Optimized Stator Design

Segmented lamination technology increases motor efficiency, power and compactness

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Thermal efficiency, defined as the motor's power output for a given temperature rise, is an important factor in brushless motor performance. A more thermally efficient motor not only wastes less input power, but also results in higher continuous torque and power density, produces less temperature rise and lengthens the motor's functional life. Newer designs for brushless dc motors are using segmented lamination stator technology to reduce winding and thermal resistance, and achieve 40 percent higher thermal efficiency than traditional brushless motors of the same size.

Using higher slot fills, reduced end turns and thermally conductive epoxy potting, T-LAM™ stator technology from Exlar Corp. offers individual phase wiring for maximum motor efficiency by limiting the heat generation qualities inherent in electric motors.

The key to the technology, as demonstrated in the Continuous Power-Speed Curve for Exlar's SLM90-238 servomotor on page S9, is the ability to achieve both high continuous torque and power density. The combination of 40 percent less winding resistance and 50 percent lower winding-to-ambient thermal resistance results in a more efficient design that also helps reduce energy usage.

A brushless dc motor is a synchronous electric motor powered by direct current electricity that has an electronically controlled commutation system. Permanent magnets fixed to the rotor and rotating within a static multi-phase stator winding are efficient at converting electricity into mechanical power for effective velocity, position and torque control.

“T-LAM stators provide higher slot fill with more copper wire, offering greater than 20 to 30 percent more slot fill than in traditional brushless motor stators of equal size,” says John Walker, vice president of marketing and sales at Exlar. “This increase directly results in higher current rating, hp and torque.”

Substantially reducing end turns is a key design advantage because, on a traditional brushless motor, end turns are the most susceptible area to heat and voltage damage because they are surrounded by air. Without a good thermal path for generated heat to escape, this damage could short the windings, rendering the motor inoperable.

The end turns of a traditionally wound brushless motor do not provide additional power or torque. Instead, they can make a motor less efficient and generate unnecessary heat. Reducing the percentage of the stator that is comprised of end turns increases the motor's thermal efficiency and reduces its susceptibility to heat or voltage damage in the end turns.

The end turns of a traditional brushless motor unnecessarily increase the length of the motor stator. Forming or compressing the end turns reduces this length, but it results in significant strain on the wire, potentially leading to insulation breakdown.

Walker says T-LAM technology reduces end turns to less than 10 percent of those on a traditional brushless motor. Plus, the end turns that are present in the stator are completely encapsulated in a heat conductive epoxy, further increasing the thermal efficiency of the motor and protecting the end turns. Greater thermal efficiency means the motor will run cooler at a given load, may provide a safety benefit and also may result in longer motor life.

In a traditional brushless motor, all of the phase wires from one phase are in contact with wires from the other two phases within the end turns. This leads to massive voltage potential (peak-to-peak, drive bus voltage) differences in the adjacent phase end turns, high stress on the insulation and potential for motor failure.

Only one wire passes from phase to phase in a T-LAM stator, resulting in negligible voltage potential differences between these wires. The wire used to wind the stators is heavy build, inverter-grade wire which provides a robust solution for operating with IGBT-based servo amplifiers.

A UL-recognized, thermally conductive epoxy completely encapsulates the stator which, combined with polyester resin lamination caps and slot insulation using flame-resistant material, results in Class 180(H) 460 Vrms (700V dc bus) ratings for all T-LAM motor stators (180C motor temperature rating). Walker says most traditional brushless motor stators are limited to a 155C temperature rating.

The wire in a T-LAM motor is also externally wound on a straight stack of laminations, resulting in the least amount of stress to the wires. Complete phases are wound on a single contiguous wire, removing any current-carrying solder joints from the stator winding. In comparison, the phase windings in traditional brushless motors are done externally of the stator and inserted after the coil is wound, creating high stress on the wires.

The T-LAM motor's straight winding and minimized end turns, as well as elimination of the need for compressing or forming the end turns, provide effective phase insulation. The motor's design also eliminates many of the difficulties associated with insulating inserted coil-type brushless motors, which can lead to voltage-related failures.

The winding method allows for maximum flexibility by allowing custom windings to be designed and manufactured in short time periods — without the need for special tooling, complicated winder programming or special equipment. Traditional brushless motors often require that the lamination stack be skewed the width of one slot of the motor stator to reduce cogging torque, further stressing the wires. The straight coil design of the T-LAM stators eliminate this need to skew the stator slots, and as a result puts less strain on the wire during assembly.

The T-LAM design provides minimum cogging torque, while delivering maximum usable torque through the design of the magnet and lamination geometry. Cogging torque is typically defined as a percentage of the motor's T-LAM comparison to traditional stators continuous torque. A common misconception is that traditional brushless motors have lower cogging torque. A T-LAM motor has higher continuous torque than a traditional motor of the same size. So, at the same percentage cogging torque, only the absolute value will be greater.

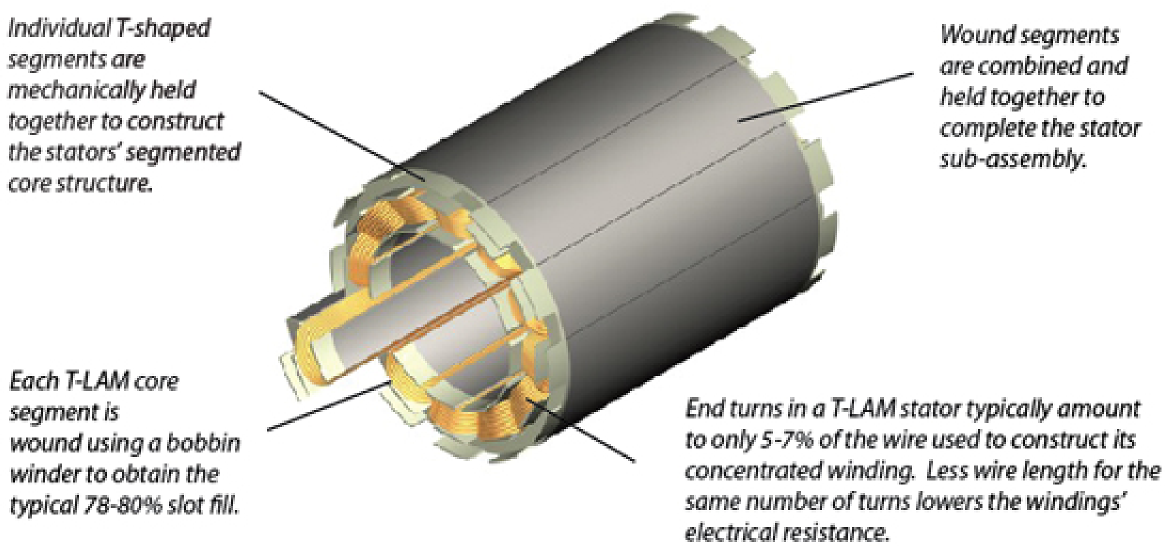
“The combination of higher slot fill, thermally conductive epoxy potting and minimized end turns results in a motor that can be 40 percent more thermally efficient than a traditional brushless motor of the same size,” Walker says. “The result is a motor that can be rated for higher power or, for the same power production, can run much cooler, saving user’s energy and costs.”

A cooler motor case temperature, in applications that require it, creates a more compact motor than traditional stator technology and conserves space while delivering comparable results.

Segmented lamination stator technology reduces winding and thermal resistance, boosting motor performance, power density and ultimately saving energy versus traditional brushless motors.

A Power-Speed Curve shows how an SLM90-238 motor achieves high power output performance versus a traditional servomotor using a solid core stator. Winding resistance is 40 percent lower compared to the original Solid Core design due to increased slot fill and less end turn waste. Potting the T-LAM motor with thermally conductive epoxy lowers the winding to ambient thermal resistance by 50 percent while increasing the maximum allowable power dissipation inside the motor by the same 50 percent.

T-LAM Segmented Lamination Stator Technology



SLM90-238 Continuous Power-Speed Curve