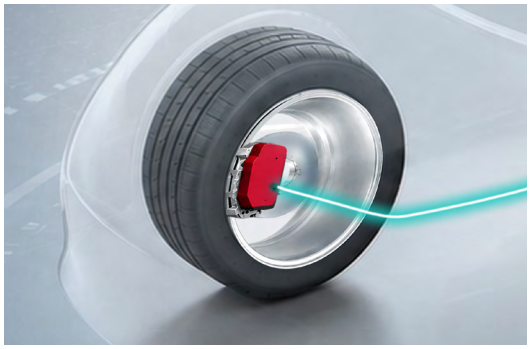
APPLICATION NOTE 2026

Enabling Reliable Brake-by-Wire Systems

with Advanced NTC Temperature Sensing

Overcoming thermal and integration challenges in Electro-Mechanical Brakes (EMBs)

The automotive industry is rapidly transitioning toward X-by-wire architecture, enabling the next generation of electrified vehicles, advanced driver assistance systems (ADAS), and future autonomous driving functions. A key example is brake-by-wire technology, also known as electro-mechanical brakes (EMBs). These replace conventional hydraulic systems with smart electric actuators powered by technologies such as brushless DC motors (BLDC) and permanent magnet synchronous motors (PMSM). This can enable new levels of precision, responsiveness, and system integration.
However, these advancements also introduce new engineering challenges. As EMB systems become increasingly compact and powerful, effective thermal management emerges as a critical factor. Electric motors, power electronics, and mechanical transmission components operate under demanding conditions, generating significant heat during braking events.



Product details
https://www.tdk-electronics.tdk.com/en/ntc_elements

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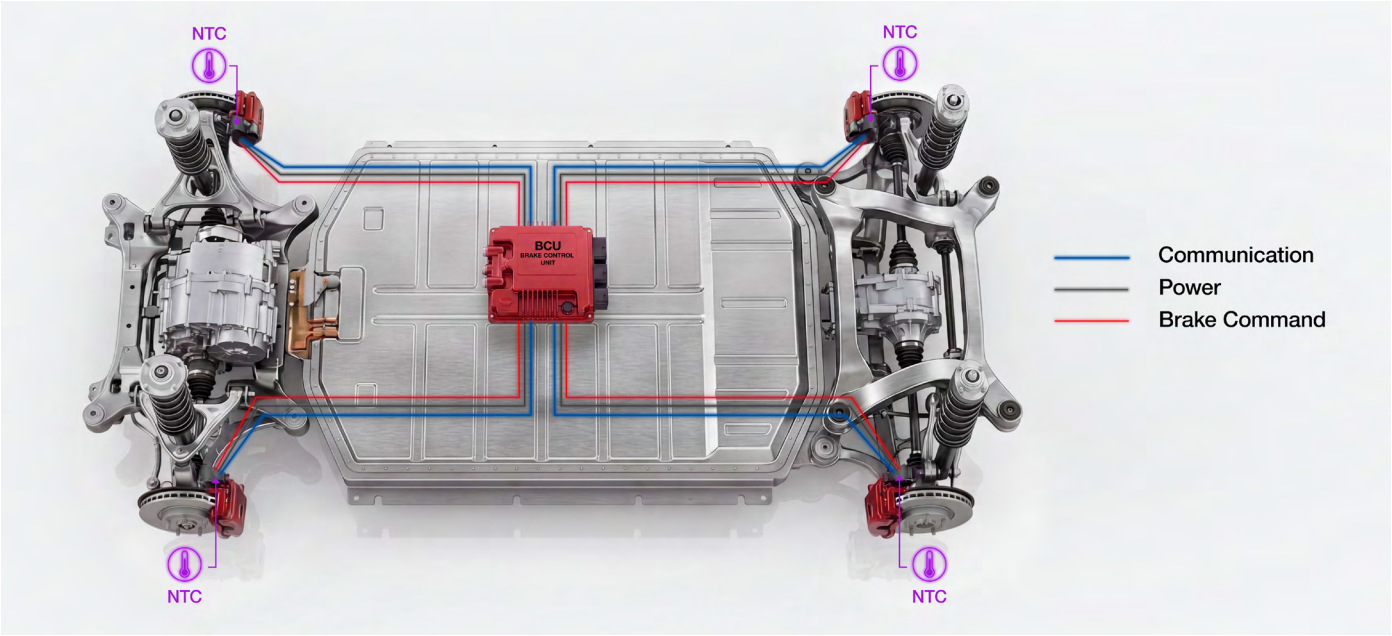
Brake-by-Wire Systems

Performance and thermal challenges in EMB system design



Key challenges in EMB design

One of the key challenges is miniaturization. To meet modern vehicle architecture requirements, electric motors must be integrated into increasingly constrained spaces. At the same time, performance requirements keep rising, pushing for higher power densities, which means higher torque within a smaller space. This, in turn, calls for higher copper fill factors. Consequently, efficient heat extraction becomes more challenging due to limited surface area and restricted cooling pathways.

The second critical challenge stems from constraints related to manufacturability and system integration. To achieve cost efficiency on a large scale, EMB actuators must be compatible with highly automated production processes. This requires precise alignment of all motor components and the ability to maintain stable positioning throughout assembly. Meeting these manufacturing constraints while simultaneously optimizing thermal performance and ensuring overall system reliability significantly increases the complexity of designing the actuators and sensors.

Thermal impact on performance and in EMB systems

An EMB actuator converts electrical energy into mechanical torque, inevitably resulting in losses. These include electrical losses in the windings, core losses in magnetic materials, and mechanical losses in gears and bearings. Collectively, these losses are dissipated as heat, thereby increasing operating temperatures.

As power density increases and installation space becomes smaller, thermal margins decrease. Even moderate temperature rises can significantly impact motor efficiency, torque generation, and the lifetime of components and systems. As a result, accurate thermal monitoring is essential to ensure stable and reliable operation of the EMB system.

In modern systems, temperature is not only a safety-related parameter but also a key indicator of actuator health and overall system performance. It indicates efficiency losses, excessive load conditions, and accelerated component ageing early on.

Instead of reacting solely to critical temperature limits, advanced EMB designs use continuous thermal data to actively manage thermal loads. By monitoring temperature trends in real time, control units can proactively address thermal stress, maintain optimal operating conditions, and ensure the long-term reliability of the system.

Brake-by-Wire Systems

Advanced temperature sensing for EMB applications

Requirements for temperature sensing in EMB systems
Effective thermal management relies on accurate temperature measurements from the most thermally critical locations within the actuator, such as motor windings, power electronics, or transmission components. This imposes stringent requirements on sensor response time, integration flexibility, temperature capability, and long-term reliability. To enable predictive thermal management strategies, temperature sensors must deliver continuous, high precision measurements while accommodating increasingly compact actuator architectures and compatibility with automated manufacturing environments.

These challenges need sensing solutions that combine high precision, a quick response time, a compact design, and flexible integration. Our NTC sensor portfolio is specifically engineered to meet these demanding requirements for electro-mechanical brakes and other high-duty e-motor applications.

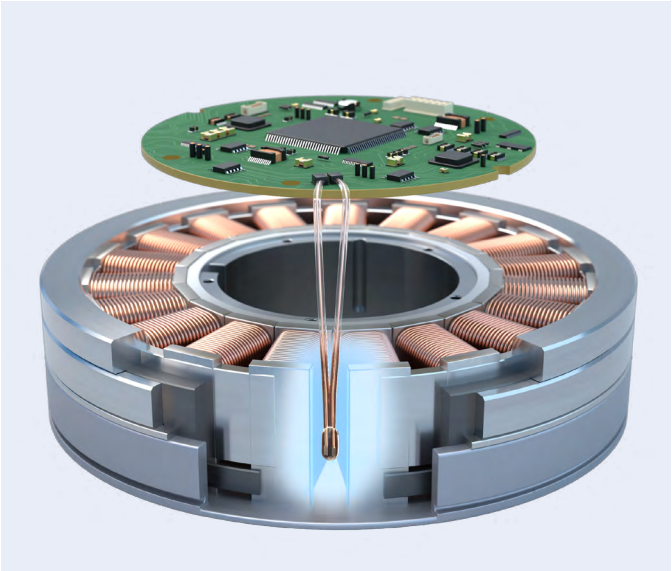
- **Compact integration**
  Miniaturized sensor designs allow for installation within highly space-constrained actuator architectures.
- **Fast thermal response**
  Quick temperature detection enables predictive thermal management and helps maintain stable actuator performance under dynamic load conditions.
- **Design flexibility**
  A range of package types and connection options makes it easy to integrate with many different types of actuators.
- **High reliability**
  Robust sensor designs enable long-term operation in challenging environments.

TDK offers advanced NTC sensor technology for EMB applications
TDK's comprehensive portfolio of miniaturized NTC sensor solutions is specifically designed to meet the thermal management requirements of modern EMB systems. Featuring sensor head diameters from just 0.8 mm to 2 mm, operating capabilities beyond +200 °C, and fast thermal response, TDK's solutions enable accurate temperature monitoring and predictive thermal control.

By providing accurate thermal data, TDK's sensors help improve reliability, extend system lifetime, and ensure consistent performance under demanding operating conditions.

With decades of experience in the industry, TDK offers a variety of solutions from design to packaging.

TDK NTC solutions for EMB applications



As EMB systems evolve toward higher power density, tighter packaging, and greater functional complexity, the importance of precise temperature sensing becomes increasingly critical. Our NTC sensor portfolio provides the foundation for reliable, high-performance thermal management in next-generation braking systems.

We invite you to download the full specifications from our website for detailed technical data and integration options. If you have specific application requirements, our team of TDK experts will support you by providing customized sensor solutions tailored to your design and production needs. Contact us today and discover and learn how we can help you maximize the reliability and efficiency of your EMB system.

Brake-by-Wire Systems

		L860	L871	L862, L852	G1541, G1551, G1561	K862
						
Design		Chip thermistor with various electrode systems	Epoxy coated	Epoxy coated	Glass encapsulated	Ceramic embedded
			Copper clad steel wire	Ni Ag wire	With insulated Dumet (FeNi alloy) wires	Ni Ag wire
			Lead spacing 2.5 mm	Flexible leads		Flexible leads
Engineers choice		For PCB mounting: Silver sintering, glueing, soldering and wire bonding	For automated assembly, customized wire kinks on demand	For small space and challenging wire routing	For small available space or high temperatures	For high prove voltage require-ments of up to 4000 V AC in head area
Maximum operating temperature	**[°C]**	+200	+155	+105 ... +155	+250	+155 (+180 for 168 h)
Head Ø	**[mm]**	0.5 ... 2.0	2.3 ±0.3	2.2 ±0.21 1.9 ±0.3*	1.4 (max. for G1541)	2.5 ±0.2
Dielectric strength for 1 s	**[V (AC)]**				500	2500
Recommended resistance (+25 °C)	**[kΩ]**	2/10	2/10	2/10	10/50	10

*Smaller versions under development

A wide range of additional design options, including sensor systems, is available.
Please contact us for further information.

www.tdk-electronics.tdk.com

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