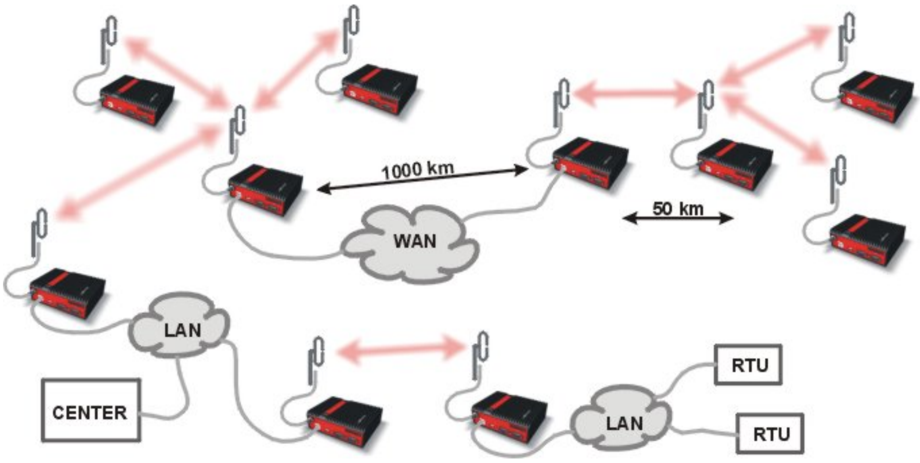
RACOM
RADIO DATA NETWORKS

Application notes



RipEX
GRE Tunnels

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Introduction

GRE (Generic Routing Encapsulation) is a tunneling protocol developed by Cisco Systems that can encapsulate a wide variety of network layer protocols inside virtual point-to-point links over an Internet Protocol network. The GRE Tunnel can be configured between any two devices that are compatible with this protocol.

- From the point of view of the traffic transferred, the GRE tunnel is one hop.
- There are 2 modes of GRE operation: TUN (Tunnel mode) or TAP (L2 transparent connection) with SW bridge. Implementation within RipEX only covers the TUN mode.
- Packets passing through the GRE tunnel are not protected against loss and are not encrypted.
- The GRE tunnel neither establishes nor maintains a connection with the peer. The GRE tunnel is created regardless of peer status (peer need not exist at all).
- The GRE tunnel has its own IP address and mask. Network defined by this address and mask contains only 2 nodes – each end of the tunnel.
- As the GRE tunnel adds an additional header, a lower MTU is set (1476 B) to prevent GRE packet fragmentation. Incoming packets may be fragmented within the GRE interface.

NOTE:
Packet acknowledgment and encryption (AES256) can be configured on the Radio channel. Both options are independent of GRE tunnels and apply to all the radio traffic.

1. Basic Configuration Parameters

GRE — Enables the whole GRE subsystem, the default value is “Off”.

GRE tunnels — Each row/record corresponds to one GRE tunnel. There should not be more than 20 simultaneous GRE tunnels (recommendation). The Key/Primary Field of the table is “Peer address”, which uniquely identifies each tunnel.

Peer address — The IP address of a remote GRE tunnel end-point. This end-point IP address must be unique and cannot be used for more than one tunnel. The local address (interface) is automatically selected based on the destination address type. Addresses on both ends must correspond to each other.

Tunnel IP/MASK — The tunnel IP address and mask. The network defined by this item must cover only the local tunnel address and remote end-point address. Both tunnel end-points must be within the same subnet, but IP addresses must be different. The remote end-point IP address is used as a “Gateway” for tunnel configuration. The network mask can even be /31 (255.255.255.254), because it is a p2p (no need for a network address and a broadcast address).

Note — The tunnel description.

Active — Enables or disables the particular tunnel.

Routing into the GRE tunnels can be configured in the Routing menu. The Gateway must be set as a remote end-point GRE tunnel IP address.

2. Configuration Example

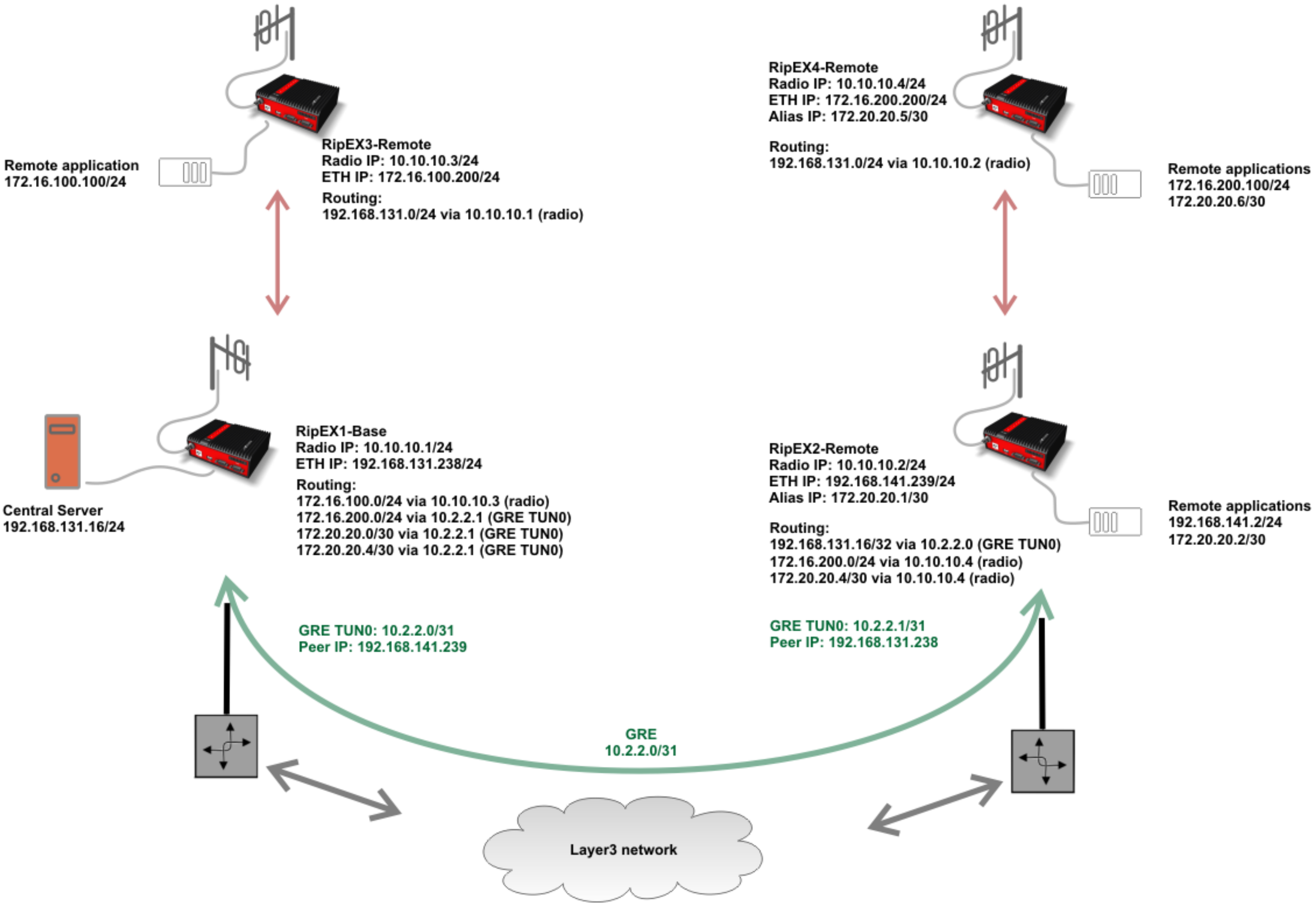


Fig. 2.1: Topology

In this example, 4 RipEX units will be interconnected using a GRE tunnel. Routing will be configured for particular subnets and the communication will be verified.

RipEX1, acts as a centre for three remote units. Flexible Router mode will be utilized. Each RipEX is connected via Ethernet to its own local network and two remote RipEX units simulate using several subnets by “Alias” addresses (e.g. SLIP protocol). The Radio network subnet is 10.10.10.0/24. The GRE tunnel is not used on the radio channel. It is only utilized on the Ethernet network.

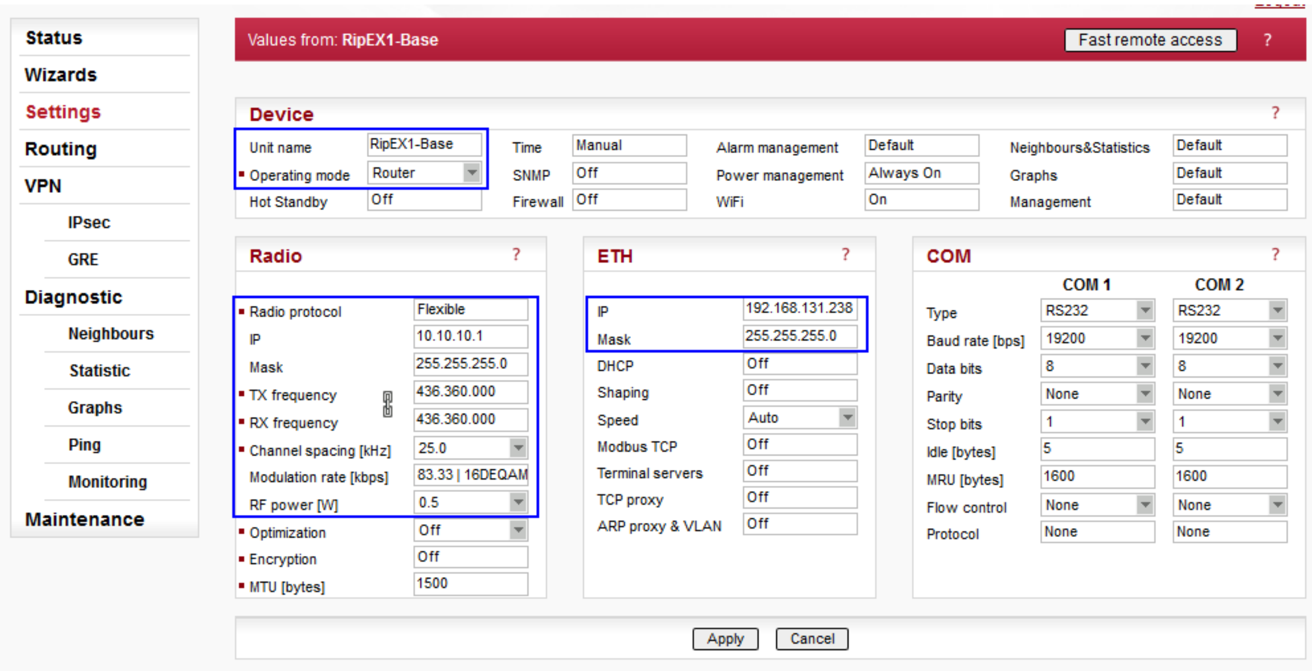
This example shows how a GRE tunnel can be used to route data via any L3 network without being able to alter the routing rules of this network – i.e. we cannot add RipEX subnets to the current routers, firewalls or other existing infrastructure. That’s the reason to encapsulate all data to GRE, changing all packets to have IP headers from routable subnets – i.e. 192.168.131.0/24 and 192.168.141.0/24 in our example.

The RipEX configuration can be performed via Ethernet, USB/ETH or USB/WiFi access. Another option is to use the “Fast Remote Access” feature from any of the units to configure the rest of the network.

There is only one GRE tunnel. Both end-points are RipEX units; there is no need for any other external device.

RipEX1-Base <--> RipEX2-Remote: 10.2.2.0/31

3. RipEX1-Base Configuration



Values from: RipEX1-Base

Device

Unit name	RipEX1-Base	Time	Manual	Alarm management	Default	Neighbours&Statistics	Default
▪ Operating mode	Router	SNMP	Off	Power management	Always On	Graphs	Default
Hot Standby	Off	Firewall	Off	WiFi	On	Management	Default

Radio

▪ Radio protocol	Flexible
IP	10.10.10.1
Mask	255.255.255.0
▪ TX frequency	436.360.000
▪ RX frequency	436.360.000
▪ Channel spacing [kHz]	25.0
Modulation rate [kbps]	83.33 | 16DEQAM
RF power [W]	0.5
▪ Optimization	Off
▪ Encryption	Off
▪ MTU [bytes]	1500

ETH

IP	192.168.131.238
Mask	255.255.255.0
DHCP	Off
Shaping	Off
Speed	Auto
Modbus TCP	Off
Terminal servers	Off
TCP proxy	Off
ARP proxy & VLAN	Off

COM

	COM 1	COM 2
Type	RS232	RS232
Baud rate [bps]	19200	19200
Data bits	8	8
Parity	None	None
Stop bits	1	1
Idle [bytes]	5	5
MRU [bytes]	1600	1600
Flow control	None	None
Protocol	None	None

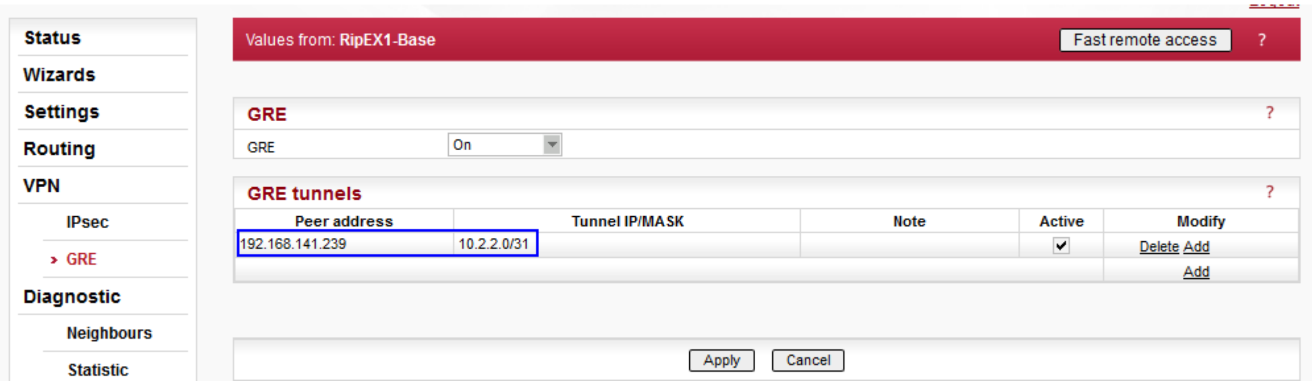
Fig. 3.1: Centre configuration

In the Settings menu, change the Unit name to RipEX1-Base. The Operating mode is set to “Router” (“GRE” is not configurable in the Bridge mode).

Within the Radio parameters, “Flexible” mode is set. Configure the 10.10.10.1/255.255.255.0 IP address/netmask parameters. The frequency must be the same for all RipEX units, but otherwise is configurable as required. The channel spacing is set to 25 kHz and Modulation rate to 16DEQAM (83.33 kbps).

NOTE:
The parameters marked with a small red square must be the same within all RipEX units in network.

The last step is the Ethernet IP configuration – 192.168.131.238 / 255.255.255.0.



Values from: RipEX1-Base

GRE

GRE: On

GRE tunnels

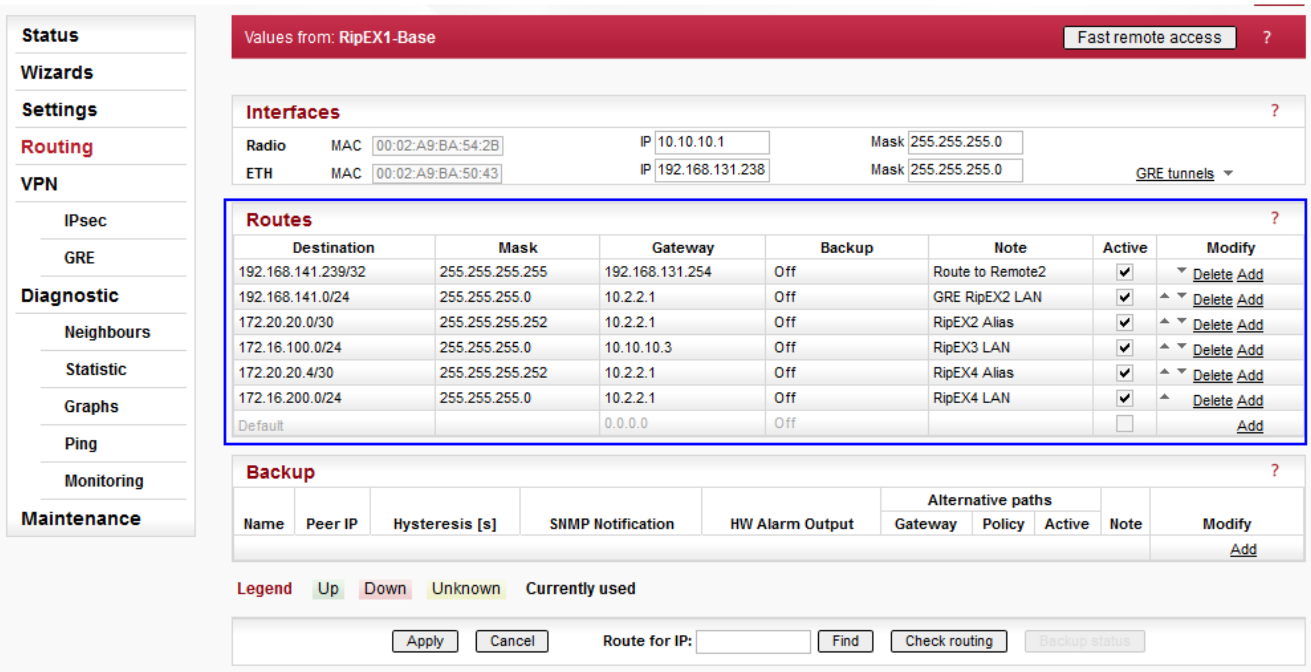
Peer address	Tunnel IP/MASK	Note	Active	Modify
192.168.141.239	10.2.2.0/31		✓	Delete Add
				Add

Fig. 3.2: Centre station GRE configuration

GRE configuration is very straight-forward (all parameters are described at the beginning of this chapter). The Peer address is set to RipEX2-Remote Ethernet address – 192.168.141.239. The tunnel address should not overlap with any other subnet in the network.

IMPORTANT:
The GRE tunnel only ever uses two IP addresses; thus the /31 mask is recommended.

Because the local GRE IP address was set as 10.2.2.0 the remote must be set to 10.2.2.1. The check box "Active" is enabled.



Values from: **RipEX1-Base**

Interfaces

Radio	MAC	00:02:A9:BA:54:2B	IP 10.10.10.1	Mask 255.255.255.0
ETH	MAC	00:02:A9:BA:50:43	IP 192.168.131.238	Mask 255.255.255.0

Routes

Destination	Mask	Gateway	Backup	Note	Active	Modify
192.168.141.239/32	255.255.255.255	192.168.131.254	Off	Route to Remote2	☑	Delete Add
192.168.141.0/24	255.255.255.0	10.2.2.1	Off	GRE RipEX2 LAN	☑	Delete Add
172.20.20.0/30	255.255.255.252	10.2.2.1	Off	RipEX2 Alias	☑	Delete Add
172.16.100.0/24	255.255.255.0	10.10.10.3	Off	RipEX3 LAN	☑	Delete Add
172.20.20.4/30	255.255.255.252	10.2.2.1	Off	RipEX4 Alias	☑	Delete Add
172.16.200.0/24	255.255.255.0	10.2.2.1	Off	RipEX4 LAN	☑	Delete Add
Default		0.0.0.0	Off		☐	Add

Backup

Name	Peer IP	Hysteresis [s]	SNMP Notification	HW Alarm Output	Alternative paths			Note	Modify
					Gateway	Policy	Active		
									Add

Route for IP:

Fig. 3.3: Centre station routing rules

The last menu to configure is "Routing". Together, 6 routes are configured in this example. You might configure different rules, but be consistent across all RipEX units.

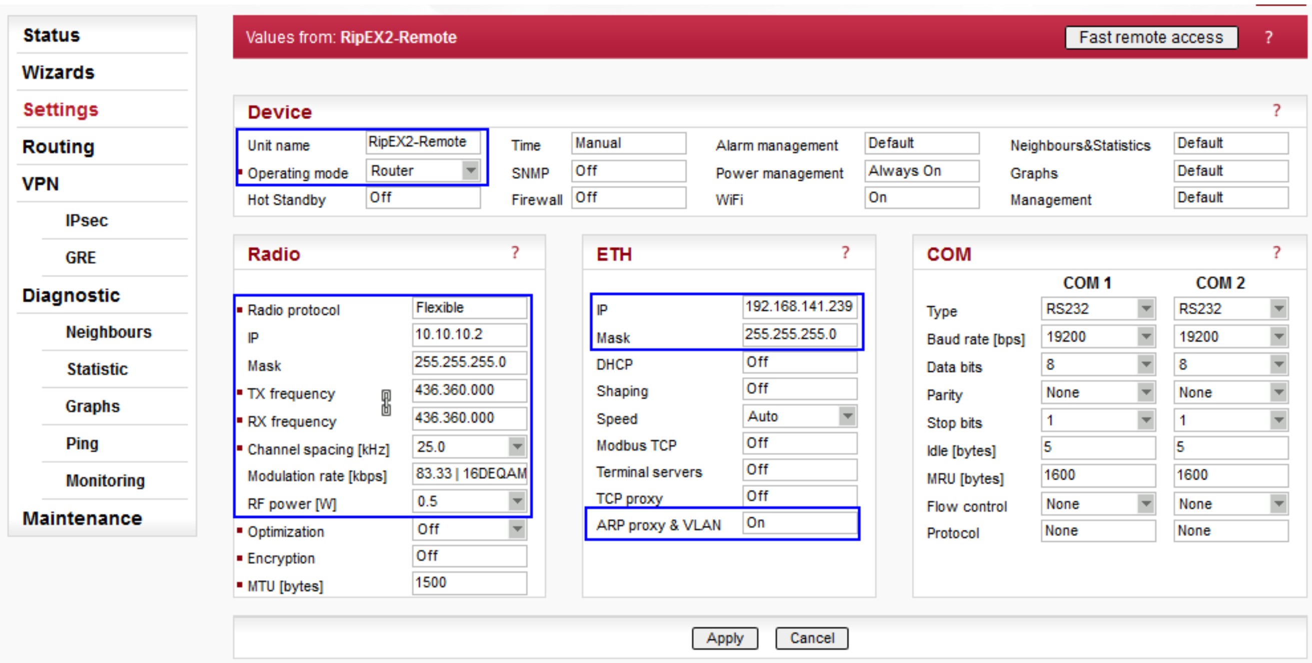
- 192.168.141.239/32, Gateway 192.168.131.254
  - This route will probably be different in your network – usually it is the nearest router that handles routing in your existing L3 network. For testing purposes, you can use our cellular router M!DGE.
  - The routing rule for RipEX2-Remote Ethernet subnet is required due to the accessibility of this remote RipEX unit –> correct GRE tunnel functionality.

- 192.168.141.0/24, Gateway 10.2.2.1
  - This route is used for all other units in 192.168.141.0/24 subnet and is routed to the RipEX2-Remote unit via GRE tunnel.

- 172.16.100.0/24, Gateway 10.10.10.3
  - Route to the RipEX3-Remote unit – no GRE tunnel is used, common radio transmission.

- 172.20.20.0/30, 172.20.20.4/30 and 172.16.200.0/24, Gateway 10.2.2.1
  - Three routes to remote RipEX networks – as a gateway, 10.2.2.1 Remote GRE IP address is used –> no need to add any routing rules in the existing L3 network.

4. RipEX2-Remote Configuration



Values from: **RipEX2-Remote**

Device

Unit name	RipEX2-Remote	Time	Manual	Alarm management	Default	Neighbours&Statistics	Default
Operating mode	Router	SNMP	Off	Power management	Always On	Graphs	Default
Hot Standby	Off	Firewall	Off	WiFi	On	Management	Default

Radio

Radio protocol	Flexible
IP	10.10.10.2
Mask	255.255.255.0
TX frequency	436.360.000
RX frequency	436.360.000
Channel spacing [kHz]	25.0
Modulation rate [kbps]	83.33 | 16DEQAM
RF power [W]	0.5
Optimization	Off
Encryption	Off
MTU [bytes]	1500

ETH

IP	192.168.141.239
Mask	255.255.255.0
DHCP	Off
Shaping	Off
Speed	Auto
Modbus TCP	Off
Terminal servers	Off
TCP proxy	Off
ARP proxy & VLAN	On

COM

	COM 1	COM 2
Type	RS232	RS232
Baud rate [bps]	19200	19200
Data bits	8	8
Parity	None	None
Stop bits	1	1
Idle [bytes]	5	5
MRU [bytes]	1600	1600
Flow control	None	None
Protocol	None	None

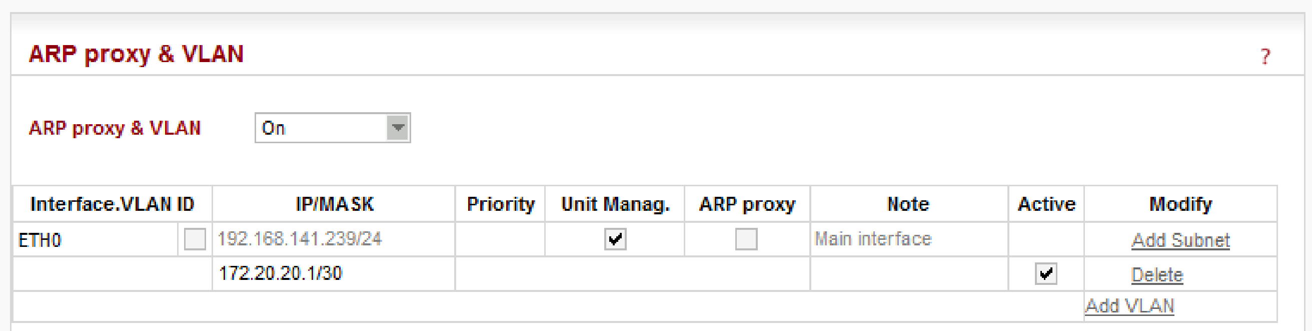
Fig. 4.1: RipEX2-Remote settings

The Settings menu is the same as on the Centre station except for the following:

- Unit name: RipEX2-Remote
- Radio IP: 10.10.10.2/24
- ETH IP: 192.168.141.239/24
- ARP Proxy & VLAN: On

ARP Proxy & VLAN menu must be opened and configured. Set the Alias IP address for the Ethernet interface. We simulate several subnets behind local RipEX's Ethernet (or SLIP protocol).

NOTE:
That is not necessary for GRE functionality; it is just used to show this configuration option.



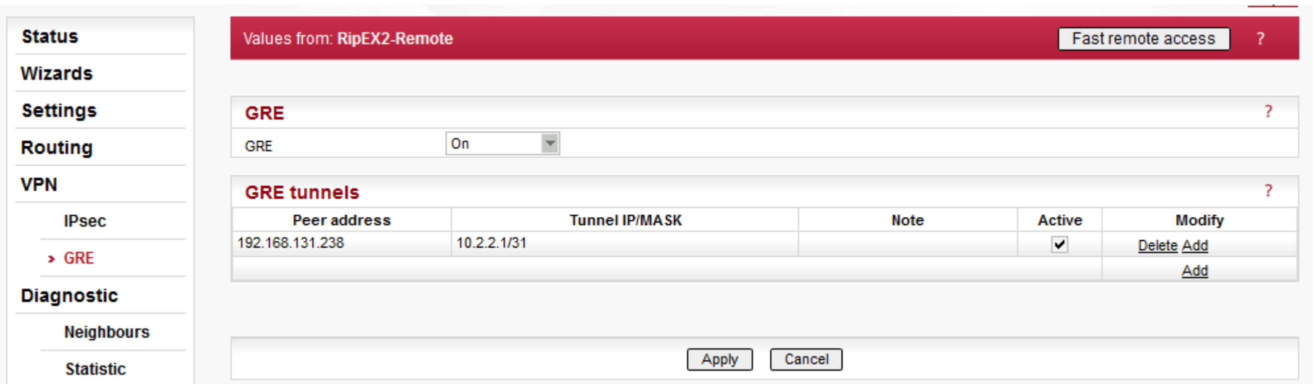
ARP proxy & VLAN

ARP proxy & VLAN: On

Interface.VLAN ID		IP/MASK	Priority	Unit Manag.	ARP proxy	Note	Active	Modify
ETH0	□	192.168.141.239/24		☑	□	Main interface		Add Subnet
		172.20.20.1/30					☑	Delete
								Add VLAN

Fig. 4.2: RipEX2-Remote ETH Alias/Subnet

To set and enable this alias, you need to click on the “Add Subnet” button and fill in the 172.20.20.1/30 subnet into the “IP / MASK” field.



GRE

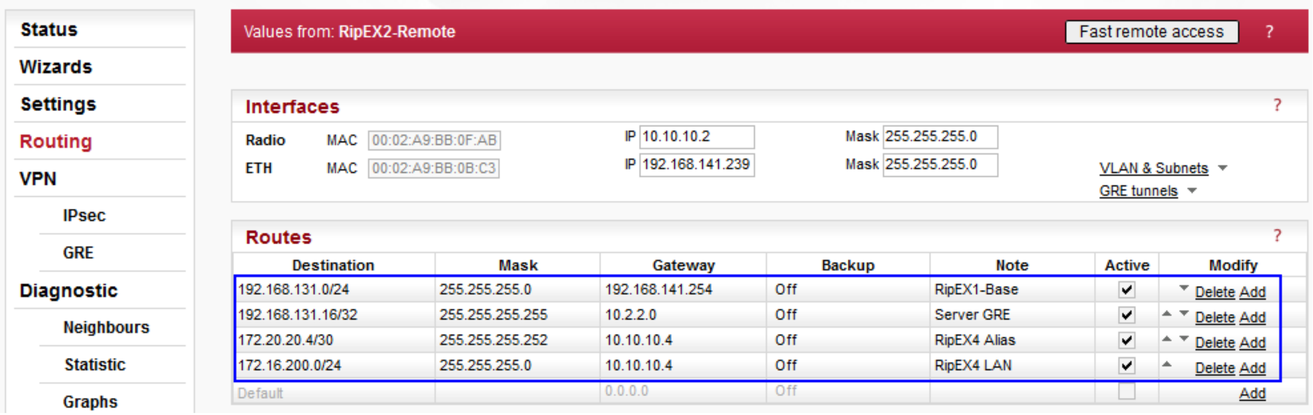
GRE	On

GRE tunnels

Peer address	Tunnel IP/MASK	Note	Active	Modify
192.168.131.238	10.2.2.1/31		☑	Delete Add
				Add

Fig. 4.3: RipEX2-Remote GRE tunnel configuration

Set the Peer IP to the RipEX1-Base Ethernet IP address – 192.168.131.238. The GRE subnet must correspond to the Centre settings, i.e. choose the second IP address within a given subnet – 10.2.2.1/31.



Interfaces

Radio	MAC	00:02:A9:BB:0F:AB	IP	10.10.10.2	Mask	255.255.255.0	
ETH	MAC	00:02:A9:BB:0B:C3	IP	192.168.141.239	Mask	255.255.255.0	

Routes

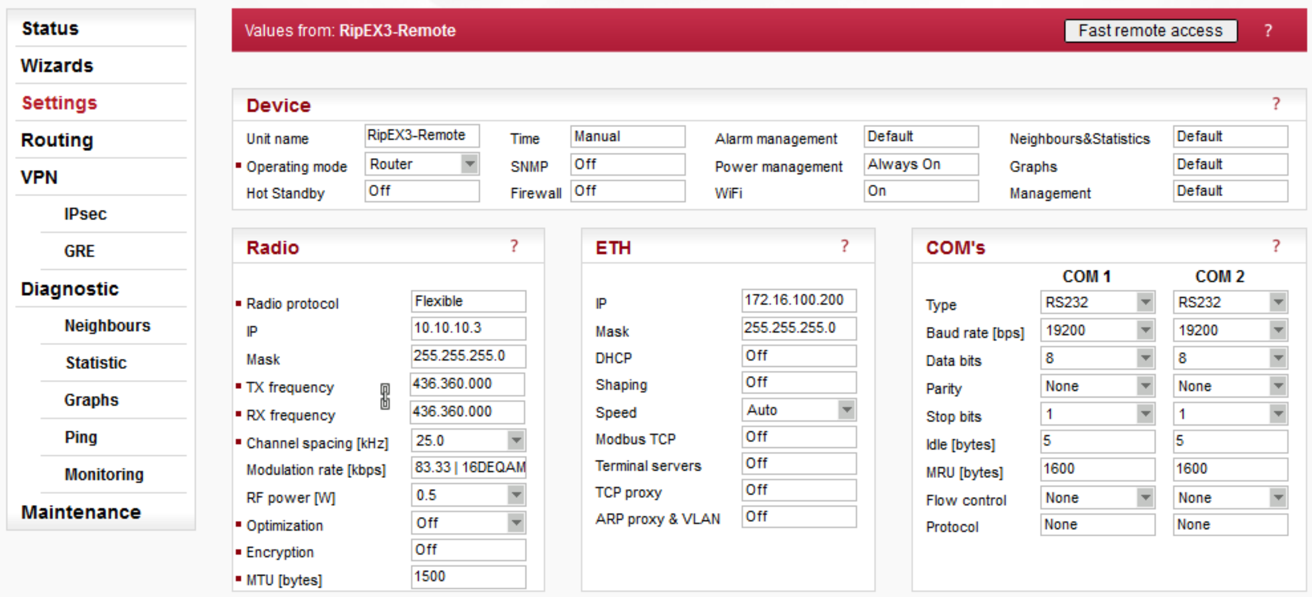
Destination	Mask	Gateway	Backup	Note	Active	Modify
192.168.131.0/24	255.255.255.0	192.168.141.254	Off	RipEX1-Base	☑	▼ Delete Add
192.168.131.16/32	255.255.255.255	10.2.2.0	Off	Server GRE	☑	▲ ▼ Delete Add
172.20.20.4/30	255.255.255.252	10.10.10.4	Off	RipEX4 Alias	☑	▲ ▼ Delete Add
172.16.200.0/24	255.255.255.0	10.10.10.4	Off	RipEX4 LAN	☑	▲ Delete Add
Default		0.0.0.0	Off		□	Add

Fig. 4.4: RipEX2-Remote routing rules

The last step is to configure Routing rules.

- 192.168.131.0/24, Gateway 192.168.141.254
  - This rule depends on your L3 infrastructure, but in our example, we use the rule to route data for 192.168.131.0/24 network via local gateway.
- 192.168.131.16/32, Gateway 10.2.2.0
  - The route using the GRE tunnel – packets for the Server (192.168.131.16) are encapsulated into the GRE. You might configure other destinations within this subnet if required, but not 192.168.131.238 (RipEX Ethernet – Peer IP, i.e. RipEX1-Base).
- 172.16.200.0/24 a 172.20.20.4/30, Gateway 10.10.10.4
  - Data for subnets behind RipEX4-Remote are routed to its 10.10.10.4 Radio IP address (i.e. not using GRE tunnel).

5. RipEX3-Remote Configuration



Values from: RipEX3-Remote

Device

Unit name	RipEX3-Remote	Time	Manual	Alarm management	Default	Neighbours&Statistics	Default
▪ Operating mode	Router	SNMP	Off	Power management	Always On	Graphs	Default
Hot Standby	Off	Firewall	Off	WiFi	On	Management	Default

Radio

▪ Radio protocol	Flexible
IP	10.10.10.3
Mask	255.255.255.0
▪ TX frequency	436.360.000
▪ RX frequency	436.360.000
▪ Channel spacing [kHz]	25.0
Modulation rate [kbps]	83.33 | 16DEQAM
RF power [W]	0.5
▪ Optimization	Off
▪ Encryption	Off
▪ MTU [bytes]	1500

ETH

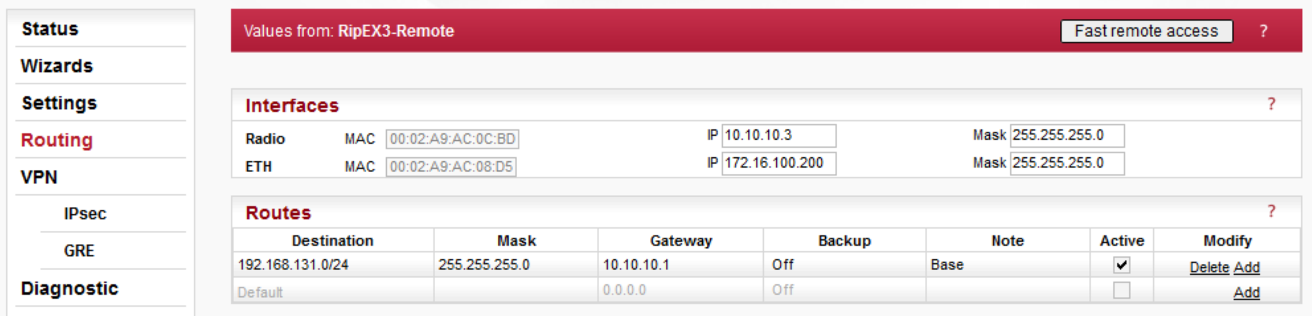
IP	172.16.100.200
Mask	255.255.255.0
DHCP	Off
Shaping	Off
Speed	Auto
Modbus TCP	Off
Terminal servers	Off
TCP proxy	Off
ARP proxy & VLAN	Off

COM's

	COM 1	COM 2
Type	RS232	RS232
Baud rate [bps]	19200	19200
Data bits	8	8
Parity	None	None
Stop bits	1	1
Idle [bytes]	5	5
MRU [bytes]	1600	1600
Flow control	None	None
Protocol	None	None

Fig. 5.1: RipEX3-Remote unit settings

Configure a correct Unit name and ETH/Radio IP addresses. There is no Alias IP address.



Values from: RipEX3-Remote

Interfaces

Radio	MAC	00:02:A9:AC:0C:BD	IP	10.10.10.3	Mask	255.255.255.0
ETH	MAC	00:02:A9:AC:08:D5	IP	172.16.100.200	Mask	255.255.255.0

Routes

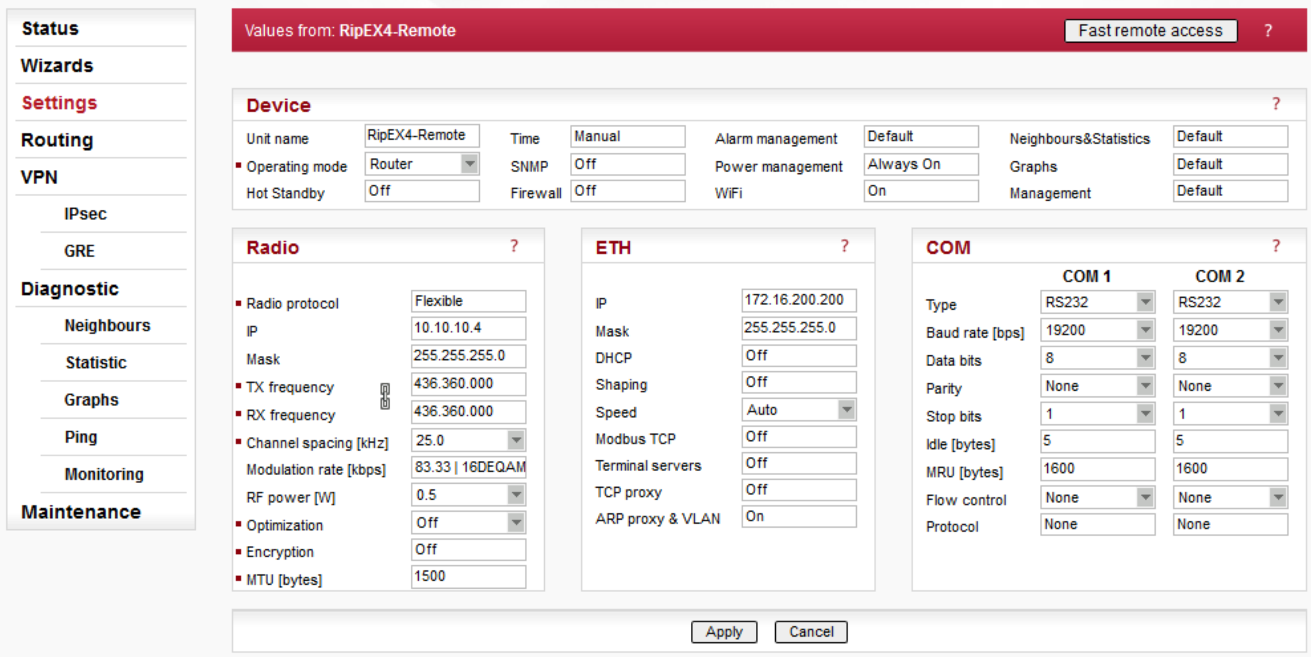
Destination	Mask	Gateway	Backup	Note	Active	Modify
192.168.131.0/24	255.255.255.0	10.10.10.1	Off	Base	☑	Delete Add
Default		0.0.0.0	Off		☐	Add

Fig. 5.2: RipEX3-Remote routing rules

There is only one Routing rule – 192.168.131.0/24 is routed to the central RipEX radio in the centre - IP 10.10.10.1

- 192.168.131.0/24, Gateway 10.10.10.1

6. RipEX4-Remote Configuration



Values from: RipEX4-Remote

Device

Unit name	RipEX4-Remote	Time	Manual	Alarm management	Default	Neighbours&Statistics	Default
Operating mode	Router	SNMP	Off	Power management	Always On	Graphs	Default
Hot Standby	Off	Firewall	Off	WiFi	On	Management	Default

Radio

Radio protocol	Flexible
IP	10.10.10.4
Mask	255.255.255.0
TX frequency	436.360.000
RX frequency	436.360.000
Channel spacing [kHz]	25.0
Modulation rate [kbps]	83.33 | 16DEQAM
RF power [W]	0.5
Optimization	Off
Encryption	Off
MTU [bytes]	1500

ETH

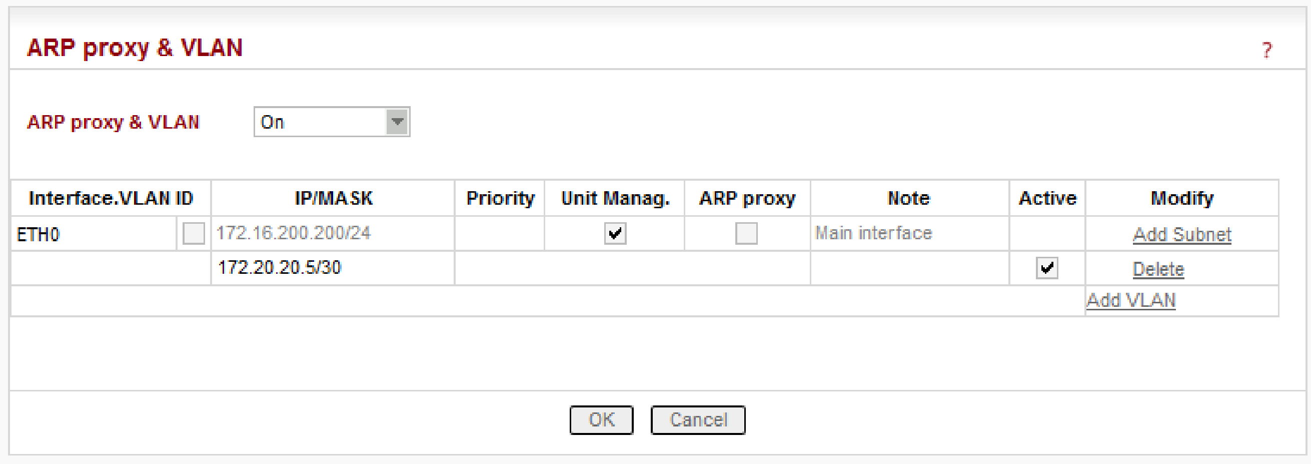
IP	172.16.200.200
Mask	255.255.255.0
DHCP	Off
Shaping	Off
Speed	Auto
Modbus TCP	Off
Terminal servers	Off
TCP proxy	Off
ARP proxy & VLAN	On

COM

	COM 1	COM 2
Type	RS232	RS232
Baud rate [bps]	19200	19200
Data bits	8	8
Parity	None	None
Stop bits	1	1
Idle [bytes]	5	5
MRU [bytes]	1600	1600
Flow control	None	None
Protocol	None	None

Fig. 6.1: RipEX4-Remote settings

Configure the correct Unit name and Radio/Ethernet IP addresses.



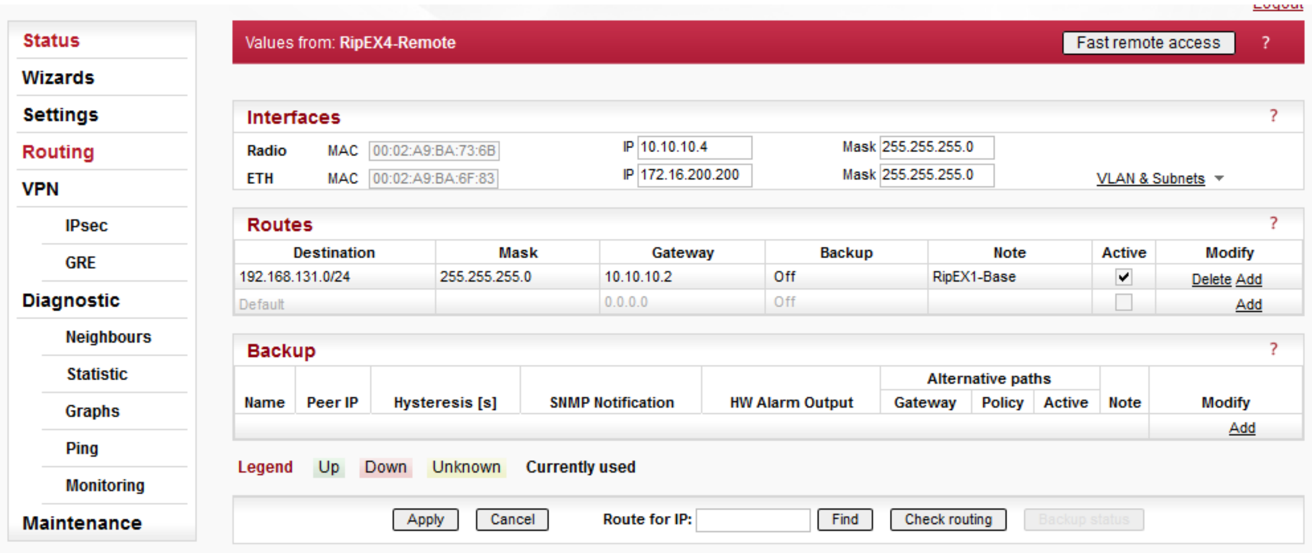
ARP proxy & VLAN

ARP proxy & VLAN: On

Interface.VLAN ID		IP/MASK	Priority	Unit Manag.	ARP proxy	Note	Active	Modify
ETH0	□	172.16.200.200/24		☑	□	Main interface		Add Subnet
		172.20.20.5/30					☑	Delete
								Add VLAN

Fig. 6.2: RipEX4-Remote ETH Alias/Subnet configuration

Click on the “Add Subnet” button to add the alias IP. Fill in the 172.20.20.5/30 and click on the “OK” button.



Values from: RipEX4-Remote

Interfaces

Radio	MAC	00:02:A9:BA:73:6B	IP	10.10.10.4	Mask	255.255.255.0
ETH	MAC	00:02:A9:BA:6F:83	IP	172.16.200.200	Mask	255.255.255.0

VLAN & Subnets

Routes

Destination	Mask	Gateway	Backup	Note	Active	Modify
192.168.131.0/24	255.255.255.0	10.10.10.2	Off	RipEX1-Base	☑	Delete Add
Default		0.0.0.0	Off		□	Add

Backup

Name	Peer IP	Hysteresis [s]	SNMP Notification	HW Alarm Output	Alternative paths			Note	Modify
					Gateway	Policy	Active		
									Add

Legend Up Down Unknown Currently used

Apply Cancel Route for IP: Find Check routing Backup status

Fig. 6.3: RipEX4-Remote routing rules

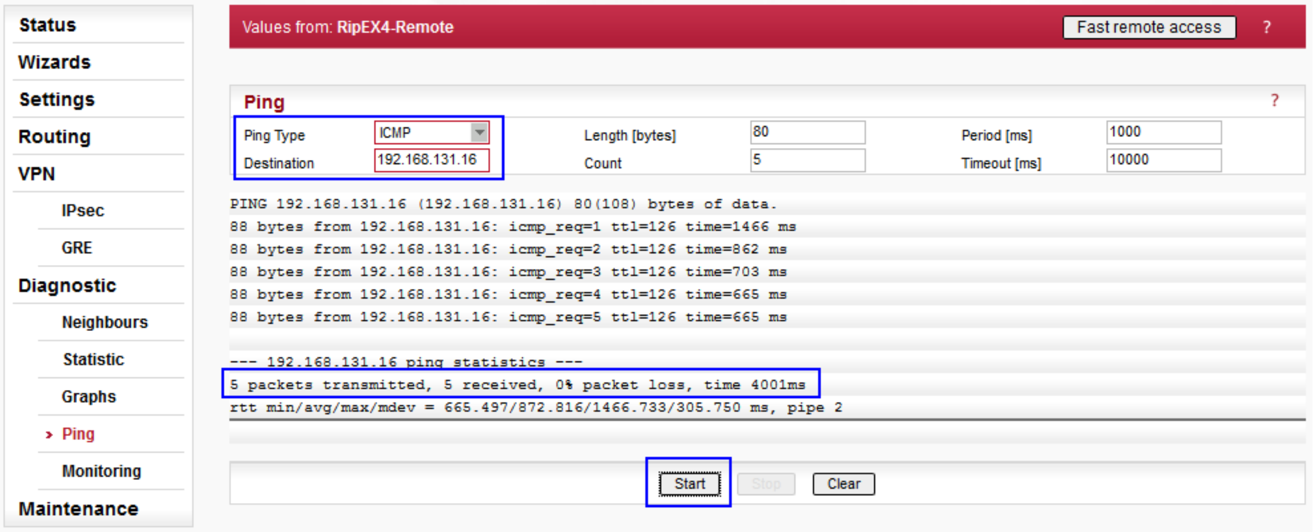
There is only one routing rule – 192.168.131.0/24 is routed to the RipEX2-Remote Radio IP address. There is no GRE tunnel used. Data for 192.168.131.16/32 server will be encapsulated on RipEX2-Remote unit and routed via GRE tunnel over the Ethernet.

- 192.168.131.0/24, Gateway 10.10.10.2

7. Testing

The simplest way is to verify the connectivity via ICMP ping, e.g. a ping from RipEX4-Remote to the server connected to the RipEX radio in the centre - 192.168.131.16.

Go to the Diagnostic/Ping menu in the RipEX4-Remote unit. Choose the ICMP type and fill in the Destination IP (192.168.131.16). Other parameters might stay in default values.



Values from: RipEX4-Remote

Ping

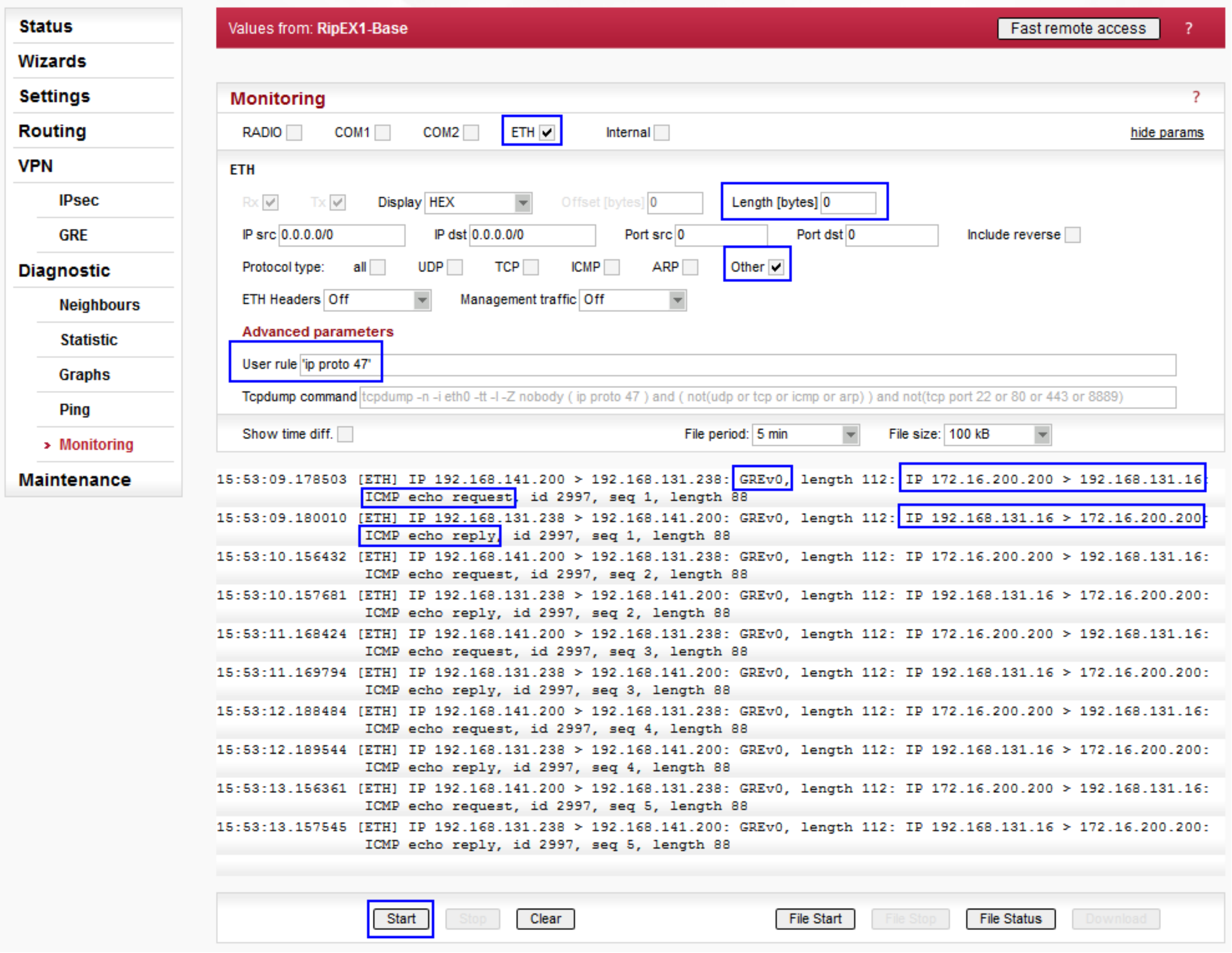
Ping Type	ICMP	Length [bytes]	80	Period [ms]	1000
Destination	192.168.131.16	Count	5	Timeout [ms]	10000

```
PING 192.168.131.16 (192.168.131.16) 80(108) bytes of data.
88 bytes from 192.168.131.16: icmp_req=1 ttl=126 time=1466 ms
88 bytes from 192.168.131.16: icmp_req=2 ttl=126 time=862 ms
88 bytes from 192.168.131.16: icmp_req=3 ttl=126 time=703 ms
88 bytes from 192.168.131.16: icmp_req=4 ttl=126 time=665 ms
88 bytes from 192.168.131.16: icmp_req=5 ttl=126 time=665 ms

--- 192.168.131.16 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4001ms
rtt min/avg/max/mdev = 665.497/872.816/1466.733/305.750 ms, pipe 2
```

Fig. 7.1: Ping from RipEX4-Remote to the server connected to the radio in the centre

The ICMP ping proved the remote server accessibility. But how can we make sure the packets are encapsulated to GRE? Login to the RipEX1-Base unit and choose the Diagnostic/Monitoring menu. Set the parameters as depicted on Fig. 7.2 below and click on the “Start” button. Afterwards, execute the ping requests from RipEX4-Remote unit.



Values from: **RipEX1-Base**

Monitoring

RADIO □ COM1 □ COM2 □ ETH ☑ Internal □

ETH

Rx ☑ Tx ☑ Display HEX Offset [bytes] 0 Length [bytes] 0

IP src 0.0.0.0/0 IP dst 0.0.0.0/0 Port src 0 Port dst 0 Include reverse □

Protocol type: all □ UDP □ TCP □ ICMP □ ARP □ Other ☑

ETH Headers Off Management traffic Off

Advanced parameters

User rule 'ip proto 47'

Tcpdump command tcpdump -n -i eth0 -tt -l -Z nobody (ip proto 47) and (not(udp or tcp or icmp or arp)) and not(tcp port 22 or 80 or 443 or 8889)

Show time diff. □ File period: 5 min File size: 100 kB

```
15:53:09.178503 [ETH] IP 192.168.141.200 > 192.168.131.238: GREv0, length 112: IP 172.16.200.200 > 192.168.131.16:
                ICMP echo request, id 2997, seq 1, length 88
15:53:09.180010 [ETH] IP 192.168.131.238 > 192.168.141.200: GREv0, length 112: IP 192.168.131.16 > 172.16.200.200:
                ICMP echo reply, id 2997, seq 1, length 88
15:53:10.156432 [ETH] IP 192.168.141.200 > 192.168.131.238: GREv0, length 112: IP 172.16.200.200 > 192.168.131.16:
                ICMP echo request, id 2997, seq 2, length 88
15:53:10.157681 [ETH] IP 192.168.131.238 > 192.168.141.200: GREv0, length 112: IP 192.168.131.16 > 172.16.200.200:
                ICMP echo reply, id 2997, seq 2, length 88
15:53:11.168424 [ETH] IP 192.168.141.200 > 192.168.131.238: GREv0, length 112: IP 172.16.200.200 > 192.168.131.16:
                ICMP echo request, id 2997, seq 3, length 88
15:53:11.169794 [ETH] IP 192.168.131.238 > 192.168.141.200: GREv0, length 112: IP 192.168.131.16 > 172.16.200.200:
                ICMP echo reply, id 2997, seq 3, length 88
15:53:12.188484 [ETH] IP 192.168.141.200 > 192.168.131.238: GREv0, length 112: IP 172.16.200.200 > 192.168.131.16:
                ICMP echo request, id 2997, seq 4, length 88
15:53:12.189544 [ETH] IP 192.168.131.238 > 192.168.141.200: GREv0, length 112: IP 192.168.131.16 > 172.16.200.200:
                ICMP echo reply, id 2997, seq 4, length 88
15:53:13.156361 [ETH] IP 192.168.141.200 > 192.168.131.238: GREv0, length 112: IP 172.16.200.200 > 192.168.131.16:
                ICMP echo request, id 2997, seq 5, length 88
15:53:13.157545 [ETH] IP 192.168.131.238 > 192.168.141.200: GREv0, length 112: IP 192.168.131.16 > 172.16.200.200:
                ICMP echo reply, id 2997, seq 5, length 88
```

Fig. 7.2: Monitoring parameters and monitoring output

The packet length might be set to be 0 Bytes, because the payload is not important now. To display only GREv0 packets, define the advanced parameter as ‘ip proto 47’ (GRE protocol port).

NOTE:
The GRE interface might be monitored directly using the ‘-i gretun0’ advanced parameter.

The ICMP packets are displayed in the output as GREv0 packets. There is no encryption and thus the packets are readable.

You can try to test accessibility of other units. The principle is the same.

Accessibility issues might be caused by:

- Missing routing rules (or default gateway, …) on one of the computers
- Enabled firewall blocking the incoming ICMP requests
- Misconfigured routing rules or GRE tunnels in RipEX units
- Etc...

Appendix A. Revision History

Revision 1.0	2017-11-07

First issue