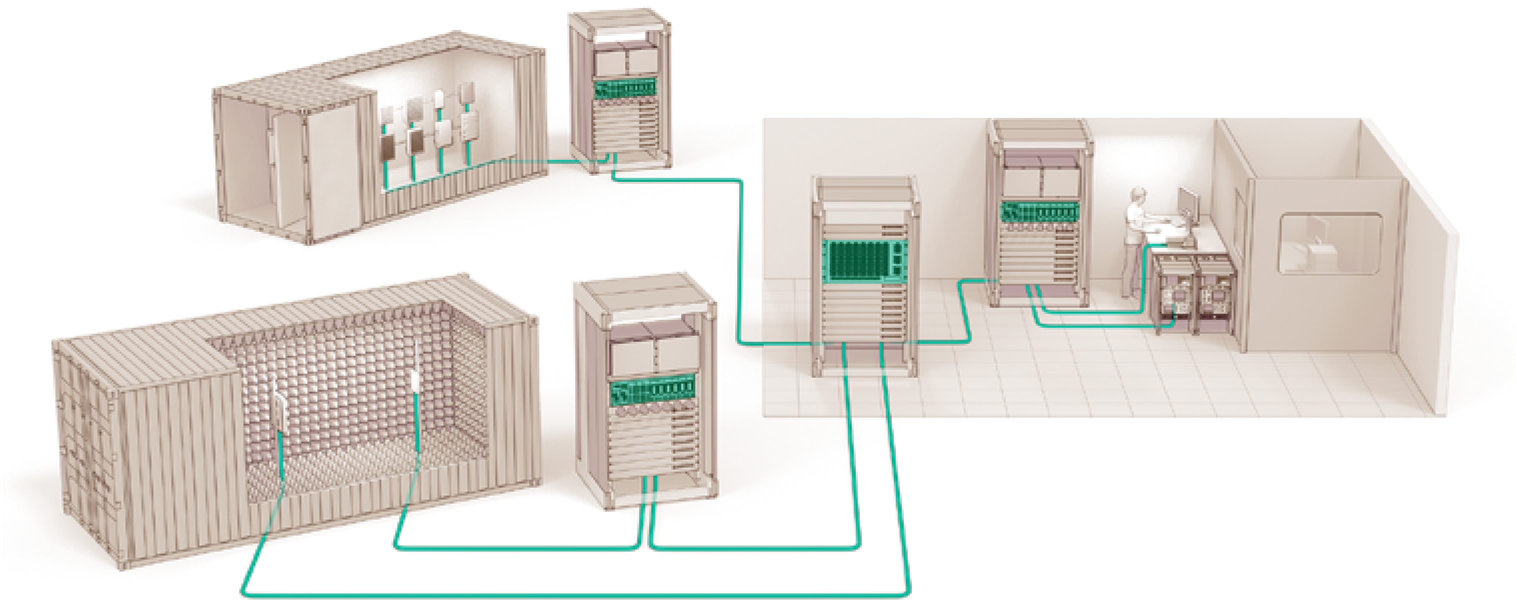
application note



Lab automation for carriers

Key Features
- End-to-end automation solution for carriers' labs
- 3-4 times faster testing
- Technology agnostic
- Maximisation of equipment usage
- RF over Fiber solution

Introduction

Carriers are under intense pressure to rapidly test and deliver enhanced network services, validate new equipment, and even networks as a whole. They also need to be able to reproduce, diagnose and resolve customer issues quickly. All this with the additional challenge of having to test both radio frequency (RF) and fiber optic (FO) technologies. This drives the need to get even more out of their network test lab resources and effectively combine the testing of the two technologies in the same lab.

HUBER+SUHNER

Step away from manual testing and move toward an automated lab landscape

In today's rapidly evolving business climate, the longer it takes to certify new equipment and new services by relying on manual lab operations, the further away the organization gets from increasing revenue and remaining competitive. In place of traditional coaxial interconnected and manually controlled labs, the integration of fiber connectivity and optical circuit switching provides an automated, transparent, user-configurable fiber layer that is fully independent of test traffic formats or bit rates. This allows labs to be reconfigured in seconds rather than hours or days, thereby allowing customers to meet challenging test cycle turnaround times, increasing efficiency and reliability.

Moreover, with automation, labs can share expensive equipment and reconfigure tests remotely and immediately. Using readily available tools, resources can be securely shared between labs dedicated to different parts of the network without conflict. This also enables 'follow the sun' access to lab resources with 24-hour global access to shared test equipment.

Carriers challenges in "live" networks

- Extensive test cases involving regression, features, interoperability and extensions such as Common Protocol Radio Interface (CPRI)
- Continuous software updates of network elements
- Fast deployment of security-related software in network elements
- Complex regression testing due to coexistence of numerous technologies, frequencies and access modes
- New software releases can have a negative impact on features and functionality of current live release

The HUBER+SUHNER solution

- End-to-end lab automation solution.
- High reproduceability, traceability, reporting and increased efficiency.
- Future ready including new 5G bands and beyond.
- Optical circuit switch which is protocol and data rate agnostic.
- Faster time to market.

Examples of typical carriers' test procedures

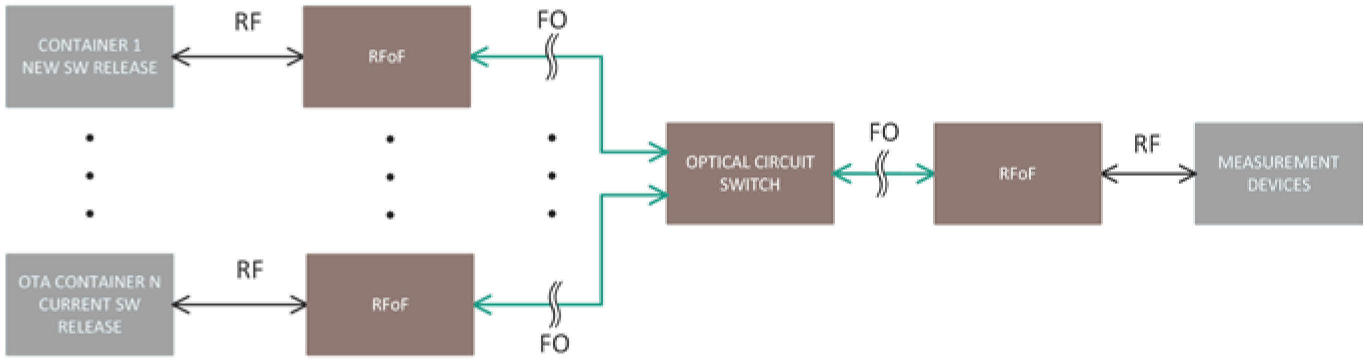
Regression

Regression testing is needed to verify that new software releases do not impact the existing functionality of the network.

The new releases may be due to a change in the requirements like adding new functionality or patching for issues such as bugs or security vulnerabilities.

The software updates have to be done constantly and with ever-increasing complexity due to the use in the network of multiple-vendors' equipment, multiple spectrum bands and different technologies.

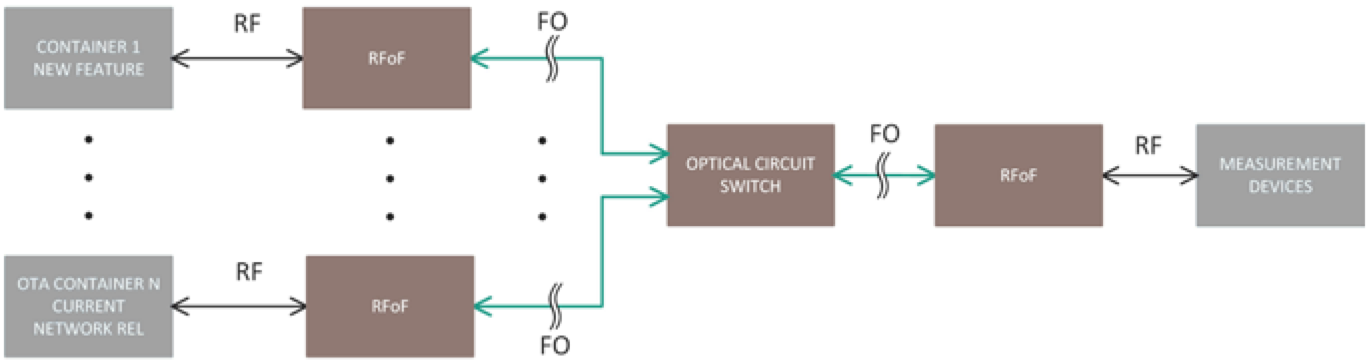
Regression testing can include thousands of individual software tests that must be run in cascaded sequences, therefore using an end-to-end automated solution can drastically reduce the time for test set-up and for actual testing. This allows carriers to introduce new software releases faster than before and in a simple and reliable manner.



Feature

There is an enormous effort from the carriers' side to improve the network performance and to enhance user experience. At the same time the new features (i.e. extremely high throughput, ultra-low latency and network slicing) which are needed to improve the network functionality are increasing in complexity as well as in the pace at which they are being released.

To overcome this challenging environment, carriers can implement automated lab scenarios that allow agile and efficient feature testing. Feature testing is needed to verify that the new functionalities work on an end-to-end basis before being introduced into the live network.



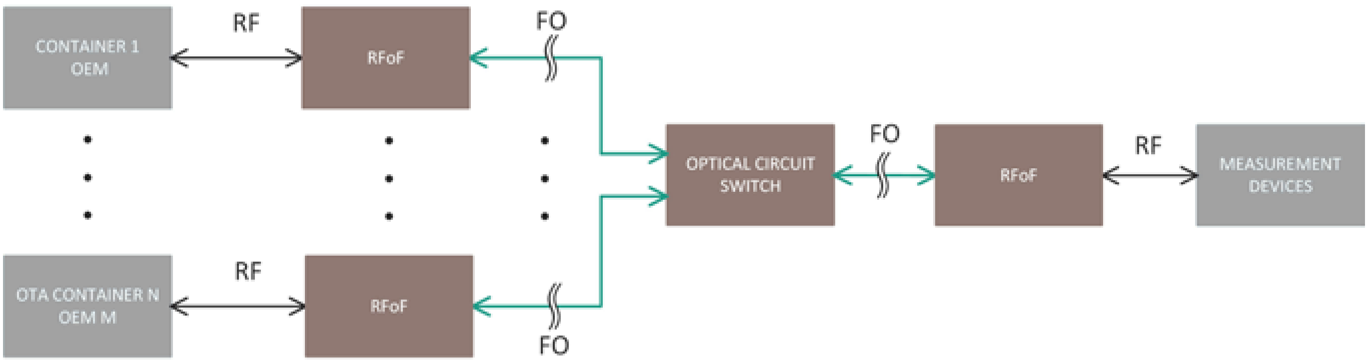
HUBER+SUHNER

Interoperability

In a mobile network, various Original Equipment Manufacturers' (OEMs) equipment as well as different technologies (i.e. 4G LTE and 5G NR) typically co-exist. Moreover the introduction of new network architectures like Open RAN , disaggregated and centralized networks, challenges carriers by requiring additional testing of interoperability to ensure that all network elements and interfaces function according to predefined standards and can coexist.

To overcome this complexity, interoperability testing can be done with the help of a lab automation solution that simplifies the testing of virtual RANs, open standard software and hardware.

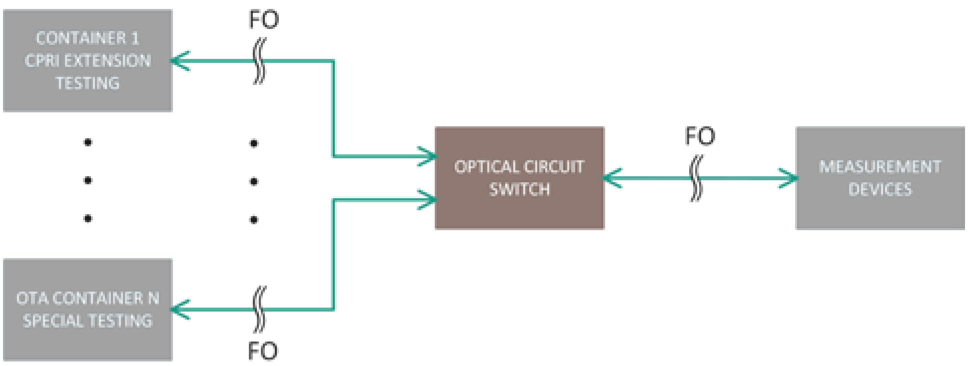
O-RAN ALLIANCE is a worldwide community of mobile operators, vendors, and research & academic institutions with the mission to re-shape Radio Access Networks to be more intelligent, open, virtualized and fully interoperable.



CPRI extension

CPRI extension testing verifies the digitized radio data and control information between the Base Band Unit (BBU) and the Remote Radio Unit (RRU) or Active Antenna Unit (AAU); or between the Radio Unit (RU) and the Decentralized Unit (DU), referred as the front-haul interface.

As these interfaces are digital, they do not require RF over Fiber components but can be fully measured with fiber optic connectivity and can be easily, reliably and rapidly tested within an automated lab environment.



Transport and core labs

Transport and core labs must thoroughly test new equipment and services before deploying in the infrastructure to verify reliability and performance. These test labs are also used to simulate customer network environments so that issues can be identified and resolved quickly. In transport labs the transport equipment which could be muxponders, DWDM terminals, edge routers, amplifiers, line cards, to mention a few, will be integrated for testing. The typical use cases are optical component testing, optical module testing and characterization of optical devices.

Technology considerations

Radio frequency (RF) over fiber

RF signals have been distributed over coaxial cables for decades, but given a modern lab's complexity, it can be limiting, expensive, and unreliable. To overcome these limitations, RF and test systems engineers are turning more and more to RF distribution over optical fiber (RFoF).

In RFoF systems, electro-optical (E/O) converters are used to convert RF to optical at the signal source, then transmit it along a length of single-mode optical fiber and via an optical circuit switch to the destination where optical-electrical (O/E) converters convert the signal back to RF.

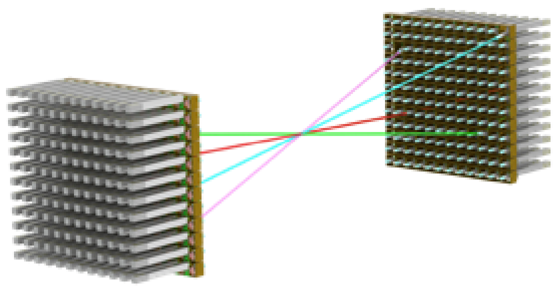
Benefits of converting RF signals

By deploying RFoF for transmission and switching of RF signals in the lab, organisations can take full advantage of the benefits of fiber optics end-to-end, including:

- Much greater transmission distances with much lower losses.
- Immunity to electromagnetic signal interference providing a high level of security from DUT to test equipment.
- Fiber runs in test chambers do not interfere with anechoic chamber performance.
- Future proof: can accommodate any frequency, any data rate, any modulation format – today and in the future end-to-end.
- Extremely light weight, compact form factor, with better bend radius than coax so much easier to deploy.
- Optical circuit switches less expensive and far more compact at scale than RF switches.
- Improved performance, readiness, and resilience at lower overall costs.

Piezo-based vs. MEMS-based optical circuit switching

The analog nature of RF requires a switching infrastructure that does not degrade the RF signal. This requires a high-performance optical circuit switch with ultra-stable operation as well as low back reflections and low insertion loss.



The patented POLATIS® DirectLight™ high-performance switching technology from HUBER+SUHNER, minimizes impairments to RF signals traversing the switch connections.

DirectLight™ high-performance switching technology uses integrated position sensors to directly align optical collimators to make and hold connections which eliminates the need for signal dithering that can degrade RF signals. DirectLight™ enables the creation of dark fiber connections, meaning test paths can be preprovisioned if needed.

This is a critical advantage over MEMs-based optical switching technologies that use mirror dithering as part of the alignment process, to make and hold connections, which adds unwanted signal modulation. In RF systems this MEMS-based excess modulation is mixed directly with the RF signal, adding to the signal noise floor and degrading the RF performance.

Lab automation architecture

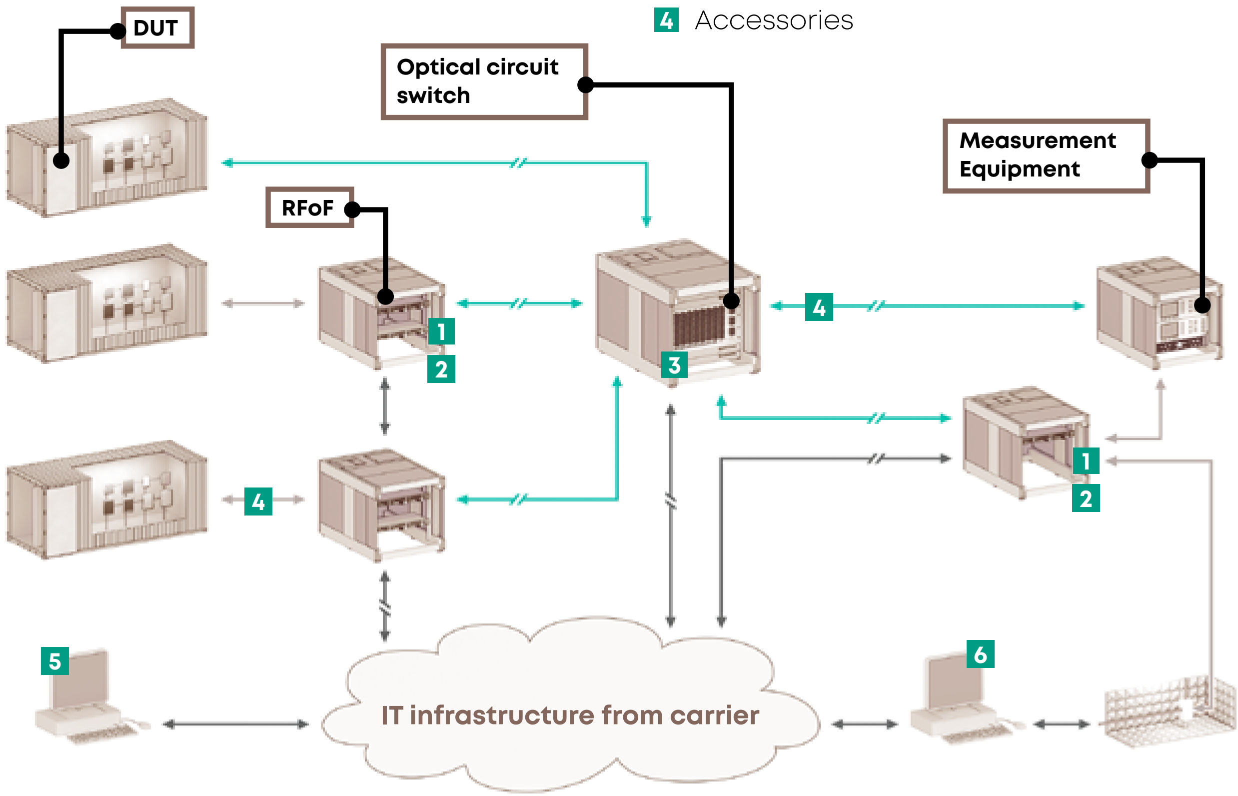
The lab automation solution interconnects Device under Test (DUT) with measurement equipment to perform automated RAN and core/transport testing.

The interconnection consists of:

1 RFoF module
2 19" CUBOrack 3U or 1U
3 Optical Circuit Switch
4 Accessories

Additional features such as:

5 Local system control
6 API for customer specific software developments



Item	Description	Items	Part Number
1	RFoF Bidirectional RF and FO Transceiver (2 channels, with LC-APC and WDM) Duplexer (4 channels)	RS-RFoF08-T13T15R2W RS-RFoF08-DUP	85240467 85225216
2	19" CUBOrack 3U (for 9 RFoF modules) Power Supply Unit (PSU): AC Variant DC Variant Management Module	RS-CH3U-0 (empty chassis) RS-AC350-1 RS-DC350-1 RS-MO-1	85095578 85109107 85115711 85095577
	19" CUBOrack (for 2 RFoF modules) including external power supply unit Management Module	RS-CH1U-0 (empty chassis) RS-MO-1	85124083 85095577
3	Optical Circuit Switch (Custom configurable - any-to-any port connections)	32 x CC 48 x CC 64 x CC 192 x CC 256 x CC 384 x CC	I-OST-32xCC-LA1-HMHNS I-OST-48xCC-LA1-HMHNS I-OST-64xCC-LA1-HMHNS I-OST-192xCC-LA1-HMWNS I-OST-256xCC-LA1-HMWNS I-OST-384xCC-LA1-HMWNS
4	Accessories	RF Jumpers FO assemblies and FO management systems	Harsh environment cabling for the mobile network catalog Structured cabling for data centers catalog

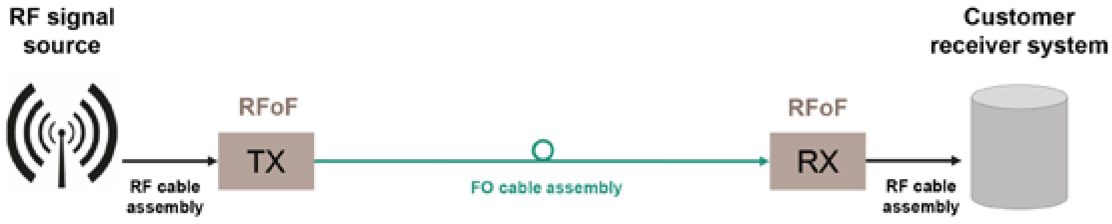
5 and 6 are additional features (interfaces) provided through 1, 2 and 3

HUBER+SUHNER

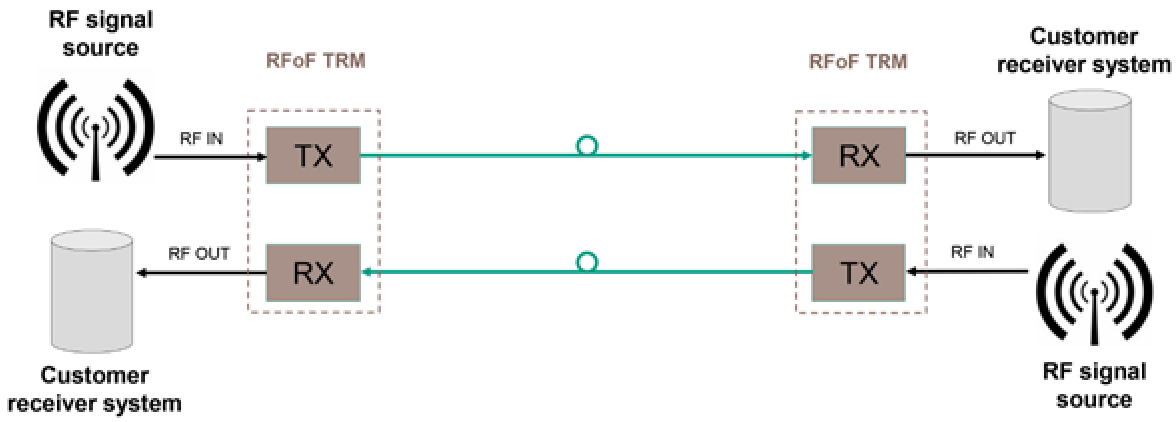
(1) RF over Fiber (RFoF) modules

The RFoF modules have diverse configurations in order to fulfill the different interconnection requirements from the carriers. The RFoF module is available as:

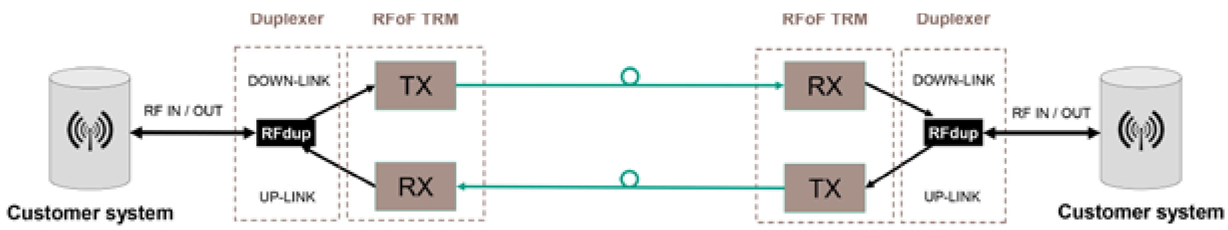
Transmitter (TX) and Receiver (RX) as separate modules
This means for an RF signal connection, a Transmitter (TX) is used to convert the RF signal into an optical signal prior to transportation. While on the Receiver (RX) side the optical signal is converted to RF through the RX module. The optical link operates at either 1310nm or 1550nm.



Transceiver module (TRM)
This module incorporates both Transmitter (TX) and Receiver (RX) within the same electronic card reducing by half the amount of RFoF modules needed for a bi-directional link. Two fibers transport two TX signals respectively.

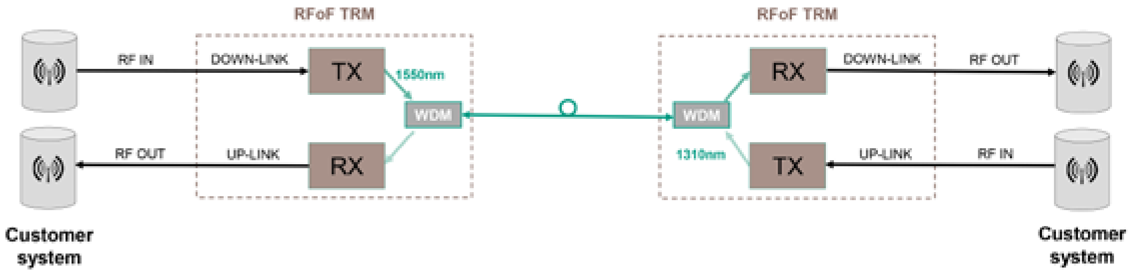


Transceiver module with bi-directional RF functionality
This module incorporates both Transmitter (TX) and Receiver (RX) within the same electronic card and an RF duplexer module to separate transmission and reception signals. This type of module support Time Division Duplex (TDD) scenarios where the RF connection to the customer system is done through a single connection which carries uplink and downlink traffic together. Two fibers transport the TX and RX signals respectively.



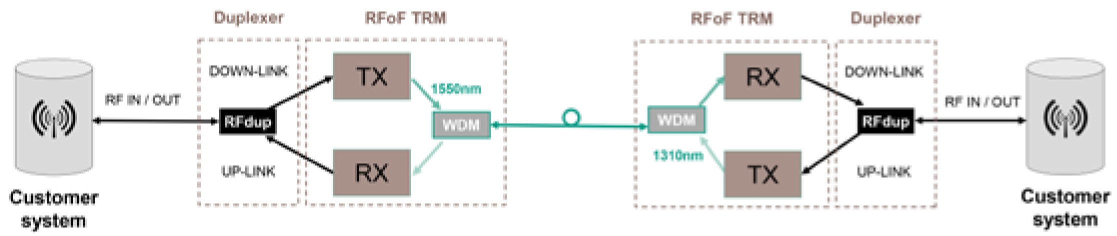
Transceiver module with bi-directional FO functionality

This module incorporates both Transmitter (TX) and Receiver (RX) within the same electronic card, a dual RF connection to the customer system for RF-IN (uplink) and RF-OUT (downlink), and a Wavelength Division Multiplexer (WDM) to transmit and receive the UL/DL signals on two different wavelengths (1310 nm and 1550 nm) within a single fiber.



Transceiver module with bi-directional RF & FO functionality

This module incorporates both Transmitter (TX) and Receiver (RX) within the same electronic card, an RF diplexer to separate transmission and reception signals, and a WDM to transmit and receive the UL/DL signals on two different wavelengths (1310 nm and 1550 nm) within a single fiber.



Using intensity modulation of optical laser light by RF signal amplitude ensures that the analogue characteristics of the RF signal are retained from end to end.

The RFoF modules can handle RF frequencies from 1 MHz to 7.1 GHz. Modules with frequency range up to 40 GHz are scheduled for future development.

The RFoF technology is based on Single Mode Fiber (SMF) transmission, which allows long link distances.

Aditionally, the type of fiber optic connection proposed on the RFoF modules, transceivers, is based on LC-APC.

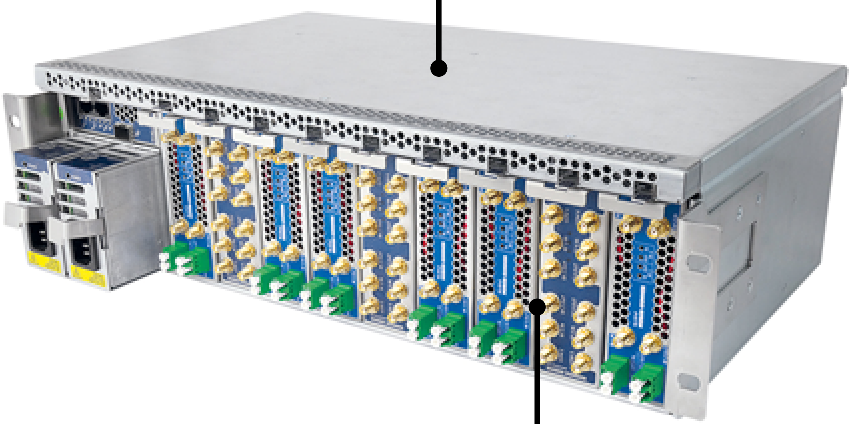
The selection of the type of RFoF modules needed and the number of them is dependent on the type of tests required and the number of RF links to be tested by the carrier.

(2) RFoF modules in 19" CUBOrack

The 19" CUBO chassis is utilized to power and manage the RFoF modules. It consists of 9 slots for RFoF module electronic cards and 2 slots for Power Supply Unit (PSU), redundant and supporting both AC and DC.

The Management Module with Network Interface Controller (NIC) is plugged above the power supplies, for the 3RU variant, and supports Web-GUI, SNMP as well as RESTCONF interfaces. Besides the 19" CUBO chassis in 3RU format there is a 1RU version.

The 1RU consists of 2 slots for RFoF module electronic cards and one slot for the Management Module. The Power Supply Unit (PSU) is AC, redundant and external to the CUBO chassis.



Chassis
The depth of the 19" CUBOrack allows installation of another 19" CUBOrack back to back, allowing up to 36 transceivers within the same installation height. If the configuration of the system requires bi-directional RF functionality an RFoF duplexer module electronic card is used.

RFoF modules
Each RFoF module electronic card (transceiver) has 2 transmitters and 2 receivers. The transceiver card is proposed with WDM and with fiber optic connector based on LC-APC Each RFoF duplexer module electronic card has 4 duplexers.

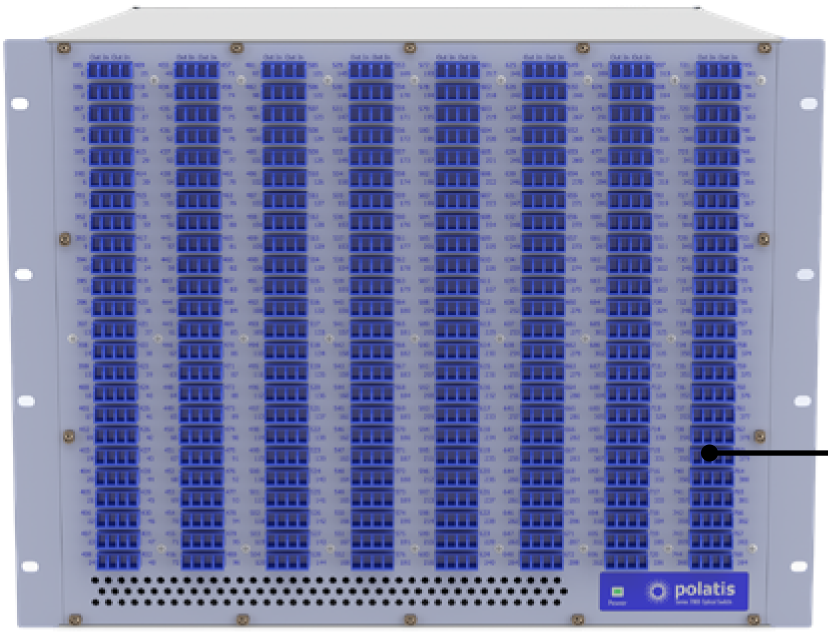
(3) POLATIS® optical circuit switch

The optical circuit switch allows the system test resources to be remotely interconnected and easily shared across multiple test topologies in carrier lab environments, without any concern for conflict between different test groups. This enables the provisioning of Lab-as-a-Service (LaaS).

The optical circuit switch realizes completely transparent connections without packet processing. This means that tests have a high degree of accuracy.

Additionally, the optical circuit switch is transparent to transmission wavelengths, signal direction, protocol and bit rate so the same switch can be used for any media and speed up to 800 Gbps and beyond.

The optical circuit switch can be integrated within test orchestration suites including Quali CloudShell, NETSCOUT® nGeniusONE®, Spirent Velocity® and Spirent iTest®, taking advantage of their ability to store and recall test configurations and topologies enhancing the efficiency of the test setup and process.



Various port configurations available from 32 up to 384 ports.
The OCS can be configured with LC-UPC or LC-APC fiber optic connectors.

(4) Accessories

HUBER+SUHNER can provide a comprehensive portfolio of RF jumpers as well as FO assemblies and FO cable management solutions suitable for lab automation needs.

(5) Local system control

The CUBOrack is supplied with an Element Management System, a WebGUI which displays the status of the 19" CUBOrack and the RFoF modules and allows the user to access them for configuration as well as to perform other management tasks such as general management, slot management, reset functions and reading system status.

The POLATIS® optical circuit switch is also supplied with a WebGUI which displays the status of the switch and all its cross connections and allows the user to configure the switch settings and make/break cross connections as required.

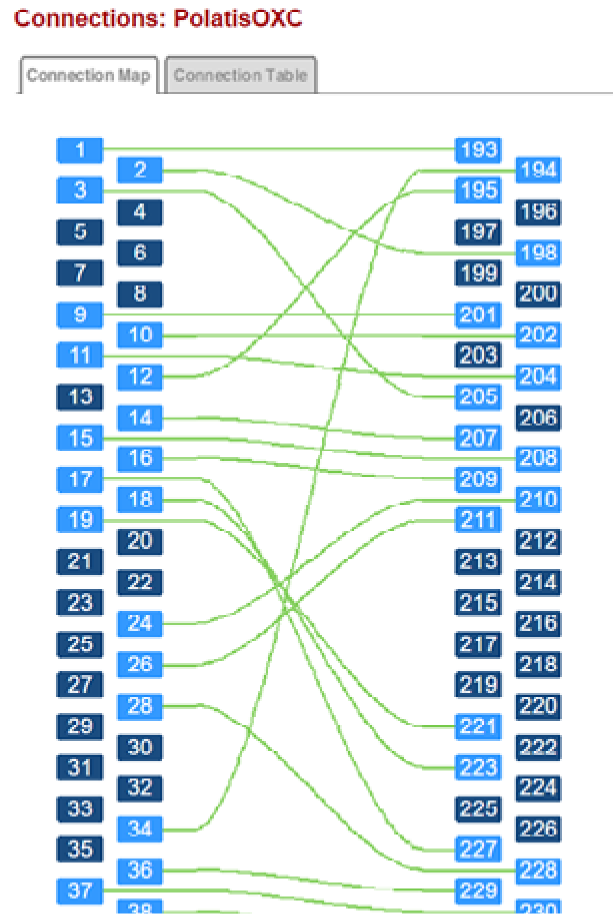


Figure - Cross-connect management screen - WebGUI - POLATIS® OCS

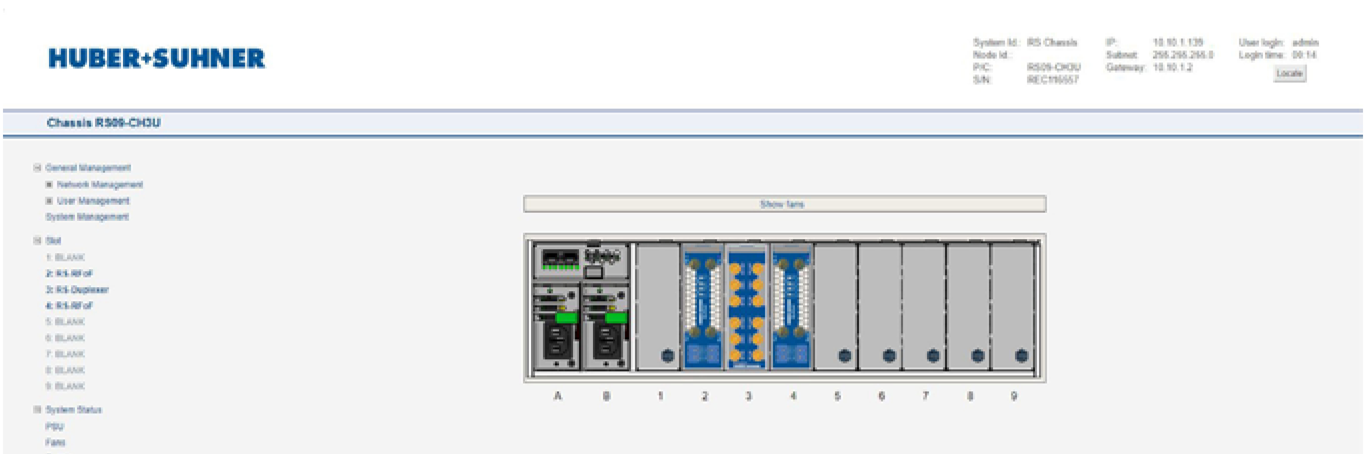


Figure – Software Status – WebGUI – RFoF modules in 19" CUBOrack

HUBER+SUHNER

(6) API for customer specific software developments

Lab operators have a number of options for integrating the CUBOrack with RFoF modules and the POLATIS® switch into the wider lab network management system so that automated test routines can be set up.

Both systems come with a number of APIs and protocols that reflect the evolution of networking and lab equipment management over the last few decades. These include SNMP, SCPI, TL1, NETCONF and RESTCONF.

For those with a datacomms networking background, a starting point might be to use SNMP (Simple Network Management Protocol), supported via a set of device-specific MIB files that determine the structure of the data exchanged between the automation applications and the devices.

For those more familiar with operating lab-centric automated control and data acquisition setups SCPI (Standard Commands for Programmable Instrumentation) would be the interface of choice.

For those with a telecommunications background, TL1 (Transaction Language 1) may be more familiar.

Another network management protocol is NETCONF, which makes use of the widely adopted YANG specification language, which is used to model device capabilities and methods for configuration and management data interchange in a fully device and vendor independent manner.

Software developers familiar with web-centric approaches to application development may be more at home with HTTP-based REST (Representational State Transfer) interfaces. RESTCONF allows a web-centric approach to access the same datastores, using the same schemas as those underlying the NETCONF protocol.

All of these protocols and APIs are supported by the HUBER+SUHNER solutions described here. Customers can use combinations of one or more to integrate the products into customized and sophisticated lab automation software, based on scripting and other techniques, to fulfil complex testing needs.

Alternatively there are a number of off-the-shelf lab automation solutions provided by leading vendors in the test and measurement market, some of which already have native drivers for the POLATIS® switch and scheduled for future development for the RFoF. Even where such drivers do not currently exist, these solutions often implement flexible frameworks and code-generation tools that make it relatively easy to create such drivers – e.g. from a YANG model.

Furthermore there are many well-established and widely-used open-source IT equipment automation and workflow management frameworks available that could be suitable platforms upon which to base lab automation systems. These often support multiple southbound interfaces accessed through abstracted interfaces. Even though the adoption of such approaches will inevitably require some level of software development and system integration by the customer, this may not be as much as might initially be assumed.

Related documents

Optical circuit switching for network test laboratory automation
Link (PDF)

Further information

RF coaxial cable assemblies
Harsh environment cabling for the mobile network

Fiber optic management system and fiber optic patch cords
Structured cabling for data centers

Transceivers
We make transceivers work

GNSS-over-Fiber (GNSSoF) for Mobile network operators lab automation time synchronization
Mobile network connectivity solutions

Optical circuit switching solutions
Advancing software-controlled networks

The HUBER+SUHNER team has extensive experience and knowledge in RF and FO systems actively driving the global evolution of network test lab automation for Carriers. Our best-in-class portfolio is broad and can solve any RF or FO testing challenges.

Contact

European Headquarters
HUBER+SUHNER AG
Degersheimerstrasse 14
9100 Herisau
Switzerland
Phone +41 71 353 41 11
hubersuhner.com

HUBER+SUHNER