MODEL: 4500402

FCC ID: 2AXVJ4500402

Revision	Date	Author
Added FCC Related Language	10/23/2020	Connor Crowley

Contents

Disclaimer

THIS DEVICE COMPLIES WITH PART 15 OF THE FCC RULES. OPERATION IS SUBJECT TO THE FOLLOWING TWO CONDITIONS: (1) THIS DEVICE MUST ACCEPT ANY INTERFERENCE, AND (2) THIS DEVICE MUST ACCEPT ANY INTERFERENCE RECEIVED, INCLUDING INTERFERENCE THAT MAY CAUSE UNDERSIRED OPERATION.

NOTE: TOWERIQ, INC. IS NOT RESPONSIBLE FOR ANY CHANGES OR MODIFICATIONS NOT EXPRESSLY APPROVED BY THE PARTY RESPONSIBLE FOR COMPLIANCE. SUCH MODIFICATIONS COULD VOID THE USER'S AUTHORITY TO OPERATE THE EQUIPMENT.

FCC RF Exposure Limits

THIS UNIT COMPLIES WITH FCC RF EXPOSURE LIMITS FOR AN UNCONTROLLED ENVIRONMENT. TO COMPLY WITH FCC RF EXPOSURE LIMIT REQUIREMENTS, ANTENNAS MUST BE OPERATED AT A MINIMUM DISTANCE OF 5.04 CM OR 0.166’ BETWEEN THE RADIATOR AND ANY PERSON’S BODY.

PART 90 Signal Booster

THIS IS A 90.219 CLASS A DEVICE

WARNING, This is **NOT** a **CONSUMER** device. It is designed for installation by **FCC LICENSEES** and **QUALIFIED INSTALLERS**. You **MUST** have an **FCC LICENSE** or express consent of an FCC Licensee to operate this device. You **MUST** register Class A signal booster (as defined in 47 CFR 90.219) online at **www.fcc.gov/signal-booster/registration** Unauthorized use may result in significant forfeiture penalties, including penalties in excess of $100,000 for each continuing violation.

Default antenna and devices statement

THIS DEVICE IS INTENDED TO BE UTILIZED WITH THE ANTENNAS AND COUPLING DEVICES LISTED BELOW. UTILIZING ALTERNATIVE ANTENNAS AND COUPLING DEVICES MAY RESULT IN UNINTENDED PERFORMANCE. SELECT THE APPROPRIATE ANTENNAS FOR YOUR APPLICATION WHEN ORDERING, THE UNIT DOES NOT SHIP WITH DEFAULT ANTENNAS.

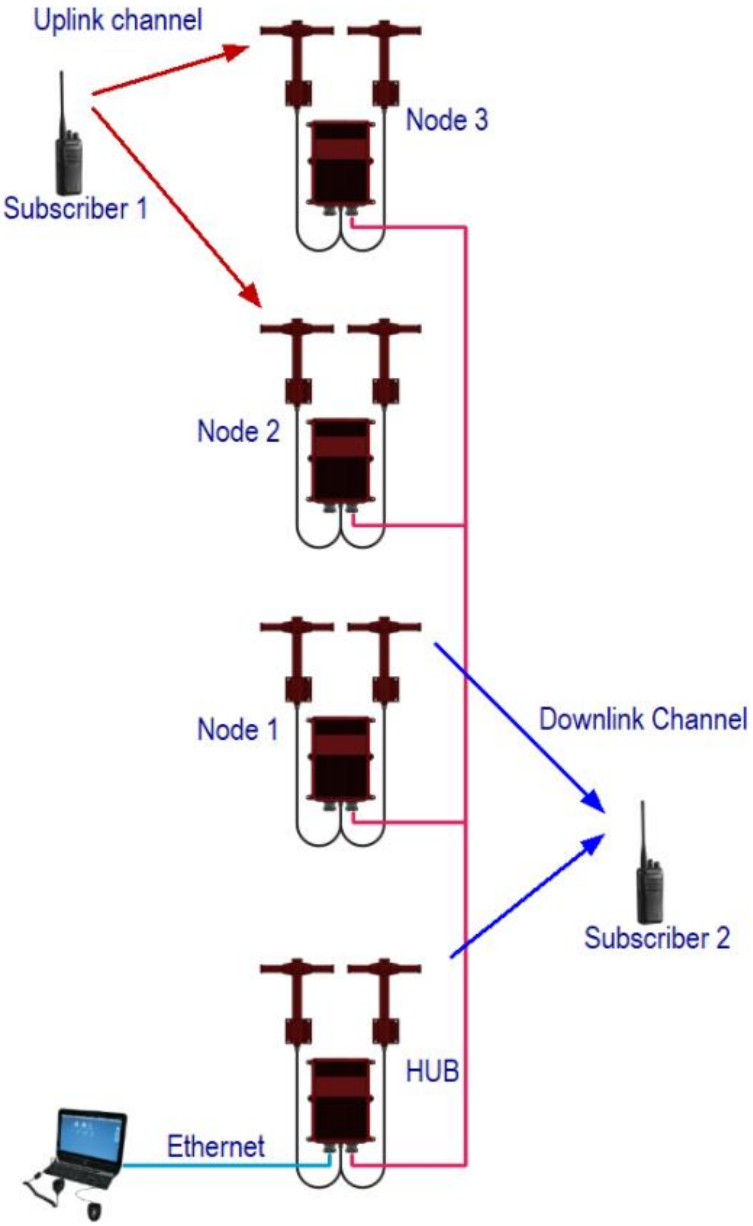
Part Number	Order	Description
4500104	TPP.50-10164-01.00	Antenna, Dipole, Omni-Directional, 470-512MHz (RED)
4500108	TPP.50-10363-01.00	Antenna, Ceiling Mount, 480-490MHz (White)
4500241	TGP.51-10293-01.00	Jumper, Coaxial Cable, (1.0 Meter, N-Male Straight, N-Male Straight)

Overview

Introduction

TowerlinQ 4500402 is a distributed active auxiliary radio communication system (ARCS).

It's intended to be used as a substitution of passive distributed antenna systems (DAS) in auxiliary radio communication systems. 4500402 operates inside the building in isolated conditions. It consists of a number of distributed Gateways. Each Gateway provides reception of two wideband radio channels (uplink) in 470 – 512 MHz frequency range, signal amplification, normalization and retransmission at two downlink channels respectively. The signal received by one Gateway is transmitted by all other Gateways to ensure entire building radio coverage. The signals are converted to digital form and are distributed throughout the building for retransmission via twisted pair cabling.



System Architecture

The TowerlinQ system implements primary-secondary architecture. It includes one Hub gateway and configurable number of regular gateways. All system activities (data exchange, radio operation, etc.) are controlled by the Hub. Secondary gateways only respond to the Hub's commands with predefined behaviour and data streams.

The Hub responds to external commands and transmits data via command interface (Ethernet) using embedded web application Web-configurator on Hub.

Operation modes

The TowerlinQ network can be set to Service or Active operational modes (for Web-configurator details see chapter below).

Service mode

Service mode is special maintenance mode used for deployment, configuration and troubleshooting. All Gateways radio channels are disabled in this mode. Using Web-configurator application on the Hub it's possible to read, change and write system configuration, including radio channels receiving (uplink) and transmitting (downlink) frequencies or switch system mode to Active. Changes to the hub gateway are pushed to the secondary gateways.

Active mode

When entering Active mode, the Hub commands all Gateways to turn on their transmitters and prepare for transmission. Each Gateway enables its hardware and data processing capabilities and starts to receive radio signals. If portion of radio signal of 10.24 ms duration have been received, the Gateway calculates its RSSI and sends the calculated value to Hub. Then Hub selects the Gateway(s) with highest RSSI as the best signal source and commands it to transmit digitized radio data to other Gateways via the Signalling Line Circuit. Any Gateway receiving data through signalling line circuit will then transmit over the air the data received via that interface.

In Active mode the system can be turned to Service mode using Web-configurator application. Any other commands from Web-configurator are ignored in this mode.

Gateway Description of Operation

TowerlinQ Gateway provides reception of two independent wideband signals at CH1UL and CH2UL (uplink) frequencies, their amplification and retransmission at CH1DL and CH2DL (downlink) frequencies respectively. The input signal's maximum bandwidth 25 kHz. Input frequency range 470 – 512 MHz. Neither baseband spectrum modification nor demodulation/modulation are performed.

Each Gateway converts received signals to low-frequency baseband, digitize it, calculates RSSI and reports it to Hub. The Hub Gateway selects the Gateway with highest RSSI and commands it to broadcast the received digital data to other Gateways via wired communication network. Any Gateway being receiving digital data via network converts it to RF signal and transmits to its Tx antenna.

Radio processing chain consists of Antenna Interface Unit (AIU) and two Radio Frequency Units (RFU). Each RFU contains Receiver subunit (RFU-RX), Transmitter subunit (RFU-TX) and Analog Front-End subunit (RFU-AFE).

Antenna Interface Unit

The AIU provides:

- RX antenna interface and received RF signal primary conditioning, amplification and feeding to RFUs
- TX antenna interface, combining and filtering of RF signals transmitted by RFUs
- Means of radio and antenna self-diagnostics

The RX antenna path contains local low and high pass filters, as well as a digitally gain and attenuation control. The gain/attenuation is automatically adjusted in 2 dB steps. Providing up to 18 dB in gain or 30 dB in attenuation.

The TX antenna path combines the transmitted signals from the two downlink channels, while providing a low pass filter and forward/reverse power sensing circuitry.

Radio Frequency Unit

The RFU provides:

- Received Signal Strength Indication
- Signal conversion from RX antenna interface to digital data.
- Signal conversion from digital data to TX antenna interface.
- TX power amplification.
- Special differential filtering to reduce unwanted heterodyne harmonics.

RFU - Analog Front-End

The AFE receiving path has two Rx channels. Within each channel the analogue signal is filtered and digitized twice. Further digital filtering and processing is then applied to the data for transmission to the Gateway's high-speed processor.

The AFE transmitting path has two Rx channels. Within each channel the data is received from the Gateway's high-speed processor with further digital filtering applied. The data is reconstructed to an analogue signal with variable pre-gain amplification being applied, up to 22dB.

RFU - Transmitter

The RFU's Transmitter (TX) subunit receives the analogue signal from the Analog Front-End and applies automatic gain control to provide consistent +20dBm composite power. A cartesian feedback loop provides for stable linear transmissions.

RFU - Calibration

Upon initiating Active Mode the Gateway's RFU will perform a calibration procedure to compensate for environmental and electrical conditions. The calibration procedure may take up to 15 seconds.

Digital Signal Processing

All data processing is performed by the Gateway's high-speed processor, including:

- Data Filtering
- RSSI Calculation
- DC Offset Processing
- Automatic Gain Control
- Signalling Line Circuit Communications

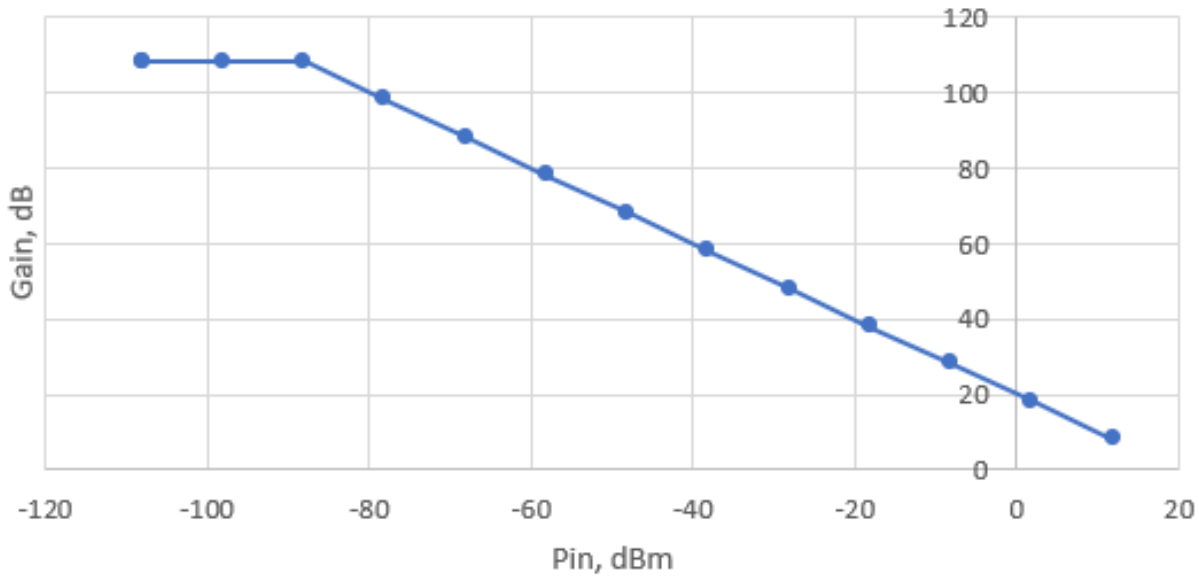
Automatic Gain Control

RFU implements Automatic Gain Control (AGC) algorithm to avoid receiver's overload and to ensure the transmitter's output power equalization in wide range of input levels. AGC is performed on each channel separately. The AGC starting point or minimum input level then it starts operation is about -88 dBm. In the lower input power range from - 88 to -58 dB the regulation is performed using AFE bit selectors in digital domain only. At higher input signals the regulation algorithm uses analogue variable gain amplifiers.

The resulting AGC range is about 100 dB and the output power remains stable if input signal is within it. If the input signal decreases lower than -88 dBm, the output power decreases proportionally to input until the low cut off threshold point -108 dBm is achieved.

Thus the maximum system gain is 108 dB and total dynamic range about 116 dB.

The system gain plot is shown on the picture below.



Network Connections

4500402 contains the following wired communication ports:

- A Two-Wire, Signalling Line Circuit.
- Gigabit Ethernet Port

The Signalling Line Circuit, TowerlinQ SLC, is certified to operate on standard and fire resistant fire-alarm cable, 16 AWG or better. The Gateways do not support a loop style (Class A, Style 7) Signalling Line Circuit and it is recommended to install them as close to “in Series” as is possible. Each Gateway includes a Signalling Line Circuit repeater that can be used to reinforce the signal. The

Standard CAT5 or better ethernet cabling can be utilized for local area network connectivity.

Power Supply

Recommended parameters of external power source: 16 - 24 VDC, 1A max per Gateway.

TowerlinQ Gateway's internal power supply unit is galvanically isolated and EMI protected. It provides polarity inversion, overvoltage, undervoltage and overcurrent protection.

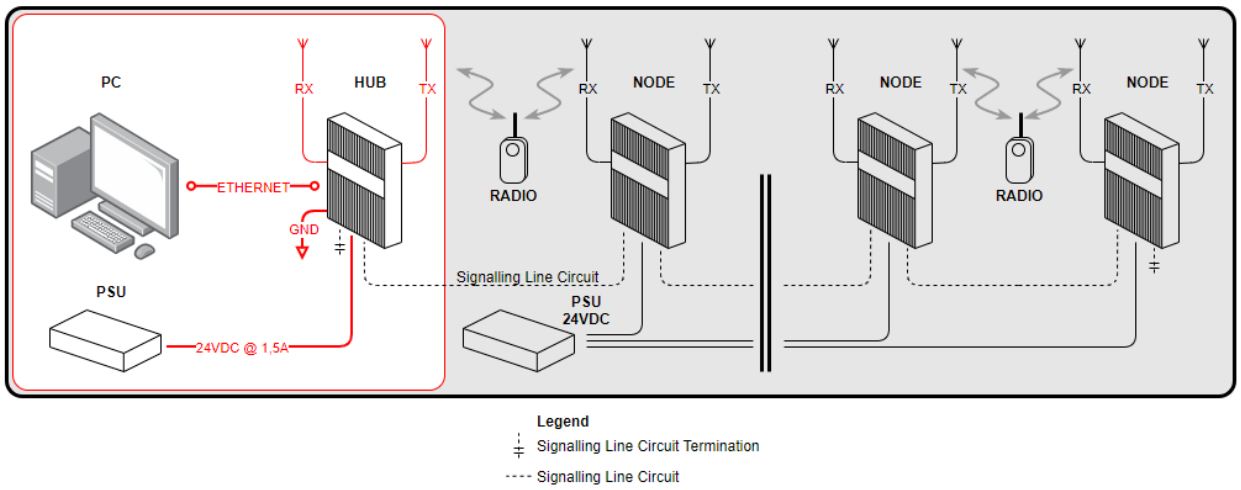
Undervoltage threshold is set to 10V, overvoltage - 34V, current limit 1.2A.

Installation

Towerlinq system composition

Structural diagram of typical system is provided below on Figure below, where:

- PC - Operational Console for System Management
- PSU - DC Power Supply with 24VDC @ 1,5A
- GND - Gateway Ground
- HUB - Main Device of the Network
- NODE – Secondary Gateways
- LINE – Signalling Line Circuit, terminated on each of the ENDs by internal DIP switches.

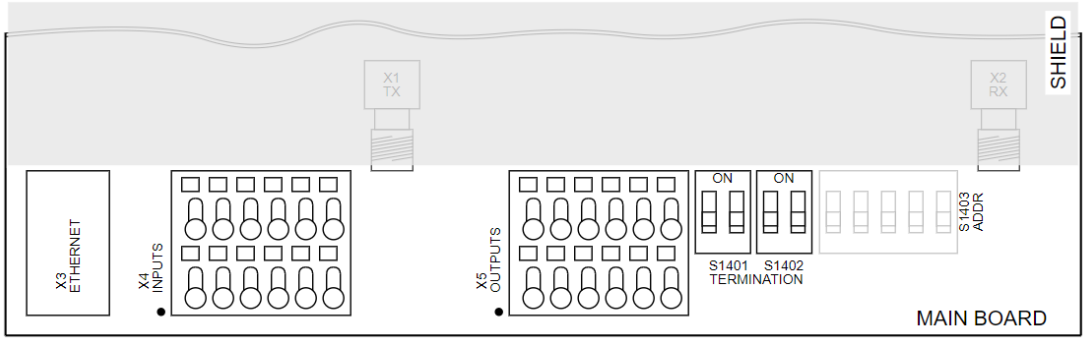


Wiring diagram

Wiring diagram shows how to provide power supply, link with PC and attach dry contacts.

Most of all wires and cables are connect to the side of MAIN BOARD. This side of the board is not covered by the shield allows to make connection as easy as possible.

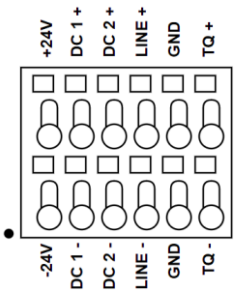
This side of the board shown on the following Figure

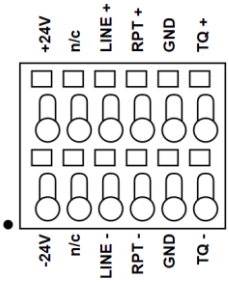


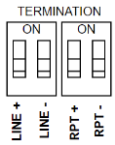
Terminals and Contact Descriptions

Described in the tables below:

X3 ETHERNET	Description
100BASE-TX	PC or Switch/Router connection port

X4 INPUTS	Description
	[-24V] - negative power supply [+24V] - positive power supply [DC1-] - dry contact 1 [DC1+] - dry contact 1 [DC2-] - dry contact 2 [DC2+] - dry contact 2 [LINE-] – Signalling Line Circuit Negative Wire [LINE+] – Signalling Line Circuit Positive Wire [GND] - grounding [GND] - grounding [TQ-] - reserved [TQ+] - reserved

X5 INPUTS	Description
	[-24V] - negative power supply [+24V] - positive power supply [n/c] - not connected [n/c] - not connected [LINE-] – Signalling Line Circuit Negative Wire [LINE+] – Signalling Line Circuit Positive Wire [RPT-] – Signalling Line Circuit Repeater Negative wire [RPT+] - Signalling Line Circuit Repeater Positive wire [GND] - grounding [GND] - grounding [TQ-] - reserved [TQ+] - reserved

S1401, S1402 TERMINATION	Description
	[LINE+] - Line A-wire termination [LINE-] - Line B-wire termination [RPT+] - Repeater A-wire termination [RPT-] - Repeater B-wire termination

Preparing DC Power Supply unit

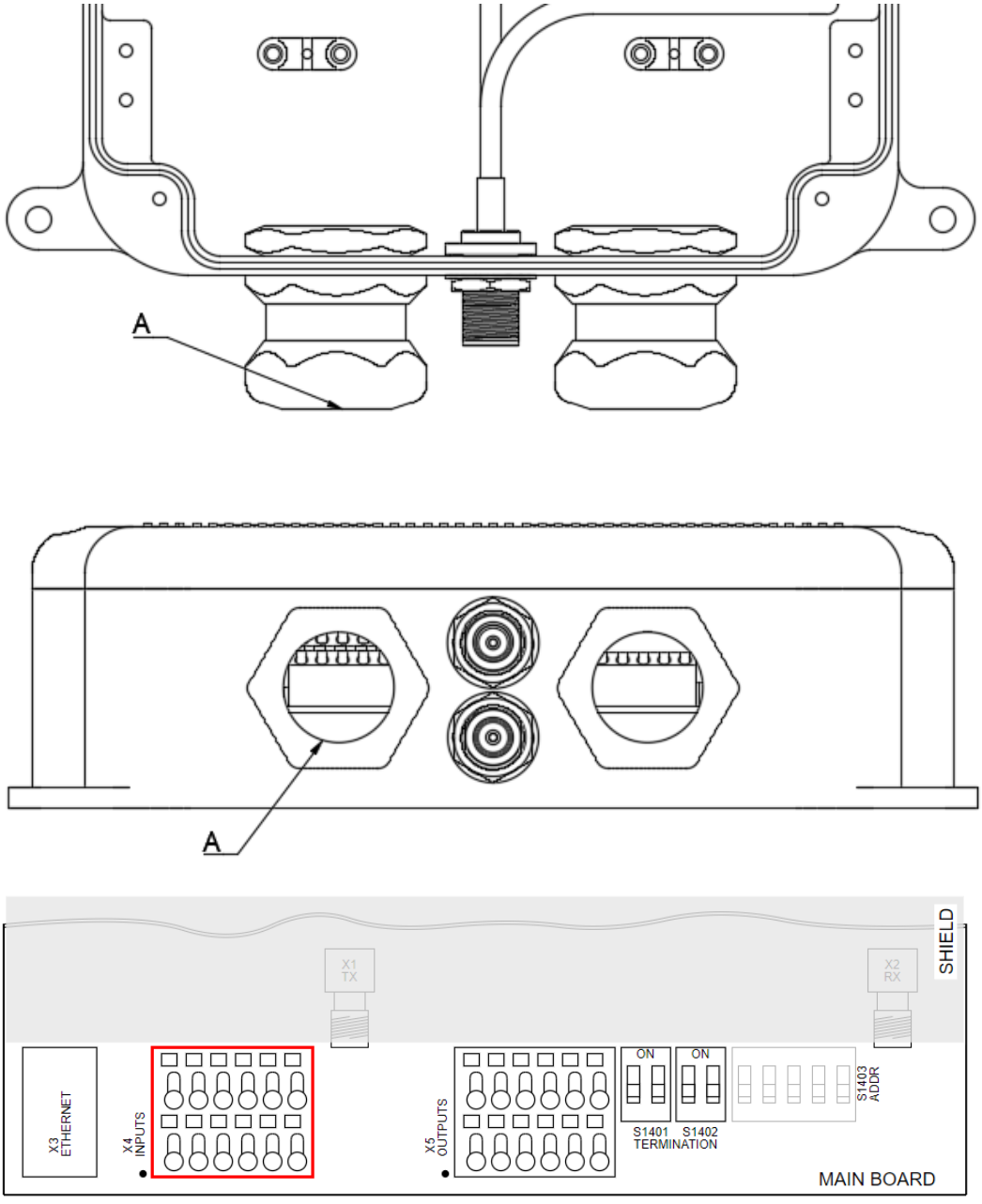
Before powering Hub unit with DC Power Supply unit (PSU) read and follow its user manual concerning safety and cabling. Make sure that PSU can produce 24VDC @ 1,5Amp currency.

Providing power supply for Hub unit

To provide power supply for Hub unit follow instruction:

1. Take off enclosure's cover if attached;

2. Pull powering cable through the Raintight Compression Connector (A) at the bottom of enclosure inside as shown on the following Figure;

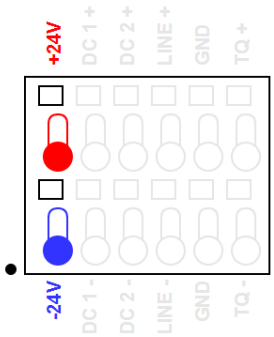


NOTE: Terminal block pinout additionally printed in the table on a board surface at the terminal block. It is printed from a left side relatively to spring clamp terminal block.

ATTENTION! Be sure that PSU is not powered ON! Do not connect power cables to the Main Board in case of PCB protection shield removed!

4. Attach powering cable to the dedicated contacts of **INPUT** spring clamp terminal block as it explain below;

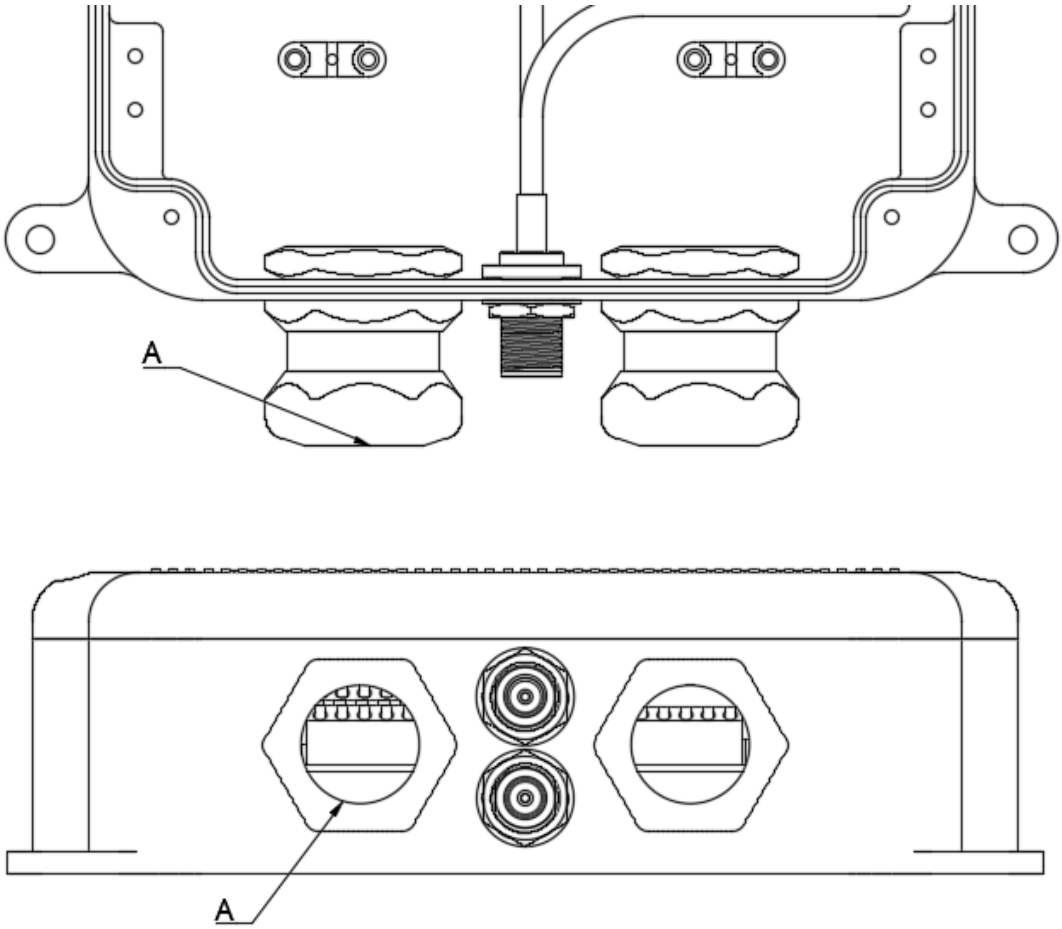
- **Positive** polarity wire (+24V) must be connected to the terminal hole marked **RED**;
- **Negative** polarity wire (-24V) must be connected to the terminal hole marked **BLUE**;



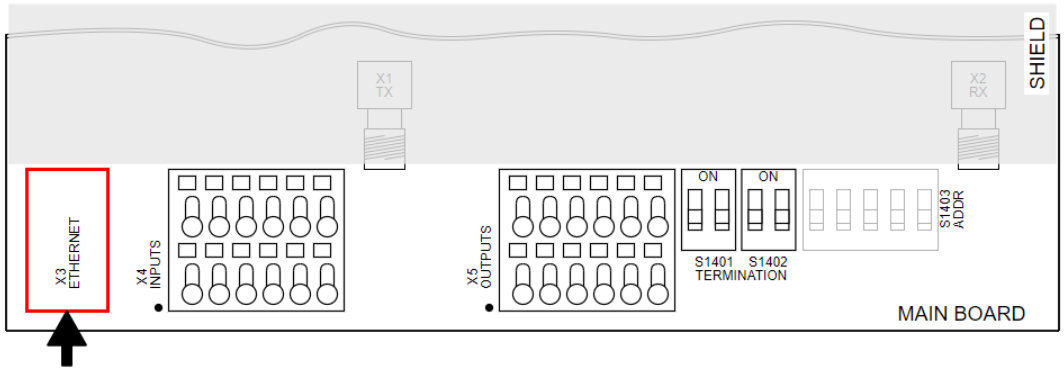
PC connection

For system managing, tuning and operation an ethernet connection must be established. Do this by following steps:

- Remove enclosure cover if present;
- Put one of the end of the ethernet cable through the Raintight Compression Connector (A) at the bottom of enclosure inside as shown on the Figure below;



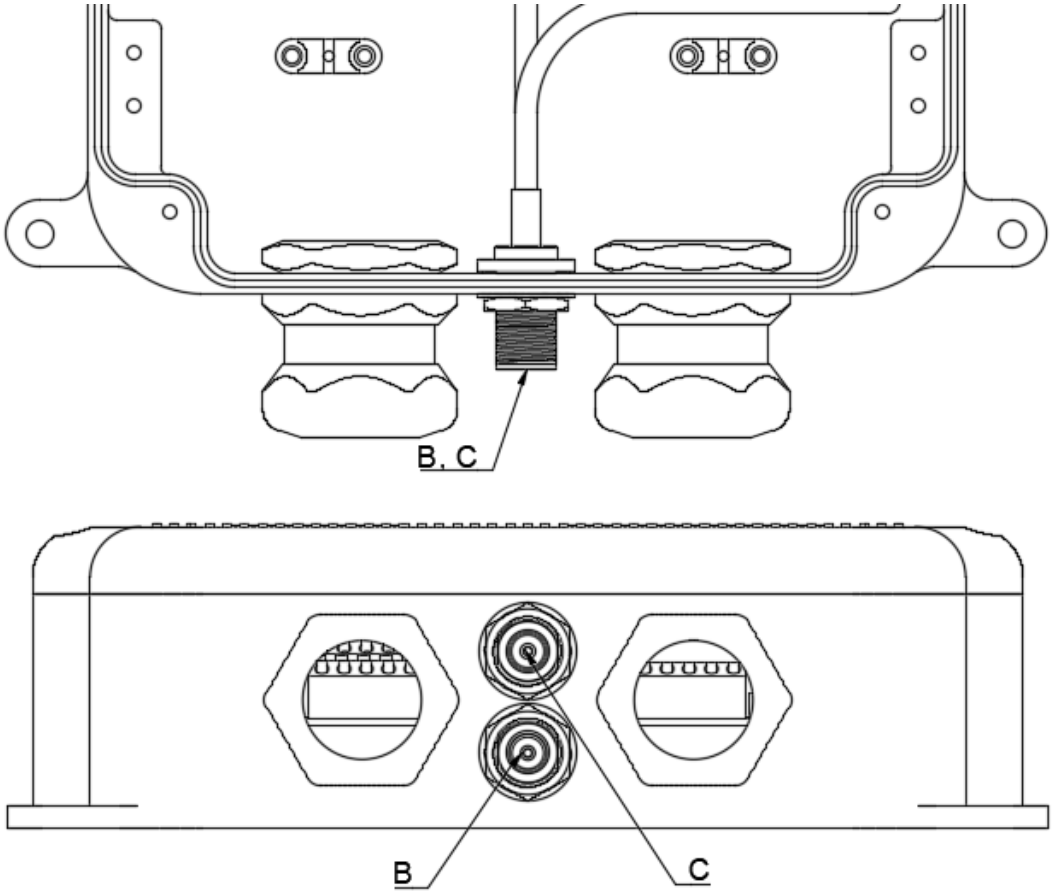
- Find 100Base-T socket which is marked red on a Figure below on a PCB inside of enclosure;
- Plug in RJ45 connector of the pulled Ethernet cable into the socket.



Antennas connection

Unit has two N-connectors at the bottom of the enclosure which are presented on a Figure, and marked with arrows 'B' (TX) and 'C' (RX).

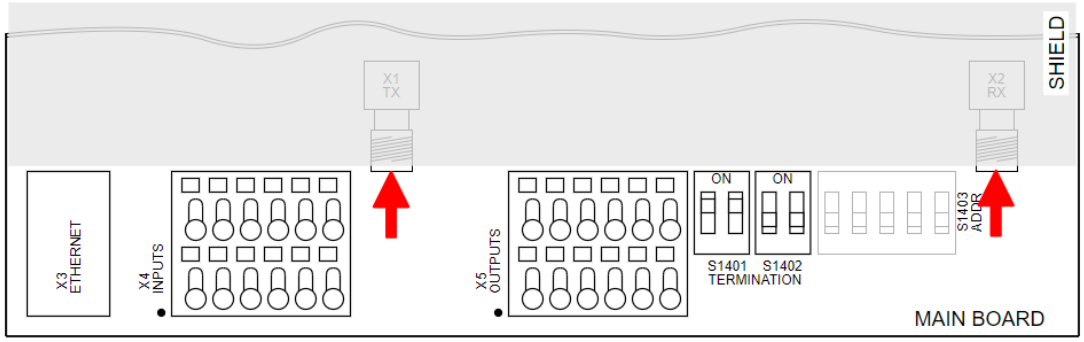
These connectors are intended for connecting receiving (RX) and transmitting (TX) antennas with coaxial cables provided along with the rest of equipment.



To connect antennas follow next steps:

- Find N-connectors at the bottom of enclosure as it showed on a Figure above;
- Attach coaxial cables of TX antenna to the connectors marked “B”;
- Attach coaxial cables of RX antenna to the connectors marked “C”;
- With another end of coaxial cables connect provided antennas.

ATTENTION: To avoid transmitters damage at HUB unit powering make sure that internal coaxial antenna jumpers between PCB SMA-connectors and enclosure N-connectors are attached according to the Figure below.


SHIELD
X1
TX
X2
RX
X3
ETHERNET
X4
INPUTS
X5
OUTPUTS
ON
ON
S1401
TERMINATION
S1402
S1403
ADDR
MAIN BOARD

Tunning

Configuring and Managing system with web configuration page

Configuration procedure allow to change default settings (system mode, channels frequencies, etc) of the Towerlinq system via WEB configuration page [e.g. WEB-configurator].

ATTENTION: To create a new configuration you have to connect a laptop/PC into the unit as it described on chapter [PC connection]

NOTE: WEB-Configurator tested with:

Browser	Version, Build	OS
Microsoft Edge	85.0.564.51 (Official build)	Windows (64-bit)
FireFox	80.0	Windows (64-bit)
Chrome	85.0.4183.121 (Official Build)	Windows (64-bit)

WARNING: Switching Power ON without attached antennas may damage transmitters. Switching power ON with de-attached PCB shield or not attached Enclosure's cover is not allowed!

To start configuring switch power ON for the HUB unit.

Connecting from the configurator

Follow next steps to connect to a web-configurator:

- Open an appropriate WEB browser;
- Connect to an IP http://10.0.5.1/ [laptop should have static IP address within 10.0.5.0/24 network address range manually set by operator. For example: 10.0.5.2/24.]

WEB tool Introduction

Interface

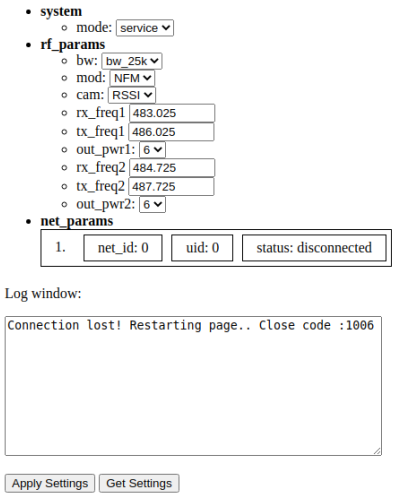
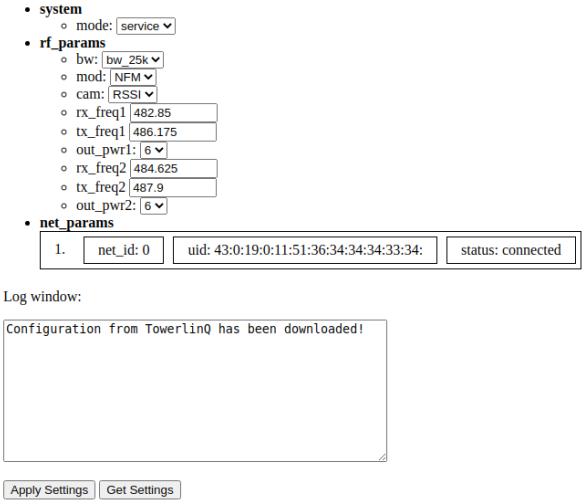
Web interface described above has been developed specifically to manage parameters and states of the TowerlinQ system.

The interface allows to change RX/TX frequencies of two channels. Also, the system can be turned off by switching mode to service.

Main screen virtually may be divided on 3 space:

1. Space reflected current values and affect on state (**system** and **rf_params**)
2. Space reflected devices connected to the network and they state (**net_params**)
3. Space which reflects feedback on applied commands (**log window**)

Starting

When you land [link to how to open web configurator] on the web-configurator , you'll see the following page:	Right after you connect to web-configurator it requests system parameters from TowerlinQ and displays them on the screen.
	

system

Drop-down box allows to switch between system modes:

System mode	RF transmitters and amplifiers	Description
Service	OFF	Low power mode. Ready for configuration apply.
Active	ON	Normal operation as a booster.

rf_params

Set of fields to monitoring it values for **GET** and **APPLY** commands.
Purpose of fields described in the table below:

rf_params name	Allowed value	Description
bw:	**not changeable**	Fixed 25kHz
mod:	**not changeable**	NFM
cam:	**not changeable**	fixed RSSI
rx_freq1	470…500 MHz	rx frequency for channel 1 with step 25kHz

tx-freq1	470…500 MHz	tx frequency for channel 1 with step 25kHz
out_pwr1:	**not changeable**	fixed 6. Output power for channel 1
rx_freq2	470…500 MHz	rx frequency for channel 2 with step 25kHz
tx-freq2	470…500 MHz	tx frequency for channel 2 with step 25kHz
out_pwr2:	**not changeable**	fixed 6. Output power for channel 2

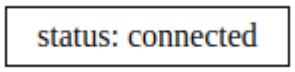
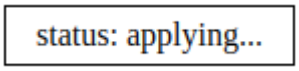
Net_params

Provide following information:

Parameters	Description
net_id:	network id (by default 0 - hub)
uid:	unique id (HW id of STM32)
status:	mirrors current state of the system

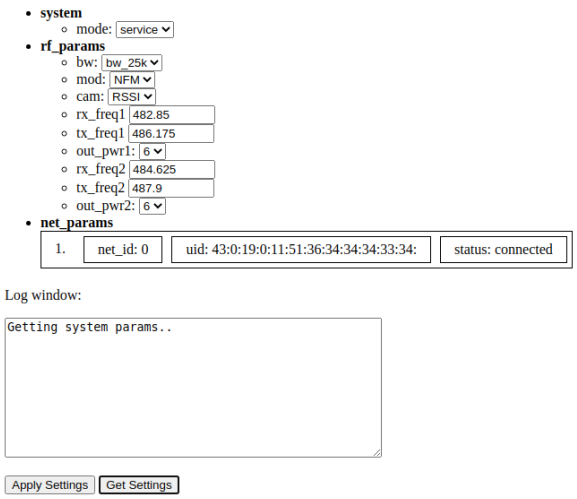
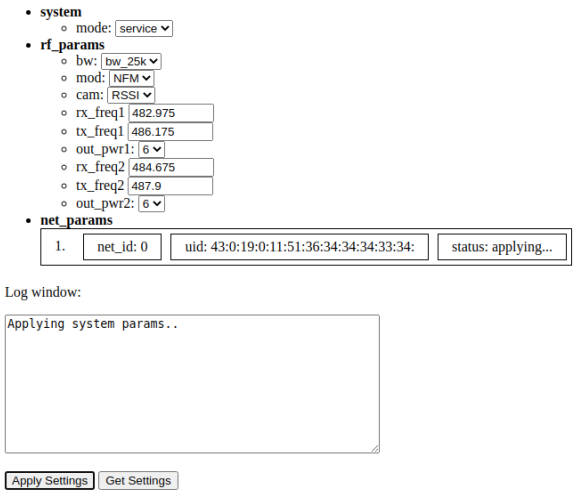
Status

There are three state of status :

Shown Status	Description
	system is not connected with web interface
	system is connected with web interface
	system applies new configuration from web interface

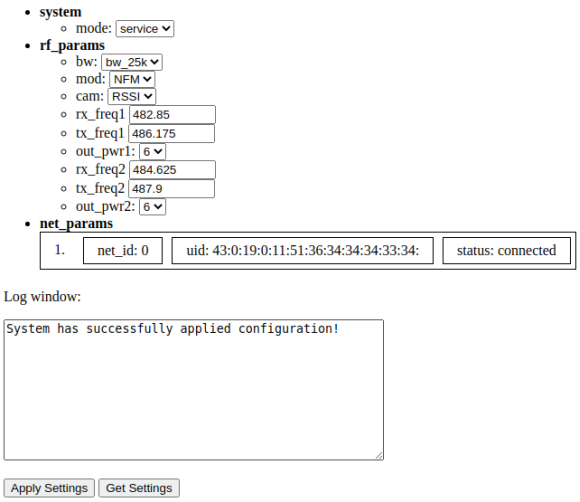
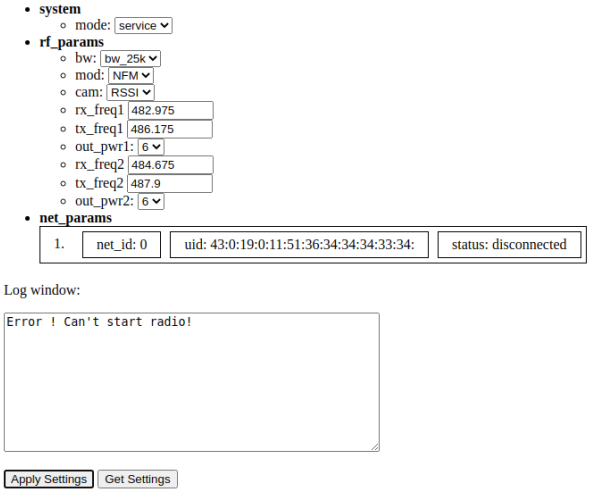
Interaction

Generally, to manipulate the system you need two buttons - Apply and Get settings.

Get settings	Apply settings
You can manually get system parameters by pressing **Get Settings** button. When you press **Get Settings**, you'll update web-interface with settings which are already uploaded (defined) in the TowerlinQ system.	When you press **Apply Settings,** you'll update the TowerlinQ system with the frequencies entered on the appropriate fields.
	

System Response

As soon a new parameters injected into the system, it reflects possible changes by answering.

Successful applying	Didn't apply
In case of **successful applying** of parameters you'll get next information in the Log window:	In case when system **didn't apply** the configuration, some of possible errors (described below) will be written to the Log window, f.e. :
	

Log window

Log window displays current state of the system, errors and information about success.

Possible errors	Description
Can’t set netsettings	Configuration is not applied
Can’t set mode	Active or Service mode can’t be set
Can’t get net settings	Configuration can’t be read
Can’t start radio	Radio can’t synchronize
Can’t get mode	Current mode of system can’t be read
Connection lost	Server is down