Asian Journal of Applied Science and Technology (AJAST)
(Open Access Quarterly International Journal) Volume 1, Issue 9, Pages 151-153, 2017

Potential Research Trends in Electrical Engineering

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Electrical engineering caters to various challenges encountered in electrical energy generation, distribution and utilization. The field covers a variety of sub-disciplines that deal with power engineering, optoelectronics, digital & analog electronics, instrumentation, artificial intelligence, control systems, signal processing, telecommunications, computer engineering, and microelectronics. Many of these sub-disciplines overlap within selves and are inter-disciplinary too, straddling a large number of research prospects such as hardware engineering, power electronics, electromagnetics & waves, microwave engineering, nanotechnology, electrochemistry, renewable energies, mechatronics, electrical materials science, and many more. [1]

Control Systems Engineering deals with the regulation of dynamical systems in different processes and machines. The objective is to develop a control model such that it commences a response to any stimuli in an optimum manner immediately and ensuring a stable operation. The classical controllers were of PI and PID type, which are slowly being replaced by modern controllers based on *Artificial Intelligence* (AI).The AI is sub-categorized into three main branches: Artificial Neural Networks, Fuzzy Inference Systems and Nature Inspired Optimization Techniques like Genetic Algorithms, Particle Swarm Optimization, Ant Colony Optimization, etc. These methods find there applicability in almost every aspect of engineering and can be a vital area of research for any research aspirant. [2]-[4]

Electrical machines deals with various rotating machines like synchronous machines, DC machines, induction machines. Lately, some new rotation machines been introduced like the Permanent Magnet Synchronous Machines, Brushless DC machines, Switched Reluctance Machines. Thus, designing of these machines is a good research field or the speed controller designing using the modern control techniques can be a good alternate. [5]-[6]

Power Systems deals with the generation, transmission and distribution of electrical power over the geography. Abstractly, electrical engineering is all about power system. It is an ocean with innumerous research topics few of which are enlisted below:

- Power Quality
- Harmonic Analysis, Harmonic State Estimation and Observability, Marginal Pricing of Harmonics
- Power Conditioning
- Computer Analysis of Power Systems
- more efficient Algorithm for Load Flow Studies
- Fault Analysis

 Online ISSN: 2456-883X Impact Factor: 0.825 Website: www.ajast.net

- Electromagnetic Transient Analysis
- Mixed time-frame Analysis
- Power Electronic Systems
- HVDC Transmission
- FACTS and Custom Devices
- Frequency Domain Modelling of Large Power Electronic Circuits
- Deregulation and its market performance evaluation
- Network Operation Optimization. [7]-[8]

Power electronics is one of the modern day subjects of electrical engineering that has witnessed scores of advancements in past few decades. Power electronics is a fusion of power engineering, analog electronics, semiconductor devices and control systems. Electrical energy needs to be transformed into a tangible form of energy such as motion, light, sound, heat etc. In order to regulate these forms of energy, an effective way is to regulate the electrical energy itself and this forms the content of the subject power electronics. Majorly there are five types of power electronic circuits, each having different purpose:

Rectifiers - converts fixed AC to variable DC
Choppers - converts fixed DC to variable DC
Inverters - converts DC to AC having variable amplitude and variable frequency
AC Voltage Controllers - converts fixed AC to variable AC at same input frequency
Cycloconverters - converts fixed AC to AC with variable frequency.

Below are enlisted some research topics in this domain:

- Designing new converter topologies like SMPS (flyback converters), MLI, Choppers, etc.
- Matrix converters
- Fabrication of new power semiconductor devices
- Designing converters for machines such as SRM, PMSM, and BLDC.
- Harmonics reduction.
- Designing inverters and converters for solar and wind systems. [9]-[10]

Renewable Energy deals with the generation of electricity from alternate sources like sun, tides, wind, geothermal, hydro, biomass and waves. To accentuate, India is the fifth largest power generation portfolio in the world. At present, 44.81 GW is contributed by the renewable sources, which includes 27.44 GW by wind and 8.06 GW by solar. India is ambitiously targeting to achieve 175 GW of renewable power by 2022, which will include 5 GW from small hydropower, 10 GW from biomass power, 60 GW from wind power and 100 GW of solar power. Thus, this domain features numerous research topics like design of induction generators, more efficient power converter

units between the renewable sources and the grid, design and study of stand-alone systems for rural areas, efficient Maximum Power Point Tracking systems for solar and wind. [11]-[13]

One very hastily evolving realm is the ***Internet of Things*** (IoT). Kevin Ashton of Procter & Gamble coined the term "Internet of things" in 1999. IoT is the interconnections of physical devices like automobiles, smart homes, sensors and actuators through internet thereby enabling these objects accessible remotely anytime and exchange information for good. Each individual object is distinctively detectible through internet via its embedded computing system. This is accomplished by using the standard 6LoWPAN. Thus, it allows a vast number of smart entities to communicate using the humongous address space of IPv6 for information and data garnering through the Internet. This as a result, has instigated a new era of automation in industries like Transportation, Hospitality, Smart Buildings, Defense and Agriculture. Nonetheless, Security still encumbers the development and applications of IoT.[14]

Few other domains worth mentioning are electric vehicles, electric traction, robotics, smart grids, microcontroller technology, FPGA's, reducing carbon footprints in electricity generation, Wireless Power Transfer in 3D Spaces, High Voltage Direct Current by Marx Generator Principles, Space Vector Pulse Width Modulation.

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