DESIGN NOTE

Revolutionizing Magnetic Component Temperature Monitoring by Measuring its Core DCR

INTRODUCTION

Temperature monitoring is crucial to helping ensure reliability and maintaining efficiency in power electronics systems. Magnetic components, such as inductors and transformers, often experience high internal temperatures that can accelerate system failure and thermal runaway conditions. Traditional monitoring methods, which rely on surface-mounted sensors like thermocouples or NTCs, typically fail to capture the internal **hotspot** temperatures that are most critical to monitor. Moreover, these conventional methods are prone to inaccuracies caused by induced eddy currents in the sensor or its circuitry.

A breakthrough presented at the 2023 IEEE ECCE conference by David Menzi et al. from ETH Zurich introduced a new method called **Core-as-a-Sensor**[1]. This novel approach leverages the temperature-dependent resistivity of the ferrite materials in Magnetic components to achieve more accurate core temperature measurements.

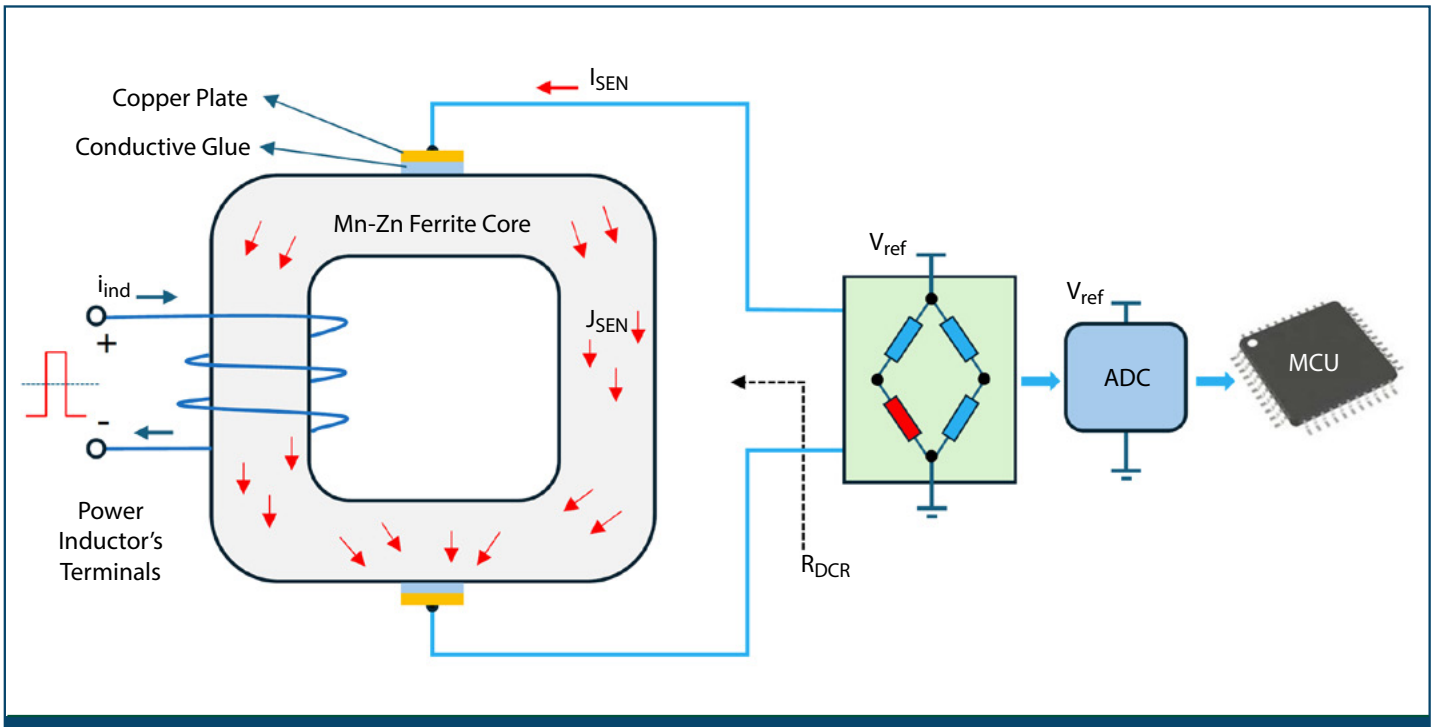

Figure 1 Diagram of a new temperature monitoring method called Core-as-a-Sensor[1]

[1]D. Menzi, G. Eðvaldsson, J. E. Huber and J. W. Kolar, "Core-as-a-Sensor: Ferrite DC-Resistance-Based Core Temperature Measurement of Magnetics," 2023 IEEE Energy Conversion Congress and Exposition (ECCE), Nashville, TN, USA, 2023, pp. 6532-6534, doi: 10.1109/ECCE53617.2023.10362938.

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HOW IT WORKS

Polycrystalline ferrite materials, widely used in high-frequency magnetics, exhibit a semiconductor-like property where the component's electrical resistance decreases as the temperature rises. By measuring this resistance, the 'Core-as-a-Sensor' method provides a reliable estimate of the average internal core temperature, which is often significantly higher than the surface temperature.

This technique was validated through the development of a smart inductor using a DCR-sensing circuit built around a Bourns® 10 µH inductor (Model PQ2614BLA-100K Shielded Power Inductor), which was selected for this test based on its reliability and performance. The study confirmed that this method outperforms surface-mounted sensors, particularly under high thermal stress, to provide a higher level of temperature measurement accuracy. Notably, the accuracy of the resistance-based temperature measurement remained unaffected under nominal operating conditions, even as nominal DC and high-frequency AC magnetic fields pass through the core.

REAL-WORLD IMPLICATIONS

In practical testing, the smart inductor was integrated into a 1.6 kW DC-DC converter. The method consistently detected core temperatures more than 10 °C higher than the surface readings that would have been collected from traditional surface-mounted sensors.

This confirmed that the 'Core-as-a-Sensor' method offers a more accurate representation of thermal conditions. Another advantage is that this advancement enables in-situ, real-time temperature monitoring, which is becoming more in demand by power electronics systems designers for predictive maintenance and improved system reliability.

THE FUTURE OF MAGNETIC COMPONENTS

This research highlights the potential for smarter, self-monitoring Magnetic components in failure diagnostics, health monitoring and other Industry 4.0 applications. Techniques such as the 'Core-as-a-Sensor' method pave the way for enhanced diagnostics that contribute to higher reliability, reduced downtime, and extended system lifespan.

Bourns continues to develop leading-edge Magnetics components while adopting methodologies that help advance power electronics and support the evolving needs of the industry. The Company is known for its innovative core material breakthroughs that enable more compact high-power inductor designs offering stable inductance values, minimal core losses and improved performance.

ADDITIONAL RESOURCES

To learn more about Bourns® high current shielded power inductors, please see the range of products on the website:
https://bourns.com/products/magnetic-products/power-inductors-smd-high-current-shielded

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