# Review of Recent Developments in Sensors for Internet of Things using 5G Technology

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***Abstract* - Internet of Things (IoT) is a recent technology which will applicable in every devices and system, now a days industrial demand are based on speed of data transforming, security & data exchange, this type of requirement can be fulfil by IoT but today 4G is used for this technology, Now a days a demand of data exchanges, and security are grow more and more so a 5G technology is on the way, to fulfil all the requirement a different kinds of sensors are used, In this paper we discuss about a different kinds of sensors are used for future technology, also this types of sensors can be used in 5G technology.**

***keywords* - Introduction, Development of IoT, configuration, Block Diagram, Sensors used in IoT.**

## I. INTRODUCTION:

A revolution in technology is going so fast. When an internet is applicable for common people & for industrial purpose a requirement of data exchange, speed of data transforming and security of data are become a part of technology, A technology which fulfil this requirements with low power consumption and which tends to revolutionizer the global world through connected physical object, An IoT technology is developed based on this demands, Now a days, technology is going from "Internet of Computer" to "Internet of Things" (IoT), Also an Artificial-Intelligent(AI) which is most popular revolution technology of devices. An IoT is promising technology with low power devices which interact with each other through internet. There are various places where IoTs are implemented like health, education, industrial automation, home, transportation, environment etc, also a concept of IoT implemented in different like smart phones, smart appliances, sensors, tablet, washing machine etc. A common things of IoT operation is a speed of internet, but current demand for machine communication has result various technology with good services to achieve the modern IoT vision, Today 4G technologies is used for mobile devices for cellular standard but not suited for low power and low rate devices such as IoTs, So based on that in future 5G(Fifth Generation) aims to address to previous cellular standard mobile network , In this chapter we discus about development of and working of IoT.

## II. DEVELOPMENT OF IOT:

As we know that day by day devices are becoming smaller because a recently, we integrate a micro mechanical and micro electro-mechanical devices with wireless communication devices, that's why boundary of internet expand day by day,

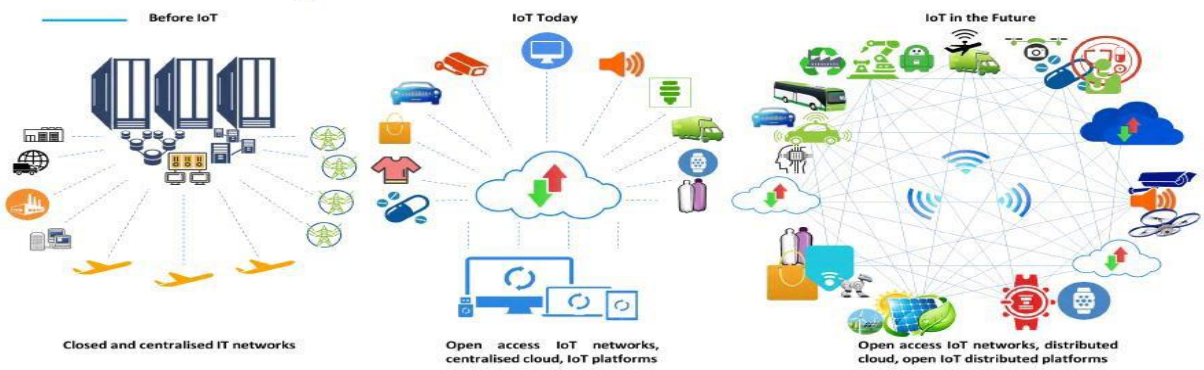



FIGURE 1. DEVELOPMENT OF IOT

From the figure 1 we can observe that in previous year an internet is mostly used at IT sector for business development and different business scopes, but considering a revolution of technology and demand of different areas , an IoT technology is implemented at different devices, also we can see that a common internet cloud is linked with computer with different devices, by using wireless devices and sensors, also in future a using Wi-Fi technology this development goes to open IoT distributed platform.

## III. CONFIGURATION OF IOT:

According to International Telecommunication Union (ITU) "IoT connect the Object of world in both sensor and intelligent manner, The IoT has four dimensions

1. Tagging things
2. Feelings things
3. Thinking
4. Shrinking

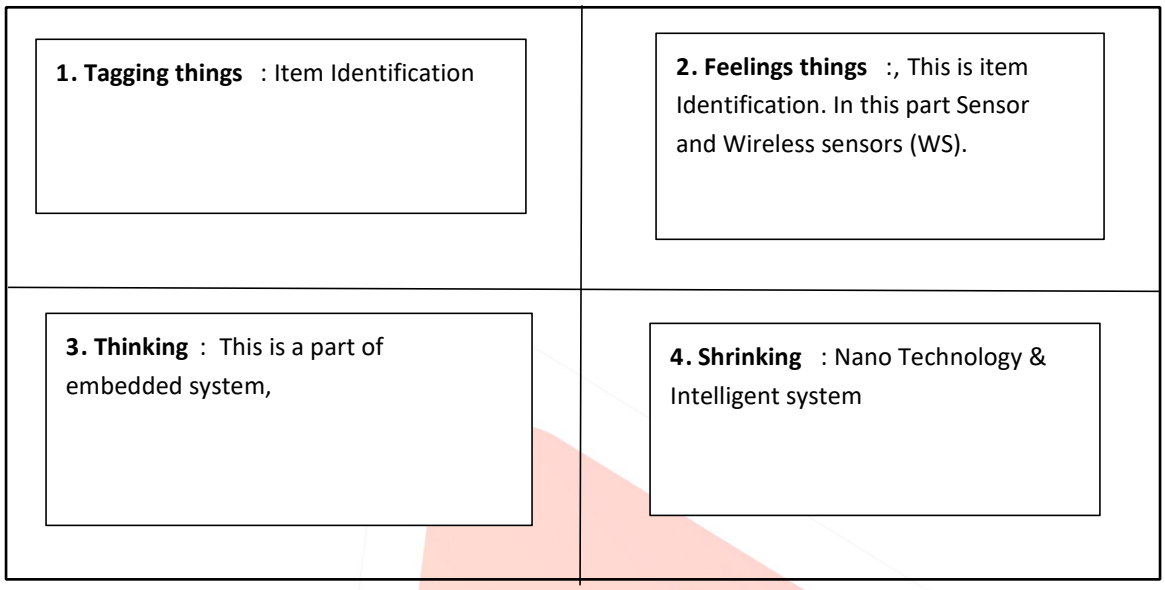
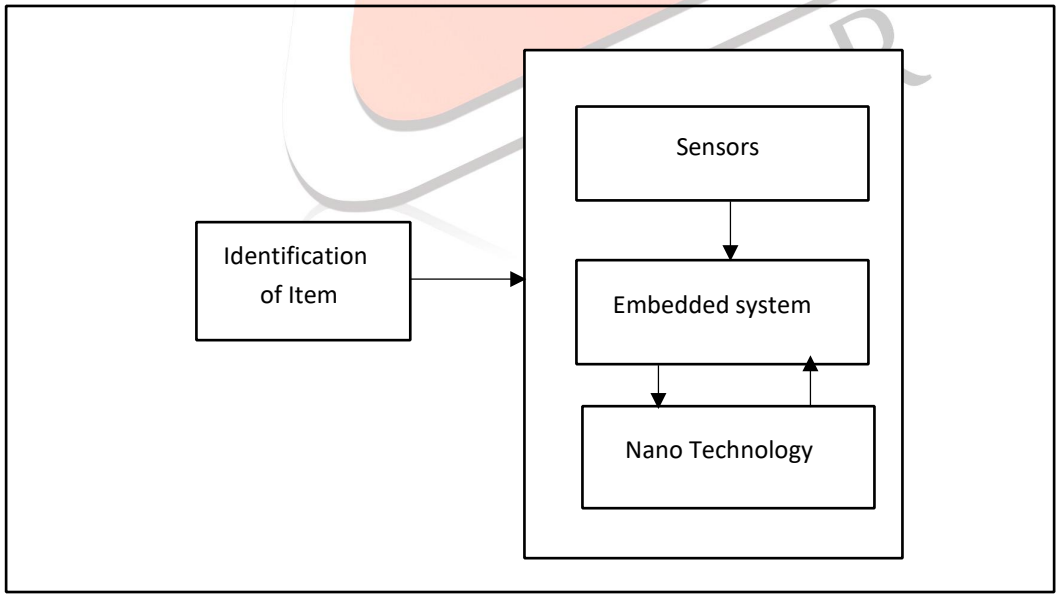



FIGURE 2. CONFIGURATION OF IOT

In fig 2. a configuration of IoT are represented, In tagging things an identification of item by different technology. After that feelings things consist of a sensors and wireless sensors are implemented also a wireless sensors Network (WSN) are design for good data exchanges, after that Thinking things consist of embedded system, and last shrinking is a part of this section, if we merge all the configuration in one set then a whole IoT configuration can be determine.




## IV. BLOCK DIAGRAM OF IOT:

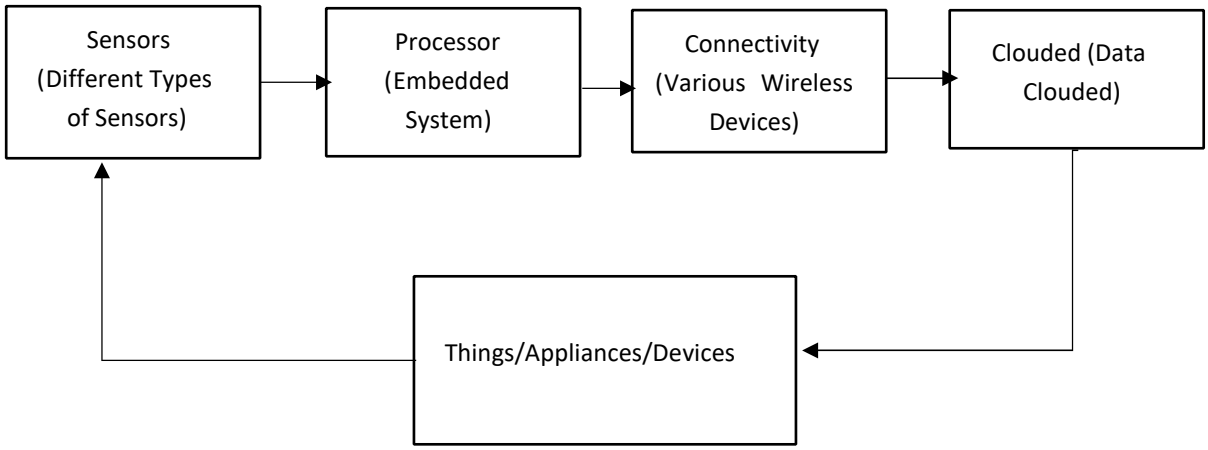



FIGURE 4. BLOCK DIAGRAM OF IOT

Here a block diagram of IoT, using this diagram we can determine that how the IoT works for particular application, it is a closed loop system so it should be a accurate and have a low latencies. A detail of different blocks as follow:

- **Sensors**: Sensors is an important part of every devices which works under automatization technology, there are different types of sensors which we are discuss in details of this chapter, A types of sensors are used for any devices is depends upon its application or a purpose, Here some example of sensors like RFID, Accelerometer, Humidity, Temperature etc.

- **Processors:** There are different kinds of processors are used in IoT but all are made up by embedded system, it works to know about a signal and how to executed a signal to further side, this all processors are work by computer programmer code, now a days there are lots of programming languages are used which are so simple and easy to installed in processors

- **Connectivity**: Different RF modules are used for connection of internet with devices to cloud, if modules are strong then it takes a less time to exchange an information of devices to cloud. There are many of modules are used like Wi-Fi, Zigbee, Bluetooth, Radio transceiver, Duplexer etc.

- **Cloud:** In cloud have a receiver which received signal from transmitter convert it into required domain, filtered & mapping the data then gives the signal to particular devices/ object/ appliances, there are also big storage disc capacity of hard-disc which can stored a data.

## V. SENSOR USED FOR IOT:

Many of sensors are used in IoT, an implementation of sensors in devices based on its applications, there are so many sensors but here we discuss about some sensors which are commonly used in different application.

1) **Accelerometer**: It is a MEMS (Micro Electro Mechanical System) which is a combination of mechanical and electrical components into small structure into micron scale. It consists by a combination of semi-conductor & micro fabrication technology. Basically, this sensor used to measure a displacement of mass using position interface circuit. A signal comes from the sensor is analog signal so for digital processing it will converted into digital signal by A to D (ADC) converter

Here an Accelerometer used in IoT for different appliances also in industrial automation, also now a days it used in automatic wheel chair and automatic bicycle.

- **Basics working of Accelerometer:**

According to newton's second law state that "Acceleration of object depends upon two variables "Net force" & "mass of object" so a second law can be define in "The acceleration of object is depends directly upon the net force acting upon the object and inversely proportional to mass of object"

$$A = F/M \ldots\ldots\ldots\ldots\ldots\ldots (1)$$


FIG 5 ADLX345 ACCELEROMETER

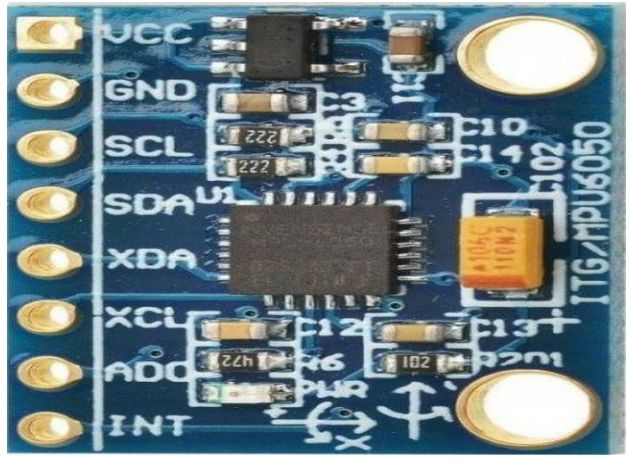



FIG 6 MPU6050 ACCELEROMETER

Where A = Acceleration of object
F= Force of object
M = Mass of object

Also, this can understand by its schematic diagram, In figure 7, a Mass (M) attached to spring stiffness (k) also a dashpot with damping coefficient (C) is attached to mass in parallel with spring, When the spring mass system is subjected to liner acceleration a force equal to mass times acceleration acts on proof mass causing it to deflect. A deflection is sensed by a suitable means and converted into electrical signal.

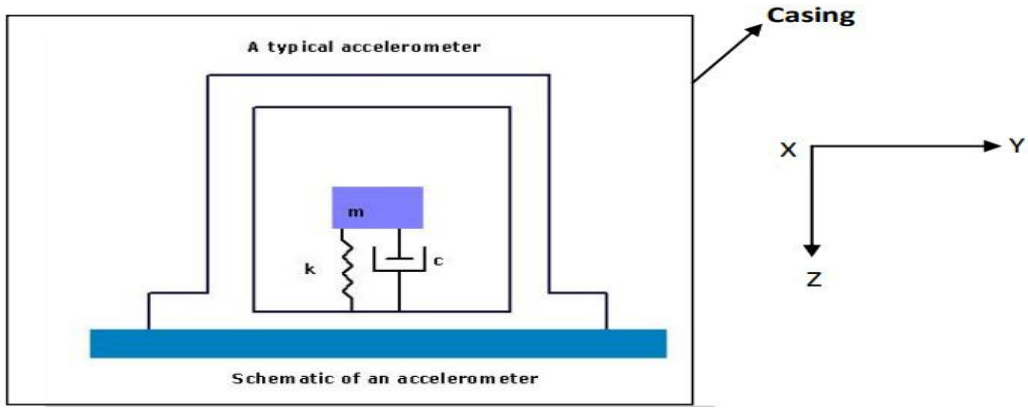



FIGURE 7 SCHEMATIC DIAGRAM OF ACCELEROMETER

- **Structure of Accelerometer:**

Accelerometer can be implemented in IoT based on its application, commonly accelerometer used in IoT is 1) Pizo-Resistive Accelerometer 2) Capacitive Accelerometer 3) Vibration Accelerometer, Let's we discus about its structure

**1) Pizo-Resistive Accelerometer:**

From the figure 8 we can observe that

- A middle wafer is laminated by upper & lower wafers using glass bound
- Sensing elements of this type of accelerometer in middle wafer which sandwich between upper and lower wafer
- This sensing elements are comprised of flexure; these flexures cause a measurable change in resistance that is proportional to applied acceleration
- An upper and lower wafer are provided a hermetic enclosure for the flexure as well as mechanical stops for over-range protection
- A gas damping used for lowers the resonant amplification when it used at high shock applications

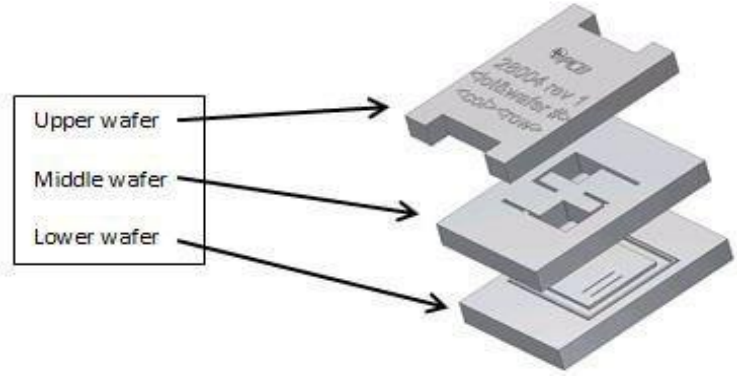



FIGURE 8 LAYERS OF PIZO-RESISTIVE ACCELEROMETER

In practice a design of piezo resistive accelerometer shown in fig 9.

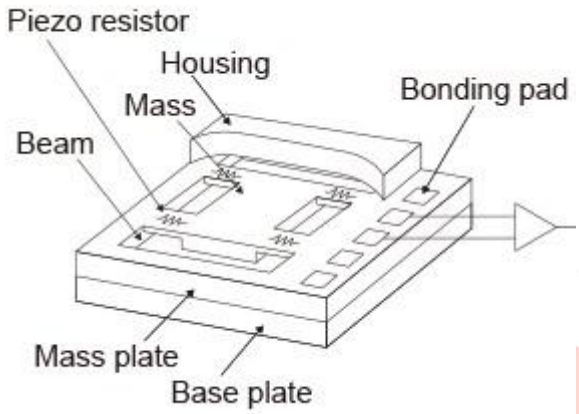



FIGURE 9, PIZO-RESISTIVE ACCELEROMETER

This stable structure comprised on silicon cheap created by micro-machining and semi-conductor technology. On silicon cheap mass and a beam on which set of Pizo-resister are created. A set of electrical bridge is formed by such Pizo-resistive resistor to generate signals proportional to applied acceleration.

**2) Capacitive Accelerometer**:

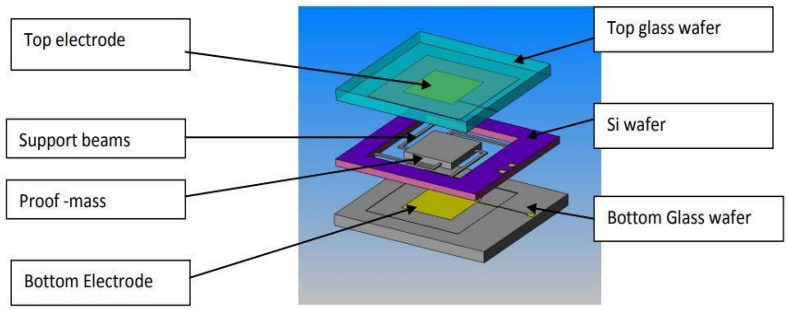



FIGURE 10, CAPACITIVE ACCELEROMETER

- This type of accelerometer has three layers Glass, Silicon, Glass.
- By using E-beam metal evaporation process method a two glass wafers (Top, & Bottom) are used and between this one thin film aluminum is deposited on the inner side of glass wafer.
- We can see that a proof mass is supported by four “L” shaped beams. This proof mass work like a piston and remain parallel to all acceleration.
- If any change in beam length due to temperature variation, limits the proof mass to in plan rotation only and dose not experience any out of plane banding. This type of configuration can reduce a size of sensors like a “chip” size which reduce non-linearity associated with cantilever support structure.

- The gap between proof of mass and bottom electrode is 22 micron which eliminates the requirements of complicated device level vacuum sealing.
- MEMS chip and signal conditioning devices are realized separately and packed on single platform.

➢ **Application of accelerometer sensors:**

**1) Smart Bicycle Lock:** This application based on accelerometer assisted authentication scheme to realize smart bicycle lock. Bluetooth and accelerometers are used for this application. When we riding a bicycle then smart locks and users' smart phone simultaneously measure acceleration and generate one-time code from it. Using raw acceleration measurements as authication cade brings about pour concordance rate between lock and smartphone. Here each device calculates a score vector based on how moving acceleration changes by each measurement and use it for authentication. If the similarity of two score vector sufficiently high a lock regarding that smart phone is truly vicinity of lock and is unlocked


FIGURE 11. 1) TWO SMART PHONES MOUNTED ON A BICYCLE AS A SMART PHONE AND SMART KEY, 2) ROUTE OF USERS PASSES

**3) Fall detection using accelerometer and RFID Technology:** This application implemented for elder people who live alone in the house, this fall detection system design using RFID and accelerometer sensors through indoor and outdoor tracking using embedded system. Also, some elder people who live life alone in house are handicap can have certain incident like falling so to monitor the elder people activities can be identify.

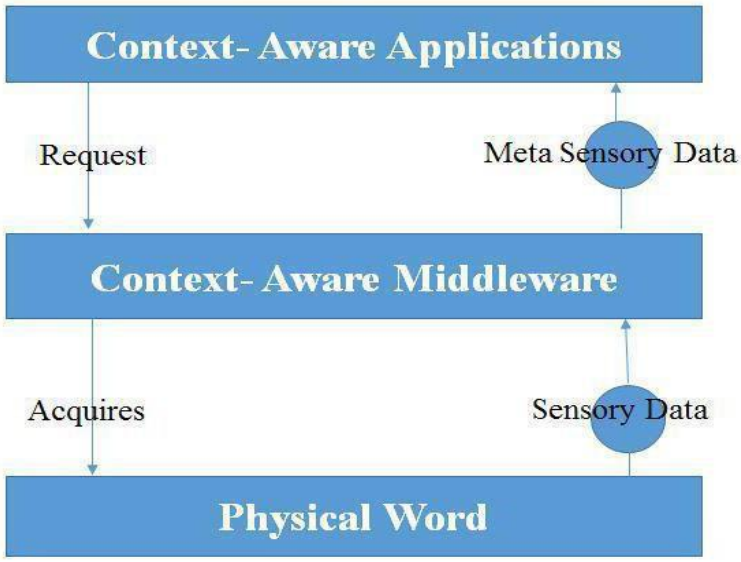



FIGURE 12 CONTEXT OUR REPRESENTATION

The work based on context-aware computing. This method has context information can help better services and suggestion and change the system behavior for better health care. Figure 12 shows the context representation. First Sense the data from sensor, then there is need of classification algorithm to classify the sensor data, this need will fulfil by context aware middleware. The context aware application request to middleware to get raw sensor data. Using the smart phone middleware is going to acquire raw sensor data, also it stores all sensor data & it applies some pre-processing techniques on it for future experiment where extract inference is computed with help of particular algorithm applying on that pre-processing sensor data. Then inference core part or Meta sensory data is passed to that context aware application. In this application tri-axial accelerometer, RFID, & Arduino Uno, use to detect fall of elder people who is unable to walk properly.

**2) Magnetometer:**

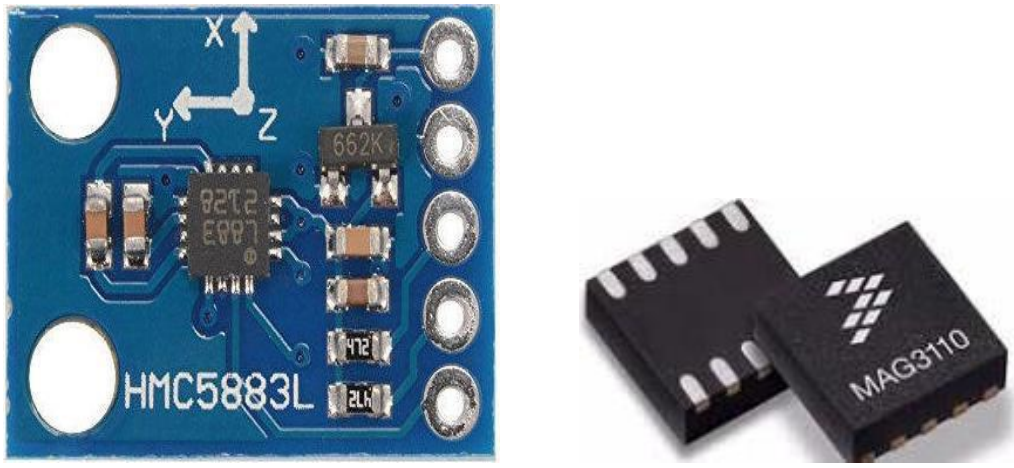



FIGURE 13 DIFFERENT TYPES OF MAGNETO-METER

Commonly magnetic type sensors widely used in automotive sector, Industrial side, Aerospace, and consumer application. This sensor mostly used for navigation & tracking purpose like in military and industrial arenas. But few year smart phones, computer, tablet, gaming and audio/video devices etc have emerged for magnetic sensor by advanced in MEMS technology as well as IC processing. Now a day's consumer application is "Magnetometer" for mobile phone, also known as E-Compass which generally measure magnetic field grater then 1nT. There are five methods to magnetic sensing approaches like Hall effect, GMR (Giant Magnetoresistance), MTJ (Magnetic Tuning junction), AMR (Anisotropic Magnetoresistance) & Lorentz Force. Designing magnetometer with wider bandwidth can reduces noise sensitivity also not cost effective, so this can be improving by the use of additional electronic signal processing circuit as well as software algorithm. But this approach involves a trade off with cost, size & power, thus this track off must be made very carefully. Some magnetometer make use of separate 2 or 3-axis accelerometer chip.

- **Structure of Magnetometer:**

In accelerometer we can use vertical plane, at least static situation but we do not have references for horizontal plan, this problem can be solved by "magnetometer" in MEMS" Technology.

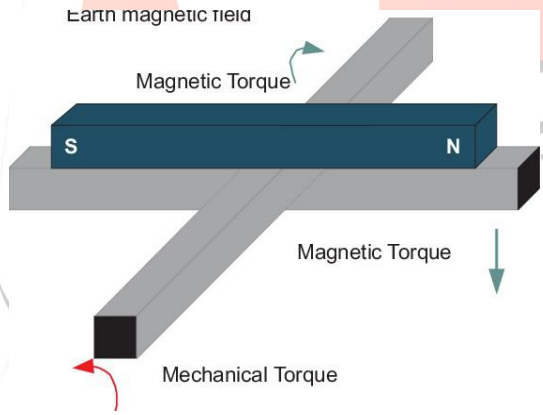



FIGURE 14 PRINCIPLE OF MAGNETOMETER

Figure shown that depending on the orientation of the magnetic field a torque is generated and can be calculated in order to obtain the angle of incidence of the sensor. Now let's we see the structure of magnetometer.

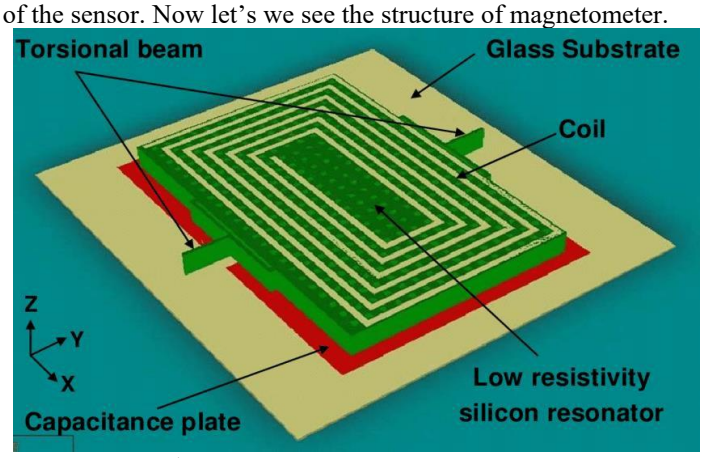



FIGURE 15 STRUCTURE OF MAGNETOMETER

Figure shows that low resistance silicon structure is suspended over the glass substrate by torsional beam. This low resistance silicon structure is 1 micrometer thick 50 micro-meter wide multi-turn excitation coil is deposited. Using anchors bonded onto glass substrate, a free end of the torsional beams is fixed. A capacitance plates are fabricated onto the glass substrate to form the capacitor with the low-resistivity silicon resonate which resistivity between **0.001Ω-cm to 0.004Ω-cm.**

• **Types of Magnetometer**:

Here some types of magnetometers are used for different types of application a type are based on which approaches is used to make a sensor.

- ➢ Flux gate Magnetometer
- ➢ SQUID Magnetometer
- ➢ Induction Coil
- ➢ Proton Pression

• **Application of Magnetometer:**

1. RF driven squid & its application
2. Navigation
3. Speed, Angular. Position Sensing for Vehicle
4. Mobile application for "E-Compass"

**3) PIR Sensor (Motion Sensor):**

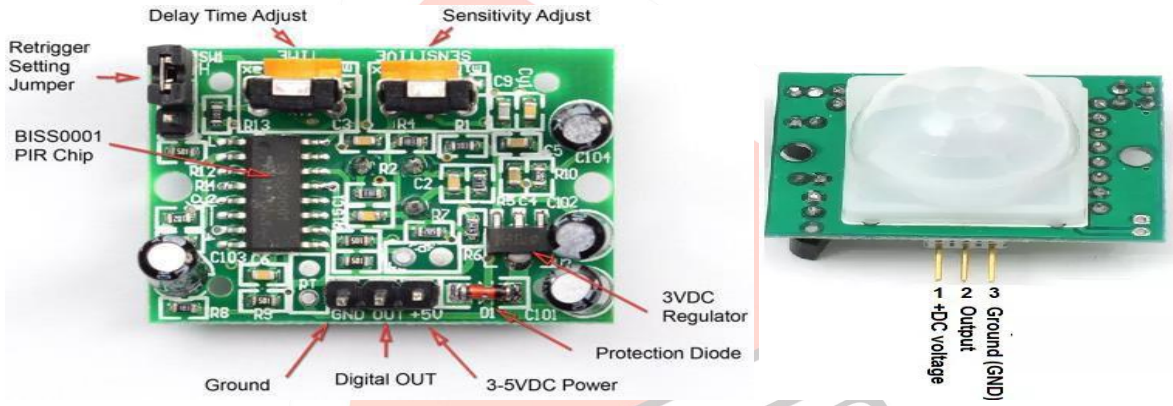



FIGURE 16 PIR MODULE

Pyroelectric Infrared Sensor (PIR) which widely used for cheap surveillance. It has high sensitivity & area of detection that's why PIR sensor most popular in security. Also, PIR has excellent in in human & animal detection. Output of this sensor is proportional to several temporal relationship between "an object in the field of view of the sensor", "It's lens feature", "Environment heat conduction" etc. Also, It has a low power consumption feature from 3 W to 800 W. PIR sensor detect any heat emitting body moving in-front of it. Every object radiate energy as function of their temperature, relative to absolute zero which is inform of black body radiation rays. So PIR detect this black body radiation. PIR sensor doesn't required any type of generate or emit radiation device.

- **Structure of PIR:**

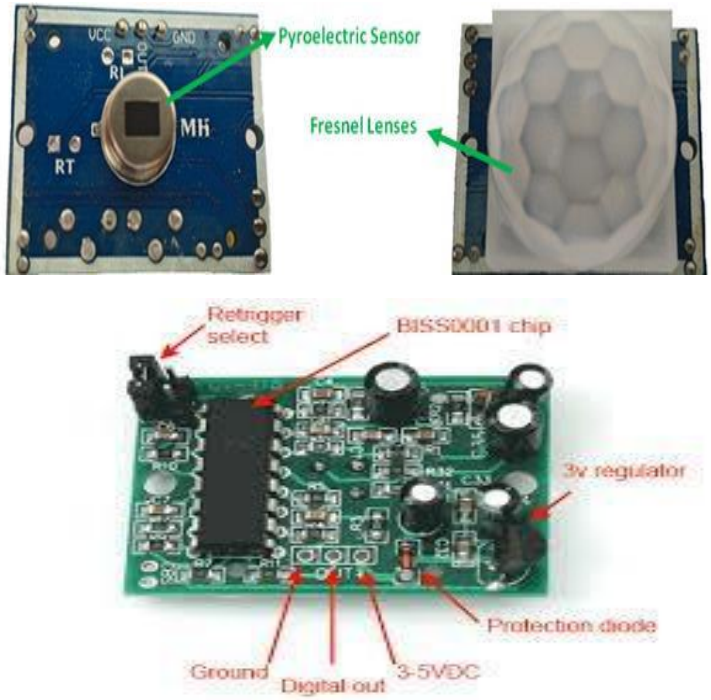



FIGURE 17 FRONT SIDE AND BACK SIDE OF PIR

From above figure we have front side and back side. At front side one lens cap which protect a pyroelectric sensor of PIR, this lens if Fresnel lens. At backside IC's, adjustment resistors, protection devices are mounted in circuit board. Here "BISS0001"is a motion IC which is an important part of circuit. Using time adjustment, we can adjust the timing of output whereas sensitivity adjustment we can adjust a range of PIR sensing area. PIR has a 3-pin, A 5V pin we attached positive terminal of battery volt is 3 to 5V DC, and negative terminal to GND, and output can be getting at output pin.

- **Working of PIR:**

It is very complex to explain the operation of PIR as compared to any-other sensor, because there are multiple variables that affect the sensor input & output. As we know that PIR sensor sensing change in amount of infrared radiation incident on it. This radiation varies depending on the surface characterises & temperature of object in-front of sensor, any object passes in-front of it the sensor temperature area will be change from the room temperature, the temperature will be back again when the object has moved ahead. When warm body passes in-front of PIR then first half of detecting area gets triggered, it causes a differential positive pulse as output, but when it leaves that sensor area, the sensor generates negative differential change. Here we said that PIR sensor has Fresnel lens, It is just a piece of plastic, this sensor should have a large detection area so that it ca cover more area & tell us about motion, that's why without this lens PIR sensor's range is restricted. Hence Fresnel lens increased the area range & sensitivity.

- **Types of Motion Sensor:**

- Micro-wave
- Dual Technology
- Area-Reflective Sensor
- Ultrasonic Sensor
- Vibration Sensor

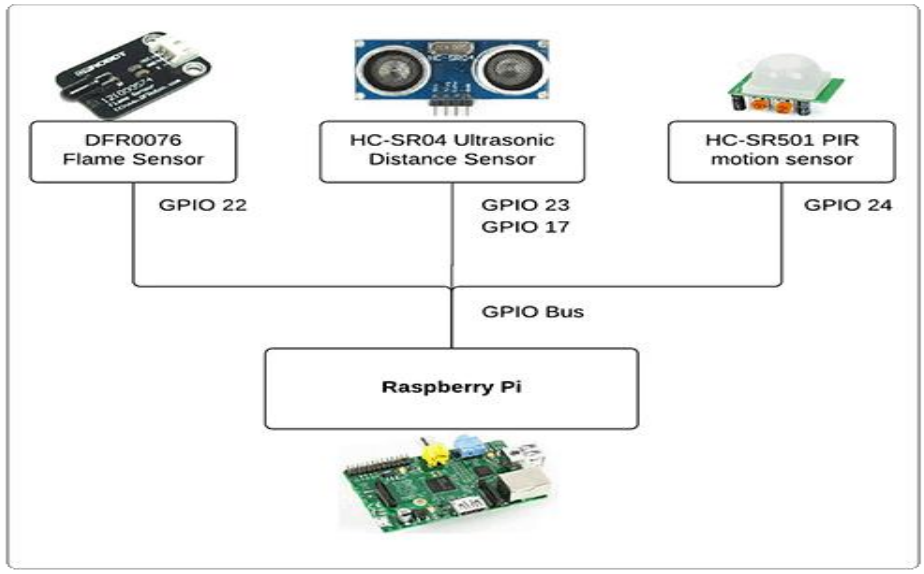



FIGURE 18 DIFFERENT TYPES OF MOTION SENSOR

- **Application:**

- Automatic Ticket gate
- Entry way lighting
- Security lighting
- Automate sink/toilet flusher
- Hand dryer
- Automatic door
- Temperature sensing of remote object

4) **Image Sensor**:

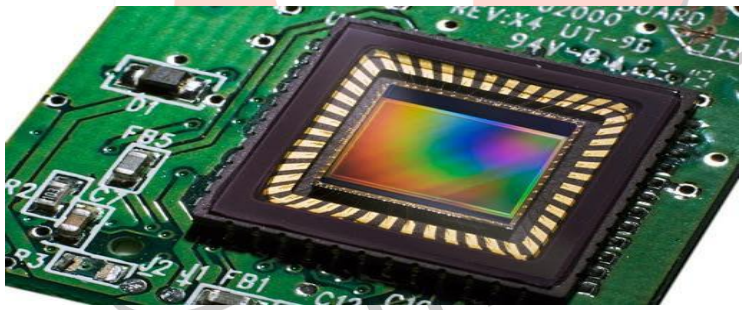


FIGURE 19 SAMSUNG IMAGE SENSOR

There are various places where image sensors are used like single-shot digital camera, Digital video camera, embedded in cell phone, smart phone etc. When user buy a digital imager first priority gives to pixel array size which expressed in Mega-Pixel (MP), higher the mega pixel gives better imager is the revealing wisdom to consumer. Even-though another parameter which indication of better performance like type of image technology like CCD (Coupled Charge Devices) and CMOS (Complementary Metal Oxide Semiconductor). We know that today Mega-Pixel is to be largest used parameter of sensor performance. Furthermore, it may require the optimization of one aspect of the sensor's performance of its specific application. As silicon process technology improves some of these parameters may get better.

The digital imaging invented in 1969 at AT&T bell labs by Willard Bogle & George E Smith. CCD are electronic devices which work by converting light into electronic charge in silicon chip. This charge is deposited

- **Structure of Image Sensor:**

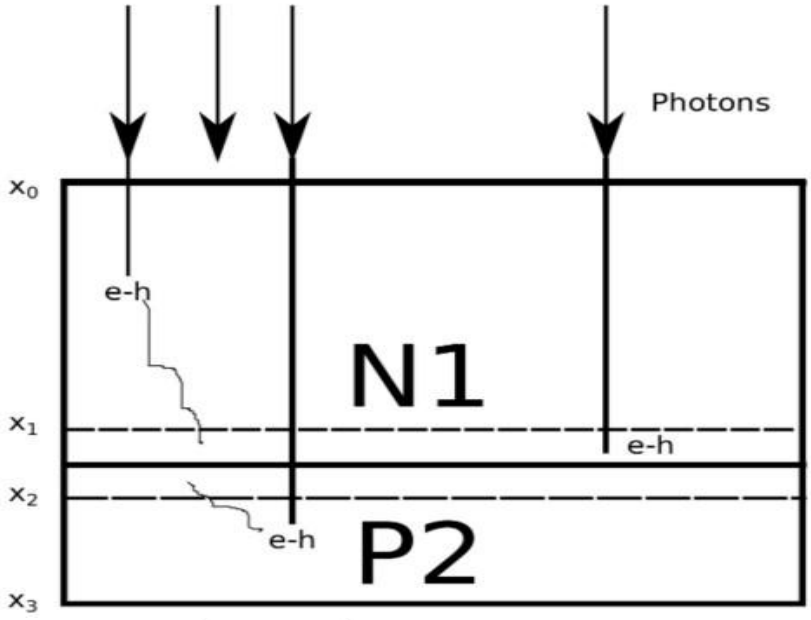



FIGURE 20 PHOTO CHARGE CONVERSION

First, we should know how image sensor works, Every image sensor is made by silicon because silicon is a semiconductor which has a energy gap is between valance band to conduction band, On the base of this gap it is a perfect for capturing light in the visible & near infrared spectrum. Silicon energy ban gap is 1.1eV, if photon hits silicon & it's energy more then 1.1eV then that photon will be absorbed in the silicon & produce charge. The energy of photon is defined as "Plank constant h", time of speed c, and this divided in wavelength λ, According to research, visible light has wavelength between 450nm to 650nm and has photon energy is 1.9eV and 2.75eV respectively. These wavelengths are absorbed from surface based on their energy in exponentially form, that's why blue light is mostly absorbed at surface, while red light goes deeper into silicon. Most of silicon photodiodes are based on a diode structure, when photons hit the silicon, it will penetrates based on its wavelength & if it absorbed it will create an "electron-hole" pair where it absorbed. Thus, three places where "electron-hole" can be formed either P-type & N-type or depletion region.

- ➢ If it forms in depilation region then electron-hole pair are swept away which creating drift current by charged movement.
- ➢ If it is absorbed in N-type region then electron will remain as majority carriers in Ntype electrons-hole that is formed is left to diffuse toward the depletion region. ➢ This situation is reversed if it absorbed in P-type region.

These diffusions also create current, the total current in the photodiode is addition of two diffusion current also drift current. With the amount of current based on how many photons are hitting the sensor & sensor area, although large sensor can collect more photons & can be more sensitive to lower light intensities.

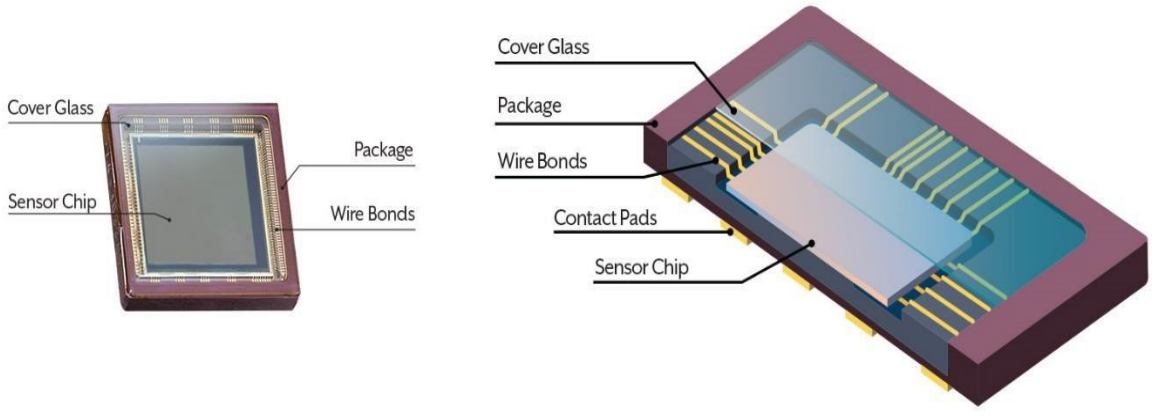



FIGURE 21 STRUCTURE OF IMAGE SENSOR

From above figure we can see that, a wire bonds transfer for the signal from the die to contact pads at the back of sensor. Packaging of sensor protects the sensor chip & wire bonds against physical & environment harms, provide thermal dissipation & interconnecting electronic for signal transfer. In front of the packaging a transparent window called "cover glass" which protect the sensor chip & wire which allowing light to reach the light sensitive area. A manufacture makes a chip by semiconductor companies and cut from wafers, on silicon wafers large batches of sensor dies are produces.This wafer is cut into many pieces with each pieces housing a single sensor die. When sensor die size is larger than lower

number of sensors per wafer. One thing should be carefully that if single defect wafer will have higher probability of impacting image sensor.

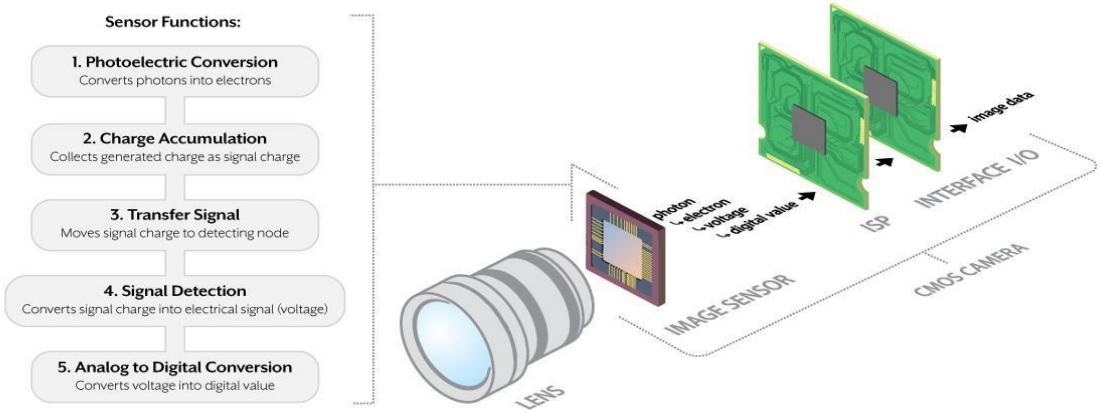



FIGURE 22 SENSOR FUNCTION INSIDE THE CAMERA

Figure shows that how the sensor works inside the camera, in a camera by lens or other optical, the image sensor receives the incident light which focused on it. Depending on either using CCD or CMOS it will transfer information to next stage either voltage or digital signal. If we use only CMOS sensor then it converts photons into electrons then to voltage into digital signal by using on-chip ADC.

- Types of Image Sensor:
  1. CCD (Coupled Charge Device): This sensor can start & stop exposure for all pixel at same time, this will transfer this exposure charge to horizontal shift register

  2. CMOS (Complementary Metal Oxide Semiconductor): This sensor able to start & stop exposure one-pixel row at a time which is know as "rolling shutter". CMOS sensor has smaller ADC for each pixel column which allowing for higher frame rates than CCD. CMOS has also two type "Mono & Colour Sensor".
- Application:
  1. Area scan
  2 .Image taking
  3. 3D scanning
  4Video shooting

**5) RFID Sensor:**

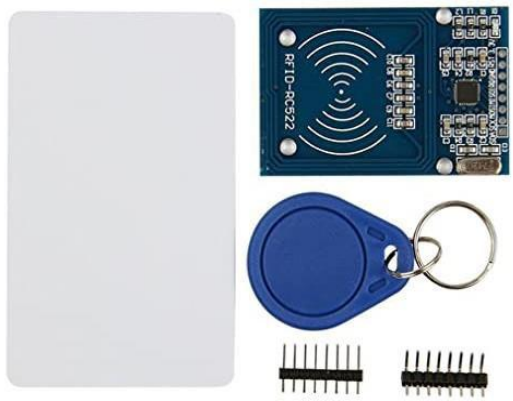



FIGURE 23 RFID SENSOR MODULE

The full-form of RFID is "Radio Frequency Identification" like a smart card. A smart card system data is stored on electronics data carrying system called "transponder", the power supply to data-carrying devices & data exchange between data-carrying device & reader is achieved without that use of any galvanic contact. RFID system has tags, that allows user to automatically & identify & track inventory & assets. Also, RFID takes barcodes technology to the next level by allowing tags to be read without line of sight & depending on the type of RFID. Now a days to make a RFID system more cost effective & efficient.

➢ **Structure of RFID & RFID System:**

RFID has two components: 1) Transponder or Tags: It is located on the object which is to be identifier 2) Interrogator or Reader: It is depending on design & technology. RFID transponder tags made up by

- Micro-chip
- Antenna

- Case
- Battery

RFID tags are fixed to that item in order to track it, using RFID reader & antenna.

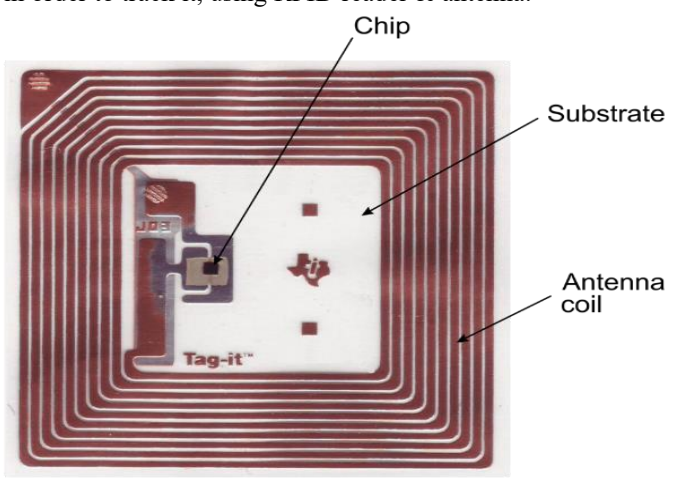



FIGURE 24 RFID TAG

RFID fixed to that item in order to track it, using RFID reader & antenna.

Figure shows a construction of RFID tag. At the middle we can clearly see antenna. Size of chip depending upon the antenna and area of used. Antenna size & form depends upon frequency, it's ranges from less than millimetre to size of book. Also, some tags have re-writable memory attached where the tag can store updates between new data.

- **Working of RFID tags:**

➢ RFID tags transmit the information by radio-wave to antenna or reader.
➢ Unless RFID don't have a battery except if we use active RFID tag.
➢ That's why it receives energy from radio-wave generated by reader.
➢ When tags receive the transmission from reader, the energy runs through the internal antenna to the tags chip.
➢ Energy activates the chip which modulates the energy with desire data & then transmit a signal back towards the reader.
➢ During reading reader has to continuously power the tag, this field called "Continues Wave"

It's strength of the field decreases with the square of distance the reader has to use a larger power.

- **Types of RFID tags:**

The tags are in relation to power, here some tags are given below:

➢ Passive RFID tags: This tag doesn't have an internal power source & they rely on the power induced by reader
➢ Semi-passive RFID tags: This tag have an internal power sources which keeps the power in micro-chip all time. But it uses the energy supplied for both sides to power the microchip & generate a signal on antenna.
➢ Active RFID tags: This tag already have internal power sources and send signal which is called "beacons". Active tags have tens of meter range & making it ideal for locating object. It life is up to five years.

- **RFID System:**

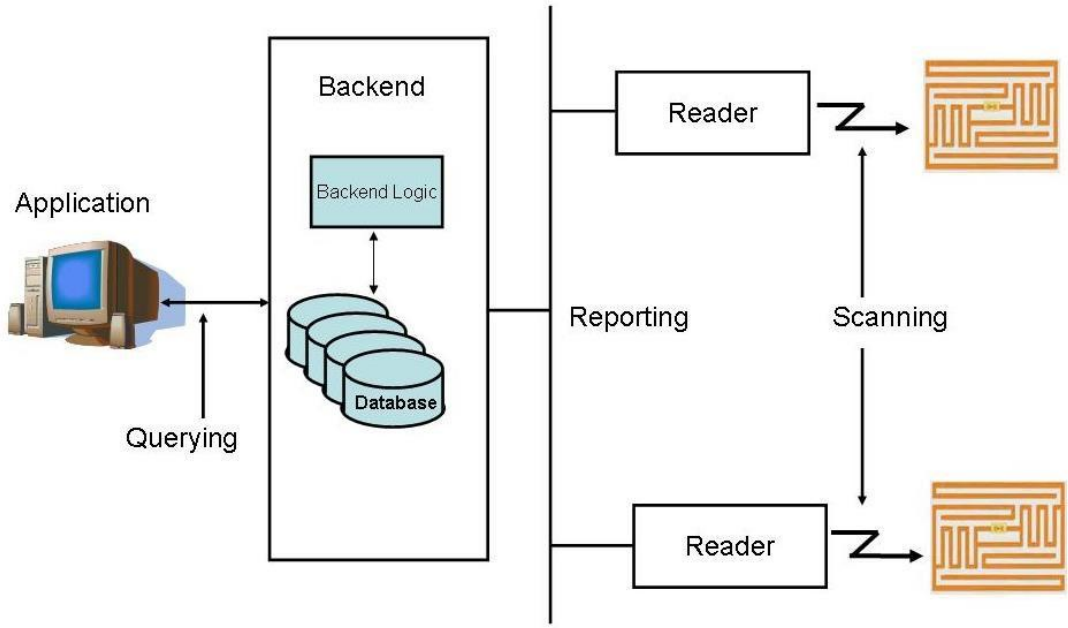



FIGURE 25: RFID SYSTEM WHOLE

System contains four components

- Reader
- Antenna
- Tags
- Cables

Figure shows the RFID system, when RFID reader scan the tags then it forwards the information to the backend. This backend consists of database as well as well-defined application interface. If backend receives any new information it adds to database if needed performs some computation on related fields. The application retrieves the data from backend. The simplest system can be comprised of mobile handheld RFID reader & RFID tags. On other side Complex system are design using GPI boxes, multi-port reader other additional functional devices, multiple antenna, cable & software.

- **Application:**
  1) Security/ Interrogator
  2) Contactless payment
  3) Electronic Passport
  4) Public Transport
  5) Human/Animal Identification
  6) Container Identification
  7) Industrial Automation
  8) Medical Application

**Conclusion**

After studying a literature of sensors which will used in 5G technology for automation of devices, all sensors are reliable and give a good requirement output as per application, also function of sensors are simple and easy to understand and easy to installed, In future technology this are sensors can be used.

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