RACOM
RADIO DATA NETWORKS

RAy10 User Manual

RAy Microwave Link

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Quick Start Guide

- The default addresses of the RAy unit are 192.168.169.169/24 and 192.168.169.170/24.
- On your PC set up a similar address with the same mask, e.g. 192.168.169.180/24.
  - To configure your PC's address in Windows XP do the following: *Start – Settings – Network Connections*:
    Change properties of this connection – Internet Network Protocol (TCP/IP) – Properties – Use the following IP address – input 192.168.169.180 and use the mask 255.255.255.0. Click OK twice.
- Connect both RAy units to a PoE source and connect to a PC via PoE for configuration, see Fig. Link Configuration.
- Input the address of the connected RAy unit into the address field of your internet browser (such as Mozilla Firefox), e.g. 198.168.169.169. Login as *admin* with password *admin*.
- Status menu provides information on connection. Choose your language by clicking *cesky/english* in the corner of the screen.
- Bridge menu enables you to change the parameters of the radio and ethernet channel, Device menu lets you change login parameters.
- Continue as suggested by the *Step-by-step Guide*.

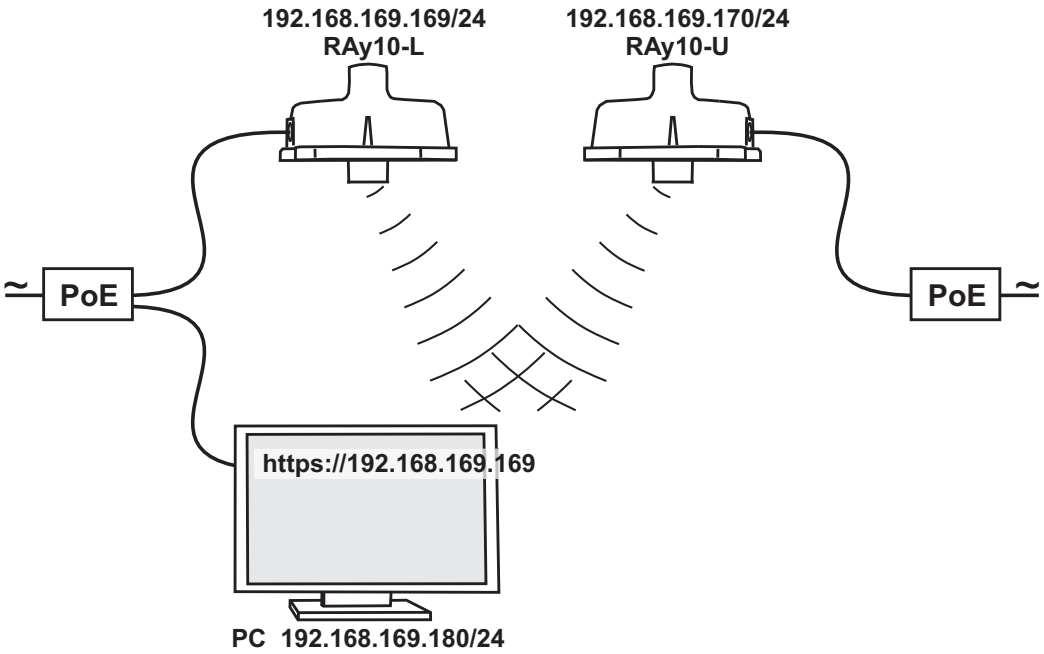


Fig. 1: Link Configuration

List of documentation

User manuals

- ***Microwave Link RAy***[1]
  User manual RAy11, RAy17, RAy24
- **Microwave link RAy** ... this document
  User manual RAy10

Specification

- **RAy10, 11, 17** - *Leaflet*[2]

For actual version of documentation please see *www.racom.eu*[3]

[1] https://www.racom.eu/eng/products/m/ray17/index.html
[2] https://www.racom.eu/download/hw/ray/free/eng/08_ray1/datasheet_RAY_en.pdf
[3] https://www.racom.eu/eng/products/microwave-link.html

1. RAy – Microwave Link

Microwave links RAy is designed as high-speed point-to-point wireless bridge for data transmission under the latest requirements of modern wireless transmission equipment. It is a completely new platform with a modern component base.

RAy is designed to transmit ethernet protocol and can be used in backhaul networks as well as last-mile terminal.The design of microwave link RAy reflects effort on meeting the strictest criteria ETSI standards, particularly for durability to interference, high receiver sensitivity and high output power to achieve maximum link distance. Native gigabit Ethernet interface is able to cope with full speed of user data throughput at low latency. High availability of the link (up to 99.999%) is able to be achieved with using hitless Adaptive coding and modulation.

The link properties can be summed as:

- High data throughput
- Spectrum effeciency
- Robustness
- Security - configuration via https, ssh
- User friendly interface, advanced diagnostics

Key technical features

Frequency range	RAy10-A	10.30–10.42 GHz	Lower	10.47 – 10.59 GHz	Upper
	RAy10-B	10.15–10.30 GHz	Lower	10.50 – 10.65 GHz	Upper
Modulation		QPSK, 16, 32, 64, 128, 256 QAM		fixed or ACM	
Channel spacing		7, 14, 28 MHz			
Data rate		user data rate up to 170 Mbps			
Forward Error Correction		LDPC			
User interface		1 Gb Eth (10,100,1000). (IEEE 802.3ac 1000BASE-T)			
Optional service interface		100 Mbps (IEEE 802.3u 100BASE-TX)			
Power via PoE		40–60 VDC, IEEE 802.3at up to 100 m			
Mechanical design		FOD (full outdoor)			
Security		configuration via https, ssh			

Standards

Radio parameters	ETSI EN 302 217-2-2 V1.3.1
EMC	ETSI EN 301 489-1 V1.8.1 (2008-04), ETSI EN 301 489 -17 V1.3.2 (2008-04)
Electrical safety	EN 60 950-1: 2004

Note

Operation of the RAy10 is described in this user manual. Operation of the RAy11, RAy17 and RAy24 is described in the *User Manual RAy11, RAy17, RAy24*[1].

[1] https://www.racom.eu/eng/products/m/ray17/index.html

2. Implementation Notes

2.1. Link calculation

Before a microwave link can be installed, an analysis and calculation of the microwave link must be made first. The analysis should take place before the site survey itself to get a clear idea about the dimensions of the antennas. The analysis consists of the following steps:

- Free space loss calculation
- Link budget calculation
- Rain attenuation
- Multipath fading
- Fade margin
- Fresnel zones calculation

This chapter explains the individual steps and an example of link design is given at the end.

NOTE - For quick reference you can use the *calculator on www.racom.eu*[1]

2.1.1. Free space loss calculation

As the electromagnetic waves travel through open space they are attenuated. This attenuation is described as Free-space Loss. This loss depends on the distance travelled by signal and its frequency. Both parameters are in direct proportion. Longer distance means greater attenuation and higher frequency means greater attenuation. Free-space loss can be calculated thus:

$FSL = 32.44 + 20\log f + 20\log D$

Where:

FSL free-space loss (dB)

f frequency of the emitted signal (MHz)

D length of the link (km)

2.1.2. Link budget calculation

To goal is to design a link so that the received signal is stronger than the receiver's sensitivity at the required BER (typically 10-6). Since every radio signal in earth atmosphere is subject to fading, some difference between received signal level under normal circumstances and receiver sensitivity is needed to serve as a fade margin. The minimum value of fade margin can be calculated from the requirement for link availability (typically 99.999% of the time). The required margin depends on the length of the link as well as other factors such as rain attenuation, diffraction and multipath propagation.

If we ignore the additional loss along the path, the received signal strenght can be calculated using the formula for signal propagation in free space as follows:

$P_R = P_T + G_T + G_R - FSL$

Where

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

P_R received power level (dBm)

P_T transmitted power (dBm)

G_T transmitting antenna gain (dBi)

G_R receiving antenna gain (dBi)

FSL free space loss (dB)

P_R must be:

$P_R > P_S$

Where:

P_S receiver sensitivity (dBm)

The receiver's sensitivity defines the minimum level of the received signal at which the receiver is able to process the received signal without losses or affecting the transmitted data (for BER better then 10^{-6}).

2.1.3. Fade margin

Determining sufficient fade margin is the most important step in microwave link design. If the margin is too small, the link will be unstable – as a result, sufficient availability of the link or quality of the provided services cannot be guaranteed. On the other hand, unnecessarily large margin makes the link more expensive (higher performance, larger and more expensive antennas) and increases the cost of creating the microwave link.

The following paragraphs describe the two most significant types of attenuation – rain and multipath attenuation, which are the most frequent along with free space loss. Mutual relation between rain and multipath attenuation rules out the possibility that the link could be affected by both types of attenuation at the same time – **these types of attenuation do not add up**. To determine the fade margin it is necessary to calculate both rain and multipath attenuation. The larger of the two types of attenuation determines the value of fade margin. In areas with high precipitation, rain attenuation can be expected to be more prominent. By contrast, links located in drier climates and little inclination, will suffer more from multipath attenuation.

2.1.4. Rain attenuation

FSL is not the only attenuation that influences the emitted signal. For frequency ranges upward of 10 GHz rain attenuation also plays a role. Precipitation is not identical in all areas which is why ITU released a recommendation Rec. ITU-R PN.837-1 for splitting into 15 regions according to precipitation intensity see *Fig. 2.1*, for more detail *Appendix B, Rain Zone Map*. In the areas with higher precipitation greater rain attenuation must be expected and a greater signal fade margin must be established, see the *calculation* of link availability.

The following properties are inherent to rain attenuation:

- It increases exponentially with rain intensity
- It becomes significantly larger as the distance travelled increases (>10 Km)
- Horizontal polarization causes greater rain attenuation than vertical polarization
- Rain outage increases dramatically with frequency and path length

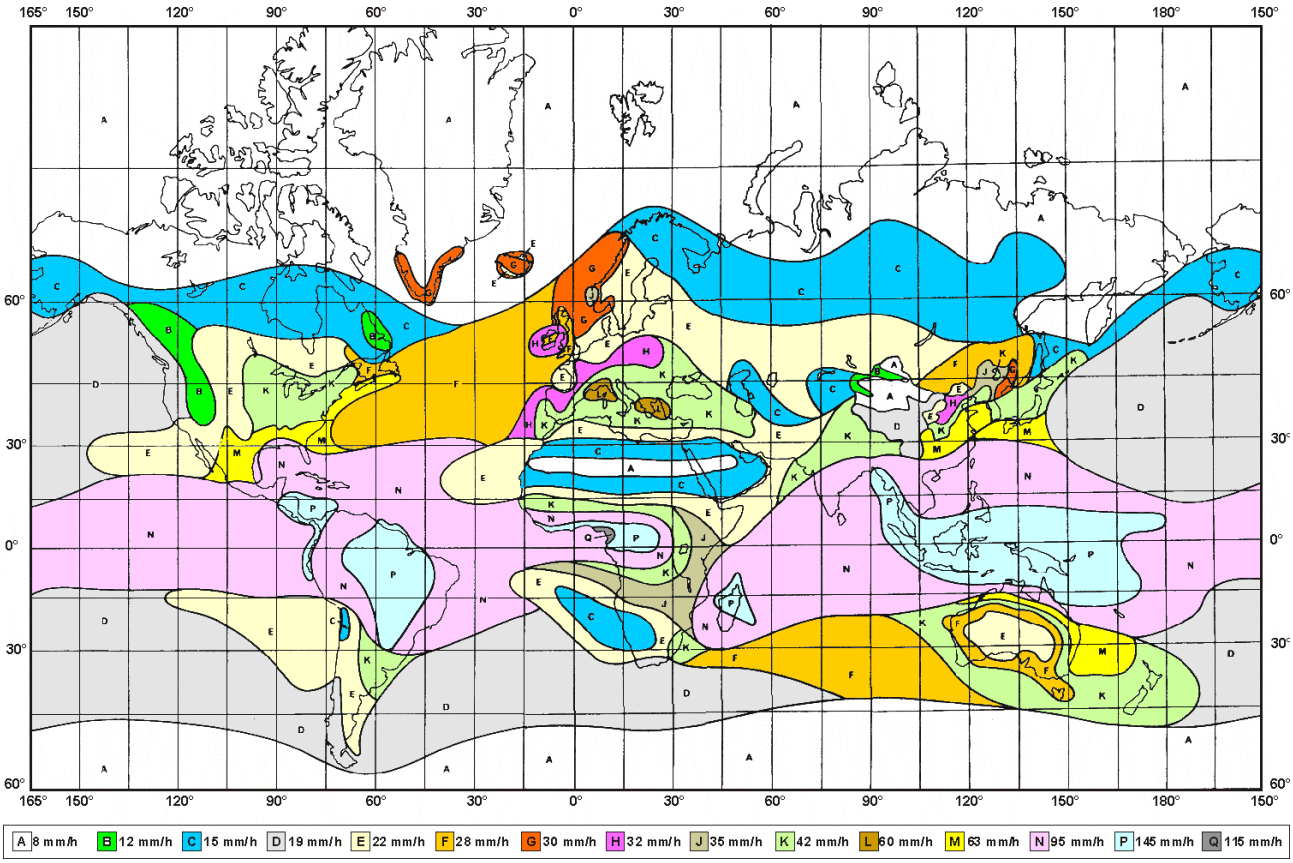


Fig. 2.1: Rain zone map, based on Rec.ITU-R PN.837-1

Raid attenuation can be calculated using ITU-R outage model, which consists of the following:

Obtain the rain rate $R_{0.01}$ exceeded for 0.01 per cent of the time (with an integration time of 1 min). $R_{0.01}$ values are defined for 15 rain zones and different time percentages and they are given in ITU-R Recommendation P.837.

Tab. 2.1: Rain rate R (mm/h) ITU-R P.837

Percentage of time (%)	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q
1.0	<0.1	0.5	0.7	2.1	0.6	1.7	3	2	8	15	2	4	5	12	14
0.3	0.8	2	2.8	4.5	2.4	4.5	7	4	13	42	7	11	15	34	49
0.1	2	3	5	8	6	8	12	10	20	12	15	22	35	65	72
0.03	5	6	9	13	12	15	20	18	28	23	33	40	65	105	96
0.01	8	12	15	19	22	28	30	32	35	42	60	63	95	145	115
0.003	14	21	26	29	41	54	45	55	45	70	105	95	140	200	142
0.001	22	32	42	42	70	78	65	83	55	100	150	120	180	250	170

Compute specific attenuation γ_R (dB/km) for the frequency, polarization, specific rain rate using ITU-R recommendation P.838. Rain attenuation for rain rate $\gamma_{R_{0.01}}$ can be calculated as follows:

$$\gamma_{R_{0.01}} = k_{h,v} . R_{0.01}^{\alpha_{h,v}}$$

where:

$k_{h,v}$, $\alpha_{h,v}$ constants for horizontal and vertical polarization. Constants are slightly different for each polarization. For 10 GHz band constants are in table 2.3.

Tab. 2.2: Constants k, α for horizontal and vertical polarization at 10 GHz

k_h	α_h	k_v	α_v
0.01217	1.2571	0.01129	1.2156

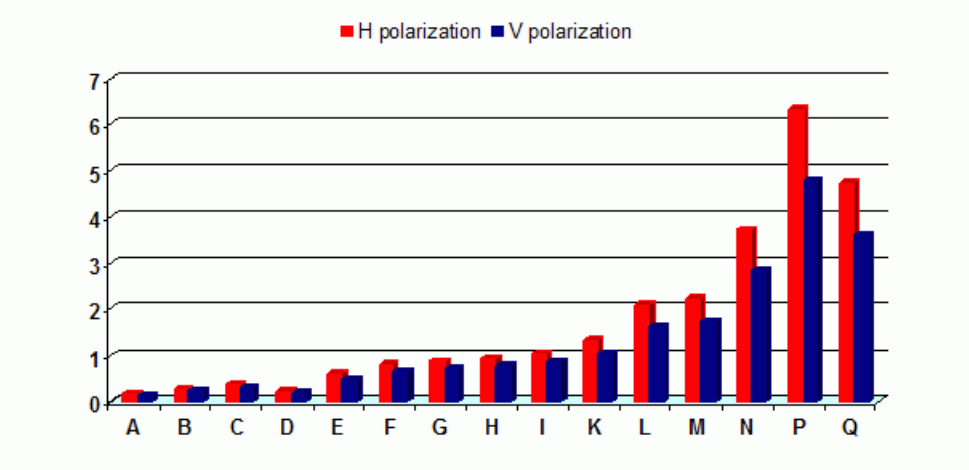


Fig. 2.2: Specific rain attenuation $\gamma_{R_{0.01}}$ (dB/km) for H, V polarization and rain zones at 10 GHz

Fig. 2.2, "Specific rain attenuation $\gamma_{R_{0.01}}$ (dB/km) for H, V polarization and rain zones at 10 GHz" shows that rain attenuation is greater for horizontal polarization. In regions with higher precipitation the difference in attenuation is more marked. This is why it is almost necessary to use vertical polarization and sufficient fade margin when designing links in high precipitation environment (regions K through Q).

2.1.5. Multipath fading

Multipath fading is another dominant fading mechanism for 10 GHz frequency. A reflected wave causes a phenomenon known as multipath, meaning that the radio signal can travel multiple paths to reach the receiver. Typically, multipath occurs when a reflected wave reaches the receiver at the same time in opposite phase as the direct wave that travels in a straight line from the transmitter.

Multipath propagation gives rise to two kinds of signal degrading effects, i.e., flat fading and frequency selective fading. A flat fading is a reduction in input signal level where all frequencies in the channel of interest are equally affected and there is dependent on path length, frequency, and path inclination. In addition, it is strongly dependent on the geoclimatic factor K.

To calculate the probability of outage due to multipath propagation of microwave links in the 10 GHz band can be used ITU-R probability model which describes a single frequency (or narrowband) fading distribution suitable for large fade depths A in the average worst month in any part of the world (based on ITU-R p.530-12)5 and for detailed link design is given as follows [1]:

$$P_0 = Kd^{3.2}(1+|\varepsilon_P|)^{-0.97}\times 10^{0.032f-0.00085h_L-A/10}$$

where:

d link distance (km)

f frequency (GHz)

h_L altitude of lower antenna (m)

A fade depth (dB)

K is geoklimatic factor and can be obtained from:

$K = 10^{-4.2-0.0029dN1}$

The term dN1 is provided on a 1.5° grid in latitude and longitude in ITU-R Recommendation P.453. The data are available in a tabular format and are available from the Radiocommunication Bureau (BR)

From the antenna heights h_e and h_r (meters about sea level), calculate the magnitude of the path inclination $|\varepsilon_P|$ (mrad) using the following expression:

$$|\varepsilon_P| = \frac{|h_r - h_e|}{d}$$

where:

d link distance (km)

h_r, h_e antenna heights above sea level (m)

2.1.6. Fresnel zones calculation

The position of obstacles between points of the bridge can significantly influence the quality of the microwave link. The radio signal doesn't only radiate along the line of sight, but also in the area around it, i.e. in the so-called 1st Fresnel zone. Within this zone 90 % of the energy is transmitted between the transmitter and receiver antenna. This space has the shape of an ellipsoid. If it is disturbed the link has worse transmission properties and a higher quality antenna is required. For this reason the position of the antenna can be just as important as its height above ground. 60 % of the 1st Fresnel zone is considered as the most important.

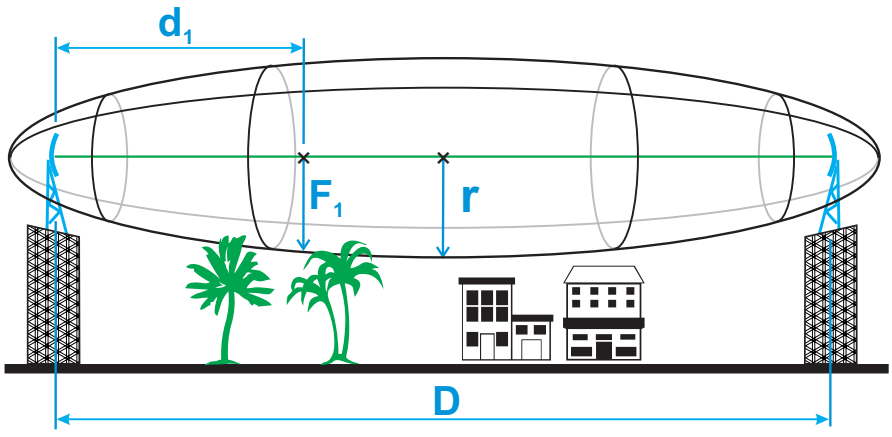


Fig. 2.3: Fresnel zone

The general equation for calculating the first Fresnel zone radius at any point P in between the endpoints of the link is the following:

$$F_1 = \sqrt{\lambda \frac{d_1 . d_2}{d_1 + d_2}}$$

Where:

F_1 first Fresnel Zone radius in metres

d_1 distance of P from one end in metres

d_2 The distance of P from the other end in metres

λ wavelength of the transmitted signal in metres

The cross sectional radius of each Fresnel zone is the highest in the center of link, shrinking to a point at the antenna on each end. For practical applications, it is often useful to know the maximum radius of the first Fresnel zone. From the above formula can be simplified calculation of the first Fresnel zone.

$$r = 8.657\sqrt{\frac{D}{f}}$$

where:

r radius of first Fresnel zone (m)

D total link distance (km)

f frequency (GHz)

Tab. 2.3: 60 % of the 1st Fresnel zone for 10 GHz

Length of link D	Radius of zone r
0,5 km	1.16 m
1 km	1.64 m
2 km	2.32 m
4 km	3.28 m
6 km	4.02 m
8 km	4.64 m
10 km	5.19 m
15 km	6.35 m
20 km	7.33 m
50 km	11.60 m

2.2. Example of microwave link design

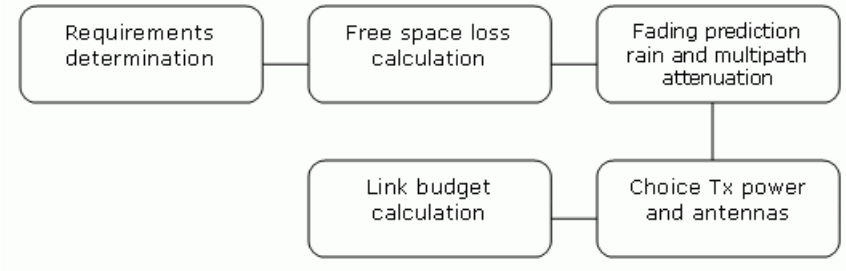


Fig. 2.4: Design flowchart

Link parameters:

- Link distance: 15 km
- First antenna height above sea level: 295 m
- Second antenna height above sea level: 320 m
- Location: Central Europe (rain zone B, refraction gradient dN1= −200)

Transmission requirements:

- Required data rate: 170 Mbps
- Required availability: 99.99 %

RAy parameters:

- 100 Mbps -> Modulation 256QAM; BW=28 MHz; P_S(BER 10^{-6})= −67 dBm
- Tx power 10 dBm (max. Tx power)
- Antenna gain:
  - 60 cm ... 34.6 dBi
  - 90 cm ... 38.0 dBi
  - 120 cm ... 40.1 dBi

Step 1 - Free space loss calculation

$$FSL = 32.44 + 20\log f + 20\log D = 32.44 + 20\log 10 \cdot 10^3 + 20\log 15 = 135.9 \text{ dB}$$

Step 2 - Rain attenuation

For 99.99% availability in rain zone B the rain rate is $R_{0.01}$=12 (see *Fig. 2.1*)

For f=10 GHz k_h=0.01217; α_h=1.2571; k_v=0.01129; α_v=1.2156

Vertical polarization:

$$\gamma_{R0.01} = k_v \cdot R^{\alpha_v}_{0.01} = 0{,}01129 \cdot 12^{1.2156} = 0.23 \text{ dB/km} \Rightarrow \text{for 15km distance } 3.47 \text{ dB}$$

Horizontal polarization

$$\gamma_{R0.01} = k_h \cdot R^{\alpha_h}_{0.01} = 0{,}01217 \cdot 12^{1.2571} = 0.28 \text{ dB/km} \Rightarrow \text{for 15km distance } 4.15 \text{ dB}$$

Step 3 - Attenuation due to multipath propagation

We have to find required fade margin for reliability of the link 99.99 percent.

Path inclination:

$$|\varepsilon_P| = \frac{|h_r - h_e|}{d} = \frac{|295 - 320|}{15} = 1.67 mrad$$

The percentage of time that fade depth A (dB) is exceeded in the average worst month is calculated as:

$$P_0 = Kd^{3.2}(1+|\varepsilon_P|)^{-0.97} \times 10^{0.032f - 0.00085h_L - A/10}$$

$$P_0 = 10^{-4.2-0.0029\times(-200)} \times 15^{3.2}(1+|1.67|)^{-0.97} \times 10^{0.032\times 10 - 0.00085\times 295 - A/10}$$

$$P_0 = 0.537 \times 10^{0{,}0692 - A/10}$$

For reliability 99.99% is P_0=0.01 we get exponential function for A:

$$A = 0.692 - 10\log\frac{0.01}{0.537} \approx 18dB$$

The minimum fade margin required to suppress multipath fading on this link would be 18 dB.

Step 4 - Link budget calculation

Calculation in steps 2 and 3 determines the minimum fade margin required for stable link operation as 18 dB (multipath attenuation is dominant). If you use the maximum performance of antenna with diameter of 60 cm, complete the radio formula as follows:

$P_R = P_T + G_T + G_R - FSL = 10 + 34.6 + 34.6 - 135.9 = -56.7$ dB

Fade margin:

$A = |P_S| - |P_R| = 67 - 56.7 = 10.3$ dB

The resulting fade margin is lower than the required 18 dB. Therefore, it is necessary to either increase the output or use larger antennas (120 cm and 90 cm). The calculation would then be as follows:

$P_R = P_T + G_T + G_R - FSL = 10 + 40.1 + 38 - 135.9 = -47.8$ dB

Fade margin:

$A = |P_S| - |P_R| = 67 - 47.8 = 19.2$ dB

The fade margin is now sufficient. 99.99% reliability is ensured for the required speed of 170 Mbps. Technical literature often gives the minimum fade margin of 20 dB. For very long links (more than 10 km) fade margin will, indeed, be approximately 20 dB. For shorter links, however, such large margin is not necessary. It is helpful to first conduct the calculation above to receive an idea of the attenuation affecting the link.

The result

To achieve the required transmission speed and availability 10 dBm output and antenna size of 120 cm, resp. 90 cm, will be necessary.

Sources for *Chapter 2, Implementation Notes*:

[1] Lehpamer, H.: Microwave transmission network, Second edition, ISBN: 0071701222, McGraw-Hill Professional, 2010.

ITU-R recommendation used:

- ITU-R P.837-5 – Characteristics of precipitation for propagation modelling
- ITU-R P.530-12 - Propagation data and prediction methods required for the design of terrestrial line-of-sight systems
- ITU-R P.453-9 - The radio refractive index: its formula and refractivity data

3. Product

The RAy10 microwave bridge is designed for operation in backbone networks for transmission in the licence-free 10 GHz band.

It works as a point-to-point bridge in full duplex mode with a signalling rate of up to 170 MBps. The bandwidth is optional, namely 28/14/7 MHz. Modulation can be set to be fixed or adaptive in the range QPSK to 256-QAM.

Fig. 3.1: RAy microwave bridge

The link is formed by two stations of FOD (Full Outdoor) design. One of them is labelled RAy10-LB and transmits in the lower half of the frequency band, and the second is labelled RAy10-UB and transmits in the upper half of the band (or RAy10-LB-2 and RAy10-UB-2 – see *Section 3.2, "Installation"*).

The line can be assembled with several types of antennas.

3.1. Model offerings

			eth connectors	microwave band	standard
RAy10-LA	+	RAy10-UA	common	10.3 – 10.6 GHz	Czech
RAy10-LA-2	+	RAy10-UA-2	separated	10.3 – 10.6 GHz	Czech
RAy10-LB	+	RAy10-UB	common	10.15 – 10.65 GHz	Europe
RAy10-LB-2	+	RAy10-UB-2	separated	10.15 – 10.65 GHz	Europe

Detailed frequency table see *Section 9.2.4, "Nominal frequencies RAy10-xB, duplex 350 MHz"*.

3.2. Installation

Antenna is attached to a mast tube with an adjustable mounting rack. A RAy unit is then mounted onto the antenna. Two assembly positions are possible – either for horizontal or vertical polarization. The rack installation and setting up is described in the *Antenna mounting* chapter.

Fig. 3.2: RAy microwave bridge – image of the antenna and FOD unit

Connection to LAN may use one or two connectors:

- RAy10-LB RAy10-UB uses a shared connector for user data, service access and PoE power supply
- RAy10-LB-2, RAy10-UB-2 uses two connectors, one for user data and PoE power supply, and one for service access. Connector setup is described in the *Connectors* chapter.

A third BNC connector enables connecting a voltmeter for RSS indication during setup.

Fig. 3.3: RAy microwave bridge – connectors

3.3. Technical parameters

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

3.4. Dimensions

Communication unit ODU	Outer size		245 x 245 x 150 mm	
	Weight	RAy10	2.9 kg	
Diameters of supplied antennas		RAy10	Jirous	Arkivator
			38 cm	30 cm
			65 cm	60 cm
			90 cm	99 cm
				120 cm
Mast diameter at point of link holder fixing			ø40 – ø115 mm	
Distance of antenna axis from mast axis			cca 270 mm	
The antenna dimension drawings can be found in:			*Appendix A, Antenna dimensions*	
Technical data can be found at www.racom.eu:			*RAy10*[1]	

Name plate

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

- Type – RAy product line identification
- Code – detailed identification of the station type (for details see *Section 3.5, "Ordering codes"*)
- S/N – serial number, link contains stations with two different numbers
- MAC – HW address of user ethernet port

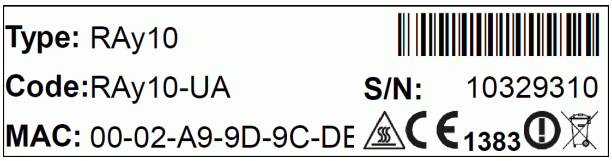


Fig. 3.4: Name plate RAy10-xA

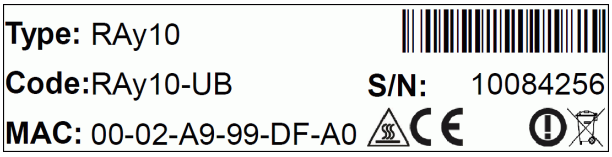


Fig. 3.5: Name plate RAy10-xB

[1] https://www.racom.eu/eng/products/mikrovlnny-spoj-ray.html#download

3.5. Ordering codes

3.5.1. Microwave units

The proper pair of Lower and Upper units should be selected when ordering the microwave link. This is not true for ISM bands units (RAy17, RAy24). In such a case the same unit is used for both sides of the link.
Note - The Lower and Upper unit has to be selected from the same sub-band (i.e. from the same row of the table).

The RAy11, RAy17 and RAy24 ordering codes are stated here for clarity. Their User manual can be found *here*[2].

Type	Licenced bands		ISM bands	
	10 GHz	11 GHz	17 GHz	24 GHz
Frequency range	A 10.30 – 10.59 GHz	A,B 10.70 – 11.70 GHz	17.10 – 17.30 GHz	24.00 – 24.25 GHz
	B 10.15 – 10.65 GHz	C,D 10.50 – 10.68 GHz		

Sub-bands	Lower [GHz]	Upper [GHz]	Lower [GHz]	Upper [GHz]	no sub-bands	no sub-bands
A	10.30-10.42	10.47-10.59	10.70-10.96	11.20-11.45		
ordering code	**RAy10-LA**	**RAy10-UA**	**RAy11-LA**	**RAy11-UA**	**RAy17**	**RAy24**
B	10.15-10.30	10.50-10.65	10.96-11.20	11.45-11.70		
ordering code	**RAy10-LB**	**RAy10-UB**	**RAy11-LB**	**RAy11-UB**		
C			10.5005-10.5425	10.5915-10.6335		
ordering code			**RAy11-LC**	**RAy11-UC**		
D			10.5425-10.5845	10.6335-10.6755		
ordering code			**RAy11-LD**	**RAy11-UD**		

ver. 3.1

In case of the two-port units, the “-2” label shall be connected to the end of the ordering code. Example:

- **RAy10-LA-2**
- **RAy10-UB**

3.5.2. Feature keys

The Feature keys ordering code consists of three parts:

XXX-YYY-ZZZ
XXX -product type, e.g. “RAy10”.
YYY - Feature key type.
Key to permit the user maximum speed is marked SW, value in Mbps
The key to increased transmission power is labeled PWR, value in dBm
ZZZ - Feature key value, example:

- **RAy10-SW-170** ... RAy10 user data speed enabled on the maximum value 170 Mbps.
- **RAy10-PWR-10** ... Increasing the maximum transmission power for RAy10 from 3 dBm to 10 dBm.

[2] https://www.racom.eu/eng/products/m/ray17/index.html

3.6. Accessories

The microwave bridge comes supplied as standard with:

- two FOD units
- tub of NOVATO silicon lubricant (mixture of silicon grease, PTFE and other additives) for lubricating the antenna pin (see *Section 5.2.3, "Lubrication and preservation of the antenna pivot"*).

Microwave bridge accessories need to be ordered separately, for further details please see *www.racom.eu*[3]

- Two pieces of parabolic antennas with mast holder - according to user needs and specifications. The antenna from two different vendors are available currently (year 2013). The overview of different antenna types is listed in paragraph *Dimensions*. The antenna choice determines radio link properties. The radio link calculation should be performed to determine proper antenna size. Rough calculation can be done using *simple on-line calculator.*[4]
  The other antenna producers can be used with RAy links as well. The RAy unit can be attached to the antenna by flexible waveguide or directly by means of special interconnetion part. There are several types of those parts for Andrew and Arkivator antennas. It is possible to develop the interconnetion part also for other antenna types.
- FOD unit power supplies – 30W PoE adapters
- two connectors (plastic IE-PS-V01P-RJ45-FH or metallic IE-PS-V01M-RJ45-FH) for connecting the FOD unit for outdoor use – these quality connectors allow the connection of cables with conductors of cross-sectional area 0.129–0.329 mm^2 (AWG 26 – AWG 22, i.e. ø0.4–ø0.64 mm). For assembly instructions see chapter *Section 5.3.2, "Fitting an external IE-PS-V01P-RJ45-FH connector"*
- two IE-PS-RJ45-BK connectors for connecting the FOD unit for indoor use.
- S/FTP Cat.7 cable for connecting FOD units to the network.
- AGC cable for connecting a voltmeter to the RAy unit for adjusting the antenna direction. (see "Antenna mounting", point g - *g*)
- Grounding set for grounding the CAT7 cable. Manufactured by PEWTRONIC s.r.o., code S/FTP 4+2
- RAy grounding set for grounding RAy equipment to the mast. Contains a ZSA16 grounding terminal, grounding tape and a cable with grounding lugs.

Grounding set for grounding the CAT7 cable, RAy grounding set – see images *Fig. 5.61* - "Grounding kit for S/FTP 4+2 cable" and *Fig. 5.63* - "RAy grounding kit".

Additional microwave bridge accessories which have been specially selected for installation of RAy microwave bridges can also be ordered :

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

- Set of tools for installation of the bracket and mounting of connectors in the **RAy Tool** set. Branded tools which allow complete installation of the microwave bridge.

Fig. 3.6: RAy Tool set

4. Step-by-step Guide

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

- Pre-installation check out
- *Installation*
- *Advanced configuration*
- *Troubleshooting*

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. 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 RAy and perform a basic setup.

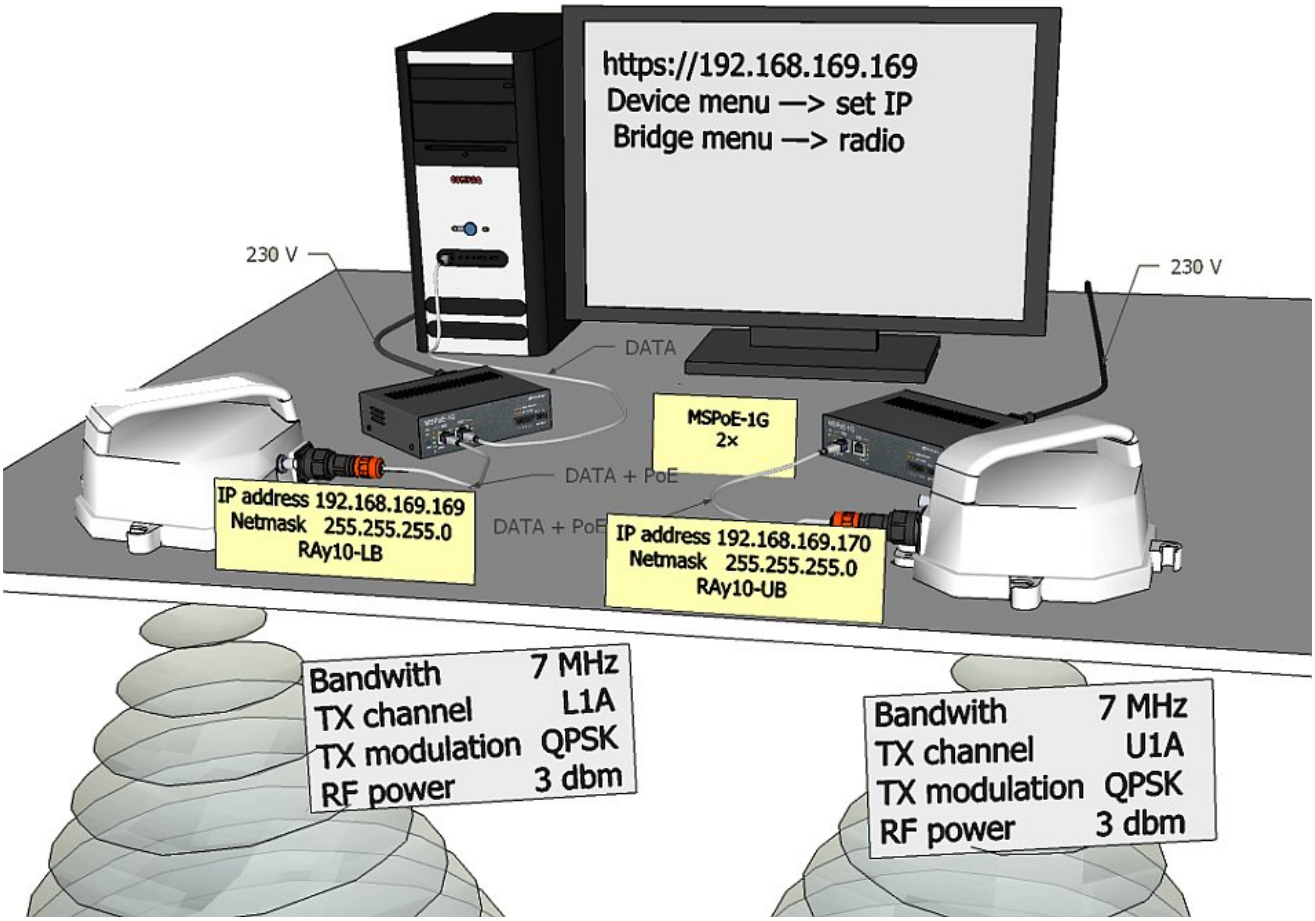


Fig. 4.1: Link Configuration

4.1. Service access

RAy link is supplied with a default configuration of access parameters or a customised configuration tailored to customer's needs.

In this default state the following access parameters are set:

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,
access is allowed over HTTPS or ssh with a key,
the username is *admin* and the password is also *admin*.

On your PC setup an IP address that is within the mask, i.e. 192.168.169.180.

Then open the https configuration interface, e.g.

https://192.168.169.169.

Other access options are described in the chapter *Device – Service Access* of this manual.

When connection has been established, use the Device menu to customise access parameters. Default IP addresses should be replaced with well-chosen operating addresses. Leaving default addresses in place can lead to later network problems.

The menu contains parameters for the entire link, both for the local and remote 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.

The configuration described above is the default *Access open* setup, see *Settings/Device/Configuration/Default*.

Note

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

4.1.1. Device configuration menu

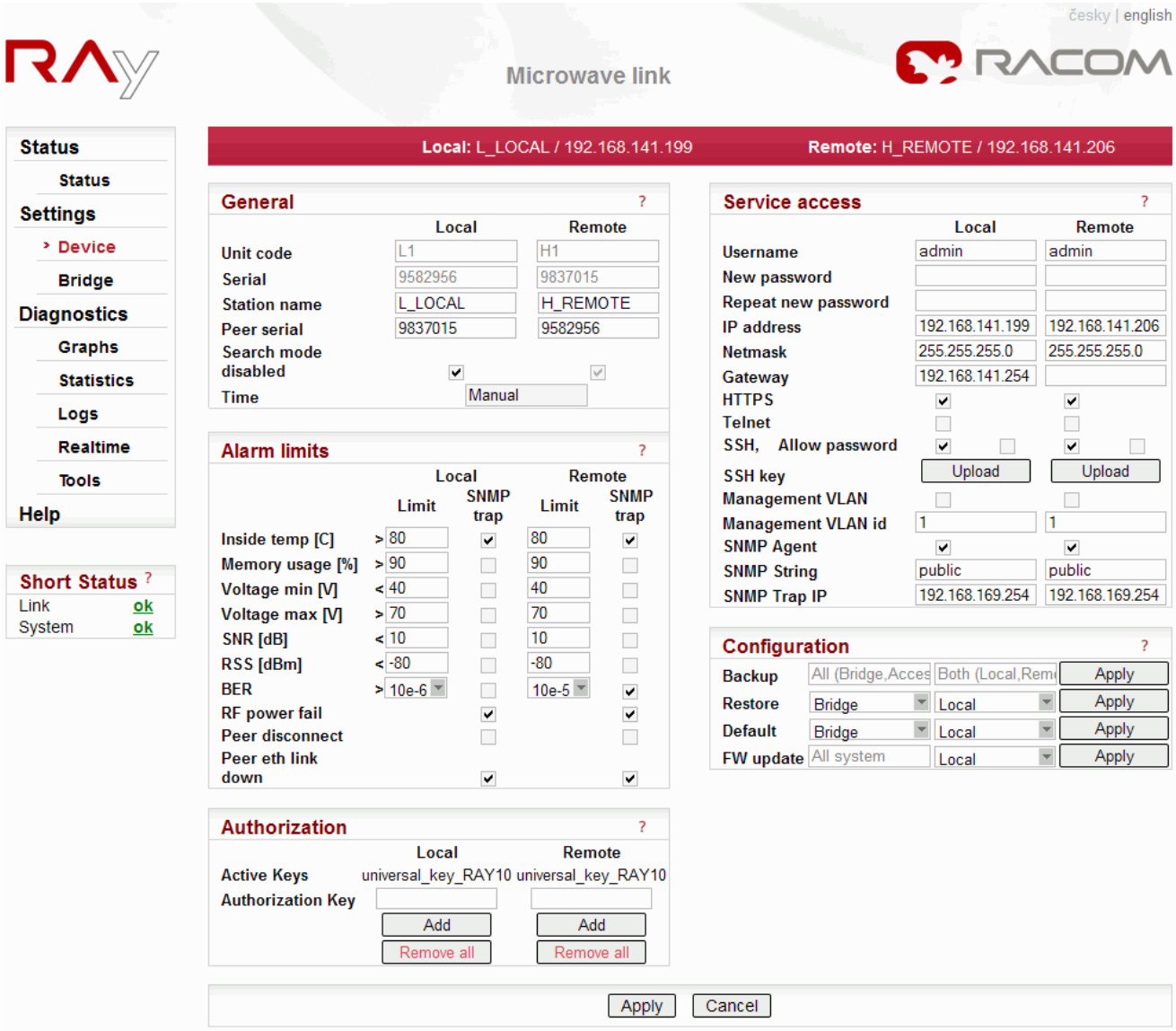


Fig. 4.2: Service Access Configuration

- Station name – station can be indicated by name, e.g. according to the place of installation
- Peer serial – serial number of peer station, recorded during production
- Username – enter your name and enter your new password concurrently
- New password – choose your access password and write it in
- Repeat new password – write in the password again
- IP address – write in **the valid IP address** for the access to the station. The default IP address **must be replaced** by a valid address. Keeping the default address will most probably lead to future problems within the network.
- Netmask – write in the mask
- Gateway – if necessary, write in the gateway or leave the item empty
- Allow the access protocols you will need. For safety reasons, do not allow more than necessary:
- HTTPS, Telnet – access permission
- SSH, Allow passwd – the first mark allows access with a key, both marks allow access with a password, without a key

Save the menu content by clicking on the button *Apply*.

4.2. Basic Configuration of the Link

Default parameters for the line are configured for channels L1a and U1a, bandwidth 7 MHz, modulation QPSK, coding High, output 3 dBm and are ready to establish contact. If it is possible to work with these channels in the considered site, you can install and run the link. Then set the real operation configuration on the running link.

If changes need to be implemented, perform them in the menu *Settings* a save them by the command *Apply*. Again, you are working with both stations at once if they are in contact, otherwise configure the stations separately. Pay attention to correct configuration of duplex pairs of TX and RX channels while configuring separately. For example, if one station (RAy10-LB) has the TX channel L1a, then the second station (RAy10-UB) must have the RX channel L1a, too.

Authorization keys

To fully utilize the transmission rate and transmit power is necessary to use the software Authorization keys. Without keys the link works with the lowest modulation QPSK / 8,45 Mbps only and with power at most 3 dBm.

Under *Settings/Device/Authorization* input your key (29 letters, digits and symbols long) and click Add. Using the key opens up advanced options for Bandwidth, Modulation and Coding strength or RF power for the respective unit. To find out more about keys, refer to the *Device – Authorization* chapter.

Example of configuration in the menu *Settings Bridge*:

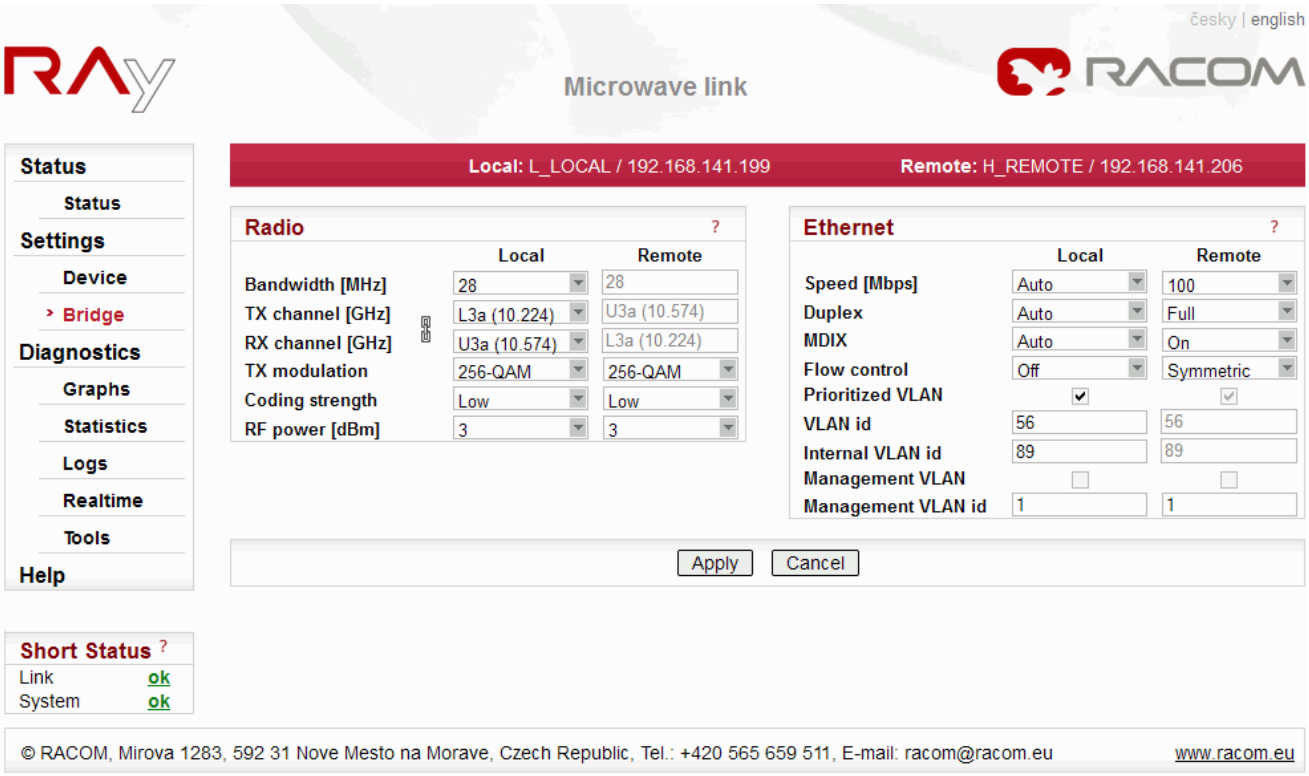


Fig. 4.3: Link Configuration

4.3. Tests

Verify the status of the radio link:

- Short Status displays *Link ok*.
  If instead of *System ok* the message displayed is *System alarm*, this doesn't necessarily mean there is a problem. The message indicates that the limit of one of the parameters has been exceeded. Essential is the *Link ok* message.
- The menu contains values for both local and remote units. N/A next to Remote indicates that the data from the remote unit has not been transferred. If *Link* is *ok*, simply click Refresh at the bottom of the screen and Remote data will be updated.
- *Status/Radio* shows the RSS and SNR links and the selected modulation and Net bit rate for ACM.
- *Diagnostics/Realtime* shows the current RSS, SNR and BER.
- Menu Diagnostics/Ping enables ping-testing the other unit.

Test modulation options:

- ACM modulation – under *Settings Bridge/Radio* setup TX modulation ACM. Refresh *Status/Radio* to monitor the changes in modulation based on the quality of signal SNR. The status and quality of modulation are well shown by setting *Diagnostics Tools/RX constellation diagram*, *Read Continuously* to *Yes*.
- To set a fixed modulation go to *Settings Bridge/Radio* 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. *Short 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 ethernet to access each unit individually and set the basic modulation QPSK. You can monitor the quality of the received signal under *Diagnostics Tools/RX constellation diagram*.

Verify the functionality of the entire link:

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

Prepare installation configuration:

- Bandwidth 7 MHz
- TX channel within the supposed range, e.g. use 7 MHz channel L6a inside the 28 MHz L2a range, see *Frequencies table*.
- RX channel will setup automatically when channel lock activates.
- TX modulation QPSK
- Coding strength High
- RF power +3 dBm
- To save click Apply.
- Record the access parameters from the Service access menu, especially the IP addresses.
- Restart by interrupting 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 working environment.

5. Installation

5.1. Line of sight test

Before you install the device to a mast tube, verify visually that the view in direction of the remote unit is unobstructed. Watch out for these obstacles in particular:

- Free Fresnel zones. Signal needs space wider than is 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.

5.2. Antenna mounting

5.2.1. Mounting methods

- according to the method of mounting on the mast tube
  - right-side mounting
  - left-side mounting
- according to the method of mounting the FOD unit – antenna polarization
  - horizontal mounting
  - vertical mounting

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

Fig. 5.1: Left-side mounting – horizontal polarization

Fig. 5.2: Left-side mounting – vertical polarization

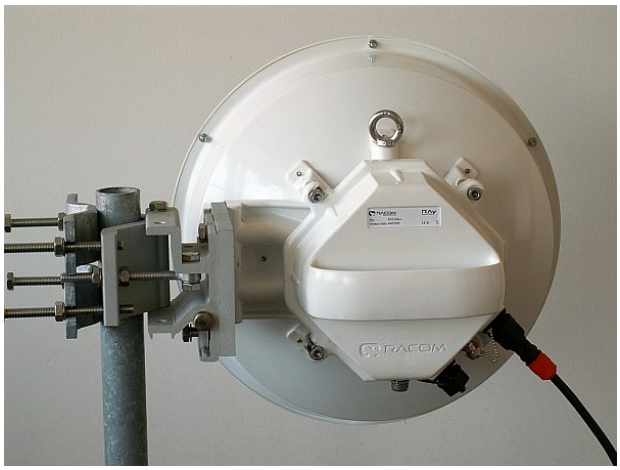


Fig. 5.3: Right-side mounting – horizontal polarization

Changing the mounting method

Antenna bracket is supplied as standard partly assembled, and ready for right-side mounting.

On changing the **Jirous** antenna bracket for left-side mounting the adjustment bolt (part No. 11) and swivel bolt (part No. 12) need to be unscrewed, then shift the bracket body (part No.13) to the other side of clamp plate (part No. 4), (do not turn upside down) and then insert bolt (part No. 12) into the second hole on the mounting plate holder and through the same hole on the clamp plate and secure in place with the nuts. The adjustment bolt (item No. 11) and nuts (item No. 9) are switched to the other side of the clamp plate (part No. 4). It is also necessary to switch the hanging bolt (part No. 7) on the mounting plate (part No. 5) to the second hole so that after switching sides with the antenna it is on the top again.

On changing the **Arkivator** type antenna bracket for left-side mounting the adjustment pin (part No. 17) needs to be unscrewed and switched to the other side of the bracket body (part No.3) and clamp plate (part No. 4). It is also necessary to switch the adjustment bolt (part No. 21) and U-plate (part No. 13) to the other side of the bracket body (part No.3). This ensures that there is still good access to the adjustment elements for changing the direction of the antenna when mounted on this opposite side.

In the case of the antenna when changing the method of mounting from right-side to left-side it is only necessary to change the eye hook on the top and rotate the plastic cover of the antenna. This is not only important from an aesthetic point of view, so that the RACOM logo is not upside down, but also because there is a discharge channel on the lower edge of the dish (except for ø380 mm dishes).

When changing the polarization from horizontal to vertical only the FOD unit needs to be turned through 90° around the central antenna pin by unscrewing the four bolts on the dish using a No. 6 Allen key. (or on the reducing crossplate (part No. 7) for the Arkivator type antenna)

5.2.2. Mounting the FOD unit on the antenna

RAy microwave bridge equipment is generally supplied as several component parts packaged separately in a box.

- Two ø38 and 65 cm Jirous parabolic antennas or ø30, 60 and 120 cm Arkivator antennas depending on the parameters of the bridge.
- Two brackets for mounting the antenna to the mast.
- Two FOD stations, each separate in a box, in a single package.
- Other accessories based on the order placed (for more detailed information see chapter *Section 3.6, "Accessories"*)

When ordering a RAy microwave bridge there is a choice of antennas from two manufacturers to be connected to the RACOM FOD unit.

Mounting the FOD unit on the Jirous antenna

A No. 17 spanner and a No. 6 Allen key are required for mounting the mechanical parts of the antenna. Spanner No. 17 serves for precisely setting the direction of the antenna. Both spanner and key can be found in the **RAy Tool** set for installing RAy microwave bridges.

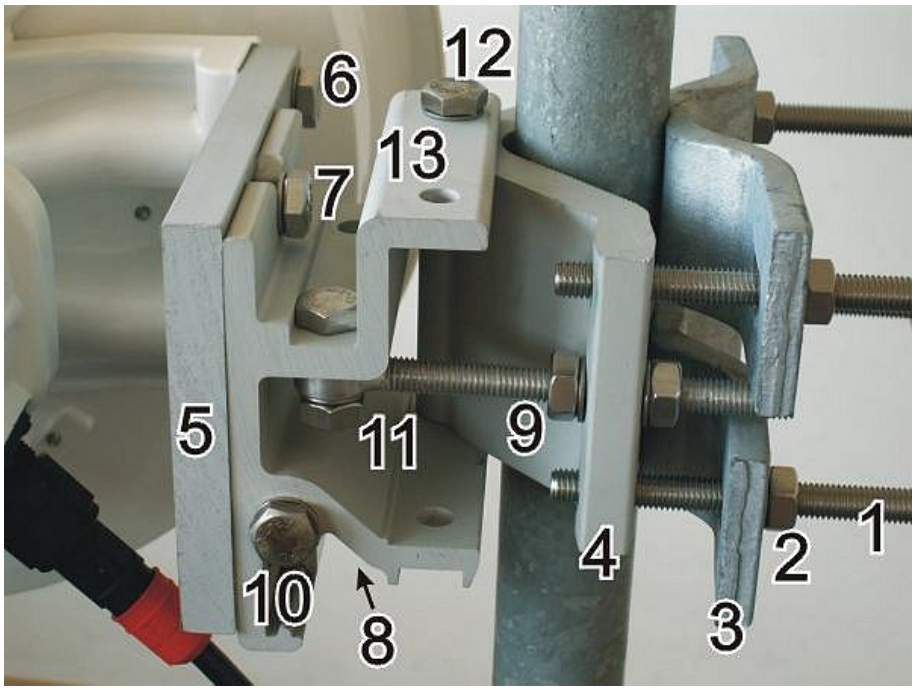
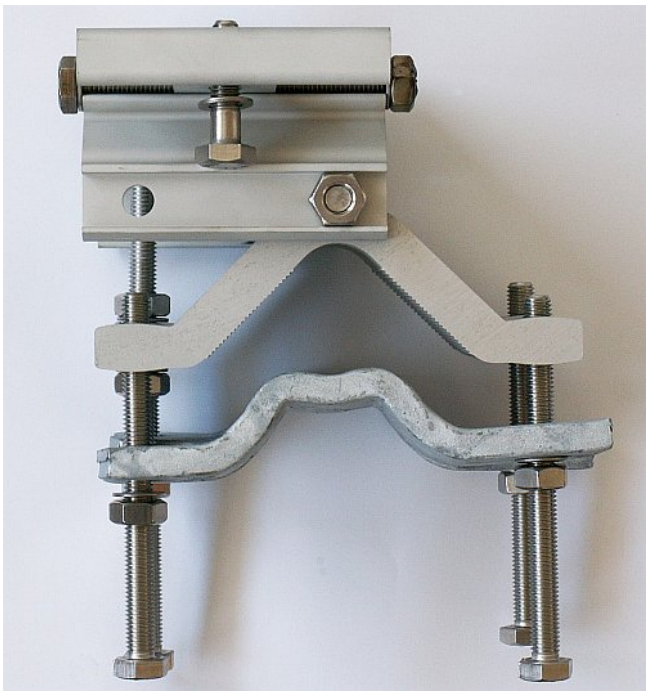


Fig. 5.4: Close up image of the mounted bracket showing numbered parts

a. Prepare the antenna bracket based on the diameter of the mast tube. For smaller diameters face the bent part of the saddle plate (part No. 3) to the inside. For larger diameters to the outside. Screw the bolts (part No. 1) into the clamp plate (part No. 4) so that they protrude approx. 1 cm through the clamp plate. Clamp the saddle plate to the mast by tightening the nuts (part No. 2) on the bolts.



Slide the antenna bracket onto the mast tube and clamp to the mast by tightening the nuts.

Fig. 5.5: Position of the saddle plate for ø 40–80 mm

Fig. 5.6: Position of the saddle plate for ø 65–115 mm

b.

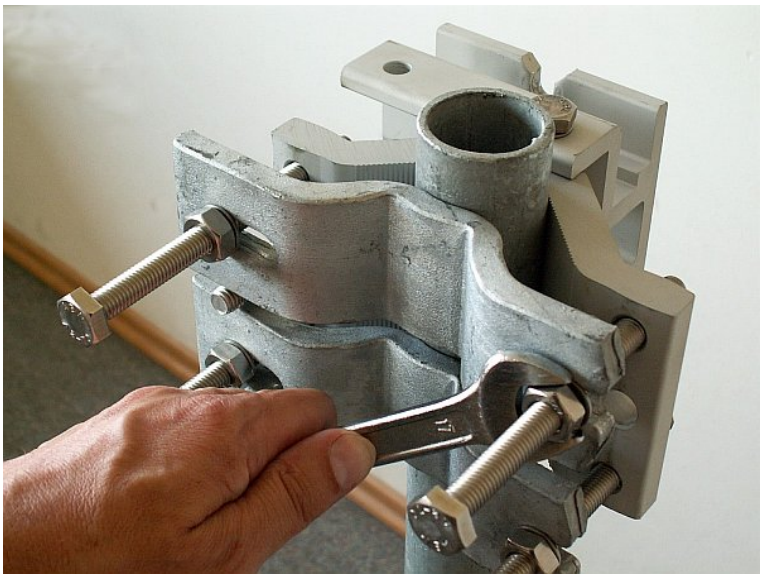


Fig. 5.7: Attaching the bracket to the mast tube

c. The second part of the bracket – mounting plate (part No. 5), is screwed to the antenna dish with three bolts (part No. 6). Screw the eye hook into the upper threaded hole of the dish to ease handling of the dish during installation. The position of the eye hook on the dish and hanging bolts on the plate change according to the type of installation, see *Section 5.2.1, “Mounting methods”*.

Screw the hanging bolt (part No. 7) into the upper hole of the mounting plate so that the antenna can be hung on the mounting plate holder. Hang the antenna on it and tighten the lower bolt. (part No. 8)

Fig. 5.8: Dish without mounting plate

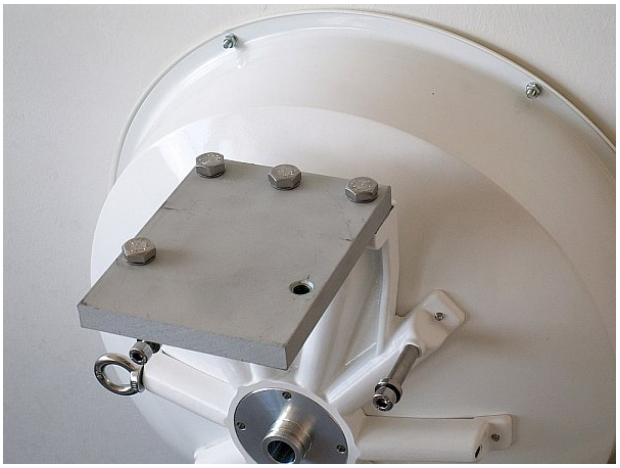
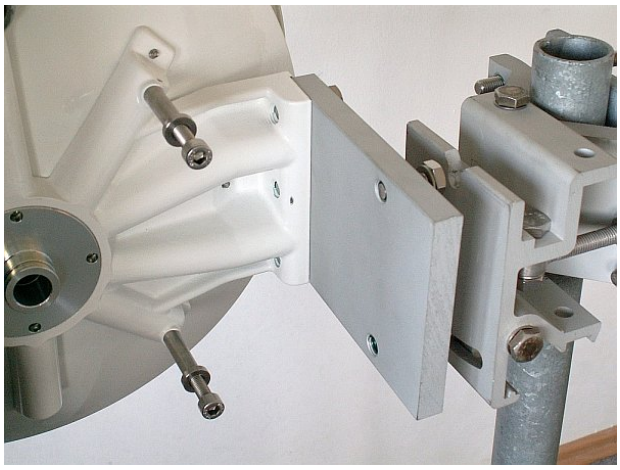


Fig. 5.9: Dish with mounting plate

d.



Tighten both bolts to the plate before continuing with installation to prevent any unnecessary movements of the whole equipment. Before precisely adjusting the vertical direction of the antenna upon completing installation it will be necessary to unscrew them again as the lower bolt passes through the adjustment block and the upper one serves as the axis of rotation.

Fig. 5.10: Hanging the bolt on the holder

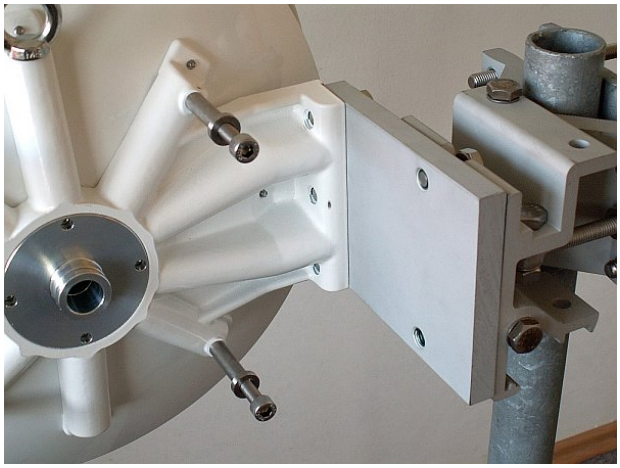


Fig. 5.11: Correct position of the mounting plate

e.

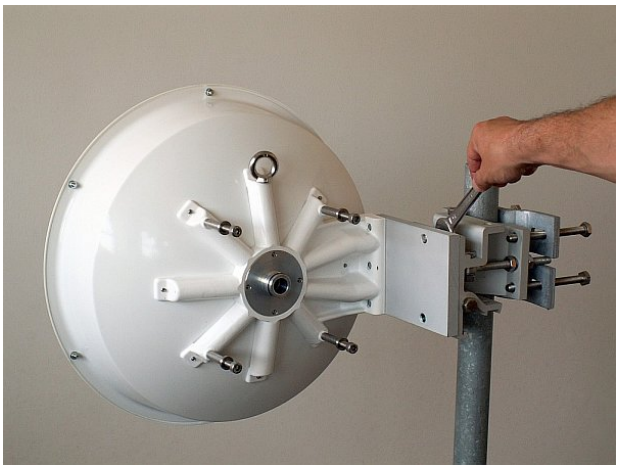


Fig. 5.12: Tightening the upper bolt to the mounting plate

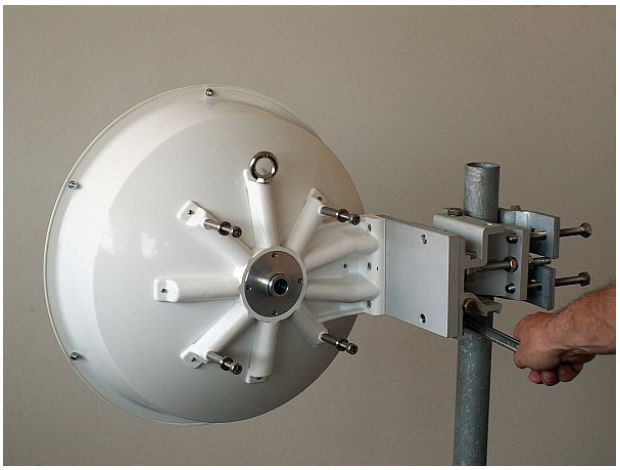


Fig. 5.13: Tightening the lower bolt to the mounting plate

f.

Before installing the FOD unit on the antenna first unscrew the 4 bolts on the back of the antenna enough 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 5.2.3, "Lubrication and preservation of the antenna pivot"*. Then remove the protective plastic cover from the central pin of the antenna and fit the FOD unit to it carefully so as not to damage the "O" ring. Secure it in place with the four bolts. Carefully ensure the correct polarization of the antenna – see *Section 5.2.1, "Mounting methods"*. Finally tighten the bolts with a No. 6 Allen key.

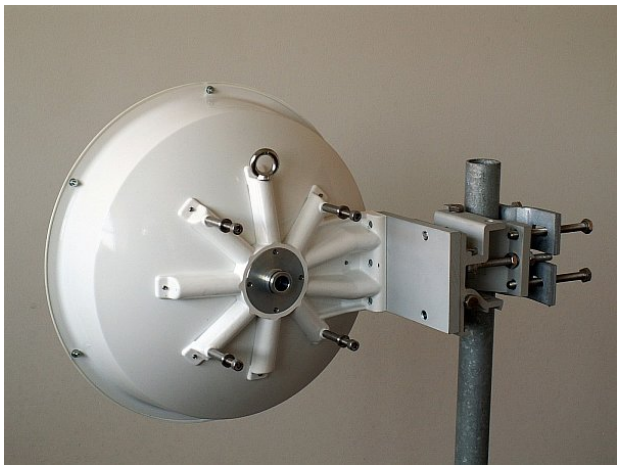


Fig. 5.14: Dish before installing the FOD unit

The precise horizontal direction the antenna is pointing in can be adjusted using the bolt with two nuts (part No. 9). Once the direction has been set the antenna is fixed in place by tightening the nuts against the bracket to prevent further movement of the antenna. The vertical direction the antenna is pointing in can be adjusted by turning the fine adjustment bolt (part No. 10) by the bracket mounting plate. After selecting the correct direction the position is secured by tightening the bolt – see point e (part No. 7 and 8). The correct position in both directions is found by monitoring RSS – voltmeter, or with an audible alarm (if equipped) – see *Section 5.5.2, "Antennas directing"*.

Fig. 5.15: Tightening bolts on the FOD unit

g.

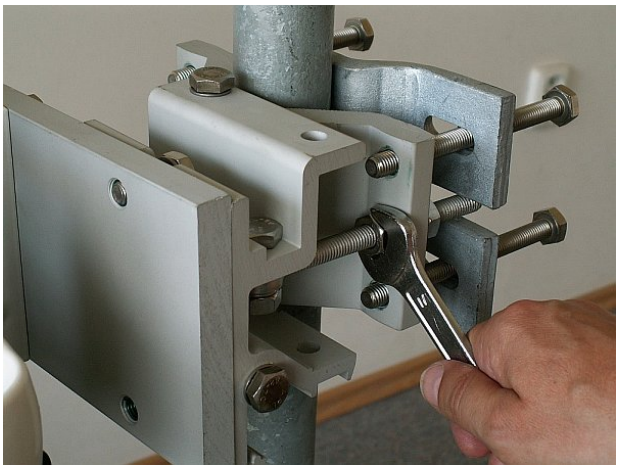


Fig. 5.16: Horizontal adjustment of the antenna direction

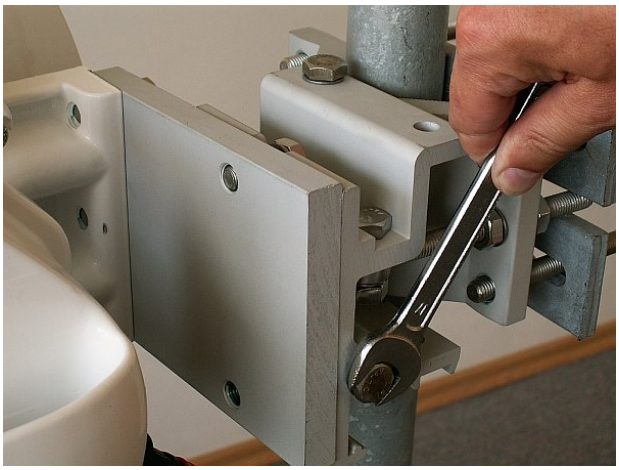


Fig. 5.17: Vertical adjustment of the antenna direction

h.

After pointing the antenna in the right direction tighten the bolts on the bracket on the axes of rotation (part No. 11 and 12). Then check again that all other bolts have been sufficiently tightened. We can now proceed to connecting the FOD unit to the user network.

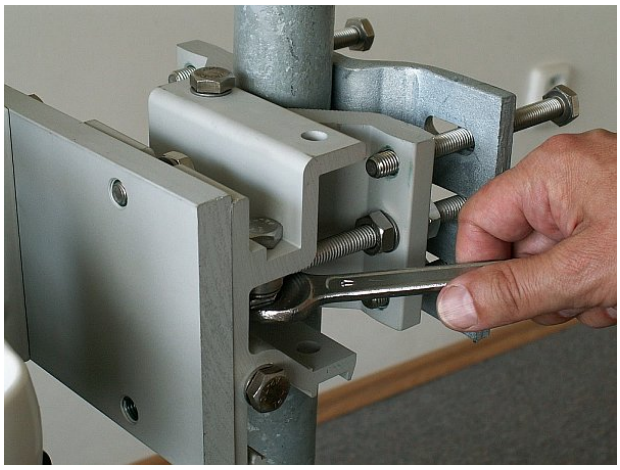


Fig. 5.18: Tightening the axis at the fine adjustment bolt

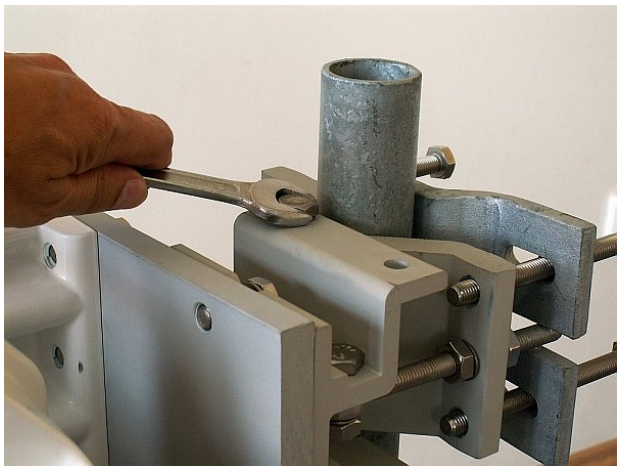


Fig. 5.19: Tightening the axis at the bracket

Mounting the FOD unit on the Arkivator antenna

Installation of a RAy microwave bridge with an Arkivator type antenna is very similar to the installation described above, and is clear from the following images. The tools required for installation can be found in the **RAy Tool** kit for installation of RAy microwave bridges. No. 13, 16 and 17 spanners and No. 4 and 6 Allen keys are required for installation. For an antenna with a nominal diameter of 120 cm a No. 14/24 double open ended spanner, supplied with the antenna.

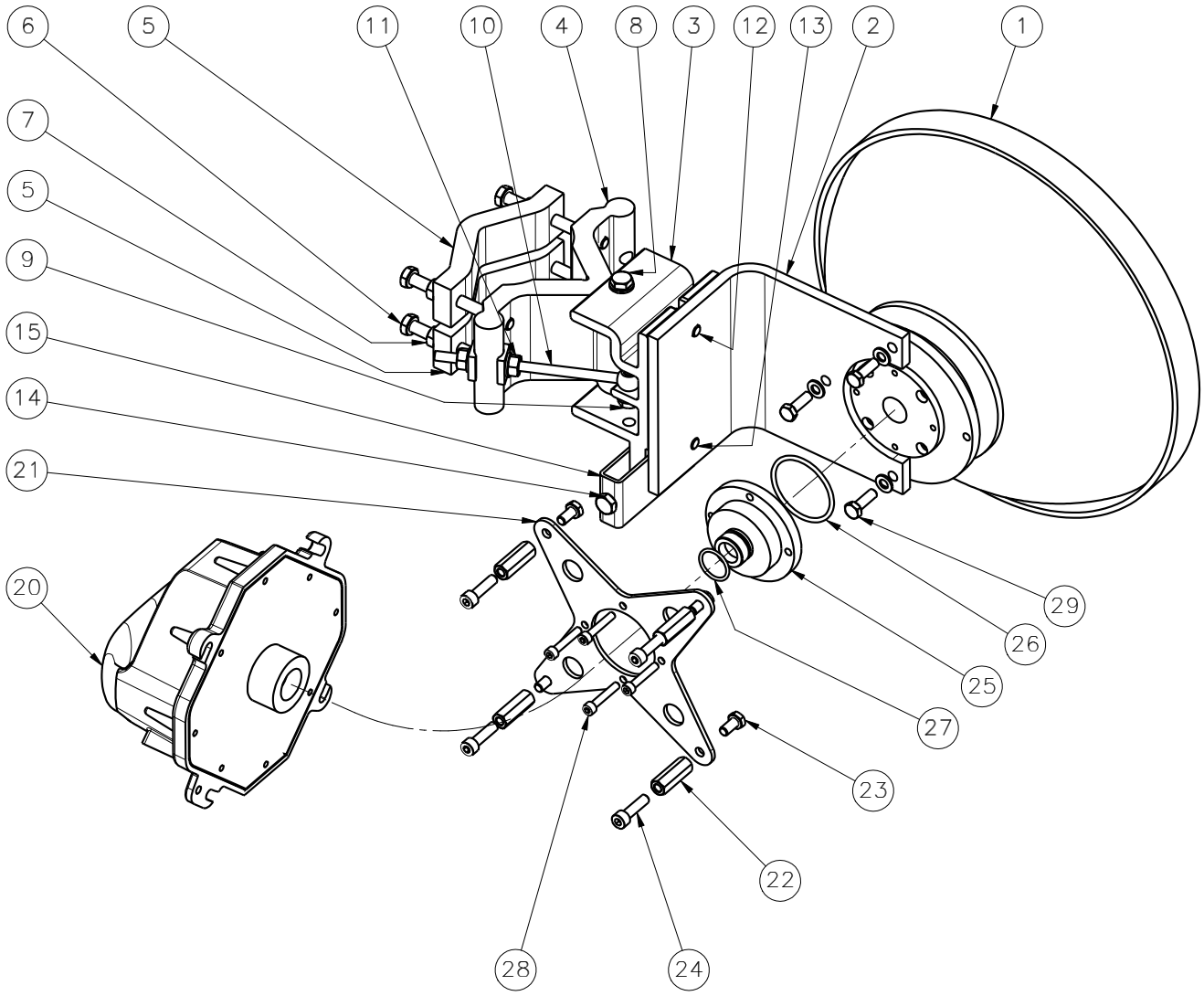


Fig. 5.20: Installation diagram for the Arkivator antenna, 30 and 60 cm

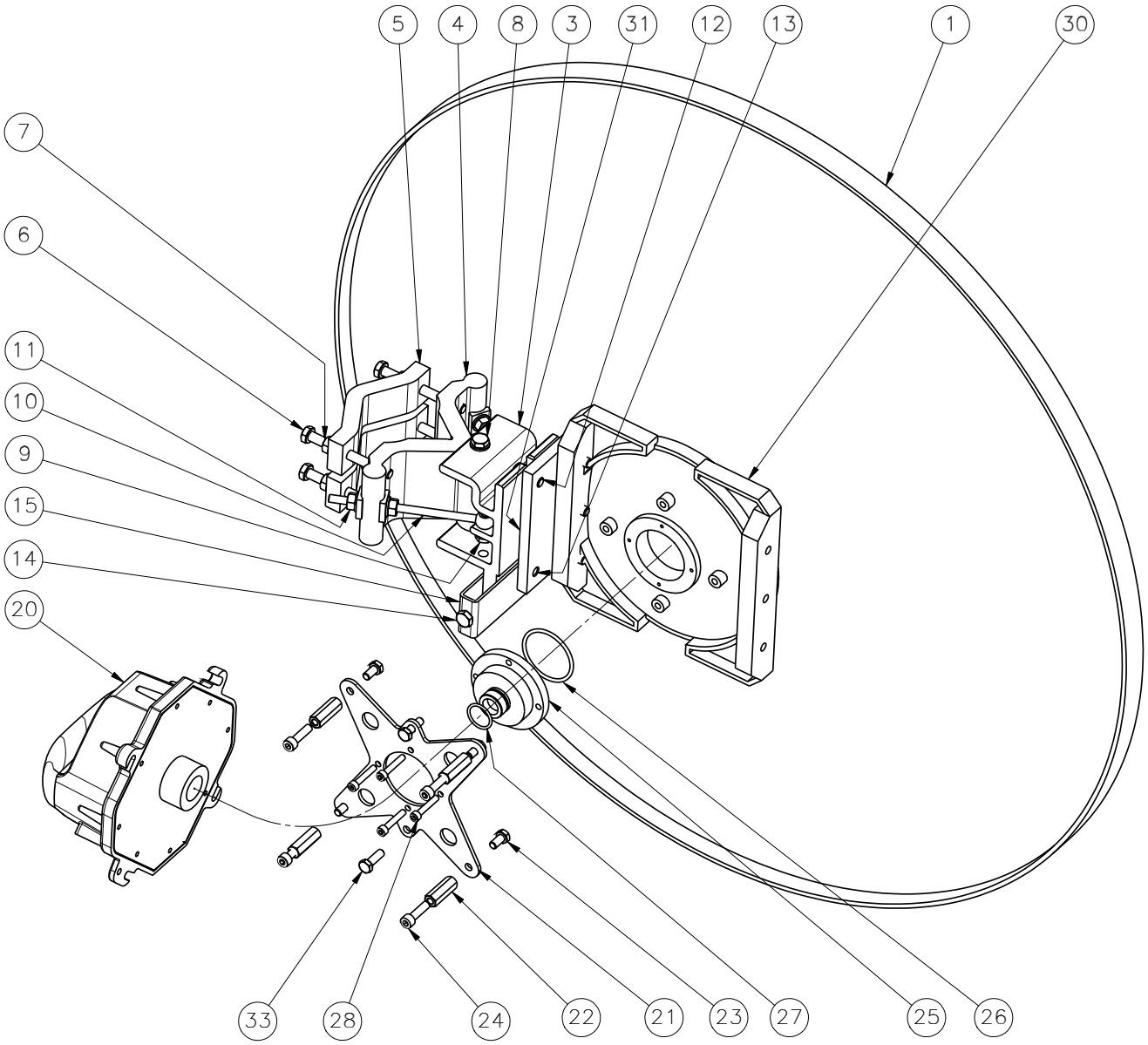


Fig. 5.21: Installation diagram for the Arkivator antenna, 99 cm

The antenna bracket (part No. 3 and 4) is supplied assembled as per the following image. The bracket is installed on the mast tube in a similar way to that of the Jirous antenna (*point a*). The bracket is ready for tube diameters up to 115 mm. The bolts (part No. 6) should be screwed to the clamp plate (part No. 4) in such a way that the end of the bolt protrudes approx. 6-10 mm through the other side of the clamp plate. Saddle plates (part No. 5) are then clamped against the mast tube by tightening nuts (part No. 7).

Warning

Before mounting the adapter (part No. 25) to be removed the green foil from the antenna (part No. 1). This film covers the transport of the center hole in the waveguide.

After mounting the bracket on the mast tube bolt the bent plate (part No. 2, for Arkivator 30 and 60) or (part No. 30, for Arkivator 99) to the bracket. The actual antenna (part No. 1) is then bolted to this plate.

Fig. 5.22: Arkivator antenna bracket

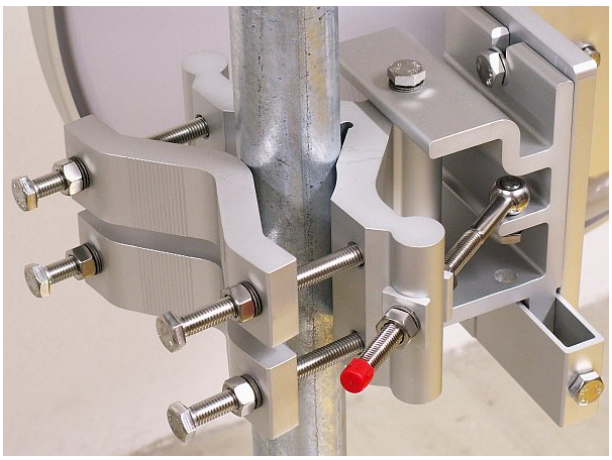


Fig. 5.23: Bracket on the mast

A reducing adapter (part No. 25), a reducing crossplate (part No. 21) and sleeves (part No. 22) are used for mounting the FOD unit (part No. 20) on the antenna. During installation do not forget "O" rings (part No. 26 and 27) and to lubricate "O" ring (part No. 27), see *Section 5.2.3, “Lubrication and preservation of the antenna pivot”*.

Bolt (part No. 14) serves for accurately setting the vertical direction of the antenna. When setting the direction release bolt (part No. 12 and 13), and then tighten it again once you have the correct position. The nuts on bolt (part No. 10) serves for setting the horizontal direction. Once the direction is set these nuts (part No. 11), pivot bolt (part No. 9) in the hanging eye of bolt and two pivot bolts (part No. 8) where the tilt bracket, need to be tightened.

Fig. 5.24: 30 and 60 cm diameter Arkivator antenna

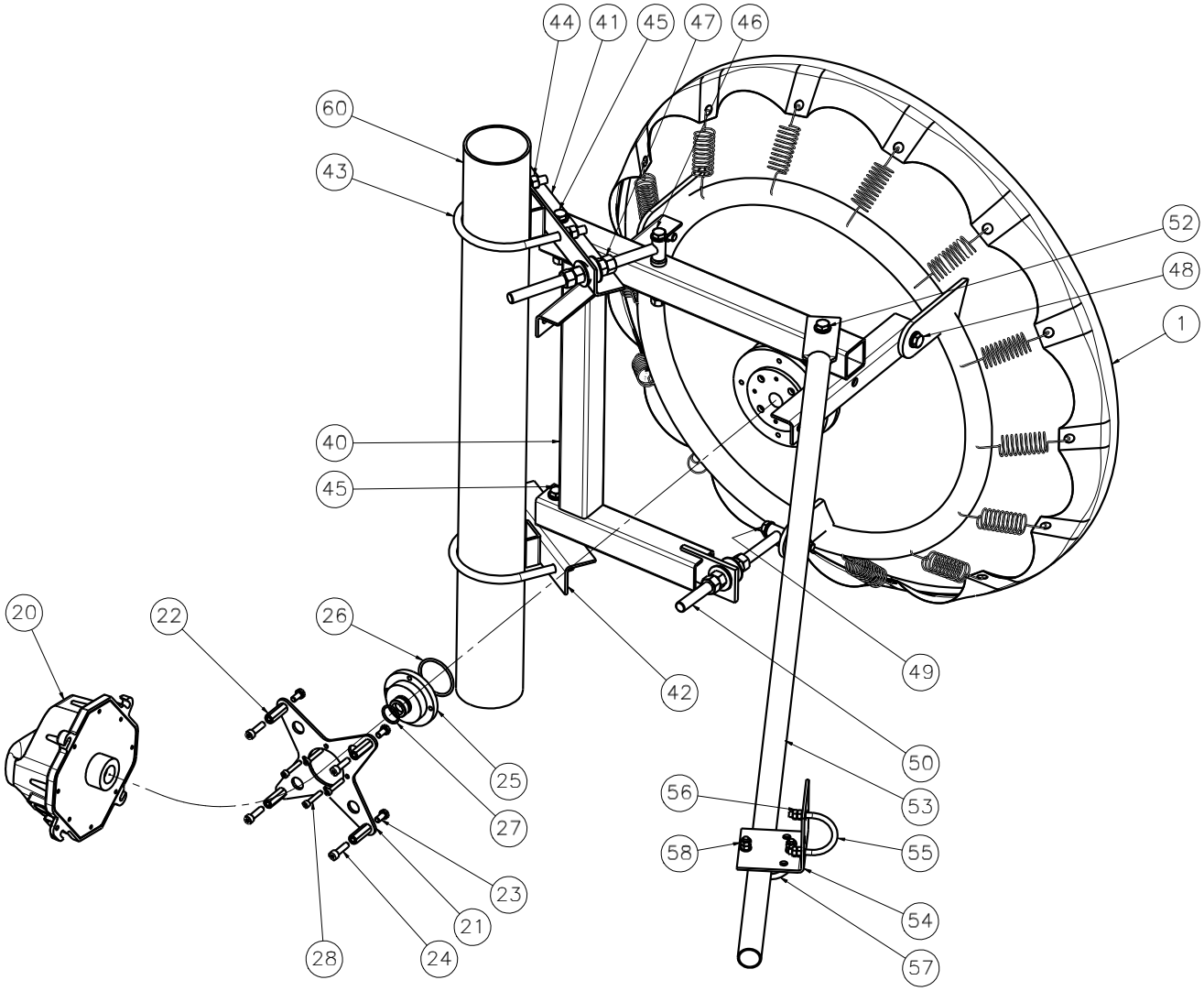


Fig. 5.25: Installation diagram for the Arkivator antenna, 120 cm

5.2.3. Lubrication and preservation of the antenna pivot

Before fitting the FOD unit bush onto the antenna pivot ensure that 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 lubricant grease which is supplied in the box marked *RAy bridge accessories*. If you use a different grease for lubrication then it should be a Teflon grease or at least a silicon lubricant grease.

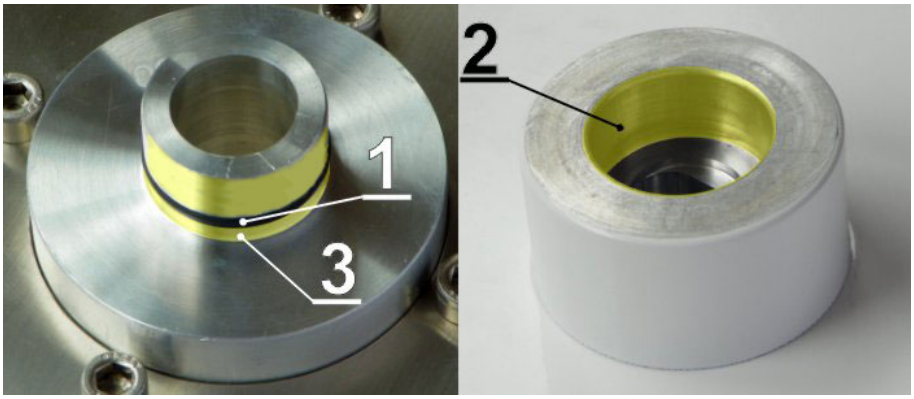


Fig. 5.26: Grease points on the antenna pivot and FOD unit bush

Grease the internal area of the bush on the FOD unit (2) and the "O" ring (1) with a thin even layer that allows the pin to slide easily into the bush without damaging the "O" ring. Grease the area beyond the "O" ring on the antenna pin (3) with a thicker layer so that it fills the gap caused by the play between the pin and the bush (max. 0.1 mm/ø) thus preventing moisture getting in. Installation should be carried out according to the antenna installation description – *see **point f*** of this description.

5.3. Connectors

5.3.1. Connecting the FOD communication unit to the user network

The FOD communication unit is connected to the user network by an Ethernet cable via interfaces GbE, IEEE802.3ac 1000BASE-T. As standard, RACOM recommends using an S/FTP CAT 7 cable and two RJ45 connectors for outdoor installations. One for the internal (IE-PS-RJ45-FH-BK) and the second for the external (plastic IE-PS-V01P-RJ45-FH or metallic IE-PS-V01M-RJ45-FH) end of the cable.

Based on the PoE standard the station is powered over the Ethernet cable.

If the station is equipped with two connectors, the right one carries user data, and the left connector is to be used for servicing.

The middle BNC type connector serves for connecting a voltmeter for precisely setting direction.

Fig. 5.27: Connecting the FOD communication unit

Important

Before connecting the FOD communication unit to the supply (to the user network) the FOD unit must be grounded according to *Section 5.4, “Grounding”*.

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

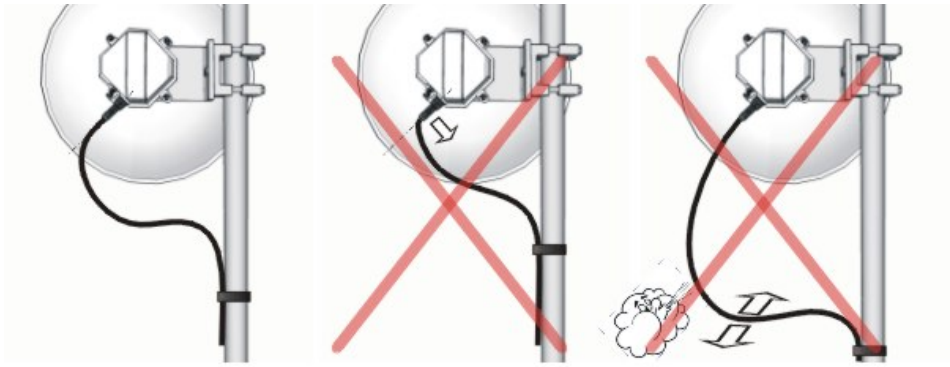


Fig. 5.28: Example of a correct lead installation.

5.3.2. Fitting an external IE-PS-V01P-RJ45-FH connector

We recommend using an S/FTP 4×(2×23AWG) Cat.7 + 2×(2×24 AWG) cable for connecting the FOD unit, as it is designed for external use. The cable contains two additional twisted pairs, 2x(2x24 AWG), which are not used. The following images show the internal cable without these additional pairs.

a. Use the tools from the **RAy Tool** set for fitting connectors. See chapter *Section 3.6, "Accessories"*.

Undo the nut on the connector cover and push it on to the cable. Then trim at least 20 mm of insulation from the end of the cable.

Fig. 5.29: Tools for fitting connectors

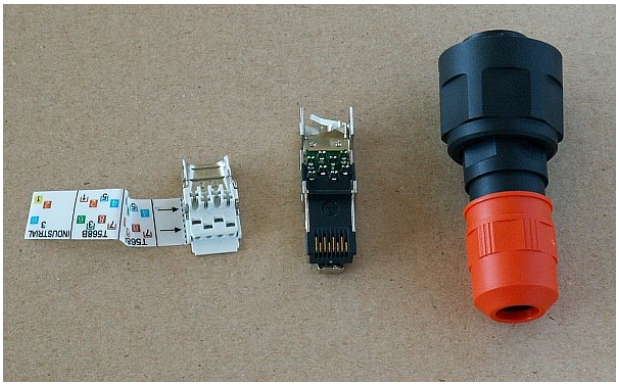
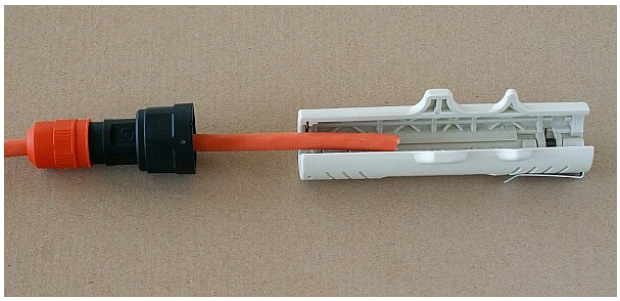


Fig. 5.30: IE-PI-RJ45-FH connector before fitting

b.



Twist the braid forming the cable shielding together and wrap around the cable so that 2-3 loops are next to each other at the end of the insulation.

Fig. 5.31: Tool for removing insulation

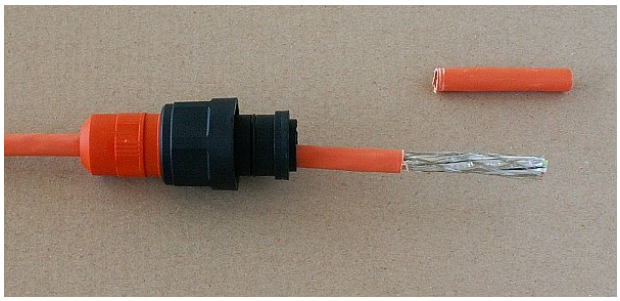
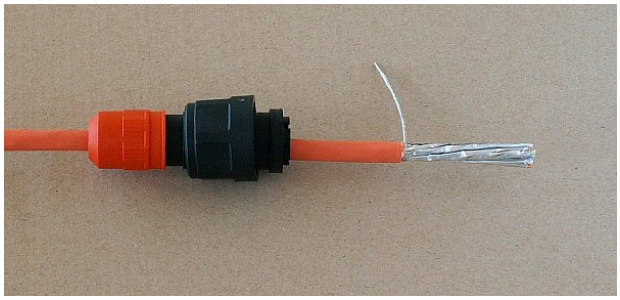


Fig. 5.32: Insulation removed

c.



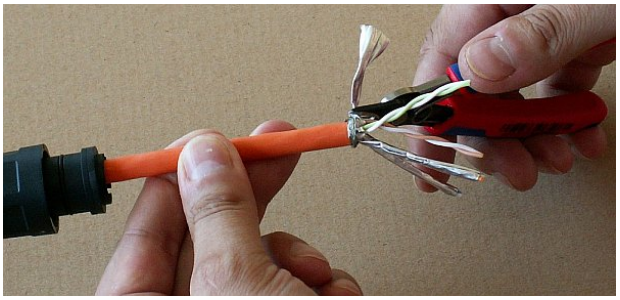
Separate individual pairs of conductors, remove the aluminium shielding from them, cut it off, and

Fig. 5.33: Twisted shielding

Fig. 5.34: Shielding wrapped around the cable

d.

separate individual conductors. Cut off the two additional twisted pairs from the thinner wire in the middle (not seen on these images).



Push the lower layer of conductors into the openings as per the pinout sticker (T568B) attached to the connector. Take care not to confuse white conductors from individual pairs.

Fig. 5.35: Trimming shielding

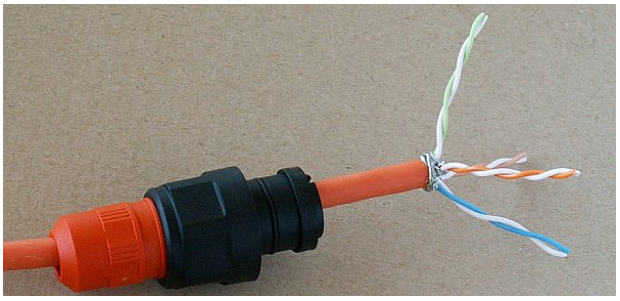


Fig. 5.36: Separated pairs of conductors

e.

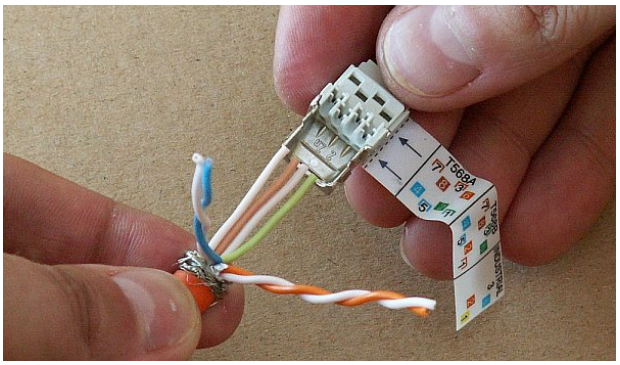


Fig. 5.37: Pushing the lower pairs into the connector

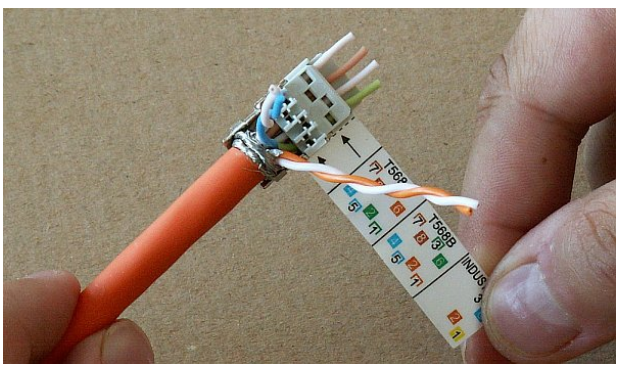
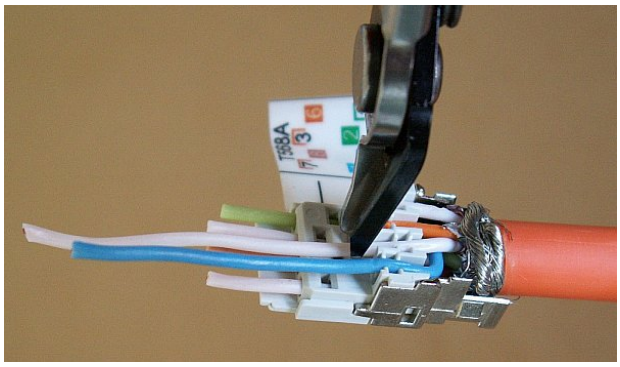


Fig. 5.38: Lower pairs pushed in

f. Then from above push the upper conductors into the connector according to the pinout sticker and trim them. The cable must be pushed in far enough so that the braided shielding is inside the metal part of the connector.



Remove the pinout sticker and fit the complementary half of the connector. Squeeze the parts togeth-

Fig. 5.39: Cutting off of the upper conductors

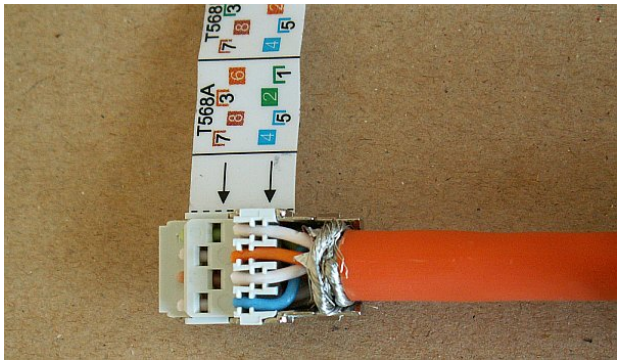
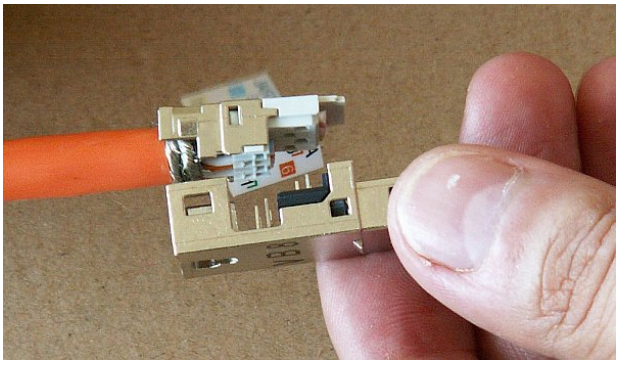


Fig. 5.40: All conductors in the connector

g.

er until the locks snap into place. Use the pair of pliers with parallel jaws from the **RAy Tool** set for this. Standard pliers would damage the connector.



Then slide the protective cover onto the connector. It must fit into the grooves after snapping into place. Finally tighten the nut on the cover to seal the point where the cable enters the connector.

Fig. 5.41: Fitting the complementary half of the connector

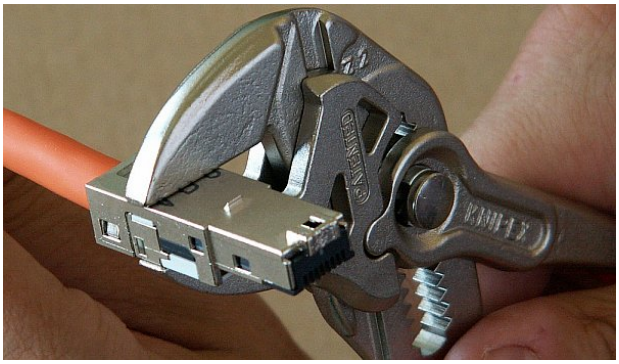


Fig. 5.42: Squeezing the connector until the locks snap into place

h.

Fig. 5.43: Sliding the cover onto the connector

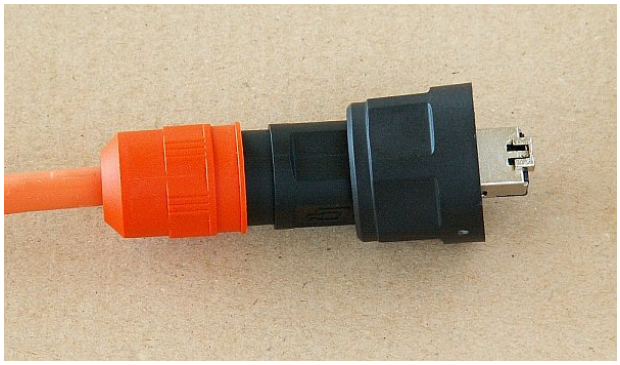


Fig. 5.44: Finished IE-PI-RJ45-FH connector

5.3.3. Fitting an internal IE-PS-RJ45-FH-BK connector

Use the same tools as for fitting the external connector. The internal connector does not have a cover.

a.

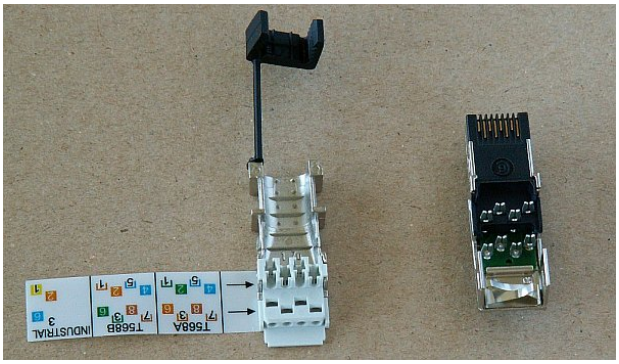


Fig. 5.45: IE-PS-RJ45-FH-BK connector before fitting

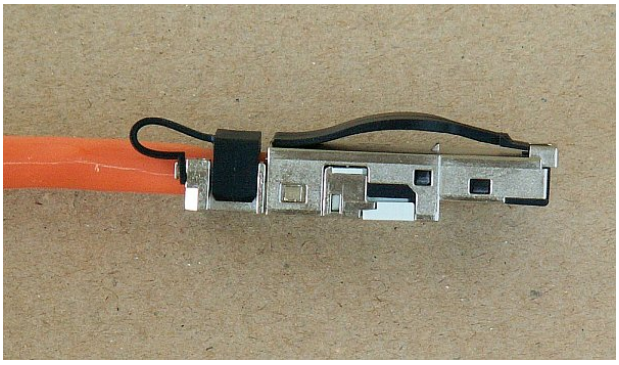
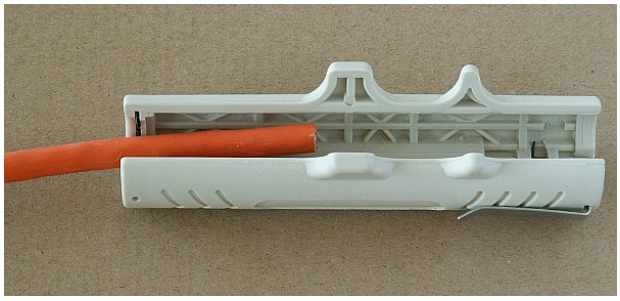


Fig. 5.46: Finished connector IE-PS-RJ45-FH-BK

b. Trim at least 20 mm of insulation from the end of the cable.



Twist the braid forming the cable shielding together and wrap around the cable so that 2-3 loops are next to each other at the end of the insulation. Separate individual pairs of conductors, remove the aluminium shielding from them, cut it off, and separate individual conductors. Cut off the two additional twisted pairs from the thinner wire in the middle (not seen on these images).

Fig. 5.47: Removing insulation

Fig. 5.48: Removed insulation

c.

Fig. 5.49: Twisted shielding

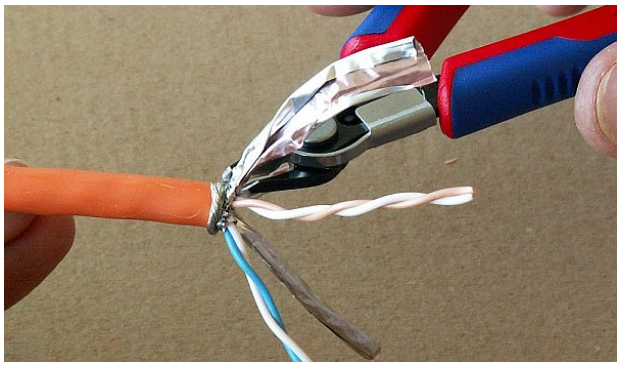


Fig. 5.50: Removing aluminium conductor shielding

d. Prepare individual pairs according to the pinout sticker attached to the connector (T568B) and unwind the two pairs for the bottom part of the connector. Take care not to confuse white conductors from individual pairs.

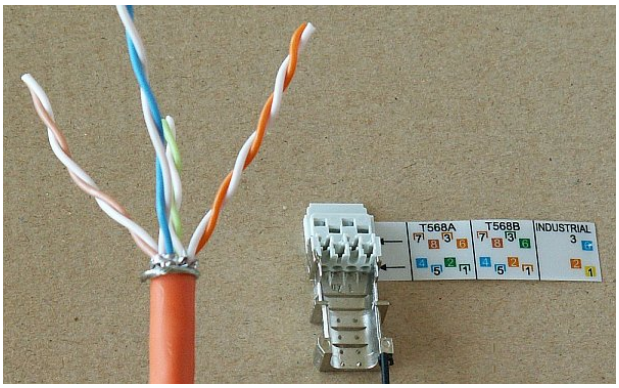


Fig. 5.51: Separated pairs of conductors

First insert the lower row of conductors from the back. Then unwind the others and insert them into the holes for the upper row of conductors, as per the pinout sticker. Ensure that the wrapped around shielding braid is inserted sufficiently to create a good contact with the second part of the connector fitted with sprung contacts. Snap the plastic clamp onto the cable. Squeeze it together tight enough so that it doesn't allow movement of the cable.

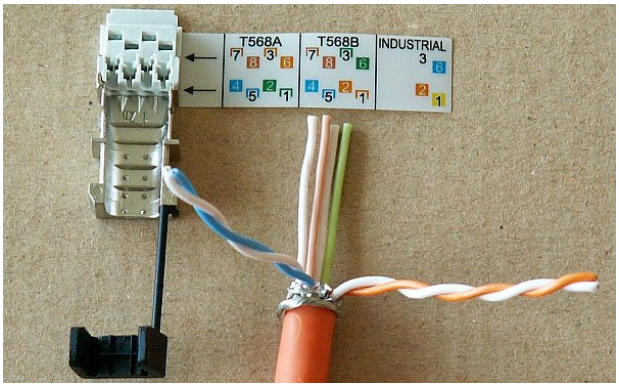
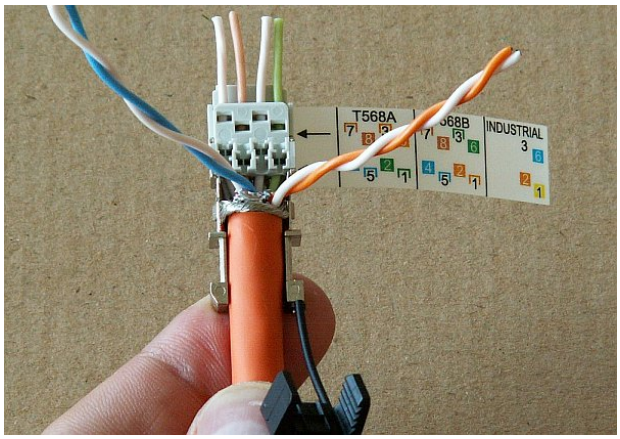


Fig. 5.52: Lower two pairs ready for inserting

e.



Trim the overhanging conductors.

Fig. 5.53: Lower pairs pushed in

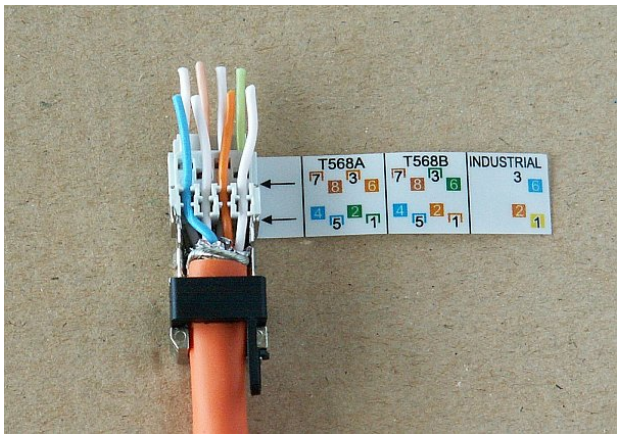
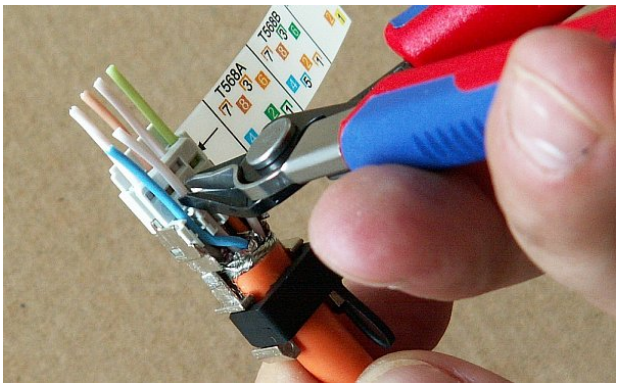


Fig. 5.54: All conductors in the connector

f.



Remove the pinout sticker from the connector and slide on the mate. Clamp the whole connector together until the locks snap into place. Use a pair of pliers with flat heads from the **RAy Tool** set. Ordinary pliers could damage the connector.

Fig. 5.55: Trimming conductors

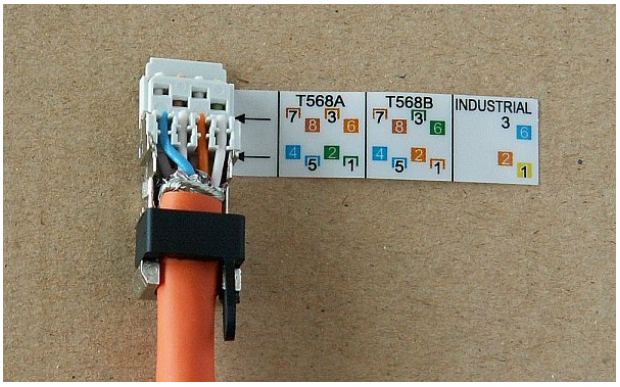


Fig. 5.56: Inserted and trimmed conductors

g.

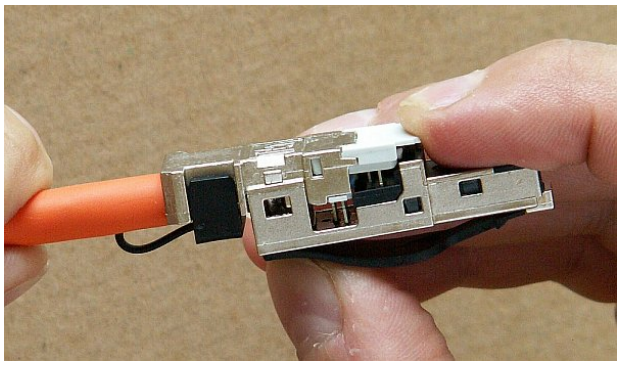


Fig. 5.57: Fitting the mate to the internal connector

Fig. 5.58: Clamping the internal connector together with pliers

5.4. Grounding

The lightning and overvoltage protection system example, designed in accordance with regulation CSN EN 62305.

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.

1.

2. When meeting conditions for ensuring electrical insulation (distance from the lightning conductor) in accordance with article 6.3, it is not recommended to ground the load-bearing structure and antenna to the external air termination network. Ground should be connected to the protective system of the internal LV wiring or grounded internal structures using a CYA 6 mm^2 bonding conductor , see *Fig. 5.59, “Grounding installation 1”*

3. If it is not possible to set up conditions of electrical insulation in accordance with article 6.3 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. 5.60, “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.

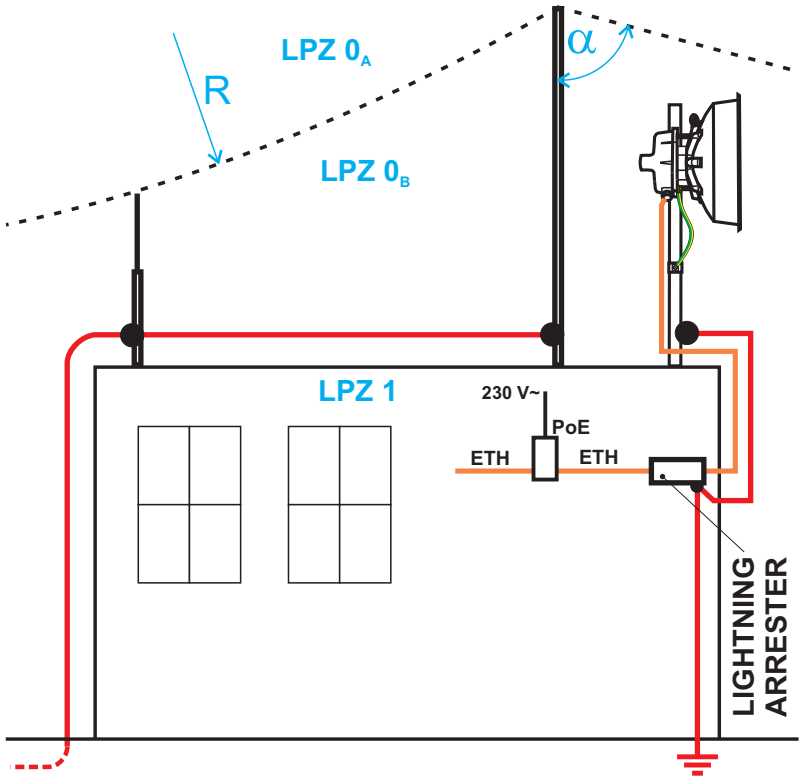


Fig. 5.59: Grounding installation 1

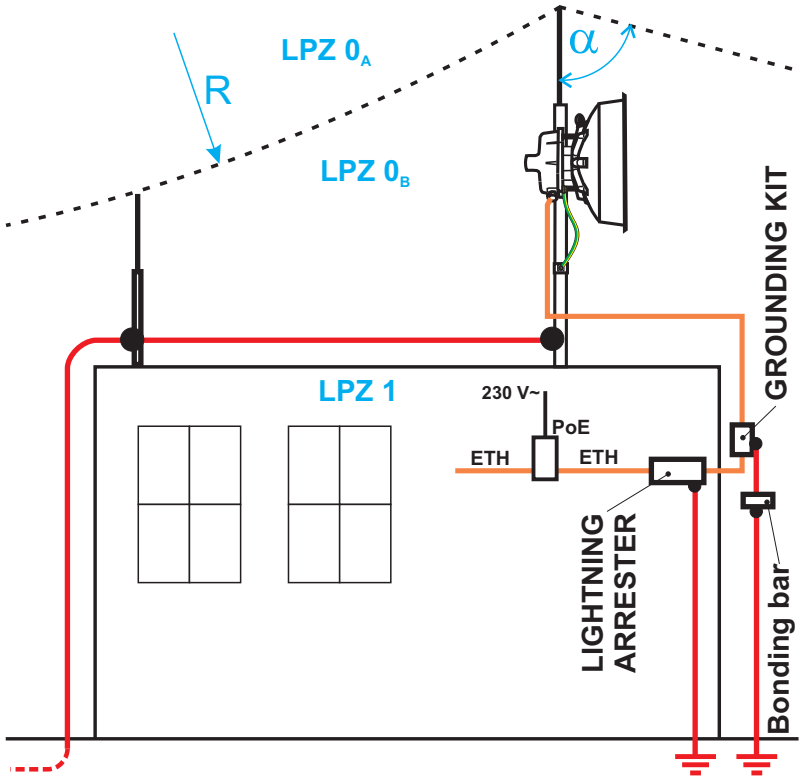


Fig. 5.60: Grounding installation 2

The RAy unit is grounded to the flange by the Ethernet connector using an M6 screw. An insulated copper cable with a minimum diameter of 6 mm^2 terminated with a terminal lug is used as a protective

conductor. The conductor should have a green/yellow sheath across its whole length. For grounding a RAy grounding kit can be ordered as an accessory (see *Section 3.6, "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*[1]. A qualified person must install the antenna.

Racom supplies surge protection for installation on Ethernet cables entering buildings. For more details see *Surge protection*[2].

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 open metal parts must be temporarily grounded.
- The antenna and antenna cable must be grounded at all times. See *Section 5.4, "Grounding"*.
- 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.

[1] https://www.racom.eu/download/hw/ray/free/eng/07_prislusenstvi/ZSA16-en.pdf
[2] https://www.racom.eu/eng/products/microwave-link.html#accessories

Fig. 5.61: Grounding kit for S/FTP 4+2 cable

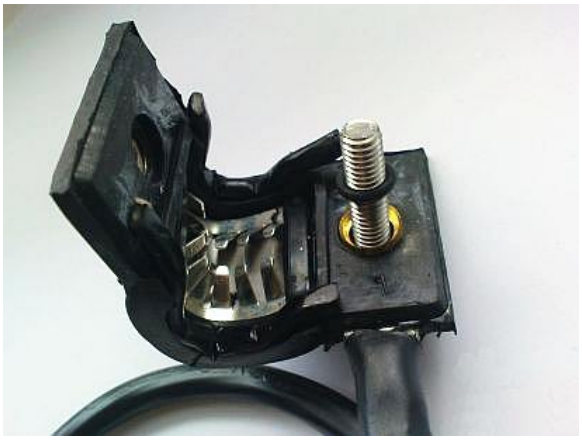


Fig. 5.62: Grounding kit detail

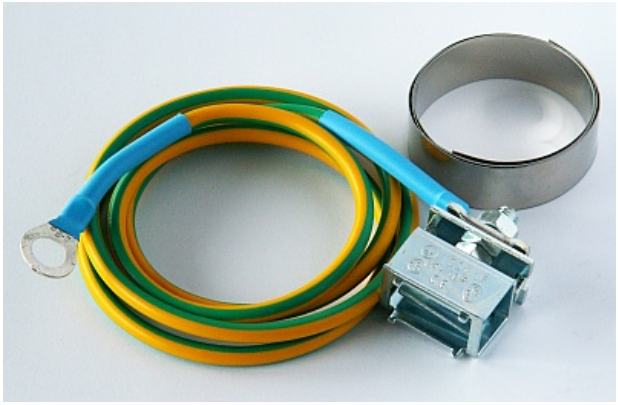


Fig. 5.63: RAy grounding kit

Fig. 5.64: Grounding the FOD unit

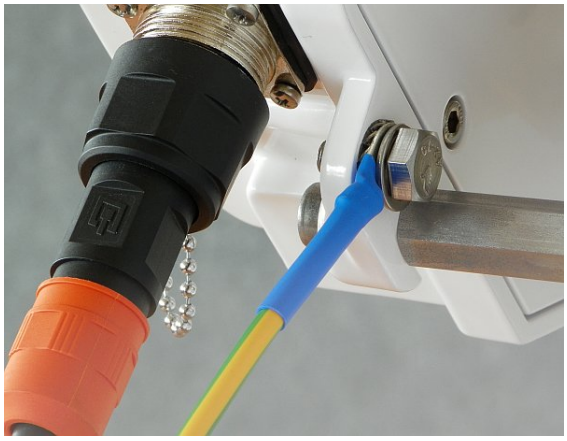


Fig. 5.65: Protective conductor at the FOD unit

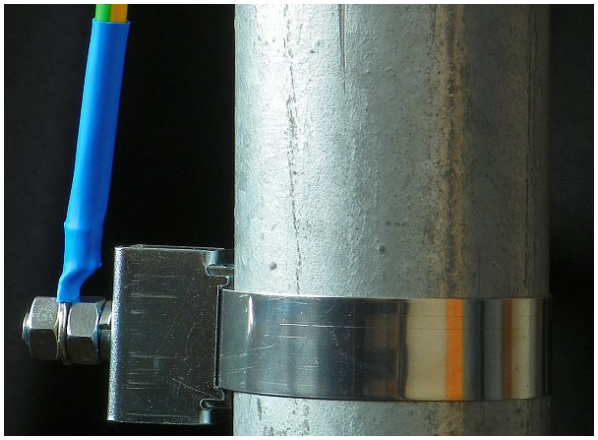


Fig. 5.66: Protective conductor at the mast on a ZSA16 terminal

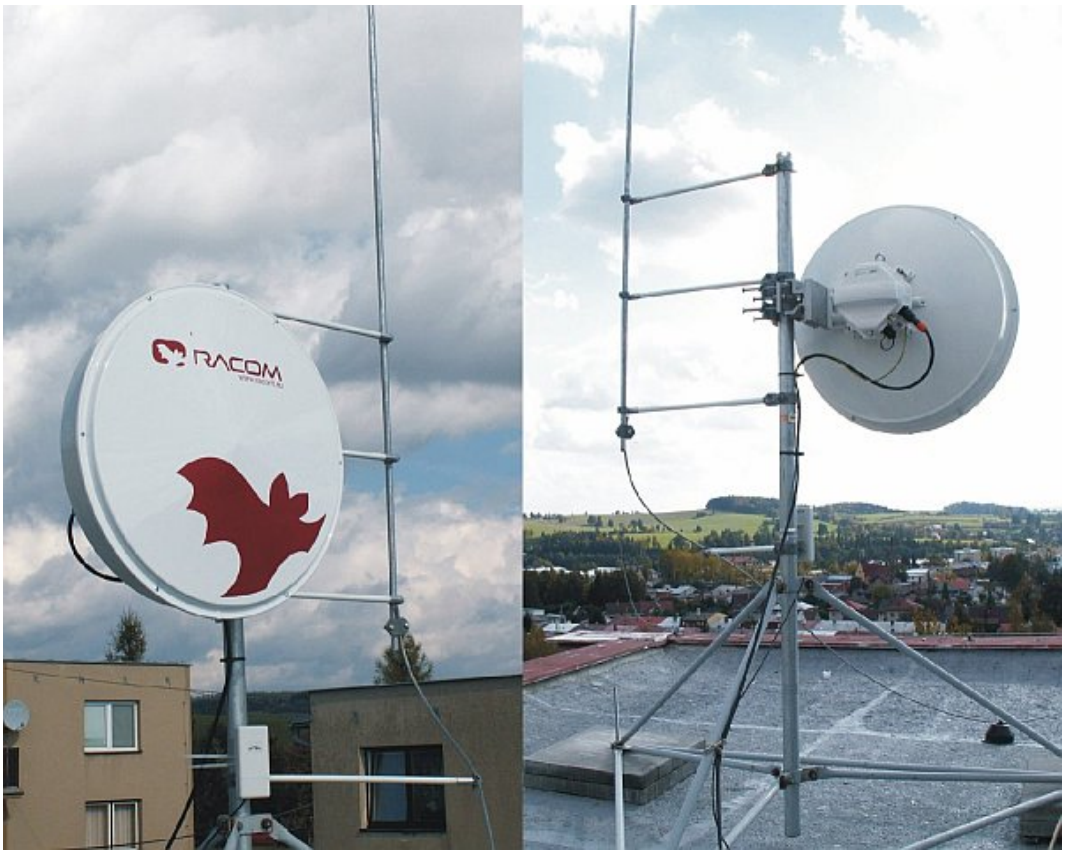


Fig. 5.67: Separated lightning conductor

5.5. Start up

Connect a power supply to the installed FOD unit via ethernet cable and connect the configuration PC. Use an internet browser (such as Mozilla Firefox) to enter the configuration menu.

5.5.1. Noise on the site

Analyse the level of noise in the individual channels using the spectrum analyser under *Diagnostics/Tools*. 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 signal in the upper half H of the range and receive it in the lower half L of the range, or the other way round. A transmitter must not be installed in the half of the spectrum where other units function as receivers.

5.5.2. Antennas directing

When directing the antenna for the first time, use the parameters in the Step-by-step Guide, *Section 4.3, "Tests"* (7 MHz, QPSK, High, +3 dBm). It is good when both sides of the link are available for simultaneous manipulation. Connect a voltmeter to the BNC connector and watch the changes in RSS on a range of 2 V DC. Alternate units on both sides and slowly adjust the antenna vertically and horizontally to find the position with the strongest reception. At the same time look for the main signal maximums. To differentiate between the main and the side maximums refer to *Main and side lobes* paragraph.

RSS measuring

For correctly setting the bridge and positioning it in the right direction it is advisable to connect a PC a use the diagnostic capabilities of the RAy station. In uncomplicated cases it is enough to connect a voltmeter via a BNC connector and adjust to the highest indicated voltage.

Fig. 5.68: Connecting a voltmeter to the BNC connector.

A voltage in the range from 0.5 to 2 V indicates the strength of the received signal. Adjust the antenna with the station to the maximum voltmeter voltage using *point g* of the mounting instructions. If the station is equipped with audible indication: We can also use audible indication which can be switched on in the Diagnostics Tools menu. Switch off audible indication after making any adjustment.

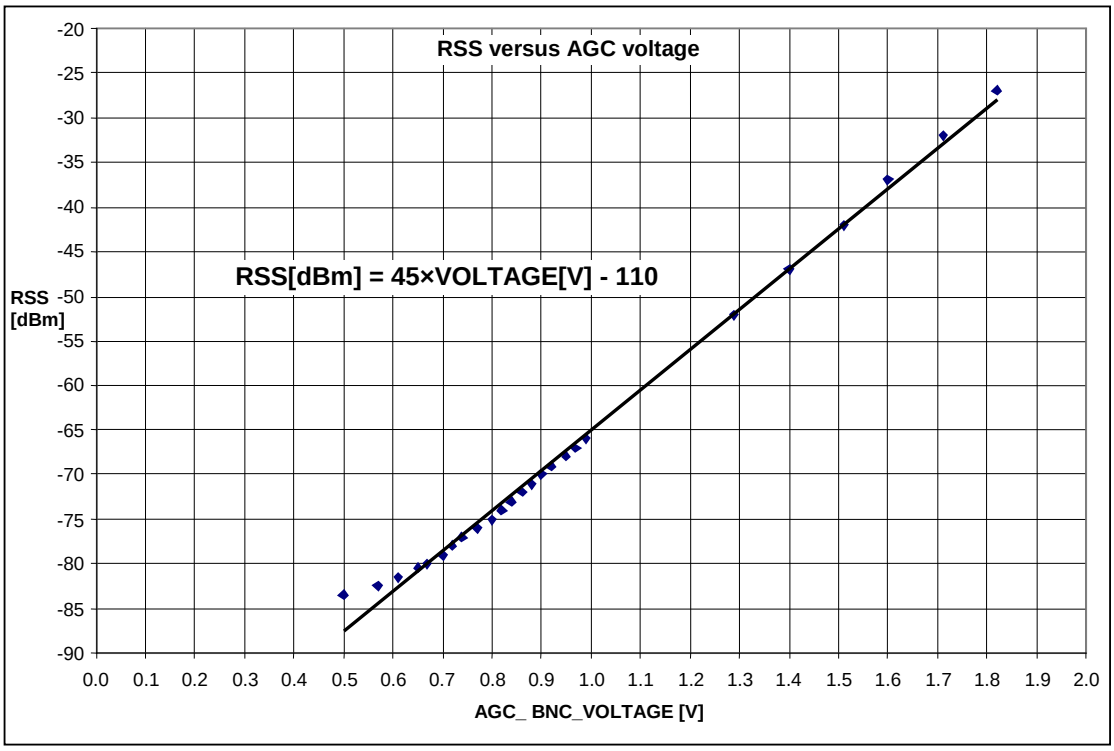


Fig. 5.69: Voltage-signal strength diagram

Main and side lobes

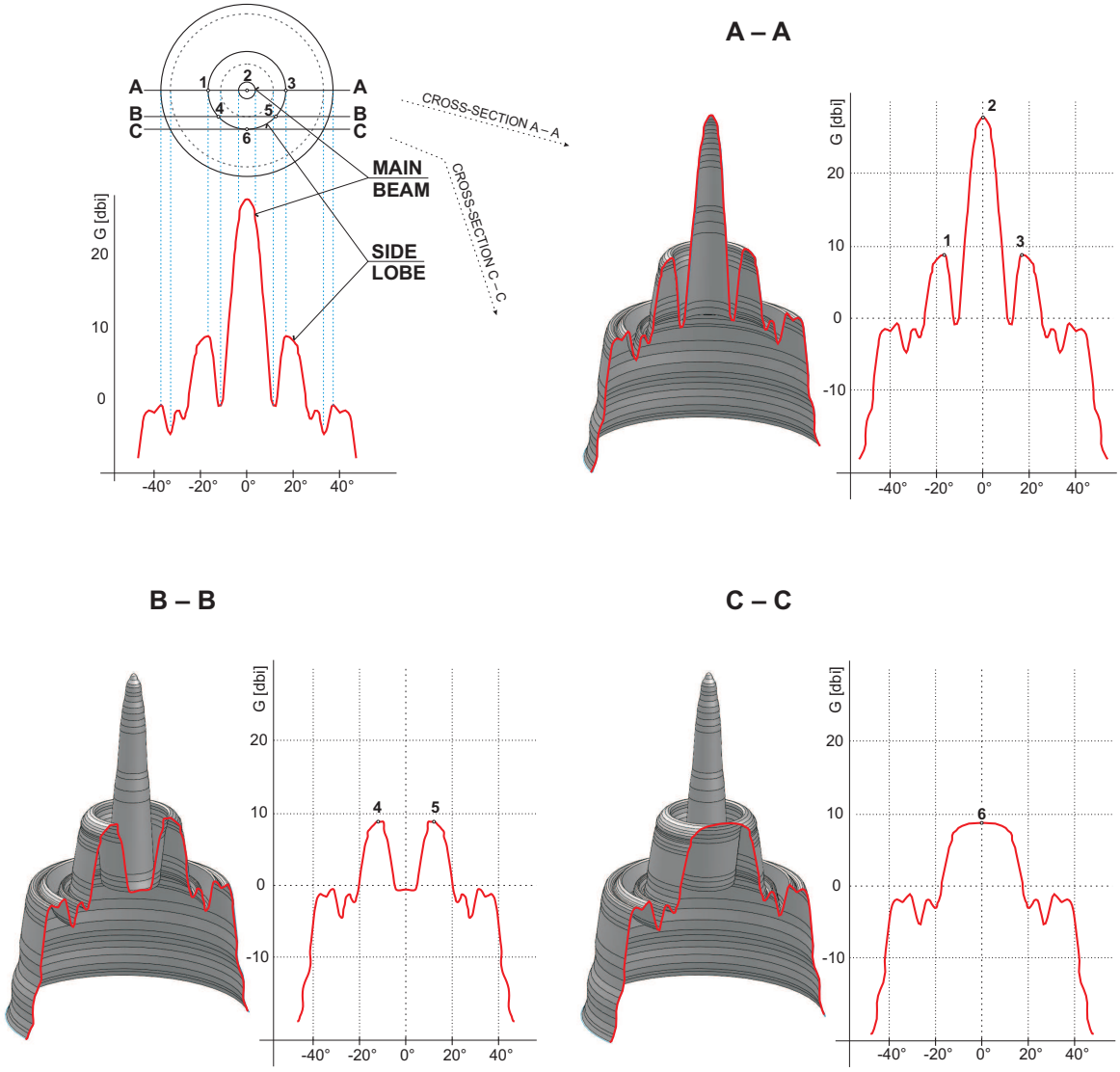


Fig. 5.70: Radiation diagrams

Both antennas should be oriented towards each other using the peaks of 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 signal ca 20 dBm weaker (*https://www.racom.eu/eng/products/microwave-link.html#calculation*[3]).

[3] 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:

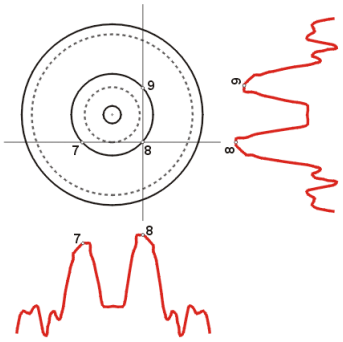


Fig. 5.71: Radiation diagram – incorrect adjustment

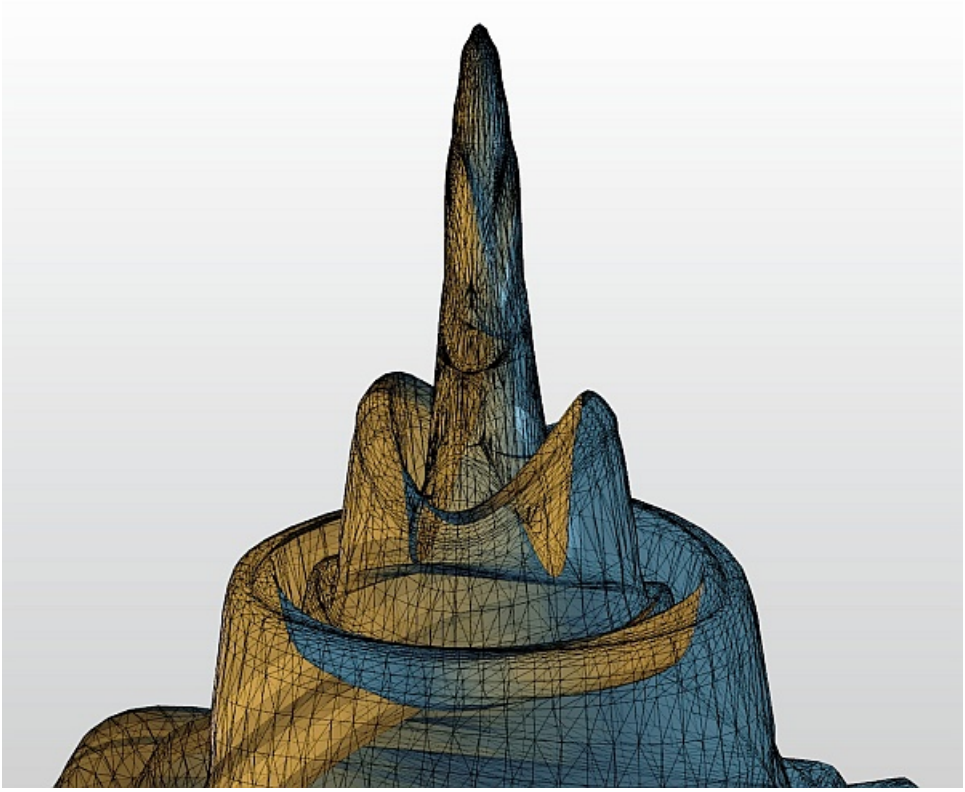


Fig. 5.72: 3D example of more complicated Radiation Pattern

5.5.3. Link test

The antenna directing parameters of the link are shown in the *Status* menu while its quality is characterised by RSS and SNR.

RSS, SNR and BER values are refreshed in real time every few seconds – see *Diagnostics/Realtime*.

When the configuration is finished it is recommended that you reset the statistics using the Clear button in *Diagnostics/Statistics*. This allows an easier diagnostics of the link's reliability over time.

5.5.4. Setup adjustment

After both antennas have been directed, setup operation parameters for the link:

- Bandwidth 28 / 14 / 7 MHz
- Channel number (TX / RX channel)
- Modulation (TX modulation) – ACM is recommended. When choosing a fixed modulation a margin must be taken into account. 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.
- Encoding (Coding strength) – automatic for ACM.
- Transmitting power (RF power)
- Verify and record IP addresses
- Define access channels – https / telnet / ssh / ssh with password

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 memory.

Go to *Device/Configuration/Backup* and save your configuration to file "ray.conf".

This finishes the installation. Further configuration can be performed remotely. For better orientation all menus feature **help**. The next chapter contains their transcription.

6. Advanced Configuration

This chapter is identical with the content of **Helps** for individual menu.

6.1. Status

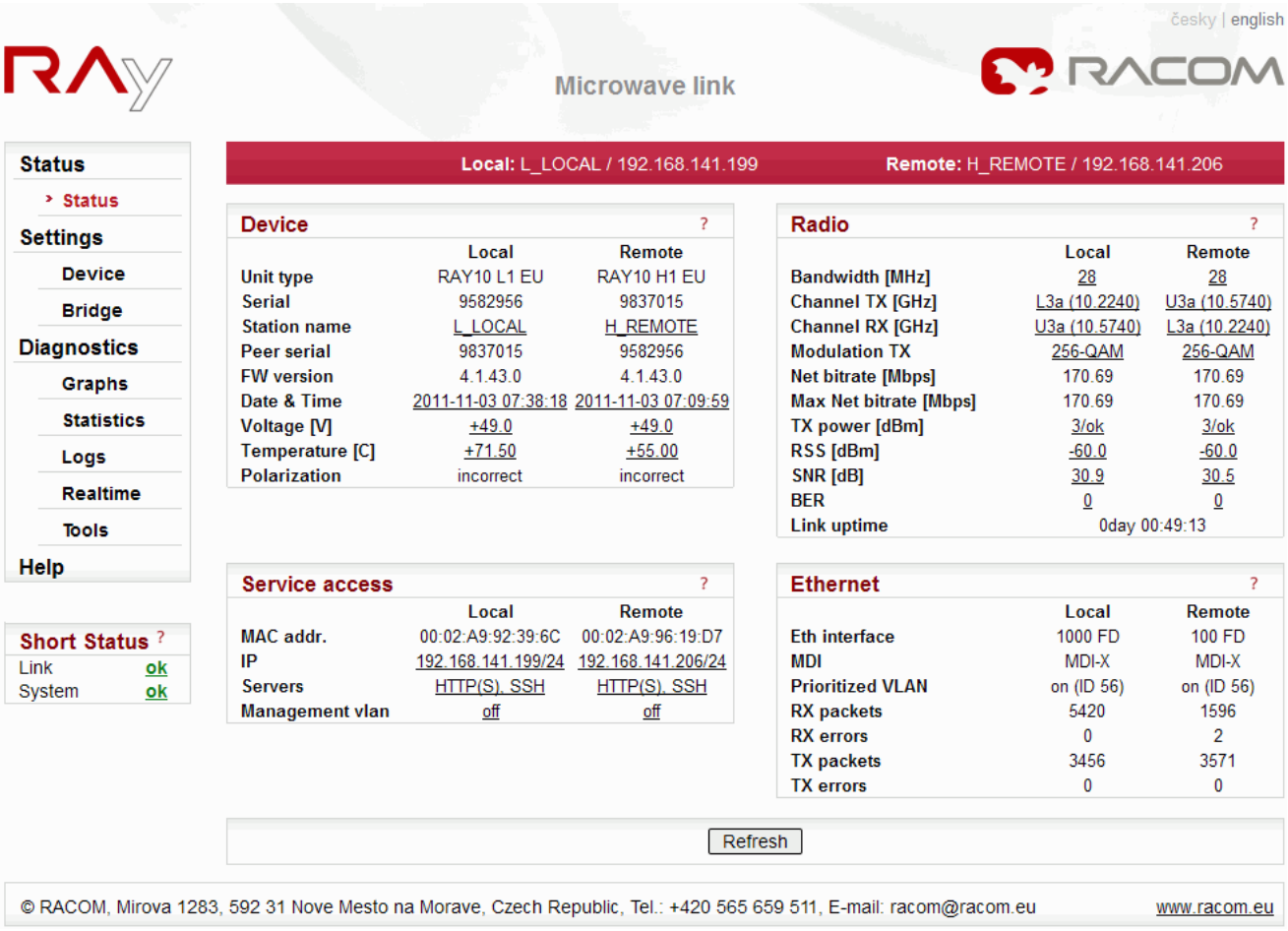


Fig. 6.1: Status Menu

6.1.1. Status – Device

Device section provides basic information on the local and remote units. Please note, that the status page displays information valid at the moment of opening the page or pushing the "**Refresh**" button.

Unit type	Unit manufacturing label, conversion Unit type = Ordering code: RAY10L1 = RAy10-LA (Low frequency part, band A) RAY10H1 = RAy10-UA (Upper frequency part, band A) RAY10H1EU = RAy10-UB (Upper frequency part, band B) RAY10H2EU = RAy10-UB-2 (Upper frequency part, band B, 2 connectors) The order code use U (Upper) letter for unit identification, instead of H (High), see *Ordering code*.
Serial	Production serial No. Every unit has a unique serial number (a link consists of two units).
Station name	Unit name assigned by user

Station location	Unit location assigned by user The text is displayed trimmed to 14 characters followed by three dots. The tool-tip with whole text is given, when mouse pointer is located above the text.
Peer serial	Serial No of the peer unit which is supposed to form the Point-to-Point link with the unit being configured. The red exclamation mark is displayed in the case of the disconnected radio link because of incorrect Peer serial, see *Short Status*.
SW ver.	Firmware version and subversion
Date & Time	The internal real-time clock. The clock is set manually or it is synchronized with SNTP server and is set identically in both units
Voltage [V]	Voltage measurement at the input pins of the power supply connector
Temperature [°C]	Unit internal temperature
Polarization	The current state of the signal polarization (according to the physical installation of the unit). Local and Remote units are indicated separately to be able to check proper installation. The polarization is given by the orientation of the main handle-bar of the unit. The proper position of the cable is sideways down.

6.1.2. Status – Service access

Service access section provides basic information of the unit management options.

MAC addr	HW address of the ethernet module
IP	IP address in the standard decimal "dot" notation, including the bit width of netmask after the forward slash.
Servers	Enabled servers for service access (HTTPS and/or Telnet and/or SSH)
Management vlan	Service access via management VLAN only

6.1.3. Status – Radio link

Radio section provides basic information on settings and current state of the radio link.

Bandwidth [MHz]	Nominal channel width. Both units in a link have to use the same bandwidth.
Channel TX [GHz]	
Channel RX [GHz]	Channels used, expressed both in GHz and channel Nos according to standard.
Modulation TX	TX modulation currently in use. Letters ACM are displayed when the Adaptive Coding and Modulation mode is set.
Net bitrate [Mbps]	Channel capacity currently available to the user
Max Net bitrate [Mbps]	The maximum RF channel capacity according to installed SW key.
TX power [dBm]	RF output power level currently used. If the transmission output is over 3 dBm lower than configured, then the red exclamation mark is displayed instead of letters *ok*, see *Short Status*.

RSS [dBm]	The intensity of the received signal is between −30 and −85 dBm. The weaker signal is identified as −110 dBm.
SNR [dB]	Signal to Noise Ratio
BER	Bit Error Rate registered at the receiving end during the last second
Link uptime	Time elapsed since the current link connection has been established

6.1.4. Status – Ethernet bridge

Ethernet bridge section gives short overview of Ethernet interface settings and data flow.

Eth interface	Status of the 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) is shown. The red exclamation mark is displayed in the case of the disconnected Ethernet link in the opposite unit, see *Short Status*.
MDI	Status of internal crossover of twisted pairs of the ethernet cable (MDI-X = internally crossed pairs, MDI = direct connection, N/A means an unknown state).
Prioritized VLAN	VLAN packets are permanently supported. The state "on (ID 4)" indicates the prioritized treating of the VLAN id 4 packets. The state "off" indicates that all VLAN packets are treated equal.
RX packets	Counter of all received packets.
RX errors	Counter of received packets containing errors.
TX packets	Counter of all transmitted packets.
TX errors	Counter of packets with errors during transmitting.

6.2. Settings Device

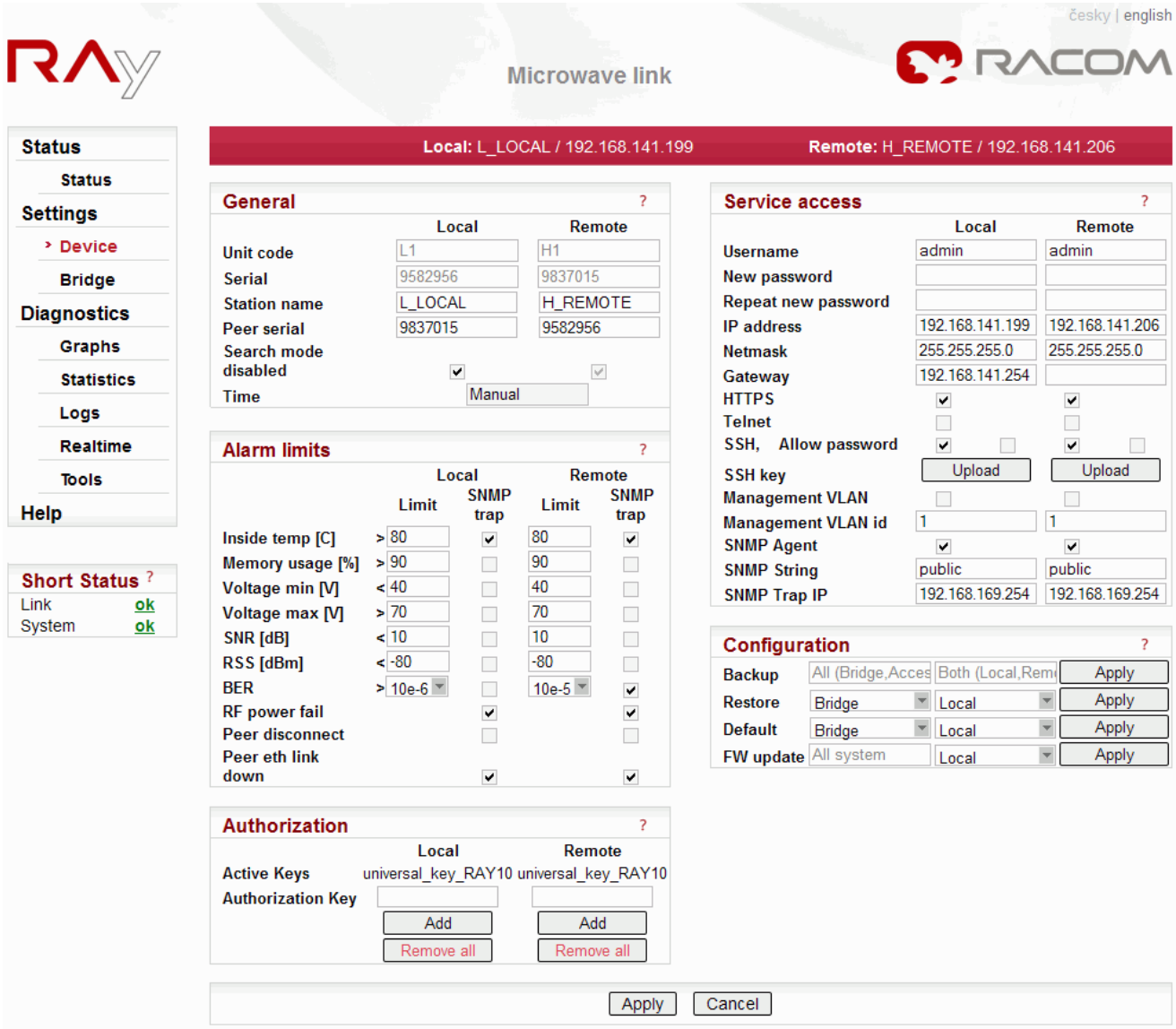


Fig. 6.2: Device Menu

6.2.1. Device – General

Section General contains fundamental system settings, including authentication parameters

Unit code The unit code, e.g.:
L1 - the Lower unit broadcasts in the lower group of channels
H2 - the Upper unit broadcasts in the upper group of channels, 2 stands for two separate ethernet connectors, one for data and one for service access.
The *Ordering code* use U (Upper) letter for unit identification, instead of H (High) .

Serial Unit serial number, unique for the H unit and the L unit.

Station name A name assigned to the device by user. Maximum length is 64 characters, the first character has to be a letter or a number and characters allowed are the letters of english alphabet a-z/A-Z, numbers 0-9 and two special characters "_" and "-".

Station location The station location assigned to the device by user. Maximum length is 254 characters. The characters allowed are numbers 0-9, letters of english alphabez a-z/A-Z and special characters: "_.,:;/() -". The quotation marks are NOT allowed.

Peer serial Serial No of the peer unit which is supposed to form the Point-to-Point link with the unit being configured.

Search mode disabled Setting of this option has to be the same for both Local and Remote units. Make this setting prior to unit installation (especially when replacing damaged unit):

- **on**, checked - In the case of the mismatched Local "Peer serial" and Remote "Serial", the link can not be established.
- **off**, unchecked - Even if the Local "Peer serial" and Remote "Serial" are not matched, the both units can be configured. Warning - the user data traffic is interrupted. Such a system status is indicated as a Short Status "Link *connecting*" message. Exclamation mark is displayed in the Status menu next to the mismatched "Peer serial" configuration item. The whole link is fully operational immediately after matching of the Local "Peer serial" with Remote "Serial" for both units.

Time Clicking the Time box brings up the Time dialog window. The first selection is whether the time shall by synchronized manually or through the SNTP protocol from a time server.

- **Time manual** – Date and Time shall be filled in, Time zone and Daylight saving selected.
- **Time SNTP** – Server IP address and synchronization period shall be filled in, Time zone and Daylight saving selected

- WARNING -
When the time zone and/or daylight saving is changed, the GMT time is kept unchanged within the unit. The operating system is however restarted to avoid unpredictable behaviour due to the local time change.

After clicking Ok in the Time window, the configuration has to be confirmed by clicking the main **Apply** button on the Device page

6.2.2. Device – Alarm limits

Alarm limits section allows the user the set the limits on both link performance and environment conditions. Whenever a configured limit is reached, an alarm is written in the alarm log. At the same time, the Warning or Alarm appear in the Short Status. The consequent SNMP trap signal generation can be controlled individually for each item by checking the respective tick-box.

List of alarms and respective default limit values:

warning

Inside temperature [°C]	>80	Unit internal temperature high level alarm.
Memory usage [%]	>90	System memory usage high level alarm.
Voltage min [V]	<40	Supply voltage - low level alarm.

Voltage max [V]	>70	Supply voltage - high level alarm. The SNMP trap is common for both - high and low level alarms. The SNMP trap is common for both - high and low level alarms.
SNR [dBm]	<10	Signal to noise ratio low level alarm.
RSS [dBm]	<-80	Received signal strength low level alarm.

alarm

BER	$>10^{-6}$	Bit error rate high level alarm.
RF power fail		RF output power amplifier failure.
Peer disconnect		Radio link to peer station is interrupted.
Peer eth link down		User Ethernet link of the peer station is disconnected.

6.2.3. Device – Authorization

Some RAy features may be controlled by the sw key installed. Typically the transmitted bitrate or power is limited by such key.

Active Keys All valid keys in the station are listed here:

- **Speed** – maximal accessible transmiting bitrate is defined by the *speed_xx* key. Consequently the parameters Bandwidth, Modulation and Coding strength can be set in a limited range only. The received bit rate is never limited, hence different keys can be installed in the local and remote units. The "Remove all" button clears all keys installed in the unit. Without keys the unit transmits with the minimal bit rate of 8.45 Mbps only.
- **Power** – maximal accessible RF power is +3 dBm without this key and +10 dBm with installed *rfPower* key.

Authorization Key Text box for input of a key.

Add The key activation button. The key typed in the text box will be activated in the respective (local or remote) unit immediatelly after clicking OK in the dialog box (there's no need to use the Apply button).

Remove all Before removing all keys, it is recommended to configure the link to comply with the limitations (i.e. 7 MHz bandwith, QPSK modulation with high coding strength and max. 3 dBm output power for Ray10). If the configuration left does not comply with the no-key limitations, the default configuration is forced in after the next restart of the unit, which may cause a disconnect of the radio link. Immediatelly after executing the "Remove all" command the state of the link does not change, except the ACM level dropping to the lowest speed (if ACM is configured). A new key should be entered and/or the configuration should be changed to comply with the active limitation, otherwise the link may be disconnected after the next restart.

6.2.4. Device – Service Access

Service Access section gives full control over different ways to configure and manage the link.

Username	The login name selected by the user. Maximum length is 25 characters, the first character has to be a letter and characters allowed are the letters of english alphabet a-z/A-Z, numbers 0-9 and one special character "_".
New password	The new password selected by the user. The length is 5 to 8 characters. The characters allowed are the letters of english alphabet a-z/A-Z, numbers 0-9 and four special characters ".", ":", "_" and "-".
Repeat new password	A new password has to be repeated to avoid typing errors
IP address	The service and management interface IP address, default 192.168.169.169 in L station and 192.168.169.170 in H station. Four 169.254.173.236/30 addresses are used for internal communication. Not be used as a service IP address.
Unknown management IP address	The LLDP protocol is implemented for the sake of the management IP address discovery. The LLDP protocol message is sent as a broadcast every 60s with the following informations: • **IP address** – item: Management address • **Serial number** - item: System Description • Station type, e.g. **RAy10_L** - item: Chassis Subtype • **DATA_PORT** for one Eth version, or **SERVICE_PORT** for the two Eth version - item: Port Subtype The LLDP message can be captured and converted to human readable format by any LLDP client. The Wireshark IP traffic analyzing tool is a very nice tool for that purpose (both Windows and Linux license free versions are available). When using Wireshark - the Capture filter "ether proto 0x88cc" can be used to ease the job.
Netmask	The service and management interface netmask, default 255.255.255.0
Gateway	The service and management interface default gateway, no gateway by default
HTTPS	Tickbox to enable the HTTPS server. When disabling, remember that you will not be able to access the unit by web browser afterward! Enabled by the Open-access default.
Telnet	Tickbox to enable the Telnet server. Telnet server provides CLI (Command Line Interface) for simple telnet clients. Disabled by default.
SSH	Tickbox to enable the SSH server. SSH server provides a secure CLI connection. It should be the only server left running when security of the link management is the primary concern. Enabled by both Open and Secure-access defaults.
Allow passwd	Enables SSH access by password. Disabled by the Secure-access default.
Management VLAN	Tickbox to enable service access only via the managent VLAN (it disables access via untagged LAN packets). See Management VLAN id below. This feature is disabled by default. **- WARNING -** Switching the Management VLAN on/off affects all types of access from the LAN – make sure you will not be cut off afterwards. It is recommended to switch only one end of a link at a time.
Management VLAN id	Managent VLAN id, default 1. This field has to be filled in even when the Management VLAN tickbox is not checked.
SSH key	SSH key is uploaded from a file.

SNMP agent Enabling the SNMP agent to monitor the unit's operation using traditional NMS (Network Management Systems).

SNMP String SNMP community string. Maximum length is 256 characters. The characters allowed are the letters of english alphabet a-z/A-Z, numbers 0-9 and four special characters ".", ":", "_" and "-".

SNMP Trap IP An IP address to which SNMP trap datagrams are sent.

6.2.5. Device – Configuration

Configuration section provides tools for saving/restoring configuration data to/from a file. The configuration data file can be edited by an ordinary text editor. Service Access section gives full control over different ways to configure and manage the link. The factory default setting Access open is shown.

Backup Complete configuration settings are saved to a file named *ray.conf*. The configuration file can be edited by any common text editor.

Restore The configuration data are uploaded to the unit.
Type of configuration to be uploaded:

- **Bridge** – Bridge parameters (Radio channel, Ethernet, ...)
- **Access** – Access parameters (HTTPS, Telnet, SSH, SSH Allow passwd, IP address, Netmask, Gateway, Management VLAN, Management VLAN id)
- **All** – Bridge together with Access

Destination:

- **Local** – Local unit only
- **Remote** – Remote unit only
- **Both** – Both units

When the configuration file was downloaded from a disconnected link, the upload is possible to the local unit only.

- WARNING -
the management OS is restarted after changing the time zone and daylight saving.

Default The selected groups of parameters are set to default values.).
Type of configuration:

- **Bridge** – Bridge parameters (Radio channel, Ethernet, ...)
- **Access secure** – Access parameters default to values which ensure the secure access (HTTPS=off, Telnet=off, SSH=on, SSH Allow password=off, Management VLAN=off).

Warning

The web interface is disabled on activating Access secure default parameters. The SSH access using password is disabled as well. The only possibility to configure the station is CLI with SSH keys authentication.

- **Access open** – Access parameters default to values which ensure simple and open access (HTTPS=on, Telnet=off, SSH=on, SSH Allow password=off, Management VLAN=off).
- **All secure** – Bridge + Access secure

- **All open** – Bridge + Access open

  Management access default values:

  IP address – unit L: 192.168.169.169
  unit H: 192.168.169.170
  Username: admin
  Password: admin

Destination:

- **Local** – Local unit only
- **Remote** – Remote unit only
- **Both** – Both units

- WARNING -
the management OS is restarted after changing the time zone and daylight saving.

Update

Update of the **unit firmware** is possible through this menu. The fw pack is labelled as bm1-x.x.x.x.cpio. The unit is rebooted after the firmware change.

Warning

The unit power must not be interrupted during the firmware upgrade!

Destination:

- **Local** – Local unit only
- **Remote** – Remote unit only
- **Both** – Both units

Apply – choose the firmware pack in a new window and by the next Apply button start the transfer and installation of the new firmware. The process takes about 6 minutes and displays the next messages:

- **Start** – Please wait. Transferring data to update (green)
- **1 min** – Please wait. Transferring data to remote unit (green)
- **3 min** – Update software. Wait approximately 5 minutes until RAy10 unit firmware installation is finished. DO NOT TURN OFF THE POWER UNTIL THE WHOLE PROCESS IS COMPLETED! (grey)

  or – in case of choosing the same fw version -
- **Error Remote unit:** Versions of the software are identical (red)
- **6 min** – it is not possible to get a report after the restart, please verify the result on the Status screen. The pings can be send from PC to RAy to get a faster feedback, the update is ready after receiving ping answer (in case of L station: "ping 192.168.169.169 -t", In case of H station: "ping 192.168.169.170 -t")

In the same way, we can insert into RAy unit the ***package with manuals*** labelled as bm1-doc-x.x.x.x.cpio

Note

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

6.3. Settings Bridge

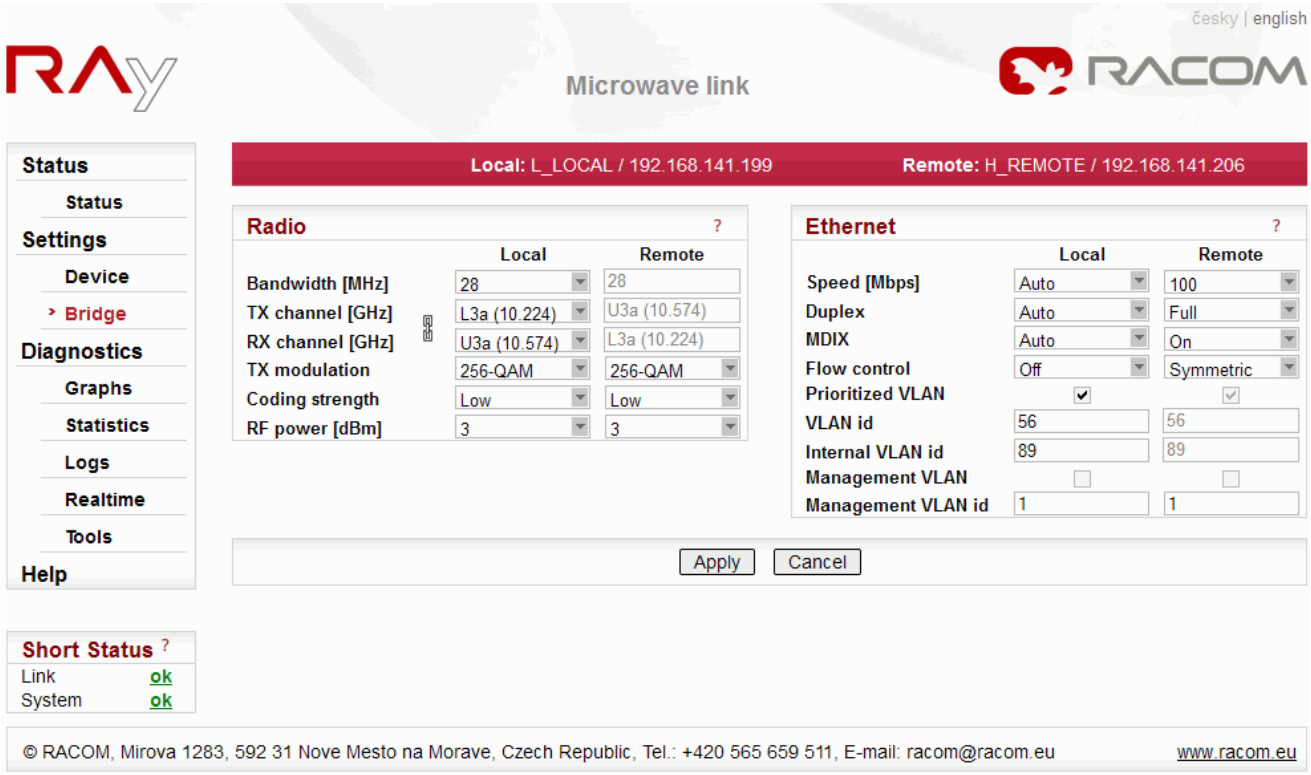


Fig. 6.3: Bridge Menu

6.3.1. Settings – Radio link

Radio link section comprises all necessary settings which influence the radio part operation. Some parameters (Bandwidth, Modulation, Coding strength and RF power) are influenced by installed Authorization Keys. See the menu Settings/Device/Authorization.

Bandwidth [MHz]
One of standard channel widths can be selected. This parameter must be set identically in local and remote.

Channel TX [GHz]
Channel RX [GHz]
TX and RX channel frequencies can be selected from the list of available channels. Normally, the standard duplex spacing is maintained, hence setting one channel box results in automatic change of the remaining three. When special conditions require different duplex setting than the standard one, the TX-RX lock symbol may be unlocked. Then the TX and RX channels can be set independently. The respective channel at the peer side is again changed automatically.
Warning: Non-standard duplex setting leads to non-effective use of the spectrum and should be used in well-justified cases only.
RAy10-xB version:
Channels are marked as L1a... according to CEPT/ERC/REC 12-05 E (2007).
The "L" and "U" letters stand for the lower and upper segments of the range.
The "a" index complies with CEPT standards, other indices "c", "e"... identify shifted channels (in this case, by 7 MHz). This allows selecting channels according to other national standards.
Channel identification also requires the bandwidth used - 28/14/7 MHz. For an overview of bandwidths and their mean frequencies refer to the manual - *table of nominal frequencies*.

Modulation TX The desired modulation is selected from the list. When ACM (Adaptive Coding and Modulation) mode is selected, the modulation is selected automatically by the device, according to the signal strength and quality. This way the link always operates with the maximum bit rate allowed by signal conditions, up to the limit given by the Authorization key. When signal deteriorates, e.g. because of a heavy rain, the modulation rate decreases (e.g. from 256-QAM to 128-QAM). That results in the respective decrease of the throughput, nevertheless the link is not interrupted completely.
The ACM always uses the coding=High, except when the maximum speed limited by the Authorization key corresponds to coding=Low. Then the Low coding is used for this maximum speed only.
The ACM mode should be set on both units. The second possibility is the manualy set modulation on both units. The modulation can be set manualy from QPSK to 256-QAM, equally or differently on the unit L and H.

Coding strength The FEC (Forward Error Correction) coding is always used over the RF channel. Its strength means its ability to combat channel impairments, to avoid frame losses because of data errors. The stronger the coding, the higher the overhead, and consequently, the lower the net throughput. If the link speed is your highest priority and your application can tolerate slightly higher number of lost frames, you may want to use weaker coding. Normally the stronger coding is the recommended option. Note that when the ACM mode is configured, the coding is controlled automatically, hence the manual setting of it does not affect the link.

RF power [dBm] The RF output power desired. To access the full power of +10 dBm, the rfPower Authorization Key has to be activated. Without the rfPower Key the power range is limited to +3 dBm.

6.3.2. Settings – Ethernet bridge

Speed [Mbps] One of the ethernet standards which determines bitrate can be selected (10BASE-T, 100BASE-TX or 1000BASE-T). "Auto" (default setting) allows automatic negotiation of bitrate with the wire-link peer.

Duplex Possibility to select transmitting and receiving simultaneously (full duplex) or one-at-a-time (half duplex) on the ethernet link. "Auto" (default setting) allows automatic negotiation of this feature with the wire-link peer.
Auto and 1000 speeds may only be used with Duplex auto settings.
100 and 10 speeds may be combined with Duplex full and Duplex half.

MDIX Media Dependent Interface Crossover indicates the ability of the interface to crossover the twisted pairs of cable internally. "Auto" (default setting) allows automatically detect and set crossover if it is necessary (Auto-MDIX).

Flow control Ethernet flow control is a mechanism for temporarily stopping the transmission of data on an ethernet network.

Prioritized VLAN RAy wireless bridge has the ability to specially treat VLAN packets. Selection "On" enables priority treatment of packets having the selected VLAN id (see below).

VLAN id Packets with this identification number in their VLAN header are preferentially treated when Prioritized VLAN "On" is set.

Internal VLAN id The RF bridge uses one VLAN id for internal purposes. It can be changed if there is a conflict with user data.
The L2/H2 version of the RAy uses internally one more VLAN id, which is set to value 'Internal VLAN id' plus 1.

Management VLAN	Tickbox to enable service access only via managent VLAN (it disables access via untagged LAN packets). See Management VLAN id below. This feature is disabled by default. **- WARNING -** Switching the Management VLAN on/off affects all types of access from the LAN - make sure you will not be cut off afterwards. It is recommended to switch only one end of a link at a time.
Management VLAN id	Managent VLAN id, default 1. This field has to be filled in even when the Management VLAN tickbox is not checked.

6.4. Diagnostics Graphs

Fig. 6.4: Diagnostics Graphs Menu

Graphs section provides graphical information on history of basic link parameters. The main page gives access to seven graphs:

- RSS
- BER
- SNR
- Internal temperature
- Net bitrate
- Voltage
- Ethernet traffic

with last 24 hours course. Clicking one of the mini-graphs or selecting the desired parameter from the listbox opens the Detailed graph page.

Primary	Primary parameter to be displayed
Secondary	Optional secondary parameter to be displayed in the same graph
Side	Graph from Local or Remote or Both ends of the link can be selected
Show Alarm	Active alarms are indicated on the graph time axis
Interval	Time period displayed. To use time intervals it is recommended to synchronise the time zone and daylight saving settings in your PC and RAy unit. To do this, go to the *Status /Device /Date&Time menu*, and then use the *Time* submenu. The X, Y axes interval will be set up automatically using the extreme values of the monitored interval. For that reason, to display a *Custom* interval up to present, select *Interval To* greater than the present time. To refresh intervals *Last hour, Last day…* up to now you need to reload web page in your browser, the Refresh button itself is not enough.
Legend	Legend explains meaning of the different colors
Zoom	Zoom in by dragging the mouse, get back to full scale by Reset zoom

Refresh button applies selected changes

6.5. Diagnostics Statistics

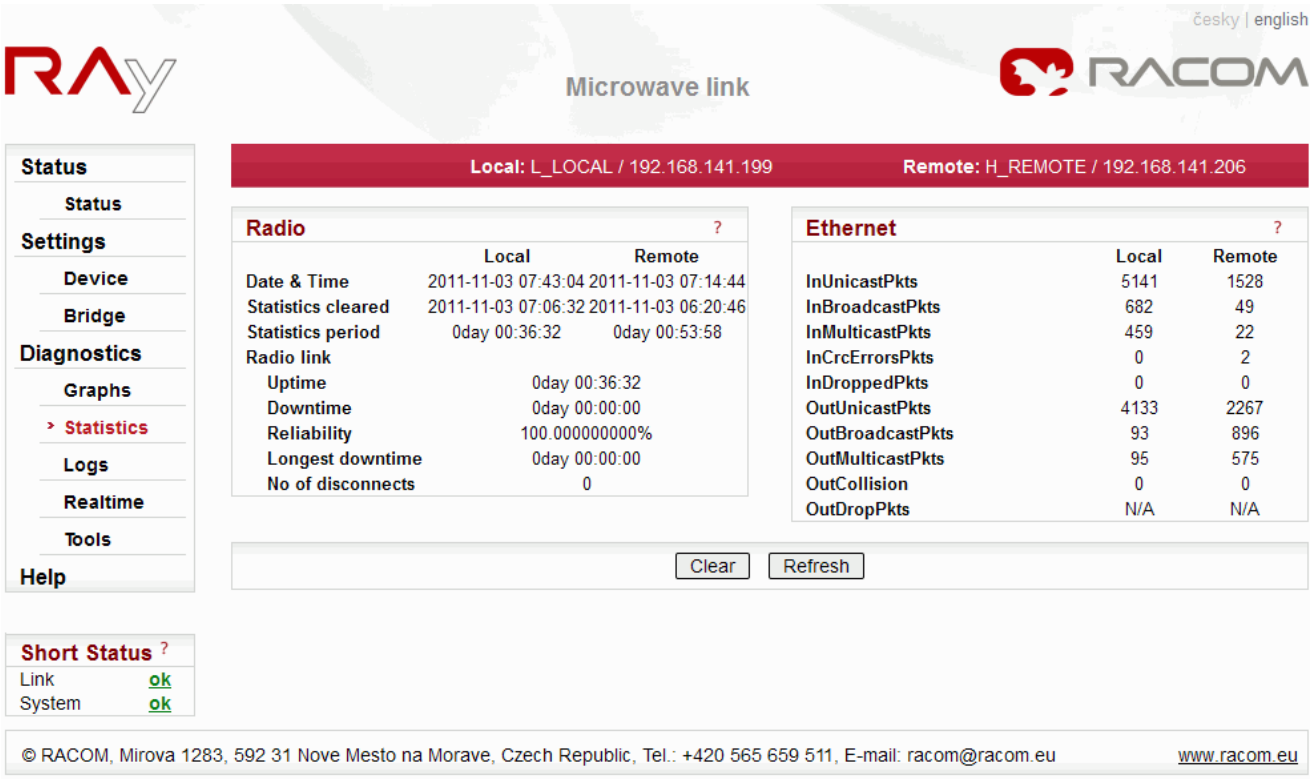


Fig. 6.5: Diagnostics Statistics Menu

Date & Time	Internal clock date and time
Statistics cleared	Date and time of clearing the statistic counters
Statistics period	Time elapsed from the clearing of the statistics

Radio link

Uptime	Sum of time intervals when the radio link was connected
Downtime	Sum of time intervals when the radio link was disconnected
Reliability	"Uptime" to "Downtime" ratio
Longest downtime	The longest downtime period recorded
No of disconnects	Number of disconnect events

Ethernet bridge

InUnicastPkts	Counter of unicast packets received
InBroadcastPkts	Counter of broadcast packets received
InMulticastPkts	Counter of multicast packets received
InCrcErrorsPkts	Counter of corrupted packets (CRC error) received
InDroppedPkts	Counter of received packets, which were discarded because of buffer overflow
OutUnicastPkts	Counter of unicast packets transmitted
OutBroadcastPkts	Counter of broadcast packets transmitted
OutMulticastPkts	Counter of multicast packets transmitted
OutCollisionPkts	Counter of detected collisions during transmitting
OutDropPkts	Counter of transmitted packets, which were discarded because of buffer overflow

6.6. Diagnostics Logs

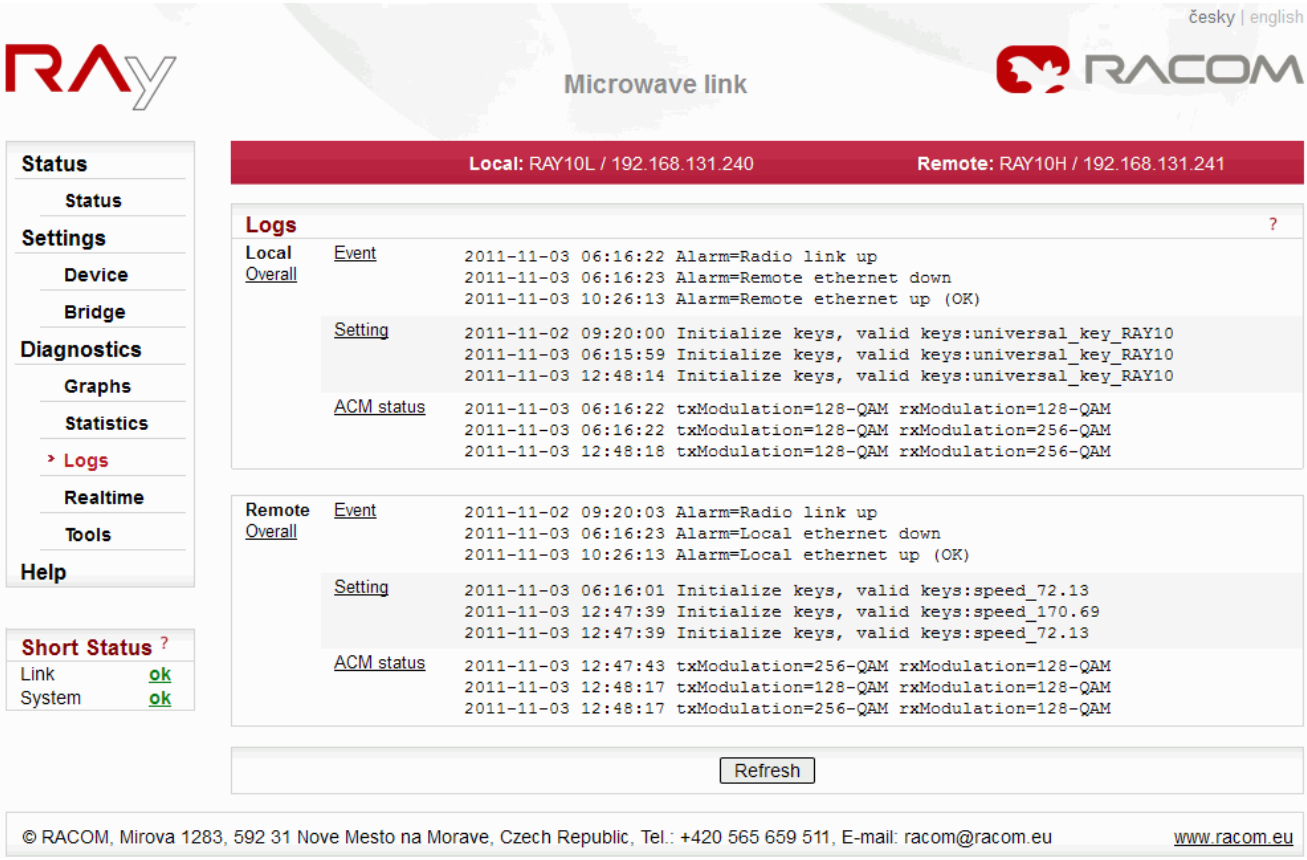


Fig. 6.6: Diagnostics Logs Menu

Last three records from the each log are displayed. The complete log is accessible by clicking the respective log name. The Local Overall and Remote Overall titles brings the respective overall log.

Event	Warning and Alarm states, see Alarm limits and Short Status.
Setting	Configuration changes log.
ACM status	ACM switching log.
Overall	Unsorted overview of the whole log. Last three records from the each log are displayed. The complete log is accessible by clicking the respective log name.

6.7. Diagnostics Realtime

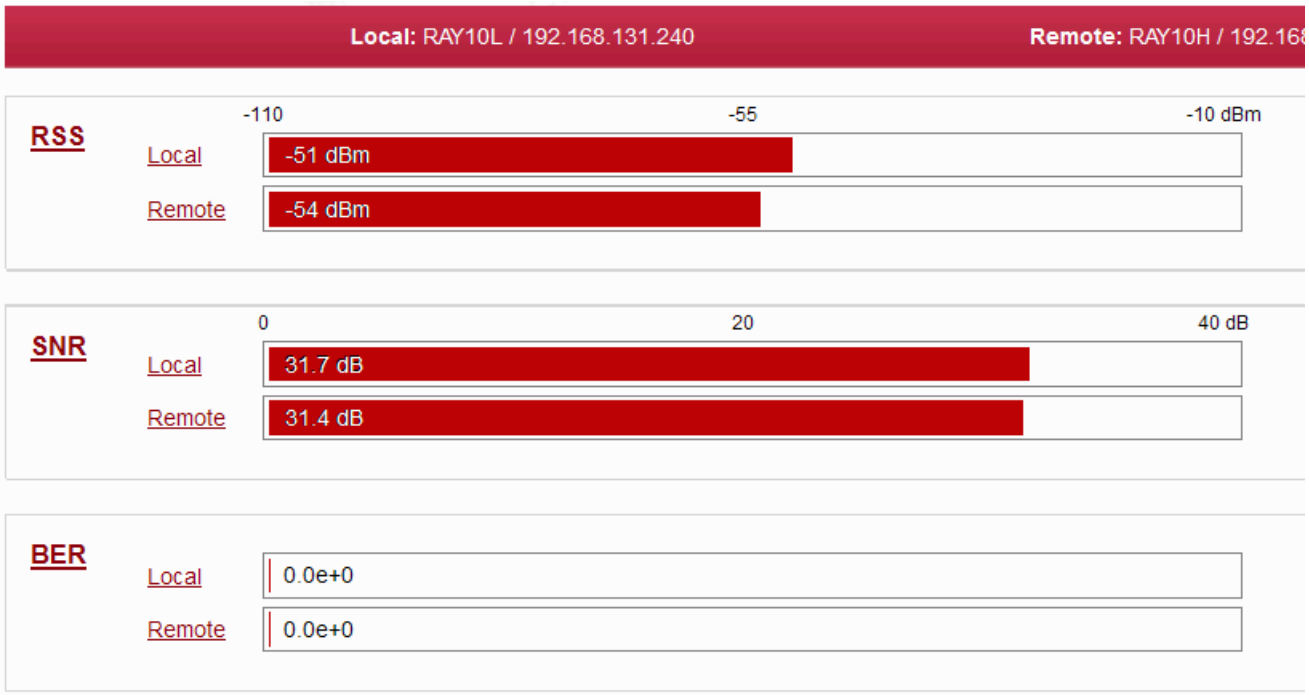


Fig. 6.7: Realtime Menu

The values of RSS, SNR and BER are updated with a period of 1 second.

6.8. Diagnostics Tools

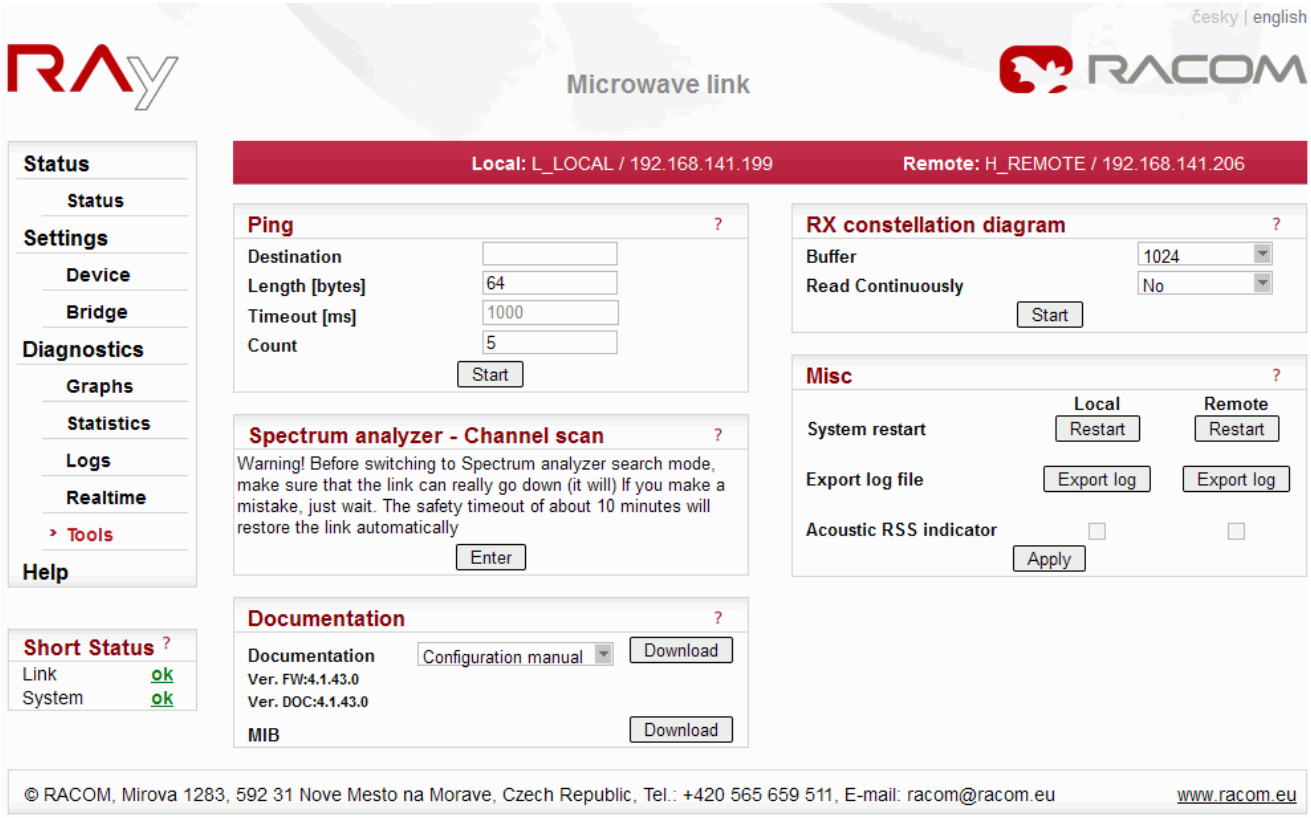


Fig. 6.8: Tools Menu

6.8.1. Diagnostics – Ping

Ping is the simplest tool to check the connection to any member of the network

Destination	Destination IP address (numerical only, in dotted decimal notation format)
Length [bytes]	Random data bytes sent in the ping packet, 8 byte header will be added in the result
Timeout [ms]	Pings are always transmitted in 1000 ms period
Count	Number of pings which will be transmitted (0 means continuous transmission)

Complete report is displayed after clicking the Refresh button

6.8.2. Diagnostics – Spectrum analyzer

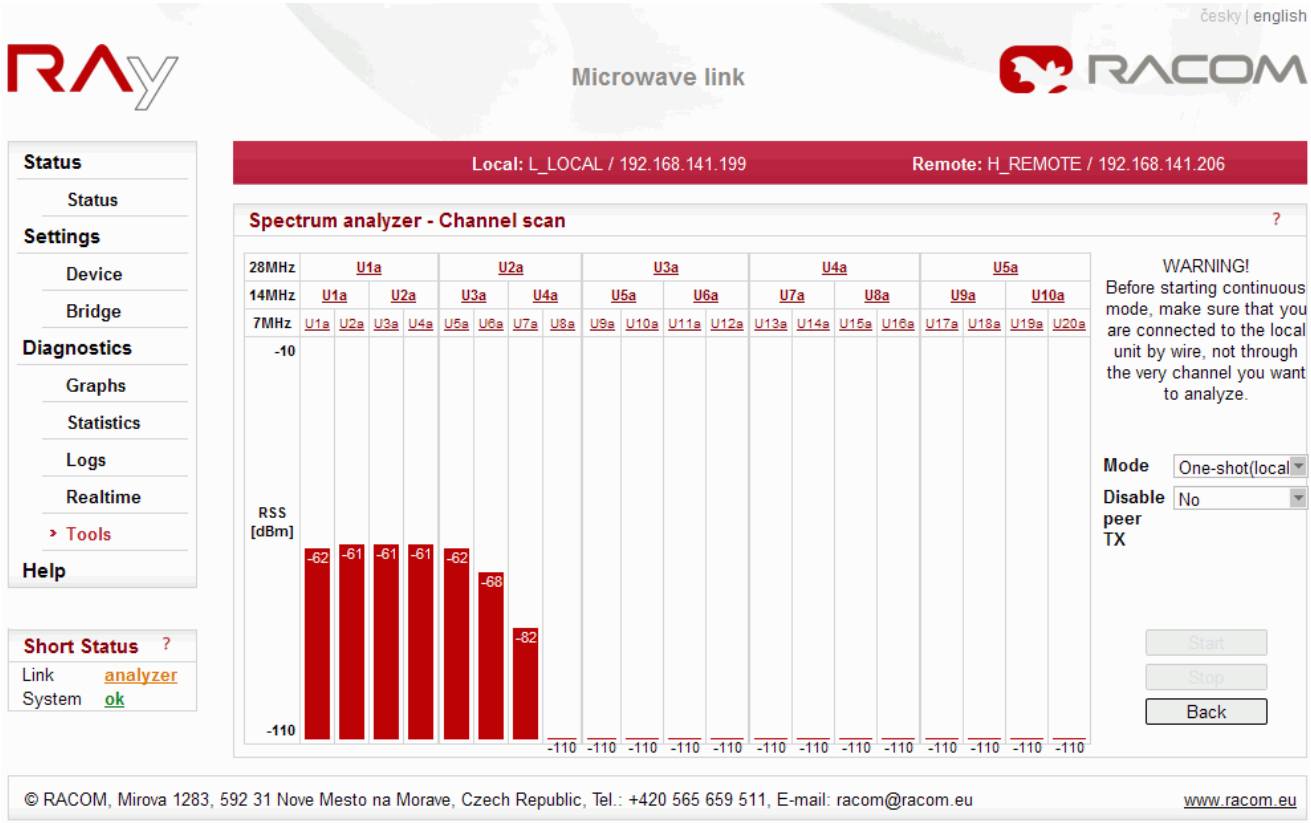


Fig. 6.9: Tools - Spectrum analyzer Menu

A very useful tool to evaluate in-band interference and to locate a free channel at a site. This is not a full-blown spectrum analyzer. The spectrum is only scanned with 7MHz channel resolution. The spectrum measurement accuracy is limited by RSS measurement accuracy.

Enter Enter the Spectrum analyzer menu.

Warning

BEWARE! Whenever the *Spectrum analyzer* mode is activated by clicking the **Start** button, the RF link is disconnected. The unit is switched to receive-only mode, bandwidth set to 7 MHz and all channels are scanned. The recorded RSS is then graphically displayed.

The **One-shot** mode results in only about 20 sec interruption of the RF link and can be activated even at the remote end of the link.

The **Continuous** mode is intended for use during a site survey and/or installation. It is automatically cancelled after 10 minutes to avoid permanent link shutdown by mistake. The peer TX transmitter can be optionally disabled in all modes. BEWARE! Before starting the "Continuous" mode, make sure you are not connected to the "local" unit through the very link you want to analyze.

Mode A listbox to select the scanning mode. "One-shot" does one scan of all channels and automatically restores the RF link to normal operation. "Continuous" means the scanning is done repeatedly until the "Stop" button is clicked or the safety timeout of 10 minutes expires.

Disable peer TX	The opposite end transmitter can be switched off during the scan. This is a very useful option for detecting an in-channel interference. In continuous mode the switch-off period has to be selected (10 sec - 10 min) before starting the analyzer. Note that the RF link can not be restored before the switch-off period expires, even if you stop the analyzer manually.
Start	Click the button to start the actual scanning. After, and only after, clicking this button the link will go down.
Stop	Click the button to stop the scanning in continuous mode. If the peer transmitter is on, the link will be restored within few seconds.
Back	Click the button to leave the Spectrum analyzer screen.
Channel id	If you choose a range by clicking in the upper rows, you can use it to configure the link by clicking the OK button. The frequency will change after you click the Apply button in Bridge Settings. This function applies to One-shot (local) and Continuous (local) modes but not to One-shot (remote).

The results of the Spectral analyzer are merely informative. RAy10 is not a properly calibrated measuring instrument. It cannot, for instance, be used to evaluate the compliance of a remote transmitter's channel mask with a prescribed standard.

6.8.3. Diagnostics - Documentation

Documentation

The pdf format manuals can be downloaded directly from the RAy unit:

- RAy10 Configuration manual - EN
- RAy10 Konfiguracni manual - CZ
- RAy10 Installation manual - EN/CZ

The content of those documents is the same as content of the User manual accessible at *https://www.racom.eu*. Some chapters ("Implementation notes", "Safety, environment, licencing" and some attachments) were omitted to reduce the size of the pdf files. The complete manual can be downloaded from *https://www.racom.eu/eng/products/m/ray/index.html*

MIB

The MIB table can be downloaded directly from the RAy unit.

6.8.4. Diagnostics – RX constellation diagram

Constellation diagram is a powerful tool to assess the received signal quality. Samples of the demodulated signal are displayed along amplitude and phase coordinates. Ideally a perfect grid of single points should be seen. The degree of random dispersion indicates the distortion and noise in the channel. The smaller the gaps between neighboring groups of points are, the higher is the probability of an error.

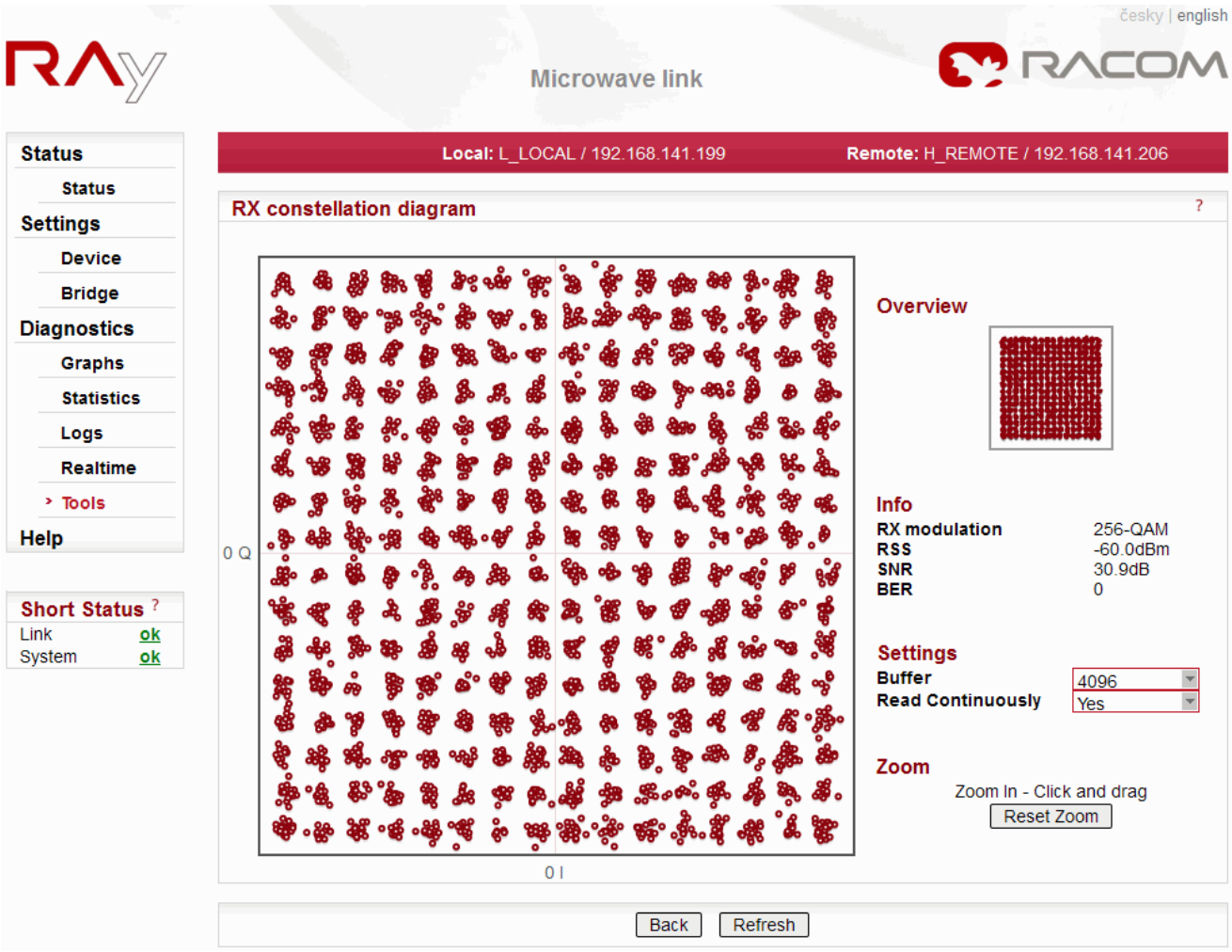


Fig. 6.10: Menu Tools - Constellation 2

Buffer	Number of signal samples shown in one image
Read Continuously	The diagram is updated every couple of seconds
Info	Basic parameters of received signal (Modulation, RSS, SNR, BER)

Zoom in is possible by dragging the mouse, getting back to full scale by Reset zoom.

Internet Explorer's performance while displaying the RX constellation diagram is very poor (it takes minutes); we recommend using another browser, such as Mozilla Firefox, Opera or Chrome.

6.8.5. Diagnostics – Miscellanous tools

System restart	Hard reset.
Export log file	Special diagnostic package (configuration and system logs) can be exported for service purposes.
Acoustic RSS indicator	The built-in acoustic indicator of RSS is an optional feature. It can be used for the final adjustment of the antenna. Even a small difference in the RSS is reflected in the tone frequency - the higher the pitch, the stronger the signal. The beeper is switched on only after clicking the Apply button. Remember to switch it off after completing the work. It automatically switches off after 30 minutes.

6.9. Short Status

The Short Status is refreshed automatically every 3 seconds.

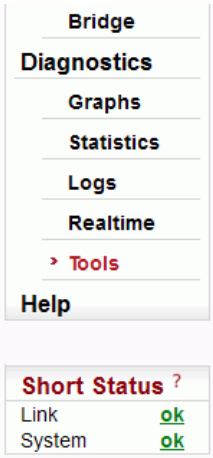


Fig. 6.11: Short Status Menu

Link

- **ok (green)** – Radio link is connected.
- **connecting (red)** – Local radio is receiving a valid data signal and trying to establish connection with the peer. If the peer serial No does not match the one configured in menu Device – General, the connecting phase never completes.
- **searching (red)** – Local radio is searching for a valid signal from the peer. It may also mean that the remote radio transmitter is turned off.
- **analyzer (orange)** – Local radio is in Spectrum analyzer mode. Communication with the peer is not possible.
  The Overall log is displayed on link click.

System

- **ok (green)** – Unit is working correctly.
- **warning (orange)**
  alarm (red) – Some of the system Warnings or Alarms is active - see *Device/Alarm limits* menu. The Event log with Warning or Alarm messages can be displayed on link click.

  If you refresh the *Status* menu, you will see these error warnings (if applicable):
  - *Peer serial* – the serial number of the peer unit does not match
  - *TX power* – the transmission output is over 3 dBm lower than configured
  - *Eth interface* – the ethernet link has been lost

7. Command Line Configuration

Command Line Interface (CLI) provides an alternative to HTTPS access. CLI allows you to use a ssh (putty) or telnet client.

To connect using **telnet** to a unit with service access IP of 192.168.169.169 open the command line and type:

```
telnet 192.168.169.169
```

Then use the username and password setup via *configure device user* (default values are *admin*, *admin*).

Putty client connection. Type into the Host Name (or IP address) field:

```
admin@192.168.169.169
```

Click Open. Then input admin password. This method (without key) is only possible if *configure service_access ssh local on* was enabled previously.

If you own the private key, then you don't need a password. In putty continue by selecting *Connection / SSH / Auth* and choosing the path to the key file, e.g. *key.ppk*. To save putty configuration go to *Session / Logging*. To access the unit via CLI simply select the connection in putty and press Open. More details in the *appendix*.

To connect via **ssh** in Linux.

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

If you know the password and it has been enabled under *configure service_access ssh local on*, then you can skip the key and enter the password when prompted.

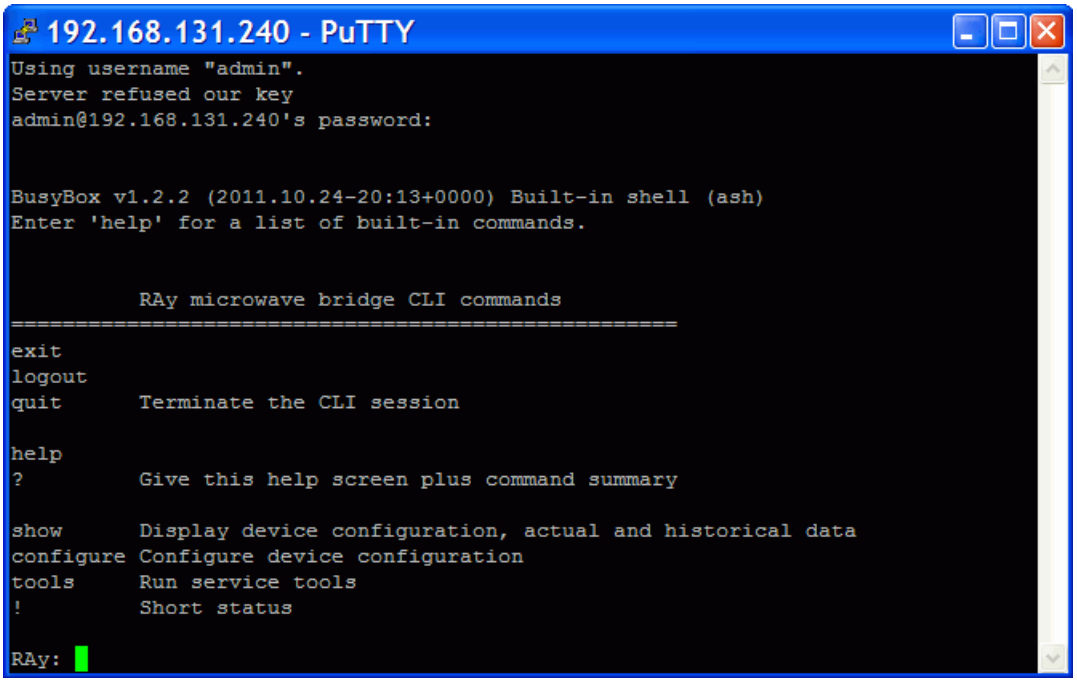


Fig. 7.1: CLI menu

The menu then branches out with three main commands:

show	configuration status, communication data, this menu is **read only**
configure	**change and save** configuration parameters
tools	controls service tools

To execute a command simply type only so many letters as it takes to distinguish it from others and then press Enter. Spacebar divides individual levels of the command, for example:

`show radio local Enter` will give you the same result as `s r l Enter`

After pressing Enter you will always return to the base level of `show-configure-tools`, so every step must begin either with `s, c` or `t`.

If the command is not clear, help is displayed which contains possible choices at the next level:

```
RAy: t r
-----------------------------------------
WARNING: The given command "r" is not unique within set of possible commands:
restart
rx_scan
```

Continue by typing `t re` for restart or `t rx` to measure the received spectrum.

For initial overview type `help` or `?`. Doing so will add a schematic overview of commands to the first menu:

```
=========================================================================
to read:           to write:                                 to test:

show               configure                                 tools
  radio       l|r    radio        fre mod pow                  ping
  eth_bridge  l|r    eth_bridge   spe dup mdi flow vlan         spectrum
  device      l|r    device       name peer user search time    rx_scan
  service_acc l|r    service_acc  htt tel ssh snmp ip def manv  tx_disabl
  keys        l|r    keys         add delete                   indicator
  alarm_limit l|r    alarms       cpu mem pow snr rss ber air   restart
  measure     l|r                             rf_pow peer_eth
  log         ...
  graph       ...
  traffic_stat...
  config      ...    config       restore default
```

The commands in the first column ending in `l|r` (i.e. local or remote) are final. Other commands further branch as illustrated and are described in detail in help for the respective level.

`!` command provides a report on the status of the link, type `exit` to quit CLI.

7.1. Show Command

The output of the Show command is self-explanatory, only Graph and Configuration merit elaborating on:

7.1.1. Show Graph

The **show graph** displays history of several values over the last hour. The graph is represented by a table with two columns with timestamp on the left and the monitored value on the right. Graphs are available for the following values:

Command	Command in words	Content - history	frequency of records
s g be l	show graph ber local	bit error rate	1 min
s g m l	show graph modulation local	modulation status	modulation changes
s g v l	show graph voltage local	power source voltage	5 min
s g r l	show graph rss local	signal strength	1 min
s g bi l	show graph bitrate local	net bitrate	speed changes
s g s l	show graph snr local	signal quality (local unit)	1 min
s g t r	show graph temperature remote	unit inside temperature (remote unit)	5 min
s g e l	show graph ethernet local	traffic history	1 min

For example, typing **show graph modulation local Enter** displays the history of modulation states in the local unit:

```
RAy: s g m l
-------------------------------------------
Command> show graph modulation local
["2010-06-29 08:03:39",8],
["2010-06-29 08:46:52",6],
["2010-06-29 08:50:19",5],
```

The degree of modulation is expressed by a number from 0 through 11, see ACM status.

7.1.2. Show configuration

The **show configuration Enter** command prepares the configuration file of the unit for download using a `tftp` client.

```
RAy: s c
-------------------------------------------
Command> show configuration
Inactivity timeout expired.
INFO:    The file with configuration "ray.conf" is ready
         to be downloaded by some TFTP client.
         The file is accessible for approx. 60 seconds.
```

After the command is executed a configuration file *ray.conf* is ready for download using a `tftp` client for 60 seconds. The file contains configuration of both local and remote units.

How download is initiated depends on the `tftp` client used. For instance, in Linux type the following:

```
tftp 192.168.169.169
tftp> get ray.conf
```

7.2. Configure Command

The command **configure Enter** or **c Enter** opens the menu that enables you to save configuration values to the unit. The individual items are analogous to menu show:

```
RAy: c
-------------------------------------------

NAME
     configure

SYNOPSIS
     configure { radio | eth_bridge | device | service_access
               | alarms | configuration | keys } ...

DESCRIPTION
     Configure device parameters

     radio            Configure radio parameters
     eth_bridge       Configure ethernet bridge parameters
     device           Configure device parameters
     service_access   Configure service access parameters
     alarms           Configure alarm limits
     configuration    Put stored configuration to device
     keys             Configure product keys
```

The configuration menu further branches out like this:

radio	frequency, modulation, power
eth_bridge	speed, duplex, mdix, flow control, vlan
device	device name, peer number, user name, search, time
service_access	enable access protocols, IP address, default access
alarms	alarm limits
configuration	configuration file upload
keys	product keys upload

The commands are defined in detail in help which displays when the command is run. The commands may be shortened but the final parameters must be given in full. E.g. the parameters in the following commands are: `28, CH3, 32-QAM, hi, 16-QAM, low, auto`

RAy: c r f m 28 CH3 32-QAM hi 16-QAM low

RAy: c r f m 28 CH3 auto

7.3. Tools Command

The command **tools Enter** offers several diagnostic tools:

```
tools { ping | spectrum | rx_scan | tx_disable | indicator_rss | restart } ...
```

`ping`	send out a test ping
`spectrum`	determine rss in the received spectrum
`rx_scan`	function spectrum for Local / Remote, with disabling of the other unit
`tx_disable`	disables transmission for a set time
`indicator_rss`	rss sound indication
`restart`	unit restart

8. Troubleshooting

- **Polarization incorrect**

  To receive the *horizontal* or *vertical* message the transmission axis must be horizontal, the handgrip must be either horizontal or vertical and the connectors must point downward at an angle. Each unit is evaluated separately.

- **The link cannot be established**

  Start with the most “resilient” configuration, i.e. Bandwidth 7 MHz, TX Modulation QPSK, Coding strength High, RF power +3 dBm. 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, continue to operation parameters.

- **Access to the Local unit is blocked**

  Access to the Local unit may be accidentally blocked, for instance by disabling HTTPS access. If you can access the Remote unit over HTTPS, type its address in your web browser's address field. The link will transfer the packet over the Local unit with blocked service access all the way to the Remote unit, which will give you access to the control menus of both units. Attention, the Remote unit will report as Local.

- **Distinguishing Local-Remote**

  The unit accessed via service access always reports as Local. If you connect through another (peer) unit and radio channel, certain amount of caution is necessary. For example, do not activate the Spectrum analyser in Continuous mode.
  Local and remote can be differentiated through CLI. Type `t t l 30s` to interrupt the radio link for 30 seconds. If you lose connection to the unit, you accessed the remote unit via radio channel. After 30 seconds the link can be resumed.
  In Linux you can compare the ping times for Local and Remote. Pinging a unit over radio channel takes approximately 0.1 ms longer.

- **Access security**

  For better protection against unauthorised access to configuration you should only allow as few way of access as possible. The most secure type is SSH with key – leave only SSH checked. Leave HTTPS, Telnet and Allow password boxes unchecked.

- **Graphs take too long to display**

  Use a different browser than Internet Explorer. We recommend Mozilla Firefox.

- **RSS**

  To configure the link and monitor its state several menus display the RSS signal strength. Please keep in mind, that Ray is not a measuring instrument, hence the precision of the RSS reading is limited. Though in most situations the RSS reading accuracy is better than ± 2dB, the absolute RSS value should not be used for accurate comparisons e.g. between two links.

- **https certificate problem**

  This problem can occur when you upgrade the firmware to version 4.1.44.0. See the *Appendix F, Https certificate*

9. Technical parameters

The RAy11, RAy17 and RAy24 basic technical parameters are stated here for clarity. Their manual can be found *here*[1].

9.1. General parameters

9.1.1. Technical parameters overview

Type	Licensed bands		ISM bands	
	RAy10	RAy11	RAy17	RAy24
Band [GHz] sub-bands A,B..	A: 10.30 – 10.59	A,B: 10.70 – 11.70	17.1 – 17.3	24.0 – 24.25
	B: 10.15 – 10.65	C,D: 10.50 – 10.68		
ODU units	Unit L and U		One universal unit	
Duplex *spacing* [MHz]	any combination L and U units	A,B: 490, 530 C,D: 91	optional min 60	optional min 60
Channel spacing CS [MHz]	7, 14, 28	1.75, 3.5, 7, 14, 28, 30, 40, 56	3.5, 7, 14, 28, 40, 56	3.5, 7, 14, 28, 40, 56
Channel frequencies	*detail*	*detail*[2]	*detail*[3]	*detail*[4]
User speed [Mbps]	8.5 – 170	2.5 – 360	4.9 – 360	4.9 – 360
	detail	*detail*[5]		
Latency [µs]	140 (64B/170Mbps)	81 (64B/359Mbps), 234 (1518B/359Mbps)		
Sensitivity, BER 10^{-6} [dBm]	-96 (8.5 Mbps) -69 (166 Mbps)	-99 (2.5 Mbps) -67 (340 Mbps)	-96 (4.9 Mbps) -66 (340 Mbps)	-96 (4.9 Mbps) -65 (340 Mbps)
	detail	*detail*[6]		
Output Power [dBm]	-5 – +10	-5 – +23 (QPSK) -5 – +17 (256QAM)	-25 – +5	-25 – +10
ATPC	no	yes	yes	yes
Consumption [W]	17	24	21	23
Weight [kg]	2.9	2.8	2.5	2.5
Radio parameters	EN 302 217-2-2 V 1.3.1		EN 300 440-2 V 1.4.1	

ver. 2.0

[1] https://www.racom.eu/eng/products/m/ray17/index.html
[4] https://www.racom.eu/eng/products/m/ray17/tech_par.html#kmit24
[3] https://www.racom.eu/eng/products/m/ray17/tech_par.html#kmit17
[2] https://www.racom.eu/eng/products/m/ray17/tech_par.html#kmit11
[5] https://www.racom.eu/eng/products/m/ray17/tech_par.html#mod11
[6] https://www.racom.eu/eng/products/m/ray17/tech_par.html#rad11

Modulation	fixed QPSK, 16, 32, 64, 128, 256 QAM or ACM
FEC	LDPC
User interface	1 Gb Eth. (10/100/1000) (IEEE 802.3ac 1000BASE-T) , MTU1536B, recommended cable S/FTP CAT7
Service (optional)	100 Mb (10/100) Eth. (IEEE 802.3u 100BASE-TX) , S/FTP CAT7 or CAT5
Power	PoE, 40 - 60 VDC , IEEE 802.3at up to 100m , user interface
Operating temperature range	-30 – +55°C (ETSI EN 300019-1-4, class 4.1.)
Mechanical design	FOD (Full Outdoor)
Dimensions	245 × 245 × 150 mm
EMC	ETSI EN 301 489-1 V 1.8.1 (2008-04), ETSI EN 301 489-17 V1.3.2 (2008-04)
Electrical safety	EN 60 950-1:2004

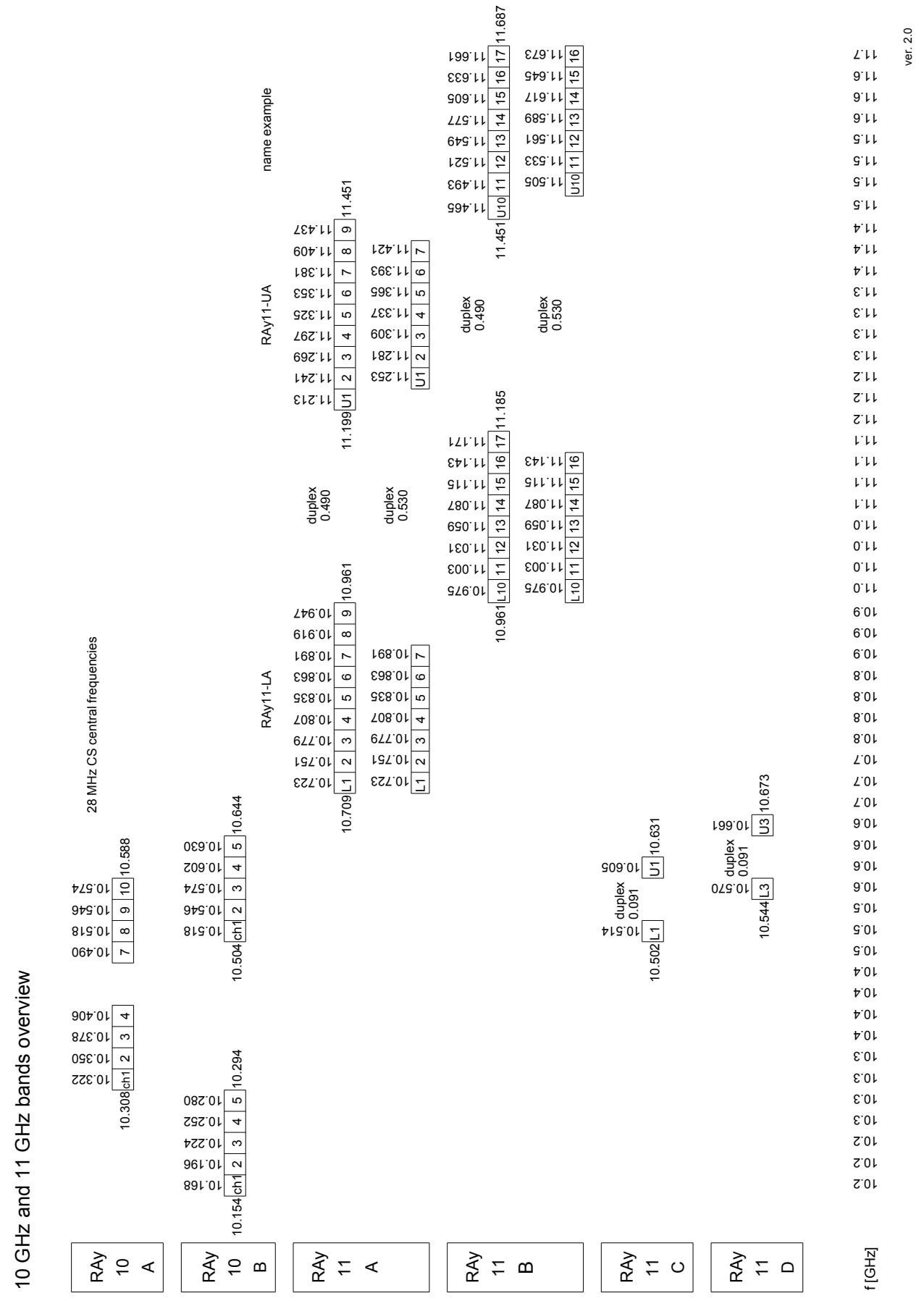
ver. 1.0

9.1.2. Duplex spacing

Duplex spacing L and U channels			
RAy10			
Sub-bands			
A	All combinations of channels		
B	All combinations of channels		
RAy11			
Sub-bands	Duplex spacing [MHz]		
A, B	490, 530		
C,D	91		
RAy17			
	Optional duplex spacing		
Channel width	minimum	default	maximum
[MHz]	[MHz]	[MHz]	[MHz]
3.5	60	73.5	192.5
7	60	73.5	192.5
14	65	87.5	185.5
28	70	87.5	171.5
40	70	73.5	157.5
56	85	87.5	143.5
RAy24			
	Optional duplex spacing		
Channel width	minimum	default	maximum
[MHz]	[MHz]	[MHz]	[MHz]
3.5	60	73.5	241.5
7	60	73.5	238.0
14	65	87.5	234.5
28	70	87.5	220.5
40	70	73.5	206.5
56	85	87.5	192.5

ver. 2.2

9.1.3. Frequency overview 10 GHz and 11 GHz, for CS 28 MHz



9.1.4. Nominal frequency tables description

RAy10 – xA [1]				TX channel nominal frequencies Band 10.30 – 10.59 GHz, [3] default duplex 168 MHz [4]				
Bandwidth: **14 MHz** [2]				VO-R/14/12.2012-17 [5]		duplex range 70 – 273 MHz [6]		
A sub-band [7]								
Ch.No.	Ch.No. old	Lower [MHz]	Ch.No. old	Upper [MHz]	Ch.No.	Ch.No. old	Lower [MHz]	Ch.No. old	Upper [MHz]
1	CH0A	10308			**6**	CH3A	10308	CH9A	10539
2 [8]	CH1A [9]	10315 [10]	CH7A [9]	10483 [11]	**7**	CH3B	10315	CH9B	10553
3	CH1B	10329	CH7B	10497	**8**	CH4A	10329	CH10A	10567
4	CH2A	10343	CH8A	10511	**9**	CH4B	10343	CH10B	10581
5	CH2B	10357	CH8B	10525					

ver. 1.1 [12]

1) The respective RAy unit name. The letter “x” stands for “L” or “U” (Lower or Upper band unit).

   Example: “RAy10-xA” means both “RAy10-LA” and “RAy10-UA” units. See *overview table* for details.

   Note: The optional last figure in the unit name (e.g. RAy10-LA-2) denotes number of Ethernet ports and it is not relevant for the Nominal frequency tables.

2) The respective channel set (nominal frequencies) name in the Ray unit configuration interface (see *Configuration, item “Bandwith [MHz]”*. In addition to the bandwith definition, the name can contain additional text which defines the respective alternative of channel plan.

3) The whole frequency range.

4) Default duplex - the frequency difference between the Upper and Lower channels in a duplex pair.

5) The name of standard or recommendation defining the respective channel plan.

6) Min. and max. possible difference frequencies Lower and Upper channels.

7) Name of the sub-band defined by channels in the table.

8) The channel number according to RAy unit configuration interface (see *Configuration, item “TX channel [GHz]”*).

   Bold indicates the channel number pair with the default interval, the other can be used with the channel to the extent duplex range.

9) Channel name according to Public permission.

10) The nominal TX frequency of the Lower-band channel

11) The nominal TX frequency of the Upper-band channel.

12) Table version.

9.2. RAy10 A,B parameters

9.2.1. Link speed

RAy10-xA, RAy10-xB		User data rate [Mbps]			ACM status
Modulation	Coding strenght	CS 7 MHz	CS 14 MHz	CS 28 MHz	
		ACCP	ACCP	ACCP	
QPSK	High	8.5	17.7	36.8	0
QPSK	Low	9.9	19.9	41.4	1
16 QAM	High	17.3	34.6	72.1	2
16 QAM	Low	19.4	38.8	80.9	3
32 QAM	High	22.3	44.6	92.8	4
32 QAM	Low	24.6	49.1	102.4	5
64 QAM	High	28.3	57.8	120.5	6
64 QAM	Low	28.8	62.3	129.8	7
128 QAM	High		69.8	145.3	8
128 QAM	Low		73.4	155.5	9
256 QAM	High		79.3	166.4	10
256 QAM	Low		80.3	170.7	11

ver. 2.1

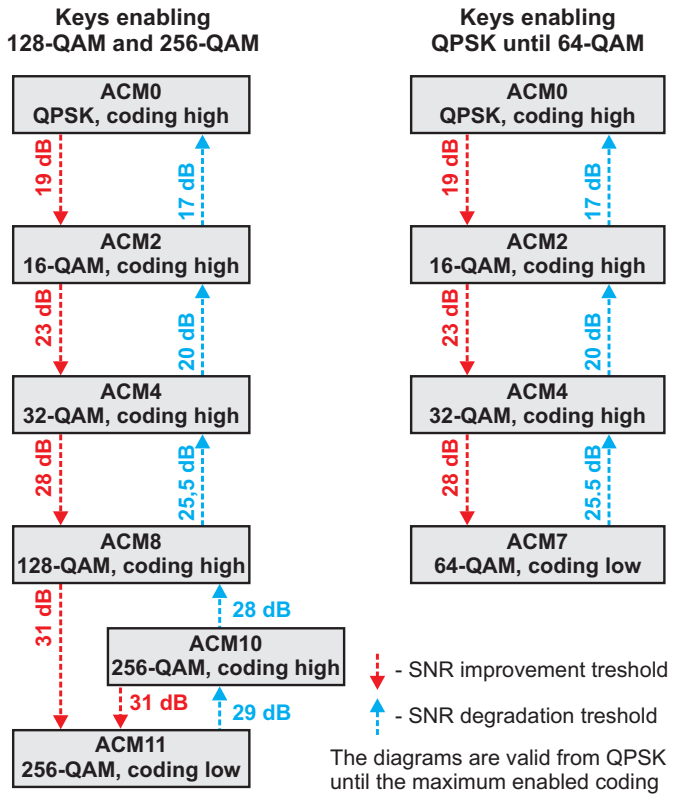


Fig. 9.1: Status diagram of ACM switching according to SNR state

9.2.2. Radio parameters

RAy10-xA, RAy10-xB			Channel spacing 7 MHz; ACCP/CCDP operation			
			RSS / SNR for BER 10^{-6}		Co-channel Rejection	Adjacent channel Selectivity
					1 dB	1 dB
Modulation	**Raw Bit Rate**	**User Bit Rate**	**RSS**	**SNR**	declared / limit	declared / limit
[-]	*[Mbps]*		*[dBm]*	*[dB]*	*[dB]*	*[dB]*
QPSK	12/H	8.5	-96	7.5	11 / 23	17 / 0
QPSK	12/L	9.9	-93	8.5	14 / 23	15 / 0
16-QAM	24/H	17.3	-88	13.5	17 / 30	14 / 3
16-QAM	24/L	19.4	-87	14.5	19 / 30	14 / 3
32-QAM	30/H	22.3	-83	17.5	22 / 33	12 / 2
32-QAM	30/L	24.3	-82	18.5	24 / 33	11 / 2
64-QAM	36/H	28.3	-80	20.0	24 / 33	11 / 2
64-QAM	36/L	28.8	-79	20.5	25 / 33	10 / 2

ver. 2.0

RAy10-xA, RAy10-xB			Channel spacing 14 MHz; ACCP/CCDP operation			
			RSS / SNR for BER 10^{-6}		Co-channel Rejection	Adjacent channel Selectivity
					1 dB	1 dB
Modulation	**Raw Bit Rate**	**User Bit Rate**	**RSS**	**SNR**	declared / limit	declared / limit
[-]	*[Mbps]*		*[dBm]*	*[dB]*	*[dB]*	*[dB]*
QPSK	24/H	17.7	-92	7.5	12 / 23	16 / 0
QPSK	24/L	19.9	-90	8.5	14 / 23	15 / 0
16-QAM	48/H	34.6	-85	13.5	17 / 30	14 / 3
16-QAM	48/L	38.8	-83	14.5	19 / 30	13 / 3
32-QAM	60/H	44.6	-81	17.5	22 / 33	12 / 5
32-QAM	60/L	49.1	-79	18.5	24 / 33	11 / 5
64-QAM	72/H	57.8	-78	20.0	24 / 33	11 / 2
64-QAM	72/L	62.3	-76	21.5	26 / 33	10 / 2
128QAM	84/H	69.8	-75	23.5	28 / 33	8 / 2
128QAM	84/L	73.4	-73	24.5	31 / 33	5 / 2
256-QAM	96/H	79.3	-71	26.0	31 / 33	5 / 2
256-QAM	96/L	80.3	-69.5	26.5	33 / 33	3 / 2

ver. 2.0

RAy10-xA, RAy10-xB			**Channel spacing 28 MHz; ACCP/CCDP operation**			
			RSS / SNR for BER 10^{-6}		**Co-channel Rejection**	**Adjacent channel Selectivity**
					1 dB	1 dB
Modulation	**Raw Bit Rate**	**User Bit Rate**	**RSS**	**SNR**	declared / limit	declared / limit
[-]	*[Mbps]*		*[dBm]*	*[dB]*	*[dB]*	*[dB]*
QPSK	50/H	36.8	-89	7.5	12 / 23	20 / 0
QPSK	50/L	41.1	-87	8.5	14 / 23	18 / 0
16-QAM	100/H	72.1	-82	13.5	17 / 30	18 / 3
16-QAM	100/L	80.9	-80	14.5	19 / 30	16 / 3
32-QAM	125/H	92.8	-78	17.5	22 / 33	16 / 5
32-QAM	125/L	102.4	-76	18.5	24 / 33	15 / 5
64-QAM	150/H	120.5	-75	20.0	24 / 35	15 / 5
64-QAM	150/L	129.8	-73	21.5	26 / 35	13 / 5
128QAM	175/H	145.3	-72	23.5	28 / 35	11 / 5
128QAM	175/L	155.5	-70	25.0	31 / 35	8 / 5
256-QAM	200/H	166.4	-69	26.0	31 / 35	8 / 5
256-QAM	200/L	170.7	-67	26.5	33 / 35	5 / 5

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9.2.3. Nominal frequencies RAy10-xA, duplex 168 MHz

RAy10 – xA — TX channel nominal frequencies
Bandwidth: **7 MHz** — Band 10.30 – 10.59 GHz, default duplex 168 MHz
VO-R/14/12.2012-17 — duplex range 63 – 280 MHz

A sub-band

Ch.No.	Ch.No. old	Lower [MHz]	Ch.No. old	Upper [MHz]	Ch.No.	Ch.No. old	Lower [MHz]	Ch.No. old	Upper [MHz]
1	x	10304.5			**10**	CH2BB	10360.5	CH8BB	10528.5
2	CH0AA	10308.0			**11**	CH3AA	10367.5	CH9AA	10535.5
3	CH1AA	10311.5	CH7AA	10479.5	**12**	CH3AB	10374.5	CH9AB	10542.5
4	CH1AB	10318.5	CH7AB	10486.5	**13**	CH3BA	10381.5	CH9BA	10549.5
5	CH1BA	10325.5	CH7BA	10493.5	**14**	CH3BB	10388.5	CH9BB	10556.5
6	CH1BB	10332.5	CH7BB	10500.5	**15**	CH4AA	10395.5	CH10AA	10563.5
7	CH2AA	10339.5	CH8AA	10507.5	**16**	CH4AB	10402.5	CH10AB	10570.5
8	CH2AB	10346.5	CH8AB	10514.5	**17**	CH4BA	10409.5	CH10BA	10577.5
9	CH2BA	10353.5	CH8BA	10521.5	**18**	CH4BB	10416.5	CH10BB	10584.5

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RAy10 – xA — TX channel nominal frequencies
Bandwidth: **14 MHz** — Band 10.30 – 10.59 GHz, default duplex 168 MHz
VO-R/14/12.2012-17 — duplex range 70 – 273 MHz

A sub-band

Ch.No.	Ch.No. old	Lower [MHz]	Ch.No. old	Upper [MHz]	Ch.No.	Ch.No. old	Lower [MHz]	Ch.No. old	Upper [MHz]
1	CH0A	10308.0			**6**	CH3A	10371.0	CH9A	10539.0
2	CH1A	10315.0	CH7A	10483	**7**	CH3B	10385.0	CH9B	10553.0
3	CH1B	10329.0	CH7B	10497	**8**	CH4A	10399.0	CH10A	10567.0
4	CH2A	10343.0	CH8A	10511	**9**	CH4B	10413.0	CH10B	10581.0
5	CH2B	10357.0	CH8B	10525					

ver. 1.2

RAy10 – xA — TX channel nominal frequencies
Bandwidth: **28 MHz** — Band 10.30 – 10.59 GHz, default duplex 168 MHz
VO-R/14/12.2012-17 — duplex range 84 – 252 MHz

A sub-band

Ch.No.	Ch.No. old	Lower [MHz]	Ch.No. old	Upper [MHz]	Ch.No.	Ch.No. old	Lower [MHz]	Ch.No. old	Upper [MHz]
1	CH1	10322.0	CH7	10490	**3**	CH3	10378.0	CH9	10546.0
2	CH2	10350.0	CH8	10518	**4**	CH4	10406.0	CH10	10574.0

ver. 1.2

9.2.4. Nominal frequencies RAy10-xB, duplex 350 MHz

RAy10 – xB Bandwidth: **7 MHz**			TX channel nominal frequencies Band 10.15 – 10.65 GHz, duplex spacing 350 MHz CEPT/ERC/REC 12-05 E				
	B sub-band						
Ch.No.	Lower [MHz]	Ch.No.	Upper [MHz]	Ch.No.	Lower [MHz]	Ch.No.	Upper [MHz]
L1a	10157.5	U1a	10507.5	L11a	10227.5	U11a	10577.5
L2a	10164.5	U2a	10514.5	L12a	10234.5	U12a	10584.5
L3a	10171.5	U3a	10521.5	L13a	10241.5	U13a	10591.5
L4a	10178.5	U4a	10528.5	L14a	10248.5	U14a	10598.5
L5a	10185.5	U5a	10535.5	L15a	10255.5	U15a	10605.5
L6a	10192.5	U6a	10542.5	L16a	10262.5	U16a	10612.5
L7a	10199.5	U7a	10549.5	L17a	10269.5	U17a	10619.5
L8a	10206.5	U8a	10556.5	L18a	10276.5	U18a	10626.5
L9a	10213.5	U9a	10563.5	L19a	10283.5	U19a	10633.5
L10a	10220.5	U10a	10570.5	L20a	10290.5	U20a	10640.5

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RAy10 – xB Bandwidth: **14 MHz**			TX channel nominal frequencies Band 10.15 – 10.65 GHz, duplex spacing 350 MHz CEPT/ERC/REC 12-05 E + 7 MHz based channels				
	B sub-band						
Ch.No.	Lower [MHz]	Ch.No.	Upper [MHz]	Ch.No.	Lower [MHz]	Ch.No.	Upper [MHz]
L1a	**10161**	U1a	**10511**	L6a	**10231**	U6a	**10581**
L1c	10168	U1c	10518	L6c	10238	U6c	10588
L2a	**10175**	U2a	**10525**	L7a	**10245**	U7a	**10595**
L2c	10182	U2c	10532	L7c	10252	U7c	10602
L3a	**10189**	U3a	**10539**	L8a	**10259**	U8a	**10609**
L3c	10196	U3c	10546	L8c	10266	U8c	10616
L4a	**10203**	U4a	**10553**	L9a	**10273**	U9a	**10623**
L4c	10210	U4c	10560	L9c	10280	U9c	10630
L5a	**10217**	U5a	**10567**	L10a	**10287**	U10a	**10637**
L5c	10224	U5c	10574				

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RAy10 – xB Bandwidth: **28 MHz**			TX channel nominal frequencies Band 10.15 – 10.65 GHz, duplex spacing 350 MHz CEPT/ERC/REC 12-05 E + 7 MHz based channels				
	B sub-band						
Ch.No.	Lower [MHz]	Ch.No.	Upper [MHz]	Ch.No.	Lower [MHz]	Ch.No.	Upper [MHz]
L1a	**10168**	U1a	**10518**	L3c	10231	U3c	10581
L1c	10175	U1c	10525	L3e	10238	U3e	10588
L1e	10182	U1e	10532	L3g	10245	U3g	10595
L1g	10189	U1g	10539	L4a	**10252**	U4a	**10602**
L2a	**10196**	U2a	**10546**	L4c	10259	U4c	10609
L2c	10203	U2c	10553	L4e	10266	U4e	10616
L2e	10210	U2e	10560	L4g	10273	U4g	10623
L2g	10217	U2g	10567	L5a	**10280**	U5a	**10630**
L3a	**10224**	U3a	**10574**				

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10. Safety, environment, licensing

10.1. Frequency

The microwave link RAy10 has to be used in compliance with the license be issued by the radio regulatory authority with jurisdiction over the territory in which the equipment is being operated.

10.2. 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. COMPANY 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
Tel.: +420 722 937 522 | E-mail: racom@racom.eu

www.racom.eu

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Fig. 10.1: EU Declaration of Conformity RoHS, WEEE

10.3. Conditions of Liability for Defects and Instructions for Safe Operation of Equipment

Please read these safety instructions carefully before using the product:

- Liability for defects does not apply to any product that has been used in a manner which conflicts with the instructions contained in this operator manual, or if the case in which the radio modem is located has been opened, or if the equipment has been tampered with.
- 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.
- 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.
- 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.
- Only undermentioned manufacturer is entitled to repair any devices.
- Should the RAy unit be used with other than recommended accessories, Racom takes no responsibility for any malfunction caused by such accessories. Using unsuitable accessories (e.g.cable connectors) can result in a mechanical damage to RAy internal connectors, allow the penetration of water inside the unit, or reduce the efficiency of internal surge protection circuits.

10.4. Important Notifications

RACOM reserves the right to make changes in the technical specification or in this product function or 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 spread by this license has been freed with the purpose to be useful, but without any specific guarantee. Under any circumstances the author or another company or person is not responsible for secondary, accidental or related damages resulting from application of this product.

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

RACOM Open Software License

Version 1.0, November 2009

Everyone can copy and spread word-for-word copies of this license, but any change is not permitted.

The program (binary version) is available for free on the contacts listed on https://www.racom.eu. This product contains open source or another 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 is mentioned in 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 contacts listed on https://www.racom.eu. This product also includes software developed by the University of California, Berkeley and its contributors.

10.5. Product conformity

RACOM
RADIO DATA NETWORKS

Declaration of Conformity – RAY10

In accordance with **1999/5/EC** Directive of the European Parliament and of the Council of 9th of March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity.

Manufacturer:	**RACOM**
Address:	**Mirova 1283, 592 31 Nove Mesto na Morave, Czech Republic**
VAT:	**CZ46343423**
Product:	**RAY 10**
Purpose of use:	**Microvave IP Bridge 10.3–10.6 GHz**

CE 1383

We, the manufacturer of the above mentioned product, hereby declare that:
all essential radio test suites have been carried out and that the above named product is in conformity to all the essential requirements of the European Union directive **1999/5/EC** – ANNEX IV (the technical documentation relevant to the abovementioned equipment can be made available for inspection on application to manufacturer);

The Declaration of Conformity is based on the following documents:

Spectrum:	EN 302 217-2-2 V1.4.1
EMC:	EN 301 489-1 V1.8.1, EN 301 489-4 V1.3.2
Safety:	EN 60950-1:2006

Notified Body Opinion:
Notified Body confirms that compliance has been properly established.

According to:	European Union Directive 1999/5/EC – ANNEX IV
Document No.:	0120-CC-C005-09
Issued by:	Ceský metrologicky institut, Okruzni 31 Brno, CR, 15th of October. 2009
Notified Body:	No. 1383

Nove Mesto na Morave, 14th of October 2013
Jiri Hruska, CEO

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Fig. 10.2: Declaration of conformity for RAy10–xA (10.3 - 10.6 GHz)

RACOM
RADIO DATA NETWORKS

Declaration of Conformity – RAY10

In accordance with **1999/5/EC** Directive of the European Parliament and of the Council of 9th of March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity.

Manufacturer:	**RACOM**
Address:	**Mirova 1283, 592 31 Nove Mesto na Morave, Czech Republic**
VAT:	**CZ46343423**
Type:	**RAY 10**
Code:	**RAy10-LB, RAy10-UB, RAy10-LB-2, RAy10-UB-2**
Purpose of use:	**Microvave IP Bridge 10,15 – 10,65 GHz (CEPT/ERC/REC 12-05 E)**

CE

We, the manufacturer of the above mentioned product, hereby declare that:
all essential radio test suites have been carried out and that the above named product is in conformity to all the essential requirements of the European Union directive **1999/5/EC** – ANNEX III (the technical documentation relevant to the abovementioned equipment can be made available for inspection on application to manufacturer);

The Declaration of Conformity is based on the following documents:

Spectrum:	EN 302 217-2-2 V1.4.1
EMC:	EN 301 489-1 V1.8.1, EN 301 489-4 V1.3.2
Safety:	EN 60950-1:2006

Nove Mesto na Morave, 14th of October 2013
Jiri Hruska, CEO

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Fig. 10.3: Declaration of conformity for RAy10–xB (10.15 - 10.65 GHz)

Product conformity

RACOM s. r. o. hereby declares that its RAy10 microwave bridge product complies with the basic requirements and other relevant provisions of directive 1999/5/EC. Therefore this equipment has the CE mark. The exclamation mark warning symbol identifies the equipment in as class 2 equipment, which is radio equipment with certain restrictions, or requirements on authorisation for use of the equipment in certain countries. In the EU this equipment can be operated according to recommendation CEPT/ERC/REC 12-05 E.

10.6. Warranty

COMPANY-supplied parts or equipment ("equipment") is covered by 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 COMPANY 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 COMPANY direct. The serviced equipment shall be returned by COMPANY to the customer by prepaid freight. If circumstances do not permit the equipment to be returned to COMPANY, then the customer is liable and agrees to reimburse COMPANY for expenses incurred by COMPANY during servicing the equipment on site. When equipment does not qualify for servicing under warranty, COMPANY 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 COMPANY to the customer, as an agreement freely entered into by both parties.

COMPANY warrants the equipment to function as described, without guaranteeing it as befitting customer intent or purpose. Under no circumstances shall COMPANY's liability extend beyond the above, nor shall COMPANY, 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.

Appendix A. Antenna dimensions

The dimensions of the RAy10 unit including the mounting and **Jirous** antenna:

Tab. A.1: Dimensions for various sizes of antenna

Nominal ø ant.	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]
380	440	319	202	211	0
650	730	407	290	300	58

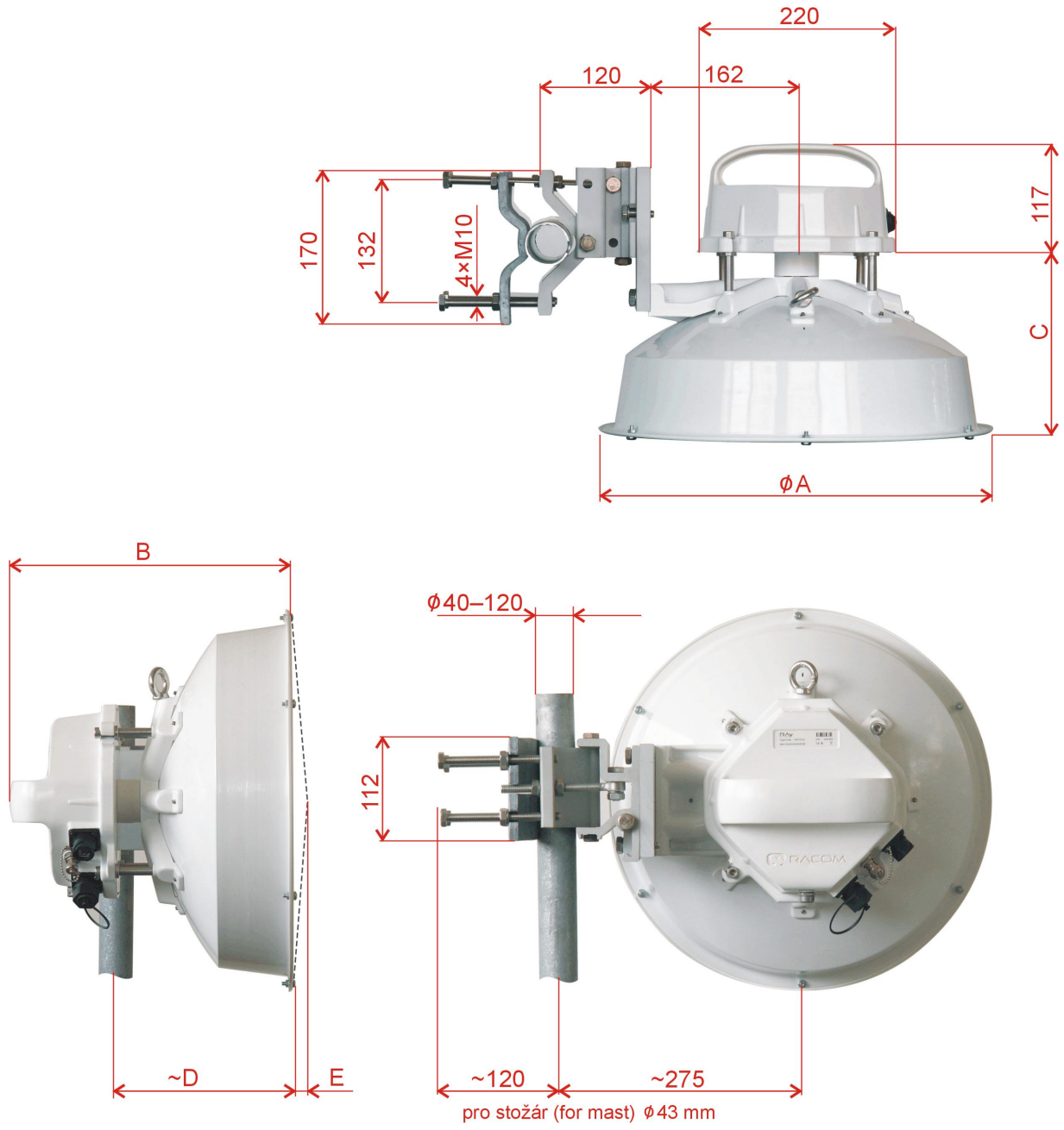
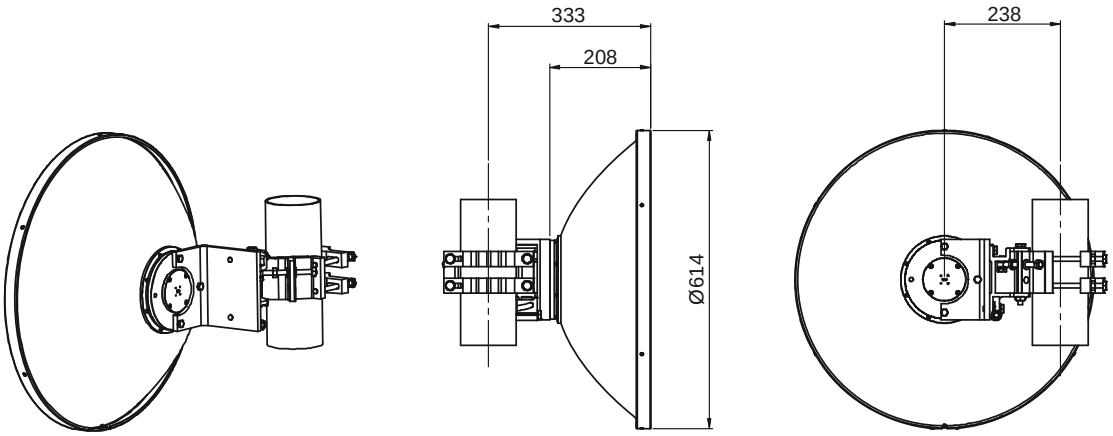


Fig. A.1: Dimensional layout of the RAy10 with the Jirous antenna

Example of antennas diameter of 60 and 99 cm. For more details see *www.racom.eu*[1].



Telephone: +46 515 72 36 00 Telefax: +46 515 72 36 99
Email: info@arkivator.se Internet: www.arkivator.se
Arkivator AB, Box 743, SE-521 22 Falköping, Sweden

Fig. A.2: 0.6 m Arkivator antenna

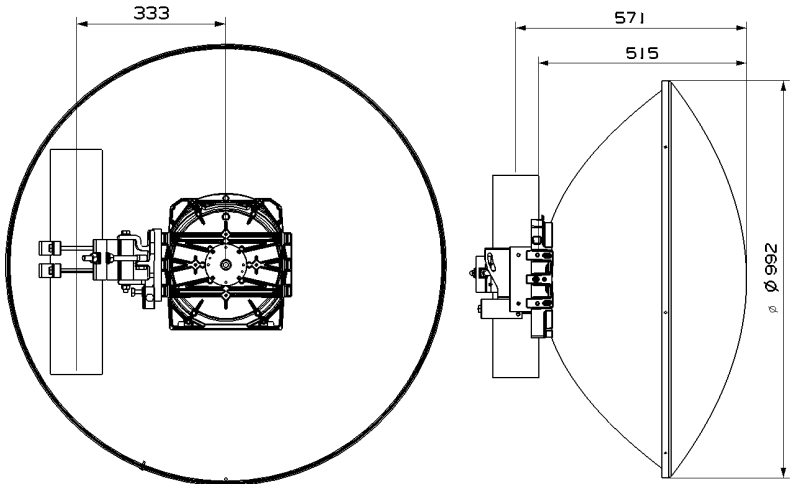
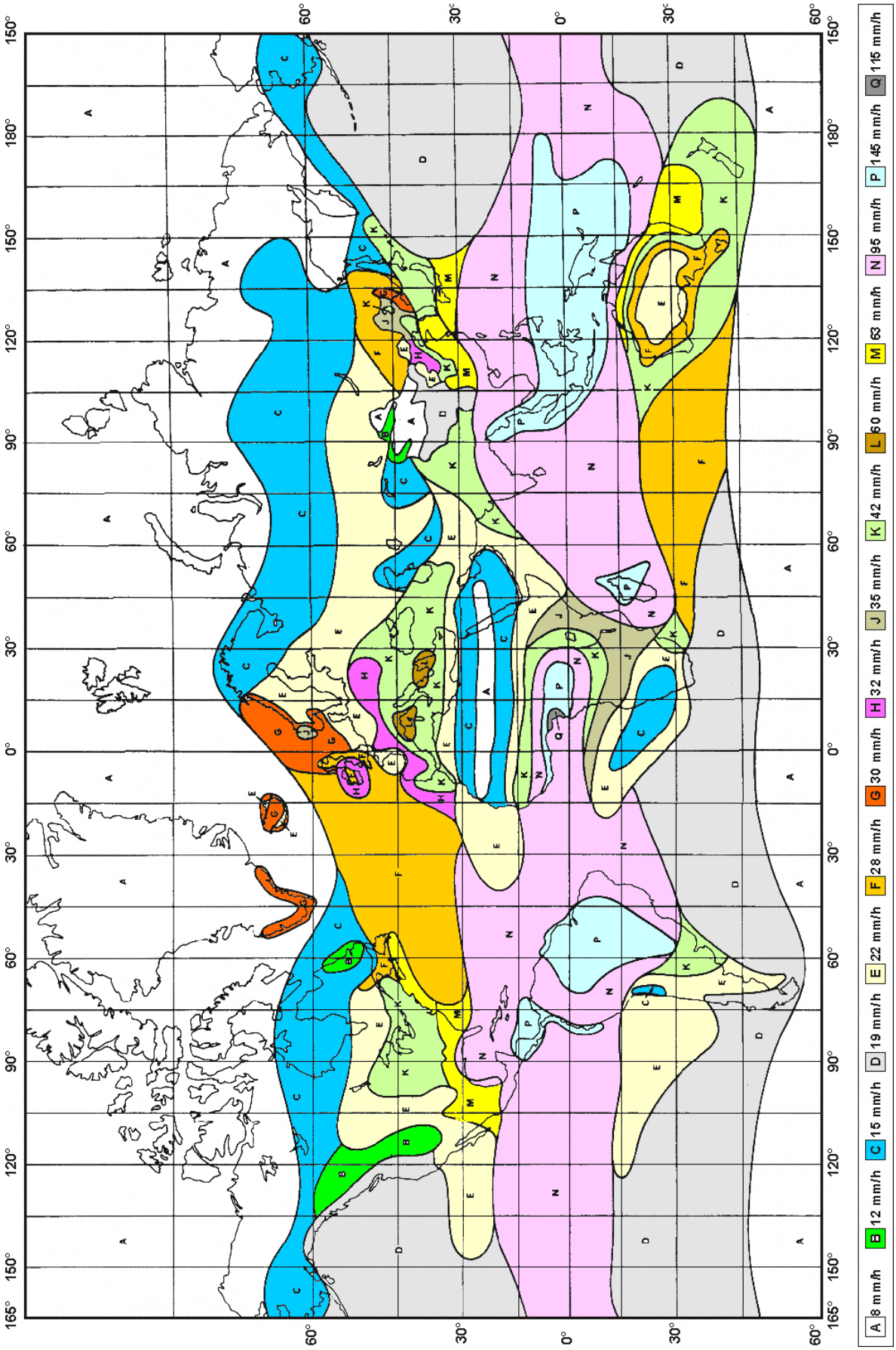


Fig. A.3: 0.99 m Arkivator antenna

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

Appendix B. Rain Zone Map

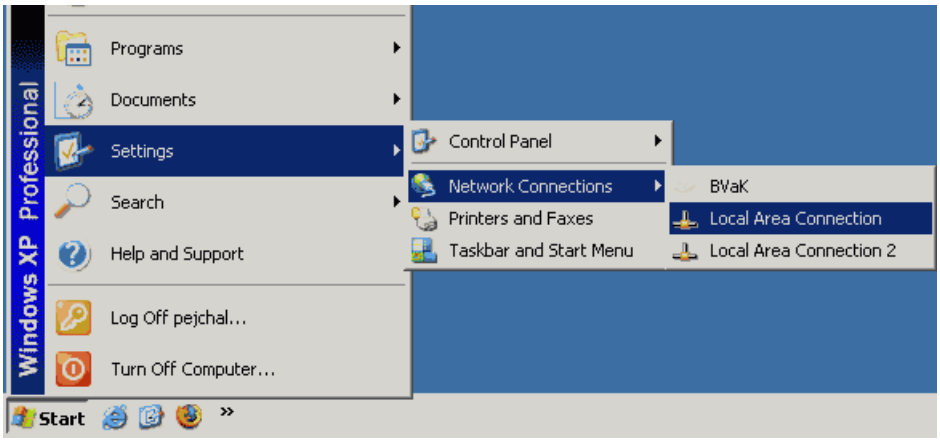


Appendix C. IP address in the PC (Windows XP)

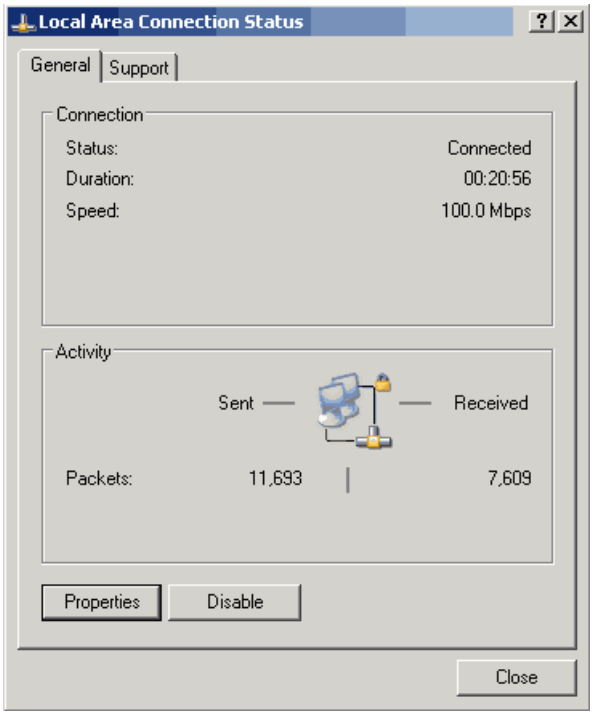
Setting up the IP address in the PC

For configuration of the link a suitable IP address has to be set up in the PC, for example 192.168.1.233.

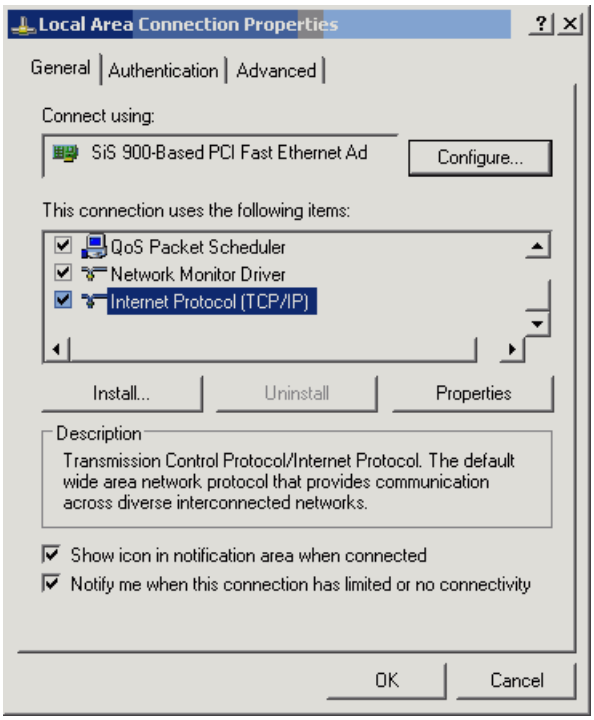
- Open the Start menu, **Settings**, **Network Connections**, **Local Area Connection**



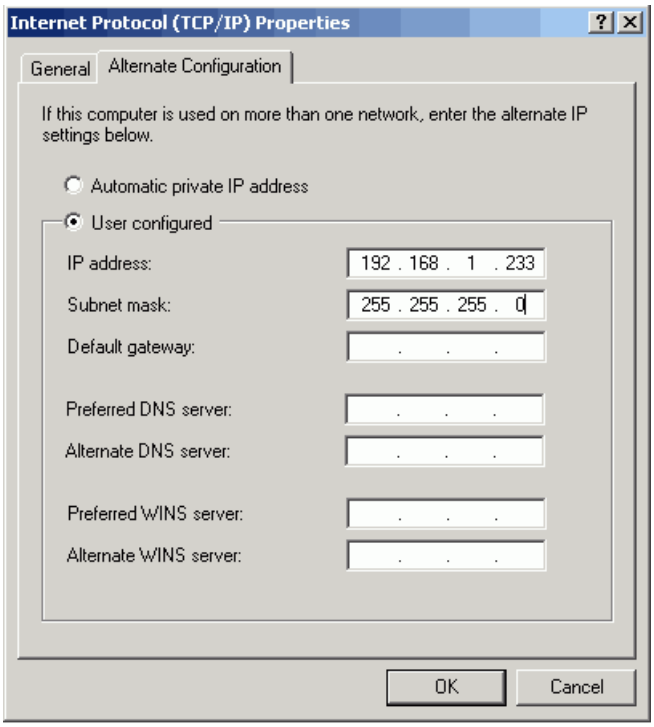
- In the window **Local Area Connection** select **Properties**



- 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 192.168.1.233
- Set Subnet mask to 255.255.255.0
- Click **OK** to acknowledge this window and acknowledge the previous window in the same manner
-
- The second option is to use automatic switching. In this case on the *General* tab select, for example *Obtain an IP address from the DHCP server automatically* and address 192.168.1.233 will be seen on the Alternate configuration tab. However, this detection and subsequent switching works slower and isn't entirely reliable.
- Select tab **Alternate configuration**
- Select **User defined configuration**
- Enter IP Address 192.168.1.233
- Set Subnet mask to 255.255.255.0



- Click **OK** to acknowledge this window and acknowledge the previous window in the same manner

If you don't use Windows XP then proceed according to the manual when setting up the IP address.

Checking the IP address in the PC

In Windows XP proceed in the following manner:

1. Open the Start menu and click **Run...**
2. Enter command **cmd**
3. Enter command **ipconfig** and read the PC IP address and mask:

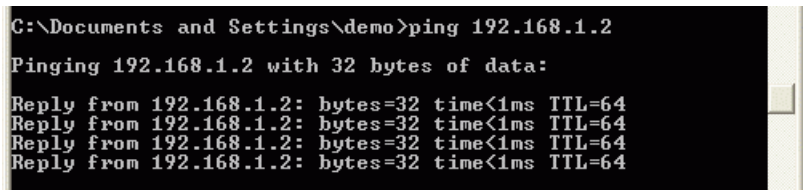
Checking the PC - unit connection using Ping

In Windows XP send a ping as follows:

1. Check the connection between the PC and the unit via the Ethernet cable.
2. In the Start menu click **Run...**
3. Enter command **cmd**

4. Write **ping 192.168.1.2** and press OK

5. A message appears in a window:



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

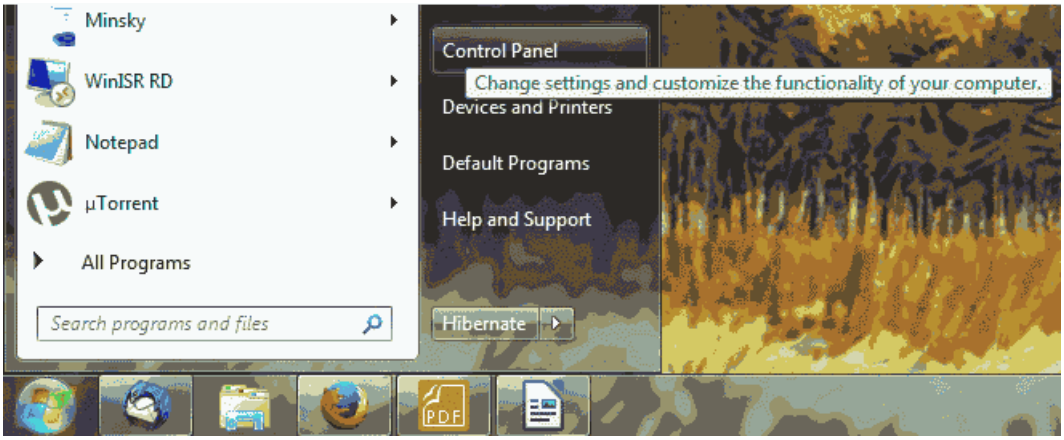
If communication between the web browser and the unit doesn't take place check the browser settings. The *Work offline* item in the *File* menu cannot be crossed out.

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

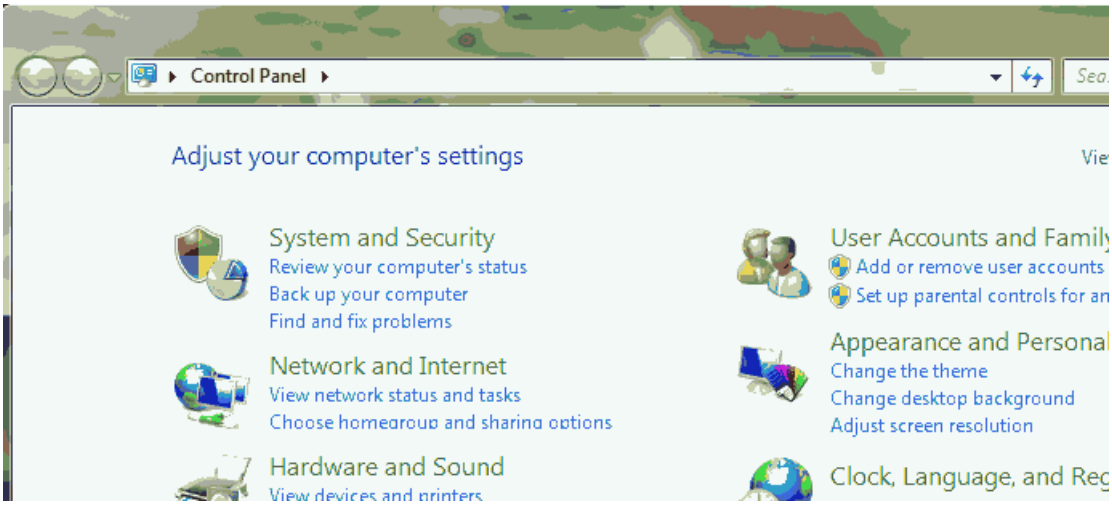
Setting up the IP address in the PC

For configuration of the link a suitable IP address has to be set up in the PC, for example 192.168.1.233.

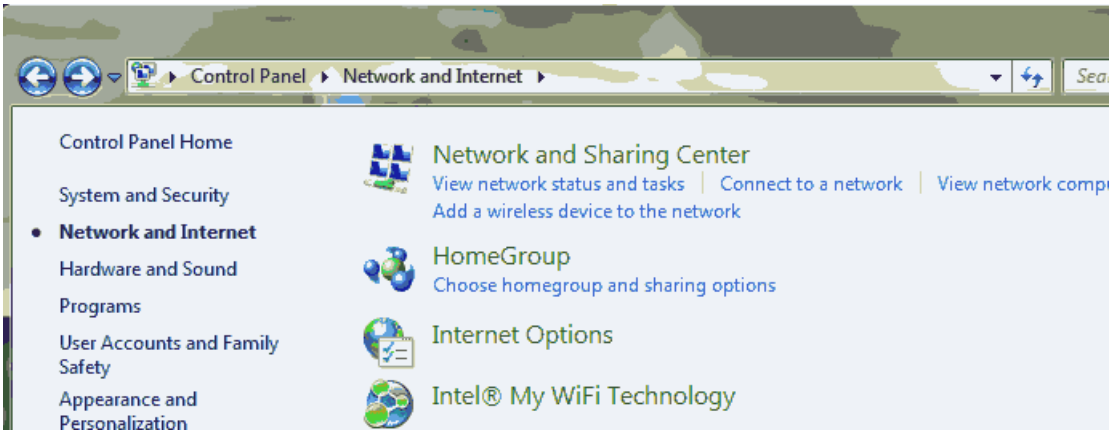
- Open the Start menu, **Control Panel**



- In new window choose **Network and Internet**

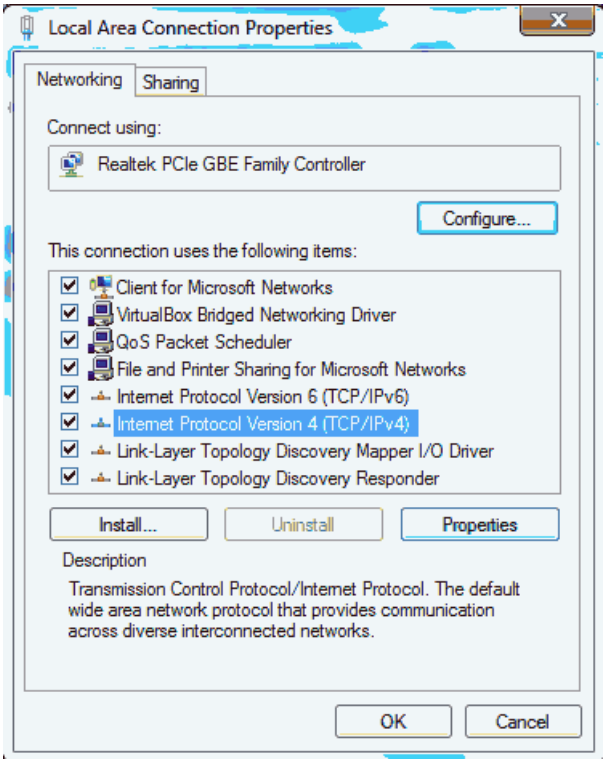


- Continue **Network and Sharing Center**

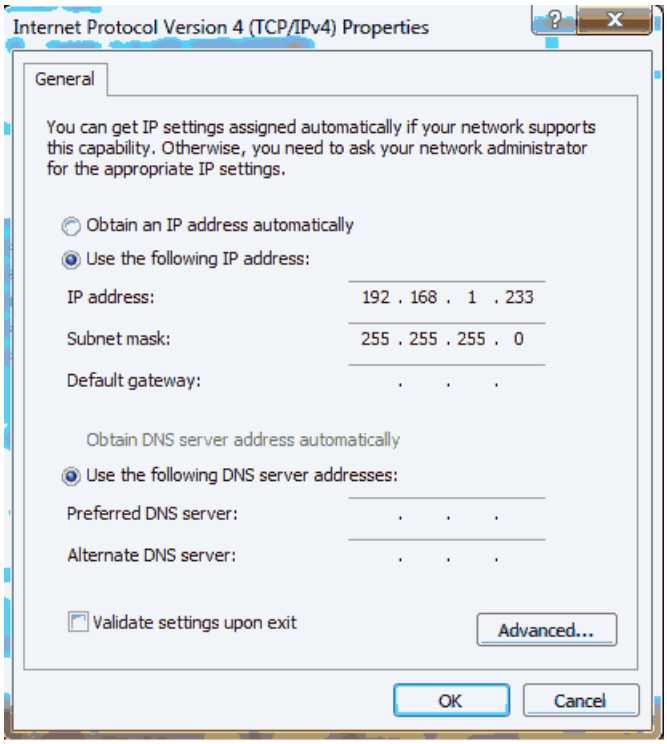


- In the Network Connections window, right-click on **Local area connection** and then left-click on **Properties**

- Select **Internet Protocol Version 4 (TCP/IPv4)** and **Properties**



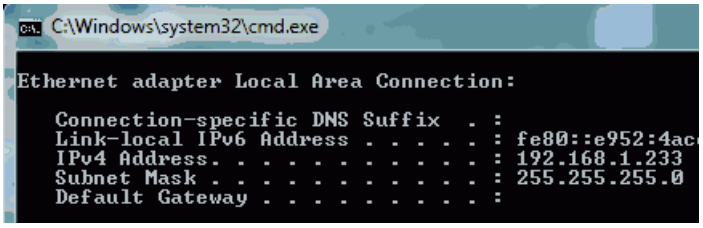
- On the **General** tab select **Use the following IP address**
  - Enter IP Address 192.168.1.233
  - Set Subnet mask to 255.255.255.0
  - Click OK to acknowledge this window and close the previous window also



Checking the IP address in the PC

In Windows 7 proceed in the following manner:

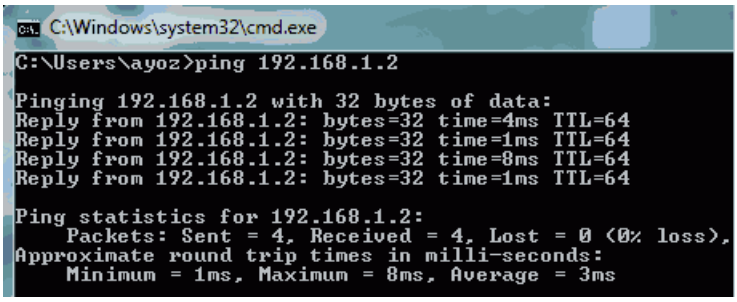
1. Under the **Start** menu, type the command **cmd** in the *Search programs and files* box and press Enter.
2. Inside the *cmd.exe* window that opens, enter the command **ipconfig** at the command prompt and find the information about IP address and mask among the list of messages returned.



Checking the PC - unit connection using Ping

In Windows 7 send a ping as follows:

1. Check the connection between the PC and the unit via the Ethernet cable.
2. Under the **Start** menu, type the command **cmd** in the *Search programs and files* box and press Enter.
3. Inside the *cmd.exe* window that opens, type **ping 192.168.1.2** at the command prompt and press Enter.
4. 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 doesn't take place check the browser settings. E.g. the *Work offline* item in the *File* menu cannot be crossed out.

Appendix E. Linux key conversion

Conversion Linux key – PuTTY

To use CLI (Command Line Interface) access the unit with a PuTTY client. Access is protected by a key supplied with the RAy link. The key is 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

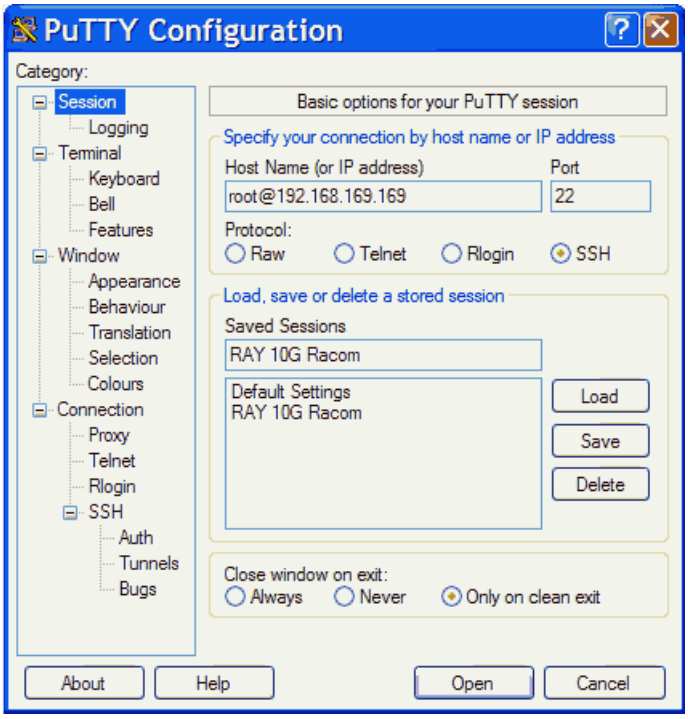
Click on “Load” and choose the private key supplied by the manufacturer.

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

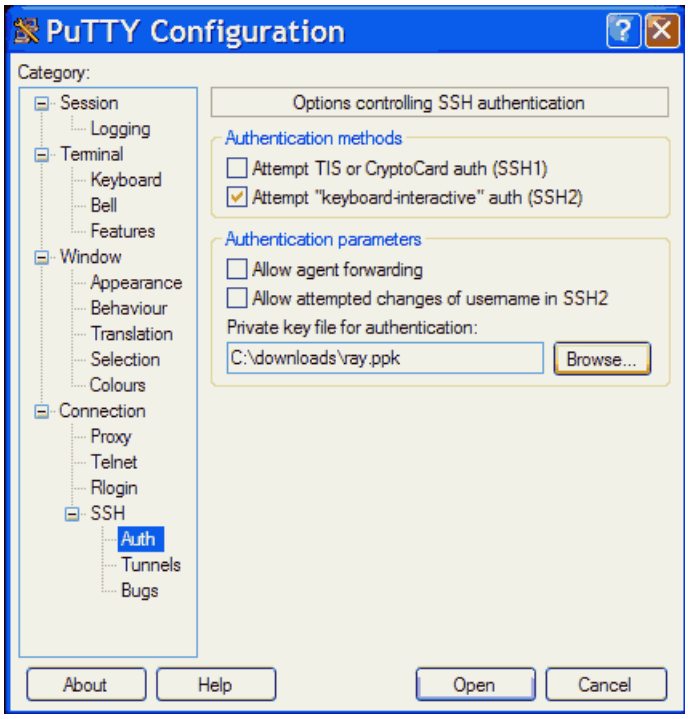
Choose location and save the key.

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 F. Https certificate

When switching from older versions of the firmware the access certificate for https was changed. The web browser configuration has to take place in order to remove link between microwave link management IP address and 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.

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Revision History

Revision 2.0 2011-11-07
First issue

Revision 2.1 2011-12-22
Appendix F, Https certificate

Revision 2.2 2013-01-16
Acoustic indication cancelled.
Adding data of *MTU*.
Supplemented Station description-location: *Settings*, *Status*.
Conditions of liability for defects (*outer connector*).
Updated the table *Modulations and frequencies*, *Measured Values*

Revision 2.3 2013-05-27
Addition of antennas that are used

Revision 2.4 2013-06-20
Added:
Preface - *Important Notice*
Preface - *List of documentation*
Paragraph - *Warranty*

Revision 2.5 2013-10-10
Updated:
Basic technical parameters
Technical parameters tables
Ordering codes
Correction:
Grounding installation
Printscreen changes

Revision 2.6 2014-02-17
Supplemented by *ACM switching* diagram