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DC Universal Motor Control — Migrating to High Performance

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If you are considering a high-performance universal motor drive, you owe it to yourself to at least kick the tires on a DC architecture.

The migration from an AC universal motor drive to a DC drive is not unlike the migration from a circa-1980s Chevrolet Caprice Classic station wagon to a brand-new Audi Quattro.

There is absolutely nothing wrong with the old station wagon; it will get you where you need to be, but let's face it: The car is going to be noisy, inefficient, and not particularly responsive. With the Audi, there are significant performance improvements to be gained. It offers a far more nimble, responsive, and efficient drive. The Audi is quieter, its power plant more sophisticated. It's a fantastic car for those who can afford it, just as a DC drive is an excellent choice for demanding universal motor applications in which cost takes a back seat to performance.

The speed of a universal motor is established by the voltage applied to it: the greater the voltage, the faster the rotation. In an AC drive, speed control is achieved by applying longer or shorter portions of a mains half-cycle. This can be accomplished very simply using a diac, a triac, and some passives. A higher-performance AC topology might replace the diac and passive components with a low-cost microcontroller to drive the triac; going one step further, closed-loop speed regulation is readily performed with a microcontroller and can be realized with or without a tachometer.

Even with these performance enhancements, though, the responsiveness and overall operation of the AC universal motor drive is far from optimal. Relying on a triac for speed regulation means waiting at least one entire half-cycle for the next opportunity to make adjustments. And the current ripple inherent in this approach has ramifications across the application, including greater triac dissipation, diminished motor efficiency, and shorter motor life.

DC drive architecture, by contrast, can address these issues rather handily. For starters, speed is proportional to the duty cycle of the PWM drive, allowing for multiple correction opportunities within each half-cycle. This enables a far more agile speed regulation loop -- a more nimble drive. The switching frequency can also be adjusted for minimal acoustic effect.

But perhaps the greatest system improvement is the reduction in current ripple afforded by the DC topology. The motor runs more efficiently and lasts longer with a chopped DC supply.

As with the Caprice/Quattro scenario, the increased sophistication and improved performance of the DC architecture comes with a significant price tag. Whereas AC control requires a microcontroller, a triac, and simple protection circuitry, its DC counterpart will employ a bridge rectifier and a power switch to establish and chop the DC voltage. The inclusion of the switch -- either a MOSFET or IGBT -- necessitates drive circuitry and a fast (not cheap) freewheeling diode.

But with all these cost adders comes significant value: a product that outlives and outperforms its predecessor. If you're considering a high-performance universal motor drive, you owe it to yourself to at least kick the tires on a DC architecture.