

Why “SLOTLESS” brushless DC motors?

The “Slotless” brushless DC motor technology has been, and continues to be, pioneered by Elinco. It has been proven in production and field operation. This patented design consists, basically, of a stator winding positioned inside a laminated stator ring (without conventional teeth) and at permanent magnet rotor. This design provides several advantages over conventional Brushless DC motor construction. Understanding these advantages and properly applying them has resulted in the slotless design making major advances into applications normally served by conventional motors.

1. **Zero cogging torque:** In the conventional permanent magnet motor the magnets take a preferred angular position with respect to the stator teeth. If no power is applied to the motor and the shaft is rotated by hand the magnetic positioning effect can be felt. The amount of force required to move the rotor from this position is known as cogging torque. As motor designers, have changed their designs to high energy magnets the cogging torques have become larger and thus increased the number of application problems, particularly where smooth operation is required at low speeds. By eliminating the stator teeth the slotless motors have no preferred rotor position and the shafts rotate smoothly at any speed. In addition, shaft position can be more finitely controlled.
2. **Smooth torque:** Motors have a variation of torque during the 360 degrees of angular motion known as torque ripple. This is normally the result of the combined motor and controller dynamics. Usually the best operation is obtained when the controller and back EMF wave forms are matched. A portion of the torque ripple is traceable to the reaction of the magnets with the stator teeth. In the slotless design this is eliminated. The resulting reduced torque ripple provides smooth torque during acceleration, deceleration, and running. This allows tape drive manufacturers to store more data in the same tape as it can be positioned more accurately. Controlling tensions during start, run, and stop cycles can be controlled to previously unattainable levels.
3. **High speed performance:** The stator coils in the slotless motors are not surrounded by laminated iron as in conventional toothed construction. As a result, motor winding inductance is significantly reduced. The lower electrical time constant allows improved performance at high speeds. This, combined with high flux densities associated with high energy magnets and resulting high torque to inertia ratios, has made slotless motors popular for high performance centrifuges, lens grinding, high speed spindles, and high speed compressors.

4. **Low noise levels:** Motor noise generally originates from bearings, windage, mechanical and electrical imbalances, and noises due to rapid flux changes in the lamination steel. The slotless design enables a more uniform winding distribution and reduces the amount of lamination material by eliminating teeth. This dramatically reduces electrical (or transformer) noise and makes the motor particularly attractive in applications where noise has been a problem. In medical centrifuges and mixing applications we have been able to achieve noise levels under 57 db.

5. **High efficiency:** Elimination of the stator teeth enables the stator windings to be placed more compactly and evenly within the stator circumference. This coupled with reduced core loss due to less stator iron produces a more efficient unit for the same speed and torque output. At high speeds and/or high flux densities (high energy magnets) tooth saturation becomes an issue with conventional designs. With no teeth, the opportunity for efficiency improvement increases dramatically with the slotless designs. To maximize this improvement controller-motor matching is essential.

6. **Easier cooling:** In an induction and wound rotor motors the hottest spot in the motor is in the rotor. In most BLDC motors (including slotless motors) the heat loss is primarily in the stator. Consequently, the heat can be more readily removed through the frame of the motor without a significant amount of heat being transferred through the bearings.

7. **Smaller envelope:** The increasing availability of high energy magnets provide the slotless motor with additional advantages. The resulting high gap flux densities, without concern for tooth saturation, enable high torque to weight ratios and result in overall envelope size reduction. As the energy product of magnets increases and costs decrease this type of construction will increasingly become the meter of choice where size is an issue.

The following chart shows how these key features lead designers to slotless in their applications. Compare your application with these factors to see if you should consider slotless motors for your equipment.

Application	FEATURE						
	Zero Cog.	Smooth Torque	High Spee	Low Noise	High Eff.	Easier Cooling	Small Env.
Air Conditioning				X	X	X	
Centrifuge	X	X	X	X	X	X	
Compressors & Fans			X	X	X		X
Grinder	X	X	X	X	X	X	X
Medical Appliance	X	X	X	X	X		X
Mixer			X	X	X	X	
Positive Pump	X	X		X			X
Servo	X	X	X	X	X	X	X
Spindle	X	X	X	X	X	X	X
Tape Drives	X	X		X			
Marine Propulsion	X	X		X	X	X	X
Electric Vehicles	X	X		X	X	X	