Hypercable

User manual

INTEGRAL
INTEGRAL-S
INTEGRAL-G
INTEGRAL-GS

VER 2.23

FW 3.10.7

Proprietary notice

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The specifications or information contained in this document are subject to change without notice due to continuing introduction of design improvements. If there is any conflict between this document and compliance statements, the latter will supersede this document.

HYPERCABLE has no liability for typing errors in this document or damages of any kind that result from the use of this document.

To get up to date information about accessories and their availability, please contact a sales representative.

FODU does not contain serviceable parts. Warranty will not be applicable in the event FODU has been hermetically unsealed.

HYPERCABLE is not responsible for any radio or TV interference caused by unauthorized modifications to this equipment. Such modifications could void the user's authority to operate the equipment.

This device complies with part 15 of the FCC Rules. The operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from the one connected to the receiver.
- Consult the dealer or an experienced radio/TV technician for help.

This device complies with Industry Canada licence-exempt RSS standard(s). The operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Contents

Chapter 1: OVERVIEW

Labelling

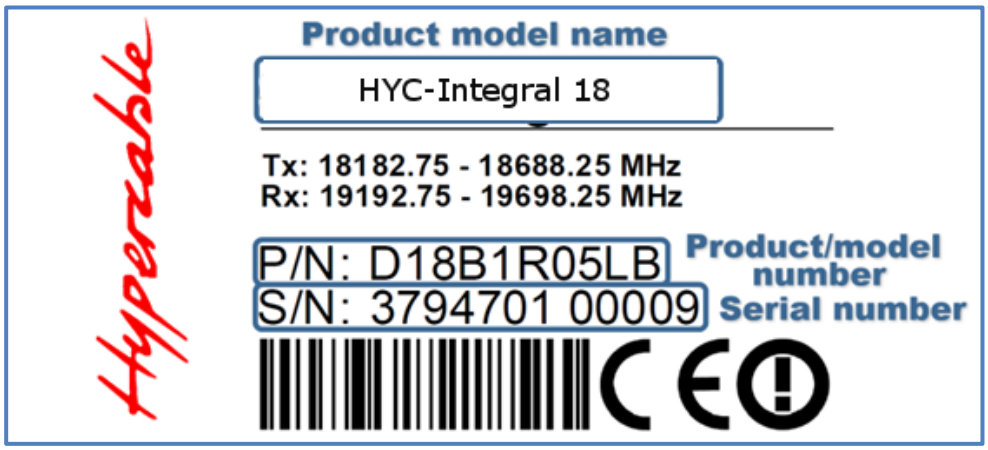
The label contains the following information (see samples in the picture below):

Product model name ("HYPERCABLE INTEGRAL-18"). The FODU model name example is:

- HYPERCABLE INTEGRAL-18 for INTEGRAL 18GHz FODU,
- HYPERCABLE INTEGRAL-GS-23 for INTEGRAL-GS 23GHz FODU, etc

Product Number / Model Number (P/N or M/N) (D18B1R05LB): product/model number contains various information about the unit. Please see translation below.

Serial Number (3794701 00009): the serial number uniquely identifies the unit.



P/N or M/N translation:

"**D**" designates INTEGRAL series product;

"**18**" designates frequency band (18 GHz) of the radio;

"**B**" designates INTEGRAL/INTEGRAL-S product type;

- "**G**" - designates INTEGRAL-G/INTEGRAL-GS product type;

"**1**" designates 1ft antenna diameter and ETSI Class 3;

- "**0**" - <1ft (20cm) antenna diameter and ETSI Class 3;
- "**2**" - 2ft antenna diameter and ETSI Class 3;
- "**3**" - 3ft antenna diameter and ETSI Class 3;
- "**4**" - 4ft antenna diameter and ETSI Class 3;
- "**5**" - <1ft (20cm) antenna diameter and ETSI Class 4;
- "**6**" - 1ft antenna diameter and ETSI Class 4;
- "**7**" - 2ft antenna diameter and ETSI Class 4;
- "**8**" - 3ft antenna diameter and ETSI Class 4;
- "**9**" - 4ft antenna diameter and ETSI Class 4;
- "**S**" - split-mount, without INTEGRALted antenna.

"**R**" designates INTEGRAL with full capacity licence;

- "**N**" - 10 Mbps Basic Licence;
- "**L**" - 100 Mbps Basic Licence;
- "**K**" - 220 Mbps Basic Licence;
- "**X**" - without AES encryption

"**05**" designates the version number of the radio;

"**L**" designates low side radio;

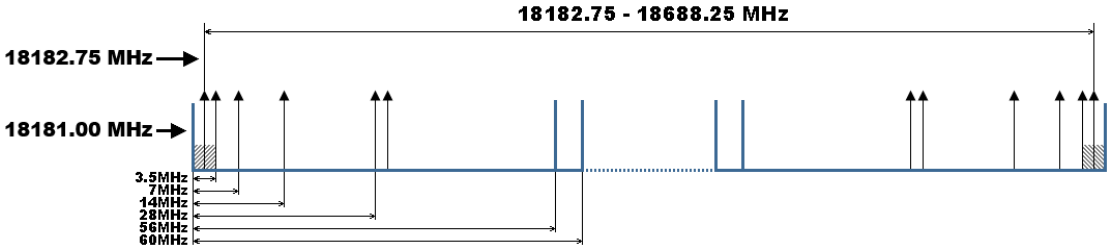
- "**H**" - high side radio

"**B**" designates B subband radio;

- "**A**" - A subband radio;
- "**C**" - C subband radio

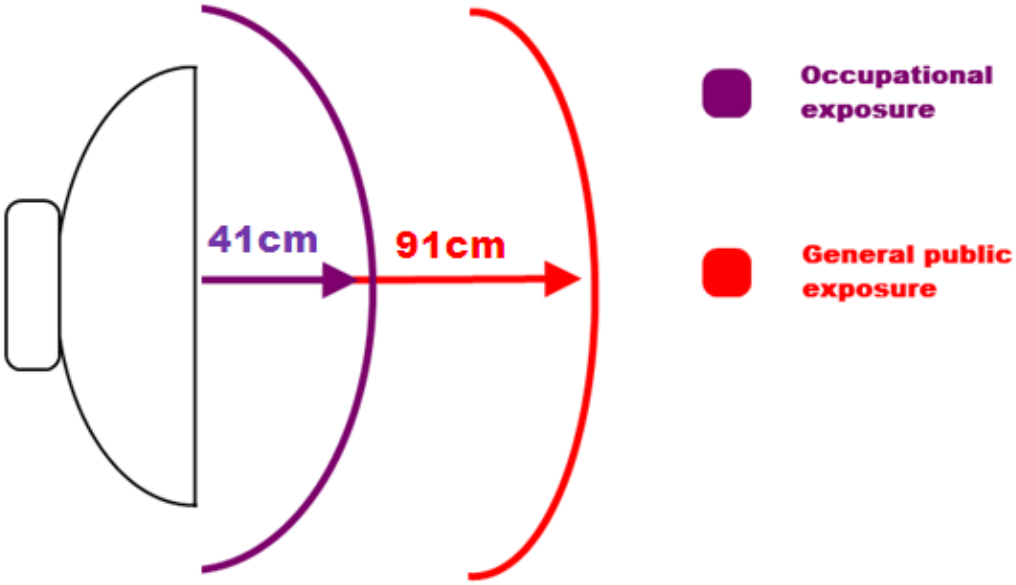
Please note that frequency range is set from the central frequency of the first 3.5 MHz channel to the central frequency of the last 3.5 MHz channel (see the diagram below).

The frequency range of subband B low side INTEGRAL 18 GHz FODU:



Microwave Radiation

In April 1998, ICNIRP (International Commission on Non-Ionizing Radiation Protection) published its ´Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300GHz)´. As shown in Table 2.2-1, the guidelines (Tables 6 and 7) specify the ´Reference levels on power density for occupational exposure and general public exposure to time-varying electric and magnetic fields (unperturbed rms values)´ between 2 and 300 GHz.



ICNIRP Reference levels within the frequency range 24 GHz

Frequency range	Exposure characteristics	Equivalent plane wave power density Seq (W/m2)	Average time period (min)
24GHz	occupational 41cm	50	$68/f^{1.05}$ (f in GHz)
	general public 91cm	10	$68/f^{1.05}$ (f in GHz)

Note: For pulsed signals, it is suggested that the peak equivalent plane wave power density, as averaged over the pulse width, does not exceed 1000 times the Seq exposure levels given in the table.
Note: Within the frequency range the 10 – 300 GHz the basic restrictions are identical to the reference levels.
Remarks on the definition of basic restrictions:
1. Power densities are to be averaged over any 20 cm^2 of exposed area and any 68/f1.05 minute period (where f is in GHz) to compensate for progressively shorter penetration depth as the frequency increases.
2. Spatial maximum power densities, averaged over 1 cm^2, should not exceed 20 times the values above.

Compared to the ICNIRP restrictions, FCC CFR 47 specifies the Maximum Permissible Exposure (MPE) levels for the occupational/controlled environment and general public/uncontrolled environment, as shown in the table below.

FCC MPE limits within the frequency range 1.5-100 GHz

Frequency range	Exposure characteristics	Equivalent plane wave power density Seq (W/m2)	Average time period (min)
24GHz	occupational 41cm	50	6
	general public 91cm	10	30

Quite a few other documents specify or refer to exposure limits comparable to those given above, e.g.:

- 1999/519/EC: Council Recommendation of July 12, 1999, on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz);
- WHO: Environmental Health Criteria 137: ´Electromagnetic Fields (300 Hz to 300 GHz);
- ANSI/IEEE C95.1, 1999:
´IEEE Standard for Hypercableety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz;
- BRD, Bundesimmissionsschutzgesetz, 26. BImSchV Verordnung über elektromagnetische Felder;
- Bundesamt für Umwelt, Wald und Landwirtschaft (BUWAL), Bern/Schweiz
Schriftenreihe Umwelt Nr. 164, Luft, Mai 1992
´Messung nichtionisierender elektromagnetischer Strahlung, 1. Teil: Frequenzbereich 100 kHz bis 300 GHz;
- DIN VDE 0848-2, Entwurf, Oktober 1991:
´Sicherheit in elektrischen, magnetischen und elektromagnetischen Feldern, ´Teil 2: Schutz von Personen im Frequenzbereich von 30 kHz bis 300 GHz;
- ENV 50166-2, January 1995 (withdrawed in December 1999 by CENELEC)
´Human Exposure to Electromagnetic Fields (10 kHz – 300 GHz)´

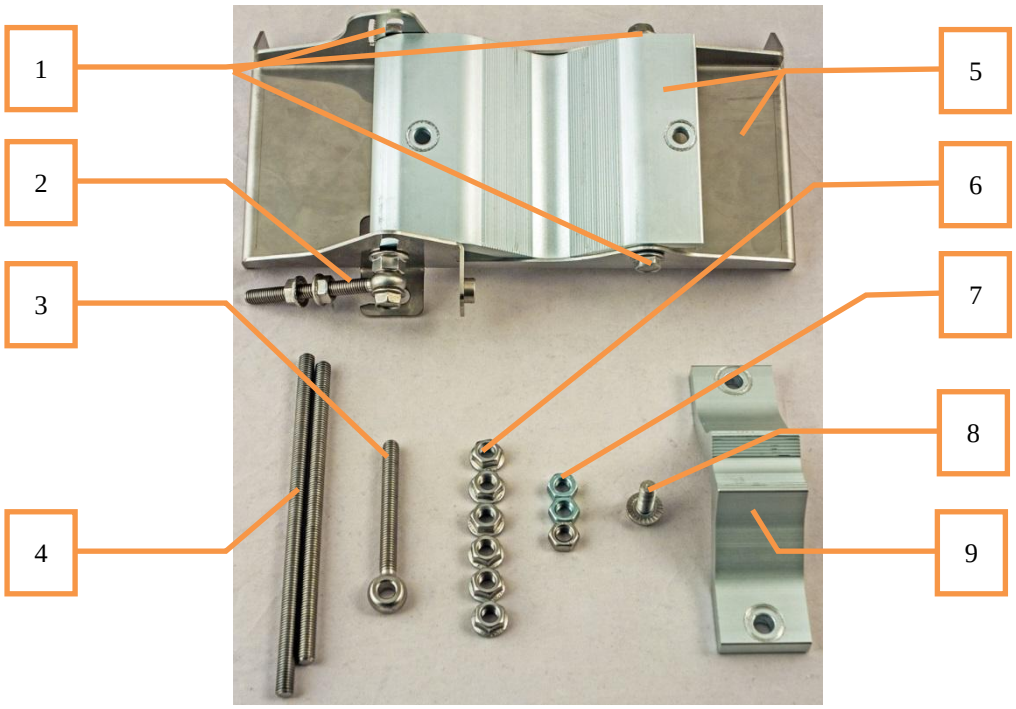
Chapter 2: INSTALLATION

Package contents

INTEGRAL/INTEGRAL-G	INTEGRAL-S/INTEGRAL-GS
- INTEGRAL FODU D**B1*****, D**B2*****, D**G1***** or D**G2*****, - Mounting bracket D0SPKR02 - Locking key for INTEGRAL D0ALK001 - Kit of replacement parts D0AZIP01 - RJ-45 connector 8P shield solid FOACNR02 - Installation manual D0DB2RM1	- INTEGRAL D**BS***** or D**GS***** - Locking key for INTEGRAL-S D0ALK002 - RJ-45 connector 8P shield solid FOACNR02 - Installation manual D0DBSRM1

INTEGRAL/INTEGRAL-G FODU: assembling mounting bracket and installing with an antenna on a pole

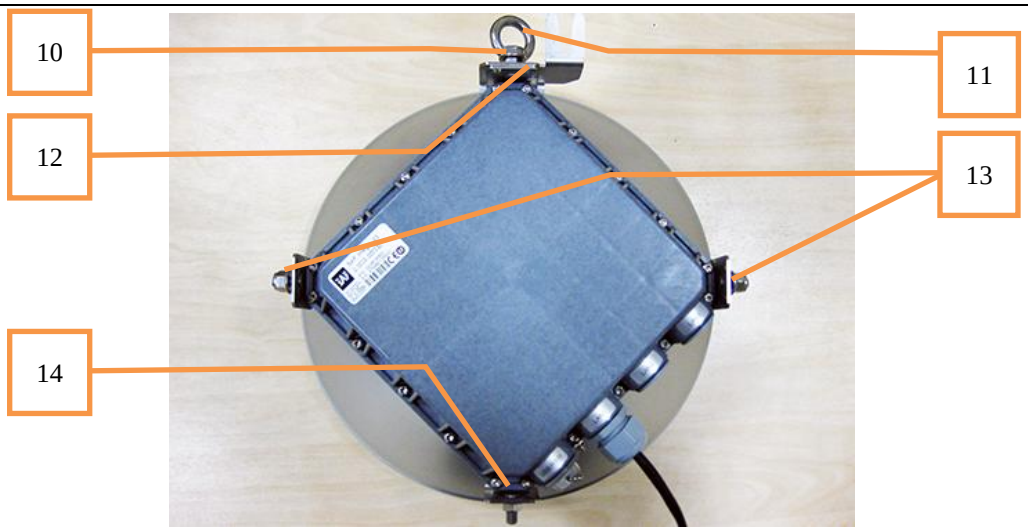
Disassembled mounting bracket and tools required for assembly



Parts of the disassembled mounting bracket

#	Parts of the disassembled mounting bracket
1	Three M8x1.25x16 hex flange bolts already attached to clamps for housing and pipe [5]
2	One hex flange bolt M8x1.25x30, one M10x1.5 hex flange nut and one M8x80 eye screw already attached to clamps for housing and pipe [5]
3	One M8x80 eye screw
4	M8x160 and M8x130 threaded rods

5	Clamps for housing and pipe interconnected with three M8x1.25x16 hex flange bolts [1] and an eye screw for horizontal alignment [2]
6	Six M8x1.25 hex flange nuts
7	Three M8x1.25 hex nuts
8	One hex flange bolt M8x1.25x20
9	Mounting bracket clamp



#	Parts of INTEGRAL/INTEGRAL-G FODU
10	Spacer hex flange nut
11	Lifting eye nut
12	Fixation plate
13	Side screw flange nuts
14	Grounding flange nut

Numbers of the mounting bracket and INTEGRAL/INTEGRAL-G FODU parts in next sections will be mentioned in square brackets [ ].

Changing polarization of INTEGRAL/INTEGRAL-G FODU and antenna

Tools required: 13mm (0.512”) wrench (comes in package)

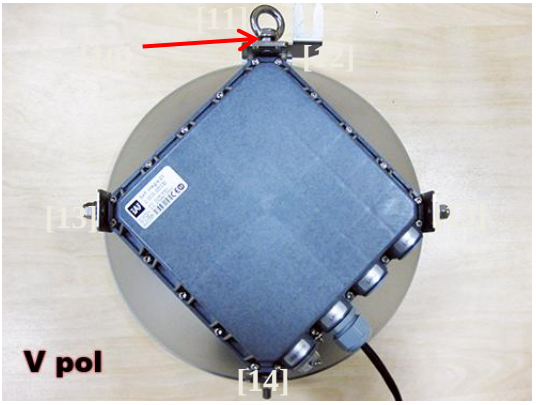
The default polarization for licensed frequency band radios is vertical.

INTEGRAL series 17/24GHz FODUs should be installed in opposite polarizations.

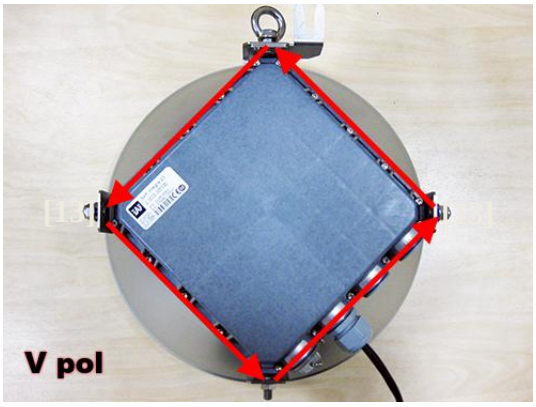
By default, INTEGRAL series 17/24GHz FODU radios are shipped with opposite polarizations pre-installed for low and high side units.

1 Remove INTEGRAL/INTEGRAL-G FODU with an antenna from mounting bracket.

Default polarization is vertical.

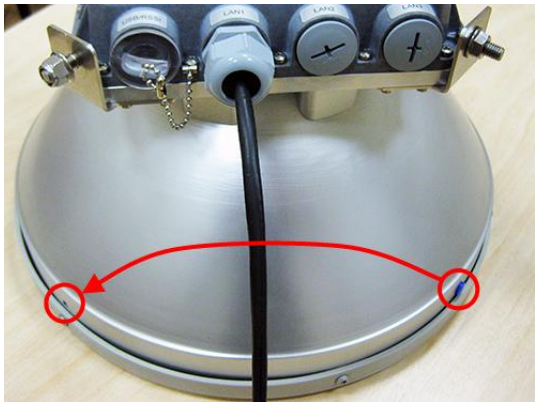


2 Using 13mm wrench remove indicated nuts and fixation plate [10, 11, 12, 13, 14].



3 Removed parts must be attached back with 90 degree offset (see above). The gap between side screw flange nuts [13] and fastening angles should be 5mm.

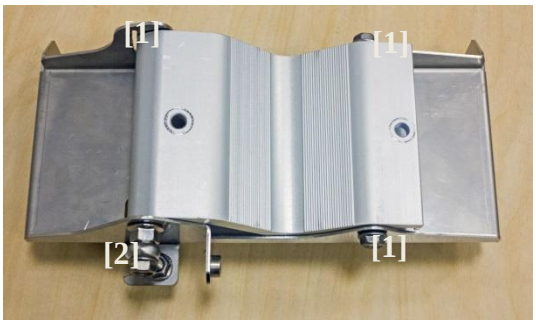
4 View of INTEGRAL/INTEGRAL-G FODU with swapped polarization.



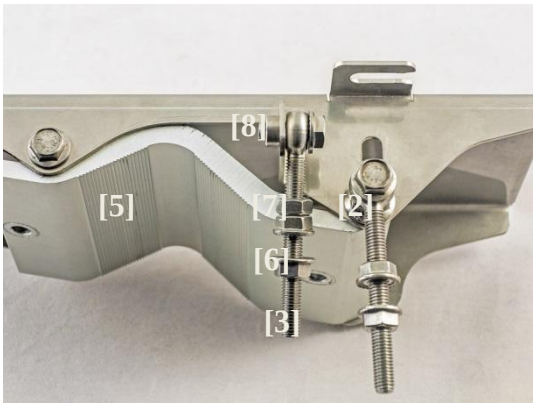
5 When polarization is changed, make sure that the drain hole cap located at grounding flange nut is removed and inserted into the previous drain hole.

Assembly procedure

Tools required: 13mm (0.512”) wrench (comes in the package)

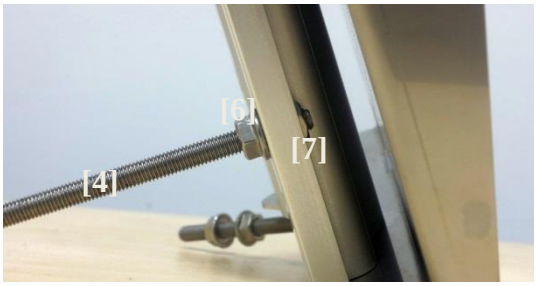


1 Using 13mm wrench slightly loosen three hex flange bolts [1] and hex flange bolt, nut and eye screw [2] interconnecting clamps for housing and pipe [5].

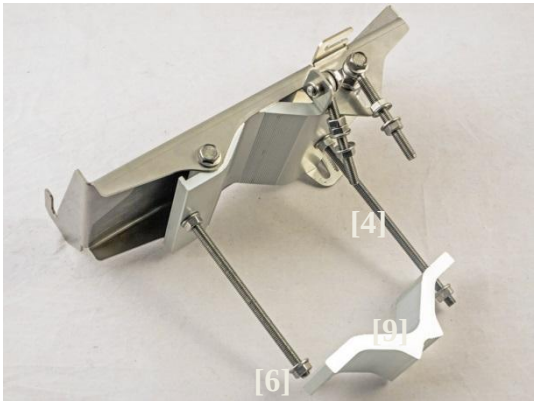


2 Attach vertical alignment eye screw [3] to clamps for housing and pipe [5] using hex flange bolt [8] and screw on one hex nut [7] and two hex flange nuts [6]. Make sure that both eye screws are positioned as shown in the image (turned to the back side of clamps). The gap between each two flange nuts on eye screws should be 15..20mm (0.6..0.8 in.). Do not tighten both hex flange bolts [8] and [2].

3 Screw on one hex flange nut [6] on each of threaded rods [4]. Note that flange nuts should be screwed on exposing approx. 20mm (0.8 in.) of threaded rods.

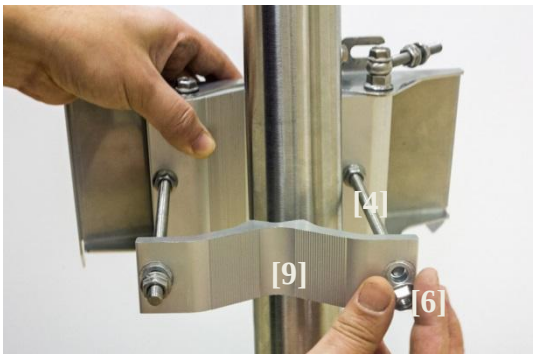


4 Insert both threaded bolts into two available holes of mounting clamp. Put hex nuts [7] on the other side of the clamp and screw on the threaded bolts until it is visible from the other side of the clamp no more than 2mm. Tighten hex flange nuts [6] with torsion 20..25 N·m.



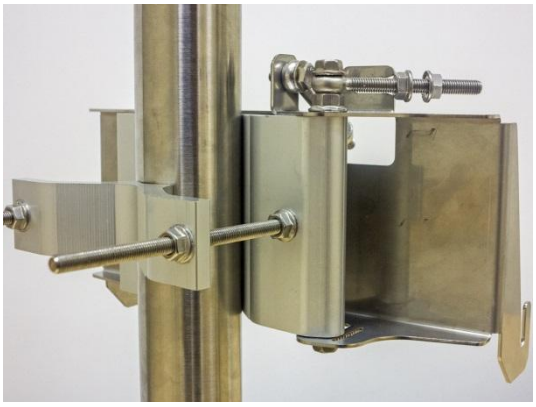
5 Attach mounting bracket clamp [9] on the longest threaded rod [4] as shown in the picture and afterwards screw on remaining two hex flange nuts [6] on both threaded rods. No parts should remain unassembled.

Bracket clamps in the following position support mast Ø 55..120mm. Reversing clamps allows support of smaller masts Ø 25..75mm.



6 Unscrew hex flange nut [6] from the shortest threaded rod [4]. Make sure that hex flange nuts on the longest threaded rod are not too far; otherwise adjust nut's position accordingly. Put another end of mounting bracket clamp [9] on free threaded rod and screw on hex flange nut.

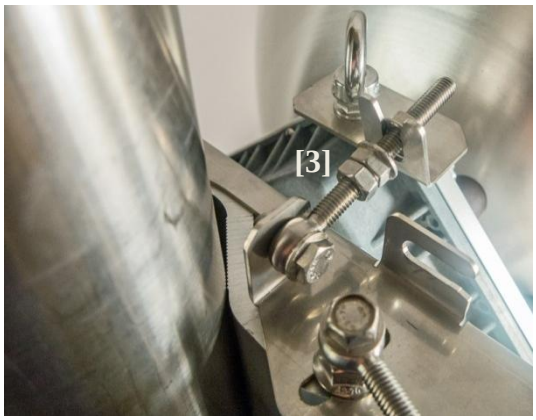
7 Hex flange nuts should be evenly aligned on threaded bolts so that mounting bracket clamp [9] is tightly attached to the pipe. Tighten hex flange nuts with torsion not exceeding 20 N·m.



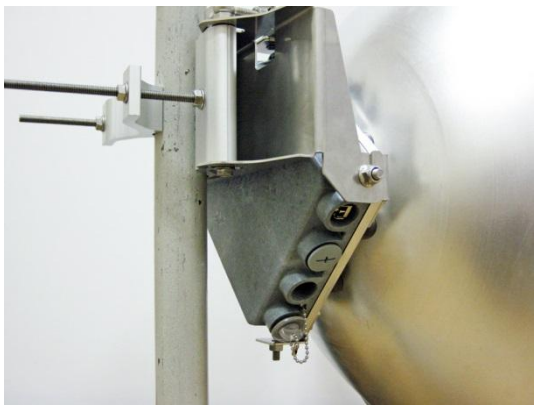
8 View of the assembled mounting bracket on the mast pole.

9 Make sure that both horizontal and vertical alignment eye screws are turned to the mast before attaching INTEGRAL/INTEGRAL-G FODU.

10 Attach INTEGRAL/INTEGRAL-G FODU with the antenna to the mounting bracket so that side screws fit into grooves of the housing clamp [5].



11 Connect vertical alignment eye screw [3] to the upper groove on INTEGRAL/INTEGRAL-G housing.



12 View of the assembled bracket on the mast pole with INTEGRAL/INTEGRAL-G FODU attached and secured.

It is recommended to protect the installed radio from direct sunlight.

Antenna alignment

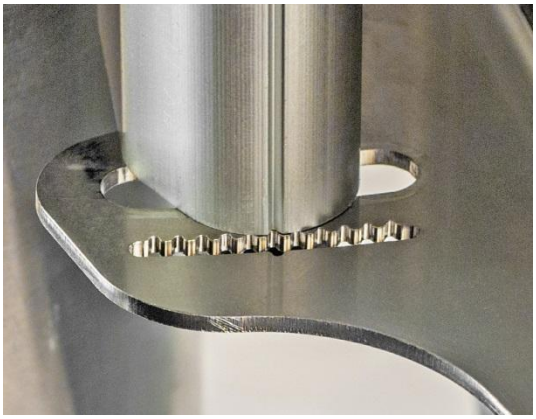
Tools required: 13mm (0.512”) wrench (comes in package)

1 Before aligning the antenna, make sure that screws marked with red dots on the right side view of the mounting bracket are loosened - hex flange nuts and bolts of azimuth and elevation eye screws, right side screw on INTEGRAL/INTEGRAL-G FODU and hex flange bolt on azimuth angle indicator.

2 Additionally loosen the following screws marked with red dots on the left side view of the mounting bracket: left side screw on INTEGRAL/INTEGRAL-G FODU and two hex flange bolts between both mounting bracket clamps for housing and pipe.

3 For initial alignment make sure that elevation is approximately at zero degrees angle by adjusting hex flange nuts [9] on vertical alignment eye screw so that INTEGRAL/INTEGRAL-G housing is parallel with the bracket.

4 Adjust azimuth angle by manually moving mounting bracket in the horizontal axis. Note that all azimuth position fixing hex flange bolts, as well as horizontal alignment eye screw with flange bolt need to be loosened ensuring free movement in the horizontal axis.



5 Each notch corresponds to one degree of azimuth angle. The half distance between notches (each lip) corresponds to 0.5 degrees.

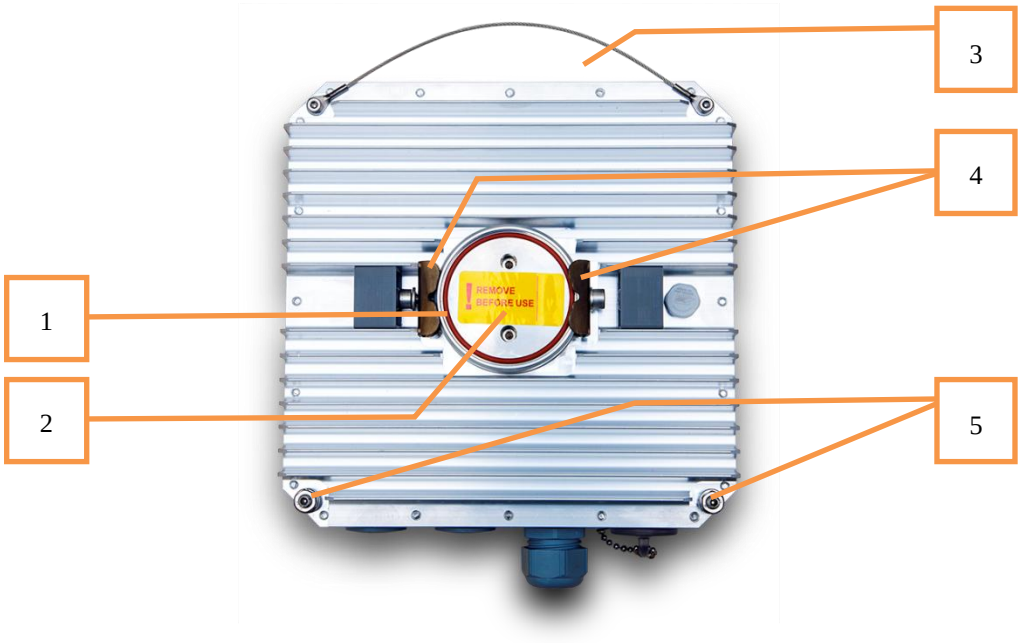
6 Fix azimuth angle on the horizontal axis by adjusting the position of flange nuts [6] on both horizontal and vertical alignment eye screws.

7 When alignment is finished tighten screws marked with red dots on the right side view of the mounting bracket: hex flange nuts and bolts of azimuth and elevation eye screws, right side screw on INTEGRAL FODU and hex flange bolt on azimuth angle indicator with torsion 20..25 N·m.

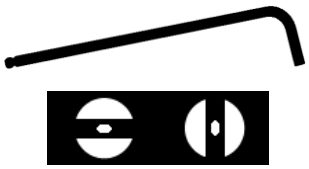
8 Additionally tighten the following screws marked with red dots on the left side view of the mounting bracket: left side screw on INTEGRAL/INTEGRAL-G FODU and two hex flange bolts between both mounting bracket clamps for housing and pipe with torsion 20..25 N·m.

INTEGRAL-S/INTEGRAL-GS 15-42GHz* FODU: attaching to the antenna

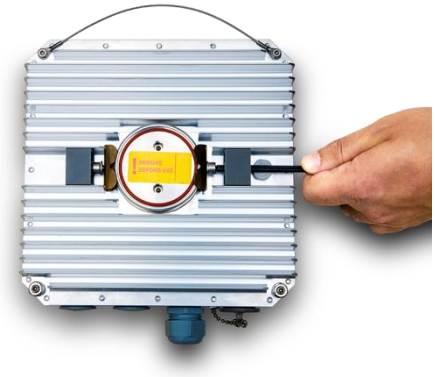
Parts of INTEGRAL-S/INTEGRAL-GS FODU: **1** – O-ring; **2** – flange protecting sticker; **3** – wire handle; **4** – fixation clamps; **5** – grounding screws.



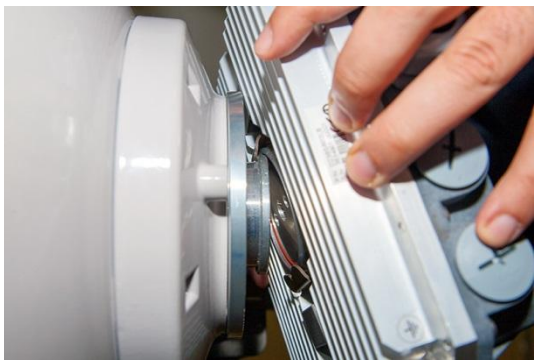
Tools required: Size 5 Allen wrench



Level (not supplied)



1 Using size 5 Allen wrench loosen one clamp completely and second clamp by a half-turn.



2 Put INTEGRAL-S/INTEGRAL-GS on antenna adapter flange by hooking half-turn loosened clamp at the top and leaving the completely loosened clamp at the bottom. Make sure O-ring is in place and the adapter flange fits into the INTEGRAL-S/INTEGRAL-GS transition flange socket.

Note! The protective sticker should be removed before attaching the INTEGRAL-S/INTEGRAL-GS FODU to the antenna.

3 Secure the interconnection by tightening the bottom clamp (not fully). Make sure rotation of the INTEGRAL-S/INTEGRAL-GS is still possible.

4 Rotate INTEGRAL-S/INTEGRAL-GS to match the required polarization.

5 The sticker on the back lid indicates the polarization of the INTEGRAL-S/INTEGRAL-GS. Adjust polarization so that the interface ports are located at the lower side of the INTEGRAL-S/INTEGRAL-GS.

6 Verify polarization accuracy with a level, by placing it on the top edge of the INTEGRAL-S/INTEGRAL-GS housing

7 Secure the position of INTEGRAL-S/INTEGRAL-GS by fully tightening both fixation clamps.

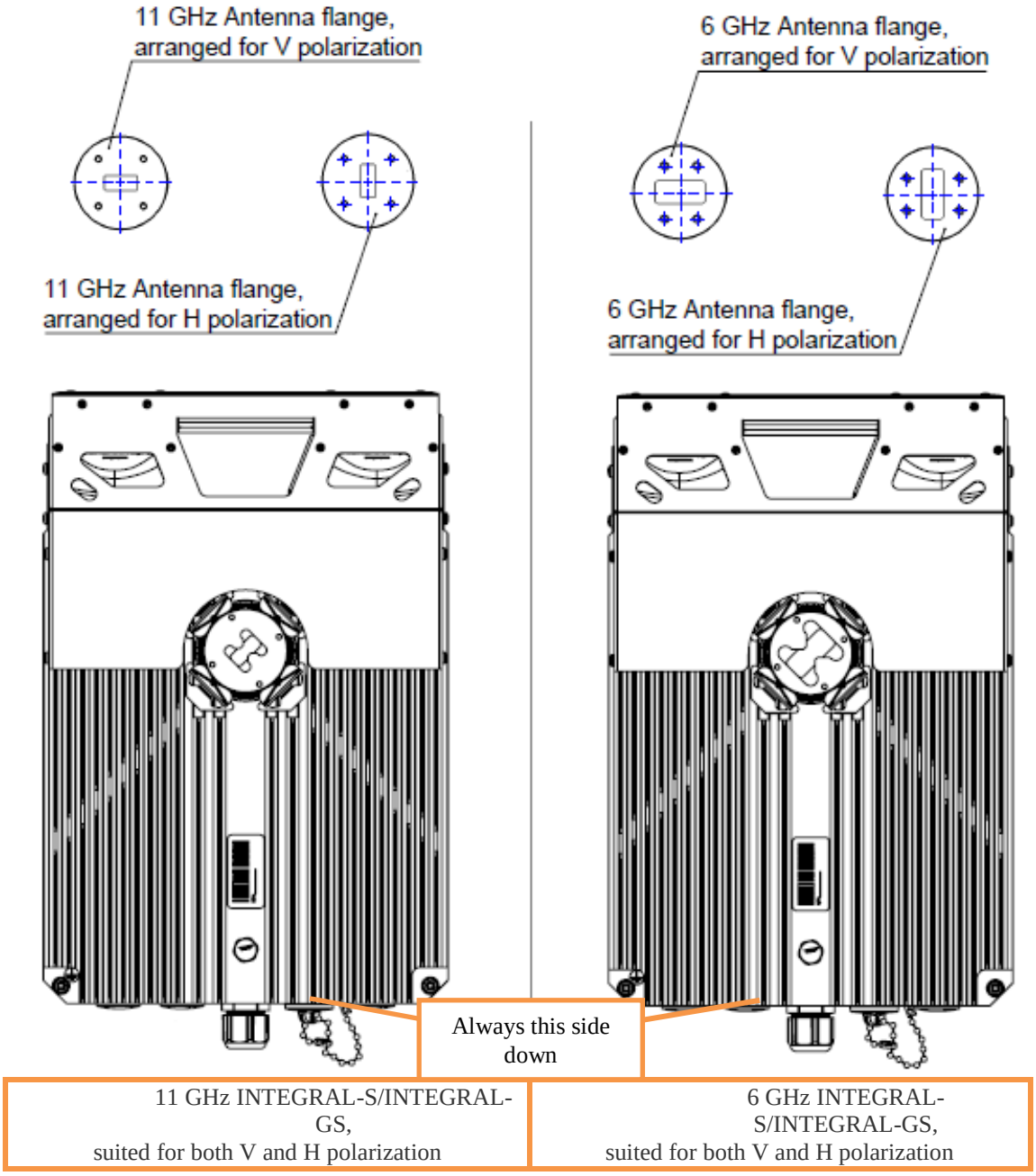
* INTEGRAL-S/INTEGRAL-GS 15/18/17/23/24/26/32/38/42GHz are separate FODU models

It is recommended to protect the installed radio from direct sunlight.

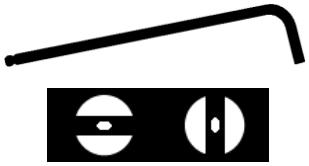
The default polarization for licensed frequency band radios.

INTEGRAL-S/INTEGRAL-GS 6-13GHz* FODU: attaching to the antenna

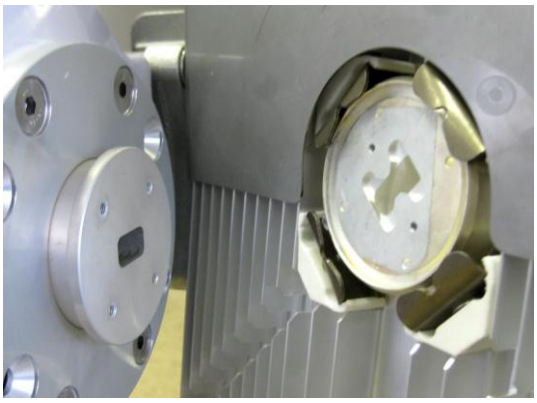
INTEGRAL-S/INTEGRAL-GS 6-13GHz* FODU features twisted polarization flange and resulting signal polarization is determined by Interface on antenna/OMT. To change signal polarization, please rotate only the antenna interface, as radio always remains in vertical position.



Tools required: Size 5 Allen wrench, 240mm

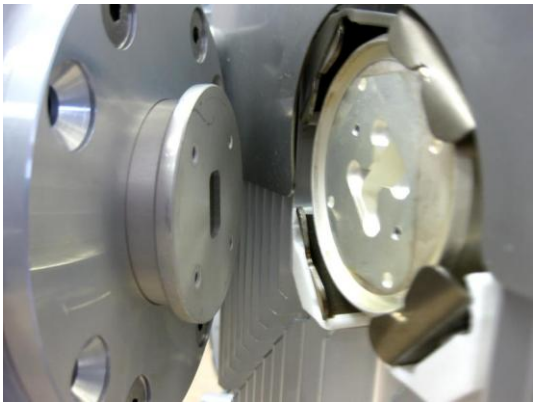


Level (not supplied)



1 INTEGRAL-S/INTEGRAL-GS 6-13GHz* FODU features twisted polarization flange and resulting signal polarization is determined by Interface on antenna/OMT. To change signal polarization, please rotate only the antenna interface, as radio always remains in vertical position.

Example of vertical polarization interconnection.

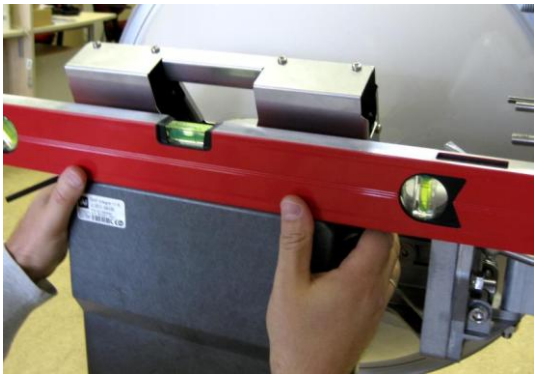


2 Example of horizontal polarization interconnection.

3 Put INTEGRAL-S/INTEGRAL-GS on antenna adapter flange by hooking half-turn loosened clamp at the top and leaving the completely loosened clamp at the bottom. Make sure O-ring is in place and the adapter flange fits into the INTEGRAL-S/INTEGRAL-GS transition flange socket.

Note! The protective sticker should be removed before attaching the INTEGRAL-S/INTEGRAL-GS FODU to the antenna.

4 Tighten bottom fixation clamps.



5 Use air level to verify that INTEGRAL-S/INTEGRAL-GS FODU is properly levelled. Tighten all four fixation clamps properly.

6 Final view of assembled INTEGRAL-S/INTEGRAL-GS 6-13GHz* 1+0 setup.

* INTEGRAL-S/INTEGRAL-GS 6U/6L/7/8/10/11/13 are separate FODU models

If any further assistance is required please contact info@hypercable.fr

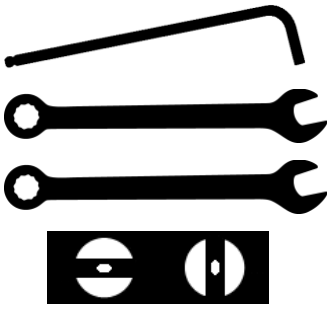
INTEGRAL-S/INTEGRAL-GS 6-13GHz* 2+0 & OMT interconnection

Tools required: Size 5 Allen wrench, 240mm

10mm (0.394”) wrench (not supplied)

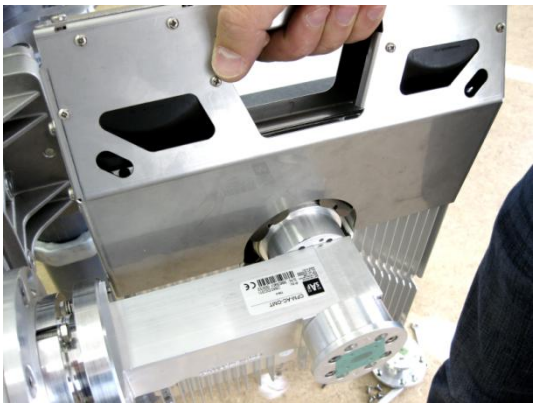
8mm (0.315”) wrench (not supplied)

Level (not supplied)



It is recommended to perform steps 1-2 on the ground.

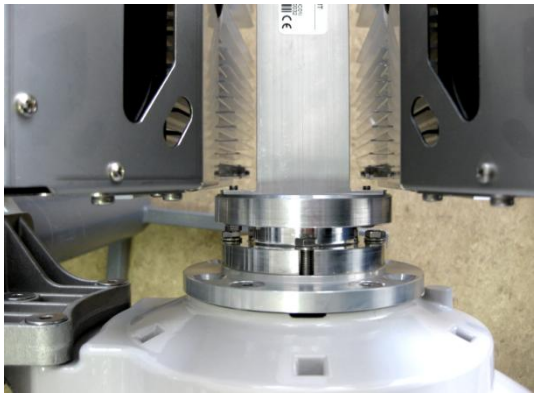
1 Prepare INTEGRAL-S/INTEGRAL-GS 6-13GHz* FODU by loosening both bottom clamps (should not overlap the flange plate) and tightening both upper clamps (will be used as a hook).



2 Attach INTEGRAL-S/INTEGRAL-GS 6-13GHz* FODU to the OMT using both upper clamps INTEGRAL-S/INTEGRAL-GS 6-13GHz* FODU features twisted polarization flange and resulting signal polarization is determined by Interface on antenna/OMT. To change signal polarization, please rotate only the antenna interface, as radio always remains in a vertical position

3 Slightly tighten both bottom fixation clamps to secure FODU to the OMT.

4 Use air level to verify that FODUs are properly levelled. Note that radio position should be in parallel with the OMT. Thus, if antenna is inclined or declined in elevation, radio position should be kept in the same angle.



5 Tighten all 4 INTEGRAL-S/INTEGRAL-GS fixation clamps on both FODUs. When properly attached there's a gap between FODUs, OMT and antenna.

6 Final view of assembled INTEGRAL-S/INTEGRAL-GS 6-13GHz* 2+0 setup.

* INTEGRAL-S/INTEGRAL-GS 6U/6L/7/8/10/11/13 are separate FODU models

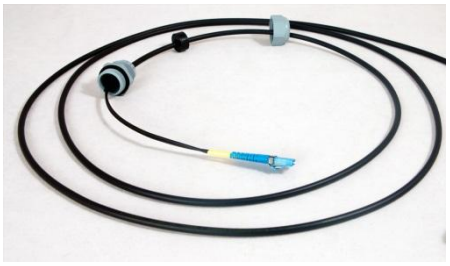
For connecting INTEGRAL-S/-GS 15-42GHz to an OMT, please follow the instructions in Chapter INTEGRAL-S/INTEGRAL-GS 15-42GHz* FODU: attaching to the antenna

If any further assistance is required please contact info@hypercable.fr

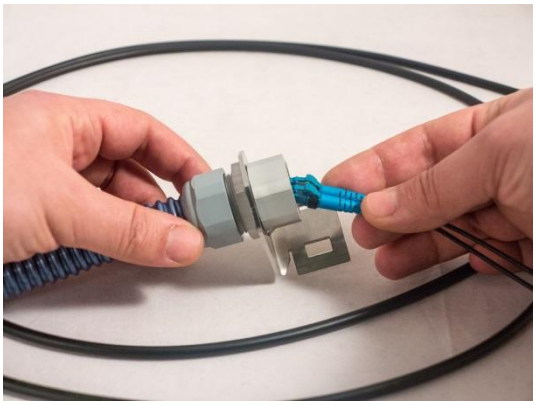
Connecting FO interface using fiber conduit kit

1 Fiber conduit kit.

2 Unscrew the cap of the SFP port (LAN2 or LAN3) that will be used and install an SFP module.



3 Disassemble conduit kit and put its parts in the following sequence (left – FODU direction, right – CPE direction).



4 Push FO cable from LC connector side through the conduit.

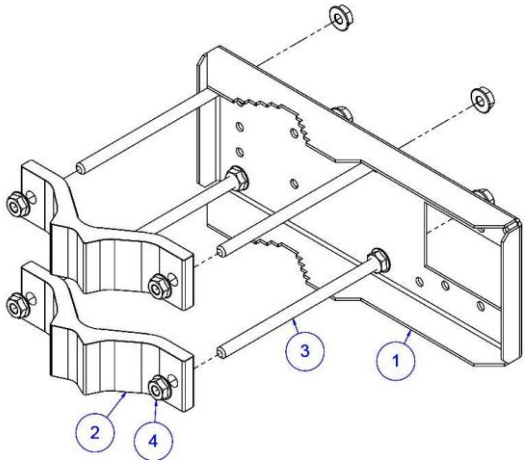
5 Connect LC connector to SFP module.

6 Tighten parts on both ends of the conduit. Fasten another end of fiber conduit to the pole using included tie-wrap. Assembled view.

INTEGRAL-GS 6-13GHz* remote mount kit assembly

Tools required: Size 5 Allen wrench

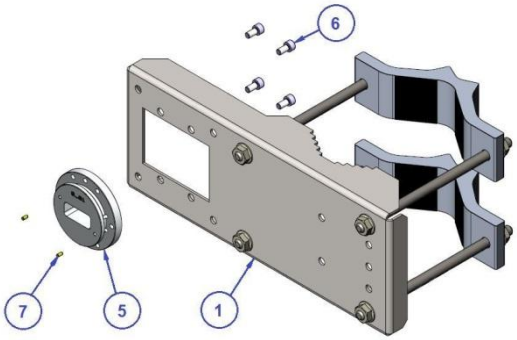
13mm (0.512”) wrench (not supplied)



1 Assemble mounting bracket using 13mm wrench:

Screw on one hex flange nut [4] on each of four threaded rods [3]. Insert threaded rods into available holes of mounting clamp [1]. Put hex nuts [4] on the other side of the clamp and screw on the threaded rods until these are visible from another side of the clamp not more than 2mm. Tighten hex flange nuts with torsion 20..25 N·m.

Attach two mounting bracket clamps [2] on threaded rods [3] as shown in the picture and afterwards screw on remaining four hex flange nuts [4] on all threaded rods.



2 Attach waveguide transition flange to the mounting bracket using size 5 Allen wrench:

Put flat side of transition flange [5] on the flat side of mounting clamp [1] as shown on the picture and screw in four socket head screws [6] from another side of the clamp. Put in two dowel pins [7] in appropriate holes of transition flange. Pins are sitting in holes very loose; therefore, perform the last action immediately before FODU installing.

3 View of the assembled mounting bracket on thick pole mast:

Bracket clamps in following position support mast diameters 55..120 mm.

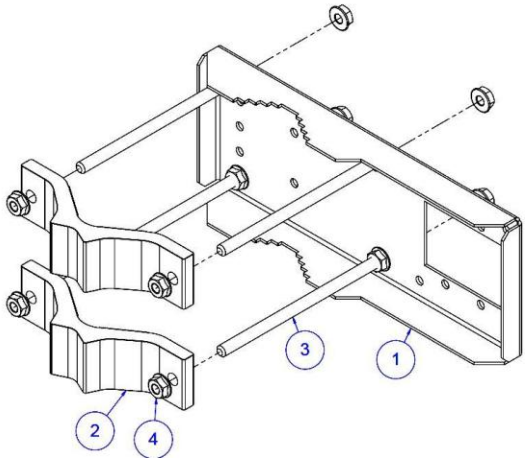
4 View of the assembled mounting bracket on thin pole mast: Bracket clamps in reverse position support smaller mast diameters 25...75mm.

*INTEGRAL-GS 6U/6L/7/8/10/11/13 are separate FODU models

INTEGRAL-GS 15-42GHz* remote mount kit assembly

Tools required: Size 5 Allen wrench

13mm (0.512”) wrench (not supplied)

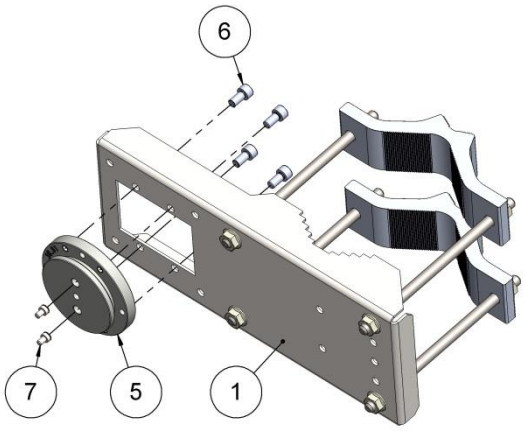


1

Assemble Mounting Bracket using 13mm wrench:

Screw on one hex flange nut [4] on each of four threaded rods [3]. Insert threaded rods into available holes of mounting clamp [1]. Put hex nuts [4] on the other side of the clamp and screw on the threaded rods until these are visible from another side of the clamp not more than 2mm. Tighten hex flange nuts with torsion 20..25 N·m.

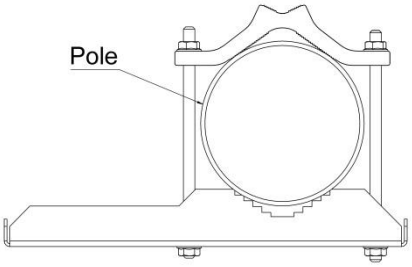
Attach two mounting bracket clamps [2] on threaded rods [3] as shown in the picture and afterwards screw on remaining four hex flange nuts [4] on all threaded rods.



2

Attach Waveguide transition flange to the mounting bracket using Size 5 Allen wrench:

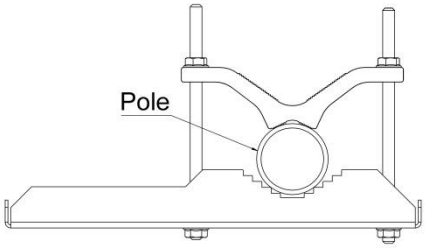
Put flat side of transition flange [5] on the flat side of mounting clamp [1] as shown on the picture and screw in four socket head screws [6] from another side of the clamp. Two screws [7] have to be screwed into antenna flange of ODU (not shown here). Screws' heads serve as guiding pins while the ODU is attached to the transition flange [5].



3

View of the assembled mounting bracket on thick pole mast:

Bracket clamps in following position support mast diameters 55..120 mm.



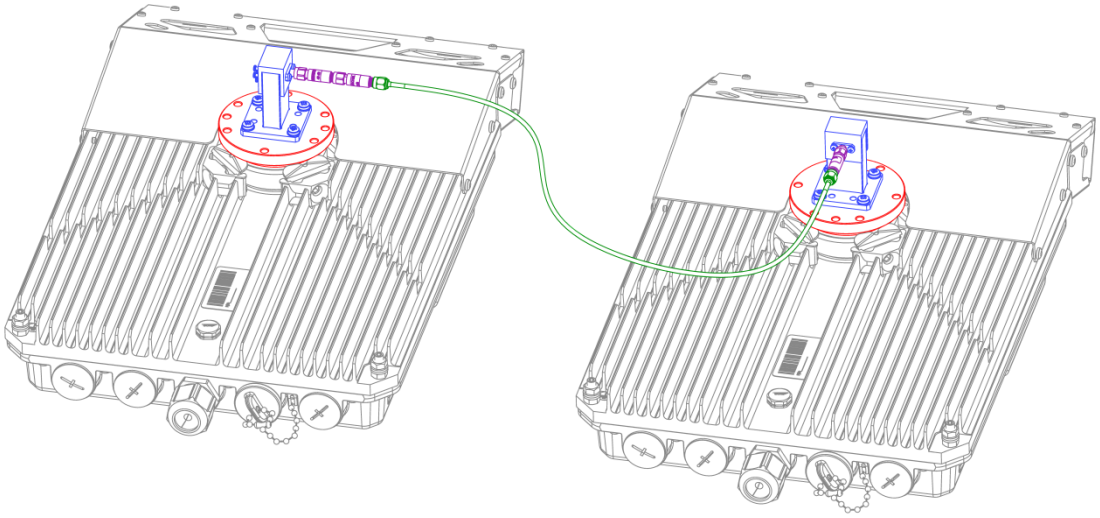
4

View of the assembled mounting bracket on thin pole mast: Bracket clamps in reverse position support smaller mast diameters 25...75mm.

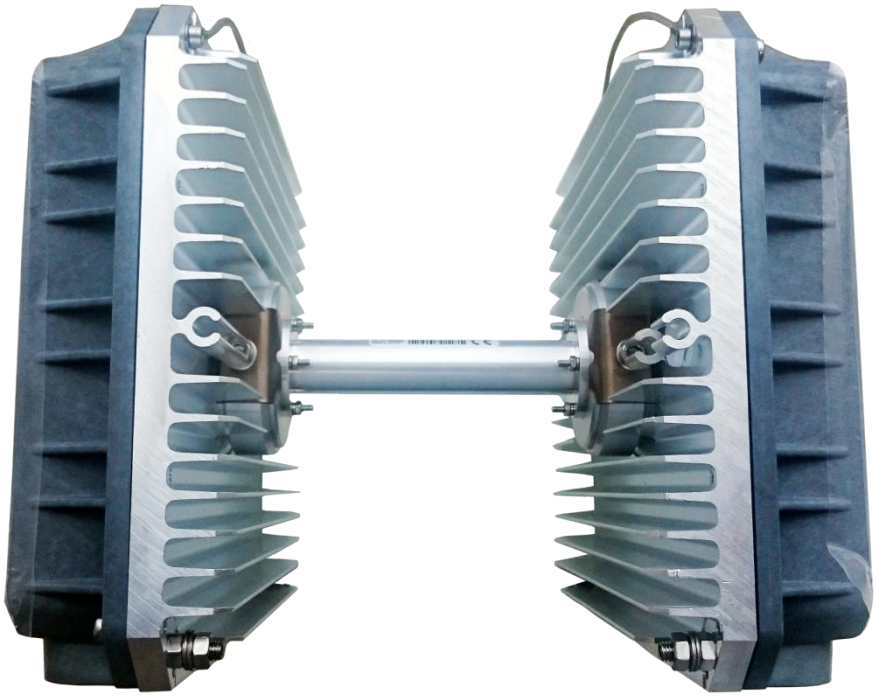
*INTEGRAL-GS 15/18/17/23/24/26/32/38/42GHz are separate FODU models

Initial setup in the indoor environment

INTEGRAL-S/INTEGRAL-GS FODUs can be interconnected using a test kit (available for purchase as optional accessory). P/N is DxxTST01, where xx – frequency band, e.g. D11TST01 for 11GHz. The exception is 17 and 24GHz radios.



Test kit consists of adapter flange, waveguide-to-coaxial adapter, attenuators and coaxial cable.
In case of 17 and 24 GHz radios a test tube (P/N D0S17TST01 or D0S24TST01) should be used:

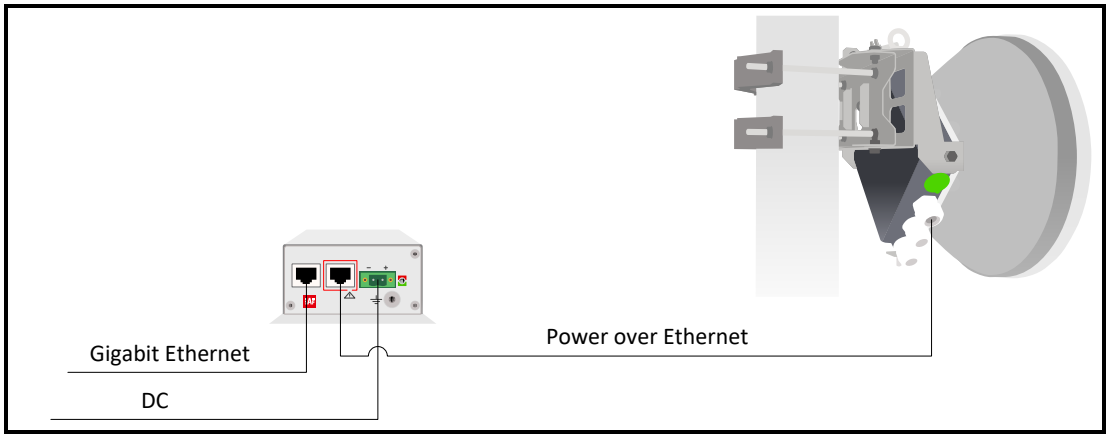


Chapter 3: WEB GUI

Initial configuration

Powering INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODU and connecting to PC

Use Power over Ethernet (PoE) injector P/N I0ATPI22/24 with appropriate power supply (22…60VDC, at least 80W). Please see interconnection scheme below.



Ethernet cable from PoE injector should be connected to RJ-45 port on INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODU (LAN1). The total length of Ethernet cables from CPE to PoE injector (DATA port) and from INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS to PoE injector (DATA+PWR port) combined should not exceed 100m. It is recommended to use outdoor rated STP/FTP Ethernet cable Cat5e or better.

When powered, the RSSI LED will light up a solid green color for approx. 20sec. Afterwards, RSSI LED will go out for approx. 35sec. and eventually, start blinking indicating current Rx level.

Please refer to the chapter RSSI LED for further details on blinking patterns and corresponding Rx levels.

PoE injector (P/N I0ATPI22)

The injector has a built-in DC/DC converter which can be enabled with a switch at the back by switching it to the “54V” position. In this mode, 22..60VDC input voltage will be converted to the 54VDC output voltage. It is required to use this mode when the input voltage is below 48V DC or when a longer Ethernet cable is used in order to ensure sufficient input voltage to the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODU (36…57VDC). In “48V” mode, the output voltage of the PoE injector is the same as the input voltage.

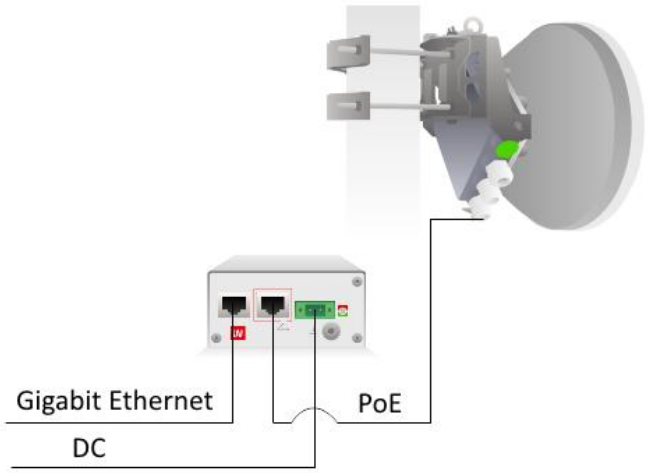
In case input voltage is between 22..36V DC, the output current is limited to 1.2A, which will not be sufficient for low frequency band radios (6-13GHz). Use 36..60V DC input voltage instead.

Universal programmable PoE injector (P/N I0ATPI24)

The I0ATPI24 injector is designed to operate with any PoE capable product with a Fast Ethernet / Gigabit Ethernet interface. Built-in protection conforms to the IEC 61000-4-5 standard.

Accepted input voltage is 24…60VDC. The output voltage is stabilized to 54VDC.

Interconnection scheme:



The front panel has 3 indication LEDS. LED3 indicates the position of DIP switch S1. Color indication of all LEDs must be ignored in Forced mode (DIP switch S4 in DOWN position).

Load detected and voltage fed at the output of PoE injector (POWER GOOD)		No load at the output of PoE injector (OPEN)
PoE controller detected and voltage fed at the output of PoE injector (POWER ON)		Short at the output of PoE injector (SHORT)
Classified PoE mode (PoE CLASSIFIED) (if S4 is UP; see table below).		Unclassified PoE mode (PoE MANUAL) (if S4 is UP; see table below).

The back panel has 4 switches in order to operate the PoE injector in different modes.

The appropriate I_{max} selection, while unclassified PoE mode is enabled (S1 UP, S4 UP), will provide the most effective surge protection for the radio. In case I_{max} exceeds set value, upper LEDs (LED1&LED2) will blink in a green color.

Connecting device in Unclassified or Forced modes will introduce approx. 5 second delay of LED indication.

In case classified PoE mode is enabled (S1 position DOWN, S4 position UP) I_{max} mode (PD class) is negotiated automatically with the device connected.

The position of DIP switches should be changed only while PoE injector is turned off.

Nr.	S1	S2	S3	S4	Description
1	↓	×	×	↑	**Classified PoE mode** (PoE controller enabled). I_{max}= **auto**.
2	↑	↓	↓	↑	**Unclassified PoE mode** (PoE controller disabled). I_{max}=**750mA**.
3	↑	↓	↑	↑	**Unclassified PoE mode** (PoE controller disabled). I_{max}=**1000mA**.
4	↑	↑	↓	↑	**Unclassified PoE mode** (PoE controller disabled). I_{max}=**1250mA**.
5	↑	↑	↑	↑	**Unclassified PoE mode** (PoE controller disabled). I_{max}=**1700mA**.
6	×	×	×	↓	**Forced mode**. I_{max}=**2000mA**. **DIP switches S1, S2, S3 ignored.** LED3 color will be **blue** or **green** depending on the position of **S1**.

↓ — DIP switch position DOWN, ↑ — DIP switch position UP, × — any position

Recommended modes

Mode Nr. **1** or **5*** (Classified or Unclassified PoE mode. I_{max}= auto or I_{max}=1700mA);

* depending on HW revision

Electrical specification

Data rate	Up to 1000 Mb/s
Classified PoE mode	Green indicator LED*
Unclassified PoE mode	Blue indicator LED*
Input Voltage	22 – 65 V
Output Voltage	54 V
Max Current	1.2 A (22…36V DC), 1.6 A (36…60V DC)
Power Connector	2ESDV-02P with screw locks
Ethernet Connectors	Shielded RJ45 jacks
Data Lines	Pins (1, 2), (3, 6), (4, 5) and (7, 8)
Power Lines	+ (1, 2) and (4, 5); - (3, 6) and (7, 8)
Power Clamping Voltage	+/- 70 V
Max data cable length	100 m

* Color indication can be disregarded in Forced mode (DIP S4 position DOWN), will indicate only Power ON.

Mechanical specification

Ports	-RJ45 - Data -RJ45 - Data + Power -DC - 2ESDV-02P socket with screw locks** -Grounding screw
Dimensions (W/H/D):	82 mm/41 mm/154 mm
Weight	0.4 kg
Enclosure	Steel
Operating Temperature	-10ºC to + 50ºC
Mounting	-With bracket (included) -19” rack mounting shelf (p/n I0KTPI11.003) -DIN-rail clip (p/n I0STPI11.01)

** 2ESDV-02P plug with screw locks included.

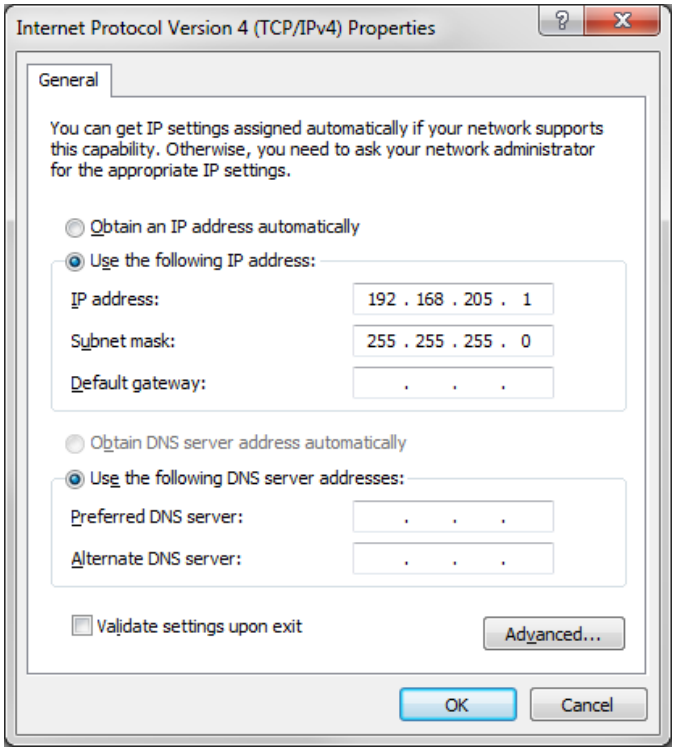
System requirements

To access the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS Web GUI you will need a PC with the following Web browser:

- Google Chrome;
- Mozilla Firefox;
- Internet Explorer 8 (or above)

Ethernet management connection configuration

Before proceeding with the initial link setup in the Web GUI, you must adjust the IPv4 settings of your LAN adapter to 192.168.205.0 subnet. The IP address should be something other than the default low/high side IP addresses (192.168.205.10/192.168.205.11).



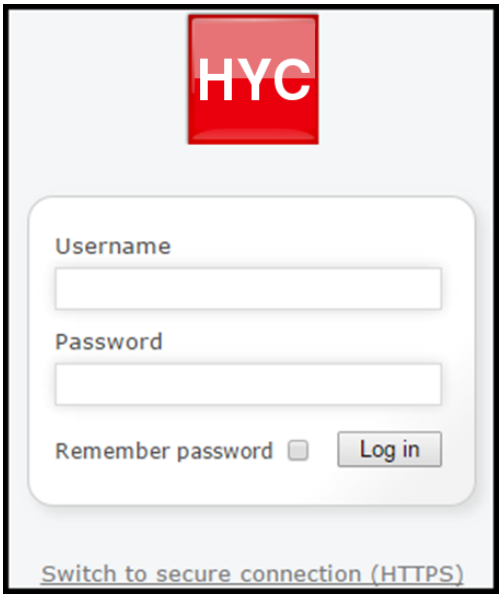
After applying these settings you are ready to connect to the Web GUI or establish a SSH/Telnet connection. Refer to Chapter 4: COMMAND LINE INTERFACE for details on how to connect to other CLI interfaces (serial, SSH, Telnet).

Accessing Web GUI

1. Launch your browser and in the address field enter the IP address of a FODU. Default IP addresses are as follows:
   - 192.168.205.10 for low side FODU (P/N D*******L*)
   - 192.168.205.11 for high side FODU (P/N D*******H*)

For secure connection use *https://* prefix.

2. Press “Enter” key.
3. The login screen will appear.
4. Enter username and password. Default credentials are as follows:
   - Username: **admin**
   - Password: **changeme**



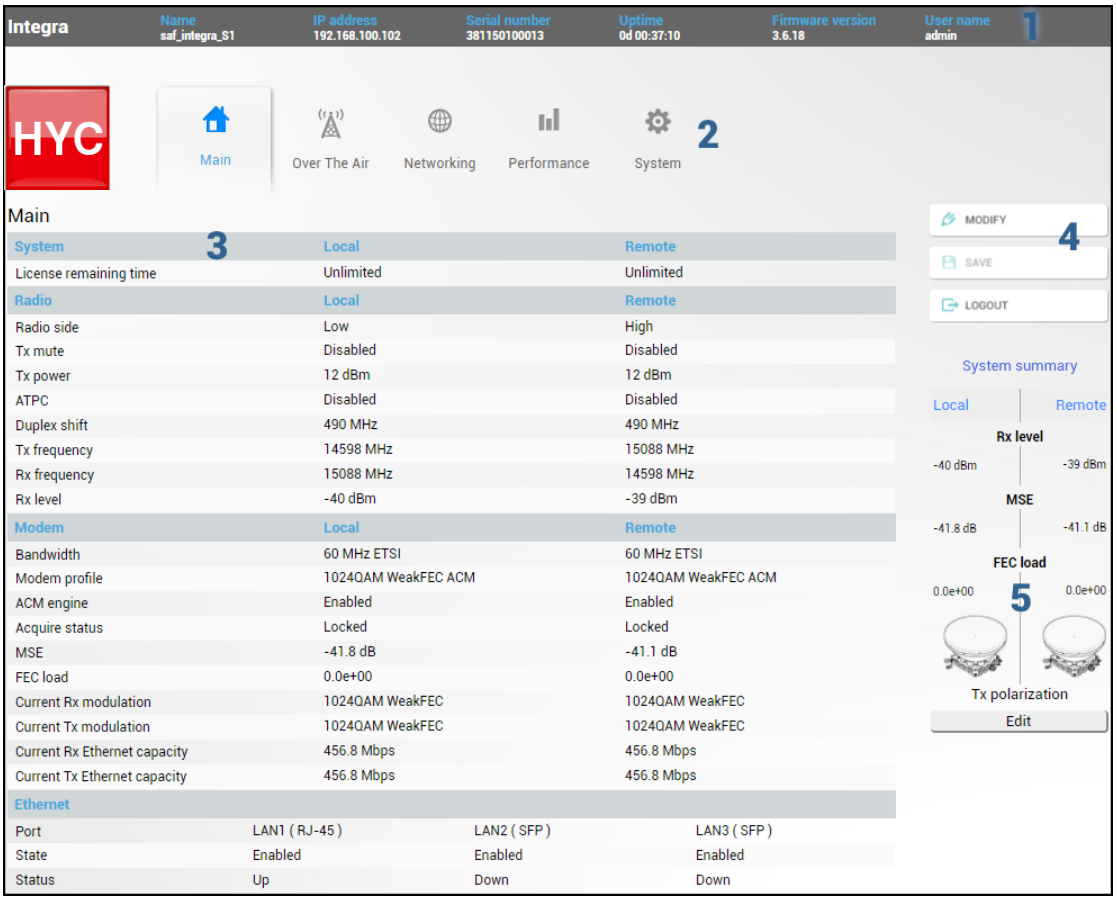
5. Select “Remember password” if you want the browser to remember entered login credentials.
6. Press “Log in” button.

“Switch to secure connection (HTTPS)” indicates that HTTP protocol is being used. Press on the link and you will be redirected to secure HTTPS URL.

Minimum supported horizontal resolution is 1024px.

Main page

After login you will be automatically redirected to the Main page of the Web GUI:



Web GUI is divided into 5 sections:

1 Top panel

Shows information about the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODU you are connected to including:

- Model name
- System name
- IP address
- Serial number
- Uptime
- Firmware version
- User name

2 Menu panel

Allows navigating between the Main page (“Main”) and subpages of 4 sections:

- Over the air (Radio/modem (NP) configuration)
- Networking (Ethernet configuration)
- Performance
- System

3 Main Web GUI window

By default, the Main page (“Main”) is shown. Contents will change according to menu panel selection.

4 MODIFY / SAVE / LOGOUT

Allows modifying parameters in the main window. If none can be modified, the MODIFY button appears inactive. After modification, the SAVE button becomes active and indicates a number of unsaved changes as well as their type (when moving the cursor over the button). The LOGOUT button will logout from the current session.

5 System summary

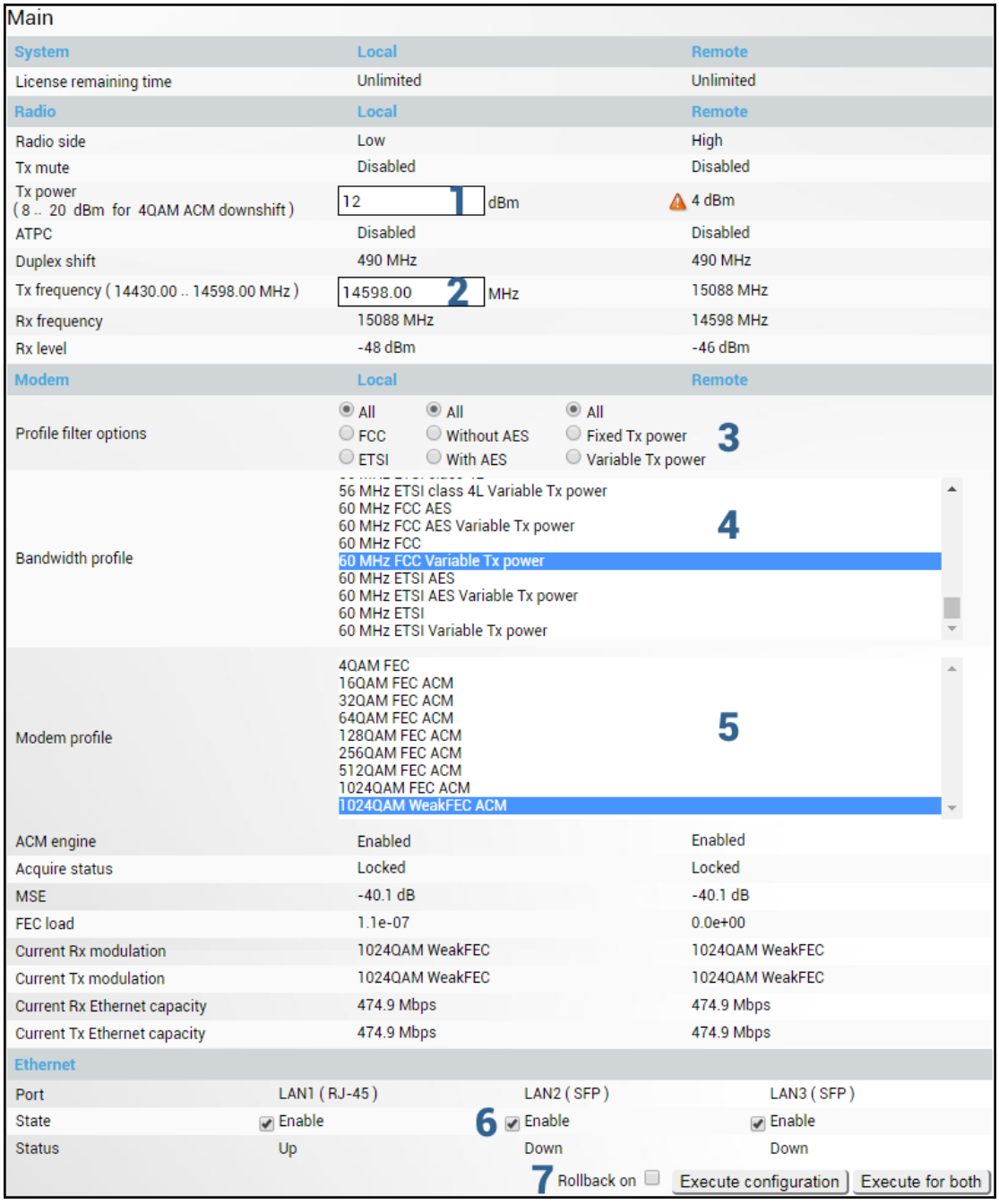
Shows one to four (default value – three) selected parameters of the local and remote systems and Tx polarization (as read from the internal accelerometer).

Values appear in red color in case of exceeding alarm threshold values Performance → Alarm → Alarm threshold configurationor in case of a warning (e.g. if loopback is active).

Values appear in orange color in case alarm threshold values were exceeded during last 15 seconds.

Modifying basic system parameters

In order to proceed with initial configuration, press the MODIFY button and the entry fields will appear for adjustable values:



1 Tx power

The available range depends on the radio model and selected modulation. The actual range will be indicated in the brackets. If a Variable Tx power bandwidth profile was selected, the available range is the maximum Tx power at 4QAM modulation when ACM downshift occurs.

2 Tx frequency

The available range depends on the frequency band, subband, radio side and channel bandwidth selected. Actual range will be indicated in the brackets.

Tx frequency range indicates the range of central frequencies for the configured channel bandwidth.

The default frequency range (indicated on the label) is defined for 3.5MHz channel bandwidth.

3 Profile filter options

Allows filtering the bandwidth selection list by FCC or ETSI standard and with or without AES encryption enabled, as well as select "All" to disable filtering.

If allowed by the license, AES encrypted bandwidth options will be available. Please refer to the Over the Air→Security→AES encryption chapter for further details and activation steps of AES encryption.

4 Bandwidth profile

Allows choosing between available channel bandwidth options along with the indication of fixed modulation or maximum modulation for ACM, bandwidth standard ETSI or FCC, AES encryption functionality and Tx power mode – fixed or variable – in case ACM profile is chosen.

Please refer to the Over the Air→Security→AES encryption chapter for further details and activation steps of AES encryption.

5 Modem profile

Allows choosing between available modulations for the selected channel bandwidth.

The "FEC" suffix indicates better sensitivity mode (longer FEC overhead), while "Weak FEC" indicates higher capacity mode (shorter FEC overhead).

"Weak FEC" is available only for the highest modulation for the selected channel bandwidth.

ACM stands for Adaptive Coding and Modulation and enables the adaptive modulation change according to MSE value. Modulation indicates maximum modulation, while the minimum is 4QAM.

6 State

Allows enabling/disabling each of three available LAN ports.

In case 2+0 aggregation is enabled, the LAN2 state is "Restricted" as it can be used only for interconnection between two INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODUs. Please refer to the Over The Air → Modem → Aggregation configuration chapter for further details.

7 Execute

By pressing *„Execute configuration"*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback on"* is selected, the configuration will be reverted in case erroneous configuration changes are applied.

Rollback triggers when configuration changes applied interrupt management connectivity. For this reason, rollback will not work if the remote side of the link is not reachable.

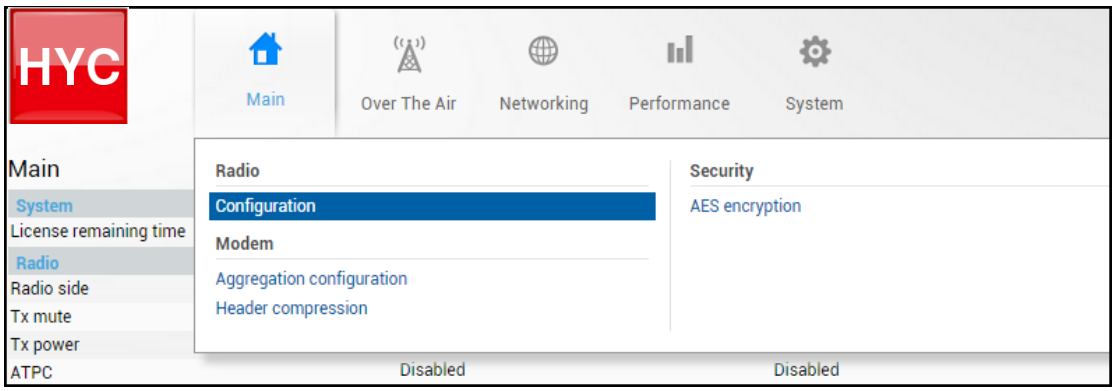
Pressing *„Execute for both"* applies changes made to the corresponding section both for local and remote side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODUs.

Over The Air

Over The Air → Radio → Configuration

The Radio configuration page is available in the menu (Over The Air→ Radio→Configuration).

Refer to the chapter Radio configuration – extra fields for description of the extra fields of the 17/24 GHz INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODUs.



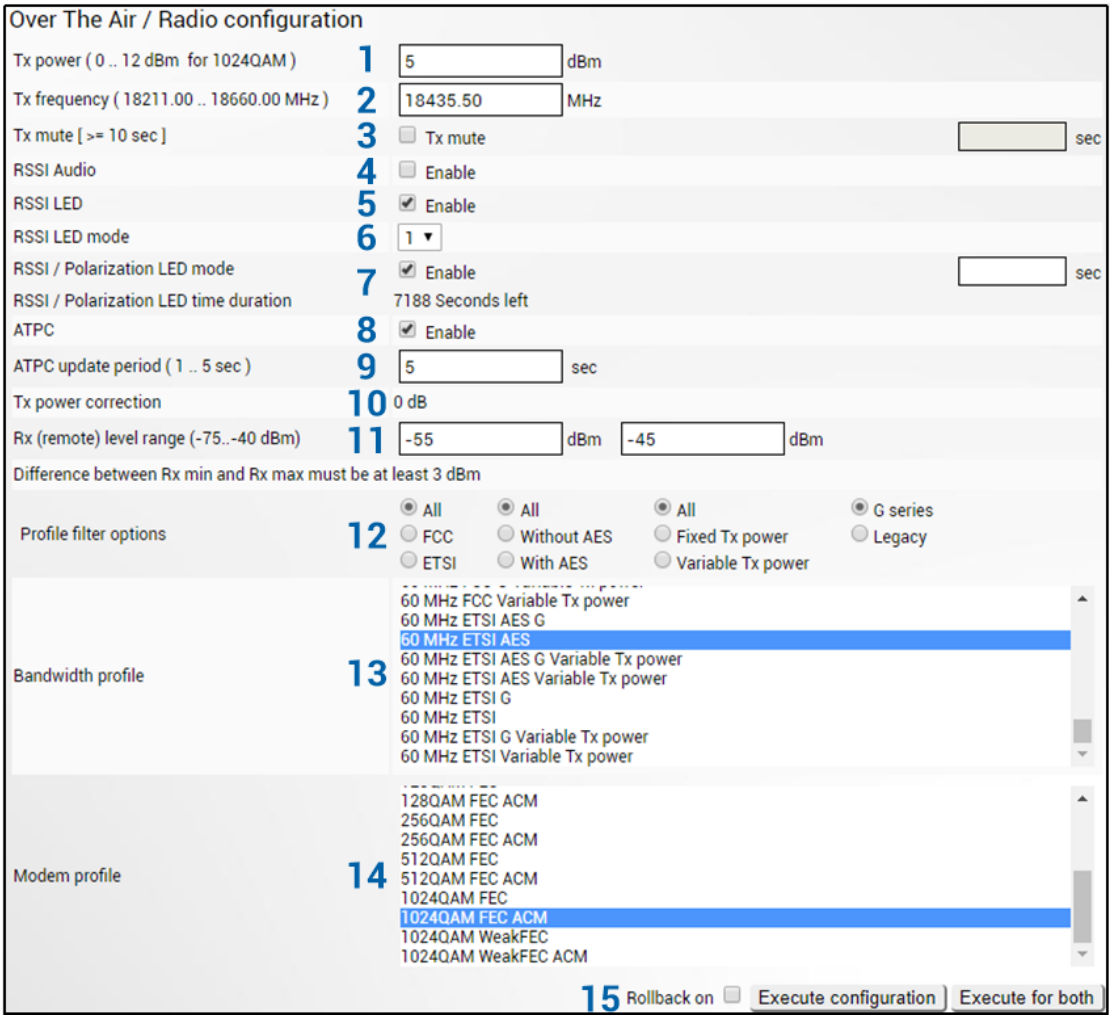
Status mode

Over The Air / Radio configuration

Tx power (0 .. 12 dBm for 1024QAM)	1	5 dBm
Tx frequency (18211.00 .. 18660.00 MHz)	2	18435.5 MHz
Tx mute [>= 10 sec]	3	Disabled
RSSI Audio	4	Disabled
RSSI LED	5	Enabled
RSSI LED mode	6	1
RSSI / Polarization LED mode	7	Enabled
RSSI / Polarization LED time duration		7196 Seconds left
ATPC	8	Enabled
ATPC update period (1 .. 5 sec)	9	5 sec
Tx power correction	10	0 dB
Rx (remote) level range (-75..-40 dBm)	11	-55 dBm -45 dBm
Difference between Rx min and Rx max must be at least 3 dBm		
Bandwidth profile	13	60 MHz ETSI AES
Modem profile	14	1024QAM FEC ACM

Press MODIFY button.

Modify mode



1) ***Tx power*** – Indicates current Tx (transmit) power value (status mode); allows specifying Tx power value (modify mode). Available range depends on the radio model and selected modulation. Actual range will be indicated in the brackets. ⚠ sign indicates that Tx power value was adjusted by ATPC. Move mouse over the sign for further details.
2) ***Tx frequency*** – Indicates current Tx (transmit) frequency (status mode); allows specifying Tx frequency (modify mode). Available range depends on the frequency band, subband, radio side and channel bandwidth selected. Actual range will be indicated in the brackets.
   Tx frequency range indicates the range of central frequencies for the configured channel bandwidth.
   Default frequency range (indicated on the label) is defined for 3.5MHz channel bandwidth.
3) ***Tx mute [>=10 sec]*** – Indicates whether Tx mute is enabled or disabled (status mode); allows muting the transmitter to limited time interval in seconds (modify mode). The minimum value is 10 seconds. Note that the transmitter will be muted only if a valid value in seconds is entered.
4) ***RSSI Audio*** – Indicates whether RSSI audio is enabled or disabled (status mode); allows disabling or enabling RSSI audio (modify mode). RSSI audio is available using the 3.5mm jack beside USB port. By default, RSSI Audio is disabled. Please refer to the RSSI/audio port description for further details.
5) ***RSSI LED*** – Indicates whether the RSSI LED is enabled or disabled (status mode); allows disabling or enabling RSSI LED operation (modify mode). By default, the RSSI LED is enabled. Please refer to the RSSI LED section for further details.

6) ***RSSI LED mode*** – Indicates which RSSI LED mode is active (status mode); allows selecting RSSI LED operation mode (modify mode). By default Mode 1 is enabled. Please refer to the RSSI LED section for further details.
7) ***RSSI / Polarization LED mode*** **-** Indicates if the red RSSI LED mode is enabled and remaining time (status mode); allows to enable/disable the red RSSI LED operation mode for n seconds (modify mode). Its main purpose is an indication of polarization alignment accuracy +/- 3deg. Functionality may not be available in older HW revisions. Please refer to the RSSI LED section for further details.
8) ***ATPC*** – Indicates whether ATPC (Automatic Transmit Power Control) is enabled (status mode); allows enabling/disabling ATPC (modify mode). By default this feature is disabled. Please refer to the ATPC (Automatic Transmit Power Control) description for further details.
9) ***ATPC update period*** – Indicates the ATPC update period (status mode); allows defining the period in seconds with which ATPC parameters are being updated (modify mode). By default, the update period is 5 seconds. The range is 1..5 seconds. Please refer to the ATPC (Automatic Transmit Power Control) description for further details.
10) ***Tx power correction*** – Indicates Tx power correction made by the ATPC function. Please refer to the ATPC (Automatic Transmit Power Control) description for further details.
11) ***Rx (remote) level range (-75..-40dBm)*** – Indicates minimum and maximum Rx level of the remote side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS for ATPC operation (status mode); allows defining the minimum and maximum Rx level of the remote side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS (modify mode). There should be at least 3dB difference between min and max values. ATPC Tx power correction will be performed only in case of exceeding these thresholds. Values should be defined between -75 and -40 dBm. Please refer to the ATPC (Automatic Transmit Power Control) description for further details.

Minimum Rx level threshold should be set at least 10dB above sensitivity threshold in order to avoid ACM/ATPC switching loops.

ATPC operates only when ACM is at maximum modulation (if ACM is enabled).

12) ***Filter*** – Allows filtering the bandwidth selection list by standard (ETSI or FCC) or by AES encryption (with or without). "All" disables filtering.
13) ***Bandwidth*** – Indicates currently configured channel bandwidth (status mode); allows choosing between available profiles, as well as according to the standard of channel bandwidth – ETSI or FCC, with or without AES encryption (modify mode).
14) ***Modem profile*** – Indicates currently configured modulation (status mode); allows choosing between available modulations for selected channel bandwidth (modify mode).
    The "FEC" suffix indicates a better sensitivity mode (longer FEC overhead), while "WeakFEC" indicates a higher capacity mode (shorter FEC overhead).
    "WeakFEC" is available only for the highest modulation in the selected channel bandwidth.
    An option with "ACM" (please refer to the chapter **Erreur ! Argument de commutateur inconnu. Erreur ! Source du renvoi introuvable.**for further details) enables adaptive modulation change according to MSE value. Modulation indicates maximum modulation, while the minimum is 4QAM.
    In case current Tx power value is above maximum value for any of the modulations, the maximum value will be indicated.
15) By pressing *„Execute configuration"*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback on"* is selected, the configuration will be reverted in case erroneous configuration changes are applied.
    Pressing *„Execute for both"* applies changes made to the corresponding section both for local and remote side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODUs.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

radio [status]	Use to show radio status.
radio power <Tx power>	Use to set Tx power in dBm.
radio frequency <frequency>	Use to set Tx frequency in kHz.
radio rssi-led {disable | enable [mode {1|2|3}]}	Use to enable or disable RSSI LED operation.
radio rssi-led enable mode {1|2|3} **polarization** <seconds>	Use to enable the red RSSI LED's operation for n seconds. Its main purpose is an indication of polarization alignment accuracy +/- 3deg. Functionality may not be available in older HW revisions.
radio tx-mute {<time>|disable}	Use to mute transmitter on specific time in seconds or unmute.
radio factory	Use to reset radio settings to factory defaults – Tx power will be disabled and frequencies set to factory defaults.
radio upgrade <firmware>	Use to upgrade radio firmware version. Firmware file must be located in FTP directory.
radio version	Use to check radio software version
radio atpc [status]	Use to check the status of ATPC (Automatic Transmit Power Control).
radio atpc state {enable|disable}	Use to enable/disable ATPC.
radio atpc delay <1..5>	Use to define ATPC update period.
radio atpc rx_level <-75..-43> <-72..-40>	Use to define ATPC remote Rx level min and max thresholds.
modem configuration set <bandwidth> <min_mod> <max_mod>	Use to set modem configuration – bandwidth, minimum and maximum modulation. "e" suffix indicates "AES". "s" suffix indicates "ETSI or "ETSI class 4L" (for 56 MHz). "_VP" suffix indicates "Variable Tx power". "_W" suffix indicates "Weak FEC" modulation.
modem configuration set factory	Use to reset modem settings to factory defaults – bandwidth and modulation will be reset to a minimum.
modem loopback [{none | digital <time>}]	Use to check, disable, or enable modem loopback for n seconds.
modem allowed	Use to check the list of available modem configurations.

Over The Air → Modem → Aggregation configuration

INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS **2+0 aggregation** (link bonding) provides ACM-aware binding of user available capacities of two parallel links each using an individual frequency pair. Traffic is split per-frame over two links on the modem level.

2+0 aggregation **is not** based on MAC-MAC connections. A single MAC address (e.g. router) can be used.

INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS 2+0 aggregation features full link synchronization / power / cable redundancy by reconfiguring to 1+0 operation mode in case of failure.

Full 2+0 to 1+0 redundancy will operate only when an external switch is used. Please see below interconnection schemes **c** and **d**.

INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS **1+1 Hot StandBy** aggregation provides protection of user available capacities of two parallel links each using the same frequency pair. Traffic is using only one link at a time. Transmitters of the second link will be automatically muted.

Full 1+1 redundancy (including cables, power, HW protection) will be available only when an external switch is used. Please see below interconnection schemes **c** and **d**.

Two pairs of INTEGRAL/INTEGRAL-G or INTEGRAL-S/INTEGRAL-GS FODUs are required. In case of 2+0 aggregation with INTEGRAL-S/INTEGRAL-GS OMT, dual-polarized antenna, or coupler can be used. In case of 1+1 HSB with INTEGRAL-S/INTEGRAL-GS, only coupler can be used (as only a single frequency pair in the same polarization is being utilized).

Necessary equipment for INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS 2+0 or 1+1

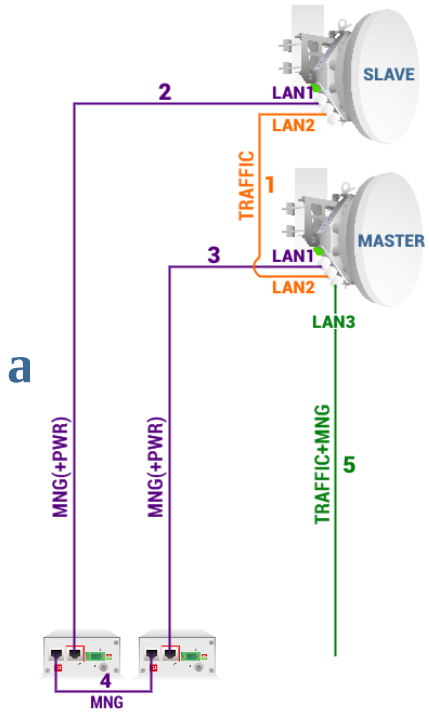
1. 4 INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODUs – 2 low side, 2 high side;
2. 2 or 4 SFP modules and appropriate FO cables (multi-mode or single-mode) for INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS interconnection (depending on interconnection scheme **a**, **b**, **c** or **d**; see below);
3. A number of electrical or optical Ethernet cables (together with corresponding SFP modules) for user traffic (depending on chosen interconnection scheme);
4. In case of INTEGRAL-S/INTEGRAL-GS – additionally 4 antennas, or 2 antennas and OMT/couplers. Please refer to the chapter INTEGRAL-S/INTEGRAL-GS 6-13GHz* 2+0 & OMT interconnection for instructions on INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS installation to an antenna or an OMT.

General configuration guide

1. Do not interconnect INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS with each other and do not plug INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS into switches before you have finished the configuration of each node.
2. Choose one link (low/high side radio) which will operate as the “Master”. The second link will operate as the “Slave”;
3. Configure radio/modem parameters for each link. It’s important that channel bandwidths are same (e.g. 40MHz) for both links. All other parameters can differ, except for 1+1 also frequency must be same;
4. Both links should be polarized according to ACCP (Adjacent Channel Co-Polarized) or ACAP (Adjacent Channel Alternate-Polarized) principles. CCDP (Co-Channel Dual-Polarization) operation of both on the same frequency channel and opposite polarizations is not allowed. In case of ACCP a guard band equal to ¼ BW should be introduced (e.g. 20MHz in case of 80MHz channels).
5. Configure different IP addresses for all 4 INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODUs.
6. Remote IP address for all units must be entered manually. In order to do that, remove the selection in the “Auto” checkbox and afterwards enter appropriate remote IP address in the menu ”IP configuration” (please refer to Chapter System → Configuration → IP configuration).

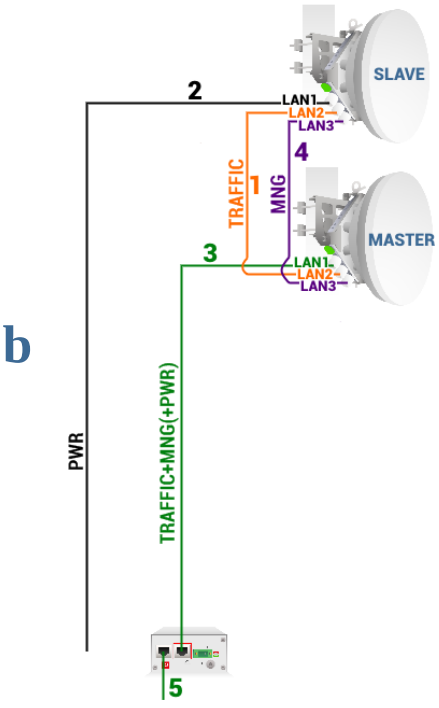
Interconnection schemes

There are 4 possible interconnection schemes:



1. Mandatory fiber optic cable between LAN2 (optical) ports on both units.
2. Electrical Ethernet cable (1000Base-T) between PoE injector's (#1) DATA+PWR port and LAN1 (electrical) port of the Slave FODU. Both data and power are carried, therefore total length of cables #2, #3 and #4 combined should not exceed 100m.
3. Electrical Ethernet cable (1000Base-T) between PoE injector's (#2) DATA+PWR port and LAN1 (electrical) port of Master FODU. Both data and power are carried, therefore total length of cables #2, #3 and #4 combined should not exceed 100m.
4. Electrical Ethernet cable (1000Base-T) between PoE injectors' (#1 and #2) DATA ports. Provides management access to Slave FODU. The total length of cables #2, #3 and #4 combined should not exceed 100m.
5. Fiber optic cable between LAN3 (optical) port of the Master or Slave FODU and CPE for both traffic and management traffic.

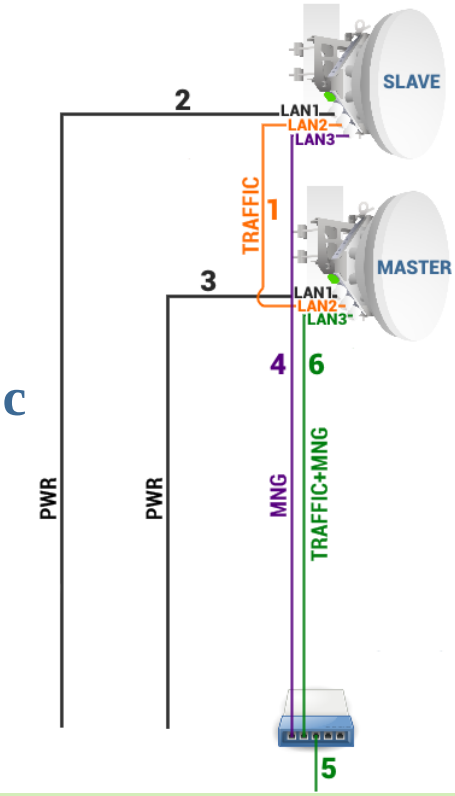
Advantages: 1) external switch not required; 2) length of optical cable for traffic/management up to 10km.



1. Mandatory fiber optic cable between LAN2 (optical) ports on both units.
2. Cable for powering Slave FODU. You can use a 2-wire power cable with DC power adapter (P/N D0ACPW01) or standard Ethernet cable with PoE injector. Depending on power consumption cable length can be extended up to 700m. Refer to chapter RJ-45 port for details.
3. Electrical Ethernet cable (1000Base-T) between PoE injector's (#2) DATA+PWR port and LAN1 (electrical) port of the Master FODU. Both data and power are carried, therefore total length of cables #3 and #5 combined should not exceed 100m.
4. Fiber optic cable between LAN3 (optical) ports on both units. Provides management access to the Slave FODU.
5. Electrical Ethernet cable (1000Base-T) between PoE injector's (#1 or #2) DATA port and CPE or both traffic and management traffic. The total length of cables #3 and #5 combined should not exceed 100m.

Advantages: 1) external switch not required; 2) optical cable used only for interconnection between both FODUs; 3) only two cables installed between FODUs and indoor facility.

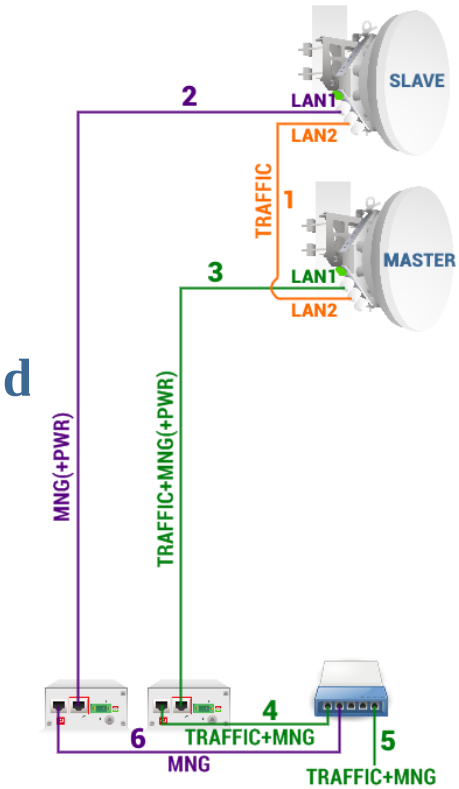
c



1. Mandatory fiber optic cable between LAN2 (optical) ports on both units.
2. Cable for powering the Slave FODU. You can use a 2-wire power cable with DC power adapter (P/N D0ACPW01) or standard Ethernet cable with PoE injector. Depending on power consumption cable length can be extended up to 700m. Refer to chapter RJ-45 port for details.
3. Cable for powering the Master FODU. You can use a 2-wire power cable with DC power adapter (P/N D0ACPW01) or standard Ethernet cable with PoE injector. Depending on power consumption cable length can be extended up to 700m. Refer to chapter RJ-45 port for details.
4. Fiber optic cable between LAN3 (optical) port of the Slave FODU and external switch. Provides management access to the Slave FODU. If the Master link is down, traffic will be redirected through this cable.
5. Electrical Ethernet cable (1000Base-T) between the external switch and CPE for both traffic and management traffic.
6. Fiber optic cable between LAN3 (optical) port of the Master FODU and an external switch for both traffic and management traffic.

Advantages: 1) solution provides greatest cable length for powering INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS and length of optical cable for traffic/management can be up to 10km. For details on the power cable length refer to chapter RJ-45 port; 2) Slave link will be able to reconfigure to 1+0 in case Master unit goes down (2+0 redundancy).

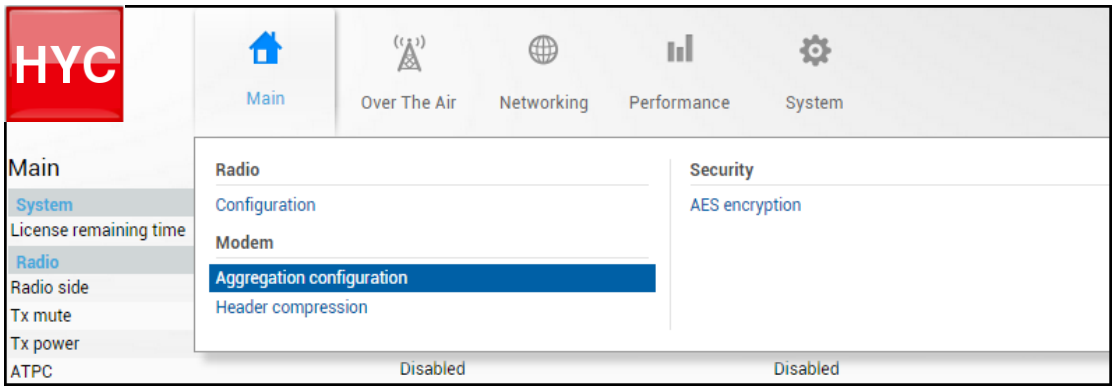
d



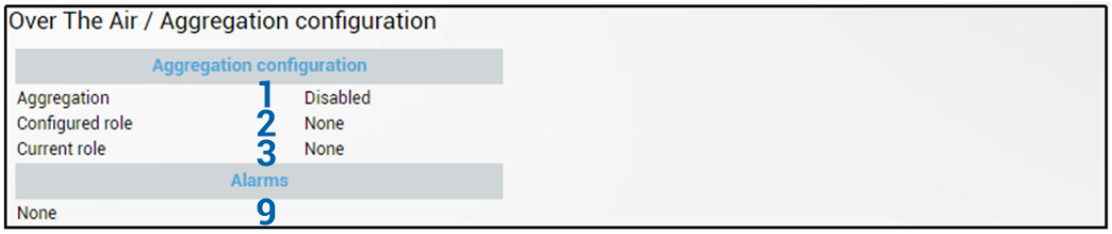
1. Mandatory fiber optic cable between LAN2 (optical) ports on both units.
2. Electrical Ethernet cable (1000Base-T) between PoE injector's (#1) DATA+PWR port and LAN1 (electrical) port of the Slave FODU. Both data and power are carried, therefore total length of cables #2 and #6 combined should not exceed 100m. If Master link is down, traffic will be redirected to this cable.
3. Electrical Ethernet cable (1000Base-T) between PoE injector's (#2) DATA+PWR port and LAN1 (electrical) port of the Master FODU. Both data and power are carried, therefore total length of cables #3 and #4 combined should not exceed 100m.
4. Electrical Ethernet cable (1000Base-T) between PoE injector's (#2) DATA port and external switch. The total length of cables #3 and #4 combined should not exceed 100m.
5. Electrical Ethernet cable (1000Base-T) between the external switch and CPE for both traffic and management traffic.
6. Electrical Ethernet cable (1000Base-T) between PoE injector's (#1) DATA port and external switch. The total length of cables #2 and #6 combined should not exceed 100m.

Advantages: 1) only single fiber optic cable required; 2) only two cables installed between FODUs and indoor facility; 3) Slave link will be able to reconfigure to 1+0 in case the Master unit goes down (2+0 redundancy).

Configuration in Web GUI

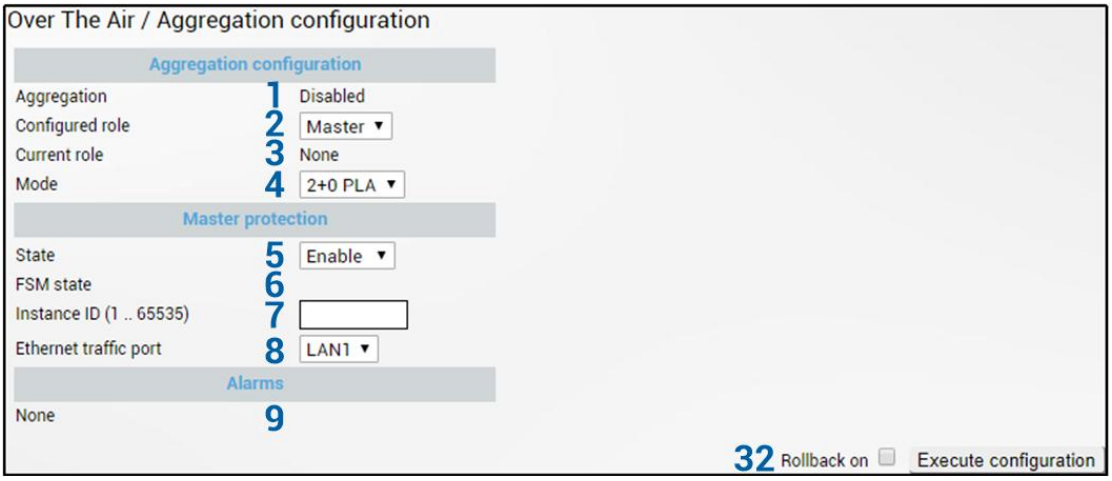


Status mode

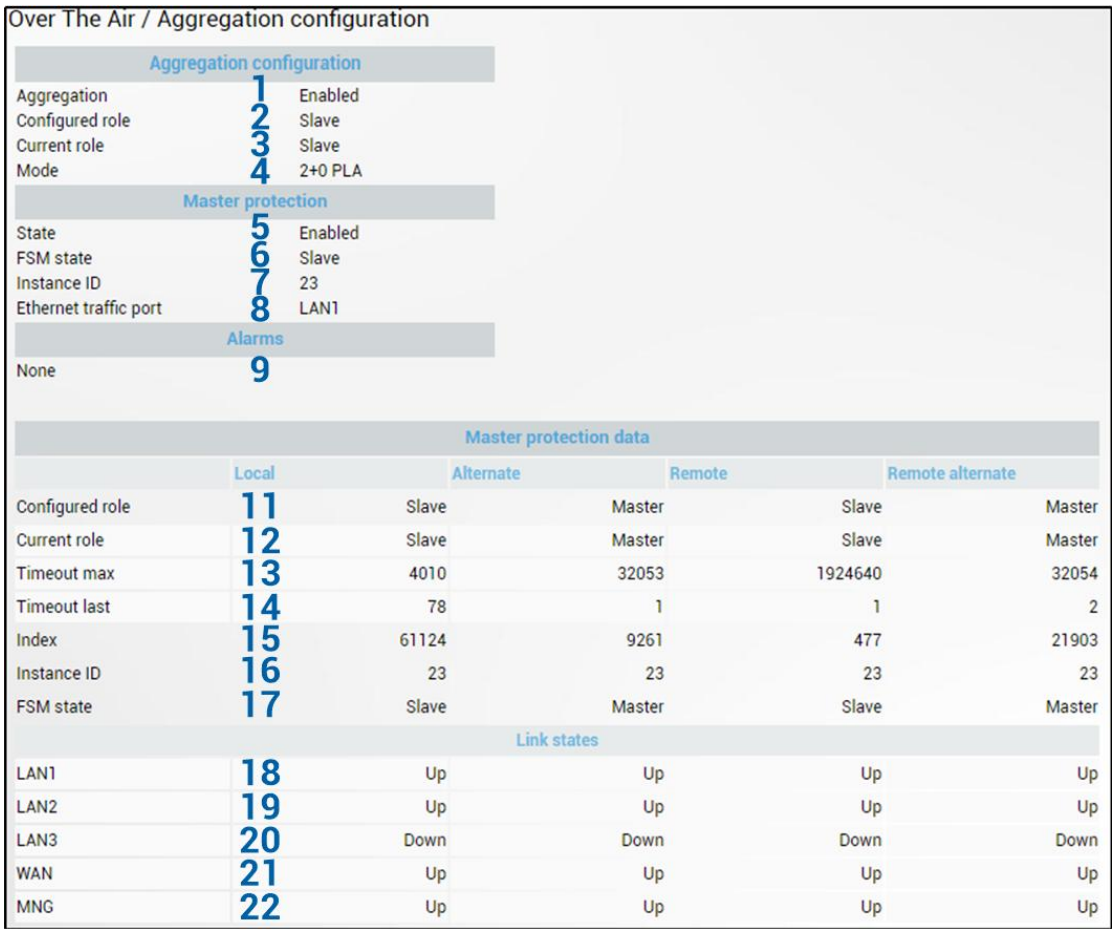


Press MODIFY button.

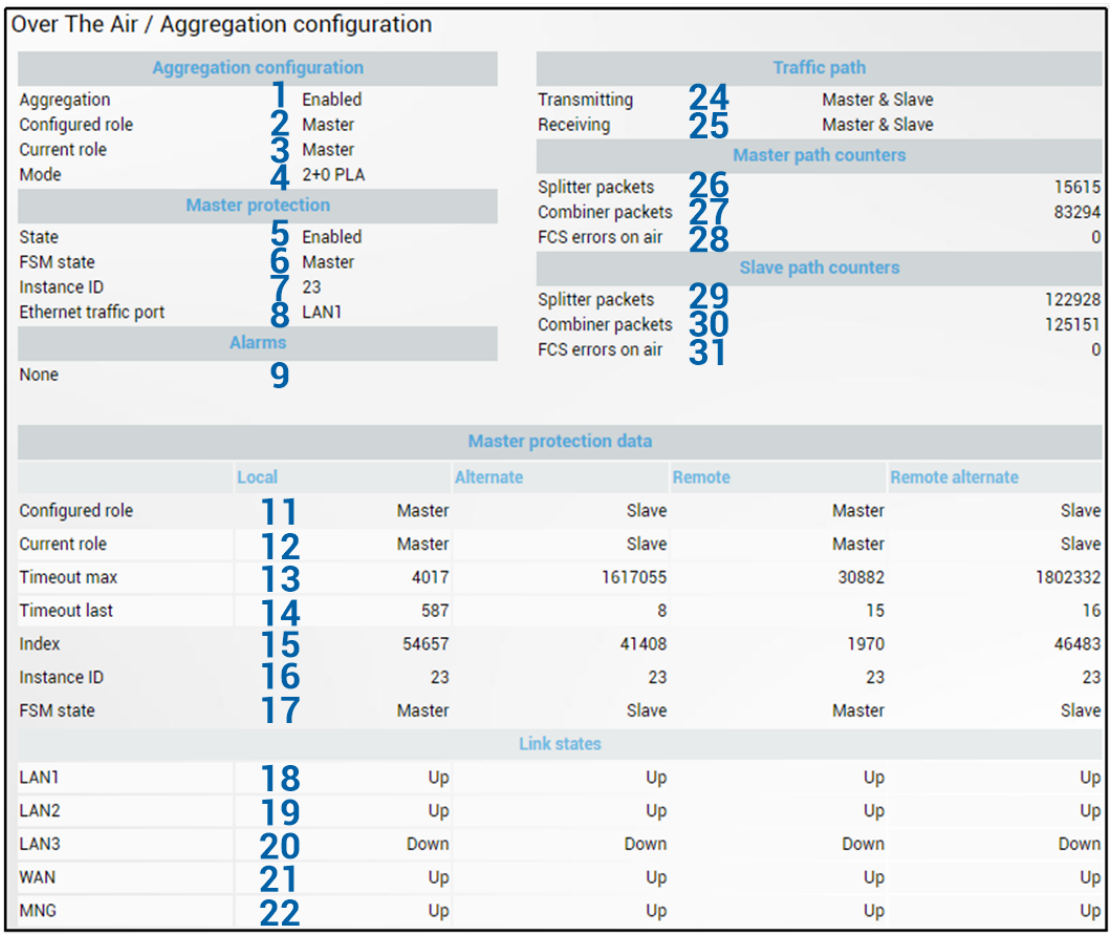
Modify mode



Slave status after enabling aggregation



Master status after enabling aggregation



Over The Air / Aggregation configuration

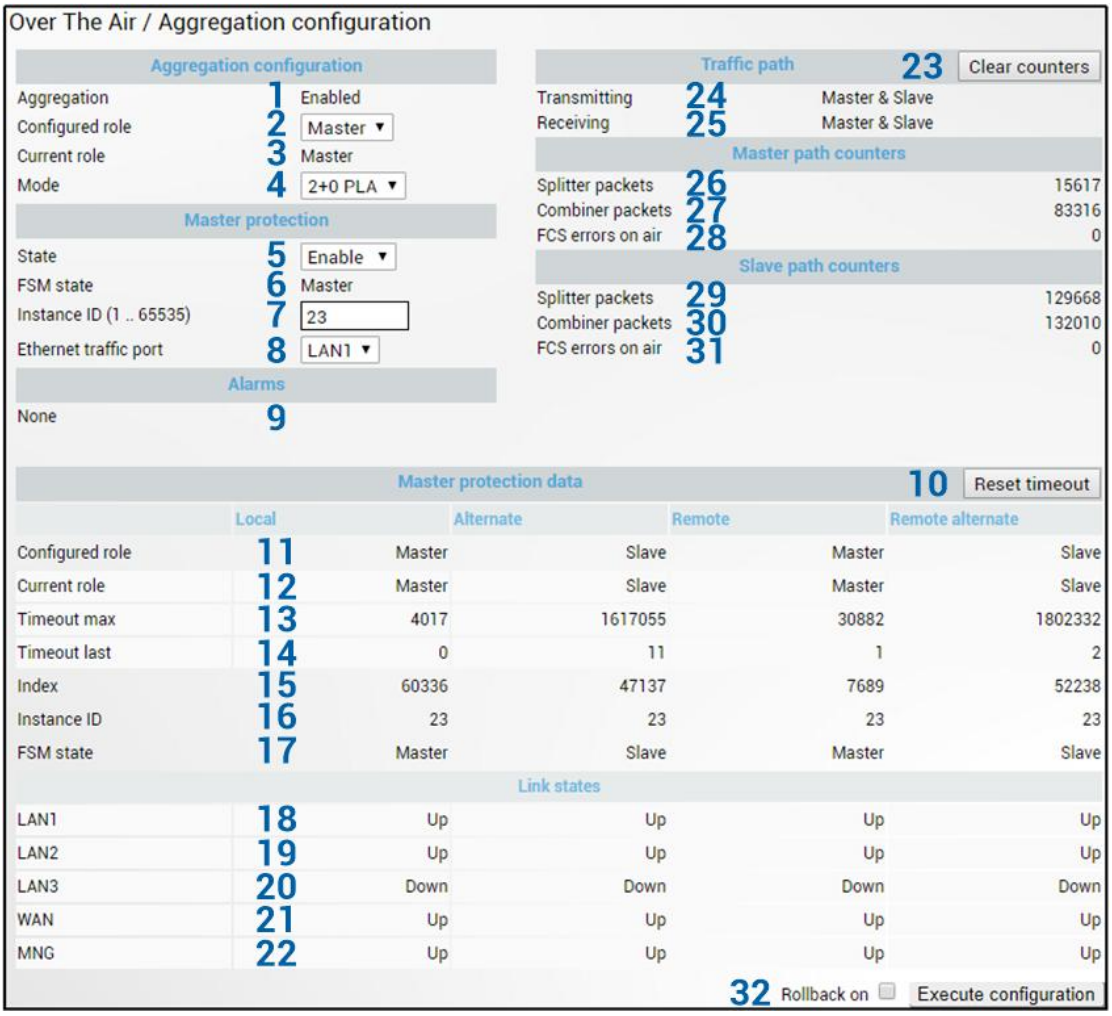
Aggregation configuration		
Aggregation	1	Enabled
Configured role	2	Master
Current role	3	Master
Mode	4	2+0 PLA
Master protection		
State	5	Enabled
FSM state	6	Master
Instance ID	7	23
Ethernet traffic port	8	LAN1
Alarms		
None	9	

Traffic path		
Transmitting	24	Master & Slave
Receiving	25	Master & Slave
Master path counters		
Splitter packets	26	15615
Combiner packets	27	83294
FCS errors on air	28	0
Slave path counters		
Splitter packets	29	122928
Combiner packets	30	125151
FCS errors on air	31	0

Master protection data		Local	Alternate	Remote	Remote alternate
Configured role	11	Master	Slave	Master	Slave
Current role	12	Master	Slave	Master	Slave
Timeout max	13	4017	1617055	30882	1802332
Timeout last	14	587	8	15	16
Index	15	54657	41408	1970	46483
Instance ID	16	23	23	23	23
FSM state	17	Master	Slave	Master	Slave
Link states					
LAN1	18	Up	Up	Up	Up
LAN2	19	Up	Up	Up	Up
LAN3	20	Down	Down	Down	Down
WAN	21	Up	Up	Up	Up
MNG	22	Up	Up	Up	Up

Press MODIFY button.

Master modify mode after enabling aggregation



When all four INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODUs are successfully configured and interconnected, the status on the Master unit should look as shown above.

Explanation of status/configuration fields

Aggregation configuration

1) ***Aggregation*** - Indicates whether aggregation is enabled or disabled.
2) ***Configured role*** – Indicates the configured role (status mode); allows specifying aggregation role (modify mode).
3) ***Current role*** – Indicates the current role. May differ from configured role in case Master protection is enabled, alternate device is or was not available and reconfiguration to 1+0 configuration took place.
4) ***Mode –*** "2+0 PLA" for 2+0 Physical Layer Aggregation. "1+1 HSB" for 1+1 Hot StandBy protection.

Master protection

5) ***State*** – Indicates whether Master protection is enabled or disabled (status mode); allows enabling or disabling Master protection (modify mode). (For 1+1 configuration always in Enable state)
6) ***FSM state*** – Indicates current Finite State Machine's state. Will be visible only when Master protection is enabled.
   8 states are possible – Master, Slave, Active (transition to Passive, Slave, or Active Try), Passive (transition to Slave), Active Try (1+1 transition to Active Tx), Active Tx (1+1

transmitting), Standby (ready for 1+1 protection), and TpDown (Slave state when Traffic port is down). In case of TpDown aggregation port (LAN2) is shut down as well.

7) ***Instance ID (0…65535)*** – Indicates configured instance ID (status mode); allows entering instance ID (modify mode). Will be available only when Master protection is enabled.

Instance ID should be the same on all 4 devices.

8) ***Ethernet traffic port*** – Indicates which LAN port is configured as the traffic/management port (status mode); allows setting LAN1 or LAN3 port as the traffic/management port (modify mode).

Alarms

9) Indicates which alarms are active. If none, "None" is shown.

Aggregation port link is down – link status of aggregation port (LAN2) of local device is down.

AIS condition – synchronization loss of Master or Slave device or link status of aggregation port (LAN2) of the remote device is down.

Master protection data

Status of all four units is shown. Local – unit you are currently connected to; alternative – unit interconnected with the local unit; remote – unit on the remote side of the link synchronized to the local unit; remote alternate – unit interconnected with the remote unit.

The section is visible when aggregation is enabled.

If no data is available "N/D" will be displayed in red color.

10) ***Reset timeout*** – Allows resetting protection data refresh time counters. The button is available only in modify mode.
11) ***Configured role*** – Indicates configured role;
12) ***Current role*** – Indicates current role. May differ from the configured role in case Master protection is enabled, the alternate device is or was not available and reconfiguration to 1+0 configuration took place;
13) ***Timeout max*** – Maximum refresh time of protection data in milliseconds;
14) ***Timeout last*** – Most recent refresh time of protection data in milliseconds;
15) ***Index*** – Aggregation data identifier. Value sequentially increments to 65535 and resets to 0;
16) ***Instance ID*** – Indicates configured instance ID;
17) ***FSM state*** – Indicates current Finite State Machine's state. Will be visible only when Master protection is enabled.
18) ***LAN1*** – Indicates link status of LAN1 port – up or down;
19) ***LAN2*** – Indicates link status of LAN2 port – up or down;
20) ***LAN3*** – Indicates link status of LAN3 port – up or down;
21) ***WAN*** – Indicates link status of WAN port – up or down;
22) ***MNG*** – Indicates link status of MNG port – up or down;

Traffic path

23) ***Clear counters*** - Allows resetting master and slave path counters. The button is available only in modify mode.
24) ***Transmitting*** – For 2+0 configuration: Indicates whether Master, Slave or both are transmitting traffic. For 1+1 configuration: Indicates whether current role Master (Local master) or Slave (Alternate Slave) is transmitting.
25) ***Receiving*** – For 2+0 configuration: Indicates whether Master, Slave or both are receiving traffic. For 1+1 configuration: Indicates whether current role Master (Local master) or Slave (Alternate Slave) is receiving.

Master path counters

26) ***Splitter packets*** – Indicates a number of packets transmitted by Master FODU.
27) ***Combiner packets*** – Indicates a number of packets received by Master FODU.
28) ***FCS errors on air*** – Indicates a number of FCS errors received by Master FODU.

Slave path counters

29) ***Splitter packets*** – Indicates a number of packets transmitted by Slave FODU.
30) ***Combiner packets*** – Indicates a number of packets received by Slave FODU.
31) ***FCS errors on air*** – Indicates a number of FCS errors received by Slave FODU.

Slave path counters

32) By pressing *„Execute configuration”*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback on”* is selected, the configuration will be reverted in case erroneous configuration changes are applied.

Configuration example

Configuration for both Slave FODUs

For 2+0:

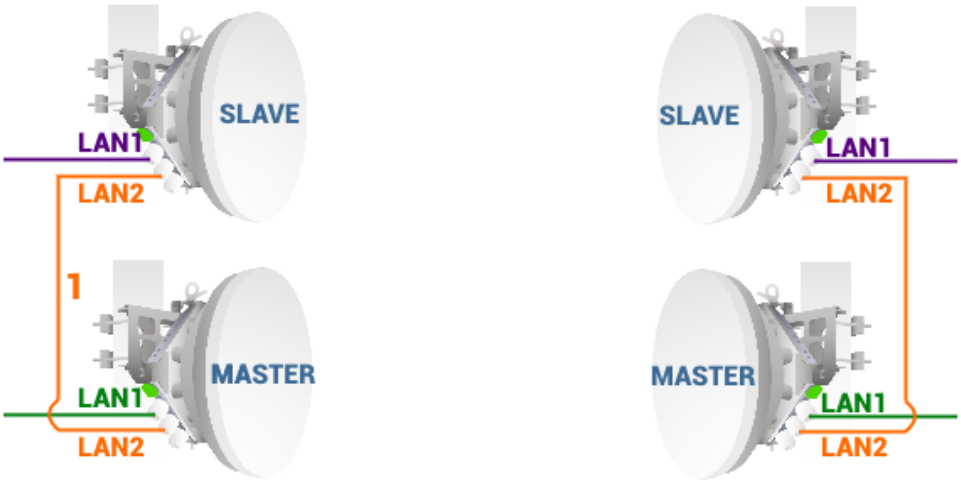
Aggregation configuration	
Aggregation	Enabled
Configured role	Slave
Current role	Slave
Mode	2+0 PLA
Master protection	
State	Enabled
FSM state	Slave
Instance ID	23
Ethernet traffic port	LAN1

For 1+1:

Aggregation configuration	
Aggregation	Enabled
Configured role	Slave
Current role	Slave
Mode	1+1 HSB
Master protection	
State	Enabled
FSM state	Standby
Instance ID	11
Ethernet traffic port	LAN1

192.168.205.100

192.168.205.200



192.168.205.10

192.168.205.20

Configuration for both Master FODUs

For 2+0:

Aggregation configuration	
Aggregation	Enabled
Configured role	Master
Current role	Master
Mode	2+0 PLA
Master protection	
State	Enabled
FSM state	Master
Instance ID	23
Ethernet traffic port	LAN1

For 1+1:

Aggregation configuration	
Aggregation	Enabled
Configured role	Master
Current role	Master
Mode	1+1 HSB
Master protection	
State	Enabled
FSM state	Active Tx
Instance ID	11
Ethernet traffic port	LAN1

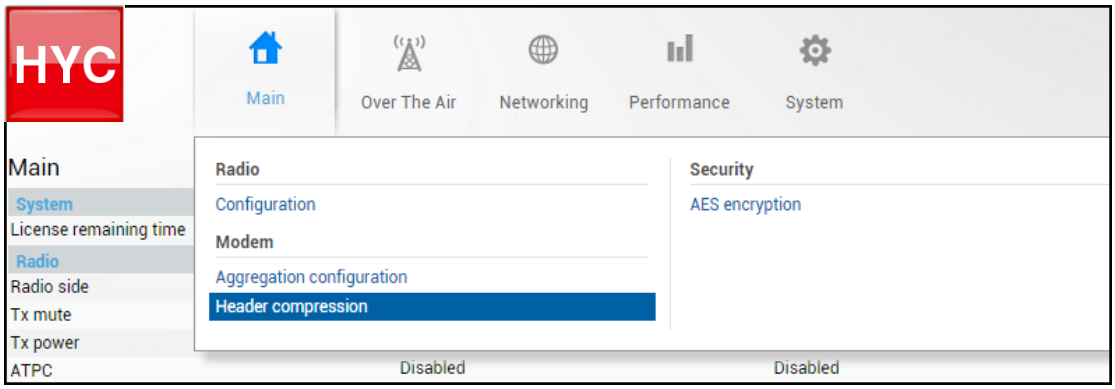
CLI commands (Chapter 4: COMMAND LINE INTERFACE)

aggr status	Use to show aggregation status, statistics and alarms.
aggr status clear	Use to clear aggregation statistics.
aggr role {none|master|slave}	Use to specify 2+0 aggregation role – Master or Slave. “none” disables aggregation.
aggr role {none|master 1+1| slave 1+1}	Use to specify 1+1 Hot StandBy role – Master or Slave. “none” disables aggregation.
aggr force {none|master|slave}	Use to force traffic to transmit solely via Master or Slave FODU.
aggr mprot enable <id> {LAN1|LAN3}	Use to enable master protection by specifying instance ID and traffic port – LAN1 or LAN3.
aggr mprot disable	Use to disable master protection.
aggr mprot data	Use to show master protection refresh data.
aggr mprot data reset	Use to reset master protection refresh data counters.
aggr mprot smpdata	Use to show the status of all 2+0 devices.
aggr mprot state <state>	Use to change FSM state. For testing purposes only!

Over The Air → Modem → Header compression

In many applications such as Voice over IP (VoIP), interactive gaming, or messaging, the size of the header is significant compared to the size of the payload. Over the end-to-end connection comprised of multiple hops, these headers are significant, but they can be omitted over a single link. It is beneficial to compress those headers to provide high-capacity packet saving, achieve better bandwidth utilization, and use the expensive resources in an efficient manner. Reduction in packet loss and improved interactive response time are additional important benefits gained by the header compression.

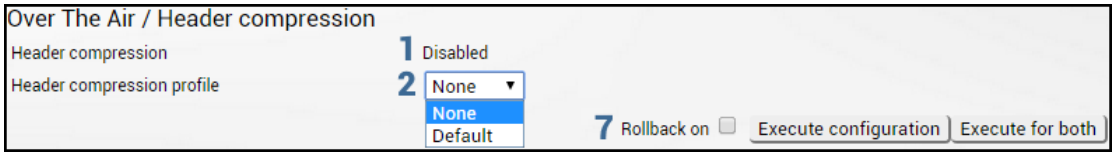
In summary, header compression is the process of compressing excess protocol headers before transmitting them on a link and uncompressing them to their original state on reception at the other end of the link.



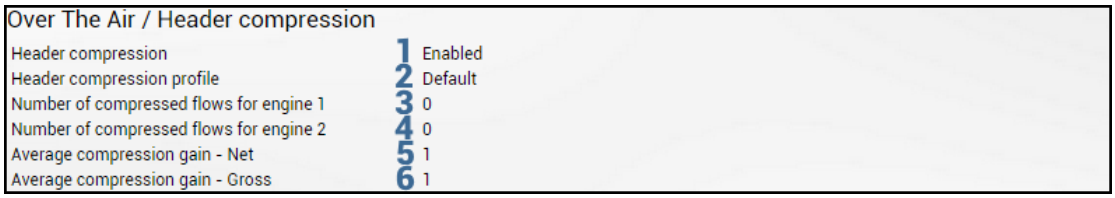
Status mode

Press MODIFY button.

Modify mode

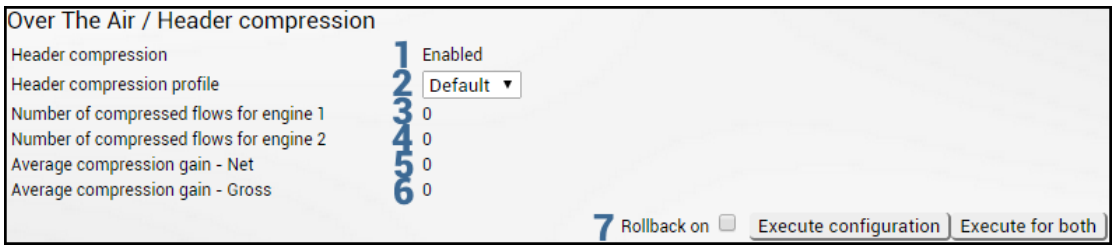


Status mode after enabling header compression



Press MODIFY button.

Modify mode after enabling header compression



Explanation of status/configuration fields:

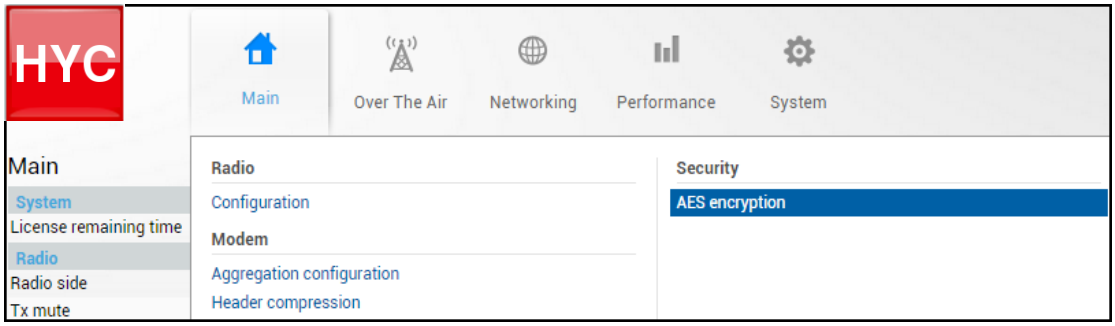
1) ***Header compression*** – Indicates whether header compression is enabled or disabled.
2) ***Header compression profile*** – Indicates which header compression profile is selected (status mode); allows choosing compression profile and thus enabling header compression or disabling it using the "None" profile (modify mode).
3) ***Number of compressed flows for engine 1*** – Indicates the number of compressed entries for engine #1. The maximum is 2048.
4) ***Number of compressed flows for engine 2*** – Indicates the number of compressed entries for engine #2. The maximum is 2048.
5) ***Average compression gain - Net*** – Indicates compression percentage between ingress and egress data.
6) ***Average compression gain - Gross*** – Indicates compression percentage between ingress and egress data including GFP (Generic Framing Procedure) overhead.
7) By pressing *„Execute configuration"*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback on"* is selected, the configuration will be reverted in case erroneous configuration changes are applied.
   Pressing *„Execute for both"* applies changes made to the corresponding section both for local and remote side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODUs.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

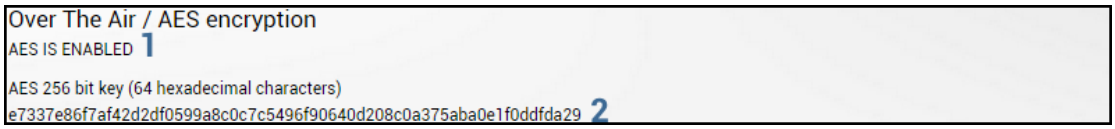
modem hc preset {none|default}	Use to enable (preset "default") or disable (preset "none") header compression.
modem hc statistics	Use to show head compression statistics.

Over The Air → Security → AES encryption

Enabling AES encryption provides payload data encryption over the air using Advanced Encryption Standard (AES).



Status mode



Press MODIFY button.

Modify mode

1) Indicates current AES status – enabled or disabled.
2) ***AES 256 bit key (64 hexadecimal characters)*** – Indicates AES key used. Key should be exactly 64 hexadecimal characters long. A dialog window will not allow more than 64 characters.
3) By pressing *„Execute configuration”*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback on”* is selected, the configuration will be reverted in case erroneous configuration changes are applied.

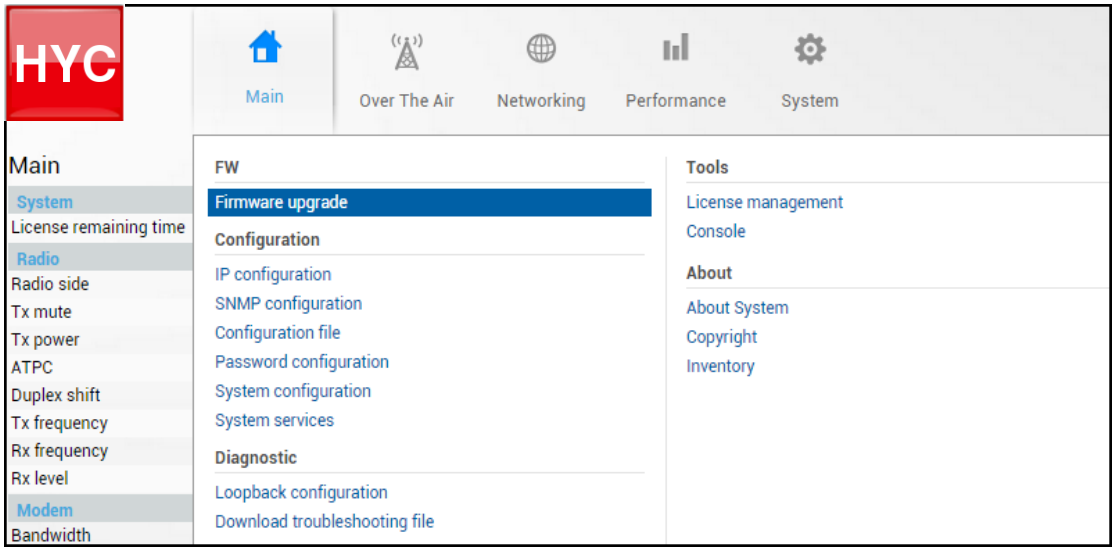
Activation of AES for INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODU

Step-by-step instructions

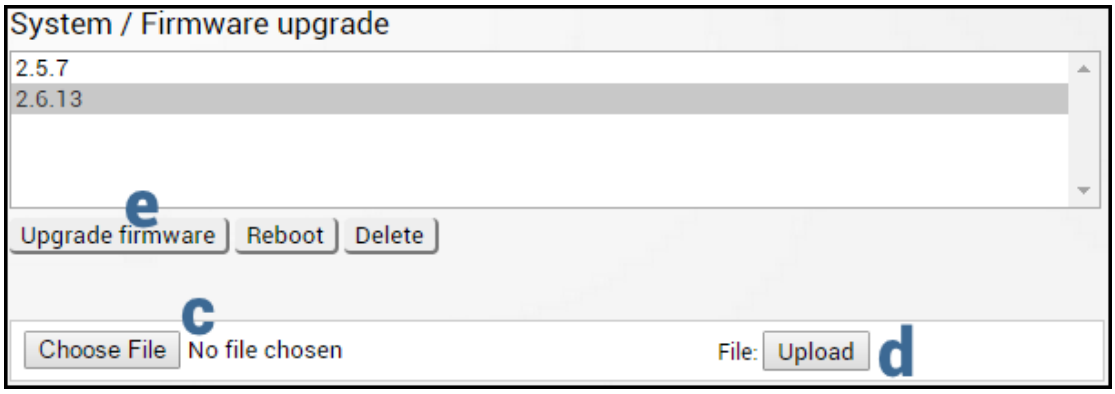
1) Make sure firmware version is V2.5.13 or later.
   If required perform firmware (link) upgrade:

   ⚠ Skip this step if the firmware version is V2.5.13 or later.

   a) Go to “System→FW→Firmware upgrade” of remote side of the link.



b) Press MODIFY button.



c) Locate *.bin firmware file on your hard disk drive.
d) Upload selected *.bin firmware file.
e) Select uploaded *.bin firmware file from the list and press “Upgrade firmware”.

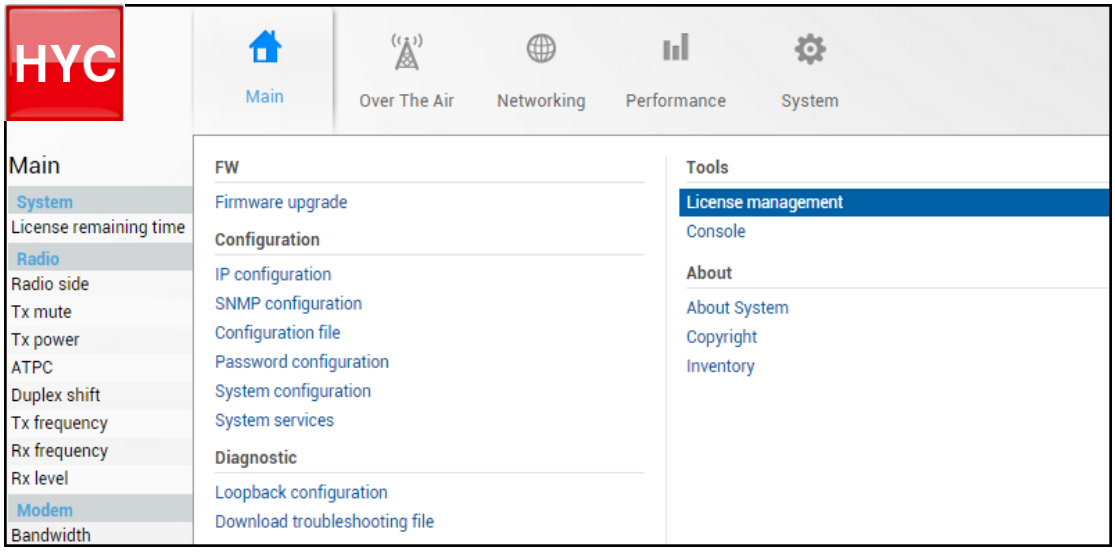
⚠ The remote side should be upgraded first.

f) Repeat steps a)-e) for local side of the link.

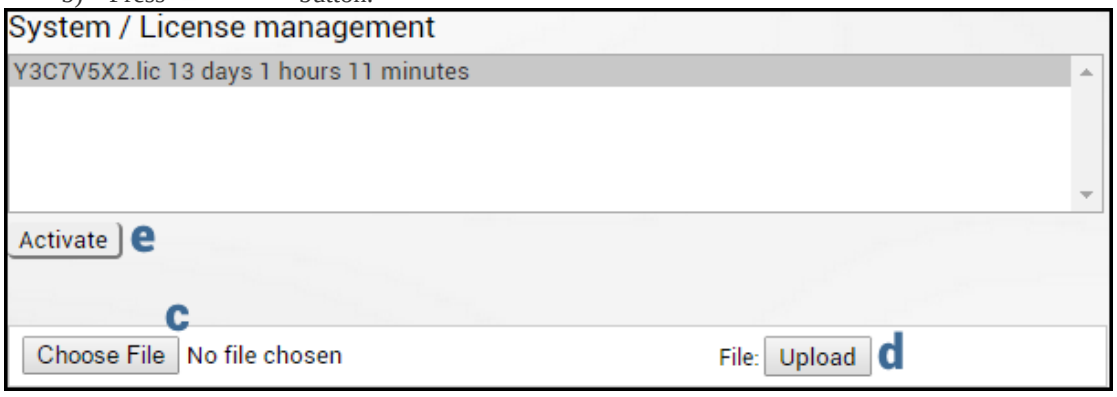
2) Upload and activate licence key enabling AES functionality

⚠ Skip this step if AES license is already uploaded.

a) Go to “System→Tools→License management” of remote side of the link.



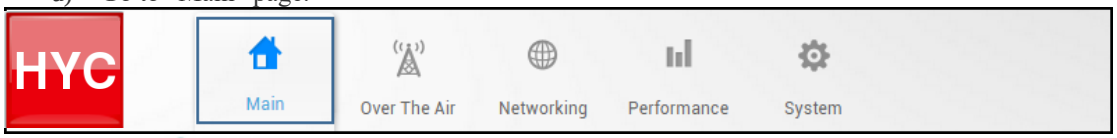
b) Press MODIFY button.



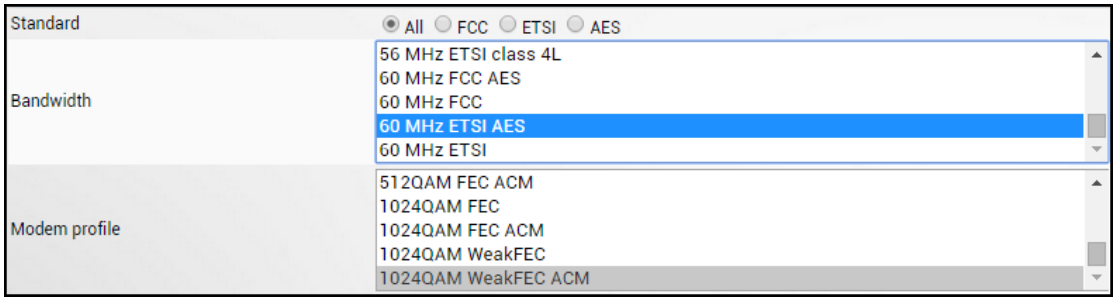
c) Locate *.lic license file on your hard disk drive.
d) Upload selected *.lic license file.
e) Select uploaded *.lic license file from the list and press “Activate”.
f) Repeat a)-e) for local side of the link.

3) Set bandwidth with AES

a) Go to “Main” page.



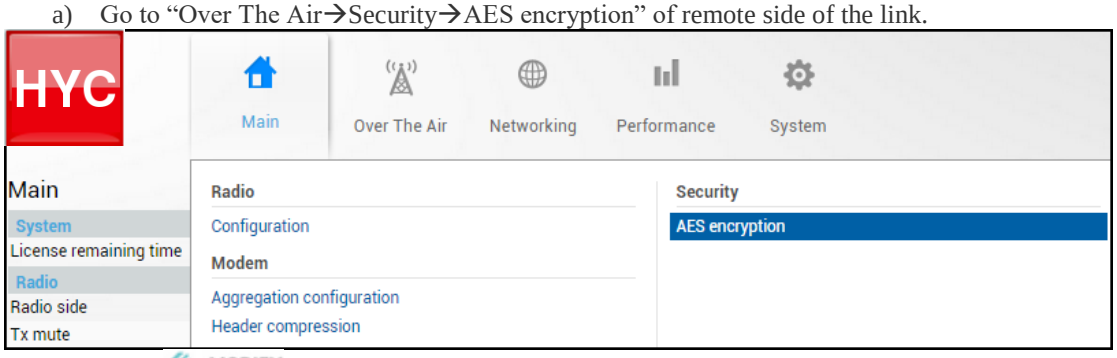
b) Press MODIFY button.
c) Select required bandwidth with AES and required modulation.



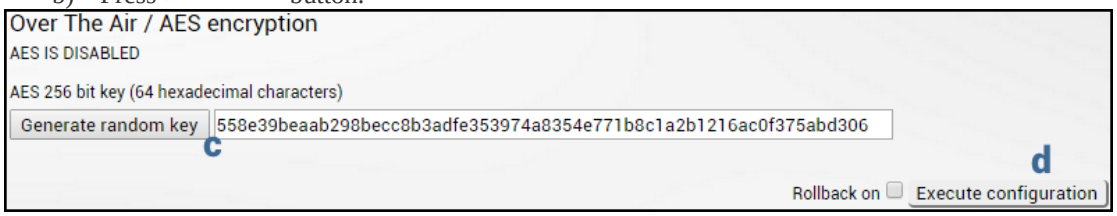
d) Press “Execute for both” button.

4) Apply AES 256-bit key

a) Go to “Over The Air→Security→AES encryption” of remote side of the link.



b) Press MODIFY button.



c) Enter 64-symbol key consisting of hexadecimal values (0-9, A-F) or press “Generate random key” button.
d) Select and copy generated key.
e) Press “Execute configuration” button.
f) Repeat steps a)-e) for local side of the link using the same copied AES key.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

modem aes key <64hexkey>	Use to set AES 256 bit key.
modem aes	Use to show AES state and key.

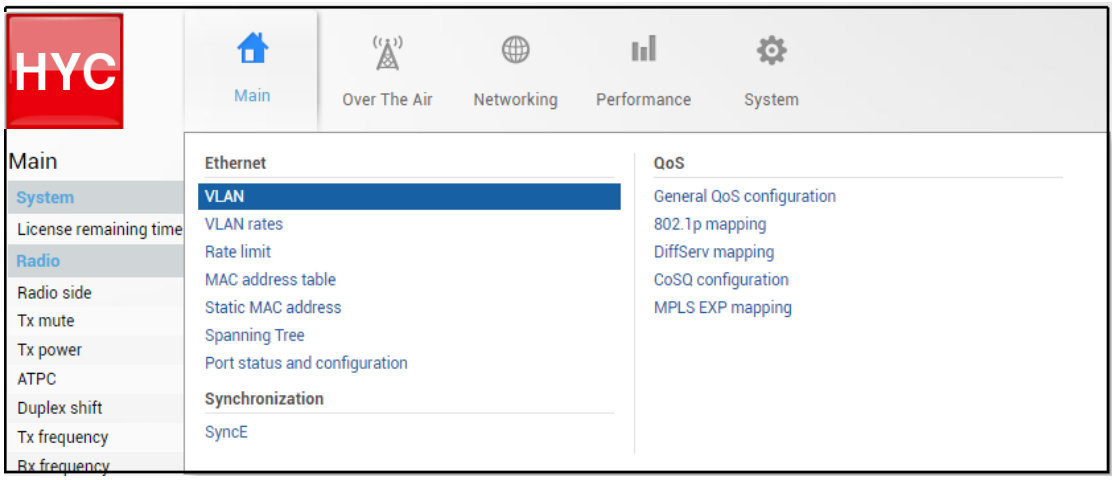
Networking

Networking → Ethernet → VLAN

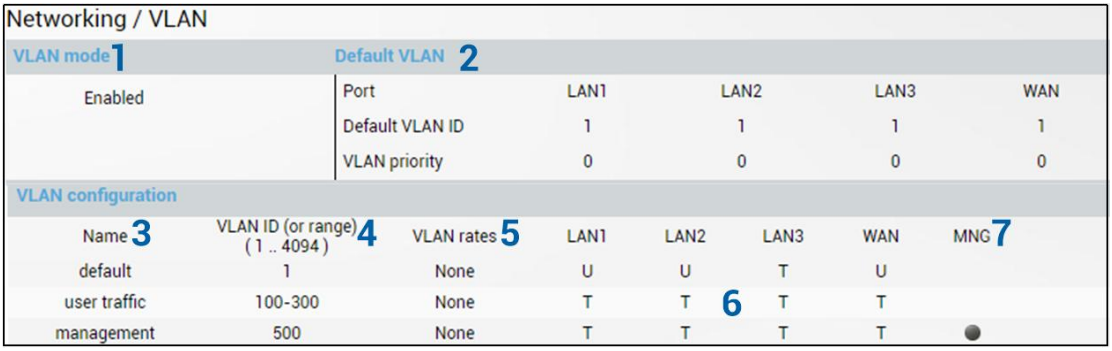
The VLAN configuration window provides the configuration of port-based Ethernet Virtual Local Area Networks (VLANs), allowing up to 4094 different VLAN IDs. It is possible to set VLAN IDs as tagged or untagged members on each LAN port.

In order to add a VLAN tag to untagged packets on ingress direction, “Default VLAN” (2) should be specified. By default, the “Default VLAN” value on all ports is VLAN ID 1.

An example below shows sample configuration with VLAN IDs 100-300 configured as tagged members on LAN2 and WAN ports (user traffic) and VLAN ID 500 as a tagged member on LAN2 and WAN ports and untagged member on MNG port (management traffic).

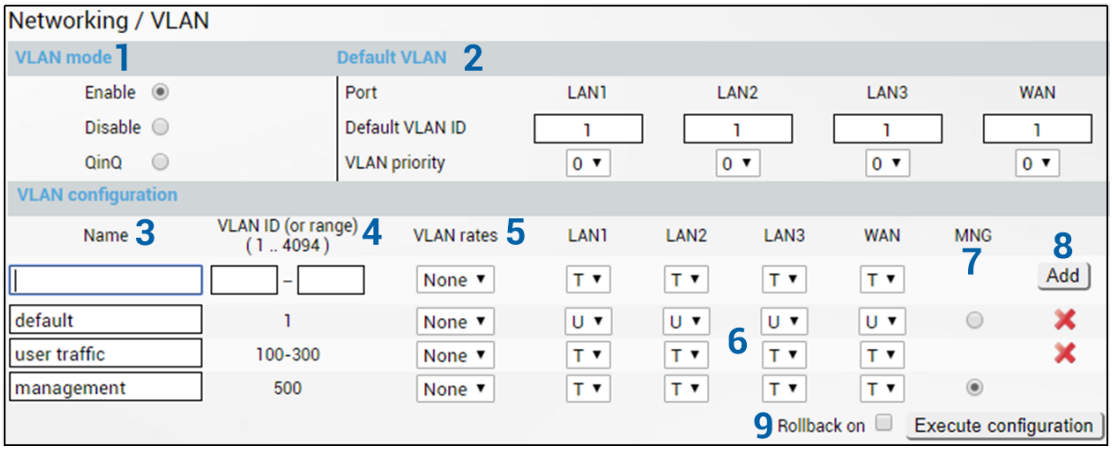


Status mode



Press MODIFY button.

Modify mode



1) ***VLAN state*** – Indicates VLAN operational mode. The default is "Disable" – 802.1Q disabled. Change to "Enable" to enable 802.1Q VLAN support. Change to "QinQ" to enable 802.1ad QinQ VLAN support.

⚠ As soon as you enable VLAN operational mode connectivity with untagged traffic will be lost.

2) ***Default VLAN*** – Indicates Default VLAN IDs and VLAN priorities on LAN and WAN ports (status mode); allows specifying the default VLAN ID and priorities on each of LAN and WAN ports. Specified VLAN ID and priority will be added to untagged ingress packets. VLAN priority will be removed from tagged egress packets on particular ports as well, but the

VLAN ID will be removed according to tagged/untagged configuration (see below) of that particular port.

3) ***Name*** – Indicates configured (if assigned) VLAN ID or VLAN ID range names (status mode); allows entering a name for each individual entry, i.e. individual VLAN ID or VLAN ID range (modify mode).
4) ***VID (1 .. 4094)*** – Indicates configured VLAN IDs and VLAN ID ranges (status mode); allows entering individual VLAN IDs or VLAN ID ranges, e.g. "100-300", "500" (modify mode).
5) ***VLAN rates*** – Indicates configured VLAN rate (status mode); allows to select a defined VLAN rate (modify mode). Please refer to the chapter Networking → Ethernet → VLAN rates.
6) ***T/U/D*** – Indicates whether VLAN ID entries are configured in U - untagged (access) mode, T - tagged (trunk) mode or D - disabled (status mode); allows changing VLAN mode on LAN and WAN ports (modify mode). Changing from T to U will change previous untagged VLAN ID on same port to T (trunk) mode and will highlight this change in yellow color. Note that only single U (untagged) VLAN ID can be configured on each available port.
7) ***MNG*** – indicates management VLAN ID (status mode); allows specifying which individual VLAN ID will be used for management access (modify mode).
8) ***Add / Delete*** – Press "Add" to add entered individual VLAN ID or VLAN ID range or press red cross (×) to delete VLAN entry;
9) By pressing *„Execute configuration"*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback on"* is selected, the configuration will be reverted in case erroneous configuration changes are applied.

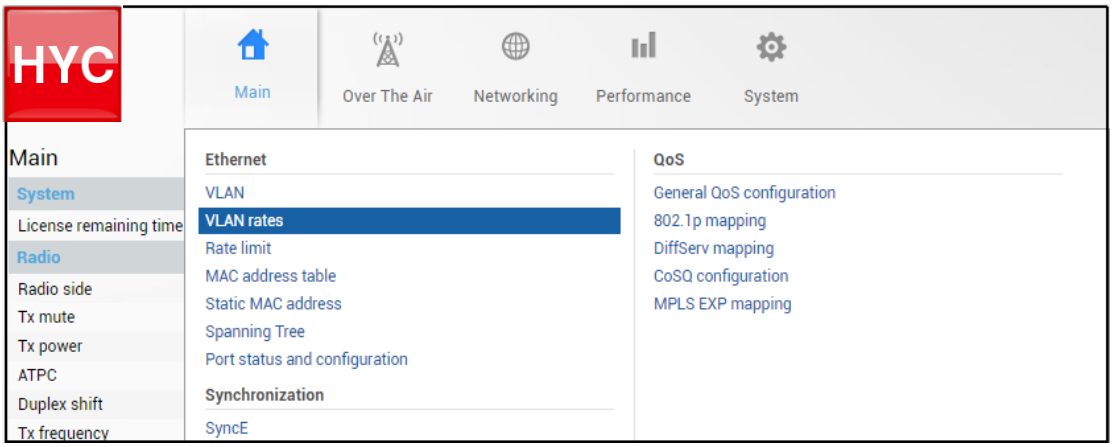
CLI commands (Chapter 4: COMMAND LINE INTERFACE)

network vlan set mng <1…4094>	Use to set Management (MNG) VLAN ID.
network vlan set mode {disable|enable|qinq}	Use to set VLAN operation mode. "disable" – packets ingress/egress unmodified; "enable" – packets are handled according to VLAN configuration; "qinq" - packets are handled according to VLAN configuration for QinQ.
network vlan set mode qinq tpid <0x0001...0xFFFF>	Use to set tag protocol identifier (TPID) for S-TAG.
network vlan set vid <1…4094> **add** {tagged|untagged} {LAN1|LAN2|LAN3|WAN}	Use to add VLAN ID as a tagged (trunk) or untagged (access) type on a specified port.
network vlan set vid <1…4094> **delete** {LAN1|LAN2|LAN3|WAN}	Use to delete VLAN ID on a specified port.
network vlan set vid <1…4094> **name** <name>	Use to name a VLAN ID. Same name can be applied for multiple VLAN IDs.
network vlan set vid <1…4094> **rate** <name>	Use to apply existing rate profile to a VLAN ID. Please refer to Chapter Networking → Ethernet → VLAN rates.
network vlan set vid <1…4094> **remove**	Use to remove defined rate profile from a VLAN ID.
network vlan set default priority <0…7>	Use to set default VLAN priority value for untagged packets.
network vlan set default vid <1…4094>	Use to set default VLAN ID for untagged packets.
network vlan show summary	Use to show general VLAN configuration summary.
network vlan show default	Use to show the configuration of untagged packets.

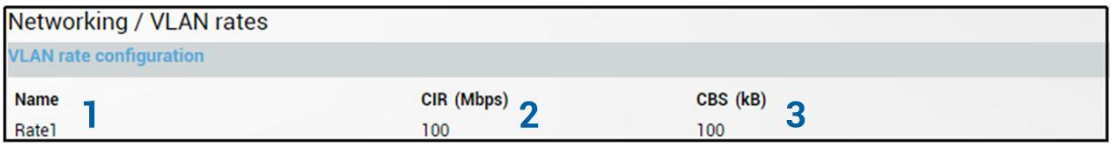
network vlan show mng	Use to show Management (MNG) VLAN ID.
network vlan show mode	Use to show current VLAN operational mode and custom EtherType ID.
network vlan show vids	Use to show currently configured VLAN IDs on all ports.

Networking → Ethernet → VLAN rates

The VLAN rates page allows configuring rates for selected VLANs.

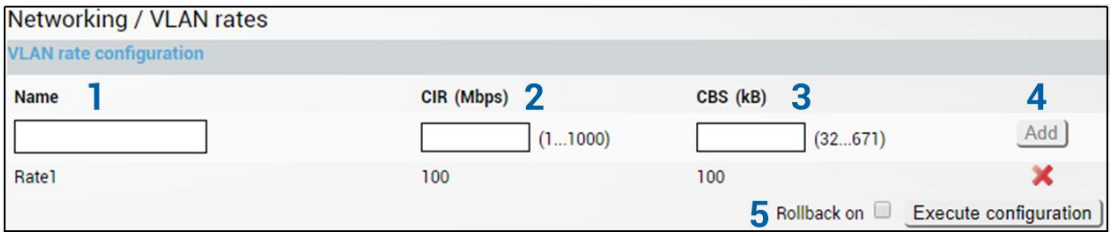


Status mode



Press MODIFY button.

Modify mode



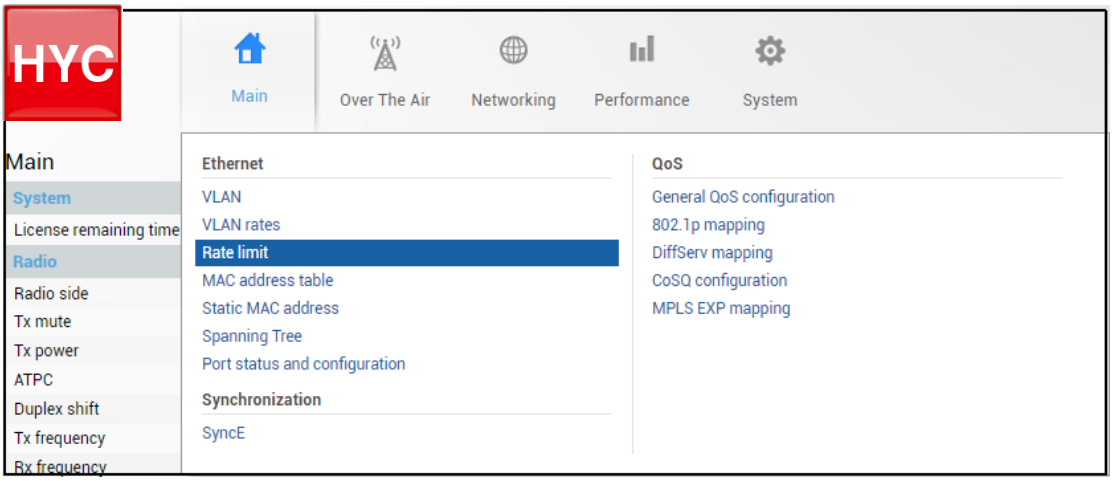
1) ***Name*** – Indicates whether egress rate is enabled or disabled on a particular port (status mode); allows enabling/disabling egress rate on a particular port (modify mode).
2) ***CIR (Mbps)*** – Indicates configured rate CIR (Committed Information Rate) on a particular VLAN rate item in Mbps (status mode); allows setting rate CIR on a particular VLAN rate item in Mbps (modify mode).
3) ***CBS (kB)*** – Indicates configured rate CBS (Committed Burst Size) on a particular VLAN rate item in kB (status mode); allows setting rate CBS on a particular VLAN rate item in kB (modify mode).
4) ***Add / Delete*** – Press "Add" to add entered VLAN rate or press red cross (✕) to delete this entry;
5) By pressing *„Execute configuration"*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback on"* is selected, the configuration will be reverted in case erroneous configuration changes are applied.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

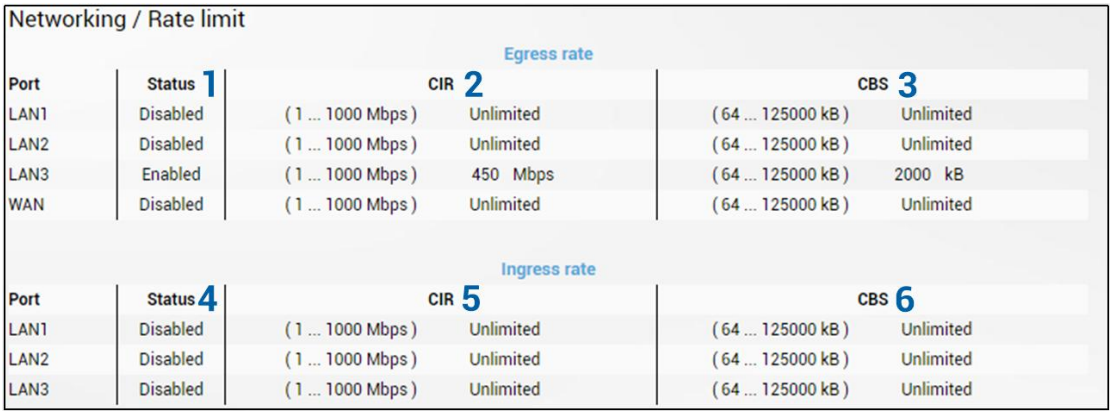
network vlan show rates	Use to show created rate profiles.
network vlan set rate {add|delete} <name> **cir** <1000…1000000kbps> **cbs** <32…671kB>	Use to create new or delete existing rate configuration profile. Please refer to Chapter Networking → Ethernet → VLAN in order to apply created rate profile to a VLAN ID.

Networking → Ethernet → Rate limit

The rate limit page allows configuring ingress and egress rates on available Ethernet switch ports. In case license with an Ethernet rate limitation is applied, the Ethernet limitation will be indicated as egress rate of WAN port.

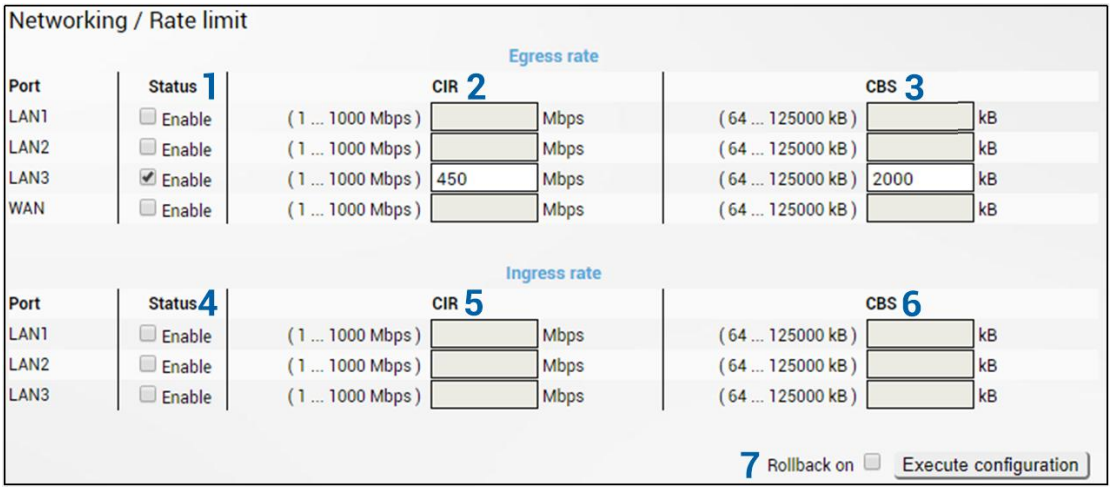


Status mode



Press MODIFY button.

Modify mode



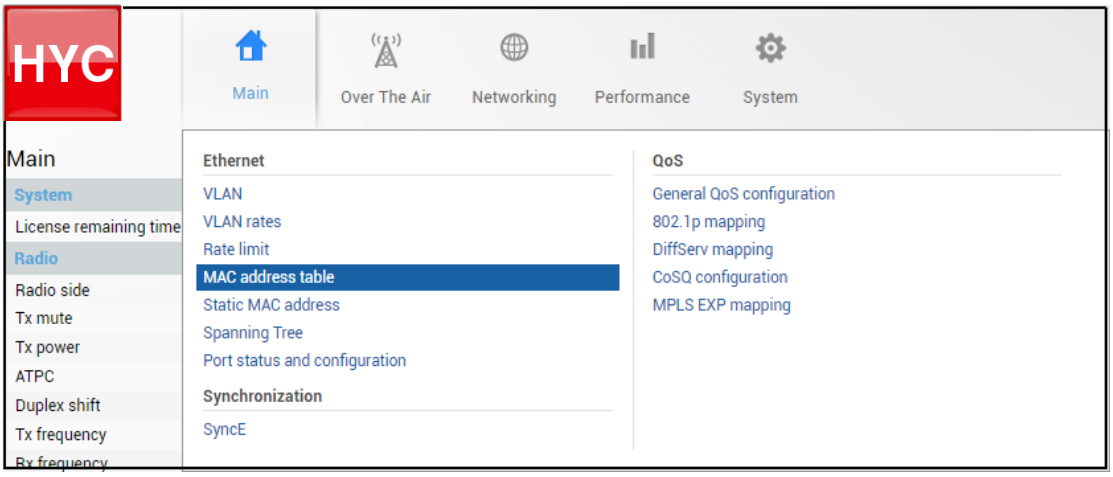
1) ***Egress rate / Status*** – Indicates whether egress rate is enabled or disabled on a particular port (status mode); allows enabling/disabling egress rate on a particular port (modify mode).
2) ***Egress rate / CIR*** – Indicates configured egress rate CIR (Committed Information Rate) on a particular port in Mbps (status mode); allows setting egress rate CIR on a particular port in Mbps (modify mode). The default setting is "1000".
3) ***Egress rate / CBS*** – Indicates configured egress rate CBS (Committed Burst Size) on a particular port in kB (status mode); allows setting egress rate CBS on a particular port in kB (modify mode). The default setting is "2000".
4) ***Ingress rate / Status*** – Indicates whether ingress rate is enabled or disabled on a particular port (status mode); allows enabling/disabling ingress rate on a particular port (modify mode).
5) ***Ingress rate / CIR*** – Indicates configured ingress rate CIR (Committed Information Rate) on a particular port in Mbps (status mode); allows setting ingress rate CIR on a particular port in Mbps (modify mode). The default setting is "1000".
6) ***Ingress rate / CBS*** – Indicates configured ingress rate CBS (Committed Burst Size) on a particular port in kB (status mode); allows setting ingress rate CBS on a particular port in kB (modify mode). The default setting is "2000".
7) By pressing *„Execute configuration"*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback on"* is selected, the configuration will be reverted in case erroneous configuration changes are applied.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

network port show egress-rate <port>	Use to show egress rate limit settings and status of a particular port.
network port show ingress-rate <port>	Use to show ingress rate limit settings and status of a particular port.
network port set <port> **egress-rate cir** <96…1000000kbps> **cbs** <64…125000kB>	Use to set Committed Information Rate (CIR) and Committed Burst Size (CBS) setting for egress rate limit on particular port.
network port set <port> **ingress-rate cir** <96…1000000> **cbs** <64…125000>	Use to set Committed Information Rate (CIR) and Committed Burst Size (CBS) setting for ingress rate limit on particular port.
network port set <port> **egress-rate state** {enable|disable}	Use to enable or disable egress rate limiting on a particular port.
network port set <port> **ingress-rate state** {enable|disable}	Use to enable or disable ingress rate limiting on a particular port.

Networking → Ethernet → MAC address table

The MAC address table displays the forwarding table of MAC addresses learned by the switch (Dynamic) and manually entered (Static).



Status mode

Networking / MAC address table

MAC address table

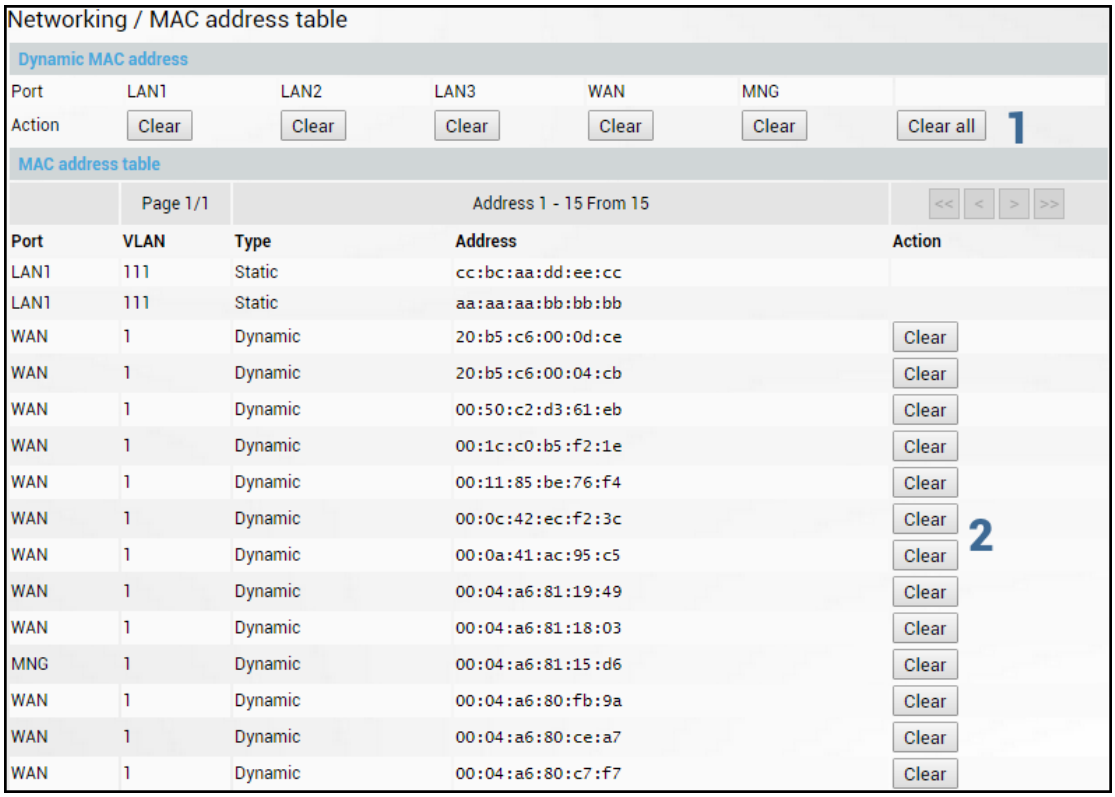
Page 1/1 Address 1 - 17 From 17 << < > >>

Port	VLAN	Type	Address
LAN1	111	Static	cc:bc:aa:dd:ee:cc
LAN1	111	Static	aa:aa:aa:bb:bb:bb
WAN	1	Dynamic	20:b5:c6:00:0d:ce
WAN	1	Dynamic	20:b5:c6:00:04:cb
WAN	1	Dynamic	00:50:c2:d3:61:eb
WAN	1	Dynamic	00:1c:c0:b5:f2:1e
WAN	1	Dynamic	00:11:85:be:76:f4
WAN	1	Dynamic	00:0c:42:ec:f2:3c
WAN	1	Dynamic	00:0a:41:ac:95:c5
WAN	1	Dynamic	00:04:a6:81:19:ea
WAN	1	Dynamic	00:04:a6:81:19:49
WAN	1	Dynamic	00:04:a6:81:18:03
MNG	1	Dynamic	00:04:a6:81:15:d6
WAN	1	Dynamic	00:04:a6:80:fb:9a
WAN	1	Dynamic	00:04:a6:80:ce:a7
WAN	1	Dynamic	00:04:a6:80:c7:f8
WAN	1	Dynamic	00:04:a6:80:c7:f7

2

Press MODIFY button.

Modify mode



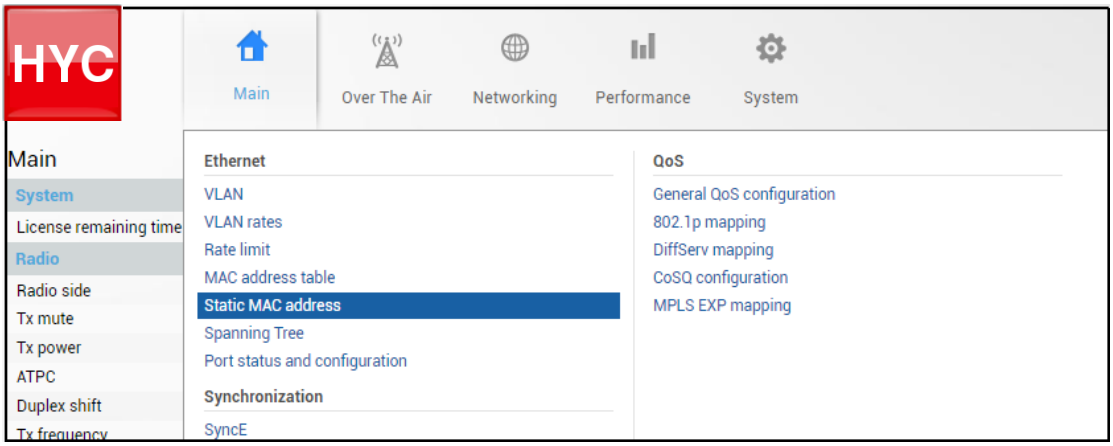
1) Use to clear the dynamic MAC address table on a particular port (“Clear”) or all ports simultaneously (“Clear all”).
2) Use to clear specific MAC address entry.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

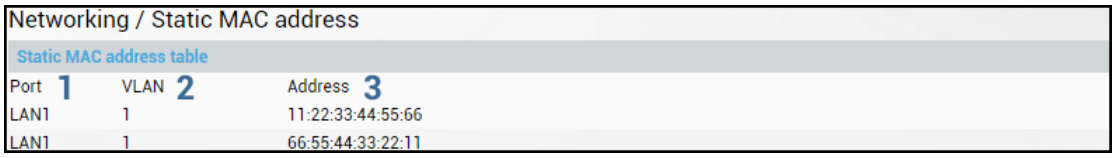
network mac table show	Use to show MAC table entries.
network mac table info	Use to show MAC table statistics.
network mac table clear vlan <vid>	Use to clear MAC table entries for a specific VLAN ID.
network mac table clear port <port>	Use to clear MAC table entries for a specific port.
network mac table clear mac-address <MAC>	Use to clear a dynamic MAC address for all VLAN IDs and ports.
network mac table clear all	Use to clear the whole dynamic MAC address table.

Networking → Ethernet → Static MAC Address

Allows adding and editing static MAC address entries.

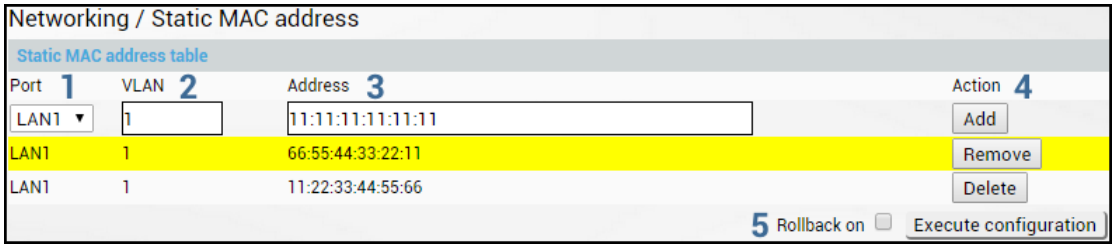


Status mode



Press MODIFY button.

Modify mode



1) ***Port*** – Indicates ports of configured static MAC addresses (status mode); allows specifying the port for static MAC address (modify mode).
2) ***VLAN*** – Indicates VLAN IDs of configured static MAC addresses (status mode); allows specifying VLAN for static MAC address (modify mode).
3) ***Address*** – Indicates configured static MAC addresses (status mode); allows specifying static MAC address (modify mode).
4) ***Action*** – Allows adding new static MAC address ("Add"), removing temporarily entered static MAC address ("Remove") or deleting permanently entered static MAC address ("Add").
5) By pressing *„Execute configuration"*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback on"* is selected, the configuration will be reverted in case erroneous configuration changes are applied.

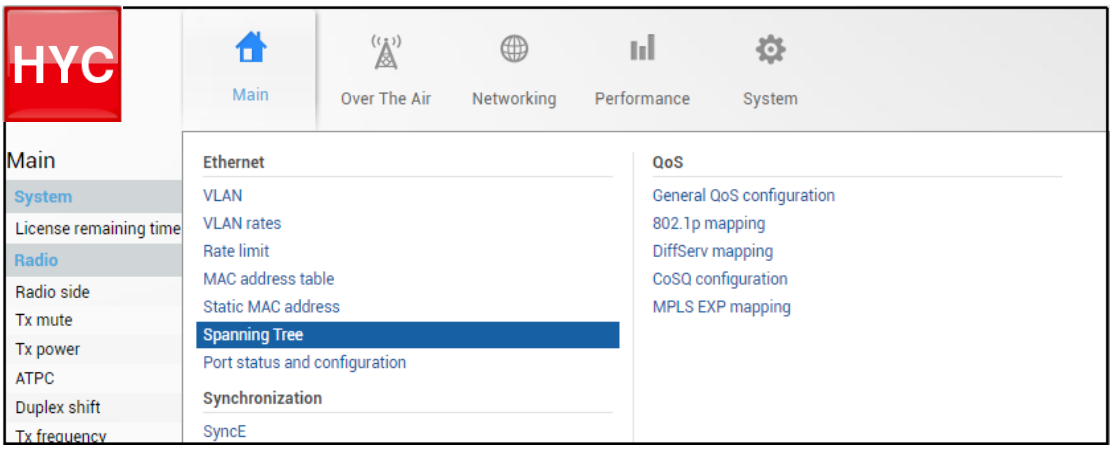
CLI commands (Chapter 4: COMMAND LINE INTERFACE)

network mac static show	Use to show static MAC address table.
network mac static add mac-address <MAC> **vlan** <vlan> **port** <port>	Use to add static MAC address for selected VLAN ID and port.

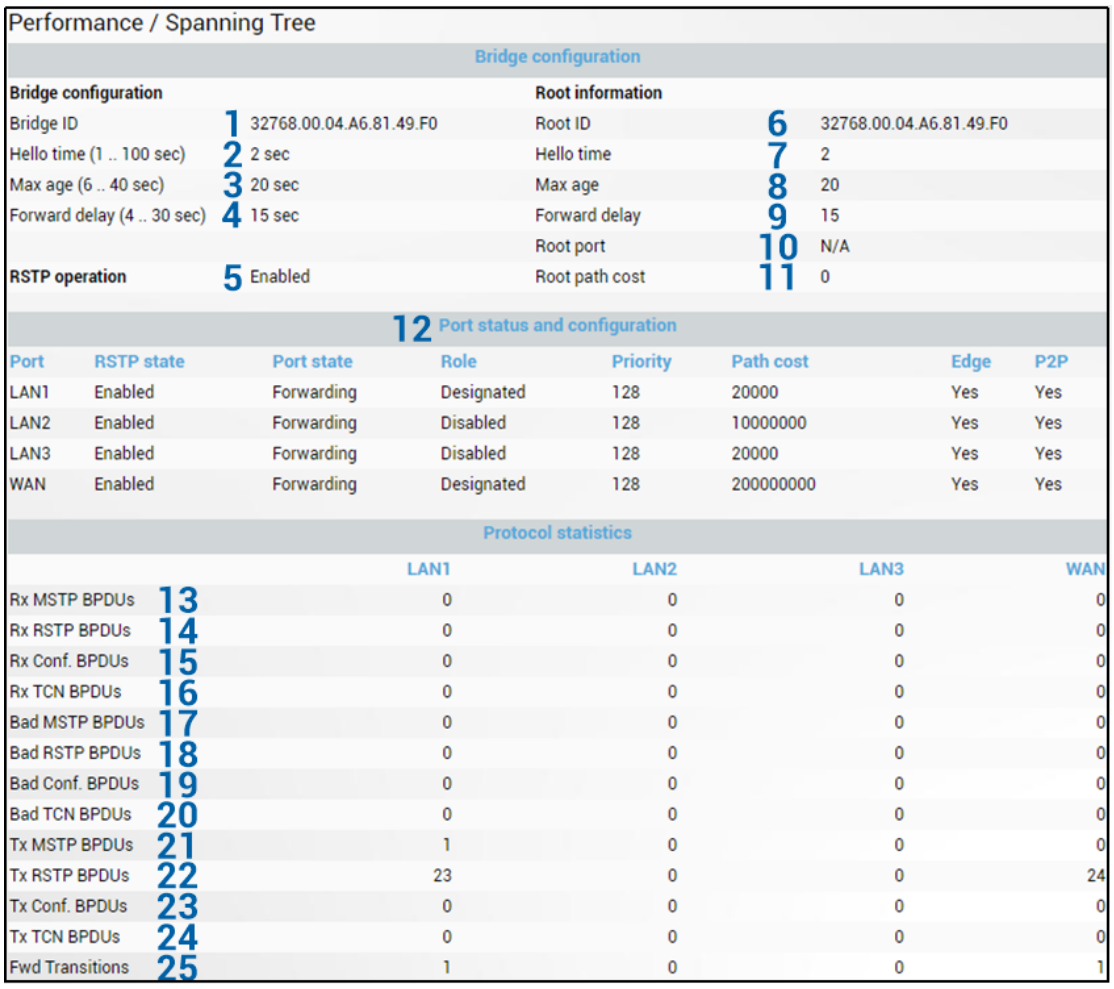
network mac static delete mac-address <MAC> **vlan** <vlan> **port** <port>	Use to remove static MAC address from selected VLAN ID and port.

Networking → Ethernet → Spanning Tree

The Spanning Tree page provides the configuration of Rapid Spanning Tree Protocol (Rapid STP).

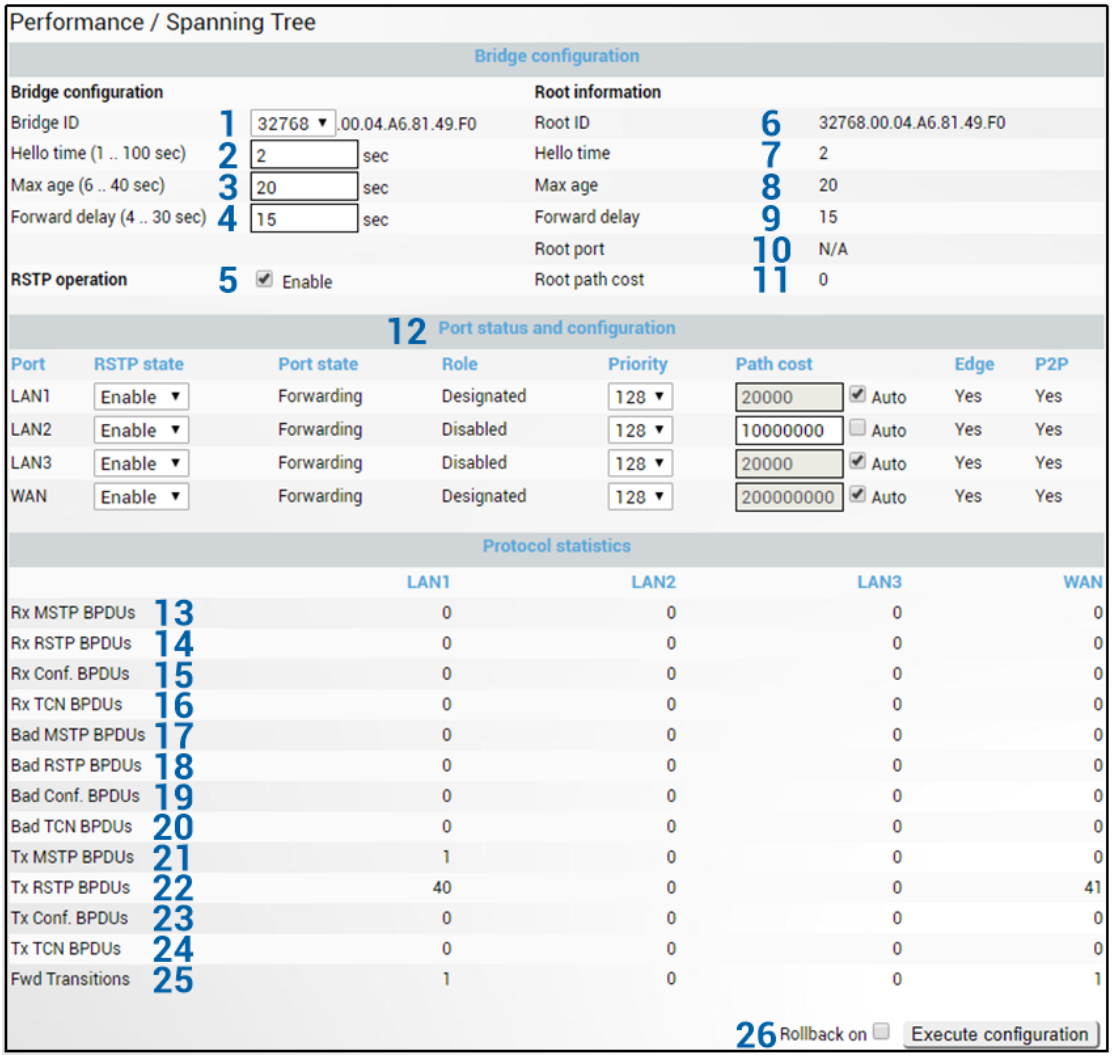


Status mode



Press MODIFY button.

Modify mode



1) ***Bridge ID*** **–** Indicates configured value of Bridge ID (status mode); allows specifying the value of Bridge ID (modify mode). This parameter and MAC address determine whether a given Bridge is Root Bridge. The advantage is given to the combination of Priority and Address, which is numerically smaller.
2) ***Hello Time (1 – 100 sec)*** **–** Indicates configured time gap between which the BPDU packets are being sent (status mode); allows specifying the value of Hello Time in seconds (modify mode).
3) ***Max Age (6 – 40 sec)*** **–** Indicates configured time period, during which the received BPDU packets' information is stored for a separate port (status mode); allows specifying the value of Max Age in seconds (modify mode).
4) ***Forward Delay (4 – 30 sec)*** **–** Indicates configured time period that determines the time a separate port stays in Listening and Learning conditions (status mode); allows specifying the value of Forward Delay in seconds (modify mode).
5) ***RSTP operation*** **–** Indicates configured status of RSTP (status mode); allows enable or disable RSTP operation (modify mode).

Root information **–** displays the data only when RSTP is enabled:

6) ***Root ID*** **–** Indicates the Bridge ID of current Root bridge;
7) ***Hello Time*** **–** Indicates the current hello time;
8) ***Max Age*** **–** Indicates the current max age;
9) ***Forward Delay*** **–** Indicates the current forward delay;
10) ***Root Port*** **–** Indicates elected root port is being shown;
11) ***Root Path Cost*** **–** Indicates the path cost from current bridge to root bridge;

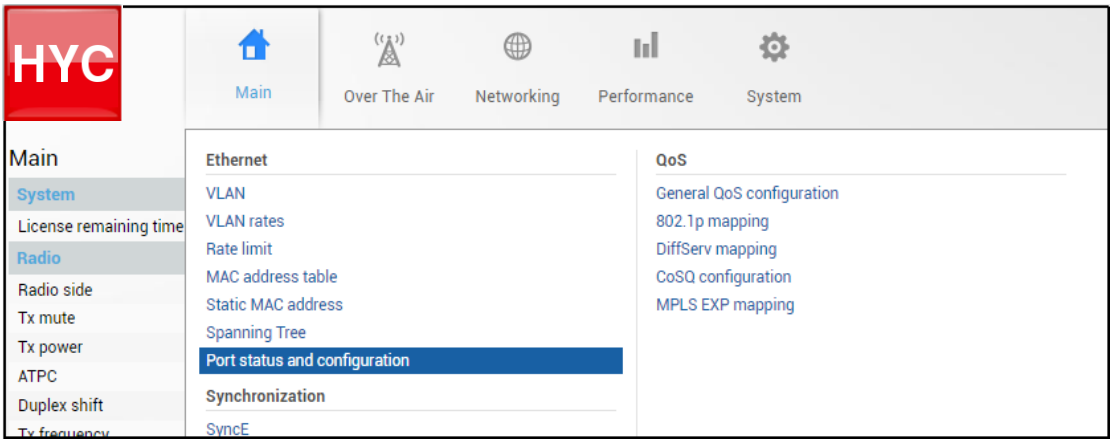
12) ***Port status and configuration*** **–** STP parameters of every port:
    - ***RSTP state*** **–** Indicates RSTP state of the particular port (status mode); allows enable or disable RSTP operation for the particular port (modify mode);
    - ***Port state*** **–** Indicates port condition. Can be one of the following: *Disabled*, *Blocking*, *Listening*, *Learning* or *Forwarding*;
    - ***Role*** **–** the role of the particular port. Can be one of the following: *Root*, *Designated*, *Alternate*, *Backup* or *Disabled*;
    - ***Priority*** **–** Indicates Port Priority (status mode); allows specifying Port Priority (modify mode). Combination of Priority, Port number and Path Cost determines whether the port will be selected as Root port or will be blocked on the occasion of loop, etc;
    - ***Path cost*** **–** Indicates Path cost of the particular port (status mode); allows specifying Path cost for the particular port by setting Path cost value or by selecting *Auto* mode (modify mode). This parameter setting depends on the capacity of a separate port;
    - ***Edge*** **–** displays that this particular port is Edge port;
    - ***Point-to-point*** **–** displays whether there is a point-to-point connection from the particular port or not;
13) ***Rx MSTP BPDUs*** **–** Indicates how many MSTP BPDUs packets received;
14) ***Rx RSTP BPDUs*** **–** Indicates how many RSTP BPDUs packets received;
15) ***RX Conf BPDUs*** **–** Indicates how many STP BPDUs packets received;
16) ***RX TCN BPDUs*** **–** Indicates how many topology changing notification BPDUs packets received;
17) ***Bad MSTP BPDUs*** **–** Indicates how many bad MSTP BPDUs packets received;
18) ***Bad RSTP BPDUs*** **–** Indicates how many bad RSTP BPDUs packets received;
19) ***Bad Conf BPDUs*** **–** Indicates how many bad STP BPDUs packets received;
20) ***Bad TCN BPDUs*** **–** Indicates how many bad topology changing notifications BPDUs packets received;
21) ***Tx MSTP BPDUs*** **–** Indicates how many MSTP BPDUs packets sent;
22) ***Tx RSTP BPDUs*** **–** Indicates how many RSTP BPDUs packets sent;
23) ***Tx Conf BPDUs*** **–** Indicates how many STP BPDUs packets sent;
24) ***Tx TCN BPDUs*** **–** Indicates how many topology changing notification BPDUs packets sent;
25) ***Fwd Transitions*** **–** Indicates how many times port has been changed to forward status;
26) By pressing *„Execute configuration”,* changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback on”* is selected, the configuration will be reverted in case erroneous configuration changes are applied.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

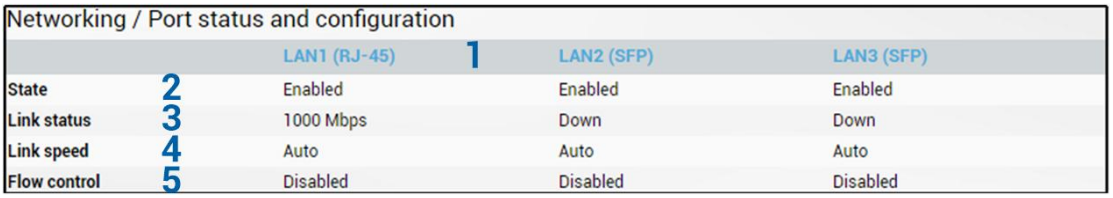
stp status	Use to show the status of STP configuration.
stp bridgeID {0 | 4096 | 8192 | 12288 | 16384| 20480 | 24576 | 28672 | 32768 | 36864 | 40960 | 45056 | 49152 | 53248 | 57344 |61440}	Use to set the value of Bridge ID.
stp helloTime <1..100>	Use to set the value of the time gap in seconds between which the BPDU packets are being sent.
stp maxAge <6..40>	Use to set the time period in seconds, during which the received BPDU packets' information is stored for a separate port.
stp forwardDelay <4..30>	Use to set the time period that determines the time in seconds a separate port stays in Listening and Learning conditions.
stp state {enable|disable}	Use to enable or disable RSTP operation.

Networking → Ethernet → Port status and configuration

Shows status of Ethernet switch ports, allows enabling and disabling the ports, Flow control and modifying link speed/duplex.

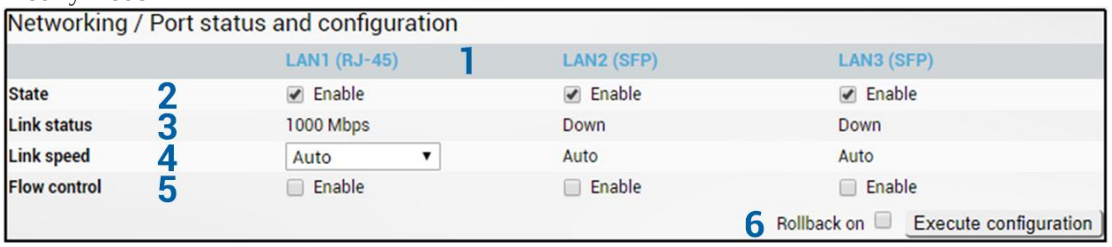


Status mode



Press MODIFY button.

Modify mode



1) ***Port*** – Indicates available switch ports.
2) ***State*** – Indicates operation status of each LAN port (status mode); allows enabling/disabling each LAN port (modify mode). "(Restricted)" will be indicated on LAN2 port if 2+0 aggregation or 1+1 protection is enabled.
3) ***Link status*** – Indicates whether a link with the appropriate port is established as well as its link speed.
4) ***Link speed*** – Indicates whether link speed is configured to automatic speed setting or manual (status mode); allows changing link speed to the manual setting (modify mode).

LAN2 and LAN3 (SFP ports) support Auto Gigabit (1000FDX) only and cannot be modified.

Maximum L2 frame size supported in 1000FDX mode is 9600B, while in 100FDX mode (LAN1) – 9070B.

5) ***Flow control*** – Indicates whether flow control is enabled or disabled on a particular port (status mode); allows enabling/disabling flow control on each available port (modify mode). The default setting is disabled.
6) By pressing *„Execute configuration"*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback*

on" is selected, the configuration will be reverted in case erroneous configuration changes are applied.

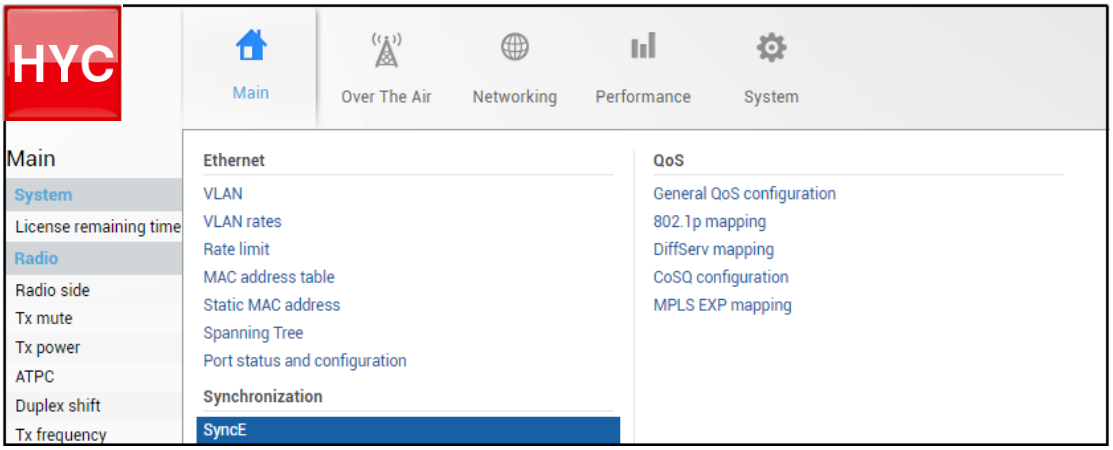
CLI commands (Chapter 4: COMMAND LINE INTERFACE)

network port show info	Use to show the status of all ports.
network port show config	Use to show the configuration of all ports.
network port set <port> **admin-state** {enable|disable}	Use to enable or disable particular port.
network port set LAN1 speed {auto|100fdx|100hdx|10fdx|10hdx}	Use to change speed and duplenex setting on LAN1 port. Default value is "auto" (auto negotiation).
network port set <port> **flow-control** {enable|disable}	Use to enable or disable flow control on particular port.

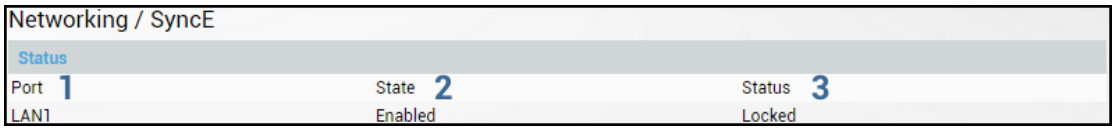
Networking → Synchronization → SyncE

Synchronous Ethernet (SyncE) allows synchronizing the Ethernet switch clock to an external source clock by specifying an ingress port.

Incorrect SyncE configuration may result in a loss of connectivity.

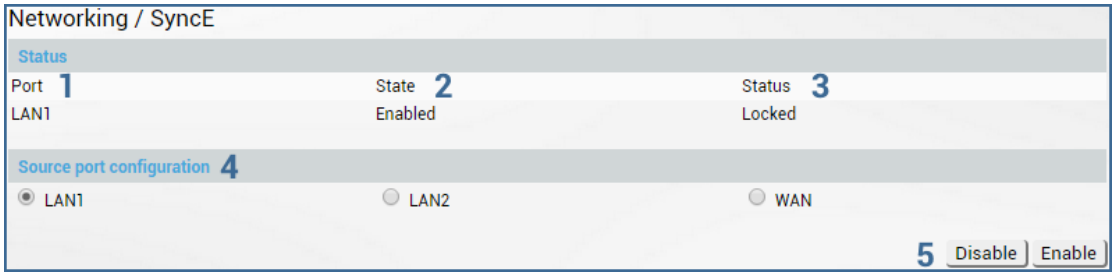


Status mode



Press MODIFY button.

Modify mode

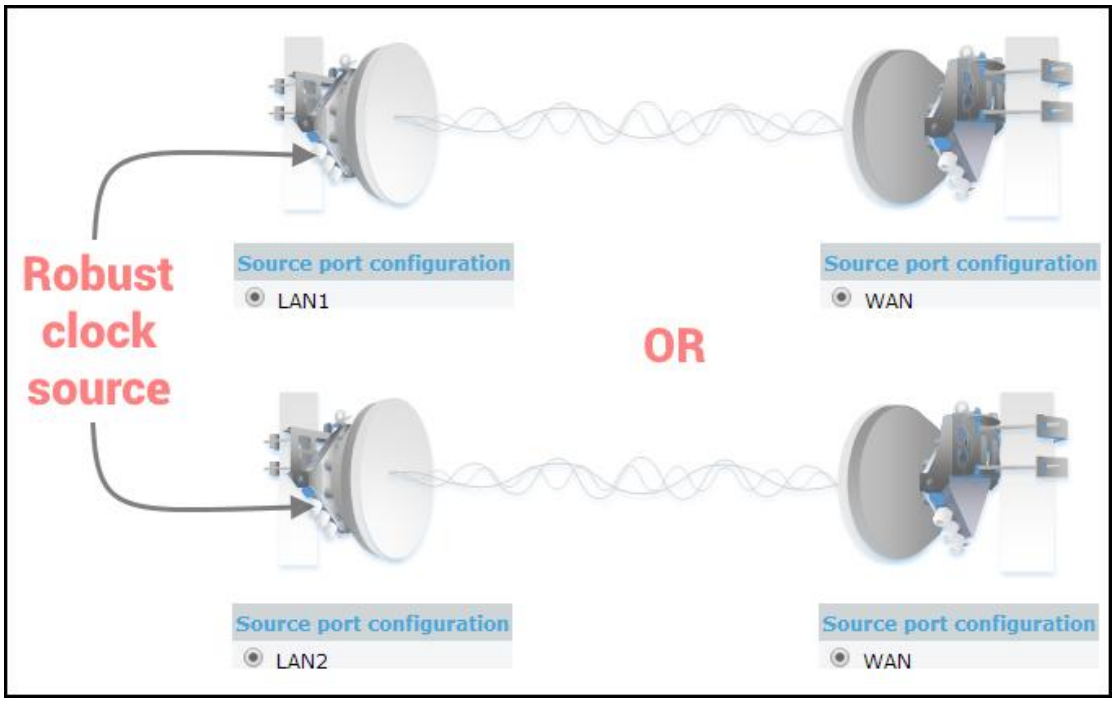


1) ***Port*** - Indicates SyncE source port (if enabled);
2) ***State*** – Indicates if SyncE is enabled.

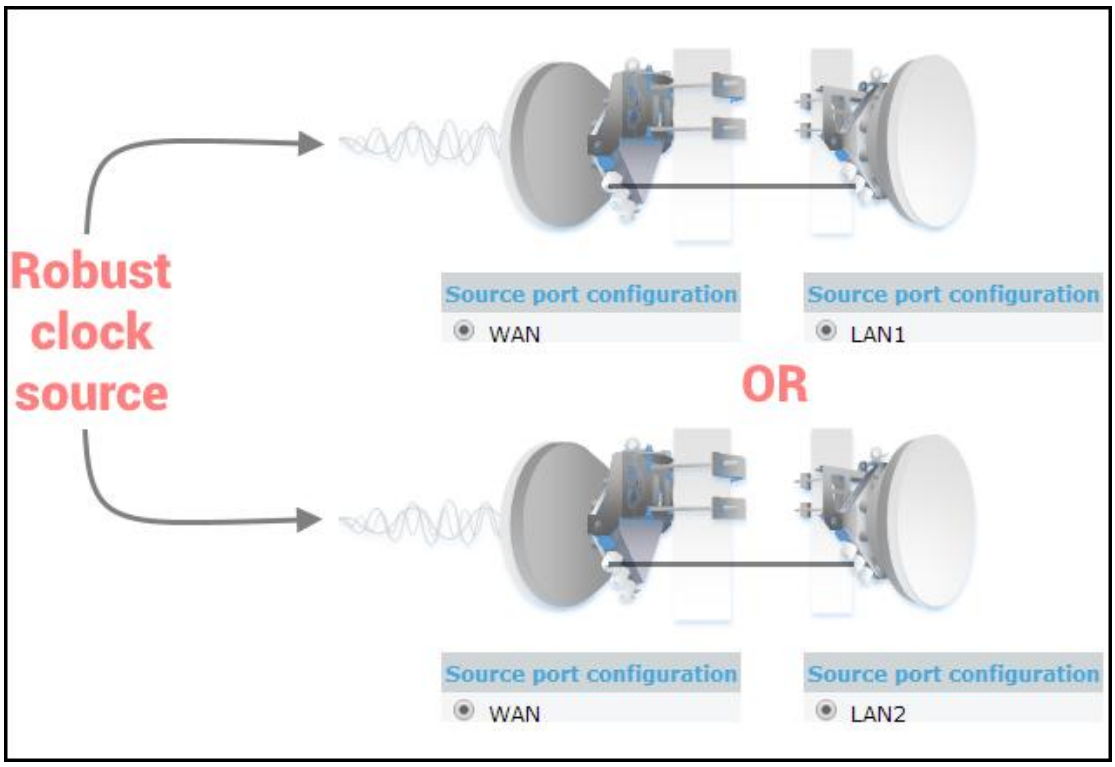
3) ***Status*** – Indicates "Locked" if SyncE is operating normally.
4) ***Source port configuration*** – Allows specifying SyncE source port.
5) ***Disable/Enable*** – Allows enabling or disabling SyncE operation.

Configuration examples

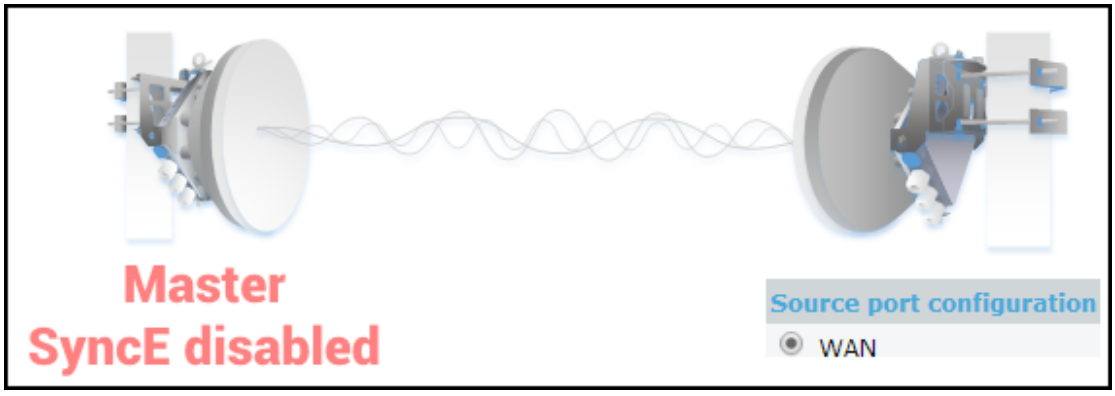
1) INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS link with an external clock source



2) INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS back-to-back interconnection with an external clock source



3) INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS as a master clock source



⚠ Auto negotiation will not function properly when the clock source ports on both INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODUs are pointing at each other (e.g. WAN-WAN in a link or LAN-LAN in a back-to-back connection).

⚠ SyncE will function properly on LAN2 and LAN3 ports only with appropriate SFP modules.

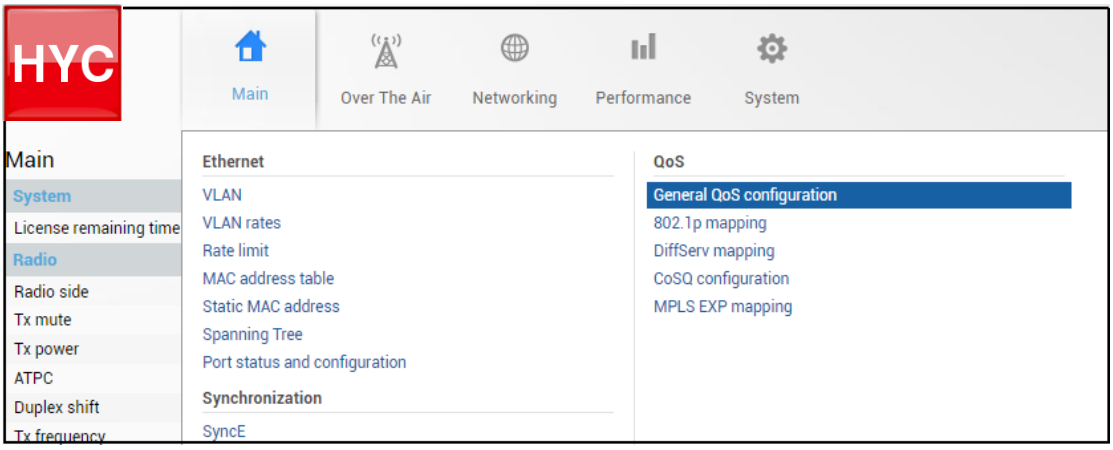
CLI commands (Chapter 4: COMMAND LINE INTERFACE)

network sync enable {LAN1|LAN2|WAN}	Use to enable SyncE on a port connected to a clock source. The selected port will become “slave”, while other ports – “master”. Auto negotiation will not function properly between two “slave” ports.
network sync disable	Use to disable SyncE on all ports.
network port show info	'SyncE_Act' and 'SyncE_Prio' field nonzero values indicate synchronous Ethernet activity.
network sync status	*Enabled* – shows if SyncE is enabled; *Polling failed* – indicates last data polling failure; *Speed Grade* – shows Ethernet speed on LAN1 port - 1000BASE-T(1G) or 100BASE-T(100M); *Port* – current port used as clock source; *State* – clock status, "Locked" if SyncE operates normally; *State info* – additional information

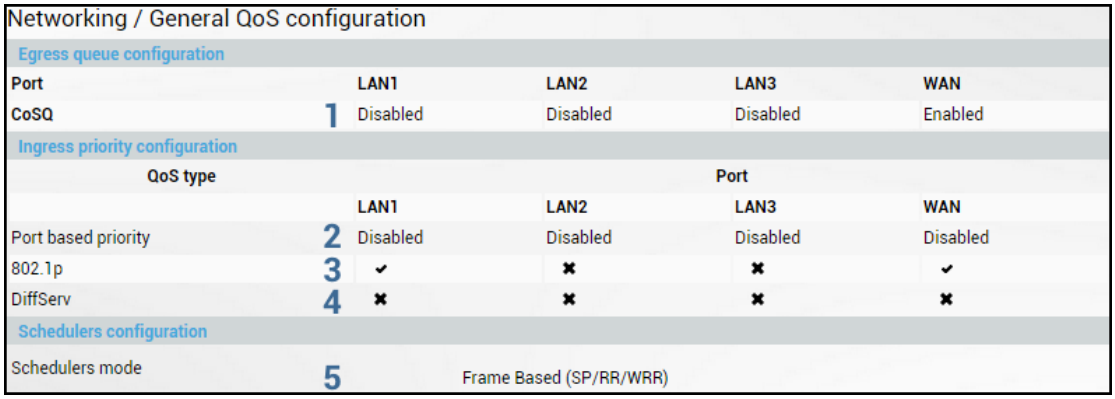
Networking → QoS → General QoS configuration

The General QoS configuration page allows defining QoS queueing rules.

⚠ Only one priority classification method (port/802.1p/DiffServ) can be enabled on a single port.

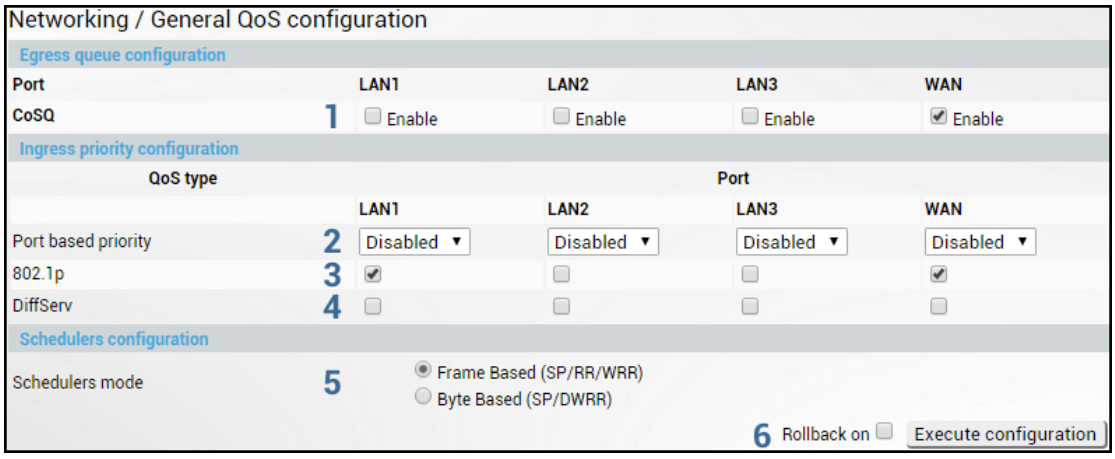


Status mode



Press MODIFY button.

Modify mode



1) ***CoSQ*** – Indicates whether CoSQ (Class of Service Queue) is enabled on the egress direction of a particular port (status mode); allows enabling or disabling CoSQ on available ports (modify mode). CoSQ is enabled by default on WAN port.
2) ***Port based priority*** – Indicates whether port based prioritization is enabled (status mode); allows enabling or disabling port based prioritization on available ports (modify mode). If enabled all packets on the egress of a port are put in a specified queue. 802.1p (PCP) and DiffServ (DSCP) values are ignored. Available values are 0…7 according to eight available priority queues from the lowest to the highest.

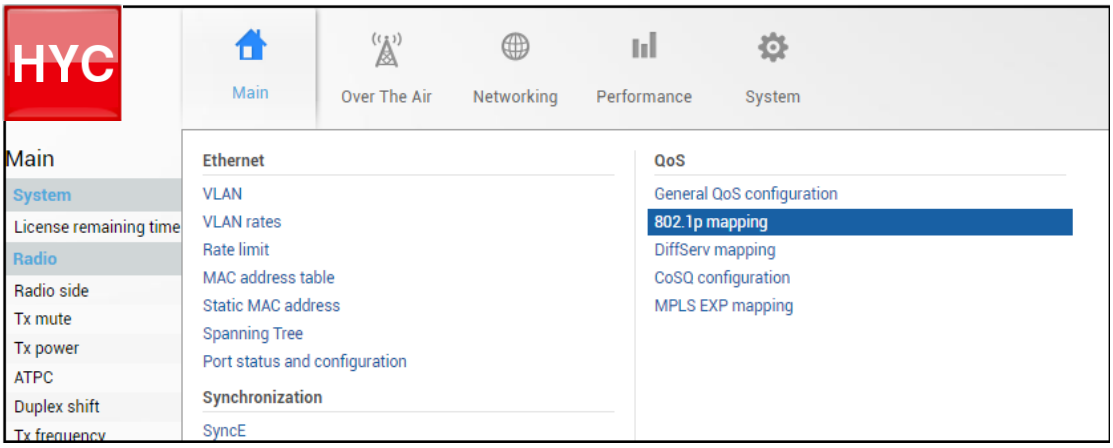
3) ***802.1p*** – Indicates whether the 802.1p mapping is enabled (status mode); allows enabling or disabling 802.1p mapping on available ports (modify mode). If enabled configured mapping (Networking→QoS→802.1p mapping) is taken into account.
4) ***DiffServ*** – Indicates whether DiffServ prioritization is enabled (status mode); allows enabling or disabling DiffServ prioritization on available ports (modify mode). If enabled DSCP value is taken into account according to configured mapping (Networking→QoS→DiffServ mapping).
5) ***Schedulers mode*** – Indicates whether frame based (SP/RR/WRR – Strict Priority/Round Robin/Weighted Round Robin) or byte based scheduling schemes (SP/DWRR – Strict Priority/Deficit Weighted Round Robin) are available (status mode); allows switching between frame based to byte based scheduling schemes (modify mode). Specific scheduling scheme can be set in Networking→QoS→CoSQ configuration. Scheduler's mode specifies how frames are handled at egress flow. DWRR compared to WRR is configured in kilobytes (KB), rather than the number of frames passed. The default setting is frame based mode.
6) By pressing *„Execute configuration"*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback on"* is selected, the configuration will be reverted in case erroneous configuration changes are applied.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

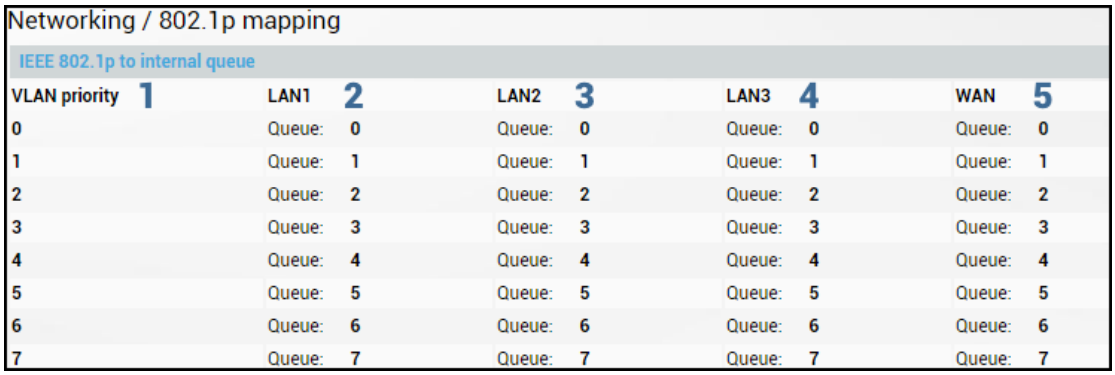
network qos set <port> **cosq state** {enable|disable}	Use to enable or disable CoSQ priority queues on a particular port.
network qos set <port> **vlan state** {enable|disable}	Use to enable or disable ingress 802.1p mapping on a particular port.
network qos set <port> **diffserv state** {enable|disable}	Use to enable or disable ingress DiffServ mapping (DSCP) on a particular port.
network qos reset config {LAN1|LAN2|LAN3|WAN|all}	Use to reset QoS configuration on a particular port or all ports simultaneously.
network qos set <port> **base state** {enable|disable}	Use to enable or disable port-based priorities.
network qos set <port> **base priority** <0…7>	Use to specify queue of port-based priority.
network qos set sched_mode {frame|byte}	Use to select scheduler's mode – frame (SP/RR/WRR) or byte (SP/DWRR).
network qos show config {LAN1|LAN2|LAN3|WAN|all}	Use to show QoS user configuration.
network qos show info {LAN1|LAN2|LAN3|WAN|all}	Use to show actual status of QoS configuration.
network qos show sched_mode	Use to show CoSQ Scheduling Mode.

Networking → QoS → 802.1p mapping

The 802.1p mapping page allows customizing mapping of IEEE 802.1p priority tags and available QoS queues.

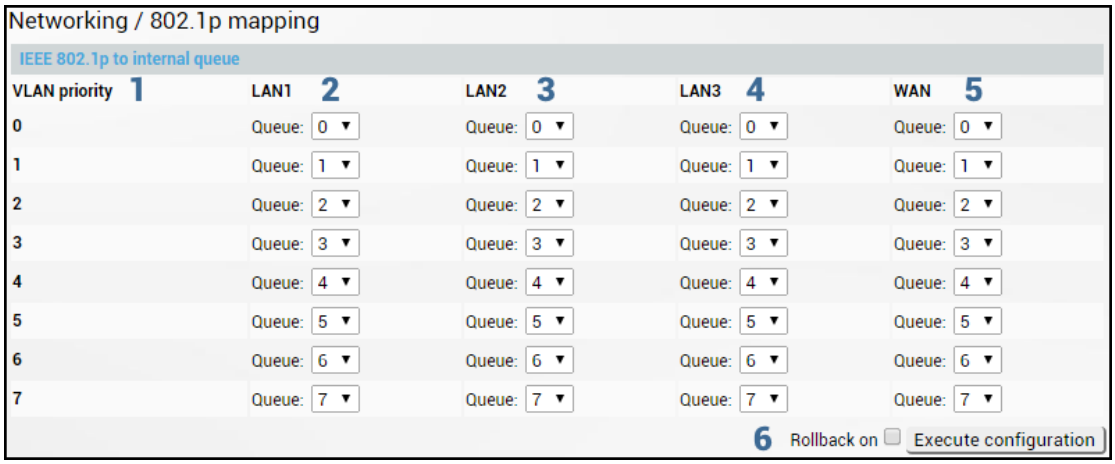


Status mode



Press MODIFY button.

Modify mode



1) ***VLAN priority*** – Indicates PCP (Priority Code Point) values 0 – 7.
2) ***LAN1*** – Indicates to which egress queue packets will, according to 802.1p priority, be put in if 802.1p QoS prioritization is enabled on LAN1 port (status mode); allows modifying default mapping of priority values and queues (modify mode).
3) ***LAN2*** – Indicates to which egress queue packets will, according to 802.1p priority, be put in if 802.1p QoS prioritization is enabled on LAN2 port (status mode); allows modifying default mapping of priority values and queues (modify mode).
4) ***LAN3*** – Indicates to which egress queue packets will, according to 802.1p priority, be put in if 802.1p QoS prioritization is enabled on LAN3 port (status mode); allows modifying default mapping of priority values and queues (modify mode).

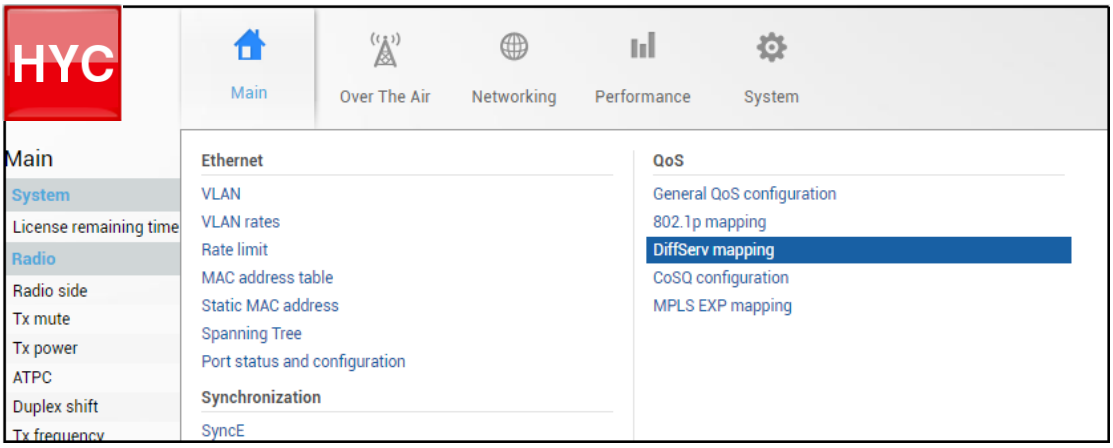
5) ***WAN*** – Indicates to which egress queue packets will, according to 802.1p priority, be put in if 802.1p QoS prioritization is enabled on WAN port (status mode); allows modifying default mapping of priority values and queues (modify mode).
6) By pressing *„Execute configuration”,* changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback on”* is selected, the configuration will be reverted in case erroneous configuration changes are applied.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

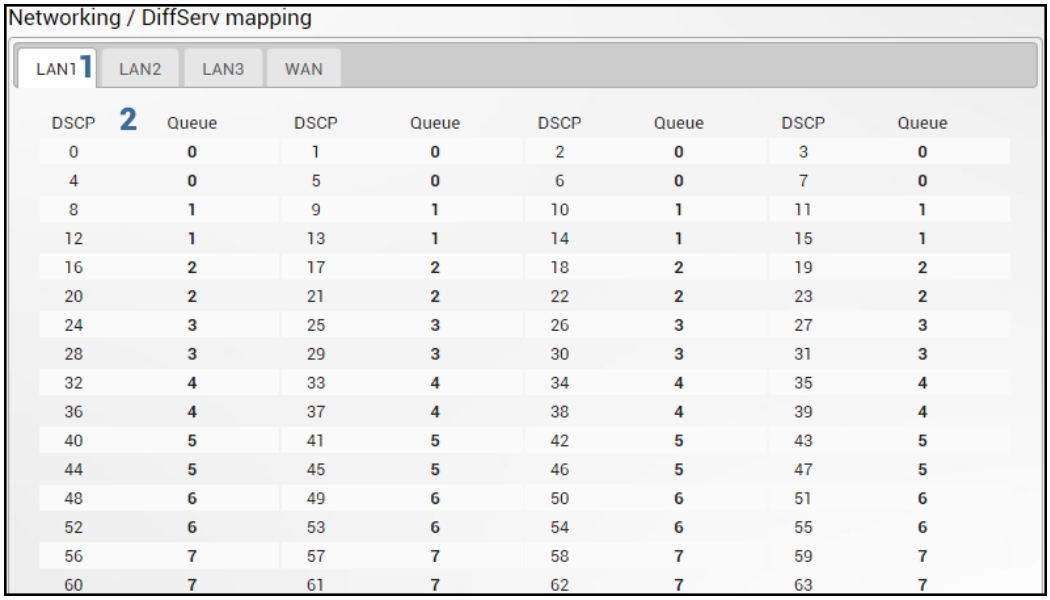
network qos set <port> **vlan priority** <0..7> **priority** <0..7>	Use to change default 802.1p priority mapping.

Networking → QoS → DiffServ mapping

The DiffServ mapping page allows customizing mapping of DSCP priority tags and available QoS queues.

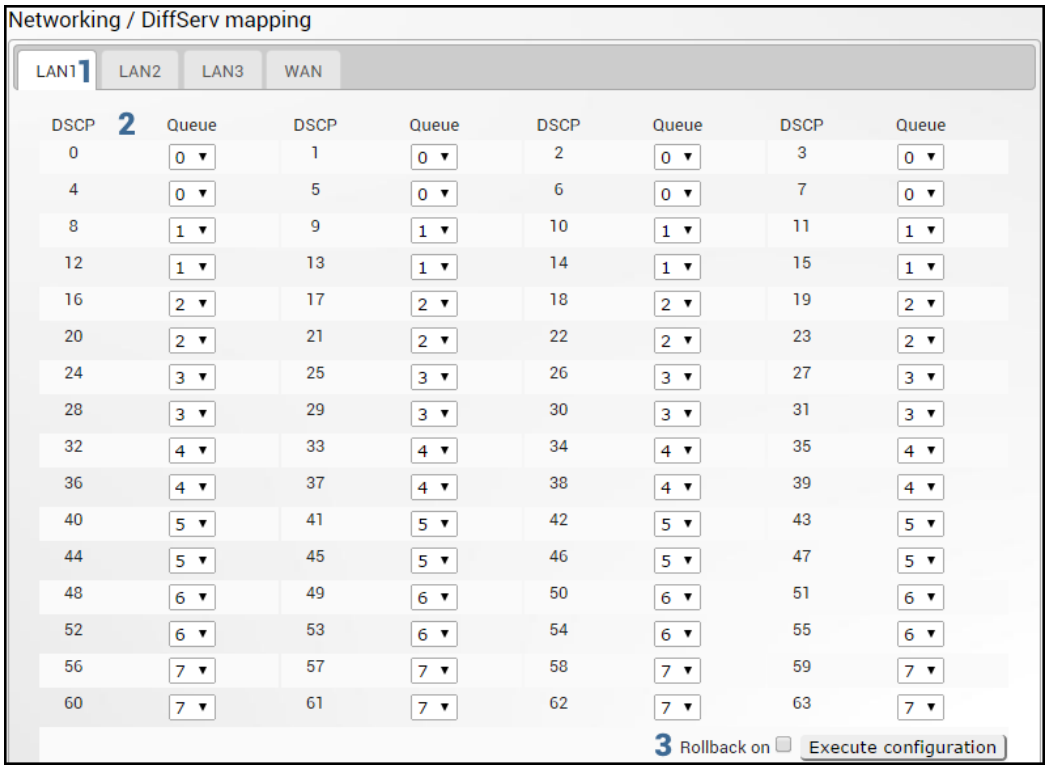


Status mode



Press MODIFY button.

Modify mode



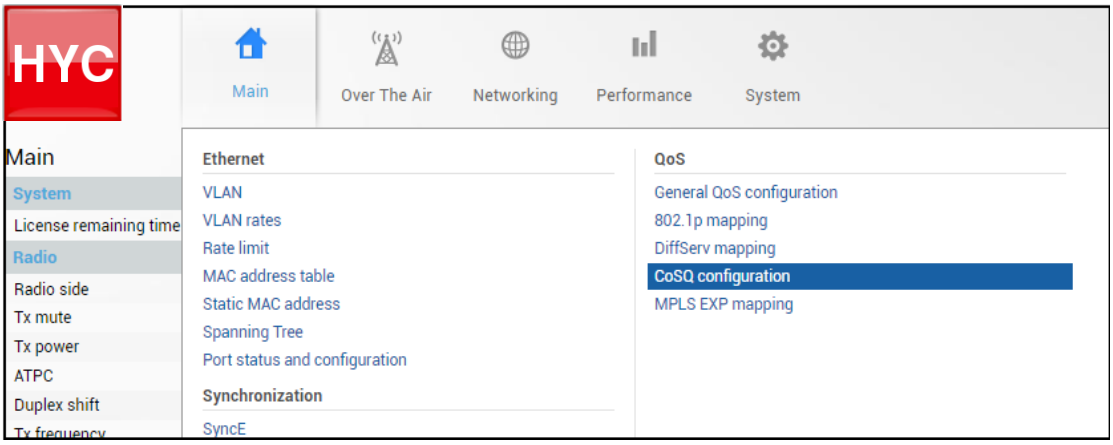
1) ***LAN1/LAN2/LAN3/WAN*** – Tabs allow selecting a particular port.
2) The table shows the mapping between DSCP values and CoS queues (status mode); allows modifying default mapping of DSCP priority values and queues (modify mode).
3) By pressing *„Execute configuration”*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback on”* is selected, the configuration will be reverted in case erroneous configuration changes are applied.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

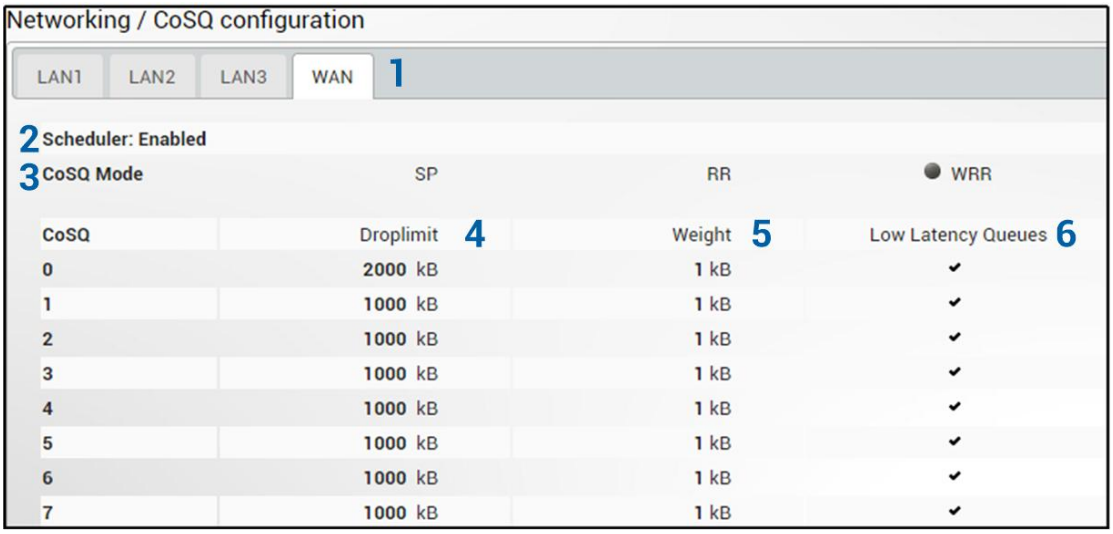
network qos set <port> **diffserv dscp** <0..63> **priority** <0..7>	Use to change default DiffServ priority (DSCP) mapping.

Networking → QoS → CoSQ configuration

The CoSQ configuration page allows modifying droplimit (buffer) size, queue weights or sizes (depending on queueing) and queueing scheduler. On WAN port it is possible to enable packet fragmentation and interleaving (by disabling low latency queues).

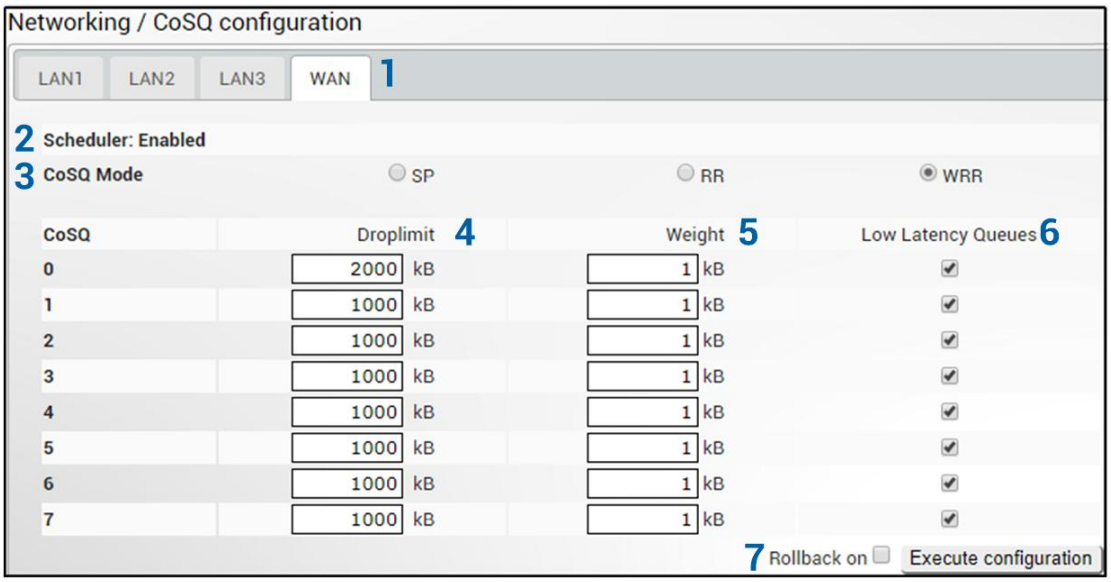


Status mode



Press MODIFY button.

Modify mode



1) ***LAN1/LAN2/LAN3/WAN*** – Tabs allow selecting a particular port.
2) ***Scheduler*** – Indicates whether CoSQ scheduler is enabled on the particular port. Corresponds to the "CoSQ" setting in the Networking→QoS→General QoS configuration page.

3) ***CoSQ Mode*** – Indicates which CoSQ scheduler mode is set on a particular port (status mode); allows setting Strict Priority (SP); Round Robin (RR) or Weighted Round Robin (WRR) if "Frame Based (SP/RR/WRR)" schedulers mode is set or Strict Priority (SP) or Deficit Weighted Round Robin (DWRR) if "Byte Based (SP/DWRR)" is set in Networking→QoS→General QoS configuration (modify mode).

   SP – scheduler drains all packets queued in the highest priority queue before continuing to service lower priority queues. Such approach can be used for latency sensitive traffic.

   RR – scheduler drains all queues consecutively with the same ratio (1:1:1:1:1:1:1:1). Such approach allows utilizing droplimit buffers of all available queues.

   WRR – scheduler drains all queues consecutively according to the specified ratio (queue weights) specified in a number of packets. Default ratio is equal for all queues (1:1:1:1:1:1:1:1). Such approach allows minimizing stacking delay for high priority traffic and at the same time retaining traffic flow at lower priority queues.

   DWRR – scheduler drains all queues consecutively according to specified ratio (queue weights) specified in kilobytes (KB). Compared to WRR excess bandwidth used in the current pass is remembered and subtracted from the allocated weight in the next pass and as a result statistically over time bandwidth used by each queue will be closer to the configured value. Default ratio is equal for all queues (1:1:1:1:1:1:1:1).

4) ***Droplimit*** – Indicates droplimit buffer size assigned for each queue (status mode); allows modifying droplimit buffer size for each queue (modify mode). By default, a 2000KB droplimit buffer size is assigned for queue #0 (lowest priority) and 1000KB for all other queues. Maximum size 4000KB.

Increasing buffer size increases data transmission latency.

5) ***Weight*** – Indicates weights in packets or kilobytes configured for WRR or DWRR respectively (status mode); allows configuring weights in packets or kilobytes for WRR or DWRR respectively (modify mode). The default weight is set to "1" for each queue. Value range is 1..255.

6) ***Low latency queues*** – Indicates whether modem low latency queue is enabled for the priority queues (status mode); allows disabling low latency queues, thus enabling packet fragmentation and interleaving (Please refer to the Chapter Fragmentation and interleaving for further details.) (modify mode).

Low latency queues are available on WAN port only.

7) By pressing *„Execute configuration"*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback on"* is selected, the configuration will be reverted in case erroneous configuration changes are applied.

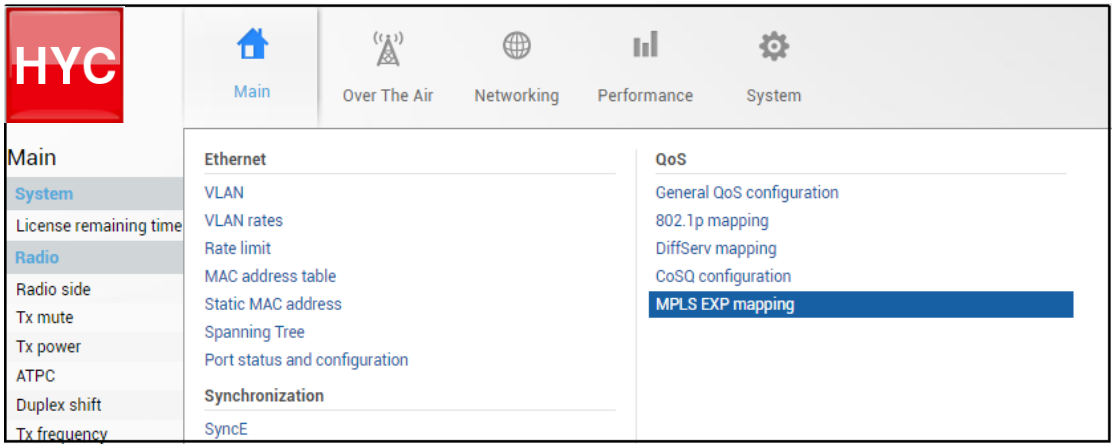
CLI commands (Chapter 4: COMMAND LINE INTERFACE)

network qos set <port> **cosq scheduler mode** {sp|{{rr|wrr}|dwrr}}	Use to set CoSQ scheduler mode on a particular port.
network qos set <port> **cosq scheduler weight** <1..255> **queue** <0..7>	Use to assign a weight for a particular queue #. CoSQ scheduler should be enabled for that particular port and CoSQ scheduler mode should be set to WRR or DWRR.
network qos set <port> **cosq droplimit** <0..4000KB>	Use to set droplimit buffer size for a particular port.
network qos set WAN cosq lowlatency {enable|disable}	Use to enable or disable low latency queue, thus disabling or enabling packet fragmentation. This functionality is available for

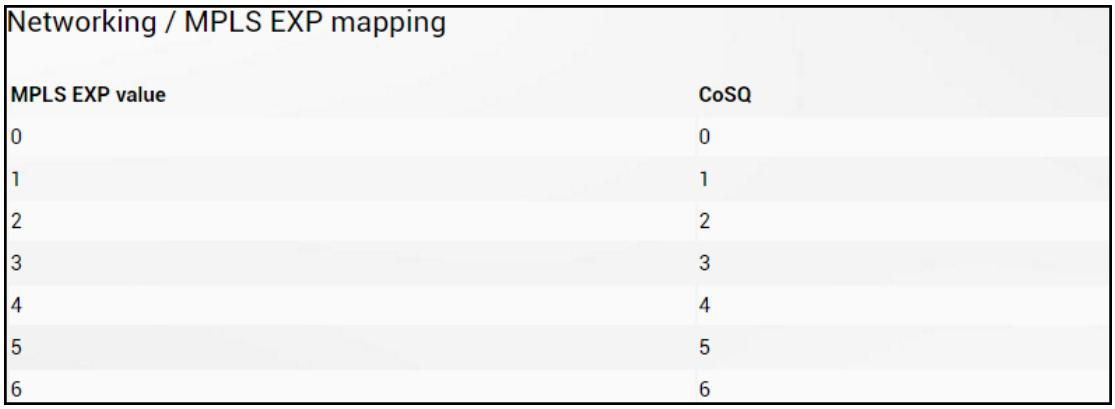
queue <0..7>	WAN port only and by default low latency queues are enabled and therefore packet fragmentation is disabled.
network qos show info {LAN1|LAN2|LAN3|WAN|all}	Use to show actual status of QoS configuration.

Networking → QoS → MPLS EXP mapping

The MPLS EXP mapping page allows customizing mapping of MPLS EXP priority bits and available QoS queues.

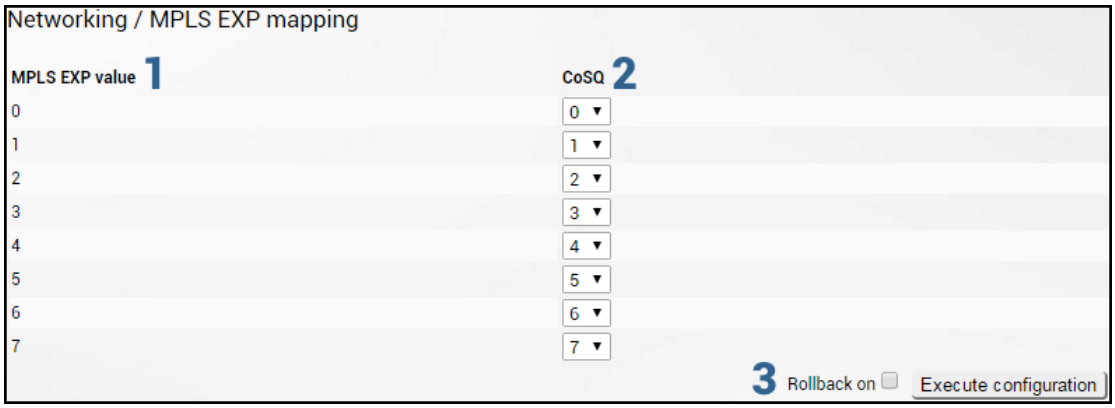


Status mode



Press MODIFY button.

Modify mode



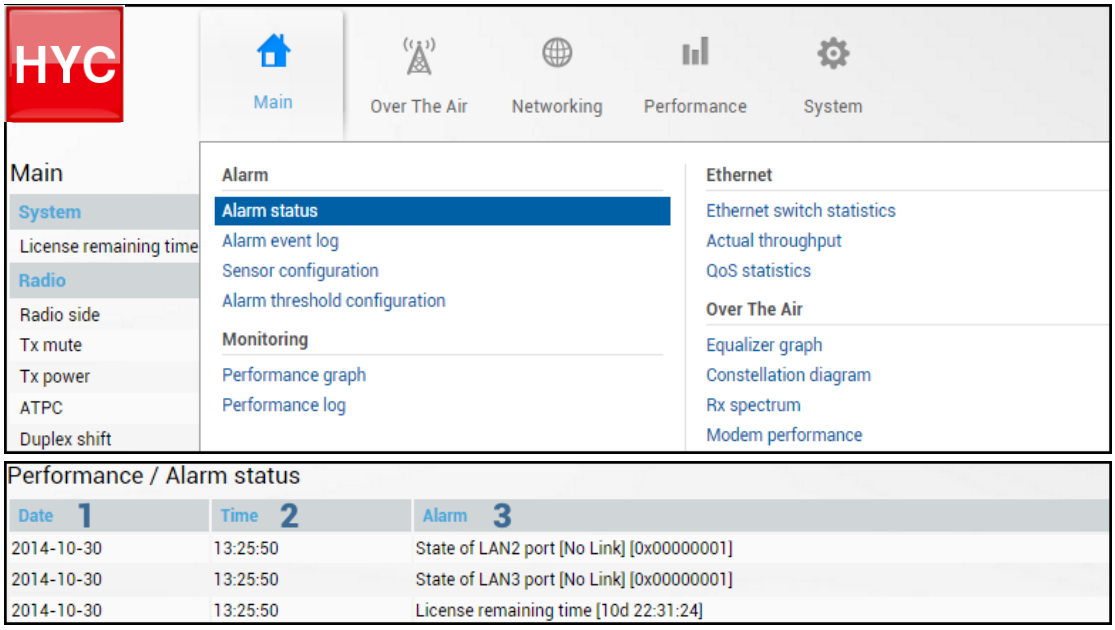
1) ***MPLS EXP value*** – Indicates MPLS EXP values 0 – 7;

2) ***CoSQ*** – Indicates to which egress queue will packets with according MPLS EXP value be put (status mode); allows modifying default mapping of MPLS EXP values and queues (modify mode).
3) By pressing *„Execute configuration”*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. If *„Rollback on”* is selected, the configuration will be reverted in case erroneous configuration changes are applied.

Performance

Performance → Alarm → Alarm status

Alarm status page summarizes current alarms by showing the date and time the alarm occurred and its name.



1) ***Date*** – shows the date when the alarm was initiated;
2) ***Time*** – shows time when the alarm was initiated;
3) ***Alarm*** – shows the name of the alarm.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

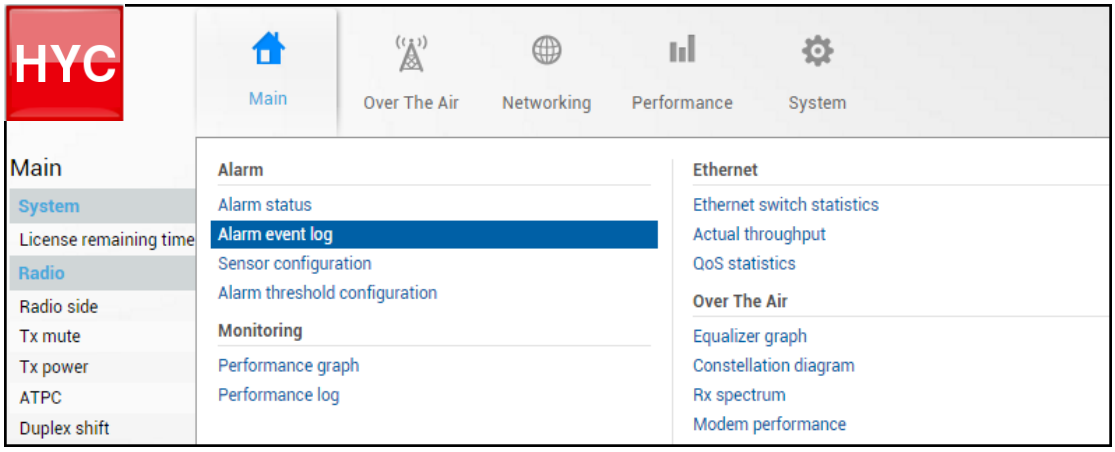
log sensor setlist	Use to show alarm status.

Performance → Alarm → Alarm log

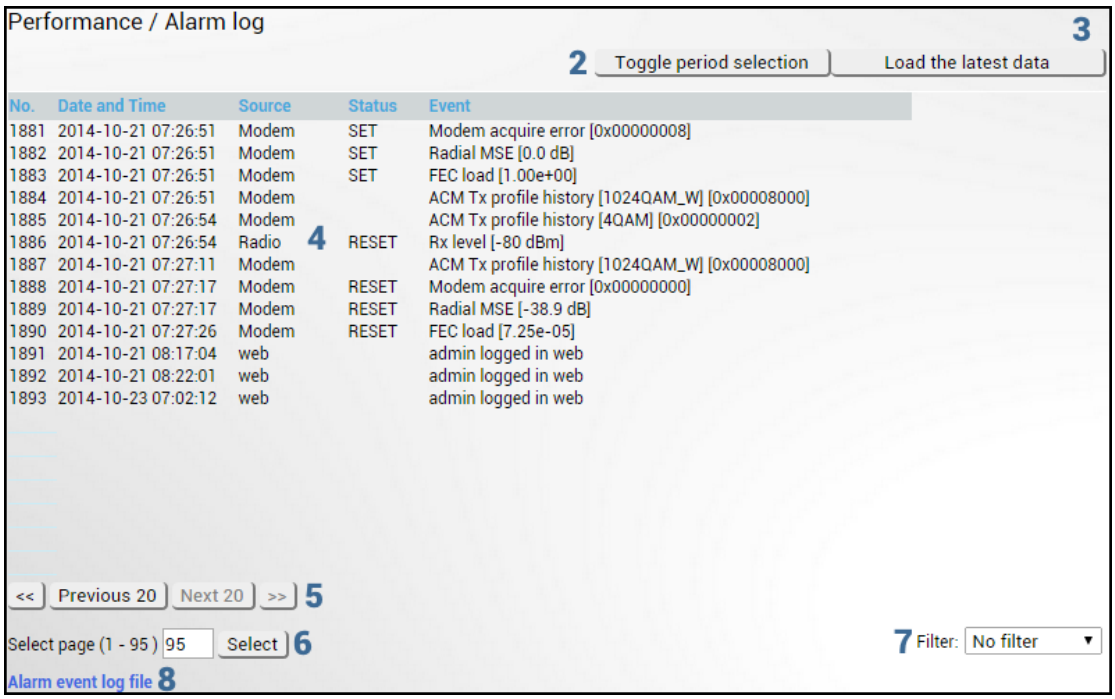
Alarm log shows 20 alarm entries per page and about 5000 alarm entries in total. Full alarm log can be downloaded by pressing on "Alarm event log file". The last page of log entries is shown by default.

Alarm entries are mostly distributed in two groups – *"Set"'* when alarm appears and *"Reset"* when alarm disappears.

You also have fast access to alarm filtering, where it is possible to choose which alarm groups you are willing to filter out of all log entries.

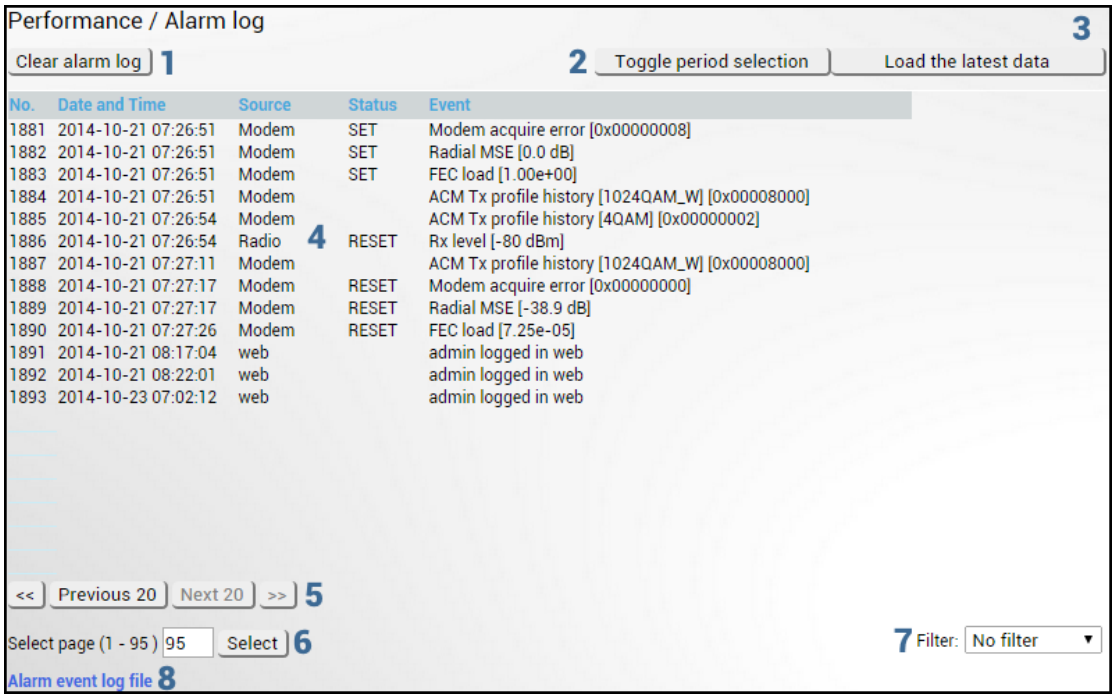


Status mode

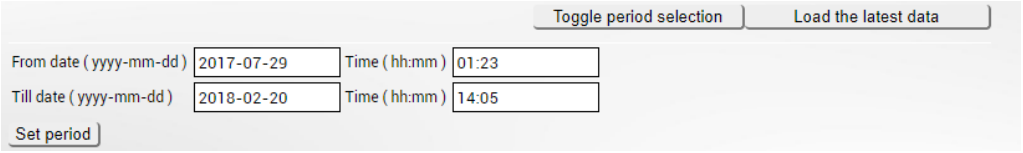


Press MODIFY button.

Modify mode



1) ***Clear alarm log*** – deletes all alarm log entries;
2) ***Toggle period selection*** – opens/closes period selection controls;



3) ***Load the latest data*** – refreshes alarm log and shows last 20 log entries;
4) List of alarm log entries – entry number, date and time, source node, status and event name;
5) Navigation controls. "<<" navigates to start of alarm log, while ">>" – to the end; "Previous 20" navigates to previous alarm log page showing 20 previous alarm log entries (if available), while "Next 20" – to next alarm log page showing 20 next alarm log entries (if available).
6) Shows the number of the currently viewed alarm log page. You can enter the specific page number to navigate to the required page;
7) ***Filter*** – press to filter alarms from a certain source node (e.g. Radio);
8) ***Alarm event log file*** – press the link to download full alarm log text file.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

log event show last <#_of_entries>	Use to show a certain number of last alarm log entries.
log event show time <starttime> [<endtime>]	Use to show entries from a certain time point. Following formats are supported: YYYY-MM-DD/hh:mm:ss; MM-DD/hh:mm:ss; MM-DD/hh:mm; hh:mm:ss; hh:mm
log event show sensor <sensor> [last <#_of_entries>] [time <starttime> [<endtime>]]	Use to show entries for a specific sensor. Regarding subcommands "last" and "time" refer to commands above.
log event show module {modem| psu | radio | system | alarm_only | iman} [last <#_of_entries>] [time <starttime>	Use to show entries for a specific module. Regarding subcommands "last" and "time" refer to commands above.

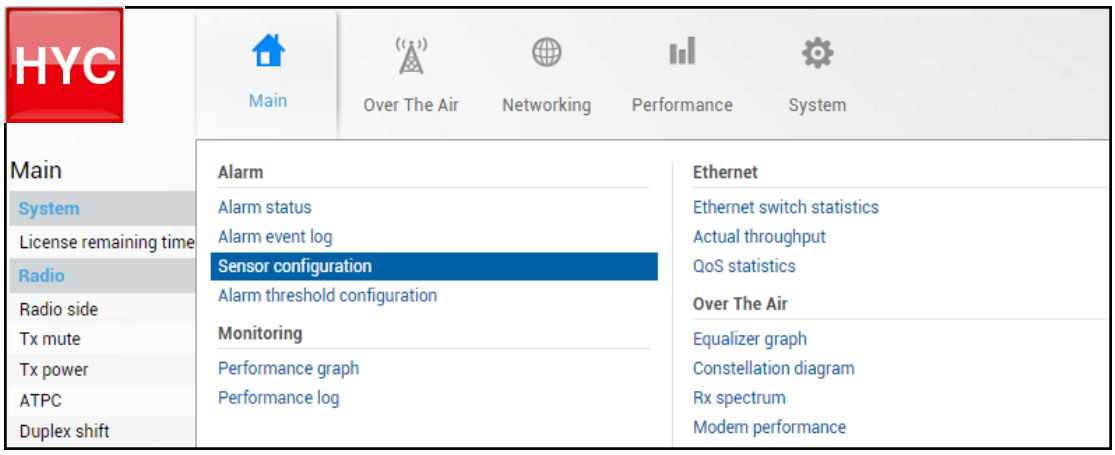
[<endtime]]	
log event clear	Use to clear alarm log
log event configure {enable|disable}	Use to enable or disable event log filter.
log event configure dump <1…60>	Use to configure duration in minutes during which filter is monitoring repetitions.
log event configure pattern <1…10>	Use to configure a number of log entry repetitions to be monitored.
log event configure status	Use to display the current configuration of grouped repetitive alarm-event log entries (filter).

Performance → Alarm → Sensor configuration

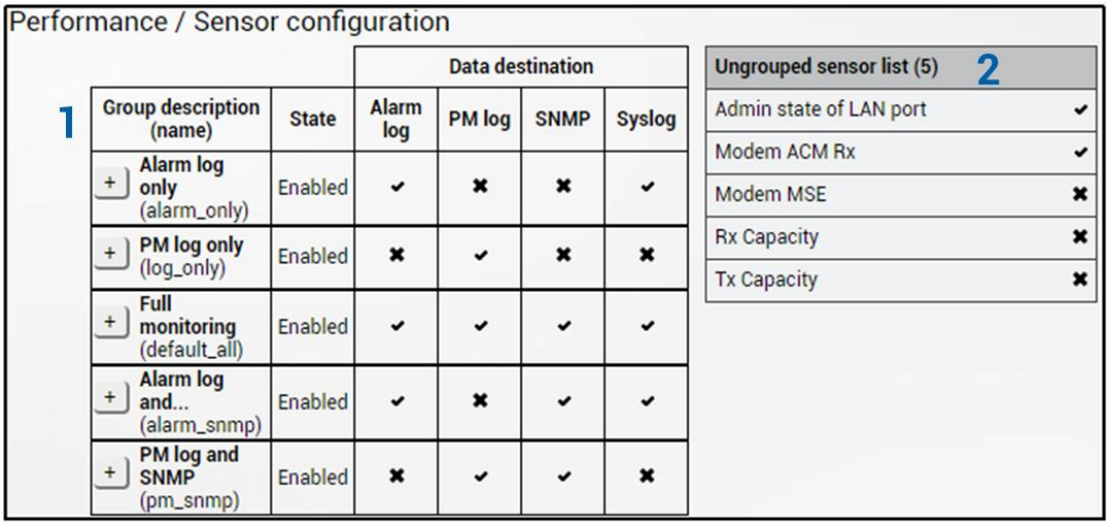
The following section allows the specifying behavior of available sensor parameters.

After the firmware upgrade, it is required to reset sensor configuration to default using "Set all to default" button and reconfigure sensors as required.

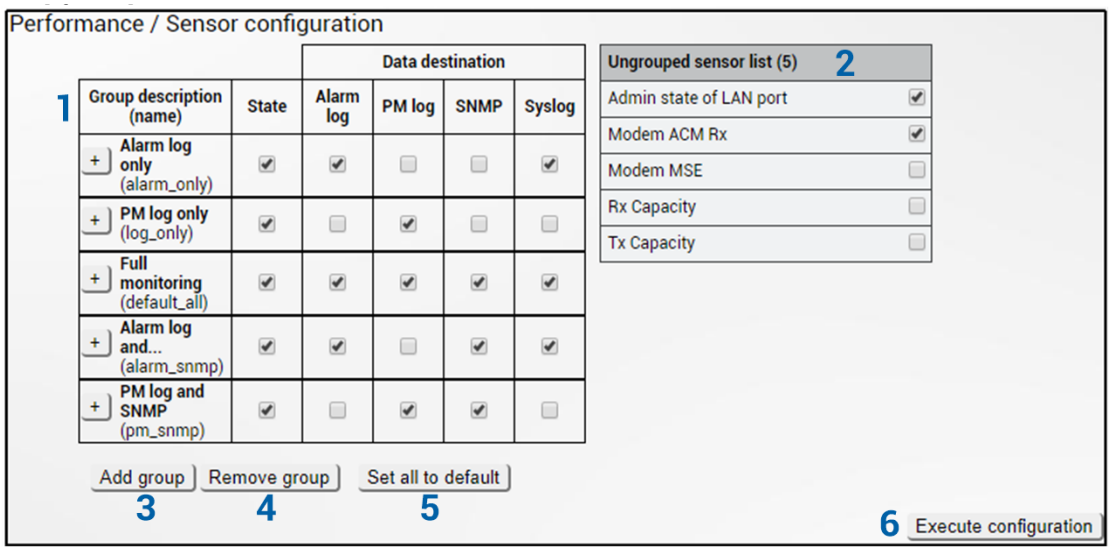
It is not recommended to add "License remaining time" sensor parameter to performance ("perfd") type parameters.



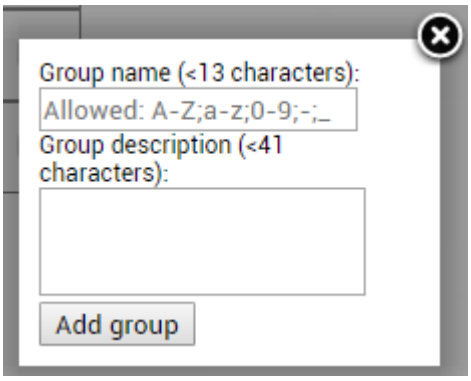
Status mode



Press MODIFY button.

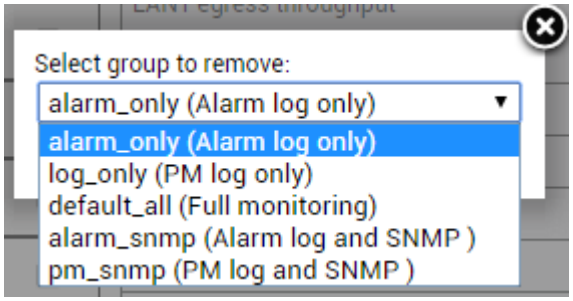


1) ***Group description (name)*** – Shows 5 groups of sensors divided by different group data destinations (event; perf; snmp), as well as indicates whether the group is enabled (State);
2) ***Ungrouped sensor list*** – Shows list of sensors not added to any of the existing groups (status mode); allows dragging to any of the existing groups, thus specifying how the sensor will be treated. Unchecking the checkbox next to the sensor disables the sensor (modify mode).
3) ***Add group*** – Allows creating a new group with a custom name and description.



Afterwards, sensors from the ungrouped sensor list or other groups can be added to the group by dragging them in.

4) ***Remove group*** – Allows deleting existing groups via a dialog window.



5) ***Set all to default*** – Restores default settings for all groups and sensors.
6) By pressing *„Execute configuration”*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

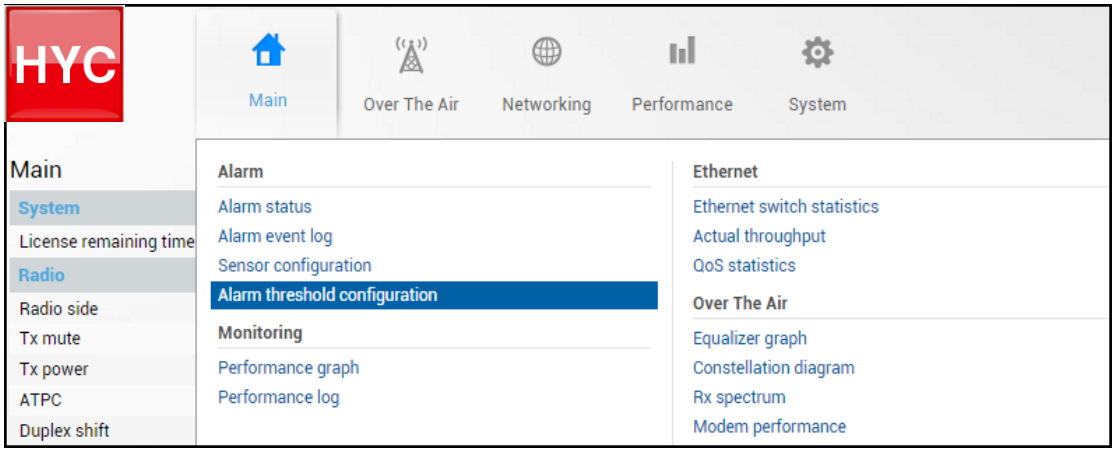
log group info	Use to show sensor group configuration.

log group create <name> <description>	Use to create a new group.
log group mgmt <name> **add destination** {event|perf|snmp|syslog}	Use to add a destination for a group.
log group mgmt <name> **add sensor** <sensor>	Use to add a sensor to a group.
log group mgmt <name> **config** {enable|disable}	Use to enable or disable a group.
log group mgmt <name> **delete**	Use to delete a group.
log group mgmt <name> **remove destination {**event|perf|snmp|syslog}	Use to remove a destination from a group.
log group mgmt <name> **remove sensor** <sensor>	Use to remove a sensor from a group.
log sensor info	Use to show current sensor status.
log sensor list	Use to list all available sensors.
log default {all|group|sensors [<sensor>]}	Use to set group, individual sensor or all sensor configuration to default.

Performance → Alarm → Alarm threshold configuration

The page provides a summary of parameters' alarm thresholds. All thresholds are predefined and some change dynamically according to the system configuration. Thresholds can be modified if required.

Alarm activates when current value exceeds (low-delta) or (high+delta) values. Alarm deactivates when current value exceeds (low+delta) or (high-delta) values.



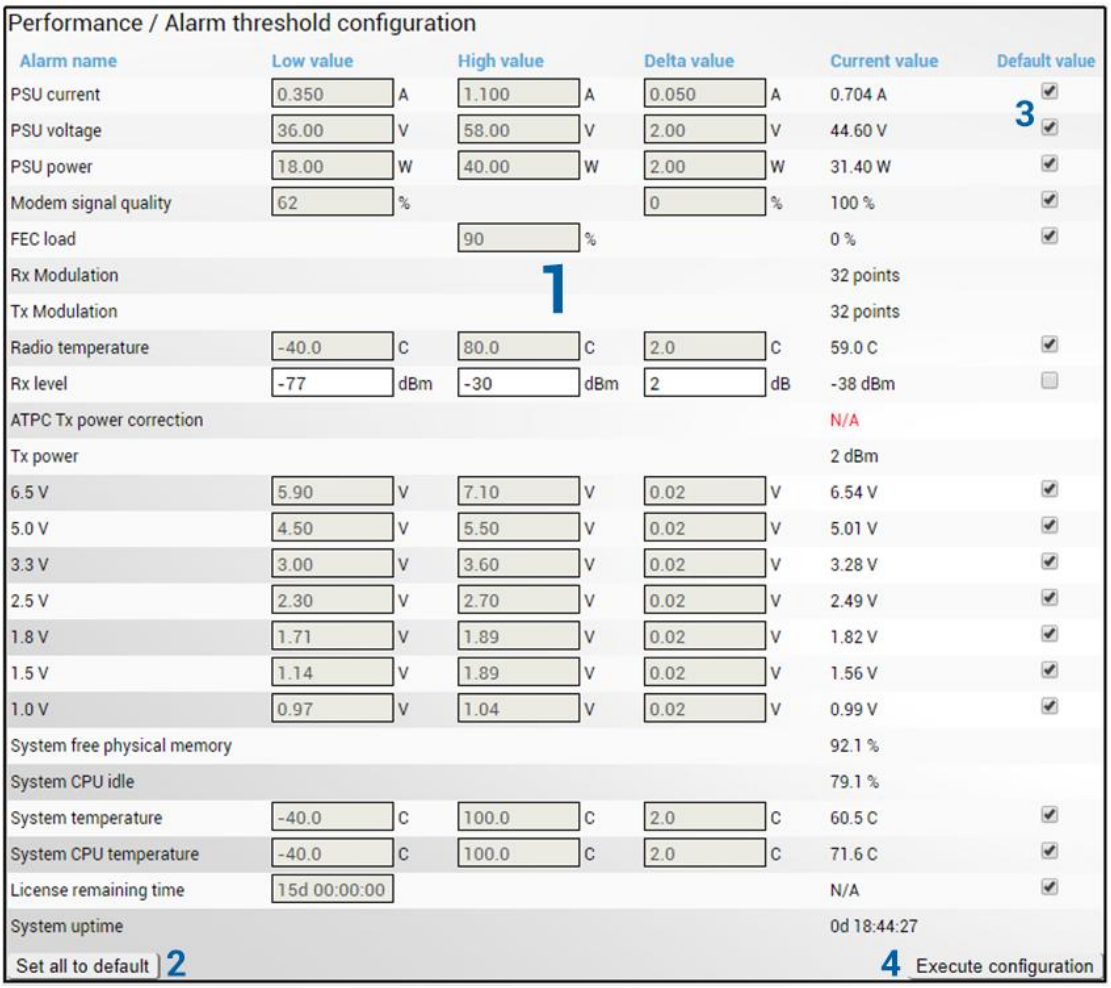
Status mode

Performance / Alarm threshold configuration

Alarm name	Low value	High value	Delta value	Current value
PSU current	0.350 A	1.100 A	0.050 A	0.704 A
PSU voltage	36.00 V	58.00 V	2.00 V	44.60 V
PSU power	18.00 W	40.00 W	2.00 W	31.40 W
Modem signal quality	62 %		0 %	100 %
FEC load		90 %		0 %
Rx Modulation				32 points
Tx Modulation				32 points
Radio temperature	-40.0 C	80.0 C	2.0 C	59.0 C
Rx level	-77 dBm	-30 dBm	2 dB	-38 dBm
ATPC Tx power correction				N/A
Tx power				2 dBm
6.5 V	5.90 V	7.10 V	0.02 V	6.54 V
5.0 V	4.50 V	5.50 V	0.02 V	5.01 V
3.3 V	3.00 V	3.60 V	0.02 V	3.28 V
2.5 V	2.30 V	2.70 V	0.02 V	2.49 V
1.8 V	1.71 V	1.89 V	0.02 V	1.82 V
1.5 V	1.14 V	1.89 V	0.02 V	1.55 V
1.0 V	0.97 V	1.04 V	0.02 V	0.99 V
System free physical memory				92.1 %
System CPU idle				91.3 %
System temperature	-40.0 C	100.0 C	2.0 C	61.0 C
System CPU temperature	-40.0 C	100.0 C	2.0 C	71.4 C
License remaining time	15d 00:00:00			N/A
System uptime				0d 18:40:26

Press MODIFY button.

Modify mode



1) Indicates low, high and delta values of the parameters (status mode); "Low value", "High value" and "Delta value" fields for all parameters become editable when "Default value" is deselected (modify mode);
2) ***Set all to default*** – resets "Low value", "High value" and "Delta value" for all parameters to factory defaults;
3) ***Default value*** – deselect to activate manual threshold modification;
4) By pressing *„Execute configuration"*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS.

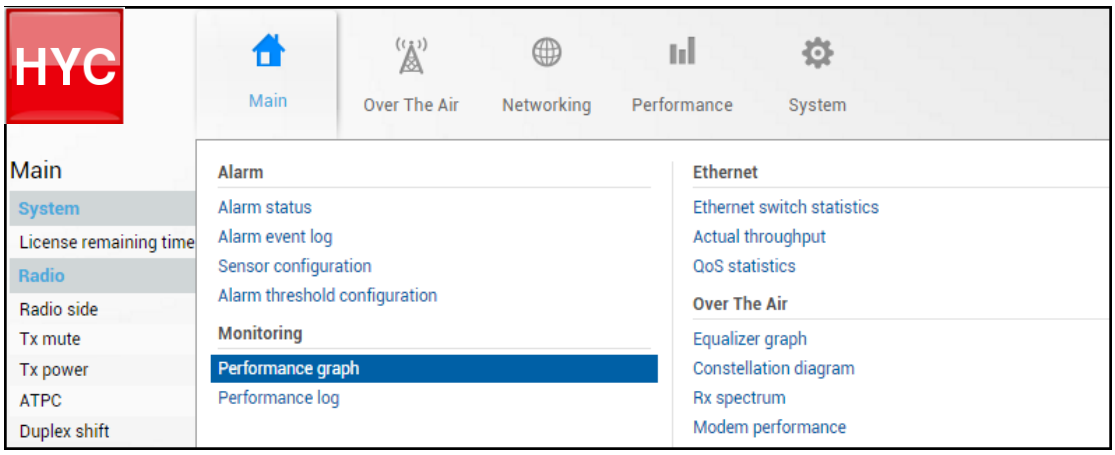
CLI commands (Chapter 4: COMMAND LINE INTERFACE)

log sensor info	Use to show the configuration of sensor thresholds.
log sensor mgmt <sensor> **control {enable|disable}**	Use to enable or disable a sensor.
log sensor mgmt <sensor> **thold** <min> <max> <delta>	Use to set sensor's min, max thresholds and delta value manually.
log sensor mgmt <sensor> **time** <0…30>	Use to set sensor hysteresis time in seconds. Will be used to show value in orange color indicating that sensor value recently exceeded its thresholds.
log default {all| group| sensors [sensor]}	Use to set group, individual sensor or all sensor configuration to default.
log sensor list	Use to list all available sensors.

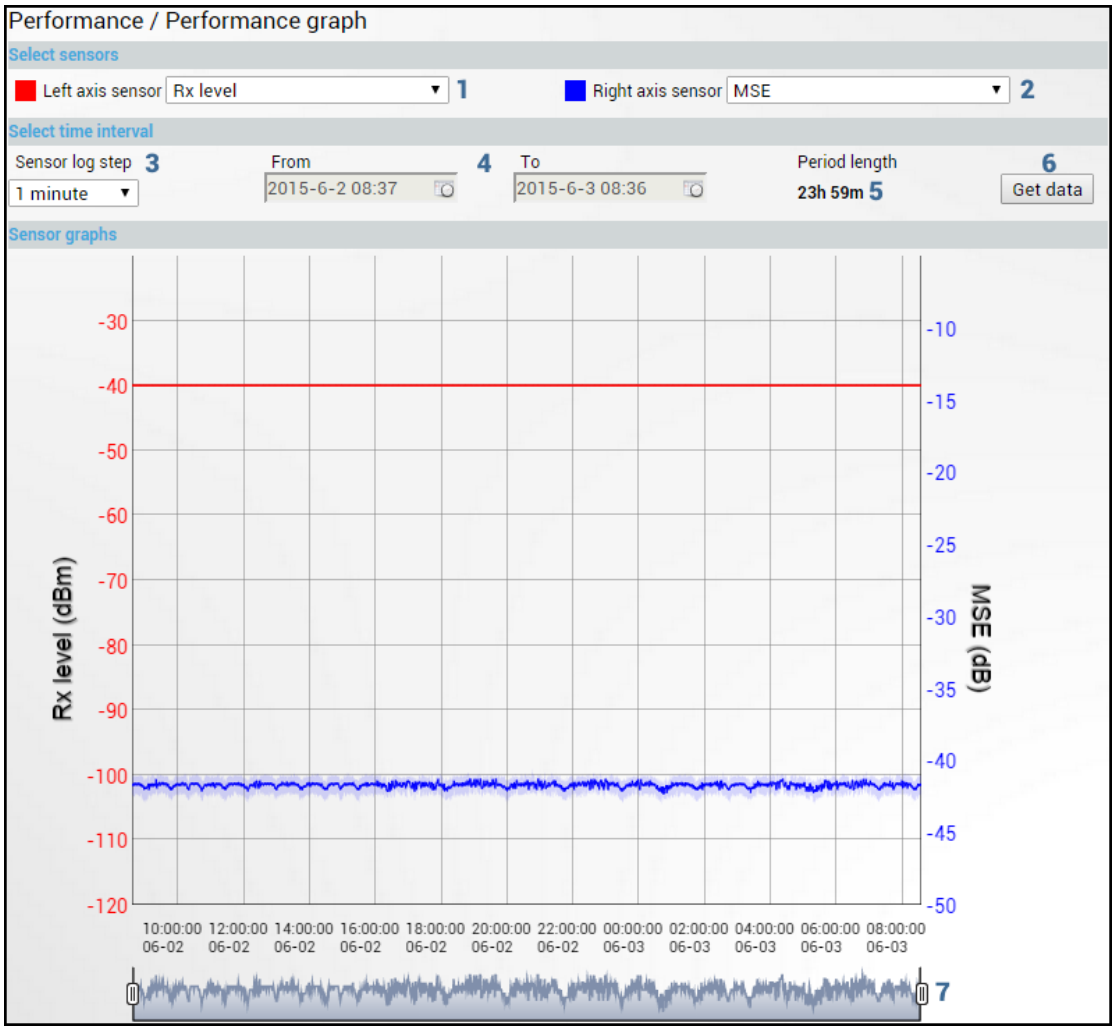
Performance → Monitoring → Performance graph

The Performance graph allows visualizing various parameters over a chosen time period as curves. Available parameters will depend on the Sensor Configuration. Any two parameters can be shown at a time. By default Rx level (dBm) and MSE (dB) are selected.

Not all sensors available in Sensor Configuration can be displayed in the Performance graph.



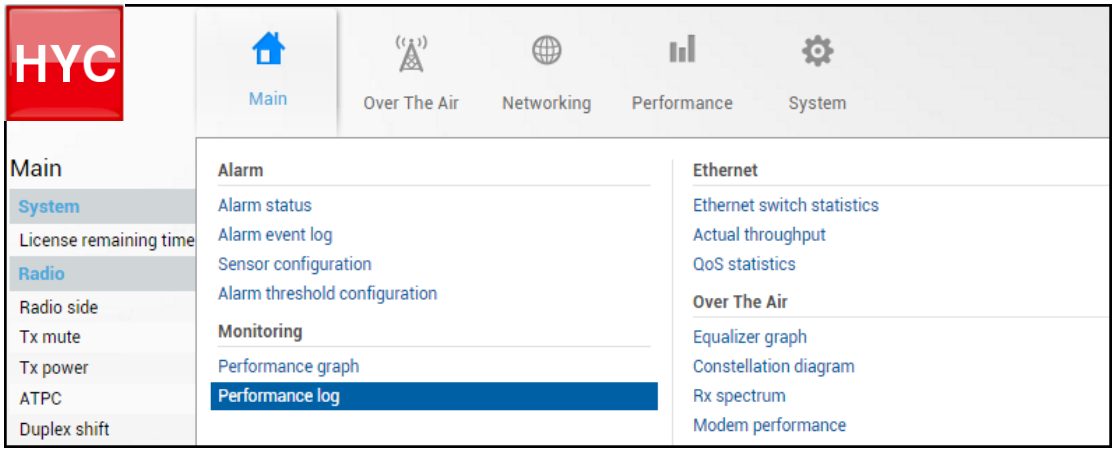
MODIFY button is deactivated in the Performance graph page.



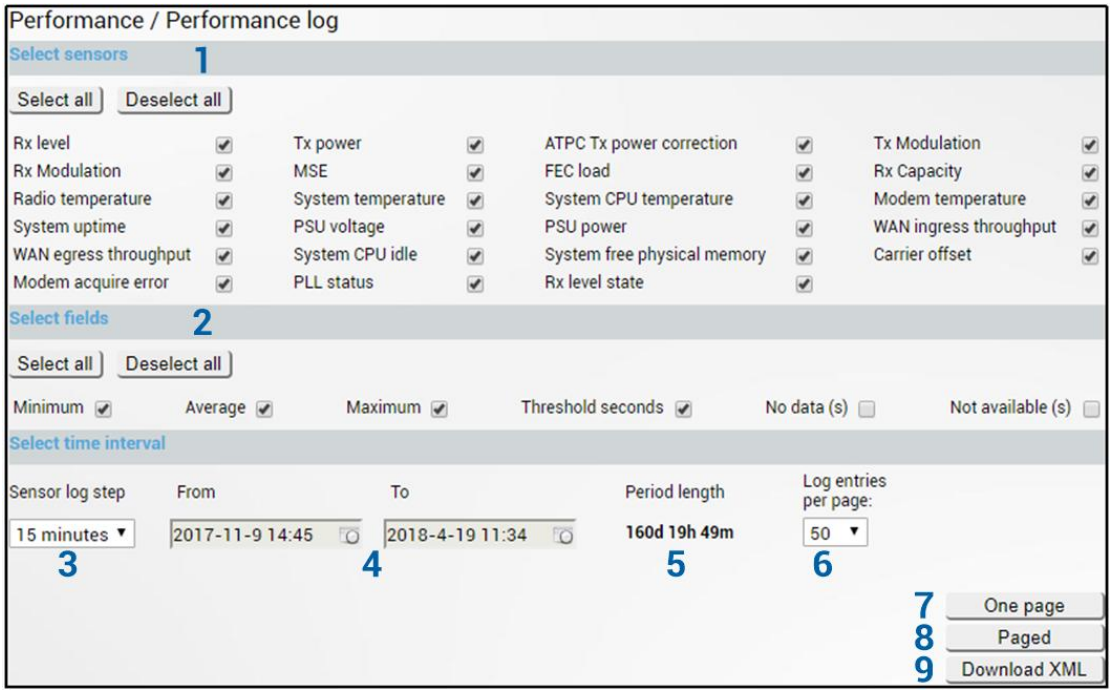
1) ***Left axis sensor*** – Allows choosing sensor parameter colored in red and displayed on the left axis.
2) ***Right axis sensor*** – Allows choosing sensor parameter colored in blue and displayed on the right axis.
3) ***Sensor log step*** – Allows choosing graph granularity – 1, 15 or 60 minutes.
4) Indicates start and end date/time of period displayed and allows selecting specific period to show.
5) ***Period length*** – Indicates length of the currently displayed period.
6) ***Get data*** – Press to apply selected time interval changes.
7) Left and right sliders allow to “zoom” currently selected time period.

Performance → Monitoring → Performance log

Allows viewing and downloading performance log.



MODIFY button is deactivated in the Performance log page.



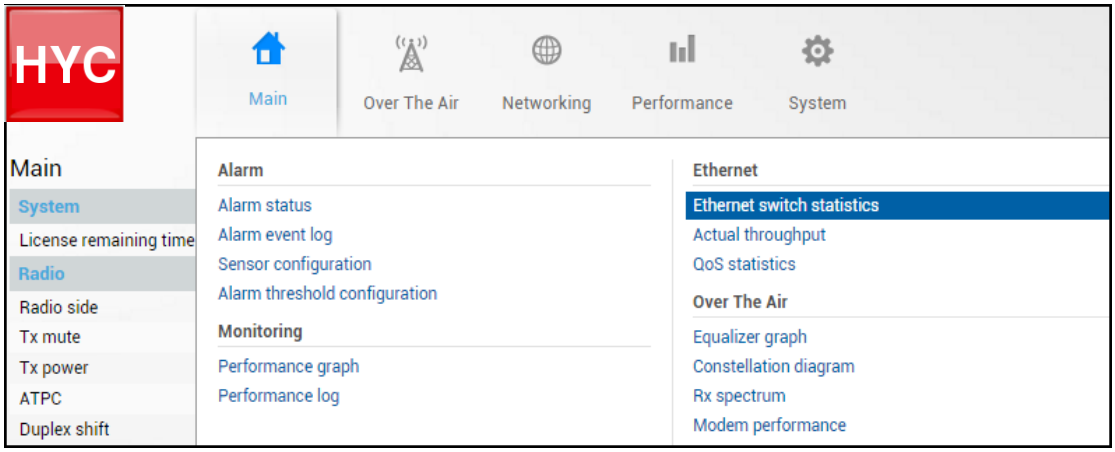
1) ***Select sensors*** – Allows choosing the sensor parameters to be displayed in performance log.
2) ***Select fields*** – Allows choosing the parameter fields to be displayed in the performance log. "Minimum" and "Maximum" represent minimum and maximum values in specified sensor log step, while "Average" displays average value; "Threshold seconds" will show the number amount of seconds in a chosen time interval when parameter exceeded minimum or maximum alarm thresholds; "No data (s)" and "Not available (s)" show respectively the time when there was no data of according parameter and it was not available.
3) ***Sensor log step*** – Allows choosing log step – 1, 15 or 60 minutes.
4) Indicates start and end date/time of period displayed and allows selecting specific period to show.
5) ***Period length*** – Indicates length of the currently displayed period.
6) ***Log entries per page*** – Allows choosing 20, 50 or 100 entries per page for Paged representation.
7) ***One page*** – Will display performance log on a single page in a separate tab.
8) ***Paged*** – Will display performance log divided into pages in a separate tab.

9) ***Download XML*** – Press to download performance log in an extensible markup language (.xml) file.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

log perf show {1M|15M|60M} **last** <1…1440> <sensor>	Use to show a specified number of last performance log entries with specified sensor log step.
log perf show {1M|15M|60M} **time** <start_time> <end_time> <sensor>	Use to show entries for a certain time frame. Following formats are supported: YYYY-MM-DD/hh:mm:ss; MM-DD/hh:mm:ss; MM-DD/hh:mm; hh:mm:ss; hh:mm
log perf clear	Use to clear performance log.

Performance → Ethernet → Ethernet switch statistics



Status mode

Performance / Ethernet switch statistics

		LAN1	LAN2	LAN3	WAN	MNG
Statistics for	1	0d 01:25:09	0d 01:25:09	0d 01:25:10	0d 01:25:10	0d 01:25:10
Ingress Pkts.	2	1219	0	0	30656	42283
Ingress Bytes	3	278098	0	0	41682836	44127807
Egress Pkts.	4	1517	0	0	31201	42009
Egress Bytes	5	1562130	0	0	41861499	42866069
Total Multicast Pkts.	6	345	0	0	N/A	32776
Total Broadcast Pkts.	7	231	0	0	N/A	0
Total Pkts. 64 Octets	8	833	0	0	N/A	20861
Total Pkts. 65 to127 Octets	9	256	0	0	N/A	1087
Total Pkts. 128 to 255 Octets	10	291	0	0	N/A	283
Total Pkts. 256 to 511 Octets	11	190	0	0	N/A	199
Total Pkts. 512 to 1023 Octets	12	214	0	0	N/A	10331
Total Pkts. 1024 to 1518 Octets	13	952	0	0	N/A	15
Total Oversize Pkts.	14	0	0	0	N/A	51514
Rx Oversize Pkts.	15	0	0	0	0	26219
Tx Oversize Pkts.	16	0	0	0	25270	25295
Total Octets	17	1840228	0	0	N/A	86993812
Total Pkts.	18	2736	0	0	N/A	84292
Tx No Errors	19	1517	0	0	N/A	42009
Rx No Errors	20	1219	0	0	N/A	42283
Total Pkts. 1519 to 1522 Octets	21	0	0	0	N/A	0
In. Octets	22	278098	0	0	N/A	44127807
Out. Octets	23	1562130	0	0	N/A	42866069
Dot1 Port In Frames	24	1219	0	0	N/A	42283
Dot1 Port Out Frames	25	1517	0	0	N/A	42009
Received Pkts. 64 Octets	26	493	0	0	0	10435
Transmitted Pkts. 64 Octets	27	340	0	0	302	10428
Received Pkts. 65 to 127 Octets	28	236	0	0	0	352
Transmitted Pkts. 65 to 127 Octets	29	20	0	0	267	735
Received Pkts. 128 to 255 Octets	30	284	0	0	0	7
Transmitted Pkts. 128 to 255 Octets	31	7	0	0	276	276
Received Pkts. 256 to 511 Octets	32	18	0	0	0	173
Transmitted Pkts. 256 to 511 Octets	33	172	0	0	26	26
Received Pkts. 512 to 1023 Octets	34	185	0	0	5059	5085
Transmitted Pkts. 512 to 1023 Octets	35	45	0	0	5087	5303
Received Pkts. 1024 to 1518 Octets	36	3	0	0	25455	12
Transmitted Pkts. 1024 to 1518 Octets	37	1046	0	0	0	3
In. Broadcast Pkts.	38	226	0	0	1	0
Out. Broadcast Pkts.	39	6	0	0	230	0
In. Multicast Pkts.	40	345	0	0	0	16232
Out. Multicast Pkts.	41	0	0	0	340	16889
Dot3 In. Pause Frames	42	0	0	0	N/A	0
Dot3 Out. Pause Frames	43	0	0	0	N/A	0
EtherStatsUndersize Pkts.	44	0	0	0	N/A	0
Fragments	45	0	0	0	N/A	0
CRC Align. Errors	46	0	0	0	N/A	0
Jabbers	47	0	0	0	N/A	0
Ingress BPS	48	633	N/A	N/A	8514	12860
Ingress PPS	49	1	N/A	N/A	6	12
Egress BPS	50	4122	N/A	N/A	8541	9347
Egress PPS	51	4	N/A	N/A	6	9
MAC learn limit drop (Ingress Pkts.)	52	0	0	0	0	0
L2 cache drop (Ingress Pkts.)	53	0	0	0	0	0
Illegal SA drop (Ingress Pkts.)	54	0	0	0	0	0
Port rate limit drop (Ingress Pkts.)	55	0	0	0	0	0
Port rate limit drop (Ingress Bytes)	56	0	0	0	0	0
PAUSE/PFC frames generated (Ingress Pkts.)	57	0	0	0	0	0
PAUSE/PFC frames generated (Egress Pkts.)	58	0	0	0	0	0
Rate limit drop for unknown unicast (Ingress Pkts.)	59	0	0	0	0	0
Rate limit drop for unknown unicast (Ingress Bytes)	60	0	0	0	0	0
Rate limit drop for broadcast (Ingress Pkts.)	61	0	0	0	0	0
Rate limit drop for broadcast (Ingress Bytes)	62	0	0	0	0	0
Rate limit drop for known multicast (Ingress Pkts.)	63	0	0	0	0	0
Rate limit drop for known multicast (Ingress Bytes)	64	0	0	0	0	0
Rate limit drop for unknown multicast (Ingress Pkts.)	65	0	0	0	0	0
Rate limit drop for unknown multicast (Ingress Bytes)	66	0	0	0	0	0
All CoSQ out Pkts.	67	2144	0	0	31948	43293
All CoSQ out bytes	68	2151700	0	0	42848639	43798556
All CoSQ dropped Pkts.	69	0	0	0	0	0
All CoSQ dropped bytes	70	0	0	0	0	0
Processed Rx Pkts.	71	1547	0	0	31382	43855
Processed Rx bytes	72	373548	0	0	42671492	45721532

Press MODIFY button.

Modify mode (buttons appear at the bottom of the page)

1) ***Statistics for*** – time during which statistics have been gathered;
2) ***Ingress Pkts.*** – Packets that ingress on the port;
3) ***Ingress Bytes*** – Bytes that ingress on the port;
4) ***Egress Pkts.*** – Packets that egress on the port;
5) ***Egress Bytes*** – Bytes that egress on the port;
6) ***Total Multicast Pkts.*** – The total number of good packets received that were directed to a multicast address. Note that this number does not include packets directed to the broadcast address;
7) ***Total Broadcast Pkts.*** – The total number of good packets received that were directed to the broadcast address. Note that this does not include multicast packets;
8) ***Total Pkts. 64 Octets*** – The total number of packets (including bad packets) that were 64 octets in length (excluding framing bits but including FCS octets);
9) ***Total Pkts. 65 to 127 Octets*** –The total number of packets (including bad packets) that were between 65 and 127 octets in length inclusive (excluding framing bits but including FCS octets);
10) ***Total Pkts. 128 to 255 Octets*** – The total number of packets (including bad packets) that were between 128 and 255 octets in length inclusive (excluding framing bits but including FCS octets);
11) ***Total Pkts. 256 to 511 Octets*** – The total number of packets (including bad packets) that were between 256 and 511 octets in length inclusive (excluding framing bits but including FCS octets);
12) ***Total Pkts. 512 to 1023 Octets*** – The total number of packets (including bad packets) that were between 512 and 1023 octets in length inclusive (excluding framing bits but including FCS octets);
13) ***Total Pkts. 1024 to 1518 Octets*** –The total number of packets (including bad packets) that were between 1024 and 1518 octets in length inclusive (excluding framing bits but including FCS octets);
14) ***Total Oversize Pkts.*** – The total number of packets that were longer than 1522 octets (excluding framing bits but including FCS octets) and were otherwise well formed;
15) ***Rx Oversize Pkts.*** – The total number of packets received that were longer than 1522 octets (excluding framing bits but including FCS octets) and were otherwise well formed;
16) ***Tx Oversize Pkts.*** – The total number of packets transmitted that were longer than 1522 octets (excluding framing bits but including FCS octets) and were otherwise well formed;
17) ***Total Octets*** – The total number of octets of data (including those in bad packets) received on the network (excluding framing bits but including FCS octets);
18) ***Total Pkts.*** – The total number of packets (including bad packets, broadcast packets, and multicast packets) received and transmitted;
19) ***Tx No Errors*** – The number of frames that have been transmitted by this port from its segment excluding fragmented and FCS error frames;
20) ***Rx No Errors*** – The number of frames that have been received by this port from its segment excluding fragmented and FCS error frames;
21) ***Total Pkts. 1519 to 1522 Octets*** – The total number of packets (including bad packets) that were between 1519 and 1522 octets in length inclusive (excluding framing bits but including FCS octets);
22) ***In. Octets*** – The total number of octets received on the interface, including framing characters;

23) ***Out. Octets*** – The total number of octets transmitted out of the interface, including framing characters;
24) ***Dot1 Port In Frames*** – The number of frames that have been received by this port from its segment. Note that a frame received on the interface corresponding to this port is only counted by this object if and only if it is for a protocol being processed by the local bridging function, including bridge management frames;
25) ***Dot1 Port Out Frames*** – The number of frames that have been transmitted by this port to its segment. Note that a frame transmitted on the interface corresponding to this port is only counted by this object if and only if it is for a protocol being processed by the local bridging function, including bridge management frames.;
26) ***Received Pkts. 64 Octets*** – The total number of packets (including bad packets) received that were 64 octets in length (excluding framing bits but including FCS octets);
27) ***Transmitted Pkts. 64 Octets*** – The total number of packets (including bad packets) transmitted that were 64 octets in length (excluding framing bits but including FCS octets);
28) ***Received Pkts. 65 to 127 Octets*** – The total number of packets (including bad packets) received that were between 65 and 127 octets in length inclusive (excluding framing bits but including FCS octets);
29) ***Transmitted Pkts. 65 to 127 Octets*** – The total number of packets (including bad packets) transmitted that were between 65 and 127 octets in length inclusive (excluding framing bits but including FCS octets);
30) ***Received Pkts. 128 to 255 Octets*** – The total number of packets (including bad packets) received that were between 128 and 255 octets in length inclusive (excluding framing bits but including FCS octets);
31) ***Transmitted Pkts. 128 to 255 Octets*** – The total number of packets (including bad packets) transmitted that were between 128 and 255 octets in length inclusive (excluding framing bits but including FCS octets);
32) ***Received Pkts. 256 to 511 Octets*** – The total number of packets (including bad packets) received that were between 256 and 511 octets in length inclusive (excluding framing bits but including FCS octets);
33) ***Transmitted Pkts. 256 to 511 Octets*** – The total number of packets (including bad packets) transmitted that were between 256 and 511 octets in length inclusive (excluding framing bits but including FCS octets);
34) ***Received Pkts. 512 to 1023 Octets*** – The total number of packets (including bad packets) received that were between 512 and 1023 octets in length inclusive (excluding framing bits but including FCS octets);
35) ***Transmitted Pkts. 512 to 1023 Octets*** – The total number of packets (including bad packets) transmitted that were between 512 and 1023 octets in length inclusive (excluding framing bits but including FCS octets);
36) ***Received Pkts. 1024 to 1518 Octets*** – The total number of packets (including bad packets) received that were between 1024 and 1518 octets in length inclusive (excluding framing bits but including FCS octets);
37) ***Transmitted Pkts. 1024 to 1518 Octets*** – The total number of packets (including bad packets) transmitted that were between 1024 and 1518 octets in length inclusive (excluding framing bits but including FCS octets);
38) ***In. Broadcast Pkts.*** – The number of packets, delivered by this sub-layer to a higher (sub-)layer, which were addressed to a broadcast address at this sub-layer;
39) ***Out. Broadcast Pkts.*** – The total number of packets that higher-level protocols requested to be transmitted, and which were addressed to a broadcast address at this sub-layer, including those that were discarded or not sent;
40) ***In. Multicast Pkts.*** – The number of packets, delivered by this sub-layer to a higher (sub-)layer, which were addressed to a multicast address at this sub-layer. For a MAC layer protocol, this includes both Group and Functional addresses;

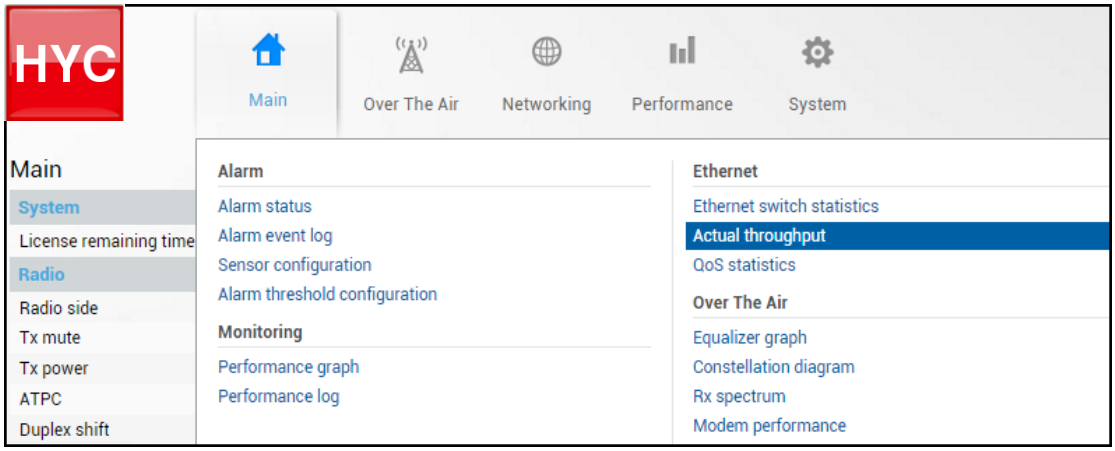
41) ***Out. Multicast Pkts.*** – The total number of packets that higher-level protocols requested be to transmitted, and which were addressed to a multicast address at this sub-layer, including those that were discarded or not sent. For a MAC layer protocol, this includes both Group and Functional addresses;
42) ***Dot3 In. Pause Frames*** – A count of MAC Control frames received on this interface with an opcode indicating the PAUSE operation. This counter does not increment when the interface is operating in half-duplex mode. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.;
43) ***Dot3 Out. Pause Frames*** – A count of MAC Control frames transmitted on this interface with an opcode indicating the PAUSE operation. This counter does not increment when the interface is operating in half-duplex mode. Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime;
44) ***EtherStatsUndersize Pkts.*** – The total number of packets received that were less than 64 octets long (excluding framing bits, but including FCS octets) and were otherwise well formed;
45) ***Fragments*** – The total number of packets received that were less than 64 octets in length (excluding framing bits but including FCS octets) and had either a bad Frame Check Sequence (FCS) with an INTEGRALl number of octets (FCS Error) or a bad FCS with a non-INTEGRALl number of octets (Alignment Error).
    Note that it is entirely normal for etherStatsFragments to increment. This is because it counts both runts (which are normal occurrences due to collisions) and noise hits;
46) ***CRC Align. Errors*** – The total number of packets received that had a length (excluding framing bits but including FCS octets) of between 64 and 1518 octets, inclusive, but had either a bad Frame Check Sequence (FCS) with an INTEGRALl number of octets (FCS Error) or a bad FCS with a non-INTEGRALl number of octets (Alignment Error);
47) ***Jabbers*** – The total number of packets received that were longer than 1518 octets (excluding framing bits but including FCS octets), and had either a bad Frame Check Sequence (FCS) with an INTEGRALl number of octets (FCS Error) or a bad FCS with a non-INTEGRALl number of octets (Alignment Error).
    Note that this definition of jabber is different than the definition in IEEE-802.3 section 8.2.1.5 (10BASE5) and section 10.3.1.4 (10BASE2). These documents define jabber as the condition where any packet exceeds 20 ms. The allowed range to detect jabber is between 20 ms and 150 ms;
48) ***Ingress BPS*** – Indicates byte per second rate on the input of the port;
49) ***Ingress PPS*** – Indicates packet per second rate on the input of the port;
50) ***Egress BPS*** – Indicates byte per second rate on the exit of the port;
51) ***Egress PPS*** – Indicates packet per second rate on the exit of the port;
73) ***Clear all statistic*** – Clears statistics on all switch ports;
74) ***Clear*** – Clears statistics on a particular port.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

network port show statistics	Use to show Ethernet statistics on all ports.
network port reset statistics {LAN1|LAN2|LAN3|MNG|WAN|all}	Use to reset Ethernet statistics for a particular port or all ports.

Performance → Ethernet → Actual throughput

Shows ingress and egress traffic statistics on all available switch ports.



Performance / Actual throughput

Port		LAN1	LAN2	LAN3	WAN	MNG
Ingress Mbps	1	0.014	N/A	N/A	0.102	0.102
Ingress pps	2	4	N/A	N/A	11	10
Egress Mbps	3	0.068	N/A	N/A	0.053	0.054
Egress pps	4	10	N/A	N/A	6	6

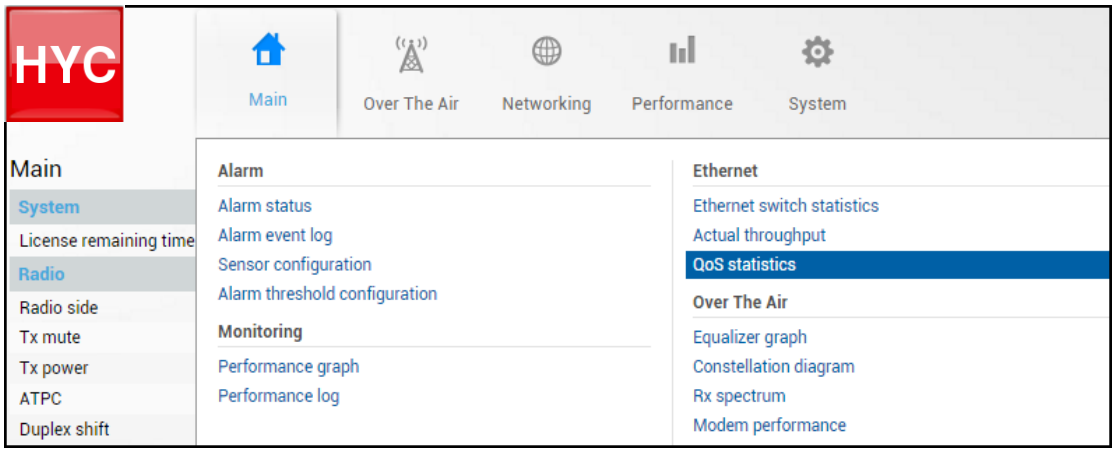
MODIFY button is deactivated in this page.

1) ***Ingress Mbps*** – Indicates megabit per second rate on the input of the port;
2) ***Ingress pps*** – Indicates packet per second rate on the input of the port;
3) ***Egress Mbps*** – Indicates megabit per second rate on the exit of the port;
4) ***Egress pps*** – Indicates packet per second rate on the exit of the port.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

network port show throughput	Use to show current throughput on all ports.

Performance → Ethernet → QoS statistics



Status mode

Performance / QoS statistics

Queue		Port				
Statistics for 1		LAN1 1d 08:50:17 Bytes / packets	LAN2 1d 08:50:17 Bytes / packets	LAN3 1d 08:50:17 Bytes / packets	WAN 1d 08:50:17 Bytes / packets	MNG 1d 08:50:18 Bytes / packets
0	Passed	113.06 M / 231572	0 / 0	0 / 0	2.99 M / 38220	2.99 M / 38221
	Dropped	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
1	Passed	0 / 0	0 / 0	0 / 0	276.40 k / 1874	276.40 k / 1874
	Dropped	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
2	Passed	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Dropped	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
3	Passed	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Dropped	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
4	Passed	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Dropped	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
5	Passed	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Dropped	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
6	Passed	0 / 0	0 / 0	0 / 0	68 / 1	68 / 1
	Dropped	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
7	Passed	0 / 0	0 / 0	0 / 0	614.29 M / 1150579	644.19 M / 1375404
	Dropped	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0

Press MODIFY button.

Modify mode (buttons appear at the bottom of the page)

Clear all data 2 Clear 3 Clear Clear Clear Clear

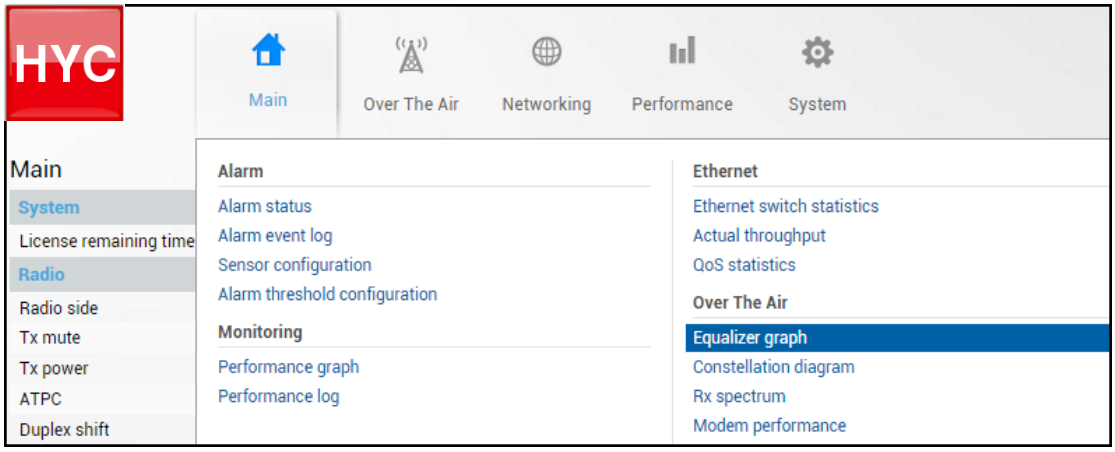
1) QoS statistics for all 8 available priority queues, indicating passed and dropped packets and bytes. Elapsed time is indicated as well.
2) ***Clear all statistic*** – Allows clearing QoS statistics on all switch ports.
3) ***Clear*** – Allows clearing QoS statistics on individual switch ports.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

network qos show statistics {all|LAN1|LAN2|LAN3|WAN}	Use to check QoS statistics on all available ports.
network qos reset statistics {all|LAN1|LAN2|LAN3|WAN}	Use to clear QoS statistics on a specific switch port or all ports simultaneously.

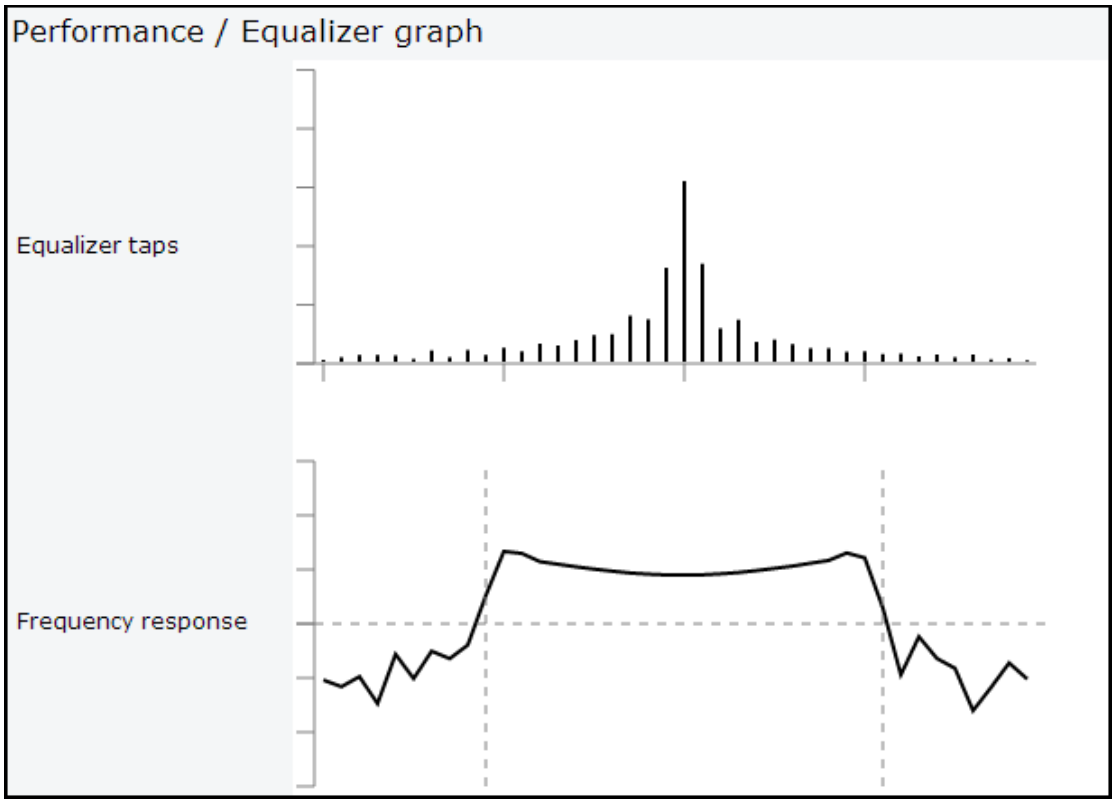
Performance → Over The Air → Equalizer graph

The Equalizer graph window shows adaptive equalizer taps' coefficients, which at a set time moment minimize multipath fading effect in the channel.



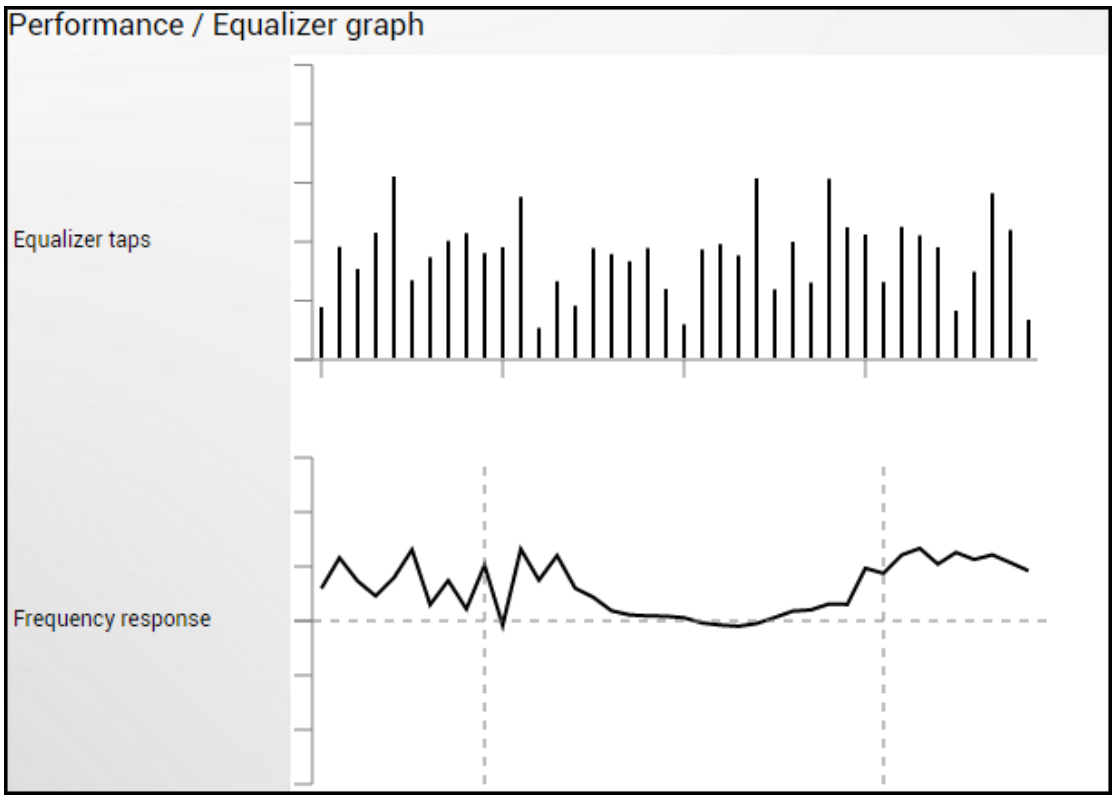
MODIFY button is deactivated in Equalizer graph page.

Example of equalizer taps' coefficients and its frequency response in case of a normal operation is shown below:



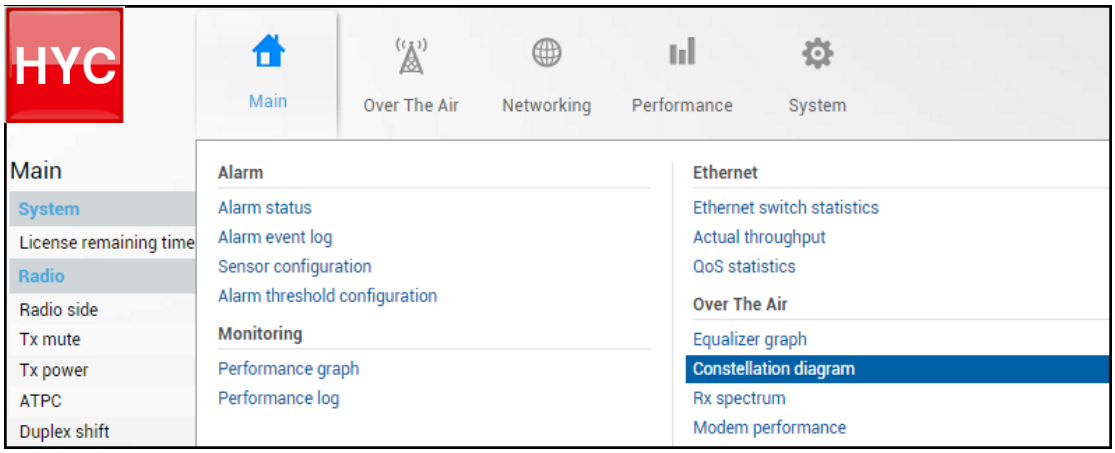
During normal operation, the frequency response curve is smooth at the center and central equalizer tap is higher, while side towers evenly decrease. If equalizer taps and frequency response curve significantly differ from the one above, it may be an indication of a multipath issues, which must be inspected with use of precise and accurate path profiling. Higher taps mainly on the right side indicate a weaker reflected signal compared to the main signal, while higher taps mainly on the left side – stronger reflected signal.

Below is an example of Equalizer graph in a link aligned to reflected signal:



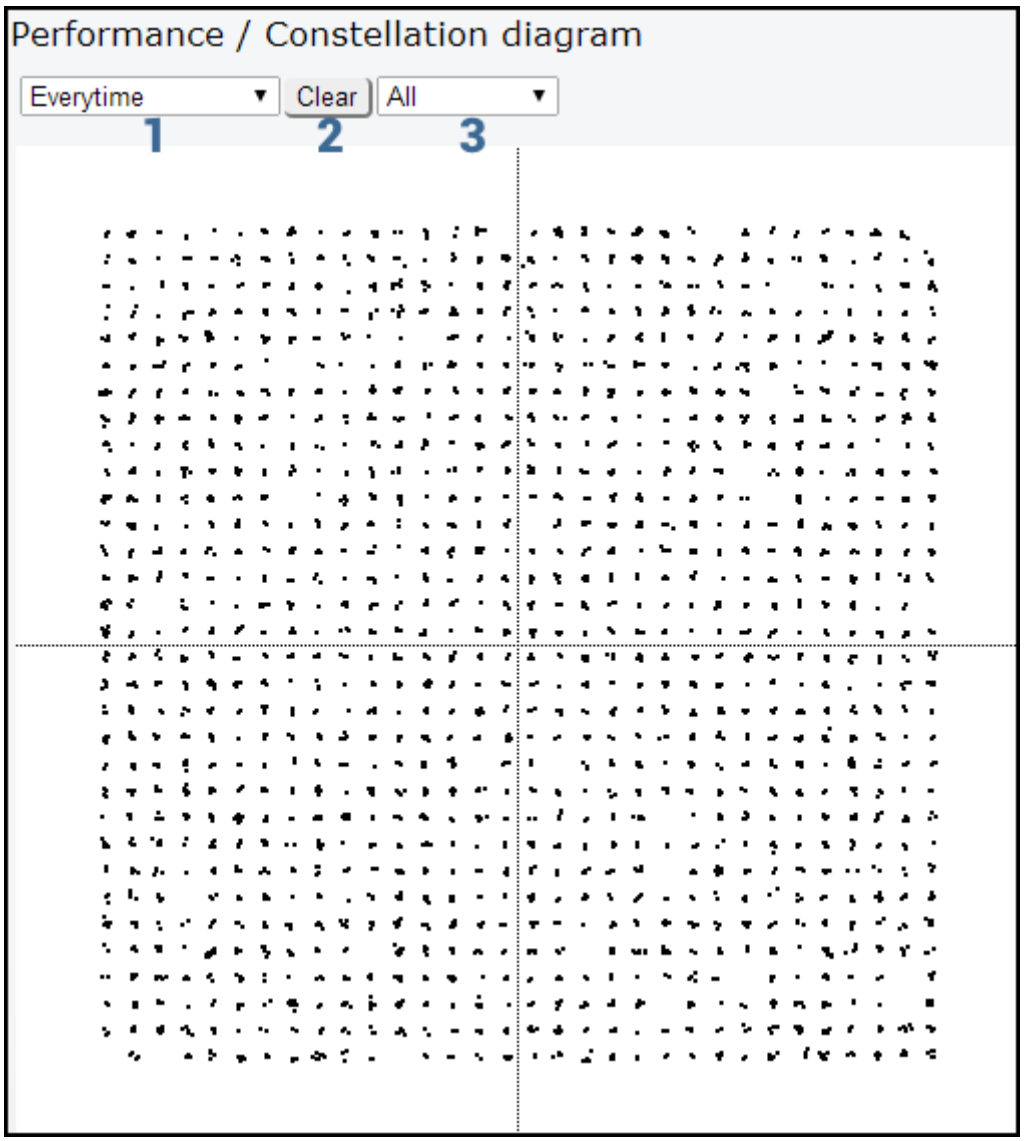
Performance → Over The Air → Constellation diagram

A constellation diagram is a representation of a signal modulated by the digital modulation schemes 1024QAM, 512QAM, 256QAM, 128QAM, 64QAM, 32QAM, 16QAM or 4QAM. It displays the signal as a two-dimensional scatter diagram in the complex plane at symbol sampling instants. A measured constellation diagram can be used to recognize the type of interference and distortion in a signal.



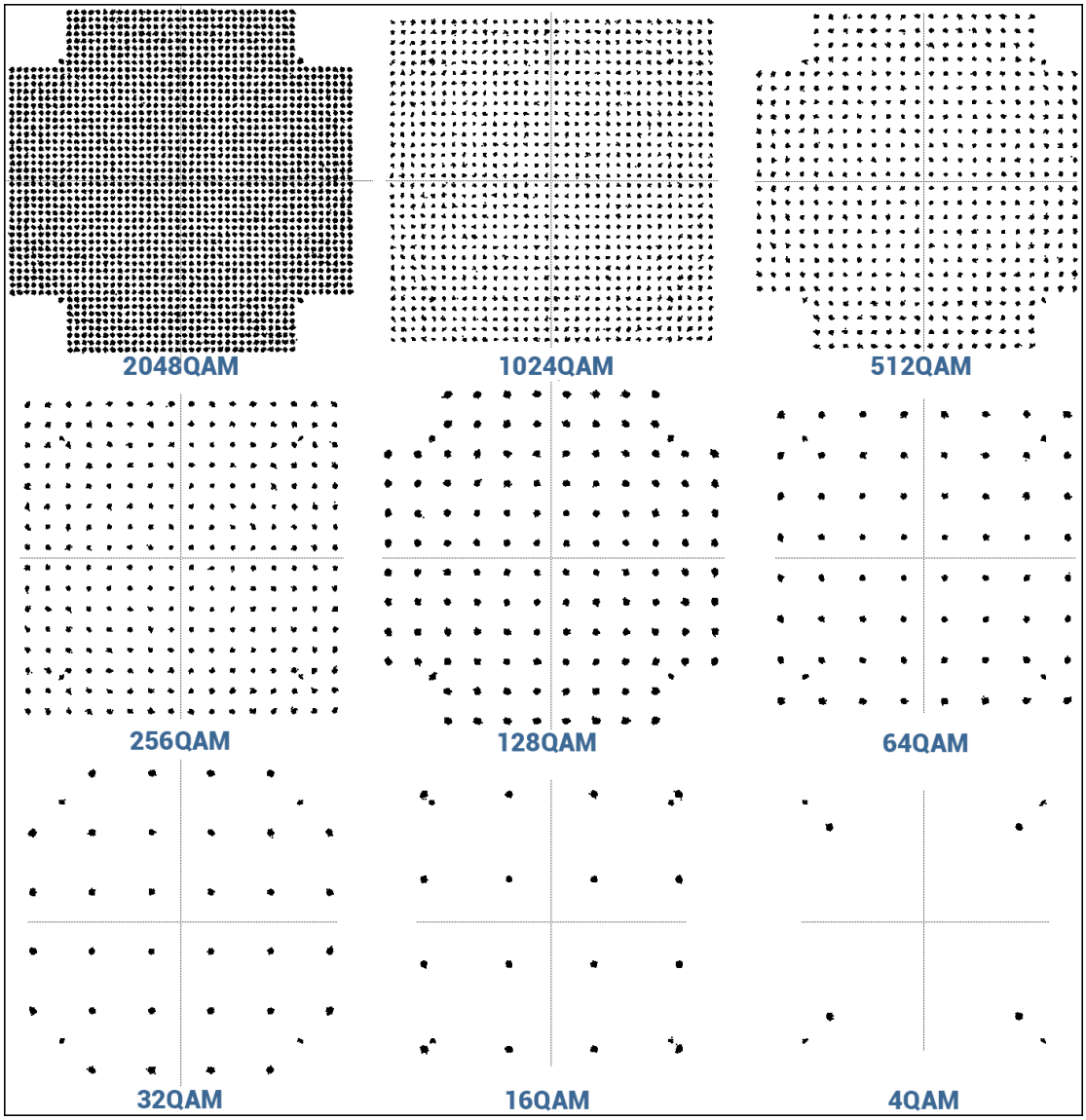
MODIFY button is deactivated in Constellation diagram page.

Only a single user can see Constellation at a time.



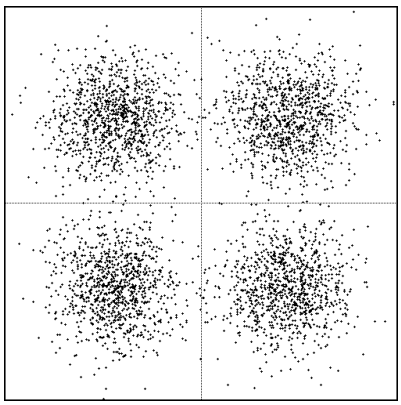
1) Allows choosing how often is constellation automatically cleared;
2) Manually clear current constellation;
3) Allows zooming to one of 4 constellation quadrants.

Examples of INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS constellation diagrams under ideal conditions are shown below:

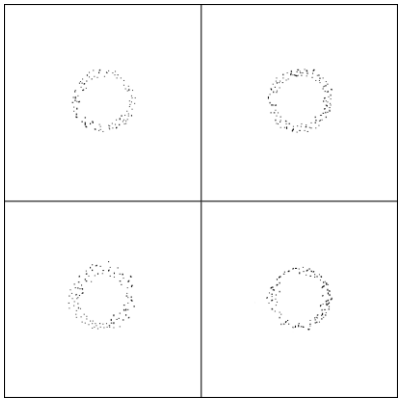


For the purpose of analyzing the received signal quality, some types of corruption are evident in the constellation diagram. For example:

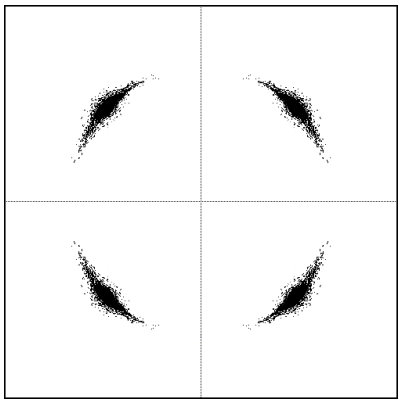
1) Gaussian noise is displayed as fuzzy constellation points:



2) Non-coherent single frequency interference is displayed as circular constellation points:

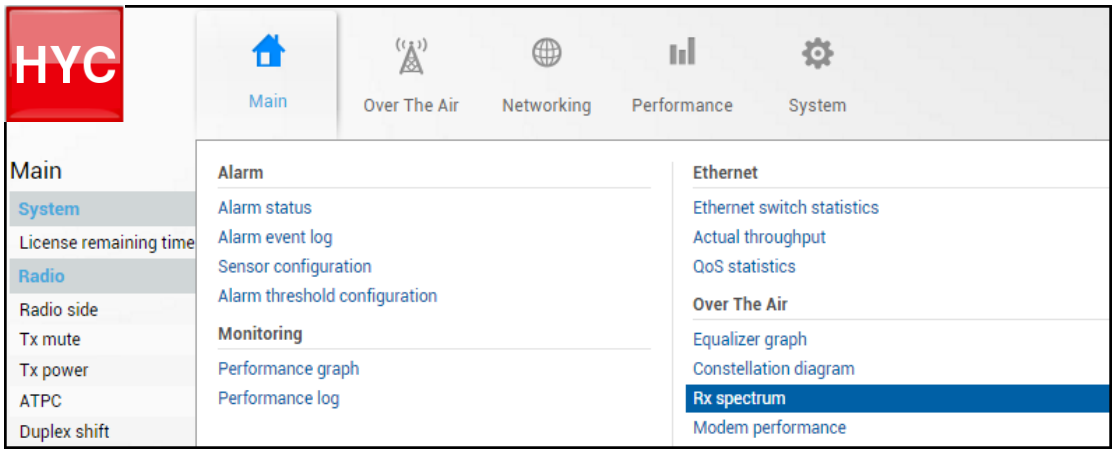


3) Phase noise is displayed as rotationally spreading constellation points:



Performance → Over The Air → Rx spectrum

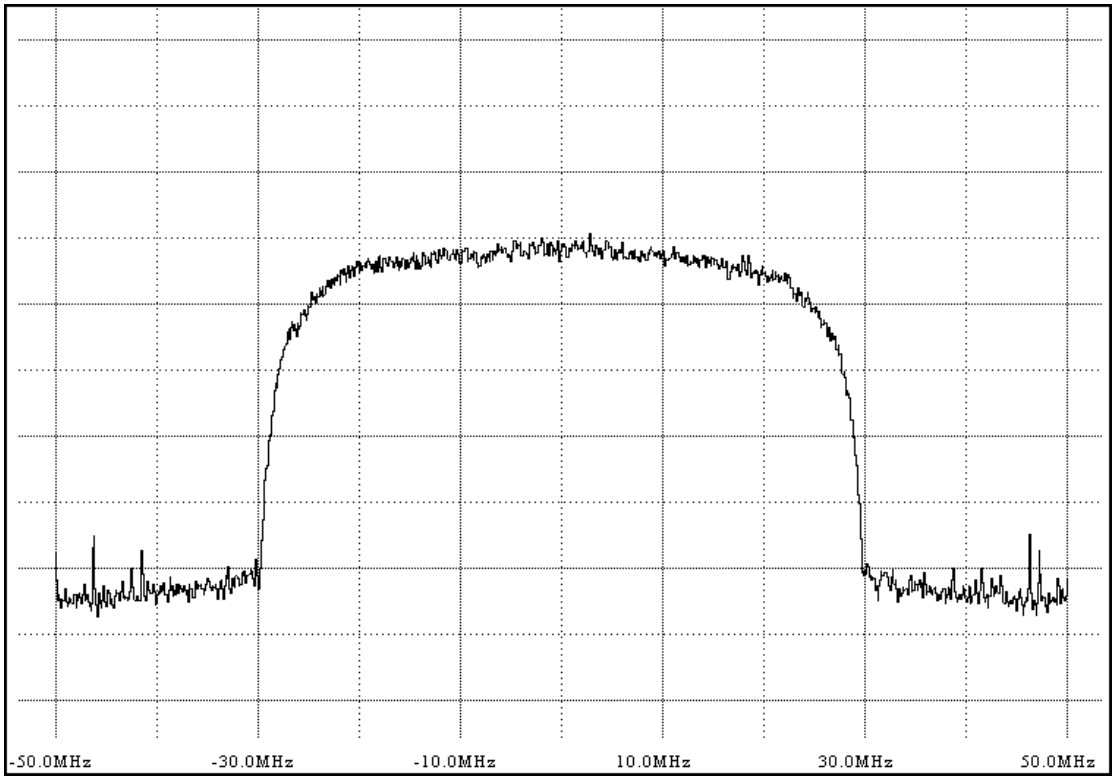
A spectrum curve is a representation of the received signal on the input of the modem. For this reason, spectrum signal levels will not correspond to actual radio receiver's signal level. The signal appearance will depend on configured channel bandwidth. An measured spectrum curve can be used to recognize in-band interference or very powerful out-band interference (due to filters applied).



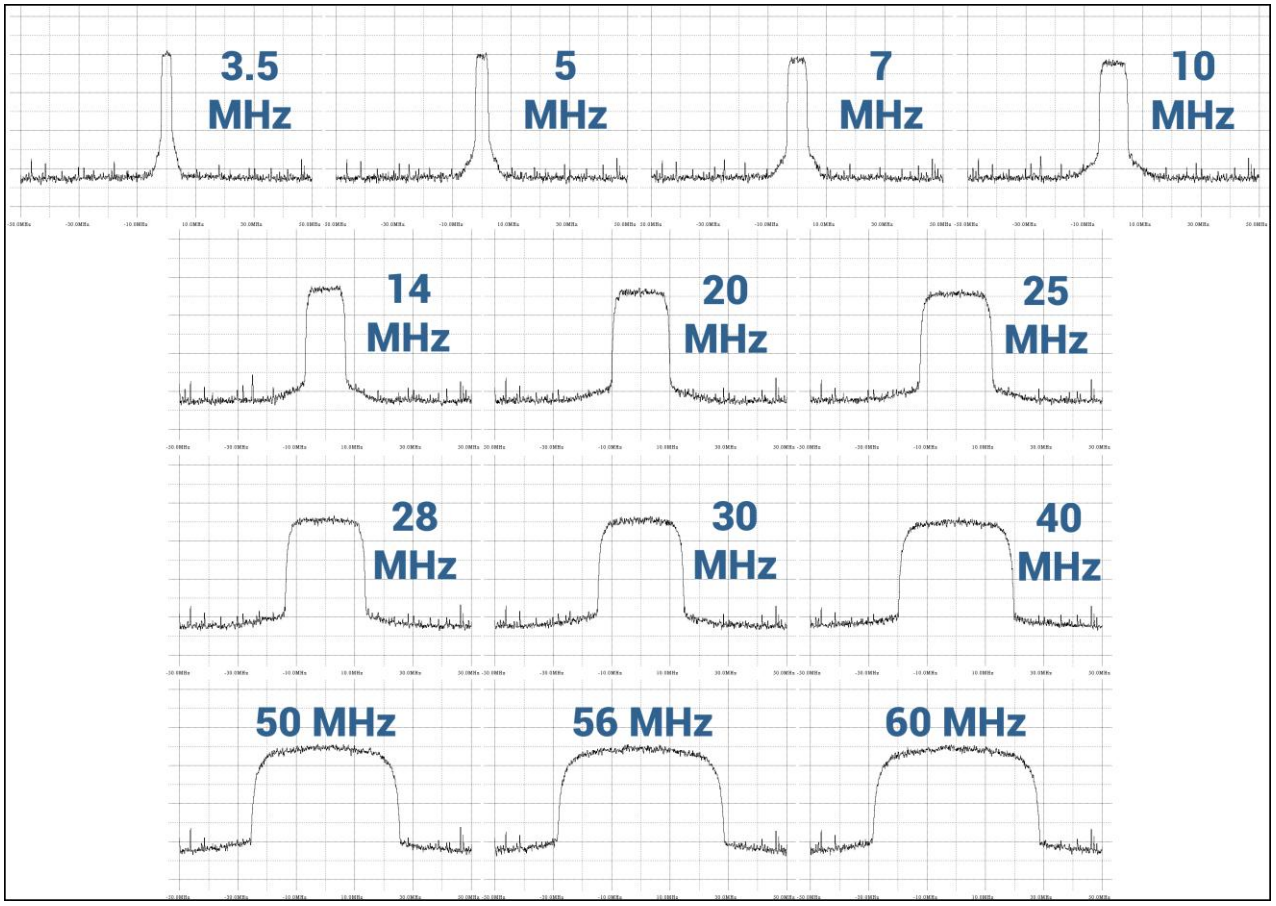
MODIFY button is deactivated in Rx spectrum page.

Only a single user can see Rx Spectrum at a time.

Spectrum (80MHz):

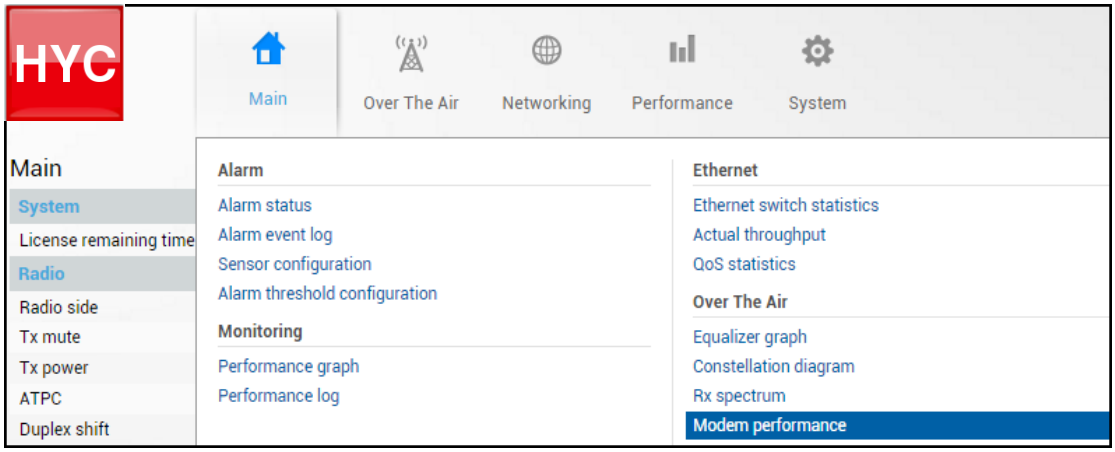


Examples of INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS spectrum curves in various channel bandwidths:

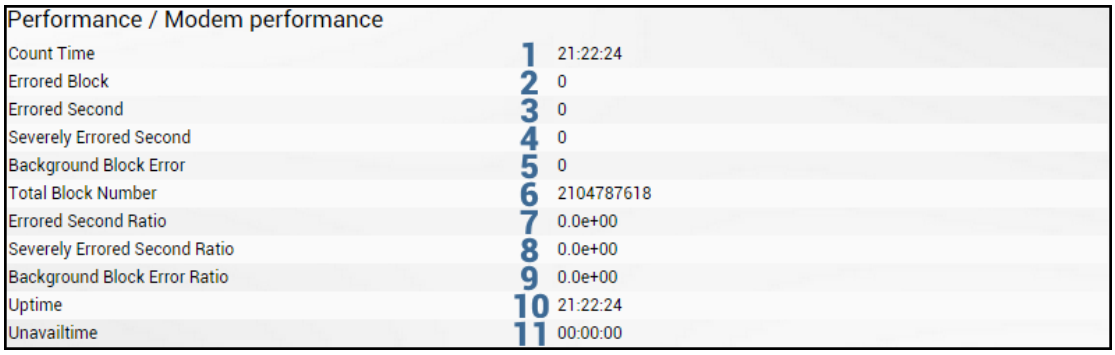


Performance → Over The Air → Modem performance

The Modem performance section shows modem statistics according to ITU-T G.826.



Status mode



Press MODIFY button.

Modify mode (buttons appear at the bottom of the page)

1) ***Count time*** – time during which statistics are gathered;
2) ***Errored Block (EB)*** – Number of blocks having at least one-bit error;
3) ***Errored Second (ES)*** – Number of seconds during which errored blocks were registered;
4) ***Severely Errored Seconds (SES)*** – Number of seconds which contain 30% errored blocks or one or more defects;
5) ***Background Block Error (BBE)*** – Number of errored blocks which are not part of SES;
6) ***Total Block number*** - Number of blocks received which are not part of SES;
7) ***Errored Second Ratio (ESR)*** – The ratio of ES to total seconds;
8) ***Severely Errored Second Ratio (SESR)*** – The ratio of SES to total seconds;
9) ***Background Block Error Ratio (BBER)*** – The ratio of BBE to total seconds;
10) ***Uptime*** – time in seconds during which the link was synchronized;
11) ***Unavailtime*** – time in seconds during which the link was not synchronized;
12) ***Clear*** – Clears all counters.

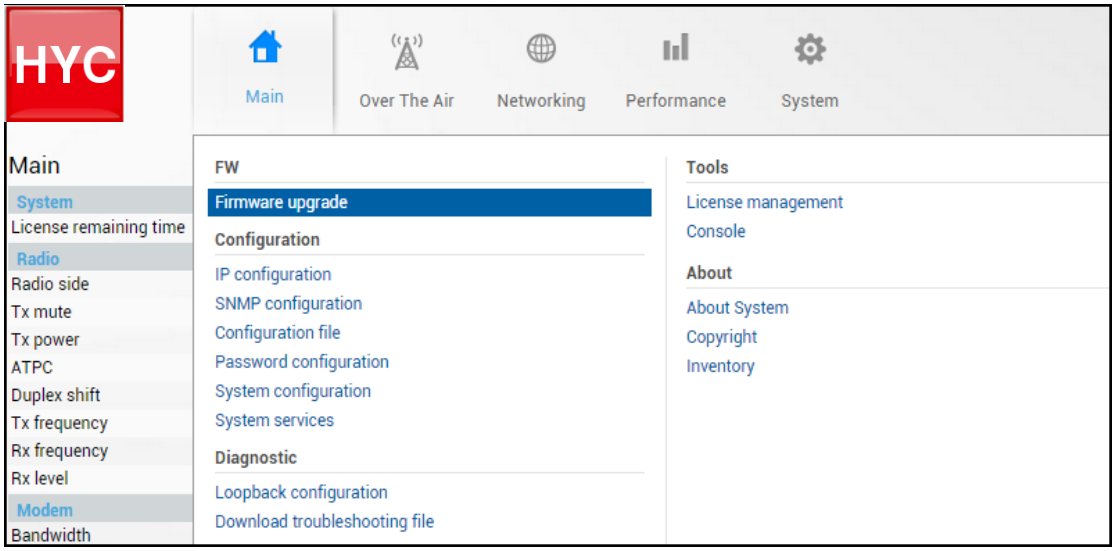
CLI commands (Chapter 4: COMMAND LINE INTERFACE)

modem performance	Use to check modem statistics according to ITU-T G.826. See detailed description above.
modem performance clear	Use to clear modem statistics.

System

System → FW → Firmware upgrade

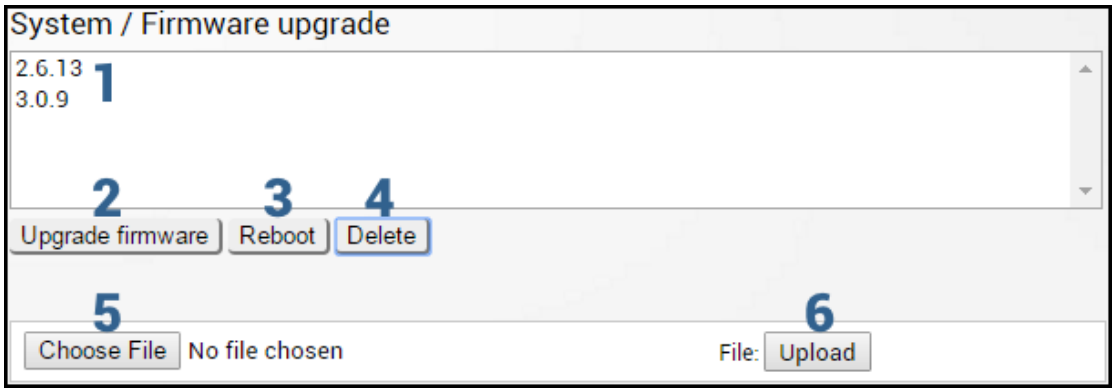
Upload the .bin firmware file and upgrade the firmware version on the "Firmware upgrade" page.



Status mode

Press MODIFY button.

Modify mode



1) Shows list of available firmware files;
2) ***Upgrade firmware*** – click on preferred firmware in the list and press "Upgrade firmware" button to initiate firmware upgrade process.

If existing INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS firmware version is older than V2.5.13, firmware must be upgraded to V2.5.13 (link) before the upgrade to the latest firmware version.

Latest INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS firmware can be downloaded in https://Hypercabletehnika.com/en/downloads in "Firmwares" section. Login required.

3) ***Reboot*** – Reboots INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS (cold restart).

4) ***Delete*** – Deletes selected firmware file from the list.
5) ***Choose File*** – Press to browse for a firmware file on your hard disk drive.
6) ***Upload*** – Press to upload a firmware file to INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS.

INTEGRAL series firmware upgrade via Web GUI

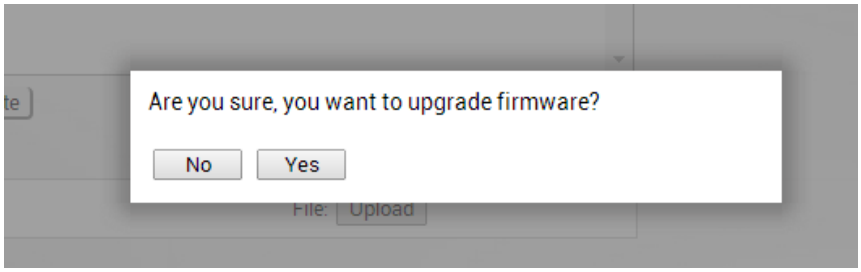
Firmware update package contains firmware file (.bin extension), release notes and firmware upgrade instructions.

If existing INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS firmware version is older than V2.5.13, firmware must be upgraded to V2.5.13 (link) before the upgrade to the latest firmware version.

Latest INTEGRAL firmware update package can be downloaded at the following URL: https://www.Hypercabletehnika.com/en/downloads (registration required).

The main method for firmware upgrade is upload via Web GUI, which automates the whole firmware upgrade process. To perform a software upgrade from Web GUI, please follow these steps:

1) Go to "System → FW → Firmware upgrade";
2) Press "MODIFY" button on right side of the page;
3) Press "Choose File" button, locate *.bin firmware file on your hard disk (extracted from the firmware update package) and press "Open" button;
4) Press "Upload" button;
5) Select uploaded firmware from firmware list and press "Upgrade firmware" button;
6) Confirm the upgrade and reboot the system.



The remote side must be upgraded first.

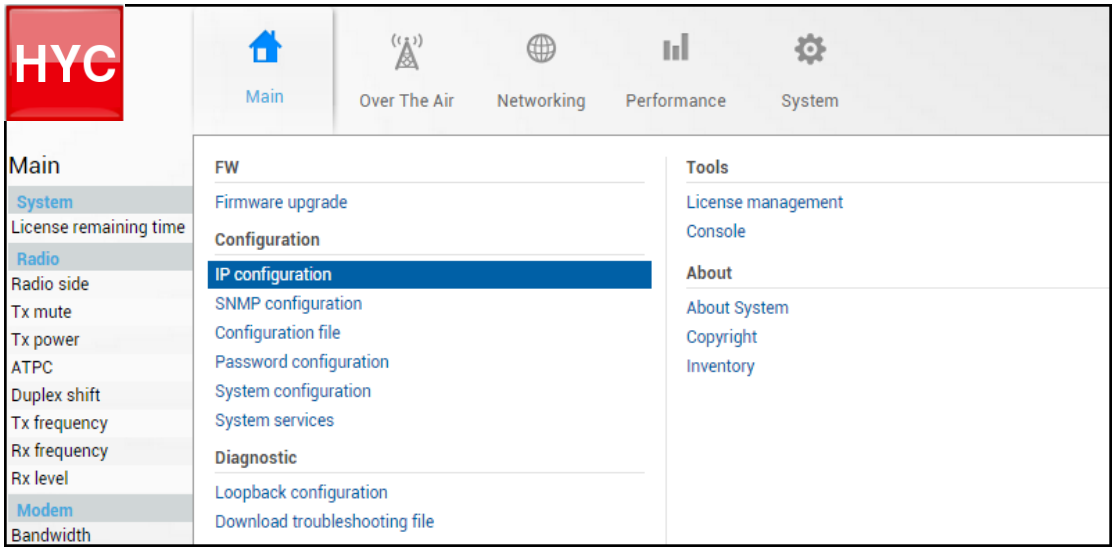
Please do not unplug power until firmware upgrade procedure is finished - Web GUI will automatically reconnect and login page will appear.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

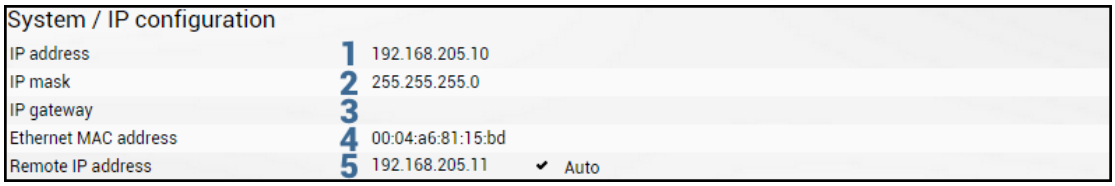
firmware info [<version>]	Use to show detailed information on current or specific INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS firmware.
firmware install <version>	Use to install firmware version uploaded. Note that exact version needs to be entered. Check available firmware versions using command "firmware list".
firmware list	Use to list uploaded firmware versions.
firmware remove <version>	Use to remove firmware version uploaded. Note that exact version needs to be entered. Check available firmware versions using command "firmware list".
firmware remove.list	Use to remove all uploaded firmware versions.

firmware switch	Use to check running firmware bank and bank that will be used at the next boot.
firmware upload <file>	Use to upload firmware file from the FTP directory.
firmware switch {fs|fw1|fw2|toggle}	Use to define the bank that will be used at the next boot. "fw1" and "fw2" subcommands set appropriate bank, "toggle" forces to set another bank than the running one, "fs" is factory defined emergency bank, which is used if both "fw1" and "fw2" fail.
system reboot	Use to cold reboot radio unit.

System → Configuration → IP configuration

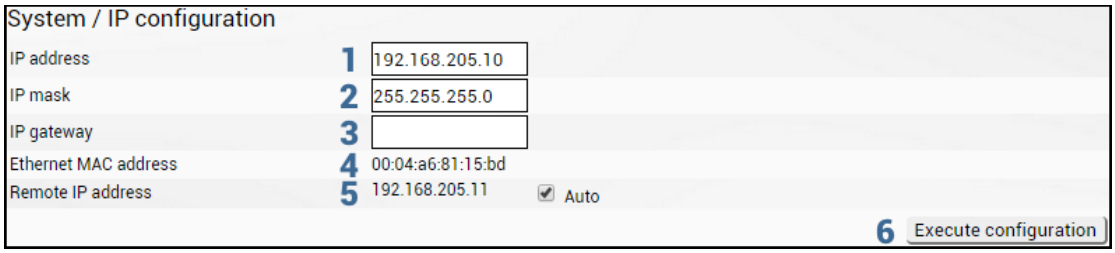


Status mode



Press MODIFY button.

Modify mode



1) ***IP address*** – Indicates the IP address of the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS you are currently logged in (status mode); allows specifying the IP address of the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS you are currently logged in to (modify mode). Default IP address is 192.168.205.10 or 192.168.205.11 – depending on which side the specific INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS is – low side has 192.168.205.10 IP address and high side – 192.168.205.11.

INTEGRAL/INTEGRAL-S IP addresses need to be on the same subnet.

2) ***IP Mask*** – Indicates the IP mask of the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS you are currently logged in (status mode); allows specifying the IP mask of the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS you are currently logged in to (modify mode). Default IP mask is 255.255.255.0.
3) ***IP gateway*** – Indicates the gateway address of the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS you are currently logged in to (status mode); allows specifying the gateway address of the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS you are currently logged in (modify mode). By default, the gateway is not specified (blank).
4) ***Ethernet MAC address*** – shows the MAC address of the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS you are currently connected to.
5) ***Remote IP address*** – shows the IP address of the remote (far-end) INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS. By default, the remote IP address is being retrieved automatically and therefore the "Auto" checkbox is selected. In modify mode you can unselect the "Auto" option and enter the remote IP address manually.
6) By pressing *„Execute configuration"*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS.

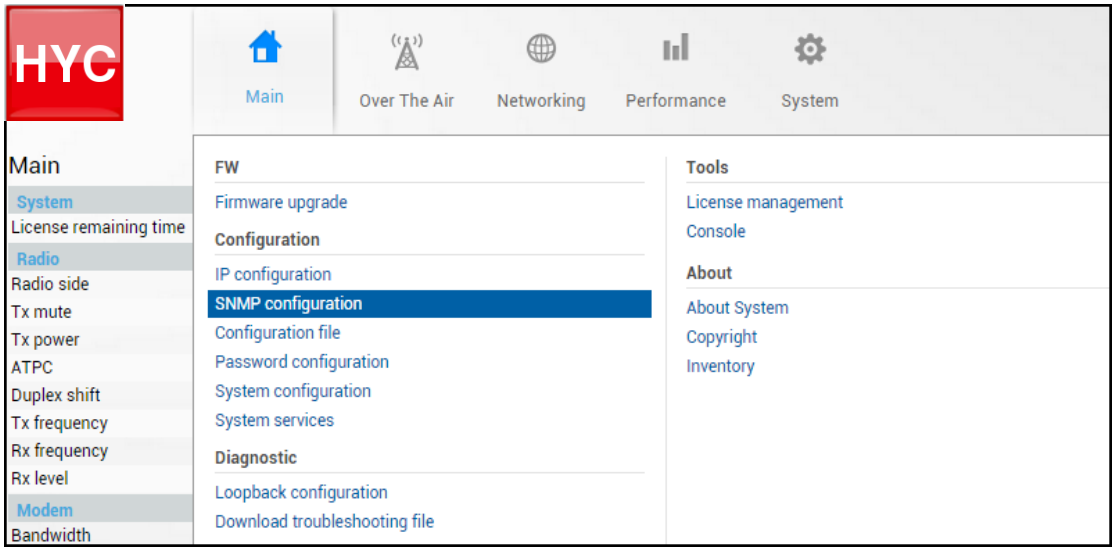
CLI commands (Chapter 4: COMMAND LINE INTERFACE)

system ip addr [<IP>]	Use to show/set IP address of management CPU.
system ip gw [{<IP>|clear}]	Use to show/manage IP address of the gateway.
system ip mask [<mask>]	Use to show/set subnet mask.
system ip mac	Use to show MAC address of management CPU.
system ip cfg {<ip address> <mask> | <ip address> <mask> <gateway> | <ip address/CIDR> | <ip address/CIDR> <gateway>}	Use to set IP address and subnet or optionally IP address, subnet mask and gateway simultaneously.
system remoteip show	Use to show remote IP address.
system remoteip auto	Use to set automatic retrieving of remote IP address.
system remoteip set <IP>	Use to define remote IP address (deactivates automatic retrieving of remote IP address).
system diag ping <IP_address>	Use to ping an IP address.

System → Configuration → SNMP configuration

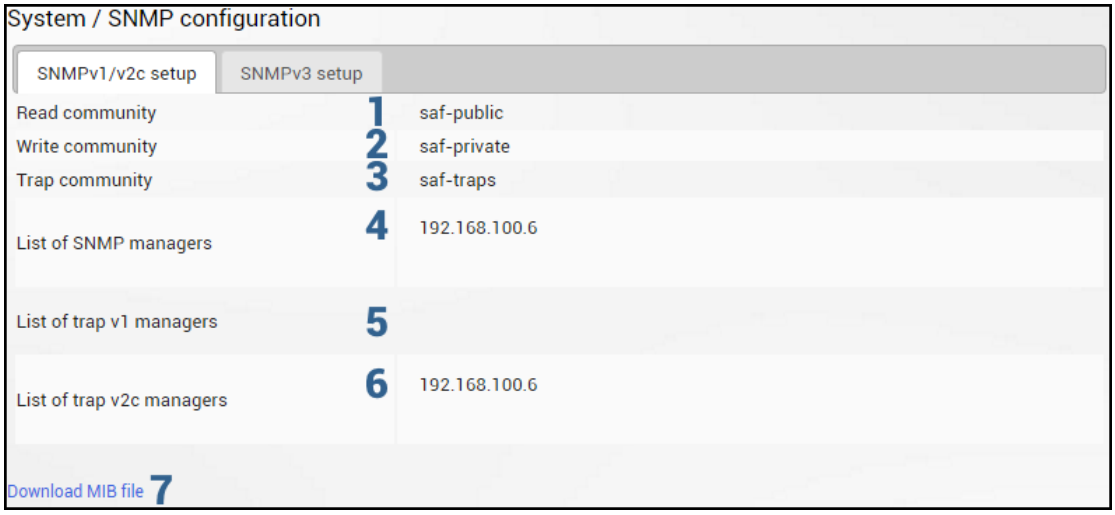
The SNMP configuration pages provide configuration of SNMP communities, host and trap addresses. The HYPERCABLE NMS system will work only when SNMP is properly configured.

Relevant MIB files can be downloaded directly from INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS Web GUI. See (7) below.



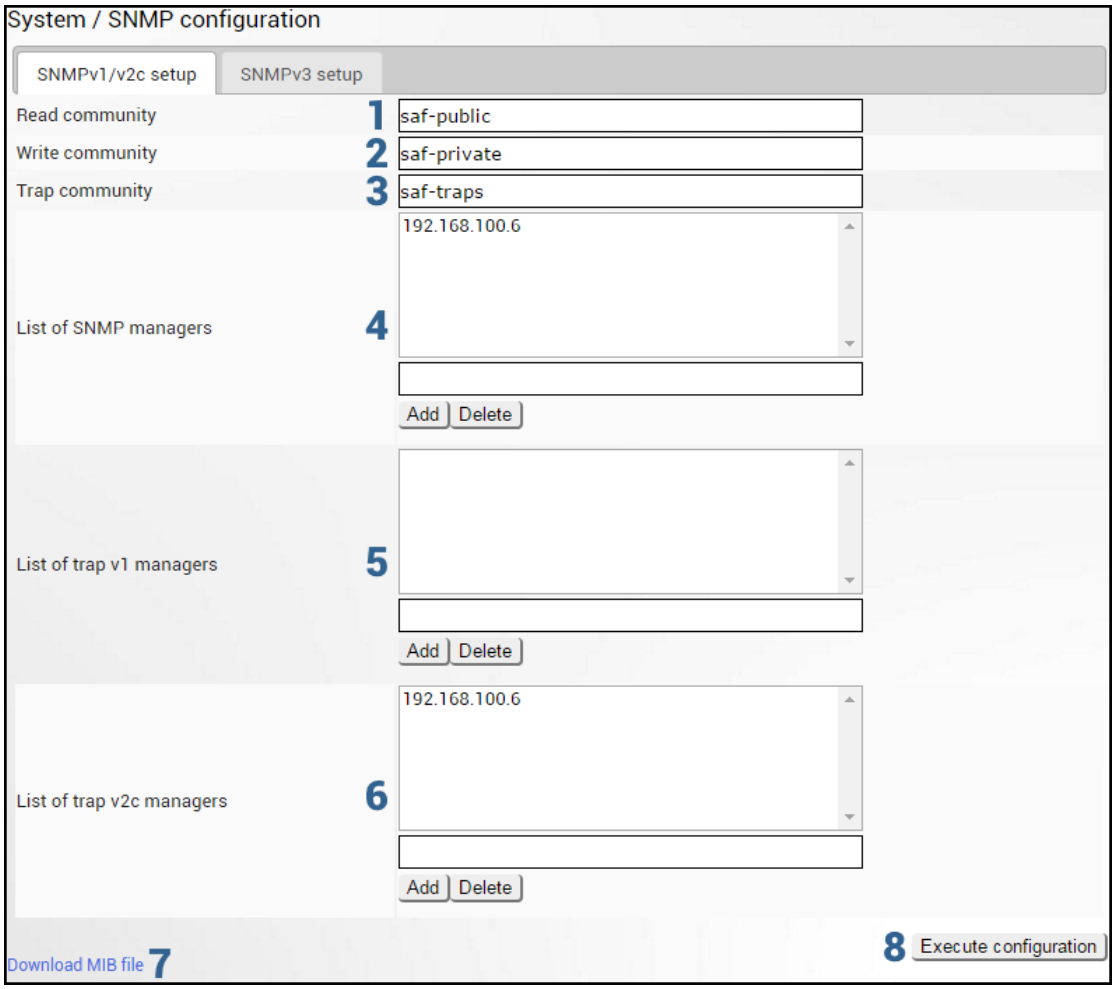
SNMPv1/v2c setup

Status mode



Press MODIFY button.

Modify mode



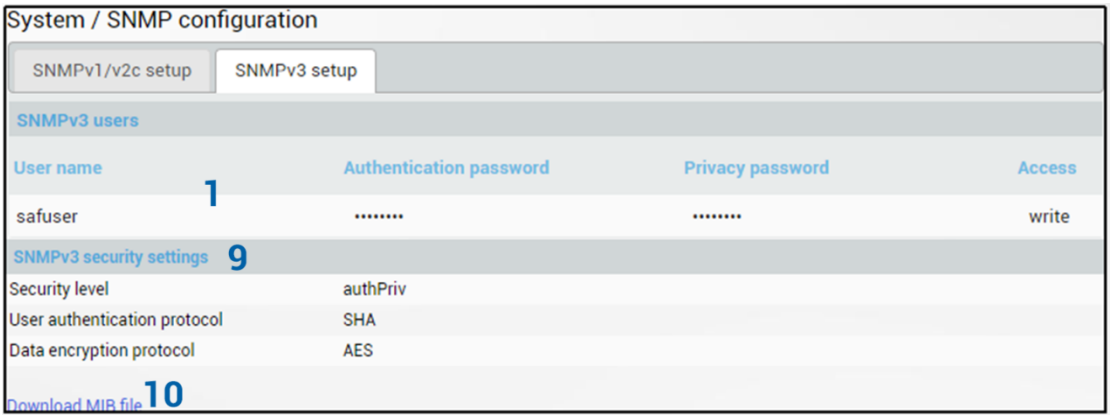
1) ***Read community*** – Indicates currently specified read community for SNMPv1/v2c (status mode); allows specifying read community for SNMPv1/v2c of the agent to enable parameters to be read (modify mode). Default read community name is “Hypercable-public”.
2) ***Write community*** – Indicates currently specified write community for SNMPv1/v2c (status mode); allows specifying write community for SNMPv1/v2c of the agent to enable parameters to be written (modify mode). Default write community name is “Hypercable-private”.
3) ***Trap community*** – Indicates currently specified trap community for SNMPv1/v2c (status mode); allows specifying trap community for SNMPv1/v2c for trap authentication in monitoring applications (modify mode). Default trap community name is “Hypercable-traps”.
4) ***List of SNMP managers*** – Shows list of configured SNMPv1/v2c host IP addresses (status mode); allows adding/deleting SNMPv1/v2c host IP addresses (modify mode). Specified IP addresses have access to read and modify configuration parameters using the appropriate read and write community names.
5) ***List of trap v1 managers*** – Shows a list of configured SNMPv1 trap IP addresses (status mode); allows adding/deleting SNMPv1 trap IP addresses (modify mode). The INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS management controller sends SNMPv1 traps to the Trap Manager with the IP address specified here;
6) ***List of trap v2c managers*** – Shows a list of configured SNMPv2c trap IP addresses (status mode); allows adding/deleting SNMPv2c trap IP addresses (modify mode). The INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS management controller sends SNMPv2c traps to the Trap Manager with the IP address specified here.
7) ***Download MIB file*** – Click to download INTEGRAL/INTEGRAL-S MIB files.

8) By pressing *„Execute configuration”*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS.

SNMPv3 setup

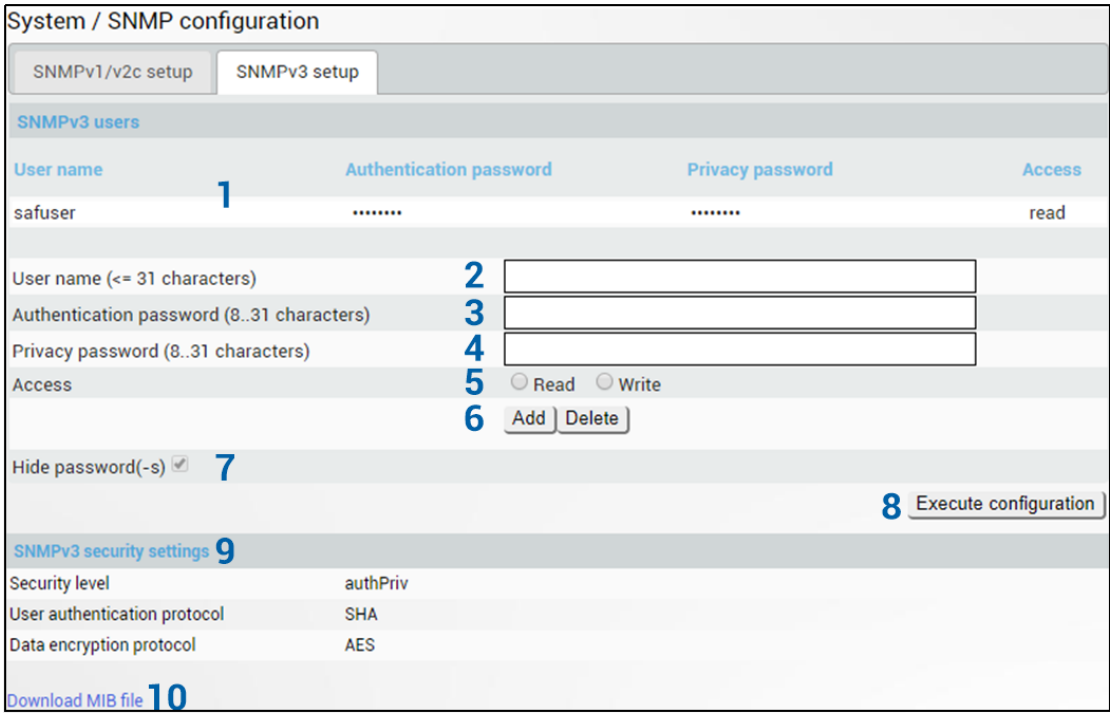
SNMPv3 primarily is improved with security settings. It does not relay on SNMP community names as it is in versions 1 and v2c.

Status mode



Press MODIFY button.

Modify mode

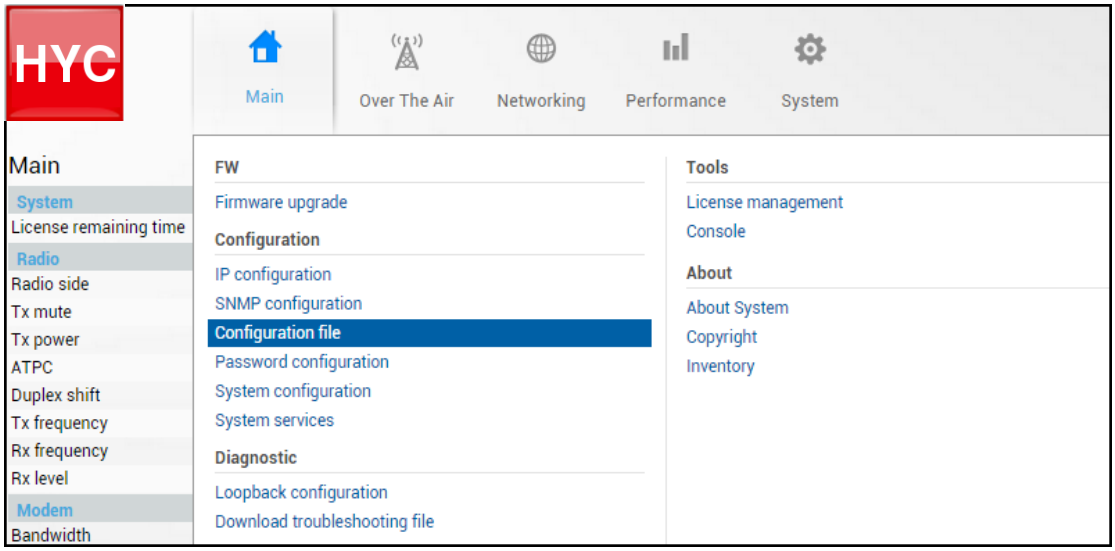


1) ***SNMP users*** – Shows list of configured SNMPv3 users;
2) ***User name (<=31 characters)*** – Enter SNMPv3 authentication user name. Length can be up to 31 symbols;
3) ***Authentication password (8..31 characters)*** – Enter SNMPv3 authentication password. Length can be between 8 and 31 symbols;
4) ***Privacy password (8..31 characters)*** – Enter SNMPv3 data encryption password (AES protocol is used on SNMP agent’s side). Length can be between 8 and 31 symbols;
5) ***Access*** – Select “Read” for read-only access or “Write” for read-write access;

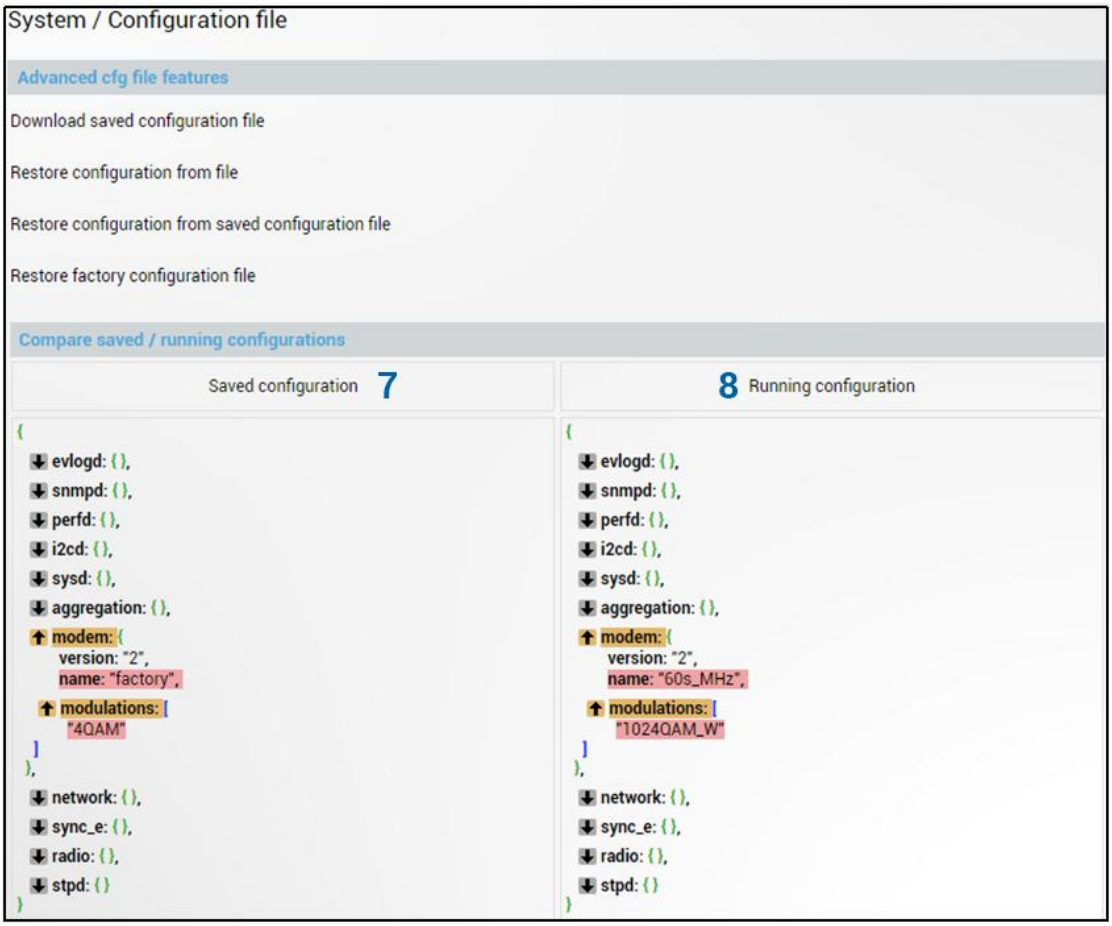
6) ***Add/Delete*** – Use to add or delete selected user name. In order to delete user names from the list, click on the required user name in the list above;
7) **Hide passwords(-s)** – uncheck to display passwords for selected SNMPv3 user;
8) By pressing *„Execute configuration”*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS;
9) ***SNMPv3 security settings*** – Shows SNMPv3 security settings used;
10) ***Download MIB file*** – Click to download INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS MIB files.

System → Configuration → Configuration file

Shows saved and running configurations, highlighting differences between both (unsaved changes).

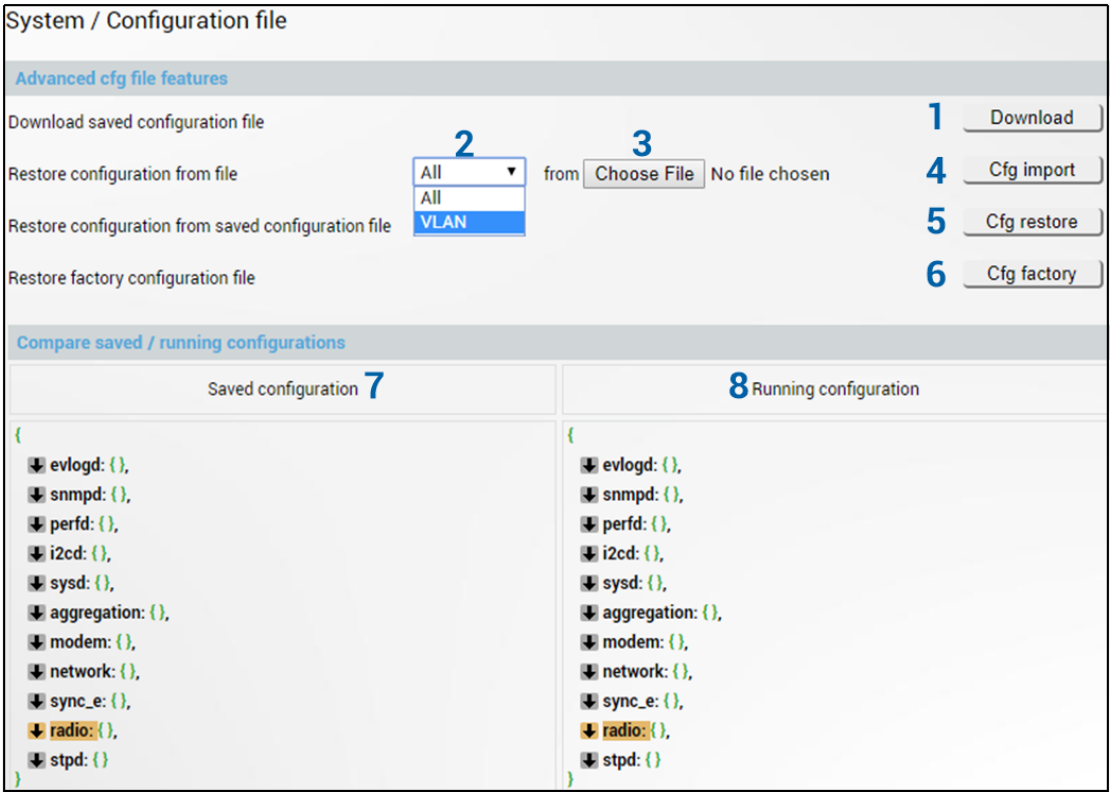


Status mode



Press MODIFY button.

Modify mode



1) ***Download*** – Press to download the system configuration txt file and save it on your hard drive.
2) ***All/VLAN*** – Select *All* to restore complete configuration or *VLAN* to restore only VLAN configuration.
3) ***Choose File*** – Press to browse for a saved configuration file on your hard disk drive.
4) ***Cfg import*** – Press to upload a configuration file to the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS.

Uploaded configuration overwrites the saved configuration.

5) ***Cfg restore*** – Press to restore saved system configuration, i.e. unsaved changes will be discarded!

Restoring configuration overwrites running configuration with the saved configuration.

6) ***Cfg factory*** – Resets system configuration to factory defaults.
7) ***Saved configuration*** – Shows saved system configuration.
8) ***Running configuration*** – Shows currently running system configuration.

Distinct sections in saved and running configurations are highlighted in color. In order to examine particular differences expand highlighted sections of configuration by clicking on down arrow of the appropriate configuration section.

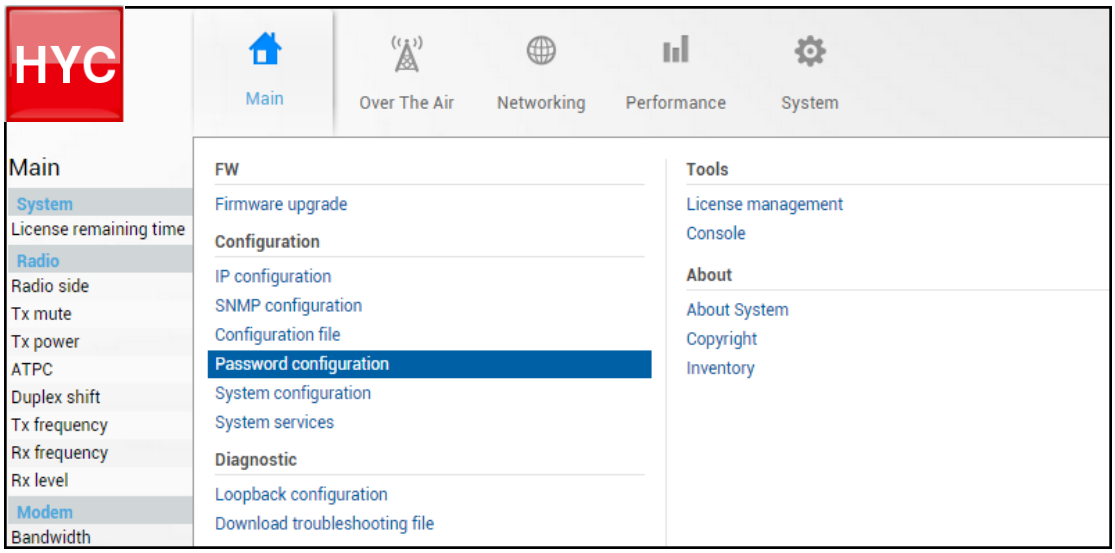
CLI commands (Chapter 4: COMMAND LINE INTERFACE)

configuration factory	Use to reset system configuration to factory defaults.
configuration factory aggr	Use to reset aggregation configuration to factory defaults.
configuration factory modem	Use to reset modem configuration to factory defaults.
configuration factory sysd	Use to reset whole system configuration to factory defaults.
configuration factory sync_e	Use to reset SyncE configuration to factory defaults.
configuration factory netsys {mac-table|port-state|qos|rate|vlan}	Use to reset whole Ethernet configuration to factory defaults or particular sections using subcommands – "mac-table" for MAC

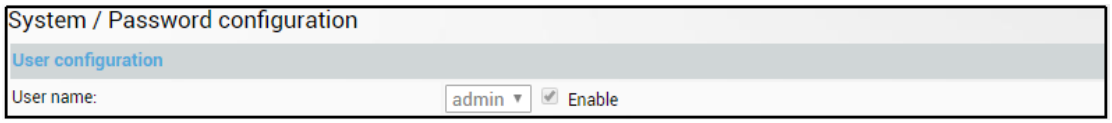
	table; “port-state” for port state configuration; “qos” for QoS configuration; “rate” for rate limit configuration; “vlan” for VLAN configuration.
configuration load	Use to restore saved system configuration, i.e. unsaved changes will be discarded!
configuration status	Use to check whether the running configuration is saved.
configuration store	Use to save running configuration.
configuration download	Use to create a copy of saved configuration file as txt file in the FTP directory.
configuration import {all | VLAN} <**filename**>	Use to restore configuration from a txt file stored in FTP directory.

System → Configuration → Password configuration

INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS features 2 default user accounts – *admin* (full control) and *guest* (read only).

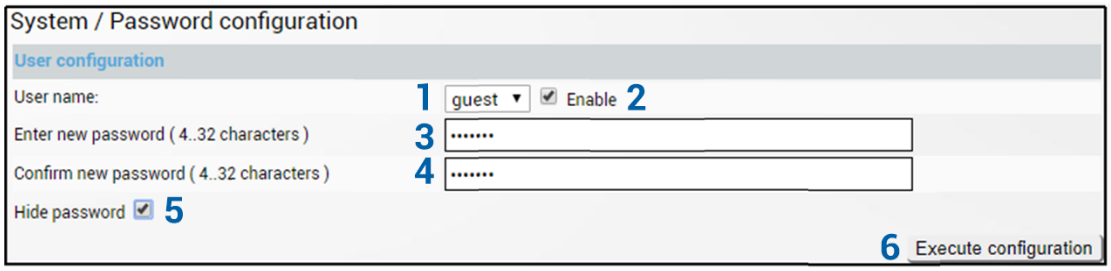


Status mode



Press MODIFY button.

Modify mode



1) ***User name*** – Choose between “admin” and “guest” user accounts. “guest” user has monitoring privileges and cannot apply configuration changes.

By default, the password for the “admin” account is ‘*changeme*’, while no password is defined for the “guest” account (user disabled).

2) ***Enable*** – Check/uncheck to enable/disable user account. “admin” account can not be disabled.

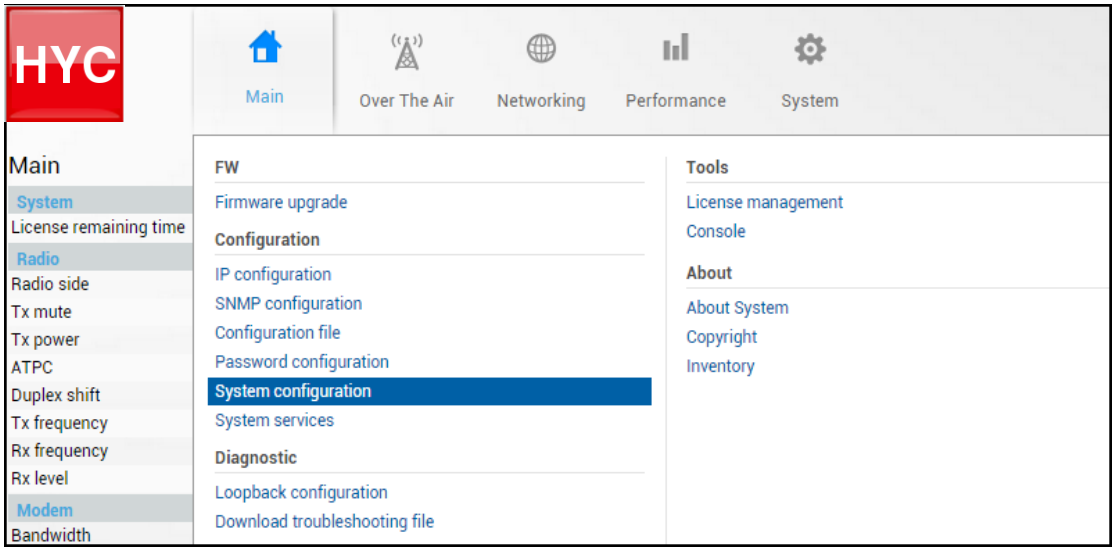
3) ***Enter new password (4..32 characters)*** – Enter a new password. The length between 4 and 32 characters;
4) ***Confirm new password (4..32 characters)*** – Confirm new password. The length between 4 and 32 characters;
5) ***Hide password*** – Uncheck to display the entered password in plaintext.
6) By pressing *„Execute configuration”*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

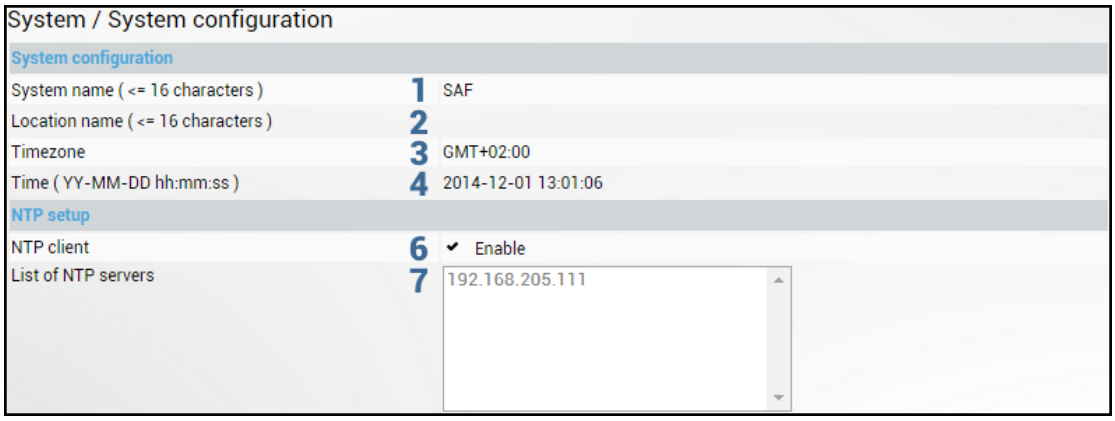
system user info	Use to show information on the current user.
system user mgmt <username> **access** {r|w}	Use to set read (“r”) or write (“w”) access right for particular <username>.
system user mgmt <username> **delete**	Use to delete particular <username>. “admin” user cannot be deleted.
system user mgmt <username> {enable|disable}	Use to enable or disable particular <username>.
system user mgmt <username> **info**	Use to show information on particular <username>.
system user mgmt <username> **password** <password>	Use to set password for particular <username>.
system user new <username> <password> {r|w} <fullname>	Use to create new user with specified <username>, <password>, <fullname> and read (“r”) or write (“w”) permissions.
system user factory	Use to reset all users to factory defaults.
system password change <password>	Use to change the password for the current user.
system password reset	Use to reset all passwords to default.

System → Configuration → System configuration

Specify time settings and system/location names.

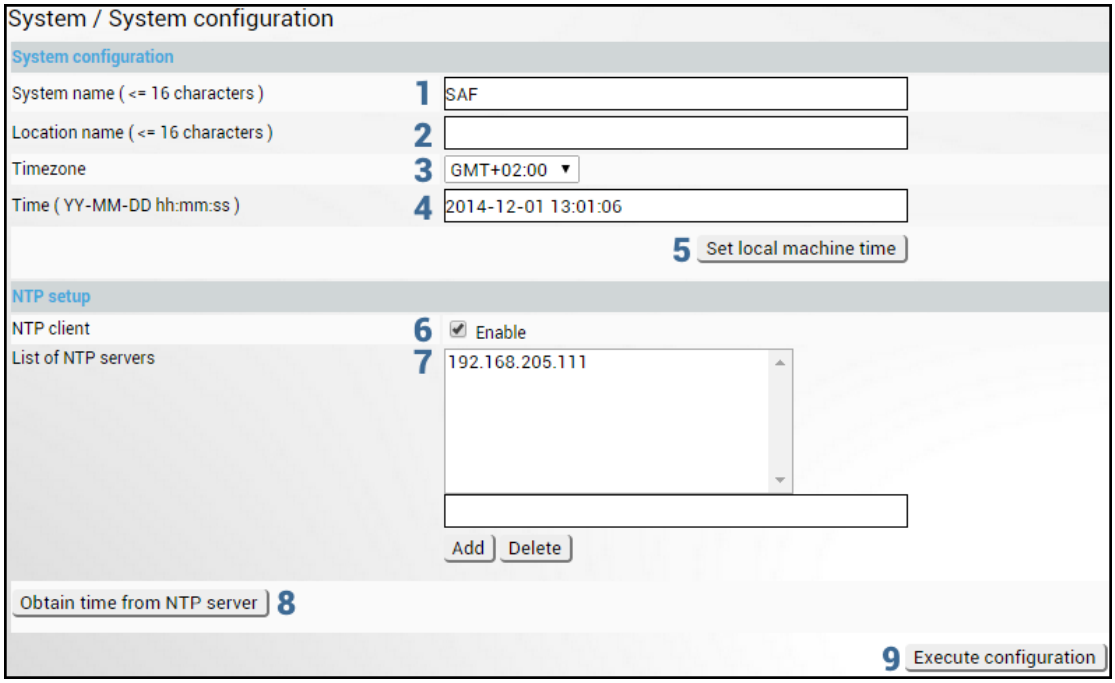


Status mode



Press MODIFY button.

Modify mode



1) ***System name*** – Allows entering a preferable system name. The maximum length of the system name cannot exceed 16 symbols. The default name is 'HYPERCABLE'.
2) ***Location name*** – Allows entering preferable system location name. The maximum length of the location name cannot exceed 16 symbols. By default, the system location is not specified.
3) ***Timezone*** – Allows specifying time zone.
4) ***Time (YY-MM-DD hh:mm:ss)*** – Allows changing system date and time manually by entering date and time in a specific syntax.
5) ***Set local machine time*** – Press to force the system to use the time set on your PC, from which you are connected to the Web GUI.
6) ***NTP client*** – Allows enabling or disabling the NTP (Network Time Protocol) client.
7) ***List of NTP servers*** – Allows adding or deleting IP addresses of NTP servers.
8) ***Obtain time from NTP server*** – Press to force the system to obtain the time from an NTP server.
9) By pressing *„Execute configuration"*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS.

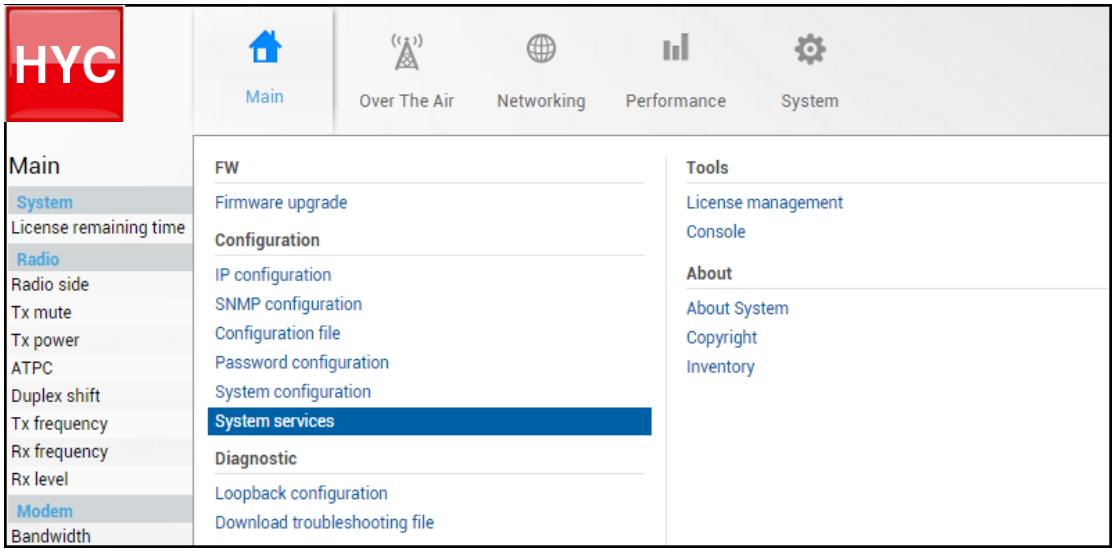
CLI commands (Chapter 4: COMMAND LINE INTERFACE)

system datetime [<datetime>]	Use to show/set system time and date. Use "YYYY-MM-DD/hh:mm:ss" syntax for date/time.
system name [<name>]	Use to show/define system name.
system location [<location>]	Use to show/define system location.
system uptime	Use to show system uptime since last system start.
system ntp status	Use to show NTP status.
system ntp {enable|disable}	Use to enable or disable NTP client.
system ntp server add <IP_address>	Use to add an IP address of an NTP server.
system ntp server remove <IP_address>	Use to remove an IP address of an NTP server.
system ntp server clear	Use to clear the list of NTP servers.
system ntp timezone [<-12:00 ... 14:00>]	Use to show/define UTC time zone.
system ntp sync	User to force the system to obtain the time from an NTP server.

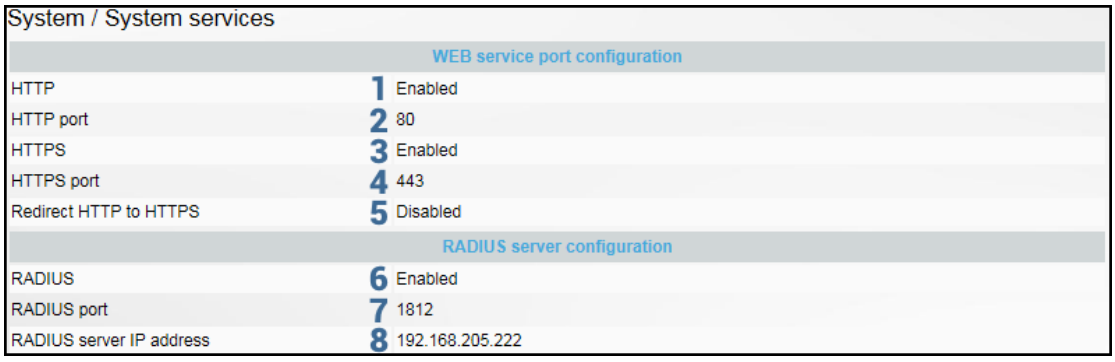
System → Configuration → System services

Define Web GUI connection parameters and centralized user management (RADIUS).

Refer to chapter RADIUS authentication for an example of RADIUS configuration.

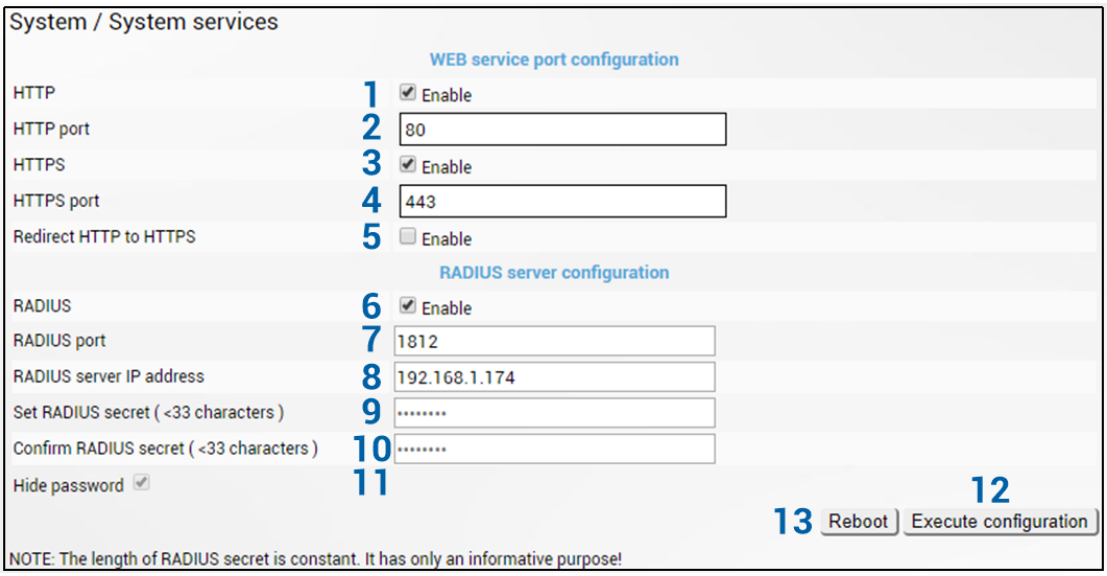


Status mode



Press MODIFY button.

Modify mode



1) ***HTTP*** – Allows disabling or enabling HTTP access to Web GUI. By default, HTTP access is enabled.
2) ***HTTP port*** – Allows specifying TCP port for Web GUI access via HTTP. By default TCP port 80 is defined.
3) ***HTTPS*** – Allows disabling or enabling HTTPS access to Web GUI. By default, HTTPS access is enabled.
4) ***HTTPS port*** – Allows specifying TCP port for Web GUI access via HTTPS. By default TCP port 443 is defined.
5) ***Redirect HTTP to HTTPS*** – Allows enabling automatic redirect from HTTP to HTTPS.
6) ***RADIUS*** - Allows enabling or disabling RADIUS (Remote Authentication Dial In User Service). By default, RADIUS is disabled.
7) ***RADIUS port*** – Allows specifying RADIUS port. By default port 1812 is defined.
8) ***RADIUS server IP address*** – Allows specifying RADIUS server IP address.
9) ***Set RADIUS password*** – Allows specifying RADIUS password.
10) ***Confirm RADIUS password*** – Allows confirming RADIUS password.
11) ***Hide password*** - Uncheck to display the entered password in plaintext.
12) By pressing *„Execute configuration”*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS.
13) ***Reboot*** – Reboots INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS (cold restart).

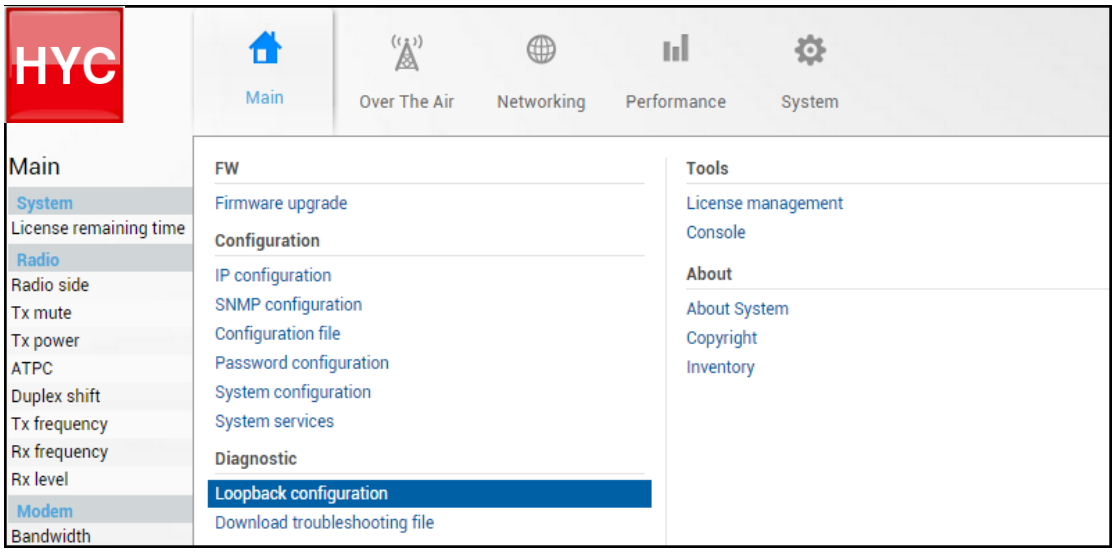
CLI commands (Chapter 4: COMMAND LINE INTERFACE)

system service http [{enable|disable}]	Use to show status or enable/disable HTTP service.
system service http port [<port>]	Use to show/change port number for HTTP service.
system service https [{enable|disable}]	Use to show status or enable/disable HTTPS service.
system service https port [<port>]	Use to show/change port number for HTTPS service.
system service redirect [{enable|disable}]	Use to show status or enable/disable HTTP redirection to HTTPS.
system radius status	Use to show RADIUS configuration status.
system radius {enable|disable}	Use to enable or disable RADIUS configuration.
system radius addr <IP_address>	Use to define RADIUS server IP address.
system radius port <port>	Use to define a port number of a RADIUS server. By default port 1812 is defined.
system radius secret <psw>	Use to define RADIUS server password.
system service ftp	Use to show status or enable/disable FTP service.

[{enable|disable}]	
system service ssh status	Use to show status of SSH service.
system service ssh [{enable|disable}]	Use to enable/disable SSH service.
system service ssh port {set <port>|reset}	Use to define/reset a port number of SSH service. By default port 22 is defined.
system service telnet status	Use to show status of TELNET service.
system service telnet [{enable|disable}]	Use to enable/disable TELNET service.
system service telnet port {set <port>|reset}	Use to define/reset a port number of TELNET service. By default port 23 is defined.

System → Diagnostic → Loopback configuration

Loopback configuration allows verifying system operation.



Status mode

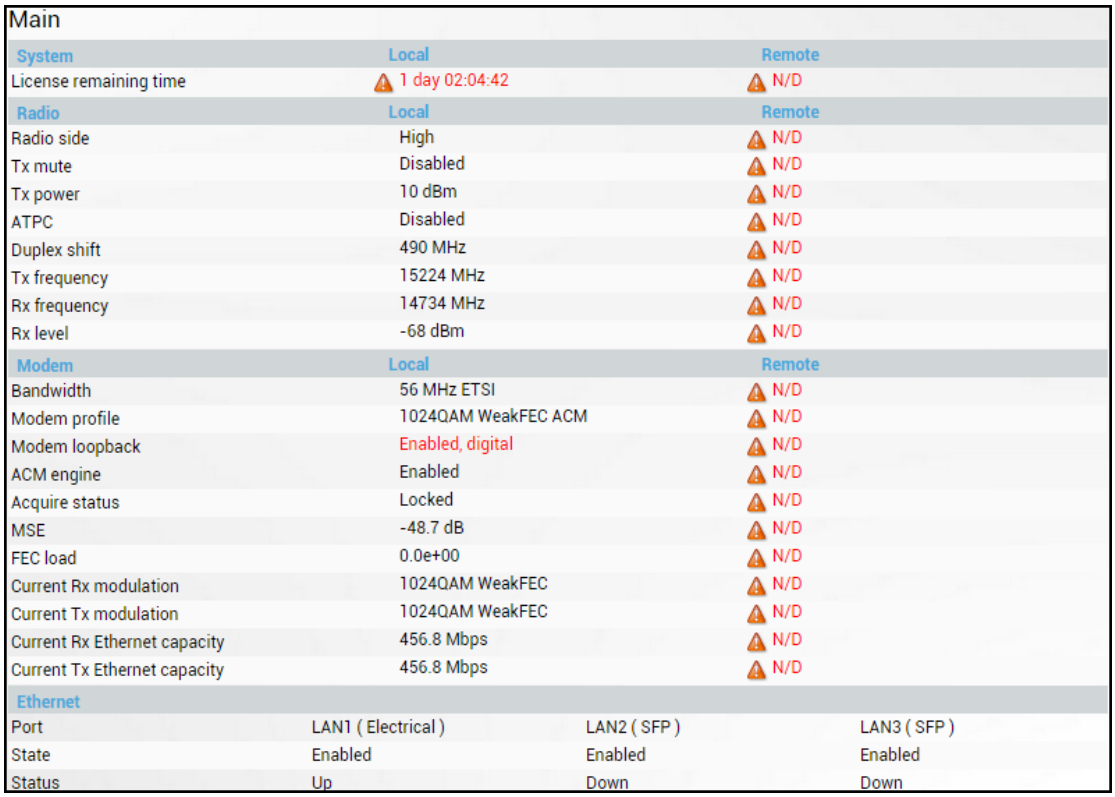
Press MODIFY button.

Modify mode

1) ***Modem loopback*** – Indicates whether modem loopback is active (status mode); Allows enabling modem loopback by changing status to "On" and specifying loopback duration time (modify mode). During modem loopback, the signal is looped back to local end after the modem and INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS should be able to synchronize to itself. Both MSE and FEC load should not generate an alarm (values should not be colored in red). When loopback is activated, "Loopback duration time" countdown timer will appear.
2) By pressing *„Execute configuration"*, changes made to the corresponding section apply only to the local side INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS.

While modem loopback is active “Modem loopback: Enabled, digital” indication will be shown on the Main status page.

Below is an example of the Main status page during modem loopback:



Main

System	Local	Remote
License remaining time	1 day 02:04:42	N/D
Radio	**Local**	**Remote**
Radio side	High	N/D
Tx mute	Disabled	N/D
Tx power	10 dBm	N/D
ATPC	Disabled	N/D
Duplex shift	490 MHz	N/D
Tx frequency	15224 MHz	N/D
Rx frequency	14734 MHz	N/D
Rx level	-68 dBm	N/D
Modem	**Local**	**Remote**
Bandwidth	56 MHz ETSI	N/D
Modem profile	1024QAM WeakFEC ACM	N/D
Modem loopback	Enabled, digital	N/D
ACM engine	Enabled	N/D
Acquire status	Locked	N/D
MSE	-48.7 dB	N/D
FEC load	0.0e+00	N/D
Current Rx modulation	1024QAM WeakFEC	N/D
Current Tx modulation	1024QAM WeakFEC	N/D
Current Rx Ethernet capacity	456.8 Mbps	N/D
Current Tx Ethernet capacity	456.8 Mbps	N/D

Ethernet			
Port	LAN1 (Electrical)	LAN2 (SFP)	LAN3 (SFP)
State	Enabled	Enabled	Enabled
Status	Up	Down	Down

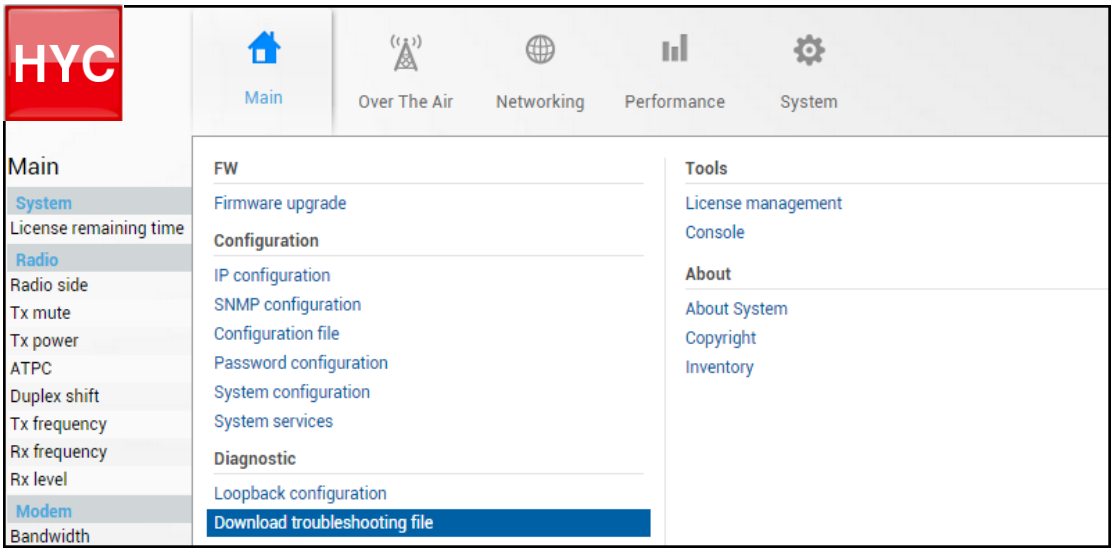
CLI commands (Chapter 4: COMMAND LINE INTERFACE)

modem loopback	Use to show modem loopback status.
modem loopback digital <10..1000000>	Use to enable modem loopback for a specified time in seconds.
modem loopback digital none	Use to disable modem loopback.

System → Diagnostic → Download troubleshooting file

By navigating to the "Download troubleshooting file" a .tar.gz archive containing various troubleshooting data files will be automatically generated and downloaded to your PC.

When contacting HYPERCABLE technical support team (techsupport@Hypercabletehnika.com) regarding troubleshooting issues, please provide the troubleshooting file.



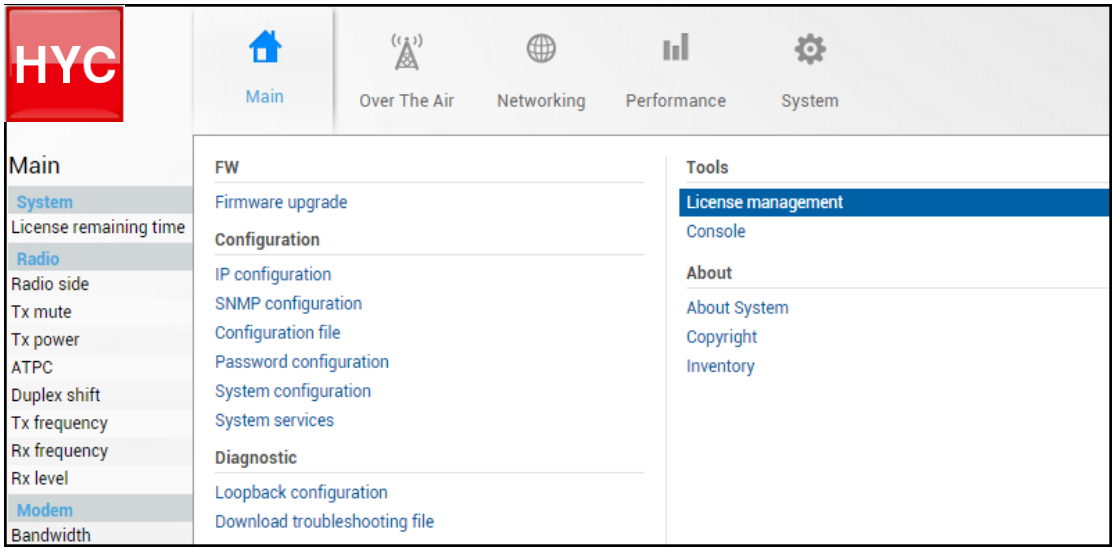
Clicking on the link will download troubleshooting file archive package to your hard disk drive ("Downloads" folder of your browser).

Contents:

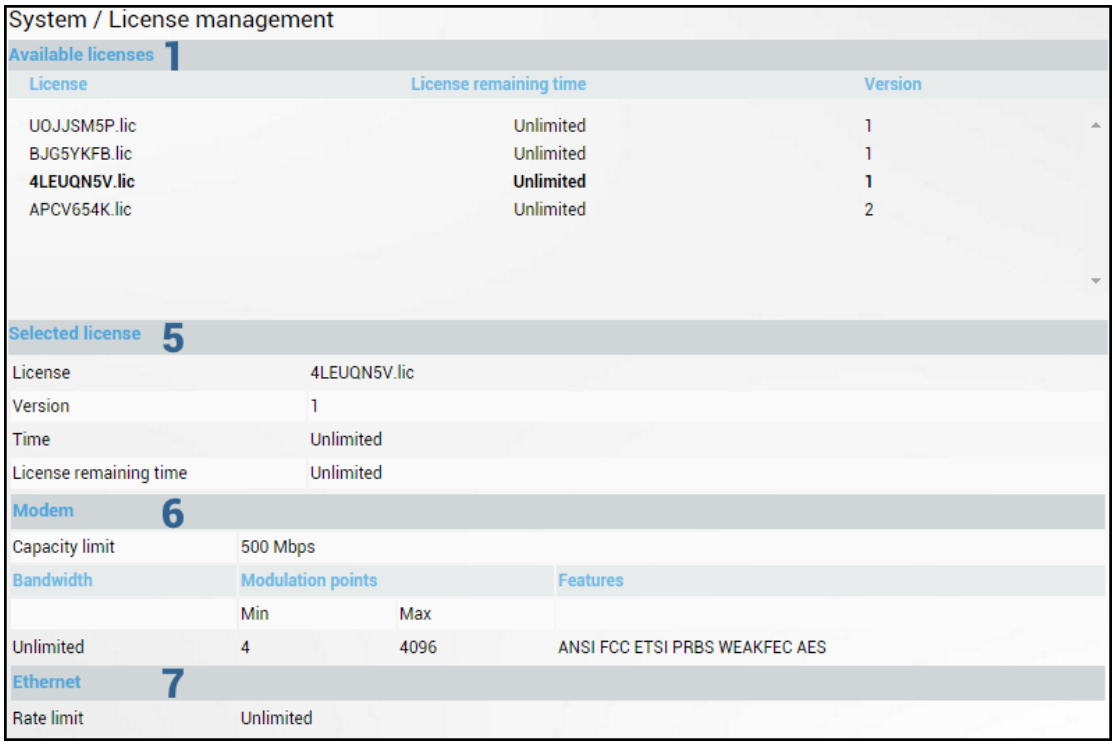
config.txt	Saved system configuration file
conf	Subfolder with last configuration files.
devel.tar.gz	For debugging only
eventlog.txt	Alarm-event log file
Perflog.xml	Performance log with maximum 1440 entries for 1, 15 and 60-minute intervals
troubleshoot.html	Information on currently running firmware and stored firmware files; system configuration including Web services, RADIUS, IP address, user, NTP configuration and inventory info; SNMP v1/v2c/v3 configuration; alarm status, alarm threshold and sensor configurations; radio status, configuration and counters; currently active license and added license files; modem including modem status and configuration, counters, list of allowed modem profiles, header compression; Ethernet configuration and counters of LAN, WAN and MNG ports.
constell.bmp	Snapshot of modem constellation graph.
spectrum.bmp	Snapshot of modem Rx spectrum graph.

System → Tools → License management

Provides a list of available licenses, time left for each license and license upload controls.

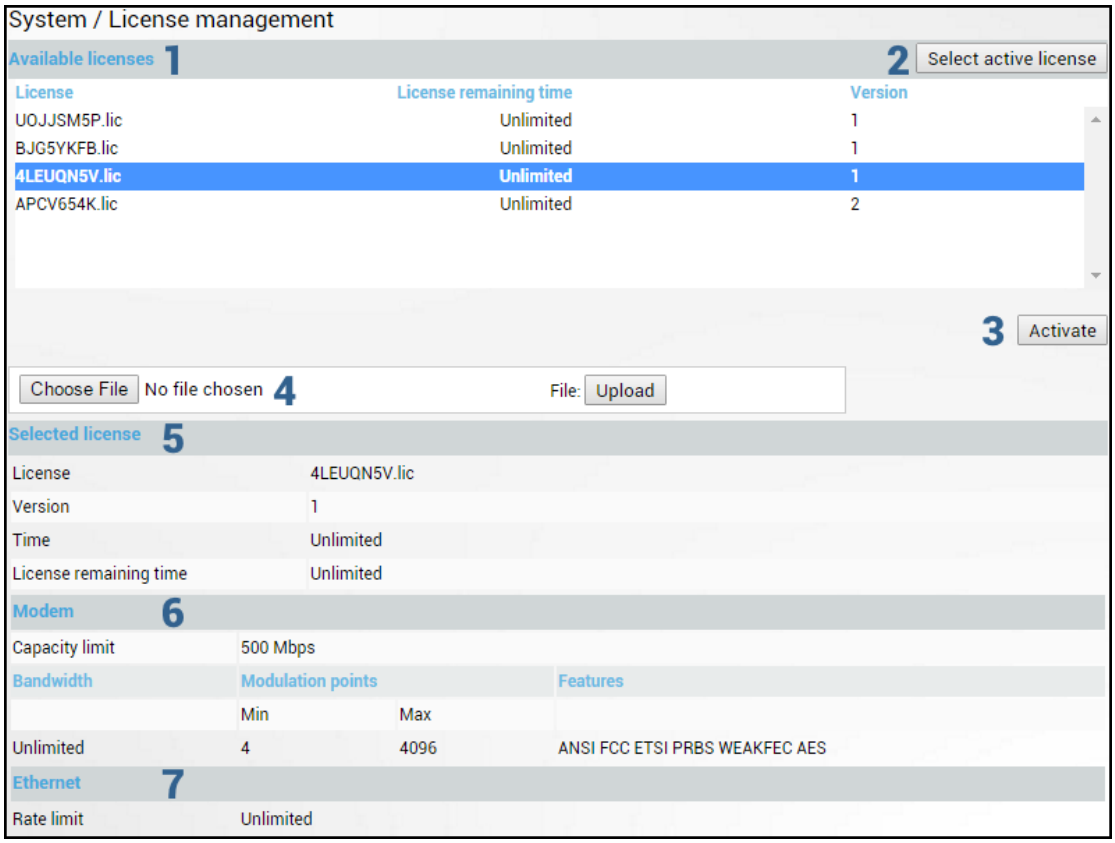


Status mode



Press MODIFY button.

Modify mode



1) ***Available licenses*** – shows a list of available licenses, remaining time and version;
2) ***Select active license –*** automatically selects currently active license from the list;
3) ***Activate*** – Select license from the list and press "Activate" to switch to preferable license;
4) ***Choose file&Upload*** – Press to browse for a license file (*.lic) on your hard disk drive. Press "Upload" to upload a license file (*.lic) to the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS;
5) ***Selected*** – shows version and time of currently selected license;
6) ***Modem*** – shows modem settings of currently selected license;
7) ***Ethernet*** – shows Ethernet rate limitation of currently selected license.

If a new license supports the current modem configuration, no changes will be applied.

If the modem was configured to a modem configuration which is not supported by the new license key, the modem will be reconfigured to the maximum allowed configuration in the chosen channel bandwidth.

When the license expires, the modulation will drop to "4QAM FEC Limited" and the link capacity will drop to 256Kbps.

When the license expires, the next license in the list needs to be activated manually.

Version 1 licenses always have an "Unlimited" Ethernet rate limit.

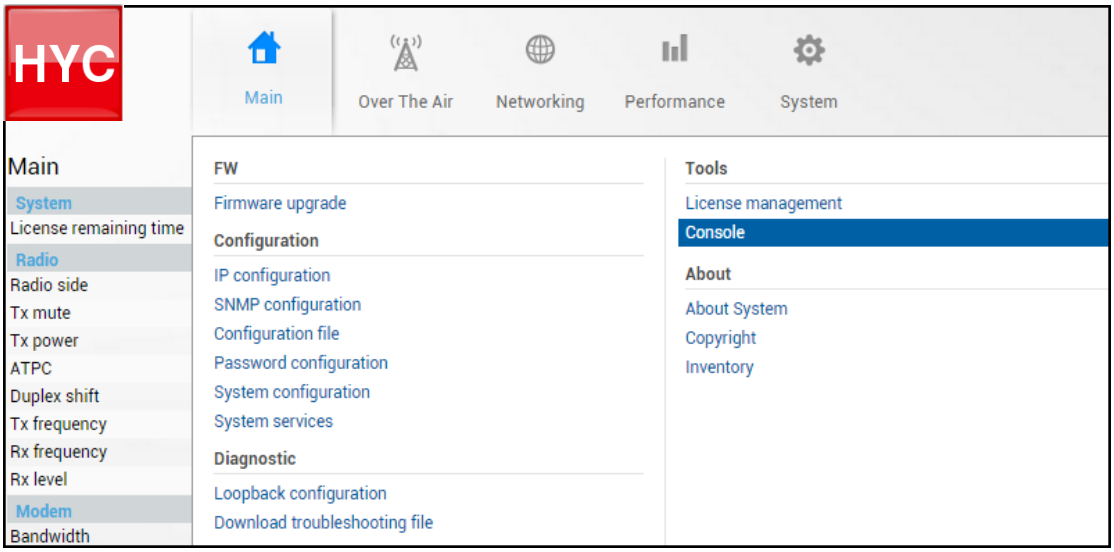
CLI commands (Chapter 4: COMMAND LINE INTERFACE)

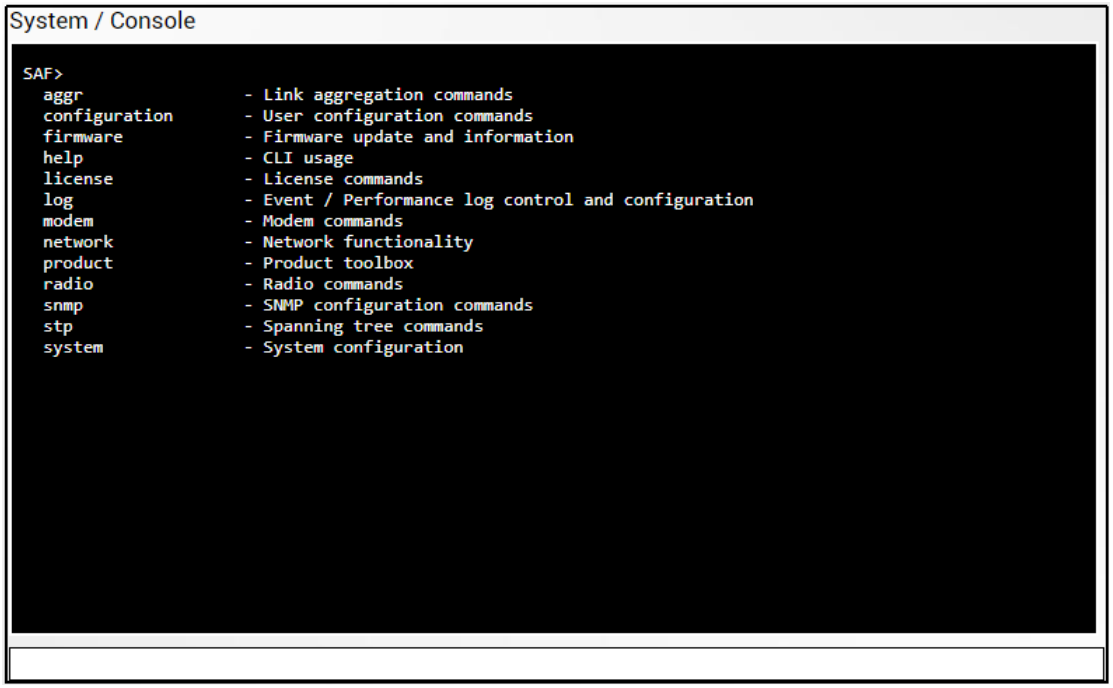
license list	Use to list available licenses.
license list active	Use to view settings of currently active license.
license file list	Use to list available license files.
license file add <filename>	Use to add uploaded the license file to license file list from the

	FTP directory.
license file activate <filename>	Use to activate previously added license file.
license file restriction <filename>	Use to view settings of a license file.

System → Tools → Console

Console provides CLI functionality in Web GUI.





Use syntax "<command> ?" to see information on subcommands.

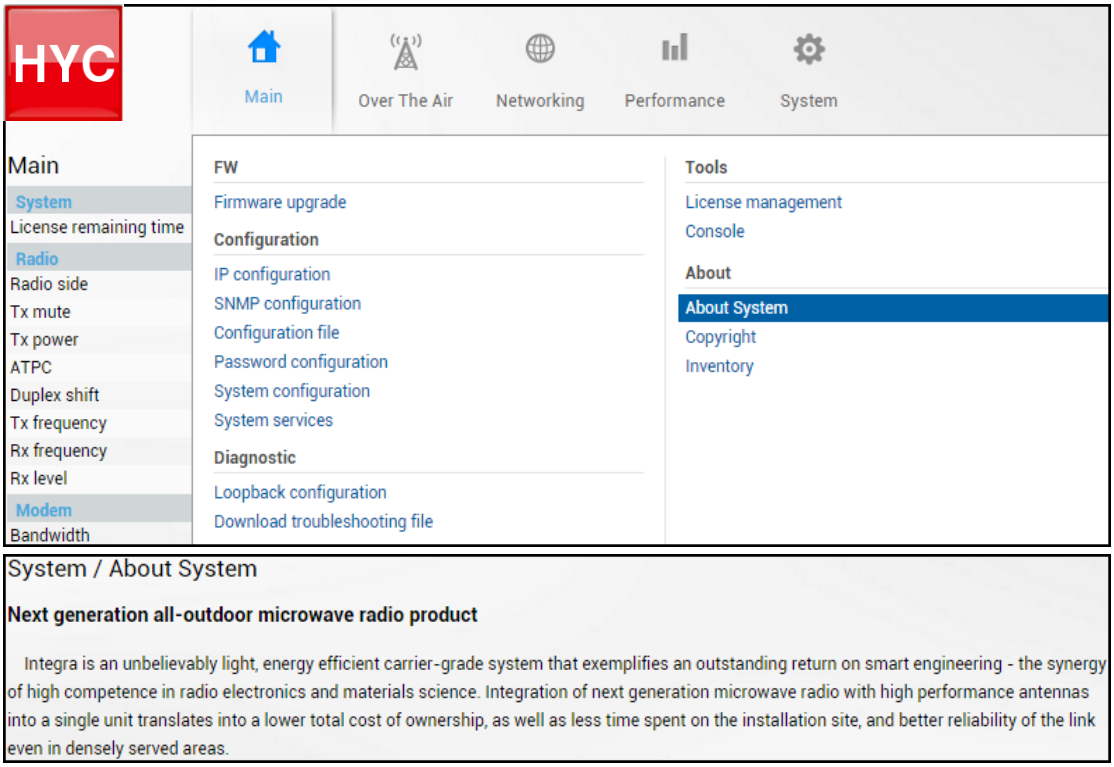
Use ↵ ENTER key to execute entered command.

List of valid CLI commands can be found at the end of each Web GUI page description.

Refer to Chapter 4: COMMAND LINE INTERFACE for details how to connect to other CLI interfaces (serial, SSH, Telnet).

System → About → About System

Provides a short description of INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS series products.

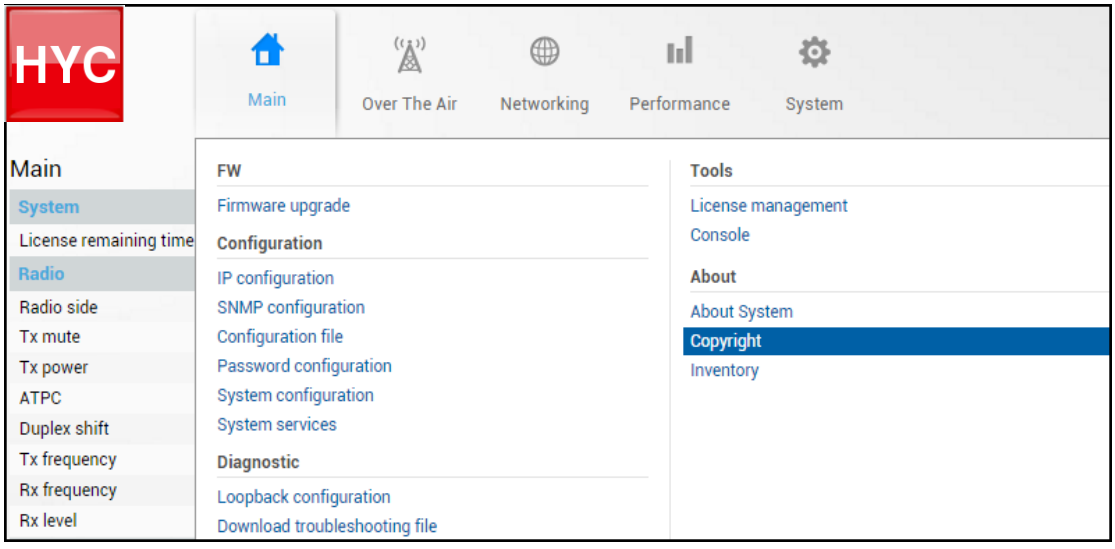


CLI commands (Chapter 4: COMMAND LINE INTERFACE)

product info	Use to show detailed information on the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODU.
system number	Use to show the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS serial number.

System → About → Copyright

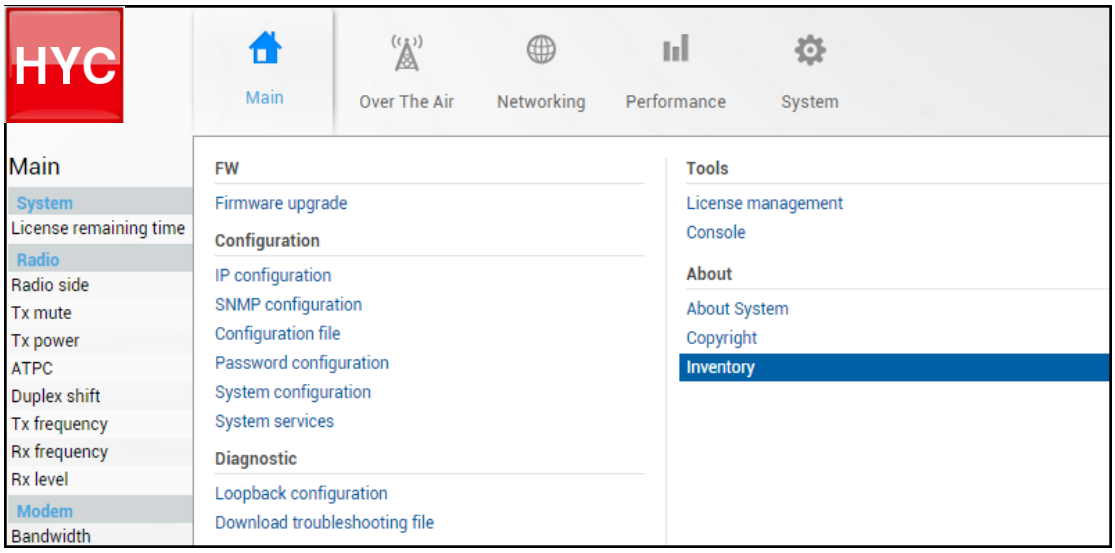
Displays copyright information.



System / Copyright

System → About → Inventory

Displays hardware related information.



System / Inventory

MB ID	0
MB Sub ID	-1
MB revision	1
MAC	000.004.166.129.021.214 - 00.04.A6.81.15.D6
Model	Integra
System Contact	techsupport@saftehnika.com
Device Name	SAF
Description	SAF microwave radio
Copyright	Copyright (c) 2013 SAF Tehnika JSC. All rights reserved.
ODU ID	SAF
Enterprice ID	7571
Product Code	D15B1R12LA
Product Serial Number	381150100013

Chapter 4: COMMAND LINE INTERFACE

Command line interface (CLI) is available via 4 individual interfaces:

- Secure Shell (SSH);
- Telnet;
- Serial terminal;
- Web GUI (System → Tools → Console, partial functionality)

The available CLI commands are found in "CLI commands" tables in appropriate Web GUI page sections in Chapter 3: WEB GUI.

For SSH, Telnet or serial connection you can use any client supporting corresponding interfaces (e.g. PuTTY, Tera Term etc.).

CLI commands are not case sensitive.

A User can abbreviate commands and parameters as long as they contain enough letters to be distinguished from any other currently available commands or parameters.

Useful CLI keyboard shortcuts can be printed by CLI command **help.**

```
SAF>help
  Enter             - Execute current line
  Tab               - Complete current line
  Home              - Move cursor to beginning
  End               - Move cursor to the end
  Up/Down           - History navigation
  Ctrl-k            - Delete the rest of the line
  Ctrl-w            - Delete a word
  Ctrl-c            - End session
  marked text       - Indication of erroneous user input
```

Note that in Web GUI (System → Tools → Console) those shortcuts will not work.

Connecting to serial RS232 interface

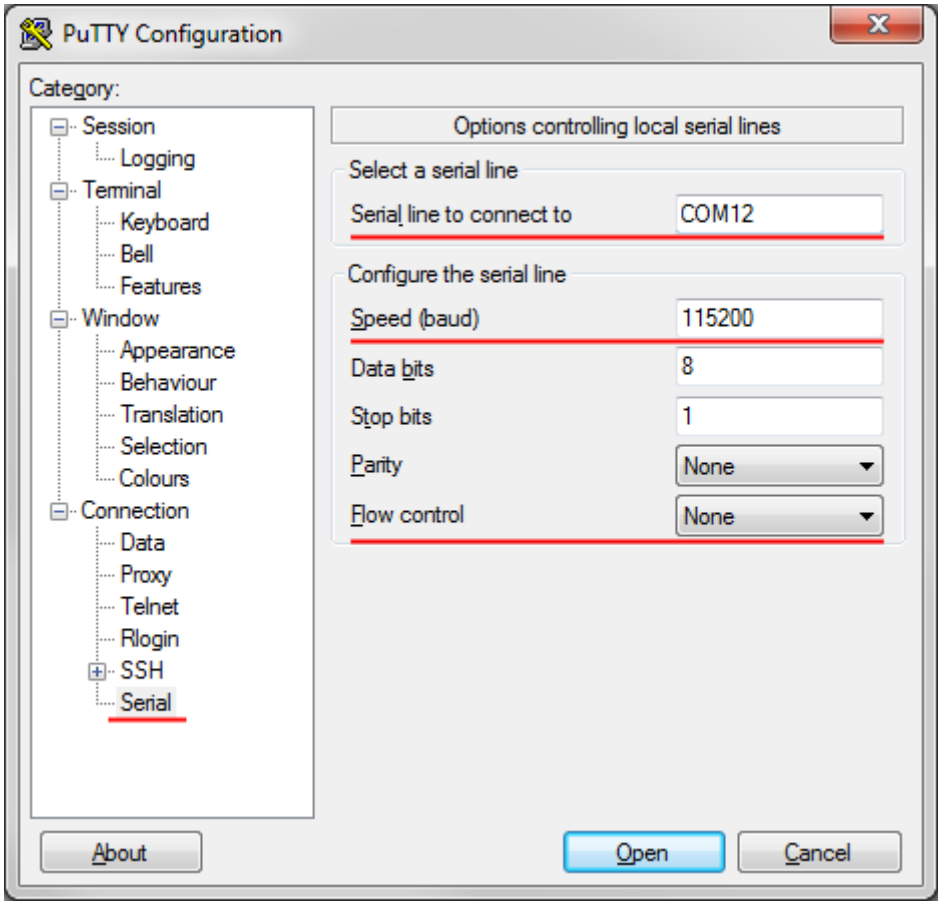
In order to connect to an INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS serial terminal, you will require a USB cable with a USB Type B connector. Please refer to Chapter USB port for pinouts.

To connect the PC to the RS232 management port, using serial terminal-emulation software (e.g. *PuTTY*), use the following parameters:

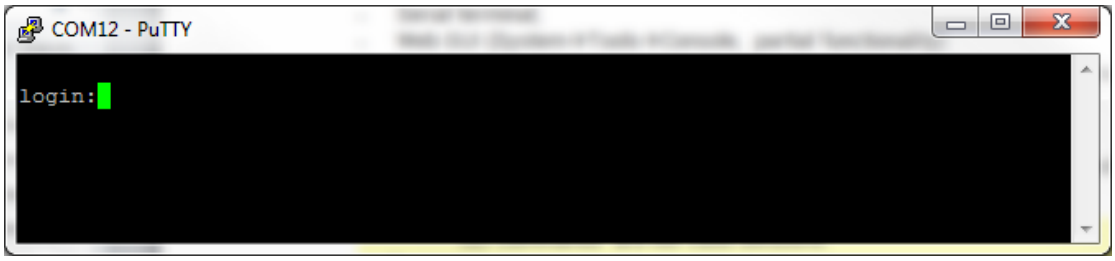
- Baud rate: 115200
- Data bits: 8
- Parity: None
- Stop bits: 1
- Data flow control: None

Below are connection steps with *PuTTY* - Windows freeware software.

1. Open *PuTTY* and go to "Serial" category. Specify your COM port number you will be using, change "Speed (baud)" to "115200" and "Flow control" to "None":



2. Press “Open” and after pressing “Enter” key following login dialog should appear:



3. Enter username and password. Default credentials are as follows:
   - login: **admin**
   - password: **changeme**

4. After successful login “HYPERCABLE>” prompt should appear (prompt will differ if system name is not the default one):

5. Press “Ctrl+C” to log off from the current session.

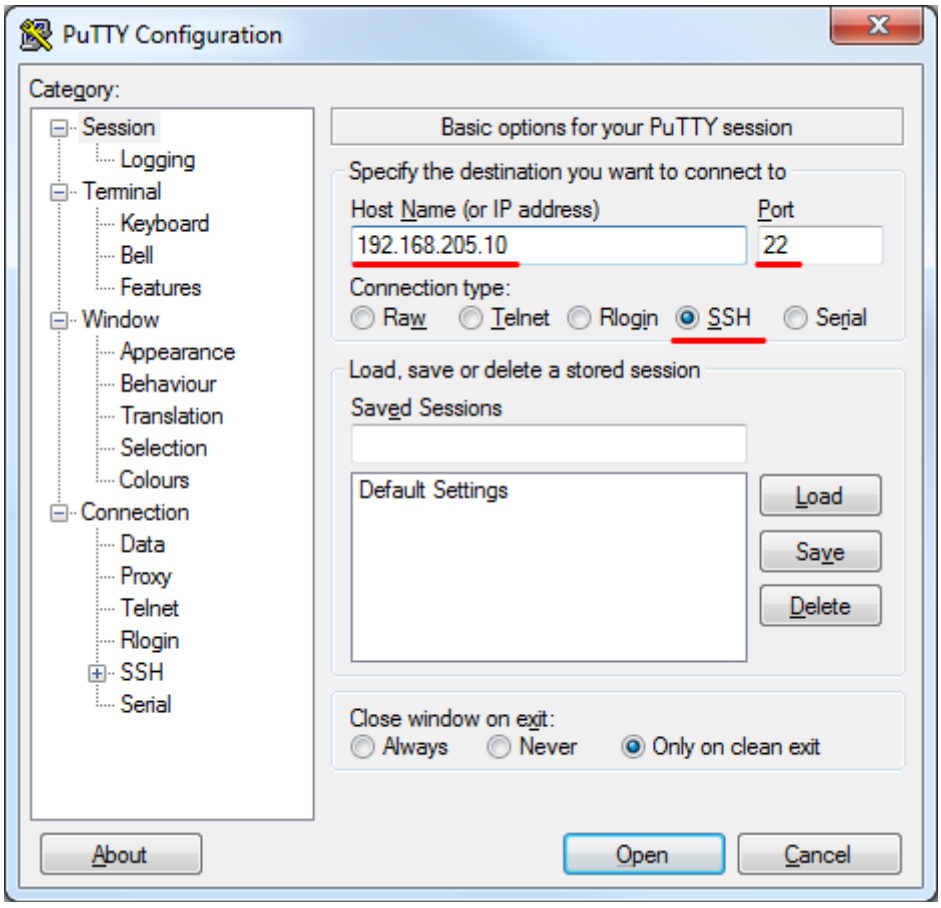
Closing the *PuTTY* window does not log off from the current serial terminal session.

Connecting to SSH

The SSH connection to the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODU is carried out using Ethernet management connection. Please refer to the chapter Ethernet management connection configuration for Ethernet management port connection details.

You can use any SSH client. Below are connection steps with *PuTTY* - Windows freeware software.

1. Open *PuTTY*, choose “Connection Type”: “SSH”, enter the IP address and make sure that the correct port number is used (“22” by default):



2. Press “Open”, enter login credentials (default user name is *admin* and password - *changeme*). After successful login, the following prompt should appear:

3. Enter username and password. Default credentials are as follows:
   - login: **admin**
   - password: **changeme**

4. After successful login “HYPERCABLE>” prompt should appear (prompt will differ if system

name is not the default one):

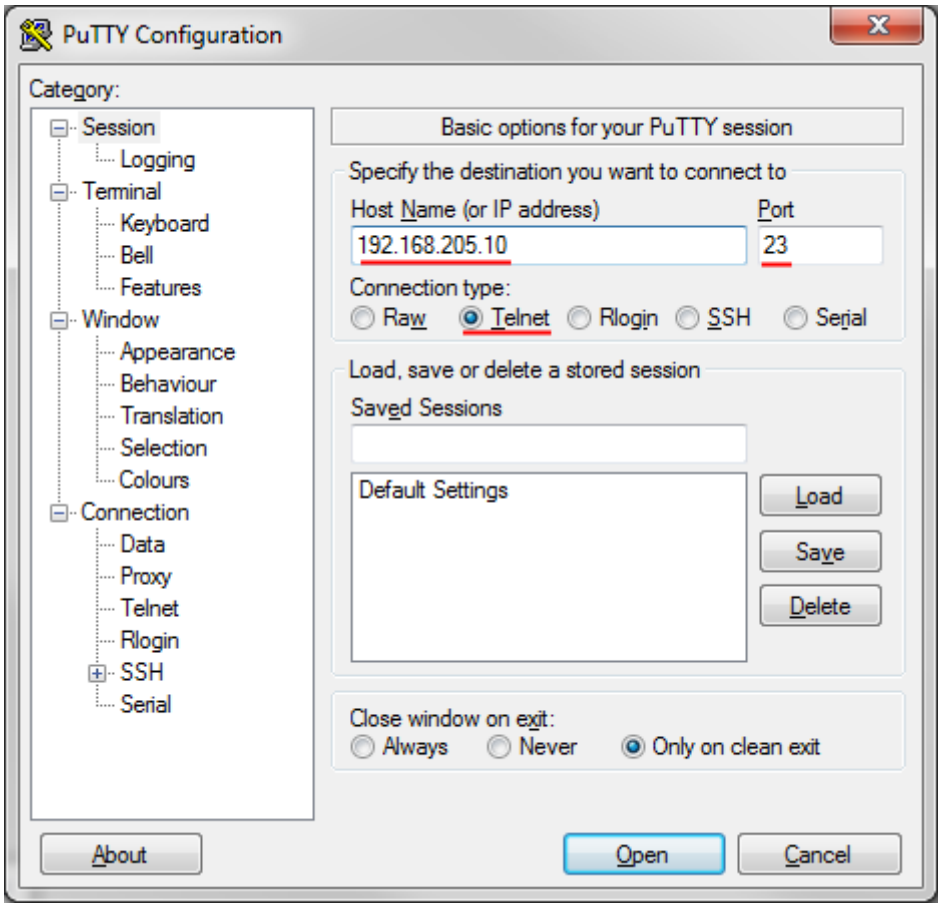
Connecting to Telnet

A telnet connection to the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODU is carried out using the Ethernet management connection. Please refer to Chapter "Ethernet management connection configuration" for Ethernet management port connection details.

By default Telnet service is disabled. See the chapter System → Configuration → System services on how to manage system services.

You can use any Telnet client. Below are connection steps with *PuTTY* - Windows freeware software.

1. Open *PuTTY*, choose "Connection Type": "Telnet", enter the IP address and make sure that the correct port number is used ("23" by default).



2. Press "Open" to connect. After successful connection following prompt should appear:

3. Enter username and password. Default credentials are as follows:
   - login: **admin**
   - password: **changeme**

4. After successful login "HYPERCABLE>" prompt should appear (prompt will differ if system

name is not the default one):

Chapter 5: 17/24GHz

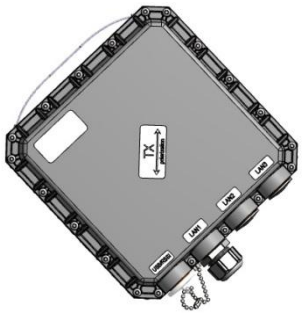
Polarization Considerations

Polarizations at both ends of the link must be opposite for the 17/24 GHz INTEGRAL/ INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODUs.

For example:

***If High side** radio is installed in **Horizontal polarization**,*

***then Low side** radio must be installed in **Vertical polarization**:*



Changing radio side

1) Access the Web GUI of the remote side radio first. Check its current radio side value on the Main page:

Radio	Local	Remote
Radio side	Low	High

2) Go to “System -> Console” and execute the command “**radio side high**” to change the radio side to High (in this particular example) or “**radio side low**” to change the radio side to Low. You will lose the connection to your remote side now.

3) Access the Web GUI of the local side radio. Check its current radio side value on the Main page:

Radio	Local	Remote
Radio side	High	Low

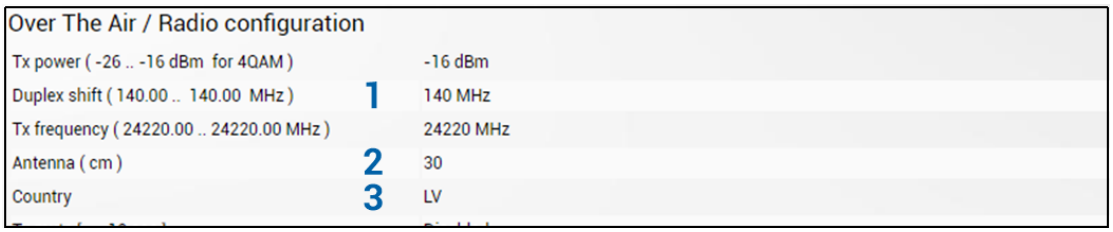
4) Go to “System -> Console” for the local side unit and execute the command “**radio side low**” to change the radio side to Low (in this particular example) or “**radio side high**” to change the radio side to High. The connection to your remote side now will be restored.

5) Save the configuration on both radios.

Radio configuration – extra fields

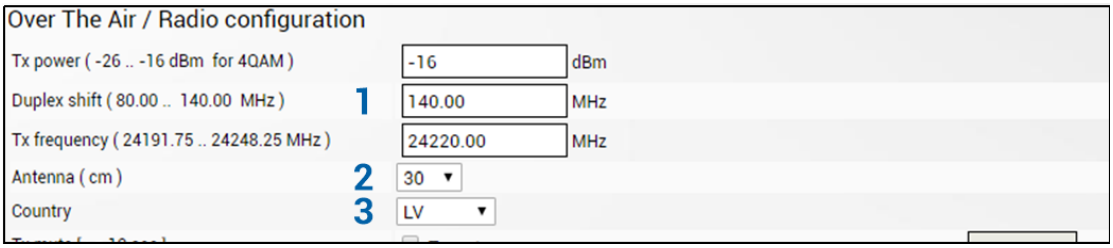
This chapter describes **only differences** of the configuration for the 17/24 GHz INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODUs. For configuration in general, refer to the chapter Over The Air → Radio → Configuration.

Status mode



Press MODIFY button.

Modify mode



1) ***Duplex shift*** – Indicates the value between the transmitter frequency and receiver frequency (status mode); allows specifying the value of duplex shift in MHz (modify mode)
2) ***Antenna*** – Indicates the set size of the installed antenna (status mode); allows specifying the diameter of the installed antenna in cm (modify mode). Max Tx power settings depend on national regulatory EIRP allowance and antenna size. Available values - 20, 30, 60, 99, 120 cm.
3) ***Country*** – Indicates the set country code (status mode); allows specifying the country code (modify mode). Max Tx power settings depend on national regulatory EIRP allowance and antenna size. Available values - AU, AT, BE, BG, CA, CY, CZ, DK, EE, FI, FR, DE, GR, HU, IE, IR, IT, LV, LT, LU, MT, NL, PL, PT, RO, SK, SI, ES, SE, UK, US, Custom.

CLI commands (Chapter 4: COMMAND LINE INTERFACE)

radio duplex-shift [<value>]	Use to show/define the value of duplex shift in kHz.
radio eirp set <antenna> <country>	Use to define antenna size in cm and country code.
radio [status]	Use to show radio status and the existing values.

Setting bandwidth to 60MHz

This chapter describes only differences of setting 60 MHz bandwidth for the 17/24 GHz INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODUs. For configuration in general, refer to the chapter Over The Air → Radio → Configuration.

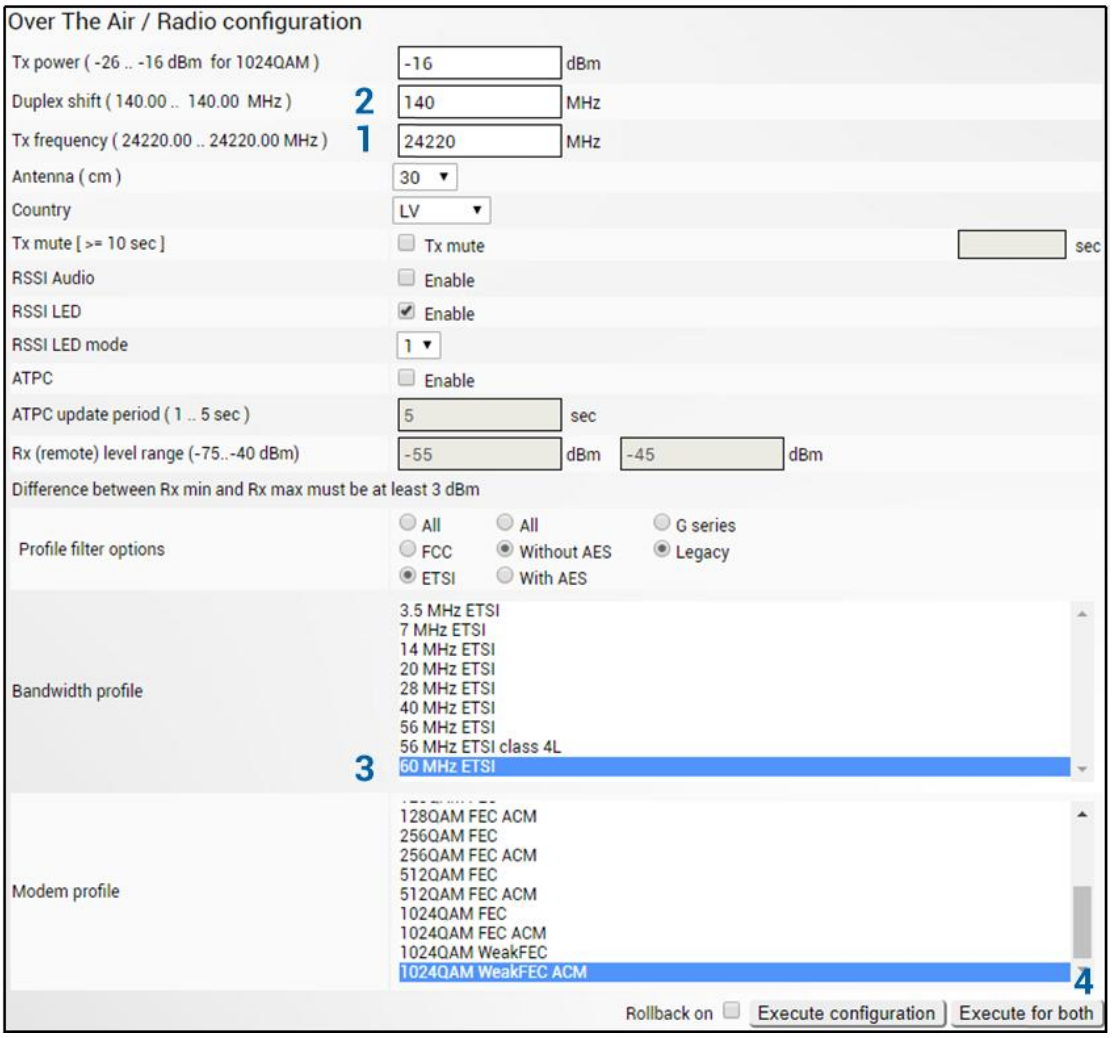
1) Access the Web GUI. Configure the Tx frequency to 17130MHz (17GHz) or 24080MHz (24GHz) if it is low side unit. If it is high side unit, configure the Tx frequency to 17270MHz (17GHz) or 24220MHz (24GHz).

2) Configure the Duplex shift to 140 MHz.

3) Configure Bandwidth profile by selecting needed 60 MHz profile (ETSI/FCC, with/without AES, "G-series"/Legacy).

4) Configure Modem profile and press "Execute for both".

5) Save the configuration on both radios.



Chapter 6: FUNCTIONAL DESCRIPTION

ACM (Adaptive Coding and Modulation)

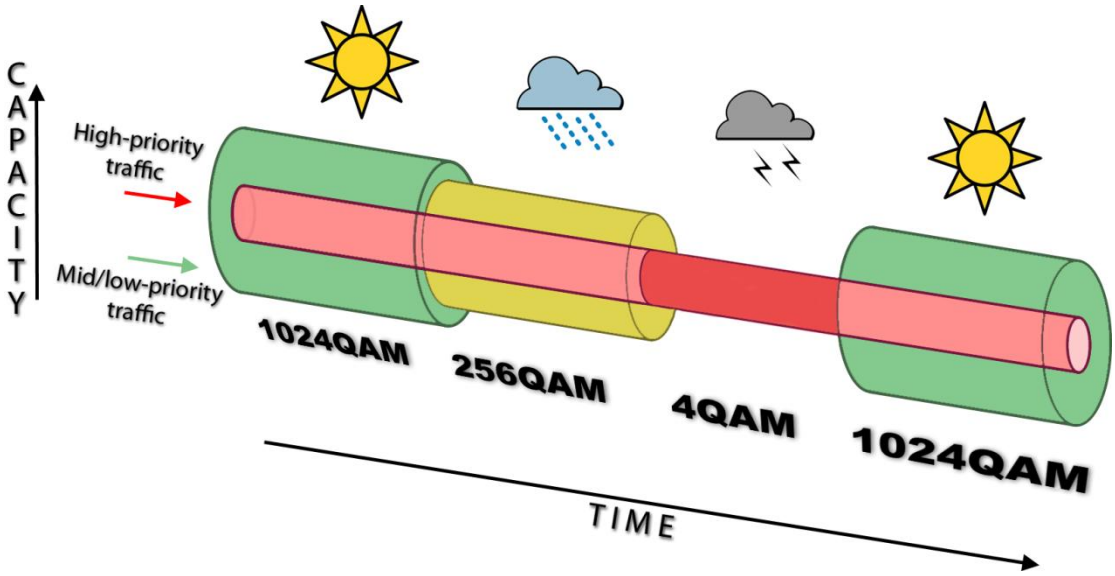
ACM technology allows operators to achieve high-capacity data transmission over microwave links and improve the link utilization. This reduces both operational and capital expenditures for maintaining high-capacity links. ACM can maintain the highest link spectral efficiency possible at any given time in any link condition.

In traditional voice-dominated wireless backhaul transmission networks, service availability levels of 99.995% are the norm.

However, newer services such as Internet browsing, video streaming and video conferencing can operate at more relaxed availability levels. With the use of QoS prioritizing ACM can allocate the required availability based on the priority. As a result, high-priority services such as voice enjoy 99.995% availability, while low-priority services like video streaming are allocated lower priorities.

Use of QoS prioritizing defines which services should be transmitted under any link condition and which services should be adapted whenever the link condition is degraded and the link payload is decreased.

For example, when bad weather has decreased the channel capacity of a link, ACM maintains high-priority services – such as voice data – with full bandwidth capacity while adapting the bandwidth capacity of low- and mid-priority services such as Internet browsing.



Traffic can be mapped into different priorities, which define the level of service for each application. The figure below illustrates how different services – such as rich voice and video – are mapped into different classes of availability (CoA) such as 99.995% or 99.687%.

The implementation of multiple priorities increases the available capacity up to 10 times that of standard links. When conditions are clear, the wireless link operates at maximum capacity and provides all services with the full data rate. When link conditions are poor – during harsh rain, for example – predefined high-availability services such as voice are not affected. However, the capacity of low-priority services is adapted dynamically to the changing link conditions. This is done by provisioning bandwidth according to the link conditions and traffic priority.

An ACM profile defines the link parameters (modulation) for a given range of the MSE (Mean Square Error), which is inverse of SNR (Signal to Noise Ratio). The MSE range of each profile defines the threshold for switching from one ACM profile to another. Each ACM profile has a different spectral efficiency, derived from its modulation and FEC mode.

FEC mode can be Weak or Strong depending on FEC overhead size – smaller or weaker respectively. As a result, Weak FEC mode provides higher throughput (5…10%) sacrificing 2-4dB of sensitivity, and vice versa for StrongFEC.

In order to maintain linearity, Tx power decreases for higher modulations. Tx power difference between 4QAM and 1024QAM is 8dB.

The receiver continuously monitors the link condition based on MSE value.

Once the MSE exceeds the threshold of the current ACM profile, an ACM switching process will be initiated. In case of degradation in the link performance, the new ACM profile will include lower modulation, decreasing the link bitrate. The ACM switching rate is hitless, meaning that no data will be lost during a change of ACM profiles.

MSE values for ACM downshift and upshift can be found in the table below:

	3.5 MHz	**5 MHz**	**7 MHz**	**10 MHz**	**14 MHz**	**20 MHz FCC**	**20 MHz ETSI**	**25 MHz**
16QAM SF-->4QAM SF	-17.9	-18	-18	-18	-18.2	-16.7	-16.7	-16.2
4QAM SF-->16QAM SF	-19.9	-19.4	-19.5	-19.1	-19.6	-18.4	-18.3	-18.8
32QAM SF-->16QAM SF	-22.1	-22.2	-21.5	-21.8	-21.7	-20.5	-20.6	-20.9
16QAM SF-->32QAM SF	-24	-23.6	-23.2	-23.2	-23.4	-22.3	-22.7	-22.5
64QAM SF-->32QAM SF	-24.6	-24.3	-24.3	-23.8	-23.7	-23.5	-23.2	-23.2
32QAM SF-->64QAM SF	-26.1	-26	-25.9	-25.5	-25.5	-25.2	-25.2	-25.2
128QAM SF-->64QAM SF	-28.3	-27.5	-26.9	-27.5	-27.1	-26.3	-26.5	-26.2
64QAM SF-->128QAM SF	-29.7	-29.1	-28.5	-28.9	-28.7	-28.2	-28.2	-27.7
256QAM SF-->128QAM SF	-31.5	-31.4	-30.3	-30.4	-30.1	-24.8	-29.8	-29.4
128QAM SF-->256QAM SF	-32.3	-32.7	-32	-31.9	-31.8	-31.6	-31.3	-31.3
512QAM SF-->256QAM SF			-32.9	-33.3	-33.3	-32.6	-32.9	-32.8
256QAM SF-->512QAM SF			-34.3	-34.9	-34.7	-34.3	-34.5	-34.3
1024QAM SF-->512QAM SF					-36.5	-36.1	-36.4	-36.4
512QAM SF-->1024QAM SF					-38.1	-37.5	-37.8	-37.5
1024QAM WF-->1024QAM SF						-38.6	-38.3	-38

	28 MHz	**30 MHz**	**40 MHz FCC**	**40 MHz ETSI**	**50 MHz**	**56 MHz**	**60 MHz FCC**	**60 MHz ETSI**
16QAM SF-->4QAM SF	-17	-16	-17	-17.2	-17.1	-17.2	-17.2	-17
4QAM SF-->16QAM SF	-18.6	-18.6	-18.6	-18.6	-18.8	-18.6	-18.8	-18.6
32QAM SF-->16QAM SF	-20.2	-20.6	-21.6	-20.9	-20.3	-21.2	-21.7	-20.6
16QAM SF-->32QAM SF	-22.6	-22.5	-22.5	-22.6	-22.2	-22.1	-22.3	-22.3
64QAM SF-->32QAM SF	-22.9	-23	-23.2	-23.1	-23.1	-23.4	-23.1	-23.1
32QAM SF-->64QAM SF	-24.7	-24.6	-24.7	-24.8	-25.1	-25.3	-25.1	-25
128QAM SF-->64QAM SF	-26.5	-26.3	-26.5	-26.2	-26.4	-27.1	-27	-26.7
64QAM SF-->128QAM SF	-27.9	-28.4	-27.9	-27.8	-27.9	-28.1	-28.2	-28.1
256QAM SF-->128QAM SF	-29.6	-30	-29.4	-29.6	-29.6	-29.9	-29.6	-29.6
128QAM SF-->256QAM SF	-31.3	-31.7	-31.3	-31.3	-31.6	-31.1	-31.1	-31.1
512QAM SF-->256QAM SF	-32.8	-32.7	-32.6	-32.7	-32.6	-32.8	-32.7	-32.8
256QAM SF-->512QAM SF	-34.5	-34.5	-34	-34.1	-34.2	-34	-34	-33.8
1024QAM SF-->512QAM SF	-36.3	-36.4	-35.7	-36.2	-35.9	-35.8	-35.3	-35.8
512QAM SF-->1024QAM SF	-36.5	-37.4	-37.3	-37.2	-36.9	-37	-36.8	-36.7
1024QAM WF-->1024QAM SF	-38.1	-38.1	-37.6	-37.8	-37.7	-37.6	-38.3	-38.3
1024QAM SF-->1024QAM WF	-39.4	-39.3	-38.8	-38.9	-39.2	-38.9	-39	-38.7

For example, the link is configured to 1024QAM WeakFEC modulation in 60MHz FCC bandwidth. In order to operate with the highest modulation (and maximum capacity), MSE should be <-38.3dB. If MSE exceeds this threshold, ACM will downshift to 1024QAM StrongFEC. Degrading further below -

35.3dB will downshift to 512QAM StrongFEC. The last ACM downshift will happen after exceeding -17.2dB and link will lose synchronization when MSE reaches -6.8dB.

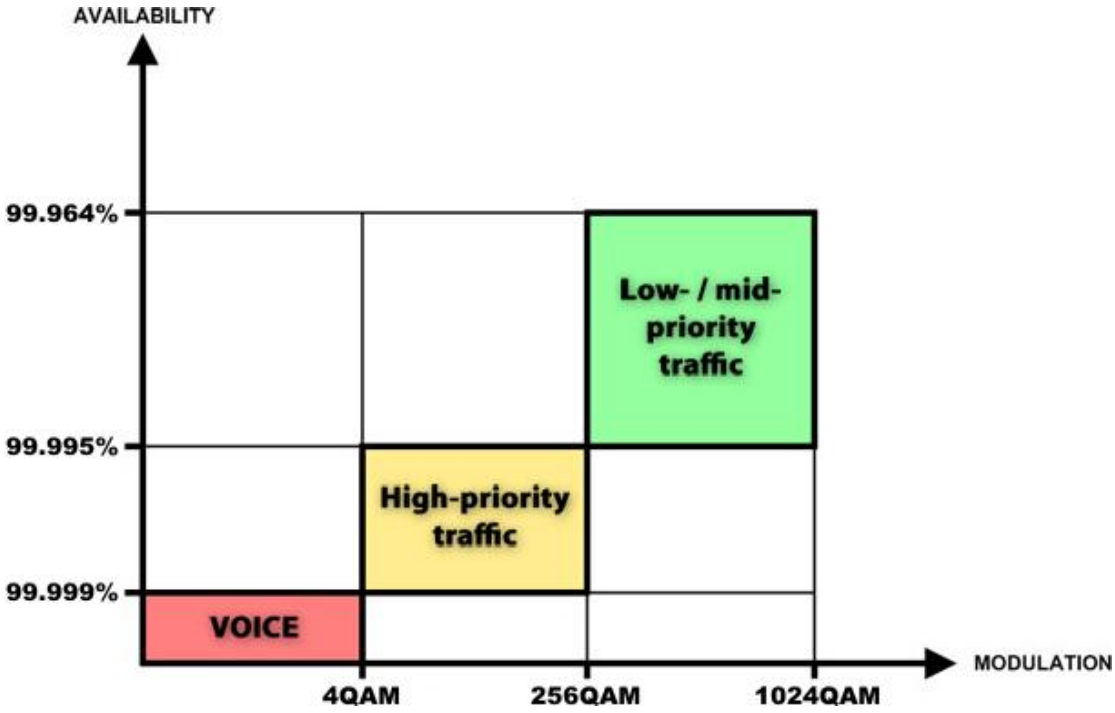
When MSE improves, upshift thresholds will be used. ACM will upshift back to 1024QAM WeakFEC when MSE exceeds -39dB.

Alternatively, ACM can also be used to increase the link distance, resulting in added link spectral efficiency. The same concept is implemented as previously, with the margins that were kept for 99.995-percent bandwidth availability now used to increase the link distance. Whenever the link conditions are degraded, the system will switch to an ACM profile with lower spectral efficiency to maintain link synchronization.

The following real-world example illustrates the benefits of ACM. Consider an INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS link operating at 23 GHz with 60 MHz channel spacing an INTEGRALted antenna with 40.5 dBi (60cm/2ft) gain. The link is operating in a moderate rain zone G (30mm/h) a distance of 11.3 kilometers (7 miles).

The system operation is set to a minimal payload of 74Mbps (4QAM) Ethernet for 99.999% annual availability.

Most of the time system would operate at full capacity of 474Mbps (1024QAM) instead of 74 Mbps (4QAM). The system automatically monitors MSE and changes the capacity without interrupting the data transmission and losing any frames (hitless).



In comparison, a system using 1024QAM without ACM and providing similar capacity would offer only 99.964% of availability. You would have to decrease the distance, decrease modulation or increase antenna sizes to achieve 99.999% availability for the given link.

This example demonstrates how the new technology, based on an ACM mechanism, can play a key role in the development of cost-effective next-generation wireless access networks, by taking advantage of traffic evolution from synchronous TDM traffic to packet IP-based traffic.

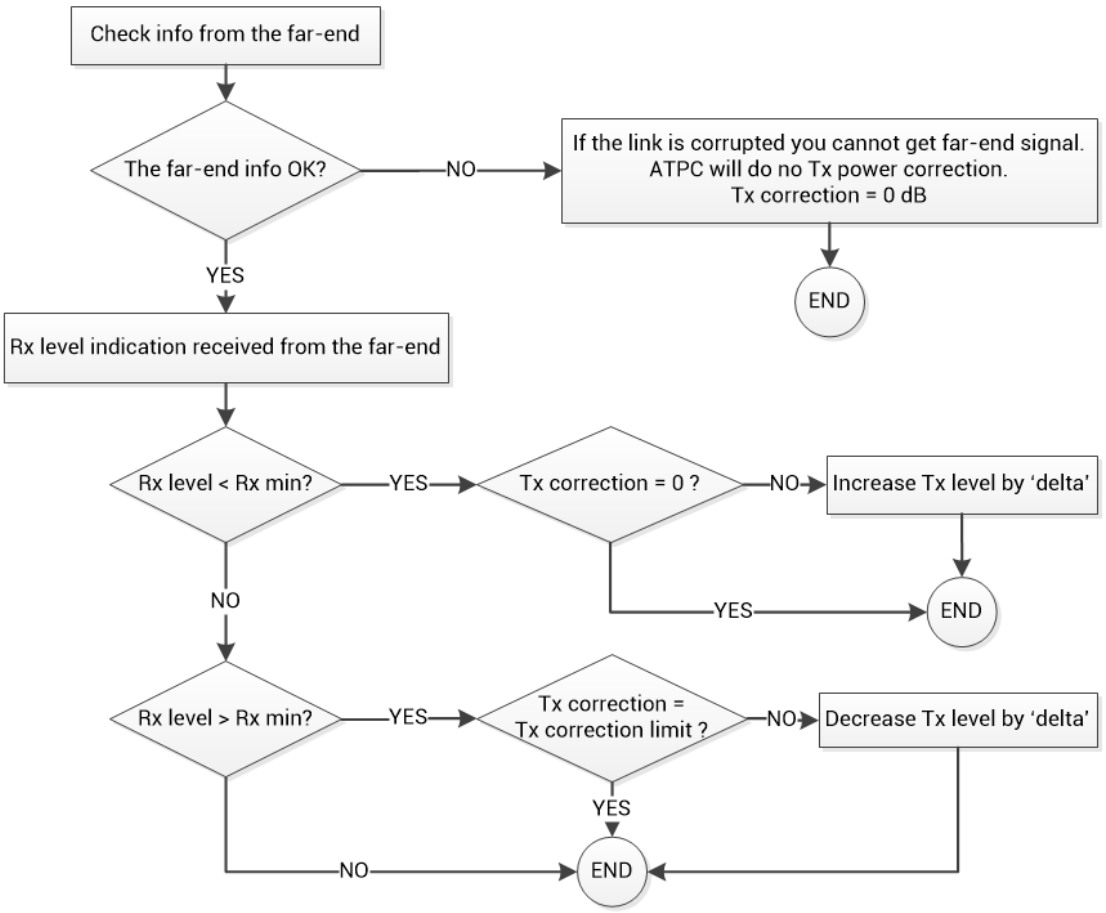
ATPC (Automatic Transmit Power Control)

ACM can be implemented together with **automatic transmit power control (ATPC)**. ATPC reduces the average transmitted power as well as co-channel interference (CCI), and adjacent-channel interference (ACI), which is caused by extraneous power from a signal in an adjacent channel. It also enables a more efficient and cost-effective network frequency plan and deployment, as well as eliminating some of the receivers' "upfade" problems by changing the transmitted power according to

the link momentary conditions. The lower average Tx power also extends the equipment's mean time between failures.

ATPC can be used together with ACM to control the transmitted power in any given ACM profile. Different configurations can be implemented to achieve maximal spectral efficiency or minimal transmitted power using both features in combination. One implementation could target maximal spectral efficacy by trying to reach the highest ACM profile, while the other is willing to compromise on some of the spectral efficiency enabling CCI and ACI reduction. In any chosen configuration, ATPC reduces the average transmitted power, benefiting each ACM profile and any link condition.

The local INTEGRAL receives information about Rx level from the far-end INTEGRAL through the service channel. Depending on the received Rx level parameter, the local INTEGRAL adjusts the transmitter power in accordance with the algorithm shown below.



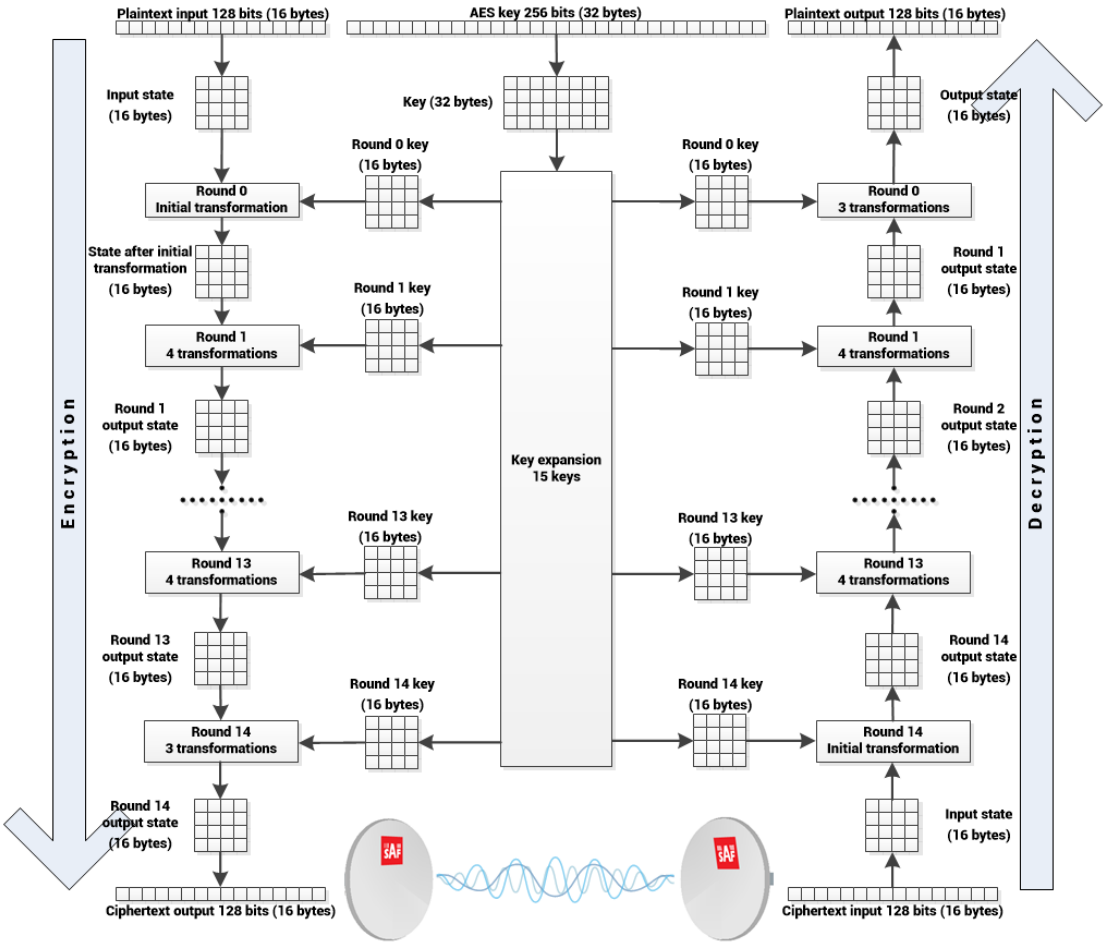
Rx level – the Rx level value received from the far-end site
Rx max – maximum permissible Rx level at the far-end site
Rx min – minimum permissible Rx level at the far-end site
Tx correction – value by what ATPC has decreased Tx power
Tx correction limit – defined maximum of Tx correction
Delta – the value by which Tx power is changed according to the far-end Rx level indication (1dB by default)

AES - Advanced Encryption Standard

Encryption helps to protect information by transforming the original message, called plaintext into an encoded message, called ciphertext. For example, plaintext message "*This is text*", encoded might look like "*RtÜxø«5Ð$·hî*".

AES (Advanced Encryption Standard) is a standardized version of Rijndael cipher algorithm. The AES algorithm is capable of using cryptographic keys of 128, 192, and 256 bits to encrypt and decrypt data in blocks of 128 bits. Based on key size AES is named as AES-128, AES-192, or AES-256.

HYPERCABLE's AES-256 encryption fully complies with Federal Information Processing Standards Publication 197 (2001).



The plaintext input 128-bit block is arranged in the form of 4 x 4 square matrix of bytes. This block is copied into the state array, which is modified at each stage of encryption or decryption. After the final stage, the output state is copied to an output matrix.

Encryption/decryption starts with an initial single transformation (AddRoundKey), followed by 13 rounds each containing four distinct transformation functions: byte substitution (perform a byte-by-byte substitution of the block), ShiftRows (permutation), AddRoundKey (bitwise XOR of the current block with a portion of the round key), and MixColumns (a substitution that makes use of arithmetic over bytes). The final round contains only the first three transformations of above.

Each transformation takes 4 x 4 matrices as input and produces a 4 x 4 matrix as output.

The key expansion function generates 15 round keys to be used at rounds. Each round key serves as one of the inputs to the AddRoundKey transformation.

Header compression

In many applications such as Voice over IP (VoIP), interactive gaming, or messaging, the size of the header is significant compared to the size of the payload data. Over the end-to-end connection comprised of multiple hops, these headers are significant, but they can be omitted over a single link. It is beneficial to compress those headers to provide high-capacity packet saving, achieve better bandwidth utilization, and use the expensive resources in an efficient manner. Reduction in packet loss and improved interactive response time are additional important benefits gained by the header compression.

Header compression is accomplished by identifying packets with a recurring pattern of their header fields. Such header fields with recurring values are omitted and replaced with a much shorter tag (2 to 4 bytes). The tag that replaces the mask is known as a compression tag.

Packet Header Compression Header compression engine enables compression of the following protocols over the radio link:

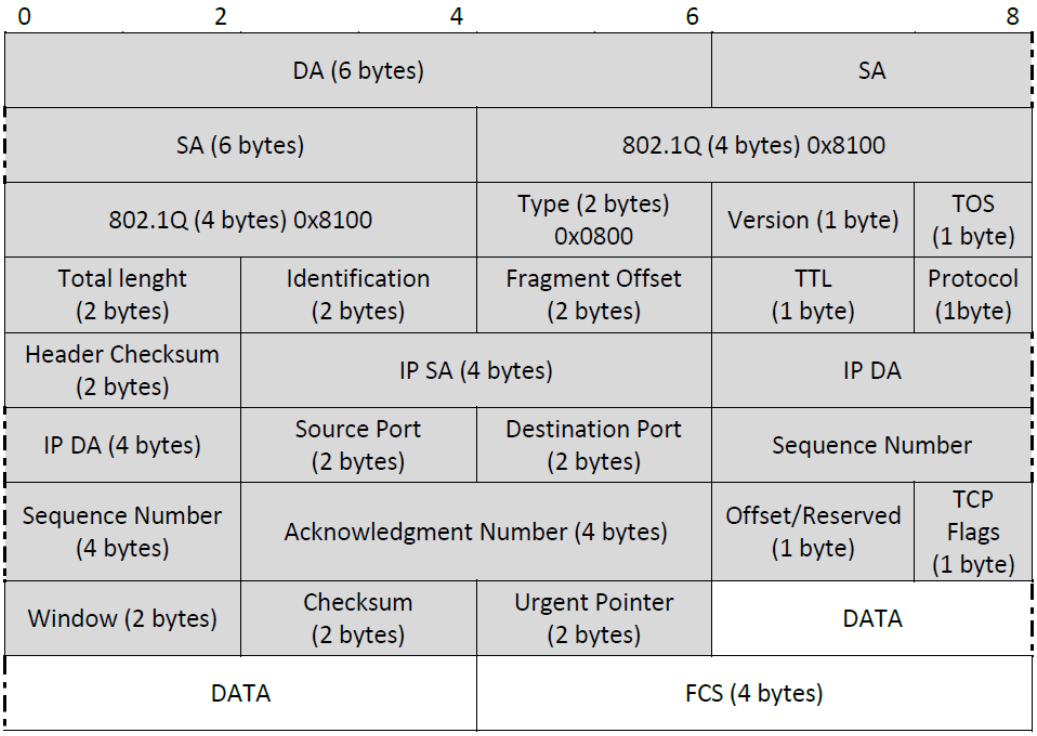
- VLAN
- IPv4
- IPv6
- UDP
- TCP

Header compression creates a compression gain which is the ratio between the original packet capacity and the compressed packet capacity. The compression gain achieved depends on the header and packet size, and the recurrence of the various packet types. For example, compressing Layer 2 and Layer 3 headers of a 128-byte long Ethernet frames yields more than 37% compression gain (this includes IFG, Preamble and FCS removal, and GFP-added encapsulation), e.g. instead of 460 Mbps without Header compression, tests show 633 Mbps with Header Compression.

In this example packets had Layer2+VLAN(0x8100)+VLAN(0x8100)+IPv4+TCP headers. See the picture below (header fields in white are not subject to compression).

In addition, removal of Layer1 Preamble (7 bytes), start frame delimiter (1 byte), FCS (4 bytes), and Interframe Gap (12 bytes) takes place.

A handshake mechanism between the transmitter and the receiver ensures that header compression is synchronized on both sides of the link. Receiving side is removing the compression headers and reconstructing the original header fields.



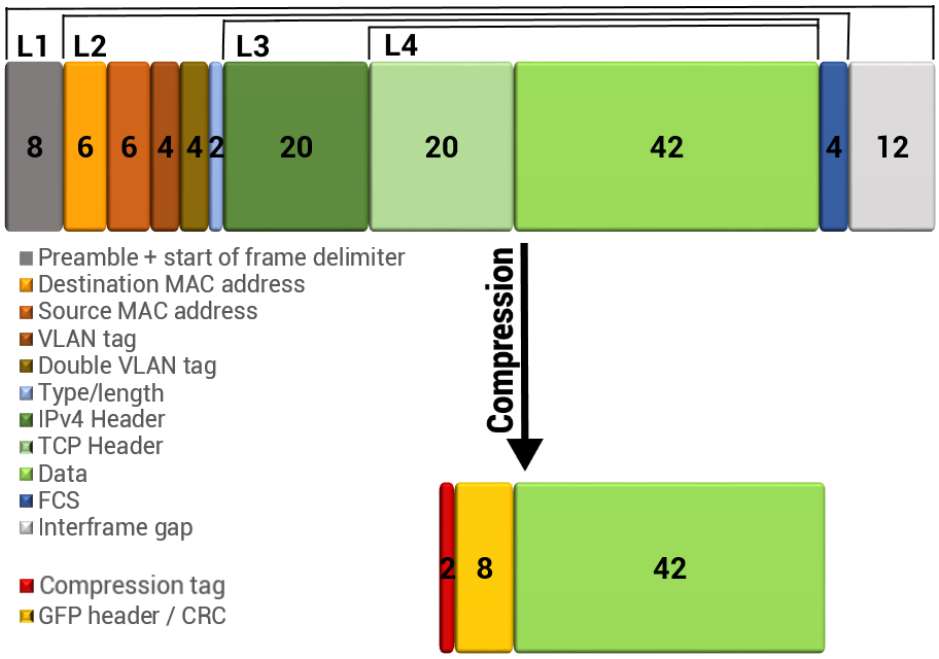
Header Replacement

At the transmitter, the header is removed and replaced by the compression tag.

One of the bits in the GFP header indicates to the receiver if the packet is compressed.

The receiver uses the compression tags to search the database for the original header fields. It then replaces the compressed tags with the original header fields. In case the original packet CRC was removed, a new CRC is recalculated at the MAC.

Example with the same as above (2x802.1Q VLAN + IPv4 + TCP) 128-bytes frame:



Header Compression Statistics

The average compression gain is calculated by reading the byte counters in a resolution period of 1s.

The compression measure the net compression gain and the gross compression gain:

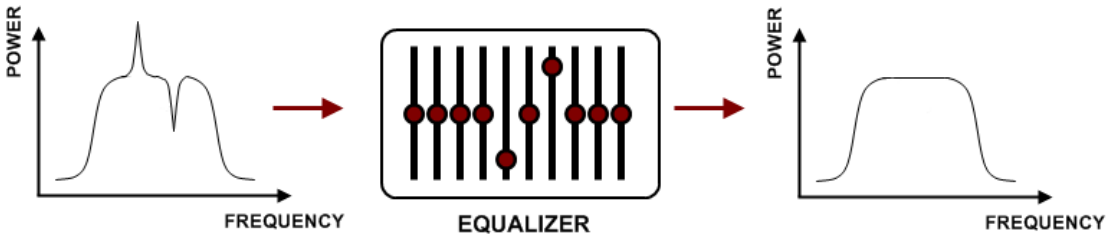
- Net compression gain represents the compression ratio in percentage of the outgoing bytes of the header compression block to the incoming bytes.

- Gross compression represents the compression ratio in percentage between incoming bytes to the outgoing bytes including the PLA and the GFP overheads.

Adaptive equalizer

The INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS features an adaptive equalizer, which is a filter that automatically adapts to time-varying properties of a communication channel with selective fading, having a target to compensate the inequalities in frequency response, mitigating the effects of multipath propagation. In wireless telecommunications, using QAM modulation this filter equalizes not only a separate quadrature channel, but provides a cancellation of cross-interference between them.

In INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS, the adaptive equalizer is realized as a complex-arithmetic 40-taps digital FIR (Finite Impulse Response) filter. In other words, the equalizer is a selective frequency amplifier and attenuator, a device, which in application to IF (Intermediate Frequency) band-limited signal is schematically shown in the picture below:



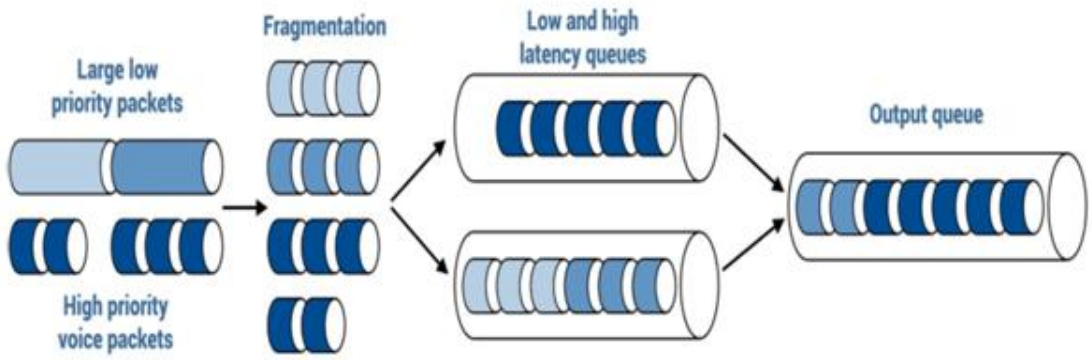
Fragmentation and interleaving

When transmitting delay or jitter sensitive traffic, like, for example, Voice over IP, it must be transmitted across the network within a specific amount of time in order to ensure high quality.

The problem occurs is that a high priority packet needs to be transmitted across the link at the same time the link is committed to transmitting some large packet. Without fragmentation and interleaving active, the high priority packet will wait behind this large packet until it is sent completely and this could introduce a delay that will make the VoIP packet unusable for an active VoIP conversation.

Packet fragmentation and interleaving allow reducing the delays and jitters by splitting packets into fragments and interrupting transmission of low priority fragments. To achieve best results packet fragmentation and interleaving should be enabled on lower priority queues. As result, packets and packet fragments are arranged and transmitted according to the priorities. The fragmented datagrams are reassembled at the receive side.

The figure below illustrates the process of fragmentation and interleaving. When large low priority packets and small high priority (like voice) packets arrive at the same time, the large packets are fragmented into small fragments, which are then added to the queues along with the high priority packets.



The “price” for using fragmentation and interleaving is that it creates an extra overhead. Depending on the size of fragments produced overhead is approx. 1-3%. Resulting latency decrease might reach up to 1.5%.

FTP directory

FTP directory of INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS can be used in combination with CLI commands to backup/restore system configuration, upload another FW version, upload new license file.

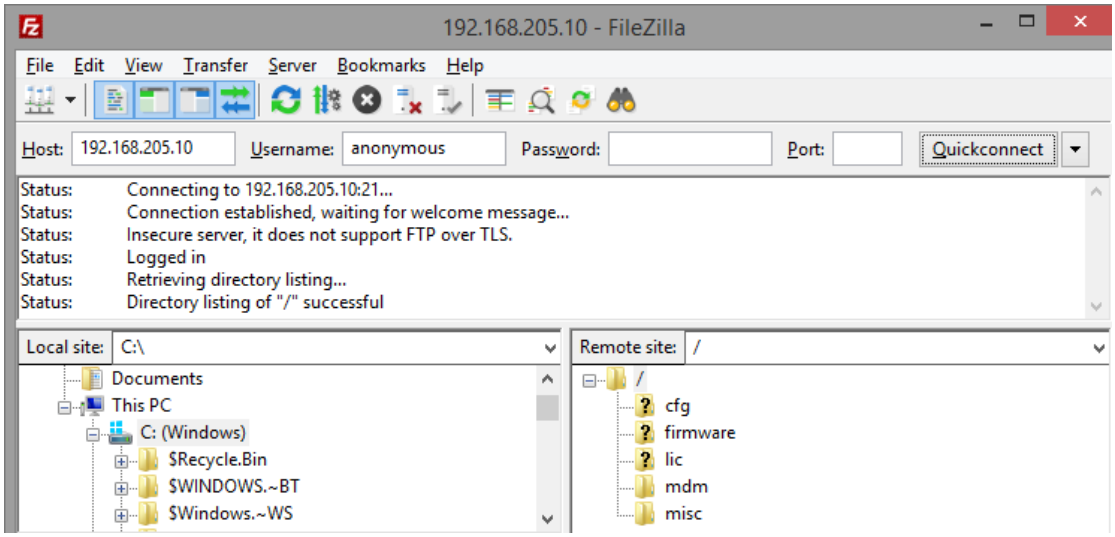
FTP directory is separated area of internal memory in INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS.

FTP directory function is deactivated by every restart of INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS and all files from this special area are wiped out.

Use CLI command **system service ftp enable** to activate FTP directory function.

After system service ftp is enabled it is possible to connect to INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS by using your favorite FTP client. Username is **anonymous** and password is empty.

Here is an example of FTP connection to INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS using FileZilla:



FTP area has a number of sub-directories separating every sub-function:

cfg	For managing system configuration backup/restore files. More information in Chapter System → Configuration → Configuration file.
firmware	For uploading a firmware files. For more information see Chapter System → FW → Firmware upgrade and CLI commands of Chapter Over The Air → Radio → Configuration.
lic	For uploading a license files. For more information see Chapter System → Tools → License management
mdm	For service use only.
misc	For service use only.

After finishing your work with FTP directory, deactivate it by CLI command **system service ftp disable** .

RADIUS authentication

Configuration of the Radius server authentication

The configuration of the FreeRADIUS software based in Linux system (Ubuntu) is given as an example.

1. Add new user data to the users configuration file: */etc/freeradius/users*

   Add the following line to the users` list:

   user_1 Cleartext-Password := "pass_1"

   where *user_1* is a user name and *pass_1* is a password.

```
# This is a complete entry for "steve". Note that there is no Fall-Through
# entry so that no DEFAULT entry will be used, and the user will NOT
# get any attributes in addition to the ones listed here.


user_1  Cleartext-Password := "pass_1"

#
#steve  Cleartext-Password := "testing"
```

2. Add client (INTEGRAL) data editing the clients configuration file: */etc/freeradius/clients.conf*

   Add the following lines specifying INTEGRAL IP address and the RADIUS secret:

   client 192.168.205.10 {

   secret = radiuspass_1

   }

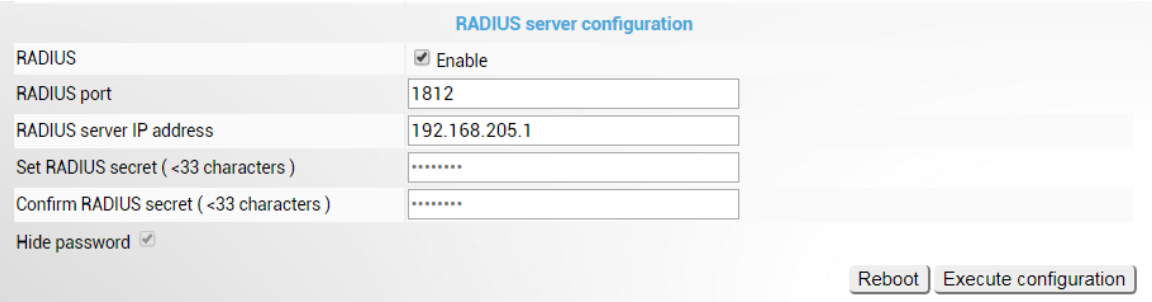
   where *192.168.205.10* is the IP address of INTEGRAL, *radiuspass_1* is the RADIUS secret word.

```
#  the "ipaddr" or "ipv6addr" fields.  For compatibility, the 1.x
#  format is still accepted.
#


client 192.168.205.10 {
secret = radiuspass_1
}
```

3. Restart FreeRADIUS.
4. Set up the RADIUS configuration in INTEGRAL Web GUI:
   4.1. Open the RADIUS server configuration page (System → Configuration → System services).
   4.2. Configure RADIUS port, RADIUS server IP address and RADIUS secret parameters according to your setup.

RADIUS server should belong to the same subnet as INTEGRAL and should have the same secret word as INTEGRAL.



5. Execute a configuration, save the configuration changes and reboot INTEGRAL.
6. Log in to INTEGRAL using the secure HTTPS connection.
7. Proceed to assigning the administrative rights for a user if needed.

Assigning administrator rights to RADIUS user

1. Add the following Attribute to the main FreeRADIUS dictionary file. Open the file: */etc/freeradius/dictionary*

   Add the following line under the *"Miscellaneous attributes…"*:

   ATTRIBUTE HYPERCABLE-User-Level 52 string

```
#
#       If you want to add entries to the dictionary file,
#       which are NOT going to be placed in a RADIUS packet,
#       add them here.  The numbers you pick should be between
#       3000 and 4000.
#
ATTRIBUTE       SAF-User-Level          52      string
#ATTRIBUTE      My-Local-String         3000    string
#ATTRIBUTE      My-Local-IPAddr         3001    ipaddr
#ATTRIBUTE      My-Local-Integer        3002    integer
~
```

2. Provide the specified attribute to the user that must be granted administrator rights. Open the users configuration file: */etc/freeradius/users*

   Insert the following line below the definition of the user name and password:

   HYPERCABLE-User-Level = admin

   For example:

   user_1 Cleartext-Password := "pass_1"

   HYPERCABLE-User-Level = admin

```
# This is a complete entry for "steve". Note that there is no Fall-Through
# entry so that no DEFAULT entry will be used, and the user will NOT
# get any attributes in addition to the ones listed here.


user_1  Cleartext-Password := "pass_1"
        SAF-User-Level = admin

#
#steve  Cleartext-Password := "testing"
```

3. Restart FreeRADIUS.
4. Log in to INTEGRAL using the secure HTTPS connection.

Chapter 7: TOOLS

Link Layer Discovery tool

The Link Layer Discovery Tool is a command line application for MS Windows. It sends requests to LLD server application which runs on all INTEGRAL series devices. The tool is used to discover INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS/ INTEGRAL-W/INTEGRAL-WS devices and reset their passwords or settings.

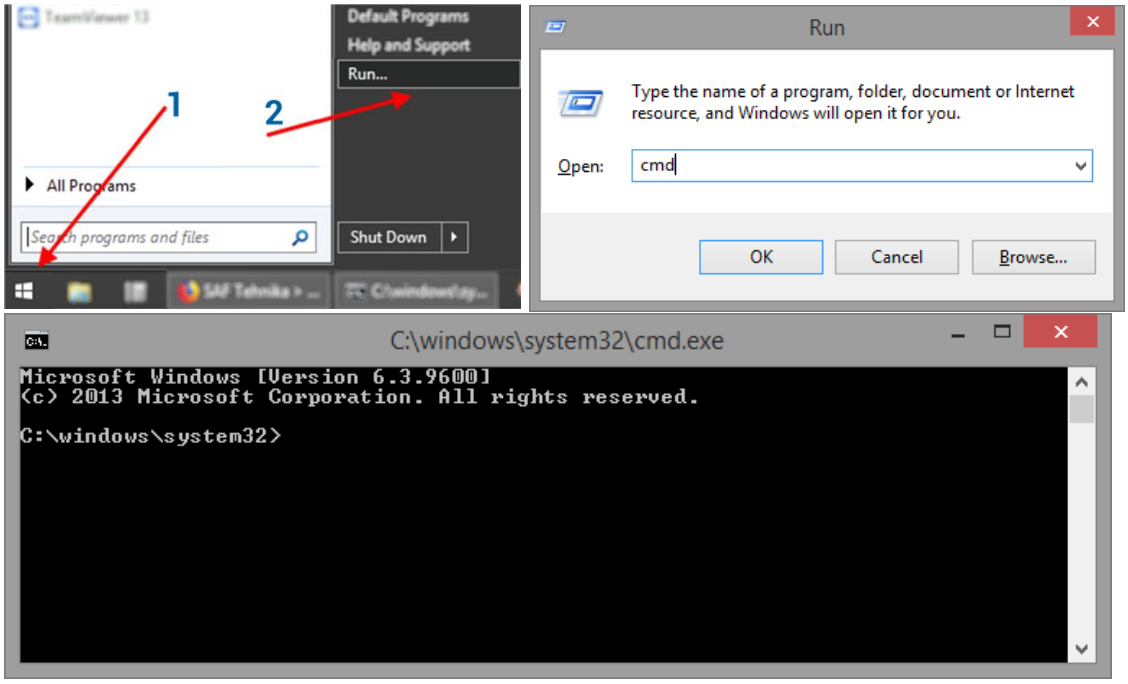
The application runs on the following version of Windows: Windows Vista, Windows 7, Windows 8, and Windows 10.

WinPCAP must be installed to use the Link Layer Discovery Tool.

The Link Layer Discovery Tool for INTEGRAL series can be downloaded in https://Hypercabletehnika.com/en/downloads in "Tools" section. Login required.

1) Unzip the LLD.zip file you downloaded to a directory of your choice, for example, C:\HYPERCABLE\LLD\ .

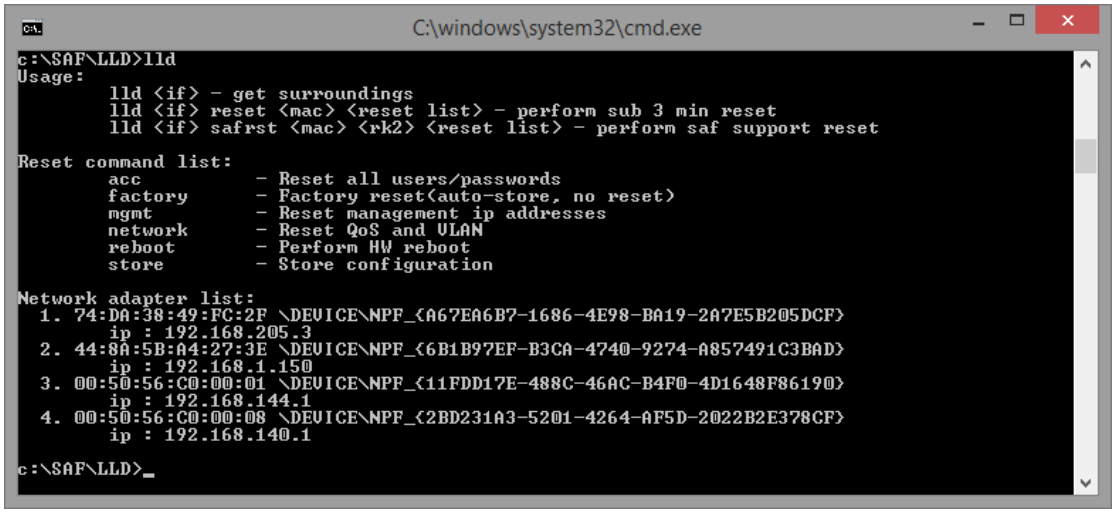
2) The application is started via the command prompt (Start menu→Run→type "cmd"→press ENTER). Command line console window should appear.



3) The default directory in the console is the current user directory. To change it, type:
`cd <directory path>`

For example: `cd c:\Hypercable\lld`

4) Run the recovery tool by typing "`lld`" without quotes in the console prompt and press ENTER.



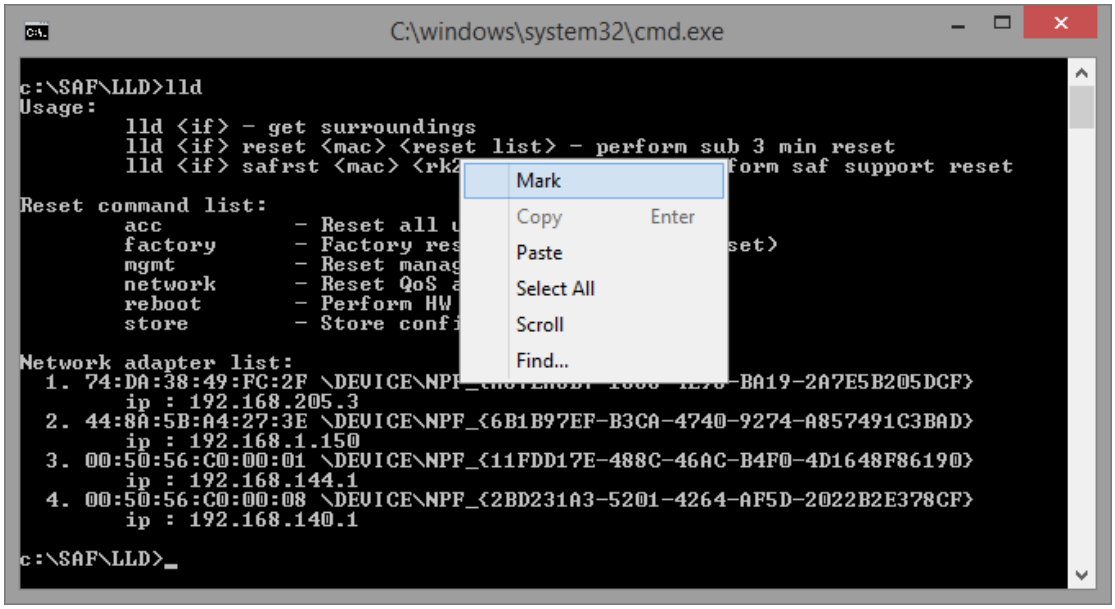
5) Available commands and network adapter list should be shown. To scan for INTEGRAL devices, the command should be run as follows:

```
lld <network interface>
```

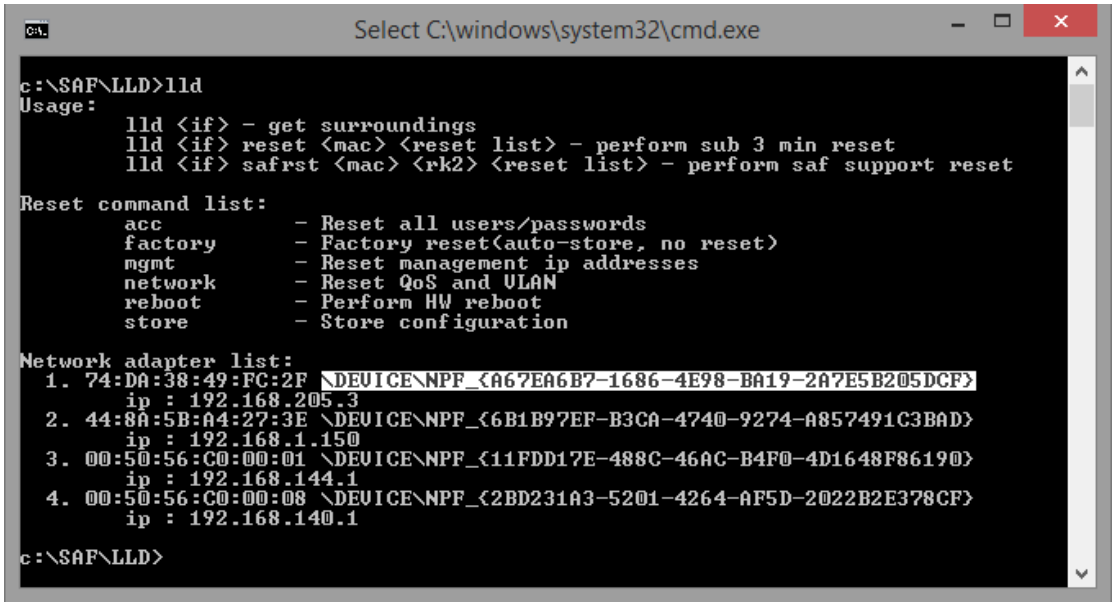
For example:

```
lld \DEVICE\NPF_{A67EA6B7-1686-4E98-BA19-2A7E5B205DCF}
```

In order to copy the interface address from network adapter list, click the right mouse button over the console and select “Mark”:

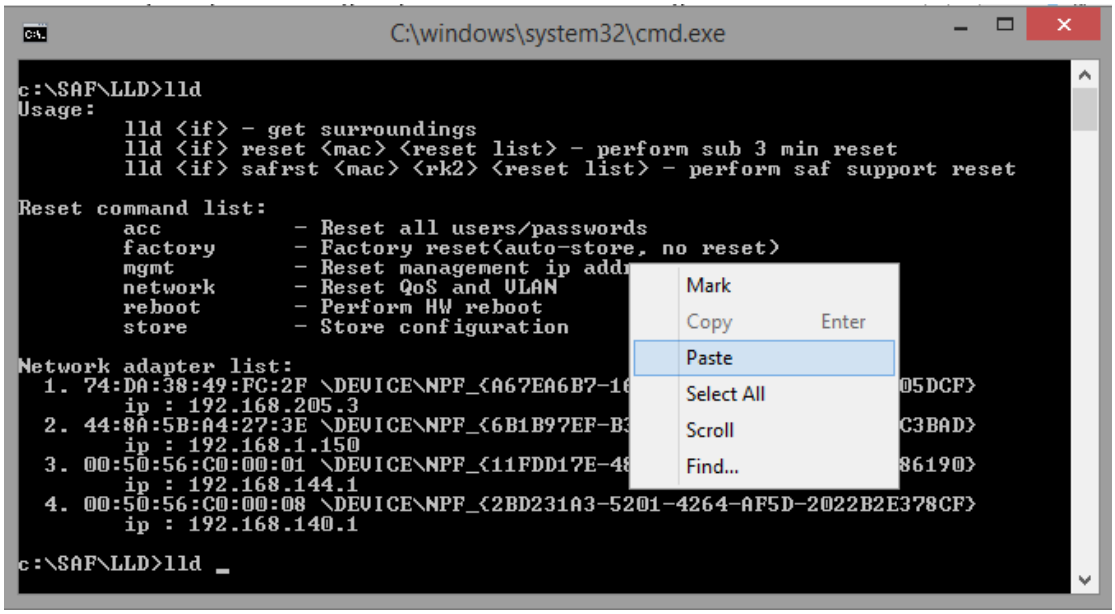


Then by holding the left button select the interface address:

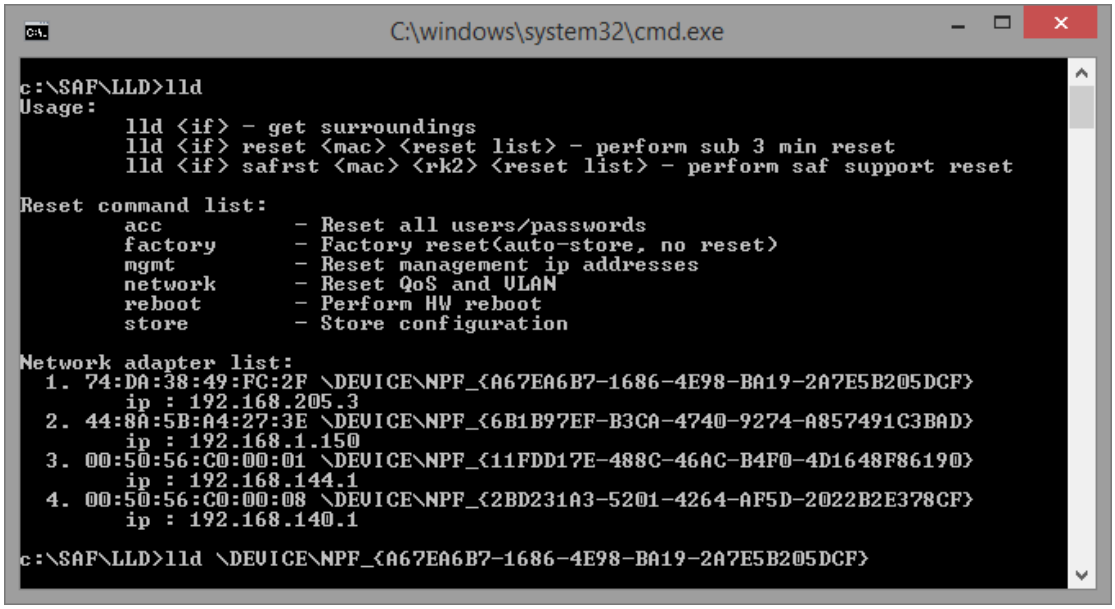


After selecting, release the left button and click the mouse right button anywhere on the console. The address should be copied.

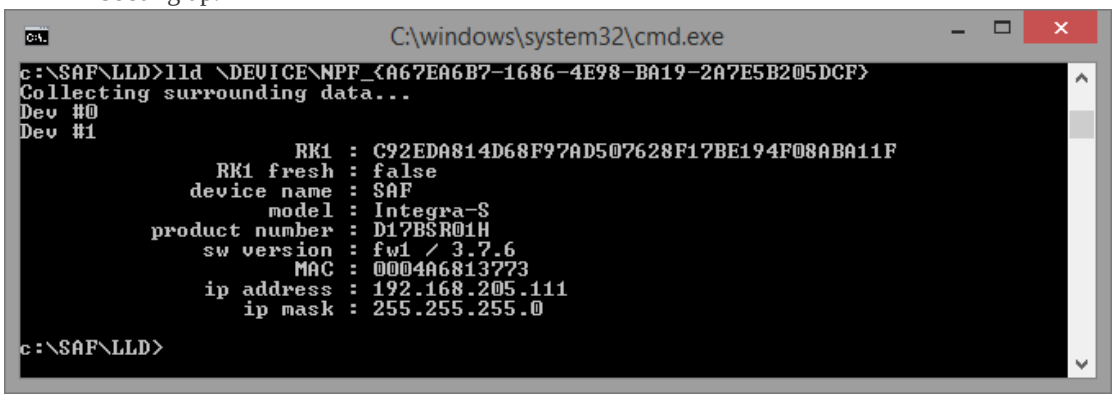
Type "`lld` " and paste the address by clicking the right button anywhere on the console:



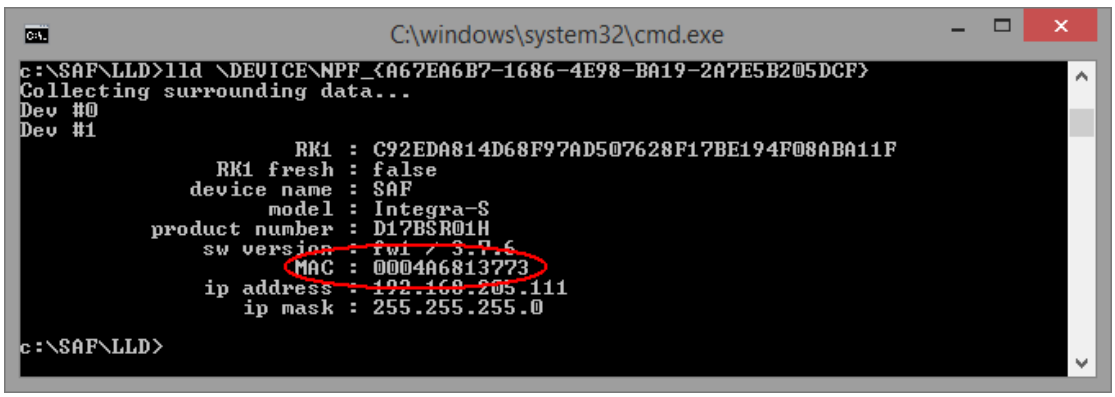
The result should be similar as in the image below:



6) Press ENTER and the recovery tool will now scan for INTEGRAL devices. Available devices and their information will appear in the console. Make sure that the device has finished booting up.



7) Use the MAC address of the device with the reset command to reset this specific device. The MAC address can be copied the same way as the interface address.



8) The device is reset by using the required reset command with the recovery tool:
lld <interface> reset <MAC> <reset command>

where <*interface*> − network interface from the network adapter list
<*MAC*> − required INTEGRAL device address
<*reset command*> − reset options

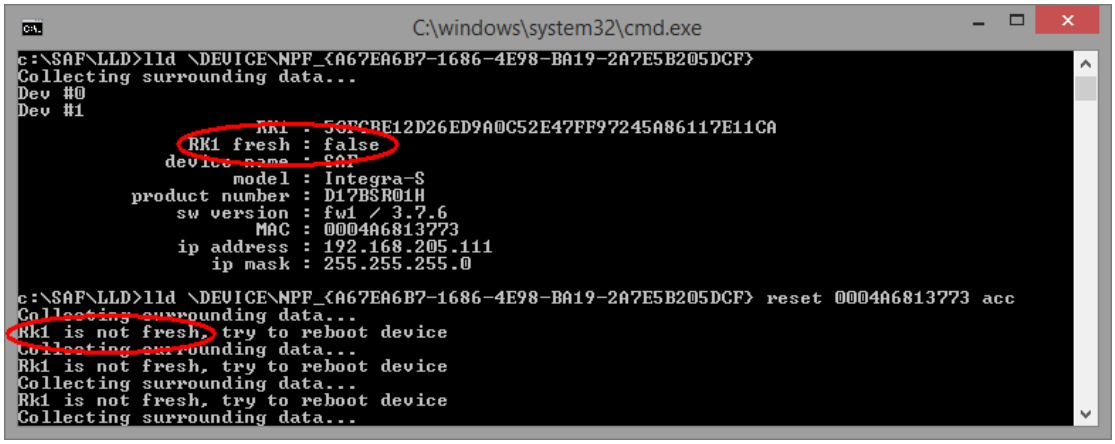
Different reset options are available depending on the reset requirement. Reboot and store options are also available. Store option saves the device current configuration so it will be restored after system reboot. The commands are available in the reset command list. Use the command after the MAC address of the device as shown in the previous reset command example.

```
Reset command list:
        acc             - Reset all users/passwords
        factory         - Factory reset(auto-store, no reset)
        mgmt            - Reset management ip addresses
        network         - Reset QoS and VLAN
        reboot          - Perform HW reboot
        store           - Store configuration
```

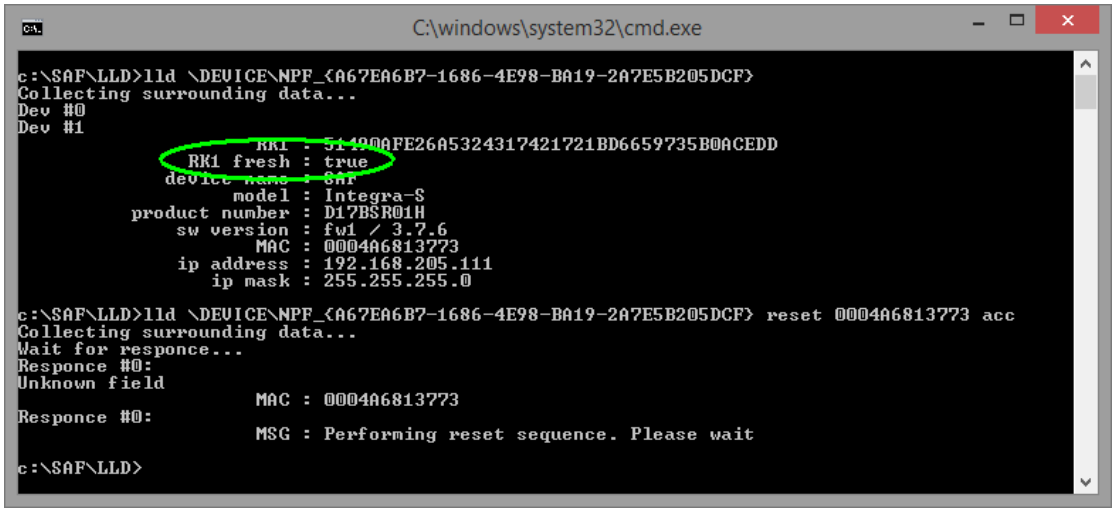
For example, to reset users and passwords on INTEGRAL device #1, use:

```
lld \DEVICE\NPF_{A67EA6B7-1686-4E98-BA19-2A7E5B205DCF} reset 0004A6813773 acc
```

Make sure the command is run within 3 minutes after INTEGRAL reboot ("*RK1 fresh*" must be "*true*" in the console), otherwise error shown in the screenshot below error will occur. The recovery tool will continue to retry the command.



Power down the INTEGRAL device and power it up again, the reset should be completed soon.

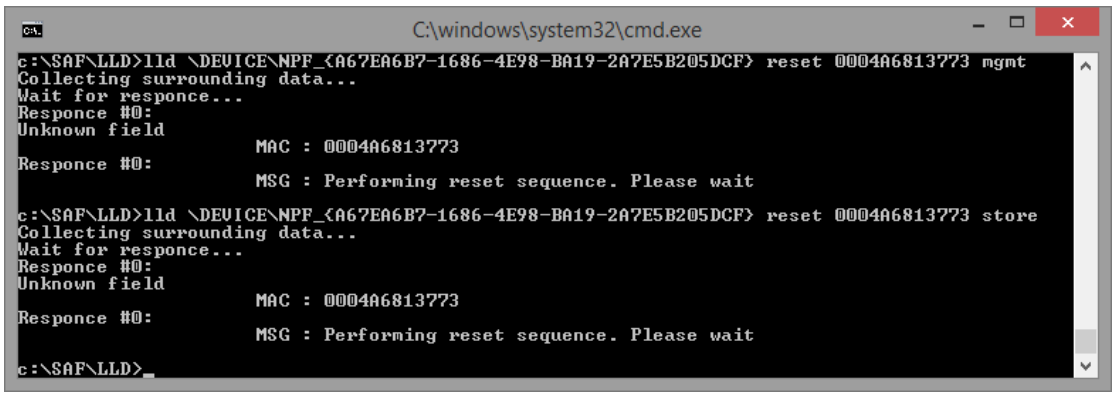


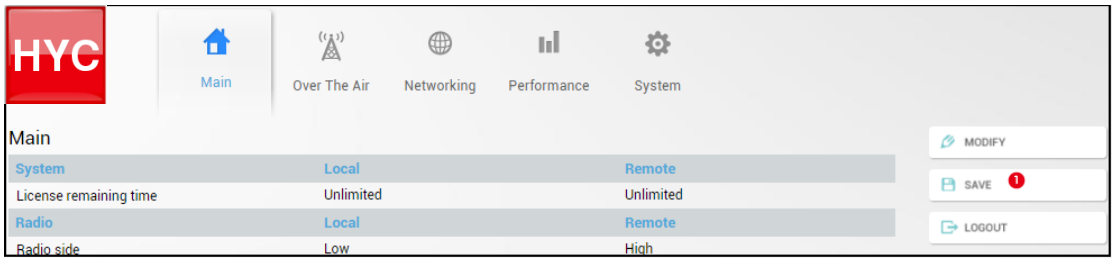
If the reset cannot be completed, redo step 8).

9) Store changes by command (must be done within the time frame of 3 minutes after boot) or by using WEB GUI (any time before the INTEGRAL device is powered off) “SAVE” button.

For example,

```
lld \DEVICE\NPF_{A67EA6B7-1686-4E98-BA19-2A7E5B205DCF} reset
0004A6813773 store
```





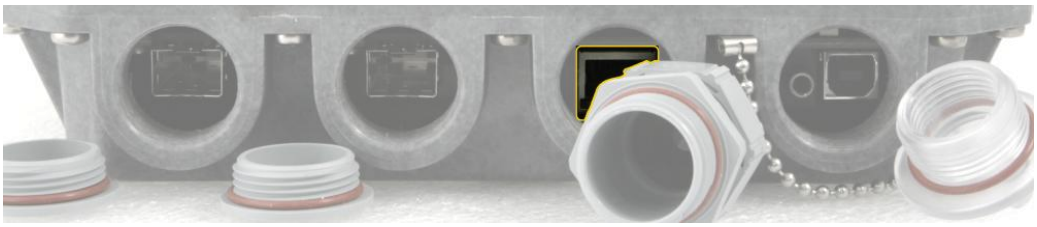
MIB files

Relevant MIB files can be downloaded directly from the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS Web GUI. See Chapter System → Configuration → SNMP configuration for further details.

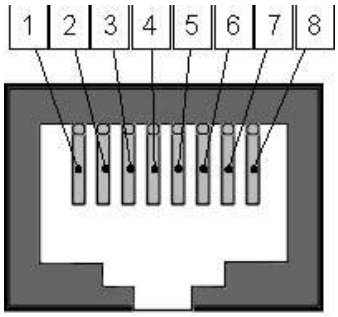
Chapter 8: INTERFACES

RJ-45 port

The RJ-45 port complies with IEEE 802.3-2005 1000Base-T, 100Base-T and 10Base-T Ethernet and IEEE 802.3at, LTPoE++ Power over Ethernet standards.



The pinouts of that socket are as follows:



Pin	Data	PoE
1	Bi-directional A+	VB1+
2	Bi-directional A-	VB1+
3	Bi-directional B+	VB1-
4	Bi-directional C+	VB2+
5	Bi-directional C-	VB2+
6	Bi-directional B-	VB1-
7	Bi-directional D+	VB2-
8	Bi-directional D-	VB2-

In case an Ethernet cable is used for power & data (with PoE injector), the combined Ethernet cable length from PoE injector to INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODU and from PoE injector to CPE is limited to 100m / 328ft.

In case SFP interfaces on LAN2 / LAN3 ports are used as the data interface, it is possible to use LAN1 port solely for the power supply. Two options are possible:

1) Ethernet cable with PoE injector.
   Please refer to the table below for maximum Ethernet cable length from PoE injector to INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODU based on AWG wire size and INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODU power consumption.

AWG	Lmax @ 45W	Lmax @ 40W	Lmax @ 35W
26	202m / 662ft	227m / 745ft	259m / 851ft
24	321m / 1053ft	361m / 1184ft	413m / 1353ft
22	510m / 1674ft	574m / 1884ft	656m / 2153ft

2) 2-wire power cable together with a DC power adapter cable for the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS (P/N D0ACPW01).
   Please refer to the tables below for maximum power cable length based on AWG wire size or cross-section are and INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS FODU power consumption.

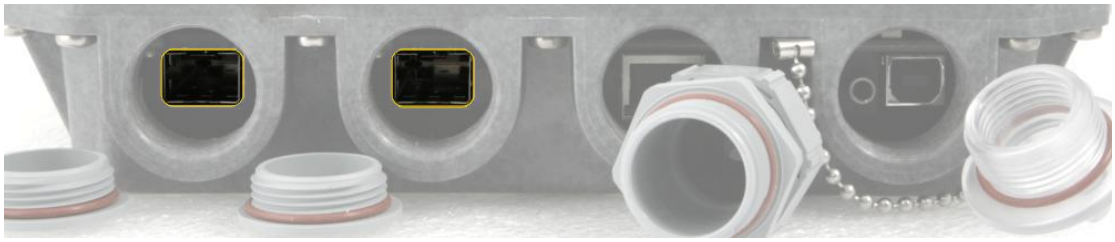
AWG	Lmax @ 45W	Lmax @ 40W	Lmax @ 35W
24	80m / 263ft	90m / 296ft	103m / 338ft
22	127m / 419ft	143m / 471ft	164m / 538ft
20	203m / 666ft	228m / 749ft	260m / 856ft
18	322m / 1058ft	362m / 1190ft	414m / 1360ft
16	512m / 1682ft	576m / 1892ft	659m / 2163ft
14	815m / 2675ft	917m / 3010ft	1048m / 3440ft

Cross-section area	Lmax @ 45W	Lmax @ 40W	Lmax @ 35W
0.25mm^2	101m / 331ft	113m / 370ft	129m / 423ft
0.5mm^2	201m / 659ft	226m / 741ft	259m / 849ft
0.75mm^2	302m / 990ft	339m / 1112ft	388m / 1273ft
1.0mm^2	402m / 1318ft	452m / 1482ft	517m / 1696ft
1.5mm^2	603m / 1978ft	679m / 2227ft	776m / 2545ft

Maximum cable length calculation is done using copper resistance.

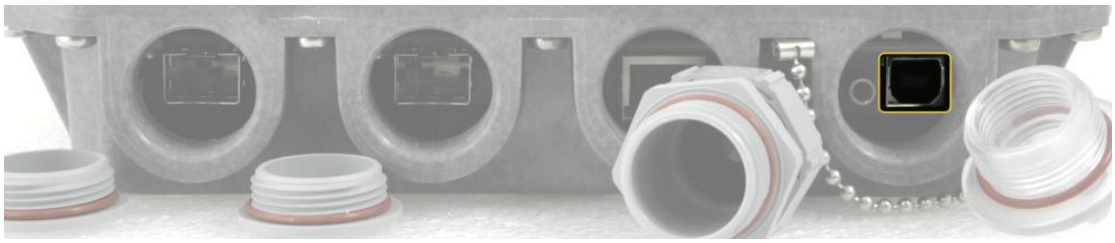
SFP ports

SFP ports provide SFP transceiver connectivity.
Both SFP ports comply with the following Gigabit Ethernet standards:
1000BASE-SX, 1000BASE-LX, 1000Base-T (note: 1000FDX only).

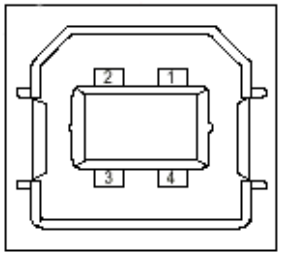


USB port

USB port provides serial terminal access to CLI. The socket is B type.



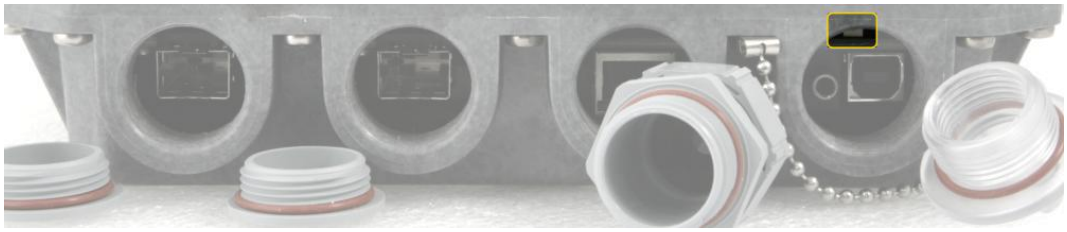
USB Type B Socket



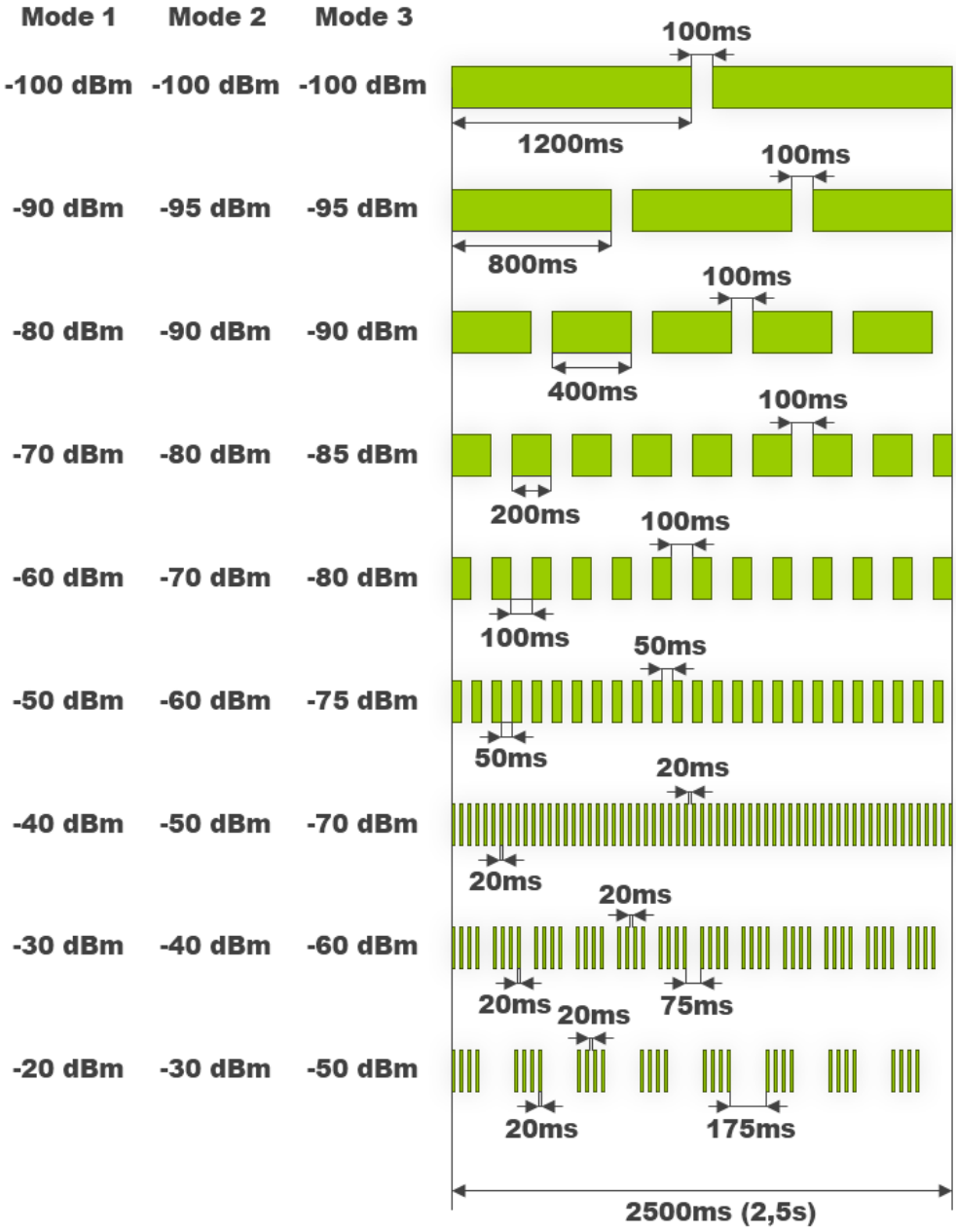
1=Vbus (5V)
2=D–
3=D+
4=GND

RSSI LED

The RSSI LED can be activated in three operational modes – Mode 1, Mode 2 and Mode 3. By default RSSI LED is enabled in Mode 1. For further details please refer to the chapter Over The Air → Radio → Configuration.



Corresponding Rx signal levels and LED blinking pattern for each mode is represented in the figure below:



INTEGRAL-S/INTEGRAL-GS RSSI LED description

The 15-42 GHz INTEGRAL-S/INTEGRAL-GS FODUs have a dual color RSSI LED. The RSSI LED can blink either in green or in red color. The blinking pattern is as given in the figure above and is the same for both colors. (Functionality may not be available in older HW revisions.)

A red RSSI LED warns about mistakes in the FODU installation. It turns red in the following circumstances:

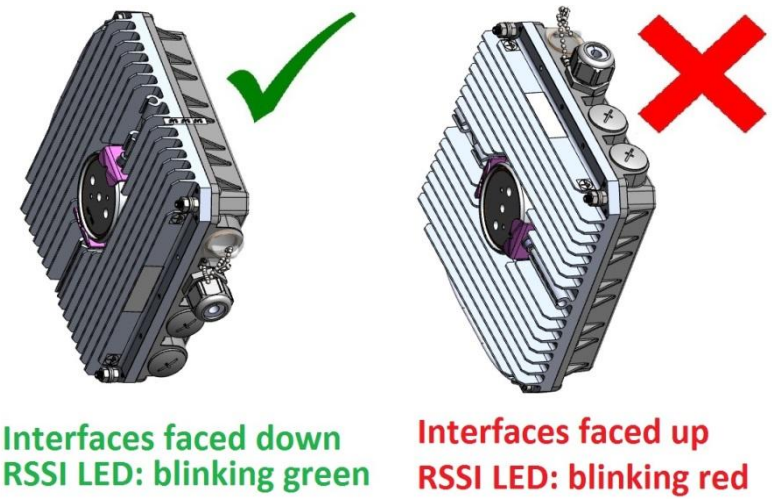
1) If the polarization offset from Vertical polarization axis (zero-degree level) is more than 3 degrees to both sides.

2) If the polarization offset from Horizontal polarization axis (zero-degree level) is more than 3 degrees to both sides.
3)

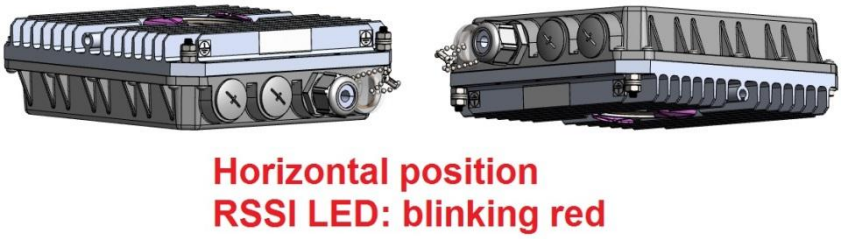
> This will be included in one of next firmware releases. Firmware version 3.7.6 does not change RSSI LED color based on the Horizontal polarization axis position and stays on red.

4) If the elevation angle of the INTEGRAL-S/INTEGRAL-GS FODU will differ for more than +/-20 degrees from zero-degree elevation angle

5) If the FODU will be installed with its interfaces upwards.



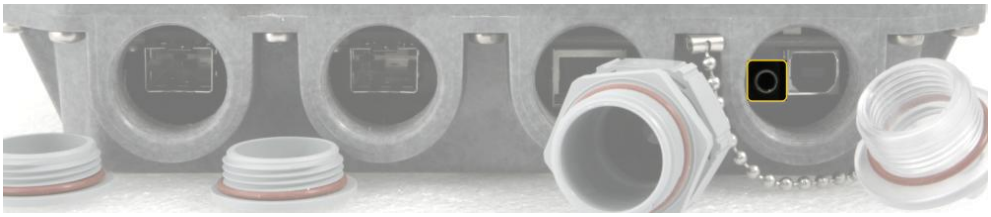
6) If the FODU will be placed on any surface horizontally.



Note that 17&24 GHz INTEGRAL-S/INTEGRAL-GS FODUs must be installed in opposite polarizations

RSSI/audio port

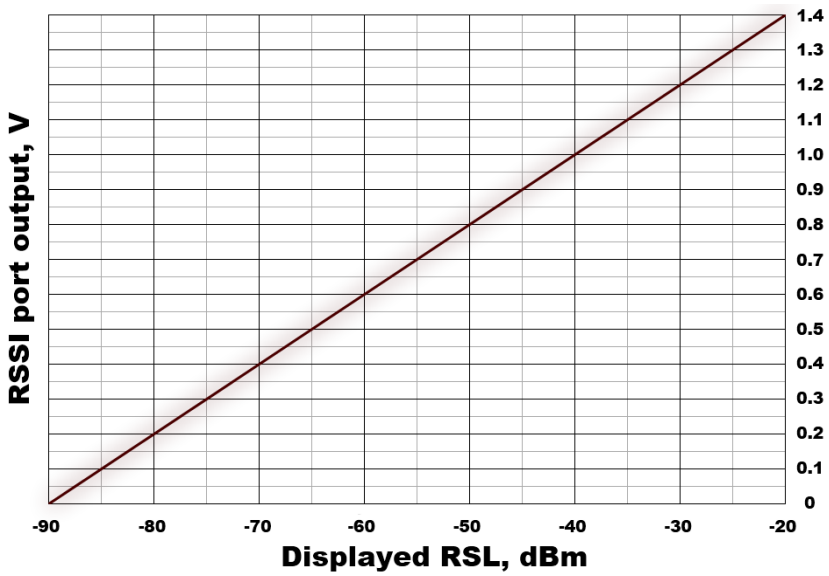
The RSSI (Received Signal Strength Indicator) port is used to adjust the alignment of the antenna for best performance (for both rough and fine adjustment); this can be done using a digital multimeter or headphones connected to the RSSI port. The RSSI port is a 3.5mm socket. The output of the RSSI port is DC voltage and an audio frequency and varies depending on received signal level. Both are linear curves.



In order to connect a voltmeter you will require the appropriate RSSI cable (P/N D0ACRS01):

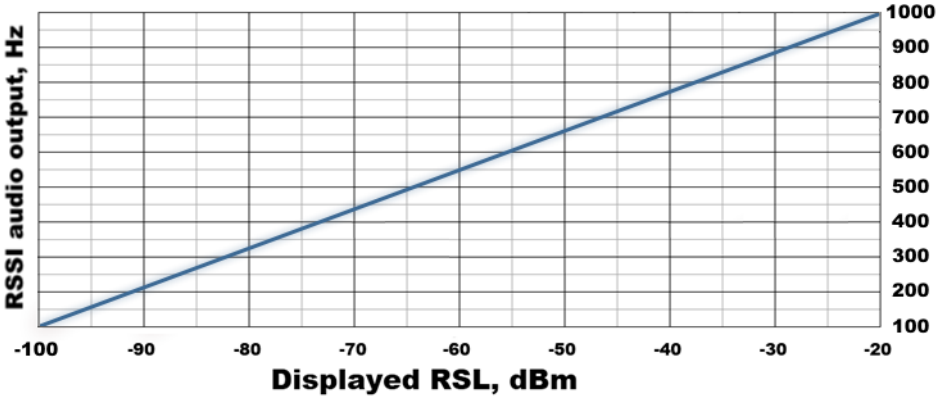
The following charts and tables show the typical relationship of the received signal level (Rx level) displayed by the INTEGRAL/INTEGRAL-S/INTEGRAL-G/INTEGRAL-GS vs. the RSSI port output voltage (RSSI – Received Signal Strength Indicator) and audio frequency. The RSSI port is located on the FODU. The evaluated Rx level has the error +/-2 dB.

Output voltage



Rx level (dBm)	RSSI voltage (V)
-90	0
-85	0.1
-80	0.2
-75	0.3
-70	0.4
-65	0.5
-60	0.6
-55	0.7
-50	0.8
-45	0.9
-40	1.0
-35	1.1
-30	1.2
-25	1.3
-20	1.4

Output audio frequency



Rx level (dBm)	Audio frequency (Hz)
-100	100
-96	145
-92	190
-88	235
-84	280
-80	325
-76	370
-72	415
-68	460
-64	505
-60	550
-56	595
-52	640
-48	685
-44	730
-40	775
-36	820
-32	865
-28	910
-24	955
-20	1000

Appendix A: TECHNICAL SPECIFICATION

		INTEGRAL, INTEGRAL-S	**INTEGRAL-G, INTEGRAL-GS***
General			
Concept / form factor		FODU with antenna or FODU Slip-fit	
Frequency bands		6GHz, 7GHz, 11GHz, 13GHz*, 15GHz, 17GHz UL, 18GHz, 23GHz, 24GHz UL, 25GHz, 26GHz, 28GHz, 38GHz, and more*	
Capacity		up to **1Gbps*** with HC at 1+0 or 2+0	
		474 Mbps at 60 MHz	491Mbps at 60 MHz
Max modulation		1024QAM	2048QAM
Configurations		1+0, 2+0 link bonding, 1+1 HSB	
ATPC		Yes	
Channel bandwidth		ETSI: from 3.5 MHz up to 56 MHz FCC: from 5 MHz up to 60 MHz	
Ports			
Gigabit Ethernet	1x RJ-45	Electrical with built-in PoE splitter and surge arrestor	
	2x SFP	Fiber Optics	
Service ports	3.5mm	Audible alignment and RSSI	
	USB B	Terminal Access	
	LED	Power On, Link Synchronization, RSL, Polarization accuracy*	
Ethernet			
Ethernet		Built-in Carrier Ethernet Gigabit Network Processor	
Gigabit Switch functionality		802.1Q VLANs with QoS/CoS including *WRED**, shaping, DWRR and on MPLS-TP exp bit; Spanning Tree Protocol, Jumbo frames and more*	
Synchronization		SyncE, IEEE 1588v2 PTP*	
Carrier Ethernet functionality		Provider Bridging, MEF9&14, High Efficiency Header Compression, OAM*	
Jumbo frames		Yes, 9600 bytes	
Encryption		AES 256-bit encryption, licensed feature	
Management		SNMP v1/2c/3, SSH, Telnet, HTTPS, Serial, RADIUS, Network Time Protocol	
Performance monitoring		Performance graphs, constellation diagram, alarms, detailed counters	
Electrical			
Power consumption		See table below	
Power range	INTEGRAL	36 … 57 V DC	
	PoE injector	36…60 V DC all INTEGRAL models; 22...60 V DC models with ≤50 W consumption	
Temperature range		-33 ... +55 °C / -28 … +130 °F	

* Inquire HYPERCABLE representative for more information

Power consumption at 48V DC[1]

L6 GHz	U6, 7 GHz	11, 13[2] GHz	15 GHz	17 GHz	18 GHz	23 GHz	24 GHz	25, 26, 28 GHz	38 GHz
74W	69W	65W	40W	35W	45W	41W	38W	45W	47W

[1] *Power consumption of INTEGRAL radio shown only. For power consumption of complete system add up to 8% (at 48V DC input) for PoE in DC/DC mode, around 4W for 100m cable (depends on cable) and approx. 1W for SFP transceiver, if used.*

[2] *Preliminary data*

Mechanical specification

		INTEGRAL, INTEGRAL-G		INTEGRAL-S, INTEGRAL-GS
Antenna		**0.3m / 1ft**	**0.6m / 2ft**	**External antenna**
Mechanical & Environmental				
Antenna performance		High Performance and *Super High Performance**		
Stationary use		Conforms to ETSI EN 300 019 Class 4.1, IP66, NEMA 4X		
Size, w/o mount		378 x 378 x 227 mm / 14.9” x 14.9” x 9”	669 x 669 x 289 mm / 26.3” x 26.3” x 11.4”	235 x 250 x 72 mm / 9.26” x 9.85” x 2.84”
Size, 6..13 GHz		N/A	N/A	280 x 437 x 100 mm / 11.02” x 17.2” x 3.9”
Weight, w/o mount		5 kg / 11 lbs	5 kg / 11 lbs	2.9 kg / 6.4 lbs
Weight, 6..13 GHz		N/A	N/A	6.5 kg / 14.3 lbs
Mount	Mount size	292 x 176 x 250 mm / 11.5” x 7” x 10” max		Mount on antenna
	Pole size	Ø 40 – 120 mm / Ø 1.6” – 4.7”		
	Weight	2.55 kg / 5.6 lbs		

** Inquire HYPERCABLE representative for more information*

INTEGRAL, INTEGRAL-G

15-42 GHz

6-13 GHz

INTEGRAL-S, INTEGRAL-GS

Maximum Tx Power for INTEGRAL, INTEGRAL-S, INTEGRAL-G and INTEGRAL-GS

Modulation	Tx power, dBm						
	L6, U6, 7 GHz[2]	11 GHz	13 GHz[3]	15, 18HP GHz	17 GHz[1], 24 GHz[1]	18, 23, 25, 26, 28 GHz	38 GHz
4 QAM	+31	+26	+25	+23	-26 … +5	+20	+15
16 QAM	+30	+25	+24	+22	-26 … +5	+19	+14
32 QAM	+29	+24	+23	+21	-26 … +5	+18	+14
64 QAM	+28	+23	+22	+20	-26 … +5	+17	+13
128 QAM	+28	+23	+22	+20	-26 … +5	+17	+13
256 QAM	+27	+22	+21	+19	-26 … +5	+16	+12
512 QAM	+26	+21	+20	+18	-26 … +5	+15	+11
1024 QAM	+23	+18	+17	+15	-26 … +5	+12	+10
2048 QAM[2]	+22	+17	+16	+14	-26 … +5	+11	+9

[1] Max Tx power settings depend on national regulatory EIRP allowance and antenna size.

[2] Available only for INTEGRAL-G and INTEGRAL-GS.

[3] Preliminary data

High Performance INTEGRALted antenna specification

Size	Frequency, GHz	Gain, dBi	Half power beamwidth	XPD dB	F/B ratio, dB	Compliance	
						ETSI	FCC
0.3m	**15**	32.1	4.3°	30	58	Class 3	N/A
	17	33.4	3.5°	30	60	Class 3	B2
	18	34.2	3.3°	30	61	Class 3	B2
	23	35.3	3.0°	30	62	Class 3	A
	24	36.1	2.6°	30	62	Class 3	N/A
	26	36.6	2.5°	30	63	Class 3	N/A
	38	40.1	1.6°	30	61	Class 3B	A
	42	40.8	1.5°	30	60	Class 3	A
0.6m	**15**	37.5	2.4°	30	62.5	Class 3	N/A
	17	38.2	2.3°	30	65	Class 3	A
	18	39.1	1.9°	30	64.5	Class 3	A
	23	41.4	1.6°	30	66.5	Class 3	A
	24	41.1	1.4°	30	66	Class 3	N/A
	26	41.6	1.5°	30	68	Class 3	A
	38	45.2	0.9°	30	64	Class 3B	A
	42	46	0.8°	30	65	Class 3	A

INTEGRAL-G,-GS RSL Thresholds and Capacity for ETSI channels [3, 6, 7]

Bandwidth, MHz	Modulation	6GHz	7GHz	11GHz	13GHz[3]	15GHz	17GHz	18GHz	23GHz	24GHz	26GHz	28GHz	38 GHz	Capacity, Mbps	
		Guaranteed RSL Threshold, dBm												-G, -GS modes	Legacy modes
3.5	4QAM StrongFEC	-97	-96	-96	-96	-95.5	-94	-96	-96	-96.5	-95.5	-95	-92		4
	16QAM StrongFEC	-90	-90.5	-89	-89	-88.5	-87,5	-89.5	-89	-89.5	-89.5	-89	-86		8
	32QAM StrongFEC	-86	-86.5	-85	-85	-84	-83	-85.5	-84.5	-85.5	-84.5	-84	-82		10
	64QAM StrongFEC	-83.5	-83.5	-82.5	-82.5	-81.5	-80.5	-82.5	-81.5	-83	-82	-82	-79		13
	128QAM StrongFEC	-80	-80.5	-79	-79	-77.5	-76.5	-78.5	-77	-79.5	-78.5	-79	-76		16
	128QAM WeakFEC	-77.5	-78	-76	-76	-73.5	-75	-76.5	-75	-77.5	-76.5	-76	-74		17
7	4QAM StrongFEC	-94	-94.5	-93	-93	-93	-91	-94	-93	-93.5	-92.5	-93	-90.5		8
	16QAM StrongFEC	-87	-87.5	-86.5	-86.5	-86	-84.5	-87.5	-86	-87	-86	-86	-84		16
	32QAM StrongFEC	-84	-84.5	-83.5	-83.5	-82.5	-80.5	-83.5	-82	-83.5	-82.5	-83	-80		20
	64QAM StrongFEC	-80.5	-81.5	-80.5	-80.5	-80	-78	-80.5	-80	-80.5	-79	-80	-77.5		27
	128QAM StrongFEC	-77	-78	-76.5	-76.5	-76	-75	-77.5	-77	-77.5	-76	-76.5	-74		33
	256QAM StrongFEC	-74	-74.5	-73.5	-73.5	-73	-71	-74.5	-72	-73.5	-72.5	-73	-71		39
	256QAM WeakFEC	-72	-73	-71.5	-71.5	-70	-69	-72.5	-71	-71.5	-69	-71	-69		41
14	4QAM StrongFEC	-91	-91	-90.5	-90.5	-90	-88	-91	-87.5	-91	-90	-90	-87		17
	16QAM StrongFEC	-85	-85	-84	-84	-83.5	-81.5	-84.5	-82	-84	-83.5	-84	-81		33
	32QAM StrongFEC	-80	-81	-80	-80	-79	-77	-80.5	-78	-80	-79	-79	-77		44
	64QAM StrongFEC	-78	-78.5	-77	-77	-77	-75	-78.5	-76	-78	-77	-77	-74		56
	128QAM StrongFEC	-75	-75.5	-74	-74	-74	-72	-75.5	-73	-74.5	-73.5	-74	-71		67
	256QAM StrongFEC	-71.5	-72	-71	-71	-71	-68.5	-71.5	-69.5	-71	-70.5	-70.5	-69		79
	512QAM StrongFEC	-68.5	-68	-67	-67	-67	-65	-68.5	-67	-67.5	-67.5	-67	-65		90
	512QAM WeakFEC	-65.5	-66	-64.5	-64.5	-64	-61.5	-65.5	-63	-65	-64	-64	-62		97
20	4QAM StrongFEC	-89	-90	-88,5	-88,5	-88.5	-87	-89.5	-86	-89	-89.5	-89	-86		25
	16QAM StrongFEC	-83	-84	-83	-83	-82.5	-80	-83.5	-81	-83	-82.5	-82.5	-79.5		51
	32QAM StrongFEC	-80	-80	-79	-79	-78	-76.5	-79.5	-77	-79	-78.5	-79	-75.5		64
	64QAM StrongFEC	-77	-77	-76,5	-76,5	-76	-74	-77	-75	-77	-75.5	-76	-73		85
	128QAM StrongFEC	-74	-74	-73	-73	-73	-70.5	-74	-72	-73	-72.5	-73	-70		102
	256QAM StrongFEC	-70,5	-71	-69,5	-69,5	-69.5	-68	-70.5	-68.5	-70	-70.5	-71	-67		119
	512QAM StrongFEC	-67,5	-68	-67	-67	-66	-64.5	-67.5	-65.5	-67	-66	-66	-63.5		136
	1024QAM StrongFEC	-64	-64	-62,5	-62,5	-63	-60.5	-64.5	-62	-63	-62.5	-62	-60		153
	1024QAM WeakFEC	-62	-62	-61	-61	-60	-58	-62.5	-59.5	-61	-60.5	-60	-58		163
28	4QAM StrongFEC	-88	-89	-88	-88	-87	-85	-88	-84	-88	-86.5	-87	-85	34	35
	16QAM StrongFEC	-82	-83	-81.5	-81.5	-81	-79	-82.5	-79.5	-82	-81.5	-81	-78	69	69
	32QAM StrongFEC	-79	-79	-77.5	-77.5	-77	-75	-78.5	-75.5	-78	-77.5	-77	-74	87	88
	64QAM StrongFEC	-76	-76	-75.5	-75.5	-75	-72	-75.5	-73.5	-75	-74.5	-74.5	-72	114	115
	128QAM StrongFEC	-73	-73	-71.5	-71.5	-72	-69	-72.5	-70.5	-72	-71.5	-71	-69	137	138
	256QAM StrongFEC	-70	-70	-68.5	-68.5	-68	-66	-69.5	-67.5	-69	-68	-68	-65	160	161
	512QAM StrongFEC	-66.5	-66	-65	-65	-65	-62.5	-66.5	-64	-65	-64.5	-64	-62	183	184
	1024QAM StrongFEC	-63	-63	-62	-62	-61.5	-59	-63.5	-61	-62	-61.5	-61	-58	206	207
	1024QAM WeakFEC	-61		-59.5	-59.5	-59	-57	-60.5	-59.5	-60	-58.5	-59	-56		220
	2048QAM StrongFEC	-59	-60	-58	-58	-58	-54.5	-59	-57	-59	-58	-57	-54	226	
40	4QAM StrongFEC	-86.5	-87	-85	-85	-85.5	-83	-86.5	-83	-85.5	-85	-85.5	-83	50	50
	16QAM StrongFEC	-81	-81	-79.5	-79.5	-79.5	-77	-81	-78.5	-80	-79.5	-79	-76.5	98	98
	32QAM StrongFEC	-77	-77	-76.5	-76.5	-75.5	-73	-77	-74.5	-76	-75.5	-75.5	-73	125	125
	64QAM StrongFEC	-74	-74	-73.5	-73.5	-73	-71	-74	-72	-73	-73.5	-73.5	-70.5	165	165
	128QAM StrongFEC	-71	-71	-70.5	-70.5	-70.5	-67	-71	-69	-70	-69.5	-70	-67	198	198
	256QAM StrongFEC	-68	-68	-67	-67	-66.5	-64	-68	-66	-67	-66.5	-65	-63.5	231	231
	512QAM StrongFEC	-65	-65	-64	-64	-63.5	-61	-65	-63	-63.5	-63.5	-63	-60.5	264	264
	1024QAM StrongFEC	-61	-61	-60.5	-60.5	-60	-57	-61.5	-59.5	-60.5	-59.5	-59	-56.5	298	298
	1024QAM WeakFEC	-59		-59	-59	-57	-55	-59	-57.5	-58.5	-58	-57.5	-55		314

Bandwidth, MHz	Modulation	6GHz	7GHz	11GHz	13GHz[3]	15GHz	17GHz	18GHz	23GHz	24GHz	26GHz	28GHz	38 GHz	Capacity, Mbps	
		Guaranteed RSL Threshold, dBm												-G, -GS modes	Legacy modes
	2048QAM StrongFEC	-58	-58	-56.5	-56.5	-56	-54	-57.5	-55.5	-56.5	-56	-56	-52.5	336	
56	4QAM StrongFEC	-85	-85	-84	-84	-84	-81	-85	-82	-84	-83.5	-84	-81	71	72
	16QAM StrongFEC	-79	-79.5	-78.5	-78.5	-78	-75	-79	-77	-78.5	-78	-78	-75	144	145
	32QAM StrongFEC	-75	-75.5	-74.5	-74.5	-74	-71.5	-75	-73	-74.5	-73.5	-74	-72	183	183
	64QAM StrongFEC	-72	-73	-72	-72	-71	-69	-72	-70	-72.5	-71	-71	-69	238	241
	128QAM StrongFEC	-70	-69.5	-68.5	-68.5	-69	-66	-69	-67.5	-69.5	-68	-68	-65	286	289
	256QAM StrongFEC	-67	-66	-65.5	-65.5	-65	-62	-66	-64.5	-65.5	-64.5	-65	-62	334	337
	512QAM StrongFEC	-63	-63.5	-62	-62	-62	-59	-63	-61.5	-62.5	-61	-62	-59	382	385
	1024QAM StrongFEC	-60	-60	-58.5	-58.5	-58	-56	-59	-57.5	-59.5	-57.5	-58	-55	430	433
	1024QAM WeakFEC	-58		-57	-57	-55	-54	-57.5	-55.5		-55.5	-55.5	-54		456
	2048QAM StrongFEC	-56	-57	-54.5	-54.5	-54	-52.5	-55	-53.5	-55.5	-54	-54.5	-52	472	

[3] Preliminary data

[6] 2048QAM modulation is available only for INTEGRAL-G and INTEGRAL-GS, not supported by legacy models

[7] 1024QAM modulation with Weak FEC setting is available for legacy models or in legacy modes only

INTEGRAL-G,-GS RSL Thresholds and Capacity for FCC channels [3, 6, 7]

BW, MHz	Modulation	6GHz	7GHz	11GHz	13GHz[3]	15GHz	17GHz	18GHz	23GHz	24GHz	26GHz	28GHz	38 GHz	Capacity, Mbps	
		Guaranteed RSL Threshold, dBm												-G, -GS modes	Legacy modes
5	4QAM StrongFEC	-96	-96	-95	*-95*	-94	-92.5	-95	-94	-95.5	-94.5	-95	-91		5
	16QAM StrongFEC	-89	-89.5	-88	*-88*	-87	-86.5	-88.5	-88	-89	-87.5	-88	-85		10
	32QAM StrongFEC	-85	-85.5	-84	*-84*	-83.5	-82.5	-84.5	-84	-85	-83.5	-84	-81		12
	64QAM StrongFEC	-82.5	-82.5	-81,5	*-81,5*	-80.5	-79.5	-81.5	-81	-82	-81	-81	-79		17
	128QAM StrongFEC	-79	-79.5	-78.5	*-78,5*	-77.5	-76.5	-78.5	-77.5	-79	-78	-78	-75		20
	128QAM WeakFEC	-77	-77	-76.5	*-76,5*	-74	-73.5	-76.5	-75.5	-76.5	-75.5	-75.5	-73		22
10	4QAM StrongFEC	-92	-92.5	-91	*-91*	-91	-89	-92	-90	-92	-91.5	-91.5	-89		12
	16QAM StrongFEC	-86	-86.5	-85	*-85*	-84.5	-82.5	-85.5	-84	-85.5	-84.5	-85	-82		24
	32QAM StrongFEC	-82	-82.5	-81.5	*-81.5*	-81	-79	-82.5	-80	-82	-81	-81	-78		30
	64QAM StrongFEC	-79.5	-80	-79	*-79*	-78	-76	-79.5	-78	-79	-78	-78	-76		40
	128QAM StrongFEC	-76	-76.5	-75.5	*-75.5*	-75	-73	-76.5	-75	-76	-75	-75	-73		48
	256QAM StrongFEC	-73	-73.5	-72	*-72*	-72	-69	-72.5	-71	-72.5	-71.5	-71	-70		56
	256QAM WeakFEC	-70	-70.5	-69	*-69*	-69	-66.5	-70.5	-68	-69.5	-68.5	-68.5	-66		60
20	4QAM StrongFEC	-89	-90	-88.5	*-88.5*	-88.5	-86	-89	-86.5	-89	-88.5	-88	-86		24
	16QAM StrongFEC	-83	-84	-83	*-83*	-83	-80	-83.5	-81	-83	-82.5	-82.5	-80		49
	32QAM StrongFEC	-80	-80	-79	*-79*	-79	-76.5	-79.5	-77	-79	-78.5	-79	-77		62
	64QAM StrongFEC	-77	-77	-76.5	*-76.5*	-76	-74	-76.5	-74.5	-77	-75.5	-76	-73		82
	128QAM StrongFEC	-74	-74	-73	*-73*	-73	-70.5	-73.5	-71.5	-73	-72.5	-73	-71		99
	256QAM StrongFEC	-70.5	-71	-69.5	*-69.5*	-70	-67	-70.5	-68.5	-70	-69.5	-70	-67.5		115
	512QAM StrongFEC	-67.5	-68	-67	*-67*	-66	-64.5	-67.5	-65.5	-67	-66	-66	-64		132
	1024QAM StrongFEC	-64	-64	-62.5	*-62.5*	-63	-60.5	-64.5	-62.5	-63	-62.5	-62	-61		148
	1024QAM WeakFEC	-62	-62	-61	*-61*	-60	-58	-62.5	-59.5	-61	-60.5	-60	-58		157
25	4QAM StrongFEC	-88	-88.5	-88	*-88*	-88	-85	-88	-85	-88	-87.5	-87	-85		31
	16QAM StrongFEC	-82	-83	-82.5	*-82.5*	-82	-79	-82.5	-80	-82	-81.5	-81.5	-79		62
	32QAM StrongFEC	-79	-79	-78.5	*-78.5*	-78	-75.5	-78.5	-77	-78.5	-77.5	-78	-75		78
	64QAM StrongFEC	-76	-76	-75.5	*-75.5*	-75	-73	-76.5	-73.5	-75.5	-74.5	-75	-72		104
	128QAM StrongFEC	-73	-73	-72.5	*-72.5*	-72	-70	-72.5	-70.5	-72.5	-71.5	-72	-69		124
	256QAM StrongFEC	-70	-70	-69.5	*-69.5*	-69	-66	-69.5	-68	-69	-68.5	-68	-66		145
	512QAM StrongFEC	-66.5	-67	-65.5	*-65.5*	-66	-63	-66.5	-65	-66	-65.5	-64.5	-63		166
	1024QAM StrongFEC	-63	-63	-61.5	*-61.5*	-62	-59	-63.5	-61.5	-62.5	-61.5	-61	-60		187
	1024QAM WeakFEC	-61	-61	-59.5	*-59.5*	-58	-57	-60.5	-59.5	-60	-59.5	-59	-57		198
30	4QAM StrongFEC	-88	-88	-87	*-87*	-87	-85	-88	-84.5	-87	-86.5	-86.5	-84		37

BW, MHz	Modulation	6GHz	7GHz	11GHz	13GHz[3]	15GHz	17GHz	18GHz	23GHz	24GHz	26GHz	28GHz	38 GHz	Capacity, Mbps	
		Guaranteed RSL Threshold, dBm												-G, -GS modes	Legacy modes
40	16QAM StrongFEC	-82	-82	-81.5	*-81.5*	-81	-78.5	-81.5	-79	-81.5	-80.5	-81	-78		73
	32QAM StrongFEC	-78	-79	-77.5	*-77.5*	-77	-75	-78.5	-75	-77.5	-76.5	-77	-74		93
	64QAM StrongFEC	-76	-76	-74.5	*-74.5*	-74	-72	-75.5	-73	-75	-74.5	-74	-71.5		123
	128QAM StrongFEC	-72	-73	-71.5	*-71.5*	-71	-69	-72.5	-70	-71.5	-71.5	-71	-69		148
	256QAM StrongFEC	-69	-69	-68.5	*-68.5*	-68	-66	-69	-67.5	-68.5	-67.5	-68	-65		173
	512QAM StrongFEC	-66	-66	-65.5	*-65.5*	-65	-62	-66.5	-64.5	-65	-64.5	-64	-62		197
	1024QAM StrongFEC	-63	-62	-61.5	*-61.5*	-61	-59	-62.5	-61.5	-61.5	-61	-60	-58		222
	1024QAM WeakFEC	-61		-60	*-60*	-58	-57	-60.5	-59.5	-60.5	-59	-58.5	-56		235
	2048QAM StrongFEC	-59	-60	-58	*-58*	-56	-54.5	-58	-57	-58.5	-57	-57.5	-54	244	
50	4QAM StrongFEC	-86.5	-87	-85	*-85*	-85.5	-83	-86	-83	-85.5	-85	-85.5	-82		51
	16QAM StrongFEC	-81	-81	-79.5	*-79.5*	-79	-77	-80.5	-78	-80	-79.5	-79	-77		101
	32QAM StrongFEC	-77	-77	-76.5	*-76.5*	-76	-73	-77	-74	-76	-75.5	-75.5	-73		129
	64QAM StrongFEC	-74	-74	-73.5	*-73.5*	-73	-70	-74	-72	-73	-72.5	-72.5	-70		170
	128QAM StrongFEC	-71	-71	-70.5	*-70.5*	-70	-67	-71	-69	-70	-69.5	-70	-67		204
	256QAM StrongFEC	-68	-68	-67	*-67*	-66.5	-64.5	-67	-66	-67	-66.5	-65.5	-64		238
	512QAM StrongFEC	-65	-65	-64	*-64*	-64	-61	-64.5	-63	-63.5	-63.5	-63	-61		272
	1024QAM StrongFEC	-61	-61	-60.5	*-60.5*	-58	-57.5	-61.5	-59	-60.5	-59.5	-59.5	-56.5		306
	1024QAM WeakFEC	-60		-59	*-59*	-55	-55	-59.5	-57.5	-58.5	-58	-57.5	-55.5		323
	2048QAM StrongFEC	-58	-58	-57	*-57*	-53	-54	-57.5	-55	-56.5	-55.5	-56	-53	336	
60	4QAM StrongFEC	-85	-86	-84.5	*-84.5*	-85	-82	-85	-82.5	-85.5	-84	-84	-81.5	63	63
	16QAM StrongFEC	-80	-80	-78.5	*-78.5*	-78	-76	-79.5	-77	-79.5	-78	-78	-76	128	130
	32QAM StrongFEC	-76	-76	-74.5	*-74.5*	-75	-72	-75.5	-73	-75.5	-74.5	-74.5	-72.5	163	163
	64QAM StrongFEC	-73	-73.5	-72.5	*-72.5*	-72	-69	-72	-71	-72.5	-71.5	-72	-69.5	212	216
	128QAM StrongFEC	-70	-70	-69	*-69*	-69	-66	-70	-68	-69.5	-68	-69	-66.5	254	258
	256QAM StrongFEC	-67	-67	-65.5	*-65.5*	-66	-63	-66	-64.5	-66.5	-65	-65	-63	297	301
	512QAM StrongFEC	-64	-63.5	-63	*-63*	-63	-59	-63.5	-62	-63	-62	-62	-60	339	344
	1024QAM StrongFEC	-61	-61	-60	*-60*	-58	-56	-60	-58.5	-59.5	-58.5	-58	-56	382	385
	1024QAM WeakFEC	-59		-57	*-57*	-55	-54	-57.5	-55.5	-57.5	-56	-56	-54		410
	2048QAM StrongFEC	-57	-57	-56	*-56*	-53	-52.5	-56	-54	-56.5	-55.5	-55	-52	420	
80	4QAM StrongFEC	-84	-85	-83.5	*-83.5*	-84	-81	-85	-82	-84	-83.5	-83.5	-81	74	74
	16QAM StrongFEC	-79	-79.5	-78	*-78*	-78	-75	-78.5	-76	-78.5	-77	-77.5	-75	149	151
	32QAM StrongFEC	-75	-75.5	-74.5	*-74.5*	-74	-71	-75	-73	-74.5	-73.5	-74	-71	190	190
	64QAM StrongFEC	-72	-73	-71.5	*-71.5*	-71	-69	-72	-70	-71.5	-71	-71	-69	247	251
	128QAM StrongFEC	-70	-69.5	-68.5	*-68.5*	-68	-66	-69	-67	-69	-67.5	-68	-65	297	301
	256QAM StrongFEC	-66	-66	-65	*-65*	-65	-62	-66	-64.5	-65.5	-64.5	-65	-62	347	351
	512QAM StrongFEC	-63	-63	-62.5	*-62.5*	-62	-59	-62.5	-61.5	-62.5	-61	-61	-59	397	401
	1024QAM StrongFEC	-60	-59	-58.5	*-58.5*	-58	-55	-59	-57.5	-58.5	-57.5	-57	-54.5	447	451
	1024QAM WeakFEC	-58		-57	*-57*	-55	-53	-57	-55.5	-56.5	-55.5	-55.5	-53		474
	2048QAM StrongFEC	-56	-56	-54	*-54*	-54	-52	-55	-53	-55.5	-54.5	-54	-51.5	491	

[3] Preliminary data

[6] 2048QAM modulation is available only for INTEGRAL-G and INTEGRAL-GS, not supported by legacy models

[7] 1024QAM modulation with Weak FEC setting is available for legacy models or in legacy modes only

ABBREVIATIONS

ACI – Adjacent-Channel Interference
ACM – Adaptive Coding and Modulation
ATPC – Automatic Transmit Power Control
BER – Bit-Error Ratio
CCI – Co-Channel Interference
CLI – Command-Line Interface
CPU – Central Processing Unit
CRC – Cyclic Redundancy Check
DC – Direct Current
DiffServ – Differentiated Services
DSCP - Differentiated Services Code Point
ETSI – European Telecommunications Standards Institute
FCC - The Federal Communications Commission
FCS - Frame check sequence
FEC – Forward Error Correction
FO – Fiber Optics
FODU – Full Outdoor Unit
FTP – File Transfer Protocol
GUI – Graphical User Interface
IEEE - Institute of Electrical and Electronics Engineers
IF – Intermediate Frequency
ISP – Internet Service Provider
ITU-T – International Telecommunication Union – Telecommunication Standardization Sector
LAN – Local Area Network
LED – Light-Emitting Diode
MAC – Media Access Control
MSE – Mean Square Error
NMS – Network Management System
PC – Personal Computer
MAC – Media Access Control
MSE – Mean Square Error
NMS – Network Management System
PC – Personal Computer
PLL – Phase-Locked Loop
PoE - Power over Ethernet
QAM - Quadrature amplitude modulation
QoS – Quality of Service
RSL – Received Signal Level
RSS – Radio Standards Specification
RSSI – Received Signal Strength Indicator
Rx – Receive
SNMP - Simple Network Management Protocol
SNR – Signal-to-Noise Ratio
STP – Spanning Tree Protocol
TCP/IP – Internet Protocol Suite (Transmission Control Protocol / Internet Protocol)
TDM – Time-Division Multiplexing
TFTP – Trivial File Transfer Protocol
TM – Tide Mark
TP – Twisted Pair
TS – Threshold Seconds
Tx – Transmit
USB – Universal Serial Bus
VLAN – Virtual Local Area Network
WAN – Wide Area Network