C.H. MOHAMMED KOYA
KMEA ENGINEERING COLLEGE
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KRCC
KMEA
RESEARCH AND CONSULTANCY COUNCIL

"Science may set limits to knowledge, but should not set limits to imagination"
- Bertrand Russell

TECHNO-VIBES: THE TECHNICAL ARTICLES

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Kerala Muslim Educational Association

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Message from Director

It is a matter of great pride and utmost satisfaction for our college to bring out the online technical magazine: Techno-vibes under KMEA Research and Consultancy Council (KRCC). The college has crossed many milestones, targeting to become a centre of excellence in the field of technical education. Very recently, the college has been accredited by the National Assessment and Accreditation Council (NAAC).

I am confident that this technical magazine will provide a platform for both the staff and students of the college to showcase their academic and research activities and help them to develop and enrich the writing skills of students in particular and teaching faculty in general.

I express my sincere gratitude to Dr Sangeetha C P, Coordinator-KRCC for her sincere effort to take the lead role and accomplish the task of releasing the first issue of this biannual technical magazine within the stipulated time. I appreciate the efforts put in by the editorial board to bring out this technical magazine in record time. Also, I render my heartfelt congratulations to the faculty members for their contribution to the first issue of the magazine.

Best wishes!

Dr Amar Nishad T M
Principal & Director

Message from Vice Principal

It is a pleasure for me to see the initiative taken by KRCC to present the first issue of the online technical magazine, "Techno-vibes". This magazine will definitely provide a platform for staff to share their technical knowledge, thereby creating a technically trained community. The college has been simply unstoppable in its progress as it has been actively involved in providing quality education.

My appreciation to the team who took the responsibility for the arduous task most effectively. Reading this magazine would definitely be an inspiration and motivation for all students and staff to contribute even more to the forthcoming issues. I hope that everyone will continue to work hard to keep the momentum going and to raise the magazine's standards.

Dr. Rekha Lakshmanan
Vice Principal

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Role of Technical Education in India

Dr. Amar Nishad T M
Principal & Director, KMEA Engineering College

Engineers form the backbone of any country. India takes pride in our engineers who graduate from the numerous engineering colleges in our country every year. In fact, it is estimated that 25 percent of the world's engineers today are from India. However, it is disappointing to note that we cannot boast about the research and innovation undertaken by our engineers and organizations in a similar fashion. The reality is that we are far behind other countries in the areas of research and innovation despite producing a major chunk of the engineers across the world.

Globally there is a notable shift from the conventional teaching practices to a student-centric teaching learning process which centers on an outcome and experience based learning with content based learning getting replaced by technology empowered learning and teachers thus becoming facilitators. It's a sad reality that our country is more inclined to the conventional teaching processes to a huge extent and has failed to keep up with the global shift in perspectives related to teaching and learning in the field of engineering education. For us, it's still a work in progress; however, we are steadily catching up with the pace and finally embracing change and making commendable efforts in raking up research and innovation in the engineering sector of our country. We have miles to go to achieve the global benchmarks of excellence in these areas; however, the giant strides and achievements we have made in the recent years instil in us a great sense of confidence that engineering education in the country is in the path of reforms and it augurs well for the thousands of aspiring engineering students in the country.

As the Covid-19 pandemic accelerates the speed and scale of digital transformation, emerging technologies such as artificial intelligence, machine learning, big data and automation, among others, are revolutionising the way businesses run and almost all industries have been influenced by digitisation in one way or another and the role of engineers in the country has been redefined like never before. The country and the world are seeing a new demand for technology, products and materials. These trends are very reassuring and promise a bright and prosperous future for the budding engineers in the country. An engineering degree will be soon in high demand again and will offer exciting career options to the young engineers in the immediate future.

With these promising trends setting in, the future of Indian engineering education is indeed looking bright. However, to make full use of the opportunity that unfolds in front of us, we need to have solid plans in place to overcome any fundamental drawbacks in our

teaching and learning process as discussed initially. We need to move away as much as possible from the chalk and board teaching process towards the latest technology-driven and outcome based teaching techniques. Lessons should be made more interactive and students should be engaged in an interactive learning environment to make them more interested in the various fields and possibilities of engineering. Syllabuses and curriculums should reflect the rapidly changing trends of engineering and more emphasis must be given to the latest technologies embracing the industry. This is very important in ensuring our budding engineers will be employable in the rapidly changing job market once they graduate. We also need to set a culture of research and innovation among our students as we would definitely need to rely on them in the future years to spearhead innovation and research in our country. All these and more will be possible if our engineering education sector quickly embraces the changes as discussed. The future of the engineers and our engineering sector is indeed looking bright and the renewed interest shown by students and their parents in pursuing engineering education in recent years is a very good sign and signifies the arrival of a new engineering era in our country!

Jetson Nano – A Developer Kit for AI

Dr. Rekha Lakshmanan
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A Software Development Kit (SDK) is a collection of software development tools in one installable package. SDKs let developers use them to build applications for specific platforms. Software development toolkits allow developers to add functionality to their applications and enable them to build the standard components of their apps easier and faster.

The NVIDIA Jetson Nano Developer Kit is a small, powerful computer that lets makers, learners, and developers run Artificial Intelligence (AI) frameworks and models in parallel for applications like image classification, object detection, segmentation, and speech processing. It runs multiple neural networks in parallel and processes several high-resolution sensors simultaneously. The NVIDIA Jetson Nano Developer Kit delivers the performance to run modern AI workloads in a small form factor, power-efficient (5W) and at low cost. Jetson Nano Developer Kit brings the power of modern artificial intelligence to a small, easy to use platform. NVIDIA recommends that the Jetson Nano Developer Kit should be powered using a 5V/2A to 3.5A micro-USB power supply. Jetson Nano supports many popular AI frameworks like TensorFlow, Caffe, MXNet, and PyTorch. Figure 1 depicts various parts of the Jetson Nano.

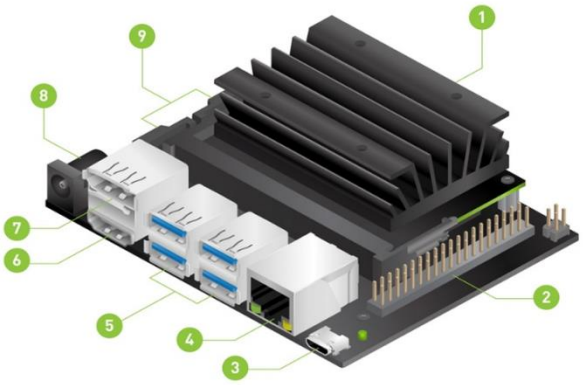

Fig 1. Jetson Nano Developer Kit

1. MicroSD card slot for main storage
2. 40-pin expansion header
3. Micro-USB port
4. Gigabit Ethernet port
5. USB 3.0 ports (x4)
6. HDMI output port
7. Display Port connector
8. DC Barrel jack for 5V power input
9. MIPI CSI-2 camera connectors

To start working with the kit, insert a microSD card with the system image, boot the developer kit, and begin using the same NVIDIA JetPack SDK used across the entire NVIDIA Jetson family of products. JetPack is compatible with NVIDIA's world-leading AI platform for training and deploying AI software, reducing complexity and effort for developers. All Jetson products are supported by NVIDIA software libraries such as CUDA, cuDNN, and TensorRT for accelerated AI applications. The official operating system for the Jetson Nano and other Jetson boards is called Linux4Tegra, which is actually a version of Ubuntu 18.04 (designed to run on Nvidia's hardware).

The Jetson Nano is built around a 64-bit quad-core Arm Cortex-A57 CPU running at 1.43GHz alongside NVIDIA Maxwell architecture GPU with 128 CUDA cores capable of 472 GFLOPs (FP16), and has 4GB of 64-bit LPDDR4 RAM onboard along with 16GB of eMMC storage and runs Linux4Tegra. The 70 × 45 mm module has a 260-pin SODIMM connector which breaks out interfaces including video, audio, USB, and networking, and allows it to be connected to a compatible carrier board. There's also a Barrel jack for powering supplies up to 4A. To power the device using the barrel jack or using the 5V bins on the expansion header, a jumper can be placed. It will disable power via micro-USB and enable the other sources. This camera connector supports IMX219 camera modules, including the Raspberry Pi camera module. There is an M 2 Key E connector for wireless networking and a micro-SD card slot on the underside of the module. The module comes with a passive heat sink supporting the default 10W module power budget at 25^0C ambient temperature. An additional cooling is possible by attaching a 40mm PWM fan to these mount points on the heat sink and connecting its cable to this fan control.

The primary features of the Raspberry Pi 4 and NVIDIA Jetson Nano are similar. Compared to the Raspberry Pi 4B Jetson Nano is expensive. But Jetson Nano has a much more capable GPU than the Raspberry Pi 4 which makes it more suited for AI, Machine Learning and IoT applications because of the availability of CUDA cores, GPU and multiple video encoders and decoders.

"Jetson Nano makes AI more accessible to everyone — and is supported by the same underlying architecture and software that powers our nation's supercomputers. Bringing AI to the maker movement opens up a whole new world of innovation, inspiring people to create the next big thing." — Deepu Talla, VP and GM of Autonomous Machines, NVIDIA.

References

1. Cass, S. (2020). Nvidia makes it easy to embed AI: The Jetson nano packs a lot of machine-learning power into DIY projects-[Hands on]. *IEEE Spectrum*, *57*(7), 14-16.
2. Nvidia Jetson Nano Developer Kit. *https://developer.nvidia.com/embedded/jetson-nano-developer-kit*

Early Detection of Cancer Cells Using MEMS

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The diagnosis of diseases like cancer generally requires a biopsy. However, this is a procedure which is invasive, where prognosis is minimum. MEMS-based micro fluidic channels can be used to screen and recognize different cells depending on the size and various characteristics of the cells (Syed et al., 2020). Accuracy in analysis is in need of new technologies such as micro arrays to trace susceptibility and severity levels. Genomics analysis requires sophisticated instruments in large numbers and highly trained personnel for analysis of data with respect to the high number of people who have cancer. As an alternative method, physio chemical changes that occur during illnesses like cancer can be analyzed by making use of procedures that are non-invasive. Cancer in Lungs is one of the many illnesses that can be diagnosed by means of analyzing volatile organic compounds exhaled by the patient. Volatile organic compounds like methyl pentane, hexane and benzene derivatives such as aniline and *toluene* have been used as lung cancer biomarkers many times. This technology can replace the use of X-rays which do not show illness manifestation until a tumor has formed and grown.

Medical oncologists may be able to give a good explanation about the several stages that intervene between the carcinogenic stimuli. Oncologists must be highly competent and efficient to diagnose at an early stage, exclude healthy cells from cancer cells, and treat cancer. A micro gripper could be used for mechanical properties' characterization of circulating tumor cells (CTCs) (Moncada et al., 2018).

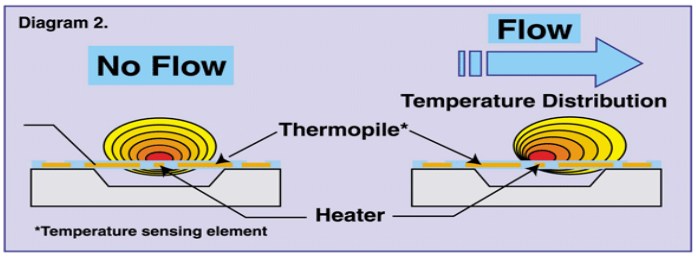

Fig 1. Thermal Expansion Sensor heat flow

Advanced MEMS based optical fiber endoscopy can provide cellular and molecular features with deep tissue penetration enabling guided resections and early detection of cancer cells to help in giving better treatment (Qiu and Piyawattanamatha, 2017). The growing demand for mutation analysis tool has stimulated intensive research in the field of high throughput analytical methods.

The subsequent development of capillary electrophoresis methods in the past decade has brought out innovative ideas that became essential for sequencing the human genome. The use of capillary electrophoresis with laser-induced fluorescence detection has been found to reduce analysis time and increase detection sensitivity when compared with conventional electrophoresis methods. An early detection of cancer is very essential for successful treatment of cancer with a positive long-term prognosis. Molecular imaging is often performed using radioactive isotopes. Their dosage is limited by toxicity and then given to critical organs such as liver and heart. The challenge in minimally invasive therapies like coagulative therapy and thermal ablation, Brachytherapy and photodynamic therapy remains as the localization of the treatment dose to the tumor while sparing nearby critical healthy tissues. The clinical potential of high-speed optical-sectioning microscopic devices helps in validating measurements with reflective targets, as well as in-vivo and ex-vivo images of tissues' demonstration (Yin et al., 2016).

Thermal Expansion Method for Detection of Tumors

Whenever there is a change in temperature of any substance, the stored energy in the intermolecular bonds between atoms changes. Whenever there is an increase in stored energy, the length of the molecular bonds increases. So solids typically expand in response to heating and contract on cooling. This response to temperature change is expressed by its coefficient of thermal expansion. Thermal expansion analysis is a common method used in the micro scale to displace a part of a component, as in an actuator. A device with a minimum of thermal expansion could be included in a micro gyroscope or any other sensor for acceleration or positioning. The model consists of a thermal balance with a heat source in the device originating from Joule heating (ohmic heating). This principle is applied in early cancer detection as shown in Figure 1.

Early Detection of Lung Cancer (Tumor)

The lung cancer (tumor) causes major issues during breathing. In non-invasive methods, the early detection of such issues involves detection of available biomarkers in exhaled breath at ppb level (Kumar, 2019). The reason is that during inhalation and exhalation tumors will move along with the lungs. It is hard to focus on the tumor while applying dose to the affected part. It is also important that the dose applied should not affect the normal lung tissue. In recent years, methods have been developed to account for respiratory motion in real time. Real-time tumor tracking and gated radiation therapy are examples. To understand the breathing dynamics deeply, it is necessary to model the structure of lungs. In medical diagnosis a tumor can be detected using various tests but all tests fail to explain lung structure during inhalation and exhalation. To overcome this issue we use sensors to investigate the motion of lungs. MEMS INTELLISUITE software can be used to model and design a thermal expansion sensor which helps to detect tumors in lungs during breathing.

References

1. Syed, Shameem., RamaKrishna, T. V., Sahithi, M., Rohitha, B., Keerthana, J., Hasane, Ahammad Sk., Srinivas Babu, P. S., & Saikumar, K. (2020). Design of MEMS-based Microfludic Channel to Detect Cancer Cells in Blood. *International Journal of Research in Pharmaceutical Sciences*, *11*(1), 561-566.
2. Kumar, R. (2019). MEMS based cantilever biosensors for cancer detection using potential bio-markers present in VOCs: A Survey. *Microsystem Technologies*, 1-15.
3. Velosa-Moncada, L. A., Aguilera-Cortés, L. A., González-Palacios, M. A., Raskin, J. P., & Herrera-May, A. L. (2018). Design of a novel MEMS micro gripper with rotatory electrostatic comb-drive actuators for biomedical applications. *Sensors*, *18*(5), 1664.
4. Qiu, Z., & Piyawattanamatha, W. (2017). New endoscopic imaging technology based on MEMS sensors and actuators. *Micro machines*, *8*(7), 210.
5. Yin, C., Glaser, A. K., Leigh, S. Y., Chen, Y., Wei, L., Pillai, P. C. S., ... & Liu, J. T. C. (2016). Miniature in vivo MEMS-based line-scanned dual-axis confocal microscope for point-of-care pathology. *Biomedical optics express*, *7*(2), 251-263.

Electromagnetic Compatibility- The need of the era

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The use of electronic gadgets is increasing exponentially all over the world. Rapid growth in the use of personal communication systems such as mobile phones, laptops and the very large user base for network systems such as the internet have increased the possibility of Electromagnetic Interference EMI leading to malfunctions. This rapid growth of electronic devices in all areas of engineering, technology and consumer products makes Electromagnetic Compatibility **(**EMC) design a critical part of electronic design nowadays. Every industry focuses on electronic systems with high levels of integration with decreasing size. This may lead to a huge risk of failure due to electromagnetic interference. This is not only important for common products such as radios, television sets, computers, telephones, washing machines, mobile phones, etc ,but it is also especially important for complex products such as vehicles, aircraft, ships, and large industrial installations.

Electromagnetic Interference (EMI): Electromagnetic Interference (EMI) is an unwanted disturbance in the electronic system due to electromagnetic radiation or electromagnetic conduction. Conducted EMI requires a physical electrical connection between the affected devices and the noise signal source for its transmission, while radiated EMI propagates through air or space without the need for any physical electrical connection between the noise signal source and the affected devices. The source of EMI can be divided into two parts, man-made and natural. In natural EMI sources, natural phenomena like lightning and static radiation, from the sun and galactic sources such as radio stars, galaxies are the main causes. The man-made EMI sources are produced by a number of different classes of electrical and electronic equipment. Man-made EMI receptors can be divided into categories like communication electronic receivers, amplifiers, industrial etc. The electromagnetic emissions that have the ability to cause interference in electrical and electronic devices are intentional or unintentional (Paul, 2006).

Electromagnetic Compatibility (EMC): EMC, or Electromagnetic compatibility means that a device is compatible with its electromagnetic environment and it does not emit levels of EM energy that cause EMI in other devices in the vicinity. Measurement of EMC requires the use of proper instrumentation, specific measurement procedures, and particular sites for making reliable radiated emission and immunity tests. All electronic devices must conform to the standards of electromagnetic emission set by different bodies in different countries (Paul, 2006).

A system is electromagnetically compatible if it satisfies three criteria (Paul, 2006):

1) It does not cause interference with other systems.
2) It is not susceptible to emissions from other systems.
3) It does not cause interference with itself.

EMC Standards: The EMC standards are required to provide knowledge about EMI to the users, as users have limited knowledge about EMI. They are also required to establish harmonized standards to reduce international trade barriers and to improve product reliability and the life of the product. The EMC standards ensure good product life and profit by providing a design safety margin.

The EMC standards may be Military standards or Civilian Standards. Military EMC standards are made in order to ensure system-to-system compatibility in the real time military environment. The civilian EMC standards are applicable for equipment used for commercial, industrial and domestic applications. The emission standards are specified to protect the broadcast services from interference (Impact Series, IIT Delhi).

EMC design can be approached either through a crisis approach or a systems approach. In the crisis approach, the designer will deal with EMC only when a problem exists after finishing the design of the product. The Crisis approach is expensive and is undesirable. In the systems approach, the designer considers EMC problems at the beginning of the design process, which is a cost effective approach (Impact Series, IIT Delhi). Designing for EMC is a long process that starts early in the life cycle and proceeds through the testing stage and even in the post-production stage. Therefore, EMC is a concern for engineers at all phases of the development of an electronic system. And also, EMI problems with medical devices can be very complex, not only from the technical standpoint but also from the view of public health issues and solutions.

EMI measurement: The scheme of the experimental setup to evaluate the effects of the electromagnetic signals generated by a UWB system on IEEE 802.11a/b systems is shown in Figure 1.The radio signals of IR and MB-OFDM UWB systems are taken as disturbance sources, and IEEE 802.11a/b wireless systems are taken as victim systems (Manzi et al., 2009).

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Fig.1. Scheme of the EMI produced by UWB radio (Manzi et al., 2009).

The communication channel attenuation depends on both obstacles and the separation distance between the narrow-band transmitter and the receiver. The results of these studies have led to a definition of the typical operational conditions as the relationship between distance (meters) and attenuation (decibels). The EMI measurement setup using a conducted coupling test is shown in Figure 2.

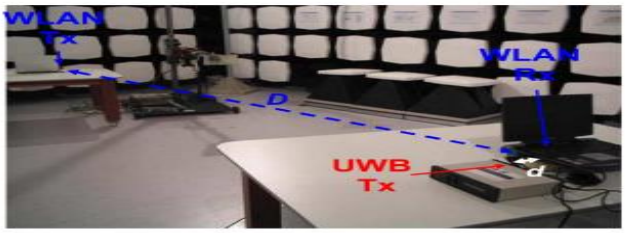

Fig 2. EMI measurement setup (conducted coupling test) (Giuliano Manzi et al., 2009).

There are different types of probes like E-field probes and H- field probes which are useful for measuring EMI. Probe designer focuses on enhancing the sensitivity and spatial resolution, discriminating against unwanted field components, and obtaining slow impedance variation over the operating frequency band.

References

1. Paul, C. R. (2006). *Introduction to electromagnetic compatibility* (Vol. 184). John Wiley & Sons.
2. Impact Series. Electromagnetic Interference and Compatibility, IIT-Delhi, Modules 1-9.
3. Manzi, G., Feliziani, M., Beeckman, P. A., & van Dijk, N. (2009). Coexistence between ultra-wideband radio and narrow-band wireless LAN communication systems—part II: EMI evaluation. *IEEE Transactions on Electromagnetic Compatibility*, *51*(2), 382-390

Indoor Air Pollution – The Silent Killer

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Indoor Air Quality (IAQ) has gained much attention in recent years, mainly due to the large amount of time we spend indoors in modern times. Over the last four decades, most of the air quality management programmes have been targeted only to regulate outdoor air pollution and Indoor Air Pollution (IAP) has typically under-reported and less regulated than its counterpart. Most people are aware that outdoor air pollution can impact their health, but indoor air pollution can also have significant, harmful effects. The U.S. Environmental Protection Agency (U.S. EPA) studies of human exposure to air pollutants indicate that indoor pollutant concentrations may be two to five times and occasionally more than 100 times higher than outdoor levels. Comparative risk studies conducted by the EPA have consistently ranked IAP among the top five environmental risks to public health. The World Health Organization (WHO) has reported IAP as the 8th most important risk factor and responsible for 2.7% of the global burden of ill health measured as disability adjusted life years (DALYs). Every year, IAP is responsible for the death of 1.6 million people in the world. In developing countries, indoor smoke is responsible for an estimated 3.7% of the overall disease burden, making it the most lethal killer after malnutrition, unsafe sex and lack of safe water and sanitation (WHO, 2002). The Global Burden Disease study 2010, published recently, found that household air pollution (HAP) from solid fuels accounted for 2.6-4.4 million deaths and 3.4–5.3% of global DALYs (Lim et al., 2013).In India, approximately 1.04 million premature deaths and 31.4 million DALYs to be attributable to HAP, and account for 6% of the total national burden of disease (IHME, 2013).

The origins of poor IAQ issues are well known. In the early 1970s, public recognized the importance of energy saving because of severe energy crisis, across the world. As a result, the buildings built since then are more airtight and use a great deal of insulation materials to minimize the loss of energy through the building envelope. Fresh air is reduced in air conditioning systems in order to reduce the energy consumption. Meanwhile, economic growth and urban development changed people's lifestyles and the usage of synthetic materials and chemical products (e.g., building materials, furnishings, carpeting and decorating materials) has increased in the indoor work environment. Technological changes have made copiers, printers, computers, etc., more common in office buildings. The combination of low ventilation rates and the presence of numerous synthetic chemicals results in elevated concentrations of indoor volatile organic compounds (VOCs), bacteria, fungi and dust.

In developed countries, the major contributor of poor IAQ is low ventilation rate, emissions from building materials and furnishings, and improper maintenance and operation of building ventilation systems. In the developing world, the types, sources, concentrations of various indoor air pollutants, and their exposure profiles are significantly different from the developed world. People in developing countries are exposed to high concentrations of indoor air pollutants due to the usage of biomass fuels for cooking (Colbeck et al., 2010; Lim et al., 2013). Exposures to indoor air pollutants and their sources vary over a wide range in different regions of the world, and they are closely linked to socioeconomic developments.

Exposure to indoor air pollutants can cause infections, lung cancer, and chronic lung diseases such as asthma. In addition, it can cause headaches, dry eyes, nasal congestion, nausea and fatigue. There is consistent evidence that exposure to IAP increases the risk of pneumonia, acute lower respiratory infections (ALRI), chronic obstructive pulmonary disease (COPD), cataracts and tuberculosis. On the basis of the limited available studies, there is tentative evidence for an association between IAP and adverse pregnancy outcomes, in particular low birth weight, ischaemic heart disease and nasopharyngeal and laryngeal cancers (WHO, 2004). According to the World Health Report 2002, about 35% of ALRI, 21% of COPD and 3% of cancers of the trachea, lung and bronchus are caused by exposure to IAP. The COPD and lung cancer are the main causes of death associated with IAP in China, whereas ALRI accounts for more than 80% of the deaths and DALY's lost in India (WHO, 2002). Poor IAQ will not only affect health but also the productivity and morale of the occupants. The consequences include the loss of concentration and an increase in absenteeism which gives rise to direct and indirect financial losses associated with medical costs, material and equipment damages.

References

1. Mao, G., Fidan, B., & Anderson, B. D. (2007). Wireless sensor network localization techniques. *Computer networks*, *51*(10), 2529-2553
2. WHO (2002). The world health report 2002: reducing risks, promoting healthy life. World Health Organization, Geneva, Switzerland.
3. Lim, S. S., Vos, T., Flaxman, A. D., Danaei, G., Shibuya, K., Adair-Rohani, et al. (2013). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The lancet*, 380(9859), 2224-2260.
4. IHME (2013). Institute for Health Metrics and Evaluation, Human Development Network, The World Bank. The Global Burden of Disease: Generating Evidence, Guiding Policy – South Asia Regional Edition. Seattle, WA.
5. Colbeck, I., Nasir, Z. A., and Ali, Z. (2010). The state of indoor air quality in Pakistan—a review. *Environmental Science and Pollution Research*, 17(6), 1187-1196.
6. WHO (2004). Indoor air pollution, health and the burden of disease. World Health Organization, Geneva, Switzerland

Digital Twin

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Digital twins refer to computerised companions of physical assets that can be used for various purposes. Digital twins use data from sensors installed on physical objects to update the representation of reality based on a mathematical and statistical model. The digital twin is meant to be an up-to-date and accurate copy of the physical object's properties and states, including shape, position, gesture, status and motion.

Consider a manufacturing unit where the operations manager remotely monitors the unit. The products, processor technology are constantly being tracked for any issues while sitting miles away. Digital Twin technology helps to accomplish this process. The physical object, processor a system for various purposes is represented in a digital or digital instantiation. It includes the virtual model of the physical object, data from the object, a unique one-to-one correspondence to the object and the ability to monitor the object. This pairing of the virtual and physical worlds allows analysis of data and monitoring of systems to mitigate problems before they even occur, prevent downtime, develop new opportunities, and even plan by using simulations. The various processes involved in this technology are shown in Figure 1.

Fig 1.The Digitalized Process

With the help of all this information, Digital Twin can perform tasks like (Maulshree et al., 2021):

- In-depth analysis of physical twins;
- Designing and validating new or existing products or processes;
- Simulating the health conditions of a physical twin;
- Increasing the safety and reliability of the physical twin;
- Optimization of a part, product, process, or production line;
- Tracking the status of the physical twin throughout its lifetime;
- Predicting a physical twin's performance;
- Real-time control over the physical twin.

A digital twin is an integrated multi-physics, multiscale, probabilistic simulation of an as-built vehicle or system that uses the best available physical models, sensor updates, fleet history, etc., to mirror the life of its corresponding flying twin (Glaessgen and Stargel, 2012), as defined by the National Aeronautical Space Administration (NASA).

The healthcare sector is one of the areas for the application of Digital Twin technology. The growth and developments in technology in healthcare are unprecedented as the once impossible is becoming possible. One future application is a digital twin of a human, giving a real-time analysis of the body. A more realistic current application is a digital twin used for simulating the effects of certain drugs. Another application sees the use of a digital twin for planning and performing surgical procedures (Fuller et al., 2020). An example from the health care sector is shown in Figure 2.

Fig 2. Digital Twin in Healthcare

References

4. Maulshree Singh, Evert Fuenmayor, Eoin P. Hinchy, YuansongQiao, Niall Murray and Declan Devine (2021). Digital Twin: Origin to Future. Applied System Innovation,4,36.
5. E. Glaessgen and D. Stargel (2012, April).The Digital Twin Paradigm for Future NASA and U.S. Air Force Vehicles. 53rd AIAA Structures, Structural Dynamics and Materials Conference, (Honolulu, Hawaii), American Institute of Aeronautics and Astronautics.
6. Aidan Fuller, Zhong Fan, Charles Day and Chris Barlow (2020). Digital Twin: Enabling Technologies, Challenges and Open Research. IEEE Access.

Crucial Analysis of Novel Half Controlled Random Frequency Inverted Sine Carrier PWM for Three Phase VSI

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The Pulse Width Modulation inverter has been the foremost choice in power electronics for decades, because of its circuit simplicity and rugged control scheme. It is generally accepted that the performance of an inverter with any switching strategy can be related to the harmonic content of its output voltage (Mahesh A Patel et al., 2009). The harmonic content of the three phase inverter can be reduced by employing Pulse Width Modulation (PWM). Sinusoidal PWM (SPWM) is effective in reducing the lower order harmonics in the output voltage of the inverter by modulating the width of the pulses. However, the fundamental amplitude in the SPWM output waveform is smaller than for the rectangular waveform. So that it exhibits poor performance with regard to maximum dc power utilization. The heart of any PWM inverter scheme is undoubtedly the switching strategy used to generate the switching edges of PWM control waveform. The important inverter characteristics desired by the switching strategy in a PWM technique include: 1.Good utilization of DC supply voltage, 2. Linearity of the voltage control, 3. Low amplitudes of the low-order harmonics of the output voltage, to minimize the harmonic content of the output voltage/current, 4. Low switching losses in the inverter switches. 5. Sufficient time allowance for proper operation of the inverter switches and control system. A superior trade-off between conflicting requirements 3 and 4 is particularly important. Amplitudes of the lower order harmonics can be reduced by increasing the number of switching per cycle. But this can also increase the switching losses of the inverter. Thus, the quality of the output waveform of the inverter can be increased at the expense of dc power utilization.

The PWM technique can be divided into two groups based on the boundary of carrier amplitude and the number of references (Lei Bo et al., 2013). Bipolar PWM is the one, in which the boundary of the carrier from -1 to +1 and single reference has been used. Unipolar PWM carrier boundary from 0 to 1 and two references (positive reference, negative reference) have been used. While comparing these two, it can be observed that the bipolar PWM gives better harmonic reduction than the unipolar PWM. But unipolar PWM gives a better modulation control index resulting in higher fundamental amplitude, especially for the lower range of modulation index (ma) attracts drive applications where low speed operation is required.

The PWM method can move unwanted frequency components to a higher frequency region, i.e., the sidebands of a carrier frequency. Thus the output waveform of a PWM inverter

is generally improved by using a high ratio between the carrier frequency and the required output fundamental frequency. The proposed generated waveform is shown in Figure 1.By randomly varying consecutive switching periods, aperiodic switching patterns are generated, and part of the harmonic power is shifted to the continuous spectrum of the output voltages (Young-Cheol et al., 2010). The random PWM techniques have been found to alleviate undesirable acoustic, vibration and electromagnetic interference effects in PWM inverters fed ac drives (Zheng Wang et al., 2008-Jayamala V et al., 2011).Digital implementation of proposed work is shown in Figure 2.

The Shape of the carrier waveform is also a significant factor, which influences the variation of the bandwidth of the pulses. Inverted sine carrier is the carrier which gives maximum fundamental compare with the conventional triangular carrier SPWM (Nandhakumar R. and Jeevananthan S, 2007). The aim of this paper is to add the benefits of inverted sine carrier PWM having the maximum width of the pulses for the particular modulation index and the benefits of randomly varying switching frequency which helps to distribute the clusters of higher order harmonics centered about multiples of switching frequency (fsw) in the frequency spectra of output voltage and current. Based on that new random frequency, inverted sine carrier based half controlled (reference like bipolar(-1 p.u to +1 p.u), carrier amplitude like unipolar(0 to +1 p.u)) sinusoidal PWM method is proposed, which provides the better spectral quality, minimizes the total harmonic distortion and enables better dc link utilization. The switching strategy of this method has been implemented by using VHDL language simulated by ModelSim SE Plus 6.3f digital simulator. Crucial harmonic analysis is done by using MATLAB R2010a Simulink. XC3S500E-320F Spartan FPGA device has been used for real time implementation.

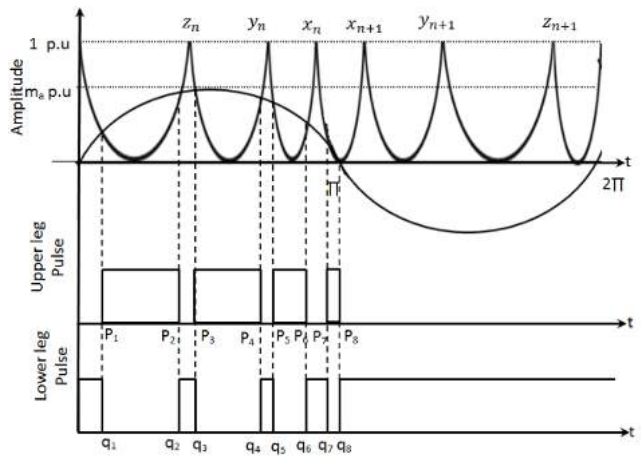

Fig 1. Proposed Inverter Sine Carrier PWM Generation Method

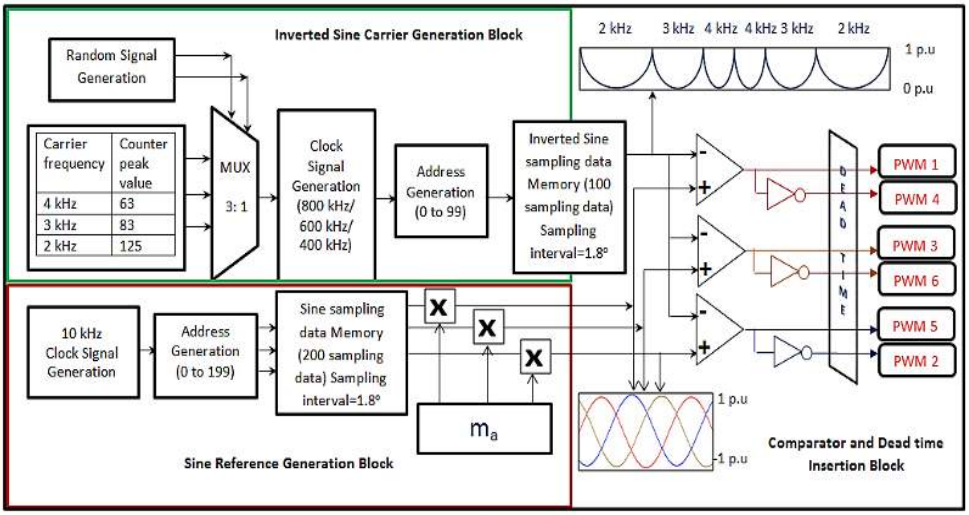

Fig 2. Digital Implementation of Random Frequency ISCPWM

The result of the proposed work shows that there is significant improvement in the fundamental voltage, THD and HSF for the given switching frequency in a three phase inverter. Obviously the simulation waveforms obtained by Matlab-Modelsim co-simulation validate the improved performance of random frequency ISCPWM.

References

1. Mahesh A Patel., Ankit R Patel., Dhaval R Vyas., Ketul M Patel.(2009). Use of PWM Techniques for Power Quality Improvement. *International Journal of Recent Trends in Engineering* 1(4): 99-102
2. Lei Bo., Xiao Guo-Chun & Wu Xuan-L. (2013). Comparison of performance between bipolar and unipolar double-frequency sinusoidal pulse width modulation in a digitally controlled H-bridge inverter system. *Chinese Physical Society and IOP Publishing Ltd*, vol. 22, no. 6,pp. 060509-1:060509-8
3. Young-Cheol.,Lim,Seog-Oh.,Wi,jong-Nam Kim &Young-Gook Jung. (2010). A Pseudo Random Carrier Modulation Scheme. *IEEE Transactions on Power Electronics*, vol. 4, pp. 797-805
4. Zheng Wang., K.T.Chau& M. Cheng. (2008). A Chaotic PWM Motor Drive for Electric Propulsion.*IEEE Vehicle Power and Propulsion Conference (VPPC)*, Harbin, China,pp.1-6
5. Jayamala V., RamasamyS., Jeevananthan S.(2011). Investigation of Pseudorandom Carrier Pulse Width Modulation Technique for Induction Motor Drives. *Proceedings of 2nd International Conference on Current Trends in Technology EE22, NuCONE:* 1-5
6. Nandhakumar R., Jeevananthan S. (2007). Inverted Sine Carrier Pulse Width Modulation for Fundamental Fortification in DC-AC Converters. *Serbian Journal of Electrical Engineering* 4(2):171-187

How Professional Are We?

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"Professional is not a label you give yourself – it's a description you hope others will apply to you." — David Maister

In the wide spectrum of workplace roles, whether you are an accountant or an artist, a builder or a banker, a coach or a chef, a developer or a doctor, an engineer or an educator, professionalism is a quality highly valued and sought out in your respective sector and therefore, it's your flourishing state of being which you should be continuously aspiring for and working towards. The key features attributed to professionalism are "specialized training, recognition of the need for standards of practice, and the commitment to provide a service that goes beyond the personal interests of a professional" (Perez, 2019). While claiming professionalism based on the above criteria, a profound introspection needs to be done conscientiously and meticulously in order to achieve higher standards of performance, creating trailblazers and pacesetters on an individual level and/or at the institutional level. How to benchmark professionalism, though it's a strenuous enterprise, is a prerequisite for developing a professional identity amongst us, validating what is in and what is out. This is true when sectors discern the problem of a blurred professional self-image ranging from a conceited one to a deflated one - both are extremely jeopardising - in their task force, from the managerial level to the administrative level. Attempting to characterise the professional qualities, we can assimilate that our level of excellence in academics and in the delivery of our workplace responsibilities, our experience as a leader resulting in great teamwork, and our work environment are the factors conducive to the enhancement of our professionalism (Perez, 2019). Research elucidates that though the term professionalism can be contextualized and redefined for the twenty-first century workforce comprised of Gen X, Gen Y, and mostly Gen Z, the core elements prevail. Those can be listed under the umbrella term "professionalism", which pegs itself over the ABC's attitude, behaviour, and communication.

A healthy amalgamation of cutting-edge hard skills and refined soft skills needs to be embodied in a professional of the digital era. Adeptness, competence, and integrity need to be incorporated in a person to attain higher goals of professional development contributing to organisational attainment. Adeptness refers to the attribute of a high performer when he is knowledgeable, well-trained, and skilled to undertake tasks with conscientiousness and appropriateness. Moreover, the adaptability and the eye for detail he possesses enable him to make the right decisions, effectively enhancing his level of competence. For instance, a

diligent employer averts potential loss of the company when he doesn't overlook the importance of consensus in strategic decision making and comprehends the dividing undercurrents based on biases. Competence pertaining to professionalism is displayed when an individual is regarded as reliable and assertive, proactively responding to situations. An institution working with a people-first approach by valuing the personal space and time of their employees, succeeding in creating a workforce that would commit itself to the company on a long-term basis, is a perfect example of competence. Continuous enrichment is possible only when a professional finds himself to be coachable while assuming leadership, persuasive, and compelling enough to think big for the work community. "The role of most leaders is to get people to think more of the leader but the role of the exceptional leader is to get people to think more of themselves." - Booker T. Washington. Integrity is an indispensable quality that requires a professional to be courageous to stay committed and scrupulous to feel confident. For example, when people see candidness in a leader, the motivation it gives to the people working under him to speak the truth with a think aloud process in place, thus productively engaging in achieving organisational goals, is immense. Emotional intelligence enables you as a professional to comprehend and communicate well with the world around you in a way that allows you to empathize with people, thus upholding humanitarian values. Conclusively, we see that professionalism is invariably specialized training coupled with attitude, behaviour, and communication (Kramer, 2012).

Extrapolating that just being in a professional sector doing jobs with technical expertise without getting equipped to ground yourself doesn't qualify you as a professional, the way forward to meet the professional in you demands a dedicated approach toward self-improvement. The desperate job market scenario in which organizations, institutions, and firms require experts but end up with professionals who lack professionalism necessitates educational institutions' conscious and persistent efforts to create Gen A who are truly professionals. The development of professional identity in undergraduates is a target to achieve by providing orientation on and preparation for professional practice when we expect our students to enter the workforce and perform with excellence and proficiency. Therefore, cultivating and harvesting professionalism must be on the agenda of the curriculum developers in such a manner that it culminates in a holistic approach in which the terms professional, proficiency and professionalism can be internalized as an attitude and practicalized in day-to-day life of new generation inside and outside educational institutions right from secondary level education.

References

1. Perez, R. (2019). What Does It Mean to Be a Professional? *Professional Case Management, 24(4),* 212. 10.1097/NCM.0000000000000373
2. Kramer, P. A. (2012). The ABC's of Professionalism. *Kappa Delta Pi Record, 40(1),* 22-25. 10.1080/00228958.2003.10516409

Prevention of Second Primary Cancer using Radiation Shielding Materials

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Over the decades, neutron radiations has been generated and utilized in applications such as nuclear power plants, the medical sector, and the aerospace industry (Mozhayev et al., 2016). In addition, boron neutron capture therapy is an emerging cancer therapy in circumstances where traditional radiation therapies become ineffective.During operating conditions in such applications, uncontrolled neutron particle radiation escapes and interacts with the atoms of the surrounding materials that make the environment radioactive. Exposure of neutron radiation to human beings can lead to serious human illnesses such as cancer, heart disease, haemopoietic syndrome, etc (Walsh, 2013).

Understanding the radiobiological effectiveness of by-product neutron particle radiation doses occurring during radiation therapy treatment has been very important due to public health consequences (Walsh, 2013). Photo neutrons of 25-10 MeV generated during the acceleration of the electron in radiation therapy will result in in-room contamination, which is a threat to the patient (Konefał et al., 2016). Even with very low energy, these liberated secondary neutrons (thermal neutrons) will change the healthy tissues of the patients into cancerous ones, which is one of the side effects of this treatment. Apart from these, the thermal neutrons escaping through the ducts in the walls of the radiotherapy room will cause exposure of neutrons to the public.

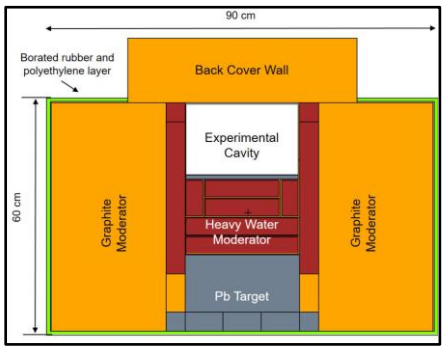

Fig 1. Photoconvertor assembly in radiotherapy treatment (Monti et al., 2020)

Most neutrons are generated by collimation systems, applicators, and scattering foils in the accelerator. Metal-based and polymer-based shielding materials (Deng et al., 2017) are provided to protect the patient from exposure to this neutron radiation and, in particular, flexible materials are needed to protect walls, floors, ceilings, ventilation ducts, air

conditioning, etc. Borated rubber used to shield the thermal neutrons from the photo-converter of the radiotherapy treatment facility is schematically shown in Figure 1.

In this context, the demand for reliable neutron shielding materials with structural and functional integrity is important for the safety of patients and the public in the area of radiotherapy vaults. The physical entity that is placed between the source of ionizing radiation and the object to be protected is commonly called a shield. The main function of this shield is to reduce the level of radiation at the position of the object.

The traditional way of shielding includes deceleration of fast neutrons through several elastic collisions to reduce the energy. According to the conservation of energy, isotopes with an equal mass of neutrons like hydrogen can cause maximum energy loss during elastic scattering. Further, the slow neutrons were absorbed using neutron-absorbing elements with relatively large neutron absorption cross-sections. Therefore, for effective shielding of neutrons, the material should have a large number of hydrogen atoms together with neutron-absorbing elements with a large cross-section absorption of neutrons.

References

1. Deng, L., Zhou, N., Chen, Y. shui, & Tu, Y. (2017). Photoneutron radiation field of ducts in barrier of 15 MV medical electron accelerators. *Radiation Physics and Chemistry*, *140*(199), 340–344.
2. Gómez, F., Sánchez-Doblado, F., Iglesias, A., & Domingo, C. (2010). Active on-line detector for in-room radiotherapy neutron measurements. *Radiation Measurements*, *45*(10), 1532–1535.
3. Konefał, A., Orlef, A., & Bieniasiewicz, M. (2016). Measurements of neutron radiation and induced radioactivity for the new medical linear accelerator, the Varian TrueBeam. *Radiation Measurements*, *86*, 8–15.
4. Liu, W. S., Changlai, S. P., Pan, L. K., Tseng, H. C., & Chen, C. Y. (2011). Thermal neutron fluence in a treatment room with a Varian linear accelerator at a medical university hospital. *Radiation Physics and Chemistry*, *80*(9), 917–922.
5. Monti, V., Costa, M., Durisi, E., Mafucci, E., Menzio, L., Sans-Planell, O., … Gomez-Ros, J. M. (2020). The e_LiBANS facility: A new compact thermal neutron source based on a medical electron LINAC. *Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, *953*.
6. Mozhayev, A. V., Piper, R. K., Rathbone, B. A., & McDonald, J. C. (2016). Moderator design studies for a new neutron reference source based on the D-T fusion reaction. *Radiation Physics and Chemistry*, *123*, 87–96.
7. Walsh, L. (2013). Neutron relative biological effectiveness for solid cancer incidence in the Japanese A-bomb survivors: An analysis considering the degree of independent effects from γ-ray and neutron absorbed doses with hierarchical partitioning. *Radiation and Environmental Biophysics*, 52(1), 29-36.

Fog Computing: From a Healthcare Perspective

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With the technological advancement in the field of information and communication, human life has become much easier with the Internet of Things (IoT), where devices are interconnected. The IoT devices communicate and exchange data with each other. In order to execute the desired functionality, the sensor devices or things in IoT are controlled remotely. Commenting on the applications of IoT (Kashani et al., 2021), the healthcare sector is one of the most promising fields, in addition to home automation, agriculture, industrial automation, etc.

IoT has gained enough momentum to transform our traditional healthcare into a smart healthcare system. It has influenced the daily routine of a person by monitoring everyday activities for a healthier life. To perform this, IoT sensors and devices gather and exchange data in a large volume that is processed and analyzed in remote locations. The major issue with this technology is the storage and security of the data. To address this issue, the integration of cloud computing (Kumar and Kumar, 2019) with IoT was introduced. Cloud computing is a paradigm that can track, store, and analyze patient data. This integrated technique can be effectively used in emergency medical cases, including early diagnosis of various abnormal and degenerative diseases (Awaisi et al., 2020).

Although cloud computing paved the way for a tremendous change in the healthcare sector, there are some challenges that need to be addressed with this integration (Darwish et al., 2019). Cloud computing has a limit for latency –sensitive applications, which is one of the important factors that needs to be addressed. The data collected from a patient is transferred to the cloud and then returned to the physician with a delay. Also, the day-to-day increase in patient health data becomes a large burden on the cloud. Hence, higher bandwidth requirements and longer processing time results which cannot be tolerated in emergency healthcare scenarios. Also, there are concerns with respect to the security of data in addition to the real-time patient monitoring applications.

In order to address these challenges faced by IoT based cloud systems, fog computing was proposed by Cisco in 2012 (Ketel, 2017). Fog computing is an extension of cloud computing that is introduced between the cloud and IoT devices. In fog computing, services such as storing and processing are done near end devices rather than in the cloud. Between the device and the cloud, Fog Computing adds an additional layer of computational power, keeping the device's vital analytics closer to it, and minimizing response times. Individual devices become processing nodes in this manner, allowing them to execute smaller, time-

sensitive activities without having to transfer huge quantities of data to the cloud. To make smart decisions during an emergency, fog computing enables physicians to use cloud-based applications. It also helps to secure confidential data with minimum delay than cloud-based applications. The fog based healthcare architecture is as shown in Figure1.

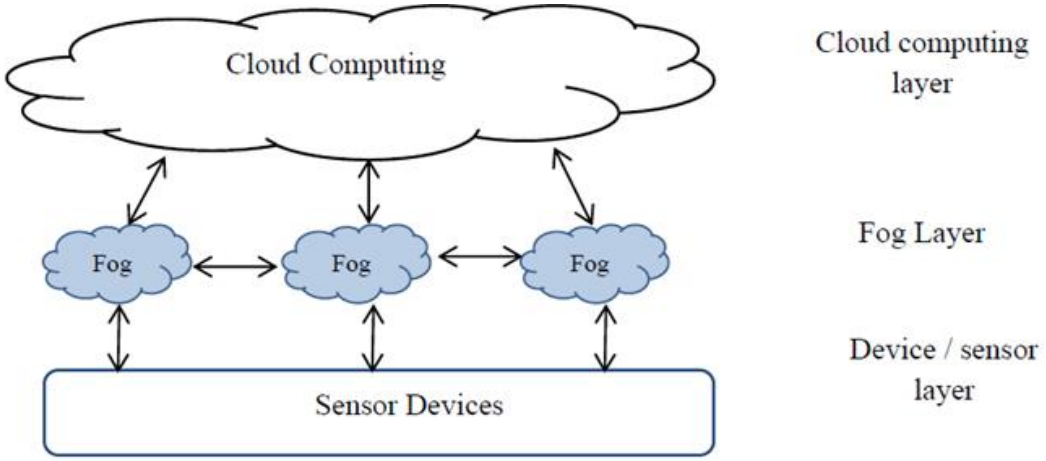

Fig 1. Fog-based Healthcare Architecture (Aladwani, 2019)

The IoT-fog computing-based healthcare architecture is made up of three layers, called the device layer, fog layer, and cloud computing layer (Aladwani, 2019). **Device Layer**: Sensors and monitors are attached to patients to keep track of their health. These devices can sense and transmit data in real time. These gadgets, which are positioned on the device layer, are responsible for choosing and transmitting healthcare data to the fog layer for access through Wi-Fi or mobile network. **Fog Layer**: The fog computing layer gathers medical information from various IoT health tracking devices. This layer is used to collect and analyse IoT health data in real time. **Cloud Computing Layer**: This layer is responsible for storing, preparing, and executing activities that the fog layer is unable to handle and execute. Patient conditions and reports are moved from the fog layer to the cloud layer for future actions.

Research Focus: Due to the large volume of data generated by fog computing systems, fog computing apps and services are on the rise. Aside from that, Machine Learning (ML), a crucial field, has made significant advances in a variety of research areas, including robotics, neuromorphic computing, computer graphics, natural language processing, decision making, speech recognition etc. Many studies are ongoing to evaluate how machine learning may be utilized to overcome the security issue associated with fog computing (Mohammed and Askar, 2021).

References

1. Kashani, M. H., Madanipour, M., Nikravan, M., Asghari, P., &Mahdipour, E. (2021). A systematic review of IoT in healthcare: applications, techniques, and trends. *Journal of Network and Computer Applications*, 192, 103164.
2. Kumar, P., & Kumar, R. (2019). Issues and challenges of load balancing techniques in cloud computing: A survey. *ACM Computing Surveys (CSUR)*, *51*(6), 1-35.
3. Awaisi, K. S., Hussain, S., Ahmed, M., Khan, A. A., & Ahmed, G. (2020). Leveraging IoT and fog computing in healthcare systems. *IEEE Internet of Things Magazine*, *3*(2), 52-56.
4. Darwish, A., Hassanien, A. E., Elhoseny, M., Sangaiah, A. K., & Muhammad, K. (2019). The impact of the hybrid platform of internet of things and cloud computing on healthcare systems: opportunities, challenges, and open problems. *Journal of Ambient Intelligence and Humanized Computing*, *10*(10), 4151-4166.
5. Ketel, M. (2017, April). Fog-cloud services for iot. In *Proceedings of the SouthEast Conference* (pp. 262-264).
6. Aladwani, T. (2019). Scheduling IoT healthcare tasks in fog computing based on their importance. *Procedia Computer Science*, *163*, 560-569.
7. Mohammed, C. M., &Askar, S. (2021). Machine Learning for IoT HealthCare Applications: A Review. *International Journal of Science and Business*, 5(3), 42-51.

Merit Order Dispatch using Meta-Heuristic Algorithms

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In today's world, it's always been a concern for an engineer to get a product out at a very optimal cost by minimizing both the product operating cost and raw material input to the production unit. Economic Load Dispatch (ELD) deals with the same situation and it works on operating a coordinated power system such that the lowest operating cost generators are used to the greatest extent and the highest operating cost generator is used to the lowest extent. The Economic Dispatch (ED) problem is to optimally allocate the load demand among the running units while satisfying the power balance equations and units operating limits**.** In the current scenario the Economic Dispatch problem has taken a suitable twist as the public has become increasingly concerned with environmental matters. With the unexceptional production of carbon emissions in thermal power plants, it is needed to optimize the emission together with the optimization of cost which acts as two vital parts of Economic dispatch problem. The economic dispatch solution provides the best minimum cost of fuel and emission. This indirectly makes lower cost for electricity and makes electrical utilities more competitive in the market.

Today, in a deregulated electricity market, a proper solution for economic dispatch is the prime focus for any network operator. There are many proprietary / traditional algorithms used to solve and optimize ELD problems. Due to world-wide escalating fuel costs, increasing demand for electricity, and growing concern for the environment, power utilities strive for optimal economic operation of their electric networks. Artificial intelligence based methods have also been proposed for solving the environmental economic dispatch problem. The various meta-heuristic optimization algorithms utilized to solve the problem are Particle Swarm optimization algorithm (Chaudhary et al., 2020), differential evolutionary algorithms, multiple tabu search algorithm, moth flame algorithm, ant lion optimization algorithm and whale optimization algorithm (Kaur and Arora, 2018) etc. Researchers are experimenting on incorporating economic dispatch problems with newly developed algorithms so as to minimize the cost of electricity.

References

1. Kaur, G., & Arora, S. (2018). Chaotic whale optimization algorithm. *Journal of Computational Design and Engineering*, *5*(3), 275-284.

2. Chaudhary, V., Dubey, H. M., Pandit, M., & Bansal, J. C. (2020). Multi-area economic dispatch with stochastic wind power using salp swarm algorithm. *Array*, *8*, 100044.

Ellipsometric Studies of Copper Doped Tin Oxide Thin Films by Chemical Spray Pyrolysis Method

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There is a wide range of Transparent Conducting Oxides (TCOs) available for various applications such as gas sensor devices, in transistors, window material for solar cells, optoelectronic devices (Stadler, 2012, Li et.al, 2015, Presley et.al, 2004, Elengovan, 2003) etc. Tin oxide (SnO_2) is a transparent semiconductor with a direct optical band gap of about 3.6–4 eV (Batzill. et.al, 2005). The un-doped SnO_2 is an n-type semiconductor due to the presence of intrinsic defects like oxygen vacancies. When it is doped with suitable elements (Al, Cu, Ga, Fe etc), carrier transformation takes place and get transformed to a p-type semiconductor.

In the present work, SnO_2:Cu thin films have been prepared by Spray Pyrolysis (SP) technique at substrate temperature 350^0C for different doping concentrations and its thickness is found out using ellipsometric technique. Among diverse deposition techniques we chose chemical spray pyrolysis method because of its simplicity and low cost. For copper doping, copper nitrate ($Cu(NO)_2.3H_2O$) dissolved in doubly distilled water (25 ml) was added to the starting solution($SnCl_2.2H_2O$ dissolved in distilled water), so that copper doping was in the range of 1at.%, 3at.%, 5at. %, 7at.% and 10at.%. Ellipsometric study is chosen for thickness measurement because of its accuracy.

A plane-polarized light reflected from an absorbing substrate at non normal incidence assumes elliptical polarization (J.A. Woollam. Co., Inc). The ellipticity of the reflected beam is determined by the relative phase difference Δ and the azimuth Ψ, the ratio of reflection amplitudes of p and s components (p and s represent the components in which electric vector lies parallel and perpendicular to the plane of incidence). The experimental arrangement utilized to measure Δ and Ψ is called an "ellipsometer". Analysis of the ellipticity of the reflected beam is carried out by standard methods. A commonly used arrangement employs a plane-polarized incident light with its plane of polarization at 45° to the plane of incident. The reflected light passes through a compensator and an analyzer which are rotated to give the smallest intensity of reflected light. The vibration direction of the compensator determines the angle χ between the great semi axis of the ellipse and the plane of incidence. The difference between the position of the compensator and the analyzer gives the ellipticity angle Υ. In the present work, the thickness of the films was measured by ellipsometry using J.A.Woolam Co. Inc M 2000 ellipsometer.

Ellipsometric Analysis

The ellipsometric analysis is used to determine the thickness, roughness, refractive index and extinction coefficient of the thin film samples (Kalnitsky et.al, 1990). The mean square error (MSE) is the estimation of the match quality between experimental measurement (exp) & model data (mod) and is defined according to the Levenberg-Marquardt algorithm (Woollam. Co., Inc).

$$MSE = \frac{1}{2N-M}\sum_{i=1}^{N}\left[\left(\frac{\psi_i^{\mathrm{mod}}-\psi_i^{\mathrm{exp}}}{\sigma_{\psi_i}^{\mathrm{exp}}}\right)^2+\left(\frac{\Delta_i^{\mathrm{mod}}-\Delta_i^{\mathrm{exp}}}{\sigma_{\Delta_i}^{\mathrm{exp}}}\right)^2\right] \quad (1)$$

where N is the number of measured Ψ and Δ pairs, M is the total number of real valued fitting parameters and σ_Ψ and σ_Δ are the standard deviations on the experimental data. It is required that $2N \geq M$ and minimize MSE (<10).In the present study, all the samples have MSE<10.The Table shows the Ellipsometric data obtained for SnO_2: Cu samples for different doping concentrations. From the Table, we can see that the thickness increases with increasing doping concentration.

Table 1. Ellipsometric datas of SnO_2: Cu thin films for different doping concentrations.

Cu Doping Concentration (at.%)	Thickness of the film (nm)	Roughness of the film (nm)	Mean Square Error(MSE)
1	218.44	22.19	4.29
3	225.12	14.18	4.60
5	258.58	23.75	4.15
7	275.81	15.95	4.11
10	296.23	27.25	4.33

References

1. Stadler, A. (2012). Transparent conducting oxides-an up-to-date overview. *Materials, 5*(4), 661-683.
2. Li, C., Lv, M., Zuo, J., & Huang, X. (2015). SnO2 highly sensitive CO gas sensor based on quasi-molecular-imprinting mechanism design. *Sensors, 15*(2), 3789-3800.

3. Presley, R. E., Munsee, C. L., Park, C. H., Hong, D., Wager, J. F., & Keszler, D. A. (2004). Tin oxide transparent thin-film transistors. *Journal of Physics D: Applied Physics*, *37*(20), 2810.
4. Elangovan, E., & Ramamurthi, K. (2003). Optoelectronic properties of spray deposited SnO~ 2: F thin films for window materials in solar cells. *Journal of Optoelectronics and Advanced Materials*, *5*(1), 45-54
5. Batzill, M., & Diebold, U. (2005). The surface and materials science of tin oxide. *Progress in surface science*, *79*(2-4), 47-154. J.A. Woollam. Co., Inc.; Guide to using WVASE32 software for optical data analysis
6. Kalnitsky, A., Tay, S. P., Ellul, J. P., Chongsawangvirod, S., Andrews, J. W., & Irene, E. A. (1990). Measurements and modeling of thin silicon dioxide films on silicon. *Journal of the Electrochemical Society*, *137*(1), 234.

Editorial Board

TECHNO-VIBES: THE TECHNICAL ARTICLES – Vol 1, October 2021
KMEA Research and Consultancy Council, KMEA Engineering College

Techno-vibes is a biannual online publication under KMEA Research and Consultancy Council (KRCC) with an initiative to inspire students and faculty with current trends in technology. This will help them to steer towards academics and industry research. The objective of the magazine is to focus on high quality research articles and current affairs in the field of Science, Engineering and Technology. This enables everyone to immerse themselves in innovation and innovation-based transformations in the education system.

In order to strengthen and expand the research and consultancy activities in KMEA Engineering College, KRCC has been formed. The objective of the research council is to develop good infrastructural facilities and conducive environment to inculcate research and innovation culture among faculty and students. The consultancy wing puts an emphasis on socially relevant works which includes both industrial and infrastructural projects. The objectives of KRCC are to:

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