







User manual



- Quick start**

- Hardware**

- Configuration**

- Parameters**


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- Due to the nature of wireless communications, transmission and reception of data can never be guaranteed. Data may be delayed, corrupted (i.e., have errors), or be totally lost. Significant delays or losses of data are rare when wireless devices produced by RACOM are used in an appropriate manner within a well constructed network.

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- RACOM wireless communication device should not be used in situations where failure to transmit or receive data could result in damage of any kind to the user or any other party, including but not limited to personal injury, death, or loss of property.
- RACOM products are not developed, designed or tested for use in applications which may directly affect health and/or life functions of humans or animals, nor to be a component of similarly important systems, and RACOM does not provide any guarantee when company products are used in such applications.
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- The production of the radio equipment may be postponed or discontinued by RACOM without prior notice.
- The radio equipment hardware, firmware and software can't be changed or modified by a user or any other third-party. Only officially distributed firmware from RACOM is allowed to be installed on the equipment.

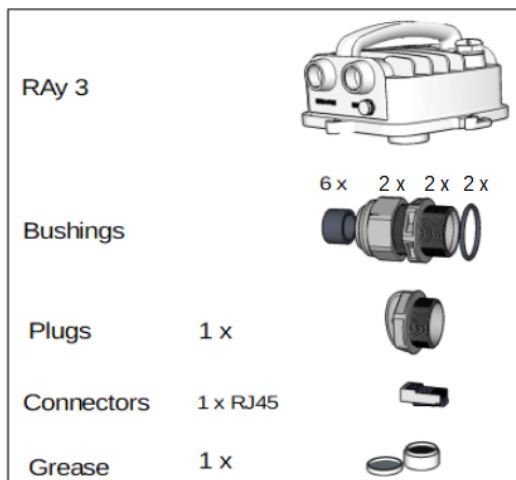


Important

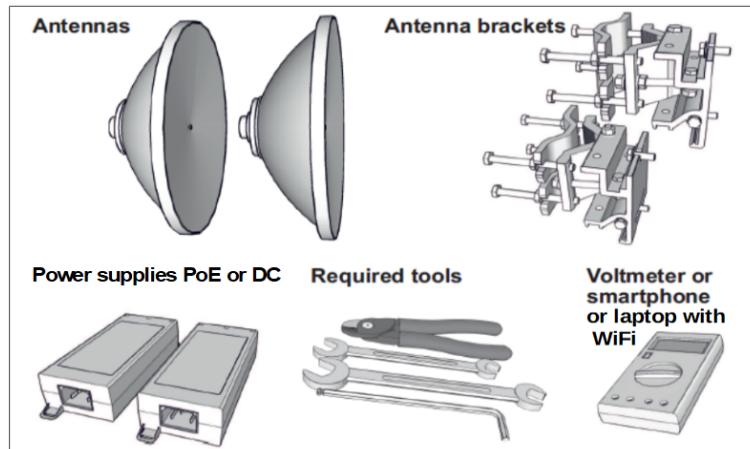
Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Quick guide

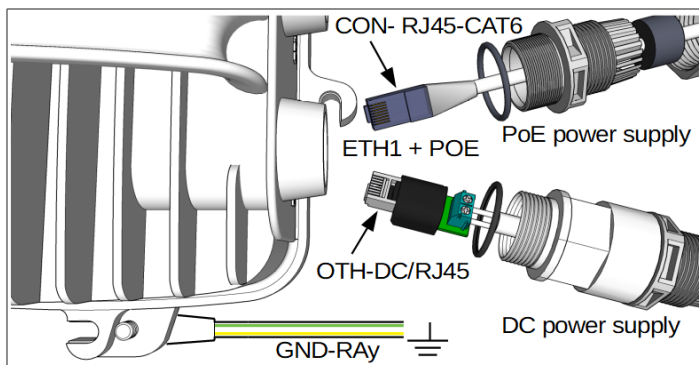
1. Delivered items



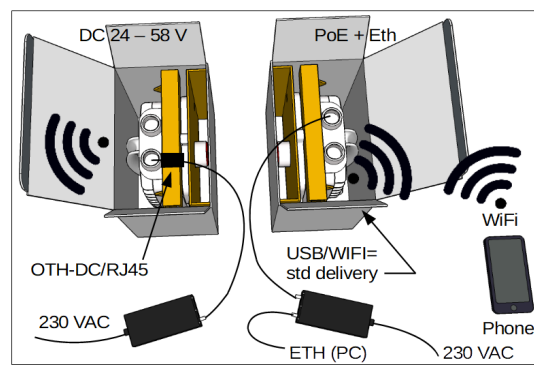
2. Accessories



3. Power supply



4. Configuration



Accessing units

- Default IP addresses for Ethernet access: 192.168.169.169/24 (L unit) and 192.168.169.170/24 (U unit)
 - Default IP address for USB/WiFi or USB/Eth access: 172.17.17.17/24 (both units)
- Ethernet access - set computer IP address within the range 192.168.169.1-255. USB/WiFi or USB/Eth access - IP address set automatically by DHCP (enabled by default, can be disabled in unit management). Recommended USB adapter must be plugged in to the unit. Default WiFi setting is without any password (recommended is to set one immediately).
- Web browser access to management:
 - http://172.17.17.17 (both units, USB/WiFi or USB/Eth)
 - or http://192.168.169.169 (L unit, Ethernet)
 - or http://192.168.169.170 (U unit, Ethernet)
 Defaults: Username: admin, Password: admin
 - Antenna Alignment Tool:
 - http://172.17.17.17/tk (both units, USB/WiFi or USB/Eth)
 - or http://192.168.169.169/tk (L unit, Ethernet)
 - or http://192.168.169.170/tk (U unit, Ethernet)
 no Username or Password is required for Tool

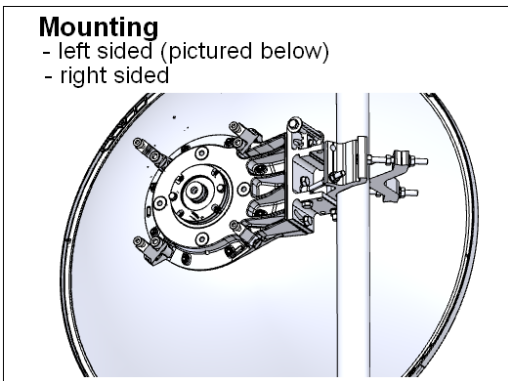
Secure HTTPS access can be optionally used instead (use „secured version“ below main entry to the management and then accept the https security certificate issued by RACOM).

If the units are linked to each other, the status indicator in management interface states “OK” and status LED “AIR” lights green. If not, utilize the antenna alignment (see pict. 10 and Antenna Alignment Tool above).

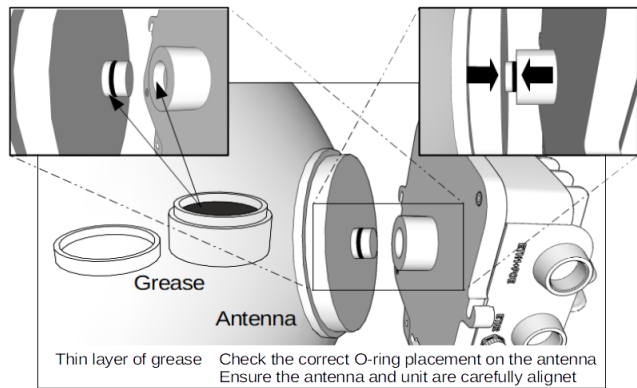
Configuration and backup of basic parameters

- Set bandwidth, channels, modulation, power, **IP addresses** (do not use the default ones), **Access channels** (ssh, https..).
- Change the password, restart both units and check the link status (to verify that the parameters are saved correctly).
- Backup the configuration in the Tools / Maintenance / Backup / Settings menu. Store the backup file to your PC.

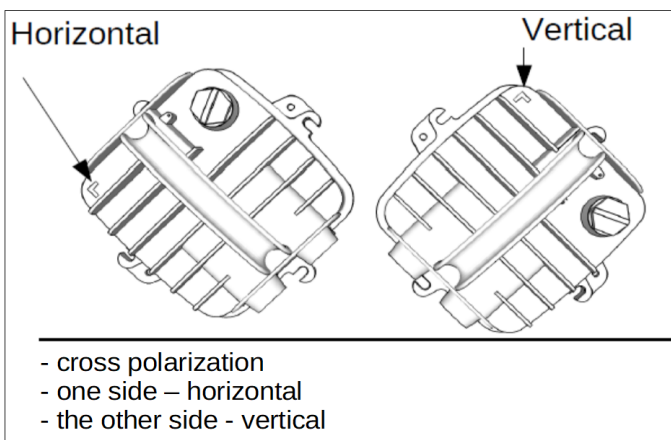
5. Bracket and antenna



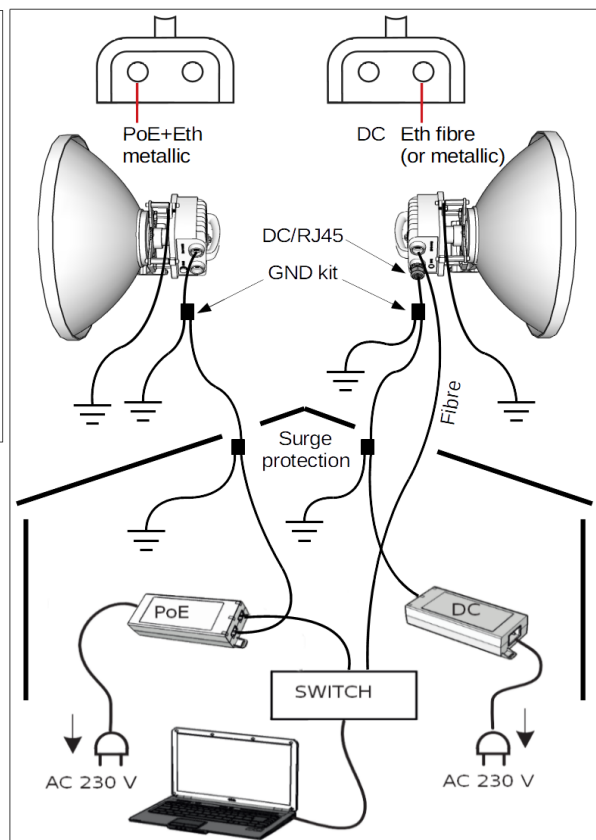
6. Unit lubrication and installation



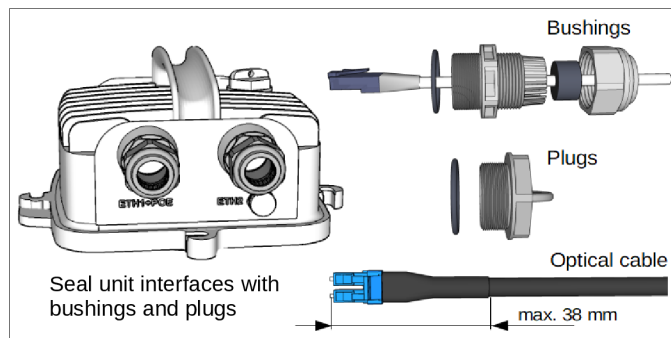
7. Unit polarization



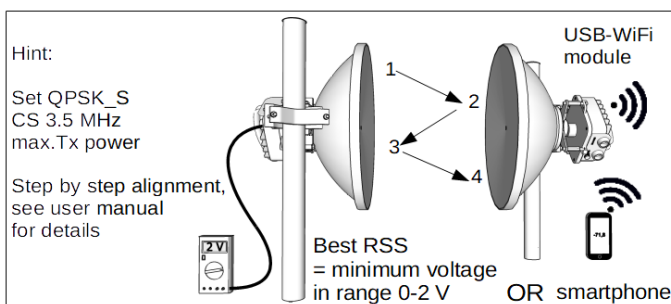
9. Power grounding and connections



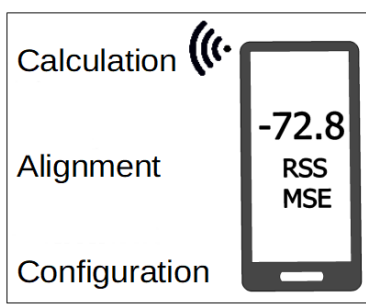
8. Sealing



10. Directing antennas



11. RSS measurement



List of documentation

■ User manuals:

RAy3 Microwave Link

- User manual RAY3-17, RAY3-24 - this document (complete reference manual). Latest revision is available on-line in *PDF*¹ and *web*² version.

RAy2 Microwave Link

- User manual RAY2-10, RAY2-11, RAY2-17, RAY2-18, RAY2-24. Latest revision is available on-line in *PDF*³ and *web*⁴ version.
- Channel arrangements - detailed tables of RAY2 channel frequencies - see *RACOM web*⁵

RAy1 Microwave Link

- User manual RAY11, RAY17, RAY24 - see *RACOM web*⁶
- User manual RAY10 - see *RACOM web*⁷

■ Datasheets:

RAy3 / RAY2 - Datasheet⁸

RAy1 - Datasheet⁹

RAy - SCADA Backbone¹⁰

■ Application notes:

RAy - Application notes¹¹

¹ https://www.racom.eu/download/hw/ray/free/eng/00_letaky/ray3-man-en.pdf

² <https://www.racom.eu/eng/products/m/ray3/index.html>

³ https://www.racom.eu/download/hw/ray/free/eng/00_letaky/ray2-man-en.pdf

⁴ <https://www.racom.eu/eng/products/m/ray2/index.html>

⁵ <https://www.racom.eu/eng/products/m/ray2tab/index.html>

⁶ <https://www.racom.eu/eng/products/m/ray17/index.html>

⁷ <https://www.racom.eu/eng/products/m/ray/index.html>

⁸ https://www.racom.eu/download/hw/ray/free/cz/00_letaky/ray-dsA3-cz.pdf

⁹ https://www.racom.eu/download/hw/ray/free/cz/08_ray_archiv/datasheet_RAY_cz.pdf

¹⁰ https://www.racom.eu/download/hw/ray/free/eng/08_ray1/leaflet_RAY_scada_en.pdf

¹¹ <https://www.racom.eu/eng/products/m/ray/app/index.html>

1. Product

1.1. Main characteristics

RAY3 microwave units work as a point-to-point link in a full duplex setting with transfer speeds of up to 1002 Mbps.

Supported are 2 license-free bands 17 GHz (17.10 – 17.30 GHz) and 24 GHz (24.00 – 24.25 GHz). Bandwidth can be configured from 3.5 up to 112 MHz, independently for Tx and Rx. Modulation can be fixed or adaptive and can be adjusted from QPSK to 4096QAM. QPSK modulation could be on the fly (without data loss) strengthened for higher receiver sensitivity by extremely robust FEC – such modulation is marked as QPSK-S (S means “strong”). RAY3 microwave links operating in 17 and 24 GHz bands can also be operated as a Short Range Device (SRD).

This link is formed by two RAY units, each equipped by its own parabolic antenna and accessories to be fully operational.

Hardware concept

RAY product line has been designed to have minimum possible number of hardware variants. Upgrade of functionality does not result in on-site hardware changes– everything is done by activating software feature keys (see *Section 1.7, “Ordering codes”* and *Chapter 5, Configuration*).

HW models are determined only by frequency bands, because both RAY units have identical hardware. Transmitting and receiving channels are freely defined by software and technically separated from each other by cross polarization.



Fig. 1.1: RAY3 – Microwave link

Cross polarization means that one side of the link uses one polarization for transmission (e.g. horizontal) and the opposite polarization for receiving (e.g. vertical). The other side of the link is turned by 90°. It therefore transmits and receives using opposite polarization with respect to the other unit. The practical result for users is that RAY units for 17 and 24 GHz must be mounted with reverse polarity on both ends of the link.



Note

Even all units for selected band are hardware identical, default factory settings for each RAY in the pair use different channels for L and U unit, so the link could be established using default radio parameters.

Ethernet concept

RAY links are transparent for IP and UDP Ethernet traffic. Practically all protocols passes through including MPLS and many others, except following packets:

- Management packets targeted for RAY units itself

- Special packets for protocols explicitly mentioned in this manual which are somehow processed by RAy units (like PTP)
- Packets which did not went through and were discarded due to capacity limitation and/or policy rules (e.g. QoS, Shaping ...)

1.2. Mechanical interfaces

This chapter describes basic properties of each RAY unit, which are important for its mechanical installation: antenna waveguide, unit fixing (screws, etc.) and *unit grounding* (screw + cable). Other interfaces (for data, power and service purposes) are described in next chapters *Ethernet + power interfaces* and *Service interfaces*.

1.2.1. Antenna waveguide

Antenna waveguide flange on RAY unit (located across the holder) ensures perfect microwave connection between the unit and the antenna.

RAY3 link requires the use of external parabolic antenna for each RAY unit – both for physical mounting as well as for the wireless transmission itself. *Parabolic antennas* from different producers are available.

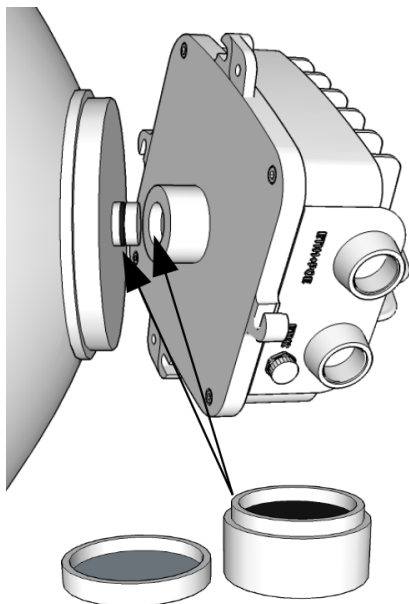


Fig. 1.2: Waveguide pivot and flange



Important

Always *carefully lubricate* both antenna waveguide pivot and RAY waveguide flange by thin layer of silicon grease before assembly to prevent the damage of O-ring and the surfaces. When lubricated, pivot nicely fits in to the flange.

1.2.2. Unit mounting

The RAY unit is mechanically fixed to the antenna by 4× M8 screws (one per each side of RAY unit). Installation and basic adjustment of the antenna is described in the *Section 4.2, “Antenna mounting”*. Attaching RAY unit to it by 4× M8×30 (Allen) screws delivered with each antenna or each mount kit is described in the *Section 4.3, “RAY unit mounting”*. For adjusting the exact antenna direction see *Section 4.7.2, “Directing antennas”*.

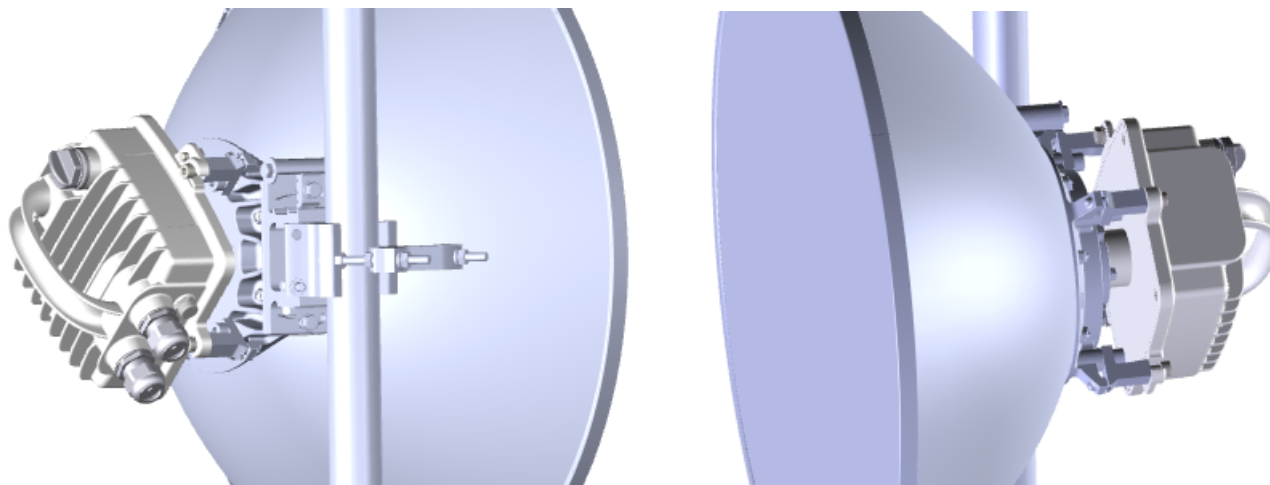


Fig. 1.3: Antenna and RAY3 unit

1.2.3. Grounding screw

Grounding screw is used for a proper grounding of the RAY unit, which is necessary for its function (ensured by galvanic connection to the grounded mast through a grounding cable).

One M8 screw (with standard 6-edge head) is delivered with each RAY unit. Grounding screw has two possible positions (two holes) to be mounted in. Those are located near the left and right fixing screws of the RAY unit and both are marked by a yellow grounding symbol ⚡ and both are equivalent (second hole remains unused). For more information about unit grounding see *Section 4.3.3, “RAY unit grounding”*.



Fig. 1.4: Grounding screw



Note

Grounding screw function is to ensure proper grounding of the RAY unit (by a grounding cable), not for mechanical fixing of the unit.

1.3. Ethernet + power interfaces

This chapter describes interfaces for user data transfer and power sourcing of the unit, as described on the picture and characterized in the table below. Remaining interfaces for service purposes are described in next chapter *Service interfaces*.

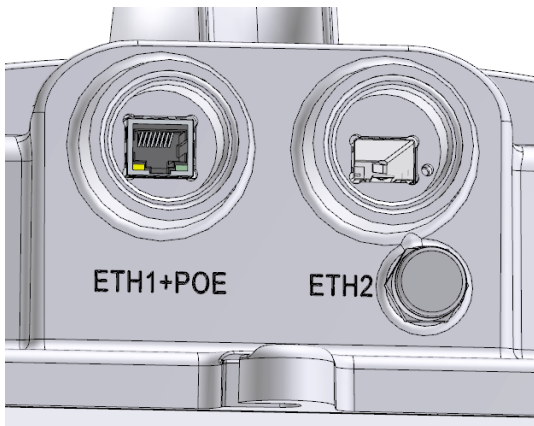


Fig. 1.5: Slots ETH1+POE, ETH2

Slot	Function
ETH1+POE	Gigabit metallic Ethernet + Power over Ethernet (PoE) port This port is capable of powering the unit with any PoE power source working according to IEEE 802.3at standard. Passive PoE from 20 to 60 V is supported (if DC input is required, it could be injected through this connector - the voltage range is identical: from 20 to 60 V).
ETH2	Slot for user exchangeable SFP module A wide range of fibre optics Ethernet modules is available. Both single or dual mode transceivers can be used. An SFP module with metallic RJ45 interface can also be used.
	The SFP LED Located on SFP, just next to connectors. It is controlled by SFP module. Its function is specific for each SFP module. The typical behavior is an indication the received signal from the optical or metallic link to be within operational range.



Note

A set of all necessary bushing parts are delivered with each RAY unit - see a description of this standard basic accessory *ACS-RAY3*. Additional bushing options for installation of *longer connectors* or other equipment are available as well. For bushings installation see *Section 4.4, "Connectors assembly and disassembly"*.

All accessories offered by RACOM for proper installation of the complete RAY link setup (including proper grounding) are tested for compatibility with RAY unit. See accessories listed in *overview* and described in *details*.



Important

All bushings and plugs (including the original plugs in the flanges) must be fitted with O-rings and carefully tightened. Otherwise, the unit is not protected against moisture intake through connectors and can not offer guaranteed functionality.

1.3.1. Ethernet 1, PoE - RJ45 connector (ETH1+POE)

RJ45 socket connector marked „ETH1+POE“ is a standard 10/100/1000Mbps metallic Ethernet port. One plastic RJ45 plug for CAT5e and CAT6 cables is delivered with each RAY unit, ready to be punched to an Ethernet cable. Higher quality and CAT7 compatible RJ45 plugs are available from RACOM as well – see for example item *CON-RJ45-TLG-CAT6*.

This port can be optionally used for power sourcing the unit by PoE (Power over Ethernet). Both an active PoE power supply (compliant with at least IEEE 802.3at standard known also as „PoE plus“) and a passive PoE power supply (with voltage range 20-60 V) are supported.

Technical parameters of PoE power input:

Supported voltage range is 20 to 60 V, both polarities are supported. For RAY unit booting the minimum required voltage is 21 V (to prevent booting with discharged 24 V battery).

It is possible to use all 4 Eth pairs (8 pins) or only 2 Eth pairs (4 pins). Use:

- either 4,5 (V+) and 7,8 (V-) or opposite +/- DC polarity
- or 1,2 (V+) and 3,6 (V-) or opposite +/- DC polarity
- or both simultaneously (with all combinations of +/- DC polarities supported)

All contacts of RJ45 connector are galvanically separated from RAY unit. It ensures galvanical separation for any kind of *PoE power supply* as well as for *DC power sourcing* (made through *OTH-DC/RJ45*).

More information about usage and installation of available power options can be found in *Section 4.6, “Power supply”* and *Section 4.5, “Grounding and overvoltage protection”*.

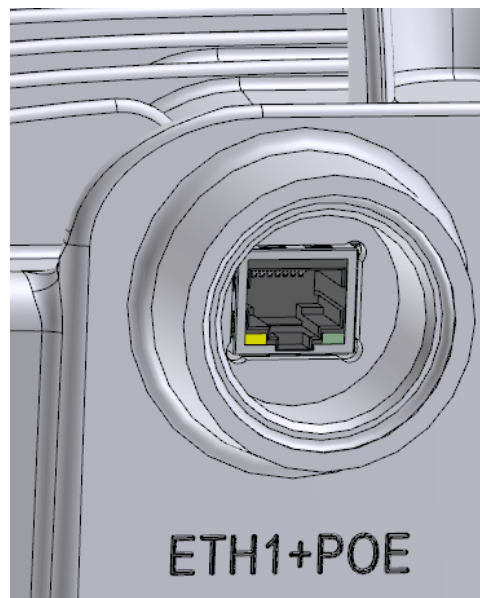


Fig. 1.6: RJ45 Ethernet connector

1.3.2. SFP slot (ETH2)

„ETH2“ is a standard SFP slot for 10/100/1000 Mbps Ethernet SFP modules, user exchangeable. Both fibre optic and metallic Ethernet SFP modules are supported. For optical both single and dual mode fibre optics Ethernet modules (= 2 or 1 fibers) can be used. CSFP modules are not supported. RACOM offers all mentioned types of SFP modules, tested to be RAY compatible as a standard *accessory*.

The SFP status LED is located just next to the slot. It is controlled by SFP module. Its function is specific for each SFP module. The typical behavior is an indication the received signal from the fibre optic or metallic link to be within operational range.

Do not remove the smaller plastic screw next to ETH2 label. It is part of the cabinet and assures pressure equalization outside and inside.

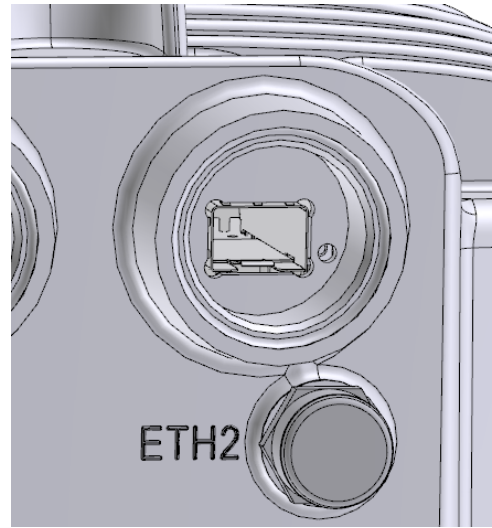


Fig. 1.7: SFP slot



Important

It is strongly recommended to use a high quality SFP module with industry temperature range. The SFP modules listed in *Accessories* are thoroughly tested by RACOM and are guaranteed to function with RAY units. It is possible to use any other SFP module, but RACOM cannot guarantee they will be completely compatible with RAY units.

1.3.3. DC power (using ETH1+POE)

Direct DC power source can be used to power the RAY3 unit. Slot „ETH1+POE“ allows to use the DC/RJ45 adapter (item OTH-DC/RJ45) as a DC connector. It is equipped by 2 terminals (each 1.5 mm² / AWG 14) with screws to ensure a perfect connection with cooper DC power cable. Its other end is then fitted into RJ45 connector slot „ETH1+POE“ in the RAY unit. Internal RJ45 pins wiring of DC/RJ45 adapter (item OTH-DC/RJ45) is:

- (V+ or V-) ... 1,2,4,5
- (V- or V+) ... 3,6,7,8
- (shield) floating (not connected to any pin)

Supported voltage range is 20 to 60 V, both polarities are supported. For RAY unit booting the minimum required voltage is 21 V (to prevent booting with discharged 24 V battery). Power input is galvanic separated inside RAY unit.

Optional grounding of DC cable should be connected directly to the mast or to the Grounding screw on RAY chassis, to ensure proper grounding of the cable. For grounding to the mast use suitable grounding kit – for example see *Grounding* in section Accessories.

More information about DC power sourcing possibilities and installation can be found in *Section 4.6, “Power supply”*.

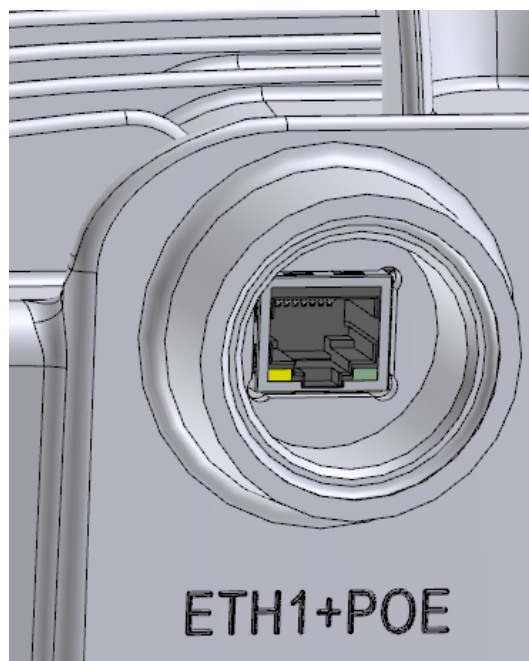


Fig. 1.8: Power supply connector



Fig. 1.9: Power via an DC-RJ45 adapter

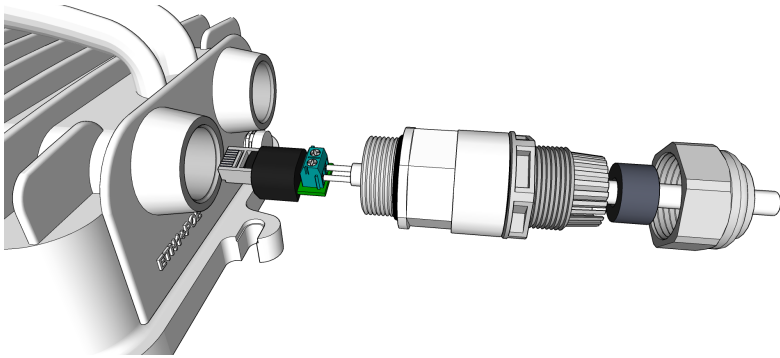


Fig. 1.10: Power via DC-RJ45 adapter



Note

DC-RJ45 adapter occupies ETH1+POE port. When used, Ethernet connection to the unit has to be made through ETH2 port. Possible solutions are:

- If fiber optic Ethernet is used (using the correct type of SFP module), RAY3 unit is powered by DC through the DC-RJ45 adapter.
- If a metallic Ethernet has to be used together with DC power source, then metallic SFP module in ETH2 SFP slot is one of valid solutions.

Other valid possibility how to power the unit using DC power source is to use passive PoE injector or active PoE power supply with DC input and deliver the power to RAY3 unit through Ethernet cable with RJ45 connector plugged in to ETH1+POE slot.

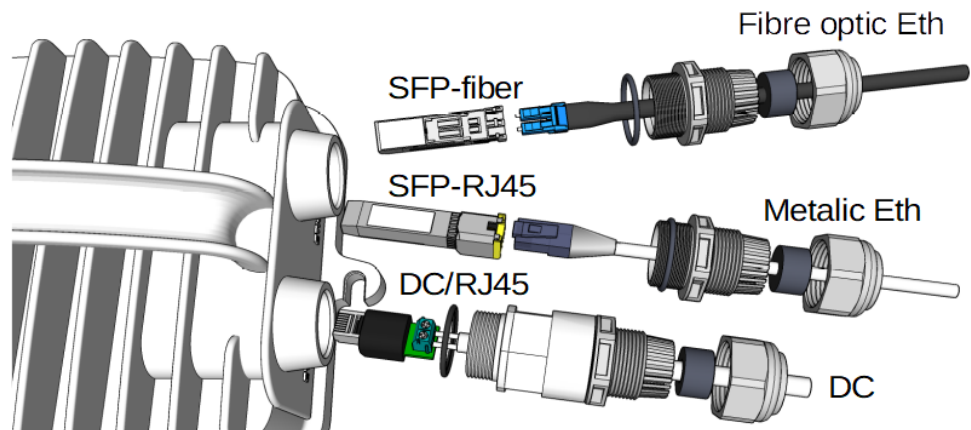


Fig. 1.11: SFP possibilities when direct DC power is used

1.4. Service interfaces

Slot „S“ is shortcut of "Service". It contains system connectors – standard USB port and a pair of contacts for RSS voltage output (red + gray ones). Also HW button and Status LED are located there.

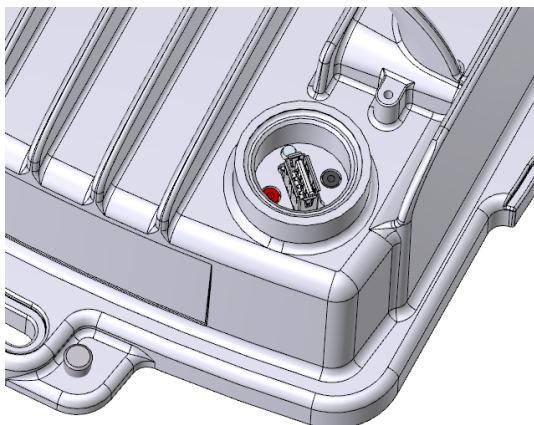


Fig. 1.12: Slot S

Slot	Function
S	USB service connector For USB/WiFi or USB/ETH adapters, see <i>Section 1.4.1, "USB connector (S)"</i>
	RSS voltage output Red and green connectors (for example 0.547 V means RSS = -54.7 dBm), see <i>Fig. 1.16, "RSS voltage contacts"</i>
	HW button For service purposes: Internal backup or Factory settings, see <i>Section 5.6.1, "Maintenance"</i>
	Status LED Visible through semitransparent plug, see <i>Section 1.5, "Status LED (S)"</i>

1.4.1. USB connector (S)

USB-A port is designed for access to RAY management through USB/WIFI adapter or USB/ETH adapter plugged in to. More information about installation and configuration of available adapters can be found in *Quick Guide* and in *Section 5.4.3, "Service access"* (part "USB Accessories").



Note

Only RACOM recommended adapters are supported. See section *USB adapters*.

1.4.2. Service WiFi - optional (using USB „S“)

Each RAY3 unit is equipped with the service WiFi interface from the factory. It is realized by standalone WiFi module inserted in to the USB connector in slot "S". WiFi can be used solely for unit management (no user traffic can be transmitted by using this WiFi connection).

WiFi module can be disabled in FW (WiFi module is out of power then) or manually unplugged. In both cases the results are identical - no WiFi is possible. Management of the WiFi port is described in *Section 5.4.3, "Service access"* (part "USB Accessories").

1.4.3. Service Ethernet - optional (using USB „S“)

RAY3 unit can be equipped with the service Ethernet interface as an option. It can be used solely for unit management (no user traffic can be transmitted using this Ethernet connection).

Optional Eth adapter (ordering code *OTH-USB/ETH-XA*) can be inserted in to the USB connector in slot "S" (instead of WiFi module). Management of this Ethernet port is described in *Section 5.4.3, "Service access"* (part "USB Accessories").

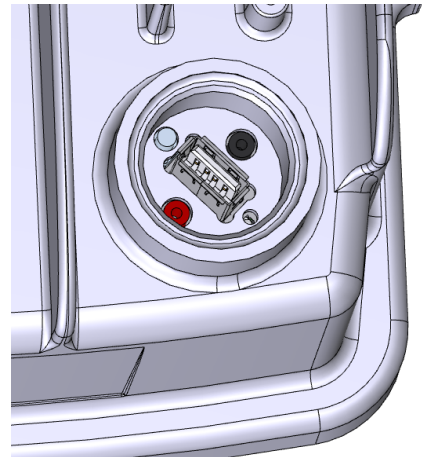


Fig. 1.13: USB connector



Fig. 1.14: USB WiFi adapter



Fig. 1.15: Ethernet adapter

1.4.4. RSS voltage contacts (S)

RSS voltage output connectors are located in slot „S“ aside USB connector. This pair of contacts (red + green ones) allows to connect a voltmeter (pin diameter 2 mm) to the RAY unit and measure RSS value transformed to the voltage output.

RSS (Received Signal Strength) is a basic parameter used for directing antennas to the optimal direction. RSS output voltage is calibrated to be proportional to actual RSS dBm (for example 0.547 V means RSS –54.7 dBm). Thus a standard digital voltmeter allows to see RSS value in a digital form interactively during the antenna alignment. More information about RSS voltage output usage is in *Section 4.7.2, “Directing antennas”* (part “Voltmeter”) together with several alternative ways to get this value by other methods.



Fig. 1.16: RSS voltage contacts

1.4.5. HW button (S)

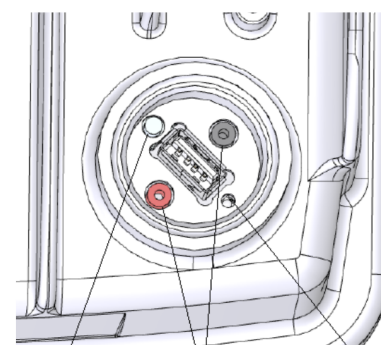
It is located in a small hole next to USB connector. It can be pushed by any tiny blunt thing with the diameter up to 2 mm. Its length has to reach about 7 mm in to the hole. (It can be ball pen cartridge – both ends work on the thin one, match, toothpick, etc.).



Important

Usage of very sharp things for pushing the HW button (like needle, edge clip etc.) may destroy the contact inside RAY unit! Such a button destruction is not covered by *warranty*.

The button supports multiple functions, which are activated dependent on the state of the unit when the button is pushed and the length of the push:



HW button RSS voltage Status LED

Fig. 1.17: Service interfaces

Action to be performed	Unit status	Button pushed	SYS LED indication
Restore internally temporary stored customer settings	Normal operation	For 5 seconds	Flashes Green
Applying Factory settings to Local unit, then reboot	Out of power	Pushed before power on, released after SYS LED stops flashing red	Flashes Red (delayed after power on, for a duration of 5 seconds)
Entering the Service mode . (Please, exit this mode by powering off the unit)	Out of power	Pushed before power on, released when SYS LED starts flashing red	Flashes Red (delayed after power on)



Note

Those actions and their use are described in detail in *Section 5.6.1, “Maintenance”*.

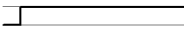
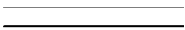
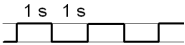
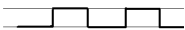
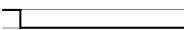
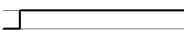

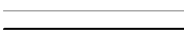
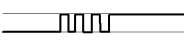
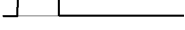
1.5. Status LED (S)

RAY3 unit is equipped with one LED indicator located inside the housing of the FOD unit in slot „S“ (during normal operation covered by semi-transparent plug). Meaning of the color combinations of this LED indicator is:



Tab. 1.1: LED status indicators

Fig. 1.18: Status LED

Green and Red LEDs	Function
G  R 	System is up and working OK
G  R 	System reports warning or alarm, which can be possibly repaired by user
G  R 	System reports HW alarm
G  R 	Unit is out of power or HW button pressed
G  R 	Unit is starting

1.6. Sizes, packaging and labeling

1.6.1. RAY3 unit

Outer sizes and weights for all RAY3 models are identical:

- Outer size: 245 × 245 × 160 mm
- Weight: 2.6 kg

Basic technical parameters like identification of the HW model, working frequency, maximum Tx power, requirements for power supply, most important certifications, etc. are visible on *RAY Production label*. All technical parameters are stated in detail in *Chapter 9, Technical parameters*.

1.6.2. Production label

The label contains identification of the HW model and its serial number, basic technical parameters, most important certifications, QR code to manual, address of the producer, etc. Meaning of the most important information listed on the production label is:

- Type – RAY3 product line identification (for details see *Section 1.7, “Ordering codes”*)
- Code – detailed identification of the unit type (for details see *Section 1.7.1, “RAY units”*)
- S/N – serial number, MW link consists of two separated units with two different serial numbers
- QR code – www link to the latest version of the User manual
- RF Power – maximum output power
- TX, RX freq – range of working frequency
- PoE – power supply characteristics
- CE, FCC ID, IC or other - available certifications

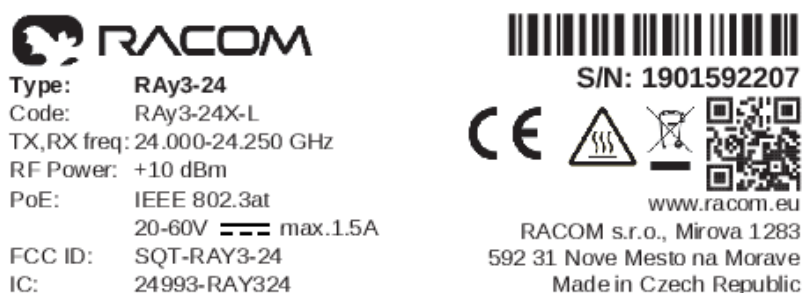


Fig. 1.19: Production label example



Important

The processor included in the unit variant S and X uses an encryption module listed as 5A002 a.1 in the COUNCIL REGULATION (EC) No 428/2009, setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items. Units are subject to export control when exporting outside the European union, according to national, *EU*¹ and US law.

¹ http://ec.europa.eu/trade/import-and-export-rules/export-from-eu/dual-use-controls/index_en.htm

Type and Code structure:

RAy3-24X-L

Trade name Gen. Band Var. FRQ

Type

Code

Trade name + Gen.	RAy3
Band	Frequency band in GHz Possible values: 17, 24
Var.	Designation of product variant, if it is used. More variants can be used within one unit, i.e. more letters can be on this position. These variants can't be ordered and included in the unit later on. Possible values: <ul style="list-style-type: none"> none – (position not used) – means same as X N – no encryption HW installed, encryption will never be possible (neither HW nor SW) E – no encryption HW installed S – encryption HW installed - see <i>export restriction above</i>, MTU 2048 Bytes (only RAY3-24 produced by 3/2019) X – encryption HW installed - see <i>export restriction above</i>, MTU 10240 Bytes R – reduced RF output power -30 to -15 dBm (always in combination with N, E, S or X)
FRQ	Frequency Possible values: <ul style="list-style-type: none"> L – unit transmits on lower part of the band U – unit transmits on upper part of the band Note: L/U indicates TX default, which can be changed. Both units have the same HW for lower and upper unit.
Type	Specific product type for which type approvals like CE, FCC etc. are issued. Possible values: RAy3-17, RAY3-24
Code	Detailed HW identification of the unit Note: SW keys and Optional accessories are not HW dependent and can be installed or de-installed later on, so they are not printed on Product label.



Note

A link should consist from a pair of “-L” and “-U” units (L and U are always a last letter in Code printed on production label of each unit), but it is not mandatory (HW for L and U unit is identical and L/U settings could be assigned by SW). Using L + U pair ensures all default settings of both units match each other (including proper IP addresses as described in this manual). It ensures the link is automatically established after factory defaults (to simplify initial setting of the unit).

1.6.3. Packaging

The RAY3 radio link is supplied in a package containing two separate boxes. Delivery includes:

- 2 pcs RAY3
- 2 pcs *Cable bushing set* (bushings and connectors)
- 1 pc *SILICONE GREASE*

If only one unit is delivered, then delivery includes one piece of each item.

The unit is fixed in the box as follows:

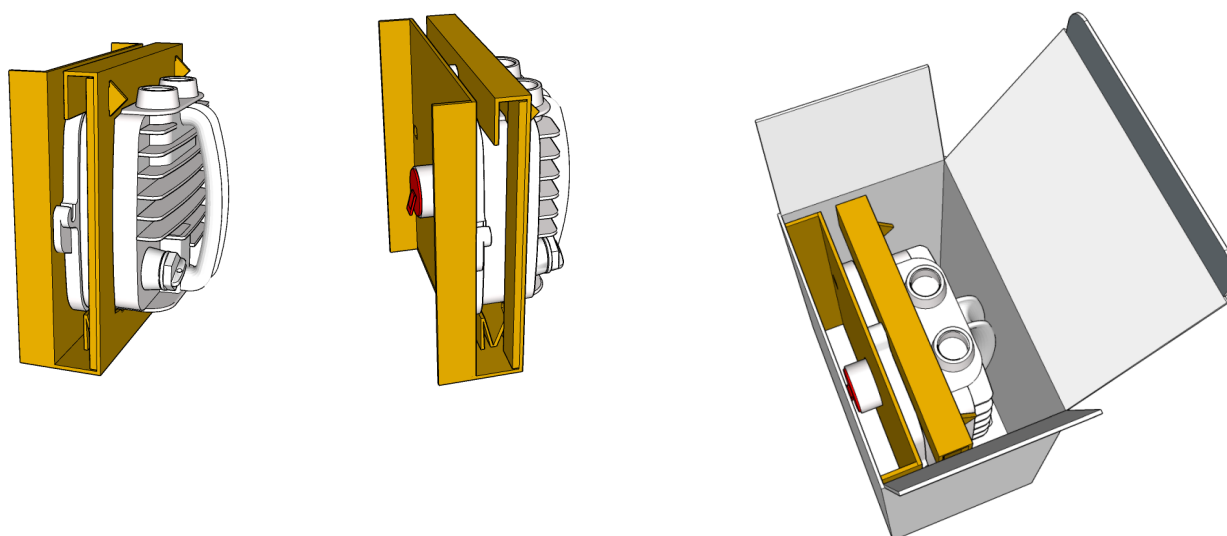


Fig. 1.20: Packaging the RAY3 unit

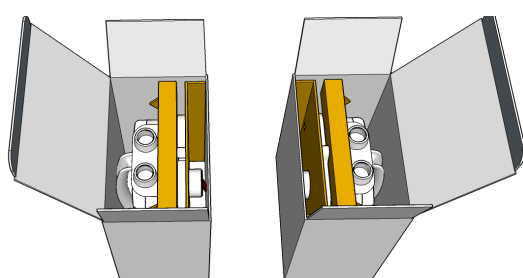


Fig. 1.21: Initial arrangement



Fig. 1.22: SILICONE GREASE capsule Ø45mm × 25mm



Note

Two separate boxes in the common package are turned such that both waveguides are heading to each other. It allows to automatically establish a link between delivered RAY3 units without unpacking them from the box. See *Quick Guide, step 4* or *Chapter 3, Step-by-step Guide*.

1.6.4. Supplied antennas

RAY3 units are ready for direct mounting to:

- LEAX-RAY Class 3 antennas (LEAX Arkivator Telecom²)
- Jirous Class 2 or Class 3 antennas (Jirous Antennas³)

Individual datasheets are accessible on RACOM website⁴.

Tab. 1.2: Overview of LEAX-RAY antennas

10, 11 GHz		17, 18 GHz		24 GHz	
diameter [m]	gain [dBi]	diameter [m]	gain [dBi]	diameter [m]	gain [dBi]
0.3	30.1	0.3	34.7	0.3	36.9
0.6	35.2	0.6	39.7	0.6	42.0
0.9	38.5	0.9	43.5	0.9	45.4
1.2	41.0	1.2	45.2	1.2	47.9

Tab. 1.3: Overview of Jirous Class 2 antennas

10, 11 GHz		17, 18 GHz		24 GHz	
diameter [m]	gain [dBi]	diameter [m]	gain [dBi]	diameter [m]	gain [dBi]
-	-	0.18	22.6	-	-
0.38	29.0	0.4	34.8	0.4	36.8
0.65	35.5	0.68	38.6	0.68	41.7
0.9	37.5	0.9	41.5	0.9	44.0
1.2	41.0	1.2	44.6	1.2	46.6

Jirous Class 3 antennas are available for RAY direct mounting as well. They have nearly identical sizes and gains as Jirous Class 2 antennas, but are a bit more expensive. RACOM does not keep those on stock and they are not available in our e-shop. Please order those directly from *Jirous Antennas*⁵.

Andrew (Class 2 or 3 or 4) or traditional Arkivator antennas or antennas from other suppliers can also be used, but require an *antenna mounting kit*. *Flexible waveguide* is a general-purpose option for any antenna usage. *Contact us*⁶ for available types and details.

² <http://www.leax-arkivator-telecom.com/>

³ <http://en.jirous.com/>

⁴ https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas

⁵ <http://en.jirous.com>

⁶ https://www.racom.eu/eng/about_us/contact.html

1.7. Ordering codes

All RAY3 models mentioned in this manual have their unique ordering codes described in following chapters. Available are also capacity keys, feature activation keys and accessories necessary to reach expected functionality of the link. All ordering codes are discussed in detail at *RACOM web*⁷, and are available for purchase at *RACOM E-shop*⁸.



Note

Please your supplier to ensure completeness of your product delivery for the individual link situation, applicable spectrum regulations, local security requirements, type of power sourcing, grounding, etc.



Important

RACOM does not have any responsibility for improper use of any offered device. It is customers full responsibility to check technical parameters of all ordered items and to use and configure them in accordance with their purpose. It is also customers full responsibility to respect all requirements applicable at the site of installation.

1.7.1. RAY units

RAY ordering codes begin with a string printed on *Production label* (9-11 characters long, lasting by „-L“ or „-U“). It defines HW parameters and factory settings which can not be changed later on (like working frequency, encryption HW acceleration, factory defaults and limitations built in to units in the factory like limitation of Tx power or prevention to use any form of encryption). Rest of the ordering code defines functionalities and options which could be added, erased or changed by a user later on (like SW feature key for initial capacity or an optional DC power adapter). For detailed description of the ordering code structure see *RACOM web*⁹.



Note

The proper pair of Lower (L) and Upper (U) units should be selected when ordering the microwave link. The difference between L and U code is only in default factory settings, which are different for each side of the link. Unit marked with L is set for transmission on lower frequency (and receive on higher one), while unit marked with U is set for transmission on higher frequency (and receive on lower one). This allows the link to be established without any initial manual settings – just by powering up both units at factory defaults (see *Quick Guide*).

1.7.2. Capacity keys

RAY units allow to pay only for purchased transmission capacity (pay as-you-grow concept). Activation keys could be purchased together with the unit or later at *RACOM E-shop*¹⁰. Each key is generated for specific S/N of the unit and the purchased capacity. It unlocks all combinations of channels and modulations up to the purchased capacity. Once installed, a specific feature or function of the unit is allowed. Feature keys could be erased or upgraded. See *Configuration / Feature keys* for more details.

⁷ <https://www.racom.eu/eng/products/microwave-link.html#order-codes>

⁸ <https://webservice-new.racom.eu/main/eshop.list>

⁹ <https://www.racom.eu/eng/products/microwave-link.html#order-codes>

¹⁰ <https://webservice-new.racom.eu/main/eshop.list>

For allowed combinations of channel width and modulation for transmitting channel see *Capacity SW keys table*¹¹. The Capacity feature key limit applies for transmitted data on the unit where the key is installed. For asymmetrical capacity keys could be different for each side of the link.

Several types of SW feature key are available for RAY units:

- Bundled capacity (ordered together with *RAY units* - see previous chapter)
- Separately purchased capacity feature keys (see below)
- Upgrade capacity feature keys (see below)



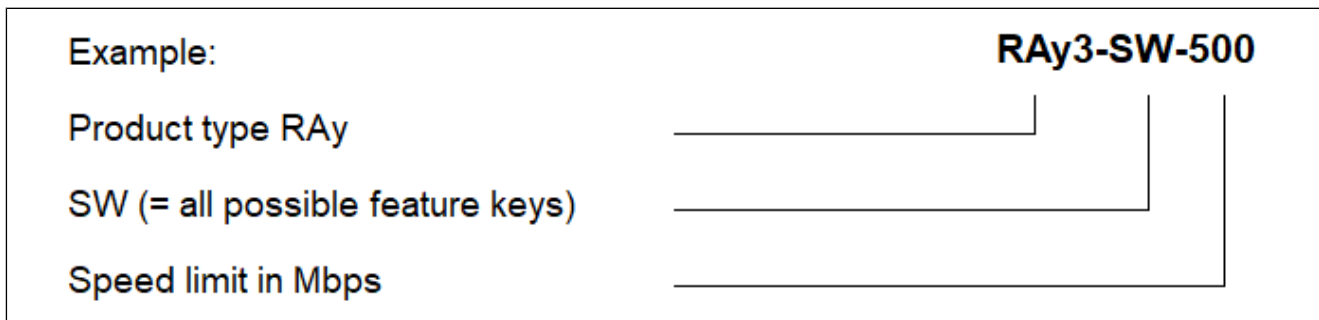
Note

RACOM is able to generate customer specific Capacity feature keys on special request.

Separately purchased capacity feature keys

Keys purchased separately and installed by user.

Tab. 1.4: Capacity keys code scheme

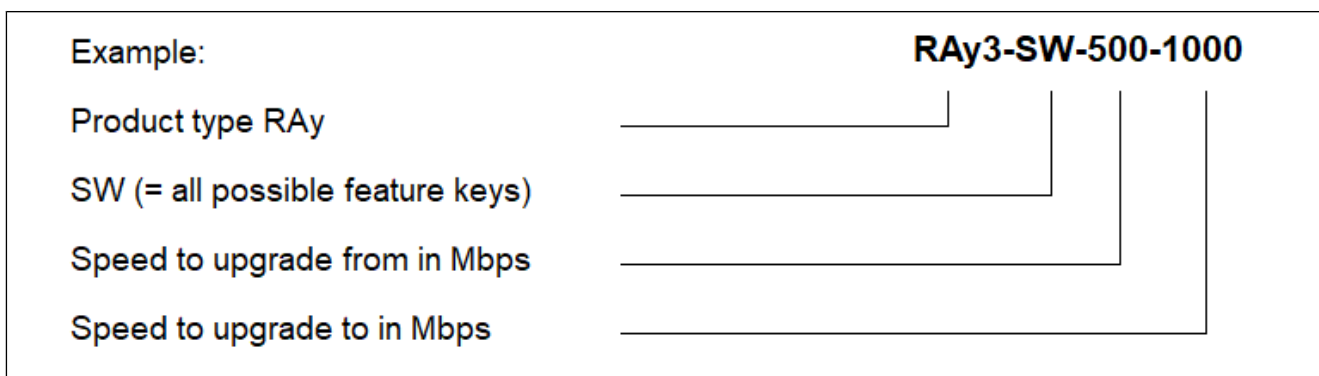


For available ordering codes see *RACOM web*¹².

Upgrade capacity feature keys

Keys purchased separately and installed by user.

Tab. 1.5: Upgrade keys code scheme



For available ordering codes see *RACOM web*¹³.

¹¹ <https://www.racom.eu/eng/products/microwave-link.html#scalability>
¹² <https://www.racom.eu/eng/products/microwave-link.html#order-codes>
¹³ <https://www.racom.eu/eng/products/microwave-link.html#order-codes>

1.7.3. Features activation

RAy units allow to pay only for purchased features (pay as-you-grow concept). Activation keys could be purchased together with the unit or later at *RACOM E-shop*¹⁴. Each key is generated for specific S/N of the unit and the purchased feature (or a set of features). Once installed, a specific feature or function of the unit is allowed. Feature keys could be erased or upgraded. See *Configuration / Feature keys* for more details.

Available feature activation keys are listed in following table:

RAy3		Ordering codes for other feature keys	
Ordering code	Meaning	Parameters	Example
RAy3-SW-TX-xyy	Limitation of Tx power	x: P = positive value N= negative value yy: value of limit in dBm	RAy3-SW-TX-N15 (limits Tx power to -15 dBm)

ver 1.0

1.7.4. Tested Accessories

Ordering codes for all accessories tested by RACOM to work properly with RAY units, are listed in *Section 2.1, "Overview "* and described in detail in *Section 2.2, "Details "* including full information where to buy them directly from original suppliers.

RACOM resells most of those on *RACOM E-shop*¹⁵ and are listed on *Accessories section*¹⁶ on RAY web sites.



Note

Accessories are necessary to be added to RAY units to allow a proper functionality of the whole microwave link. Please consult your supplier to ensure completeness of your product delivery for the individual link situation, spectrum regulations, local security requirements, type of power sourcing, grounding, etc.

¹⁴ <https://webservice-new.racom.eu/main/eshop.list>

¹⁵ <https://webservice-new.racom.eu/main/eshop.list>

¹⁶ <https://www.racom.eu/eng/products/microwave-link.html#accessories>

2. Accessories

RACOM offers a complete set of accessories to operate RAY microwave units in all relevant use-cases and environments. All accessories are selected and thoroughly tested by RACOM for compatibility and are guaranteed to function with RAY units. It is possible to use other components with same or similar functionality and temperature range, but RACOM cannot guarantee they will be completely compatible with RAY units.



Important

It is strongly recommended to double-check the mains voltage and local installation standards before purchasing accessories to ensure they comply with the accessory specifications and that all safety regulations are complied with.

In particular, we recommend that you consult your local specialists for grounding, voltage spikes, overvoltage protection and other equipment, ensuring a proper installation. For more information see *Section 4.5, “Grounding and overvoltage protection”*.

Units and accessories should be installed by trained professionals (see *Section 10.3, “Professional installation”*).

The warranty does not apply to units damaged by voltage spikes or surges (see *Section 10.6, “Warranty”*).

Ordering codes relevant for RAY3 are listed in following *Section 2.1, “Overview ”* and on *RAY web pages*¹ and can be purchased on *RACOM e-shop*². Detailed information about all accessories tested by RACOM (more than offered on *RACOM e-shop*³) including part numbers of original manufacturers are described in *Section 2.2, “Details ”*.

Following 3 marks near RACOM Part Numbers are used in chapters 2.1 and 2.2:

Part.No *	Items added or modified during year 2019.
(Part.No)	Items which are going to be phased out from pricebook during 2019.
[Part.No]	Items which are compatible and tested with RAY units, but are NOT available in RACOM e-shop and are NOT kept on stock (longer delivery time has to be expected).

2.1. Overview

List below contains all accessories tested by RACOM for proper functionality with RAY3, grouped by categories.

RACOM-PART-NUMBER	Short description
Antennas LEAX-RAY (LEAX Arkivator Telecom)	
ANT-LEAX-RAY-300-10/11	Antenna 0.3m, 10/11GHz, 30.1dBi, with holder, Class2, Leax
ANT-LEAX-RAY-600-10/11	Antenna 0.6m, 10/11GHz, 35.2dBi, with holder, Class3, Leax
ANT-LEAX-RAY-900-10/11	Antenna 0.9m, 10/11GHz, 38.5dBi, with holder, Class3, Leax

¹ <https://www.racom.eu/eng/products/microwave-link.html#accessories>

² <https://webservice-new.racom.eu/main/>

³ <https://webservice-new.racom.eu/main/>

ANT-LEAX-RAy-1200-10/11	Antenna 1.2m, 10/11GHz, 41.0dBi, with holder, Class3, Leax
ANT-LEAX-RAy-300-17/18	Antenna 0.3m, 17/18GHz, 34.7dBi, with holder, Class3, Leax
ANT-LEAX-RAy-600-17/18	Antenna 0.6m, 17/18GHz, 39.7dBi, with holder, Class3, Leax
ANT-LEAX-RAy-900-17/18	Antenna 0.9m, 17/18GHz, 43.5dBi, with holder, Class3, Leax
ANT-LEAX-RAy-1200-17/18	Antenna 1.2m, 17/18GHz, 45.2dBi, with holder, Class3, Leax
ANT-LEAX-RAy-300-24	Antenna 0.3m, 24GHz, 36.9dBi, with holder, Class3, Leax
ANT-LEAX-RAy-600-24	Antenna 0.6m, 24GHz, 42.0dBi, with holder, Class3, Leax
ANT-LEAX-RAy-900-24	Antenna 0.9m, 24GHz, 45.4dBi, with holder, Class3, Leax
ANT-LEAX-RAy-1200-24	Antenna 1.2m, 24GHz, 47.9dBi, with holder, Class3, Leax
ANT-LEAX-RAy-900-STRUT	Antenna wind strut for LEAX-RAy 0.9 m antennas, Leax
ANT-LEAX-RAy-1200-STRUT	Antenna wind strut for LEAX-RAy 1.2 m antennas, Leax

Antennas Jirous (Jirous Antennas)

ANT-JRMA-380-10/11R	Antenna 0.38m, 10/11GHz, 29.0dBi, with holder, Class2, Jirous
ANT-JRMA-650-10/11R	Antenna 0.65m, 10/11GHz, 35.5dBi, with holder, Class2, Jirous
ANT-JRMB-900-10/11R	Antenna 0.9m, 10/11GHz, 37.5dBi, with holder, Class2, Jirous
ANT-JRMB-1200-10/11R	Antenna 1.2m, 10/11GHz, 41.0dBi, with holder, Class2, Jirous
ANT-JCMA-180-17R	Antenna small 0.18m, 17 GHz, 22.6dBi, with holder, Jirous
ANT-JRMB-400-17R	Antenna 0.4m, 17/18GHz, 34.8dBi, with holder, Class2, Jirous
ANT-JRMB-680-17R	Antenna 0.68m, 17/18GHz, 38.6dBi, with holder, Class2, Jirous
ANT-JRMB-900-17R	Antenna 0.9m, 17/18GHz, 41.5dBi, with holder, Class2, Jirous
ANT-JRMB-1200-17R	Antenna 1.2m, 17/18GHz, 44.6dBi, with holder, Class2, Jirous
ANT-JRMB-400-24R	Antenna 0.4m, 24GHz, 36.8dBi, with holder, Class2, Jirous
ANT-JRMB-680-24R	Antenna 0.68m, 24GHz, 41.7dBi, with holder, Class2, Jirous
ANT-JRMB-900-24R	Antenna 0.9m, 24GHz, 44.0dBi, with holder, Class2, Jirous
ANT-JRMB-1200-24R	Antenna 1.2m, 24GHz, 46.6 dBi, with holder, Class2, Jirous
ANT-JRMB-1200-STRUT-F	Antenna wind strut, fixed, for Jirous 1.2 m antennas, Jirous
ANT-JRMB-1200-STRUT-A	Antenna wind strut, adjustable, for Jirous 1.2 m antennas, Jirous

Antenna adapters (mounting kits)

ANT-ANW-KIT-10/11	Antenna adapter RAY, 10/11 GHz, for Andrew 30,60,80,100 cm
ANT-ANW-KIT-17/18	Antenna adapter RAY, 17/18 GHz, for Andrew 30,60,80,100 cm
ANT-ANW-KIT-24	Antenna adapter RAY, 24 GHz, for Andrew 30,60,80,100 cm
ANT-ARK-KIT-10/11	Antenna adapter RAY, 10/11 GHz, for Arkivator 30,60,90,120 cm
ANT-ARK-KIT-17/18	Antenna adapter RAY, 17/18 GHz, for Arkivator 30,60,90,120 cm
ANT-ARK-KIT-24	Antenna adapter RAY, 24 GHz, for Arkivator 30,60,90,120 cm
ANT-FX-R100-KIT-10/11	Antenna flexible waveguide flange, RAY, R100, 10/11 GHz
ANT-FX-R120-KIT-10/11	Antenna flexible waveguide flange, RAY, R120, 10/11 GHz

Powering

PWS-AC/PoE-ACT	Power supply Active PoE, 90-264VAC/33W/1Gb, Pihong
PWS-DC/PoE-ACT	Power supply Active PoE, 36-72VDC/33W/1Gb, Pihong
PWS-HOL-PHIHONG	Power supply DIN rail holder for PoE Pihong

PWS-AC/PoE-PAS	Power supply Passive PoE, 100-240VAC/50W/1Gb/protected, IMCO Power
[PWS-AC/PoE-PAS-BAT *]	Power supply Pas. PoE, 100-240VAC/70W/1Gb/p., 15' battery, IMCO Power
PWS-DC/PoE-PAS	Power supply Pas. PoE injector, 8-56VDC/1.4A/1Gb/protected, IMCO Power
[PWS-DC/PoE-PAS-ODU *]	Power supply Pas. PoE inj., ODU, max 56VDC/1.4A/1Gb/p., IMCO Power
PWS-AC,DC/27VDC/37W	Pow. sup. DC, 88-264VAC,124-370VDC/27VDC/37W, Batt. charg., MeanWell
OTH-DC/RJ45	Adapter for DC power, Terminals to RJ45, RAY3
(SET-DC/RJ45-EXT35)	DC power adapter + Bushing extension 35 mm, RAY3

Grounding

GND-RAY	Grounding kit for mast, RAY
GND-CAT7	Grounding kit for Cat7 cable, Quesy
GND-CAB-UNI	Grounding kit universal for cables 5-11mm, FIMO

Surge protection

SURGE-ETH	Surge protection 1Gb Eth, PoE transparent, LPZ0B-LPZ1, Saltek
SURGE-DC	Surge protection DC 24V, LPZ1-LPZ2, Saltek

Cables and connectors

CAB-CAT5e	Cable Cat5e, outdoor, FTP, 4×(2×24AWG), Teldor
CAB-CAT7	Cable Cat7, outdoor, S/FTP, 4×(2×23AWG)+2×(2×24AWG), Pewtronic
CON-RJ45-CAT6	Connector RJ45, Cat6, Cat5e, AWG24, Ubiquity
CON-RJ45-CAT7	Connector RJ45, Cat7,Cat6a,Cat5e, AWG24-22, Telegärtner
(SET-TLG-EXT35)	Connector RJ45 Telegärtner + Bushing extension 35 mm
CAB-2F-DC-15m	Fibre hybrid patch cord, DC+2 fibres, SM, LC/LC, 15m, OFA
[CAB-2F-5m]	Fibre patch cord, 2 fibres, SM, LC/LC, 5m, OFA
CAB-DC-2×1.5	Cable for DC power, 2×1.5mm, Silicon, ProPS

USB adapters

OTH-USB/WIFI-W2	Adapter USB/Wifi for RAY, Ogemray
OTH-USB/ETH-XA	Adapter USB/ETH, Axagon

SFP modules

SFP-2F-1G-EDGE *	SFP module, 2 fibres, SM, LC, 20 km, EDGE
(SFP-2F-1G-APAC)	SFP module, 2 fibres, SM, LC, 10 km, APAC Opto
SFP-RJ45-1G-AVAGO	SFP module, 1 Gb Ethernet, RJ45, Avago

Accessory kits

ACS-RAY3 *	Accessory set shipped with every RAY3 unit
SET-BUSH65 *	Extended Cable bushing PG21, 65 mm + Accessories
(OTH-BUSH-EXT35)	Extension of the PG21 bushing, metal, 35 mm
OTH-BUSH-EXT500	Extension of the PG21 bushing, flexi, polyamide, 500 mm, Interflex

2.2. Details

Antennas for direct mounting of RAY unit (LEAX-RAY + Jirous)

All models of LEAX-RAY and Jirous antennas allow direct mounting of RAY unit.

- *Antennas overview*
- *Dimensions, gains*
- *List of datasheets*⁴
- *Installation*
- orig. part no LEAX-RAY: HAEffdd61-R1A, where ff = frequency (11, 18, 26) and dd = diameter (03, 06, 09, 12), Note: minimum order quantity = one full palette.
- orig. part no Jirous: JRMx-ddd-ff-R, where x = generation+class (A, B, C, D), ddd = diameter (380, 400, 680, 900, 1200) and ff = frequency (10/11, 17, 24)

A radio link calculation should be performed to determine appropriate antenna size (use our *on-line calculator*⁵ or *RAY-Tools application* for smartphones).

Antenna struts (LEAX-RAY + Jirous)

Bigger antennas (0.9 + 1.2 m) installed at windy sites (wind speed above 50 m/s) require installation of additional struts both for LEAX-RAY and Jirous – see *Section 2.1, “Overview ”* for items to quote and *Section 4.2.1, “LEAX-RAY antenna mounting”* or *Section 4.2.2, “Jirous antennas mounting”* for installation details.

Antenna mounting kit (for Andrew, Arkivator, Alcoma and others)

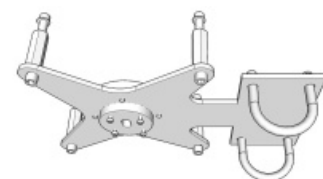
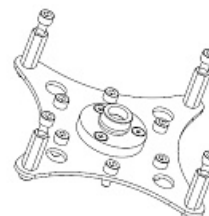
Adapters for direct mounting to different antennas. Types for different frequency bands (10/11, 17/18, 24 GHz), different antenna sizes and different manufacturers. *Contact us*⁶ for available types and details.

- *Mounting kit overview*
- *More information*

Flexible waveguide mounting kit (for other antennas)

RAY units can be attached to any antenna using flexible waveguide. Mounting kits to mount RAY unit to the mast and attach flexible waveguide are provided by RACOM. Two types of flexible waveguide flanges are supported: R100 and R120.

- *Mounting kit overview*
- *More information*



⁴ https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas

⁵ <https://www.racom.eu/eng/products/microwave-link.html#calculation>

⁶ https://www.racom.eu/eng/about_us/contact.html

Powering

- **PWS-AC/PoE-ACT**

RAY unit PoE power supply according to IEEE 802.3at,
 1× Eth PoE output 56 V / 33.6 W, 4 wires
 Input 100 to 240 VAC, -20/+50°C, no SNMP, Pihong
 ○ *Datasheet AC*⁷
 ○ orig. part no: POE36U-1AT



- **PWS-DC/PoE-ACT**

RAY unit PoE power supply according to IEEE 802.3at,
 1× Eth PoE output 56 V / 33.6 W, 4 wires
 Input 36 to 72 VDC / 1.2A, -20/+50°C, no SNMP, Pihong
 ○ *Datasheet DC*⁸
 ○ orig. part no: POE36D-1AT

- **PWS-HOL-PHIHONG**

DIN rail holder for PWS-AC/PoE-ACT or PWS-DC/PoE-ACT
 PoE power supply not included - needs to be ordered separately



- **PWS-AC/PoE-PAS**

Power supply including passive PoE injector 1Gb Eth
 surge protection, overcurrent fuse
 PoE output 55.2 V, max 0.9 A
 input 100 to 240V / 55W
 temp -25/+60°C; DIN rail, IMCO Power
 ○ *Datasheet*⁹
 ○ orig. part no: ALC01.H 5501 PoE (EV003096, IP.2121.633.55)



- **[PWS-AC/PoE-PAS-BAT *]**

Power supply with built-in 15' LiFePO4 battery and passive PoE
 injector 1Gb Eth
 surge protection, overcurrent fuse
 PoE output 55.2V, max 0.7A (38W)
 input 100 to 240V / 70W
 temp -25/+60°C; DIN rail, IMCO Power
 ○ *Datasheet*¹⁰
 ○ orig. part no: PS70.H 12550601B PoE (IP.4122.633.139)



Note

Item is NOT available on RACOM e-shop and it is NOT kept on RACOM stock. Longer delivery time has to be expected.

⁷ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/PWS-AC_PoE-ACT.pdf

⁸ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/PWS-DC_PoE-ACT.pdf

⁹ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/PWS-AC_PoE-PAS.pdf

¹⁰ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/PWS-AC_PoE-PAS.pdf

- **PWS-DC/PoE-PAS**

- PoE passive injector 1Gb Eth, max 1.4A surge protection, overcurrent fuse (1.5A) input 21 to 56 VDC (voltage to operate with RAY3) temp -30/+60°C; DIN rail; IMCO Power
- *Datasheet*¹¹
 - orig. part no: PoE.H 1Gb (EV003391, IP.8421.633.15)



- **[PWS-DC/PoE-PAS-ODU *]**

- PoE passive injector 1Gb Eth in outdoor box, max 1.4A surge protection, overcurrent fuse (1.5A) input 21 to 56 VDC (voltage to operate with RAY3) temp -30/+60°C; mast mount, IMCO Power (item is electronically identical to PWS-DC/PoE-PAS)
- *Datasheet*¹²
 - orig. part no: PoE.M 1Gb IP67 (IP.8421.033.18)

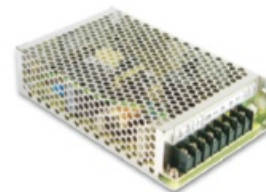


Note

Item is NOT available on RACOM e-shop and it is NOT kept on RACOM stock. Longer delivery time has to be expected.

- **PWS-AC,DC/27VDC/37W**

- RAY unit DC power supply 37 W with free air cooling (50 W with fan) Output 27.6 V DC, optional battery support with UPS function Input 90-260 V AC, -10/+50°C, MeanWell
- *Datasheet*¹³
 - orig. part no: AD-55B



- **OTH-DC/RJ45**

- Connector for DC power cable to be plugged directly to the RAY3 RJ45 PoE input
100% passive component
DC power is delivered through all 8 wires on RJ45. Internal wiring:
- One DC contact ... RJ45 pins: 1,2,4,5
 - Second DC contact ... RJ45 pins: 3,6,7,8
- RAY3 works with any DC polarity.
- *Datasheet*¹⁴



Manufactured by RACOM.



Note

Extended (65 mm) Cable bushing PG21 (see updated ACS-RAY3 or new SET-BUSH65) is recommended to be used to hide this DC adapter in to a bushing.

¹¹ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/PWS-DC_PoE-PAS.pdf

¹² https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/PWS-AC_PoE-PAS-ODU.pdf

¹³ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/PWS-AC-DC-27VDC-37W.pdf

¹⁴ https://www.racom.eu/download/hw/ray/free/cz/07_prislusenstvi/OTH-DC-RJ45.pdf

- **(SET-DC/RJ45-EXT35)**
Set DC-RJ45 adapter and cable bushing lengthening (35mm) for RAY3



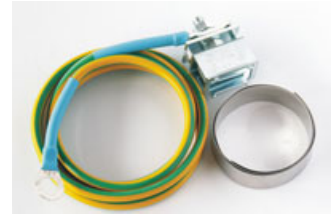
Note

Lengthening is no more required when Extended Cable bushing PG21 (65 mm) is used (see updated ACS-RAY3 or new SET-BUSH65).



Grounding

- **GND-RAY**
RAY grounding set for grounding RAY equipment to the mast. Contains a ZSA16 grounding terminal, grounding tape and a cable with grounding lugs.
Detail see *Grounding*
o *Datasheet*¹⁵
- **GND-CAT7**
Grounding kit for Cat.7 S/FTP 4×(2×23 AWG) cable, Quesy
Detail see *Grounding*
o *Datasheet*¹⁶



- **GND-CAB-UNI**
Grounding Kit universal for 5-11mm cables, FIMO
Suitable for Ethernet CAT5e + CAT6 cables and for shielded DC cables
o *Datasheet*¹⁷
o orig. part no: 6115050001



Surge protection

- **SURGE-ETH**
Protection from the voltage spikes for zones LPZ0B - LPZ1
1× 1 Gb Ethernet, RJ45 connectors
DIN rail mounting
IP20, -40/+80°C, Saltek
o *Datasheet*¹⁸
o orig. part no: DL-1G-RJ45-POE-AB



¹⁵ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/GND-RAY.pdf
¹⁶ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/GND-CAT7.pdf
¹⁷ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/GND-CAB-UNI.pdf
¹⁸ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/SURGE-ETH.pdf

- **SURGE-DC**

- Protection from the voltage spikes for zones LPZ1-LPZ2
- 24 V (both wires), max 16 A, DC terminals 2 × 2.5 mm²
- DIN rail mounting
- IP20, -40/+80°C, Saltek
 - *Datasheet*¹⁹
 - orig. part no: DP-024



Eth connectors and cables

- **CON-RJ45-CAT6**

- STP RJ45 /Cat6 / 8p8c / wire/ gold plated/ AWG24, UBNT
 - orig. part no: TC-CON connector STP RJ45



- **CON-RJ45-CAT7**

- Connector RJ45, AWG 24-22, Telegärtner
- Suitable for Cat5e, Cat6A, Cat7 cables
 - *Datasheet*²⁰
 - orig. part no: Telegärtner MFP8 Cat.6A AWG 22-27

**Note**

Extended (65 mm) Cable bushing PG21 (see updated ACS-RAY3 or new SET-BUSH65) is recommended to be used to hide this Eth connector in to a bushing.

- **(SET-TLG-EXT35)**

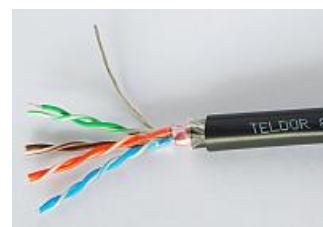
- Connector RJ45, Telegärtner + RACOM OTH-BUSH-EXT35
- Set RJ45 connector (Telegärtner) and cable bushing lengthening (35mm). Suitable for AWG24-22 (Cat5e, Cat6A, Cat7) cables.
 - *Datasheet*²¹
 - orig. part no: Telegärtner MFP8 Cat.6A AWG 22-27

**Note**

Lengthening is no more required when Extended Cable bushing PG21 (65 mm) is used (see updated ACS-RAY3 or new SET-BUSH65).

- **CAB-CAT5e**

- Cat.5e Ethernet cable for connecting RAY units to the network, outdoor,
- UV protected, -40°C to +70°C, TELDOR
 - *Datasheet*²²
 - orig. part no: PLU030078



¹⁹ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/SURGE-DC.pdf

²⁰ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CON-RJ45-CAT7.pdf

²¹ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CON-RJ45-CAT7.pdf

²² https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CAB-CAT5e.pdf

- **CAB-CAT7**

Cat.7 Ethernet cable for connecting RAY units to the network, outdoor, UV protected, -30°C to +70°C, PEWTRONIC Ltd.

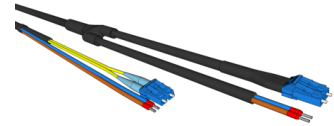
- *Datasheet*²³
- orig. part no: S / FTP 4× (2×23AWG) Cat.7 + 2× (2×24 AWG)



- **CAB-2F-DC-15m** (and other hybrid cables)

Hybrid fibre + DC cable, 15m long, upper end terminated for easy installation in to RAY2 and RAY3

- DC: 2×1.5mm²
- fibre: patchcord, 2-fibres, single mode, LC-connector - LC-connector
- *Datasheet*²⁴
- orig. part no: DLCHRAC2F015



Note

- Upper end of fibre part of the cable is terminated for the use of 35mm RAY bushings (part of ACS-RAY3). Upper end of DC cable requires for RAY3 usage of DC/RJ45 adapter (Part.No. OTH-DC/RJ45) and 65mm RAY bushings (part of ACS-RAY3 or SET-BUSH65).
- Other cable lengths and/or different number of fibres inside the cable or other types of terminals are available from OFA company (located in Czech Republic). Exact ordering codes for all variants are specified in the OFA *datasheet*²⁵.

- [**CAB-2F-5m** (and other fibre cables)]

Fibre cable, 5m long, upper end terminated for easy installation in to RAY2 and RAY3

- *Datasheet*²⁶
- orig. part no: DLCRAC2F005



Note

- Item is NOT available on RACOM e-shop and it is NOT kept on RACOM stock. Longer delivery time has to be expected.
- Upper end of fibre cable is terminated for 35mm RAY bushings (part of ACS-RAY3).
- Other cable lengths and/or different number of fibres inside the cable or other types of terminals are available from OFA company (located in Czech Republic). Exact ordering codes for all variants are specified in the OFA *Datasheet*²⁷.

²³ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CAB-CAT7.pdf

²⁴ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CAB-2F-DC.pdf

²⁵ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CAB-2F-DC.pdf

²⁶ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CAB-2F-1F.pdf

²⁷ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CAB-2F-1F.pdf

- **CAB-DC-2x1.5**
DC cable with silicone rubber, 2×1.5 mm², -55 to +180°C, ProPS
 - *Datasheet*²⁸
 - orig. part no: V05SS-F 2Dx1.50



USB adapters

- **OTH-USB/WIFI-W2**
(Shipped with every RAY3 unit - plugged in to slot "S")
USB WiFi adapter for service access to the management interface, Antenna Alignment Tool and RAY Tools smartphone application. The unit provides a built-in DHCP server. To access the unit, use by default the IP 172.17.17.17 for management and the *http://172.17.17.17/tk* for Antenna Alignment Tool.



Note

It is strongly recommended that you order this component through RACOM to ensure the WiFi chip model and version is supported by RAY firmware. RACOM cannot accept any responsibility for any issues arising from the use of non-RACOM approved WiFi adapters.

- **OTH-USB/ETH-XA**
Ethernet adapter for service access to the web interface via USB connector. RAY3 provides a built-in DHCP server with up to 6 leases. To access the RAY3 use by default the IP 172.17.17.17.



SFP modules

- **SFP-2F-1G-EDGE ***
SFP module, 2 fibres, SM, LC, 20km, -40°C to +85°C, EDGE
 - *Datasheet*²⁹
 - orig. part no: 1.25G-SFP-20DI-MS



Note

For OFA fibre cables CAB-2F-DC-XXm or CAB-2F-XXm connected to this SFP module the short (35 mm) Cable bushing PG21 (shipped with every unit as an item ACS-RAY3) is recommended to be used.

For other fibre cables and other SFP modules the length of Cable bushing PG21 has to be chosen according the length of the SFP module and the length of fibre connector.

²⁸ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CAB-DC-2x1.pdf

²⁹ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/SFP-2F-1G-EDGE.pdf

- (**SFP-2F-1G-APAC**)

SFP module, 2-fibres, LC, 10km, -40°C to +85°C, APAC Opto

- *Datasheet*³⁰

- orig. part no: LS38-C3S-TI-N-DD

(this module is replaced by a new module SFP-2F-1G-EDGE since November 2019)



- **SFP-RJ45-1G-AVAGO**

SFP module, RJ45 interface, -40°C to +85°C, Avago

- *Datasheet*³¹

- orig. part no: ABCU-5730ARZ



Note

Extended (65 mm) Cable bushing PG21 (see updated ACS-RAY3 or new SET-BUSH65) is recommended to be used to hide both the SFP module and the Eth connector in to a bushing.

Accessory kits

- **ACS-RAY3***

RAY3 supplied accessories - basic set of cable bushings and connectors (shipped with every RAY3 unit)

- 2 pc standard PG21 cable bushing (35mm)
- 1 pc extended PG21 cable bushing (65 mm) - shipped from IX/2019
- 2 pc PG21 nut
- 1 pc blind plug cover
- 2 pc O-ring
- 2 pc rubber sealing small diameter
- 2 pc rubber sealing medium diameter
- 2 pc rubber sealing big diameter
- 1 pc RJ-45 Ethernet connector
- 1 capsule of Silicone grease for 2 units



Manufactured by RACOM.



Note

- 1 pc of extended 65mm bushing is part of RAY accessory kit starting IX/2019.

³⁰ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/SFP-2F-1G-APAC.pdf

³¹ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/SFP-RJ45-1G-AVAGO.pdf

- **SET-BUSH65 ***

Extended Cable bushing PG21 (65 mm inner space) set:

- 1 pc Extended Cable bushing PG21 (65 mm)
- 1 pc Cable nut PG21
- 1 pc O-ring
- 1 pc rubber sealing small diameter
- 1 pc rubber sealing big diameter
- 1 pc rubber sealing big diameter

Manufactured by RACOM.

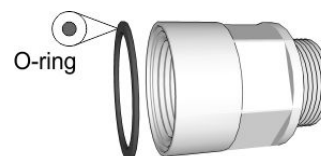


Note

- Item is needed when standard bushing is not long enough to cover e.g. *DC power adapter* or *Telegärtner RJ45 connector* or *SFP module* for Metallic Ethernet.
- This item replaces functionality provided by OTH-BUSH-EXT35.

- **(OTH-BUSH-EXT35)**

Cable bushing lengthening, PG21, 35 mm
O-ring



Note

Lengthening is no more required when Extended Cable bushing PG21 (65 mm) is used (see updated ACS-RAY3 or new SET-BUSH65).

- **OTH-BUSH-EXT500**

Cable bushing lengthening, PG21, Flexi, 50cm

- *Datasheet*³²
- orig. part no:
PA6-23N, RKG-23P21N, RKF-23P21N,
2×ORC-23, set REVELET
flat ring FSN-P21



Important

Use the flat ring at the outer end of the long lengthening, see *Connectors assembly*.

³² https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/OTH-BUSH-EXT500.pdf

Latest on-line descriptions

See www.racom.eu, Microwave link, *Accessories*³³.

E-shop

Easiest way to order accessories is *RACOM E-shop*³⁴.



Tip

Use there a search engine Ctrl+F and RACOM-PART-NUMBER of the searched item.

³³ <https://www.racom.eu/eng/products/microwave-link.html#accessories>

³⁴ <https://webservice-new.racom.eu/main/eshop.list?a=1&t=10>

3. Step-by-step Guide

The following chapters will guide you step by step through preparation, installation and activation of the RAY3 link:

- Pre-installation check out
- *Installation* (Chapter 4.)
- *Advanced configuration* (Chapter 5.)
- *Troubleshooting* (Chapter 8.)

Pre-installation Checklist

Default settings for *L* and *U* units are chosen to allow delivered units to automatically establish a link without unpacking RAY3 units from the box. It is enough to open the boxes and power both RAY units up (by PoE or DC power supplies). It allows users to comfortably set up basic parameters necessary for the installation in the lab and thus shorten the time on the tower or roof to a minimum. Following text provides a guide how to optimally arrange the workplace, how to setup the link and which parameters are good to be set up before the installation outside.

Default factory settings define the initial link to be established on the most narrow channel, strongest modulation and lowest available Tx power (in RAY3 case those are 3.5 MHz channel, QPSK_S modulation and Tx power = -30 dBm). Complete default settings are described in section 10 Technical parameters.



Note

RAY3 default factory settings allow to install both units on the mast and establish the short link without prior manual configuration. Just the distance has to be very short due to Tx power set to the minimum for the unit (-30 dBm on RAY3-17 and RAY3-24). Typically, Tx power has to be increased to a reasonable level (or even to a maximum) before link alignment.

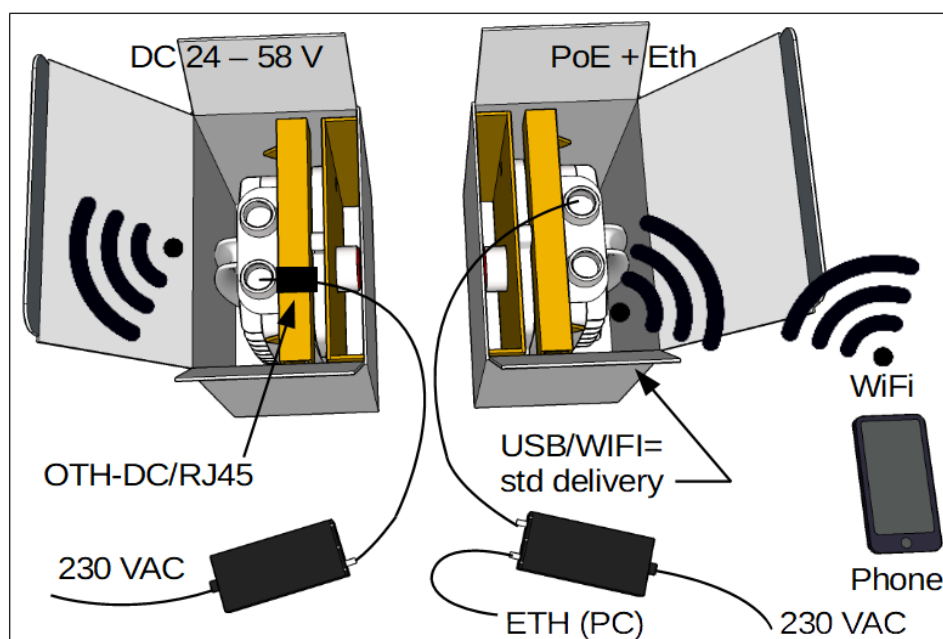


Fig. 3.1: Workplace for link testing and configuration

Take the following steps to link together both delivered RAY3 units and to establish a connection between them and PC or tablet or mobile and perform a basic setup:

- Open both boxes and double check that both RAY3 units are turned OK, so waveguides are heading to each other.
- Connect power sources (PoE or DC) to both RAY3 units (using slot ETH1+POE).
- Wait about 30 seconds until both units boot up and the link is established. The green light should be visible on both units through transparent plug on slot “S”. Until a WiFi password is set, red light periodically flashes together with green light - see *Section 1.5, “Status LED (S)”*.
- Connect by WiFi or by Ethernet cable (plugged in to LAN input on PoE power supply or in to Eth port on USB/ETH adapter) to one of those two units. Units linked together allow effectively set all IP addresses, passwords, security keys, feature keys, users, etc. from one side of the link.
 - If WiFi is used, then just select which WiFi to connect to. IP address of your PC or laptop is set automatically by DHCP.
 - If Eth over USB port is used (through USB/ETH adapter OTH-USB/ETH-XA), IP address of your PC or laptop is set automatically by DHCP as well.
 - If Eth connection to one of data ports on RAY3 (ETH1 or ETH2) is used, then the IP address on your PC or laptop has to be set manually to establish a working connection. See Quick Guide for the complete list of IP addresses to use.
 - Enter a web management of the unit and configure everything you like to change to be ready for outside installation. Following parameters are typically set in this phase:
 - IP addresses and VLANs
 - passwords
 - security keys
 - feature keys
 - users
 - WiFi password and behavior
 - Tx and Rx frequencies (if known in advance)
 - Higher Tx power (to be ready for antenna alignment) – see section “Important” below



Note

- This setup can be used for link configuration, however full radio performance can't be expected (high modulations, full Tx power range, etc.) because standard conditions between units (antenna interface, polarization planes, free space attenuation) are not met inside the box.
- High TX power does not lead to better RX signal quality, because the receiver input can be saturated with too strong signal - see *Overexcited receiver*.
- Until a WiFi password is set, red light periodically flashes together with green light - see *Section 1.5, “Status LED (S)”*.



Important

- Maximum secure Tx power for RAY units inside the box is 0 dBm. Higher Tx power risks the damage of sensitive input circuits!
- If you need to configure higher Tx power to be ready for antenna alignment during installation on the mast, you first have to turn units in to position where waveguides are not heading to each other, so reasonable attenuation is ensured. Secure is for example to put RAY units

- in parallel in to a direction without any metal material in front of the microwave beams (it could reflect waves back to units).
- Maximum time units can be powered up inside the box is 10 minutes (standard room temperature expected). Longer time may lead to the unit overheat! If more time is needed for configuration, units have to be unpacked from boxes.

3.1. Service access

The RAY3 link is supplied with a default configuration of access parameters:

For Ethernet access through RJ45 or SFP ports:

- Unit L has the service IP address 192.168.169.169 and mask 255.255.255.0
- Unit U has the service IP address 192.168.169.170 and mask 255.255.255.0

For WiFi or Ethernet access via USB/WiFi or USB/ETH adapter:

- Both units have service IP address 172.17.17.17 and mask 255.255.255.0

For Ethernet access through RJ45 or SFP ports an IP address has to be set on your PC that is within the mask, e.g. 192.168.169.180. For WiFi or USB/ETH access an IP address for laptop or mobile or tablet is set automatically by DHCP (enabled by default).

Then open the HTTP or HTTPS configuration interface, e.g. <https://192.168.169.169> or <http://172.17.17.17>

Access is allowed over HTTP, HTTPS or SSH.

The default username is "admin" and the password is also "admin" (it is strongly recommended to change it).

See *Configuration / Link settings / Service access / USB accessories* chapter for detailed information.

The Antenna Alignment Web Tool can also be used for antenna direction alignment. It can be accessed via a web browser utilizing IP addresses with „/tk“ at the end (e.g. <http://172.17.17.17/tk> for WiFi or USB/ETH adapter or <http://192.168.169.169/tk> or <http://192.168.169.168/tk> for ETH1/ETH2 ports).

When connection has been established, use the *Service access* menu to customize access parameters.

Default management IP addresses should be replaced with well-chosen operating addresses. Default can lead to network problems later.

The menu contains parameters for the entire link, both for the Local and remote Peer units. If a connection has been established, both sets of parameters have been set. While working with an isolated unit, only Local parameters are functional for the currently connected unit.



Note

If the link is **OK** and there are no parameters shown of the station **Peer**, it is necessary to click on **Refresh**.

Follows the description of basic settings. Pictures in following sections show default factory settings for L unit and RC info "rcinfo20_250_default:XXX". Default settings for unit U (for opposite side of the link) would be adequately exchanged. Values for other RCinfo may be different as well (differences typically refer to frequencies and Tx power as they are allowed by authorities for the actual band and a region).

After entering values on the screen always save the content by clicking on **Apply**.



Note

If there is any problem with HTTPS certificate after completing the firmware upgrade, please see the Annex *Https certificate* for further steps.

3.1.1. Choosing right band according the country of use

Menu Tools / Maintenance / Radio adaptation

First step is to set the right set of rules for the band according the region or country of use, so the unit is compliant with the local regulation. Go to the menu according the picture below and set parameter RCINFO accordingly.

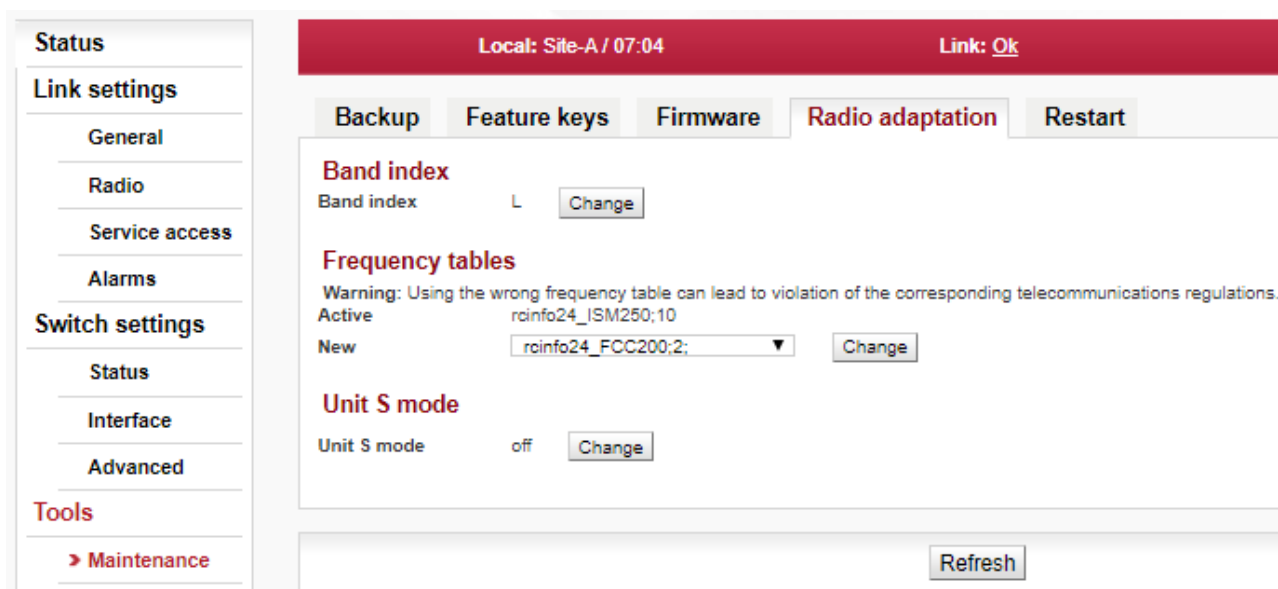


Fig. 3.2: Menu Tools / Radio adaptation

For full explanation of all possibilities of this screen see *the section called "Radio adaptation"*.

3.1.2. Setting units name and location

Menu Link settings / General

Not necessary settings. Anyhow it is beneficial to name the link and its location for easier identification later on:

- Station name – station can be assigned with a name, e.g. the place of installation.
- Station location – for easier inclusion the network hierarchy, it is possible to enter the station’s location

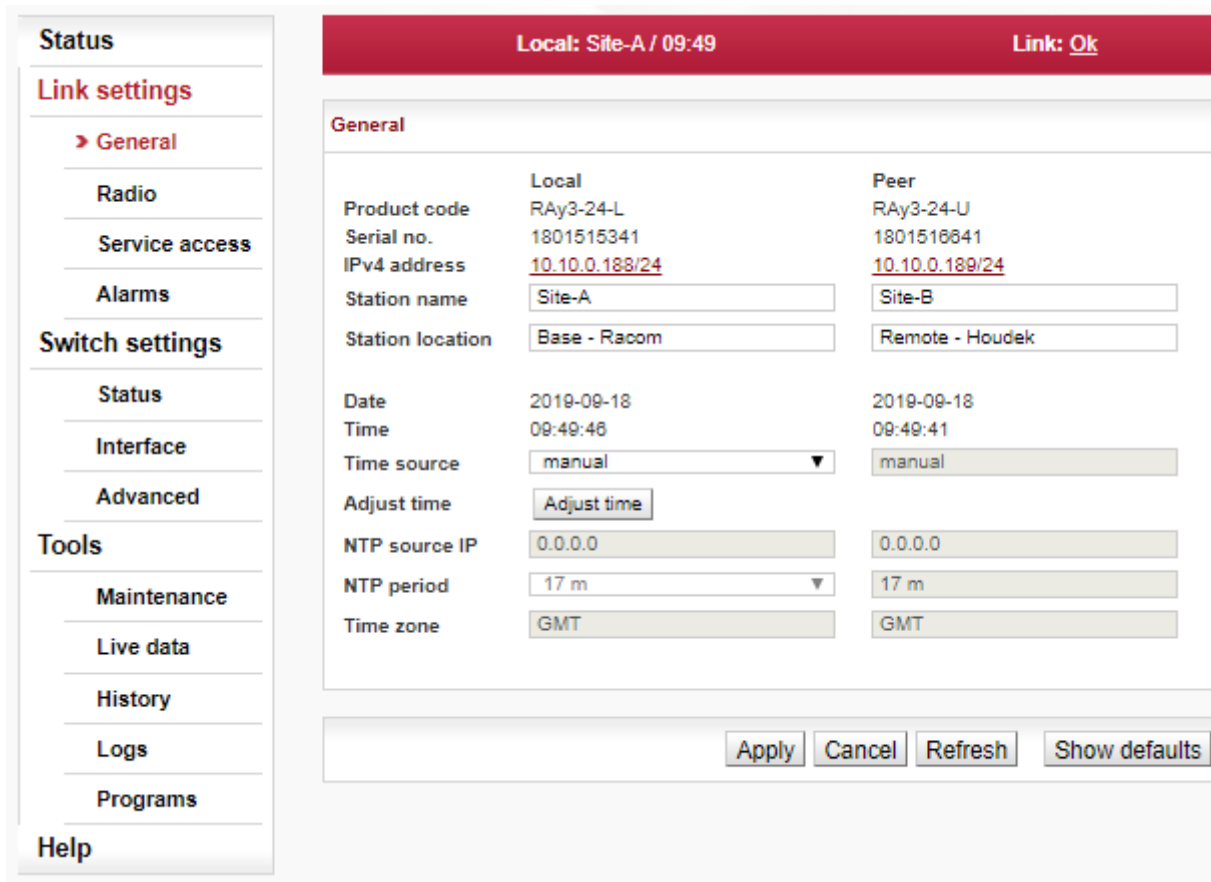


Fig. 3.3: Configuration Menu Link settings / General

For full explanation of all possibilities of this screen see *Section 5.4.1, “General”*.

3.1.3. Setting Ethernet access parameters

Menu Link / Service access / Services

Those settings are necessary to make new units accessible within target Ethernet network. Typically, all following parameters should be set according to both networks IP addressing, routing, planned access methods for data and for management, etc.:

- IPv4 address – enter a valid IP address to access the unit. The default IP address has to be replaced with a valid address. Keeping the default address will probably lead to future problems in the network.
- Netmask – enter the network mask.
- Gateway – if necessary, enter a gateway, otherwise leave blank
- Enable access protocols that you are going to need. For security reasons, do not enable more than is necessary.
- HTTP(S) – allow access to the web interface.
- Telnet – enabling access to the CLI interface using telnet protocol.
- SSH – enabling access to the CLI interface using SSH protocol.
- Management VLAN – Enabling 802.1Q VLAN tag for separation of user and service operations.
- Management VLAN id – Defining 802.1Q VLAN tag for service operations.

The screenshot displays the configuration interface for 'Service access' under 'Link settings'. The top status bar shows 'Local: Site-A / 11:47' and 'Link: Ok'. The main configuration area is divided into 'Local' and 'Peer' settings.

Parameter	Local	Peer
IPv4 address - Local	10.10.0.188	10.10.0.189
Netmask	24 255.255.255.0	24 255.255.255.0
Gateway	10.10.0.1	10.10.0.1
Management VLAN		
1 st tag	<input type="checkbox"/> 1 802.1q	<input type="checkbox"/> 1 802.1q
2 nd tag	<input type="checkbox"/> 4094 802.1q	<input type="checkbox"/> 4094 802.1q
Services		
Web server	on	on
CLI (telnet)	<input type="checkbox"/>	<input type="checkbox"/>
CLI (SSH)	on	on
SNMP	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
SNMP community string	mwl-snmp	mwl-snmp
SNMP trap IP	0.0.0.0	0.0.0.0
LED indicators	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
LLDP (Service IP info)	on	on

At the bottom of the configuration area, there are buttons for 'Apply', 'Cancel', 'Refresh', 'Show defaults', and 'Show backup'. A note states: 'Note: Individual SNMP traps can be activated at [Alarms > Config](#).'

Fig. 3.4: Configuration menu Link settings / Service access / Services

For full explanation of all possibilities of this screen see *the section called "Services"*.

3.1.4. Creation of users

Menu Link / Service access / Users

It is recommended to create user accounts managed by the main user already in this phase (for example a user with rights limited to read-only access). Following actions are available:

- Edit - enter the menu.
- New password – choose a password and enter it.
- Confirm password – enter the password again to confirm.



Fig. 3.5: Configuration menu Link settings / Service access / Users

For full explanation of all possibilities of this screen see *the section called “Users”*.

3.1.5. Applying Feature keys

Menu Maintenance / Feature keys

The firmware of the microwave link is capable of controlling several features (for example the maximum user data speed, maximum Tx power, etc.). It is recommended to install all separately purchased feature keys prior to physical installation to allow all expected features of the link to be usable after the installation.

The screenshot shows a web-based configuration interface. On the left is a sidebar menu with sections: Status, Link settings (General, Radio, Service access, Alarms), Switch settings (Status, Interface, Advanced), Tools (Maintenance, Live data). The main content area has a red header bar with 'Local: Site-A / 07:00' and 'Link: Ok'. Below the header are tabs: Backup, Feature keys (selected), Firmware, Radio adaptation, Restart. The 'Feature keys' section is divided into 'Local' and 'Peer'. The 'Local' section includes a note about restarts, a table with columns 'Feature', 'Limit / Enable', and 'Remove', and a 'Delete' button. The 'Peer' section includes a serial number, a note about restarts, and an 'Open file upload' button. A 'Refresh' button is located at the bottom right of the main content area.

Fig. 3.6: Configuration menu Maintenance / Feature keys



Note

Speed keys purchased with the unit are installed in the factory (and can be double checked within this menu). Key for limited Tx power is not installed except specifically ordered. If RCinfo limits the maximum power, it can not be overruled by feature key with the higher Tx power.

For full explanation of possibilities of this screen see *the section called "Feature keys"*.

3.1.6. WiFi settings

Menu Link / Service access / USB accessories

Go to menu Link Settings / Service Access / USB **accessories** and enter WiFi password or disable WiFi completely. Standard settings are that Enable on Air link loss is ON (when the link is down, WiFi is activated; when link is OK, WiFi will be deactivated in few minutes) and Force Enable is OFF (activates WiFi permanently). Passphrase has to be set, otherwise the WiFi is unsecured and system warning is active.

	Local	Peer
USB info	No device	148f:5370 Ralink 802.11 n WLAN WiFi : down 7c:dd:90:b8:71:d1
IPv4 address	172.17.17.17	172.17.17.17
Netmask	24 255.255.255.0	24 255.255.255.0
DHCP start	172.17.17.20	172.17.17.20
DHCP end	172.17.17.25	172.17.17.25
Ethernet adapter		
Enable	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
DHCP	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
WiFi adapter		
Enable on Air link loss	<input type="checkbox"/>	<input type="checkbox"/>
Force enable	<input type="checkbox"/>	<input type="checkbox"/>
DHCP	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
SSID	RAy3-24_1801515341	RAy3-24_1801516641
Encryption	none	none
Passphrase		
Mode	802.11n	802.11n
Channel	1	1

Fig. 3.7: Configuration menu Link settings / Service access / USB accessories



Note

If you access the unit over WiFi, do this step as last action before reboot (as the WiFi connection will be interrupted and new connection with new password would be required to continue the work).

For full explanation of possibilities of this screen see *the section called "USB accessories"*.

3.2. Basic link configuration

Default radio parameters depend on the specific type of link and the specific channel allocation table. Channels are typically set in the lower part of the band, the smallest bandwidth, QPSK modulation, and low power. Both units in the pair should be capable of immediate communication. If it is possible to work with these radio parameters at the installation location, the link can be activated. On an operating link the required operating parameters can then be set up.

If a change in the parameters is necessary, it is done in the menu *Link settings / Radio* and saved by clicking Apply. This applies when working on both units simultaneously if they are connected, otherwise each unit is configured individually. When configuring units individually, pay attention to correct settings of duplex pair for channels TX and RX. For example, if one station has TX channel L1, then the second station must also have the channel RX L1.

3.3. Link test

Verify the functionality of the radio link:

- Switch in screen *Status / Brief*.
- *Status Bar* displays Link: Ok.
If the alarm message appears at Local or Peer, this doesn't necessarily mean there is a problem. The message indicates that the limit at any of the monitored parameters has been exceeded. Essential is the "Link: Ok" message on the status bar.
- The *Status* screen contains values for both Local and Peer units. N/A next to Peer indicates that the data from the Peer unit has not been transferred. If Link is Ok, simply click Refresh at the bottom of the screen and Peer data will be updated.
- Menu *Status / Detailed / Radio* indicates link RSS and MSE values, in case of ACM also the selected modulation and Netbitrate. If the ATPC function is enabled (menu *Link settings / Radio*) it also indicates instantaneous / max. allowed power and for MSE and RSS values it indicates immediate / target value size.
- Menu *Tools / Live data / Bar indicators* displays current size of RSS, MSE and BER.
- Menu *Tools / Programs / Ping* allows you to send a ping test to the selected IP address.

Try out the possibility of modulation:

- Modulation ACM. In menu *Link settings / Radio* enable ACM. Set the TX modulation parameter to the required maximum value. In menu *Status / Brief / Radio* you can monitor (Refresh or Start) changes in used modulation based on the instantaneous MSE signal quality.
- To set a fixed modulation go to *Link settings / Radio*, switch off ACM and set the TX modulation to a value from the range of QPSK through 256-QAM based on the results of the previous test. If you choose modulation higher than allowed by MSE, the connection will be lost. *Status Link* will lose its Ok value. Both units will need to be moved closer to resume the link. If this is not possible, use the Ethernet to access each unit individually and set the basic modulation QPSK.

Verify the functionality of the entire link:

- If possible, connect user devices to both RAY units over PoE and test mutual communication.
- Another way of testing this is to connect a PC to the other unit and send a ping from one PC to the other.
- The minimum variant of this test is to use an Ethernet cable connection from the PC connected to the local RAY to the PC connected to the remote RAY and test communication between both units over Ethernet. This will verify Ethernet functionality.

Prepare installation configuration:

- Bandwidth e.g. 3.5 MHz. To get the highest possible receiver sensitivity, set the bandwidth as narrow as possible according to specific frequency band.
- TX channel: Use your allocated channel. If you do not have allocated channel yet, use for example channel L1.
- RX channel will setup automatically when channel lock activates.
- Set TX modulation QPSK to get the highest possible sensitivity.
- Set RF power according to selected antenna and according to individual frequency licence. Set the output power as high as possible.
- Set a new users *access passwords*.
- Record the access parameters from the Service access menu, especially the IP addresses.
- Restart by interrupting the power supply to verify that the parameters are stored correctly and the link works.

After this preparation phase you can continue to install your devices in a working environment.

4. Installation

4.1. Line of sight test

Before you install the device to a mast tube, verify visually that the view in the direction of the remote unit is unobstructed.

Line of sight considerations:

- Free Fresnel zones. Signal needs space wider than the diameter of the antenna.
- Trees at the lower end of the Fresnel zone. They will be taller in a few years.
- Possible building development.
- Objects in the close proximity of the antenna such as edges of other antennas, their mounting racks, edges of the roof.

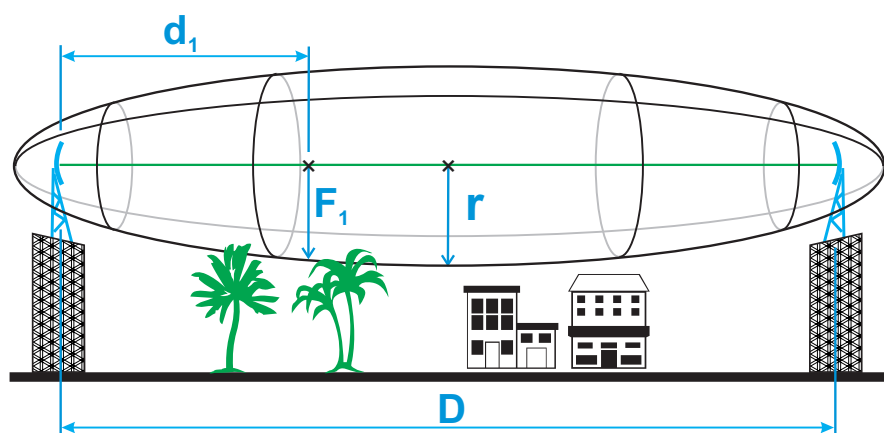


Fig. 4.1: Fresnel zone

4.2. Antenna mounting

Antenna mounting depends on the antenna vendor, antenna type and the size of the chosen antenna. The result of any antenna installation is that it is fixed to the mast, pointing to the right direction and its waveguide and fixing screws are ready for *mounting RAY unit* to it.

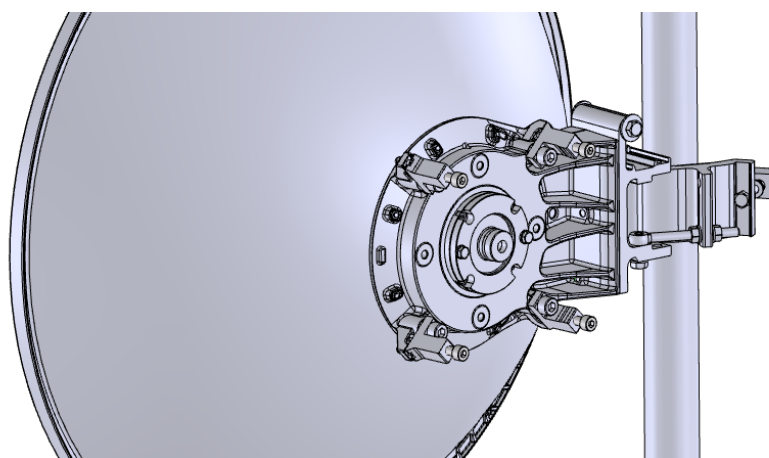


Fig. 4.2: Antenna mounting

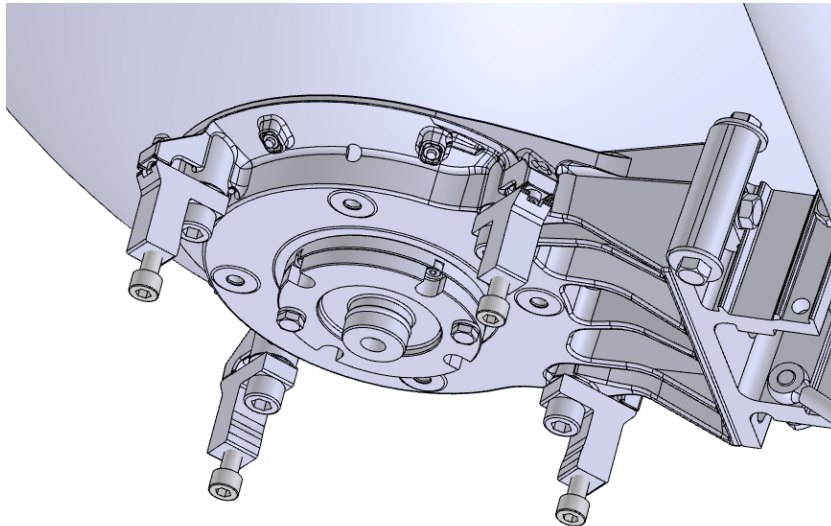


Fig. 4.3: Fixing screws

Common for all antennas is a holder which ensures:

- fixing of the antenna to the mast
- flexibility in two planes (necessary for antenna adjustment to the *proper direction*).

Each holder allows at least 2 methods of mounting antenna on the mast tube:

- right-side mounting
- left-side mounting

Following sections describe in detail installation of antennas, mounting kits and/or flexible waveguides, so the antenna is ready for mounting RAY unit to it. Choose below a chapter relevant for your antenna supplier and installation manual according to antenna type and size.



Note

Each antenna allows RAY unit to be mounted on it with horizontal or vertical polarization. This is discussed in detail in *Section 4.3, “RAY unit mounting”*.

4.2.1. LEAX-RAY antenna mounting

Mounting instructions for each LEAX-RAY antenna are shipped with each antenna. Identical mounting instructions are available within RACOM RAY *download*¹ section, on our website. See list below:

- Installation of 0.3m antennas - *ANT-LEAX-300-inst.pdf*²
- Installation of 0.6m antennas - *ANT-LEAX-600-inst.pdf*³
- Installation of 0.9m antennas - *ANT-LEAX-900-inst.pdf*⁴
optionally with standard strut *ANT-LEAX-RAY-900-STRUT - ANT-LEAX-strut-std-inst.pdf*⁵

¹ <https://www.racom.eu/eng/products/microwave-link.html#download>

² https://www.racom.eu/download/hw/ray/free/eng/04_1_anteny/ANT-LEAX-300-inst.pdf

³ https://www.racom.eu/download/hw/ray/free/eng/04_1_anteny/ANT-LEAX-600-inst.pdf

⁴ https://www.racom.eu/download/hw/ray/free/eng/04_1_anteny/ANT-LEAX-900-inst.pdf

⁵ https://www.racom.eu/download/hw/ray/free/eng/04_1_anteny/ANT-LEAX-900-strut-inst.pdf

- Installation of 1.2m antennas - *ANT-LEAX-1200-inst.pdf*⁶ (includes standard strut) optionally with extra strut *ANT-LEAX-RAY-1200-STRUT - ANT-LEAX-strut-extra-inst.pdf*⁷
- Installation of **RAY interface** for LEAX-RAY antennas - *ANT-LEAX-RAY-inst.pdf*⁸ (same for all sizes). The RAY interface is part of each LEAX-RAY delivery (one interface set per antenna). It needs to be mounted to each antenna according to the instruction manual before mounting the RAY unit. Four pcs M8x30 (Allen) screws to mount the RAY unit to the antenna are also part of the antenna delivery.



Note

0.9m and 1.2m LEAX-RAY antennas on windy sites (max wind speed above 50 m/s) has to be installed with *optional struts*. They allow to increase operational wind speed up to 65 m/s (instead of 50 m/s respectively 55 m/s). They also allow to use tower pipe Ø50-120 mm (instead standard Ø90-120 mm). Consult *LEAX website*⁹ for exact parameters and additional info.

Ensure the *pin lubrication* is completed during assembly.

4.2.2. Jirous antennas mounting

Mounting instructions for Jirous antennas are available on the manufacturer's website <http://en.jirous.com>. Mounting is also described in detail on RACOM RAY *download*¹⁰ section:

- Installation of Jirous antennas *ANT-JRM-inst.pdf*¹¹ optionally with standard strut *ANT-JRMB-1200-STRUT-F - ANT-LEAX-strut-std-inst.pdf*¹²

4 pcs M8x30 (Allen) screws to mount the RAY unit to the antenna are part of the antenna delivery.



Note

1.2m Jirous antennas on windy sites (max wind speed above 50 m/s) has to be installed with optional struts *ANT-JRMB-1200-STRUT-F* (fixed) or *ANT-JRMB-1200-STRUT-A* (adjustable). Strut allows to increase operational wind speed (typically up to 65 m/s). Consult *Jirous website*¹³ for exact parameters and additional info.

Ensure the *pin lubrication* is completed during assembly.

4.2.3. Other antennas mounting

Antenna which do not have a direct interface to RAY needs also a proper *antenna mounting kit* or a flexible waveguide with a *mounting kit* for it. Such interface has to be installed prior to RAY unit installation to the antenna.

Antenna mounting kit can be ordered as an accessory part (one per antenna). It has to be chosen according to selected band and antenna vendor - see *Overview* of currently available types. Any other antenna can be connected to the RAY by standard flexible waveguide. RACOM offers mounting kits (RAY holders) for different flexible waveguides (see *Accessories* and the picture *Flexible waveguide*).

⁶ https://www.racom.eu/download/hw/ray/free/eng/04_1_anteny/ANT-LEAX-1200-inst.pdf

⁷ https://www.racom.eu/download/hw/ray/free/eng/04_1_anteny/ANT-LEAX-1200-strut-inst.pdf

⁸ https://www.racom.eu/download/hw/ray/free/eng/04_1_anteny/ANT-LEAX-RAY-inst.pdf

⁹ <https://www.leax-arkivator-telecom.com/en/products/microwave-antennas.html>

¹⁰ <https://www.racom.eu/eng/products/microwave-link.html#download>

¹¹ https://www.racom.eu/download/hw/ray/free/eng/04_1_anteny/ANT-JRM-inst.pdf

¹² https://www.racom.eu/download/hw/ray/free/eng/04_1_anteny/ANT-LEAX-900-strut-inst.pdf

¹³ <http://en.jirous.com>

Standard mechanical tools are enough to install each of those accessories.

Antenna mounting kit for Arkivator antennas

Items "**ANT-ARK-KIT-xx**" (where xx is the band) fits all traditionally produced Arkivator antennas (from company Arkivator, acquired by LEAX Group) as well as today produced Arkivator antennas from company LEAX Arkivator Telecom sold without RAY interface.

NOTE:

All LEAX-RAY antennas listed in the RACOM portfolio contain specific RAY interface and thus no mounting kit is required.

Antenna mounting kit for Andrew antennas

Items "**ANT-ANW-KIT-xx**" (where xx is the band) fits most of Andrew antennas manufactured by CommScope with specific vendor's interface unmounted. RAY3-17 and RAY3-24 need Dual polarized antennas.

- for 17 GHz band use *ANT-ANW-KIT-17/18* and order the following dual-polarized antenna types:

VHLPX1-18W/A	30 cm
VHLPX2-18W/A	60 cm
VHLPX3-18W/A	100 cm

NOTE:

The antennas labelled for 17.700 - 19.700 GHz band are also OK for 17.100 - 17.300 GHz band (confirmed by CommScope).

- for 24GHz band use *ANT-ANW-KIT-24* and order the following dual-polarized antenna types:

VHLPX1-26W/A	30 cm
VHLPX2-26W/A	60 cm
VHLPX3-26W/A	100 cm

NOTE:

The antennas labelled for 24.250 - 26.500 GHz band are OK for 24.000 - 24.250 GHz band (confirmed by CommScope).

NOTE:

Ordering codes with "-W/A" at the end means one of suitable types of waveguide (vendor's interface), must be unmounted before installation of RAY antenna mounting kit. Ordering codes with "-GDC" at the end means no vendor's interface, so nothing needs to be unmounted in such a case.

If there is a requirement to connect different type of antenna (for example some newer antenna type), it is possible to modify the existing adapter to meet new requirements.

Flexible waveguide

Flexible waveguide mounting kit can be ordered as an *accessory part*.

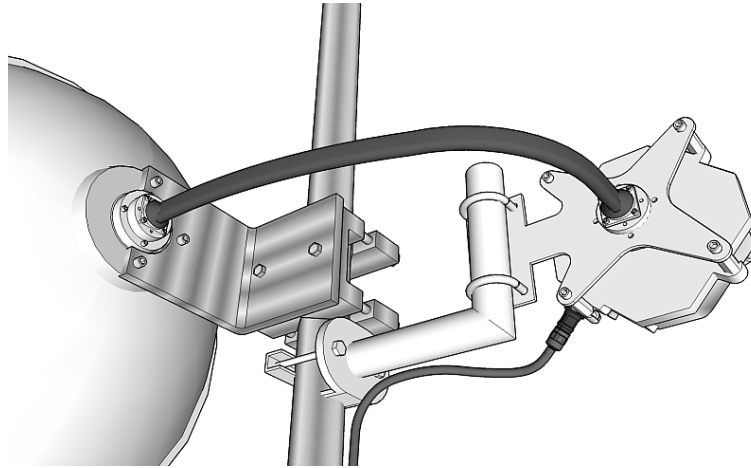


Fig. 4.4: Flexible waveguide assembly

Flexible waveguides themselves are not offered by RACOM - please consult your antenna supplier.

Ensure the *pin lubrication* is completed during assembly.

4.3. RAY unit mounting

RAY unit can be attached to several different models of antennas from several vendors. Installation of RAY unit on to LEAX-RAY or Jirous antennas or to any other antenna through proper RAY mounting kit (eventually with flexible waveguide) is very simple and it is identical for all antennas and mounting kits. Installation starts with the lubrication of antenna pivot, followed by fixing the RAY unit in a proper position to the antenna and finished by unit grounding to the mast – as described in following sections.

4.3.1. Lubrication of the antenna pivot

Before fitting the RAY bushing to the antenna pivot ensure the "O" ring (part No. 1) is in the correct position. It is also essential to prevent moisture getting in between these two parts. This moisture could cause oxidation which would complicate disassembly of this mechanical coupling in the future. For this reason we need to treat these surfaces with the grease which is supplied in the capsule marked "SILO-CONE GREASE". If you use a different grease for lubrication then it should be a Teflon or a silicone grease.

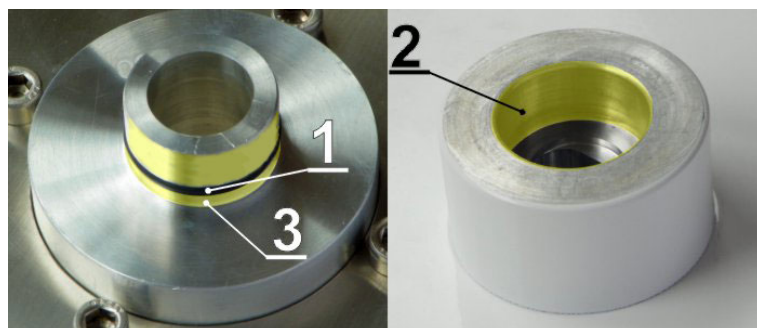


Fig. 4.5: Grease points on the antenna pivot and RAY unit flange

Lubricate both the internal area of the bushing on the RAY unit (2) and the "O" ring (1) with a thin even layer that allows the pin to slide easily into the bushing without damaging the "O" ring. The layer has to be really thin and even to ensure no grease is pushed in to the waveguide. A little bit more grease

may only be applied in the area (3) beyond the "O" ring on the antenna pin to optimally fill the small gap (max. 0.1 mm) between the pin and the bushing to prevent leakage of moisture and water into the unit. Installation should be carried out according to the antenna installation instructions.

A tub of grease is supplied with each RAY unit.



Important

Lubrication is a very important assembly step for every RAY unit. Failure to lubricate the unit can lead to operational and assembly complications.

The layer of grease has to be really thin (especially on the surface "No 2"), otherwise grease blocks the waveguide after the assembly (and many decibels of the signal are lost).



Fig. 4.6: Silicone grease

4.3.2. RAY unit mounting to the antenna

Each antenna allows RAY unit to be mounted on it with different polarization:

- horizontal TX polarization
- vertical TX polarization

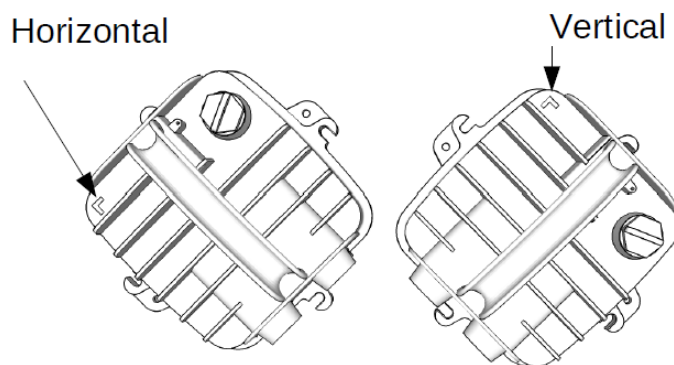


Fig. 4.7: Horizontal and vertical TX polarization – see the arrow sign

In all cases mount the unit with the connectors facing downwards at an angle.



Note

RAY3-17 and RAY3-24 links need one unit to be installed with vertical polarization and the other unit with horizontal polarization because these units use *cross polarization*.

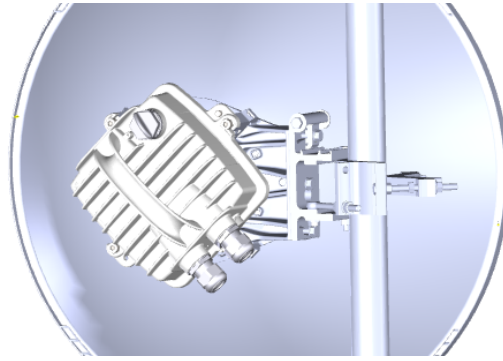


Fig. 4.8: RAY3 unit with antenna (left-side mounting and horizontal polarization)

RAY unit is fixed to the antenna by 4 pcs M8×30 (Allen) screws, which are part of the delivery of each antenna or each mounting kit. Those should be partially unscrewed so that the unit can be slid on to them. Then check whether the "O" ring is correctly fitted on the antenna pin, and make sure it is not damaged and has been lubricated with grease – see *Section 4.3.1, "Lubrication of the antenna pivot"* above.

Then remove the protective plastic cover from the central pin of the antenna and fit the unit flange (located in the center of flat part of RAY unit, across the holder) to it carefully not to damage the "O" ring. Once the RAY unit is plugged to the antenna pin, turn RAY clockwise so its screw-holders fit the right position for all 4 screws. Carefully ensure the correct polarization of the unit and secure the RAY unit in place with all four bolts. Finally, gently tighten the bolts with a No. 6 Allen key.



Important

Gently tightening all 4 screws is enough. Do not over-tighten any screw, it may damage the protective color surface of the aluminum unit (enforcing corrosion processes) and in the case of an extreme force also deformations of the RAY aluminum cover may happen. Later de-installation of the unit then becomes difficult.

Please ensure that all 4 screws are tightened equally during tightening and the gap between RAY screw-holders and spacers on all 4 sides of the RAY unit is approximately identical. Too strong tightening of one or 2 screws on one side of RAY unit may lead to the deformation of the sensitive zone of the waveguide between the antenna and the unit, resulting in weaker radio parameters.

Even a small residual gap between RAY unit and the antenna is OK, because important is a good connection of waveguide – it is good enough even with screws gently tightened. NOTE: on older LEAX-RAY antennas (shipped during the year 2017) the residual gap under each screw-holder on RAY and antenna body may be up to 1 mm.

4.3.3. RAY unit grounding

RAY unit has to be properly grounded, otherwise it can not be guaranteed its function and it can be even damaged. Grounding connection through antenna and its holder is not enough (due to color surface, oxidation etc.), thus a separated grounding is required to ensure the perfect galvanic connection.



Important

The RAY unit has to be grounded before connecting to the power supply and/or to the user network.

Typically the unit is grounded to the antenna mast, which has to be properly grounded (according to Fig. 4.19, “Grounding installation 1” and Fig. 4.20, “Grounding installation 2”, where unit grounding to the antenna mast is marked by yellow-green cable).

The RAY unit is grounded to the flange at the fixing screws using an M8 screw. An insulated copper cable with a minimum cross-section of 6 mm² terminated with a terminal lug is used as a protective conductor. The conductor should have a green/yellow plastic cover along its whole length. The RAY grounding kit can be ordered as an accessory (see Chapter 2. *Accessories*) containing a grounding terminal ZSA16, 40 cm grounding strip 15 mm wide, and 100 cm of cable with grounding lugs. For instructions on installing terminals see the datasheet *RAY grounding kit*¹⁴. The antenna must be installed by a qualified person.

Properly installed unit grounding kit (from RACOM accessory) is documented on photos below.



Fig. 4.9: Protective conductor at the RAY unit



Fig. 4.10: Grounding the RAY unit

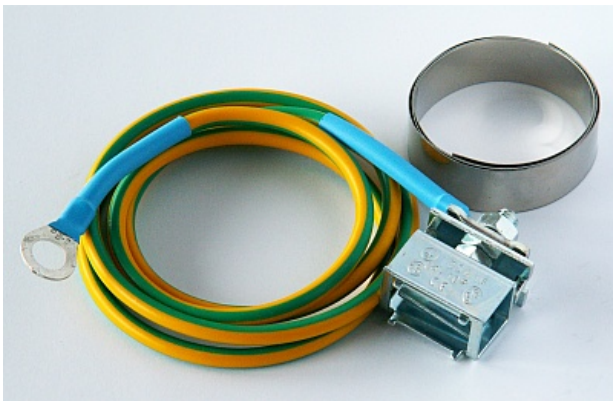


Fig. 4.11: RAY grounding kit

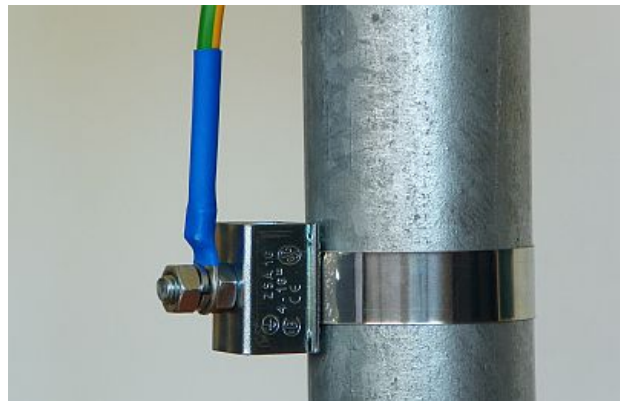


Fig. 4.12: Protective conductor at the mast on a ZSA16 terminal

¹⁴ https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/ZSA16-en.pdf

4.4. Connectors assembly and disassembly

The unit is equipped with 3 connector slots described in detail (including connectors' pin-outs) in *Section 1.3, "Ethernet + power interfaces"* and *Section 1.4, "Service interfaces"*. Use only standard counterparts to these connectors.

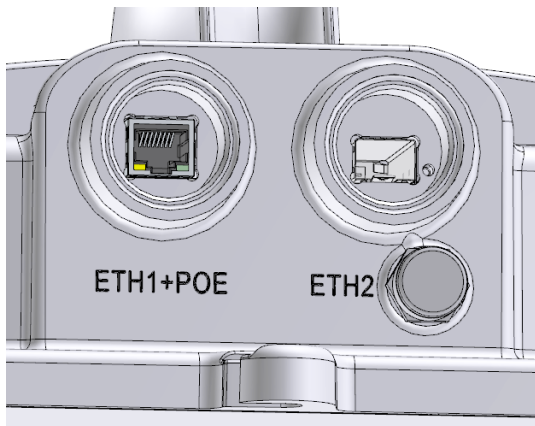


Fig. 4.13: Slots ETH1+POE, ETH2

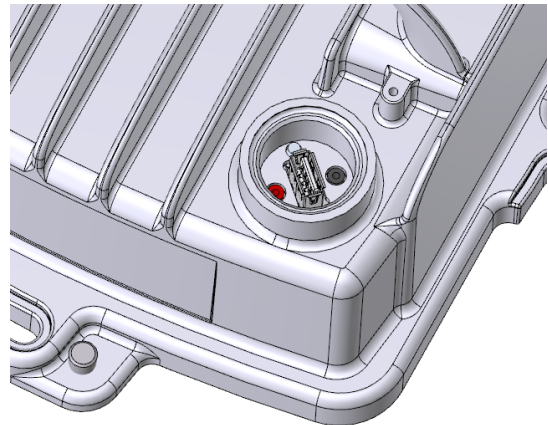


Fig. 4.14: Slot S

A set of standard bushing and plugs is delivered with each RAY unit as an accessory *ACS-RAY3*. The rubber sealing for each bushing is delivered with three different internal diameters to fit different cable diameters. The rubber is diagonally cut to enable sealing of cables with pre-installed connectors.

If the lengthening of the bushing is needed use the short extension *OTH-BUSH-EXT35* (adds 35 mm length, parts No.6 + No.7 on pictures below) or the long extension *OTH-BUSH-EXT500* (adds up to 50 cm).



Important

Before connecting the RAY unit to the power supply and/or to the user network it must be grounded according to *Section 4.3.3, "RAY unit grounding"*

All cables have to be secured by appropriate bushings which must be fitted with relevant O-rings and carefully tightened in, according the instructions below.

Remaining connector slots on RAY unit has to be secured by plugs (including the original plugs in the flanges). Those must be fitted with O-rings and carefully tightened as well. Otherwise, the unit is not protected against moisture intake through connectors and can not guarantee unit functionality.

Assembly procedure:

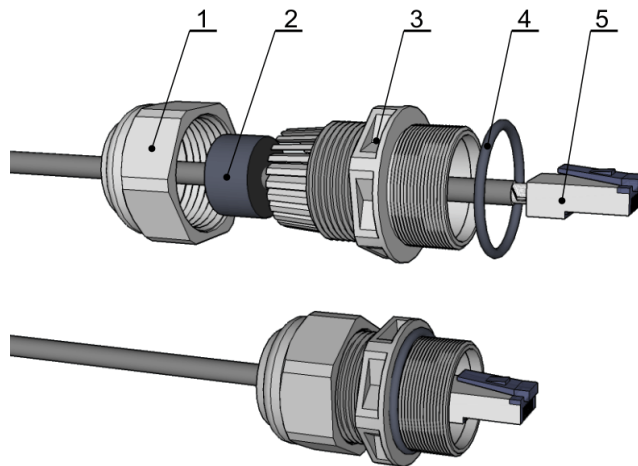


Fig. 4.15: Short bushing assembly for metallic Ethernet with short ETH connector (for example item CON-RJ45-CAT6)

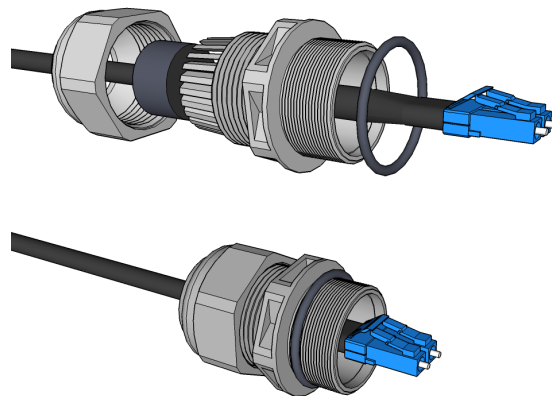


Fig. 4.16: Short bushing assembly for fibre optical Ethernet with RACOM / OFA fibre optic cable

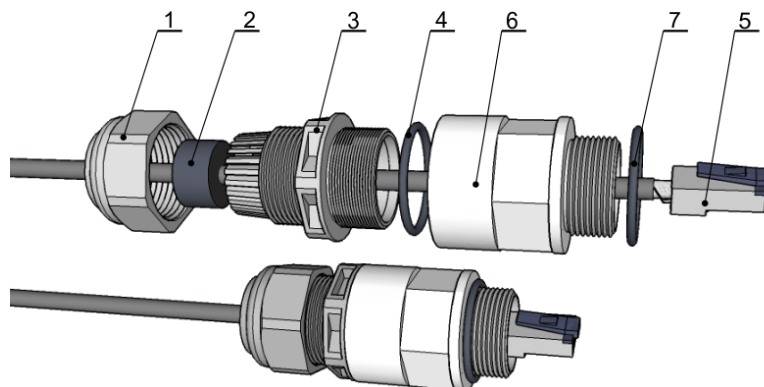


Fig. 4.17: Bushing including short lengthening (for metallic Eth with longer connector or for DC-RJ45 adapter or for non-OFA fibre optic cable)

- Put on the cable: the nut No.1, rubber sealing No.2, bushing No.3 and O-ring No.4.
- (If you use extension ring No.6 with O-ring No.7 put those on the cable as well.)
- Attach the appropriate connector No.5 to the cable.
- Plug the connector No.5 into the RAY3 unit.
- (If you use extension ring No.6 with O-ring No.7, lubricate its thread with grease and screw those into the RAY3 unit.)
- Screw the bushing No.3 with the sealing O-ring into the RAY3 unit (or into the extension if used).
- Move the rubber sealing (2) along the cable to fit in the bushing. Screw the nut (1) on bushing (3).

**Tip**

Practical tip: Screw the ring No.6 and bushing No.3 quite tightly, so they could not rotate when the nut No.1 is screwed (or released later on). Not doing so could damage the cable by twisting it during sealing. It can also create the issue later on when the nut No.1 is released (and ring No.6 or ring No.3 releases first).

Disassembly procedure:

- Release the nut No.1
- Remove the rubber sealing No.2
- Unscrew the bushing No.3 with O-ring No.4 (and extension No.6 with O-ring No.7).
- Remove the connector.

**Warning**

It is absolutely critical first to completely release and disassemble the nut No.1 and remove the rubber No.2. Failure to do so could cause the damage of Ethernet cable or fibre optic wire by cable rotation. Even connectors inside the RAY unit can be damaged. Should the rubber sealing No.2 become fastened to the cable and/or to the plastic bushings, the rubber sealing must be detached from the cable by a brute force. We suggest you use a flat screw driver to release the rubber sealing No.2.

It is always better to optionally damage the bushing rather than damage a cable or components inside the RAY unit.

At the outer end of the long lengthening there is necessary to use a flat ring supplied as part of the *OTH-BUSH-EXT500*. On other places O-rings are used. See next Figure:

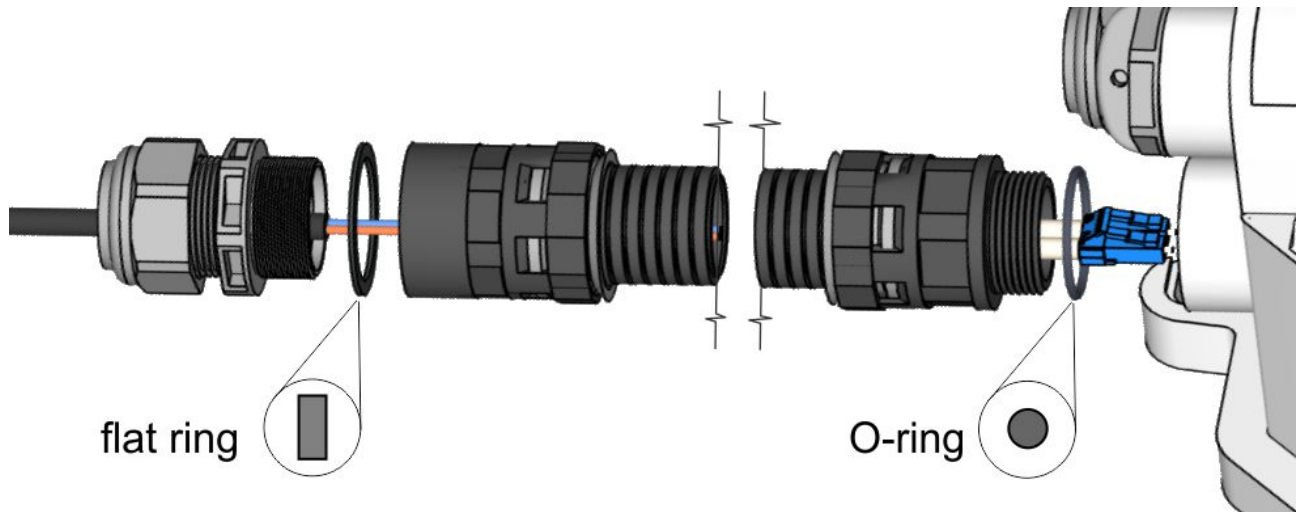


Fig. 4.18: Bushing including long lengthening



Important

- When using other bushing or connector than the delivered there is a danger of bad seal or damaging the connector. Interior space can be small.

4.5. Grounding and overvoltage protection

The proper grounding together with surge protection components should be installed on site to increase the resiliency of the whole installation against natural overvoltage situations (stimulated by storms, lightning and other atmospheric issues). Such a system has to respect local standards for grounding and electromagnetic protection, otherwise the risk of damage of the unit and/or connected IT infrastructure gets much higher. We also recommend to consult each site situation with local experts to ensure the installed grounding is enough for the actual site conditions and that the overvoltage protection of sensitive components or infrastructures is reasonably effective against typical situations on site.

The rule is that every metallic component of wireless infrastructure located outside the building (in LPZ0) should be properly grounded and protected against overvoltage, especially:

- grounded RAY unit itself (as described in *Section 4.3.3, "RAY unit grounding"*)
- grounded all shields from all metallic Ethernet cables
- grounded all DC cables (shields or one wire)
- overvoltage protection is applied on all metallic Ethernet cables at the point of entrance to the building
- overvoltage protection is applied on DC cable at the point of entrance to the building

All types of cables should be grounded and longer cables should be grounded in several places (outside the building every few meters). Overvoltage protective devices are available for all types of cables and usage. Accessories offered by RACOM for those purposes are listed in *Section 2.1, "Overview"* and described in detail in *Section 2.2, "Details"*.



Important

The unit and mast must be properly grounded before the power supply and/or the user network are connected to RAY unit.

Warranty does not apply for units destroyed by surges or over-voltage (see RACOM warranty conditions at *Section 10.6, "Warranty"*).



Note

Some PoE power sources, PoE injectors and DC power supplies have overvoltage / surge protection built in. Please consult the datasheets of those versus the local standards and site requirements.

On sensitive sites additional overvoltage protection should / could be applied between different zones (or rooms) even within one building (for example between network center and datacenter).

LPZ acronym means Lightning Protection Zone.

The example and rules below are designed in accordance with regulation EN 62305.

1. Where possible the antenna should be located in an LPZ 0B protection zone with the use of a local or artificial air termination device for protection against direct lightning strikes.
2. When meeting conditions for ensuring electrical insulation (distance from the lightning conductor) in accordance with article 6.3 of this standard, it is not recommended to ground the load-bearing structure and antenna to the external air termination network. Grounding should be attached to the protective system of the internal LV (Low Voltage) wiring or grounded internal structures using a CYA 6 mm² bonding conductor, see *Fig. 4.19 Grounding installation 1*.

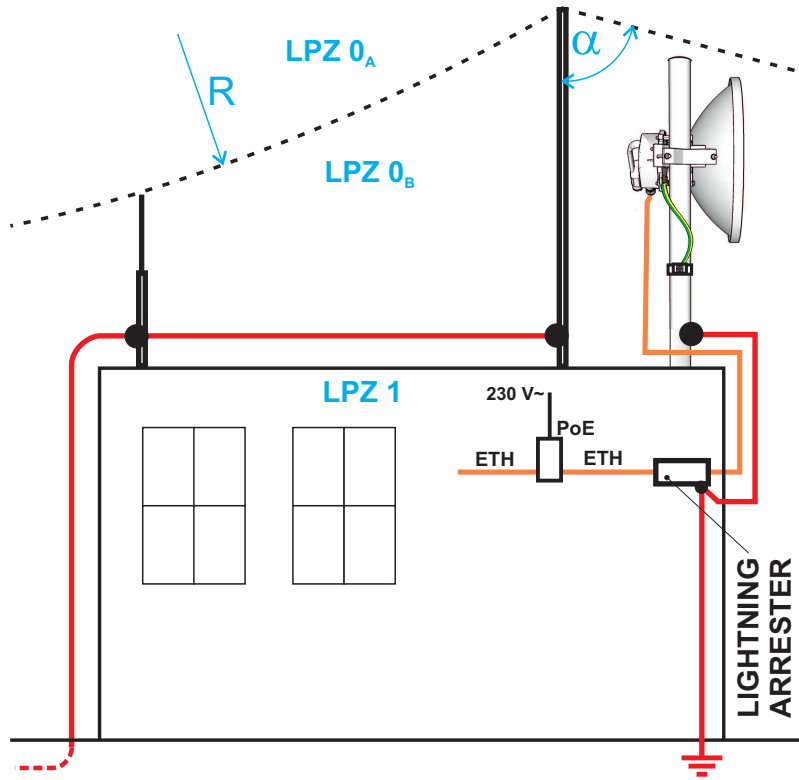


Fig. 4.19: Grounding installation 1

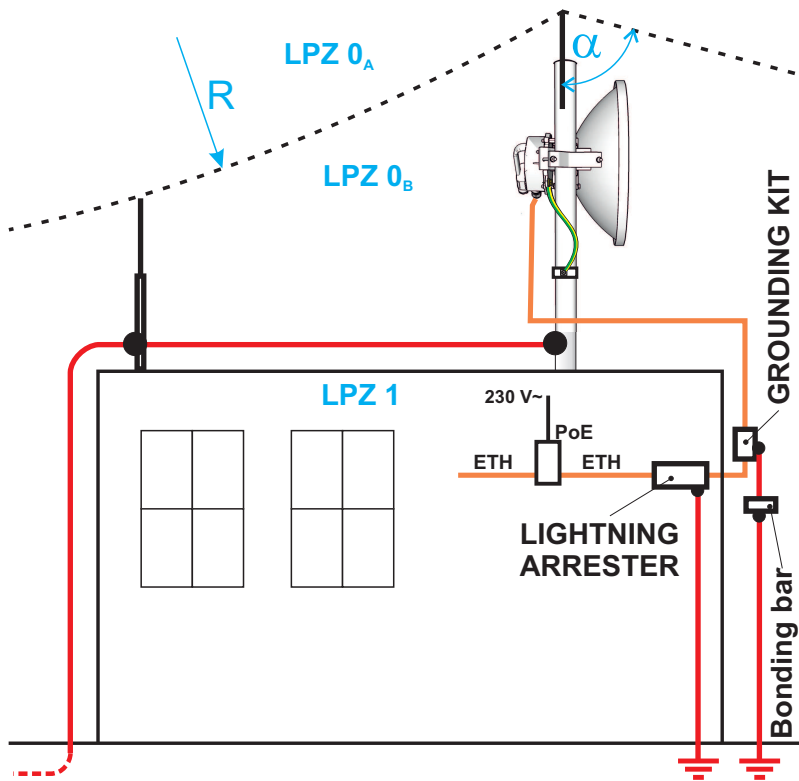


Fig. 4.20: Grounding installation 2

3. If it is not possible to set up conditions of electrical insulation in accordance with article 6.3 of this standard, we recommend connecting the load-bearing structure at roof level to the external air termination network via an 8mm diameter FeZn conductor and shielding the data cable before entry to the building with a grounding kit and CYA 6 mm² conductor to the bonding bus, and if not already set up then also to the external air termination network, see *Fig. 4.20 Grounding installation 2*.
4. If there is not an external LPS on the building we recommend routing lightning current through an 8mm FeZn conductor to a common grounding system, or to a separate grounding electrode with a ground resistance up to 10 Ω.
5. For limiting the overvoltage transferred over the data cable and into the building we recommend fitting surge protection at the interface between zones LPZ 0 and LPZ 1 connected via a CYA 4 mm² conductor to the same grounding point as the antenna or the antenna mast.
6. We recommend protecting the PoE power supply from overvoltage on the LV side with suitable class D surge protection.

RACOM supplies surge protection for installation on Ethernet cables entering buildings. For more details see *Surge protection*¹⁵.

Additional safety recommendations

- Only qualified personnel with authorisation to work at heights are entitled to install antennas on masts, roofs and walls of buildings.
- Do not install the antenna in the vicinity of electrical wiring. The antenna and bracket should not come into contact with electrical wiring at any time.
- The antenna and cables are electrical conductors. During installation electrostatic charges may build up which may lead to injury. During installation or repair work to parts of the antenna lead, bare metal parts must be temporarily grounded.
- The antenna and antenna cable must be grounded at all times.
- Do not mount the antenna in windy or rainy conditions or during a storm, or if the area is covered with snow or ice.
- Do not touch the antenna, antenna brackets or conductors during a storm.

¹⁵ https://www.racom.eu/eng/products/microwave-link.html#accessories_ochrana



Fig. 4.21: Grounding Kit universal for 5-11mm cables



Fig. 4.22: Grounding Kit for 5-11mm cables, assembled



Fig. 4.23: Grounding kit for S/FTP 4+2 cable

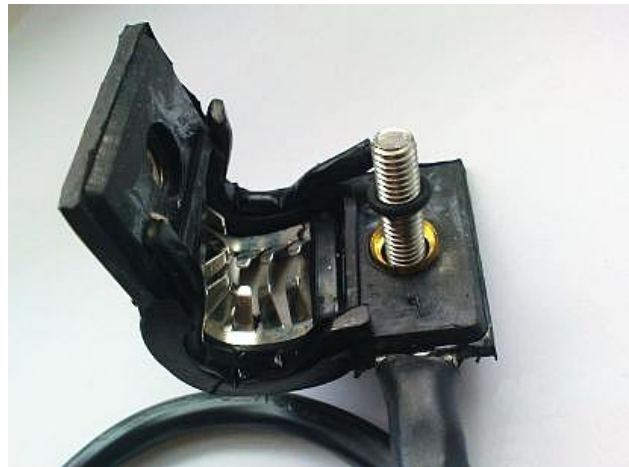


Fig. 4.24: Grounding kit detail

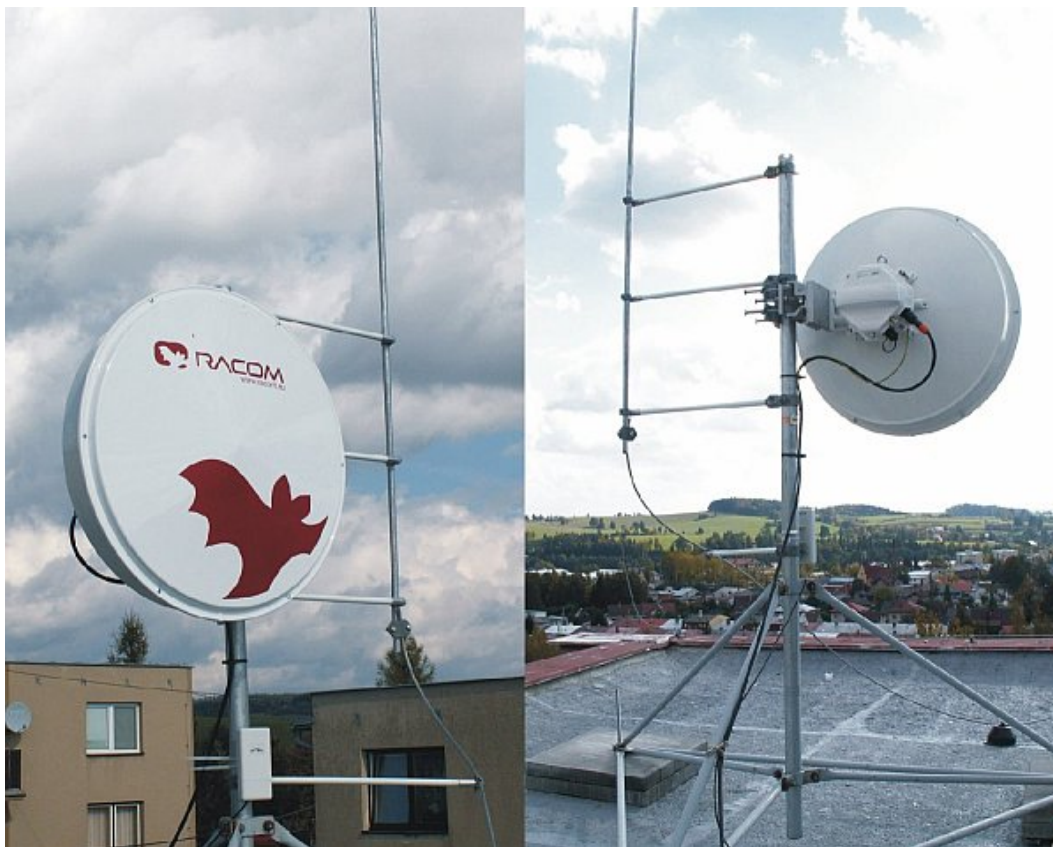


Fig. 4.25: Separated lightning conductor

NOTE: It is always better not to install the microwave unit directly under the lightning conductor holders. There is lower probability of unit being polluted by birds.

It is necessary to install the Ethernet lead so that there is no excessive mechanical stress applied on the connector bushing:

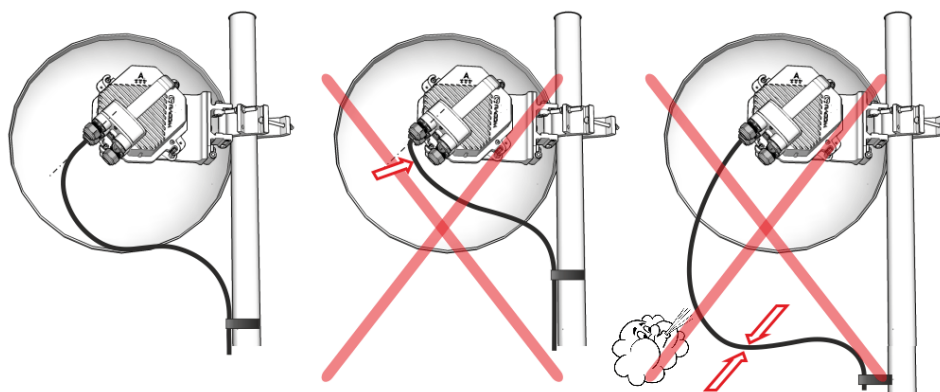


Fig. 4.26: Example of a correct lead installation.

4.6. Power supply

RAY microwave unit can be powered by active PoE, passive PoE or by DC power source. All variants of power are supplied through RJ45 Ethernet connector (in slot ETH1+POE). Detailed description and

technical parameters of the connector is described in *Section 1.3.1, "Ethernet 1, PoE - RJ45 connector (ETH1+POE)"*.

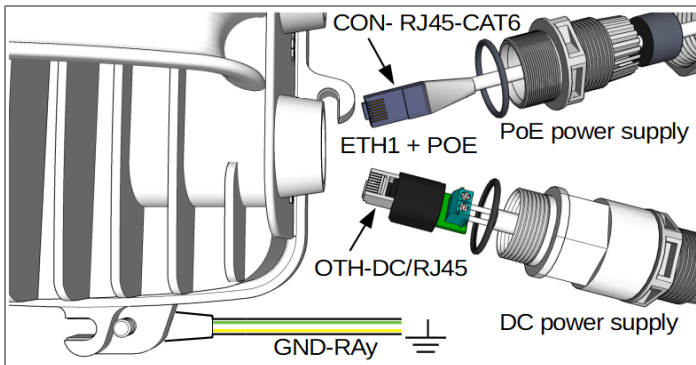


Fig. 4.27: Power supply possibilities

RACOM is offering all kinds of power supplies, all guaranteed for compatibility with RAY unit and tested for long-term stability – they are listed in *Section 2.1, "Overview"* and described in detail in *Section 2.2, "Details"*.

4.6.1. PoE power sourcing

- Active PoE plus (called also Standard PoE+) power supply compatible with IEEE 802.3at, sourced by AC or DC power. The standard IEEE 802.3at defines negotiation method, wires to be used, operating voltage (36-56V), maximum supported current, overcurrent protection and other parameters. Any power supply compatible with IEEE 802.3at standard can be used.
- Passive PoE power supply (called sometime PoE injector), is an equipment pushing to the pins of Ethernet connector DC power with a polarity and voltage compatible with IEEE 802.3at standard. Thus, supported voltage, distances, grounding and internal RJ45 pins wiring are identical with Standard PoE+ (mentioned above). Typically, the current is sourced from a DC power with adequate parameters (nominal voltage 24-60V, max current at least 1A). The only additional requirement is that non-grounded wire of DC power circuit in the PoE injector has to be secured by a fuse disconnecting the power circuit in the case of over current (similar like for DC power source connected directly to the RAY unit by a DC connector).



Note

RAY unit requires the voltage on RJ45 connector (ETH1+POE) to be at least 20 V, for booting 21 V (to prevent booting with discharged 24 V battery). If a longer Ethernet cable than few meters is used, then both voltage and Watts of power supply and PoE injector has to be adequately higher to cover the power loss within the Ethernet cable.

Quality Ethernet cable (i.e. shielded one, like *CAB-CAT7*) with UV protection is recommended for outside use.

Quality connectors (like *CON-RJ45-CAT7*) are recommend to be used on both ends of Ethernet cable to ensure long-term reliability of the connection. Such connectors have better resistance against oxidation and also against scorching contacts due to spikes during power-on and power-off the unit by plug / unplug Ethernet cable. Anyhow standard Eth cable with standard Eth connectors should work as well.

Overvoltage protection unit is recommended to be applied between RAY unit and PoE power supply – for details see *Section 4.5, “Grounding and overvoltage protection”* (easily visible on *Fig. 4.19, “Grounding installation 1”*).

4.6.2. DC power sourcing

Direct DC power input for RAY3 unit described in *Section 1.3.3, “DC power (using ETH1+POE)”* requires the use of *OTH-DC/RJ45*.

- Any kind of DC power source with supplied nominal DC voltage in the range 24-60 V and with enough power for the RAY unit plus energy loss on the DC cable. (For RAY3-17 and RAY3-24 the minimum is 25 Watts).
- RAY unit requires the voltage on RJ45 connector (ETH1+POE) to be at least 20 V, for booting 21 V (to prevent booting with discharged 24 V battery). If a longer DC cable than few meters is used, then both voltage and Watts of power supply has to be adequately higher to cover the power loss within the DC cable.
- RAY3 internal DC power circuits accept both polarities and they ensure galvanic separation of power source line from the RAY unit itself. This simplifies the DC power circuits installation.
- The DC power circuit must be fitted with a fuse to protect against short circuiting (or power supply has to have such a fuse built-in).



Note

- Typically, DC wires have cross-section 1.5 mm². DC contacts on *OTH-DC/RJ45* are designed for this cross-section.
- *OTH-DC/RJ45* occupies *ETH1+POE port* on RAY3 unit. When used, Ethernet connection to the unit has to be made through *ETH2 port*. Possible solutions are described in section NOTE at the end of *Section 1.3.3, “DC power (using ETH1+POE)”*.
- If shielded DC power cable is used, then shield should be grounded by a proper *Grounding kit* to the mast or directly to the *Grounding screw* on RAY unit.
- If the galvanic separated power source is used and the DC power line needs to be grounded (either positive or negative wire), the connection of one DC line to the ground should be made by a proper *Grounding kit* to the mast. Possible is also to use a small piece of DC cable to connect the line to be grounded directly to the *Grounding screw* on RAY unit. For more details see *Section 4.5, “Grounding and overvoltage protection”*.

4.7. Start up

Connect a power supply to the installed RAY unit. Connect the device to be used for configuration via WiFi or Ethernet cable. Access the configuration menu using browser or Alignment tool.

4.7.1. Noise on the site

This is particularly true for installation of links working in free bands, where the user has no secured frequency.

Analyze the level of noise in the individual channels using the spectrum analyzer under *Tools/Live data/Frequency spectrum analyzer*. If necessary adjust the choice of working channel on the basis of the results.

While doing so, respect the rule that all units emit a signal in the Upper part of the range and receive it in the Lower part of the range in one location, or vice versa. A transmitter must not be installed in the part of the spectrum where other units function as receivers.

4.7.2. Directing antennas

Placing the antennas to the correct antenna alignment is very important to ensure the strongest signal is received:

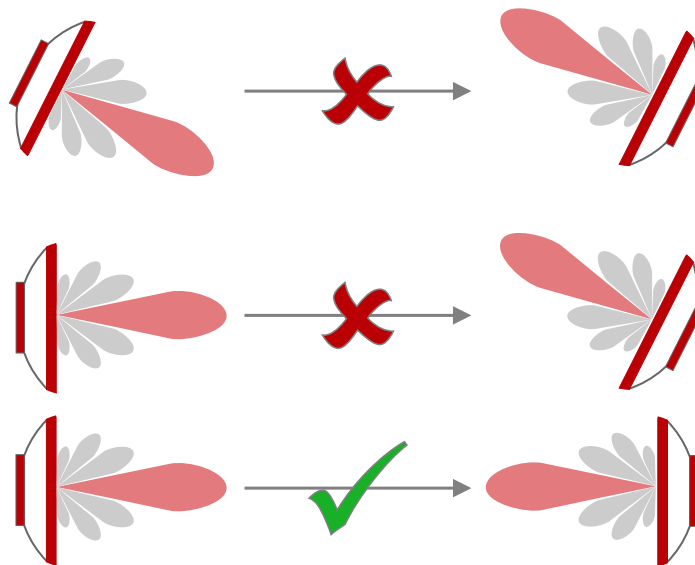


Fig. 4.28: Correct alignment diagram

- For first antenna alignment, use a narrow channel, low modulation and high power where possible.
- ATPC and ACM functions should be switched off (prevents Tx power fluctuations during alignment).
- Where possible adjust both ends of link simultaneously to speed up the process.
- Alternate adjustments at both ends of link in small increments both horizontally and vertically to establish position with strongest signal (highest value of parameter RSS, received signal strength) whilst looking for maximum main signal (see paragraph on main & side lobes).
- Link parameter RSS (received signal strength) is a key parameter for a proper antenna alignment and later on for a proper link functionality. All the adjustment effort is to maximize this parameter on both sides of the link and to reach pre-calculated RSS value (which is typically calculated before the link is physically established to ensure necessary link transmission parameters could be met).

- Several available methods to measure RSS are built in to the RAY unit. Those are discussed in detail in section 4.7.3.
- Connect a PC, tablet, mobile or voltmeter according your preferred RSS measurement method and find the best possible antenna alignment for both sides of the link. Following section Main and side lobes would help you.

Main and side lobes

Directional antennas have a specific angle within which radio waves can be transmitted or received (Angle of Tx/Rx).

The strongest signal is emitted in a forward direction; the main lobe is a graphical representation of its direction of travel and strength. However, signals are also emitted and received from unwanted directions through side lobes. In receiving antennas this is a highly significant factor contributing to the level of interference in a radio network (See Fig. 4.29 Antenna lobe diagram).

Fig. 4.30 Signal strength graph provides an indication of comparative signal strength from different beams emitted from a directional antenna.

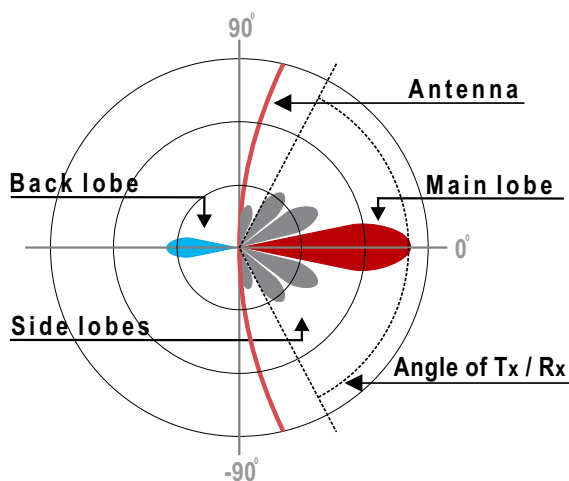


Fig. 4.29: Antenna lobe diagram

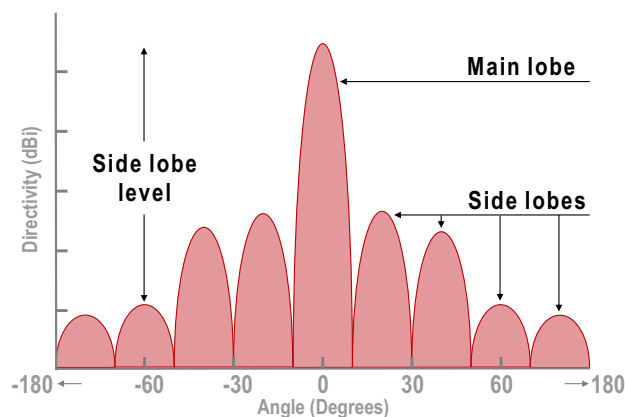


Fig. 4.30: Signal strength graph

Examples

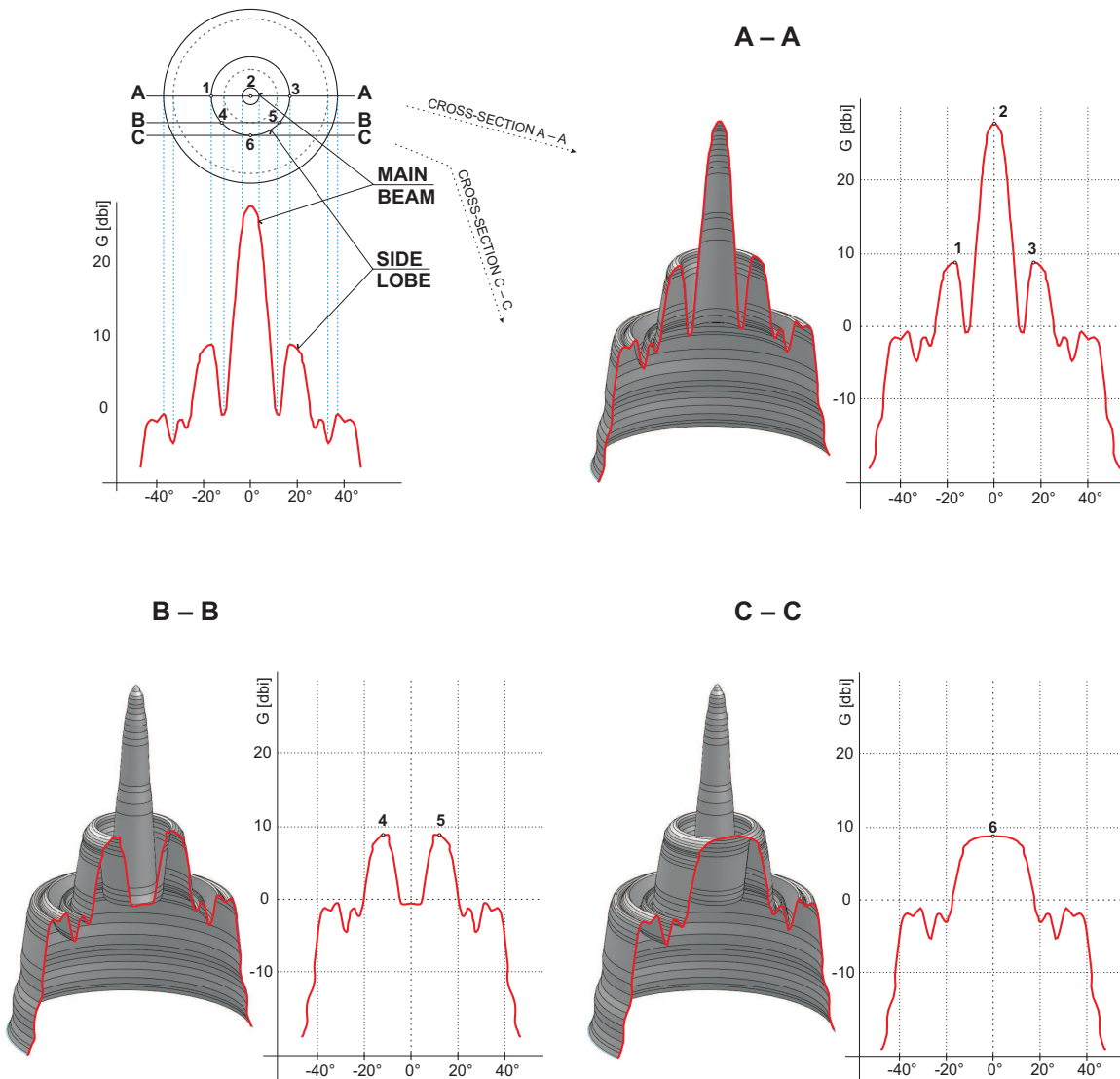


Fig. 4.31: Radiation diagrams

Both antennas should be oriented towards each other using the peaks of the radiation diagram. Adjust the antenna alternately in the horizontal and vertical axes and monitor the resulting signal strength. Use the calculation of the expected RSS with the precision of several dBm as guidance. Side lobes transmit a signal ca 20 dBm weaker, see the *Microwave link Calculation*¹⁶.

¹⁶ <https://www.racom.eu/eng/products/microwave-link.html#calculation>

The resulting RSS helps distinguish between the states A-A and C-C which appear similar. It also helps in situations where simple search for a maximum doesn't work as shown in the illustration "incorrect adjustment".

Real radiation diagrams are more complex, especially in that they run differently in horizontal and vertical axes. The basic steps for determining the main radiation lobe however stay valid. For example:

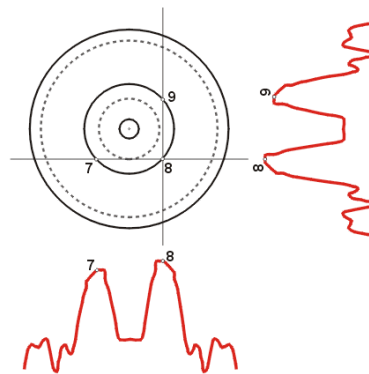


Fig. 4.32: Radiation diagram – incorrect adjustment

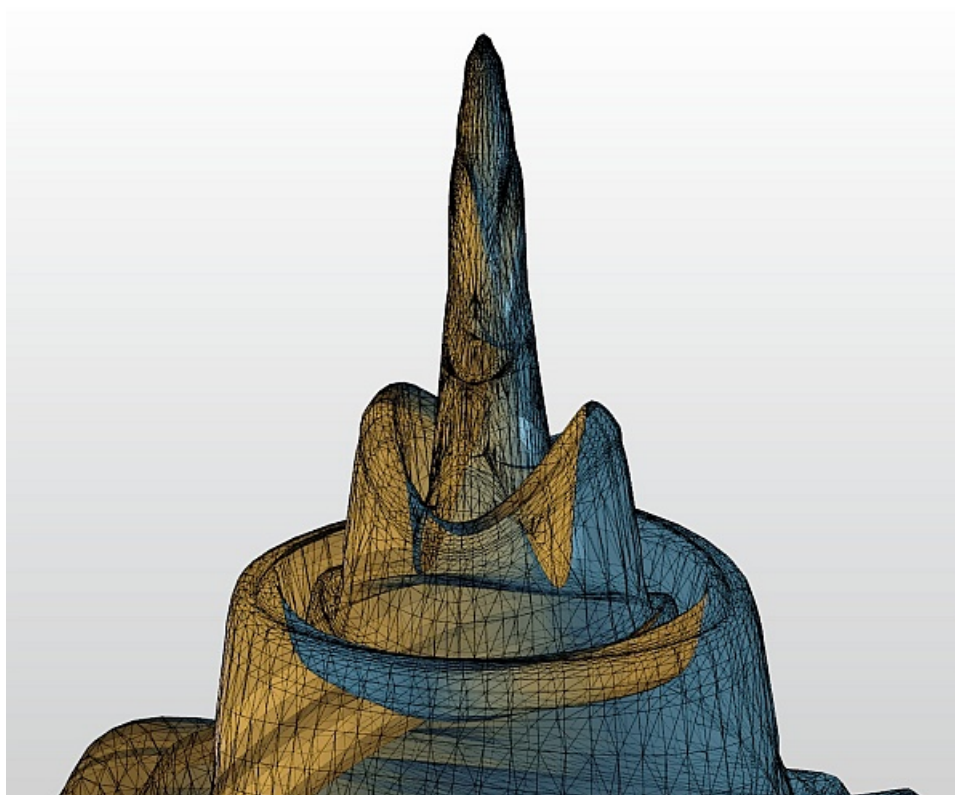


Fig. 4.33: 3D example of more complicated Radiation Pattern

4.7.3. RSS measurement

There are 4 tools available to support measurement of the 2 basic parameters for optimum antenna alignment: RSS (Radio Signal Strength) and MSE (Mean Square Error, the inverse to often used value called SNR - Signal to Noise Ratio):

1. **Voltmeter** – indicates local RSS
2. **RAY Tools smartphone** application – indicates RSS, MSE - Local & Peer
3. **Antenna Alignment Tool** web page – indicates RSS, MSE – Local & Peer
4. **Bar graph** on Live Data page inside web management – indicates RSS, MSE, BER – Local & Peer

Before antenna alignment starts it is recommended to find out RSS and MSE values from the link design for the installed link or calculate these values yourself. There are 4 methods available with increasing levels of accuracy:

- Module Calculation inside RAY Tools *smartphone application*
- Link calculation on *RACOM website*¹⁷
- Use Link calculation chapter in *Application notes*¹⁸
- Precise link calculation using dedicated tools (e.g. Pathloss)

Voltmeter

RAY units support traditional antenna alignment using a voltmeter measurement representing RSS in dBm (only for a local unit). Connect a voltmeter with the range 2V DC via connectors to the operational unit and adjust antennas to the lowest indicated voltage. Voltage is calibrated according to signal strength. E.g.:

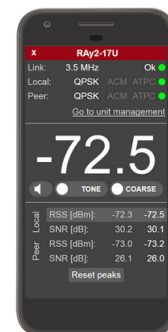
RSS -65 dBm corresponds to voltage 0.65 V,
 RSS -80 dBm corresponds to voltage 0.80 V etc.



RAY Tools – smartphone application

RAY Tools is an application described in detail in Chapter 7. *RAY Tools app for Mobile devices*. Module *Alignment* displays RSS and MSE for both local and peer RAY unit. All key functionality in this module performs an identical function to Antenna Alignment Tool described in Section 5.6.2 *Live data*.

More about RAY Tools in Chapter 7. *RAY Tools app for Mobile devices*.



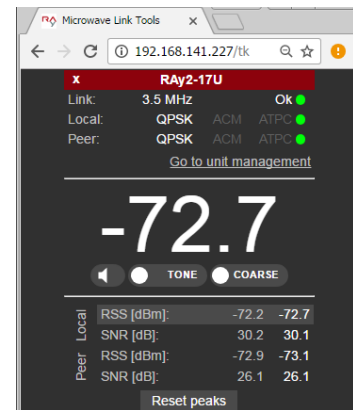
¹⁷ <https://www.racom.eu/eng/products/microwave-link.html#calculation>

¹⁸ <https://www.racom.eu/eng/products/m/ray/app/linkcalc/index.html>

Antenna Alignment Tool – html page within unit management

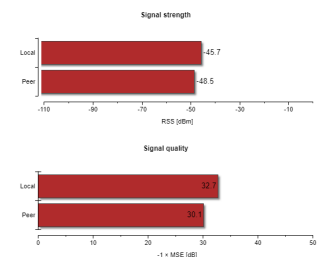
Antenna Alignment Tool is optimized for devices with smaller displays. All values are refreshed ten times per second to enable smooth operation. The Antenna Alignment Tool is described in Section 5.6.2 *Live data*. The Tool is available on <http://<ip>/tk>, (e.g. <http://192.168.169.169/tk> for standard Ethernet ports, alternatively on <http://172.17.17.17/tk> in the case of connection through USB/WiFi or USB/Eth).

The Tool is accessible without any username or password.



Bar graph in web management

Within user management *Tools / Live data / Bar indicators* shows bar graphs of RSS and MSE values for local and peer units. Values are refreshed every second or manually. See Section 5.6.2 *Live data* for detailed information.



4.7.4. Link test

Basic parameters of the link are RSS and MSE. They can be checked by many different ways:

- in *RAYTools* page Alignment (both sides, refreshed automatically)
- in the menu *Status/Brief* and *Status/Detailed* (both sides, can be refreshed manually by pressing the Refresh button or in real time with a period of several seconds after activating the Start button)
- on the screen *Tools/Live data/Bar indicators* (both sides, refreshed once a second After pressing the Start button)
- on voltmeter (only local RSS value)

Verify the functionality of the radio link similar like in chapter *Link test*.

After installation, it is good to reset the statistics using the *Clear stats* button in menu *Status/Detailed*. This allows easier diagnostics of the link's reliability over time.

4.7.5. Parameters setup

After both antennas have been aligned, setup operation parameters for the link. In the case of links operating in the free band, setup the parameters based on survey results from the tool *Tools/Live data/Frequency analyzer*. In the case of links operating on a licensed band, setup the parameters based on the assigned license:

- Bandwidth
- Channel Selection (TX / RX channel)

- Modulation (TX modulation) – ACM is recommended. When selecting fixed modulation it is necessary to account for the fade margin. If fixed modulation is setup close to a possible maximum, then a deterioration in RSS could endanger the link both for data transfer as well as service access.
- Transmit power (TX power), or ATPC
- Verify and record IP addresses
- Define access channels – HTTPS / telnet / ssh / ssh with password
- Check the *users password settings*
- Check / setup the WiFi password or deactivate WiFi access permanently (in unit management menu *USB accessories* or physically by removing the WiFi module from slot “S”)

Restart both units by interrupting their power supply and verify the status of the link. This verifies that all parameters have been stored correctly in the memory.

Select *Tools/Maintenance/Backup/Settings (Local & Peer)/Full* and save the configuration to backup file “cnf_backup.tgz”.


This completes the installation. Further configuration can be performed remotely.

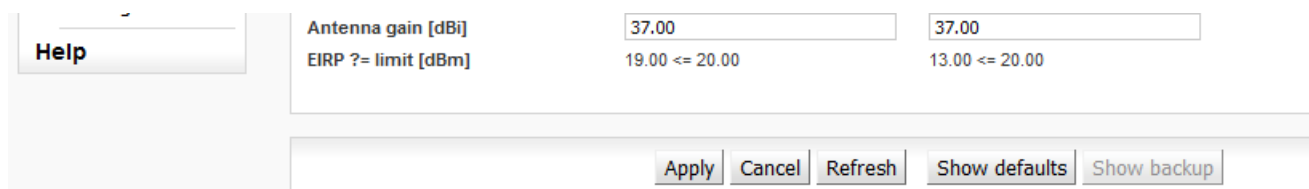
5. Configuration

5.1. Introduction

Controls

The following configuration buttons are used for configuration:

Apply	Apply and save parameters.
Cancel	Set parameters are overwritten with original values.
Refresh	Reload all current values of the unit / both units.
Show defaults	Clicking the button displays the default values of all individual parameters on the current screen. To use these values, you must click on the "Apply" button.
Show backup	Clicking the button displays the values of individual parameters held in the backup file (<i>Backup/Settings/Open file upload</i>). To use any of these values, you must use the "Apply" button. For loading the backup configuration see menu <i>Tools/Maintenance/Backup</i> .
Start	Activating automatic refresh fields marked by  icon using the <i>Start</i> button with the frequency circa 1 sec.
Stop	Use the "Stop" button to stop automatic refresh of displayed information with 1sec period. Date and time values are refreshed anyway.



The screenshot shows a configuration panel with a 'Help' button on the left. The main area contains two rows of parameters: 'Antenna gain [dBi]' with a value of 37.00, and 'EIRP ?= limit [dBm]' with a range of 19.00 <= 20.00. Below these are five buttons: 'Apply', 'Cancel', 'Refresh', 'Show defaults', and 'Show backup'.

Fig. 5.1: Configuration Controls

Help

The microwave link configuration system is equipped with built in Help - see *Help section*. The Help is accessible in two forms:

- Configuration parameter context help. The help text is displayed in the pop-up window after clicking the parameter name.
- The whole user interface help, activated by clicking the *Help* menu.

Login

You can login into the configuration interface using either the **insecure HTTP** protocol (default login screen), or the **secure HTTPS** protocol. You should select the connection method on the login screen. If the HTTPS protocol is used, it is not possible to tap the network communication and acquire the station's login information.

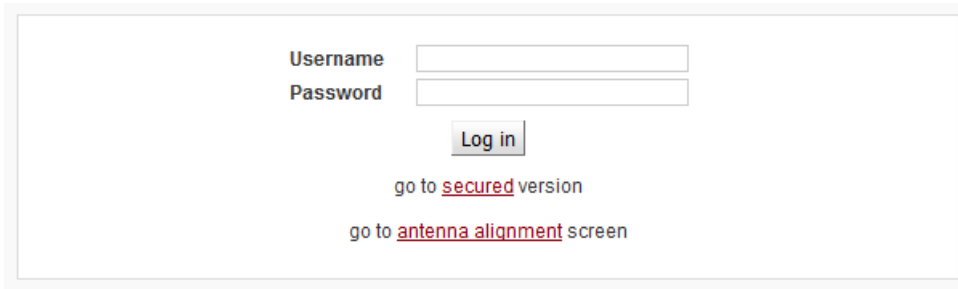


Fig. 5.2: Login



Note

Antenna alignment link below Login window activates smartphone Antenna alignment tool. See its detailed description in chapter *Live data*.

Rollback function

If you interrupt the connection on an operating link by entering inappropriate radio link parameters, the original parameters will be restored after 1 minute. The connection is automatically restored.

5.2. Status bar



Fig. 5.3: Status bar 1

The Status bar is located on the upper part of the screen below the title bar. It consists of 3 fields:

- **Local** unit status (unit assigned to the IP address entered in the browser or CLI)
- Local to Peer **Link** status.
- **Peer** unit status.

Local and Peer field displays:

- Station name according to configuration.
- Actual time valid for respective unit.
- Warning or Alarm icon in case of warning or alarm.

Link field display:

- Status of the link between both sides of the microwave link.
- Warning icon when the link is not capable of user data transfer.

The Link status can be one of the following values:

UNKNOWN	Unit start up. The initialization is not yet finished.
SETUP	Unit initialization according to valid configuration.

SINGLE	Unit in operation status. Link to peer unit is not established.
CONNECTING	Connection to peer unit in progress.
AUTHORIZING	Authorization of the peer unit in progress.
OK	Link is connected. Peer unit is authorized.
ANALYZER	Spectrum analyzer mode active. User data are not transferred.

All link states except for the state of OK are highlighted with a triangle.:

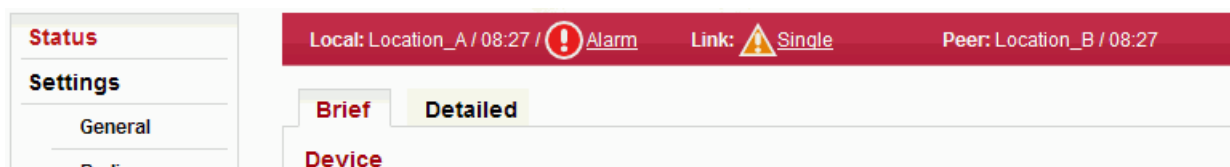



Fig. 5.4: Status bar 2

Example of a complete page - status bar, menu and control buttons:

5.3. Status

The "Status" menu provides basic information about local and remote station. Information is valid the moment the page is open, or the Refresh button is hit.

The *Status/Brief* tab shows only the most important values whereas the *Status/Detailed* tab provides further details. Below is a list of all values according to the tab *Status/Detailed*.

The  icon marks fields which are automatically updated with 30 sec period (or 1 sec when the "Start" button is active).

Local: Site-A / 09:45
Link: [Ok](#)

Status

Link settings

General

Radio

Service access

Alarms

Switch settings

Status

Interface

Advanced

Tools

Maintenance

Live data

History



Logs

Programs






Help

Brief
Detailed




General

	Local	Peer
Product code	RAY3-24-L	RAY3-24-U
Station name	Site-A	Site-B
Inside temperature [°C] 	17.0	16.4
Voltage [V] 	55.4	50.4

Radio

	Local	Peer
Net bitrate [Mbps]	1002.11	1002.11
TX, RX bandwidth [MHz]	112 MHz	112 MHz
TX channel [GHz]	L1 24.060000	U1 24.190000
RX channel [GHz]	U1 24.190000	L1 24.060000
TX modulation 	2048QAM.ACM / 2048QAM	2048QAM.ACM / 2048QAM
TX power [dBm] 	-4 ATPC / 10	-4 ATPC / 10
RSS [dBm] 	-45.0 ATPC / -45.0	-45.0 ATPC / -45.0
MSE [dB] 	-39.0 ATPC / -38.0	-39.7 ATPC / -38.0
BER [-] 	0.00e+00	0.00e+00

Switch interface

	Local	Peer
Egress rate limit Air 	disabled	disabled
Link mode Eth1 	1000 Mbps / full	1000 Mbps / full
Link mode Eth2 	down	down

Service access

	Local	Peer
IPv4 address	10.10.0.188 / 24	10.10.0.189 / 24
Management VLAN	off	off
Unit S mode	off	off
Services	Web, SSH, SNMP	Web, SSH, SNMP


Refresh
 Start
Stop

Fig. 5.5: Menu Status - Brief (example)

Status
Local: Site-A / 09:47
Link: [Ok](#)

Link settings

General

Radio

Service access

Alarms

Switch settings

Status

Interface

Advanced

Tools

Maintenance

Live data

History

Logs

Programs

Help

Brief
Detailed

General

	Local	Peer
Product code	RAy3-24-L	RAy3-24-U
Serial no.	1801515341	1801516641
Station name	Site-A	Site-B
Station location	Base - Racom	Remote - Houdek
Radio SW version	1.0.2	1.0.2
Firmware version	1.0.14.0	1.0.14.0
Date	2019-09-18	2019-09-18
Time	09:47:37	09:47:32
Inside temperature [°C]	17.1	17.0
Voltage [V]	55.4	50.4

Radio

	Local	Peer
Band index	L	U
Polarization	vertical	horizontal
Frequency table	rcinfo24_ISM250;10	rcinfo24_ISM250;10
Net bitrate [Mbps]	1002.11	1002.11
Max. net bitrate [Mbps]	1003	1003
TX, RX bandwidth [MHz]	112 MHz	112 MHz
TX channel [GHz]	L1 24.060000	U1 24.190000
RX channel [GHz]	U1 24.190000	L1 24.060000
TX modulation	2048QAM ACM / 2048QAM	2048QAM ACM / 2048QAM
TX power [dBm]	-4 ATPC / 10	-4 ATPC / 10
RSS [dBm]	-44.9 ATPC / -45.0	-44.9 ATPC / -45.0
MSE [dB]	-39.0 ATPC / -38.0	-39.8 ATPC / -38.0
BER [-]	0.00e+00	0.00e+00
Link uptime	29 days, 00:10:08	

Switch interface

	Local	Peer
Egress rate limit Air	disabled	disabled
Link mode Eth1	1000 Mbps / full	1000 Mbps / full
Link mode Eth2	down	down

Service access

	Local	Peer
MAC address	00:02:a9:20:06:36	00:02:a9:20:06:86
IPv4 address	10.10.0.188 / 24	10.10.0.189 / 24
Management VLAN	off	off
Unit S mode	off	off
Services	Web, SSH, SNMP	Web, SSH, SNMP
USB accessories	No device	WiFi: disabled

Radio link statistics

	Local	Peer
Statistics Cleared	2019-08-20 15:14:10	2019-08-20 15:14:11
Statistics Period	29 days, 00:06:48	29 days, 00:08:37
Overall Link Uptime	29 days, 00:06:45	29 days, 00:08:34
Overall Link Downtime	0 days, 00:00:02	0 days, 00:00:02
Reliability [%]	99.9999	99.9999
Current Link Uptime	29 days, 00:06:45	29 days, 00:08:34
The Longest Drop	0 days, 00:00:02	0 days, 00:00:02
The Last Drop	0 days, 00:00:02	0 days, 00:00:02
Number of Drops	0	0

Fig. 5.6: Menu Status - Detailed (example)

5.3.1. Status - General

Product code Unit product code - is the same as the *Ordering code*.

Serial no. Unit serial number.

Station name	Station name (for example to reflect the unit location in the network topology).
Station location	Station location (for example GPS position or to reflect the network topology hierarchy).
Radio SW version	Software defined radio version.
Firmware version	Unit's firmware version.
Date, Time	The internal real-time clock. The clock is set manually or it is synchronized with NTP server and set for both units.
Inside temperature [°C]	Temperature inside the unit (on the modem board).
Voltage [V]	Unit's power supply voltage level.

5.3.2. Status - Radio

Band index	Radio unit type: L (Lower) or U (Upper) part of the frequency band.
TX polarization	Horizontal or vertical polarization based on the physical installation. Indicates the polarization of the transmitted signal. Local and Peer are indicated separately. The proper position of the cable is sideways down. Notice for RAY3-17 and RAY3-24 links: One side of the link must be installed in vertical polarization and the other in horizontal <i>polarization</i> .
Frequency table	Displays the currently used frequency table in format <name:version>.
Net bitrate [Mbps]	Current transfer capacity of radio channel for user data.
Max. net bitrate [Mbps]	The maximum RF channel capacity according to installed feature key.
Bandwidth [MHz]	One of the standard channel widths can be selected. This parameter must be set identically in local and remote.
TX and RX channel [GHz]	Used channels. Both number of the channel and frequency in GHz are listed.
TX modulation	Modulation type currently used for transmitting. When adaptive modulation is enabled, the ACM letters are displayed as well as information about maximum permitted modulation: "current modulation ACM / maximum modulation"
TX power [dBm]	Current output power on the RF channel in dBm. If ATPC is enabled, the ATPC letters are displayed as well as information about maximum permitted power: "current power ATPC / maximum power"
RSS [dBm]	Received signal strength. If ATPC is enabled, the ATPC letters are displayed as well as information about threshold value for activation of power control loop: "current RSS ATPC / threshold RSS"
MSE [dB]	Mean Square Error (the inverse to often used SNR - Signal to Noise Ratio). If ATPC is enabled, the ATPC letters are displayed as well as information about threshold value for activation of power control loop: "current MSE ATPC / threshold MSE"
BER [-]	Bit Error Rate is registered at the receiving end; instantaneous value.
Link uptime	Time elapsed since the current link connection has been established.

5.3.3. Status - Switch interface

Egress rate limit Air	Status of the Egress rate limiter on the Air interface. The traffic can be limited according to bits per second or frames per second. Message format for bits per second: "xx.xx Mbps Ly auto" where: xx.xx Mbps Egress speed limit. Ly L1/L2/L3 which Ethernet layer is used for speed calculation. auto gives information about active <i>Speed guard</i> function. Message format for frames per second: "xx.xx fps" where: xx.xx fps Egress frames per second limit.
Link mode Eth1, 2	Status of Ethernet interface. Current bit rate (10 = 10BASE-T, 100 = 100BASE-TX and 1000 = 1000BASE-T) and state of duplex (FD = full duplex, HD = half duplex).

5.3.4. Status - Service access

MAC address	HW address of the Ethernet module.
IPv4 address	IP address in the standard dotted decimal notation, including the bit width of netmask after the forward slash.
Management VLAN	Service access via VLAN management only.
Unit S mode	Shows 'ON' if unit type 'X' or 'E' behaves like unit type 'S' (i.e. if most modern unit emulates the older "S" model). Used only if a combination of different type units has to be used to build the link.
Services	Services enabled for unit management and monitoring (Web, Telnet, SSH, SNMP, NTP).
USB accessories	Indicates physical devices inside USB connector in system slot 'S' and its status (for example: 'WiFi: disabled').

5.3.5. Status - Radio link statistics

Information on statistical data:

Statistics Cleared	Time of log clearing.
Statistics Period	Period of log refresh.
Overall Link Uptime	Overall time the link has been connected.
Overall Link Downtime	Overall time the link has been disconnected.
Reliability [%]	The ratio of "Uptime" and "Downtime".
Current Link Uptime	Current time the link has been connected.
The Longest Drop	The longest downtime period recorded.
The Last Drop	Length of the last link interruption.
Number of Drops	Number of link interruptions.

5.4. Link settings

5.4.1. General

Setup of general parameters of the link.

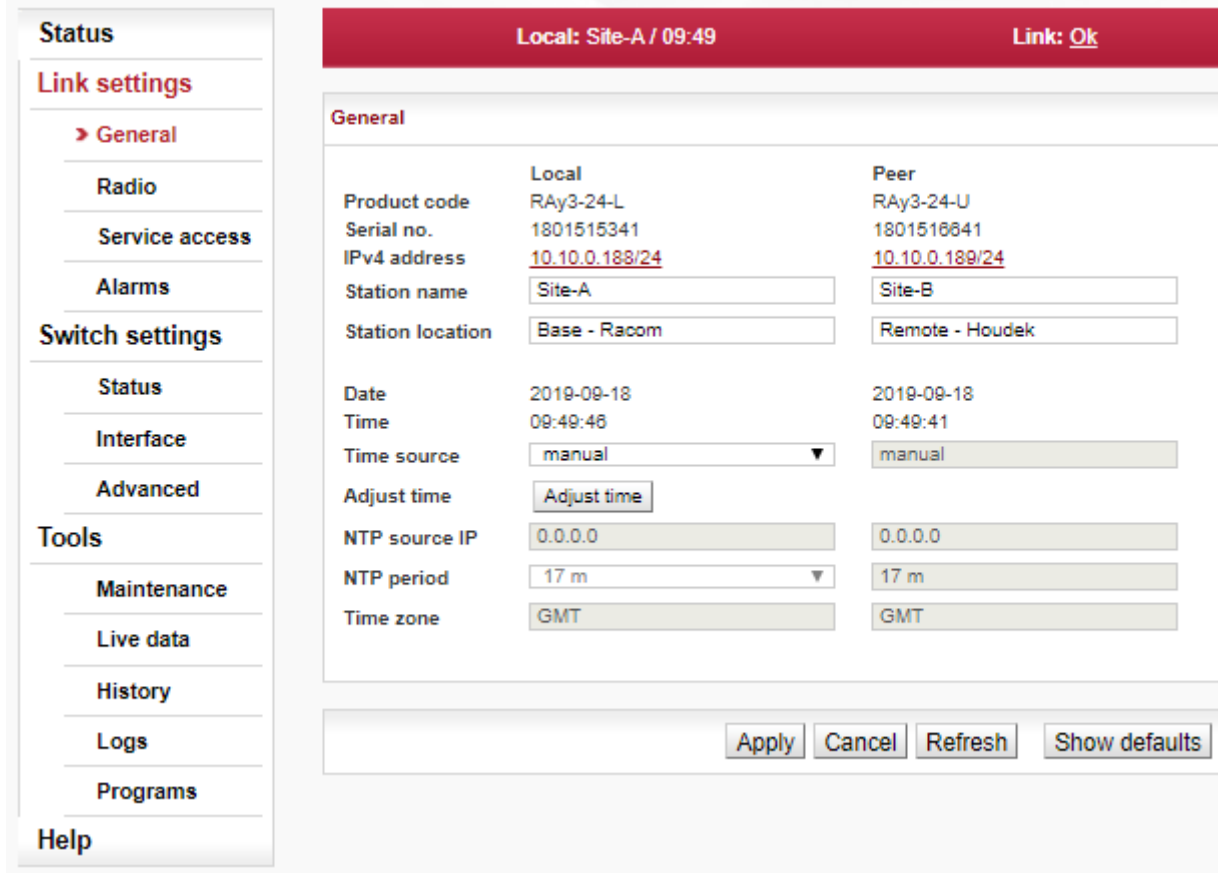
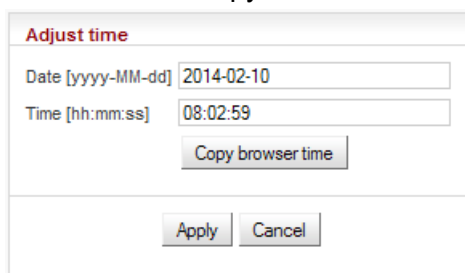


Fig. 5.7: Menu Link settings / General

Product code	Unit type indicator.
Serial no.	Unit serial number.
IPv4 address	IP address in the standard dotted decimal notation, including the bit width of netmask after the forward slash.
Station name	Station name can be modified by user (for example to reflect the unit location in the network topology).
Station location	Station location can be modified by user (for example to reflect the network topology hierarchy).
Date, Time	The internal real-time clock. The clock is set manually or it is synchronized with NTP server and set for both units.
Time source	Time synchronization source setup. Manual setup or NTP protocol use. For easier diagnostics of link operation, it is recommended to use the NTP time synchronization.

Adjust time

Manual time setup. Use the dialog box to manually set the current date and time. You can copy time from browser (local PC).



The dialog box titled "Adjust time" contains two input fields: "Date [yyyy-MM-dd]" with the value "2014-02-10" and "Time [hh:mm:ss]" with the value "08:02:59". Below these fields is a button labeled "Copy browser time". At the bottom of the dialog are two buttons: "Apply" and "Cancel".

NTP source IP

IP address of the time synchronization server.

NTP period

Time synchronization interval.

Time zone

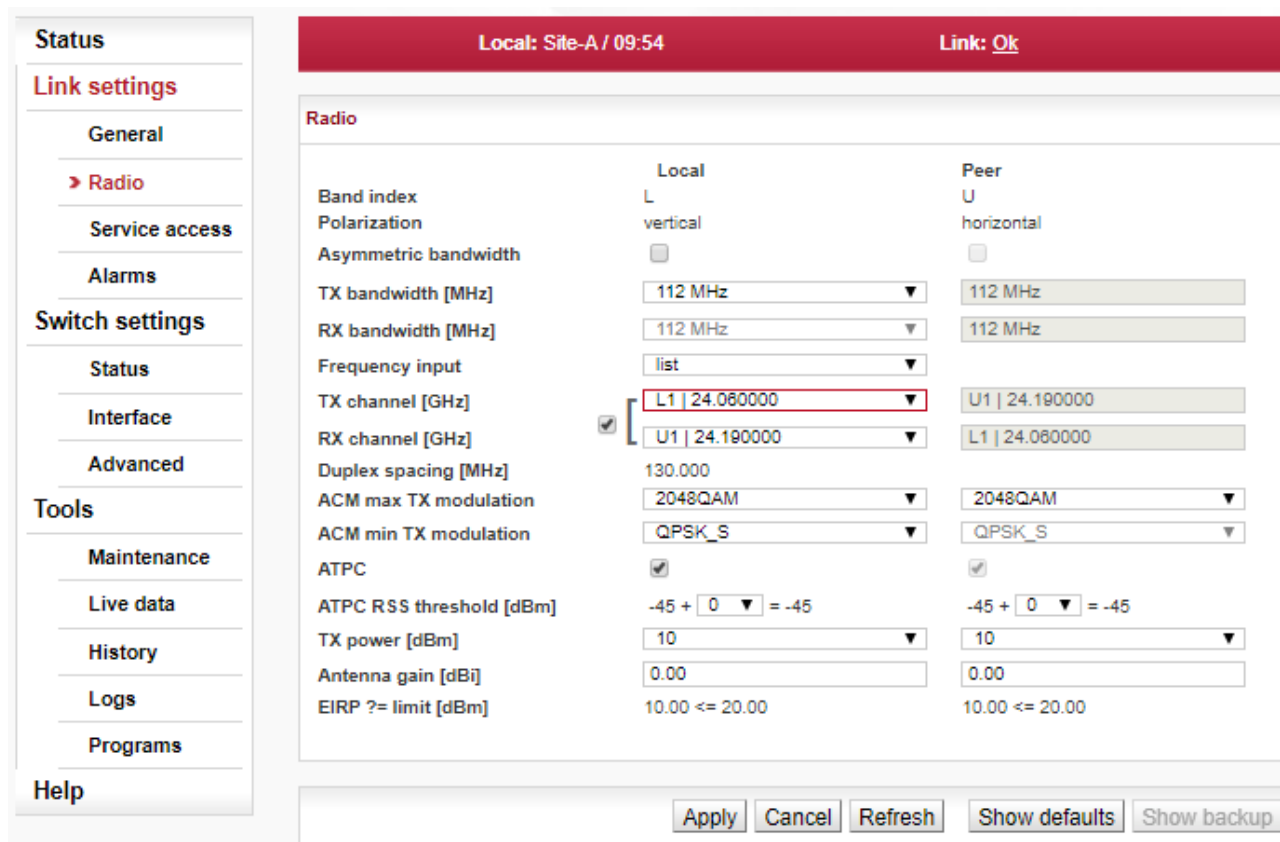
Time zone

**Note**

When the time zone is changed, the original values set in the RAY unit are kept. The actual change takes place after OS restart in order to prevent unexpected states related with local time change.

5.4.2. Radio

Setup of general parameters of the radio link.



The screenshot shows the "Radio" settings page in a web interface. The top status bar indicates "Local: Site-A / 09:54" and "Link: Ok". The left sidebar contains a navigation menu with sections: Status, Link settings (selected), Service access, Alarms, Switch settings, Tools, Maintenance, Live data, History, Logs, Programs, and Help. The "Radio" section is expanded, showing a table of parameters for Local and Peer configurations.

	Local	Peer
Band index	L	U
Polarization	vertical	horizontal
Asymmetric bandwidth	<input type="checkbox"/>	<input type="checkbox"/>
TX bandwidth [MHz]	112 MHz	112 MHz
RX bandwidth [MHz]	112 MHz	112 MHz
Frequency input	list	
TX channel [GHz]	L1 24.080000	U1 24.190000
RX channel [GHz]	U1 24.190000	L1 24.080000
Duplex spacing [MHz]	130.000	
ACM max TX modulation	2048QAM	2048QAM
ACM min TX modulation	QPSK_S	QPSK_S
ATPC	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
ATPC RSS threshold [dBm]	-45 + 0 = -45	-45 + 0 = -45
TX power [dBm]	10	10
Antenna gain [dBi]	0.00	0.00
EIRP ?= limit [dBm]	10.00 <= 20.00	10.00 <= 20.00

At the bottom of the settings area are buttons for "Apply", "Cancel", "Refresh", "Show defaults", and "Show backup".

Fig. 5.8: Menu Link settings / Radio

Band index	Radio unit type: L(ower) or U(pper) part of the frequency band.
TX polarization	Horizontal or vertical polarization based on the physical installation. Indicates the polarization of the transmitted signal. Local and Peer are indicated separately. The proper position of the cable is sideways down. Notice for RAY3-17 and RAY3-24 links: One side of the link must be installed in vertical polarization and the other in horizontal <i>polarization</i> .
Asymmetric bandwidth	Enable asymmetric channel bandwidth.
TX bandwidth [MHz]	One of the standard channel widths can be selected. This parameter must be set identically in local and remote (local TX bandwidth = peer RX bandwidth and local RX bandwidth = peer TX bandwidth). When units are connected, this is ensured automatically. If asymmetry is not allowed, then TX bandwidth = RX bandwidth on both units.
RX bandwidth [MHz]	
Frequency input	Allows to choose if TX and RX channel frequencies are selected from the list of predefined channels or if manual input of frequencies would be possible (if supported).
TX channel [GHz]	TX and RX channels are selected from a list of channels. The basic configuration has the TX and RX options interconnected. In this case the basic duplex spacing between channels is preserved and by selecting one channel, the other three are defined as well. For units operating in free bands, it is possible to disconnect the TX-RX lock and select TX and RX channels individually. Corresponding channels at peer unit are set automatically. NOTE: Non-standard duplex setting leads to non-effective use of the spectrum.
RX channel [GHz]	
Duplex spacing [MHz]	Information about duplex spacing of TX and RX channel.
ACM max TX modulation	Setting of minimum and maximum modulation level for ACM on TX channel (can be set differently for local and peer unit). ACM is always enabled on RAY3 and would operate within those boundaries. You can select in range from QPSK_S (highest sensitivity for difficult conditions) up to 4096QAM (highest speed for good conditions). NOTE: On some channel widths the highest available modulation to select may be lower than 4096QAM.
ACM min TX modulation	
ATPC	Enable automatic <i>control of RF power</i> . Once enabled, the TX power is regulated towards lower level while maintaining signal level high enough not to affect current degree of modulation.
ATPC RSS threshold [dBm]	The ATPC algorithm controls the output power according to RSS of the peer unit. The lowest allowed RSS (the threshold) is approx. 10 dBm above declared sensitivity for BER 10^{-6} . If necessary, it is possible to use this parameter to move the threshold slightly up or down.
TX power [dBm]	RF output power. With ATPC enabled this parameter defines maximum RF power level.
Antenna gain [dBi]	Gain of used antenna. It is used to calculate approximate EIRP. Valid only for RAY3-17 and RAY3-24 links.
EIRP ?= limit [dBm]	Approximate calculation of EIRP. Number on the right shows the allowed EIRP limit. Sign between numbers gives information on compliance / noncompliance with allowed EIRP limits. If the <i>EIRP limit</i> field background is RED, the value shown may be used but will exceed the EIRP limit.

This field value will only be shown for certain RAY3-17 and RAY3-24 links and based on the *Frequency tables* used.

The principle behind ATPC is to maintain the lowest transmitting power without affecting the throughput of the link. The output is primarily controlled by RSS on the opposite side. ATPC is also used to maintain MSE thus protecting the selected modulation level.

The ATPC Control loop is evaluated once per second.

The principle behind ACM is to maintain the connection between the two units even when degraded propagation conditions are experienced which make it impossible to maintain the selected modulation level. ACM regulates TX modulation across all ranges from ACM min TX modulation up to ACM max TX modulation (as configured by the user) according to the limits in table *ACM switching according to MSE state*.

ACM control loop is evaluated with each frame, i.e. roughly after tens of microseconds.

In normal operating conditions, ATPC is applied first (even if it is the slower control loop). When deterioration in propagation conditions gradually increases the attenuation on the route, it is compensated by increasing RF power. ACM control will only be applied in conditions when ATPC reaches its ceiling.

5.4.3. Service access

Services

Access routes for link configuration.

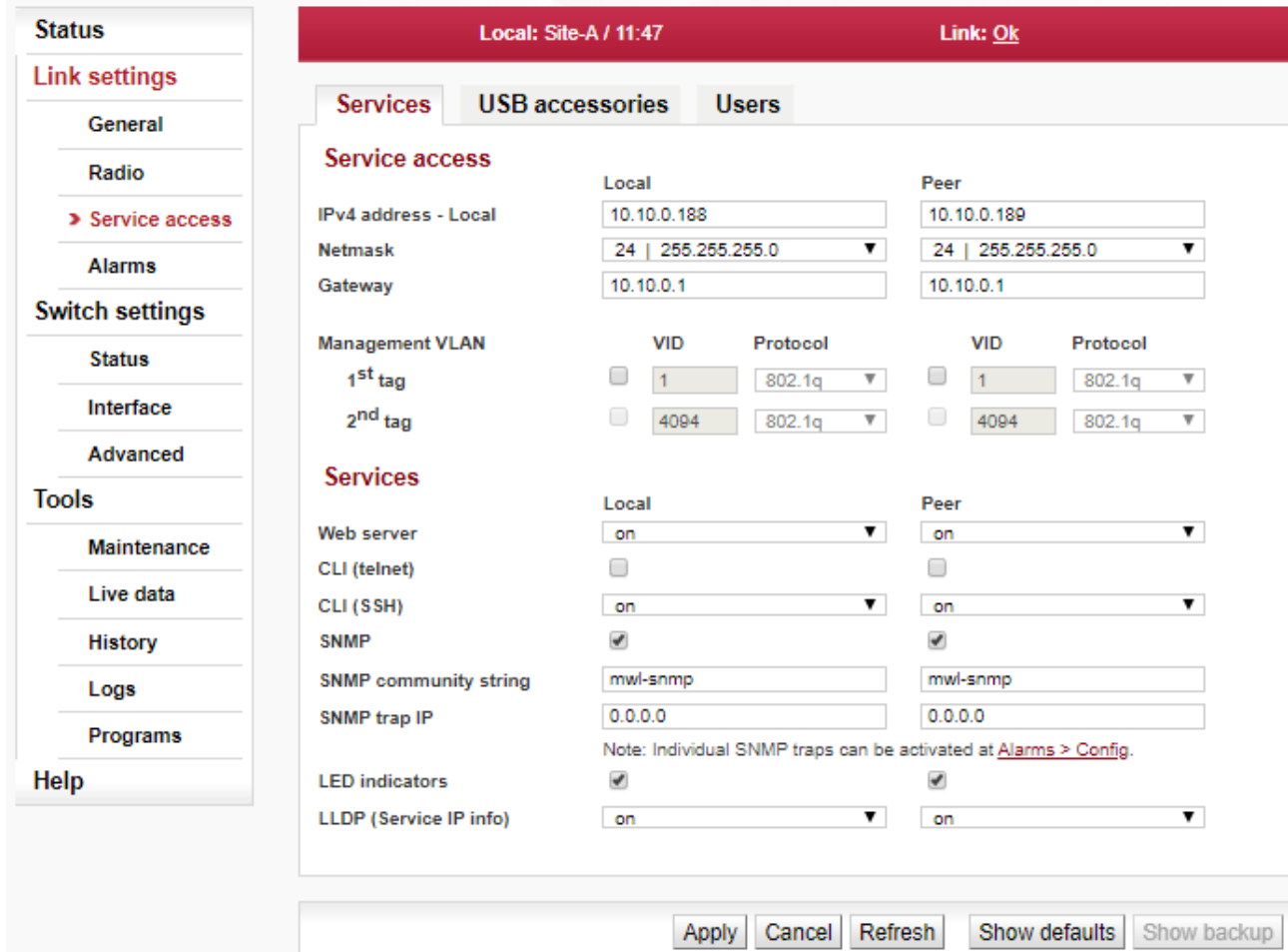


Fig. 5.9: Menu Link settings / Service access / Services

- IPv4 address** Service IP address, by default 192.168.169.169 for L unit and 192.168.169.170 for U unit. Management address of the Peer station has to be set up as well.
- Netmask** Mask for service access, 24 by default.
- Gateway** Default gateway for service access; empty by default.
- Management VLAN, 1st tag, 2nd tag** Enables management access via VLAN. Management VLAN can be single-tagged or dual-tagged. Line for 2nd tag gets active only after 1st tag is activated. Blocks access for HTTPS, ssh and telnet configuration via untagged packets (without VLAN) making only VLAN access possible. VLAN management is off by default.
WARNING:
 By enabling VLAN management, ALL accesses are blocked for configuration using normal (untagged) LAN! During tests, you may enable VLAN management on one unit only. Then it is possible to access the link via LAN and VLAN either directly or via radio link.
- VID** VLAN management id, by default 1. This field must have a value entered even when VLAN management is not active.

Protocol	Protocol 802.1q or 802.1ad												
Web server	Allows access via web server (for HTTP and HTTPS protocol). WARNING: after disabling access via web server, you will not be able to access the unit using a web browser!												
CLI (telnet)	Enables access via telnet protocol. Provides access to CLI (Command Line Interface) for simple telnet clients. Disabled by default.												
CLI (SSH)	Enables access via SSH protocol. Provides secure access to CLI. If preventing unauthorized access to the unit is the number one priority, leave only this server on.												
SNMP	Enabling SNMP server. Off by default.												
SNMP community string	SNMP community string. Can contain both lower and uppercase letters, numbers, four characters . : _ - and can be up to 256 characters long.												
SNMP trap IP	Address for sending SNMP traps. It is possible to record up to 3 addresses separated by commas.												
LED indicators	Enable LED status indicators on the body of the unit. You can turn off LED indication with this option.												
LLDP (Service IP info)	Data transmitted through the LLDP protocol can be accessed in two ways: <table border="0" style="margin-left: 20px;"> <tr> <td>On</td> <td>Transmissions every 60 seconds</td> </tr> <tr> <td>Single</td> <td>Transmitted once only when unit is rebooted</td> </tr> </table> <p>If you forget the Service IP address, it can be found by reading data broadcast through LLDP protocol. Data contains the following information:</p> <table border="0" style="margin-left: 20px;"> <tr> <td>Management address</td> <td>IP address</td> </tr> <tr> <td>System Description</td> <td>Serial number</td> </tr> <tr> <td>Chassis Subtype</td> <td>Type (e.g. RAY3-17-L)</td> </tr> <tr> <td>IEEE 802.1 - Port and Protocol VLAN ID</td> <td>Port and Protocol VLAN Identifier: (e.g. 300 (0x012C)) but only if Management VLAN is enabled</td> </tr> </table> <p>The message can be recorded and converted into a readable form using a LLDP client. A suitable tool for this purpose is Wireshark IP traffic analyzing tool, with free licenses available for both Windows and Linux. To locate the message easily, use the Capture filter "ether proto 0x88cc" in Wireshark. Management address of the Peer station has to be set up as well.</p>	On	Transmissions every 60 seconds	Single	Transmitted once only when unit is rebooted	Management address	IP address	System Description	Serial number	Chassis Subtype	Type (e.g. RAY3-17-L)	IEEE 802.1 - Port and Protocol VLAN ID	Port and Protocol VLAN Identifier: (e.g. 300 (0x012C)) but only if Management VLAN is enabled
On	Transmissions every 60 seconds												
Single	Transmitted once only when unit is rebooted												
Management address	IP address												
System Description	Serial number												
Chassis Subtype	Type (e.g. RAY3-17-L)												
IEEE 802.1 - Port and Protocol VLAN ID	Port and Protocol VLAN Identifier: (e.g. 300 (0x012C)) but only if Management VLAN is enabled												

USB accessories

The USB connector is used for management access (not for user data) to the local unit using Ethernet or WiFi adapter. Only RACOM recommended adapters are supported.

Default WiFi IP address of the unit is 172.17.17.17 with DHCP enabled by default allocating IP address automatically to connected device.

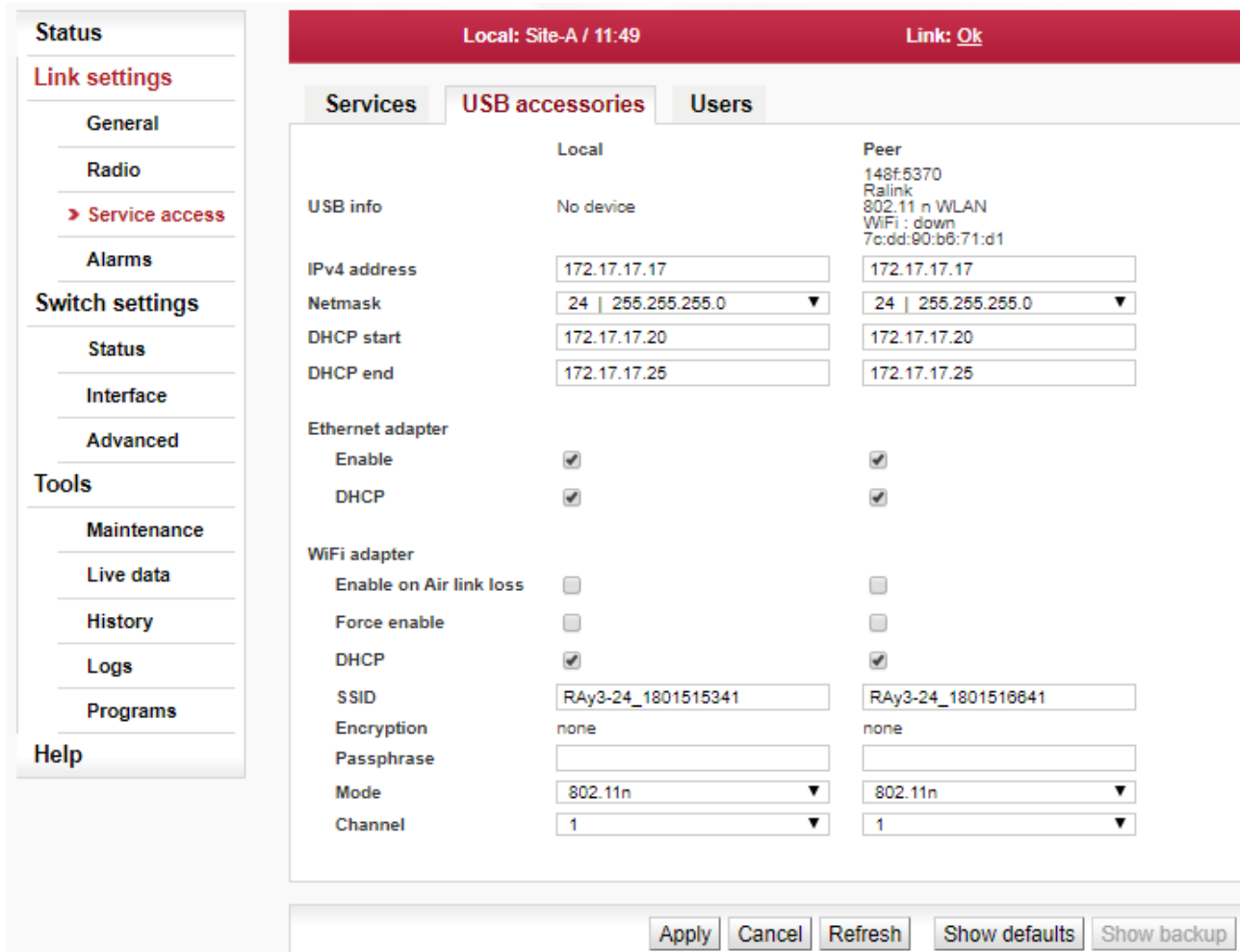


Fig. 5.10: Menu Link settings / Service access / USB accessories

USB info

Status information about device connected via the USB:

n/a - info not available (HW not known to RAY3 FW = probably not RACOM supplied accessory), or

No device - no device plugged in the USB port, or

List of basic USB module credentials:

- Vendor ID: Product ID
- Manufacturer
- Product
- WiFi/Eth: up/down ... only for network device
- MAC ... only for network device

IPv4 address

Unit service management address when connecting via USB port.

Netmask

Network mask when connecting via USB port.

DHCP start	DHCP range for dynamic address allocation of the management client
DHCP end	connected via USB port.
Ethernet adapter enable	Enables operation of USB/Eth adapter.
Ethernet adapter DHCP	Enables DHCP on WiFi adapter if present (for automatic setting of client(s) IP address).
WiFi adapter enable on Air link loss	WiFi is activated only during Air-Link loss – means WiFi starts to work and transmit SSID. WiFi is activated 60 seconds after Air-Link loss and deactivated 600 seconds after the Air-Link is restored. The WiFi passphrase should be set by admin before using this option (if not <i>WiFi management</i> alarm is activated).
WiFi adapter Force enable	WiFi is forced to be permanently active (and to transmit SSID) and <i>WiFi management</i> alarm is activated. WiFi passphrase should be set by admin before using this option. This parameter has a higher priority than "WiFi adapter enable on Air link loss", so if it is set ON then WiFi activity does not depend on Air-Link status.
WiFi adapter DHCP	Enables DHCP on WiFi adapter if present (for automatic setting of client(s) IP address).
WiFi SSID	Name of service WiFi visible by clients (can be max 32 characters long).
WiFi encryption	Service WiFi encryption is WPA2 and can not be changed. Factory default is "none" due to missing passphrase. WPA2 is applied automatically once any passphrase is entered.
WiFi passphrase	Service WiFi passphrase has to be 8-64 characters long. The WiFi passphrase should be set by admin before any use of WiFi. Until passphrase is set, <i>WiFi management</i> alarm is activated.
WiFi mode	Service WiFi mode can be IEEE 802.11n or IEEE 802.11g
WiFi channel	WiFi channel can be set 1-11 depending on WiFi mode setting (see parameter above): IEEE 802.11n - channels 1-7 IEEE 802.11g - channels 1-11 The WiFi adapter does not search for conflicts in the air. If problems occur, changing the channel is the easiest way to resolve the issue.

Users

List and setup of users. Example menu of the `cli_super` level user.

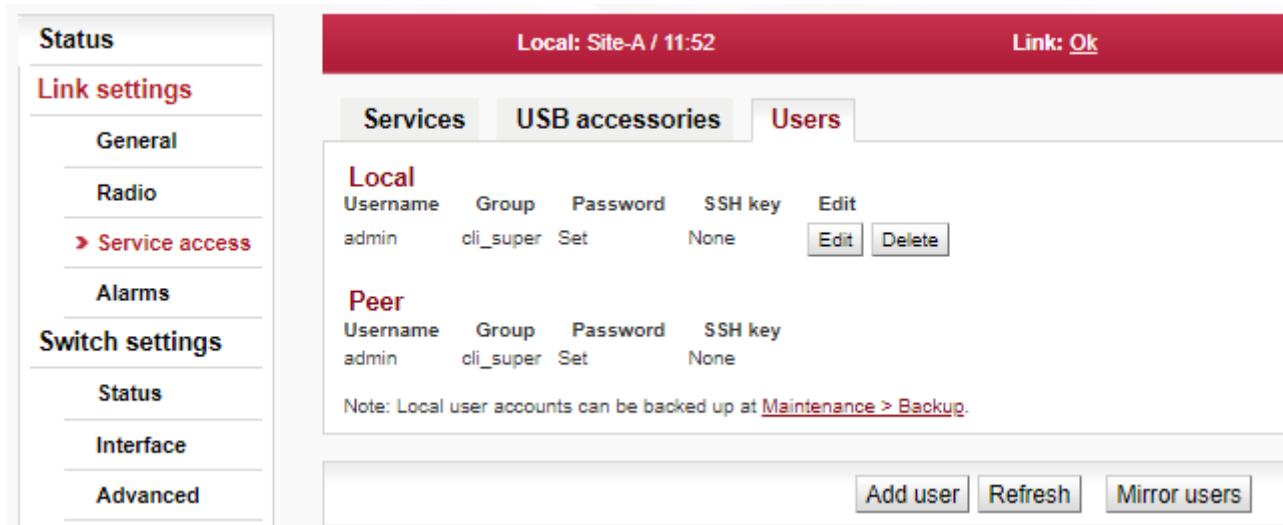


Fig. 5.11: Menu Link settings / Service access / Users

Within the default Factory Settings one user is defined in the system. This user has username **admin** and password **admin** and is assigned the highest level of permissions `cli_super`. This user then assigns other users to the system along with their level of permissions.

Service access has three levels of permissions. Numbers of users that can be defined in the system:

Permissions	No of users
<code>cli_guest</code>	10
<code>cli_admin</code>	10
<code>cli_super</code>	2

Permissions defined in the system	<code>cli_guest</code>	<code>cli_admin</code>	<code>cli_super</code>
Create new user	No	No	Yes
Change own password	Yes	Yes	Yes
Delete user *	No	No	Yes
Copy (Mirror) permissions local to peer	No	No	Yes
Configure and modify link settings	No	Yes	Yes

* The system prevents the user from deleting both `cli_super` accounts.

The logged-on user is shown in the top right of the screen. There can be different users on either end of the link.



Important

It is strongly recommended that the default password `admin` is changed. Similarly, all other users should change their password. Using the CLI, it is appropriate to supplement the SSH key.

Local, Peer	List of users on Local and Peer stations.
Username	This name is entered at Login to log into the link management.
Group	User group to which the user belongs. cli_guest Read Only cli_admin Configure and modify link settings cli_super Configure and modify user accounts and link settings
Password	Information about whether user has a password
SSH key	Information about whether user has at least one ssh key defined.



Note

More users concurrently

If two or more users work concurrently on the unit any change of configuration settings should be applied by all users. This applies to the menu *Link settings* which works with both, Local and Peer parameters. Notification to other users:

If one user sends the Apply command, other users will receive a message: "Configuration changed, please go to Link settings and click Refresh". Other users can only use the Apply command after refreshing Link Settings.

Edit user

Clicking "Edit" next to a username opens a screen with configuration of the given account.

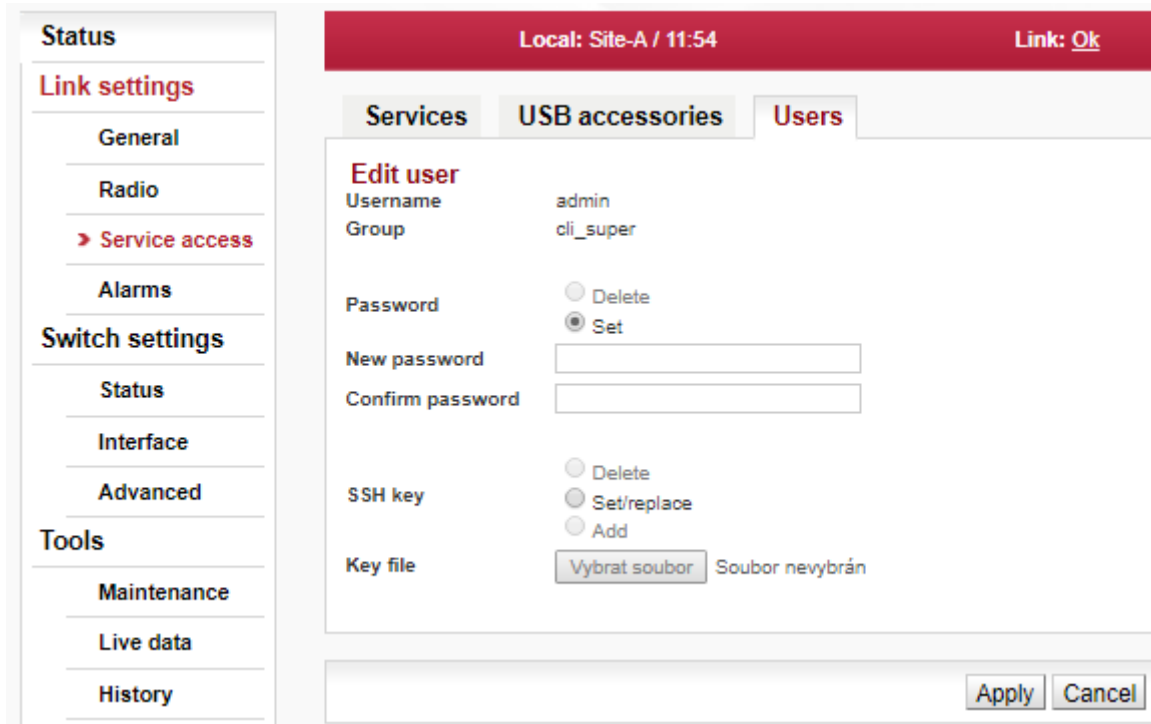


Fig. 5.12: Menu Link settings / Service access / Users / edit

- Username** User name
 - Group** The group to which this user will belong.
 - Password** Password can be set or deleted.
 - Delete** – User will not have a password. The user will only be able to log in with a ssh key. In order to delete the password, you must first upload the ssh key.
 - Set** – Password settings.
 - New password** New password.
 - Confirm password** Repeat password.
 - SSH key** Working with ssh key.
 - Delete** – Clear all ssh keys from user account.
 - Set/replace** – Add a new key. If there already was any key(s), it will be overwritten.
 - Add** – Add a new key. You can enter multiple ssh keys in this way.
 - Key file** Insert key file.
- Save the menu content by clicking on the button Apply.

Backup user

The user settings can be backed up, see *Tools / Maintenance / Backup*.

Delete user

Users at level `cli_super` have a Delete button next to each user. Delete a user using this button without being asked to confirm deletion. Users at level `cli_super` cannot both be deleted.

Add user

The button is located on the bottom bar.

For level `cli_super` users, the "Add user" button is active. Use it to create a new user within any group.

Username	Name of new user.
Group	The group to which this user is assigned.
New password	Password for this user.
Confirm password	Repeat password.
SSH key	If you want the user to have access using ssh protocol and identity verification using ssh key, enter the ssh key here.

Create a new user account by clicking on the button Apply.

Mirror users

The button is located on the bottom bar.

For level `cli_super` users, the "Mirror users" button is active. This function will copy all user accounts from Local unit to Peer unit. All existing user accounts on the Peer unit are deleted.

5.4.4. Alarms

Alarms Config

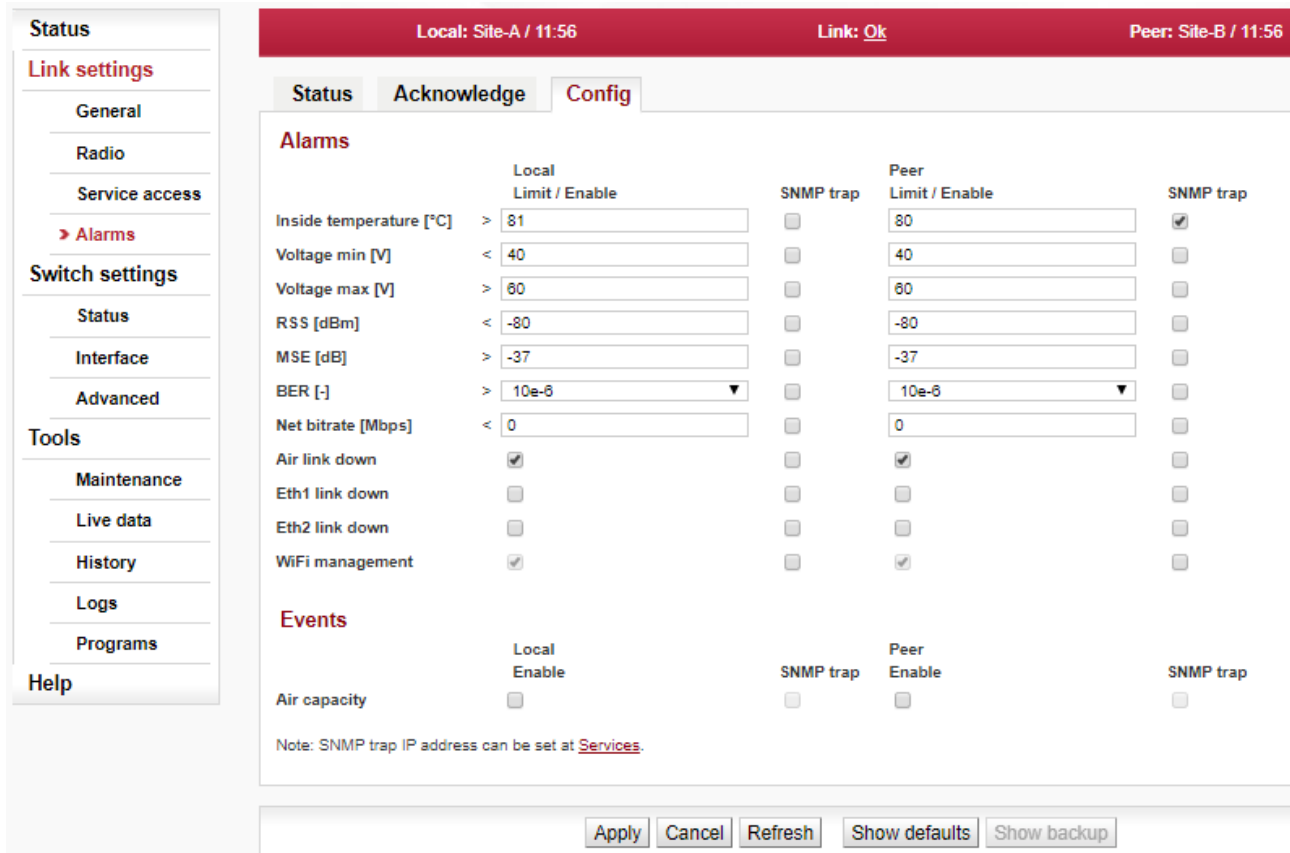


Fig. 5.13: Menu Link settings / Alarms / Config

The diagnostics system of the link monitors the operation of both units.

It generates various event outputs - system warnings and alarms. The event is always written to the system log and indicated in the *status bar* and *Alarms/Status* screen. Some events have adjustable thresholds. Events with no adjustable thresholds may or may not be Enabled. If they are not Enabled, the system event is not activated even if the system status is changed.

If the event goes above or below the set parameter limits or a link goes down or up, you can choose to send an SNMP trap. All SNMP traps are OFF in defaults.

alarm	default	description
Inside temper. [°C]	>80	Temperature inside the unit (on the modem board). Active if temperature exceeds the threshold.
Voltage min [V]	<40	Lower threshold of supply voltage. Active if voltage drops below min voltage threshold. The same SNMP trap (same OID) applies for both Voltage min and max.
Voltage max [V]	>60	Upper threshold of supply voltage. Active if voltage rises above max voltage threshold. The same SNMP trap (same OID) applies for both Voltage min and max.
RSS [dBm]	<-80	Received Signal Strength. Active if RSS drops below RSS threshold.

MSE [dB]	>0	Mean Square Error (the inverse to often used SNR - Signal to Noise Ratio). Active if MSE rises above MSE threshold.
BER [-]	>10e⁻⁶	Bit Error Rate is registered at the receiving end of the link- instantaneous value. Active if BER exceeds the threshold set in this parameter.
Net bitrate [Mbps]	0	The system warning is generated when the current transfer capacity of radio channel is lower than the threshold set in this parameter.
Air link down	on	Interruption of radio link. Active if radio link is interrupted and units can not communicate by Air.
Eth1/Eth2 link down	off	Corresponding user Eth link (Eth1/Eth2) on station interrupted. NOTE: The "EthX link" system alarm can only be activated if this alarm is Enabled. When the alarm is not Enabled, the "EthX link" alarm on <i>Status</i> screen is always "Ok" regardless of the current status of the Ethernet link.
WiFi Management	on	Warning is generated when WiFi passphrase is not set or WiFi adapter (and Host Access Point) is permanently enabled (WiFi Force Enable is ON). Parameter can not be changed in web interface (only through CLI).

Alarms Status

	Local	Peer
Inside temperature	25.5 °C is over limit 20 °C	OK
Voltage min	OK	OK
Voltage max	OK	55.4 V is over limit 50 V
RSS	-48.8 dBm is under limit -40 dBm	OK
MSE	OK	OK
BER	OK	OK
Net bitrate	OK	OK
Air link	OK	OK
Eth1 link	disabled	disabled
Eth2 link	disabled	disabled
WiFi management	OK	is up

Note: Alarm history is recorded in [Logs](#).

Fig. 5.14: Menu Link settings / Alarms / Status

Overview of alarms

All system alarms are listed on this screen. Inactive alarms are colored white with an "OK" text label. Active alarms are colored according to the severity of the alarm with a text message describing the measured value status.

- critical
- major
- minor
- warning
- cleared / OK
- ✓ confirmed

For a detailed description of each Alarm click on the Alarm name.

Fig. 5.15: Alarm severity

Alarms Acknowledge

Local: Unit-L / 08:58 / **Alarm** Link: [Ok](#) Peer: Unit-U / 08:58

Status **Acknowledge** **Config**

Alarm acknowledge

Name	State	From	To	Ack	User	Com
Inside temperature	Ack	2018-09-27 08:54:32		2018-09-27 08:57:40	admin	
Voltage min	OK					
Voltage max	OK					
RSS	Alarm	2018-09-27 08:54:32				
MSE	OK					
BER	OK					
Net bitrate	OK					
Air link	OK	2018-08-28 09:04:41	2018-08-28 09:04:42			
Eth1 link	OK					
Eth2 link	OK					
WiFi management	OK	2018-08-28 09:04:40	2018-09-25 06:30:30			

Comment

[Acknowledge](#) [Refresh](#)

Fig. 5.16: Menu Link settings / Alarms / Acknowledge

Alarm acknowledgement allows the operator to confirm the system is set in alarm state. Only an active alarm can be acknowledged. Multiple selections of active alarms (to acknowledge groups of alarms) can be performed using Shift or Ctrl keys.

- Name** Alarm identification - The following alarms can appear:
Inside temperature, Voltage min, Voltage max, RSS, MSE, BER, Net bitrate, Air link, Eth1 link, Eth2 link, RF power, WiFi management
- State** There are three possible alarm states:
OK ... No alarm (alarm is inactive) or alarm disabled.
Ack ... Alarm is active and acknowledged.
Alarm ... Alarm is active and is not acknowledged.
- From** Time stamp when the alarm occurred.
- To** Time stamp when the alarm expired (returned to normal conditions).
- Ack** Time stamp when the alarm was acknowledged.
Time stamp format: yyyy-MM-dd hh:mm:ss
- User** Name (login) of the user who acknowledged the alarm.
- Comment** The comment field can be used to add user defined comments when an 'alarm acknowledge' is performed. Use this comment field to describe important details of the alarm status. The comment can be up to 50 characters long. Special characters are not allowed. The alarm can be acknowledged multiple times with different comments. Every acknowledgement is written to the internal memory and is visible in the alarm log.

5.5. Switch settings

5.5.1. Status

Port status

The unit internal Ethernet switch port status

Local: Site-A / 12:49		Link: Ok		
	Port status	RMON counters	RSTP	
Port name	Eth1 (p1) data_1	Eth2 (p10) data_2	CPU (p0) cpu	Air (p9) air
Link status	up	down	up	up
Speed / duplex	1000 Mbps / full	n/a	1000 Mbps / full	2500 Mbps / full
SFP info	-	-	-	-
MDIX	-	-	-	-
Tx state	transmitting	n/a	transmitting	transmitting
Stp state	forwarding	forwarding	forwarding	forwarding
Flow control	OK	n/a	OK	OK
QoS	802.1p, DSCP	802.1p, DSCP	802.1p, DSCP	802.1p, DSCP

Fig. 5.17: Menu Switch settings / Status / Port status

Port name Identification of the internal switch port. The switch ports are connected to an external port or to an internal device (radio modem, management CPU).

Eth1	port1	The external port (with RJ45 interface) labeled "ETH1+POE".
Eth2	port10	The external port (with SFP interface) labeled "ETH2".
CPU	port0	The internal port to management CPU.
Air	port9	The internal port to radio modem, i.e. link to the peer unit.

Link status Ethernet link status can be

down	no link signal detected
up	link signal detected

Speed / duplex Ethernet link Speed and duplex.

Speed:	10/100/1000 Mbps.
Duplex:	full/half

SFP info Information about the (optionally) inserted SFP module. The three different types of SFP modules can be used:

Fibre	dual mode with LC connector
Fibre	single mode with LC connector
Copper	with RJ45 connector

There can be one of the following scenarios:

scenario	message
----------	---------

SFP OK	The SFP vendor string read out of SFP module. The vendor, model, connector (RJ45/LC) and wavelength values are shown. Separate window with more detailed information can be opened by clicking the "more..." link.
No SFP	No SFP module
read error	n/a
no SFP option	–

MDIX Status of the internal crossover of Ethernet cables. (MDIX = internally crossed pairs, MDI = direct connection, N/A means an unknown state).

Tx state Port transmitting status can be

transmitting	Normal port operation.
paused	Port transmitter is paused due to Pause frames reception.
n/a	Info not available.

Flow control Indication of Flow control status of the port. See *Flow control* and Pause limit parameters to configure Flow control settings.

QoS Quality of Service status can be one of the following values:

disabled	QoS functions are disabled.
802.1p	QoS according to 802.1p is enabled.
DSCP	QoS according to DSCP is enabled.
802.1p,DSCP	QoS according to 802.1p and DSCP is enabled. The 802.1 prefer tag is selected.
DSCP,802.1p	QoS according to 802.1p and DSCP is enabled. The DSCP prefer tag is selected.

RMON counters

The unit internal Ethernet switch RMON counters

Status
Local: Site-A / 13:53
Link: Ok
Peer: Site-B / 13:53

Link settings

General

Radio

Service access

Alarms

Switch settings

► Status

Interface

Advanced

Tools

Maintenance

Live data

History

Logs

Programs

Help

Port status
RMON counters
RSTP

Port name	Eth1 (p1) data_1 total	diff	Eth2 (p10) data_2 total	diff	CPU (p0) cpu total	diff	Air (p9) air total	diff
In good octets	17888144819888	0	0	0	15581458334	0	1588457881887	0
In bad octets	0	0	0	0	0	0	0	0
In unicasts	488825474	0	0	0	874741	0	3544082149	0
In multicasts	445044705	0	0	0	70381934	0	17887358	0
In broadcasts	180804318	0	0	0	112840538	0	8988897	0
In pause	0	0	0	0	0	0	157708	0
In undersize	0	0	0	0	0	0	0	0
In oversize	0	0	0	0	0	0	0	0
In FCS errors	0	0	0	0	0	0	0	0
In fragments	0	0	0	0	0	0	0	0
In jabber	0	0	0	0	0	0	0	0
In RX errors	0	0	0	0	0	0	0	0
In discards	0	0	0	0	0	0	0	0
In filtered	0	0	0	0	0	0	0	0
In accepted	1115574885	0	0	0	183897212	0	3588848288	0
In bad accepted	0	0	0	0	0	0	0	0
In good AVB A	0	0	0	0	0	0	0	0
In good AVB B	0	0	0	0	0	0	0	0
In bad AVB A	0	0	0	0	0	0	0	0
In bad AVB B	0	0	0	0	0	0	0	0
In TCAM 0	0	0	0	0	0	0	0	0
In TCAM 1	0	0	0	0	0	0	0	0
In TCAM 2	0	0	0	0	0	0	0	0
In TCAM 3	0	0	0	0	0	0	0	0
In dropped AVB A	0	0	0	0	0	0	0	0
In dropped AVB B	0	0	0	0	0	0	0	0
In DA unknown	830450380	0	0	0	183341178	0	24880318	0
In management	0	0	0	0	183897212	0	0	0
Out octets	1581075848313	0	0	0	281233272114	0	17848184328273	0
Out FCS errors	0	0	0	0	0	0	0	0
Out unicasts	3544841811	0	0	0	5088852	0	303758790	0
Out multicasts	29471778	0	0	0	482912078	0	503821558	0
Out broadcasts	10015421	0	0	0	187901018	0	290728137	0
Out pause	0	0	0	0	0	0	0	0
Out collisions	0	0	0	0	0	0	0	0
Out deferred	0	0	0	0	0	0	0	0
Out single	0	0	0	0	0	0	0	0
Out multiple	0	0	0	0	0	0	0	0
Out late	0	0	0	0	0	0	0	0
Out excessive	0	0	0	0	0	0	0	0
Out queue 0	3583870453	0	0	0	855531938	0	1097942884	0
Out queue 1	0	0	0	0	387	0	387	0
Out queue 2	0	0	0	0	1	0	3	0
Out queue 3	0	0	0	0	0	0	0	0
Out queue 4	0	0	0	0	0	0	0	0
Out queue 5	0	0	0	0	0	0	0	0
Out queue 6	258588	0	0	0	388941	0	380028	0
Out queue 7	0	0	0	0	507	0	511	0
Out cut through	0	0	0	0	0	0	0	0
Out octets A	0	0	0	0	55770	0	54073	0
Out octets B	30853158	0	0	0	29478851	0	28138888	0
Out yellow	0	0	0	0	0	0	0	0
Out dropped yellow	0	0	0	0	0	0	0	0
Size 64 octets	19874250	0	0	0	75489	0	25214970	0
Size 65-127 octets	4130881337	0	0	0	559745180	0	4108320558	0
Size 128-255 octets	518050444	0	0	0	58208764	0	518984480	0
Size 256-511 octets	283881332	0	0	0	34382987	0	281891770	0
Size 512-1023 octets	243825188	0	0	0	13850378	0	24248888	0
Size 1024-max octets	3800778284	0	0	0	173424158	0	3787794273	0

Histogram counters mode Received and transmitted

Measure time 00:00:00

Fig. 5.18: Menu Switch settings / Status / RMON counters

The Remote Network MONitoring (RMON) MIB was developed by the IETF to support monitoring and protocol analysis of LANs.

Port name Identification of the internal switch port. The switch ports are connected to an external port or to an internal device (radio modem, management CPU).

Eth1	port1	The external port (with RJ45 interface) labeled "ETH1+POE".
Eth2	port10	The external port (with SFP interface) labeled "ETH2".
CPU	port0	The internal port to management CPU.
Air	port9	The internal port to radio modem, i.e. link to the peer unit.

The Internal switch port RMON counters

These counters provide a set of Ethernet statistics for frames received on ingress and transmitted on egress.

Ingress statistics counters

In good octets	The sum of lengths of all good Ethernet frames received, that is frames that are not bad frames.
In bad octets	The sum of lengths of all bad Ethernet frames received.
In unicasts	The number of good frames received that have a Unicast destination MAC address.
In multicasts	The number of good frames received that have a Multicast destination MAC address. NOTE: This does not include frames counted in "In broadcasts" nor does it include frames counted in "In pause".
In broadcasts	The number of good frames received that have a Broadcast destination MAC address.
In pause	The number of good frames received that have a Pause destination MAC address.
In undersize	Total frames received with a length of less than 64 octets but with a valid FCS.
In oversize	Total frames received with a length of more than MaxSize octets but with a valid FCS.
In FCS errors	Total frames received with a CRC error not counted in "In fragments", "In jabber" or "In MAC RX" errors.
In fragments	Total frames received with a length of less than 64 octets and an invalid FCS.
In jabber	Total frames received with a length of more than MaxSize octets but with an invalid FCS.
In MAC RX errors	Total frames received with an RxErr signal from the PHY.
In discards	Total number of frames that normally would have been forwarded, but could not be due to a lack of buffer space.
In filtered	Total number of good frames that were filtered due to ingress switch policy rules.

Egress statistics counters

Out octets	The sum of lengths of all Ethernet frames sent from this MAC.
Out FCS errors	The number of frames transmitted with an invalid FCS. Whenever a frame is modified during transmission (e.g., to add or remove a tag) the frame's original FCS is inspected before a new FCS is

added to a modified frame. If the original FCS is invalid, the new FCS is made invalid too and this counter is incremented.

Out unicasts	The number of frames sent that have a Unicast destination MAC address.
Out multicasts	The number of good frames sent that have a Multicast destination MAC address. NOTE: This does not include frames counted in "Out broadcasts" nor does it include frames counted in "Out pause".
Out broadcasts	The number of good frames sent that have a Broadcast destination MAC address.
Out pause	The number of Flow Control frames sent.

Out deferred	The total number of successfully transmitted frames that experienced no collisions but are delayed because the medium was busy during the first attempt. This counter is applicable in half-duplex only.
Out collisions	The number of collision events seen by the MAC not including those counted in "Out Single", Multiple, Excessive, or Late. This counter is applicable in half-duplex only. See <i>Auto negotiation</i> .
Out single	The total number of successfully transmitted frames that experienced exactly one collision. This counter is applicable in half-duplex only.
Out multiple	The total number of successfully transmitted frames that experienced more than one collision. This counter is applicable in half-duplex only.
Out excessive	The number frames dropped in the transmit MAC because the frame experienced 16 consecutive collisions. This counter is applicable in half-duplex only.
Out late	The number of times a collision is detected later than 512 bits-times into the transmission of a frame. This counter is applicable in half-duplex only.

Out filtered	Total number of good frames that were filtered due to egress switch policy rules.
--------------	---

Frame size histogram counters

Size 64 octets	Total frames received (and/or transmitted) with a length of exactly 64 octets, including those with errors.
Size 65-127 octets	Total frames received (and/or transmitted) with a length of between 65 and 127 octets inclusive, including those with errors.
Size 128-255 octets	Total frames received (and/or transmitted) with a length of between 128 and 255 octets inclusive, including those with errors.
Size 256-511 octets	Total frames received (and/or transmitted) with a length of between 256 and 511 octets inclusive, including those with errors.
Size 512-1023 octets	Total frames received (and/or transmitted) with a length of between 512 and 1023 octets inclusive, including those with errors.
Size 1024-max octets	Total frames received (and/or transmitted) with a length of between 1024 and MaxSize (see MTU parameter) octets inclusive, including those with errors.

Histogram counters mode	Frame size histogram counters can count received and/or transmitted octets. The mode of histogram counters is indicated here.
Measure time	This is the time interval, the <i>diff</i> column is valid for. The "diff" column shows the difference of the actual value of the counters at the moment of pressing the Difference button and the value of the counters at the moment of pressing the Refresh button.
Refresh Difference	<p>In another way: The Difference counter reference value can be reset by pressing the Refresh button. The time point at which the Difference counter sample is triggered and the "diff" value is calculated is defined by pressing the Difference button.</p> <p>The "total" column always shows the actual values. It is refreshed either by pressing the Refresh and also the Difference button.</p>

5.5.2. Interface

Port

Configuration of port settings

Port name	Eth1 (p1)	Eth2 (p10)	CPU (p0)	Air (p9)
Label	data_1	data_2	cpu	air
Port enable	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Auto negotiation	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Speed / duplex	auto / auto	1000 Mbps / full	1000 Mbps / full	2500 Mbps / full
Frame mode	normal	normal	DSA	normal
Ether type	0x9100	0x9100	0x9100	0x9100
MTU [B]	10240	10240	10240	10240
TX flow control	off	auto	auto	auto
RX flow control	off	auto	auto	auto
Pause limit in [frame]	0	0	0	0
Pause limit out [frame]	3968	3968	3968	3968
Ignore checksum	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Fig. 5.19: Menu Switch settings / Interface / Port

Port name	Identification of the internal switch port. The switch ports are connected to an external port or to an internal device (radio modem, management CPU).
Eth1	port1 The external port (with RJ45 interface) labeled "ETH1+POE".
Eth2	port10 The external port (with SFP interface) labeled "ETH2".
CPU	port0 The internal port to management CPU.
Air	port9 The internal port to radio modem, i.e. link to the peer unit.

Label Name of each port on the switch (up to 15 characters).

Port enable Enables functionality of individual port on the switch. Each port can be enabled or disabled.

WARNING: When the port is disabled, no communication is possible through this port.

Auto negotiation Enables Auto-Negotiation functionality of individual port. Negotiation is an Ethernet procedure by which two connected devices choose common transmission parameters, such as speed, duplex mode and flow control. In this process, the connected devices first share their capabilities regarding these parameters and then choose the highest performance transmission mode they both support.

The device supports three types of Auto-Negotiation:

- 10/100/1000BASE-T Copper Auto-Negotiation. (IEEE 802.3 Clauses 28 and 40)
- 1000BASE-X Fiber Auto-Negotiation (IEEE 802.3 Clause 37)
- SGMII Auto-Negotiation (Cisco specification)

Auto-Negotiation provides a mechanism for transferring information from the local unit to the link partner to establish speed, duplex and Master/Slave preference during a link session.

Auto-Negotiation is initiated upon any of the following conditions:

- Power up reset
- Hardware reset
- Software reset
- Restart Auto-Negotiation
- Transition from power down to power up
- The link goes down

The **10/100/1000BASE-T Auto-Negotiation** is based on Clause 28 and 40 of the IEEE 802.3 specification. It is used to negotiate speed, duplex and flow control over CAT5 (or higher) UTP cable. Once Auto-Negotiation is initiated, the device determines whether or not the remote device has Auto-Negotiation capability. If so, the device and the remote device negotiate the speed and duplex with which to operate.

If the remote device does not have Auto-Negotiation capability, the device uses the parallel detect function to determine the speed of the remote device for 100BASE-TX and 10BASE-T modes. If a link is established based on the parallel detect function, it is then required to establish the link at half-duplex mode only. Refer to IEEE 802.3 clauses 28 and 40 for a full description of Auto-Negotiation.

1000BASE-X Auto-Negotiation is defined in Clause 37 of the IEEE 802.3 specification. It is used to auto-negotiate duplex and flow control over fibre cable.

If one side of the link enables 1000BASE-X Auto-Negotiation and the link partner does not, the link cannot linkup. The device implements an Auto-Negotiation bypass mode.

SGMII Auto-Negotiation. SGMII is a de-facto standard designed by Cisco. SGMII uses 1000BASE-X coding to send data as well as Auto-Negotiation information. However, the contents of the SGMII Auto-Negotiation are different than the 1000BASE-X Auto-Negotiation.

WARNING: If one device provides Auto-negotiation and the other works with a manual link parameters setting (i.e. without Auto-negotiation) the link operates in half-duplex mode. If the manual setting is set to full-duplex, the "Out collisions" may occur.

Speed / duplex

Ethernet link speed and duplex mode can be selected. Both parameters can be either auto negotiated or set manually. When the Auto negotiation parameter is disabled, only manual setting of the speed and duplex is possible. In most cases it is better to enable the auto negotiation and use "auto / auto" speed and duplex settings.

There are two possibilities to force the link to operate in specific speed and duplex:

Auto negotiation enabled. Select the desired Speed / duplex. The auto negotiation process advertises only this specified link mode. The link partner is asked to use it.

Auto negotiation disabled. Select the desired Speed / duplex. The link is set to this specified link mode. The link partner has to be set manually to the same mode.

Frame mode	<p>Ethernet Frame mode control defines the expected Ingress and the generated Egress tagging frame format for this port as follows:</p> <p>normal Normal Network mode uses industry standard IEEE 802.ac Tagged or Untagged frames. Tagged frames use an Ether Type of 0x8100. Ports that are expected to be connected to standard Ethernet devices should use this mode.</p> <p>DSA Inactive options are not required.</p> <p>provider Provider mode uses user definable Ether Types per port (see Ether type parameter) to define that a frame is Provider Tagged. Ports that are connected to standard Provider network devices, or devices that use Tagged frames with an Ether Type other than 0x8100 should use this mode.</p> <p>Frames that ingress this port with an Ether Type that matches the port's "Ether Type" parameter will be considered tagged, will have the tag's VID and PRI bits assigned to the frame (i.e. they will be used for switching and mapping), and will have the Provider Tag removed from the frame. If subsequent Provider Tags are found following the 1st Provider Tag, they too will be removed from the frame with their VID and PRI bits being ignored. Modified frames will be padded if required.</p> <p>Frames that ingress this port with an Ether Type that does not match the "Ether Type" parameter will be considered untagged. The ingressing frames are modified so they are ready to egress out Customer ports (Normal Network Frame Mode ports) unmodified.</p> <p>Frames that egress this port will always have a tag added (even if they were already tagged). The added tag will contain this port's "Ether Type" as its Ether Type. The PRI bits will be the Frame Priority assigned to the frame during ingress. The VID bits will be the source port's Default VID bits (if the source port was in Normal Network mode), or the VID assigned to the frame during ingress (if the source port was in Provider mode).</p>
ether type	Valid only for the "p5 CPU" port.
DSA	<p>Ether Type DSA mode uses standard Marvell DSA Tagged frame information following a user definable Ether Type (see Ether type parameter). This mode allows the mixture of Normal Network frames with DSA Tagged frames and is useful on ports that connect to a CPU.</p> <p>Frames that ingress this port with an Ether Type that matches the port's "Ether Type" will be considered DSA Tagged and processed accordingly. The frame's Ether Type and DSA pad bytes will be removed so the resulting frame will be ready to egress out Marvell DSA Tag Mode ports unmodified. Frames that ingress this port with a different Ether Type will be considered Normal Network Frames and processed accordingly.</p>

Marvell DSA Tag control frames that egress this port will always get the port's "Ether Type" inserted followed by two pad bytes of 0x00 before the DSA Tag. Marvell DSA Tag Forward frames that egress this port can egress just like the control frames (with the added Ether Type and pad) or they can egress as if the port was configured in Normal Network mode. This selection is controlled by the port's Egress Mode bits above.

Ether type

Ethernet frame type (often called EtherType) is used to indicate which protocol is encapsulated in the payload of an Ethernet Frame. This parameter is important when one protocol is encapsulated to another protocol.

Examples:

Eth. type	Standard	Comment
0x8100	IEEE 802.1q	Double-tagged, Q-in-Q or C-tag stacking on C-tag. C-tag in IEEE 802.1ad frames.
0x88a8	IEEE 802.1ad	S-Tag
0x88e7	IEEE 802.1ah	S-Tag (backbone S-Tag)
0x9100	--	It is used very often. For example an old non-standard 802.1QinQ protocol uses this value.

See <http://en.wikipedia.org/wiki/EtherType> for further details.

MTU [B]

Defines maximum transmission unit (MTU) frame size allowed to be received or transmitted from or to a given physical port. This implies that a Jumbo frame may be allowed to be received from a given input port but may or may not be allowed to be transmitted out of a port or ports.

The possible values are 1522, 2048 and 10240 Bytes.

NOTE: The definition of frame size is counting the frame bytes from MAC_DA through Layer2 CRC of the frame.

TX / RX flow control

Defines method of Flow control for each port separately for data transmission (TX) and data receive (RX).

It is the mechanism for temporarily stopping the transmission of data on an Ethernet network. Enabling flow control allows use of buffers of connected active network elements for leveling uneven flow of user data. For correct operation it is necessary to also enable Flow control on the connected device. Flow control is handled by sending Pause frames to the connected device. Possible values:

- off Flow control is disabled.
- on Flow control is enabled (forced to be active).
- auto Sending pause packets is advertised and depends on result on the auto-negotiation process. Auto-Negotiation has to be supported and enabled on the port to take effect.



Important

For optimal utilisation of Ethernet switch buffers and maximal operational speed of the link it is recommended to upgrade unit to the latest FW version (those set all internal parameters for optimal buffers cooperation including Flow control automatically). FW versions 1.0.16.0 and earlier require RX FlowControl for port 'Air (p9)' on both units to be set to 'on'. The only excep-

tion is FW version 1.0.14.0 with activated 'Unit S mode' (for more info see the topic 'Setting up a link from unit 'type X or E' and unit 'type S' in chapter *Troubleshooting*).

Pause limit in [frame] Value limits the number of continuous Pause refresh frames that can be received on this port (if full-duplex) or the number of 16 consecutive collisions (if half-duplex). When a port has flow control enabled, this parameter can be used to limit how long this port can be Paused or Back Pressured off to prevent a port stall through jamming.

The Flow Control on the port is (temporarily) disabled when the Pause refresh frames count exceeds the value of this parameter.

Setting this parameter to 0 will allow continuous jamming to be received on this port.

Pause limit out [frame] Value limits the number of continuous Pause refresh frames that can be transmitted from this port – assuming each Pause refresh is for the maximum pause time of 65536 slot times. When full-duplex Flow Control is enabled on this port, this parameter is used to limit the number of Pause refresh frames that can be generated from this port to keep this port's link partner from sending any data.

Clearing this parameter to 0 will allow continuous Pause frame refreshes to egress this port as long as this port remains congested.

Setting this parameter to 1 will allow 1 Pause frame to egress from this port for each congestion situation.

Setting this parameter to 2 will allow up to 2 Pause frames to egress from this port for each congestion situation, etc.

Ignore checksum Enables ignoring Frame checksum (FCS) - or in other words - Force good FCS in the frame. When this parameter is not set (default behaviour), frames entering this port must have a good CRC or else they are discarded. When this parameter is set, the last four bytes of frames received on this port are overwritten with a good CRC and the frames are accepted by the switch (assuming that the frame's length is good and it has a destination).

5.5.3. Advanced

STU setup

The STU (Spanning Tree Unit) is related to VLAN functionality (pages STU, VTU and VLAN has to correspond to each other). The per VLAN STU in the device supports user commands to access and modify the contents of the Port State database.

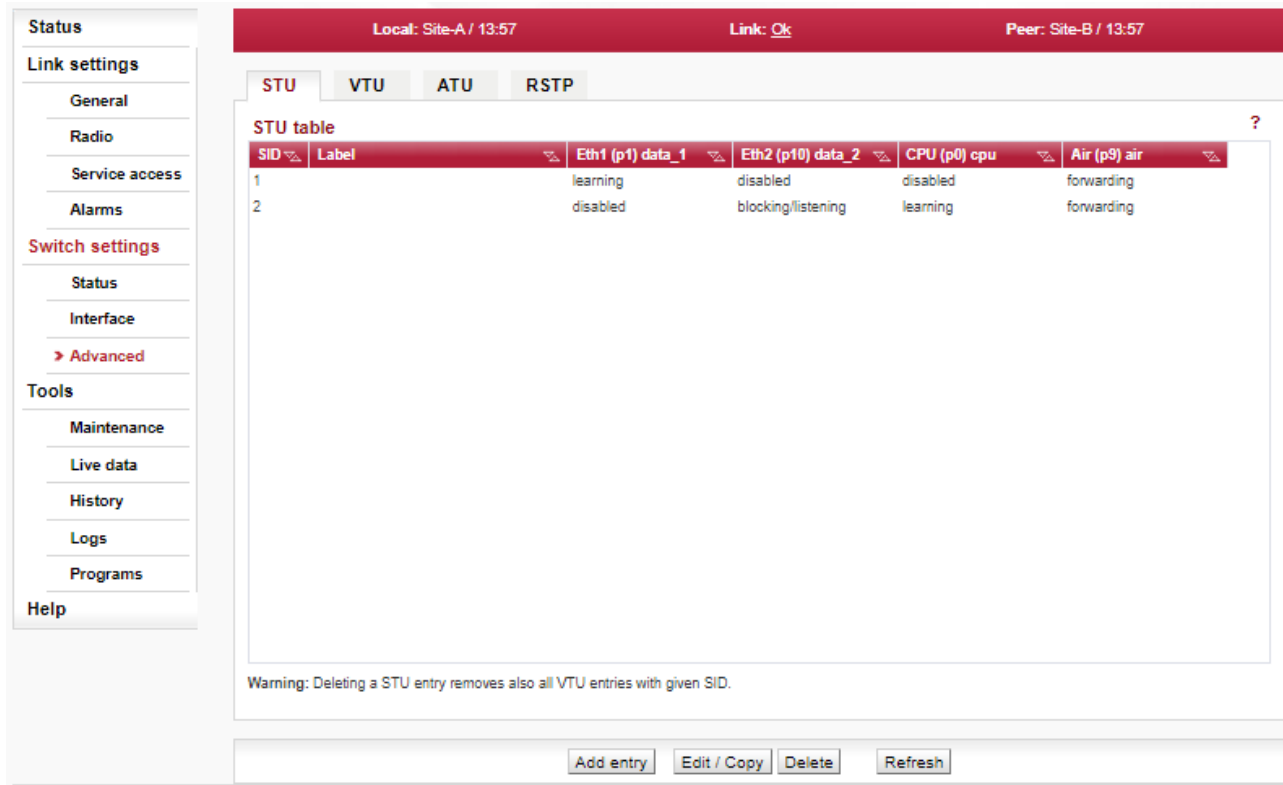


Fig. 5.20: Menu Switch settings / Advanced / STU

Add entry Add a new STU database entry.

Edit/Copy Opens the configuration dialog of the selected STU database record.


Note: Should the Primary key value be modified, the "other" record - identified by the entered Primary key - is added (if it doesn't exist yet) or modified (if it exists already).

Delete Deletes the selected STU database record.

The screenshot shows a configuration page for STU settings. At the top, there's a status bar with 'Local: Site-A / 13:59', 'Link: Ok', and 'Peer: Site-B / 13:59'. Below this are tabs for 'STU', 'VTU', 'ATU', and 'RSTP'. The 'STU' tab is active, showing an 'Add STU entry' form. The form includes a 'SID' field with a key icon and the value '0', a 'Label' text input, and a 'Port state' section with four dropdown menus: 'Eth1 (p1) data_1', 'Eth2 (p10) data_2', 'CPU (p0) cpu', and 'Air (p9) air', all set to 'disabled'. At the bottom of the form are 'Apply' and 'Cancel' buttons.

Fig. 5.21: Menu Switch settings / Advanced / STU / Add Entry

Enter values to each field (see their meanings below):

- Primary key** The  icon indicates which parameter field is taken as the unique identifier in the database. This field entry ensures each record is unique and must not be duplicated.
- SID** VTU 802.1s (MSTP) Port State Information Database number. This parameter indicates the SID number that is associated with the 802.1s "Port state" parameter. It is essential to define the SID to be able to create records in the VTU (VLAN Table).
- Label** A custom string label for a STU entry.
- Port state** This parameter is used to support 802.1s per VLAN spanning tree. Port states are valid for frames with a VID that is associated to this SID:
- disabled ... Use non-VLAN Port States (i.e., the port's default Port State) for this port.
 - blocking/listening
 - learning
 - forwarding
- This "Port state" takes precedence over the port's Port State bits unless the port's Port State (driven by STP) is Disabled (which prevents all frames from flowing).

VTU setup

The VTU (VLAN Table Unit) is related to VLAN functionality (pages STU, VTU and VLAN has to correspond to each other). Its records form the VLAN Table.

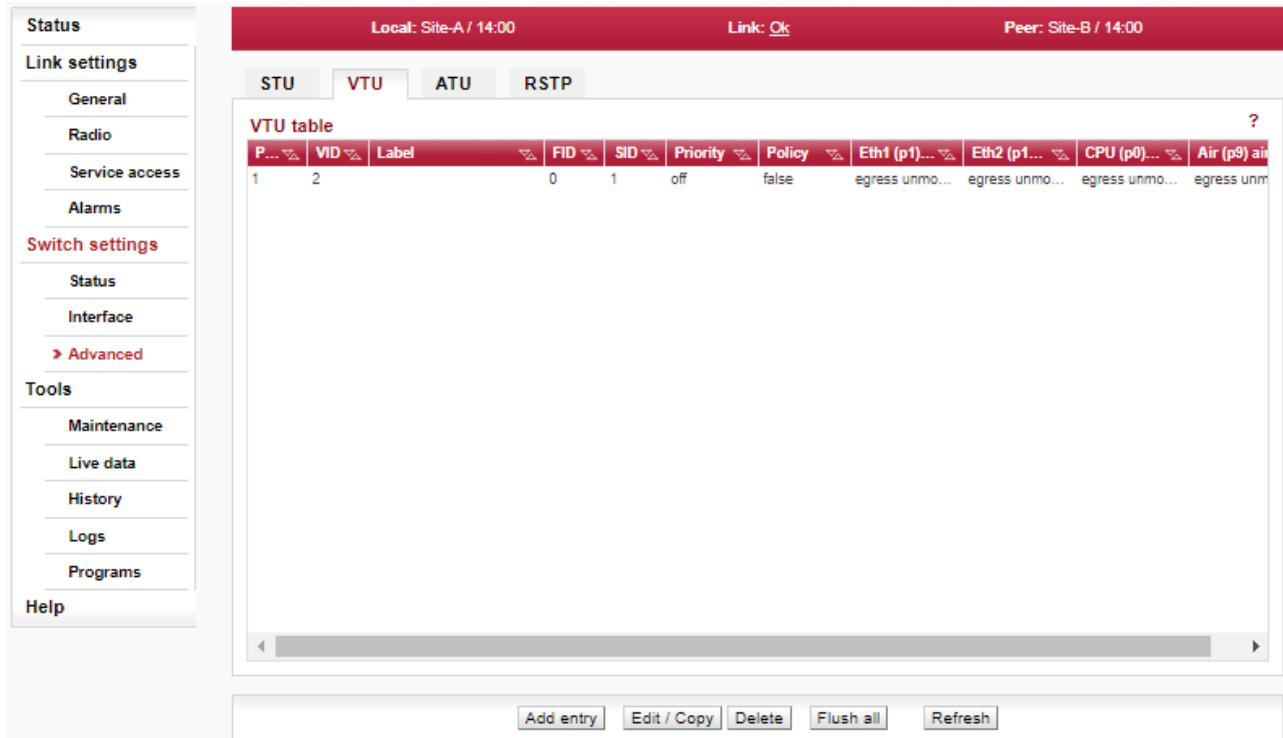


Fig. 5.22: Menu Switch settings / Advanced / VTU

Add entry

Adds a new VTU database entry.

Edit/Copy

Opens the configuration dialog of selected VTU database record.

Note: Should the Primary key value be modified, the "other" record - identified by the entered Primary key - is added (if it doesn't exist yet) or modified (if it exists already).

Delete

Deletes the selected VTU database record.

Flush all

Deletes the whole VTU database.

The screenshot displays the 'Add VTU entry' configuration page. At the top, it shows 'Local: Site-A / 14:02', 'Link: Ok', and 'Peer: Site-B / 14:01'. Below this, there are tabs for 'STU', 'VTU', 'ATU', and 'RSTP', with 'VTU' selected. The main form area is titled 'Add VTU entry' and contains the following fields:

- Page:** 0 (indicated as a primary key with a yellow icon)
- VID:** 0 (indicated as a primary key with a yellow icon)
- Label:** (empty text field)
- FID:** 0
- SID:** 1
- VID frame priority:** 0 (checkbox)
- VID queue priority:** 0 (checkbox)
- VID policy:** (checkbox)
- Don't learn:** (checkbox)
- Filter:** UC (checkbox), BC (checkbox), MC (checkbox)
- Member tag:**
 - Eth1 (p1) data_1: egress unmodified
 - Eth2 (p10) data_2: egress unmodified
 - CPU (p0) cpu: egress unmodified
 - Air (p8) air: egress unmodified

At the bottom of the form, there are 'Apply' and 'Cancel' buttons.

Fig. 5.23: Menu Switch settings / Advanced / VTU / Add Entry

Enter values to each field (analogically to STU pages):

- Primary key** The 🟡 icon indicates which parameter field is taken as the unique identifier in the database. This field entry ensures each record is unique and must not be duplicated.
- Page** To be implemented yet.
- VID (VLAN ID)** This parameter indicates the VID number that is associated with the Member tag, VTU Priority, VTU policy and the FID (Forwarding Information Database number).
- Label** A custom string label for a STU entry.
- FID** Forwarding Information Database number. If separate address databases are used, this parameter indicates the address database number to use for all frames assigned with this VID. All MAC DA look-ups and SA learning will refer to the address database number defined by the FID associated with the frame's VID. Multiple VID's can use the same FID. If separate address databases are not used, the FID must be zero. The ATU database records are joined with the VTU database records via this number.
- SID** 802.1s Information Database Number. If 802.1s per VLAN spanning tree is being used, this parameter indicate the spanning tree instance number to use for all frames assigned with this VID. Multiple VID's can use the same SID. The STU database records are joined with the VTU database records via this number.
- VID frame priority** VID Frame Priority Use. This parameter is used to indicate that frames assigned with this VID can have their priority overridden with the "VID priority" value (see below) if the port's "VTU priority override" parameters is enabled to do so. See "VTU priority override" for more details.
VID Priority override value when enabled by the "Use VID priority" parameter (see above). Used for priority override on ingressing frames. Enabling a priority on a VID will override the frame's priority only if the port's "VTU priority override" parameter is enabled to do so.
- VID queue priority** VID Queue Priority Use. This parameter is used to indicate that frames assigned with this VID can have their priority overridden with the "VID priority" value (see

below) if the port's "VTU priority override" parameters is enabled to do so. See "VTU priority override" for more details.

VID Priority override value when enabled by the "Use VID priority" parameter (see above). Used for priority override on ingressing frames. Enabling a priority on a VID will override the frame's priority only if the port's "VTU priority override" parameter is enabled to do so.

VID policy This parameter is used to indicate that frames assigned with this VID can have Layer 2 Policy actions applied to it if the port's "Policy VTU" (menu Advanced/Monitoring, Policy/Policy) is enabled to do so.

Don't learn To be implemented yet

Filter UC/BC/MC To be implemented yet

Member tag This parameters is used to indicate which ports are members of the VLAN (i.e, with the given VID) and if these VLANs frames should be tagged or untagged, or unmodified when exiting the port as follows:

- egress unmodified ... Port is a member of this VLAN and frames are to egress unmodified.
- egress untagged ... Port is a member of this VLAN and frames are to egress Untagged.
- egress tagged ... Port is a member of this VLAN and frames are to egress Tagged.
- not member ... Port is not a member of this VLAN. The result is that frames assigned with this VID can not egress this port.

This parameter takes effect only if the "802.1q mode" parameter (see menu Advanced/VLAN) is set to "secure" mode.

ATU setup

The Address Translation Unit (ATU) in the device supports user commands to access the contents of the MAC address database.

There is one static record which can't be deleted. This is the management CPU record. The unicast frames directed to management are allowed to access the CPU port. The "VLAN tunnel" parameter is also used to enable the AP frames to access the CPU port.

The screenshot shows the ATU setup interface with the following data in the ATU table:

FID	MAC	Label	Entry state	Priority	Destination type	Port association / Trunk id
0	00:00:5e:00:01:01		dynamic	off	port association	Eth1 (p1)
0	00:00:5e:00:01:06		dynamic	off	port association	Eth1 (p1)
0	00:00:5e:00:01:0a		dynamic	off	port association	Eth1 (p1)
0	00:00:5e:00:01:0f		dynamic	off	port association	Eth1 (p1)
0	00:00:5e:00:01:83		dynamic	off	port association	Eth1 (p1)
0	00:00:5e:00:02:0a		dynamic	off	port association	Eth1 (p1)
0	00:00:74:ce:d8:35		dynamic	off	port association	Eth1 (p1)
0	00:02:72:87:53:b0		dynamic	off	port association	Air (p9)
0	00:02:a9:20:06:36		static	off	port association	CPU (p0)
0	00:02:a9:20:06:86		dynamic	off	port association	Air (p9)
0	00:02:a9:90:31:c6		dynamic	off	port association	Air (p9)
0	00:02:a9:90:49:36		dynamic	off	port association	Air (p9)
0	00:02:a9:90:54:ee		dynamic	off	port association	Air (p9)
0	00:02:a9:90:60:a8		dynamic	off	port association	Air (p9)
0	00:02:a9:90:c2:8c		dynamic	off	port association	Air (p9)
0	00:02:a9:92:31:9c		dynamic	off	port association	Air (p9)
0	00:02:a9:9b:cc:76		dynamic	off	port association	Eth1 (p1)
0	00:08:19:4b:a3:48		dynamic	off	port association	Eth1 (p1)

Fig. 5.24: Menu Switch settings / Advanced / ATU

- Add entry** Adds a new ATU database entry.
- Edit/Copy** Opens the configuration dialog of the selected ATU database record.
- Note: Should the Primary key value be modified, the "other" record - identified by the entered Primary key - is added (if it doesn't exist yet) or modified (if it exists already).
- Delete** Deletes the selected ATU database record.
- Flush all and use default** Deletes the whole ATU database and create default record(s).
- Flush non-static** Delete all but static ATU database records.

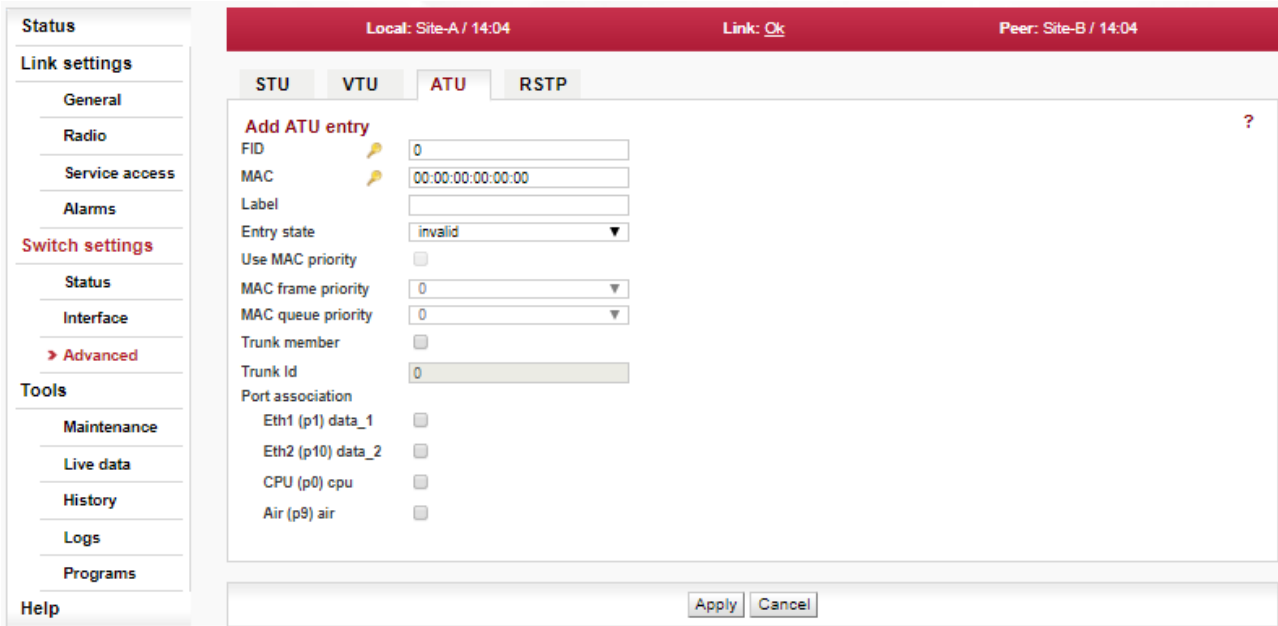


Fig. 5.25: Menu Switch settings / Advanced / ATU / Add Entry

Enter values to each field (analogically to STU or VTU pages):

- Primary key** The 🗝 icon indicates which parameter field is taken as the unique identifier in the database. This field entry ensures each record is unique and must not be duplicated.
- FID** Forwarding Information Database number. If multiple address databases are not being used, this parameter must remain zero. If multiple address databases are being used, this parameter is used to set the desired address database number that is to be associated with this ATU Entry's MAC Address. When frames ingress the switch, the VID assigned to the frame is used to access the VTU. The VTU returns the FID associated with that VID for MAC address lookups in to the ATU..
- MAC** MAC address associated with this ATU entry in the database number defined by the FID.
- Label** A custom string label for a STU entry.
- Entry state** The Entry state parameter is used to determine the entry's age or its type as follows:
 - static ... Use for ordinary static entry.
 - static policy ... Use for "Policy DA" and/or "Policy SA" (menu Advanced/Monitoring/Policy).
 - static non rate limiting ... Use for "SA non rate limit" and/or "DA non rate limit" (menu Interface/PIRL).
 - static management ... This value is used for the mapping of the DA even if the "DA mapping" parameter is disabled (menu Advanced/ATU settings).
 - dynamic ... ordinary dynamic entry.
- Use MAC priority** Use this parameter to enable the "MAC priority" (see "MAC priority" description).
- MAC frame priority** The MAC's Frame Priority override value when enabled by the "Use MAC priority" parameter. Used for priority override on ingressing frames. Enabling a priority on a MGMT MAC address will override all priorities for these MGMT frames. Enabling a priority on a static, non-MGMT MAC address, will only override the frame's priority if the port's "DA priority override" or "SA priority override" parameters are enabled.

- MAC queue priority** The MAC's Queue Priority override value when enabled by the "Use MAC priority" parameter. Used for priority override on ingressing frames. Enabling a priority on a MGMT MAC address will override all priorities for these MGMT frames. Enabling a priority on a static, non-MGMT MAC address, will only override the frame's priority if the port's "DA priority override" or "SA priority override" parameters are enabled.
- Trunk member** When this parameter is enabled, the MAC address is a member of a trunk - according to the "Trunk Id" parameter. When this parameter is disabled, the MAC address is associated with port(s) - according to the "Port association" parameter.
- Trunk ID** The Trunk ID associated with this MAC address.
The port or ports that this DA MAC address is associated with is determined by the "Port association" parameter below.
Use this parameter to ensure the proper unit management CPU is accessed when two units are connected in trunk.
- Port association** Mask of ports associated with this MAC address.

RSTP

Page allows to configure RSTP (Rapid Spanning Tree Protocol by IEEE 802.1w). RSTP provides significantly faster recovery in response to network changes or failures, introducing new convergence behaviors and bridge port roles to do this. RSTP was designed to be backwards-compatible with standard STP. For more information about RSTP, STP, related Path cost, etc. see https://en.wikipedia.org/wiki/Spanning_Tree_Protocol.

Fig. 5.26: Menu Switch settings / Advanced / RSTP

- RSTP enable** Enables RSTP protocol. When RSTP is enabled, the bridge is created and RSTP service is initiated. Should the unit be connected via two Ethernet cables (using Eth1 and Eth2 ports), the active participation of the RSTP protocol may be necessary. If the parameter is not enabled, the unit transfers the BPDU frames transparently.

NOTE: To enable proper RSTP functionality, these switch parameters has to be set:

- Switch settings / Interface / Port advanced / Frame mode / p5 CPU: "ether type DSA"
- Switch settings / Interface / Port advanced / Ether type / p5 CPU: "0xDADA"
- Switch settings / Advanced / ATU settings / Reserved multicast to CPU: "Enable"

Bridge priority	The priority value is a number between 0 and 61440 in incremental steps of 4096, with a default value of 32768. Lower priority values are 'better'. The bridge with the lowest priority value will be elected 'root bridge'.												
Hello time [s]	The hello time is the time between each Bridge Protocol Data Unit (BPDU) that is sent on a port. Hello time is equal to 2 seconds by default.												
Max age [s]	The max age timer controls the maximum length of time that passes before a bridge port saves its configuration BPDU information. This time is set to 20 sec by default.												
Forward delay [s]	The forward delay is the time that is spent in the listening and learning state. This time is equal to 15 sec by default.												
Algorithm	This parameter sets the bridge's spanning tree algorithm to operate in normal (RSTP) or force it to operate in slow (STP) mode. In normal mode, RSTP reverts back to STP on ports where it sees other hosts operating in STP mode.												
Port name	<p>Identification of the internal switch port. The switch ports are connected to an external port or to an internal device (radio modem, management CPU).</p> <table border="0" style="margin-left: 20px;"> <tr> <td>Eth1</td> <td>port1</td> <td>The external port (with RJ45 interface) labeled "ETH1+POE".</td> </tr> <tr> <td>Eth2</td> <td>port10</td> <td>The external port (with SFP interface) labeled "ETH2".</td> </tr> <tr> <td>CPU</td> <td>port0</td> <td>The internal port to management CPU.</td> </tr> <tr> <td>Air</td> <td>port9</td> <td>The internal port to radio modem, i.e. link to the peer unit.</td> </tr> </table>	Eth1	port1	The external port (with RJ45 interface) labeled "ETH1+POE".	Eth2	port10	The external port (with SFP interface) labeled "ETH2".	CPU	port0	The internal port to management CPU.	Air	port9	The internal port to radio modem, i.e. link to the peer unit.
Eth1	port1	The external port (with RJ45 interface) labeled "ETH1+POE".											
Eth2	port10	The external port (with SFP interface) labeled "ETH2".											
CPU	port0	The internal port to management CPU.											
Air	port9	The internal port to radio modem, i.e. link to the peer unit.											
Port priority	The ports' priority value is a number between 0 and 240 in increments of 16, with a default value of 128.												
Path cost	<p>The Path cost indicates "suitability of the link for the data transmission" and it is used in networks with redundant connections to choose the best route for packets.</p> <p>The Path cost can be set automatically or manually. Entering the value of zero sets this parameter automatically. The automatic setup is based on link speed. It is calculated as 20 Tbits/sec divided by a link capacity.</p> <p>For manual settings, lower value increase probability the link is chosen as a primary one for the data transmission.</p>												
Edge	Selecting the checkbox sets the port as an "edge" port. If a port is an edge port it is assumed to be a leaf link in the graph, not connected to any other bridges. Receiving any STP BPDU's on a port configured as an edge port temporarily overrides edge port behaviour for the port.												
MAC address	The ports' default MAC addresses are the same as the MAC address of the unit. Value can be overwritten by a user.												

5.6. Tools

5.6.1. Maintenance

Backup

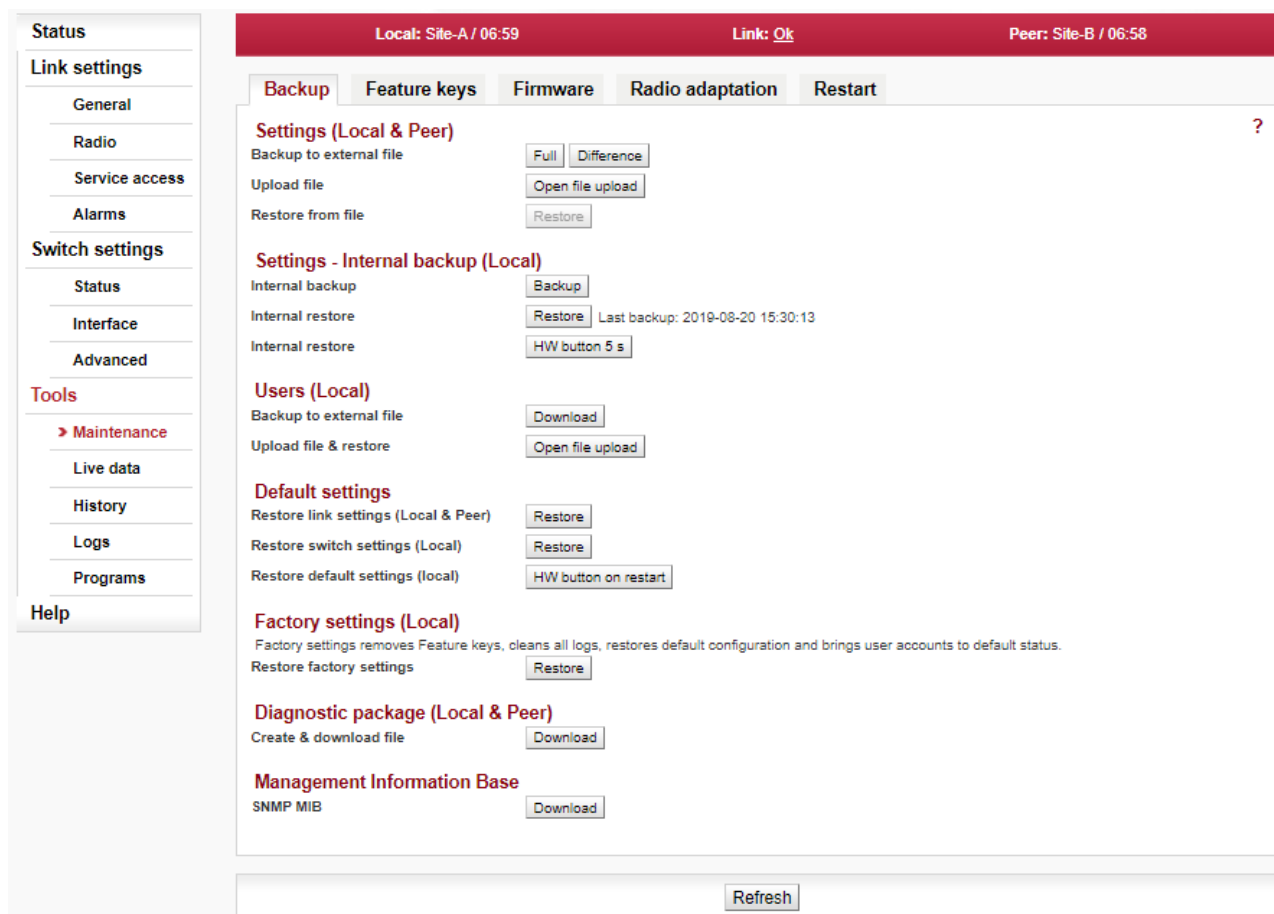


Fig. 5.27: Menu Tools / Maintenance / Backup

Settings (Local & Peer)

Local	Peer	
<input type="radio"/>	<input type="radio"/>	Link
<input type="radio"/>	<input type="radio"/>	Switch
		Users

Saving and restoring whole link (both units) configuration. User accounts are not affected by those functions.

Backup
to external file

Configuration is saved to backup file which is downloaded to management PC. The backup file name contains the date, time and RAY serial number as follows:

yyyyMMddhhmm_SN_cnf_backup.tgz.

It can be either a full configuration or a difference to the default configuration.

Upload file

Upload configuration from a backup file into buffer. The current unit configuration is not affected. The uploaded configuration can be displayed using "Show backup" button on particular configuration screens. The configuration of the entire unit can be restored (from this buffer) using "Restore" button below.

Restore from file After the configuration backup file has been loaded into the unit buffer (using Upload button above), the whole unit configuration can be restored using Restore button.

Settings - Internal backup (Local)

It is possible to make a temporary backup of the unit configuration. The backup is stored directly in the unit FLASH memory.

L	P
O	L
O	S
	U

Internal backup

NOTE: The internal backup is deleted if factory settings or firmware upgrade are performed.

Make a temporary backup of the unit configuration locally in the unit FLASH memory.

Internal restore

Restore (from the unit FLASH memory) the temporary backup of the unit configuration.

Internal restore - HW button

The local temporary backup of the unit configuration can be restored using *the hardware button*. The HW button is located next to the USB connector within the *slot marked "S"*. The rollback and reboot functions are suppressed while restoring from internal backup. All changes are applied immediately. Should the time zone be changed, the unit has to be restarted for changes to take effect. Press the HW button for the required time interval of 5 seconds. The button being pressed is confirmed by the Status LED flashing green. After the 5 seconds guard time, the unit restores to customer settings.

Users (Local)

Saving and restoring user accounts.

L	P
	L
	S
O	U

Backup to external file

Backup local unit user accounts to an external file. The file is downloaded to management PC.

NOTE: The "super" user privileges are necessary to be able to perform this action.

Upload file & restore

Restoring user accounts from an external backup file.

Default settings	Applying default values to configuration parameters.													
<table border="1"> <tbody> <tr> <td>L</td> <td>P</td> <td></td> </tr> <tr> <td>O</td> <td>O</td> <td>L</td> </tr> <tr> <td></td> <td></td> <td>S</td> </tr> <tr> <td></td> <td></td> <td>U</td> </tr> </tbody> </table>	L	P		O	O	L			S			U	Restore link settings (Local & Peer)	Whole set of parameters from the <i>Link settings</i> menu tree is affected.
L	P													
O	O	L												
		S												
		U												
<table border="1"> <tbody> <tr> <td>L</td> <td>P</td> <td></td> </tr> <tr> <td></td> <td></td> <td>L</td> </tr> <tr> <td>O</td> <td></td> <td>S</td> </tr> <tr> <td></td> <td></td> <td>U</td> </tr> </tbody> </table>	L	P				L	O		S			U	Restore switch settings (Local)	Whole set of parameters from the <i>Switch settings</i> menu tree is affected.
L	P													
		L												
O		S												
		U												
Factory settings (Local)	Restore factory settings	Applying Factory settings to Local unit. The unit reboots itself after applying all changes.												
<table border="1"> <tbody> <tr> <td>L</td> <td>P</td> <td></td> </tr> <tr> <td>O</td> <td></td> <td>L</td> </tr> <tr> <td>O</td> <td></td> <td>S</td> </tr> <tr> <td>O</td> <td></td> <td>U</td> </tr> </tbody> </table>	L	P		O		L	O		S	O		U	Restore factory settings - HW button	<p>It is possible to bring the unit to Factory settings by holding <i>the hardware button</i> depressed during unit's boot. The HW button is located next to the USB connector within the <i>slot marked "S"</i>.</p> <p>Disconnect the power supply from the unit. Keep the HW button depressed while reconnecting the power. The LED marked SYS starts to flash red after a few seconds. Keep the HW button pressed another 5 seconds until the red status LED stops flashing. The unit's boot up sequence continues and Factory settings are applied.</p> <p>Should the HW button be released when the status LED is in the red flashing phase (but before the 5 s guard time), the unit stays in Service mode. Please, leave this mode by re-booting the unit.</p> <p>WARNING: Using the factory settings function will revert the unit to its original state. All configuration items, user accounts, measured values and system messages (logs) will be irreversibly deleted.</p> <p>WARNING: This task takes a few minutes to complete. Do not interrupt the power supply during the operation.</p>
L	P													
O		L												
O		S												
O		U												
Diagnostic package (Local & Peer)	To facilitate communication with the technical support you can create an archive file with detailed information about the unit. If connection with Peer unit is active the diagnostic information from both units are saved.	<p>Create & download file</p> <p>Saving a file with information about the unit (Local and Peer).</p> <p>NOTE: This task takes a few minutes to complete.</p>												
Management Information Base	SNMP MIB	Saving a file with SNMP MIB (Management Information Base) table. The downloaded file is identical to the SNMP MIB table file downloaded from RACOM web (<i>section Downloads</i> ¹) for relevant FW version.												

¹ https://www.racom.eu/download/hw/ray/free/eng/03b_fw/ray3-mib.mib

Feature keys

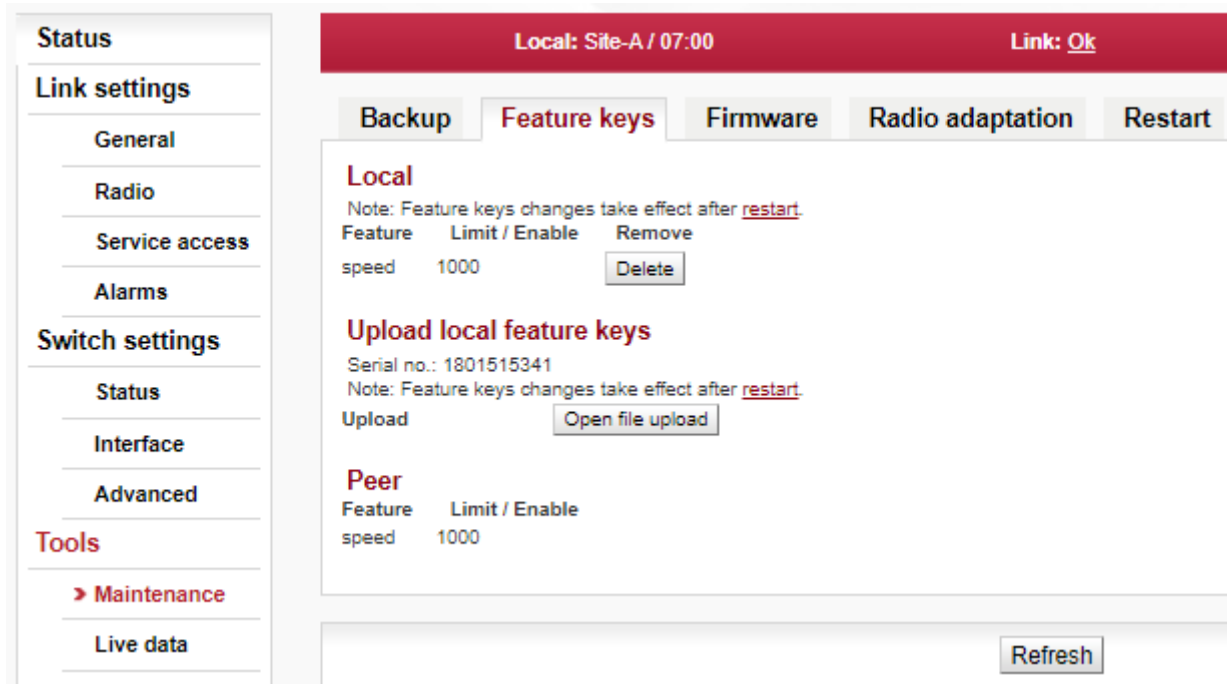


Fig. 5.28: Menu Tools / Maintenance / Feature keys

The sub-set of RAY parameters is affected by use of Feature keys.

The feature keys limiting data transfer speed [Mbps] and/or few other parameters and functionality of the RAY unit are available. Speed of the transferred data is determined by a combination of the radio channel bandwidth (parameter Bandwidth [MHz]) and modulation order (parameter TX modulation). The Feature key limiting the data transfer speed enables only certain combinations of the channel bandwidth and modulation order to get the data transfer speed according to the Feature key. The data transfer speed is typically slightly higher than declared.

When installed, the Feature key is activated after the unit restart. The unit can be restarted using the Tools – Maintenance – Restart. Choose the Restart mode – warm.

Feature Name of the function controlled by the Feature key.

Available feature keys:

- speed
- Tx power
- Sync Eth
- AES encryption
- etc.

Limit / Enable The numeric value set by the key.

Remove The specific Feature key can be deleted using the Delete button. The parameters controlled by this Feature key are reset to their default values after the unit restart. Only Local feature keys could be deleted. To be able to manipulate the Feature keys, it is necessary to access directly the management system of the relevant unit - use the IP address of the relevant unit.

NOTE: Before deleting the feature key it is recommended to configure the link such a way that it does not require this feature key.

Upload

Feature keys are installed into the unit from the binary files.

NOTE: Use the file as it is (do not unpack).

Open file upload - Dialog for the Feature key binary file selection is open.

The Feature key is activated after the unit restart.

Firmware

The screenshot shows the 'Firmware' tab selected in the maintenance menu. At the top, it indicates 'Local: Site-A / 07:02' and 'Link: Ok'. Below this are tabs for 'Backup', 'Feature keys', 'Firmware', 'Radio adaptation', and 'Restart'. The 'Firmware' tab is active, showing an 'Info' section with a table of versions for 'Radio SW version' and 'Firmware version' for both 'Local' and 'Peer' units. Below the table is a 'Firmware upgrade' section with a warning: 'Warning: Upgrading to a wrong firmware may result with station malfunction.' It includes an 'Open file upload' button, fields for 'File name' and 'File size [B]' (both showing 'n/a'), a 'Clean buffer' button, 'Force upgrade' checkboxes (both unchecked), and an 'Upgrade' button. At the bottom right of the main area is a 'Refresh' button.

Fig. 5.29: Menu Tools / Maintenance / Firmware

If a new firmware version is released for the given microwave link type, you can upload it to your RAY units.

Info

Radio SW version

Information about the Software Defined Radio (SDR) version on the Local and Peer units.

Firmware version

Information about the current firmware package version on the Local and Peer units.

Firmware upgrade

Firmware upload Open file upload - opens a dialog for uploading firmware package to the unit buffer. Only after firmware has been prepared in the buffer, can you perform the actual upgrade.
NOTE: Use the file as it is (do not unpack).

File name Name of the uploaded firmware file.

File size [B] Size of the uploaded firmware file (in bytes).

Version in buffer Information about firmware version prepared in the buffer for installation into the unit (Local, Peer). This firmware must first be prepared in the Firmware upload section (see above).

Clean buffer You can use the Clean buffer button to delete prepared firmware package in the buffer.

Force upgrade Force mode blocks all safety and compatibility checks and may result in breaking your unit.
IMPORTANT: You should not use force mode until instructed to do so by the technical support.

Upgrade Use the Upgrade button to perform the firmware installation.



Warning

Installing the firmware takes several minutes (about 3 minutes). During this time, transmission of user data is interrupted. Do not interrupt the power supply during firmware installation!

Radio adaptation

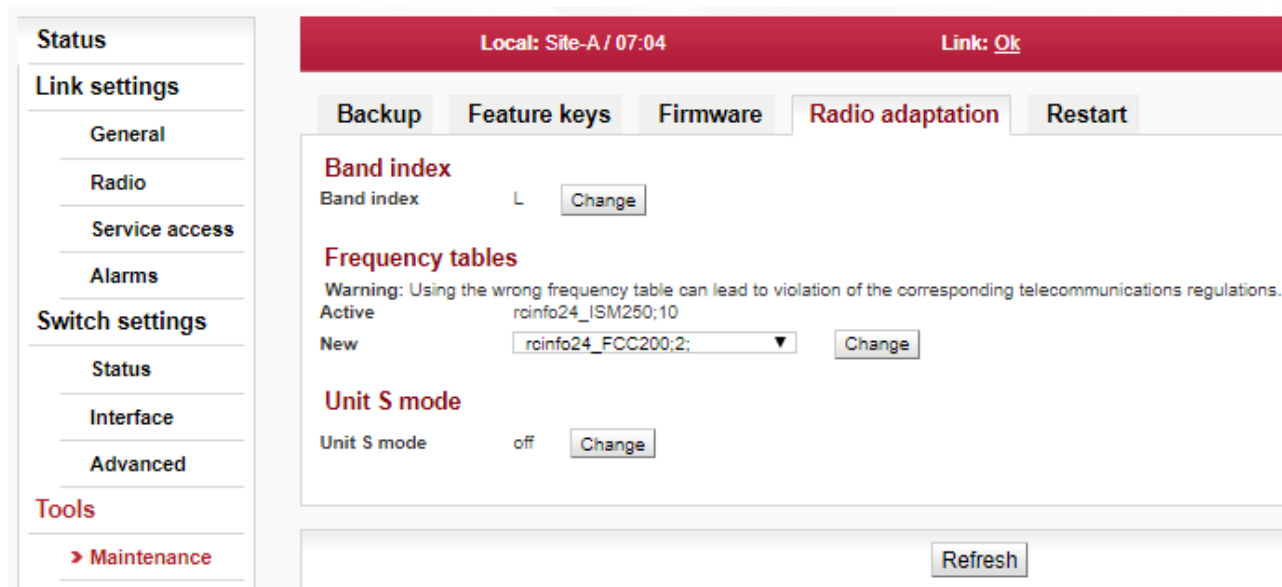


Fig. 5.30: Menu Tools / Maintenance / Radio adaptation

Band index

Band index displays radio channel assignment of local unit transmitter (Tx) for **L (Lower)** or **U (Upper)** part of the frequency band.

Change button

Change button changes the band index (L -> U and U-> L). If units are linked together both Local and Peer units are changed in the same time.

NOTE: Change button applies only for 17 GHz and 24 GHz links, where hardware of each RAY unit is universal for the entire frequency band.

NOTE: After restoring *factory settings* Band index is set to its pre-defined state L or U as typed on *Product Label*.

WARNING: When the radio type is changed, the "Link settings" menu parameters of each unit are **reset to default** values except login / password details.

Frequency tables

The microwave link contains one or more frequency tables (called rcinfo). These tables contain the following information:

List of available bandwidths and modulations.

Assignment of frequencies to the channels and the names of these channels. These channels are used to configure radio parameters of the link (see screen *Link settings / Radio*).

Default values of radio parameters.

A set of radio parameters, needed for the ATPC operation.

Active

Name of the currently used frequency table in format <name:version>.

New

Select a new frequency table. Available tables are displayed in format <name:version>. Use the Change button to change the table.



Warning

Using the wrong frequency table can lead to violation of the corresponding telecommunications regulations.

Unit S mode

Activates unit type 'X' or 'E' to emulate unit type 'S' (older model). Used only if a combination of different type units has to be used to set up the link. For more info see the topic 'Setting up a link from unit type 'X' or 'E' and unit type 'S' in chapter *Troubleshooting*).

Restart

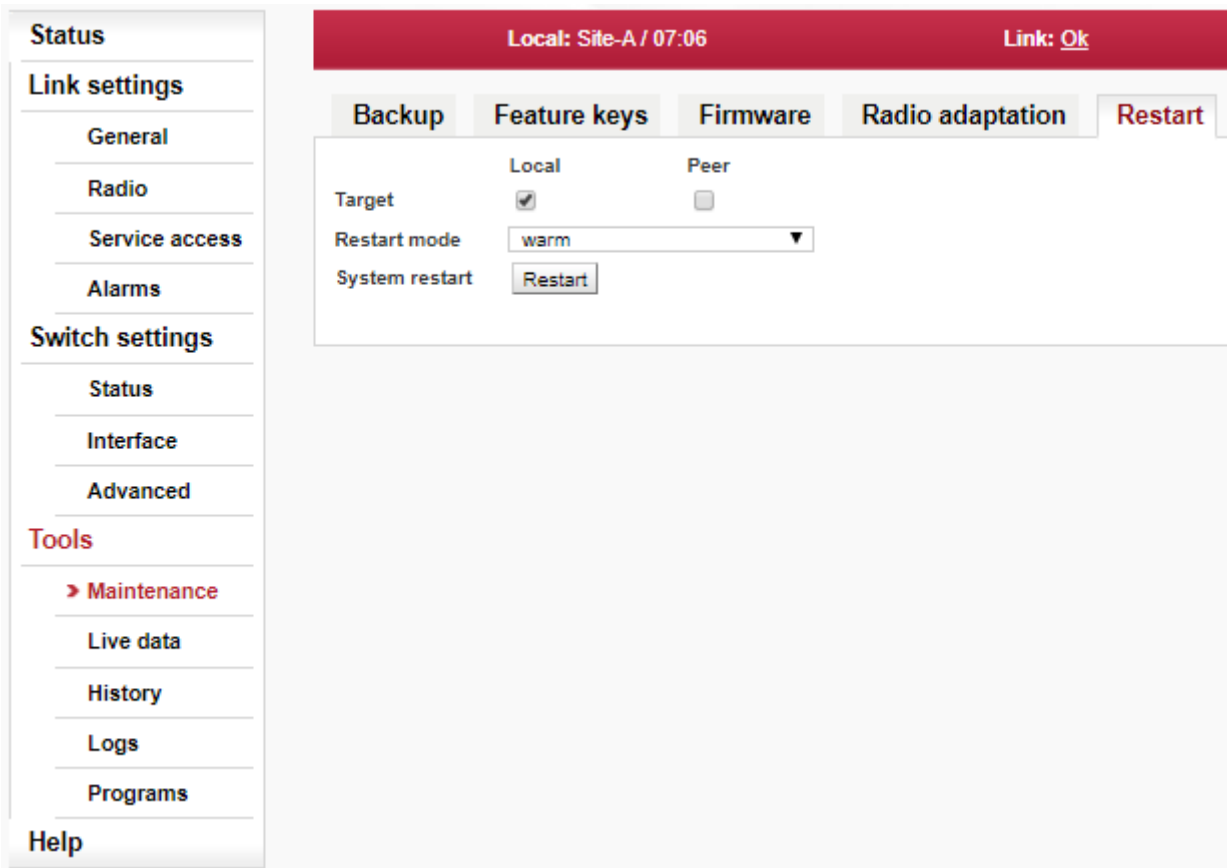


Fig. 5.31: Menu Tools / Maintenance / Restart

Target Chose the unit(s) to be restarted: Local or Peer or both.

Restart mode Chose the type of the restart:

- Warm Reboot only management system and web interface.
- Cold Restart the whole unit as if power was removed.

System restart Pushing the "Restart" button performs the selected restart.

5.6.2. Live data

Bar indicators



Fig. 5.32: Menu Tools / Live Data / Bar indicators

Graphical indication of RSS and MSE.

- Refresh** One-time update of displayed values.
- Start, Stop** Start button starts automatic update of displayed values with a period of 1 second. Stop button stops refreshing of both graphs.
- Antenna alignment** Link "go to antenna alignment screen" activates Antenna Alignment Tool (black page explained below).

Antenna Alignment Tool

The Antenna Alignment Tool supports interactive antenna alignment. RSS and MSE are displayed for both local and peer unit. A selected value can be indicated in large font and acoustically. Values are refreshed 10× per second.

When performing antenna alignment, both ATPC and ACM functions should be disabled; their automatic behaviour interferes with the alignment process which is based on finding the maximum signal strength.

The tool is accessed via e.g. <http://192.168.169.169/tk> for standard Ethernet ports, and via <http://172.17.17.17/tk> for connections using USB/WiFi or USB/Eth. The Antenna Alignment Tool does not require user authentication.

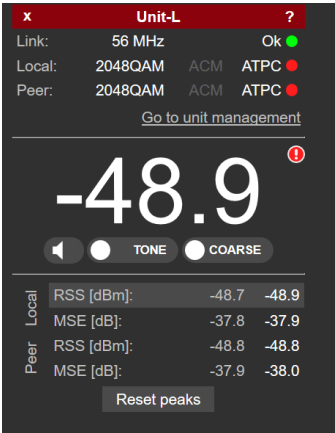


Fig. 5.33: RAY Tools

Red strip (top of the page)	<p>+ Increases the number of displayed parameters</p> <p>x Decreases the number of displayed parameters</p> <p>text Local Station name (e.g. RAY3-17L)</p>
Link	<p>3.5 MHz Channel width</p> <p>Ok Link connected (green icon). The Peer values (see below) are visible when the connection between Local and Peer unit has been established.</p>
Local, Peer	<p>QPSK Current modulation of the Tx signal</p> <p>ACM, ATPC Status of ACM + ATPC (red colour warns ACM or ATPC is enabled).</p>
Go to unit management	<p>Link to the full configuration interface of the microwave unit; user authentication is required.</p>
-71.8	<p>Actual RSS [dBm] or MSE value. The selected value is chosen by clicking/tapping on the respective value below the main display.</p>
Exclamation icon !	<p>An exclamation icon is displayed when either Local or Peer unit has ACM or ATPC enabled. ACM and ATPC mode should be disabled; they can affect signal strength.</p>
Icon of speaker	<p>Acoustic indication for local RSS value ON/OFF. The TONE or BEEP signal is supplemented with voice output every 10 seconds, notifying signal strength.</p>
TONE / BEEP	<p>Select the sound generated.</p> <p>The better the signal, the higher the frequency. The acoustic indication is linked to the value on the main display. If a WiFi connection is used to access Antenna Alignment, the 'noise' audio signal is used to notify low quality or low stability of the WiFi signal.</p>
COARSE / FINE	<p>Choose the scale of acoustic indication</p>

- COARSE - for approximate alignment. Range of tones (or frequency of beeps) is equal to -100 to -30 dBm
- FINE - for a more precise alignment. Range of tones (or frequency of beeps) is equal to ± 10 dBm from the value sampled at the moment when the FINE button was pressed)

RSS, MSE

Values RSS and MSE for local and peer unit (4 values in total):

First column Best values recorded

Second column Current values

The value to be displayed on the main display is selected by a tapping/clicking on the respective value.

Reset peaks

Best values history is cleared.

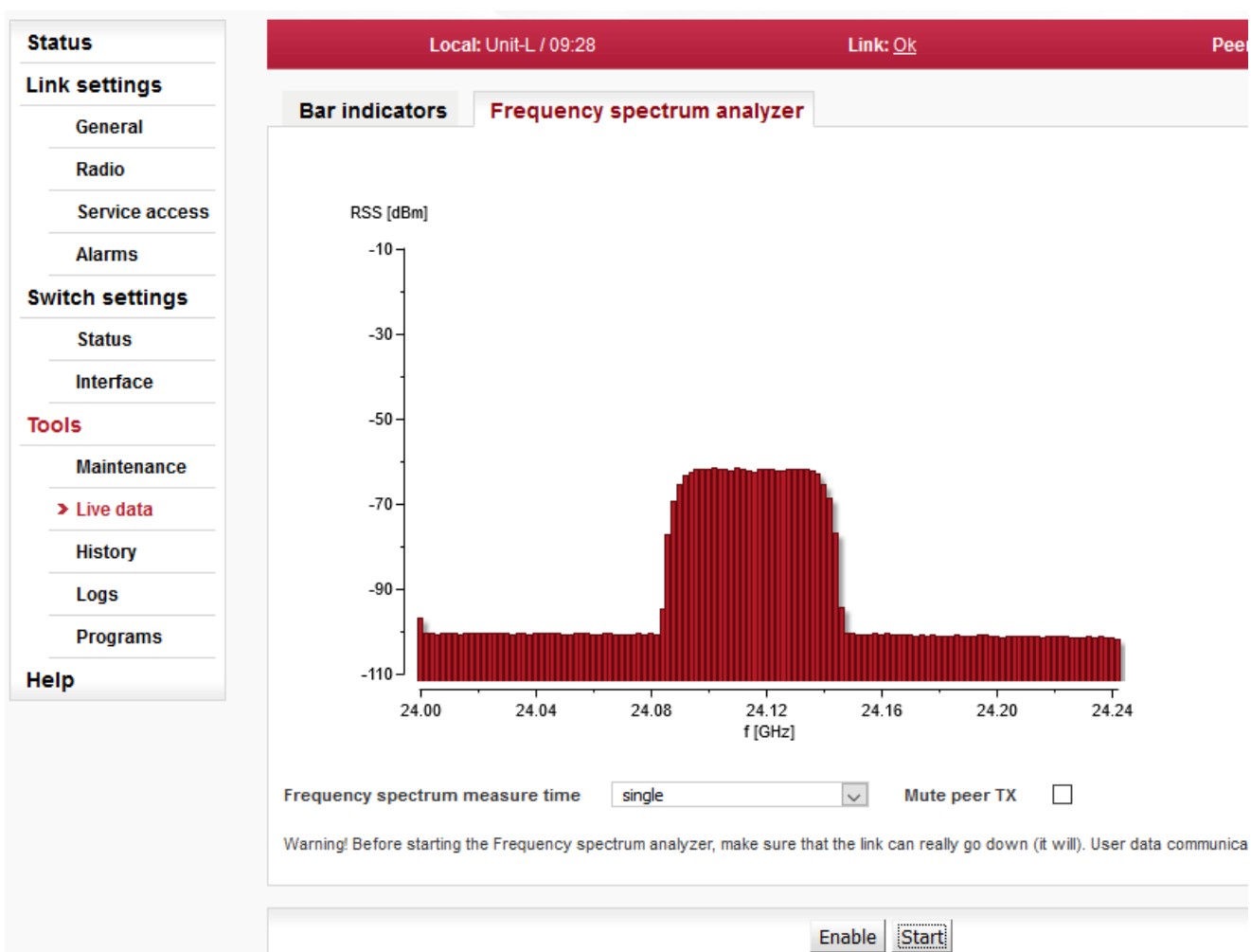
Frequency spectrum analyzer

Fig. 5.34: Menu Tools / Live Data / Frequency spectrum analyzer

A very useful tool for identifying in-band interference and locating a free channel. It is not a full-blown spectrum analyzer as it scans the spectrum with 2 MHz channel resolution. The accuracy of measured results is given by the accuracy of measuring RSS.

Enable	Opening analyzer functions.
Start	Interrupts communication on the link and starts scanning frequencies in the band.
Spectrum measure time	Selection of measurement length in range: single sweep ... up to 15 min
Mute peer TX	The deactivation of Peer station transmission during measurement.

NOTE: single sweep takes about 2 seconds for the whole band scan. The link is automatically re-established after it is finished.



Warning

Running spectrum measurement causes interruption of user data flow between stations!

Interruption of the scan before selected measure time can be achieved anytime by visiting any of the *Link menu* settings and select Refresh. This restores the configuration connection (message Peer: n/a).

5.6.3. History

The unit continuously stores information about the values of important variables. Stored values can be viewed using three methods - Thumbnails, Viewer and Data

Thumbnails

Preview all values for the last 24 hours. Click on a thumbnail to open the viewer with a chart.

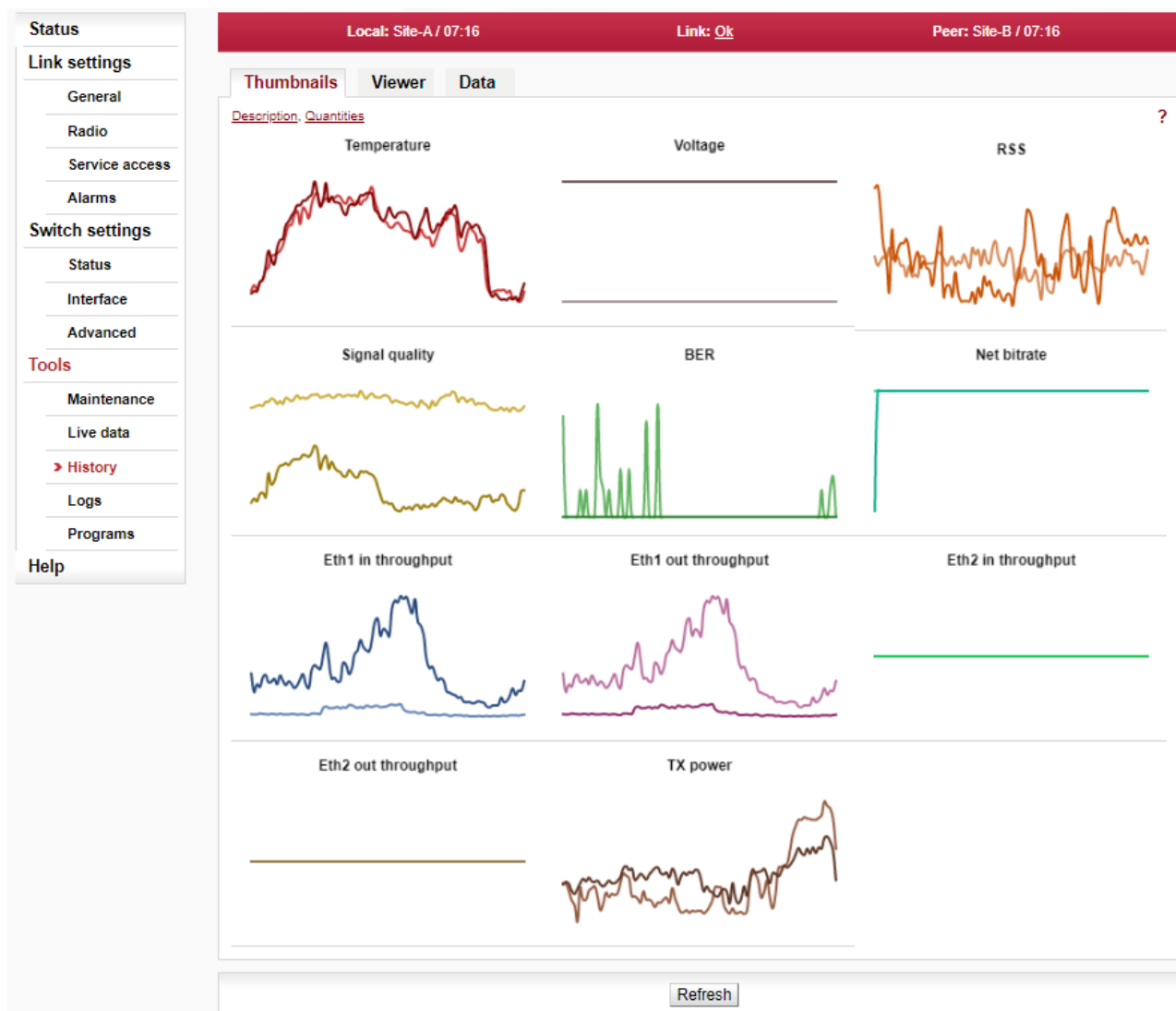


Fig. 5.35: Menu Tools / History / Thumbnails

Temperature	Instantaneous value of temperature inside the unit. Measured on the modem board.
Voltage	Instantaneous value of unit supply voltage.
RSS	Received signal strength.
Signal quality	Signal quality of the received signal. It is negative value of Mean Square Error (MSE, the inverse to often used SNR - Signal to Noise Ratio).
BER	Instantaneous bit error rate on link.
Net bitrate	Instantaneous transmission capacity.

Eth1, Eth2 in throughput

Instantaneous speed (20s average) of incoming user data on the user Ethernet port.

Eth1, Eth2 out throughput

Instantaneous speed (20s average) of outgoing user data on the user Ethernet port.

TX power

Instantaneous value of transmission power.

Viewer

Detailed graphical view of one or two selected values for the given interval. You can choose to view data from Local or Peer or both.

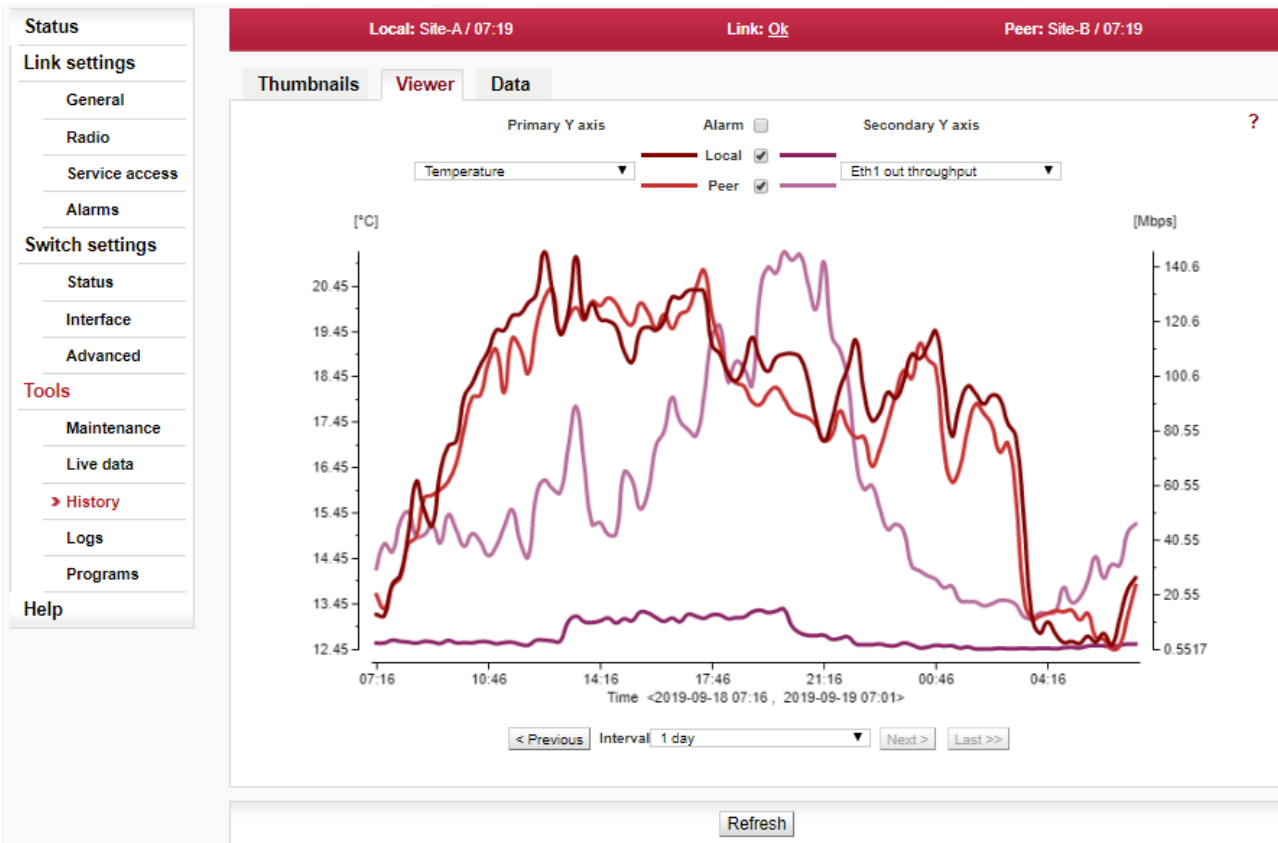


Fig. 5.36: Menu Tools / History / Viewer

The values are saved in the following resolutions and history lengths:

- Resolution 1 minute, length of history 7 days
- Resolution 15 minutes, length of history 30 days
- Resolution 1 day, length of history about 180 days

Interval

Selecting width of interval to be displayed. Based on the interval width, data is displayed in a suitable grid: Up to 3 hours at one minute. Up to 4 days at 15 minutes. For longer intervals at one day.

Interval	Resolution	History
1 hour - 3 hours	1 minute	7 days
6 hours - 4 days	15 minutes	30 days

1 week - 6 months 1 day 180 days

More options:

Previous Move by one width of selected interval towards older values.

Next Move by one width of selected interval towards newer values.

Last Move to the newest values.

Primary Y axis Selecting one of the observed values:
Temperature, Voltage, RSS, Signal quality, BER, Net bitrate, Ethernet in
throughput, Ethernet out throughput, TX power

**Secondary
Y axis** Selecting a second value:
None
Temperature, Voltage, RSS, Signal quality, BER, Net bitrate, Ethernet in
throughput, Ethernet out throughput, TX power

Alarm Enables the display of alarms, if there were any.

Data

Numerical view of all values

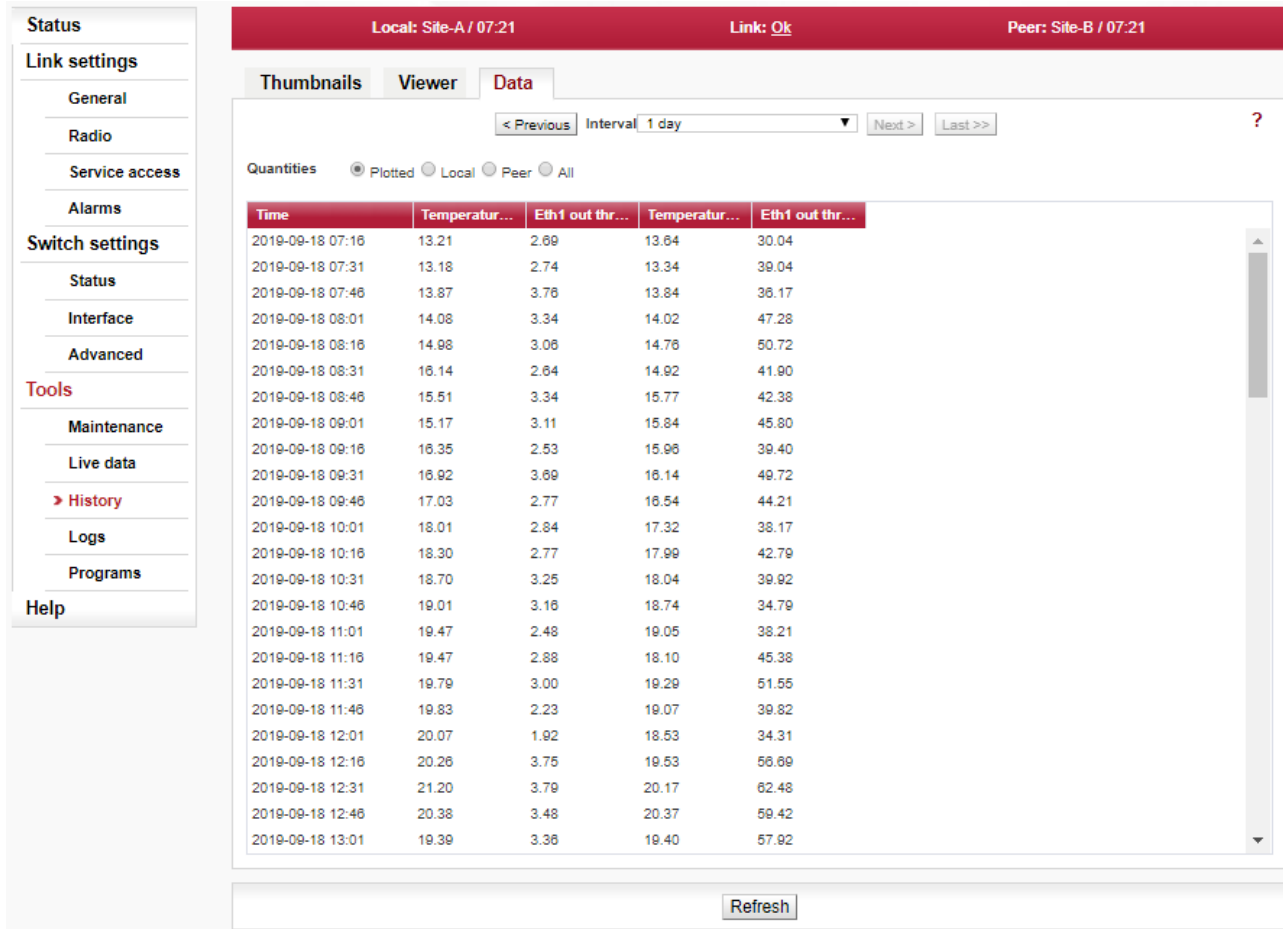


Fig. 5.37: Menu Tools / History / Data

Quantities

Detailed graphical view of values for selected interval.

Plotted - Shows only the values that are selected for the graph.

Local, Peer, All - Shows all logged values. Filtering of values from local, remote or both.

Interval, Previous, Next, Last

See explanation of those in Viewer section above.

5.6.4. Logs

Shows internal unit logs. Individual tabs allow total or filtered view.

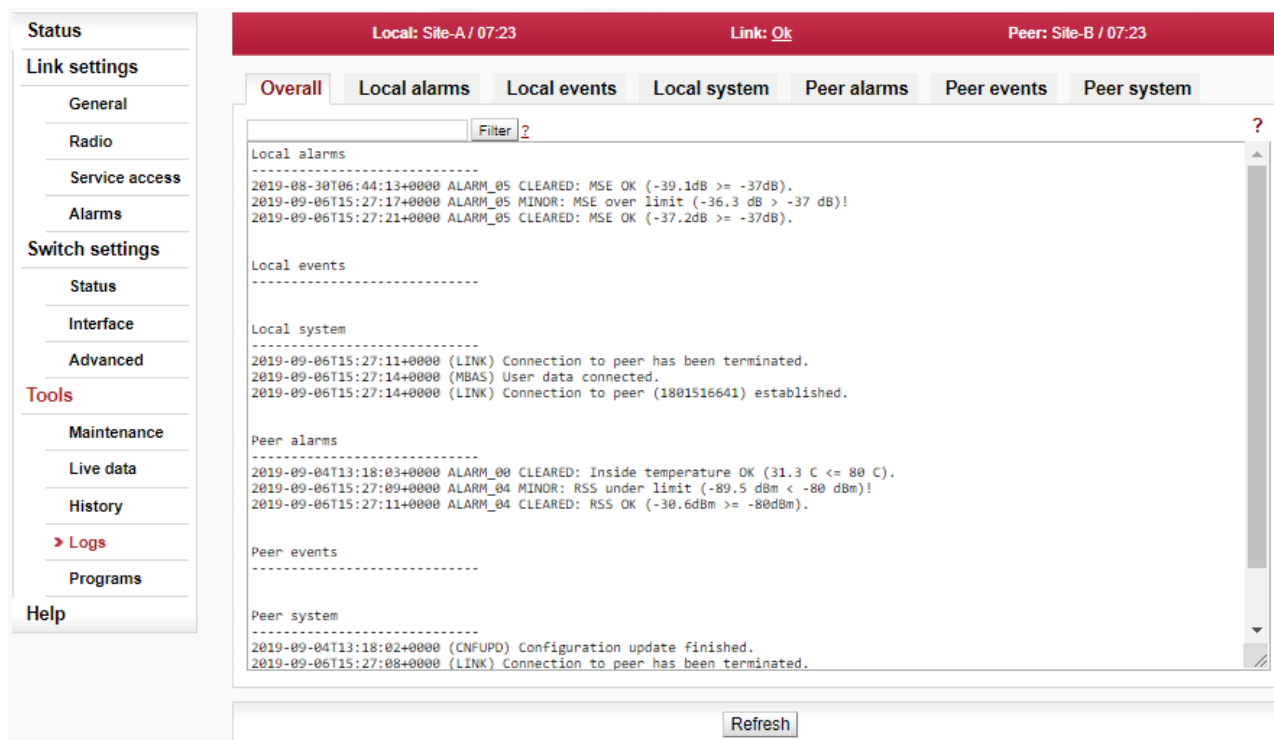


Fig. 5.38: Menu Tools / Logs

When you first open the screen, it is necessary to start browsing logs by pressing the Refresh button.

Maximum length of displayed logs is 250 entries. If you need to display longer history, use CLI interface instead.

Overall	Displays the last 3 records from all types of logs.
Local alarms, Peer alarms	Alarms from Local or Peer unit.
Local events, Peer events	Events from Local or Peer unit.
Filter	Listings of all logs can be filtered. Filtering string is entered in to the upper left corner window and Filter button is pushed. For example, you want to know when the configuration of the unit was modified: On the Local events screen, enter <code>Con-figuration</code> and hit Enter. Plain text or regular expressions can be used for filtering (JavaScript format).

5.6.5. Programs

Ping

The Ping tool allows sending ICMP pings to a selected address

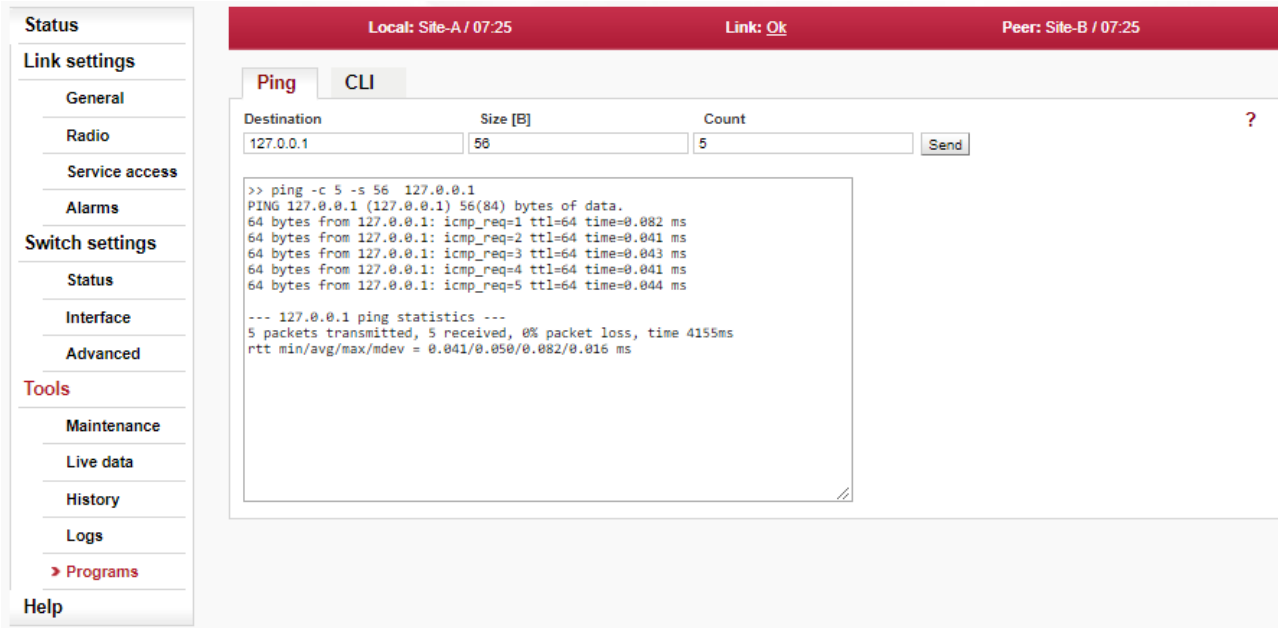


Fig. 5.39: Menu Tools / Programs / Ping

Destination Destination address in dotted decimal notation. The default address 127.0.0.1 is the localhost address - i.e. the unit itself.

Size [B] Length of sent data 7 to 1500 bytes, 8 bytes of the header will be added.

Count Number of sent pings.

Start the test by clicking on *Send*. The period for sending pings is constant: 1000 ms. The result is displayed in the text window.

CLI

Web interface for executing non-interactive scripts and programs.

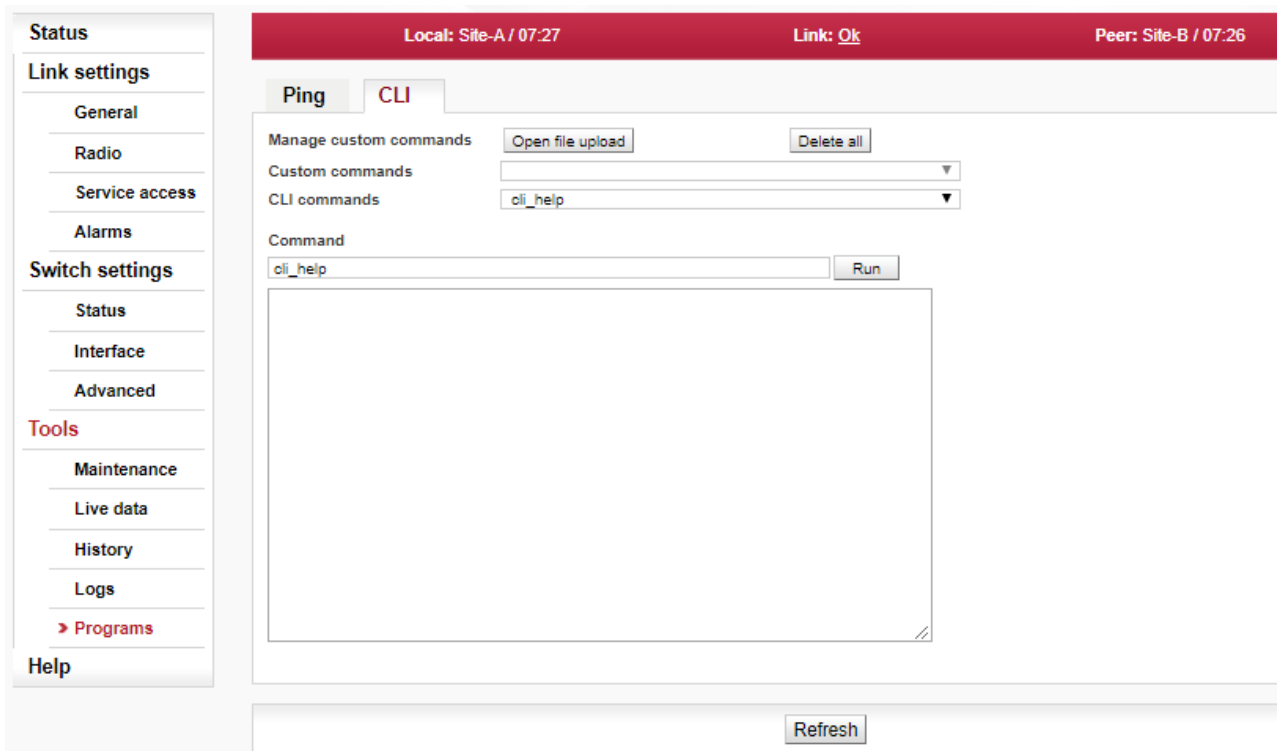


Fig. 5.40: Menu Tools / Programs / CLI

Manage custom commands

Using "Open file upload"/"upload" the user can upload scripts to the unit. The uploaded file can be either a single shell script with extension `.sh` (e.g. `my_script.sh`) or package with multiple scripts with extension `.tar.gz` or `.tgz` created using `tar`.

"Delete all" removes all custom scripts from the unit.

Custom scripts are located in `/home/shared/bin`.

Custom commands

A custom script can be selected here and initial comments/help is shown.

CLI commands

A CLI command can be selected here. You can use `cli_help` for listing all CLI commands or `<command> --help` to obtain detailed help on a selected command.

Command

Command line for writing commands with parameters. You can use any non-interactive program/script according to your permissions. Command is executed by pushing the "Run" button.

Format of custom scripts

Custom scripts must be a shell script with preamble `#!/bin/sh` and extension `sh`. Blocks of lines beginning with the comment sign (`#`) after preamble are considered to be help and are listed when the script is selected in the web interface.

Scripts should not be interactive as there is no possibility to send a response from the web interface. All script options should be implemented as parameters.

Syntax should be valid for interpret shell `ash` from `BusyBox v1.20.1`.

Example of

custom script

```
#!/bin/sh
#script checks if service with the same name or vid already exists
#if not creates a new entry in VTU with given VID
#
# input parameters:
#     service_name - name of the new service
#     VID - vid of the new service
#
# return values:
#     0 - ok
#     3 - bad parameter
#     5 - service already exists
#     6 - there already exists an entry with given VID
#     42 - other error

D42_NAME="$1"
D42_VID="$2"

D42N="service_data42"

error()
{
    echo "$D42N: Error: $" >&2
}

info()
{
    echo "$D42N: $" >&2
}

die()
{
    error "$*"
    exit 42 #error
}

# basic check if not empty
if [ -z "$D42_NAME" ]; then
    error "Bad service name"
    exit 3
fi
if [ -z "$D42_VID" ]; then
    error "Bad service VID"
    exit 3
fi

D42_FOUND=$(cli_nw_get --vtu all | grep "$D42_NAME")
if [ -n "$D42_FOUND" ]; then
    error "Service(s) with name $D42_NAME found"
    echo $D42_FOUND
}
```

```
        exit 5
fi

D42_VALID=$(cli_nw_get --vtu "$D42_VID" | sed -n 's/^valid=(.+)\$/\1/p')
if [ "pre_$D42_VALID" = "pre_true" ]; then
    error "VID $D42_VID is used"
    cli_nw_get --vtu "$D42_VID"
    exit 6
fi

D42_VALID=$(cli_nw_get --stu 1 | sed -n 's/^valid=(.+)\$/\1/p')
if [ "pre_$D42_VALID" = "pre_false" ]; then
    info "Creating STU entry with SID=1"
    cli_nw_set --stu 1 'label="D42_auto", port_state=["disabled", "disabled", ►
"forwarding", "disabled", "disabled", "forwarding", "forwarding"]'
    if [ $? -ne 0 ]; then
        die "Failed to create STU entry"
    fi
fi

info "Creating service \"$D42_NAME\" with VID=$D42_VID"
cli_nw_set --vtu "$D42_VID" label="$D42_NAME" 'fid=0, sid=1, pri_override=true, priority=5, ►
policy=false, member_tag=["unmodify", "unmodify", "tag", "unmodify", "not_member", ►
"not_member", "unmodify"]'
if [ $? -ne 0 ]; then
    die "Failed to create service \"$D42_NAME\" with VID=$D42_VID"
fi
```

5.7. Help

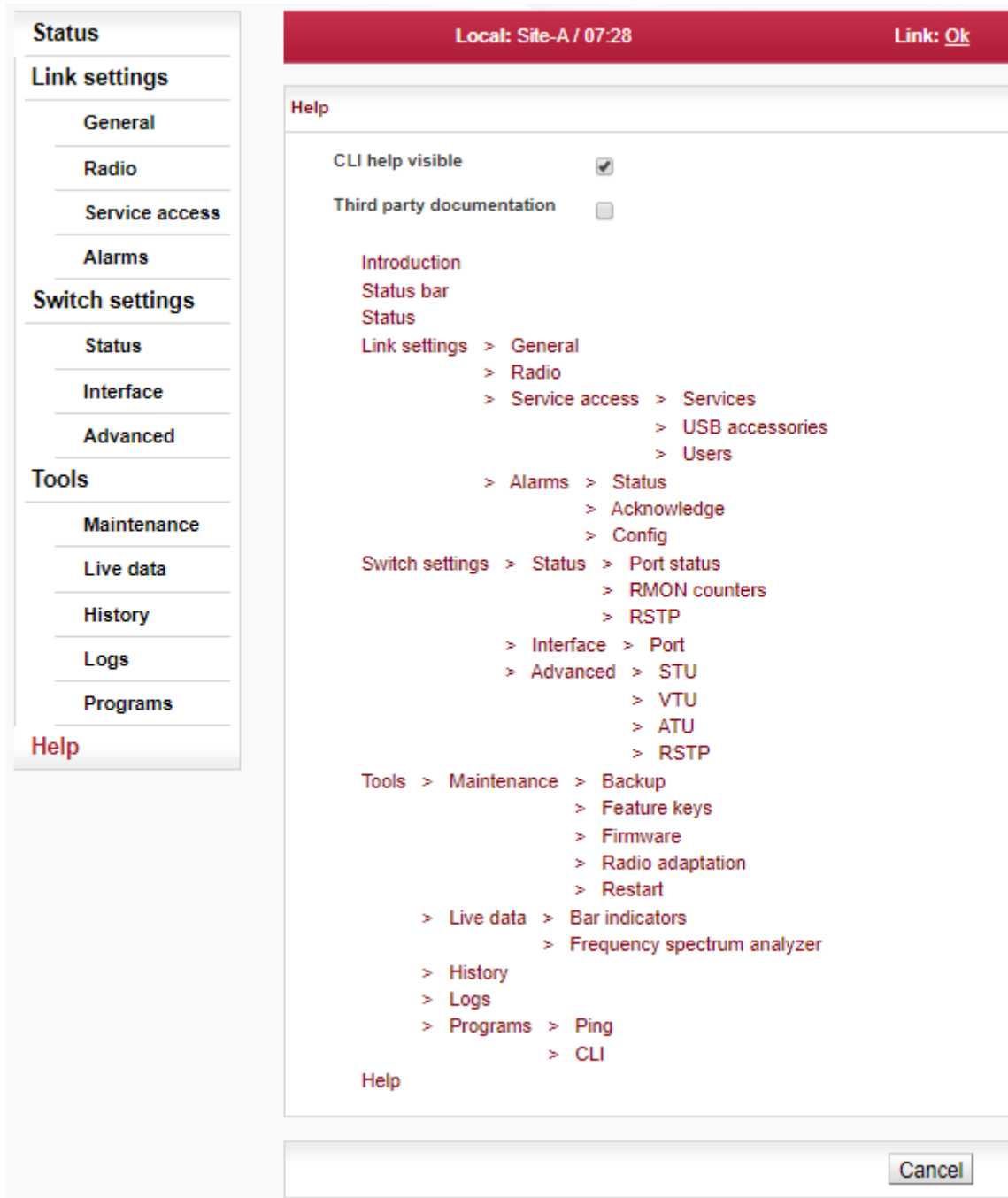


Fig. 5.41: Help menu

Help from Help menu

The Help screen displays contents of the embedded help. The help text is displayed in the whole configuration window. The text structure corresponds to individual configuration screens. Every item of this Help opens the specific help menu.

CLI help visible Allows displaying of the CLI help with examples.

Third party documentation Allows displaying references to the third party documentation (e.g. internal switch documentation).

Help from configuration menu

Clicking the **name of the specific parameter** in the configuration menu brings up the help belonging to this parameter. The help text is displayed in the pop-up window:

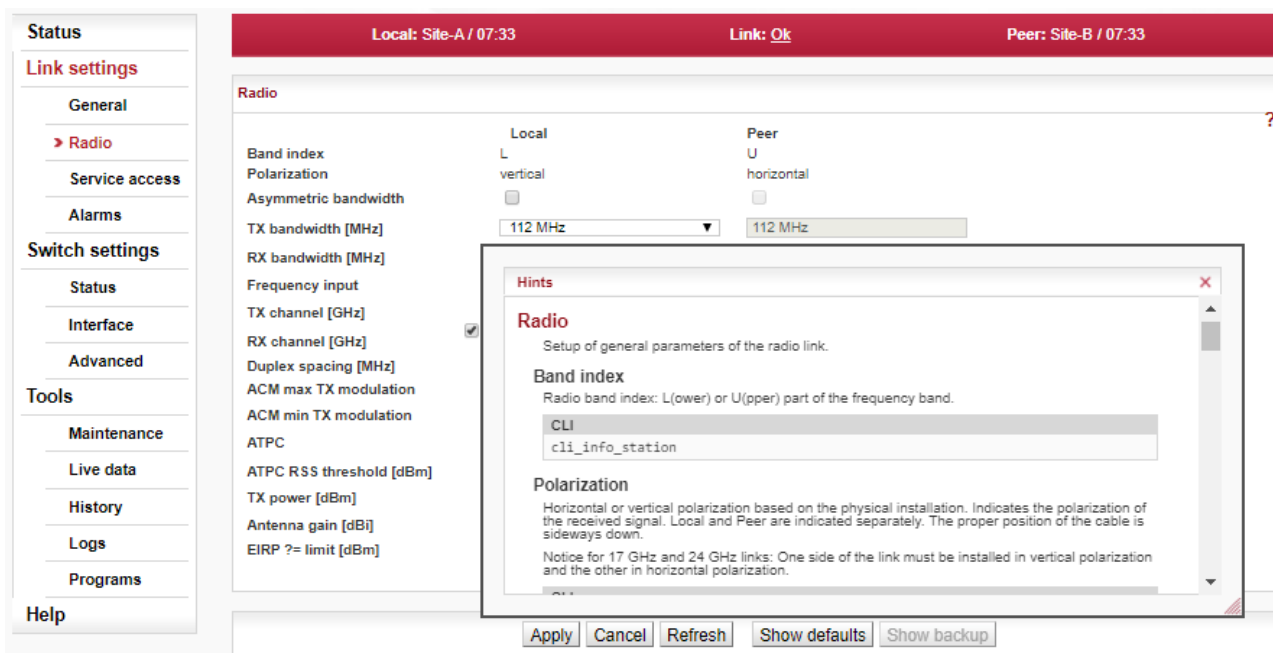


Fig. 5.42: Parameter help

There is a **Go to help** link within the help text. It displays the whole configuration menu help:

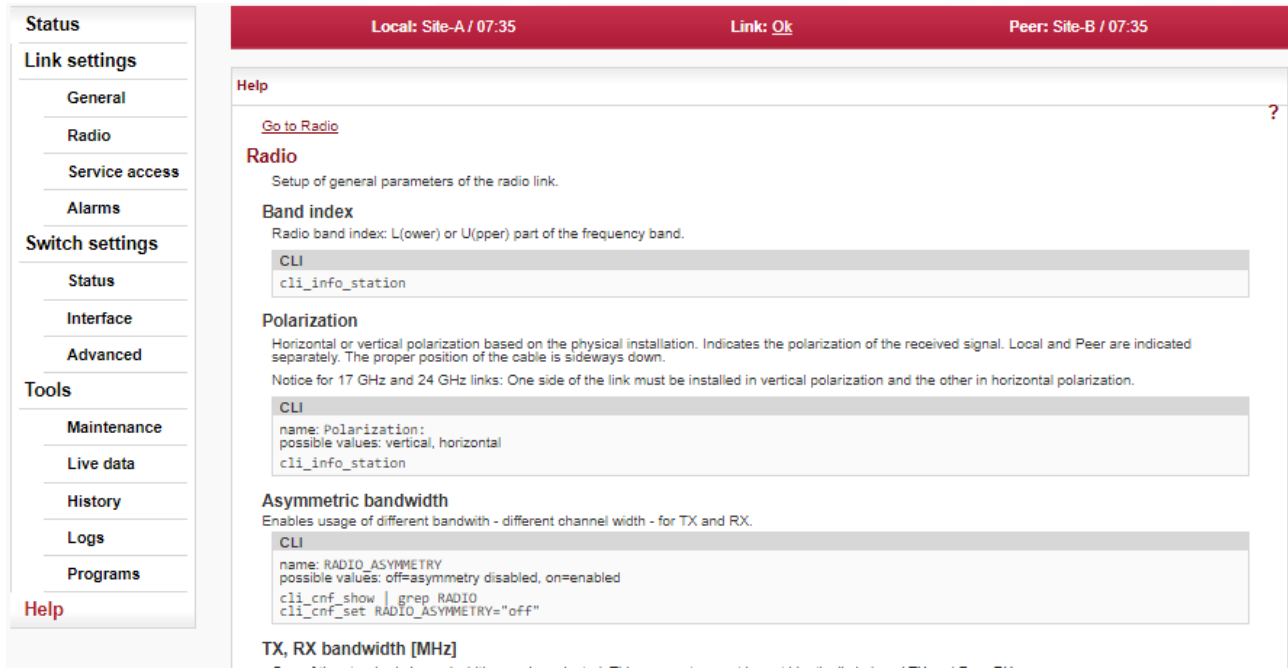


Fig. 5.43: Configuration menu help

There is a link on each help screen which points to the respective configuration screen.

Clicking the **question mark** icon in the upper right corner of the configuration screen brings a summary help for the configuration screen in the pop up window:

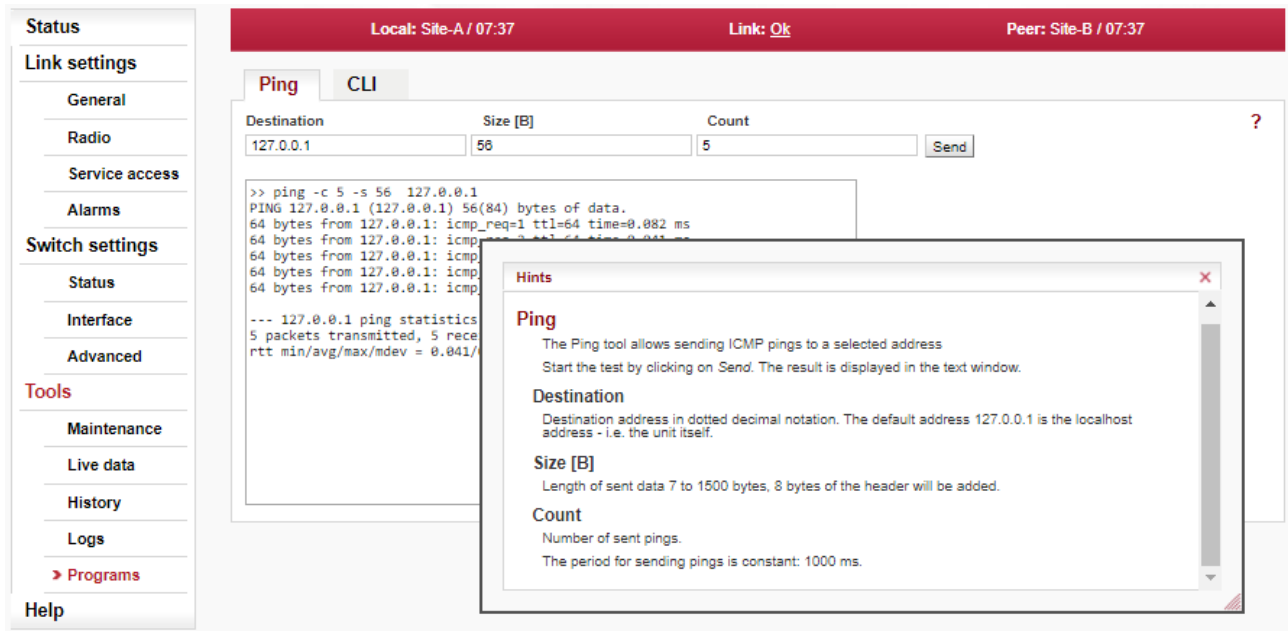


Fig. 5.44: Summary help

The Help window can be moved by dragging the *Hints* bar. Resize it by dragging the bottom corner.

6. Command Line Interface

The Command Line Interface (CLI) provides an alternative to HTTPS access. CLI allows you to work in a text regime interface using a ssh (putty) or telnet client.

6.1. Connection via CLI

6.1.1. Telnet

Use the **telnet** client to connect to the unit with service IP address 192.168.169.169. Type this in the command prompt:

```
telnet 192.168.169.169
```

Then use the username and password from the menu `Service access/Users` for HTTPS access (by default `admin, admin`). This works if `Service access/Services/Telnet` is checked in HTTPS access.

6.1.2. Putty

Connection using **putty client**. Type this into the Host Name (or IP address) field:

```
admin@192.168.169.169
```

Click Open. Then enter the password `admin`. This procedure (without key) is subject to selection `Service access/Services/SSH on` in HTTPS access.

If you own the private key part, then you do not need a password. In putty, continue by selecting `Connection/SSH/Auth` and selecting path to file with key e.g. `key.ppk`. Use `Session/Logging` to save the putty configuration. To access the unit via CLI simply select the connection in putty and click Open.

6.1.3. SSH

Connection using client **ssh** in Linux.

```
ssh admin@192.168.169.169 -i key
```

If you know the password and it is enabled in `Service access/Services/SSH onlykey` in HTTPS access, you can skip the key and use password in the next query.

6.2. Working with CLI

- Overview of CLI options

cli_help

```

192.168.141.202 - PuTTY
Using username "admin".
admin@192.168.141.202's password:

BusyBox v1.2.2 (2012.10.10-19:50+0000) Built-in shell (ash)
Enter 'help' for a list of built-in commands.
Fri Nov 30 07:38:20 UTC 2012
Welcome to Ray Command Line Interface (CLI) on station: RAY17L

For help try: cli_help

CLI(admin):/rrusrhomes/admin$ cli_help
CLI commands:
- configuration:
  cli_cnf_backup_get      - create configuration backup package
  cli_cnf_def_show        - show default configuration
  cli_cnf_factory_set     - return to factory settings
  cli_cnf_set              - update configuration
  cli_cnf_show            - show configuration
  cli_time_set            - change time
- radio channel configuration:
  cli_rcinfo_list         - show list of stored and active rcinfo files
  cli_rcinfo_load         - load rcinfo package into storage
    
```

Fig. 6.1: CLI menu

- Parameters of CLI commands are listed in the help. For example:

```

-h      help listing
-t      target unit
-t l    local, default option
-t b    both, both units, command item for remote unit has PEER_ prefix
-t p    peer, opposite unit, when reading using the show command
    
```

- When inserting commands, using the tabulator can help
- An incorrect command is rejected (e.g. inserting forbidden frequency)
- A parameter that caused the loss of the connection is restored after 1 minute (Rollback)

- Reading parameters of local unit

```
cli_cnf_show
```

- Reading radio parameters of peer unit

```
cli_cnf_show -t p | grep RADIO
```

- Entering parameters (TX power of local unit)

```
cli_cnf_set RADIO_TX_PWR=-3
```

Items of command (RADIO_TX_PWR=) are taken from the list cli_cnf_show

- Entering more parameters in both units

```
cli_cnf_set -t b RADIO_TX_CHAN=17128000 PEER_RADIO_RX_CHAN=17128000
```

- Put parameters containing spaces in quotation marks:

```
cli_time_set -t b -T '2012-11-27 10:55:00'
```

Set time in both units

6.2.1. SSH keys

- Generation using ssh-keygen

```
[user@laptop ~]$ ssh-keygen -t dsa -f usr_ssh_key
```

Uses working directory to save private `usr_ssh_key` and public part of the key `usr_ssh_key.pub`

- Copying the key into the RAY unit

```
[user@laptop ~]$ scp usr_ssh_key.pub admin@192.168.141.202:/tmp
```

The public part of the key is written to the folder `/tmp`

- Installation of key in RAY unit

```
CLI(admin):/rrusrhomes/admin$ cli_user_authkey -c a -k /tmp/usr_ssh_key.pub
```

- Testing access to RAY unit using SSH key

```
[user@laptop ~]$ ssh -i usr_ssh_key admin@192.168.141.202
```

6.2.2. Scripts

- Script example with access using key

```
[user@laptop ~]$ ssh -i usr_ssh_key admin@192.168.141.202
"source /etc/profile;cli_info_link;echo \${?};cli_cnf_show | grep TX_PWR;echo ${?}"
Warning: Permanently added '192.168.141.202' (DSA) to the list of known hosts.
cli_info_link: Link status: up
0
RADIO_TX_PWR=4
0
[user@laptop ~]$
```

- The script contains:

<code>source /etc/profile;</code>	environment settings
<code>cli_info_link;</code>	query for link status
<code>echo \\${?};</code>	reading return value
<code>cli_cnf_show grep TX_PWR;</code>	query for radio power
<code>echo \\${?}</code>	reading return value
<code>cli_info_link: Link status:up</code>	return value
<code>0</code>	OK command
<code>RADIO_TX_PWR=4</code>	power +4 dBm
<code>0</code>	OK command

6.3. Configuration with CLI

6.3.1. Configuration file

- Configuration backup

```
cli_cnf_backup_get
```

Saves the configuration of both units to file `cnf_backup.tgz` into the working directory.

- Configuration restore

```
cli_cnf_set -t b -b cnf_backup.tgz
```

Restores configuration of both units from file `cnf_backup.tgz`

- Default configuration list

```
cli_cnf_def_show
```

Warning, the command

```
cli_cnf_factory_set
```

is not a default setting - it uses factory settings, deleting all logs and saved data. It is very likely that the connection to peer unit will be interrupted!

6.3.2. Firmware upgrade

- Current version of fw

```
cli_info_station
```

- Preparation of files

fw package, for example `bm4-RACOM-0.1.12.0.cpio` copy using ssh or putty into folder `/tmp` in RAY17

Command

```
cli_fw_clear_buffer
```

Clears the RAY buffer

```
cli_fw_buffer_status
```

Checks buffer status

- Saving into buffers

```
cli_fw_load_package -f /tmp/bm4-RACOM-0.1.12.0.cpio
```

A new fw package is loaded into the buffer (20 sec)

```
cli_fw_upload2peer
```

The fw package is also loaded into the peer unit (20 sec)

- Upgrade

```
cli_fw_upgrade -t b
```

Firmware in both units will be replaced with new version from the buffer. After 3 minutes, this message appears:

```
Firmware upgrade started. Estimated time to finish is 370 s.
```

Connection is terminated. After a few minutes, log in to RAY again

6.3.3. Remote unit authorization

The RAY unit in default configuration, establishes a connection with any remote unit and both units act as a communication pair. Should the higher protection from the unauthorized communication take-over be required, it is possible to use the so called Secured mode of remote unit authorization. This mode is based on locking the two specific units into one communication pair. Units with Secured mode activated

refuse to make a connection with any other communication unit. The units are locked using the unique authorization keys. The keys are exchanged between the units concerned. The authorization keys can be backed up to an external medium to be able to make a service unit exchange, if necessary. Should the *Link authorization guard* be disabled, the user data occurs even the remote unit is not authorized.

The Secured mode set up process consists of a few steps:

- Unique authorization keys generation:
`cli_link_key_gen -t b`
- Authorization keys exchange between the two communication units:
`cli_link_key_swap`
- Authorization keys activation:
`cli_link_key_apply -t b`
Parameter `-t` determines whether we configure the whole link (`-t b`) or only one unit (`-t 1`).
- Secured mode activation. Both sides of the link must have identically secured mode set On or Off:
`cli_cnf_set -t b SVC_SECURE_PEER_MODE=on PEER_SVC_SECURE_PEER_MODE=on`
- Secured mode de-activation:
`cli_cnf_set -t b SVC_SECURE_PEER_MODE=off PEER_SVC_SECURE_PEER_MODE=off`
- Backup of the keys to an external medium. The backup has to be performed to be able to make service exchange of the corrupted unit, if necessary. The new exchanged unit is not able to make an active connection with the other unit if it is not loaded with the proper authorization key.
`cli_link_key_save -s s -f <file>`
The key is backed up to a selected file in the internal unit file system. It can be transferred to an external medium using for example the scp client.
- Authorization key restoration from the external medium.
The key has to be transferred to the unit internal file system first. The scp client can be used. The CLI commands can be applied subsequently:
`cli_link_key_load -t b -f <file>`
`cli_link_key_apply -t b`

6.3.4. Radio loopback

"Radio loopback" function (accessible via CLI only) provides indicative measurement of XPD (cross polar discrimination). XPD is the ratio between desired signals on preferred polarization and signals on opposite polarization.

- Command
`cli_rloop`

The Radio loopback command takes 10 seconds. The result is suppression [dB] of the unwanted signal (transmitter to receiver penetration). Radio loopback can only be used with units operating in 17 GHz or 24 GHz band.

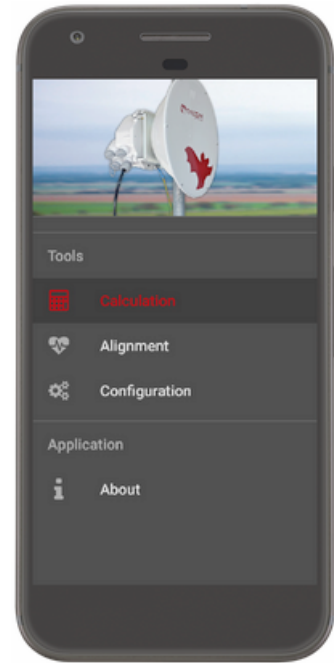
WARNING: User traffic is interrupted during command execution!

7. RAY Tools app for Mobile devices

RAY Tools is a stand-alone application designed to perform link management, is optimised for use on mobile devices with smaller displays and especially in challenging conditions.

RAY Tools supports the following functions:

- Link Calculation – to calculate or verify the link budget
- Antenna Alignment – provide measurement of RSS and MSE for fast antenna alignment
- Link Management – standard web-based unit management



7.1. Menu options

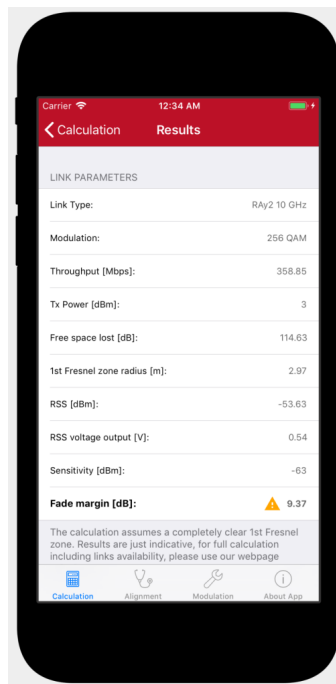
Calculation

Can be used in conjunction with all RACOM microwave products and compatible antennas. Available parameters to input that affect link budget are:

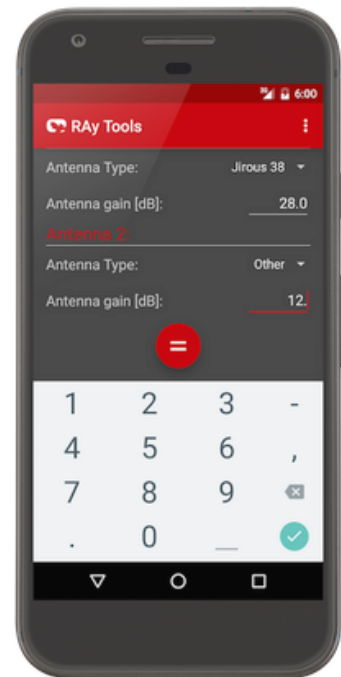
- Modulation
- Throughput
- Tx Power
- Link distance
- Antenna specifications

RAY Tools calculation outputs are:

- Free Space Loss (FSL)
- 1st Fresnel Zone radius
- RSS
- Sensitivity
- Fade margin (shown to be acceptable/marginal/inadequate)



iOS version

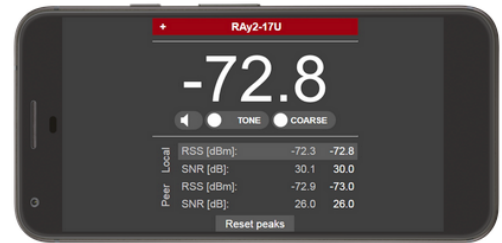


Android version

The calculation assumes a clear line of sight and makes no allowance for precipitation. A more accurate calculation can be performed using the tool available on RACOM web pages (see <https://www.racom.eu/eng/products/microwave-link.html#calculation>). Precise link calculation should be performed using dedicated tools (e.g. Pathloss).

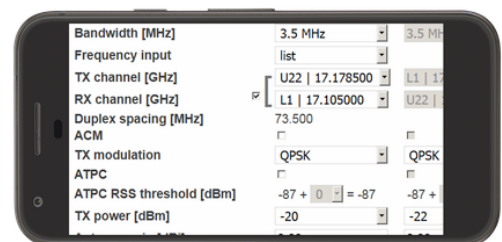
Alignment

Antenna Alignment Tool is accessed using this menu. See Section 5.6.2 *Live data* for description.



Configuration

Links to web management of RAY unit. User authentication is required.



About

This item shows the application version and its Release notes.

Note

If gloves are used it is strongly recommended to activate smartphone option for “work in gloves”, which increase the sensitivity of touch screen display (quite common option for modern smartphones).

7.2. Application availability

RAY Tools application version 2.xx requires RAY3 unit with firmware version 1.0.0.0 or later. The same application and same version of RAYTools works also with all RAY2 units (with firmware version 2.1.28.0 or later).

RAY Tools version 2.xx or later is available for mobile operating systems Android (Google compatible devices) and iOS (Apple devices). All display sizes are supported on both operating systems. Android version can be downloaded from Google Play (<https://play.google.com/store>¹), iOS version is available for download on AppStore (<https://www.apple.com/ios/app-store>²) or their local versions.

Note

RAY Tools application contains an automatic crash report feature; Firebase tool is used to report the crash. Any data transmitted is for the exclusive use of RACOM developers to analyze the problem. It will not be used in any other way by Apple, Google, Firebase or RACOM.

¹ <https://play.google.com/store/apps/details?id=job.raytools>

² <https://itunes.apple.com/cz/app/ray-tools/id1279358257?l=cs&mt=8>

7.3. Feedback to RACOM

Any feedback for this application is welcome. Please contact us on email address:
<*raytools@racom.eu*>

We would also like to hear from any who would like to become a beta tester of upcoming versions of RAY Tools.

8. Troubleshooting

- **Polarization incorrect**

Units RAY3-17 and RAY3-24 must be mounted with opposite polarization; one with TX horizontal polarization (horizontal arrow) and the second with TX vertical polarization (vertical arrow). See *Cross polarization* for more info.

Install the unit with the correct *horizontal* or *vertical* polarization: The arrow mark indicates the unit TX polarization. When the arrows heading perpendicular to the earth, the unit transmits a signal in vertical polarization. When the arrow is heading parallel to the earth, the unit transmits a signal in horizontal polarization. The connectors must point downward at an angle.

- **The link cannot be established**

Double check the correct polarization (see above) of both units on the link.

Start with the most “resilient” configuration. This configuration depends on the type of unit. We recommend using the narrowest available bandwidth (e.g. 3.5 MHz), the lowest modulation level (QPSK_S) and maximum available output power. TX and RX channels must be the same as the RX and TX channels in the remote unit. When the connection has been established and the antennas have been directed, proceed with operation parameters.

- **RSS and Antenna alignment**

To configure the link and monitor its state, several menus display the RSS signal strength (most interactive are pages *Live Data / Bar indicators* or *Antenna Alignment Tool*). Additionally RSS can be monitored by a voltmeter connected to *RSS voltage contacts* or by RACOM smartphone application *RAY Tools* on a mobile phone connected to *RAY WiFi*.

**Note**

Please keep in mind, that RAY is not a measuring instrument, hence the precision of the RSS reading is limited. Though, in most situations the RSS reading accuracy is better than ± 2 dB, the absolute RSS value should not be used for accurate comparisons e.g. between two links.

- **Ethernet Buffers are small**

To optimise the total buffer size of RAY radio (by optimizing a cooperation between Ethernet switch buffer and a buffer inside modem chip) it is required to set RX FlowControl for port 'Air (p9)' (in menu Switch settings / Interface / Port) on both units to be 'on'. (FW versions after 1.0.16.0 solve that automatically, so there is no need to manually set the parameter).

**Note**

Correct Flow Control setting typically increases operational speed of the link for mixed traffic, where bigger capacity of buffers helps to optimize the link performance.

- **Ethernet throughput far below published RFC2544 numbers**

In the case when Ethernet throughput of the link is far below expectations based on *published Ethernet speeds* measured according RFC2544, one of the reasons may be wrong settings for a cooper-

ation between Ethernet buffers inside RAY3 unit and between RAY unit (Ethernet switch inside the unit) and outside network (Ethernet switches and routers RAY is connected to).

To ensure buffers inside RAY unit are cooperating optimally please double-check RX FlowControl parameter for port 'Air (p9)' (in menu Switch settings / Interface / Port) - it should be 'on' for both units. (FW versions after 1.0.16.0 solve that automatically, so there is no need to manually set the parameter).

- **Access to the Local unit is blocked**

Access to the Local unit may be accidentally blocked, for instance by disabling HTTPS access. If you can access the Remote unit over HTTPS, type its address in your web browser's address field. The link will transfer the packet over the Local unit with blocked service access all the way to the Remote unit, which will give you access to the control menus of both units. Warning, the Remote unit will report as Local.

- **Distinguishing Local-Remote**

A unit accessed via service access always reports as Local. If you connect through another (peer) unit and radio channel, a certain amount of caution is necessary. For example, do not reduce the transmission power so that the link interrupts accidentally. Errors of this type should be fixed by the rollback function within approx. 1 minute.

Resolution can be done by comparing the length of ping on Local and Remote. Pinging the unit behind the radio channel is slower. The difference is more pronounced in the case of a long packet and the low speed of the radio channel.

- **Access security**

For better protection against unauthorised access to configuration you should only allow as few kinds of access as possible. The most secure type is SSH with key – leave only SSH active with "only key" choice.

- **Problem with HTTPS certificate**

See the *Appendix B, HTTPS certificate*

- **Overexcited receiver**

A natural property of each radio receiver is to compress the signal in one of the functional blocks, when the signal level gets out of the AGC (automatic gain control) dynamic range. The result of this effect is non-linear distortion of the received signal which is observed as decrease in the signal to noise ratio, i.e. in case of digital modulations increase of the Mean Square Error (MSE).

Limit for guaranteed functionality of RAY3 radio receiver is -15 dBm (measured on the waveguide input). This limit applies for all channel bandwidths and all modulations.

Beyond this limit the distortion of linearity appears and signal quality is depreciated. In extreme cases, this can lead to the disintegration of the radio link due to reduced signal to noise ratio (as a result of signal distortion).

- **Setting up a link from unit type 'X' or 'E' and unit type 'S'**

Emulation of unit 'type S' (like RAY3-24S) on the unit 'type X' (like RAY3-24X on product label) requires to activate 'X/S compatibility' by parameter 'Unit S mode' (in menu Tools / Maintenance / Radio adaptation), see *Section 5.6.1, "Maintenance"*.

Sometime it is necessary to set up a link from a unit type 'S' (like RAY3-24S) and a unit type 'X' or 'E' (like RAY3-24X) - for example after exchange of failed unit on one end of the link (for differences between 'X', 'E' and 'S' type units see *Section 1.6.2, "Production label"*).

Then it is necessary to configure unit 'X' or 'E' to behave like unit type 'S' (older model). To achieve that the parameter 'Unit S mode' (in menu Tools / Maintenance / Radio adaptation) has to be activated (set to 'on'). For more details see *Section 5.6.1, "Maintenance"*.

**Note**

Unit with FW version 1.0.14.0 with activated 'Unit S mode' requires to manually set RX FlowControl for port 'Air (p9)' (in menu Switch settings / Interface / Port) to the value 'auto'. On FW version 1.0.16.0 it is recommended to set this parameter to 'on'. Later FW versions solve settings of this parameter automatically.

9. Technical parameters

9.1. General parameters

9.1.1. Overview

Tab. 9.1: Parameters 1

RAy3		Technical parameters 1	
Type		RAy3-17	RAy3-24
Band	[GHz]	17.10 – 17.30	24.00 – 24.25
Type of duplex traffic		FDD (Frequency division duplex)	
ODU units		One universal unit	
Bandwidth	[MHz]	3.5, 5, 7, 10, 14, 20, 28, 40, 56, 80, 100, 112	
Modulation		QPSK_S ¹⁾ , QPSK, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096 QAM	
ACM		yes	
Forward Error Corr.		LDPC, RS	
Channels gap	[MHz]	Flexible, min. 24 MHz between channel edges or 18 MHz in case of 2 × 112 MHz Bandwidth	
User data speed (each direction)	[Mbps]	2.7 – 1002 <i>detail</i>	
Data speed according to RFC 2544	[Mbps]	Up to 987 Mbps <i>detail</i>	
Latency	[μs]	268 μs (64 B / 366 Mbps); 313 μs (1518 B / 366 Mbps) 173 μs (64 B / 1002 Mbps); 198 μs (1518 B / 1002 Mbps)	
Sensitivity, BER 10 ⁻⁶	[dBm]	-99.0 (2.7 Mbps)	-99.0 (2.7 Mbps)
		-52.5 (1002 Mbps)	-52.5 (1002 Mbps)
		<i>detail</i>	<i>detail</i>
Output Power	[dBm]	-30 to +10	-30 to +10, (-30 to -15) ²⁾
ATPC		yes	

ver. 1.2

¹⁾Stability optimized (stronger) FEC

²⁾RF Output power -30 to -15 dBm for all models with variant “R” (e.g. RAY3-24R or RAY3-24NR)

Tab. 9.2: Parameters 2

RAy3	Technical parameters 2
User interface RJ45	1 Gb Eth. (10/100/1000) 1000BASE-T, MTU 10240 bytes ³⁾ , recommended cable S/FTP Cat.6, Cat.7
User interface SFP	1 Gb Eth. (10/100/1000) 1000BASE-T / 1000BASE-SX / 1000BASE-LX, MTU 10240 bytes ³⁾ , user exchangeable SFP, power consumption max. 1.25 W
Service interface	USB 2.0, Host-A: USB / WiFi, USB / ETH
Synchronization	Synchronous Ethernet; IEEE-1588v2, Transparent clock
Config. & Manag.	Web, CLI, RAY Tools (HTTP, HTTPS, SSH, Telnet)
Encryption	AES 128, 192, 256 ⁴⁾
Power	Floating; PoE IEEE 802.3at; PoE injector (20-60 VDC), DC/RJ45 (20-60 VDC)
Power consumption	22.5 W (typ.) – 24.5 W (incl. SFP)
Operating temperature range	-30 to +55°C (EN 300 019-1-4, class 4.1.)
Surge immunity	4 kV according to EN 61000-4-5
ESD immunity	8 kV according to EN 61000-4-2
Mechanical design	FOD (Full Outdoor), antenna mounting compatible with RAY1 and RAY2
IP code	IP66 (Ingress Protection)
Dimensions	245 × 245 × 160 mm
Weight	2.6 kg
Antenna	LEAX-RAY, Class3, 0.3–1.2 m, direct mounting (or others, e.g. Jirous)
Spectrum	EN 300 440 V2.2.1
EMC	EN 301 489-1 V2.1.1 EN 301 489-3 V1.6.1 EN 301 489-4 V3.1.1
Safety	EN 62368-1:2014 + A1:2017
FCC / IC	CFR 47 part 15 (SQT-RAY3-24) / (24993-RAY324) - for RAY3-24 only

ver. 1.3

³⁾ Model RAY3-24S (produced December 2018 till April 2019) has MTU 2048 bytes. All other models have MTU 10240 bytes.

⁴⁾ Encryption is possible only with model variants 'X', 'S' and 'E'. Variants 'S' and 'X' means the unit is equipped with HW module for encryption acceleration, variants 'E' and 'N' are not equipped. Variant 'E' allows SW encryption, while variant 'N' does not allow any encryption to be used.

9.1.2. Link speed

Tab. 9.3: Link speed - raw link

RAy3		Radio parameters – Bit Rate [Mbps]									
Band width MHz	Modulation										
	QPSK _S ¹⁾	QPSK	16 QAM	32 QAM	64 QAM	128 QAM	256 QAM	512 QAM	1024 QAM	2048 QAM	4096 QAM
3.5	2.7	5.0	9.5	11	15	17	19	21	23		
5	3.8	7.1	14	16	21	25	28	31	33		
7	5.8	10	20	24	31	37	42	47	52	57	
10	7.9	14	27	33	42	50	57	64	71	78	
14	12	22	41	50	65	77	88	98	109	119	128
20	17	32	60	72	94	111	127	142	158	171	185
28	24	38	81	105	132	157	181	202	227	249	269
40	34	54	113	148	185	220	253	283	318	348	377
56	49	81	169	213	268	319	366	414	459	501	540
80	69	115	240	303	381	454	521	589	653	713	
100	87	145	299	381	479	569	653	736	820	895	
112	97	162	334	426	537	637	731	824	918	1002	

ver. 1.2

¹⁾ Stability optimized (stronger) FEC

Tab. 9.4: Link speed - Ethernet (according to RFC 2544)

The full-size table is located on the next page.

ver. 1.1

¹⁾ Stability optimized (stronger) FEC

RAy3		Link speed [Mbps] for Ethernet frames 64 B / 1518 B / 8960 B									
Band width	Modulation										
	QPSK _S ¹⁾	QPSK	16 QAM	32 QAM	64 QAM	128 QAM	256 QAM	512 QAM	1024 QAM	2048 QAM	4096 QAM
MHz											
3.5	2.4	4.6	8.8	11	14	16	18	20	21		
	2.6	4.7	9.3	11	14	17	19	21	23		
	2.6	4.8	9.4	11	14	17	19	21	23		
5	3.5	6.6	13	15	20	23	26	29	31		
	3.6	6.9	13	16	21	24	27	30	33		
	3.6	7.0	13	16	21	24	28	31	33		
7	5.2	9.8	19	23	29	34	39	44	48	53	
	5.5	10	20	24	31	36	41	46	51	57	
	5.6	10	20	24	31	37	42	46	51	57	
10	7.3	13	26	31	40	47	54	60	67	73	
	7.7	14	27	33	42	50	57	64	71	78	
	7.8	14	27	33	42	50	57	64	71	78	
14	11	21	39	47	61	72	82	92	103	112	121
	12	22	41	50	65	77	87	98	109	118	128
	12	22	41	50	65	77	88	98	109	119	128
20	16	30	56	68	88	104	119	133	148	161	174
	17	32	59	72	93	111	126	141	157	171	184
	17	32	59	72	93	111	127	141	157	171	185
28	23	36	76	99	124	148	170	190	213	234	252
	24	38	81	105	131	157	180	202	226	248	268
	24	38	81	105	132	157	180	202	227	248	269
40	32	50	107	139	174	207	238	267	299	328	352
	34	53	113	147	184	220	252	282	317	347	375
	34	54	113	147	184	220	252	283	317	348	376
56	46	76	158	200	252	300	345	390	432	471	508
	48	81	168	212	267	318	365	413	458	499	539
	48	81	168	213	267	319	366	413	459	500	540
80	65	108	226	285	358	428	491	555	615	671	
	69	115	239	302	380	453	519	587	651	711	
	69	115	239	303	380	454	520	588	653	712	
100	81	136	281	358	451	535	615	692	739	760	
	86	144	297	380	478	567	651	733	817	892	
	86	144	298	381	479	568	652	735	820	894	
112	91	152	314	393	505	599	688	740	761	762	
	96	161	333	425	535	635	728	821	916	987	
	97	161	334	426	536	636	730	823	918	998	

9.2. RAY3-17 parameters

9.2.1. Upper/Lower Limits

Tab. 9.5: Frequency limits - 17

RAY3-17	Band Range [GHz]	
	Unit L	Unit U
min	17.104	17.104
max	17.296	17.296

ver. 1.0

9.2.2. Radio parameters

Tab. 9.6: Radio parameters - 17, BER = 10⁻⁶

Table cells contain values:		ver. 1.0
User Bit Rate	[Mbps]	Bit Rate for the selected modulation and bandwidth
RSS (Received Signal Strength)	[dBm]	Minimum required RSS (Receiver Threshold, Rx Sensitivity)
MSE (Mean Square Error)	[dB]	Maximum required MSE (the inverse to often used value SNR)

The full-size table is located on the next page.

¹⁾ Stability optimized (stronger) FEC

RAy3-17 Radio parameters – Bit Rate [Mbps] / RSS [dBm] / MSE [dB]												ver. 1.1
Band width MHz	Modulation											
	QPSK _S ¹⁾	QPSK	16 QAM	32 QAM	64 QAM	128 QAM	256 QAM	512 QAM	1024 QAM	2048 QAM	4096 QAM	
3.5	2.7	5.0	9.5	11	15	17	19	21	23			
	-99.0	-94.5	-88.5	-85.0	-82.0	-79.0	-76.0	-73.0	-69.5			
	-6.1	-9.0	-15.2	-18.4	-21.6	-24.9	-28.0	-31.0	-34.6			
5	3.8	7.1	14	16	21	25	28	31	33			
	-97.5	-93.0	-87.5	-84.0	-81.0	-78.0	-75.0	-72.0	-69.0			
	-6.5	-9.0	-15.1	-18.0	-21.3	-24.6	-27.6	-30.7	-34.3			
7	5.8	10	20	24	31	37	42	47	52	57		
	-95.5	-92.0	-86.5	-83.0	-80.0	-77.0	-74.0	-71.0	-67.0	-63.0		
	-6.2	-8.5	-14.4	-17.7	-20.9	-24.2	-27.5	-30.3	-34.6	-38.2		
10	7.9	14	27	33	42	50	57	64	71	78		
	-93.5	-90.5	-85.0	-81.5	-78.5	-75.5	-72.5	-69.5	-66.0	-62.5		
	-7.0	-8.5	-14.4	-17.4	-20.5	-23.8	-26.9	-29.7	-33.6	-37.0		
14	12	22	41	50	65	77	88	98	109	119	128	
	-92.0	-89.0	-83.5	-80.0	-77.0	-74.0	-71.0	-68.0	-65.0	-61.5	-57.5	
	-6.6	-8.7	-14.3	-17.4	-20.6	-23.6	-26.7	-29.6	-33.3	-36.5	-40.2	
20	17	32	60	72	94	111	127	142	158	171	185	
	-91.5	-87.5	-82.0	-78.5	-75.5	-72.5	-69.5	-66.5	-63.5	-60.5	-57.0	
	-6.1	-8.7	-14.2	-17.3	-20.2	-23.5	-26.5	-29.3	-32.6	-35.4	-39.1	
28	24	38	81	105	132	157	181	202	227	249	269	
	-91.0	-88.0	-81.5	-77.0	-74.0	-71.0	-68.0	-65.0	-62.0	-59.0	-56.0	
	-5.8	-7.2	-13.5	-17.2	-20.1	-23.3	-26.2	-29.2	-32.7	-35.5	-38.7	
40	34	54	113	148	185	220	253	283	318	348	377	
	-89.0	-86.0	-79.5	-75.5	-72.5	-69.5	-66.5	-63.5	-60.5	-57.5	-54.5	
	-5.8	-7.3	-13.6	-17.3	-20.1	-23.3	-26.1	-29.0	-32.4	-35.2	-38.1	
56	49	81	169	213	268	319	366	414	459	501	540	
	-88.0	-84.5	-77.5	-73.5	-70.5	-67.5	-64.5	-61.5	-58.5	-55.5	-52.5	
	-5.5	-7.3	-13.9	-17.4	-20.2	-23.4	-26.5	-29.3	-32.3	-35.0	-38.2	
80	69	115	240	303	381	454	521	589	653	713		
	-86.5	-83.0	-76.0	-72.0	-69.0	-66.0	-63.0	-60.0	-57.0	-54.0		
	-5.5	-7.3	-13.8	-17.5	-20.2	-23.5	-26.5	-29.4	-32.4	-35.0		
100	87	145	299	381	479	569	653	736	820	895		
	-85.5	-82.0	-75.0	-71.0	-68.0	-65.0	-62.0	-59.0	-56.0	-53.0		
	-5.6	-7.4	-13.7	-17.2	-20.3	-23.3	-26.3	-29.0	-32.2	-34.9		
112	97	162	334	426	537	637	731	824	918	1002		
	-85.0	-81.5	-74.5	-70.5	-67.5	-64.5	-61.5	-58.5	-55.5	-52.5		
	-5.5	-7.3	-13.7	-17.2	-20.3	-23.2	-26.5	-29.1	-32.2	-35.0		

9.2.3. ACM switching

Tab. 9.7: ACM switching-17 according to MSE state

RAY3-17		MSE degrade [dB] / MSE improve [dB]									
Band width MHz	Modulation										
	QPSK _S ¹⁾	QPSK	16 QAM	32 QAM	64 QAM	128 QAM	256 QAM	512 QAM	1024 QAM	2048 QAM	4096 QAM
3.5	--	-10.5	-16.7	-23.1	-23.1	-26.4	-29.5	-32.5	-36.1		
	-11.5	-17.7	-20.9	-24.1	-27.4	-30.5	-33.5	-37.1	--		
5	--	-10.5	-16.6	-22.8	-22.8	-26.1	-29.1	-32.2	-35.8		
	-11.5	-17.6	-20.5	-23.8	-27.1	-30.1	-33.2	-36.8	--		
7	--	-10.0	-15.9	-22.4	-22.4	-25.7	-29.0	-31.8	-36.1	-39.7	
	-11.0	-16.9	-20.2	-23.4	-26.7	-30.0	-32.8	-37.1	-40.7	--	
10	--	-10.0	-15.9	-22.0	-22.0	-25.3	-28.4	-31.2	-35.1	-38.5	
	-11.0	-16.9	-19.9	-23.0	-26.3	-29.4	-32.2	-36.1	-39.5	--	
14	--	-10.2	-15.8	-22.1	-22.1	-25.1	-28.2	-31.1	-34.8	-38.0	-41.7
	-11.2	-16.8	-19.9	-23.1	-26.1	-29.2	-32.1	-35.8	-39.0	-42.7	--
20	--	-10.2	-15.7	-21.7	-21.7	-25.0	-28.0	-30.8	-34.1	-36.9	-40.6
	-11.2	-16.7	-19.8	-22.7	-26.0	-29.0	-31.8	-35.1	-37.9	-41.6	--
28	--	-8.7	-15.0	-21.6	-21.6	-24.8	-27.7	-30.6	-34.2	-37.0	-40.2
	-9.7	-16.0	-19.8	-22.6	-25.8	-28.7	-31.6	-35.2	-38.2	-41.2	--
40	--	-8.8	-15.1	-21.6	-21.6	-24.8	-27.6	-30.5	-33.9	-36.7	-39.6
	-9.8	-16.1	-19.8	-22.6	-25.8	-28.6	-31.5	-34.9	-37.7	-40.6	--
56	--	-8.8	-15.4	-21.7	-21.7	-24.9	-28.0	-30.8	-33.8	-36.5	-39.7
	-9.8	-16.4	-19.9	-22.7	-25.9	-29.0	-31.8	-34.8	-37.5	-40.7	--
80	--	-8.8	-15.3	-21.7	-21.7	-25.0	-28.0	-30.9	-33.9	-36.5	
	-9.8	-16.3	-20.0	-22.7	-26.0	-29.0	-31.9	-34.9	-37.5		
100	--	-8.8	-15.2	-21.8	-21.8	-24.7	-28.0	-30.6	-33.7	-36.5	
	-9.8	-16.2	-19.7	-22.8	-25.7	-29.0	-31.6	-34.7	-37.5		
112	--	-8.8	-15.2	-21.8	-21.8	-24.7	-28.0	-30.6	-33.7	-36.5	
	-9.8	-16.2	-19.7	-22.8	-25.7	-29.0	-31.6	-34.7	-37.5		

ver. 1.1

¹⁾ Stability optimized (stronger) FEC

9.2.4. Frequency tables

Tab. 9.8: Frequency tables 17

RAy3-17		Frequency tables	
name		description	
rcinfo17_ISM200_default	17.100 - 17.300 GHz	default table	

The microwave link contains one or more frequency tables (called rcinfo), see menu *Radio adaptation*. Tables are labeled in format <name:version>, e.g.: rcinfo17_ISM200_default:15

9.3. RAY3-24 parameters

9.3.1. Upper/Lower Limits

Tab. 9.9: Frequency limits -24

RAY3-24	Band Range [GHz]	
	Unit L	Unit U
min	24.004	24.004
max	24.246	24.246

ver. 1.0

9.3.2. Radio parameters

Tab. 9.10: Radio parameters -24, BER = 10⁻⁶

Table cells contain values:		ver. 1.1
User Bit Rate	[Mbps]	Bit Rate for the selected modulation and bandwidth
RSS (Received Signal Strength)	[dBm]	Minimum required RSS (Receiver Threshold, Rx Sensitivity)
MSE (Mean Square Error)	[dB]	Maximum required MSE (the inverse to often used value SNR)

The full-size table is located on the next page.

¹⁾ Stability optimized (stronger) FEC

RAy3-24		Radio parameters – Bit Rate [Mbps] / RSS [dBm] / MSE [dB]										ver. 1.1
Band width	Modulation											
	QPSK _S ¹⁾	QPSK	16 QAM	32 QAM	64 QAM	128 QAM	256 QAM	512 QAM	1024 QAM	2048 QAM	4096 QAM	
MHz												
3.5	2.7	5.0	9.5	11	15	17	19	21	23			
	-99.0	-94.5	-88.5	-85.0	-82.0	-79.0	-76.0	-73.0	-69.5			
	-6.1	-9.0	-15.2	-18.4	-21.6	-24.9	-28.0	-31.0	-34.6			
5	3.8	7.1	14	16	21	25	28	31	33			
	-97.5	-93.0	-87.5	-84.0	-81.0	-78.0	-75.0	-72.0	-69.0			
	-6.5	-9.0	-15.1	-18.0	-21.3	-24.6	-27.6	-30.7	-34.3			
7	5.8	10	20	24	31	37	42	47	52	57		
	-95.5	-92.0	-86.5	-83.0	-80.0	-77.0	-74.0	-71.0	-67.0	-63.0		
	-6.2	-8.5	-14.4	-17.7	-20.9	-24.2	-27.5	-30.3	-34.6	-38.2		
10	7.9	14	27	33	42	50	57	64	71	78		
	-93.5	-90.5	-85.0	-81.5	-78.5	-75.5	-72.5	-69.5	-66.0	-62.5		
	-7.0	-8.5	-14.4	-17.4	-20.5	-23.8	-26.9	-29.7	-33.6	-37.0		
14	12	22	41	50	65	77	88	98	109	119	128	
	-92.0	-89.0	-83.5	-80.0	-77.0	-74.0	-71.0	-68.0	-65.0	-61.5	-57.5	
	-6.6	-8.7	-14.3	-17.4	-20.6	-23.6	-26.7	-29.6	-33.3	-36.5	-40.2	
20	17	32	60	72	94	111	127	142	158	171	185	
	-91.5	-87.5	-82.0	-78.5	-75.5	-72.5	-69.5	-66.5	-63.5	-60.5	-57.0	
	-6.1	-8.7	-14.2	-17.3	-20.2	-23.5	-26.5	-29.3	-32.6	-35.4	-39.1	
28	24	38	81	105	132	157	181	202	227	249	269	
	-91.0	-88.0	-81.5	-77.0	-74.0	-71.0	-68.0	-65.0	-62.0	-59.0	-56.0	
	-5.8	-7.2	-13.5	-17.2	-20.1	-23.3	-26.2	-29.2	-32.7	-35.5	-38.7	
40	34	54	113	148	185	220	253	283	318	348	377	
	-89.0	-86.0	-79.5	-75.5	-72.5	-69.5	-66.5	-63.5	-60.5	-57.5	-54.5	
	-5.8	-7.3	-13.6	-17.3	-20.1	-23.3	-26.1	-29.0	-32.4	-35.2	-38.1	
56	49	81	169	213	268	319	366	414	459	501	540	
	-88.0	-84.5	-77.5	-73.5	-70.5	-67.5	-64.5	-61.5	-58.5	-55.5	-52.5	
	-5.5	-7.3	-13.9	-17.4	-20.2	-23.4	-26.5	-29.3	-32.3	-35.0	-38.2	
80	69	115	240	303	381	454	521	589	653	713		
	-86.5	-83.0	-76.0	-72.0	-69.0	-66.0	-63.0	-60.0	-57.0	-54.0		
	-5.5	-7.3	-13.8	-17.5	-20.2	-23.5	-26.5	-29.4	-32.4	-35.0		
100	87	145	299	381	479	569	653	736	820	895		
	-85.5	-82.0	-75.0	-71.0	-68.0	-65.0	-62.0	-59.0	-56.0	-53.0		
	-5.6	-7.4	-13.7	-17.2	-20.3	-23.3	-26.3	-29.0	-32.2	-34.9		
112	97	162	334	426	537	637	731	824	918	1002		
	-85.0	-81.5	-74.5	-70.5	-67.5	-64.5	-61.5	-58.5	-55.5	-52.5		
	-5.5	-7.3	-13.7	-17.2	-20.3	-23.2	-26.5	-29.1	-32.2	-35.0		

9.3.3. ACM switching

Tab. 9.11: ACM switching -24 according to MSE state

RAY3-24		MSE degrade [dB] / MSE improve [dB]									
Band width MHz	Modulation										
	QPSK _S ¹⁾	QPSK	16 QAM	32 QAM	64 QAM	128 QAM	256 QAM	512 QAM	1024 QAM	2048 QAM	4096 QAM
3.5	--	-10.5	-16.7	-23.1	-23.1	-26.4	-29.5	-32.5	-36.1		
	-11.5	-17.7	-20.9	-24.1	-27.4	-30.5	-33.5	-37.1	--		
5	--	-10.5	-16.6	-22.8	-22.8	-26.1	-29.1	-32.2	-35.8		
	-11.5	-17.6	-20.5	-23.8	-27.1	-30.1	-33.2	-36.8	--		
7	--	-10.0	-15.9	-22.4	-22.4	-25.7	-29.0	-31.8	-36.1	-39.7	
	-11.0	-16.9	-20.2	-23.4	-26.7	-30.0	-32.8	-37.1	-40.7	--	
10	--	-10.0	-15.9	-22.0	-22.0	-25.3	-28.4	-31.2	-35.1	-38.5	
	-11.0	-16.9	-19.9	-23.0	-26.3	-29.4	-32.2	-36.1	-39.5	--	
14	--	-10.2	-15.8	-22.1	-22.1	-25.1	-28.2	-31.1	-34.8	-38.0	-41.7
	-11.2	-16.8	-19.9	-23.1	-26.1	-29.2	-32.1	-35.8	-39.0	-42.7	--
20	--	-10.2	-15.7	-21.7	-21.7	-25.0	-28.0	-30.8	-34.1	-36.9	-40.6
	-11.2	-16.7	-19.8	-22.7	-26.0	-29.0	-31.8	-35.1	-37.9	-41.6	--
28	--	-8.7	-15.0	-21.6	-21.6	-24.8	-27.7	-30.6	-34.2	-37.0	-40.2
	-9.7	-16.0	-19.8	-22.6	-25.8	-28.7	-31.6	-35.2	-38.2	-41.2	--
40	--	-8.8	-15.1	-21.6	-21.6	-24.8	-27.6	-30.5	-33.9	-36.7	-39.6
	-9.8	-16.1	-19.8	-22.6	-25.8	-28.6	-31.5	-34.9	-37.7	-40.6	--
56	--	-8.8	-15.4	-21.7	-21.7	-24.9	-28.0	-30.8	-33.8	-36.5	-39.7
	-9.8	-16.4	-19.9	-22.7	-25.9	-29.0	-31.8	-34.8	-37.5	-40.7	--
80	--	-8.8	-15.3	-21.7	-21.7	-25.0	-28.0	-30.9	-33.9	-36.5	
	-9.8	-16.3	-20.0	-22.7	-26.0	-29.0	-31.9	-34.9	-37.5	--	
100	--	-8.8	-15.2	-21.8	-21.8	-24.7	-28.0	-30.6	-33.7	-36.5	
	-9.8	-16.2	-19.7	-22.8	-25.7	-29.0	-31.6	-34.7	-37.5	--	
112	--	-8.8	-15.2	-21.8	-21.8	-24.7	-28.0	-30.6	-33.7	-36.5	
	-9.8	-16.2	-19.7	-22.8	-25.7	-29.0	-31.6	-34.7	-37.5	--	

ver. 1.1

¹⁾ Stability optimized (stronger) FEC

9.3.4. Frequency tables

Tab. 9.12: Frequency tables 24

RAy3-24		Frequency tables	
name	description		
rcinfo24_ISM250_default	24.000 - 24.250 GHz	default table	
rcinfo24_ISM250_-9dBm	24.000 - 24.250 GHz	limited RF power	
rcinfo24_ISM250_-15dBm	24.000 - 24.250 GHz	limited RF power	
rcinfo24_ISM200	24.050 - 24.250 GHz		
rcinfo24_ISM150	24.000 - 24.150 GHz		

The microwave link contains one or more frequency tables (called rcinfo), see menu *Radio adaptation*. Tables are labeled in format <name:version>, e.g.: rcinfo24_ISM250_default:15

10. Safety, environment, licensing

10.1. Regulations

RAy3 microwave links must be used in accordance with rules issued by the Telecommunications Authority for the area the device is operating in.

RAy3 microwave links must comply with the maximum permitted radiated power (EIRP) in accordance with conditions of the given country.



Important

For US:

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation of the device.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

For Canada:

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

1. L'appareil ne doit pas produire de brouillage;
2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

10.2. Safety distance



Safety distances with respect to the US health limits of the electromagnetic field intensity are in the Minimum Safety Distance tables below, calculated for different antennas and RAY power levels.

Tab. 10.1: Minimum Safety Distance 24 GHz

RAY3-24		24.000 – 24.250 GHz		+10 dBm RF power	
Antenna code	Parabolic antenna diameter [m]	Gain [dBi]	Distance where the FCC limits is met for		
			General Population / Uncontrolled Exposure [cm]	Occupational / Controlled Exposure [cm]	
ANT-LEAX-RAY-300-24	ø 0.3	37.0	70	30	
ANT-JRMB-400-24R	ø 0.4	36.8			
ANT-LEAX-RAY-600-24	ø 0.6	42.4	120	60	
ANT-JRMB-680-24R	ø 0.7	41.7			
ANT-LEAX-RAY-900-24	ø 0.9	45.7	180	80	
ANT-JRMB-900-24R	ø 0.9	44.0			
ANT-LEAX-RAY-1200-24	ø 1.2	48.4	240	110	
ANT-JRMB-1200-24R	ø 1.2	46.6			

ver. 1.0

10.3. Professional installation

RAY units are only intended for installation by professionally trained people and in locations not accessible to the public. Installation and servicing must be carried out by personnel with appropriate technical training and knowledge of potential hazards.

RAY units shall be installed according to local Electrical Safety Codes. Each person participating on the installation has to respect all local standards and regulations for personal security and electromagnetic protection for everybody on the site. We also recommend to consult each site situation with local experts to ensure both the people and installed equipment are safe, the grounding and other protection are chosen reasonably for the actual site conditions. Trained staff must check that all parts recommended by experts regarding grounding and overvoltage protection of sensitive components or infrastructures are perfectly installed, so they effectively protect the equipment against typical situations.

It is the responsibility of the installer to ensure that all building and safety codes are met and that the installation is fully completed and equipment properly secured.

10.4. RoHS and WEEE compliance

RoHS
compliant

This product is fully compliant with the European Parliament's 2011/65/EU RoHS (Restriction of Certain Hazardous Substances in Electrical and Electronic Equipment), as amended by Directive (EU) 2015/863, and Directive 2012/19/EU WEEE (Waste Electrical and Electronic Equipment) environmental directives.

WEEE
compliant



Disposed equipment must be collected separately, and disposed of properly. In any case it may not be put aside as unsorted municipal waste. Equipment has to be returned to supplier or producer (RACOM) or placed to a designated collection point ensuring proper recycling and recovery of waste in an environmentally safe manner using processes that comply with the WEEE Directive.

Battery Disposal

RACOM products and accessories may contain a battery. Batteries must be disposed of properly, and may not be put aside as unsorted municipal waste. For proper recycling, return the product or its battery to your supplier or place it to a designated collection point.

10.4.1. RoHS and WEEE Declaration of Conformity

RACOM
www.racom.eu

EU DECLARATION OF CONFORMITY

Equipment	RipEX, RipEX2 RAY2, RAY3 MIDGE, MIDGE2 MRxxx, MDxxx
Manufacturer	RACOM s.r.o. Mirova 1283, 592 31 Nove Mesto na Morave, Czech Republic

This declaration of conformity is issued under the sole responsibility of the manufacturer.

The equipment described above is in conformity with the Directive 2011/65/EU of the European Parliament and of the Council on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS), as amended by Directive (EU) 2015/863, and Directive 2012/19/EU of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE).

RoHS Applicable Exemption: 7(b)

Compliance has been verified via internal design controls, supplier declarations and/or analytical test data.

Signed for and on behalf of the manufacturer:

Nove Mesto na Morave, 11th July 2019
Jiri Hruska, CEO

J. Hruska

RACOM s.r.o. | Mirova 1283 | 592 31 Nove Mesto na Morave | Czech Republic
Tel.: +420 722 937 522 | E-mail: racom@racom.eu

www.racom.eu

ver. 1.0

Fig. 10.1: RoHS and WEEE Declaration of Conformity

10.5. RACOM Open Software License

Version 1.0, November 2009

Copyright (c) 2019, RACOM s.r.o., Mírová 1283, Nové Město na Moravě, 592 31

Everyone can copy and spread word-for-word copies of this license, but no changes are permitted.

The program (binary version) is freely available on <https://www.racom.eu>. This product contains open source or other software originating from third parties subject to GNU General Public License (GPL), GNU Library / Lesser General Public License (LGPL) and / or further author licences, declarations of responsibility, exclusion and notifications. Exact terms of GPL, LGPL and some further licences are mentioned in the source code packets (typically the files COPYING or LICENSE). You can obtain applicable machine-readable copies of source code of this software under GPL or LGPL licences on <https://www.racom.eu>. This product also includes software developed by the University of California, Berkeley and its contributors.

10.6. Warranty

RACOM supplied parts or equipment ("equipment") are covered under warranty for inherently faulty parts and workmanship for a warranty period as stated in the delivery documentation from the date of dispatch to the customer. The warranty does not cover custom modifications to software. During the warranty period RACOM shall, on its option, fit, repair or replace ("service") faulty equipment, always provided that malfunction has occurred during normal use, not due to improper use, whether deliberate or accidental, such as attempted repair or modification by any unauthorised person; nor due to the action of abnormal or extreme environmental conditions such as overvoltage, liquid immersion or lightning strike.

Any equipment subject to repair under warranty must be returned by prepaid freight to RACOM direct. The serviced equipment shall be returned by RACOM to the customer by prepaid freight. If circumstances do not permit the equipment to be returned to RACOM, then the customer is liable and agrees to reimburse RACOM for expenses incurred by RACOM during servicing the equipment on site. When equipment does not qualify for servicing under warranty, RACOM shall charge the customer and be reimbursed for costs incurred for parts and labour at prevailing rates.

This warranty agreement represents the full extent of the warranty cover provided by RACOM to the customer, as an agreement freely entered into by both parties.

RACOM warrants the equipment to function as described, without guaranteeing it as befitting customer intent or purpose. Under no circumstances shall RACOM's liability extend beyond the above, nor shall RACOM, its principals, servants or agents be liable for any consequential loss or damage caused directly or indirectly through the use, misuse, function or malfunction of the equipment, always subject to such statutory protection as may explicitly and unavoidably apply hereto.

Liability for defects does not apply to any product that has been used in a manner that conflicts with the instructions contained in this operator manual, if the case in which the radio modem is packed has been opened, or if the equipment has been tampered with.

10.7. Declarations of Conformity

10.7.1. RED Declarations of Conformity



RACOM
www.racom.eu

EU DECLARATION OF CONFORMITY

Radio equipment type	RAY3-17	Radio SW version	1.0.2
Manufacturer	RACOM s.r.o. Mirova 1283, 592 31 Nove Mesto na Morave, Czech Republic		

This declaration of conformity is issued under the sole responsibility of the manufacturer.

The radio equipment described above is in conformity with the Directive 2014/53/EU of the European Parliament and of the Council on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.

Harmonised standards used for demonstration of conformity:

Spectrum	EN 300 440 V2.2.1
EMC	EN 301 489-1 V2.1.1
	EN 301 489-3 V1.6.1
	EN 301 489-4 V3.1.1
Safety	EN 62368-1:2014+A1:2017

Signed for and on behalf of the manufacturer:

Nove Mesto na Morave, 15th of August 2019
Jiri Hruska, CEO

J. Hruska

RACOM s.r.o. | Mirova 1283 | 592 31 Nove Mesto na Morave | Czech Republic
Tel.: +420 722 937 522 | E-mail: racom@racom.eu

www.racom.eu

ver. 1.0

Fig. 10.2: RED Declaration of Conformity for RAY3-17



EU DECLARATION OF CONFORMITY

Radio equipment type	RAy3-24	Radio SW version	1.0.2
Manufacturer	RACOM s.r.o. Mirova 1283, 592 31 Nove Mesto na Morave, Czech Republic		

This declaration of conformity is issued under the sole responsibility of the manufacturer.

The radio equipment described above is in conformity with the Directive 2014/53/EU of the European Parliament and of the Council on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.

Harmonised standards used for demonstration of conformity:

Spectrum	EN 300 440 V2.2.1
EMC	EN 301 489-1 V2.1.1
	EN 301 489-3 V1.6.1
	EN 301 489-4 V3.1.1
Safety	EN 62368-1:2014+A1:2017

Signed for and on behalf of the manufacturer:

Nove Mesto na Morave, 26th of October 2018
Jiri Hruska, CEO

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Tel.: +420 565 659 511 | Fax: +420 565 659 512 | E-mail: racom@racom.eu

www.racom.eu

ver. 1.0

Fig. 10.3: RED Declaration of Conformity for RAY3-24

10.7.2. Simplified declaration

Simplified EU declaration of conformity

- BG С настоящото RACOM s.r.o. декларира, че този тип радиосъоръжение RAY3 е в съответствие с Директива 2014/53/ЕС.
- ES Por la presente, RACOM s.r.o. declara que el tipo de equipo radioeléctrico RAY3 es conforme con la Directiva 2014/53/UE.
- CS Tímto RACOM s.r.o. prohlašuje, že typ RAY3 rádiového zařízení RAY3 je v souladu se směrnicí 2014/53/EU.
- DA Hermed erklærer RACOM s.r.o., at radioudstyrstypen RAY3 er i overensstemmelse med direktiv 2014/53/EU.
- DE Hiermit erklärt RACOM s.r.o., dass der Funkanlagentyp RAY3 der Richtlinie 2014/53/EU entspricht.
- ET Käesolevaga deklareerib RACOM s.r.o., et käesolev raadioseadme tüüp RAY3 vastab direktiivi 2014/53/EL nõuetele.
- EL Με την παρούσα ο/η RACOM s.r.o., δηλώνει ότι ο ραδιοεξοπλισμός RAY3 πληροί την οδηγία 2014/53/ΕΕ.
- EN Hereby, RACOM s.r.o. declares that the radio equipment type RAY3 is in compliance with Directive 2014/53/EU.
- FR Le soussigné, RACOM s.r.o., déclare que l'équipement radioélectrique du type RAY3 est conforme à la directive 2014/53/UE.
- HR RACOM s.r.o. ovime izjavljuje da je radijska oprema tipa RAY3 u skladu s Direktivom 2014/53/EU.
- IT Il fabbricante, RACOM s.r.o., dichiara che il tipo di apparecchiatura radio RAY3 è conforme alla direttiva 2014/53/UE.
- LV Ar šo RACOM s.r.o. deklarē, ka radioiekārta RAY3 atbilst Direktīvai 2014/53/ES.
- LT Aš, RACOM s.r.o., patvirtinu, kad radijo įrenginių tipas RAY3 atitinka Direktyvą 2014/53/ES.
- HU RACOM s.r.o. igazolja, hogy a RAY3 típusú rádióberendezés megfelel a 2014/53/EU irányelvnek.
- MT B'dan, RACOM s.r.o., niddikjara li dan it-tip ta' tagħmir tar-radju RAY3 huwa konformi mad-Direttiva 2014/53/UE.
- NL Hierbij verklaar ik, RACOM s.r.o., dat het type radioapparatuur RAY3 conform is met Richtlijn 2014/53/EU.
- PL RACOM s.r.o. niniejszym oświadcza, że typ urządzenia radiowego RAY3 jest zgodny z dyrektywą 2014/53/UE.
- PT O(a) abaixo assinado(a) RACOM s.r.o. declara que o presente tipo de equipamento de rádio RAY3 está em conformidade com a Diretiva 2014/53/UE.

- RO Prin prezenta, RACOM s.r.o. declară că tipul de echipamente radio RAY3 este în conformitate cu Directiva 2014/53/UE.
- SK RACOM s.r.o. týmto vyhlasuje, že rádiové zariadenie typu RAY3 je v súlade so smernicou 2014/53/EÚ.
- SL RACOM s.r.o. potrjuje, da je tip radijske opreme RAY3 skladen z Direktivo 2014/53/EU.
- FI RACOM s.r.o. vakuuttaa, että radiolaitetyyppi RAY3 on direktiivin 2014/53/EU mukainen.
- SV Härmed försäkrar RACOM s.r.o. att denna typ av radioutrustning RAY3 överensstämmer med direktiv 2014/53/EU.

10.8. FCC and IC authorization

FCC (US) compliance

RAy3-24 complies with CFR 47 part 15.

Code	FCC part	FCC ID
RAy3-24	15	SQT-RAY3-24

IC / ISED (Canada) compliance

RAy3-24 complies with ISED Canada RSS-210 Issue 9.

Code	IC specification	IC Certif. No.
RAy3-24	RSS-210 Issue 9	24993-RAY324

10.9. Country of Origin Declaration

 **RACOM**
www.racom.eu

To whom it may concern

Country of Origin Declaration

Producer: RACOM s.r.o.
Address: Mirova 1283, 592 31 Nove Mesto na Morave, Czech Republic
VAT No: CZ46343423

We, the manufacturer, hereby declare that Country of Origin of the RAY microwave links and its accessories is the Czech Republic, EU.

Part Number	Description
RAY3-24	Unit RAY3-24, 2× Gb Eth

Nove Mesto na Morave, 26 of October 2018
Jiri Hruska, CEO 

RACOM s.r.o. | Mirova 1283 | 592 31 Nove Mesto na Morave | Czech Republic
Tel.: +420 565 659 511 | E-mail: racom@racom.eu

www.racom.eu

ver. 1.0

Fig. 10.4: Country of Origin Declaration

Appendix A. SSH key generation

Linux

Use "ssh-keygen" command.

Windows

Use "PUTTYGEN.EXE" software, which is typically located in the c:\Program Files\putty\ directory and apply the "Generate" button.

To use CLI (Command Line Interface) access the unit with a PuTTY client. Access is protected by a key. The key can be in Linux format and it begins:

```
-----BEGIN DSA PRIVATE KEY-----
.....
```

or in PuTTY format which begins:

```
PuTTY-User-Key-File-2: ssh-dss
.....
```

To convert the Linux format to PuTTY do the following:

In c:\Program Files\putty\ directory run PUTTYGEN.EXE

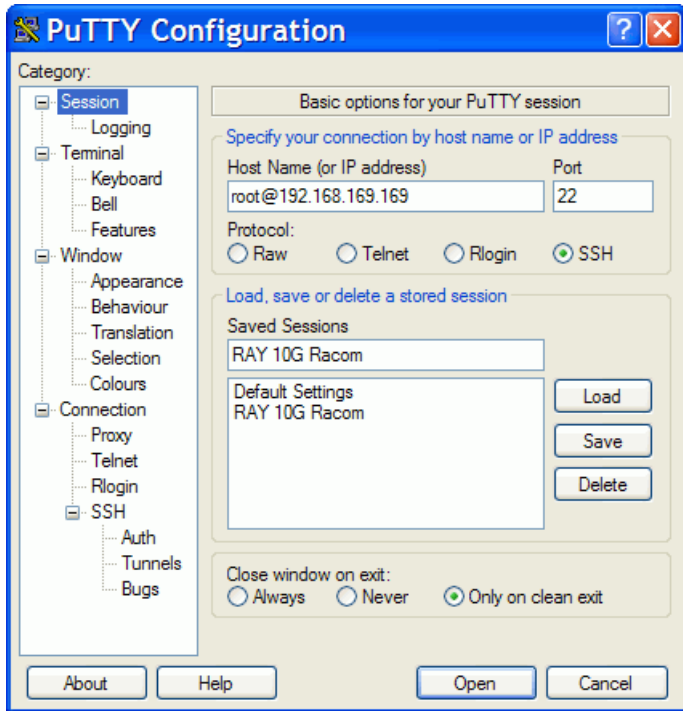


Click on "Load" and choose the Linux private key.

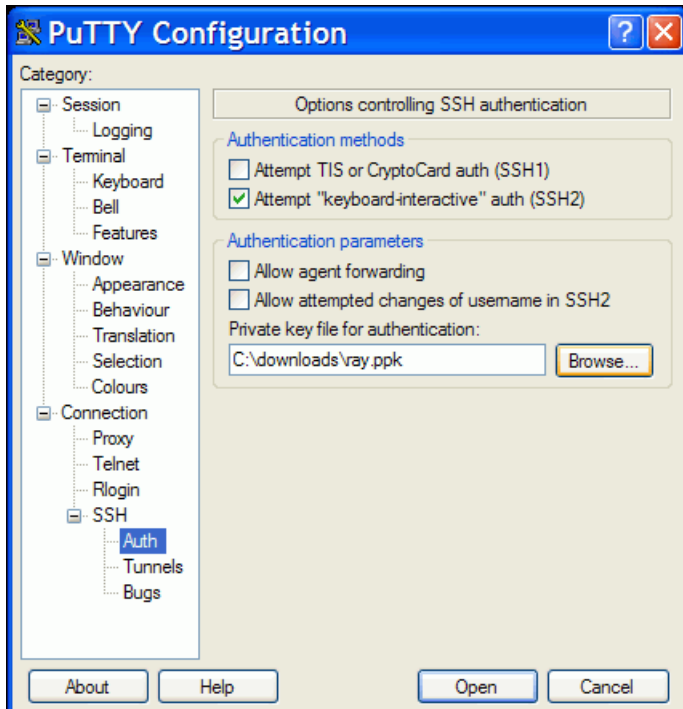
In the next window type your password into the "Key passphrase" and "Confirm passphrase" fields. After that click "Save private key". Choose location and save the key.

PuTTY access with key

In PuTTY menu fill in the address, e.g. `root@192.168.169.169` and the name of the link, e.g. RAY 17 RACOM.



Go to "Connection / SSH / Auth" in the left column and locate the key C:\downloads\ray.ppk



Go back to "Session" and Save the configuration.

To connect select the name of the connection and click Open. PuTTY asks for password created during key conversion.

Appendix B. HTTPS certificate

When switching from older versions of the firmware the access certificate for HTTPS is changed. New web browser configuration must take place in order to remove the link between the microwave link management IP address and the previous HTTPS certificate.

Mozilla Firefox how-to:

1. HTTPS certificate

Remove management IP address from the list: Tools - Options - Advanced - Encryption - View Certificates - Servers

Another possibility: remove certificate RACOM "RAy" or RACOM "RACOM's product" from the list: Tools - Options - Advanced - Encryption - View Certificates - Authorities

2. Upon the new RAY unit connection following message appear: "This Connection is Untrusted".
3. If you are sure that there is no security risk, choose: "I Understand the Risks".
4. The next step is "Add Exception..."
5. Finally, you have to "Confirm Security Exception". If the Apply button is not active, it is necessary to perform step No. 1/ and restart web browser.

Internet Explorer may give following message "There is a problem with this website's security certificate". Choose "Continue to this website (not recommended)". The address line gives you status information "Certificate Error". This inconvenience is caused by impossibility to create security certificate valid for list of user selected IP addresses.

Appendix C. Unit block diagrams

Unit overview

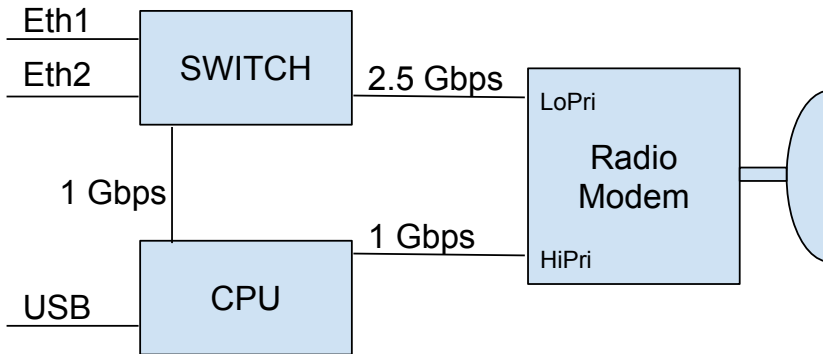


Fig. C.1: Block diagram of the unit

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Revision History

Revision 1.0	2018-10-04
First issue	
Revision 1.1	2019-04-15
RAY3-17 data - preliminary RAY3 HW variants introduced	
Revision 1.2	2019-05-20
Extended <i>Chapter 5, Configuration</i> (to reflex FW development)	
Revision 1.3	2019-07-23
Updated <i>Legal Notice, Section 1.6, "Sizes, packaging and labeling", Section 1.7, "Ordering codes"</i> and <i>Section 10.8, "FCC and IC authorization"</i> (RAY3-24 FCC for US and IC for Canada compliance) Extended <i>Chapter 5, Configuration</i> (to reflex FW development)	
Revision 1.4	2019-09-06
Updated Accessories Extended <i>Chapter 5, Configuration</i> (to reflex FW development) Declaration of conformity RAY3-17	
Revision 1.5	2019-11-11
New items in Accessories (marked by '*') Improved description of some items (accepted polarities of PoE and power supply, FlowControl parameters in Eth switch, chapter Troubleshooting). Final parameters for RAY3-17	