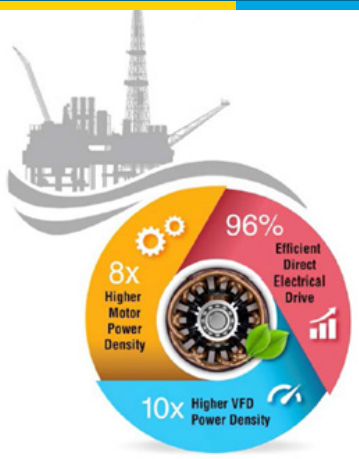
Next Generation Energy Efficient, Small Footprint, and Highly Reliable Integrated Motor

Integrated Variable Speed Drive (VSD) and High Speed Motor for Gas Compression

Enabling increased efficiency and power density with advanced motor drive design



Left: Visual of benefits of integrated variable speed drive and high-speed megawatt motors for gas compression. Right: A Calnetix rotor with the type of composite fiber carbon fiber sleeve and copper shielding to be used in the high-speed motor. *Images courtesy of Eaton*

Deploying variable speed drive (VSD) in one megawatt (MW) size motors would provide large electricity savings, yet the adoption rate of medium voltage VSDs is still very low. Barriers include high capital cost, large footprint, low switching frequency, and high losses at medium voltage ratings for today's silicon power electronics-based VSDs. One way to remove these barriers is to incorporate next-generation power conversion technologies based on high voltage silicon carbide semiconductor switching technology. Yet underinvestment in commercial products with silicon carbide semiconductor technology continues to be an issue due to low technology and manufacturing readiness levels and lack of manufacturer and end-use customer acceptance.

To improve drive efficiency and power density of motors, researchers are developing an integrated silicon carbide VSD and high speed megawatt motor for gas compression applications. The key innovation is integrating a VSD (using high current silicon carbide devices, high-frequency inductors, and other advanced reactive components) with state-of-the-art switching frequency power electronics into a permanent magnet motor to increase power density and energy efficiency.

When compared to a silicon-based drive, a silicon carbide VSD has nearly 10 times the power density. The integrated VSD and motor will demonstrate a combined minimum 96% efficiency without the use of any gears to perform compression.

Benefits for Our Industry and Our Nation

This project will help the U.S. gain a competitive technical advantage in the design and manufacture of medium voltage-class electric motor systems and spur the necessary investment to commercialize the technology. The development of the integrated silicon carbide VSD and high-speed motor has many benefits, including the following:

- Produces a motor drive operating in excess of 96% efficiency and with eight times the power density of state-of-the-art silicon-based drives.
- Develops a scalable design for VSD in terms of the silicon carbide modules used to reach higher levels of power density and performance.
- Reduces volume, footprint, losses, and maintenance by eliminating the traditional motor gearbox.

Applications in Our Nation's Industry

This project will develop a megawatt-class, gearless, all-electric drive integrated with a high power density, efficiency, and speed motor applicable for high speed compression applications. This advancement will be especially valuable for industries with harsh industrial operating environments such as oil and gas, mining, utility, water and wastewater , and other critical applications, where it can increase reliability, cost effectiveness, and safety (mainly by reducing equipment size and protecting electronic components). The oil and gas industry uses onshore and offshore gas compressors that operate in the multiple megawatt range.

Project Description

The project objective is to develop and test an integrated high voltage VSD and integrate it into a high-speed motor to meet aggressive performance targets and take advantage of direct, high-frequency drive benefits. The VSD will use silicon carbide transistor devices, high-frequency inductors, and will be integrated into a permanent magnet motor with magnetic bearings, to demonstrate high efficiency (motor inverter efficiency equal or higher than 99% and motor efficiency of more than 96%) and power density levels (less than five cubic meters per MW). The VSD will have the capability to withstand the harsh environments of the targeted industries (e.g., oil and gas and other emerging energy markets).

Barriers

- Achieving the combined high power density and high efficiency goals.
- Successfully implementing the appropriate combination of design improvements.

Pathways

The technical approach of this project builds upon a strong foundation of existing commercial products and techniques, leverages R&D technological advancements, and includes a solid understanding of the end use requirements, markets, and value drivers. Project partners will complete the work across several tasks such as: program management, requirement definition, design, testing, and market transformation and commercialization planning. Project partners will establish performance specifications while working closely with their customers. Design subtasks will make use of established new product development practices, resulting in an integrated VSD and motor ready for testing. Multiple rounds of testing will be performed and all team members will participate in planning and data analysis. Finally, the team will develop a market launch plan to launch the technology to commercial readiness.

Milestones

This three year project began in 2016.

- Complete design and layout for the power electronics modules for the VSD (2017).
- Complete testing of high speed, one MW motor, meeting performance specifications (2018).
- Complete design of VSD (including power electronics, packaging and control, etc.) to meet requirement for compatibility with motor (2018).
- Assemble and complete testing of integrated motor, meeting or exceeding targets (> 96% total system efficiency) (2019).

Commercialization

The project seeks to demonstrate a pilot scale integrated VSD and high-speed motor by achieving proposed performance targets. Reaching this goal, along with the planned tech-to-market activities centered on the value proposition of the integrated motor drive, will significantly advance the commercial readiness of the system for gas compression applications. The project team involves representatives across the domestic supply chain for silicon carbide power electronics, high speed motors, and the oil and gas industries. Their experience will enable them to define the technology's commercial merits, identify target customers, quantify benefits, and show competitive distinctness. Project partners will work directly with an oil and gas industry partner interested in the potential VSD system described in this document. The partner will cooperate closely with the development team to ensure that the application solution fits the needs of the industry.

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