RACOM
RADIO DATA NETWORKS

User manual

RAy2 Microwave Link

Quick start

Hardware

Configuration

Parameters

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version 2.16

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Important

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

Quick guide

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).

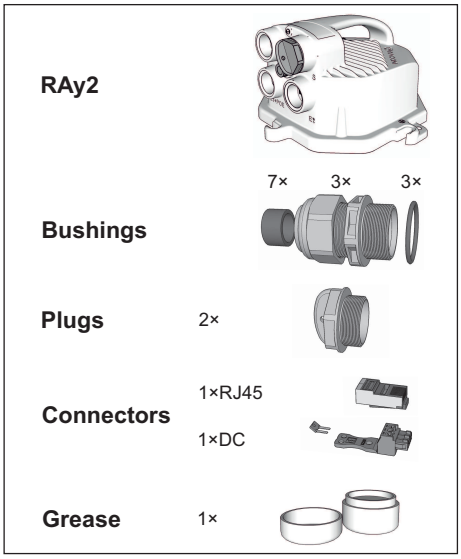
- Web browser access to management:
  http://172.17.17.17 (both units, USB/WiFi or USB/Eth)
  or http://192.168.169.169 (L unit, Ethernet)
  or http://192.168.169.170 (U unit, Ethernet)
  Defaults: Username: admin, Password: admin
- Antenna Alignment Tool:
  http://172.17.17.17/tk (both units, USB/WiFi 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).

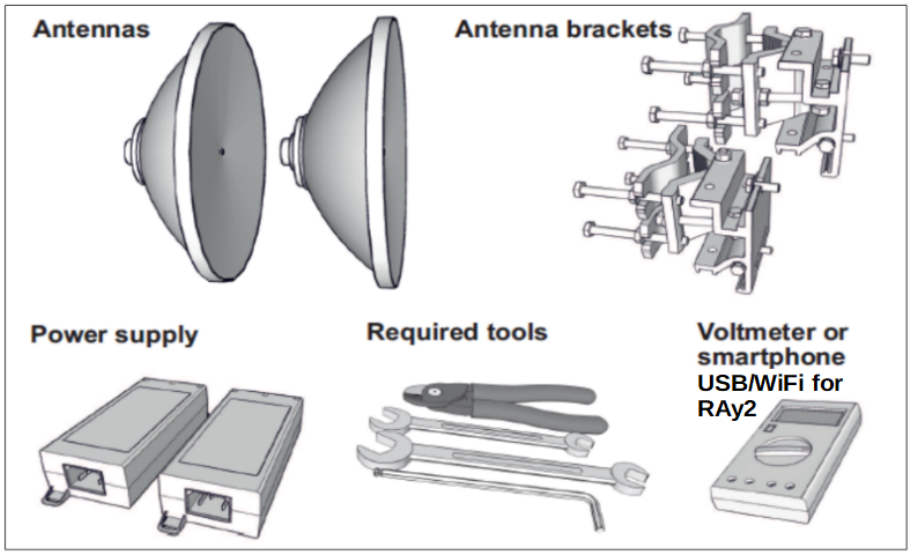
Configuration and ***backup*** of basic parameters

- 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.

1. Delivered items

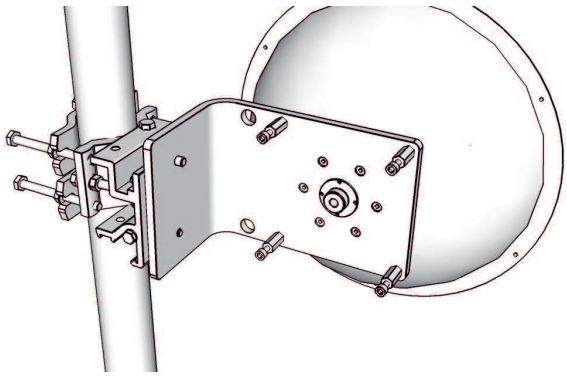


2. Accessories

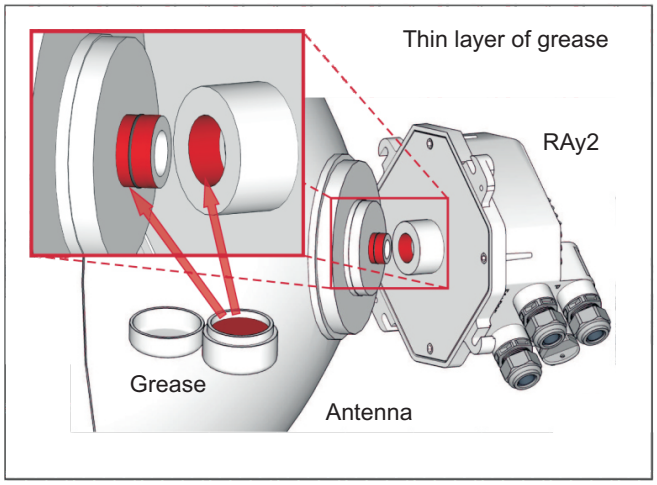


3. Bracket and antenna mounting

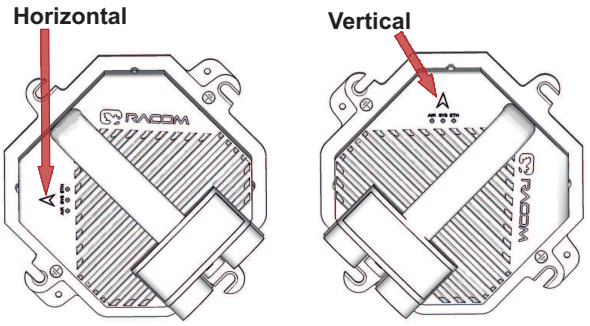
Mounting
- right sided (pictured below)
- left sided



4. RAy unit and antenna lubrication



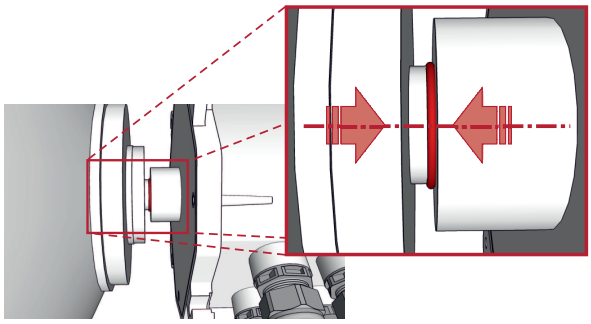
5. Unit polarization



RAy2-10, RAy2-11
- the same polarization for both units
- either horizontal or vertical

RAy2-17, RAy2-24
- cross polarization
- one side - horizontal
- the other side - vertical

6. Unit installation

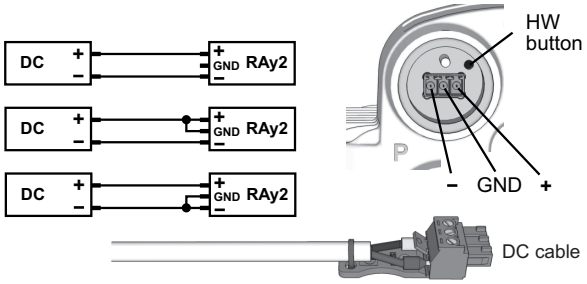


Check the correct O-ring placement on the antenna

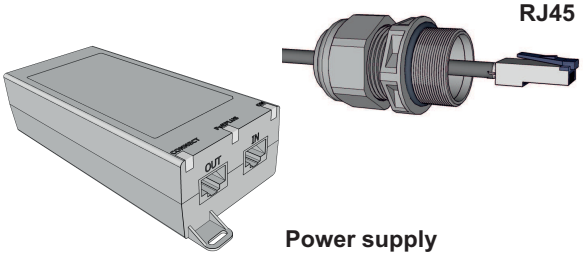
Ensure the antenna and unit are carefully aligned

Do not use excessive force!

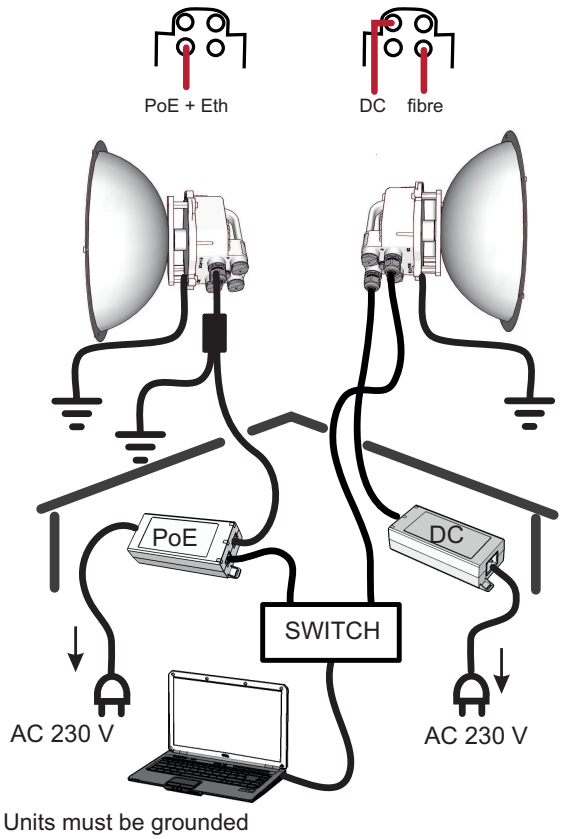
7a. Power - DC



or 7b. Power - PoE



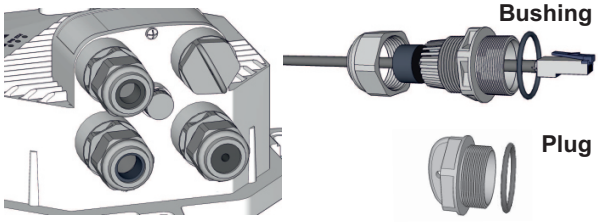
8. Power grounding and connections



Units must be grounded
For surge protection - see user manual

9. Sealing

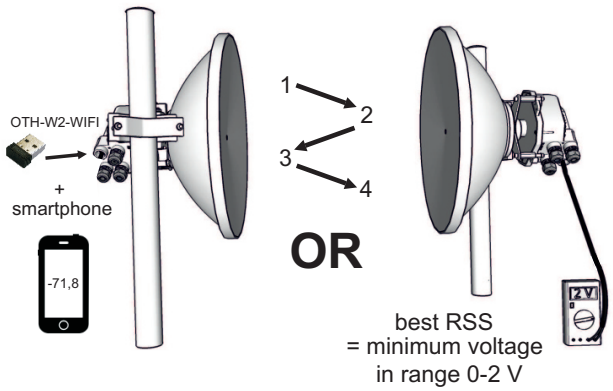
Disassembly warning



Seal unit interfaces with bushings and plugs

10. Antenna alignment

Hint: Set QPSK, CS 7 MHz, max.TX power
Step-by-step alignment-see user manual for details



List of documentation

- User manuals:

  RAy2 Microwave Link

  - User manual RAy2-10, RAy2-11, RAy2-17, RAy2-18, RAy2-24 - this document (complete reference manual). Latest on-line revision is available in *PDF*[1] and *web*[2] version.
  - *Channel arrangements*[3] (detailed tables with channel frequencies)

  RAy1 Microwave Link

  - *User manual RAy11, RAy17, RAy24*[4]
  - *User manual RAy10*[5]

- Datasheets:

  ***RAy2** - Datasheet*[6]

  ***RAy1** - Datasheet*[7]

  ***RAy** - SCADA Backbone*[8]

- Application notes:

  ***RAy** - Application notes*[9]

[1] https://www.racom.eu/download/hw/ray/free/eng/00_letaky/ray2-man-en.pdf
[2] https://www.racom.eu/eng/products/m/ray2/index.html
[3] https://www.racom.eu/eng/products/m/ray2tab/index.html
[4] https://www.racom.eu/eng/products/m/ray17/index.html
[5] https://www.racom.eu/eng/products/m/ray/index.html
[6] https://www.racom.eu/download/hw/ray/free/eng/00_letaky/ray-dsA3-en.pdf
[7] https://www.racom.eu/download/hw/ray/free/eng/08_ray1/datasheet_RAY_en.pdf
[8] https://www.racom.eu/download/hw/ray/free/eng/08_ray1/leaflet_RAY_scada_en.pdf
[9] https://www.racom.eu/eng/products/m/ray/app/index.html

1. Product

1.1. Main characteristics

RAy2 microwave units work as a point-to-point link in a full duplex setting with transfer speeds of up to 360 Mbps. Supported are 2 license-free bands (17 and 24 GHz) and 3 licensed bands (10, 11 and 18 GHz). Bandwidth can be configured from 1.75 up to 56 MHz. Modulation can be fixed or adaptive and can be adjusted from QPSK to 256QAM. RAy2 microwave links operating in 17 and 24 GHz bands can also be operated as a Short Range Device (SRD).

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

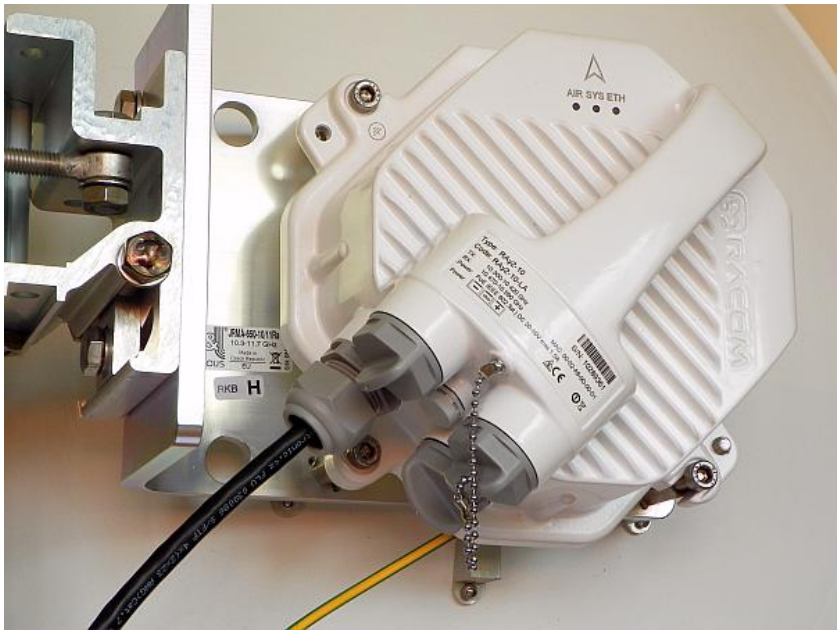


Fig. 1.1: RAy2 – Microwave link

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 except installing a WiFi module – everything else 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 and sub-bands and by a frequency range for RX and TX channels:

- Licensed bands (10, 11 and 18 GHz) require one RAy unit (labeled L) to transmit in the Lower and receiving in the Upper part of the band. The other unit (labeled U) is operating vice versa. This difference is realized by HW, thus L + U models are necessary for each band (and sub-band). Those units use single polarization only.

- License-free bands (17 and 24 GHz) are designed differently and 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 (letters L or U are labeled on each unit inside yellow ring below connector flanges), so the link could be established without reconfiguration of radio parameters.

Cross polarization (used only for RAy operating in 17 and 24 GHz bands) 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 RAy2 units for 17 and 24 GHz must be mounted with reverse polarity on both ends of the link.

Note

RAy units for 10, 11 and 18 GHz are all mounted with the same polarization on both ends of the link.

Ethernet concept

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

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

1.2. Mechanical interfaces

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

1.2.1. Antenna waveguide

Antenna waveguide flange on RAy unit (located across the holder) ensures perfect microwave connection between the unit and the antenna. All RAy units are equipped with identicaly sized round flange (with the outer diameter 50 mm and the inner diameter 28 mm). The only visible mechanical difference between RAy models are the diameters of the round waveguide hole in the middle of the flange. Those diameters differs according frequency ranges and are following:

10-11 GHz	19.00 mm
17-18 GHz	11.00 mm
24 GHz	8.00 mm

RAy2 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*[1] from different producers are available.

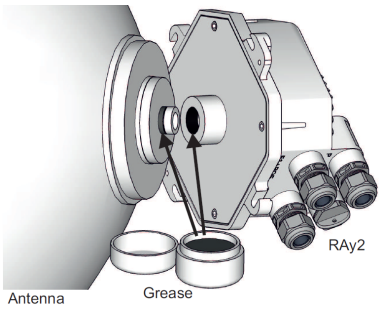


Fig. 1.2: Waveguide pivot and flange

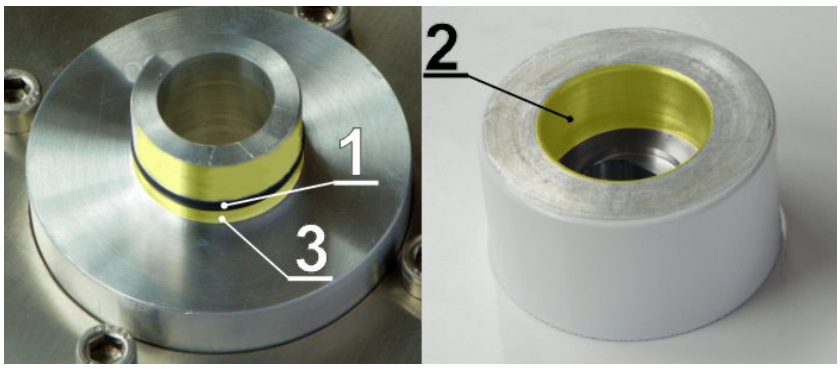


Fig. 1.3: Antenna pivot with O-ring and RAy waveguide flange

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

Important

Each antenna has to be equipped by a corresponding RACOM RAy antenna waveguide interface - the metalic pivot (28 mm diameter) with a rubber O-ring on it, otherwise the signal to/from the unit can not be transmitted from/to the antenna and such a link would not work.

Before assembling RAy unit with antenna, always *carefully lubricate* both antenna waveguide pivot and RAy waveguide flange with thin layer of silicone grease to prevent the damage of O-ring and surfaces. Pivot fits smoothly in to the flange, if it is properly lubricated. A box with silicone grease is packaged with each delivery of new units - see *Section 1.6.3, "Packaging"*.

Note

If O-ring is injured or damaged, please exchange it immediately for a new one (size 22x2 mm, type 'FPM80'), otherwise moisture + dust can leak into the waveguide and emitter. It may eliminate several dB of signal and cause a corrosion.

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 are 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. 1.4: RAy2 Microwave link – antenna and RAy unit

Note

Antennas from Jirous, LEAX Arkivator and Shenglu ordered for RAy mounting are automatically equipped for mechanical fixing of RAy unit (including the delivery of 4× M8×30 Allen screws).

Adapters for antennas from other vendors always contain proper mechanical fixing of RAy unit (including the delivery of 4× M8×30 Allen screws). The adapter has to be mounted to the antenna first, the RAy unit is then mounted on this adapter.

All available antennas and adapters are listed on RAy web pages in section *Accessories / Antennas*[2].

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

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 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. 1.5: 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.

1.2.4. Pressure equalization

Pressure equalization between outside and inside of RAy unit is an important technical requirement. It is realized by a small plastic screw located in the geometrical center of 4 unit interfaces (for 2x Ethernet, Power and System). It ensures the pressure equalization without letting moisture or humidity to enter the unit.

Important

Do not manipulate or remove this small plastic screw. It is part of the cabinet and its manipulation or a deformation can damage the water protection of the unit.

Warranty does not apply for units with this screw missing or deformed.

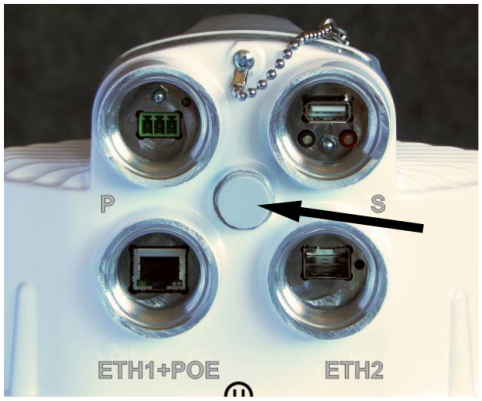


Fig. 1.6: Pressure equalization screw

1.3. Ethernet + power interfaces

Each unit is equipped with the following interfaces (on top of antenna waveguide and mechanical properties described above):

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 40 to 60 V is also supported.
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) 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.
P	DC power connector, from 20 to 60 V.
	HW button for service purposes: *Internal backup* or *Factory settings*, see *Section 1.4.5, "HW button (P)"* and *Section 5.6.1.1, "Backup, Default settings, Diagnostic package, MIB"*.
S	USB service connector for USB/WiFi or USB/Eth adapters. See *Section 1.4, "Service interfaces"*.
	RSS voltage output connectors (for example 0.547 V means RSS –54.7 dBm) - see *Section 1.4.4, "RSS voltage contacts (S)"*.

Fig. 1.7: Connectors

Note

A set of all necessary bushing parts are delivered with each RAy unit - see a description of this standard basic accessory *ACS-RAy2*[3]. Additional *bushing options*[4] for installation of *longer connectors*[5] or other equipment are available as well. For bushings installation see *Section 4.4, "Connectors assembly and disassembly"*.

[3] https://www.racom.eu/eng/products/microwave-link.html#accessories_kit
[4] https://www.racom.eu/eng/products/microwave-link.html#accessories_cable
[5] https://www.racom.eu/eng/products/microwave-link.html#accessories_cable

All accessories offered by RACOM for proper installation of the complete RAy link setup (including proper *grounding*[6]) are tested for compatibility with RAy unit. See accessories described on RAy web pages in section *Accessories*[7].

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 Ethernet connector (ETH1+POE)

RJ45 socket connector marked „ETH1+POE“ is a standard 10/100/1000Mbps metallic Ethernet port. One plastic RJ45 plug for CAT5e and CAT6 cables is delivered with each RAy unit, ready to be punched to an Ethernet cable.
NOTE: Higher quality and CAT7 compatible RJ45 plugs are available from RACOM as well – see for example item *CON-RJ45-CAT7*[8].

Fig. 1.8: RJ45 Ethernet connector

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 40-60 V) are supported.

Technical parameters of PoE power input:

Supported voltage range is 40 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

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

Note

The microwave unit does not support a combination of both power supplies. Only one power supply - DC or PoE - can be connected at any one time.

[6] https://www.racom.eu/eng/products/microwave-link.html#accessories_zemneni
[7] https://www.racom.eu/eng/products/microwave-link.html#accessories
[8] https://www.racom.eu/eng/products/microwave-link.html#accessories_cable

1.3.2. SFP slot (ETH2)

„ETH2“ is a standard SFP slot for 1000Mbps Ethernet SFP modules, user exchangeable. Both fibre optic and metallic Ethernet SFP modules are supported. For optical both single and dual mode fibre optics Ethernet modules (= 2 or 1 fibers) can be used. CSFP modules are not supported. RACOM offers all mentioned types of SFP modules, tested to be RAy compatible as a standard *accessory*[9].

Fig. 1.9: SFP slot

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

Note

It is strongly recommended to use a high quality SFP module with industry temperature range (up to 80°C). The SFP modules listed in *Accessories*[10] are thoroughly tested by RACOM and are guaranteed to function with RAy units.

It is possible to use any other SFP module with power consumption up to 1.25 W, but RACOM cannot guarantee their complete compatibility with RAy units.

Important

SFP module has to be inserted to out-of-power unit, otherwise its function is unpredictable and the module and/or the RAy unit can be damaged.

Do not remove the small plastic screw in the middle of 4 flanges. It is a part of the cabinet and assures *pressure equalization* between outside and inside.

1.3.3. DC connector (P)

Slot „P“ is named according to “Power” and it contains a 3 pins DC power source connector (see picture on right). HW button for service purposes is situated next to the DC connector - discussed in *Section 1.4.5, “HW button (P)”* .

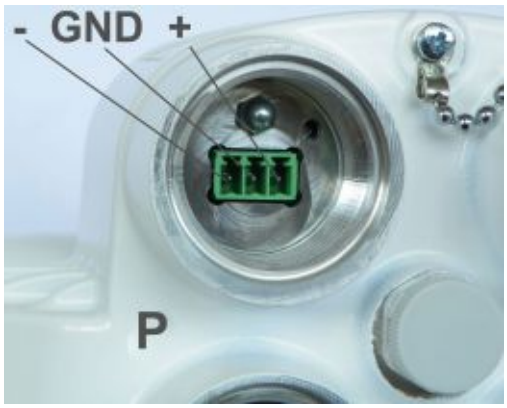


Fig. 1.10: Power supply connector

Supported voltage range is 20 to 60 V, polarity is documented on the *Fig. 1.10, “Power supply connector”*. RAy internal DC power circuits ensure galvanic separation. Ground pin is connected with the RAy chassis (grounded by Grounding screw to the mast) and it can be used for grounding of DC cable (either positive or negative wire or the shield).

One 3-pin power plug with screw-terminals is delivered with each RAy unit (see *ACS-RAy2*[11]), ready to be mounted to

[9] https://www.racom.eu/eng/products/microwave-link.html#accessories_sfp
[10] https://www.racom.eu/eng/products/microwave-link.html#accessories_sfp
[11] https://www.racom.eu/eng/products/microwave-link.html#accessories_kit

a customer DC cable. The connector is designed for electric wires with a cross section up to 1.5 mm^2 (AWG 14).

More information about usage and installation of DC power sourcing can be found in section *Section 4.6, "Power supply"* .

Note

The microwave unit does not support a combination of both power supplies. Only one power supply - DC or PoE - can be connected at any one time.

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 + green ones).

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”).

Fig. 1.11: USB connector

Note

Only RACOM recommended adapters are supported. See USB adapters on RAy *Accessories*[12] web.

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

RAy2 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).

Fig. 1.12: USB WiFi adapter

Optional WiFi module (ordering code *OTH-USB/WIFI-W2*[13]) 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”).

Note

Only RACOM recommended adapters are supported.

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

RAy2 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).

Fig. 1.13: Ethernet adapter

Optional Eth adapter (see *RAy USB accessories web*[14] for available types 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”).

Note

Only RACOM recommended adapters are supported.

[12] https://www.racom.eu/eng/products/microwave-link.html#wifi-adapter
[13] https://www.racom.eu/eng/products/microwave-link.html#wifi-adapter
[14] https://www.racom.eu/eng/products/microwave-link.html#wifi-adapter

1.4.4. RSS voltage contacts (S)

RSS voltage output connectors are located in slot „S“ aside USB connector. This pair of contacts (red + green ones) allows to connect a voltmeter 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. 1.14: RSS voltage contacts

1.4.5. HW button (P)

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

Important

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

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

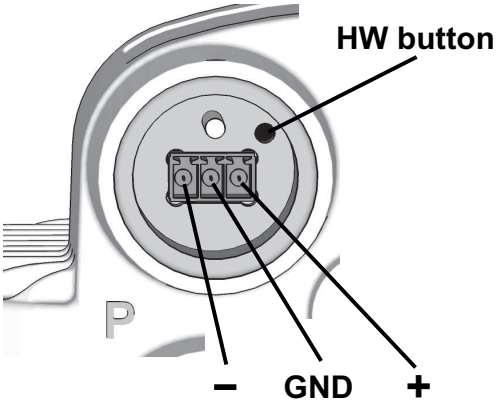


Fig. 1.15: Hardware button

Action to be performed	Unit status	Button pushed	SYS LED indication
Restore temporary stored **customer settings** (backuped previously to FLASH memory of the unit)	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 LEDs

Fig. 1.16: Status LEDs (AIR - SYS - ETH)

Tab. 1.1: Meaning of LED status indicators

Diode	Colour	State	Function
ETH	Green ETH1, (10/100/1000)	Flashing irregularly	Link Activity
		Permanently lit	Port without operation (Auto Negotiat. was carried out)
		Flashing regularly	Auto Negotiation in progress
	Yellow ETH2, (1000)	Flashing irregularly	Link Activity
		Permanently lit	Port without operation (Auto Negotiat. was carried out)
		Flashing regularly	Auto Negotiation in progress
SYS	Orange (red+green)	Permanently lit	Unit is starting
	Green	Permanently lit	System OK
		Flashing regularly	*HW button* pushed on the unit running
			Factory defaults in progress
			Firmware writing in progress. DO NOT POWER OFF !!
	Red	Permanently lit	Serious system error
		Flashing regularly	*HW button* pressed during unit start (HW button continuously pressed)
		Flashing intermittently	Unit in the service Linux
AIR	Green	Permanently lit	Link: OK
		Flashing intermittently	Link: Connecting
	Red	Permanently lit	Link: Single

Flashing regularly 500 ms on / 500 ms off
Flashing intermittently 50 ms on / 950 ms off
Flashing irregularly by passing frames

1.6. Sizes, packaging and labeling

1.6.1. RAy2 unit

Outer size
- 244 x 244 x 157 mm

Weight
- RAy2-10 — 2.8 kg
- RAy2-11 — 2.8 kg
- RAy2-17 — 2.5 kg
- RAy2-18 — 2.7 kg
- RAy2-24 — 2.5 kg

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

1.6.2. Production label

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

- Type – RAy2 product line identification (for details see *Section 1.7, "Ordering codes"*).
- 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
- CE, FCC ID - available certifications
- 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
- GND – meaning of 3 DC power source contacts (located next to the production label)

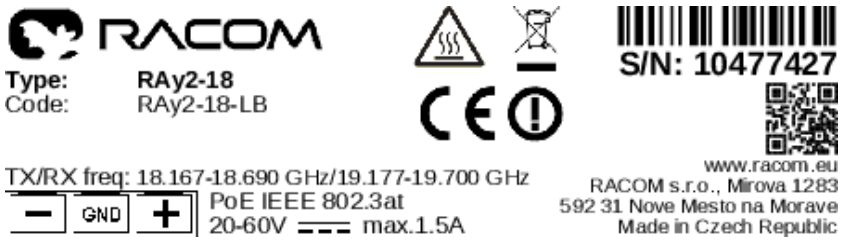


Fig. 1.17: Example of production label - RAy2-18

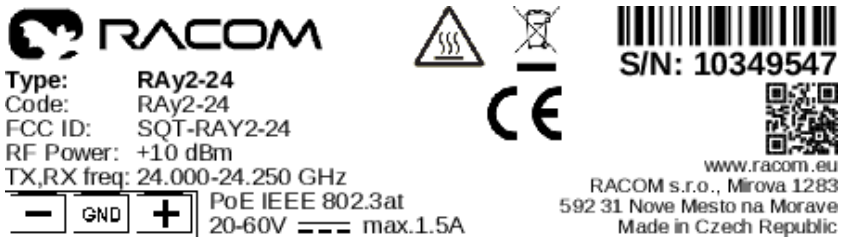


Fig. 1.18: Example of production label - RAy2-24

1.6.3. Packaging

- 2 pcs RAy2
- 2 pcs *Cable bushing set*[15] (bushings and connectors)
- 1 pc *SILICONE GREASE*

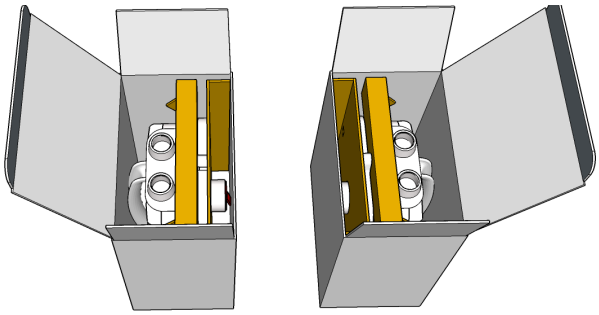


Fig. 1.19: Packaging of both units

Fig. 1.20: SILICONE GREASE capsule

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

Single unit packaging

Outer size
- 290 x 280 x 180 mm

Weight
- RAy2-10 — 3.4 kg
- RAy2-11 — 3.4 kg
- RAy2-17 — 3.1 kg
- RAy2-18 — 3.3 kg
- RAy2-24 — 3.1 kg

Double unit packaging

Outer size
- 380 x 320 x 290 mm

Weight
- RAy2-10 — 7.4 kg
- RAy2-11 — 7.4 kg
- RAy2-17 — 6.7 kg
- RAy2-18 — 7.2 kg
- RAy2-24 — 6.7 kg

1.6.4. Supplied antennas

RAy2 units are ready for direct mounting to:

- *Jirous Class 3*[16] or Class 2 antennas (*Jirous Antennas*[17])

[15] https://www.racom.eu/eng/products/microwave-link.html#accessories_kit
[16] https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas
[17] http://en.jirous.com/

- *LEAX-RAy Class 3*[18] antennas (*LEAX Arkivator Telecom*[19])
- *Shenglu-RAy Class 3*[20] antennas (*Shenglu Telecomunication*[21])

Note

Jirous Class 3 antennas (type JRMC in Ordering code) smoothly replaced Jirous Class 2 antennas (types JRMA or JRMB in Ordering code) in RACOM portfolio of antennas during Q1/2020.

Individual datasheets with exact sizes and weights are accessible on *RACOM website*[22].

Standard antennas shipment is one antenna in its own box. RACOM is able to arrange more compact shipment for a bigger amount of antennas (on a special request).

Tab. 1.2: Overview of Jirous Class 2 and Class 3 antennas

10, 11 GHz		17, 18 GHz		24 GHz	
diameter [m]	gain [dBi]	diameter [m]	gain [dBi]	diameter [m]	gain [dBi]
-	-	0.18	22.6	-	-
0.4	28.0-30.5	0.4	34.6-35.6	0.4	36.8-37.4
0.7	33.6-36.0	0.7	38.6-40.0	0.7	41.7-42.0
0.9	36.5-37.5	0.9	41.0-42.5	0.9	44.0
1.2	39.5-41.0	1.2	44.6-44.8	1.2	46.0-46.6
1.8	43.0-44.0				

Tab. 1.3: Overview of LEAX-RAy antennas

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

[18] https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas
[19] http://www.leax-arkivator-telecom.com/
[20] https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas
[21] https://www.shenglu.com/microwave-antennas-and-accessories.html%5D
[22] https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas

Tab. 1.4: Overview of Shenglu-RAy antennas

		Bands		
		10, 11 GHz	**17, 18 GHz**	**24 GHz**
nominal diameter [m]	dish diameter [m]	gain [dBi]	gain [dBi]	gain [dBi]
0.3	0.38	28.7-30.0	33.3-34.6	36.5
0.6	0.66	33.5-35.0	38.4-39.6	41.5
0.9	1.02	37.8-39.0	42.3-43.5	45.4
1.2	1.30	40.2-41.0	44.0-45.1	46.6
1.8	1.89	-	47.1-48.2	-

Andrew (Class 2 or 3 or 4) or traditional Arkivator antennas or antennas from other suppliers can also be used, but they require an *antenna mounting kit*[23]. *Flexible waveguide*[24] is a general-purpose option for any antenna usage. *Contact us*[25] for available types and details.

1.6.5. Supplied accessories

Antennas and other accessories are necessary for RAy units to allow a proper functionality of the whole microwave link.

RACOM always tries to ship all ordered accessories together with RAy units and antennas. Accessories are mostly small items, so typical RACOM packaging is that all accessories are shipped on the same palette with other material (within one additional *RAy box*).

[23] https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas
[24] https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas
[25] https://www.racom.eu/eng/about_us/contact.html

1.7. Ordering codes

All RAy2 models mentioned in this manual have their unique ordering codes. Available are also capacity keys, feature activation keys and accessories necessary to reach expected functionality of the link. All ordering codes are discussed in detail in this chapter and at *RACOM web*[26], and are available for purchase at *RACOM E-shop*[27].

Note

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

Important

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

1.7.1. RAy units

RAy ordering codes begin with a string printed on *Production label* (8-10 characters long, lasting by „-L“ or „-U“). It defines HW parameters and factory settings, which cannot be changed later on (like working frequency, factory defaults and limitations built in to units in the factory like limitation of Tx power). Rest of the ordering code defines functionalities and options which could be added, erased or changed by a user later on (like SW key for initial capacity).

Ordering Code structure:

[26] https://www.racom.eu/eng/products/microwave-link.html#order-codes
[27] https://webservice-new.racom.eu/main/eshop.list

RAY2-24R-L (100)

Trade name Gen. Band Var. FRQ SW keys

Type

Code

Order code

Trade name + Gen. – Trade and marketing name of the product and its product generation.
Possible values: **RAy2**

Band – frequency band in GHz
Possible values: **10, 11, 17, 18, 24** (bands 17 and 24 were under production until III/2021)

Var. – designation of product variant, if it is used. These variants are fixed in unit HW and cannot be changed later on.
Possible values:
none
R – RF Output power -30 to -15 dBm, for RAy2-24 only

FRQ – frequency
Possible values:
L – unit transmits on lower part of the band
U – unit transmits on upper part of the band
RAy2-10, RAy2-11, RAy2-18 – different HW for upper and lower unit
RAy2-17, RAy2-24 – L/U is not used, the same HW for upper and lower unit
A,B,C – frequency ***sub-bands***[28] for RAy2-10, RAy2-11, RAy2-18
Two letters (L/U and A/B/C) are used then.

SW keys – if unit is ordered with SW keys, those are specified in this bracket. SW keys activate the *Data speeds*[29]. Every SW key can be ordered independently for specific S/N anytime later on.
Possible values:
100, 200, 360, default is 100 Mbps, optional SW key for 200 or 360 Mbps
Standalone Part No's.: RAy2-SW-100, *RAy2-SW-200*[30], *RAy2-SW-360*[31]

Type – specific product type for which type approvals like CE, FCC etc. are issued
Possible values:
RAy2-10, RAy2-11, RAy2-17, RAy2-18, RAy2-24

[28] https://www.racom.eu/eng/products/microwave-link.html#specifications
[29] https://www.racom.eu/eng/products/microwave-link.html#scalability
[30] https://webservice.racom.eu/main/eshop.detail?i=1463
[31] https://webservice.racom.eu/main/eshop.detail?i=1462

Code – Detailed HW identification of the unit printed on *Production label* on the housing. SW keys and Optional accessories are not HW dependent and can be ordered, installed or de-installed later on, so they are not printed on Product label.

Order code – the complete product code, which is used on Quotations, Invoices, Delivery notes etc.

In order to find out the correct Order code, please use ***E-shop***[32].

Note

For 10, 11 and 18 GHz a link has to consist from a pair of 'L' and 'U' units (L/U of each unit is always indicated within the last part of the Code).

For 17 and 24 GHz a link should also consist from a pair of 'L' and 'U' units (L/U of each unit is always indicated by a yellow circle label nearby Ethernet slots), but it is not mandatory (HW for L and U unit is identical and L/U settings could be assigned by SW).

Using L + U pair ensures all default settings of both units match each other (including proper IP addresses as described in this manual). It ensures the link is automatically established when received from the factory or after applying *Default link settings or Factory settings* (to simplify initial setting of both units).

1.7.2. Capacity SW keys

RAy units allow to pay only for purchased transmission capacity (pay as-you-grow concept). Activation keys could be purchased together with the unit or later at *RACOM E-shop*[33]. Each key is generated for specific S/N of the unit and the purchased capacity. It unlocks all combinations of channels and modulations up to the purchased capacity. Once installed, a specific feature or function of the unit is allowed. Feature keys could be erased or upgraded. See *Configuration / Feature keys* for more details.

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

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

Maximum transmitted data capacity can be limited by a SW feature key. Capacity feature key defines allowed combinations of channel width and modulation for transmitting channel according *Capacity SW keys table*[34]. The Capacity feature key limit applies for transmitted data on the unit where the key is installed. It means, that for asymmetrical capacity keys could be different for each side of the link.

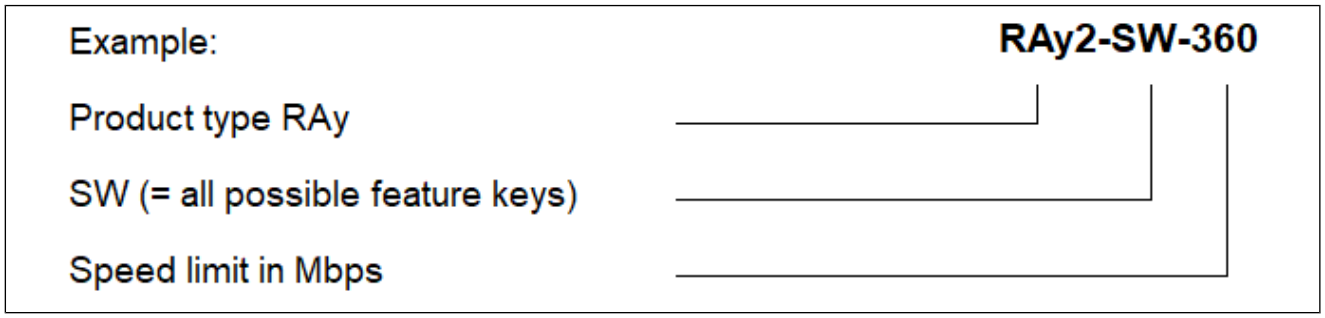
Capacity feature keys could be purchased bundled with RAy2 unit (and installed in the factory) or standalone or as a capacity upgrade key (both installed by user). Every Capacity feature key could be upgraded.

Separately purchased capacity

Keys purchased separately and installed by user.

[32] https://webservice-new.racom.eu/main/eshop.list?t=10
[33] https://webservice-new.racom.eu/main/eshop.list
[34] https://www.racom.eu/eng/products/microwave-link.html#scalability

Tab. 1.5: Capacity keys code scheme



For available ordering codes see *RACOM web*[35].

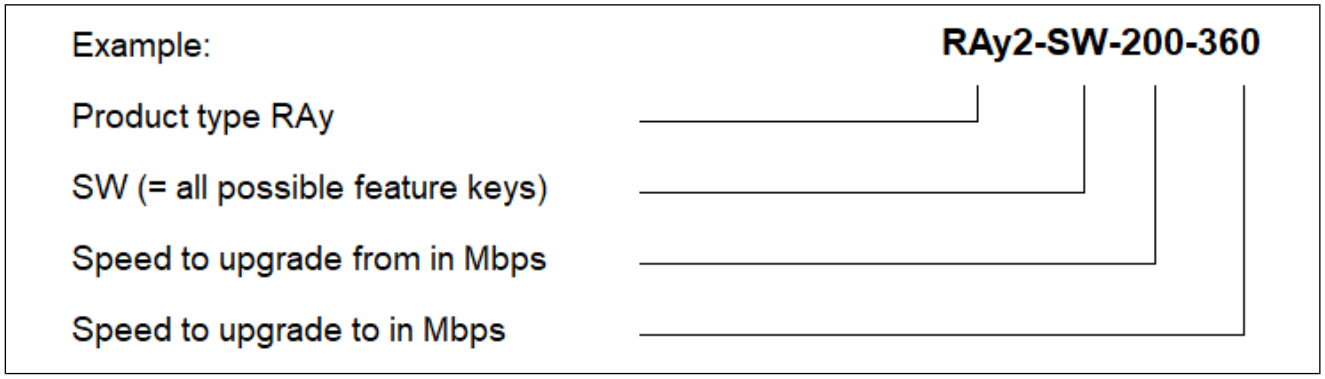
Note

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

Capacity upgrade

Keys purchased separately and installed by user.

Tab. 1.6: Upgrade keys code scheme



For available ordering codes see *RACOM web*[36].

1.7.3. Certified Accessories

Ordering codes for all accessories offered by RACOM to allow a proper functionality of the whole microwave link are listed on *Accessories section*[37] of RAy web site and they are available for purchase in *RACOM E-shop*[38].

More information about accessories can be also found in *Chapter 2, Accessories*.

Note

Accessories are necessary to be added to RAy units to allow a proper functionality of the whole microwave link. Please consult your supplier to ensure completeness of your product delivery

[35] https://www.racom.eu/eng/products/microwave-link.html#order-codes
[36] https://www.racom.eu/eng/products/microwave-link.html#order-codes
[37] https://www.racom.eu/eng/products/microwave-link.html#accessories
[38] https://webservice-new.racom.eu/main/eshop.list

for the individual link situation, spectrum regulations, local security requirements, type of power sourcing, grounding, etc.

2. Accessories

RACOM offers a complete set of accessories to operate RAy microwave units in all relevant use-cases and environments. All accessories are selected and thoroughly tested by RACOM for compatibility and are guaranteed to function with RAy units. There are only a very few accessories which has to be purchased from RACOM to work properly - e.g. WiFi adapters (the reason is limited set of WiFi drivers in RAy FW). Such an information is always part of accessory description. With most types of accessories it is possible to use other components with same or similar functionality and temperature range, but RACOM cannot guarantee they will be completely compatible with RAy units.

All accessories are listed on *Accessories section*[1] of RAy web site and they are available for purchase in *RACOM E-shop*[2].

Important

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

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

Units and accessories should be installed by trained professionals (see *Section 10.4, “Professional installation”*).

The warranty does not apply to units damaged by voltage spikes or surges (see *Section 10.8, “Warranty”*).

[1] https://www.racom.eu/eng/products/microwave-link.html#accessories
[2] https://webservice-new.racom.eu/main/eshop.list

3. Step-by-step Guide

The following chapters will guide you step by step through preparation, installation and activation of the RAy2 link:

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

Pre-installation Checklist

Familiarise yourself with the controls and prepare your configuration ahead of the installation of the link on the mast tube.

Both units (without antennas) can lie on a desk with flanges running parallel and facing up at an angle; on a non-metal desk they can also face downward.
– In the case of units **RAy2-17** and **RAy2-24** turn the unit holders so that they are roughly perpendicular to each other and set higher power, about 3 dBm. Before installation return power to a minimum.
– In the case of units operating in licensed bands (**RAy2-10, RAy2-11, RAy2-18**), turn unit holders so that they are roughly parallel to each other. Use an ethernet cable to connect each of the units to a PoE source and connect a PC to one of them for configuration.

Take the following steps to establish a connection between the PC and RAy2 and perform a basic setup.

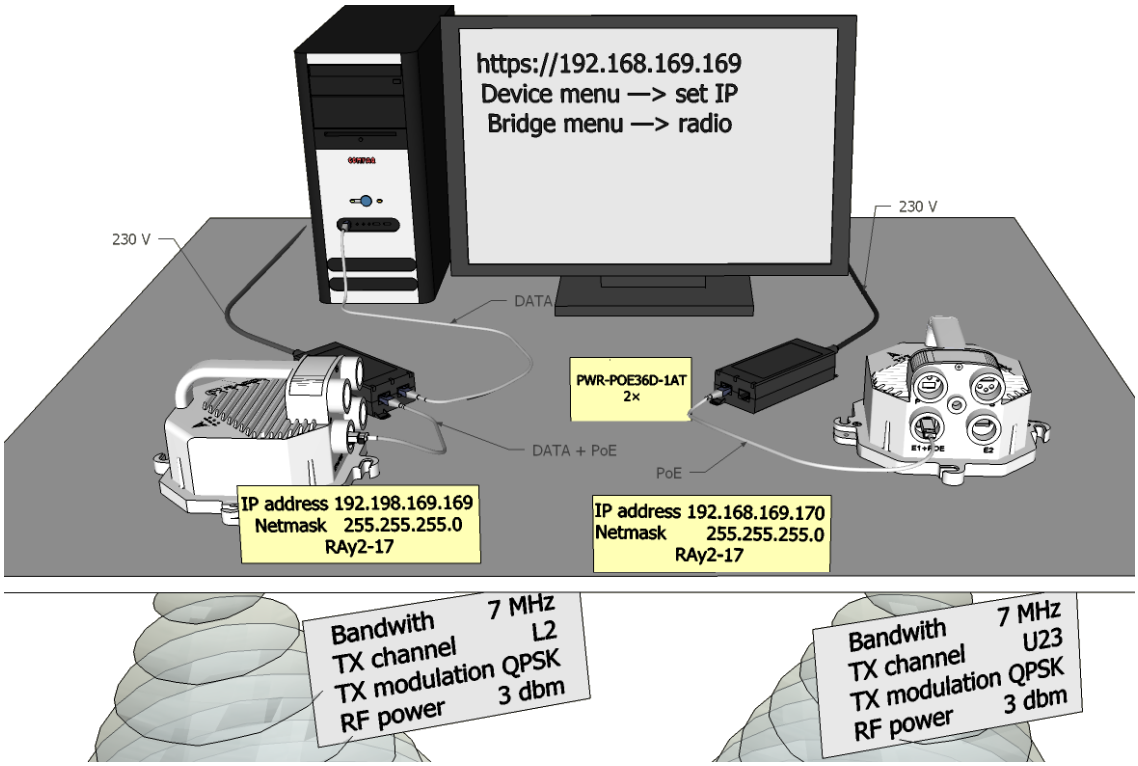


Fig. 3.1: Link Configuration (RAy2-17, perpendicular holders)

WARNING: During operation, never bring the waveguides of the stations close to each other. There is a risk of damaging sensitive input circuits.

3.1. Service access

The RAy2 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 Tool can also be used for antenna direction alignment accessed via a web browser utilising IP addresses of the unit with „/tk“ at the end (e.g. http://192.168.169.169/tk or http://172.17.17.17/tk).

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. 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. Menu Link settings - General

- 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

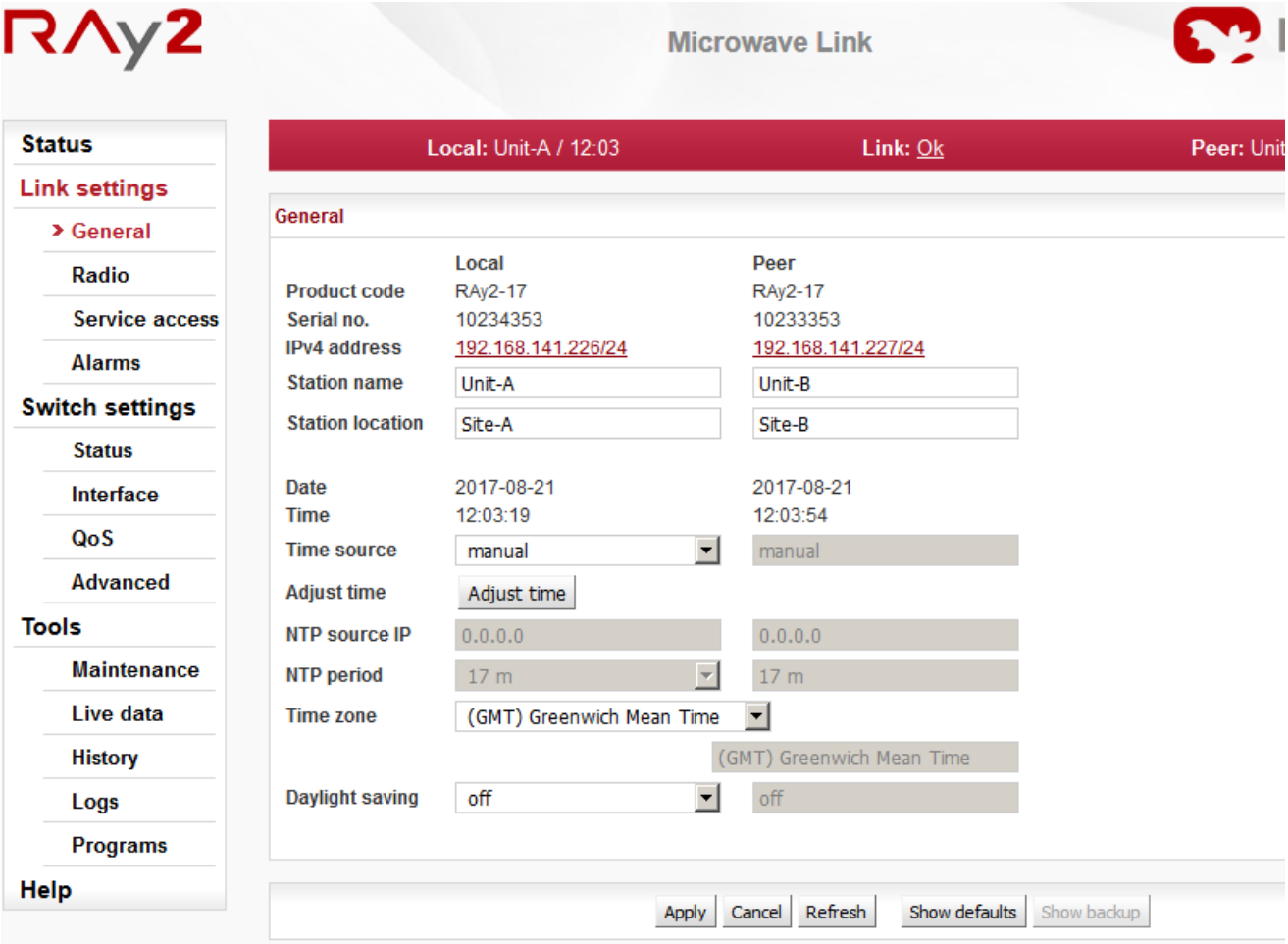


Fig. 3.2: Configuration Menu Link settings - General

3.1.2. Menu Link - Service access - Services

- 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.

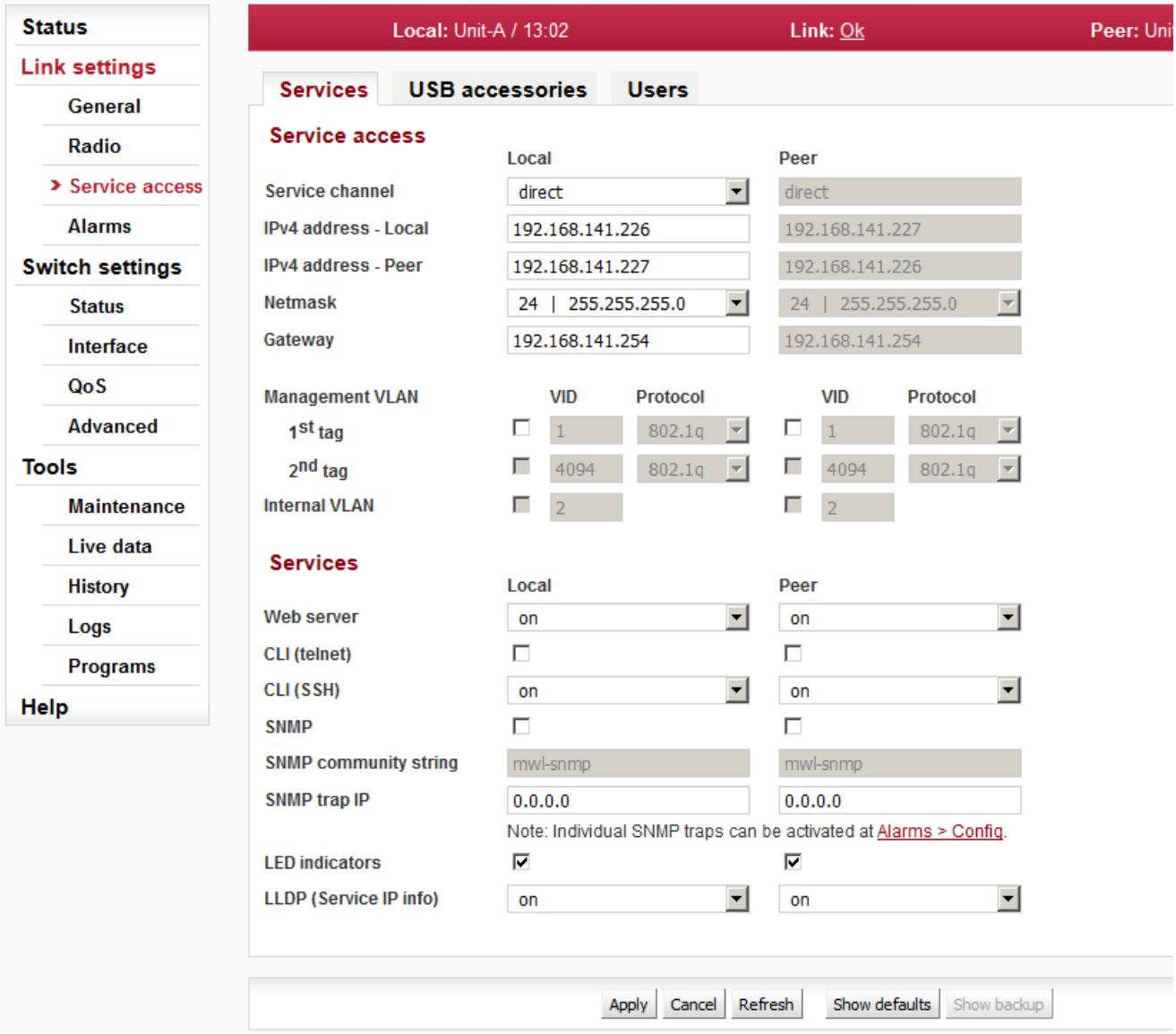


Fig. 3.3: Configuration menu Link settings – Service access – Services

3.1.3. Menu Link - Service access - Users

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

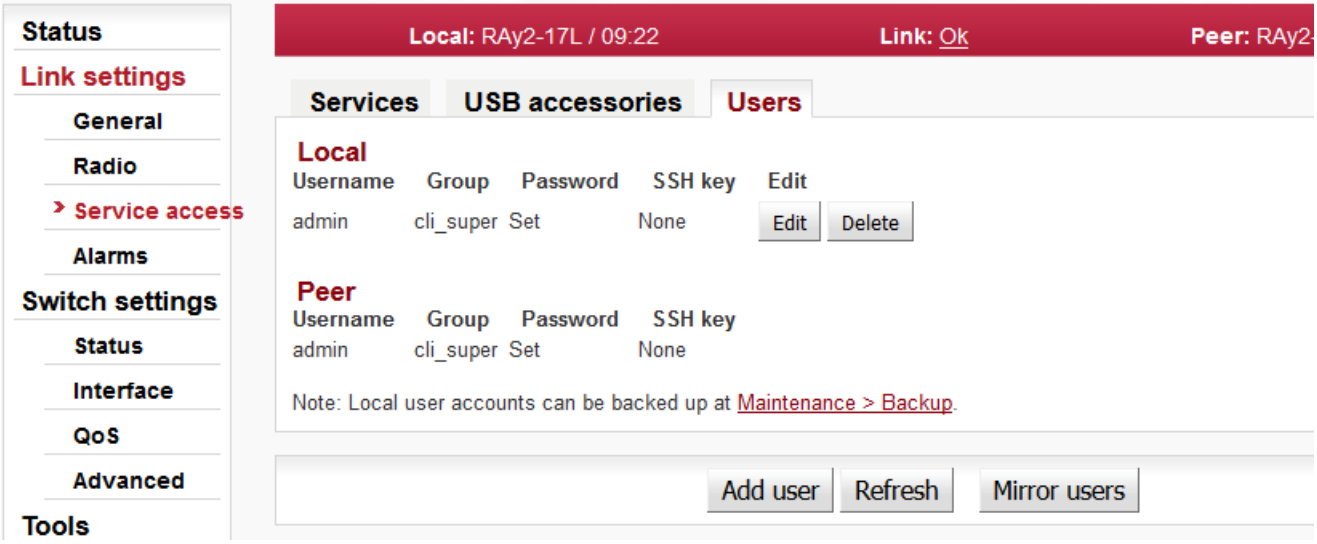


Fig. 3.4: Configuration menu Link settings – Service access – Users

3.1.4. Menu Maintenance - Feature keys

The firmware of the microwave link is capable of controlling the maximum user data speed. The default user speed without the feature key is the minimum for the respective hardware unit. The feature key to assign the maximum user data speed, should be installed prior to physical installation. For further details see *Section 5.6.1.2, "Feature keys"* .

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. The status and quality of modulation is demonstrated well in menu *Tools / Live data / RX constellation diagram*, hit Refresh.
- 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. You can monitor the quality of the received signal under *Tools / Live data / RX constellation diagram*.

Verify the functionality of the entire link:

- If possible, connect user devices to both RAy2 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 RAy2 to the PC connected to the remote RAy2 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.

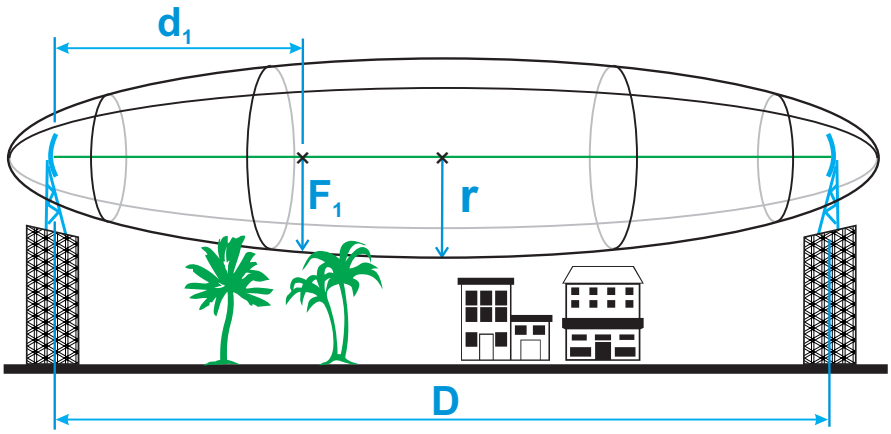
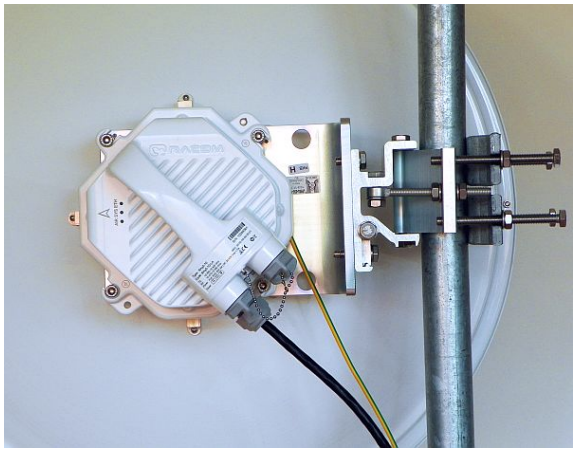


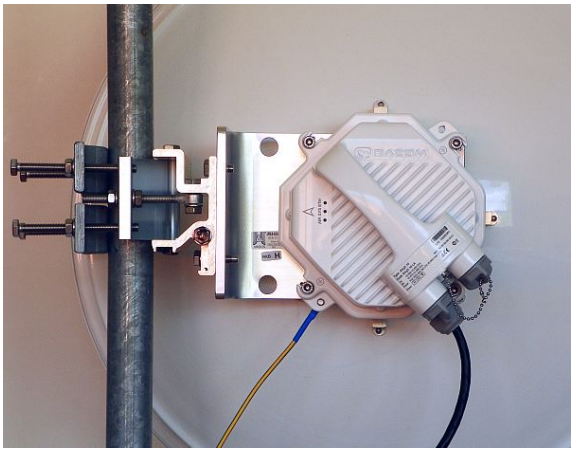
Fig. 4.1: Fresnel zone

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.



Left-side mounting
– horizontal RX polarization



Right-side mounting
– horizontal RX polarization

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 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]
  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.

[1] https://www.racom.eu/eng/products/microwave-link.html#download
[2] https://www.racom.eu/download/hw/ray/free/eng/04_1_anteny/ANT-LEAX-300-inst.pdf
[3] https://www.racom.eu/download/hw/ray/free/eng/04_1_anteny/ANT-LEAX-600-inst.pdf
[4] https://www.racom.eu/download/hw/ray/free/eng/04_1_anteny/ANT-LEAX-900-inst.pdf
[5] https://www.racom.eu/download/hw/ray/free/eng/04_1_anteny/ANT-LEAX-900-strut-inst.pdf
[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

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 ANT-JRMB-1200-STRUT-F or ANT-JRMB-1200-STRUT-A (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*[11] or a flexible waveguide with a *mounting kit*[12] 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 - contact your local supplier or *RACOM*[13] to check 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*[14] and the picture *Flexible waveguide*).

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

4.2.3.1. 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.

4.2.3.2. 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. Suitable models of Andrew antennas are listed below. RAy2-10, RAy2-11 and RAy2-18 can use Single polarized antennas. RAy2-17 and RAy2-24 need Dual polarized antennas.

- for 10 and 11 GHz bands use *ANT-ANW-KIT-10/11*[15] from RACOM and order the following single-polarized antenna types:

[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
[11] https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas
[12] https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas
[13] https://www.racom.eu/eng/about_us/contact.html
[14] https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas
[15] https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas

VHLP2-11W/A 60 cm
VHLP3-11W/A 100 cm

- for 17 GHz band use *ANT-ANW-KIT-17/18*[16] 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 18 GHz band use *ANT-ANW-KIT-17/18*[17] and order the following single-polarized antenna types:
  VHLP1-18W/A 30 cm
  VHLP2-18W/A 60 cm
  VHLP3-18W/A 100 cm

- for 24GHz band use *ANT-ANW-KIT-24*[18] 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.

4.2.3.3. Flexible waveguide

Flexible waveguide mounting kit can be ordered as an *accessory part*[19].

[16] https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas
[17] https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas
[18] https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas
[19] https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas

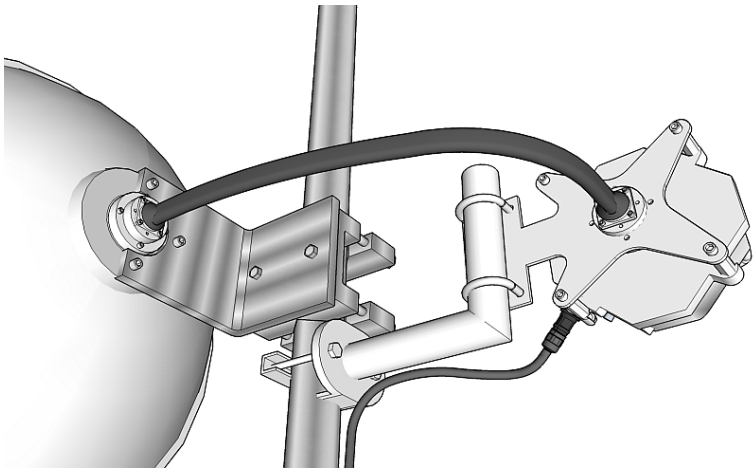


Fig. 4.2: Flexible waveguide assembly

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

Ensure the *pin lubrication* is completed during assembly.

4.2.4. Dual polarization extender (OMT)

Antenna extensions for dual polarization are available for bands 10, 11 and 18 GHz using OMT extenders on LEAX-RAy antennas - *see overview*[20]. It enables to double the link capacity by mounting two RAy units on a single antenna with each unit operating in a different polarization. OMT extenders need to be quoted as separated items (one extender per antenna).

Each RAy unit mounted on an OMT extender provides the same technical parameters and same level of service as a unit mounted directly to the antenna (without OMT between) except when both RAys are transmitting and receiving data on identical channels (on identical frequencies). In this situation the solution provided using an OMT extender generates slightly poorer SNR and thus higher modulations may become difficult. This may influence maximum distance and/or capacity of the link). See *Application Notes*[21] for more details.

OMT extender allows the customer to install one RAy unit only; in such a case a special kit (item LEAX-OMT-LID, 6-8 weeks lead time) has to be ordered. This kit works as a 'blind flange' instead of the 2nd RAy unit. It protects the OMT against moisture. For details contact RACOM's Technical Support (*support@racom.eu*[22]).

OMT = Orthomode transducer

[20] https://www.racom.eu/eng/products/microwave-link.html#accessories_antennas
[21] https://www.racom.eu/eng/products/m/ray/app/omt/index.html
[22] mailto:support@racom.eu

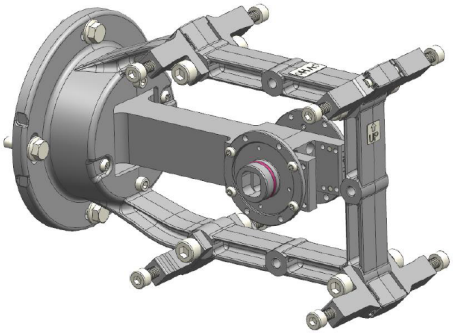


Fig. 4.3: OMT interface plate

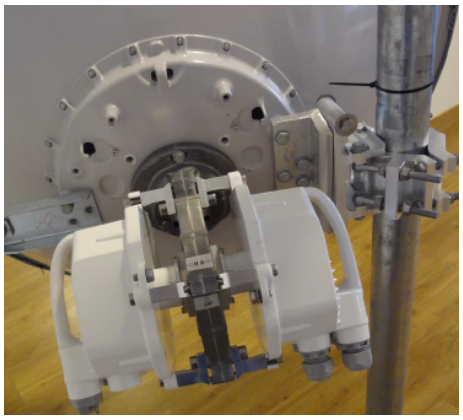


Fig. 4.4: Mounting example

Mounting instructions for LEAX-RAy dual polarization extender (OMT) are part of each delivery (inside the shipped box with every OMT). Identical mounting instructions are available on RACOM RAy download section in separate document *ANT-LEAX-dual-RAy-inst.pdf*[23].

Ensure the *pin lubrication* is completed during assembly for each RAy unit installed.

Note

Active network components (routers) need to be installed and configured on both ends of the link for a dual-polarized antenna with 2x RAy. The routers divide the data stream to both RAy links and then merge it again after transmission. Please consult RACOM *Technical Support*[24] before quoting this option. See also the application note *Dual-RAy & OMT*[25].

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 enclosed in the box. If you use a different grease for lubrication then it should be a Teflon or a silicone grease.

[23] https://www.racom.eu/download/hw/ray/free/eng/04_1_anteny/ANT-LEAX-dual-RAy-inst.pdf
[24] https://www.racom.eu/eng/about_us/contact.html
[25] https://www.racom.eu/eng/products/m/ray/app/omt/index.html

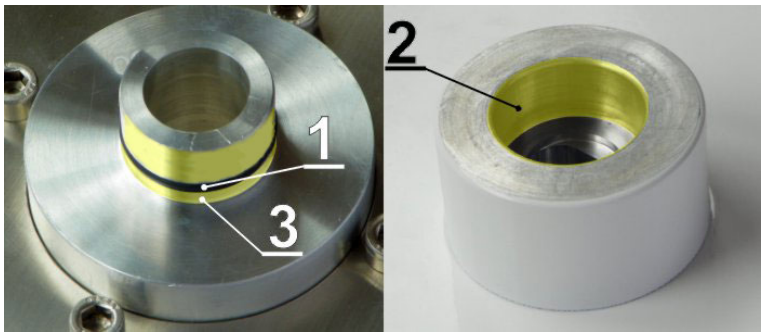


Fig. 4.5: Grease points on the antenna pivot and RAy unit flange

Lubricate both the internal area of the bushing on the RAy unit (2) and the "O" ring (1) with a thin even layer that allows the pin to slide easily into the bushing without damaging the "O" ring. The layer has to be really thin and even to ensure no grease is pushed in to the waveguide. A little bit more grease may only be applied in the area (3) beyond the "O" ring on the antenna pin to optimally fill the small gap (max. 0.1 mm) between the pin and the bushing to prevent leakage of moisture and water into the unit. Installation should be carried out according to the antenna installation instructions.

A capsule 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 capsule

4.3.2. RAy unit mounting to the antenna

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

- horizontal RX polarization
- vertical RX polarization

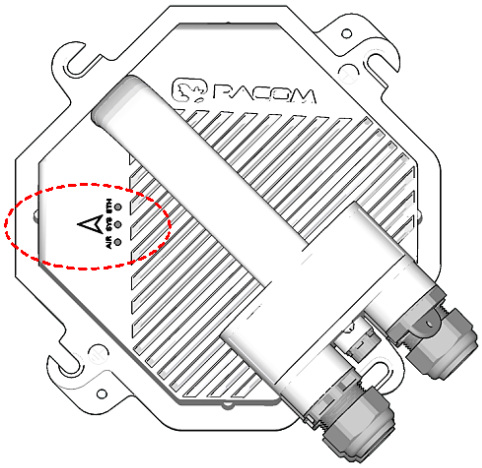


Fig. 4.7: Horizontal RX polarization
– see the arrow sign

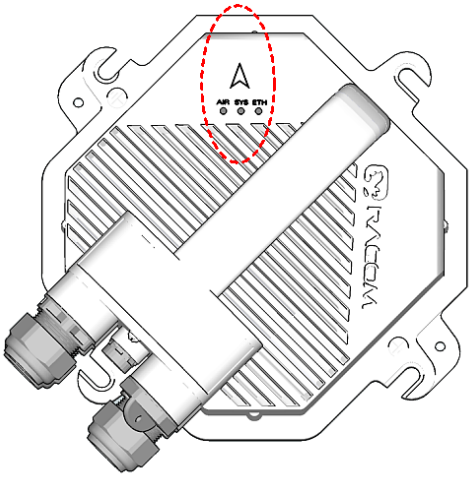


Fig. 4.8: Vertical RX polarization
– see the arrow sign

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

Note

RAy-17 and RAy-24 links need one unit to be installed with vertical polarization and the other unit with horizontal polarization because these models use cross polarization. RAy-10, RAy-11 & RAy-18 require the same polarization at both ends of the link to be used.

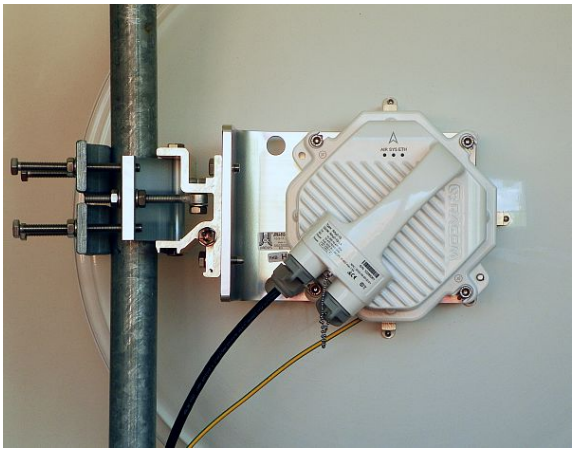


Fig. 4.9: Right-side mounting
– vertical RX polarization

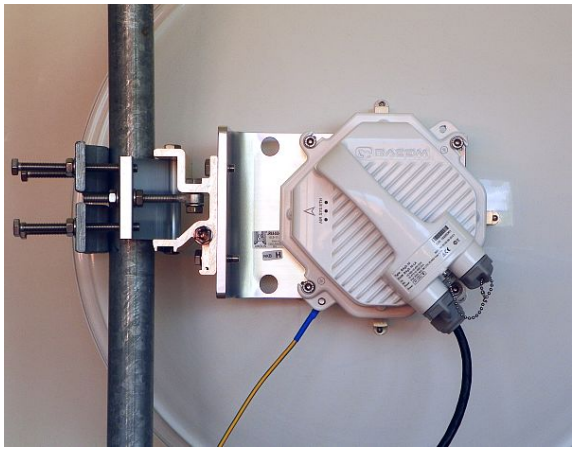


Fig. 4.10: Right-side mounting
– horizontal RX polarization

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 *Fig. 4.21, "Grounding installation 1"* and *Fig. 4.22, "Grounding installation 2"*, where unit grounding to the antenna mast is marked by yellow-green cable).

The RAy2 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*[26]. The antenna must be installed by a qualified person.

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

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

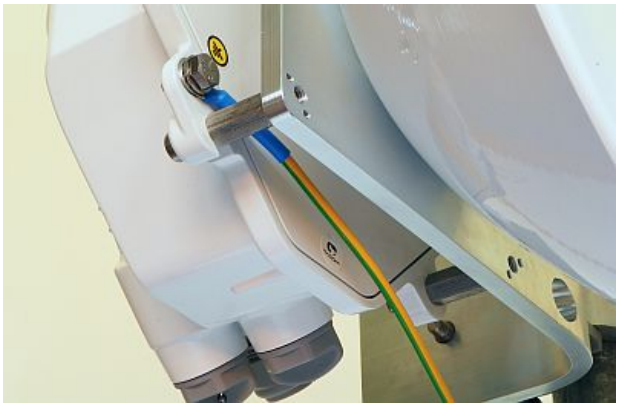


Fig. 4.11: Protective conductor at the RAy unit

Fig. 4.12: Grounding the RAy unit

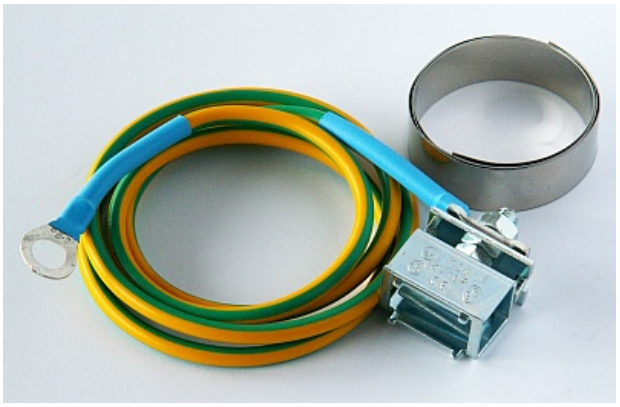


Fig. 4.13: RAy grounding kit

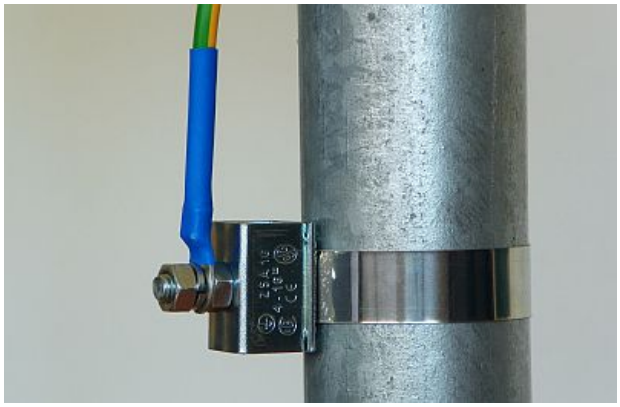


Fig. 4.14: Protective conductor at the mast on a ZSA16 terminal

4.4. Connectors assembly and disassembly

The unit is equipped with 4 standard connectors described in detail (including connectors' pin-outs) in *Section 1.3, "Ethernet + power interfaces"* . Use only standard counterparts to these connectors.

Fig. 4.15: RAy2 connectors

A set of standard bushing and plugs is delivered with each RAy unit as an accessory *ACS-RAy2*[27]. 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 preinstalled connectors.

If the lengthening of the bushing is needed use the long bushing delivered within standard accessory kit *ACS-RAy2*[28] or purchased separately as an option *SET-BUSH65*[29] (providing 65 mm long inner space for connector) or the long extension *OTH-BUSH-EXT500*[30] (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.

[27] https://www.racom.eu/eng/products/microwave-link.html#accessories_kit
[28] https://www.racom.eu/eng/products/microwave-link.html#accessories_kit
[29] https://www.racom.eu/eng/products/microwave-link.html#accessories_cable
[30] https://www.racom.eu/eng/products/microwave-link.html#accessories_cable

Assembly variants:

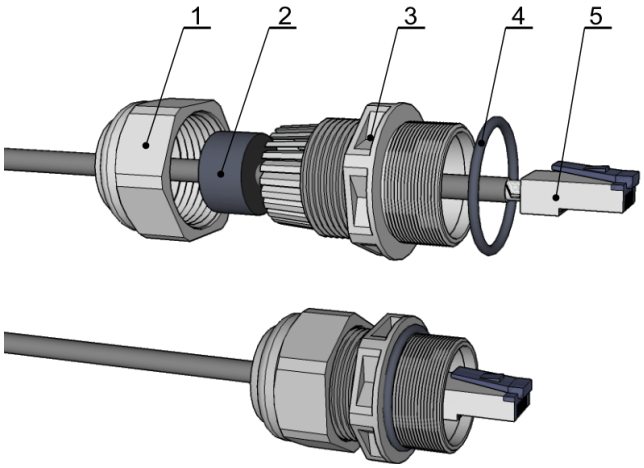


Fig. 4.16: Bushing assembly for metallic Ethernet with short *ETH connector*[31]

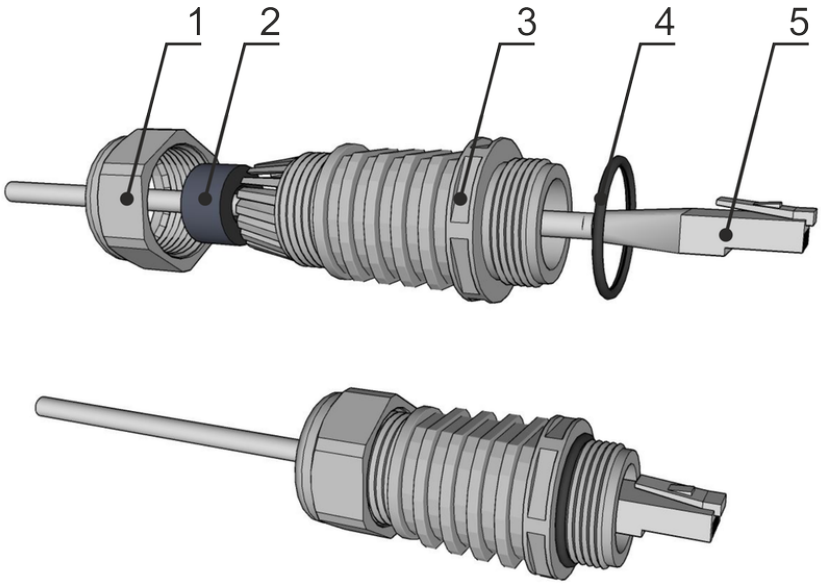


Fig. 4.17: Bushing assembly for metallic Ethernet with long *ETH connector*[32] (or for non-OFA fibre optic cable)

[31] https://www.racom.eu/eng/products/microwave-link.html#accessories_cable
[32] https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CON-RJ45-CAT7.pdf

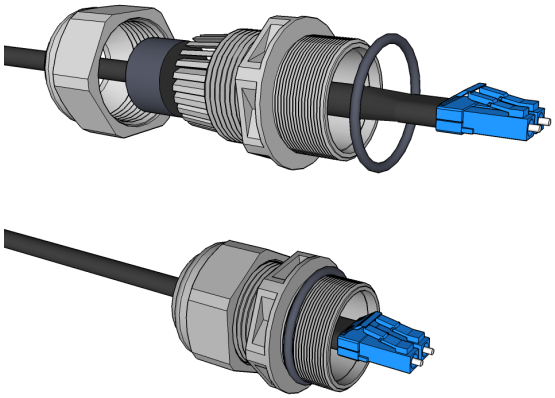


Fig. 4.18: Bushing assembly for optical Ethernet (with *RACOM / OFA fibre*[33] optic cable)

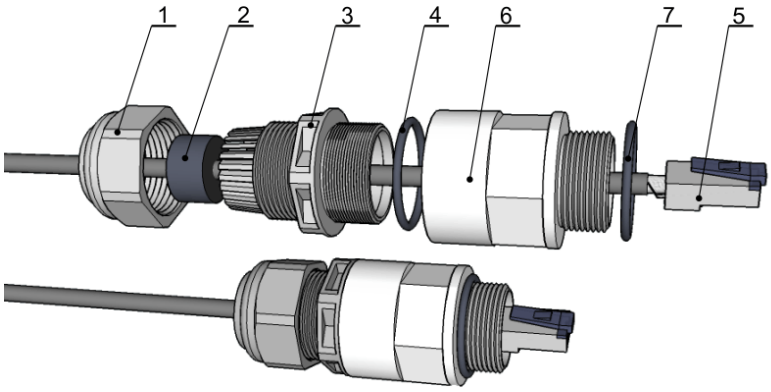


Fig. 4.19: Old-style bushing including 35 mm metallic lengthening

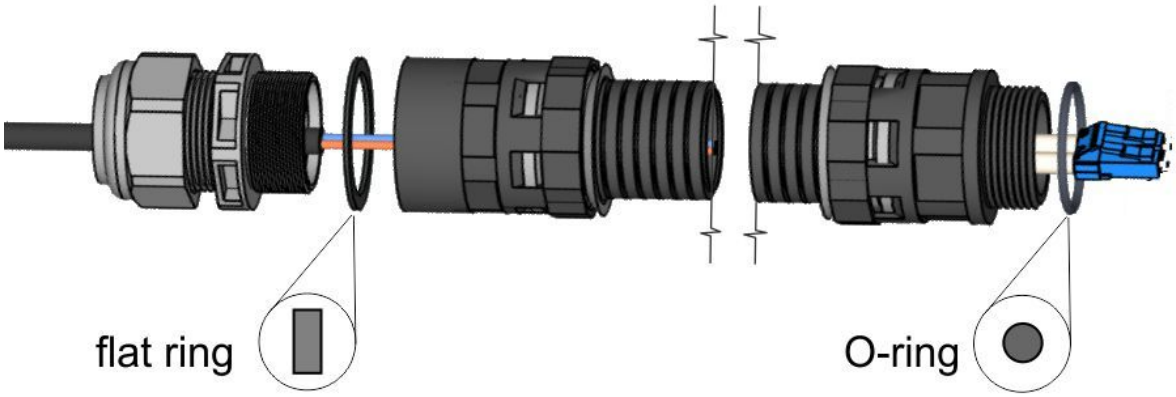


Fig. 4.20: Bushing including long lengthening

[33] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CAB-2F-DC.pdf

Important

At the outer end of the long lengthening there is necessary to use a flat ring supplied as part of the *OTH-BUSH-EXT500*[34]. On other places O-rings are used. See Figure above:

Assembly procedure:

- 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 RAy2 unit.
  (If you use extension ring No. 6 with O-ring No.7, lubricate its thread with grease and screw those into the RAy2 unit.)
- Screw the bushing No.3 with the sealing O-ring into the RAy2 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 lengthening 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.

Important

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

[34] https://www.racom.eu/eng/products/microwave-link.html#accessories_cable

4.5. Grounding

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 *Grounding section*[35] of RAy web site.

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 10.8, "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. 4.21 Grounding installation 1*.

[35] https://www.racom.eu/eng/products/microwave-link.html#accessories_zemneni

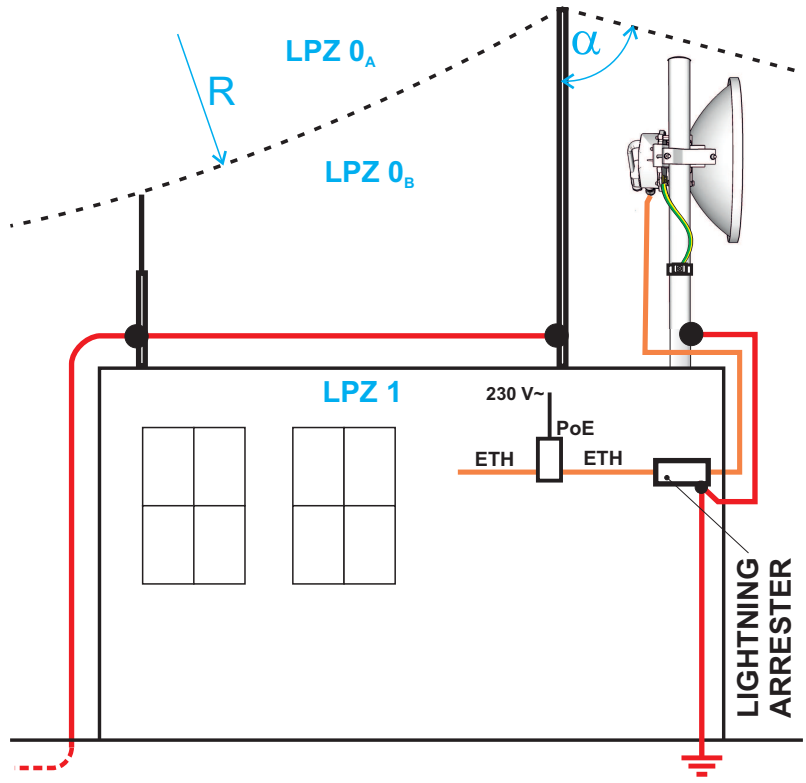


Fig. 4.21: Grounding installation 1

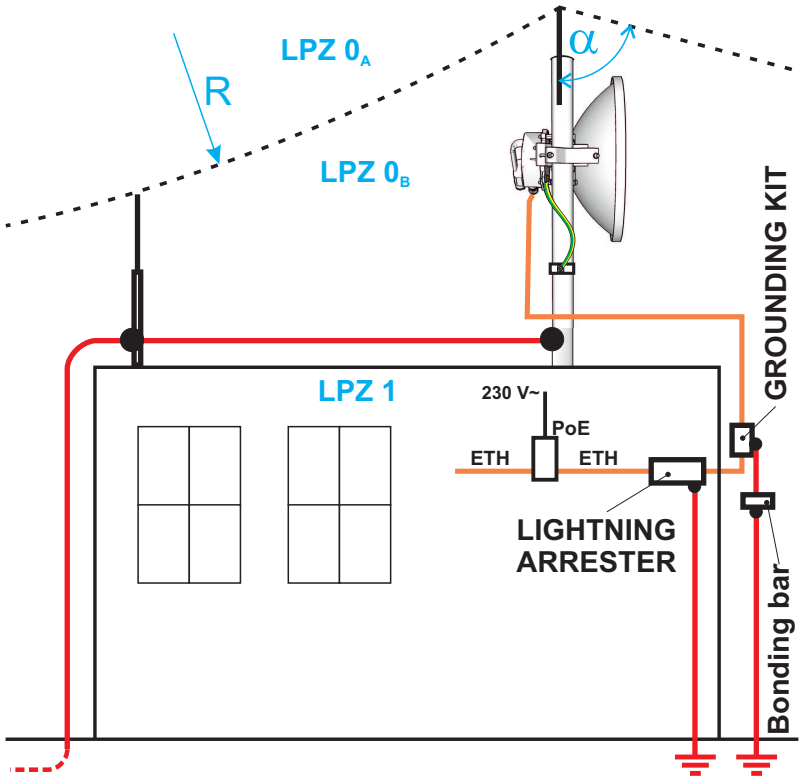


Fig. 4.22: Grounding installation 2

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. 4.22 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*[36].

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.

Fig. 4.23: Grounding kit universal for 5-11mm cables

[36] https://www.racom.eu/eng/products/microwave-link.html#accessories_ochrana

Fig. 4.24: Grounding kit for S/FTP 4+2 cable

Fig. 4.25: Grounding kit detail

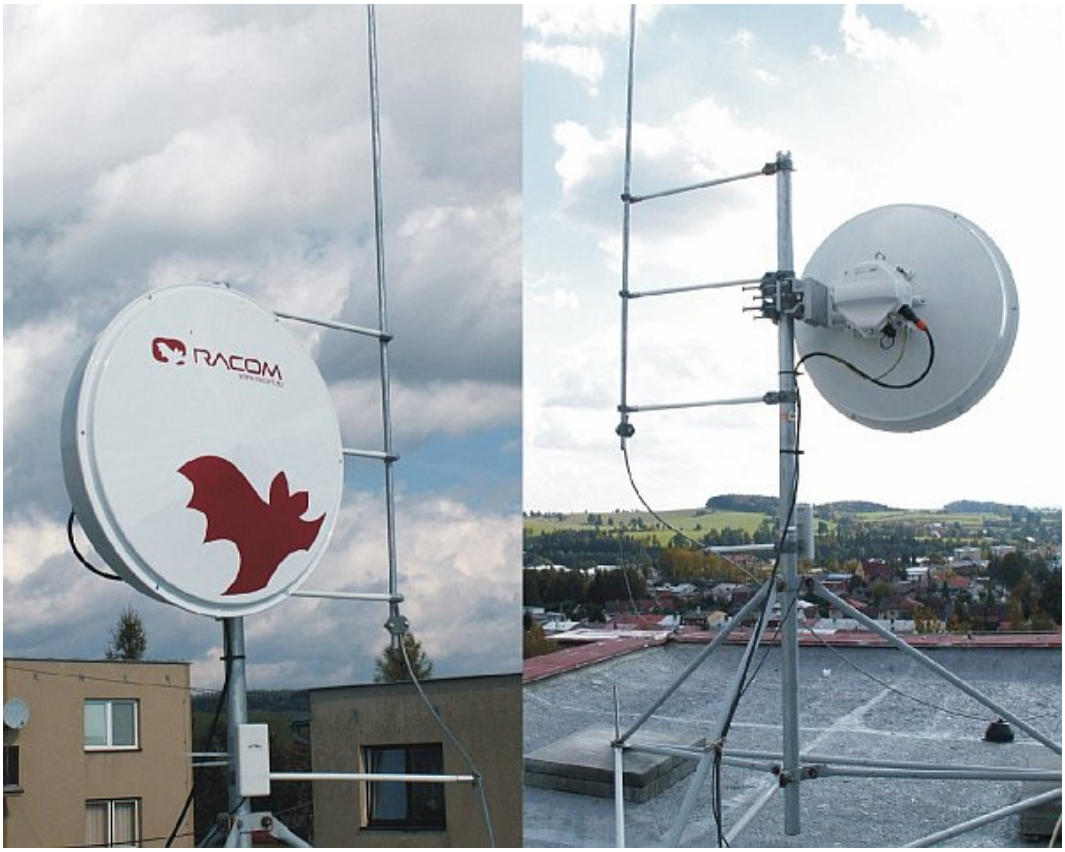


Fig. 4.26: Separated lightning conductor

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:

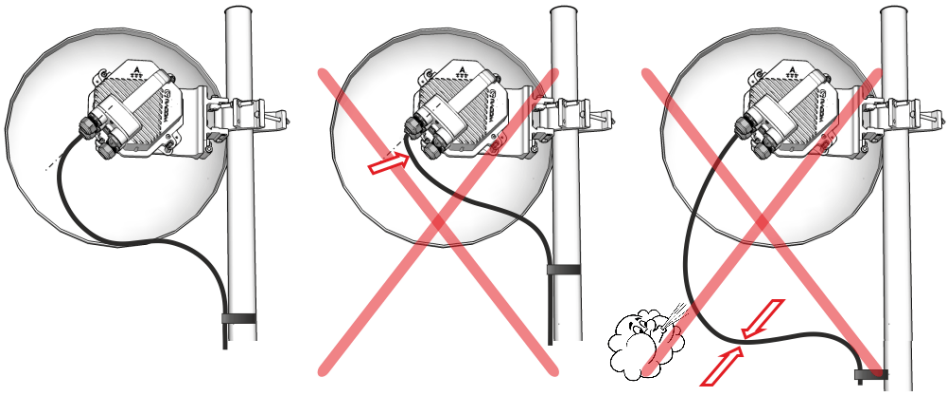


Fig. 4.27: Example of a correct lead installation.

4.6. Power supply

RAy microwave unit can be powered by active PoE, passive PoE or by DC power source. All PoE are supplied through RJ45 Ethernet connector (in slot "*ETH1+POE*"), for DC power sourcing there is a dedicated DC connector (*in slot "P"*). Detailed description and technical parameters of both connectors can be found in *Section 1.3, "Ethernet + power interfaces"* . RAy unit doesn't support a combination of DC + PoE power supplies in the same time.

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 *Powering section*[37] of RAy web site.

PoE power sourcing compatible with RAy unit:

- 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 to PoE injector has the 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*[38] (i.e. shielded one) with UV protection is recommended for outside use.

Quality connectors (like *CON-RJ45-CAT7*[39]) 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-

[37] https://www.racom.eu/eng/products/microwave-link.html#accessories_poe
[38] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CAB-CAT7.pdf
[39] http://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/CON-RJ45-CAT7.pdf

on and power-off the unit by plug / unplug Ethernet cable. Anyhow standard Eth cable with standard Eth connectors should work as well.

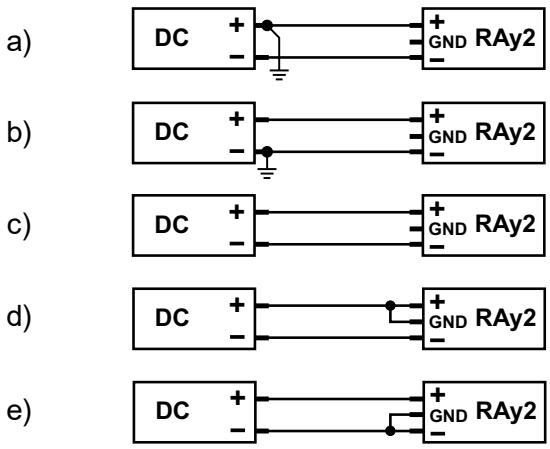
Overvoltage protection[40] unit is recommended to be applied between RAy unit and PoE power supply – for details see *Section 4.5, "Grounding"* (easily visible on *Fig. 4.21, "Grounding installation 1"*).

DC power sourcing compatible with RAy unit:

- Any kind of DC power source can be used to power the unit through the DC male connector (supplied with each RAy unit) plugged in to "P" 3-pin DC connector. 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). Power supply has to be able to provide enough power both for the RAy unit plus to cover the energy loss on the DC cable.

RAy internal DC power circuits ensure galvanic separation. If the galvanic separated power source is used and the DC power line needs to be grounded (either positive or negative wire), the middle pin of the 3-port DC connector can be used to make a connection between ground and the respective power wire, see Grounding options (d), (e). If grounding is required it should only be made in one of the following ways: on the DC power source side or using ground pit on the 3-port DC connector plugged into the unit.

The next figure shows all available grounding options. We recommend the use of a galvanic separated power source and no additional DC grounding - see *Fig. 4.28, "Grounding options"* version c).



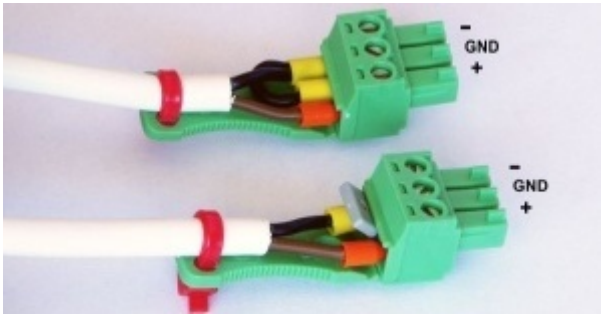


Fig. 4.28: Grounding options

[40] https://www.racom.eu/eng/products/microwave-link.html#accessories_ochrana

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:

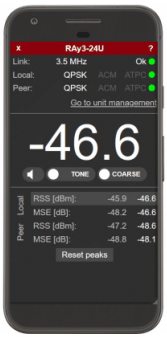
- Module Calculation inside RAy Tools *smartphone application*
- Link calculation on *RACOM website*[41]
- Use Link calculation chapter in Application notes
- Precise link calculation using dedicated tools (e.g. Pathloss)

[41] https://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.

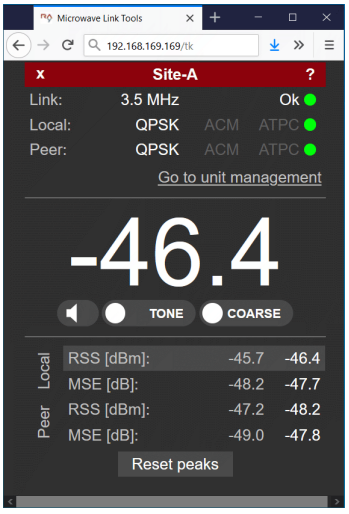
RAy Tools – smartphone application



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



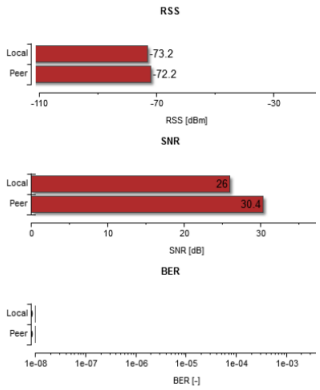
Antenna Alignment Tool is optimized for devices with smaller displays. All values are refreshed ten times per second to enable smooth operation. The Antenna Alignment Tool is described in Section *5.6.2 Live data*. The Tool is available on *http://<ip>/tk*, (e.g. http://192.168.169.169/tk for standard 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 *Fig. 4.29 Antenna lobe diagram*).

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

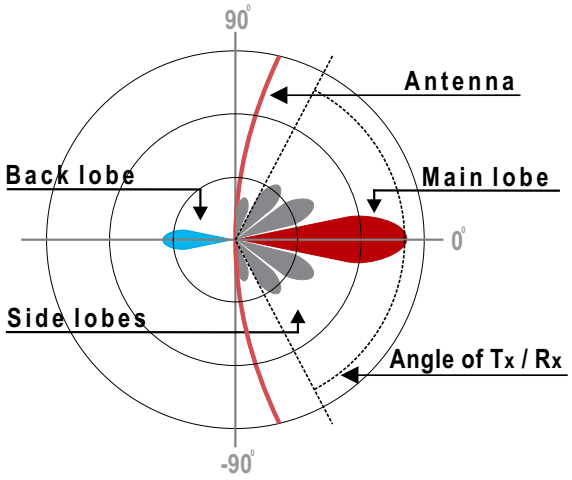


Fig. 4.29: Antenna lobe diagram

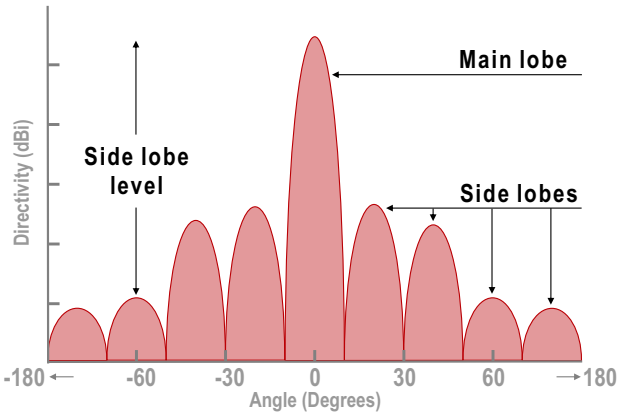


Fig. 4.30: Signal strength graph

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

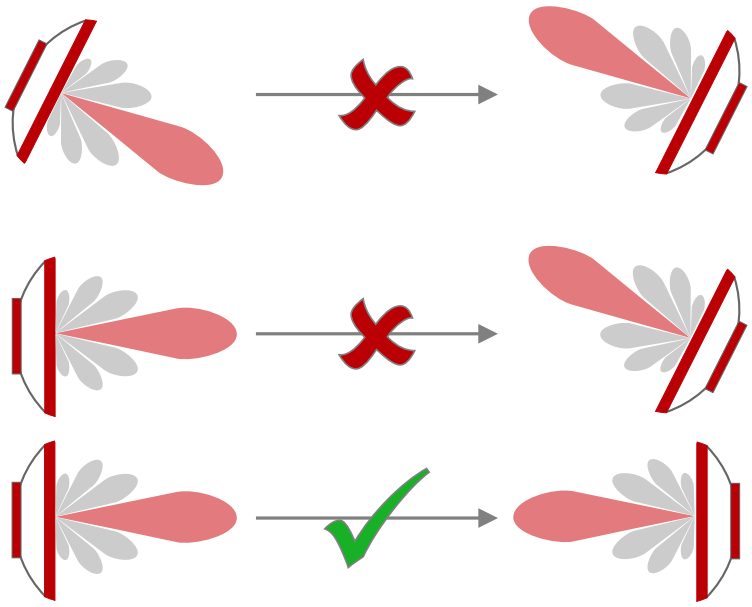


Fig. 4.31: Correct alignment diagram

Examples

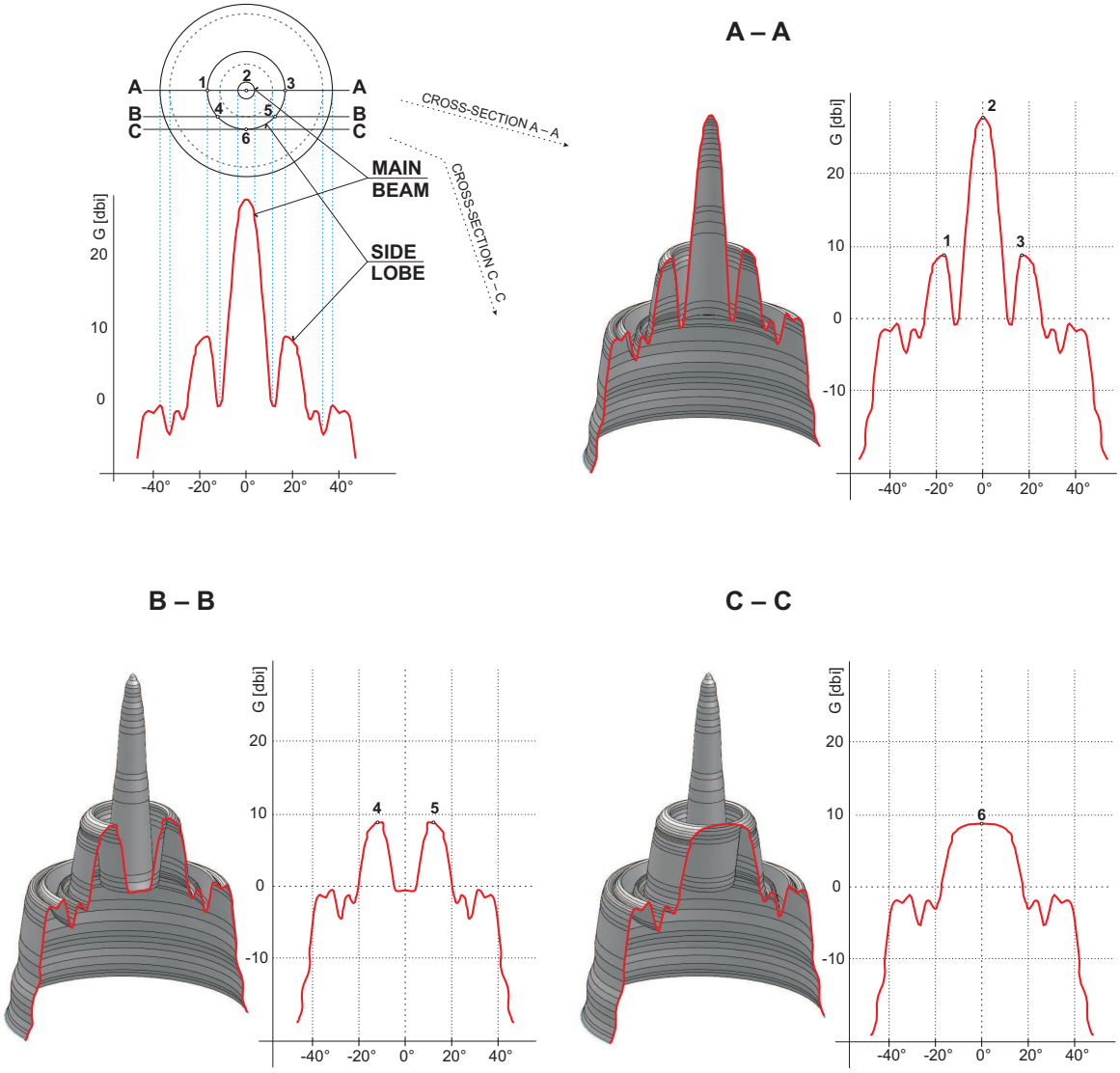


Fig. 4.32: Radiation diagrams

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*[42] .

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

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

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

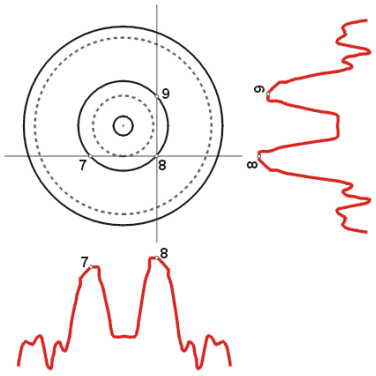


Fig. 4.33: Radiation diagram – incorrect adjustment

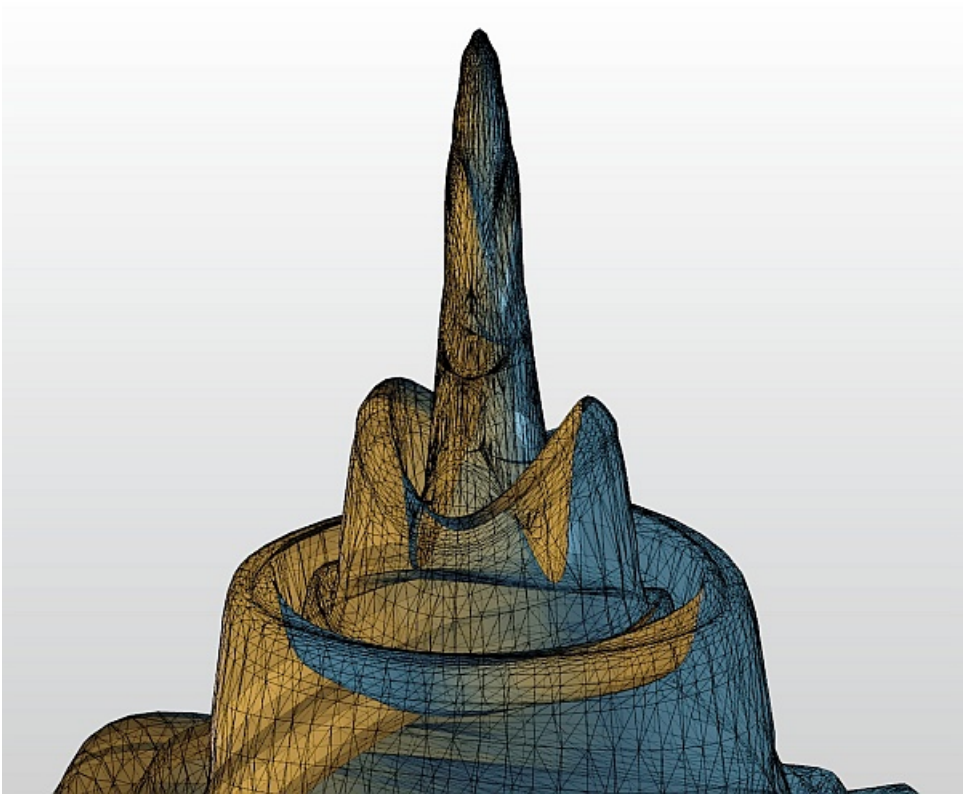


Fig. 4.34: 3D example of more complicated Radiation Pattern

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 downloaded from 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 cca 1 sec.
Stop	Use the "Stop" button to stop automatic refresh of displayed information with 1sec period. Date and time values are refreshed anyway.

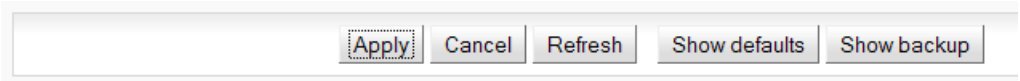


Fig. 5.1: Info Refresh

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.

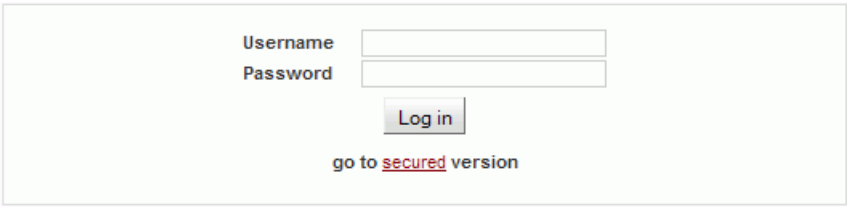


Fig. 5.2: Login

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

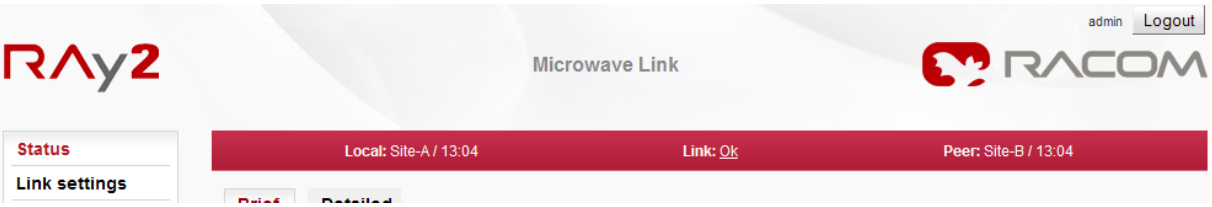


Fig. 5.3: Status bar 1

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.:

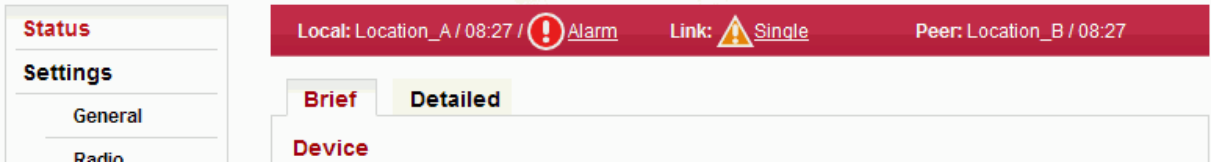


Fig. 5.4: Status bar 2

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

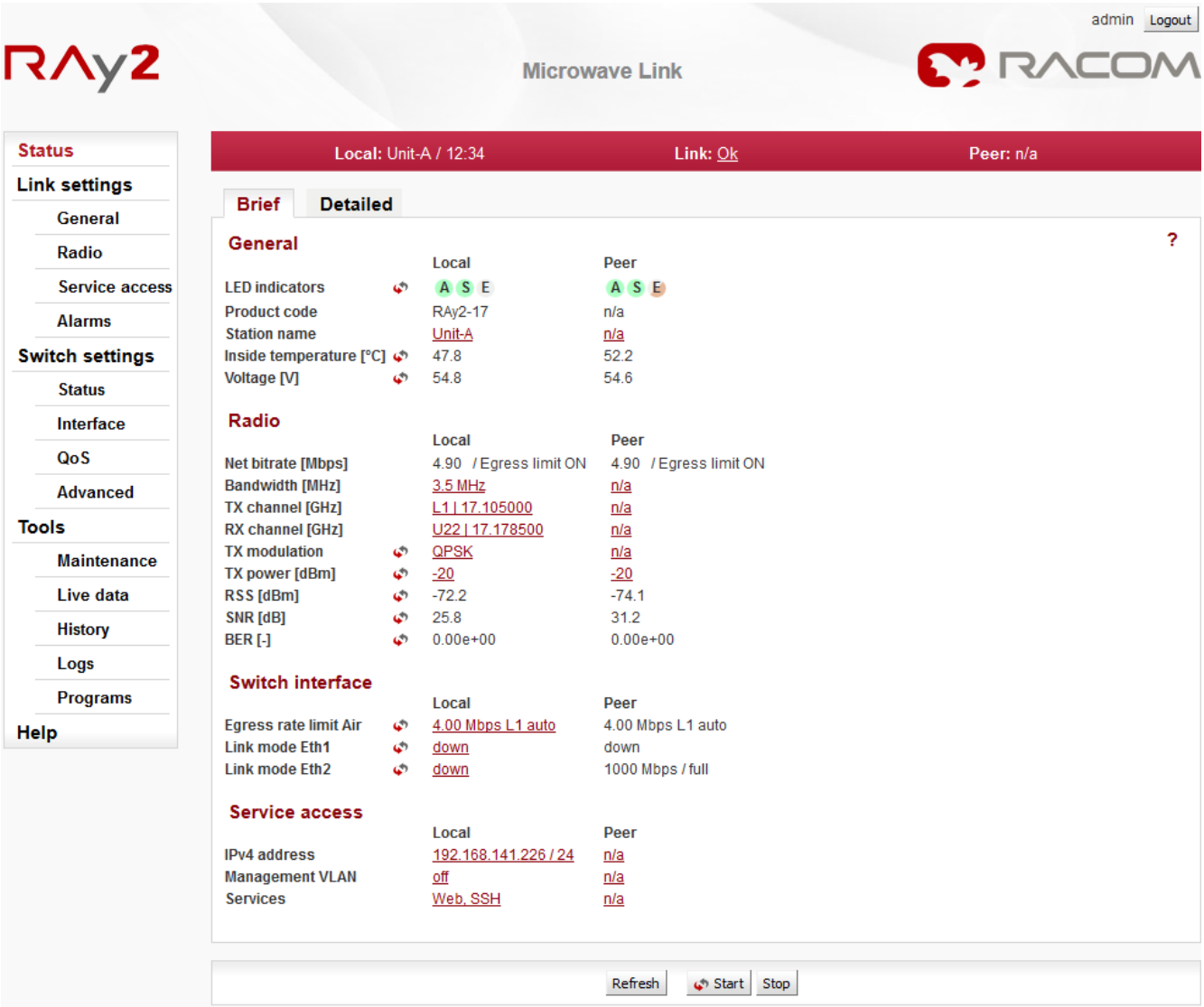


Fig. 5.5: Page example

5.3. Status

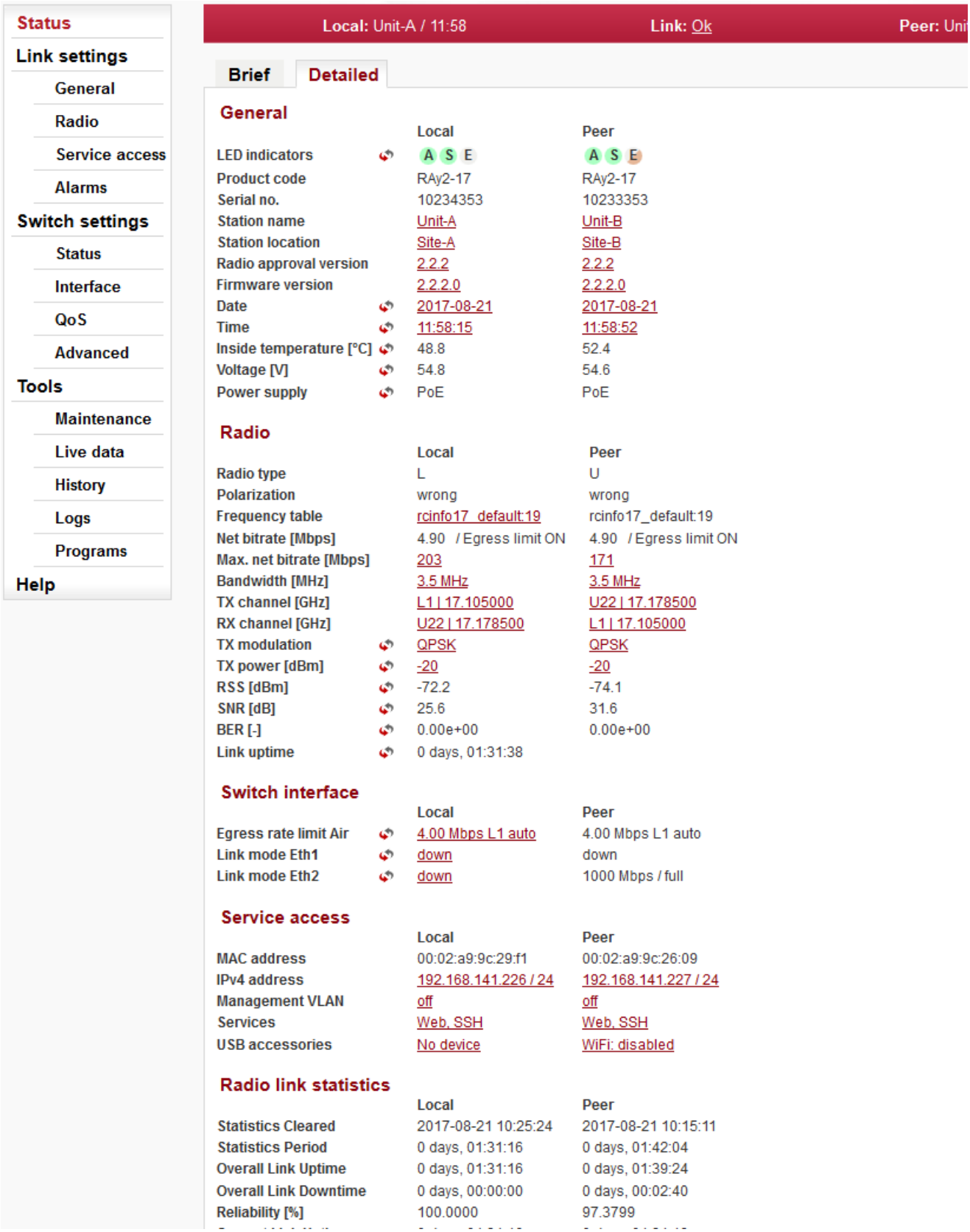


Fig. 5.6: Menu Status

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	- Radio link OK
	Red	- Radio link interrupted
S - SYS	Green	- System OK
E - ETH	Green	- ETH1 port - Link 10/100/1000
	Orange	- 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.

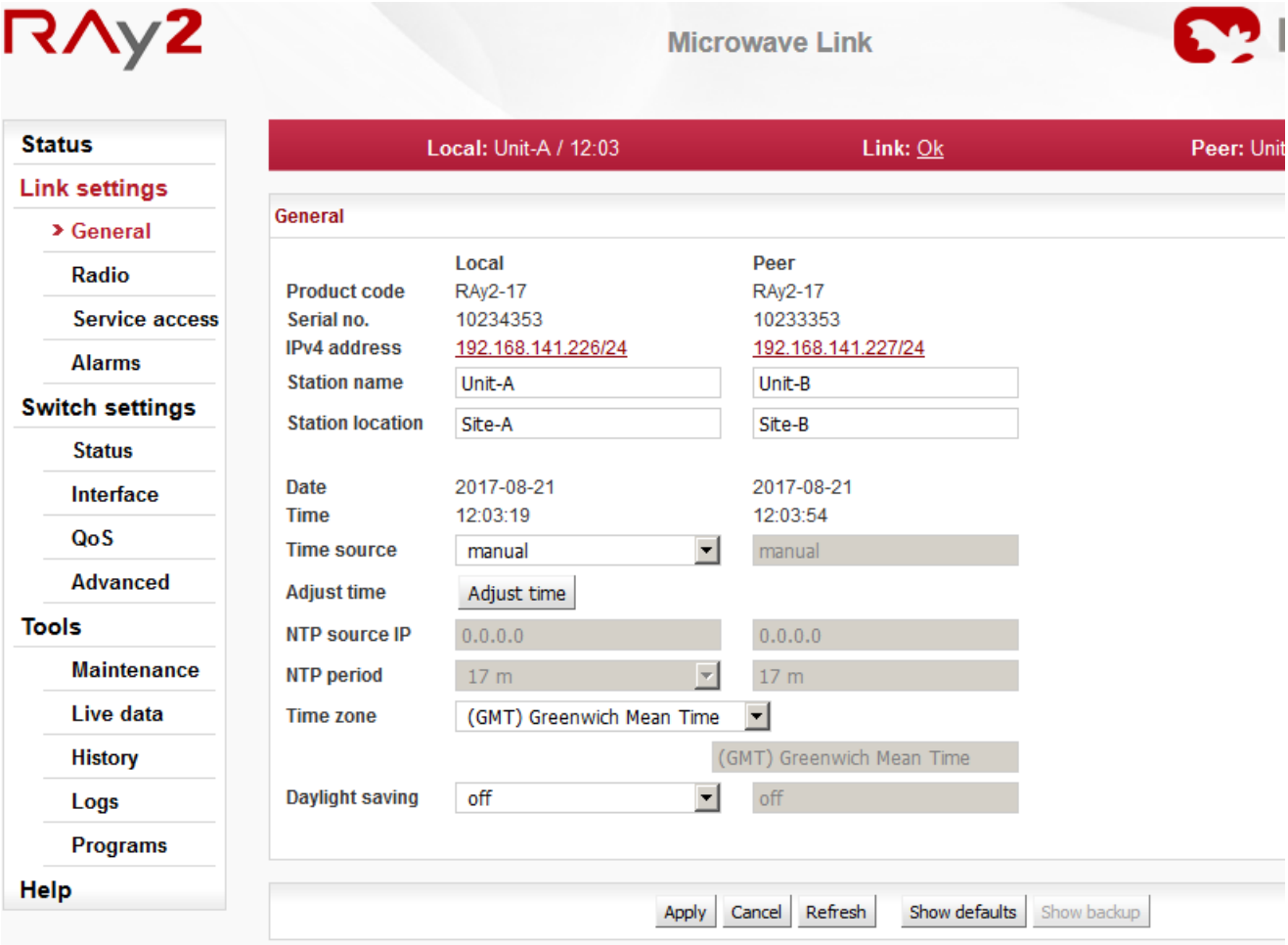
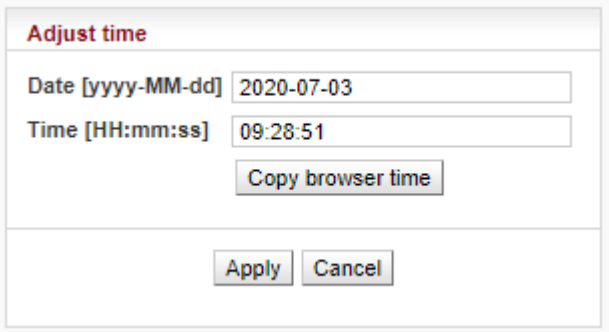


Fig. 5.7: Menu Link settings / General

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.

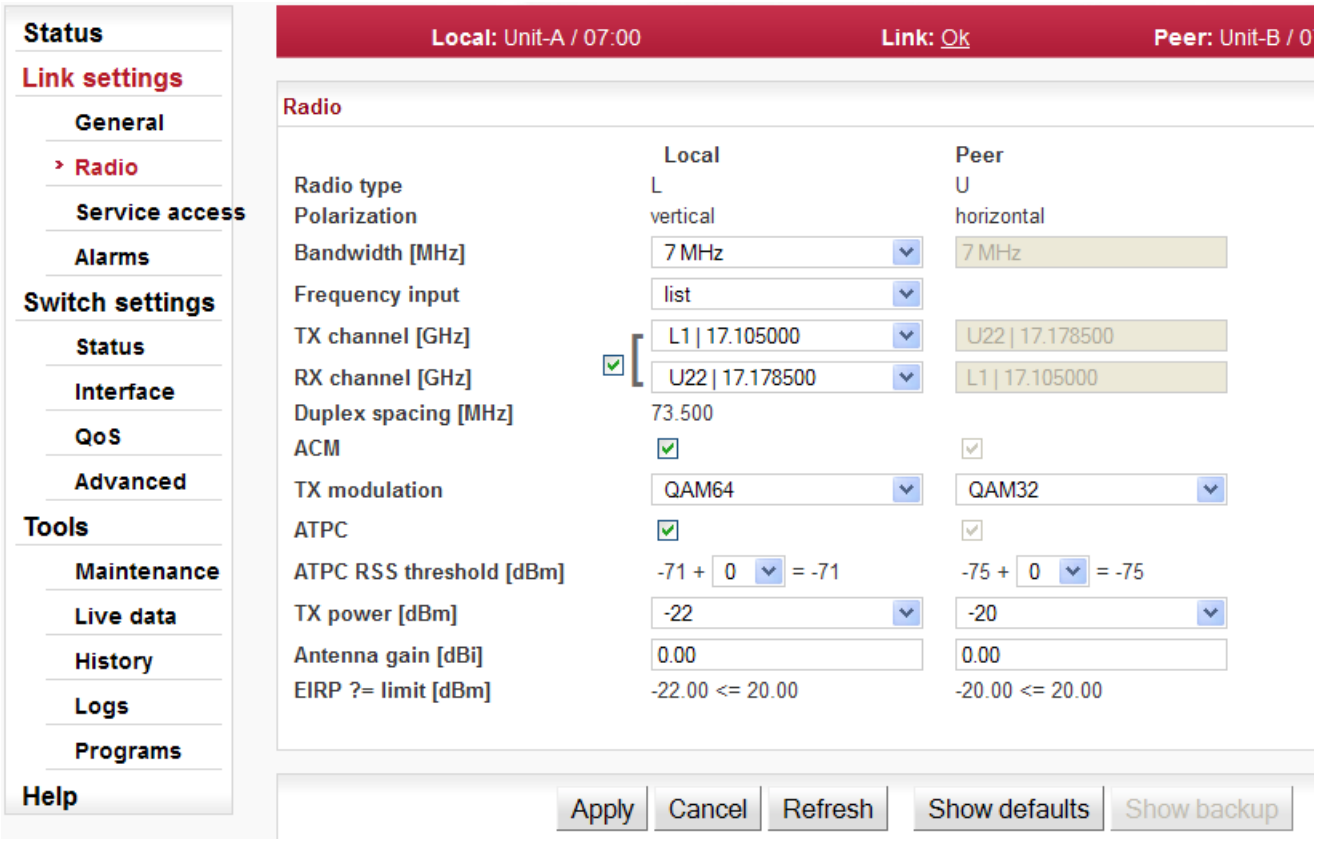


Fig. 5.8: Menu Link settings / Radio

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 (see Note below for more details). Its maximum is defined by parameter 'TX power' below. 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.

Note

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, ie. 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

5.4.3.1. Services

Access routes for link configuration.

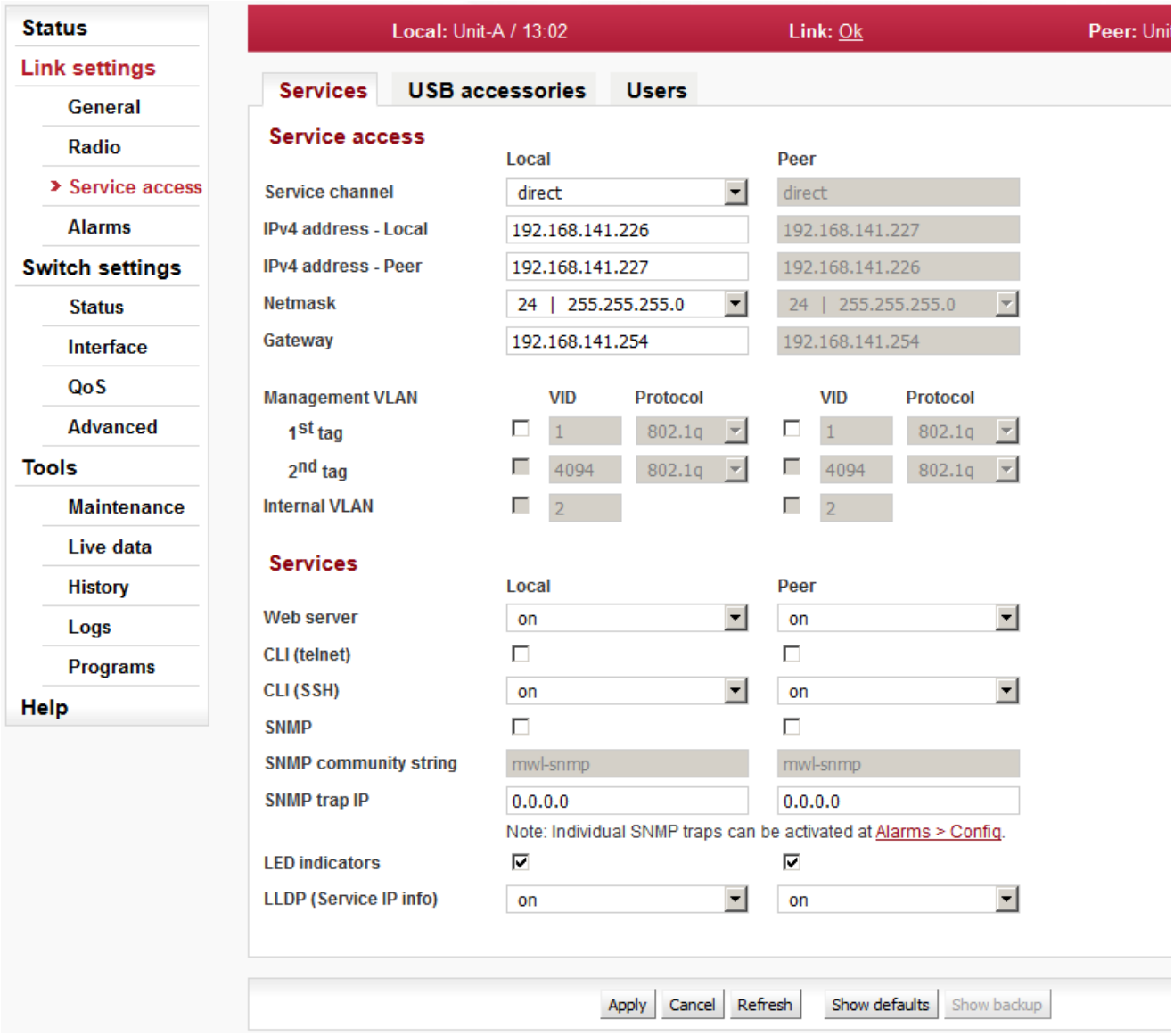


Fig. 5.9: Menu Link settings / Service access / Services

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.

Note

Unknown IP address
If you forget the Service IPv4 address, it can be found by reading data broadcast through LLDP protocol. Data is transmitted every 60 seconds and contains the following information:

1. Management address: IP address
2. System Description: Serial number
3. Chassis Subtype: Type (e.g. RAY2-17-L)
4. 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.

5.4.3.2. 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.

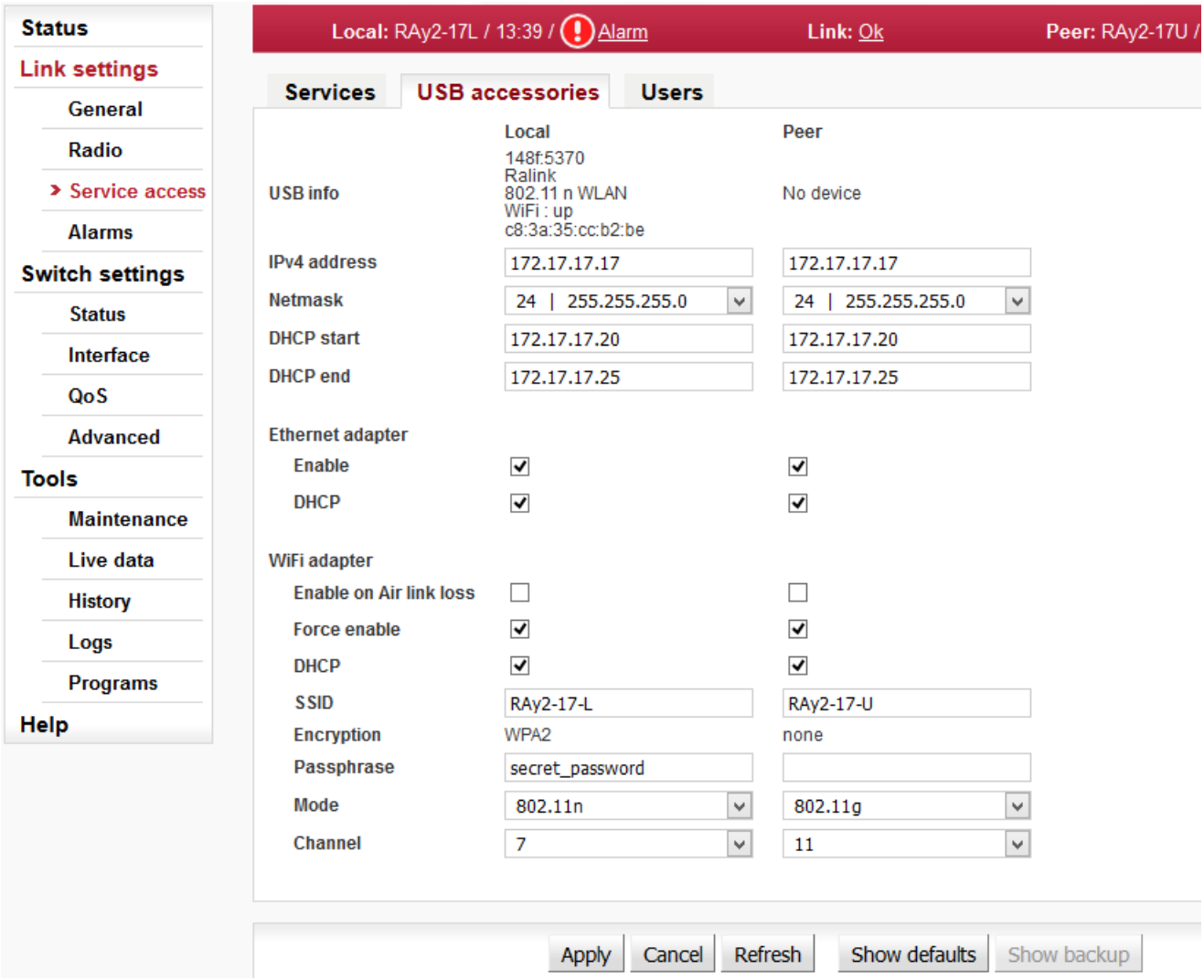


Fig. 5.10: Menu Link settings / Service access / USB accessories

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.

5.4.3.3. Users

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

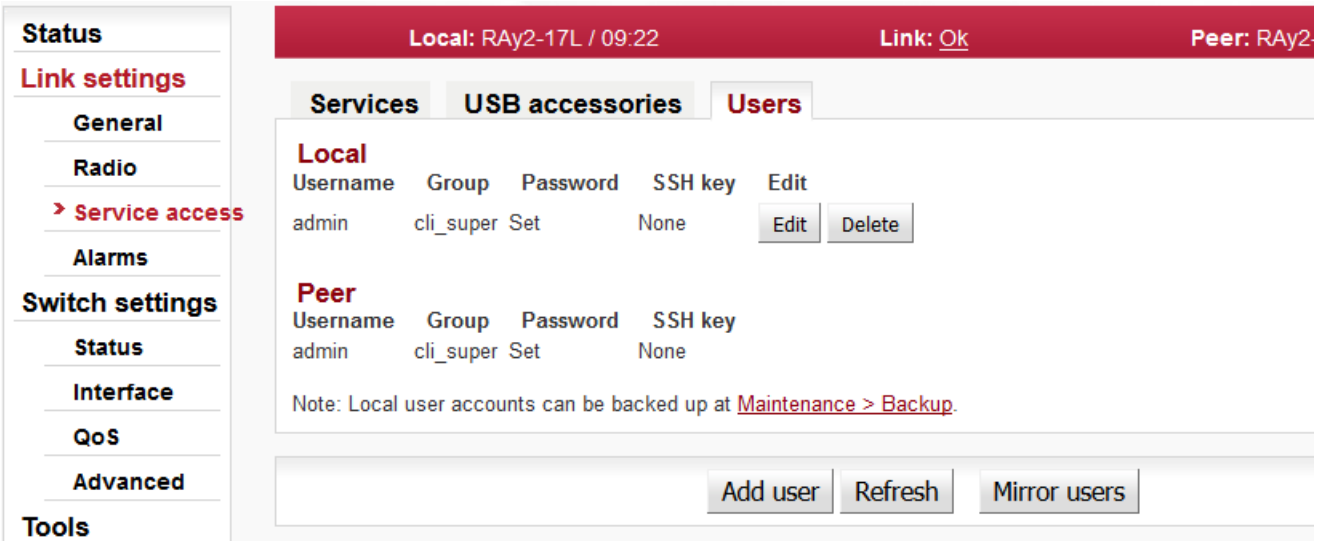


Fig. 5.11: Menu Link settings / Service access / Users

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 groups of users with different levels of permissions.

Permissions	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

Numbers of users that can be defined in the system:

Group	No of users
cli_guest	10
cli_admin	10
cli_super *	2

* 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.

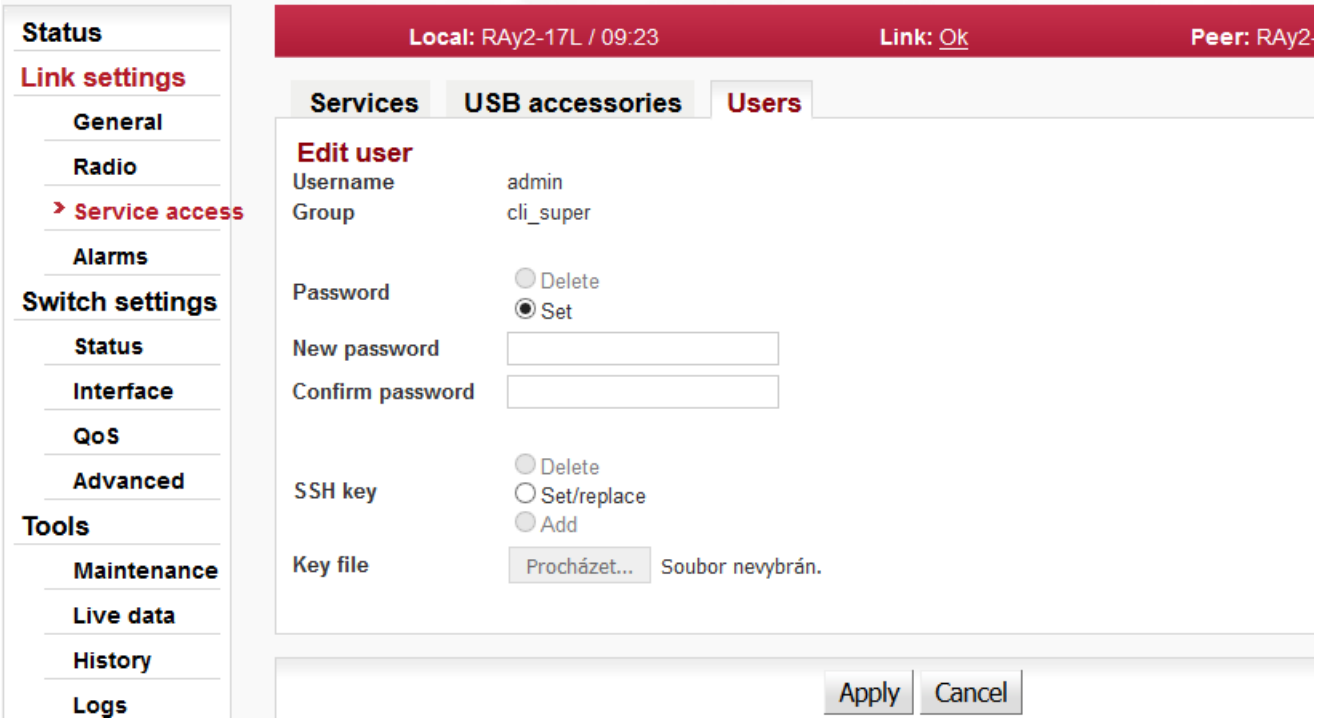


Fig. 5.12: Menu Link settings / Service access / Users / edit

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

5.4.4.1. Alarms Status

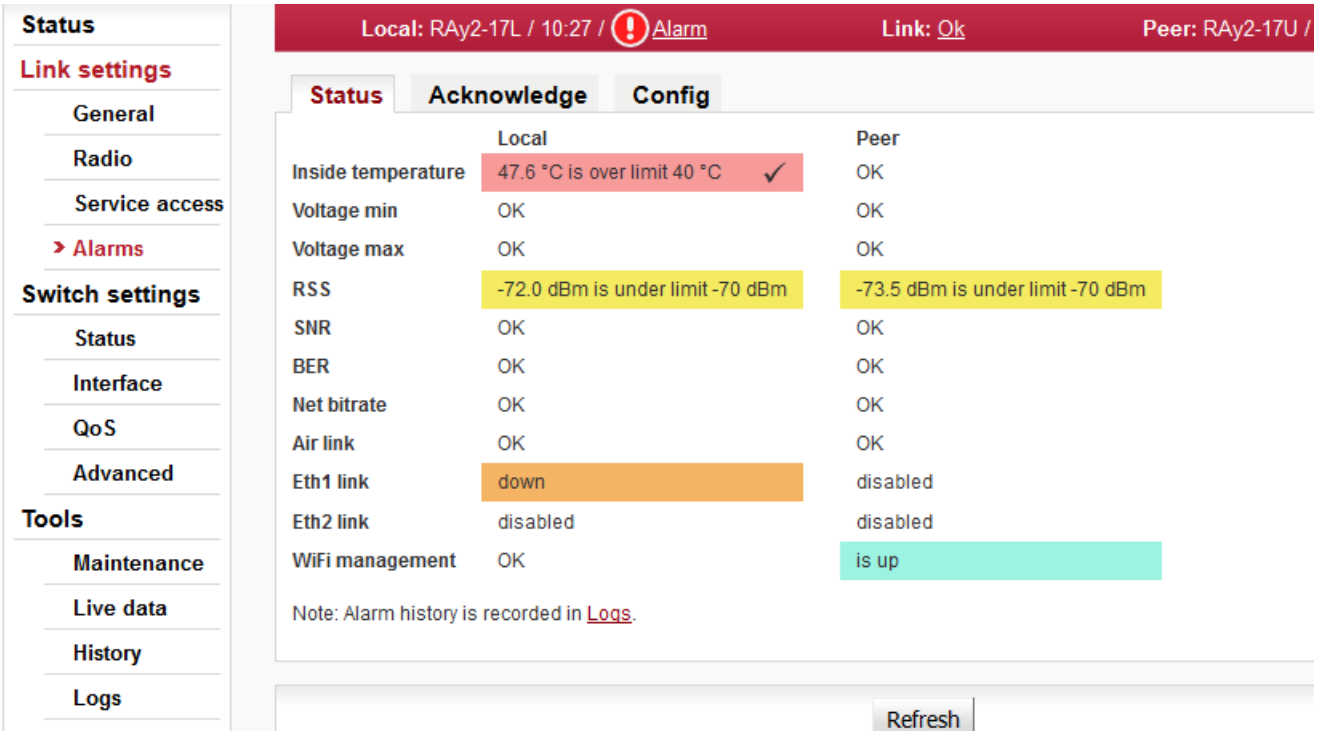


Fig. 5.13: Menu Link settings / Alarms / Status

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. 5.14: Alarm severity

5.4.4.2. Alarms Acknowledge

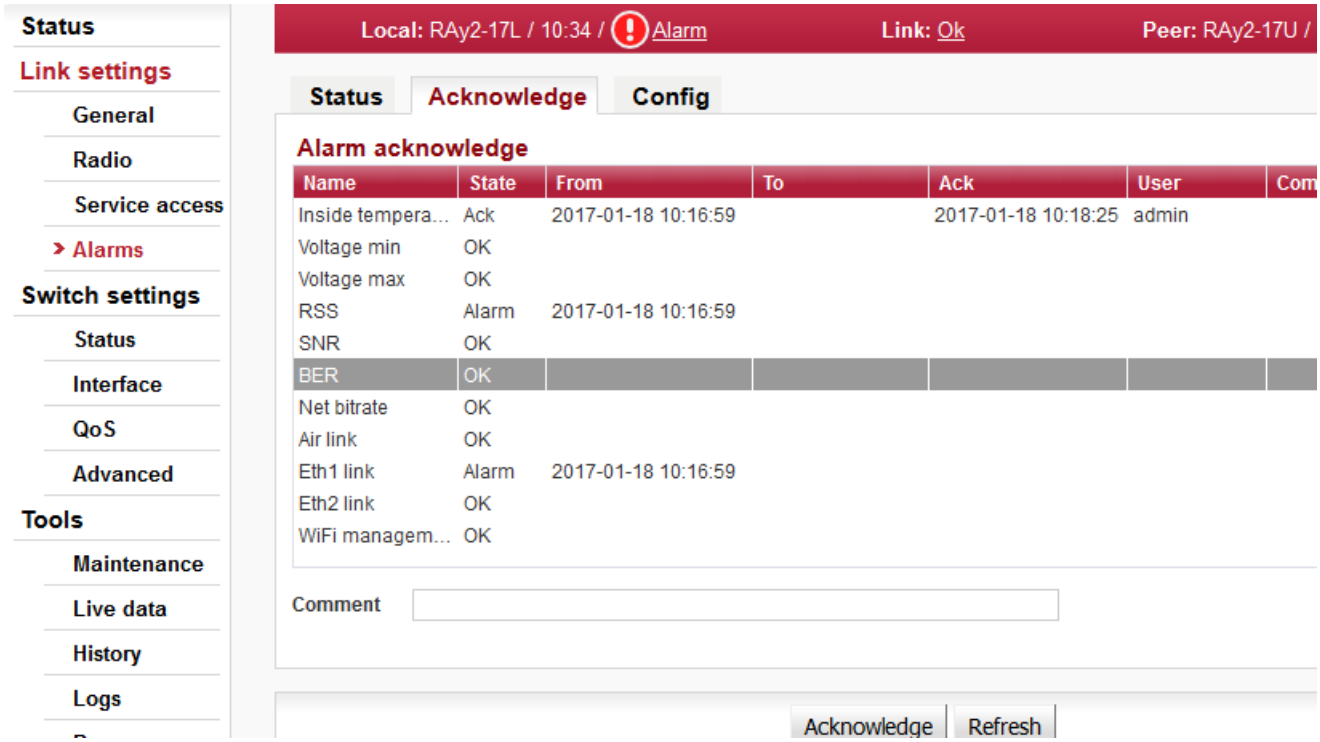


Fig. 5.15: Menu Link settings / Alarms / Acknowledge

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.

5.4.4.3. Alarms Config

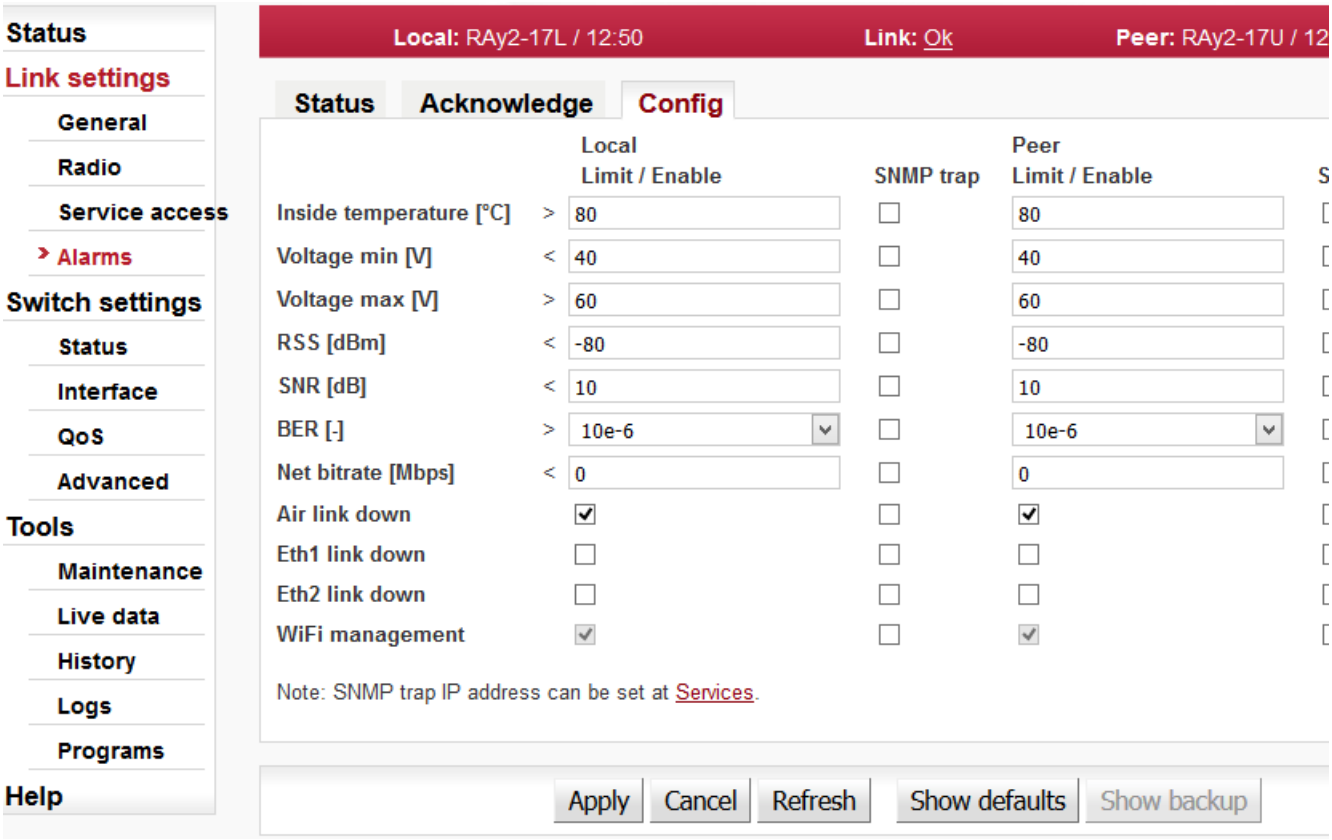


Fig. 5.16: Menu Link settings / Alarms / Config

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).

5.5. Switch settings

5.5.1. Status

5.5.1.1. Port status

The unit internal Ethernet switch port status

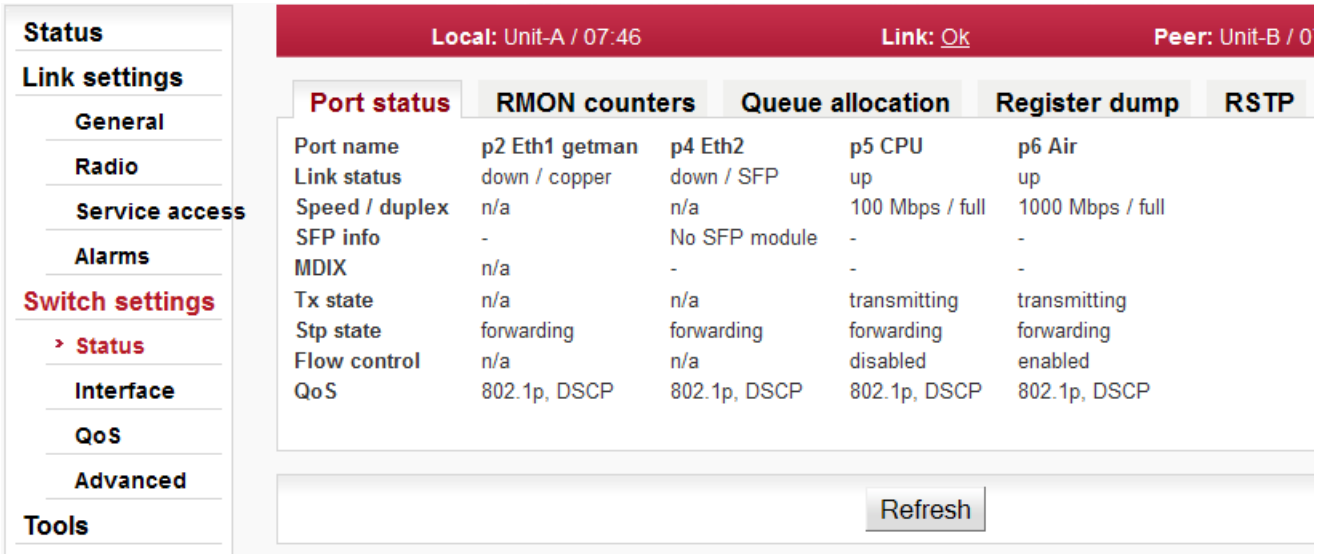


Fig. 5.17: Menu Switch settings / Port status

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.

5.5.1.2. RMON counters

The unit internal Ethernet switch RMON counters

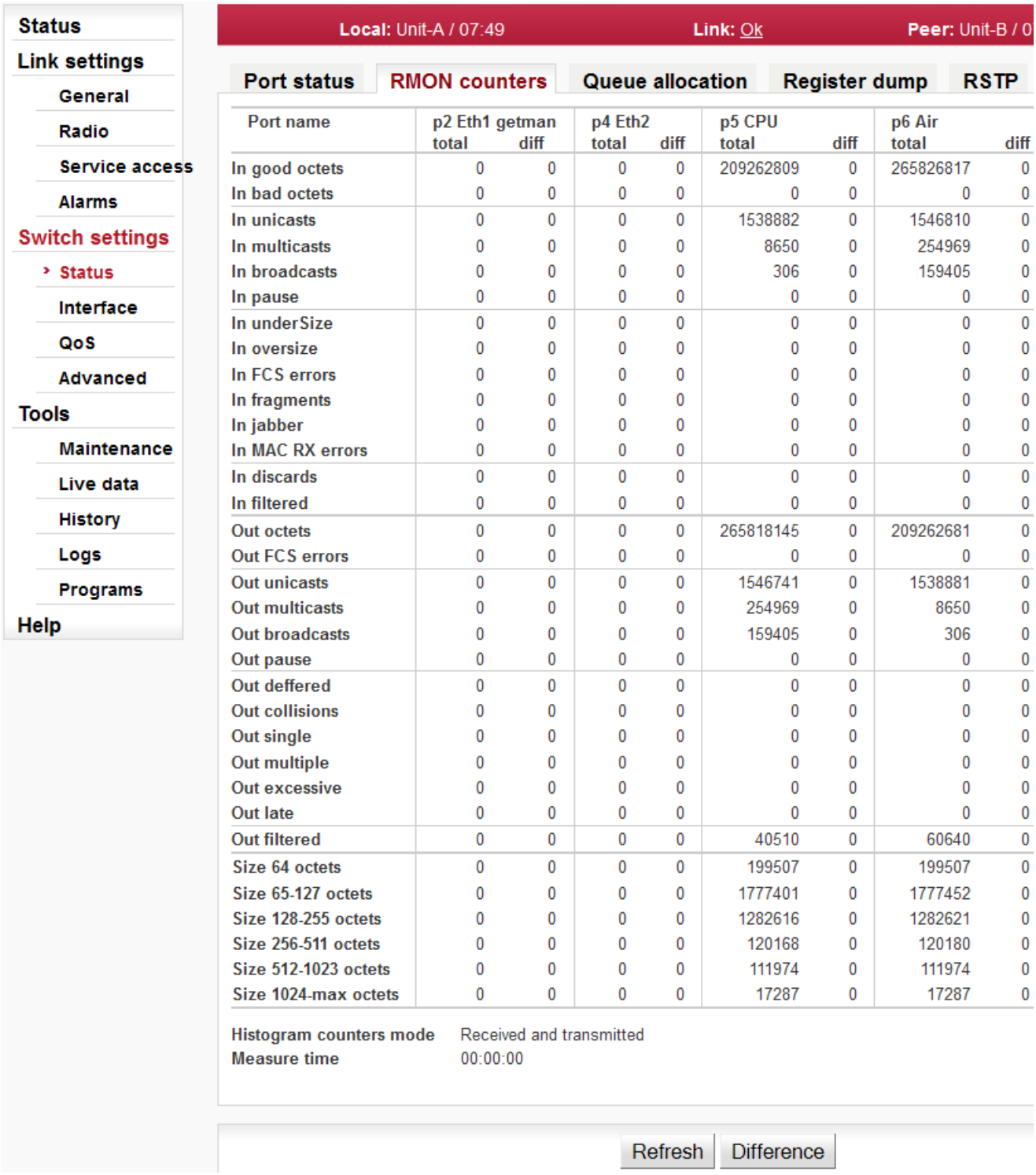


Fig. 5.18: Menu Switch settings / RMON counters

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 deffered	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.

5.5.1.3. Queue allocation

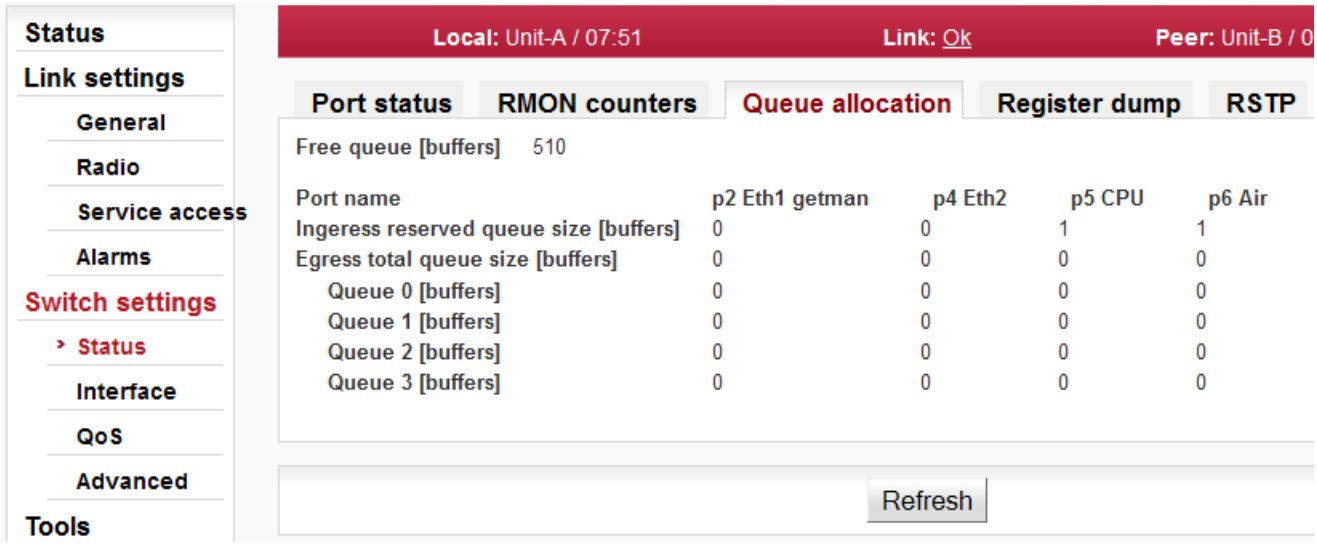


Fig. 5.19: Menu Switch settings / Queue allocation

Free queue Free Queue Size Counter. This counter reflects the current number of unallocated buffers available for all the ports [buffers].

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.

Ingress ... This counter reflects the current number of reserved Ingress buffers assigned to this port [buffers].

Egress ... This counter reflects the current number of Egress buffers switched to this port. This is the total number of buffers across all priority queues [buffers].

Queue 0~3 [buffers] Those counters reflect the current number of Egress buffers switched to this port for individual priority queues [buffer].

5.5.1.4. Register dump

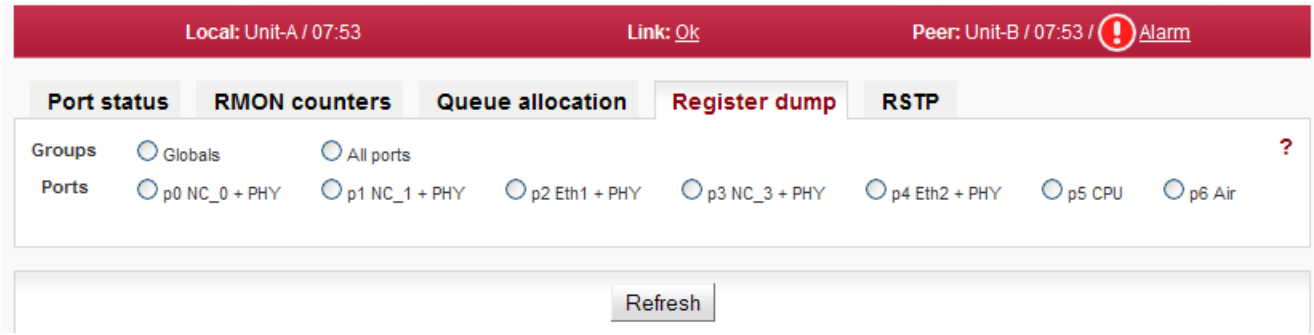


Fig. 5.20: Menu Switch settings / Register dump

The exact contents of the internal switch configuration and diagnostic registers can be listed for diagnostic purposes. All registers are separated into several groups.

Groups	Globals	Global switch parameters.
	All ports	Global port related parameters.
Ports	Port specific parameters.	
Registers	Registers contents is listed in hexadecimal notation.	

5.5.1.5. RSTP

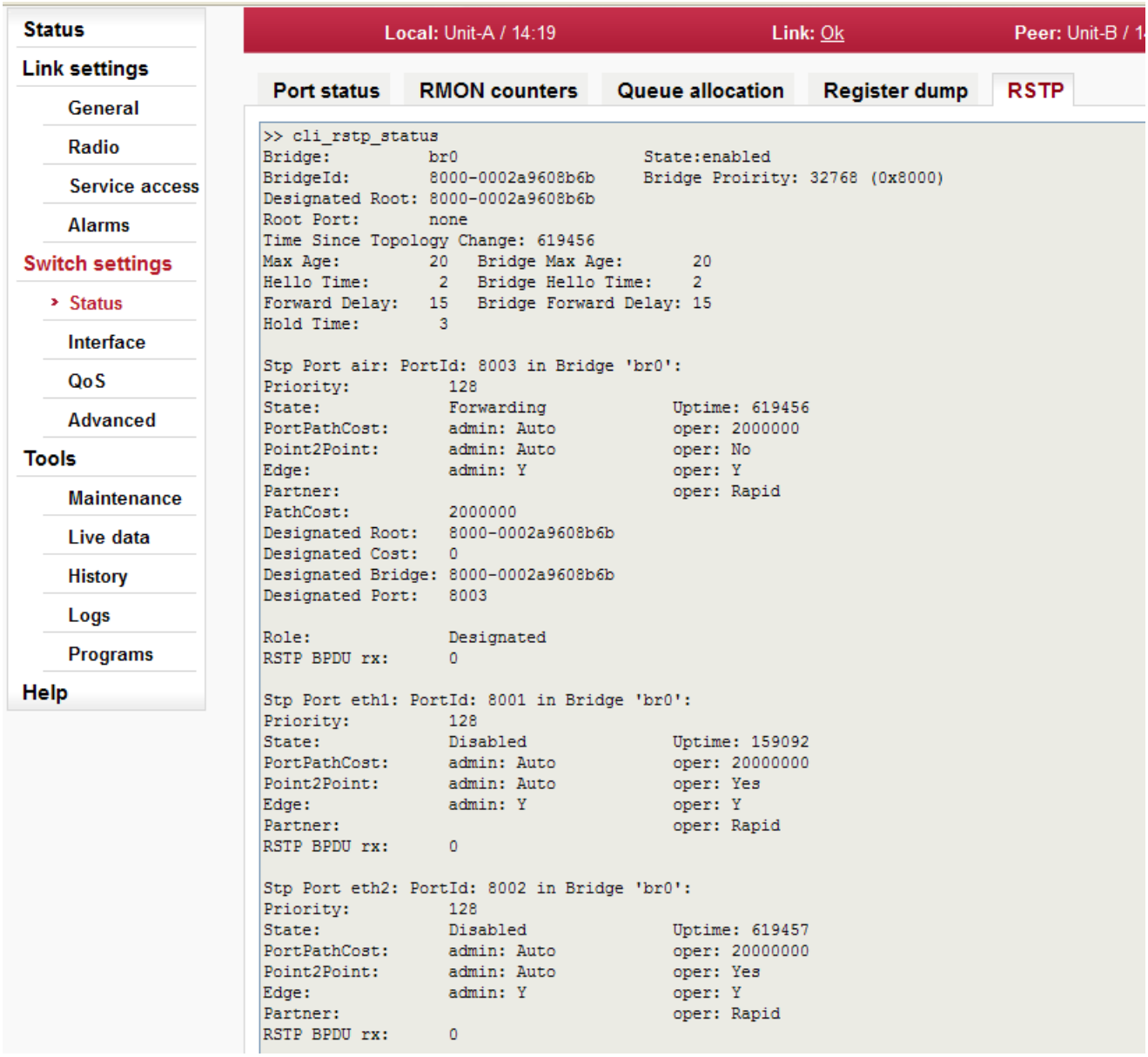


Fig. 5.21: Menu Switch settings / RSTP

RSTP service status

5.5.2. Interface

5.5.2.1. Port

Port settings

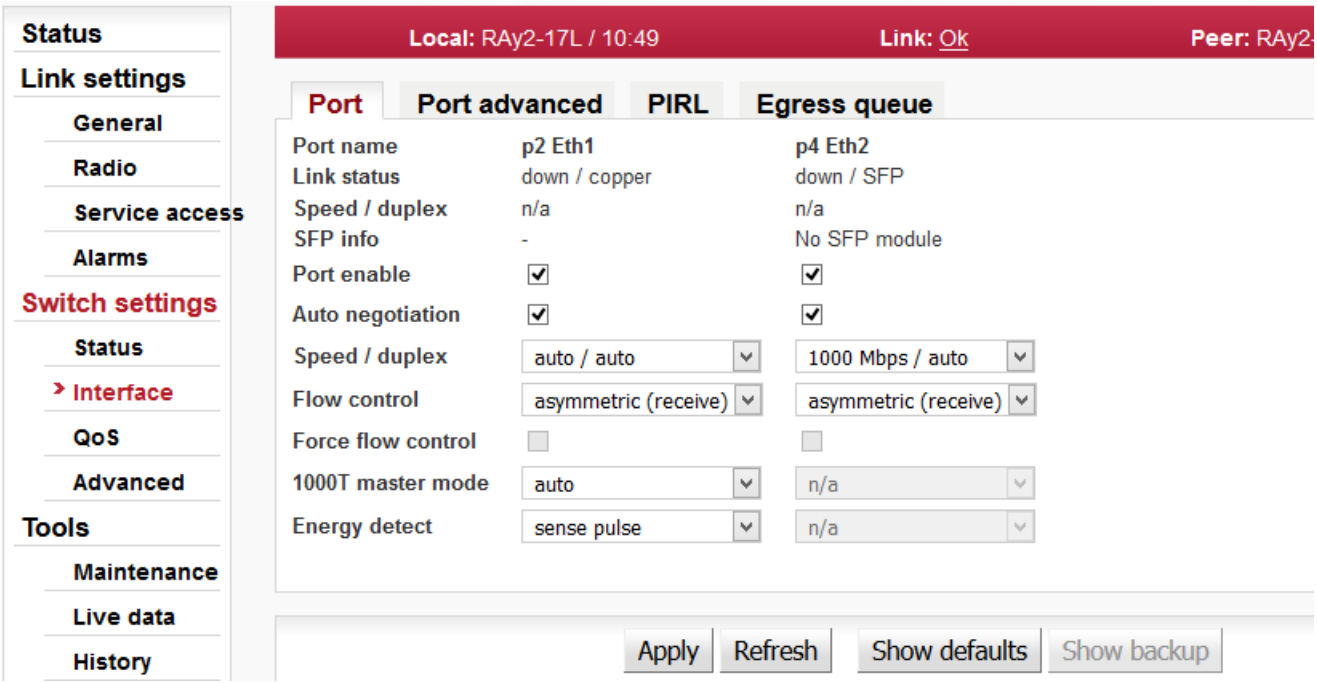


Fig. 5.22: Menu Switch settings / Port

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).

5.5.2.2. Port advanced

The unit internal Ethernet switch Port settings

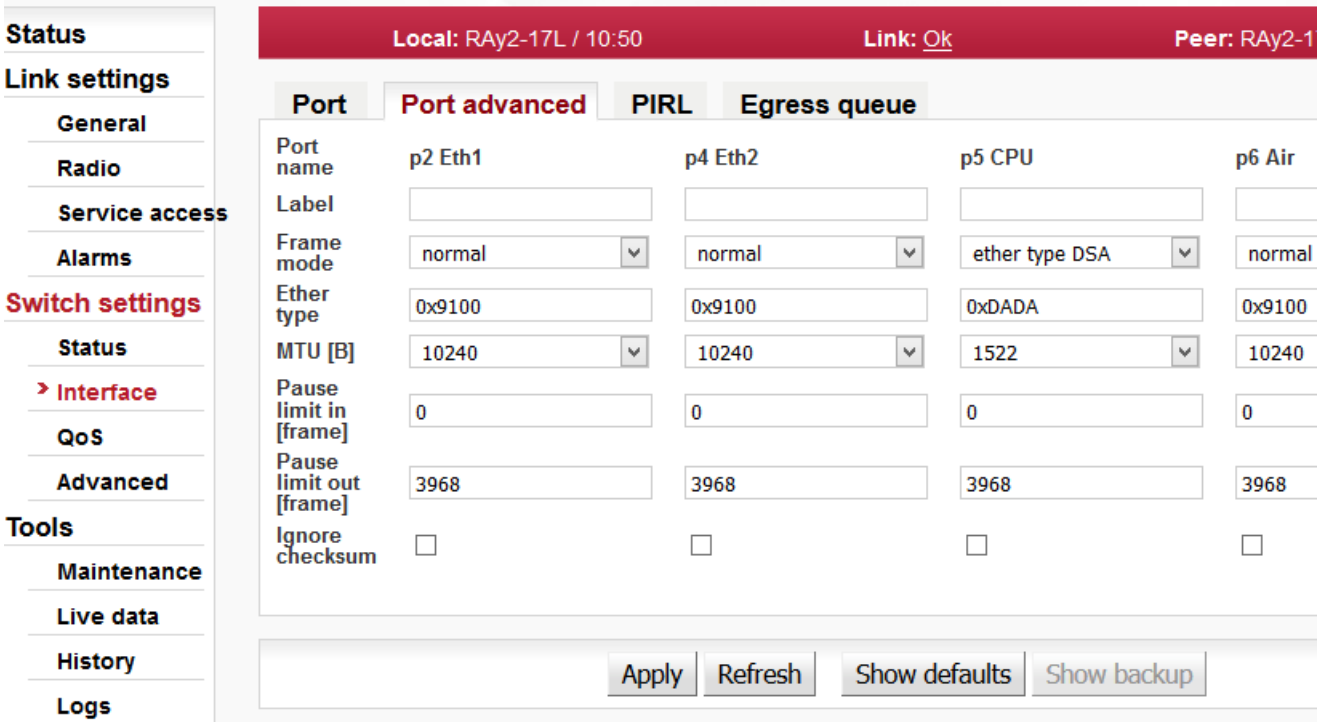


Fig. 5.23: Menu Switch settings / Port advanced

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.

Label Custom port name.

Frame mode Ethernet Frame mode control defines the expected Ingress and the generated Egress tagging frame format for this port as follows:

normal	Normal Network mode uses industry standard IEEE 802.3ac Tagged or Untagged frames. Tagged frames use an Ether Type of 0x8100. Ports that are expected to be connected to standard Ethernet devices should use this mode.
DSA	Inactive options are not required.
provider	Provider mode uses user definable Ether Types per port (see Ether type parameter) to define that a frame is Provider Tagged. Ports that are connected to standard Provider network devices, or devices that use Tagged frames with an Ether Type other than 0x8100 should use this mode. Frames that ingress this port with an Ether Type that matches the port's Ether Type parameter will be considered tagged, will have the tag's VID and PRI bits assigned to the frame (i.e. they will be used for

switching and mapping), and will have the Provider Tag removed from the frame. If subsequent Provider Tags are found following the 1st Provider Tag, they too will be removed from the frame with their VID and PRI bits being ignored. Modified frames will be padded if required.

Frames that ingress this port with an Ether Type that does not match the Ether Type parameter will be considered untagged. The ingressing frames are modified so they are ready to egress out Customer ports (Normal Network Frame Mode ports) unmodified.

Frames that egress this port will always have a tag added (even if they were already tagged). The added tag will contain this port's Ether Type as its Ether Type. The PRI bits will be the Frame Priority FPri assigned to the frame during ingress. The VID bits will be the source port's Default VID bits (if the source port was in Normal Network mode), or the VID assigned to the frame during ingress (if the source port was in Provider mode).

ether type DSA

Valid only for the "p5 CPU" port.

Ether Type DSA mode uses standard Marvell DSA Tagged frame information following a user definable Ether Type (see Ether type parameter). This mode allows the mixture of Normal Network frames with DSA Tagged frames and is useful on ports that connect to a CPU.

Frames that ingress this port with an Ether Type that matches the port's "Ether Type" will be considered DSA Tagged and processed accordingly. The frame's Ether Type and DSA pad bytes will be removed so the resulting frame will be ready to egress out Marvell DSA Tag Mode ports unmodified. Frames that ingress this port with a different Ether Type will be considered Normal Network Frames and processed accordingly.

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

Ether type

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

Examples:

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

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

MTU [B]

MTU determines the maximum frame size allowed to be received or transmitted from or to a given physical port. This implies that a Jumbo frame may be allowed to be

received from a given input port but may or may not be allowed to be transmitted out of a port or ports. The possible values are 1522, 2048 and 10240 Bytes.

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

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

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

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

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

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

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

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

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

5.5.2.3. PIRL

PIRL (Port based Ingress Rate Limiting) has the task of arranging the transfer of frames; ensuring as few frames as possible are discarded and that ports are not blocked.

Diagram of framework processing options are available within the QoS, PIRL and Egress queue control menus:

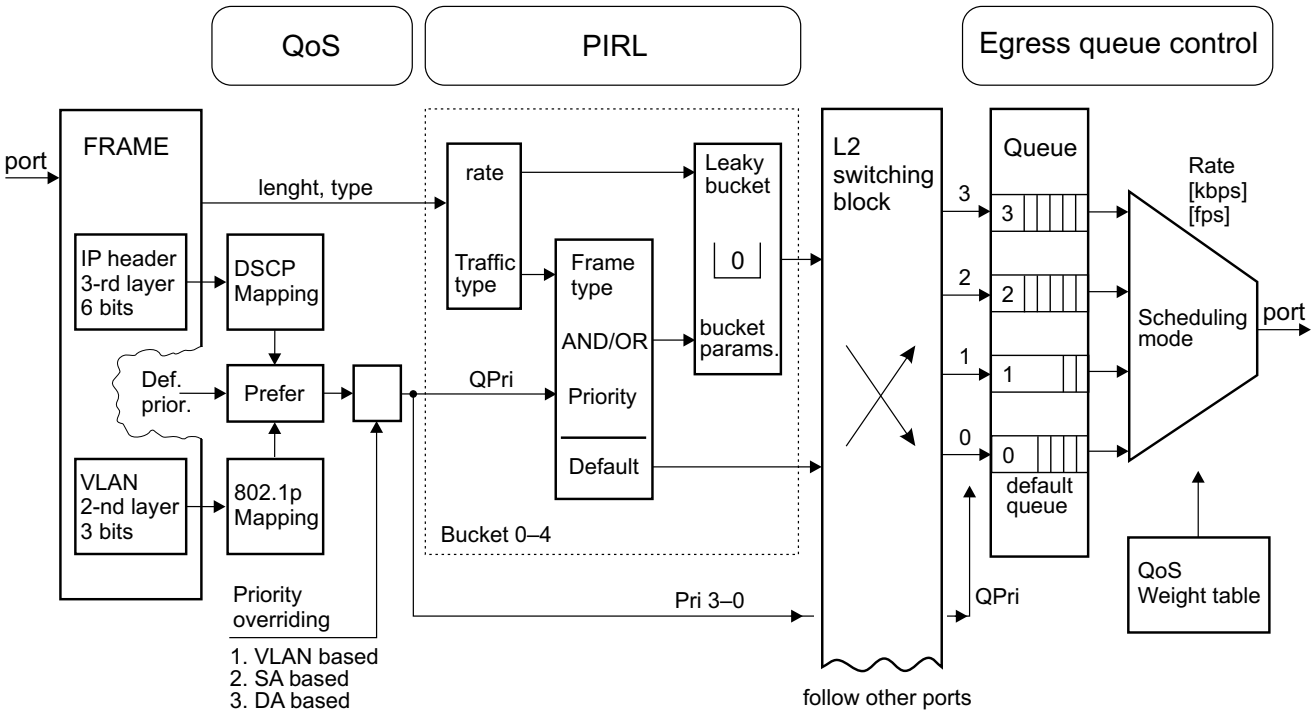


Fig. 5.24: PIRL and queues

Frame

The frame comes via port, has a certain length and MAC addresses SA and DA. The IP header carries the DSCP priority and may also carry the 802.1p VLAN priority.

QoS

The Queue priority (QPri) is created based on preferences within the DSCP or 802.1p priority. This priority takes values from 0 to 3, and controls the processing of frames inside the switch.

- Untagged frames are provided with 802.1p priority by default.
- Priorities may be remapped.
- The priority can also be overwritten by the *Advanced menu* priority derived from a VLAN, SA and/or DA addresses.

The Frame priority (FPri) is processed in a similar manner. Frame coming from the network and frame being sent to the network is marked by this priority.

PIRL

Between the port and the common switch there may be between 1 and 5 "flow restrictors" working in parallel according to the schedule "leaky bucket". These are called "Resource". This is analogous to

the container which is intermittently replenished by tokens according to incoming frames and is continuously emptied. Regulatory measures are implemented at a certain height to ensure the bucket does not overflow.

PIRL - Edit section of this menu is made up of several groups of parameters:

- Resource identification.
- Resource capacity, transfer byte into tokens.
- Method of counting frames.
- Regulatory interventions (drop frame - reduce feeding)
- Selecting frames (all - by priority QPri - by type).

The above mentioned parameters are used to allocate part of a frame to each Resource. Their passage is regulated thus avoiding network congestion. If there is a framework that does not match the filter of any Resource, this then passes to the switch without restrictions.

Switching block

In this block (L2-switch) each frame is routed to a designated port according to the Advanced menu.

Egress queue

Block output queues. Each port receives frames from the L2 switch through 4 queues (No. 3-0). The highest priority has a queue No. 3. The frames are organized into queues according to their priorities QPri.

The Method to empty queues is selected by the parameter Scheduling Mode. The emptying rate is governed by the Rate limit parameter.

A Frame sent from the port to the network can be identified by priority FPri, although it is also possible to change its tag: see menu VLAN/Egress mode.

Port based ingress rate limiting, see also the *Functional diagram*

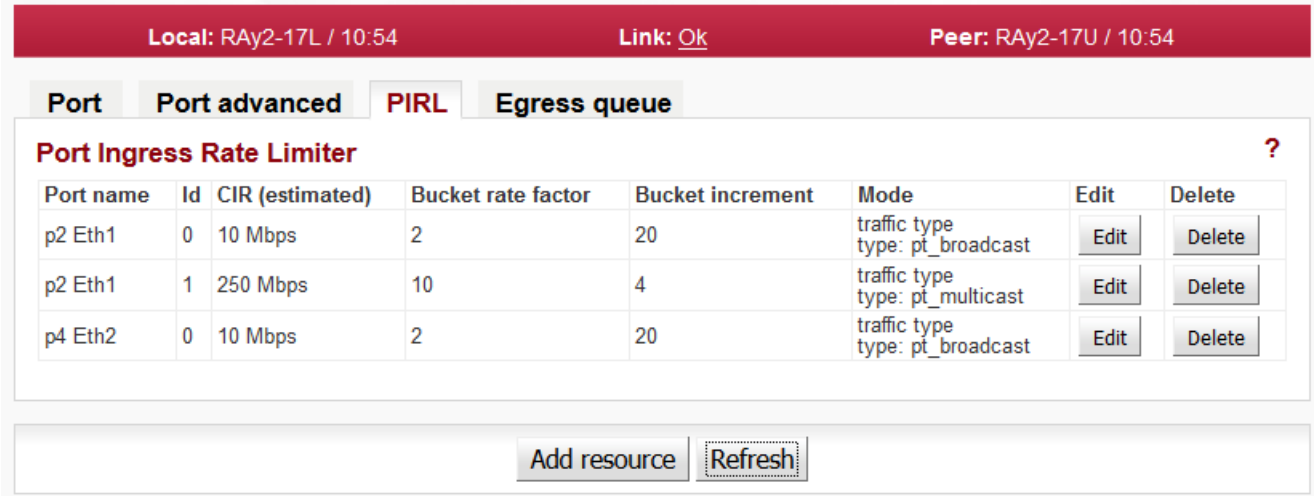


Fig. 5.25: Menu Switch settings / PIRL

The device supports per port TCP/IP ingress rate limiting along with independent Storm prevention. Port based ingress rate limiting accommodates information rates from 64 Kbps to 1 Mbps in increments of 64 Kbps, from 1 Mbps to 100 Mbps in increments of 1 Mbps and from 100 Mbps to 1000 Mbps in increments of 10 Mbps.

In addition to this, the device supports Priority based ingress rate limiting. A given ingress rate resource can be configured to track any of the four priority traffic types. One of the popular schemes for implementing rate limiting is a leaky bucket. The way a leaky bucket scheme works is that the bucket drains tokens constantly at a rate called Committed Information Rate (CIR) and the bucket gets replenished with tokens whenever a frame is allowed to go through the bucket. All calculations for this bucket are done in tokens. Therefore, both bucket decrementing and incrementing is performed using tokens (i.e., frame bytes are converted into bucket tokens for calculation purposes).

The device supports a color blind leaky bucket scheme.

The traffic below Committed Burst Size limit (CBS Limit) is passed without any further actions. If the traffic burst were to continue and the bucket token depth approaches closer to the Excess Burst Size limit (EBS Limit) by less than the CBS Limit, then a set of actions are specified. Note that if the frame gets discarded then the equivalent number of tokens for that frame will not get added to the bucket.

There are the two default ingress limiting rules already configured in the switch default configuration. They limit the maximum allowed ARP traffic coming to the CPU port to 10Mbps from Eth1 and 10Mbps from Eth2 ports.

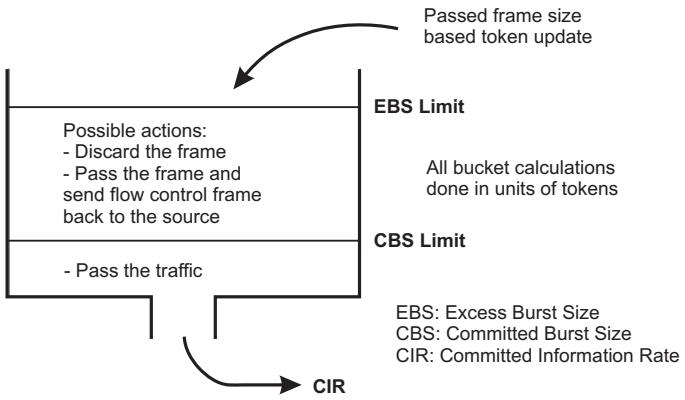


Fig. 5.26: Leaky bucket

Primary key The live data icon indicates which parameter field is taken as the unique identifier in the database. This field entry ensures each record is unique and must not be duplicated.

Port name Ports Eth1, Eth2, CPU, Air. See *Port status*.

Id Each port can be assigned up to five different ingress rate resources.

Each resource defines a rule (filter) for the incoming frame. If the rule is met, the frame is affected (as set by the EBS limit action parameter). If the incoming frame does not meet any rule, it is not affected by PIRL. The frame is accepted and forwarded further to the switch engine.

CIR (estimated) The Committed Information Rate (CIR) is dependent on the Bucket Rate factor and the Bucket increment.

The calculation is estimated as the real data throughput depends on frame size. The Accounted bytes parameter affects this as well.

The formula for the CIR (in bits per second) is as follows: CIR = a * BRF / BI.

Where "a" is constant, which is 12 500 000 for Accounted bytes="frame", and is 100 000 000 for Accounted bytes="layer1". BRF is Bucket Rate factor and BI is Bucket increment.

Bucket rate factor This is a factor which determines the amount of tokens that need to be decremented for each rate resource decrement (which is done periodically based on the Committed Information Rate).

Bucket increment Bucket increment (BI) indicates the amount of tokens that need to be added for each byte of the incoming frame.

Mode Rate type or Traffic type of rate limiting. See Bucket type parameter.

Edit Press Edit to edit selected PIRL resource.

Delete Press Delete to delete selected PIRL resource.

Add resource Press Add resource button to add another PIRL resource.

5.5.2.4. PIRL - resource configuration

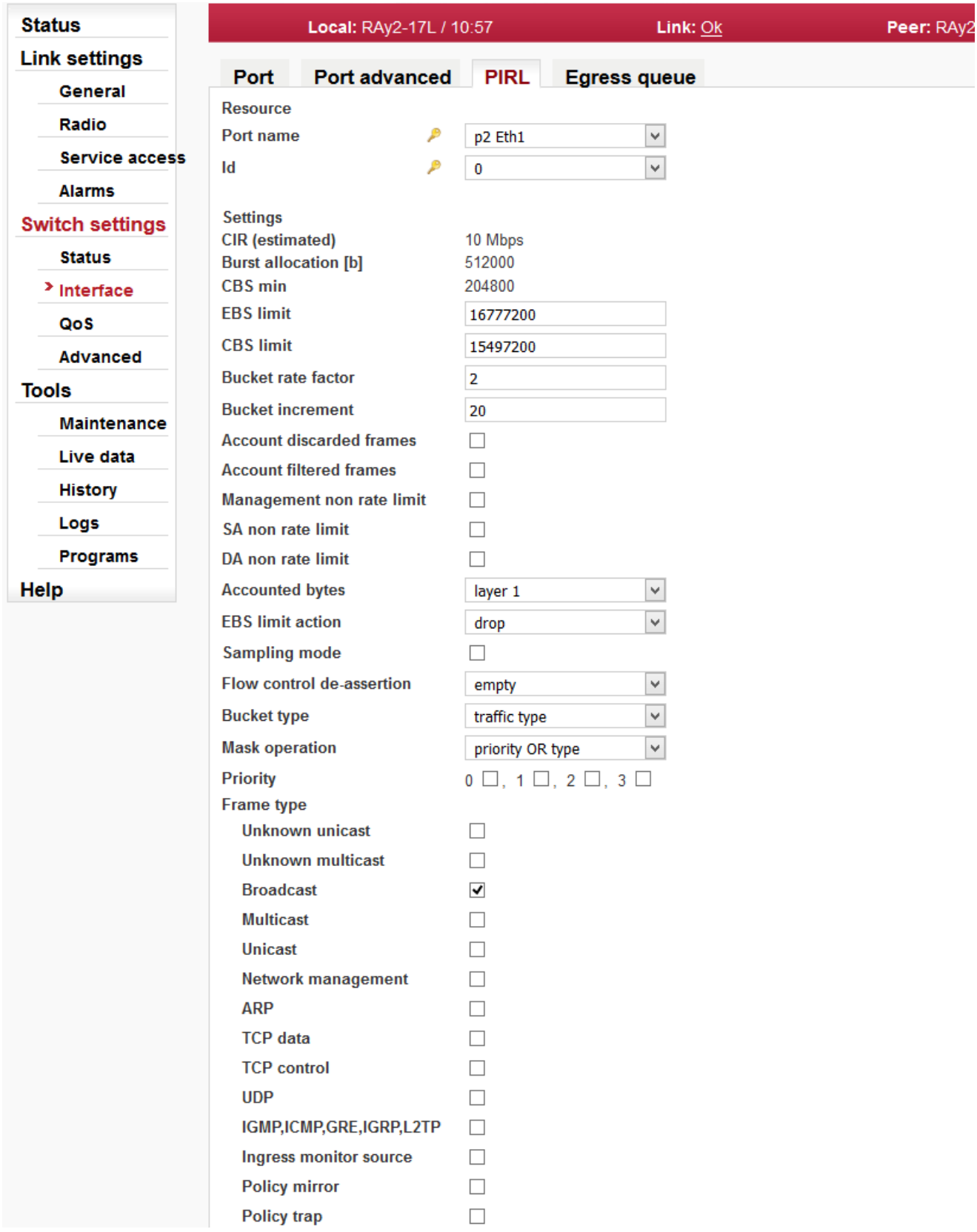


Fig. 5.27: Menu Switch settings / PIRL Resource

Each port can be assigned up to five different ingress rate resources.

Each resource defines a rule (filter) for the incoming frame. If the rule is met, the frame is affected (as set by the EBS limit action parameter). If the incoming frame does not meet any rule, it is not affected by PIRL. The frame is accepted and forwarded further to the switch engine.

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.

Id Each port can be assigned up to five different ingress rate resources.

Each resource defines a rule (filter) for the incoming frame. If the rule is met, the frame is affected (as set by the EBS limit action parameter). If the incoming frame does not meet any rule, it is not affected by PIRL. The frame is accepted and forwarded further to the switch engine.

CIR (estimated) The Committed Information Rate (CIR) is dependent on the Bucket Rate factor and the Bucket increment.

The calculation is estimated as the real data throughput depends on frame size. The Accounted bytes parameter affects this as well.

The formula for the CIR (in bits per second) is as follows: CIR = a * BRF / BI.

Where "a" is constant, which is 12 500 000 for Accounted bytes="frame", and is 100 000 000 for Accounted bytes="layer1". BRF is Bucket Rate factor and BI is Bucket increment.

Burst allocation [b] The Burst allocation (BA) is dependent of the Bucket increment, the Committed Burst Size limit and the Excess Burst Size limit.

The formula for the BA is as follows: BA = 8 * (EBS-CBS) / BI.

Where EBS is the Excess Burst Size limit, CBS is the Committed Burst Size limit and BI is the Bucket increment.

The Burst allocation size should be less than switch internal memory which is 1Mb.

CBS min The minimum value for the CBS limit is related to the maximum frame size and Bucket increment.

The CBS limit should always be bigger than the CBS min.

The calculation for CBS min is as follows:

CBS min = BI * MaxFrameSize [bytes].

Where BI is the Bucket increment.

If the CBS limit is lower than this value (i.e. to allow a large burst), then an ingress stream composed of maximum sized frames may exceed the Committed Information Rate. It is for this reason that we recommend the CBS limit value always stays above the CBS min value. Also, the CBS limit should never exceed the EBS limit.

EBS limit Excess Burst Size limit.

The EBS limit should always be bigger than CBS limit. It is recommended that the EBS limit be set to 16777200.

CBS limit Committed Burst Size limit. This indicates the committed information burst amount.

Bucket rate factor This is a factor which determines the amount of tokens that need to be decremented for each rate resource decrement (which is done periodically based on the Committed Information Rate).

Bucket increment Bucket increment (BI) indicates the amount of tokens that need to be added for each byte of the incoming frame.

Account discarded frames This parameter decides whether the ingress rate limiting logic accounts for frames that have been discarded by the queue controller due to output port queue congestion reasons. To account for all frames coming into a given port associated with this rate resource, this parameter needs to be set.

Account filtered frames This parameter decides whether the ingress rate limiting logic accounts for frames that have been discarded because of ingress policy violations. To account for all frames coming into a given port associated with this rate resource, this parameter needs to be set.

Management non rate limit When this parameter is disabled all frames that are classified by the ingress frame classifier as MGMT frames would be considered to be ingress rate limited as far as this particular ingress rate resource is concerned.
When this parameter is enabled, all frames that are classified as MGMT frames by the ingress frame classifier would be excluded from the ingress rate limiting calculations for this particular ingress rate resource.

SA non rate limit When this parameter is enabled then SA ATU non rate limiting overrides can occur on this port. An SA ATU non rate limiting override occurs when the source address of a frame results in an ATU hit where the SA's MAC address returns an "Entry state" with "static non rate limiting" value. When this occurs the frame will not be ingress rate limited.

DA non rate limit When this parameter is enabled then DA ATU non rate limiting overrides can occur on this port. A DA ATU non rate limiting override occurs when the destination address of a frame results in an ATU hit where the DA's MAC address returns an "Entry state" with "static non rate limiting" value. When this occurs the frame will not be ingress rate limited.

Accounted bytes This parameter determines which frame bytes are to be accounted for in the rate resource's rate limiting calculations.

There are for different supported configurations:

frame	Frame based configures the rate limiting resource to account for the number of frames from a given port mapped to this rate resource.
layer 1	Preamble (8bytes) + Frame’s DA to CRC + IFG (inter frame gap, 12 bytes)
layer 2	Frame’s DA to CRC
layer 3	Frame’s DA to CRC - 18 - 4(if the frame is tagged)

A frame is considered tagged if it is either Customer of Provider tagged during ingress.

EBS limit action This parameter controls what kind of action is performed when the EBS limit has been exceeded. Three types of action can be selected:

drop	The frame that was received on the port will get discarded.

flow control — In this mode an Ethernet flow control frame gets generated (if the flow control is enabled for that port) and sent to the source port but the incoming frame gets passed through the rate resource. If the port is operating in half-duplex mode then the port gets jammed.

accept — The frame that was received on the port is accepted even though there are not enough tokens to accept the entire incoming frame. This mode is expected to be selected for TCP based applications. It is not recommended for media streaming applications where data timing is critical.

Flow control mode is expected to be programmed on ports that have a trusted flow control mechanism available. The EBS limit action is a per-port characteristic. If a port has multiple rate resource buckets then all buckets enabled are expected to be programmed with the same EBS limit action.

Sampling mode

This mode is used for sampling one out of so many frames/bytes that are being monitored. The stream could be identified by the ingress engine as a Policy mirror and packet sampling can be applied for that stream using one of the rate resources.

In this mode, once the rate resource's "EBS Limit" is exceeded, the next incoming frame from this port that is assigned to this resource gets sent out to the mirror destination. After sending a sample frame, the token count within the rate resource is reset to zero and the bucket increments continue for each subsequent frame arrival.

The sampling mode is useful for limiting the number of Mirror frames sent to the mirror destination.

Flow control de-assertion

This parameter controls the flow control de-assertion when EBS limit action is set to generate a flow control message. There are two modes available:

empty — Flow control gets de-asserted only when the ingress rate resource has become empty.

CBS limit — Flow control gets de-asserted when the ingress rate resource has enough room to accept at least one frame of size specified by the CBS limit.
For example, if the CBS limit is programmed to be 2k Bytes, then the flow control will get de-asserted if there is at least 2k Bytes worth of tokens available in the ingress rate resource.

Bucket type

Any given bucket can be programmed to be aggregate rate based or traffic type based.

Rate based ingress rate limit: Limits all types of traffic on the ingress port.

Traffic type based ingress rate limit: Limits a specific type of traffic on the ingress port.

Mask operation

This parameter controls whether an ingress frame must meet both Priority and Frame type requirements to be counted for ingress rate calculations or if meeting only one requirement is sufficient to be counted for ingress rate calculations for this rate resource.

Priority

Any combinations of the four queue priorities can be selected. Frames with marked priority are accounted for in this ingress rate resource.

If there is no priority selected, priority of the frame does not have any affect on the ingress rate limiting calculations done for this ingress rate resource.

Frame type

Any of the following frame types can be selected to be tracked as part of the rate resource calculations:

Management (MGMT), Multicasts, Broadcasts, Unicasts, Address Resolution Protocol (ARP), TCP Data, TCP Ctrl, UDP, Non-TCPUDP (covers IGMP, ICMP, GRE, IGRP and L2TP), IMS, PolicyMirror, PolicyTrap, Unknown Unicasts or Unknown Multicasts.

More than one frame type can be selected for a given rate resource.

5.5.2.5. Egress queue control

See also *Output queue diagram*.

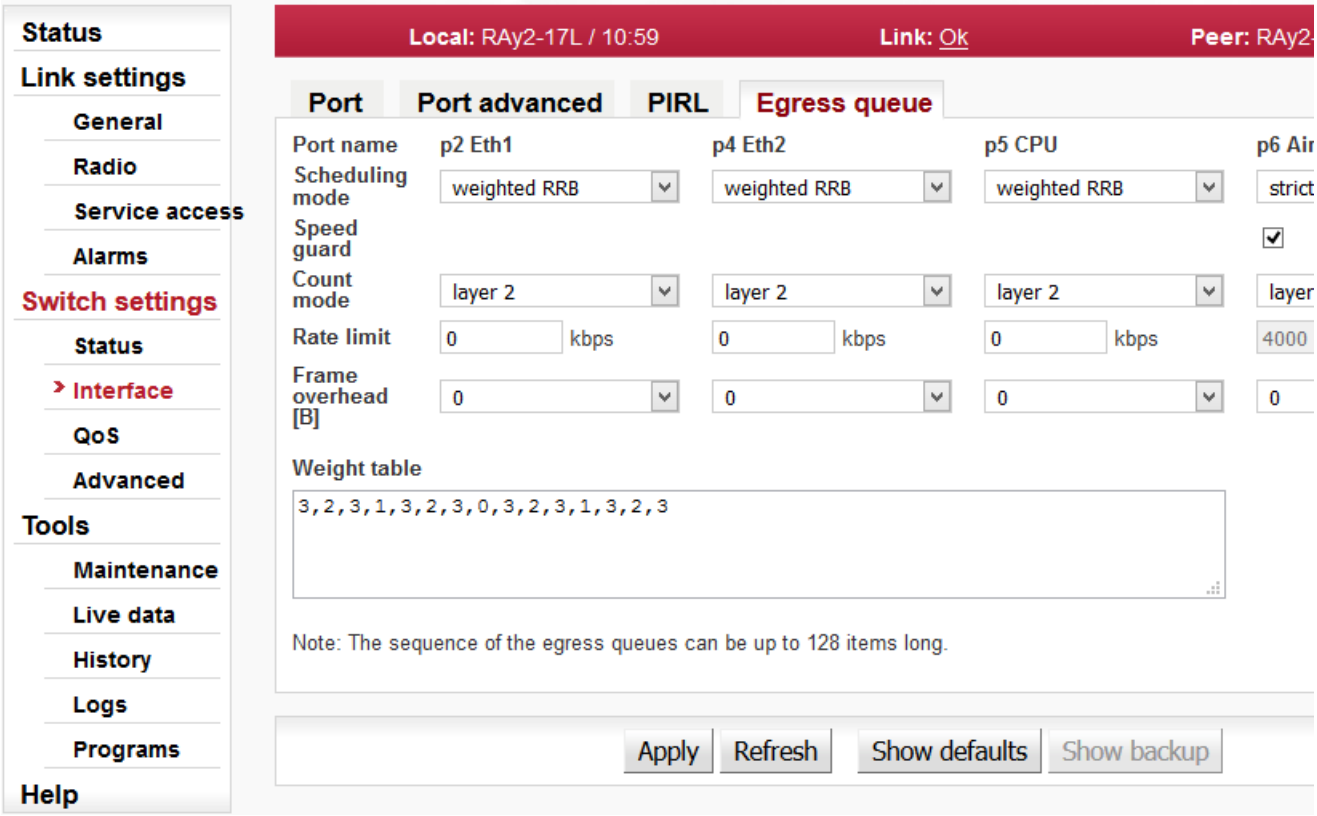


Fig. 5.28: Menu Switch settings / Egress queue

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.

Scheduling mode

Port's Scheduling mode.

The device supports strict priority, weighted round robin, or a mixture on a per egress port selection basis.

In the strict priority scheme all top priority frames egress for a port until that priority's queue is empty, then the next lower priority queue's frames egress, etc. This approach can cause the lower priorities to be starved out preventing them from transmitting any frames but also ensures that all high priority frames egress the switch as soon as possible.

In the weighted scheme an 8, 4, 2, 1 weighting is applied to the four priorities unless an alternate weighting is programmed into the QoS Weights Table. This approach prevents the lower priority frames from being starved out with only a slight delay to the higher priority frames.

Some applications may require the top priority queue, or the top two priority queues to be in a fixed priority mode while the lower queues work in the weighted approach. All scheduling modes are selectable on a per port basis.

The port scheduling mode can be one of the following values:

weighted RRB	Use a weighted round robin queuing scheme.
strict pri 3	Use Strict for priority 3 and use weighted round robin for priorities 2,1 and 0
strict pri 3, 2	Use Strict for priorities 3 and 2 and use weighted round robin for priorities 1 and 0
strict	Use a Strict priority scheme for all priorities

Speed guard

The speed guard controls automatically the Egress data rate shaping according to available capacity of the Air channel. The Air channel capacity check and the Egress shaping adjustment takes place approx. once per 50 ms.

Count mode

Egress rate limiting count mode. This parameter is used to control which bytes in the transmitted frames are counted for egress rate limiting as follows:

frame	The egress rate limiting is done based on frame count [fps] as opposed to the byte count [kbps] of the packet.
layer 1	Preamble (8bytes) + Frame's DA to CRC + IFG (inter frame gap, 12 bytes)
layer 2	Frame's DA to CRC
layer 3	Frame's DA to CRC - 18 - 4(if the frame is tagged)

Only one tag is counted even if the frame contains more than one tag. A frame is considered tagged if the egress frame going out onto the wire is tagged.

Rate [kbps] / [fps]

Egress data rate shaping. When Rate = 0 egress rate limiting is disabled.

NOTE: The Count mode parameter is used to control which bytes in the transmitted frames are counted for egress rate limiting.

If the egress shaping is controlled by frame rate, the desired frame rate can vary from 7.6k to 1.488M frames per second. Valid values are between 7600 and 1488000.

If the egress shaping is controlled by bit rate, the desired rate can vary from 64 kbps to 1 Gbps in the following increments:

Desired rate between 64 kbps and 1 Mbps in increments of 64 kbps

Desired rate between 1 Mbps to 100 Mbps in increments of 1 Mbps

Desired rate between 100 Mbps to 1 Gbps in increments of 10 Mbps

Therefore, the valid values are:

64, 128, 192, 256, 320, 384,..., 960,

1000, 2000, 3000, 4000, ..., 100000,

110000, 120000, 130000, ..., 1000000

Frame overhead [B]

Egress Rate Frame Overhead adjustment.

This parameter is used to adjust the number of bytes that need to be added to a frame's IFG (inter frame gap) on a per frame basis. This is to compensate for a protocol mismatch between the sending and the receiving stations. For example if the receiving station were to add more encapsulations to the frame for the nodes

further down stream, this per frame adjustment would help reduce the congestion in the receiving station.

This adjustment, if enabled, is added to the Egress Rate Control's calculated transmitted byte count meaning Egress Rate Control must be enabled for this Frame Overhead adjustment to work.

Weight table The weighted round robin alternate weighting can be defined here. The sequence of the output queue numbers (0,1, 2 or 3) defines the sequence of the output queue frame egressing. This sequence can be up to 128 items long.

5.5.3. QoS

Quality of Service (QoS) is the ability to provide different priorities to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow. QoS using 802.1p and DSCP are implemented.

The ingress block has the task of determining the priority of each frame to be used for the internal Queue Controller (QPri) as well as the priority assigned to the frame (FPri) if the frame egresses the switch tagged. The classification as to if the frame is discard eligible is also determined. The Ingress block does not perform the QoS switching policy, which is the task of the Queue Controller. Instead, it has the job of determining the QPri and FPri assigned to each frame for the Queue Controller and Egress block.

See the *Functional diagram*.

5.5.3.1. 802.1p

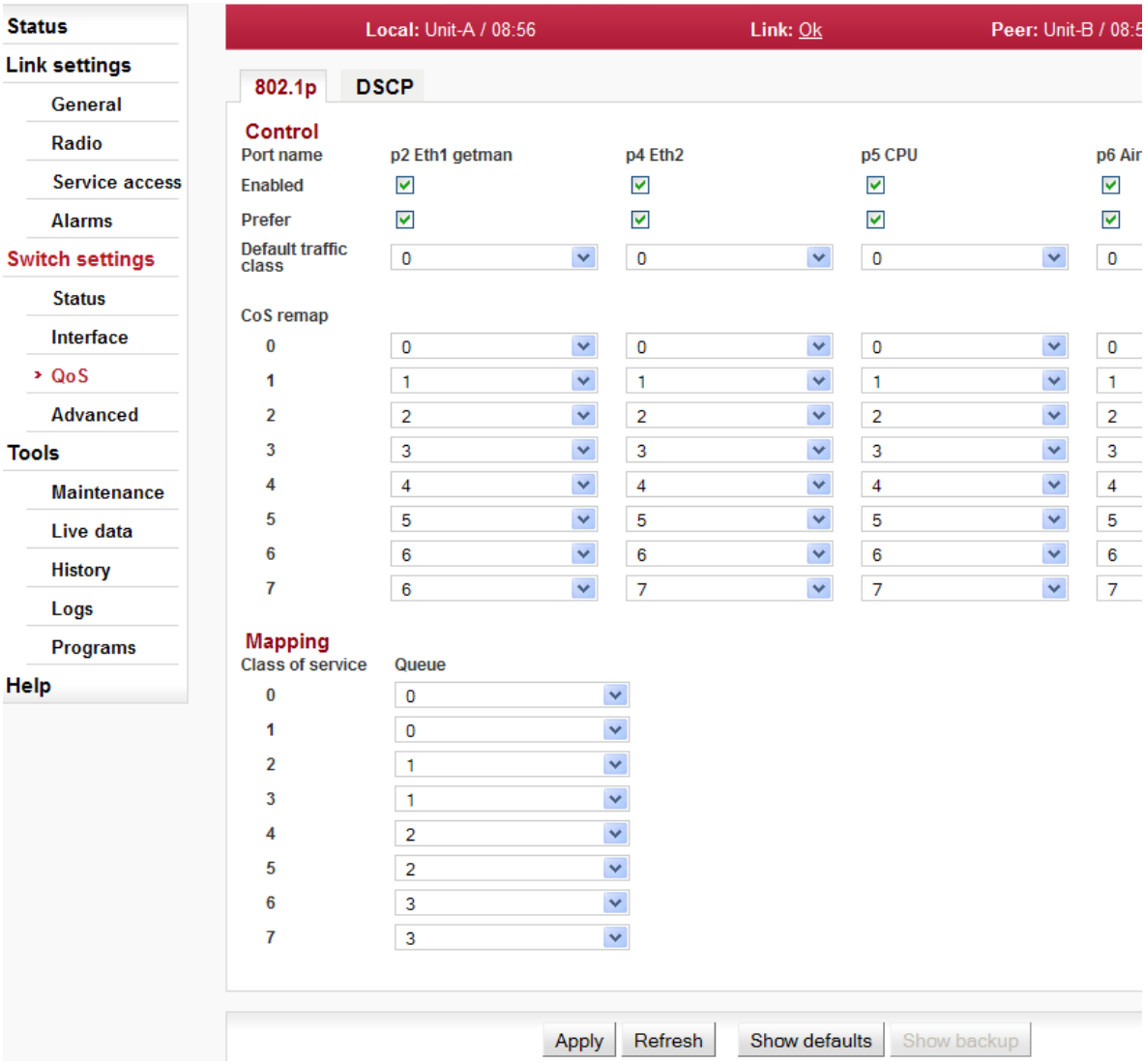


Fig. 5.29: Menu Switch settings/QoS/802.1p

The IEEE 802.1p QoS technique also known as class of service (CoS), is a 3-bit field called the Priority Code Point (PCP) within an Ethernet frame header when using VLAN tagged frames as defined by

IEEE 802.1Q. It specifies a priority value of between 0 and 7 inclusive that can be used by QoS disciplines to differentiate traffic. The value 0 is generally taken as the lowest priority and 7 as the highest priority.

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.

Enabled The QoS classification according to IEEE 802.1p priority bits is enabled/disabled.

Prefer Enable this parameter to force 802.p priority over DSCP.

When enabled, the DSCP Prefer parameter is automatically disabled.

Default traffic class The IEEE 802.1q untagged frames (thus having no IEEE 802.1p priority) are treated with this priority.

CoS remap The frame's IEEE 802.1p priority can be changed to other value.

Class of service Arranging individual priorities (coded in priority bits according to IEEE 802.1p) into selected output queue (0..3).

5.5.3.2. DSCP

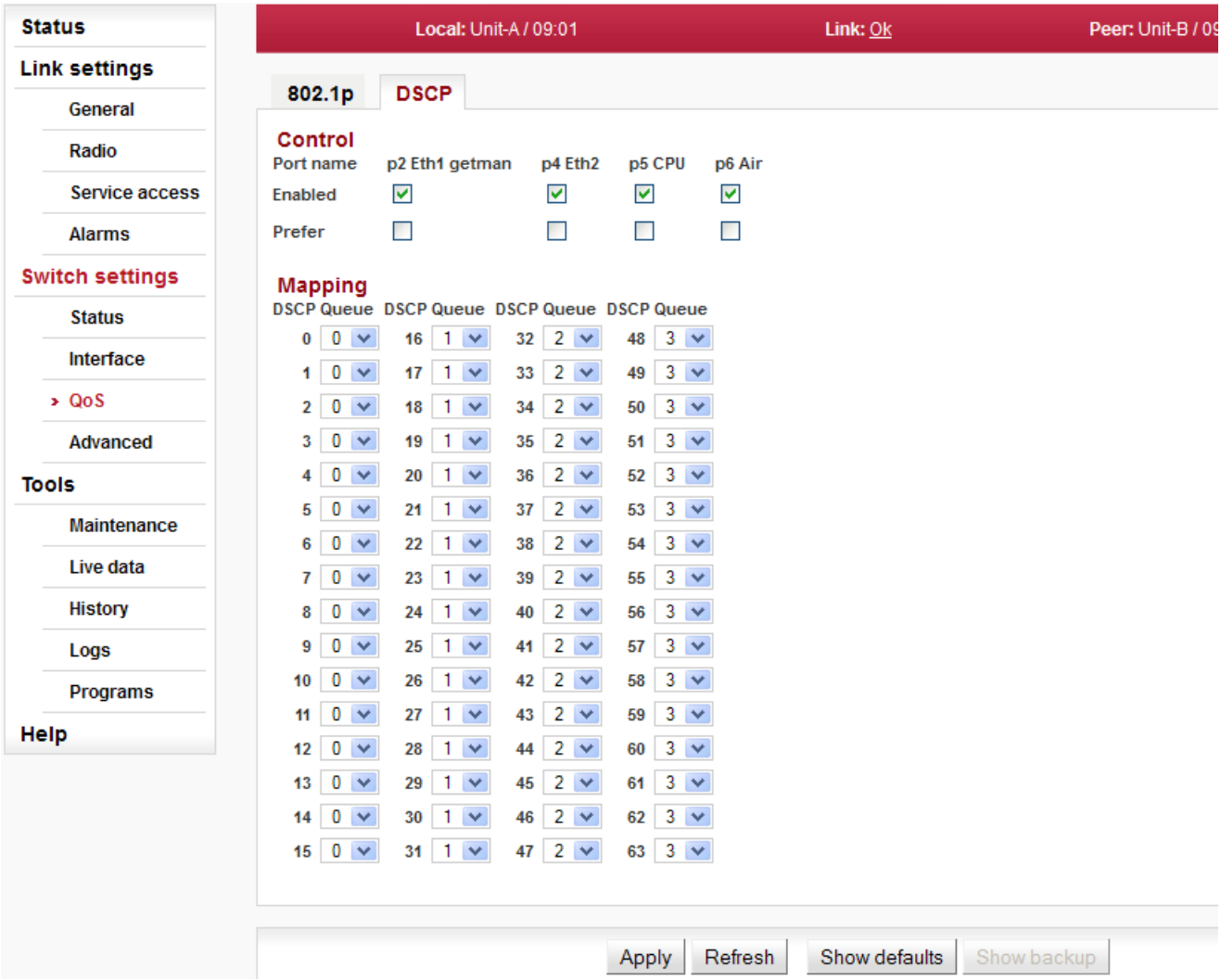


Fig. 5.30: Menu Switch settings /QoS/DSCP

The DSCP stands for Differentiated services Code Point which is a 6-bit value stored within the IP header. The QoS techniques using those bits are called DiffServ or Differentiated services.

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.

Enabled The QoS classification according to DSCP priority bits is enabled/disabled.

Prefer Enable this parameter to force DSCP priority over 802.p.

When enabled, the IEEE 802.1p Prefer parameter is automatically disabled.

DSCP 0..63 Arranging individual priorities (coded in DS field of IP header) into selected output queue (0..3).

5.5.4. Advanced

According to the Advanced menu proceeds the deciding, through which port the framework should be transmitted from RAy unit.

The processing of framework can be observed on the diagram and in the table. Table columns indicate successive steps and in the rows there is hinted the development of framework parameters.

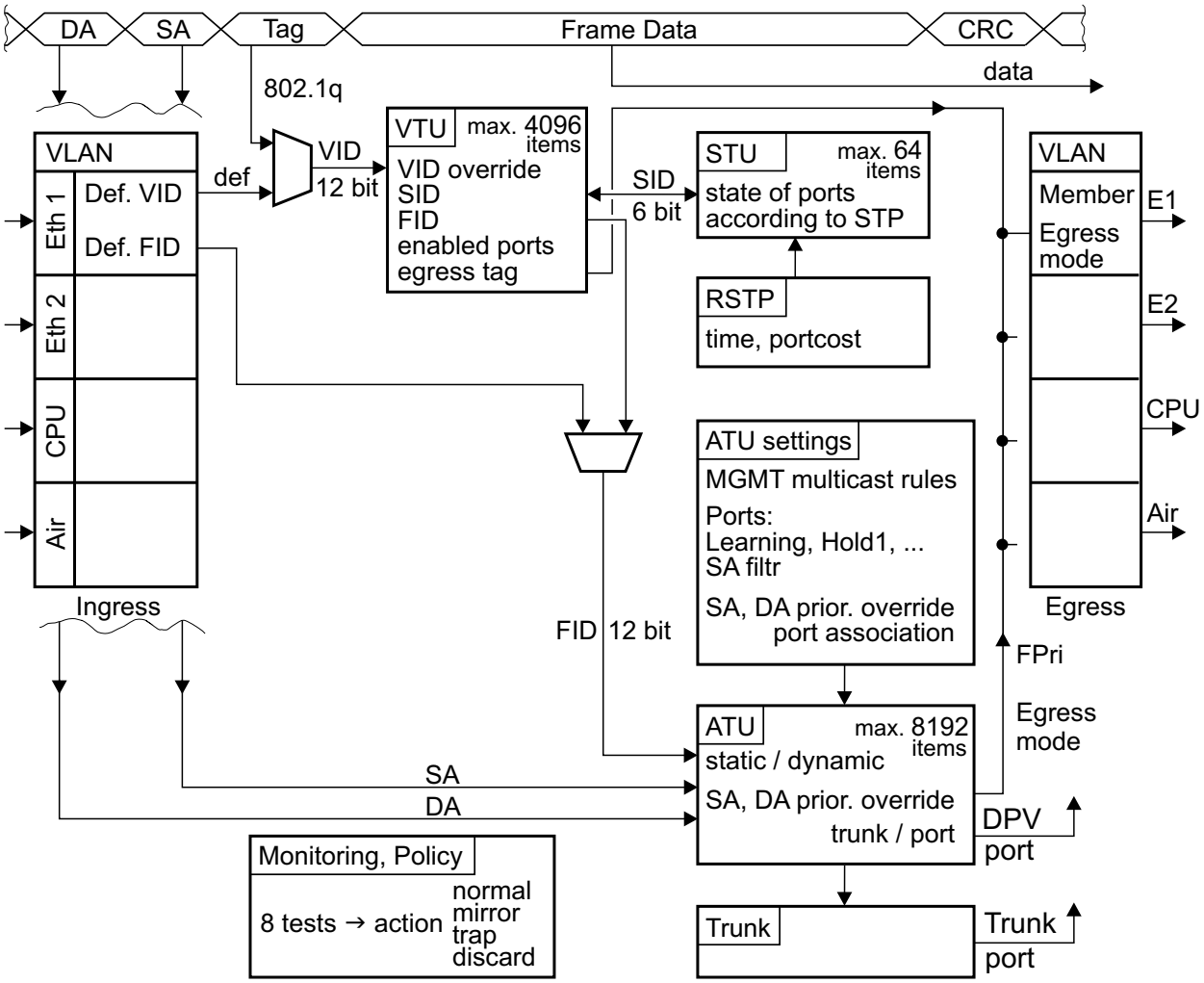


Fig. 5.31: Advanced menu diagram

	Frame	VLAN	VTU	STU	ATU	Trunk
DA, SA	DA, SA				id	
QPri	QoS, DSCP	by port	by VLAN		DA, SA	
VID	VID	def. VID	id			
SID			SID	id		
FID		by port	by VLAN		id	
Trunk					ATU-Trunk	id
port egress		by port		RSTP	ATU-Port	Trunk
tag egress		Egress mode	Member tag			

An indicative description of the function of each block:

Frame

An incoming frame contains the destination MAC address DA and the source address SA. The VLAN 802.1p priority can be contained in the Ethernet header and the DSCP priority in the IP header. If the frame is a member of a VLAN, it carries it's VID number and 802.1q priority in the tag.

VLAN

A frame is received through ports Eth1, Eth2, Air or from microwave CPU. The head of the frame may change at this time based on parameters set in the VLAN menu.

All untagged frames are assigned a VID. A tagged (VLAN) framework can have its own VID overwritten by a default VID.

The packet priority can be overwritten according to parameter menus QoS, VLAN and ATU.

The FID for searching in the ATU table is allocated to the frame within the VLAN menu (by the input port) or from the corresponding VID in the VTU table.

Member parameter can limit the allowed output direction of ports.

Frames sent from a unit transfers through an output port. The Egress mode parameter bound to the port either adds or removes the VLAN tag.

VTU

Values in the VID determine search results from the VTU table. These are created manually. The SID index (enabled ports in terms of STP) FID index (for searching in the address table ATU) taken from this search result are assigned to the frame. This FID will overwrite the FID from menu VLAN.

Based on this, the VTU can also overwrite the priority of this frame.

The permitted output ports and method of working with VLAN tag on the output are also defined here.

STU

The Spanning tree protocol in this table maintains the status of ports from the viewpoint of the authorized network throughput and the learning of routing. Protocol MSTP is used.

Each VTU entry uses some of the entries in the STU. Entries in the ATU are created in accordance with these assigned states.

The port state behaviour is determined by the STP.

ATU settings

Any assigned parameters dictate how the ATU table should be used.

The Global section of this menu provides for passage of MGMT frames (e.g. BPDU).

In the Port settings section, the behaviour of individual port is defined:

- Behaviour of the ATU table in terms of automatically creating records (Learning, Hold at 1, ATU refresh, Learn limit).

- Discarding frames according to the source addresses.

- Handling frames with unfamiliar destination addresses.

- The frames' priority can be overridden by the SA or the DA.

ATU

The ATU table determines the output port on the RAy according to the DA in the frame.

Records are arranged according to the FID and the MAC addresses.

The table is created and maintained based on informations contained in incoming frames (learning). Manual recording is also possible.

The record can be dynamic or static.

Priority frames with a static record can be overridden by the SA or DA.

The results of searching the ATU provide the set of output ports or trunk number.

RSTP

The RSTP demon turns off redundant paths through the network (switch ports), or re-activates them in the case of failure in other branch.

The Global section of this menu contains switch priority for the RSTP and necessary time constants.

The Port settings section holds the value of each port as seen by the RSTP. This information indicates if the RSTP shuts down or restarts a redundant port if a route is interrupted.

Trunk

The Trunk enables the distribution of data load on multiple ports. The ratio of distribution is determined by parameter Balancing mode.

Abbreviations used in the Advanced menu.

DA, SA	Destination and Source frame address (MAC)
LAN	Local Area Network
VLAN	Virtual LAN, menu of parameters related to the VLAN
VID	VLAN network ID
VTU	VLAN Table Unit - according to VID assigns SID and FID to the frame
SID	Spanning tree ID - record number for STP
STP	Spanning Tree Protocol - prevents a loop in the network
STU	Spanning Tree Unit - parameters associated with STP
FID	Forwarding Information Database number - according to this runs searching in the table
ATU	Address Translation Unit - conversion FID and DA to number of output port
MGMT	Management frames - service frames of the microwave link: frames "ATU / Entry state = static management" and frames "ATU settings / Reserved..."
BPDU	Bridge Protocol Data Unit - frames used by STP protocol
802.1d	Spanning tree protocol by ports
802.1s	Spanning tree protocol by VLAN
802.1q	tagging of frames (VLAN)
802.1p	priority by 2-nd layer (tagged frames Ethernet)
DSCP	Differentiated Services Code Point - priority by 3-rd layer (IP packet)
QoS	Quality of Service
FPri	Frame Priority - priority in the network
QPri	Queue Priority - priority of the frame inside the switch
Trunk	here in the sense of aggregation ethernet links - conjunction multiple ports into a single line another meaning is VLAN aggregation lines - multiple VLANs on a single port

5.5.4.1. VLAN

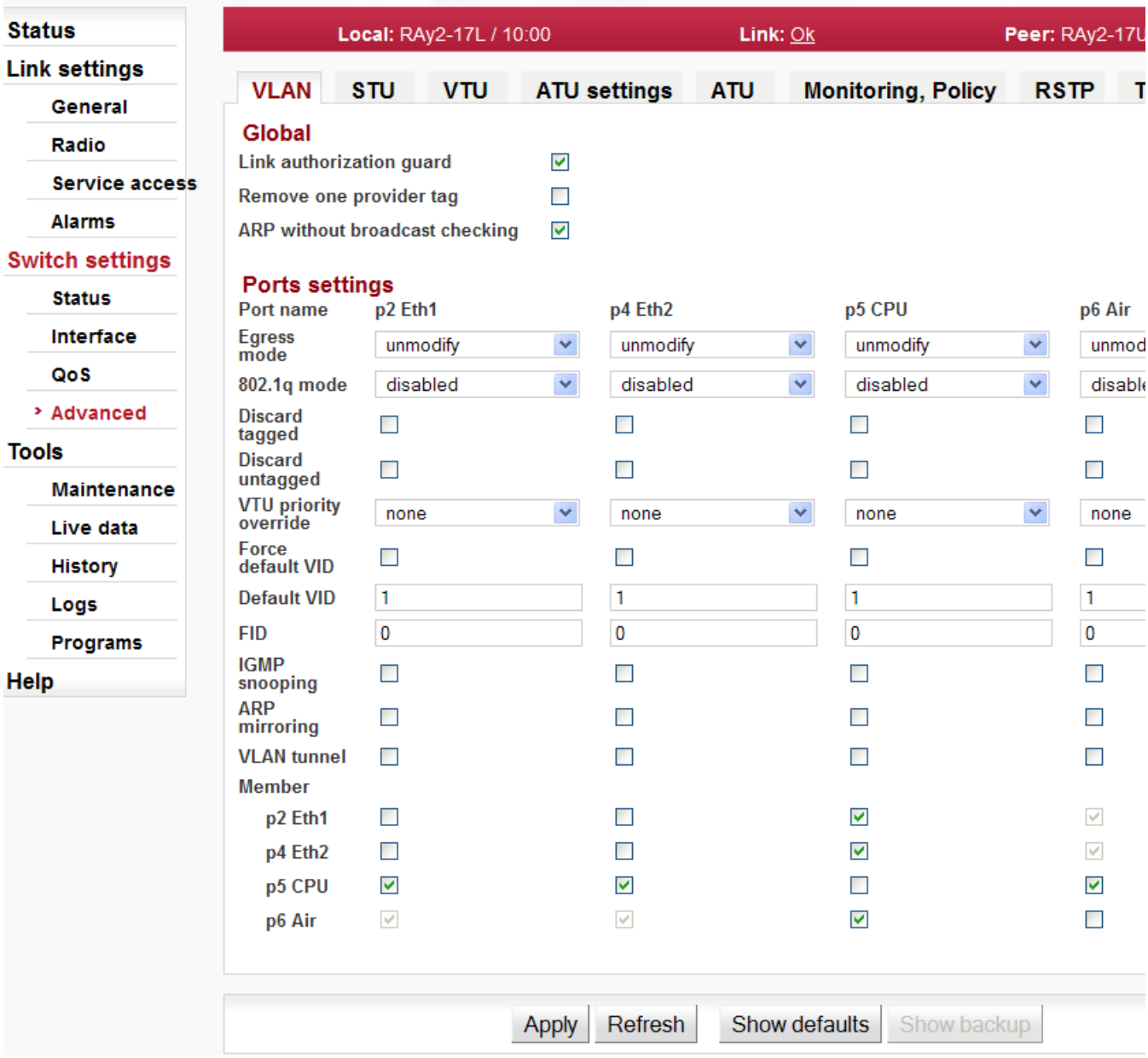


Fig. 5.32: Menu Switch settings / Advanced / VLAN

Setup of VLAN related and global parameters.

Link authorization guard

Remote unit authorization must take place to ensure user data flow between both units. See User manual Section *6.3.3 Remote unit authorization* for more details.

The Link authorization guard parameter can be used to bypass this authorization requirement.

- Disabled — Remote unit authorization is bypassed. User data flow through the Air channel occurs even if the remote unit is not authorized.
- Enabled — User data flow through the Air channel occurs only if the remote unit is authorized – according to the *Remote unit authorization* procedure.

Remove one provider tag

When this parameter is enabled and a port is configured as a Provider Port, recursive Provider Tag stripping will NOT be performed. Only the first Provider Tag found on the frame will be extracted and removed. Its extracted data will be used for switching.

When this parameter is disabled and a port is configured as a Provider Port, recursive Provider Tag stripping will be performed. The first Provider Tag's data will be extracted and used for switching, and then all subsequent Provider Tags found in the frame will also be removed. This will only occur if the port's Ether type is not 0x8100 (recursive Provider Tag removal cannot be performed when the Provider's Ether Type is equal to 0x8100).

ARP without broadcast checking

Disabled	ARP frames must contain a Broadcast Destination address to be able to access the CPU port.
Enabled	ARP frames only need an Ether type equal to 0x0806 and the frames Destination Address can be any value to be able to access the CPU port. This supports Mirroring ARP replies that are destined to a unicast address.

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.

Egress mode

This parameter determines the make up of frames when they egress this port. The Egress mode behaviour is affected by the Frame mode (menu *Interface/Port advanced/Frame mode*) parameter.

Frame mode ... normal:

unmodify	Frames are transmitted unmodified
untag	Remove the tag from any tagged frame
tag	Add a tag (e.g. according to *Default VID*) to any untagged frame. Ethernet frame type is set to 0x8100.
ether type tag	not used

Frame mode ... provider:

unmodify	Use this mode when *Frame mode* is set to *provider*.
untag	not used
tag	not used
ether type tag	not used

Frame mode ... ether type DSA:

unmodify	not used
untag	not used
tag	not used
ether type tag	Add a tag (e.g. according to "Default VID") to any untagged frame. Ethernet frame type is set according to "Ether type" parameter (menu *Switch settings/Interface/Port advanced*).

802.1q mode This parameter determines if 802.1q base VLANs are used along with port based VLANs for this Ingress port. It also determines the action to be taken if an 802.1q VLAN Violation is detected. VLAN barriers (both port based and 802.1q based) can be bypassed by VLAN Tunnel.

- disabled — Use **Port Based VLANs** only. The VID assigned to the frame is the port's Default VID which is used as the VID in the Provider Tag if the frame egresses a Provider port.
- fallback — **Enable 802.1q** for this Ingress port. Do not discard Ingress Membership violations and use the VLAN Table bits if the frames' VID is not contained in the VTU.
  The ingressing frames are not discarded and it not matter if the frames' VID is a member of the VTU.
- check — **Enable 802.1q** for this Ingress port. Do not discard Ingress Membership violation but discard the frame if its VID is not contained in the VTU.
  The ingressing frames' VID must be configured in the VTU to enable it to ingress. The VTU "Member tag" parameter does not have any effect.
- secure — **Enable 802.1q** for this Ingress port. Discard Ingress Membership violations and discard frames whose VID is not contained in the VTU. The ingressing frame is checked fully against the record in the VTU table. The "VID" and the "Member tag" parameters are validated to allow the frame to ingress.

Discard tagged When this parameter is enabled all non-MGMT frames that are processed as tagged are discarded as they enter this switch port. Priority only tagged frames (with a VID of 0x000) are considered untagged. This feature works whether 802.1q is enabled on the port or not.

If the port is configured in Provide Mode and this parameter is enabled, frames that contain an Ether Type that matches the port's PortEType (Ether type parameter) that have a non-zero VID will be discarded.

Discard untagged When this parameter is enabled all non-MGMT frames that are processed as untagged, are discarded as they enter this switch port. Priority only tagged frames (with a VID of 0x000) are considered untagged. This feature works whether 802.1q is enabled on the port or not.

If the port is configured in Provide Mode and this parameter is enabled, frames that do not contain an Ether Type that matches the port's PortEType (Ether type parameter) that have a non-zero VID will be discarded.

VTU priority override When this parameter is set to anything other than *none*, VTU priority overrides can occur on this port. A VTU priority override occurs when the determined VID of a frame results in a VID whose "Use VID priority" parameter is enabled. When this occurs three (other than *none*) forms of priority overrides are possible:

- none — Normal frame priority processing occurs.
- frame — The "VID priority" value assigned to the frame's VID (in the VLAN database) is used to overwrite the frame's previously determined FPri (frame priority). If the frame egresses tagged the priority in the frame will be this new *VID priority* value - the frame is permanently modified.

queue — The "VID priority" value assigned to the frame's VID (in the VLAN database) is used to overwrite the frame's previously determined QPri (queue priority). The QPri is used internally to map the frame to one of the egress queues inside the switch. QPri override will not affect the contents of the frame in any way.

frame+queue — Both the above overrides take place on the frame.

The VTU Priority override has higher priority than the port's Default Priority and the frame's IEEE and/or IP priorities. The priority determined by the frames' VID can however be overridden by the frames' SA and/or DA Priority Overrides.

Force default VID — Force to use Default VID. When 802.1q is enabled on this port and this parameter is enabled, all Ingress frames' VID are ignored and the "Default VID" is assigned and replaced into the frame (if the frame egresses tagged). When this parameter is disabled all IEEE802.3ac Tagged frames with a non-zero VID use the frames' VID unmodified.

When 802.1q is disabled on this port, this bit has no effect.

Default VID — Default VLAN Identifier. When 802.1q is enabled on this port the Default VID parameter is used as the IEEE Tagged VID added to untagged or priority tagged frames during egress that ingressed from this port. It is also used as a tagged frame's VID if the frame's VID was 0x000 (i.e., it is a priority tagged frame) or if the port's "Force Default VID" is enabled.

When 802.1q is disabled on this port, the Default VID field is assigned to all frames entering the port (whether tagged or untagged). This assignment is used internal to the switch.

FID — Port's Default Filtering Information Database (FID). This parameter can be used with non-overlapping VLANs to keep each VLAN's MAC address mapping database separate from the other VLANs. This allows the same MAC address to appear multiple times in the address database (at most one time per VLAN) with a different port mapping per entry. This field is overridden by the FID returned from a VTU hit and it should be zero if not used. It must be a unique number for each independent, non-overlapping, address database if used.

IGMP snooping — IGMP and MLD Snooping. When this parameter is enabled and this port receives an IPv4 IGMP frame or an IPv6 MLD frame, the frame is switched to the CPU port overriding the destination ports determined by the DA mapping. When this parameter is disabled IGMP/MLD frames are not treated specially.

IGMP/MLD Snooping is intended to be used on Normal Network or Provider ports only.

ARP mirroring — When this parameter is enabled non-filtered Tagged or Untagged Frames that ingress this port that have the Broadcast Destination Address with an Ethertype of 0x0806 are mirrored to the CPUDest port. This mirroring takes place after the ingress mapping decisions to allow ARPs to get to a CPU that is otherwise isolated. When this bit is cleared to a zero no special ARP handling will occur.

VLAN tunnel — When this parameter is disabled, the port based VLANs defined in the VLAN Table, 802.1q VLANs defined in the VTU and Trunk Masking are enforced for ALL frames.

When this parameter is enabled, the port based VLAN Table masking, 802.1q VLAN membership masking and the Trunk Masking are bypassed for any frame entering this port with a DA that is currently 'static' in the ATU. This applies to unicast as well as multicast frames.

While enabled, the Unicast frames with the management CPU DA can go from the Eth1 and Eth2 ports in to the CPU port. The static record with the CPU DA in the ATU table has to be configured (it is pre-configured by default).

Member (VLAN Table)

The In Chip Port based VLAN Table contains parameters used to restrict the output ports to which an input port can send frames. These parameters (VLANTable bits) are used for all frames, except for MGMT frames, even if 802.1q is enabled on this port. These parameters restrict where a port can send frames to (unless a VLANTunnel frame is being received). If ForceMap (Learning) is enabled, these parameters indicate which port or ports all frames that ingress this port are sent to overriding the mapping from the address database.

The default setting prevents sending frames from Eth1 to Eth2 and vice versa. This is very important for separating different networks (e.g. different customers) connected to separate user ports.

The Link authorization guard affects the user data flow through the Air channel. When the Link authorization guard is enabled, the user Ethernet ports to Air port connection control is disabled. Parameter status of user Ethernet to Air port connection changes dynamically according to Link authorization status.

5.5.4.2. STU

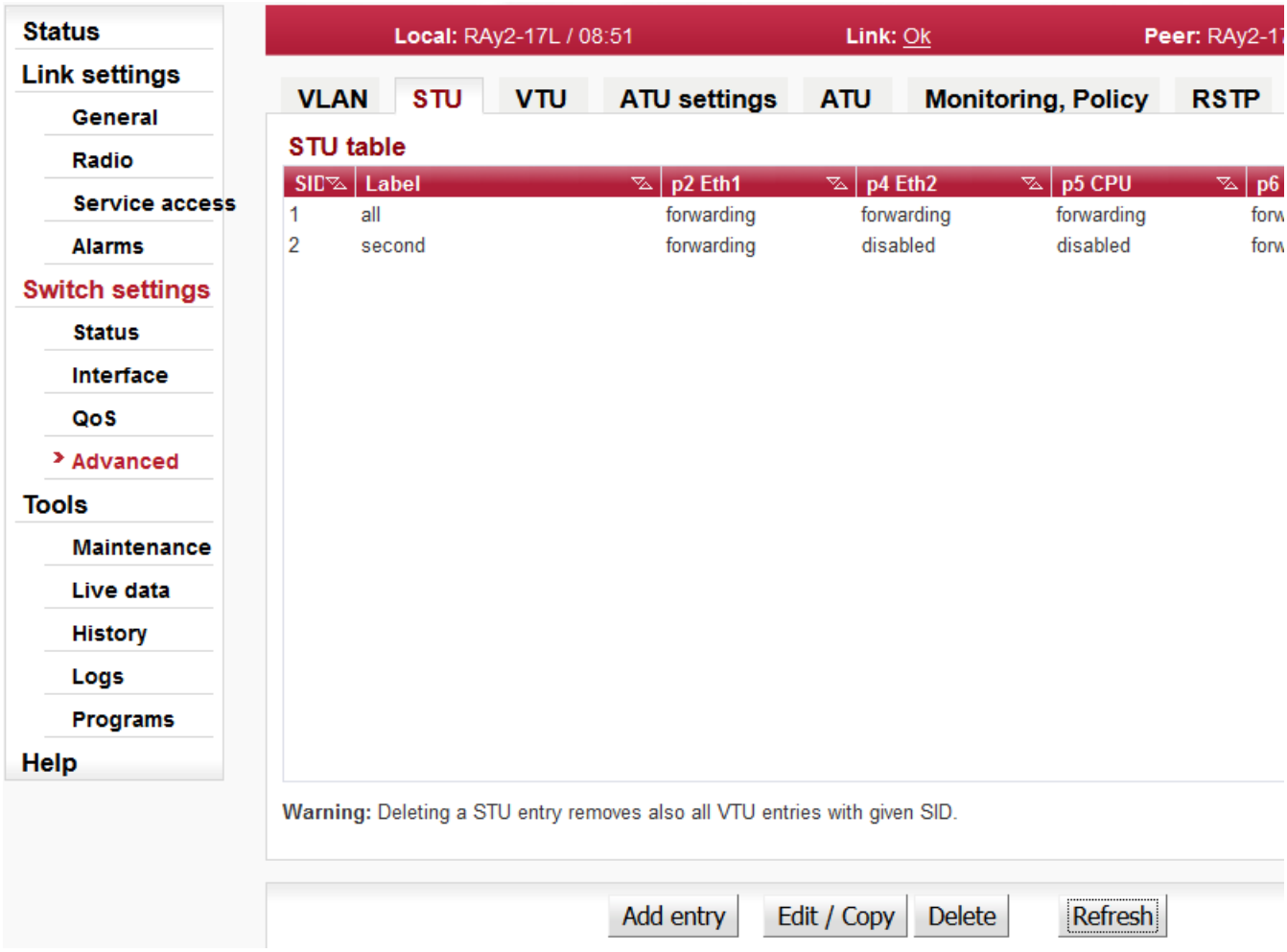


Fig. 5.33: Menu Switch settings / Advanced / STU

The per VLAN Spanning Tree Unit (STU) in the device supports user commands to access and modify the contents of the Port State database.

Primary key The 🔑 icon indicates which parameter field is taken as the unique identifier in the database. This field entry ensures each record is unique and must not be duplicated.

SID VTU 802.1s (MSTP) Port State Information Database number. This parameter indicates the SID number that is associated with the 802.1s "Port state" parameter.

It is essential to define the SID to be able to create records in the VTU (VLAN Table).

Label A custom string label for a STU entry.

Port state This parameter is used to support 802.1s per VLAN spanning tree. Port states (bellow) are valid for frames with a VID that is associated to this SID:

- disabled — Use non-VLAN Port States (i.e., the port's default Port State) for this port.
- blocking /listening
- learning

forwarding aaaa

This "Port state" takes precedence over the port's Port State bits unless the port's Port State (driven by STP) is Disabled (which prevents all frames from flowing).

Add entry Add a new STU database entry.

Edit Press the Edit button to open the configuration dialog of the selected STU database record.

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

Delete Delete the selected STU database record.

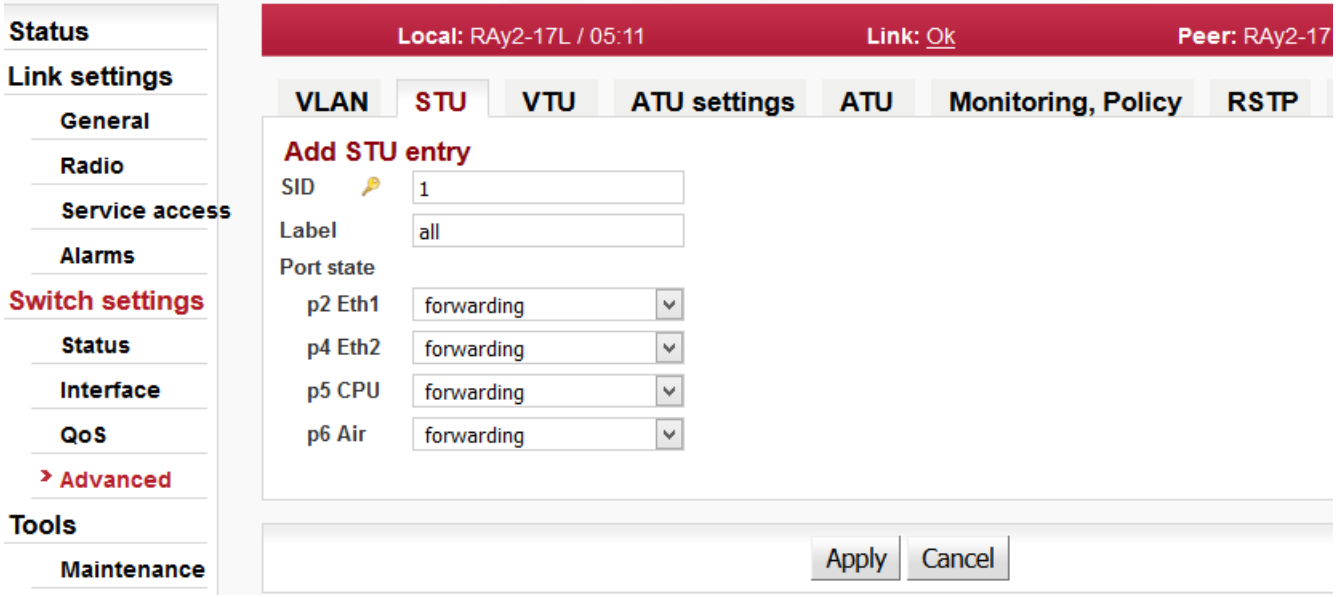


Fig. 5.34: Menu Switch settings / Advanced / STU / edit

5.5.4.3. VTU

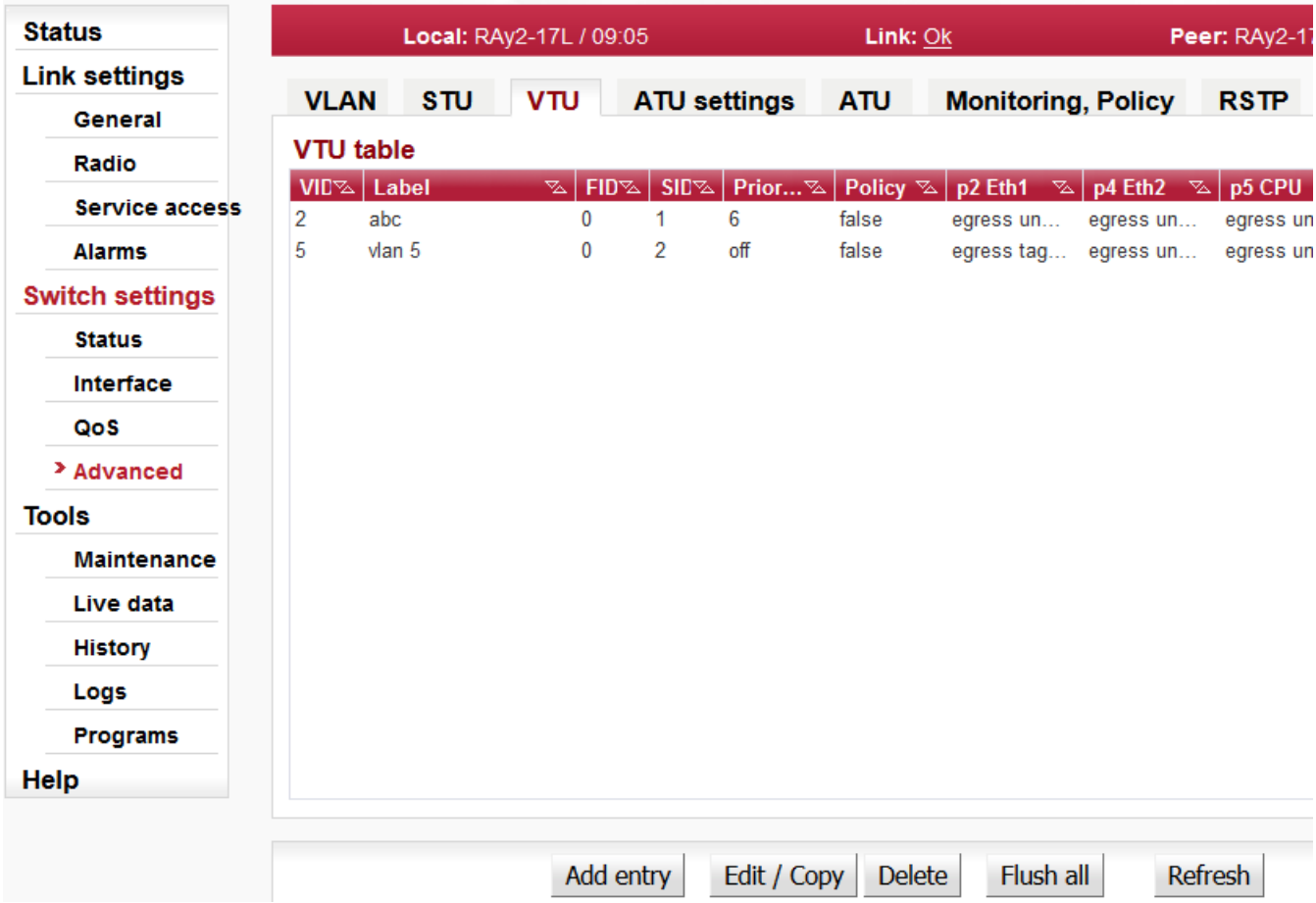


Fig. 5.35: Menu Switch settings / Advanced / VTU

The VTU (VLAN Table Unit) records form the VLAN Table.

Primary key The icon indicates which parameter field is taken as the unique identifier in the database. This field entry ensures each record is unique and must not be duplicated.

VID VLAN ID. This parameter indicates the VID number that is associated with the Member tag, VTU Priority, VTU policy and the FID (Forwarding Information Database number).

Label A custom string label for a VTU entry.

FID Forwarding Information Database number. If separate address databases are used, this parameter indicates the address database number to use for all frames assigned with this VID. All MAC DA look-ups and SA learning will refer to the address database number defined by the FID associated with the frame's VID. Multiple VID's can use the same FID. If separate address databases are not used, the FID must be zero. The ATU database records are joined with the VTU database records via this number.

SID 802.1s Information Database Number. If 802.1s per VLAN spanning tree is being used, this parameter indicate the spanning tree instance number to use for all frames assigned with this VID. Multiple VID's can use the same SID. The STU database records are joined with the VTU database records via this number.

Use VID priority VID Priority Override. This parameter is used to indicate that frames assigned with this VID can have their priority overridden with the "VID priority" value (see below) if the port's "VTU priority override" parameters is enabled to do so. See *VTU priority override* for more details.

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

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

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

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

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

Add entry Add a new VTU database entry.

Edit Press the Edit button to open the configuration dialog of selected VTU database record.

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

Delete Delete the selected VTU database record.

Flush all Delete the whole VTU database.

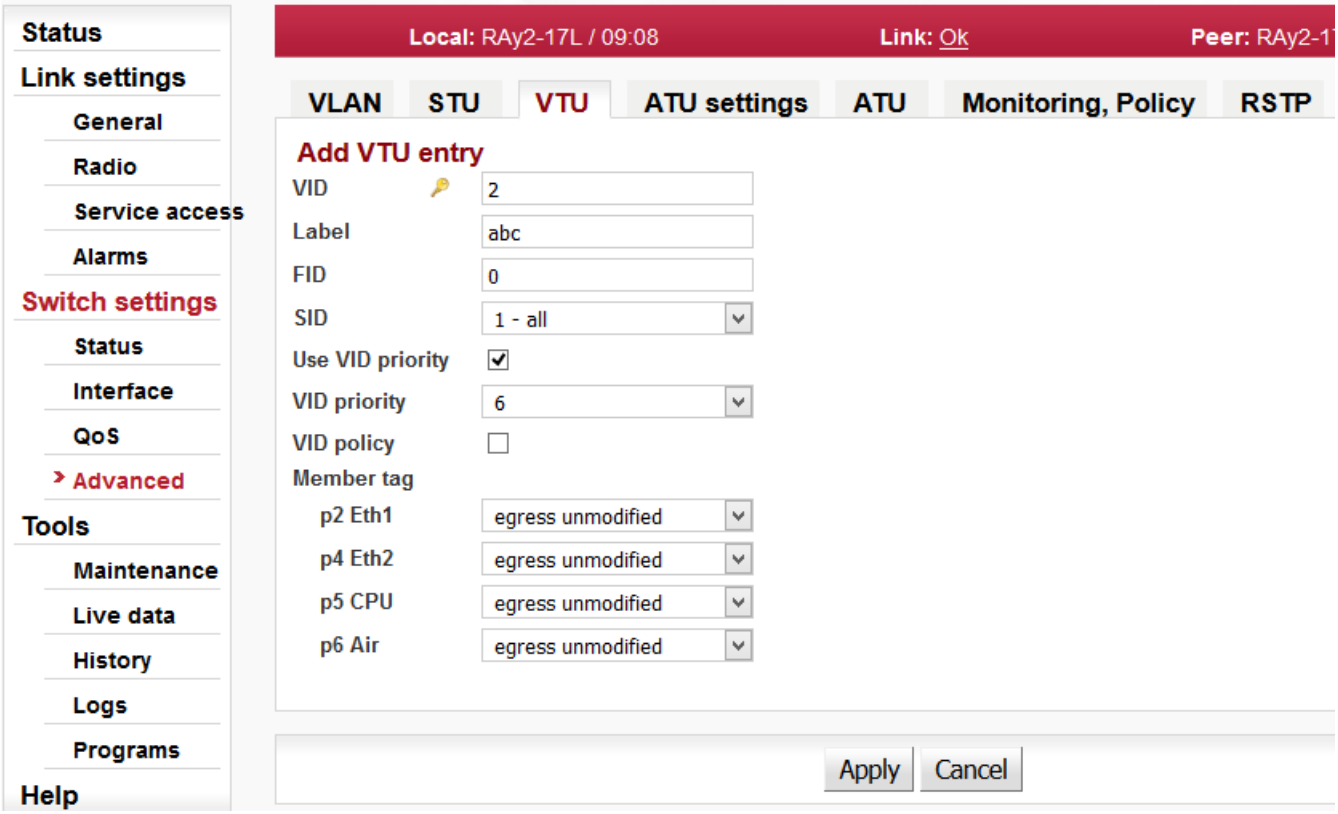


Fig. 5.36: Menu Switch settings / Advanced / VTU / edit

5.5.4.4. ATU settings

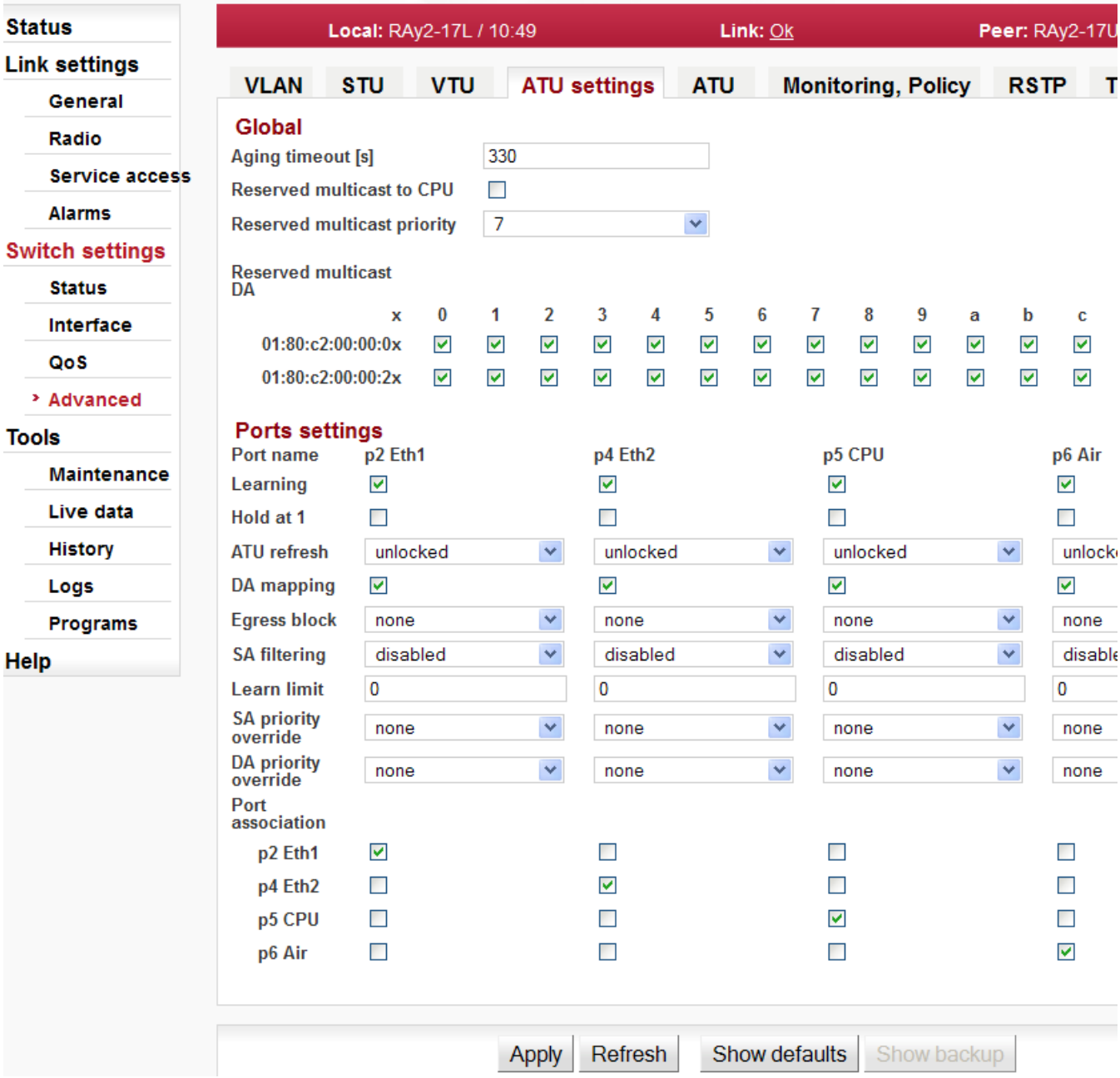


Fig. 5.37: Menu Switch settings / Advanced / ATU settings

Setup of ATU (Address Translation Unit) table related parameters.

Aging timeout [s] ATU age time. This value determines the time that each ATU Entry remains valid in the database, since its last access as a source address, before being purged.

The default value is 330 seconds.

The minimum age time is 15 seconds.

The maximum age time is 3825 seconds (almost 64 minutes).

If the Age Time is set to 0 the Aging function is disabled and all learned addresses will remain in the database forever.

Reserved multicast to CPU

When this parameter is enabled, frames with a Destination Address in the range 01:80:C2:00:00:0x or 01:80:C2:00:00:2x, regardless of their VLAN membership, will be considered MGMT frames and sent to the CPU port. See the *RSTP, RSTP enable* parameter.

Reserved multicast priority

This parameter sets the priority of the frames affected by "Reserved multicast to CPU" parameter.

Reserved multicast DA

This parameter enables individual multicast DA addresses to be affected by "Reserved multicast to CPU" parameter.

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.

Learning (ForceMap)

When this parameter is disabled, normal frame processing occurs.

When this parameter is enabled, all received frames will be considered MGMT (MGMT=Management frames, frames that can tunnel through Blocked ports) and are mapped to the port or ports defined in the VLANTable bits overriding the mapping from the address database. The forcing function is needed to get BPDU frames to egress specific ports by the CPU for the Spanning Tree Protocol. ForceMapped frames will egress ports that are not in the Disabled port state (i.e., they are MGMT frames and will egress via Blocked ports). This parameter is accessible by the CPU's Ingress Header so the CPU can enable and disable MGMT and forcing on a frame by frame bases.

NOTE: Learning is disabled on MGMT frames, so enabling this parameter also disables learning on frames entering this port.

Hold at 1

Hold Aging ATU Entries at an Entry State value of 1. When this parameter is disabled, a zero normal Aging occurs for ATU entries associated with this port. When this parameter is enabled ATU entries associated with this port will age down to an Entry state of 1 but will not go to 0. This feature can be used (for example) to keep dynamic records in the ATU table.

ATU refresh

unlocked	Normal address learning is enabled
known	Auto refreshing of known addresses will occur even if this port is Locked. Already known addresses will be auto refreshed (i.e., their Entry State will be updated to 0x7 whenever this address is used as a source address in a frame on this port) even when this port is Locked.
locked	CPU directed learning (needed for 802.1X MAC authentication) is enabled. Automatic SA learning and refreshing is disabled in this mode.

DA mapping

When this parameter is enabled, normal switch operation occurs where a frame's DA is used to direct the frame out of the correct port. When this parameter is disabled the frame will be sent out of the port defined by EgressFloods even if the DA is found in the address database. The static ATU table records are used, even in "DA mapping" disabled status.

Egress block Egress Flooding mode. The DA of every unicast and multicast frame is searched in the ATU. If the DA is found in the address database it is considered known. If it is not found it is considered unknown. Frames with known DA's are not affected by this register.

Frames with unknown DA's generally flood out all the ports (except the port they originally came in on). This register can be used to prevent frames with unknown DA's from egressing this port as follows:

unknown	Do not egress any frame with an unknown DA (unicast or multicast)
unknown multicast	Do not egress any frame with an unknown multicast DA
unknown unicast	Do not egress any frame with an unknown unicast DA
none	Egress all frames with an unknown DA (unicast and multicast)

SA filtering Source Address Filtering method:

disabled	No frame will be filtered (i.e. discarded) as a result of the contents of its Source Address field.
drop on lock	Ingressing frames will be discarded if their SA field is not in the ATU's address database (i.e. it's a new or unknown Source Address) or if this port's bit is not set in the PortVec bits for the frames' SA (i.e. this port is not the source port for that MAC address). Used for MAC based 802.1X.
drop on unlock	Ingressing frames will be discarded if their SA field is in the ATU's address database as a Static entry with a PortVec of all zeros. Used to discard frames from known untrusted sources.
drop to CPU	Ingressing frames will be mapped to the CPUDest if their SA field is in the ATU's address database as a Static entry with a PortVec of all zeros and the frame is not otherwise filtered. Otherwise, the frames will be discarded if their SA field is not in the ATU's address database (i.e. it's a new or unknown Source Address) or if this port's bit is not set in the PortVec bits for the frames' SA (i.e. this port is not the source port for that MAC address). This mode is a form of MAC based 802.1X where some frames can be forced to the CPU for further authentication prior to full authorization.

Learn limit (LearnLimit) When this parameter is set to zero, normal address learning and frame policy occurs.

When this parameter is non-zero the number of MAC addresses that can be learned on this port are limited to the value of this parameter. Automatic learning and frame policy will occur normally until the number of unicast MAC addresses auto-learned from this port reaches the port's LearnLimit (addresses that were learned from this port but were aged out are not counted - i.e., this register limits the number of 'active' unicast MAC addresses associated to this port). When the LearnLimit has been reached any frame that ingresses this port with a source MAC address not already in the address database that is associated with this port will be discarded (the port will act as if the port is Locked and the port's DropOnLock SAFiltering mode is set). Normal auto-learning will resume on the port as soon as the number of 'active' unicast MAC addresses associated to this port is less than the LearnLimit (due to address aging).

Care is needed when enabling this feature:

Enable "Learn to all" (GL1-0x0A:11:3 Learn2All=1)

Set "SA filtering" to "disabled" or "drop on unlock" (PORT-0x04:14 SAFiltering[0]=0)

Safe procedure:

Disable or block the ports (PORT-04.1 PortState[1]=0).

Flush all non-static addresses in the ATU.

Define the desired limit for the ports.

Re-enable the ports.

SA priority override

When any other than "none" mode is selected, SA ATU priority overrides can occur on this port. An SA ATU priority override occurs when the source address of a frame results in an ATU hit where the SA's MAC address returns an EntryState that indicates Priority Override. When this happens three forms of priority overrides are possible (other than "none"):

none	Normal frame priority processing is active.
frame	PRI value assigned to the frame's SA (the *MAC priority* field in the ATU database) is used to overwrite the frame's previously determined frame priority (FPri). If the frame egresses, the tagged priority in the frame will be this new PRI value.
queue	The two upper bits of the PRI value assigned to the frame's SA (the MAC priority field in the ATU database) are used to overwrite the frame's previously determined queue priority (QPri). The QPri is used internally to map the frame to one of the egress queues inside the switch. QPri override will not affect the contents of the frame in any way.
frame+queue	Both above overrides take effect on the frame

The SA ATU Priority Override has a higher priority than the port's Default Priority, the frame's IEEE and/or IP priorities and the VTU Priority Override. The priority determined by the frame's SA can however be overridden, by the frame's DA Priority Override.

DA priority override

When any other than "none" mode is selected, the DA ATU priority overrides can occur on this port. A DA ATU priority override occurs when the source address of a frame results in an ATU hit where the DA's MAC address returns an EntryState that indicates Priority Override. When this occurs three forms of priority overrides are possible (other than "none"):

none	Normal frame priority processing is active.
frame	PRI value assigned to the frame's DA (the *MAC priority* field in the ATU database) is used to overwrite the frame's previously determined frame priority (FPri). If the frame egresses the tagged priority in the frame will be the new PRI value.
queue	The two upper bits of the PRI value assigned to the frame's DA (the MAC priority field in the ATU database) are used to overwrite the frame's previously determined queue priority (QPri). The QPri is used internally to map the frame to one of the egress queues inside the switch. QPri override will not affect the contents of the frame in any way.
frame+queue	Both of the above overrides take place on the frame

The DA ATU Priority Override has the highest priority over the port's Default Priority, the frame's IEEE and/or IP priorities, the VTU Priority Override and the SA Priority Override.

Port association (PAV)

Port Association Vector for ATU learning. The value in these bits (one bit per port) is used as the port's DPV on automatic ATU Learning or Entry_State refresh whenever these bits contain a non-zero value. When these bits are all zero, automatic Learning and Entry_State refresh is disabled on this port.

For normal switch operation, this port's bit should be the only bit set in the vector. These bits must only be changed when frames are not entering the port.

The PAV bits can be used to set up port trunking (along with the VLANTable bits). For the two ports that form a trunk, set both of their port's bits in both port's PAV registers (this Port association parameter for both ports of the trunk), then use the VLANTable to isolate the two ports from each other, or to use the Trunk Mask table to steer the traffic from the other ports down the desired trunk line of the pair using DA/SA Load Balancing.

5.5.4.5. ATU

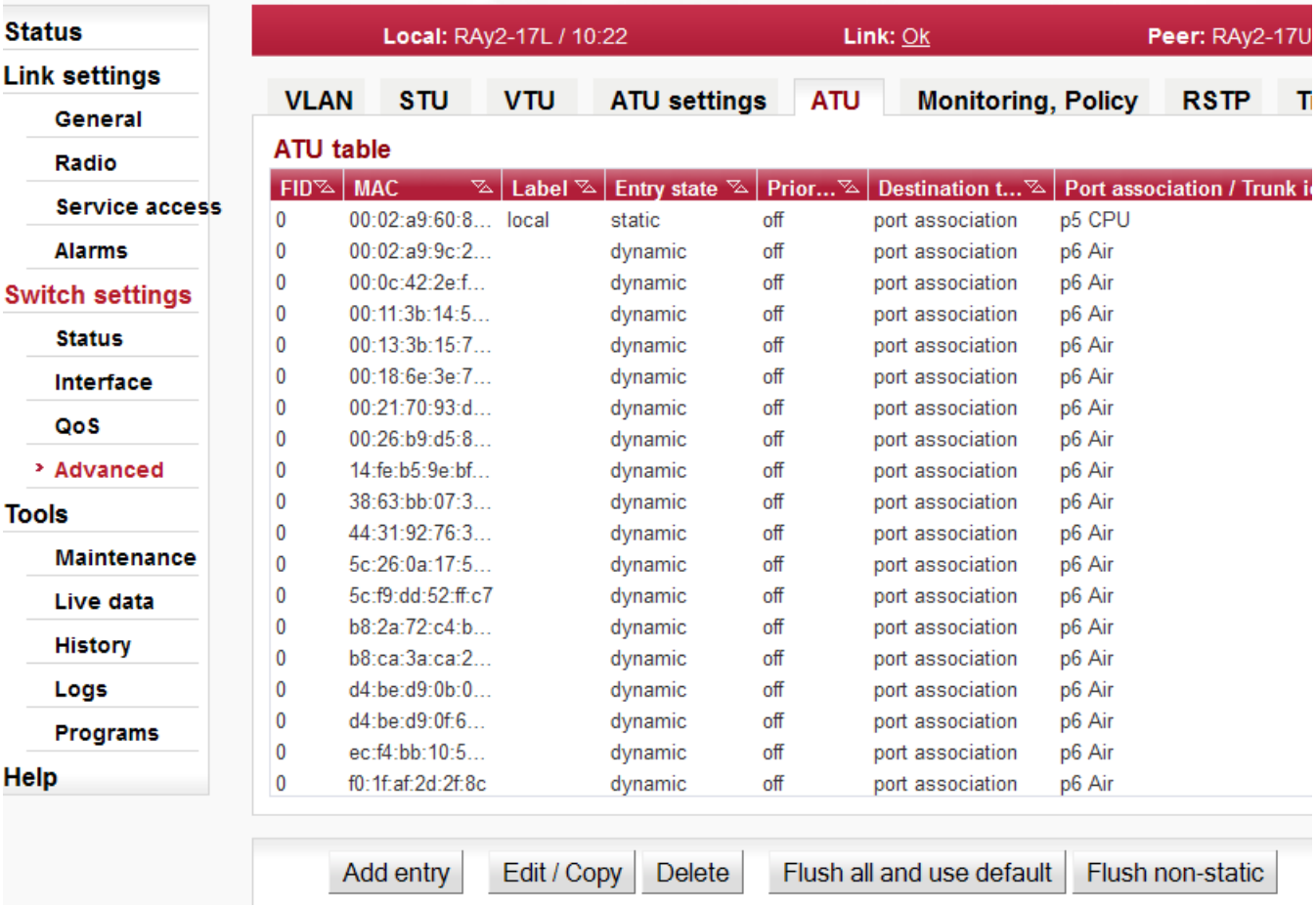


Fig. 5.38: Menu Switch settings / Advanced / ATU

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

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

Primary key The 🔑 icon indicates which parameter field is taken as the unique identifier in the database. This field entry ensures each record is unique and must not be duplicated.

FID Forwarding Information Database number. If multiple address databases are not being used, this parameter must remain zero. If multiple address databases are being used, this parameter is used to set the desired address database number that is to be associated with this ATU Entry's MAC Address. When frames ingress the switch, the VID assigned to the frame is used to access the VTU. The VTU returns the FID associated with that VID for MAC address lookups in to the ATU.

MAC MAC address associated with this ATU entry in the database number defined by the FID.

Label A custom string label for an ATU entry.

Entry state The Entry state parameter is used to determine the entry's age or its type as follows:

static	Use for ordinary static entry.
static policy	Use for "Policy DA" and/or *Policy SA* (menu *Switch settings/Advanced/Monitoring/Policy*).
static non rate limiting	Use for "SA non rate limit" and/or "DA non rate limit" (menu *Switch settings/Interface/PIRL*).
static management	This value is used for the mapping of the DA even if the "DA mapping" parameter is disabled (menu *Switch settings/Advanced/ATU settings*).
dynamic	Ordinary dynamic entry.

Use MAC priority Use this parameter to enable the MAC priority (see "MAC priority" description).

MAC priority Use the MAC priority to override value, when it is enabled by the "Use MAC priority" parameter. It is used for priority override on ingressing frames. Enabling a priority on a MGMT MAC address will override all priorities for these MGMT frames. Enabling a priority on a static, non-MGMT MAC address, will only override the frame's priority if the port's *DA priority override* or *SA priority override* parameters are enabled.

Trunk member When this parameter is enabled, the MAC address is a member of a trunk - according to the "Trunk Id" parameter. When this parameter is disabled, the MAC address is associated with port(s) - according to the *Port association* parameter.

Trunk Id The Trunk ID associated with this MAC address.

The port or ports that this DA MAC address is associated with is determined by the *Port association* parameter.

Use this parameter to ensure the proper unit management CPU is accessed when two units are connected in trunk.

Trunk port association vector Mask of ports associated with this MAC address.

Add entry Add a new ATU database entry.

Edit/Copy Press the Edit/Copy button to open the configuration dialog of the selected ATU database record.

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

Delete Delete the selected ATU database record.

Flush all and use default Delete the whole ATU database and create default record(s).

Flush non-static Delete all except static ATU database records.

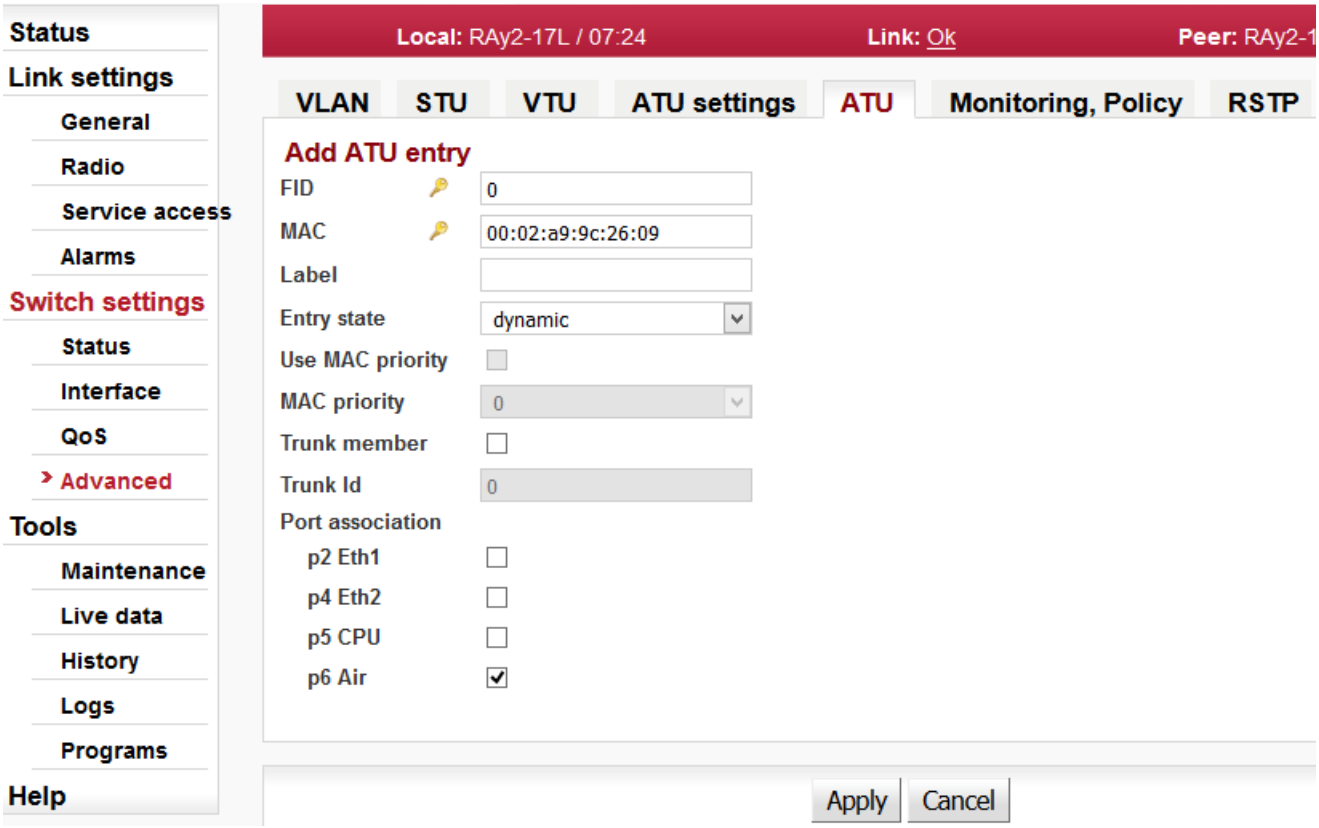


Fig. 5.39: Menu Switch settings / Advanced / ATU / edit

5.5.4.6. Monitoring, Policy

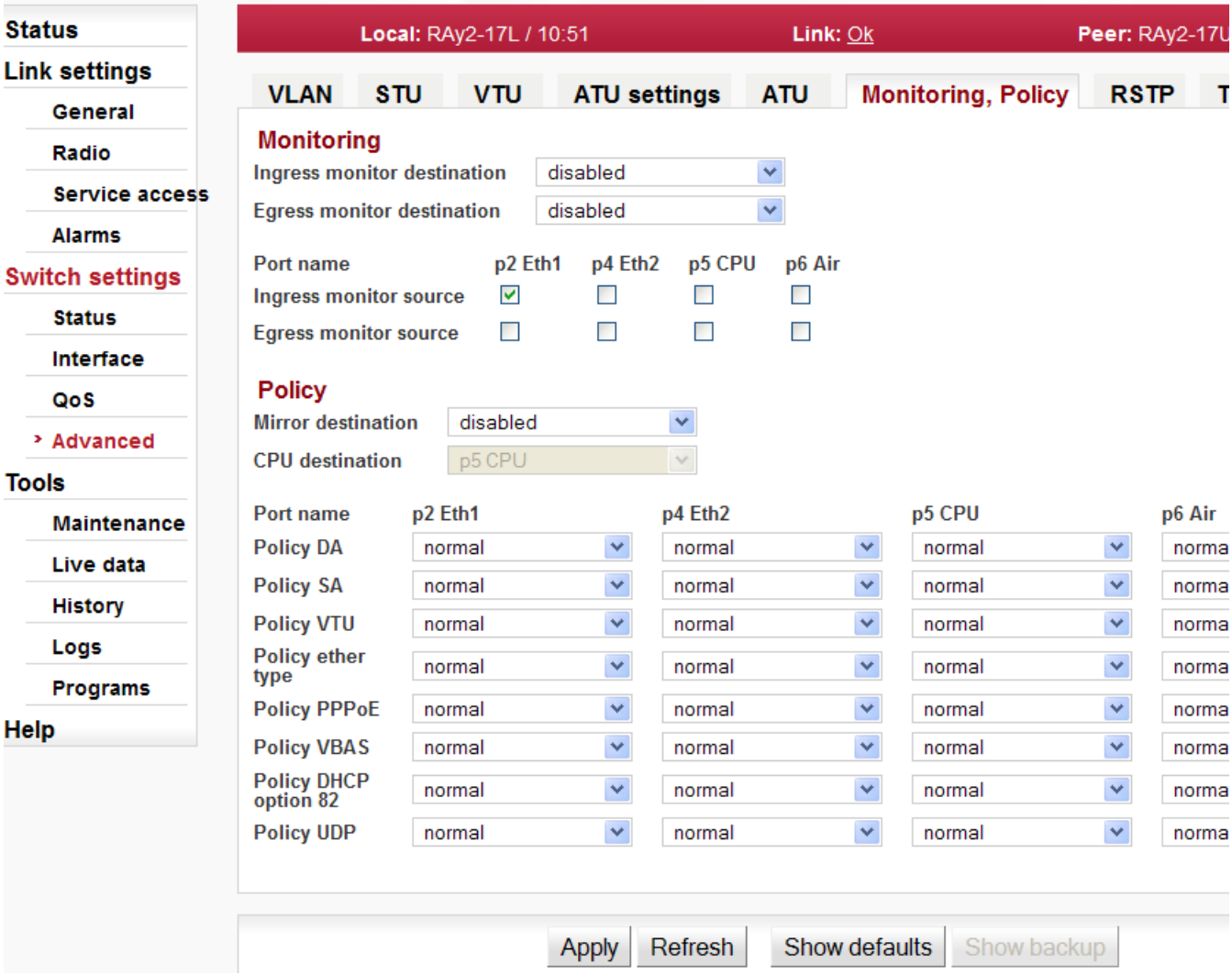


Fig. 5.40: Menu Switch settings / Advanced / Monitoring, Policy

Setup of Monitoring and Policy functions.

The Policy functions allow a special handling of specific types of ingress frames.

Ingress monitor destination Frames that are targeted toward an "Ingress Monitor Destination" leave via the port selected by this parameter. This includes frames received on a port that is enabled to be the "Ingress monitor source".

Egress monitor destination Frames that are targeted toward an "Egress Monitor Destination" leave via the port selected by this parameter. This includes frames transmitted on a port that is enabled to be the "Egress monitor source".

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.

Ingress monitor source

When this parameter is enabled, any frame that ingresses this port is also sent to the "Ingress monitor destination" port. The frame is sent to this port even if it is discarded due to switching policy but the frame will not be forwarded if it contains an error (such as CRC, etc.) or is filtered by ingress rate limiting.

Egress monitor source

When this parameter is enabled any frame that egresses this port will also be sent to the "Egress monitor destination" port. The 802.1q mode and VTU entries on the "Egress monitor destination" port must be set to be the same as they are on the "Egress monitor source" port so the frames egress with the same tagged or untagged information.

Mirror destination

Frames that ingress a port that trigger a policy mirror are mapped (copied) to this port as long as the frame is not filtered or discarded.

CPU destination

CPU destination port can not be changed. It is shown here to better understand the description of some other parameters which interact with the CPU destination port. For example the "trap" value of the "Policy* " parameters cause frames to be forwarded to this CPU destination port.

Policy

There are four different operations as a result of a policy:

normal	Normal frame switching.
mirror	Mirror (copy) frame to the "Mirror destination" port.
trap	Trap (re-direct) frame to the "CPU destination" port.
discard	Discard (filter) the frame.

There are eight different policy triggers:

DA	DA Policy Mapping occurs when the DA of a frame is contained in the ATU address database with an Entry State set to "static policy".
SA	SA Policy Mapping occurs when the SA of a frame is contained in the ATU address database with an Entry State set to "static policy".
VTU	VTU Policy Mapping occurs when the VID of a frame is contained in the VTU database with the *VID policy* parameter enabled.
ether type	EtherType Policy Mapping occurs when the Ether Type of a frame matches the Ether type parameter of this port.
PPPoE	PPPoE Policy Mapping occurs when the Ether Type of a frame matches 0x8863.
VBAS	VBAS Policy Mapping occurs when the Ether Type of a frame matches 0x8200.
DHCP option 82	DHCP option 82 Policy Mapping occurs when the ingressing frame is an IPv4 UDP with a UDP Destination port=0x0223of 0x0222.
UDP	UDP Policy Mapping occurs when the ingressing frame is a Broadcast IPv4 UDP or a Multicast IPv6 UDP.

5.5.4.7. RSTP

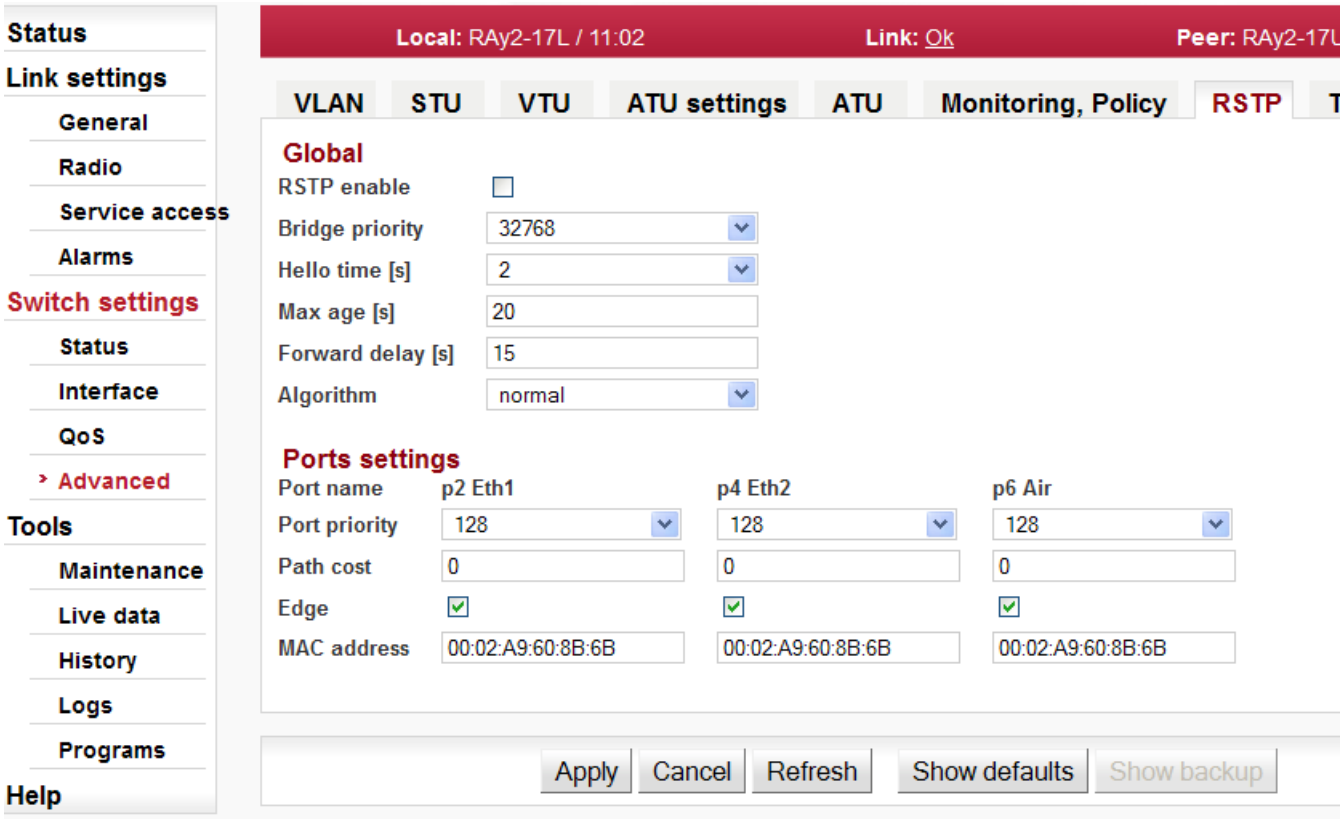


Fig. 5.41: Menu Switch settings / Advanced / RSTP

The Rapid Spanning Tree Protocol (RSTP) is a network protocol that ensures a loop-free topology for any bridged Ethernet local area network. The basic function of RSTP is to prevent bridge loops and the broadcast radiation that results from them. Spanning Tree Protocol also allows network design to include spare (redundant) links to provide automatic backup paths if an active link fails, without the danger of bridge loops, or the need for manual enabling/disabling of these backup links.

RSTP enable When RSTP is enabled, the bridge is created and RSTP service is initiated. Should the RAy2 unit be connected via two Ethernet cables (using Eth1 and Eth2 ports), the active participation of the RSTP protocol may be necessary. If the parameter is not enabled, the RAy2 unit transfers the BPDU frames transparently.

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

Switch settings / Interface / Port advanced / Frame mode / p5 CPU: "ether type DSA"

Switch settings / Interface / Port advanced / Ether type / p5 CPU: "0xDADA"

Switch settings / Advanced / ATU settings / Reserved multicast to CPU: "Enable"

Bridge priority The priority value is a number between 0 and 61440 in incremental steps of 4096, with a default value of 32768. Lower priority values are 'better'. The bridge with the lowest priority value will be elected 'root bridge'.

Hello time [s] The hello time is the time between each Bridge Protocol Data Unit (BPDU) that is sent on a port. Hello time is equal to 2 seconds by default.

Max age [s] The max age timer controls the maximum length of time that passes before a bridge port saves its configuration BPDU information. This time is set to 20 sec by default.

Forward delay [s] The forward delay is the time that is spent in the listening and learning state. This time is equal to 15 sec by default.

Algorithm This parameter sets the bridge's spanning tree algorithm to operate in normal (RSTP) or force it to operate in slow (STP) mode. In normal mode, RSTP reverts back to STP on ports where it sees other hosts operating in STP mode.

Port name 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.

Port priority The ports' priority value is a number between 0 and 240 in increments of 16, with a default value of 128.

Path cost The Path cost can be set automatically or manually. Entering the value of zero sets this parameter automatically. The automatic setup is based on link speed.

Edge Selecting the checkbox sets the port as an "edge" port. If a port is an edge port it is assumed to be a leaf link in the graph, not connected to any other bridges. Receiving any STP BPDU's on a port configured as an edge port temporarily overrides edge port behaviour for the port.

MAC address The ports' default MAC addresses are the same as the MAC address of the RAy2 unit.

5.5.4.8. Trunk

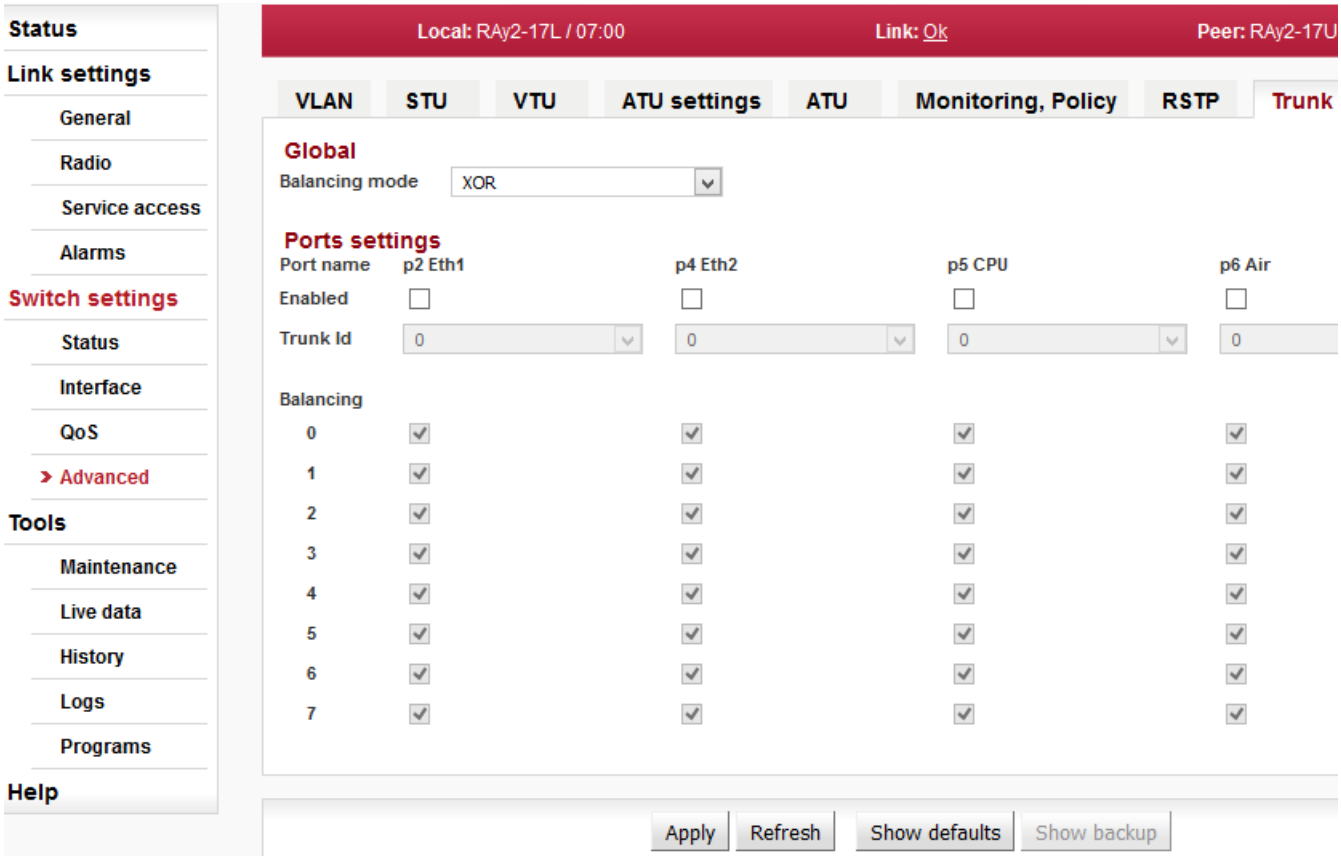


Fig. 5.42: Menu Switch settings / Advanced / Trunk

Port trunking is supported by the device using any combinations of ports. The ports that are to be associated with the trunk need to have all the port members' defined with the same "Trunk Id" and the "Enabled" parameter has to be enabled.

When a frame enters a Trunk Port its Source Address (SA) is learned with its association to the ingress port's TrunkID number. In this way the contents of the address database contain the same association with the frame's SA regardless of the link of the trunk the frame entered the switch.

When frames are routed back toward a trunk the frame will have its Destination Address (DA) found from the address database. If the frame's DA is unknown the frame will try to flood out all ports of the trunk (this is OK in so far as this will be fixed with load balancing). If the frame's DA is found, the entry will indicate mapping to a trunk and the entry's DPV bits will contain the TrunkID associated with this frame's DA. This TrunkID needs to be converted into a DPV (Destination Port Vector) that the rest of the switch can use. This is accomplished by accessing the Trunk Mapping table using the TrunkID that was in the ATU's entry.

Balancing mode Hash DA and SA for TrunkMask selection. Trunk load balancing is accomplished using the frame's DA and SA fields to access one of eight Trunk Masks. Two options are available:

- XOR — The lower 3 bits if the frame's DA and SA are XOR'ed together to select the TrunkMask to use.

hash — The hash computed for address table lookups is used for the Trunk-Mask selection. Use this parameter to reach better load balancing between the ports in the trunk.

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.

Enabled When this parameter is enabled, the port is considered to be a member of a trunk with the *Trunk Id* defined below.

Trunk Id This parameter defines which trunk the port is to be associated with. All ports that are members of the same trunk must be assigned the same Trunk ID.

Balancing Trunk Mask bits.

5.6. Tools

5.6.1. Maintenance

5.6.1.1. Backup, Default settings, Diagnostic package, MIB

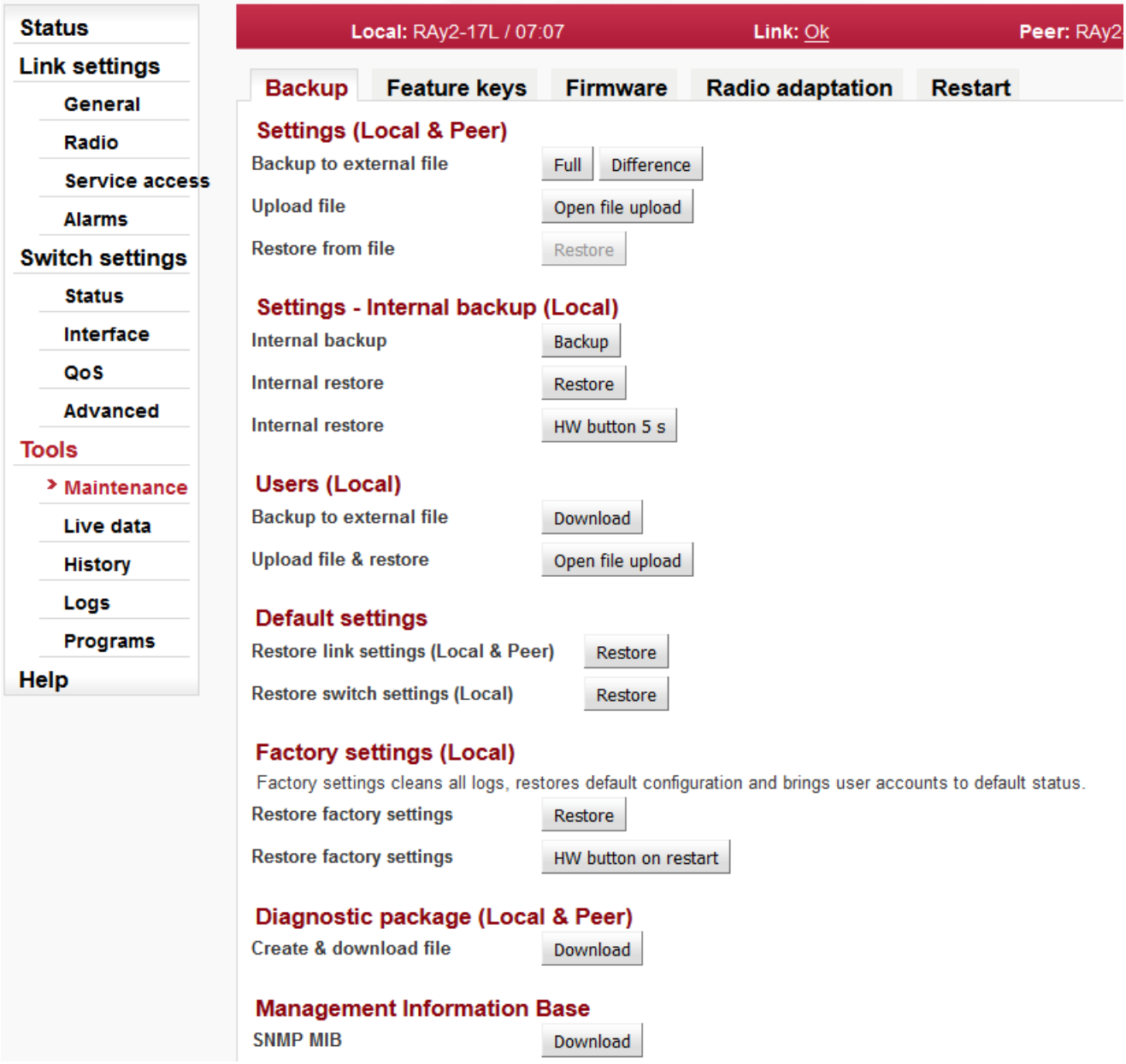


Fig. 5.43: Menu Tools / Backup

Settings - External backup (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 local unit configuration. The backup is stored directly in the unit FLASH memory. This backup is totally independent from the backup to external file and its values are not dispayed using 'Show backup' button. Such a fast backup is strongly recommended before any modification of unit parameters or before antenna alignment, because it allows fast restore to the surely working configuration.

NOTE: The internal backup FLASH 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 also 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 stored previously in to the unit FLASH memory.

Users (Local)

L	P	
		L
		S
O		U

Saving and restoring user accounts.

NOTE: The "super" user privileges are necessary to be able to perform those actions.

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

Reverting the unit to its original state - like it was shipped from the factory. All configuration items, user accounts, measured values and system messages (logs) will be irreversibly deleted.

L	P	
O		L
O		S
O		U

	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

Management Information Base (called often a MIB table) is a key info for setting up a SNMP communication between the unit and a network management system (NMS).

SNMP MIB	Saving a file with SNMP MIB (Management Information Base) table. The downloaded file is identical to the SNMP MIB table file downloaded from RACOM web (section *Download*[1]) for relevant FW version.

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

5.6.1.2. Feature keys

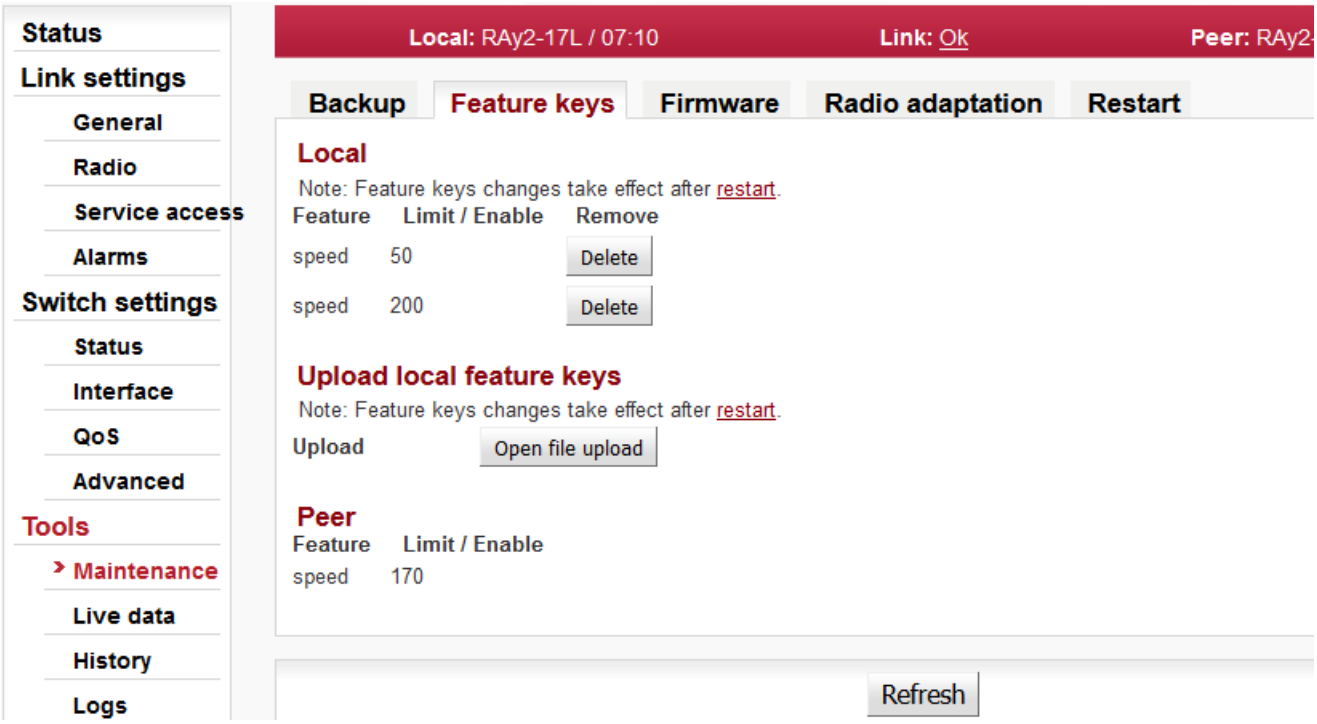


Fig. 5.44: Menu Tools / Maintenance / Feature keys

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

The SW Feature keys limiting data transfer speed [Mbps] are available. Speed of the transferred data is determined by a combination of the radio channel bandwidth (parameter Bandwidth [MHz]) and modulation order (parameter TX modulation). The 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 key. The data transfer speed is typically slightly higher than declared.

When installed, the 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.

SW keys of the local unit only are displayed. 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 / Enable — The numeric value set by the key.

Remove — The specific Feature key can be deleted using the Delete button. The parameters controlled by this Feature key are reset to their default values after the unit restart. 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.

5.6.1.3. Firmware

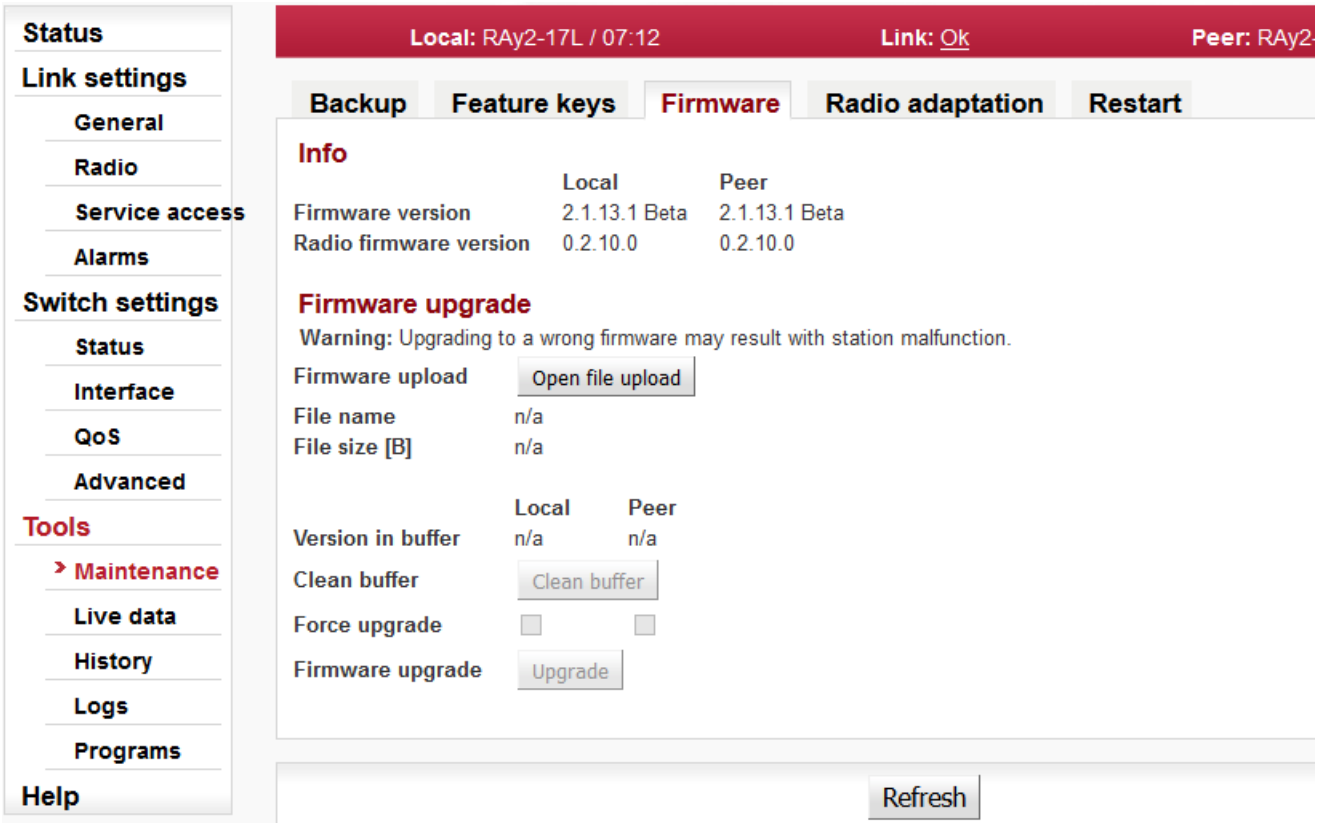


Fig. 5.45: Menu Tools / Firmware

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!

5.6.1.4. Radio adaptation

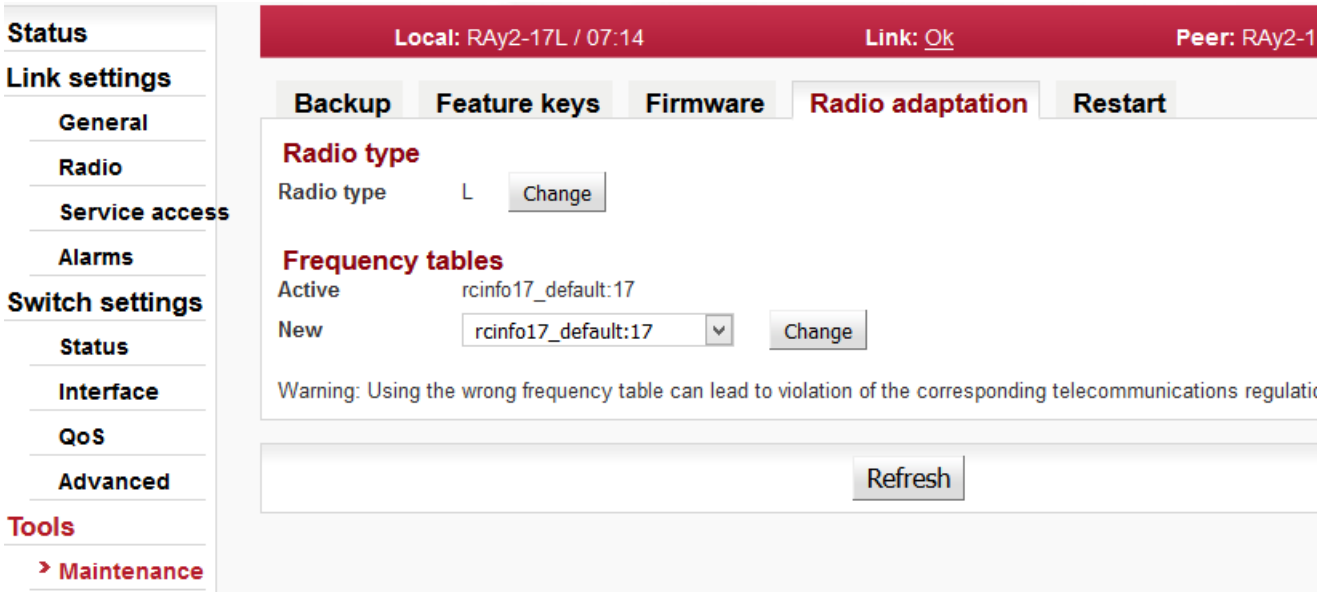


Fig. 5.46: Menu Tools / Radio adaptation

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.

5.6.1.5. Restart

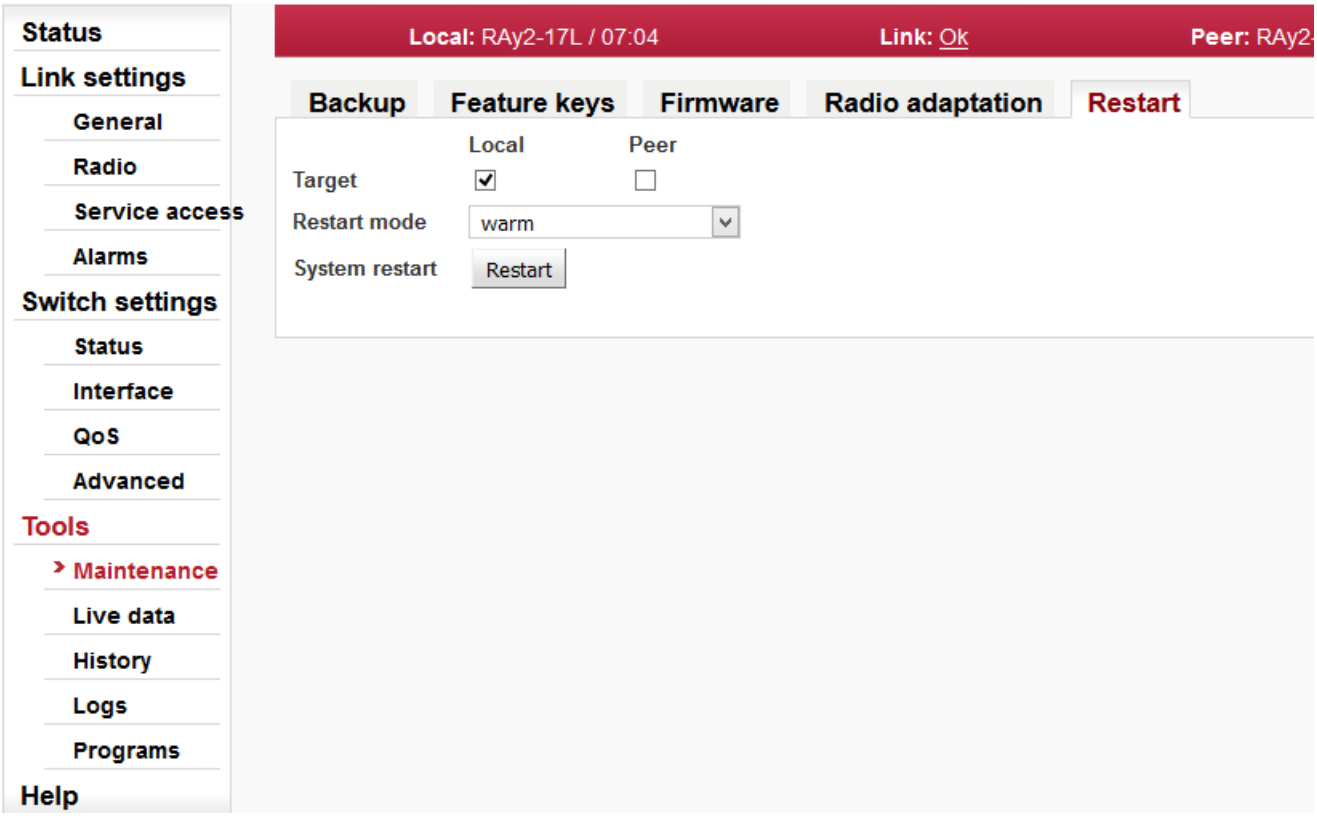


Fig. 5.47: Menu Tools / Restart

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

5.6.2.1. Bar indicators

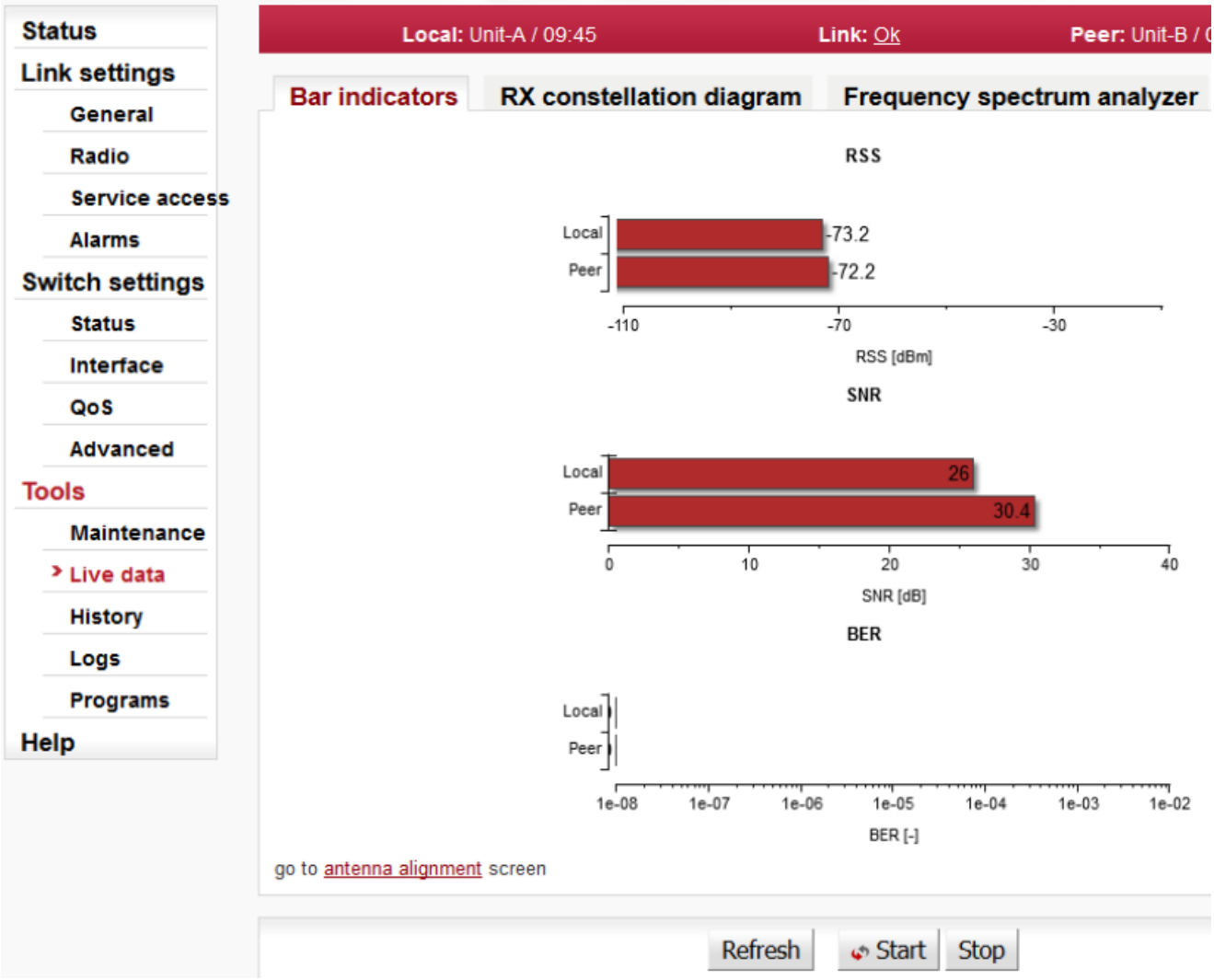


Fig. 5.48: Menu Tools / Bar indicators

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.

5.6.2.2. 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.

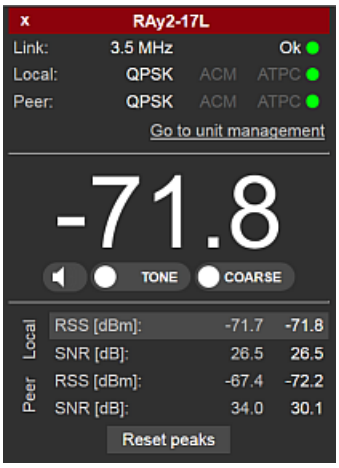


Fig. 5.49: Ray Tools

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. 'Site-A')
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.

5.6.2.3. RX constellation diagram

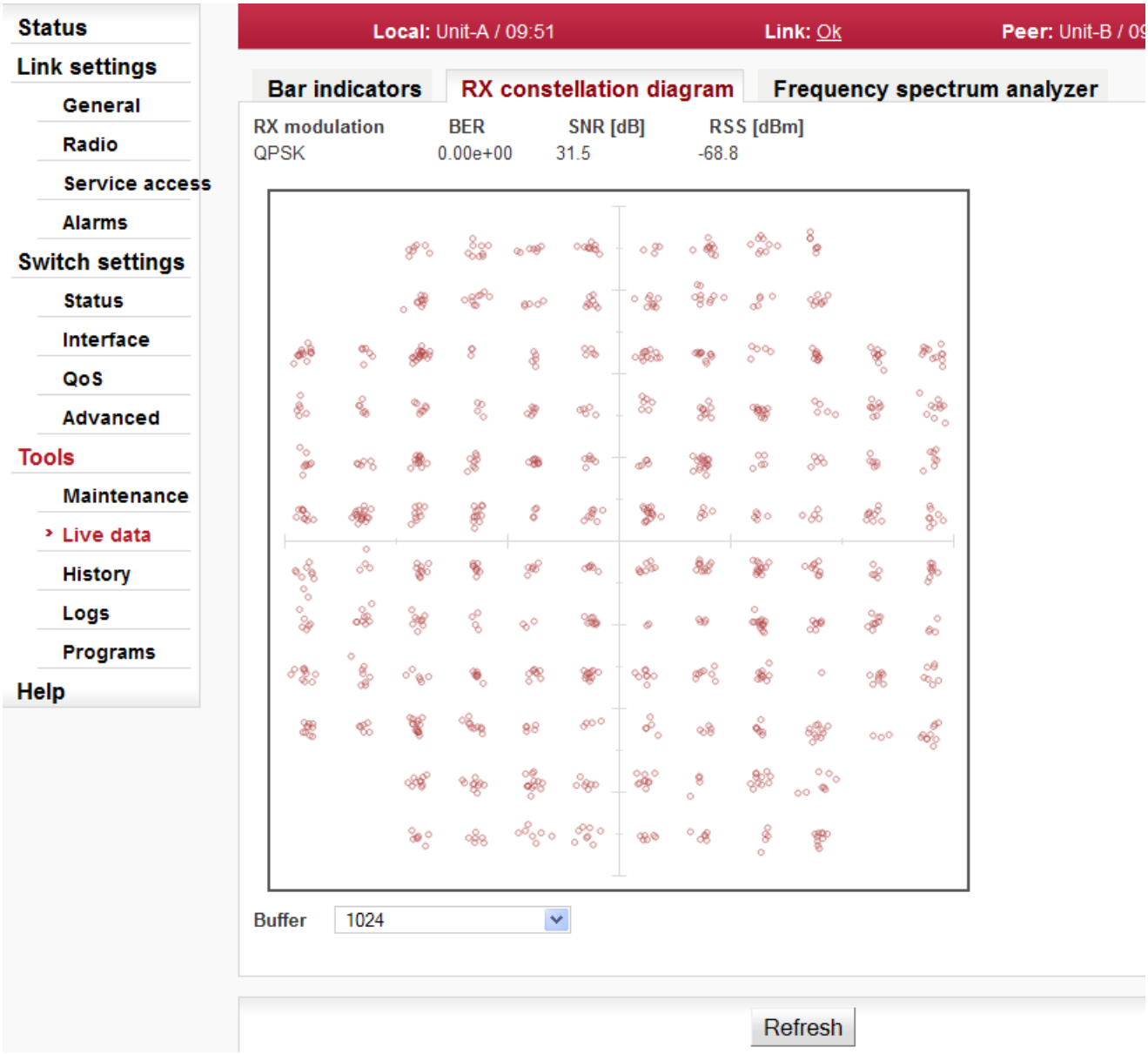


Fig. 5.50: Menu Tools / RX constellation

Constellation diagram shows the quality of received signal.

RX modulation	Modulation level of RX channel.
Buffer	Number of plotted points.
Refresh	One-time update of diagram.

5.6.2.4. Frequency spectrum analyzer

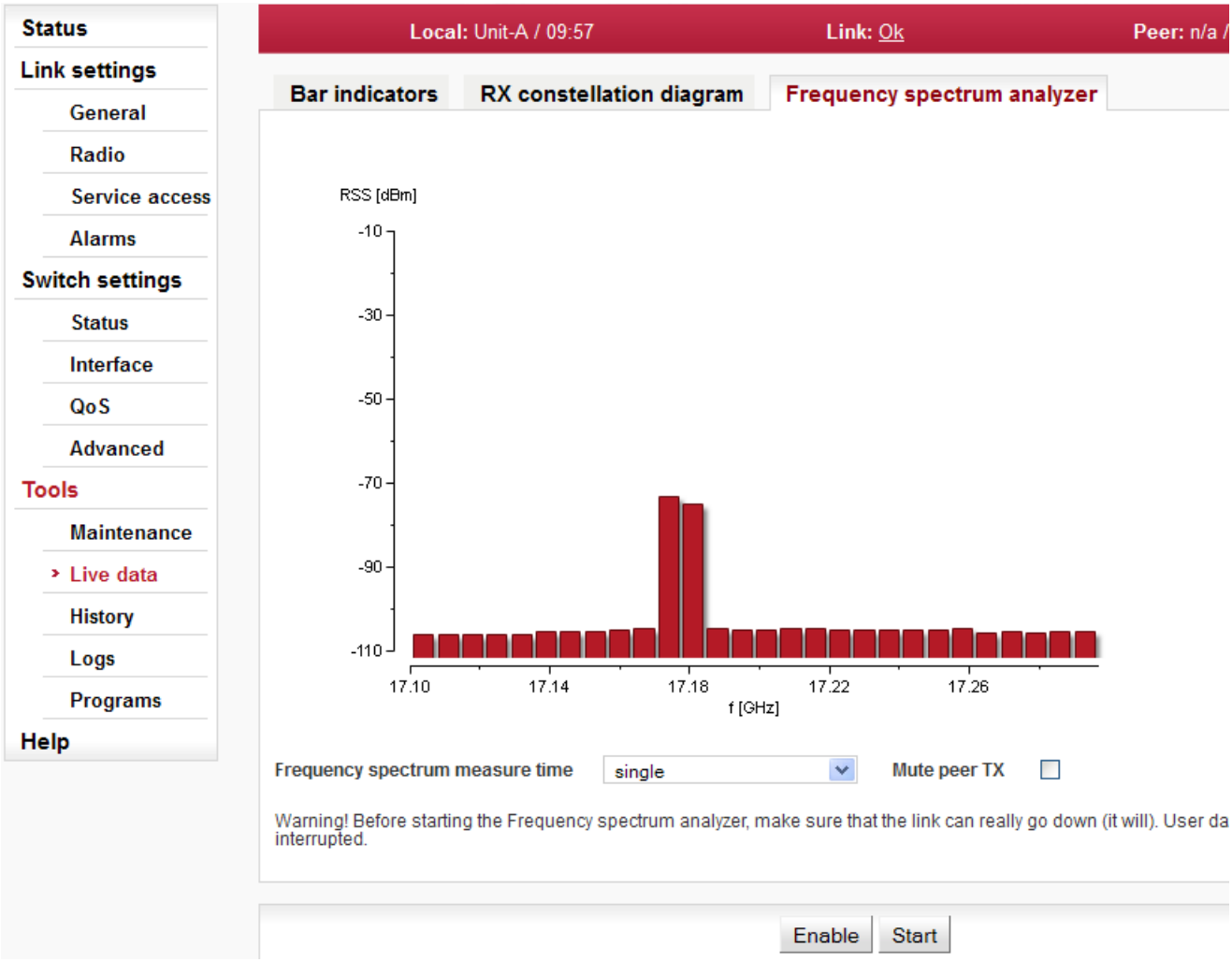


Fig. 5.51: Menu Tools / Frequency analyzer

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

5.6.3.1. Thumbnails

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

Fig. 5.52: 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.

5.6.3.2. 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.

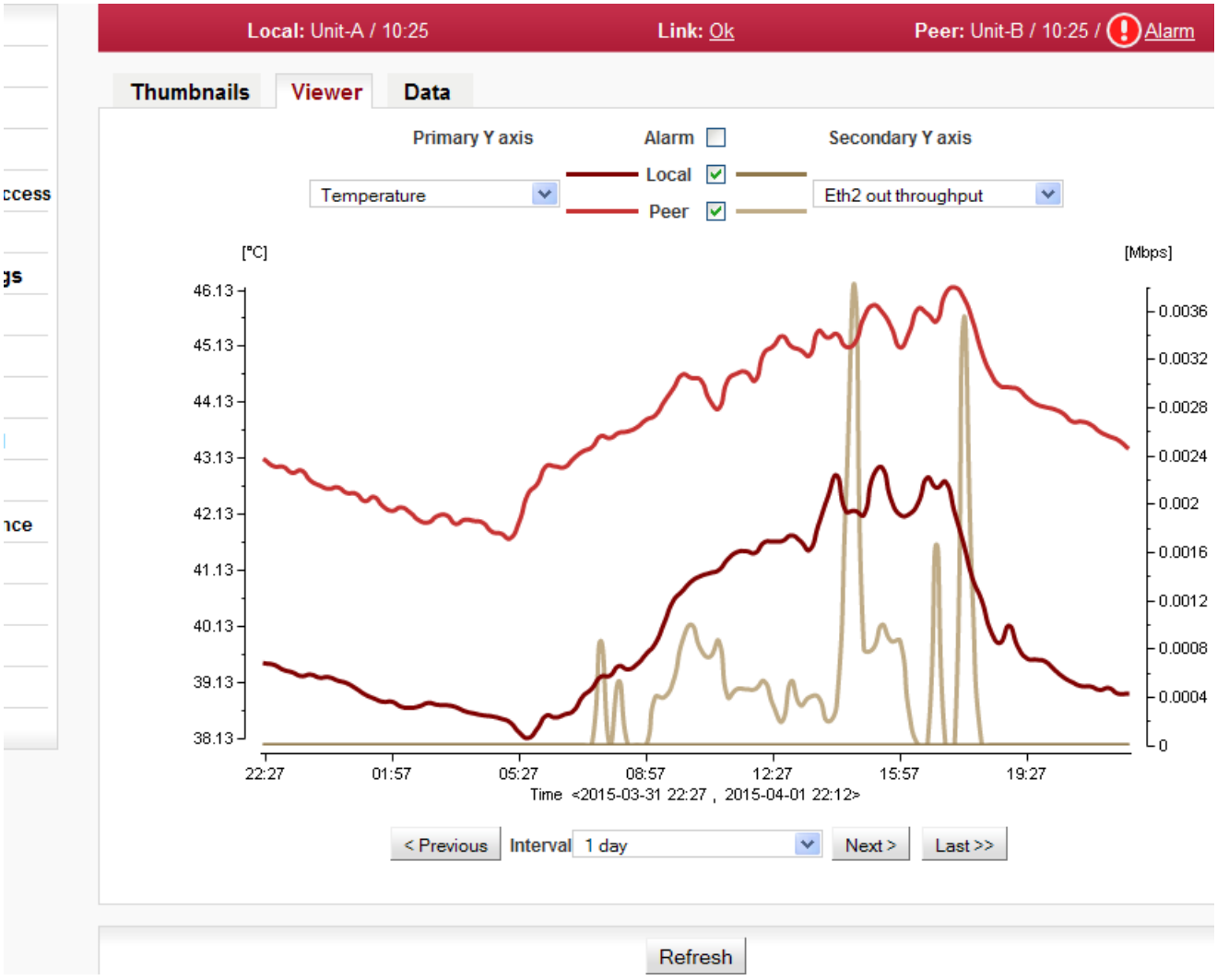


Fig. 5.53: Menu Tools / History / Viewer

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

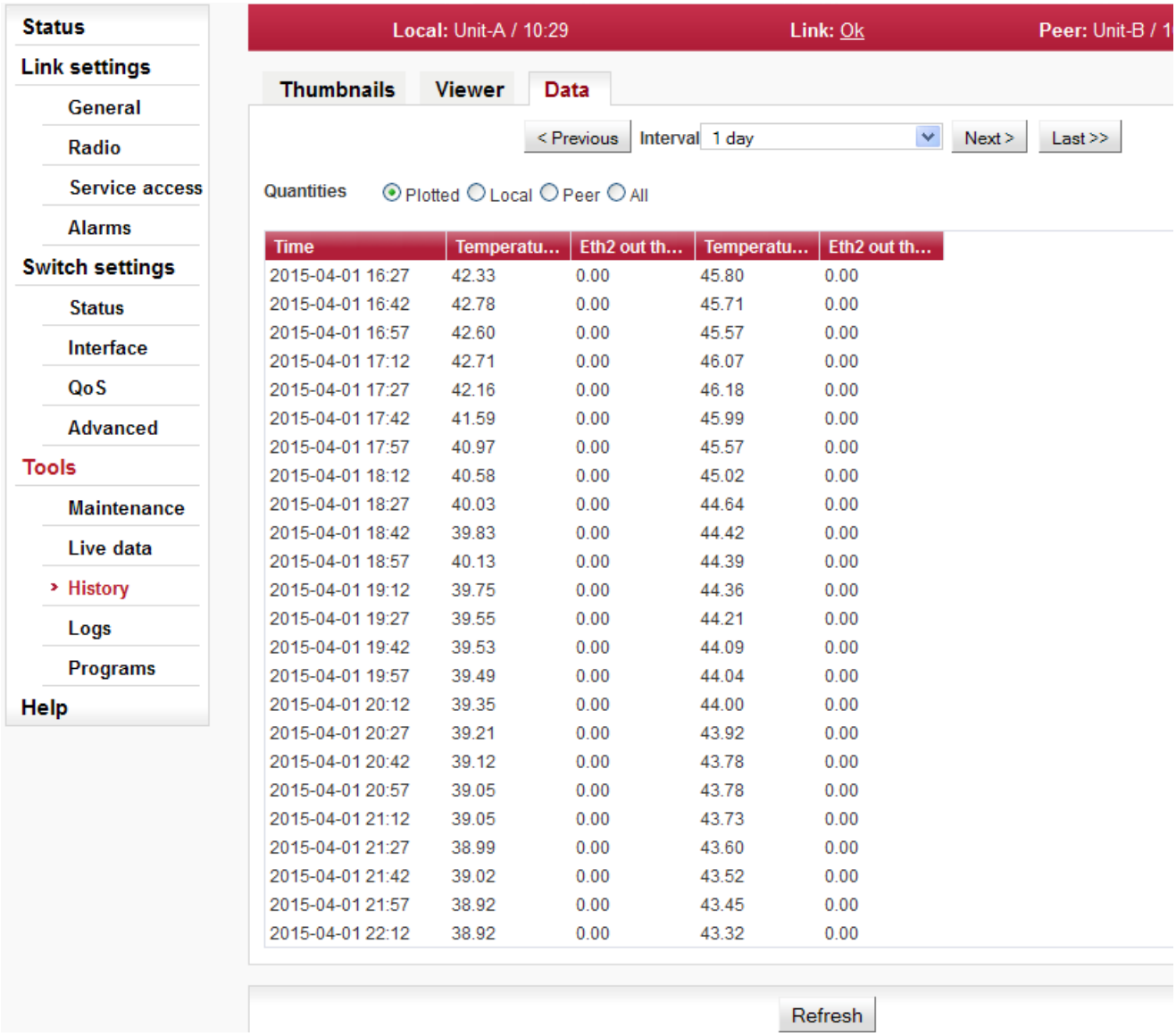
Temperature, Voltage, RSS, SNR, BER, Net bitrate, Ethernet in throughput, Ethernet out throughput, TX power

Alarm

Enables the display of alarms, if there were any.

5.6.3.3. Data

Numerical view of all values



Time	Temperatu...	Eth2 out th...	Temperatu...	Eth2 out th...
2015-04-01 16:27	42.33	0.00	45.80	0.00
2015-04-01 16:42	42.78	0.00	45.71	0.00
2015-04-01 16:57	42.60	0.00	45.57	0.00
2015-04-01 17:12	42.71	0.00	46.07	0.00
2015-04-01 17:27	42.16	0.00	46.18	0.00
2015-04-01 17:42	41.59	0.00	45.99	0.00
2015-04-01 17:57	40.97	0.00	45.57	0.00
2015-04-01 18:12	40.58	0.00	45.02	0.00
2015-04-01 18:27	40.03	0.00	44.64	0.00
2015-04-01 18:42	39.83	0.00	44.42	0.00
2015-04-01 18:57	40.13	0.00	44.39	0.00
2015-04-01 19:12	39.75	0.00	44.36	0.00
2015-04-01 19:27	39.55	0.00	44.21	0.00
2015-04-01 19:42	39.53	0.00	44.09	0.00
2015-04-01 19:57	39.49	0.00	44.04	0.00
2015-04-01 20:12	39.35	0.00	44.00	0.00
2015-04-01 20:27	39.21	0.00	43.92	0.00
2015-04-01 20:42	39.12	0.00	43.78	0.00
2015-04-01 20:57	39.05	0.00	43.78	0.00
2015-04-01 21:12	39.05	0.00	43.73	0.00
2015-04-01 21:27	38.99	0.00	43.60	0.00
2015-04-01 21:42	39.02	0.00	43.52	0.00
2015-04-01 21:57	38.92	0.00	43.45	0.00
2015-04-01 22:12	38.92	0.00	43.32	0.00

Fig. 5.54: 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.

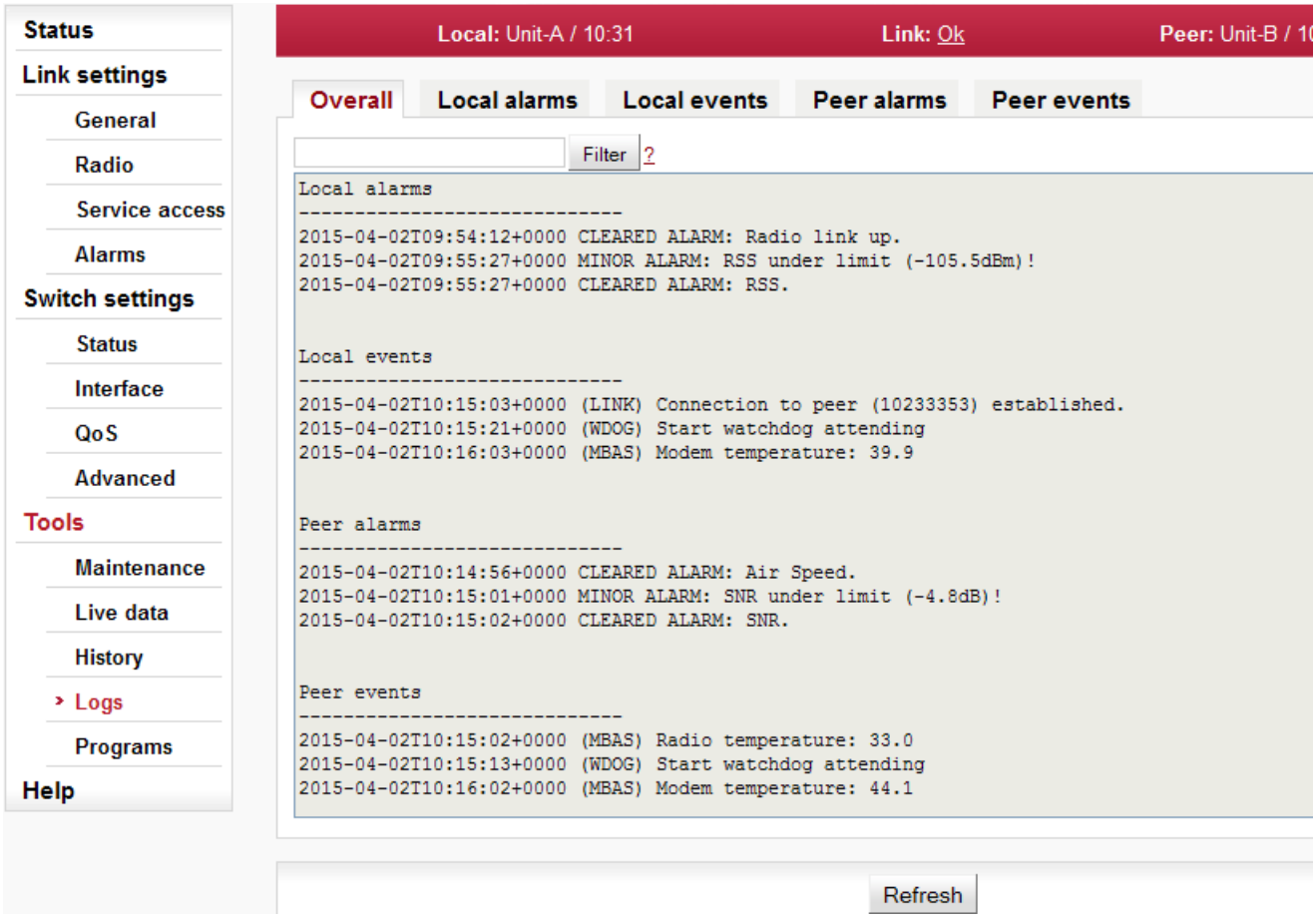


Fig. 5.55: Menu Tools / Logs

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

5.6.5.1. Ping

The Ping tool allows sending ICMP pings to a selected address

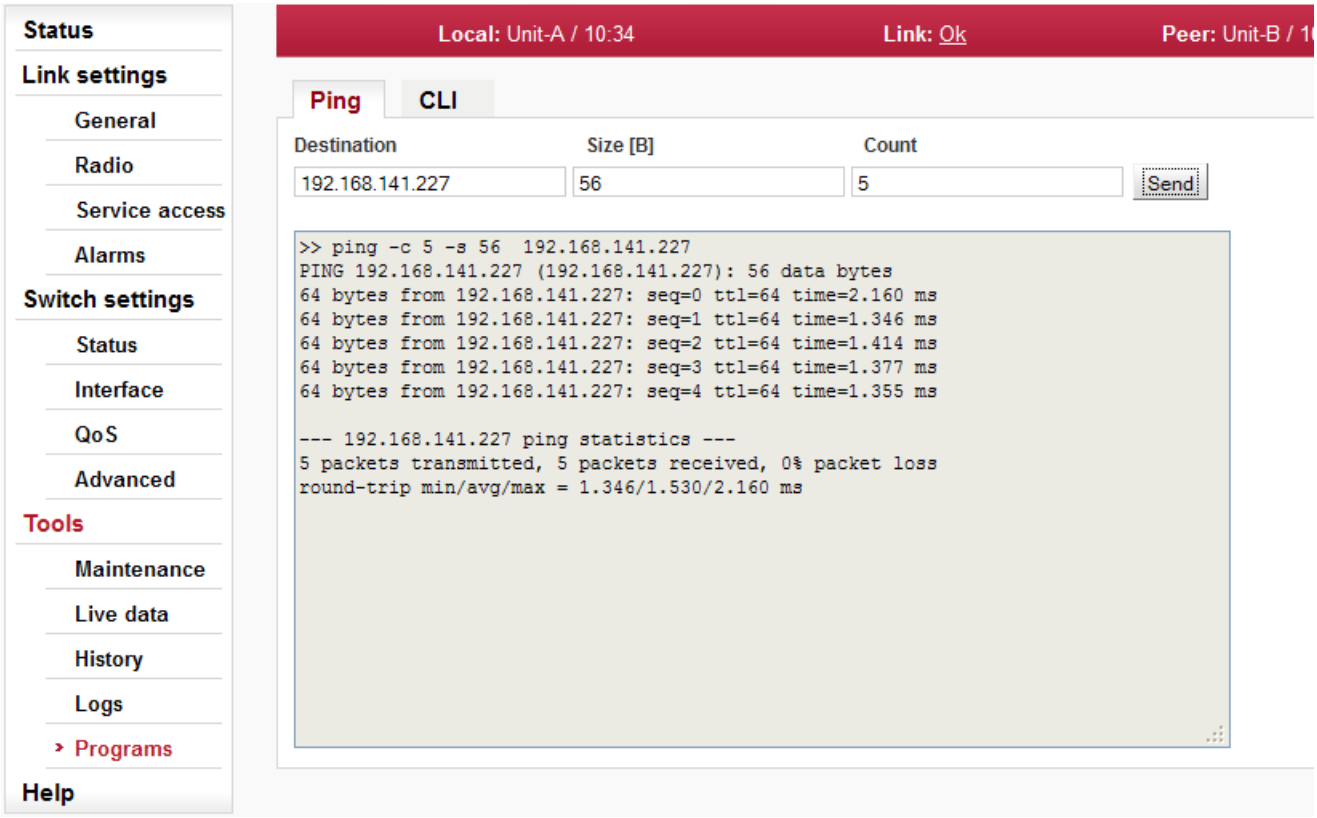


Fig. 5.56: Menu Tools / Programs / Ping

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.

5.6.5.2. CLI

Web interface for executing non-interactive scripts and programs.

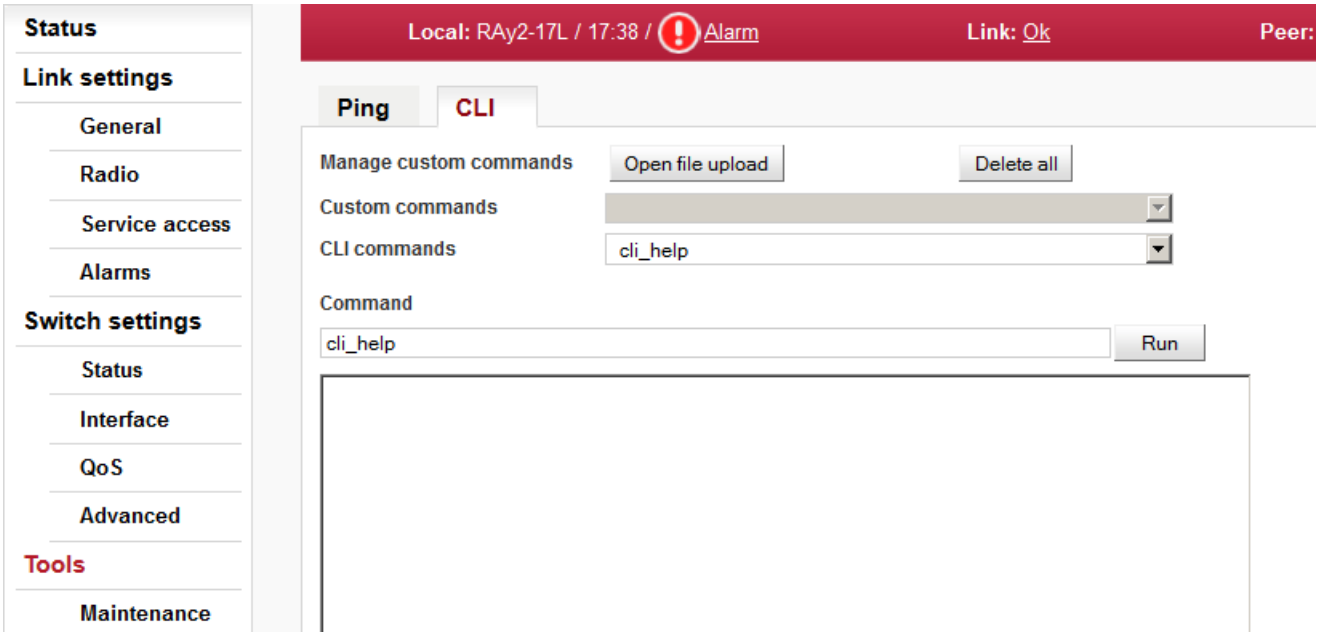


Fig. 5.57: Menu Tools / Programs / CLI

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

```
#!/bin/sh
#script checkes 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

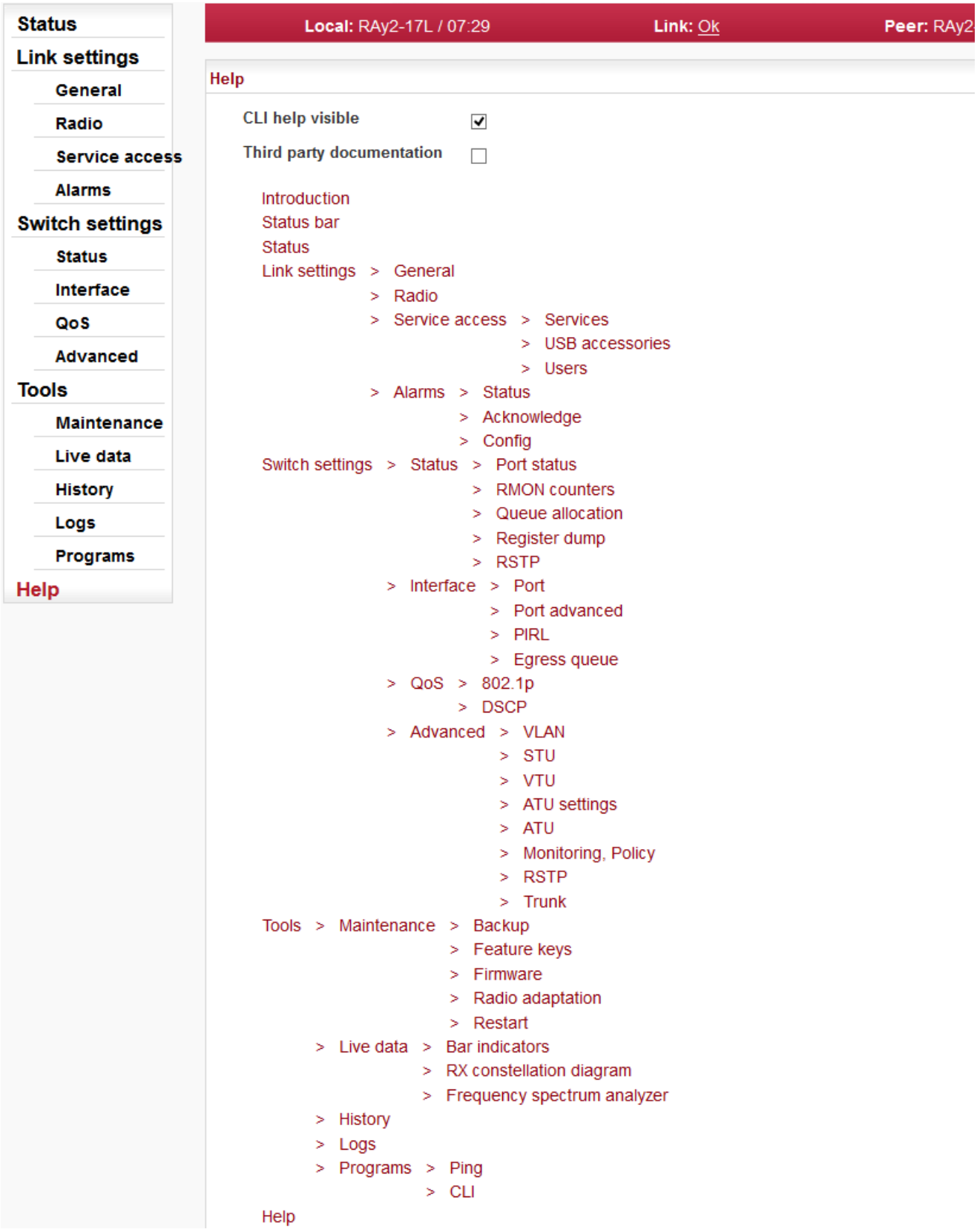


Fig. 5.58: Help menu

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:

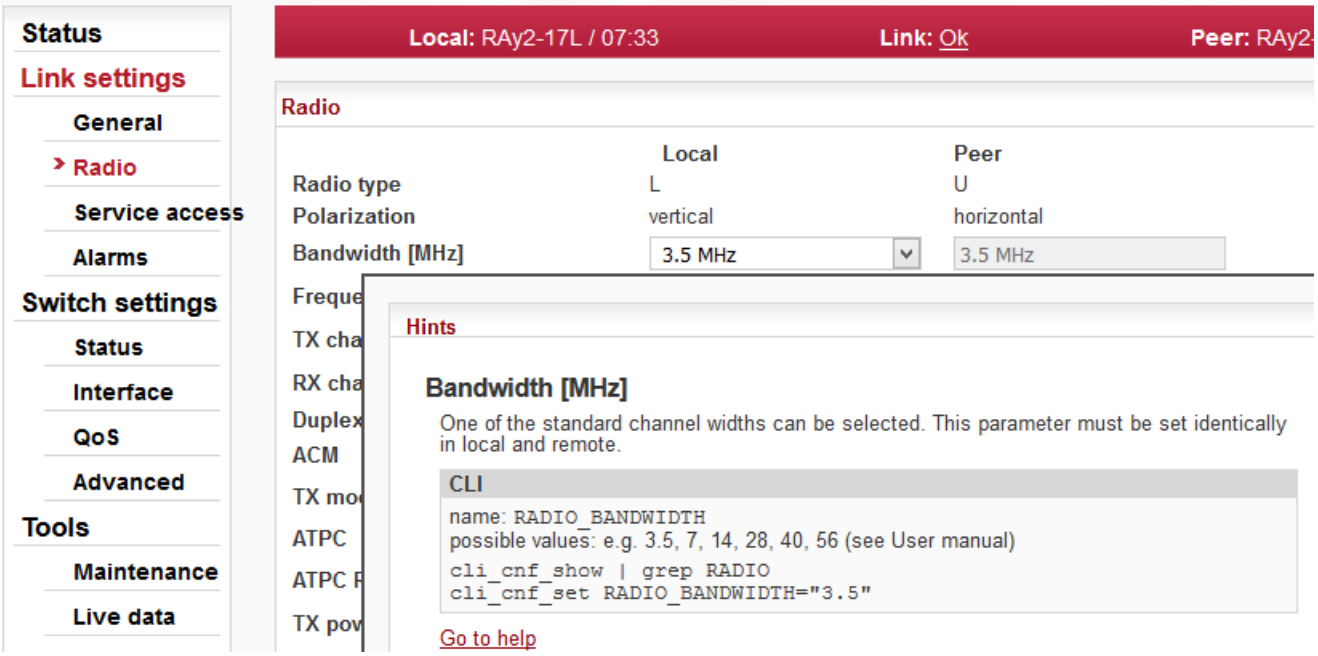


Fig. 5.59: Parameter help

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

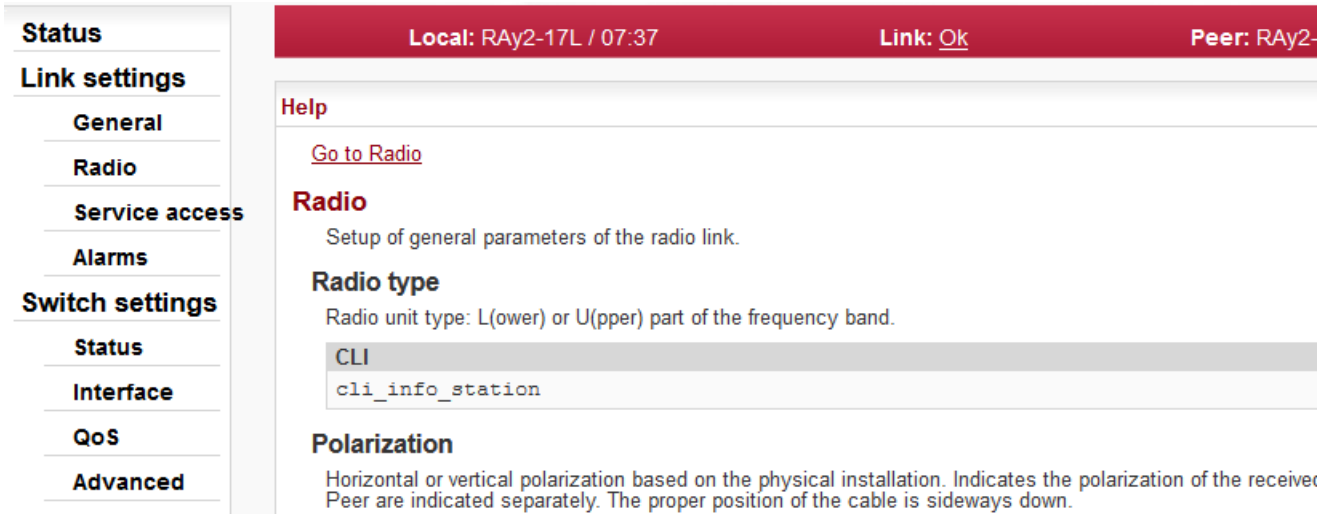


Fig. 5.60: Configuration menu help

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:

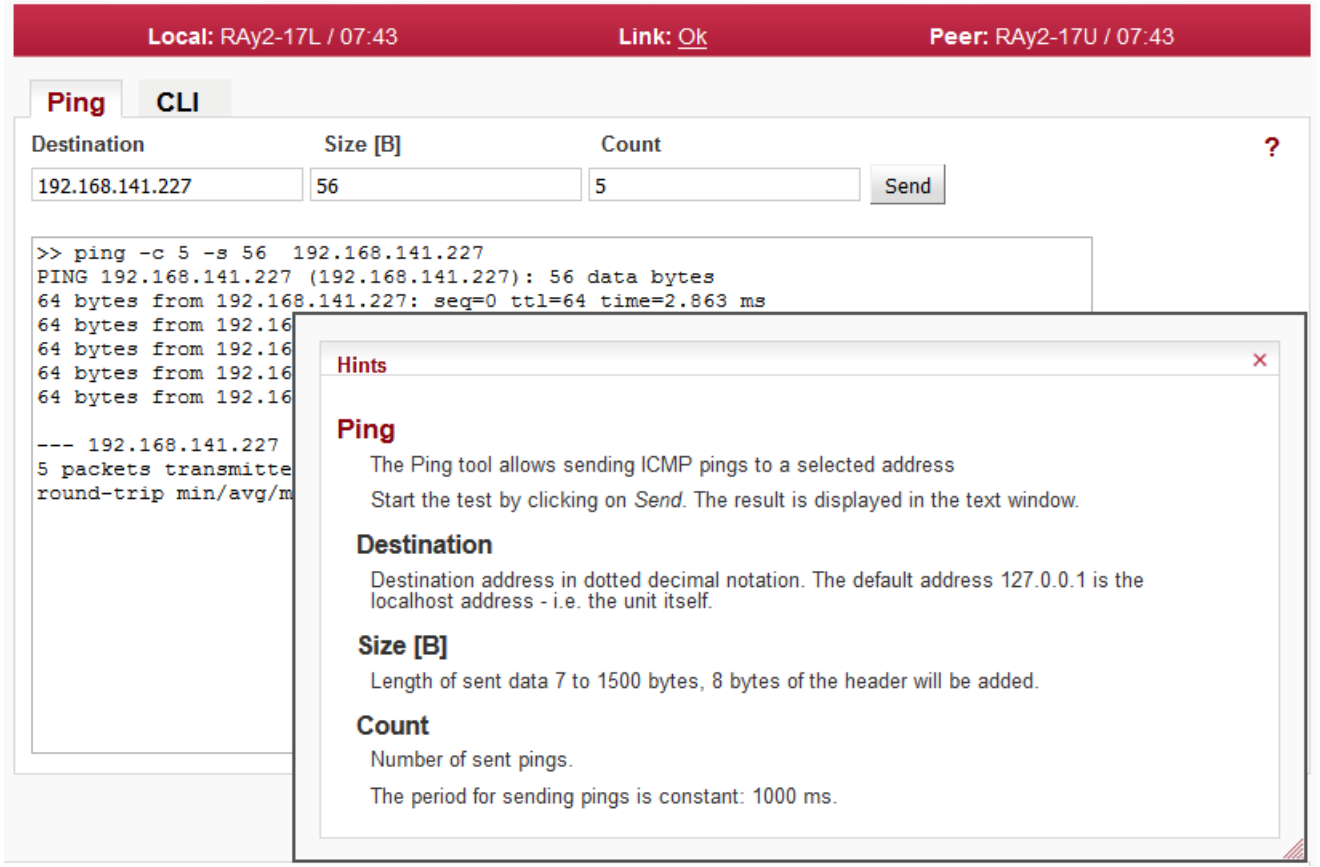


Fig. 5.61: Summary help

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
  ```

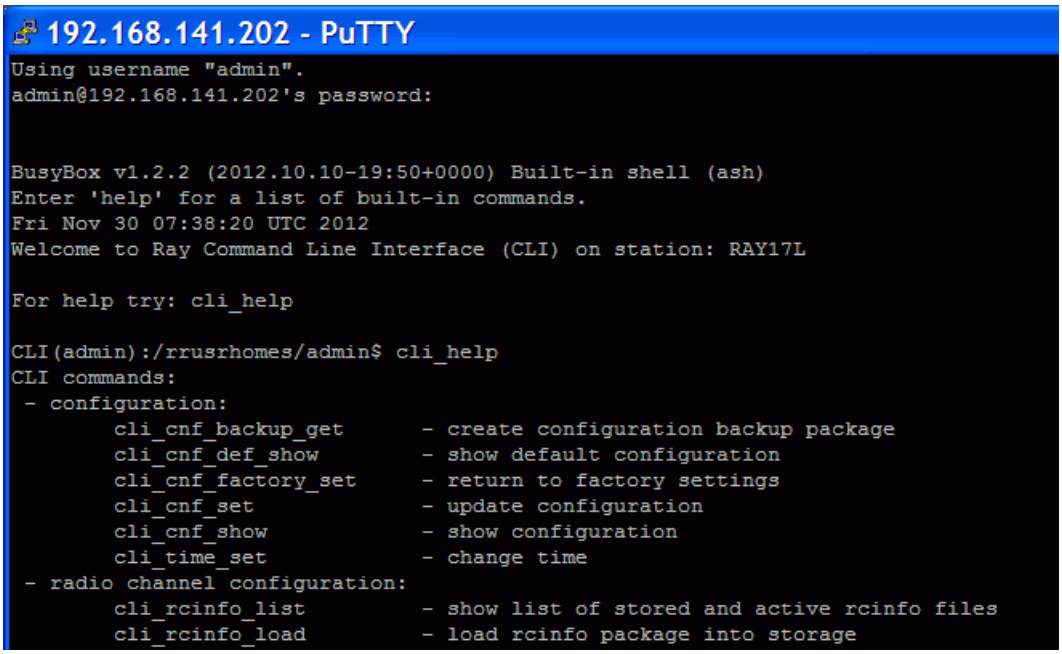


Fig. 6.1: CLI menu

- 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 RAy2 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 RAy2 unit
  `CLI(admin):/rrusrhomes/admin$ cli_user_authkey -c a -k /tmp/usr_ssh_key.pub`
- Testing access to RAy2 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 RAy2 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 RAy2 again

6.3.3. Remote unit authorization

The RAy2 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.

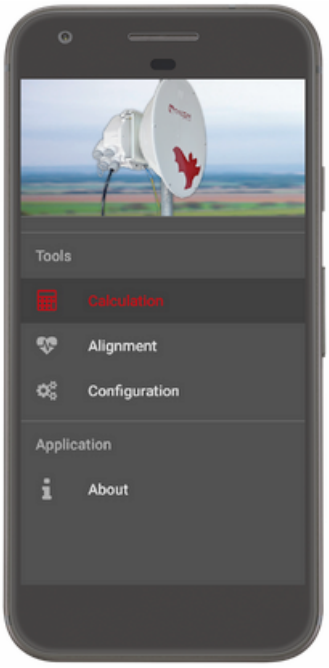
- Command
  `cli_rloop`

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.



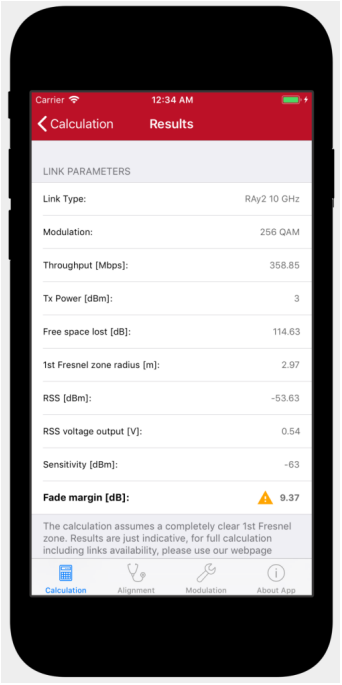
RAy Tools supports the following functions:
- Link Calculation – to calculate or verify the link budget
- Antenna Alignment – provide measurement of RSS and SNR for fast antenna alignment
- Link Management – standard web based unit management

7.1. Menu options

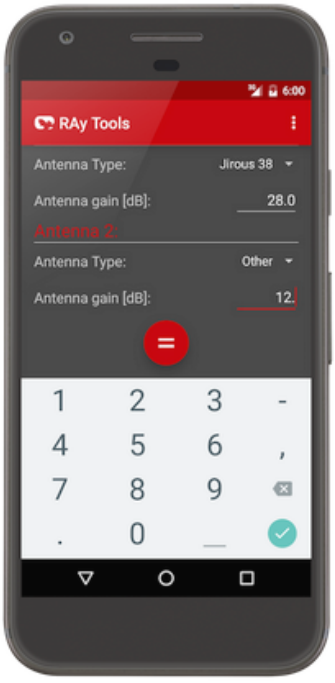
Calculation

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

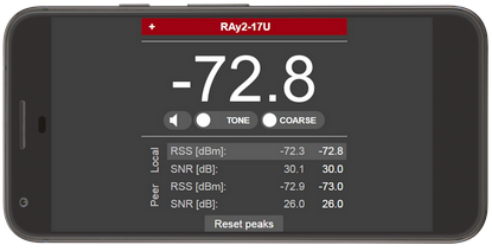


Android version

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 *https://www.racom.eu/eng/products/microwave-link.html#calculation*). Precise link calculation should be performed using dedicated tools (e.g. Pathloss).

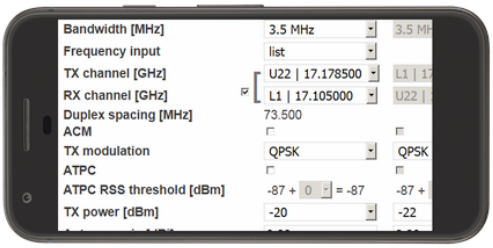
Alignment

Antenna Alignment Tool is accessed using this menu. See Section *5.6.2 Live data* for description.



Configuration

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



About

This item shows the application version and its Release notes.

Note

If gloves are used it is strongly recommended to activate smartphone option for “work in gloves”, which increase the sensitivity of touch screen display (quite common option for modern smartphones).

7.2. Application availability

RAy Tools application version 2.xx requires RAy2 unit 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**

  Install the unit with the correct *horizontal* or *vertical* polarization: The arrow mark (placed just next to the Status LED) indicates the unit RX polarization. When the arrow is perpendicular to the earth, the unit receives a signal in vertical polarization. When the arrow is parallel to the earth, the unit receives a signal in horizontal polarization. The connectors must point downward at an angle.

- **The link cannot be established**

  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) 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.

  Units operating in licensed bands (RAy2-10, RAy2-11) are mounted with the same RX polarization (the polarization indication arrows show the same polarization on both units).

  Units working in the bands equipped with RAy2-17 and RAy2-24 units must be mounted with opposite polarization; one with RX horizontal polarization (horizontal arrow) and the second with RX vertical polarization (vertical arrow).

- **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 Ray2 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 E, Https certificate*

- **Overexcited receiver**

  A natural property of each radio receiver is to compress the signal in one of the functional blocks, typically in a second receiving mixer. A downside of this property is the distortion of the input signal (decrease in the signal to noise ratio, i.e. the distortion measured as SNR).

  In extreme cases, this can lead to the disintegration of the radio link due to reduced signal to noise ratio (distortion). Extreme limits for guaranteed availability of the RAy2 connections are:

  ○ -30 dB for all channel bandwidths and fixed modulation 256QAM
  ○ -10 dB for all channel bandwidths and fixed modulation QPSK

9. Technical parameters

9.1. General parameters

9.1.1. Technical parameters overview

Type	RAy2-10	RAy2-11	RAy2-17	RAy2-18	RAy2-24
Band [GHz], sub-bands A,B..	A: *10.30 - 10.59* B: *10.125 - 10.675*	A: 10.695 – 11.460 B: 10.935 – 11.695	17.1 – 17.3	A: 17.700 - 19.219 B: 18.167 - 19700 C: 17.700 - 19.700	24.0 – 24.25
ODU units	Unit L and U		One universal unit	Unit L and U	One universal unit
Duplex spacing [MHz]	A: 58 - 285 MHz B: 350 MHz	490, 530	*optional* min 60	A, B: 1008, 1010 C: 1560	*optional* min 60
Channel spacing CS [MHz]	1.75 - 56	1.75 - 56	3.5 - 56	1.75 - 55	3.5 - 56
Channel freq.	*detail*	*detail*	*detail*	*detail*	*detail*
User speed [Mbps]	1.4 – 360	1.4 – 360	4.9 – 360	2.5 – 360	4.9 – 360
	detail	*detail*	*detail*	*detail*	*detail*
Latency [µs]	81 (64B/359Mbps), 234 (1518B/359Mbps)				
Sensitivity, BER 10^{-6} [dBm]	-103 (1.4 Mbps) -66 (340 Mbps)	-102 (1.4 Mbps) -67 (340 Mbps)	-97 (4.9 Mbps) -66 (340 Mbps)	-97 (2.5 Mbps) -64 (340 Mbps)	-96 (4.9 Mbps) -65 (340 Mbps)
	detail	*detail*	*detail*	*detail*	*detail*
Output Power [dBm]	*-10 +13 /QPSK* *-10 +8 /256QAM*	*-15 +24 /QPSK* *-15 +19 /256QAM*	*-25 .. +5*	*-10 +24 /QPSK* *-10 +19 /256QAM*	*-30 .. +10* [1)] -30 .. -15 [2)]
ATPC	yes	yes	yes	yes	yes
Consumption [W]	21	21 – 29	21	21 - 28	23
Weight [kg]	2.8	2.8	2.5	2.7	2.5
Radio param.	EN 302 217-2-2 V2.2.1		EN 300 440-2 V1.4.1	EN 302 217-2-2 V2.2.1	EN 300 440-2 V1.4.1

[1)] RAy2-24

[2)] RAy2-24R

ver. 2.15

Modulation	fixed QPSK, 16, 32, 64, 128, 256 QAM or ACM
Forward Error Correc.	LDPC
User interface RJ45	1 Gb Eth. (10/100/1000) (IEEE 802.3ac 1000BASE-T), MTU 10240 B, recommended cable S/FTP CAT7
User interface SFP	1000Base-SX / 1000Base-LX, MTU 10240 B, user exchangable SFP, power consumption max. 1.25 W
Service	USB-A
Power	PoE, 40 - 60 VDC , IEEE 802.3at up to 100m, up to 25 W
	DC, 20 - 60 V, floating
Operating temperature range	-30 – +55°C (EN 300 019-1-4, class 4.1.)
Mechanical design	FOD (Full Outdoor)
IP code	IP66 (Ingress Protection)
Security	configuration via https, ssh
Dimensions	244 × 244 × 157 mm
Spectrum	EN 302 217-2-2 V2.2.1 (RAy2-10, RAy2-11, RAy2-18) EN 302 217-1 V1.3.1 (RAy2-10) EN 300 440-1 V1.6.1 (RAy2-17, RAy2-24) EN 300 440-2 V1.4.1 (RAy2-17, RAy2-24)
EMC	EN 301 489-1 V1.9.2 EN 301 489-4 V2.1.1 EN 301 489-3 V1.6.1 (RAy2-17, RAy2-24)
Safety	EN 60950-1 ed.2:2006
FCC	CFR 47 part 101 (RAy2-11, RAy2-18 sub-band C) CFR 47 part 15 (RAy2-24)

ver. 1.6

9.1.2. Link speed

RAy2 - xx		**User data rate [Mbps]**					
Bandwidth MHz		**Modulation**					
		QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
1.75 S	ACCP	1.4	2.9	3.7	5.8	7.4	
1.75	ACCP	2.5	5.0	6.3	7.4	8.9	
2.5 S	ACCP	2.8	5.3	6.7	8.5	10.4	11.1
2.5	ACCP	3.2	6.3	8.0	9.4	11.4	13.0
3.5 S	ACCP	4.2	8.4	10.2	12.9	15.7	16.8
3.5 / 3.75	ACCP	4.9	9.6	12.1	14.3	17.2	19.7
5 S	ACCP	5.6	11.2	13.7	17.3	21.1	22.5
5	ACCP	5.7	11.5	14.8	19.8	23.1	27.2
7 S	ACCP	8.5	16.9	20.5	26.0	31.6	33.8
7	ACCP	8.5	17.2	22.1	29.7	34.7	39.7
7.5	ACCP	9.1	18.4	23.7	31.8	37.1	42.5
10	ACCP	11.4	23.2	29.9	40.0	46.8	55.0
13.75	ACCP	19.9	38.8	49.1	62.3	73.6	81.2
14	ACCP	19.9	38.8	49.1	62.3	73.6	81.2
20N (10G)	ACCP	22.8	50.2	63.5	80.5	96.4	110.4
20	ACCP	26.3	57.8	73.1	92.7	111.0	127.2
27.5 / 28 / 30	ACCP	36.8	80.9	102.4	129.8	155.5	170.7
28 / 30	**ACAP**	38.3	84.1	106.4	135.0	161.7	185.2
40	ACCP	50.1	110.0	139.2	176.5	211.4	232.1
50	ACCP	66.3	145.6	184.2	233.6	276.1	320.6
55 / 56	ACCP	72.9	160.2	202.7	256.9	303.7	337.7
56 TO	ACCP	85.8	169.9	206.2	268.1	309.0	358.9

ver. 2.12

ACCP - Adjacent Channel Co-Polarization
ACAP - Adjacent Channel Alternate Polarization

Link speed according to RFC 2544

RAy2 - xx		**Link speed [Mbps] for frames 64 - 1518 B** min / max values					
Bandwidth MHz		**Modulation**					
		QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
1.75	ACCP	2.1 2.3	4.3 4.8	5.4 6.0	6.5 7.2	7.8 8.7	
3.5	ACCP	4.2 4.6	8.4 9.3	10.6 11.9	12.6 14.1	15.1 17.0	17.4 19.4
7	ACCP	7.5 8.3	15.1 17.0	19.6 21.8	26.1 29.3	30.7 34.3	36.1 40.3
14	ACCP	17.6 19.6	34.3 38.5	43.4 48.6	55.2 61.7	65.2 73.0	71.9 80.5
28 /30	ACCP	32.6 36.5	71.7 80.2	90.7 101.5	115.1 128.8	138.0 154.5	151.5 169.5
28 /30	**ACAP**	33.8 37.9	74.6 83.4	94.3 105.6	119.7 133.9	143.5 160.5	164.4 184.0
40	ACCP	44.3 49.6	97.5 109.2	123.4 138.2	156.6 175.3	187.7 209.9	206.1 230.7
56	ACCP	64.7 72.3	142.1 159.0	179.9 201.3	228.0 255.1	269.7 301.6	300.2 335.8
56 TO	ACCP	76.1 85.2	150.7 168.6	182.9 204.8	238.1 266.4	274.5 307.1	318.8 356.5

ver. 1.2

FCC comment

Choice of modulation must respect the requirements of Section *Section 10.10, “FCC authorization of transmitters”* .

9.1.3. ACM switching

***ACM switching* according to SNR state**

RAy2 - xx		**SNR degrade / improve [dB]**					
Bandwidth MHz		**Modulation**					
		QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
1.75	ACCP	- 19.0	17.0 23.0	20.0 26.0	23.0 28.5	25.0 -	- -
2.5	ACCP	- 19.0	17.0 23.0	20.0 26.0	23.0 28.5	25.0 31.5	28.5 -
3.5	ACCP	- 19.0	17.0 23.0	20.0 26.0	23.0 28.5	25.0 31.5	28.5 -
5	ACCP	- 19.0	17.0 23.0	20.0 26.0	23.0 28.5	25.0 30.5	28.0 -
7	ACCP	- 19.0	17.0 23.0	20.0 26.0	23.0 28.5	25.0 30.5	28.0 -
10	ACCP	- 19.0	17.0 23.0	20.0 26.0	23.0 28.5	25.0 30.5	28.0 -
14	ACCP	- 19.0	17.0 23.0	20.0 26.0	23.0 28.5	25.0 30.5	28.0 -
20	ACCP	- 19.0	17.0 23.0	20.0 26.0	23.0 28.5	25.0 30.5	28.0 -
28	ACCP	- 19.0	17.0 23.0	20.0 26.0	23.0 28.5	25.0 30.5	28.0 -
30	ACCP	- 19.0	17.0 23.0	20.0 26.0	23.0 28.5	25.0 30.5	28.0 -
40	ACCP	- 19.0	17.0 23.0	20.0 26.0	23.0 28.5	25.0 30.5	28.0 -
50	ACCP	- 19.0	17.0 23.0	20.0 26.0	23.0 28.5	25.0 30.5	28.0 -
56	ACCP	- 19.0	17.0 23.0	20.0 26.0	23.0 28.5	25.0 30.5	28.0 -
56 TO	ACCP	- 19.0	17.0 23.0	20.5 26.0	24.5 28.5	27.0 31.0	29.0 -

ver. 1.4

9.1.4. Multi-Path (Distortion Sensitivity) Signature

Multipath Signature BER = 10^{-6}

RAy2 - xx	**Multipath Signature [dB]**				BER 10^{-6}	
Bandwidth MHz	**Modulation**					
	QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
5	53.5 53.5 4	44.5 44.5 4	37.5 37.5 4	32.5 32.5 4	29.5 29.5 4	27.5 27.5 4
7	52 52 6	43 43 6	36 36 6	31 31 6	28 28 6	26 26 6
7.5	52 52 6.43	43 43 6.43	36 36 6.43	31 31 6.43	28 28 6.43	26 26 6.43
10	50.5 50.5 8.1	41.5 41.5 8.1	34 34 8.1	29.5 29.5 8.1	27 27 8.1	25 25 8.1
13.75 / 14	49 49 12	40 40 12	32 32 12	28 28 12	26 25.5 12	24 23.5 12
20 N	47.5 47.5 15.5	38.5 38.5 15.5	30.5 30.5 15.5	26.5 26.5 15.5	24.5 24 15.5	22.5 22 15.5
20	47.5 47.5 17.85	38.5 38.5 17.85	30.5 30.5 17.85	26.5 26.5 17.85	24.5 24 17.85	22.5 22 17.85
27.5 / 28 / 30	46 46 25	37 37 25	29 29 25	25 25 25	23 22.5 25	21 20.5 25
40	44 44.5 34	35 35.5 34	27 27.5 34	23 23.5 34	21 21.5 34	19 19.5 34
50	43 44 45	33.5 35 45	25.5 27 45	21.5 23 45	19.5 20.5 45	18 18.5 45
55 / 56	42 43 49.5	32.5 34 49.5	24.5 26 49.5	20.5 22 49.5	18.5 20 49.5	17 18 49.5

ver. 1.0

Minimum phase [dB]
Non-minimum phase [dB]
Signature width [MHz]

Multipath Signature BER = 10^{-3}

RAy2 - xx	**Multipath Signature [dB]**				BER 10^{-3}	
Bandwidth MHz	**Modulation**					
	QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
5	55.5 55.5 4	46.5 46.5 4	39.5 39.5 4	34.5 34.5 4	31.5 31.5 4	29.5 29.5 4
7	54 54 6	45 45 6	38 38 6	33 33 6	30 30 6	28 28 6
7.5	54 54 6.43	45 45 6.43	38 38 6.43	33 33 6.43	30 30 6.43	28 28 6.43
10	52.5 52.5 8.1	43.5 43.5 8.1	36 36 8.1	31.5 31.5 8.1	29 29 8.1	27 27 8.1
13.75 / 14	51 51 12	42 42 12	34 34 12	30 30 12	28 27.5 12	26 25.5 12
20 N	49.5 49.5 15.5	40.5 40.5 15.5	32.5 32.5 15.5	28.5 28.5 15.5	26.5 26 15.5	24.5 24 15.5
20	49.5 49.5 17.85	40.5 40.5 17.85	32.5 32.5 17.85	28.5 28.5 17.85	26.5 26 17.85	24.5 24 17.85
27.5 / 28 / 30	48 48 25	39 39 25	31 31 25	27 27 25	25 24.5 25	23 22.5 25
40	46 46.5 34	37 37.5 34	29 29.5 34	25 25.5 34	23 23.5 34	21 21.5 34
50	45 46 45	35.5 37 45	27.5 29 45	23.5 25 45	21.5 22.5 45	20 20.5 45
55 / 56	44 45 49.5	34.5 36 49.5	26.5 28 49.5	22.5 24 49.5	20.5 22 49.5	19 20 49.5

ver. 1.0

Minimum phase [dB]
Non-minimum phase [dB]
Signature width [MHz]

9.2. RAy2-10 parameters

9.2.1. Upper/Lower Limits

RAy2-10-xA, **RAy2-10-x**B	**TX power**	
Modulation	**Min**	**Max**
	[dBm]	**[dBm]**
QPSK	-10	13
16-QAM	-10	11
32-QAM	-10	11
64-QAM	-10	10
128-QAM	-10	9
256-QAM	-10	8

ver. 1.2

RAy2-10-xA, **RAy2-10-x**B	**Duplex spacing**
Sub-band	**[MHz]**
A	All combinations of channels
B	All combinations of channels

ver. 2.5

RAy2-10-xA, **RAy2-10-x**B		**Sub-band Range**	
Sub-band		**Unit L**	**Unit U**
		[GHz]	**[GHz]**
A	min	10.301	10.476
	max	10.420	10.588
B	min	10.125	10.475
	max	10.325	10.675

ver. 1.3

9.2.2. Radio parameters

Radio parameters, BER = 10^{-6}

RAy2-10-x**A**, -x**B**		**Radio parameters** - Bit Rate / RSS / SNR			BER 10^{-6}		
Bandwidth [MHz]		**Modulation**					
		QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
1.75 S	ACCP	1.4 -103 9.5	2.9 -97 15.0	3.7 -94 19.0	5.8 -91 20.5	7.4 -88 23.5	
1.75	ACCP	2.5 -100 9.5	5.0 -92 15.0	6.3 -88 19.0	7.4 -87 20.5	8.9 -84 23.5	
3.5	ACCP	4.9 -96 9.5	9.6 -89 15.0	12.1 -86 18.5	14.3 -85 20.5	17.2 -83 23.5	19.7 -80 26.0
7	ACCP	8.5 -94 8.5	17.2 -87 15.0	22.1 -84 18.5	29.7 -80 21.5	34.7 -78 25.0	39.7 -76 26.0
14	ACCP	19.9 -92 8.5	38.8 -85 15.0	49.1 -81 18.5	62.3 -78 21.5	73.6 -75 25.0	81.2 -73 28.0
20	ACCP	22.8 -91 8.5	50.2 -84 15.0	63.5 -80 18.5	80.5 -77 21.5	96.4 -73 25.0	110.4 -71 28.0
28 / 30	ACCP	36.8 -90 7.5	80.9 -82 15.0	102.4 -78 18.5	129.8 -75 21.5	155.5 -71 25.0	170.7 -69 26.5
28 / 30	**ACAP**	38.3 -88.5 7.5	84.1 -81.5 15.0	106.4 -77.5 18.5	135.0 -74.5 21.5	161.7 -70.5 25.0	185.2 -67.5 26.5
40	ACCP	50.1 -87 7.5	110.0 -80 15.0	139.2 -76 18.5	176.5 -73 21.5	211.4 -69 25.0	232.1 -67 26.5
56	ACCP	72.9 -86 7.5	160.2 -79 15.0	202.7 -75 18.5	256.9 -72 21.5	303.7 -68 25.0	337.7 -66 26.5
56 TO	ACCP	85.8 -84 10.0	169.9 -77 16.0	206.2 -73 19.0	268.1 -69 22.5	309.0 -66 25.5	358.9 -63 27.5

ver. 1.1

User Bit Rate [MBps]
RSS for BER 10^{-6} [dBm]
SNR for BER 10^{-6} [dB]

Radio parameters, BER = 10^{-3}

RAy2-10-x**A**, -x**B**		**Radio parameters** - RSS / SNR BER 10^{-3}					
Bandwidth [MHz]		**Modulation**					
		QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
1.75 S	ACCP	-105 5	-99 11	-96 15	-93 19	-90 22	
1.75	ACCP	-102 5	-94 11	-90 15	-89 19	-86 22	
3.5	ACCP	-98 5	-91 11	-88 15	-87 19	-85 22	-82 25
7	ACCP	-96 5	-89 11	-86 15	-82 19	-80 22	-78 25
14	ACCP	-94 5	-87 11	-83 15	-80 19	-77 22	-75 25
20	ACCP	-93 5	-86 11	-82 15	-79 19	-75 22	-73 25
28 / 30	ACCP	-92 5	-84 11	-80 15	-77 19	-73 22	-71 25
28 / 30	**ACAP**	-90.5 5	-83.5 11	-79.5 15	-76.5 19	-72.5 22	-69.5 25
40	ACCP	-89 5	-82 11	-78 15	-75 19	-71 22	-69 25
56	ACCP	-88 5	-81 11	-77 15	-74 19	-70 22	-68 25
56 TO	ACCP	-86 6	-79 12	-75 16	-71 20	-68 23	-65 26

ver. 1.0

RSS for BER 10^{-3} [dBm]
SNR for BER 10^{-3} [dB]

9.2.3. Frequency tables 10A, B

name	description	
rcinfo10_A_default	10.30 - 10.59 GHz	default duplex 168, default table
rcinfo10_B_default	10.15 - 10.65 GHz	duplex 350, default table

The microwave link contains one or more frequency tables (called rcinfo), see menu *Radio adaptation*. Tables are labeled in format <name:version>, e.g.: rcinfo10_A_default:8

Nominal frequencies of 10 GHz bands are given in *Channel arrangements*[1].

[1] https://www.racom.eu/eng/products/m/ray2tab/nom-freq.html#kmit10a

9.3. RAy2-11 A,B parameters

9.3.1. Upper/Lower Limits

RAy2-11-xA, **RAy2-11-x**B	**TX power**	
Modulation	**Min**	**Max**
	[dBm]	**[dBm]**
QPSK	-15	24
16-QAM	-15	22
32-QAM	-15	22
64-QAM	-15	21
128-QAM	-15	20
256-QAM	-15	19

ver. 2.2

RAy2-11-xA, **RAy2-11-x**B	**Duplex spacing**
Sub-band	**[MHz]**
A	490, 530
B	490, 530

ver. 2.5

RAy2-11-xA, **RAy2-11-x**B		**Sub-band Range**	
Sub-band		**Unit L**	**Unit U**
		[GHz]	**[GHz]**
A	min	10.695	11.185
	max	10.970	11.460
B	min	10.935	11.425
	max	11.195	11.695

ver. 1.1

9.3.2. Radio parameters

Radio parameters, BER = 10^{-6}

RAy2-11-xA, -xB		**Radio parameters** - Bit Rate / RSS / SNR BER 10^{-6}					
Bandwidth [MHz]		**Modulation**					
		QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
1.75 S	ACCP	1.4 -102 9.5	2.9 -97 15.0	3.7 -94 19.0	5.8 -91 20.5	7.4 -88 23.5	
1.75	ACCP	2.5 -99 9.5	5.0 -93 15.0	6.3 -89 19.0	7.4 -88 20.5	8.9 -84 23.5	
3.5	ACCP	4.9 -97 9.5	9.6 -90 15.0	12.1 -87 18.5	14.3 -84 20.5	17.2 -81 23.5	19.7 -79 26.0
7	ACCP	8.5 -95 8.5	17.2 -88 15.0	22.1 -85 18.5	29.7 -81 21.5	34.7 -79 25.0	39.7 -76 26.0
14	ACCP	19.9 -93 8.5	38.8 -86 15.0	49.1 -82 18.5	62.3 -79 21.5	73.6 -75 25.0	81.2 -73 28.0
28 / 30	ACCP	36.8 -91 7.5	80.9 -83 15.0	102.4 -79 18.5	129.8 -76 21.5	155.5 -72 25.0	170.7 -70 26.5
28 / 30	**ACAP**	38.3 -89.5 7.5	84.1 -82.5 15.0	106.4 -78.5 18.5	135.0 -75.5 21.5	161.7 -71.5 25.0	185.2 -68.5 26.5
40	ACCP	50.1 -88 7.5	110.0 -81 15.0	139.2 -77 18.5	176.5 -74 21.5	211.4 -70 25.0	232.1 -68 26.5
56	ACCP	72.9 -87 7.5	160.2 -80 15.0	202.7 -76 18.5	256.9 -73 21.5	303.7 -69 25.0	337.7 -67 26.5
56 TO	ACCP	85.8 -85 10.0	169.9 -78 16.0	206.2 -74 19.0	268.1 -70 22.5	309.0 -67 25.5	358.9 -64 27.5

ver. 1.2

User Bit Rate [MBps]
RSS for BER 10^{-6} [dBm]
SNR for BER 10^{-6} [dB]

Radio parameters, BER = 10^{-3}

RAy2-11-xA, -xB		**Radio parameters** - RSS / SNR					BER 10^{-3}
Bandwidth [MHz]		**Modulation**					
		QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
1.75 S	ACCP	-104 5	-99 11	-96 15	-93 19	-90 22	
1.75	ACCP	-101 5	-95 11	-91 15	-90 19	-86 22	
3.5	ACCP	-99 5	-92 11	-89 15	-86 19	-83 22	-81 25
7	ACCP	-97 5	-90 11	-87 15	-83 19	-81 22	-78 25
14	ACCP	-95 5	-88 11	-84 15	-81 19	-77 22	-75 25
28 / 30	ACCP	-93 5	-85 11	-81 15	-78 19	-74 22	-72 25
28 / 30	**ACAP**	-91.5 5	-84.5 11	-80.5 15	-77.5 19	-73.5 22	-70.5 25
40	ACCP	-90 5	-83 11	-79 15	-76 19	-72 22	-70 25
56	ACCP	-89 5	-82 11	-78 15	-75 19	-71 22	-69 25
56 TO	ACCP	-87 6	-80 12	-76 16	-72 20	-69 23	-66 26

RSS for BER 10^{-3} [dBm]
SNR for BER 10^{-3} [dB]

ver. 1.0

9.3.3. Frequency tables 11A, B

name	description	
rcinfo11_A_490_default	10.7 - 11.5 GHz	duplex 490, default table
rcinfo11_B_490_default	10.9 - 11.7 GHz	duplex 490, default table
rcinfo11_A_530	10.7 - 11.5 GHz	duplex 530
rcinfo11_B_530	10.9 - 11.7 GHz	duplex 530
rcinfo11_A_FCC	10.7 - 11.5 GHz	duplex 490, FCC compliant
rcinfo11_B_FCC	10.9 - 11.7 GHz	duplex 490, FCC compliant

The microwave link contains one or more frequency tables (called rcinfo), see menu *Radio adaptation*. Tables are labeled in format <name:version>, e.g.: rcinfo11_A_490_default:17

Nominal frequencies of 11 GHz bands are given in *Channel arrangements*[2].

[2] https://www.racom.eu/eng/products/m/ray2tab/nom-freq.html#kmit11a

9.4. RAy2-17 parameters

9.4.1. Upper/Lower Limits

RAy2-17	TX power	
Modulation	Min	Max
	[dBm]	[dBm]
QPSK	-25	5
16-QAM	-25	5
32-QAM	-25	5
64-QAM	-25	5
128-QAM	-25	5
256-QAM	-25	5

ver. 2.0

Minimum (hw limit) and default duplex spacing.

RAy2-17	Optional duplex spacing	
Channel width	min	default
[MHz]	[MHz]	[MHz]
3.5	60	73.5
7	60	73.5
14	65	87.5
28	70	84
40	70	70
50	84	87.5
56	84	84

ver. 2.6

RAy2-17	Band Range	
	Unit L	Unit U
	[GHz]	[GHz]
min	17.1015	17.1015
max	17.2985	17.2985

ver. 1.2

9.4.2. Radio parameters

Radio parameters, BER = 10^{-6}

RAy2-17		**Radio parameters** - Bit Rate / RSS / SNR BER 10^{-6}					
Bandwidth [MHz]		**Modulation**					
		QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
3.5	ACCP	4.9 -97 9.5	9.6 -90 15.0	12.1 -87 18.5	14.3 -84 20.5	17.2 -83 23.5	19.7 -81 26.0
7	ACCP	8.5 -95 8.5	17.2 -88 15.0	22.1 -85 18.5	29.7 -81 21.5	34.7 -79 25.0	39.7 -77 26.0
14	ACCP	19.9 -92 8.5	38.8 -85 15.0	49.1 -81 18.5	62.3 -78 21.5	73.6 -75 25.0	81.2 -73 28.0
28 / 30	ACCP	36.8 -90 7.5	80.9 -83 15.0	102.4 -79 18.5	129.8 -76 21.5	155.5 -72 25.0	170.7 -69 26.5
40	ACCP	50.1 -88 7.5	110.0 -81 15.0	139.2 -77 18.5	176.5 -74 21.5	211.4 -70 25.0	232.1 -68 26.5
50	ACCP	66.3 -87.5 7.5	145.6 -80.5 15.0	184.2 -76.5 18.5	233.6 -73.5 21.5	276.1 -69.5 25.0	320.6 -66.5 26.5
56	ACCP	72.9 -87 7.5	160.2 -80 15.0	202.7 -76 18.5	256.9 -73 21.5	303.7 -69 25.0	337.7 -66 26.5
56 TO	ACCP	85.8 -85 10.0	169.9 -78 16.0	206.2 -74 19.0	268.1 -70 22.5	309.0 -67 25.5	358.9 -64 27.5

ver. 1.0

User Bit Rate [MBps]
RSS for BER 10^{-6} [dBm]
SNR for BER 10^{-6} [dB]

Radio parameters, BER = 10^{-3}

RAy2-17		**Radio parameters** - RSS / SNR					BER 10^{-3}
Bandwidth [MHz]		**Modulation**					
		QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
3.5	ACCP	-99 5	-92 11	-89 15	-86 19	-85 22	-83 25
7	ACCP	-97 5	-90 11	-87 15	-83 19	-81 22	-79 25
14	ACCP	-94 5	-87 11	-83 15	-80 19	-77 22	-75 25
28 / 30	ACCP	-92 5	-85 11	-81 15	-78 19	-74 22	-71 25
40	ACCP	-90 5	-83 11	-79 15	-76 19	-72 22	-70 25
50	ACCP	-89.5 5	-82.5 11	-78.5 15	-75.5 19	-71.5 22	-68.5 25
56	ACCP	-89 5	-82 11	-78 15	-75 19	-71 22	-68 25
56 TO	ACCP	-87 6	-80 12	-76 16	-72 20	-69 23	-66 26

RSS for BER 10^{-3} [dBm]
SNR for BER 10^{-3} [dB]

ver. 1.0

9.4.3. Frequency tables 17

name	description	
rcinfo17_default	17.1 - 17.3 GHz	default table

The microwave link contains one or more frequency tables (called rcinfo), see menu *Radio adaptation*. Tables are labeled in format <name:version>, e.g.: rcinfo17_default:18

Nominal frequencies of 17 GHz bands are given in *Channel arrangements*[3].

[3] https://www.racom.eu/eng/products/m/ray2tab/nom-freq.html#kmit17

9.5. RAy2-18 parameters

9.5.1. Upper/Lower Limits

RAy2-18	TX power	
Modulation	Min	Max
	[dBm]	[dBm]
QPSK	-10	24
16-QAM	-10	23
32-QAM	-10	22
64-QAM	-10	21
128-QAM	-10	20
256-QAM	-10	19

RAy2-18	TX power	
All modulations	Min	Max
	[dBm]	[dBm]
1.75 MHz, 2.5 MHz, 3.5 MHz bands	-10	19

ver. 1.1

RAy2-18	Duplex spacing
Sub-band	[MHz]
A	1008, 1010
B	1008, 1010
C	1560

ver. 2.0

RAy2-18		Sub-band Range	
Sub-band		Unit L	Unit U
		[GHz]	[GHz]
A	min	17.700	18.710
	max	18.209	19.219
B	min	18.167	19.177
	max	18.690	19.700
C	min	17.700	19.300
	min	18.300	19.700

ver. 2.0

9.5.2. Radio parameters

Radio parameters, BER = 10^{-6}

RAy2-18-xA, -x**B**		**Radio parameters** - Bit Rate / RSS / SNR BER 10^{-6}					
Bandwidth [MHz]		**Modulation**					
		QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
1.75	ACCP	2.54 -97 9.5	4.95 -91 15.0	6.26 -88 19.0	7.37 -85 20.5	8.89 -82.5 23.5	
2.5 S	ACCP	2.77 -96 8.5	5.26 -90.5 15.0	6.71 -87.5 18.5	8.53 -84.5 21.5	10.37 -81.5 25.0	11.08 -78.5 26.0
3.5 S	ACCP	4.2 -95.5 8.5	8.4 -89.5 14.5	10.2 -86 17.5	12.9 -84.5 19.5	15.7 -82 22.5	16.8 -81.5 24.5
5 S	ACCP	5.6 -93.5 8.5	11.2 -88 14.5	13.7 -85 17.5	17.3 -83 19.5	21.1 -80 22.5	22.5 -79.5 24.5
7 S	ACCP	8.5 -92 8.5	16.9 -86 14.5	20.5 -83 17.5	26.0 -81 19.5	31.6 -78.5 22.5	33.8 -78 24.5
7.5	ACCP	9.1 -92.5 8.5	18.4 -84.5 15.0	23.7 -81.5 18.5	31.8 -78.5 21.5	37.1 -75.5 25.0	42.5 -72.5 26.0
13.75	ACCP	19.9 -89 8.5	38.8 -83 15.0	49.1 -80 18.5	62.3 -77 21.5	73.6 -74 25.0	81.2 -71 28.0
27.5	ACCP	36.8 -87 7.5	80.9 -79 15.0	102.4 -76 18.5	129.8 -73 21.5	155.5 -70 25.0	170.7 -67 26.5
55	ACCP	72.9 -84 7.5	160.2 -75 15.0	202.7 -72.5 18.5	256.9 -70 21.5	303.7 -67 25.0	337.7 -64 26.5
55 TO	ACCP	85.8 -84 10.0	169.9 -77 16.0	206.2 -73 19.0	268.1 -69 22.5	309.0 -66 25.5	358.9 -63 27.5

ver. 1.3

User Bit Rate [MBps]
RSS for BER 10^{-6} [dBm]
SNR for BER 10^{-6} [dB]

RAy2-18-xC		**Radio parameters** - Bit Rate / RSS / SNR					
Bandwidth [MHz]		**Modulation**					
		QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
2.5 S	ACCP	2.77 -96 8.5	5.26 -90.5 15.0	6.71 -87.5 18.5	8.53 -84.5 21.5	10.37 -81.5 25.0	11.08 -78.5 26.0
5	ACCP	5.7 -93 8.5	11.5 -87 14.5	14.8 -84 17.5	19.8 -82 19.5	23.1 -79 22.5	27.2 -76.5 24.5
10	ACCP	11.4 -90.5 8.5	23.2 -83.5 15.0	29.9 -80.5 18.5	40.0 -77.5 21.5	46.8 -74.5 25.0	55.0 -71.5 26.0
20	ACCP	26.3 -87.5 8.5	57.8 -80.5 15.0	73.1 -77.5 18.5	92.7 -74.5 21.5	111.0 -71.5 25.0	127.2 -68.5 28.0
30	ACCP	36.8 -87 7.5	80.9 -80 15.0	102.4 -76 18.5	129.8 -73 21.5	155.5 -70 25.0	170.7 -67 26.5
40	ACCP	50.1 -86.5 7.5	110.0 -78 15.0	139.2 -75 18.5	176.5 -72 21.5	211.4 -69 25.0	232.1 -66 26.5
50	ACCP	66.3 -86 7.5	145.6 -77 15.0	184.2 -74 18.5	233.6 -71 21.5	276.1 -68 25.0	320.6 -65 26.5

ver. 1.0

User Bit Rate [MBps]
RSS for BER 10^{-6} [dBm]
SNR for BER 10^{-6} [dB]

Radio parameters, BER = 10^{-3}

RAy2-18-xA, -x**B**		**Radio parameters** - RSS / SNR					BER 10^{-3}
Bandwidth [MHz]		**Modulation**					
		QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
1.75	ACCP	-99 5	-93 11	-90 15	-87 19	-84.5 22	
2.5 S	ACCP	-98 5	-92.5 11	-89.5 15	-86.5 19	-83.5 22	-80.5 25
3.5 S	ACCP	-97.5 5	-91.5 11	-88 15	-86.5 19	-84 22	-83.5 25
5 S	ACCP	-95.5 5	-90 11	-87 15	-85 19	-82 22	-81.5 25
7 S	ACCP	-94 5	-88 11	-85 15	-83 19	-80.5 22	-80 25
7.5	ACCP	-94.5 5	-86.5 11	-83.5 15	-80.5 19	-77.5 22	-74.5 25
13.75	ACCP	-91 5	-85 11	-82 15	-79 19	-76 22	-73 25
27.5	ACCP	-89 5	-81 11	-78 15	-75 19	-72 22	-69 25
55	ACCP	-86 5	-77 11	-74.5 15	-72 19	-69 22	-66 25
55 TO	ACCP	-86 6	-79 12	-75 16	-71 20	-68 23	-65 26

RSS for BER 10^{-3} [dBm]
SNR for BER 10^{-3} [dB]

ver. 1.0

RAy2-18-xC		**Radio parameters** - RSS / SNR				BER 10^{-3}	
Bandwidth [MHz]		**Modulation**					
		QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
2.5 S	ACCP	-98 5	-92.5 11	-89.5 15	-86.5 19	-83.5 22	-80.5 25
5	ACCP	-95 5	-89 11	-86 15	-84 19	-81 22	-78.5 25
10	ACCP	-92.5 5	-85.5 11	-82.5 15	-79.5 19	-76.5 22	-73.5 25
20	ACCP	-89.5 5	-82.5 11	-79.5 15	-76.5 19	-73.5 22	-70.5 25
30	ACCP	-89 5	-82 11	-78 15	-75 19	-72 22	-69 25
40	ACCP	-88.5 5	-80 11	-77 15	-74 19	-71 22	-68 25
50	ACCP	-88 5	-79 11	-76 15	-73 19	-70 22	-67 25

ver. 1.0

RSS for BER 10^{-3} [dBm]
SNR for BER 10^{-3} [dB]

9.5.3. Frequency tables 18A, B, C

name	description	
rcinfo18_A_default	17.7 - 19.3 GHz	default table
rcinfo18_B_default	18.1 - 19.7 GHz	default table
rcinfo18_C_default	17.7 - 19.7 GHz	default table, FCC compliant

The microwave link contains one or more frequency tables (called rcinfo), see menu *Radio adaptation*. Tables are labeled in format <name:version>, e.g.: rcinfo18_A_default:8

Nominal frequencies of 18 GHz bands are given in *Channel arrangements*[4].

[4] https://www.racom.eu/eng/products/m/ray2tab/nom-freq.html#kmit18

9.6. RAy2-24 parameters

9.6.1. Upper/Lower Limits

RAy2-24	TX power	
Modulation	Min	Max
	[dBm]	[dBm]
QPSK	-30	10
16-QAM	-30	10
32-QAM	-30	10
64-QAM	-30	10
128-QAM	-30	10
256-QAM	-30	10

ver. 1.0

Minimum (hw limit) and default duplex spacing:

RAy2-24	Optional duplex spacing	
Channel width	min	default
[MHz]	[MHz]	[MHz]
3.5	60	73.5
5	60	70
7	60	73.5
10	65	75
14	65	87.5
28	70	84
30	70	75
40	70	70 (75)
50	84	87.5 (90)
56	84	84 (90)

ver. 2.6

(75, 90) - default FCC band

RAy2-24	Band Range	
	Unit L	Unit U
	[GHz]	[GHz]
min	24.0015	24.0015
max	24.2485	24.2485

ver. 1.2

9.6.2. Radio parameters

Radio parameters, BER = 10^{-6}

RAy2-24		**Radio parameters** - Bit Rate / RSS / SNR BER 10^{-6}					
Bandwidth [MHz]		**Modulation**					
		QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
3.5	ACCP	4.9 -96 9.5	9.6 -89 15.0	12.1 -86 18.5	14.3 -83 20.5	17.2 -79 23.5	19.7 -77 26.0
5	ACCP	5.7 -94.5 8.5	11.5 -87.5 15.0	14.8 -84.5 18.5	19.8 -81 21.5	23.1 -77.5 25.0	27.2 -75.5 26.0
7	ACCP	8.5 -93 8.5	17.2 -86 15.0	22.1 -83 18.5	29.7 -79 21.5	34.7 -76 25.0	39.7 -74 26.0
10	ACCP	11.4 -92 8.5	23.2 -85 15.0	29.9 -81.5 18.5	40.0 -78 21.5	46.8 -74.5 25.0	55.0 -72.5 26.0
14	ACCP	19.9 -91 8.5	38.8 -84 15.0	49.1 -80 18.5	62.3 -77 21.5	73.6 -73 25.0	81.2 -71 28.0
28 / 30	ACCP	36.8 -89 7.5	80.9 -82 15.0	102.4 -78 18.5	129.8 -75 21.5	155.5 -71 25.0	170.7 -68 26.5
40	ACCP	50.1 -87 7.5	110.0 -80 15.0	139.2 -76 18.5	176.5 -73 21.5	211.4 -69 25.0	232.1 -67 26.5
50	ACCP	66.3 -86.5 7.5	145.6 -79.5 15.0	184.2 -75.5 18.5	233.6 -72.5 21.5	276.1 -68.5 25.0	320.6 -65.5 26.5
56	ACCP	72.9 -86 7.5	160.2 -79 15.0	202.7 -75 18.5	256.9 -72 21.5	303.7 -68 25.0	337.7 -65 26.5
56 TO	ACCP	85.8 -84 10.0	169.9 -77 16.0	206.2 -73 19.0	268.1 -69 22.5	309.0 -66 25.5	358.9 -63 27.5

ver. 1.1

User Bit Rate [MBps]
RSS for BER 10^{-6} [dBm]
SNR for BER 10^{-6} [dB]

Radio parameters, BER = 10^{-3}

RAy2-24		**Radio parameters** - RSS / SNR					BER 10^{-3}
Bandwidth [MHz]		**Modulation**					
		QPSK	**16-QAM**	**32-QAM**	**64-QAM**	**128-QAM**	**256-QAM**
3.5	ACCP	-98 5	-91 11	-88 15	-85 19	-81 22	-79 25
5	ACCP	-96.5 5	-89.5 11	-86.5 15	-83 19	-79.5 22	-77.5 25
7	ACCP	-95 5	-88 11	-85 15	-81 19	-78 22	-76 25
10	ACCP	-94 5	-87 11	-83.5 15	-80 19	-76.5 22	-74.5 25
14	ACCP	-93 5	-86 11	-82 15	-79 19	-75 22	-73 25
28 / 30	ACCP	-91 5	-84 11	-80 15	-77 19	-73 22	-70 25
40	ACCP	-89 5	-82 11	-78 15	-75 19	-71 22	-69 25
50	ACCP	-88.5 5	-81.5 11	-77.5 15	-74.5 19	-70.5 22	-67.5 25
56	ACCP	-88 5	-81 11	-77 15	-74 19	-70 22	-67 25
56 TO	ACCP	-86 6	-79 12	-75 16	-71 20	-68 23	-65 26

RSS for BER 10^{-3} [dBm]
SNR for BER 10^{-3} [dB]

ver. 1.0

9.6.3. Frequency tables 24

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

Nominal frequencies of 24 GHz bands are given in *Channel arrangements*[5].

[5] https://www.racom.eu/eng/products/m/ray2tab/nom-freq.html#kmit24-250

10. Safety, regulations, warranty

10.1. Regulations

RAy2 microwave links must be used in accordance with rules issued by the Telecommunications Authority for the area the device is operating in.

RAy2 microwave links must comply with the maximum permitted radiated power (EIRP) in accordance with conditions of the given country.

Important

For US:

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation of the device.

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

10.2. Important Notice

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- Due to the nature of wireless communications, transmission and reception of data can never be guaranteed. Data may be delayed, corrupted (i.e., have errors), or be totally lost. Significant delays or losses of data are rare when wireless devices such as the RAy are used in an appropriate manner within a well-constructed network. RAy should not be used in situations where failure to transmit or receive data could result in damage of any kind to the user or any other party, including but not limited

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10.3. 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 11 GHz

RAy2-11	**10.700 – 11.700 GHz**		**+24 dBm RF power**	
Antenna code	Parabolic antenna [m]	Gain G [dBi]	Distance where the FCC limits is met for	
			General Population / Uncontrolled Exposure [cm]	Occupational / Controlled Exposure [cm]
JRMA – 380 – 10/11Ra	ø 0.38	29.0	140	60
JRMA – 650 – 10/11Ra	ø 0.65	36.0	290	130
JRMB – 900 – 10/11Ra	ø 0.9	38.0	360	160
JRMB – 1200 – 10/11Ra	ø 1.2	41.5	540	240

RAy2-11	**10.700 – 11.700 GHz**		**+13 dBm RF power**	
Antenna code	Parabolic antenna [m]	Gain G [dBi]	Distance where the FCC limits is met for	
			General Population / Uncontrolled Exposure [cm]	Occupational / Controlled Exposure [cm]
JRMA – 380 – 10/11Ra	ø 0.38	29.0	60	30
JRMA – 650 – 10/11Ra	ø 0.65	36.0	110	50
JRMB – 900 – 10/11Ra	ø 0.9	38.0	140	60
JRMB – 1200 – 10/11Ra	ø 1.2	41.5	200	90

ver. 1.0

Tab. 10.2: Minimum Safety Distance 18 GHz

RAy2-18	17.700 – 19.700 GHz		+24 dBm RF power	
Antenna code	Parabolic antenna [m]	Gain G [dBi]	Distance where the FCC limits is met for	
			General Population / Uncontrolled Exposure [cm]	Occupational / Controlled Exposure [cm]
JRMB – 400 – 17R	ø 0.4	34.8	260	120
JRMB – 680 – 17R	ø 0.68	38.6	400	180
JRMB – 900 – 17R	ø 0.9	41.0	530	240
JRMB – 1200 – 17R	ø 1.2	44.6	800	360

RAy2-18	17.700 – 19.700 GHz		+13 dBm RF power	
Antenna code	Parabolic antenna [m]	Gain G [dBi]	Distance where the FCC limits is met for	
			General Population / Uncontrolled Exposure [cm]	Occupational / Controlled Exposure [cm]
JRMB – 400 – 17R	ø 0.4	34.8	80	40
JRMB – 680 – 17R	ø 0.68	38.6	120	50
JRMB – 900 – 17R	ø 0.9	41.0	150	70
JRMB – 1200 – 17R	ø 1.2	44.6	230	110

ver. 1.1

Tab. 10.3: Minimum Safety Distance 24 GHz

RAy2-24	24.000 – 24.250 GHz		+10 dBm RF power	
Antenna code	Parabolic antenna [m]	Gain G [dBi]	Distance where the FCC limits is met for	
			General Population / Uncontrolled Exposure [cm]	Occupational / Controlled Exposure [cm]
JRMB – 400 – 24Ra	ø 0.4	36.8	70	30
JRMB – 680 – 24Ra	ø 0.68	41.7	120	60
JRMB – 900 – 24Ra	ø 0.9	44	150	70
JRMB – 1200 – 24Ra	ø 1.2	46	200	90

ver. 1.0

10.4. 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 electromag-

netic 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.

10.5. RoHS and WEEE compliance

RoHS compliant

WEEE 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.

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 documentation 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.

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EU DECLARATION OF CONFORMITY

Equipment	**RipEX, RipEX2** **RAy2, RAy3** **M!DGE, M!DGE2** **MRxxx, MDxxx**
Manufacturer	**RACOM s.r.o.** **Mirova 1283, 592 31 Nove Mesto na Morave, Czech Republic**

This declaration of conformity is issued under the sole responsibility of the manufacturer.

The equipment described above is in conformity with the Directive 2011/65/EU of the European Parliament and of the Council on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS), as amended by Directive (EU) 2015/863, and Directive 2012/19/EU of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE).

RoHS Applicable Exemption: 7(b)

Compliance has been verified via internal design controls, supplier declarations and/or analytical test data.

Signed for and on behalf of the manufacturer:

Nove Mesto na Morave, 11th July 2019
Jiri Hruska, CEO

RACOM s.r.o. | Mirova 1283 | 592 31 Nove Mesto na Morave | Czech Republic
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Fig. 10.1: EU Declaration of Conformity RoHS, WEEE

10.6. Liability for Defects and Safety Instructions

Please read these safety instructions carefully before using the product:

10.6.1. 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.

10.6.2. 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.

10.6.3. 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, accidental 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.

10.6.4. 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.

Important

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

10.6.5. RACOM Open Software License

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

Everyone can copy and spread word-for-word copies of this license, but no changes are permitted.

The program (binary version) is freely available on https://www.racom.eu. This product contains open source or other software originating from third parties subject to GNU General Public License (GPL), GNU Library / Lesser General Public License (LGPL) and / or further author licences, declarations of responsibility, exclusion and notifications. Exact terms of GPL, LGPL and some further licences are mentioned in the source code packets (typically the files COPYING or LICENSE). You can obtain applicable machine-readable copies of source code of this software under GPL or LGPL licences on ht-

tps://www.racom.eu. This product also includes software developed by the University of California, Berkeley and its contributors.

10.7. Important Notifications

The sole owner of all rights to this operating manual is the company RACOM s. r. o. (further referred to under the abbreviated name RACOM). All rights reserved. Drawing written, printed or reproduced copies of this manual or records on various media or translation of any part of this manual in foreign languages (without written consent of the rights owner) is prohibited.

RACOM reserves the right to make changes to the technical specification, in the product function, to terminate production of this product or to terminate its service support without previous written notification of customers.

Conditions of use of this product software abide by the license mentioned below. The program distributed by this license has been freed with the purpose to be useful, but without any specific guarantee. Under no circumstances is the author or another company or person responsible for secondary, accidental or related damages resulting from application of this product.

The producer does not provide the user with any kind of guarantee providing assurances of suitability and usability for his application. Products are not developed, designed or tested for utilization in devices directly affecting the health or life functions of persons or animals, nor as a part of another important device, and does not provide guarantees if the product has been used in these aforementioned devices.

10.8. 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.

10.9. EU Declaration of Conformity

10.9.1. RED Declarations of Conformity

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EU DECLARATION OF CONFORMITY

Radio equipment type	**RAy2-10** **frequency range B** **10.125 - 10.675 GHz**	**Radio SW** FW ver. 0.2.10.0
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 302 217-2-2 V2.2.1
EMC	EN 301 489-1 V1.9.2
	EN 301 489-4 V2.1.1
Safety	EN 60950-1:2006, A11:2009, A1:2010, A12:2011, A2:2013

Signed for and on behalf of the manufacturer:

Nove Mesto na Morave, 8th of June 2017
Jiri Hruska, CEO

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Fig. 10.2: EU Declaration of Conformity for RAy2-10

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EU DECLARATION OF CONFORMITY

Radio equipment type	**RAy2-11** **RAy2-18**	**Radio SW** FW ver. 0.2.10.0
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 302 217-2-2 V2.2.1
EMC	EN 301 489-1 V1.9.2
	EN 301 489-4 V2.1.1
Safety	EN 60950-1:2006, A11:2009, A1:2010, A12:2011, A2:2013

Signed for and on behalf of the manufacturer:

Nove Mesto na Morave, 8th of June 2017
Jiri Hruska, CEO

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Fig. 10.3: EU Declaration of Conformity for RAy2-11, RAy2-18

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EU DECLARATION OF CONFORMITY

Radio equipment type	**RAy2-17** **RAy2-24**	**Radio SW** FW ver. 0.2.10.0
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 300 440-2 V1.4.1
EMC	EN 301 489-1 V1.9.2
	EN 301 489-3 V1.6.1
	EN 301 489-4 V2.1.1
Safety	EN 60950-1:2006, A11:2009, A1:2010, A12:2011, A2:2013

Signed for and on behalf of the manufacturer:

Nove Mesto na Morave, 8th of June 2017
Jiri Hruska, CEO

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Fig. 10.4: EU Declaration of Conformity for RAy2-17, RAy2-24

10.9.2. Simplified declaration

10.9.2.1. Simplified EU declaration of conformity

BG
С настоящото RACOM s.r.o. декларира, че този тип радиосъоръжение RAy2-10, RAy2-11, RAy2-18, RAy2-24 е в съответствие с Директива 2014/53/ЕС.

ES
Por la presente, RACOM s.r.o. declara que el tipo de equipo radioeléctrico RAy2-10, RAy2-11, RAy2-18, RAy2-24 es conforme con la Directiva 2014/53/UE.

CS
Tímto RACOM s.r.o. prohlašuje, že typ rádiového zařízení RAy2-10, RAy2-11, RAy2-18, RAy2-24 je v souladu se směrnicí 2014/53/EU.

DA
Hermed erklærer RACOM s.r.o., at radioudstyrstypen RAy2-10, RAy2-11, RAy2-18, RAy2-24 er i overensstemmelse med direktiv 2014/53/EU.

DE
Hiermit erklärt RACOM s.r.o., dass der Funkanlagentyp RAy2-10, RAy2-11, RAy2-18, RAy2-24 der Richtlinie 2014/53/EU entspricht.

ET
Käesolevaga deklareerib RACOM s.r.o., et käesolev raadioseadme tüüp RAy2-10, RAy2-11, RAy2-18, RAy2-24 vastab direktiivi 2014/53/EL nõuetele.

EL
Με την παρούσα ο/η RACOM s.r.o., δηλώνει ότι ο ραδιοεξοπλισμός RAy2-10, RAy2-11, RAy2-18, RAy2-24 πληροί την οδηγία 2014/53/ΕΕ.

EN
Hereby, RACOM s.r.o. declares that the radio equipment type RAy2-10, RAy2-11, RAy2-18, RAy2-24 is in compliance with Directive 2014/53/EU.

FR
Le soussigné, RACOM s.r.o., déclare que l'équipement radioélectrique du type RAy2-10, RAy2-11, RAy2-18, RAy2-24 est conforme à la directive 2014/53/UE.

HR
RACOM s.r.o. ovime izjavljuje da je radijska oprema tipa RAy2-10, RAy2-11, RAy2-18, RAy2-24 u skladu s Direktivom 2014/53/EU.

IT
Il fabbricante, RACOM s.r.o., dichiara che il tipo di apparecchiatura radio RAy2-10, RAy2-11, RAy2-18, RAy2-24 è conforme alla direttiva 2014/53/UE.

LV
Ar šo RACOM s.r.o. deklarē, ka radioiekārta RAy2-10, RAy2-11, RAy2-18, RAy2-24 atbilst Direktīvai 2014/53/ES.

LT

Aš, RACOM s.r.o., patvirtinu, kad radijo įrenginių tipas RAy2-10, RAy2-11, RAy2-18, RAy2-24 atitinka Direktyvą 2014/53/ES.

HU
RACOM s.r.o. igazolja, hogy a RAy2-10, RAy2-11, RAy2-18, RAy2-24 típusú rádióberendezés megfelel a 2014/53/EU irányelvnek.

MT
B'dan, RACOM s.r.o., niddikjara li dan it-tip ta' tagħmir tar-radju RAy2-10, RAy2-11, RAy2-18, RAy2-24 huwa konformi mad-Direttiva 2014/53/UE.

NL
Hierbij verklaar ik, RACOM s.r.o., dat het type radioapparatuur RAy2-10, RAy2-11, RAy2-18, RAy2-24 conform is met Richtlijn 2014/53/EU.

PL
RACOM s.r.o. niniejszym oświadcza, że typ urządzenia radiowego RAy2-10, RAy2-11, RAy2-18, RAy2-24 jest zgodny z dyrektywą 2014/53/UE.

PT
O(a) abaixo assinado(a) RACOM s.r.o. declara que o presente tipo de equipamento de rádio RAy2-10, RAy2-11, RAy2-18, RAy2-24 está em conformidade com a Diretiva 2014/53/UE.

RO
Prin prezenta, RACOM s.r.o. declară că tipul de echipamente radio RAy2-10, RAy2-11, RAy2-18, RAy2-24 este în conformitate cu Directiva 2014/53/UE.

SK
RACOM s.r.o. týmto vyhlasuje, že rádiové zariadenie typu RAy2-10, RAy2-11, RAy2-18, RAy2-24 je v súlade so smernicou 2014/53/EÚ.

SL
RACOM s.r.o. potrjuje, da je tip radijske opreme RAy2-10, RAy2-11, RAy2-18, RAy2-24 skladen z Direktivo 2014/53/EU.

FI
RACOM s.r.o. vakuuttaa, että radiolaitetyyppi RAy2-10, RAy2-11, RAy2-18, RAy2-24 on direktiivin 2014/53/EU mukainen.

SV
Härmed försäkrar RACOM s.r.o. att denna typ av radioutrustning RAy2-10, RAy2-11, RAy2-18, RAy2-24 överensstämmer med direktiv 2014/53/EU.

10.9.3. RoHS and WEEE Declaration of Conformity

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EU DECLARATION OF CONFORMITY

Equipment	**RipEX, RipEX2** **RAy2, RAy3** **M!DGE, M!DGE2** **MRxxx, MDxxx**
Manufacturer	**RACOM s.r.o.** **Mirova 1283, 592 31 Nove Mesto na Morave, Czech Republic**

This declaration of conformity is issued under the sole responsibility of the manufacturer.

The equipment described above is in conformity with the Directive 2011/65/EU of the European Parliament and of the Council on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS), as amended by Directive (EU) 2015/863, and Directive 2012/19/EU of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE).

RoHS Applicable Exemption: 7(b)

Compliance has been verified via internal design controls, supplier declarations and/or analytical test data.

Signed for and on behalf of the manufacturer:

Nove Mesto na Morave, 11th July 2019
Jiri Hruska, CEO

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Fig. 10.5: RoHS and WEEE Declaration of Conformity for RAy

10.10. 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

10.11. 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

RACOM s.r.o. • Mirova 1283 • 592 31 Nove Mesto na Morave • Czech Republic
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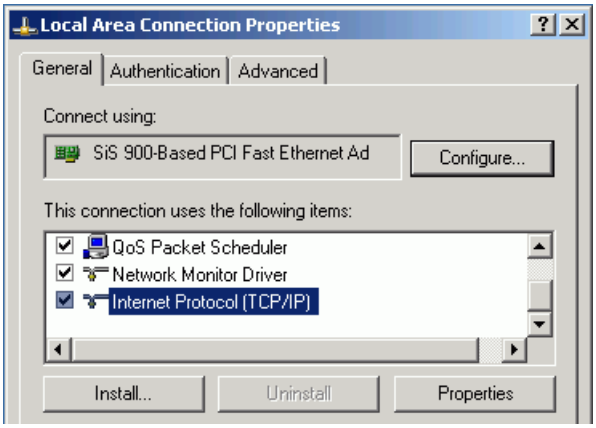
Fig. 10.6: Country of Origin Declaration

Appendix A. IP address in the PC (Windows XP)

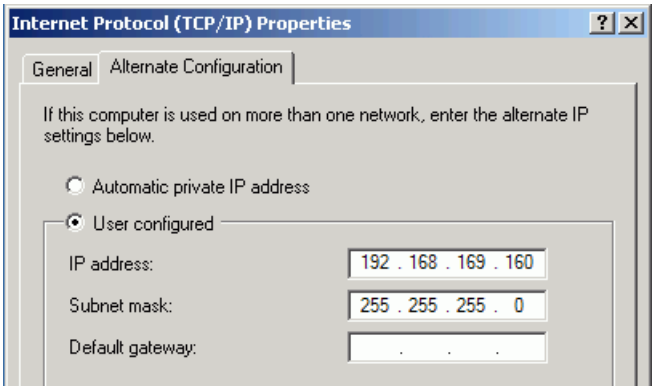
Setting up the IP address in the PC

For configuration of the link a suitable IP address has to be set up in the PC, for example 192.168.169.160

- Open the **Start** menu, **Settings**, **Network Connections**, **Local Area Connection**
- In the window **Local Area Connection** select **Properties**
- Another window opens. Select **Internet Protocol (TCP/IP)** and click **Properties**:



- Another window opens. On the **General** tab select **Use the following IP address**:



- Enter IP Address IP 192.168.169.160
- Set Subnet mask to 255.255.255.0
- Click **OK** to acknowledge these settings and close all windows

Checking the IP address in the PC

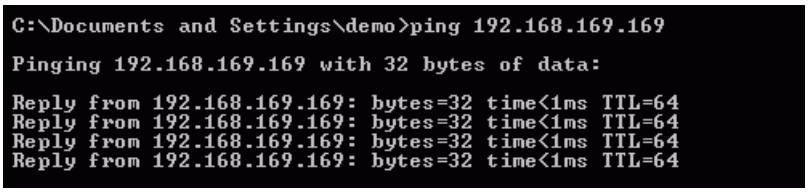
In Windows XP proceed in the following manner:

- Interconnect the configured unit and PC with an Ethernet cable
- Open the Start menu and click **Run...**
- Enter command **cmd**
- Enter command **ipconfig** and read the PC IP address and mask:

Checking the PC - unit connection using Ping

In Windows XP send a ping as follows:

- Check the connection between the PC and the unit via the Ethernet cable.
- In the Start menu click **Run...**
- Enter command **cmd**
- Write **ping 192.168.1.2** and press OK
- A message appears in a window:



If no communication takes place a message appears with the text "Request timed out".

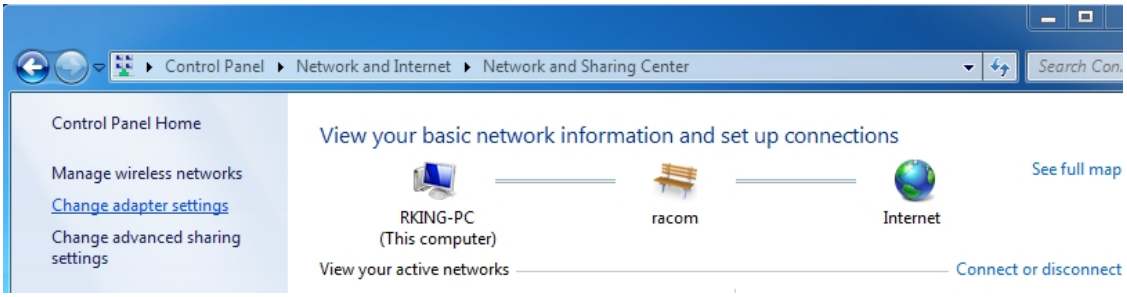
If communication between the web browser and the unit does not take place check the browser settings. The "Work offline" item in the File menu must not be crossed out.

Appendix B. IP address in the PC (Windows 7)

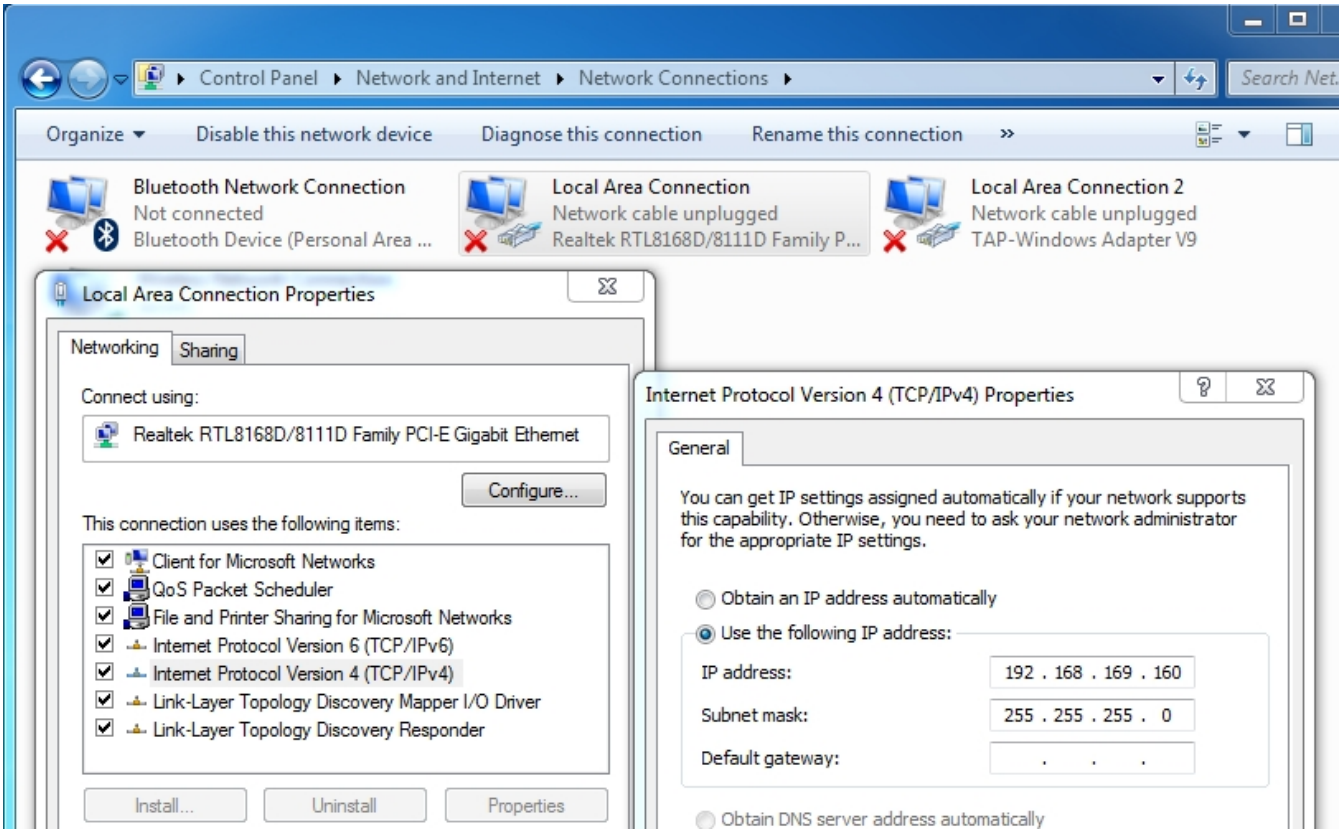
Setting up the IP address in the PC

For configuration of the link a suitable IP address has to be set up in the PC, for example 192.168.169.160

- Open the **Start** menu, **Control Panel**
- In new window choose **Network and Internet**
- Continue **View network status and tasks**
- In new window choose **Change adapter settings**:



- In the Network Connections window, right-click on **Local area connection** and then left-click on **Properties**:

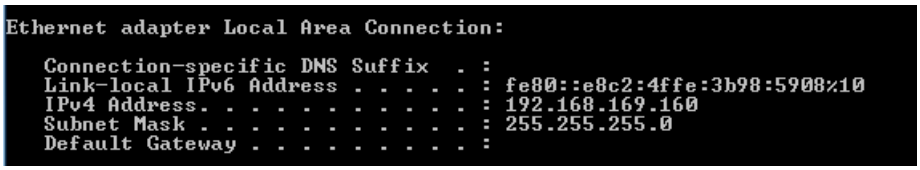


- Select **Internet Protocol Version 4 (TCP/IPv4)** and **Properties**
- On the **General** tab select **Use the following IP address**
  - Enter IP Address 192.168.169.160
  - Set Subnet mask to 255.255.255.0
  - Click **OK** to acknowledge these settings and close all windows

Checking the IP address in the PC

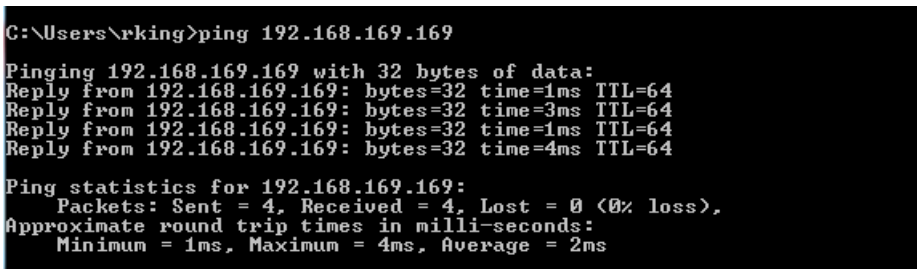
In Windows 7 proceed in the following manner:

- Interconnect the configured unit and PC with an Ethernet cable
- Under the **Start** menu, type the command **cmd** in the "Search programs and files" box and press Enter.
- Inside the `cmd.exe` window that opens, enter the command **ipconfig** at the command prompt and find the information about IP address and mask among the list of messages returned.



Checking the PC - unit connection using Ping

- Check the connection between the PC and the unit via the Ethernet cable.
- Under the **Start** menu, type the command **cmd** in the "Search programs and files" box and press Enter.
- Inside the `cmd.exe` window that opens, type **ping 192.168.169.169** at the command prompt and press Enter.
- Ping times and statistics are returned as shown:



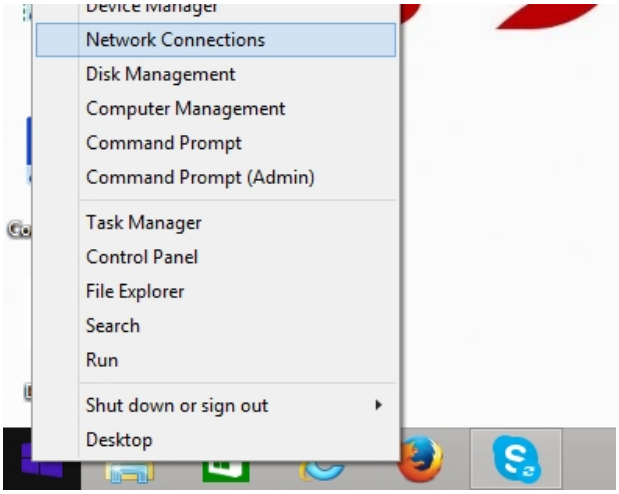
If no communication takes place a message appears with the text "Request timed" out.

If communication between the web browser and the unit does not take place check the browser settings. E.g. the "Work offline" item in the File menu must not be crossed out.

Appendix C. IP address in the PC (Windows 8)

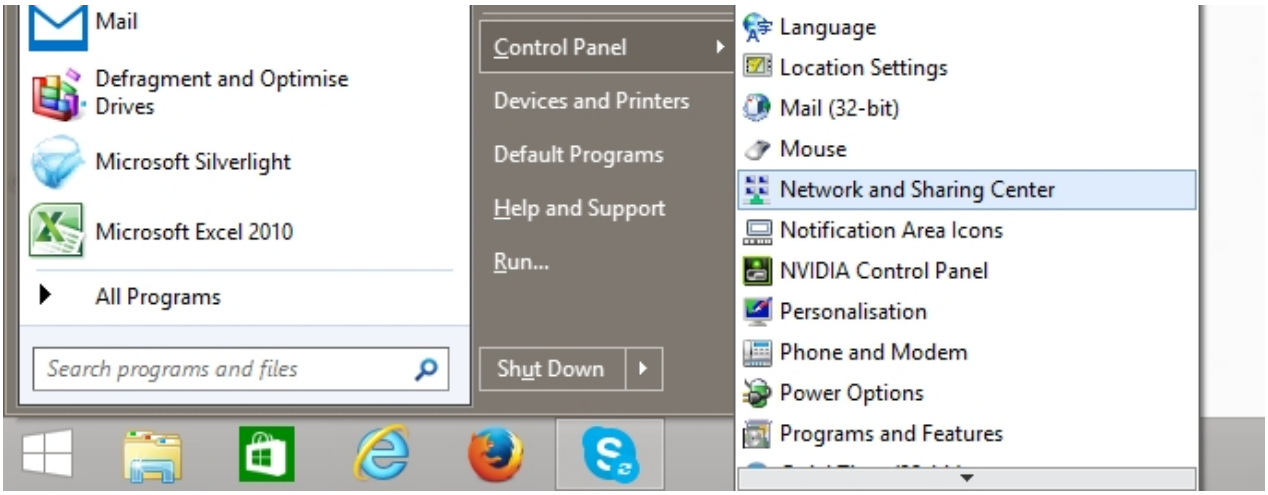
Windows 8 allows you to access the Network Connections page in different ways, for example:

- Using Start Button
  - **Start** button (left down corner), Right click, choose **Network Connections**

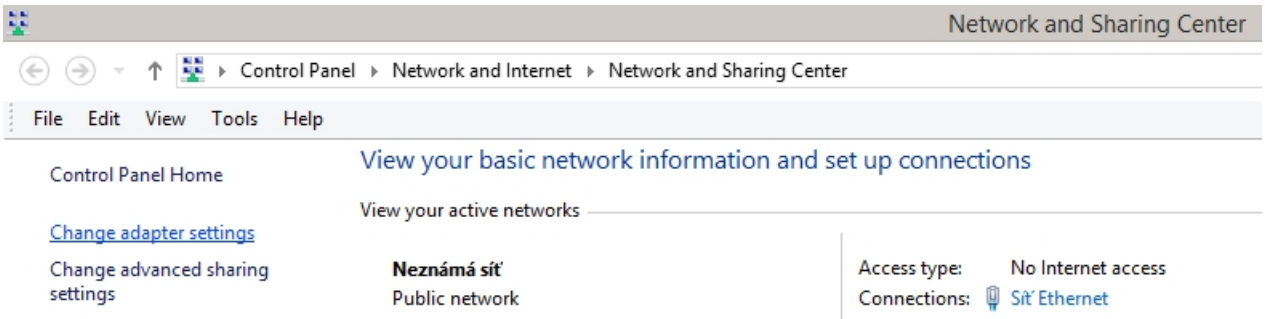


  - Continue to the Network Connections page.

- Using Start Button
  - **Start** button, Left click, choose **Control Panel** and **Network and Sharing Center**



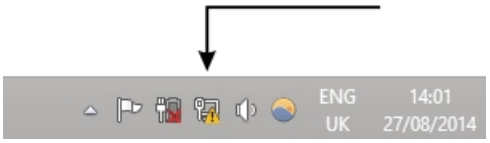
  - Select **Change adapter settings** in the Network and Sharing Center



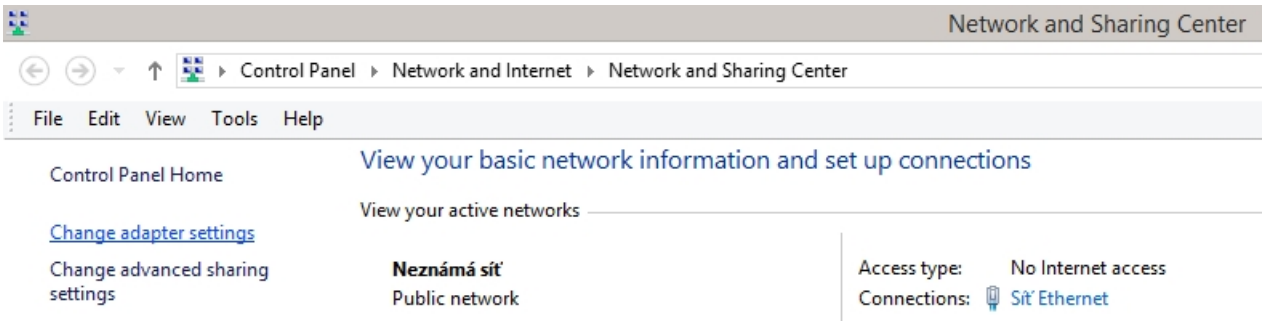
  - Continue to the Network Connections page.

- From Task Bar

- Click the icon for **Internet access** on the task bar in the lower right corner



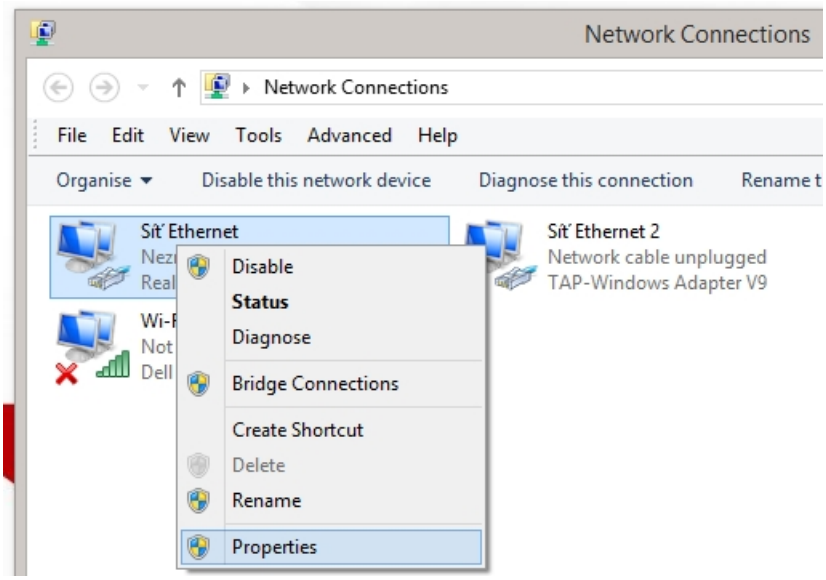
- Select **Change adapter settings** in the Network and Sharing Center



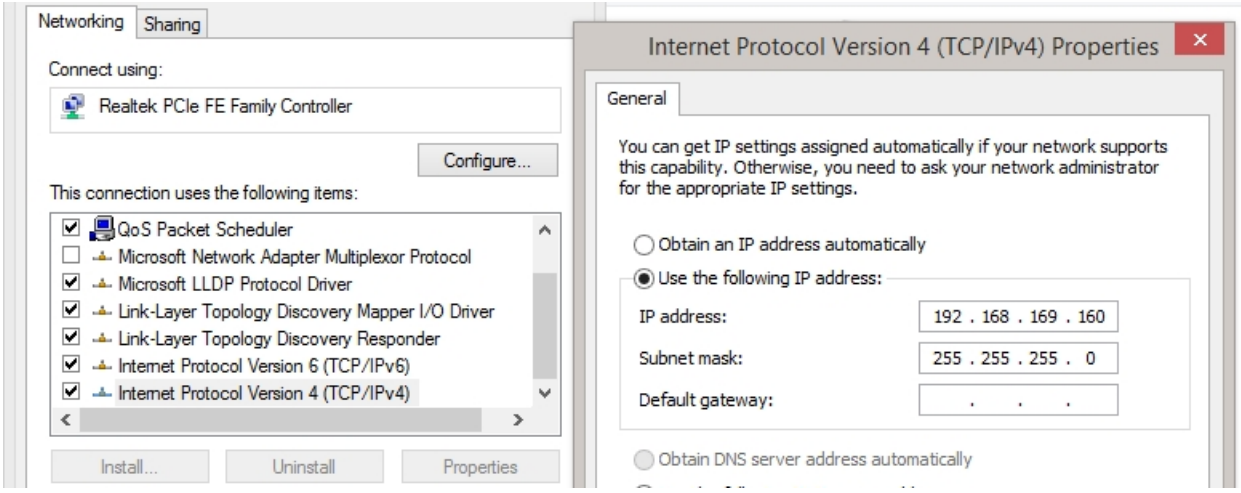
- Continue to the Network Connections page.

■ On the Network Connections page:

- Select **Properties** from **Ethernet Network** drop down menu



- Choose **Internet Protocol Version 4** (TCP/IPv4), **Properties**, **Use the following IP address**

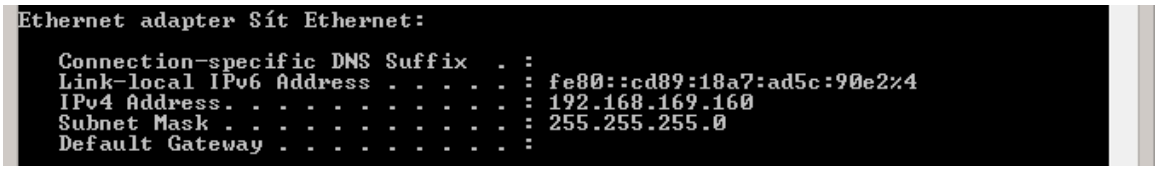


- Enter IP Address 192.168.169.160
- Set Subnet mask to 255.255.255.0
- Click **OK** to acknowledge these settings and close all windows

Checking the IP address in the PC

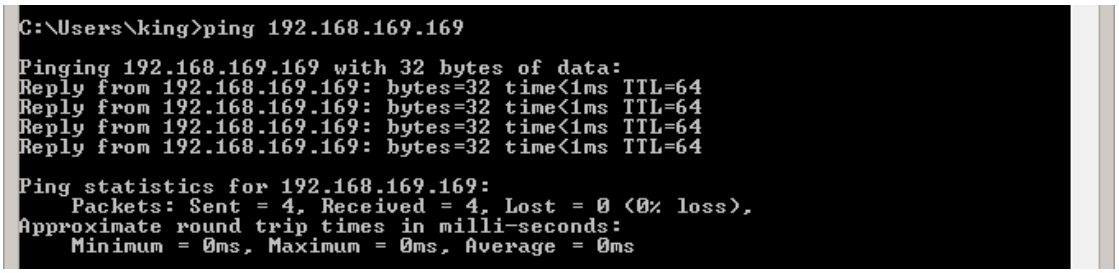
In Windows 8 proceed in the following manner:

- Interconnect the configured unit and PC with an Ethernet cable
- Right click on the **Start** button, type the command **cmd** and press Enter.
- Inside the `cmd.exe` window that opens, enter the command **ipconfig** at the command prompt and find the information about IP address and mask among the list of messages returned.



Checking the PC - unit connection using Ping

- Check the connection between the PC and the unit via the Ethernet cable.
- Right click on the **Start** button, type the command **cmd** and press Enter.
- Inside the `cmd.exe` window that opens, type **ping 192.168.169.169** at the command prompt and press Enter.
- Ping times and statistics are returned as shown:



If no communication takes place a message appears with the text "Request timed out".

If communication between the web browser and the unit does not take place check the browser settings. E.g. the "Work offline" item in the File menu must not be crossed out.

Appendix D. SSH key generation

Linux

Use “ssh-keygen” command.

Windows

Use "PUTTYGEN.EXE" software, which is typically located in the c:\Program Files\putty\ directory and apply the "Generate" button.

To use CLI (Command Line Interface) access the unit with a PuTTY client. Access is protected by a key. The key can be in Linux format and it begins:

```
-----BEGIN DSA PRIVATE KEY-----
.....
```

or in PuTTY format which begins:

```
PuTTY-User-Key-File-2: ssh-dss
.....
```

To convert the Linux format to PuTTY do the following:

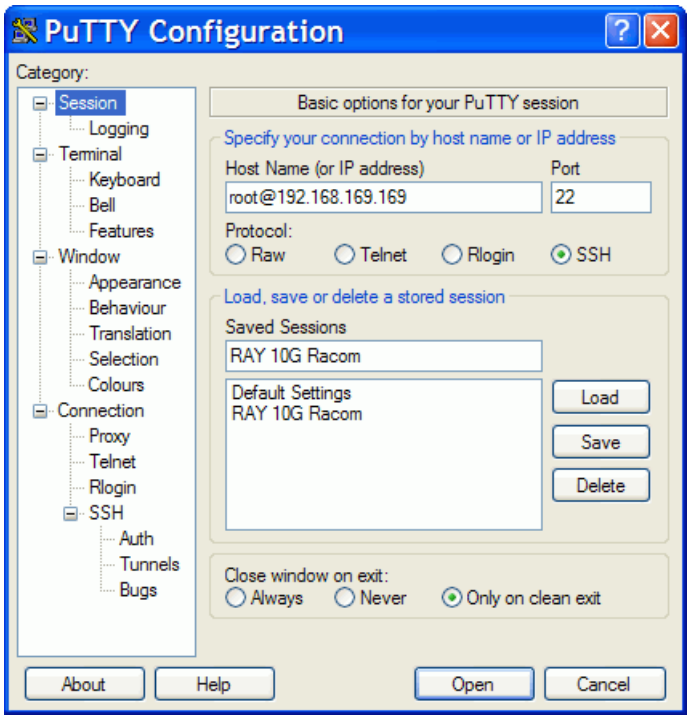
In c:\Program Files\putty\ directory run PUTTYGEN.EXE

Click on “Load” and choose the Linux private key.

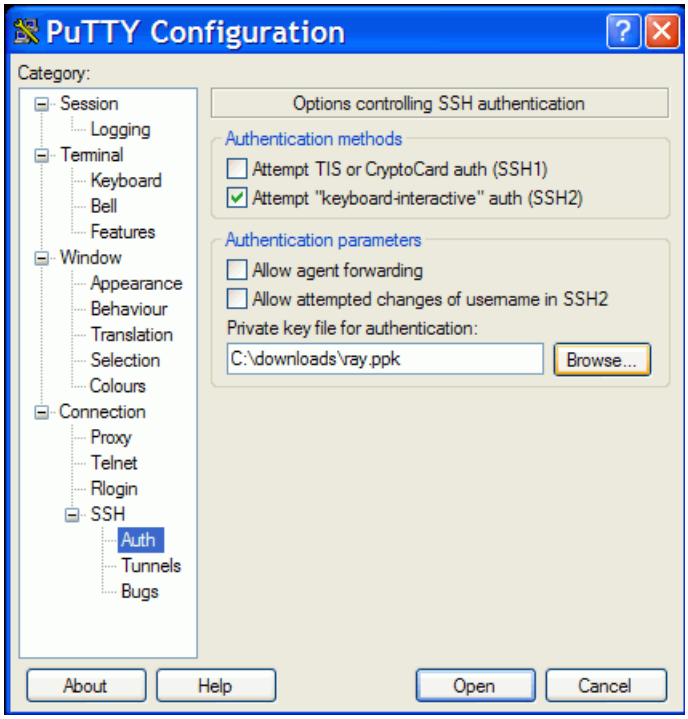
In the next window type your password into the "Key passphrase" and "Confirm passphrase" fields. After that click "Save private key". Choose location and save the key.

PuTTY access with key

In PuTTY menu fill in the address, e.g. `root@192.168.169.169` and the name of the link, e.g. RAy 17 Racom.



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



Go back to "Session" and Save the configuration.

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

Appendix E. 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 F. Unit block diagrams

Unit overview

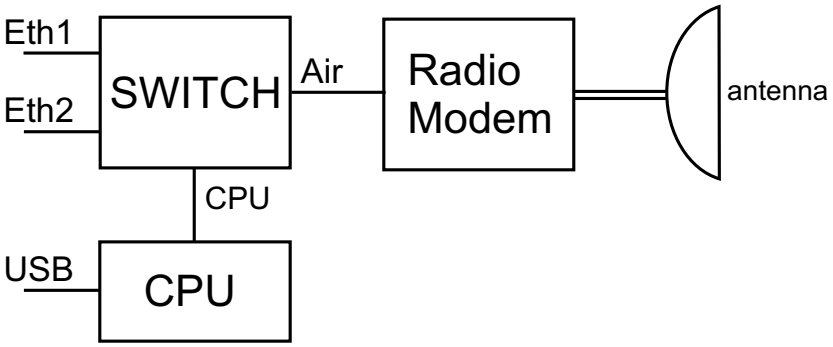


Fig. F.1: Block diagram of the unit

Switch and connected ports

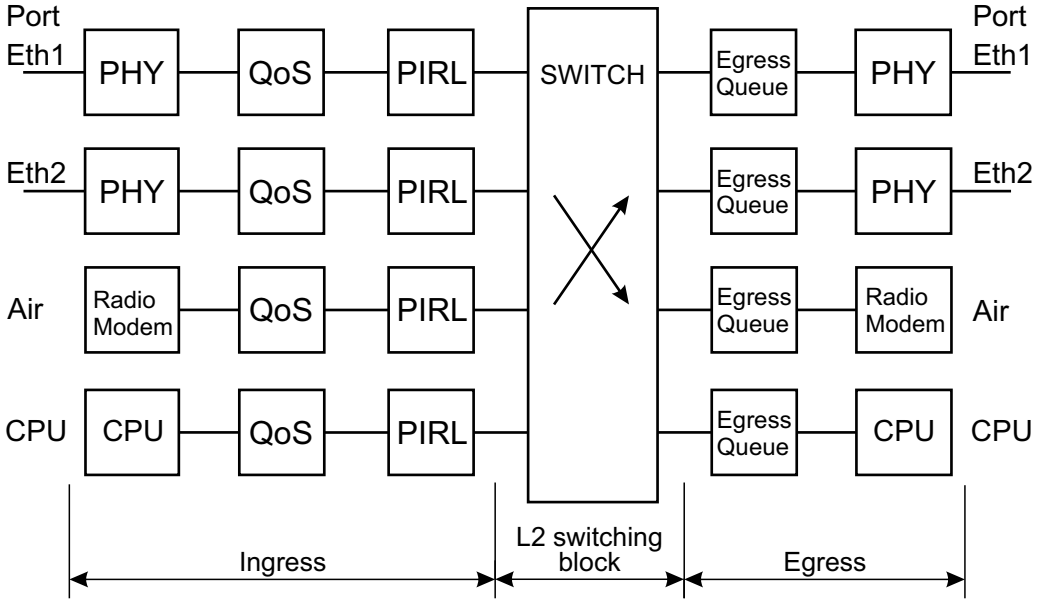


Fig. F.2: Switch and connected ports

Another block diagrams can be found here:

Menu PIRL

Chapter *Configuration, Switch setting, Interface*

Menu Advanced

Chapter *Configuration, Switch setting, Advanced*

Index

Revision History

Revision 1.0 2014-05-28
First issue

Revision 1.1 2014-06-04
Name plate changes

Revision 1.2 2014-07-15
RAy2-11 C,D user speed and CS correction.

Revision 1.3 2014-07-25
Accessory supplemented

Revision 1.4 2014-08-12
RAy2-11 A,B *frequency range* corrected

Revision 1.5 2014-09-01
Several channels added to *RAY2-11 A,B*
H/L switching *warning*
ETH cable *grounding*
Overview diagram of the unit
IP address setting in *Windows 7* and *Windows 8* PC

Revision 1.6 2014-09-10
Menu description updated for fw 1.3.3.0.

Revision 1.7 2014-09-12
Changed the Upper channels labeling at RAy2-17, RAy2-24
Changed the Upper channels frequency for 56 MHz bandwidth at RAy2-17, RAy2-24

Revision 1.8 2014-11-24
Added the Switch settings - *Advanced menu* description

Revision 1.9 2015-03-06
Quick Start Guide - new description
Chapter 1 - the technical parameters table moved to *Chapter 10*
Directing antennas - the new explanation

Revision 1.10 2015-03-25
Configuration - updated
Declaration of Conformity - updated

Revision 1.11 2015-04-21
USB accessories - updated
Alarm Acknowledge - updated
50 MHz channel on 17 and 24 GHz

Revision 1.12 2015-06-02
- Updated for fw 2.1.7.0.
- Changes in the *super user* mode
- *Order code* description
- RAy2-10 *radio parameters* updated
- *Accessories* updated

Revision 1.13 2015-12-01
- Updated for fw 2.1.13.0.
- Diagram *PIRL* improved
- Diagram *Advanced* added

Revision 1.14 2015-12-30
- *RAy2-18 channels* added
- *RAy2-24 FCC channels* added

Revision 1.15 2016-03-31
- Safety *distance FCC*
- FCC *authorization*

Revision 2.0 2016-04-20
- Simplified table *radio parameters*
- Frequency tables moved to *Channel arrangements*[1]

Revision 2.1 2016-05-05
- Updated table *Radio parameters*
- Updated table *Radio parameters RAy2-18*

Revision 2.2 2016-05-25
- *ATPC and EIRP* explanation

Revision 2.3 2016-06-14
- *Radio parameters* RAy2-18 updated

Revision 2.4 2016-06-29
- *Minimum safety distance* for RAy2-18 added

Revision 2.5 2016-09-22
- Further *RAy2-18 parameters* updated

Revision 2.6 2016-10-03
- *Multi-Path Signature* tables added
- *Sensitivity tables* BER 10^{-3} added

Revision 2.7 2017-01-25

[1] https://www.racom.eu/eng/products/m/ray2tab/index.html

Updated for fw 2.1.27.0.

WiFi access via USB adapter

Revision 2.8 2017-04-18

Updated for fw 2.1.28.0.

Antenna Alignment Tool

Mobile devices

Revision 2.9 2017-06-13

EU Declaration of Conformity

Revision 2.10 2017-10-18

LEAX-RAy antennas informations added

Antennas installation instructions *moved to web*[2]

Revision 2.11 2018-06-12

Accessories chapter updated

RAyTools iOS version added

Chapters and paragraphs rearranged

Revision 2.12 2018-09-05

Product chapter rearranged

Title page shortcuts

Revision 2.13 2018-10-24

Dual polarization extenders updated to reflect new ordering codes for 10+11 GHz.

Revision 2.14 2019-04-26

Accessories chapter updated to reflect new ordering codes

RAy2-10 added 40 MHz channel

Revision 2.15 2019-06-20

Update chapters 1.6, 1.7 and 10

Revision 2.16 2021-10-18

Improved description of *Section 1.2.1, “Antenna waveguide”* and *Section 1.2.2, “Unit mounting”*

Added *Section 1.2.4, “Pressure equalization”*

Updated *Section 1.7, “Ordering codes”* (RAy2-17/24 production stoppped).

Improved description of *Section 5.6.1.1, “Backup, Default settings, Diagnostic package, MIB”*

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