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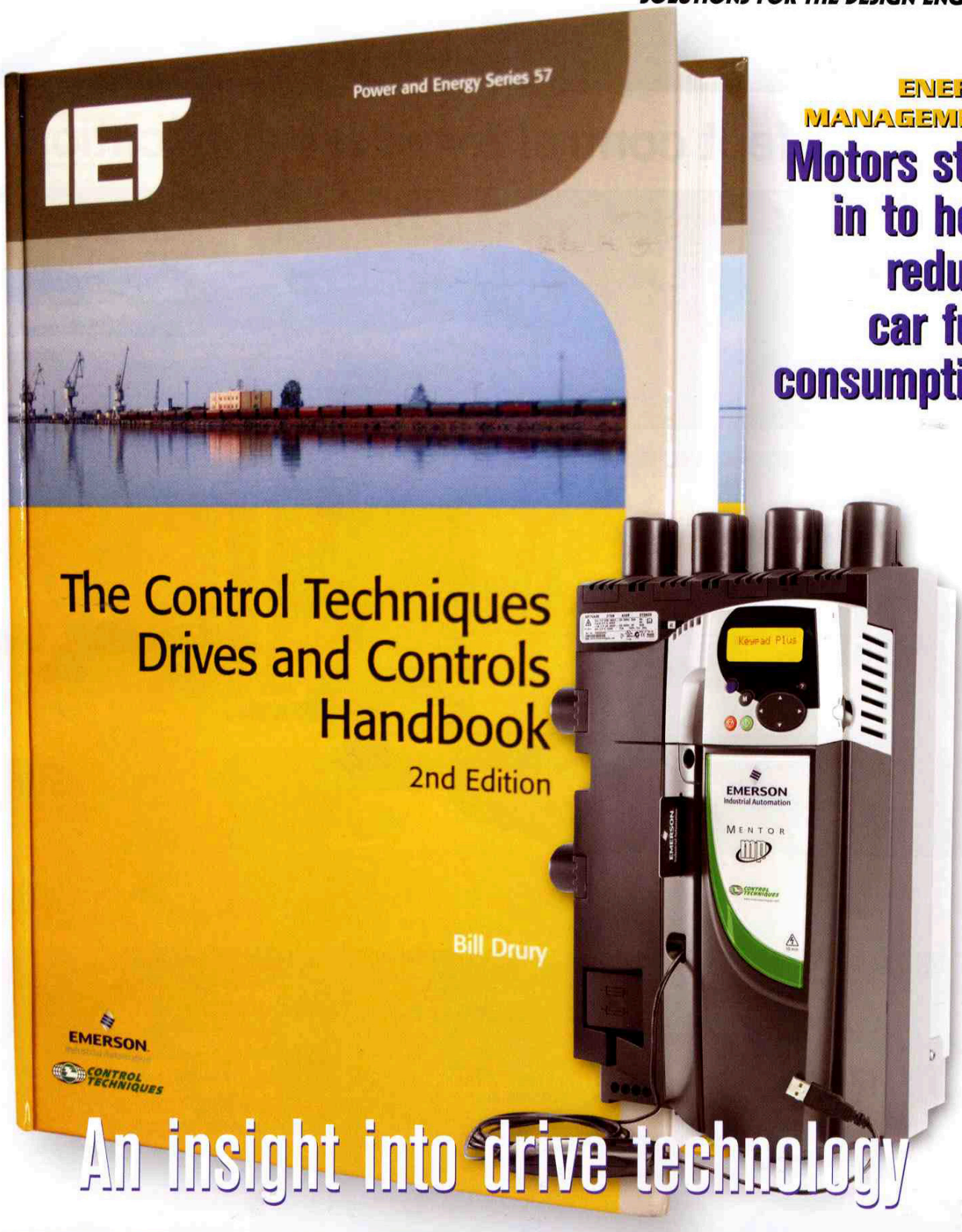

ENERGY MANAGEMENT

Motors step in to help reduce car fuel consumption

An insight into drive technology

FASTENINGS & ADHESIVES: Gearing up for adhesives

Design Solutions

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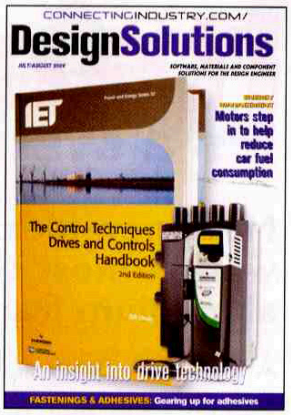

COVER STORY

Control Techniques is offering 20% off the Drives and Controls Handbook, edited by Professor Bill Drury, a book that gives a state-of-the art insight into the technology and techniques of AC and DC motor control. In addition, the company has published three new technology guides that cover supply harmonics, 'safe torque off' and electro-magnetic compatibility for variable speed drives

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Next month... Features in the September 2009 issue of Design Solutions will include • Gears & gearboxes • Bearings & linear motion • Hydraulics & pneumatics • Networking & communication • CAD • Special focus: Military & aerospace

Motors step in to help reduce car fuel consumption

One of the larger power consumers in a car is the climate control system – especially the compressor. **Bart de Cock,** from ON Semiconductor, explains how new stepper motor technologies that provide energy-saving potential for HVAC applications can help reduce fuel consumption in this area

Stepper motors are sometimes perceived as 'difficult' – mainly for historical reasons when control circuits required complex programming and resonance issues were not well understood (resonance can introduce mechanical vibration with associated wear, audible noise and risk of losing steps). However, with the latest driver technologies, control circuits are more straightforward and help developers to avoid the risk of step loss and resonance.

A stepper motor contains an 'embedded virtual sensor' whose output signal is accessible by means of Bemf sampling. Figure 1 illustrates a stepper motor that is suddenly accelerated and operated at a constant speed followed by a stall condition. The rotor position increases in a linear way followed by a constant (stalled) position. The speed oscillations in the rotor speed diagram are reflected in the sampled Bemf waveform. The stall condition is also visible in the Bemf signal when rotor speed suddenly falls to about 0 rad/s.

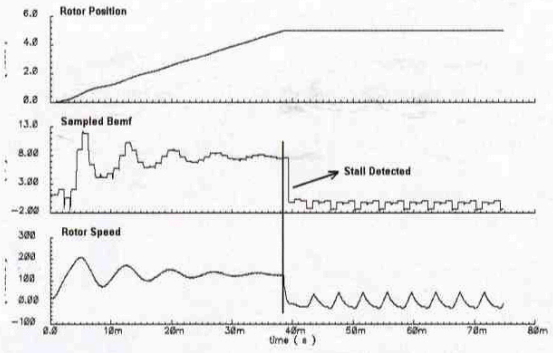

Figure 1: Stepper motor acceleration and operation

Advances

A reliable sensorless stall detection method has been implemented in ON Semiconductor's AMIS-30623 stepper motor driver, while an even more flexible implementation is available in the company's NCV70521 version. An analogue output SLA (Speed and Load Angle) pin allows direct access to Bemf samples and thus the motor's 'virtual sensor', proving useful for stall detection and troubleshooting resonance issues.

When verifying resonance issues in stepper motor applications, finding a suitable sensor and the means to attach it to the system is, in most cases, near impossible because they have neither an embedded sensor nor a place to accommodate one. Furthermore, when mounting the sensor the mass or friction on the motor-axis should not be altered because that changes the resonance behaviour being measured.

The NCV70521 and its SLA pin address this problem by allowing observation of rotor movement through the 'embedded virtual sensor'. Figure 2 shows a resonance characterisation session accomplished by means of a pulse generator to sweep the stepper driver frequency and an oscilloscope connected to the NCV70521 SLA pin.

These advances in stepper motor driver technologies will help to improve existing applications in car actuator systems. A good example is an expansion valve (EXV) that exists in most HVAC systems, and that reduces the pressure of refrigerant (in liquid form, temperature is below its boiling point or 'subcooled') coming from the condenser. After the valve, the low-pressure liquid evaporates while taking heat away from the environment, cooling the cabin air flowing over the evaporator. Several important trade-offs exist around EXV design, mostly related to efficiency of the total refrigerator system under various thermal load conditions and available power from the engine belt.

Two main operating principles for this valve are used: thermostatic expansion valves (TXV) and fixed orifice valves (FOV). The TXV operates mechanically using pressure equalisation and modulating refrigerant flow such that a certain temperature (superheat) is maintained at the evaporator output. The FOV is a passive device (basically a narrow tube) that acts as a barrier for the high-pressure liquid and feeds a limited amount of low-pressure liquid into the evaporator. Refrigerant flow through the FOV depends on orifice size, the pressure difference across it and the subcooling of the refrigerant. If the refrigerant is too close to boiling temperature (insufficient subcooling), then the mass-flow of refrigerant through the FOV is reduced because of small gas bubbles in the liquid.

Valve type selection depends on system design including refrigerant type (R-12 or R-134a), compressor operation/activation (cycled clutch vs. variable displacement), expected thermal load and OEM preference. The FOV that is always open and bleeding and the TXV that operates in open/closed mode both have advantages and flaws. The need to reduce fuel consumption and new requirements such as stop-and-go mean that HVAC manufacturers might need to look into other operating principles for the expansion valves.

Improvements

When a car engine shuts down, the compressor stops and the FOV bleeds all available subcooled refrigerant into the evaporator. Compressor activity is needed to re-build this liquid in front of the valve once the engine re-starts. On the other hand, because the TXV offers little room to modify parameters once installed, adaptive control of parameters such as the amount of superheat at evaporator output is virtually impossible.

A potential improvement for next generation HVAC systems is use of a stepper motor-based expansion valve. Such a device offers full control and is already integrated in many domestic and industrial refrigerators. Given the track record and availability of automotive stepper motor drivers, it might be the right time to re-evaluate the use of a stepper motor based mechatronic expansion valve in cars.

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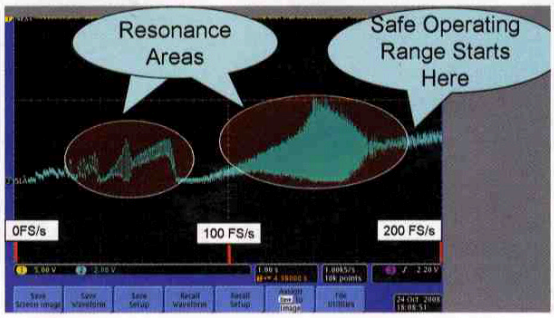

Figure 2: Resonance characterisation