The Importance of Thermal Protection for Torque Motors

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When talking about high-end machining or manufacturing applications that include direct-drive technology, one of the key advantages of utilizing this particular transmission method is its endurance. Because of the very nature of direct-drive motors they are able to operate at peak performance levels indefinitely—without any kind of wear or aging—as long as the motor isn't pushed past its capacity. Unfortunately, because this isn't a perfect world, unexpected things can happen which can cause the motor to overheat. Whether the heat source is due to a parameter being input incorrectly, or an unexpected external force causing more resistance than expected—it is important to have certain forms of thermal protection in place. Since torque motors are built in such a way that they cannot be repaired and yet maintain their efficiency, it is vital to prevent any overheating—thus precluding the need to purchase a new one.

There are currently a number of ways in which torque motors can be protected from overheating; they include having the controls monitor and maintain a certain amount of current, or using physical temperature sensors. Following are some of the methods possible to ensure optimum motor protection.

I^2t values. Within controls, the algorithms that monitor the current being used are referred to as an I^2t value. There are variations on how it is calculated depending on whose programs are used, but the principle is always the same. I^2t is an algorithm that is a function of time and current, so it uses the amount input into the motor over time and sets a limit on how much can be applied before overheating. To give an example of this, we'll take a look at the I^2t programming in Etel's AccurET control driver (Fig. 1).

A value of KF84 is set, as determined by the model of the motor. As the amount of current used goes above and below this value, integration begins. If the current remains above the selected KF84 value for too long, and the integral reaches its limit of KF85, then an I^2t error occurs. There is also an over-current limit at KF83 that sets a limit—regardless of any integration value.

Most drivers have some form of current-monitoring method to prevent overheating, and it is a way to use the motor's continuous current value to prevent motor damage at the electronics level.

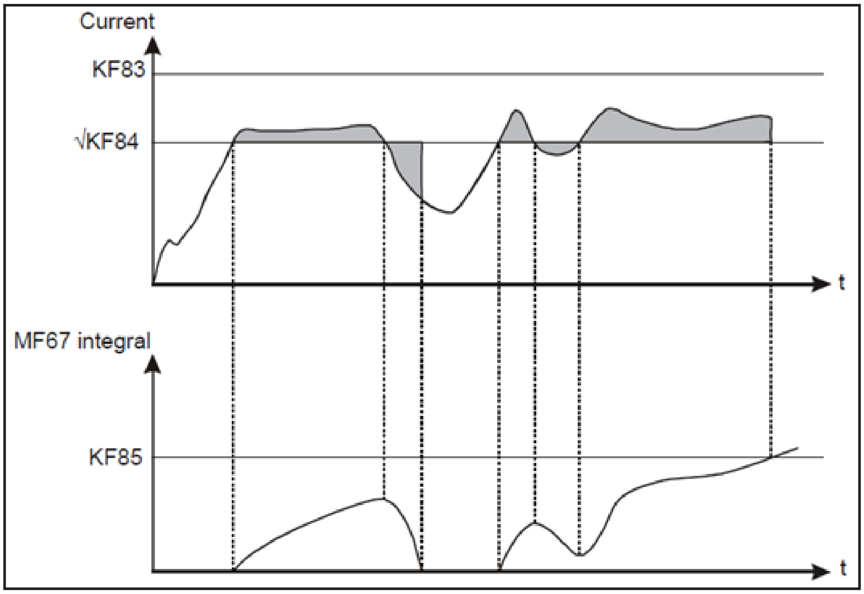

Figure 1 A value of KF84 is set, which is dependent on the model of the motor. If the current reaches its limit of KF85 — an I^2T error occurs.

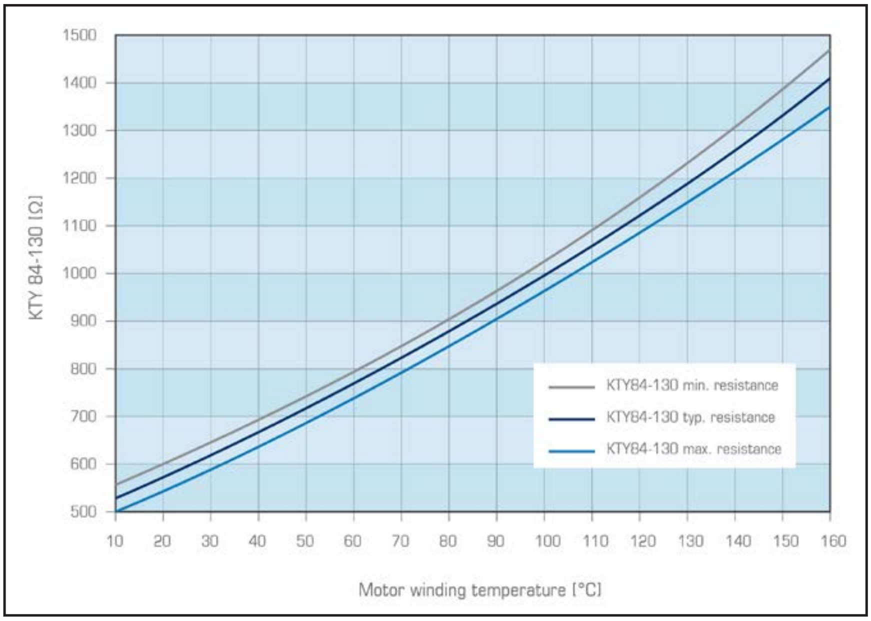

Figure 2 KTY sensors are silicon temperature sensors that have resistance values that change based on its temperature.

Temperature sensors. There are many types of motor temperature sensors on the market, but the focus here will be on some of the common ones; they are KTY, SNM, and S01 sensors.

KTY. KTY sensors are silicon temperature sensors that have a resistance value that changes based on temperature. The relationship between the temperature in the windings and between the resistance value the sensor outputs is linear (Fig. 2). Although KTY sensors are considered the most accurate of the three mentioned, one must compensate for a delayed response since the change in resistance is not instantaneous enough to detect sharp changes in temperature.

SNM. An SNM sensor is typically used in low-voltage circuits and is meant to be connected to a controller working at an electronic voltage level typically around 5 VDC. Like a KTY sensor, it outputs a resistance value based on the temperature, but the change is a lot sharper (Fig. 3).

S01. An S01 sensor is a limit switch based on a bi-metallic mechanism. It is a digital signal that reads as either open or closed. If desired, it can directly cut off the power of some electronics in overheating scenarios, as it operates more as a "switch" rather than having a temperature/resistance relationship. It is able to operate in a medium- to high-voltage range of around 50 VDC.

Sensor configuration. There are two kinds of standard temperature configuration Etel utilizes for its torque motors (Fig. 4). The first is Configuration 8, which not only uses each type of sensor, but has all three phases monitored. Although the option for having all three sensor types is available, it is Configuration H that is recommended since there is a spare set of KTY sensors on each of the phases. This is important because KTY sensors — while the most accurate of the different types — are electrostatic-sensitive devices (ESDs), and there are many stages in the machine assembly process where the sensors can be damaged; having an extra set ensures that it wouldn't be necessary to have the entire motor replaced on the off-chance one of them is damaged.

Stall conditions. It is important to note that in each of the different config-

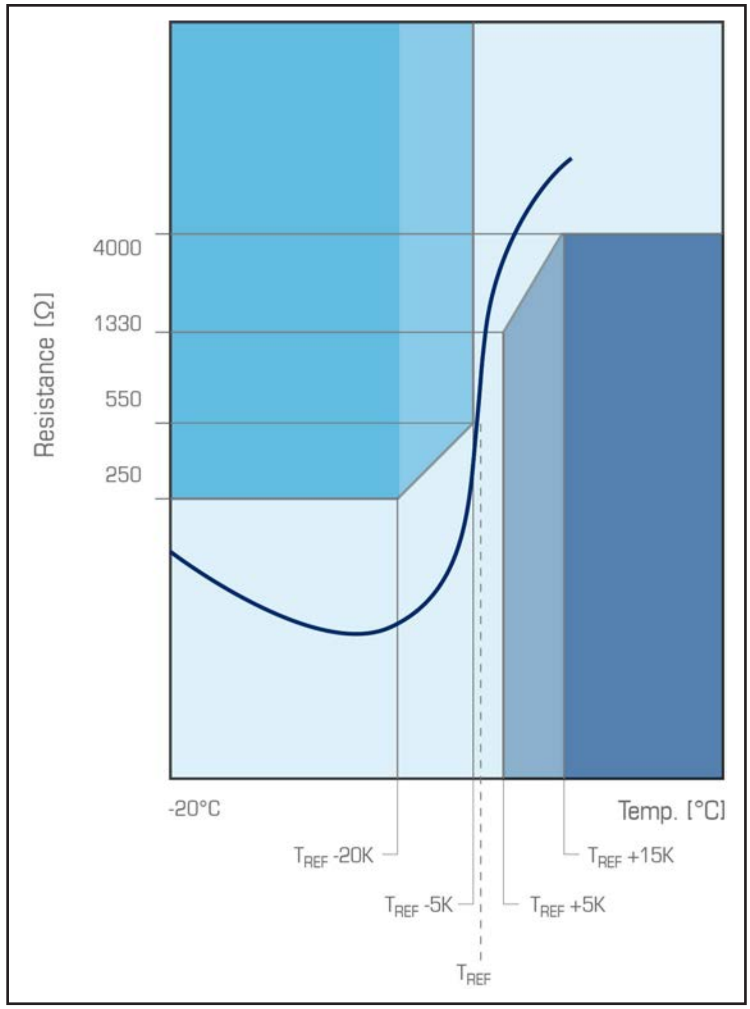

Figure 3 SNM sensors are typically used in low-voltage circuits.

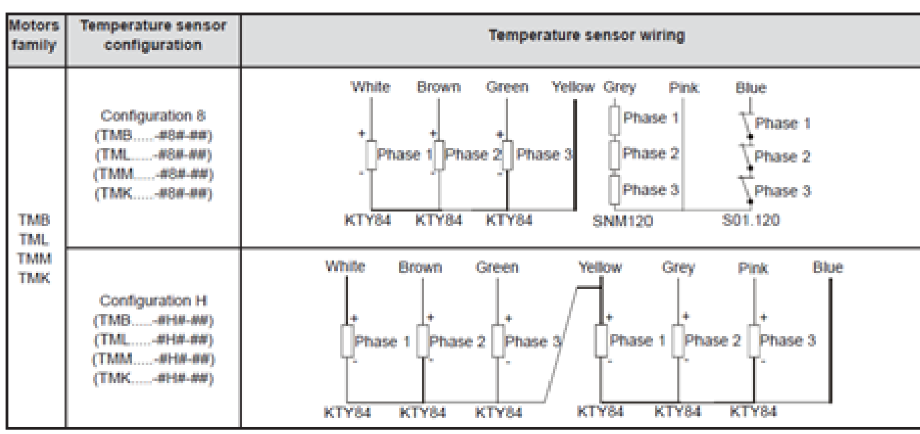

Figure 4 There are two kinds of standard temperature configuration ETEL utilizes for its torque motors.

urations, all three phases are monitored (Fig. 5). Not all motors have this set-up because it is assumed that any overheating in one phase would be evenly replicated in the others. One scenario where this wouldn't apply would be under stall conditions. In a machine tool duty cycle — where torque motors are commonly used — there may be an instance where a part is held in place for a certain amount of time and the current isn't evenly distributed amongst all the phases; this is called a "stall condition." If one phase is found to be above an acceptable level and it's not the one that has a sensor on it, then a user runs the risk of a phase overheating without the driver even being aware of it. This is why monitoring all phases is important.

Performance reduction. Usually, when a project is in its prototyping stages, not all of the demands of the applications are fully known. Therefore when the time comes to select a motor, sometimes an option that has more power than what is necessary for the application is selected. This is usually done in order to allow room for any unexpected forces that would cause the motor to overheat. Along with that, the motor could be restricted from going past a certain temperature that is well below its maximum, or not be allowed to reach its listed average current value. Since there is a delay in the KTY sensor output, these measures are put in place to anticipate overheating before the motor is damaged. The downside of these limitations is that the motor is unable to reach its full potential and in fact could be larger than what is necessary.

Depending on how over-sized the motor is, it may turn out that another smaller, less-expensive motor is up to the same task. Indeed — it could be discovered that by letting a motor reach values closer to its limit, a replacement can be chosen and end up saving a customer money in the long run.

IMTHP. In order to eliminate a lot of the safety measures that would limit the potential of a selected motor, Etel developed the IMTHP. The IMTHP is a thermal module developed for torque motors that employs the inputs of the three KTY sensors and thus creates a corrected analog temperature signal — providing the user a precise and continuous monitoring of actual motor temperature. It then takes these readings and uses its own algorithms to determine if the temperature is on-track to reaching an overheating point by outputting a simple digital warning/error signal that can be used without complex data processing on the controllers' part, and have the machine properly react if any problem is ever detected. In this way the delay in the KTY sensor reading was overcome so that a generally more accurate and precise temperature reading could be monitored. The IMTHP also provides galvanic insulation to protect the machine cabinet in case of a critical overvoltage defect (Fig. 6).

Overall, the greatest advantage of the IMTHP is that it allows the user to eliminate many of the previously mentioned safety measures (limiting the current and operating temperature, etc.) and run the motor at its full potential with minimal over-sizing.

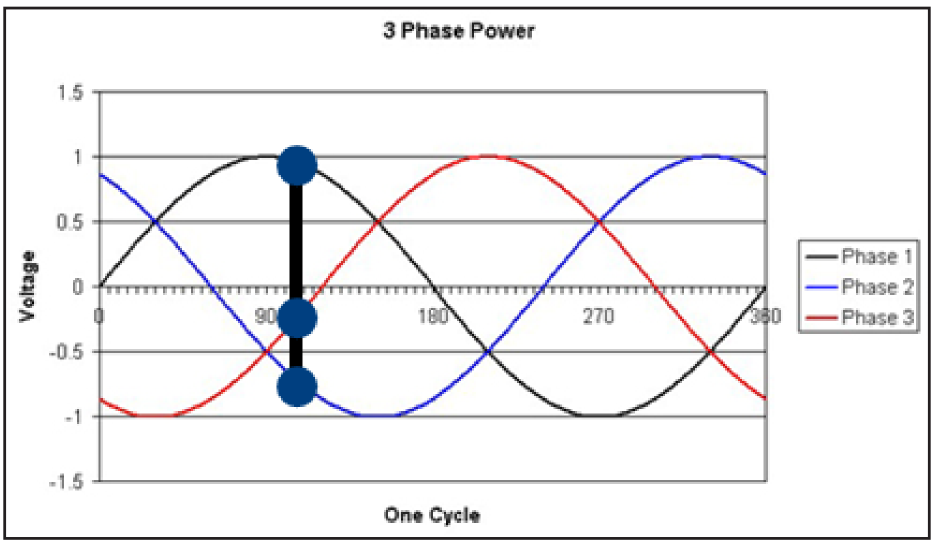

Figure 5 It is important to note that in each of the different configurations, all three phases are monitored.

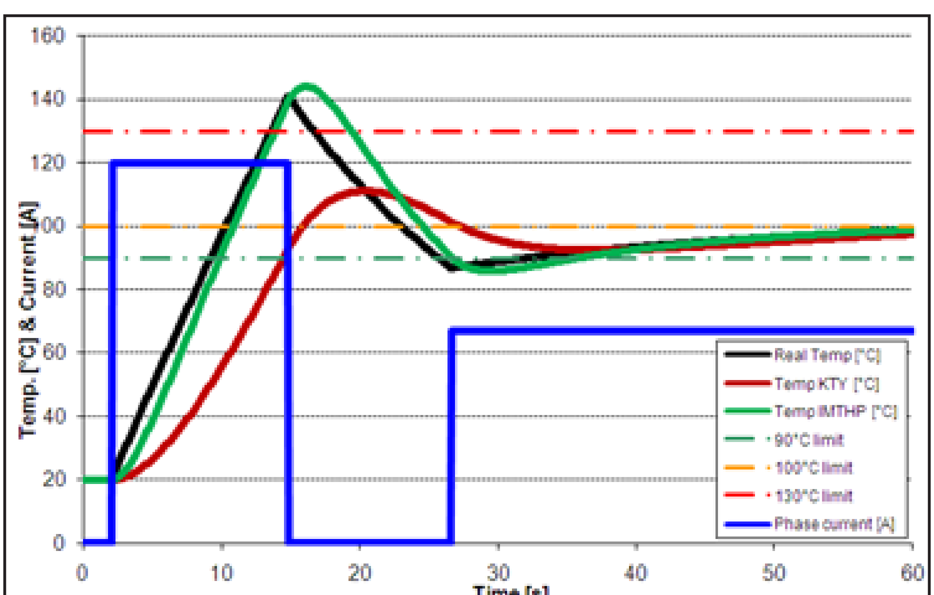

Figure 6 ETEL developed the IMTHP to eliminate the need for many of the safety measures that would limit the potential of a selected motor.

Conclusion

Multiple temperature monitoring methods have been discussed here — both physical and programmed; each serves to prevent motor overheating and damage. As anyone purchasing a machine would know, having an important element of the machine break that leads to an even wider systemic problem is a nightmare for anyone who relies on continuous operations. Acutely aware of these potential issues, Etel has not only fine-tuned these methods for their own products, but has also developed new methods — such as the IMTHP — to provide an extra degree of protection. Having everything fine-tuned not only keeps the motor, and, as a result, the machine's *operations*, fully functioning. It also allows the user's product to perform at its peak. This comprehensive fault check ensures the best efficiencies possible and a generally high-quality machine. **PTE**

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