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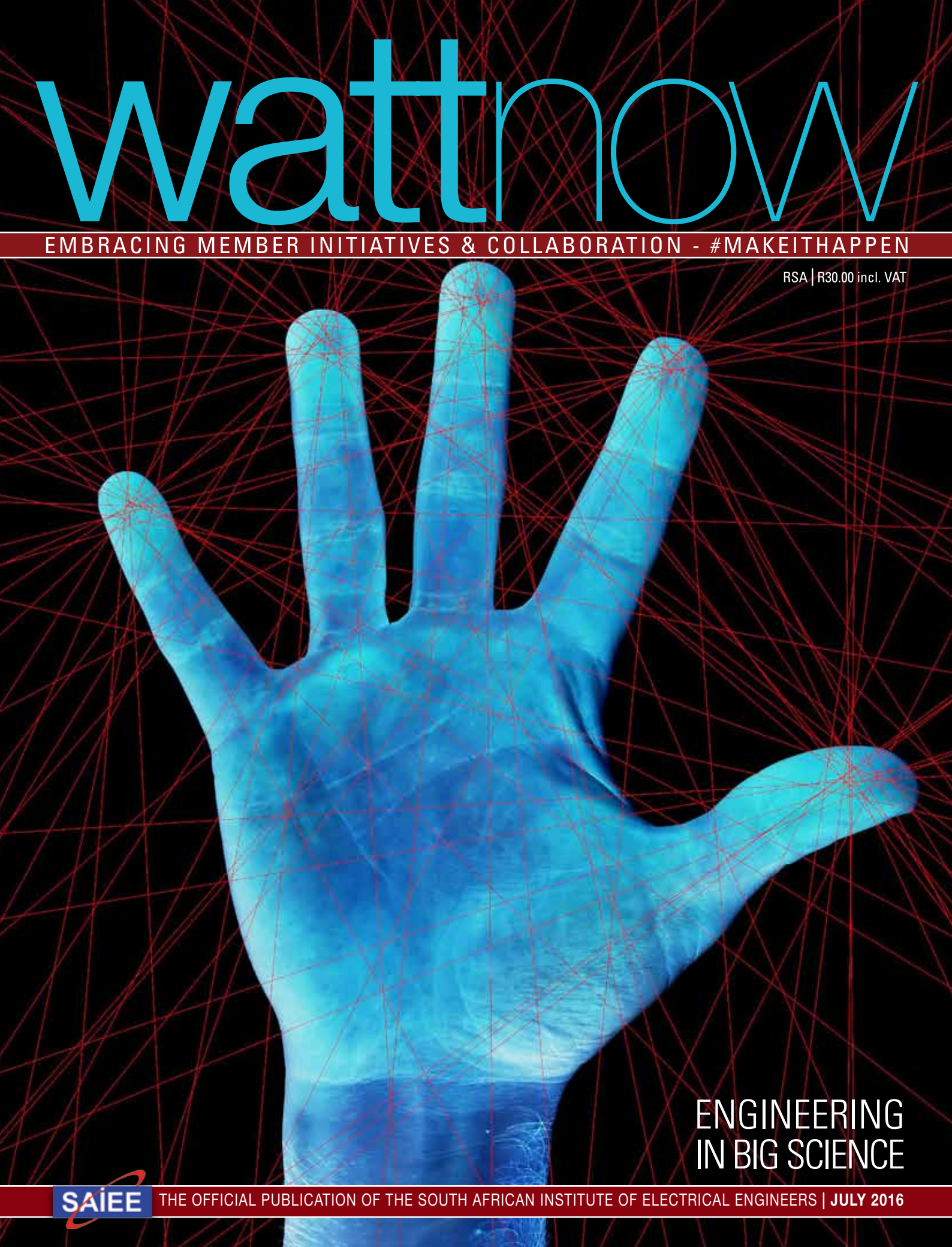

ENGINEERING IN BIG SCIENCE

SAIEE THE OFFICIAL PUBLICATION OF THE SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS | **JULY 2016**

Modeling, Detection, and Prevention of Utility Theft for Enhanced Performance and Security

Theft of Power Utilities & Technological Advancements Conference

To highlight victims, costs and solutions

18 & 19 August 2016
Amabhubesi Training Centre, Johannesburg

Overview

Social and economic sabotage on cable theft prevails across all the states in the country. However, advancement in measuring & monitoring technology has, to certain extent solved this problem. Proper assessment of the theft compounding would benefit the utility and relate to curbing the sabotage. Pitfalls in the current policy implementation and prosecution of theft cases will be discussed threadbare during the programme to evolve possible solutions.
The conference will provide a platform to understand the various facets of power theft through dedicated technological solutions. It will also bring together representatives of government and business to discuss the extent of the problem, its implications and what is being done to combat it. Everyone is affected by power theft; and detecting, reporting illegal activity will help reduce the price paid.

Objectives

- Introduction to power pilferage and effects
- Raise awareness of cable theft and effective enforcement responses to all law enforcement organisations/ agencies who are involved in the industry
- Policies regarding prosecution of theft cases
- Finding effective and innovative ways of making power utility cables less attractive or harder to steal
- Offering operational methods of deterring/ preventing, and better responding to incidents of such theft
- Evaluate on technological methods that have been established

Who should attend

- Engineers
- Cable manufacturers
- Officials of Regulatory Commission
- Consultants
- City/Municipal managers
- Banking/Finance/Investment
- SAPS officials

Panel of Speakers

1. Alan Mukoki, Chief Executive Officer, South African Chamber of Commerce
2. Piet Maseema, Executive Commitment & Tracking Specialist, City of Tshwane
3. Kyle Parker, Managing Director, Traceability Solutions
4. Evert Swanepoel, Central Director, Copper Development Association Africa
5. Keith Edmond, Chief Executive Officer, Aberdare Cables
6. Cornel Malan, Head: Research, Railway Safety Regulator

More speaker line up to be expected from Telkom, Eskom, Transnet, Municipalities, Cable manufactures and many more.

Make sure you do not miss this opportunity

Key Sectors

- Department of Energy
- Department of Trade and Industry
- Department of Public Enterprise
- SACCI
- Law enforcement agencies
- Municipalities
- Railway industries
- Power utility industries
- Research organizations
- Academic institutions
- Mining industries
- Telecommunications
- Copper industries

CPD Points accreditation with the Engineering Council of South Africa(ECSA)
Cost for attending R7 490 excl. vat
Complete brochure will be available by the end of the month.

For in house training and more information contact
Amanda on: Tel: +27 11 326 0353 / Fax: +27 11 326 0354
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JULY – another month into 2016 and it is now downhill from here. Soon we will be getting ready for the sultry hot summer months – but alas… let me not get carried away.

The July issue of wattnow features Engineering in Big Science. It is remarkable, when you read the news, especially the science & technology sections, how technology has evolved from a few years ago. South Africa can also boast with a few scientific breakthroughs, which have changed lives.

Our scientists and mathematicians continuously discover new things, which makes the world go round. We take a look at a few…

Page 16 start our feature with "Big Science in the Making", where we take a look at a few scientific projects in the world.

Another project in the not-so-distant-future is on page 20 - "Powering Automotive Cockpit Electronics". One of these days we will all be sitting back reading a book whilst our vehicle drives us.

The LED market is one of the fastest growing sectors within the electronics industry. Read more about increasing the performance and lifetime of LED Designs on page 26.

Page 34 sees a first of many essays written by the 2016 IEC Young Professional participants. This issue sports one of the two winners, Mulalo Tshivilinge's essay on how she was introduced to Standards. Next issue, I will publish the second winner, Nevin George's essay.

Dudley Basson wrote another masterpiece on the Event Horizon Telescope, which represents the culmination of a century of intellectual wrestling with Einstein's theory of relativity.

Herewith the July issue, enjoy the read.

Minx

Visit www.saiee.org.za to answer the questions related to these articles to earn your CPD points.

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TC MADIKANE
2016 SAIEE PRESIDENT

The theme for July is engineering in "Big Science". In August 2011 Popular Mechanics Magazine published a special issue titled *"The 10 awe-inspiring science projects in the Universe."*

The projects range from the world's largest undersea observatory microscope, to a Jupiter orbiter on a suicide mission. The size and scope of all the elements in that list fits perfectly the definition of "Big Science". "Big science is a term used by scientists and historians of science, to describe a series of changes in science, which occurred in industrial nations during, and after World War II, as scientific progress increasingly came to rely on large-scale projects, usually funded by national governments, or groups of governments," according to Wikipedia.

I just think It mind-boggling how all the above projects would not have been possible without Electrical Engineers. The number of exciting articles covered in this edition bear testimony to that creative role, and I encourage you to read them.

As part of our #ploughback and #makeithappen campaign, the emphasis during the youth month was on mobilising and encouraging our young members to register with Engineering Council of South Africa (ECSA). About 35% of SAIEE membership is from the youth sector. I presented ECSA's professional registration process to more than hundred (100) Consulting Engineers of South Africa's Young Professional Forum members. These presentations are done on behalf of ECSA, as part of SAIEE strategy of ensuring that Voluntary Associations support ECSA in achieving its major mandate, which is to register individuals who demonstrates competency against standards.

Gauging by the quantity and quality of questions asked after the presentation, I was convinced that young Engineers, Technologist and Technicians are more than willing to register, and to make a meaningfully contribution to the engineering fraternity. Out of my ECSA work, one of my most rewarding moments, which happen occasionally, is when I receive a message via the social media, from Candidates who have recently been successfully registered as professionals, acknowledging the role played by SAIEE in the professional registration roadshows.

Also in the month of June, as a Chairperson of ECSA's Registration Committee of Professional Engineers, I was humbled to be part of ECSA delegation at International Engineering Alliance Meeting (IEAM) 2016 in Kuala Lumpur, Malaysia. ECSA was once again granted recognitions as a Member of by the (International Professional Engineers Agreement) IPEA for the next six years. This confirms that processes, policies, standards and systems adopted by ECSA leads to outcomes substantially equivalent to those recognised IPEA.

This month, I am looking forward to address students during the orientation week in the tertiary institutions inter alia, Mangosuthu University of Technology, Durban University of Technology University, Tshwane University of Technology, Vaal University of Technology and Walter Sisulu University of Technology.

Lastly, I would like to encourage our Corporate Partners to allow their Engineers, Technologists and Technicians to participate on SAIEE activities, and also assist with industrial visits in order to ensure that our Students from Institute of Higher Learning can be exposed to real life situations while studying.

TC Madikane
Pr. (Tech.) Eng | FSAIEE

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#ThingsThatReallyMatter

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Smart And Safe Mining Machines

Legislation mandating the use of Pedestrian Detection Systems (PDS) came into being in South Africa in 2015, driving the deployment of Booyco Electronics' locally manufactured systems on local mines.

Booyco Electronics' fully integrated PDS represents the latest generation of this technology and offers a supply of information, which allows the safety intervention capability coupled with a data hub that enables integration with Trackless Mobile Machinery (TMM) and other OEM underground vehicles and equipment. Each PDS is deployed based on application specific risk assessments ensuring that it is fit-for-purpose.

Anton Lourens, Managing Director of Booyco Electronics, says the company's PDS incorporates very low frequency technology for pedestrian detection either on surface or underground together with GPS technology for vehicle detection on surface. It delivers specific warning, controlled slow-down and stopping zone alerts around a vehicle when detecting pedestrians or other vehicles. This is unique in that it is able to achieve zone shaping and create narrow band zones in close proximity on the side of vehicles.

It features full self-diagnostics, and has visual and voice display activated in the case of a PDS warning or a system failure. The technology incorporates various downloading options for recorded data including wireless when at an access point. It is supplied complete with testing equipment for both the surface and underground areas to ensure maximum functionality.

Lourens says the company has also developed a high processing power controller. It acts as a processing gateway and all sensing technologies and informational data is channelled through this. *"This enables the user to create the requisite artificial intelligence which is fed to the control systems of the trackless mobile machinery on a site."*

Research and development in the field of PDS will continue unabated, considering Booyco Electronics' ongoing interaction with mines and its participation in initiatives, such as The Earth Moving Equipment Safety Round Table (EMESRT) forum.

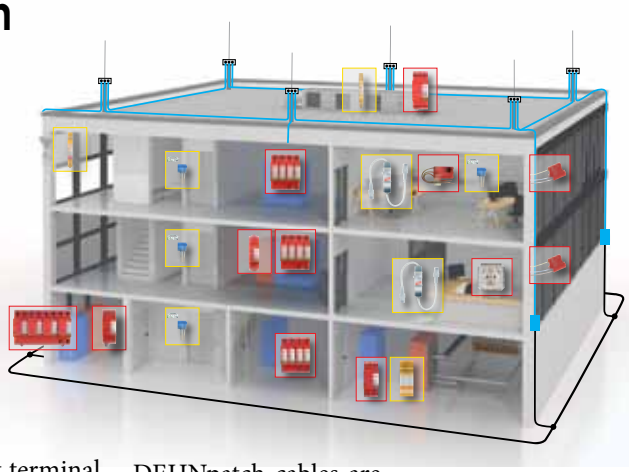
Participation at EMESRT, for example, has also allowed the company to gain insight into the global requirements for PDS equipment and share its own extensive experience gained over more than ten years in this sector with leading international mining houses. *"It is satisfying to be able to collaborate with these organisations in terms of the strides Booyco Electronics has made with its technology,"* Lourens concludes.

Gigavac Introduces New High Power Contactor

Carpinteria, California - GIGAVAC announces the latest addition to their line of patented switching devices, the HX460. This new hermitically sealed, HVDC contactor redefines the term high power switching by bringing massive power switching capabilities in a compact package. Designed and manufactured in the USA, the hermetically sealed GIGAVAC HX460 joins GIGAVAC's line-up of other sealed switching products including High Voltage Relays and EPIC® sealed contactors.

With a package size of approximately 6x6 inches (154x154 mm), the GIGAVAC HX460 power connection busbars allow continuous application circuit currents of 600A and beyond, at 1500V DC. For more info, visit www.denvertech.co.za

DEHN Africa delivers undisturbed operation in office and administration buildings



Running a business can be challenging, particularly when taking into account building maintenance costs, rates and taxes, electricity/energy consumption, as well as assets and technology equipment. For these reasons, it is critical that the office space is sufficiently protected, preferably before any damage is caused by lightning transients and/or switching surges. Lightning presents considerable risks for all living things as well as buildings and installations. This is why DEHN Africa recommends that sufficient protection for office and administration buildings be provided.

Office and administration buildings are equipped with PCs, servers, networks, air-conditioners and telecommunication systems, at the very least. Moreover, building automation systems that are used in some buildings are linked through a business system such as KNX. Should this system fail, it would bring operations to a standstill, denting the company balance sheet. Hence, it is imperative to consider the following protective solutions to protect your place of business.

Protection of power supply systems

DEHNvenCI / DEHNventil combined lightning and surge arresters can be used on your incoming lines and DEHNguard in sub-distribution boards to protect power supply systems. DEHNrail, SFL Protector or DEHNsafe can be used to protect terminal devices from surges, reduce induced voltages, and switch over-voltages to safe values.

Protection of information

To ensure safe operation, both data and voice transmission require adequate protection elements. Networks are typically designed in the form of universal cabling systems, so even if fibre optic cables between building and floor distributors are standard today, copper cables are typically installed between the floor distributor and the terminal device. Therefore, in order to protect hubs, bridges or switches, it is advisable to have the NET Protector installed.

DEHNpatch cables are used to protect terminal devices, whilst the DEHN equipotential bonding enclosure, which can be fitted with LSA disconnection blocks and lightning current carrying DEHNrapid LSA plug-in SPD blocks, can be provided for information technology lines extending beyond the building.

Protection of building automation systems

The failure of building automation systems can have fatal consequences. If the air-conditioning system fails as a result of surges, a data centre may have to be disconnected or a server may have to be shut down. Therefore, a business system such as KNX / EIB can be protected by BUStector, DEHNconnect or BLITZDUCTOR XT.

Engenamic and Wits University drive electrical energy capacity-building

"Energy, and sustainable access to energy (in particular electrical energy), is a great development enabler, enabling other infrastructure and development, industrialization, and economic growth. It also facilitates access to the evolving global "digital or knowledge-based economy", which access will be key to future African growth and development within the evolving global economic paradigm."

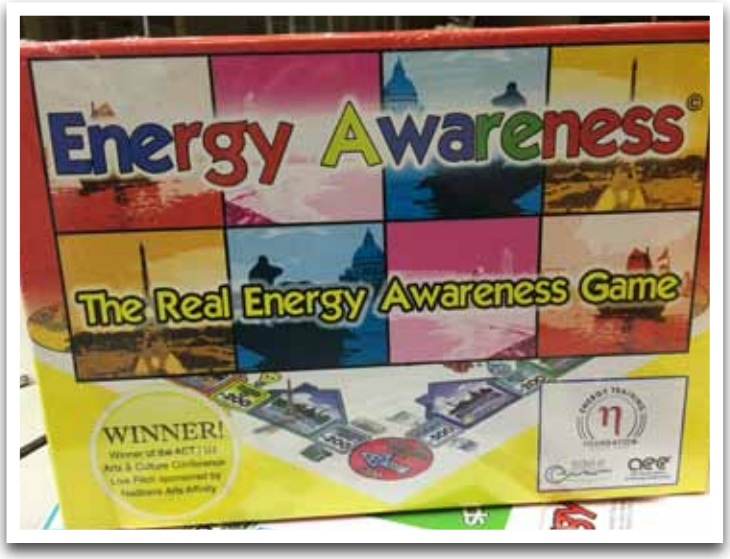
Ian McKechnie, CEO of Management, Project and Engineering Advisors, Engenamic, was commenting on the capacity-building programme initiative, dubbed enableAFRICA, that Engenamic is spearheading together with the University of the Witwatersrand.

McKechnie stated that the aim of the enableAFRICA programme was to establish and facilitate a collaborative and inclusive pan-African network, aimed at building and unlocking broad-based sustainable capacity in infrastructure development, establishment and operation, through:

- Skills development (technical & non-technical), as key to building sustainable capacity.
- Relevant research and knowledge development, focused towards African needs and priorities.
- Confidence building, through facilitating, de-risking and supporting investment and industry, and through facilitating engineering, technical and project support.

WATTSUP

Energy awareness made child's play for most ages



The Energy Awareness Game® - read the tip and play whilst learning to manage your energy and assets to optimise both – a sure-fire way to get your staff to Switch OFF Something!

The Energy Awareness Game© is a fun, entertaining and educational board game. The game uses home ownership as a basis for learning the fundamentals of energy saving and teaches anyone, above the age of 6, energy awareness. Concepts such as electricity metering, are simplified and depicted in a creative manner that's intuitive and easy to understand.

The game interplays 'Risk vs Reward', how to manage your risky energy expenses against the reward of more income from energy savings, and serves as a tool to promote energy awareness for all ages. Energy expenses are things like geysers, appliances, chargers, fridges, stoves, kettles, thermostats, etc. For example, to start playing you receive specified cash rentomoney notes, you don't roll a dice but read an energy saving tip with a movement number on it. The rule is you need to read the tip out load, for all to hear, thereby embedding the information. Studies show repetition brings automatic recognition, so maybe we will now get our kids and office colleagues to 'Switch Off Something' once they've played the game! The tips vary between residential, commercial and industrial tips so there is something for everyone.

The board is divided into 24 landing spaces that consist of energy misuse blocks, where you pay a fine for over filling a kettle before boiling water, or not having a check meter for your electricity bill, to incentive blocks where you collect cash for successfully claiming an energy efficiency tax incentive, for example, and then you can purchase a house which needs to be upgraded before any cash can be collected from opponent. Upgrading the house is cleverly done in 3 steps, starting where you first make your house efficient by upgrading lighting and hot water heating, before a solar panel can be purchased – the more efficient your house, the more cash you collect when an opponent lands on it. The game also teaches financial management, and takes the player on a learning rollercoaster of excitement and interaction whilst changing the gamer's habits towards using less energy. When your money runs out, you are out of the game, so wise decision-making is required weighing up financial risk versus the energy efficiency benefits the investment provide forms a crucial part of the game. It is designed to last no longer than 15 minutes, ideal for a tea break or during lunchtime in the staff room.

Fore more info, visit www.energytrainingfoundation.co.za

Stefano Testi

Ensuring uninterrupted service for energy sector pumps

Technologically advanced systems are required on modern-day renewable energy plants, to squeeze every available kilowatt of power out of the plant and gain the right efficiency to ensure the projects' success.

In support of these efforts, KSB Pumps and Valves is ready to assist Independent Power Producers (IPPs), to act as a fluid transfer technology partner supplying pumps for renewable energy plants, and to offer support for decades to come.

According to Stefano Testi, who is responsible for the energy sector at KSB Pumps and Valves, the company is eager to also play a leading role in the development of clean power alternatives.

As a world leader in the supply of fluid transfer solutions to the global energy sector, the company wants to leverage its global expertise for the local industry.

The future of power quality in high definition

The innovative design of the Elspec G4400 BLACKBOX device series is the most advanced power meter in the market today. The G4400 provides accurate detection and isolation of power quality anomalies for effective preventative maintenance. Its enhanced capabilities are uniquely adaptable to address the individual needs of almost any business or application.

Equipped with PQZIP patented compression technology, it offers the advantages of continuous waveform recordings and records all events on all network parameters for more than a year at 1,024 samples per cycle resolution, eliminating the need for thresholds, triggers, or parameter settings for logging. However, if required the device may be pre-programmed with any individual parameters during setup for event flagging.

Elspec's pioneering measurement method utilises a dual range gain of 2 x 16 Bit to yield, a superior accuracy surpassing IEC 61000-4-30 Class A requirements. A unique time synchronization algorithm ensures that logged data from multiple units is synchronized and displayed on the same time scale. *www.voltex.co.za*

Panel Building Facility Meets Demand for Quality & Service Excellence

In a move that underlines Zest WEG Group's customer centric business philosophy, the company established a panel building facility in 2014 to cater specifically for the demand from its existing customer base in the Western Cape.

Marthinus Greeff, Zest WEG Group Cape Town Branch Manager, explains that in addition to providing its local customer base with access to quality products, the facility is aimed at facilitating access to technically competent products at an affordable cost.

Assembly of a variable frequency drive panel (VFD) under at Zest WEG Group's facility in Cape Town.

The ISO certified panel building facility has seen phenomenal growth which can be attributed to the quality workmanship being rendered and the fact that the panels meet all the requisite electrical standard requirements. Panels are typically used to control processes across a wide range of industries including mining, water and wastewater, irrigation, HVAC, food and beverage, fishing, engineering and heavy industrial sector.

A large differentiator for Zest WEG Group customers is the level of expertise and experience residing in the team, coupled with the ability to engineer fit-for-purpose solutions. This enables the company to provide the most appropriate process control solution, accounting for all aspects of an installation such as the cooling requirements and protection for environmental conditions.

"The type of environment where a panel will be installed is important as different industry sectors have different safety and protection requirements. An example would be mitigation against the higher levels of potential corrosion that are experienced in the petrochemical sector," says Greeff. Other factors such as voltage irregularities, which can impact on an installation, can be overcome by ensuring that appropriate protection measures are implemented.

www.zestweg.com

WATTSUP

Mitech launches locally manufactured globe valve

Mitech High Pressure Stop Globe Valve, the first valve of its kind to be locally designed and manufactured in South Africa

Mitech Control Valves (Pty) Ltd is pleased to announce the launch of their locally designed and manufactured High Pressure Globe Stop Valve.

High-pressure stop valves are used in the most extreme high pressure and temperature applications. Eskom remains one of the largest consumers of these valve types, with thousands of units required in power plants across the country. Up until now, there has been no local manufacturing capability to produce the valves required to specification. With no local capability available, cost for the purchase and maintenance of these valves remains high.

In answer to this challenge, Mitech has been working in close consultation with Eskom over the last two years, to conceptualise, design and locally manufacture a high pressure stop globe valve that will fulfil the technical and safety requirements, as well as the local content requirements as set out in The Department of Trade and Industry's (the dti) designation Instruction Note for the procurement of valves and actuators.

General Manager for Mitech, Pieter Badenhorst highlights the degree to which the unit is locally produced stating that *"although we have to import some of the material used in the manufacturing process such as bar-stock which is not produced in the country at present, the valve remains 80-90% locally manufactured."* Using Mitech's design, locally sourced materials, local castings, machining, assembly and testing, the valve conforms to all the criteria for local content.

Potential benefits to industrial applications

As an alternative energy source, Compressed Natural Gas (CNG) is cleaner, safer, cheaper and more efficient than other conventional fuel sources. It is an energy source that can significantly reduce both the costs and carbon emissions of your business. With reliable supply, and consistent quality, CNG eliminates the uncertainty associated with the regular price fluctuations of liquefied petroleum gas (LPG), diesel and paraffin; thus affording you greater control of business operations across the board.

South Africa has access to large volumes of natural gas and should be utilised by far more entities. Unfortunately there is a challenge surrounding accessibility due to a severely limited supply network. This is where Virtual Gas Network offers significant benefits to the industrial & commercial sector. Introduced to South Africa in 2009 by Virtual Gas Network (Pty) Ltd, in partnership with leading equipment manufacturers, CNG can be transported directly to the customer negating the need to be on the national gas grid. Reliable, consistent supply at fixed monthly prices enables long-term, strategic financial and operational planning not possible with other conventional price-volatile fuel products.

This energy source has been tried and tested internationally and through the innovative fixed-trailer transport system of Virtual Gas Network (Pty) Ltd (VGN), industrial customers who are not on existing gas pipelines now have access to the benefits of CNG via a virtual gas distribution network.

Prof Twala, UJ, wins prestigious award

Prof Bheki Twala, Director: Institute for Intelligent Systems, Professor of Artificial Intelligence and Statistical Sciences at the Faculty of Engineering and the Built Environment (FEBE), University of Johannesburg

From left: Honourable Minister of Science and Technology, Mrs Naledi Pandor; Prof Bheki Twala, Director: Institute for Intelligent Systems, Professor of Artificial Intelligence and Statistical Sciences at the Faculty of Engineering and the Built Environment (FEBE), University of Johannesburg; and Ms Adriana Botha from the Mail and Guardian Newspaper

During June 2016, Prof Bheki Twala from the University of Johannesburg (UJ) received the prestigious annual TW Kambule-NSTF Award for his work building on diverse expertise in making decisions given incomplete information.

He utilises Artificial Intelligence (AI) techniques for predicting and for the classification of tasks in several fields such as banking and finance, insurance, biomedical, robotics, psychology, software engineering and most recently in electrical and electronic engineering science.

Prof Twala is Director: Institute for Intelligent Systems, Professor of Artificial Intelligence and Statistical Sciences at the Faculty of Engineering and the Built Environment (FEBE), UJ.

He served as primary innovator for the development of effective techniques in decision support systems given poor data quality. He has also shown how AI and grey relational systems could be used to predict road traffic accidents (RTA) in South Africa given that the RTA data are of poor quality.

The Honourable Minister of Science and Technology, Mrs Naledi Pandor presented the national 2015/2016 NSTF-South32 awards at the ceremony held in Gauteng, celebrating contributions to excellence in science, engineering and technology (SET) and innovation.

Mrs Pandor has previously stated that South Africa's science mission is to create wealth, thereby creating jobs and eradicating poverty. Its success depends on our ability as a nation to develop new products, technologies and services.

Rosatom wins Best Nuclear Project Award at World Nuclear Exhibition in Paris

During June 2016, The World Nuclear Exhibition (WNE) held a special awards ceremony to honour the industry's cutting-edge nuclear technologies and innovation projects. Rosatom's ASE Group of companies won first prize in the Operation Excellence category for its *"Multi-D-based Project Management System"*.

Construction of major facilities often implies cost overruns and longer timelines, ranging from 10% to 50% on average. According to the developers of the system, the situation can be remedied only by effective management, combining IT tools and business processes. The Multi-D-based Project Management System facilitates essential optimization and control of deadlines during assembly of capital construction facilities.

The development of the technology was initiated by the ASE Group of companies. Rosatom's experience has shown that the use of technology can be leveraged to ensure effective project management, thus allowing projects to run on time and within budget. The technology is being replicated in all Russian-designed NPP construction projects.

WATTSUP

Airtel wins the Global Telecommunication Business (GTB) award

Bharti Airtel, a leading global telecommunications services provider with operations in 20 countries across Africa and Asia, in collaboration with Nokia, has won the Global Telecommunication Business (GTB) award for a digital backbone that is driving mobile economy in Africa. Airtel also emerged the winner in Voice over internet Protocol (VoiP) App within the Exceptional Emerging Market category.

"Airtel Africa wants to fully utilise the advantages of IP/MPLS technology to economically and effectively handle high volumes of a variety of mobile broadband data and video services. The new network implementation and management not only provides a substantially improved quality of service for our existing customers; it also continues to do an excellent job of enabling us capture expansion opportunities with a wide range of intelligent services across our markets" said Christian de Faria, Executive Chairman, Airtel Africa.

"Nokia's Managed Services solution enables Airtel to focus on the development of new service offerings and the quality of experience Airtel delivers to its customers in a highly competitive environment. A specific benefit is an accelerated time-to-market for new revenue-generating services, especially toward business customers interested in seizing emerging business opportunities across the African continent" said Daniel Jaeger, Nokia's Market Unit Head Central, East & West Africa.

The awards celebrate the collaboration and partnership between operators and vendors whilst recognising the industry's commitment to deliver exciting and innovative services to its customers worldwide.

Thorium Fuel Testing Progresses on Schedule

Steenkampskraal Thorium Limited (STL), is the only company in the world manufacturing and qualifying thorium-containing fuels for use in Light Water Reactor (LWRs), and is developing important intellectual property in the process.

STL owns about 12.50% of Thor Energy AS in Norway. Thor Energy's programme is to manufacture and qualify thorium-containing fuels for use in the Light Water Reactors (LWRs) which constitute the majority of the world's nuclear reactors.

Trevor Blench, chairman of STL, says the company has also made significant progress with the overall design of its HTMR-100 small modular pebble-bed reactor and the designs of several important components. These include its core structures, the reactor pressure vessel, the steam generator, the double-set isolation valves and the fuel loading and unloading devices.

"We have prepared a detailed project plan and a schedule to proceed to a generic design assessment. We have also made progress with the design of a pebble press laboratory to produce fuel spheres. Preliminary discussions have been held with the National Nuclear Regulator about the licensing of our reactor design," he says.

"STL is also designing a factory to make the pebble fuel for this helium-cooled pebble-bed reactor. Thorium has physical properties that make it a better and safer fuel than uranium."

He said the HTMR-100, which is a Generation-4 reactor, is intrinsically-safe. *"This type of gas-cooled reactor cannot melt down like the water-cooled reactors."*

The first thorium fuel pellets were inserted into the Halden reactor in Norway in April 2013 and have now completed three years of a five-year qualification programme. Blench said the thorium fuel mixtures are demonstrating improved performance and safety characteristics. Thor Energy manufactured a second batch of thorium/

SA business delegation to explore infrastructure development opportunities in Kenya

Research and consulting specialists, Africa House, will lead a high-level business delegation to Kenya's Lamu region next month, to position South African business to take advantage of a projected development boom in the area.

Paul Runge, Director Projects & Development Finance at Africa House, says Africa House's ongoing research and fact finding missions have identified Kenya's Lamu region and the Lamu Port-South Sudan-Ethiopia-Transport (LAPSSET) East African trade corridor as a future development hotspot, due to oil and gas discoveries and an associated need for infrastructure and port development in the area over the next few years.

"On the back of decades of experience in leading business missions to key development nodes across Africa, we have refined our formula for success," says Runge. *"It is crucial to get in early and meet the primary decision-makers in government and industry, as early as possible in the planning phase."*

Kenya is regarded as a prime African business destination, with significant growth potential for transport and logistics development in the north. Among the massive infrastructure upgrading and extension projects envisaged by the Kenya Investment Authority are redevelopment of the Northern Corridor and development of the LAPSSET Corridor.

Runge, who has just returned from a fact finding and preparatory trip to Kenya, has identified significant opportunities in Lamu and the LAPSSET Corridor for enterprises involved in port development, access roads, oil refinery supply, oil pipeline, ports infrastructure, airport infrastructure and ancillary services. *"Opportunities extend to services around a coal fired power plant, a planned wind farm, a rail transport system and even commercial property development, accommodation and resorts that will be required in these areas,"* he says.

The five-day mission will take South Africa-based business development managers and senior strategic executives to Nairobi and Lamu for exploratory meetings and site visits. *"Africa House hosts two to three successful business missions per year to key development regions across Africa,"* says Runge.

"The group mission format takes care of complicated logistical arrangements for delegates, as well as allowing delegates to be taken more seriously because they are part of a formal mission supported by the Kenyan and South African authorities. The programme also supports networking and business collaboration among the members of the mission themselves."

"South African enterprises have to look across the border for growth, but logistical challenges and concerns about the unknown can stand in the way of their taking the first steps into pan-Africa," Runge says.

Africa House will lead the Nairobi/Lamu/LAPSSET mission from 10 – 15 July 2016. The mission will meet facilitators and diplomats, LAPSSET Corridor Development Authority, the Kenya Ports and National Highways Authorities, African Development Bank, Tullow Oil Kenya and other stakeholders.

uranium fuel pellets in November 2015 and inserted this second batch into the Halden reactor in December 2015.

"The Korean Atomic Energy Research Institute (KAERI) which joined the Thor Energy consortium in 2015 made a significant financial contribution to the project and sent several fuel samples from South Korea for testing in the Halden reactor," he said.

Blench said progress at the Steenkampskraal rare earth and thorium mine is proceeding well. The latest mineral resource estimate indicates the presence of 11 700 tons of thorium in the Steenkampskraal deposit. The report includes studies of where this thorium would be sourced and states that the Steenkampskraal mine in South Africa will be the lowest cost producer of thorium in the world.

STL plans to earn revenue from the sale of thorium for fuel for existing water-cooled reactors and for gas-cooled reactors. STL will also promote its HTMR-100 small modular, pebble-bed reactor.

Big Science in the making....

From bomb-sniffing locusts, a robot salamander, and other amazing images, we take a look at the wonder of science in the world...

BY | MEAGHAN LEE CALLAGHAN

JUPITER'S AURORAS

Though we have known about the auroras capping Jupiter's poles since the late 1970s, for the first time, the Hubble Space Telescope has captured some exciting new images using its ultraviolet capabilities. The northern pole's aurora, shown in this image, is larger than the Earth, and hundreds of times more energetic than any auroras we have here.

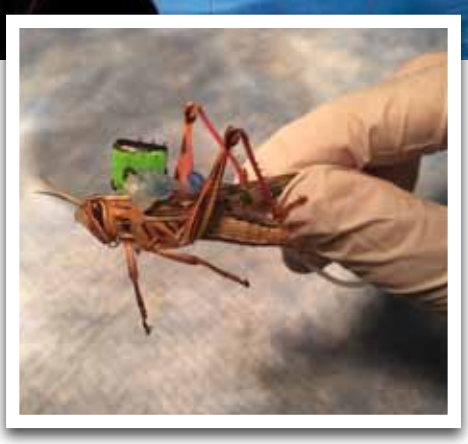
PROJECT BLOKS

While some think that code will soon be a thing of the past, we'll still need software engineers for a long time to come. And in a coming era where the computer is even more relevant than it is today, it's important that the next generation understand how it all works. By making code physical, Google hopes the concept will be easier for kids to understand.

Representing a bit of code, each block can be snapped together to make a sequence that can be sent over Bluetooth or Wi-Fi to play music, start a toy, or any number of other things.

BOMB-SNIFFING LOCUSTS

The cutting edge of bomb detection technology may soon be a bug wearing a backpack. A team of engineers from Washington University in St. Louis is developing cyborg locusts that will be



flown via remote control into hazardous areas, use their antennae to sniff for explosive chemicals, and send wireless alerts when they find them. The project is funded by the Office of Naval Research and is led by associate professor of biomedical engineering, Baranidharan Raman, who has spent years studying how locusts process smell. Raman says that human-engineered sensing devices are pretty basic compared to animal noses designed by mother nature. *"Why reinvent the wheel?"* Raman said in a statement. *"Why not take advantage of the biological solution?"*

Big science in the making

continues from page 17

FIRST-EVER SONOGRAM OF SHARK PUPS

Taken with a 12.5 foot pregnant tiger shark named "Emily," this novel event was performed to study the shark life cycle. The shark is carrying 20 pups, and in the past, researchers would have had to cut the shark open.

ROBOT SALAMANDER

Salamanders were among the first creatures to walk on land. The wriggly amphibians, with stubby legs and moist bodies, are adept at swimming and just okay at crawling. In their defence, hardly anything else made the transition from water to land, so when they arrived, few could witness their awkward gangly steps, but many creatures that evolved afterwards adapted from the salamander's humble origins.

To better grasp the evolution of locomotion, researchers at Switzerland's Ecole Polytechnique Fédérale de Lausanne (EPFL) built a salamander robot from 3D printed parts. And just for kicks, they made it look like a skeleton. They named their robomander Pleurobot, after the salamander species Pleurodeles waltl.

Specifically, the researchers are looking at the why spinal cord stimulation changes the creature's movement. Both the robot and real salamanders can walk, run, or swim. In living creatures, the intensity of electrical stimulation of the spine changes walking to a run, or running to a swimming motion in water.

OPENING A BLACK BOX

Black boxes, or flight recorders, are meant to take a lot of wear and tear. After all, they're supposed to survive plane crashes from tens of thousands of feet in the air, aboard metal vessels filled with jet fuel, but the inside of a modern black box (spoiler: they're not actually black) is a small wonder of strength and protection.

Needless to say getting inside them is no easy task. After dropping the box out of a helicopter to show its durability, the Youtube channel "What's Inside?" cut the thing in half with a saw, so we could see a cross-section of the device that captures valuable data in the event of a crash.

A NEW SELFIE DRONE RISES

For about $400 this hovering cone can be yours in all its 1080p, facial recognition capable glory.

The drone has a battery life short of half an hour, and takes two hours to charge, so don't plan on shooting the whole afternoon with it. But since Roam-e can hold 360 photos and is capable of live streaming, you can use that limited time to post plenty of things on Facebook and really capture the experience. We're hoping the battery life improves, and that helicopter parents don't see it as an opportunity.

FIREWORKS-FILLED TADPOLE GALAXY

In a spacecraft that's built to carry humans, the "pressure vessel" is the part of the structure the astronauts inhabit on their way to the International Space Station. The pressure vessel keeps air in and the vacuum of space out, and maintains a pressure that's friendly to Earthlings. Basically its job is to keep them alive despite the hazards of spaceflight. So, you know, no pressure.

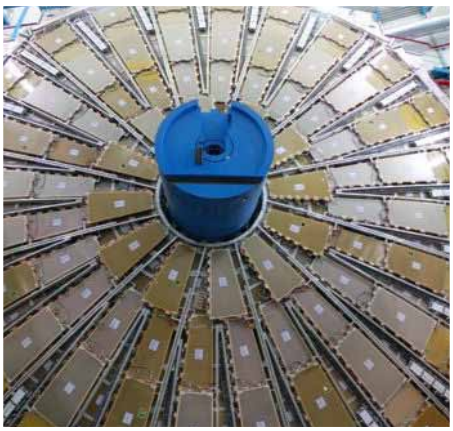
All of that means the pressure vessel has to be vigorously tested on a brand new spacecraft like SpaceX's Crew Dragon. The Crew Dragon is shaping up to be the first privately owned vehicle to carry astronauts to the space station next year or in 2018.

NASA has an unfinished Crew Dragon capsule sitting in a fixture that's meant to stress (torture?) the structure. Another kind of pressure test, which NASA's Orion capsule recently underwent, overfills the capsule with air, exposing any weaknesses in the pressure vessel structure as it expands.

PARTICLE FEVER

Will the Large Hadron Collider discover a new particle in 2016? Well, the world of particle physics is currently buzzing with excitement.

The LHC smashes beams of proton particles together, allowing physicists to look for hints of exotic particles in the debris. In this



case, researchers see an excess of photon pairs being produced at a mass scale that would make the potential new cosmic building block four times more massive than the heaviest known particle - the top quark. WN

Earn CPD Credits

The latter, in particular, has become the latest consumer "must-have" and a point of differentiation that's helping car salesmen ratchet the buyer up the price ladder. And the evolution doesn't stop here; these systems are the first stepping-stones toward driverless cars.

What differentiates these much more sophisticated systems is the processing power they employ. For example, smart forward looking cameras use Digital Signal Processors (DSPs) to analyse their images, while infotainment head units and instrument cluster displays feature Graphics Processing Units (GPUs), System on Chips (SOCs) and Field Programmable Gate Arrays (FPGAs) to implement specific functions.

All of these processors, logic devices, memory and interface circuits demand Point-of-Load (POL) power at ever-lower voltages and higher currents. Figure 1 shows an electronic control unit's typical power tree. The car battery commonly specifies a full operation range from 9V to 18V, with short transients that can exceed 40V and dip below 5V DC. The varying load needs of entry level to luxury cars require flexible solutions provided by secondary rail POL buck regulators* that can deliver higher current power supply regulation at lower voltages.

There are many different ways to implement a buck regulator. In order to determine which solution delivers the performance and features needed for a given requirement, it is important for system designers to understand the architectural choices that lie behind the various Integrated Circuit (IC) designs. This article examines the asynchronous buck versus synchronous buck configuration. It also reviews

** A buck regulator/converter (step-down converter) is a DC-to-DC power converter which steps down voltage (while stepping up current) from its input (supply) to its output (load).*

Powering Automotive Cockpit Electronics

The growth of automotive cockpit electronics has exploded over the past decade. Previously, self-contained systems such as steering, braking, traction, and other safety devices, along with entertainment equipment and navigation aids, have evolved into integrated infotainment systems, increasingly overlaid with Advanced Driver Assistance Systems (ADAS).

COMPILED BY | MINX AVRABOS

the trade-offs between the N-channel or P-channel transistors used for the switches in a synchronous buck configuration. A family of fully optimized 3A, 4A and 5A sync buck regulators is highlighted, and their wettable flank thin quad flat no-lead (WFQFN) package is examined.

THE ASYNCHRONOUS BUCK REGULATOR

As can be seen in Figure 2, the asynchronous buck DC/DC converter has one switch (S1) that is driven on and off to control the duty cycle ratio. The circuit includes a diode that acts as a secondary switch when the potential across it causes forward biasing. When switch S1 is on, the input voltage is connected to the inductor, causing current to build up in the inductor until switch S1 is shut off. When S1 is switched off, the current flowing through the switch to the inductor is interrupted.

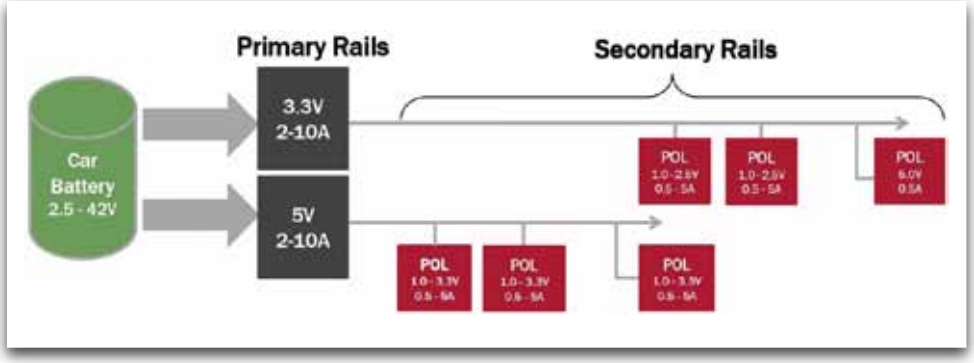


Figure 1. Typical automotive power supply architecture

However, due to the nature of the inductor, the current flowing through it wants to continue flowing in the same direction. For this to happen, the voltage polarity across the inductor changes, allowing the current to flow through in the same direction. When this occurs, the diode is forward biased, allowing the pass through current. Regulation of the output voltage is performed by feedback (not shown in Figure 2) to control the duty cycle of switch S1.

Powering Automotive Cockpit Electronics

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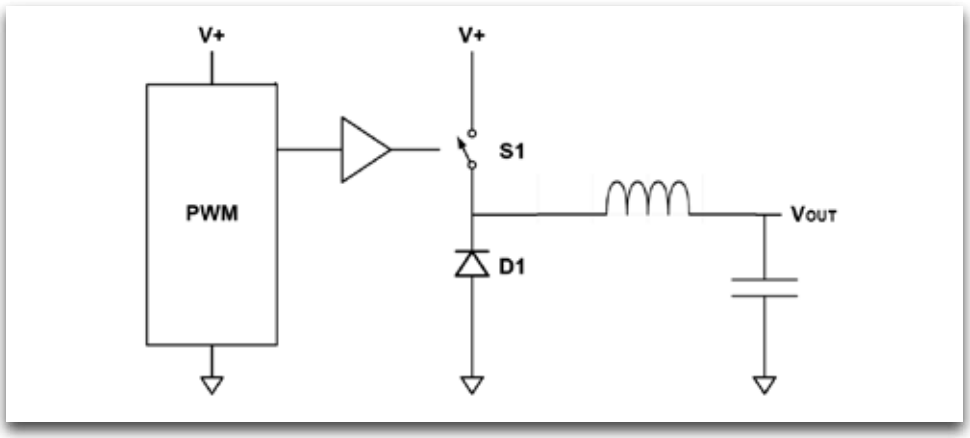


Figure 2. Asynchronous buck implementation

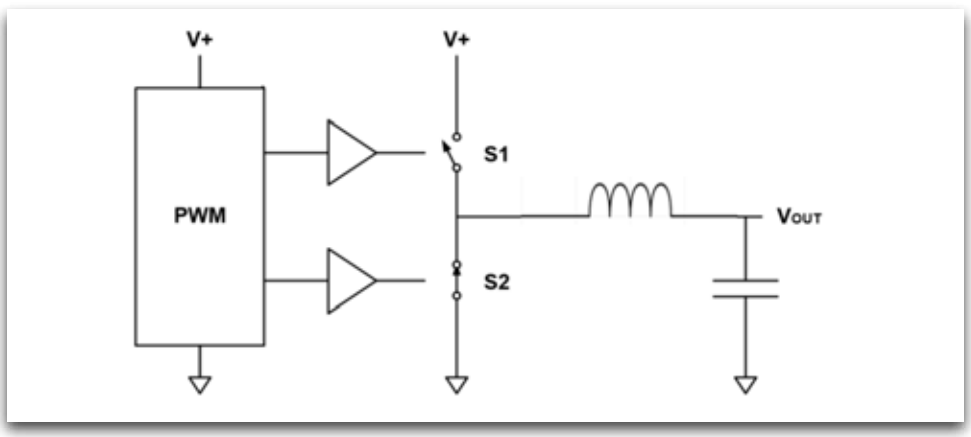


Figure 3. Synchronous buck implementation

THE SYNCHRONOUS BUCK REGULATOR

The synchronous buck DC/DC converter is illustrated in Figure 3. In this configuration, the diode is replaced with a switch. The switch is a FET (Field-effect Transistor), which is designed to have very low on-resistance (RDSon) that allows the FET switch to exhibit lower voltage drop when current flows through it. This results in the circuit having much higher efficiency in comparison to when a diode is used. For example, if the average current in the system is 5A, the power loss in the diode would be 0.5 volts x 5A = 2.5 watts (this assumes a Schottky diode with a forward voltage of 0.5 volts at 5A), versus 5A x 5A x 0.011 ohms = 0.275 watts with a transistor having 11 mohm of on-resistance. The transistor achieves better than a 9x reduction in power dissipation.

However, with switch-2 integrated onto the die, the S2 losses will be on the die. This will require better thermal design of the die, but the overall improvement in efficiency will result in less total heat generated.

The die will require more silicon area when switch S2 and its drive circuitry are included, but this will reduce the board area and component count since the external diode is no longer required.

There is another benefit to the synchronous circuit over the asynchronous circuit that is not obvious to many engineers. When the output load is very low, the inductor current may become discontinuous, meaning the current falls to zero. In the asynchronous configuration, the discontinuous current can result in electromagnetic interference (EMI) emissions.

A minimum load may be required for the asynchronous circuit to prevent discontinuous current operation. The synchronous configuration can be designed to enable switch S2 to be turned on under light load conditions. This will allow negative inductor current to flow.

While this decreases efficiency at light loads, it allows continuous current flow and prevents EMI.

Therefore, the buck regulator, implemented as a synchronous buck, can provide higher efficiency and lower EMI while occupying less board space than the asynchronous version using a diode. The synchronous buck provides even more benefits if its implementation is optimized for the specific voltage regulation applications.

A circuit implementation of the synchronous buck would use FET transistors for the upper and lower switches. The lower FET is always an N-channel FET. N-channel devices offer higher electron mobility, and therefore lower resistance for a given size.

Nevertheless, the upper FET in a synchronous buck converter can be implemented as either an N-channel or a P-channel. Each has its own advantages and disadvantages.

N-CHANNEL VS. P-CHANNEL HIGH-SIDE FET SWITCH

To examine why employing buck regulators using a P-channel device as the upper FET can be better in some applications, it is necessary to look at the switching section of a synchronous converter with an upper N-channel FET as shown in Figure 4.

When an N-channel FET is used for the upper switch, there must be a voltage supply source greater than the voltage supplying the drain of the upper switch. For the N-channel FET to turn on with its source voltage at Vs, its gate voltage must be several volts higher than Vs. This higher voltage is typically generated by using a boot capacitor. When the lower FET is on and the upper FET is off, the boot capacitor is charged by the Vc supply. Note that Vs and Vc may be equal or different in the buck converter that uses an N-channel FET for the upper switch. If Vs is higher than Vc, the IC will need to include a level shifter to level shift the PWM signal up to the drive stage that operates at the higher Vc and boot voltage level.

When the lower FET turns off and upper FET turns on, the bottom side of the boot capacitor increases to the Vs voltage on the inductor's input. When this occurs, the top side of the boot capacitor has an approximate voltage of Vs + Vc relative to ground. The upper FET's gate and the voltage swing on the boot capacitor's top side both swing from ground at their lowest potential to Vs + Vc when the upper FET is switched on.

In some applications, it's better to use a synchronous buck converter like the one shown in Figure 5. It uses a P-channel FET as the upper switch. In this circuit, the gate of the upper FET needs only to switch between ground when the upper FET is on, and Vc when the upper FET is off. There is no need for a boot capacitor and the entire circuit can operate at the Vc supply voltage potential.

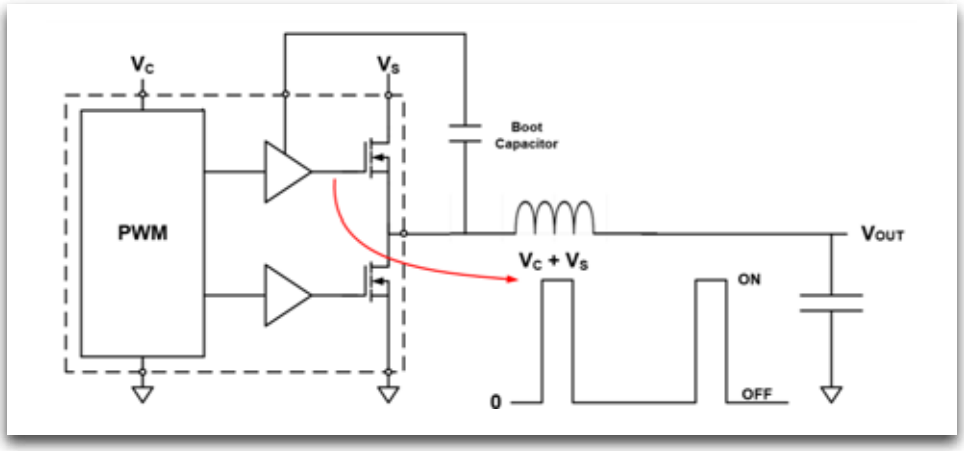


Figure 4. Synchronous buck with N-channel high-side FET switch

ADVANTAGES	DISADVANTAGES
Lower RDSon for given FET size, enables lower losses with high current	Operates from higher supply voltage, requires larger IC process geometry/die size, adds cost
	Needs boot capacitor, no 100% duty ratio
	Larger voltage swings, longer switching times and higher potential for EMI

Table 1. Upper high-side FET N-channel advantages vs. disadvantages

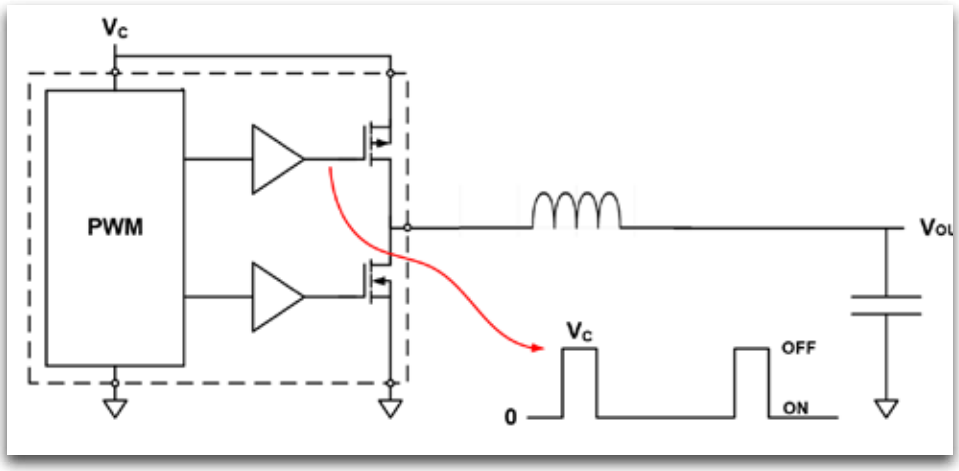


Figure 5. Synchronous buck with P-channel high-side FET switch

AUTOMOTIVE-GRADE BUCK REGULATOR FAMILY

The ISL78233, ISL78234 and ISL78235 pin compatible devices use the P-channel configuration. They integrate a low on-resistance P-channel (35mΩ, typical) high-

Powering Automotive Cockpit Electronics

continues from page 23

ADVANTAGES	DISADVANTAGES
Operates from lower voltage supplies, and smaller geometry silicon process results in smaller transistors	Requires larger FET to achieve same RDSon as N-channel, results in higher cost for FET area
Lower voltage swings enable faster switching, lower voltage signals make EMI less likely	
Operates at higher frequency above AM radio band	
Operates at 100% duty ratio, and no boot capacitor lowers cost/saves board space	

Table 2. Upper high-side P-channel FET advantages vs. disadvantages

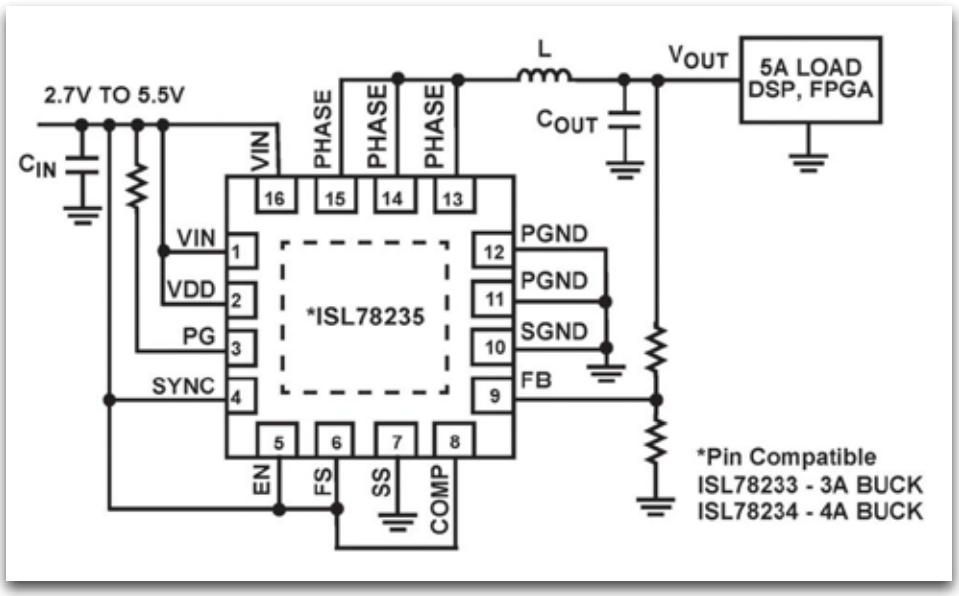


Figure 6. Typical application for ISL78235 5A sync buck regulator

side FET and N-channel (11mΩ, typical) low- side FET to maximize efficiency. At 100% duty cycle operation, there is less than 250mV drop across the P- channel FET at 5A output current. Most of the time, the devices will be converting 5 volts down to a voltage as low as 0.6 volts, and the duty ratio will be below 50%. Therefore, even though the P-channel FET has higher resistance than the N-channel FET, the P-channel will be switched on for much less time, and will have less impact on efficiency.

The ISL7823x devices shown in Figure 6 are designed to operate from lower input voltages (5.5V down to 2.7V). As a result, most of their transistors use a smaller geometry, take up less die area and can switch at higher speeds. And since the gate of the upper P-channel FET is driven with the same supply, the signal swing is lower than if an N-channel arrangement is used. This also enables faster switching. The devices can operate with a clock as high as 4MHz, and when set to switch at 2MHz, they can achieve a guaranteed minimum on time of only 100ns. Since 2MHz has a period of 500ns, the devices can down convert with a guaranteed 20% minimum duty ratio. This enables the regulators to output a wide range of voltages while operating at a high frequency.

A 100% duty ratio is possible because no time is required to charge a boot capacitor (the ISL7823x devices do not use one). Moreover, no boot capacitor equates to no radiated fields. The high 2MHz switching frequency also enables the use of a smaller power inductor and lower valued capacitors on the regulator's input and output. It's also above the AM radio band and helps prevent EMI at these frequencies.

WETTABLE FLANK PACKAGE ALLOWS OPTICAL INSPECTIONS

The ISL7823x devices are available in 5mm x 5mm 16-lead WFQFN packages with an exposed pad for improved thermal performance. Because they offer 3A, 4A or 5A output current options, it's easy to upgrade a design just by dropping in a new IC with no change in the PCB layout.

This saves development costs and time. In addition, the WFQFN shown in Figure 7 permits verification of automotive manufacturing quality by allowing optical inspections to verify proper soldering joints.

CONCLUSION

The evolution of automotive cockpit electronics into highly integrated driver assistance systems provides today's drivers with more safety, comfort, and infotainment features than ever imagined. This is placing new demands on secondary rail power supplies.

The varying loads require flexible solutions that can deliver higher current power supply regulation at lower voltages. System designers also want to be able to use the same POL devices across a range of vehicle designs, from entry level to luxury cars.

This goal is met with a synchronous buck regulator design that uses high-side P-channel MOSFETs and other architectural enhancements to deliver an optimized secondary power rail solution. As vehicle manufacturers continue to innovate, they need to be able to rely on semiconductor suppliers to deliver the flexible, rugged and higher performance ICs that help them realize their system design goals. wn

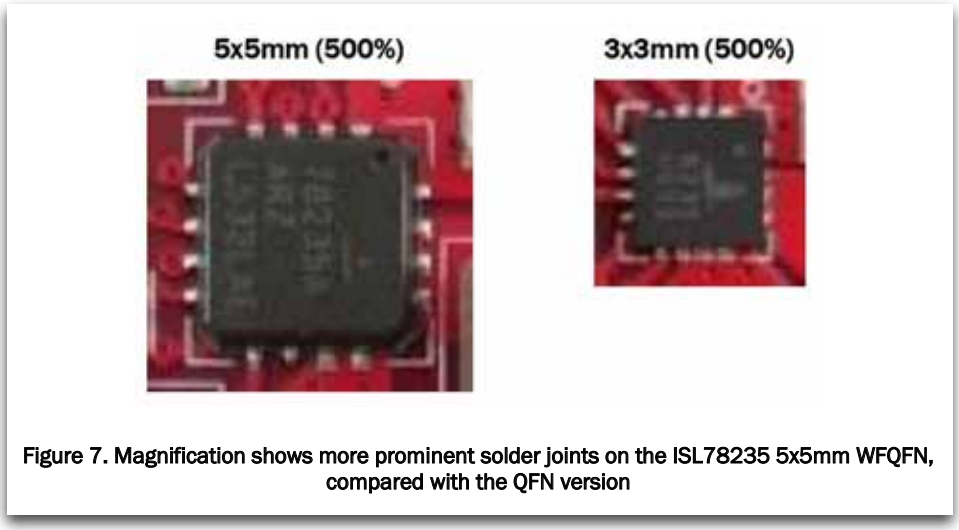


Figure 7. Magnification shows more prominent solder joints on the ISL78235 5x5mm WFQFN, compared with the QFN version

Figure 7. Magnification shows more prominent solder joints on the ISL78235 5x5mm WFQFN, compared with the QFN version

Earn CPD Credits

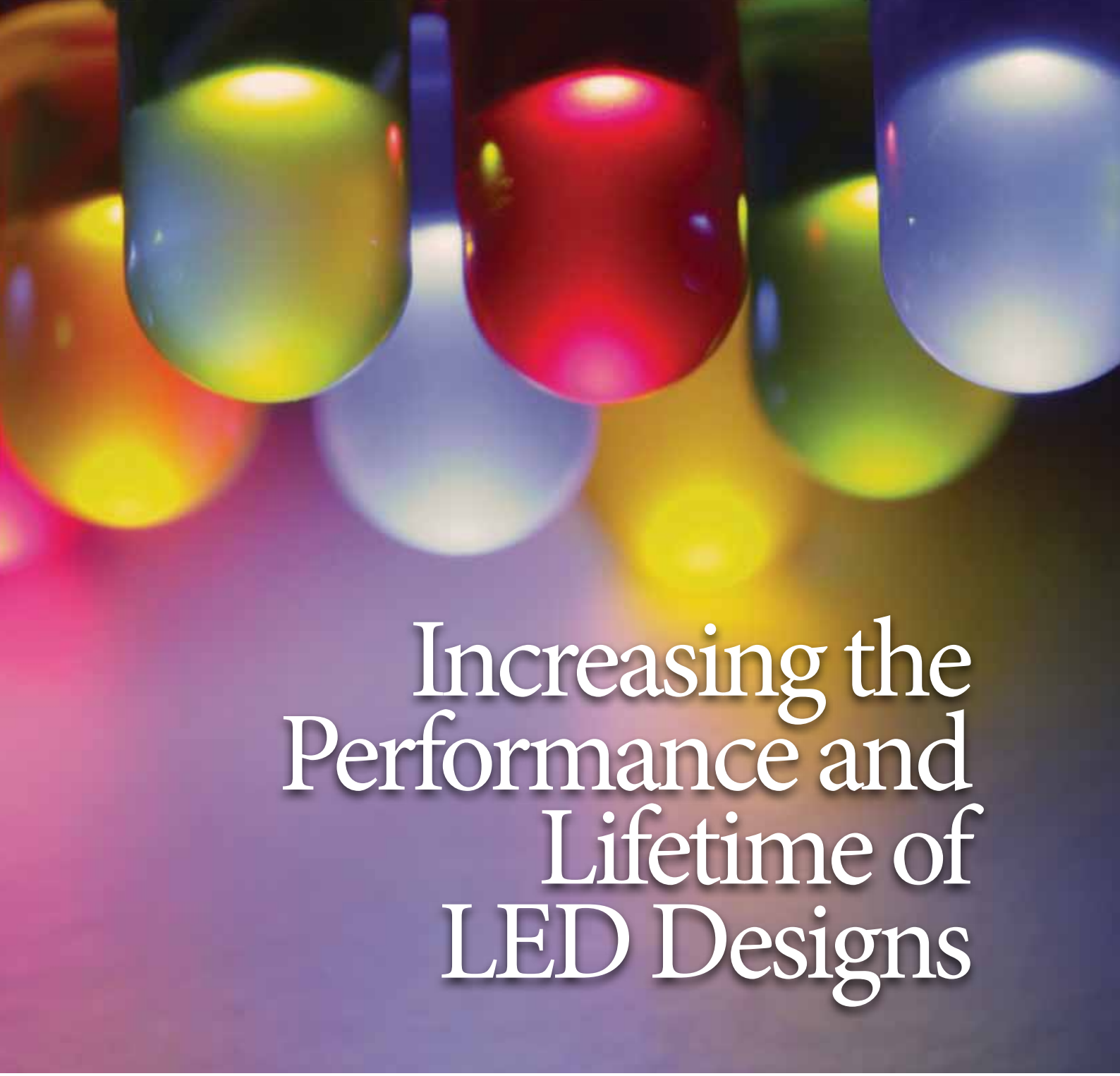
The LED market is one of the fastest growing sectors within the electronics industry, expected to grow into a $70 billion industry by 2020; rising from 18% to 70% market share of the global lighting market in just over 5 years. (Forbes).

BY | JADE BRIDGES | TECHNICAL SPECIALIST

With an ever increasing number of potential uses, Light-emitting Diodes (LEDs) are now present in all types of lighting, signage and domestic appliance products, to name just a few. In offering alternatives to halogen, incandescent and fluorescent lighting systems for both interior and exterior applications, the growth of the LED lighting market alone is impressive. Such growth is attributed to the advantages LEDs offer over traditional lighting forms in terms of adaptability, lifetime and efficiency.

Specially designed and formulated chemical products are widely used in the electronics industry for a vast array of applications. Whether it is during PCB (Polychlorinated Biphenyls) manufacture or for the protection of components or complete devices, such products have become an essential factor in ensuring the performance and quality of electronic devices.

Specifically in LED applications thermal management, conformal coating and encapsulation resin products can be used to



Increasing the Performance and Lifetime of LED Designs

assist Design Engineers in protecting LED systems in a variety of conditions.

Due to the design freedom that LEDs offer, applications are becoming more diverse and challenging and as such, aesthetic results must be achieved in conjunction with the consideration of reliability and lifetime of the product. In addition, specialist chemical products can also be used as part of the design for cosmetic reasons as well as helping to provide key functional improvements such as increased efficiency and reduced energy consumption. Design of the LEDs also allows much more freedom of application, interface materials are applied in such thin films that they account for virtually no weight or volume additions to the unit but still maximise the performance.

PERFORMING WHEN THE HEAT IS ON

Although LEDs are considerably more efficient than traditional lighting forms, they still produce some heat. This heat can have an adverse effect on the LED and must therefore be managed to ensure the true benefits of this technology are realised. Thermal management is an area where specially formulated chemical products are utilised to enhance the performance and lifetime of LED systems.

Colour temperature is not only affected by the protection media or surrounding environment, it can also be affected by the

LED Designs

continues from page 27

temperature at which the LED operates. For example, with white light an increase in operating temperature of the LED could lead to a 'warmer' colour of light being emitted. In addition, if a variance in die temperatures is present across LEDs in the same array, a range of colour temperatures may be emitted, thus affecting the quality and cosmetic appearance of the device.

LEDs themselves are very efficient but they can still be pushed further and use even less energy, this is one of the key goals in the industry and thermal management products can significantly help with this. For instance, LEDs are far less efficient when operating at higher temperatures, which significantly reduce the life of the LED.

Maintaining the correct die temperature of the LED not only extends the life but also leads to more light being produced and consequently, fewer LEDs may be required to achieve the desired effect. Thermal interface materials are used between the PCB and the heat sink in order to dissipate heat away from the LED, in turn reducing the junction temperature and prolonging the life of the LED. Thermal interface materials can be in the form of thermal bonding products or non-curing options, thus providing options should rework be required.

The choice of thermal interface material will also depend on the operating environment and power of the luminaire. Silicone and non-silicone options are available as well as mid-range and high thermal conductivity options. The application of the thermal interface material is also crucial – designed to improve the effective surface area and remove any air gaps; thermal interface materials should not form an additional thick layer within the system as this would significantly increase thermal resistance. For instance, an non-silicone paste, HTCX (Heat Transfer Compound Xtra) has significantly increased in thermally conductive filler without increasing the film thickness of the paste and without adversely affecting its viscosity/consistency; creating much higher thermal conductivity, lower oil bleed and lower evaporation weight loss. Non-curing thermal management pastes can also be applied easily in very thin films, thus dramatically reducing the thermal resistance at the interface and maximising the efficiency of heat transfer.

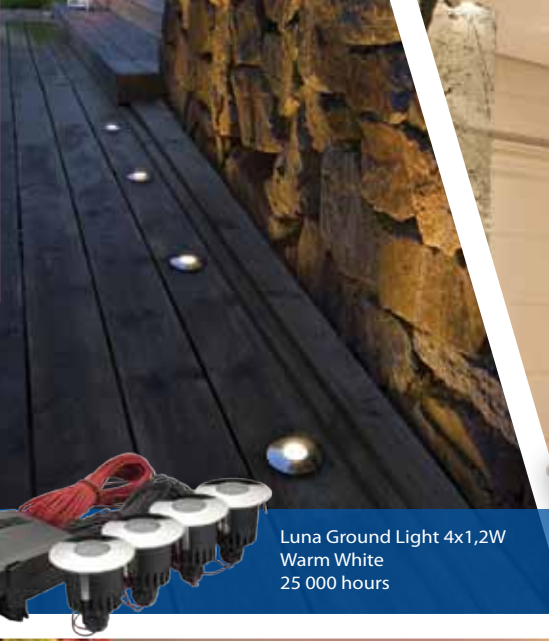
Another option for managing the transfer of heat away from electronic devices is to utilise a thermally conductive encapsulation resin. In this case, these products are designed to offer protection of the unit from environmental attack whilst also allowing heat generated within the device to be dissipated to its surroundings. The encapsulation resin essentially becomes the heat sink and conducts thermal energy away from the device. Such products can be used to encapsulate the technology behind and attached to the LED device and can also assist with the reflection of light back from within the unit, depending on the colour chosen. Resins also incorporate the use of thermally conductive fillers however the base resin, hardener and other additives used can be altered to provide a wide range of options, including epoxy, polyurethane and silicone chemistries. In challenging environments or outdoor conditions, thermally conductive resins can be used for heat dissipation and environmental protections, e.g. encapsulating LED drivers on outdoor lighting systems, street lights, signs and so forth.

This leads us to another important factor in product selection, the application of thermal management materials. Whether it is an encapsulation compound or an interface material, any gaps in the thermally conductive medium will result in a reduction in the rate of heat dissipation. For thermally conductive encapsulation resins, the key to success is to ensure the resin can flow all around the unit, including into any small gaps. This helps to remove any air gaps and ensure there are no pockets of heat created throughout the unit. In order to achieve this, the resin will have to have the correct combination of thermal conductivity and viscosity; typically, as the thermal conductivity increases, the viscosity also increases.

For interface materials, the viscosity of a product or the minimum thickness possible for application will have a great effect on the thermal resistance and thus, a highly thermally conductive, high viscosity compound that cannot be evenly spread onto the surface, may have a higher thermal resistance and lower efficiency of heat dissipation when compared to a lower viscosity product with a lower bulk thermal conductivity value. It is essential that users address bulk thermal conductivity values, contact resistance, application thicknesses and processes in order to successfully achieve the optimum in heat transfer efficiency.

ENHANCING PERFORMANCE IN CHALLENGING ENVIRONMENTS

The environment that the LEDs and associated electronic components are used in, will have an effect on the type of product required to protect the system and ensure reliability. If the assembly will be exposed to frequent and rapid changes in temperature, a flexible polyurethane or silicone material will offer better performance than a tough, rigid epoxy.



Luna Ground Light 4x1,2W
Warm White
25 000 hours

ALT 7W V3 GU10 LED
Warm White
30 000 Hours

40W LED Wall Washer
RGB DMX
15 000 hours

ALT 38W Growlight
Red & Blue
50 000 hours

ELT LED Modules
3000K, 4000K & 5700K
50 000 hours

ALT 92W Lodestar Floodlight
Natural White
50 000 hours

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Lighting your way

LED Designs

continues from page 28

Environmental challenges can be in the form of corrosive environments; when high humidity, salt mist or corrosive gases are present, for example. Due to the potential variety of LED applications it is also possible that UV exposure, water immersion or chemical exposure may also make up part of the operating environment. It is therefore imperative that the end use application is fully understood to ensure the correct protection media is applied.

Where protection directly over the LED is required there are a number of points that must be considered. The clarity of the material applied is crucial to ensuring the maximum utilisation of light output from the LED. In addition, any potential changes to the colour temperature, clarity of the material or light output of the LED during operation must also be considered. Protection can be offered in the form of conformal coatings or encapsulation resins, with the choice between the two being determined by the severity of the operating environment and the desired aesthetic effect. For example, for protection against high humidity or salt mist a thin layer acrylic conformal coating would offer a high level of protection with minimal impact on the light output and colour temperature of the LED. Encapsulation resins are used for harsh environments such as immersion in water, or where light dissipation and environmental protection are required in one process.

As briefly mentioned, the colour temperature of the LED will be affected by the protection media applied and therefore the potential colour temperature shift should be tested in accordance with the LED used. Typically, a conformal coating, will have only a small effect on these properties due to the formulation of the material and the very thin layer of 25-75µm applied. An encapsulation resin, however, may have a greater effect due to the thicker layer used, which in turn offers an increased level of protection. In such cases, it is important to understand the effect of the encapsulation resin on the LED properties and to also establish the consistency of any changes that may occur. For example, if a colour temperature shift occurs from 3500K to 4500K consistently, it is possible that an LED of lower colour temperature could be specified to account for this change; there are obviously other factors that must also be considered but this is just one example of how a colour temperature shift can be managed.

In addition to these initial changes when a protection compound is applied, it is also imperative that the performance of the LED system is tested in accordance with the end use conditions. The clarity of the protection media may be affected by the surrounding environment; exposure to UV light is a good example - a clear resin can be tested to understand more about its colour spectrum and results can be used to compare the clarity of a resin before and after UV exposure.

Long term performance in changing environments is also a challenge for both the LED's performance and the thermal interface material used. By applying a thin, uniform layer of a thermal interface material, it is possible to obtain the maximum efficiency of heat dissipation. It is also important to consider the operating temperature conditions throughout the lifetime of the product. Frequent changes in temperature are common in LED applications with devices switched on and off regularly. This results in the unit going through a thermal cycle, heating up once switched on and cooling again when powered down. Over the lifetime of the product, many thermal cycles take place and this may affect the positioning of the thermal interface material over time.

By careful consideration of the correct thermal interface material and identification of the correct test regimes, it is possible to differentiate between products and highlight the most suitable material for your application.

Design engineers have real challenges to face regarding the best solution for them; the aim for higher thermal conductivity at the potential expense of viscosity, the possible pitfalls associated with product application, ensuring there are no air voids when potting and ensuring exceptional coverage of thermal interface materials. Whether choosing a protective material for the individual LEDs or the entire unit design, it is clear that the operating environment must be considered.

With applications becoming more and more diverse, the number of challenges is increasing. By the correct selection and application of protection compounds, it is also possible to use LED arrays in a vast array of products and when combined with efficient thermal management it is possible to achieve consistent quality and appearance whilst improving the lifetime of LED arrays.

It is therefore apparent, that by the continued use of specially formulated electro-chemical compounds, the opportunities for further applications are increasing within this ever evolving industry. wn

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Nuclear Critical to Africa's Economic Growth

Africa is often referred to as the final frontier, the last and the fastest growing economy in the world. Unfortunately the huge potential of the continent with its vast natural resources and abundance of labour is limited largely by its lack of sustainable power.

BY | VIKTOR POLIKARPOV | ROSATOM REGIONAL VICE-PRESIDENT | SUB-SAHARAN AFRICA

According to the World Bank, over 1.1 billion people across the globe are living without access to electricity, more than half of these people live in Africa. To put this in perspective, only 24 percent of the population have access to electricity, meaning more than 620 million people in sub-Saharan Africa live without electricity. Excluding South Africa, the entire installed generation capacity of sub-Saharan Africa is only 28 Gigawatts, equivalent to that of Argentina.

These major shortcomings in the power sector threaten Africa's long term economic growth and competitiveness. The average cost of load-shedding

on the African economy is equivalent to 2.1 percent of GDP. In economics it is clear that GDP growth and access to sustainable electricity are more closely related than GDP Growth and total energy use.

It is abundantly clear that Africa desperately needs to increase its power capacity, but what are Africa's options for power, and how does one determine the optimum mix? Then there is the base load vs renewables argument, how does one choose between the two?

There are three important factors that should be considered when designing the optimum energy mix. The energy trilemma as it's otherwise referred to, is made up of economics, security of supply and environmental impact. Not many sources alone can bring together these three factors and therefore a mix is crucial, hydrocarbons such as coal for instance are economically viable and offer stable power but are unfortunately very bad for the environment. Renewables such as wind are great for the environment, but are intermittent by nature. Nuclear is one of the only power sources that is capable of ticking all three boxes, and is therefore crucial to help balance any mix.

One needs to understand that renewables and base load are not against one another, but rather work together in the energy mix. Base load can most appropriately be described as the essential minimum amount of power needed by the grid 24 hours a day, 7 days a week, to effectively run an economy. Energy is produced at a constant uninterrupted rate, and usually at a far lower cost when compared to other energy sources available to the system.

What is crucial to understand in the context of base load and renewables, is the Net Capacity Factor of these two complementary sources. The Net Capacity Factor of a power plant is the ratio of its actual output over a period of time, to its potential output if it were possible for it to operate at full nameplate capacity, continuously over the same period of time. Recent studies have shown that newer generation nuclear power plants can now achieve net capacity factors in excess of 92 percent, whereas wind can only achieve a net capacity factor of roughly 36 percent, and photovoltaic solar only 25 percent.

As you can see it is almost impossible for base load and renewables to compete against each other and should rather be used together to create a diverse energy mix. Renewables are great for remote standalone applications where it is difficult to extend grid infrastructure, but are unfortunately incapable of providing the base load power needed to drive industry forward.

Africa's options for base load power are limited, and at present are dominated by large-scale coal powered stations and hydro. The global community is moving towards a carbon free environment, and Africa has no option but to follow suit, which rules coal out to a certain extent. There is of course large scale hydro, which is for the most part sustainable, although the net capacity rarely exceeds 55%. It is affordable, yet the overnight costs are comparable to nuclear, and it does not emit CO^2. However, other environmental impacts must be considered. Hydro does however have one major drawback; it is very dependent on weather conditions and can be severely affected by droughts or floods.

An example of this is the Kariba Dam, which is one of the world's largest hydroelectric dams, and it contributes the majority of Zambia's energy. It has for years been a driving force behind the country's political stability and helped turn its economy into one of the fastest growing on the continent.

Unfortunately it was very recently effected by a severe drought, magnified by climate change which cut water levels to record lows, the generating capacity of the dam dropped to a point where blackouts nearly crippled the nation's economy. On a continent that is especially vulnerable to the effects of climate change, Kariba's rapid fall shows how climate change can threaten economic development across Africa.

Nuclear is an environmentally friendly, safe, reliable and affordable method of producing base load power. It is therefore no surprise that more and more African nations are exploring the possibility of a mix that includes nuclear to help solve their huge power deficits. This was proven during Atomexpo held Moscow in June 2016, where co-operation agreements on the peaceful use of nuclear energy were signed between Russia and a number of African nations, including Kenya, Ghana and Zambia.

There have been cost concerns raised by various media and environmental groups, who have asked if Africa can in fact afford to go nuclear. I fear these concerns may have been taken completely out of context. Firstly, although the overnight costs of a new build are high, they need to be viewed as an investment and not an expense. Especially when the operational lifespan of modern nuclear plant is taken into account, a nuclear plant can now provide affordable and sustainable power for over 80 years.

What is also essential to note is the fact that nuclear is far more predictable when considering long term running costs and this has everything to do with the share of fuel component of the overall cost of electricity. This share accounts for under 10 percent of the operating cost, whereas the share of fuel component for a gas or coal power station is anywhere between 60-70 percent.

Thus, even if the uranium price doubles, it will only result in a maximum 10 percent increase in the electricity price. But if gas prices double, it will result in a 60 - 70 percent increase in the cost of electricity.
The question should not be, *"can Africa afford nuclear"* but rather *"can Africa afford not to pursue nuclear?"* wn

Mulalo Tshivhilinge
Winner
2016 IEC YP Essay Competition

How I was introduced to standards ...

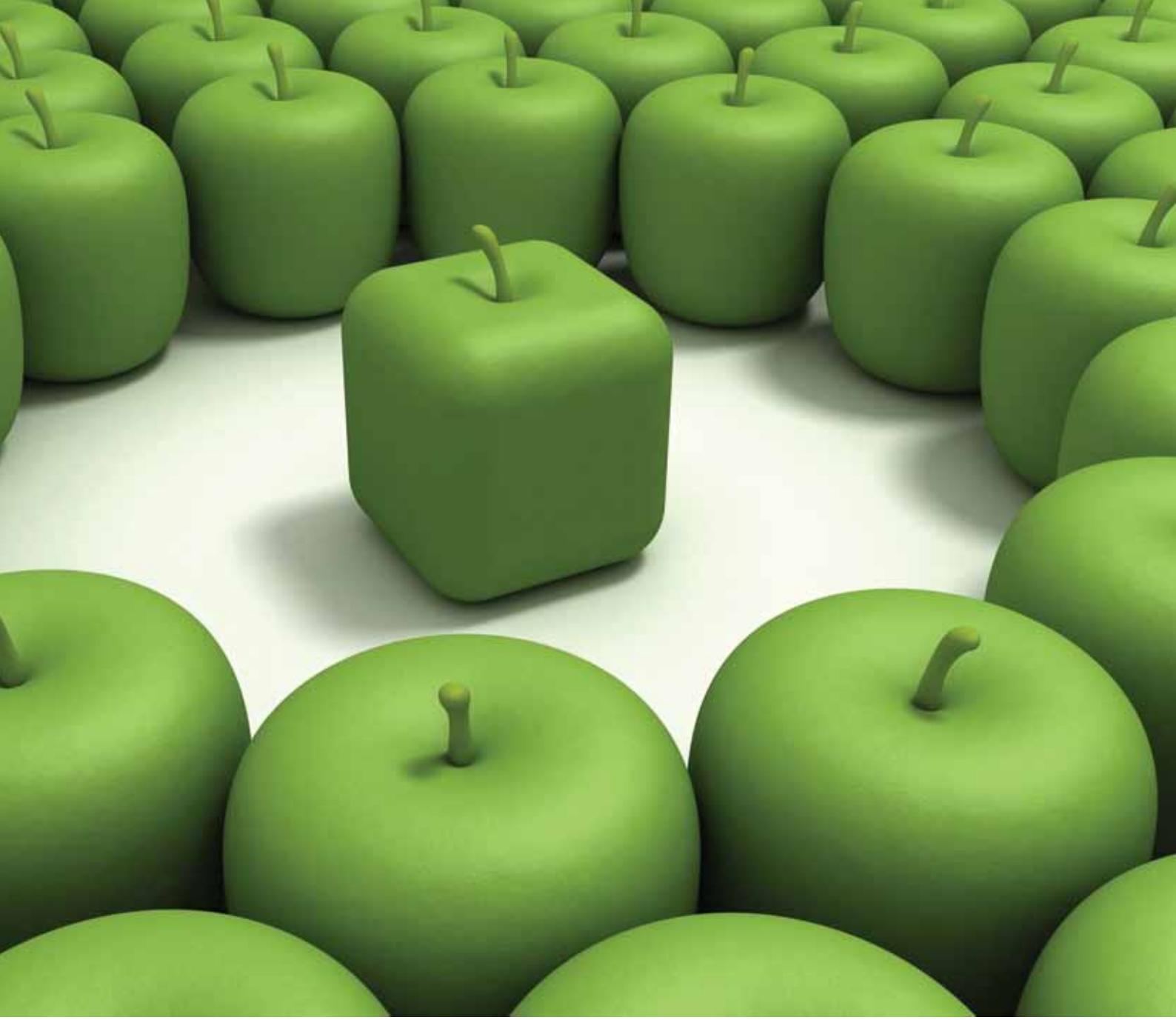
Standards are a central core of the day-to-day business conduct in science and engineering. Whenever we design, manufacture or operate equipment, and also when we use services, chances are that a standard exists to regulate the work.

BY I MULALO MERCY TSHIVHILINGE **I** WINNER 2016 IEC YP ESSAY COMPETITION

Whether we are manufacturing small to mega machinery, building communication infrastructures, bridges or residential houses, harvesting and extracting natural resources (mining), or working in the agriculture and food industries, there are standards for these industries.

In most cases we use standards intuitively. While driving on the road, we are guided by the road signs and speed limits. When building houses, City Council enforces regulations on the outlook of our houses. Even our streets have standards that must be adhered to. Simply put, standards make things better, safer, of higher quality and easier to use. However, as users, we not only benefit from existing standards, but can also help shape tomorrow's economy and knowledge by improving existing standards and developing new ones.

Improvements in economic and physical infrastructure, advances in information technology, manufacturing techniques, automation, transportation and changes in numerous other aspects affecting trade and industry have for centuries been regulated and guided by standards. The effects



of globalisation are everywhere, and standardisation has extended to not only production consumption and trade of goods and services, but also to management systems. International Organisation for Standardisation (ISO) plays a vital role in the development of management systems for quality, environment, energy, risk, food safety, information security, and occupational health and safety. Recently, a standard on Anti- bribery management system has been added. As new technologies and business emerge, newer standards are being developed. Standards are increasingly used to support technical regulations. Standards are fast-moving with the emerging of new technologies and social- economic needs for the wellbeing of the people. Standards benefit the producers and the end users of the produced goods and services.

There is no doubting the role of science and technology has in the development and advancement of humankind. The combination of technology and human skills development results in economic growth which, in turn, is necessary to generate further advances in human development. Technology has a direct link to a nation's wealth creation, improvement of standard of living, job creation, business innovation and robust international trade.

Engineers and scientists are the custodians of technology development and its advancement. Scientists develop and investigate the laws of physics that govern the existence of nature. Engineers apply laws of physics (scientific knowledge) and mathematical techniques for the advancement of these technologies and to solve social- economic problems. In improving technologies, the applied technical solutions should not contravene

Standards...

continues from page 35

the existence of the environment, health or safety of human beings. Therefore, these solutions are regulated through the guidance outlined in the standards for good practice and application of technologies. Standards are based on the experience and simulations from years of technical knowledge, collection of data by different science and technology standardisation technical committee around the world. Examples of well-known international standardisation bodies in the technical field are the International Electrotechnical Commission (IEC), the ISO and the Institute of Electrical and Electronics Engineers (IEEE).

In addition to international standards, nations develop national standards to ensure the implementation of their policies and regulations in their trade of goods and services. In South Africa, the well-known national standardisation body is South African Bureau of Standards (SABS).

Standards are key to a nation's participation in the global environment. In most cases, national standards are developed based on international standards. It is therefore important that nations develop skills and the knowhow to be able to participate in the development of standards, as this has an economic impact on the advancement of technology and therefore on the efficiency of the economy.

Although standards have been in existence for centuries, like most people, I have indirectly used them without knowing of or understanding their assistance. I was formally introduced to the existence of standards during my undergraduate electrical engineering studies at University of Witwatersrand (Wits). The High Voltage (HV) laboratory at Wits has three sections, namely the Lightning Impulse (LI) Voltage Generator, LI Current Generator and the Partial Discharge measuring station. Safety precautions are a high priority when conducting HV experiments. In 2008, I got practical exposure to the use and application of standards in conducting technical laboratory work in the HV laboratory. This was during my final year of study in the HV engineering course. The class was given a project to experimentally determine the flashover LI voltage of an overhead power line insulator under different environmental conditions.

I used the IEC 60060-1, which gives guidance on the preparation of the test object, test procedure and interpretation of the results, taking into account the atmospheric correction requirements. We also had to use IEC 60270 in laboratory work to measure partial discharges in an electrical insulation. By the end of 2008, I was fortunate enough to have worked in all the Wits HV laboratory stations. Standards became the building block of what my career is today. Little did I know that this was the start of my career and that one day I would find myself participating in the development thereof.

After my graduation, I joined Powertech Transformers (PTT) as an Engineer in Training (EIT) in 2009. PTT has a well-developed EIT programme. I was introduced to the manufacturing standards that are used in the organisation during the design, manufacturing and factory acceptance tests applicable to transformers. At this stage, it became obvious that standards are what my career would revolve around. After a year of training, I was assigned to the dielectric main insulation discipline of transformers, focusing on transformer insulation design, manufacturing, alternative materials and testing.

In 2010, I was given the opportunity to work with experts in the partial discharge failure investigation. At the time, Dr Jacko Koen was the organisation's representative in the CIGRE working group on partial discharge (PD) measurements. I had no idea that PD in transformers was such a challenge; that it is tricky to investigate its root cause (it is often said that it is like looking for a needle in a haystack).

When asked to work with the team, I saw an opportunity to advance my knowledge on the subject. During this time, I still had to decide on a research topic for my MSc studies. I remember telling Dr Koen that whatever research topic I was going to choose, it would have something to do with PD measurements as I had enjoyed the HV engineering course during my undergraduate studies. Who wouldn't – when it was presented by Prof Ian Jandrell? The energy and style with which he presented the course made it even easier to understand the subject. Also, I understood that for insulation breakdown to occur, it would involve some kind of PD in one way or another. Besides my ambitions and the reasons to be part of the team, I had no idea what was in store for me in building my career in the development of standards. I was being prepared for bigger things.

We faced so many challenges in finding the root cause of PD. We needed to employ other methods of measurement, which came in the form of an expert from Switzerland. At the time, Dr Jacko Koen had met Dr Jitka Furh, the PD expert in transformers during a CIGRE conference.

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"JB Switchgear Solutions was selected as an authorised distributor and reseller based on their longstanding working relationship with the Efficient Group" says Warwick Jackson, MD of Efficient Power.

Contact: Chris van Aardt – chrisv@jbswitchgear.co.za – 011 027 5804 / 082 908 4092.

Standards...

continues from page 36

Dr Koen invited Dr Furh to our factory to assist with the investigation. She brought in other technologies and methods of measuring PD and techniques to analyse the data. I learned a lot in the period of a week, working closely with Dr Furh. She taught me some of the techniques. When she left, I continued taking measurements under Dr Koen's guidance.

It was such a great learning opportunity for me. At the time, I had no idea of Dr Furh's involvement in the development of standards for partial discharge in transformers. I had no idea that I would later be in touch with her in a different business arrangement. After the investigation, I realised there was more that needed to be understood about the measurement of PD and the interpretation of the data.

In 2011, I enrolled for my Master's degree. My research topic was "A Comparative Study of the Effect of Surface Discharge on the Impulse Breakdown Voltage of Oil-impregnated Pressboard Insulation". This research afforded me the opportunity to solidify my knowledge on PD measurements and HV testing.

My research was based on both PD measurement and lightning impulse voltage (LI). I conducted the experimental studies at the Wits HV laboratory, as the lab was well equipped with the measuring tools required for the research. Again, the standards were the core of this research in guiding the experimental methodologies, sample preparations and interpretation of the data.

My life has significantly changed since my formal introduction to and involvement in the PD failure investigation in 2010. In 2011, my organisation gave me the opportunity to be a custodian of PD measurements in the factory. I successfully completed my MSc. in 2014! An appreciation of standards was of paramount importance to my research – particularly in respect of HV testing of electrical equipment. Dr Koen left the organisation in 2012, leaving a void in the representation of the company in the CIGRE for PD measurements. I was approached to represent the company on that platform.

In 2014 August, I joined the CIGRE working group JWG A2/D1.51 with the core focus on the improvements of PD measurements for factory and site acceptance tests of power transformers. To fully participate in this working group, one is required to travel to different parts of the world for meetings. Due to financial constraints, I am unable to attend meetings. Even though I am unable to attend the meetings and participate in person, I receive the communication on the developing activities as a corresponding member of the WG. I receive standard drafts and meeting minutes. This is an opportunity for me to expand my network and interact with experts in the field.

Since joining the working group, I have had the opportunity to get assistance in some of the PD-related challenges that I encounter in my work. This professional network has given me access to be at the development of technical standards for IEC through technical CIGRE committee. I have reconnected with Dr Furh and we have had more discussions related to PD measurement challenges.

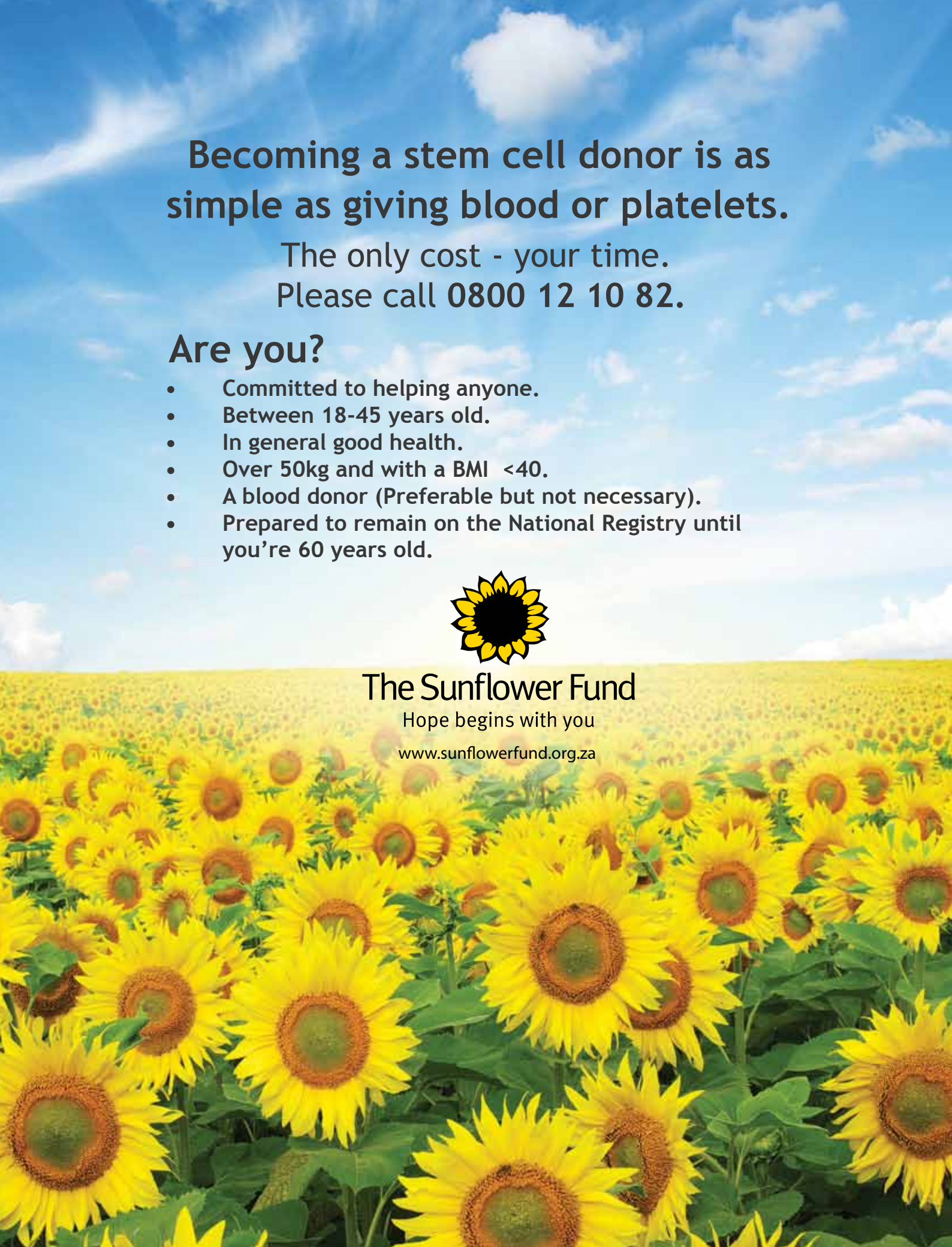
Through the group's network, I am working on getting some measurement done in South Africa to contribute in the collection of data for the development of non-conventional methods of measuring PD. So far, I have managed to secure a date and a member of the working group JWG A2/D1.51 to travel to SA to conduct the measurements. I have realised that this is my opportunity to contribute to the development of new knowledge and advancement of PD measurement in transformers.

Standards have been an integral part my career development throughout. It has allowed me the opportunity to interact with experts in the field. I have been given the opportunity to participate and develop skills.

This proves that standardisation bodies are a medium to transfer knowledge, and therefore technology, from one nation to the other. It is the responsibility of all who benefit from the technology to fully participate in the development of standards, and for government to invest in the development and participation of their people. To grow the economy and for the social wellbeing of the people, both private and public sectors must collaborate.

The development of standards is the core of economic development and is the responsibility of the education sector and public and private research institutes. It is of paramount importance to include the youth in the development of standards. This is to ensure the transfer of knowledge and to create a platform for learning. WN

PS: Look out for the 2nd IEC YP winner, Nevin George's winning essay, titled "The influence the IEC has on Transnet" - Ed.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Event Horizon Telescope

The Event Horizon Telescope (EHT) represents the culmination of a century of intellectual wrestling with Einstein's revolutionary theory of General Relativity.

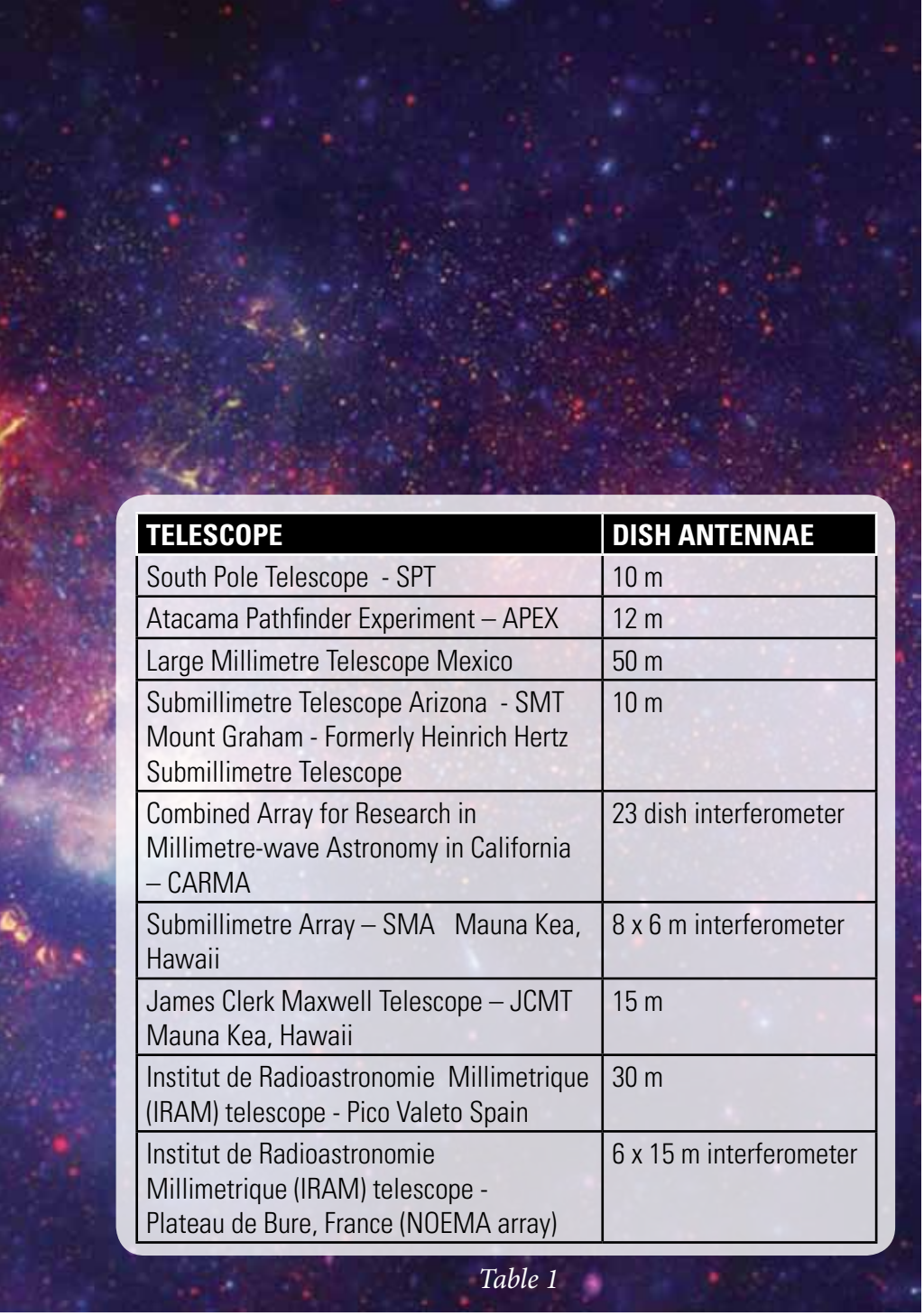
BY | DUDLEY BASSON

The EHT is an interferometric array of nine radio telescopes spanning an area nearly as large as planet Earth. The addition of the South Pole Telescope early in 2015 increased the interferometric baselines enormously. After much deliberation, a wavelength of 1,3 mm (230,61 GHz) was chosen as the best wavelength for the task. The current telescopes incorporated into EHT can be seen in Table 1.

Currently six of the radio telescopes are being used, encompassing most of the Pacific Ocean area.

The ultimate target of EHT is the supermassive black hole at the centre of the Milky Way galaxy, Sagittarius A*, referred to as A-star. This object, 25 000 light years away, has a mass of 4 million times that of the Sun and its event horizon is only 17 times the diameter of the Sun. To resolve a target of this size and distance requires an optical resolution of 20,6 micro arc-seconds, equivalent to observing a 3,5 cm disc on the surface of the Moon from Earth. The black hole will of course be much smaller and totally invisible.

Since its inception in 2006, the EHT has added telescopes to its array and it is hoped that an image of the A-star event horizon material will be achieved



TELESCOPE	DISH ANTENNAE
South Pole Telescope - SPT	10 m
Atacama Pathfinder Experiment – APEX	12 m
Large Millimetre Telescope Mexico	50 m
Submillimetre Telescope Arizona - SMT Mount Graham - Formerly Heinrich Hertz Submillimetre Telescope	10 m
Combined Array for Research in Millimetre-wave Astronomy in California – CARMA	23 dish interferometer
Submillimetre Array – SMA Mauna Kea, Hawaii	8 x 6 m interferometer
James Clerk Maxwell Telescope – JCMT Mauna Kea, Hawaii	15 m
Institut de Radioastronomie Millimetrique (IRAM) telescope - Pico Valeto Spain	30 m
Institut de Radioastronomie Millimetrique (IRAM) telescope - Plateau de Bure, France (NOEMA array)	6 x 15 m interferometer

Table 1

by 2017. The gravitation and magnetic fields of A-star are far beyond anything that can be achieved within the solar system, and will test Einstein's theory of General Relativity to the extreme.

A-star, in addition to the event horizon material, is orbited by a number of stars and also has a magnetar in close proximity. Magnetars, a special class of neutron stars, typically have a diameter of 20 km, a mass of 3 Suns and a magnetic field strength of up to 100 gigatesla. The record for a sustained magnetic field on Earth is 45 tesla. For industrial electrical machinery, a field strength of from one to two tesla is commonly used. Magnetars are strong sources of gamma and x-ray radiation. The density of neutron stars is unbelievable. 10^{17} kg/m^3 – 100 thousand tons per cubic millimetre.

A neutron star is effectively a continuous atomic nucleus. Despite their immense density, neutrons consist of three quarks and contain mostly empty space. Free neutrons are unstable and will quickly decay into a proton and an electron.

The interferometric data captured by the telescopes will be recorded on hard drives, and transported by aircraft to the MIT Haystack Observatory in Massachusetts, USA. The data will be analysed by a 40 Gbit/s network of some 800 CPUs. The processing of the interferometric data will be enhanced by an algorithm developed by MIT graduate Katie Bouman – this is known as CHIRP – Continuous High-

Event Horizon Telescope

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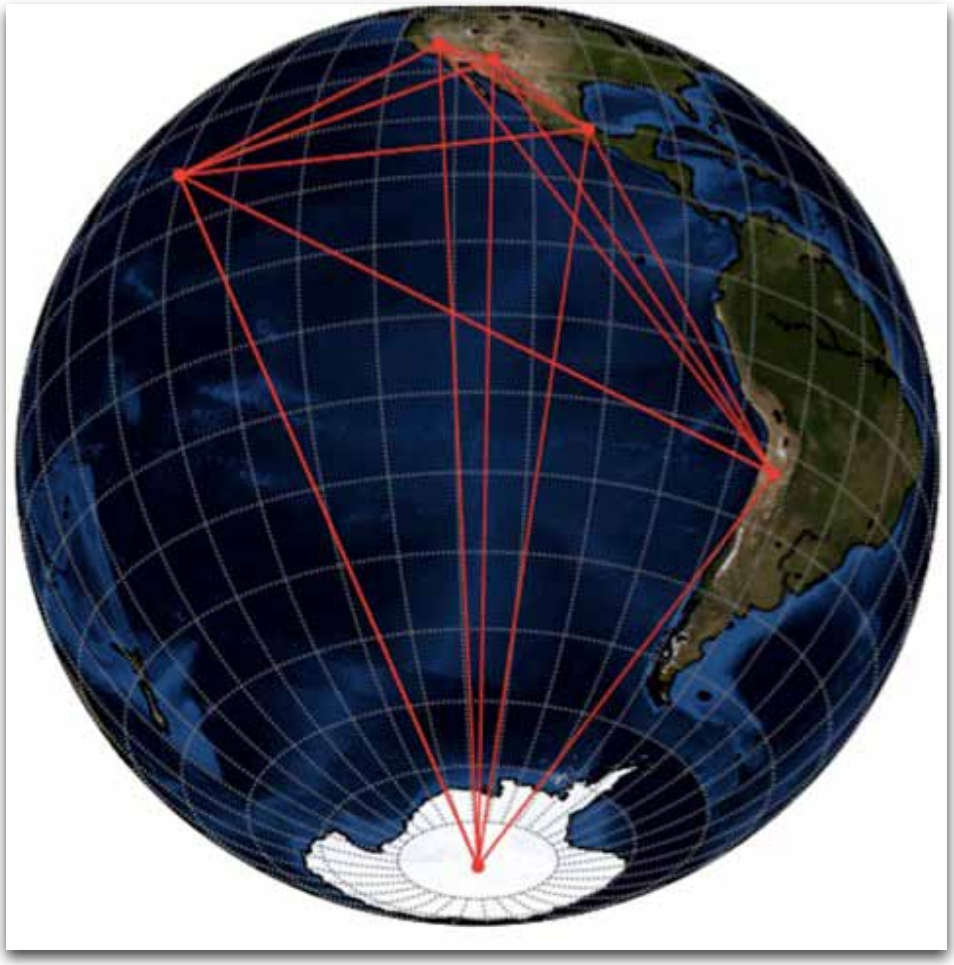


Currently used interferometer baselines with six radio telescopes

resolution Image Reconstruction using Patch priors. Instead of utilising pairs of interferometric telescopes, CHIRP will work with data from three telescopes at a time. CHIRP will use a machine-learning algorithm to identify visual patterns that tend to recur in 64-pixel patches of images.

The Atacama Large Millimetre/submillimetre Array (ALMA) in the Atacama desert of northern Chile is currently the largest, most expensive and powerful astronomical installation on the planet. This is an interferometric array of 66 dish antennae working in 0,316 mm to 9,67 mm wavelengths. The precursor observatory APEX (Atacama Pathfinder Experiment) operates in 0,2 mm to 1,5 mm wavelengths, and which will form part of EHT. ALMA is described in some detail in the August 2014 issue of **watt**now.

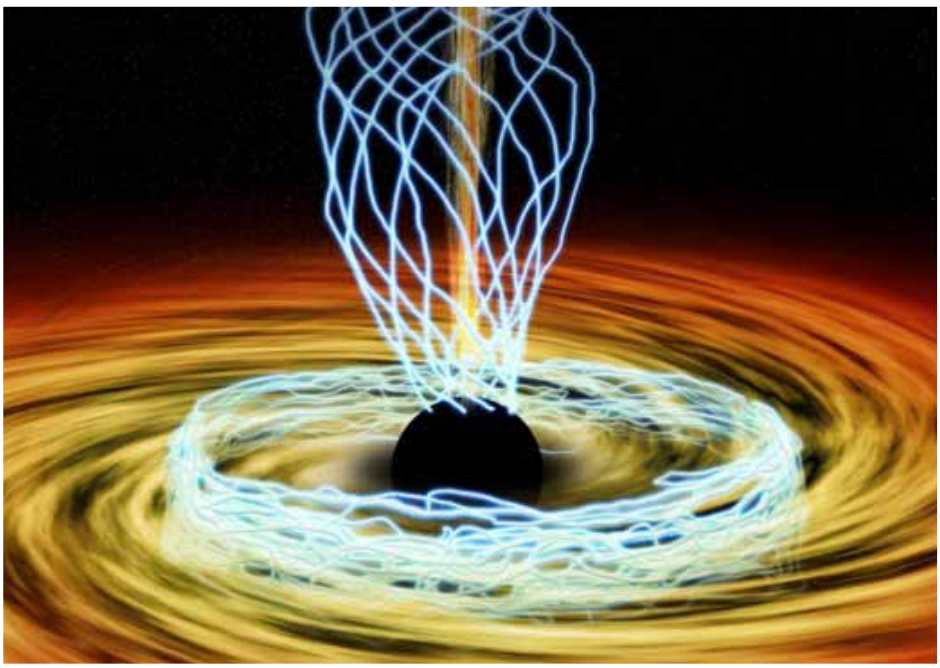
ALMA was officially opened on 13 March 2013 and has produced spectacular results. An astonishing result in 2015 was an image of a star with a protoplanetary disc in which planets were being formed. The axial image showed the disc full circle with the accretion rings cleared by the planets clearly visible.

ALMA was recently used to measure the mass of a supermassive black hole at the centre of galaxy NGC 1097, 45 million light years from Earth. This black hole has a mass 140 million times that of the Sun.

ALMA has been able to observe binary star systems which are able to support planets in stable orbits. ALMA has also detected sugar molecules in the vicinity of a star similar to the Sun, adding to the probability that life may be widespread in the universe. Astrophysics will take a huge leap forward when the SKA project, with its thousands of antennae, comes online from 2020 onwards.

ESA (European Space Agency) announced on 27 May 2016 that the Rosetta spacecraft has identified the chemicals glycine and phosphorus in the dusty halo around Comet 67P/Churyumov–Gerasimenko. The craft has been orbiting this comet since August of 2014. Scientists say the discovery is *"the first unambiguous detection of glycine at a comet"* and provides further evidence supporting the theory that the building blocks for life came to Earth from outer space. Glycine is the simplest amino acid, and one of the molecules needed to make proteins, while phosphorus is a key component of DNA and cell membranes.

On 14 September 2015, the Laser Interferometer Gravitational-Wave Observatory (LIGO) facilities in Hanford, Washington, and Livingston, Louisiana captured gravitational waves produced by a pair of merging black holes 1,3 billion light-years away. This was the first-ever detection of gravitational waves, as well as the first direct detection of black holes. The black holes were estimated at about 30 solar masses. The merging of the black holes produced a burst of power 50 times



In this artist's conception, the black hole at the centre of our galaxy is surrounded by a hot disk of accreting material. Blue lines trace magnetic fields. The Event Horizon Telescope has measured those magnetic fields for the first time with a resolution six times the size of the event horizon (6 Schwarzschild radii). It found the fields in the disk to be disorderly, with jumbled loops and whorls resembling intertwined spaghetti. In contrast, other regions showed a much more organized pattern, possibly in the region where jets (shown by the narrow yellow streamer) would be generated.
M. Weiss, Harvard-Smithsonian Centre for Astrophysics Cambridge, MA .

greater than the stellar radiation of the entire universe. This was equivalent to annihilating three Suns and radiating the energy as gravitational waves.

A large number of Earth and space based observatories turned to the event, dubbed GW150914, to observe the afterglow of a wide spectrum of electromagnetic radiation.

A gravitational observatory cannot tell from which direction the waves have come, they could even have come from below through the Earth. Two widely spaced gravitational observatories must be used together to ensure that the signal received was not spurious noise. The SWIFT satellite was launched in November 2004 with a planned service life of two years but remains fully functional. SWIFT is not an acronym – it was named Swift as it is able to swiftly alert other instruments to the occurrence of a gamma wave burst. This craft is designed to detect gamma ray bursts resulting from collisions of neutron stars or black holes. SWIFT has so far detected over 1000 gamma ray bursts. The wide angled burst alert telescope detects gamma bursts, and then alerts its narrow angle other instruments to detect the X-ray and ultraviolet radiation afterglow, as well as alerting Earth based installations. SWIFT was fortunately able to determine the exact direction of the gravitational waves detected by LIGO.

The merging of two neutron stars, or black holes, goes through three stages. Firstly they become a binary orbiting pair which will inspiral for many millions of years, losing energy by radiating gravitational waves. Then comes the extremely violent merger resulting in an enormous burst of gravitational and gamma radiation, as well as an afterglow of wide spectrum electromagnetic radiation. The final stage is the ringdown, radiating gravitational waves as predicted by Einstein.

On 25 December 2015, LIGO detected another gravitational wave, this time a collision of black holes of 14 and 8 solar masses radiating one solar mass as energy. Data was captured of the last 27 inspiralling orbits, before the cataclysmic collision.

Carlos Lousto, professor in RIT's (Rochester Institute of Technology) School of Mathematical Sciences, and a member of the LIGO Scientific Collaboration commented: *"We feel like parents of a beautiful daughter called gravitational wave astronomy born a few months ago and seeing her grow more gorgeous by the day."*

On 2 June 2016, nine pioneering scientists from Germany, Switzerland, the UK and the USA were named this year's recipients of the Kavli Prizes – one million dollar prizes that recognize scientists for their seminal advances in astrophysics, nanoscience and neuroscience.

The 2016 Kavli Prize in Astrophysics is shared between Ronald W.P. Drever and

Event Horizon Telescope

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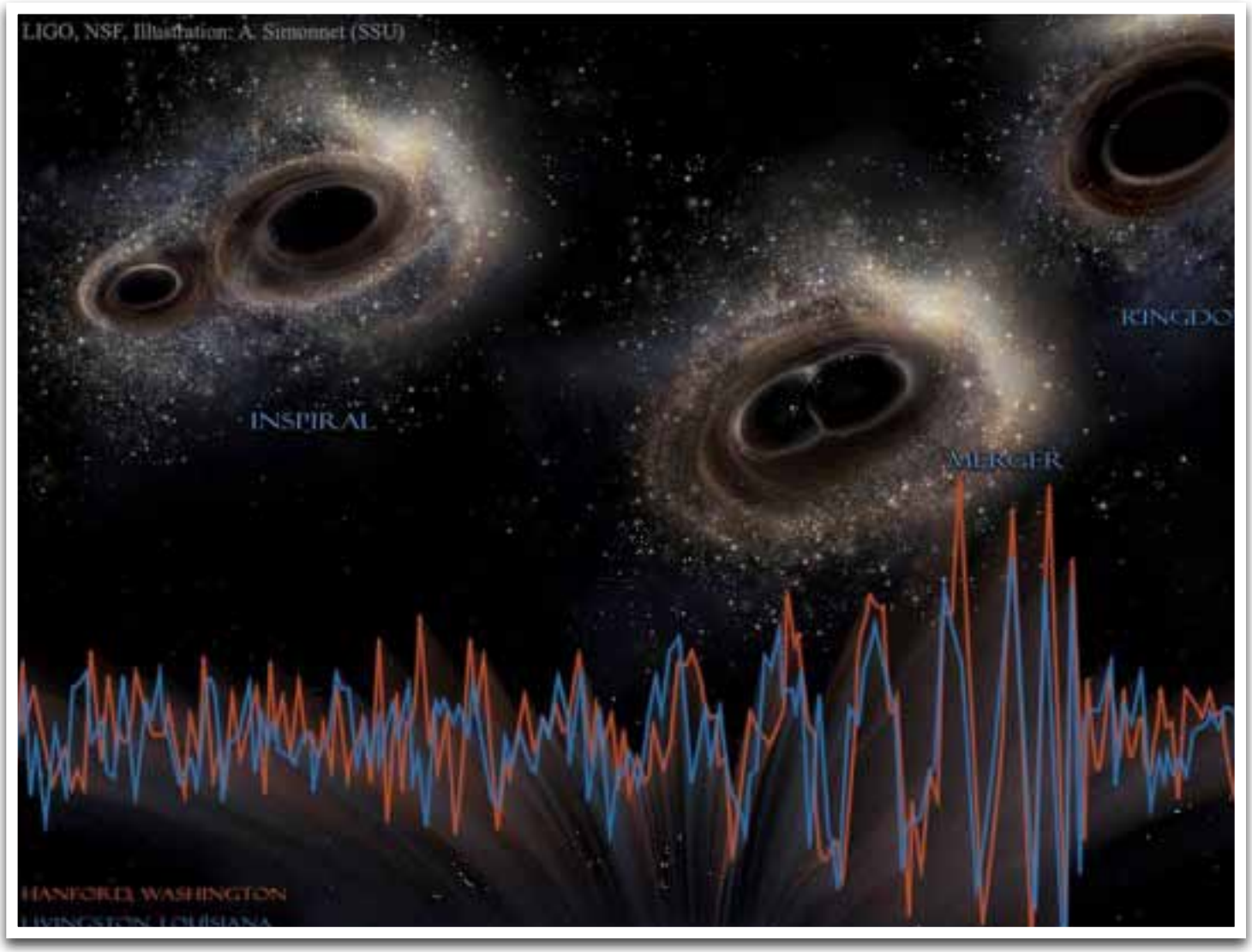

The direct detection of gravitational waves

Kip S. Thorne, both from the California Institute of Technology, USA, and Rainer Weiss of the Massachusetts Institute of Technology, USA. They received the prize for direct detection of gravitational waves.

The signal picked up by LIGO on September 14, 2015, lasted just a fifth of a second, but brought to an end a decades-long hunt to directly detect the ripples in space-time, known as gravitational waves. It also opened up a completely new way of doing astronomy, which uses gravitational rather than electromagnetic radiation, to study some of the most extreme and violent phenomena in the universe.

This detection has, in a single stroke and for the first time, validated Einstein's General Theory of Relativity for very strong fields, established the nature of gravitational waves, demonstrated the existence of black holes with masses 30 times that of our sun, and opened a new window on the universe. The LIGO observatories use pairs of evacuated light storage tubes of 4 km in length, at right angles to each other. It was estimated that a gravitational wave would cause a lengthening and shortening of the path by a hundredth of a femtometre (10^{-17} m) – less that a millionth of the size of an atom. It is expected that sensitivity in the zeptometre (10^{-21}m) range will eventually be achieved. The usual Michelson interferometer configuration cannot detect shifts of less than a nanometre.

Several other gravitational wave observatories have been established over the years.

The European Gravitational Observatory (EGO consortium) was created by the French CNRS and Italian INFI in 2000, responsible for the Virgo project started in 1993. Some of the scientific work was done to coincide with the LIGO detectors. A long upgrade phase was started to achieve Advanced Virgo by 2016. Virgo is equipped with 3 km long, 120 cm diameter evacuated pipes and will be sensitive to gravitational waves of frequencies from 10 Hz to 10 000 Hz. Virgo was constructed at the Cascina site near Pisa, Italy. When Virgo is fully operational it will be able to assist in obtaining the direction of the waves detected by LIGO.

The GEO600 (Gravitational European Observatory) is a joint British-German gravitational wave observatory situated near Hannover in Lower Saxony. This utilises two 600 m evacuated tubes of 60 cm diameter. GEO600 is a partner in the aLIGO project and contributes to the pre-stabilised laser system for all advanced LIGO detectors. GEO scientists are involved in the commissioning and operation of the LIGO interferometers.

The LISA (Laser Interferometer Space Antennae) was to have been launched as an ESA Cornerstone mission in 2015 with a fleet of four spacecraft, three of which would form a triangular interferometer with 5 million km baselines. The mission has subsequently been revised after NASA's withdrawal, and has been added as eLISA, as an L3 part of the ESA Cosmic Visions Roadmap with a planned launch for 2034, or possibly earlier.

The eLISA Pathfinder satellite was sent into orbit on 3 December 2015 to test elements of the laser measurement system that would be used on the future observatory. Performance objectives were exceeded on the very first day the equipment was switched on. The satellite was equipped with a single instrument to measure and maintain a 38 cm separation between two free floating test masses of gold-platinum blocks. The instrument was able to measure the positions of the test masses to within 30 femtometres (30 x 10-15 m) per square root hertz, which was better than requirements. Discussions are in progress for possible NASA participation.

The nature of "dark matter", which constitutes 85% of all the matter of the universe has remained a tantalising problem for decades. It has been widely thought to be made up of "WIMPS" – weakly interacting massive particles. A theory has now been proposed that dark matter consists of intergalactic primordial black holes, which formed at the beginning of the universe and not later within galaxies. Most galaxies have black holes at their centres.

The early years of the 20th century were a time of epoch making discoveries. In 1900 Max Planck proposed his Quantum Theory and 'Planck's Constant' which was a sensational departure from Newtonian physics. Quantum theory defined light as particles which later became known as photons. Planck was awarded the 1918 Nobel physics prize for his achievement. The Michelson-Morley experiment performed in 1887 proved that the velocity of light was the same in any direction and that the luminiferous ether does not exist. If light existed as waves moving through the ether then it would have different velocities in different directions due to the movement of the Earth through space. This threw theoretical physics into turmoil and paved the way to the development of the Special Theory of Relativity.

Einstein published his Special Theory of Relativity in 1905 and is usually cited as the originator, but this was actually a huge effort involving Lorentz, Poincaré, Hilbert and Minkowsky. It is quite possible that Poincaré was the originator of Special Relativity.

By 1907 Minkowski realized that the special theory of relativity, introduced by his former student Albert Einstein in 1905, and based on the previous work of Lorentz and Poincaré, could best be understood in a four-dimensional space, since known as the "Minkowski spacetime", in which time and space are not separated entities but intermingled in a four dimensional space-time, and in which the Lorentz geometry of special relativity can be effectively represented. The time dilation and length shortening of objects moving at relativistic speed are expressed mathematically by Lorentz Transformations. In 1905, Poincaré was the first to recognize that the transformation has the properties of a mathematical group, and named it after Lorentz.

According to quantum theory, photons are without mass and cannot experience gravitational acceleration, yet they will appear to accelerate towards massive objects in exactly the same way as if they did have mass. If photons did have mass it would be impossible for them to travel at the speed of light. What is happening here? In 1916 this effect was required by Einstein's Principle of Equivalence which forms part of the General Theory of Relativity. With the aid of mathematician Marcel Grossmann, found

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out how to write physical laws in a form that is valid for any choice of coordinates, by a method involving the use of general tensor analysis. General Relativity is formulated completely in the language of tensors. The word 'tensor' was originally introduced by Hamilton, but tensor calculus was developed around 1890 by Gregorio Ricci-Curbastro. Einstein entered into a correspondence with mathematician Tullio Levi-Civita for further work on tensors, writing to him in a letter: *"I admire the elegance of your method of computation; it must be nice to ride through these fields upon the horse of true mathematics while the like of us have to make our way laboriously on foot."*

In 1913 Max Planck visited Einstein who told him of the current state of his work on the General Theory of Relativity. Planck replied: *"As an older friend I must advise you against it, for in the first place you will not succeed, and even if you succeed no one will believe you."*

A famous prediction resulting from General Relativity was that light from a star would be very slightly bent when passing by the surface of the Sun. In 1704 Isaac Newton suggested that light could be deflected by gravity. There was no possibility of performing a terrestrial experiment to prove the theory.

Sir Arthur Eddington was one of the first physicists to understand the early ideas of Einstein's relativity. On 29 May 1919 Sir Arthur performed observations of the solar eclipse on the island Principe. Unfavourable weather conditions and other problems would have wasted the opportunity had Sir Arthur not taken the precaution of arranging duplicate observations to be taken elsewhere. He managed to record the bending of starlight in the vicinity of the Sun thus proving Einstein's theory. He wrote the following parody of quatrain LXVI of the Rubaiyat of Omar Khayyam:

Oh leave the wise our measures to collate
One thing at least is certain, light has weight.
One thing is certain and the rest debate
Light rays, when near the Sun, do not go straight.

In 1916, Karl Schwarzschild (1873-1916) obtained the exact solution to Einstein's field-equations for the gravitational field outside a non-rotating, spherically symmetric body. This has come to be known as the 'Schwarzschild radius' and later the 'event horizon'. This is the boundary after which nothing can escape the gravitational field of a black hole – not even light. A general acceptance of the possibility of a black hole did not occur until the second half of the 20th century. The Schwarzschild radius of the Sun is 3 km, and the Earth 9 mm, which is only meaningful if these bodies are compressed to fit within these sizes. An object can only become a black hole when it fits inside its Schwarzschild radius.

Subrahmanyan Chandrasekhar (1910-1995) is most renowned for determining the minimum mass that a stable white dwarf star must have before collapsing into a neutron star or a black hole (1,44 solar masses – 2,864 x 10^{30} kg). He made this famous prediction in 1930 aged 19 despite opposition at the time to the idea that black holes exist. Chandrasekhar was awarded the Nobel physics prize in 1983. Galaxy NGC 1277 is embedded in the nearby Perseus galaxy cluster, at a distance of 250 million light-years from Earth. The supermassive black hole at the centre of this galaxy has a mass of 17 billion Suns – about 14% of the galaxy mass. On 5 December 2011 astronomers discovered the largest supermassive black hole yet found in the nearby universe – in supergiant galaxy NGC 4889 at a distance of 336 million light-years, with a mass of 21 billion Suns. Black holes in quasars are much larger, due to their active state of accretion – the largest yet found, at a distance of 12,1 billion light-years, has a mass of 40 billion Suns.

According to Einstein's General Theory of Relativity, massive accelerating objects in space should emit gravitational waves, and which should also drain energy from the source object. Aspinning spherical object will not radiate gravitational waves, but a non-spherical one, and more particularly, orbiting objects, will. Gravitational waves must not be confused with 'gravity waves' which is a term used in hydrodynamics.

To put matters in perspective, let us consider gravitational waves emitted by the Earth orbiting the Sun. Using Einstein's quadrupole equation, the gravitational power emitted by the Earth would be about 300 watts, hardly enough to power the microwave oven in your kitchen.

The frequency period of this wave would of course be one year. When passing through physical objects, the gravitational wave would cause alternate lengthening in one direction and shortening in another, between pairs of widely spaced objects, in a plane at right angles to the direction of the wave. It is this dimensional oscillation that gravitational astronomers use to detect gravitational waves. In the case of the Earth-Sun system, at a distance of one light year,

the stretch-shrink strain factor of a ring of particles would be 10^{-26}, an impossible dream as far as practical measurement is concerned. There remained however, the possibility that gravitational waves could be detected from extreme sources such as neutron stars, or black holes, orbiting as close coupled binary systems. The loss of energy would cause a slight inspiralling of the objects, which could possibly be detected by a slight change of frequency.

In 1974 Russel Alan Hulse and professor Joseph Hooton Taylor, both of Princeton, using the 305 metre Arecibo radio telescope in Puerto Rico, discovered a binary pulsar, thus providing the first step in the new science of Gravitational Astronomy. Hulse and Taylor were awarded the 1993 Nobel Prize in Physics for the discovery of a new type of pulsar, a discovery that has opened up new possibilities for the study of gravitation.

Professor Carl Nordling of the Royal Swedish Academy of Sciences concluded his presentation address with:
Dr. Hulse, Professor Taylor,
You have been awarded the 1993 Nobel Prize in Physics for your discovery of the first binary pulsar, PSR 1913+16, a discovery which has had a great impact on gravitational physics. It is my privilege to convey to you the heartiest congratulations of the Royal Swedish Academy of Sciences, and I now ask you to receive the Prize from the hands of His Majesty the King.

The Nobel Banquet address of Professor Joseph Taylor given on 10 December 1993 is of particular interest:
Your Majesties, your Royal Highnesses, ladies and gentlemen.

We have heard earlier today that scientific discoveries come at unpredictable times. Just as a person cannot say "I shall write poetry", another cannot say "I shall make a scientific discovery."

Russel Hulse and I did not set out in 1973 to detect gravitational waves, or even to conduct experiments into the fundamental nature of gravity. Instead, we set out to chart the celestial globe with a new type of star – aware only that we were sailing a route that none had explored before, and that wondrous new lands might be revealed beyond the next horizon. We were young, well-prepared, and receptive, but not yet wise. We were playing a detective game, gathering clues and solving logical puzzles as they presented themselves. One special new island, at first only faintly visible in our telescopes, later showed its bounty in full relativistic glory. When its treasures were gathered and brought home, some after many years of labour, they provided keys to long-locked gates, and added new notes to the symphony of natural law. In discovering this new island and gathering its exotic fruits, Russel Hulse and I, and other colleagues in later years, were enjoying the privilege of doing what we liked best: satisfying our own curiosities, by asking and answering questions. We sought no other reward than the pleasure of an exciting journey. To be honoured by being here tonight is beyond our wildest youthful dreams of nineteen years ago, and brings us joy that mere words cannot express.

The details of the Hulse-Taylor binary neutron stars are extreme beyond anything we can experience on Earth. Let us take a look at some figures posted by Robert Johnston in 2004 (Table 2).

There has never been a better time for astrophysics, theoretical physics, mathematics and engineering. The advances made during the past century and early 21st century have been sensational. We can expect even greater achievements for the 21st century, arising from the Event Horizon Telescope, the new space based experiments and the phenomenal Square Kilometre Array radio telescope interferometer. wn

Distance from Earth	21 000 light years
Mass of pulsar	1,44 times Sun mass
Mass of companion	1,39 times Sun mass
Pulsar rotational period	59,029 997 929 milliseconds
(about 1016 rpm)	
Diameters of neutron stars	20 km
Orbital period (year length)	7,751 939 106 hours
Periastron separation	746,60 km
Apastron separation	3 153,6 km
Rate of decrease of orbital period	76,5 microseconds per year
Rate of decrease of semimajor axis	3,5 metres per year
Lifetime to final inspiral	300 million years

Table 2

Some years ago I attended an ECSA event at which the guest speaker made the point that Engineers were a particularly ethical group of people. The call was made for engineers to make their professional voices heard, in regards to current events in our society.

I have never found any conclusive evidence to verify this claim, but anecdotally there does seem to be something in it (one wonders if you could come to the same conclusion in casual conversation with lawyers or bankers, Managers, Directors or CEOs, or any other professional class of people?). Engineers however, don't get involved. My experience has been that the overwhelming mood of their ethical discussions has the character of dissatisfaction and disengagement. This short article is an attempt to understand that dynamic and to try to explain it to my profession and my colleagues, in a way that may be helpful to energise the sensible ethics of engineers.

Ethics is a branch of philosophy, and therein lies possibly the first issue; it is not as straightforward as one would wish it to be. The study of ethics asks the questions "how do we discern right behaviour from wrong?", "what is the right way to live our lives?" and these are not very convenient questions, especially when their answers conflict with our own interests. The answers to these questions seem to vary with the times, with culture, the state of society and

Ethics for Engineers

BY | TERRY LAWRENSON | BSC ELECTRICAL ENGINEERING | MPHIL-APPLIED ETHICS | SMSAIEE

the personal development of that minority of individuals, who may pause to actually reflect on these things. We live in a time where people long for moral clarity, and instead we get debate, obfuscation, clever people with clever words doing just what suits them. Engineers don't respond well to this kind of nonsense.

In this article I am going to try to persuade my peers why we need first, to give up our naïve wish for simple answers before we can tackle the issue of common beliefs and commonly shared moral clarity. I will deal briefly with the difficulties of embedding ethics into the complexities of the economy and business, governance and law, before dealing with the risks of oversimplification and disengagement.

So, beginning with the economy, the question is "what is it?". If one compares the global economy to other massively complex human creations such as the space station, CERN, war, it is overwhelmingly more complex, orders-of-magnitude more complex. Of course there is the obvious point that these multinational, and multi-technical creations are only possible because there is an economy. It therefore forms some small part of, and are embedded within international economies. Eric Beinhocker describes the economy as "Humanity's most complex creation, … , yet no one designed it, no one runs it".

Trade and economic activity are natural human activities. Every known society and culture, no matter how far back or isolated, have engaged in trade. It emerges spontaneously wherever humans interact with humans. Yet no one is actually in

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charge? No one fully understands it? Evidence of inflation is seen thousands of years ago in the earliest of societies, and there are even those who believe that Rome's inability to control inflation played a significant role in the fall of the Roman Empire. Governments don't control their economies, but try to manage the consequences through monetary policy, interest rates, tax - all of which impact in ways which, themselves are difficult to keep in balance. Every government struggles to maintain a balance and bring their economies and business under control. Over-regulation stalls opportunity and investment, or drives these complex and fluid webs of interactions outside of the formal systems (consider the prohibition in the USA, or prostitution and drugs, grey goods, gambling, arms, etc.) Under-regulation, a lack of legal capacity or political will, simply increases corruption and undesirable business activities (corruption is well publicized, but consider also business collusion, anti-competitive behaviour and rogue management who plunder their businesses).

Within economies is the issue of business, itself a dynamic phenomenon. The last 100 years or so, have seen the emergence of the mega and multinational corporation and the decline of the traditional, or family owned company. We think we live in a capitalist economy, but it's difficult to find real capitalists anymore? Owners of businesses have fragmented into millions, tens-of millions of faceless holders of micro-capital held in collective schemes through shares, pension funds and unit trusts – all represented by managers, who have become proxies for the original notions of owner-control. Once again the simplistic notion of someone in being in charge, someone who should be held accountable, has diluted into a complex sort of collective endeavour, in institutions too big and too complex, for single people to fully understand. Legal systems struggle to bring these institutions under law, because it's often difficult to assign blame, and regulators all over the world are legally outgunned by business. With this evaporation of clear lines of who actually owns business, it's no wonder that the last few decades have seen management salary growth outstripping all other stakeholders returns.

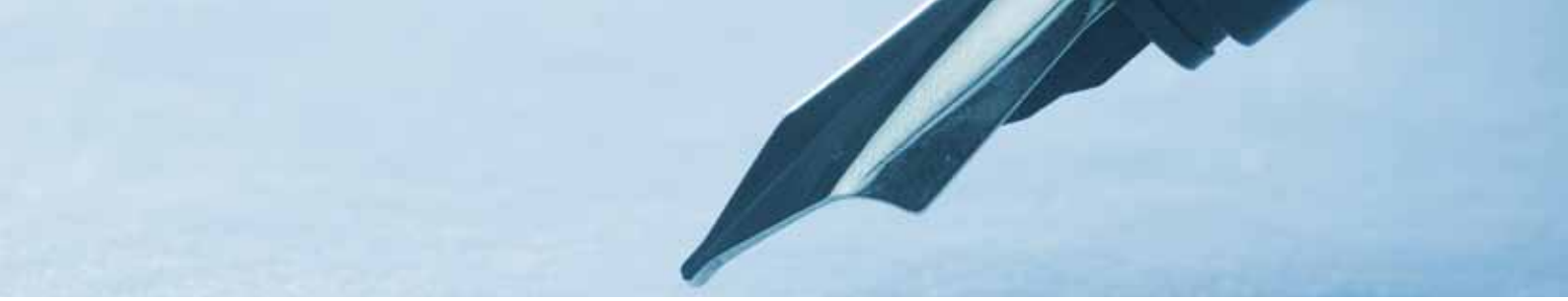
So, if you work for a large company, or hold shares, unit trusts or a pension you are embedded into the complex cycle of the economy and business. Similarly, if you are in management, a director or CEO. Even when you are a consumer, spending beyond your needs, and contributing towards growth and inflation. In all of these things we are simultaneously, and bewilderingly both victim, and perpetrator, of the current state of business and the economy.

I wonder how many people know that the emergence of Corporate Governance was originally to protect companies from their own management, to set rules to control management from running businesses in their own interests? It has only been in the last few decades that corporate governance has grown into stakeholder models, attempting to be a broader kind of ethics, than simply looking after the interests of shareholders, who have become absent in the modern capitalist model.

This again, brings us back to the naïve wish for clarity, in a world gone crazy with moral relativism. Moral relativism is a kind of convenient "each one for themselves" philosophy, that we see playing out in business, politics and practically anywhere that one looks. Moral relativism argues that, because it is difficult to agree on the kinds of rules of engagement that suite everyone, my own personal interests are as good as the next. Moral relativism supports the current phenomenon of the individualisation of moral outrage, that says that "everything must fall". Any small group, loud enough or violent enough, can escalate their own personal issue to the top of the social debate, and ahead of what may be truly the issues to be resolved for the overall benefit of society. In this way, society is fraught and overwhelmed, by a constant rearranging of the visible issues, while the foundational issues go unresolved. And in all of this good, moderate and decent people are silent, sullen and disengaged.

The problem when moderate, intelligent and decent people are silenced, is that the radical, and the outright unethical reign free. The radical use the silence to polarise, to hijack legitimate concerns, in a manner that good people don't want to be associated. The unethical use the complexity, the relativism, the struggling legal system to stall, slow and paralyse the interests of society. As it becomes clear that there is nobody that is going to resolve these issues, in the best interest of society, other than society itself, the need for the voices of the decent and moderate becomes obvious. What then, and how, should we exercise these moderate ethical voices?

What is going to follow is based on the business environment. But However, there are not different kinds of ethics for business, compared to the rest of life, so these principles are easily carried over into our personal lives, church communities, our communal and political lives.



A good first step is always a bit of self-education. Every organisation should have an ethics policy, and mostly they cover the basics. My advice is find your company's and read it, properly. King III requires companies to have a code, and to train staff, so these things tend to be done in a sort of rushed and minimal way – in order to tick it off as done. Go further, and find Chapter 1 of the King III Practice Notes.

Many would be surprised at how much guidance, suggestion and advice is offered to help companies to develop ethical cultures. It is much more than just the minimum. In our deeply divided society, business is one of the few opportunities that we have to genuinely integrate with people from different backgrounds, across the race spectrum, gender and socio-economic background. Business is in the best position to bring people together around shared values. Imagine a South Africa in which every business took Chapter 1 seriously, and put ethics in its rightful place in the range of business objectives.

Read the King III code itself. The code and practice notes are easily found on various internet sites. The Introduction and Background will only take about 30 minutes, and gives a very understandable explanation of how it is structured, and why. It also explains the trade-offs between legislating governance, versus a system of principles and practices.

Find the Dept. of Public Works' Anti-Corruption Strategy document, and read that too. I can already hear the howls of protest! The fact is that the document exists because concerned, and involved people have made the effort to try to enlighten, and empower the decent majority. What is missing is the voices of those decent majority, within these government departments, and within private companies that support them.

It is in the absence of knowledge, vigilance and courage from the majority, who would benefit from anti-corruption, that the few who benefit from the alternative are emboldened. Most engineers will do some work for government departments or SOEs in their careers, and there are many versions of this anti-corruption strategy that explain, in clear language, the kinds of things that constitute corruption, and what to do about it. It is not good enough to complain about the state of affairs, if we don't even know what exists, and what attempts are made to change the current situation.

So far these suggestions cover the basics, but the reality is that ethics gets complicated when concerns move into the subtleties and uncertainties. Corrupt acts and omissions start small, and are normally not obvious in the beginning. One of the ways in which unethical acts differ from crime, is in their early intentionality. Often they end being one-and-the-same, but early detection can change the course of events (to everyone's benefit, including those flirting with the unethical behaviour).

Robert Solomon describes an ethical decision making model that should resonate with the rationality of the engineering mind-set. He suggests a five step process, summarised as:

1. Identify the problem – why do you think what's going on is unethical, or could become unethical? Use your knowledge from the prior reading.
2. Identify the constituents – who is involved? Who is being hurt? Are they willing participants? Perhaps you are involved and you did not realise the full scope and consequences?

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3. Diagnose the situation – How bad is it? Will it get worse? how bad can it get? Who is to blame (sometimes nobody until the right people don't act)? Can something be done to prevent it, or limit its consequences?
4. Analyse your options – What are the range of options? What are the likely outcomes of each? Who can you talk to? Who will help? Almost always there are people who can be approached (a company secretary or FD, senior management, respected colleagues, Tip-off lines).
5. Take action – This is the critical step. It is a lack of action that keeps unethical behaviour in the shadows, allows it to flourish and grow into full-blown harmful consequences. Every single case study of corporate misconduct shows evidence of early detection, decent people being uncomfortable, but a veil of silence, because people don't want to rock-the-boat.

Solomon has this to say, about needing a strategy that goes beyond the basic rules, "The importance of decision making, and good judgement in business ethics cannot be overestimated. Following the rules is always a handy guide to right action, but it is never enough, and in some exceptional cases it may be disastrous". Law deals with crime, and rules cover the obvious, good judgement covers all potential scenarios.

Just recently Thuli Madonsela made the statement that ethical courage doesn't always mean choosing between right and wrong, but rather between degrees of right. Notice the use of the word "choosing", I'm quite sure this wasn't used accidentally. Being ethical doesn't just happen automatically. Rather it is purposeful, it involves knowledge, decision making and action.

A final bit of advice for my engineering colleagues, is a bit of self-reflection. How ethical are you, and are your principles and integrity known to others? Would you stand up for what is right? Would you support another who took a stand for what is right? This is important, because values and integrity are aspects of our characters that take a very long time to develop. Being seen to be ethical is inspirational to others, in a sense motivating, and encouraging others who are like-minded.

A second very good reason, to keep your own ethical behaviour beyond reproach, is that experience shows that when one speaks up, it is almost always unwelcome. This is natural human behaviour, people feel judged and react negatively. Shining the light of scrutiny into shadowy corners, makes people very uncomfortable. An almost inevitable reaction, is to question the credibility of those asking the questions, and there is no more effective way to re-silence the issue than to intimidate, bring doubt, complicate and obfuscate.

In conclusion then, the difficulty for engineers is that ethics falls within the broad scope of the humanities, that cluster of subjects that deal with the human experience. It is vulnerable to subjectivity, and to peoples' vested interests. Ultimately however, our ethics reflect our shared human nature and shared societal values, and in time take on the values of those who are prepared to stand up and be heard.

It seems to me that society is ethically poorer, for lacking the fairness and clarity, that the engineering way of thinking can bring into the corporate, social, economic and political spheres.

For ease of reading and flow, I have not referenced diligently in this article, but I acknowledge that I have borrowed from the following sources:

- *"Moral Clarity"* by Susan Neiman, Princeton University Press 2009 – An excellent read if you have the stomach for a difficult, intellectual book.
- *"The Origin of Wealth"* by Eric D. Beinhocker, Random House Business Books, 2007.
- *"Public Service Anti-Corruption Strategy"*, Department of Public Service and Administration, 2002.
- *"Ethics and Excellence"* by R.C. Solomon, Oxford, 1992. wn

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10 LinkedIn tips that can get you hired

Most recruiters these days will take a look at your LinkedIn profile to learn more about you if your CV captures their eye and they're interested in interviewing you. They also often scan relevant profiles on LinkedIn to identify people they think might be a match for positions they are struggling to fill or don't want to advertise.

BY | HEIDI DUVENAGE | SAGE TALENT SOLUTIONS

A recent study on Global Recruiting Trends 2016 showed that 43% of recruiters use social professional networks as their key source of quality and 42% use internet job boards. As such, a clean, professional and presentable LinkedIn profile can be a major asset for developing your career. It can help you land that great job or expand your network for the future.

Here are key things we look out for when we're evaluating job candidates' LinkedIn profiles.

DO

KEEP YOUR PROFILE UP-TO-DATE

Don't let your LinkedIn profile get dusty and out of date. Regularly update your experience, job titles, and career activity so that a prospective recruiter can easily see what you're up to.

Even if you've held the same job for a while, add a bit of info about your most recent projects and achievements to show that you're busy and productive.

HIGHLIGHT YOUR STRONGEST SELLING POINTS IN A PROMINENT MANNER

A LinkedIn profile should be quite detailed, offering recruiters and business contacts an at-a-glance view of your education, experience, achievements, and your community engagements.

Make sure that your most recent and important skills are easy to identify.

Take some time to polish your summary so that it really pops out and sells your strengths to the reader. And ensure that you use the right keywords in your summary and in your list of skills to make it easy for recruiters to find you when they're searching for candidates with your profile.

CONNECT WITH PEOPLE IN YOUR INDUSTRY

Don't be shy on LinkedIn - connect with people in your industry. When you seek to connect with someone, add a polite, personalised note asking them to accept your invitation and explaining what (or who) you have in common.

FOLLOW COMPANIES, PUBLISH CONTENT, AND JOIN RELEVANT GROUPS

There are millions of profiles on LinkedIn, so you might need to do a bit work to get attention from the right people. Share relevant professional content, write short posts if you have the time, join industry groups and get involved in their discussions, and follow companies to raise your profile.

Companies and groups often post job openings, which can be handy if you're looking for new career opportunities.

MAKE YOUR INTENTIONS KNOWN

Let the other LinkedIn users see what you're looking for. For example, if you're a recruiter looking for talent in a certain field, post that information so interested parties can contact you.

DON'T

USE AN INAPPROPRIATE PHOTO OR PICTURE FOR YOUR PROFILE

Profiles without photos don't get much attention. You don't necessarily need a professional portrait for LinkedIn, but you should look presentable in the picture you use.

Avoid photos taken in social settings, especially with a beer in your hand; also, don't put up a pixelated picture, or use ones with distracting backgrounds. A recent head-and-shoulders, taken in your work clothes and with a smile on your face, will be perfect.

RELY ON JARGON OR CLICHÉS

Don't get carried away with industry buzzwords or CV clichés when you talk about yourself. Even if you're a dynamic problem-solver and team player with an inspirational management style, these words sound empty and insincere because of how overused they have become.

Rather show off your characteristics by talking about your achievements ("I helped Acme Corp. to develop a widget for a new market" rather than "I'm an out-of-the-box thinker"). Consider asking people you have worked with to write endorsements for you so that the boasts aren't coming from your own mouth.

FIB OR EXAGGERATE

This should go without saying, but white lies and exaggerated claims on LinkedIn are effectively as bad as telling fibs on your CV. It's so easy for someone to check up on your claims and you will be caught out.

USE LINKEDIN AS A SOCIAL MEDIA SITE

Your profile should reflect your professional persona and not your child's first steps or pictures from your holiday at the beach.

HAVE SPELLING ERRORS IN YOUR PROFILE

Typos in your profile create an unprofessional impression. You will lose the recruiters interest if your spelling and grammar isn't correct. wn

IN MY OPINION : PASCAL-EMMANUEL GOBRY

Big Science is broken

That's the thesis of a must-read article in *First Things magazine*, in which William A. Wilson accumulates evidence that a lot of published research is false. But that's not even the worst part.

BY | PASCAL-EMMANUEL GOBRY

Advocates of the existing scientific research paradigm usually smugly declare that while some published conclusions are surely false, the scientific method has *"self-correcting mechanisms"* that ensure that, eventually, the truth will prevail. Unfortunately for all of us, Wilson makes a convincing argument that those self-correcting mechanisms are broken.

For starters, there's a *"replication crisis"* in science. This is particularly true in the field of experimental psychology, where far too many prestigious psychology studies simply can't be reliably replicated. But it's not just psychology. In 2011, the pharmaceutical company Bayer looked at 67 blockbuster drug discovery research findings published in prestigious journals, and found that three-fourths of them weren't right. Another study of cancer research found that only 11 percent of preclinical cancer research could be reproduced. Even in physics, supposedly the hardest and most reliable of all sciences, Wilson points out that *"two of the most vaunted physics results of the past few years — the announced discovery of both cosmic inflation and gravitational waves at the BICEP2 experiment in Antarctica, and the supposed discovery of superluminal neutrinos at the Swiss-Italian border — have now been retracted, with far less fanfare than when they were first published."*

What explains this? In some cases, human error. Much of the research world exploded in rage and mockery when it was found out that a highly popularized finding by the economists Ken Rogoff and Carmen Reinhardt linking higher public debt to lower growth was due to an Excel error. Steven Levitt, of Freakonomics fame, largely built his career on a paper arguing that abortion led to lower crime rates 20 years later because the aborted babies were disproportionately future criminals. Two economists went through the painstaking work of recoding Levitt's statistical analysis — and found a basic arithmetic error.

Then there is outright fraud. In a 2011 survey of 2,000 research psychologists, over half admitted to selectively reporting those experiments that gave the result they were after. The survey also concluded that around 10 percent of research psychologists have engaged in outright falsification of data, and more than half have engaged in *"less brazen but still fraudulent behaviour such as reporting that a result was statistically significant when it was not, or deciding between two different data analysis techniques after looking at the results of each and choosing the more favourable."*

Then there's everything in between human error and outright fraud: rounding out numbers the

way that looks better, checking a result less thoroughly when it comes out the way you like, and so forth.

Still, shouldn't the mechanism of independent checking and peer review mean the wheat, eventually, will be sorted from the chaff? Well, maybe not. There's actually good reason to believe the exact opposite is happening.

The peer review process doesn't work. Most observers of science guffaw at the so-called *"Sokal affair,"* where a physicist named Alan Sokal submitted a gibberish paper to an obscure social studies journal, which accepted it. Less famous is a similar hoodwinking of the very prestigious British Medical Journal, to which a paper with eight major errors was submitted. Not a single one of the 221 scientists who reviewed the paper caught all the errors in it, and only 30 percent of reviewers recommended that the paper be rejected. Amazingly, the reviewers who were warned that they were in a study and that the paper might have problems with it found no more flaws than the ones who were in the dark.

This is serious. In the preclinical cancer study mentioned above, the authors note that *"some non-reproducible preclinical papers had spawned an entire field, with hundreds of secondary publications that expanded on elements of the original observation, but did not actually seek to confirm or falsify its fundamental basis."*

This gets into the question of the sociology of science. It's a familiar bromide that *"science advances one funeral at a time."* The greatest scientific pioneers were mavericks and weirdos. Most valuable scientific work is done by youngsters. Older scientists are more likely to be invested, both emotionally and from a career and prestige perspective, in the regnant paradigm, even though the spirit of science is the challenge of regnant paradigms.

Why, then, is our scientific process so structured as to reward the old and the prestigious? Government funding bodies and peer review bodies are inevitably staffed by the most hallowed practitioners in the field.

The tenure process ensures that in order to further their careers, the youngest scientists in a given department must kowtow to their elders' theories or run a significant professional risk. Peer review isn't any good at keeping flawed studies out of major papers, but it can be deadly efficient at silencing heretical views.

All of this suggests that the current system isn't just showing cracks, but is actually broken, and in need of major reform. There is very good reason to believe that much scientific research published today is false, there is no good way to sort the wheat from the chaff, and, most importantly, that the way the system is designed ensures that this will continue being the case.

As Wilson writes: *Even if self-correction does occur and theories move strictly along a life cycle from less to more accurate, what if the unremitting flood of new, mostly false, results pours in faster? Too fast for the sclerotic, compromised truth-discerning mechanisms of science to operate? The result could be a growing body of true theories completely overwhelmed by an ever-larger thicket of baseless theories, such that the proportion of true scientific beliefs shrinks even while the absolute number of them continues to rise. Borges' Library of Babel contained every true book that could ever be written, but it was useless because it also contained every false book, and both true and false were lost within an ocean of nonsense.* [First Things]

This is a big problem, one that can't be solved overnight. But the first step is admitting you have a problem.

Science, at heart an enterprise for mavericks, has become an enterprise for careerists. It's time to flip the career track for science on its head. Instead of waiting until someone's best years are behind her to award her academic freedom and prestige, abolish the PhD and grant fellowships to the best 22-year-olds, giving them the biggest budgets and the most freedoms for the first five or 10 years of their careers.

Then, with only few exceptions, shift them away from research to teaching or some other harmless activity. Only then can we begin to fix Big Science. wn

WATT? is a forum related specifically to the industrial and commercial electrical sector.

Do you have any burning questions, topical issues or points of interest about the electrical industry, from the perspective of a contractor, supplier or professional service provider? Submit your comments, thoughts, ideas, suggestions or questions for the attention of our industry experts, and these will be addressed in a future issue of the magazine. This is your forum, and we would like to hear from you!

WATT? is an opportunity for people on the ground to engage with each other and related professionals in an informative and friendly manner. This is a platform for you to discuss anything related to your particular sector, to highlight anything new, or to ask a specific question related to a technical topic or to engage in general industry issues. . Please note that we will not be considering anything related to the domestic sector, such as residential wiring.

We hope that this section of the magazine not only becomes a regular feature, but that it is widely read and distributed among your peers. Remember, it can only become a success with the full participation of our readers! Send your burning questions to minx@saiee.org.za - subject 'WATT?'.

We look forward to hearing from you.

- Ed

The rapid pace of technological change and product development is a global trend that affects entire economies. We may have access to more information than ever before, but is this information readily understandable? Does it give us insight into the fundamental issues? Is it precise and based on technical clarity?

QUESTION ONE

When testing a transformer, what is the difference between a Furanic test and a degree of Polymerisation test?

ANSWER ONE

The insulating system of a transformer comprises both paper and oil. A transformer reaches the end of life when its insulating system has completely lost its dielectric properties. Insulation paper breaks down over time during use of the transformer. The resultant decrease in insulation will make the unit susceptible to winding failure during mechanical stresses.

The Degree of Polymerisation (DP) is a value obtained from testing insulation paper directly. However, to do this test requires that the transformer be taken out of service, opened and an insulation paper sample taken and it can end up being an expensive procedure.

The Furanic test, on the other hand, is done using an oil sample which is far easier to obtain than insulation paper.

World class laboratories use a High Pressure Liquid Chromatography (HPLC) unit to determine both the Furanic and DP value. A formula is used to provide an estimated DP value which calculates the five compounds of Furans. A DP value is determined with the Furanic test and if the DP value is unacceptable, only then is a DP test done.

The five Furanic compounds are 2-furaldehyde (2FAL), 5-methyl-2-furaldehyde (5M2F), 5-hydroxylmethyl-2-furaldehyde (5H2F), 2-acetyl furan (2ACF) and 2-furfuryl alcohol (2FOL). Each compound has its own effect on the transformer. 2FAL causes general overheating and occurs in a normal ageing transformer. 5M2F is responsible for high temperatures in the unit. 5H2F causes oxidation, 2ACF rarely occurs in the unit and its causes are not fully defined and lastly 2FOL is an indication of high moisture present in the transformer.

To conclude, HPLC along with gas chromatography is one of more sophisticated techniques used in the analysis of transformer oil. When you consider the value of a transformer, its capital cost and the impact of unscheduled downtime, it should be clear that testing is essential and may be considered alongside a gas analysis.

QUESTION TWO

Why should transformer oil samples be sent for gas analysis?

ANSWER TWO

Dissolved Gas Analysis (DGA) is an accepted standard in the electrical

WATT?

maintenance industry and is considered a very important test for transformer oils. Taking an oil sample for testing purposes is less expensive and time consuming, as the transformer does not have to be taken out of service to take this sample.

As the insulating materials breakdown they cause gases within the transformer oil. Testing for the presence of these gases will give an early indication of any thermal faults occurring in the transformer. This means that by doing DGA on an oil sample issues such as loose connections or wiring can be identified and serious damage to the transformer avoided. There is also a clear correlation between the increase in certain gases in the results and the Furanic's DP value, and this will indicate whether it is necessary to do a Furanic test on the transformer. Carbon monoxide and carbon dioxide are the two gases which need to be monitored as these could cause thermal conditions involving the insulation paper.

There are also a few other key gases to look out for in the sample and these include hydrogen, carbon monoxide, methane, ethane, ethylene and acetylene. These gases are Flammable, cause the most problems but will also give an indication as to what may be wrong. The total gas content in the transformer for the flammable/combustible gases should never exceed 720 parts per million. Anything more is an indication that a critical condition can occur in the transformer.

Corona is caused by excessive hydrogen in the sample and this is an indication of electrical stress resulting in ionization that occurs around 10 000 volts over sharp edges of current conductors. If acetylene is added to the mix there is the potential for arcing to form.

Ethylene, ethane and methane are also indications of arcing occurring in the transformer. Another major issue such as partial discharge is an indication of hydrogen, methane and small amounts of acetylene and ethane being present in the transformer.

Acetylene is the most significant gas generated in the transformer as enormous amounts of energy are needed to produce it. Excessively high overheating of the transformer oil will produce this gas in low concentrations, however when higher concentrations are reached this is a typical symptom of arcing which could cause transformer failure resulting in unscheduled downtime with a consequential loss of productivity. In the end it is recommended to keep an eye on any activity occurring within a transformer and take immediate action. wn

Japanese robot developer launched Tapia

Tapia is a communication robot that learns your lifestyle and assists in your daily life as your roommate, friend, and personal assistant.

Tapia frequently updates you on weather conditions when you are headed out, and can play music when asked to set the mood or help you relax. She will stay faithfully by your side and evolve right along with you on life's journey with the following features.

USER RECOGNITION

Tapia memorizes your facial features, name, and birthdate. Want to guess what she might say on your birthday morning?

COMMUNICATION

Conversations with Tapia will naturally change and evolve depending on your interaction. If you converse with it daily, you will start to hear new humorous and surprising words.

PERSONAL ASSISTANT

Tapia is also the perfect personal assistant able to place phone calls, manage your schedule, read you the news, etc., giving you all the perks of having a personal assistant at your disposal 24 hours a day, 7 days a week. The built-in SIM slot makes connecting to the Internet a breeze.

PERSONAL SECURITY

Tapia helps those living alone enjoy greater personal security and freedom by monitoring when they come and go and contacting family members if they've not returned home for a certain period of time.

MEDIA

Tapia can assist in taking photos of important memories and playing music when you want to relax, set the mood, or feel like dancing! Tapia is your companion.

AESTHETIC APPEARANCES

The rounded design represents *"Wa"* that characterizes the Japanese spirit. *"Wa"* means compassion for others, kindness, and peaceful relationships.

FACIAL EXPRESSIONS

Tapia's big round eyes express all emotions - joy, anger, sorrow, happiness. wn

Tapia retails at ±US$580.
For more info, visit www.mjirobotics.co.jp/en

calendar

JULY | AUGUST | SEPTEMBER

JULY 2016

11-12	MS Project Professional 2013	Cape Town	khuvutli@saiee.org.za
13-14	Core Financial Management Skills for Engineers	Johannesburg	roberto@saiee.org.za
13	Leading with the brain in mind	VUT Science Park	www.saiee.org.za
19	Joint SAIEE/IEEE President Visit	Western Cape	www.saiee.org.za
19-21	PowerGen Africa & Distributech	Johannesburg	www.powergenafrica.com
20-21	Incident Investigation & Management	Johannesburg	roberto@saiee.org.za
20-21	Leadership & Management Principles & Practice	Johannesburg	roberto@saiee.org.za
25	IEEE/SAIEE Presentation Disruptive Innovations as a Vehicle	Johannesburg	www.saiee.org.za
25-26	Optical Fibres, Cables & Systems Fundamentals	Durban	roberto@saiee.org.za
26	Eskom Lethabo Plant Tour	Lethabo Power Station	www.saiee.org.za
26	Medium Voltage Electric Cable Jointing & Terminating	Johannesburg	roberto@saiee.org.za
27-28	Fixed Broadband Access Technologies	Johannesburg	roberto@saiee.org.za

AUGUST 2016

4	Charles Landy Memorial Lecture	Johannesburg	www.saiee.org.za
12	Sunflower Fund Women's Day Breakfast	Johannesburg	www.sunflowerfund.org.za
11-12	Cloud Computing Fundamentals	Johannesburg	roberto@saiee.org.za
11-12	Design of Economical Earthing Systems	Cape Town	roberto@saiee.org.za
16-19	Managing Projects Effectively	Johannesburg	roberto@saiee.org.za
17-18	2016 Information Security for South Africa (ISSA)	Johannesburg	www.ieee.org.za
17-18	Fundamentals of Long Term Evolution Mobile Communications	Johannesburg	roberto@saiee.org.za
18-19	Power Utilities Theft Conference	Johannesburg	www.amabhubezi.co.za
23	Medium Voltage Electric Cable Jointing & Terminating	Durban	roberto@saiee.org.za

SEPTEMBER 2016

7-8	Fundamentals of Power Distribution	Johannesburg	roberto@saiee.org.za
14-15	Photovoltaic Solar Systems	Johannesburg	roberto@saiee.org.za
20	Bernard Price Memorial Lecture	Wits/Johannesburg	geyerg@saiee.org.za
21	Power Transformer Unit Protection & Testing	Johannesburg	roberto@saiee.org.za
21	Bernard Price Memorial Lecture	Cape Town	geyerg@saiee.org.za
22	Power Transformer Operating & Maintenance	Johannesburg	roberto@saiee.org.za
22	Bernard Price Memorial Lecture	KwaZulu Natal	geyerg@saiee.org.za

= CPD Courses

July

Movers, shakers and history-makers

COMPILED BY JANE BUISSON-STREET
FSAIEE | PMIITPSA | FMIITSPA

1 JULY

1979 The first Sony Walkman, the TPS-L2, went on sale in Japan. It would go on sale in the US about a year later.

2 JULY

1982 Larry Walters ("Lawnchair Larry") took flight in his homemade airship that consisted of a deckchair with 45 helium-filled weather balloons. He stayed in flight for ± an hour.

3 JULY

1969 UCLA issued a press release stating that it *"will become the first station in a nationwide computer network which, will link together computers of different makes and using different machine languages into one time-sharing system."*

4 JULY

1956 MIT's Whirlwind, which had been completed five years earlier, became the first computer in the world to allow its users to enter commands through a keyboard. Previously, all input had using dials, switches, and/or punch cards.

5 JULY

1946 Louis Reard's creation, the bikini bathing suit, made its debut during a fashion show at the Molitor Pool in Paris. Micheline Bernardini wore the two-piece outfit.

6 JULY

1996 Steffi Graf won her seventh Wimbledon title.

7 JULY

2000 Amazon.com announced that they sold ± 400 000 copies of "Harry Potter and The Goblet of Fire," making it the biggest selling ebook in history.

8 JULY

1969 The U.S. Patent Office issued a patent for the game "Twister."

9 JULY

1981 Donkey Kong, the game that launched two of the most famous characters in video game history, Mario Brothers, was released for sale.

10 JULY

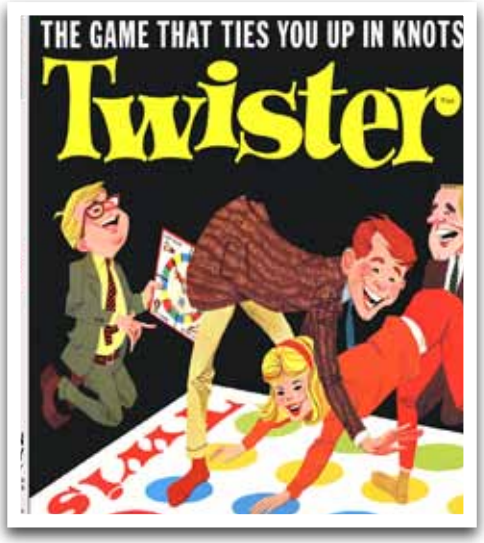
1866 *"Be it known that I, EDSON P. CLARK, of Northampton, in the county of Hampshire and State of Massachusetts, have invented a new and useful Improvement in Pencils.."*

11 JULY

1801 French astronomer Jean-Louis Pons discovered his first comet. In his lifetime he discovered or co-discovered up to 37 comets.

12 JULY

1906 The first long-distance wireless telegraphy message across water was transmitted 300km from Tasmania to Australia, to demonstrate Marconi's equipment.



13 JULY

1880 Stephen D. Field of New York City was issued a U.S. patent for *"propelling railway cars by electromagnetism"*, which became the first electric streetcar.

14 JULY

2008 The iTunes Music Store reached 10 million applications downloaded.

15 JULY

1978 Bob Dylan performed for 200 000 fans, which makes it the largest open-air concert audience (for a single artist).

16 JULY

1926 The first underwater colour photographs appeared in "National Geographic" magazine. The pictures had been taken near the Florida Keys.

17 JULY

1902 Willis Haviland Carrier completed drawings for what would become to be recognized as the world's first scientific air conditioning system.

18 JULY

1968 Intel Corporation was founded by Gordon E. Moore and Robert Noyce, originally incorporated as "NM Electronics."

19 JULY

1946 Marilyn Monroe acted in her first screen test.

20 JULY

1961 *"Stop the World, I Want to Get Off"*, the musical, opened in London, U.K.

21 JULY

1970 The Aswan High Dam in Egypt was completed after 18 years of work. It is a huge embankment dam that lies just north of the border between Egypt and Sudan.

22 JULY

1376 The legend of the Pied Piper of Hamelin, Lower Saxony, Germany, leading rats out of town is said to have occurred on this date.

23 JULY

2010 The world's heaviest hailstone fell in Vivian, South Dakota, USA, weighing 0.88kg, 20 cm diameter with a 47.3 cm circumference.

24 JULY

1938 Nescafé instant coffee was commercially introduced by the Nestlé company, as it assisted the Brazilian government in solving its coffee surplus problem.

25 JULY

1992 South Africa returned to the Olympics Games for the first time since 1960.

26 JULY

1984 Prince's movie "Purple Rain" premiered in Hollywood, CA.

27 JULY

1909 Orville Wright set a record for the longest aeroplane flight - 1 hour 12 minutes and 40 seconds.

28 JULY

1981 IBM introduced their System/23 Datamaster desktop computer. The computer was designed to be set up by end-users without the need of a computer specialist.

29 JULY

1929 Belgium's Maurice Dewaele won the Tour de France.

30 JULY

1938 The Beano, a long running British children's comic, went on sale for the first time. Characters include Dennis the Menace, Minnie the Minx, The Bash Street Kids, The Numskulls, Roger the Dodger, Billy Whizz and Ball Boy. wn

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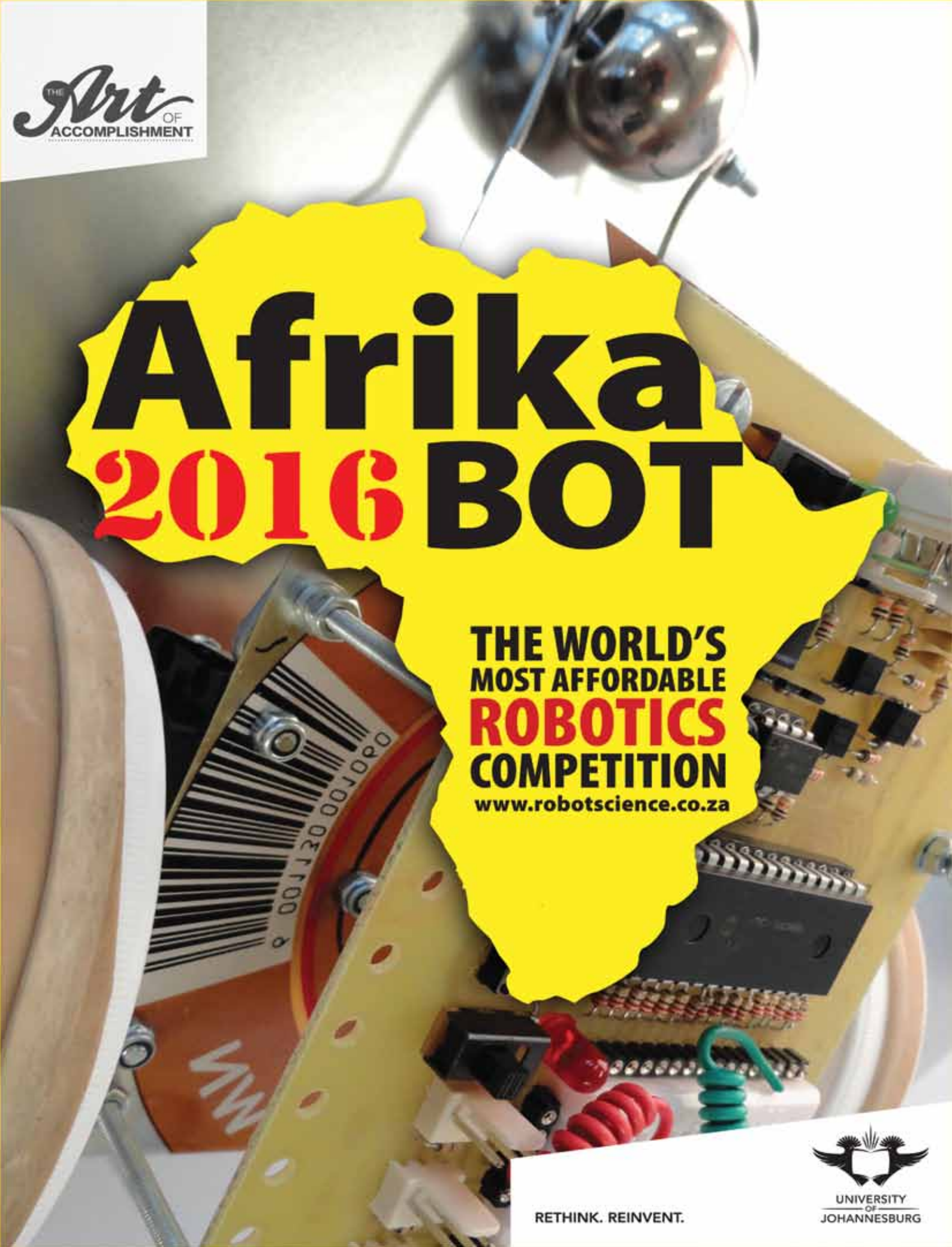
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