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BUILDING A SMARTER GRID

CAPACITORS & POWER QUALITY



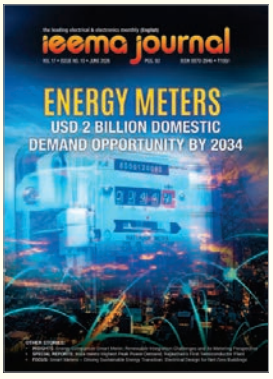
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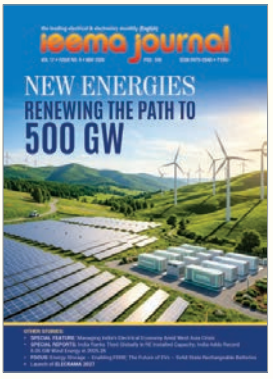
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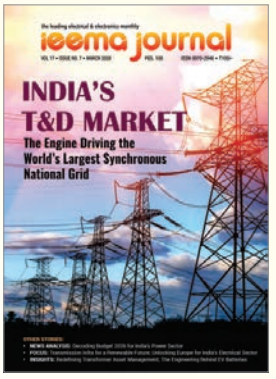
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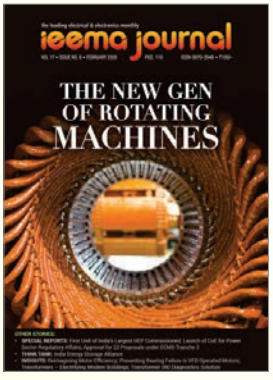
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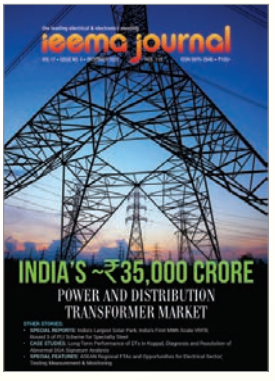
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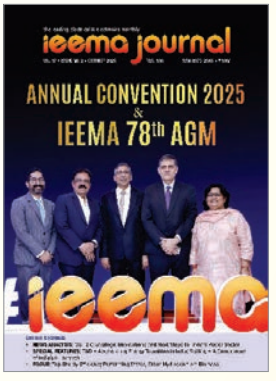
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Building a Smarter Grid: Capacitors, Power Quality & the Future of Energy 12

As renewable energy integration, digitalisation and grid modernisation gather pace, India's capacitor industry is reinventing itself through intelligent power quality solutions, advanced manufacturing and home-grown innovation.



Image courtesy: BHEL

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Hybrid Ultracapacitors of the Future – Energy Like a Battery? 64

Graphene is looked upon as the future for next generation ultracapacitor devices. This alone makes for much higher energy storage capacity than electric double-layer capacitors, writes **RP Deshpande**, a respected specialist in the Indian capacitor industry.

550 kV RIP Bushing: A Transformational Opportunity in Global Power Transmission! 26

Developing capabilities for the 550 kV positions Indian manufacturers to compete in international transmission markets where utilities are actively diversifying their supply chains, writes **Keyur Shah, CMD, Yash Highvoltage Limited.**

Why the 550 kV RIP Bushing Segment Represents a Transformational Opportunity in Global Power Transmission!



Developing capabilities for the 550 kV class reflects engineering maturity across insulation design, manufacturing precision, quality assurance, and testing – capabilities that position Indian manufacturers to compete in international transmission markets where utilities are actively diversifying their supply chains, writes **Keyur Shah, Chairman & Managing Director, Yash Highvoltage Limited.**

The global power transmission industry is transforming due to the increasing use of renewable energy sources, cross-border electricity grids, digitalisation of the grid, and increasing demand for electricity from artificial intelligence (AI), data centres, and transportation sectors. As utility companies around the world continue to develop and upgrade their transmission networks, the emphasis is not only on big-ticket items like transformers and transmission lines but other crucial components as well.

Among these components, the high-voltage transformer bushing is of particular importance. It provides safe transfer of electricity through grounded equipment while keeping the insulation intact

Grid Expansion is Raising the Bar for Critical Components

Electrical power transmission systems are undergoing fundamental structural changes. There is an increase in renewable energy facilities that are located far away from the centres of energy demands, thus increasing the distance through which electricity must be transmitted. Unlike conventional thermal power plants located relatively close to demand centres, renewable energy resources are often situated in remote regions with abundant solar irradiation or wind potential. This requires electricity to be transmitted over significantly longer distances before reaching industrial and urban load centres.

Consequently, transmission planning is increasingly centred on enabling large-scale renewable integration while maintaining grid reliability and minimising transmission losses.

Such a trend becomes especially apparent in international markets where investments are being made into building new extra high voltage (EHV) transmission systems to integrate renewable energy zones with load centres. These projects are driving sustained demand for advanced high-voltage components, including 550 kV class bushings, capable of supporting reliable long-distance power transfer.

Simultaneously, there is an unprecedented strain placed on electrical power transmission due to the process of urbanisation and electrification of more areas.

As per the International Energy Agency (IEA), fulfilling the world's clean energy objectives would need over 80 million kilometres of electrical grid construction or expansion by 2040. It is pertinent to mention that about 1,650 GW of renewable energy projects are stalled due to a lag in transmission networks across the globe.





This underscores an important reality: future-ready grids depend not only on expanding transmission capacity but also on improving the reliability, longevity, and performance of every critical component within the transmission ecosystem.

Technological Advancements in Bushings

Bushings made from oil-impregnated paper (OIP) have been dependable assets in the global transmission industry for decades and continue to be extensively used.

However, the transmission scenario of today calls for a system that can withstand increased stress without the need for frequent maintenance, along with being more fire-safe and sustainable for utilities. These changing needs have accelerated the shift to resin-impregnated paper (RIP) transformer bushings.

RIP bushings differ from traditional OIP bushings, in that they apply solid insulation technology in which the insulation is achieved via vacuum impregnating paper with epoxy resin to form an oil-free condenser core. Lack of insulating oil eliminates the risk of leakage and enhances mechanical strength and environmental performance.

A Shift Driven by Reliability, Not Replacement

From a utility perspective, this transition extends beyond adopting a different insulation technology. It reflects a broader shift towards lifecycle asset management, where purchasing decisions increasingly consider total cost of ownership, maintenance requirements, equipment availability, and long-term operational reliability rather than only initial acquisition costs.

As transmission networks become increasingly interconnected and strategically important, utilities are placing greater emphasis on reliability, resilience, and lifecycle performance.

While India primarily deploys 420 kV and 800 kV transmission systems, the 550 kV voltage class is extensively used across several international markets, including Europe, the Middle East, and parts of Asia. Consequently, the opportunity surrounding 550 kV RIP bushings is primarily an international one, where utilities continue to invest in modernising EHV infrastructure and diversifying global supply chains. For Indian manufacturers with advanced engineering capabilities and world-class manufacturing standards, this represents a significant export opportunity.

As utilities expand transmission corridors, integrate renewable energy at scale, and modernise ageing infrastructure, they are seeking reliable suppliers that can consistently deliver products meeting stringent international performance and quality standards.

Developing capabilities for the 550 kV class reflects engineering maturity across insulation design, manufacturing precision, quality assurance, and testing – capabilities that position Indian manufacturers to compete in international transmission markets where utilities are actively diversifying their supply chains.

Engineering Excellence Becomes the Differentiator

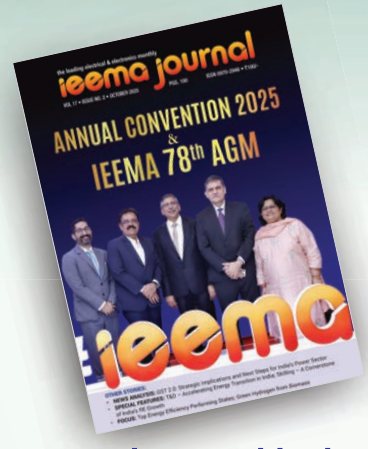
Each increase in voltage level is accompanied by a considerable increase in the electrical stresses experienced by the insulation system. Consequently, designing bushings for the 550 kV class demands the same rigorous control over condenser grading, insulation uniformity, electric field distribution, and manufacturing precision that underpins all high-quality bushings. What differentiates manufacturers is their ability to consistently achieve this level of engineering and manufacturing excellence across every voltage class, including the most demanding 550 kV applications, meeting global standards, and scalability to meet the increasing demand.

Since 550 kV bushings are not deployed in India's domestic transmission system, Indian manufacturers are able to focus their engineering and manufacturing capacity on export markets for this kilovolt class and continue to support India's domestic transmission grid system for 420 kV and 800 kV, among other kilovolt classes with their strong technical knowledge and manufacturing processes on par with international standards.

ABOUT THE AUTHOR



Keyur Shah, Chairman and Managing Director, Yash Highvoltage Limited, is a first-generation entrepreneur who has built a strong reputation in India's power industry. With more than 25 years of experience, he has combined vision, conviction, and strategic foresight to transform the company into one of the fastest-emerging leaders in the highly specialised field of transformer bushings. His qualifications include a civil engineering diploma and a certification program in Strategy Execution from Harvard Business School.



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