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Publisher's Letter

Cable & Wire Segment Needs Focus

Although at the policy makers' level, lot of discussions are going on to improve the country's energy saving potential, there is a big disconnect with the actual user's arena. Our union government has set up targets for the country's complete electrification and overall LEDization, however, the focus is still far off from one of the significant (perhaps the most) areas of the electrical network, i.e. cable & wire.

Let us look at some facts and figures. Around 7% of the regrettable fire accidents in India originate from electrical short circuits. On an average, 54 people die here every day because of fire accidents. If we refer the National Crime Record Bureau's report, out of the total 20,377 cases of fire accidents reported in 2014 that caused injury of 1,889 persons and death of 19,513, 18.3% occurred in residential or dwelling buildings. Also, it shows that 1,426 people died in 2014 because of electrical short circuits (accidents leading to fire). Apart from fire, there are other types of accidents (caused by electricity) called (commonly) electrocution that occur mostly due to either people coming in contact with naked live wires or touching weakly insulated current carrying conductors. Using cables & wires of improper gauge is a commonly repeated mistake in India. It is not only the cables & wires, but also failure of their jointers and other accessories often lead to fatal accidents. Contextually, improper cable laying, whether it's underground or above the surface – also many times leads to the incidents of spark and electrocution.

> "Although the Indian government has set the standards, mostly the problem arises because of lack of knowledge..."

Although the Indian government has set the standards for cables & wires and their accessories, the market here is full of sub-standard products. Their sales are encouraged because of the advantage of low price. A good BIS certified cable or wire can not only enhance safety of the consumers, but also saves money by reducing energy consumption. In some cases, a good (indoor) wiring or nicely done (outdoor) cabling can lead to even 25% saving in energy bill.

Thus, the standards are there and most of the people like to stay safe. But mostly the problem arises because of lack of knowledge. Of course, higher price of the certified products is also a determiner sometimes, but that's not the case always. So, what we need now is to effectively educate the consumers on selection and use of proper cables & wires and their accessories.

Do send in your comments at miyer@charypublications.in

Mahadevan

Editor-In-Chief

The successful publishing house is the one that can guess ahead, not the one that imitates the past.

- Helen Jacobs

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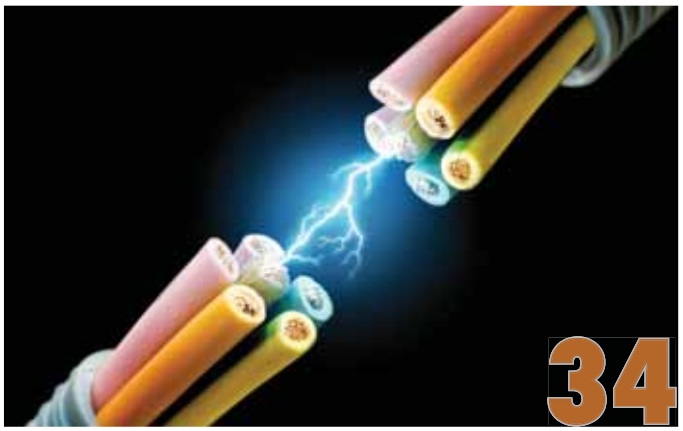

FEATURES

FOCUS

Cable, Wires & Accessories, Power Electronics

INTERVIEW

"Despite of standards being there compliances could be weak sometimes – that need to be corrected..."

Gautam Seth
Jt. Managing Director
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Editorial

Innovations In The Cables And Wires Industry

P K Chatterjee (PK)

> Our dependency on and expectation from cables and wires industry will continue to grow. In the mean time, a few fantastic innovations have happened in this industry...

Although in today's Information Technology (IT) world, the journey is directed from cable to cable-less future, as far as the flow of electricity is concerned, cables and wires in the electrical networks are still like the blood vessels in the human body. It's true that in some applications; like in Thyssen Krupp's plan to deploy magnetic levitation technology for lifts – replacing the age-long practice of using cables; cable-less technologies are being thought of considering multiple advantages, but so far those are quite at the nascent stage. So, our dependency on and expectation from cables and wires will continue to grow.

In the mean time, a few fantastic innovations have happened in this industry (including both IT and power supply cables). These are not only promising to eliminate some existing big challenges – but also paving the way to a better, easier, economic and safer method, of course in their respective application areas.

Let us look at the Hitachi Cable America's recent release of the StratoGig-HD advanced plenum-rated Category 7 cable. It has been designed to accommodate 10 gigabit Ethernet and beyond, support up to 120 watts of power for Power over Ethernet (PoE) applications and support all HDBaseT applications up to 100 metres. With a plenum listing from UL, the StratoGig-HD can be installed in almost any indoor environment. Additional features of this highly versatile cable include four pairs of 22 gauge copper conductors (each surrounded by its own foil barrier), an overall braid, 3rd party performance certified by the HDBaseT Alliance and compliance to ISO standard 11801 for Class F cables. The construction and materials used in making the StratoGig-HD enable exceptional immunity to external electrical noise such as RFI, EMI and Alien Crosstalk.

Cables and wires are basically conductors of current (electrons). Resistance is an inherent (demonic!) property of every material that opposes flow of current through it. Its obvious effect is loss of energy. As a part of the project to develop basic technologies for HTS coils used in medical devices, Furukawa Electric Co.; and Professor Kazuo Watanabe of the Institute for Materials Research, Tohoku University; have jointly developed a superconducting connection technology and an HTS persistent current switch with a resistance of around 10^{-12} ohms by connecting rare earth superconducting wire materials. It will help in supplying a persistent current maintaining a constant magnetic field for a long time around superconducting MRI scanners with no external current supply.

Aren't these great innovations boon for the entire human race?

P. K. Chatterjee

The future of Publishing is about having connections to readers and the knowledge of what those readers want.

- Seth Godin

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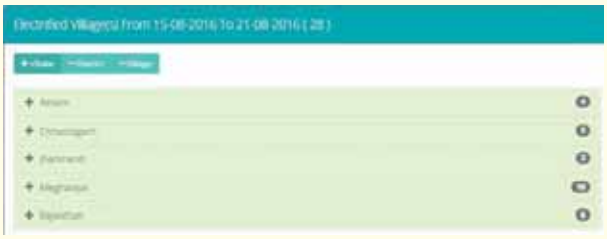
DDUGJY completes electrification of 10,079 villages

In view of the Prime Minister, Narendra Modi's address to nation, on Independence Day, Government of India (GoI) has decided to electrify remaining 18,452 un-electrified villages within 1000 days i.e., by 01st May, 2018. The project has been taken on mission mode and strategy for electrification consists of squeezing the implementation schedule to 12 months – and also dividing village electrification process in 12 stage milestones with defined timelines for monitoring.

10,079 villages have been electrified till date. Out of remaining 8,373 villages, 525 villages are uninhabited. 5,069 villages are to be electrified through grid, 2,590 villages to be electrified through off-grid where grid solutions are out of reach due to geographical barriers and 189 villages are to be electrified by the State Government.



Total 1,654 villages were electrified during April 2015 to 14thAug 2015, and after taking initiative by GoI for taking it on mission mode, 8,425 additional villages have been electrified from 15thAugust 2015 to 21stAugust, 2016.

In order to expedite the progress further, a close monitoring is being done through Gram Vidyut Abhiyanta (GVA) and various actions are also being taken on regular basis like reviewing the progress on monthly basis during the Review, Planning and Monitoring (RPM) meeting, sharing of list of villages which are at the stage of under energisation with the state DISCOM, identifying the villages where milestone progress are delayed.

Recently, 28 villages have been electrified across the country under DeenDayalUpadhyaya Gram Jyoti Yojna (DDUGJY). Out of these electrified villages, 4 villages belong to Assam, 5 to Chhattisgarh, 3 to Jharkhand, 10 to Meghalaya and 6 to Rajasthan. EI

Power Minister discloses all the agreements with neighbouring countries

Piyush Goyal, Union Minister of Power, has recently revealed that India has signed a Memorandum of Understanding (MoU) with Government of the People's Republic of Bangladesh on 'Cooperation in Power Sector' in 2010. There was no specific agreement between both the countries before.

He further disclosed that India has also signed a bilateral agreement with Government of Nepal on 'Electric Power Trade, Cross-Border Transmission Interconnection and Grid Connectivity' in 2014, and with Royal Government of Bhutan concerning 'Cooperation in the field of Hydroelectric Power' in 2006.

Moreover, SAARC (South Asian Association for Regional Cooperation) Framework Agreement for Energy Cooperation (Electricity) has also been signed, by all the SAARC member States, comprising Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka in 2014. EI

NTPC provides consultancy to Singreni Power Project

NTPC; India's largest energy conglomerate; bagged post award consultancy services contract for 2x600MW Thermal Power Plant at Adilabad from Singareni Coalieries Company Limited (SCCL) in the year 2011.

It also provided pre-award consultancy services to SCCL including preparation of technical specifications and tender documents, publication of NIT, bid evaluation etc.

Main plant package was awarded to Bharat Heavy Electricals Limited (BHEL) and balance of plant package was awarded to McNally Bharat Engineering Co. Ltd. by SCCL.

1st unit was synchronised on 13th March 2016 and achieved full load on the same day and 2nd unit was synchronised on 28th May 2016.

Singareni Thermal Power Project was dedicated to the nation by Prime Minister, Narendra Modi at a ceremony held at Gajwel, Medak Distt., Telengana on 7th August, 2016. EI

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REC executes loan documentation with JKSPDCL

Rural Electrification Corporation Limited (REC Ltd.), a 'Navratna' Public Sector Enterprise of Government of India, has executed a loan documentation with State owned GENCO, Jammu and Kashmir State Power Development Corporation Limited (JKSPDCL) recently.

The main purpose of this is to set up 37.5, (3X12.5 MW) Parnai, Hydroelectric Power Project in Tehsil Surankot and Mendhar, Poonch District of Jammu and Kashmir. The total cost of the project is Rs. 640.42 crores.

Kifayat Hussain Rizvi (IAS), Managing Director, JKSPDC, Upendrajit Singh, Director (Finance), JKSPDC, Ajay Kumar Gupta, Chief Project Manager REC, Project Office, Jammu and other senior officials were present on this occasion at JKSPDC registered office, Jammu.

REC provides loan assistance to SEBs/ State Power Utilities for investments in rural electrification schemes.

MoP to provide access to electricity to un-electrified villages

Ministry of Power (MoP) has implemented Decentralized Distributed Generation (DDG) under Deen Dayal Upadhyaya Gram JyotiYojana (DDUGJY) through Rural Electrification Corporation. The main purpose of it is to provide access to electricity to un-electrified villages/ habitations where grid connectivity is either not feasible or not cost effective.

Piyush Goyal

According to a recent statement by Minister of State (IC) for Power, Coal, New and Renewable Energy, 4604 DDG projects for a total project cost of Rs.1470.64 crore have been sanctioned.

It covers 4745 villages/hamlets (3,586 UEVs) in various states across the Indian sub-continent.

He further said that DDG can be from conventional or renewable sources such as biomass, biofuels, biogas, Mini hydro, solar etc. DDG scheme provides a subsidy towards 60% (85% for special category states) of the project cost. However, an additional subsidy of 15% (5 % for special category states) is applicable subjected to timely completion of DDG projects.

Australian gas-generating microbe breakthrough to help power India

A novel Australian research breakthrough that promises to dramatically increase gas yields from coal seams and biogas plants – will be trialled for industrial application for the first time in partnership with India's largest oil and gas producer, Oil and Natural Gas Company (ONGC).

The UNSW team and India's Energy and Resources Institute (TERI) will work together to develop the industrial application of the phenomenon in coal seams gas wells operated by India's dominant oil and gas explorer and producer, the state-owned ONGC. The Australia India Strategic Research Fund (AISRF) will grant $1 million to support the project.

UNSW's researchers have already replicated the extraordinary gains in gas volumes outside the laboratory, in tests in coal seams west of Sydney. However, the Indian trials will enable a battery of industrial scale tests factoring in critical variables such as coal seam pressure and temperature, as well as enabling the development of new technologies to precisely introduce the dye.

In the UNSW research, the crystals formed from neutral red dye were also shown to increase gas yields from microbes living on organic waste by up to 18 times. The breakthrough could extend the life of coal seam gas wells as well as greatly boost gas yields from bio-digesters that use carbon neutral organic waste to generate methane for electricity production.

In India, the national electricity grid is under intense pressure and some areas have no access to power. Accelerated methane production is not only a potential means of extracting much more energy from each coal seam gas well, but the process may also open up new sources of gas. Much of India's untapped coal deposits consist of younger, softer coal that is much easier for methane-producing microbes to digest – and, therefore, potentially a much larger sources of methane than higher-value hard, black coal. Using the UNSW synthetic dye process, these currently unviable soft coal deposits may be more commercially attractive for coal seam gas development.

Corrigendum

Dear Editor,

This has reference to the article "Harmonics - Causes and Effects" at page no. 60, in August' 2016 issue of Electrical India:

1.

f(wt) = Given non sinusoidal periodic wave form with angular velocity w = 2 Π f

Against this you have printed –

f(wt) = Given non sinusoidal periodic wave form with angular velocity w = 2 ∑ f

2.

$$THD = \sqrt{\sum_{n=2}^{N} h^2_n} \quad x\ 100\%$$

Where h_n is the individual harmonics of nth order.

Against this you have printed –

$$THD = \sqrt{\sum_{n=2}^{N} h^2_n} \quad x\ 100\%$$

Where h_n is the individual harmonics of nth order.

Yours faithfully,
Basant Kumar

Reply From The Editor:

Dear Mr. Kumar,

Thanks for pointing out the error. To avoid such errors, I request all authors to send the formulas or other mathematical calculations in clear JPEG format.

With thanks & regards,

PK

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BHEL receives EPC contracts from WBSEDCL

West Bengal State Electricity Distribution Corporation Limited (WBSEDCL) has issued a Letter of Intent (LoI) to Bharat Heavy Electricals Limited (BHEL) for setting up of 30 MW (3x10 MW) of Solar Photovoltaic (SPV) Power Plants on Engineering, Procurement and Construction (EPC) basis.

The order is worth Rs.1, 690 Million. The SPV plants of 10 MW each are to be set up at Mejia (Bankura), Santaldih (Purulia) and Chharrah (Purulia) in West Bengal.

Earlier this year, BHEL had bagged EPC orders from NLC and BEL for setting up of a 65 MW SPV Power plant at Neyveli (Tamil Nadu) and a 15 MW SPV Power Plant at Ordinance Factory Premises, Medak (Telangana), which are currently under execution.

In the previous year also, BHEL bagged EPC orders from NTPC for 50 MW Solar Power plants each at Ananthpur (AP) and Mandsaur (MP). While the Ananthpur project has been commissioned, the Mandsaur project is currently under execution.

C.R.I. Forays into the high-end specialised wires & cables market

C.R.I. has journeyed on its way to becoming a reputed player in the global pump industry. Now it has entered into the high-end specialised wires & cables market. This diversification and expansion is a part of an aggressive plan that targets a turnover of Rs. 5,000 crores in 2021.

The company's Research Centre has developed a high temperature application Cross Linked Poly Ethylene (XLPE) submersible winding wire with higher dielectric strength.

It has also developed high efficient DC solar cables for the fast growing solar industry. Its specialised wires & cables range includes: lead-free insulated cables for hygiene applications, Ethylene Propylene Diene Monomer (EPDM) cables for low ambient applications, special oil resistant and chemical resistant cables for waste water, communication cables, halogen free flame retardant wires, fire retardant wires and fire retardant low smoke wires, termite resistant wires, flexible power cables for industrial applications, submersible cables and winding wires.

The advantage of the halogen free flame retardant cables further includes low smoke emission, low generation of corrosive or toxic gases and low fire propagation characteristics.

The Indian wires & cables industry's market size is estimated as Rs. 40,000 crores. Out of this, C.R.I.'s target segment's market potential is about Rs. 14,000 crores.

This is expected to reach Rs. 25,000 crores in 2021 with a CAGR of 15%.

The company is confident to capture at least four to five per cent market share in the targeted wires & cables segment, which would fetch a revenue of Rs. 1100 crores by the year 2021.

GAIL, Bloom Energy partner to transform India's energy future

GAIL (India) and Silicon Valley-based Bloom Energy, recently entered into a partnership to transform India's energy future through the use of innovative technology. They have signed a Memorandum of Understanding (MoU) to deploy revolutionary natural gas-based fuel cell technology to generate electricity. The MoU provides an alignment of a shared vision between GAIL and Bloom Energy and opens up an opportunity for Indian consumers to experience bundled and reliable service – by the two leading brands for expanding the distributed power generation systems in India.

The state-of-the-art Solid Oxide Fuel Cell (SOFC) technology of Bloom Energy Servers convert fuel into electricity using Natural Gas as the base fuel to generate reliable and resilient electricity in a highly efficient non-combustible process that reduces emissions of greenhouse gas and harmful air pollutants, with minimal use of water vis-à-vis the conventional power producing technologies. The Bloom Energy Servers could be installed onsite at any operating premises or building – and can be plugged into natural gas pipeline to generate uninterrupted, efficient, noise-less base load power round-the-clock.

The unique tie-up seeks to leverage the strengths of both the organisations. Whilst GAIL brings a portfolio of Natural Gas to ensure reliable and competitively available Natural Gas for Bloom Energy projects along its integrated gas supply networks. Bloom Energy's power systems run on advanced solid oxide fuel cell technology that are not just acknowledged as the most efficient producers of electricity based on Natural Gas – but also combines the advantage of requiring a tenth of the space required for generating equivalent power through other modes.

(L2R) Dr. K R Sridhar, CEO and Founder, Bloom Energy; Minister of State for Petroleum & Natural Gas' Dharmendra Pradhan; GAIL CMD, BC Tripathi; and Additional Secretary, MoPNG AP Sawhney – after the signing of MoU between GAIL and Bloom Energy...

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*Based on 2.7 Hours usage per day in an open fitting.

Rays Power Infra commissions 400 kW project in Hyderabad

Rays Power Infra Pvt. Ltd., a well-known solar energy company, has commissioned a 400 kW rooftop solar PV project at the Hyderabad Campus of one of the India's leading IT companies. The project spans across four buildings of the prestigious IT company's premises. The state-of-the-art rooftop project was executed on complete turnkey basis. The solar energy company has done the complete design, engineering, civil work, installation process, testing and commissioning of the Solar PV project.

Sanjay Gupta, Executive Director and Co-founder, Rays Power Infra, said, "This marks as a momentous win, making us the company to build one of the finest rooftop PV projects in India for one of our most esteemed customers. We are immensely excited as Hyderabad & Telangana is a strategic market for us – and we have made use of an innovative technology and – skilled field manpower to execute the project on time and deliver the best to our customers."

"As a gesture of customer delight, we won a repeat order from the global IT giant for another rooftop project, execution of which is under progress," he further revealed.

Lately, the company has partnered with Hilliard Energy to jointly develop a 150 MW solar power project, entailing an investment

A view of the 400 kW rooftop solar PV project...

of $130 million (about Rs 870 crore). In the first phase, a 10-MW solar project is commissioned in April, 2016 at Kalwakurthy in Telangana and the power generated will be sold to the state's DISCOMs.

ReNew Power issues 132 MW repeat turnkey order to Suzlon

ReNew Power Ventures, India's well known renewable energy Independent Power Producer has issued an order to Suzlon Group, one of the leading renewable energy solutions providers in the world. The order comprises Suzlon's latest product offerings and includes S97 90 metre tubular tower and S97 120m hybrid tower with a rated capacity of 2.1 MW each. The project is capable of providing power to over 70,000 households and reducing 0.28 million tonnes of CO_2 emissions per annum.

Suzlon will provide a comprehensive range of services and dedicated life cycle asset management services for an initial period of 12 years. The project will be located in two sites, Elutalla and Veerbhadra sites in the Ananthpur district of Andhra Pradesh and is scheduled to be completed by March 2017. With this order, Suzlon's portfolio with ReNew Power would exceed 500 MW (510.30 MW) spanning across the states of Gujarat, Rajasthan, Maharashtra, Madhya Pradesh and Andhra Pradesh. ReNew Power has 220 MW of wind projects in pipeline in Andhra Pradesh. Renew Power is one of the

J. P. Chalasani

leading customers of Suzlon.

JP Chalasani, Group CEO, Suzlon Group, said, "The order win reiterates our role as the country's leading renewable energy solution provider. We are pleased to partner with ReNew Power yet again in contributing towards India's energy security. With our strong customer base, customer centric credentials, next generation products, end-to-end solutions and best-in-class services, Suzlon is best equipped to capitalise on the growing opportunities in India."

Schneider Electric develops lithium-ion batteries for UPS's

Schneider Electric has introduced a Lithium-Ion Battery (LIB) solution for Uninterruptible Power Supply (UPS) operations. The new LIB solution for three-phase UPSs brings compact, lightweight, long-lasting and sophisticated energy storage protection to data centres, industrial process or critical infrastructure.

The LIB system from Schneider comes as a complete package comprising a standard cabinet / rack, which houses the battery modules; the Switching-Mode Power Supply (SMPS), which powers the Building Management System (BMS); and the protection switchgear. This solution is currently supported by the company's Symmetra MW, Galaxy 7000, Galaxy VM and Galaxy VX UPSs.

Nikhil Pathak, VP and Country General Manager - IT Business India and SAARC, Schneider Electric India, said, "It is important for companies to choose the right energy storage solution for their data centres, industrial processes, or critical infrastructure. The backup storage solution must maintain or even increase availability and manageability while reducing UPS footprint."

Lithium-ion battery prismatic can cell...

"The traditional Valve Regulated Lead Acid (VRLA) batteries have been the mainstay of energy storage systems with advantages like low costs, mature technology and relatively stable performance. However, its shortcomings, which are sensitivity to elevated temperatures, large footprint, heavyweight and short lifespan have created a new set of customers shifting to Li-Ion Batteries (LIB)," he further added.

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The Compact City is a complete test and fault location system that can be installed in even very small vehicles. It consist of the SPG 40, a mobile, multi-functional system for testing, prelocation, pinpointing and burning of cable faults in low and medium voltage networks. The system is controlled directly via the connected Teleflex T 30-E reflectometer or the control panel. As a part of the "Make in India" intiative, the Compact City is built in a custom-made Mahindra Bolero Camper.

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Wärtsilä to provide a 23 MW multi-fuel power plant to Indonesia

Wärtsilä will supply a 23 MW Smart Power Generation power plant to PT. Berkah Kawasan Manyar Sejahtera (BKMS), the developer of an integrated industrial and port estate project in Java, Indonesia. The turn-key order includes three Wärtsilä 34DF multi-fuel engines running primarily on natural gas, with heavy fuel oil as the backup fuel. The plant is expected to be operational in summer 2017.

The power station will feed baseload energy to both industrial and residential consumers in one of the largest industrial parks in Gresik, located in East Java, Indonesia. The Java Integrated Industrial and Port Estate (JIIPE), currently under construction, is expected to become attractive to foreign investors due to its enticing strategic location, deep sea port, infrastructure, and reliable energy supply. BKMS is a joint venture project between PT AKR Corporindo TBK., Indonesia's leading logistics and supply chain provider for basic chemicals and energy, and Pelindo III, state owned port operator.

A schematic diagram for JIIPE...

A recent governmental decision allows companies such as BKMS to construct power plants to supply energy independently to their consumers. As these plants are not connected to the national grid, reliability of supply is extremely important.

The plant will contribute to Indonesia's growing energy demand allowing many domestic companies to become globally competitive. The availability of reliable, flexible and cost-efficient source of energy will help their production and logistic costs to be reduced.

Wärtsilä has a strong footprint in Indonesia with over 3700 MW of installed base. Globally, its installed base is 60 GW in 176 countries. EI

Canadian Solar signs PPA for 63mwp solar power project in Mexico

Canadian Solar Inc., a well known solar power company, recently has signed a Power Purchase Agreement (PPA) for the 63 MWp solar power plant in Aguascalientes, Mexico with the Federal Electricity Commission (Comision Federal de Electricidad, 'CFE'). This project was awarded in April 2016 under the Mexico's First Long Term Electricity Auction, and it is expected to generate electricity by September 2018.

All the electricity generated will be sold to the CFE under the PPA for a 15-year period and related Clean Energy Certificates for a 20-year period.

Dr Shawn Qu, Chairman and Chief Executive Officer of Canadian Solar, said, "We are pleased to sign the PPA for this solar power project awarded to us earlier this year. We will continue to leverage our global project development and execution capability to continue to expand our global late stage solar project pipeline to meet the growing demand of clean solar energy in Mexico and around the world." EI

ABB's technology to uplift Geneva's public transport

ABB Group has been bestowed orders totaling more than $16 million by Transports Publics Genevois (TPG), Geneva's public transport operator, and Swiss bus manufacturer HESS, to make available flash charging and on-board electric vehicle technology for 12 Trolleybus Optimisation Système Alimentation (TOSA) fully Electric Buses (e-buses) that will run on Line 23, linking Geneva's airport with suburban Geneva. These e-buses have the capacity to save as much as 1,000 tons of carbon dioxide per year, when compared to existing diesel buses.

The 15-second flash charging technology developed by ABB, has the potential to alter urban public transport. It will be relevant to the countries such as India, which are trying to balance infrastructure growth with sustainability. ABB provides a model for upcoming urban transport – and reinforces its vision of sustainable mobility for a better world

A TOSA fully electric bus...

by its innovative product. When Dr. Ulrich Spiesshofer, CEO, ABB met Indian Prime Minister Narendra Modi, he had reiterated the company's commitment to work on the latest technology in EV charging. Electric mobility was the key agenda driven by Prime Minister Narendra Modi with the National electric Mobility Mission 2020 – and the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME) program. The ABB's revolutionary flash charging technology also has noteworthy potential as India by 2030 draws up a plan to become a 100% electric vehicle country.

ABB will deliver and deploy 13 flash-charging stations along with an urban transit bus route, as well as three terminal & four depot feeding stations as part of the TOSA project in Geneva. It will be the world's fastest flash-charging connection technology taking less than 1 second to connect the bus to the charging point. At the bus stop, the onboard batteries can then be charged in 15 seconds with a 600-kilowatt boost of power. Such a technology has been developed by ABB engineers in Switzerland. EI

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Maxwell Technologies provides ultracapacitors for Beijing subway system

Maxwell Technologies, a well known developer and manufacturer of ultracapacitor-based energy storage and power delivery solutions, has its ultracapacitors used for regenerative braking energy storage in the Beijing subway system.

As part of the strategic partnership with China Railway Rolling Stock Corporation (CRRC-SRI), Maxwell revealed last year, the companies continue to collaborate to develop next-generation capacitive energy storage solutions for the China rail market.

The installation with the Beijing subway system is the first commercial subway wayside project for CRRC-SRI and Maxwell in China. CRRC-SRI will leverage Maxwell's 48-volt modules in two sets of regenerative braking energy storage devices for the system's No. 8 line, an urban rail network that runs north-south through China's capital, one of the most populous cities in the world. The devices fulfill China rail requirements for energy savings and environmental protection, creating an ideal opportunity for ultracapacitor application.

Maxwell ultracapacitors deliver high-power energy density performance, even under extreme temperatures. With long operational lifetimes and rapid charge/discharge capabilities, the modules are ideally suited for rail transportation applications.

Liu Baoming, Chairman of CRRC-SRI, said, "Ultracapacitor energy storage solutions are critical to meet the needs of the growing China rail market, and Maxwell Technologies leads the world in development of this technology."

"As Beijing evaluated solutions to support its goal of creating an environmentally friendly, energy-saving urban rail transport system, our relationship with the industry leader Maxwell Technologies was instrumental in first securing this deal and now implementing the system. Working together, we expect to bring more solutions to market as China strives for improved rail efficiencies and reduced carbon emissions," he further added.

Dr. Franz Fink, President and CEO of Maxwell Technologies, said, "Modernising rail systems and helping to make them more efficient through the addition of ultracapacitor-based regenerative braking solutions represents a significant opportunity for Maxwell in China."

"The Beijing subway system deployment will be the first outcome of our collaboration with CRRC-SRI, and we'll continue working closely to co-develop energy storage solutions for this expanding market," he further added.

S&C Electric acquires IPERC

S&C Electric Company, a global provider of equipment and services for electric power systems; and Intelligent Power and Energy Research Corporation (IPERC), which is well known for cybersecure, intelligent microgrid control systems; recently have entered into a definitive agreement. Under the agreement, S&C would acquire all outstanding common shares of IPERC. The terms of the transaction are not disclosed. IPERC will operate as a wholly owned subsidiary of S&C.

Kyle Seymour, S&C's Chief Executive Officer, said, "The acquisition of IPERC is part of our strategic plan to enhance our technical portfolio and drive profitable growth."

"IPERC has highly skilled team members and technology that will complement our current product offerings and advance our presence in the military market. IPERC brings industry expertise in the area of microgrid controls and cyber security. We are extremely excited to enter into this relationship," he further added.

Kyle Seymour

Dr. Darrell Massie, IPERC Founder and Chief Technology Officer, said, "We look forward to building our future with S&C Electric Company. Our organisations are customer focused and have common cultural values. With this acquisition, S&C will be uniquely positioned as a one-stop-shop for all microgrid equipment and services, worldwide."

"With S&C's commitment to innovation and smart grid development, and IPERC's expertise in intelligent microgrid technologies we believe IPERC and S&C are well matched for market growth," he further added.

TPIPL completes sale of its 50% stake in OTP

Tata Power International Pte. Limited (TPIPL), a wholly owned subsidiary of Tata Power, in Singapore, had signed an agreement for sale of its 50% stake in OTP Geothermal Pte. Ltd., Singapore (OTP) to KS Orka Renewables Pte. Ltd. (KS Orka) in April 2016. TPIPL has now completed the sale of its stake in OTP to KS Orka.

OTP, a 50:50 joint venture with Origin Energy Limited, holds a 95% interest in Indonesia's PT Sorik Marapi Geothermal Power (SMGP). SMGP is currently pursuing development of 240 MW Sorik Marapi Geothermal Power Project in North Sumatra.

The company has significant investments in Indonesia and remains committed to development of Indonesian power and energy sector. The company's other investments in Indonesia include investments in PT Kaltim Prima Coal, PT Arutmin Indonesia and PT Baramulti Suksessarana Tbk.

The company also continues to explore thermal and renewable power project opportunities within the Independent Power Producer (IPP) programs the Government of Indonesia.

The divestment of the company's interest in OTP is consistent with the company's strategy to constantly review its businesses and restructure, as required, to deliver long term value to shareholders.

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BHEL appoints Akhil Joshi as the new Director (Power)

Akhil Joshi

He has a diverse experience of over 36 years...

Akhil Joshi has been appointed as Director on the Board of Bharat Heavy Electricals Limited (BHEL). He has assumed charge as Director (Power) of the Maharatna Public Sector engineering and manufacturing enterprise. He holds a degree in Mechanical Engineering from the Delhi College of Engineering (DCE).

Prior to this, he was Executive Director (MSX and HR) at BHEL's Power Sector Headquarters in New Delhi. As Director (Power), he will be responsible for marketing, erection, commissioning, overall management of power projects and the after-market business for the company.

He has a diverse experience of over 36 years, working in major segments of BHEL. In his previous role as Executive Director of the Corporate Technology Management (CTM) group of the company, he was responsible for overseeing company-wide technology acquisition and assimilation from world leaders, in-house product development, forging strategic alliances, management of BHEL's various joint ventures and Mergers & Acquisitions (M&As).

He also held various leadership positions in Spares and Services business of Power Sector, Technology Licensing and International Operations divisions of BHEL. During his tenure at International Operations division, he played a key role in multifold growth of the company's business in highly competitive overseas markets such as the Middle East, South East Asia, Africa, the CIS regions, the Mediterranean and Europe. He successfully pioneered BHEL's maiden entry into the utility segments of various overseas markets such as Iraq, Vietnam, Belarus, Bangladesh, Cyprus and Egypt.

Ashish Gaikwad takes over as MD of HAIL

Ashish Gaikwad

He brings a successful track record of more than 26 years...

Honeywell Automation India Limited (HAIL) has appointed Ashish Gaikwad as its Managing Director (MD) effective from October 01, 2016. He succeeds Vikas Chadha, who was recently named President, Honeywell India. He has a bachelor's degree in electrical and electronics engineering from Birla Institute of Technology and Science (BITS), Pilani.

Gaikwad had joined Honeywell in 1992, and progressed through roles of increasing responsibility, most recently serving as GM for the Advanced Solutions business for the Asia Pacific region within Honeywell Process Solutions. He brings to the role a successful track record from a career spanning more than 26 years with a mix of operations, sales, strategic marketing and general management.

Suresh Senapaty, Chairman, HAIL, said, "HAIL has a 25-year legacy in India, in developing and manufacturing technologies that serve a diverse and extensive customer base across verticals including oil and gas, power, metals, pharmaceuticals, chemicals, mining, infrastructure, IT/ITeS, telecom, banking, healthcare, hospitality, automobiles, defence, aerospace, transportation and the residential sector. With more than 25 years of experience in automation, control and advanced software applications in the process industry, Ashish will strategically lead HAIL to continued growth in the region, and strengthen the brand and its equity with customers and other key stakeholders."

Quek Gim Pew joins ST Engineering

Quek Gim Pew

He joined the DSO in 1986 and held several key appointments...

Singapore Technologies Engineering Ltd (ST Engineering) has appointment Quek Gim Pew as a non-independent non-executive Director of the company and Chairman of the Research, Development and Technology Committee.

Pew was Chief Defence Scientist of Singapore's Ministry of Defence. Prior to this, he was Chief Executive Officer of DSO National Laboratories (DSO). Pew holds a Bachelor of Engineering in Electrical Engineering with First Class Honours from the National University of Singapore and a Master of Science (Distinction) in Electrical Engineering from the Naval Postgraduate School, USA.

He joined the DSO DSO National Laboratories in 1986, and held several key appointments before joining the Defence Science and Technology Agency in 2000 for a period of four years.

The Board of Directors welcomes him to the Board and looks forward to his contributions.

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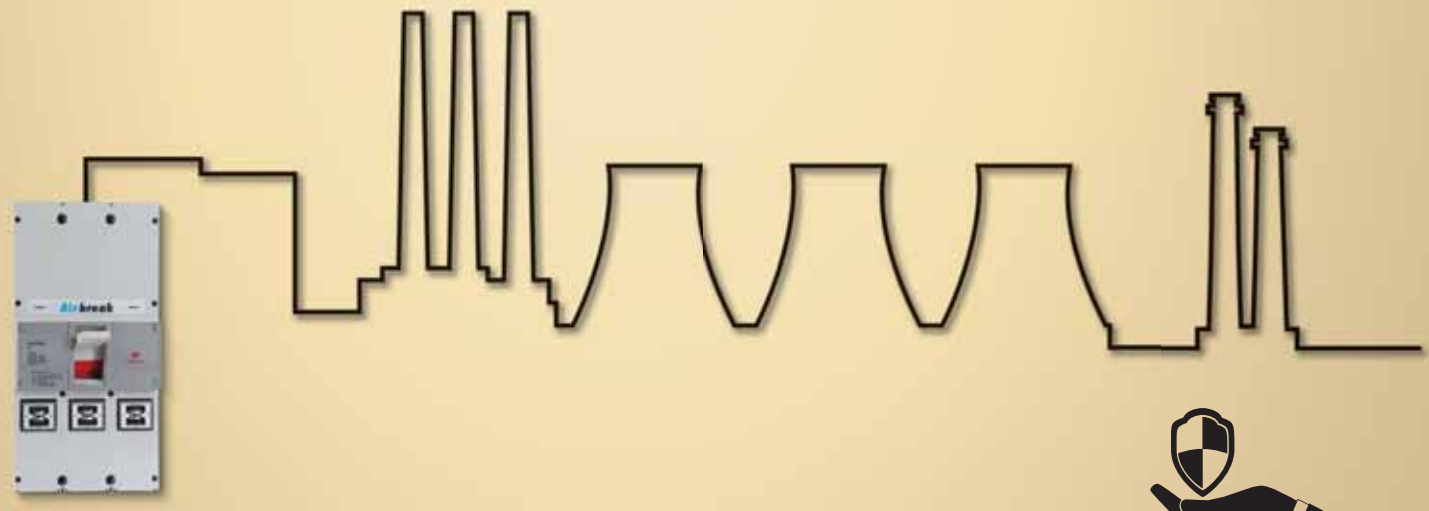

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Insulated Metallic Cable Market Witnessed Only 1.8% Growth In 2015

CRU is forecasting a modest increase in the growth rate for the global insulated metallic cable market in 2016, but it will not be until 2017 that this gets back to long term trend rates...

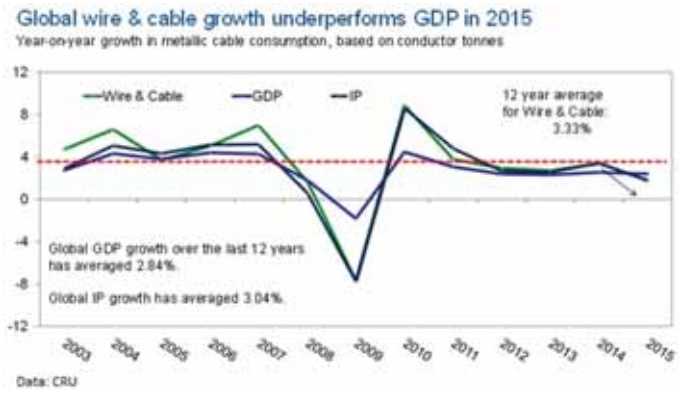
CRU estimates that the global insulated metallic wire and cable market grew by just 1.8% in 2015, following a weaker than expected Q4 2015. This growth is well below the long term average growth rate for insulated metallic wire and cable of 3.3%.

Market growth was dragged down by a big fall in the Russian market and also falling demand in other important markets such as Brazil, Australia, Japan, France and Canada.

In contrast to the metallic cable sector, the fibre optic market had another good year with global consumption rising by 16.4%. This strong growth was driven by a 29% rise in the large Chinese market, with Europe being the only major region to see a fall in demand.

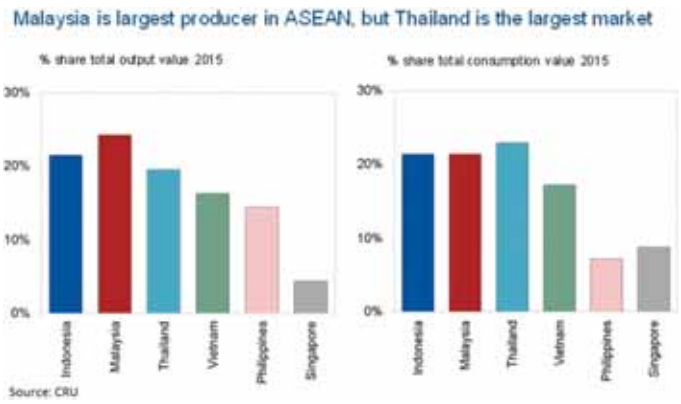
It is not surprising that the total value of the global insulated wire and cable market fell sharply, down by 10.0%. This is mainly the result of a 20% fall in the average copper price and a 10% decline in the average aluminium price, plus a nearly 50% fall in the average oil price which impacts on polymer and transport costs.

This was the fourth consecutive year of falling market value and means that the market has fallen by just over 17% since 2011. CRU is forecasting a modest increase in the growth rate for the global insulated metallic cable market in 2016, but it will not be until 2017 that this gets back to long term trend rates. For the fibre optic cable market CRU is forecasting slower growth this year at under 10%, and this slowdown in growth is expected to continue in 2017.



The report also states India is the third largest metallic wire and cable and fibre optic cable market in the world by total conductor weight or fibre km. After a slowdown in the economy which saw a fall in the market for insulated metallic cables in 2013, there was a return to growth in 2014 and stronger growth in 2015 meant that India was the fastest growing major market in the world last year.

With total consumption in 2015 only around 17% of that of the Chinese market, there is clearly good potential for continued strong growth as long as there are no shocks to the economy. Polycab remains the clear market leader – and is the only company with a market share of over 5%, which illustrates the fragmented nature of the cable industry in India.



After a mixed 2014, last year was a better year for the ASEAN cable industry with all the six countries covered other than the Philippines, showing growth in insulated metallic wire and cable consumption.

This meant that the region as a whole posted a 5.2% rise in the metallic cable market, with the fibre optic cable market up by 9.0%. Thailand was the largest market in 2015 by total value followed by Malaysia and Indonesia, but the strongest growth over the last few years has been in Vietnam.

Although market volumes increased in 2015, the total market value fell on lower copper and other raw material prices. With most companies in this region only operating in one market the overall industry is very fragmented, with the largest regional manufacturer, Sarawak Cable of Malaysia, only having a 4% share of total production. Six of the eight largest regional producers are locally owned with the other two being controlled by South Korea's LS Cable and Japan's Yazaki.

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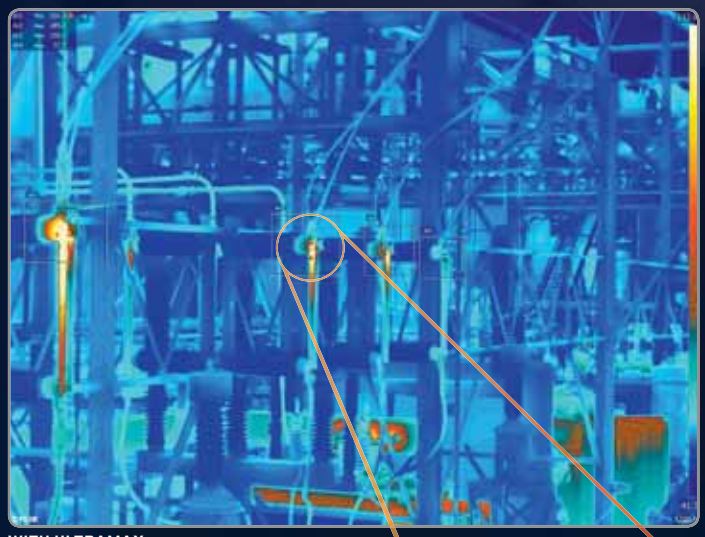

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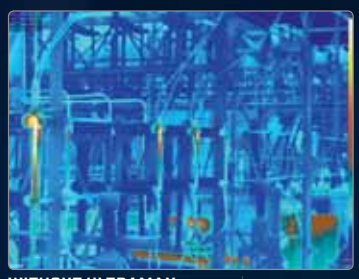

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Dr Fatih Birol Receives AEE's Annual Distinction Award

In recognition of the IEA's (International Energy Agency's) work in promoting renewable energy in Spain and across Europe, the Spanish Wind Energy Association (AEE) awarded Dr Fatih Birol (the IEA's Executive Director), its Annual Distinction award.

In a statement announcing the award, the AEE had recognised efforts by the IEA and Dr Birol at highlighting the fact that renewables are no longer a niche and should now be considered a conventional source of energy.

Dr Paolo Frankl, Head of IEA's Renewable Energy Division, accepts the award on behalf of Dr Fatih Birol...

In the opening session of the Spanish Wind Power Congress, Keisuke Sadamori, IEA Director of Energy Markets and Security, delivered a keynote speech on recent developments in wind and other renewable energy markets, integration challenges and necessary policy measures to ensure renewable growth in line with Paris Agreement ambitions. Sadamori also expressed his appreciation for the award to Dr Birol as recognition of IEA work in renewables.

Previous recipients of the award include US President Barack Obama and Christiana Figueres, Executive Secretary of the UNFCCC (United Nations Framework Convention on Climate Change).

Dr Paolo Frankl, Head of IEA's Renewable Energy Division, accepted the award on behalf of Dr Birol.

Copper Club's Ankh Awards Go To Two Recipients

The Copper Club Inc., is the leading organisation for networking, educational grants and events for those who support the copper industry. It comprises copper producers, fabricators, refiners, dealers, traders and merchants. The Copper Club seeks to promote the interests of the copper industry. By honouring those who have forged pathways in the industry and paving new paths for students working toward careers in the industry, The Copper Club ensures the past, present and future of copper.

Daniel Jones

Stephen T. Higgins

The Copper Club's Ankh Award, named for the 'ankh', a graphic symbol for the red metal dating back to ancient Egypt, also known as the Copper Man of the Year Award, was first presented in 1962 to honour outstanding individual achievements in and contributions to the copper industry.

Stephen T. Higgins, VP Marketing & Sales, Freeport-McMoRan; and President, Freeport-McMoRan Sales Co., Inc., and Daniel L. Jones, Chairman of the Board of Directors, President, and Chief Executive Officer, Encore Wire were named 2016 recipients of the prestigious Ankh Award or Copper Man of the Year. The trophy awarded to recipients is a reproduction of Auguste Rodin's famous sculpture, The Thinker. Each year, the club circulates a survey soliciting the copper industry for nominees for the award. It asks for the names of individuals who have made notable contributions to the industry, and the winner is selected by the Ankh Award committee.

The Statue of Liberty, which was bestowed with the award in 1986, has been the only 'woman' to be named Copper Man of the Year thus far. The first award was presented in 1962 to Clyde E. Weed, then President of Anaconda Co.

Frost & Sullivan presents leadership award to Wuxi Suntech

Wuxi Suntech Power Co., Ltd (Wuxi Suntech), a well known solar energy solution provider, was recently presented with the Renewable Energy Technology Growth Excellence Leadership Award by Frost & Sullivan at its 2016 Asia Pacific Best Practices Awards. The company earned the honour due to its excellence in growth, innovation, and leadership in Asia Pacific.

The award was presented based on a comprehensive range of criteria that included, above-market growth, growth diversification, growth sustainability, price / performance value and customer ownership. Frost & Sullivan appraised businesses via in-depth interviews, analysis, and extensive secondary research, in which Wuxi Suntech beat the competition by delivering the most reliable and cost-effective solar power solutions.

This award is believed to add a feather in the cap of Wuxi Suntech. As the company has so far seen it named among Bloomberg's Leading PV Module Suppliers, granted the Top Brand seal by EuPD research, and win the diamond trophy at the SNEC PV Power Expo for its HyPro Module.

Ravi K, Vice President, Energy and Environment Practice, Asia-Pacific at Frost & Sullivan, said, "Frost & Sullivan is recognising Wuxi Suntech with the Asia Pacific Renewable Energy Technology Growth Excellence Leadership award as the company is leading the way in ensuring the highest standards for quality and innovative solar power solutions across the globe."

On the occasion of receiving the award, He Shuangquan, Executive President, Wuxi Suntech Power, said, "To keep up this momentum, Wuxi Suntech will continue to upgrade its technology – and optimise management to further improve productivity and quality – and enhance customer experience. This will in turn equip us with a continuous competitive edge."

Shri Narendra Modi
Hon'ble Prime Minister of India

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Winning Women In Comtran Cable

Their presence in the largely male-dominated cable world is a part of a 'dream team' credited with Comtran's ongoing growth and success...

(L2R): Donna Fitzgerald, Danielle Braley, Tracey Pajala, Kristen Davenport, Kathy Beaudoin, Karen Credit, Brianna Cote, Paulette Blagburn.

Paulette Blagburn spends her workdays at the R&D bench, solving cable design problems and creating new products. Karen Credit manages Purchasing, Planning and Inventory Control. Kathy Beaudoin leads the Sales team in landing new accounts and closing deals in a highly competitive market. These three are parts of a group of women playing key roles at Comtran Cable. Their presence in the largely male-dominated cable world is a part of a 'dream team' credited with Comtran's ongoing growth and success.

The women in Sales, Marketing, Engineering and Materials represent 42% of the non-manufacturing staff at Comtran. This is well above average for wholesale and manufacturing industries. According to the U.S. Bureau of Labor Statistics, in 2015 women comprised about 14% of Engineering, 26% of Sales, and 44% of Purchasing in similar occupations. The good news is these national numbers are significantly higher than 20 years ago.

Comtran executives didn't set out to hire women, but they are seeing the positive impact of those decisions. "In every case we hired the most qualified person. As luck would have it, we ended up with our own dream team of talented women... and the company is doing better than ever," says Joe Barry, Comtran's General Manager.

Comtran executives didn't set out to hire women, but they are seeing the positive impact of those decisions...

The career paths of these women are as varied as their jobs. Some are just starting out in their careers. Others are 20-year veterans of wire and cable. "I was entrepreneurial from the time I could count change and work my grandparent's vegetable stand. I started at Draka working for the VP of Engineering 20 years ago and rose up through the ranks. I was fortunate to have some amazing mentors along the way," says Danielle Braley, Midwest Regional Sales Manager.

More advantages than challenges

Being the only woman at the table can have its challenges, but times are changing. More and more, women are considered equals. Paulette Blagburn, Product Design Engineer, has been at Comtran for one year. She works primarily on new and existing Fire Resistive and Rail Transit specialty cable products. She acknowledges that when she was in high school, girls weren't encouraged to go into STEM (Science, Technology, Engineering, Mathematics) careers the way they are today.

Blagburn was drawn to electronics and she started installing and terminating networks for the City of Woonsocket, R.I. She hasn't encountered discrimination, and also credits male mentors for her success. When asked about job satisfaction at Comtran, Blagburn doesn't hesitate to state, "My products contribute to saving lives. How awesome is that?"

Tracey Pajala, Comtran's Inside Sales Account Manager, shared her perspective on how to thrive when your colleagues are mainly men. "Being a woman, you tend to get more attention focused on you in a male dominated industry. The challenge is keeping that attention positive and professional. Having a good sense of humour and not being easily offended helps immensely."

Other women on Comtran's team include Kristen Davenport, Inside Sales Account Manager and Brianna Cote, Marketing Coordinator. Davenport's clients benefit from her degrees in Economics and Marketing, which help her position and market Comtran products to meet current economics of the cable industry. Cote joined Comtran 3 ½ years ago after earning her Marketing degree. As a millennial, she is fluent in Social Media and Digital Marketing, which have helped Comtran gain industry exposure and qualified leads.

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Tiger/Switch/0816/6

Hexatronic Gears Up For The Expanding Market

Hexatronic is planning to expand further. Skåne and Malmö are growth regions offering great potential...

Hexatronic Cables & Interconnect Systems develops, manufactures, markets and provides solutions within the fiber optic cable infrastructure, for telecom companies. Hexatronic Cables & Interconnect Systems manufacture fiber optic cable, duct, copper cable and network accessories. The company originates from the former Ericsson site in Hudiksvall. Now, two new roles will strengthen the company in Southern Sweden.

Kevin Fröderberg Quist, who will be responsible for Hexatronics sales and customer support in Southern Sweden from October 01, will be based in Malmö. He says, "I look forward to becoming a part of the sales and support team in Hexatronic. It feels great, right from the start we just clicked."

With a background in the installation industry, Kevin has several years of experience in sales via wholesalers, which coincides with the way that Hexatronic sells its products on the Swedish market. He comes to Hexatronic from his previous role as Sales Manager at the company PM FLEX.

(L2R) Jonas Wendelstjerna and Kevin Fröderberg Quist

Jonas Wendelstjerna, currently working as a Sales Manager since August 01, will also start a new role, as the Sales Manager for the Swedish market, which means an increased focus on the Swedish market for Hexatronic. The goal is to offer the best support across the country. Broadband expansion is booming in Sweden – and Hexatronic has in the last year expanded its product range and extended its manufacturing capacity to meet increased demand.

"This is fully in line with our strategy of being close to our customers and being on hand where things are happening. To nurture our customer relationships and provide an increased local presence is important to us. We are ready to expand further. Skåne and Malmö are growth regions with great potential, which is one of the reasons that we are now launching this venture in southern Sweden," says Håkan Bäckström, Sales and Marketing Manager at Hexatronic Cables & Interconnect Systems.

NEMRA Manufacturers Group Executive Committee Inducts Rodney Long

The National Electrical Manufacturers Representatives Association (NEMRA, US), a trade association of independent sales representatives in the electrical industry...

Rodney Long; Senior Vice President-Sales, Atkore International Group, a well known manufacturer of Electrical Raceway (Cables) products; has been appointed to the Executive Committee of the National Electrical Manufacturers Representatives Association (NEMRA, US) Manufacturers Group. Long will serve a 2-year term which began in June 2016.

Photo: Business Wire

Rodney Long

"I am proud to participate on this committee and continue the effort to maintain strong relationships between manufacturers and independent sales representatives. For close to 47 years, NEMRA has played an integral role in the electrical industry and I look forward to working with the Manufacturers Group to deliver quality programs and services to its members," says Long.

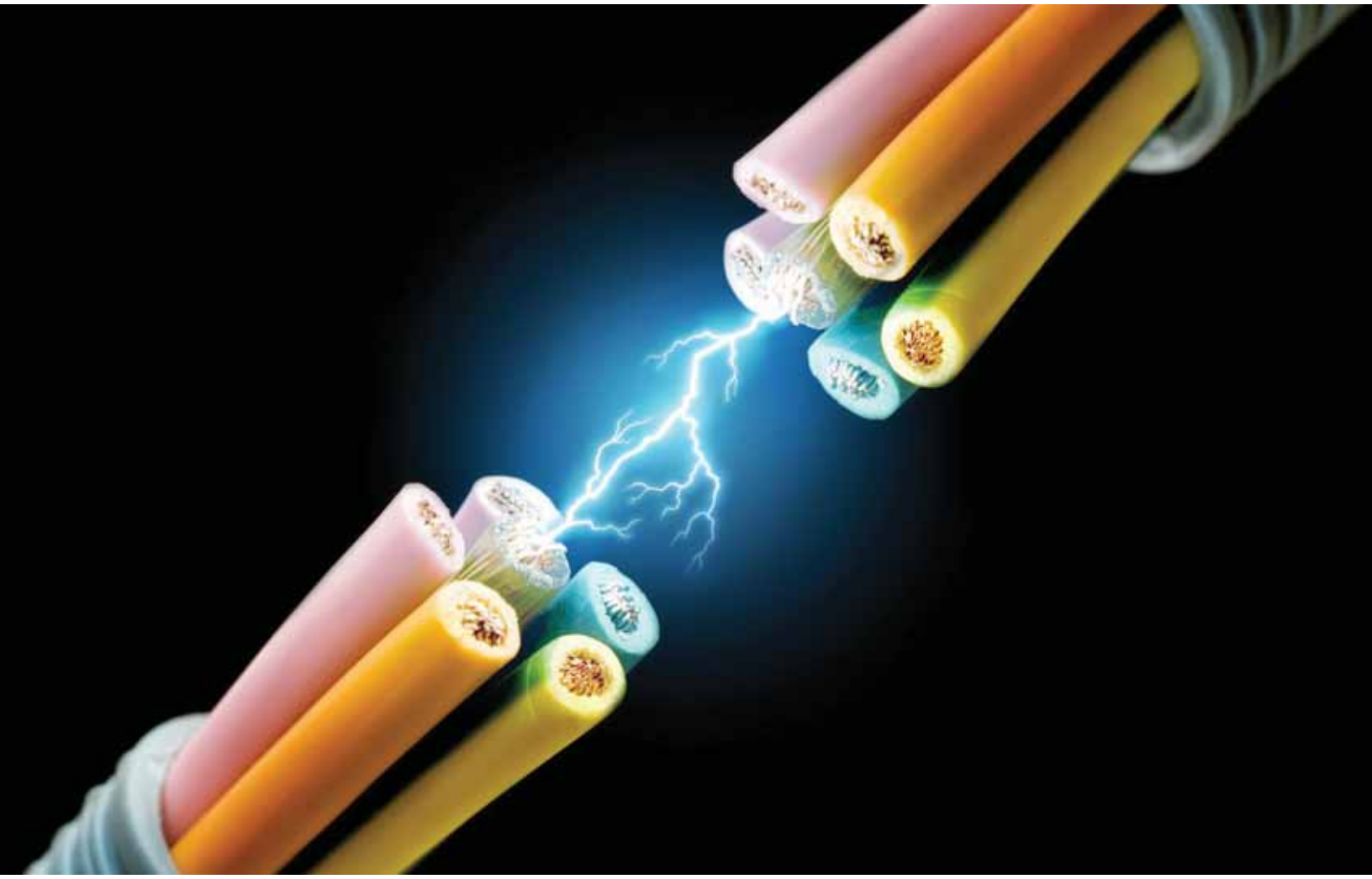
ElMeasure Shifts To A New Venue

ElMeasure, a well known Energy Management Services company based in Bangalore, has moved its plant to the state-of-the-art manufacturing & R&D facility at the Hardware Park near the Bangalore International Airport. The new plant measuring close to 60,000 sft in a 3 acre plot houses the manufacturing facility along with the new R&D center.

ElMeasure's new facility will enable the company to increase its production capacity – and also accommodates future business growth and demand for Energy Management products and solutions in India and globally.

New Address: ElMeasure India Pvt Ltd,
Plot No. 47-P, Bengaluru Hardware Park,
Huvinayakanahalli, Jala Hobli,
Yelahanka Taluk, Bangalore
Email: marketing@elmeasure.com

Selecting The Right Cable



The core cables are used generally for a perfectly balanced 3-phase system. The size of neutral depends on the value of the unbalanced current...

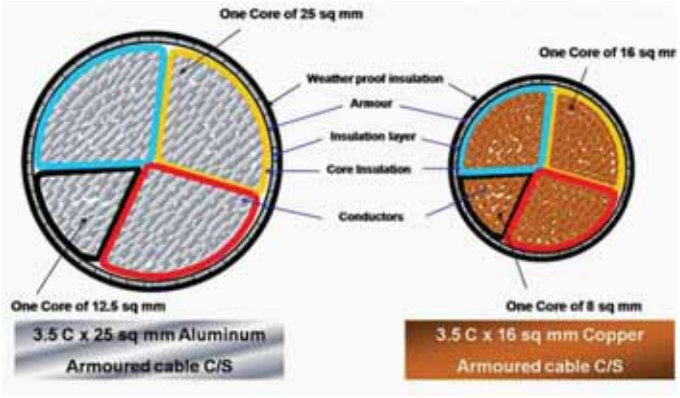
The selection of number of cable cores basically depends on the type of system where it is going to be installed.

Generally we have two types of systems:

1. A perfectly balanced system and
2. A system with some degree of unbalance (or Unbalanced System).

Generally cable sizing includes below parameters:

1. Cable installation conditions and the load it will carry
2. Continuous current rating of the cable
3. Voltage drop and short circuit considerations
4. Earth fault loop impedance



3-Core Cables

These cables are used generally for a *perfectly balanced 3-phase system*. When the currents on the 3-live wires of a 3-phase system are equal and at an exact 120° phase angle, then the system is said to be

balanced. The 3-phase loads are identical in all respects with no need of a neutral conductor. An important example of 3-phase load is electric motor and that is why, they are fed through 3-Core cables inmost cases.

3.5-Core Cables

A 3-phase system may have a neutral wire. This wire allows the 3-phase system to be used at *higher voltages* while it will still support lower voltage single phase loads. It is not likely in such cases that the loads will be identical, so the neutral will carry the *out-of-balance current* of the system. *The greater the degree of imbalance, the larger the neutral current*.

When there is *some degree of unbalance* and the amount of fault current is very small, then 3.5 core cables are used. In these types of cables, a neutral of reduced cross section as compared to the 3-main conductors is used, which is used to carry the small amount of unbalanced currents.

4-Core Cables

When there is *severe out-of-balance conditions*, the amount of fault current will raise to a very high level.

Generally in the case of *linear loads*, the neutral only carries the current due to imbalance between the phases.

The *non-linear loads* such as switch-mode power supplies, computers, office equipment, lamp ballasts andtransformers on low loads produce third order harmonic currents (Definition of Harmonics and Their Origin) which are in the phase of all the supply phases.

These currents do not cancel at the star point of a three-phase system as do normal frequency currents, but add up, so that the neutral carries *very heavy third harmonic currents*.

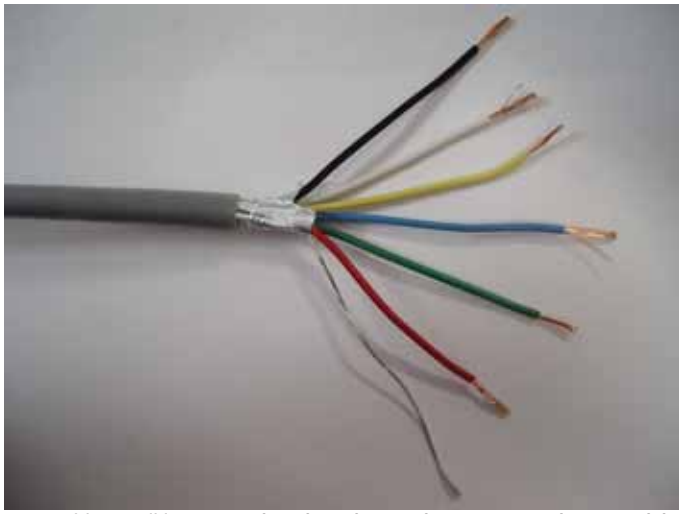
4-core PVC insulated and sheathed copper conductor cable...

That is why the neutral of the cable feeding the equipment are not reduced and made with *cross sectional area same as that of the main conductor* to carry this high amount of current.

5 and 6-Core Cables

Some conditions may arrive when the amount of *fault (neutral) current* becomes very larger than the phase currents. When the load concerned to this type of situation is fed through a multi-core cable, it is necessary to use a 5-Core or 6-Core Cable.

5-core PVC insulated and sheathed copper conductor cable...



In this condition, *two (or three) conductors can be used in parallel formation* to carry the high amount of generated unbalanced currents...

Jay B Thakar
M Tech
Power System
Renewable Energy Expert

Laying UG Cable

The building works should be finished by the end of November and the new cable ready to use. After this, the overhead powerline and its pylons will be dismantled. This will take until mid April 2017...

Glimpses from the field where the cable laying work is in progress...

With a technique that has never before been used in Berlin, a 110-kilovolt cable is being laid underground at the northeastern edge of the city. A cable plough from the Austrian company IFK will plough the ready-welded cable pipes into the ground to a depth of 2.30 m. At a later date, the 110 kV plastic cables can then be pulled through the pipes without any additional digging work. Stromnetz Berlin GmbH decided on the innovative ploughing technique, both to avoid a complicated procedure involving groundwater lowering, and interfering with the area, which is used for agriculture. Unlike the usual open deep digging technique, this cable-laying technology does not mix the layers of soil.

The ground along the line is merely 'aired' slightly. With up to 200 tonnes of force, the cable plough then pulls the prepared empty pipes into the ground and then presses the ground back to its original position.

Across a total length of 1,750 metres, Stromnetz Berlin GmbH is laying the new high-voltage cable in the northernmost region of Pankow on the border with Brandenburg. The work is connected to the six-lane expansion of the A10 motorway, and the planned construction of the 'Am Kappgraben' service area between the motorway junctions at Pankow and Barnim. For the expansion, parts of an existing 110 kV overhead powerline between the Malchow node and the Buch substation are to be replaced by the cable.

Thomas Schäfer, Chairman of the Board of Stromnetz Berlin, said, "The growing city of Berlin needs modern infrastructure. In order to achieve this, new and innovative methods must be used. I'm happy that we've managed to successfully use the technology to almost completely avoid interfering with the local agriculture, and also to shorten the building time of the project significantly."

The building works should be finished by the end of November and the new cable ready to use. After this, the overhead powerline and its pylons will be dismantled. This will take until mid April 2017. EI

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Preventing Failure With Partial Discharge Testing

Partial discharge inception voltage is one of the most important parameters used to characterise partial discharge. If the PDIV measurement at the new frequency is higher than at 50/60 Hz, it may create false negatives...

Partial Discharge (PD) measurements are increasingly used as a reliable and non-destructive diagnostic method for detecting weak spots in the insulation of underground cables. Partial discharge measurements are also routinely used in laboratories for testing cable reels prior to commissioning and in the field to verify installation quality.

Typically, many factory-testing standards require the use of 50/60 Hz high-voltage power supply when performing laboratory tests. However, the use of 50/60 Hz supplies has proven to be impractical when it comes to field-testing, due to high energy generation requirements.

The most important factor to consider when choosing an alternative test frequency is that the partial discharge characteristics at the new frequency must be similar to those at 50/60 Hz, otherwise the results cannot be reliably interpreted. This is especially true when measuring partial discharge inception voltage (PDIV), the voltage at which partial discharge first occurs.

Partial discharge inception voltage is one of the most important parameters used to characterise partial discharge. If the PDIV measurement at the new frequency is higher than at 50/60 Hz, it may create false negatives, making problems appear non-critical when they could in fact be critical at the operating voltage.

Many research papers have addressed the comparability of partial discharge characteristics at various test frequencies and with various wave shapes. This article provides a quick overview of the most commonly used test wave shapes.

0.1 Hz sinusoidal

The very low frequency (VLF) sinusoidal wave shape was introduced for partial discharge testing in the 1990s. In a scholarly paper, "Applied Voltage Frequency Dependence of Partial Discharges in Electrical Trees", researchers reported that PD is frequency dependent and diminishes at low frequencies. It is, therefore, challenging to measure partial discharge at low frequencies such as 0.1 Hz.

A Megger research paper entitled, "Influence of the Test Voltage Wave Shape on the PD Characteristics of Typical Defects in Medium-Voltage Cable Accessories" showed a greater than 300% difference when interfacial discharge was measured at 50 Hz compared to 0.1 Hz. Additionally, the authors of the paper conducted extensive literature research on previous publications comparing PDIV measurements at 50 and 0.1 Hz. Seven papers reported a difference between the two values that ranged from 10 to 250 per cent.

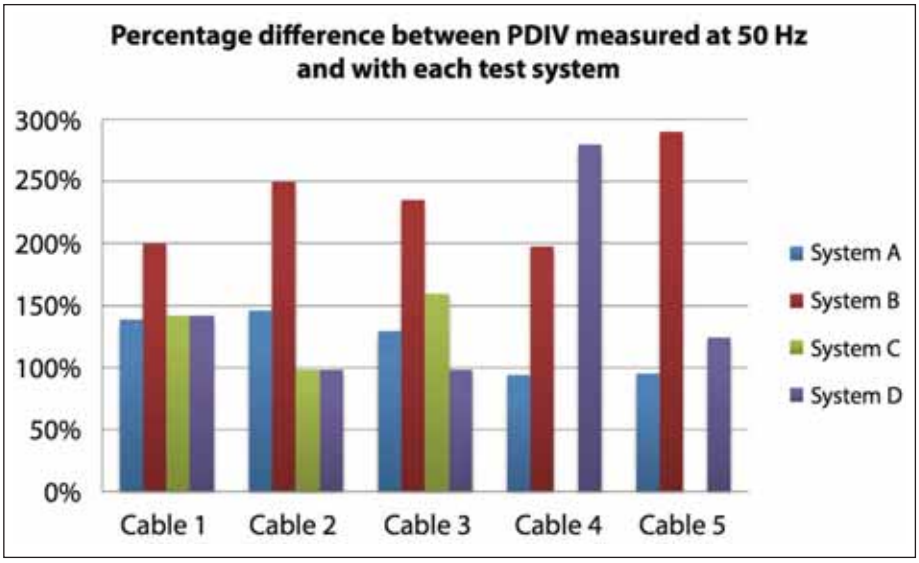

Figure 1: Comparison of PDIV at 50 Hz with each test system. Overall, the DAC method (green) was most closely comparable with 50/60 Hz testing and the 0.1 Hz sinusoidal (red) showed the largest deviation...

This huge discrepancy is due to the characteristics of interfacial discharge. Most interfacial discharges in cable systems occur at the terminations and in splices, and are very dependent on the voltage gradient. A change in voltage gradient could make the discharge 500 times smaller at 0.1 Hz compared to 50 Hz, which is a critical factor to consider when making measurements with a VLF sinusoidal test voltage.

Damped alternating current

Over the past 10 years, the Damped Alternating Current (DAC) technique has been established as a very effective method for partial discharge testing. This method is one of the voltage shapes listed for PD testing in IEEE 400.3: "Guide for Partial Discharge Testing of Shielded Power Cable Systems in a Field Environment."

Electric utilities have collected numerous examples of successful field test data that show a very strong correlation between 50/60 Hz and DAC results. This correlation prompted a broad comparative study of commercially available medium-voltage cable diagnostic systems by Centro Elettrotecnico Sperimentale Italiano Giacinto Motta (CESI), an Italian company that provides testing and certification services, energy consultancy, engineering and technology consulting for the power sector globally.

Table 1 shows the different voltage shapes compared in the study. Testing was performed on five cables. Three parameters – the partial

SYSTEM	SOURCE
A	Sinusoidal voltage at power frequency
B	Sinusoidal voltage at very low frequency (0.1 Hz)
C	Oscillating wave within power frequency and low damping (DAC)
D	Oscillating wave with fixed frequency and high damping

Table 1: Test voltage wave shapes used in a study carried out by engineering company CESI...

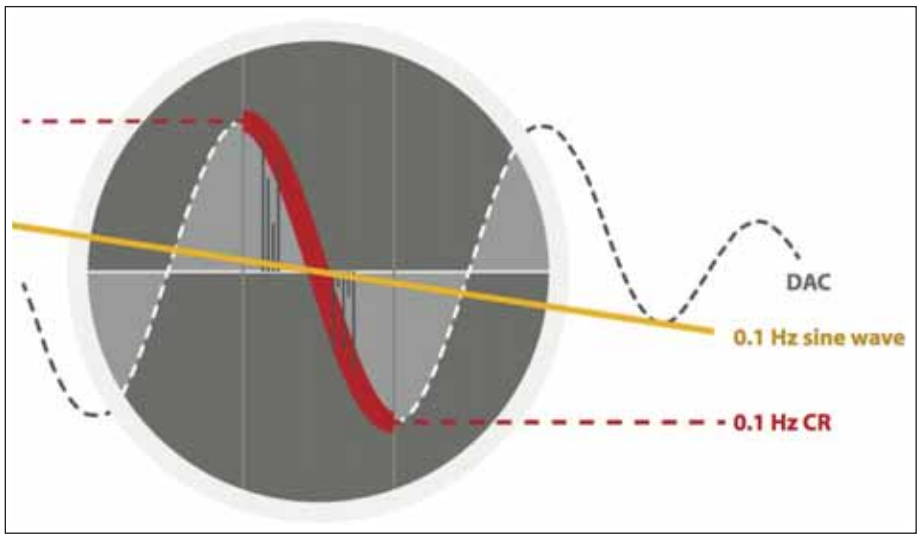

Figure 2: Comparison of DAC, 0.1 Hz sine wave and 0.1 Hz CR wave shapes. The time taken for the polarity reversal with the VLF CR wave shape closely matches that of the DAC but its peak voltage is maintained for five seconds until the next cycle in the VLF CR system...

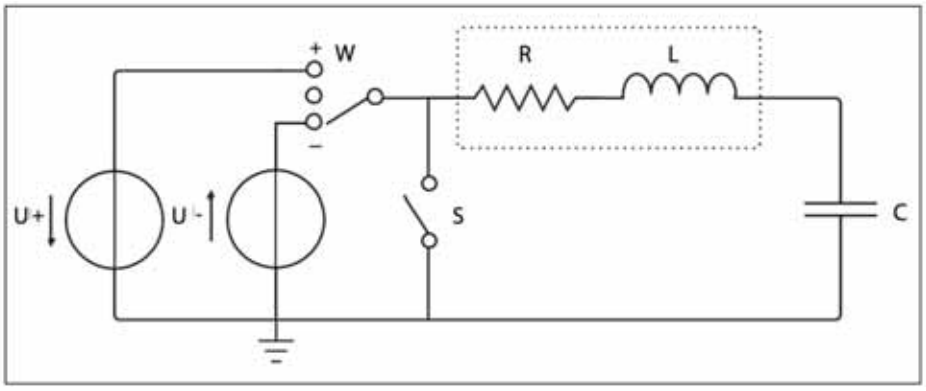

Figure 3: Block diagram of a VLF CR unit...

discharge inception voltages, the location of partial discharge spots and the PD pulse amplitudes – were selected as the comparison criteria. Figure 1 shows an excerpt from the results. Overall, the damped alternating current method proved very similar and the most comparable to 50-Hz testing while 0.1 Hz sinusoidal showed the largest deviation.

0.1 Hz cosine rectangular

The first very low frequency systems used a cosine rectangular (CR) wave, which proved very effective, and is still widely used because the time interval of its polarity change replicates that of a 50/60 Hz wave. Figure 2 shows the characteristic shape of the 0.1 Hz CR wave compared to the damped alternating current and the 0.1 Hz sine wave.

In 2003, German author and scientist Daniel Pepper performed in-depth research to evaluate merits of using a triangle voltage shape and a very low frequency cosine rectangular voltage shape as voltage sources for partial discharge testing on solid dielectric power cables. Both wave shapes performed well for this purpose; however, the cosine rectangular showed higher partial discharge levels, especially for sliding discharges.

Test wave generation

VLF Cosine Rectangular Voltage

The VLF cosine rectangular voltage is generated by a circuit as shown in Figure 3. One of the most significant advantages of the CR technology is its ability to store and recover 90 percent of the energy within the charged cable via the choke. The stored energy is used to charge the cable with the opposite polarity during the next half cycle, within the same millisecond interval of the 50/60 Hz operating frequency. This allows substantially higher test loads to be driven with fairly small input power compared to sinusoidal VLF systems. VLF cosine rectangular systems with up to 25 µF and 20 to 80 kVrms are commercially available.

Damped AC voltage

The circuit used for generating a DAC voltage is fundamentally similar to the one used for generating a VLF cosine rectangular voltage. The only difference is how switch 'S' operates. In the VLF cosine rectangular system, the switch reverses its position to allow polarity reversal. In the DAC system, this switch closes after allowing the cable to be charged to the test voltage, creating a damped resonance (fixed) circuit. The resonant frequency of the circuit is a function of the inductance of the choke, the capacitance of the auxiliary capacitor and the capacitance of the cable to be tested.

Advantages

The two main advantages of very low frequency cosine rectangular technology are its energy efficiency due to its resonant design, and the polarity reversal time interval on the VLF cosine rectangular very closely matching the one at 50/60 Hz, so that it mimics the electrical stress on the insulation under operating conditions. This

PARAMETER	TEST 1	TEST 2	TEST 3
Cable Insulation Type	XLPE	PILC/XPLE	PILC/XLPE
System Voltage	22 kV_{RMS}	11 kV_{RMS}	11 kV_{RMS}
Cable Length	469 m	662 m	1,629 m
Installation Year	1985	1960	1965/2004
Cable Age at Time of Test	26 years	51 years	46 years

Table 2: Summary of test parameters...

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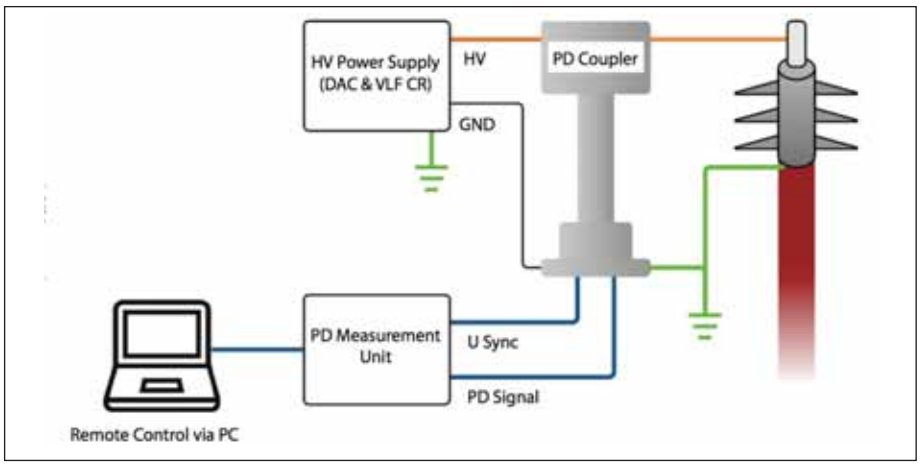

Figure 4: Set up for partial discharge test...

close time matching makes the technology an excellent candidate for use as a power supply in offline partial discharge testing.

The same two characteristics make VLF cosine rectangular technology a very effective tool for withstand testing (with or without partial discharge monitoring), enabling the testing of very long cables or simultaneous testing of three phases at 0.1 Hz. In contrast, damped alternating current technology is not ideal for withstand testing because it requires a substantial number of test cycles to generate an equivalent amount of electrical stress for the same duration. This shorter exposure time to the electrical stress at power frequency is exactly what makes DAC perfect for truly non-destructive partial discharge diagnosis.

Applications

Given the advantages of the VLF cosine rectangular wave shape, its performance as a voltage source for offline partial discharge testing was evaluated. In this study, partial discharge inception voltage and partial discharge levels were measured at the operating voltage (U0) on service-aged cross-linked polyethylene (XLPE) and paper-insulated lead covered (PILC) mixed cables using both VLF cosine rectangular and DAC methods. The damped alternating current method was chosen for comparison instead of 50/60 Hz because DAC results have already been established by numerous studies as being highly correlated with 50/60 Hz results. Table 2 summarises the test parameters for each of the three tests.

Figure 4 shows the on-site test set up for partial discharge measurements. As discussed previously, both the DAC and VLF cosine rectangular test voltages can be generated with the same circuit by controlling switching behaviour. The measurements were performed with conventional coupling and without any hardware or software noise filtering.

In summary, both methods produced very similar partial discharge inception voltage (PDIV) and maximum partial discharge (PDmax) values (refer to Tables 3, 4 and 5) with acceptable statistical fluctuations. Both methods were able to identify the same weak spots in all three cables.

PDmax values were generally slightly higher with VLF cosine rectangular. The VLF cosine rectangular waveform consists of a millisecond polarity reversal, followed by a five-second plateau of the peak voltage before the next cycle. This plateau phase most likely causes an accumulation of charges at the layered interfaces of the cable, resulting in higher PDmax values. Furthermore, this phenomenon might explain why the VLF cosine rectangular allows weak spots on longer cables to be located more easily.

Last words

Partial discharge measurements using VLF cosine rectangular test waves were benchmarked against the well-established damped alternating current method. The results showed that PDIV, PDmax, and the location of weak spots obtained by the VLF cosine rectangular method were highly comparable to the DAC method. This proves that the VLF cosine rectangular wave shape is a comparable and convenient voltage source for partial discharge testing in the field.

The similarity in the design of the VLF cosine rectangular and DAC voltage generation circuit means that it is possible for VLF cosine rectangular units to also generate a DAC voltage. The integration of both technologies offers users the flexibility of a single unit that can perform withstand testing, partial discharge monitored withstand testing, and non-destructive PD diagnostics with damped alternating current.

Megger provides testing solutions in the most critical maintenance areas including cable fault locating, protective relay testing, and power quality testing. Megger's product offering spans 30 distinct product groups with over 1,000 specific products.

TEST	PHASE	L1		L2		L3	
1 XLPE Cable 469 m	Test Voltage	DAC	VLF CR	DAC	VLF CR	DAC	VLF CR
	PDIV (kV_{RMS})	13.2	12.0	10.8	14.0	12.0	12.0
	PD_{max} (pC) @ U_0	300	620	310	-	125	490

Table 3: Comparison of PDIV and PDmax for DAC and VLF CR (Test 1)...

TEST	PHASE	L1		L2		L3	
2 Mixed cable 662 m	Test Voltage	DAC	VLF CR	DAC	VLF CR	DAC	VLF CR
	PDIV (kV_{RMS})	4.2	6.0	4.2	3.0	4.2	3.0
	PD_{max} (pC) @ U_0	2,350	1,100	600	1,400	2,650	9,300

Table 4: Comparison of PDIV and PDmax for DAC and VLF CR (Test 2)

TEST	PHASE	L1		L2		L3	
3 Mixed cable 1,629 m	Test Voltage	DAC	VLF CR	DAC	VLF CR	DAC	VLF CR
	PDIV (kV_{RMS})	2.4	6.0	2.4	<3.0	2.4	<3.0
	PD_{max} (pC) @ U_0	9,500	7,400	6,545	5,500	14,980	50,000

Table 5: Comparison of PDIV and PDmax for DAC and VLF CR (Test 3)...

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Interview

"Despite of standards being there compliances could be weak sometimes – that need to be corrected..."

HPL Electric and Power Limited ('HPL'); a multi-product electric equipment company; is an established player in the electrical equipment industry. In an e-interview with Electrical India, Gautam Seth, Jt. Managing Director, HPL, is fielding questions from PK Chatterjee. Excerpts...

Q What kind of changes are being observed in the field of metering in India, especially with the advent of renewable energy integration?

A The market for meters in India was estimated to be ` 3,000 crore in fiscal 2015, with organised participants contributing to over 80% of the total market. There has been a continued and visible shift from demand for traditional meters to demand for metering solutions, which helps in energy management as compared to mere monitoring and billing functionalities.

Demand for electronic meters dominates the market for meters and will continue due to replacement market for electromechanical and old meters and orders from power utilities. Of this, power utilities account for nearly 90% of the revenue generated from sale of tariff meters.

In fiscal 2015, the industrial segment was the largest consumer of panel meters, power generation companies for tri-vector meters and commercial establishments for electronic meters.

With increasing focus on reliability and accuracy, the contribution from these segments is likely to witness an upward trend.

Prepayment meters have recently seen steady growth as more power utilities are installing them to increase consumer visibility in terms of load patterns and to reduce the percentage of under-recovered revenue. While in developed countries prepayment meters are considered to be tariff meters, in India they are considered as smart meters – and are considered as the first step towards establishment of smart cities and smart grid projects. Smart grid pilot projects are under implementation mostly in the southern and western parts of India although, northern and eastern states also have some ongoing pilot projects.

> LEDs are gaining more prominence as compared to CFLs, especially in urban regions of India on account of their affordability and awareness. Affordable cost of LEDs and the ease of availability of such technology makes it a more attractive option.

During 2016-2020, the overall market for electricity meters is expected to grow at a CAGR of 11.5%, with prepayment meters expected to grow more than the overall growth rate, at a CAGR of 15.1%, and smart meters expected to grow at a CAGR of 5.3%. However, the market for meters is expected to witness explosive growth subsequent to 2022, when the proposed civil works for smart cities and smart grids will near completion, paving way for a robust demand for smart meters. Particularly, smart meters is expected to see a double digit growth once bottle-necks surrounding the smart grid projects are cleared.

Additionally, due to various initiatives of the Government for efficient utilisation of present generation capacity, such as the 'perform, achieve and trade scheme' for high energy consuming industries, panel meters are expected to witness nearly a 12% growth, coupled with energy efficient solution systems. Renewable integration and energy management practices will also fuel the growth of panel meters during 2016-2020.

Q How are you addressing the emerging challenges in this area?

A ***Acceptance of Technology:*** Manufacturers as well as consumers have been reluctant to accept and utilise the technology available with them to its potential, as these meters have traditionally been considered to be plug-and-play devices.

While recent trends show companies investing in technology integration using the metering and control unit system to connect all source and termination points of electricity, the systems continue to remain nonoperational. It is imperative to educate stakeholders regarding benefits of newer technologies and incentivising them to utilise such technology.

Cost and Price Pressure: The market for low-end single and three-phase meters is dominated by participants focusing on tenders from power utilities and are capable of supplying meters at competitive prices. Consequently, organised market participants with higher overhead costs face pricing pressures to match the L1 bids of such unorganized participants. The pressure on such participants for reducing prices to sustain business deters the market from growing to its actual potential.

Threat from imports in the tariff meter segment: Foreign manufacturers with capabilities to supply meters at competitive prices take advantage of the L1 based bidding process of power utilities, thereby impacting domestic players, particularly in the tariff meter segment.

Q What kind of modern technologies are in demand in India nowadays as far as switchgears are concerned?

A Products such as circuit breakers and automatic switches are capturing the demand for changeover switches and switching devices. Further, new products such as motor protection circuit breakers, which are almost completely imported by multinational companies, are gaining popularity among consumers, primarily due to their augmented features, replacing relays in certain applications.

Market Segmentation by End Users

(Source: Frost & Sullivan Report)

The industrial segment contributes approximately 28% of the entire market for LV switchgear with demand across all product segments. The retail segment mainly includes developers of residential and commercial

projects and other commercial establishments, with increasing demand primarily for modular switchgear such as MCBs, residual current devices and distribution boards due to growing awareness among customers on use of protective devices.

Demand from power utilities and consumers of infrastructure projects however, have decreased due to reduced public sector investments.

The LV switchgear market primarily depends on the growth of end-user segments. The segment comprising residential and commercial development is expected to witness positive growth, whereas the segment comprising industries and power utilities is expected to show resilience on account of low capital expenditure and investment in the near term. Growth for all products, except MCCBs and modular devices, has been slow over the last two years.

Q With growing use of LED lamps, power factor correction has been very essential even in domestic segment. What are your offerings in this field?

A LEDs are gaining more prominence as compared to CFLs, especially in urban regions of India on account of their affordability and awareness. Affordable cost of LEDs and the ease of availability of such technology makes it a more attractive option. Further, unlike CFLs, LEDs do not contain harmful substances like mercury, making its end-of life disposal easy and environment-friendly. Organisations like Electric Lamp and Component Manufacturers Association of India ('**ELCOMA**') and other government bodies are advocating the use of LEDs. LEDs are now available in various forms aiming to ease retrofit cost. This has driven the demand for LEDs over CFLs.

We believe that we have an established relationship with several institutional customers and we supply our products to various Governmental Agencies. For instance, we executed several contracts from various Governmental Agencies for supply of lighting products. For instance, we executed LED street lighting turnkey projects in Srikakulam, Prakasam and east Godavari (Andhra Pradesh), various municipalities in Rajasthan and at Varansi Ganga Ghat and Varanasi Nagar Nigam, in Varanasi (Uttar Pradesh), involving supply and installation of LED streetlights and supplied LED tube lights for installation at the office of the electricity department in Delhi during the six months ended September 30, 2015. We believe that the supply of technologically advanced products enables us to maintain such established relationships with these State Utilities and Governmental

Agencies. As on September 30, 2015 and March 31, 2015, we had confirmed orders amounting ` 2,534.24 million and ` 1,934.55 million, respectively.

Q How is the scenario changing in cables & wires segment?

A The overall electrical wires and cables market in India is estimated to be ` 180,000 million in fiscal year 2015. The low tension electrical wires and cables are estimated to account for a majority share of this market at nearly 70%. The estimated 30% of the overall ` 126,000 million low tension electrical wires and cables market during fiscal 2015 is accounted by the unorganised and regional market players.

The key market restraints to growth of the industry in the past years included:

a) unfavourable market sentiments
b) uncertain economy
c) industry slowdown
d) muted investment cycle and
e) slowdown in investments across infrastructure and utility projects.

The industry with its frequent innovations in new product features and quality products has graduated from being dominated by unorganised sector players to the branded and quality players with national repute since it has undergone a few changes.

The organised sector has been manufacturing high tension and specialty cables along with low tension domestic wires – whereas the unorganised players limit themselves to the voluminous low tension domestic wires market. The market is ruled by unfair trade practices, where small cable companies compete by selling products of dubious quality at low prices.

Q How is your wire and cable vertical doing, both among your other verticals and out there in the market?

A If you see the manufacturing setup what we have put up, it's simply cutting-edge and one of the best out there. We currently have two fine wire drawing machines from Niehoff with other machines and tools acquired from the top suppliers of the world. Overall factory, its layout and machines we use here are all world class. HPL Cables is an independent company within a company – and we can compete with anybody in this category.

Q Among the sub-segments of HPL wires & cables, which one is the most profitable? Realty is a bit slow in generating enough demands for wires and cables as of now, what do you say?

A From the sales perspective, domestic wire has the largest share. However, from the profitability angle, specialty cables are much more profitable segment. But then, it requires a different way of marketing; it's a more niche selling. Working with customers and knowing their requirements may take a few more months, but in long term it has a recurring business.

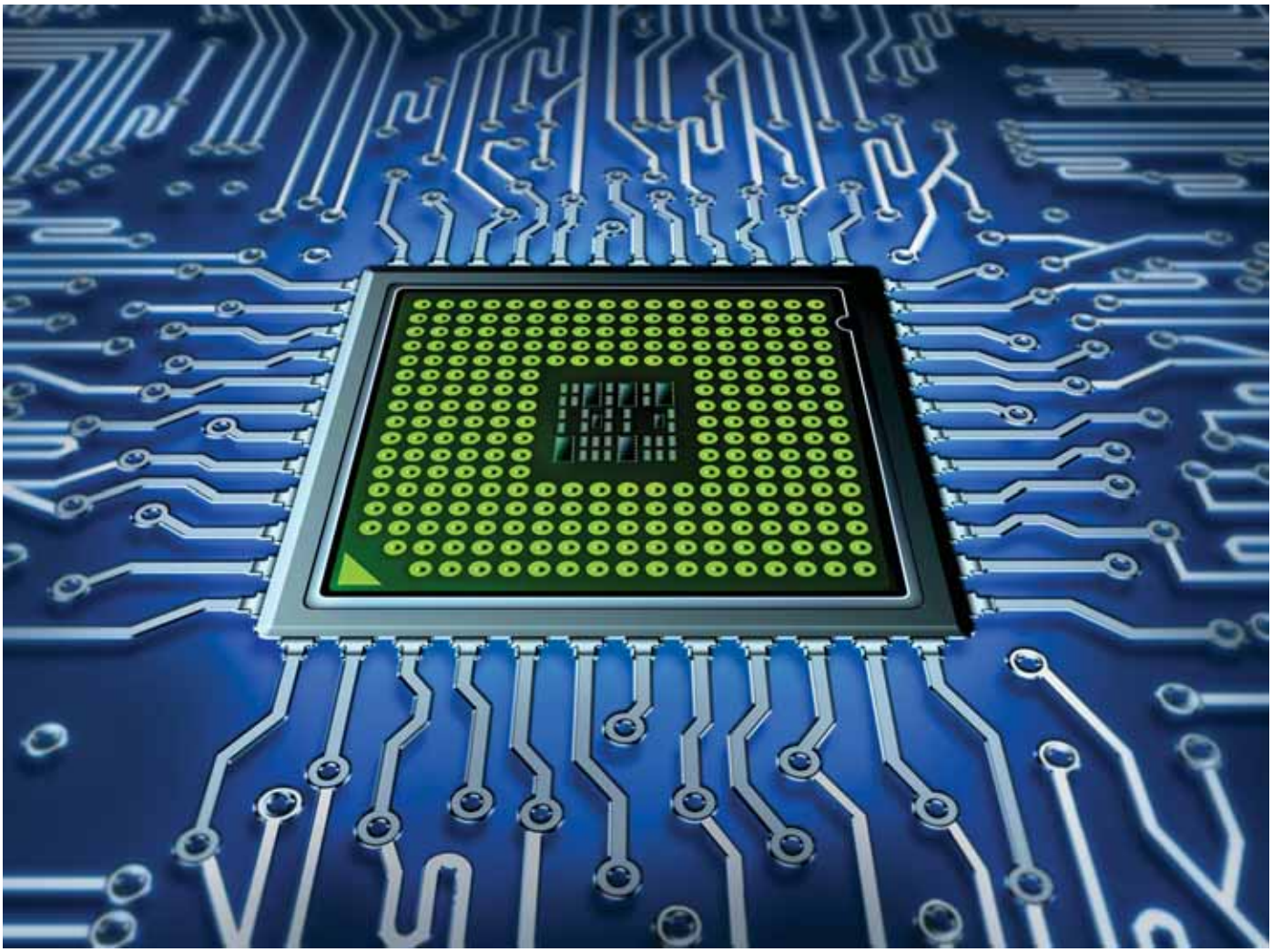
Yes, real estate sector has been pretty sluggish for part few years. I feel that things should start picking up by the end of this year.

Q With regards to the wire and cable industry, what challenges and issues do you see as affecting the growth of the industry?

A To me, compliance is a big issue here. When we talk to customers and people in trade, we feel that overall as a country we should go in for much higher specifications for cables and there needs to be a better compliance with the standards. Today, in some projects, we find that certain people are quoting the kind of prices, which only hurts the industry instead of helping it. In such scenario of unhealthy price competition, quality slides down further in the priority list. Moreover, the dynamics of technology is also affecting us a lot.

Technology changes quite fast and adaptation to the pace of change in technology is a necessity and is quite costly. For example, there used to be ordinary PVC wires earlier, which now has graduated to fire-retardant with a lot of variations in itself such as fire-retardant low smoke, etc. Accordingly, specifications are also changing and going up. As and when specifications go up, the consumer remains the ultimate beneficiary. Although the cost might go up marginally due to investment in technology and adaption to changes, the benefits are manifold and that needs to happen. Despite of standards being there compliances could be weak sometimes – that need to be corrected.

Analysis Of FPGAs



This article deals with the pros and cons of Field Programmable Gate Arrays (FPGAs) as compared to the other digital logic families like microcontrollers and digital signal processors...

As the world moves towards greener solutions for fulfilling its energy needs, power electronic devices have become an intrinsic necessity. For the proper switching of these devices, digital control is preferred. This is due to the overwhelming advantages offered by digital devices. Usage of these equipments results in greater flexibility and reduced complexity as compared to analog methods. Moreover, the implementation of very intricate strategies can be handled with ease and executed in real time.

For generating digital control signals the choice is between three families. The first of these are microcontrollers. A microcontroller is an integrated chip that contains programmable peripherals, a processor and a memory. The second group of devices are the digital signal processors. A DSP is a specialised semiconductor intellectual property core block. Its architecture is optimised for fulfilling the operational needs of mathematically manipulating an information signal. The third choice pertains to the Field Programmable Gate Arrays. An FPGA is a collection of combinational and/ or sequential logic blocks that are interconnected via reconfigurable links. Hence these devices have the facility of being reprogrammed again and again by the end user.

Linear Pulse Width Modulation

A popular strategy for controlling the voltage of converters is pulse width modulation. In this method, the amount of power sent to the load is varied by turning a switch on and off. Greater is the time duration for which the switch is ON, more is output power.

As a control strategy, PWM can be easily implemented by comparing a high frequency saw tooth or triangular waveform with a set DC level. By varying the level of the DC, the magnitude of the output can be changed.

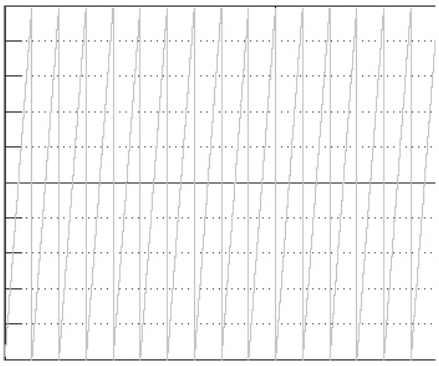


Fig. 1: PWM using saw tooth wave...

Comparison OF Devices

For implementing the above method, any of the three families can be put to use. In terms of cost, a microcontroller will be the cheapest option. Moreover, as compared to the other two devices, it is the easiest to code. However, since it can only execute statements serially, implementation of more complicated methods like Sine Pulse Width Modulation (SPWM) will not be possible.

A DSP can be used for furnishing the desired output. But its cost will be greater or equal to that of an FPGA and much more than that of a microcontroller. Additionally the coding will be typical if not difficult. However, it has enhanced facilities and built in templates for generation of a plethora of schemes. But hard coded architecture limits its functionality.

An FPGA has the inherent quality that facilitates the end user to recode its architecture. This is a huge advantage as compared to DSPs. Furthermore, FPGAs have the resource of meting out massive parallel treatment. Consequently, even complex codes can be executed in real time at a very fast rate. The cost as compared to microcontrollers is more. With advances in technology and the availability of a wide range of products to choose from, FPGAs are making rapid penetration into the digital device market. The cost being comparable to that of DSPs, coupled with the increased degree of freedom, make FPGAs a versatile gadget for control engineers. So using FPGAs for implementing PWM will be a fruitful option.

Pwm Generation Algorithm

For generating saw tooth PWM in a programming language, three variables have to be used. The saw tooth is approximated by using one variable as a counter. The DC level data is obtained by assigning a value to the other variable. These two variables are compared and the result is stored in a third variable. Whenever the DC level is greater than the counter value, the third variable is assigned one; otherwise it is assigned zero. By varying the value stored in the second variable, the third variable output can be altered.

The frequency of PWM is obtained either from the clock of a dedicated device or by the use of an external oscillator.

The algorithm stated above can be modified and used for the generation of control signals of a three phase Voltage Source Inverter (VSI). The inverter is made to operate in the 180° and 120° mode.

Three Phase Vsi

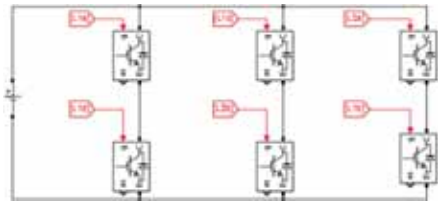


Fig. 2 Three Phase VSI...

Fig. 2 illustrates a three phase VSI. Among its various modes of operation are the 180° and 120° mode.

A. 180° Conduction

The switches of one leg are fired 180° apart. The upper/ lower switch of a leg and the respective subsequent switch is fired 120° apart. Switching frequency is 300 Hz for an output voltage of 50 Hz. Fig. 3 shows the line voltages of the three phases for a VSI in 180° mode.

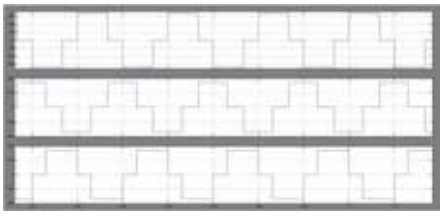


Fig. 3: Line voltages of the three phases for a VSI in 180^{O} mode

B. 120° Conduction

The switches of one leg are fired 180° apart. Each switch conducts for 120° . There is an off period of 60° for each switch. The upper/ lower switch of a leg and the respective subsequent switch is fired 120° apart. Switching frequency is 300 Hz for an output voltage of 50 Hz. Fig. 4 illustrates the line voltages of the three phases for a VSI in 120° mode

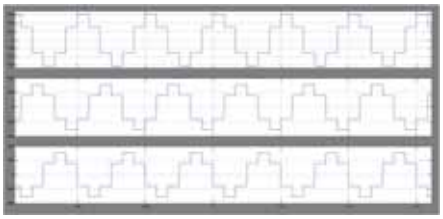


Fig. 4: Line voltages of the three phases for a VSI in 120° mode...

Platform And Kit Used

For coding, Verilog Hardware Definition Language is used. It is a language that facilitates the designing of digital logic chips. The hardware on which PWM is implemented is a Spartan 3E FPGA kit. This series provides a cost sensitive functionality. Fig. 5 shows a snapshot of the kit.

Fig. 5 Spartan 3E FPGA...

Result

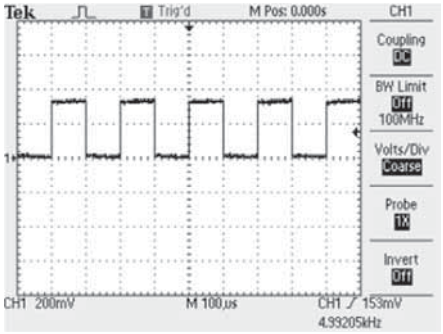


Fig. 6 PWM output...

Fig. 6 illustrates the PWM output obtained on Spartan 3E FPGA for a duty cycle of 0.5 and a frequency of 5 KHz.

By varying the variable values, the duty cycle can be changed accordingly.

The frequency is set by assigning a counter against the inbuilt FPGA oscillator.

For the kit used, the output can be obtained till a frequency of 50 MHz.

Fig. 7 and fig. 8 are the output voltage of the three phase VSI operating in 180° and 120° mode respectively.

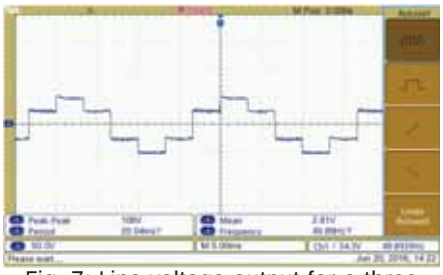


Fig. 7: Line voltage output for a three phase VSI in 180° mode of operation...

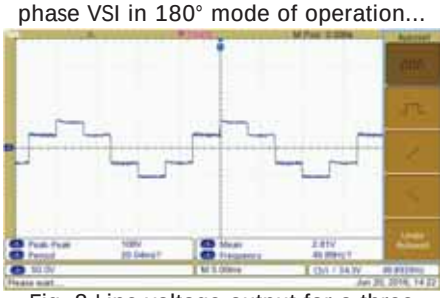


Fig. 8 Line voltage output for a three phase VSI in 120° mode of operation...

The laboratory prototype has been constructed using Insulated Gate Bipolar Transistors (IGBT) of FGA15n120 series. The control signals obtained from the FPGA have been isolated and amplified using TLP 250 driver IC. The actual hardware output obtained bears a strong co-relation with the simulation results.

Conclusion

A comparative analysis of the different means of generating digital control signals has been touched upon this article.

The advantages of FPGAs over DSPs and microcontrollers have been discussed.

Analysis of linear PWM and its implementation on a Spartan 3E FPGA kit using Verilog platform has been demonstrated.

This method can be put to use – for quick and easy construction of power electronic converters.

Sandeep Banerjee
Assistant Professor
Bharati Vidyapeeth's College of Engineering
New Delhi, Delhi

Peeping Into The Indian Electrical Safety Standards

Recently in Mumbai, at a workshop organised by ICA India, a book titled Building Wiring was launched that emphasised on benefits of copper in electrical circuits...

International Copper Association India (ICA India) as a part of its series of organising seminars on Electrical Safety across India, conducted a workshop in Mumbai recently, to raise awareness and rectification measures about electrical hazards and importance of electrical safety in India. This workshop came sixth in line after Kolkata, Ahmedabad, Bangalore, Hyderabad and Delhi, to promote Electrical Safety Practices through National Standards and Regulatory Provisions.

As per the National Crime Records Bureau's report 2014, 11000 people died in the year 2014 due to electrocution and fire due to electrical short circuits. Electric defaults have been seen as the largest single reason for cause of building fires. The Government of India has accorded high importance to this area. Unfortunately, poor practices, improper and weak installations, undersized and inferior quality of wires in the buildings have resulted in an increasing number of electrical accidents.

The workshop brought to light the need for sharing information and knowledge on international experience. It also highlighted the areas where our existing regulations and standards can be improved. The workshop was attended by various stalwarts from both public and private sector – like SR Bagde, Chief Electrical Inspector, Maharashtra; Rajkumar Singh, Director Technical, Schneider Electric; Sasikumar M, Head Electric, Chola MS Risk Services; R Natarajan, Executive Director, JEF Techno Solutions; Sanjeev Ranjan, Managing Director, International Copper Association India.

Sasikumar M, Head, Electric, Chola MS Risk Services presented the topic 'Electrical Installation Standards and regulatory provisions for New Installation and periodic Inspection.'

Further, Rajkumar Singh, Director Technical, Schneider Electric covered a couple of topics, which included 'Protection against electric shock and leakage current' and 'Limitation, Cascading, Discrimination and IEC 61439 Standard.'

(R2L) Sanjeev Ranjan, MD, ICAI; Umesh Kank, GM, Marketing, KEI; Prakash Bachani, Director, Scientist E, BIS; SR Bagde, Chief Electrical Inspector, Maharashtra; Shreegopal Kabra, MD, RR Kabel; NR Khushlani, VP, Marketing, BD, Polycab; Hemant Sali, EE, PWD, Pune; Sounder Iyengar, GM, Finolex; Mohan Kulkarni, Hon. Treasurer, CEEAMA; Mayur Karmarkar, Regional Director, ICAI; Sagar Kurda, Anchor...

The seminar was concluded by Sandeep Patil, Assistant DGM Marketing JEF Techno Solutions, with a lecture on 'Earthing of electrical installation and Lighting protection.'

Sanjeev Ranjan said, "ICA India has been enthusiastically involved in the promotion of safe wiring practices at urban and rural households. Electrical Safety is of highest importance during any electrical installation. Our various seminars and workshops are intended for various stakeholders looking to increase awareness of best practices in electrical wiring. We have been aggressively encouraging the key provisions in the National Standards for safe electrical installations and inspection of wiring installations at regular intervals to curtail fire accidents."

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NATIONAL

Electronica India

Venue: Bangalore International Exhibition Centre

Date: September 21st to 23rd, 2016

Website: www.electronica-india.com

Switch 2016

Venue: Sardar Vallabhbhai Exhibition Centre, Vadodara

Date: October 6th to 10th, 2016

Website: www.switchglobalexpo.com

PowerElec India

Venue: Hall 1, Bombay Convention & Exhibition Centre, Mumbai

Date: October 24th to 26th, 2016

Website: www.powerelec.co.in

India Smart Grid Week 2017

Venue: Manekshaw Centre, Dhaula Kuan, New Delhi

Date: March 7th to 10th, 2017

Website: www.indiasmartgrid.org

INTERNATIONAL

Solar Energy UK

Venue: The NEC, Birmingham, UK

Date: October 4th to 6th, 2016

Website: uk.solarenergyevents.com

EP China 2016

Venue: China International Exhibition Centre, Beijing, China

Date: November 2nd to 4th, 2016

Website: www.EPChinaShow.com

IEE Iran International Electricity Exhibition

Venue: Tehran International Permanent Fairground, Iran

Date: November 5th to 8th, 2016

Website: http://elecshow.ir/English/default.aspx

PowerGen & Renewable Energy Indonesia 2017

Venue: Jakarta International Expo, Kemayoran, Jakarta- Indonesia

Date: May 17th to 19th, 2016

Website: www.powergen-exhibition.net

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Selection & Application Of Surge Arrester

Electrical equipment like transformer, generator, CTs, PTs and motor requires to be protected from over voltages. Surge arrester is used to protect these equipments from lightning and switching over voltages. Modern day's surge arrester uses Metal oxide varistor as an active element and provides exceptional overvoltage protection to the equipment connected to the power system...

Electrical equipments connected in power system are exposed to many stresses, and one of major concern is protecting them from transient over voltages. Transients over voltages are caused by lightning discharges and switching operations.

A surge arrester is a protective device connected in parallel with system equipment to be protected. Overvoltages at the protected equipment are limited by the arrester that conducts energy associated with surge to ground and protect the equipment. The highly non-linear characteristics of an arrester allow the arrester to limit the voltage across its terminal nearly a constant value over a wide range of arrester current. The voltage across the equipment to be protected is almost same as voltage across arrester (Unless there is large separation distance between surge Arrester and equipment to be protected & large lead lengths).

During conduction of surge current, arrester exhibits very low impedance & forms a voltage divider to applied surge voltage in conjunction with line surge impedance. During the time arrester is in conduction, a large percentage of surge voltage appears across line surge impedance and not across equipment to be protected.

By properly applying the arrester, the equipment insulation will not be exposed to damaging voltages, thus eliminating the opportunity for insulation failure. It is important to correctly select arrester parameters so that it can do the desired protection function without causing any nuisance in system.

Over Voltages In Power Networks

A. Temporary overvoltage

These occurs due to earth faults, load rejections, resonance and ferroresonance or combinations of above. For insulation coordination purpose the representative temporary over voltage is considered to have the shape of the standard short duration (1 min) power frequency voltage. Generally, their amplitude does not significantly exceed 2.5p.u and duration varies from few cycles to several hours depending on system configuration.

(1 p.u = √2 Us / √3)

Where Us = maximum system voltage

B. Switching overvoltage

They generally arise from

- Line energization & re-energization
- Faults & fault clearing
- Load rejections
- Switching of capacitive and inductive currents
- Distant lightning strokes to the conductor of overhead line

The representative voltage shape is standard switching impulse (250 / 2500 µs). Generally the amplitude can go up to 3 p.u.

Steeper impulses with very high du/dt in the range from 0.1 to 10 µs & magnitude up to 4.0 p.u are possible in switching operations in inductive power circuits.

C. Lightning over voltages

They are caused by direct strokes to the phase conductor or back flashover or are induced by lightning strokes to earth close to the line.

Induced Lightning surge generally cause over voltage below 400 kV on the over head line and are, therefore of most importance for medium voltage networks.

The representative shape of lightning wave form is 1.2/50 µs. In a medium voltage network the amplitude of lightning voltage can go up to 10 p.u

Selection Of Surge Arrester

The user, application engineers should be aware of important surge arrester parameters and how to select it with reference to system parameters.

A) Continuous operating voltage, Uc –

is the maximum permissible value of a sinusoidal power frequency voltage, which may be continuously applied between the arrester terminals.

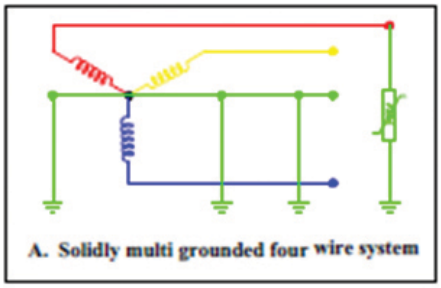
Uc is selected with reference to the highest actual system voltage **Us** or if this voltage is not known or it changes in the course of time, the highest voltage for the equipment **Um** should be taken as reference.

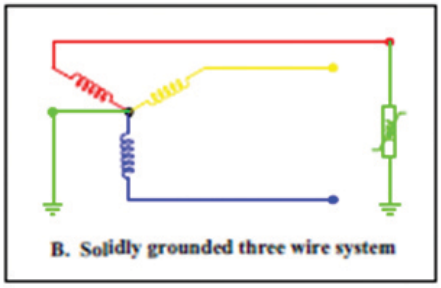
Normally, arresters are connected phase to ground so Uc should be equal to or greater than Um/√3. Additionally, a factor of 1.05 can be taken for harmonic distortion.

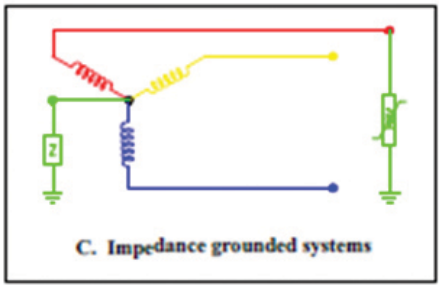
B) Rated voltage, Ur –

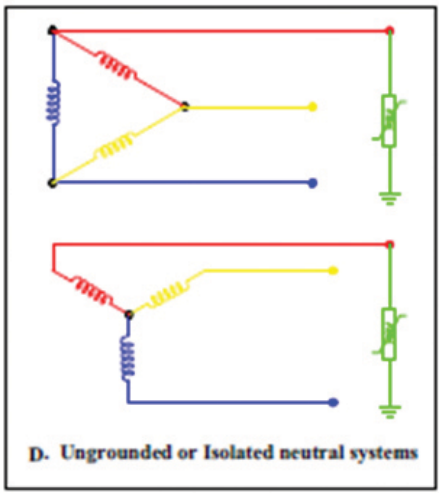
It has no particular practical significance from the user point of view. It is defined as maximum permissible 10 second power frequency rms over voltage that can be applied between the arrester, as verified in the TOV and the operating duty test.

Ur is selected with reference to temporary power frequency over voltages expected on system.









In three phase system temporary over voltages can occur due to earth faults. Single line to ground earth fault is considered to be severe condition where other two phases get over voltage & its magnitude depends on earthing of networks.

The magnitude of the expected temporary over voltage is often defined using the earth fault factor, Kd.

The typical range of factor Kd for various network configurations is listed in table-1.

Table 1

System configuration	Factor Kd
Solidly grounded 4 wire (Multi grounded	1.25
Solidly grounded 3 wire system	1.4
Impedance grounded system	1.73
Ungrounded or isolated neutral system	1.73 (Up to 2.3)

It is also important to note that the grounding of the neutral at the source transformer is the configuration referred to in determining the voltage rise of the system.

C) Selection of continuous operating voltage Uc, rated voltage, Ur & TOV of surge arrester

a) Ungrounded or isolated neutral systems–Kd 1.73 (up to 2.3)

Generally, in these networks the phase to ground voltage of healthy phase would not exceed Um. There is no earth fault clearing so this voltage can remain there till the time fault gets cleared manually.

Continuous operating voltage

Uc ≥ Um (considering Kd = 1.73)

It must be noted; however the Kd factor can reach higher values under certain circumstances as a result of resonance phenomena. In such cases the Uc value should be increased accordingly.

Rated voltage – Once the Uc value selected as above there is no special attention needed to select Rated Voltage, Ur. Generally there is margin of 20% between Uc& Ur. So Ur can be selected as

Ur = 1.25* Uc

e.g 11kV isolated neutral system

Uc ≥ 12 kV

Ur = 15 kV

b) High Impedance grounded system (with earth fault clearing) - Kd 1.73

Here the magnitude of temporary over voltage is the same as in isolated neutral system but as there is earth fault clearing, lower values of Uc& Ur can be selected giving better protection margins.

Ur = Um * Kd / √3

Uc = 0.8 * Ur

e.g 11kV impedance grounded system

Ur = 12 * 1.73 / √3 = 12 kV

Uc = 12*0.8 = 9.6 kV

c) Solidly grounded three wire system - Kd 1.4

Provided a sufficient number of transformers have low-impedance earthed neutrals, the Kd factor will not exceed the value 1.4 for thisnetwork; clearance in such networks is very rapid so here also lower values of Uc & Ur can be selected giving better protection margin.

Ur = Um * Kd / √3

Uc = 0.8 * Ur

e.g. 11kV solidly grounded system

Ur = 12*1.4/√3 = 9.6 kV

Nearest rating can be selected as 9kV or 10kV

Ur = 10kV

Uc = 8 kV

Temporary Overvoltage Curve, TOV

Generally the arrester manufacturer defines the curve temporary over voltage vs time. It means arrester can withstand specified over voltages for specified duration. The over voltage is defined per unit of rated voltage Ur and also with & without prior energy.

e.g. TOV withstand with prior energy

Time (Sec)	TOV
1	1.15 * Ur
10	1.1 * Ur
100	1.05 * Ur

Once the Ur & Uc values selected as per network configuration user should check the values defined in TOV curve of arrester datasheet with the expected over voltages & its duration at arrester location. User should keep in mind that at all time the arrester guaranteed TOV values should be greater than the expected TOV at arrester location, if not, arrester Ur & Uc to be increased accordingly.

In fact Uc, Ur & TOV of arrester are all linked parameters to be derived fromsystem highest voltage, system temporary over voltages and fault clearing time.

D) Nominal Discharge Current, In

The nominal discharge current is the peak value of lighting current impulse with wave shape as 8/20µs, which is used to classify an arrester, It is also a basis for calculating lightning impulse protection level, LIPL of a surge arrester.

Standard 'In' values are 2.5 kA, 5kA, 10kA & 20kA but the value of the nominal discharge current alone does not give enough information about the performance of the arrester. Additional information about the application either Distribution or Station class and duty low, medium or high along with repetitive charge transfer 'Qrs' rating is required to be specified.

E) Impulse and Thermal Energy Ratings -

Repetitive charge transfer rating, Qrs – is the maximum specified charge transfer capability (in coulombs C) of an arrester, in the form of a single event or group of surges that may be transferred through an arrester without causing mechanical failure or unacceptable electrical degradation to the MO resistors.

The repetitive charge transfer testing shows the capability of arrester to withstand repetitive discharges of lightning or switching surges.

This is basically impulse energy handling capability mentioned in Coulombs.

Thermal charge transfer rating. Qth - maximum specified charge that may be transferred through an arrester or arrester section within 3 minutes in a thermal recovery test without causing a thermal runaway. This is defined only for distribution class arresters.

Thermal energy rating, Wth - maximum specified energy, given in kJ/kV of Ur, that may be injected into an arrester or arrester section within 3 minutes in a thermal recovery test without causing a thermal runaway. This is defined only for station class arresters.

Both Qth and Wth relates to thermal energy handling of the arrester.

As per IEC 60099-4 ed. 3.0 a new concept of arrester classification and energy withstand testing is introduced: theline discharge classification was replaced by a classification based on repetitive chargetransfer rating (Qrs), as well as on thermal energy rating (Wth) and thermal charge transfer rating (Qth), respectively for statin & distribution class arrester. Requirements depend on the intended arrester application, being either a distribution class arrester (of In = 2,5 kA; 5 kA or 10 kA) or a station classarrester (of In = 10 kA or 20 kA). The new concept clearly differentiates between impulse and thermal energy handling capability, which is reflected in the requirements as well as in the related test procedures.

Now arrester nominal discharge and energy ratings can be simply selected based on application

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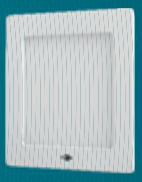

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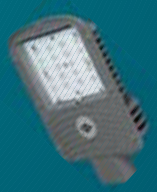

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of surge arrester as per the table below.

	Station class		
Duty	SH	SM	SL
In (kA)	20	10	10
Qrs (C)	≥2.4	≥1.6	≥1.0
Wth kJ/kV of Ur	≥10	≥7	≥4

	Distribution class		
Duty	DH	DM	DL
In (kA)	10	5	2.5
Qrs (C)	≥0.4	≥0.2	≥0.1
Qth (C)	≥1.1	≥0.7	≥0.45
approx. 8/20 µs current for Qth	14	22	34

The letters "H", "M" and "L" in the designation stand for "high", "medium" and "low" duty, respectively.

This new classification system now replaces the old classification system Class 1, 2, 3, 4 & 5.

Comparison of old classification and approx. equivalent of new classification is mentioned in Annexure L, Table L.3 of new IEC 60099-4 ed.3.0

As per this table now Old LDC class 1 will be equivalent to DH of distribution class and old LDC Class 2, 3 & 4 equivalent of SL, SM & SH of station class respectively as per new IEC.

Selection of correct Thermal Energy Rating 'Wth' for station Class arresters –

Metal-oxide surge arresters must be able to absorb the energy due to transient overvoltagesin the system.

With this new energy rating system, the required energy rating of an arrester can be determined by first calculating the level of energy the system will discharge into the arrester and then selecting the arrester with a Thermal Energy Rating Wth that is above the system discharge energy. The prospective energy that a system will require of an arrester can be determined using transient analysis software, but if that is not available a simplified formula as given in IEC 60099-5

$$W = U_{ps} \cdot \frac{(U_{rp} - U_{ps})}{Z_s} \cdot \frac{(2 \cdot L)}{c} \text{ per switching}$$

Where

L = Line length

C = Speed of light

Zs = Surge impedance of line

Ups = is the arrester residual voltage at the lower of the two switching impulse currents

Urp = is the representative maximum switching voltage

If the calculated system energy as per above is 7 kJ/kV of Ur then the desired 'Wth' rating should be minimum 7 kJ / kV of Ur.

Typical values for altitude up to 1000 meter

Highest system Voltage Us	Power Frequency withstand	Lightning impulse withstand	Switching impulse withstand
kVrms	kVrms	kVp	kVp
12	28	75	NA
24	50	125	NA
36	70	170	NA
72.5	140	325	NA
145	275	650	NA
245	460	1050	NA
420	NA	1425	1050

NA – Test not applicable as per IS 3070 part III

F) Protection Level& protective Margins -

Lightning impulse protection level, LIPL or Upl

the maximum residual voltage of the arrester for the nominal discharge current

Switching impulse protection level, SIPL or Ups

the maximum residual voltage of the arrester for the switching impulse discharge current specified for its class

Steep current impulse protection level, STIPL

the maximum residual voltage of the arrester for a steep current impulse of magnitude equal to the magnitude of the nominal discharge current.

The residual voltages as mentioned above of the selected surge arresters should be well below the equipment withstand level.

E.g., for a 33kV system the BIL of transformer is 170kV and LIPL of surge arrester is 90kV then 80 kV is the protective margin. The protective margin should be high enough to take care of lead lengths, separation distance and aging effects of equipment to be protected.

G) Selection of Arrester Housing –

The arrester housing protects the internal active elements from environment and also provides the necessary creepage distance. It can be porcelain or polymeric type.

The housing should be tested for lightning impulse voltage, power frequency withstand voltage and switching impulse voltage (For > 245 kV).

If altitude is more than 1000 metre, then correction should be applied as below

Ka = e ^ m * (H/8150)

Where

Ka = Altitude correction factor

H = Altitude above sea level in meters

m = 1.0 for lightning and power frequency withstand voltages

for switching voltage the value of m depends on the magnitude of switching voltage – and can be referred from curve given in IEC 71-2

Creepage distance of housing – can be selected as per pollution level at arrester location

Recommended creepage distance as below:

Pollution Level	Creepage distance in mm /kV (Us)
I – Light	16
II – Medium	20
III – Heavy	25
IV – Very Heavy	31

H) Short circuit Current

Rated short circuit current, Is of a surge arrester is defined as the highest tested power-frequency current that may develop in a failed arrester as a short-circuit current without causing violent shattering of the housing or any open flames for more than two minutes under the specified test conditions. Table 7 of IEC 60099-4 specifies the required current for short circuit test based on nominal discharge current of arrester.

Users should first find out the system short circuit current at arrester location and then select

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arrester with equal or higher short circuit rating.

I) Mechanical Considerations

In service surge arrester get subjected to various mechanical loading like

a) Terminal connectors – along with line conductors impose a load on the terminals as well as bending moment at the arrester base.
b) Wind Load – Heavy wind increases the horizontal loading on the arrester.
c) Seismic Load – the application of arrester in earth quake prone zone
d) Use of arrester as support
e) Vibrations
f) Tensile loading
g) Torsional loading if any

Users should study all these site conditions & correctly specifies the SLL, SSL, terminal torque values. Manufacturer type tested values should be more than the service conditions.

SLL = specified long term load

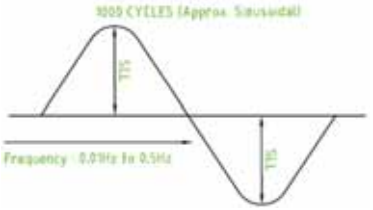
SSL = specified short term load

Both porcelain and polymeric arrester undergoes bending moment test and seismic test as applicable for the required voltage class of arrester as per IEC 60099-4

E.g., Bending Moment Test in polymer housed arrester (Us > 52kV consist of below sequence

Total no of samples - 3

1) 1000 cycles of bending moment (SLL loading) – All 3 samples

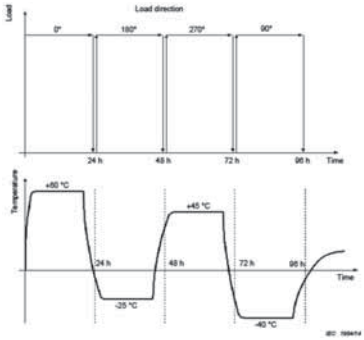


2) Bending moment test – 2 samples from step 1

3) Mechanical thermal preconditioning – Balance 1 sample from step 1

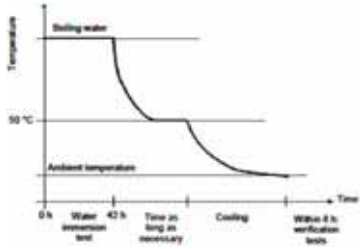
Terminal torque preconditioning for 30 seconds

4) Water immersion test – All 3 sample from step 1



Thermo-mechanical preconditioning

4) Water immersion test



5) Test conclusion
   a) No physical damage
   b) Less than 20% change in power loss
   c) PD less than 10 pC
   d) Residual voltage changes less than 5%
   e) Deviation in 2 impulse of residual voltage less than 2%
f) Reference voltage changes less than 2%

Special Applications

A) Surge Arrester for transformer neutral

One of the most widely used special applications of arresters is for the protection of transformer neutrals.

Each unearthed neutral brought out through a bushing should be protected against lightning and switching overvoltages by an arrester. The neutral insulationmay be overstressed in case of incoming multiphase lightning overvoltages, or in case ofswitching overvoltages due to asymmetrical faults in the power systems.

The Uc of surge arrester for transformer neutral should be selected as given hereafter.

Isolated neutral

Uc ≥ Um/√3 and the energy capability should be same as line to earth surge arrester.

High Impedance grounded system (with earth fault clearing)

Uc ≥ Um/(√3 *T), where T = 1.25 considering fault clearing within 10 seconds and margin of 20% between Uc& Ur.

Low Impedance grounded system

Uc ≥ 0.4 * Um / T, where T = 1.25 considering fault clearing within 10 seconds and margin of 20% between Uc& Ur.

B) Protection of Rotating machines -

If a generator under load condition disconnected from network, the generator voltage will rise sharply till the time regulator acts and readjust it. If surge arrester is connected at generator side then special care should be taken during selection as this temporary over voltage in tune of 1.5 time normal voltage will appear across arrester for up to 10 seconds. The arrester Ur & Uc should be selected accordingly for proper functioning of surge arrester.

High voltage motors connected through VCB can experience high voltage surge during switching operations especially over voltage on account of multiple re-ignition.

Surge due to current chopping can have low magnitude but very steep.Surges due to current chopping can have very high magnitude but with lower steepness that can be handled by surge arrester.

The Ur & Uc of the arrester can be selected as mentioned in 'C'.

C) Surge Arrester for capacitor switching

Arresters are installed at capacitor banks due to a variety of reasons.

- To prevent capacitor failures at a breaker restrike
- To limit the risk of repeated breaker restrikes
- To prolong the service life of the capacitors by limiting high overvoltage
- For overall limitation of transients related to capacitor bank switching, which can be transferred further in the system and cause disturbances in sensitive equipment
- To serve as protection against lightning for capacitors banks connected to lines

The possible arrester discharge energy is the most important parameter to be considered.

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This energy depends on capacitor bank design, grounded – ungrounded, arrester installation phase-ground or phase neutral, breaker performance.

Arrester energy W can be roughly estimated as below

$$W = ½ \cdot C \cdot [(3 \cdot U_o)^2-(\sqrt{2} \cdot U_r)^2]$$

Where

C is the single-phase capacitance of the bank

Uo is the phase-to-earth operating voltage; (peak voltage)

Ur is the rated voltage of the arrester (r.m.s. value).

The factor "3" comes from the assumption of a breaker restrike with full voltage of opposite polarity on the capacitor due to a previous break. Furthermore, the operating voltage at the capacitor bank may be 5 to 10% higher than at other locations due to series reactors which may be used either to limit current when switching-in with parallel banks or to form a filter with the capacitors. This enhanced voltage must be considered when selecting the continuous operating voltage of the arrester.

D) Protection of the cable sheath

Surge arresters for cable sheath protection are sometimes called Sheath Voltage Limiters (SVL). Due to thermal reasons (power losses in the cable sheath) cable sheaths of power cables in high voltage systems are earthed on one side only (majority of the cases depending on circuit length). The open cable sheath has to be protected against overvoltage.

The continuous operating voltage Uc of surge arrester to be selected based upon induced voltage in the sheath during short circuit conditions. Normally the short circuit current is defined for 3 seconds so TOV capability of selected surge arrester for 10 seconds should be greater than calculated sheath voltage during short circuit.

E) Surge arresters between phases

Considerable overvoltage between the phase terminals of transformers or reactors may occur when a reactor or a reactive loaded transformer is switched off. The withstand voltage of the reactor or the transformer between phases may be exceeded without operation of the phase-to-earth arresters. If such switching operations are expected, surge arresters should be applied between phases in addition to those applied phase-to-earth. The phase-to-phase arresters should have a continuous operating voltage equal to or higher than 1.05 times the highest system voltage

F) Transmission line arrester, TLA – non gapped

TLA are in most cases directly suspended from the line conductor close to an insulator. The ground connection is connected to the tower steel structure. It's important to understand the objective of TLA installation. There shall be one or more targets possible as listed below, hence the selection should be appropriate to address the needs.

- Reduce the total number of trips for the line to a target level.
- Reduce or eliminate double circuit tripping.
- Reduce number of shielding failures.

Employment of disconnector in series with TLA is essential. The electrical characteristics of the disconnector are in general different from those of disconnectors for distribution arresters, because the operating duties, where disconnection shall not occur, are harder. It must be ensured that after disconnection no part (swinging in the wind) will be able to produce a flashover to ground.

Selection of Ur –

The Ur shall be selected so that the lightning and switching surge protective levels are coordinated below the LIWV, and SIWV of the line insulation respectively. Ur of TLA is normally higher than substation arrester Ur as this will reduce the risk of TLA unnecessary getting stressed by system power frequency high voltage, here there is no benefit of extra protection margin as the purpose is to avoid flashover of line insulators by shielding failure or back flashover.

Selection of energy –

On shielded lines TLA typically have a nominal discharge current of 5 kA or 10 kA according to IEC with energy equivalent to classes 1 to 3, depending on their application.

Fault clearing & disconnector for TLA –non gapped

Disconnectors are used to facilitate fast reclosing as TLA are connected directly across the line insulators, which are self-restoring. Disconnectors are usually not permitted to disconnect high voltage substation arresters automatically in the event of an arrester failure since theinsulation of the substation equipment is generally not self-restoring and should not be switched in without protection.

These disconnectors in series with the TLA also serve as indicators making it simple to find overloaded TLA with visual inspection.The TLA disconnector must be capable of withstanding both higher impulse currents as well aslonger duration impulses compared to disconnectors for distribution arresters; in fact the disconnectors must pass all the type tests that the TLA is capable of and must know when disconnector shall operate and when it shall not operate. Below are the requirement to be complied for satisfactory TLA fail safe operation.

- The disconnector design shall be such that it shall always continue its opening operation once it is triggered to operate even if the system voltage trips.
- As the disconnector typically reacts on heating from power frequency currents. It cannot distinguish between TOV currents that the arrester withstands or real short-circuit currents thus it's important to always select a high enough rated voltage so that the NGLA do not see TOV stresses that can interfere with its disconnector operation.
- Disconnector shall operate before the line trips and also shall operate before fast reclosing of the line.

The disconnector device is often mechanically weaker than the rest of the installation. Hence, the conductor connecting the TLA to ground or the phase conductor must be sufficiently long to ensure that the movements of the arresters and/or the transmission line will not risk that the disconnector device may break off by mechanical fatigue.

Conclusion

This article briefed about selection of surge arrester for various application conditions based on assumptions of some system parameters, however actual service conditions at arrester location may be worse or good than assumed.

For critical application user should be well aware of system conditions like TOV, line discharge energy etc which can help to correctly dimension the surge arrester.

Only a correctly dimensioned surge arrester can survive during normal conditions and protect system in the event of abnormal switching & lighting conditions and repeat these functions over its life time.

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Installing Offshore Grid Connection

The offshore substation topside sets sail for Dudgeon offshore wind farm – installation completed...

Siemens is supporting a sustainable future as over 410,000 British homes will be powered by renewable energy when the Dudgeon offshore wind farm is fully developed in 2017. The crucial grid connection, which enables the energy generated by the wind turbines to be transported to shore, has reached another milestone as the topside to the substation sails from Sembmarine SLP in Lowestoft to be installed on site 32 kilometres (km) north of Cromer off the coast of Norfolk.

The offshore substation jacket preparing to sail

The offshore 1,500 ton steel substation jacket was designed and fabricated at Sembmarine SLP in Lowestoft and is fitted with suction bucket technology – a first for any UK substation project.

Jacket already installed in June

The completed structure took two days to install in the seabed safely and on schedule in early June 2016, and achieved a hard to come by 0.01 degrees vertical position in the water. The structure is serving its purpose in the north sea as a support mechanism for the topside.

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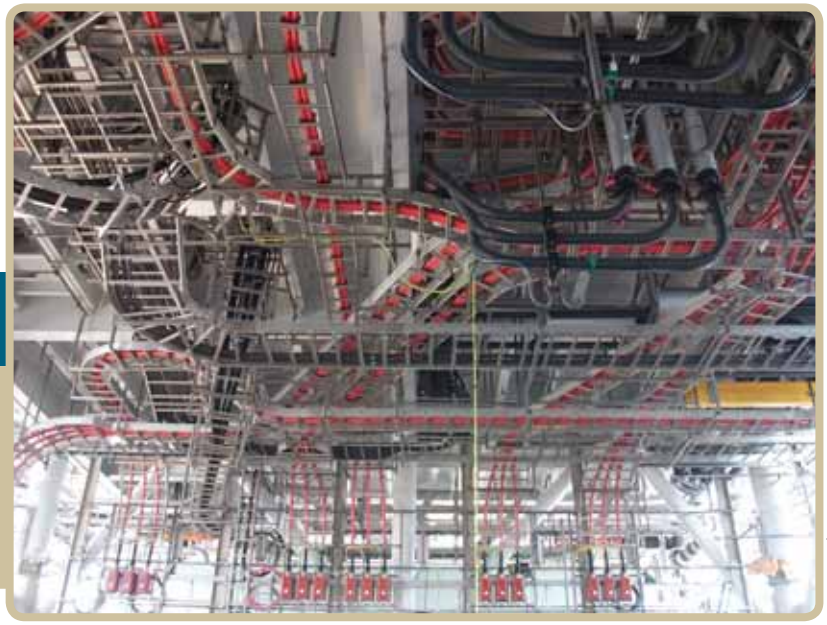
Inner life of the platform

The design and construction of the Dudgeon topside was also completed by Sembmarine SLP including the installation of internal services on behalf of STDL, which commenced in August 2015 and all primary equipment was delivered and installed within a six week period from October 2015. The plant comprises two 200MVA 132/33kV power transformers, two 132kV GIS (8DN8) and two boards of nine 33kV GIS (8DA10), as well as numerous secondary equipment including LVAC, LVDC, UPS, control & protection and a back-up diesel generator. The picture shows the topside HVAC room.

Complex installation of the under deck cables

132kV and 33kV cables and 33kV DURESCA busbar system installed underneath the cable deck (pictured). Installation of the 33kV array circuits down to 'through joints' on the cable deck significantly minimise the installation time and costs offshore. Throughout the topside there is 50,000m of cable.



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Construction of the topside completed

Pictured is the integrated 'end product' just days before the 1,700 ton platform with four decks including emergency overnight accommodation for twelve people was loaded onto the barge in preparation to sail.

© Statoil

Topside sets sail and departs Lowestoft harbour

A momentous milestone is reached as the topside sails in early August, just 18 months following the start of construction.

© Statoil

Reaching its final destination: 32km north of Cromer off the coast of Norfolk

The actual installation involved pulling the platform into the designated position and connecting it up to the previously anchored base frame. This is the most critical part of installation and cannot be done in bad weather.

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Installation completed

The platform is designed for decades of operation in the rugged North Sea and will be monitored and controlled from land – when it has been commissioned. With the Dudgeon platform, Siemens has completed the 14th installation of an offshore substation.

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67 Siemens wind turbines for the 402-megawatt (MW) project

Siemens will manufacture, deliver, install and commission 67 Siemens direct-drive wind turbines rated at 6 megawatts (MW) each and equipped with a 154-metere rotor for the Dudgeon wind power plant. The installation will start in early 2017. The picture is taken at Westermost Rough wind power plant - the first large-scale commercial project featuring this type of turbine.

Glimpses Of The Dudgeon Project

The Dudgeon Offshore Wind Farm will be located in water, which is between 18-25m deep on a 35 km^2 site located 32 km [20 miles] off the coast of the seaside town of Cromer in North Norfolk. The electricity, which it generates will be brought to shore, via a seabed cable, at Weybourne Hope, some 5 km [3 miles] west of the town of Sheringham on the North Norfolk coast. From there an underground cable will be laid to carry this electricity to Necton, near Swaffham in the Breckland district of Norfolk where a purpose build substation will enable the electricity to be transmitted into the National Grid.

Targeted time schedule during conceiving the project...

All the main consents are in place	
Financial Investment decision	Q3/2014
Onshore substation site preparation: commencement	Q3/2014
Onshore cable construction	2015
Foundations installation	2016
Offshore cables installation	2016
Turbines installed	2017
First electricity to National Grid	Q1/2017
Fully commissioned	end 2017

In March 2015 Carillion Utility Services started work to install the longest UK onshore underground cable to be associated with offshore wind farm. When completed during 2016, the 47 km cable will extend from the coastal village of Weybourne in North Norfolk to Necton, near the market town of Swaffham in the Breckland district of Norfolk...

(Source: Newsletter of Dudgeon Offshore Wind Farm)

Managing 12 Pulse Converters

This article discusses 12 Pulse Converter Circuitry commonly found in Variable Speed Drives. The simulation of 12 pulse converters performs in both the Balanced and Unbalanced condition of Line voltages as well as frequency...

Rectifier is a power electronic circuit that is used to convert AC signals into DC signals. A rectifier is a 'power processor that should give a DC output voltage with a minimum amount of harmonic contents.'

We know that a standard six pulse rectifier caused a predictable harmonic spectrum consisting of the 5^{th}, 7^{th}, 11^{th}, 13^{th}, 17^{th}, 19^{th}, 23^{th}...harmonics. For three phase power system rectifiers, the harmonics, which will normally be present in the input current harmonic spectrum, can be identified by the following equation: h = NP±1 Where, N is an integer (1, 2,3,4,5…) and P is the number of rectifier pulses on the DC bus waveform for one cycle of a input voltage. In this article, we deal with the reduction of Total Harmonic Distortion using Multi-pulse AC to Conversion scheme.

An increasing number of pulses reduce the harmonic contents in a line current. However, this technique is profound, has high cost, complex construction, and needs to be large in size.

SIMULATION OF 12 PULSE CONVERTERS

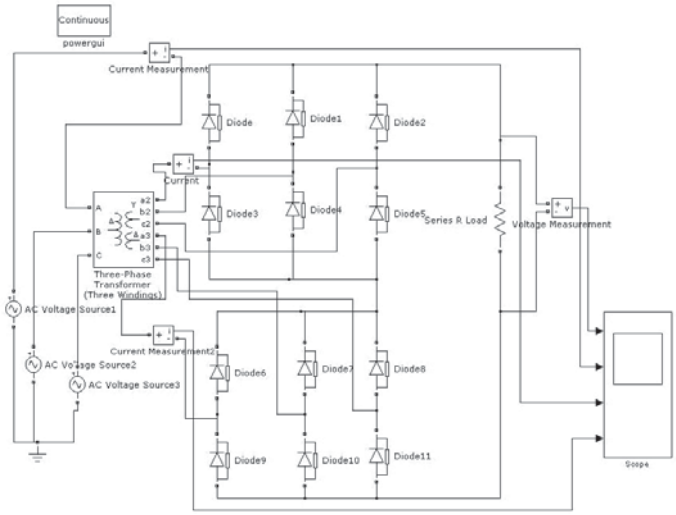

Figure 1: Simulation Model of 12 Pulse Converters...

Since two valves conduct at the same time in each bridge, there will be 4 valves conducting at a time in a 12-pulse bridge converter.

MATHEMATICAL MODELING OF BRIDGE CONVERTER

The AC Voltage of the lower bridge lags that of the upper bridge by 30° (electrical).

For Upper Bridge we have:

$$V1(\theta) = \sqrt{3}Vm\ Cos\left(\theta - \frac{\pi}{6}\right) \qquad \left(0 \le \theta \le \frac{\pi}{3}\right)$$

The Lower Bridge having 30° phase shift, the output voltage is:

$$V2(\theta) = \sqrt{3}Vm\ Cos\left(\theta - \frac{\pi}{3}\right) \qquad \left(\frac{\pi}{6} \le \theta \le \frac{\pi}{2}\right)$$

The Output Voltage,

$$V(\theta) = V1(\theta) + V2(\theta)$$

$$= \sqrt{3}Vm\ Cos\left(\theta - \frac{\pi}{6}\right) + \sqrt{3}Vm\ Cos\left(\theta - \frac{\pi}{3}\right)$$

$$= 1.9319 * \sqrt{3}Vm\ Cos\left(\theta - \frac{\pi}{4}\right) \qquad \left(\frac{\pi}{6} \le \theta \le \frac{\pi}{3}\right)$$

..... (1)

The Average Value of V (Θ) for the period Π/6 to Π/3 is:

$$V = 3.3042\ Vm$$

$$Vm = \left(\frac{1}{3.3042}\right) * V$$

$$Vm = 0.3026V \qquad \text{..... (2)}$$

The peak to peak ripple is:

$$PPR = V\left(\frac{\pi}{4}\right) - V\left(\frac{\pi}{3}\right)$$

$$= 1.9319 * \sqrt{3}Vm\left(1 - Cos\left(\frac{\pi}{12}\right)\right)$$

$$= 0.114\ Vm$$

In terms of DC Voltage:

$PPR = 0.114 \times 0.3026\ V$

$= 0.0345$ ..... (3)

Thus, it can be seen that the ripple is 3.45% in DC voltage.

TEST SYSTEM PARAMETERS

Sr. No.	Parameters	Values
1	Voltage	230V RMS ± 5%
2	Frequency	50Hz ± 3%
3	Load	Resistive Load 1Ω
4	Transformer	Y-Y (1:1),Y-Δ (1:1/√3)

Table1: System parameter for which simulation performed...

SIMULATIONS RESULTS AND DISCUSSIONS

The model of 12 pulse converter is simulated for different value of load. The comparison between the Input line current when the load is 30 percent and full loads it is shown in the figure. Moreover, the simulation is performed for different value of line voltage under balanced and unbalanced conditions as well as with the balanced and unbalanced conditions with the frequency also. In this article, the following case will be discussed. As per the common practical tolerance limit by standard the fluctuation in voltage is assume up to ±5% and in frequency is up to ±3%.

1. Balanced 3-phase line voltages Va=Vb=Vc=230V, Frequency are the same in all phases=50Hz
2. Unbalanced with Va = 230V +5%, while the other two voltages are set equal to 230V
3. Unbalanced with both Va and Vb =230V+5%, while Vc =230V
4. Unbalanced with both Va =230V+5%, Vb =230V, and Vc =230-5%V
5. Unbalanced with both Va =230V-5%, Vb =230-5%V, and Vc =230V
6. Balanced Line Voltages Va = Vb = Vc =230V, fa =50+3%, fb =50-3%, fc =50
7. Balanced Line Voltages Va = Vb = Vc =230V, fa =50+3%, fb = fc =50

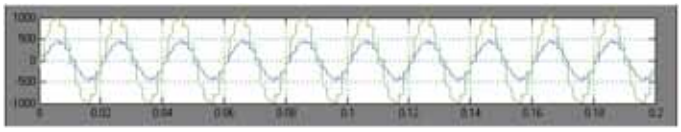

Figure 2: Comparison of input line currents at 30% load & at full load...

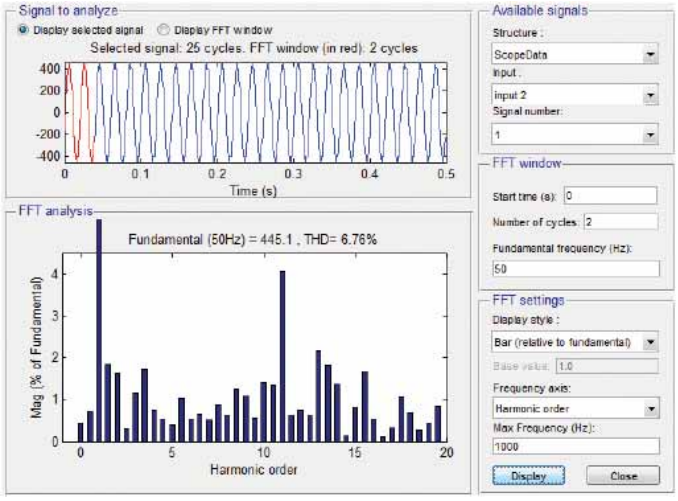

Figure 3: THD Analysis in input line current for balanced system... V line=230V, f=50Hz

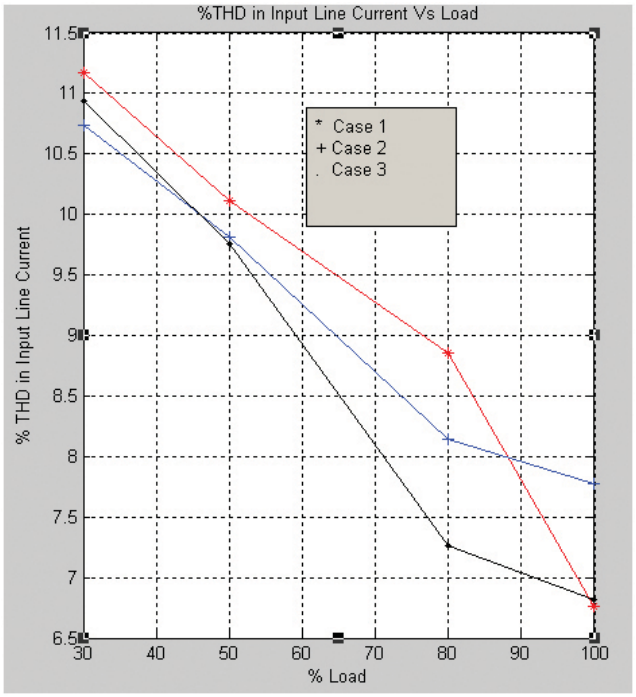

Figure 3: Comparison of %THD in input line current in Case 1, 2 and 3...

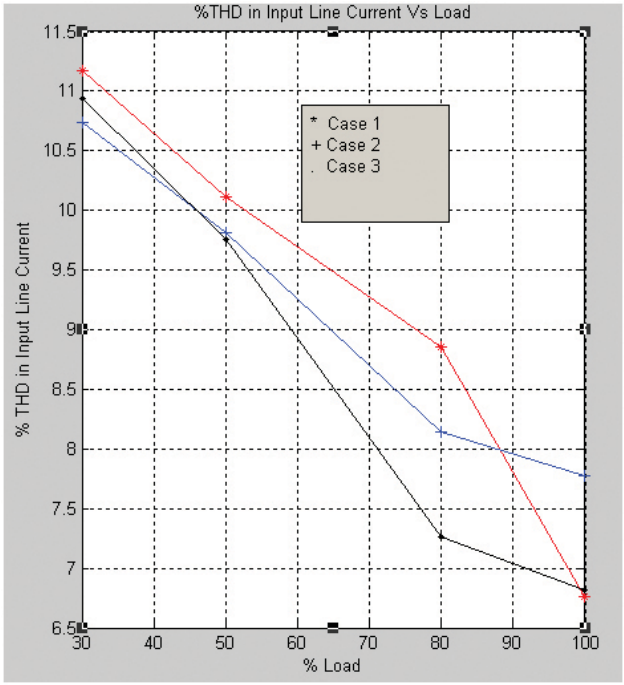

Figure 4: Comparison of %THD in input line current in Case 1, 4 and 5...

As we can see the graph of input Line current %THD and % Load of the figure 3 & 4, where the comparison is done of case 1,2,3 and case 1,4,5 in the full load condition, where all the line voltages and frequency are in balanced condition produces the least amount of harmonics. Whereas the interesting phenomenon to note down is that when load is from 30% to 80%, the unbalanced condition in line in voltages produces least amount of harmonics then the balanced condition.

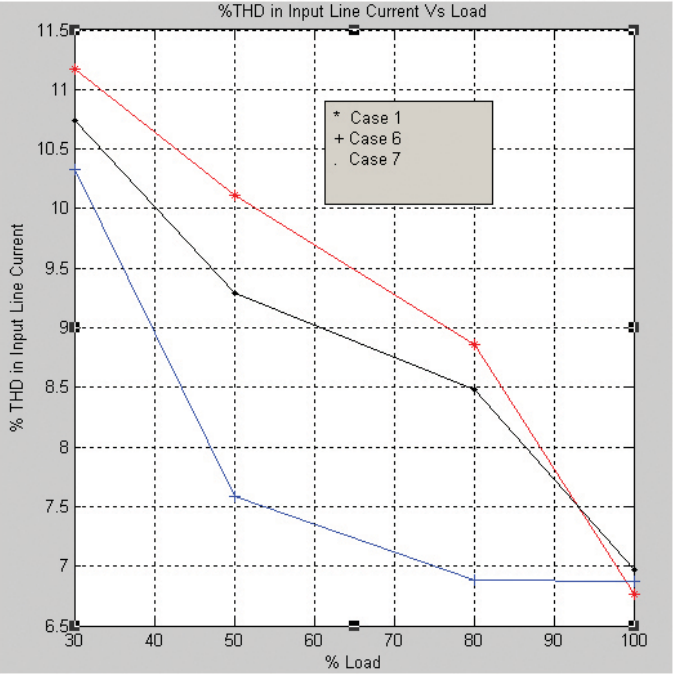

Figure 5: Comparison of %THD in input line current in Case 1, 6 and 7...

As we can see the graph of input Line current THD and percentage Load of the figure 2, where the comparison is done of case 1, case 6 and case 7. When the line voltages are in balanced condition but the frequency is in unbalanced then except the full load condition the unbalanced condition produces the least amount of harmonics when the load is in between 30% to 80%.

OBSERVATION TABLE

NO	% LOAD	%THD		
		Case1	Case2	Case3
1	30%	11.17%	10.74%	10.94%
2	50%	10.11%	9.81%	9.76%
3	80%	8.86%	8.14%	7.26%
4	Full Load (100%)	6.76%	7.78%	6.82%

Table2: % THD in input line current w.r.t. % Load in Case 1,2 and 3

NO.	% LOAD	%THD		
		Case1	Case4	Case5
1	30%	11.17%	10.13%	11.26%
2	50%	10.11%	9.11%	9.26%
3	80%	8.86%	7.37%	8.27%
4	Full Load (100%)	6.76%	7.5%	7.93%

Table3: % THD in input line current w.r.t. % Load in Case 1,4 and 5...

NO.	% LOAD	%THD		
		Case 1	Case 6	Case 7
1	30%	11.17%	10.33%	10.74%
2	50%	10.11%	7.59%	9.29%
3	80%	8.86%	6.88%	8.48%
4	Full Load (100%)	6.76%	6.87%	6.97%

Table 4: % THD in input line current w.r.t. % Load in Case 1,6 and 7...

CONCLUSION

Modeling and Simulation of twelve pulse bridge converter are discussed in this article. With simulation results, engineers will be able to predict beforehand the level of input current harmonics, dealing with practically in three phase system.

In short, to exhibit the validity of the model, here different seven cases examples are simulated and how the input line current THD are affected under balanced and unbalanced condition with variation of load is deeply discussed.

Moreover, the model discussed here is based on ideal components; the user may modify the model by adding some filtering technique to reduce the THD in input line current for future pursuits.

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Harnessed igus Cables now available in economy version

For the motion plastics specialist igus, the name 'readycable' stands for harnessed cables, with a choice of more than 4,000 cables pre-assembled according to all major manufacturer standards. Now igus has expanded its range of drive cables with its chainflex M cables – and provides these as harnessed options in required lengths, with centimetre accuracy, including connectors. This economy cable range is suitable for moving applications with medium duty for up to five million double strokes, and is about 60% cheaper.

The ready-to-connect cables are delivered for immediate use – this is the simple principle of harnessed 'readycable' cables, which igus offers from 1 piece and in desired length without any minimum quantity surcharge. To the more than 4,000 harnessed chainflex cables from igus is added the combination of low-priced chainflex M cables with matching connectors, according to 24 manufacturer standards.

Around 60% cheaper than other igus catalogue cables and also with a guaranteed service life of 36 months. "The pre-assembled chainflex M cables offer a cost-effective solution that ideally satisfies applications with moderate requirements in terms of duty cycles as well as speeds and acceleration. Users can now use this extended choice to make a more suitable choice of the cheapest cable that works for their application," explains Christian Stremlau, Head of Readychain and Readycable at igus.

The highest quality standards are achieved by the fact that a large proportion of the cable assembly is done by machine. This leads to a higher rate of readycable production and more process reliability in the applications. Using the new readycable finder 2.0 (www.igus.eu/readycable-finder) it is very easy to find the right products. Here, customers can choose the right drive cables, specify the desired length, and then order. For an even easier configuration, the matching cables from igus are shown immediately after entering the motor manufacturer's part number.

Harnessed cables worldwide – with a guarantee for 36 months

In order to ensure speedy and individual delivery, igus has considerably expanded its worldwide production and harnessing capacity in North America, Asia and Europe. In this way, customers can obtain exactly the products they need for their applications from 14 warehouses and assembly centres located around the world. As for all its cables, igus also provides a service life guarantee of 36 months on readycables from the chainflex M product range. In the process, a functional reliability for up to 5 million double strokes is promised in continuously moving applications. As usual, users get their cables from 24 hours, with centimetre precision without any cutting costs and from 1 piece without any minimum quantity surcharge.

For further information: E-mail: sreejith@igus.in

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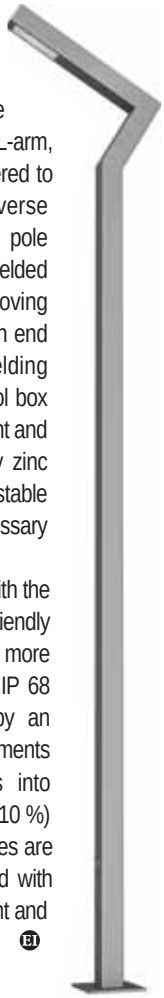
Omicron offers smart plug-and-play Recloser Control Test Set

All utilities (including municipalities and cooperatives), service providers and manufacturers will now benefit from the smart plug-and-play recloser control test set ARCO 400. With this solution, users will easily master the challenge of testing all settings to ensure correct functionality in less than 15 minutes (including the test setup) and in any weather condition. Furthermore, GPS synchronised injections to test distribution automation schemes are also possible.

At 22 lbs (10kg), the lightweight but rugged ARCO 400 is equipped with 3-phase 12.5 A and up to 6-phase 150 V amplifiers. It is designed for outdoor usage and by using smart recloser-specific test adapters. It is an ideal universal tool for testing controllers of any brand in the field. It covers all recloser and sectionalizer control functions and provides maximum testing flexibility, without any additional boxes or accessories. Operated by the ARCO Control software (available for Windows PCs and Android tablets), the test set makes commissioning and maintenance testing of recloser and sectionalizer controls easier than ever before. Dedicated test tools ensure that all functions of the controller can be tested quickly and easily, and test results can be saved to a report. To standardize testing procedures, test plans can be created using the PC-based ReCoPlan software.

For further information: E-mail: herwig.ferstl@omicronenergy.com

K-Lite offers Polar Lighting Poles



'K-LITE' surface mounted Polar Lighting Pole, integrated with LED Lighting Module is an exclusive choice of designers for city beautification lighting blended with architectural appeal. It is designed for a complete range of contemporary designs with single arm, double arm, L-arm, V-Arm, Square arm and Parallel arm. The pole is engineered to meet the adverse conditions and the pole sections are duly welded using special grooving techniques and high end MIG/ TIG welding process. The control box is integral and built-in with service door, locking arrangement and safety chain. The galvanized pole is coated with epoxy zinc phosphate primer and finished using environmentally stable polyurethane based paint. The pole is supplied with necessary foundation hardwares for normal soil condition.

The Polar Lighting Pole lighting arms are integrated with the LED modular lighting system, which is environmental friendly under green lighting category. The LED lighting offers more lumens with lesser power consumption The luminaire is IP 68 protected and the various models were evaluated by an extensive research and understanding of illumination requirements for urban spaces. Choice of drivers for LED takes into consideration the harmonic distortion level (not exceeding 10 %) PF greater than 0.9 and surge protection. The LED modules are individually rated 42 W. The control gear tray is prewired with terminal connectors, MCB and loop-in loop-out arrangement and located in the control box, integral with the pole.

For further information: Website: www.klite.in

Rishabh Instruments offers DC Energy Meter

In December 2015, Rishabh Instruments Pvt. Ltd. introduced a new DC Energy Meter : RISH EM DC. It is equipped with powerful features which will make suitable for almost all the applications areas in DC Systems. It will provide more technical flexibility to customers and stockists coupled with excellent performance.

RISH EM DC can measure energy consumption of 4 independent loads connected to one voltage source. Additionally, user selectable parameters can be logged at regular intervals with Date & Time stamp. It can also perform Load Profile Analysis wherein Energy and Demand data will be logged on daily and monthly basis.

4 relays are provided which can be used flexibly as Timer, RTC Relay, Reverse Locking Alarm, Limit Switch, Pulse Output etc. depending on the application requirement. Also these relays can be remotely configured via MODBUS.

It has got Universal Auxiliary Supply and accuracy of 0.5% for V, I & P and class 1 for Energy. It is a flush mounted meter with separate display for every load with bright seven segment LEDs. This DC Energy Meter is mainly designed for applications in Solar Power, Wind Power, Electroplating, Telecom, Data Centers, DC Metering and other Industrial DC systems.

For further information: Website: www.rishabh.co.in

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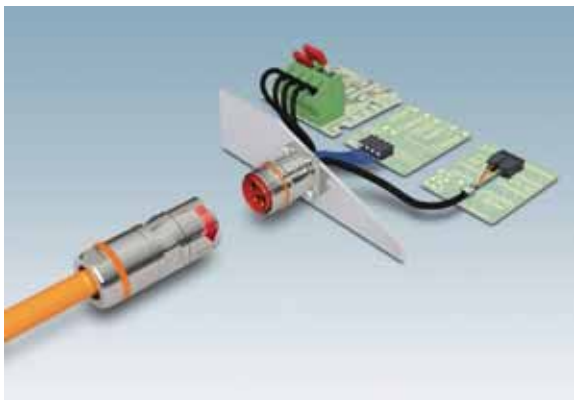
Phoenix Contact Offers Device Connectors

Smart and Reliable Connection technology for various applications...



Connectors are also among the important parts of a system or a device and how well they connect and disconnect along with the ease of assembly & installation is important to users.

Phoenix Contact brings you a complete comprehensive range of innovative PCB connectors to cope up with each and every application related to data, signal and power connection solution within and outside the device. One can find various connection solutions such as panel feed-through, PCB Terminals, Pluggable Terminals, ranges from 2.5 mm to 15 mm pitch with ratings up-to 125A, 1000V with a variety of connection technologies like screw, spring-cage, crimp, insulation displacement, piercecon. There is also a choice in mounting technologies like SMD, THR, wave-soldering and Press-in.

Product spectrum based on Data, Signal and Power

Combicon Compact

To inculcate the demand of miniaturization of modules and devices along with the increase in connection density, Phoenix Contact introduces an innovative range of products - COMBICON Compact.

The range provides solutions with Spring-cage, Push-in and Screw connection technology for all types of applications in building automation, analytical instruments and telecommunication where space saving is critical. This product line offers pitches ranges from 2.5mm to 7.5mm, with ratings up to 32A/800V and cross-section ranges from 0.5 mm2 to 4 mm2. Fiber optic PCB terminal block is also an innovative product lies in this category.

Combicon Control

This range provides connection methods for areas of Measuring, Controlling and regulation technology. PCB terminal blocks and plug connectors ranges from 2.5mm to 7.62mm pitch with ratings up to 24A/630V and cross-section ranges from 0.5 mm2 to 2.5 mm2, with the choice of screw, spring and IDC connection technology. Single level as well as double-, three-, and four level terminal blocks are available to increase the contact density on the PCB. Connectors are categorized in wave soldering, reflow soldering and press-in mounting technologies as well.

Combicon Power

This stands for absolute variety for your high current PCB connection. In this range customer(s) will find high-performance PCB terminal blocks and connectors suitable for power electronics with pitches ranges from 5mm to 15mm and ratings up to 125A/1000V and cross-section ranges from 0.2 mm2 to 35 mm2 in versions for wire-to-board or board-to-board connections, panel feed-through or shielded connections - everything is possible.

This product group also provides high-current feed-through terminal blocks which offer users the complete range of wiring “through the panel”. The portfolio includes terminal blocks with a cross-section range up to 150 mm2 and 309 A, as well as 1000 V according to IEC and 600 V according to UL.

Housing

Electronic housings comprises of different kinds of enclosures, panel mounting base and its accessories for application in the field of industrial electronics.

Phoenix Contact provides a variety of electronic housings for your needs and applications. They are installed quickly and reliably on a common 35 mm DIN rail. Apart from a few exceptions, the connecting terminal blocks can be fitted and machine-soldered during PCB assembly. If a device cannot be installed on the standard DIN rail directly, mounting plates by us are available for adaptation.

Field Device Connectors – IP67

This type of product offer connection technologies that enable the flexible, modular and efficient implementation of various concepts for all your industrial connections, whether it is Signal, Data & Power, where the application demands connections to be water & dust proof. It covers up to 65 pin signal connector, up to 150 Amps power connector & the Data connectors for all bus systems like Ethernet, PROFINET, INTERBUS, PROFIBUS, DeviceNet, CANopen etc.

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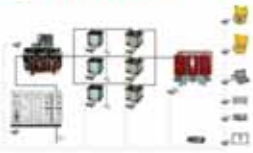

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Lapp Group's ÖLFLEX HEAT 650 SC enhances its product range

The ÖLFLEX HEAT 650 SC supplements the product range of the single cores for expanded ambient temperature and provides the consumer a solution for up to 650°C when constantly utilised. This is possible due to its nickel conductor and the temperature-resistant glass fibre as insulation material.

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For further information: www.lappkabel.com

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- Commissioning of all electrical equipments.
- Dynamic balancing of Rotors, Fans & Impellers.
- Generators Redesigning & uprating of capacity of existing machines without disturbing the rotor winding.
- Redesigning of cooling systems like air cooled to water cooled and vice versa.
- Redesigning with change in voltage like 415V to 660 volts or 3.3KV to 6.6KV or 11KV to 15KV & vice versa.

Profile

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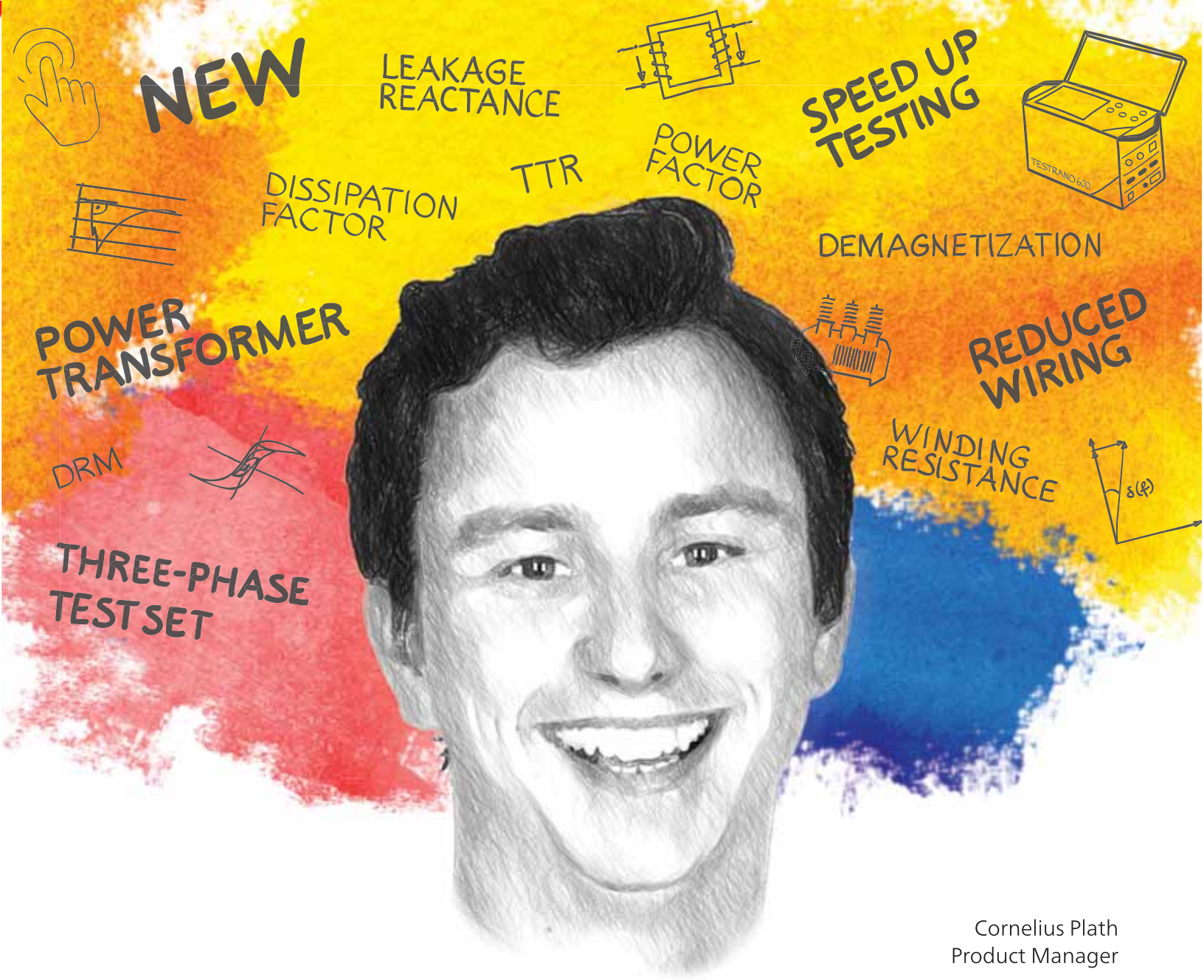

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