

Whitepaper

From Evolution to Transformation: Enabling Next-Gen Motor and Drive Solutions for OEMs

Power Electronics





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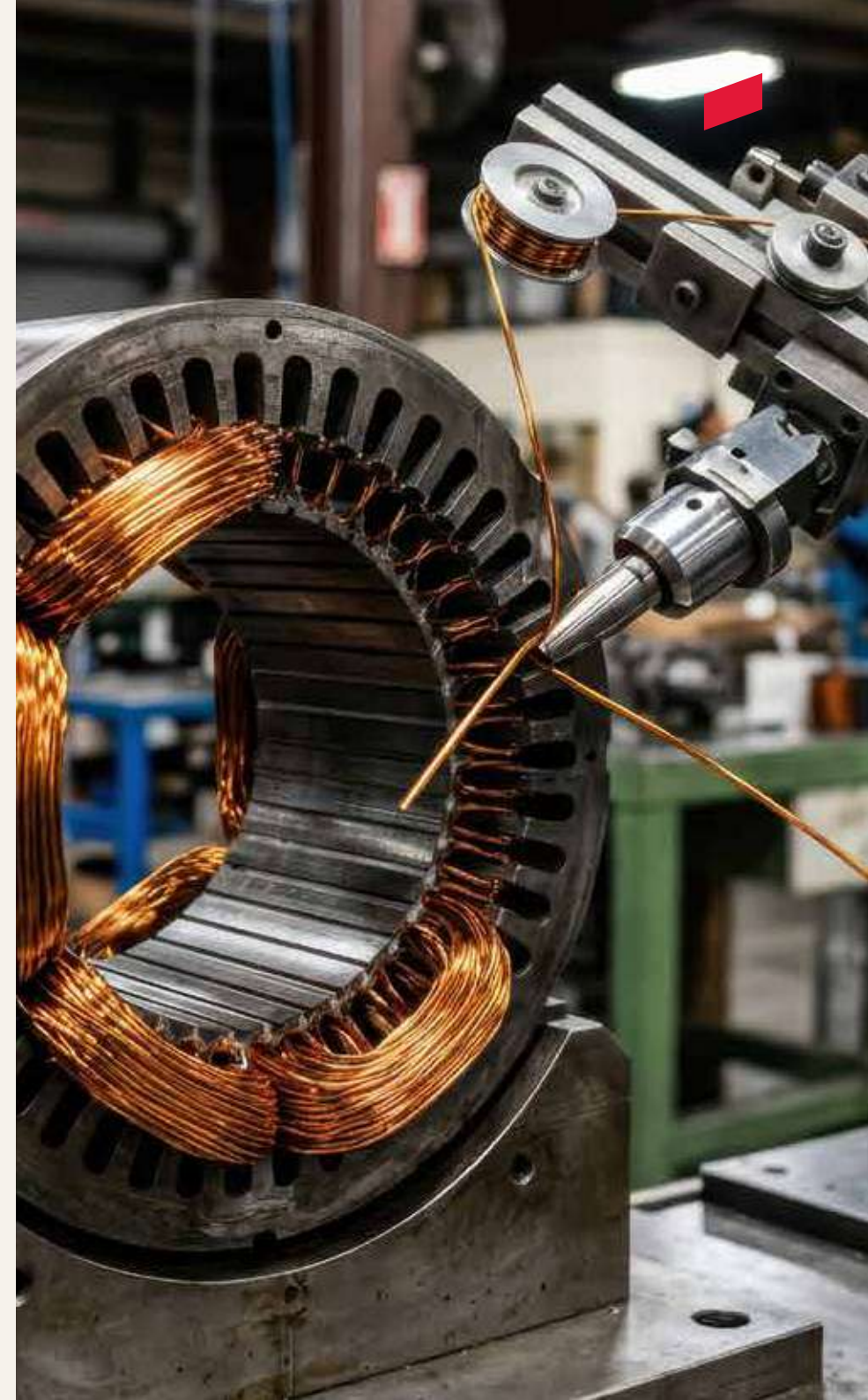
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Executive Summary

Electric motor and drive systems form the backbone of modern industrial productivity and critical infrastructure, accounting for a substantial share of global electricity consumption. As energy efficiency becomes a strategic priority worldwide, regulatory bodies and sustainability initiatives are accelerating the adoption of high-efficiency motors, variable speed drives (VSDs), and system-level optimization to unlock significant energy savings and reduce carbon footprints.

For OEMs, this evolving landscape is driving a fundamental shift in product expectations. Next-generation motor and drive solutions are no longer defined solely by performance and cost—they must now be:

- Energy-efficient to meet stringent IE3/IE4/IE5 standards and regional regulations
- Digitally connected to enable real-time monitoring and control
- Ready to minimize downtime and lifecycle costs, in other words, predictive maintenance
- Cybersecurity compliant (e.g., IEC 62443) to ensure secure industrial operations
- Power quality optimized, with built-in mitigation for harmonics and grid disturbances



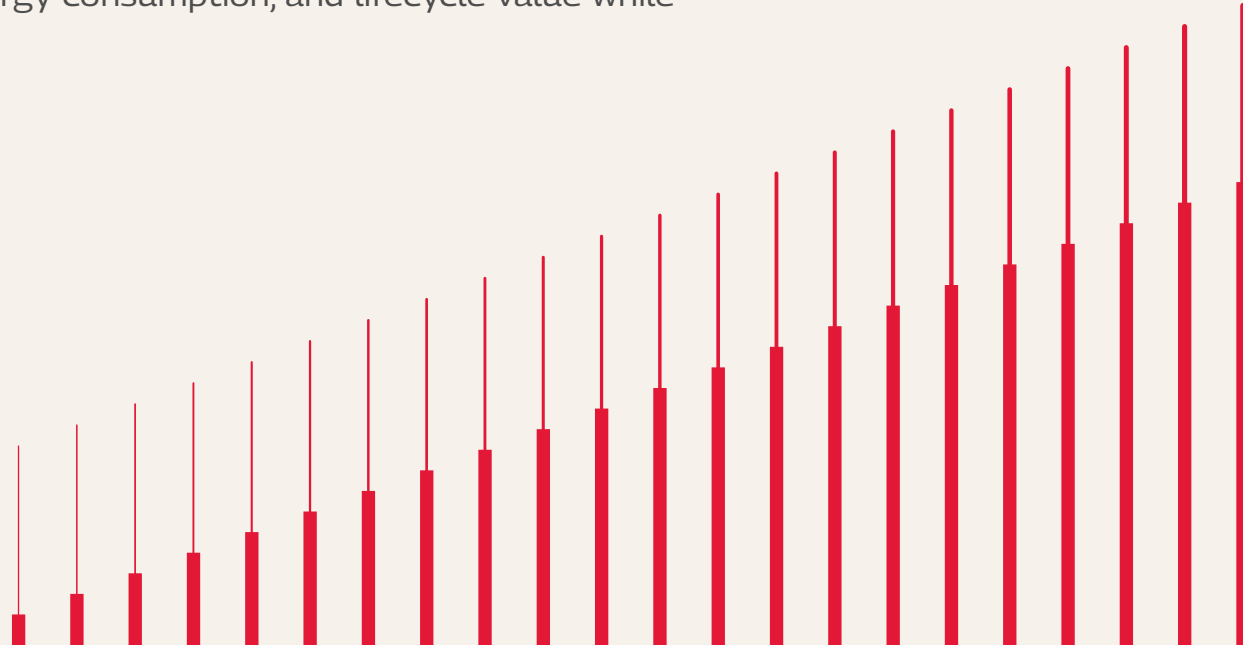


However, these advancements introduce significant engineering complexities and trade-offs. OEMs must balance:

- Efficiency improvements with stringent cost targets and competitive pricing
- Integration of VFDs/VSDs with challenges such as harmonic distortion, EMI/EMC compliance, and motor insulation stress
- Deployment of condition monitoring and predictive analytics without excessive system complexity or cost overhead
- Digitalization with the need to preserve reliability, safety, and long-term serviceability

In this context, success for OEMs depends on adopting a system-level engineering approach that integrates motor design, power electronics, control algorithms, and cohesive digital platforms.

Strategic differentiation will increasingly come from the ability to deliver holistic, compliant, and future-ready solutions that optimize performance, energy consumption, and lifecycle value while navigating regulatory and technology convergence.





Evolution of Motor and Drives

Since its origins in the 19th century, electric motor and drive technology has evolved significantly from simple electromechanical systems to highly efficient, digitally controlled solutions. The table below represents the evolution over time.

Phase	Focus	Technology	OEM Differentiation
Pre-1980s	Mechanical control	Fixed-speed motors	Reliability
1980-2000	Speed control	VFDs (IGBT)	Energy savings
2000-2015	Performance	Vector control, PM motors	Precision
2015-2022	Connectivity	IoT-enabled drives	Visibility
2022-Present	Intelligence	AI, digital twin	Predictive systems
Future	Autonomy	SiC/GaN, AI-native	Self-optimizing platforms



Current Challenges Faced by OEM

OEMs operating in this domain face key challenges, including energy efficiency vs. cost pressures, drive integration, and digitalization. In addition, rapid technological advancements and rising customer expectations further drive the need for continuous innovation. These are highlighted below:

Energy Efficiency vs Cost Pressure:

Manufacturers are under constant pressure to meet the IE3/IE4/IE5 efficiency standards without compromising on competitive pricing. To achieve higher efficiency levels, technologies such as PM motors, advanced laminations, and SiC/GaN are crucial. However, they also increase BOM cost. Adding to the pressure is the customer's expectation of a short payback period within 2 to 3 years.

Integration of Drives (VFDs/VSDs) and Power Quality Issues:

The increasing reliance on VFDs/VSDs is introducing new challenges for manufacturers in industrial power systems. Harmonics are affecting the grid and equipment. Also, issues with motor insulation stress due to dv/dt , bearing currents, and EMI/EMC compliance are increasing operational complexity. The need for filters such as LCL, dv/dt , and sine filters increases costs.

Complexity in System-Level Engineering:

The shift from component-level to system-level design drives co-design among motor, inverter, control algorithm, and load requirements. Performance depends on how these requirements work seamlessly together. With growing interdependencies, there is also the need for complex validation.



Digitalization and Added System Complexity:

As industrial systems become more intelligent and connected, manufacturers are expected to embed sensors for monitoring temperature, vibration, and current, along with connectivity modules and edge analytics. This evolution has led to increased firmware complexity and data management requirements.

Predictive Maintenance Implementation:

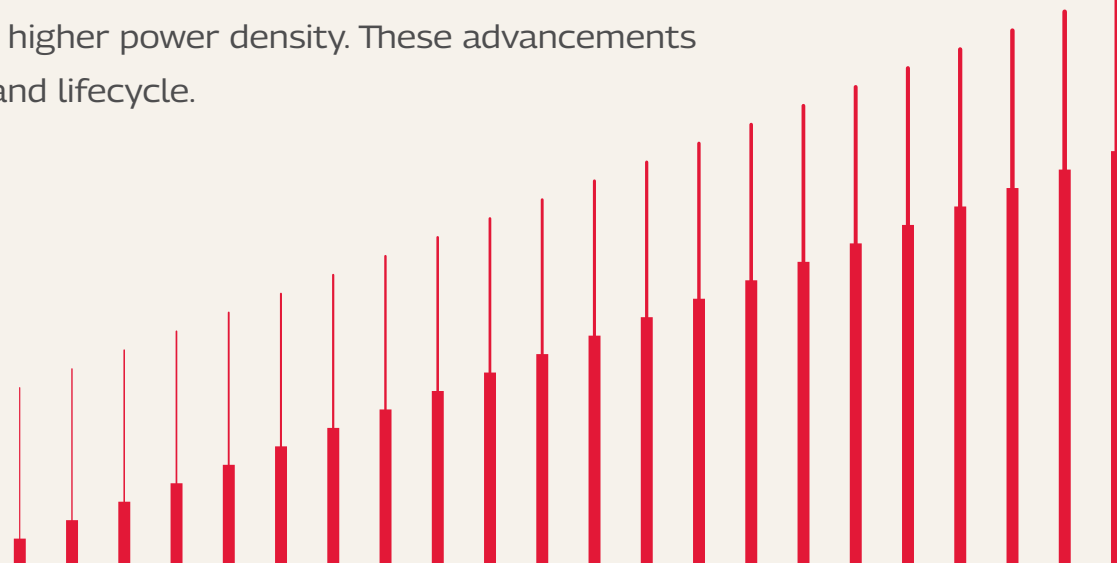
Manufacturers continue to face difficulties in developing accurate fault detection models, ensuring reliable data acquisition, and making edge vs. cloud processing decisions. These have led to a lack of standardization of datasets for ML models.

Cybersecurity Compliance (IEC 62443):

Today, connected systems are ubiquitous, necessitating secure boot, encrypted communication, and firmware update mechanisms. However, implementing these safeguards requires a careful balance between security, system performance, and costs.

Thermal Management and Power Density:

Compact designs and wide-bandgap devices are prioritizing higher power density. These advancements are increasing thermal stress, thereby impacting reliability and lifecycle.



Supply Chain and Material Constraints:

For most manufacturers, supply chain volatility remains a challenge. Greater reliance on rare-earth magnets in PM motors is driving up sourcing risks. A shortage of semiconductors may disrupt production timelines. Also, cost volatility in copper and steel creates added pressure on long-term production planning.

Regulatory and Compliance Burden:

Manufacturers need to ensure that they are compliant with multiple global standards. Also, regional variation in these compliance forces the manufacturers to redesign.

Customization vs Platformization:

While OEMs aim to standardize platforms, customers demand application-specific solutions.

Sustainability and ESG Expectations:

Customers and regulators constantly demand a lower carbon footprint and circular design. Also, organizations are under immense pressure to provide lifecycle energy reporting.





Next-Gen Solutions to Solve Challenges

Next-generation motor and drive technologies are increasingly advancing toward intelligent, adaptable systems enabled by digital connectivity and AI capabilities. These solutions enhance efficiency, enable real-time monitoring and control, and provide predictive insights that help OEMs improve reliability while optimizing operational costs. Below are a few of those.

Services	Solution	Addresses	Benefits
Platform-Based Integrated Motor-Drive Architecture	▪ Develop modular, scalable platforms integrating: Motor + Drive + Control + Digital Layer ▪ Standardized hardware + configurable software	▪ System complexity ▪ Customization vs Platformization	Reduced development time, scalable product portfolio, lower engineering cost
High-Efficiency Drive Systems with Wide Bandgap (SiC/GaN)	▪ Adopt SiC/GaN-based inverters ▪ Optimize switching strategies and magnetics	▪ Energy efficiency vs cost trade-off ▪ Thermal management issues	▪ Higher system efficiency ▪ Reduced size, improved power density
Smart Motor Platforms (Integrated Intelligence)	▪ Embed sensors (vibration, temp, current) and edge processing (MCU/DSP + AI accelerators) ▪ Enable self-learning motor behavior.	▪ Digitalization complexity ▪ Reliability concerns	Adaptive, self-optimizing systems with minimal external dependencies



Services	Solution	Addresses	Benefits
Predictive Maintenance and AI-Driven Analytics	▪ Deploy AI/ML models for bearing fault detection and insulation health monitoring ▪ Edge + cloud hybrid architecture	▪ Maintenance inefficiencies ▪ Lack of actionable insights	▪ 30-50% reduction in unplanned downtime ▪ New service revenue streams
Digital Twin and Virtual Engineering	▪ Create multi-physics + data-driven digital twins ▪ Virtual commissioning and testing	▪ System-level design complexity ▪ Validation time	▪ 20-40% faster development cycles ▪ Reduced field failures
AI-Assisted Engineering and Automation	▪ AI tools for design optimization, code generation, and test automation	▪ Engineering productivity	▪ 20-30% engineering efficiency improvement
Sustainability and Circular Design Solutions	▪ Eco-design principles to reduce material usage and modular repairability ▪ Lifecycle energy tracking	▪ ESG and regulatory pressure	▪ Improved sustainability positioning and compliance readiness

TechM Help in Adopting Next- Gen Solutions

Tech Mahindra supports organizations in advancing toward next-generation solutions through its strong capabilities in digital engineering, automation, and system integration. We enable the transition to intelligent, connected, and energy-efficient ecosystems by leveraging modern digital technologies and innovative engineering practices. Tech Mahindra has

- End-to-end engineering, digital, AI integration-engineering intelligent, efficient, and secure motion platforms
- Integrated engineering partner (hardware, software, and digital)
- Strong compliance and regulatory expertise
- AI-first engineering approach
- Proven delivery via ODC + platform engineering models





Challenges	Next-Gen Solution
Energy Efficiency	SiC/GaN Drives, IE5 Motors
Harmonics and Power Quality	AFE Drives, Multi-level Inverters, Filters
System Complexity	Modular Platform Architecture
Digitalization	IIoT Connectivity + Edge Intelligence
Predictive Maintenance	AI/ML Analytics
Cybersecurity	IEC 62443 Secure Design
Thermal Challenges	Advanced Cooling and Packaging
Supply Chain Constraints	SynRM Motors, multi-sourcing
Compliance	Pre-certified Design Frameworks



TechM Expertise in Motors and Drives

Tech Mahindra has extensive experience in motors and drives, supporting global OEMs across the complete engineering lifecycle—from concept design to validation and sustenance. Our capabilities span power electronics, embedded systems, and motion control, enabling the development of high-performance and energy-efficient motor drive solutions. With a strong focus on digital engineering, we help customers advance toward intelligent, connected, and future-ready motor-drive ecosystems.

We are credited for:



Over 20 years of experience in the design and development of motor and drive solutions, resulting in long-standing engagements with various global customers.



Our strong talent pool of over 1000 domain experts and SMEs, supported by dedicated power electronics and embedded engineering labs for end-to-end product validation.



Our specialized test center of excellence (CoE) supports comprehensive testing across motor drives, inverters, and converters, ensuring robust product performance and compliance.

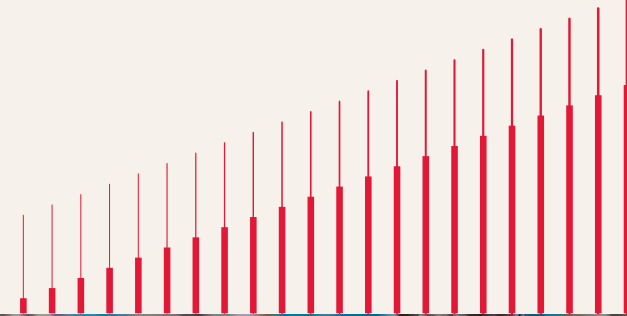


Offering advanced validation capabilities, including UL-certified lab support for EMI/EMC, ESD, surge testing, IGBT double pulse testing, and end-to-end ownership of CE and UL certifications.



Our Differentiator

-  End-to-end ownership with reusable IP
-  Platform approach (variant velocity)
-  Compliance-ready engineering with UL-certified lab + automation
-  Deep power-electronics validation expertise (device-to-system)
-  Lifecycle and installed-base modernization baked in
-  Digital condition monitoring and predictive maintenance readiness



Success Stories

- Delivered a 600A / 680 VRMS OVP module for a high-speed PMSM test rig with end-to-end ownership and client-validated TechM IP
- Built a cost-optimized common BLDC controller PCB (6/12/24V, 24W) with complete HW/FW + testing, hitting \$5.8 at 10K and enabling a scalable 24-70W platform with 30-40% faster delivery via shared BOM/layout
- Delivered an 800V SiC traction motor controller with end-to-end HW/FW, prototyping, and compliance support using the latest SiC MOSFETs—scalable, reusable TechM-owned IP
- Delivered a 48V mild hybrid EV motor control unit using MBD (FOC + SVPWM), including dyno validation—spec to part ownership with a size-optimized, thermally efficient, virtually validated design
- Designed a variable frequency drive with active front end (AFE) rectifier using model-based development and integrated test automation to improve efficiency and reduce harmonics for a water and waste management application
- Established a test CoE for motor drives/inverters/converters with multi-power load testing, SIL/HIL, multi-protocol validation, automation, and UL-certified EMI/EMC/ESD/surge capability
- Validated IGBTs via double pulse testing (15/22/50kW) and optimized gate drive/SOA/switching losses to extend VFD power from 7.5kW to 15kW and 22kW.



Conclusion

Tech Mahindra enables OEMs to accelerate next-gen adoption, reduce engineering risks, and unlock new revenue streams—transitioning from product manufacturers to intelligent motion solution providers.

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About the Author

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He is a seasoned Principal Consultant with over 30 years of extensive experience in the design, development, and delivery of embedded systems, power electronics, industrial automation, and control systems across. His expertise spans multiple industry sectors including industrial, energy & utilities, aerospace, healthcare, consumer appliances, semiconductor, and transportation.

He has led end-to-end product development from concept through commercialization, driving engineering innovation across system architecture, embedded technologies, power conversion systems, and connected solutions. He has also played a key role in establishing centers of excellence, shaping technology roadmaps, and leading global engineering and delivery programs.

About **Tech Mahindra**

Tech Mahindra (NSE: TECHM, BSE: 532755) offers technology consulting and digital solutions to global enterprises across industries, enabling transformative scale at unparalleled speed. With 146,000+ professionals across 90 countries, Tech Mahindra provides a full spectrum of services including consulting, information technology, enterprise applications, business process services, engineering services, network services, customer experience & design, AI & analytics, and cloud & infrastructure services. It is the first Indian company in the world to have been awarded the Sustainable Markets Initiative's Terra Carta Seal, which recognizes global companies that are actively leading the charge to create a climate and nature-positive future. Tech Mahindra is part of the Mahindra Group, founded in 1945, one of the largest and most admired multinational federation of companies.



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