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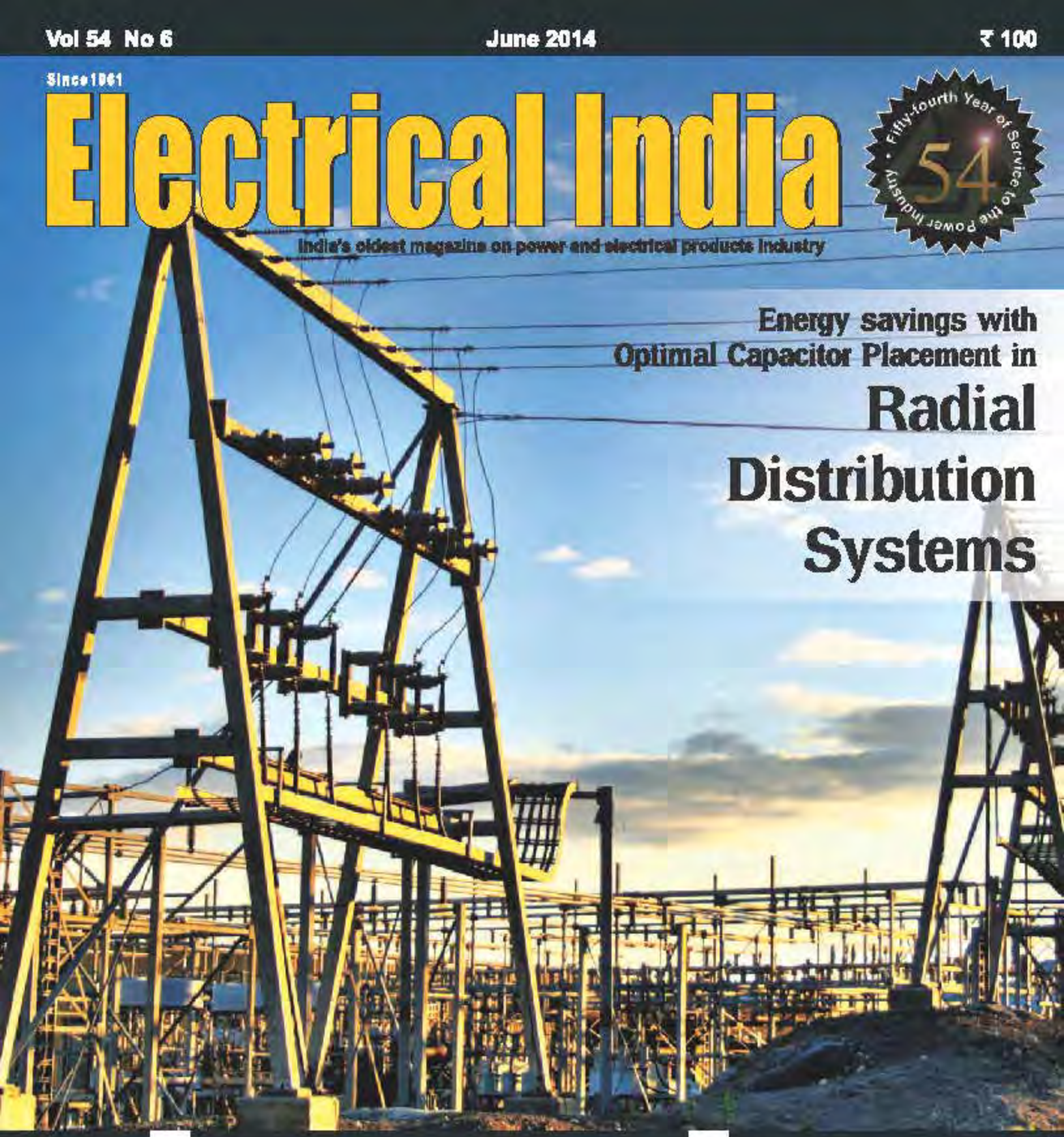
Fifty-fourth Year of Service to the Power Industry 54



Energy savings with Optimal Capacitor Placement in Radial Distribution Systems

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Economic revival and power issues are the prime concerns that pose challenge to the new Modi government. Besides, an environment conducive to huge infrastructure investments, needs to be created to consolidate governance norms with focus on development to stimulate global energy too.

In this fast and wide development of electrical structure the most crucial objective is the requirement of uninterrupted quality power. To achieve this objective most important task is the maintenance of switchgear accessories. The write up 'Importance of Maintenance for Fuses & Circuit Breakers in Selectively Coordinated Systems' deals with this aspect in detail.

The distribution system is a backbone for carrying power to load centers through distribution lines at primary and secondary level of distribution voltages. A write-up 'Energy savings with Optimal Capacitor Placement in Radial Distribution Systems' presents an approach based on sensitivity based methods and the optimal size of the capacitors have been obtained to improve voltage profile and to reduce the losses in the network.

"Consolidate governance norms with focus on development"

Recent trends in the investment in energy sector require the decision making capability for a healthy economy. The Life Cycle Costing analysis allows utility to examine projected life cycle costs for comparing competing capital and O&M project solutions and allows for appropriate comparison of alternatives of different capital values, and lengths of time.

All the more, we present a new layout for you and would like feedback from our patrons, readers, advertisers and subscribers.

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Mahadevan

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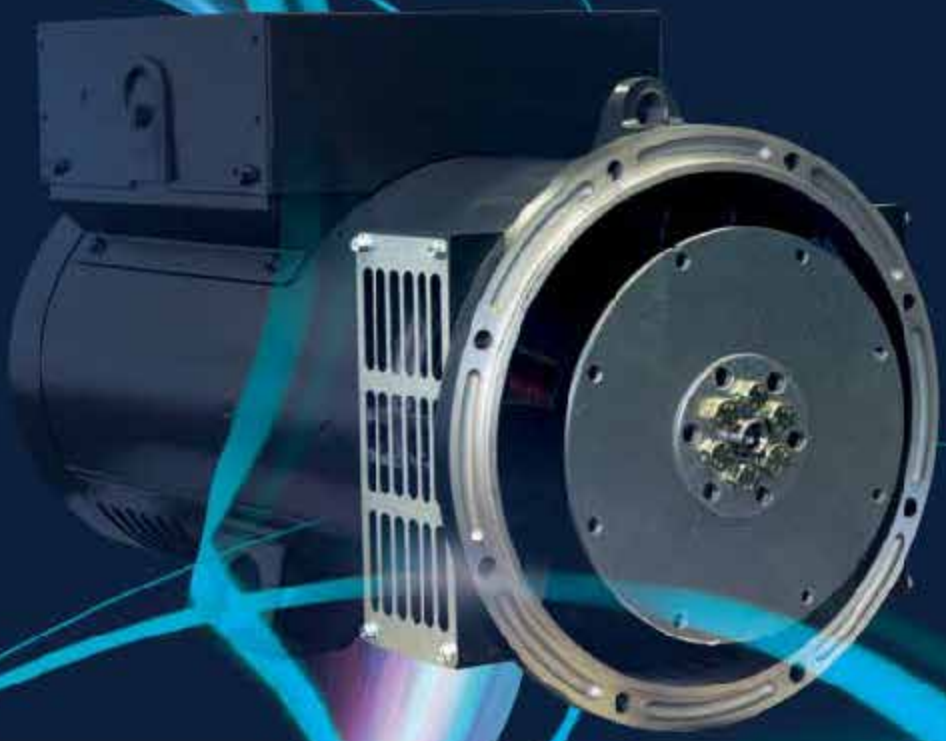

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Modi Government
Taking on Challenges for
Economic Revival

"Progressive development in the infrastructure sector will boost economy"

Gopal Krishna Anand

Narendra Modi and his party swept country's Lok Sabha polls in 2014, in this historic election. If governance as committed by Modi is to be believed; the present political party can steer India into global markets, more of development, power generation and creating jobs. However, India's medium-term growth prospects are good and will benefit from a stable government for the next five years which is pretty seen in Modi as evidenced by his track record and restructuring several ministries to have precise control.

The country's economy is currently facing high inflation and bureaucratic attitudes - moulded in the erstwhile eerie regime. Transforming the economy can be bolted to new heights when our private sector creates a confidence in new governance, of being transparent and for real growth, then only private-government joint ventures can flourish. Further, there is over 20000 MW of fluctuating generating capacity due to coal shortage.

Power and energy sector is the vein of India to spur economic development. If Modi could create optimism and enthusiasm there is every reason for us in the specified activity to be jubilant, and share contribution towards development. There is hope for structural reforms and better investment climate. The new government's reform agenda includes removing impediments to growth, reducing fiscal deficit, encouraging infrastructure investment, focusing on manufacturing and improving governance. We do believe, progressive development in the infrastructure sector will boost economy.

Expectation involve, reducing area of government functioning/ role where private sector participation becomes evident; utilizing sources of alternative energy available within the country such as solar and promoting renewable generation. Electrical equipment market can be rejuvenated as the manufacturing activity pours in. Do not wait till crisis occurs. The decision taking is well laid out in his plan communication to his ministers for 100 days and if basic necessities are met out, infrastructure would pave beginning the reverse reform and ushering onto transparency with which our PM is engrossed in primarily.

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Alstom commissions Uri II hydroelectric project in India

Alstom commissioned NHPC's Uri II (4x60 MW) hydropower project situated in the state of Jammu & Kashmir, in India after availability of full water for running all the four units of the project. The synchronisation of the four units was done in phases. While unit 1 and 3 were synchronised in September 2013, unit 2 was synchronised in November 2013. Despite limited water availability during commissioning and other challenges in terms of a difficult terrain, Alstom was successful in completing the synchronisation of the fourth unit in February 2014 as targeted by the customer. All the four units were declared by the customer in commercial operation from 1st March 2014. Alstom was awarded the Uri II HEP contract by NHPC in 2007. The scope of work included turnkey execution of the electro-mechanical package comprising of hydro turbines, generators and auxiliaries. Last year, the hydro project achieved a major milestone when all four 60 MW Francis vertical turbines installed by Alstom successfully completed the simultaneous spinning of the four units in less than twenty four hours. The 240 MW hydropower project aims to use downstream water discharge of 480 MW Uri-I (already running) hydro project for power generation. It will also provide additional stability to the northern transmission grid. Frederic Teyssedou, Unit Managing Director, Alstom Hydro India, commented, "Following the successful execution, this project is certainly amongst major references for Alstom Hydro in India. The team overcame the challenges presented by the project and worked relentlessly to stick to the timelines. The completion of the project and satisfaction of our customer is testimony of the efforts and commendable work done by the team."

CG gets order to supply Transformers for CAMEG Algeria's Mega Project

Avantha Group Company CG has bagged an order from CAMEG (Comptoir Algérien du Matériel Electrique et Gazier) for the supply and installation of 60kV Instrument Transformers at numerous substations across Algeria. CG will provide indigenously built high-voltage equipment worth Euro 4 million, which include 800x60 kV Current Transformers, 800x60 kV Capacitive Voltage Transformers, and 250x60 kV Inductive Voltage Transformers. The project commenced in April 2014 and will be completed by October 2015. CG's manufacturing facilities in Nashik and Aurangabad (in India) will be a part of the project that involves CG delivering equipment in Algiers, Oran, Skikda, DjenDjen and Mostaganem. CG's HV substations will be dispatched across Algeria. CAMEG is a subsidiary of Algeria's state-owned energy company Sonelgaz, in charge of electricity and natural gas distribution in the country. Sonelgaz is investing heavily to expand and upgrade Algeria's power generation and distribution network. CG's high-end transformers will play a vital role in improving the reliability of the Algerian energy infrastructure. CG was selected for this project due to its successful track record in Algeria backed by global recognition of its technical expertise in manufacturing and supplying high-voltage transformers at the best quality to price ratio. CG has developed in-depth understanding of the power grid network in Algeria and has highlighted key areas that need efficient 60 and 220 kV High Voltage equipment. The demand is further heightened by ongoing upgrades to Algeria's medium voltage network (from 10kV to 30kV), which will involve erection of many substations. CG has also established a new office in Alger, Algeria, to oversee and provide end-to-end support for the ongoing project.

Tata Power Solar expands manufacturing capacity by 60%

Tata Power Solar, one of the pioneering solar manufacturers in the world and India's largest specialised EPC player, announced a 60% expansion of its manufacturing facility in Bangalore, taking the total production capacity to 200 MW. The expansion is based on the significant increase in demand that the company has seen for its solar modules, as well as the expected increase in demand due to supportive policy steps announced recently by the Government of India such as Domestic Content Requirement and anti-dumping duties. Tata Power Solar, erstwhile known as Tata BP Solar, is one of the few companies globally to have a long operating history of 25 years. This is a strong proof point for the company's ability to honour the 25 year warranty that solar modules come with. It is also the only company in India whose modules are rated as Tier 1 in Bankability by GTM Research, a globally recognized PV market research firm. The expansion comes against the backdrop of extremely difficult times for the Indian solar industry. Despite challenges, Tata Power Solar has seen an increase in demand for its products which reaffirms the faith customers put in the quality of its products. Commenting at inauguration of the expanded facility, Ajay Goel, CEO, Tata Power Solar said, "This substantial expansion, in an extremely competitive and price-sensitive sector, is a testimony to our products' superior quality and global competitiveness. Our 25 years of strong credentials in providing high quality solar products, which also corresponds to the warranty period of our modules, adds credibility to our offerings." Currently, the company operates three world-class manufacturing units in Bangalore, including module, cell and solar water heaters.

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BHEL commissions 4x130 MW hydro-electric project in Himachal Pradesh

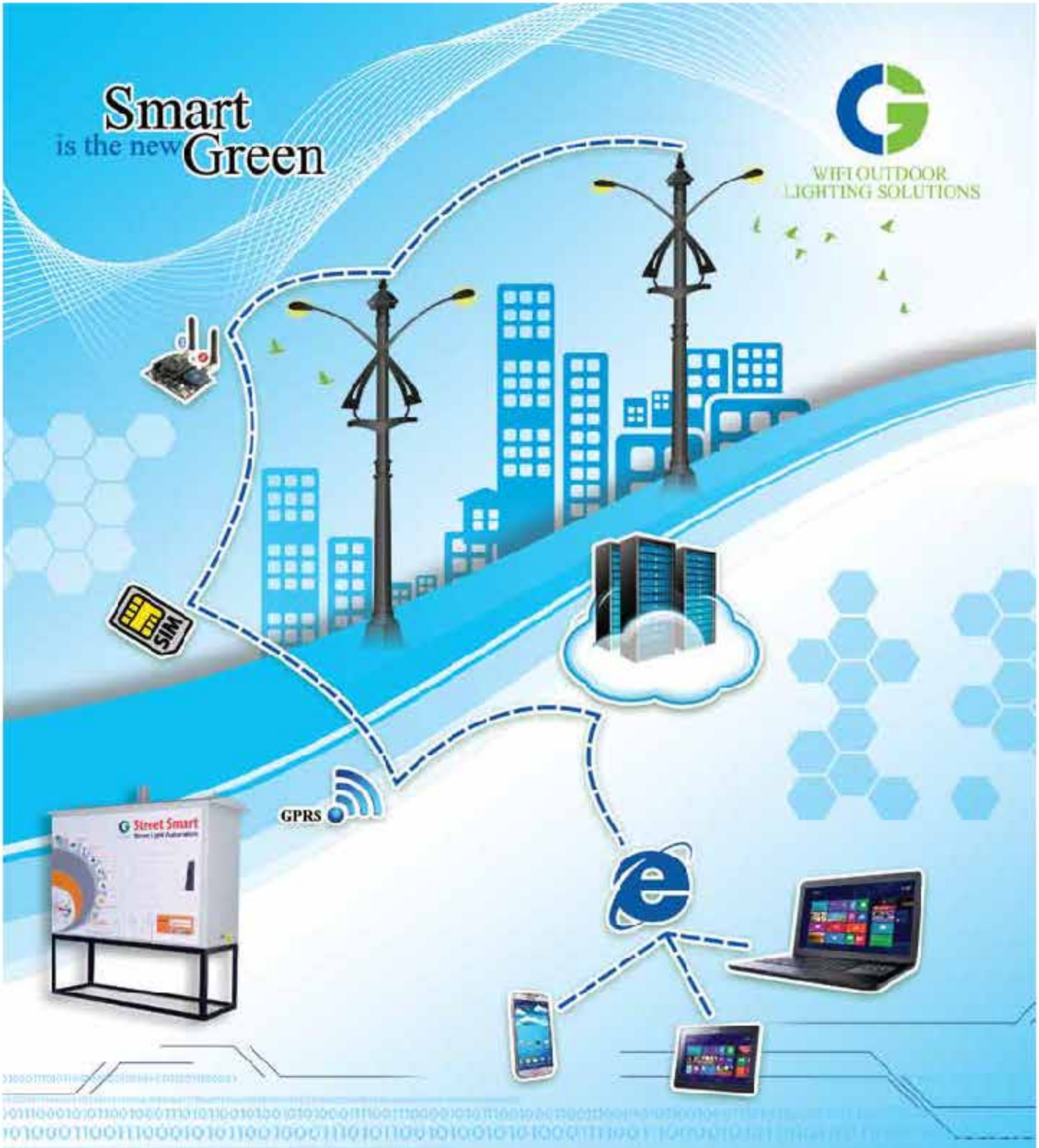
With the commissioning of the fourth and final 130 MW hydro generating unit at Parbati III Hydro Electric Project (HEP) in Himachal Pradesh, Bharat Heavy Electricals Limited (BHEL) has commissioned all the four units of the 520 MW underground hydro power plant of NHPC. The first three units at Parbati III HEP were commissioned by BHEL in February and March 2014. Parbati III HEP powerhouse is located near village Bihali on the left bank of river Sainj, in Kullu district of Himachal Pradesh. BHEL's scope of work in the project included supply and installation of 4 numbers 130 MW Francis turbines, static excitation system, main inlet valves, digital governors, state-of-the-art control & monitoring system (SCADA), associated station auxiliaries, Gas Insulated Switchgear (GIS) and electrical & mechanical Balance of Plant (BoP). BHEL has a long standing association with NHPC beginning with setting up of NHPC's first hydro generating plant at Baira Siul (3x60 MW), by BHEL in 1981. With the addition of another 130 MW, BHEL's contribution to NHPC's total generating capacity now stands at 2,884 MW. BHEL is presently executing three more hydro projects of NHPC viz. 3x110 MW Kishanganga HEP in J&K, 4x40 MW Teesta Low Dam IV HEP in West Bengal and 4x200 MW Parbati II in Himachal Pradesh, which are in different stages of execution. BHEL is presently executing Hydro power projects of around 5,000 MW which are under various stages of implementation. In Himachal Pradesh, another hydro project at Rampur, being set up by BHEL, is in an advanced stage of commissioning. Significantly, so far, more than 500 hydro generating sets of various ratings have been contracted on BHEL in India and abroad, with a cumulative capacity of more than 26,000 MW, out of which, equipment for about 5,000 MW generating capacity has been contracted outside India. Notably, Nine hydro sets totalling 641 MW were commissioned by BHEL in the year 2013-14 including 3 Units of Parbati and 3 Units of Nimoo Bazgo of NHPC. Responding to the growth in the nation's demand for power equipment, BHEL has enhanced its manufacturing capacity to 20,000 MW per annum.

India experiences thrust for alternative sources of energy as Modi's plan for power

Piyush Goyal took over as the Minister of State (Independent Charge) of Ministry of New & Renewable Energy. He said that his priority would be to expand scope and usage of clean and green energy and to ensure synergy in the power, coal and renewable energy sectors. A holistic vision for ensuring energy security of India would be developed. Appreciating Gujarat model in the development of renewable energy, he said that he would learn from the experiences of Gujarat, Madhya Pradesh, Goa as well any other best practices from anywhere in the world that could be brought to India. India plans 20 GW of solar by 2022, and adds less than 5 GW of clean energy capacity (solar, wind, small-hydro and biomass) per year. There is a strong case for an integrated energy ministry. India's new government has three energy related ministries merged in contrast to what the previous government had. Newly elected Prime Minister Narendra Modi won on the strength of his populist speeches and same is evidenced by bullish markets propelling sentiment on alternative energy. He had already announced plans for his government's biggest infrastructural project, solar panels. PTI stated about Modi as the country's 'first energy literate Prime Minister, and said industry groups are hoping the BJP party, which won a landslide victory against the Indian National Congress, will design polices allowing for the faster expansion of clean power generation. Tulsi Tanti, Chairman of the Pune India based wind power company The Suzlon Group, told the newswire that, "the BJP-led government will provide an environment conducive for growth and investments, with major reforms in the infrastructure and renewable energy sector. This is important as India's economic environment will act as a catalyst in reviving the global economy." Smaller power stations attached to wind and solar might be easier to set up in rural parts of India that remain unconnected to the national grid. And to that effect country needs to promote R&D for relevant technologies.

IREDA and AFD Sign Euro 100 million Agreement

The Agence Francaise de Developpement (AFD) is extending a Line of Credit (LoC) of Euro 100 million to Indian Renewable Energy Development Agency Ltd. (IREDA) to be utilized for financing Renewable Energy and Energy Efficiency projects in India. The said Line of Credit is being extended for tenure of 15 years and without any guarantee from Government of India. Agreement for availing the LoC of Euro 100 million from AFD, was signed by K S Popli, Chairman and Managing Director, IREDA and Aude Flogny - Director of AFD's Regional Office in New Delhi in the presence of Senior officials of MNRE & IREDA. Developing renewable energy sources helps address environmental concerns and also improves energy security and spurs regional economic development. The agreement signed today will help in supporting the Government of India's focus on a low carbon growth strategy for power generation in India. IREDA is a dedicated financing institution for financing RE projects under the aegis of Ministry of New and Renewable Energy (MNRE). It has till date disbursed more than Rs 14,550 crores for RE projects and has total loan portfolio of over Rs 8200 crores. IREDA has been raising resources from various bilateral / multilateral agencies as also from domestic sources through both taxable and tax-free bonds for providing long term finance on competitive terms and conditions.



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Eaton unveils Customer Experience Center in Asia Pacific

Power Management Company Eaton has recently unveiled a Customer Experience Center for its existing & potential customers in Asia Pacific. The Experience Center is spread across 2,045 sq ft and is located at Shenzhen in China. The center will enable customers to test complex integrated systems before installing them at their facilities and give them an opportunity to experience real-life electrical conditions in a safe and controlled environment. The customers will be able to view product demonstrations, observation of tests, and learn about Eaton's power management expertise by understanding the advanced approaches to power quality, energy management, and arc flash safety. The center will house an all-glass observatory room to closely view the tests without being exposed to heat and electrical hazards. Customers can see how Eaton manages and monitors the entire power system with the Power Xpert Software on a monitor placed in the observatory room. "Ensuring a rewarding experience to our customers through our advanced products & technologies has been our utmost priority. The Customer Experience Center will take us a step further in strengthening the trust our customers have on us. We are excited that our customers will now witness and experience Eaton's expertise & its commitment to safety, reliability and efficiency," said Syed Sajjhadh Ali, managing director, India, Electrical Sector, Eaton. Eaton's electrical sector is a global leader with expertise in power distribution & circuit protection; backup power protection; control & automation; lighting and security; structural solutions & wiring devices solutions for harsh & hazardous environments; and engineering services.

Emerson collaborates with Facebook on Design for Rapid Deployment Data Center

Emerson Network Power, a business of Emerson and a global leader in maximizing availability, capacity and efficiency of critical infrastructure, announced that it is working with Facebook to design and deploy the company's second data center building in Luleå, Sweden. "Luleå 2" will be the pilot for Facebook's new "rapid deployment data center," (RDDC), which was designed and developed in collaboration with Emerson Network Power's data center design team. Facebook's RDDC incorporates a number of modular design elements, including pre-fabricated materials and on-site assembly, to enable an increase in the speed of deployment and reduction in material use. "We worked with Facebook to understand their wants and needs, and we collectively developed an integrated, cost-effective, tailored solution," said Scott Barbour, global business leader of Emerson Network Power. "This collaboration with Facebook illustrates our competencies in modular construction and showcases next-generation thinking. Emerson is able to deliver innovative, global, turnkey data center solutions comprising design, construction, critical infrastructure equipment, building management system, and services." "Because of our relentless focus on efficiency, we are always looking for ways to optimize our data centers including accelerating build times and reducing material use," said Jay Park, director of data center design, Facebook. "We are excited to work with Emerson to pilot the RDDC concept in Luleå and apply it at the scale of a Facebook data center." Luleå 2 will span approximately 125,000 sq ft and Emerson will deliver over 250 shippable modules, including power skids, evaporative air handlers, a water treatment plant, and data center superstructure solutions. It will be built next to Facebook's first data center building in Luleå, which came online in June 2013. Like its predecessor, Luleå 2 will be one of the most efficient and sustainable data centers in the world, powered by 100 percent renewable energy.

Power factor correction: high performance thyristor module

TDK Corporation presents new EPCOS TSM-LC-S thyristor module for dynamic power factor correction (PFC). It is designed for voltages of 200 V AC to 440 V AC (50/60 Hz) and is suitable for compensating reactive powers of up to 55 kvar. Installation takes place via the system bus (RJ45). An integrated measuring electronics logs key operating data such as voltage of the grid and the current, temperature and switching state of the PFC capacitor. The maximum values of these parameters are simultaneously stored. The data is transmitted via the interface to the power factor controller and processed further, thus enabling comprehensive capacitor and system protection. In addition, the TSM-LC-S features a high-contrast OLED display for the operating data and alarm and error messages. Like all EPCOS thyristor modules, the TSM-LC-S (B44066T1050E402) operates silently with no wear and is maintenance free. It has a switching time of only 5 ms. The module also increases the operating life of the capacitors, as it switches at the zero crossing of the current and monitors the capacitor current. Dangerous overcurrents are avoided and the power line is not exposed to transients. The EPCOS TSM-LC-S thyristor module is especially suitable for PFC applications with presses, welding machines, elevators, cranes and wind turbines, for example. Reactive power: This always occurs when the phase angle between current and voltage is shifted. It is caused by inductive loads such as electric motors and transformers and has no use, but is unavoidably generated by power plants. Power factor correction: Reactive power can be almost completely compensated by switching PFC capacitors. PFC reduces energy costs and relieves the load on the environment. Applications include PFC in single-phase and three-phase industrial networks, PFC applications with presses etc.

Gamesa signs 100 MW turbine supply agreement with CGN Wind Energy

Gamesa, a global technology leader in wind energy, has achieved another milestone in its Chinese sales strategy, signing a contract with CGN Wind Energy, a subsidiary of China's General Nuclear Power Group, for the supply of 100 MW to a wind farm being developed in the Asian giant. The scope of the agreement encompasses the supply and installation of 50 G97-2.0 MW wind turbines, specifically configured for high-altitude locations, at the Yangchajie wind complex located in the province of Yunnan, in southeast China. Fulfilment of this order is slated for the last quarter of 2014. In addition, Gamesa and CGN have agreed the potential supply another 100 MW during a second phase of this project in the course of 2015. "This agreement marks a very important step in Gamesa's sales and product strategy in China, where we recently announced another two contracts, one for Fujian for 48 MW and one for CGN for 49.3 MW. The Chinese wind market offers spectacular growth prospects", according to José Antonio Miranda, Gamesa's CEO in China. Gamesa's technological prowess and its know-how in respect of the entire wind power value chain enable it to tailor its turbines to customer demands and market. In this case, the turbines to be installed at the Yangchajie wind farm are configured to withstand the low temperatures and low air density conditions typically encountered in the province of Yunnan, which is 2,000 metres above sea level. In China, as well as turbines tailored for high-altitude, low temperature and low air density sites (the G97-2.0 MW class II), the company develops WTGs specifically adapted for the strong coastal winds typical of Fujian (the G90-2.0 MW class I) and for low and medium speed wind sites (the G97-2.0 MW class III). The G97-2.0 MW turbines' low power density helps customers reduce their cost of energy.

Coastal Gujarat Power Limited generates power at 92% capacity

Tata Power, India's largest integrated power company, announced generating 23,928 MUs at Coastal Gujarat Power Limited (CGPL) and 6328 MUs at Maithon Power Limited (MPL). In FY14, CGPL generated 23,928 MUs as compared to 12,440 MUs in FY13, whereas MPL recorded 6,328 MUs as compared to 4,588 MUs. For the Quarter ended 31st March 2014, generation of CGPL increased from 6,039 MUs in Q4 FY13 to 6,800 MUs in Q4 FY14 whereas Maithon Power Plant generation capacity increased from 1,514 MUs to 1, 653 MUs in Q4 FY14. Both CGPL and MPL generation capacity in Q4 FY14 increased by 13% & 9% respectively. With a strong business presence across the power value chain the company has an installed gross generation capacity of 8560 MW. The Company is also one of the largest renewable energy players in the country with significant capacity in wind and solar. The Company has continued to demonstrate robust operations with a substantial contribution by the CGPL and MPL through achieving full operations. The Company aims to generate 18000 MW and 4000 MW of distribution and secure 50 MTPA of fuel resources by 2022. CGPL is the wholly owned subsidiary of Tata Power and has developed India's first operational 4000 MW Mundra UMPP currently catering to 2% of India's total power needs. The project is among world's largest Greenfield Thermal Generation Project and is most efficient and fully operational thermal power plant of the country today. CGPL supplies power to five states namely Gujarat, Rajasthan, Haryana, Punjab and Maharashtra in the country.

Lapp Group: cabling solutions for export-oriented engineering companies Cabling across the pond

At the Hannover Messe, the Lapp Group presented cabling solutions that will be interesting to export-oriented engineering companies. The ÖLFLEX® FD 855 P, its screened version ÖLFLEX FD 855 CP, as well as UNITRONIC® 300 STP cables are now available with UL certifications for the North American market. The highly ÖLFLEX flexible control cables offer long travel distances and small bending radii. Their polyurethane sheath gives them increased oil, abrasion and impact resistance. The cables, which will be integrated into the top performance class "Extended Line", provide a long service life and, thanks to the choice of special insulation and sheath materials and the highly flexible design, are

the ideal solution for power chains with high acceleration and speed parameters or with particularly long travel distances, for all conceivable production lines, as well as assembly conveyors or high bay warehouses. The flame retardant and halogen free ÖLFLEX FD 855 P and ÖLFLEX FD 855 CP can therefore be used for any machine and plant engineering applications, particularly where oils or low ambient temperatures make life tough for the cables. The new UL and cUL AWM Styles enable export-oriented machine and plant engineering companies to send the cables on their way to North America for applications up to 1,000 V with no problems. The UNITRONIC 300 STP is a twisted pair screened signal and control cable for low voltage communication, as well as for internal and external equipment wiring for industrial applications. Already established as part of the Lapp USA range, it is now also available in Europe. Lapp's primary intention is to offer export-oriented machine and plant engineering companies a solution for domestic and international use in the USA and Canada. The cable rounds off the range of UL CMG approved data cables for low frequency data communication systems. UNITRONIC 300 STP is extremely flexible & easy to install.

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Siemens to provide eight turbines for Klixbüll community wind farm

Siemens Energy gets order for community wind power plant Klixbüll in Schleswig-Holstein. Eight modern wind turbines with direct drive technology and a 3 MW capacity each will be installed at the onshore project close to the coast of the North Sea near the Danish border. The fully citizen-owned Zweite Klixbüller Energie GmbH & Co. KG with the new wind farm extends the locally installed capacity by 24 MW up to 39 MW till autumn. Even in case of no wind an innovative feature to stabilize the grid by supplying wattless power assures additional profit to the project. Siemens provides a 20 year maintenance. It will supply eight direct drive wind turbines with rotor diameters of 113 meters and a rating of

3 MW each to Klixbüll. Six SWT-3.6-107 turbines have been in operation at the windy site in the region of Nordfriesland. Two of them are the basis of the first community wind farm of Klixbüll commissioned in 2006. Another eight SWT-3.0-113 wind turbines with a rotor diameter of 113 meters & a capacity of 3 MW will not only more than double the total capacity, but also provide technological features that will make the project even more profitable. Once the installation will be completed this fall, the wind farm will contribute to the energy transition even in the case of complete wind calm. A key feature is the 'Reactive Power at No Wind' option which turns the wind turbines into a phase shifting VAR compensator which then solve a technical problem in the AC voltage grid: Industrial customers who draw large amounts of active power from the grid can disrupt the supply frequency because of their need for reactive power and may lead to a heating of the power lines.

Energy Department announces Projects to advance cost-effective Concentrating Solar Power Systems

The Energy Department announced $10 million for six new research and development projects that will advance innovative concentrating solar power (CSP) technologies. The projects will develop thermochemical energy storage systems to enable more efficient storage of solar energy while using less storage material, cutting the cost for utility-scale CSP electricity generation as a result. Also, the Department released a new report highlighting the progress of five major CSP deployment projects that are already producing clean, renewable energy. "By improving energy storage technologies for concentrating solar power systems, we can enhance our ability to provide clean and reliable solar power, even when the sun is not shining," said Energy Secretary Ernest Moniz. Concentrating solar power technologies use mirrors to focus and concentrate sunlight onto a receiver from which a heat transfer fluid carries the intense thermal energy to a power block to generate electricity. The research and development projects announced will explore and develop novel thermochemical energy storage systems, which could store the sun's energy at high densities and temperatures in the form of chemical bonds. The chemical compounds used to store the chemical energy are later broken down to release energy when needed. Six teams from universities, national laboratories and research institutes, working with industrial partners, will test different chemical processes for CSP thermochemical energy storage that could further advance CSP technology, helping the industry step closer to meeting the SunShot Initiative's technical and cost targets for CSP and moving the U.S. toward its clean energy future.

Perkins celebrates production of its 20 millionth engine

Perkins recently celebrated a major milestone with the production of its 20 millionth engine. Eighty-one years after the brand was established, the 20 millionth Perkins engine, a 1206 two-stage turbo Tier 4 diesel

engine, rolled off the production line at the company's facility in Peterborough, UK. At a small ceremony, attended by around 70 employees, Perkins president Ramin Younessi said: "Twenty million engines is a significant achievement of which we're all very proud. "Today, Perkins is one of the world's leading suppliers of off-highway diesel and gas engines in the industry. Our engines are manufactured across four continents and power more than 800 different applications in the construction, power generation, agricultural, material handling, industrial and marine markets." He continued: "Our global manufacturing facilities have all contributed to this 20 million milestone for the Perkins brand, to which I extend my sincere thanks to the team, while our global customer base have of course, made their contribution too, by continuing to value their ongoing relationships with us as their power provider, as much as we value our partnerships with them." 20 million Perkins engines have been built, of which at least 4.5 million are still in service. Perkins engines are sold around the world and power more than 800 different applications for major equipment manufacturers in the construction, power generation, agricultural, material handling, industrial and marine markets.

Honeywell UOP Renewable Fuel Technology powering Biofuel Facility in US

Honeywell UOP LLC, a Honeywell company, announced that its UOP/Eni Ecofining™ process technology is powering the largest commercial advanced biofuel facility in the U.S., capable of producing more than 130 million gallons of renewable diesel per year. The Diamond Green Diesel facility in Norco, La., converts inedible oils and other waste feedstocks to produce high-quality renewable diesel, also known as Honeywell Green Diesel™. Unlike biodiesel, renewable diesel produced using the UOP process is chemically identical to petroleum-based diesel and can be used as a drop-in replacement in vehicles with no modifications. Renewable diesel produced using the Ecofining process also features up to an 80 percent lifecycle reduction in greenhouse gas emissions compared with diesel from petroleum. The facility, a joint venture of Darling International Inc. and Diamond Alternative Energy, LLC, a subsidiary of Valero Energy, achieved all of its performance and quality targets. "Commercial production at the Diamond Green Diesel facility is a significant milestone for the renewable energy industry," said Veronica May, vice president and general manager for Honeywell's UOP Renewable Energy and Chemicals business unit. "UOP has leveraged 100 years of refining technology to make real alternative fuels, including Honeywell Green Diesel and Honeywell Green Jet Fuel™, from a range of inedible biofeedstocks." John Roach, senior vice president at Valero, said "Both the performance of the Ecofining unit and the quality of the diesel produced has exceeded our expectations." Randall C. Stuewe, chairman and CEO at Darling, said, "The availability of sustainable feedstocks is a key driver for the continued growth of renewable fuels. One of the benefits of the Ecofining process is that the technology is capable of processing a variety of feedstocks collected and manufactured by Darling to produce high-quality Green Diesel."

ABB and Solar Impulse form technology alliance

ABB's heritage of technology innovation in renewables, sustainable transportation and energy efficiency makes it an ideal partner for Solar Impulse, which is attempting the first round-the-world flight powered by the sun. ABB, the leading power and automation technology group, announced it will support Bertrand Piccard and André Borschberg in their attempt to fly around the world in a solar powered airplane in 2015. The first-ever flight through the night with a solar airplane as well as record-breaking missions across Europe, the Mediterranean Sea and the United States brought worldwide attention to Bertrand Piccard and André Borschberg with their Solar Impulse endeavor, demonstrating the enormous potential of clean technologies and showing how a pioneering spirit can achieve the impossible. Now the Solar Impulse team is preparing for the ultimate technological challenge: to circumnavigate the globe in a plane powered only by the sun's energy. On April 9, the team will unveil a new airplane, which will be used to attempt the round-the-world flight in 2015. "This partnership brings together two Swiss-based global leaders that are passionate about pushing the boundaries of technology and innovation to achieve a better world," said ABB CEO Ulrich Spiesshofer. "Solar Impulse and ABB are technology innovators and pioneers," said Andre Borschberg, Co-Founder and CEO of Solar Impulse.

Fortum in agreement with Rolls-Royce modernisation of its Loviisa Nuclear Power Plant automation

Fortum has signed an agreement with Rolls-Royce about the modernisation of automation at its Loviisa nuclear power plant in Finland. The parties have agreed not to disclose the value of the agreement. The modernisation will be carried out over several years and it is included in Fortum's normal capital expenditure. The project mainly covers the automation modernisation of safety related systems in both production units at Loviisa. The project is agreed to be implemented by the end of 2018. Rolls-Royce will deliver all the required automation systems including planning, testing and installations. Metso is Rolls-Royce's sub-supplier providing non-safety operational instrumentation and control (I&C), field design and implementation on site. The project will be implemented in close co-operation with Fortum. The aim of the automation modernisation project is to secure the safe and reliable operation of the Loviisa nuclear power plant until the end of the plant's operational licenses. Unit 1 at Loviisa power plant has an operational license to 2027 and unit 2 to 2030. In 2013, the load factor at Fortum's fully-owned Loviisa nuclear power plant was 92.5%. On an international scale this was excellent compared to the worldwide load factor for pressurised water power plants of approximately 83% last year. The plant produced a total of 8.04 terawatt-hours, which is approximately 9% of the total electricity production in Finland. With the electricity produced, 6 million tonnes of CO_2 emissions are avoided annually. Fortum has a historically large investment program in progress at Loviisa. In addition to the modernisation of automation, Fortum is modernising the turbines & enhancing the safety of the nuclear power plant with new air-cooling towers. In 2013, Fortum invested EUR 60 million into the Loviisa nuclear power plant.

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Capacitors

In power systems, the reactive power (VAr) compensation is not provided centrally at generating voltage levels at generating plant itself, instead the reactive power compensation is preferred to be exercised locally at different voltage levels throughout transmission and distribution lines and at tail end - consumer side using fixed/switched capacitors. The tail-end consumer side reactive power compensation is the most effective and essential practice to be observed by all the grateful consumers of electricity to meet the systems' intolerable reactive power demand required by all the loads in industry, domestic, offices etc., which are connected after the distribution transformers below the substation.

S Ponnayira Sundaravel and S Kannan

The next and immediate level of reactive power compensation is at the secondary winding (i.e., 440 V, 3-phase, 4-wire system) of all the individual distribution transformers by the utility providers to meet the reactive power demand needed by all the 440 V feeders from the distribution transformer to the individual service points (Energy meter) and by the left out tail-end consumers who are not knowing/ willing to adapt tail-end VAr compensation. The third level of reactive power compensation must be observed at the sub-station level having a step-down transformer like 110 kV to 11 kV. The switchable/selectable fixed capacitors installed at this 11 kV level (at secondary of sub-station) are required to nullify/ reduce the useless reactive power flowing through the sub-station transformer all the way from the generating station down to the distribution zones. This fixed capacitors at 11 kV level at sub-station supplement the VAr demand caused by inductiveness of all distribution lines after sub-station and of distribution transformers' windings. Finally, some amount of

reactive power management is also essential at the generating plant itself to overcome the VAr demand caused by the transmission line's inductance distributed between the generating station and the sub-station.

Capacitors are the common elements in the reactive power compensation methods using fixed capacitors, manually or Thyristor based Switched Capacitors, sub-station & distribution capacitor banks or static VAr compensators. The consumer end Power Factor (PF) correction practices using fixed/switched capacitors have been employed even now, for cost effectiveness even though the State-of-art STATCOMs have come.

Power system shunt capacitors are important in PF correction or VAr compensation. Shunt capacitors are also used in static VAr compensators. Series Capacitors are important in improving the maximum real power transfer capability of long-distance transmission lines and are to improve the system stability.

Series Capacitors are important in improving the maximum real power transfer capability of long-distance transmission lines and are to improve the system stability.

Basics of PF angle ϕ

The current drawn by motors, lights, computers etc., to do their work, consists of two components viz: real current and reactive current components.

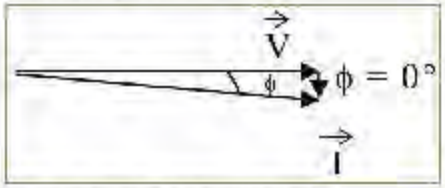

Fig. 1a: Vector Representation of V & I of a resistive Load

The current $\vec{I}$ drawn by an iron box (Heater coil) falls in-phase with its cause - the supply voltage $\vec{V}$. That is, the current neither leads or lags the voltage and the phase angle difference (ϕ) between V and I is, $\phi = 0^{\circ}$

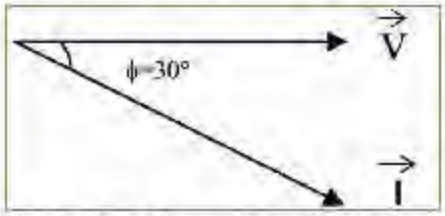

Fig. 1b: Vector Representation of V & I of an inductive Load

The current $\vec{I}$ drawn by an induction motor lags behind the supply voltage $\vec{V}$ (cause for current) by an angle $\phi = 30^{\circ}$ lagging. (for example)

Iron box

The voltage applied to the iron box is kept as reference vector V, drawn in horizontal position along with 0° (See Fig. 1 a). The current I, drawn by the iron box is also drawn horizontally, i.e., in phase with voltage vector. Since both V & I vectors are parallel to each other, the electrical angle, ϕ between them is 0°. This indicates that the wave shape of the current flowing through the heater coil follows the wave shape of the cause of that current - the supply/excitation voltage as shown in Fig. 2 (a).

We know that, π Radian = 180°; 180° = ½ cycle

Time period taken for 1 complete cycle, T = 1/f = 1/50 Hz = 20 milli second

So, Radian = 180° = 20 ms/2 = 10 ms = time period taken for ½ cycle.

Induction Motor

After the rated voltage V is applied across the winding of an induction motor during steady state condition (i.e., after start and the motor running at nominal speed), the current drawn by the motor coil lags behind the supply voltage by an angle different $\phi = 30^{\circ}$ (for an example) (see Fig. 1b and 2b).

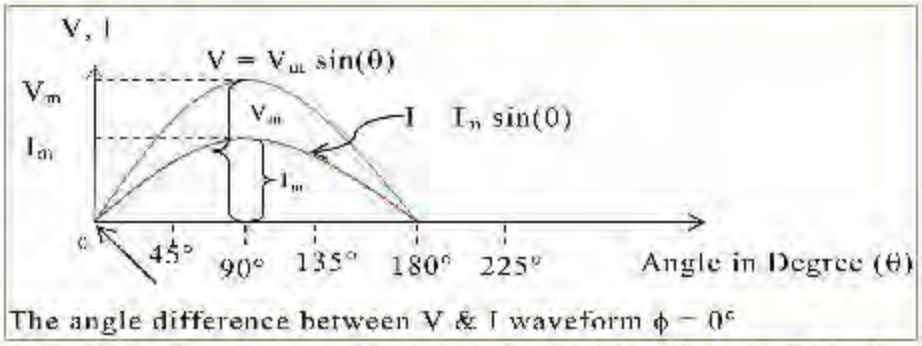

Fig. 2a: The instantaneous representation of the supply voltage (V) and the current (I) drawn by the iron box versus angle θ in X-axis

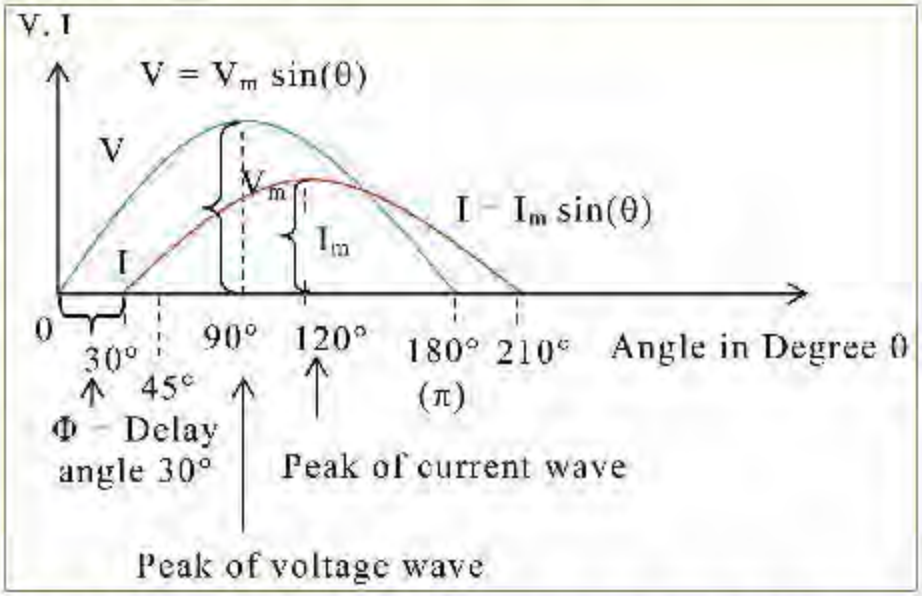

Fig. 2b: The instantaneous representation of the supply/excitation voltage (V) and the response current (I) of induction motor versus angle θ in X-axis.

This indicates that the response current does not closely follow the voltage wave shape instant - by - instant (as in Fig.2: a), instead, the current waveform rises from X-axis (i.e., zero Ampere of instantaneous value) after the voltage waveform has rised from X-axis (i.e., zero volt of instantaneous) with a delay/ difference angle, ϕ of 30°.

Active and Reactive Currents

Now the lagging current of the induction motor (shown in Fig. 1 b) which lags the supply voltage by $\phi = 30^{\circ}$ can be resolved into two components, that is the horizontal component of motor current (I cos ϕ) & the vertical component of motor current (I sin ϕ) as shown in Figure 3.

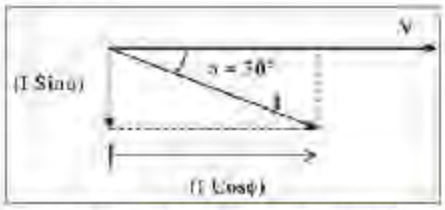

Fig. 3: Resolving the current into magnetizing current - I sinϕ & the working current - I cosϕ

Here, the vertical component of current, I (I sin ϕ) falls perpendicular to the supply voltage vector V & the horizontal component of current (I cos ϕ) coincides in-phase with supply voltage V.

As we know that Power = (Voltage) x (total current) in general, here this vertical (I sin ϕ) cannot be multiplied with V to get power in Watts, since V & (I sin ϕ) are not in-phase with each other, so they cannot be multiplied to get the active/true/real power. So to calculate the active power, drawn by the motor, only the horizontal component of I (i.e., I cos ϕ) which is in phase with the supply voltage V must be multiplied, with V.

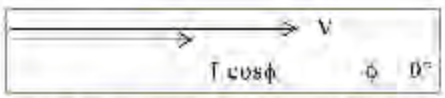

Fig. 4: Active power, P = V (I cos ϕ) in Watts (in-phase vectors can be multiplied)

The horizontal component of load current (I cos ϕ) is called as the real component of motor current. And the vertical component of motor current (I sin ϕ) if multiplied with V produces, Q = V (I sin ϕ) which is called as reactive power. This (I sin ϕ) is called as reactive component of motor current. Now, the total/original current, $\vec{I}$ as the vector sum of (I cos ϕ) + (I sin ϕ), is written as $\vec{I} = \vec{I}\cos\phi + \vec{I}\sin\phi$. This total motor current is represented as in Fig. 5.

This total current I (nothing but the current measured by any ordinary AC Ammeter connected in series with motor) is now called as the apparent current as in Fig. 5.

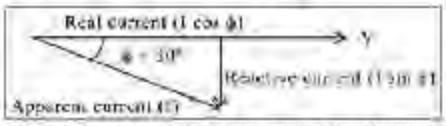

Fig. 5: The relation between Real, Reactive and Apparent current with reference to reference vector V

The angle difference between V & (I cos ϕ) is zero, the angle difference between (I cos ϕ) & (I sin ϕ) is 90° & the angle difference between total current I and voltage V is $\phi = 30^{\circ}$. This concept of two components of current is helpful in understanding the capacitor current also.

Leading and Lagging Current

As a summary,

- Loads such as resistive heater coil require the supply of only the real component of current.
- Some loads such as a induction motor, require both real and reactive currents. The real current (I cos ϕ) provides the power (called as real/active power in Watts) for the useful work to be done by the motor. The reactive current (I sin ϕ) provides the power (called as reactive power in VAr) to produce the magnetising flux necessary for acting as the common medium between electrical & mechanical sides of the motor.
- A power system capacitor is also a load if it is connected across the supply voltage for some purpose. This such kind of pure capacitive load (assume the ideal capacitor) requires only the reactive component of leading current and it does not require any real current, for an ideal capacitor is an energy storing component (like pure Inductive Choke). It does not dissipate any heat because it does not do any useful work like induction motor (RL-load) which does useful mechanical work and like heater (R-load) which converts real current into useful work as production of heat through its heating element. The unit of measurement of real, reactive & apparent current is Ampere (A).

Nature of Capacitor

The Vector diagram of a pure (ideal) capacitor is shown in Fig. 6

The reactive current (I sin ϕ) drawn by capacitor is in negative direction (drawn upside), i.e., it leads the V by 90°. The current (I sin ϕ =I) can be considered as the reactive current "supplied" by the capacitor. It is also observed that real current (I cos ϕ) drawn by the pure capacitor is zero Ampere, and hence the real power (V x I cos ϕ) is also zero watt, satisfying that the useful work done by the pure capacitor is also zero, because the capacitor is not an energy dissipating element but it is an energy storing element like pure inductor. The difference between the capacitor and inductor is that the capacitor stores electrical energy in the form of electrostatic flux, proportional to the voltage applied across the capacitor and the inductor stores electrical energy in the form of electromagnetic flux, proportional to the current flowing through the inductor.

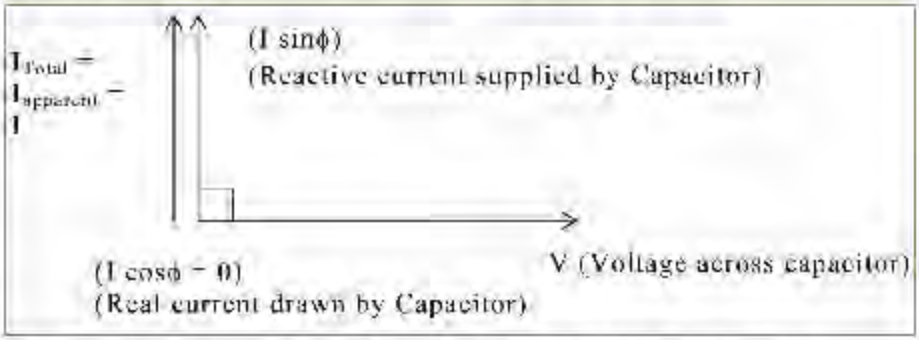

Fig. 6: The relation between the reactive current (I sin ϕ) and total (apparent) current I, drawn by the capacitor

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Nature of Resistor

The vector diagram of pure resistive load is shown in Fig. 7. Here the I cos ϕ = I (i.e., total current/apparent current = real current alone) and the reactive current (I sin ϕ) = 0 Ampere, because a resistor is not a reactive/ energy storing element but it is an energy dissipating element.

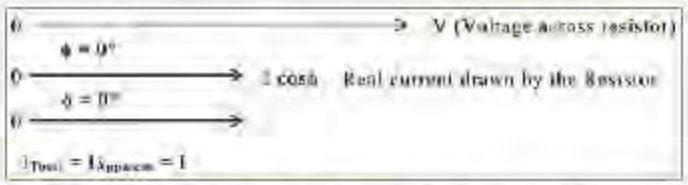

Fig. 7: The relation between the real current (I cos ϕ) and total (apparent) current, I drawn by the pure resistor

Nature of Inductor

The vector diagram of pure Inductive Load is shown in Figure 8.

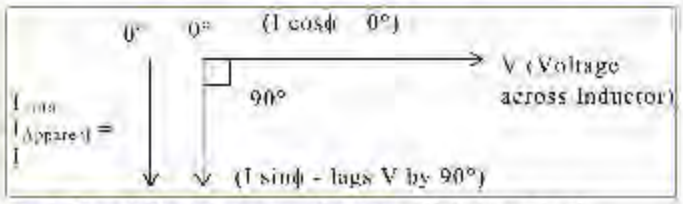

Fig. 8: The relation between reactive current (I sin ϕ) and total (apparent) current I drawn by pure inductor

Here, I sin lags V by 90° (since inductor is assumed to be pure; practically, pure inductor and pure capacitor are not possible to realize, so the phase angle ϕ will be less than 90° depending on the RL and RC proportions and the phase angle will be zero if inductiveness or capacitiveness are nil in that element (as resistor). Also for pure inductor the real current (I cos ϕ) drawn is zero Ampere and hence the real power (P in Watts) dissipated by the pure inductor is also zero watts. Satisfying that a pure inductor is not an energy dissipating element but an energy storing element.

Power Triangle

As a summary the total current I can be written as

$$\text{Apparent Total Current} = \sqrt{(\text{Real current})^2 + (\text{Reactive current})^2}$$

$$I = \sqrt{(I\cos\phi)^2 + (I\sin\phi)^2}$$

$$\text{Also, Apparent Total Power, s} = \sqrt{(\text{Raeal Power, P})^2 + (\text{Reactive Power, Q})^2}$$

The power factor may be expressed as the ratio of the real current (I cos ϕ) to the total current (I) in a circuit of RL or RC load. Alternatively, the PF is the ratio of Watt to total power VA.

Power Factor = I cos ϕ (Real current) / I (total current) = Watt/VA = kW drawn by the load / kVA supplied by the Source (Mains supply)

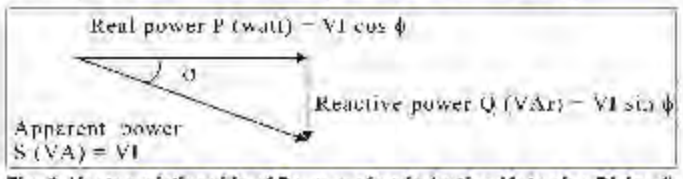

Fig. 9: Vector relationship of Powers of an Induction Motor (an RL load)

The phase angle difference ϕ included between P & S (or between I cos ϕ and I) is called the PF angle. The cosine of this angle (cos ϕ) is the PF.

Bi-directional flow of VAr

The source (say an alternator) sends both real power in Watts and reactive power in VArs, towards the induction motive load.

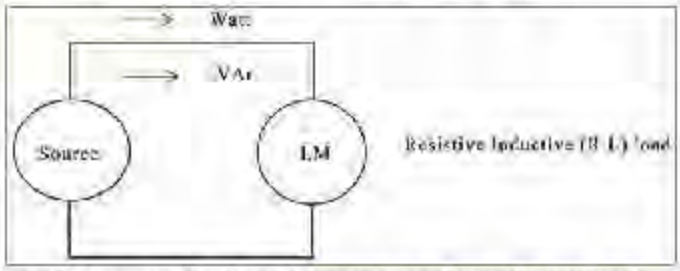

Fig. 10: Concept of lagging PF of an Induction Motor (IM) of RL load

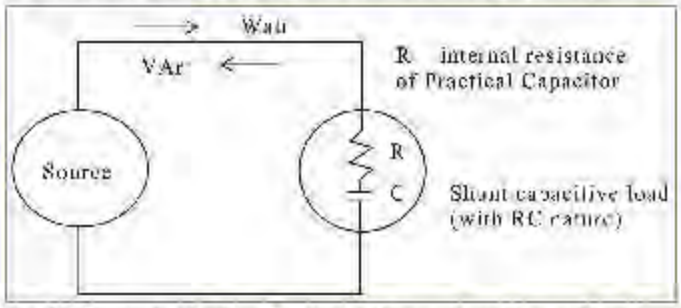

Fig. 11: Concept of leading PF of a shunt capacitor with considerable internal resistance, RC load

The source sends only the real power in Watts towards the 'R' component of load and the Capacitor component of load sends the reactive power in VArs towards the source in opposite direction to Watt.

PF Improvement

The Industrial loads like Induction motors operate at moderately low power factors (0.4 lag to 0.95 lag). Around 60% of the utility loads consists of induction motors and hence the overall/resultant PF of the power system is low. Depending on the percentage level of the load, these motors are inherently low PF devices. The operating PF of these motors varies from 0.4 lag to 0.95 lag depending on whether they are fully loaded or partially loaded at their mechanical shafts, their size and other operating conditions (e.g: intermittent loads like motors in lifts).

Therefore the improvement of PF level is always a concern for Industrial Power systems, utilities and other users. The overall performance of the power system can be easily improved by correcting the PF of the Industrial loads at consumer end by shunt connecting individual power capacitors at every load with suitable VAr values or by Automatic PF correction panels for a group of loads after the location of the energy meter at service locations. The system PF is given by-

PF = Real power, P (in kW) / Apparent power, S (in kVA).

The knowledge/measurement of the PF is the direct indication of the reactive power demand by that load. By keeping the real power demand of a group load as reference/constant, depending on their effective

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inductiveness, the PF angle, ϕ (the angle between P & S) can be calculated as:

cos (ϕ) = P/S = Real Power/Apparent Power (from Power triangle of Fig. 9).

Therefore, $\phi = \cos^{-1}(P/S)$, where P is the real power and S is the Apparent power (the product of the voltmeter reading & the Ammeter reading). Consequently, the value of reactive power demand Q also can be calculated as

$$Q = \sqrt{S^2 - P^2}\ (\text{measured in kVAr})$$

Table 1 shows the relation between the PF and the Q/P ratio which is the percentage of reactive power demand for 100% of real power demand for particular PF angle ϕ. For an example it can be seen that even at 90% PF (i.e, cos ϕ = 0.9), the corresponding reactive power (VAr) requirement is 48% of the real power. That is if the real power demand, P of the group of load is 100 kW, for an example, then the reactive power Q, required by that group of load is 48 kVAr if the overall/resultant PF of that group of load is 0.90 (say 90% power factor).

So the measurement of PF is the direct indication of the VAr demanded by any system, knowing the real power. Further, at low PF, the VAr demanded by the loads is much higher for the given kW. The drawing of higher VAr demands by the loads from the system/ generator through the distribution lines, must be avoided, instead if the required VArs are drawn from the local stand-alone VAr generators/compensators (like Capacitors, Static VAr Compensators, SVC) then the distribution lines and hence the utility generators will feed only real power to the loads without bothering about sourcing of reactive power leading the generators to work at their maximum efficiency (i.e., maximum kW delivering capacity of that generator for the given kVA rating).

Power Factor %	Angle Degree	Q/P ratio
100	0	0.00
95	11.4	0.20
90	26.8	0.48
85	31.8	0.62
80	36.5	0.75
70.7	45.0	1.00
60	53.1	1.33
50	60.0	1.73

Table 1: Power Factor and Q/P ratio
(Courtesy: Rajendra Ramadoss, Power system capacitors, CRC Press, 2015, Table 2.1, pp. 19)

From Table 1, at the PF angle $\phi = 45^{\circ}$, the PF, cos ϕ = cos (45°) = 0.707 (unitless), the Q/P ratio shown is 1, indicating that at the P.F value of cos (ϕ) = 0.707, the numerical value of reactive power in kVAr is equal to the numerical value of real power in kW. That is if the real power demand, P of the load is 100 kW, then the reactive power, Q required by that load is also 100 kVAr (note that the numerical values of two sides are equal for the isosceles power triangle at $\phi = 45^{\circ}$). Therefore, some form of PF correction mechanism is required in all the industrial and commercial consumer locations.

The PF of any operating system can be either lagging (from 0.0 lag to 0.99 lag) or leading (from 0.99 lead to 0.0 lead). The direction of active and reactive power flow can also be used to determine the nature (inductive or capacitive) of the power factor.

If both the real and reactive power flow are in the same direction (i.e., from Source to the load, as shown in Fig. 10), then the load's power factor is known as "lagging power factor". If the reactive power flows in the direction opposite to that of the real power (as shown in Fig. 11), then the load's PF is known as "leading PF". A typical lagging PF load is an induction motor. A typical leading PF load is a capacitor.

Consider a three-phase induction motor of 20 horse power (hp) capacity coupled to drive a mechanical pump. The metering details are given below.

Line current of R-phase (Ammeter-A_1),

I_{L1} = 13.912 A

Line current of Y-phase (Ammeter-A_2),

I_{L2} = 13.912 A

Line current of B-phase (Ammeter-A_3),

I_{L3} = 13.912 A

Line (phase to phase) voltage between 'R' phase & 'Y' phase (Voltmeter - V_1),

$V_{RY} = V_{L1}$ = 415 V

Line (phase to phase) voltage between 'Y' phase & 'B' phase (Voltmeter – V_2),

$V_{YB} = V_{L2}$ = 415 V

Line (phase to phase) voltage between 'B' phase & 'R' phase (Voltmeter – V_3),

$V_{BR} = V_{L3}$ = 415 V

The PF reading taken from the three phase energy meter while that motor runs at particular load is monitored as cos ϕ = 0.8 lag.

The capacity of the given motor is 20 hp, that is it can be loaded up to a power rating of 20 x 735 Watts = 14,700 Watts = 14.7 kW. To find the actual / present loading of the motor the meter readings are to be substituted in the formula for power consumption.

Power consumed by the motor corresponding to the existing pump load at its shaft, from the energy meter,

$$P = \sqrt{3}\, V_L I_L \cos\phi$$

All the three line-currents are equal to each other and the three line-voltages are equal to each other as per the measurements.

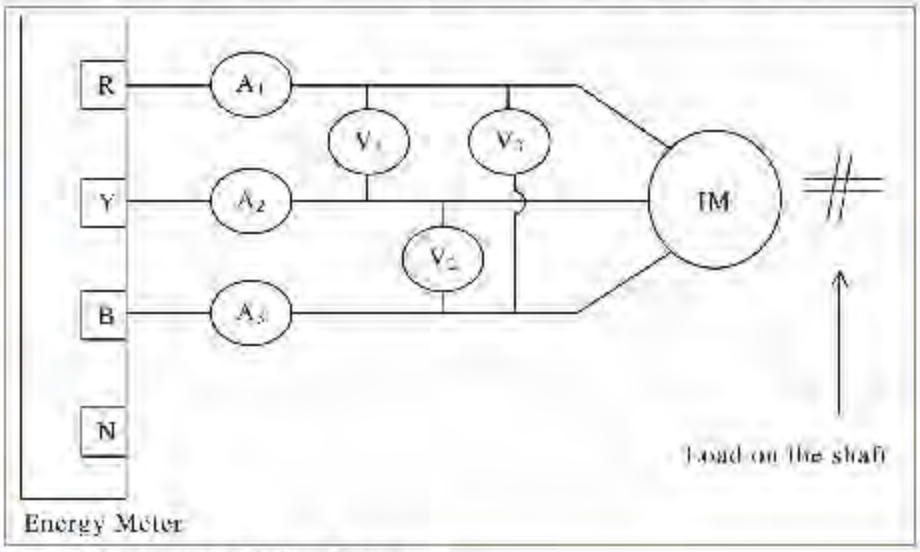

Fig. 12: Measurement of VAr from Energy meter

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So, let $V_{L1} = V_{L2} = V_{L3} = V_L = 415$ Volts and $I_{L1} = I_{L2} = I_{L3} = I_L = 13.912$ Amperes.

$$Now, P = \sqrt{3} \times 415\,V \times 13.912 \times 0.8$$
$$= 7,999.968 \approx 8000\,Watts$$

That is the real power consumed by the motor is 8 kW for the given loading conditions.

And the apparent power consumed is

$$S = \sqrt{3}\,V_L I_L = \sqrt{3} \times 415 \times 13.912\,A$$
$$= 9,999.960 \approx 10,000\,VA \approx 10kVA$$

Now, rewriting, the power factor of a 20 hp motor having 10 kVA present load is 0.8 lag. If it is necessary to improve the PF from 0.8 lag to 1.0 unity power factor (UPF), the rating of the required shunt capacitor bank can be calculated as below.

Solution: Part 1

The present total apparent power loading of the motor, S = 10 kVA

The real power drawn by the motor, P = 8 kW

The present (initial) PF, $\cos(\phi_1) = 0.8$

The initial PF angle $\phi_1 = \cos^{-1}(0.8) = 36.869$

The reactive power consumed by the motor from the energy meter, Q = (S x sin 36.869°)

= 10,000 VA x 0.6 = 6000 VAr = 6 kVAr

Part 2

Improved (target) power factor condition (to read PF = $\cos\phi = 1$ from energy meter).

The PF will be UPF only if the value of kVA is reduced to be equal with value of kW. That is at improved PF condition, the apparent power would be S_2 = 8 kVA (previously 10 kVA) The real power would be $P_2 = P = 8$ kW.

P_2 will be same as previous P because work done is not changed before and after PF improvement.

The target $PF_2 = \cos\phi_2 = 1$

The target PF angle $\phi_2 = \cos^{-1}(1) = 0^{\circ}$.

The reactive power to be supplied by the Energy meter (during UPF) (to the load) $Q_2 = S_2 \times \sin(\phi_2)$

= (8 kVA x 0) = 0 kVAr (since $\sin(0^{\circ}) = 0$)

Now the required shunt capacitor = (kVAr (Q1) supplied by energy meter without shunt capacitor – initially) – (kVAr (Q2) supplied by the energy meter during improved UPF condition with the shunt capacitor)

= (Q1 – Q2)

= (6 kVAr – 0 kVAr) = 6 kVAr = C1, the value of the Delta connected three phase Capacitor to improve PF from 0.8 lag to UPF.

Result 1

A three phase Delta- connected – 415 V rated, 6 kVAr, shunt capacitor can be had from the market and that can be connected across the 3-phase induction motor (tail end compensation) with sufficient fuse protection to improve PF from 0.8 to UPF.

If the UPF is not necessary/compulsory to be achieved and the target PF is only 0.95 lag (enough for avoiding penalty), the new calculation can be done for part 2 (retaining the part 1) to get the required shunt capacitor to reach PF = 0.95 lag from the original value of PF = 0.8 lag

Re-doing Part 2

The new target $(PF)_3 = \cos(\phi_3) = 0.95$ lag

Target PF angle $\phi_3 = \cos^{-1}(0.95) = 18.195^{\circ}$

The real power to be drawn by motor from Energy meter, P3 = P1 = 8 kW only (the real power does not change, before and after the PF improvement because we are not willing to change the work to be done by the motor, for the reason that the water pump coupled with the shaft of the motor needs to exhibit constant characteristics to lift the water).

The apparent power would be $S_3 = P_3/(PF)_3$ = 8 kW/0.95 = 8,421.05 VA = 8.421 kVA

The reactive power to be supplied by the energy meter (not by the capacitor) to the load, $Q_3 = [S_3 \times \sin(\phi_3)]$

= [8.421 kVA x sin (18.195°)]

= [8.421 kVA x 0.3122] = 2.629 kVAr

Now, the required shunt Capacitor to be connected across motor to improve the PF reading at the energy meter point from 0.8 lag to 0.95 lag = [(kVAr (Q_1) supplied by energy meter without the shunt capacitor – initially) – (kVAr (Q_3) to be supplied by energy meter during improved PF [$(PF)_3$ = 0.95 lag] condition with economic value of shunt capacitor)]

= ($Q_1 - Q_3$)

= 6 kVAr – 2.629 kVAr = 3.371 kVAr = C_2, the economic value of capacitor to improve PF from 0.8 lag to 0.95 lag

Result 2

A 3 phase Delta - connected 415 V rated, 3.371 kVAr, shunt Capacitor can be had from the market and can be connected across the 3-phase Induction motor (tail-end compensation) to improve PF of source measured by energy meter from 0.8 lag to 0.95 lag.

Comparison of two results

The result 1 and 2 are super-imposed in Figure 13, the Q_3 of 2.629 kVAr in the upper triangle shows the uncompensated VAr supplied through the energy meter to the load and the C_2 of 3.371 kVAr in the lower portion shows the local compensation VAr supplied from the shunt capacitor to the load. Finally the load receives the total of 6 kVAr from both energy meter and capacitor.

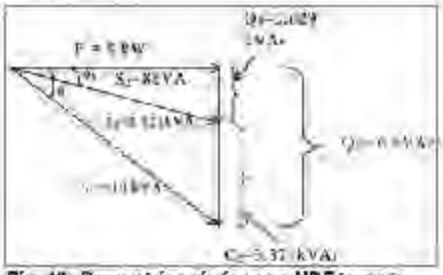

Fig. 13: Power triangle for non UPF targets

Note: Both angle $\phi_3 = 0^{\circ}$ and Q_3 = 0 kVAr are hidden/merged between P & S_2 –horizontal lines

- To improve the PF to UPF (from 0.8 at 8 kW load) the capacitor required was 6 kVAr
- To improve PF to 0.95 lag (from 0.8 at 8 kW load) the Capacitor required was only 3.371 kVAr. Thus the cost of 2.629 kVAr can be saved if the target PF is only 0.95 lag, as the case may be only to avoid the low PF penalty imposed by the electricity providers.

External Electronic PF meter

In the above illustration if the three phase energy meter is not available or if it does not show the present/instantaneous PF [please do not consider the monthly average /resultant PF (from the energy meter) for here, because it is used at the end of the month in the electricity bill to impose the low PF penalty or to rebate by incentive for having maintained the good PF], then connect a 3-phase electronic PF meter to know present PF of the supply side before and after the compensation.

The strange result

Even though the PF is improved to UPF viewed at the supply energy meter side & the VAr delivered through energy meter is brought zero after proper compensation by appropriate shunt Capacitor, the PF of load is still 0.8 lag only (can be measure by another energy/PF meter connected between the Capacitor & the terminals of the motor) & the

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VAr being drawn by the motor is still 6 kVAr only, because the PF of Induction motor will not change (as long as the real power, P drawn by the motor is 8 kW) and the reactive power, Q needed by the Induction Motor is also very essential for its operation so it cannot draw zero VAr from the system. This essential, 6 kVAr [to setup the magnetic flux medium between electrical & mechanical forms of energy within the Induction motor (for 8 kW at 0.8 PF lag)] of reactive power is locally supplied by the compensating shunt Capacitor (C_1) & is not drawn from the source through supply energy meter, then the energy meter can show UPF & zero VAr supply into the load system.

The PF correction Capacitors can be installed at the high voltage bus, distribution line or at the load point itself. The PF correction Capacitors can be installed for a group of loads, at the branch location or for a local load, across the terminals of the load.

The benefits of improved PF for the utility

- The release in system's kW generation capacity (kVA capacity is fixed).
- The savings in transformer's kW capacity.
- The reduction in line's wattage loss (I^2R Wattage loss is reduced), causing lower peak demand beneficial to the consumer and utility.
- The improved voltage profile.
- The reduction of un-balance in line voltage & line current since the reactive power transportation is reduced/nullified between source and load.
- The reduction of nuisance failures of switch-gears in the line through which the apparent current [$I = I\cos\phi + I\sin\phi$] is reduced after improved PF, [since $I\sin\phi = 0$].
- The reduced energy rate (cost) associated with good-improved PF.
- The reduced energy consumption and good efficiency of the load due to the good voltage profile etc.
- The increased short-circuit rating for the system (since kW delivering capacity of system is increased).
- The additional kW-load of new consumer (limited to kVA) can be connected on the same transformer without the need for another transformer with increased kVA rating.

Fixed and Variable Capacitors

The distribution Capacitors can be fixed or switched depending on the load condition. The fixed Capacitors are used for minimum (constant-base) load condition and the switched Capacitors are used for compensating the varying load levels above the minimum load and up to the peak load.

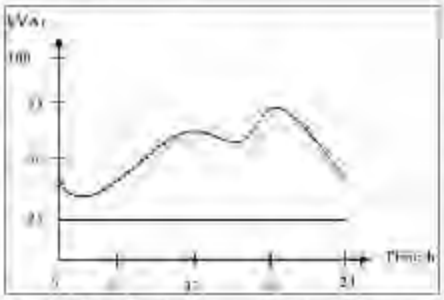

Fig. 13: Distribution curve showing the base VAr requirement (for fixed Capacitors) and peak VAr needs (for Switched Capacitors)
(Courtesy: Natarajan, Ramasamy: Power system capacitors. CRC Press, 2006., Fig.8.2, pp.128)

Figure 13 shows the reactive power requirements of an industry whose connected load is 120 kW, for a period of 24 hours. The base load (for kW always connected to energy meter during 24 hours) reactive demand is shown as 25 kVAr, so a fixed 25 kVAr rated Capacitor is permanently connected after the energy meter. The varying and the peak load reactive power demand conditions can be commonly managed by switching (by electromagnet Contactors or recent Solid State Relays) the different Capacitors in-steps up to the peak kVAr demand either by manually at intermittent timings or by using the automatic power factor control (APFC) panels, by sensing the kVAr demand by reactive power transducers available in market.

Sizing and Location of Capacitors

To obtain the best results, the shunt Capacitors should be located where they can produce maximum "loss reduction", provide better Voltage profile (due to V = IR drop) and Capacitors are closer to the load. When this is not practical (due to the cost and space constraints) the following alternate approaches can be followed.

For uniformly distributed loads, the Capacitor can be placed at two thirds of the distance from the sub-station.

For uniformly decreasing distributed loads, the Capacitor can be placed at half the distance from the sub-station.

For maximum voltage rise (towards rated V), the Capacitor should be placed near the individual load.

In a distribution system, usually, the Capacitor banks are placed at the location of minimum (lowest) PF by measuring the voltage, current, kW, kVAr and kVA on the feeder to determine the maximum and minimum load conditions. Many utilities prefer a PF of 0.95 and above. The peak points and the valley points in the kVAr demand curve make it difficult to follow a single fixed Capacitor bank to correct the PF to the desired level at every slice of time.

If the UPF is somehow achieved during the peak load by connecting fixed Capacitor banks (by trial and error method), then there would be a leading PF and leading kVAr condition at the Capacitor point on the same line during off - peak kVAr condition, resulting in an over – compensation condition.

The over-correction of PF (leading PF condition) can definitely produce the excess loss in the system, as bad as the lagging (uncompensated) PF condition in the system. We know that the under voltage condition will occur during lagging PF condition, similarly over voltage condition may occur during leading PF (excess Capacitor than required) condition causing damage to the equipment which are designed to receive the nominal supply voltage. And it is the mandatory to the utility provides to maintain the standard voltage profile (without under and over voltage) in the distribution line uniformly up to the consumer points. And it is also the equal responsibility of every electricity consumer (industrial as good as domestic) to maintain good PF at any cost as far as possible to serve back our provider.

Therefore, a leading PF situation is not an advantageous condition & it should be corrected towards UPF immediately by switching off the excess capacitor banks. In order to manage such conditions, fixed Capacitors are used to supply the constant kVAr demands and switched (variable in steps of kVAr) Capacitors are used for supplying the kVAr demand for the peak load & other varying (above the minimum constant kVAr level) conditions. Specifically, this will prevent over-correction of the PF.

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Effect of Shunt Capacitors on Radial Feeders

Fixed Capacitors can be used to improve the PF on radial feeders

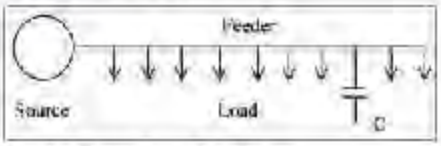

Fig. 14: Example radial system
(Courtesy: Natarajan, Ramasamy. Power system capacitors. CRC Press, 2005., Fig. 8.3, pp. 133)

The Capacitors can be located at the source or at the load end. In a radial system, the Capacitor can be located very close to the load as shown in Figure 14. The voltage profile during light (less) load on the radial system without and with Shunt Capacitors is shown in Figure 15.

The voltage dropping effects are dominant in the radial system when shunt Capacitors is not present. The voltage rise effects are seen when the Capacitor is present and during light (less) load conditions.

The voltage profile along the heavily loaded condition is shown in Figure 16. The voltage profile is within the allowed limits with the shunt Capacitors and during heavy load condition. Therefore, there is always a need to find the optimum location for the installation of fixed shunt Capacitors.

Switched Capacitors

The switched Capacitors provide additional flexibility to control the system voltage, PF and losses. Switched Capacitors are usually applied with some type of automatic PF controllers. A sensor detects a particular condition (like kVAr or I sin ϕ values) & then initiates a closing signal or tripping signal to the circuit breakers (CB) connected in series with the Capacitor bank.

A typical automatic Capacitor Controller mechanism includes the following control parameter:

- Voltage: Control of the voltage regulation is a major consideration.
- Current Control: If the current magnitude is directly proportional to the kVAr demand.
- VAr Control: The VAr demand increases when certain loads are put on and decreases when the specific load is put OFF.
- Time Switch: To switch on the Capacitors during peak hours and to switch them off during off-peak hours.
- Temperature dependent Control: In certain loads such as air-conditioners, the VAr demand goes up (multiple compressors are made on) when the room/hall temperature increases.

The fixed Capacitor banks are usually left energized on a continuous basis. In certain loading conditions, the selected Capacitor banks can be switched on and off based on the seasonal (varying VAr demands from the load) conditions.

Remote switching of Capacitor banks is used in some areas. The Capacitor switching is generally performed using radio command signals, a power line carrier communication (PLCC) networks or through telephone signals.

A typical Controller for switching the Capacitors by electromagnetic contactors and reactive power Transducers (RPT11) in an automatic power factor controller (APFC) panel designed, assembled and installed at authors Institution is shown in the Figure 17.

This panel is the most suitable for unbalanced three-phase L.T and H.T service connections. The individual panels having capacity of 33 kVAr (11 kVAr maximum per phase) are connected across the three phase, four wire system after energy meter to compensate the source having real power of 50 kW at many locations in the system of 1500 kVA campus.

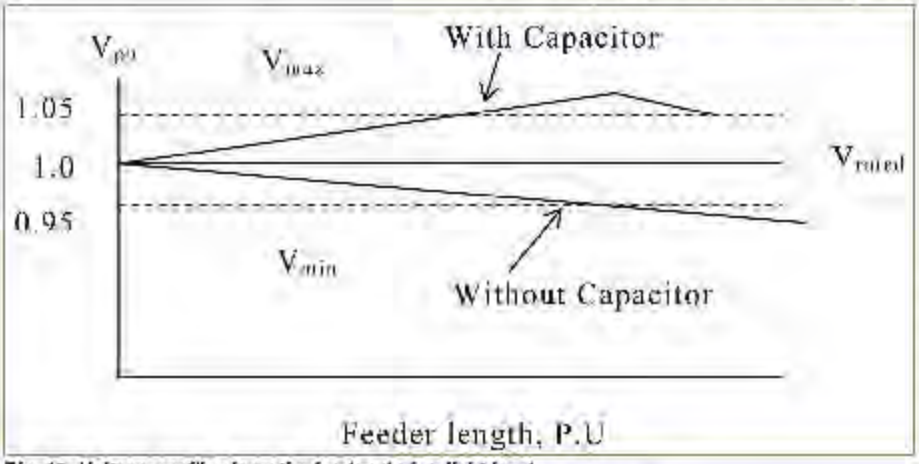

Fig. 15: Voltage profile along the feeder during light load
(Courtesy: Natarajan, Ramasamy. Power system capacitors. CRC Press, 2005., Fig. 8.4, pp. 133)

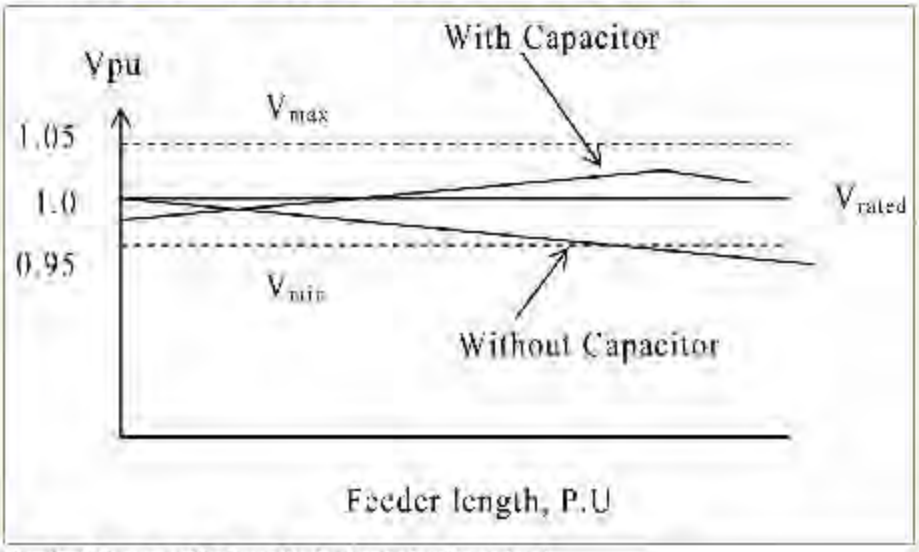

Fig. 16: Voltage profile along the feeder during heavy load,
(Courtesy: Natarajan, Ramasamy. Power system capacitors. CRC Press, 2005., Fig. 8.5, pp. 134)

Fig. 17: Photograph of APFC Panel – Kalasalingam University

The first author's control printed circuit board does not have any micro controller since the control system required to control the PF is simple in nature along with the use of RPT 11.

Conclusion

The study of Capacitors may seem complicated because failures of Capacitors are related to equipment voltage rating and power system transients and are very difficult to correlate even if time-domain measurements are available. The readers are encouraged to explore more about the reactive power demands, the power factor phenomenon and to some extent about the Harmonics and the Total Harmonic Distortion (THD) within their premises to improve the power quality of our electrical distribution system, beneficial to both the nation and the consumers.

Profile

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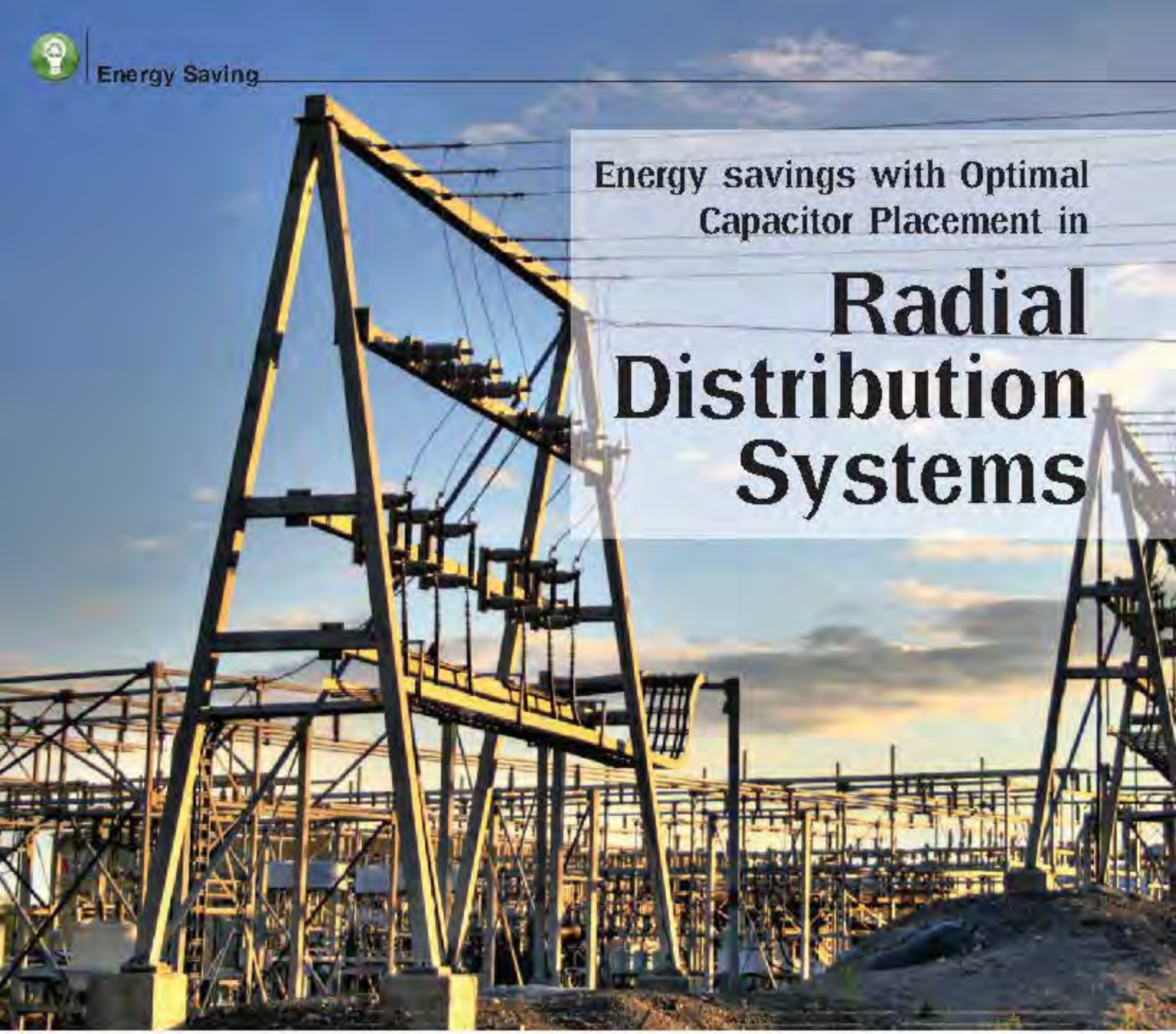

Energy savings with Optimal Capacitor Placement in Radial Distribution Systems

This article presents an approach based on sensitivity based methods viz. Power Loss Index, index vector, and power loss sensitivity to determine optimal location for the capacitors in radial distribution systems. The optimal size of the capacitors have been obtained to improve voltage profile and to reduce the losses in the network. The cost saving potential has been determined with sensitivity methods and comparison has been provided. The approaches are tested on IEEE-10 and 22 bus systems radial distribution systems (RDS). Load growth and realistic load model as ZIP load model has also considered to obtain the impact on sizes of capacitor banks and the savings.

V V S N Murty Vallem and Ashwani Kumar

The distribution system is a backbone for carrying power to load centers through a distribution lines at primary and secondary level of distribution voltages. This network is most commonly a radial network in nature and the voltage profile variation may be large due to the load connection points in the entire path of network from upstream to downstream and that may give lower voltage available at the end of the path. This requires an optimal distribution system planning for effective

usage of the distribution system. To maintain the proper voltage profile at every level in the entire path, the reactive support is optimally required to put less burden on the substation transformers and deferred their higher KVA ratings.

With the growing effort to reduce system losses, increase in the efficiency of the system, and proper voltage profile, many papers refer to optimal distribution system planning. The planning studies require load flow and the placement of reactive devices judiciously. The methods which are adopted for the analysis of radial distribution systems are based on the concept of the backward/ forward method. In the radial distribution system based on the load tapped from start to end of the feeders results in considerable voltage drop. Thus, the capacitors are installed in distribution systems for voltage profile improvement using reactive power compensation. The installation of shunt capacitors in primary distribution systems can also effectively reduce peak power and energy losses by improving the voltage profile and compensating reactive power consumption patterns of loads. The extent of these benefits is based on location and size of the installed capacitors. Bala et al. proposed a sensitivity-based method for the optimal capacitor placement in the distribution system network. Sensitivity based approach for optimal capacitor placement in radial distribution system is presented in. In the proposed methods for optimal capacitor location, reactive power loss has not been included. With capacitor in the network, reactive power loss component cannot be neglected and shall be included for optimal capacitor placement.

In this article, a power loss index, index vector, and index based on real and reactive power losses has been presented and the results have been compared. The optimal capacitor placement has been obtained based on these indices. The results have been obtained for three test systems of 10 bus, 22 bus test systems. The values of the reactive compensation have been calculated with the three sensitivity methods and are compared for loss reduction, total kVAR support, cost savings, and operating cost. The analysis has been carried developing codes in MATLAB 7.04.

Radial Distribution Load Flow

There are many solution techniques for load flow calculations. However, an acceptable load flow method should meet the following requirements

- It should be high speed and low storage requirements, especially for real time large system applications, as well as multi case and iterative applications;
- It should be highly reliable, especially for ill conditioned problems, outage studies;
- It should attain accepted versatility and simplicity.

Fig. 1 shows the equivalent circuit model of distribution system.

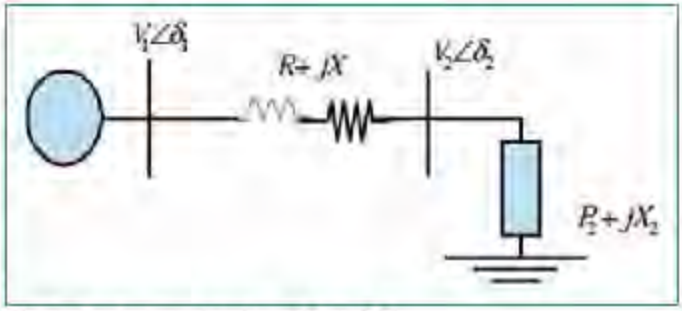

Fig. 1: Equivalent circuit model of RDS

In fast conventional load flow methods, which were developed to solve transmission networks, encounter convergence problem when applied to distribution networks, the reason being that the R/X ratio is usually high for a radial distribution systems (RDS). The load flow algorithm used in this article consists of forward and backward sweep methods. The forward sweep is mainly a voltage drop calculation from sending end to receiving end of a feeder or a lateral and the backward sweep is primarily a current summation based on voltage updates from far end of the feeder to sending end. Then by using KVL, KCL the voltage drop can be obtained.

n=number of buses.

nb=number of branches.

IL=Load currents.

$$IL[i] = \left[\frac{S(i)}{V(i)}\right] for\ i = 1, 2, 3 \ldots n.$$

IL(se(k))=IL(se(k))+IL(re(k)) for k=1,2,3,...nb

$$I_{br} = IL(re)$$

$\Delta V = I \times Z$ for all branches.

$$V_2 = V_1 - \Delta V$$

$$Ploss(k) = I^2_{k\,ab} x R(k) \text{ for } k = 1,2,3,...nb$$

$$Qloss(k) = I^2_{k\,ab} x X(k) \text{ for } k = 1,2,3,...nb$$

$$\text{TPL} = \sum_{k=1}^{nb} \text{Ploss(k)}$$

$$\text{TQL} = \sum_{k=1}^{nb} \text{Qloss(k)}$$

Load Growth

It is desirable that a system engineer know the future estimate of the system solutions for planning and expansion or the efficient operation of distribution systems. In the proposed load flow method, load growth is modeled as

$$Load_i = \text{Load} \times (1 + \text{rate})^m$$

rate = annual growth rate

m = plan period up to which feeder can take the load

Polynomial load model

A static load model that represents the power-voltage relationship as a polynomial equation of voltage magnitude. It is usually referred to as the ZIP model, as it is made up of three different load models: constant impedance (Z), constant current (I) and constant power (P). The real and reactive power characteristics of ZIP load model are given as:

$$P = P_i o\,[a_i p\,(V/V_i o)^{\wedge}2 + b_i p\,(V/V_i o) + c_i p]$$

$$Q = Q_i o\,[a_i q\,(V/V_i o)^{\wedge}2 + b_i q\,(V/V_i o) + c_i q]$$

$$a_p + b_p + c_p = 1$$

$$a_q + b_q + c_q = 1$$

P_0 and Q_0 are the real and reactive power consumed at a reference voltage V_0.

Cost calculations

The objectives of the capacitor placement are to reduce the power loss and keep voltages within the prescribed limits with minimum cost. The total power loss TPL is given as:

$$\text{TPL} = \sum_{k=1}^{nb} \text{Ploss(k)}$$

The cost function F can be selected as:

$$Running\ Cost = C_p\, x\, P_{loss}$$

$$Fixed\ Cost = Q_c x \frac{13.24\$}{100 MVARh}$$

F = Running cost + Fixed cost

Life span = 15 years

where, Kp is the cost per power loss ($/kW/year). For the test feeder, Kp is selected to be U.S.$168/kW.

Algorithm for Capacitor Placement

Power Loss Index

- Step 1: Read the given data for balanced RDS
- Step 2: Perform the load flows and calculate the base case total active power loss.
- Step 3: By compensating the reactive power injections (QC) at each node (except source node) in all the phases, run the load flows and calculate the active power losses in each case.
- Step 4: Calculate the power loss reduction and power loss indices using the following equation

The power loss indices (PLIs) are calculated as

$$\text{PLI}[1] = \frac{(X(l) - Y)}{(Z - Y)} \text{ for } l = 2,3,4,...,n$$

X=Reduction in loss.

Y=minimum loss reduction

Z=maximum loss reduction.

- Step 5: Select the candidate node whose PLI > tolerance.
- Step 6: Stop.

After identifying the candidate nodes inject capacitive reactive power which is equals to the reactive power loss obtained in step 3 until loss goes on increasing. Power loss indices plots for ZIP load model with load growth at a rate of 0.07 shown in Fig. 2. Power loss index at bus 3 is highest compared to the other buses. For IEEE 22 bus test system, the PLI is higher at buses 3 and 4 compared to other buses. The buses where PLI is higher are the potential candidates for the capacitor placement.

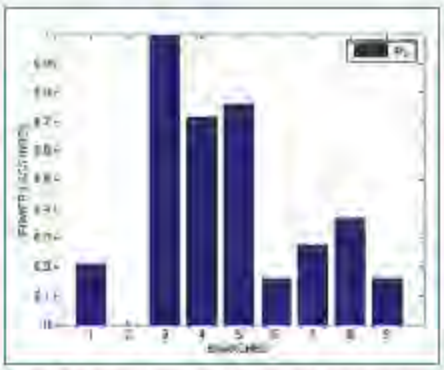

Fig. 2: Power loss index for 10 bus system

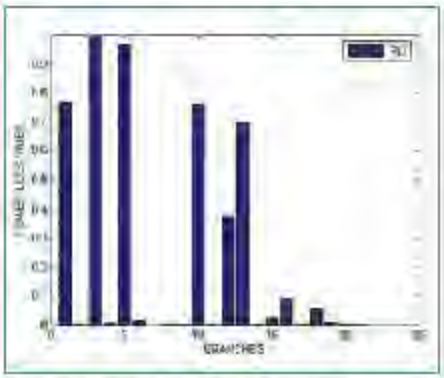

Fig. 3: PLI plot for 22 bus system

Index Vector Based Method

Index Vector is formulated running the base case load flow on a given radial distribution network, and calculating reactive component of current in the branches and reactive power load concentration at each node. Based on the elements of the Index Vector, this method identifies a sequence of nodes to be compensated. The sequence of priority of the nodes is mainly determined by the Index-Vector.

The Index-Vector for bus n is given by

$$\text{Index[n]} = \frac{1}{Vn^2} + \frac{Iq[k]}{Ip[k]} + \frac{Qeff[n]}{total\,Q}$$

Index[n] ="Index" for nth bus

V[n] = Voltage at nth bus

Iq[k] = Imaginary component of current in branch

Ip[k] = Real component of current in branch

Qeff[n] = Effective load at nth bus

TotalQ = Total reactive load of the given Distribution System

After formulating the Index Vector multiply the index value by the load reactive power at that bus to estimate the size of the capacitor

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to be placed. Thus, the potential location and size of the capacitor to be placed are obtained directly. Arrange the Index vector in descending order so that highest priority bus will come first and the lowest priority bus will come at end. Now place the capacitor at the first potential location and run the load flow and estimate the losses. Then assume capacitors at first two potential locations and perform load flow again evaluate the corresponding losses. It may be observed that the loss will reduce. Repeat this with estimated capacitors at first "n" busses till losses reduce to minimum and for the first (n+1) potential locations the loss start increasing Then the estimated capacitors at first n potential locations will give optimal location and size for the given radial distribution system. The index vectors obtained for IEEE 10 bus and 22 bus test system are shown in Fig. 4 and Fig. 5. Based on these figures, the buses can be easily identified for capacitor placement.

Power Loss Sensitivity Analysis

Loss sensitivity factors are calculated for determining the candidate nodes for placement of capacitors. Estimation of these sensitive nodes helps in reducing the search space.

$$\frac{\partial Ploss}{\partial Q_2} = \frac{2 * Q_2 * R[j]}{V_2^2}$$

$$\frac{\partial Qloss}{\partial Q_2} = \frac{2 * Q_2 * X[j]}{V_2^2}$$

Combined loss sensitivity with respect to reactive power =

$$\frac{\partial Sloss}{\partial Q_2} = \frac{\partial ploss}{\partial Q_2} + j\frac{\partial Qloss}{\partial Q_2}$$

Combined loss sensitivity with respect to real power =

$$\frac{\partial Sloss}{\partial P_2} = \frac{\partial ploss}{\partial P_2} + j\frac{\partial Qloss}{\partial P_2}$$

Loss sensitivity matrix=

$$\begin{vmatrix} \frac{\partial ploss}{\partial P_2} & \frac{\partial Qloss}{\partial Q_2} \\ \frac{\partial ploss}{\partial P_2} & \frac{\partial Qloss}{\partial Q_2} \end{vmatrix}$$

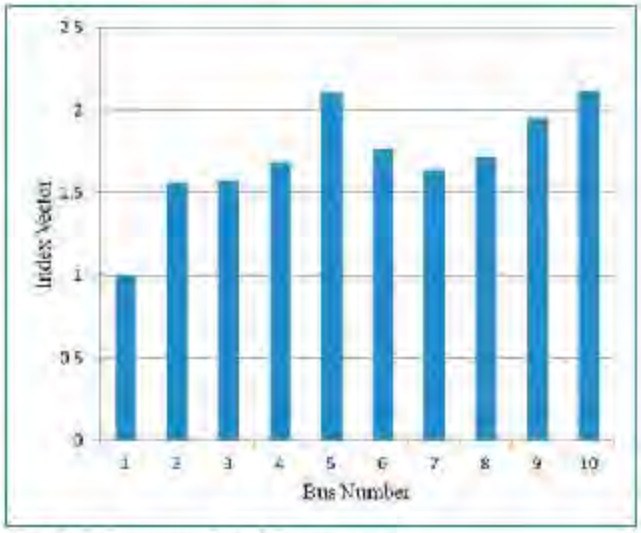

Fig. 4: Index vector for 10 bus test system

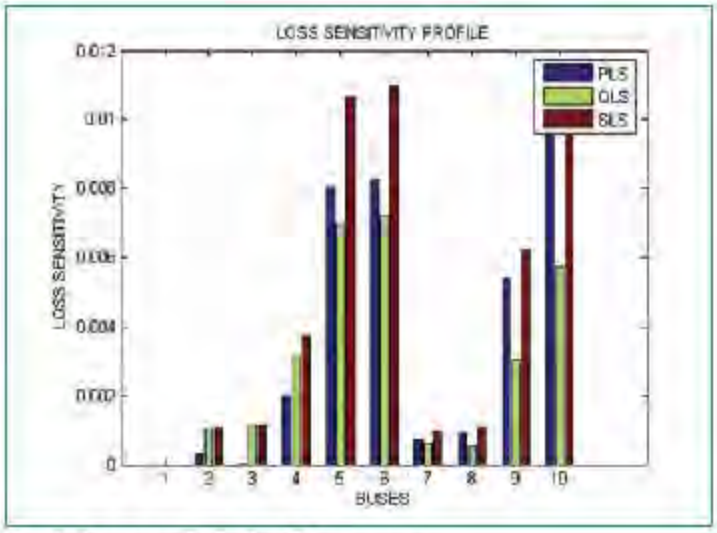

Fig. 6: Loss sensitivity for 10 bus system

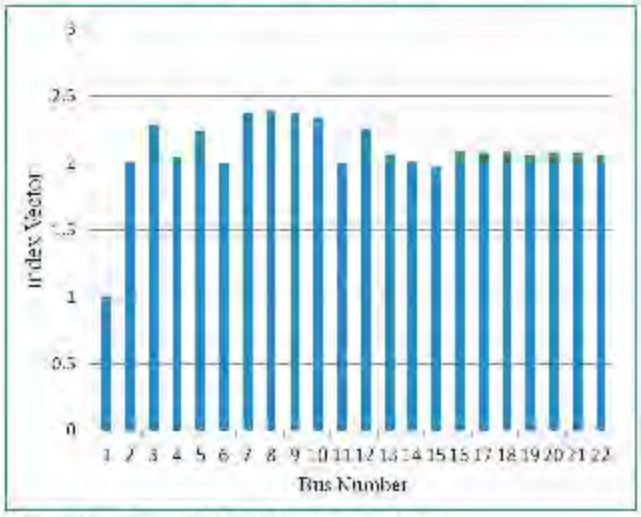

Fig. 5: Index vector for 22 bus test system

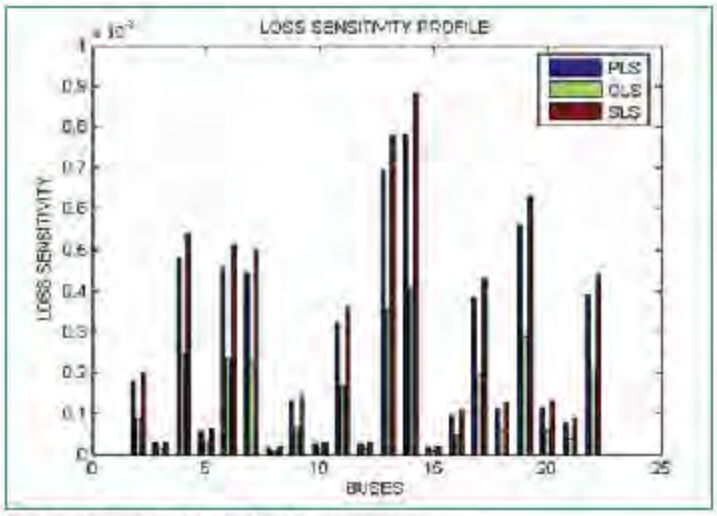

Fig. 7: Loss sensitivity for 22 bus system

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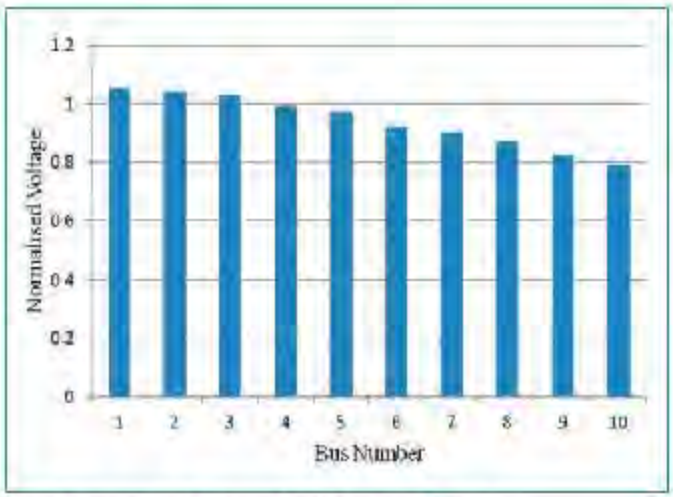


Fig. 8: Normalized voltage for 10 bus test system

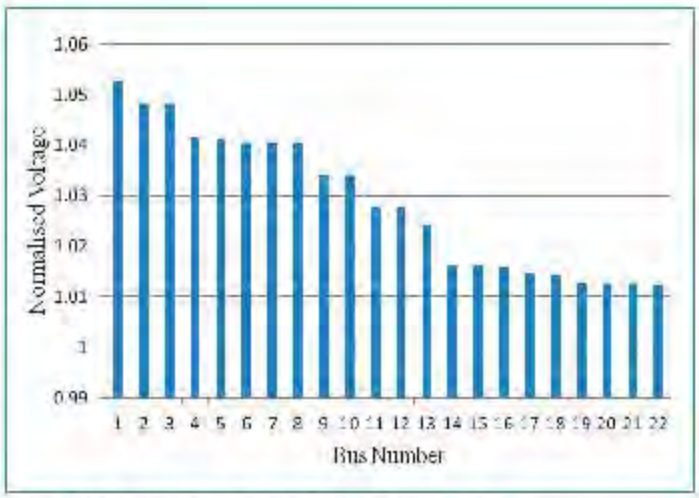


Fig. 9: Normalized voltage for 22 bus test system

Loss sensitivity index calculated for IEEE 10 bus and 22 bus test system are shown in Fig. 6 and 7. Loss sensitivity factors are calculated from load flow analysis and values are arranged in descending order for all the lines. Normalized voltage magnitudes are calculated for all the buses by the following formula:

$$Norm[i] = \frac{V[i]}{0}.95$$

Buses, whose normalized values are less than 1.01 are considered as candidate nodes that require compensation. The normalized voltages obtained for IEEE 10 bus and IEEE 22 bus test systems are shown in Fig. 8 and 9.

Results and Discussions

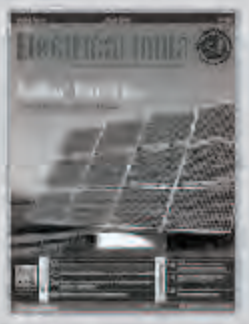
The results obtained for IEEE 10 bus test system are given in Table 1. It gives the minimum voltage at base case and comparison of minimum voltage obtained with other methods. The real and reactive power loss is also given in Table. Reduction in the losses is higher with capacitors in case of power loss index based method. The total cost is also observed lower with PLI based capacitor placement. Total KVAr supplied from capacitors is observed lower with PLI based method as given in Table 2. The voltage profile and real and reactive power loss profile is also shown in Fig. 10 to 12. It is observed that results with PLI based method are overall better.

	Base Case	Power Loss Index	Power Loss Sensitivity	Index Vector
Min Voltage	0.7500	0.8337	0.7970	0.8219
TPL(KW)	1801.0	1446	1556.1	1466.9
TQL(KVAR)	2333.8	1908	2000.6	1884.7
Run Cost	302563.9423	242936.1110	261419.7224	246438.3710
Fixed Cost	0	6329.5582	1801.5908	4255.9016
Total Cost	302563.9423	249265.6693	261419.7224	250694.2726
Reduction in TPL(KW)	0	355	244.9	334.1
Reduction in TQL(KVAR)	0	425.8	333.2	449.1
Savings	0	53298.273	41144.2199	51869.6697

Table 1: Results for IEEE 10 bus test system

Bus	Base Case Q Load	Power Loss Index Based Compensation	Power Loss Sensitivity	Index Vector
1	0	0	0	0
2	460	460.0	0	645.2
3	340	1855.3	0	476.9
4	446	1961.2	443.4000	625.5
5	1840	3355.2	178.4300	2580.7
6	600	600.0	552.0000	841.5
7	110	110.0	994.0000	154.3
8	60	60.0	52.4000	84.2
9	130	130.0	107.2000	182.3
10	200	200.0	157.9000	280.5
TOTAL Q(KVAR)	4186	8731.8	2485.3	5871.1

Table 2: Capacitors placement for IEEE 10 bus test system



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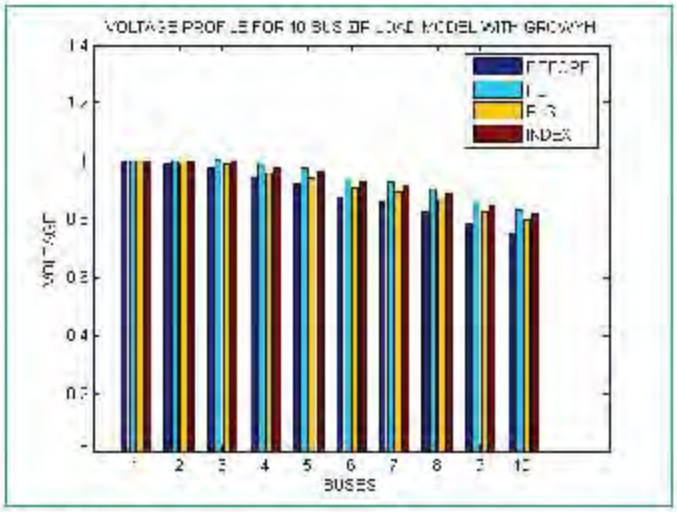

Fig. 10: Voltage profile

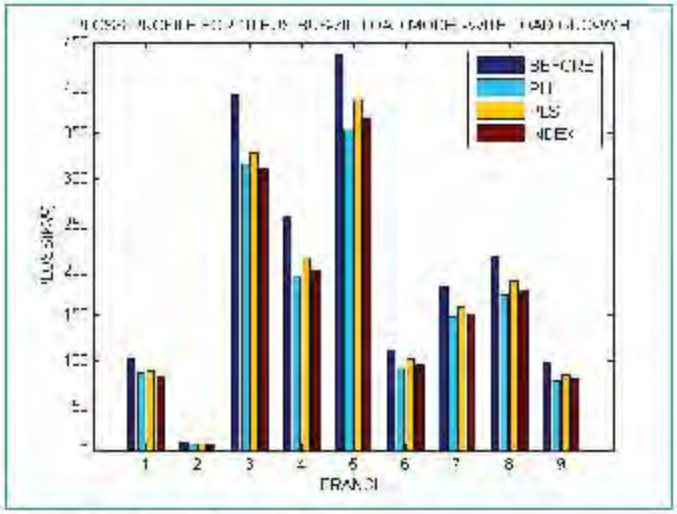

Fig. 11: Real power loss profile

	Base Case	Power Loss Index	Power Loss Sensitivity	Index Vector
Min Voltage	0.9617	0.9753	0.9751	0.9737
TPL(KW)	35.4490	18.2139	18.1929	18.7086
TQL(KVAR)	18.1407	9.3230	9.3123	9.5774
Run Cost	5955.4377	3059.9352	3056.4092	3143.0490
Fixed Cost	0	5.102986	487.7689	524.3964
Total Cost	5955.4377	3570.2339	3544.1781	3667.4454
Reduction In TPL(KW)	0	17.2351	17.2561	16.7404
Reduction In TQL(KVAR)	0	8.8177	8.8284	8.5633
Savings	0	2385.2038	2411.2596	2287.9923

Table 3: Results for IEEE 10 bus test system

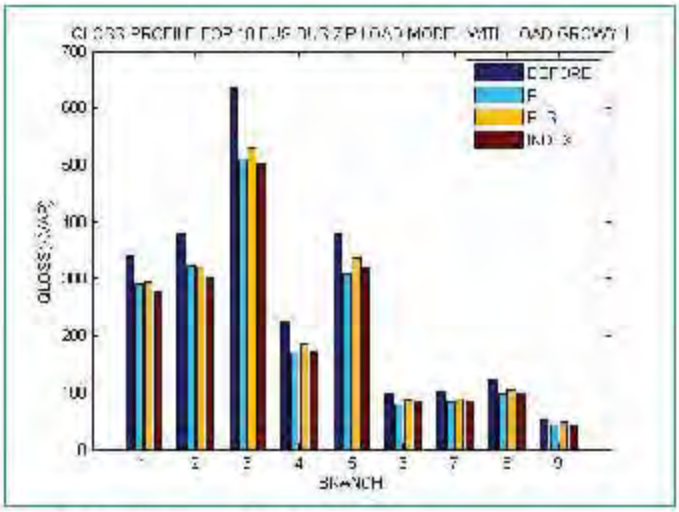

Fig. 12: Reactive power loss profile

The results obtained for IEEE 22 bus test system are given in Table 3. It gives the minimum voltage at base case and comparison of minimum voltage obtained with other methods. The real and reactive

Bus	Base	PLI	PLS	Index
1	0	0	0	0
2	20.9100	20.9100	21.9154	0
3	20.9100	30.2234	21.9150	66.9559
4	37.3200	37.3200	38.8735	0
5	12.5200	21.8334	13.0386	39.3333
6	25.8700	25.8700	26.9143	0
7	14.2100	14.2100	14.7834	47.3207
8	11.6600	11.6600	12.1301	39.0087
9	18.5900	18.5900	19.2231	61.9449
10	18.5900	27.9034	19.2228	61.1624
11	19.4800	19.4800	20.0172	0
12	19.4800	28.7934	20.0169	61.7254
13	71.6500	80.9634	73.3738	0
14	30.1200	30.1200	30.6104	0
15	30.1200	30.1200	30.6102	0
16	70.1200	70.1200	71.2385	205.5865
17	47.8200	47.8200	48.5112	0
18	47.8200	47.8200	48.5081	140.3774
19	38.9300	38.9300	39.4308	0
20	35.9600	35.9600	36.4148	0
21	35.9600	35.9600	36.4148	0
22	29.3600	29.3600	29.7240	0
Total (KVAR)	657.4000	703.9670	672.8869	723.4152

Table 4: Capacitors placement for IEEE 22 bus test system

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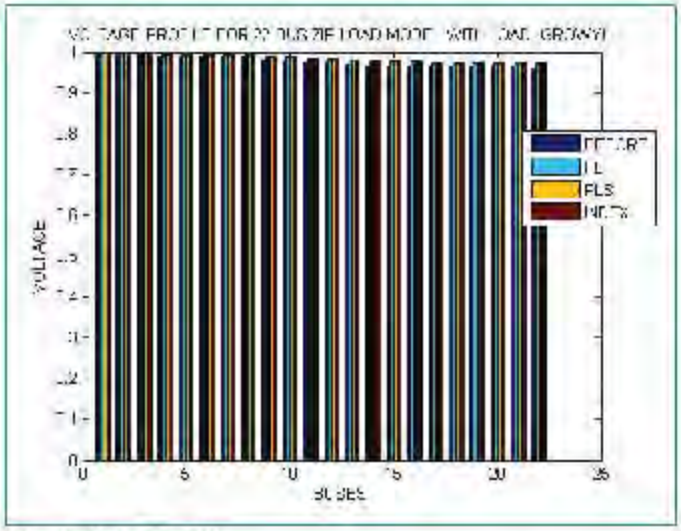

Fig. 13: Voltage prilfe

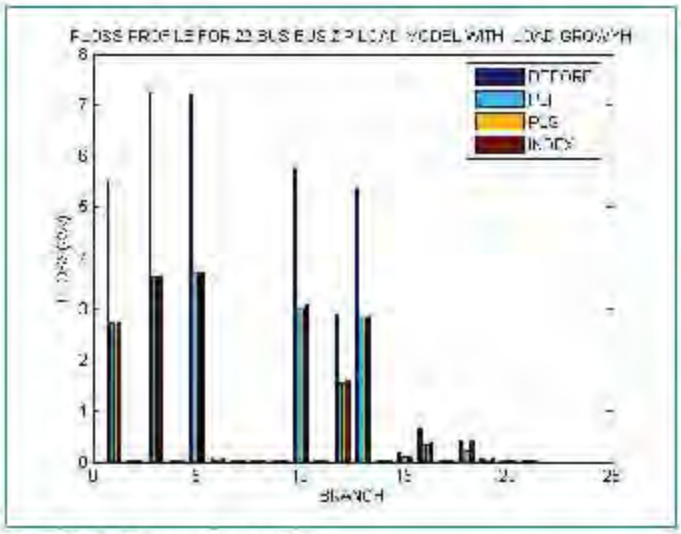

Fig. 14: Real power loss profile

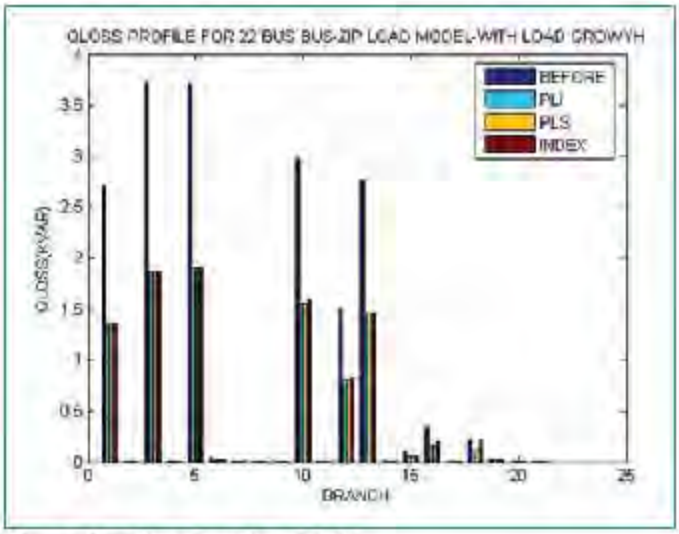

Fig. 15: Reactive power loss profile

power loss is also given in Table. Reduction in the losses is higher with capacitors in case of power loss index based method. The total cost is also observed lower with PLI based capacitor placement. Total KVAr supplied from capacitors is observed lower with PLI based method as given in Table 4. The voltage profile and real and reactive power loss profile is also shown in Fig. 10 to 12. It is observed that results with PLI based method are overall better.

Conclusions

Optimal location and size for capacitors is given by power loss index, power loss sensitivity and index vector method. The sizes of capacitors, voltages, and power losses are compared. The results are very promising. It is interesting to find that the locations are not same given by three methods and the sizes are also different in both the methods. For 10 bus system Power Loss Index method gives maximum cost saving of 53298.273, maximum real power loss reduction of 355 KW and requires high amount reactive compensation. For 22 bus system power loss sensitivity approach gives maximum cost saving of 2411.25, maximum real power loss reduction of 17.25 KW and requires less amount of reactive compensation. For 22 bus system power loss index and power loss sensitivity approaches gives almost similar results. With compensation, the savings potential is considerable due to losses reduction. For proper planning of distribution network, it is therefore essential to carry out such studies and compare the best methods to be adopted for deciding the optimal sizes and location of capacitor banks for economic planning of distribution systems.

Profile

V V S N Murty Vattem

MTech from NIT Kurukshetra was a gold medalist throughout till Master of Technology. He got POSOCO award from IIT Delhi for best thesis in M.Tech level. He has published papers on Comparison of optimal Capacitor Placement methods in radial distribution systems, Comparison of Optimal DG Placement Methods and Load flow analysis etc.

Ashwani Kumar

BTech in Electrical Engg from G B Pant University, Pant Nagar and MTech in Power Systems from Panjab University, Chandigarh and PhD in Electrical Engineering from IIT Kanpur is presently working as an Asst. Prof. in the Department of Electrical Engineering at NIT-Kurukshetra. He is a life member of ISTE and MIE, India.

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MERSEN

Importance of Maintenance for Fuses & Circuit Breakers

Selectively Coordinated Systems

In this fast and wide development of electrical structure the most crucial objective is the requirement of uninterrupted quality power. To achieve this objective, most important task is the maintenance of switchgear accessories. The regular maintenance should be a top priority around your operations.

Jay B Thakar

As with so many other aspects of electrical systems, in order to ensure selective coordination in a system, the over-current protective device scheme must be properly engineered, installed and maintained. Even if a system is designed and installed properly, a lack of proper maintenance can negate the selective coordination scheme that may be vital for life safety or critical business reasons. The same applies to electrical safety for workers.

Selective coordination

The way electrical distribution systems are laid can be likened to a tree. As depicted in Fig. 1, the building service is typically one large ampacity circuit (a tree trunk) that divides into a number of lower ampacity feeders (limbs) that further are divided into many still lower ampacity branch circuits (branches), which supply power to individual end-use equipment such as motors, lighting circuits, computers and HVAC units. Each segment of the electrical distribution system (service, feeder and branch) has a circuit breaker or fuse and sometimes a relay that provides over-current protection for its respective segment of the circuit. When over-current protective devices in an electrical distribution system are chosen by the engineer to be selectively coordinated, by design, whenever there is an over-current condition on a circuit, only the nearest

upstream protective device should open for an over-current condition (Fig. 2). This is applicable for any over-current condition, whether an overload or short-circuit.

Most people assume that if there is a short-circuit condition on a 20A branch circuit, only the 20A circuit breaker or fuse will open and the larger 200A feeder circuit breaker or fuse will not open. This, however, is not always the case (Fig. 3). In some situations, if the engineer did not choose the proper over-current protective devices and/or specify the proper settings or amp rating, a feeder (limb) or even the service (trunk) over-current protective device may unnecessarily open for a branch circuit fault. In the same manner, a short-circuit on a feeder circuit should only open the feeder over-current protective device and not cause the service over-current protective device to open.

Selective coordination of all the over-current protective devices for the circuits supplying vital loads improves the reliability of the system to supply power.

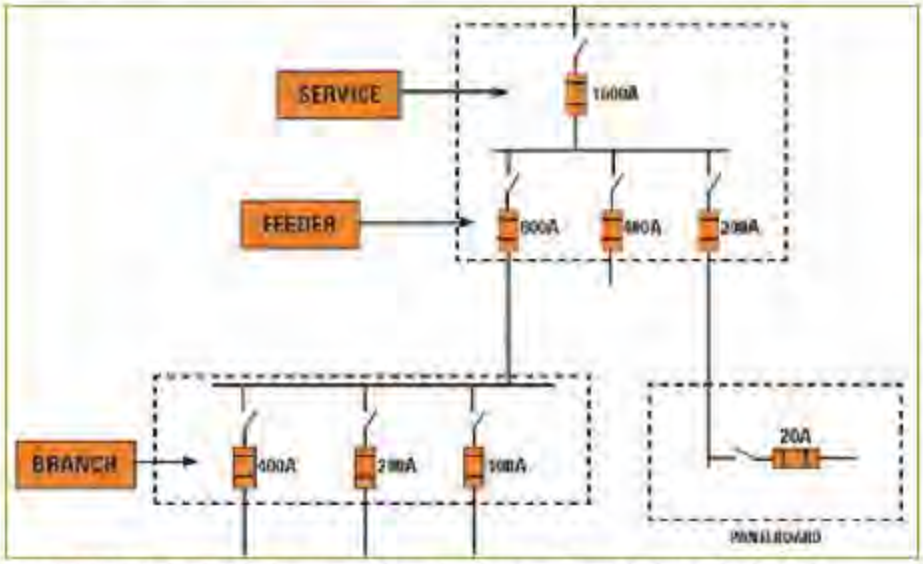


Fig. 1: A building's electrical system with service, feeders & branch circuits is similar in topology to that a tree with trunk, limbs & branches

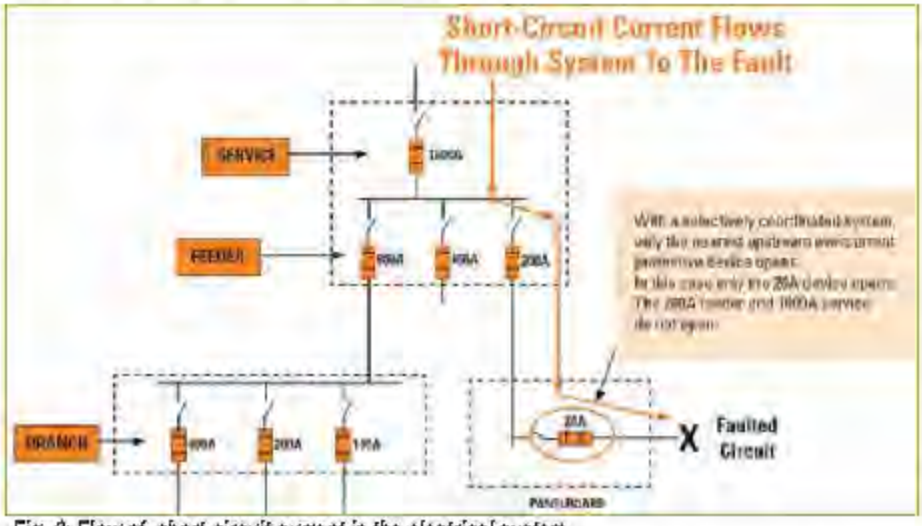


Fig. 2: Flow of short-circuit current in the electrical system

Importance of selective coordination

Selective coordination of all the over-current protective devices for the circuits supplying vital loads improves the reliability of the system to supply power. In today's buildings and manufacturing processes, there is a far greater dependence on electricity.

The ability of the electrical distribution system to provide continuous availability of power to vital loads is ever more important. Worker productivity, industrial process loads, critical computer business system loads and life safety emergency loads, such as exit lighting and healthcare essential electrical system loads, depend on a continuity of power. In some cases, the unexpected loss of power to some industrial processes can be a hazardous condition. When there is a dangerous over-current condition, the over-current protective devices are expected to open the circuit. But, if a lack of selective coordination unnecessarily opens higher level upstream over-current protective devices, critical loads could be disrupted needlessly.

Selective coordination can be either a design consideration or a mandatory NEC requirement. The National Electrical Code has mandatory selective coordination requirements in 517.26 Healthcare Essential Electrical Systems, 620.62 Elevator Circuits, 700.27 Emergency Systems, 701.18 Legally Required Standby Systems and 708 Critical Operations Power Systems. Typically, these systems already have periodical maintenance requirements for generators, automatic transfer switches and other key components. This article is advocating maintenance of the over-current protective devices wherever selective coordination is an important consideration for the system.

How is selective coordination achieved?

Although it is not within the scope of this article to fully explain how to select fuses or circuit breakers to achieve selective coordination, some mention of this process definitely is in order here. Suffice it to say, in most cases, selective coordination must be designed in up-front for an electrical system. This is especially important with circuit breakers. In some cases with fusible systems, after the

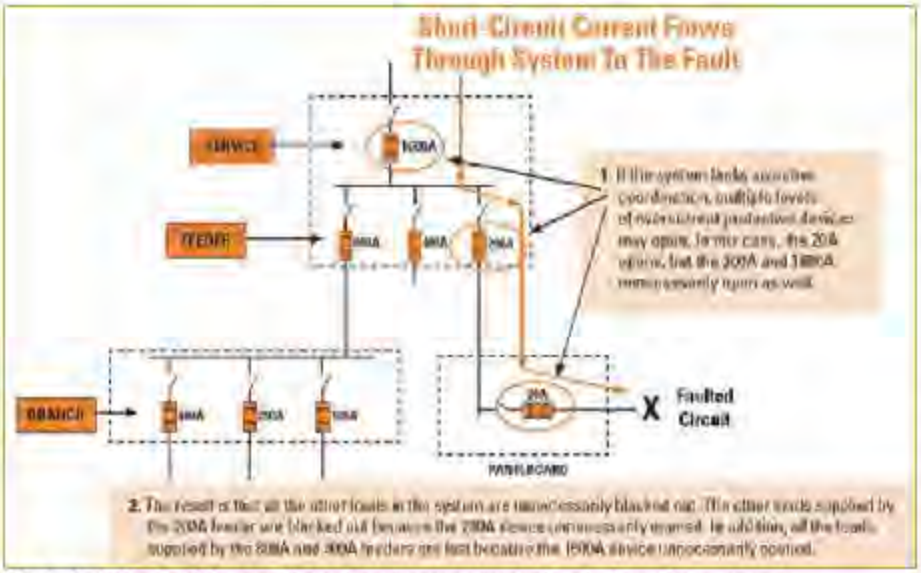


Fig. 3: lack of selectivity coordinated over-current protective devices that causes an unnecessary blackout to other loads

installation there is more flexibility to merely change to different fuse types to achieve selective coordination. The best practice occurs during the system design phase, when the electrical engineer does short-circuit current analysis and coordination analysis of the electrical system. In this process, the engineer must select the proper circuit breakers or fuse types and amp rating/settings to achieve selective coordination.

The engineer's specification should provide a selectively coordinated electrical system. Yet, merely installing a system with the proper circuit breakers, fuses and relays that provide a selectively coordinated system is not sufficient. Proper maintenance of the over-current protective devices will help ensure that the system will perform as specified over its lifetime.

Requirement of maintenance

Now that you have an idea what selective coordination is and what impact it has on the reliability of an electrical distribution system to deliver power to the loads, let's focus on what maintenance needs to be performed on over-current protective devices.

Fuses

The internal parts of modern current-limiting fuses do not require maintenance. There are no adjustments or settings necessary—or possible. However, like all electrical components, the integrity of fuses can be negatively affected by the surrounding environment and components. That's why it is important to periodically check fuse bodies, fuse mountings/ clips and adjacent conductor terminations for signs of overheating, poor connections or insufficient conductor ampacity.

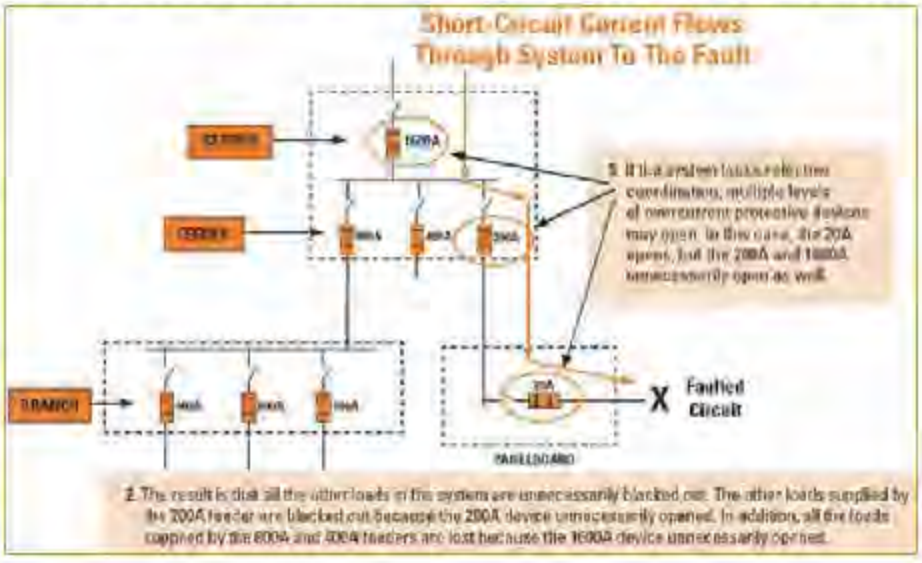
Always have spare fuses of the correct type and ampere rating readily available. For critical circuits, it is best to keep ample spares in a cabinet marked "spare fuses" near the electrical equipment. Also, label the equipment with the proper fuse type and ampere rating. Fuses from different manufacturers should not be mixed in usage since the claims for selective coordination by individual manufacturers are applicable only to their respective products. A continuity tester can verify that a fuse has not opened.

In addition, a resistance check of fuses can be made using a sensitive four-wire instrument such as a Kelvin bridge. The ANSI/NETA MTS 2007 ANSI/NETA MTS-2007, Standard for Maintenance Testing Specification has a guideline of 15% variance for fuse resistance. If the resistance of fuses checked in a disconnect deviates by more than 15%, further investigation should be made. Fuses that are within the manufacturer's resistance tolerance and meet industry standards for performance may have resistance values that deviate by more than 15%. Highly skilled electrical maintenance contractors, though, have told this author that the 15% guideline works well for maintenance purposes. Generally, when they find a fuse out of tolerance, the percentage difference is far greater than 15% (an order of magnitude or greater).

Circuit breakers

Circuit breakers are mechanical devices that require periodic maintenance to ensure proper operation. A popular misconception is that if a circuit breaker has not tripped due to an over-current it is in original condition. In fact, a circuit breaker that sits without opening over long periods can have performance issues. The lubrication of the mechanism, which is vital for its proper operation, can degrade or dry over time and affect the circuit breakers ability to operate properly. A circuit breaker also can be damaged or degraded after interrupting a fault.

Good preventive maintenance for circuit breakers should include periodic exercise of



the operating mechanism. A better practice is to exercise the trip latch mechanism since it can seize due to lack of use. The trip latch mechanism can be exercised by primary injection testing or, if a circuit breaker is equipped, by pushing the Push-to-Trip or similar button (usually red in color), which directly operates the trip latch. It is recommended that periodic circuit breaker maintenance include exercise (every six to 12 months), visual and mechanical inspections and calibration tests.

In addition, periodically check conductor terminations for signs of overheating, poor connections and/or insufficient conductor ampacity. The "as found" and "as left" records should be retained and trended for each circuit breakers condition and maintenance tests. When a circuit breaker is nearing the point where it requires repair or replacement, the trending of the test data tends to escalate.

For fuse and circuit breaker assemblies, as well as other electrical components, infrared thermographic scans are one method for monitoring conditions where loose connections or other situations may cause intolerable thermal conditions.

Relays

Relays also should undergo period maintenance. Such maintenance should entail calibration; checking the relay power source; ensuring that all wiring schemes are correctly installed; and maintaining the disconnecting means that the relay will signal to open if there is an over-current condition that must be removed.

How often, etc!

One consideration in maintenance of over-current protective devices is the frequency of maintenance. This is dependent on many factors including the device type, environment of the installation, usage, loading, age of equipment, prior maintenance data trends and necessary reliability. Your first source of information should be the device manufacturer's maintenance manual. Other industry sources include NFPA 70B, Recommended Practice for Electrical Equipment Maintenance & Appendix B, "Frequency of Maintenance Tests" of ANSI/NETA MTS 2007 ANSI/NETA MTS-2007, Standard for Maintenance Testing Specification. The "Frequency of Maintenance Tests" provides a very useful matrix and schedule table for determining which maintenance activities should occur, as well as the frequency based on the condition of equipment & its criticality.

Profile

Jay B Thaker

MTech in Power System and entrepreneur in renewable energy sector had presented 6 research papers in conferences & published 3 Papers in International Journals. His interests are in renewable energy secotor, wind power generation power system, protection and restructuring.

Polyvinyl Chloride

An Un-acknowledged Performance Material

Polyvinyl Chloride (PVC) is the third most widely used plastics globally after Polyethylene and Polypropylene. Due to its wide ranging performance characteristics and its applications base in infrastructure industries, PVC is also called as Infrastructure Plastic.

PVC is composed of 57% chlorine & 43% Carbon which signifies that PVC has smaller carbon footprint and only 0.3% of all oil and gas is consumed globally for annual production of PVC. PVC is the most versatile plastics that can be customised into flexible, semi flexible and rigid grades and can also be formulated into transparent, translucent, opaque and colorful grades.

PVC Consumption Pattern

PVC market in the country is estimated to be worth of Rs 135 billion. PVC production capacity in the country was approximately 1350 (2013-14 E) thousand tons against a demand of ~2400 thousand tons. The production - demand deficit in the country has been increasing steadily during the past four fiscals. India's import dependency on PVC is expected to increase in future. PVC consumption is expected to go up in urban/rural housing, agriculture sector and other end use applications.

Sector wise consumption in 2012-13 depicts the following pattern:

In India, rigid applications of PVC comprises almost exclusively of pipes and fittings while globally rigid applications are broad based and pipes and fittings normally accounts for less than 50% of PVC consumption. Actually, in Europe the consumption of PVC for pipes and fittings application comprises less than 20% of total PVC consumption.

Demand Drivers

The demand for PVC resin depends upon the growth in


Application: Medical Connector


Application:Modular Switch Plate


Application:Double-Gang Box

demand for PVC products from sectors as varied as construction, pharmaceuticals and agriculture.

- PVC has replaced other materials such as wood, aluminum, glass etc. used in the construction and is also used as a raw material in window frames and shutters, pipe, cabling etc. Around 50% of PVC produced is used in the construction industry which has strong growth potential due to large investment taking place in housing and infrastructure development along with commercial segments like IT parks, malls and multiplexes. Same characteristics are important for high end engineering injection moulding applications.
- Growth in commercial and residential construction thus pushes up the demand for PVC products.

PVC in Infrastructure

For many decades PVC is majorly used in infrastructural applications. PVC has high resistance level to chemical reactions and chemical reagents, is flexible to work with and is durable making it ideal for applications in construction (residential and commercial), packaging, electronic / electrical applications, irrigation, drinking water supply and sewage disposal.

The core characteristics of PVC such as inherent flame retardant, excellent chemical resistance, weatherability and low heat release during fire make it suitable and economical choice for replacing some engineering applications. The design freedom for customising PVC from rigid to flexible and transparent to opaque, makes PVC the best alternative to engineering plastics which are over engineered for the applications.

Value proposition of PVC compound

- Inherent flame retardant meets the UL requirement V0 at 0.75 mm thickness and saves the cost which is incurred to make other polymers flame retardant and offers flammability performance to replace FR polycarbonate, FR ABS & PC+ABS Blend.
- High modulus and high toughness.
- Best fit for electrical application and meeting UL 541 C requirement.
- Excellent chemical resistance and weatherability: chemical resistance reduces the part failure by discoloration or cracking in presence of oil, grease, salt water, and cleaning agents.
- Superior aesthetics.
- Meets regulatory compliances and approvals include FDA, UL, IEC and RoHS.

Above characteristics of PVC compounds are making it cost effective alternative material to high end engineering plastics in many Injection molding applications as follows-

- Appliances: Washer/Dryer Consoles, Ice-Maker Housings, Blender Lids, R.O. Cabinets.
- Electrical and Electronics: Surface Mounting Boxes, Conceal Boxes Wiring Devices, Modular Switch Plates, Battery Container.
- Hand Tool Grips.
- Medical Connectors, Check Valves, Louvers.

Though PVC offers the excellent value proposition still it is positioned as infrastructural plastics and 70% of PVC goes into long lasting building and construction applications such as pipe, siding, windows, flooring, fencing, wall protection devices, cladding, etc.

PVC Processing

To get the optimum results for injection moulded products from PVC compound it is highly recommended to select right kind of processing equipment and desired molecular weight PVC resin in combination with appropriate formulation.

Processing equipment

Injection Moulding Equipment for Processing Rigid PVC Compounds

The injection moulding machines which are designed to process other engineering plastics are normally suitable for rigid PVC compounds. Best moulding performance can be achieved in the injection moulding which has bimetalic barrel.

The recommended shot weight of the part should be two third of the rated barrel capacity.

2 - 2.5 tons clamp tonnage for per square inch of projected area is recommended.

Screw design

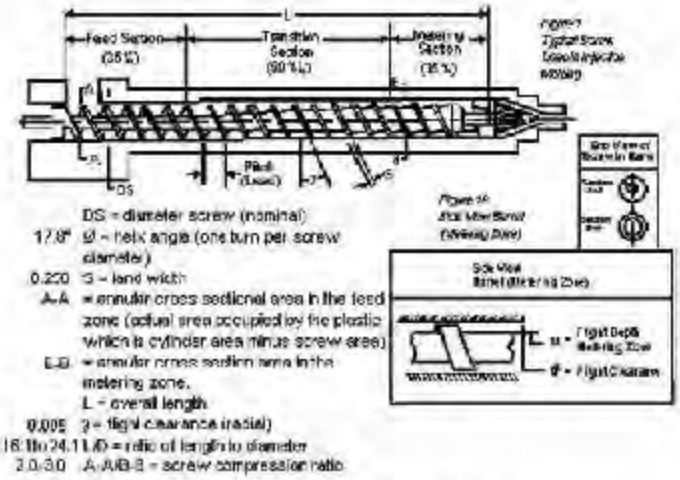
The best suited L/D ratio is 16:1 to 24:1 and compression ratio is 2.0:1 to 2.6:1 and can also go upto 3:1.

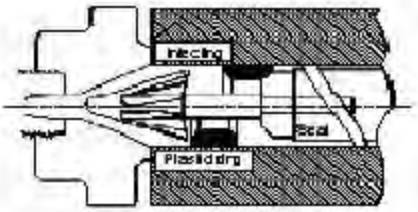
For easy flow, PVC grade and thin wall large parts free flow sliding check ring is recommended and for mid flow grade of PVC smear head tip is preferred.

Nozzle

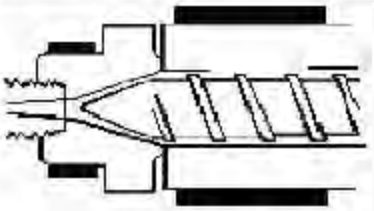
Nozzle length should be short and 1-8 Inch range is suggested.


Application:R.O. Cabinets

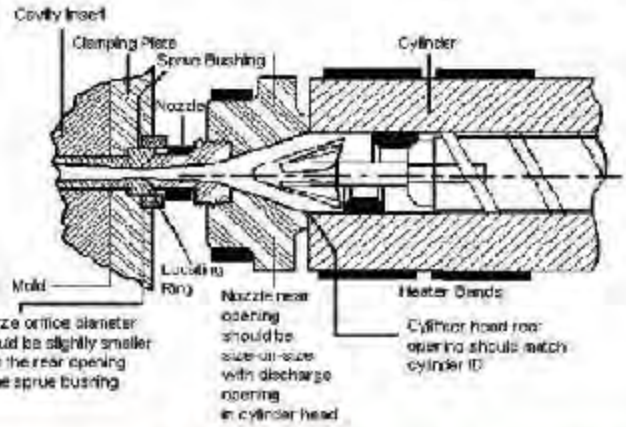




Sliding Check-Ring Type



Smearhead Type



Mould Design

420 stainless steel is recommended for core and cavities, moving parts should be made of hardened steel and should be chrome plated. Although 420 type stainless steel or equivalent is generally recommended and most widely used, 414 pre-hardened stainless steel has been found to have good chemical resistance, is easily repairable and can also be used. The moving parts of the mould (knock outs, sliding cores, etc.) should be made from hardened steel and plated. Metal galling can occur when two similar steels move in contact with each other. Pre-hardened & conventionally hardened steels are also acceptable mould materials, but require plating on all plastic contact surfaces.

Heater Band Setting			
Rear Zone	Middle zone	Front Zone	Nozzle
140°C - 150°C	160°C - 170°C	170°C - 180°C	180°C - 190°C

Application: 1,2,& 3 Gang Boxes

Melt Temperature

To achieve the best application performance in rigid PVC, the ideal melt temperature range is 190 - 205°C. The temperature is measured by taking an 'air shot' and measuring the temperature of the melt with a needle probe pyrometer. In addition, the melt should look smooth and glossy.

A dull-looking melt indicates too low of a temperature. A rough surface melt indicates too hot of a melt or moisture in the compound.

Purging Recommendations

- PVC compounds must be purged from the barrel after molding is complete or during a prolonged interruption in the molding cycle.
- Purge at least once if the interruptions are more than 15 minutes
- During shutdown it is highly recommended to flush out the remaining PVC compound to empty cycle and then purge out with general purpose natural ABS or natural polystyrene which are ideal purge materials for PVC compound.
- After completion of production or shutdown of the machine the mould surfaces (core and cavities, inserts etc) of the moulds should be cleaned properly & corrosion resistant spray should be applied to the mould surfaces.

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Interview

"To become a Power System Solution provider"

Sanjay Kulkarni, Chairman in India
Scope T&M Pvt Ltd

SCOPE is a pioneer in developing portable Testing & Measuring instruments for power sector in India, and also in providing Test & Measuring Instruments, Power System Control & Protection solutions and Testing & Commissioning services for live switchyards up to 1200 kV. It offers a range of Field Testing Instruments capable of working in live switchyards and solutions for improving efficiency of capital equipment in Power Industry. In an exclusive interview to **Electrical India, Sanjay Kulkarni,** states, we are now focusing more on expanding our presence & market share in Export Market.

➢ **What role does SCOPE plays in power sector in India? Your company is pioneer in developing portable Testing & Measuring instruments. What do you think is the significance of testing instruments in power industry?**

SCOPE has a very critical role to play in Power Industry. We are like doctors, providing Testing Instruments to check healthiness of substation equipment. In short, you may say that- SCOPE maintains the substation equipment, which maintain power to your homes without interruptions. SCOPE has developed a special Domain knowledge for Transmission sector by virtue of working closely with Power Utilities over past 26 years. In this process our R&D, has developed more than 50 products for different and challenging applications for 1200 kV substation. We were the first Indian company who has developed Circuit Breaker Operational Analyzer in year 1995 and won an award at Elecrama 1996 for the best product amongst all products exhibited by all exhibitors.

➢ **How would you measure that SCOPE's solutions greatly improve the efficiency of capital equipment in the power and energy sector?**

In energy and power sector it is very essential to reduce the Down Time and ensure continuous supply. SCOPE is developing the products having high accuracy, efficient & simple to use. This reduces not only testing time but also generate the test data which gives the trend of a particular parameter getting drifted from its safe limits. This trend analysis is a powerful tool for Predictive Maintenance where utility can take a Planned Shutdown and take corrective action to resolve the problem and bring back the equipment on its original condition. Since it is been said "A stitch in time saves nine". SCOPE is investing a lot in its R&D to provide the world class solution with capabilities of quick & efficient testing and our customers acknowledge these sincere efforts. We are also working on developing products which would do measurements online. Thus it's eliminating outage time required for testing.

Could you detail about your company's product range and the various solutions being offered by you? What is its response domestically?

SCOPE offers products under verticals as:

Scope T&M

- Circuit Breaker Operational Analyser
- Circuit Breaker Time Interval Meter
- Real Time Monitoring of Circuit Breaker
- Control Switching Device
- Leakage Current Analyser for Surge Arresters/ Lightning Arresters
- Real Time Monitoring of Surge Arresters/ Lightning Arresters
- Transformer Winding Resistance Measurement with OLTC Analyser
- Sweep Frequency Response Analyser
- CT/PT Analyser
- Cable Fault & DC Earth Fault Locator
- Travelling Wave Fault Locator for Online monitoring of Transmission Line
- Relay Testing, Battery Testing Kits
- Insulation Testers; Thermo vision and
- Corona Detection Camera.

Scope Protect

- RTU Automation
- SCADA / OMS / DMS solutions
- CRP & SAS
- Testing & Commissioning Services upto 765 kV substation equipment.

All these products are well established & stable in the market domestically. We are having a huge demand for our products in International market; we have supplied our products to more than 35 different countries across all continents and the demand is increasing.

Do your products, the' Leakage current analyzer and circuit breaker analyzer are capable to detect the fault and improve functioning of the equipment involved?

Yes of course! Where ever we mention analyzer, we mean to say detailed analysis; our products are capable of detecting the functional faults, internal faults, wear & tear of important part etc. Its very important for a periodic maintenance of equipment's.

What is your marketing strategy in the back-drop of challenges being faced in the power industry? Do share something about Power System Protection Division and its contribution?

We have customer centric marketing plans, where we are in close touch with our customer giving them service as well as training on our products. In fact they are directly in touch with us for anything and everything they wish to get from us. This customer centric approach has helped us to achieve the targeted goal. Power System Protection division: It designs & executes state-of-the-art Protection and Substation Automation Solutions up-to 765 kV.

- Control Relay & Protection Panel and Substation Automation Solutions
- Control Switching Device for point on wave control of Circuit Breakers
- RTU Automation & Retrofitting of old substations; SCADA, OMS & DMS.

Protection division contributes near to 40% of the company's total business.

Tell about scope of the SCOPE's products domestically and about your manufacturing facilities with respect to the cutting edge your products command over other companies' products in similar line of production?

SCOPE always had a good amount of market share domestically. We are now focusing more on expanding our presence & market share in Export Market. We have a 5000 sq mtr Built up facility for our factory in Bhosari MIDC, Pune where most of the manufacturing is taking place. Our R&D facility is at Aundh, Pune. Entire manufacturing and R&D is built with antistatic flooring to ensure the long life of components we use in the instrument. Air-conditioning ensures the dust free environment. Burning Oven and Freezer to remove the weak components during the thermal cycling ensures reliable and long operation of our products in the field.

How does it benefit being a one-stop solution provider as SCOPE is stated to be?

Being in this field of Test & Measurement offering products and services of highest quality to the customer SCOPE has developed a tremendous Goodwill. It was on insistence of our customers that we should outsource products for them from other manufacturers; we had decided to offer "One Stop" solutions to them. SCOPE applies same quality standards to all such outsourced products as we apply for our own manufactured products. This ensures a good and reliable quality of products to be supplied under an umbrella of "One-Stop Solutions".

All this we are doing for one aim, total customer satisfaction.

What is your contribution to substation maintenance management, could you detail about it?

We have developed SCHELOG Software which is used for Substation maintenance management. The key points are-

- A system by which maintenance of equipment is scheduled and monitored
- Startup graphics in the form of single line diagrams for substations Visual Alarms
- Schedules tests automatically as per test frequency for every year and logs the data, logged data is available in terms of reports and analysis
- Compares test results of different types of EUT against test parameter
- Maintains a history of all devices, test schedules and EUT locations.

Purpose

- Schedule test activities for the various devices (Function as well as Support devices)
- Monitor test activities, Collect and analyze test results
- Take timely action thereby minimizing the possibility of a system failure
- Trend Analysis & Component Performance.

What is your immediate vision for the company in the next two years?

SCOPE is to become a Power System Solution provider restricted not only to a substation but to expand and contribute in Smart Grid, Automation and address the Grid Problems.

RMU Compatible with SCADA/DMS

Next step to distribution

RMU is compact unit which is applicable to all MV power distribution ring or radial network for connection, supply and protection of transformers up to 8000 kVA. In power distribution networks, sometimes it requires tap points for switching. Hence, to overcome the effect of a fault on the network, load break switch & circuit breaker is to be provided. A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. It contains SF6 (Sulfur hexafluoride) gas to quench the arc around contacts of load break switches & vacuum interrupters are used in Circuit Breakers.

SCADA/DMS

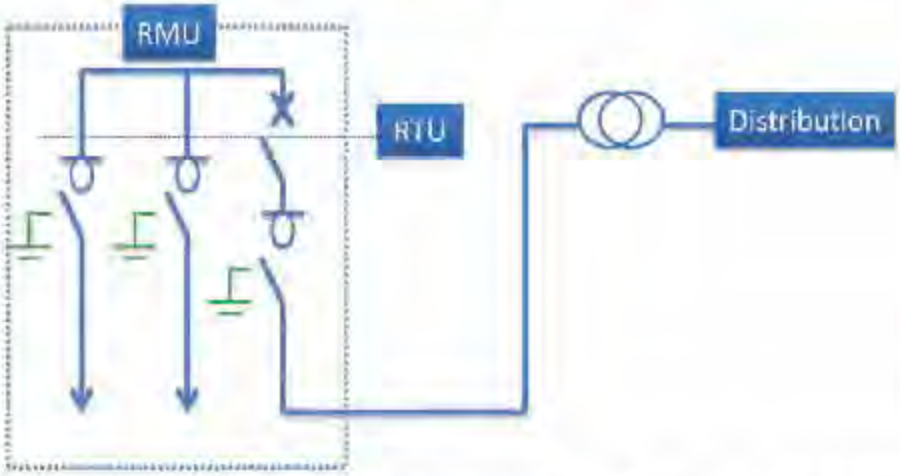
The term SCADA usually refers to centralized systems which monitor and control entire sites, or complexes of systems spread out over large areas. Supervisory Control and Data Acquisition (SCADA) system usually consists of Remote Terminal Units (RTUs) which have telemetry hardware capable of collecting data of field devices and also communicate control commands.

RTUs installed at centralized locations such as the utility control center are having SCADA software operator. Operators consoles, which can be connected to the main system or to the other systems. Middleware software allows access to the consoles via intranet, using a standard browser. Additionally to the main servers, three redundant additional servers are included, which correspond to existing, in-house developed applications that store network information and make it accessible to users outside the dispatch centers alarms archive

measurements and counters archive quality of service archive and index calculation.

These applications are today connected to all the control systems. They will be adapted to the new solution, connected in real time. It is advantageous to keep them because they are quite customized to the company needs, and will alleviate the system from the load of the number-crunching, massive data management performed and the large number of users accessing themV24 port cards are integrated in transmission equipment which betters reliability, control, commissioning, troubleshooting and testing of circuits.

Earlier RMU was getting used with only manual function. Looking at the SCADA/DMS requirement remote operation of the RMU comes in.



Latest Requirements

Earlier RMU was getting used with only manual function. Looking at the SCADA/DMS requirement, remote operation of the RMU comes in. To operate from remote, motorization concept got popular. To accommodate the latest requirements of the customer, Jyoti Ltd has developed the total solution. As on date Jyoti provides RMU with extensibility on both sides, motorization for remote operations, metering unit for PTs, Auxiliary Transformer, ON/OFF control & suitable NO/NC contacts for SCADA. These requirements have now become basic specifications of the RMU.

Motorization

Load break switch motorization

- The LBS motorization unit is just "ADD ON" to the JYOTI RINGTM that can be installed on site without de-energizing the unit.
- The motorization unit is having 14 pin plug for electric source and other signals, which is easy to plug.
- An electrical interlocking assembly prohibits any wrong operating as it is motorized.

Circuit Breaker motorization

- The CB motorization unit is just "ADD ON" to the JYOTI RINGTM that can be installed on site without de-energizing the unit.
- The motorization unit is having 14 pin plug for electric source and other signals, which is easy to plug.

LBS Motor unit

Circuit breaker Motor unit

- An electrical interlocking assembly prohibits any wrong operating as it is motorized.

Metering Unit

The Metering function unit (M- function) is a factory assembled air insulated metering cubical with Voltage transformers and Auxiliary-transformer. This function allows metering of electricity consumption.

Auxiliary transformer (optional) is used to generate the 230V AC for battery charger. 24 V DC Batteries are used for RTU & Motorization. With this unit becomes a standalone & it does not require any auxiliary supply.

Standard features

- All compartments i.e. HT Compartment, LT compartment, RTU Compartment (SCADA) are independently separate.

- Both side identically extensible to JYOTI RINGTM
- Direct coupling between RMU and transformer
- Safety mesh to prevent to access live parts
- Potential free contact for Warning to access HT compartment
- HT connections are sleeved
- Space heater in HT compartment
- Minimum available space of RTU (SCADA) is 600 X 300 X 1200 (L X B X H)
- Suitable for outdoor application.

Marshalling box

- Separate box with potential free terminals is provided
- SCADA compatible, I/O signals are brought to the Terminal Strip on a Din Rail.
- Potential free and control contacts are for operations of Circuit breaker, LBS, CB earth switch, For signals of status of Low SF6 gas pressure, FPI, Battery Charger Fail, CB trip coil healthy and RMU Door open.

Connection with RMU

- With the use of Joining kit Metering panel can be coupled either side of JYOTI RINGTM
- Factory coupled Metering supplied along with standard base frame
- Top mounted sleeved bus bars are covered with duct suitable for outdoor application.

By accomplishing this remarkable technology, Jyoti Ltd has footsteps in the new era with great success. This will lead our customers to step ahead in advance and in the global world of distribution.

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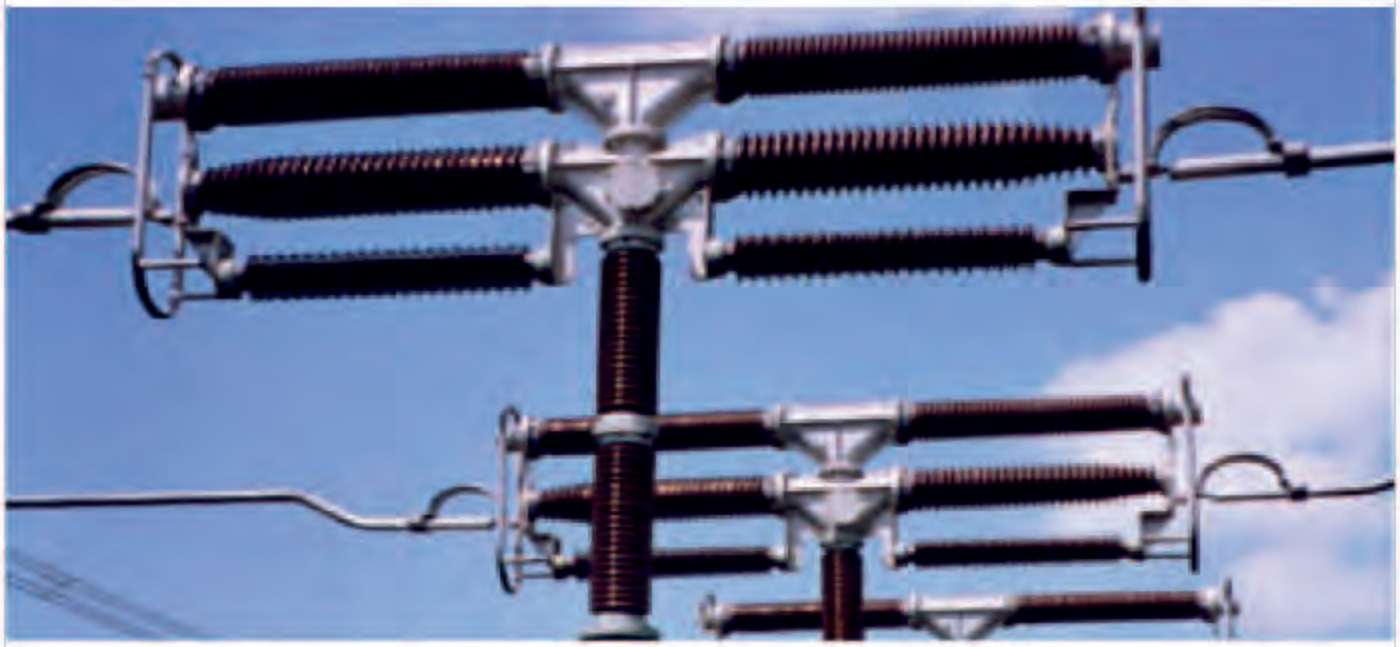

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Calculate Size of Contactor, Fuse, CB, O/L Relay of Star-Delta Starter

Calculate Size of each Part of Star-Delta starter for 10HP, 415 Volt Three Phase Induction Motor having Non Inductive Type Load, Code A, Motor efficiency 80%, Motor RPM 600, Power Factor 0.8. Also Calculate Size of Overload Relay if O/L Relay Put in the windings (overload is placed after the Winding Split into main and delta Contactor) or in the line (Putting the overload before the motor same as in DOL).

Basic Calculation of Motor Torque & Current

- Motor Rated Torque (Full Load Torque) = 5252 x HP x RPM
- Motor Rated Torque (Full Load Torque) = 5252 x 10 x 600 = 88 lb-ft.
- Motor Rated Torque (Full Load Torque) = 9500 x KW x RPM
- Motor Rated Torque (Full Load Torque) = 9500 x (10 x 0.746) x 600 = 119 Nm
- If Motor Capacity is less than 30 KW than Motor Starting Torque is 3xMotor Full Load Current or 2X Motor Full Load Current.
- Motor Starting Torque = 3 x Motor Rated Torque (Full Load Torque).
- Motor Starting Torque ==3x119=356 Nm.
- Motor Lock Rotor Current = 1000 x HP x figure from below Chart/1.732 x 415

As per above chart Minimum Locked Rotor Current = 1000 x 10 x 1/1.732 x 415 = 14 Amp

- Maximum Locked Rotor Current = 1000 x 10 x 3.14/1.732 x 415 = 44 Amp.

Locked Rotor Current		
Code	Min	Max
A	1	3.14
B	3.15	3.54
C	3.55	3.99
D	4	4.49
E	4.5	4.99
F	5	2.59
G	2.6	6.29
H	6.3	7.09
I	7.1	7.99
K	8	8.99
L	9	9.99
M	10	11.19
N	11.2	12.49
P	12.5	13.99
R	14	15.99
S	16	17.99
T	18	19.99
U	20	22.39
V	22.4	

- Motor Full Load Current (Line) = KW x 1000/1.732 x 415
- Motor Full Load Current (Line) = (10 x 0.746) x 1000/1.732 x 415 = 13 Amp.
- Motor Full Load Current (Phase) = Motor Full Load Current (Line)/1.732.
- Motor Full Load Current (Phase) = = 13/1.732 = 7 Amp.
- Motor Starting Current (Star-Delta Starter) = 3 x Full Load Current.
- Motor Starting Current (Line) = 3 x 13 = 39 Amp

Size of Fuse

Fuse as per NEC 430-52		
Type of Motor	**Time Delay Fuse**	**Non-Time Delay Fuse**
Single Phase	300%	175%
3 Phase	300%	175%
Synchronous	300%	175%
Wound Rotor	150%	150%
Direct Current	150%	150%

- Maximum Size of Time Delay Fuse = 300% x Full Load Line Current.
- Maximum Size of Time Delay Fuse =300%x13= 39 Amp.
- Maximum Size of Non Time Delay Fuse =1.75% x Full Load Line Current.
- Maximum Size of Non Time Delay Fuse=1.75%13=23 Amp.

Size of Circuit Breaker

Circuit Breaker as per NEC 430-52		
Type of Motor	**Instantaneous Trip**	**Inverse Time**
Single Phase	800%	250%
3 Phase	800%	250%
Synchronous	800%	250%
Wound Rotor	800%	150%
Direct Current	200%	150%

- Maximum Size of Instantaneous Trip Circuit Breaker = 800% x Full Load Line Current.
- Maximum Size of Instantaneous Trip Circuit Breaker = 800% x 13 = 104 Amp.
- Maximum Size of Inverse Trip Circuit Breaker = 250% x Full Load Line Current.
- Maximum Size of Inverse Trip Circuit Breaker = 250% x 13 = 32 Amp.

Thermal over Load Relay

Thermal over Load Relay (Phase)

- Min Thermal Over Load Relay setting = 70% x Full Load Current (Phase)
- Min Thermal Over Load Relay setting =70%x7= 5 Amp
- Max Thermal Over Load Relay setting = 120% x Full Load Current (Phase)
- Max Thermal Over Load Relay setting =120%x7= 9 Amp.

Thermal over Load Relay (Line)

- For a star-delta starter we have the possibility to place the overload protection in two positions, in the line or in the windings.
- If O/L Relay Placed in Line: (Putting the O/L before the motor same as in DOL).Supply>Over Load Relay>Main Contactor
- If Over Load Relay supply the entire motor circuit and are located ahead of where the power splits to the Delta and Star contactors, so O/L Relay size must be based upon the entire motor Full Load Current.
- Thermal over Load Relay setting =100%xFull Load Current (Line).
- Thermal over Load Relay setting =100%x13= 13 Amp
- Disadvantage: O/L Relay will not give Protection while Motor runs in Delta (Relay Setting is too High for Delta Winding)
- If O/L Relay Placed In the windings: (overload is placed after the Winding Split into main and delta Contactor).Supply>Main Contactor-Delta Contactor>O/L Relay
- If overload is placed after the Point where the wiring Split into main and delta Contactor, Size of over load relay at 58% (1/1.732) of the motor Full Load Current because we use 6 leads going to the motor, and only 58% of the current goes through the main set of conductors (connected to the main contactor).
- The overload then always measures the current inside the windings, & is thus always correct. The setting must be x0.58 FLC (line current).
- Thermal over Load Relay setting = 58% x Full Load Current (Line).

Application	Contactor	Making Cap
Non-Inductive or Slightly Inductive, Resistive Load	AC1	1.5
Slip Ring Motor	AC2	4
Squirrel Cage Motor	AC3	10
Rapid Start / Stop	AC4	12
Switching of Electrical Discharge Lamp	AC5a	3
Switching of Electrical Incandescent Lamp	AC5b	1.5
Switching of Transformer	AC6a	12
Switching of Capacitor Bank	AC6b	12
Slightly Inductive Load in Household or same type load	AC7a	1.5
Motor Load in Household Application	AC7b	8
Hermetic refrigerant Compressor Motor with Manual O/L Reset	AC8a	6
Hermetic refrigerant Compressor Motor with Auto O/L Reset	AC8b	6
Control of Restive & Solid State Load with opto coupler Isolation	AC12	6
Control of Restive Load and Solid State with T/C Isolation	AC13	10
Control of Small Electro Magnetic Load (<72VA)	AC14	6
Control of Small Electro Magnetic Load (>72VA)	AC15	10

- Thermal over Load Relay setting = 58% x 13 = 8 Amp.
- Disadvantage: We must use separate short-circuit and overload protections.

Size and Type of Contactor

Main and Delta Contactor: The Main and Delta contactors are smaller compared to single contactor used in a Direct on Line starter because they Main and Delta contactors in star delta starter are controlling winding currents only. The currents through the winding are 1/ 3 (58%) of the current in the line. These two contactors (Main contactor and Delta Contactor) are close during run. These rated at 58% of the current rating of the motor.

Star Contactor: The third contactor is the star contactor and that only carries star current while the motor is connected in star in starting. The current in star winding is 1/ 3= (58%) of the current in delta, so this contactor can be rated at 1/3 (33%) of the motor rating. Star contactor can be selected smaller than the others, providing the star contactor pulls first before the main contactor. Then no current flows when third contactor pulls. In star connection at start, the motor draws and delivers 1/3 of its full rated power. When the starter switches over to Delta, the motor draws full power, but since the contactors and the overload relay are usually wired within the Delta, you need to use contcators and relay which are only rated 1/ 3 = 58% of the full rated power of the motor.

As per above Chart

- Type of Contactor= AC1
- Making/Breaking Capacity of Contactor = Value above Chart x Full Load Current (Line).
- Making/Breaking Capacity of Contactor = 1.5 x 13 = 19 Amp.
- Size of Star Contactor (Starting Condition) = 33% X Full Load Current (Line).
- Size of Star Contactor = 33% x 13 = 4 Amp.
- Size of Main Contactor (Starting-Transition-Running) = 58%X Full Load Current (Line).
- Size of Main Contactor =58%x13 = 8 Amp.
- Size of Delta Contactor (Running Condition) = 58% X Full Load Current (Line).
- Size of Delta Contactor = 58% x 13 = 8 Amp.

Profile

Jignesh Parmar

Electrical Engineer has more than a decade experience in Power Transmission, Power Distribution (T&D Loss control, Electrical energy theft detection),electrical Maintenance and Projects. He designs unique Excel base Electrical programs as per NEC, IEEE code. He is also Technical Blogger and contribute Technical papers to various national and international site.

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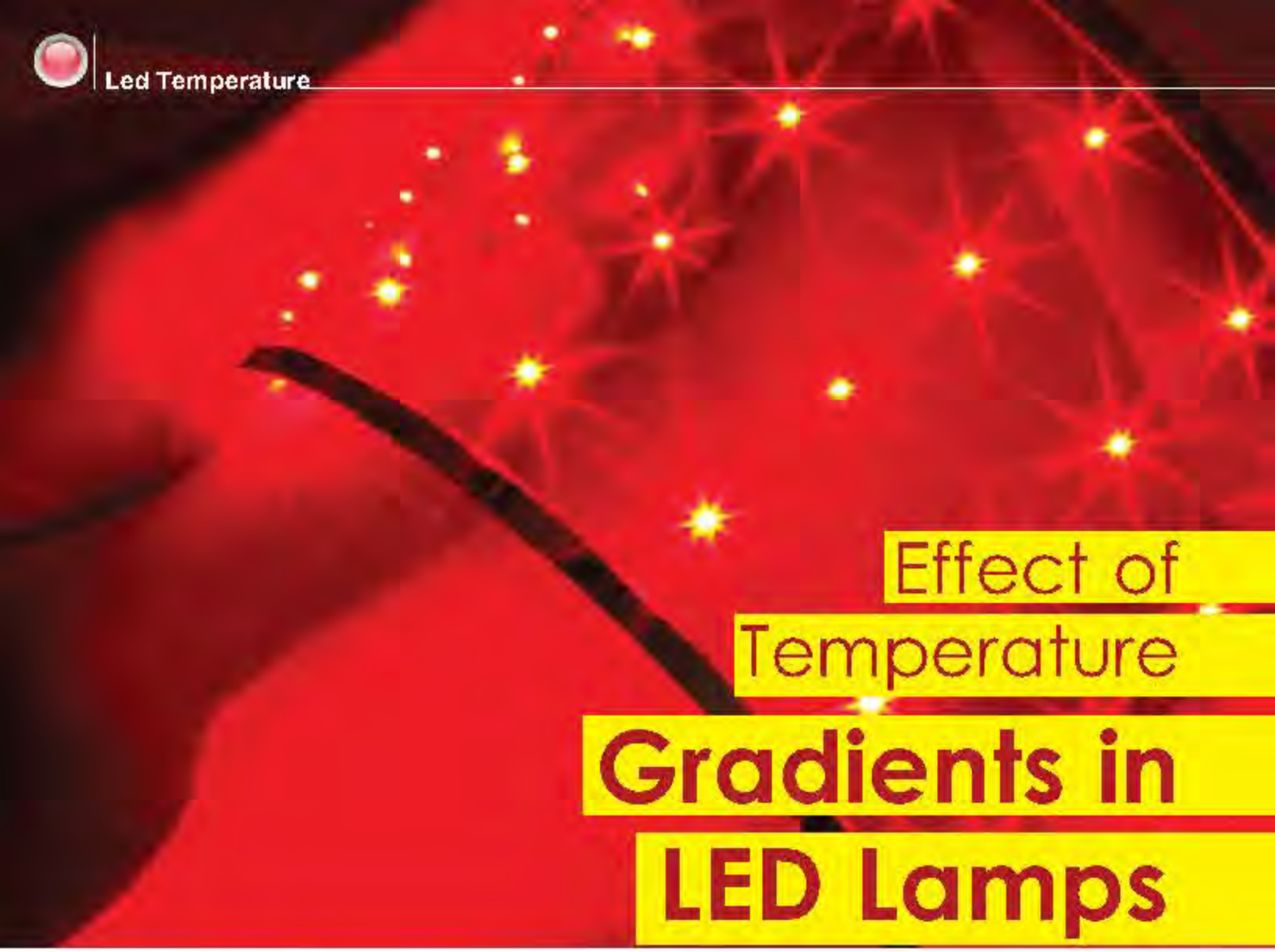

Effect of Temperature Gradients in LED Lamps

Solid state lighting devices are based on conversion of electric power to light energy. The 100% conversion equivalent of electric power to light energy or theoretical maximum of a light source matching the chromaticity co-ordinates of white light is the Photopic luminous efficiency of monochromatic light at 555 nm which is 683 lumen/W. As per the International Standards 1 lumen is equivalent to 0.001496 W which gives a Mesophic luminous efficiency of 668.45 lumen/W. Thus, in absolute terms, 1W is the equivalent of 668.45 lumen which is considered here as the 100% luminous output.

In LEDs using Group III semiconductors, the internal quantum efficiency in multilayered conversion is 100% for blue light of 490 nm at 2.7 eV energy level. The external quantum efficiency is given by,

$$\varepsilon_{external.quantum.efficiency} = \varepsilon_{internal.quantum.efficiency}\ \eta_{electricalchip}\ \eta_{optical.chip} \quad (1)$$

The external quantum efficiency considers the optical loss due to refraction and absorption in the LED lens and electrical loss due to contact resistance in the LED. Taking each of these as 90%, the external quantum efficiency of a LED works out to 72.9% which is 487.30 lumen/W.

The energy efficiency of the lamp is given by,

$$\varepsilon_{lamp} = \varepsilon_{emitter}\ \eta_{driver}\ \eta_{reflector} \quad (2)$$

Thus the lumen efficiency of market LEDs which includes the drive & reflector is around 100 lumen/W (energy efficiency = 15%). The installed energy efficiency will experience further drops.

Fig. 1 gives the increase in energy efficiency of LEDs (represented by lumen efficiency lumen/electrical Watt and denoted as lumen/W). One of the factors responsible for penetration of LED lamps is because steep drop in cost of solar photovoltaic power packs. Fig. 2 gives the decrease in unit cost of crystalline and amorphous silicon SPV and LED from 2000 and projected up to 2020.

The rate of increase of temperature in the LED is given by,

The heat generation is from the LED system (inclusive of driver) and the heat dispersion is from the heat sink and from thermal dispersion.

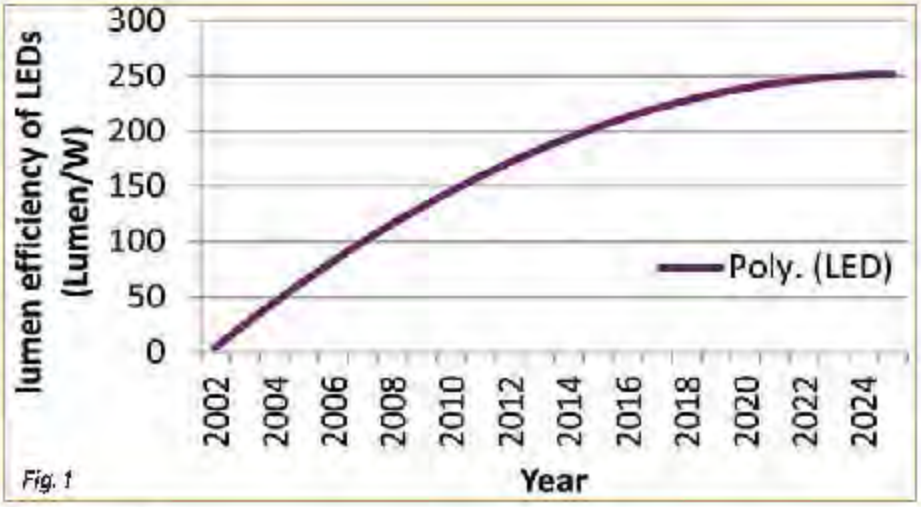

Fig. 1

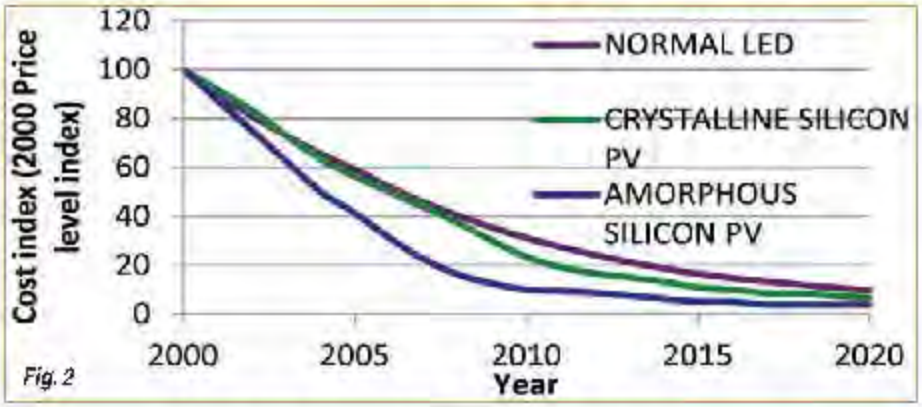

Fig. 2

$dT/dt = (dQ_{LED\ system}/dt) - (dQ_{sink}/dt) - (dQ_{dispersion}/dt)$

The heat generation is from the LED system (inclusive of driver) and the heat dispersion is from the heat sink and from thermal dispersion. While the thermal dispersion is a small quantity (15% of the heat generation) the bulk of the heat is to be dispersed through the heat sink. Inadequate or inefficient heat sink will result in rise in temperature which will cause loss of performance as discussed below.

The increase in junction temperature is on account of either excessive generation of heat or inadequate withdrawal of heat.

The heat generation or thermal load (q) (W) of the LED emitter/source/engine of electric power input of P (W) is given by,

$$q = \left[1 - \left[\frac{\varepsilon_{emitter}}{668.45}\right]\right]P \qquad (3)$$

For a typical LED with a lumen efficiency of 100 lumen/W the thermal load is 85% of the input electric power to the emitter (after subtracting of the thermal loss in the driver). Heat sinks must be designed of conditions of higher power and lower lumen efficiency.

The thermal load (q) (W) of the driver of rating P (W) is given by,

$$q = [1 - (\eta_{driver})]P \qquad (4)$$

The driver thermal load is the fraction of the electric power absorbed in the driver as heat which is typically between 2% to 15% of the input electric power.

Inadequacy in the heat sinks in the LED emitter and increase in temperature of the electrolytic capacitors at the output stage of the LED drivers also lead to Increase in junction temperature (over the design temperature).

The parameters which characterize the performance of LEDs and represented in the LM-79 standard are:

- Lumen output
- Electrical Power input
- Energy Efficiency
- Chromaticity
- Intensity distribution.

In addition in LM-80, life cycle testing of 6 kh in intervals of 1 kh is involved. TM-21 uses inputs from LM-80 for estimation of lumen maintenance beyond 6 kh.

The lumen output of LED is directly proportional to the driving current as given by,

$L(T) = L_0 - K_1 x I(T)$

Where K_1 is a constant giving the rate of lumen drop (lumen/A) and the current (I) is a function of the operating temperature.

Among LEDs of different colors blue and green LEDs (InGaN) are not much sensitivity to temperature while red and amber (AlGaInP)

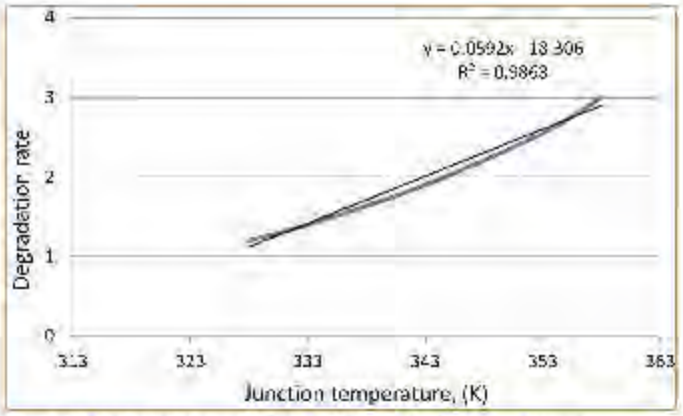

Fig. 3: Variation of degradation rate with junction temperature

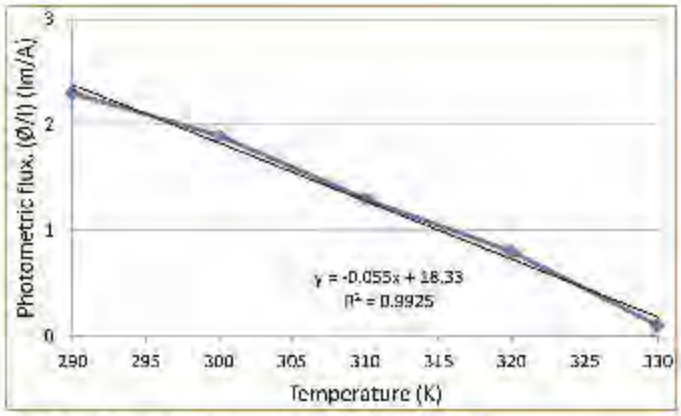

Fig. 4: Variation of photometric lux with temperature

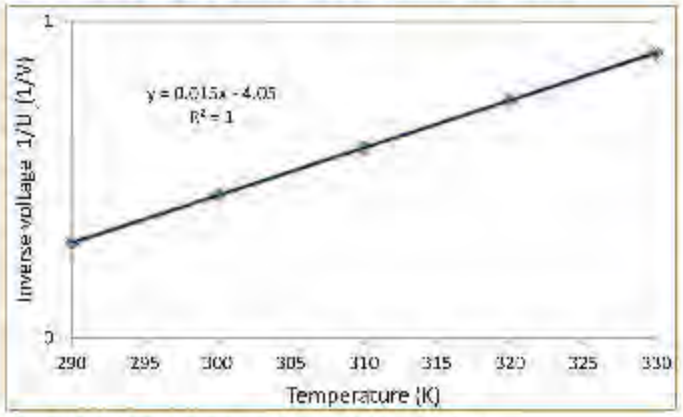

Fig. 5: Variation of inverse voltage with temperature

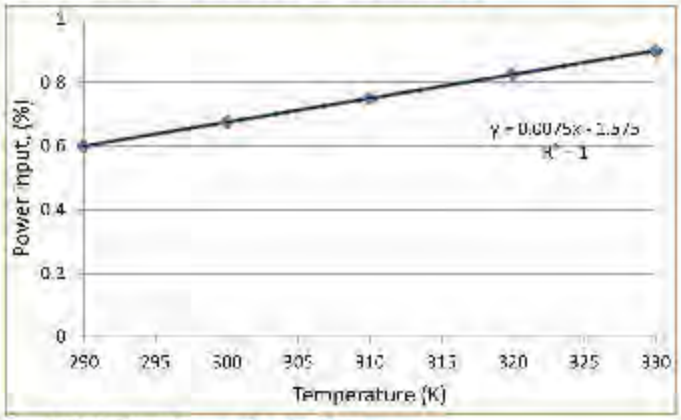

Fig. 6: Variation of power input with temperature

are highly sensitive. Thus, in a three colour system, the three LEDs respond differently to temperature. This factor has a bearing on the colour rendering index of the composite while LED. The sensitivity of wavelength to temp. is in the range of 0.05 to 0.15 nm/^{O}C

The forward voltage and driving current are governed by a linear relationship as,

$I(T) = A_0 + A_1 \times V(T)$

The constant A1 is 0.101 A per V.

As the LED temperature increases, the forward voltage drops as given by the relationship,

$V(T) = V_0 - K_2 \times (\Delta T)$

Where K_2 is a constant. The constant K_2 is 0.015 V per degree K Generally, a decreased current causes decreased lumen output. In a constant power environment, the controls will result in increased current which restores the lumen level but further increases the operational temperature sometimes leading to thermal run away.

Figures 3, 4, 5 & 6 give the variation of degradation rate, photometric flux, inverse voltage & power input with junction temperature.

Typical performance limiting factors in LED systems caused by temperature rise are:

- Reduced capacity factor as forward current and lumen output are decreased. The constant for flux per unit current is -0.05 lumen/A per K.
- Thermal stresses and thermal fatigue caused by temperature ramp rates going beyond the permissible values leading to life reduction.
- Reduced energy efficiency (lumen/W) The flux per unit current is reduced. The factor is -1.65 lumen/A per A. The power consumption is reduced because of reduced current as -3.4% per A & -0.007% per K.
- Reduced light quality (color temperature & CRI). The light output degrades with operation at higher temperature. The degradation rate is enhanced by +0.06% per K.

Figure 7 gives the buildup of temperature in a LED lamp measured through thermography.

Figure 8 gives views of different types of heat sinks.

Figure 9 gives views of solar powered LED lamp systems.

The lumen efficiency, heat generation rate and heat dissipation rate of the LED system are dynamically coupled. If the lumen efficiency is low, the heat generation rate will be high. If the heat dissipation rate is in adequate, then there will be rise in the temperature across the junctions which will further decrease the lumen efficiency and lead to further heat generation. The equilibrium is achieved by the heat sink performance. The design of the heat sink plays a major role in halting the degradation of not only the energy efficiency but the system life. As the temperature of the driver components (key points) increase from 100^{O}C to 180^{O}C, there is non linear reduction in life from 10 kh down to 0.1 kh. The mean time between failures [(MTBF) -the total operating time duration divided by the number of failures] applies to the whole system and not for individual components.

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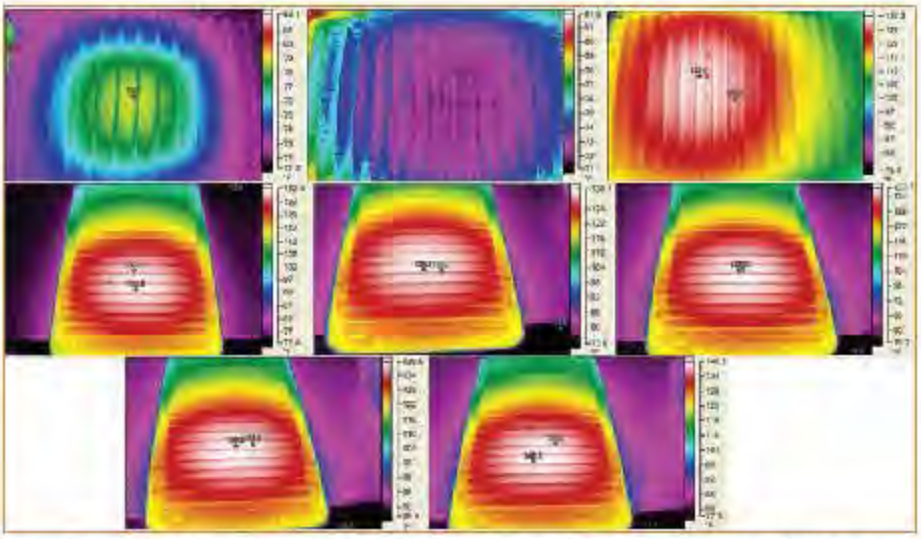

Fig. 7: The buildup of temperature in a LED lamp measured through thermography for 6 hour

Fig. 8: Views of different types of heat sinks

Fig. 9: Views of solar powered LED lamp systems

is through heat sinks of copper or aluminum or metal composites with air cooled fins or forced cooling (fans). LEDs are epoxy packed and the connection pins are used as heat sinks to dissipate the heat. If the thermal balance is maintained, i.e., the rate of heat dispersed is equal to the rate of heat generated, then the life of the LEDs will be unaffected by the heat generation. Otherwise there will be temperature rise leading to degradation of life and performance.

To compensate for lumen depreciation over time, variable drive current system are developed but this can result in acceleration of life, enhance power input and decreased energy efficiency. Epoxy die mounting or eutectic mounting techniques lead to better heat dispersion and thermal management.

LED lighting systems in present use-some results

In the case of nonlinear degradation, the constant will be second order dependent on the hours. As mentioned earlier with increase in operating temperature the degradation rate increases at +0.06% per K.

The linear degradation rates are as follows	
Hours to attain 70% of the lumen original level	Degradation rate
10^5 h	-3×10^{-4}%/h
50 kh	-6×10^{-4}%/h
34 kh	-9×10^{-4}%/h

Temperature gradients and thermal cycling play a role in the acceleration of the degradation of LEDs. The degradation curve also exhibits a sag from its linear behavior due to thermal up gradation.

Discussion and Conclusions

Heat generation and its inadequate dispersion results in creation of thermal gradients in the LED and its components which results in decrease in energy efficiency, aberration of the colour rendering and acceleration of lumen depreciation.

Profile

M Siddhartha Bhatt

is Additional Director and Divisional Head of Energy Efficiency & Renewable Energy Division of CPRI, Bangalore. He has published over 45 international papers in the area of energy efficiency and one book. He has developed several energy products and holds 5 patents and received many awards such as Award for Science and Technology, CBIP Best paper Award etc.

K Pradeep

is working as Engineering Assistant in Energy Conservation & Development Division, Central Power Research Institute, Bangalore. His industrial experience includes energy auditing and energy efficiency in thermal power plants, hydro power stations, process industries, and electrical distribution system. He is working in the area of testing and certification of solar photovoltaic lighting systems.

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Artist's impression of SAHMRI's facade. Photo courtesy of SAHMRI.

South Australian Health and Medical Research Institute (SAHMRI)

Creating a diamond standard in health and medical research

Medical research generates new ideas and innovation every day. To swiftly incorporate these developments into healthcare delivery, the South Australian Health and Medical Research Institute (SAHMRI) is building an innovative 25,000 sq mtr facility, designed to foster researchers' creativity and productivity. Together with Schneider Electric Life Sciences solution experts, SAHMRI will realise its vision of a highly intelligent and responsive facility.

Already destined for icon status on the Adelaide city skyline, SAHMRI's diamond shape construction, elevated on flower columns, also features a pine cone inspired transparent skin to allow in plenty of natural light into the building. It features wet and dry laboratory areas, modern research areas and even a medicinal garden.

By working with Schneider Electric, SAHMRI will maximise operational efficiencies and energy conservation, ensure a reliable and secure environment, reduce risks and achieve regulatory compliance and green building certification. The ultimate aim is to create a world-class facility where experts will be able to rapidly translate medical research results into health outcomes for patients.

The Challenge

The ideal facility needs to provide capacity to respond to new and emerging research challenges, foster innovation and improvements in research services. Enabling this requires a purpose-built, iconic facility for health and medical research, with state of the art laboratories and equipment.

"We need environments that encourage creativity, the right temperature, right lighting and right systems to ensure researchers are at their best, most creative and productive," says Professor Steve Wesselingh, Executive Director, SAHMRI.

It is a theme reiterated by Michelle Gheorghiu, SAHMRI Project Director, "We are creating a hub of knowledge to imbibe passion into the young generation about research."

The Solution

EcoStruxure: An Integrated Building System approach

Key to the building's success was early engagement with Schneider Electric and the company's EcoStruxure architecture during the design phase. EcoStruxure provides a solid foundation for an Integrated Building System (IBS), bringing together five key domains: power management, process automation, building management, IT management and security.

The IBS integrates the most innovative building technologies such as heating and cooling, hydraulics, lifts, fire monitoring, electrical monitoring, lighting, security, & lab controls, to maximise building performance, energy efficiency and ongoing cost savings throughout the facility's life cycle. It also provides a safe and secure environment for researchers, visitors, and staff improving their experience, satisfaction and operational productivity. This unique system will easily accommodate future technologies and regulatory changes.

By working with Schneider Electric, SAHMRI will maximise operational efficiencies and energy conservation, ensure a reliable & secure environment, reduce risks and achieve regulatory compliance and green building certification.

SAHMRI's Integrated Building System (IBS) has started as a concept to align the importance of technology and innovation in delivering a flexible and adaptable facility, responsive to the needs of a world-class research environment. The integrated platform has evolved from a design concept, into a fully integrated system where all building services communicate and are accessed on a single platform. The IBS design philosophy is to provide a holistic system architecture which will bring together these services, to improve building efficiencies and play an integral part in extending the life of the building.

The IBS also provides maximum efficiency through a collaborative design, construction, and delivery process, utilising innovative 3D building information modelling (BIM) software. This avoids design changes and rework and ensures sustainability and optimisation of the facility's operation post construction.

Schneider Electric's intelligent building solution for SAHMRI is based on the success of its Andover Continuum technology. Andover Continuum is an internationally recognised integration and building management platform that allows the facility operator to monitor and control heating, ventilation, air conditioning, humidity, lighting, power, access control, video, lifts and other security features across the facility.

End users within the building can view and control any of the services via the Magelis human machine interface (HMI) touch screens located throughout the building. The screens employ 3D graphics and provide a simple and effective means of connecting systems, collecting data and presenting information.

Integrated security solution

Schneider Electric's integrated security offering including smart card access control, close circuit video management and high-definition cameras, and monitoring provided a very safe, flexible and secure solution, attractive to SAHMRI.

AHMI's impression of SAHMRI's internal cafe. Photo courtesy of SAHMRI.


Artist's impression of SAHMRI's laboratories. Photo courtesy of SAHMRI.

Each smart card can be programmed to allow access to designated areas only for key personnel and prevent entry to restricted areas such as the laboratory.

The Video Management System designed for SAHMRI deploys the latest in Pelco by Schneider Electric's high-definition cameras, with increased capabilities for video analytics and identification – more than standard resolutions. More than 55 cameras have been specified for this site, based on a fully integrated platform incorporating intercom networks.

Intelligent lighting control

Another key part of the EcoStruxure architecture is the Clipsal by Schneider Electric DALIcontrol lighting control system, designed to maximise energy efficiencies in the building. DALI is an open control protocol system that ensures compatibility between lighting and control devices.

Although there are key scenes programmed into the building, the system also allows for customised programming in research areas that require constant lighting to simulate daylight levels of light.

DALIcontrol also includes an emergency lighting solution. Test sequences have been scheduled into the operation and provide reports to the facility operator to confirm that the evacuation lighting is functioning properly. Clipsal by Schneider Electric has also supplied energy efficient exit light fittings for the entire building.

A reliable emergency power supply

It is critical in medical facilities to have the assurance that the backup power system will perform in an emergency. Schneider Electric's Emergency Power Supply System (EPSS) test solution provides automated analysis and accurate reporting as well as complete power system information. It tests the back-up generator supply and gives reports on the precise timing of transfer switches, the condition and health of the generator, monitors EPSS load levels and duration of test, It makes manual testing obsolete, saving time and also collecting data during real outages. This ensures that the system is healthy and will perform if and when needed. The EPSS test solution increases patient safety by reducing the chance of an EPSS failure due to human error or inadequate manual testing procedures. To further increase SAHMRI's standing as a modern facility Schneider Electric worked with the design team to install their EPSS test solution into the facility.

Power interruptions also have the potential to create data loss and hardware damage to all communications and computer equipment. With 18 communication hubs located throughout the SAHMRI building, Schneider Electric is providing uninterruptible power supplies (UPS) to maintain power continuity and protect vital communications equipment such as computers, data centres and telecommunication. Each UPS is networked to the IBS for instant monitoring and status.

A monitored power network

Many clients are now asking for more functional energy monitoring and reporting capabilities as part of their electrical distribution network and SAHMRI is no exception. Schneider Electric included their new StruxureWare Power Monitoring 7.0 (SPM7) energy management software platform to better integrate SAHMRI's energy metering. To achieve even better Power Quality and reliability outcomes for SAHMRI, Schneider Electric collaborated with electrical contractors, Nilsen to upgrade the metering hardware to allow for better Power Quality event diagnostics and therefore ensure a shorter 'mean time to repair' should any electrical network issues arise. SMP7 will allow the SAHMRI to monitor the entire installation from the Utility Grade Power Quality (PQ) Meter on the main incomer, to the PQ meters on the Sub sectional feeders; and via low voltage Masterpact air-circuit breakers and Compact NSX moulded case circuit breakers fitted with Micrologic control units installed on key sub mains. SAHMRI's project design team including electrical services


Artist's impression of SAHMRI by the river. Photo courtesy of SAHMRI.

Project at a Glance

Project Type
Integrated Building Management and Security Solution

Location
North Terrace, Adelaide, South Australia.

Applications
- Intelligent Building Management System
- Integrated Security: Access Control, CCTV monitoring
- Clipsal DALI control lighting control
- StruxureWare Power Monitoring 7.0 (SPM7) & PowerLogic ION metering system
- Masterpact air-circuit breakers & Compact NSX molded case circuit breakers with Micrologic control units
- Emergency Power Supply System (EPSS) Test solution
- Magelis Human Machine Inter face
- Altivar Variable Speed Drives
- Uninterruptible Power Supplies (UPS).

Customer Benefits
- Interoperability, scalability, reliability, and flexibility in operation
- Outstanding energy efficiency
- Sustainable, world-class infrastructure control systems.

consultant, Aurecon also ensured sub-metering was installed strategically in specially designed distribution boards, to separately meter the power and lighting chassis. Thus making it easier to identify energy wastage, act on opportunities, improve efficiencies, discriminate energy consumption per level, per pod and to comply with SAHMRI's energy efficiency expectations.

SMP7 offers real time power quality & energy monitoring and is able to alarm and report by exception using its various out of the box and customisable reports that a user can subscribe to. SPM7 is also able to present a user with an easy to interoperate energy dashboard display to indicate how a facility is performing against its energy usage targets and carbon emission targets.

By adopting an EcoStruxure approach the SAHMRI design team could foresee the further operational & maintenance benefits by combining SPM7 with a fit for purpose Schneider Electric Medium & Low Voltage electrical distribution system. Schneider Electric partnered with local energy solution integrator AZZO to deliver this integrated technological solution to maximise the functionality and efficiency of the SAHMRI's electrical distribution network. The key distinguishing factor for Schneider Electric with this type of integrated circuit protection and monitoring system is that no other manufacturer can offer this one package.

More drive for less input

A facility such as SAHMRI requires an enormous number of pumps, fans and motors to ensure the HVAC system is operational. These consume vast amounts of energy, however the SAHMRI design team has conserved as much energy as possible with the addition of Schneider Electric's Altivar variable speed drives. These will limit energy usage on start up and allow for the precise control of heating and cooling through the IBS achieving further efficiencies, whilst extending the mechanical life of the equipment.

Team of local experts

Local representation was an important prerequisite for SAHMRI as in the event of any technical issues, Schneider Electric could quickly resolve them and limit any project delivery delays. Schneider Electric provides this unique combination of local support and back up with with global access to world leading expertise in technology implementation, and therefore is ideally suited to healthcare and life sciences.

Meeting certification standards

Schneider Electric's solution also helps the SAHMRI building meet Leadership in Energy and Environmental Design (LEED) certification standards. This is a globally recognised standard in ensuring that a building project is environmentally responsible, profitable and a healthy place to work.

Bottom line

The building is a diamond example of how a holistic approach, based on Schneider Electric's EcoStruxure architecure is poised to create great energy efficiencies and intelligent building systems for the long term.

Courtesy: Schneider Electric

Life Cycle Cost Analysis

A Step towards Strengthening Knowledge to assess the Power Plant Investment Decisions

Recent trends in the investment in energy sector required the decision making capability for a healthy economy. The international framework of United Nations Environment Program (UNEP) targets the mandate to become the leading global environmental authority that sets the global agenda and promotes the rational implementation of the environmental dimensions of sustainable development.

Dr Ambika Prasad Dash

The Society of Environmental Toxicology and Chemistry (SETAC) is a non-profit, worldwide professional society comprised of individuals and institutions engaged in conducting the study, analysis, and solution of environmental problems, management, regulations of natural resources, environmental education and the research and development. UNEP and the SETAC launched in 2002 an International Life Cycle Partnership, known as the Life cycle initiative (LCI), to enable users around the world to put life cycle thinking into effective practice. Thus the business guide to sustainability provides the linkages between the effective use of resources with better capacity to have better understanding and difference critical approach to deal with the shortage of resources.

The Life Cycle Costing (LCC) analysis allows utility to examine projected life cycle costs for comparing competing capital and O&M project solutions and allows for appropriate comparison of alternatives of different capital values, and

lengths of time. Given the condition of the utility's assets, the amount of capital available from the budget, and historical evidence, the project manager must decide which project alternatives will incur the least life cycle costs over the life cycle.

LCC analysis allows utility to examine projected LCCs for comparing competing capital and O&M project solutions and allows for appropriate comparison of alternatives.

Life Cycle Initiative

UNEP

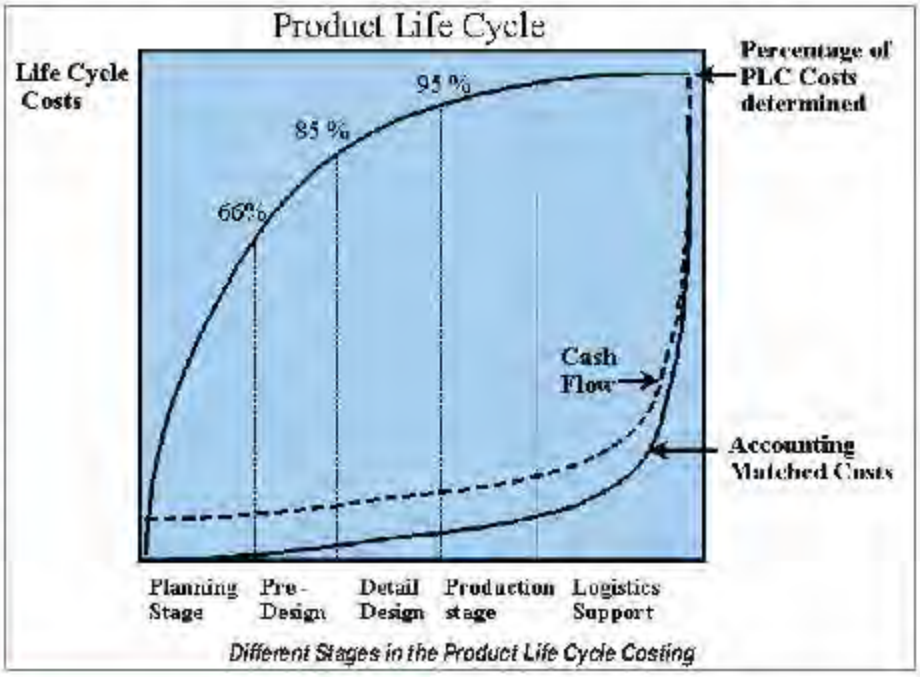
SETAC

What is life cycle costing?

Life Cycle Costing or LCC is a technique developed for identifying and quantifying all costs, initial and ongoing, associated with a project or installation over a given period. The full cost of a project includes projections of future interest and inflation rates, maintenance intervals and costs, and the desired service life. Materials costs are assessed taking into consideration such long- and short-term factors as initial outlay, maintenance and its frequency, downtime effects, production losses, repair, replacement, and other operationally related costs such as manpower & energy consumption. LCC uses the standard accounting principle of discounted cash flow, so that total costs incurred during a life cycle period are reduced to present day values. This allows a realistic comparison to be made of the options available in choosing the most cost effective material.

Why life cycle costing!

Experience has shown that the costs associated with a product of both future maintenance and associated downtime can far outweigh the initial material costs. A full life cycle cost analysis enables the materials specifier to consider the full implications of future costs over the life of the project both in terms of actual monetary value & inconvenience of future maintenance and replacements. The graph below illustrates that the cost of Alternate Materials A and B substantially increases over time while the cost.



Different Stages in the Product Life Cycle Costing

Why is LCC important to a utility!

The LCC analysis allows utility to examine projected life cycle costs for comparing competing capital and O&M project solutions and allows for appropriate comparison of alternatives of different capital values, and lengths of time. Given the condition of the utility's assets, the amount of capital available from the budget, and historical evidence, the project manager must decide which project alternatives will incur the least life cycle costs over the life cycle.

Understading LCC from the examples

When evaluating capital investment options, using LCC can help you determine the option which is most cost effective. Rather than evaluating projects solely on the basis of initial costs, LCC looks at the total cost of owning, operating and maintaining a project over its useful life (including its fuel, energy, labour and replacement components). Life cycle costing calculates operating and maintenance costs incurred during the lifetime of the project plus the initial capital costs. Life cycle costing often shows that a project with a higher initial cost may be more financially beneficial in the long run. It is especially useful for evaluating energy efficiency projects since they often require a higher initial investment but have lower operating and maintenance costs over the life of

the project. By overlooking the purchase of energy-efficient products because their initial costs maybe higher, businesses may save money in the short-term but will end up paying more for the project through higher energy costs and other operating costs over the life of the project. The basic formula for calculating the LCC is given by:

Life Cycle Cost = Initial Cost + (Annual Cost x Project Life x Discount Factor)

Few terms associated with the estimation of LCC:

NPV = Net present value which is the value today of future cash flows.

IRR = Internal rate of return. The higher a project's internal rate of return, the more desirable it is to undertake the project.

Pay-back time = the time span required to recover the cost of an investment.

Discount rate = the rate of return that could be earned on an investment in the financial markets with similar risk.

The following examples give the better understanding about the concept.

Let say Company (X) is considering whether to pursue Project (A) or Project (B) where Project (B) has an initial cost of $2,000, while Project (A) has an initial cost of $3,000. Company (X) is more inclined to take on Project (B) because of the perceived lower cost. However, a applying the life cycle cost formula will help Company (X) determine if Project (B) is truly more cost-effective than Project (A).

Sr. no.	Project Cost Components	Project A (Rs.)	Project B (Rs.)
a)	Initial Cost	3000	2000
	Annual Cost		
	Electricity Cost	150	250
	Maintenance Cost	50	150
b)	Total (Annual Cost)	200	400
c)	Project Life	15	15
d)	Discount factor (Based on the Interest Rate of 3%)	0.64	0.64
e)	Calculations	(a) +(b) * (c)* (d)	
	Total Life Cycle Cost (LCC)	4920	5840

As the above comparison demonstrates, the lowest initial cost does not lead to the lowest cost overall. Project (A) is the more cost effective option to pursue. Thus in general if the project is having different cost components, as in the case of thermal and solar power projects, the LCC analysis may be carried out and it is case to case vary as per the assumption taken in to consideration. However, the general formula for estimating the LCC is given by:

$$\text{Life cycle cost} = AC + IC + \sum_{n=1}^{N}\left[\frac{\alpha}{(1+i)^n}\right] + \sum_{n=1}^{N}\left[\frac{LP}{(1+i)^n}\right] + \sum_{n=1}^{N}\left[\frac{RC}{(1+i)^n}\right]$$

Where,

AC = Initial materials acquisition costs

IC = Initial fabrication and installation costs

N = Desired service life of project in years

i = Discount rate (calculated from interest and inflation rates)

OC = Operating and maintenance costs in year (n)

LP = Lost production and downtime costs in year (n)

RC = Replacement costs in year (n).

Once the cost data have been gathered, the calculation of the LCC is straightforward. Software/Simulation packages are available which prompt the user to collect the relevant data, carry out the calculations and allow different options to be compared easily.

Salient points on importance of LCC technique in power & energy sector

- First issues are too much emphasis on financial returns

After the much heated debate on global warming worldwide, there is an overwhelming consensus among developers/ procurers to factor in the socio-economic costs associated with different alternatives. Traditional pay back method completely avoids this critical aspect. Such gains/costs need to be demonstrated for wider acceptability of LCC method over the still being used pay back methodology. Apart from calculating the Net Present Value (NPV), Internal Rate of return (IRR) for a project, LCC can be extended to introduce the concept of Economic Internal Rate of return (EIRR) which gives a much more holistic picture of actual costs from the economic perspective.

- Second issue is top inclusion of renovation and modernization(R&M) cost.

In the currently used pay back methodology, the focus is on the time period when the entire costs are recovered i.e. the pay back threshold. However, for assets like generation assets, lifetime is often enhanced by undertaking R&M at the end of asset life. Such costs are very important but often ignored. Hence, there is a wide scope for introduction of LCC methodology in valuing power generating alternatives which we intend to explore. Though many businesses are aware of benefits of LCC methodology, its applicability is far from being systematic and calculation methodologies are far from being robust because of data constraints in most practical research on the subject. As a result of no clear demonstrations on the subject, Developers are not able to use LCC to make more sustainable & strategically advantageous decisions. The above analysis highlights that the decision makers get carried away by immediate gains and if more practical and mathematical findings on benefits of LCC are established, they will be able to make more sustainable and financially viable investment decisions.

LCC analysis of thermal power plants

The long term global trend towards increasing demand has put ever growing pressure on power supply investment decisions. Even though electricity is not explicitly mentioned in Maslow's hierarchy of needs, one can easily understand the importance of power supply security for the wellbeing of the population. (Maslow's hierarchy of needs is a theory in psychology proposed by Abraham Maslow in his 1943 paper "A Theory of Human Motivation" in Psychological Review).

Due to the recent turbulence in the financial markets and the subsequent global investment hesitation, decisions are now being made faster than ever for areas in need of electricity to secure a sufficient supply, but slower than ever elsewhere. Consultants and decision makers tend to assess the alternatives the easy way by looking only at today's price tag, and are less

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concerned with the effects of lifecycle costs and their impact on the long term profitability and competitiveness of the power plant. Determining the LCC has become an art in itself, thanks to the various characteristics of the different means of power generation. At one end we have renewable energy sources, like wind and hydro power, with high capital expenditures but low operational costs. Then there are small, diesel-fired generators, which have quite the opposite cost structure, with reasonably low investment costs but having modest efficiencies and expensive fuel. The purpose behind the plant also has an effect on the LCC. It may be a developer looking at an Independent Power Producer (IPP) project, or perhaps an industrialist looking to increase his own electricity production capacity. Different decision criteria apply when planning investments in new power generation. Nonetheless, the key criteria when choosing the optimal power generation technology are still the basic parameters of net present value (NPV) of project cash flows, the internal rate of return (IRR) in relation to the perceived risk of the investment, and pay-back time. Hence, understanding the concept of LCC, as well as the accuracy of the assumptions underlying the LCC calculations, remains crucial for power industry decision makers.

Role of assumptions

The role of assumptions In order to analyze different options for electricity production, LCC financial models is used. However, the results of a model, be it at any level of complexity, is never better than its inputs. It is always matter of a questioned that the more sophisticated and detailed the financial model is, the more accurate the calculated results will be. This is unfortunately not the case, as the calculated results will always depend on the reliability of the underlying assumptions. By considering the fuel cost component, which is usually the largest component of the LCC in thermal power production, it is not enough merely to know what the fuel consumption of the proposed power plant will be on day one; i.e. the CERC heat rate guaranteed by the EPC contractor or the manufacturer. Thus it is also needed to evaluate the impact of time and ambient conditions on the actual heat rate during the full lifetime of the power project.

LCC parameters for thermal power project (Project A)

The LCC of a power generation facility incorporates all foreseen costs associated with the acquisition and the long-term ownership of the asset over its entire life. The up-front acquisition cost is usually the most easily quantifiable, and also the single largest factor in the LCC. But it is certainly not the only item, nor necessarily the largest component of the total LCC seen over the measured time period. The list of parameters varies a lot but most drivers can nevertheless be summarized under the following headline.

Capital cost related parameters

- Up front investment costs (equipment, buildings etc.)
- Implementation time (engineering, development, construction etc.)
- Debt parameters (interest during construction, interest rates, debt service reserves etc.)
- Other costs (fuel reserves, working capital, consulting etc.)
- Contingencies granted by the regulators or the Government.

Fuel cost related parameters
Fuel price and quality
Plant efficiency
New and clean" vs. lifetime efficiency
Part load efficiencies
Start up time and efficiency impact
Load following capabilities and efficiency impact
Plant output
Derating over time (heat rate and power output)
Ambient conditions

Operating parameters
Variable costs related to generation
Fixed fees irrespective of generation
Fuel flexibility
Availability and reliability.

Cost components and project details of a typical thermal power project

Of these parameters the consequences of part load, ramp-up, and load following are the ones most likely to be disregarded by evaluators, even though they play a crucial role in the LCC calculations. However considering above facts, the total LCC of the plant is estimated as given in the table. Some renewable production forms, such as wind and solar, are not exposed to the price of fuel but rather to the availability of their

Cost components of thermal power plant		Tariff components 2009-14	Remarks / Assumptions
A	Capacity Charges		
	Return on Equity	15.5	Pre Tax, allowed additional. 5% of project commissioned after April 2009
	Interest on loan capital	As per actual	DER: 70:30 (Re- financing - 1/3 benefits retention allowed)
	Depreciation	5.28%	Previously, AAD/ Presently (3.6% to 5.28%)
	Interest of working capital	Based on normative parameters	Coal stock, SFOS, Sales Receivables, O&M Expenses, Maintenance Spares,
	Operations and Maintenance Costs		Rs. Lakhs /MW (13 for MW) / For multiple units -Multiply reduction Factor
	Cost of Secondary Oil		Based on parameters & on PAF
	Special allowance in lieu of Renovation & Modernization		Added to previously approved gross block to determine future tariff / Now avail beyond the useful life of the plant
B	Energy Charges	Based on normative parameters (CERC Regulation)	
	Plant load factor (PLF)	0.85	
	Gross station heat rate (500 MW & Above Capacity)	2425	
	Specific fuel oil consumption (ml./KWh)	1	
	Aux. consumption (500 MW & Steam driven)	6.5	

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Sl. no.	Cost Components	Sub-Components	Rs. Cr.
1.	Capital Cost	-	6,000
2.	Running Cost	O&M cost	1,072
		Coal cost	14,519
		Oil cost	1,42
		Int. on term loan	1,385
		Int. on working capital	3,27
3	Terminal value (10% SV)	-	6,00
	Total LCC value	-	22,846

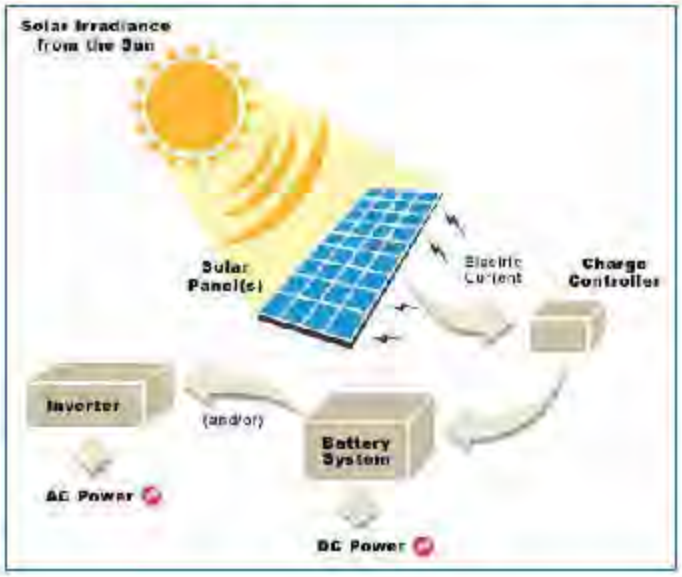
Total LCC of Thermal, Project A

respective natural forces. Calculating their LCC deviates considerably from that of thermal power production because of their nature of high unpredictability, and will not be further commented upon in this article.

The empirical results and analysis includes Defining and selection of regulatory time period of the study in both the case of thermal power plant and solar power plant, estimating the all cost components at the present values on the concept of time value of the money. The analysis includes NPV of the total cost followed by total value of LCC of the project.

Various cost components and assumptions in typical Solar PV - power plant

In the pursuit of a cleaner and sustainable environment, solar photovoltaic (PV) power has been established as the fastest growing alternative energy source in the world. This extremely fast growth is brought about, mainly, by government policies and support mechanisms world-wide. Solar PV technology that was once limited to specialized applications and considered very expensive, with low efficiency, is becoming more efficient and affordable. Solar PV promises to be a major



contributor of the future global energy mix due to its minimal running costs, zero emissions and steadily declining module and inverter costs. The various cost components has been considered in different way to look up to calculate rough LCC in different countries. The replacement and maintenance cost of the battery has significant cost and present values of the same contributes much in assessing the rough LCC of the project. In the given calculations the same has not been considered.

As per the detailed report of 5 MW Solar PV plant exists in the northern part of the county, the total energy available to the grid yearly as per METEONORM data is around 7.26 Million Units. On estimating the LCC of the solar power plant, it is assumed that no maintenance and replacement cost is invested over the period. Simply, the capital and operating cost for the plants have been considered.

Camparision of LCC values

Cost components particulars of a typical 5 MW Solar PV plant	Capital cost for Solar PV Project (Rs. Lakhs/ MW)	% Total cost
PV modules	344.5	0.43
Land cost	16.8	0.02
Civil & general works	94.5	0.12
Mounting structures	105	0.13
Power conditioning units	60	0.07
Evacuation cost	105	0.13
Pre-operative & Interest during construction (IDC)	80	0.1
Total capital cost	805	1
# Operating cost	58.15	-

Cost components and project details of a typical Solar power project (Project B)

Sr. no.	Cost description of solar project	Rs.
1.	Capital cost	80,50
2.	Operating cost	5,80
3.	Total LCC Cost (Rs. Cr.)	86,30

Total LCC of (Solar, Project B)

After making relevant assumptions in both the case of LCC application estimations, the total LCC for a solar power plant is approximately 2.5 less than that of a thermal power plant of equivalent capacity i.e. 1000 MW. This lesser factor is high on the assumptions that no maintenance and replacement cost is invested over the period. The above LCC of solar is estimated and extended at the capacity of 1000 MW for the comparison purpose.

The assumptions in the applications have very important and the accuracy of LCC analysis diminishes as it predicts further into the future. While the technique is little time consuming as one has to have fair idea about the tariff structure of the technology used. During the literature

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survey, it is found that for making the analysis at the micro levels, the sensitivity analysis may be carried out using the few software applications available free of the cost. For assessing the close values of total LCC, the model may be incorporated and simulation work can be done to have better picture on the application area.

Limitation of LCC applications

Using and application of LCC could increase propagation of knowledge for taking effective decision towards sustainable energy systems and help enable governments to enact long-term energy policies. The importance and benefits of such methodology in using sustainable energy systems are clear but creating a policy framework to achieve those goals remains a challenge for all countries. These challenges may include the complex tariff structure and cost components and lack of manpower to handle the new technologies. The limitation of the paper is that the accuracy of LCC analysis diminishes as it predicts further into the future and is time consuming. However for projecting and comparing the nearest LCC values, one can have the simulation based approach, but again LCC is an expensive concept, not appropriate for all applications.

In case of power from Solar energy, sometimes the direct normal irradiance in the prominent states has been questioned which is dominating factor for estimating the generation cost from the module. Governments view the energy industry as a key player in managing the technological and behavioural change needed to realize sustainable energy systems. By providing information about evolving energy options, the cost of energy, the benefits of new technologies, and the need to foster energy efficiency, the clear cut investment approach in alternative energy resources can support this transformation. Lastly, the effective application may be useful for development of the draft guidelines based on the more comparatively study. These guidelines define LCCA, explain their relevance to the plants, projects, and instruct plants /project teams on their implementation to adopt least energy cost and further this may provide technical specifications for preparing LCCA studies in India. But it will always be restricted to the assumptions taken for the LCC applications.

Profile

Dr Ambika Prasad Dash

FDPM from IIM Ahmedabad, is presently working as Sr. Faculty/ Professor in the area of Finance& Strategy, in Power Management Institute (PMI) of NTPC Ltd. Apart from teaching at PMI, he has been visiting faculty at institutes like FMS, Delhi, MDI, Gurgaon, IMT Ghaziabad, and International Management Institute, New Delhi. He has produced 08 PhD Students. He is the National Expert in Management for UGC in UGC-NET and got best faculty award from AIMA-NMA, has published six books.

Interview

"Best support to power utilities, industry and all our customers in India"

Yuji Hamasaki, President
Meidensha Corporation

MEIDENSHA CORPORATION has sought to better serve society devoting itself to developing a wide array of technological innovations, products and services through its role as an electrical equipment manufacturer. Its business domain covers social infrastructure systems, industrial systems, engineering systems and real estate. It has Meiden India Pvt Ltd, as one of the overseas office of Meidensha, Japan. In an exclusive interview to **Electrical India, Yuji Hamasaki,** states, the biggest challenge is to improve our price competitiveness while maintaining the product quality.

➢ **On a brief note tell us about Meidensha Corporation and consolidated subsidiaries worldwide?**

We are a major player in power generation, transmission and distribution, as well as social infrastructure systems and industrial control systems in Japan with a history of 117 years. Outside Japan, we are an established player in power transmission and distribution business especially in Southeast Asia. We have 5 consolidated companies in China, 7 in Southeast Asia, 2 in the US and 1 in the UK. For non-consolidated companies, we have 1 in Korea and another in India.

➢ **You offer different products for all system business, define your views towards Indian market?**

Many of our products and services are for social infrastructure markets, such as electrical power, water treatment, and general industries. This seems to be a perfect fit for present Indian needs. Having said this, India is a very tough market to enter. In order to be accepted in India, you must have an established presence in the market and product designs and costs that match the requirements of the Indian market.

➢ **What has led you to the investment in an Indian transformer company and how much you expand and cover the part for investment?**

India has been very appealing to us, because it is a young country with a huge population and vast land, offering a lot of business opportunities with a good margin for growth for our business for many years to come. We thought it the best to enter this Indian market with T&D products, in particular, transformers and switchgear, which we have many years of experience and expertise in Southeast Asia. This time, we have invested in a transformer company, since we have met a good partner to work with on a long-term basis. We will look to the possibility of a further alliance with them on other products, which we hope will help Prime Meiden become an established T&D company in India.

➢ **What are the plans of your company towards the Indian market?**

We will concentrate on the T&D business for the time being, and in future, or at any time we find appropriate, we will expand our focus to other areas, too.

➢ **What are the technologies, products and services that you offer to the market?**

We put the quality on the top of anything else. We have our own quality assurance processes and systems that we have been building up for more than 100 years. In our T&D product range, the products that we believe will appeal to the market are shunt reactors and traction transformers for high-speed train systems. We believe that these products will be good additions to Prime Meiden s product portfolio.

➢ **Could you differentiate your view for Indian and International market?**

We find India is a tough market in that it demands both good quality and good services at a very low cost. However, India represents BRICs and emerging countries, and if we are successful in this market, we will also be successful in other emerging countries. India will be a good springboard for further expansion to these countries, especially to the west of India.

➢ **What are the challenges you are facing in the International as well as Indian market in power sectors and what you will do to cope with this?**

The biggest challenge is to improve our price competitiveness while maintaining the product quality at the highest level. We expect that our alliance with Prime Group will be an ideal step in this direction.

➢ **What are your future plans and where would you like to see Meidensha in next five years?**

We would like to see Prime Meiden Limited as a premier T&D products manufacturing company in India with its export business expanded to the west of India, especially to the Middle East and Africa. We are also looking to strengthen our project

management business in India. We manufacture superior quality products, and proper execution and maintenance are the key to get the best results from our products.

➢ **How would you like to explain Meidensha from its competitors?**

We believe that on top of the price competitiveness, the quality of products as well as services is the key to the success. We have been pursuing customer satisfaction on this line, and we would like to say that our transformers have been very well accepted in Japan and Southeast Asia. We will bring and combine this philosophy backed by our quality management system with the advanced, state-of-the-art manufacturing facilities of Prime Meiden. We trust that this will surely create one of the best transformer companies in Asia.

➢ **Do you also look to possibilities investing in other sectors in India?**

We do not have any specific idea at the moment, but are willing to consider any possibility that will be coming up for us. We have a vast range of products, such as solar inverters, industrial power generators, automated guided vehicles, water treatment membranes, etc. These technologies can be very useful for Indian utilities and companies for their business growth. We are open to any possibility of becoming a partner in an Indian growth story.

➢ **What are all your expectations from the Indian customers and investors?**

We expect that Indian customers are now beginning to seek more quality in products. We would like to show them that it is the right direction, as the quality and reliability can reduce downtime of the products and eventually increase production time and revenues.

Consolidated Group Companies

China: Dongguan Meiden Pacific Electrical Engineering Co Ltd; Meiden Zhengzhou Electrical Co Ltd; Meiden Shanghai Co Ltd; Meiden Hangzhou Drive Systems Co Ltd; Shanghai Meidensha Changcheng Switchgear Co Ltd.

Hong Kong: Meiden Pacific (China) Ltd; Southeast Asia; PT Meiden Engineering Indonesia; Meiden Malaysia Sdn Bhd; Meiden Metal Engineering Sdn Bhd; Meiden Asia Pte Ltd; Meiden Singapore Pte Ltd; Thai Meidensha Co Ltd; Meiden Electrical (Thailand) Ltd.

UK: Meiden Europe Ltd.

USA: Meiden America Inc; Meiden Technical Center North America LLC

Non-consolidated Group Companies

Korea: Meiden Korea Co Ltd.

India: Meiden India Pvt Ltd.

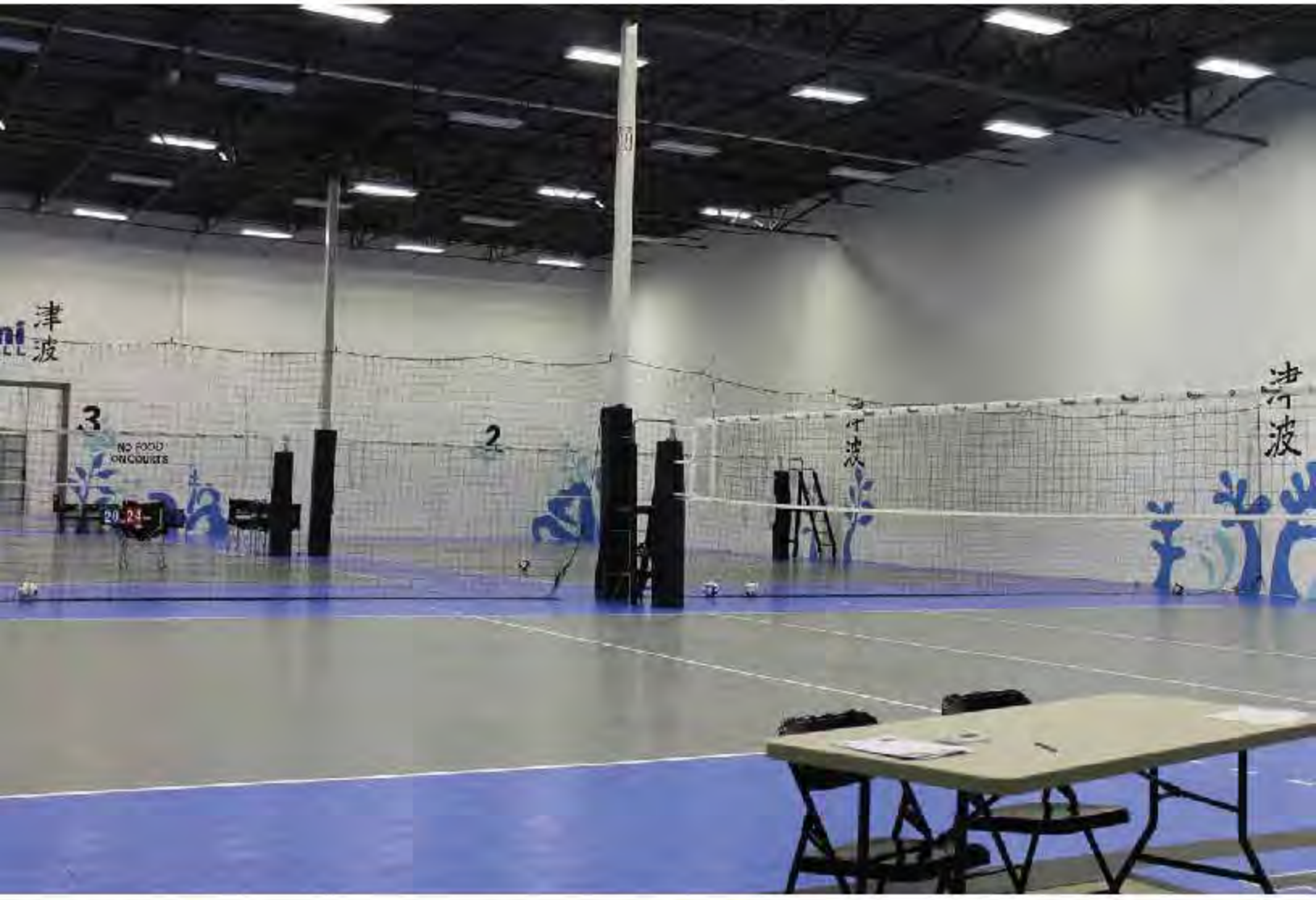
➢ **What is your message as President of Meidensha for our readers. What are your views and hopes from Indian markets?**

We are quite happy to have formed a partnership with Prime Group. We both share the same philosophy of achieving manufacturing excellence in whatever we do. Both of us believe that quality and reliability of products and services will bring customer profits and satisfaction for our customers.

We will together endeavour to materialize this philosophy in the products delivered from Prime Meiden. With a new government currently being formed, it is believed that India is now able to enjoy a very strong government after long years. We anticipate this will lead to a strong growth momentum in Indian market. We promise our best support to power utilities, industry and all our customers in India.

Artificial Lighting

Principles for Indoor Sports



The creation of an appropriate visual environment is a fundamental requirement in indoor sports design and the effective integration of the artificial lighting system should be considered as a standard part of a modern sports facility for indoor sports. The basic principles of indoor sports lighting design are illustrated by a few descriptive outlines referring to the type of sports and activities. Similar methods and principles can be used in the procurement of lighting for any indoor sport or mixture of indoor sports.

Ashish Batra

The general benefits of good artificial lighting are-

- Indoors, artificial lighting helps designers to provide consistent, uniform, adequate lighting levels, sometimes using artificial lighting alone and sometimes with supplementation by daylight.
- The high, uniform levels of light necessary for many televised indoor sports events can only be ensured through artificial lighting.
- Providing artificial lighting on an indoor sports facility greatly extends the hours of play, particularly in winters.

Technical complexities

Lighting is a subject area with a high degree of technical complexity that can be difficult to understand. The complicating factors which need to be taken into account in preparing lighting design can be-

- The varying and conflicting requirements of individual sports in an indoor multi sports complex.
- A lack of appreciation of the needs of some individual sports that are particularly sensitive to poorly designed lighting.
- Wider inter relationships with issues such as user satisfaction, overall sustainability, energy usage, environmental factors and availability of a suitable electrical supply.
- Complex inter relationships with other elements of the building such as reflectance and colour of surfaces, variation in background surfaces/walls, location of structural supports and configuration of roof.
- Health and safety issues, for example in swimming or in fast moving ball games such as table tennis or squash where the maintenance of a good lighting system is a fundamental requirement.

Design Issues

It is important that the lighting requirements of each indoor sport are fully understood at the outset of a project. This requires an understanding of the nature of the sporting activity and key characteristics. Many indoor sports involve swift player actions and reactions and involve relatively small objects such as shuttlecocks and balls travelling within three dimensions at a very high speed.

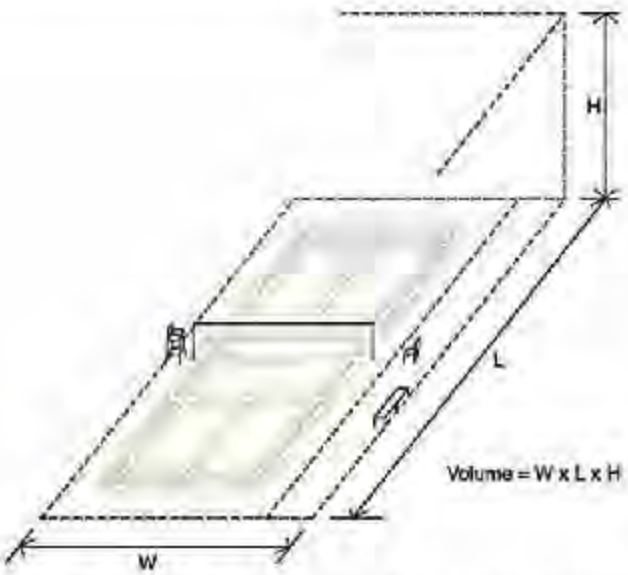


Fig. 1: Diagram showing the volume of the sports space to be illuminated

Fig. 2: Contrast in illumination levels and shadows should be avoided in the field of play

Design considerations

Lighting installations for indoor sport should balance the following issues within an integrated design:

- Levels of illuminance
- Uniformity of illuminance
- Contrast
- Glare control
- Colour rendering
- Compliance with mandatory design regulations.

Volume of the field of play

The whole of the three dimensional volume above and including the field of the play should be considered, rather than just two dimensional surface of the playing area.

This can include:

- Safety zones around the play area
- Space reserved for officials and team benches
- Spectator facilities.

Where events are televised, or for indoor sports which involve great use of height above the playing area like badminton, tennis, volley ball etc, consideration of the full volume is especially important. In engineering terms, this means the consideration of both horizontal and vertical planes for the full volume of play are important (Refer Figure 1). For example, a lighting scheme for badminton should not be based solely on illuminance on the floor, when the path of the shuttlecock can be anywhere in playing volume 7-10 m high.

Even illumination

Generally the full volume of the field should be illuminated evenly to create equal playing conditions for all players and to create a consistent level of visibility. Changes in illumination levels can create difficulties in judging the speed and the trajectory of the playing object.

Sports areas should be lit so that those taking part and those watching can see clearly all that is going on. This needs the suitable brightness and contrasts over the playing area, sufficient light at all the

points, correct distribution of the light and adequate control of the glare. Playing objects will be seen because they contrast with their background in brightness, colour or both. The more marked the contrast, the more clearly objects are perceived in general.

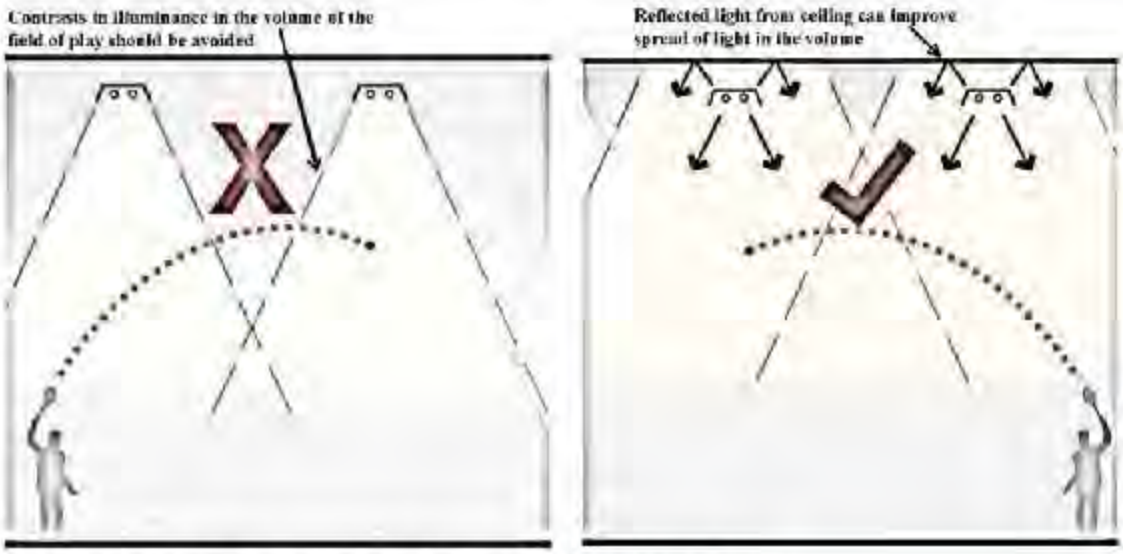


Fig. 3: Even illumination is required in the full volume of the field of the play

Lamp types

There is a variety of lamp types used for indoor sports lighting like tubular fluorescent, compact fluorescent, metal halide, high pressure sodium, light emitting diode (LED) etc. Their characteristics differ and manufactures are continually developing improved products. Selection is often made on the basis of colour of light emitted, energy consumption and life expectancy. For both indoor and outdoor sports, sodium lighting will only be acceptable where its relatively poor colour rendering can be tolerated. Tungsten halogen lights are inexpensive, but inefficient. Metal halide lamps are efficient and give good colour rendering. They are specially recommended by many international sports authorities. For indoor use, fluorescent lamps offer a good balance between cost and efficiency.

Levels of illumination

The level of illumination that is appropriate for a particular sport should be checked with the requirements of the governing body or the organization that is promoting a particular event. This can vary with the level of play and competition.

Glare

The complete elimination of glare in indoor sport is difficult to achieve due to the ever-changing directions of view of the participants. Nevertheless, measures should be taken to minimise glare that may affect the visual performance of participants. When attempting to minimise the likelihood of glare, the factors over which a designer has control are:

- Selection of luminaries designed with attention to the avoidance of glare
- The location of luminaries.

In designing a luminaire, there are two main methods of avoiding causing glare, which are:

- To make any direct view of the light source impossible by placing it deep within the luminaire, behind baffles
- To use low intensity light sources, such as fluorescent tubes.

Where possible, luminaries should be located in positions which mean that players will not need to look towards them or in their general direction in the course of a game.

For indoor sports, generally down lighter type luminaries should be used that incorporate some glare control with some degree of back lighting to avoid high levels of contrast. The locations of luminaries relative to directions of view should be considered carefully.

Fig. 4: Inappropriately located lights can cause discomfort glare

Colours of surfaces

The colours of the surfaces in an indoor sports hall- wall, ceiling and dividing nets are often important because the play object will be seen against them. Choosing the right colours can help make the play object more visible to the players and spectators as well. For example, a mid-range reflective surface helps badminton players see a white shuttlecock and a surface of higher reflectance helps players see the flight or height of a red/yellow volleyball. The brightness of a surface depends on its colour and its reflectance.

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- Puncture welding and magnetizing
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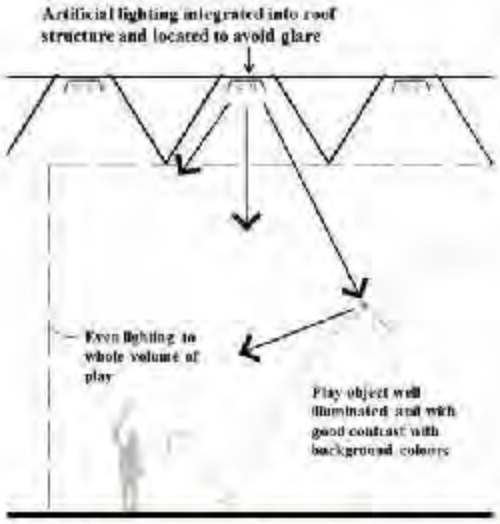

Fig. 5: lighting sources integrated with building structure

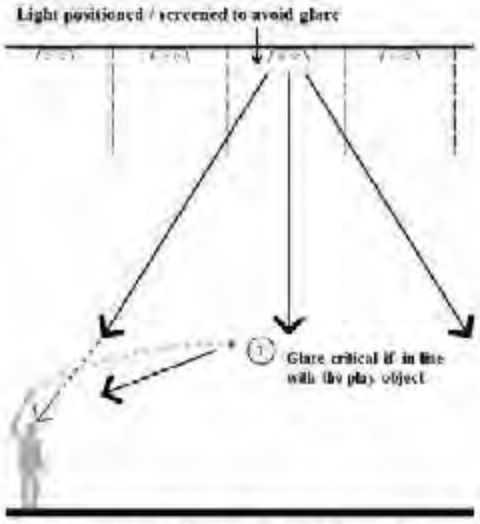

Fig. 6: Lighting should not be located in direct line of sight of the player

Indoor Sports Lighting

As discussed above good indoor sports lighting system should provide adequate illuminance, suitable brightness, contrast, uniformity of light distribution and satisfactory control of glare for the activities in question. The lighting schemes will have a major influence on the overall ambience of the playing space.

Many indoor sports facilities cater for a range of activities. Some of these different activities can take place simultaneously, for example in a sports hall divided into sections. There may also be a need to achieve adequate visual conditions for spectators. Where substantial variations in illuminance are required, additional switching of supplementary lighting could be considered.

Developing a design strategy

Developing a lighting design strategy is very important. The key steps in developing a lighting design strategy are:

- Confirmation of the layout of sports area
- Define the volume of the field of play
- Establish the general lighting requirements
- Establish the detailed lighting requirements.

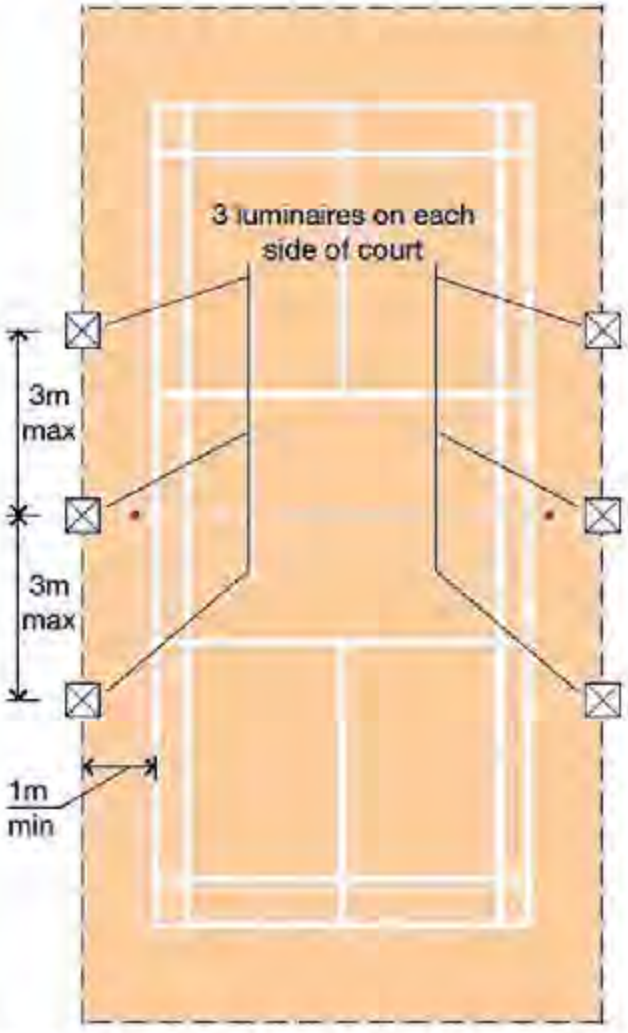

Fig. 7: Plan of Badminton Court with location of luminaries (International Standards)

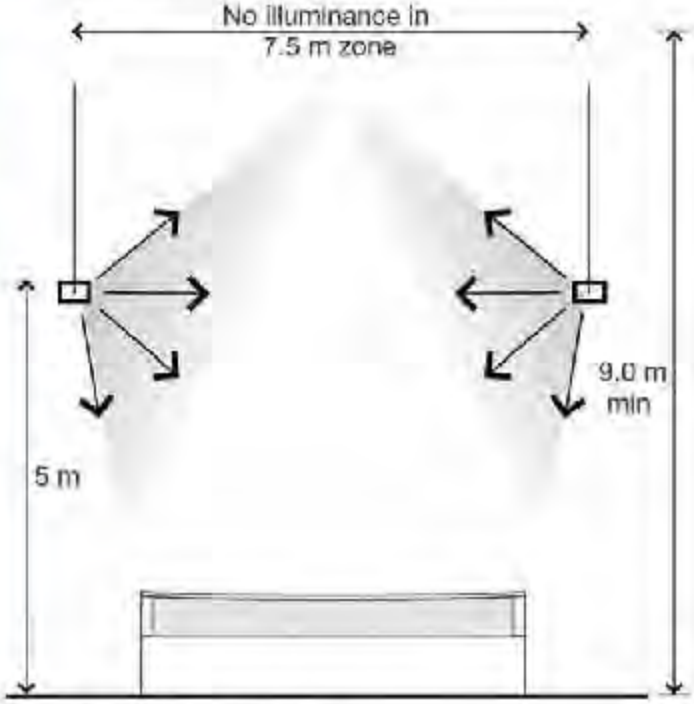

Fig. 8: Section of Badminton Court

Sports lighting should be considered early in the indoor stadium/hall design process. The lighting should be well integrated into the design of the facility and should not treat as a separate specialist fit out issue.

Balancing priorities

It is generally recommended that the lighting design is based on the requirements of the priority activities i.e. the sports that are played most often or have the most stringent requirements. However all other potential activities should be catered for in terms of basic visual safety and functionality as well.

Specialist sports hall - Badminton

Let us take an example of indoor badminton sports hall. Badminton requires very carefully designed lighting to enable the game to be played to a good level. When designing the lighting for badminton halls, it is essential to appreciate how the game is played. The shuttlecock can move at very high speeds over the net, requiring maximum light reflectance from its white feathers. The white shuttlecock can best be seen when illuminated against a darker background. The path of the shuttlecock is often high above the net and sufficient vertical illuminance within the overall volume of the field of play must therefore be provided. Players must be able to follow the flight of the shuttlecock against the background without being troubled by glare or having their attention distracted by bright light source. Luminaries must not be directly positioned over the court. Doors and windows to other lit areas are all a potential distraction and arrangements should be made for such light sources to be temporarily screened or switched off (refer Figure 7 and 8).

It is often thought that badminton requires very high illuminance levels but this is not necessarily the case. Badminton requires lighting throughout the full volume of the field of play and for the luminaries to be grouped centrally around the net. Any luminaries towards the rear of the court should ideally be turned off (or controlled) in order to darken the background to give a contrast with the white shuttlecock. It is essential to consider lighting early in the design process so that the lamp type and locations can be co-ordinated with the court layout and background colours. Lighting and colours should be considered as an entity. The similar methods and principles discussed above can be used in the procurement of lighting for any indoor sport or mixture of indoor sports.

Profile

Ar. Ashish Batra

MTech Urban Planner from GRD School of Planning, Amritsar and Bachelor's in Architecture from Department of Architecture, is currently working in LEA Associates South Asia private limited (LASA), New Delhi as a Consultant (Urban and Regional Development). He is a contributor to several publications in architecture, lighting, transport systems and related fields.

Interview

"To expand more production lines with full automisation"

R A Gotur, Director, India operations
Xiamen Hongfa Electroacoustic Co Ltd

HONGFA is the first largest relay manufacturer in China and one of the leading relay manufacturers and suppliers in the world. HONGFA relays become the most perfect choice for all the customers. In total it produces more than 180 series of relays, with over 40,000 kinds of standard specifications, with an annual production capacity of 1 billion million pieces of relays & factory area of 330000 sq mtrs. In an exclusive interview to **Electrical India, R A Gotur** states, we are able to aggressively perform since we have wide range of relay series segments.

What is your perception about the electronic components market in power sector?

Power Sector market is growing steadily due to - increased demand from power conversion; Low voltage devices & Switch Gear Products which are ever green market; the advancement of smart metering, solar energy harvesting. Due to the frequent power failures, the demand for inverters and UPS are growing which in turn adds up the sale. The predicted growth is about 40 to 50% from 2013-2014.

How do you feel about Indian electronics industry and power scenario as a whole when new governance at Delhi is coming into force?

We hope the new government at Delhi will provide lot of benefits & incentive schemes to boost manufacturing and for electronics industry & particularly the power scenario sectors.

Could you detail us about company's product range?

HONGFA's main products include Electro-mechanical relays, low-voltage devices, switchgears, (DP CONTACTORS, MCB, MCCB, ACB, ATS etc, with annual production capacity over 1 billion pieces. Electromechanical relays have a moving plate with contacts on it, while solid state relays work similar to transistors and have no moving parts.

- Power relays use electromagnet to move a set of contacts. The contacts are pulled towards the electromagnet while current is flowing in it. The contacts are connected to a spring that pulls them back when current stops flowing.
- Latching relays act like a two-pole switch in that the contacts stay in position when the current stops flowing. This is achieved by using a solenoid to move a ratchet and cam, or by using an electromagnet on either side.
- Automotive relays: These relays are mainly used in two wheelers, passenger cars and commercial vehicles. The general applications for these relays are in automotive flashers, wiper controls, head lamp relays, horn relays and wiring harness applications.
- Signal/Telecom relays: Landline telephones operate on relays. The quick response from the telephone exchange when the phone is picked up occurs because of the switching of the telecom relay. In fact, the only moving part in a modern landline telephone exchange is the relay.

- Power and industrial relays: Various types of industrial and auxiliary relays are used in power generation plants and other industrial controls.
- Hermetic relays: Hermetic sealed MIL approved relays are used in defense, navigational /communication equipment, aircraft, and in areas where environmental conditions are severe.

How the company has attained the feat of such global scale production capacity and its utilization potential?

HONGFA has a specialised solid wealth of 30 years experience in relay development & manufacturing. HONGFA has been focusing on Technology innovation. The adoption level in this sector are stringent quality norms fully automized plant which helps: reduce operating cost; improve product quality; enhance quality of work for employees; increase production output rates; boost manufacture flexibility; reduce labour turn over; reduce wastage & increase yield.

HONGFA support starts with, First understanding the customers requirement, suggests improvements/alternates depends on the application of the product. HONGFA offers the total application engineering support & helps the customer to select the most cost-optimized relay solution. HONGFA team ensures continues follow up with the customers for any issues or suggestions they have. The firm network OF OUR DISTY"S, Stockiest and dealers are spread across the country provides the professional support. HONGFA is supporting customers and providing services in every stage such as Design, free samples, Protocol, Pilot lot and regular production. HONGFA believes in customer satisfaction, Product quality assurance, Technology support & provide facilities with adequate systems & processes in place. We sincerely taking care of customers demand in crisis management at cost effective prices, On time delivery. HONGFA's innovative products exceed customer's expectations. Hongfa is very quick in action for custom build relays as per customers requirement as Hongfa have a separate Design group for supporting customs made products. HONGFA are also committed to expand more production lines with full automisation to increase productivity to help our customers remain cost effective & concentrate on core competency. HONGFA supplies relays, credible & authorized inspection data & test report of our products.

What are the standards & certifications being used to achieve manufacturing excellence in production?

HONGFA has a full set of quality assurance systems including ISO9001, ISO/TS16949, ISO14001, OHSAS18001, GJB9001A, and IECQ QC080000. HONGFA has a state level technical centre post-doctoral and an academician research station & a UL, VDE and CNAS recognized testing and experimenting centre for relay and relevant products. Its lab is approved by CNAS & UL America as a WTDP lab; and by VDE Germany as TDAP-lab - the only one in china and the sixth one in the world. HONGFA uses 3D CAD software design in new product development & mould tooling design.

Latching relay is also an auto switch. Could you state its specific applications and advantages?

The latching relay is mainly applied in 4 fields which are smart meter, relay protection for electric power system, industrial control & home appliance etc.

The main advantages are -

- Zero power consumption for circuit maintenance, energy-saving; suitable for concentrated installation in a room.
- Compared with power relay, the volume is smaller but with the same contact rating; more compatible with the digital logic circuit. There is extra magnetic steel which give the cost rise from 10% to 20% compared with power relay.
- HONGFA manufacturers various series of latching relay.

What strategy do you have over competition in similar range of manufacturing by other companies and how do you perceive relays playing a role in economic growth?

There is very stiff competition in the market with similar products from OMRON, TYCO, PANASONIC, Goodsky etc. HONGFA's strategy is that, We are able to aggressively perform since we have wide range of relay series segments and we are able to deliver high quality products and competitive prices with JIT (Just in time) terms. Within a span of short time we are able to enter with major companies in all segments. HONGFA commitment to quality and value pricing has helped us immensely. The relays are ever green market & used in universal applications in all most all the products. Hence it has great impact on economic development.

What advances do you expect in relays market domestically, globally and what according to you is best suited product for Indian market?

The future advance technology in relays in reducing the size of the relays (Minature relays – Small size) and also in SMT relays (Surface Mount Technology). These changes are invevitable. Relays which have low contact resistance and low voltage drop across contacts and this enhances long time reliability and also the life. Permanent magnet relays & contactors are becoming popular due to lower power consumptions.

- Sugar cube relays are highest consumption in India & also Globally.
- Telecom relays 1 amps 12 volts & 24 volts are very fast moving relays
- Starter & Flasher relays for Automotive application relays have high potential market for 2, 3, & 4 wheelers
- Latching relays: This relay is used in smart/Intelligent meter application & there is potential growth for coming years. Also there is huge demand in lighting & solar segments.

What is your future vision in the next two years?

HONGFA INDIA is growing at a steady pace. Hongfa is becoming more and more popular due its product quality and reliability. We are sure that we are going to be the most preferred choice for any designers and quality experts. Moreover we have a clear road map of new product developments for the coming years to cater to the emerging markets.

Indian Stalwarts Views on newly appointed Modi Government

India recently elected a stable government which has its vision priority for growth, expansion, reducing inflation and increasing GDP. It has embarked into a new period and encouraging responses coming from industrial and manufacturing sector is donning the shape of future India. Positive vibrancy in stock market trend already set in the pitch though it is riding for its small part on positive global cues too. India urgently needs to build more roads, ports, boost its electricity supply, and indulge into infrastructural activity. Below are some of responses we received from select faces in the power industry sharing their views on new governance on the occasion of change of leadership and expectations from new government.

Manoj Kumar Upadhyay, CEO, ACME Solar

"We welcome the new government and extend all support in its endeavour to secure India's energy future! We expect the government will have policy-push in order to grow developers and customers interest in the solar energy. We believe that the new government will give the much-needed impetus to green energy and enable increase in implementation of solar power projects in JNNSM PH-II."

Anil Chaudhry, Country President & Managing Director, Schneider Electric India

"Schneider Electric India is committed to all efforts to transform India into a self-sufficient, energy-surplus nation. We hope to partner with the country in developing smart cities as well as boosting the renewable energy segment, in particular. We look forward to policies that will bolster infrastructure development in India, acting as an engine of growth, creating thousands of new jobs and pushing up GDP growth, while lowering poverty levels and bringing alive our collective dream of inclusive growth."

Sanjeev Ranjan, Managing Director, International Copper Association India (ICAI)

"We congratulate the new government and are hopeful of positive development in the infrastructure segment. By kick-starting stalled infrastructure projects, the entire economy can be pushed into momentum. The most important task in front of the new government is how to unlock $255 billion of stalled projects to bring back India on the much desired growth path of 8-9% of YoY GDP growth rate. Reviving stuck projects should be the top focus of the new government, from thermal power plants to steel mills are stuck for reasons ranging from delayed environmental clearances to blocked land acquisition. The consumption of copper is directly related to growth in infrastructure and manufacturing which are its two main components. Current consumption rate has been stuck for last few years for want of government support. On the energy sector, identification of low hanging fruits can be immediately executed for example - Energy efficiency savings can be one of the first thing which the government should look at. The compliance and monitoring mechanism is so weak that the good work which is being done by some is getting negated by not being able to enforce the standards. Another can be how to give a fillip to the renewable energy sector – implementation of mandatory Renewable Purchase Obligation (RPOs) by the states for which the dates are regularly being rolled over."

Sumit Sharma, Vice President and Global Capability Lead, Sapient Global Markets

Sumit shares his thoughts around how new governance can change the game as far as the energy sector is concerned, how this deal can affect the energy paradigm of emerging market players like India.

"With a new and expected to be a stable government in India, it is expected that the industrial activity will pick up which, along with good numbers from China, will have positive impact on the demand for energy resources. The pricing of this deal is described as a 'commercial secret' with some analysts pricing the commodity at $10 could provide a benchmark for long term supplies to take place in and around Asia where current prices are around $16. The chances of Iran-India pipeline also have increased as a more business friendly government has been elected. The fact that power and coal ministry have been combined towards a more integrated Energy ministry is a sign towards focus on energy security for the country."

Prakash Kumar Chandraker, Managing Director & Vice President – Energy Business, Schneider Electric India

"The government needs to invest more in smart grid technologies to ensure more reliable and efficient systems in transmission and distribution sector. Promoting renewable generation and its integration to the grid shall greatly help in reducing the dependencies on conventional fuel. But at the same time the issues faced during the implementation of conventional generation projects should be tackled swiftly. The government is required to take measures in providing a conducive business environment that would encourage greater involvement of technology companies. Innovative financing and business models need to be identified for financial feasibility of the infrastructure projects".

Tulsi Tanti, Chairman, Suzlon Group

TRT's view on Narendra Modi

- Narendra Modi is an Architect of Reforms driven by development and governance We at Suzlon Group are confident that under his able leadership, Indian economy will revive and India's Economic Development Will Act. As A **Catalyst In Reviving The Global Economy**
- India will achieve **Energy Independence** by optimizing resources within the country with a clear thrust on renewables viz. renewable energy
- Shri Narendra Modi after delivering a **Vibrant Gujarat**, we wish you all the very best to deliver a **Vibrant India**
- Congratulate government that is taking a holistic view on merging and aligning value chain of various ministries under one umbrella.

Suzlon's recommendation to new Government on Renewable Energy

- The national target of 15,000 MW of wind energy during the current plan period (2012-17), can be easily doubled to 30,000 MW.
- India has an installed capacity of 21000 MW of wind energy, with the country's potential in excess 300,000 MW. I am hopeful that the country can easily meet 10% of its energy need from wind energy alone in the future.

"As we usher in a new progressive era, the SUZLON family extends its heartiest congratulations to Shri. Narendra Modi and his team for their vision and ability to bring in a clear mandate. We at Suzlon remain confident that the new government will steer our nation into prosperity with good governance & development in the coming period. We believe the BJP led government will provide an environment conducive for growth & investments, with major reforms in infrastructure & renewable energy sector. This is important as India's economic environment will act as a catalyst in reviving the global economy. I sincerely extend my best wishes to the new Government."

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Siemens solutions ensure 24/7 optimal performance of Data centers

Electrical India attended the 'Technology Round Table', hosted by Siemens, Tata Communications & Datacenter Dynamics at Siemens Worli Convention Center, Mumbai on May 21, 2014. The round table discussion focused on innovative technologies, global and regional growth trends and their impact on the strategic priorities of the Data Center markets. In light of the large economic potential as well as enormous energy demand of Data Centers, effective facility management of Data Centers is of primary strategic concern. The host attendees included Tilak Raj Seth, Philip Krause, Varoon Raghavan, Stephen Worn, Souvik Bhattacharya and others. The round table and panel discussion was compared by Brian Pereira.

Philip Krause, Head of Datacenter Centre of Competence, Asia Pacific, Siemens deliberated about Technologies that enable 24x7 operational excellence for Data Center.' Varoon Raghavan, AVP Growth Ventures, Tata Communications Limited delivered on 'An End User perspective on designing, building, and maintaining efficient Data Centres.' Stephen Worn CTO and CEO, North America Datacenter Dynamics gave an account of 'A global perspective on the Data Centre market and its growth potential, with focus on India.'

Siemens has introduced a Centre of Competence (CoC) for Data centers for the Asia Pacific region, head quartered in Mumbai. The CoC will drive and support the growth of Siemens products and solutions for customers in Data Center vertical covering 10 countries across Asia Pacific region. The totally integrated solutions from Siemens help create reliable and efficient Data centers and help reduce operating costs. Philip Krause says 'Asia is one of the fastest growing markets in the Data center vertical and the CoC is strategically placed to offer global competency locally to the customers. Siemens has a unique strength to offer a wide portfolio of products and solutions spanning from power, safety, security, data center management solution and services from a single reliable partner. With account managers located in key countries, we are locally present at the customers place and this makes us unique'.

Globally, Data centers are among the world's largest users of electricity and producers of CO2, with servers running 24 hours per day, seven days a week, under tightly controlled environmental conditions and often not at full capacity. Data centers are estimated to already consume 1.5 to 2 percent of total worldwide energy production. In the past decade, the number of worldwide Internet users has increased from 300 million to over 2 billion – that is a growth rate of more than 400%. And this is a trend that is increasing rapidly: In 2020, the level of CO2 emissions generated by Data centers could exceed that of all air traffic combined. This huge growth of social networking, internet usage, electronic banking, paperless storage and modern IT services such as virtualization and cloud computing will trigger the requirement for safe, resilient and energy-efficient Data centers. Siemens offers solutions to effectively reduce the energy consumption in Data centers

The amount of data stored doubles every 18 months, with demand on supporting infrastructures rising in equal measure. Data centers play an essential role in the world of networked data. This is where the worlds of IT and infrastructure meet. From managing complexity to improving energy efficiency, from meeting security to business regulatory requirements, Data center operators face many challenges. As the world's largest electrical engineering company, Siemens has a global portfolio of products and solutions for Data centers and engineering teams around the world.

Siemens has developed specific technologies and portfolios to meet the demanding requirements of every area in a Data center. On the power distribution front, Siemens offers products and solutions for a totally integrated power system. Siemens also partners with customers to offer consulting, planning, designing and site selection, to engineering, commissioning, full documentation, training, maintenance and expansion planning for Data centers.

(L to R) Tilak Raj Seth, Philip Krause, Head of Data centre of competence, Asia Pacific, Siemens; Varoon Raghavan, AVP Tata Communications, Stephen Worn, CTO & CEO, North America Datacenter Dynamics

Mission: Transmission




Clarity/07052014

L&T's total solutions help strengthen India's Power Transmission Infrastructure

L&T Construction - part of the Larsen & Toubro conglomerate - is executing a major share of India's on-going transmission line projects.

L&T is among the very few companies in India with end-to-end capability, encompassing design, testing and manufacturing of towers, installation and commissioning of projects on a turnkey basis.

Design and construction services are complemented by state of the art testing and manufacturing facilities.

L&T's Transmission Line Testing & Research Station at Kanchipuram near Chennai is an NABL accredited tower test bed. Tower manufacturing units at Puducherry, Tamil Nadu and Pithampur, Madhya Pradesh produce one lakh tonnes of high-end tower components per year, to stringent time frames and to international standards.

The track record includes transmission systems up to 765kV HVAC and 800kV HVDC systems.

Transmission infrastructure offered by L&T involve a small footprint. Narrow base multi-circuit towers save on land and resources, ensuring that L&T's power transmission solutions remain at the forefront of the green thrust.

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CIN: L99999MH1946PLC004768

L&T Construction
Power Transmission & Distribution

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Tamil Nadu Energy Development Agency powered up for Renergy 2014 show

India's Number 1 Renewable Energy event RENERGY 2014 embarks in Chennai during June 12-14, 2014 at Chennai Trade Centre (CTC). The event is hosted by Tamil Nadu Energy Development Agency (TEDA) and supported by Government of Tamil Nadu is expected to witness participation from over 250 companies, 200 exhibitors, 15,000 business visitors and 75 industry captains, international experts, regulatory bodies from across the globe.

RENERGY 2014 encompasses a comprehensive exhibition and thought-provoking conference on Solar, Wind Energy, Waste to Energy, Biomass and Energy Efficiency covering the broad development and advancements of Renewable Energy sector.

RENERGY 2014 displays various product launches and live demos under one roof which highlights the principal concepts and prevailing trends in Renewable Energy fraternity across world.

Commenting on the conference, Vineeth Vijayaraghavan, coordinator for RENERGY 2014 said, "Tamil Nadu has been the champion of Renewable Energy and pioneer in developing the wind energy programme in India. We are confident that this three day conference organised by TEDA concurrently with the exhibition will provide a platform for thought leadership and provide an opportunity for the exhibitors to showcase their latest products and technology trends in the sector".

Rajneesh Khattar, UBM India, Knowledge Partner for RENERGY 2014 further elaborated "This conference will be an ideal platform for different companies to present and expand their business portfolio by networking with around 15,000 business visitors from across sectors who are expected to attend the conference over the span of three days."

Tamil Nadu: The Champion of Renewable Energy in India

- Over 200 exhibitors,
- 15,000 business visitors
- Focus on companies providing unique and innovative solutions in all sectors, product launches and live demos
- CEO conclave, networking sessions and workshops

The Government of Tamil Nadu has launched an ambitious solar policy targeting 3000 MW by 2015. The state is the leader in wind power, with an installed capacity of over 7252 MW, of the total of 21136 MW all over India.

The 3 day conference will cover critical areas pertaining to Solar, Wind, Smart Grids, Green buildings, Bio-Energy etc. Some of the esteemed speakers at the conference include the following:

- Alok Srivastava, IAS, Joint Secretary, Ministry of New & Renewable Energy (Session Chair)
- Dr. S Gomathinayagam, Executive Director, Centre for Wind Energy Technology (Session Co-Chair)
- Madhusudan Khemka, Chief Executive Officer, Regen Powertech
- Pashupathy Gopalan, Managing Director, SunEdison South East Asia & Sub Saharan African Operation
- Parag Sharma, Chief Operating officer, Renew Power
- Vineet Mittal, MD, Welspun Energy
- Bhupesh Juneja, Director INOX Wind.

RENERGY 2013 was a huge success and provided an opportunity for the participants to have a productive detailed interactive session with experts, peers, prospects and suppliers. It also provided a significant boost to the Indian renewable energy ecosystem. RENERGY 2014 has raised the expectations of the industry at large which aims to gather investors, entrepreneurs, professionals, suppliers, and corporate representatives from across the globe on how renewable energy had an important role to play in addressing the growing energy needs of India as it adopts a clean and green approach.

Over Five Golden Decades of dedicated service to Power Sector

For over five decades now, one name has facilitated Applied Research in electrical power engineering, enabling Testing and Certification of electrical Power Equipment as an Independent Third Party Agency - CPRI. The Institute is renowned Internationally as a reputed brand and well-recognised for its quality and excellence. CPRI is also adequately equipped with advanced infrastructure to handle Collaborative Research with Academic Institutions and Training to Utilities/Industry.

CPRI

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- State-of-the-art Test facilities for High Power Short Circuit, Ultra High Voltage, High Voltage testing of Transformers and Switchgears, Cables and Capacitors, Transmission Line Towers, Material characterisation, Seismic Qualification, Power System Studies, Energy meter testing.
- Four Short Circuit testing facilities
- Facilities for testing equipment of 800kV/1200kV rating
- Evaluation of Vibration Characteristics
- Protocol testing for Power System Automation
- Refrigerator and Air-Conditioner test facility

RESEARCH

- Center of excellence for undertaking Collaborative and advanced Research in Power Sector
- Sponsored Research Projects of relevance to Power Sector
- Coordination of National Perspective Plan Projects

CONSULTANCY SERVICES

- Smart Grid initiative - Design and Development of Pilot Project for BESCOM
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Giantlok Introduces Cable Ties

Giantlok offers a high quality and full range of Cable Ties for use in various different applications. By constantly refining products and satisfying the ever-changing demands of the market, various locking technologies have been developed. They pay attention to product engineering details, which is greatly contributed to improving efficiency levels of work. Furthermore, they insist on continuously providing high quality products to minimize possibilities of operational failure, so that the cost of rework can be effectively reduced. Giantlok also offers complete series of ergonomically designed crimping tools with just the benefits the one is looking for in effort-saving and hassle free installations.

Giantlok's locking mechanism is used in 90% of all their polyamide (PA) cable ties. In order to cover a variety of applications, there are different variants of this system, for example: releasable versions and in-line versions. These one-piece cable ties, that the pawl is molded as an integral part of the cable tie, thereby building in inherent strengths. Giantlok's cable ties made by Polyamide 6,6 could be heat-resistant, UV-resistant or flame-retardant. Company provide a full line of high quality cable ties in a wide range of sizes, materials, colors and styles for fastening, bundling, securing and identifying in a variety of applications. All Giantlok's cable ties are engineered and manufactured to meet or exceed industry standards to guarantee maximum reliability. The entire product range of Giantlok is compliant to RoHS and REACH regulations and has gained UL, CSA, GL, Lloyd's Register, ABS and CQC accreditations. 99.9% of their products are made of recyclable and reusable engineering plastic and metal and over 85% of them are made by Polyamide 6,6 which is low smoke and halogen free.

Website:
www.giantlok.com

Parker Hannifin's AC30V series provides a AC variable frequency drive solution for pump and fan control

Parker Hannifin India announces the launch of their new series of AC variable frequency drive, the AC30V Drive. Engineered specifically for flexibility, simplicity and reliability, the AC30 series of variable frequency AC drives covering a range from 0.75 kW to 75 kW.

AC30 drive has been designed to provide users with exceptional levels of control, from simple open-loop pumps and fans through to closed-loop process line applications. Its flexible and highly modular construction enables a wide range of communications and I/O modules to be easily added as required. The AC30 has been designed with simplicity in mind, but this doesn't compromise its functionality. Integrated macros for a range of applications and PLC functionality enable more capable users to create sophisticated control that would previously have required a separate PLC.

Designed for operation in environment class 3C3 and 3C4 for Hydrogen Sulphide (H_2S) as standard(tested at 25 ppm for 1200 hours), temperatures up to 50°C with optional integrated EMC filter to C2 1st environment and DC link choke to reduce line harmonics. AC30V also complies with RoHS substance restrictions in accordance with EC Directive 2011/65/EU.

AC30 variable speed drives give comprehensive and cost effective control of either AC induction or permanent magnet (PMAC) servo motors and are suitable for the Open- and Closed-loop control of pump, fan and many other general purpose applications.

For further details contact:
sales.augindia@parker.com

Polar Lighting Poles by K-LITE

K-LITE surface mounted Polar Lighting Pole, integrated with LED Lighting Module is an exclusive choice of designers for city beautication 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 nished 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 %) power factor greater than 0.9 and surge protection. The LED modules are individually rated 42 watts. 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 details contact:
info@klite.in

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E-mail : hpl@hplindia.com

www.hplindia.com

eNavigator – High Profile Power Analyser by Elmeasure

Elecon Measurements has developed "eNavigator", a product that would help in conserving energy. Categorized as high profile Multifunction meter, eNavigator is used for measuring the amount of power consumed and for keeping a tight check on power wastage.

True to its name, this navigator has four 4 different keys and digits to display the digital converted data for smooth and easy navigation.

The features of this product include: 4 keys in the Front Panel. Displays energy, power, basic and options like minimum and maximum demand, etc. A built-in memory for data storage up to 40 days. The 6 digits contain the value of parameters. In Power, Basic & Options, the first 4 digits correspond to Value and the last 2 digits correspond to the parameter name. 4 rows with 6 digits display the parameter name.

Generally, for any industry, electrical measurement is different from process measurement (temperature, pressure, etc), whereas in the eNavigator, these electrical and process parameters can be clubbed together and both these parameters can be read in real time and can be integrated to a common network (PC). eNavigator comes with a multiple communication port so that the process parameter network can access the instrument simultaneously while the electrical parameter network is accessed. Since the power of the TI processor is high, one can even measure individual harmonics to the tune of 15th level. eNavigator can reduce power cost and therefore enable elimination of power wastage. By connecting such instruments to different symmetrical loads (Motors, Transformers, etc.), one can compare the efficiency of the power and rectify it if required, thereby increasing efficiency of the equipments.

For further details contact:
marketing@elmeasure.com

Harting brings Han High Temp

Han® High Temp is a new product series that is based on our well-established Han® B and Han® E series. They used high-quality materials with wide temperature ranges to produce connectors that are uniquely suited for a wide variety of applications.

These connectors can withstand temperatures up to 200°C – so they can be used directly in machines and facilities that would otherwise require cumbersome and complex constructions.

For their users, this delivers direct advantages.

The electro-mechanical design process is optimized. Machine parts which are exposed to high temperatures can be designed modularly. The work process is optimized since lower wiring complexity results in reduced maintenance costs.

Design overview

The basic structure of the Han High Temp connector consists of a bulkhead mounted housing and a cable-side hood.

Hoods and housings

The aluminium die-cast hoods and housings feature a highly compressed surface with excellent non-stick properties. It also has a special non-stick coating on the bulkhead-side seal which allows easy handling without significant sticking.

Inserts

The Han High Temp series features very rugged contact inserts, which are really the heart of any connector. The LCP injection-moulded insert delivers outstanding temperature resistance coupled with excellent mechanical stability.

Website:
www.HARTING.in

Omicron offers RelaySimTest

OMICRON's new RelaySimTest software allows CMC test set users to easily perform simulation-based relay tests independent of the relay type, manufacturer and detailed parameters. For end-to-end testing in the field, even multiple CMCs can be controlled from one PC, using a standard Internet connection. This considerably simplifies distributed testing of systems. With RelaySimTest, distributed tests can be performed in the same way as single-end shots. The required injection signals are calculated for all ends automatically, making troubleshooting of the network very efficient. Furthermore, RelaySimTest simulates relay-controlled breaker operations. With iterative closed-loop simulation, the testing of auto-recloser functions is possible even in distributed protection systems.

RelaySimTest is also an effective solution for challenging testing tasks including power swings, transient ground faults, capacitive line phenomena as well as complex teleprotection and adaptive protection schemes. The software is capable of simulating steady-state values and transient signals even without a CMC connected.

For further details contact:
herwig.ferstl@omicron.at

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Contact: 91-9903999511 | 91-9903999566 | 91-9903999516
E-mail: info@supreme.in, sales@supreme.in

Multifunctional safety relay for smaller machine applications by Phoenix

The PSR-MXF multifunctional safety relays from Phoenix Contact monitor up to three

safety functions in one module and are therefore particularly suited to smaller machine applications. Safety-related control circuits with up to PLe or SILCL 3 can be created with the relays.

The new product range comprises four different special function modules, with three terminal block versions each. Different protection areas can be monitored in one machine, due to two local sensor circuits. Safety concepts are thereby simplified and machine productivity is increased. Furthermore, the relay has a higher-level sensor circuit, which can be used for emergency stop signals, for example. All relevant sensors can be monitored, such as mechanical emergency stop signals or safety door locking, light grids, and magnetic switches. The device does not need to be configured and for this reason, is particularly easy to maintain. The push-in fast connection technology enables tool-free installation which in turn reduces startup times.

For further details contact:
adverts@phoenixcontact.co.in

Venture brings energy efficient Pulse-Start Metal Halide Tubular Lamp

Venture Lighting introduces Uni-Form Horizontal Tubular Pulse-start Metal Halide lamp. The first pulse start Metal Halide systems specifically designed for horizontal orientation in fixtures. Uni-Form Horizontal tubular lamps features Uni-Form arc tube technology, which follows the shape of the arc stream for improved thermal characteristics, resulting in greater light output and 80% lumen maintenance. The lamps have a rated life of 20,000+ hours, which means that 70% of lamps installed will still be operating at the end of rated life. Uni-

Form Horizontal tubular pulse-start metal halide lamps use patented weld less technology for robust, reliable construction. As a result 200 Uni-Form Energy Saving lamps are designed to replace standard 250. Total system energy saved for 365 days-12Hrs operation is 241 Kwhr, average savings per luminaries @ Rs 11 Per Unit is Rs 2651. Available range 70-1000w.

Features

Longer lamp life, enhanced lumen maintenance, excellent system color. Uniformity, hot restart in less than half the time of standard pinch body metal halide systems, 50% faster warm-up,

Applications

It is applicable for flood lighting, security lighting, street lighting, energy retrofits, sports lighting.

For further details contact:
marketing@vlindia.com

Xiamen Hongfa brings Latching Relay

Latching relay by Xiamen Hongfa Electroacoustic Co Ltd, is a newly developed relay in recent years which is also an auto switch. The difference is the latching relay rely on the magnetic steel to maintain the NO or NC status. The on-off switch is triggered by a pulse signal with certain width. The latching relay is mainly applied in 4 fields which are smart meter, relay protection for electric power system, industrial control & home appliance. In the first two fields, the product itself and its utilization are both quite mature. While in the latter two, the latching relay has gained more and more favours as the time of 'Energy saving & Environment protection' comes by. New latching relays are for more diversified loads in various application. It is mainly utilized in intelligent building, energy saving for home, appliance, relay protection & auxiliaries for power meter. Compared with the power relay, latching relay is with a magnetic steel in the magnetic system. Hence there is no need for continuous power supply. A 50ms electrical pulse can fulfill the switch of the relay.

Features

Zero power consumption for circuit maintenance, energy-saving. Save room for installation. Compared with power relay, the volume is smaller but with the same contact rating. No heat generation of the coil. It is suitable for concentrated installation in a limit room. Switch is triggered by pulse voltage.

For further details contact:
marketing@hongfa.com

Index to Advertisers

Motwane introduces 5KPI 5KV Diagnostic Insulation Tester

Motwane introduces its 5KV Digital High Voltage Insulation Tester '5KPI' which is a versatile industrial grade Diagnostic Insulation Tester. 5KPI is suitable for testing insulation resistance of Power Transformers, Current Transformers, Distribution Transformers, HT Cables, Motors, Generators, Circuit Breakers etc. 5KPI is designed and developed in Motwane's DSIR accredited research laboratory and is manufactured under stringent manufacturing processes. The instrument comes in an easy-grip, tough, industrial grade casing with detachable lid. Information is displayed on large LCD with backlit for easy viewing during dim light condition. 5KPI provides Programmable test voltage of 250~5000V, insulation resistance up to 10T, leakage current up to 3mA, simultaneous measurement of Voltage-Current-Capacitance, Digital & Analog Display and Mains-cum-Battery Operation. 5KPI is CE certified, CAT IV 600V and IP65 protected. This makes it suitable for use in harsh industrial environment.

For further details contact:
sales@motwane.com

Solar Street lighting with LEDs

Solar energy, radiant light and heat from the sun, has been harnessed by humans since ancient times, using a range of innovative & evolving technologies. India is densely populated and has high solar Insolation, an ideal combination for using solar power in India.

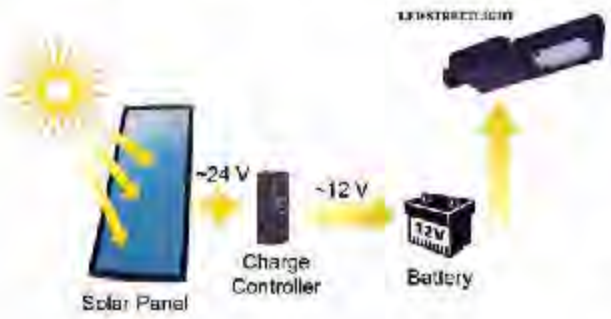
Sanjay Biswas

Solar Power, is a clean and silent source of power, which is free and in plentiful supply. Solar power is the conversion of sunlight into electricity, by directly using photo-voltaics (PV), which converts light into electric current using the photoelectric effect.

Solar energy is not available at night, making energy storage an important issue in order to provide the continuous availability of energy. As LEDs can be powered directly by the DC and needless current than other sources like CFL, they are being preferred for Solar Street Lighting. LED based solar lighting system works to provide solar electricity for operating LED Lights for specified hours of operation per day.

What is Solar street-light & how does it work

Street light that is powered by DC source battery which gets charged in daytime via photovoltaic cells is called solar street light.



Working principle: During daytime, the battery is charged by the solar panel. After sunset, the battery discharges which power the fixture usually till next day sunrise: dusk-to-dawn concept.

Benefits of Solar Street Lighting

- No Tension of power failure.
- Battery backup for cloudy days through 3 days autonomy.
- Savings from electricity bills.
- Contributing to environment with reduced fossil fuel consumption
- IP 65 luminaire with long life.
- Long life of solar panel.
- Auto light on/off operation.
- Long life batteries specially designed for solar application.
- Long life LED white light with instant start.
- Very Low maintenance only for the batteries.
- No cost of electric meters & charges for electric service.
- Ideal for locations with erratic supply/ difficult to provide supply.

The Government of India has announced Jawaharlal Nehru National Solar Mission (JNNSM) on 11th Jan 2010, which has provided the required Impetus for Implementation of Solar Energy Alternatives. Under this mission India has drafted an ambitious target of deploying 20,000 MW of grid connected solar power by 2022.

Solar based street lighting is covered under JNNSM also. The rebates offered under this scheme are as under-

- Exemption of Excise Duty on the products sold through Excise Duty Exemption Certificate.
- Funding aid upto 30% of capital costs involved for the solar projects.
- CDM mechanism under JNNSM for the CDM registered projects.
- Rebate of duties for export of the solar street lights.

Solar Lighting, will slowly become the best alternative to conventional lighting, as it is becoming increasingly competitive over Traditional sources of Power. Solar lighting has thus arrived and is here to stay and create a lasting Impact on the Industry.

- Compiled by Sanjay Biswas.

Profile

Sanjay Biswas
Deputy General Manager
Crompton Greaves Limited
Lighting Division - Mumbai

Power Statistics

Progress of Transmission Sector in the Country upto March 2014																	As on 31.03.2014
Transmission Lines (Stringing Progress) (All fig. in CKM)																	
At the end of	± 500 kV HVDC				765 kV				400 kV				220 kV				Grand Total
	Central	State	JV/Private	Total	Central	State	JV/Private	Total	Central	State	JV/Private	Total	Central	State	JV/Private	Total	
6th pan	0	0	0	**0**	0	0		**0**	1831	4198		**6029**	1641	44364		**46005**	52034
7th pan	0	0	0	**0**	0	0		**0**	13068	6756		**19824**	4560	55071		**59631**	79455
8th pan	1634	0	0	**1634**	0	0		**0**	23001	13141		**36142**	6564	73036		**79600**	**117376**
9th pan	3234	1504	0	**4738**	751	409		**1160**	29345	20033		**49378**	8687	88306		**96993**	**152269**
10th pan	4368	1504	0	**5872**	1775	409		**2184**	48708	24730	2284	**75722**	9444	105185		**114629**	**198407**

Transmission Lines (Commissioned) (All fig. in CKM)																	
At the end of	± 500 kV HVDC				765 kV				400 kV				220 kV				Grand Total
	Central	State	JV/Private	Total	Central	State	JV/Private	Total	Central	State	JV/Private	Total	Central	State	JV/Private	Total	
11th pan	5948	1504	1980	**9432**	5319	411	0	**5730**	75889	31873	5605	**113367**	10387	128947	830	**140164**	**268693**
12th pan (upto March 2014)	5948	1504	1980	**9432**	10378	837	361	**11576**	84478	37861	10166	**132505**	10736	137421	878	**149035**	**302548**

Transmission Lines Commissioned (Due to Change in Policy During Nov. 12 as Decided in the Meeting Held in Planning Commission)																	
At the end of	± 500 kV HVDC				765 kV				400 kV				220 kV				Grand Total
11th pan	5948	1504	1980	**9432**	4839	411	0	**5250**	71023	30191	5605	**106819**	10140	125010	830	**135980**	**257481**
12th pan (upto March 2014)	5948	1504	1980	**9432**	9898	837	361	**11096**	79612	36179	10166	**125957**	10489	133484	878	**144851**	**291336**

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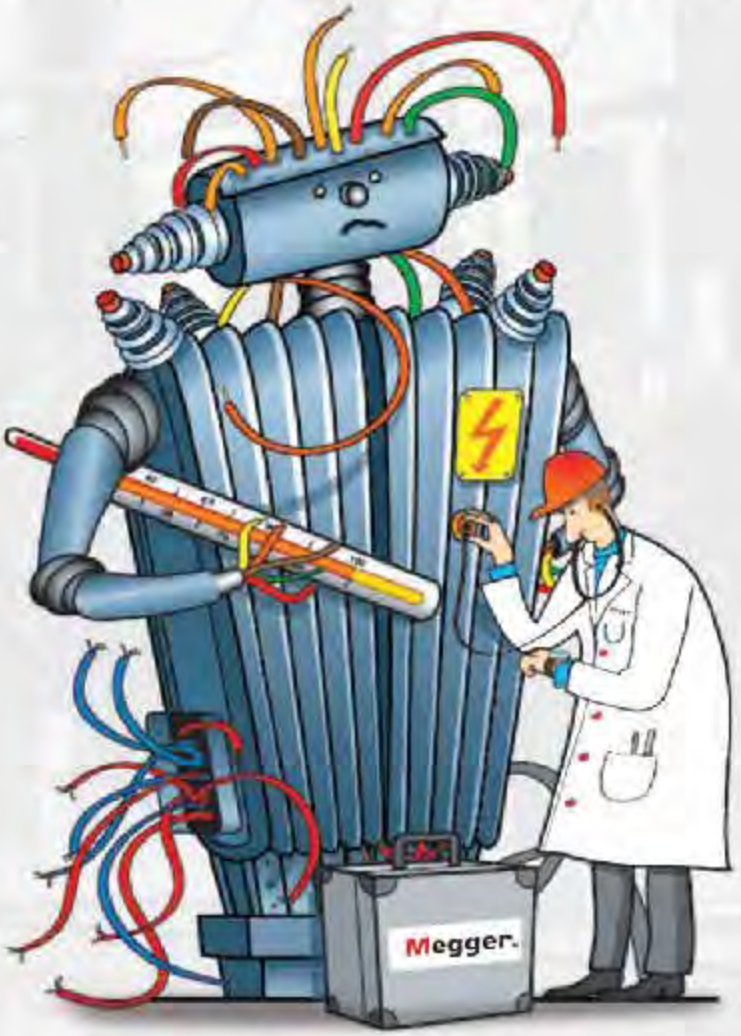
The doctor is in...



MIT1025 - DC Insulation Tester

FRAX 101 - Sweep Frequency Response Analyzer

OTS100AF - Oil Test Set

DELTA4210 - Capacitor and Tan Delta Test Set

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(Asset Management Software)

TTR350 - 3-Phase Transformer Turns Ratio

MTO310 - Transformer Ohm-meter

IDAX 300 - Insulation Diagnostic Analyzer
(Moisture Measurement in Paper)

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