Balancing design objectives with low-power braking

As Plato once said, the measure of a man is what he does with power. Of course the ancient Greek philosopher wasn't referencing motion control with that statement, but it holds true here as well: Electrification and batteries in our modern world demand top efficiency from all components, including clutches and brakes … because there's no workaround for the fact that electrical power P = V×I … and electrical power dissipated $P_d = I^2R$.

In fact, power can be saved while using electromagnetic brakes. Cooler operation is better for efficiency and machine design longevity … and oftentimes, optimizing a brake's performance is possible through customization. Consider how electromagnetic spring-applied brakes work: These brakes mechanically hold loads but electrically actuate to release. So without power applied, the brakes stop and hold a shaft in place to prevent rotation. In fact, some modern parking brakes in passenger vehicles use this design: The brake releases upon the application of power to allow wheel rotation.

Where is more power a design objective? Rapid adoption of mobile robotics and battery-powered equipment has made power density more important than ever. Electromagnetic brakes for these applications must draw as little power as possible. This allows more power for essential equipment operation, longer battery life, lower cost of operation, and a healthier environment. Design engineers can limit power draw from electromagnetic brakes in three ways — by customizing to optimize the brake … and taking steps to keep the brake cool … and selecting a brake that's lightweight … and using a power controller on the brake.

How to customize a brake: Leading brake manufacturers offer motion designers supportive engineering and application expertise. Many have online application-submission forms to make the first reviews more convenient. Of course, customization doesn't change the way electromagnetic brakes function … but design modifications to the brake's airgaps, spring force, materials, coils, and flux paths can make for dramatic performance improvements.

Pulse width modulation: Magnetic flux takes the path of least resistance. So within milliseconds of initial application of current to the brake coils, the brake disengages and inductance changes. The exact response time is a function of the brake size and design. In this disengaged brake state, the mechanical pressure plate is contacting the coil body. In addition, the magnetic flux no longer needs to travel across the airgap distance to close the electromagnetic circuit.

Once the brake is disengaged, power can be reduced to hold the brake in a disengaged state. This is the most useful design approach in boosting efficiency … because after all, the maximum amount of electric current should go into performing work — and wasted power should be minimized. Here, pulse width modulation **(PWM)** is indispensable for drawing down power into the brake to keep it disengaged. In fact, brakes with PWM input can expect to consume 50% less power during holding … and some 24-V brakes can average down to about 7 V — which is closer to 70% energy savings.

Over-excitation is another technique to make designs more efficient. It lets designers get more torque for a given size. For example, when disengaging a spring-applied 12-V-coil brake, an over-excitation routine might apply 24 V for a short duration while the brake's coil magnetically attracts the pressure plate and compresses the springs. Required power drops once the pressure plate comes into contact with the coil body. Note: Over-excitation should only be used in applications where the brake has a coil specifically designed for this type of operation. After all, the goal is to have long-lasting products that meet life expectations.

Keeping cool: Combining over- excitation and PWM reduces total average voltage on the brake, thus eliminating excess heat buildup (from wasted energy) in the coil. The benefit is compounded by the fact that as coil temperature rises, so does its resistance. Conversely, a constant-current situation with rising resistance will also see an increased power requirement. So to prevent wasted power, keeping the brake cool is the way to go.

Competing design objective — eliminating weight: Unless the design at hand is a steamroller, there's no point in engineering extra weight into a new build. While it would be easy to employ a brake with a large surface to dissipate heat, it just isn't practical in most mobile applications. Instead, design engineers should focus on eliminating excess weight in mobile robotics and electrification projects. Lower weight necessitates less power from the drivetrain and can usually improve response time for better overall performance. Weight associated with a brake can be reduced by eliminating parts; by building a brake into the motor endbell; and by removing unneeded material from a brake flange. In addition, brakes should be designed for a particular application to meet torque, temperature, speed, inertia, duty cycle, and mounting. Customization leads to optimization in performance while minimizing weight.

BI-STABLE BRAKES ARE ANOTHER EFFICIENT OPTION

There exists another braking solution called bi-stable brakes for applications needing power savings. Just consider how central duty cycle is to efficiency — because after all, fewer actuation events lead to greater energy conservation. Bi-stable brakes serve this function by only actuating when a pulse of power is sent to the brake — to change its state from engaged to disengaged or vice versa.

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