MSD
MOTION SYSTEM DESIGN

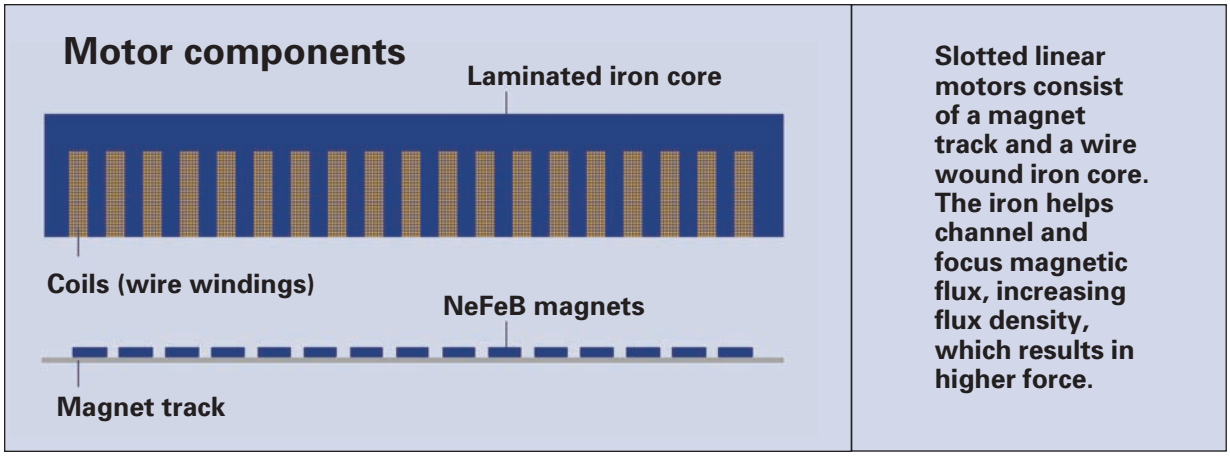
Cures for cogging in slotted linear motors

MSD 101

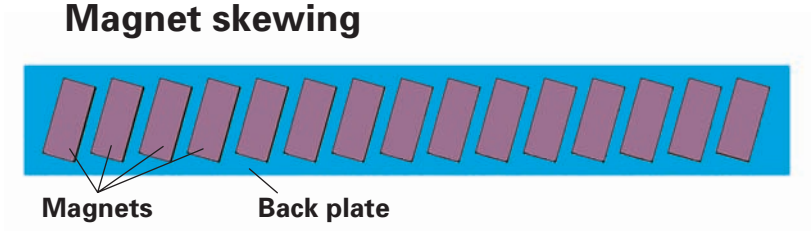
Slotted linear motors move with speed and precision, and are raising the bar on linear motion applications. They consist basically of magnets and windings. The magnets bond to an iron plate, forming a magnet-track assembly often called a "primary." The coils are wound in the teeth or slots on a laminated iron core, forming the "secondary" or forcer assembly. As in any motor, current applied to the coils controls speed, force (based on voltage), and direction (based on phase).

Slotted motors stack up well against the more common slotless types. They are less expensive, generate more force, and like their slotless counterparts, operate without backlash or contact. They also provide comparable speed and acceleration. On the downside, slotted linear motors exhibit a fair amount of cogging, limiting their use to point-to-point motion applications.

Although there are various ways to limit the force "ripple" and velocity variations caused by cogging, most involve design changes that make slotted motors more expensive and less efficient. Another approach, which leaves the motor unchanged, is software-based compensation. In some cases, software compensation can reduce cogging by nearly an order of magnitude, making slotted motors a viable alternative for laser cutting, welding, scanning, and other processes requiring smooth motion. **MSD**



Slotted linear motors consist of a magnet track and a wire wound iron core. The iron helps channel and focus magnetic flux, increasing flux density, which results in higher force.



Skewing the magnets along the magnet assembly is one way to reduce cogging in slotted linear motors. It works by modifying the crossover point between the fields associated with the magnets and coils.

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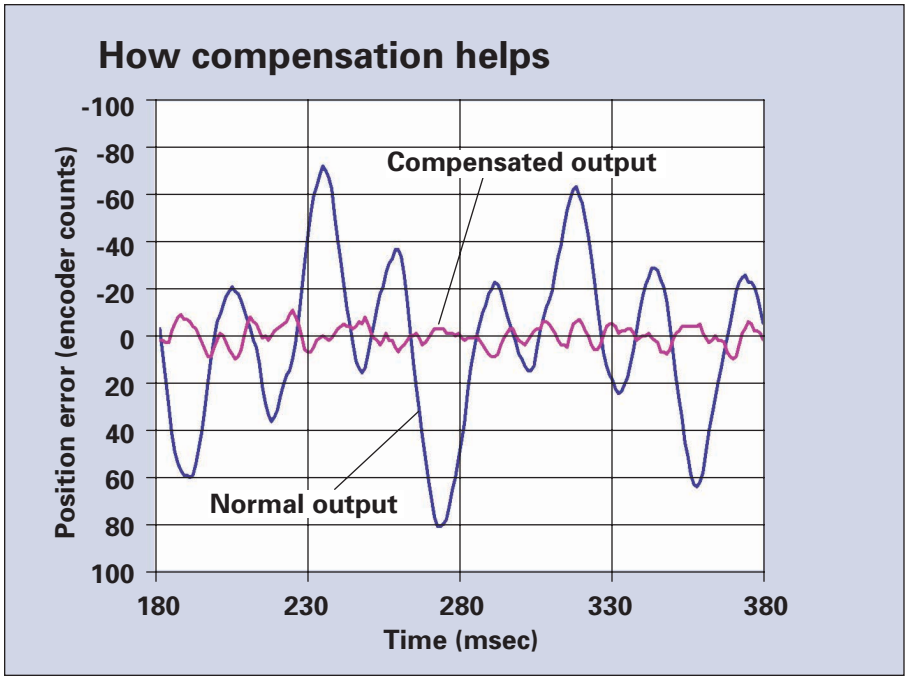

Software-based compensation offers almost an order of magnitude improvement in cogging compared to uncompensated motor output.

Q & A

What is cogging?

Cogging is a term used to describe non-uniform force or torque, and refers to movement occurring in short, jerky increments. In the case of slotted linear motors, cogging is caused by magnetic interactions between the leading and trailing edges of the iron slots as they pass over the permanent magnets on the track. The intermittent nature of the coils also contributes to cogging.

What can be done to reduce cogging?

One solution is to skew, or angle, the magnets or slots. This creates a more gradual crossover point between the magnetic fields, leveling out the bumps. Reshaping the magnets is another method. The intent here is to more uniformly distribute the magnetic flux throughout the windings and slots. Both solutions come at a price, however, adding cost and complexity to the manufacturing process.

What about software compensation?

Software compensation is another way to reduce cogging in slotted linear motors. It works by adjusting motor current to minimize variations in position output, allowing standard slotted motors to run much like the smoother slotless types. Software compensation is an option for new designs as well as field upgrades because it doesn't require hardware changes.