RACOM
RADIO DATA NETWORKS

User manual

RAy3 Microwave Link

fw 1.0.x.x
11/13/2018
version 1.0

Quick start
START →
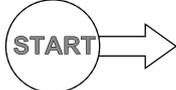
Hardware
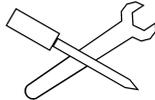
Configuration
RF ● ○
ETH ○ ●

Parameters

Safety

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Copyright

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Quick guide

1. Delivered items

Ray 3		
Bushings	6 x 2 x 2 x	
Plugs	1 x	
Connectors	1 x RJ45	
Grease	1 x	

2. Accessories

Antennas   Antenna brackets

Power supply   Required tools   Voltmeter or smartphone +OTH-W2-WIFI

3. Power supply

ETH1+POE   PoE power supply

DC 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

Mounting
- left sided (pictured below)
- right sided
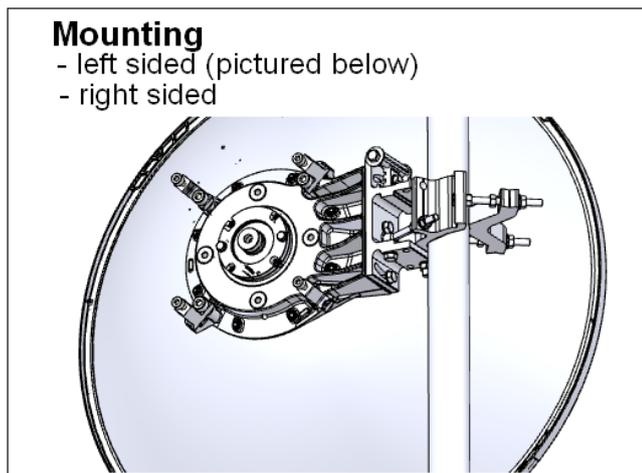
6. Unit lubrication and installation

Grease

Antenna

Ray 3

Thin layer of grease | Check the correct O-ring placement on the antenna
Ensure the antenna and unit are carefully alignet

7. Unit polarization

Horizontal

Vertical

- cross polarization
- one side – horizontal
- the other side - vertical
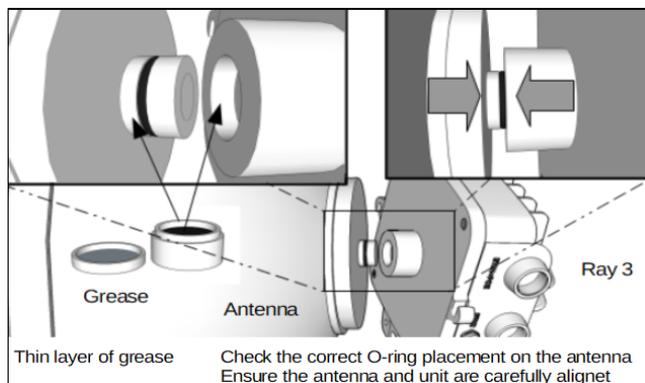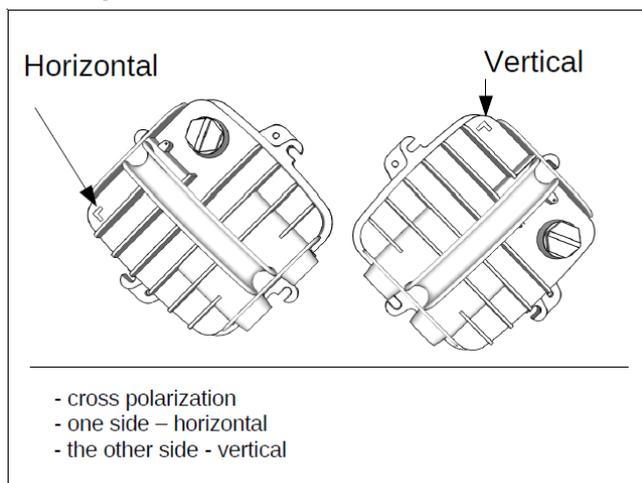
8. Power grounding and connections

PoE + Eth   DC   fibre

Units must be grounded
For surge protection - see user manual

AC 230 V   AC 230 V

9. Sealing

Bushing

Plug

Seal unit interfaces with bushings and plugs

max. 38 mm

Optical cable

10. Directing antennas

Hint: Set QPSK_S, CS 3.5 MHz, max. TX power
Step-by-step alignment, see user manual for details

OTH-W2-WIFI

+
smartphone

-71,8

OR

Best RSS
= minimum voltage
In range 0-2 V

11. RSS measurement

Calculation

Alignment ← -72,8

Configuration RSS
SNR
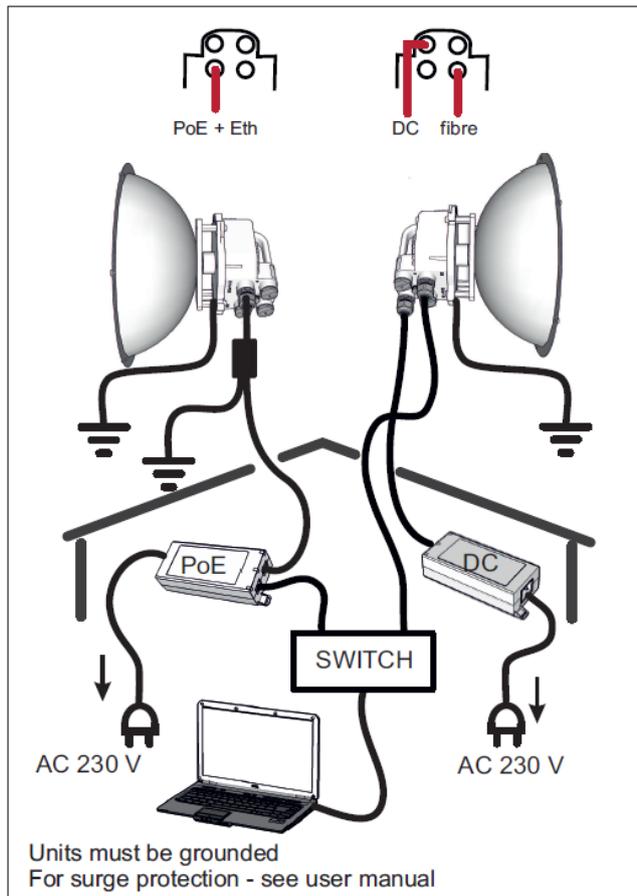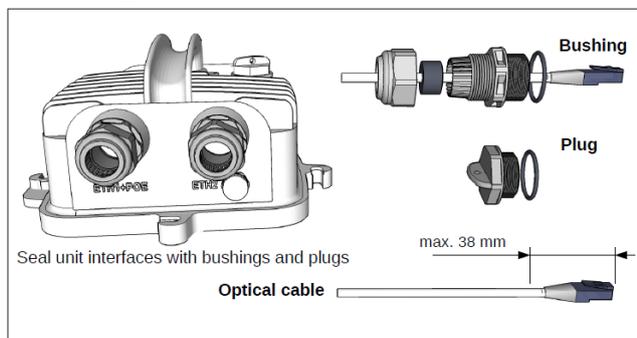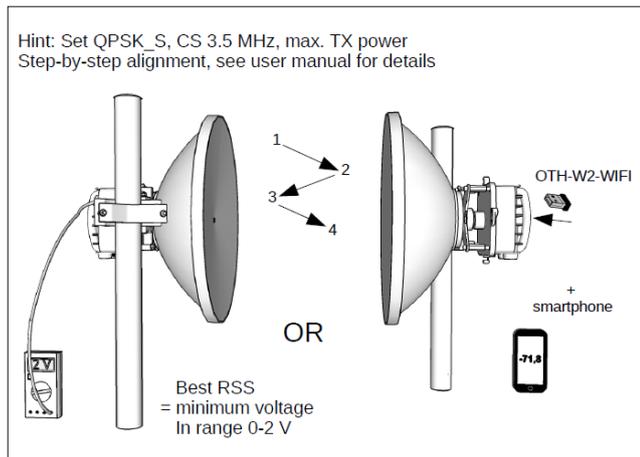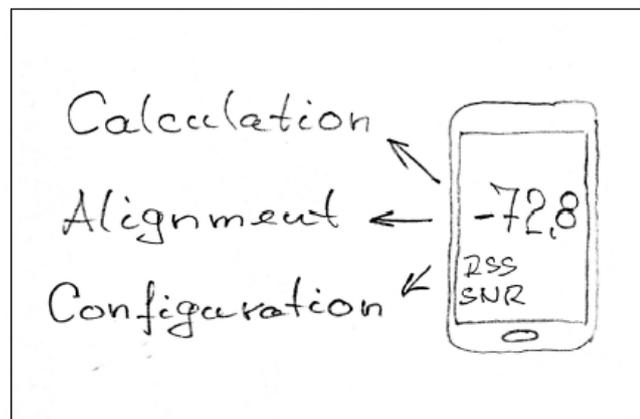
List of documentation

User manuals:

- **RAy3 Microwave Link - User manual**

    User manual RAy3-24 - this document

- *RAy2 Microwave Link*[1] **- User manual**

    User manual RAy2-10, RAy2-11, RAy2-17, RAy2-18, RAy2-24

- *RAy2 Microwave Link*[2] **- Channel arrangements**

    Detailed tables of RAy2 frequencies

- *RAy1 Microwave Link*[3] **- User manual RAy11, 17, 24**

    User manual RAy11, RAy17, RAy24

- *RAy1 Microwave Link*[4] **- User manual RAy10**

    User manual RAy10

Datasheets:

- *RAy2 - Datasheet*[5]

- *RAy1 - Datasheet*[6]

- *RAy1 - SCADA Backbone*[7]

Application notes:

- *RAy - Application notes*[8]

Contents of the box

- 2 pc RAy3
- 2 pc *Cable bushing set*, connectors
- 1 pc Silicone grease

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[1] http://www.racom.eu/eng/products/m/ray2/index.html

[2] http://www.racom.eu/eng/products/m/ray2tab/index.html

[3] http://www.racom.eu/eng/products/m/ray17/index.html

[4] http://www.racom.eu/eng/products/m/ray/index.html

[5] http://www.racom.eu/download/hw/ray/free/eng/00_letaky/ray-dsA3-en.pdf

[6] http://www.racom.eu/download/hw/ray/free/eng/08_ray1/datasheet_RAY_en.pdf

[7] http://www.racom.eu/download/hw/ray/free/eng/08_ray1/leaflet_RAY_scada_en.pdf

[8] http://www.racom.eu/eng/products/m/ray/app/index.html

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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.

Link transparency notes

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. Shaping ...).

Fig. 1.1: RAy3 – Microwave link

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.

> **Note**
>
> Even all units 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.

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.

1.2. Mechanical interfaces

1.2.1. Antenna waveguide
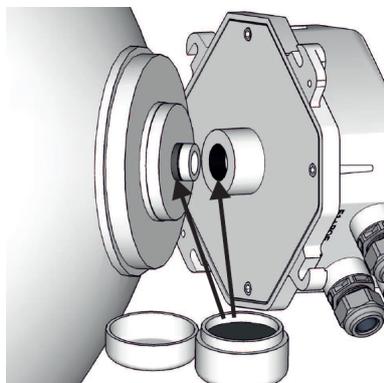
Fig. 1.2: Waveguide pivot

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.

Radio connection between the antenna and RAy unit is ensured by the waveguide on RAy unit (located across the holder), where *well lubricated* antenna waveguide pivot nicely fits in.

1.2.2. Unit mounting

The RAy unit is mechanically fixed to the antenna by 4x 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 4x M8x30 (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"* .
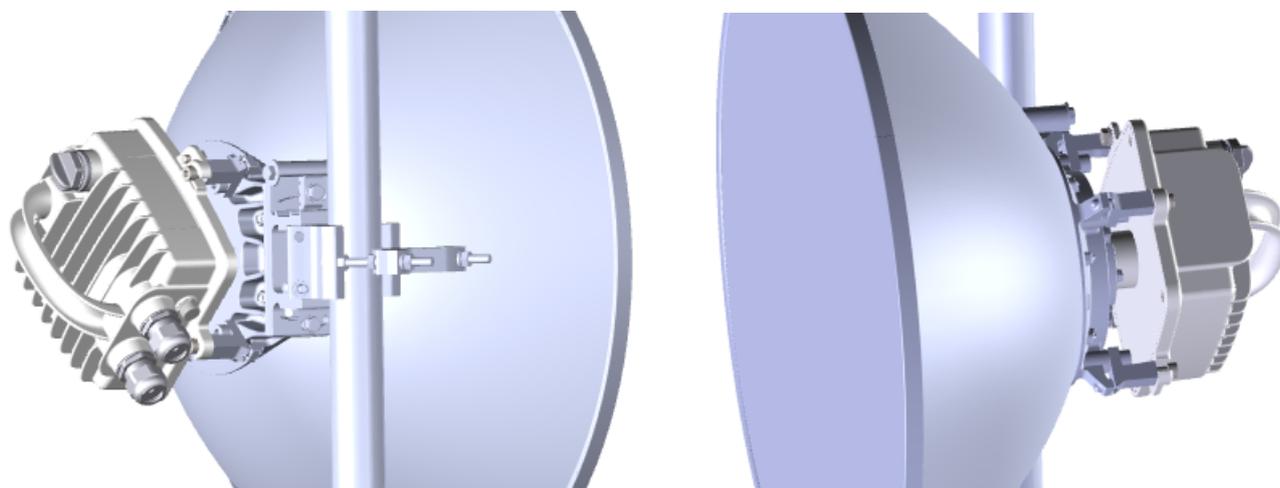
Fig. 1.3: Antenna and RAy3 unit

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. User interfaces

Each unit is equipped with basic mechanical interfaces (antenna waveguide, mounting screws and grounding screw) and several interfaces for data, power and service purposes located in 3 slots:
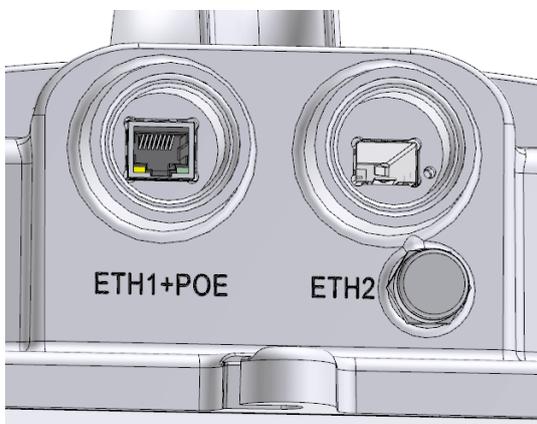
Fig. 1.5: Slots ETH1+POE, ETH2

Fig. 1.6: Slot S

ETH1+POE	Gigabit metallic Ethernet port
	This port is capable of powering the unit with any Power over Ethernet (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.
S	USB service connector
	For USB/WiFi or USB/Eth adapters, see *Section 1.4.1, "USB connector (S)"*
	RSS voltage output
	Red and green connectors (for example 0.547 V means RSS = –54.7 dBm), see *Fig. 1.15, "RSS voltage contacts"*
	HW button
	For service purposes: Internal backup or Factory settings, see *Section 5.6.1, "Maintenance"*
	Status LED
	Visible through semitransparent plug, see *Section 1.5, "Status LED (S)"*

Note

A set of all necessary bushing parts are delivered with each RAy unit - see a description of this standard basic accessory *SET-RAY3-CON*. 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. RJ45 (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.
NOTE: 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.

Fig. 1.7: RJ45 Ethernet connector

Technical parameters of PoE power input:

Supported voltage range is 20 to 60 V, distances up to 100 m. Internal RJ45 pins wiring is :
- (V+) ... 1,2,4,5
- (V-) ... 3,6,7,8

It is possible to use all 8 pins or only 4 pins. Use:
- either   4,5 (V+) and 7,8 (V-)
- or   1,2 (V+) and 3,6 (V-)
- or both simultaneously

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 *DC-RJ45 adapter*).

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"*.

1.3.2. SFP slot (ETH2)

„ETH2" is a standard SFP slot for 10/100/1000 Mbps Eth-
ernet 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 *ac-
cessory*.

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 re-
ceived signal from the fibre optic or metallic link to be
within operational range.

Fig. 1.8: SFP slot

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

> ⚠️ **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 RA-
> COM cannot guarantee they will be completely compatible with RAy units.

1.3.3. DC power (ETH1+POE)

Direct DC power source can be used to power the RAy3
unit. Slot „ETH1+POE" allows to use the *DC-RJ45 adapter*
as a DC connector. It is equipped by 2 terminals (each 1.5
mm^2 / 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.

Supported voltage range is 20 to 60 V, both polarities are
supported. 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 ex-
ample see *Grounding kits* in section Accessories.

More information about DC power sourcing possibilities
and installation can be found in *Section 4.6, "Power supply"*.
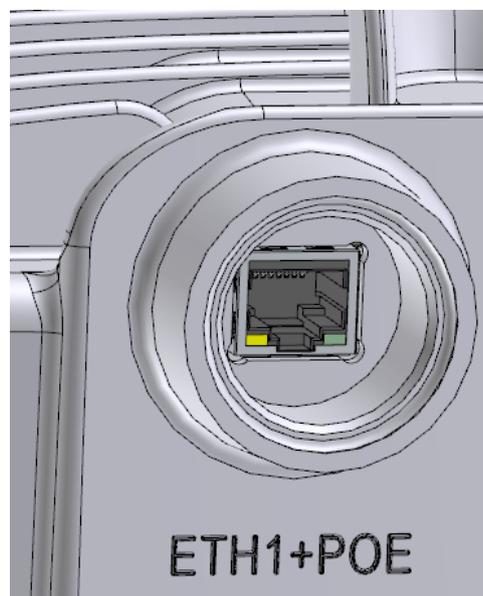
Fig. 1.9: Power supply connector

Fig. 1.10: Power via an 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.
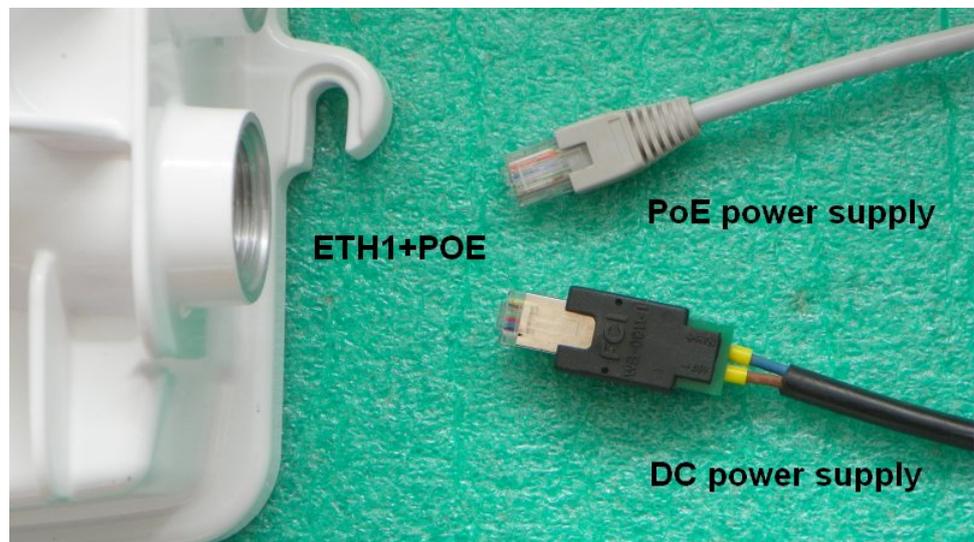
Fig. 1.11: Power supply possibilities

1.4. Service interfaces

1.4.1. USB connector (S)

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.

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 icon]

Note

Only RACOM recommended adapters are supported. See section *Access adapters*.
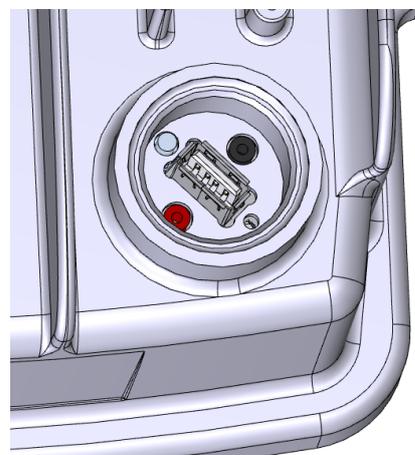
Fig. 1.12: USB connector

1.4.2. Service WiFi (USB „S")

RAy3 unit can be equipped with the service WiFi interface as an option. It can be used solely for unit management (no user data can be transmitted using this WiFi connection).

Optional OTH-W2-WIFI WiFi module (ordering code *OTH-W2-WIFI*) can be inserted in to the slot "S" USB connector (see chapter *Section 1.4.1, "USB connector (S)"* for more details). Management of the WiFi port is described in *Section 5.4.3, "Service access"* (part "USB Accessories").

Fig. 1.13: USB WiFi adapter

1.4.3. Service Ethernet (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 data can be transmitted using this Ethernet connection).

Optional Eth adapter (ordering code *SET-XA-ETH/USB*) can be inserted in to the slot "S" USB connector (see chapter *Section 1.4.1, "USB connector (S)"* for more details). Management of this Ethernet port is described in *Section 5.4.3, "Service access"* (part "USB Accessories").

Fig. 1.14: Ethernet adapter

1.4.4. RSS voltage (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. 1.15: 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*.

HW button   RSS voltage   Status LED
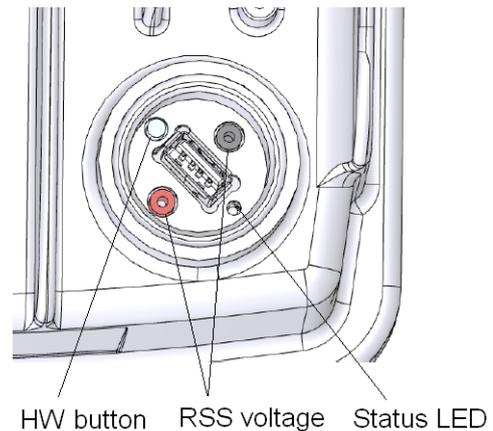
Fig. 1.16: Service interfaces

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:

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 id 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:

Fig. 1.17: Status LED

Tab. 1.1: LED status indicators

Green and Red LEDs	Function
G R	System is up and working OK
G (1 s 1 s) 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
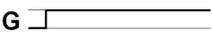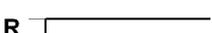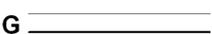
1.6. Basic technical parameters

Detailed technical parameters are stated in *Chapter 9, Technical parameters*.

1.6.1. Communication unit RAy3-24

Outer size   • 245 x 245 x 160 mm

Weight   • 2.6 kg

1.6.2. Diameters of supplied antennas

RAy3 units are ready for direct mounting to:

• *LEAX-RAy Class 3* antennas (*LEAX Arkivator Telecom*[1])
• *Jirous Class 2* antennas (*Jirous Antennas*[2])

Individual datasheets are *accessible here*[3].

Tab. 1.2: Overview of LEAX-RAy antennas

10, 11 GHz		17, 18 GHz		24 GHz	
diameter	gain	diameter	gain	diameter	gain
30 cm	30.1 dBi	30 cm	34.7 dBi	30 cm	37.0 dBi
60 cm	35.2 dBi	60 cm	39.7 dBi	60 cm	42.4 dBi
90 cm	38.5 dBi	90 cm	43.5 dBi	90 cm	45.7 dBi
120 cm	41.5 dBi	120 cm	45.5 dBi	120 cm	48.4 dBi

Tab. 1.3: Overview of Jirous antennas

10, 11 GHz		17, 18 GHz		24 GHz	
diameter	gain	diameter	gain	diameter	gain
38 cm	29.0 dBi	40 cm	34.8 dBi	40 cm	36.8 dBi
65 cm	35.5 dBi	68 cm	38.6 dBi	68 cm	41.7 dBi
90 cm	37.5 dBi	90 cm	41.0 dBi	90 cm	44.0 dBi
120 cm	41.0 dBi	120 cm	43.7 dBi	120 cm	46.6 dBi

Andrew (Class 2 or 3 or 4) or traditional Arkivator antennas can also be used but require an *antenna mounting kit*. *Flexible waveguide* is a general-purpose option for any antenna usage.

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[1] http://www.leax-arkivator-telecom.com/
[2] http://en.jirous.com/
[3] http://www.racom.eu/eng/products/microwave-link.html#accessories_antennas

1.6.3. Name plate

The plate contains name, bar code record, CE label, etc.:

• Type – RAy3 product line identification
• Code – detailed identification of the unit type (for details see *Section 1.7, "Ordering codes"*).
• 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

Fig. 1.18: Name plate

1.7. Ordering codes

RAy3 microwave link consists from a pair of units for the chosen band (selected according to *Ordering codes for HW units*) with the proper *SW feature keys for capacity* and *SW feature keys for other functions*. Each feature key is generated for the unique serial number of the unit (and does not work in other unit). Once installed, feature key unlocks a specific feature or function of the unit. Feature keys could be erased or upgraded.

Ordering codes for accessories, necessary to be added to RAy units to ensure a proper functionality of the whole microwave link, are listed in *Chapter 2, Accessories*.

1.7.1. Ordering codes for HW units

The proper pair (from the same row) of **Lower and Upper units** should be selected when ordering the microwave link. Both RAy3-17 and RAy3-24 have only one HW model. 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.

Tab. 1.4: HW ordering codes

RAy3	Ordering codes for HW units		
Band	Frequency [GHz]	Ordering codes	
		Lower unit	Upper unit
24 GHz	24.000 – 24.250	**RAy3-24S-L**	**RAy3-24S-U**

ver 1.1

1.7.2. Ordering codes for Capacity feature keys

Maximum user data capacity can be limited by a SW feature key. Capacity feature key defines the maximum speed of the link. Available speed limits for RAy3 unit are 360 Mbps, 500 Mbps and 1000 Mbps.

Table below shows what combinations of channels + modulations each feature key allows (marked by colors according the capacity limit in the most right column and in the last row).

Tab. 1.5: Speeds according to Capacity feature keys

RAy3					User data rate [Mbps]							Capac. feature keys
Band width MHz	\	\	\	\	\	Modulation						
	QPSK_S	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	10	11	15	17	19	21	23			360M
5	3.8	7.1	14	16	21	25	28	31	33			
7	5.8	10.5	20	24	31	37	42	47	52	57		
10	7.9	14.4	27	33	42	50	57	64	71	78		
14	11.9	22.2	41	50	65	77	88	98	109	119	128	
20	17.2	32.0	60	72	94	111	127	142	158	171	185	
28	24.3	38.5	81	105	132	157	181	202	227	249	269	
40	34.0	53.9	113	148	185	220	253	283	318	348	377	500M
56	48.7	81.1	169	213	268	319	366	414	459	501	540	1000M
80	69.3	115.4	240	303	381	454	521	589	653	713		
100	86.6	144.5	299	381	479	569	653	736	820	895		
112	97.0	161.8	334	426	537	637	731	824	918	1002		
Capac. feature keys	360M			500M	1000M							

ver 1.0

Feature keys for capacity could be installed in the factory or purchased separately (and installed by user). Every Capacity feature key could be upgraded. The capacity limitation for the unit is applied according the highest speed feature key installed.

Capacity feature keys installed in the factory

Tab. 1.6: Keys installed in the factory

RAy3		Ordering codes for Capacity feature keys installed in the factory	
Ordering code Extension	Capacity allowed [Mbps]	Examples	
		RAy3-17	RAy3-24
RAy3-xx-x-360	360	RAy3-17-L-360	RAy3-24-U-360
RAy3-xx-x-500	500	RAy3-17-L-500	RAy3-24-U-500
RAy3-xx-x-1000	1000	RAy3-17-L-1000	RAy3-24-U-1000

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x - means numbers or letters according to *the section called "Feature keys"*

Note

If no Capacity feature key is ordered, the unit is shipped with RAy3-xx-x-360 key.

Capacity feature keys purchased separately (and installed by user)

The feature key ordering code consists from three parts:

Example: **RAy3-SW-500**

Product type RAy

SW (= all software feature keys)

Speed limit in Mbps. Possible values 500, 1000
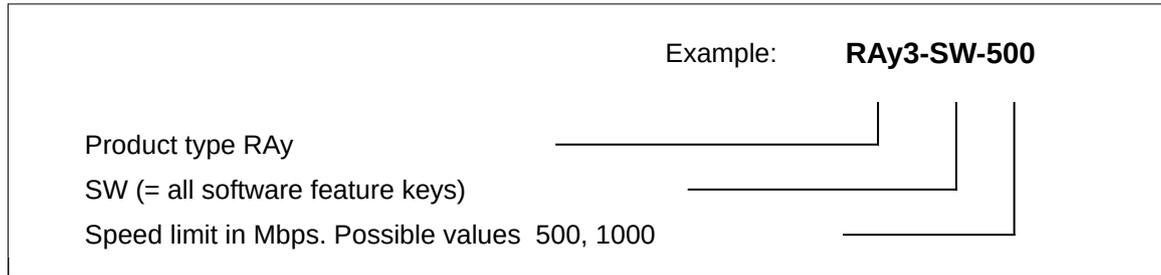
Available ordering codes:

• **RAy3-SW-500**
• **RAy3-SW-1000**

> **Note**
>
> The default user speed delivered without the feature key is defined by a business condition for the HW unit and country of sale.

Capacity upgrade feature keys (purchased separately)

Example: **RAy3-SW-500-1000**

Product type RAy

SW (= all software feature keys)

Speed to upgrade from in Mbps. Possible values 360, 500

Speed to upgrade to in Mbps. Possible values 500, 1000
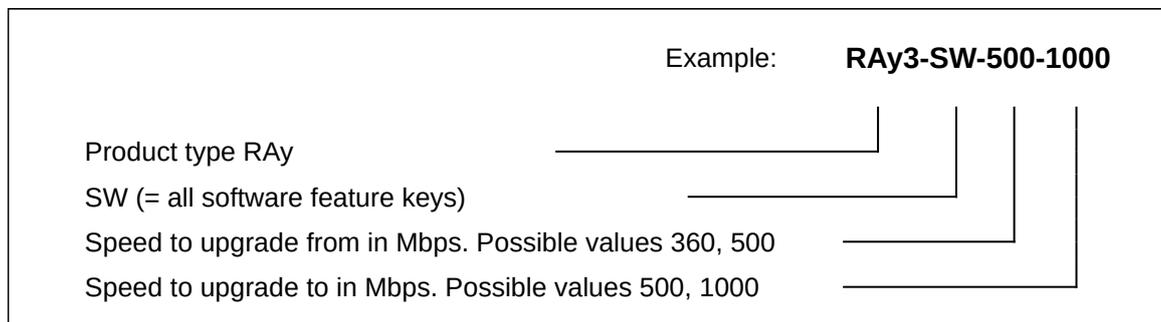
Available ordering codes:

• **RAy3-SW-360-500**
• **RAy3-SW-360-1000**
• **RAy3-SW-500-1000**

> **Note**
>
> RAy3 functionality with the upgrade feature key (example:RAy3-SW-360-1000) is identical with functionality of the full capacity feature key with identical final capacity (example RAy3-SW-1000). The difference is just in purchase price.

1.7.3. Ordering codes for other feature keys

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)

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2. Accessories

RACOM offers a complete set of accessories to operate RAy microwave units in all relevant use-cases and environments and provide surge protection. All accessories are 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, but RACOM cannot guarantee they will be completely compatible with RAy units.

⚠ **Important**

We strongly recommend to double check local power voltage level and local standards for all necessary accessories to be compliant with local voltage and with all regulations related to safety and surge protection.

We especially recommend to consult local experts and study local standards regarding grounding and surge protection to ensure the chosen and installed grounding and protection meets actual site conditions and safety regulations.

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

2.1. Overview

RACOM-PART-NUMBER	Short description
Antennas LEAX-RAy (LEAX Arkivator Telecom)	
ANT-LEAX-RAy-300-10/11	Antenna parabolic 0.3 m 10-11GHz with holder 30.1 dBi Class 2
ANT-LEAX-RAy-600-10/11	Antenna parabolic 0.6 m 10-11GHz with holder 35.2 dBi Class 3
ANT-LEAX-RAy-900-10/11	Antenna parabolic 0.9 m 10-11GHz with holder 38.5 dBi Class 3
ANT-LEAX-RAy-1200-10/11	Antenna parabolic 1.2 m 10-11GHz with holder 41.5 dBi Class 3
ANT-LEAX-RAy-300-17/18	Antenna parabolic 0.3 m 17-18 GHz with holder 34.7 dBi Class 3
ANT-LEAX-RAy-600-17/18	Antenna parabolic 0.6 m 17-18 GHz with holder 39.7 dBi Class 3
ANT-LEAX-RAy-900-17/18	Antenna parabolic 0.9 m 17-18 GHz with holder 43.5 dBi Class 3
ANT-LEAX-RAy-1200-17/18	Antenna parabolic 1.2 m 17-18 GHz with holder 45.2 dBi Class 3
ANT-LEAX-RAy-300-24	Antenna parabolic 0.3 m 24GHz with holder 37.0 dBi Class 3
ANT-LEAX-RAy-600-24	Antenna parabolic 0.6 m 24 GHz with holder 42.4 dBi Class 3
ANT-LEAX-RAy-900-24	Antenna parabolic 0.9 m 24 GHz with holder 45.7 dBi Class 3
ANT-LEAX-RAy-1200-24	Antenna parabolic 1.2 m 24 GHz with holder 48.4 dBi Class 3
SET-LEAX-STRUT-90	Optional wind strut for 90 cm LEAX-RAy antenna
SET- LEAX-STRUT-120	Optional second wind strut for 120 cm LEAX-RAy antenna
Antennas Jirous (Jirous Antennas)	
ANT-JRMA-380-10/11R	Antenna parabolic 0.38 m 10-11GHz with holder 28.0-29.0 dBi Class 2
ANT-JRMA-650-10/11R	Antenna parabolic 0.65 m 10-11GHz with holder 34.1-35.5 dBi Class 2
ANT-JRMB-900-10/11R	Antenna parabolic 0.9 m 10-11GHz with holder 37.0-37.5 dBi Class 2
ANT-JRMB-1200-10/11R	Antenna parabolic 1.2 m 10-11GHz with holder 40.0-41.0 dBi Class 2
ANT-JCMA-17R	Lens antenna 17GHz with holder 22.6 dBi

ANT-JRMB-400-17R	Antenna parabolic 0.4 m 17-18 GHz with holder 34.8 dBi Class 2
ANT-JRMB-680-17R	Antenna parabolic 0.68 m 17-18 GHz with holder 38.6 dBi Class 2
ANT-JRMB-900-17R	Antenna parabolic 0.9 m 17-18 GHz with holder 41.0 dBi Class 2
ANT-JRMB-1200-17R	Antenna parabolic 1.2 m 17-18 GHz with holder 44.6 dBi Class 2
ANT-JRMB-400-24R	Antenna parabolic 0.4 m 24 GHz with holder 36.8 dBi Class 2
ANT-JRMB-680-24R	Antenna parabolic 0.68 m 24 GHz with holder 41.7 dBi Class 2
ANT-JRMB-900-24R	Antenna parabolic 0.9 m 24 GHz with holder 44.0 dBi Class 2
ANT-JRMB-1200-24R	Antenna parabolic 1.2 m 24 GHz with holder 46.6 dBi Class 2
SET-JRMB-1200-FIX	Wind bracing set – Fixed – for Jirous 120cm antenna
SET-JRMB-1200-ADJ	Wind bracing set – Adjustable – for Jirous 120cm antenna

Antenna mounting kits

SET-RAY10-ANW	Set mouting RAy10/11 Antenna Andrew 60, 100
SET-RAY10-ARK	Set mouting RAy10/11 Antenna Arkivator 30, 60, 99, 120
SET-RAY17-ANW	Set mouting RAy17/18 Antenna Andrew 30, 60, 100
SET-RAY17-ARK	Set mouting RAy17/18 Antenna Arkivator 30, 60, 99
SET-RAY24-ANW	Set mouting RAy24 Antenna Andrew 30, 60, 100
SET-RAY24-ARK	Set mouting RAy24 Antenna Arkivator 30, 60, 99, 120

Flexible waveguide mounting kit

SET-RAY-FX-R100	Set mouting RAy to flange R100
SET-RAY-FX-R120	Set mouting RAy to flange R120

Cable bushing

SET-RAY3-CON	RAy3 suplied accessories - bushings and connectors
SET-RAY2-EXT35	Cable bushing lengthening, PG21, 35 mm
SET-RAY2-EXT-F50	Cable bushing lengthening, PG21, Flexi, 50cm

Grounding kits

KIT-GROUNDING-RAY	Mast grounding kit for RAy
KIT-GROUNDING-5-11MM	Grounding kit universal for 5-11 mm cables
KIT-GROUNDING-1/4"	Grounding kit for Ethernet CAT7 cable

DC power supply and DC surge protection

PWS-AC/DC-AD-55B	Power sup. 27.6VDC, 37W / 90-260VAC, -10/+50°C, opt. battery, MeanWell
OTH-DP-024	Surge protection, DC 24V, LPZ1-LPZ2, IP20, -40/+80°C , Saltek

DC-RJ45 adapter

OTH-DC-RJ45	DC power adapter, RJ45 to terminals
SET-DC-RJ45-EXT35	DC-RJ45 + Cable bushing lengthening

PoE power supply - passive, protected

PWR-POE-ALC01H	PoE power sup 1Gb Eth, 50 W, 100-240VAC, protected, IMCO Power
PWR-POE-PAS-H	PoE passive injector 1Gb Eth, max 1.4 A, protected, IMCO Power

PoE power supply - active

PWR-POE36U-1AT	Power supply PoE 1xGb Eth 33.6 W at 56 VDC / 90-264 VAC, Phihong
PWR-POE36D-1AT	Power supply PoE 1xGb Eth 33.6 W at 56 VDC / 36-72 VDC, Phihong

HOL-POE-PHI-1A   DIN rail holder for PoE Phihong

ETH surge protection

OTH-DL-1GRJ45   Eth surge prot. 1Gb Eth, PoE, LPZ0B-LPZ1 IP20 -40/+80°C, Saltek

ETH connectors and cables

CON-RJ45-UBNT-CAT6   Connector TC-CON, STP RJ45, Cat6, 8p8c, wire, pleated, AWG24, UBNT

CON-RJ45-TLG-CAT6   Connector RJ45, AWG 24-22 (Cat5e, Cat6A, Cat7), Telegärtner

SET-RAY2-TLG-EXT35   Set RJ45 connector (Telegärtner) and cable bushing lengthening (35mm)

CAB-CAT5E-FTP-TLD   Double shell outdoor FTP Cat5e cable TELDOR

CAB-S/FTP 4x   Double shell outdoor FTP Cat7 cable PEWTRONIC

SFP modules

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

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

Fibre cables

CAB-FIB-2F-DLC/DLC- ...   Fibre patch cord, 2-fibres, single mode, LC-conn - LC-conn, OFA, 5 m

CAB-FIB-1F-LC/LC-OFA-5m   Fibre patch cord, 1-fibre, single mode, LC-conn - LC-conn, OFA, 5 m

CAB-FIB-2F-DLC/x-OFA-5m   Fibre pigtail, 2-fibres, single mode, LC-connector - loose end, OFA, 5 m

CAB-FIB-1F-LC/x-OFA-5m   Fibre pigtail, 1-fibre, single mode, LC-connector - loose end, OFA, 5 m

Fibre & DC outdoor cables

CAB-HYB-2F-DLC/DLC- ...   DC power cable - Fibre: patchcord, 2-fibres

CAB-DC-2x1.5   DC power cable 2x1.5 mm, silicone rubber

Access adapters

OTH-W2-WIFI   WiFi adapter

SET-XA-ETH/USB   Ethernet adapter

2.2. Details

Antennas with Direct Mounting (LEAX-RAy + Jirous)

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

- *Antennas overview*
- *Dimensions*
- *List of datasheets*[1]
- *Installation*

A radio link calculation should be performed to determine appropriate antenna size (use our *on-line calculator*[2] or *RAy-Tools application* for smartphones).

Bigger antennas (90 + 120 cm) installed at windy sites (wind speed above 50 m/s) require installation of additional struts both for LEAX-RAy and Jirous – see *Section 4.2.1, "LEAX-RAy antenna mounting"* for more details and *Section 2.1, "Overview "* for items to quote.

Antenna mounting kit (for Andrew and Arkivator)

These antennas can also be used for mounting of RAy unit using special brackets. Please *contact us*[3] for other possibilities.

- *Mounting kit overview*
- *More information*
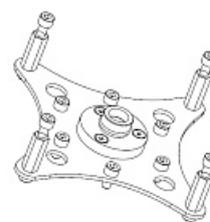
Flexible waveguide mounting kit (other antennas)

RAy units can be attached to the antenna using flexible waveguide mounting kits. Two types of flexible waveguide flanges are supported: R100 and R120.

- *Mounting kit overview*
- *More information*
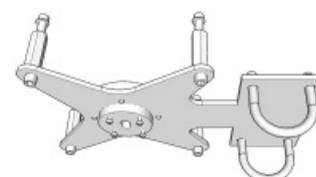
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[1] http://www.racom.eu/eng/products/microwave-link.html#accessories_antennas

[2] http://www.racom.eu/eng/products/microwave-link.html#calculation

[3] http://www.racom.eu/eng/about_us/contact.html

Cable bushing

- **SET-RAY3-CON**
  RAy3 suplied accessories - basic set of cable bushings and connectors
  - 2 pc standard PG21 bushing with nut
  - 1 pc blind plug Racom
  - 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

- **SET-RAY2-EXT35**
  Cable bushing lengthening, PG21, 35 mm
  O-ring
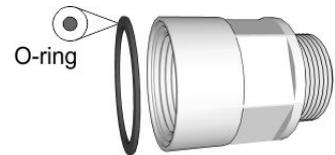
- **SET-RAY2-EXT-F50**
  Cable bushing lengthening, PG21, Flexi, 50cm
  - orig. part no:
    PA6-23N,   RKG-23P21N,   RKF-23P21N,
    2xORC-23, set REVELET
    flat ring FSN-P21
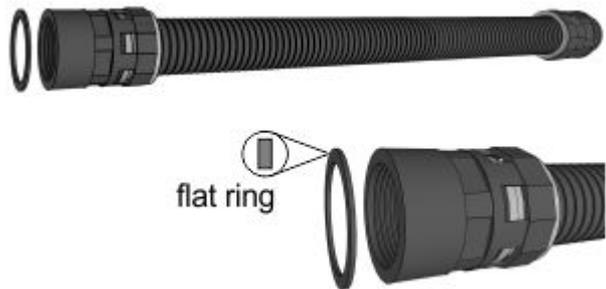
Grounding kits

- **KIT-GROUNDING-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*
  - *Datasheet*[4]

- **KIT-GROUNDING-5-11MM**
  Grounding Kit universal for 5-11mm cables.
  Suitable for Ethernet CAT5e + CAT6 cables and for shielded DC cables
  - *Datasheet*[5]
  - orig. part no: 6115050001

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[4] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/KIT-GROUNDING-RAY.pdf
[5] https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/KIT-GROUNDING-5-11MM.pdf

- **KIT-GROUNDING-1/4"**
  Grounding kit for Cat.7 S/FTP 4x(2x23 AWG) cable. Pewtronic.
  Detail see *Grounding*
  ○ *Datasheet*[6]

DC power supply and DC surge protection

- **PWS-AC/DC-AD-55B**
  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*[7]
  ○ orig. part no: AD-55B

- **OTH-DP-024**
  DC surge protection, 24V, LPZ1-LPZ2, IP20, -40/+80°C, Saltek
  ○ *Datasheet*[8]
  ○ orig. part no: DP-024

DC-RJ45 adapter

- **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

- **SET-DC-RJ45-EXT35**
  Set DC-RJ45 adapter and
  cable bushing lengthening (35mm) for RAy3

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[6] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/KIT-GROUNDING-CAT7.pdf

[7] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/PWS-AC-DC-AD-55B.pdf

[8] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/OTH-DP-024-ds-en.pdf

PoE power supply - passive, protected

- **PWR-POE-ALC01H**
  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)

- **PWR-POE-PAS-H**
  PoE passive injector 1Gb Eth, max 1.4A
  surge protection, overcurrent fuse
  input 20 to 56 VDC
  temp -30/+60°C; DIN rail; IMCO Power
  ○ *Datasheet*[10]
  ○ orig. part no: PoE.H 1Gb (EV003391, IP.8421.633.15)

PoE power supply - active

- **PWR-POE36U-1AT**
  RAy unit PoE power supply according to IEEE 802.3at,
  1x Eth PoE output 56 V / 33.6 W, 4 wires
  Input 100 to 240 VAC, -20/+50°C, no SNMP, Phihong
  ○ *Datasheet AC*[11]
  ○ orig. part no: POE36U-1AT

- **PWR-POE36D-1AT**
  RAy unit PoE power supply according to IEEE 802.3at,
  1x Eth PoE output 56 V / 33.6 W, 4 wires
  Input 36 to 72 VDC / 1.2A, -20/+50°C, no SNMP, Phihong
  ○ *Datasheet DC*[12]
  ○ orig. part no: POE36D-1AT

- **HOL-POE-PHI-1A**
  DIN rail holder for PoE power supply from Phihong
  PoE power supply not included - needs to be ordered separately

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[9] https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/PWR-POE-ALC01H.pdf

[10] https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/PWR-POE-PAS-H.pdf

[11] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/PWR-POE36U-1AT.pdf

[12] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/PWR-POE36D-1AT.pdf

ETH surge protection

- **OTH-DL-1GRJ45**
  Eth surge protection for LPZ0B-LPZ1,
  1Gb, RJ45 sockets, PoE transparent, DIN rail, IP20
  -40/+80°C, Saltek
  - *Datasheet*[13]
  - orig. part no: DL-1G-RJ45-POE-AB

ETH connectors and cables

- **CON-RJ45-UBNT-CAT6**
  STP RJ45 /Cat6 / 8p8c / wire/ gold plated/ AWG24, UBNT
  - orig. part no: TC-CON connector STP RJ45

- **CON-RJ45-TLG-CAT6**
  Connector RJ45, AWG 24-22, Telegärtner
  Suitable for Cat5e, Cat6A, Cat7 cables
  - *Datasheet*[14]
  - orig. part no: Telegärtner MFP8 Cat.6A AWG 22-27

- **SET-RAY2-TLG-EXT35**
  Connector RJ45, AWG 24-22, Telegärtner
  + Racom SET-RAY2-EXT35
  Set RJ45 connector (Telegärtner) and cable bushing lengthening
  (35mm). Suitable for AWG24-22 (Cat5e, Cat6A, Cat7) cables.
  - *Datasheet*[15]
  - orig. part no: Telegärtner MFP8 Cat.6A AWG 22-27

- **CAB-CAT5E-FTP-TLD**
  Cat.5e cable for connecting RAy units to the network, outdoor,
  UV protected, -40°C to +70°C, TELDOR
  - *Datasheet*[16]
  - orig. part no: PLU030078

- **CAB-S/FTP 4x**
  Cat.7 cable for connecting RAy units to the network, outdoor,
  UV protected, -30°C to +70°C, PEWTRONIC Ltd.
  - *Datasheet*[17]
  - orig. part no: S / FTP 4x (2x23AWG) Cat.7 + 2x (2×24 AWG)

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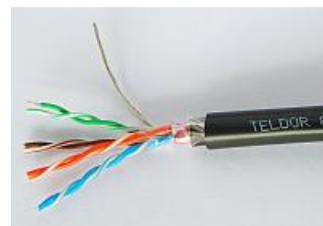
[13] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/OTH-DL-1GRJ45-ds-en.pdf

[14] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CON-RJ45-TLG-CAT6.pdf

[15] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CON-RJ45-TLG-CAT6.pdf

[16] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CAB-CAT5E-FTP-TLD.pdf

[17] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CAB-S-FTP-4x.pdf

SFP modules

- **SFP-RJ45-AVAGO**
  SFP module, RJ45 interface, -40°C to +85°C , Avago
  - *Datasheet*[18]
  - orig. part no: ABCU-5730ARZ

- **SFP-DLC-APAC**
  SFP module, 2-fibres, LC, 10km, -40°C to +85°C, APAC Opto
  - *Datasheet*[19]
  - orig. part no: LS38-C3S-TI-N-DD

Fibre optic cables

- **CAB-FIB-2F-DLC/DLC-OFA-5m**
  patchcord, 2-fibres, single mode, LC-connector — LC-connector,
  yyy meters, OFA
  - orig. part no: DLCRAC2Fyyy

- **CAB-FIB-1F-LC/LC-OFA-5m**
  patchcord, 1-fibre, single mode, LC-connector — LC-connector,
  yyy meters, OFA
  - orig. part no: LCRAC1Fyyy

- **CAB-FIB-2F-DLC/x-OFA-5m**
  pigtail, 2-fibres, single mode, LC-connector — loose end,
  yyy meters, OFA
  - orig. part no: DLC0RAC2Fyyy

- **CAB-FIB-OFA-1F-LC/x-OFA-5m**
  pigtail, 1-fibre, single mode, LC-connector — loose end,
  yyy meters, OFA
  - *Datasheet*[20]
  - orig. part no: LC0RAC1Fyyy

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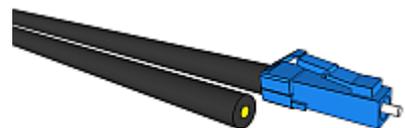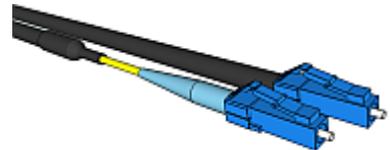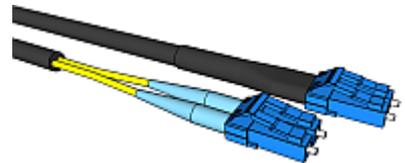
[18] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/SFP-RJ45-AVAGO.pdf

[19] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/SFP-DLC-APAC.pdf

[20] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CAB-FIB-OFA.pdf

Fibre & DC outdoor cables
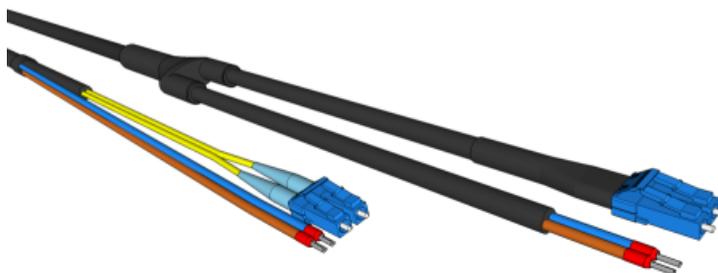
- **CAB-HYB-2F-DLC/DLC-OFA-030m (example for 30m long cable)**
  DC: 2x1.5mm^2; fibre: patchcord, 2-fibres, single mode, LC-connector — LC-connector
  - *orig. part no: DLCHRAC2Fyyy Phoenix Microwave Hybrid Cable LSOH, yyy meters, OFA*
  - *Datasheet*[21]

- **CAB-DC-2x1.5**
  silicone rubber, 2x1.5 mm², -55 to +180°C, ProPS
  - *Datasheet*[22]
  - orig. part no: V05SS-F 2Dx1.50

Access adapters

- **OTH-W2-WIFI**
  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.

  (i) 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.

- **SET-XA-ETH/USB**
  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.

Extended descriptions

See www.racom.eu, Microwave link, *Accessories*[23]

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[21] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CAB-HYB-OFA.pdf

[22] https://webservice-new.racom.eu/main/eshop.detail?i=1479

[23] http://www.racom.eu/eng/products/microwave-link.html#accessories

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E-shop

Accessories easiest to order on *E-shop RACOM*[24]

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

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[24] 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.
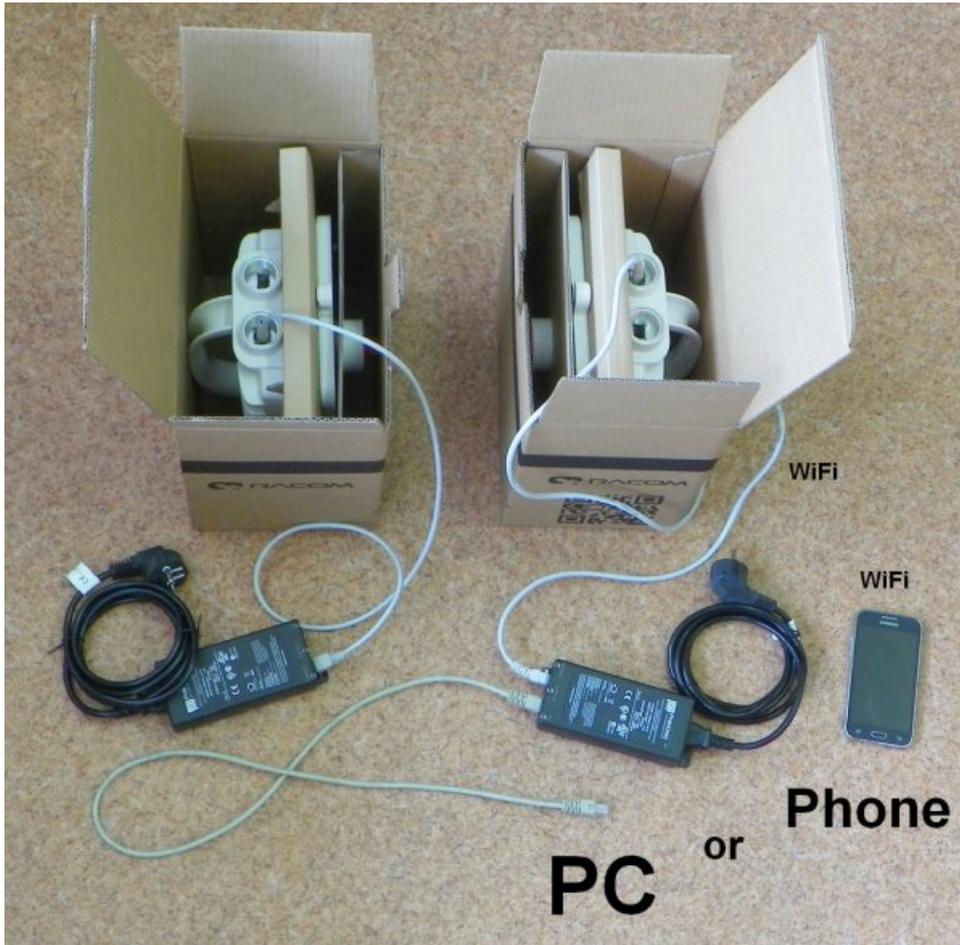
Fig. 3.1: Workplace for link testing and configuration

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".

■ 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 Eth /USB adapter SET-XA-ETH/USB), 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 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) inside the box are not met.

• High TX power does not lead to better RX signal quality, because the receiver input can be saturated with too strong signal (see more info in chapter 8. Troubleshooting, topic *Overexcited receiver*).

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 refers 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
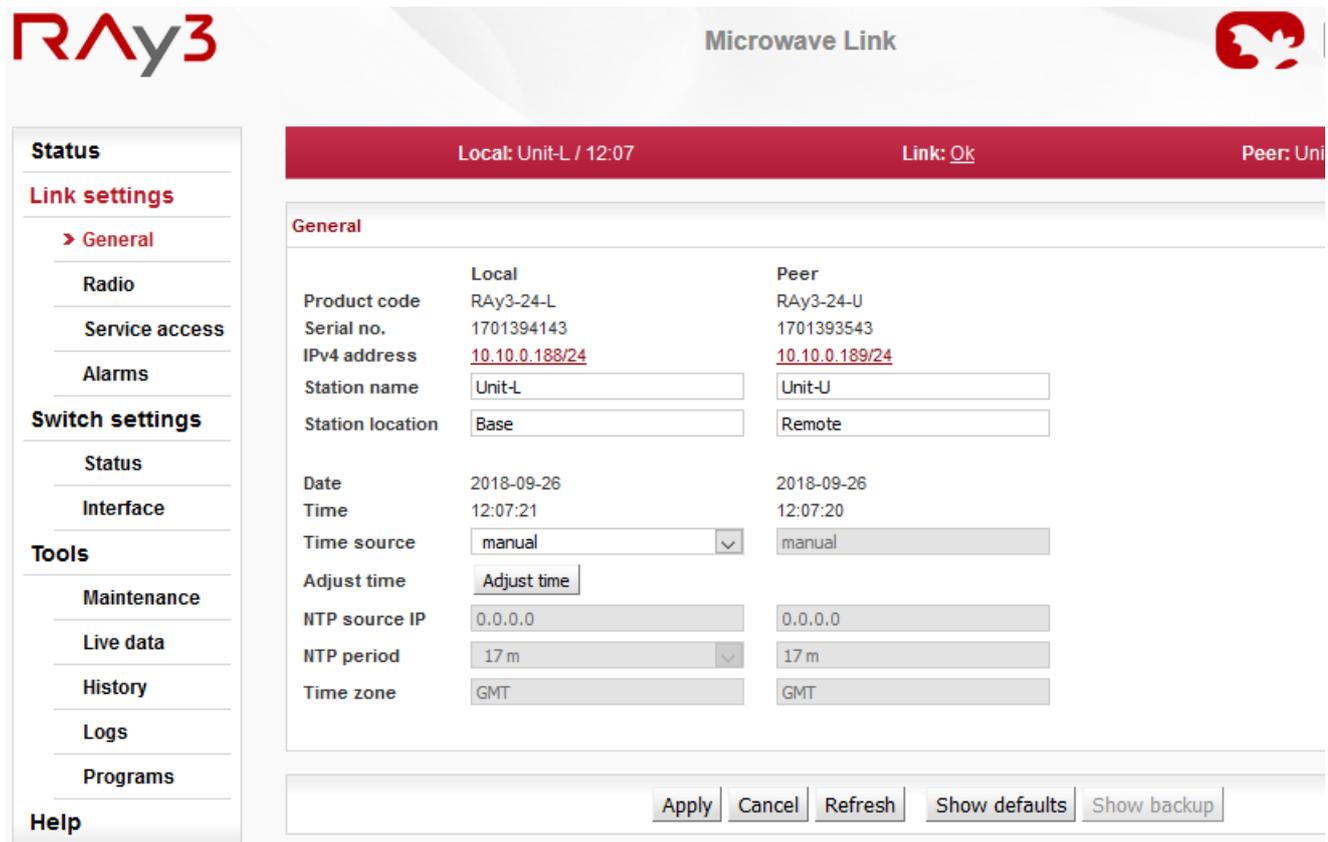
Fig. 3.3: Configuration Menu Link settings / General

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.

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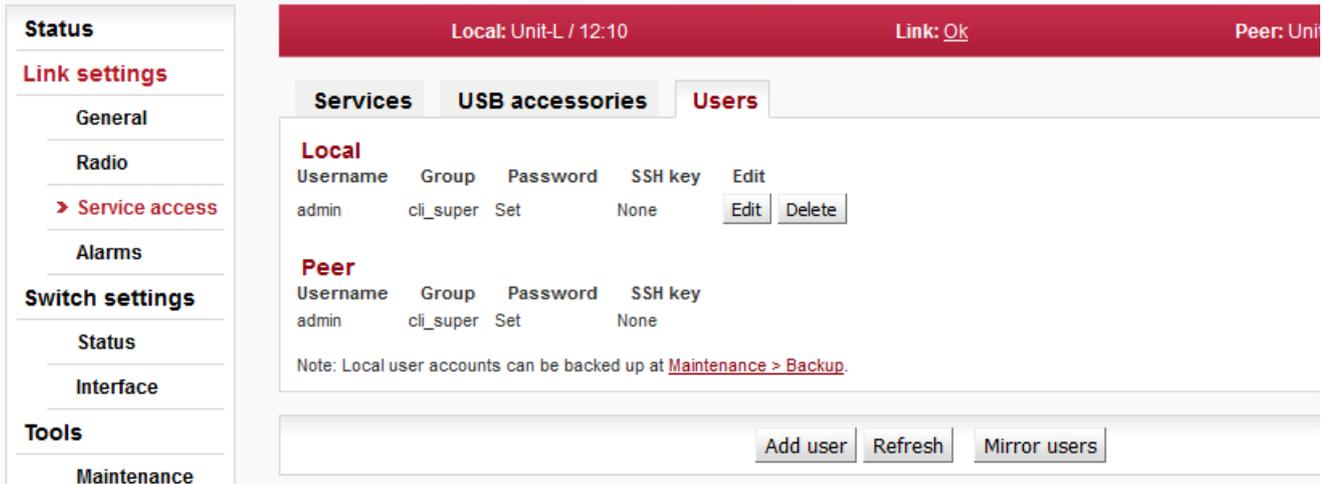
Fig. 3.5: Configuration menu Link settings / Service access / Users

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.

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.

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"*.

RAy3 Microwave Link – © RACOM s.r.o.

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 SNR 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 SNR and RSS values it indicates immediate / target value size.
- Menu *Tools / Live data / Bar indicators* displays current size of RSS, SNR 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 SNR 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 SNR, 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.
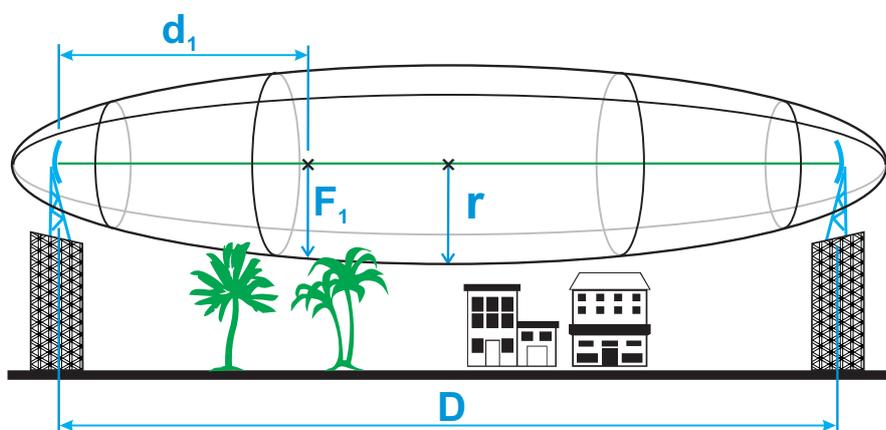
Fig. 4.1: Fresnel zone

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.
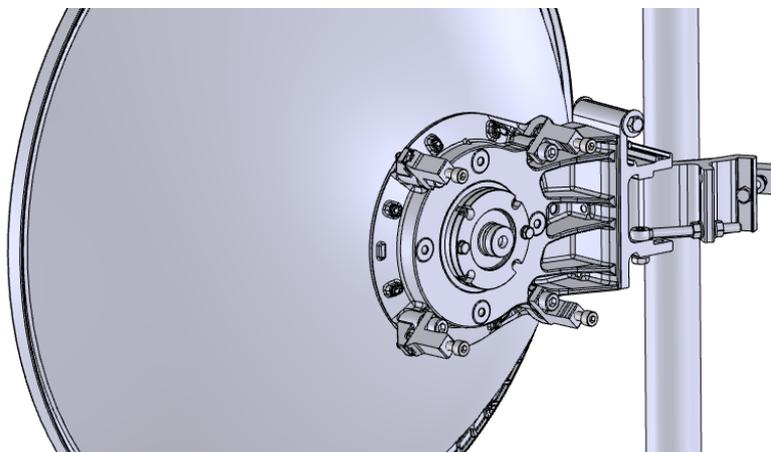
Fig. 4.2: Antenna mounting
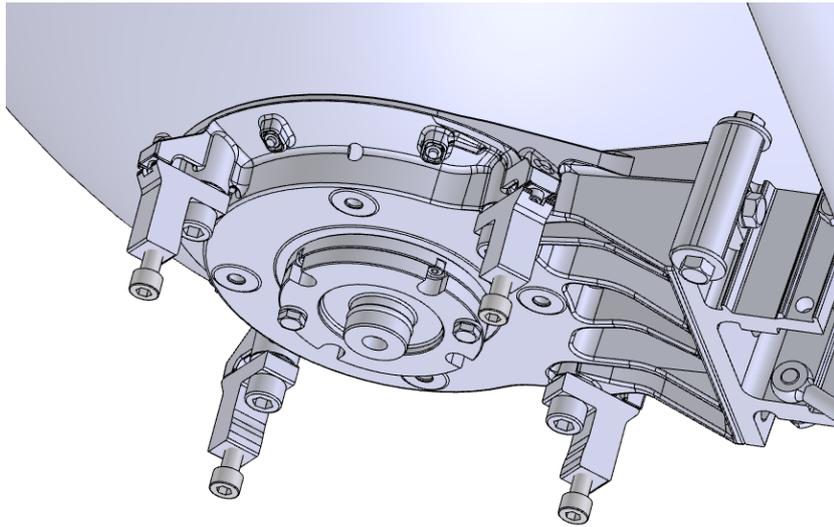
Fig. 4.3: Fixing screws

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 RX 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   30cm antennas - *ANT-LEAX-300-inst.pdf*[2]

* Installation of   60cm antennas - *ANT-LEAX-600-inst.pdf*[3]

* Installation of   90cm antennas - *ANT-LEAX-900-inst.pdf*[4]

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[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

optionally with standard strut - *ANT-LEAX-strut-std-inst.pdf*[5]

- Installation of 120cm antennas - *ANT-LEAX-1200-inst.pdf*[6] (includes standard strut)
optionally with extra 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.

Item ANT-LEAX-STRUT-90 (for 90 cm antennas) respectively ANT-LEAX-STRUT-120 (for 120 cm antennas) allows to increase operational wind speed up to 65 m/s (instead of 50 m/s respectively 55 m/s). Also allows to use tower pipe Ø50-120 mm (instead standard Ø90-120 mm).

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*[9] section:

- Installation of Jirous antennas *ANT-JRM-inst.pdf*[10]

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

Item SET-JRMB-1200-FIX or SET-JRMB-1200-ADJ (optional wind bracing sets, both for 120 cm antennas) allows to increase operational wind speed for extreme sites.

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*).

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

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

[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.racom.eu/eng/products/microwave-link.html#download

[10] https://www.racom.eu/download/hw/ray/free/eng/04_anteny/ANT-JRM-inst.pdf

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Antenna mounting kit for Arkivator antennas

Items "**SET-RAYxx-ARK**" (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 "**SET-RAYxx-ANW**" (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 *SET-RAY17-ANW* 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 *SET-RAY24-ANW* 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*.
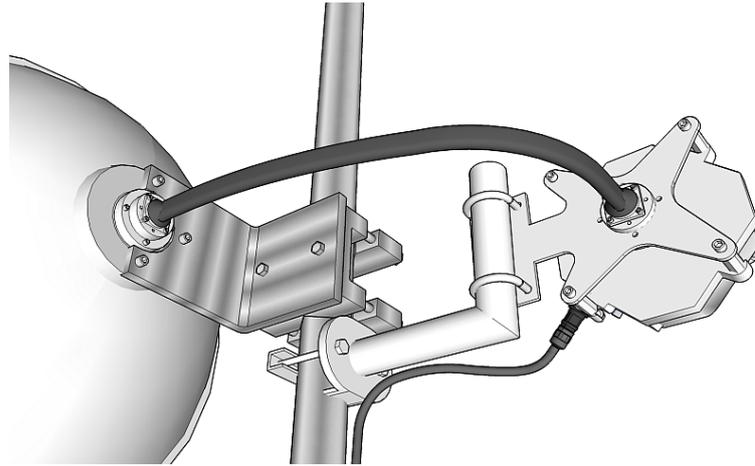
Fig. 4.4: Flexible waveguide assembly

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 box marked "SILIKONOVE MAZIVO". If you use a different grease for lubrication then it should be a Teflon or a silicon grease.
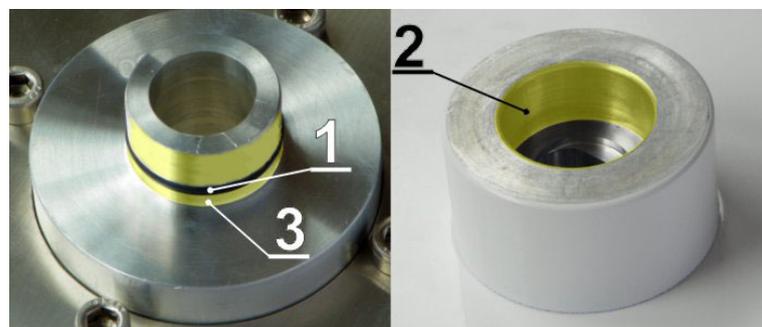
Fig. 4.5: Grease points on the antenna pivot and RAy unit bushing

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.

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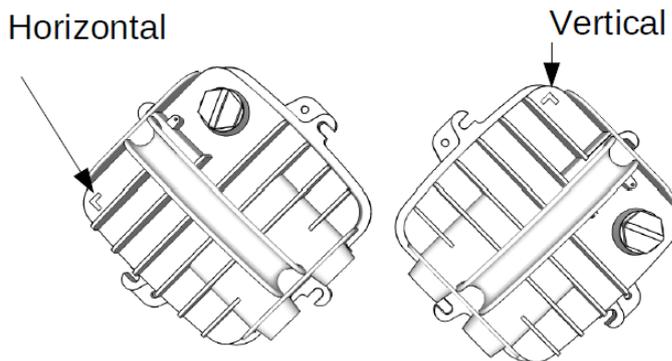
Fig. 4.7: Horizontal and vertical TX polarization – see the arrow sign

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

Note

RAy3 links need one unit to be installed with vertical polarization and the other unit with horizontal polarization because these units use cross polarization.
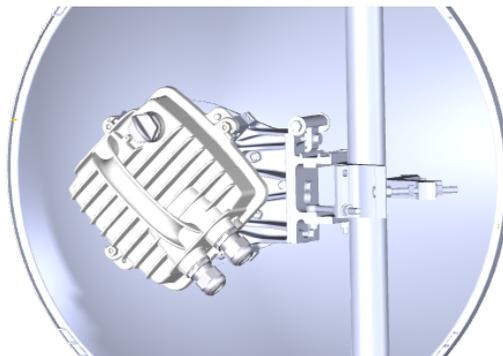
Fig. 4.8: RAy3 unit with antenna (left-side mounting and horizontal polarization)

RAy unit is fixed to the antenna by 4 pcs M8x30 (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 – see *Section 4.3.2, "RAy unit mounting to the antenna"* 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 mm^2 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*[11]. 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

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[11] http://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 standard connectors described in detail (including connectors' pin-outs) in *Section 1.3, "User interfaces"* and *Section 1.4, "Service interfaces"*. Use only standard counterparts to these connectors.
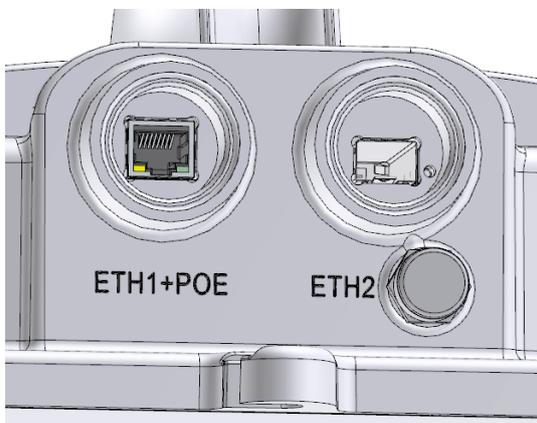
Fig. 4.13: Slots ETH1+POE, ETH2
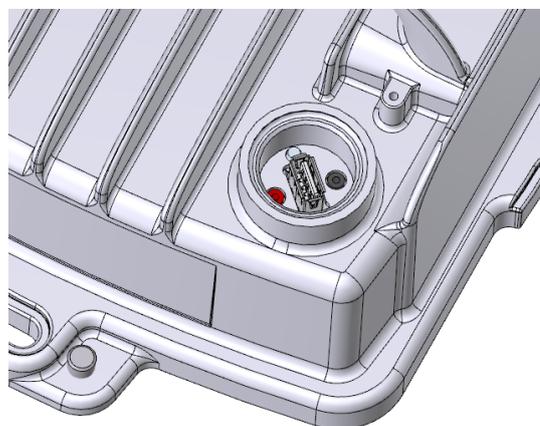
Fig. 4.14: Slot S

A set of standard bushing and plugs is delivered with each RAy unit as an accessory *SET-RAY3- CON*. 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 *SET-RAY2-EXT35* (adds 35 mm length, parts No.6 + No.7 on pictures below) or the long extension *SET-RAY2- EXT-F50* (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:
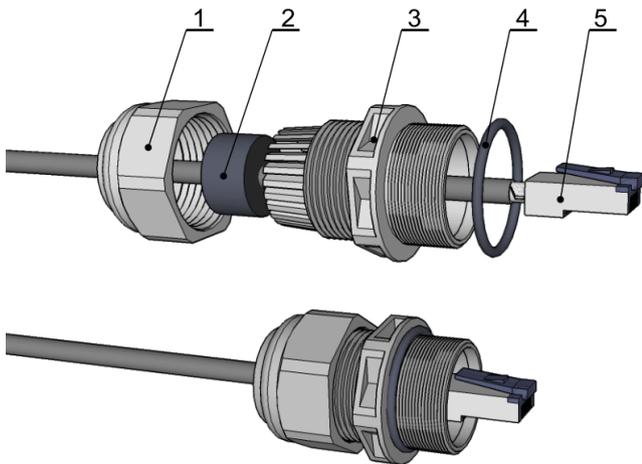
Fig. 4.15: Short bushing assembly for metallic Ethernet with *short ETH connector*
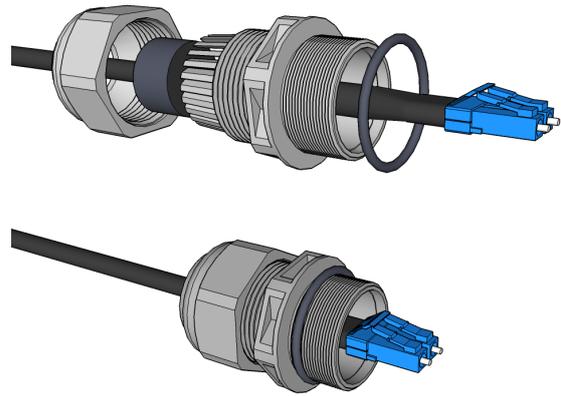
Fig. 4.16: Bushing and optical Ethernet assembly (with *RACOM / OFA fibre optic cable*)
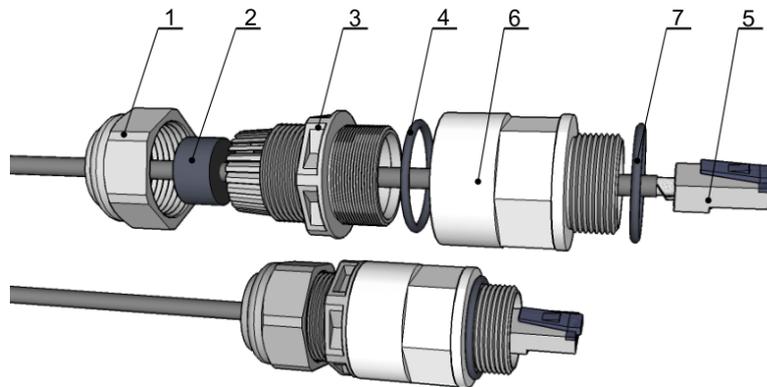
Fig. 4.17: Bushing including short lengthening (for metallic Eth with longer connector or for non-OFA fibre optic cable)

- 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.
- Move the rubber sealing (2) along the cable to fit in the bushing. Screw the nut (1) on bushing (3).
- (If you use extension ring No. 6 with O-ring No.7 lubricate its thread with grease.)

> **Tip**
>
> Practical tip: Screw the ring No.6 and bushing No.3 quote 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 *SET-RAY2-EXT-F50*. On other places O-rings are used. See next Figure:
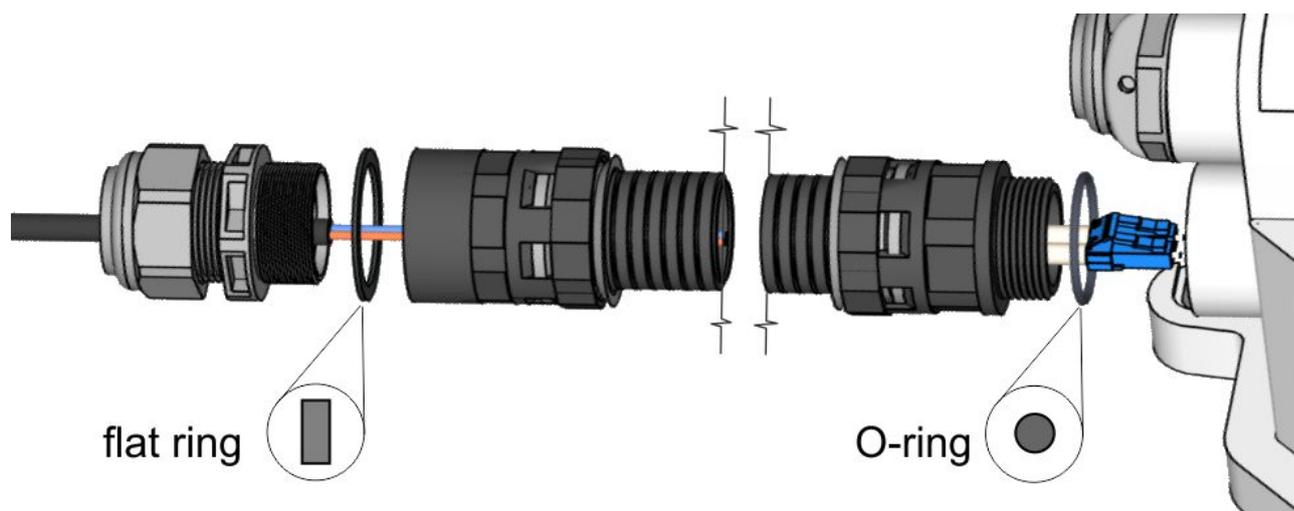
Fig. 4.18: Bushing including long lengthening

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 mm^2 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 mm^2 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 mm^2 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*[12].

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.

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[12] http://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
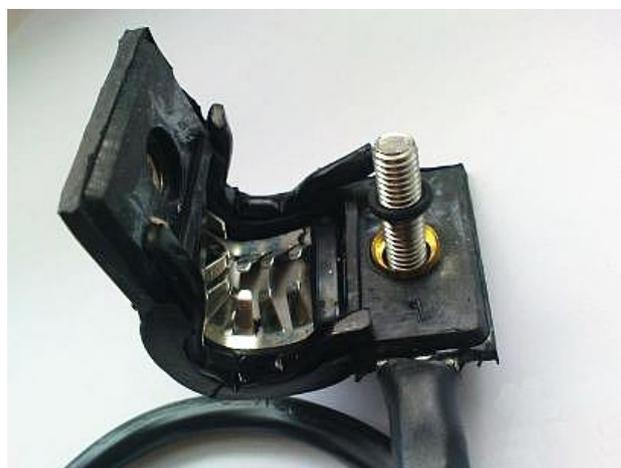
Fig. 4.24: Grounding kit detail
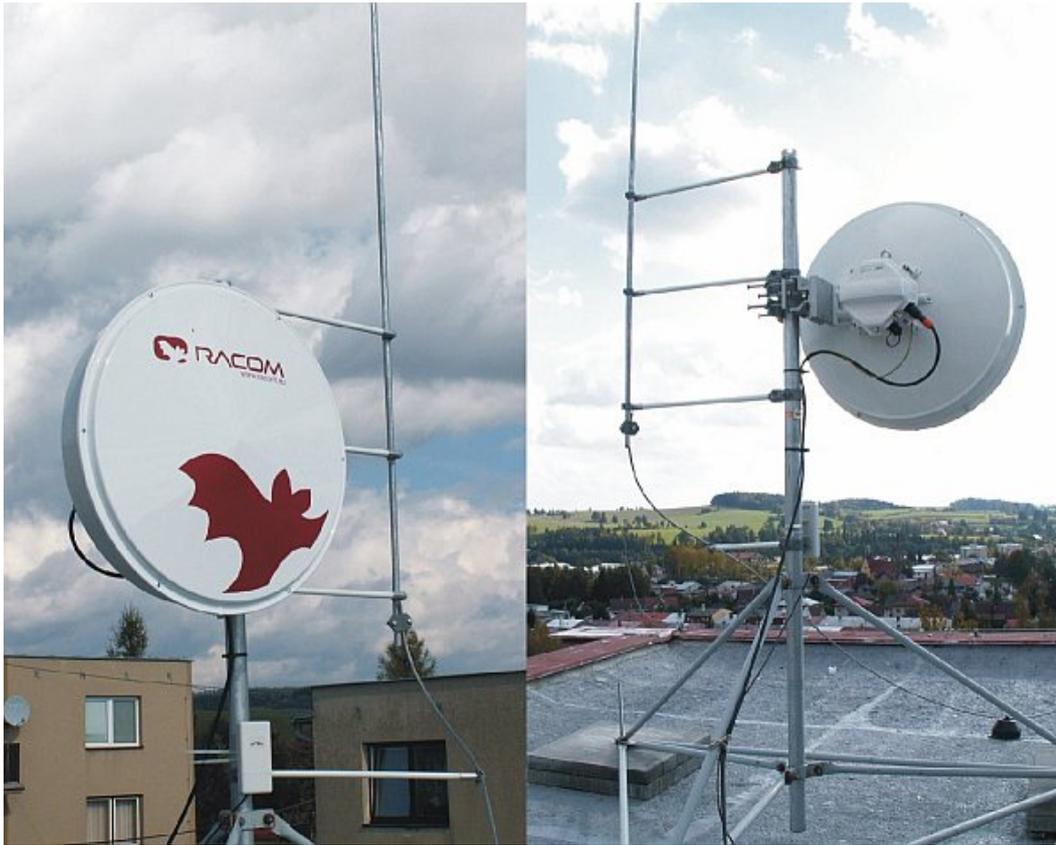
Fig. 4.25: Separated lightning conductor

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:
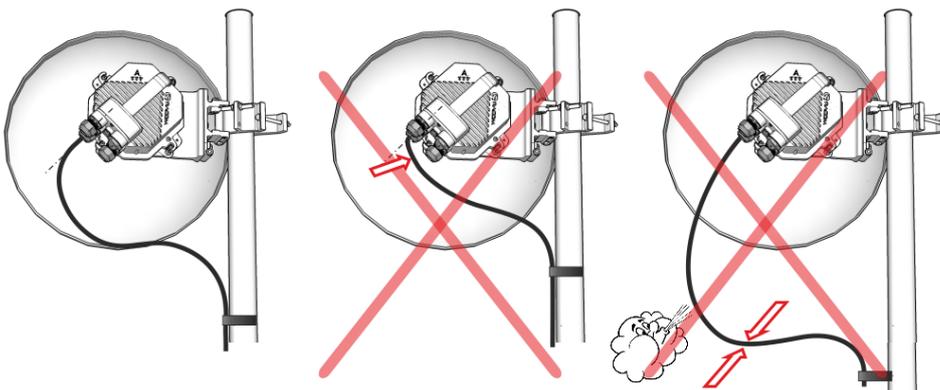
Fig. 4.26: Example of a correct lead installation.

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, "RJ45 (ETH1+POE)"*.

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 (voltage 40-60V, 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**
>
> Quality *CAT7 Eth cable* (i.e. shielded one) with UV protection is recommended for outside use.
>
> Quality connectors (like *CON-RJ45-TLG-CAT6*) 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 (ETH1+POE)"* requires the use of *DC-RJ45 adapter*.

• Any kind of DC power source with supplied DC voltage in the range 20-60 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). If a longer DC cable than few meters is used, then 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 mm^2. DC contacts on *DC-RJ45 adapter* are designed for this cross-section.

- *DC-RJ45 adapter* 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 (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.

Analyse 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 in one location all units emit a signal in the Upper part of the range and receive it in the Lower part of the range, or the other way round. A transmitter must not be installed in the part of the spectrum where other units function as receivers.

4.7.2. Directing antennas

- 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 whilst looking for maximum main signal (see paragraph on main & side lobes).
- RSS measurement chapter provides overview for available methods to measure RSS.

RSS measurement

To align antennas accurately connect a PC, tablet or mobile and use the diagnostic and measurement capabilities built in to the RAy unit. There are 4 tools available to support measurement of the 2 basic parameters for optimum antenna alignment: RSS (Radio Signal Strength) and SNR (Signal to Noise Ratio):

1. **Voltmeter** – indicates local RSS

2. **RAy Tools smartphone** application – indicates RSS, SNR - Local & Peer

3. **Antenna Alignment Tool** web page – indicates RSS, SNR – Local & Peer

4. **Bar graph** on Live Data page inside web manag. – indicates RSS, SNR, BER – Local & Peer

Before antenna alignment starts it is recommended to find out RSS and SNR 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*[13]
- Use Link calculation chapter in Application notes
- Precise link calculation using dedicated tools (e.g. Pathloss)

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[13] http://www.racom.eu/eng/products/microwave-link.html#calculation

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 SNR 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* .

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).
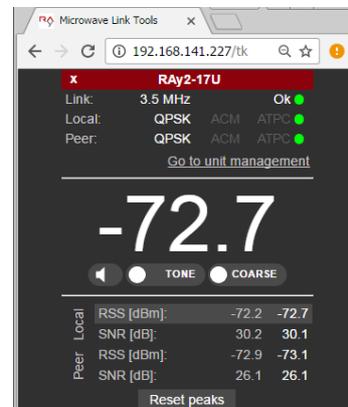
The Tool is accessible without any username or password.

Bar graph in web management

Within user management *Tools / Live data / Bar indicators* shows bar graphs of RSS, SNR and BER (Bit Error Rate) values for local and peer units. Values are refreshed every second or manually. See Section 5.6.2 *Live data* . for detailed information.

NOTE: The BER value should be close to zero after antenna alignment.
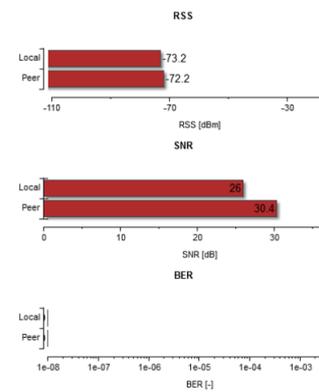
Main and side lobes

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 *Antenna lobe diagram*).

Fig. 4.28 *Signal strength graph* provides an indication of comparative signal strength from different beams emitted from a directional antenna.
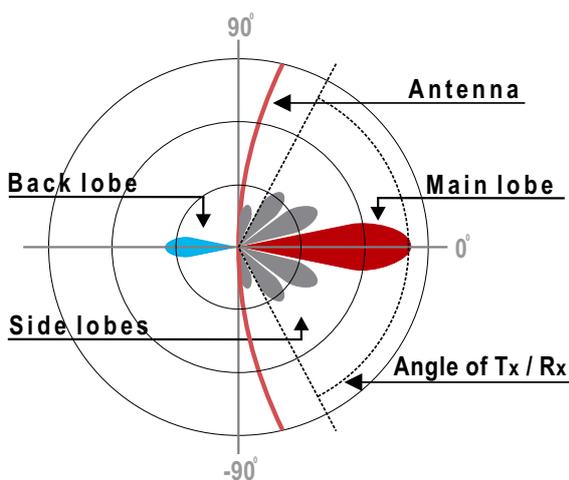
Fig. 4.27: Antenna lobe diagram   Fig. 4.28: Signal strength graph
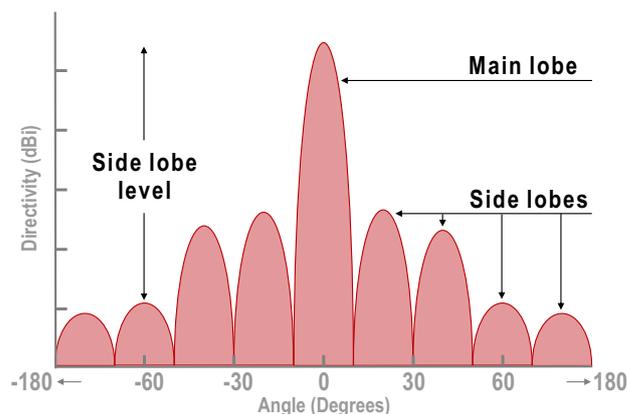
Placing the antennas to the correct antenna alignment is very important to ensure the strongest signal is received:
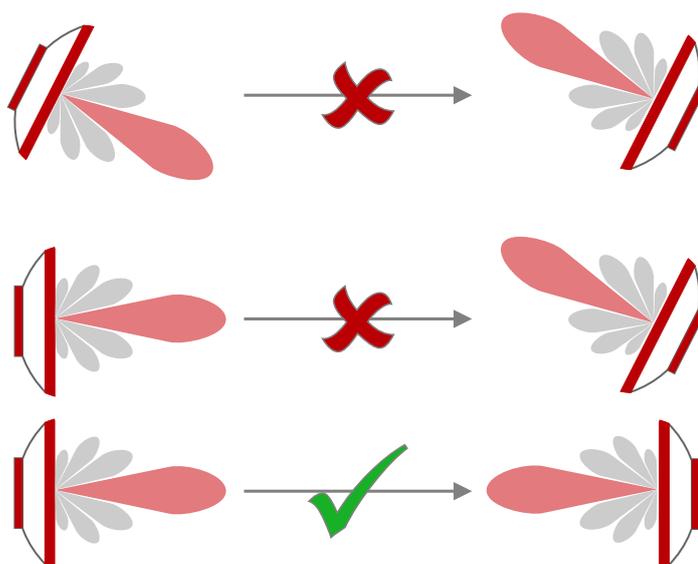
Fig. 4.29: Correct alignment diagram

Examples
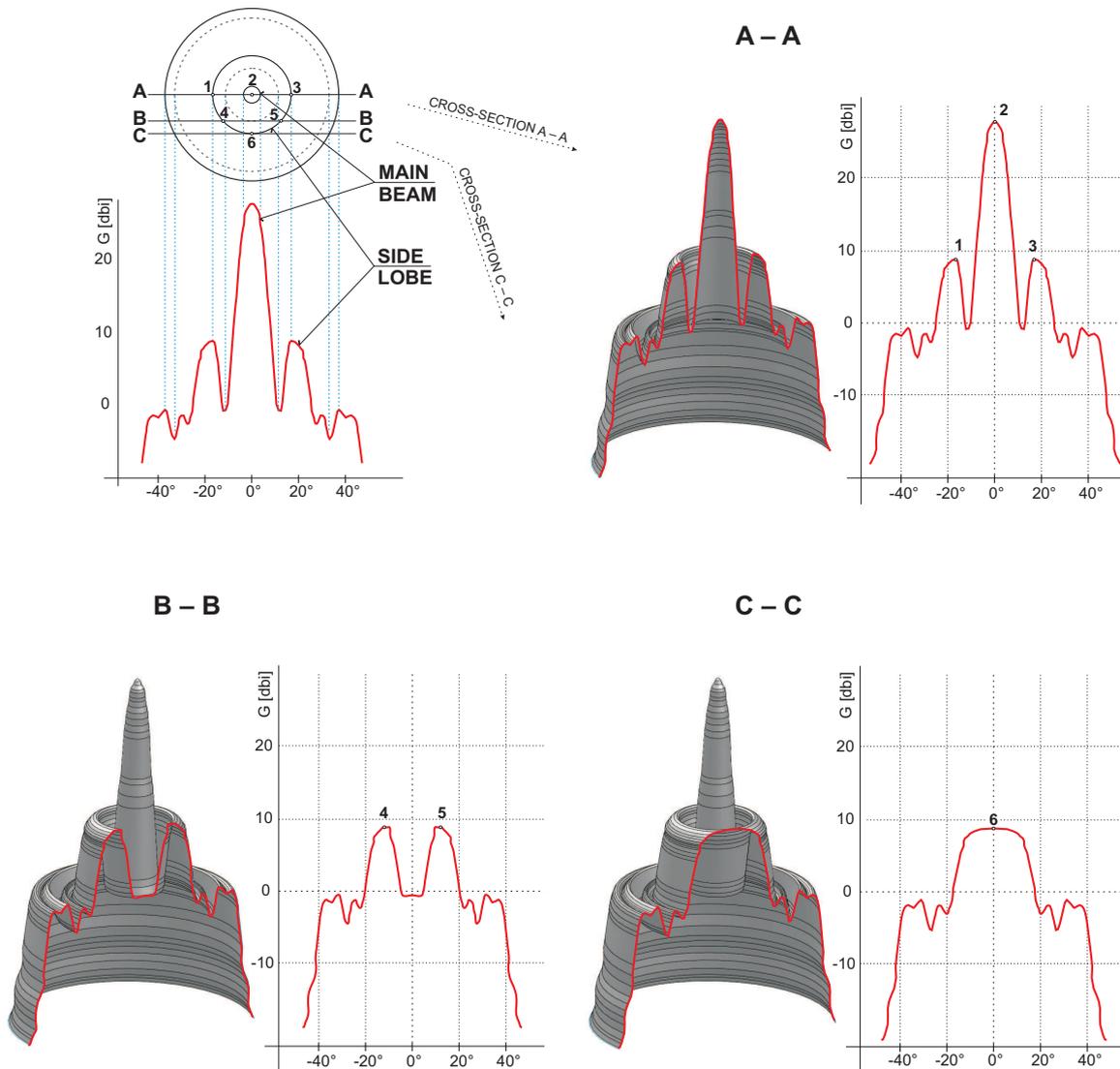
Fig. 4.30: Radiation diagrams

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*[14] .

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[14] http://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:
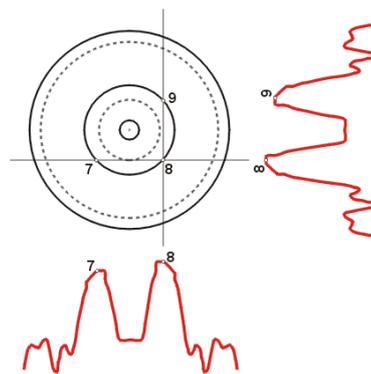
Fig. 4.31: Radiation diagram – incorrect adjustment
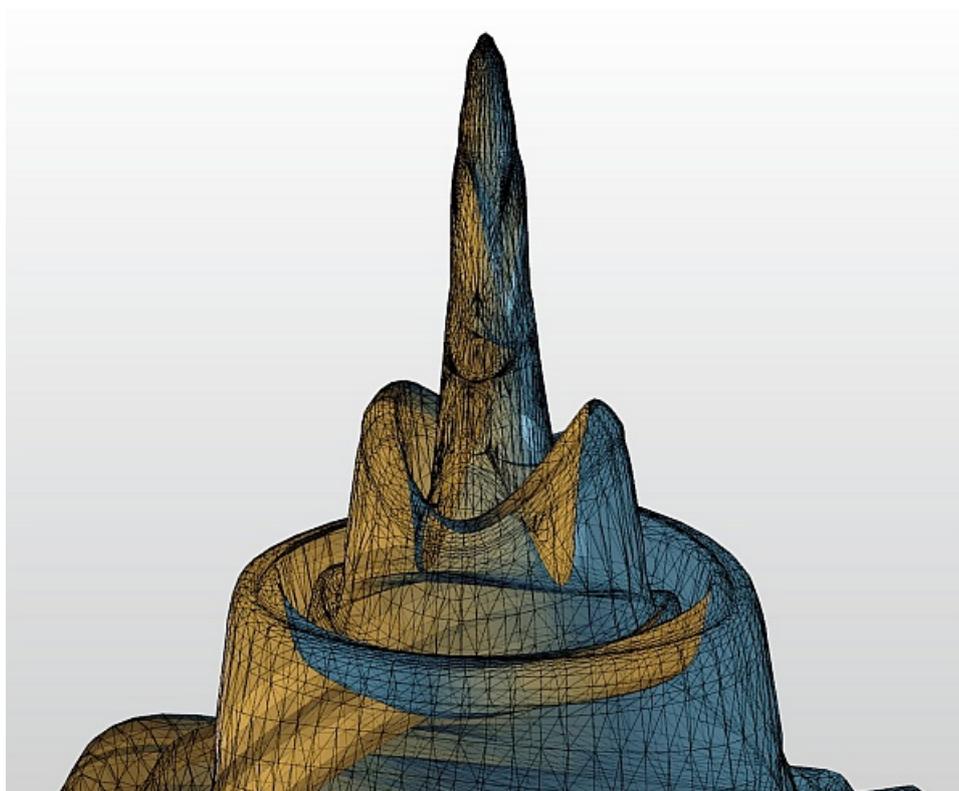
Fig. 4.32: 3D example of more complicated Radiation Pattern

4.7.3. Link test

Basic parameters of the link are shown in the menu Status/Brief, its quality is characterized by RSS and SNR. Values on Status screens can be refreshed manually by pressing the Refresh button or in real time with a period of several seconds after activating the Start button. Press the Stop button to terminate the periodic refresh of values.

The RSS, SNR and BER values can also be viewed on the screen Tools/Live data/Bar indicators. After pressing the Start button, values will be refreshed with a period of one second.

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.

4.7.4. 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 analyser. 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*.

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	Show values of individual parameters as they are stored in backup configuration (in the buffer). To use any of these values, you must use the "Apply" button.
Show backup	Clicking the button displays the values of individual parameters held in the backup file (*Backup/Settings/Open file upload*). To use any of these values, you must use the "Apply" button. For loading the backup configuration see menu *Tools/Maintenance/Backup*.
Start	Activating automatic refresh fields marked by ☼ icon using the *Start* 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.
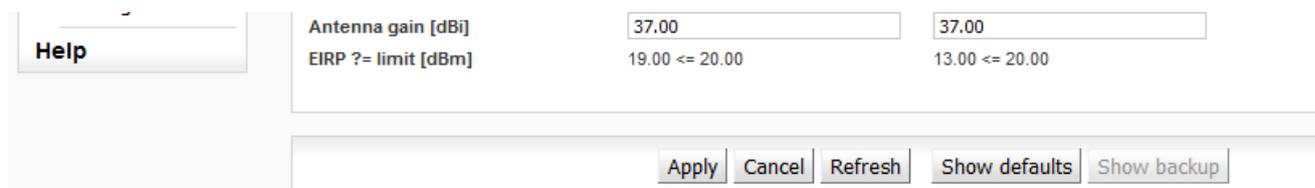
Fig. 5.1: Info Refresh

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. The help text is displayed within the configuration screen after clicking the *Help* menu.

Secure 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.
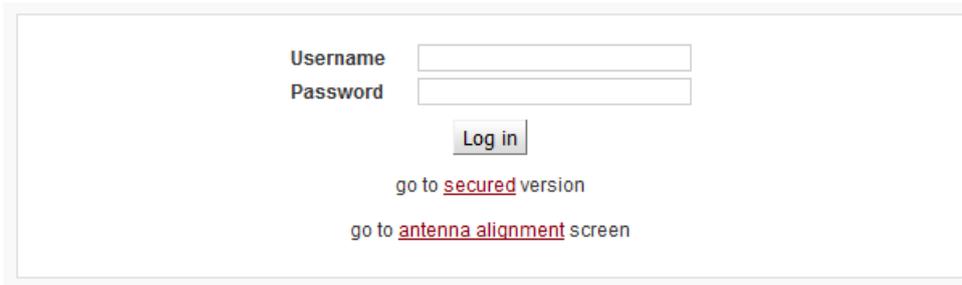
Fig. 5.2: Login

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.:
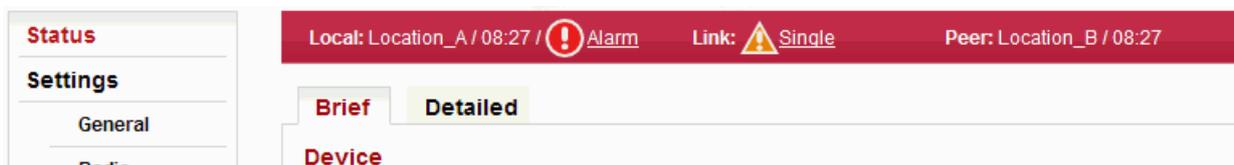
Fig. 5.4: Status bar 2

Example of a complete page - status bar, menu and control buttons:
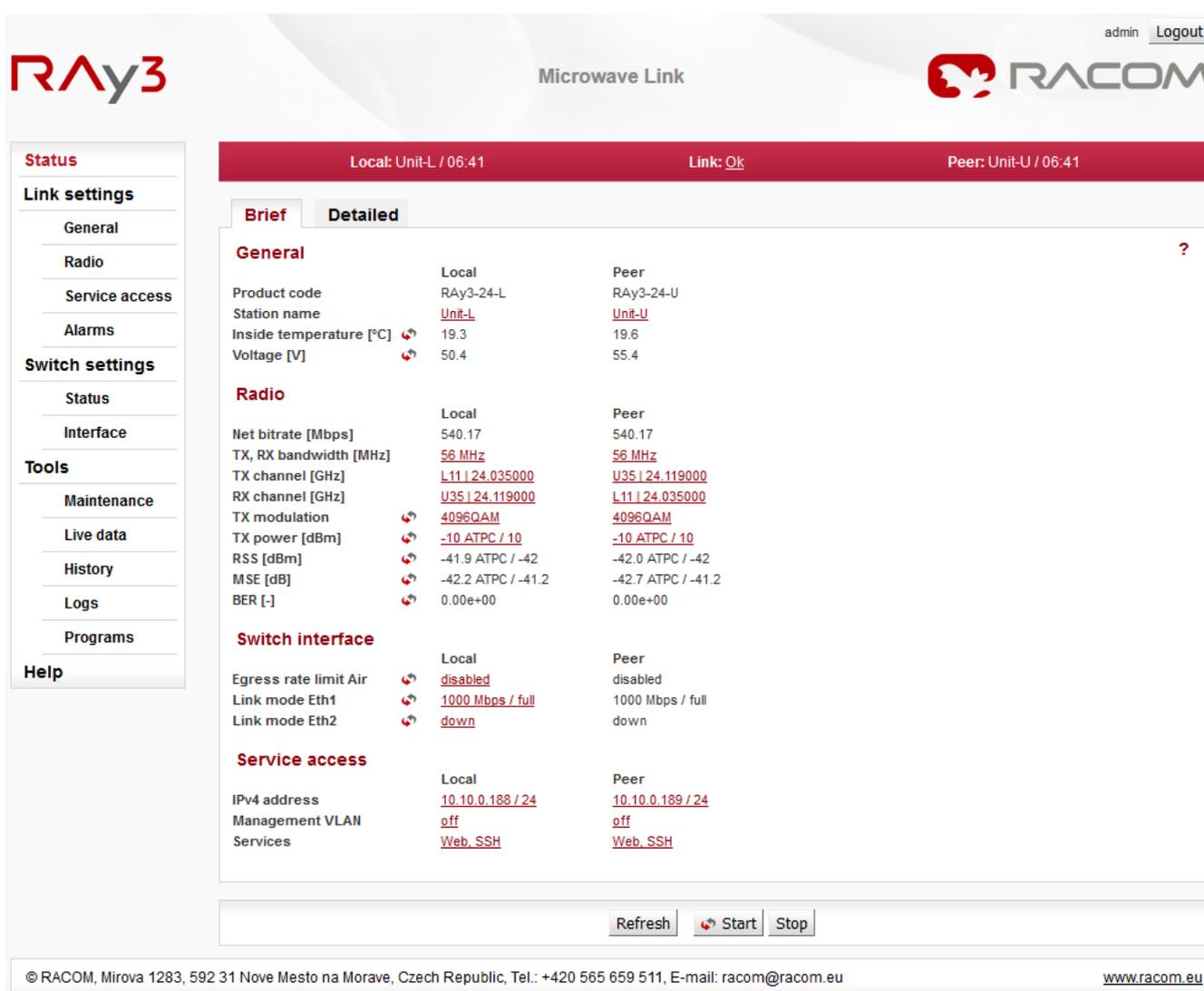
Fig. 5.5: Page example

5.3. Status

Status
Link settings
General
Radio
Service access
Alarms
Switch settings
Status
Interface
Tools
Maintenance
Live data
History
Logs
Programs
Help

Local: Unit-L / 06:44   Link: Ok   Peer: Uni

Brief **Detailed**

General

	Local	Peer
Product code	RAy3-24-L	RAy3-24-U
Serial no.	1701394143	1701393543
Station name	Unit-L	Unit-U
Station location	Base	Remote
Radio approval version	1.0.0	1.0.0
Firmware version	1.0.0.0	1.0.0.0
Date	2018-09-27	2018-09-27
Time	06:44:59	06:44:54
Inside temperature [°C]	19.3	19.6
Voltage [V]	50.4	55.4

Radio

	Local	Peer
Band index	L	U
Polarization	horizontal	vertical
Frequency table	rcinfo24_ISM250;3	rcinfo24_ISM250;3
Net bitrate [Mbps]	540.17	540.17
Max. net bitrate [Mbps]	1003	1003
TX, RX bandwidth [MHz]	56 MHz	56 MHz
TX channel [GHz]	L11	24.035000	U35	24.119000
RX channel [GHz]	U35	24.119000	L11	24.035000
TX modulation	4096QAM	4096QAM
TX power [dBm]	-10 ATPC / 10	-10 ATPC / 10
RSS [dBm]	-41.9 ATPC / -42	-42.2 ATPC / -42
MSE [dB]	-42.4 ATPC / -41.2	-42.7 ATPC / -41.2
BER [-]	0.00e+00	0.00e+00
Link uptime	30 days, 21:20:46	

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:a9:20:00:e4	00:02:a9:20:00:d8
IPv4 address	10.10.0.188 / 24	10.10.0.189 / 24
Management VLAN	off	off
Services	Web, SSH	Web, SSH
USB accessories	No device	No device

Radio link statistics

	Local	Peer
Statistics Cleared	1970-01-01 00:00:00	1970-01-01 00:00:00
Statistics Period	30 days, 20:32:50	30 days, 20:34:19
Overall Link Uptime	30 days, 20:32:46	30 days, 20:33:58
Overall Link Downtime	0 days, 00:00:03	0 days, 00:00:20
Reliability [%]	99.9999	99.9992
Current Link Uptime	30 days, 20:32:46	30 days, 20:33:28
The Longest Drop	0 days, 00:00:03	0 days, 00:00:17
The Last Drop	0 days, 00:00:03	0 days, 00:00:17
Number of Drops	0	1

Fig. 5.6: Menu Status

The "Status" menu provides basic information about local and remote station. Informations 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).

5.3.1. Status - General

LED indicators	Unit status indication		
	A - AIR	Green Red	- Radio link OK - Radio link interrupted
	S - SYS	Green	- System OK
	E - ETH	Green Orange	- ETH1 port - Link 10/100/1000 - ETH2 port - Link 1000

Product code	Unit product code - is the same as the Ordering code.
Serial no.	Unit serial number.
Station name	Station name can be modified to reflect the unit location in the network topology.
Station location	Station location can be used to reflect the network topology hierarchy.
Radio approval 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.
Power supply	The power supply input the unit is powered from. PoE - unit is powered via Ethernet cable plugged into port "ETH1+POE". AUX - unit is powered via DC cable plugged into port "P".

5.3.2. Status - Radio

Radio type	Radio unit type: L (Lower) or U (Upper) part of the frequency band.
Polarization	Horizontal or vertical polarization based on the physical installation. Indicates the polarization of the received signal. Local and Peer are indicated separately. The proper position of the cable is sideways down. Notice for RAy2-17 and RAy2-24 links: One side of the link must be installed in vertical polarization and the other in horizontal *polarization*.
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"
SNR [dB]	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 SNR ATPC / threshold SNR"
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 *Speed guard* 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.
Services	Services enabled for unit management and monitoring (Web, Telnet, SSH, SNMP, NTP).

5.3.5. Status - Radio link statistics

Information on statistical data:

Statistics Cleared	Time of log clearing.
Statistics Period	Period of log refresh.

Radio link statistics:

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.
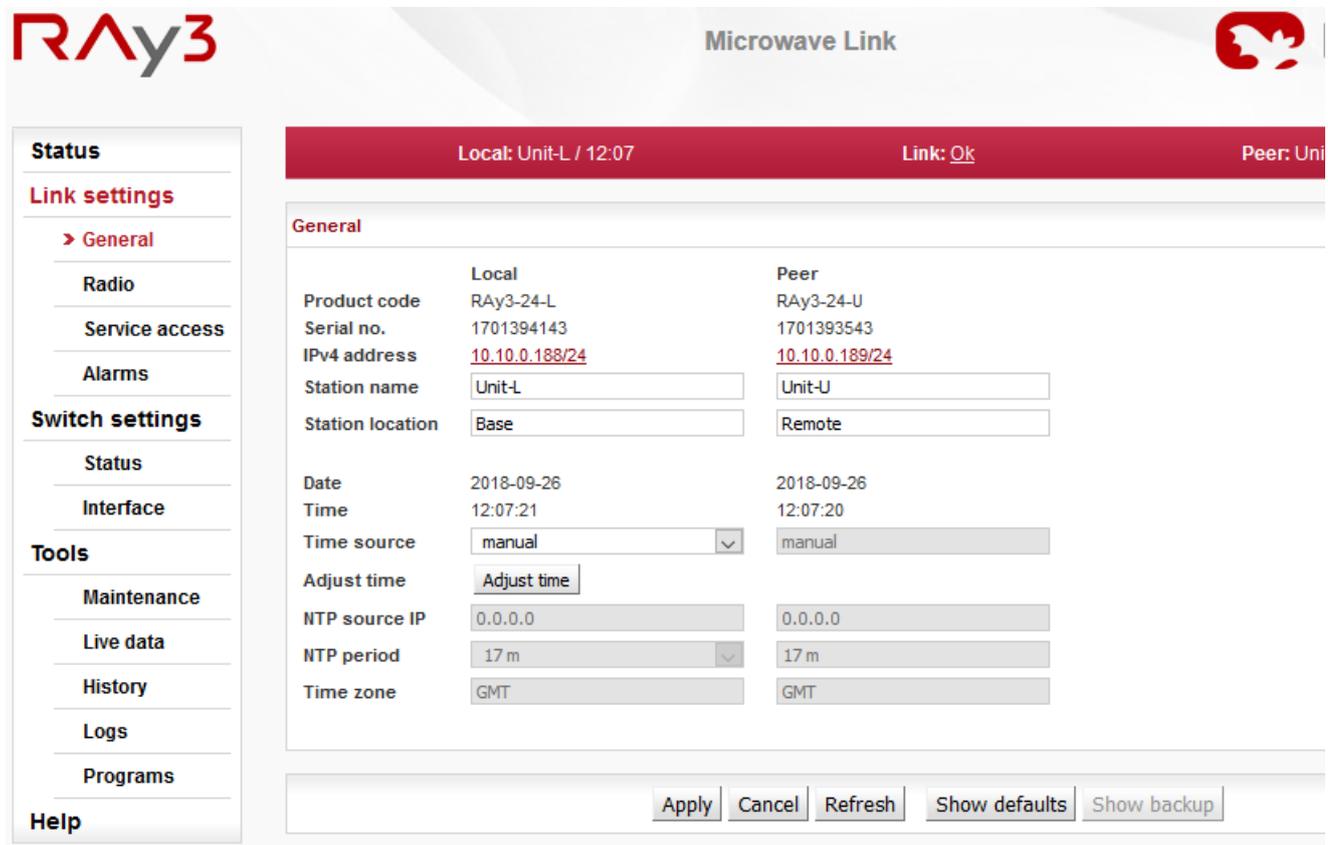
Fig. 5.7: Menu Link settings / General

Unit 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 to reflect the unit location in the network topology.
Station location	Station location can be used 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).

NTP source IP   IP address of the time synchronization server.

NTP period   Time synchronization interval.

Time zone   Time zone

Daylight saving   Enable daylight saving time

Note

When the time zone and/or daylight saving time 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.

Fig. 5.8: Menu Link settings / Radio

|	
Radio type	Radio unit type: L(ower) or U(pper) part of the frequency band.
Polarization	Horizontal or vertical polarization based on the physical installation. Indicates the polarization of the received signal. Local and Peer are indicated separately. The proper position of the cable is sideways down. Notice for RAy2-17 and RAy2-24 links: One side of the link must be installed in vertical polarization and the other in horizontal *polarization*.
Bandwidth [MHz]	One of the standard channel widths can be selected. This parameter must be set identically in local and remote.
Frequency input	Enable manual input (if supported). TX and RX frequencies [GHz] are manually entered. It is possible to disconnect the TX-RX lock and select TX and RX channels individually. Corresponding channels at peer unit are set automatically.
TX channel [GHz] **RX 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.
Duplex spacing [MHz]	Information about duplex spacing of TX and RX channel.
ACM	Enable automatic *control of modulation*.
TX modulation	Modulation level for TX channel. You can select in range from QPSK (high sensitivity for difficult conditions) to 256QAM (high speed under appropriate conditions). With ACM enabled the modulation will automatically operate from QPSK to the selected modulation.
ATPC	Enable automatic *control of RF power*. 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 RAy2-17 and RAy2-24 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 *EIRP limit* 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 RAy2-17 and RAy2-24 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 SNR 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 modulation across all ranges from QPSK to TX modulation according to the limits in table *ACM switching according to SNR 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.
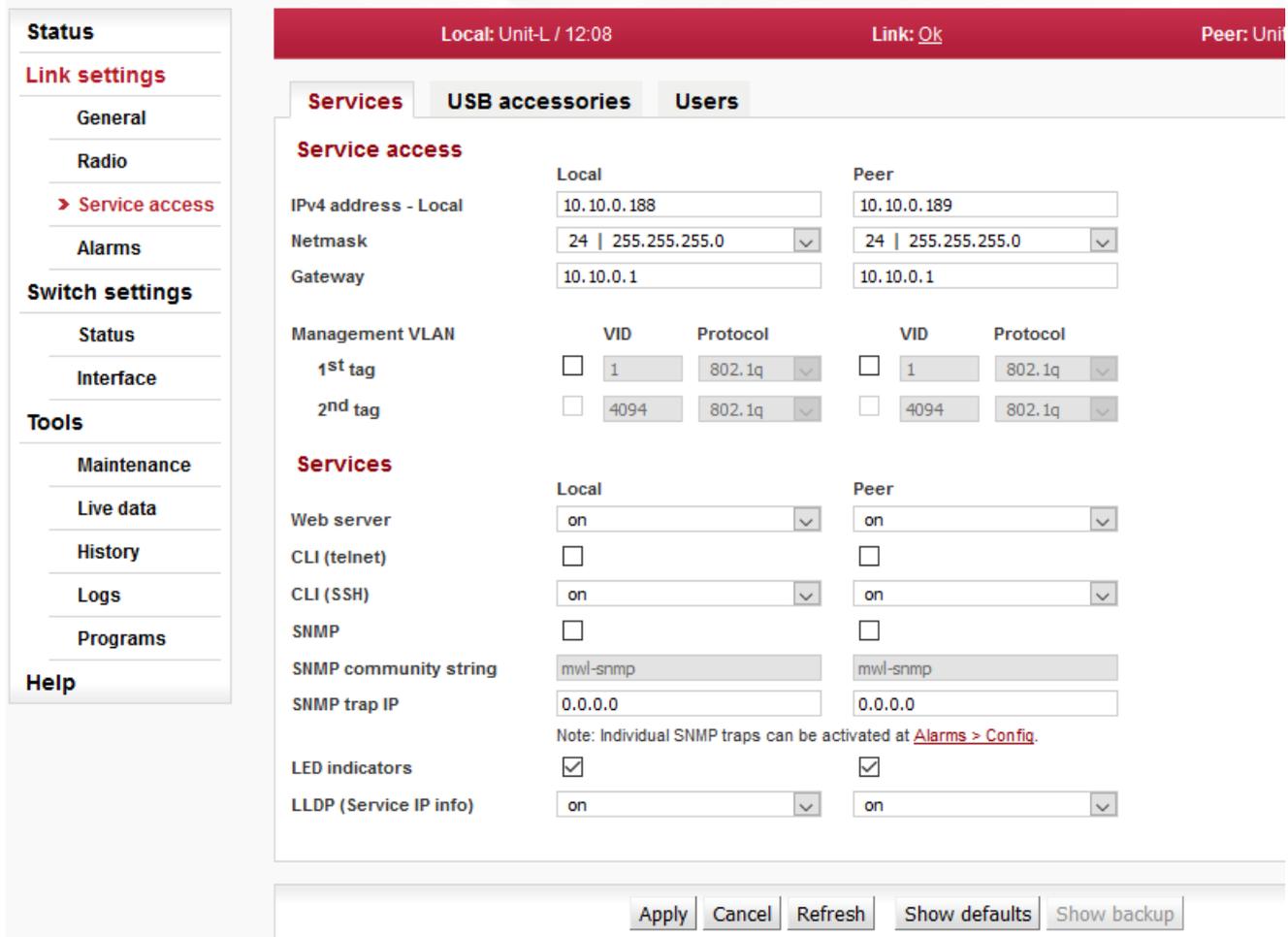
Fig. 5.9: Menu Link settings / Service access / Services

Service channel	There are two modes of accessing the internal management system of the microwave link: standard and direct

standard:

Both units are configured with the separate IP addresses, Netmasks, Gateways and Management VLANs. IP addresses of both units does not have to belong in to the same sub-net. The "Internal VLAN" is required to encapsulate the internal service traffic between both units of the microwave link. There are additional internal service addresses used for this internal service traffic (see "IPv4 address - Local" section for further details).

direct:

Both units are configured with the separate IP addresses but with the **same Netmask, Gateway and the Management VLAN**. IP addresses of both units must belong in to the same sub-net. There is no need for "Internal VLAN" to handle the internal

service traffic between both units of the microwave link. No additional internal service addresses exist.

NOTE: It is strongly recommended to use "Management VLAN" to encapsulate and prioritize the management traffic when the *direct* mode is selected. If the "Management VLAN" is not used (while in direct mode), the internal service traffic is NOT prioritized.

IPv4 address - Local
Service IP address, by default 192.168.169.169 for L unit and 192.168.169.170 for U unit. Four addresses 169.254.173.236/30 are used for internal communication. Must not be used as service IP address. Those four addresses are not used while "Service channel" is set to "direct" mode.

Unknown IP address
If you forget the Service IP address, it can be found by reading data broadcast through LLDP protocol. Data is transmitted every 60 seconds and contains the following information:

Management address	IP address
System Description	Serial number
Chassis Subtype	Type (e.g. RAY2-17-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

The message can be recorded and converted into a readable form using an 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.

IPv4 address - Peer
Management address of the Peer station. This address has to be set up when the "Service channel" is set to "direct" mode.

Netmask
Mask for service access, 24 by default.

Gateway
Default gateway for service access; empty by default.

Management VLAN
Enables access via VLAN management. 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 (if the "Service channel = standard"). 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

Internal VLAN
Valid only for "Service channel = standard": The RAy uses one VLAN id for internal service communication between both units.
There are two situations when it might be necessary to change the Internal VLAN id:
- Conflict within user data flow when the same VLAN id is already present within a data flow.
- Conflict with the internal management address of another RAy unit located at the same site and connected in the same LAN segment.
NOTE: The Ethernet frames within this service channel are marked with IEEE 802.1p priority class "7". Default parameters for QoS and Egress queue control are pre-set to prioritize this service communication channel.

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 all LEDs with this option.
LLDP (Service IP info)	Data transmitted through the LLDP protocol can be accessed in two ways:

On	Transmissions every 60 seconds
Single	Transmitted once only when unit is rebooted

See "IPv4 address - Local ... Unknown IP address" for description of the data transmitted through the LLDP protocol.

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 (peer has older fw), or No device - no device plugged in the USB port, or 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 end**	DHCP range for dynamic address allocation of the management client connected via USB port.
Ethernet adapter enable	USB to Ethernet adapter operation Enable/Disable.

Ethernet adapter DHCP enable	DHCP server for the client(s) connected via USB to Ethernet adapter.
WiFi adapter enable on Air link loss	USB to WiFi adapter is only activated 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 *WiFi management* alarm is activated).
WiFi adapter Force enable	USB to WiFi adapter is forced to be permanently active (and to transmit SSID) and *WiFi management* 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 enable	DHCP server for the client(s) connected via the USB to WiFi adapter.
WiFi SSID	Service WiFi SSID 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, *WiFi management* 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.

Note

When upgrading from FW older than 2.1.28.0 it is necessary to click "Show Defaults" followed by "Apply" to enable smooth WiFi functionality.

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
cli_guest	10
cli_admin	10
cli_super	2

Permissions defined in the system	cli_guest	cli_admin	cli_super
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 use

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 an 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 the unit.

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.
SNR [dB]	**<10**	Signal to Noise Ratio. Active if SNR drops below SNR threshold.

BER [-]	**>10e^{-6}**	Bit Error Rate is registered at the receiving end - 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 link down		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 *Status* screen is always "Ok" regardless of the current status of the Ethernet link.
RF power fail		Loss of transmit power (not applicable for RAy2-17 neither RAy2-24).
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

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.

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

Fig. 5.15: Alarm severity

Alarms Acknowledge

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, SNR, 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
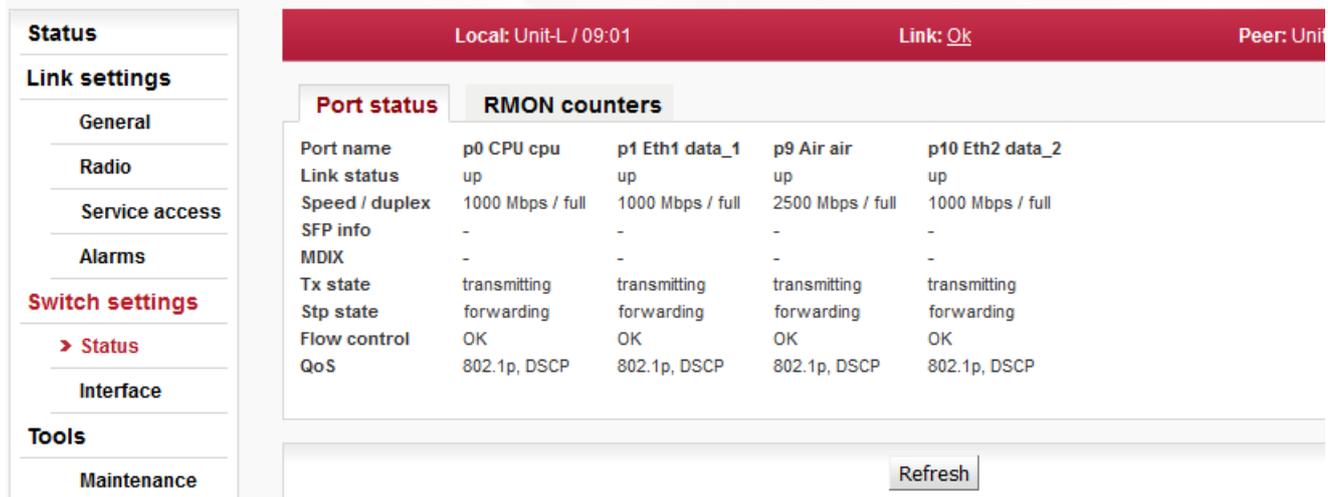
Fig. 5.17: Menu Switch settings / Port status

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   The external port (with RJ45 interface) labeled "ETH1+POE". Port 2.
    Eth2   The external port (with SFP interface) labeled "ETH2". Port 4.
    CPU   The internal port to management CPU. It is physical port number 5.
    Air   The internal port to radio modem, i.e. link to the peer unit. Port 6.

Link status   Ethernet link status can be

    down / type   no link signal detected
    up / type   link signal detected

The type of the physical layer is indicated after the slash

    copper   metallic Ethernet interface
    SFP   SFP module can be either optic or metallic

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

Flow control   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. See *Flow control* and Pause limit parameters.
Flow control can be one of the following values:

disabled	Flow control is disabled.
enabled	Flow control is enabled.
active	Flow control is enabled and activated. The port has requested the link partner not to send any more data (by sending Pause frames).

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

Fig. 5.18: Menu Switch settings / 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   The external port (with RJ45 interface) labeled "ETH1+POE". Port 2.
Eth2   The external port (with SFP interface) labeled "ETH2". Port 4.
CPU   The internal port to management CPU. It is physical port number 5.
Air   The internal port to radio modem, i.e. link to the peer unit. Port 6.

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 *Auto negotiation*.
	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 *diff* 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 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.

The "total" column always shows the actual values. It is refreshed either by pressing the Refresh and also the Difference button.

5.5.2. Interface

Port

Port settings
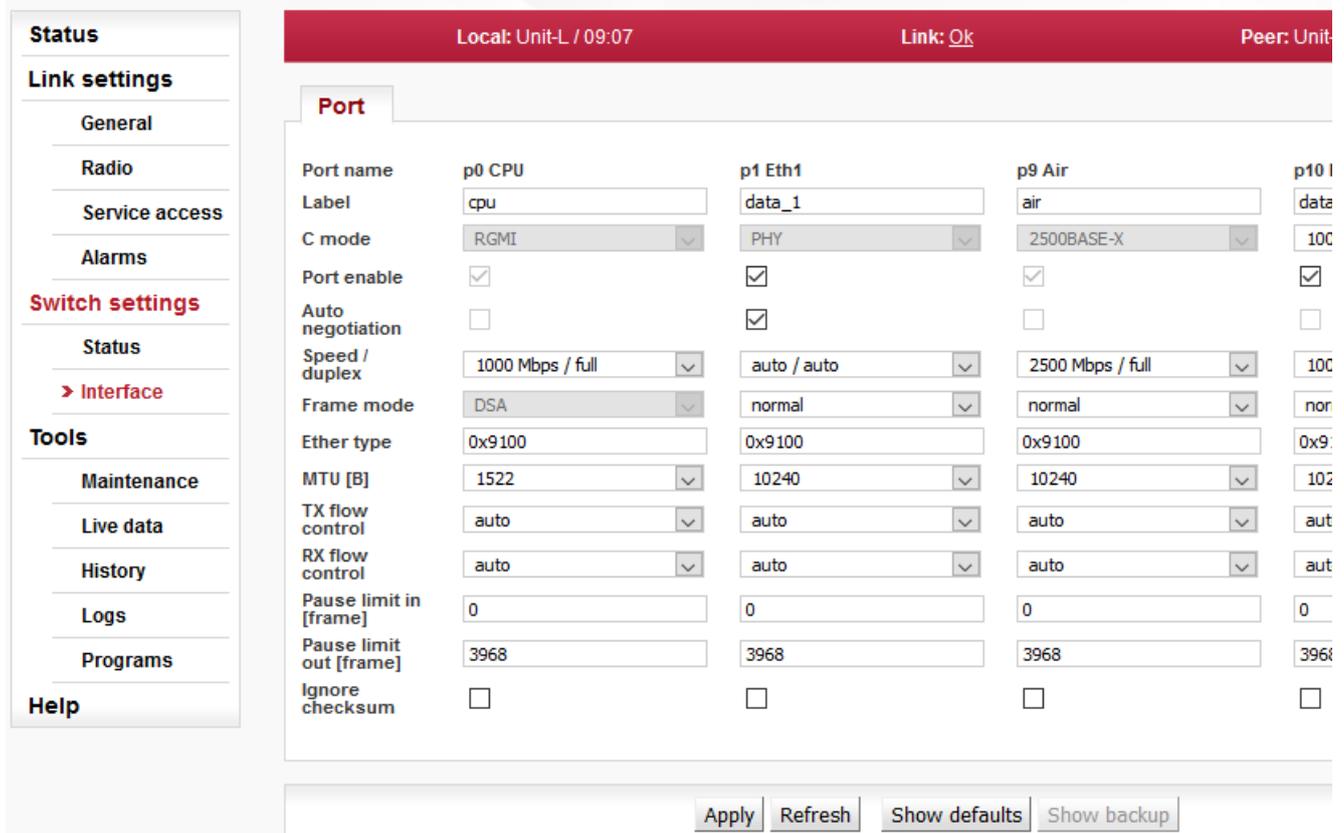
Fig. 5.19: Menu Switch settings / Port

Phyter is responsible for Ethernet signal conversion between wire (e.g. CAT7 cable) and internal switch bus.

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   The external port (with RJ45 interface) labeled "ETH1+POE". Port 2.

    Eth2   The external port (with SFP interface) labeled "ETH2". Port 4.

Link status   Ethernet link status can be

    down / type no link signal detected

    up / type   link signal detected

The type of the physical layer is indicated after the slash

    copper   metallic Ethernet interface

    SFP   SFP module can be either optic or metallic

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	–

Port enable The port can be enabled or disabled.

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

Auto negotiation Auto-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 the PHY 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 between the PHY and the MAC. 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 settings (i.e. without Auto-negotiation) the link operates in half-duplex mode. If the manual settings 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.

Flow control The flow control mechanism is handled by sending Pause frames to the connected device. There are several modes of Pause frames generation:

no pause	Pause frames disabled.
symmetric	Pause frames transmission and reception enabled.
asymmetric (send)	Pause frames transmission enabled, reception disabled.
asymmetric (receive)	Pause frames reception enabled, transmission disabled.

Auto-Negotiation has to be enabled to enable Pause frames sending and receiving.

Force flow control If the Auto-Negotiation is disabled and Flow control is required, the Force flow control parameter can be used. Flow control is turned on without having to be Auto-Negotiated

1000T master mode The 1000BASE-T master/slave mode can be manually configured.

auto	Automatic MASTER/SLAVE configuration.

master	Manual configure as MASTER.
slave	Manual configure as SLAVE.

Energy detect   The device can be placed in energy detect power down modes by selecting either of the two energy detect modes. Both modes enable the PHY to wake up on its own by detecting activity on the Ethernet cable. The energy detect modes only apply to the copper media.

In the first "sense" mode, if the PHY detects energy on the line, it starts to Auto-Negotiate sending FLPs (Fast Link Pulse) for 5 seconds. If at the end of 5 seconds the Auto-Negotiation is not completed, then the PHY stops sending FLPs and goes back to monitoring received energy. If Auto-Negotiation is completed, then the PHY goes into normal 10/100/1000 Mbps operation. If during normal operation the link is lost, the PHY will re-start Auto-Negotiation. If no energy is detected after 5 seconds, the PHY goes back to monitoring received energy.

In "sense pulse" mode, the PHY sends out a single 10 Mbps NLP (Normal Link Pulse) every one second. Except for this difference, this is identical to the previous mode (sense) operation. If the device is in *sense* mode, it cannot wake up a connected device; therefore, the connected device must be transmitting NLPs. If the device is in "sense pulse" mode, then it can wake a connected device.

off	Off
sense pulse	Sense and periodically transmit NLP (Energy Detect+TM).
sense	Sense only on Receive (Energy Detect).

5.6. Tools

5.6.1. Maintenance

Backup
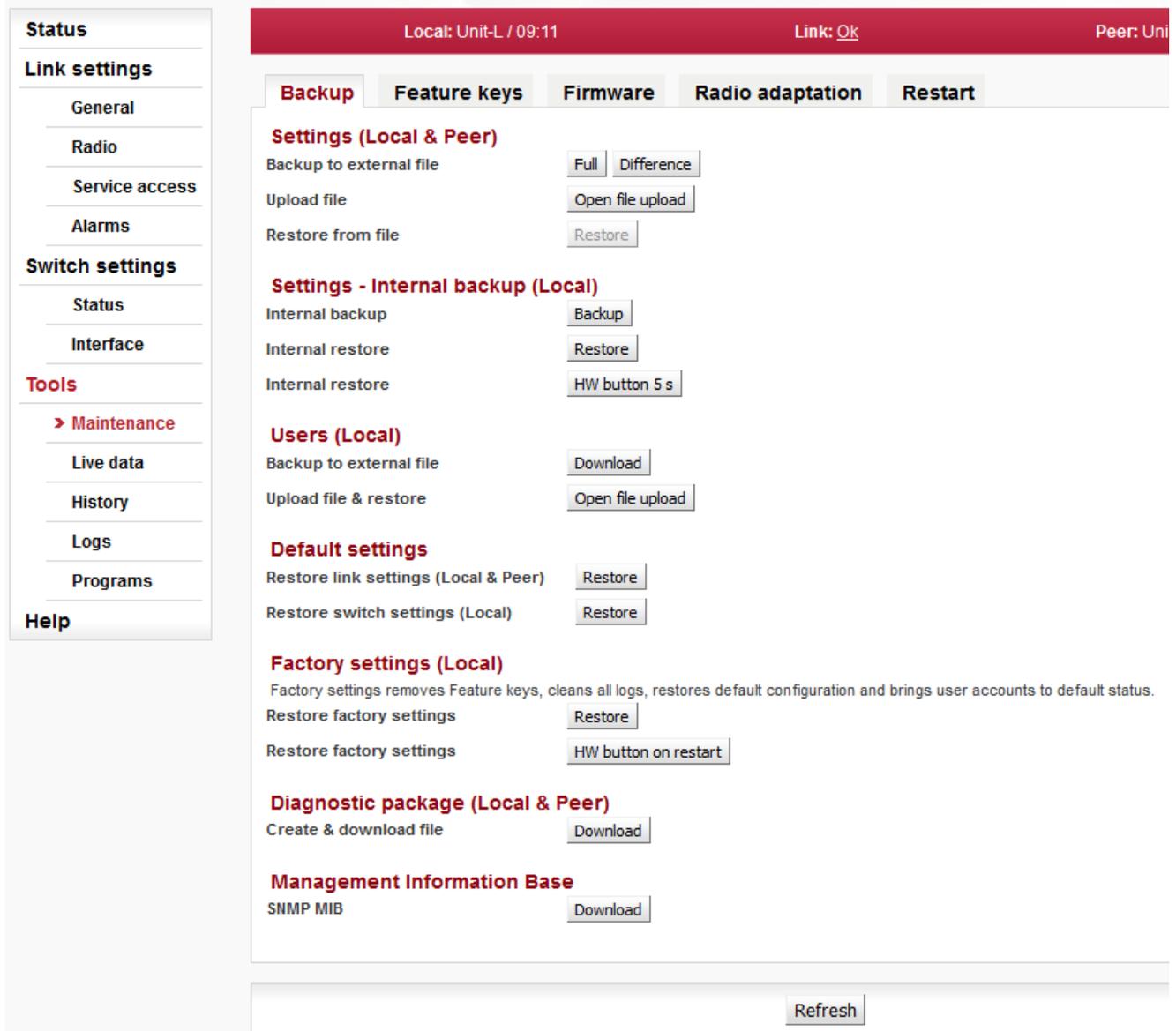
Fig. 5.20: Menu Tools / Backup

Settings (Local & Peer)	Saving and restoring unit configuration. User accounts are not affected by those functions.

Local	Peer	
O	O	Link
O	O	Switch
		Users

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)**

```
 L  P
 ┌─────────
 O │  L
───┼─
 O │  S
   │  U
```

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

		NOTE: The internal backup is deleted if factory settings or firmware upgrade are performed.
	Internal backup	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 DC connector within the port marked "P". 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)

```
 L  P
   │  L
───┼─
   │  S
 O │  U
```

Saving and restoring user accounts.

| | 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.
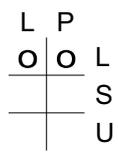
L P
O|O L
    S
    U
	Restore link
	settings
	(Local & Peer)
		Whole set of parameters from the *Link settings* menu tree is affected.
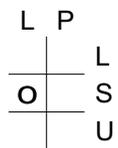
L P
    L
O   S
    U
	Restore switch
	settings (Local)
		Whole set of parameters from the *Switch settings* menu tree is affected.

Factory settings (Local)

L P O L O S O U		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. WARNING: This task takes a few minutes to complete. Do not interrupt the power supply during the operation.
	Restore factory settings	Applying Factory settings to Local unit. The unit reboots itself after applying all changes.
	Restore factory settings - HW button	It is possible to bring the unit to Factory settings by holding the hardware button depressed during unit's boot. The HW button is located next to the DC connector within the port marked "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. 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 rebooting the unit.

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.

	Create & download file	Saving a file with information about the unit (Local and Peer).
		NOTE: This task takes a few minutes to complete.

Management Information Base

	SNMP MIB	Provides Management Information Base table.

Feature keys

Fig. 5.21: Menu Tools / Feature keys

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

The feature keys limiting data transfer speed [Mbps] are now 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.
	Here are listed the keys used in both units. Feature keys of the Peer unit only, are displayed. They can be neither added, nor 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.
Limit	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. NOTE: The link radio parameters can be changed subsequently (e.g. to a different operating frequency)!
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
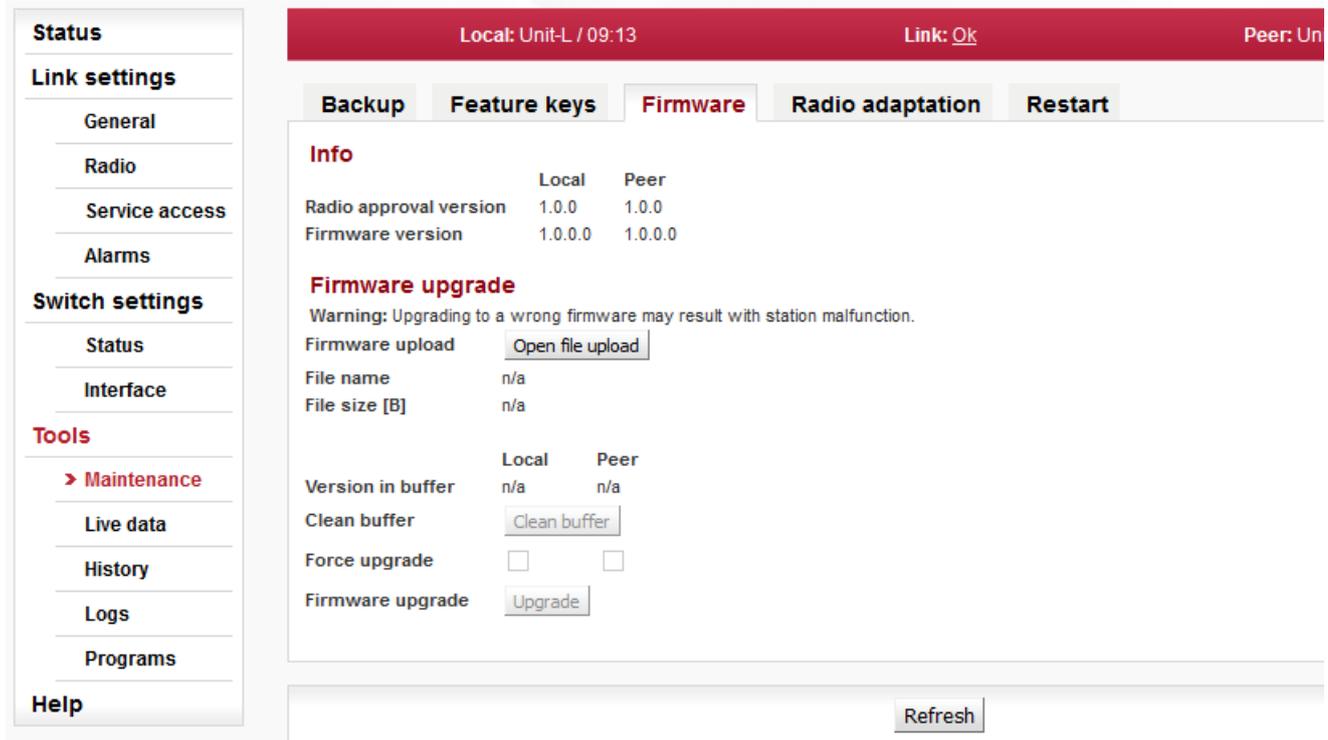
Fig. 5.22: Menu Tools / Firmware

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

Info

Firmware version	Information about the current firmware package version on the Local and Peer units.
Radio firmware version	Information about the radio board current firmware version on Local and Peer unit.
Radio configuration version	Radio board calibration data format version.
Hardware version	Information about the HW version of the modem board.
Radio hardware version	Information about the HW version of the radio board.

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.

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 probably bricks your unit.
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
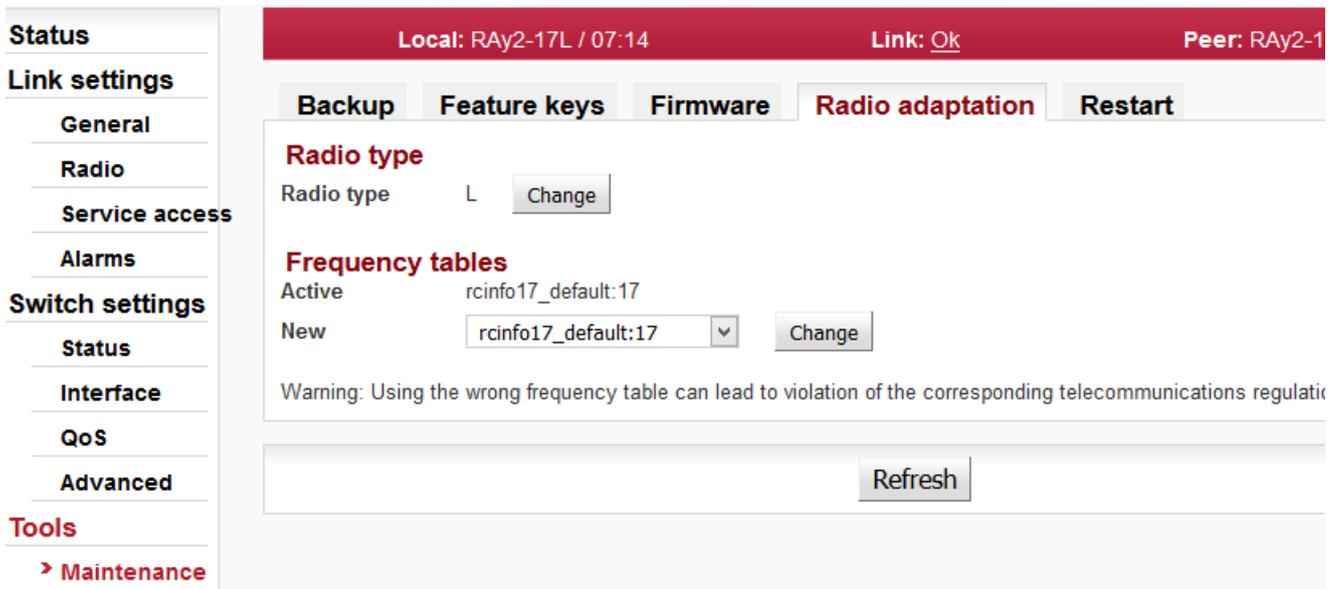
Fig. 5.23: Menu Tools / Radio adaptation

Radio type IMPORTANT: Applies only for RAy2-17 and RAy2-24 links.

Hardware of these links is universal for the entire frequency band. To facilitate the configuration of radio parameters, units are coded for L (Lower) and U (Upper) part of the band. L or U band assignment can be modified.

Radio type Radio unit type: L (Lower) or U (Upper) part of the frequency band. Use the Change button to change the radio type.

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.

New Select a new frequency table. Available tables are displayed in format <name:version>. Use the Change button to change the table. The following dialog appears, e.g.:

WARNING: This change will only affect the Local station.
The station reboots and radio parameters may get changed.

Warning

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

Restart

Fig. 5.24: Menu Tools / Restart

Target   Restart of selected unit, Local or Peer.

Restart mode   Warm   Reboot management system.

Cold   Restart the whole station as if power was removed.

System restart   Performs the selected restart.

5.6.2. Live data

Bar indicators
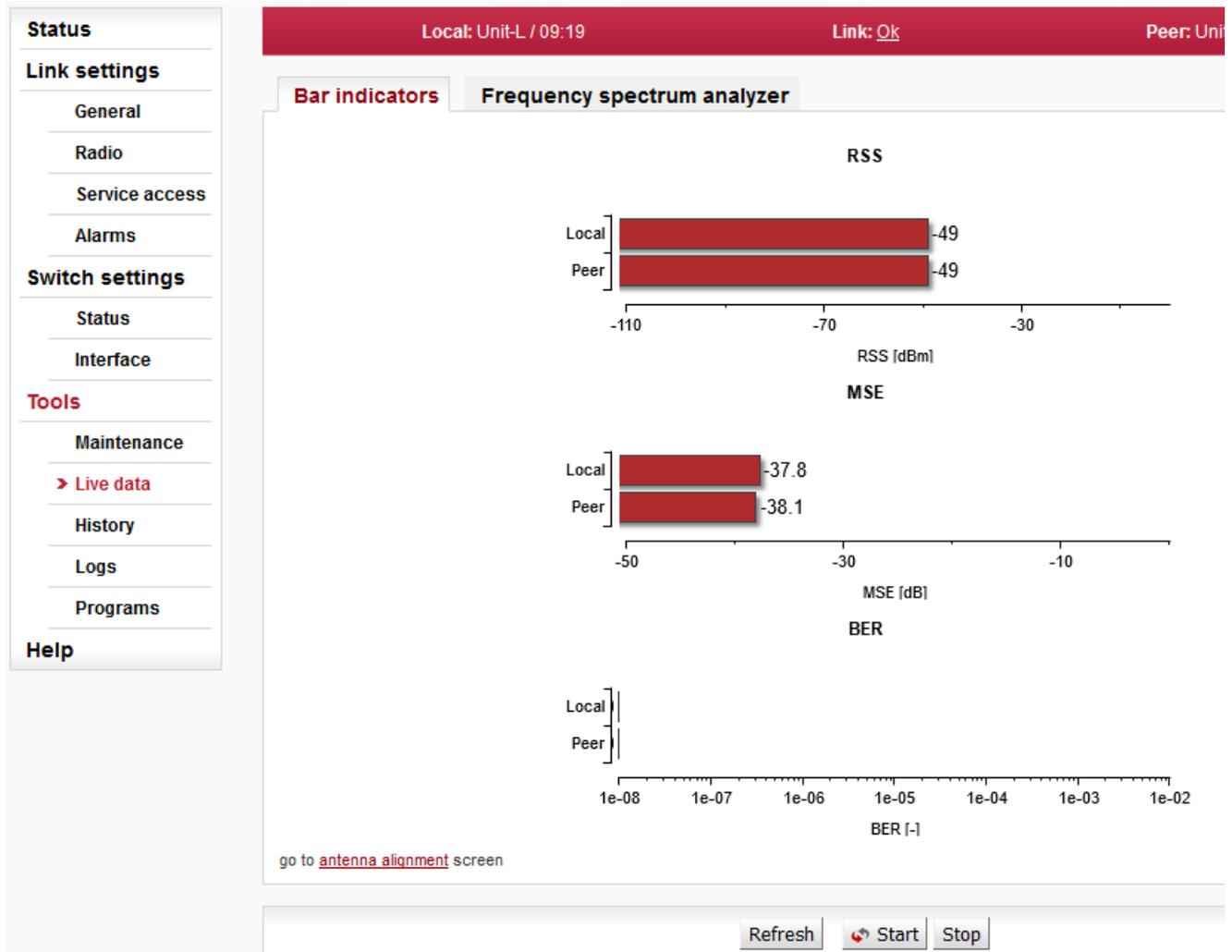
Fig. 5.25: Menu Tools / Bar indicators

Graphical indication of BER, SNR and RSS.

Refresh	One-time update of displayed values.
Start, Stop	Use the Start button to start automatic update of displayed values with a period of 1 second. Use the Stop button to stop it.

Antenna Alignment Tool

The Antenna Alignment Tool supports interactive antenna alignment. RSS and SNR are displayed for both local and peer unit. A selected value can be indicated in large font and acoustically. Values are refreshed 10x 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. 5.26: Ray Tools

Red strip (top of the page)	**+**	Increases the number of displayed parameters
	x	Decreases the number of displayed parameters
	text	Local Station name (e.g. RAy2-17L)
Link	3.5 MHz	Channel width
	Ok	Link connected (green icon). The Peer values (see below) are visible when the connection between Local and Peer unit has been established.
Local, Peer	QPSK	Current modulation of the Tx signal
	ACM, ATPC	Status of ACM + ATPC (red colour warns ACM or ATPC is enabled).
Go to unit management		Link to the full configuration interface of the microwave unit; user authentication is required.
-71.8		Actual RSS [dBm] or SNR value. The selected value is chosen by clicking/tapping on the respective value below the main display.
Exclamation icon !		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.
Icon of speaker		Acoustic indication for local RSS value ON/OFF. The TONE or BEEP signal is supplemented with voice output every 10 seconds, notifying signal strength.
TONE / BEEP		Select the sound generated.
		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.
COARSE / FINE		Choose the scale of acoustic indication

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, SNR   Values RSS and SNR 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
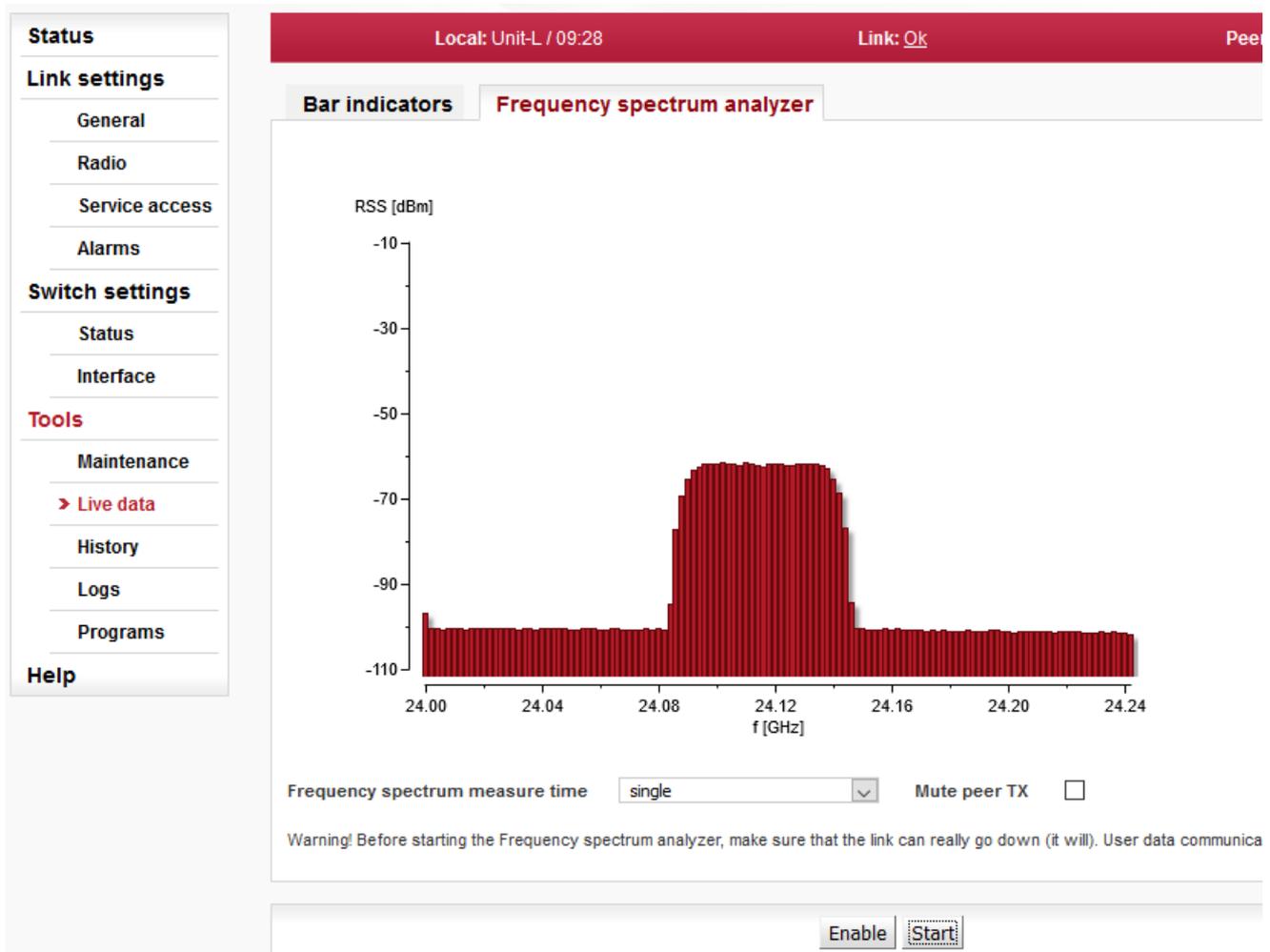
Fig. 5.27: Menu Tools / Frequency analyzer

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 7MHz channel resolution. The accuracy of measured results is given by the accuracy of measuring RSS.

Warning

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

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.

After using the analyzer visit 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.
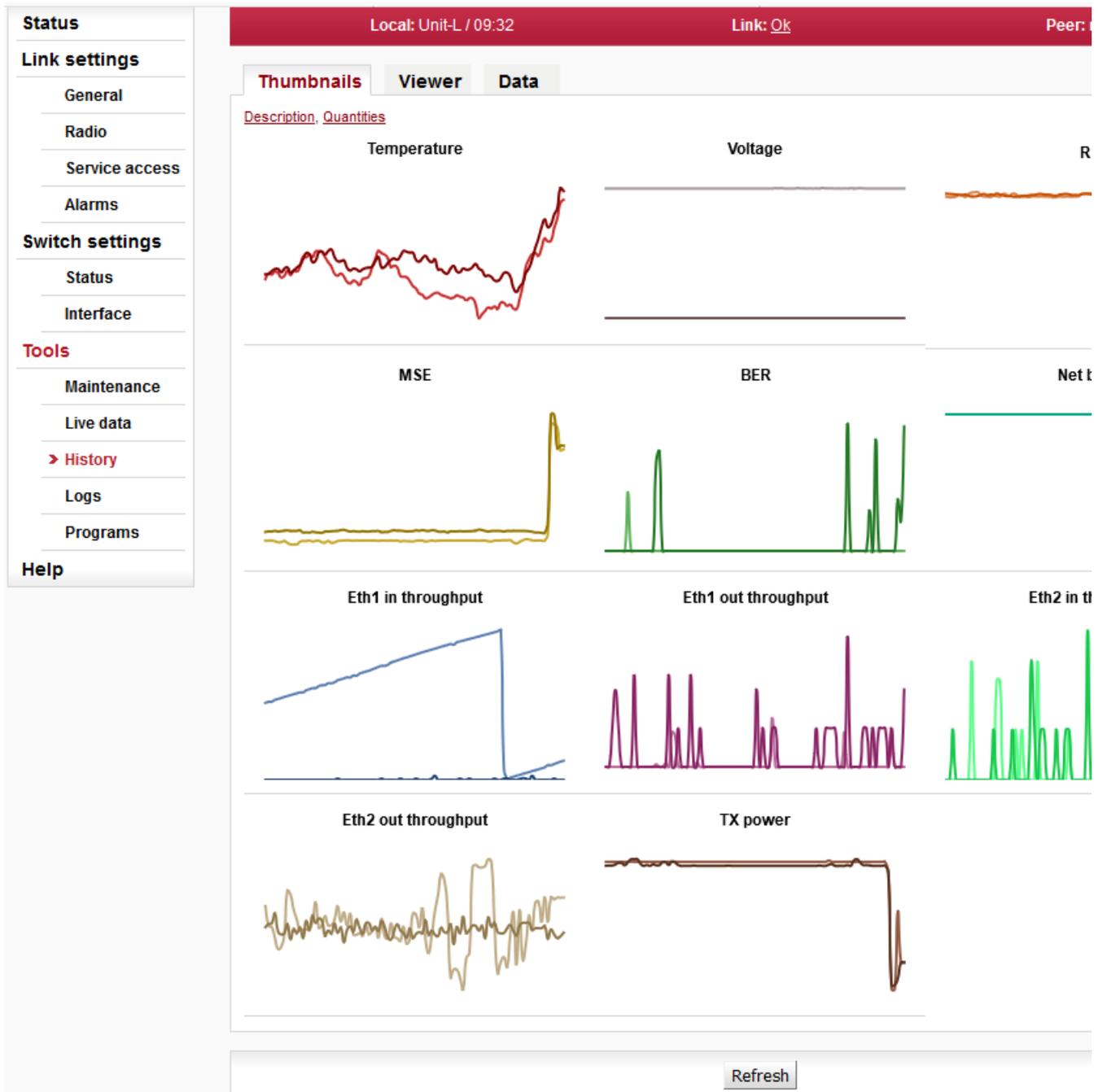
Fig. 5.28: Menu Tools / History / Thumbnails

Temperature	Instantaneous value of temperature inside the unit. Measured on the modem board. Temperature of radio board is available via SNMP.
Voltage	Instantaneous value of unit supply voltage.
RSS	Received signal strength.
SNR	Signal-to-noise ratio of the received signal.
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.
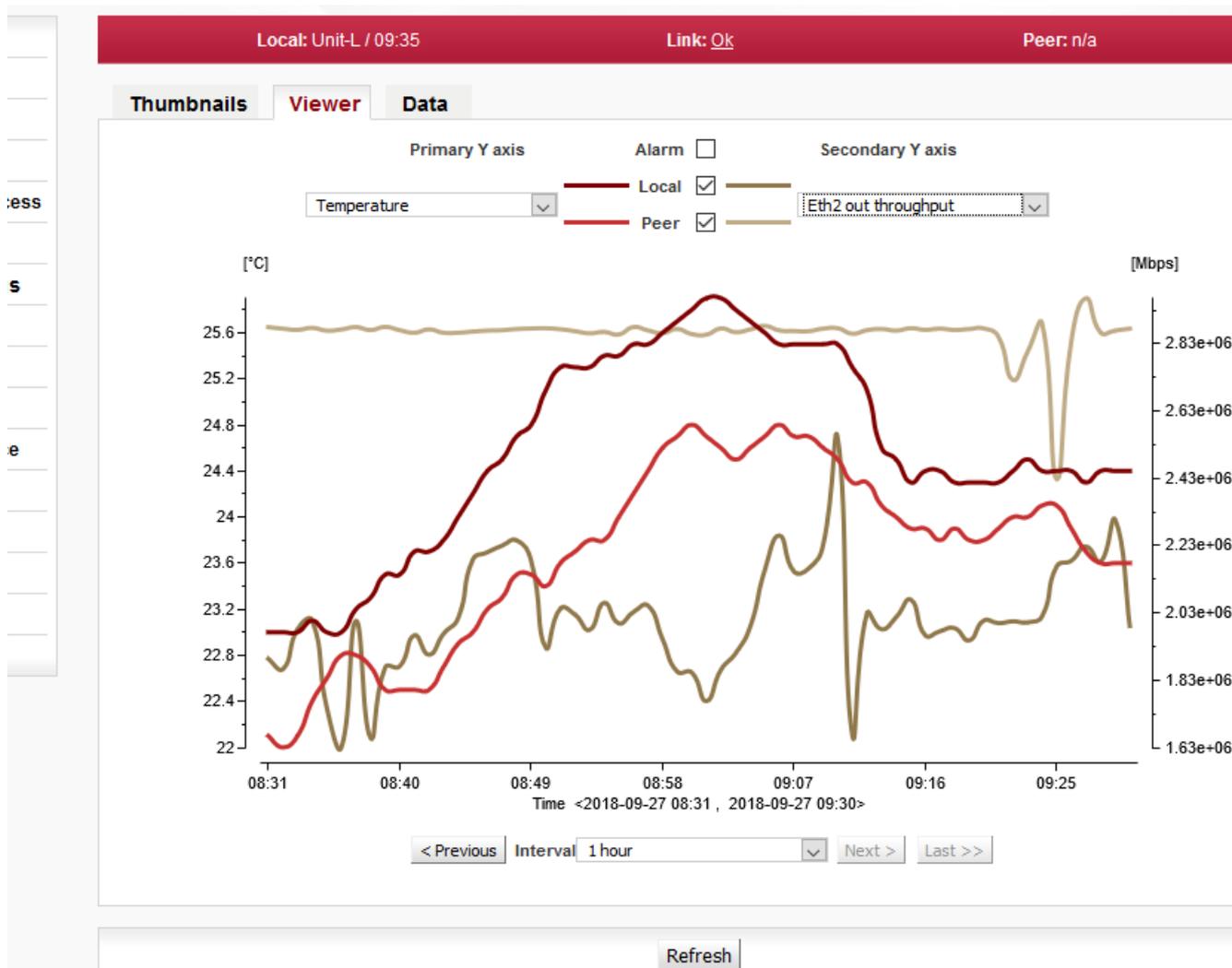
Fig. 5.29: Menu Tools / History / Viewer

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, SNR, BER, Net bitrate, Ethernet in throughput, Ethernet out throughput, TX power

Secondary Y axis Selecting a second value:

None

Temperature, Voltage, RSS, SNR, 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. 5.30: 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.

5.6.4. Logs

Shows internal unit logs. Individual tabs allow total or filtered view.
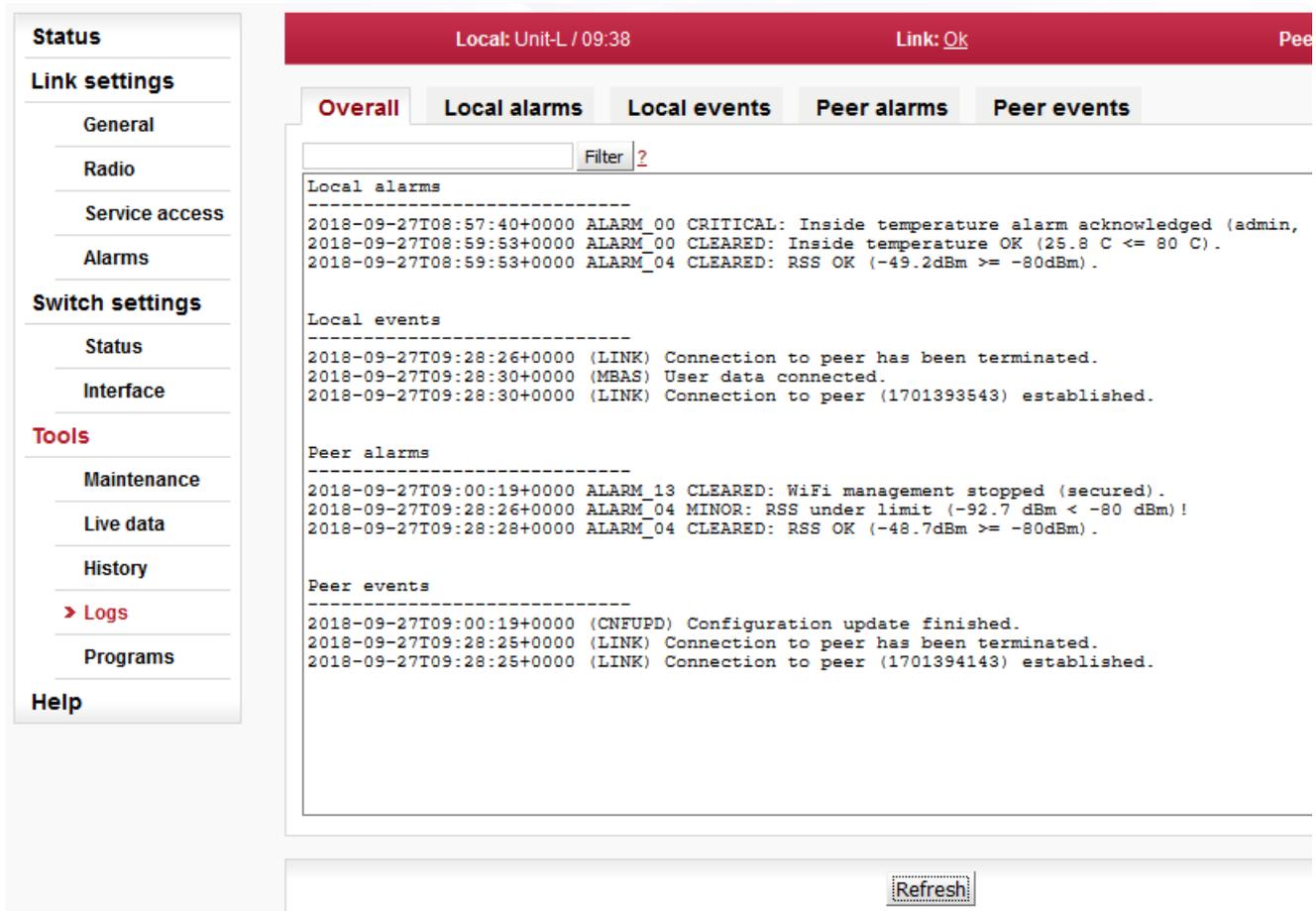
Fig. 5.31: Menu Tools / Logs

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 of CLI interface is needed.

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. You can enter text in the upper left corner window for filtering listings. For example, you want to know when the configuration of the unit was modified: On the Local events screen, enter `Configuration` and hit Enter.
	You can use plain text or regular expressions for filtering (JavaScript format).

5.6.5. Programs

Ping

The Ping tool allows sending ICMP pings to a selected address

Fig. 5.32: Menu Tools / Programs / Ping

Start the test by clicking on *Send*. The result is displayed in the text window.

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. The period for sending pings is constant: 1000 ms.

CLI

Web interface for executing non-interactive scripts and programs.
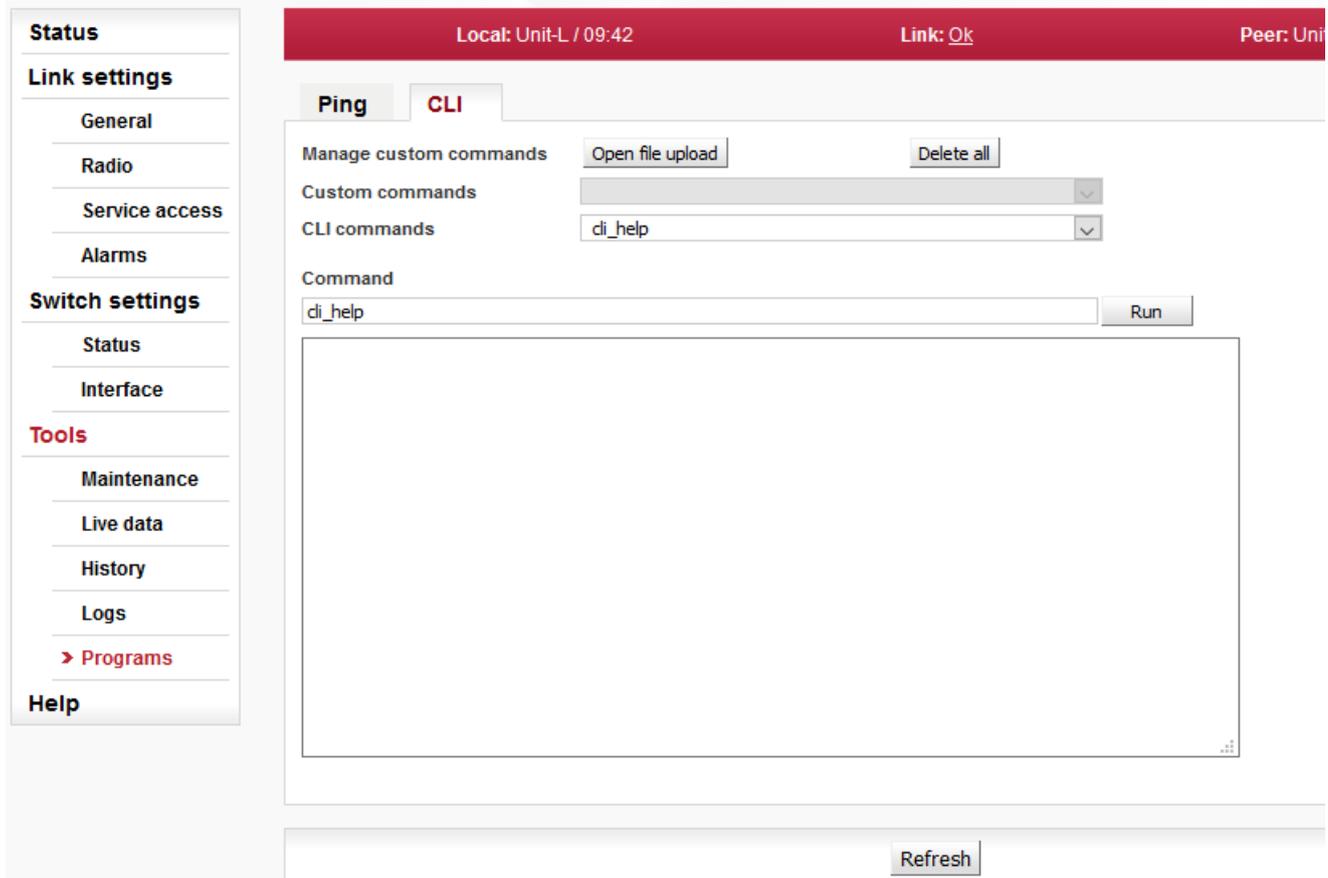
Fig. 5.33: Menu Tools / Programs / CLI

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.
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**

```sh
#!/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
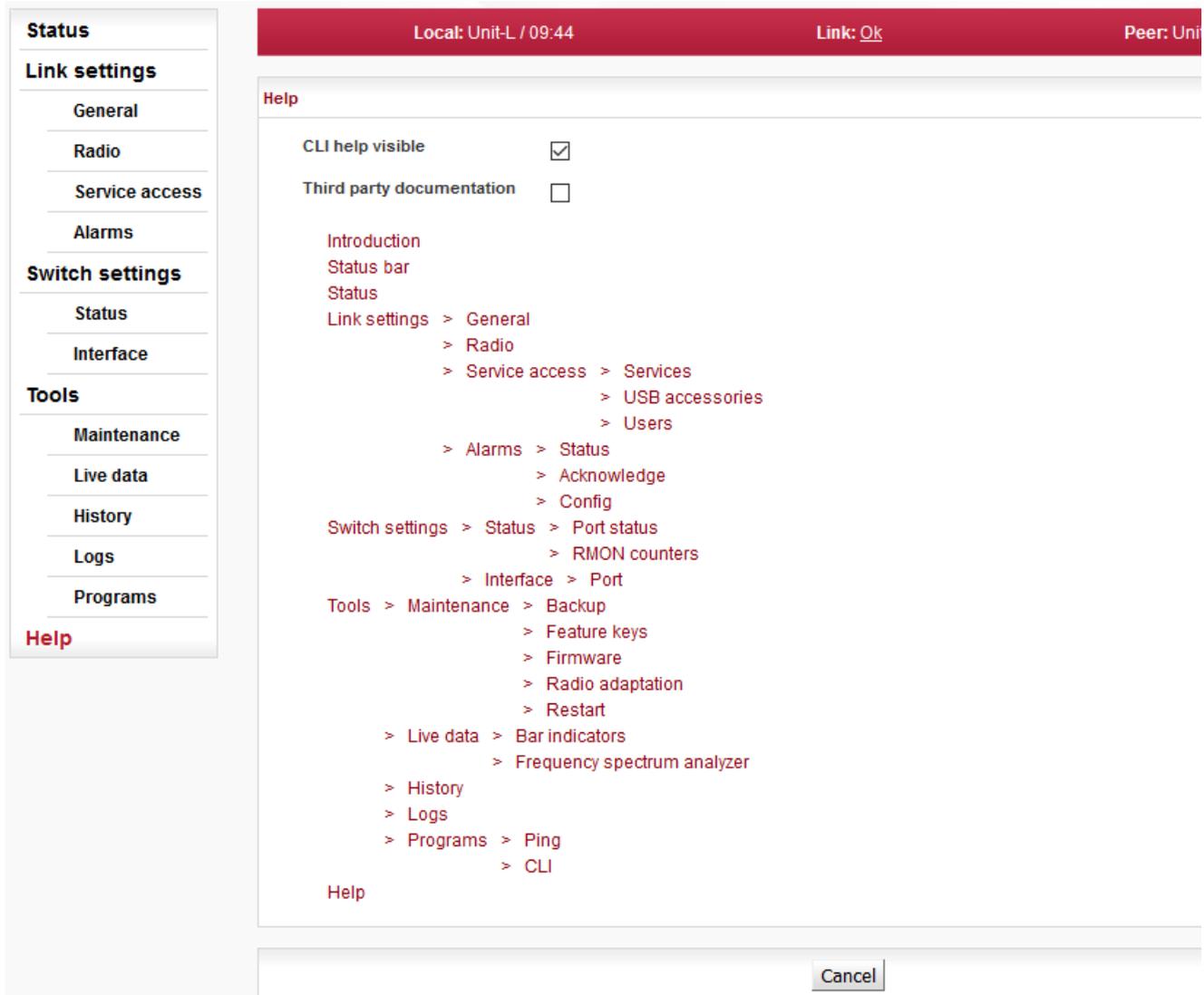
Fig. 5.34: Help menu

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. 5.35: Parameter help

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

Fig. 5.36: 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:
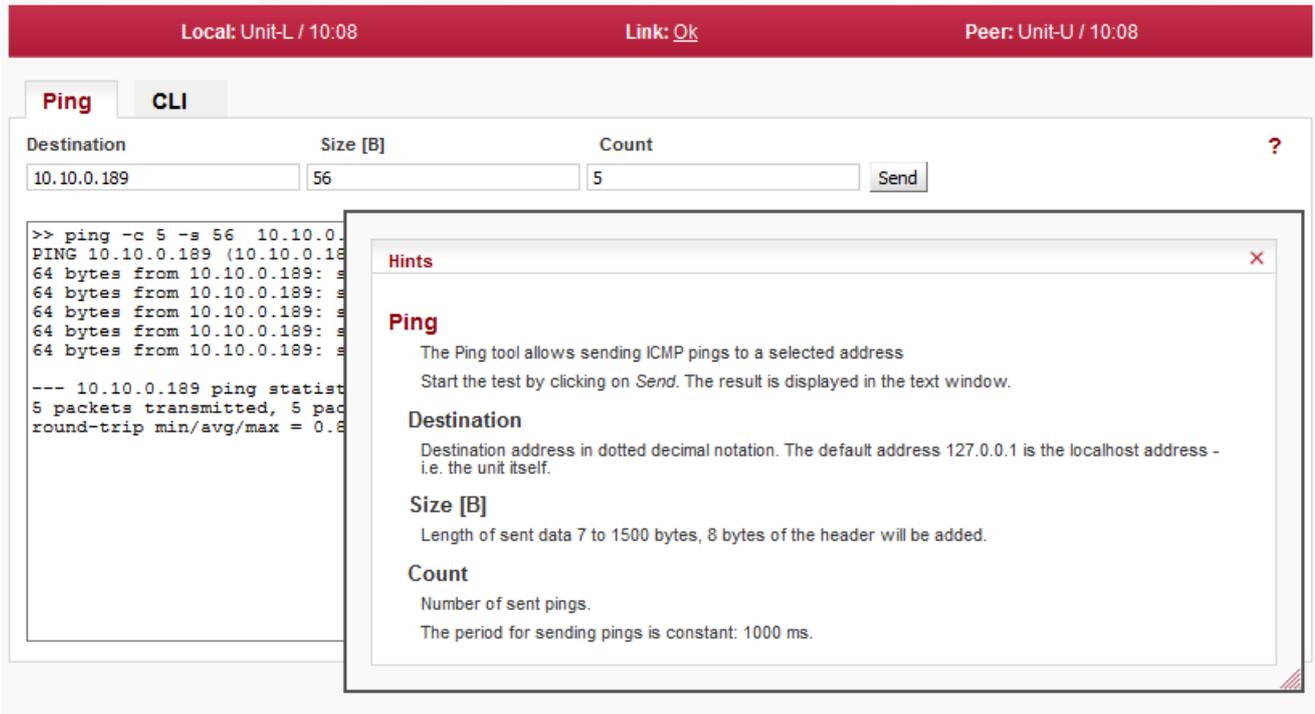
Fig. 5.37: Summary help

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 an 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:

`source /etc/profile;`	environment settings
`cli_info_link;`	query for link status
`echo \$?;`	reading return value
`cli_cnf_show	grep TX_PWR;`	query for radio power
`echo \$?`	reading return value
`cli_info_link: Link status:up`	return value
`0`	OK command
`RADIO_TX_PWR=4`	power +4 dBm
`0`	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 it 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 l`).

- 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 SNR for fast antenna alignment
○ Link Management – standard web based unit management
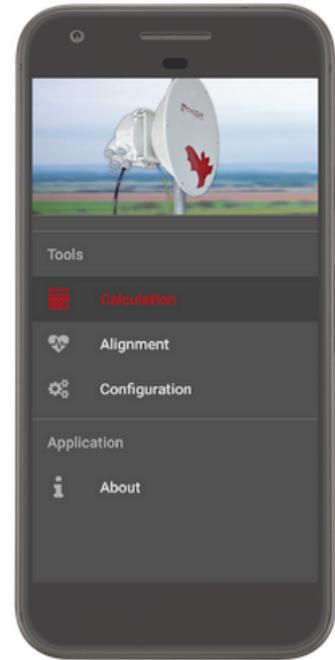
7.1. Menu options

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)
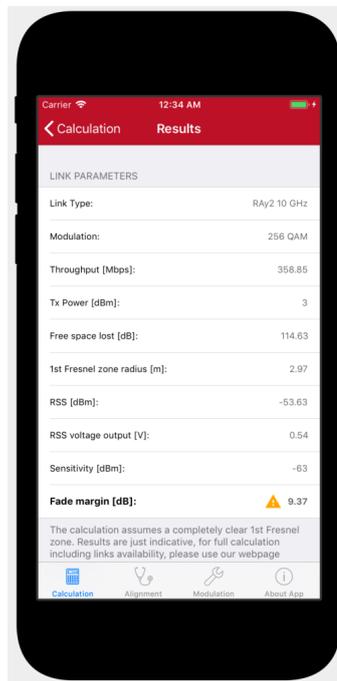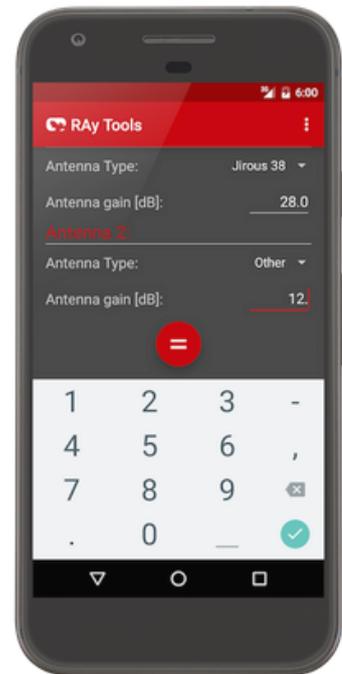
iOS version   Android version

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 *http://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.
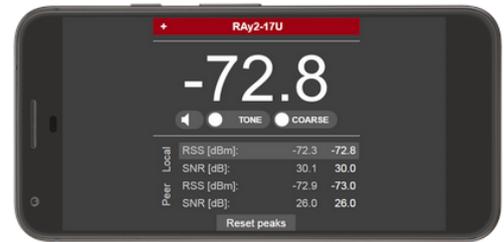
Configuration

Links to web management of RAy unit. User authentication is required.
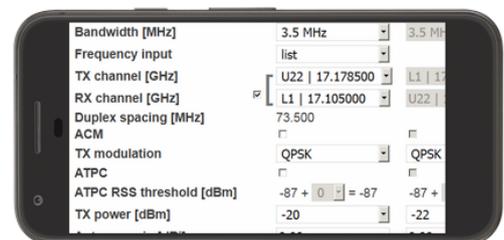
About

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*), iOS version is available for download on AppStore (*https://www.apple.com/ios/app-store*) 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 analyse the problem. It will not be used in any other way by Apple, Google, Firebase or RACOM.

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.

- **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.

- **RSS**

  To configure the link and monitor its state, several menus display the RSS signal strength. 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 ± 2dB, the absolute RSS value should not be used for accurate comparisons e.g. between two links.

- **Problem with https certificate**

  See the Appendix C, *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).

9. Technical parameters

9.1. General parameters

9.1.1. Overview

Tab. 9.1: Parameters 1

RAy3		Technical parameters 1	
Type		RAy3-17[1]	RAy3-24
Band	[GHz]	17.1 – 17.3	24.0 – 24.25
ODU units		One universal unit	
Bandwidth	[MHz]	3.5, 5, 7, 10, 14, 20, 28, 40, 56, 80, 100, 112	
Channels gap	[MHz]	Flexible, min. 24 MHz between channel edges or 18 MHz in case of 2 x 112 MHz Bandwidth	
User data speed	[Mbps]		2.7 – 1002
			detail
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 (2.7 Mbps) -52 (1002 Mbps)
			detail
Output Power	[dBm]		-30 .. +10
ATPC			yes
Consumption	[W]		22.5
Weight	[kg]		2.6

[1] Pending

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Tab. 9.2: Parameters 2

RAy3	Technical parameters 2
Modulation	QPSK_S, QPSK, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096 QAM
ACM	yes
Forward Error Corr.	LDPC, RS
User interface RJ45	1 Gb Eth. (10/100/1000) 1000BASE-T, MTU 10240 B[2)], 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 B[1)], user exchangeable SFP, power consumption max. 1.25 W
Service	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
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
Antenna	LEAX-RAy, Class3, 30–120 cm, direct mounting (or others, e.g. Jirous)
Spectrum	EN 300 440 V 2.2.1
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	CFR 47 part 15, pending

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[2)] MTU 10240 bytes is pending. Currently produced units (RAy3-24S) are limited to MTU 2048 bytes.

9.1.2. Link speed

Tab. 9.3: Link speed and RSS

RAy3	Radio parameters – Bit Rate / RSS										
Band width	Modulation										
	QPSK _S	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	10	11	15	17	19	21	23		
	-99	-94	-88	-85	-82	-79	-76	-73	-69		
5	3.8	7.1	14	16	21	25	28	31	33		
	-97	-93	-87	-84	-81	-78	-75	-72	-69		
7	5.8	10.5	20	24	31	37	42	47	52	57	
	-95	-92	-86	-83	-80	-77	-74	-71	-67	-63	
10	7.9	14.4	27	33	42	50	57	64	71	78	
	-93	-90	-85	-81	-78	-75	-72	-69	-66	-62	
14	11.9	22.2	41	50	65	77	88	98	109	119	128
	-92	-89	-83	-80	-77	-74	-71	-68	-65	-61	-57
20	17.2	32.0	60	72	94	111	127	142	158	171	185
	-91	-87	-82	-78	-75	-72	-69	-66	-63	-60	-57
28	24.3	38.5	81	105	132	157	181	202	227	249	269
	-91	-88	-81	-77	-74	-71	-68	-65	-62	-59	-56
40	34.0	53.9	113	148	185	220	253	283	318	348	377
	-89	-86	-79	-75	-72	-69	-66	-63	-60	-57	-54
56	48.7	81.1	169	213	268	319	366	414	459	501	540
	-88	-84	-77	-73	-70	-67	-64	-61	-58	-55	-52
80	69.3	115.4	240	303	381	454	521	589	653	713	
	-86	-83	-76	-72	-69	-66	-63	-60	-57	-54	
100	86.6	144.5	299	381	479	569	653	736	820	895	
	-85	-82	-75	-71	-68	-65	-62	-59	-56	-53	
112	97.0	161.8	334	426	537	637	731	824	918	1002	
	-85	-81	-74	-70	-67	-64	-61	-58	-55	-52	

Bit Rate   [Mbps]
RSS   [dBm]

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Tab. 9.4: Link speed according to RFC 2544

RAy3	Link speed [Mbps] for frames 64 - 1518 B										
Band width	Modulation										
MHz	QPSK_S	QPSK	16 QAM	32 QAM	64 QAM	128 QAM	256 QAM	512 QAM	1024 QAM	2048 QAM	4096 QAM
3.5							14.3 / 18.5		19.0 / 18.5		
5									28.6 / 30.8		
7										52.4 / 55.5	
10										71.4 / 74.0	
14											119.0 / 123.4
20											171.6 / 178.9
28							166.7 / 178.9				252.0 / 265.2
40											351.6 / 370.2
56							342.2 / 363.9				507.9 / 536.6
80										666.7 / 709.3	
100							609.5 / 647.6			761.9 / 888.2	
112							680.9 / 728.1			761.9 / 987.0	

Link speed for frames 64 B   [Mbps]
Link speed for frames 1518 B   [Mbps]

FCC comment

Choice of modulation must respect the requirements of Section *Section 10.8, "FCC authorization of transmitters"* .

9.1.3. ACM switching

Tab. 9.5: *ACM switching* **according to MSE state**

RAy3		MSE degrade / improve [dB]									
Band width		Modulation									
	QPSK_S	QPSK	16 QAM	32 QAM	64 QAM	128 QAM	256 QAM	512 QAM	1024 QAM	2048 QAM	4096 QAM
MHz											
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	--	

Mean Square Error degrade   [dB]
Mean Square Error improve   [dB]

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9.2. RAy3-24 parameters

9.2.1. Upper/Lower Limits

Tab. 9.6: Frequency limits

RAy3-24	Band Range [GHz]	
	Unit L	Unit U
min	24.004	24.004
max	24.246	24.246

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9.2.2. Radio parameters

The table is located on the next page.

Tab. 9.7: Radio parameters, BER = 10^{-6}

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User Bit Rate	[Mbps]	
RSS (Received Signal Strength) for BER 10^{-6}	[dBm]	
MSE (Mean Square Error) for BER 10^{-6}	[dB]	

RAy3-24	Radio parameters – Bit Rate / RSS / MSE										
Band width	Modulation										
MHz	QPSK_S	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	11.4	14.6	17.2	19.4	21.5	23.1		
	-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		
5.0	3.8	7.1	13.6	16.3	20.9	24.5	27.7	30.6	32.9		
	-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		
7.0	5.8	10.5	20.0	24.1	30.8	36.7	41.8	46.5	51.7	56.9	
	-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	
10.0	7.9	14.4	27.5	33.2	42.4	50.5	57.4	63.9	71.1	78.2	
	-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	
14.0	11.9	22.2	41.3	50.0	64.9	77.1	87.9	98.4	109.4	118.7	128.2
	-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
20.0	17.2	32.0	59.5	72.1	93.5	111.1	126.7	141.9	157.7	171.2	184.9
	-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
28.0	24.3	38.5	81.0	105.4	131.9	157.4	180.5	202.5	227.0	248.8	269.1
	-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
40.0	34.0	53.9	113.5	147.5	184.7	220.3	252.7	283.4	317.8	348.3	376.7
	-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
56.0	48.7	81.1	168.6	213.1	267.7	319.3	366.2	414.0	459.2	501.1	540.2
	-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
80.0	69.3	115.4	239.9	303.3	380.9	454.4	521.1	589.1	653.4	713.0	
	-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	
100.0	86.6	144.5	298.6	380.9	479.4	568.7	652.5	735.7	820.2	895.1	
	-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	
112.0	97.0	161.8	334.3	426.5	536.7	636.6	730.5	823.6	918.2	1002.1	
	-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. Frequency tables

Tab. 9.8: 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_FCC200	24.050 - 24.250 GHz	FCC compliant channel configuration
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. Frequency

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.

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

RAy2-24	24.000 – 24.250 GHz		+10 dBm RF power	
			Distance where the FCC limits is met for	
Antenna code	Parabolic antenna	Gain G [dBi]	General Population / Uncontrolled Exposure [cm]	Occupational / Controlled Exposure [cm]
JRMB – 400 – 24Ra	ø 400 mm	36.8	70	30
JRMB – 680 – 24Ra	ø 680 mm	41.7	120	60
JRMB – 900 – 24Ra	ø 900 mm	44	150	70
JRMB – 1200 – 24Ra	ø 1200 mm	46	200	90

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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) and 2012/19/EU WEEE (Waste Electrical and Electronic Equipment) environmental directives.

WEEE compliant

Used equipment must be collected separately, and disposed of properly. Racom has instigated a programme to manage the reuse, recycling, and recovery of waste in an environmentally safe manner using processes that comply with the WEEE Directive.

Battery Disposal - This product may contain a battery. Batteries must be disposed of properly, and may not be disposed of as unsorted municipal waste within the European Union. See the product document-ation for specific battery information. Batteries are marked with a symbol, which may include lettering to indicate cadmium (Cd), lead (Pb), or mercury (Hg). For proper recycling, return the battery to your supplier or to a designated collection point.

10.5. Liability for Defects and Safety Instructions

Please read these safety instructions carefully before using the product:

10.5.1. Ownership of product rights

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.

10.5.2. Conditions of use

Equipment mentioned in this operator manual may only be used in accordance with instructions contained in this manual. Error-free and safe operation of this equipment is only guaranteed if this equipment is transported, stored, operated and controlled in the proper manner. The same applies to equipment maintenance.

10.5.3. Limitation of responsibility

In order to prevent damage to the radio modem and other terminal equipment the supply must always be disconnected upon connecting or disconnecting the cable to the radio modem data interface. It is necessary to ensure that connected equipment has been grounded to the same potential.

Under no circumstances is RACOM or any other company or person responsible for incidental, acci-dental or related damage arising as a result of the use of this product. RACOM does not provide the user with any form of guarantee containing assurance of the suitability and applicability for its application.

10.5.4. Product changes

The radio equipment can only be operated on frequencies stipulated by the body authorised by the radio operation administration in the respective country and cannot exceed the maximum permitted output power. RACOM is not responsible for products used in an unauthorised way.

10.5.5. RACOM Open Software License

RACOM Open Software License

Version 1.0, November 2009
Copyright (c) 2001, RACOM s.r.o., Mírová 1283, Nové Město na Moravě, 592 31

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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.

10.7. EU Declaration of Conformity

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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Fig. 10.1: EU Declaration of Conformity for RAy3-24

10.8. FCC authorization of transmitters

FCC verification

RAy2-11 and RAy2-18-C were verified for compliance according to CFR 47 part 101 [see §101.139(a)].

FCC comment -
according to §101.141 and considering the low spectral efficiency the following modulations are not allowed in RAy2-11:

Bandwidth	Modulation
2.5 MHz	QPSK
3.75 MHz	QPSK
5 MHz	QPSK
10 MHz	QPSK, 16-QAM, 32-QAM
30 MHz	QPSK
40 MHz	QPSK

Except during anomalous signal fading. During anomalous signal fading, licensees may adjust to a modulation specified in their authorization if such modulation is necessary, to allow the licensees to maintain communications, even if the modulation does not comply with the capacity and loading requirements -101.141 (3).

FCC compliance

RAy2-24 complies with CFR 47 part 15.

Code	FCC part	FCC ID
RAy2-24	15	SQT-RAY2-24

10.9. Country of Origin Declaration

RACOM
RADIO DATA NETWORKS

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
RAy2-10	Unit RAy2-10, 2× Gb Eth
RAy2-11	Unit RAy2-11, 2× Gb Eth
RAy2-17	Unit RAy2-17, 2× Gb Eth
RAy2-18	Unit RAy2-18, 2× Gb Eth
RAy2-24	Unit RAy2-24, 2× Gb Eth

Nove Mesto na Morave, 10 of June 2016
Jiri Hruska, CEO

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ver. 1.2

www.racom.eu

Fig. 10.2: Country of Origin Declaration

Appendix A. Antenna dimensions

Example antenna's diameter of 68 and 90 cm. More on *www.racom.eu*[1].
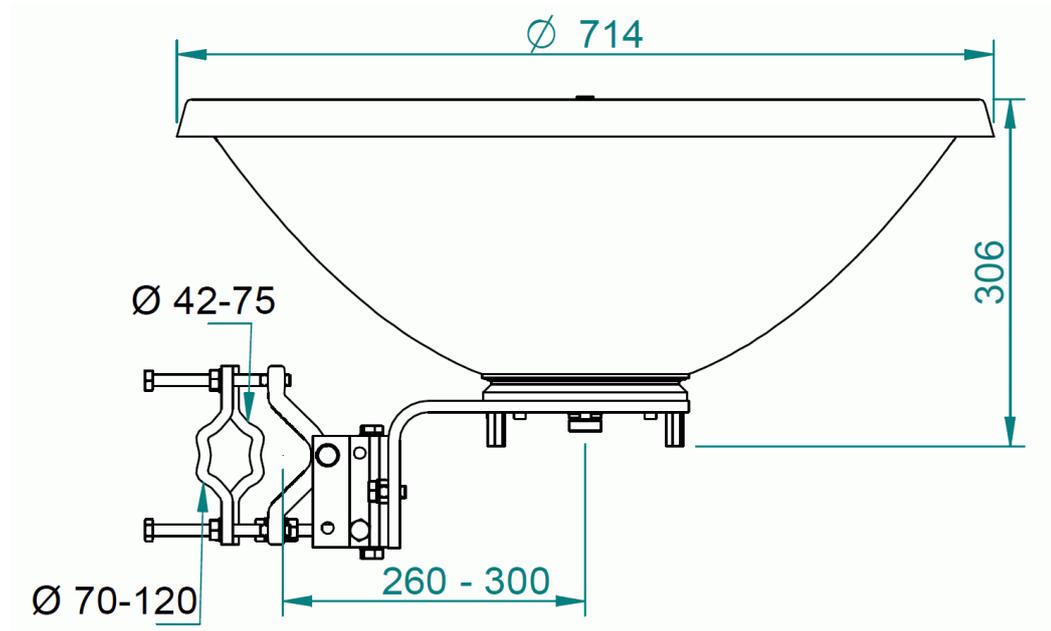

Fig. A.1: Jirous antenna 68
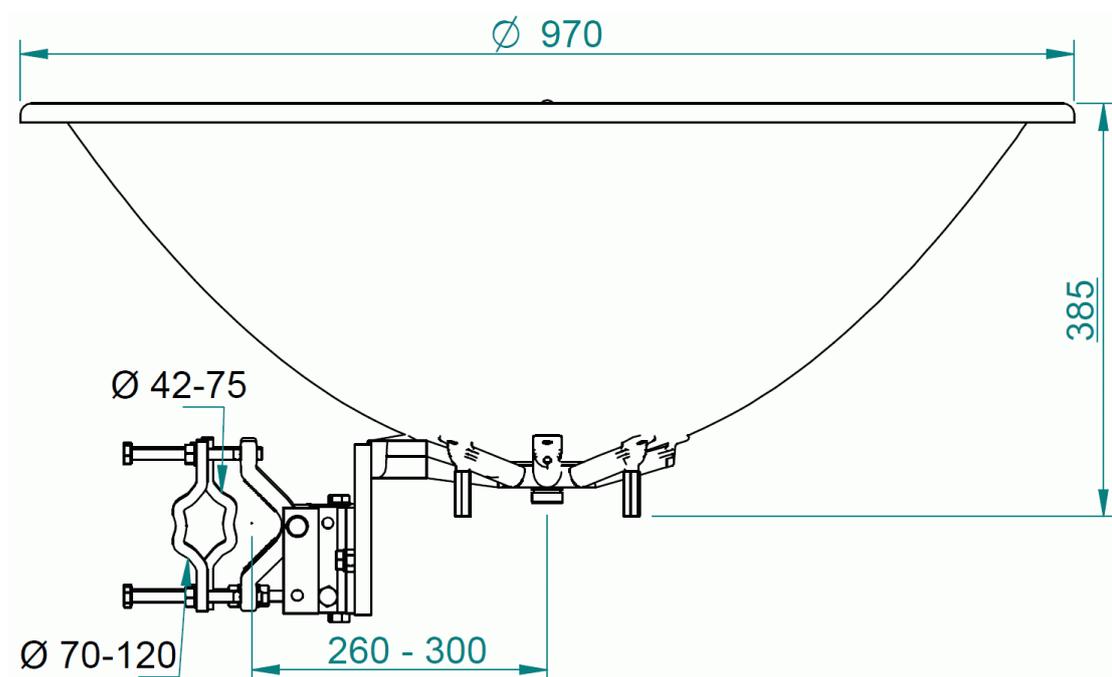
Fig. A.2: Jirous antenna 90

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[1] http://www.racom.eu/eng/products/microwave-link.html#download

Appendix B. 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.

RAy3 Microwave Link – © RACOM s.r.o.

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.
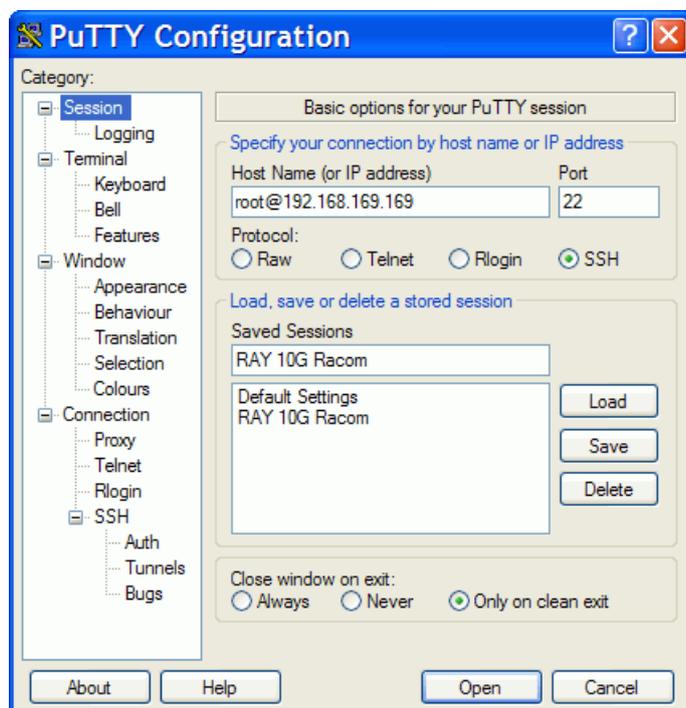
Go to "Connection / SSH / Auth" in the left column and locate the key C:\downloads\ray.ppk
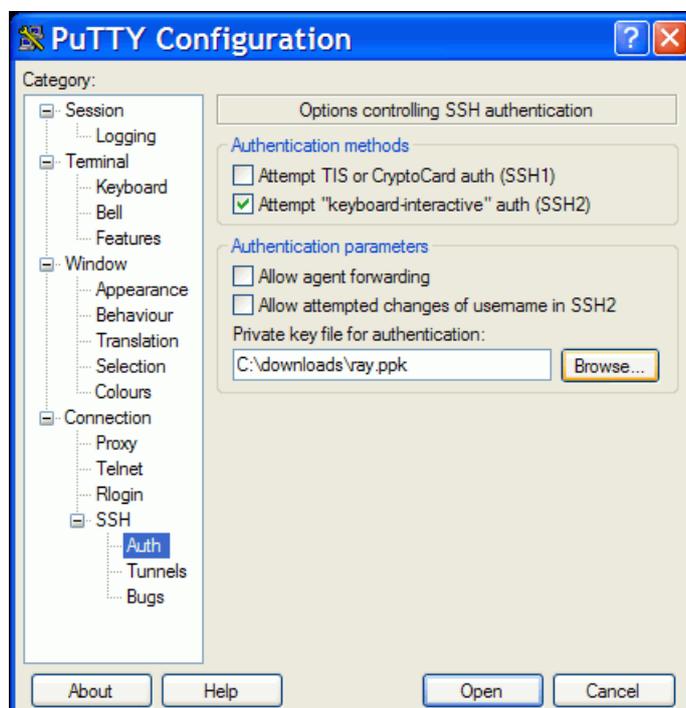
Go back to "Session" and Save the configuration.

To connect select the name of the connection and click Open. PuTTY asks for password created during key conversion.

Appendix C. 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 D. Unit block diagrams

Unit overview
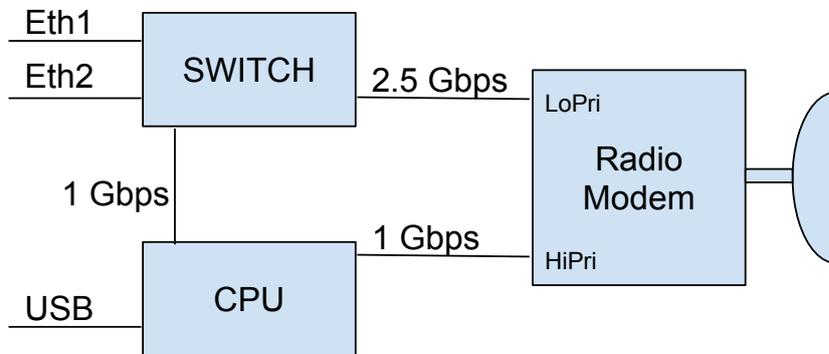
Fig. D.1: Block diagram of the unit

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Appendix E. Revision History

Revision 1.0   2018-10-04
   First issue