



**Meeting Critical Stabilization Needs for
Remote Weapon Systems:
The Case for KVH Fiber Optic Gyros**



KVH INDUSTRIES, INC.

MOBILE BROADBAND COMMUNICATIONS,
GUIDANCE & STABILIZATION

Executive Summary

Warfare and weapons have come a long way from a gunner bouncing around on top or in the back of a vehicle like an extra in “Kelly’s Heroes” – exposed to enemy fire and using his weapons largely for suppressing fire rather than a true tactical tool. The emergence of Remote Weapon Systems (RWS) in 2004 changed all of that. For the first time, gunners in smaller vehicles such as up-armored HMMWV’s, could operate their weapons from within the safety of the vehicle itself, removing them from the line of enemy fire and reducing their vulnerability to IEDs and other threats. The RWS brought cutting-edge remote control technology to the warfighter, enabling him to identify targets, aim, and fire using a fire control console and display inside the vehicle. Just as importantly, these weapons systems added integrated high-resolution optics for surveillance and spotting targets, and dynamic positioning systems to keep the weapon on the target even as the vehicle travels over rough terrain or engages in rapid fire mode.

Key to the success of RWS technology is a precision sensor system capable of measuring vehicle and weapon motion and instantly relaying this data to the RWS computers and servos to keep the gunner’s video image crystal clear and his gun on its target. The resulting system maximizes the weapon’s effectiveness while minimizing the risk to non-combatants. To achieve the level of stabilization necessary for this precision performance of optics and weapons, RWS manufacturers around the globe rely on high-performance fiber optic gyros (FOGs) developed and manufactured by KVH Industries, Inc.

KVH – Supporting RWS Technology from the Start

Since the introduction of the first remote weapon systems in 2004 (ordered by the U.S. Army under a program named “Common Remotely Operated Weapon Stations” or CROWS), KVH Industries’ FOGs have been the premier choice of the world’s leading manufacturers of RWS. KVH’s DSP-3000 FOGs were used in the first generation CROWS units designed and built by Recon/Optical, which featured interchangeable weapons coupled with various optical capabilities on the exterior vehicle, stabilized by gyros from KVH. The soldier inside the protective shell of the vehicle could then operate the entire system with a joystick and visual display. In 2008, KVH was chosen by Kongsberg Defence to provide precision FOGs for CROWS II, a new generation of RWS that had additional optical and fire control capabilities. More recently, Rafael Advanced Defense Systems selected KVH’s militarized dual-axis FOG, the DSP-4000, for its next generation remote weapon system.

The Common Remotely Operated Weapon Stations (CROWS)



KVH’s FOGs are used in both the original CROWS and CROWS II units.

The Concepts Behind KVH FOGs

KVH fiber optic gyros are particularly well suited to applications requiring precise performance in demanding environments. Unlike mechanical gyros that rely on a spinning mass, KVH FOGs obtain rotational information by measuring the variations in wavelengths of light passing through an optical fiber. Two beams of light are sent in opposite directions around a coil of optical fiber. If the FOG is stationary, the beams travel through an optical circuit and reach the detector at the same time. If the FOG rotates, the beams do not arrive at the detector in phase. The phase difference is then used to calculate the precise angular rotation. Because this process happens at the speed of light, KVH FOGs are capable of providing information to an RWS at tremendously high data rates, allowing instant responses for stabilization purposes.

KVH's open-loop fiber optic gyros offer outstanding accuracy and excellent durability in a small package, at a reasonable cost. KVH's family of FOGs includes innovations in several key fields, including:

- proprietary D-shaped optical fiber, with an elliptical core,
- innovative optical circuit design, component fabrication, and system integration, and
- patented digital signal processing for improved performance.

In addition, KVH FOGs are lightweight yet rugged devices that output angular rotation data and do so without any moving parts, significantly improving the life span of the device while making it highly resistant to vibration. KVH FOGs are also designed to offer ease of integration by providing multiple interfaces and outputs. Two or more axes of gyros can be easily integrated into a remote weapons system, and communication within the system remains seamless.

Why KVH FOGs Meet the Challenges of RWS Design

RWS designers have specific challenges to overcome when developing a weapon system that is both accurate and responsive. The weapon must stay on target whether the vehicle is stationary or on the move. The optical elements must provide rock-steady, clear images to the gunner despite severe vibration and shock caused by weapons' firing and the movement of the vehicle. KVH's precision fiber optic gyros -- the commercial off-the-shelf DSP-3000 and DSP-3100, and the militarized DSP-4000 -- offer RWS designers the ideal combination of extreme accuracy, exceptional shock and vibration resistance, very high bandwidth, and outstanding durability with an all-fiber, ruggedized design.

The KVH DSP-4000



KVH's militarized DSP-4000 is a dual-axis FOG selected for RWS developed by Rafael Advanced Defense Systems.

Resistance to Shock and Vibration

The precision operation of camera and pointing systems is essential to the effectiveness of a RWS. However, the environment in which RWS units operate is dominated by intense shock and vibration caused by vehicle movement, as well as rapid and repeated light and medium caliber weapon recoil. RWS designers need a sensor package immune to these factors, which is where KVH FOGs enter the picture. Since KVH FOGs are solid state precision sensors with no moving parts, they are extremely vibration- and shock-resistant, while also offering exceptionally long life.

Precision Guidance for Multiple Axes

As RWS technology has evolved, designers have incorporated multiple axes of gyros into the weapon stabilization systems to account for vehicle and turret motion in a three-dimensional world. The small size and integration capabilities offered by KVH high-performance FOGs enable designers to include tracking with multiple axes without sacrificing precision or adding prohibitive weight and cost to the RWS. The DSP-3000 and DSP-3100 FOGs can be mounted in single-, dual- or three axis-installations, while the militarized DSP-4000 is built as an integrated dual-axis FOG.

Ease of Integration

Since RWS designers continue to expand the capabilities of these systems, they require components that offer flexibility and versatility in addition to performance. With each RWS manufacturer handling data interfaces differently, sensors must be able to adapt to meet their needs. Versatile KVH FOGs offer a variety of interfaces including:

- DSP-3100 -- RS-422 output with a high speed 1000 Hz asynchronous interface
- DSP-3000 -- choice of analog, TTL, RS-422 or RS-232 outputs, with either 100 Hz or 1000 Hz synchronous or asynchronous interfaces
- DSP-4000 -- military connectors and weather-resistant gasketing, and the choice of analog or RS-422 outputs

The KVH DSP-3000, DSP-3100



KVH's DSP-3000 and DSP-3100 FOGs are commercial off-the-shelf (COTS) products ideal for military and commercial applications.

Optical Stabilization

One of the critical attributes that makes remote weapon systems so effective is their built-in optical elements including live video and thermal cameras. The RWS gunner needs a rock-solid view of the surrounding area and an unstabilized camera introduces bounces and jitter into the video image. FOGs stabilize the image so it is steady under all conditions -- while the vehicle is moving or under fire, and during firing of a variety of weapons. Also, when the targeting cameras zoom in on distant targets, small movements on the vehicle can be magnified and move the image off target. By

measuring and rapidly relaying the vehicle movement data to the video system, KVH FOGs cancel out the movement, resulting in a stable image for the gunner.

Precision Pointing

Another essential attribute for remote weapon systems is pointing accuracy. In order for a RWS to be an effective weapon on the modern digital battlefield, it must be capable of showing the gunner the target and then accurately aiming the weapon on target. KVH FOGs, with patented Digital Signal Processing (DSP) technology, precisely measure the weapon recoil and immediately relay that data to the servo mechanism in the RWS, which then uses the data to keep the optics and the weapon on target.

Ensuring Mission-critical Quality and Performance

KVH is the world's only vertically integrated FOG manufacturer. As such, the company completely controls all aspects of its FOG manufacturing process, from drawing the fiber to manufacturing optical components out of the fiber, to assembly of the optical circuit, and then final integration and testing with the FOG electronics, with every step guided by the company's ISO 9001-certified quality program. Rigorous in-house testing at every stage of the manufacturing process ensures that each KVH FOG reliably delivers high-performance accuracy and precision. Plus, the company's high-volume capacity has earned KVH an unmatched track record of timely delivery of fiber optic gyros. This complete control over all of the various processes and quality testing involved in the manufacture of its FOGs means that KVH customers are assured the highest level of quality, complete repeatability, and timely delivery.

Kongsberg's Protector RWS



KVH FOGs were chosen by Kongsberg Defence for its Protector series of remote weapon systems.

Conclusion

KVH has fielded more FOGs for RWS units than any other manufacturer, giving us unmatched experience in meeting all of the performance requirements of these high-tech weapon systems. The KVH family of FOGs, including the DSP-3000 and DSP-3100 single-axis, commercial off-the-shelf fiber optic gyros and the militarized dual-axis DSP-4000 FOG are the established choice of remote weapon system designers and manufacturers because they offer exceptional accuracy and reliability and are designed for full-functionality in the most demanding environments. Contact KVH Industries today to discuss your RWS technology and discover how KVH's high-performance, low-cost fiber optic gyros can solve your particular stabilization design challenges.

For additional information regarding the capabilities of KVH's family of high-performance FOGs and FOG-based inertial measurement systems, please visit the KVH resource page – <http://www.fiberopticgyro.com> – where you can also download



the free companion white paper: *Update on KVH Fiber Optic Gyros and Their Benefits Relative to Other Gyro Technologies, second edition.*

You can also see KVH FOG-equipped RWS in action online at <http://vimeo.com/6708251>.

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