High-Density Multi-Channel 6.0GHz HP Bidirectional RF over Fiber System

preliminary image used for illustration purpose only.

RFOptic's RFoF Bi-directional system provides RF performance that is superior to coaxial cable interface. RFOptic's solutions are tailored to the 5G/6G cellular band and covers the entire 0.5GHz to 6GHz bandwidth or narrower bandwidths (2.5GHz, 3GHz and 4GHz) should that be preferable.

RFOptic's high-density (HD) multi-channel mainframe provides a compact and flexible solution for 5G and 6G RFoF signal distribution applications. This 2U 19" rack mountable HD mainframe is designed to house up to 5 RFoF hot-swappable drawers each of which includes 8 RFoF units. With this modular approach, the HD mainframe provides high RFoF link density with modularity to simplify maintenance and configuration flexibility. It supports flexible drawer configurations to allow for growth as more RFoF channels become necessary over time and can seamlessly handle multiple drawer configurations and a wide range of application requirements. The HD mainframe provides redundant power supply, forced air thermal management along with remote management services to monitor and control of the system and each of its components through HTML/REST/SNMP interfaces.

The drawer configurations provide any combination of RFoF transmitters (Tx) and Receivers (Rx) and support components such as RF switches and combiners as may be necessary to achieve for example channel redundancy. The flexible monitoring and control management system in combination with the HD multi-link system modularity allow unmatched flexibility that can handle massive wideband connectivity and distribution multiple RF signals on independent fibers or common fibers using WDM technology.

A drawer holds 8 RFoF units which can be organized in number of configurations to provide diverse RFoF connectivity functions including unidirectional and bidirectional RFoF links using single, paired or multiple fibers. The bidirectional configuration of the drawer provides 4 one side terminals of the bidirectional links (4 half bi-dir terminals). This standard configuration includes optical multiplexing and wideband RF combiners integrated with suitable RF filers. In this configuration, a wideband high isolation RF combiner is used to deliver the RFoF to the RFoF Tx and combine the RF output from the RFoF Rx of each half bi-dir terminal. A High Pass Filter (HPF) with a 0.5GHz cut-off and sufficient stopband isolation is included in line of the RFoF Tx input in order to provide sufficient isolation outside the RF combiner's bandwidth. The uplink and downlink optical signals are separated by wavelength to insure complete isolation while using a single connecting fiber. Another bidirectional available drawer configuration excluding the optical multiplexing and uses 8 connecting fibers. Such configuration may be used in non-symmetrical bidirectional applications or in signal distribution cases where optical amplification is required.

The D1, D2 and D3 drawer configurations provide both terminals respectively which complete a quad channel RFoF bidirectional link. The system is offered with configuration (D1, D2) wavelength multiplexed single fiber connections which can be used to transmit both uplink and downlink signals of each port over the same single-mode fiber. Configuration (D3, D3) operates over single wavelength using two independent cross connected fibers. The block diagram on page 2 of this brochure provides details of the RF and Optical configuration.

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Key Features:

- Integrated high-density and flexible multi-channel RFoF sub- system.
- Full support for the 0.5GHz to 6GHz bandwidth.
- Excellent linearity, gain flatness, and gain control.
- Programmable RF and Optical performance.
- Built-in end-to-end diagnostics reduces installation and maintenance time.
- Integrated RF power sensors.
- Reduced gain variation over temperature option.
- Remote management and control via HTML/REST/SNMP interface

Configuration:

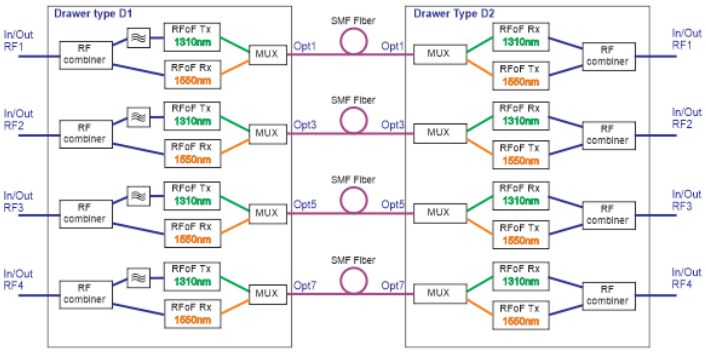
- Mainframe 19" 2U indoor enclosure with 5 drawer bays, dual redundant power supply, remote management support and thermal management.
- Drawers with 4-channel half bi-dir RFoF terminals each integrated optical MUX, RF combiner and suitable isolation filter.
- Drawer with 8 unidirectional RFoF terminals in custom configuration.

Each RFoF link uses RFOptic programmable RFoF technology and includes a 30dB LNA that can be bypassed along with Tx and Rx variable attenuators which can be used to customize the Noise Figure, Input P1dB, and IP3 over wide range of values. For special applications requiring improved temperature stability, a unique optional temperature compensation algorithm supports ±0.5 dB over 100˚C variation of the ambient temperature. The RFoF link has excellent gain flatness with 0.5dB gain adjustment and tracking between different links.

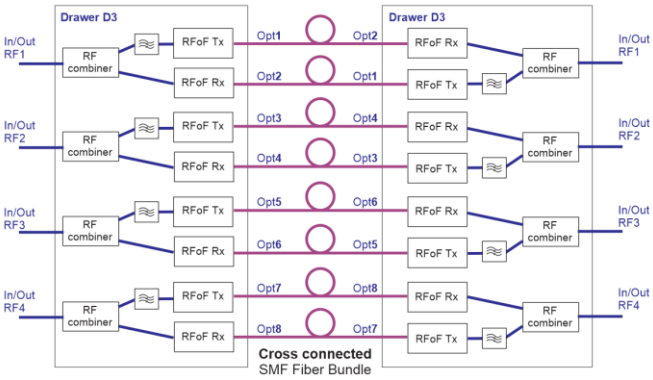
Applications:

- 5G/6G test sites
- DAS
- Distributed Antenna

Drawer to Drawer HP Bidirectional RFoF 6GHz Links Block diagrams - Standard Configurations



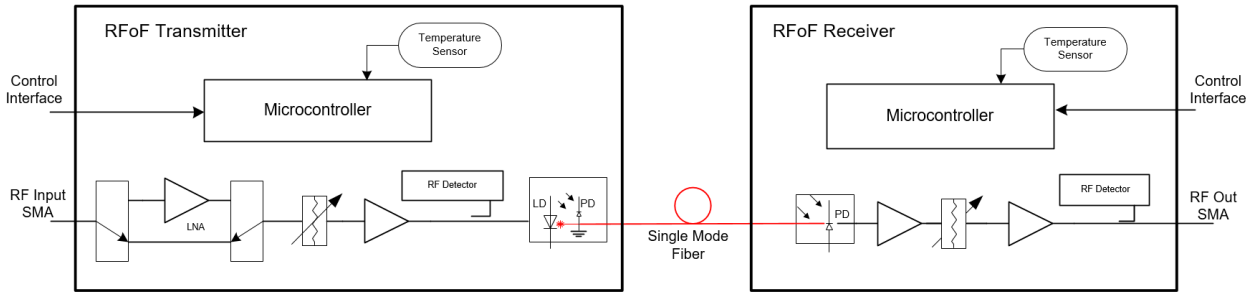
CWDM2 4 Channel HP Bidirectional Configuration



8 Fiber 4 Channel HP Bidirectional Configuration

RFoF Programmable Link Simplified Block diagram

Each RF signal is transmitted over an RFoF programmable link. A simplified block diagram of such a link is shown below.



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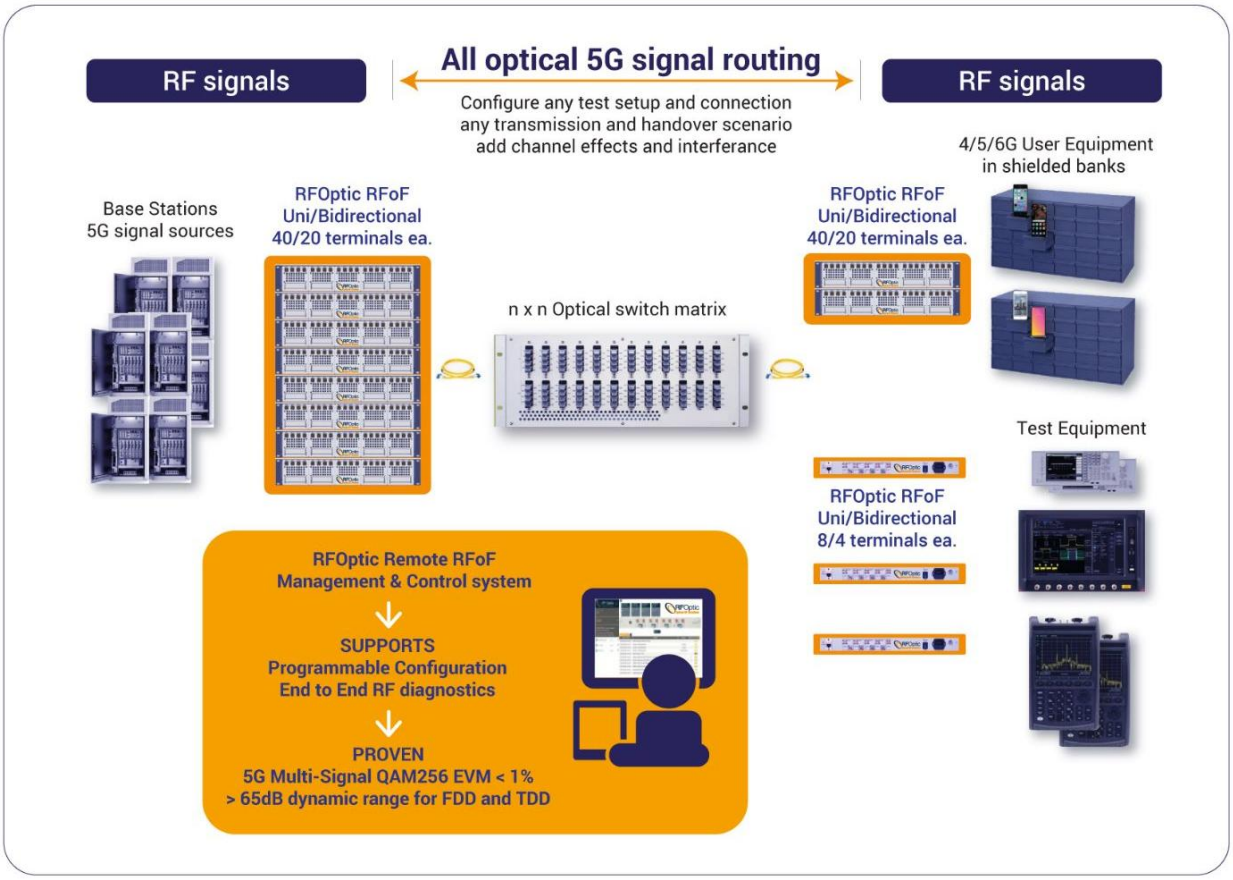
5G Testing Applications overview

Interoperability test of cellular 4G/5G and 6G as well as product testing has been migrating to use RFoF infrastructure as the preferred interface between test equipment and devices under test. The obvious benefits of optical fiber routing include compact and low-cost interconnects, excellent EMC performance and effectively unlimited bandwidth for the RF test environment that insures that the expensive infrastructure can be migrated to future RF bandwidth needs easily at minimal expense. Unlike coaxial cables the RFoF transport of test signals provides excellent and frequency independent dynamic range performance that can be upgraded as new frequency bands are introduced. RFOptic offers proven RFoF products with exceptional performance that are specifically tailored to the demanding requirements of such applications. All RFOptic RFoF terminals are supported with API driven Management and Control system which makes tight and efficient integration of the testing environment simple and flexible. Having done so the integrated test environment can be configured to handle different test protocols in a matter of minutes with minimal or no setup crew involvement. This flexibility is a huge multiplier in test equipment usage rates and provides access of the test infrastructure to many more applications.

The setup diagram below shows an implementation of such flexible environment with RFoF terminals and an optical switch matrix serving as the main interconnect fabric between Signal sources, devices under test and test equipment. RFOptic's Management and Control system which is API enabled is integrated into the test bed configuration management along with other equipment which allows that test environment to meet any test configuration when and as it may be needed. Furthermore, the flexible programmable environment can support multiple concurrent tests as long as there are sufficient and free resources to handle them all. Immediate diagnostics are available at any critical signal transmission point make calibration and validation simple and quick. No more test equipment sitting idle on work benches and no more setup crews working long shifts to reroute and reconnect equipment and devices. In fact, the environment can be configured to report usage levels and therefore it is simple to apply OPEX criteria to optimize management decisions including Buy/Rent.



High-Density 6.0GHz RF over Fiber HP Bidirectional Link Specifications – CWDM2 HP Configuration – D1,2

HP Bidirectional Link Performance (two RFoF terminals using a single fiber)		
RF Performance – Bidirectional channel	**Unit**	**Specification (typical)**
		LNA Off
Frequency Range	MHz	500 - 6000
Nominal Link Gain (adjustable) [1]	dB	0
Gain adjustment Tx & Rx attenuators range/step	dB	31.5/0.5
Gain Flatness	dB	±2.5
Input P1dBc [2]	dBm	5
Noise Figure [2]	dB	33
Calculated SFDR [2]	$dB/Hz^{2/3}$	104
Max Input Return Loss	dB	-11
Max Output Return Loss	dB	-11
Maximum Input No damage	dBm	+23
Input / Output impedance	Ohm	50
Optical and Electrical		
Laser diode wavelength	µm	1.310 & 1.550
Optical Power [4]	mw	8
Mechanical and Environmental Parameters		
RF Input / Output Connectors	-	SMA
Optical Connectors (optional: FC/APC or SC/APC)	-	LC/UPC
Operating temperature	°C	-20 to +70
Storage temperature	°C	-40 to +85

[1] The link Gain is measured using a short fiber patch cord, and can be adjusted by the Tx Attenuator using the user software.

[2] Noise Figure and Input P1 dB are measured at 3GHz, and can be adjusted by using the Tx Attenuator at 'LNA Off/On'.

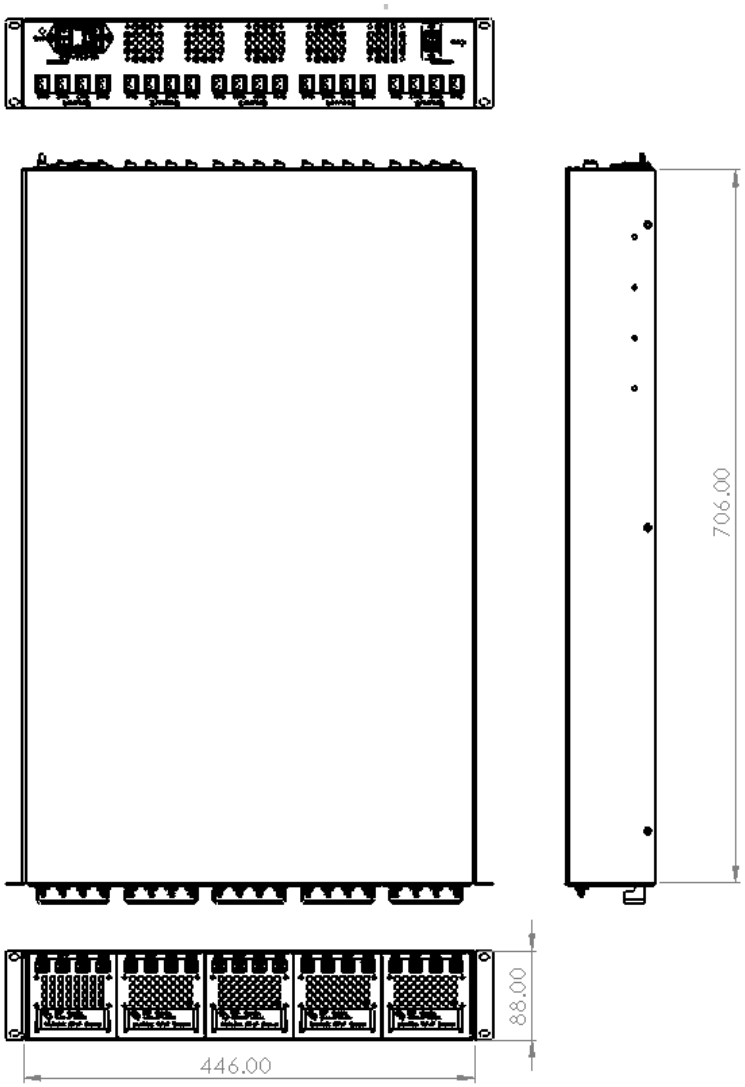
[3] Bidirectional specifications are measured with the two Bidir Rx attenuators set to 5dB due to loop gain considerations.

High-Density RF over Fiber System and Mainframe and Drawer Specifications

Mainframe Specifications		
Electrical Parameters	**Unit**	
System Monitor & Control	-	HTML/REST/SNMP
Thermal Management	-	Front to rear forced air
Power and consumption	-	110/220 VAC, 60W
Mechanical and Environmental Parameters		
19" 2U Enclosure dimensions	mm	445(W)* 700(L)*88(H)
Number of High-Density Drawers	-	5
Power Connectors	-	HP Socket
Data Connector		RJ-45
Operating temperature	°C	-20 to +70
Storage temperature	°C	-40 to +85
Weight including 5 HD drawers	kg	47

Drawer Specifications		
Parameters	**Unit**	
RFoF capacity	-	8 unidirectional or 4 bidirectional terminals
RF connectors	-	SMA
Optical connectors	-	LC/UPC
Storage temperature	°C	-40 to +85

19” 2U HD Enclosure Drawings



Ordering Information

The HD Multilink system can be ordered in several Drawer configurations as shown below. Normally, drawer D1 and D2 are used as a bidirectional pair for a 4 fibers interface. Alternatively, for the 8 fibers interface, cross connected drawer D3 is used. For most applications a mainframe enclosure is required at both terminals to achieve a complete the RFoF Multi-link configuration. Other custom drawer RFoF configurations can be configured upon request including unidirectional Tx and Rx multi-links.

ERP P/N	Marketing P/N	Description
SYSA00026	RFoFc-HDNIHR04	19" 2U HD Mainframe enclosure with 5 drawer bays, dual redundant power supply, remote management with HTML/REST/SNMP and thermal management.
SYSA00027	RFoFc-D1SU4T4R06 Ver.1	HD HP Drawer with 4*RFoF 6GHz bidirectional 1310nm terminals, combiners, filters, 1310/1550nm multiplexers, SMA, LC/UPC, HTML
SYSA00028	RFoFc-D2SU4T4R06	HD HP Drawer with 4*RFoF 6GHz bidirectional 1550nm terminals, combiners, 1310/1550nm multiplexers, SMA, LC/UPC, HTML
SYSA00321	RFoFc-D3SL4T4R06HP	HD HP Drawer with 4*RFoF 6GHz bidirectional 1310nm terminals, combiners, filters, SMA, LC/UPC, HTML

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