RFOptic
Remote Management Manual

System Rev 2.015.x

Document Revision 06272024

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

Table of contents

1 Introduction 4
2 Connecting the Cage to a network 4
2.1 Setup using Dynamic IP 4
2.2 Setup using Static IP 4
2.3 Network setup of systems with IFL 5
2.4 Communication and Security 6
2.4.1 Local RFOptic CA 6
2.4.2 Adding the local RFOpticCA certificate to a Windows host 7
2.4.3 Adding the local RFOpticCA certificate to a Linux host 8
2.5 Hosts file configuration 8
3 HTML web-server interface 10
3.1 Selecting a web browser 10
3.2 Webserver main screen 10
3.2.1 Left sidebar 11
3.2.2 Groups 11
3.2.3 The Cage Model 14
3.2.4 Server connection and power supplies status 14
3.2.5 Event Log 15
3.2.6 Service menu 15
3.2.7 Alternative cage enclosure images 16
3.3 Configuration 17
3.3.1 RFoF programmable configuration controls 18
3.3.2 RFoF HF/HSFDR configuration controls 20
3.3.3 RFoF ODL configuration controls 22
4 Heterogeneous system under M&C server control 23
5 Setup of the static IP 23
6 Setup Date and Time mode 24
7 Setup web-server Access and Security 25
8 REST interface 26
8.1 HTML basic information 26
8.1.1 Status 26

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

8.1.2 Configuration and state 26
8.1.3 Module details 27
8.1.4 Event log 27
8.1.5 Power status 28
8.2 Control interface 28
8.2.1 Client only messages 28
8.2.2 Client and M&C Server messages 29
8.2.3 M&C Server only messages 31
9 SNMP interface 31
9.1 Traps and Notifications 32
9.2 RFOptic standard MIB file and OID's 32
9.3 RFOptic's SNMP V2c MIB, interface definition file 32
9.4 SNMP interface ports and access levels 35
9.5 Module OID's 36
9.6 MIB file structure 36
9.7 Standard transaction interface 36
9.8 SNMP Automation and security 38

Table of illustrations

Figure 1: Certificate Authorities Store under Windows OS 7
Figure 2: Select CA certificate file under Windows OS 7
Figure 3: Warning message for adding a new RFOpticCA to the CA store under Windows OS 8
Figure 4: CA certificates store after adding RFOpticCA under Windows OS 8
Figure 5: HTTPS Secured access example using RFoFBox2.rfoptic.server hostname in the hosts file 9
Figure 6: Main Web server screen example with an indoor cage 14
Figure 7: Main Web server screen example with an outdoor cage 14
Figure 8: RFOptic standard RFoF enclosures 16
Figure 9: Configuration page for RFoF programmable series Tx terminal module 17
Figure 10: Automatic control configuration mode functions 19
Figure 11: Configuration page for RFoF HSFDR series Tx terminal module 21
Figure 12: Configuration page for an ODL 22
Figure 13: Heterogeneous system M&C server display 23
Figure 14: Static IP setup window 24
Figure 15: Date and Time setup forms: Manual, Automatic and Automatic with Local NTP server Modes 24
Figure 16: Web Server Access and Security window 25

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

1 Introduction

RFOptic multilink products and sub-systems may include Remote Management and Control (M&C) option. These products can be managed and controlled over Internet Protocol (IP). This document describes the remote management and control capabilities and provides information necessary for the deployment of such products. The document addresses the capabilities of revision 2.01 of the M&C interfaces. The document includes a common network interface section and 3 sections, each devoted to a different M&C interface that is supported. The M&C supports HTML (AKA Web Server), REST and SNMP V2c protocols.

In general, RFOptic products are RF Over Fiber (RFoF) wideband multilinks, ODL test equipment and custom subsystems. For the sake of the forgoing discussion it is useful to consider the components of these RFoF products as Modules or Terminals which can be either Rx or Tx and sub-systems such as an ODL. The M&C interface treats each of these components independently. For each component the M&C exposes all the associated status and control capabilities particular to that component under all the above interface protocols.

2 Connecting the Cage to a network

Using a CAT5 or higher-grade Ethernet cable connect the RJ 45 port of the cage to a network or a host. Power up the cage and follow the appropriate section below to gain access to the HTML interface screen. RFOptic M&C supports cable connection to a router managed network or a private peer-to-peer connection using a static IP.

2.1 Setup using Dynamic IP

In router managed networks a DHCP server automatically provides (leases) a unique IP address to network clients. To access the M&C interface, one would need to identify the IP address that is assigned to a particular cage by the host network DHCP server. This IP (IPv4) address takes the form of 4 integers each ranging from 0 to 255 which are separated by dots (e.g. 123.152.45.3).

In many cases the router's DHCP leases may not be accessible to any user for security reasons. Please contact your network administrator to find the cage IP address and insure that the connection of the cage to the network is open and that port 20080 used by the system for management is accessible.

a. Identify the IP address that is assigned to the cage by the network DHCP service.
b. Test the connection, type the IP address followed by port: 20080 in your web browser search bar; (e.g. 123.152.45.3:20080) and press Enter. The connection is established if the HTML web server interface is displayed in the browser.

2.2 Setup using Static IP

In certain circumstances a DHCP service is not available. In such instances the RFOptic M&C is designed to fallback to a Static IP address. The RFoF cage will automatically default to a static IP address after 30 seconds from power-up if it is unable to obtain an IP address from a DHCP server. A static IP address is a fixed IP address that is pre-defined for each cage at the factory. To gain access to the M&C interface, the host's Ethernet interface must be configured to communicate on the same network segment that is used by the cage. The factory default static IP address is 10.0.1.2. The M&C responds on port 20080. Therefore, the complete IP address would be:

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

10.0.1.2:20080. The factory default static IP address can be modified from the M&C web server interface as may be needed.

Important: Multiple devices may not share the same static IP address on the same network segment. It is important therefore to connect each new cage, one at a time, and to update its static IP such that it is unique within the segment.

a. Set the host IP address to the same segment (i.e. Host IP 10.0.1.1, subnet mask 255.255.255.0) which is used by the RFOptic cage (factory default is 10.0.1.2).
b. Test the connection, type the IP address followed by port: 20080 in your web browser search bar; (e.g. 10.0.1.2:20080) and press Enter. The connection is established if the HTML web server interface is displayed in the browser.

The web server interface supports the redefinition of the Static IP address, the subnet mask and an optional static router or gateway into other segments.

Important: Some IPv4 address ranges are reserved for particular applications and uses. For example: the 0.0.0.0 to 0.255.255.255 and 127.0.0.0 to 127.255.255.255 are loopback address ranges. Other reserved addresses are the 169.254.0.0 to 169.254.255.255 which are reserved for link local access which is used by some systems when no static IP is set and DHCP service is not present. Other restricted IPv4 ranges exist and support functions such as Network Time Protocol and more. When selecting a Static IP address, it is best to remain within the Internet Assigned Numbers Authority (IANA) allotted Private IPv4 ranges:
10.0.0.0 to 10.255.255.255 or 172.16.0.0 to 172.31.255.255 or 192.168.0.0 to 192.168.255.255

2.3 Network setup of systems with IFL

An IFL is an optical TCP/IP network interface which provides access to a remote connected RFOptic product from a local one. Typically, it uses a single additional fiber connection between the local and remote products. However, in some cases it may use separate transmit and receive fibers or it may communicate over a common fiber with the RFoF signals using Wavelength Division Multiplexing (WDM) technology. The IFL can be configured to provide a secondary Ethernet port at the remote and local site such that in addition to the M&C over fiber it provides a fast TCP/IP connection at the remote site for user equipment.

The setup of a pair of local and remote RFOptic products with IFL interface is simple in a network that has DHCP server. In such case follow the following steps;

1. Connect the fiber(s) between the local and remote products
2. Connect a network cable to the local product Data or IFL port
3. Important: Do not connect the remote port Data cable to the same network – this will form a TCP/IP loop which is not allowed. The remote product will get network access through its IFL fiber.
4. Connect both products to the appropriate power sources
5. Power up both local and remote products.
6. Using the DHCP server lease list find the IP addresses which were assigned to each of the products and use those to access the web servers of each.

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

The DHCP server will assign unique IP addresses to each of the products. Web server access is then achieved following the steps in section 2.1 above.

For the case where there is no DHCP server on the network and a static IP is required the cages should be connected one at a time to a computer using the initial static IP address with which each product is labelled. Once a connection is established following the instructions in section 2.2 above, the static IP should be changed to the one required by the target network. The same procedure should be done with each of the products, one at a time. It is a good idea to relabel each of the products with their updated static IP. Follow steps 1 through 5 above to connect and power up the products. Once all products are thus configured, it will be possible to access the web servers of the products using the assigned static IP addresses.

2.4 Communication and Security

The M&C interface is typically used with unsecure HTTP interface within internal networks. In such cases the communication between the web-server and the browser is performed using plain text. When RFoF systems are deployed with Internet connection plain text interface can be hijacked by unauthorized parties. To prevent unauthorized access to the RFoF systems it is common practice to secure the web-server to browser interface by encryption of all the communication. The encryption is performed using standard Secure Sockets Layer (SSL). This type of interface is commonly known as HTTPS. In general terms both web-service and browser exchange public encryption keys which allow them to verify the identity and decode messages from one to the other. See section 7 for Access and Security configuration instructions.

In a one-way SSL the web-server provides an SSL encrypted certificate to the browser which is obtained from a trusted certificate authority (CA) to prove its identity to the browser similarly under two-way SSL the browser could send a certificate to the web-server to positively identify itself (in such case the public key of the browser must be previously stored in the web-server). As a result, the connection under HTTPS is secure trusted and protected from hacking and spoofing attempts. RFOptic's M&C system implements one-way SSL TLS 1.3 HTTPS as an optional mode of communication between the web-server and browser. The setup of this mode of communication requires several steps outlined in this document.

Note: RFOptic ships all relevant products with HTTP interface active and HTTPS inactive. After setting up the interface requirements for HTTPS as explained in this section, follow the instructions in Section 7 to enable the HTTPS access mode.

2.4.1 Local RFOptic CA

A custom Root Certification Authority RFOpticCA is defined with certificate that can be added to the Trusted Root Certification Authorities pool of the host computer to accommodate private or internal networks where access to the internet is restricted or not available. The file RFOpticCA.crt should be loaded into the Trusted Root Certification Authorities using the host computer Operating system services.

Compatibility: This procedure has been verified with the following web browsers: Google Chrome and Chromium, Brave, Microsoft Edge. On Mozilla Firefox an additional step of importing the RFOpticCA into the browser certificates store is required to avoid the security warning. This is performed from the Settings menu,

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

selecting Privacy & Security section and scrolling to the bottom to the Certificates section under the Security heading. Use the button on the Right to View and Import the RFOpticCA certificate into the browser store.

Note: that if you intend to provide your own certificates for the web-server which may or may not relay on third party CA authority you can skip the steps for installation of the RFOpticCA.crt and follow the steps in section 7 to configure the web-server and your host to communicate under HTTPS.

2.4.2 Adding the local RFOpticCA certificate to a Windows host

For a single user under Windows based system start the certmgr.msc and select the Trusted Root Certification Authorities under Current User and select it. To add the RFOpticCA certificate for all users of the host computer you will need Administrator privileges and use these to run certmgr.msc as an administrator. In its Certificates sub-menu right-click to reveal the actions menu and select All Tasks → Import. Alternatively use the Action menu selecting from it All Tasks → Import.

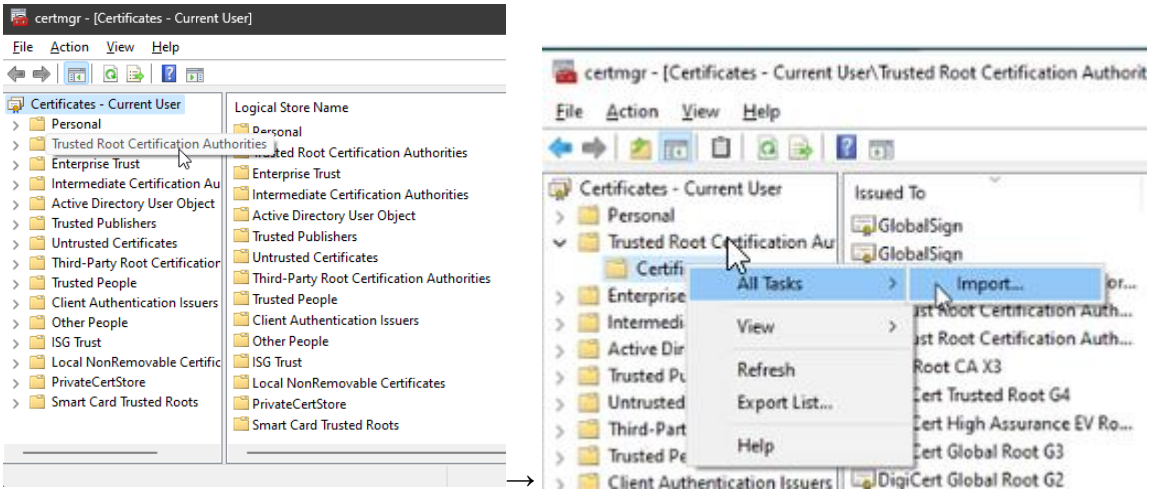


Figure 1: Certificate Authorities Store under Windows OS

Use the Certificate Import Wizard to browse and select the *RFOpticCA.crt* file that is provided by RFOptic Ltd. and click on Next.

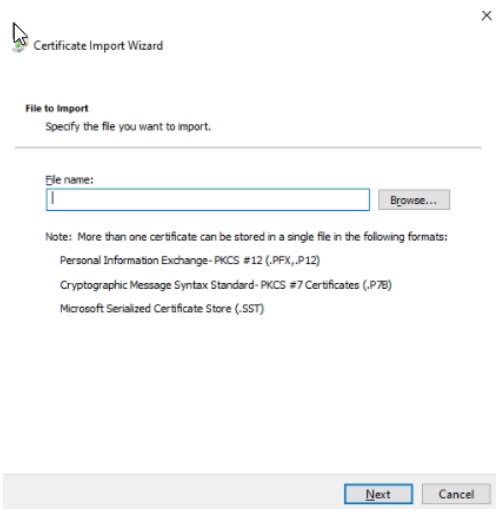


Figure 2: Select CA certificate file under Windows OS

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

In the following page select Next once more, to store the new certificate in the Trusted Root Certification Authorities Store. In the following page review all the settings and click Finish to complete the import. You will need to click Yes to approve the addition of the new certificate in the Alert dialog

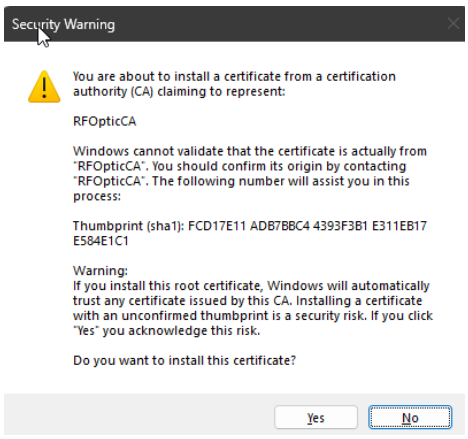


Figure 3: Warning message for adding a new RFOpticCA to the CA store under Windows OS

Finally verify that the new imported certificate is listed in the Certificates list

He CA-certificates directory

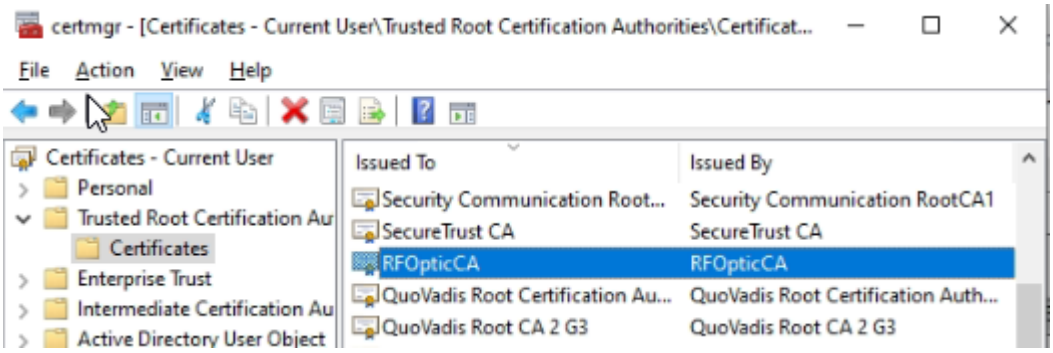


Figure 4: CA certificates store after adding RFOpticCA under Windows OS

2.4.3 Adding the local RFOpticCA certificate to a Linux host

The following describes the task of adding the RFOpticCA certificate to a Linux host computer. The following is for Debian based distros but it can be easily adopted to other distros.

First copy the RFOpticCA.crt file to the ca-certificates directory using the following command:

sudo cp RFOpticCA.crt /usr/local/share/ca-certificates/

Next reload the CA certificates using the command:

sudo update-ca-certificates

2.5 Hosts file configuration

Browsers check several criteria along with the Certification of the remote web-server including its hostname versus its certificate. The hostname is associated with the IP address of the web-server in the hosts file. In

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

network with Domain Name Server (DNS) this association is written into the DNS hosts file, Otherwise the hosts file of the host computer is used. Either way once the IP addles of the web-server is determined (refer to Sections 2 and 5), edit the appropriate (DNS or local hosts file to add the correspondence between hostname of the web-server and its IP address. Remember that just as the IP address on a local domain must be unique so does the web-server name to allow for 1:1 correspondence. Since in a realistic scenario there may be a number of RFOptic systems in a single network domain the RFOptic M&C web-server uses a wildcard sub-domain hostname (A.K.A. Common name (CN) format) of the form:

*.rfoptic.server

Therefore, a valid hostname may be

RFoFcage94000397.rfoptic.server or box1.rfoptic.server

Each line in the hosts file identifies an IP address with a hostname as follows:

IP_address hostmname

For example

10.0.1.2 RFoFcage94000397.rfoptic.server

The hosts file under Windows is found in *C:|Windows|System32|drivers|etc|hosts* the file has no extension and can be edited with Notepad started by using Run as Administrator (use **All files** option). Under Linux the hosts file is located in the */etc/hosts* path. Changes in the Hosts file take effect immediately.

This hostname for the web-server will allow the browser to validate the web-server name with its certificate. Without this step you will need to use the IP address to access the web-server and the browser will display a warning that the hostname in its certificate does not match the name in the URL field of the browser thus raising the concern that the web-server is untrusted.

With this definition the HTTPS interface is accessible using the URL address:

https:// RFoFcage94000397.rfoptic.server:20443

where 20443 is the default port for HTTPS in RFOptic's products.

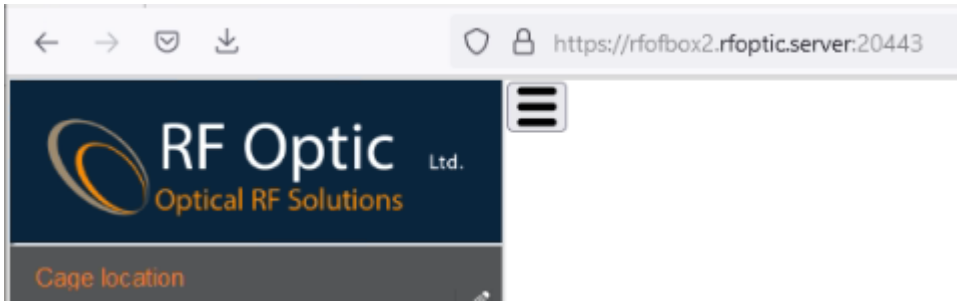


Figure 5: HTTPS Secured access example using RFoFBox2.rfoptic.server hostname in the hosts file

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

3 HTML web-server interface

An HTML web-server provides an intuitive and easy to use M&C interface for enabled RFOptic products. The web server illustrates the cage or enclosure physical interfaces and the components which are present within. To organize the contents of the cage, components are grouped by function. The M&C provides status information for each component as well as an aggregate group level indication. Configuration pages are available for each component module or terminal. These pages allow detailed monitoring and adjustment of certain operating parameters as may be available for each terminal type. An event log is included to list the operating history of the system.

3.1 Selecting a web browser

The HTML web-server interface is available for most internet browsers which can access the network to which an RFOptic enclosure with M&C option is connected. The system operates well with Microsoft's Internet Explorer / Edge, Brave, Mozilla Firefox, and Google's Chrome. Most cellphone browsers are compatible as well, however in some cellphone browsers it is preferable to access the server using the "desktop mode".

It is possible to connect to the M&C from multiple computers and web browsers simultaneously. When changes are made to the configuration of the cage they are treated on first come first served basis. All connected browsers are simultaneously updated on the account of any such change.

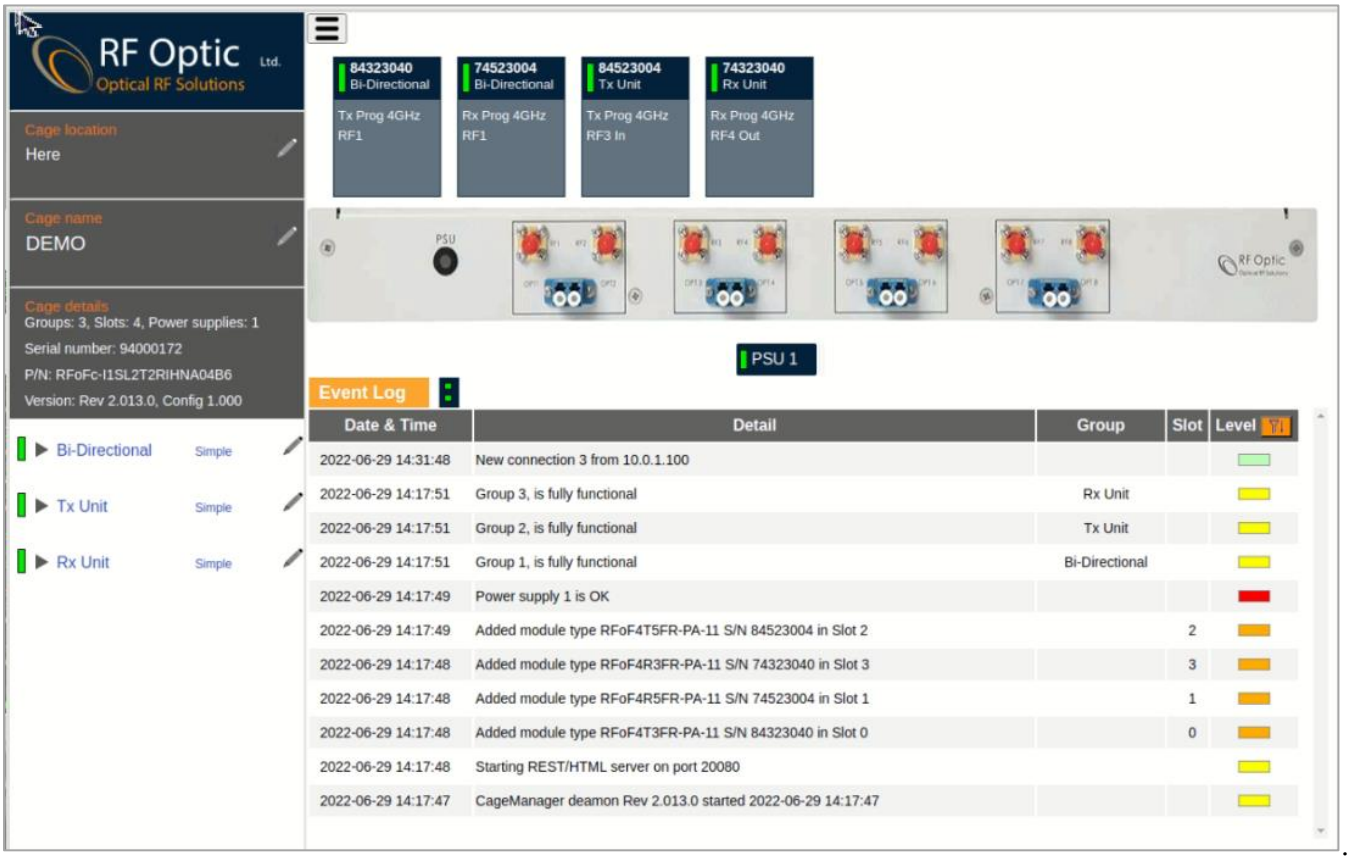
3.2 Webserver main screen

The web server displays on the browser's window an image of the connections panel of the cage. This image and the number of component modules that are represented on the screen may be different for each cage and represent the components which are present in the particular cage. Each one of the cage enclosures may have different components and may have limitations on the number and type of modules that it can support.

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

3.2.1 Left sidebar

The main HTML web server screen is shown for an indoor cage.



. It contains a summary of the cage information on the left side bar while the main portion of the screen is dedicated to a model of the cage. Editable fields indicated by a pencil icon; allow user defined name and location as well as group names. To update these fields, click on the pencil icon and type in the new information. The update is completed by clicking away from the field or clicking back on the pencil icon.

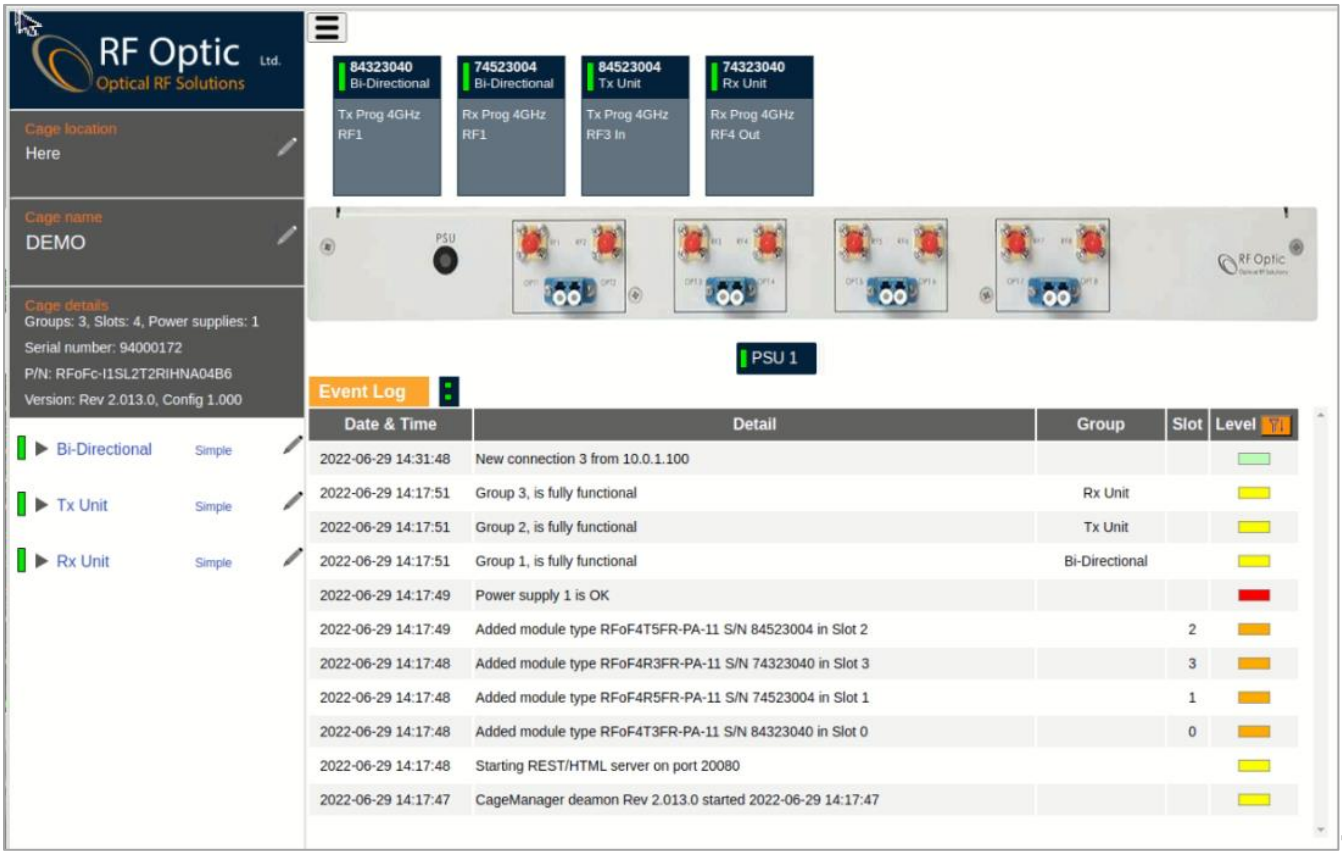
The overview panel contains a hardware summary along with the Part, Serial, Version number and hardware of the cage.

3.2.2 Groups

Components in the cage are grouped together to indicate a specific physical or logical functionality such as Redundancy, frequency range or link direction. The group association is configured by the factory to provide association and organization of terminal modules. This association is used to logically group together components

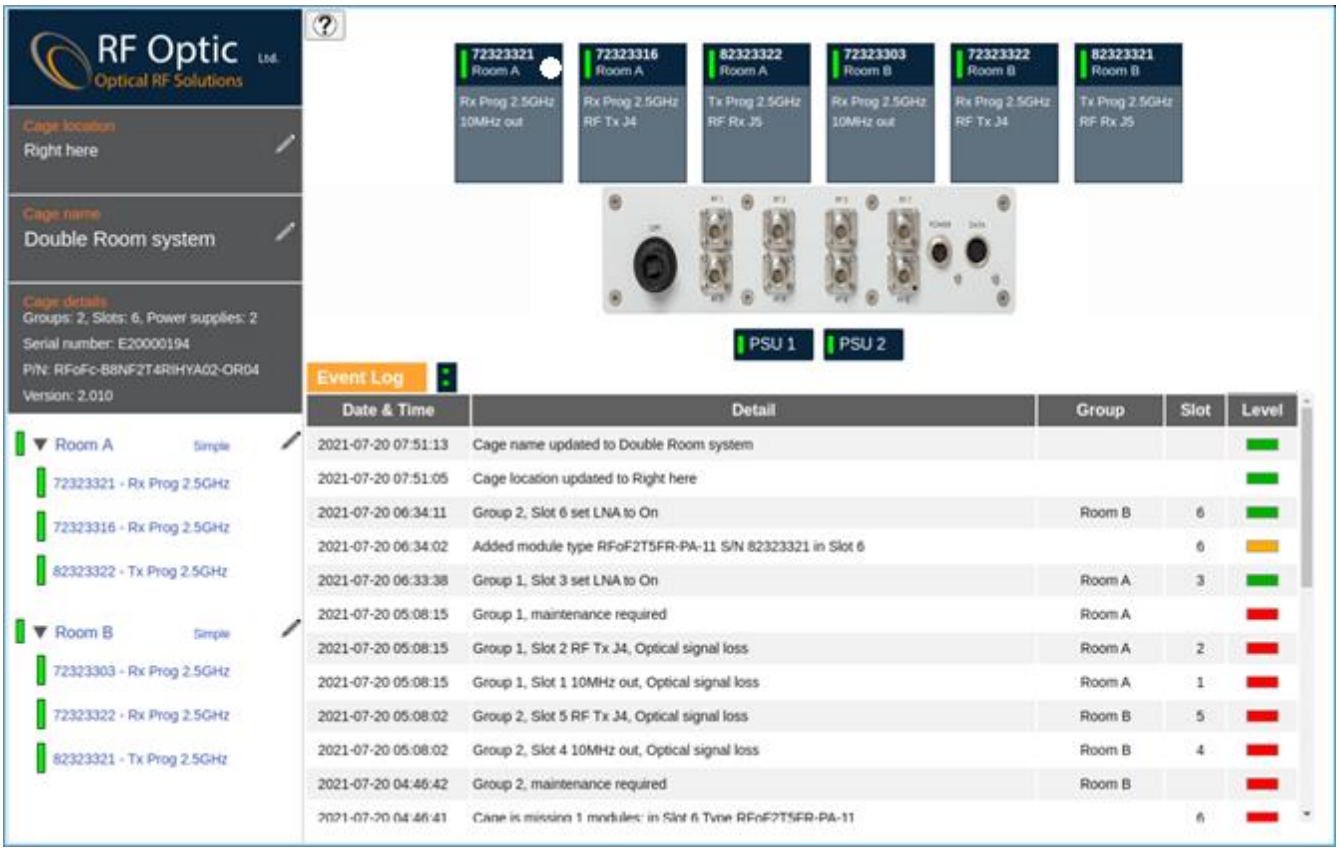
Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

that operate together such as Uplink terminals, WDM sets etc. In most cases the Components would have the Simple property meaning that each of the components within the group operates independently of the others.

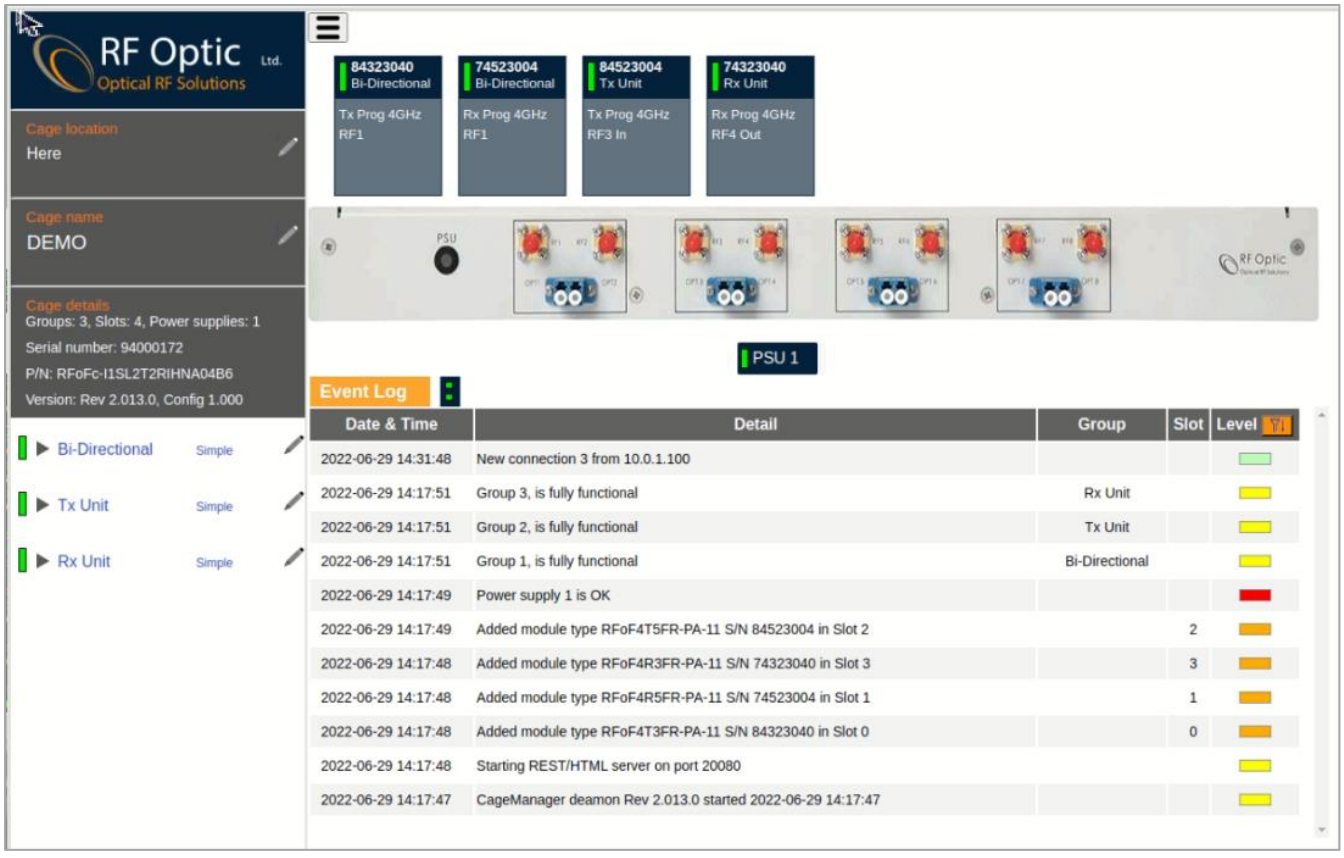


The components that are associated with each group are labelled and can be highlighted by hovering the mouse pointer over the group name. A group status LED icon aggregates the status of all the components in the group. Therefore, if any of the component modules has a fault the containing group LED will indicate the Fault with a red LED icon. Green group LED indicates that all the component modules in the group are OK. The group list is expandable with the help of the dropdown icon, see

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com



When expanded, each of the associated modules is represented with its own status LED icon and its identification. The list of components provides access to the configuration page of each component by double-clicking on the module description.



Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

Figure 6: Main Web server screen example with an indoor cage

3.2.3 The Cage Model

The cage model represents the component terminals as tabs arranged around a physical image of the cage. They are positioned in slots to form an association with the position of the RF ports of the enclosure to which they are internally connected. These slots are sequentially numbered left to right and from top to bottom forming a grid. The component or modules are identified by their serial number identification and a status color coded LED's. The RF port label and group association of each module and its type are shown as well for each component module. The relevant module configuration page can be accessed by clicking on the module tab header.

3.2.4 Server connection and power supplies status

A small panel below the cage and modules shows the connection status of the web server. A traffic light icon updates frequently to indicate that the connection is live when the bottom indicator is green and the top one is flashing green.



The status of one or two power supplies is indicated with color coded LED icons in the middle of the panel. The power supply LED icon is green when the power supply delivers its nominal voltage and will change to red (over-voltage) or yellow (under-voltage) in case that the corresponding power supply output is out of spec.

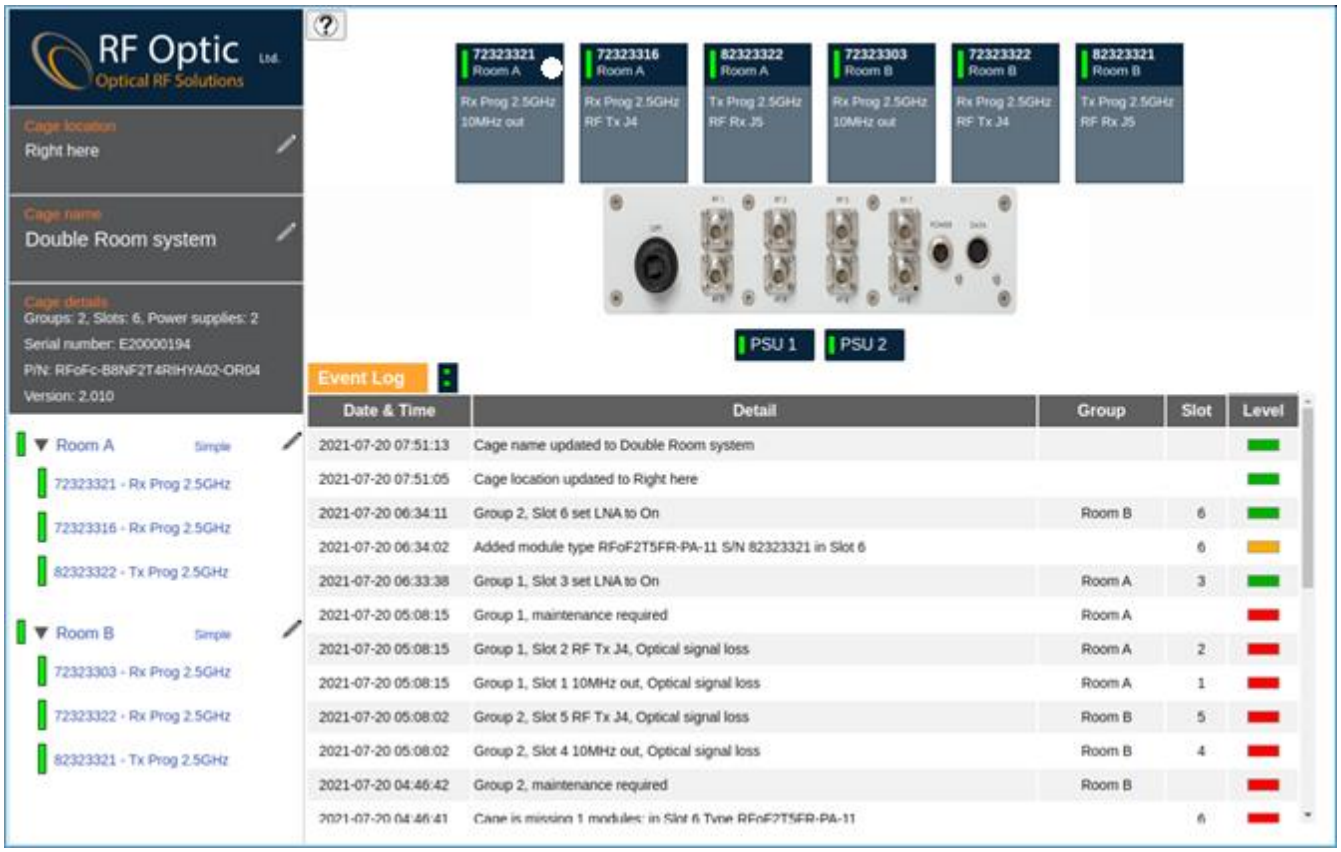


Figure 7: Main Web server screen example with an outdoor cage

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

3.2.5 Event Log



An Event Log is displayed below the cage model. The log is sortable by clicking in the column headings and can be filtered for convenience by event importance. The filter menu above the importance icons column can be used to hide events of lesser importance. The Event Log includes a time stamp, a description of the event as well as group and slot association if applicable, along with a color coded importance level.

- Red indicates critical events which effect the operation of a module or a group
- Orange is used to identify system warnings
- Green indicates user-initiated changes to the cages
- Yellow is used for all other mundane system notifications
- Light green indicates system events

Certain user-initiated changes (e.g. turning a Laser Off in an RFoF transmitter) will result in a change notification that soon thereafter could be followed by a Critical notification such as a loss of the Optical signal.

The Event log includes connection notices to allow tracking of users and detect unauthorized access.

3.2.6 Service menu

A service menu is accessible from the  button at the top. The menu contains the following selections:

Help - accesses this help documentation in pdf file format.



Start or Stop logfile – Accumulates and provides trace data used for service and technical support. Note that the logfile can become very large and over a long time can overwhelm the M&C server resources. It is therefore suggested to keep that option inactive (Displaying 'Start logfile;).

Get Logfile - downloads the current logfile from the M&C server for RFOptic analysis. The logfile is a binary file which includes status information and the operating conditions of the RFoF components and M&C server. It DOES NOT contain any user data of any kind. It is left up to the user to email this file to RFOptic for diagnostic and support.

Config Static IP – is a configuration interface which reports the current static IP and allows easy update as may be necessary when the RFoF cage is used in Intranet network environment without a DHCP service.

Set Date, Time – is a configuration interface which reports the current Date and Time configuration and allows easy update with three modes; manual, automatic and automatic with local NTP server synchronization.

Config Comm – provides setup and configuration of the active interface protocols and setup of HTTPS secure access.

About – lists M&C version information and copyright statement of RFOptic Ltd.

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

3.2.7 Alternative cage enclosure images

The cage images below are only for illustration purposes; actual products may differ in the number of RF and optical ports. Other custom enclosures may be displayed as appropriate for such products.



Large Outdoor



Small Outdoor



1U 19" Generic



1U 19" Removable Panel



2U 19" Removable Panel



3U 19" ODL

Figure 8: RFOptic standard RFoF enclosures

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

3.3 Configuration

The operating parameters of each module can be viewed and modified by opening the Configuration page. To view the configuration page for a particular component, click on the header of the terminal or module tab found on the Cage Image or on the corresponding group member in the expanded Group list(s) found on the left sidebar.

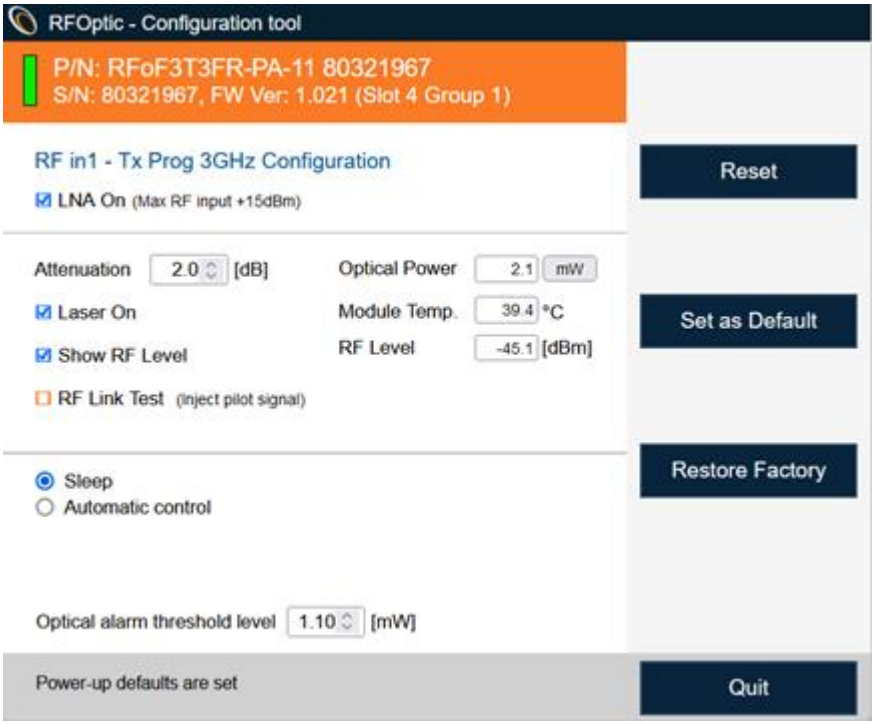


Figure 9: Configuration page for RFoF programmable series Tx terminal module

The configuration page contains controls which are specific to the selected component. That page displays a header that fully identifies the component. A sample configuration window is illustrated in Figure 9. That configuration page is specific to an RFoF Transmitter programmable series module. The page shows the operating conditions and provides access to the control parameters of a particular module.

Changes to the settings will affect equipment immediately but such settings are not saved under power cycling. If a loss of power to the equipment is experienced, whether voluntary or involuntary, it will result in loss of these temporary changes. The components will revert to the last saved configuration. Please see section on "Set as Default" that describes how to save the configuration permanently.

Header Box (orange area) - This area displays a status LED icon on the top left. Next to it in the header it displays the module part number (P/N), serial number (S/N), firmware revision and group and slot position. A line below the header area describes the type of component and its RF port label.

Buttons are used to provide access to several functions which are common to all components. These functions include:

- **Reset** – This button sends a reset command to the particular component or module. The reset action is equivalent to power cycling of the module. The All unsaved configurations are lost on reset and the

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

component will actually disconnect and reconnect to the cage upon completion of the reset cycle. This action may interrupt the RFoF transmission for the duration of the reset cycle.

- **Set as Default** – This button saves the current configuration settings as the power-up default. All the settings are stored within the component and are not shared with the M&C system. For this reason, replacement of a component requires re-definition of the power-up default state.
- **Restore Factory** – This button reverts the module to the factory configuration settings. These settings are activated but are not stored. Click the Save as Default button to use these Factory settings as the power-up default setup.
- **Quit** – Closes the configuration page. Any changes made and which were not saved as Default will remain in effect until a Reset of the component is initiated or until power interruption occurs.

Status line area shows messages which acknowledge changes or provide failure notifications.

3.3.1 RFoF programmable configuration controls

The configuration page of an RFoF programmable Transmitter module is shown in Figure 9. This page is similar for RFoF programmable Transmitters and Receivers. The Receivers lack the LNA and Laser controls.

- **Status LED** - Shows the state of the module similar to the panel LED.
  - **Green** indicates normal operation, all is ok.
  - **Cyan** indicates that the RF Link test is active.
  - **Blue** is used during module identification.
  - **Blinking Red** indicates a loss of optical power.
- **LNA On** – Checkbox that sets the RFoF Transmitter input LNA (30dB Gain) On or Off where it is bypassed. The gain of the LNA is fixed. The additional gain improves the noise performance of the module at the expense of a lower maximum signal level (IP1dBc).
- **Laser On** – Checkbox that sets the RFoF Transmitter laser On or Off. Typically this control can be used for diagnostic purpuses. For eample it may be switched off to measure the noise level of a connected RFoF receiver alone.
- **Attenuation** – This setting controls a digital step attenuator that is integrated into the RFoF programmable modules. This field can be entered by typing a value in range or clicking on the up/down adjustment arrow buttons. The attenuator is located at the input of the RFoF Transmitter module after the LNA bypass or before the final gain stage of the RFoF Receiver module. The attenuator can increase the IP1dBc of the Transmitter at the expense of its Noise Figure. In the Receiver module the attenuator provides gain control with minimal side effects.
- **Temperature** – Sensor reading of the module temperature.
- **Optical power** – Sensor reading of the output optical power in a Transmitter module or the input optical power of a Receiver module. Note that the Optical power is affected by the RF signal and may vary considerably when the RF signal power is high.
- **Optical power unit** – Button located on the right of the **Optical power** field. Use this button to select the representation mode for the optical power with two alternatives; **mW** or **dBm**.
- **Show RF Level** – This checkbox activates a built in RF power sensor which is integral to both Transmitter and Receiver modules. The sensor is connected to the end of the RF chain in either module and provides indication of the RF power level. The sensors may be calibrated to indicate Transmitter input RF level or

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

Receiver output RF level. In conjunction with the Pilot signal injection feature these two RF power sensors provide quick and easy means for link diagnostics and fault identification.

- **RF Link test** – This checkbox activates a pilot signal which is injected at the beginning of the RF chain of each module. This is a powerful BIT feature that can be used to track the RF signal throughout the RFoF link from the Transmitter input RF connector all the way through the connecting fiber to the Receiver RF output connector. The power level indications are provides by the RF power sensors. The Pilot signal may interfere with the function of the RFoF link and therefore, it is automatically terminated after a prescribed user specified time period.
- **RF injection automatic shutdown time** – A set of entry fields that is revealed when the RF Link test is active. Using these fields one can define the time interval for the RF pilot injection. The RF signal is discontinued after the expiration of the selected interval. An associated progress bar shows the remaining interval. The RF pilot interval is controlled by the module and is independent from the management platform. Therefore, the RF pilot injection will proceed for the prescribed time even if the module is not in the configuration mode.
- **Operation Mode** – sets the mode of operation of the module with 3 options:

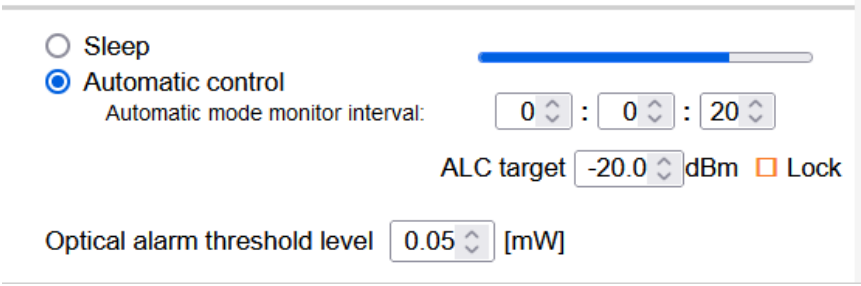


Figure 10: Automatic control configuration mode functions

  - **Sleep** mode option sets the module to normal operation without any type of dynamic adjustment.
  - **Automatic control** – In this mode the RFoF module makes dynamic adjustments to its operation parameters in response to changes. This mode includes two optional behaviours
    - **AGC** – In this mode, active when ALC is not locked, the module is able to adjust its operating parametes to correct for temperature variations. It reduces natural variation of the RFoF link gain from about 4dB worst case to about 1dB variation over more than 100°C (-40°C to +75°C).
    - **ALC** – In this factory enabled mode the module is activated when the ALC Target is locked and adjusts its operating parametes to hold the RF level constant as defined by the ALC target field over a wide range (~ 70dB) of input signal levels. It can perform this function under CW, wideband and for TDD type signals. TDD type signal may require additional parameter adjustments which are only available to RFOptic factory. The default TDD parameters are defined for standard cellular communications protocol timing.
- **ALC Target** – This entry field allows target RF levels to be entered in dBm units between -45dBm to +10dBm. To achieve reliable results it is suggested to keep the ALC target level to a bit narrower range such as -35dBm to +5dBm.
- **ALC Lock** – This checkbox activates the ALC mode. It is a factory enabled function. When ALC is activated the module would begin tracking the RF level and will modify the operating parameters to

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

achieve the required RF level. The module uses multiple samples and sufficient integration time with hysteresis to insure smooth and reliable operation when the signal is relatively stable. Nevertheless, a quick response to signal level variations is afforded by an implemented adaptive behaviour when substantial RF level changes are detected. The ALC operates equally well for FDD and TDD signals and is capable of tracking standard LTE signals thus doubling the dynamic range of the RFoF link for such applications.

- **Automatic mode monitor interval** – This set of three entry fields for Hours, Minutes and Seconds entry fields makes it possible to select the period between adjustments in the Automatic control modes. The choice is between frequent updates or corrections and slower less frequent adjustments. For the ALC mode it is useful to keep the update period short (typically 1s) since signal levels can change rapidly while for the AGC mode it is best to keep the control interval moderately long to keep the RFoF performance as steady as possible. Progress of the control interval is illustrated by a bar indicator which is synchronized with the module. A module which is ser to operate in any of the modes herein can be set to default to that configuration on powerup using the **Set As Default** button.
- **Optical alarm threshold level** – This field defines the alarm level for loss of optical power. The value is different for a Transmitter module and a Receiver module. In a transmitter module the optical power is measured at the laser output. It is set to a high value and an alarm condition may indicate laser failure or that the laser was turned off. In a Receiver module the alarm level is set much lower allowing for some fiber loss of optical power. In this case the alarm condition indicates a high fiber loss or broken optical connection.

3.3.2 RFoF HF/HSFDR configuration controls

RFOptic supports higher bandwidth RFoF links with its HSFDR series which cover the mm-Waves frequency range. The M&C system supports the full functionality of these advanced modules. It offers diagnostic information as well as custom control features that are available with these sophisticated RFoF links. A sample configuration page is found in Figure 11. The image shows the standard indicators for the laser and module temperatures as well as the optical powers which can be used to troubleshoot the RFoF link. Additional customizable controls are shown as well. These controls and others may be displayed for custom module configurations.

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

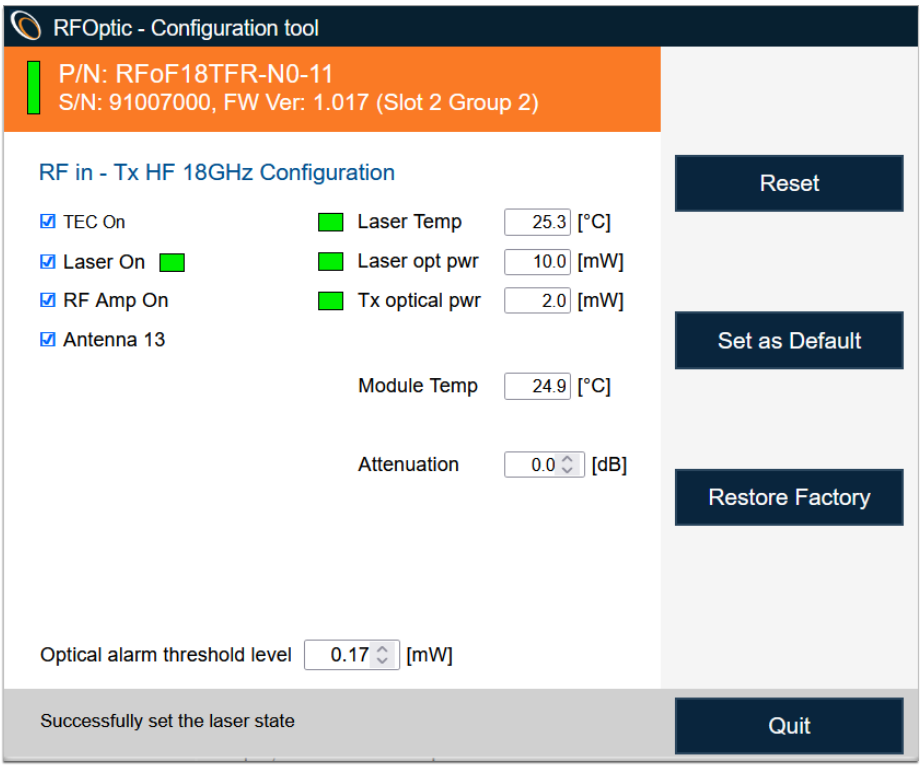


Figure 11: Configuration page for RFoF HSFDR series Tx terminal module

In some instances, it is important to conserve power which may be done by turning off a custom RF Amplifier if present or placing the Laser in standby mode. Several of the information fields have associated small LED icons which provide quick diagnostic. These LED icons change color according to the status of the associated indication. As a rule, Green indicates status is Ok, Red indicates that the value is out of normal limits while Orange is used to identify standby or transitional stage.

- **Status LED** - Shows the state of the module similar to the panel LED.
  - **Green** indicates normal operation, all is ok.
  - **Blue** is used during module identification.
  - **Blinking Red** indicates a loss of optical power.

The following indications are present only for Transmitter terminal modules.

  - **Blinking Blue** is displayed during initial stabilization which lasts a few seconds and during which the RFoF link is not operating.
  - **Blinking Red/Green** indicates that the transmitter is in standby mode and the link is not operating.

- **TEC On** - Shows the state of the module similar to the panel LED.

- **Optical alarm threshold level** – This fiels defines the alarm level for loss of optical power. The value is different for a Transmitter module and a Receiver module. In a transmitter module the optical power is measured at the laser output. It is set to a high value and an alarm condition may indicate laser failure or

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

that the laser was turned off. In a Receiver module the alarm level is set much lower allowing for some fiber loss of optical power. In this case the alarm condition indicates a high fiber loss or faulty optical connection.

Optional Controls:

- **Attenuation** – Controls an optional attenuator if one is present in the module.
- **RF Amp On** – Controls the DC bias to an optional RF amplifier allowing the component to minimize the power consumption in cases that that is usefull such as when battery operated remote installations.
- **Antenna 13** – This demonstrates an optional external switch control function which in this case diverts the RF signal to 'antenna 13'. The label of such custom controls can be edited by a right-click of the mous on the label and antering a new name. The RFoF HF/HSFDR terminals support a number of such optional controls which will display if they are available.

3.3.3 RFoF ODL configuration controls

The ODL component controls are shown in Figure 12. It is very similar to the controls of the RFoF HF module described above with the addition of ODL component controls. These controls are defined below focusing on the group of ODL controls:



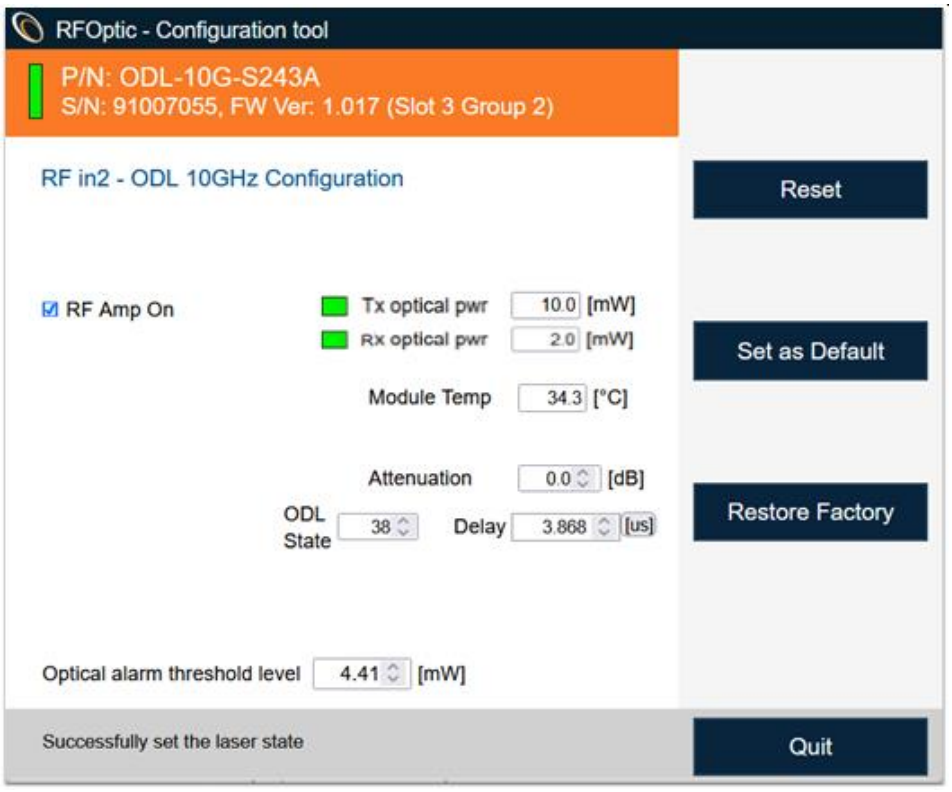


Figure 12: Configuration page for an ODL

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

- **ODL State** – A numerical state which is available for a progressive ODL. It controls the ODL stste as an integer number ranging from 0 to 2n-1 where n is the number of delay segments of the particular the ODL. At the the 0 state all the delay segments are taken out and the observed time delay of the ODL is minimal. Each incremental state introduces more delay segments and increases the overall ODL delay. The ODL state can be entered from the keyboard or clicking on the increment / decrement arrows. The ODL Delay field on the right in the selected units is updated after the M&C server updates the ODL state and computes the correct delay.

- **ODL Delay** – is another way to set the ODL delay value. Using the up and down arrow buttons it is possible to step up and down in the configuration of delay segments which are engaged. It is important to note that these delay steps (and their sequence) are unique and customized to each ODL. Therefore, in some cases the ODL delay steps will not be monotonous and will have discrete values depending on the custom primary delay segments.

- **ODL unit** – The ODL unit is a button that can switch the ODL Delay units between several predefined options which are suitable for particular applications. The units and delay format will cycle among the available options by clicking the ODL unit button repeatedly. These display formats include:
  - **Delay** measured in [**ns**] or [**us**].
  - **Distance** (free space / air) – is the equivalent of the time delay but expressed in **meters** [**m**] or **feet** [**ft**].
  - **Range** (free space / air) – is the one way distance to a target, where Distance is the round trip and can be expressed in **meters** or **feet**.
  - **Altitude** (free space / air) – is similar to Range and is convenient for ODLs that are used in the Altimeter industry. Agin it is the one way distance to the ground in that case and can also be displayed in **meters** or **feet**.

4 Heterogeneous system under M&C server control

An ODL can be the single component under the M&C server control or one component of a heterogenic system that has other types of components as mentioned above. In such a case the M&C server will display the ODL as a module component as is shown in Figure 13 below. The image illustrates that the M&C is capable of management of a mix of components using a similar and intuitive interface.

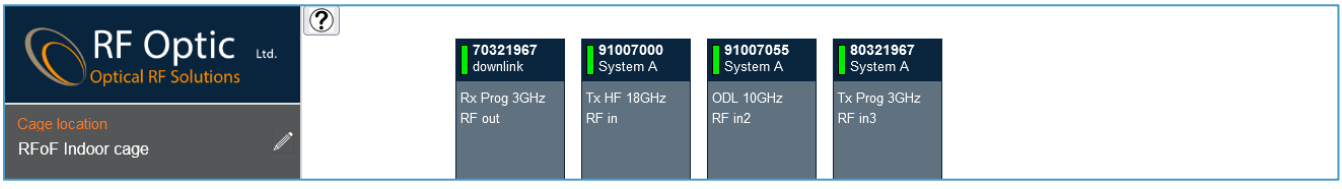


Figure 13: Heterogeneous system M&C server display

5 Setup of the static IP

Access the Static IP setup window from the menu (?) button. The window depicted in

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

Figure 14, below displays the current settings and provides fields for the definition of the Static IP and subnet mask. The mask is defined by the number of masked bits of the 32bit mask. The options are 8, 16 and 24 (default) which correspond to 255.0.0.0, 255.255.0.0 and 255.255.255.0 respectively. If the network is segmented and the cage is placed on a different segment of the network from the host then a definition of a static router or gateway is required in order to tunnel through the router / gateway and link the host to the cage. This option can be enabled by the checkbox adjacent to the Router IP address fields.

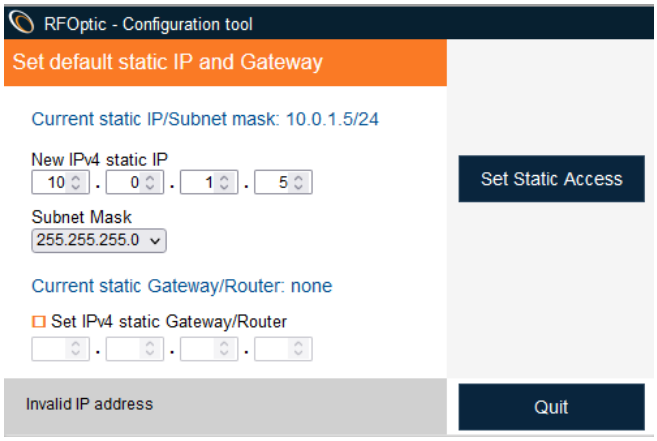


Figure 14: Static IP setup window

IP entries are validated and the validity is displayed at the status field of the window. The setup button is only enabled if all the entries are valid. The cage will attempt to reconfigure itself to the new values as soon as possible after the Static IP values are submitted. Nevertheless, in some cases the cage will require a reset by a power cycle to register the updated network settings with the rest of the network.

In the case where the new settings are wrong and render the cage inaccessible using the static IP configuration then it is always possible to access the cage over a DHCP serviced network and then correct the static IP settings

6 Setup Date and Time mode

Date and Time configuration and allows three modes: **Manual**, **Automatic** and **Automatic with local NTP server** synchronization.

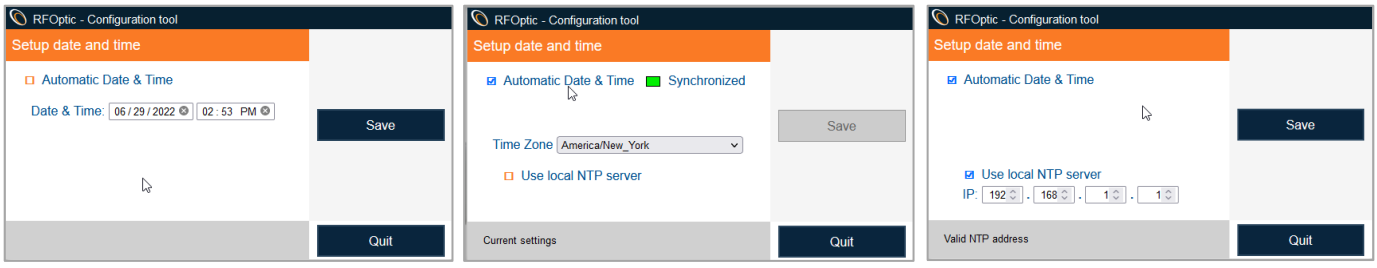


Figure 15: Date and Time setup forms: Manual, Automatic and Automatic with Local NTP server Modes

The **Manual** mode should be used for systems which have no access to the Internet and no local NTP service.

The **Automatic** mode the system requires an Internet access to synchronize to public NTP servers. In such mode it is useful to set the Time Zone to correctly reflect the local Date and Time.

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

The **Automatic with Local NTP server** mode may be used in place of public NTP services when the system is part of an isolated network. In such case the IP address of the local NTP server needs to be defined and once the setup is saved the dialog will display a Synchronized LED icon. The Synchronized LED is green when the when the system is Synchronized to the public or local NTP service otherwise it will be red.

7 Setup web-server Access and Security

The M&C system is shipped with its SNMP and HTTP/REST communication modes enabled and HTTPS disabled. Please refer to Section 2.4 for more information of these communication options. Use the Config Comm option in the menu to open the Web Server Access and Security window. In that form it is possible to set several communication parameters and enable / disable certain modes of communication.

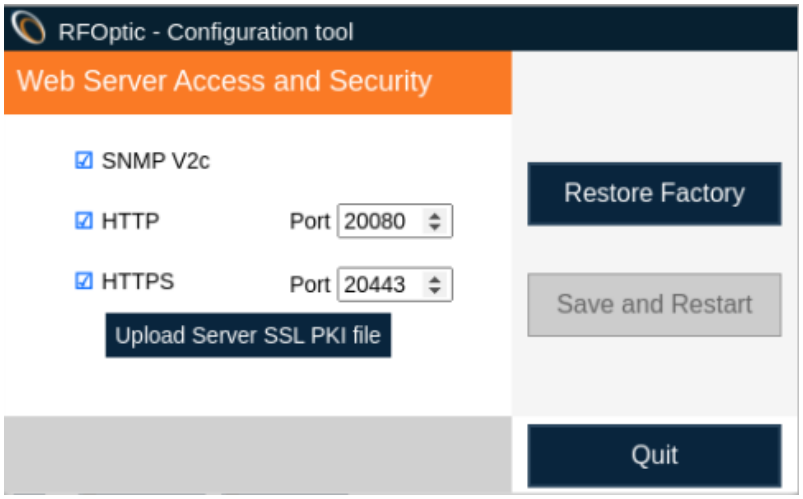


Figure 16: Web Server Access and Security window

SNMP, HTTP, and **HTTPS** – are check boxes that enable each of the control interfaces.

HTTP port and **HTTPS Port** – fields allow selection of port numbers which are associated with the HTTP and HTTPS interfaces.

Upload Server PKI file – button is displayed when HTTPS interface is enabled to allow custom SSL certificate upload. The PKI file should contain both Certificate and RSA Private Key sections in *.pem format.

Note that to ensure that connection to the webserver is not lost when HTTPS access is enabled, the web-server automatically activates HTTP interface when HTTPS interface is activated or a new Server PKI file is loaded. *HTTP access should be disabled only after the HTTPS access is tested and is working.*

Restore factory button resets the web-server to the factory access settings including the HTTPS PKI setup to allow access when HTTPS is enabled under the factory configuration as described in section 2.4.

Save and Restart – button saves the setting updates and restarts the web-server to enact the changes. Restart of the web-server can take up to one minute. Please refresh the browser page to get the updated screen. Note that depending on the changes made you might need to switch to another port number or a new hostname in the URL line.

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

8 REST interface

The M&C system supports a REST protocol which is capable of reporting data to the REST host and perform changes to the system. The interface is intended to be used under a host computer control and it is based on exchanging Java Script Objects (JSON) between the host and the M&C system.

8.1 HTML basic information

The interface uses native HTML for obtaining the 'model' of the RFoF cage. The command interface requires web-socket upgraded HTML connection. The M&C system will automatically grant web-socket upgrade requests. The following section defines the syntax of the interface according to interface types. In the following, the IPV4 address of the cage will be denoted by 'ip'. The slot index which is correlated to the position of the component module is used to specify each configured module.

To make the JSON more readable sub JSONs are separated with added line breaks in the following REST responses. Actual JSON responses do not contain any line breaks.

8.1.1 Status

The status endpoint is used to verify that the M&C is online and responsive.

Endpoint	ip:20080/api/cage/state	Description	Get the cage state, always 1 if the cage is online
Example	{ "state": 1 }		

8.1.2 Configuration and state

The configuration of the cage is available using an HTML request to the cage endpoint. It provides several levels of detail, starting with the cage information, followed by detailed group and module information concluding with the power supplies status. The data is delivered as a set of nested JSONs.

Endpoint	ip:20080/api/cage	Description	Get the cage configuration
Example	{"cage":{ "name":"RFoptic Demo Cage", "loc":"Lab1", "part":"S4oFc-S4SF1Tx3RxIP2AC110", "serial":"90007021", "prodDate":"3/1/2019", "version":"2.010", "psCount":"2", "grCount":"2", "slCount":"5", "logfile":"on", "eventsFilter": 5, "groups": [{"name":"Group 1", "type":"Simple", "modules":[{ "slot":1, "part": "RFoF6T3FR-PA-11", "serial": "80322502", "type": "Tx Prog 6GHz", "label": "RF in", "led": 64 }] }, {"name":"Group 2", "type":"Simple", "modules":[{ "slot":2, "part": "missing", "serial": "missing", "type": "Tx Prog 6GHz", "label": "RF In", "led": 64 }, { "slot":3, "part": "RFoF3T5FR-PA-11", "serial": "80321986", "type": "Tx Prog 3GHz", "label": "RF in2", "led": 64 }, { "slot":4, "part": "RFoF6R3FR-PA-11", "serial": "70322405", "type": "Rx Prog 6GHz", "label": "RF Out3", "led": 64 }, { "slot":5, "part": "missing", "serial": "missing", "type": "Rx Prog 6GHz", "label": "RF Out", "led": 64 }] }], "psu": [{"status": "ok"}, {"status": "ok"}] } }		

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

Notice that in slot 2 there is a placeholder for a missing module.

8.1.3 Module details

The complete configuration data including all properties of the component modules is available from the modules' endpoint. The properties of each module are specific to the type of module. There are three families of modules; RFoF programmable (Tx and Rx), RFoF HF (Tx and Rx) and ODLs.

Endpoint	ip:20080/api/cage/modules	Description	Get all the configured modules and their details
Example	{ "modules": [{ "slot":1, "statusLED":130, "dca":" 0.0", "laser":2, "lna":2, "biasT":2, "rfLinkTest":0, "showRFlevel":0,"rfPilotTime":"00:00:05", "optAlarmLevel":"0.03", "rfLevel":"-99.9", "temp":" 41.4", "optPower":" 0.0", "optPowerUnit":"mW", "rfPilotTimer":100 }, { "slot":2, "statusLED":194, "laser":0, "tec":1, "rfAmp":0, "userCont1":1, "userCont2":1, "userCont3":1, "optAlarmLevel":"0.17", "sw1":0, "sw2":1, "sw3":0, "sw4":0, "temp": 24.0, "laserTemp": 25.2, "laserPower":" 0.0", "txpd":1, "txpdPower":" 0.0", "rxpd":2, "rxpdPower":" 0.0", "dca":1, "dcaBits":5, "dcaLsb":"0.5", "dcaValue":" 0.0", "odl":0, "odlState":0, "odlLabel":"Delay", "odlValue":"0.000", "odlUnit":"[us]", "odlMax":"255", "ledLaser":0, "ledTec":64, "ledLaserPD":0, "ledTxPD":0, "ledRxPD":0, "uCont1lbl":"Antenna 13", "uCont2lbl":"UserCont2 On", "uCont3lbl":"UserCont3 On", "sw1lbl":"SW1 On", "sw2lbl":"SW2 On", "sw3lbl":"SW3 On", "sw4lbl":"SW4 On" }, { "slot":3, "statusLED":130, "laser":2, "tec":2, "rfAmp":1, "userCont1":2, "userCont2":2, "userCont3":2, "optAlarmLevel":"4.41", "sw1":2, "sw2":2, "sw3":2, "sw4":2, "temp": 33.7, "laserTemp": 0.0, "laserPower":" 0.0", "txpd":1, "txpdPower":" 0.0", "rxpd":2, "rxpdPower":" 0.0", "dca":1, "dcaBits":5, "dcaLsb":"0.5", "dcaValue":" 0.0", "odl":1, "odlState":38, "odlLabel":"Delay", "odlValue":"3.868", "odlUnit":"[us]", "odlMax":"1023", "ledLaser":0, "ledTec":0, "ledLaserPD":0, "ledTxPD":2, "ledRxPD":0, "uCont1lbl":"UserCont1 On", "uCont2lbl":"UserCont2 On", "uCont3lbl":"UserCont3 On", "sw1lbl":"SW1 On", "sw2lbl":"SW2 On", "sw3lbl":"SW3 On", "sw4lbl":"SW4 On" }, { "slot":4, "statusLED":64, "dca":" 0.0", "laser":1, "lna":0, "biasT":2, "rfLinkTest":0, "showRFlevel":0,"rfPilotTime":"00:00:10", "optAlarmLevel":"0.89", "rfLevel":"-99.9", "temp":" 43.2", "optPower":" 2.1", "optPowerUnit":"mW", "rfPilotTimer":100 }]}		

LED status codes:

LED status code	LED State
0	Off
1	Blue
2	Red
64	Green
130	Blinking Red
192	Blinking Green
194	Blinking RED / Green

8.1.4 Event log

The events endpoint provides the list of events which occurred since power was applied to the system. Each event is listed with a time stamp a description, and a severity qualifier. The events list is ordered by the time stamp with the last event to occur listed first. All the events are listed and the events filter does not filter the list.

Endpoint	ip:20080/api/cage/events	Description	Get all the configured modules and their details
Example	{ "eventsFilter": 5, "events": [{ "time": "2021-07-15 18:15:52", "level": "4", "detail": "New connection 2 from 192.168.1.7" }, { "time": "2021-07-15 18:15:48", "level": "0", "detail": "Group 2, maintenance required" },		

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

	{ "time": "2021-07-15 18:15:48", "level": "0", "detail": "Group 1, is fully functional" }, { "time": "2021-07-15 18:15:45", "level": "0", "detail": "Power supply 1 is OK, Power supply 2 is OK" }, { "time": "2021-07-15 18:15:45", "level": "0", "detail": "Cage is missing 2 modules: in Slot 2 Type RFoF3T3FR-PA-11, Slot 4 Type RFoF3T3FR-PA-11" }, { "time": "2021-07-15 18:15:45", "level": "1", "detail": "Added module type RFoF3R3FR-PA-11 S/N 70321967 in Slot 1" }, { "time": "2021-07-15 18:15:45", "level": "0", "detail": "Rejected incompatible module type RFoF18TFR-N0-11 in slot 2, expected RFoF3T3FR-PA-11" }, { "time": "2021-07-15 18:15:45", "level": "1", "detail": "Added module type ODL-10G-S243A S/N 91007055 in Slot 3" }, { "time": "2021-07-15 18:15:45", "level": "3", "detail": "Starting REST/HTML server on port 20080" }, { "time": "2021-07-15 18:15:45", "level": "3", "detail": "CageManager deamon Build 2.013 started " }] }

8.1.5 Power status

The power endpoint provides status information for the configured power supplies in the cage. There may be one or two power supplies. For cages with two power supplied the additional power supply is provided as an online backup. Such cage is designed to operate with a single power supply.

Endpoint	ip:20080/api/cage/power	Description	Get all the status of the power supplies
Example	{"psu": [{"status": "ok"}, {"status": "ok"}] }		

8.2 Control interface

The REST control interface uses web socket upgraded HTML connection. This upgrade should be performed after the basic HTML interface is established. To upgrade the HTML interface to web socket the client needs to send a request header to *ws://ip:20080/socket.io/* . Once the upgrade is granted the client can access the web socket interface as defined below. These interface exchanges include three categories: Client requests, M&C server only updates and both Client and M&C server sets. Just as before, all communication is performed via JSON objects.

8.2.1 Client only messages

There are two types of client message. The getSlot JSON is used to obtain current status of a particular component in a given slot. The setSlot JSON is used to set the control property of a slot to a new value. This request is processed immediately by the M&C server according to the current most recent status of the requested component module. The response of the M&C, as with all its responses, is broadcasted to **all** connected clients.

Client only	getSlot	Description	Get the current state of the component in the specified slot
Example	{ "getSlot" : { "slot": 10}}		
Server reply	{ "slotInfo" : { "slot":10, "statusLED":130, "dca":" 0.0", "laser":2, "lna":2, "biasT":2, "rfLinkTest":0, "showRFlevel":0,"rfPilotTime":"00:00:05", "optAlarmLevel":"0.03", "rfLevel":"-99.9", "temp":" 41.4", "optPower":" 0.0", "optPowerUnit":"mW", "rfPilotTimer":100 }}		

The respond is identical to the information provided for the particular slot with the module details request defined in section 8.1.3.

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

Control actions such as reset, setAsDefault and restoreFactory use the set JSON with the value '1' following the control property. The M&C server does not broadcast these commands or acknowledge them.

Client and M&C	setSlot	Description	Set a parameter of component in a given slot
Example	{ "setSlot" : { "slot":10,"reset" : 1}}		
Example	{ "setSlot" : { "slot":10,"setAsDefault" : 1}}		
Example	{ "setSlot" : { "slot":10,"restoreFactory" : 1}}		

8.2.2 Client and M&C Server messages

The setSlot JSON is used by the client or the M&C server to send a change value for a parameter of a component in a particular slot. The parameter name and state format must be the same as used by the M&C server in the module details request defined in section 8.1.3. The "status" property is exclusively for use by the M&C server.

Client and M&C	setSlot	Description	Set a parameter of component in a given slot
Example 1	{ " setSlot" : { "slot":10,"lna" : 1}}		
Server Ok reply	{ "slotInfo" : { "slot":10,"lna" : 1, "status": "Successfully set the LNA state"}}		
Failure reply	{ "slotInfo" : { "slot":10,"status": "Failed to set the LNA state"}}		
Additional event	{ "event": { "time": "2021-11-03 12:04:37", "level": "2", "detail": "Group 2, Slot 10 set LNA to On" }}		

Client and M&C	setSlot	Description	Set a parameter of component in a given slot
Example 2	{ "setSlot": { "slot":3, "dca":"1.5"}}		
Server Ok reply	{ "slotInfo" : { "slot": 3, "dca": 1.5, "status": "Successfully set the attenuator state"}}		
Additional event	{ "event": { "time": "2021-11-03 12:12:36", "level": "2", "detail": "Group 2, Slot 3 set attenuator to 1.5dB" }}		

Client and M&C	setSlot	Description	Set a parameter of component in a given ODL slot
Example 3	{ "setSlot": { "slot":2, "odlState":23 }}		
Server Ok reply	{ "slotInfo" : { "slot": 2, "odlState": 23, "odlValue": "45" "odlLabel":"Delay", "odlUnit": "us", "status": "Successfully set the ODL state" }}		
Additional event	{ "event": { "time": "2021-11-03 12:12:36", "level": "2", "detail": " Group 1, Slot 2 set ODL Delay to 45us" }}		

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

8.2.2.1 Controllable Module Parameters

The REST interface can be used to set the following parameters (sorted by product). Some parameters may not be available in all configurations and are labelled optional.

Product	Parameter	Comment
RFoF programmable	lna: {0, 1}	Tx module only,
RFoF programmable	laser: {0, 1}	Tx module only, 0=Off, 1=On
RFoF programmable	dca: “dd.d”	dd.d = 0.0 to 31.5 step 0.5 [dB]
RFoF programmable	"biasT":2	0=Off, 1=On, Optional if controlled mode is present
RFoF programmable	rfPilotTime: "hh:mm:ss"	hh:mm:ss hours:minutes:seconds
RFoF programmable	optAlarmLevel: “d.dd”	d.dd = 0.00 to 3.00 [mW] (1.00 Tx, 0.03 Rx default)
RFoF programmable	showRFlevel: {0, 1}	0=Off, 1=On
RFoF programmable	rfLinkTest: {0, 1}	0=Off, 1=On
RFoF programmable	optPowerUnit: {"mW" | “dBm” }	
RFoF HF	tec: {0, 1}	Tx module only, 0=Off, 1=On
RFoF HF	laser: {0, 1}	Tx module only, 0=Off, 1=On
RFoF HF	rfAmp: {0, 1}	0=Off, 1=On, Optional
RFoF HF	optAlarmLevel: “d.dd”	d.dd = 0.00 to 15.00 [mW] (6.50 Tx, 0.1 Rx default)
RFoF HF	dcaValue: "dd.d"	dd.d = 0.0 to xx.x step y, see configuration [dB], Optional
RFoF HF	userCont1: {0, 1}	0=Off, 1=On, Optional
RFoF HF	uCont1lbl: "user-label"	user-label=1 - 12 characters label, Optional
RFoF HF	userCont2: {0, 1}	0=Off, 1=On, Optional
RFoF HF	uCont2lbl: "user-label"	user-label=1 - 12 characters label, Optional
RFoF HF	userCont3: {0, 1}	0=Off, 1=On, Optional
RFoF HF	uCont3lbl: "user-label"	user-label=1 - 12 characters label, Optional
RFoF HF	sw1: {0, 1}	0=Off, 1=On, Optional
RFoF HF	sw1lbl: "user-label"	user-label=1 - 12 characters label, Optional
RFoF HF	sw2: {0, 1}	0=Off, 1=On, Optional
RFoF HF	sw2lbl: "user-label"	user-label=1 - 12 characters label, Optional
RFoF HF	sw3: {0, 1}	0=Off, 1=On, Optional
RFoF HF	sw3lbl: "user-label"	user-label=1 - 12 characters label, Optional
RFoF HF	sw4: {0, 1}	0=Off, 1=On, Optional
RFoF HF	sw4lbl: "user-label"	user-label=1 - 12 characters label, Optional
ODL	odlState: ddd	ddd = 0 to max ODL state, see configuration
ODL	odlUnit: 1	Cycles through 8 available options in sequence Delay [us], Delay[ns], Distance [m], Distance [ft], Range[m], Range [ft], Altitude [m], Altitude [ft].

8.2.2.2 Controllable Cage Parameters

The cageInfo JSON is used by either the client or the M&C server to update the cage parameters. These cage parameters are all user definable and are saved automatically. The updated values are broadcasted to all client and are immediately available to any new client connection.

Client and M&C	cageInfo	Description	When sent by the client it sets the provided cage parameter value. The M&C server uses this message to update all clients.
Example	{ "cageInfo: { "name":"indoor cage", "loc":"my back yard", "eventsFilter": 3, "groups": [{"name":"HF Uplinks"},{"name":"LF Group"}] }}		

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

8.2.3 M&C Server only messages

The following JSON messages are exclusively for the use of the M&C server. These messages are asynchronous and may be sent to the client at any time. The first of these is the event JSON which is broadcast to all clients when a new event is added to the Event Log.

M&C server	event	Description	Adds a new event to the event log
Example	{ "event": { "time": "2021-03-15 17:44:07", "level": "0", "detail": "Update: Group 1, is fully functional" }}		

The M&C server can issue the add JSON whenever a new component is hot plugged and added to the cage model. The content of the JSON is identical to the slot information provided in 8.1.2 module part.

M&C server	add	Description	Adds a new component in a slot
Example	{ “add”: { "slot":2, "part": "missing", "serial": "missing", "type": "Tx Prog 6GHz", "label": "RF In", "led": 64 }}		

The M&C server can issue the remove JSON whenever a component is hot unplugged and needs to be removed from the cage model.

M&C server	remove	Description	Removes a component from a slot
Example	{ “remove”: {“slot”: 5 }}		

The M&C server issues a slotLed JSON to update the status LED icon of a particular slot if the component module status has changed.

M&C server	slotLed	Description	Updates the status LED icon of a slot
Example	{ “slotLed”: {“slot”: “5”, “ledState”: 40 }}		

The M&C server sends a ‘heartbeat message regularly to indicate the status of the HTTP connection. This message includes a time stamp. Note that this is not a JSON object.

M&C server	heartbeat	Description	Updates the status LED icon of a slot
Example	Server Time is: 2021-07-15 18:15:45		

9 SNMP interface

The SNMP interface is documented by an MIB file which lists all the properties of the cage and components which are addressable within it. It defines the possible values and their interpretation as well as the control parameters. An SNMP protocol is typically used by a Network Management System (NMS) to which the MIB file is uploaded. Once the file is loaded into the NMS that environment creates a model of the RFoF cage which can be integrated into the managed system.

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

9.1 Traps and Notifications

SNMP supports provides for Traps AKA Notifications which can be sent to a subscribed list of Trap Receivers. Trap Receivers can be added to the RFoF cage SNMP server by specifying their network IPV4 address and with appropriate notification filter. The notification filter level is designed to block all lower level notifications. Each Trap Receiver must listen on the standard SNMP notification port 162 in order to receive the notifications. Each notification includes a time stamp as well as a description of the event and its severity level.

It is possible to use a 3rd party MIB browser to interface with the SNMP service. Several such bowsers are available for download as freeware for testing purposes.

It is important to insure that an SNMP v2c Trap Receiver is listening on each host computer on port 162 for the SNMP Trap/Notifications that are sent out from the RFoF cage.

9.2 RFOptic standard MIB file and OID's

The full RFoF-Cage-MIB.txt file is available upon email request from service@RFOptic.com. Samplings of the SNMP MIB interface is shown below to illustrate the definition of properties of the cage and the syntax used.

The MIB file defines the SNMP Object Identifiers (OID) which are strings of numbers separated by periods that uniquely identify properties as if they were an address of those parameters. An example of an OID is:

.1.3.6.1.4.1.40570.1.1.1

In this OID the prefix part **.1.3.6.1.4.1** is the standard ISO segment of the OID. The **.40507** segment uniquely identifies RFOptic Ltd. and the suffix **.1.1.1** specifies the first property in RFOptic's MIB tree which happens to be the product description or pDescription.

Given a MIB file it is possible to translate any property from property identifier in the MIB to an OID using the snmptranslate transaction:

snmptranslate -On RFoF-Cage-MIB::pDescription

will return: .1.3.6.1.4.1.40570.1.1.1

It is also possible to provide a textual version of the OID using this transaction by using the -Of flag

snmptranslate -Of RFoF-Cage-MIB::pDescription

will return: .iso.org.dod.internet.private.enterprises.eRFoptic.cRFoFcage.product.pDescription

9.3 RFOptic's SNMP V2c MIB, interface definition file

As mentioned above the MIB file defines the RFoF cage interfaces that are available to the SNMP interface. Each property is defined with information regarding the access rights, type of property and a description along with allowed values if relevant. A short snippet of the beginning of the MIB file is included below. Relevant snippets are included in the definition of SNMP transactions or commands that are supported in the following sections.

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

```
-- This version covers RFoFprog, RFoF HF and ODL products --

RFoF-Cage-MIB DEFINITIONS ::= BEGIN

IMPORTS
    MODULE-IDENTITY, OBJECT-TYPE, Integer32, enterprises,
    NOTIFICATION-TYPE       FROM SNMPv2-SMI
    OBJECT-GROUP, NOTIFICATION-GROUP,
    MODULE-COMPLIANCE     FROM SNMPv2-CONF
;

eRFoptic MODULE-IDENTITY
    LAST-UPDATED "202107150000Z"
    ORGANIZATION "www.RFoptic.com"
    CONTACT-INFO
            "postal: Kibbutz Einat,
            P.O.B 312, Israel 4880500

            email: support@RFoptic.com"
    DESCRIPTION "SNMP V2c Agent MIB for RFoptic RFoF cage"
    REVISION "202107150000Z"
    DESCRIPTION "Release 2.010"
    ::= { enterprises 40570 }

cRFoFcage    OBJECT IDENTIFIER ::= { eRFoptic 1 }

snmpObjectGroups     OBJECT IDENTIFIER ::= { eRFoptic 2 }

eRFopticObjectCompliance MODULE-COMPLIANCE
    STATUS current
    DESCRIPTION
            "The compliance statement for enRFoptic entities which
            implement the RFoptic cRFoFcage MIB."
    MODULE
    MANDATORY-GROUPS {
            snmpProductGroup,
            snmpCageGroup,
            snmpCageSettingsGroup,
            snmpTrapReceiversGroup,
            snmpEventLogGroup,
            snmpNotificationsGroup,
            snmpGroupObjects,
            snmpModuleObjects,
            snmpRFoFprogModuleObjects,
            snmpRFoFhfModuleObjects,
            snmpOdlObjects
    }
    ::= { eRFoptic 3 }

notifications OBJECT IDENTIFIER ::= { cRFoFcage 0 }

tRFoFcage NOTIFICATION-TYPE
    OBJECTS { cEventDetail }
    STATUS current
    DESCRIPTION
            "A status change in the cage"
    ::= { notifications 1 }

product        OBJECT IDENTIFIER ::= { cRFoFcage 1 }
```


Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

```
snmpProductGroup OBJECT-GROUP
    OBJECTS {
                pDescription,
                pPartNumber,
                pSerial,
                pVersion,
                pVerDate,
                pPSCount,
                pGrpCount,
                pSlotsCount
    }
    STATUS current
    DESCRIPTION
                "product identification objects"
    ::= { snmpObjectGroups 1 }

pDescription OBJECT-TYPE
    SYNTAX OCTET STRING
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
                "Product description"
    ::= { product 1 }

pPartNumber OBJECT-TYPE
    SYNTAX OCTET STRING
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
                "Product part number"
    ::= { product 2 }

pSerial         OBJECT-TYPE
    SYNTAX OCTET STRING
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
                "Product serial number"
    ::= { product 3 }

pVersion OBJECT-TYPE
    SYNTAX OCTET STRING
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
                "Revision name"
    ::= { product 4 }

pVerDate OBJECT-TYPE
    SYNTAX OCTET STRING
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
                "Revision Date"
    ::= { product 5 }

pPSCount OBJECT-TYPE
    SYNTAX Integer32(1..4)
    MAX-ACCESS read-only
    STATUS current
```


Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

```
        DESCRIPTION
                "Number of power supplies in the cage. typically, 1 or 2 power supplies are used."
        ::= { product 6 }

    pGrpCount OBJECT-TYPE
        SYNTAX Integer32(1..16)
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The number of installed groups in the cage. Groups are functional
                elements of a cage. Groups contain one or more RFoF modules.
                Each group may be a single RFoF module or a set of modules that
                operate as a functional unit such as a redundant transmitter or receiver,
                a link with a transmitter and receiver (ODL), a bi-directional transceiver
                or a set of CWDM modules."
        ::= { product 7 }

    pSlotsCount OBJECT-TYPE
                SYNTAX Integer32(1..32)
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The number of available slots in the cage. Slots are place holders for RFoF
                modules. A slot holds one single RFoF module a Transmitter or a Receiver"
        ::= { product 8 }

     Etc…
```

9.4 SNMP interface ports and access levels

The SNMP interface uses port 20162 on the server for the transaction interface. It will issue Trap/Notification messages to each IP address and port that are subscribed to the server. These subscriptions are defined using the 'Add Trap Receiver' transaction and can be removed using the 'Delete Trap Receiver' transaction.

Each subscriber and transaction request must supply a community string which is SNMP V2c version of a password. There are two access levels in this regard:

1. Public – is a read only access which is open to all
2. Authorized – is a read/write access which is open to users who supply the designated community string.

For public access simply provide the SNMP transaction option –c public as in the following example:

snmpget -v2c –c public *cageIPaddress* sysUpTime.0

In that transaction call *cageIPaddress* should be replaced with the IP address of the RFoF cage.

The Authorized community string is case sensitive and is provided to RFOptic clients upon request sent to service@RFOptic.com.

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

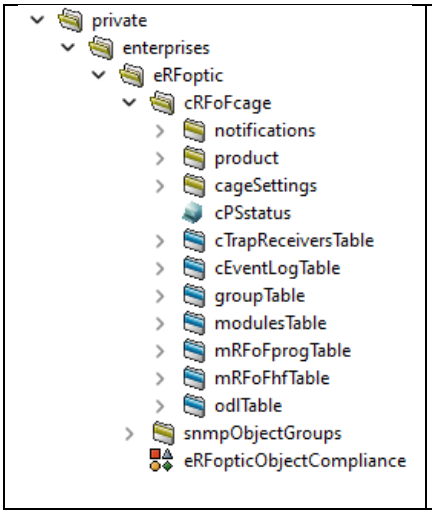
9.5 Module OID's

Modules are members of Group(s), therefore the OID for a particular module involves two indices rather than one. For any property the Module is referenced by the propertyOID.GroupIndex.ModuleIndex. This is illustrated in the following example for the modules in group 0 with slot indices 0, 1, 3:

```
mdlPartNumber.0.0 = STRING: "RFoF3T3FR-PA-11"
mdlPartNumber.0.1 = STRING: "RFoF3T3FR-PA-11"
mdlPartNumber.0.2 = STRING: "RFoF3R3FR-PA-11"
```

9.6 MIB file structure

The MIB file defines the parameters that can be observed and defined in the product. The MIB is common to all RFOptic products and includes sections that are specific to certain types of component modules. The overall structure can be illustrated by the following object tree:



The MIB structure root is the cRFoFcage object with separate sections for the enclosure level product definition and control elements.

The remainder of the MIB uses 7 tables to provide detailed information and access to all the parameters of the components of the RFoF cage.

The first 3 tables (TrapReceivers, EventLog and Groups) are simple single index tables. The Modules table is indexed by group and module in-group indices and with the remaining 3 tables form an Augmented Tables structure. All the RFoF components are represented in the modules Table, if some are not connected there will be place holder for unavailable properties. The remaining 3 tables are indexed in the same way and will be populated only if the relevant product is present in the cage.

9.7 Standard transaction interface

The following are examples of valid SNMP transaction requests. For each property that is requested the SNMP protocol generates a single or series of requests to the server to get each property that is required to complete the transaction.

- snmpget -v2c –c public *cageIPaddress* RFoF-Cage-MIB::pDescription
  Gets the description of the RFoF cage as defined in the associated MIB section:

```
pDescription OBJECT-TYPE
        SYNTAX OCTET STRING
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "Product description"
        ::= { product 1 }
```

  Note that the RFoF-Cage-MIB:: part of the OID identifier can be dropped if there is no ambiguity with another MIB file. Hence the following is also valid:

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

snmpget -v2c –c public *cageIPaddress* pDescription

- snmpgetnext -On -v2c localhost -c public pPartNumber
  Gets the next property after the specified property and returns its OID. This transaction is able to traverse all the MIB properties tree by repeating the transaction with the last property returned by the previous one.

- snmpset -On -v2c -c *authorizedCommunityString cageIPaddress* cName s "My Cage"
  Sets the cage name property cName to “My Cage” using the following portion of the MIB file which specifies the access to the cName property as follows:

```
cName OBJECT-TYPE
        SYNTAX OCTET STRING
        MAX-ACCESS read-write
        STATUS current
        DESCRIPTION
                "Optional User assigned cage name"
        ::= { cageSettings 1 }
```

  Note that the community string must be replaced by the *authorizedCommunityString* In order for the transaction to be performed by the SNMP service.

  String values must be enclosed in single or double quotes if they contain space characters.

- snmpwalk -On -v2c *cageIPaddress* -c public cRFoFcage
  This transaction transvers the entire RFoF cage properties tree starting from its cRFoFcage root property (itself not accessible) by repeatedly and automatically requesting the next available / accessible property.

  Example:

```
snmpwalk  -Os -Ci -t 10 -v2c localhost -c public groupTable
gName.0 = STRING: "Transceiver"
gName.0 = STRING: "Transceiver"
gType.0 = INTEGER: eSimple(2)
gMdlCount.0 = INTEGER: 3
gRedundancySwitch.0 = INTEGER: none(0)
gSetSwitchMode.0 = INTEGER: none(0)
gStatus.0 = INTEGER: primaryFailed(2)
```

- snmptable -Os -v2c *cageIPaddress* -c public gTable
  This transaction obtains a table formatted textual output of table structures that are defined in the RFoF Cage MIB. These structures include ‘sparse’ tables and are defined for the component module groups, the RFoF component modules and for each of the Component module types; RFoFprog, RFoF HF and ODLs.

  Example:

```
snmptable -Os -Ci -t 10 -v2c localhost -c public modulesTable
SNMP table: modulesTable

 index mdlSlot mdlSlotLabel     mdlType     mdlStatus mdlStatusLED     mdlPartNumber  mdlSerial mdlFWrev     mdlName mdlTemperature
   0.0       3     "RF In 1" RFoFprogTx            ok           64 "RFoF3T3FR-PA-11" "80321967"  "1.020" "80321967"        " 25.0"
```


Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com

```
0.1       2   "RF Out 1" RFoFprogRx not-installed           ?                 ?          ?        ?          ?             ?
0.2       1   "RF Out 2" RFoFprogRx         faild         130 "RFoF3R3FR-PA-11" "70321967"  "1.017" "70321967"        " 25.0"
```

9.8 SNMP Automation and security

SNMP transactions can be automated by using them in batch files and / or activating them on prescribed schedule as may be necessary. However, the main purpose of the SNMP interface is to be used by an NMS to monitor and control the RFoF cage.

SNMP V2c security is insufficient in many cases where transactions need to be performed over unsecure Internet connections. A workaround that brings the security level up to the highest currently available is possible by keeping the SNMP transaction private within the server. This is possible by blocking all outgoing connections from the server except for the *ssh* interface. Once a user is logged into the server over the secure encrypted *ssh* connection it is possible to execute SNMP commands on the shell of the server and view the responses over the secure connection. In such case the commands should use 'localhost' in place of the enclosure IP address in the SNMP commands.

Phone: 972-76-5400180 • US: 1-708-RFOPTIC • 21 Yagia Kapaim, Petach Tikva 4913020 • Israel
www.rfoptic.com