Next-Generation Aerospace Actuation: A Solid-State Architecture for Resilient Position Measurement

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Keywords: absolute position estimation, Hall sensors, 3D magnetic sensors, actuators

Abstract. Electromechanical actuators in modern aerospace systems require high reliability and resilience to environmental stressors, yet traditional position-sensing technologies often suffer from mechanical wear, complexity, and performance degradation under extreme conditions. This paper introduces a solid-state architectural framework for resilient absolute position measurement based on multi-axial magnetic sensing integrated with edge-deployed data processing. The proposed system utilizes a spatial array of three 3D Hall sensors to monitor the magnetic field locus of a neodymium magnet attached to the actuator arm. To mitigate systemic inaccuracies caused by thermal drift and sensor noise, a lightweight Multi-Layer Perceptron (MLP) neural network is implemented for real-time compensation. Deployed on a resource-constrained 8-bit microcontroller via post-training weight quantization, the model non-linearly maps magnetic flux densities and temperature data to a stabilized coordinate system. Experimental results across a range of −40∘C to +40∘C demonstrate that this methodology effectively overrides the limitations of thermal sensitivity. The result is a robust, low-mass, and high-durability alternative to conventional LVDT and potentiometer-based sensing solutions, offering comparable accuracy with significantly reduced mechanical complexity.