



Abstract

KVH Industries designs and manufactures fiber optic gyros (FOGs) specifically designed to provide a high-performance, low-cost successor to mechanical gyros. The all-fiber design, with no moving parts to wear out or fail, ensures high reliability, excellent performance and exceptional vibration, shock and acceleration survivability. Unlike mechanical gyros, KVH FOGs are insensitive to cross-axis motion and inertia. They also feature high bandwidth and bias stability, making them suitable for a wide range of rotation measurement applications.

KVH FOGs such as our DSP-3000 and DSP-4000 employ our patented Digital Signal Processing (DSP) technology. Digitizing the rate measurement provides an order of magnitude improvement in performance and reliability of a fiber optic gyro. The KVH DSP chip implementation synthesizes our experience with analog designs to provide high performance with ease of use. Such an approach offers an array of benefits:

- More accurate measurement of rotation rate changes over full environment (e.g., temperature, vibration, shock, etc.)
- Operation over a wide range of input rotation rates
- Flexibility of output interface bandwidth and format
- Improved reliability
- Built-in test (BIT) self-diagnostic software, which enables the FOG to detect and report failures



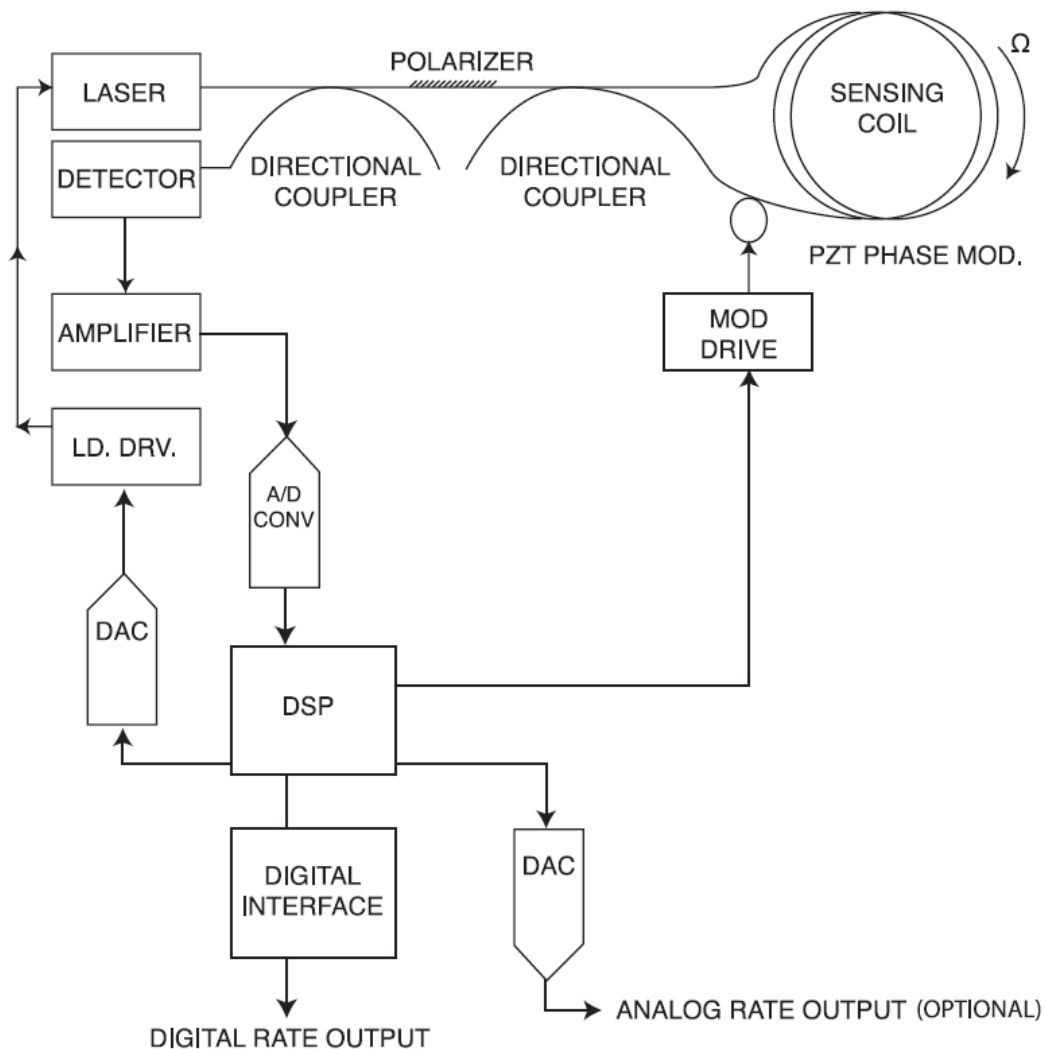
Overview of KVH FOG Technology

KVH is the only FOG manufacturer in the world to fabricate 100% of the fiber used in its gyro products. More than 20 years of research into fiber design has resulted in our E•Core fiber, a proprietary class of D-shaped cross-section, non-stress induced fiber with an elliptical core. The temperature instability present in standard stress-induced fibers has historically precluded the use of FOGs in military applications. However, the elliptical core in E•Core fiber acts as an optical wave guide for the FOG sensing light, resulting in stable performance over a wide temperature range that now make KVH FOGs a practical alternative to iron gyros.

Our E•Core polarization maintaining (PM) fiber is drawn from raw glass. Competitive approaches use the opposite philosophy, choosing instead to start with inexpensive telecommunication optical fiber that requires numerous processes related to coil winding in order to perform rate measurement. By deriving the rate measurement from within the optical fiber, KVH is able to preclude the need for exotic coil winding techniques but still produce a rate gyro that provides robust performance over a tactical-grade temperature range.

KVH FOG designs employ an open-loop optical configuration consisting of a broadband solid-state optical source and PM fiber components all fabricated from E-Core elliptical core fiber.

Figure 1: Single-axis Gyro Assembly



The light energy passes through a first directional coupler that isolates the detector and a polarizer to ensure a single polarization state. The light is then split in two by the second directional coupler and fed in to opposite ends of a coil of PM fiber. The coil with the counter-propagating lightwaves serves as the sensing element.

The operating principle is the Sagnac effect, which is also the basis of the ring laser gyro. When the coil is not rotating, the light path in either direction is the same length so the two wavelengths are coherent upon their return to the directional coupler and passage through the polarizer to the detector. Rotating the coil introduces an optical path length difference in the counter-rotating light paths. The phase difference in the two paths results in a change in amplitude of the recombined signals proportional to the input rate. This light amplitude is measured at the detector and, after processing, results in an output



that is proportional to the rate of turn about the axis of the sensing coil. This design permits KVH to create exceptionally high-performance open-loop gyros that use minimal amounts of fiber and couplers as well as low cost light sources. Competing closed-loop FOG designs require expensive integrated electronic optic chips, which make cost reduction problematic.

The new DSP-3000 Fiber Optic Gyro (FOG) offers high performance in a smaller, OEM-style modular package. The DSP-3000 is intended to be the highest performance, smallest form-factor, single-axis FOG in the KVH rotation rate sensor product line. The DSP-3000 mechanical design also offers improved performance over vibration and shock.

The DSP-4000 series consists of the same optical and digital signal processing core design that is used in the DSP-3000, but placed in a ruggedized housing with additional circuit boards for customer-unique power supply and electrical interface requirements. DSP-4000 models can be engineered to meet a wide variety of connector and mounting provision configurations for both Ground Mobile and Naval Unsheltered applications.

Product Feature(s)	Customer Benefit
Asynchronous RS-232, synchronous TTL digital and analog interfaces Software selected digital output rates, nominal of 100 per sec asynchronous and 1000 per sec sync. Analog 3 dB, 200 Hz BW.	Flexibility of output interface bandwidth and format
+5 VDC \pm 10% (DSP-3000)	Input power
Digital components and digital PCB design are more reliable than analog designs. Operating point control loops compensate for optical component long-term aging.	Improved reliability
Self-diagnostic software	Built-in Test capabilities, enabling gyro to detect and report failures