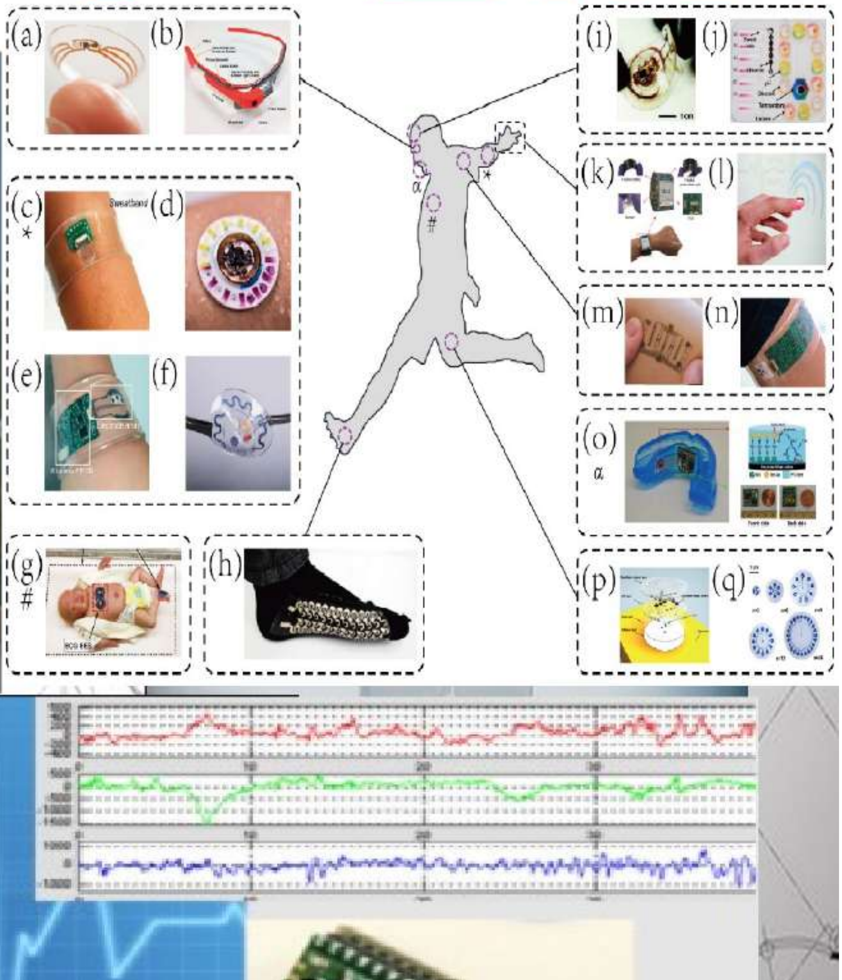
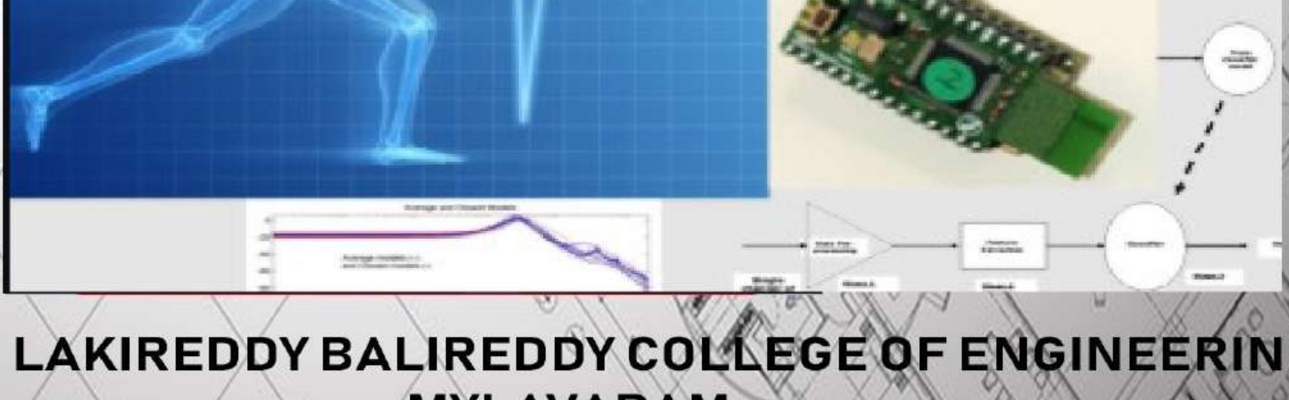
ELECTRONICS & COMMUNICATION ENGINEERING

TECH CONNECT

June,2022





LAKIREDDY BALIREDDY COLLEGE OF ENGINEERING
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Contents

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1.Wearable bio sensors

A biosensor is an analytical device, used for the detection of a chemical substance, that combines a biological component with a physicochemical detector. The sensitive biological element, e.g. tissue, microorganisms, organelles, cell receptors, enzymes, antibodies, nucleic acids, etc., is a biologically derived material or biomimetic component that interacts with, binds with, or recognizes the analyte under study. The biologically sensitive elements can also be created by biological engineering. The transducer or the detector element, which transforms one signal into another one, works in a physicochemical way: optical, piezoelectric, electrochemical, electrochemical luminescence etc., resulting from the interaction of the analyte with the biological element, to easily measure and quantify. The biosensor reader device connects with the associated electronics or signal processors that are primarily responsible for the display of the results in a user-friendly way. This sometimes accounts for the most expensive part of the sensor device; however, it is possible to generate a user friendly display that includes transducer and sensitive element (holographic sensor). The readers are usually custom-designed and manufactured to suit the different working principles of biosensors.

With the increasing prevalence of growing population, aging and chronic diseases continuously rising healthcare costs, the healthcare system is undergoing a vital transformation from the traditional hospital-centered system to an individual-centered system. Since the 20th century, wearable sensors are becoming widespread in healthcare and biomedical monitoring systems, empowering continuous measurement of critical biomarkers for monitoring of the diseased condition and health, medical diagnostics and evaluation in biological fluids like saliva, blood, and sweat. Over the past few decades, the developments have been focused on electrochemical and optical biosensors, along with advances with the non-invasive monitoring of biomarkers, bacteria and hormones, etc. Wearable devices have evolved gradually with a mix of multiplexed biosensing, microfluidic sampling and transport systems integrated with flexible materials and body attachments for improved wearability and simplicity. These wearables hold promise and are capable of a higher understanding of the correlations between analyte concentrations within the blood or non-invasive biofluids and feedback to the patient, which is significantly important in timely diagnosis, treatment, and control of medical conditions. However, cohort validation studies and performance evaluation of wearable biosensors are needed to underpin their clinical acceptance. In the present review, we discuss the importance, features, types of wearables, challenges and applications of wearable devices for biological fluids for the prevention of diseased conditions and real-time monitoring of human health

Wearable biosensors are garnering substantial interest due to their potential to provide continuous, real-time physiological information via dynamic, non-invasive measurements of biochemical markers in biofluids, such as sweat, tears, saliva and interstitial fluid. Recent developments have focused on electrochemical and optical biosensors, together with advances in the non-invasive monitoring of biomarkers including metabolites, bacteria and hormones. A combination of multiplexed biosensing, microfluidic sampling and transport systems have been integrated, miniaturized and combined with flexible materials for improved wearability and ease of operation. Although wearable biosensors hold promise, a better understanding of the correlations between analyte concentrations in the blood and non-invasive biofluids is needed to improve reliability. An expanded set of on-body bio affinity assays and more sensing strategies are needed to make more biomarkers accessible to monitoring. Large-cohort validation studies of wearable biosensor performance will be needed to underpin clinical acceptance. Accurate and reliable real-time sensing of physiological information using wearable biosensor technologies would have a broad impact on our daily lives.

Wearable sensors have received much attention since the arrival of smartphones and other mobile devices, owing to their ability to provide useful insights into the performance and health of individuals. Early efforts in this area focused on physical sensors that monitored mobility and vital signs, such as steps, calories burned or heart rate. The face of wearable devices has changed rapidly in recent years, with researchers branching out from tracking physical exercise activity to focus on tackling major challenges in healthcare applications, such as the management of diabetes or remote monitoring of the elderly. To accomplish these goals, researchers have devoted substantial efforts to the development of wearable biosensors, which are defined as sensing devices that incorporate a biological recognition element into the sensor operation (for example, enzyme, antibody, cell receptor or organelle). The potential utility of wearable biosensors is evident from the rapidly increasing rate of newly reported proof-of-concept studies. Although several of these platforms are under clinical evaluation, successful translation to the commercial market has been lacking. Significant endeavours are underway toward the commercialization of non-invasive biosensors. However, these products still require further large-scale validation studies, the necessary device regulatory approvals and final marketing paths. Driven by the promise of the huge glucose sensing market, this commercial activity focuses largely on minimally invasive glucose monitoring devices.

A typical biosensor contains two basic functional units: a ‘bioreceptor’ (for example, enzyme, antibody or DNA) responsible for selective recognition of the target analyte and a physico-chemical transducer (for example, electrochemical, optical or mechanical) that translates this biorecognition event into a useful signal as shown in Fig.1.1.

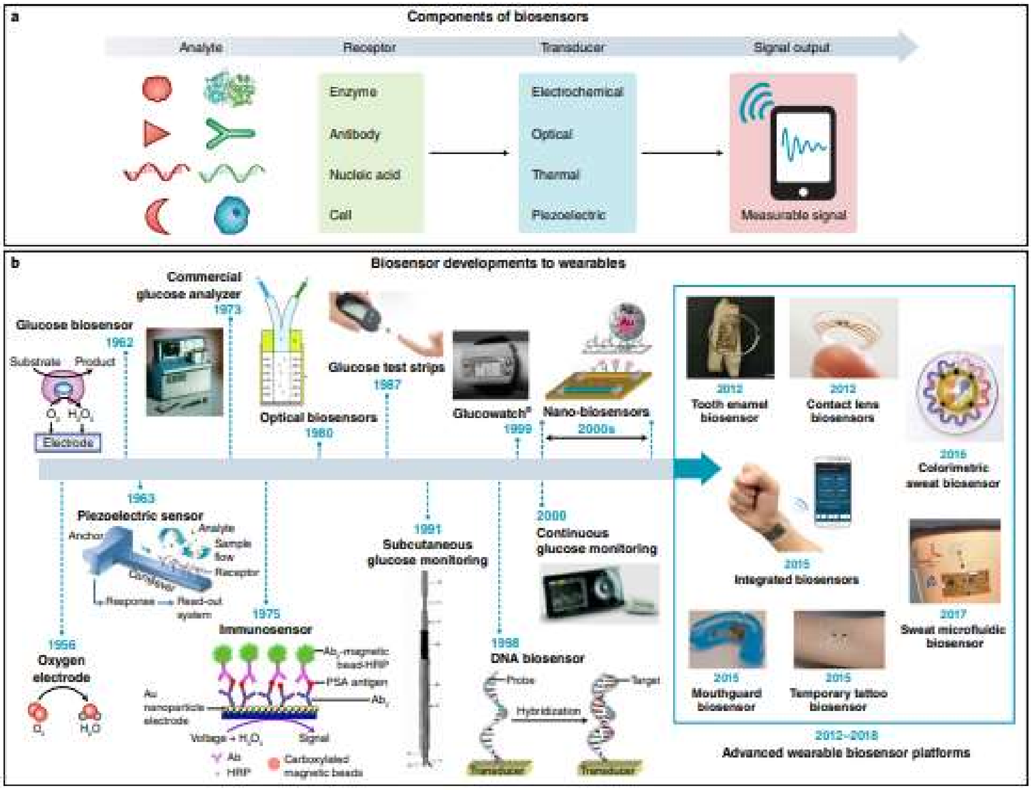

Fig.1.1. Different bio sensors.

Such devices were initially developed for in vitro measurements in controlled (laboratory or point-of-care) settings or for single-use home testing (for example, blood glucose test strips).The past advances have paved the way to modern wearable biosensors for non-invasive biomonitoring applications as an alternative to blood monitoring biomedical devices in connection to wide range of healthcare applications. Biosensors hold considerable promise for wearable applications due to their high specificity, speed, portability, low cost and low power requirements. Indeed, innovative biosensor platforms for non-invasive chemical analysis of biofluids, such as sweat, tears, saliva or interstitial fluid (ISF), have already been widely applied to a variety of head-to-toe application sites, targeting an array of important analytes in proof-of-concept demonstrations. Sweat, tears, saliva and ISF have been targeted as they can be sampled in a non-invasive manner, meaning that they can be readily accessed without disrupting the outermost protecting layers of the body's skin (the stratum corneum) and without contacting blood. As such, non-invasive sensing methods pose minimal risk of harm or infection and are generally more user friendly. The wide acceptance of such wearable biosensor technology requires a deep understanding of the biochemical composition of bodily fluids, such as sweat or tears, and its relation to blood chemistry. Wearable monitoring platforms can lend insights into dynamic biochemical processes in these biofluids by enabling continuous, real-time monitoring of biomarkers that can be related to a wearer's health and performance. Such real-time monitoring can provide information on wellness and health, enhance the management of chronic diseases and alert the user or medical professionals of abnormal or unforeseen situations.

Wearable biosensors can obviate painful and risky blood sampling procedures and can be readily blended with a wearer's daily routine. To accomplish this capability, the biosensing platform must provide direct contact with the sampled biofluids without inducing discomfort to the wearer. Such body compliance can be achieved through use of advanced materials and smart designs that provide the necessary flexibility and stretchability45–48. Continuous multidisciplinary development of new biosensing technologies (and corresponding new materials and energy sources) has led to numerous proof-of concept demonstrations and has driven growing efforts toward the commercialization activity of wearable sensors. Unlike physical or chemical wearable sensors, the wearable biosensors reviewed here rely on highly specific bioreceptors capable of recognizing target analytes in complex samples at physiologically relevant concentrations.

The commercialization of wearable bioanalytic sensors is substantially more challenging than that of activity-tracking counterparts or common lab-based biosensors because such devices must be capable not only of continuous on-body biochemical sensing but also of reliable measurement of a biorecognition element (or elements) that is highly specific yet fragile. Robust, reliable measurement also must overcome such challenges as gradual surface biofouling at the body–sensor interface, inefficient transport of sample over the sensor, limited stability of many bioreceptors, the complexity of multistep bio affinity assays and related receptor regeneration, and issues posed by calibration for on-body biosensors.

Reference:

[1]. Kim J, Campbell AS, de Ávila BE, Wang J. Wearable biosensors for healthcare monitoring. Nat Biotechnol. 2019 Apr;37(4):389-406.

~P.Narendra(21765A0406)

2. Bio Medical Signal Processing

A biosignal is any signal in living beings that can be continually measured and monitored. The term biosignal is often used to refer to bioelectrical signals, but it may refer to both electrical and non-electrical signals. The usual understanding is to refer only to time-varying signals, although spatial parameter variations (e.g. the nucleotide sequence determining the genetic code) are sometimes subsumed as well.

Electrical biosignals, or bioelectrical time signals, usually refers to the change in electric current produced by the sum of an electrical potential difference across a specialized tissue, organ or cell system like the nervous system.

In biology, the classical doctrine of the **nervous system** determines that it is a highly complex part of an animal that coordinates its actions and sensory information by transmitting signals to and from different parts of its body. The nervous system detects environmental changes that impact the body, then works in tandem with the endocrine system to respond to such events.[1] Nervous tissue first arose in wormlike organisms about 550 to 600 million years ago. However, this classical doctrine has been challenged in recent decades by discoveries about the existence and use of electrical signals in plants. On the basis of these findings, some scientists have proposed that a plant nervous system exists and that a scientific field called plant neurobiology should be created.[3][4] This proposal has led to a dispute in the scientific community between those who think we should talk about the nervous system of plants and those who are against it.[5][6] The inflexibility of the positions in the scientific debate on both sides has led to the proposal of a solution to the debate, consisting of redefining the concept of the nervous system by using only physiological criteria and avoiding phylogenetic criteria.

In vertebrates it consists of two main parts, the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS consists of the brain and spinal cord. The PNS consists mainly of nerves, which are enclosed bundles of the long fibers or axons, that connect the CNS to every other part of the body. Nerves that transmit signals from the brain are called motor nerves or efferent nerves, while those nerves that transmit information from the body to the CNS are called sensory nerves or afferent. Spinal nerves are mixed nerves that serve both functions. The PNS is divided into three separate subsystems, the somatic, autonomic, and enteric nervous systems. Somatic nerves mediate voluntary movement. The autonomic nervous system is further subdivided into the sympathetic and the parasympathetic nervous systems. The sympathetic nervous system is activated in cases of emergencies to mobilize energy, while the parasympathetic nervous system is activated when organisms are in a relaxed state. The enteric nervous system functions to control the gastrointestinal system. Both autonomic and enteric nervous systems function involuntarily. Nerves that exit from the cranium are called cranial nerves while those exiting from the spinal cord are called spinal nerves.

At the cellular level, the nervous system is defined by the presence of a special type of cell, called the neuron, also known as a "nerve cell." Neurons have special structures that allow them to send signals rapidly and precisely to other cells. They send these signals in the form of electrochemical impulses traveling along thin fibers called axons, which can be directly transmitted to neighbouring cells through electrical synapses or cause chemicals called neurotransmitters to be released at chemical synapses. A cell that receives a synaptic signal from a neuron may be excited, inhibited, or otherwise modulated. The connections between neurons can form neural pathways, neural circuits, and larger networks that generate an organism's perception of the world and determine its behaviour. Along with neurons, the nervous system contains other specialized cells called glial cells (or simply glia), which provide structural and metabolic support.

Nervous systems are found in most multicellular animals, but vary greatly in complexity. The only multicellular animals that have no nervous system at all are sponges, placozoans, and mesozoans, which have very simple body plans. The nervous systems of the radially symmetric organisms ctenophores and cnidarians consist of a diffuse nerve net. All other animal species, with the exception of a few types of worms, have a nervous system containing a brain, a central cord (or two cords running in parallel), and nerves radiating from the brain and central cord. The size of the nervous system ranges from a few hundred cells in the simplest worms, to around 300 billion cells in African elephants.

The central nervous system functions to send signals from one cell to others, or from one part of the body to others and to receive feedback. Malfunction of the nervous system can occur as a result of genetic defects, physical damage due to trauma or toxicity, infection, or simply senses. The medical specialty of neurology studies disorders of the nervous system and looks for interventions that can prevent or treat them. In the peripheral nervous system, the most common problem is the failure of nerve conduction, which can be due to different causes including diabetic neuropathy and demyelinating disorders such as multiple sclerosis and amyotrophic lateral sclerosis. Neuroscience is the field of science that focuses on the study of the nervous system.

Thus, among the best-known bioelectrical signals are:

- Electroencephalogram (EEG)
- Electrocardiogram (ECG)
- Electromyogram (EMG)
- Electrooculogram (EOG)
- Electroretinogram (ERG)
- Electrogastrogram (EGG)
- Galvanic skin response (GSR) or electrodermal activity (EDA)

EEG, ECG, EOG and EMG are measured with a differential amplifier which registers the difference between two electrodes attached to the skin. However, the galvanic skin response measures electrical resistance and the MEG measures the magnetic field induced by electrical currents (electroencephalogram) of the brain.

With the development of methods for remote measurement of electric fields using new sensor technology, electric biosignals such as EEG and ECG can be measured without electric contact with the skin. This can be applied, for example, for remote monitoring of brain waves and heartbeat of patients who must not be touched, in particular patients with serious burns. Electrical currents and changes in electrical resistances across tissues can also be measured from plants.

Biosignals may also refer to any non-electrical signal that is capable of being monitored from biological beings, such as mechanical signals (e.g. the mechanomyogram or MMG), acoustic signals (e.g. phonetic and non-phonetic utterances, breathing), chemical signals (e.g. pH, oxygenation) and optical signals (e.g. movements).Biomedical signal processing involves acquiring and pre-processing physiological signals and extracting meaningful information to identify patterns and trends within the signals.

Sources of biomedical signals include neural activity, cardiac rhythm, muscle movement, and other physiological activities. Signals such as electrocardiogram (ECG), electroencephalogram (EEG), electromyography (EMG) can be captured non-invasively and used for diagnosis and as indicators of overall health.

The biomedical signal processing workflow involves:

- Signal Acquisition
- Signal Visualization and Annotation

- Artifact Removal and Pre-processing
- Feature Extraction

The extracted features are then fed into classification models or used directly for diagnosis.

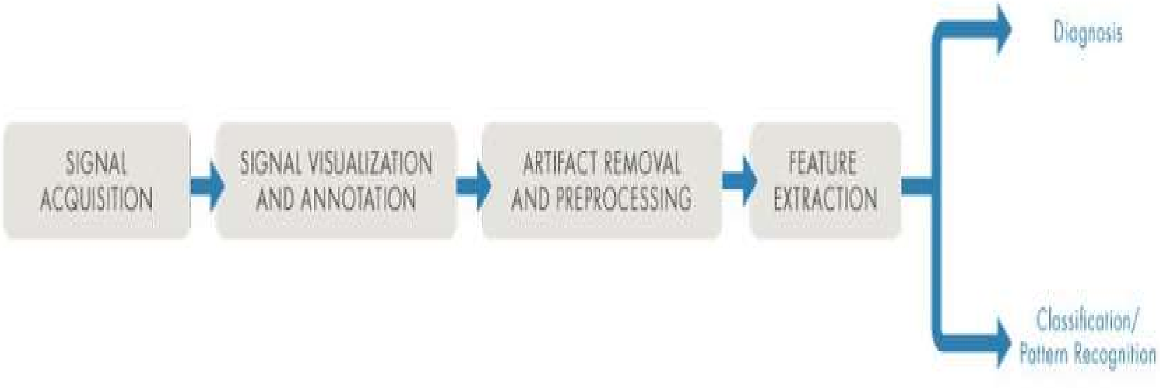

Fig.2.1. Work flow for processing biomedical signals.

Artifact Removal and Signal Filtering: Biomedical signals often contains noise or unwanted artifacts that can distort the analysis of the signals. For instance, while measuring EKG signals, activities such as breathing and walking can add unwanted components. One of the main challenges in preprocessing biomedical signals is to remove unwanted artifacts while preserving the sharp features within signals. Most popular techniques for artifact removal are digital filtering, adaptive filtering, independent component analysis (ICA), and recursive least square. A combination of preprocessing techniques may also be used to address the limitations of individual techniques.

Feature Extraction with Signal Processing: Feature extraction can be accomplished manually or automatically. Signal processing techniques like AR modeling, Fourier analysis, and spectral estimation can be used to manually compute key features from signals. Time-frequency transformations, such as the short-time Fourier transform (STFT) can be used as signal representations for training data in machine learning and deep learning models. Automatic feature extraction techniques like wavelet scattering can be used to reduce dimensionality and extract important features. These features can be used directly for diagnosis or as input to machine learning and deep learning classifiers.

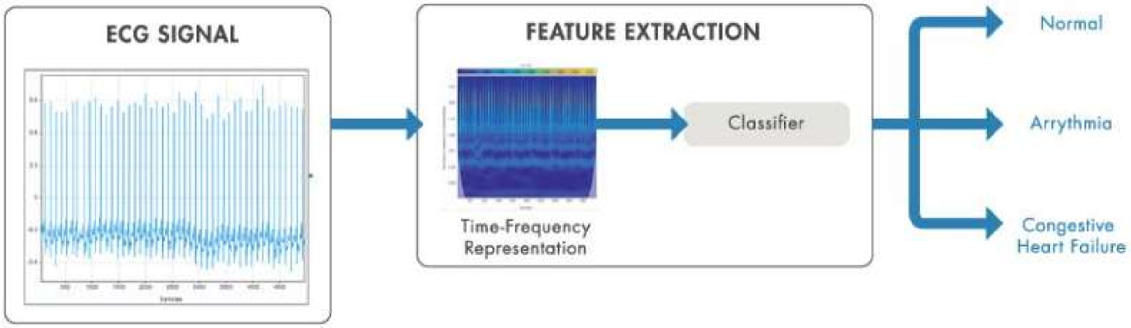

Fig.2.2. Time-frequency analysis used to extract features from ECG signals for classification.

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[1]. https://en.wikipedia.org/wiki/Biosignal

[2]. https://in.mathworks.com/discovery/biomedical-signal-processing.html

~K.Nagababu(21765A0404)

3. Small Satellite Launch Vehicle

The Small Satellite Launch Vehicle (SSLV) is a small-lift launch vehicle developed by ISRO with payload capacity to deliver 500 kg (1,100 lb) to low Earth orbit (500 km (310 mi)) or 300 kg (660 lb) to Sun-synchronous orbit (500 km (310 mi))[7] for launching small satellites, with the capability to support multiple orbital drop-offs.[11][12][13] A small-lift launch vehicle is a rocket orbital launch vehicle that is capable of lifting up to 2,000 kg (4,400 lb) (by NASA classification) or up to 5,000 kilograms (11,000 lb) (by ROSCOSMOS classification) of payload into low Earth orbit (LEO). The next larger category consists of medium-lift launch vehicles.

Fig.3.1.SSLV-D1/EOS-02 at First Launch Pad

The first small-lift launch vehicle was the Sputnik rocket, launched by the Soviet Union, which was derived from the R-7 Semyorka ICBM. On 4 October 1957, the Sputnik rocket was used to perform the world's first satellite launch, placing the Sputnik 1 satellite into a low Earth orbit. NASA responded by attempting to launch the Vanguard rocket. However, the Vanguard TV3 launch attempt failed, with the 31 January 1958 launch of the Explorer 1 satellite using the Juno I rocket being the first successful NASA orbital launch. The Vanguard I mission was the second successful NASA orbital launch. This was the start of the space race.

ISRO's Sriharikota Spaceport is ideal for launching heavy rockets, but poses a major threat during the launch of smaller rockets. Sriharikota presents a threat when rockets are launched in polar orbit (circling the Earth above the poles). The island nation of Sri Lanka is in the path of a rocket traveling to the South Pole from the Sriharikota spaceport. Given the huge risk of flying over a country, India's rockets are programmed to perform a maneuver to avoid Sri Lanka's landmass. So, instead of flying in a straight line, the rocket follows a curved path. To perform this maneuver, the rocket has to burn a reasonable amount of fuel. While big rockets can perform this maneuver without much impact on the rocket's payload carrying capacity, but smaller rockets such as the SSLV consume a lot of fuel. Fuel consumption to follow a curved trajectory means the rocket's payload capacity is reduced. To avoid this problem, ISRO has undertaken the construction of the Kulasekharapatnam Spaceport, from which small rockets can be launched in a straight line without the risk of crossing Sri Lanka's landmass and save fuel

Since the late 1950s, small-lift launch vehicles have continued launching payloads to space. Medium-lift launch vehicles, heavy-lift launch vehicles, and super heavy-lift launch vehicles have also been extensively developed but have not completely been able to supersede the small launch vehicles. Small launch vehicles can meet the requirements of some spacecraft, and can also be less expensive than a larger launch vehicle would be.

SSLV is made keeping low cost, low turnaround time in mind with launch-on-demand flexibility under minimal infrastructure requirements.

The maiden flight SSLV-D1 was conducted on 7 August 2022, from the First Launch Pad, but failed to reach orbit.

In the future, a dedicated launch site called SSLV Launch Complex (SLC) near Kulasekharapatnam in Tamil Nadu will handle SSLV launches to Sun-synchronous orbit. After entering the operational phase, the vehicle's production and launch operations will be done by a consortium of Indian firms along with New Space India Limited (NSIL). The SSLV was developed with the aim of launching small satellites commercially at drastically reduced price and higher launch rate as compared to Polar Satellite Launch Vehicle (PSLV). The development cost of SSLV is ₹169.07 crore (US$21 million) and the manufacturing cost is expected to be ₹30 crore (US$3.8 million) to ₹35 crore (US$4.4 million).

The projected high launch rate relies on largely autonomous launch operation and on overall simple logistics. To compare, a PSLV launch involves 600 officials while SSLV launch operations would be managed by a small team of about six people. The launch readiness period of the SSLV is expected to be less than a week instead of months. The launch vehicle can be assembled both vertically like the existing PSLV and Geosynchronous Satellite Launch Vehicle (GSLV) and horizontally like the retired Satellite Launch Vehicle (SLV) and Augmented Satellite Launch Vehicle (ASLV).

The first three stages of the vehicle use HTPB based solid propellant, with a fourth terminal stage being a Velocity-Trimming Module (VTM) with eight 50 N thrusters for reaction control and eight 50 N axial thrusters for changing velocity.[10] With these VTM can add delta-v of up to 172 m/s.

The first stage (SS1) and third stage (SS3) of SSLV are newly developed while second stage (SS2) is derived from third stage (HPS3) of PSLV. The early developmental flights and those to inclined orbits will launch from Sriharikota, at first using existing launch pads and later from dedicated facility called SSLV Launch Complex (SLC) in Kulasekharapatnam. Tenders related to manufacturing, installation, assembly, inspection, testing and Self-Propelled launching Unit (SPU) were released in October 2019.

This new spaceport, under development, near Kulasekharapatnam in Tamil Nadu will handle SSLV launches to Sun-synchronous orbit when complete.

References:

[1]. https://en.wikipedia.org/wiki/Small_Satellite_Launch_Vehicle

~Ch.Jyoshna (21765A0402)

4. 3D Printing

3D printing or additive manufacturing is the construction of a three-dimensional object from a CAD model or a digital 3D model.[1] It can be done in a variety of processes in which material is deposited, joined or solidified under computer control,[2] with material being added together (such as plastics, liquids or powder grains being fused), typically layer by layer.

In the 1980s, 3D printing techniques were considered suitable only for the production of functional or aesthetic prototypes, and a more appropriate term for it at the time was rapid prototyping.[3] As of 2019, the precision, repeatability, and material range of 3D printing have increased to the point that some 3D printing processes are considered viable as an industrial-production technology, whereby the term additive manufacturing can be used synonymously with 3D printing.[4] One of the key advantages of 3D printing[5] is the ability to produce very complex shapes or geometries that would be otherwise impossible to construct by hand, including hollow parts or parts with internal truss structures to reduce weight. Fused deposition modelling (FDM), which uses a continuous filament of a thermoplastic material, is the most common 3D printing process in use as of 2020.

There are three broad types of 3D printing technology; sintering, melting, and stereolithography. Sintering is a technology where the material is heated, but not to the point of melting, to create high resolution items. Metal powder is used for direct metal laser sintering while thermoplastic powders are used for selective laser sintering.

Melting methods of 3D printing include powder bed fusion, electron beam melting and direct energy deposition, these use lasers, electric arcs or electron beams to print objects by melting the materials together at high temperatures.

Stereolithography utilises photopolymerization to create parts. This technology uses the correct light source to interact with the material in a selective manner to cure and solidify a cross section of the object in thin layers.

All forms of 3D printing fall into one of the following types:

- Binder Jetting
- Direct Energy Deposition
- Material Extrusion
- Material Jetting
- Powder Bed Fusion

- Sheet Lamination
- VAT Polymerization

Binder Jetting:

Binder jetting deposits a thin layer of powered material, for example metal, polymer sand or ceramic, onto the build platform, after which drops of adhesive are deposited by a print head to bind the particles together. This builds the part layer by layer and once this is complete post processing may be necessary to finish the build. As examples of post processing, metal parts may be thermally sintered or infiltrated with a low melting point metal such as bronze, while full-colour polymer or ceramic parts may be saturated with cyanoacrylate adhesive.

Binder jetting can be used for a variety of applications including 3D metal printing, full colour prototypes and large-scale ceramic moulds.

Direct energy depositioning uses focussed thermal energy such as an electric arc, laser or electron beam to fuse wire or powder feedstock as it is deposited. The process is traversed horizontally to build a layer, and layers are stacked vertically to create a part.

This process can be used with a variety of materials, including metals, ceramics and polymers.

Material Extrusion

Material extrusion or fused deposition modelling (FDM) uses a spool of filament which is fed to an extrusion head with a heated nozzle. The extrusion head heats, softens and lays down the heated material at set locations, where it cools to create a layer of material, the build platform then moves down ready for the next layer.

This process is cost-effective and has short lead times but also has a low dimensional accuracy and often requires post processing to create a smooth finish. This process also tends to create anisotropic parts, meaning that they are weaker in one direction and therefore unsuitable for critical applications.

Material Jetting

Material jetting works in a similar manner to inkjet printing except, rather than laying down ink on a page, this process deposits layers of liquid material from one or more print heads. The layers are then cured before the process begins again for the next layer. Material jetting requires the use of support structures but these can be made from a water-soluble material that can be washed away once the build is complete.

A precise process, material jetting is one of the most expensive 3D printing methods, and the parts tend to be brittle and will degrade over time. However, this process allows for the creation of full-colour parts in a variety of materials.

Powder Bed Fusion

Powder bed fusion (PBF) is a process in which thermal energy (such as a laser or electron beam) selectively fuses areas of a powder bed to form layer, and layers are built upon each other to create a part. One thing to note is that PBF covers both sintering and melting processes. The basic method of operation of all powder bed systems is the same: a recoating blade or roller deposits a thin layer of the powder onto the build platform, the powder bed surface is then scanned with a heat source which selectively heats the particles to bind them together. Once a layer or cross-section has been scanned by the heat source, the platform moves down to allow the process to begin again on the next layer. The final result is a volume containing one or more fused parts surrounded by unaffected powder. When the build is complete, the bed is fully raised to allow the parts to be removed from the unaffected powder and any required post processing to begin.

Selective laser sintering (SLS) is often used for manufacture of polymer parts and is good for prototypes or functional parts due to the properties produced, while the lack of support structures (the powder bed acts as a support) allows for the creation of pieces with complex geometries. The parts produced may have a grainy surface and inner porosity, meaning there is often a need for post processing.

Direct metal laser sintering (DMLS), selective laser melting (SLM) and electron beam powder bed fusion (EBPBF) are similar to SLS, except these processes create parts from metal, using a laser to bond powder particles together layer-by-layer. While SLM fully melts the metal particles, DMLS only heats them to the point of fusion whereby they join on a molecular level. Both SLM and DMLS require support structures due to the high heat inputs required by the process. These support structures are then removed in post processing ether manually or via CNC machining. Finally, the parts may be thermally treated to remove residual stresses.

Both DMLS and SLM produce parts with excellent physical properties - often stronger than the conventional metal itself, and good surface finishes. They can be used with metal superalloys and sometimes ceramics which are difficult to process by other means. However, these processes can be expensive and the size of the produced parts is limited by the volume of the 3D printing system used.

Sheet Lamination

Sheet lamination can be split into two different technologies, laminated object manufacturing (LOM) and ultrasonic additive manufacturing (UAM). LOM uses alternate layers of material and adhesive to create items with visual and aesthetic appeal, while UAM joins thin sheets of metal via ultrasonic welding. UAM is a low temperature, low energy process that can be used with aluminium, stainless steel and titanium.

VAT Photopolymerization

VAT photopolymerization can be broken down into two techniques; stereolithography (SLA) and digital light processing (DLP). These processes both create parts layer-by-layer through the use of a light to selectively cure liquid resin in a vat. SLA uses a single point laser or UV source for the curing process, while DLP flashes a single image of each full layer onto the surface of the vat. Parts need to be cleaned of excess resin after printing and then exposed to a light source to improve the strength of the pieces. Any support structures will also need to be removed and additional post-processing can be used to create a higher quality finish.

Ideal for parts with a high level of dimensional accuracy, these processes can create intricate details with a smooth finish, making them perfect for prototype production. However, as the parts are more brittle than fused deposition modelling (FDM) they are less suited to functional prototypes. Also, these parts are not suitable for outdoor use as the colour and mechanical properties may degrade when exposed to UV light from the sun. The required support structures can also leave blemishes that need post processing to remove.

~L.Uday Kiran(21761A04G0)

5. Visible Light Communication

Visible light communication is a form of wireless technology that uses radiation in the visible to infrared light spectrum to transmit data. It is seen as an increasingly robust and reliable way of doing so, and needs not much more than conventional, low-power LEDs to work. Its market is now thought to be capable of being worth US$101.3 billion by the end of 2024.

Visible light communication shown in Fig.5.1. , is a form of data-transfer using radiation in the visible to infra-red range. It is viewed as a viable alternative to fiber-optics and other similar forms of connectivity-conferring hardware, particularly in situations for which this equipment is not suitable. Visible light communication is also regarded as capable of good speeds, and is also bidirectional.

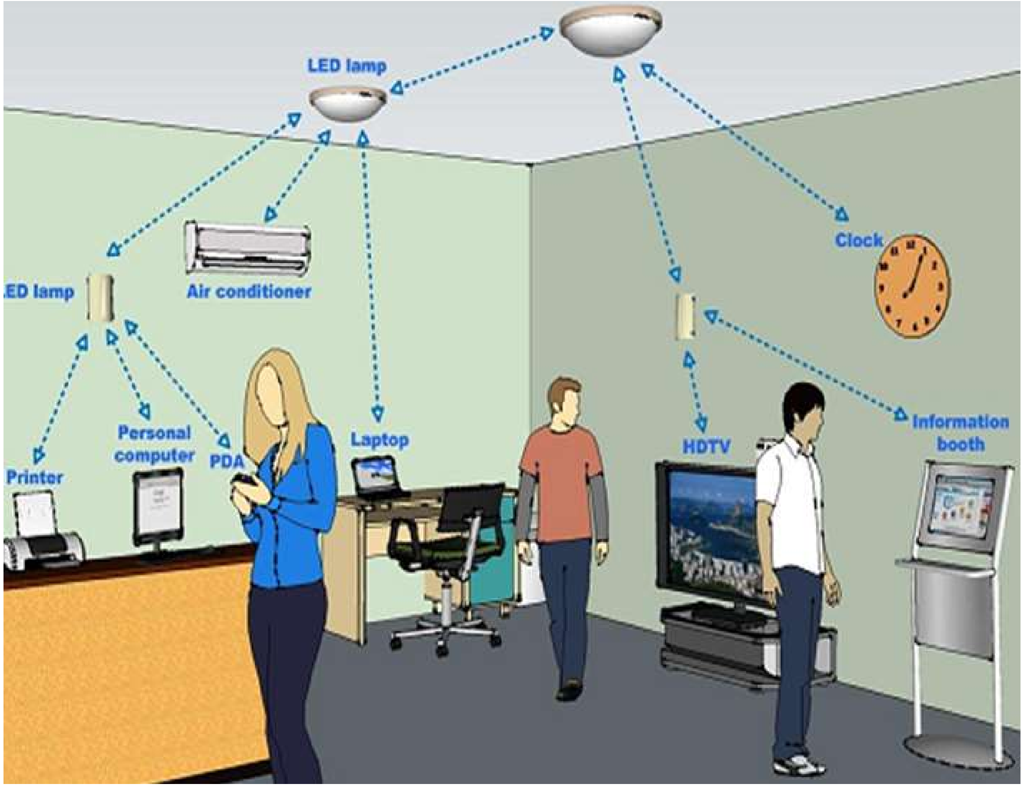

Fig.5.1. Visible light Communication Scenario

This form of communication has various sub-categories, the most prominent of which may be light-fidelity (Li-Fi). This variation on the technology may allow data to reach devices through typical household or commercial light fittings - particularly as it is possible to do so using simple, economical LEDs. However, this technology can also work using alternative components such as photodetectors or microcontrollers.

Accordingly, the latest market research suggests potential for Li-Fi in areas such as internet-of-things (IoT) and 5G. Furthermore, it is also currently applied to purposes and industries such as smart cities, connected cars, underwater communications, healthcare, security, aviation, aerospace, logistics, mobile devices and retail. Visible light communication (VLC) shown in Fig. 5.2, is the use of visible light as a method of wirelessly transmitting data. VLC is an affordable method of transmitting data at light speed. The light used in VLC is between 780-375 nanometers. The majority of modern VLC implementations are digital, but early uses included pre-radio transmission of sound by modulated sunlight in the photophone invented by Alexander Graham Bell in the 1880s.

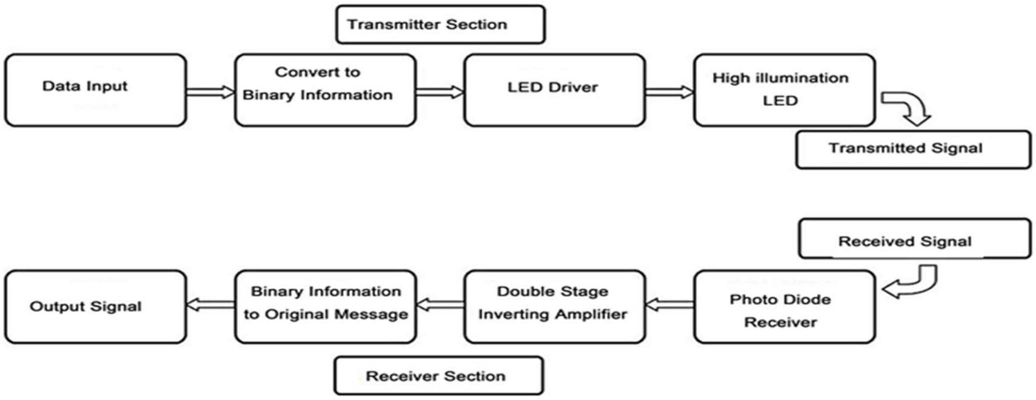

Fig.5.2.VLC System Block diagram

Although radio frequency is more commonly used for communications, VLC has a number of advantages over the invisible frequencies of radio. VLC offers very low latency and high bandwidth, while radio has both a more limited spectrum and more potential for cross talk and interference than VLC. The limitation of line of sight can also be a security feature, unless a hacker has line of sight to a network device on a private network. If so, it can still be susceptible to an air gap attack from the outside world. Li-Fi is an implementation of wireless networking that uses VLC.

Although VLC technologies have been historically uncommon, the draw of light-based communication is strengthening as the proliferation of wireless devices increases and radio's limited spectrum becomes more crowded. The increased draw toward VLC technologies grows because networks, which affect each other in different radio frequencies, cause no interference to VLC. In IoT, VLC tech is being used as a communication method to connect millions of consumer electronics and machine-to-machine (M2M) devices cost-effectively .

Modulation Techniques:

In order to send data, a modulation of light is required. A modulation is the form in which the light signal varies in order to represent different symbols. In order for the data to be decoded. Unlike radio transmission, a VLC modulation requires the light signal to be modulated around a positive dc value, responsible for the lighting aspect of the lamp. The modulation will thus be an alternating signal around the positive dc level, with a high-enough frequency to be imperceptible to the human eye.

Due to this superposition of signals, implementation of VLC transmitter usually requires a high-efficiency, higher-power, slower response DC converter responsible for the LED bias that will provide lighting, alongside a lower-efficiency, lower-power, but higher response velocity amplifier in order to synthetize the required ac current modulation.There are several modulation techniques available, forming three main groups: Single-Carrier Modulated Transmission (SCMT), Multi-Carrier Modulated Transmission (MCMT) and Pulse-Based Transmission (PBT).

Single-Carrier Modulated Transmission

The Single-Carrier Modulated Transmission comprises modulation techniques established for traditional forms of transmission, such as radio. A sinusoidal wave is added to the lighting dc level, allowing digital information to be coded in the characteristics of the wave. By keying between two or several different values of a given characteristic, symbols attributed to each value are transmitted on the light link.

Possible techniques are Amplitude Switch Keying (ASK), Phase Switch Keying (PSK) and Frequency Switch Keying (FSK). Out of these three, FSK is capable of larger bitrate transmission once it allows more symbols to be easily differentiated on frequency switching. An additional technique called Quadrature Amplitude Modulation (QAM) has also been proposed, where both amplitude and phase of the sinusoidal voltage are keyed simultaneously in order to increase the possible number of symbols.

Multi-Carrier Modulated Transmission

Multi-Carrier Modulated Transmission works on the same way of Single-Carrier Modulated Transmission methods, but embed two or more sinusoidal waves modulated for data transmission. This type of modulation is among the hardest and more complex to synthetize and decode. However, it presents the advantage of excelling in multipath transmission, where the receptor is not in direct view of the transmitter and therefore makes the transmission depend on reflection of the light in other barriers.

Pulse-Based Transmission

Pulse-Based transmission encompasses modulation techniques in which the data is encoded not on a sinusoidal wave, but on a pulsed wave. Unlike sinusoidal alternating signals, in which the periodic average will always be null, pulsed waves based on high-low states will present inherit average values. This brings two main advantages for the Pulse-Based Transmission modulations:

- It can be implemented with a single high-power, high-efficiency, dc converter of slow response and an additional power switch operating in fast speeds to deliver current to the LED at determined instants.
- Once the average value depends on the pulse width of the data signal, the same switch that operates the data transmission can provide dimming control, greatly simplifying the dc converter.

Due to these important implementation advantages, these dimming-capable modulations have been standardized in IEEE 802.15.7, in which are described three modulation techniques: On-Off Keying (OOK), Variable Pulse Position Modulation (VPPM) and Colour Shift Keying (CSK).

On-Off Keying

On the On-Off Keying technique, the LED is switched on and off repeatedly, and the symbols are differentiated by the pulse width, with a wider pulse representing the logical high '1', while narrower pulses representing logical low '0'. Because the data is encoded on the pulse width, the information sent will affect the dimming level if not corrected: for instance, a bitstream with several high values '1' will appear brighter than a bitstream with several low values '0'. In order to fix this problem, the modulation requires a compensation pulse that will be inserted on the data period whenever necessary to equalize the brightness overall. The lack of this compensation symbol could introduce perceived flickering, which is undesirable.

Because of the additional compensation pulse, modulating this wave is slightly more complex than modulating the VPPM. However, the information encoded on the pulse width is easy to differentiate and decode, so the complexity of the transmitter is balanced by the simplicity of the receiver.

Variable Pulse Position Modulation

Variable Pulse Position also switches the LED on and off repeatedly, but encode the symbols on the pulse position inside the data period. Whenever the pulse is located at the immediate beginning of the data period, the transmitted symbol is standardized as logical low '0', with logical high '1' being composed of pulses that end with the data period. Because the information is encoded at the location of the pulse inside the data period, both pulses can and will have the same width, and thus, no compensation symbol is required. Dimming is performed by the transmitting algorithm, that will select the width of the data pulses accordingly.

The lack of a compensation pulse makes VPPM marginally simpler to encode when compared to OOK. However, a slightly more complex demodulation compensates for that simplicity on the VPPM technique. This decoding complexity mostly comes from the information being encoded at different rising edges for each symbol, which makes the sampling harder in a microcontroller. Additionally, in order to decode the location of a pulse within the data period, the receptor must be somehow synchronized with the transmitter, knowing exactly when a data period starts and how long it lasts. These characteristics makes the demodulation of a VPPM signal slightly more difficult to implement.

Colour Shift Keying

Colour shift keying (CSK), outlined in IEEE 802.15.7, is an intensity modulation based modulation scheme for VLC. CSK is intensity-based, as the modulated signal takes on an instantaneous colour equal to the physical sum of three (red/green/blue) LED instantaneous intensities. This modulated signal jumps instantaneously, from symbol to symbol, across different visible colours; hence, CSK can be construed as a form of frequency shifting. However, this instantaneous variation in the transmitted colour is not to be humanly perceptible, because of the limited temporal sensitivity in the human vision — the "critical flicker fusion threshold" (CFF) and the "critical colour fusion threshold" (CCF), both of which cannot resolve temporal changes shorter than 0.01 second. The LEDs’ transmissions are, therefore, preset to time-average (over the CFF and the CCF) to a specific time-constant colour. Humans can thus perceive only this preset colour that seems constant over time, but cannot perceive the instantaneous colour that varies rapidly in time. In other words, CSK transmission maintains a constant time-averaged luminous flux, even as its symbol sequence varies rapidly in chromaticity.

~G.Manaswitha (21761A04E6)

Editorial

As dawn after sunset, in life also happiness will be waiting for each but time has to come. Within this brief pause, one need to face the circumstances with lot of courage and confidence. Best wishes to one more batch going out with more aspirations and ambitions. Whenever days are going odd , face them , take each situation as a challenge and transform yourself as a like a caterpillar into a beautiful butterfly

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