solutions are increasing the functionality of IoT devices more successfully than via the internet. This creates a more reliable framework for further connectivity. BLE technology will enhance and optimize the overarching operability of smart home devices by creating faster communication speeds and extending signal range.

Even though using the internet to connect devices works very well, inconsistencies in its connection will shorten the battery life of various devices. BLE technology resolves these issues. Using BLE in IoT technology, devices will operate for extended periods of time on small power sources. Implementing Bluetooth technology within different IoT devices will help make managing a smart home a very energy efficient process.

The improved functionality of the IoT with the use of BLE goes far beyond simply saving power. BLE has the ability to extend the range of connection between devices by nearly 4 times that of a Wi-Fi network. This makes it a more reliable method for connecting numerous smart devices throughout a home environment. Not only is there a further range, but the communication speeds are revamped and much more capable to fulfill the demands of the always-on and always communicating IoT devices.

Smart devices will be able to take full advantage of increased communication speeds and range. This is due to the fact that BLE utilizes mesh networking. It is a network topology that allows for each device to be fully connected to each other within a network, allowing each node to assist in the data distribution. A mesh network is reliable for maintaining a smart home environment. It's because individual devices can still communicate if one device runs out of power or is disconnected.

An increasing amount of manufacturers are beginning to integrate Bluetooth technology within their IoT technology. BLE will improve the overall functionality of the IoT and aid in establishing much more sturdy networks that will sustain the operation of numerous devices.

Applications Of Bluetooth In IoT

Applications for Bluetooth mesh networks include those found in almost every consumer's home. These include door locks, lights, HVAC systems, and white goods (washers, dryers, refrigerators), and so on. You use your smartphone in your car for audio streaming, GPS updates, or hands-free calling. But Bluetooth has much more to offer than a safer, more attentive commute though. Devices ranging from coffee machines to thermostats are being built with Bluetooth access. Meaning, all it takes to brew your coffee and warm your house are a few taps on your phone.,

Health and fitness is another area of broad Bluetooth adoption. Wearable tracking devices and pedometers like the popular Fitbit — easily sync to smartphones using Bluetooth. Consider chronic health conditions like sleep apnea. Here remote patient monitors are now equipped to track a person's progress and the nuances of a medical condition. The information is archived, via Bluetooth.

In **industry**, Bluetooth is primarily used in machine-to-machine communications and connections before the information is sent to a gateway. It happens since Bluetooth makes it very easy for devices to communicate with each other. For example, in a factory or warehouse, employees can receive Bluetooth alerts from machinery on their tablets or smartphones. This information can be logged for record-keeping purposes, saving the company money or even employee's lives.

Drawbacks

1. Security is one of Bluetooth's significant drawbacks. This is because it functions on radio frequency, which allows it to pass through barriers.
2. Because HomeRF technology uses the same frequency, it suffers from interference.
3. In comparison to WiFi, the bandwidth is limited.

4. In comparison to when Bluetooth turns off, battery utilization is higher. Bluetooth low energy or innovative Bluetooth technology is created to extend the battery life.

Communication through Wi-Fi

Wireless communication involves the transmission of information over a distance without the help of wires, cables or any other forms of electrical conductors.
Wireless communication is a broad term that incorporates all procedures and forms of connecting and communicating between two or more devices using a wireless signal through wireless communication technologies and devices.

Features of Wireless Communication

The evolution of wireless technology has brought many advancements with its effective features.

- The transmitted distance can be anywhere between a few meters (for example, a television's remote control) and thousands of kilometers (for example, radio communication).
- Wireless communication can be used for cellular telephony, wireless access to the internet, wireless home networking, and so on.
- Other examples of applications of radio wireless technology include GPS units, garage door openers, wireless computer mice, keyboards and headsets, headphones, radio receivers, satellite television, broadcast television and cordless telephones.

Wireless - Advantages

Wireless communication involves transfer of information without any physical connection between two or more points. Because of this absence of any 'physical infrastructure', wireless communication has certain advantages. This would often include collapsing distance or space. Wireless communication has several advantages; the most important ones are discussed below –

Cost effectiveness

Wired communication entails the use of connection wires. In wireless networks, communication does not require elaborate physical infrastructure or maintenance practices. Hence the cost is reduced.

Example − Any company providing wireless communication services does not incur a lot of costs, and as a result, it is able to charge cheaply with regard to its customer fees.

Flexibility

Wireless communication enables people to communicate regardless of their location. It is not necessary to be in an office or some telephone booth in order to pass and receive messages.
Miners in the outback can rely on satellite phones to call their loved ones, and thus, help improve their general welfare by keeping them in touch with the people who mean the most to them.

Convenience

Wireless communication devices like mobile phones are quite simple and therefore allow anyone to use them, wherever they may be. There is no need to physically connect anything in order to receive or pass messages.

Example − Wireless communications services can also be seen in Internet technologies such as Wi-Fi. With no network cables hampering movement, we can now connect with almost anyone, anywhere, anytime.

Speed

Improvements can also be seen in speed. The network connectivity or the accessibility were much improved in accuracy and speed.

Example − A wireless remote can operate a system faster than a wired one. The wireless control of a machine can easily stop its working if something goes wrong, whereas direct operation can't act so fast.

Accessibility

The wireless technology helps easy accessibility as the remote areas where ground lines can't be properly laid, are being easily connected to the network.

Example − In rural regions, online education is now possible. Educators no longer need to travel to far-flung areas to teach their lessons. Thanks to live streaming of their educational modules.

Constant connectivity

Constant connectivity also ensures that people can respond to emergencies relatively quickly.

Example − A wireless mobile can ensure you a constant connectivity though you move from place to place or while you travel, whereas a wired land line can't.

Wi-Fi (Wireless Fidelity) is the most popular **IOT communication protocols** for wireless local area network (WLAN) that utilizes the IEEE 802.11 standard through 2.4 GHz UHF and 5 GHz ISM frequencies. Wi-Fi provides Internet access to devices that are within the range of about 20 - 40 meters from the source. It has a data rate upto 600 Mbps maximum, depending on channel frequency used and the number of antennas. In embedded systems, ESP series controllers from Espressif are popular for building IoT based Applications. **ESP32** and **ESP8266** are the most commonly use wifi modules for embedded applications.