# High Spur Free Dynamic Range RF Photonic Links allow MIL SATCOM and RF Distribution Networks to Leverage Optical Communication Infrastructure

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Radio Frequency (RF) Photonic links have been the focus of researchers since the early 1980's, and the advances in performance capabilities have been continually expanded by innovative industry development of academically proven principles and techniques. The initial introduction of RF Photonic technology to the civilian and defense markets provided limited deployment options due in large part to their high costs, limited RF performance envelope, and prohibitive size, weight and power (SWaP) requirements. In addition to these technical limitations, there existed the ever present cultural mindset to resist the adoption of new technologies into front line military platforms.

Since then, the ever increasing proliferation and reliance on RF systems has necessitated the need for robust, secure, and distributed network topologies. As a result, the defense industry is incorporating optical fiber cabling in lieu of coaxial cables or waveguides within major communications and weapons systems. This trend has put increased demands on the RF performance of optical links to achieve ever improved Spurious Free Dynamic Range (SFDR) capabilities. That is, system link budgets can no longer be sacrificed, with regard to the SFDR design trade space, at the expense of using sub-optimal RF Photonic technologies.

Microwave Photonic Systems (MPS), an industry leader in RF Photonic technology, has leveraged its 15 years of research, design, and manufacturing experience to develop proprietary technology for deployment of optical communications equipment that offer **SFDR ranges in excess of 116.0 dB-Hz$^{2/3}$.**

MPS is a RF Systems engineering and design house that leverages core knowledge in RF Photonic technologies to develop capabilities and deliver products that seamlessly integrate into advanced communication networks within the modern battle space (signal) Electro-Magnetic Environment (EME).

## RF Photonic Antenna Interfacility Links

An RF Photonic Antenna Interfacility Link (IFL) is a specialized transmission subsystem designed to support the optical signal conversion, transport and distribution of RF signals over distances in excess of 80 km. The IFL provides a high dynamic range, low noise transport capability to remote RF Radio Transceiver Uplink and Downlink signals beyond the limits of conventional coaxial cable. The IFL RF distribution architecture incorporates a suite of Line Replaceable Units (LRUs) that provide the capability to bi-directionally transport Fiber Optic Channels between the radio transceivers and antennas. An IFL offers operational capabilities beyond that of conventional copper solutions:

- Increased Bandwidth Distance Product
- Reduction in Size, Weight and Volume
- Immunity to High Altitude Electromagnetic Pulse (EMP)
- Immunity to Electromagnetic Interference (EMI).

## OFW-5300 Product Spotlight

The OFW-5300 IFL, manufactured by MPS is a **Commercial Off the Shelf (COTS)** RF fiber optic subsystem that consists of multiple sets of optical transceiver equipment; that is, configured to support Uplink & Downlink (redundant) transport of RF (L-Band), Frequency Reference, Ethernet Data, and other complimentary analog satellite communication signals. These signals are transported using a multi-strand single mode fiber optic cable that connects between the antennas and the corresponding radio transceivers. The characteristics of the fiber optic IFL have been designed to **seamlessly replace a copper based IFL** and provide primary and redundant backup capability to the high priority RF channels.

The OFW-5300 IFL utilizes a complimentary set of technologically unique RF photonic modules that incorporates MPS's proprietary **linearizer technology** in order to enhance the SFDR of MIL SATCOM IFLs beyond that which is achievable with standard RF fiber links. Typical **SFDR** that can be achieved is greater than **116.0 dB-Hz$^{2/3}$** depending on the system Gain, Noise Figure, and Optical Loss Budget requirements.

**OFW-5300 High Density Rack Mount Modular Chassis**

## System Design Highlights

The OFW-5300 is packaged in a 19", 4RU high density rack chassis and is designed to house a compliment of LRU Plug-In modules. These LRU modules are the optical conversion and transmission interfaces between the antennas and the radio transceivers for the various fiber optic channels.

The OFW-5300 Transmit and Receive Plug-In modules are capable of a broad range of RF transmission frequencies including **L-Band, S-Band, C-Band, X-Band and Ku/Ka-Band.**

In addition to offering a broad spectrum of Transmit and Receive Plug-In configurations, the OFW-5300 can be outfitted with a host of other Plug-Ins including **Frequency Reference, RF Redundant Switches, Monitoring & Control** (M&C), **Data Links, Variable Attenuators,** and **Dual Redundant Power Supplies.**

Each OFW-5300 Plug-In has remote alarm reporting capability. The **M&C Plug-In** provides a RS-485 interface that provides the user with the capability to monitor the full complement of LRU's and control the RF Redundant Switch Plug-In.

The **Redundant Switch Plug-in** provides "intelligent" RF redundant channel switching. The redundant switching can be initiated by one of two different methods: **auto-switching** or **remote user-controlled** manual override. The primary or redundant channel selection determined by the RF redundant switch module, when in auto-switching mode, is initiated based upon a set of health status fault indicators provided by each Plug-In receiver. These indicators are communicated directly to the redundant switch module using a dedicated digital communications interface. Remote user-controlled manual override is initiated by the operator using a **Command Monitor & Alarm (CMA)** interface such that the override command is received by the onboard M&C RS-485 interface which initiates the RF redundant switch action.

**Compatible with Mil Tactical Fiber Optic Cable**

## Fault Tolerant Architecture

A key system benefit to deploying the OFW-5300 IFL is that it can provide a redundant fault tolerant architecture. The nature of active redundancy allows flexibility that in the event that a system health fault occurs, and system redundancy has been compromised, the system is capable of continuing the required function and operation. All modules, including power supplies, in the OFW-5300 chassis can be removed and replaced while power is on and the system is functioning. Due to the **"hot swappable"** nature of the Plug-In module support concept, the M&C functionality allows the User to initiate corrective action without incurring system downtime. Each LRU is fitted with front panel mounted LED indicators to alert operators to malfunctions and to aid service personnel with troubleshooting. LED's are tied to failures such as AC Power Loss; DC Power Supply Fail and Received Optical Power Low.

## Optical Matrix Switch Integration

The OFW-5300 has been successfully integrated with an Optical Switching Matrix to handle multi-signal traffic in a compact form factor. This integration allows the user to replace bulky coaxial switch matrices needed to switch the RF signals. Utilizing an Optical Switch as the backbone for traffic routing is a pivotal technology for any platform that necessitates a multi-mission environment or dynamic re-configurability. Implementing a **network-centric based routing and distribution** of RF signals enables "plug and play" methodology of the RF signal traffic. This results in significant rack space, power and cooling requirement reductions.

**OFW-5300 Outdoor Ruggedized Enclosure**

## Conclusion

The technological maturation and commercialization of RF Photonics have yielded a new and robust generation of fiber optic communication components interconnects, and active devices that are not only cost effective but also offer improved RF performance and SFDR characteristics. These technical improvements, coupled with a growing list of fielded and proven RF Photonic systems, has successfully positioned Microwave Photonic Systems as the leading company for the design, development, manufacturing, and deployment of RF Photonic architectures. ■

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