RADIO DATA NETWORKS

## User manual

# RipEX
# Radio modem & Router

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**RACOM s.r.o.** • Mirova 1283 • 592 31 Nove Mesto na Morave • Czech Republic
Tel.: +420 565 659 511 • Fax: +420 565 659 512 • E-mail: racom@racom.eu

**www.racom.eu**

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# Getting started

RipEX is a widely configurable compact radio modem, more precisely a radio IP router. All you have to do to put it into operation is to connect it to an antenna and a power supply and configure it using a PC and a web browser.

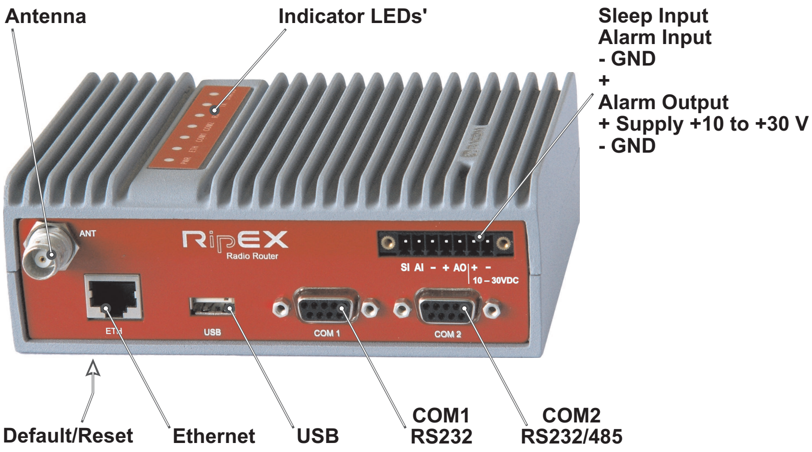


*Fig. 1: RipEX radio router*

**RipEX access defaults: IP 192.168.169.169/24, username: admin, password: admin**

Set a static IP 192.168.169.x/24 on your PC, power on the RipEX and wait 25 seconds for the RipEX OS to boot. Connect your PC to RipEXs' ETH interface, start your browser and type https://192.168.169.169 in the address line. When accessing RipEX for the first time, you have to accept the https security certificate issued by Racom.

Before attempting to do any configuration, make sure your RipEX is the only powered-up unit around. Since all units coming from factory share the same default settings ex factory, you could be accessing a different unit over the air without being aware of it.

When accessing over the optional “X5” USB/ETH adapter, your PC will get its IP settings from the built-in DHCP server and you have to type https://10.9.8.7 in your browser. Remaining steps are the same and you do not need to worry about other RipEX's, you will be connected to the local unit in all cases.

## SCADA radio network step-by-step

Building a reliable radio network for a SCADA system may not be that simple, even when you use such a versatile and easy-to-operate device as the RipEX radio modem. The following step-by-step checklist can help you to keep this process fast and efficient.

1. Design your network to ensure RF signal levels meet system requirements.
2. Calculate and estimate the network throughput and response times when loaded by your application.
3. Perform a bench-test with 3-5 sets of RipEX's and SCADA equipment (Chapter 5, *Bench test*).
4. Design the addressing and routing scheme of the network (Chapter 2, *RipEX in detail* and *RipEX App notes, Address planing*[1])
5. Preconfigure all RipEX's (Section 5.4, “Basic setup”).
6. Install individual sites
    1. Mount RipEX into cabinet (Section 6.1, “Mounting”).

[1] http://www.racom.eu/eng/products/m/ripex/app/routing.html

   2. Install antenna (Section 6.2, “Antenna mounting”).
   3. Install feed line (Section 6.3, “Antenna feed line”).
   4. Ensure proper grounding (Section 6.4, “Grounding”).
   5. Run cables and plug-in all connectors except from the SCADA equipment (Section 4.2, “Connectors”)
   6. Apply power supply to RipEX
   7. Test radio link quality (Section 5.5, “Functional test”).
   8. Check routing by the ping tool (the section called “Ping”) to verify accessibility of all IP addresses with which the unit will communicate.
   9. Connect the SCADA equipment

7. Test your application

# 1. RipEX – Radio router

## 1.1. Introduction

RipEX is a best-in-class radio modem, not only in terms of data transfer speed. This Software Defined Radio with Linux OS has been designed with attention to detail, performance and quality. All relevant state-of-the-art concepts have been carefully implemented.

RipEX provides 24x7 reliable service for mission-critical applications like SCADA & Telemetry for Utilities, SmartGrid power networks or transaction networks connecting lottery terminals, POS or ATM’s.

Any unit can serve as the central master, repeater, remote terminal, or all of these simultaneously, with a configuration interface easily accessible from a web browser.

Anybody with even basic knowledge of IP networking can set up a RipEX within a matter of minutes and maintain the network quite easily.

## 1.2. Key Features

- Exceptional data speeds on the radio channel
  - 83 kbps / 25 kHz, 42 kbps / 12.5 kHz, 21 kbps / 6.25 kHz

- 1× ETH, 2× COM, 1× USB, 5× virtual COM
  - Simultaneously on radio channel. COM1-RS232, COM2-RS232 or RS485, software configurable. Virtual COMs over ETH controlled by Terminal servers. USB for independent service access via USB/ETH adapter.

- 135–175; 300–370; 368–470; 928–960 MHz
  - Licensed radio bands
  - Software-selectable channel spacing 25, 12.5 or 6.25 kHz

- 10 watts
  - Transmission output control, nine stages from 0.1 to 10 W (max. 2 W for linear modulations).

- Energy saving
  - Sleep mode – 0.1 W, controlled via a digital input.
  Save mode – 2.3 W, wake up by receiving a packet from the radio channel

- Extended temperature range
  −40 to +70 ºC

- Easy to configure and maintain
  - Web interface,
  - Wizards,
  - On-line help,
  - Balloon tips,
  - Fastest web access to remote units

- Bridge or Router
  - RipEX is a device with native IP support which can be set as a standard bridge or router.

- Modbus, IEC101, DNP3, Comli, RP570, C24, DF1, Profibus, Modbus TCP, IEC104, DNP3 TCP etc.
  - Unique implementation of industrial protocols enables a secure addressed transmission of all packets in all directions

- Anti-collision protocol on radio channel
  - Allows multi polling & report-by-exception concurrently for several independent applications simultaneously

- Optimization – 3× higher throughput
  - Optimisation method which joins short packets, compresses data, optimises both the traffic to the link peer and the sharing of the radio channel capacity among the links.

- Embedded diagnostic & NMS
  - Real time and historical (20 periods, e.g. days) statistics and graphs for the unit and its neighbours.
  - SNMP including generation of TRAP alarms when preset thresholds are exceeded
  - on-line/off-line (recorded to a file in the RipEX) monitoring of all interfaces

- 256 AES encryption
  - The most secure encryption meets FIPS 140 2 requirements

- Pay only for what you need
  - Software authorisation keys allow you to add advanced features when needed (Router mode, 83 kbps, COM2, 10 W)
  - Free Master-key trial – (all coded features) for 30 days in every RipEX

- Reliability
  - 3 years warranty, rugged die cast aluminium case, military or industrial components
  - Every single unit tested in a climatic chamber as well as in real traffic

## 1.3. Standards

| | |
|---|---|
| Radio | ETSI EN 300 113-2 |
| | ETSI EN 302 561 |
| | ETSI EN 301 166-2 |
| | FCC part 90 |
| EMC | ETSI EN 301 489-1 |
| | ETSI EN 301 489-5 |
| | ETSI EN 301 489-5 |
| | EN 61000-3-2 |
| | EN 61000-3-3 |
| Safety | EN 60 950-1 |
| Vibration | EN 61 373 |
| | |
| ETH | IEEE 802.3i |
| | IEEE 802.3u |
| | IEEE 802.3af |

| | |
|---|---|
| RS232 | EIA-232-F |
| RS485 | EIA RS-485 |
| | |
| IEC101 | IEC 60870-5-101 |
| IEC104 | IEC 60870-5-104 |
| DNP3 | IEEE 1815-2010 |
| Profibus DP-V0 | IEC 61158 Type 3 |

# 2. RipEX in detail

## 2.1. Modes of operation

Radio modem RipEX is best suited for transmission of a large number of short messages where a guaranteed delivery time is required, i.e. for mission critical applications.

RipEX has the following basic uses:

- Polling

  In poll-response networks a central master unit communicates with a number of remote radiomodems one at a time. The master unit exchanges data with the currently connected remote radio, and when finished, it establishes a new connection with the next remote radio according to the polling order.

- Report-by-exception

  In report-by-exception networks remote units can be contacted similarly to polling networks. In addition, any remote unit can spontaneously send data to the master unit (typically an alarm).

- Mesh

  In mesh type networks any radio modem in the network can access any other radio modem randomly and spontaneously. Mesh network can also host polling or report-by-exception applications, even in several instances.

## 2.2. Bridge mode

A packet received through any interface is broadcast to the appropriate interfaces of all units within the network. Packets received on COM are broadcast to both COM1 and COM2 at remote sites, allowing you to connect 2 RTU's to any radio modem.

Any unit can be configured as a repeater. A repeater relays all packets it receives through the radio channel. The network implements safety mechanisms which prevent cyclic loops in the radio channel (e.g. when a repeater receives a packet from another repeater) or duplicate packets delivered to the user interface (e.g. when RipEX receives a packet directly and then from a repeater).

Beside standard packet termination by an "Idle" period on the serial port (a pause between received bytes) the bridge mode also offers "streaming". While in streaming mode, transmission on the radio channel starts immediately, without waiting for the end of the received frame on COM => zero latency.

The bridge mode is suitable for all polling applications.

### 2.2.1. Detailed Description

Bridge mode is suitable for Point-to-Multipoint networks, where Master-Slave applications with polling-type communication protocol are used. RipEX in bridge mode is as easy to use as a simple transparent device, while providing communication reliability and spectrum efficiency by employing a sophisticated protocol in the radio channel.

In bridge mode, the radio channel protocol do not solve collisions. There is a CRC check of data integrity, however, i.e. once a message is delivered, it is 100% error free.

All the messages received from user interfaces (ETH&COM's) are immediately transmitted to the radio channel.

ETH - The whole network of RipEX radiomodems behaves as a standard ethernet network bridge. Each ETH interface automatically learns which devices (MAC addresses) are located in the local LAN and which devices are accessible over the radio channel. Consequently, only the ethernet frames addressed to remote devices are physically transmitted on the radio channel. This arrangement saves the precious RF spectrum from extra load which would be otherwise generated by local traffic in the LAN (the LAN to which the respective ETH interface is connected).

COM1,COM2 - All frames received from COM1(2) are broadcast over the radio channel and transmitted to all COM's (COM1 as well as COM2) on all radio modems within the network, the other COM on the source RipEX excluding.

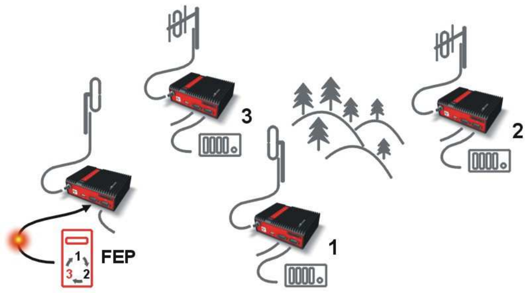
There is a special parameter TX delay (*Adv. Config., Device*), which should be used when all substations (RTU's) reply to a broadcast query from the master station. In such case massive collisions would ensue because all substations (RTU's) would reply at nearly the same time. To prevent such collision, TX delay should be set individually in each slave RipEX. The length of responding frame, the length of radio protocol overhead, modulation rate have to be taken into account.

## 2.2.2. Functionality example

In the following, common acronyms from SCADA systems are used:

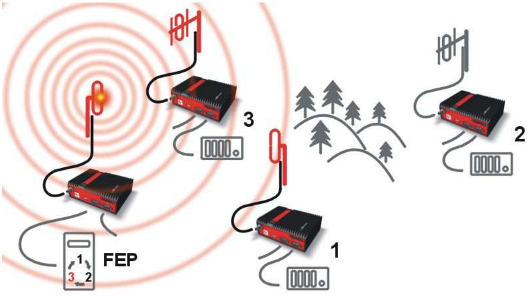
- FEP - Front End Processor, designates the communication interface equipment in the centre
- RTU - Remote Telemetry Unit, the terminal SCADA equipment at remote sites

The single digits in illustrations are “site names” and do not necessarily correspond with actual addresses of both the RipEX's and SCADA equipment. Address configuration examples are given in the *next chapter*.



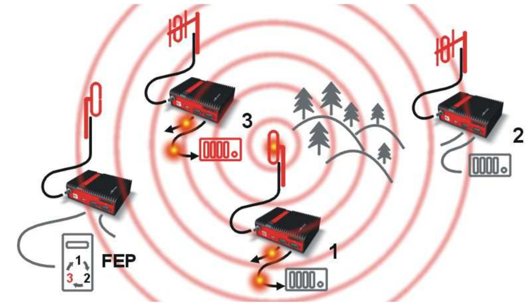
Step 1

Polling cycle starts:
FEP sends a request packet for RTU3 through COM1 to the connected RipEX.



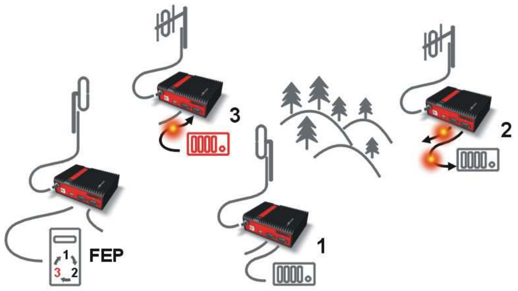
Step 2

FEP’s RipEX broadcasts this packet on Radio channel.
RipEX3 and RipEX1 receive this packet.
RipEX2 doesn’t receive this packet, because it is not within radio coverage of FEP’s RipEX.



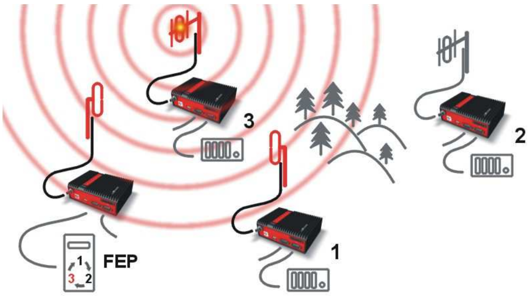
Step 3

RipEX3 and RipEX1 send the received packet to their COM1 and COM2.
Packet is addressed to RTU3, so only RTU3 responds.
RipEX1 is set as a repeater, so it retransmits the packet on Radio channel. Packet is received by all RipEXes.



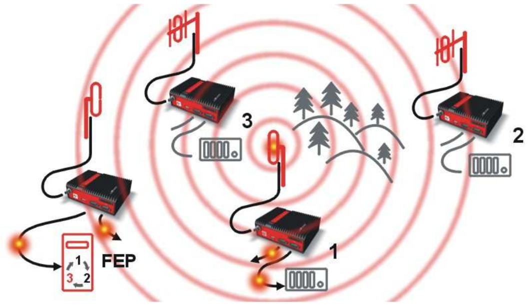
Step 4

RipEX2 sends repeated packet to its COM1 and COM2.
RTU2 doesn't react, because the packet is addressed to RTU3.
RipEX3 and FEP's RipEX **do not** send the repeated packet to their COM ports, because it has already been sent (RipEX3) or received (FEP's RipEX) on their COM (anti-duplication mechanism).
RTU3 sends the reply packet.



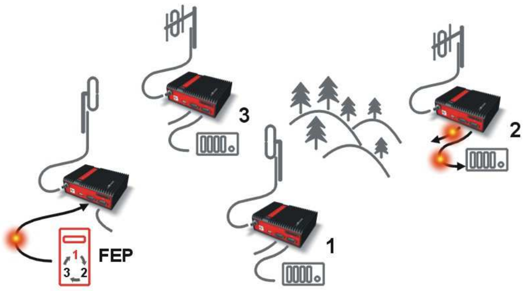
Step 5

RipEX3 broadcasts the reply packet from RTU3 on Radio channel.
Packet is received by RipEX1 and FEP's RipEX.



Step 6

FEP's RipEX sends the packet (the reply from RTU3) to FEP through COM1.
RipEX1 sends this packet to RTU1. RTU1 doesn't react, because the packet is addressed to FEP.
RipEX1 repeats the packet on Radio channel.
All RipEXes receive the packet.



Step 7

RipEX2 sends repeated packet to its COM1 and COM2.
RTU2 doesn't react, because the packet is addressed to FEP.
RipEX3 and FEP's RipEXes **do not** send the repeated packet to their COM ports, because it has been handled already.
FEP processes the reply from RTU3 and polling cycle continues…..

### 2.2.3. Configuration examples

You can see an example of IP addresses of the SCADA equipment and RipEX's ETH interfaces in the picture below.

In Bridge mode, the IP address of the ETH interface of RipEX is not relevant for user data communication. However it is strongly recommended to assign a unique IP address to each RipEXs' ETH interface, since it allows for easy local as well as remote service access. Moreover, leaving all RipEX's with the same (= default) IP on the ETH interface may cause serious problems, when more RipEX's are connected to the samX5e LAN, even if by accident (e.g. during maintenance).

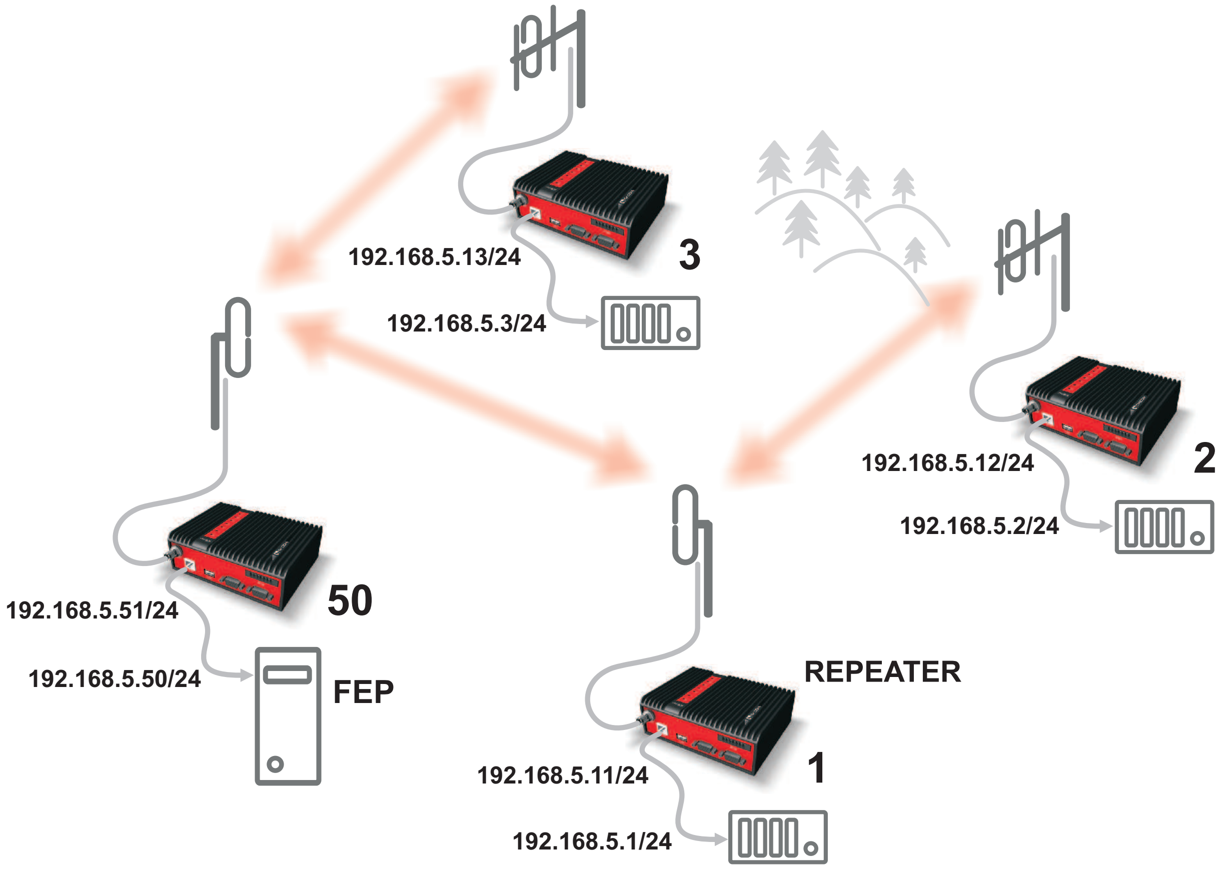


*Fig. 2.1: Bridge mode example*

**Repeater**

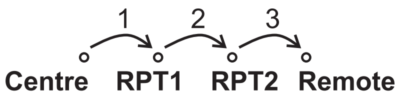
Because using the bridge mode makes the network transparent, the use of repeaters has certain limitations. To keep matters simple we recommend using a single repeater. However, if certain rules are observed, using multiple repeaters in the same network is possible.

The total number of repeaters in the network is configured for every unit individually under Bridge mode parameters. This information is contained in every packet sent. All units that receive such packet will resume transmission only after sufficient time has been allowed for the packet to be repeated. The packets received from user ports remain buffered and are sent after the appropriate time passes. This prevents collisions between remote radio modems. There can be no repeater collisions if only one repeater is used.

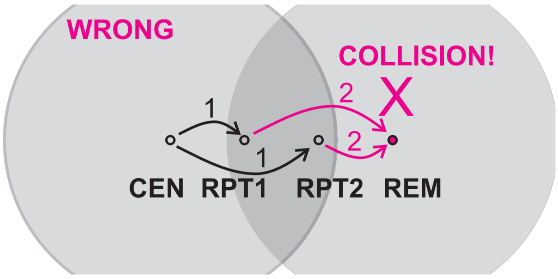
Where two or more repeaters are used, collisions resulting from simultaneous reception of a repeated packet must be eliminated. Collisions happen because repeaters repeat packets immediately after reception, i.e. if two repeaters receive a packet from the centre, they both relay it at the same time. If there is a radiomodem which is within the range of both repeaters, it receives both repeated packets at the same time rendering them unreadable.

Examples:

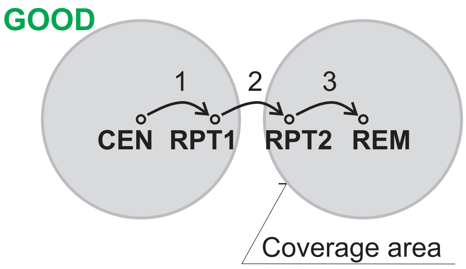
### 1. Repeaters connected serially



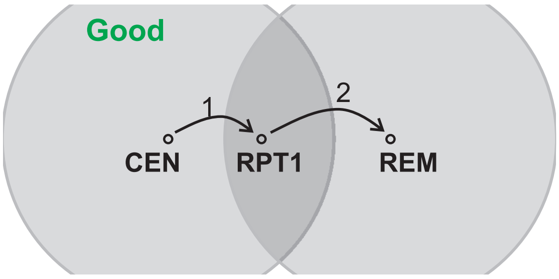
A packet is transmitted and repeated in steps 1, 2, 3.



In improperly designed networks collisions happen if a remote radio modem lies in the range of two repeaters (see the image): the packet sent from the centre (1) is received by both repeaters. It is repeated by them both (2) causing a collision at the remote. In other words – there should not be more than one repeater where the centre and remotes' coverage areas overlap.

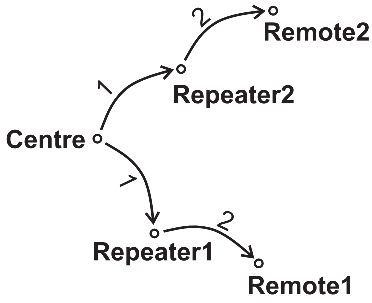


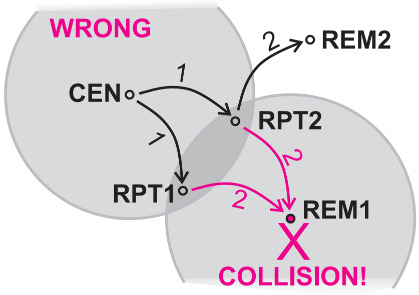
Solution 1.
Adjust signal coverage so that RPT2 is out of range of the centre and RPT1 is out of the range of the remote radio modem. This can be achieved for example by reducing the output power or using a unidirectional antenna.



Solution 2.
Use a single repeater. (Whenever network layout allows that.)

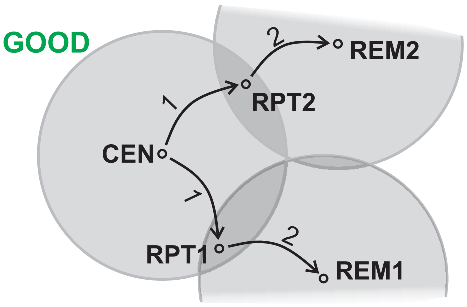
### 2. Parallel repeaters





Improperly designed network:

- RipEX REM1 is within the range of two repeaters (RPT1 and RPT2). The repeaters receive a packet (1) from the centre (CEN) and repeat it at the same time (2) causing a collision at REM1.



Well-designed network:

- A remote is only in the range of a single repeater (REM1-RPT1, REM2-RPT2).
There is always only one repeater where the centre and remote coverage areas overlap.

## 2.3. Router mode

RipEX works as a standard IP router with two interfaces (radio and ethernet) and two COM port devices. There is a sophisticated anti-collision protocol on the radio channel, which checks and verifies every single packet. Being an IP router, each unit can simultaneously work as a store-and-forward repeater and deliver packets to the connected equipment.

The router mode is suitable for all uses. In contrast to the bridge mode, a packet reception is confirmed over the radio channel even in very simple polling type applications, and if necessary the packet is retransmitted.

### 2.3.1. Detailed Description

Router mode is suitable for multipoint networks, where multi-master applications with any combination of polling and/or spontaneous data protocols can be used. The proprietary link-layer protocol on the radio channel is very sophisticated, it can transmit both unicast and broadcast frames, it has collision avoidance capability, it uses frame acknowledgement, retransmissions and CRC checks to guarantee data delivery and integrity even under harsh interference conditions on the radio channel.

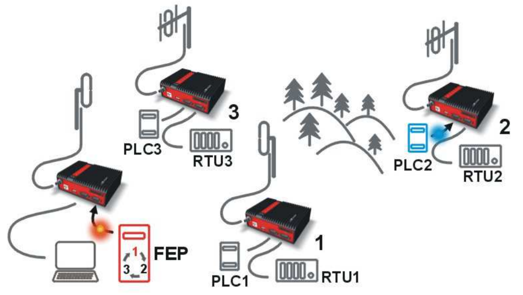
RipEX works as a standard IP router with 2 independent interfaces: radio and ETH. Each interface has its own MAC address, IP address and mask.

IP packets are processed according the routing table rules. You can also set the router’s default gateway (applies to both interfaces) in the routing table.

The COM ports are treated as standard host devices, messages can be delivered to them as UDP datagrams to selected port numbers. The destination IP address of a COM port is either the IP of ETH or the IP of a radio interface. The source IP address of outgoing packets from COM ports is always the IP of the ETH interface.

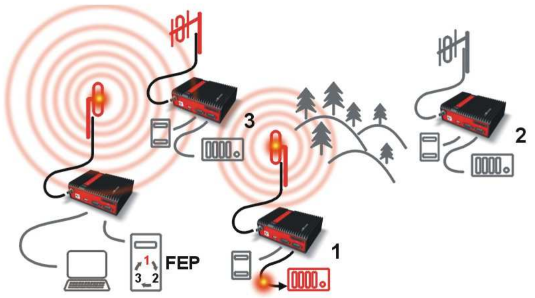
## 2.3.2. Functionality example

In the following example, there are two independent SCADA devices connected to RipEX's two COM ports. One is designated RTU (Remote Telemetry Unit) and is assumed to be polled from the centre by the FEP (Front End Processor). The other is labelled PLC (Programmable Logic Controller) and is assumed to communicate spontaneously with arbitrary chosen peer PLCs.



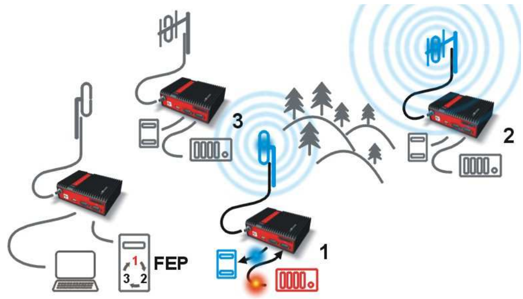
Step 1

FEP sends a request packet for RTU1 through COM2 to its connected RipEX.
Simultaneously PLC2 sends a packet for PLC1 to RipEX2 through COM1.



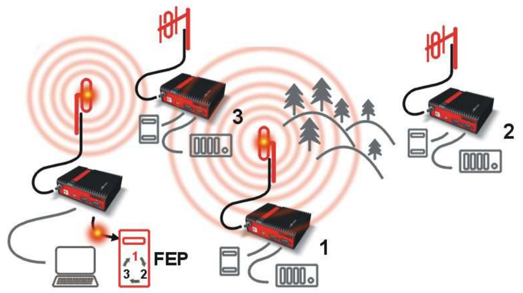
Step 2

FEP’s RipEX transmits an addressed packet for RTU1 on Radio channel.
RipEX1 receives this packet, checks data integrity and transmits the acknowledgement.
At the same time packet is sent to RTU1 through COM2.
RipEX3 receives this packet too. It doesn’t react, because this packet is directed to RipEX1 only.



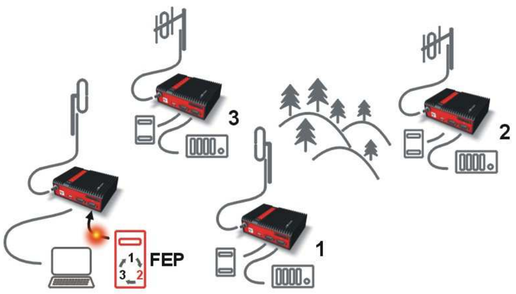
Step 3

RipEX2 waits till previous transaction on Radio channel is finished (anti-collision mechanism).
Then RipEX2 transmits on Radio channel the addressed packet for PLC1.
RipEX1 receives this packet, checks data integrity and transmits acknowledgement.
At the same time packet is sent to PLC1 through COM1.
Simultaneously the reply packet from RTU1 for FEP is received on COM2.



Step 4

RipEX1 transmitts the reply packet from RTU1 for FEP on Radio channel.
All RipEXes receive this packet. This packet is addressed to FEP’s RipEX, so only FEP’s RipEX reacts. It checks data integrity and transmits the acknowledgement to RipEX1.
At the same time the packet is sent to FEP through COM2.



Step 5

FEP receives the response from RTU1 and polling cycle continues…

However any PLC or RTU can spontaneously send a packet to any destination anytime.

### 2.3.3. Configuration examples

As it was mentioned above, RipEX radiomodem works as a standard IP router with two independent interfaces: radio and ETH. Each interface has got its own MAC address, IP address and mask.

The IP router operating principles stipulate that every unit can serve as a repeater.. Everything what is needed is the proper configuration of routing tables.

Radio IP addresses of the RipEX's required to communicate over the radio channel must share the same IP network. We recommend planning your IP network so that every RipEX is connected to a separate sub-network over the ethernet port. This helps to keep the routing tables clear and simple.

**Note**

Even if the IP addresses of all RipEXes in a radio channel share a single IP network, they may not be communicating directly as in a common IP network. Only the RipEXes that are within the radio range of each other can communicate directly. When communication with radio IP addresses is required, routing tables must include even the routes that are within the same network (over repeaters), which is different from common IP networks. The example configuration below does not show such routing rules for the sake of simplicity (they are not needed in most cases).

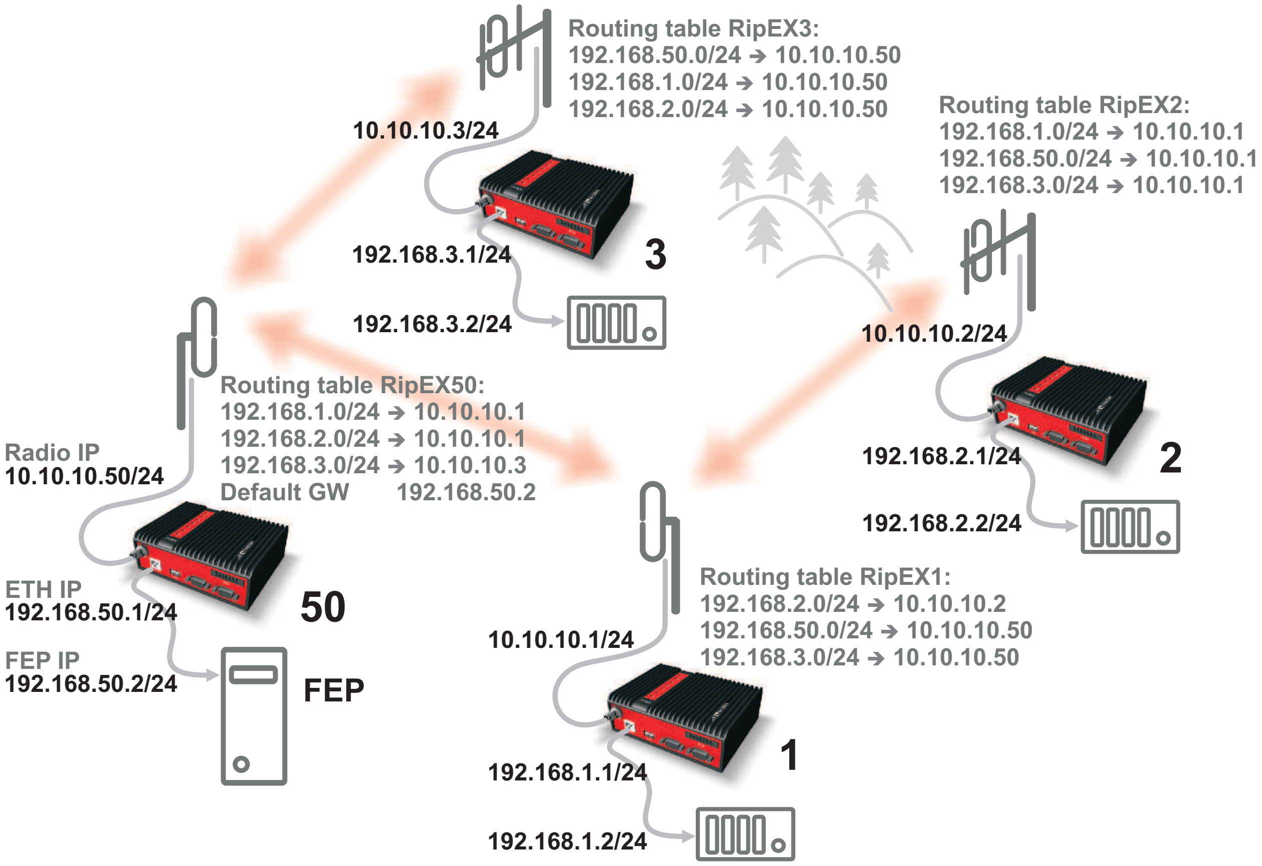


*Fig. 2.2: Addressing*

Formal consistency between the last byte of the radio IP address and the penultimate byte of the ethernet address is not necessary but simplifies orientation. The “Addressing” image shows a routing table next to every RipEX. The routing table defines the next gateway for each IP destination. In radio transmission, the radio IP of the next radio-connected RipEX serves as the gateway.

Example of a route from FEP (RipEX 50) to RTU 2:

- The destination address is 192.168.2.2
- The routing table of the RipEX 50 contains this record:
  Destination 192.168.2.0/24 Gateway 10.10.10.1
- Based on this record, all packets with addresses in the range from 192.168.2.1 to 192.168.2.254 are routed to 10.10.10.1
- Because RipEX 50’s radio IP is 10.10.10.50/24, the router can tell that the IP 10.10.10.1 belongs to the radio channel and sends the packet to that address over the radio channel
- The packet is received by RipEX 1 with the address 10.10.10.1 where it enters the router
- The routing table of RipEX 1 contains the record:
  Destination 192.168.2.0/24 Gateway 10.10.10.2
  based on which the packet is routed to 10.10.10.2 over the radio channel
- The packet is received by RipEX 2
- The router compares the destination IP 192.168.2.2 with its own ethernet address 192.168.2.1/24 and determines that the packet’s destination is within its ETH network and sends the packet over the ethernet interface – eventually, the packet is received by RTU 2.

## 2.3.4. Addressing hints

In large and complex networks with numerous repeaters, individual routing tables may become long and difficult to comprehend. To keep the routing tables simple, the addressing scheme should follow the layout of the radio network.

More specifically, every group of IP addresses of devices (both RipEX's and SCADA), which is accessed via a repeater, should fall in a range which can be defined by a mask and no address defined by that mask exists in different part of the network.

A typical network consisting of a single centre and number of remotes has got a tree-like layout, which can be easily followed by the addressing scheme – see the example in the Figure *Optimised addressing* below.

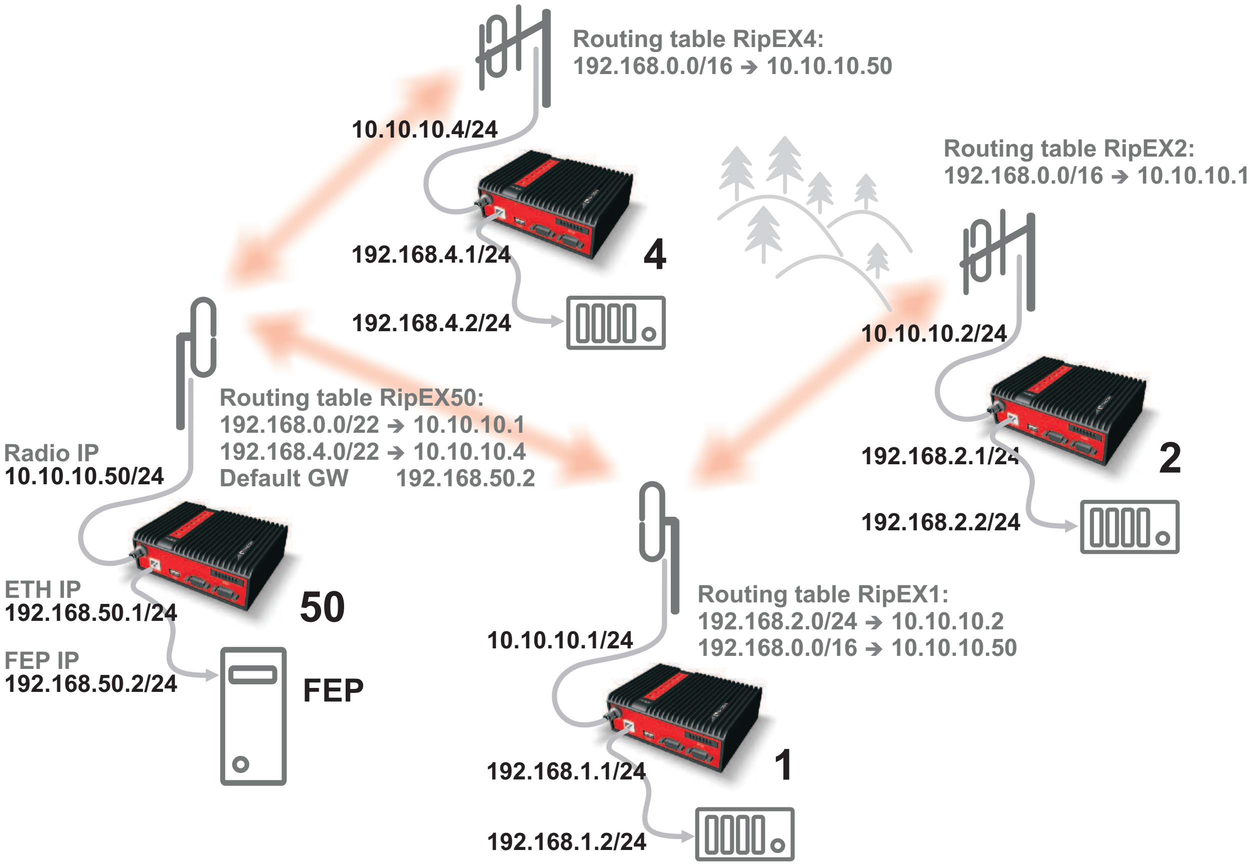


*Fig. 2.3: Optimised addressing*

The default gateway is also a very powerful routing tool, however be very careful whenever the default route would go to the radio interface, i.e. to the radio channel. If a packet to non-existing IP destination came to the router, it would be transmitted over the radio channel. Such packets increase the load of the network at least, cause excessive collisions, may end-up looping etc. Consequently the default route should always lead to the ETH interface, unless you are perfectly certain that a packet to non-existing destination IP may never appear (remember you are dealing with complex software written and configured by humans).

## 2.4. Serial SCADA protocols

Even when the SCADA devices are connected via serial port, communication remains secured and address-based in all directions (centre-RTU, RTU-centre, RTU-RTU).

In router mode, RipEX utilises a unique implementation of various SCADA protocols (Modbus, IEC101, DNP3, Comli, RP570, C24, DF1, Profibus). In this implementation SCADA protocol addresses are mapped to RipEX addresses and individual packets are transmitted as acknowledged unicasts. Polled remote units respond to the unit that contacted them (multi master network possible) using secure packets. When needed, RTU-RTU parallel communication is also possible.

### 2.4.1. Detailed Description

Each SCADA protocol, such as Modbus, DNP3, IEC101, DF1, etc., has its own unique message format, and more importantly, its unique way of addressing remote units. The basic task for protocol utility is to check whether a received frame is in the correct protocol format and uncorrupted. Most of the SCADA protocols use some type of error detection codes (Checksum, CRC, LRC, BCC, etc.) for data integrity control, so RipEX calculates this code and check it with the received one.

RipEX radio network works in IP environment, so the basic task for the protocol interface utility is to convert SCADA serial packets to UDP datagrams. Address translation settings are used to define the destination IP address and UDP port. Then these UDP datagrams are sent to RipEX router, processed and typically forwarded as unicasts over the radio channel to their destination. If the gateway defined in the routing table belongs to the ethernet LAN, UDP datagrams are rather forwarded to the ethernet interface. After reaching the gateway (typically a RipEX router), the datagram is again forwarded according to the routing table.

Above that, RipEX is can to handle even broadcast packets from serial SCADA protocols. When broadcasts are enabled in the respective Protocol settings, the defined packets are treated as broadcast (e.g. they are not acknowledged on Radio channel). On the Repeater station, it is possible to set whether broadcast packets shall be repeated or not.

Note: UDP datagrams can be acknowledged on the radio channel (ACK parameter of router mode) but they are not acknowledged on the ethernet channel.

When a UDP datagram reaches its final IP destination, it should be in a RipEX router again (either its ETH or radio interface). It is processed further according its UDP port. Either it is delivered to COM1(2) port daemon, where the datagram is decapsulated and the data received on serial interface of the source unit is forwarded to COM1(2), or the UDP port is that of a Terminal server or any other special protocol daemon on Ethernet like Modbus TCP etc. Then the datagram is processed by that daemon accordingly to the respective settings.

RipEX uses a unique, sophisticated protocol on the radio channel. It guaranties data integrity even under heavy interference or weak signal conditions due to the 32 bit CRC used, minimises the likelihood of a collision and retransmits frames when collision happens, etc. These features allow for the most efficient SCADA application arrangements to be used, e.g. multi-master polling and/or spontaneous communication from remote units and/or parallel communication between remote units, etc.

Note: The anti-collision protocol feature is available only in the router mode. The bridge mode is suitable for simple Master-Slave arrangements with polling-type application protocol.

## 2.5. Combination of IP and serial communication

RipEX enables combination of IP and serial protocols within a single application.

Five independent terminal servers are available in RipEX. A terminal server is a virtual substitute for devices used as serial-to-TCP(UDP) converters. It encapsulates serial protocol to TCP(UDP) and vice versa eliminating the transfer of TCP overhead over the radio channel.

If the data structure of a packet is identical for IP and serial protocols, the terminal server can serve as a converter between TCP(UDP)/IP and serial protocols (RS232, RS485).

RipEX also provides a built-in converter Modus RTU – Modus TCP, where data structure is not the same, so one application may combine both protocols, Modus RTU and Modus TCP.

### 2.5.1. Detailed Description

Generally, a terminal server (also referred to as serial server) enables connection of devices with a serial interface to a RipEX over the local area network (LAN). It is a virtual substitute for the devices used as serial-to-TCP(UDP) converters.

Examples of the use:

A SCADA application in the centre should be connected to the radio network via serial interface, however, for some reason that serial interface is not used. The operating system (e.g. Windows) can provide a virtual serial interface to such application and converts the serial data to TCP (UDP) datagrams, which are then received by the terminal server in RipEX. This type of connection between RipEX and application provides best results when:

- There is no hardware serial interface on the computer
- Serial cable between RipEX and computer would be too long. E.g. the RipEX is installed very close to the antenna to reduce feed line loss.
- LAN already exists between the computer and the point of installation

**Note:** The TCP (UDP) session operates only locally between RipEX and the central computer, hence it does not increase the load on the radio channel.

In special cases, the terminal server can reduce network load from TCP applications . A TCP session can be terminated locally at the terminal server in RipEX, user data extracted from the TCP messages and processed as if it came from a COM port. When the data reaches the destination RipEX, it can be transferred to the RTU either via the serial interface or via TCP (UDP), using the terminal server again. Please note, that RipEX Terminal server implementation also supports the dynamical IP port change in every incoming application datagram. In such case the RipEX sends the reply to the port from which the last response has been received. This feature allows to extend the number of simultaneously opened TCP connections between the RipEX and the locally connected application up to 10 on each Terminal server.

## 2.6. Diagnostics & network management

RipEX radiomodem offers a wide range of built-in diagnostics and network management tools.

### 2.6.1. Logs

There are ‘Neighbours’ and Statistic logs in RipEX. For both logs there is a history of 20 log files available, so the total history of saved values is 20 days (assuming the default value of 1440 min. is used as the Log save period).

**Neighbours**

The ‘Neighbours’ log provides information about neighbouring units (RipEX’s which can be accessed directly over the radio channel, i.e. without a repeater). Every RipEX on the network regularly broadcasts its status, the set of so called “Watched values”: the probability of packet loss when transmitting data over the radio channel, current supply voltage, internal temperature, measured RF output power, the Voltage Standing Wave Ratio on the antenna feed line and the total number of packets received from / transmitted to ETH, COM1, COM2 interfaces. In addition, the RipEX that records this data in its log also keeps track of how many times it listened to its neighbouring unit as well as of the RSS and DQ recorded. See *Adv. Conf., Diagnostic* for more.

**Statistic**

The ‘Statistic’ log provides information about the volume of data traffic on all interfaces: radio, ETH, COM1, COM2. It offers detailed information about the number of transmitted packets, their size and the throughput per second. Moreover, a detailed division into user and service packets is available for the radio channel. See chapter *Adv. Conf., Diagnostic* for more.

### 2.6.2. Graphs

An independent database periodically stores the Watched values (see 'Neighbours' log above) from up to five neighbouring RipEX's and from the local one, there including most important values from the Statistic log. All these values can be displayed as graphs.

The graphs are available in summary and detailed versions. Detailed logging is triggered on when a threshold value has been reached for the specific item to enable a more detailed investigation into the units’ operation when an alarm event occurs. Each graph can display two different elements at once, including their set thresholds. Each of the values may originate from a different RipEX unit.

See chapter *Adv. Conf., Graphs* for more.

### 2.6.3. SNMP

RipEX implements an SNMP client ver. 1. The values provided by RipEX are shown in the MIB table. RipEX also allows generating SNMP traps when thresholds have been reached for the monitored values: RSScom, DQcom, TXLost[%], Ucc, Temp, PWR, VSWR, ETH[Rx/Tx], COM1[Rx/Tx], COM2[Rx/Tx], HW Alarm Input.

See chapter *RipEX App notes, SNMP for RACOM RipEX*[1] for more.

### 2.6.4. Ping

To diagnose the individual radio links RipEX is equipped with an enhanced Ping tool. In addition to the standard info such as the number of sent and received packets or the round trip time, it provides the

[1] http://www.racom.eu/eng/products/m/ripex/app/snmp.html

overall load, the resulting throughput, BER, PER and specific data about the quality of the radio transmission, RSS and DQ for the weakest radio link on the route.

See chapter *Adv. Conf., Ping* for details.

### 2.6.5. Monitoring

TMonitoring is an advanced on-line diagnostic tool, which enables a detailed analysis of communication over any of the interfaces of a RipEX router. In addition to all the physical interfaces (RADIO, ETH, COM1, COM2), some internal interfaces between software modules (e.g. Terminal servers, Modus TCP server etc.) can be monitored when such advanced diagnostics is needed.

Monitoring output can be viewed on-line or saved to a file in the RipEX (e.g. a remote RipEX) and downloaded later.

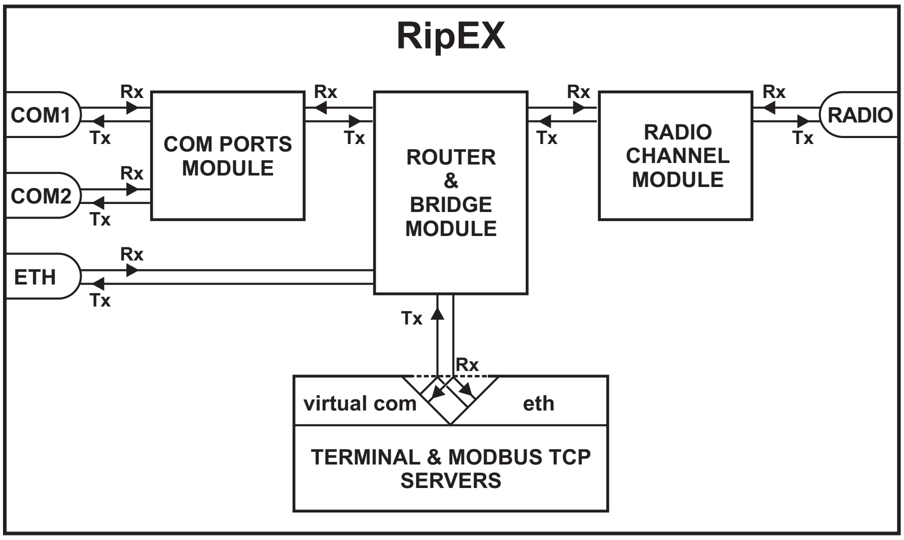


*Fig. 2.4: Monitoring*

See chapter *Adv. Conf., Monitoring* for details.

## 2.7. Firmware update and upgrade

Occasionally RipEX firmware update or upgrade is released. An update improves functionality and/or fix software bugs. Updates can be downloaded for free from www.racom.eu.

A firmware upgrade implements significant improvements and new functions which take the product to a new level. Downloading and applying a firmware upgrade is the same as with firmware update. However a software key may have to be purchased and applied to activate the new functionality or the upgrade itself (see the next chapter).

See chapter *Adv. Conf., Firmware* for more.

## 2.8. Software feature keys

Certain advanced RipEX features are activated with software keys. Among such code protected features are the *Router mode, 83 kbps (High speed), COM2, 10 W*. This enables the users to initially purchase only the functionality they require and buy additional functions as the requirements and expectations grow. This protects the investment into the hardware. Thanks to SDR-based hardware design of RipEX no physical replacement is necessary – the user simply buys a key and activates the feature.

Software keys are always tied to a specific RipEX production code. When purchasing a software key, this production code must be given.

See chapter *Adv. Conf., SW feature keys* for more.

# 3. Network planning

The significance of planning for even a small radio network is often neglected. A typical scenario in such cases goes as follows – there's not enough time (sometimes money) to do proper planning, so the network construction is started right away while decisions on antennas etc. are based mainly on budget restrictions. When the deadline comes, the network is ready but its performance does not meet the expectations. Finally the (expensive) experts are invited to fix the problem and that fix costs ten times more than a proper design process done beforehand would have.

The following paragraphs are not a guide to network planning – that is a topic far beyond the scope of a product manual. What is provided is the essential RipEX data needed plus some comments on common problems which should be addressed during the planning process.

## 3.1. Data throughput, response time

A UHF radio network provides very limited bandwidth for principal reasons. Hence the first and very important step to be taken is estimating/calculating the capacity of the planned network. The goal is to meet the application bandwidth and time-related requirements. Often this step determines the layout of the network, for example when high speed is necessary, only near-LOS (Line-of-sight) radio hops can be used.

RipEX offers an unprecedented range of data rates. The channel width available and signal levels expected/measured on individual hops limit the maximum rate which can be used. The data rate defines the total capacity of one radio channel in one area of coverage, which is shared by all the radio modems within the area. Then several overhead factors, which reduce the total capacity to 25-90% of the "raw" value, have to be considered. They are e.g. RF protocol headers, FEC, channel access procedures and number of store-and-forward repeaters. There is one positive factor left – an optimum compression (e.g. IP optimization) can increase the capacity by 20-200%.

All these factors are heavily influenced by the way the application loads the network. For example, a simple polling-type application results in very long alarm delivery times – an event at a remote is reported only when the respective unit is polled. However the total channel capacity available can be 60-95% of the raw value, since there are no collisions. A report-by-exception type of load yields much better application performance, yet the total channel capacity is reduced to 25-35% because of the protocol overhead needed to avoid and solve collisions.

The basic calculations of network throughput and response times for different RipEX settings can be done at www.racom.eu[1].

Let us add one comment based on experience. Before committing to the actual network design, it is very wise to do a thorough bench-test with real application equipment and carefully monitor the load generated. A difference against the datasheets, which may be negligible in a LAN environment, may have fundamental consequences for the radio network design. To face that "small" difference when the network is about to be commissioned may be a very expensive experience. The bench test layout should include the application centre, two remotes (at least) and the use of a repeater. See the following picture for an example.

[1] http://www.racom.eu/eng/products/radio-modem-ripex.html#calculation

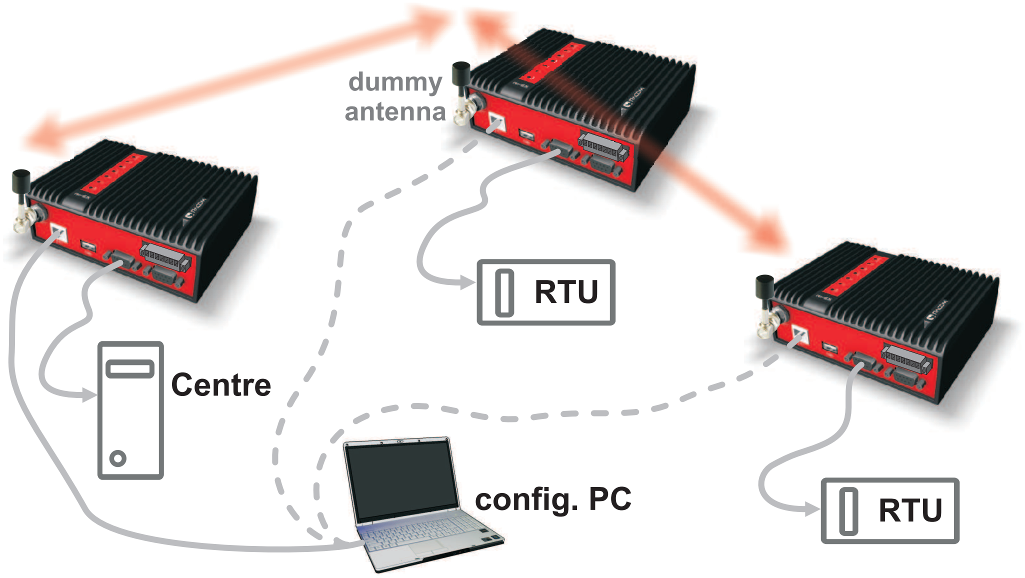


*Fig. 3.1: Application bench test*

## 3.2. Frequency

Often the frequency is simply given. If there is a choice, using the optimum frequency range can make a significant difference. Let us make a brief comparison of the most used UHF frequency bands.

### 160 MHz

The best choice when you have to cover a hilly region and repeaters are not an option. The only frequency of the set of options which can possibly make it to a distant valley, 20 km from your nearest point-of-presence, it can reach a ship 100 km from the shore base. The penalty you pay is tremendous – high level of noise in urban and industry areas, omnipresent multi-path propagation, vulnerability to numerous special propagation effects in troposphere etc. Consequently this frequency band is suitable for low speeds using robust modulation techniques only, and even then a somewhat lower long-term communication reliability has to be acceptable for the application.

### 450 MHz

The most popular of UHF frequency bands. It still can get you slightly “beyond the horizon”, while the signal stability is good enough for 99% (or better) level of reliability. Multi-path propagation can be a problem, hence high speeds may be limited to near-LOS conditions. Urban and industrial noise does not pose a serious threat (normally), but rather the interference caused by other transmissions is quite frequent source of disturbances.

### 900 MHz

This band requires planning the network in “microwave” style. Hops longer than about 1 km have to have “almost” clear LOS (Line-of-sight). Of course a 2–5 km link can handle one high building or a bunch of trees in the middle, (which would be a fatal problem for e.g. an 11 GHz microwave). 900 MHz also penetrates buildings quite well, in an industrial environment full of steel and concrete it may be the best choice. The signal gets “everywhere” thanks to many reflections, unfortunately there is bad news attached to this - the reliability of high speed links in such environment is once again limited. Otherwise, if network capacity is your main problem, then 900 MHz allows you to build the fastest and most reliable links. The price you pay (compared to lower frequency bands) is really the price – more repeaters and higher towers increase the initial cost. Long term reliable performance is the reward.

The three frequency bands discussed illustrate the simple basic rules – the higher the frequency, the closer to LOS the signal has to travel. That limits the distance over the Earth's surface – there is no other fundamental reason why shorter wavelengths could not be used for long distance communication. On the other hand, the higher the frequency, the more reliable the radio link is. The conclusion is then very simple – use the highest frequency band you can.

## 3.3. Signal budget

For every radio hop which may be used in the network, the signal level at the respective receiver input has to be calculated and assessed against requirements. The fundamental requirements are two – the data rate, which is dictated by total throughput and response times required by the application, and the availability, which is again derived from the required reliability of the application. The data rate translates to receiver sensitivity and the availability (e.g. 99,9 % percent of time) results in size of the fade margin.

The basic rule of signal budget says, that the difference between the signal level at the receiver input and the guaranteed receiver sensitivity for the given data rate has to be greater than the fade margin required:

RX signal [dBm] – RX sensitivity [dBm] >= Fade margin [dB]

To calculate the RX signal level, we follow the RF signal path:

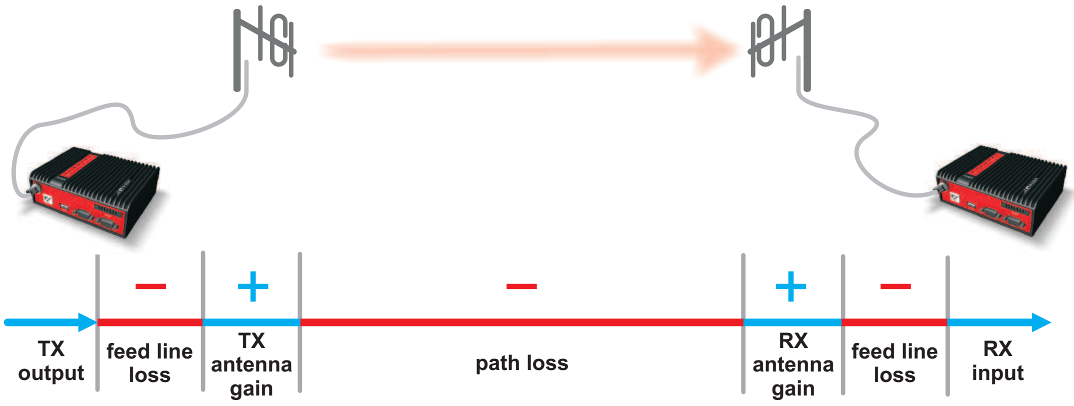


*Fig. 3.2: Signal path*

| RX signal [dBm] = | example: |
|---|---|
| + TX output [dBm] | +30.0 dBm (TX output 1 W) |
| - TX antenna feeder loss [dB] | -2.5 dB (20m cable RG-213 U, 400 MHz) |
| +TX antenna gain [dBi] | +2.1 dBi (half-wave dipole, 0 dBd) |
| - Path loss [dB] | -125.0 dB calculated from field measurement) |
| + RX antenna gain [dBi] | +9.7 dB (7-al Yagi antenna, 7.6 dBd) |
| - RX antenna feeder loss [dB] | -3.1 dB (10 m cable RG-58 CU, 400 MHz) |
| | = -88.8 dBm Received Signal Strength (RSS) |

The available TX output power and guaranteed RX sensitivity level for the given data rate have to be declared by the radio manufacturer. RipEX values can be found in Table 4.6, “Technical parameters”.

Antenna gains and directivity diagrams have to be supplied by the antenna manufacturer. Note that antenna gains **against isotropic radiator (dBi)** are used in the calculation. The figures of feeder cable loss per meter should be also known. Note that coaxial cable parameters may change considerably with time, especially when exposed to an outdoor environment. It is recommended to add a 50-100 % margin for ageing to the calculated feeder loss.

### 3.3.1. Path loss and fade margin

The path loss is the key element in the signal budget. Not only does it form the bulk of the total loss, the time variations of path loss are the reason why a fade margin has to be added. In reality, very often the fade margin is the single technical figure which expresses the trade-off between cost and performance of the network. The decision to incorporate a particular long radio hop in a network, despite that its fade margin indicates 90 % availability at best, is sometimes dictated by the lack of investment in a higher tower or another repeater. Note that RipEXs Auto-speed feature allows the use of a lower data rate over specific hops in the network, without the need to reduce the rate and consequently the throughput in the whole network. Lower data rate means lower (= better) value of receiver sensitivity, hence the fade margin of the respective hop improves. See the respective Application note to learn more on the Auto-speed feature.

When the signal path profile allows for LOS between the TX and RX antennas, the standard formula for free-space signal loss (below) gives reliable results:

Path loss [dB] = 20 * log10 (distance [km]) + 20 * log10 (frequency [MHz]) + 32.5

In the real world the path loss is always greater. UHF radio waves can penetrate obstacles (buildings, vegetation), can be reflected from flat objects, can bend over round objects, can disperse behind sharp edges – there are numerous ways how a radio signal can propagate in non-LOS conditions. The additional loss when these propagation modes are involved (mostly combined) is very difficult to calculate. There are sophisticated methods used in RF design software tools which can calculate the path loss and its variations (statistical properties) over a computer model of terrain. Their accuracy is unfortunately very limited. The more obstacles on the path, the less reliable is the result. Such a tool can be very useful in the initial phase of network planning, e.g. to do the first network layout for the estimate of total throughput, however field measurements of every non-LOS radio hop should be done before the final network layout is designed.

Determining the fade margin value is even more difficult. Nevertheless the software tools mentioned can give some guidance, since they can calculate the statistical properties of the signal. Generally the fade margin (for given availability) is proportional to the difference between the real path loss and the LOS path loss over the same distance. Then it is about inversely proportional to frequency (in the UHF range at least). To give an example for 10 km, non-LOS, hop on 450 MHz, fade margin of 20 dB is a bare minimum. A field test may help again, provided it is run for longer period of time (hours-days). RipEX diagnostic tools (ping) report the mean deviation of the RSS, which is a good indication of the signal stability. A multiple of the mean deviation should be added to the fade margin.

## 3.4. Multipath propagation, DQ

Multipath propagation is the arch-enemy of UHF data networks. The signal coming out of the receiving antenna is always a combination of multiple signals. The transmitted signal arrives via different paths, by the various non-LOS ways of propagation. Different paths have different lengths, hence the waveforms are in different phases when hitting the receiving antenna. They may add-up, they may cancel each other out.

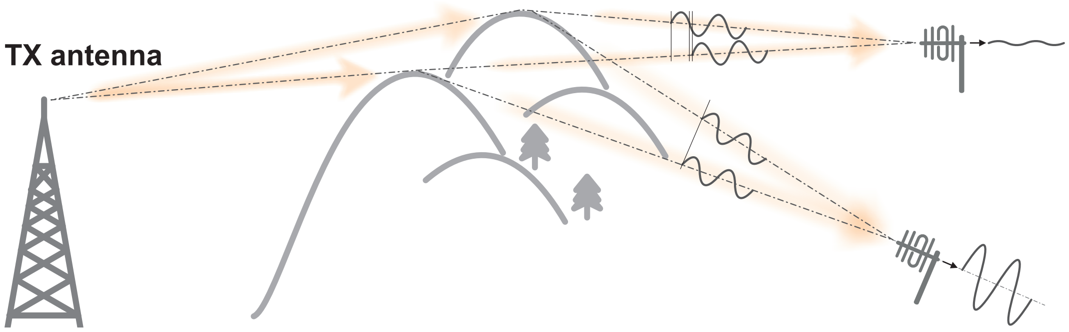


*Fig. 3.3: Multipath propagation*

What makes things worse is that the path length changes over time. Since half the wavelength – e.g. 0.3 m at 450 MHz - makes all the difference between summation and cancellation, a 0.001% change of a path length (10 cm per 10 km) is often significant. And a small change of air temperature gradient can do that. Well, that is why we have to have a proper fade margin. Now, what makes things really bad is that the path length depends also on frequency. Normally this dependency is negligible within the narrow channel. Unfortunately, because of the phase combinations of multiple waveforms, the resulting signal may get so distorted, that even the sophisticated demodulating techniques cannot read the original data. That is the situation known to RF data network engineers – signal is strong enough and yet “it” does not work.

That is why RipEX reports the, somewhat mystic, figure of DQ (Data Quality) alongside the RSS. The software demodulator uses its own metrics to assess the level of distortion of the incoming signal and produces a single number in one-byte range (0–255), which is proportionate to the “quality” of the signal. Though it is very useful information, it has some limitations. First, it is almost impossible to determine signal quality from a single packet, especially a very short one. That results in quite a jitter of DQ values when watching individual packets. However when DQ keeps jumping up and down it indicates a serious multipath problem. In fact, when DQ stays low all the time, it must be noise or permanent interference behind the problem. The second issue arises from the wide variety of modulation and data rates RipEX supports. Though every attempt has been made to keep the DQ values modulation independent, the differences are inevitable. In other words, experience is necessary to make any conclusions from DQ reading. The less experience you have, the more data you have to collect on the examined link and use other links for comparison.

The DQ value is about proportional to BER (bit error ratio) and about independent of the data rate and modulation used. Hence some rule-of-thumb values can be given. Values below 100 mean the link is unusable. At 125 short packets should get through with some retransmissions, 150 and above can be considered “good” values.

### 3.4.1. How to battle with multipath propagation?

The first step is the diagnosis. We have to realize we are in trouble and only a field measurement can tell us that. We should forget about software tools and simply assume that a multipath problem may appear on every non-LOS hop in the network.

These are clear indicators of a serious multipath propagation problem:

- directional antennas "do not work", e.g. a dipole placed at the right spot yields a better RSS than a long Yagi, or rotating the directional antenna shows several peaks and troughs of the signal and no clear maximum
- RSS changes rapidly (say 10 dB) when antenna is moved by less than a meter in any direction

- ping test displays the mean deviation of RSS greater than 6 dB
- DQ value keeps "jumping" abnormally from frame to frame

Quite often all the symptoms mentioned can be observed at a site simultaneously. The typical "beginner" mistake would be to chase the spot with the best RSS with an omnidirectional antenna and installing it there. Such a spot may work for several minutes (good luck), sometimes for several weeks (bad luck, since the network may be in full use by then). In fact, installing in such a spot guaranties that trouble will come - the peak is created by two or more signals added up, which means they will cancel out sooner or later.

The right strategy is to find an arrangement where a single signal becomes dominant, possibly the most stable one. "Sweeping" a directional antenna around the place (in different heights and with different polarization) can tell us where the signals come from. If individual signals come from different directions, there is a good chance a long yagi can solve the problem by selecting just one of the bunch. Finding a spot where the unwanted signal is blocked by a local obstacle may help as well (e.g. installing at a side of the building instead of at the roof).

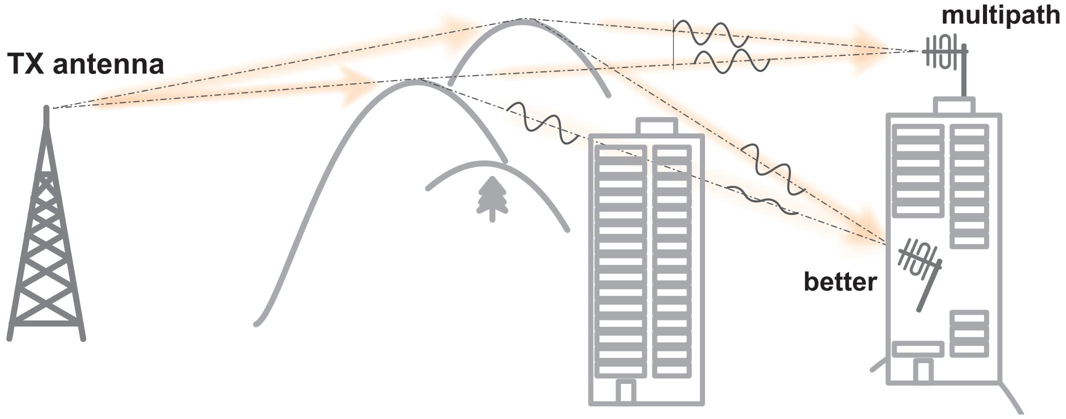


*Fig. 3.4: Antenna location*

When the multiple signals come from about the same direction, a long yagi alone would not help much. We have to move away from the location, again looking for a place where just one of the signals becomes dominant. 20–50 metres may save the situation, changing the height (if possible) is often the right solution. Sometimes changing the height means going down, not up, e.g. to the base of the building or tower.

We have to remember our hop has two ends, i.e. the solution may be to change antenna or its placement at the opposite end. If everything fails, it is better to use another site as a repeater. Even if such problematic site seems to be usable after all (e.g. it can pass commissioning tests), it will keep generating problems for ever, hence it is very prudent to do something about it as early as possible.

**Note:** Never design hops where a directional antenna is used for a direction outside its main lobe. However economical and straightforward it may seem, it is a dangerous trap. Enigmatic cases of dropouts lasting couple of minutes every other day, over a clear LOS hops were created exactly like that. They look like interference which is very difficult to identify and , alas, they are caused by pure multipath propagation, a self-made one. So always use a combiner and another directional antenna if such arrangement is needed. Always.

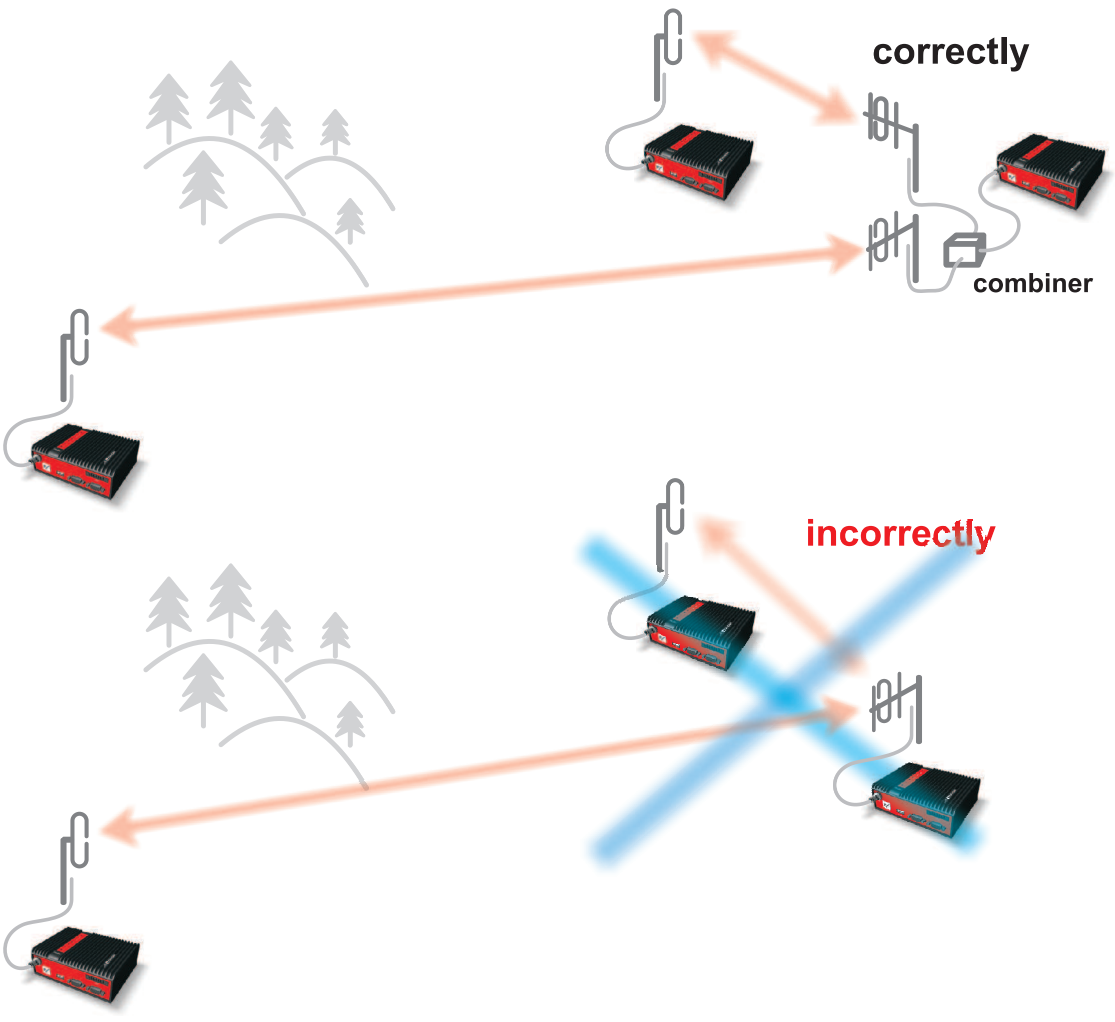


*Fig. 3.5: Main lobe*

## 3.5. Network layout

Certainly the network layout is mostly (sometimes completely) defined by the application. When the terrain allows for direct radio communication among all sites in the network, the designer can do neither too good nor too bad a job. Fortunately for RF network designers, the real world is seldom that simple.

The conditions every single radio hop has to meet were discussed in previous paragraphs. If we are so lucky, that different layouts meeting that conditions are possible, we should exploit that for the benefit of the network. The following rules should be followed when defining the layout of radio hops:

- dominant radio sites (e.g. telco towers on hill tops) should be avoided whenever possible. Placing a single repeater which serves most part of the network from the top of a hill is a straightforward but worst alternative, which makes the whole network very vulnerable. First, a dominant site is exposed to interference from a large area; second, such site is typically crowded with radio equipment of all kinds, which keeps being added, moved (also failing to work properly), so local interference may appear anytime; third, it makes the majority of communication paths dependent on a single site, so one isolated failure may stop almost the entire network.

- when total throughput is important, typically in report-by-exception networks, splitting the network into several independent or only slightly overlapping areas of coverage can help. The placement of repeaters which serve the respective areas is crucial. They should be isolated from each other whenever possible.

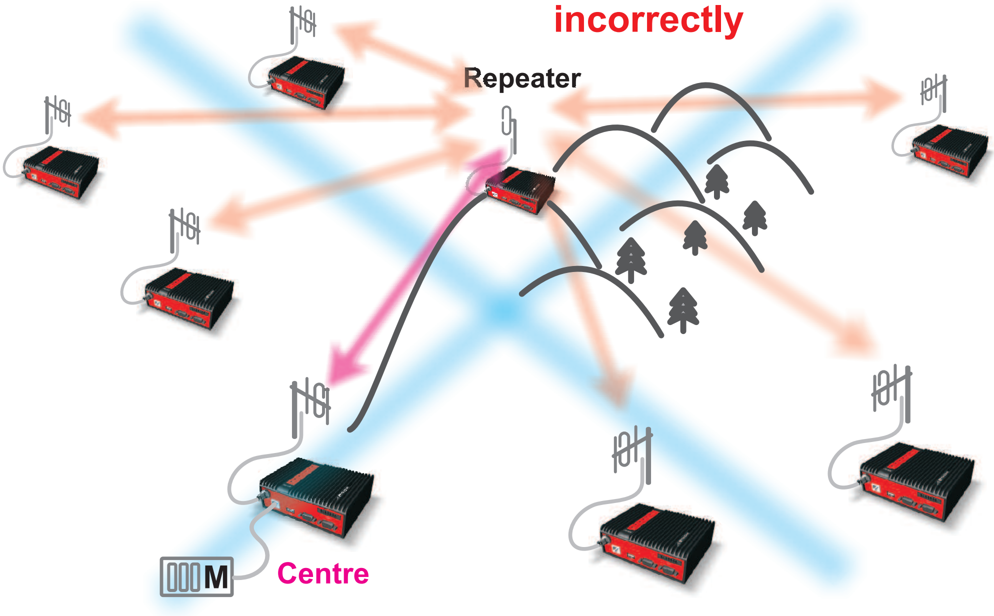


*Fig. 3.6: Dominant repeater*

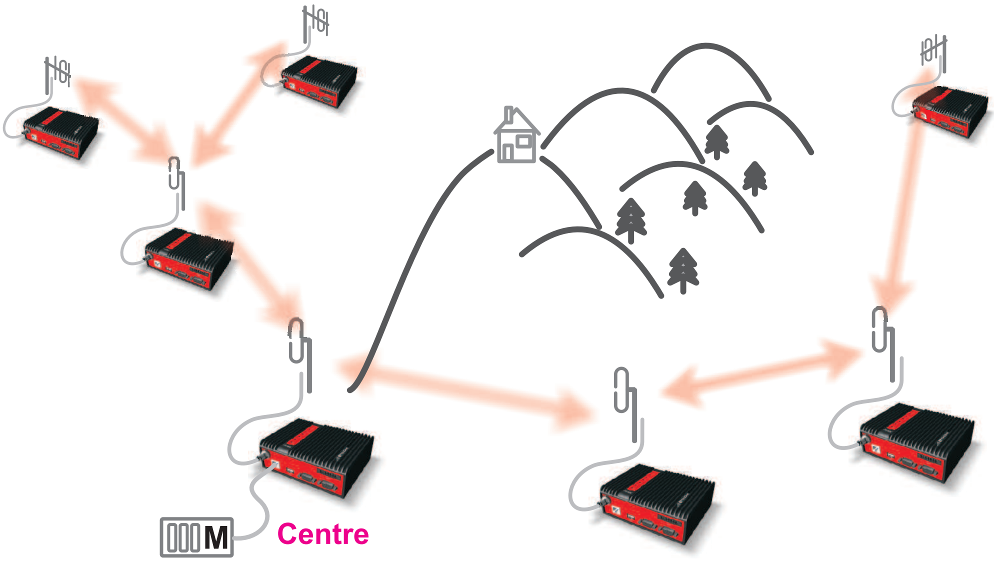
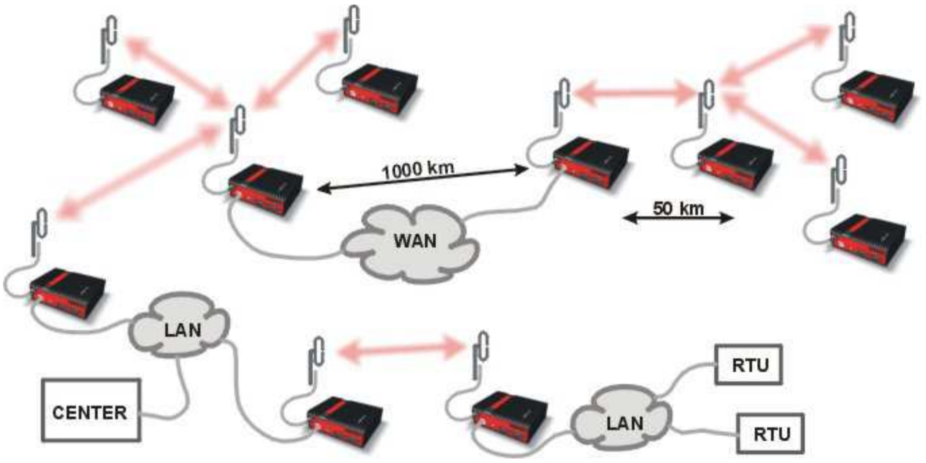


*Fig. 3.7: Isolated branches*

- in report-by-exception networks the load of hops connecting the centre to major repeaters forms the bottle-neck of total network capacity. Moving these hops to another channel, or, even better, to a wire (fibre, microwave) links can multiply the throughput of the network. It saves not only the load itself, it also significantly reduces the probability of collision. More on that in the following chapter 3.6..

## 3.6. Hybrid networks

If an extensive area needs to be covered and multiple retranslation would be uneconomical or unsuitable, RipEX's can be interconnected via any IP network (WLAN, Internet, 3G, etc.). This is quite simple because RipEX is a standard IP router with an ethernet interface. Consequently interconnecting two or more RipEX's over a nested IP network is a standard routing issue and the concrete solution depends on that network.



## 3.7. Assorted practical comments

Let us mention few issues, whose influence on network reliability or performance is sometimes neglected by less experienced planners:

- Both vegetation and construction can grow. Especially when planning a high data rate hop which requires a near-LOS terrain profile, take into consideration the possible future growth of obstacles.

- When the signal passes a considerable amount of vegetation (e.g. a 100m strip of forest), think of the season. Typically the path loss imposed by vegetation increases when the foliage gets dense or wet (late spring, rainy season). Hence the fade margin should be increased if your field measurements are done in a dry autumn month. The attenuation depends on the distance the signal must penetrate through the forest, and it increases with frequency. According to a CCIR, the attenuation is of the order of 0.05 dB/m at 200 MHz, 0.1 dB/m at 500 MHz, 0.2 dB/m at 1 GHz. At lower frequencies, the attenuation is somewhat lower for horizontal polarization than for vertical, but the difference disappears above about 1 GHz.

- Though being a rare problem, moving metallic objects may cause serious disruptions, especially when they are close to one end of the radio hop. They may be cars on a highway, blades of a wind turbine, planes taking off from a nearby airport runway etc.

- Even when the signal is very strong, be careful when considering various cheap whips or more generally any antennas requiring a ground plane to function properly. A tempting scenario is to use the body of the metallic box, where the radio modem and connected application equipment (often a computer) is installed, as the ground plane, which leads to never-ending problems with locally generated noise. The ground plane forms an integral part of such an antenna, hence it has to be in a safe distance (several metres) from any electronic equipment as well as the antenna itself. A metallic plate used as shielding against interference must not form a part of the antenna.

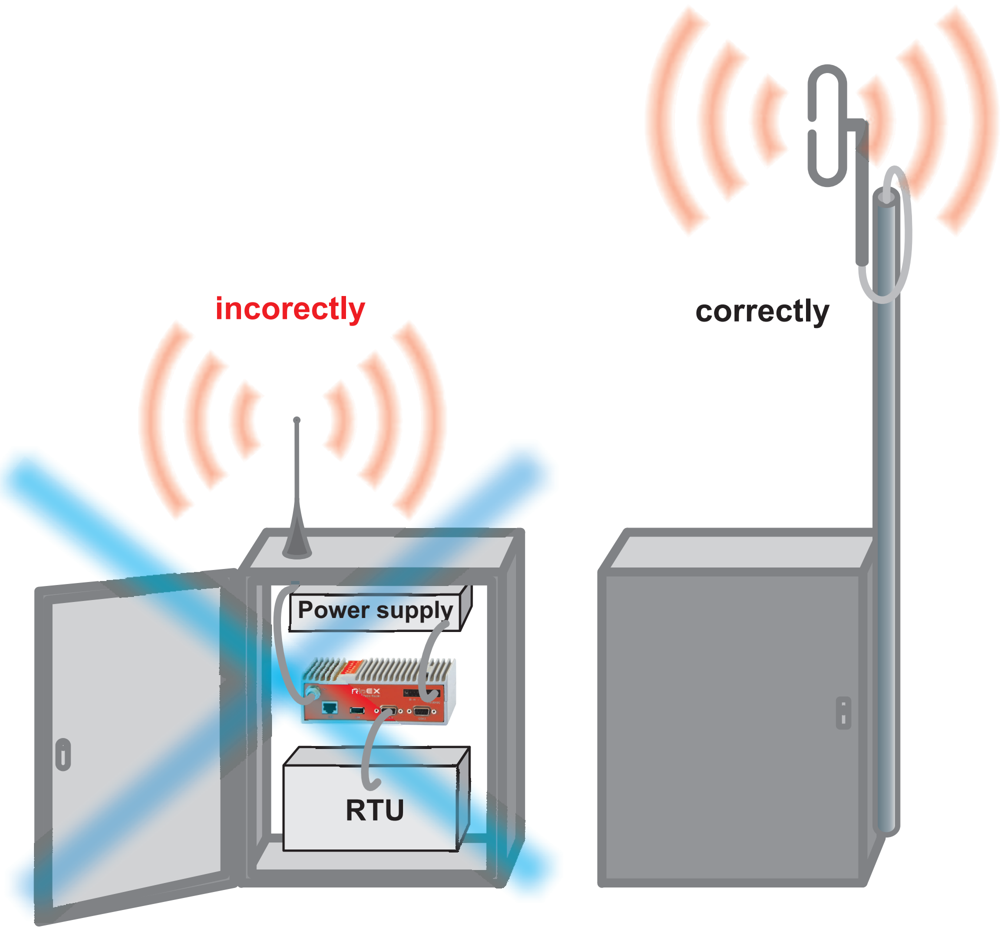
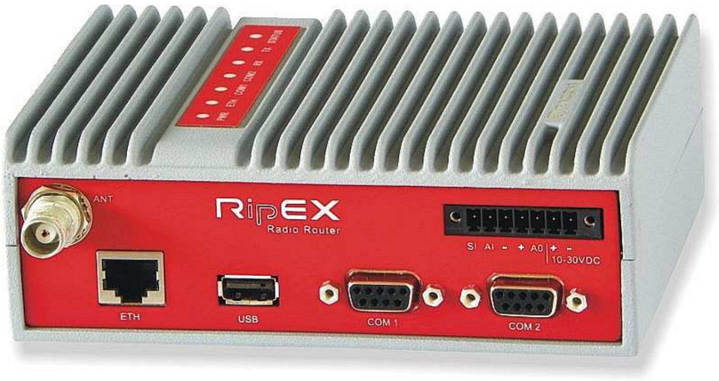


*Fig. 3.8: Antenna mounting*

- Do not underestimate ageing of coaxial cables, especially at higher frequencies. Designing a 900 MHz site with 30 m long antenna cable run outdoors would certainly result in trouble two years later.
- We recommend to use vertical polarization for all radio modem networks.

# 4. Product

RipEX is built into a rugged die-cast aluminium casing that allows for multiple installation possibilities, see Section 6.1, “Mounting”.



## 4.1. Dimensions

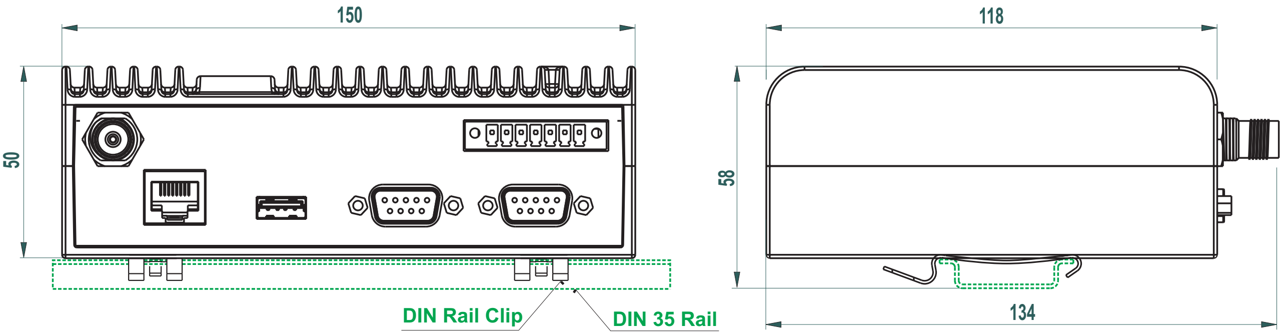


*Fig. 4.1: RipEX dimensions, see more*

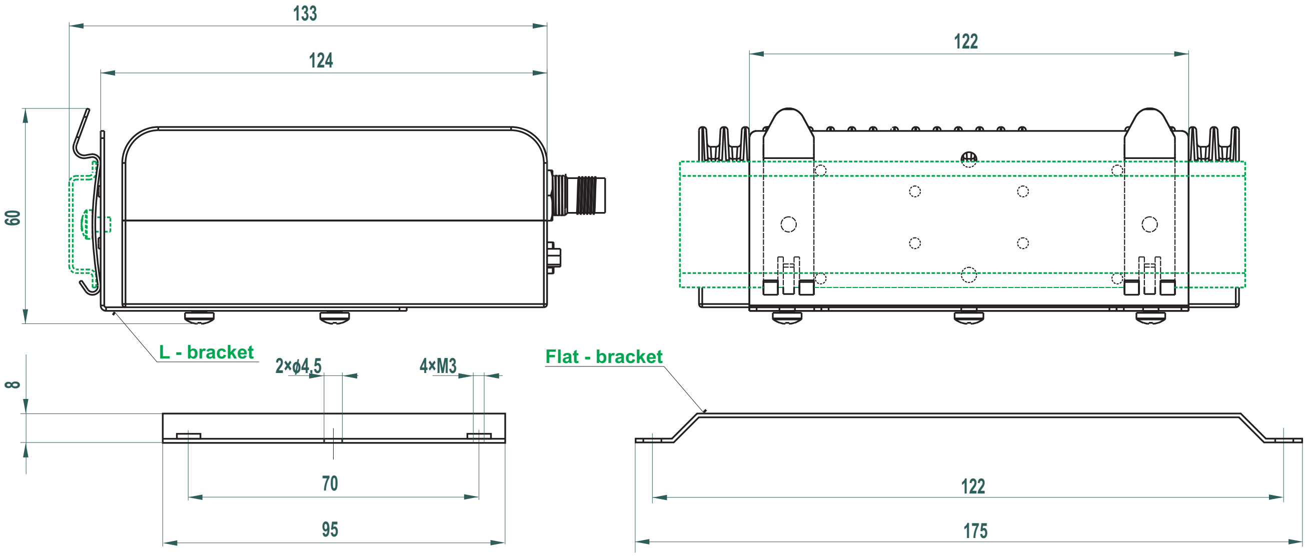


*Fig. 4.2: L-bracket and Flat-bracket, see more*

## 4.2. Connectors

All connectors are located on the front panel. The upper side features an LED panel. The RESET button is located in an opening in the bottom side.

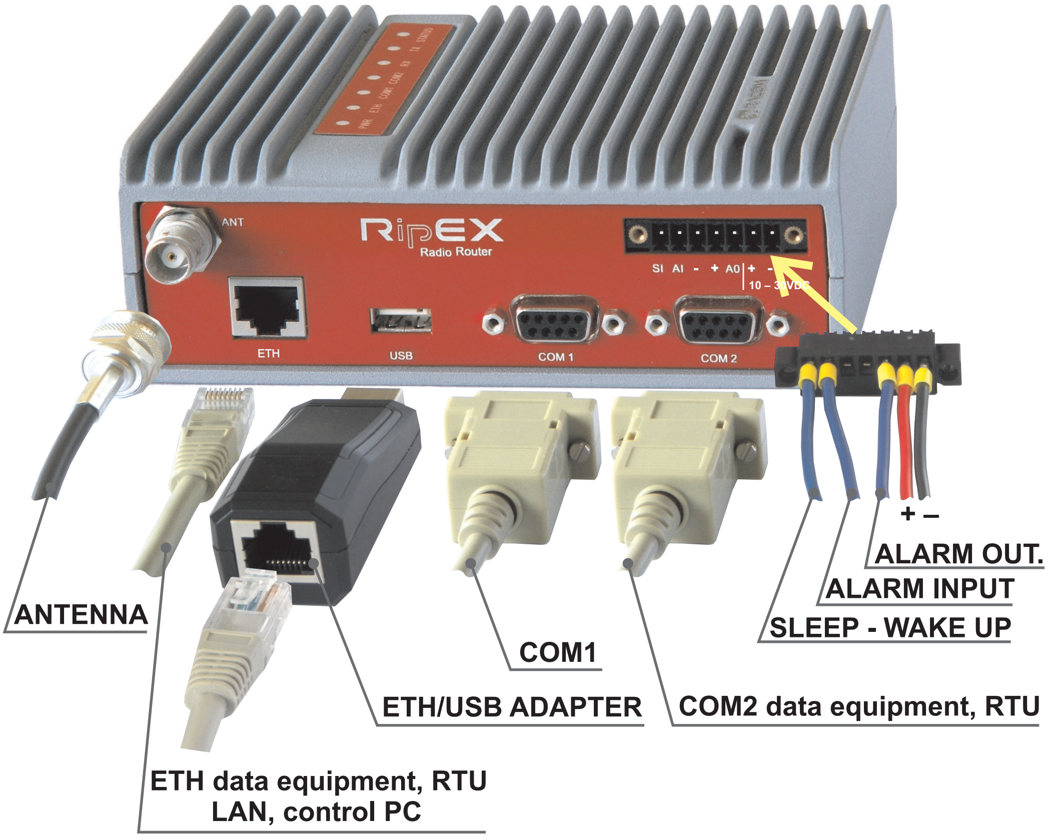


*Fig. 4.3: Connectors*

### 4.2.1. Antenna

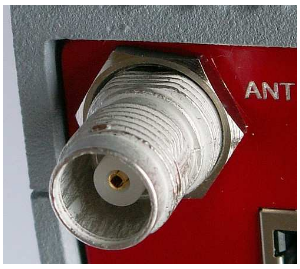


*Fig. 4.4: Antenna connector TNC*

An antenna can connect to RipEX via TNC female 50Ω connector.

A model with two antenna connectors can be supplied to order, in which the Rx and Tx antennas are separate. See chapter Section 4.5, “Model offerings”.

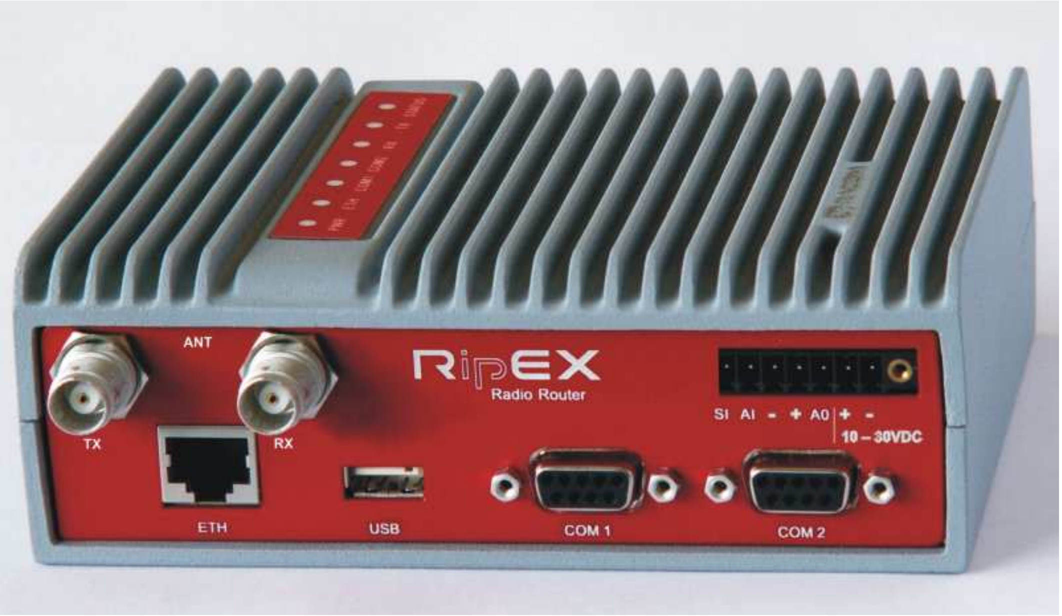


*Fig. 4.5: Separated Rx and TX antennas*

**Warning:** RipEX radio modem may be damaged when operated without an antenna or a dummy load.

### 4.2.2. Power and Control

This rugged connector connects to a power supply and it contains control signals. A Plug with screw-terminals and retaining screws for power and control connector is supplied with each RipEX. It is Tyco 7 pin terminal block plug, part No. 1776192-7, contact pitch 3.81 mm. The connector is designed for electric wires with a cross section of 0.5 to 1.5 mm$^2$. Strip the wire leads to 6 mm (1/4 inch). Isolated cables should receive PKC 108 or less end sleeves before they are inserted in the clip. Insert the cables in the wire ports, tightening securely.

**Tab. 4.1: Pin assignement**

| pin | labeled | signal |
|---|---|---|
| 1 | SI | SLEEP IN |
| 2 | AI | ALARM IN |
| 3 | − | −(GND) – for SLEEP IN, ALARM IN |
| 4 | + | +(PWR) – for ALARM OUT |
| 5 | AO | ALARM OUT |
| 6 | +10–30VDC | +PWR (10 to 30 V) |
| 7 | −10–30VDC | −PWR (GND) |

Pins 3 and 7, 4 and 6 are connected internally.

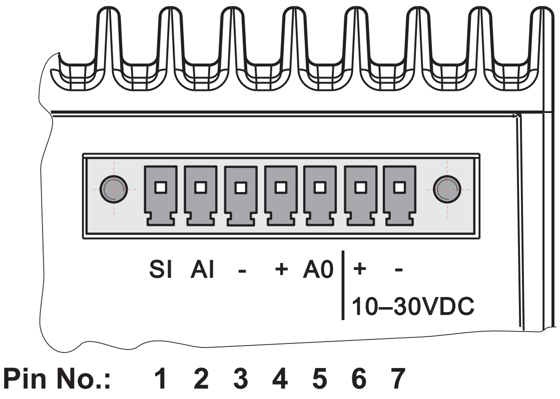


*Fig. 4.6: Supply connector*

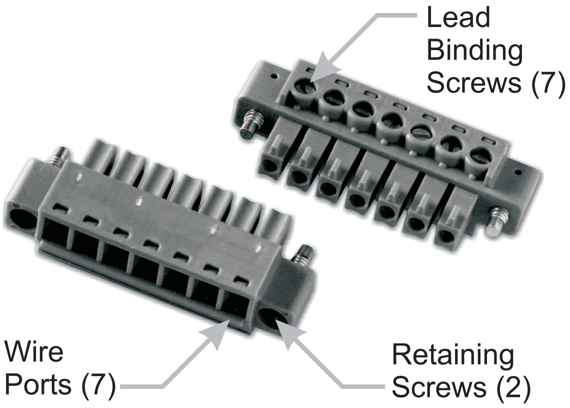
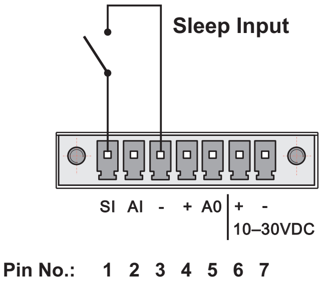


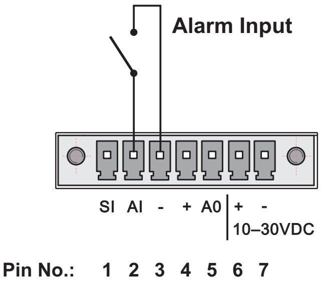
*Fig. 4.7: Power and Control - cable plug*

### SLEEP IN



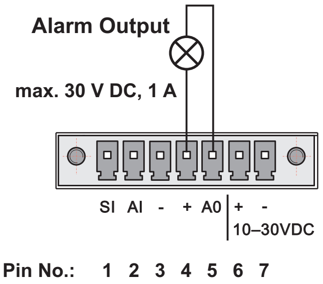
SLEEP IN is the digital input for activating the Sleep mode. When this pin is grounded (for example when connected to pin 3), the RipEX switches into the Sleep mode. Using Power management (*Advanced Config.*), the Entering the Sleep mode can be delayed by a set time. Disconnecting SLEEP IN from GND (-) ends the Sleep mode. Note that RipEX takes 25 seconds to wake up from the Sleep mode.

### ALARM IN



ALARM IN is a digital input. If grounded (e.g. by connecting to PIN 3), an external alarm is triggered. This alarm can be used for example to transmit information using SNMP trap, informing for instance about a power outage or RTU problem. For details about Alarm management see chapter *Advanced Configuration*.

### ALARM OUT



ALARM OUT is a digital output. It can be activated in Alarm management settings, chapter *Advanced Configuration*. It may be used for instance to switch on the Fan kit if the preset maximum internal temperature is exceeded or to inform the connected RTU about a RipEX alarm. If an alarm is triggered, ALARM OUT is internally connected to GND. If the external device requires connection to positive terminal of the power supply, PIN 4 should be used.

### PWR

The PWR pins labelled + and - serve to connect a power supply 10–30 VDC. The requirements for a power supply are defined in Section 6.6, “Power supply” and Section 4.4, “Technical specification”.

### 4.2.3. ETH

Standard RJ45 connector for ethernet connection. RipEX has 10/100 BaseT Auto MDI/MDIX interface so it can connect to 10 Mbps or 100 Mbps ethernet network. The speed can be selected manually or recognised automatically by RipEX. RipEX is provided with Auto MDI/MDIX function which allows it to connect over both standard and cross cables, adapting itself automatically.

**Pin assignement**

**Tab. 4.2: Ethernet to cable connector connections**

| PIN | Signal | Direct cable | Crossed cable |
|---|---|---|---|
| 1 | TX+ | orange – white | green – white |
| 2 | TX− | orange | green |
| 3 | RX+ | green – white | orange – white |
| 4 | — | blue | blue |
| 5 | — | blue – white | blue – white |
| 6 | Rx− | green | orange |
| 7 | — | brown – white | brown – white |
| 8 | — | brown | brown |

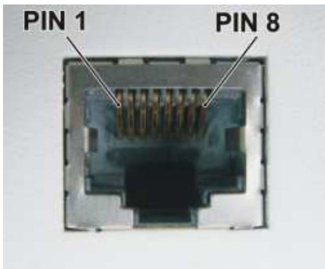


*Fig. 4.8: RJ-45F*

### 4.2.4. COM1 and COM2

RipEX provides two serial interfaces COM1 and COM2 terminated by DSUB9F connectors. COM1 is always RS232, COM2 can be configured as RS232 or RS485 (more in *Adv. Conf., COM's*).

RipEX‘s RS232 is a hard-wired DCE (Data Communication Equipment) device. Equipment connected to the RipEX’s serial ports should be DTE (Data Terminal Equipment) and a straight-through cable should be used. If a DCE device is connected to the RipEX‘s serial ports, a null modem adapter or cross cable has to be used.

**Tab. 4.3: COM1,2 pin description**

| DSUB9F | COM1, 2 – RS232 | | COM2 – RS485 | |
|---|---|---|---|---|
| pin | signal | In/ Out | signal | In/ Out |
| 1 | CD | O | — | |
| 2 | RxD | O | line B | I/O |
| 3 | TxD | I | line A | I/O |
| 4 | DTR | I | — | |
| 5 | GND | | GND | |
| 6 | DSR | O | — | |
| 7 | RTS | I | — | |
| 8 | CTS | O | — | |
| 9 | — | — | — | |

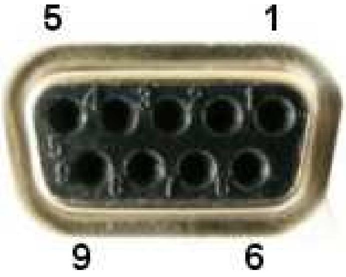


*Fig. 4.9: Serial connector*

RipEX keeps pin 6 DSR at the level of 1 by RS232 standard permanently.

### 4.2.5. USB

RipEX uses USB 1.1, Host A interface. USB interface is wired as standard:

**Tab. 4.4: USB pin description**

| USB pin | signal | wire |
|---|---|---|
| 1 | +5 V | red |
| 2 | Data(−) | white |
| 3 | Data (+) | green |
| 4 | GND | black |

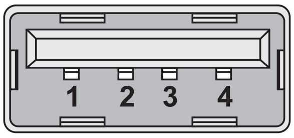


*Fig. 4.10: Serial connector*

The USB interface is designed for the connection to the "X5" – external ETH/USB adapter. The "X5" is an optional accessory to RipEX, for more see Section 5.3, “Connecting RipEX to a programming PC”. The adapter is used for service access to RipEX’s web configuration interface.

The USB connector also provides power supply (5 V/ 0.5 A). It can be used to temporarily power a connected device, for instance a telephone. The USB connector should not be used as permanent source of power supply.

### 4.2.6. Reset button

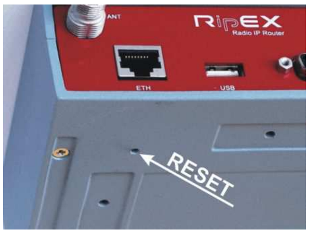


*Fig. 4.11: Reset*

RipEX’s bottom-side enclosure includes a reset button accessible through an opening. When this button is pressed, the STATUS diode on the LED panel goes dark (indicating that the button has been pressed). If you hold the button for 5 seconds, the STATUS diode starts flashing slowly indicating that the reset is complete. If you continue to hold the button for 15 or more seconds (the STATUS diode starts flashing quickly) and then release it, you will reset the device’s access information to default: parameters such as the **login, password** and **ethernet IP** will be reset to their defaults. Resetting access parameters to defaults also sets the Ethernet speed to „Auto“ and results in clearing all **firewall** rules (which may have been blocking the access by accident). Remember to re-install your firewall if you are using one.

**Note**

To reset the RipEX only use the RESET button as described above or use the button in RipEX’s web configuration, see *Adv. Conf., Maintenance*. Never use a power cycling (disconnecting and reconnecting power supply) to reset it. While power cycle resets, or rather reboots the RipEX, its software will not terminate correctly resulting in logs, statistics and graphs not being saved properly.

### 4.2.7. GPS

RipEX can be equipped with an internal GPS, see Section 4.5, “Model offerings”. The GPS module is used for time synchronisation of the NTP server inside RipEX. See *Adv. Conf., Time* for more. In this case the front panel contains a SMA female 50 ohm connector for connecting the GPS antenna.

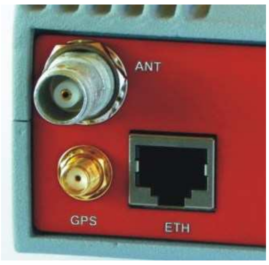


*Fig. 4.12: GPS Connector SMA*

## 4.3. Indication LEDs

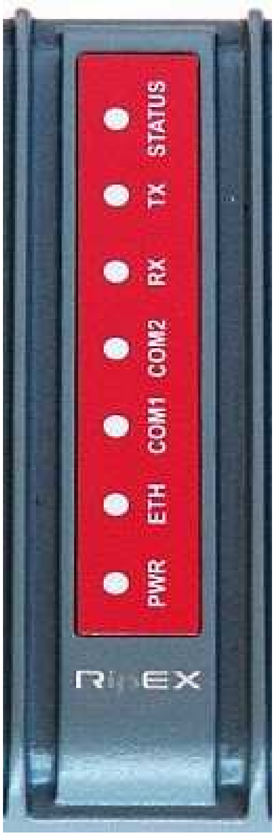


*Fig. 4.13: Indication LEDs*

**Tab. 4.5: Key to LEDs**

| | **Color** | **Description** |
|---|---|---|
| STATUS | Green | The RipEX OS (Linux) is running succesfuly |
| | Dark | Reset button has been pressed |
| | Green flashes slowly | reset after five-seconds pressing the Reset button |
| | Green flashes quickly | default access after 15-seconds pressing the Reset button |
| | Red | Status alarm |
| TX | Red | transmitting to radio channel |
| RX | Green | receiver is synchronised to a packet |
| | Yellow | there is a signal stronger than −80 dBm on Radio channel |
| COM2 | Green | data receiving |
| | Yellow | data transmitting |
| COM1 | Green | data receiving |
| | Yellow | data transmitting |
| ETH | Yellow ON | 100 Mb/s speed |
| | Yellow OFF | 10 Mb/s speed |
| | Green ON | connected |
| | Green flashes | ethernet data |
| PWR | Green | powered succesfuly |
| | Blinks with a period of 1 sec | Save mode |
| | Flashes once per 3 sec | Sleep mode |