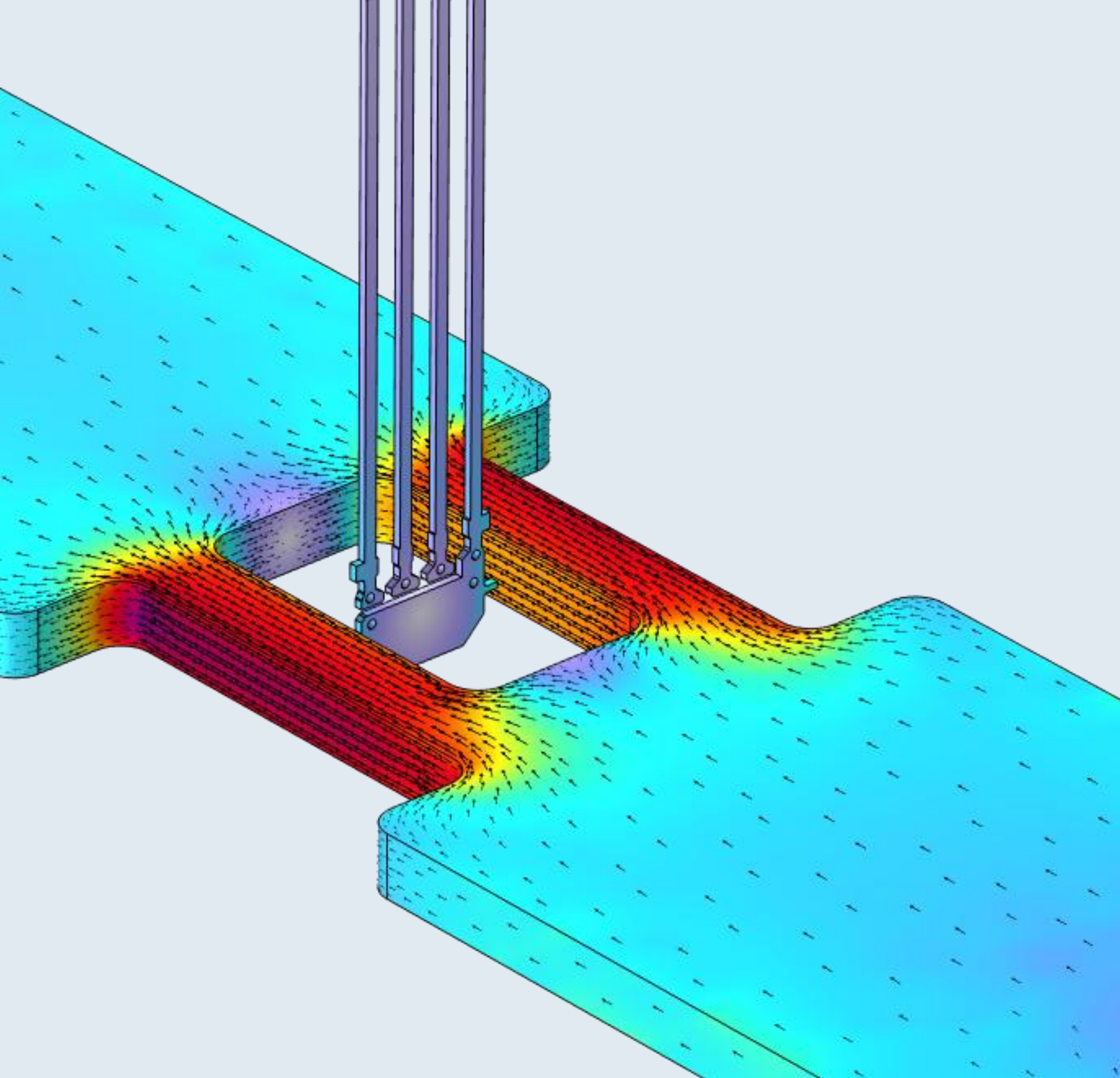




Busbar Geometry Optimization for Coreless TMR Current Sensors in EV Power-Electronics Application

TMR sensors integrated through the busbar, with optimized busbar dimensions to maximize the coupling factor and reduce sensitivity to mechanical placement errors.

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Introduction & Goals

Coreless current sensors are increasingly adopted in electric-vehicle (EV) power-electronics applications due to their compact size, low mass, and high bandwidth. However, eliminating the magnetic core and magnetic shielding necessitates careful design adaptations to preserve sensor performance. This work investigates a through-slit TMR integration concept, in which the sensing elements are placed directly through the busbar. Two Hall-based configurations are included as benchmarks. COMSOL

Multiphysics® is used to evaluate magnetic coupling and the sensitivity of each architecture to sensor displacement, with the objective of identifying a compact and mechanically robust solution for power-electronics packaging.

Methodology

Three architectures are compared through-slit TMR and two Hall-based benchmark configurations [1]. The AC/DC Module, Magnetic Fields interface is used to calculate the average coupling factor F_c which is proportional to the sensor's output [2]:

$$F_c = (B_1 - B_2) / I * 0.5$$

B is magnetic field along the easy axis (in-plane for TMRs and out-of plane for Halls)

The busbar design, including the shape and size of the slit and the placement of the sensing elements, is defined and optimized to meet high coupling factor, low attenuation at 2kHz, and crosstalk mitigation.

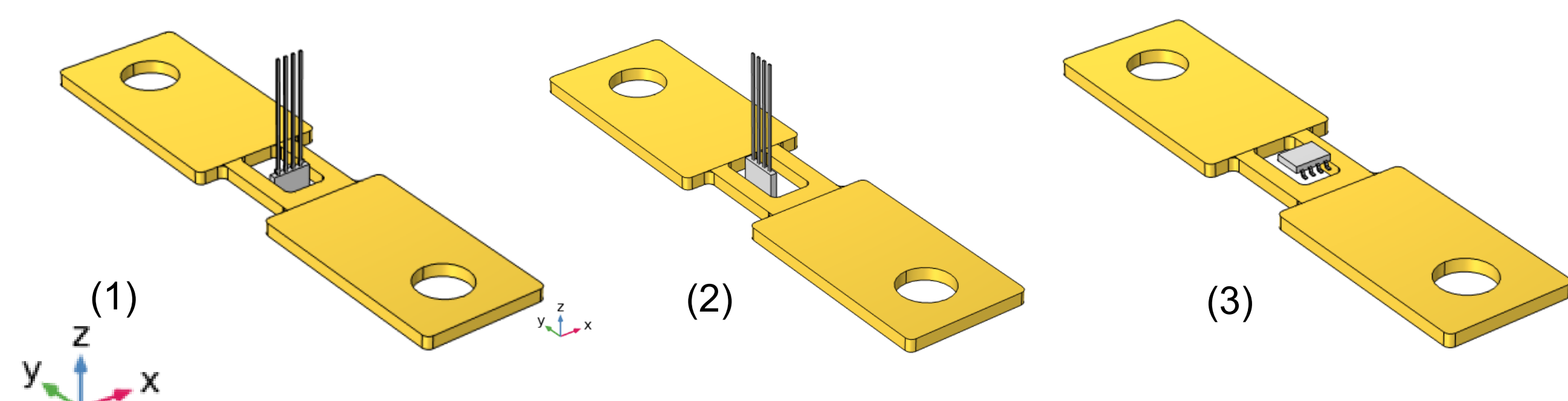


FIGURE 1. Differential sensor integration concepts: (1) through-slit TMR sensors; (2) through slit Hall sensors; (3) Over-the busbar Hall sensors,

Results

The through-slit TMR reaches a magnetic coupling of 16 $\mu\text{T/A}$, comparable to Hall configuration 1 and higher than Hall configuration 2.

At 2 kHz, all three configurations show less than 2% attenuation and a phase shift of approximately 1.6°.

More importantly, the through-slit arrangement provides more stable coupling when the sensor position changes, especially along the z-axis, where larger placement errors are common (FIGURE 2)

The through-slit TMR combines high magnetic coupling, good frequency response, and improved stability against mechanical placement errors, making it suitable for applications requiring high precision and stability.

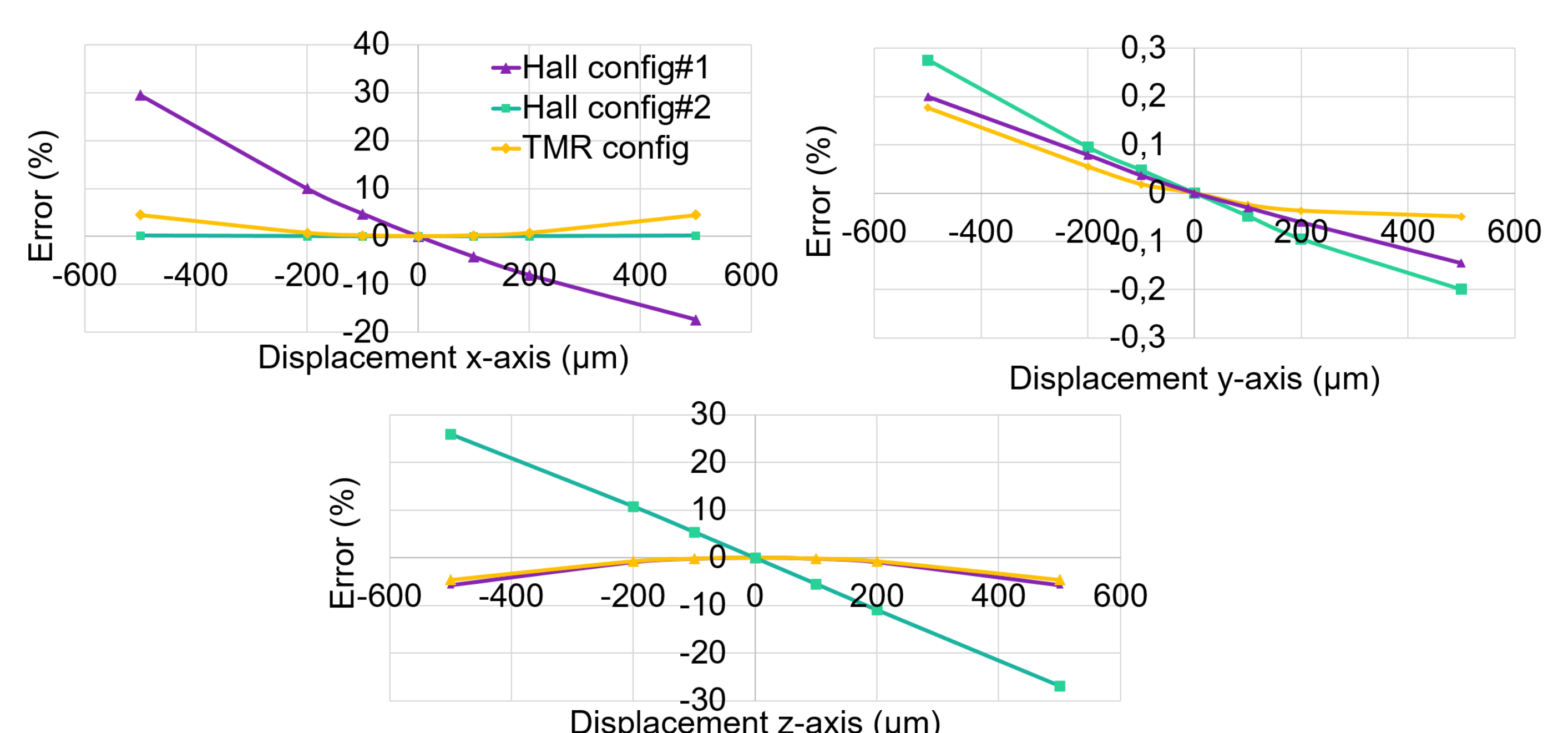


FIGURE 2. Sensitivity of magnetic coupling to sensor displacement along the x-, y-, and z-axes.

REFERENCES

[1] J. Henry, "CT452/CT453 SLIT BUSBAR design", Application Information by Allegro Microsystems, 2023.

[2] Alexander Latham, "Common Mode Field Rejection in Coreless Hall-Effect Current Sensor ICs," Application Information by Allegro Microsystems, 2015.

