International Journal of
Electrical Machine Analysis and Design

Volume 4, Issue 1, 2026
January–June
DOI (Journal): 10.37591/IJEMAD

https://journals.stmjournals.com/ijemad

Review IJEMAD

New Ideas and Inventions in Electrical Engineering

V. Basil Hans[1], *

Abstract

Electrical engineering has been a key part of technical progress, leading to new ideas in many fields and changing society. This article looks at how important inventions and new ideas in electrical engineering have changed throughout time, from the creation of early electrical systems to today's advances in smart grids, renewable energy technologies, and intelligent automation. It shows how improvements in electricity generation, transmission, and distribution have made things more efficient, reliable, and long-lasting. The report also looks at new sectors including electric cars, systems that use the Internet of Things (IoT), and AI applications in electrical networks. Innovation is important for solving global problems like energy demand, environmental issues, and updating infrastructure. The combination of cutting-edge communication technologies and electrical systems has facilitated the creation of intelligent, interlinked energy networks that enhance real-time oversight and management. The implementation of sustainable energy solutions and designs that prioritize energy efficiency is also hastening the shift to greener, more resilient power systems. Moreover, continuous studies in automation, power electronics, and embedded systems are broadening the scope of electrical engineering across various applications. This article looks at historical successes and current trends to give us an idea of where electrical engineering is going in the future and how important it is to making the world smarter and more sustainable.

Keywords: Smart grids, renewable energy, the internet of things (IoT), and electrical engineering, electricity generation

INTRODUCTION

The field of electrical engineering is based on new ideas and technologies in both theory and practice. This kind of work directly deals with basic, real-world problems in the generation, distribution, and use of electric energy. It includes coming up with new theoretical ideas, building practical devices based on those ideas, and putting those devices into working systems.

Change is always happening, and people often talk about how things have gotten better over time, either on a global or institutional level. Electrical engineering changes a lot throughout time, and each period of history has its own set of drives, goals, and limits. Paying attention to these things might help you guess how things will change in the future. Electrical engineering started with the study of generation, and reporting on new ideas in the area often follow the main, application-based ideas that are included below.

Amber and fur show that electricity has been around for a long time. Experimental research by Benjamin Franklin in the 18th century substantially altered the understanding of the phenomenon. Franklin built the lightning rod in 1747 because he saw that it could safely discharge electricity from the air. Three years later, in 1750, he guessed that a lightning strike is an electrical discharge. He came

***Author for Correspondence**
V. Basil Hans
E-mail: vhans2011@gmail.com

[1]Research Professor, Department of Commerce and Management and Humanities & Social Sciences, Srinivas University, Mangalore, Karnataka, India

Received Date: March 28, 2026
Accepted Date: March 29, 2026
Published Date: April 21, 2026

Citation: V. Basil Hans. New Ideas and Inventions in Electrical Engineering. International Journal of Electrical Machine Analysis and Design. 2026; 4(1): 16-27p.

up with the ideas of conservation of charge and absolute neutrality in 1785. Franklin's work marked a pivotal shift: from the simple observation of discrete electrical phenomena to a comprehensive theory with significant practical ramifications.

A second big change in the way people thought happened in the early 1800s and had nothing to do with breakthroughs in electromagnetism. In 1848, William Thomson took on the problem of how to measure time accurately. During the 1800s, great minds like André-Marie Ampère, George Simon Ohm, Michael Faraday, Georg Simon Ohm, Heinrich Hertz, Thomas Edison, Nikola Tesla, and Charles Steinmetz worked hard to make the changing electrical paradigm clearer and better. The comprehension of the phenomenon and attributes of electricity remained largely unchanged from the inception of electric theory until the 1970s.

The electric dynamo, the electric motor, the electric telegraph, and the telephone were four important technologies that broke down the barriers to scientific knowledge and theoretical comprehension. There were sources of electrical energy, but the problem was changing and managing mechanical, heat, and chemical energy into electric energy that could be sent to faraway places and changed back into other forms of energy. The dynamo connected mechanical and electrical energy and came up with the idea of an electrical engineering system. Long-distance control and information transfer needed signals to be sent by electrical energy. Still, the current scientific knowledge was not enough for this complicated endeavour.

BASIC NEW IDEAS IN ELECTRICAL THEORY

The ancient Greeks were the first people to notice electrical phenomena. They saw that when amber was rubbed, it attracted light things. People weren't interested in electricity for about two thousand years. Then, in 1600, William Gilbert published "De magnete" [On the Magnet], which was the first time he separated magnetism from electricity and came up with the word "electricus" to describe the attracting property of amber and jet [1]. Even with this base, real electrical research didn't start until a second groundbreaking book came out: "The Fashionable Science" by Friedrich Hoffmann, which came out in 1702 (Semat & Katz, 1958). First, the characteristics of charged glass, sulphur, resins, amber, and crystals, as well as the differentiation between "vitreous" and "resinous" electricity, were elucidated, facilitating initial enquiries into electrical phenomena. Otto von Guericke, Anton van Leeuwenhoek, Georg Simon Ohm, Charles Coulomb, Charles François de Cisternay du Fay, Benjamin Franklin, and Alessandro Volta, among others, began to study electrical problems in their own ways. This laid the groundwork for the electrical sciences as we know them today (Semat & Katz, 1958). Electric circuits don't get much attention these days, but they do get some since electrical engineers use circuit theory in their work on design and connectivity.

Maxwell's publications bring together previously separate ideas about both electricity and magnetism into one theory that applies to all matter (Semat & Katz, 1958). Anderson calculates magnetic fields in specific regions by utilising the broader concept of electric circuits, where at each place, the designated electric currents are derived solely from the harmonics of the examined network. The steady-state method can be used to solve transient differential equations, but the generality of the magnetic-field-to-current formulation suggests that it can be used in other limit circumstances as well. It seems like fields are useful enough to guess the ground potential of a humming transformer, provided the soil resistivity between the gallery and the surface is fixed, without needing to know a lot about circuits. It is easy to use a-c, d-c, transmission-line, and electromechanical formulations since they come immediately from the continuity equation. One may easily relate the charge of a capacitor, the mutual inductance between coils, and the mechanical inertia by multiplying them by a scalar.

Ohm's Law and Electromagnetism

Electrical engineering combines basic theoretical ideas with real-world uses in many different areas of expertise. There have been times when innovations and the ideas behind them have been directly related, like with the mechanical clock, the steam engine, and the vacuum tube. The discoveries that led to current electrical engineering were more scattered, with basic theoretical advances happening before they were widely used in technology. In common conversation, the link between practical electric power systems and the electromagnetic concepts that underlie them is still weak, even though modern transmission line theory is based on geomatic principles. The same theoretical frameworks now serve as the basis for subjects ranging from electric accounting to electromagnetics, however some of the most basic theoretical contributions are scarcely recognised as electro-technical by practitioners today. Around 1850, when electrical engineering became contemporary, several important ideas were already out there, but they hadn't been put together in a strict way to make a real system.

The next few paragraphs utilise Ohm's law as an example to explain what theory is and how it affects electrical engineering creativity and innovation. These advancements have led to the creation of common circuit parameters including resistance, capacitance, inductance, voltage, current, and power that are found in undergraduate texts.

In 1856, William Thompson, who would eventually become Lord Kelvin, said that Ohm's law is more like a relationship between voltage and current than between electromotive force and current. [2] Some formulations still use the phrase "electromotive force" since the difference between voltage and electromotive force is still important to engineers. However, many electrical educators prefer to talk only about the voltage-current relation. This preference for voltage and current indicates the formation of an electric circuit as the focal parameter, with broadly defined transmission lines considered electro-technical rather than telecommunication equipment. An electric circuit is made up of the energy source and the load. However, important intermediate phenomena like reflection, amplification, or backlash are usually not covered by theory and are not part of the traditional electro-technical field.

Electricity Generation and Distribution

Electric generation, transmission, distribution, and use are all moving toward a complete electric power system or grid, which is still a huge task. Progress means making all parts of routing electrical energy more efficient. In generation, the focus is on making renewable energy sources better, making conventional generators easier to control, cutting down on losses in units, busbars, and transmission lines, improving the quality of power at the end use, extending the life of energy storage devices, and separating backup supply or distributed generation from the main grid for smarter energy management [3]. Distributed generators that are part of a microgrid setup make it possible for island operation, which greatly improves reliability by providing a large amount of energy that is not delivered. Modern planning for the growth of transmission networks takes security into account, which improves the traditional approach. It also uses a weighted transmission loading relief index to find a balance between reliability and capital spending.

EARLY ELECTRICAL MACHINES AND SYSTEMS

The essential parts of electrical machinery and systems design from the past made it possible to employ electrical energy on a large scale in factories. During this time, many new inventions, ways of doing things, and design ideas were created that were important steps in the development of technology. They worked together to make electric power, build electric motors, and send electrical signals across telephone and telegraph lines.

Several important patent filings show how the dynamo and electric motor came to be. The dynamo was basically an extension of Faraday's discovery of electromagnetic induction. For example, the movement of a coil or winding might create a higher voltage than the spinning of a disc through a magnetic field. However, in fact, the specifics of these devices were determined by the conflicting needs for power production and cost. The most important thing that happened after the dynamo was made was that it became more efficient, or less energy was wasted as heat in the winding resistance. There are several ways to do this, such as by increasing the electrical power produced compared to the mechanical power input, or the power out for a given input, or the input power for a given power out.

Development of Electric Motors and Dynamos

The dynamo and the electric motor are two important inventions that have been at the heart of electrical engineering since it began. They not only represented the beginning of electrical engineering as a field, but they also still represent the two main divisions of electrical technology. R. says that According to N. D. Boileau, a historian of electrical engineering, the main polarities of the field were already set by 1880. These were based on two types of machines: those that generate and convert electrical energy and those that use it, such as for lighting, heating, and powering things. The dynamo was made in the early 1830s, and the electric motor was made almost 200 years ago. Most of them, though, were not useful in real life. As the field grew, government financing for research became quite important. Around 1875, the first useful AC motor was made by someone else. The first central-station system went live in Paris in 1881. One of the first electrical inventors proved the common notion at the time that a fixed magnetic field could not create an electromotive force. There are three main parts to the history of the electric motor. The first one started with Mary Shelley's "Frankenstein" and ended around 1910 [4]. The first AC machines were powered by a dynamo. They couldn't be used since they needed huge amounts of force to work in a lot of different ways. A 2000-volt alternator powered a 104-hp alternating-current motor that the Paris electric tramways utilised for traction. The first commercial interest in electric motors originated from electric traction. However, it was the electrical transfer of power to drive the already-built and commonly used machinery of industry that made the development of the electric motor branch possible. The other important branch of electric power was sound broadcasting. One of the main goals of electricity was to make light; the first incandescent lamp was made in 1802, and the first commercial incandescent lights were utilised in the US and other countries around 1840.

Around 1900, the introduction of the AC motor led to a number of important changes. For example, a state electromechanical plant was built in Saint-Petersburg and Orel to make electric motors in large quantities. This factory also built the first Russian asynchronous motor with 75 horsepower. The experimental motors' diameters were made significantly bigger so that they could make kinetic energy from a thin copper wire and so that scientists could learn as much as possible about the hammering effect. The second publication about motors said that motors running without a load had consistent torque at all frequencies.

Invention means making new things, while innovation means finding new things and putting them to use. Electricity has been known since the beginning of recorded history, and batteries have been used for about six thousand years. This means that there was enough knowledge of electrical principles for scientists, engineers, and inventors working in the laboratories of leading countries to start making electrical machines.

Telecommunications and Telegraphy

Before electrical engineering became its own field in the late 1800s, the necessity for quick communication across large distances and the rise of mass media led to substantial changes in electrical telegraphy, signalling systems, and transmission networks. Revolutionary discoveries about the physics of transmission lines showed how important medium capacitance and magnetism are. These ideas are still used in many modern data networking and telecommunication systems [5].

THE DIGITAL LOGIC AND SEMICONDUCTOR REVOLUTION

John Bardeen, Walter Brattain, and William Shockley invented the point-contact transistor in 1947, which started the transistor revolution. Jack Kilby and Robert Noyce invented the integrated circuit in the late 1950s, which ended the revolution. The development of semiconductor technology has led to amazing levels of integration. Every two years, the number and frequency of transistors in digital systems doubles. At all levels of abstraction in information processing and control, semiconductor-type devices are the most common. There are many important points in the evolution of these systems when it comes to logical processing, storage, and memory hierarchies. Digital electronic systems use transistors to make Boolean logic gates at the most basic level. By merging these gates, higher-level architectures make bigger, more complicated logical functions. Depending on whether information is always or just sometimes available, it can be kept in different ways. This also affects the devices that make memories to satisfy these needs.

The transistor and the integrated circuit were both important steps in engineering that started this revolution. Nonlinear devices, including the diode, vacuum tube, and gas tube, had previously been integrated into systems, albeit with significant constraints on dimensions and energy consumption. Applications were limited by the effects of more complicated control signals and faster switching on a transmission-chain basis. Electrical engineering then suffered since the math behind switching circuits using these kinds of devices wasn't very strong. The advent of semiconductors eliminated these obstacles, resulting in a plethora of architectural options in logic design, which, from a pragmatic perspective, offered the most adaptable method for encoding knowledge and making decisions across many systems [6].

Quantum Leap: Transistors and Circuits That Are All in One

During the second part of the twentieth century, the semiconductor revolution changed electrical engineering. The transistor and the integrated circuit made electronic systems much faster, more powerful, more sophisticated, and more flexible. Strong market demand for novel materials and design ideas, along with decades of better fabrication methods, made it possible to quickly increase both integration density and usefulness. Improvements in power and speed efficiency made many systems cheaper to build and more useful. Long-standing problems with dependability started to be fixed, and the benefits of digital logic, such as large energy and bandwidth dissipation margins, outweighed the performance problems. Slowly but surely, all electronics were made out of silicon, which took a lot of the technological momentum from the electrical engineering fields and made electronics the main part of computers.

Digital circuits use relatively little power and give off very little heat, which made it easy to move control and data processing from central hosts to the final devices, which led to the microcontroller. These flexible devices are self-contained and made for specific applications. They make up the vast majority of electronics manufacturing today. Processing without an integrator allows for genuine real-time control of all sensory inputs without the need for multipoint integration that adds speed or power consumption overhead. This also makes the system more sensitive and gives users a wider range of sensing and actuation options. The lack of a control cycle increases dependability and makes designs that are completely fault-tolerant cheaper and perhaps last longer than mostly analogue control solutions.

Computing and Processing Information Digitally

Claude Shannon, who is renowned as "the father of information theory," came up with the contemporary idea of digital information, which John Tukey called a "bit." Shannon wrote a huge paper in 1948 called "A Mathematical Theory of Communication." The title alone is a short summary of how information theory was created, a field that had a lasting impact on the theoretical framework that helped keep devices, ideas, and people connected.

Digital information processing is defined by a stratified architectural framework comprising devices, abstraction definitions, operating principles, and advanced design methodologies that evolved autonomously, particularly in relation to the diverse facets of digital integrated circuit technology, the computer itself, and data communication and networking. The discrete one-bit information perspective emerged from a collaborative study integration of probability theory and Boolean algebra, with multiplication as the fundamental operation. The information basic theorem established the highest rate of information transmission that ensures a specified level of fidelity in reception over any channel. It characterised intelligible language as a noisy channel and constrained the quantity of the language itself, concepts that were synthesised for the first time in engineering to address industrial issues such as telephone and telegraph line noise, among others.

The idea of the Computer was taken in a U-shape. The upper level realised Turing's thoughts and functions, while the lower level, with the rise of discrete digital technology, saw an explosion of machines and logics working according to Boolean Algebra. The telecommunications idea of a channel was further expanded to include the entire category of signals, which eventually became the basis for the idea of a layered connection of thoughts.

NETWORKING AND COMMUNICATION TECHNOLOGIES

In the early 1900s, communication technologies were radio waves. By the 2000s, they were satellite communications and broadband Internet. Telecommunications has been a big reason why people choose to study electrical engineering and electronics. The main goal has been to increase the speed of information transfer while also making it more reliable. Digital signals are superior for sending information over long distances than analogue signals, hence they have become the most common way to send information. The advent of packet-switched networks facilitated further advancements in communication systems. The Internet Protocol suite established a standard for all kinds of communication, making it easier to set up voice-over-Internet Protocol and other multimedia applications. The use of digital technology in optical fibre and wireless communications led to more improvements. Still, the essential way that communications function has not changed: the source signal is first digitised, then compressed to save bandwidth, and lastly sent over communications networks. At the destination, the signal is restored and decompressed to get the original source signal back. This process is often called compression–transmission–decompression [7].

Radio and television broadcasts have become important ways for people to get information. The biggest problem for radio systems has been finding enough spectrum to avoid interference, while the biggest problem for television systems has been finding enough bandwidth to send pictures. Cultural and political factors have affected the switch from analogue to digital methods in ATSC and DVB systems, respectively. In many countries, direct broadcast satellites in the C-band and Ku-band have given people access to national television. Mobile phones let people talk to each other quickly within a certain wireless service area. The rapid rise of smart mobile devices has also added new ways to share, find, and process information. Because of these changes, the mobile Internet is now mostly about getting to content and location-based services.

Radio, TV, and Satellite Systems

Radio, television, and satellite communications are all important parts of modern life, but their widespread use frequently hides how complicated science and technology make them work. Broadcasting is a way to talk to many people at once. A single signal sends information to numerous receivers. This procedure includes a third dimension for some radio and TV broadcasts: the signals are spread out in space, so a large area can get the same information. Crews communicate information using satellites that can see the Earth from space. Radio waves between antennas mostly travel in straight lines because the distances are short. However, because the antennas are on a curved surface, they follow the curvature of the Earth. The curving broadcasts go to and from the satellite in space above the equator for satellites that go around the Earth once a day.

Radio and TV use areas of the electromagnetic (EM) spectrum that countries have agreed on. Because many distinct radio and TV signals are delivered at the same time across the air and received by many different individuals, they need to be organised carefully. A modulation method is a way to organise things. A modulation method (or modulation technique) changes the properties of an EM wave to encode the information it carries. The voice or music on radio waves is a clear example of a way to modulate radio signals. Radio stations that are supposed to work on separate frequencies also modulate their transmissions in different ways so that many stations can deliver different signals at the same time. Bandwidth management is the skill of organising numerous diverse signals that use the same medium. It is a powerful approach to make radio waves carry more information. Satellites use spatial multiplexing to deliver numerous signals at the same time, at various angles, and on the same frequency band. The antennas on the ground split the signals up and send them to the right satellite receiver.

Fibre Optics and Fast Communications

Optical communications research has moved forward quickly, but it still takes knowledge of physics, photonics, electronics, algorithms, and network technologies to create a high-performance optical communication system. Optical fibres, amplification, spatial division multiplexing, and coherent transceivers are some of the most important hardware parts. Communication and signal processing include things like modulation formats, digital signal processing, optical signal processing, nonlinear channel modelling, and forward error correction. The field includes point-to-point connectivity and complicated networks including long-haul, access, and data centers. A lot of research is going into new technologies, which could lead to new ways to build systems in the future. In 1966, scientists predicted that silica glass would have negligible loss, which led to the first tests of field signals in 1977. Some important events are: fiber-to-the-home in 1978, the first 1300-nm systems in 1981, the switch to single-mode fibres starting in 1982, undersea fibre deployments in 1984, and high data speeds of 5 Gb/s in 1991 [8].

Fibre optic systems are becoming necessary for global broadband networks because they can send signals with a lot of bandwidth and very little delay. For long-distance, high-data-rate communication, they have a lot of transmission capacity and very little latency. Technological advances like wavelength division multiplexing have greatly expanded the capacity. Future systems will try to make optical processing better for switching and amplification, which will make them more efficient and reliable. Even though researchers are currently working on problems, fibre optics are still very dependable, safe, and not very prone to interference. This means that telecommunication capacity may keep growing [9].

POWER ELECTRONICS AND ENERGY SYSTEMS

Power electronics has changed quickly, making big strides in the technology used to convert electrical energy and modernising the way the electrical grid is built. It also plays a key role in combining renewable energy sources and enabling smart energy management. The growing role of intermittent renewable energy sources, such as solar photovoltaic (PV) and wind, has led to a lot of study on converter topologies and controllers, strategies for modernising the grid, and ways to filter active power and manage voltage [3].

Electric mobility is not a novel idea, but the rapid growth of battery-energy-storage technology is speeding up the process of making transportation electric. The need for long ranges and low energy prices has led researchers to look into different battery chemistries for electric vehicles (EVs). This transformation has also led to a lot of effort on charging standards and infrastructure, onboard chargers, vehicle-to-grid energy transfers, and fast charging. This has made grid-connected electric vehicles look like good ways to shift loads and lower the peak power of charging stations [10].

Renewable Integration, Grid Modernisation, and Power Converters

It is quite hard to add renewable energy sources to power grids. Wind and photovoltaic (PV) energy sources aren't always available, which makes power generation unstable. In a DC–AC conversion stage, an inverter is used before a direct-current (DC) link to change the voltage and allow AC grids with different voltage levels or frequencies to work together. In these converter topologies, grid synchronisation happens at the inverter, which adds more control features and makes the system more complicated [11].

Additionally, active filtering of the harmonics produced by the proposed converter is being looked at as a way to improve efficiency, control, and system stability. At the inverter stage, these harmonics can be removed even more, which meets the regulations and improves the quality of the current.

Power systems are using energy storage technologies like batteries, supercapacitors, and flywheels to meet power needs that change over time. It is important for the total cost of ownership (TCO) to go down and for electric vehicles to get better that energy storage systems last longer. The main purpose of energy management strategies is to keep certain circuits open while maximising battery life. These tactics are usually carried out utilising expert control or basic control strategies.

Technologies For Electric Mobility and Storage

Electric mobility, which includes a wide range of alternative powertrains, is seen as a major technological change that could have big benefits for the environment [12]. When combining, expanding, or changing electric drive systems, it's important to think about more than just propulsion. You also need to think about different system architectures and how they will affect transportation and delivery applications [13].

With today's technical breakthroughs, we may think of electric mobility in a lot of different ways, such as on the ground, on the water, in the air, on the rail, and in other mixed modes. Since electric systems can be directly and individually affected, the main goals of a central energy supply—battery and ultra-capacity storage, clear operations, and the distribution of charging strategies—can be met.

Still, the limited range and significant recharge times that come with the storage principle are still big problems. Over the past few decades, productivity has gone up and supply operations have moved toward always being just-in-time. This has led to cycles and times getting shorter and shorter. Energy supply designs that are properly adapted and charged before, during, and after runs in the depot using specialised, low-impact rapid connections will come next.

COMPUTING, CONTROL, AND AUTOMATION

In the last thirty years, embedded systems have become more common. This is a big change toward intelligence and independence in many different types of gadgets. Most of the time, embedded systems have a microcontroller or microprocessor and peripheral interfacing parts. This means that they can do control, sensing, actuation, calculation, and data logging all in one package. Embedded systems can do a lot of real-time functions, like monitoring, controlling, and communicating. Microcontrollers let you handle electrical devices efficiently while also keeping an eye on energy use and making things more comfortable for the user. They are used in numerous products, including home appliances, motor controllers, lighting systems, and building energy management systems.

Embedded systems can be employed in distributed control topologies, however many applications need centralised decision-making based on data from sensors spread out over a network and commands sent to actuators spread out over a network. The Internet can help with these kinds of needs. The initial computers were mostly used for maths, but with time they became more important for processing data and communicating, which made designs even more important. After that, the focus shifted to interfaces and peripheral devices, which made it possible to use them in a wider range of ways, including controlling physical systems. The fast growth of device complexity, processing speed, and capability has opened up new possibilities for embedded systems to run processing-intensive applications.

Microcontrollers and Embedded Systems

Microcontrollers and embedded systems are an important and common feature of modern living and electrical engineering. For many devices, the technological problem is not making the desired function work (such a microwave oven, blood glucose meter, or light bulb dimmer) but rather meeting low-cost and low-power needs without giving up performance, durability, or suitability for the intended task [14]. These limitations frequently restrict the engineering computation to an embedded microcontroller. Digital clocks, washing machines, music players, and multimeters are all examples of embedded systems. These systems generally handle tasks that need to be done in real time, like timing and controls, and they connect to the real world through buttons, switches, and displays.

Embedded systems and microcontrollers are what make it possible for many applications to have real-time control systems. These include avionics, chemical process control, computer communications, industrial automation, medical equipment, telecommunications, and many more [15]. These kinds of systems need to be able to connect to the real world. Sensors, actuators, electronics, and peripherals are all examples of devices that may be divided into two groups: start and end. There is a clear and essential difference between the two; in general, an exchange protocol controls how processes talk to each other.

When e-Systems talk to each other, they send Processing Communication Signals (also known as Process Control Signals). Time, actions, and conventions are represented by Calibrated Time Units (CTU), Action-Calibration Sequence (ACS), and Communication Conventions (CC). The first one sets the calculation rate of e-Process State, and the second one works like programming languages with different syntax and grammar. Universal Asynchronous Receiver Transmitter (UART) is the most used serial communication protocol for microcontroller applications nowadays. Bluetooth Low Energy (BLE) technology has become the best choice for many low-power and short-range uses.

Robotics, Sensors, and Automation Systems

Robots and automated systems use several different sensors to get information that controls motion and other activities that are powered by electricity. The type and quantity of sensors depend on the use and the level of accuracy needed. Distance, temperature, pressure, motion, and sound are all common ways to sense things. Measurement devices turn data from these physical factors into electrical signals that can be used for feedback control. Many applications need to know where moveable parts are, which is especially crucial. There are two main types of computer-based control systems that use sensors and actuators: open-loop systems that work based on pre-set information and closed-loop systems that compensate for errors by sending back measurements of the output signal or state.

Research on using sensors to regulate navigation in robots is well-known. Using sensors that measure range, odometry, directional indicators, and other factors, systems have been made that can work in complete darkness or other situations where visual guiding is not possible [16]. The added capacity to detect distance helps avoid obstacles and find a path for autonomous navigation using an RFID-based system and ultrasonic range sensors. The Internet of Things (IoT) lets different computerised devices get data from many sensors. Industrial robots that can gather data is a more advanced equipment design project [17].

NEW MATERIALS AND NANOTECHNOLOGIES

There are still a lot of new ideas and a lot of possibilities, as shown by work done with nanotech [18], for λόγος. A wide variety of novel materials, such graphene and others, as well as the widespread use of nanoparticles, could lead to huge improvements in the efficiency, dependability, multi-functionality, and performance of devices, systems, and materials [19]. For example, the best combination of better reliability, electrical, thermal, and other properties that wide bandgap semiconductors can provide opens up new areas of application that silicon and other materials that have been employed in the past can't reach. The transition from magnetrons and themacore resonators to fully integrated telescopes or generic medium-soaked algorithms that can handle the increased need for bandwidth and monitoring shows how engineering is always changing. The traditional level of innovation is quite high and not close to being used up. Because of this, engineering and science are predicted to keep getting a lot of attention, revealing more unmet needs and making unexpected discoveries easier.

Wide Bandgap Semiconductors and Devices That Work Well

Semiconductors have material properties that are between those of conductors and insulators, and their electrical qualities can be controlled by engineers. Silicon (Si) and germanium (Ge) are standard semiconductors that work at a bandgap of 0.67 to 1.12 eV [20]. Silicon carbide (SiC), gallium arsenide (GaN), diamond, zinc oxide (ZnO), and gallium nitride (GaN) are examples of wide bandgap semiconductors that go above 1.12 eV. These materials, along with new innovation, help meet important goals including better performance, more stability and durability in tough operating circumstances, and being better for the environment. New semiconductors help create new devices and applications that are good for society. Wide bandgap semiconductors make it possible for power switches to work at full power and use less energy even when the temperature rises. They also help silicon-based technology work at higher supply voltages, switching frequencies, and temperatures, which makes the technology last longer. These kinds of features make it possible to use them in electric cars, smart grids, renewable energy systems, and other areas.

Nanostructured Materials for Energy and Sensing

Nanostructured materials for energy conversion, storage, and sensing have garnered significant interest owing to their superior electrochemical performance. Researchers have made enormous arrays of composite nanowires and three-dimensional nanostructures that have benefits such anisotropic charge transfer, a large surface area, and high crystallinity [21]. Even though many different types of nanostructures are being developed quickly, it is still hard to manage their production accurately and consistently. New technologies make it possible to make three-dimensional hybrid structures out of carbon nanotubes, three-dimensional graphene, manganese dioxide, and tungsten trioxide. They also make it possible to make nanowire composite arrays out of SnO2, ZnO, CuO, or Co3O4 [18].

Nanostructured materials are also very important for making sensors. Organic-inorganic hybrid films have certain nanomechanical properties, and layered titanate nanocomposites and hybrid films have been employed to make very sensitive nanocomposite membranes and photonic media for distant sensing [22]. Improvements in organic-inorganic electronics and hybrid sensors have made it possible to sense chemicals, living things, and physical things. Nanotube molecular wires, nanocomposite membranes, and fiber-optic chemical nanosensors are all used to make nanosensors that are very sensitive and selective. Nanotechnology is changing the entire sensor environment, from the creation of solid-state devices to the use of nanotechnology in sensors in many different industries.

NEW WAYS TO MEASURE, SET STANDARDS, AND KEEP PEOPLE SAFE

Inventions and new ideas in electrical engineering have had a huge effect on safety, standards, and measurements. The last two hundred years have seen incredible progress in technology, as well as improvements in how we measure things, set standards, and make sure that electrical and electronic equipment is safe. You can see a lot of changes, but the worry stays the same.

Electrical engineering began to establish itself as a separate science around 1889-1890, when electrical communication was growing quickly and electrical energy was being produced, sent, and used in more and more areas. It became necessary to define the standard units and methods of measuring in the field of electricity. There were already certain parts for measuring, like galvanometers, resistors, and batteries. A scientific and organised way to test and calibrate electrical proposals and equipment was needed [23].

In Electrical Engineering, Metrology

Metrology is the study of measurement, including how to define measurement units, make sure they are accurate and can be repeated, and describe exact measurement procedures. In real-world engineering, meeting these objectives means setting up measurement systems that meet both contract and regulatory standards. National metrology facilities that can trace measurements back to international standards make ensuring that measurement results are accepted around the world [24]. Electrical metrology is very important since electrical engineering depends on measurements a lot. The requirement to set the values of the basic electrical quantities of voltage, current, resistance, capacitance, and inductance led to the invention of electrical metrology. Measurement is an important part of engineering, and being able to measure things well is a sign of being a good engineer. Electrical metrology helps engineers think about their work when they first start out.

The ampere, which is the unit of electric current, is a good example. Mechanical metrology frequently utilises analogue calibration methods, utilising standard weights as benchmarks for the mass to be measured. When it comes to electrical quantities like voltage or power, analogue approaches based on Ohm's law don't work very well because real circuits are complicated and have a lot of factors that affect them. After a short introduction to metrology in electrical engineering and national standards-setting bodies, we will look at the problems that come up when trying to design a standard for measuring current. We will also talk about the ideas that were offered to make the ampere a reality.

Safety, Dependability, and Cyber-Physical Issues

In electrical engineering, metrology, standards, and safety are very important since unreliable systems can lead to big losses of equipment and even lives. Electrical devices and systems are quite advanced and have gotten more complicated throughout time. In the 19th century, most electrical engineering was analogue, but now digital devices are everywhere and are very important to the operation of many systems. In telecoms, they are working on metrological features and a framework for standardising wireless power transfer.

Reliability and safety are often thought of as the same thing because safety is a specific part of reliability that has to do with people. When it comes to electrical and micro-electronic systems, safety has three main parts: hardware reliability, software reliability, and cyber-security. Hardware dependability is about making sure that the design still works even when some parts come loose. The design could be based on having extra copies of important systems or something like that. Electrical engineers often forget just how reliable software is. If two systems are separated and an algorithm is run on both of them, a third system will have to make sure that the sequence of execution is correct. Having one wire attached to only one side might still operate, but if this wire is disconnected, it might not work. This is a good example of what people generally think of as safety. The eventual broadening of design criteria leads to a more significant unboxing of acceptability. These would ideally conduct those algorithm computations in a time-sliced way and yet travel on the whole code. Cyber security is about attacks from outside that put the real control in the wrong hands [25].

CONCLUSION

The collection of inventions and improvements examined in this study encompasses a duration of 250 years. The electricity-related career began with the observation of electric effects in the mid-17th century, following long-standing experimental work on static electricity and a thorough, self-sufficient theoretical framework developed in the early to mid-19th century. These concepts are the basis of modern, consolidated electricity theory. There was also a lot of work focused on performance and the arrangement of electrical equipment on an industrial scale that made it possible for everyone to use it. The semiconductor revolution that followed changed signal processing, computation, information representation, control, and system design in ways that were both similar and different from each other. This led to new ideas in core fields that were not directly related to the inventor's board, and it built on and added to progress in electrical machines and circuits, telecommunications, and power engineering.

The theory of electricity is still very important to electrical engineering because it is the basis for electric energy and information systems. Some people use the broader terms "electrical engineering" or "dialectic exchange" because traditional definitions don't include groundbreaking work in static and electric signal devices done within the field, and because the basic definitions are incomplete, putting electric energy in a second-class position that is then ignored. These types of transmission, called "electromagnetic" or more generally "electrokinetic," are what make telecommunications systems work in everyday life. Still, most people agree that "electric studies" is a good compromise.

Since the 1980s, there have been big advances to hardware that have made it possible to create new types of non-contact control and monitoring. We need to work harder to fully use renewables while keeping modelling and standards for new energy carriers that are compatible with protocols. We also need to improve energy-conversion efficiency for the final uses of energy and create a more general framework to improve control, stability, and acceptance. Every time a new technology comes out, it brings with it new problems that make it harder to use safely and reliably.

REFERENCES

1. Mil'shtein S, Tello S. Innovation as part of electrical engineers education. Current Journal of Applied Science and Technology. 2019 Feb 25;33(1):1-7.
2. Abduvali M, Abdurahmonov T. MOST IMPORTANT INVENTIONS AND FUTURE TECHNOLOGY IDEAS. TADQIQOTLAR. 2026 Apr 3;83(3):53-8.

3. Ramos-Paja CA, González-Montoya D, Trejos-Grisales A, Serna-Garcés SI. Advances in Power and Energy Systems. TecnoLógicas. 2018 Aug;21(42):9-11.
4. Guarnieri M. The development of ac rotary machines [Historical]. IEEE Industrial Electronics Magazine. 2018 Dec 19;12(4):28-32.
5. CAPILLARY E. The Electrical Engineer. The Electrical Engineer: A Weekly Review of Theoretical and Applied Electricity. 1897;24:48.
6. Lee J, Kang T. Structure-based Optical Logics Without Using Transistors. In2020 IEEE International Conference on Consumer Electronics-Asia (ICCE-Asia) 2020 Nov 1 (pp. 1-6). IEEE.
7. Simon M, Slay J. Investigating modern communication technologies: the effect of internet-based communication technologies on the investigation process. Journal of Digital Forensics, Security and Law. 2011;6(4):4.
8. Gisin N, Thew R. Quantum communication. Nature photonics. 2007 Mar;1(3):165-71.
9. Idachaba F, Ike DU, Hope O. Future trends in fiber optics communication. InProceedings of the World Congress on Engineering 2014 Jul 2 (Vol. 1, pp. 2-4). London, UK: WCE.
10. Laplante PA, Cravey R, Dunleavy LP, Antonakos JL, LeRoy R, East J, Buris NE, Conant CJ, Fryda L, Boyd RW, Filanovsky I. Comprehensive dictionary of electrical engineering. CRC Press; 2018 Oct 3.
11. Yadav A, Subedi D, Lundeberg MA, Bunting CF. Problem-based learning: Influence on students' learning in an electrical engineering course. journal of engineering education. 2011 Apr;100(2):253-80.
12. Fekete P, Martin S, Kuhn K. The Sustainability of Integrating Contactless Occasional Charging in Electric Vehicle Material Handling. Studies in Engineering and Technology. 2018 Aug;5(1).
13. Czerwinski F. Aluminum alloys for electrical engineering: a review. Journal of Materials Science. 2024 Aug;59(32):14847-92.
14. Pasricha S. Embedded systems education in the 2020s: Challenges, reflections, and future directions. InProceedings of the Great Lakes Symposium on VLSI 2022 2022 Jun 6 (pp. 519-524).
15. Qing A. Differential evolution: fundamentals and applications in electrical engineering. John Wiley & Sons; 2009 Jul 23.
16. Gueaieb W, Miah MS. An intelligent mobile robot navigation technique using RFID technology. IEEE Transactions on Instrumentation and Measurement. 2008 Apr 18;57(9):1908-17.
17. Al Shahrani AM, Alomar MA, Alqahtani KN, Basingab MS, Sharma B, Rizwan A. Machine learning-enabled smart industrial automation systems using internet of things. Sensors. 2022 Dec 28;23(1):324.
18. Lord SM, Layton RA, Ohland MW. Trajectories of electrical engineering and computer engineering students by race and gender. IEEE Transactions on education. 2011 Jan 13;54(4):610-8.
19. Ivanov LA, Demenev AV, Muminova SR. The inventions in nanotechnologies as practical solutions. Part II. Nanotekhnologii v Stroitel'stve. 2019;11(2):175-85.
20. Jiya IN, Gouws R. Overview of power electronic switches: A summary of the past, state-of-the-art and illumination of the future. Micromachines. 2020 Dec 16;11(12):1116.
21. Olin R, Vågerö D, Ahlbom A. Mortality experience of electrical engineers. British journal of industrial medicine. 1985 Mar;42(3):211.
22. Kaushik A, Kumar R, Jayant RD, Nair M. Nanostructured gas sensors for health care: an overview. Journal of personalized nanomedicine. 2015 Jul 27;1(1):10.
23. Etukudoh EA, Fabuyide A, Ibekwe KI, Sonko S, Ilojianya VI. Electrical engineering in renewable energy systems: a review of design and integration challenges. Engineering Science & Technology Journal. 2024 Jan;5(1):231-44.
24. Elmquist RE, Cage ME, Tang YH, Jeffery AM, Kinard Jr JR, Dziuba RF, Oldham NM, Williams ER. The ampere and electrical standards. Journal of research of the National Institute of Standards and Technology. 2001 Feb 1;106(1):65.
25. Faza AZ, Sedigh S, McMillin BM. Reliability analysis for the advanced electric power grid: From cyber control and communication to physical manifestations of failure. InInternational Conference on Computer Safety, Reliability, and Security 2009 Sep 15 (pp. 257-269). Berlin, Heidelberg: Springer Berlin Heidelberg.

