Magnetic Nanoparticle-Based Gyroscopic Sensor

Product:
Magnetic Nanoparticle-Based Gyroscopic Sensor

Development Stage:
Proof of Concept

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One of the primary ways that gyroscopic motion can be applied is in the monitoring and/or maintaining of the orientation of an object. A broad array of engineering applications are based on gyroscopic motion including accelerometers, inertial navigation systems, surveying theodolites, compasses, heading indicators, camera stabilizers, etc. As such, there is an ever growing variety of end use applications of gyros, such as in surveying; navigation for marine vessels, aircraft, satellites, and weapons; user interfaces for smartphones and video gaming devices; toys, drones and R/C hobby crafts; autonomous vehicles; and robots (domestic as well as industrial), to name a few.

Various technologies have been employed to provide such adaptations of gyroscopic motion. Some of these technologies are: mechanical gimbals, vibrating structures, HRGs, MEMS, ring lasers, and fiber optics, among others. Each platform technology addresses different measurement parameters, with attendant trade offs inherent to each platform. In this regard, typical considerations include: size, weight, cost, detection and response speed, precision, accuracy, repeatability, power consumption, resistance to shock, resistance to vibration, resistance to environment and other elements, etc.

To summarize, there are myriad technical approaches to utilizing gyroscopic motion, each with advantages, trade offs, and best-suited applications. In this highly complex and competitive field, there remains substantial room for improvement over the currently available platform technologies, both for existing applications as well as for new applications that may arise over the coming years.

Technology Description

WMU researchers have developed a new gyroscopic sensor platform that has a distinct combination of advantages, providing a superior solution for various end uses.

At its core, the WMU sensor utilizes magnetism to monitor changes in orientation. More specifically, suspended magnetic nanoparticles are spun via alternating orthogonal magnetic fields that essentially create a “rotating” magnetic field (Figure 1). When external forces cause a change in physical orientation of the sensor, corresponding orientation changes are undergone by the suspended nanoparticles which induce changes in the magnetic field. Accordingly, the circuit that drives *(continued on next page)*

the magnetic field will undergo changes in current that directly correspond to the changes in the magnetic field. This allows for extremely sensitive monitoring of changes in sensor orientation.

The nanoparticles utilized are iron oxide (ferrous powder) particles, with average sizes less than 30 nm, suspended in water. The nanoparticles each behave like miniature gyroscopes and collectively act as one single gyro. Use of these nanoparticles allows the nano-gyroscope to be manufactured using low cost materials and simple packaging to create multiple-sized, inexpensive gyroscopes, in comparison to existing technologies.

The rotating magnetic field enclosure was constructed by a cuboid shaped wrap of two magnetic coils, which were each connected to a current source. As the sensor was physically rotated on one axis, changes in current were easily detected for the corresponding coil without affecting the other coil (Figure 2). This demonstrates the high sensitivity capabilities of this technology.

In addition to the high sensitivity, other advantages of the WMU gyroscopic sensor include omnidirectional capability (detection of orientation changes in any direction), potential for higher accuracy than existing devices having similar cost and power, shock resistance due to lack of any mechanical moving parts, and the ability to self-heal upon otherwise catastrophic impacts due to the unique physical nature of suspended nanoparticles.

Potential applications of the WMU technology include mobile devices, smart wrist watches, prosthesis, robots, autonomous vehicles, satellites of all sizes, aircraft, weaponry, hobby drones, other R/C toys, camera stabilizers including body mounts, etc.

Potential Benefits

- Omnidirectional capability that is highly sensitive to changes in orientation
- Suspended magnetic nanoparticles allow for simple packaging, low cost, low power, and long operational life
- No mechanical moving parts means extremely shock resistant for reliability under challenging conditions
- Potential for self-healing compared with catastrophic failure in equivalent technologies

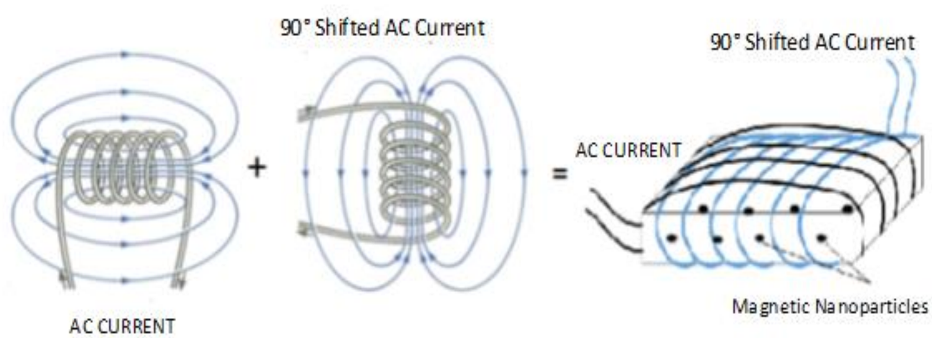

Figure 1. Rotating Magnetic Field Encapsulates Magnetic Nanoparticles

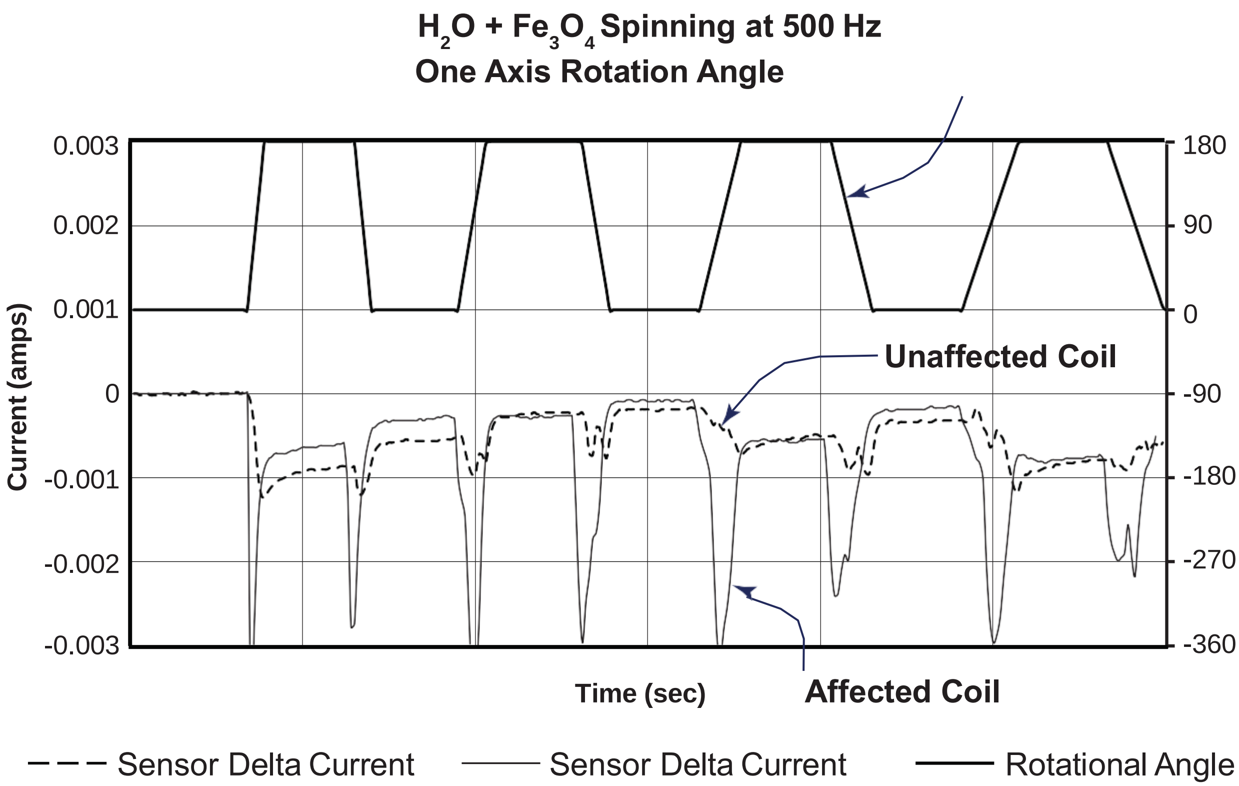

Figure 2. Proof of Concept Experiment