Product Overview

TI Coreless Hall Sensors Redefine Current Sensing

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ABSTRACT

With the widespread adoption of SiC/GaN high-frequency power devices, equipment for electric vehicles, energy storage PCS, AI server power supplies, and photovoltaic inverters continues to iterate toward miniaturization, high power density, and high-speed protection. Traditional cored Hall sensors face growing constraints including magnetic saturation, hysteresis, bulk size, and assembly tolerance. TI Coreless Hall current sensors eliminate the flux-concentrating core, leveraging multiple signal combination, on-chip calibration and compensation, and a stray field rejection algorithm to address these pain points, emerging as a leading sampling architecture for next-generation current sensing.

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1 Introduction

1.1 Industry Pain Points: Bottlenecks of Traditional Cored Hall Schemes

For decades, traditional hall sensors leveraging magnetic cores to concentrate conductor magnetic fields have dominated current sensing in industrial and automotive applications. However, as power electronics systems push for higher power, tighter mechanical packaging and elevated switching frequencies and inherent limitations of magnetic core structures become critical bottlenecks:

1. Magnetic saturation and dynamic distortion: Large current surges drive cores into saturation, distorting waveforms and causing delayed/false overcurrent/short-circuit protection;
2. Hysteresis and zero drift: Mismatched magnetic paths during current rise/fall and residual magnetism after heavy current stress amplify offset and degrade long-term precision;
3. Excessive footprint: Cores require through-holes, insulation and mounting structures, making sensors major space consumers that crowd thermal management and connector layouts;
4. Poor assembly consistency: Air-gap variation, conductor offset and mounting tolerances degrade magnetic focusing, leading to wide precision spread;
5. Large and bulky module structure: The C-core solution still needs the ferrite core with heavy weight and big volume, causing lower power density and restriction to further decrease the distance between adjacent busbars.
6. Limited high-frequency bandwidth: Eddy current losses and magnetic path latency cap response speed, failing to support MHz-level high di/dt detection required by SiC/GaN devices.

Cored Hall sensors remain stable for general industrial use, yet coreless Hall technology emerges as a key upgrade path for high-density new-generation systems. TI's newly launched coreless Hall TMCS2100-Q1 current sensors eliminate magnetic core architectures entirely, resolving fundamental core-induced flaws to meet compact power electronics design demands.

2 Comprehensive Comparison: TI Coreless Hall versus Traditional Cored Hall

2.1 Fundamental Architectural Differences

1. Traditional Cored Hall

   Cored Hall sensors rely on a ferrite core to concentrate magnetic flux, enabling high-sensitivity current measurement through a fixed magnetic path, with larger size and greater mechanical complexity.

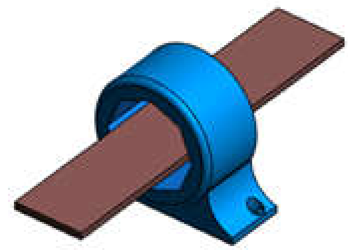

Figure 1. Traditional Cored Hall

2. Coreless Hall

   No magnetic concentrating core is implemented. Devices support surface mounting against the top PCB of external busbars, paired with multiple signal combination architecture that directly measures raw magnetic fields from the current-carrying conductor. On-chip signal conditioning and compensation maintain reliability across temperature, frequency, and lifetime. A crosstalk rejection algorithm suppresses crosstalk from adjacent phases. Packaged as monolithic surface-mount chips, they support PCB soldering or side mounting to busbars without through-hole requirements. The devices can be simply mounted on the traction inverter board above the busbar region, which looks like any normal device without any requirement on the module, fixture, and busbar modification.

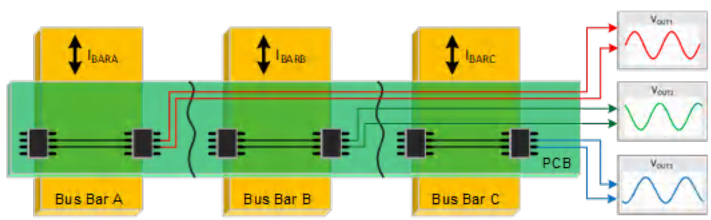

Figure 2. TI Coreless Hall

2.2 Key Performance and Engineering Pain Point Comparison Table

Table 1. Key Performance and Engineering Pain Point Comparison

Key System Needs		C-core or Int. Module	Over-The-Trace Sensor With U-Shield	TMCS2100 Multi-sensor Coreless
Ease of manufacturing		Buy or Build	Bus Bar Mod and Shield Placement	Place IC on PCB
Phase cross talk rejection		< 1% with core design	< 1% with shield design	< 1% after characterization
Displacement error		N/A	1mm = about 3.5%	1mm = about 3.7%
Phase delay at 1kHz		< 4°	< 3°	< 2°
IC Power per phase		> 25mA	10 ~ 15mA	~ 50mA
Accuracy	Over temp	about 3% and core error	~ 2%	~ 1%
	Linearity	about 3%	~ 1%	~ 0.1%
	Across frequency	about 3% and core error	< 5%	~ 1%
	Over lifetime	> 5%	> 7.5%	~ 1%
Height above bus bar		> 15mm	> 1mm	> 3mm
System complexity		IC + core + housing/fixture	IC + Shield + bus bar modification + fixture	IC + simple fixture
Key benefits		• Fully calibrated from factory • Wide mechanical options • Wide performance portfolios • If closed, loop has good accuracy across a wide current range	• Mechanical flexibility • Good integration for PCB on bus bar • Smaller form factor than *C* Cores or Modules	• No magnetics needed • Smaller form factor than *C* Cores • Multiple sensor combination Architecture, minimizes non-static stray fields
Challenges		• Cost • Large space requirements • Bandwidth limited by magnetics • If open, loop has large offset leading to inaccuracy at low-currents	• Requires magnetic expertise and design capability • Susceptible to magnetic interference • Open-loop measurement inaccurate for low currents	• Requires preliminary magnetic simulation and busbar layout tuning • System Level Characterization In-Lab Required

2.3 Cost and Research and Development Investment Breakdown

1. Traditional Cored Hall: Low component cost, but structural tooling and complex assembly, bulky structure drive total system costs higher. Field failures from mounting drift add after-sales overhead.
2. Coreless Hall: Eliminate cores, brackets and insulating hardware, delivering equivalent or lower total BOM cost. Streamlined assembly to keep the mass manufacturing economics.

Research and development investment: Cored sensors center on part selection; coreless designs require preliminary magnetic simulation and busbar layout tuning. However, TI's reference designs, simulation tools and evaluation kits support lower development barriers. For more information, visit TMCS2100-Q1.

3 Advantages of TI Coreless Hall

1. Eliminate core limitations for dynamic performance: Removing ferromagnetic cores erases magnetic saturation, hysteresis and remanence as error sources. During motor start-up transients, high-power charge/discharge cycles or instantaneous server load spikes, current waveforms remain undistorted, with fast, reliable short-circuit/overcurrent protection free from core-induced latency or failure. Integrated high-speed signal conditioning enables 250kHz bandwidth and <1us fault response, matching high di/dt and dv/dt operating conditions and enabling fast closed-loop control.
2. Ultra-Compact, Lightweight Form Factor Frees Mechanical Design: Without cores, mounting frames and through-hole clearance requirements, TI coreless Hall sensors use standard surface-mount packages that solder directly to power PCBs or mount flush alongside high-current copper busbars without drilling. For equivalent current ranges, footprint shrinks over 60% and mass drops drastically, creating room for thermal routing, high-voltage insulation and connectors—critical for automotive traction controllers and dense AI server power supplies, which can further to improve the system power density.
3. Multiple sensor combination Architecture Suppresses Inter-Phase crosstalk compared with traditional coreless designs. Generic coreless sensors struggle with crosstalk from neighboring busbars; TI multiple signal combination architecture distinguishes in-phase magnetic field and crosstalk magnetic field. Real-time frequency detection and compensation to eliminate the frequency effect (skin effect and proximity effect) on the 3-phase busbar. Dense inverter and energy storage converter layouts maintain rated accuracy without external shielding, easing EMC engineering.
4. Better displacement error performance compared with traditional coreless designs. For each phase, 2 TI coreless current sensors at different locations are used to measure the magnetic field at the same time, which offers more information about the total magnetic field and therefore allows the TI design to be more robust with cross-talk and displacement errors. TI recommends leaving 3mm-11mm distance between the busbar and device, for both insulation requirement and better SNR, which is shown in Figure 3. Based on this structure, any vibration on the vehicle causing the distance changing has minimum impact on the magnetic field amplitude, adding very limited error on the sensor output.

3mm < G < 11mm D > 5mm

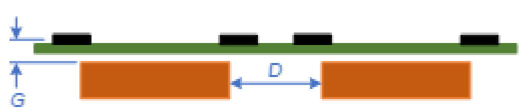

Figure 3. Installation Instructions

5. Quick EOL calibration and ease of use

TI coreless current sensor only requires characterization in the lab at researching stage. After finishing this characterization, all characterized register data can be uploaded with MCU for every platform with the same mechanical structure. The simple calibration is needed for EOL production due to assembly tolerance, requiring simple gain/offset optimizing with either customized calibration method or TI calibration process, consuming truly short time to save cost on the production stage.

4 Conclusion

Miniaturization, high-frequency operation and higher power density are irreversible trends across power electronics, positioning cored and coreless Hall sensors as complementary technologies for segmented use cases—cored designs retaining cost advantages for steady-state low-frequency applications, while TI coreless Hall sensors emerge as the preferred choice for next-generation high-density systems.

Leveraging multiple signal combinations, monolithic isolated packaging, <1us overcurrent response and freedom from magnetic saturation, TI coreless Hall sensors resolve pain points of bulk size, limited dynamic performance and inconsistent mass production seen with cored alternatives, addressing current sensing demands across EVs, energy storage and AI computing power.

5 References

1. Texas Instruments, *TMCS2100 Evaluation Module*
2. Texas Instruments, *TMCS2100-Q1 Coreless Multi-Sensor Hall-Effect Current Sensor*