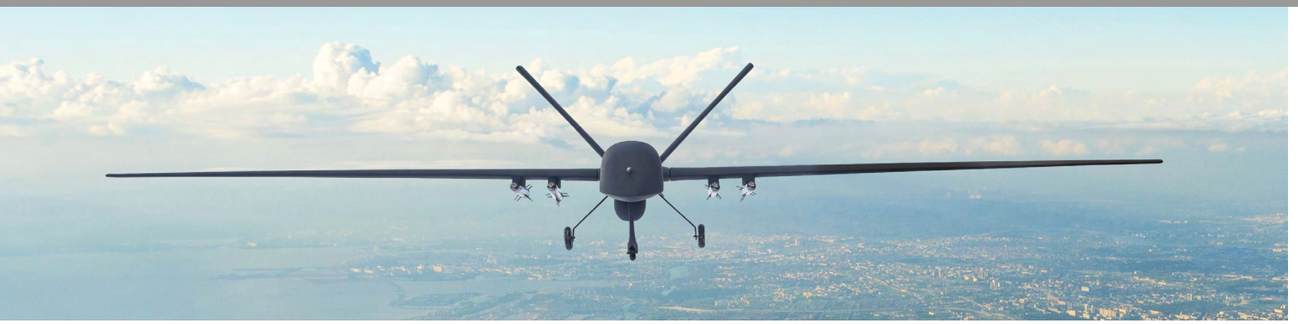


Forging Inertial Synergy with Quartz MEMS and Fiber Optics

Hitting High-Performance Benchmarks at Low C-SWaP

Diversity brings strength. This holds true in inertial technology, where EMCORE's dual offering of quartz micro-electromechanical (QMEMs) and fiber-optic technologies delivers solutions across a broad range of tactical- and navigation-grade applications. EMCORE QMEMS gyros and accelerometers, fiber-optic gyros (FOGs) and hybrid inertial QMEMS-FOG sensors are ideal for north-finding, targeting, stabilization, marine and unmanned applications that are not dependent on GPS or GNSS for accuracy.

The flexibility and versatility of this family of products provides solutions for every application environment from weapon systems to attitude and heading reference systems (AHRS), unmanned autonomous vehicles (UAVs) and more. One supplier—EMCORE—delivers a multi-mission capable portfolio of gyros, accelerometers, inertial measurement units (IMUs) and inertial navigation systems (INS) for north-finding, pointing and geolocation, all that can be tailored to meet customer needs and objectives.

QMEMS

Quartz is particularly well suited as a micromachining substrate for inertial sensors due to its extreme stability and anisotropic fabrication characteristics. These EMCORE Systron Donner sensors are mature and proven over three decades, with performance under environmental stress superior to that of legacy open-loop FOGs and ring-laser gyros (RLGs). They are also significantly better under shock, vibration and temperature extremes than competing alternatives such as silicon MEMS.

EMCORE's Systron Donner Inertial QMEM gyros supply key additional strengths for tactical-grade applications including: exceptional bias stability; and low gyro noise ideally suited for weapons-based applications.

These products include:

SDG1400 Single-Axis Analog Gyroscope, with bias in-run stability of <6°/hour and angle random walk (ARW) of ≤0.1°/√hour.

QRS116 Single-Axis Tactical Grade Analog Gyroscope with ARW reaching as low as 0.002°/sec/√hz. It boasts an Allan Variance 100-second correlation time. (The Allan Variance analysis identifies and quantifies noise in inertial sensor data. The test provides a wealth of information about the quality of the sensors. EMCORE has and can share this data for all its devices.)

SDD3000 Single-Axis Digital Gyroscope with bias in-run stability under 1°/hour and ARW of 0.01°/√hour

This range of performance accuracy fits the requirements for tactical-grade applications. See **FIGURE 1** for a comparison of the key characteristics of QMEMS sensors versus other inertial technologies.

Taking advantage of design techniques used in more expensive rate sensors, these devices afford a high level of performance without commensurate cost.

And, importantly, they are not International Traffic in Arms Regulations (ITAR)-restricted.

EMCORE's latest research and testing has demonstrated a new QMEMS gyroscope that has the potential to reach high-end navigation grade in-run bias. IMU testing in a customer lab revealed ARW of 0.001°/√hr where in-run bias reached a value of 0.02 °/hr without temp control across all three gyros after 20 seconds.

The QMEMS portfolio also includes higher bandwidth gyros and advanced tactical accelerometers. EMCORE has invested in upgrades to its accelerometer technology that now reach navigation grade. The company is one of very few in the world that produces both gyro and accelerometer technologies.

EMCORE's Systron Donner QMEMS gyros and accelerometers provide the foundational building blocks of its:

SDI500 tactical-grade multi-axis IMU which has capabilities in angle random walk values of 0.02°/√hr, plus maintains tactical-grade 1°/hr gyro and 1 mg accel bias levels across military environments.

Images courtesy of EMCORE.

FIBER-OPTIC GYROS (FOG)

The **EMCORE-Hawkeye series FOG** product line combines patented input/output concentrator (IOC) transceiver technology that enables unique closed-loop FOG design capable of very high bandwidth and very high accuracy for short-term to full navigation-grade applications. EMCORE's FOGs have higher navigational accuracy than QMEMS gyros, with wide sensing bandwidth for image stabilization and lower ARW values for extreme far-targeting and stabilizing precision.

Models include:

EG-120 FOG with in-run bias accuracy of ≤1.0°/hr and ARW of <0.04°/√ hr

EG-200 FOG with in-run bias accuracy of <0.1°/hr and ARW of <0.012°/√ hr

EG-1300 FOG with in-run bias accuracy of ≤0.001°/hr and ARW of 0.001°/√hr.

This range of performance accuracy is well positioned for navigational-grade applications. See **FIGURE 2** for a comparison with other technologies. In addition, the EG-120 and EG-200 are non-ITAR.

EMCORE has leveraged its unique closed-loop FOG technology for use in the **EN-300 precision FOG IMU** which can offer 10 times the performance of and is form-, fit- and function-compatible with legacy IMUs. Its superior performance makes it an ideal choice for GPS denied navigation, precise targeting and line-of-sight stabilization.

HYBRID SOLUTIONS

Both QMEMS and FOG gyros are capable of accuracies necessary for north-finding applications. Over 100 seconds, the QMEMS gyro showed a fundamental limit of .04 milliradians. Combining the two technologies will show the fundamental limit of QMEMS compared to FOG, where FOG can achieve higher accuracies for north-finding or short-term navigation, with the difference being bandwidth and high precision vs. cost between FOG and QMEMS, respectively.

The gyrocompassing capability of the two technologies is compelling for man-portable applications where CSWaP is critical and requires low-noise sensors and stable in-run performance.

Where ultimate accuracy is required, a hybrid solution can be proposed. Where long-distance targeting is needed, the strongest core solution would be FOG-based.

The in-run performance of the latest next-gen QMEMS vibrating quartz accelerometers (VQAs) gets down to single-digit micro-g accuracy. This shows a path forward to a hybrid solution of FOG and QMEMS VQAs which brings the best of both worlds: high performance and low cost.

Another solution could combine QMEMS gyros for pitch-roll accuracy and FOG for heading accuracy.

QUALITY-CONTROLLED MANUFACTURING

All EMCORE quartz inertial sensors are designed and manufactured at the company's ISO 9001 and AS9100 microfabrication facility in Concord, CA. EMCORE FOGs are designed and manufactured at the company's ISO 9001 certified wafer fabrication facility at its headquarters in Alhambra, CA.

A SOLUTION FOR ALL YOUR NEEDS

EMCORE offers a unique combination of FOG and QMEMS gyros, accelerometers, IMUs and INSs that form the foundation for navigation solutions and can be tailored to civil and military customer needs and objectives.

EMCORE can meet customer timing and cost objectives with off-the-shelf models or develop and qualify customized solutions from tactical- to navigational-grade systems at unmatched performance vs. CSWaP points.

The company is mature and sustainable with a steady long-term production history and the demonstrated ability to consistently deliver compelling advantages over legacy devices:

FIGURE 1: EMCORE QMEMS Inertial Sensor Technology Points of Difference for Tactical Applications

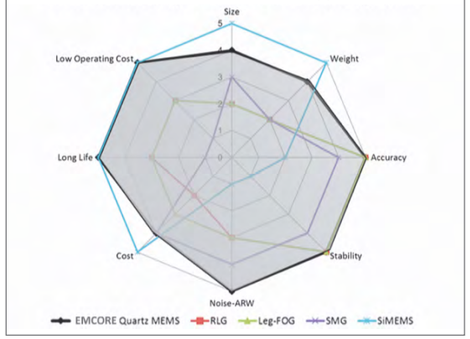
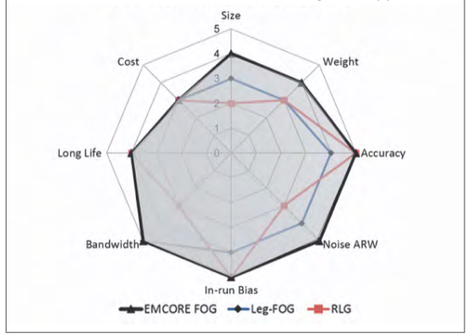


FIGURE 2: EMCORE FOG Inertial Sensor Technology Points of Difference for Tactical Short-term Navigation Applications



- QMEMS advantages for tactical to short-term navigation grade
- FOG advantages over RLGs up to precision navigation grade
- Low in-run bias
- Low angle random walk values

EMCORE QMEMS, FOG and hybrid inertial sensors are ideal for north-finding, targeting, guidance kits, stabilization, marine and unmanned applications that are not dependent on GPS or GNSS solutions for accuracy.

Finally, EMCORE's performance thresholds are constantly evolving to anticipate the future needs of their rapidly growing user communities. ◈

Visit www.emcore.com/navigation for more information.