IEI Centenary Publication

Prof S K Mitra Memorial Lecture

A Compilation of Memorial Lectures
presented in

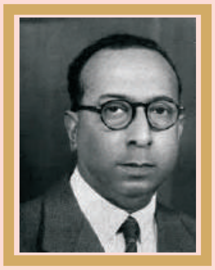
National Conventions of Electronics & Telecommunication Engineers

35th Indian Engineering Congress

December 18-20, 2020

The Institution of Engineers (India)

8 Gokhale Road Kolkata 700020



Background of

Prof S K Mitra Memorial Lecture

A renowned scientist, an excellent lecturer and a reputed author, Prof Sisir Kumar Mitra is a pioneer in the field of radio-physics and ionosphere research in the country.

Born in Calcutta on October 24, 1890, Sisir Kumar Mitra had his initial insights into the field of scientific research and development during his stint in Presidency College, Calcutta where he came in close contact with Sir J C Bose and Acharya P C Roy. Sir J C Bose's equipment for the generation and detection of Herizian waves had left in him an indelible interest in radio physics — a faculty he cultivated later in life.

In 1916, the University College of Science was founded and Mitra joined the Department of Physics. He began researches on the diffraction and interference of light and in 1919 obtained the D.Sc. Degree from the University of Calcutta.

In 1920, he joined the University of Sorbonne where he worked for the determination of wavelength standards of the copper spectrum and received the Doctorate Degree in 1923. Later, he joined the Institute of Radium to work under Madame Curie and subsequently joined the University of Nancy. On his return to India, he was appointed Khaira Professor of Physics in the University College of Science, Calcutta.

While developing teaching and research facilities in the University, he also took active interest in the development of broadcasting in India. His proposal for the establishment of a Radio Research Board was accepted by the newly formed Council of Scientific and Industrial Research, and he was appointed as its first Chairman and continued in this position until 1948.

Prof Mitra's greatest contribution to scientific knowledge was in the field of ionosphere. His ideas and guidance was at the root of most of the contributions made by the Ionosphere Laboratory of Calcutta. His findings on upper atmosphere ionization and night sky luminescence was presented in a treatise 'Active Nitrogen – a New Theory' in 1945.

After his retirement from University service in November 1955, he was appointed Professor Emeritus of the University of Calcutta. Subsequently he assumed the Administratorship of the Board of Secondary Education of the State of West Bengal and was instrumental in the introduction of Higher Secondary Syllabus in the State.

In 1958, he was elected as a Fellow of the Royal Society, London for his contribution to the study of upper atmospheric phenomena. He was the recipient of the King George V Silver Jubilee Medal in 1935, Joy Kissen Mukherjee Gold Medal of the Indian Association for the Cultivation of Science in 1943, Science Congress (Calcutta) Medal of the Asiatic Society in 1956 and Sir Devaprasad Sarabadhikary Gold Medal of Calcutta University in 1961.

He held many responsible positions including: President, Asiatic Society of Bengal (1951-52); General President, Indian Science Congress (1955) and President, National Institute of Sciences of India (1956-58). He was a member of the Indian National Committee for the International Geophysical Year and was in the Editorial Board of a number of Indian and foreign scientific journals.

Prof Mitra received Padmabhushan in 1962 and in the same year was appointed National Research Professor in Physics by the Government of India.

In memory of his dedicated service, The Institution of Engineers (India) instituted an Annual Memorial Lecture in his name during the National Convention of Electronics and Telecommunication Engineers.

Prof S K Mitra Memorial Lecture

presented during **National Conventions** of **Electronics & Telecommunication Engineers**

Mobile ad-hoc Network (MANET) : A New Communication Paradigm

Prof P K Banerjee

Dept. of Electronics & Tele-communication Engineering, Jadavpur University, Kolkata

Synopsis

During last few decades there are revolutionary changes in the computer and communication world due to the spectacular development in the computing devices (laptop, hand held digital devices, personal digital assistances: PDA), wearable computers etc.) and wonder in communication techniques (digital wireless, satellite, fiber optic communication system etc). In early years of its existence, computer system were highly centralised, functioning within a single large room (Fig. I) known as computer center. The convergence of computer and communication technique has profound influence on the way the computer systems are now organised. Concept of single computer serving the computational requirement of large number of users has been replaced by large number of autonomous and interconnected computers placed in different users locations. These computers are used on one to one basis for the users and are well known personal computers (PC).

In the ever changing scenario, the concept of personal computing is changing to ubiquitous computing system in which the individual users may access several electronic platform/workstation for all the required information whenever and wherever they may be. The nature of devices used and to avail whenever and wherever connectivities, wireless networks are the easiest solution for their interconnections and led tremendous growth in the use of wireless technologies for local area network (LAN), wide area network (WAN). WLAN require large power and has wide coverage, beyond the necessity of may personal electronic gadgets and computing devices. A new class of network has emerge which allows the proximal devices to share dynamically their mutual facilities with minimum power requirement are known as personal area network (PAN).

In some particular situations (assembly line work, search and rescue operations, war fields etc) carry and holding a computer is not possible and as such LAN and p AN do not satisfy the requirement of ubiquitous computing. A wearable computer (Smart Shirt) solves this problem by distributing the computer components (hand mounted input/out devices, processors chip, control unit and storage device etc) on the body. Users may access and process the informations, control the devices, while they are on move and hands remain free for other works. A new class of network within the working range of human body thus emerged and known as body area network (BAN) provides the best solution for networking of wearable devices with wireless connectivity as the natural choice.

The motive behind ubiquitous computing revolution is to avail the ability of the technology to adapt itself to the user without changing their behaviour and knowledge. This new trend is to help the users in every day life by taking advantages of technologies and infrastructures surrounding himself and don't need any major change in its behaviour. The new philosophy of integrating digital devices and network into everyday environment known as ambient intelligence, places the users at the centre of information society. This will render accessibility through easy and natural interaction, a multitude of services and applications. Specifically with the advances of wireless and mobile communication technology, ambient intelligence philosophy at the background led to a new communication paradigm: Self organizing information and communication system. In this new networking paradigm the users mobile devices are networked and cooperatively provide functionality that is usually provided by the network infrastructure (i.e., router, switches and servers). Such systems are infrastructure less wireless networks and referred as mobile adhoc network (MANETs).

Wireless mobile Ad-hoc network consists of mobile nodes interconnected by multi-hop communication paths, are dynamically and arbitrarily located in such a manner that the interconnection between the nodes are capable of changing on a continual basis. Ad-hoc network have no permanent infrastructure or administrative support. Topology of such network changes dynamically as mobile nodes join and depart the network and, the ratio links between the nodes become unusable. Ad-hoc wireless networks are self-creating, self -organizing and self - administering. They come into being solely by interaction among their constituent wireless mobile nodes and it is the only such interaction that are used to provide necessary control and administrative support of such network.

In this presentation, firstly it is tried to explain the basic principle of Ad-hoc networking. As this type of networks are self creating, self-organizing and self administrative nature, the number of nodes are not fixed but dynamically changing, inclusion and deletion of nodes are random, the topology of network connection will be ever changing. The topology of the network routing technique must be adoptive in nature as the number of nodes and their distance of separation may change continuously. The topology of routing technique which leads to complicated protocol to used. A review routing protocol and topology of the network in presently in used is discussed.

In communication system reliability security and safety of networking is the prime concern. In this presentation it is tried to explained the above three aspect and its intricacy in implementation in this type of networking.

A brief introduction to the new but rapidly growing area of research on guaranteeing QoS in ad hoc mobile wireless network will be presented. The issues are challenging, many of the underlying algorithmic problems are currently perceived as generally intractable (NP-complete), and opportunities exist for creating more effective heuristics. The issues are complicated by the lack of sufficiently accurate knowledge, both instantaneous and predictive, of the states of the network, e.g., the quality of the radio links and availability of routes and their resources. Successful QoS routing includes the necessary knowledge of the network state and algorithms for feasible route selection and resource reservation. Location-based routing, including predictive QoS routing, is now an active area of research.

Performance and scalability studies of ad hoc networks with QoS constraints remain an open are of research, although important results are now appearing in this area for general routing issues associated with such networks. The indispensable issues of performance and scalability remain open for all secure routing protocols. Comprehensive performance studies are a prerequisite to making secure QoS useful for mobile ad hoc networks. Since none exist at al, the goals for simultaneously meeting security and QoS objectives for mobile ad hoc networks offer exceptionally challenging research opportunities.

References:

1. M. Conti and S. Giordano, Special Issue on Mobile Ad-hoc Networking, Chister Computing Journal, April 2002.

2. R. Bruns, M. Conti and E. Gregori, WLAN Technology for Mobile Ad-hoc Networks, Proc. HISC-34, Mani, January 2001.

3. C.E.Perkins, et al, Performance Comparison of Two on Demand Routing Protocols for Ad-boc Networks, IEE Communication Magazine, February 2001.

Next Generation Communication: Materials, Devices and Systems

Dr P K Basu

Institute of Radio Physics and Electronics, University of Calcutta
92 Acharya Prafulla Chandra Road, Kolkata 700 009
Email: pkbasu.rpe@ieee.org

Sisir Kumar Mitra was born in Calcutta on October 24, 1989 to Jaykrishna and Saratkumari. After studying in Bhagalpur District School, Sisir studied B.Sc in Presidency College as well as M.Sc there in which he stood first. He worked for some time under Acharya J. C. Bose, but joined as a teacher in lNJ College, Bhagalpur and then Bankura Christian College. When Sir Asutosh founded Science College, he inducted Raman, Mitra, S. N. Bose and Saha as teachers. After working under Raman, Sisir went to France to work under Fabry and then Marie Curie. But his interest in radio valves and applications brought him to University of Nancy under Gutton. Since then wireless became his passion.

With encouragement from Sir Asutosh, Mitra as Khaira Professor started work on wireless. In Calcutta University he studied E and F layers, discovered D layer, made outstanding work on active nitrogen glow and the like. He founded IRPE, the first University Department to impart teaching and research in all branches of Radio Science. This dept was given the status of CAS in 1962. Mitra wrote the bible Upper Atmosphere, served as President of BSE, of National academy of Science. He was conferred FRS, Padmabhushan, National Professor. He breathed his last on August 13, 1963.

Mitra has been the pioneer of radio research in India and therefore radio communication was his field of study. He also encouraged development of all branches in Radio Science. He brought Biswa Ranjan Nag in RPE, where he did pioneering research in semiconductors, microwaves, ionosphere, nanostructures.

The present speaker started his research career under Prof. Nag on semiconductors and later did some work on optical communication, a special branch of communication. In delivering this S K Mitra Memorial lecture he has chosen the title that matches his limited knowledge about next generation communication. The following paragraphs give a brief outline of the talk.

The modern age is truly information age. The coveted environment for information society is "any body any time anywhere". Though this demand is not totally met, the remarkable progress made so far is due to all out development in areas of electron devices, computers and communication. The developments in the latter two areas needed cheap devices and systems needing tiny space and consuming very little power. The Integrated Circuits made that feasible.

Miniaturization in electron devices started with announcement of transistors 10 1947: a discovery earning Nobel Prize. The miniaturization took the shape in the form of ICs: another Nobel Prize winning work. Since its first form in 1959 the number of transistors in a chip has doubled every 18 months (Moore's law) and the number in today's Pentium processors is more than a billion with very little cost. The transistors shrink in dimensions day by day. However, there is now doubt if this trend will continue. The power dissipation, reduction in speed due to interconnects and other limitations call for alternate route. The solution might be found in nanoelectronics: a branch of nanotechnology first introduced by Feynmann in 1959. The Quantum Nanostructures like Quantum Wells, Wires, Dots and Carbon Nanotube Transistors are thought to be practical replacement of VLSI Circuits. Recently the Graphene has attracted attention due to their remarkable electronic properties. The importance is recognized by this year's Nobel Prize.

Remarkable progress has been made in communication: in areas like mobile, satellite, millimeter wave and fibre optic communication. The impact of optical fibre communication in society has been recognized with the award of Nobel Prize to Prof. Charles Kao last year. The optical fibre network has spread out throughout the world, particularly the undersea cable networks give wide range connectivity throughout the globe. With introduction of All wave fibre the total bandwidth of optical fibre today is ~ 50 THz. This enormous bandwidth is still untapped, though Wavelength Division multiplexing using hundreds of wavelengths each modulated at 40 Gb/s covers a bandwidth of ~ 4-5 THz. The remarkable progress in optical communication led to development of optoelectronic devices like lasers, modulators, photodetectors using III-V compounds and passive waveguide devices grown on Silicon platform. The usual structures are heterostructures involving two or more dissimilar semiconductors. Kroemer and Alferov were given Nobel Prize for their seminal work on heterostructures. Recently Quantum Nanostructures are employed for improved performance.

The progress in long haul optical fibre communication link has been enhanced with the advent of Er Doped Fibre Amplifiers. Currently and in future Distributed Raman Amplifiers will work with EDFAs. Semiconductor Optical Amplifiers show promise as wavelength converters, and are employed to produce digital optical logic. These devices will find their place in next generation optical networks. Advanced modulation formats and coherent detection systems are being studied. Active research is being done on "Holey Fibre" and Photonic Band Gap Structures". In microwave research, "Metamaterials" form an intensively pursued field.

The connectivity from local exchange to individual home by fibre optic cable is still unattained. Work is in progress in the area of Fibre-To-The-Home (FTTH) and currently Fibre- To-The-Curb (FTTC). Radio Over Fibre (ROF) technique is actively pursued to increase the functionality of mobile networks.

Communication using THz frequencies is still an unexplored area. The race is on and the winner will enjoy the monopoly in the business. There are many applications using THz communication: atmospherics, pollution monitoring, space technology, security in airports, etc. Suitable active and passive components like lasers, detectors, antenna, and guiding devices are being developed. The emphasis is now on development of portable equipment using semiconductors to replace vacuum electronic devices.

The talk will briefly mention the progress in magnetoelectronics and spintronics and the possible applications in computers.

Nanocomposites — Applications in Electronics

Prof K Lal Kishore

Vice Chancellor, JNTU-A, Anantapur

ABSTRACT

Considerable research work is going on to develop composite materials for various industrial applications. The aim is to develop composite materials which either can give newer properties or give rise to properties which enable the materials to be used with unique properties. Composite materials are playing an important role in the development of various components and devices for the electronic applications. This paper summarizes the concepts of composites, types of composites and the methods for developing the devices based on functional requirements, nanocomposites and their applications in the electronic industry.

Key words: Composite, additive, product, nano-composite, PVCR, NVCR, varistors.

1. Introduction:

Composite technology in general sets out, to combine materials in such a way that the properties of the composites are the optimum for a particular application. The property, whether mechanical, thermal, electrical etc., is determined by the choice of the components and their relative amounts and, most importantly, the' connectivity', that is the manner in which the components are interconnected. Composite materials have been in existence for a long time, in the broad sense, glass, cement concrete etc. But, the idea of designing a composite for a specific purpose is completely of recent origin. In the past, engineer was forced to choose materials which were available. But in future, it appears that it might be possible to synthesize a composite for the required material properties. Composites are considered as the oldest and newest of materials. Though it is a paradox, it is true. In primitive times, people discovered empirically that, in some cases, when two or more different materials are used together, as one, the combination does a better job than either of the materials alone. Clay bricks were strengthened by embedding glass fibers. Mongol bow was constructed of bull tendons, wood, silk and bonded together with animal glue, to give just the right combination of strength and elasticity. This is an example of a composite. But only since 1965, technology of composite materials began to emerge.

Main idea behind developing composite material is to have some specific physical characteristics such as high strength, stiffness, and thermal resistance than one individual material. Composites are combination of metals, ceramics, plastics and other materials. Concrete, plywood, and fiber glass are examples of composite materials. Fiber glass is made by dispersing glass fibers in a polymer matrix. The glass fibers make the polymers stiffer with out increasing its density. With composites we can produce lightweight, strong, ductile, high temperature resistant materials or we can produce hard, shock resistance cutting tools that would otherwise shatter. Today, space sciences rely heavily on composites for aircrafts and space shuttles. A large number of composites such as electronic materials, magnetic materials, photonic or optical materials, and smart materials are being used in electronics engineering. A smart material can sense and respond to an external stimulus such as a change in temperature, the application of stress, or a change in humidity or chemical environment. A typical example of a smart material is lead zirconate titanate (PZT) . When properly processed, PZT can be subjected to a stress and voltage is generated. This effect can be used to make such devices as spark generators for gas grills and sensors that can detect underwater objects such as fish and submarines. The aim is to develop composite materials which either can give newer properties or give rise to properties which enable the materials to be used beyond the normal range of operation. Composite materials are playing an important role in the development of various components and devices for the electronic applications.

2. Composites:

A composite material consists of two or more different constituents known as phases. The dominant or containing phase is called matrix. The phases can take different forms like particles, fibres, sheets etc. Accordingly, the composite materials are classified as [1]

a) Fibrous composites : consisting of fibers in a matrix

b) Laminated composites : consisting of layers of various materials

c) Particulate composites : consisting of particles in a matrix

3. Classification of Composite materials:

Depending on the way by which the resultant property of a composite is derived, they are classified as [2] :

i) Additive Composites
ii) Product composites

Additive composites exhibit a property which lies in between the properties of the constituent phases. For example, a composite consisting of a conductor and an insulator will have conductivity lying in between the two extreme values.

In product composites, the stimulus acting on the composite material affects anyone of the phases and the reaction of this phase becomes the stimulus for the second phase and the outcome of this reaction, is the property of the composite material. In such a composite material it may so happen that, neither of the individual phases posses the

property that the composite exhibits. The same may be expressed schematically as shown in Fig.1.

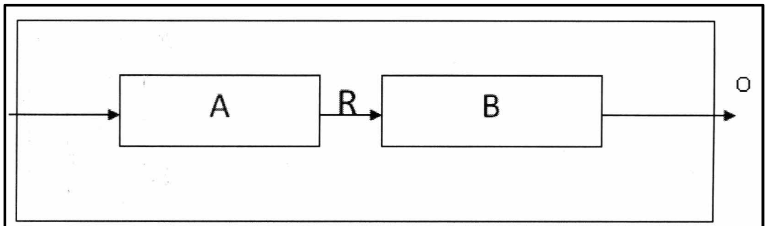


Fig. 1: Principle of operation of Product Composite.

A and B are the two phases of the composite. The stimulus S acts on phase A and produces reaction R. R acts on phase B and produces output O. Neither A, nor B produce the output O, when they are acted upon by stimulus S. As an example, composite of a piezoelectric material and an electroluminescent material will have the property of piezoluminescence.

The Properties of the composites are not only affected by composition, shape, size etc of the particles, but also by connectivity patterns, i.e. the way in which different phases are connected with each other. For a simple two phase system connectivity, there can be a series connection and a parallel connection of individual phases. Composites consist of two or more materials. If a composite is made of two materials, it is called as 'two phase composite'. Meredith and Tobias [3] have reviewed the theoretical investigations on the conductivity of two phase systems, carried out by some investigators.

Van Suchttelen[2] has described how a new class of physical properties of composites can be realized through product properties, wherein, an effect in one of the phases leads to a second effect in another phase. Giving an example, he has stated that, with one phase as magnestostrictive material and another, as piezoelectric, magneto electric effect can be realized. Various possible interactions between different phases in a composite are given in Table I, below:

Table 3.1: Matrix of Properties in Composites

X-Y-Z	Property of Phase I X-Y	Property of Phase II Y-Z	Result X-Z
1 2 3	Piezomagnestism	Magnetoresistance	Piezoresistance
2 1 3	Magnetostriction	Piezoresistance	Magnetoresistance
2 1 3	Magnetostriciton	Piezoelectricity	Magnetoelectric effect
3 1 2	Electrostriction	Piezomagnetism	Electromagnetic effect
4 2 1	Photomagnetic effect	Magnetostriction	Photostriciton
4 3 4	Photoconductivity	Electrostriction	Photostriction

1 - mechanical parameter

2 - magnetic parameter

3 - electrical parameter

4 - optical and particle radiation

1 2 3 - that interaction of phases 1 2 and 2 3 will give a result of 13

4. Historical view on Composites in Electronic industry:

Van Den Boomgaard et al.[4] have described the quinary Fe-Co-Ti-Ba-O system which contains a piezomagnetic phase and a piezoelectric phase. The resulting composite is a magnetoelectric material, which can convert magnetic fields into electric fields and vice versa.

Hale [5] in an extensive review has shown how the theoretical and experimental information that is already available may be used to design and construct composite materials with predetermined physical properties.

Newnharn, Cross et al.[6] have identified ten important connectivity patterns in diphase solids, ranging from a 0- 0 unconnected check board pattern to a 3-3 pattern in which both phases are three dimensionally self connected. Processing methods for manufacturing some of these patterns are described. They predicted some interesting results, such as a diphasic pyroelectric, in which neither phase is pyroelectric.

Rajagopal and Satyam[7] have studied variation of electrical resistivity of wax (insulator)-graphite (conductor) composites, with temperature, grain size and volume fraction (V_f). To explain the observations, they have proposed a model consisting of elemental cells with small granules of the insulating phase covered with the particles of the conducting phase. For analytical purposes, they have assumed that, the insulating particles are cubes, and the conducting particles are distorted spheres. They explained that the resistivity of the material is controlled by the contact resistance between the conducting particles and the number of contacts each particle has with its neighbours.

In another article[8], they have explained the variation of specific capacitance of the above composite samples with the same parameters viz. V_f etc, using the same model. Variation of specific capacitance with temperature is attributed to the change in contact area.

The variation of resistivity with volume percent of iron powder-polymer composite has been studied by Aharoni[9]. He proposed a model based on chains of contacts. It predicts the conductivity to be directly dependent on the surface area of the conducting particles and also shows a 2/3 power dependence on their volume.

Skinner et al[10] proposed the concept of connectivity to be applied in the evaluation of type of structure needed to optimize the properties of the composite. They considered simple one dimensional solutions (neglecting transfers coupling) for a two phase composite with two possible cases of series connection and parallel connection. They have made flexible Lead zirconate titanate (PZT) - Polymer Composite transducers with a novel microstructure configuration, and employed replamine form process for producing 3-3 connectivity. The d_{33} value of the 3-3 composite was reasonably good, typical value being 100×10^{-12} CIN. The hydrostatic voltage sensitivity of the composite was large, about 200 times the sensitivity of an equal sized, homogeneous PZT.

Furukawa et al[11] have studied the piezoelectric properties of PZT-PVDF (Polyvinylidene Fluoride), PZT-PE (Polyethylene), PZT-PVA (Polyvinyl Alcohol), systems. The piezoelectric activity in all the composites was attributed, mainly to PZT. The contribution of PVDF was minimal compared to PZT. The observed values of dielectric constant and 'd' constants were higher than predicted in the case of PZT-PVDF composites. For the PZT-PE system, the temperature dependence of the piezoelectric constants was ascribed to the elastic relaxation in PE. The retardation and relaxation frequency dependence of the 'd' constant observed in PZT-PVA systems between 80-130°C were accounted for, in terms of the interfacial and electrode polarizations due to the d.c. conduction in PYA phase.

Newnharn et al.[12] have made ceramic-plastic composites with 3-3 phase connectivity, by the duplication of natural template structure such as coral. Such composites had piezoelectric g_{33} and g_h coefficients more than an order of magnitude higher than the homogeneously poled ferroelectric ceramic. Large voltage coefficients were also obtained from 3-1 piezoelectric composites made by embedding PZT fiber arrays in epoxy cement.

Safari et al.[13] have made piezoelectric composites from PZT spheres and several polymers with 1-3 connectivity and have summarized the advantages of PZT sphere-polymer composites.

Bhalla et al.[14] have investigated composites of SBSI and spur epoxy in 1:3 and 3:3 connectivity patterns. They found that hydrostatic voltage coefficient g_h and hydrophone sensitivity $d_h.g_h$, to be substantially higher than those of SBSI single crystals.

Safari et al.[15] have studied composites of PZT and polymer, with 3-1 and 3-2 connectivity patterns. They have been fabricated by drilling holes in the sintered PZT blocks and filling the holes with epoxy. By decoupling the d_{33} and d_{31} coefficients in the composite, they could greatly enhance the hydrostatic coefficient.

Rittenmyer, Schrout et al.[16] have made PZT-polymer composites by mixing tiny plastic spheres with PZT powder in an organic binder and firing the mixture to give a ceramic skeleton. After cooling, the ceramic was back fired with polymer and poled. They found that composite containing 50% PZT and 50% silicone rubber to be useful for hydrophone applications with $d_h.g_h$ product 100 times larger than PZT.

Matsushita et al[17] have studied variation of volume resistivity of hot pressed silver-polystyrene powder mixture. Resistivity decreased with increasing pressure at all temperatures studied. They concluded that, through appropriate hot pressing of a metal-polymer powder, composites with a desired electrical resistivity can be made.

Hisao Banno[18] has described a composite of ceramic particles and synthetic rubber, which he called as 'Piezorubber'. Since it has the flexibility of rubber, he mentions that, it can be fabricated in the shape of electric wire, and so, called it as 'Piezo Wire'. It can be used as a hydrophone, probe for measuring the ultrasonic field in water, blood pressure sensor, guitar pick-up and electric piano pick-up.

5. Nano-composites:

Gleiter[23] and co-workers discovered nano-crystalline materials and then onwards there has been tremendous efforts taken by scientists and technologists to prepare nano-structured materials for engineering and electronic applications. Nano-composites are materials that incorporate nanosized particles into a matrix of standard material. The result of the addition of nanoparticles is a drastic improvement in properties that can include mechanical strength, toughness and electrical or thermal conductivity.

Nanoparticles have an extremely high surface area to volume ratio which dramatically changes their properties when compared with their bulk sized equivalents. It also changes the way in which the nanoparticles bond with the bulk material. The result is that the composite can be many times improved with respect to the component parts. Some nanocomposite materials have been shown to be 1000 times tougher than the bulk component materials.

Nanocomposites can dramatically improve properties like:

- Mechanical properties including strength, modulus and dimensional stability
- Electrical conductivity
- Decreased gas, water and hydrocarbon permeability
- Flame retardancy
- Thermal stability
- Chemical resistance
- Surface appearance
- Optical clarity.

Typical applications of nanocomposites include:

- Electronic industry
- Automotive engine parts and fuel tanks
- Impellers and blades
- Oxygen and gas barriers
- Food packaging
- Pharmaceutical industries

6. Electronic Application of Composites:

A typical electronic application of composites is the development of varistors. Any two terminal devices with nonlinear I-V characteristic are considered as a varistor. Varistors with negative voltage coefficient of resistance are usually found in electronic systems. Varistors with NVCR are connected in parallel with the load for the protection of circuits against power transients.

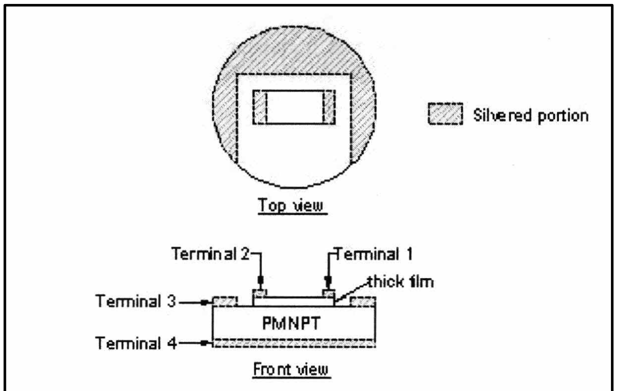
K. Lal Kishore et al[19] proposed varistors with PVCR based on conductor - piezoelectric composites using Barium titanate, frit glass powder and graphite. They obtained V-R and T-R characteristics and observed that resistance increases initially showing a positive coefficient of voltage or temperature and then decreases beyond a critical voltage or critical temperature. These parameters have been found to depend on the composition used.

K. Lal Kishore et al[20] also demonstrated that one of the possible methods of obtaining PVCR is through the introduction of an electro strictive material along with a conducting material, and an elastic binding medium in a composite form. If the electrostrictive material elongates in the same direction as the applied field, resulting in the movement of conducting particles apart, electronic emission between the conducting particles is expected to reduce, and hence the resistance of the composite sample may increase. To verify this thought process, composite samples, with $BaTiO_3$, graphite and synthetic rubber were prepared in the form of circular pellets, tested, and developed mathematical model to investigate the experimental and theoretical results.

They have concluded that it is possible to realize varistors with positive voltage coefficient of resistance, at least over a certain voltage range, through particulate composites of an electrostrictive phase, a conductive phase, and an insulating phase. The binding phase in the above mentioned composite samples was replaced with frit glass powder, which can withstand higher temperature compared to rubber.

K. Lal Kishore et al [21] proposed another method to develop varistors with PVCR using PZT and concluded that these varistors can be used in the range of 140V to 450V as electronic regulators. These composite varistors are having a voltage coefficient of resistance from 1.5×10^{-3} to 3×10^{-3} per volt. These varistors with PVCR are connected in series with the load to act as voltage regulator.

K.Y. N. S. Y. P. L. Narasirnham and K. Lal Kishore[22] developed varistors with PVCR using PMNPT composite structure and concluded that these varistors can be used in the range of 20V to 309V as electronic voltage regulators. These composite varistors are having a voltage coefficient of resistance from 7.3×10^{-3} to 9.93×10^{-3} per volt. The typical varistor with PVCR based on PMNPT structured composite device is shown in Fig.2 below:



STRUCTURE OF THE PMNPT - THICK FILM DEVICE WITH 4 TERMINALS

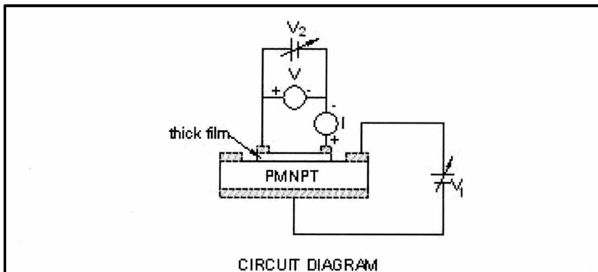


Fig.2 : Schematic Diagram for obtaining I-V Characteristics of PMNPT Varistors

7. Electronic applications of Nanocomposites:

Nanocomposites are currently being used in number of fields and new applications are being continuously developed. There are numerous applications using nanocomposites. Typical applications for nano-composites include:

- Very Low-Voltage Varistors for VLSI & computer chips
- Thin-film capacitors for computer chips
- Solid polymer electrolyes for batteries
- Nano Electro Mechanical Switches (NEMS).

Narasimham [24] et al., proposed a method for developing low-voltage varistors based on doped nano zinc oxide composites with a breakdown voltage rating of about 40 V/mm and non-linear coefficient ranging from 11 to 18. These samples are sintered at 1250°C for 5 hours. They have demonstrated that by changing the composition of the nano zinc oxide powder with different dopants of appropriate concentrations and by selecting suitable sintering temperatures, it is possible to have varistors with tailor made characteristics.

Tan et al[25] developed a new composition comprising various dopants and nano-materials. They achieved Nanostructured Metal Oxide Varistors for surge protection by sintering at lower temperatures, giving rise to smaller grain size and favorable grain boundaries. When compared to the commercial varistors, these devices posses high breakdown voltage with better nonlinearity coefficient.

8. Conclusions:

Composites in general and Nano-composites in particular are facilitating the development of various electronic components and systems for electronic industry. Devices exploiting piezoceramics have been developed for the generation of high voltages, electro-mechanical actuators and sensors, frequency control and the generation and detection of acoustic and ultrasonic energy. Continuous efforts are on for developing Varistors with NVCR and PVCR as protection devices and voltage regulators respectively. A number of nanocomposites such as nano wires, nano tubes and nano rods are being developed for fabricating electronic components. A variety of ferrite composites are already in use in various electronic systems. Nanotechnologies are expected to enable the production of smaller, cheaper devices with increasing efficiency.

9. References:

1) Robert. M. Jones: Mechanics of Composite Materials; Mc.Graw Hill Book Company, (1975).

2) J. Van Suchtelen, "Product properties: a new application of composite materials," Philips Research Report, vol. 27, p. 28-37, 1972.

3) R.E. Meredith and C.W. Tobias: Advances in Electrochemistry and Electro-chemical Engineering; Vol.2, (1962), Interscience.

4) J. Van Den Boomgaard, D.R. Terrell, R.A.J. Born, H.EJ.!' Giller: "An in situ grown eutectic magnetoelectric composite material", J. Mater .. Sc; Vo1.9, No.1 0, p.l705-1709, (1974).

5) D. K. Hale: "Review- The Physical Properties of Composite Materials", J. of Mat. Sc.; VoU1, p.2105-2141, (1976).

6) R.E. Newnham, D.P. Skinner, L.E. Cross, "Connectivity and Piezoelectric-Pyroelectric Composites", Mat. Res. Bull.; VoU3, p.525, (1978).

7) C. Rajagopal, M. Satyam : "Studies on electrical conductivity of insulator-conductor composites" , 1. of Appl. Phy; Vo1.49, (11), p.5336-5342, (1978).

8) C. Rajagopal, M. Satyam: "Studies on dielectric behavior of insulator-conductor composites" ,J. of Appl. Phy; Vo1.50, (12), p.8193-8197, (1979).

9) Shaul. M. Aharoni : "Electrical Resistivity ofa Composite of Conducting Particles in an Insulating Matrix" , J. of Appl. Phy; Vo1.43, (5), p.2463-2465, (1972).

10) D.P. Skinner, R.E. Newnham and L.E. Cross, "Flexible Composite Transducers", Mat. Res. Bull., vol. 13, p. 599-607 (1978).

11) T Furukawa, K. Ishida, E. Fukada : "Piezoelectric properties in the composite systems of polymers and PZT ceramics" ,J. Appl. Phy; VoI.50,(7), p.4904-4912, (1979).

12) R. E. Newnham, D. P. Skinner, K. A. Klicker, A. S. Bhalla, B. Hardiman, and T R. Gururaja, "Ferroelectric ceramic-plastic composites for piezoelectric and pyroelectric applications"; Ferroelectrics, Vol.27, p49-55 (1980).

13) A. Safari, A. Hilliyal, L.J. Bowen, R.E. Newnham : "Flexible Composite Transducers" ; J. of Amer. Cer. Soc. Vo1.65, (4), p.207-209 , (1982).

14) A.S.Bhalla, R.E. Newnham, TR. Shrout and L.E. Cross, "Piezoelectric SbSI:Polymer Composite"; Ferroelectrics, vol. 41, p. 207-211 (1982).

15) A. Safari, R.E. Newnham, L.E. Cross and W.A. Schulze, "Perforated PZT-Polymer Composites for Piezoelectric Transducer Applications"; Ferroelectrics, vol. 41, p. 197-205 (1982).

16) K. Rittenmyer, T Shrout, W.A. Schulze and R.E. Newnham, "Piezoelectric 3-3 Composites" ; Ferroelectrics, vol. 41, p. 189-195 (1982).

17) Ritsu Matsushita, Mamoru Senna and Hiroshi Kuno : "Electrical resistivity of hot-pressed silver-polystyrene powder mixture"; J. of Mater. Sci., VoU2, (3), p.509-516, (1977).

18) H. Banno, "Recent Developments of Piezoelectric Ceramic Products and Composites of synthetic Rubber and Piezoelectric Ceramic Particles" ; Ferroelectrics, vol. 50, p. 3-12, (1983) . Presented at the 1983 IEEE International Symposium on Applications of Ferroe1ectrics, Maryland, 1-3 June 1983.

19) K.Lal Kishore , K.Ramkumar and M.satyam: "Solid state varistors with a positive voltage coefficient of resistance" ; J.Pl1ys.D:AppI.Phys. 19, L61 - L62 ,(1986).

20) K. Lal Kishore, K. Ramkumar and M. Satyam: "Varistors based on Barium titanate -graphite - rubber composites" ; J.Appl.Phys., Vo1.61,No.l, p.397-403, (1987).

21) K. Lal Kishore, K. Ramkumar and M.Satyam : "Variable resistors based on composites"; :J.Phys.D:Appl.Phys.20,pp.3 86-3 89(1987).

22) K.Y.N.S.Y.P.L.Narasimham and K. Lal Kishore: "Dimensional dependence of voltage coefficient of resistance (av) for PMNPT based varistors" ; Journal ofInstitution of Engineers(India) -Series-B (Communicated).

23) Gleiter.H: "Proc. of the 2nd Riso Int. Syrnp. on Metallurgy and Materials Science.Deformation of Poly crystals: Mechanisms and Microstructures, Roskilde, Denmark Sept. 14-18", Second Riso Symposium, Editors: N. Hanson, A. Horsewell and TLeffers, (Riso National Laboratory, Roskilde, Denmark), p.15, (!981).

24) K.Y.N.S.y'P.L Narashimham, Y.Sunitha, Dr. J. Arunachalam and Dr. K. Lal Kishore : "Development of Low-Voltage varistors using Doped Nano Zinc-oxide Powder"; Technology Spectrum, No.3, p.36-39, (2011).

25) Tan,D.Q.Younsi, K.Yingneng Zhou Irwin,P.Yang Cao: IEEE Transactions on Dielectric and Electrical Insulation, y'16,Issue:4,pp.934-939,(2009).

Suitable Modulation Techniques for 4-G Mobile Communication Systems

Dr E Gopinathan

Dean, School of Engineering, Vels University, Chennai

Abstract

The two main broad band services proposed for 4-G mobile communication systems are WiMAX (802.16e) and Long Term Evolution (LTE) Advanced. These two systems require 100 Mbps with full mobility and 1 Gbps with limited mobility for data transmission. The existing techniques such as Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA) or Code Division Multiple Access (CDMA) which are used in 2-G and 3-G systems will not support such high rate of transmission required for 4-G mobile communication systems. Bit Error Rate (BER) performances for different values of Signal to Noise (E_b/N_0) Ratio (SNR) for techniques such as Orthogonal Frequency Division Multiplexing (OFDM), Multi Carrier CDMA (MC-CDMA), Orthogonal Frequency and Code Division Multiplexing (OFCDM) are evaluated to find their suitability for 4-G mobile communication systems.

In OFDM high data rate input is split into number of sub-streams which are transmitted in parallel over narrow band orthogonal subcarriers and hence high data rate is obtained. This method also provides high robustness against multi-path fading. The modulation and demodulation can be performed easily since we can use well known FFT and IFFT techniques. However, since each symbol is transmitted using a single carrier, the method cannot exploit channel diversity. Also the method requires high Peak to Average Power Ratio (PAPR) which reduces overall efficiency. The method is also highly sensitive to frequency offset and phase noise.

In multi-carrier transmission, a serial high data rate is converted into multiple parallel low rate sub streams. Each such sub stream is modulated using a sub carrier. Since symbol rate of the sub stream is much lower than the original data rate, Inter Symbol Interference (ISI) is decreased. MC-CDMA is a combination OFDM and CDMA and hence enjoys the benefits of both. Since symbols are modulated using multiple sub carriers, frequency diversity is achieved. MC-CDMA can provide symbol rate up to 100 Mbps. However MC-CDMA suffers from high PAPR. Moreover it requires synchronous transmission. Also MC-CDMA is suitable only if there are limited numbers of users.

OFCDM spreads symbol in both time and frequency domain. Data bits are spread and modulated in the time domain by a spreading factor which is equivalent to multiplexing in the time domain. Each of this multiplexed data stream is spread in the frequency domain using a code similar to MC-CDMA. The data is finally transmitted as is done in OFDM.

Comparison of BER performances of ODM, MC-CDMA and OFCDM in the frequency domain using Zero Forcing (ZF) and Minimum Mean Square Error (MMSE) Equalizers and time and frequency domain spreading show that OFCDM gives the best performance for a given value of SNR.

Prof S K Mitra Memorial Lecture

Mr Ajay Singhal

Indian Radio Regulatory Service
Government of India

The world has come a long way since the era of Late Shri S K Mitra , a renowned Physicists who had contributed immensely in the field of wireless & Radio physics. Currently, wireless technologies has come up as the most important resource to meet the requirements of network connectivity worldwide. Perhaps, wireless is the biggest invisible boon of the 21st Century which is connecting people or things invisibly.

Internet of things or IOT is one such field where wireless communication technologies are playing a key role in providing network connectivity. The advent of wireless communication technology in the 21st century has led to severe engineering challenges concerning interference and network densification. As we begin to touch the Internet of Things, these challenges are sure to grow. Indeed, it is predicted that connection densities will surpass one million per square kilometre in the near future, largely owing to the deployment of IoT networks and services. Yet, relatively little has been done to quantify the growing complexity of these networks, and the subsequent implications that this growth will have on network performance.

According to research firm Gartner, more than 20 billion connected things will be in use worldwide by 2020. From connected vehicles to connected homes, the Internet of Things (IoT) promises a host of benefits for industry and consumers.

But are we prepared to handle 20 billion connections emanating from planes , desert areas, mountainous terrains and oceans .

As we all know, Internet of things is nothing but interconnection of physical devices. The success of IOT in the country depends heavily on internet penetration. The need of the hour is to explore new options for enhancing the network capabilities supporting internet connections. The challenges are not restricted to big metro cities only but also in the remote areas where the conventional means of communication are yet to reach.

According to Internet and Mobile Association of India and market research firm IMRB International, overall Internet penetration in India is currently around 31%.Urban India with an estimated population of 444 million already has 269 million (60%) using the Internet. Rural India, with an estimated population of 906 million as per 2011 census, has only 163 million (17%) Internet users. Thus, there are potential approximately 750 million users still in rural India who are yet to become Internet users; if only they can be reached out properly.

The engineering fraternity has to face this challenge of Digital Divide while taking on the IOT Movement in the years to come.

Apart from terrestrial networks providing connectivity to IOT devices, use of satellite communication can prove to be game changer. No single technology or company can reach all the possible markets and customers — while handling the flood of connections required and mounds of data that will be captured.

Keeping in view the ubiquity of space-based communications, satellite technology will play a crucial role in supporting the development of the IoT sector and realizing the full potential of interconnected devices. Business operations that extend into remote areas rely on satellites to provide communications for facility monitoring and instantaneous asset management at unmanned sites and offshore platforms. This is why satellite operators are investing and collaborating to develop services and hardware that can enable IoT. At the same time, operators are making sure satellite-based solutions can be easily integrated into hybrid networks that combine fiber, wireless networks and satellite to best serve the IoT sector and customers at all levels.

Machine to Machine (M2M) communication is paramount to the Internet of Things landscape, and satellite technology is foundational for the development of this technology. As per NSR , there will be 5.8 million machine-to-machine (M2M) and IoT connections via satellite worldwide by 2023. Because M2M communication must be reliable, these applications often rely on satellite, rather than terrestrial networks like many consumer-facing devices and applications. Combined with new technologies that generate low cost-per-bit connectivity, the satellite industry is redefining the solutions it can provide to address the largest communications requirement our world has ever known.

With the advent of high throughput Ku, Ka band satellite connections, the capabilities in orbit have created a broadband super highway in space — easily handling the potential volume of opportunity in the IoT and M2M sectors. In addition, a new model that combines the advantages of satellites in geostationary orbit with those offered by constellations of satellites in low-earth orbit will redefine satellite communications. These hybrid fleets will deliver broadband coverage of the polar regions. They also will be able to layer bandwidth for regions or applications with high-density traffic, as well as for critical applications where redundancy is required.

In order to have a major impact, it is essential to make the satellite technology accessible to people or things. This requires innovations throughout the satellite ecosystem, to facilitate access while complementing other technologies to enable hybrid solutions. For example, the most progressive satellite operators have made strategic investments with meta-material-based antenna-technology providers. These partnerships will yield a range of antenna and terminal products no bigger than a laptop in size. They'll serve application verticals such as mobility, content delivery and wireless backhaul.

IOT via satellite can play an important role in providing uninterrupted coverage to vehicles. We are just beginning to see the connected vehicles using cellular networks. The day is not far , when we will be using hybrid connectivity featuring both satellite and terrestrial technology. The global nature of satellite systems and the ability to broadcast to multiple points is the most efficient signal delivery on earth. Satellite broadcasts can work seamlessly with terrestrial cell carriers to achieve global coverage and enable auto manufacturers to reach all of their vehicles on a single network. This means the billions of dollars spent each year by car manufacturers to recall vehicles for software upgrades could be avoided. Instead, satellites will broadcast software updates to cars on a global basis. Broadcast capabilities give satellites a strategic advantage in delivering both operating and navigation software updates that will be essential as we move into the next decade.

The intelligent cars of future will depend heavily on satellite technology. Terrestrial Wi- Fi and cellular networks support just a portion of the grid that will be required to allow fully autonomous vehicles to navigate city streets and highways. Satellite communications will play an important role in the connectivity and autonomy of intelligent cars. An autonomous vehicle requires two different types of external signal connections. Functions of the car such as steering or braking that need information about other vehicles along a route must rely on terrestrial networks with virtually no signal latency, because of the time-sensitive nature of these interactions. Other vehicle functions that need less time-sensitive information can rely on satellites as a medium of communications, because of the inherent attributes of ubiquity and broadcast for satellite technology. For example, satellites can multicast updates to cars concerning road conditions ahead, and local imaging of city streets and mapping of selected routes — without fear that a sudden peak in traffic on the wireless network slows or knocks out response times.

When we talk about intelligent vehicles, there is another big innovation in the agriculture sector. A renowned manufacture in farming equipment) has begun connecting its tractors to the Internet and has created a method to display data about farmers' crop yields. Similar to smart cars, the company is pioneering self-driving tractors, which would free up farmers to perform other tasks and further increase efficiency. Farmers can use their smartphones to remotely monitor their equipment, crops, and livestock, as well as obtain stats on their livestock feeding and produce. They can even use this technology to run statistical predictions for their crops and livestock. Sensors placed in fields allow farmers to obtain detailed maps of both the topography and resources in the area, as well as variables such as acidity and temperature of the soil. They can also access climate forecasts to predict weather patterns in the coming days and weeks. Hence it will not be too long to think about Smart Villages having Smart Farming.

The connection between the Internet of Things and satellite technology continues to grow. As more and more devices become connected, that link is going to continue to expand, proving the true benefit of satellite technology in the modern connected world.

Apart from challenges arising due to technological limitations for IOT movement, there are certain other issues like Standardization, Interoperability handling of Big Data and cyber security.

Before we conclude, just imagine a world where we have Smart Cities, Smart homes, Smart Vehicles, Smart Environment, Smart Farming, Smart Transportation etc. and huge amount of data arising out of them. Handling of such Big Data will be the biggest challenge for Engineers. The task becomes even more difficult when we think of handling such enormous data within the ambit of Cyber Security.

In this quickly evolving world, all the things that connect to the Internet are exponentially expanding the attack surface for hackers and enemies. A recent study showed that 70 percent of IoT devices contain serious vulnerabilities. There is undeniable evidence that our dependence on interconnected technology is defeating our ability to secure it. The industry needs to learn from its mistakes as it innovates and builds devices to function interconnectedly with the Internet. Many of the best security practices can be leveraged, such as hardening the systems, using secure protocols for communication or installing the latest updates, fixes and patches. Innovators need to consider that future security will be managed automatically by the system instead of users, and designing secure technology will require a new approach and mindset.

It is very true that the challenges are multi dimensional, but it will be up to the Engineers of today and tomorrow, to take this IOT movement for the betterment of the country and the world.

It's the time to buckle up now.

Thank You.

34Intelligent Communications Networks for Sustainable Growth

Dr Amar Partap Singh

Professor, Sant Longowal Institute of Engineering &Technology, Longowal

Internet of Things (IoT) technology has been widely researched in the last decade or so.Number of new innovations and concepts have been generated from this technology.In fact, these innovations and concepts are employed frequently to realize efficient communication networks including smart homes, smart cities, and smart health services, etc.However, out of these communication networks, emergence of green communication networks, is also one of the emerging technological trends of great significance.These networks, with a focus on energy efficiency, can appreciablyimprove sustainability for Internet of Things (IoT) technology with respect to power resources as well as environmental requirements and conditions.In fact, IoT is an eco-system of large number of connected physical objects.These objects are accessible through the Internet.IoT involves creation of smart communication environment between smart homes, smart transportation, and smart healthcare systems.

This smart communication environment is generated with the help of several devices in a network.Moreover, this network enables transmission of data within these devices.Such networks include Wireless Sensor Network (WSN), Radio Frequency Identification (RFID) Networks, Cloud Services, Near Field Communication (NFC) Networks, Gateways, Data Storage &Analytics and Visualization Elements.The exponentially increasing number of nodes in IoT eco-system will lead to significant energy consumption. Thus, reducing carbon footprint in green communication networks is one of the key challenges, which are faced by researchers in recent years.Further, due to growing use of Artificial Intelligence (AI) in this area, several green communication approaches are entering a more mature phase, with exciting applications in various networks.In order to address these issues, the present talk presents state-of-the-art technologies in this respect.Moreover, this will also discuss the developments in the two main fields - Engineering and Sustainable Computing.

In fact, this talk highlights significant current and potential international research and innovation work relating to theoretical and practical methods towards developing Sustainable Communication and Networking Technologies.In particular,this will also focus on emerging technologies such as Wireless Communications, Mobile Networks, Internet of Things [IoT], Sustainability and Edge Network Models. The information sharing and intelligent decision-making capabilities are a part and parcel of this technology.This specific capability of green communication networks play an important role in improving not only energy efficiency but also network performance too.For instance, a simple and effective green communication solution is to place a node in an intelligent sleep mode. This is achieved with the help of various MAC protocols with broad applications in wireless networks.However, it is essential to investigate the trade-off between the energy efficiency for green communication networks and IoT requirements. Moreover, it is crucial to evaluate the performance concerning the energy consumption, the throughput, and the response time in respect of IoT ecosystem.

Similarly, Internet of Vehicles (IoV) has already become another emerging technology for supporting intelligent vehicles and autonomous vehicles.As the number of vehicles operating on green and renewable energies is increasing day by day at an unprecedented fashion.Hence, controlling the operation of these vehiclesneed further research innovation such as the Internet of Energy (IoE).This IoE concept is recently coined with an aim of providing clean energy to electric vehicles, smart homes as well as smart buildings.Meanwhile, Artificial Intelligence (AI) due to the self-sustainable nature with self-governing and independent decision-making capabilities, has appeared as a possible alternative to achieve the aim of full autonomous communication systems. However, the current research trends consist of a few key research ideas covering the concept of IoE and intelligent communication networks. The aim of present talk is to explore intelligent communication network technologies to smartly and efficiently manage the available resources.Further, the demand for clean energy and micro-grids can be enabled for saving energy in powerful and deep saving batteries for future use.

In this modern era of information and communication technologies [ICT], there is a growing need for new sustainable and energy-efficient communication and networking technologies. The contributions cover a number of key research issues in software-defined networks, blockchain technologies, big data, edge/fog computing, computer vision, sentiment analysis, cryptography, energy-efficient systems, and cognitive platforms.In particular, we seek submissions, which efficiently integrate novel AI approaches, focusing on IoT ecosystem performance evaluation across existing green communication solutions. Now-a-days, both theoretical and experimental studies for such scenarios are encouraged tremendously. The major topics of interest, in which, present research scenario is being getting focused include:

- Machine learning approaches for energy-aware green wireless communication networks for IoT
- AI based modeling and analysis for green communications for IoT applications.
- AI based green cognitive radio networks
- Carbon-neutral intelligent communication networks for IoT
- AI based green wireless sensor networks
- Architectures and models for smart green communication networks for IoT.
- Power consumption trends and reduction in intelligent communications for IoT.
- Experimental test-beds and results for intelligent green communication networks.
- Quality of service in smart green communication networks for IoT ecosystem.
- Intelligent green communication network designs and implementations for IoT ecosystem.

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The Institution of Engineers (India) has established Electronics & Telecommunication Engineering Division Board in the year 1961. The Division consists of quiet a large number of corporate members from Government, Public, Private sectors and Academia and R&D organizations.

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Due to multi-level activities related to this engineering discipline, the Electronics & Telecommunication Engineering Division encompasses the following the thrust and emerging areas of technology:·

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The Institution of Engineers (India)
8 Gokhale Road, Kolkata 700020
Phone : +91 (033) 2223-8311/14/15/16, 2223-8333/34
Fax : +91 (033) 2223-8345
e-mail : technical@ieindia.org; iei.technical@gmail.com
Website : http://www.ieindia.org