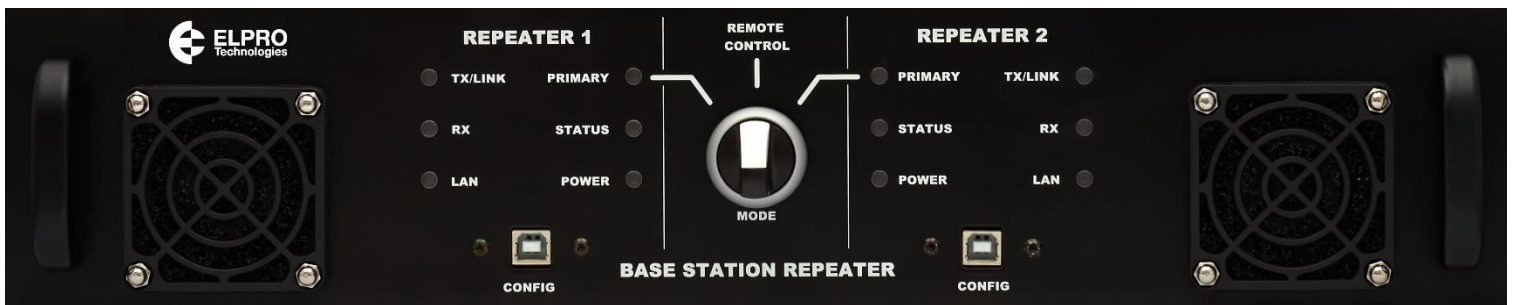


415U-E-BSR

Base Station Repeater

Version 1.1



 **ATTENTION**

INCORRECT TERMINATION OF SUPPLY WIRES MAY CAUSE INTERNAL DAMAGE AND WILL VOID THE WARRANTY. TO ENSURE THAT YOUR 415U-E-BSR BASE STATION REPEATER ENJOYS A LONG LIFE, CHECK THIS USER MANUAL TO VERIFY THAT ALL CONNECTIONS ARE TERMINATED CORRECTLY BEFORE TURNING ON POWER FOR THE FIRST TIME.

Avoid

- Operating the transmitter unless all RF Connectors are secure, and any open connectors are properly terminated.
- Operating the equipment near electrical blasting caps or in an explosive atmosphere

Note: All equipment must be properly grounded for safe operation. All equipment should be serviced only by a qualified technician.

Important notice

ELPRO products are designed to be used in industrial environments by experienced industrial engineering personnel with adequate knowledge of safety design considerations.

ELPRO products use communications channels that are subject to noise and interference. The products are designed to operate in the presence of noise and interference, but in an extreme case noise and interference can cause product operation delays or operation failure. Like all industrial electronic products, ELPRO products can fail in a variety of modes due to misuse, age, or malfunction. We recommend that users and designers design systems using design techniques intended to prevent personal injury or damage during product operation and provide failure tolerant systems to prevent personal injury or damage in the event of product failure. Designers must warn users of the equipment or systems if adequate protection against failure has not been included in the system design. Designers must include this Important Notice in operating procedures and system manuals.

These products should not be used in non-industrial applications, or life-support systems, without first consulting ELPRO.

To avoid accidents during maintenance or adjustment of remotely controlled equipment, all equipment should be first disconnected from the module during these adjustments. Equipment should carry clear markings to indicate remote or automatic operation. For example: "This equipment is remotely controlled and may start without warning. Isolate at the switchboard before attempting adjustments."

Release notice

This is the 2021 release of the 415U-E-BSR Base Station Repeater User Manual version 1.1. This user manual should be read in conjunction with the 415U-E User manual release 2.20 or later.

GNU Free Documentation License:

Copyright (C) 2009 ELPRO Technologies.

ELPRO Technologies is using a part of Free Software code under the GNU General Public License in operating the 415U-E-BSR product. This General Public License applies to most of the Free Software Foundation's code and to any other program whose authors commit by using it. The Free Software is copyrighted by Free Software Foundation, Inc., and is licensed "as is" without warranty of any kind. Users are free to contact ELPRO Technologies for instructions on how to obtain the source code used in the 415U-E-BSR. A copy of the license is included in "Appendix B – GNU General Public License" below.

Follow instructions.

Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment. Practice all plant and safety instructions and precautions. Failure to follow the instructions can cause personal injury and/or property damage.

Proper use

Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment. Any such unauthorized modifications: (1) constitute "misuse" and/or "negligence" within the meaning of the product warranty, thereby excluding warranty coverage for any resulting damage; and (2) invalidate product certifications or listings.

Deployment of ELPRO products in customer environment

There is increasing concern regarding cybersecurity across industries, where companies are steadily integrating field devices into enterprise-wide information systems. This is why ELPRO has incorporated secure development life cycle in their product development to ensure that cybersecurity is addressed at all levels of development and commissioning of our products. There is no protection method that is completely secure. Industrial Control Systems continue to be the target for attacks. The complexities of these attacks make it very difficult to have a complete secure system. A defense mechanism that is effective today may not be effective tomorrow as the ways and means of cyber-attacks constantly change. Therefore, it's critical that our customers remain aware of changes in cybersecurity and continue to work to prevent any potential vulnerability of their products and systems in their environment. At ELPRO we are focusing on analyzing emerging threats and ensuring that we are developing secure products and helping our customers deploy and maintain our solutions in a secure environment. We continue to evaluate cybersecurity updates that we become aware of and provide the necessary communication on our website as soon as possible. ELPRO strongly recommends our customers to apply the deployment practices that are outlined on our Cybersecurity whitepaper "[Electrical Distribution Cybersecurity considerations](#)".

Table of Contents

Introduction.....	1
Overview.....	1
Repeater Structure	1
Method of Operation.....	1
Installation.....	2
Mode and Status Indication.....	3
Mode Switch Operation.....	3
Status LEDs	3
Configuration.....	3
Main Configuration Page	3
Quick Start Configuration	3
System Size	4
415U-E-BSR specific Items	4
Connecting to the device’s USB port	4
Connecting to the Device’s Ethernet port	5
Configuring PC networking settings.....	5
Remote Control and Status Monitoring.....	5
Repeater Control Register	5
Repeater Status Registers.....	5
Using Fail-Safe on loss of Remote Master	6
Combining Local and Remote Control	6
Diagnostics.....	6
Web Page Diagnostics.....	6
Modbus Register Diagnostics.....	7
Digital Input Registers (Bits).....	7
Input Registers (Words)	7
LED Diagnostic Charts	8
Example 1 – Repeater hard fault.....	8
Example 2 – Repeater soft fault	8
Example 3 – Both Repeaters Primary	8
Example 4 – Both Repeaters Primary	8
Maintenance.....	8
Firmware Update.....	8
Fuse	8
Dust Filters.....	8
Appendix A – Specifications.....	9
Appendix B – GNU General Public License	10

Introduction

Overview

The 415U-E-BSR Base Station Repeater Provides a redundant Base Station and Repeater for ELPRO 450U-E, 415U-E and 415U-2 Remote radio modules.

The 415U-E-BSR is a UHF redundant base station, repeater or remote which provides smart redundancy via the use of adaptive switching schemes based on the proven 415U-E modems.

The 415U-E-BSR operates in redundant mode which can be configured to operate in auto or manual/maintenance modes allowing the switching between primary and secondary units whilst also providing remote monitoring of operation selections and diagnostics.

Repeater Structure

The 415U-E-BSR incorporates two fully independent repeaters, utilizing separate RF connection, power supply, data connection, and cooling system. The 415U-E-BSR should be installed with two fully independent power supplies and with independent antenna systems to ensure that failure of any of these elements does not impact the system reliability.

Method of Operation

In normal operation, both repeaters are active. One operates in primary mode and the other operates in secondary mode. Where possible, remote device will connect through the repeater that is acting in primary mode. If the repeater operating as primary fails or degrades so that its signal to the remote sites is too weak, then the remote devices will select the secondary repeater.

Note: If using remote 450U-E devices, firmware version 1.30 or later is required to recognize and correctly roam to the primary repeater, which is standard operation in all 415U-2 and 415U-E Firmware.

LEDs on the front panel indicate which device is acting as primary, as well as indicating the status of the repeater.

Both repeaters monitor their own status and indicate alarms on hard faults such as antenna fault, over-temperature, or low supply voltage. A repeater that experiences a hard fault while it is primary will continue to operate as primary. If the fault impacts radio communications, the remote sites will migrate to the secondary.

To ensure that both of the redundant repeaters are operating correctly, the primary repeater should be swapped between Repeater 1 and Repeater 2 regularly.

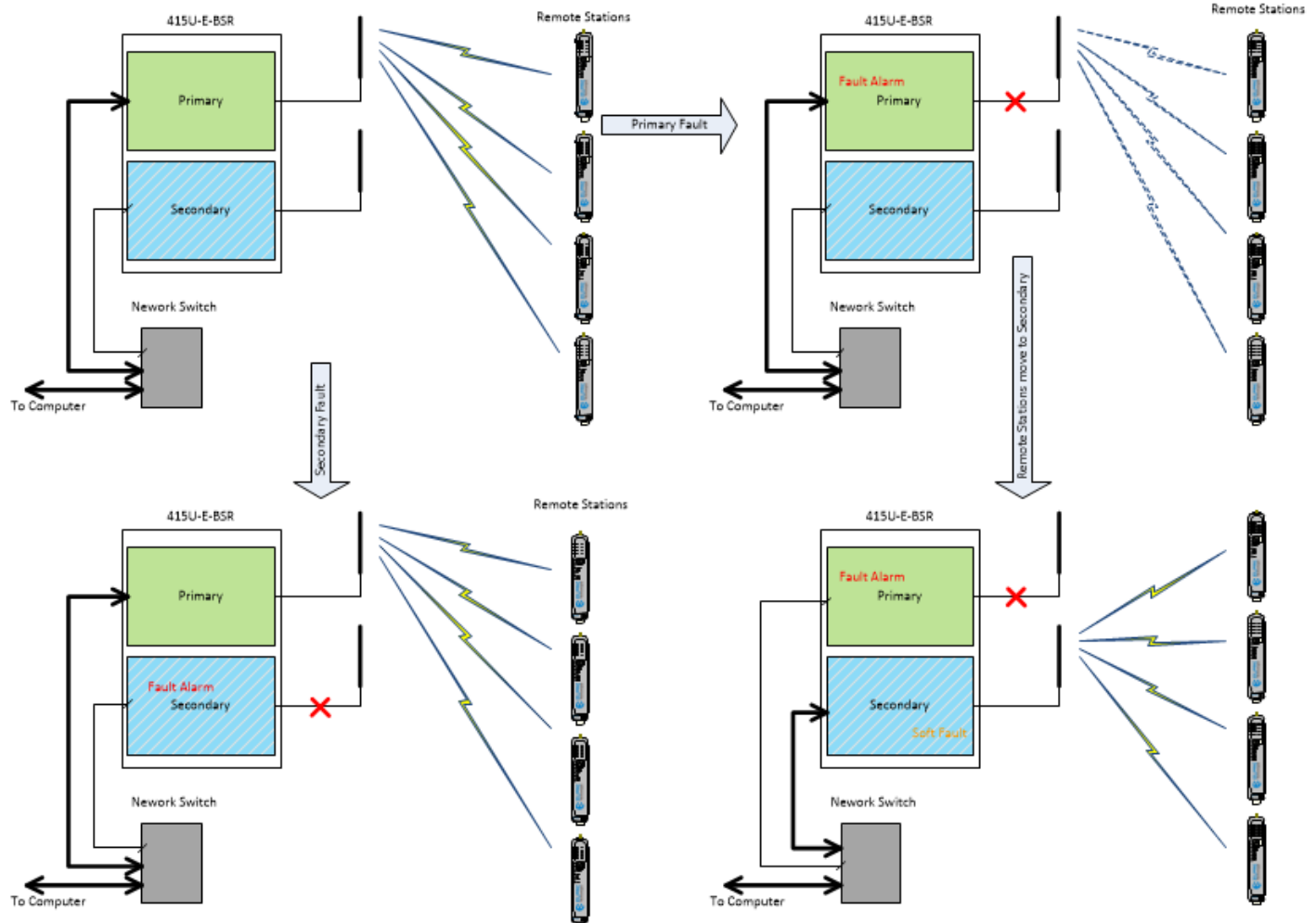


Figure 1 - Operation Overview

Installation

To achieve the best performance from your 415U-E-BSR, installation should follow accepted best practice. Install the 415U-E-BSR according to Figure 2 below. Take note of the following points.

- Each repeater should be powered by an independent power supply of 2.5A 12V or 24V nominal. For maximum reliability these should incorporate independent battery backup.
- Surge arrestors should be fitted to provide effective protection from Lightning damage. Surge arrestors should have a turn-on voltage of 90V. Recommended part ELPRO CSD-N-6000.
- An Ethernet Switch provides connection to the two internal repeaters and to the base Computer. For maximum reliability, choose an Ethernet Switch with dual supply capacity, and supply from each of the two independent supplies. Recommended part ELPRO EL-1050-E-T.

- Antennas should be mounted one above the other. They should be separated by at least 1m vertically, and at least 1m from the mast and or any other local obstructions. (mounting antennas at the same level is acceptable, but could impact performance in cases where both repeaters are active)
- Take care when running RF coaxial cable to observe minimum bending radius and to not crush the cable when restraining.
- Connections between the antenna and the coaxial cable should be carefully taped to prevent ingress of moisture. We recommend that the connection be taped—first with a layer of PVC tape, next with vulcanizing tape (such as 3M™ 23 tape), and finally with another layer of PVC UV-stabilized insulating tape. The first layer of tape allows the joint to be easily inspected when troubleshooting because the vulcanizing seal can be easily removed.

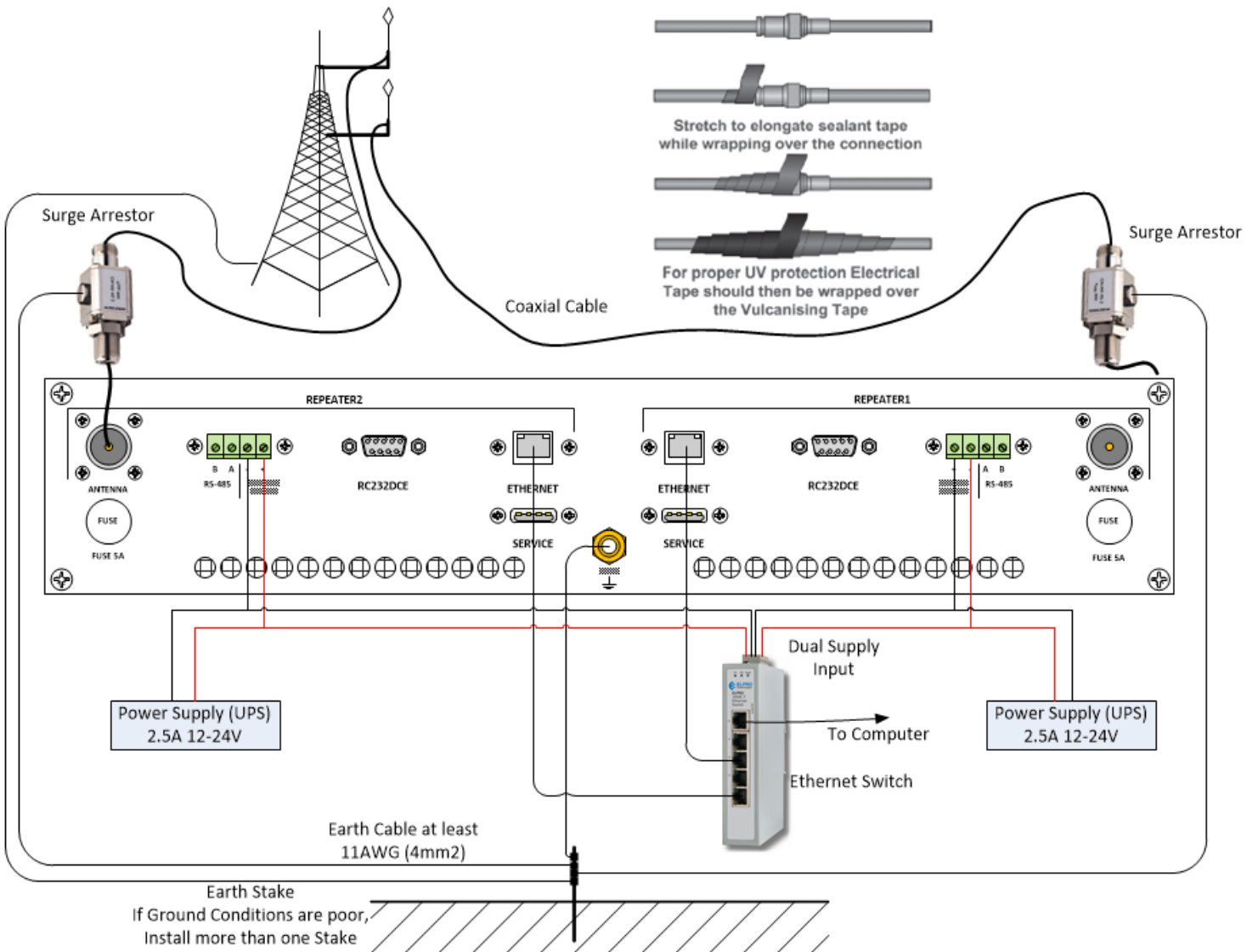


Figure 2 - Installation

Mode and Status Indication

The 415U-E-BSR incorporates a mode switch and twelve status LEDs. You can use the mode switch to select which repeater is the primary. Six LEDs indicate the status of each of the two repeaters.

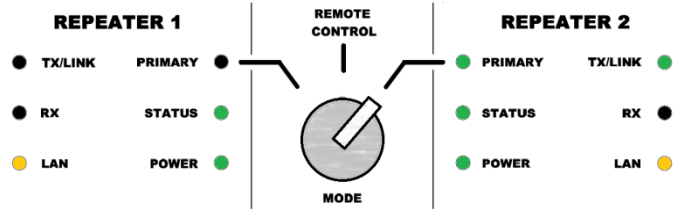


Figure 3 – Normal Operation

Mode Switch Operation

The Mode Switch selects which repeater is the primary. It supports three positions.

Position	Function
Repeater 1 (Left)	The left Repeater is selected as primary
Remote Control	Neither repeater is selected as primary. The primary repeater can be selected by the remote master (SCADA/HMI/DCS).
Repeater 2 (Right)	The right Repeater is selected as primary

Status LEDs

Each repeater incorporates six LEDs indicating the status of that repeater.

LED	Color	Meaning
Primary	Green	This repeater is primary. No Fault detected
	Orange	This repeater is primary. Fault detected. Status LED indicates Soft or Hard fault.
	Off	This repeater is secondary
Status	Green	No Fault Detected
	Orange	Soft Fault detected
	Red	Hard Fault detected
Power	Green	Repeater Functioning correctly
	Red	Configuration Error or Hardware Fault
	Red/Green flashing	Device Boot-up
Tx/Link	Green	Link established to upstream base, or to one or more remotes
	Orange flash	Transmit radio message
Rx	Green flash	Radio message received – Good signal
	Red flash	Radio message received – poor signal
LAN	Orange	Link established on Ethernet port
	Flash	Data activity on Ethernet port

When the system is operating correctly, there should be no remotes connected to the secondary, and all remotes should be connected to the primary. The Soft Fault status indicated by the Status LED turning Orange indicates when this is not the case. The Soft Fault meaning depends on whether the repeater is operating as primary or secondary.

Repeater Mode	Orange Status (Soft Fault) Indication
Primary	There are no remote stations connected to this repeater
Secondary	There is at least one remote station connected to this repeater

Configuration

Before you configure the repeaters, you need to access their internal Web servers. You can use the USB port on the front panel to access the web-server locally, or you can use the Ethernet connection to access remotely. Refer to the sections below; “Connecting to the device’s USB port” and “Connecting to the Device’s Ethernet port” for instructions on how to connect.

Main Configuration Page

Once you have connected to the repeater, you will see the home page of the web-based configuration utility.

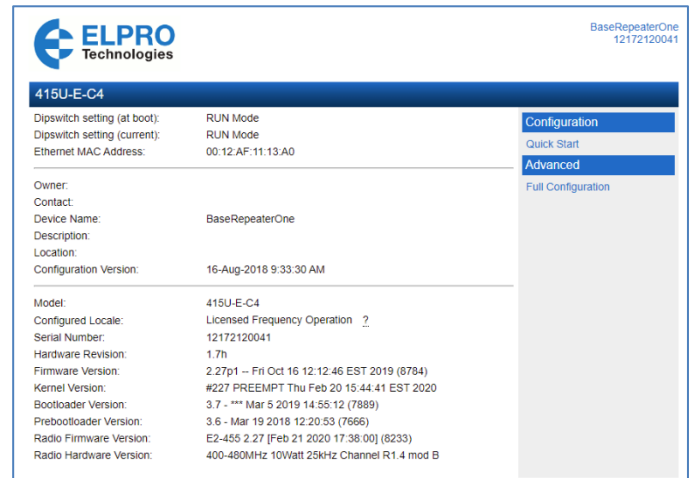


Figure 4 - Web Configuration

Quick Start Configuration

You configure Radio Setup, and Wireless Interface sections for both repeaters in the BSR identically. They must be configured with the same System Address. This is the same system address configured in the remotes.

The repeaters need to be configured to Access Point operating mode to work as redundant base / repeater. Check the 415U-E User manual for detail of the other device configuration items common between this module and the 415U-E.

You should configure a different Device Name in each repeater. This device name is displayed in the connectivity list of remote devices, so it is easy to see which repeater they are connected to.

The two repeaters in the 415U-E-BSR must be configured with separate IP Address settings. Normally you can use the default network settings.

Security:
Enable Remote Webserver Access ?

Identification:
Separate Device Name
Device Name: BaseRepeaterOne ?

Wireless Interface:
Networking Mode: Manual ?
802.11 Mode: Access Point
System Address (ESSID): system
Encryption Passphrase: Show

Radio Setup:
Bandwidth: 25 kHz
Transmit Power Level: 40 dBm (Average: 4.0W)
Transmit Frequency: 472.100000 (400.0000 - 480.0000) MHz
Receive Frequency: 472.100000 (400.0000 - 480.0000) MHz

Network Settings:
IP Address: 192.168.0.110
Subnet Mask: 255.255.255.0

Filter Settings:
Separate IP Address
Enable Easy Filter:

Save Changes Save Changes and Reset

System Size

The networking protocol used by the 450U and 415U series devices incorporates a range of delays to ensure that the radio network is not overloaded during high traffic events such as network startup and repeater change-over. These delays are controlled by the system size setting. If you expect more than 10 remote stations to be connecting to your repeater, then set the system size parameter to reflect the approximate number of remotes that will be connected to the repeater.

To set the system size, click “Full Configuration” under Advanced, then select “Radio” under the Configuration Heading to reach the Radio Setup page.

Basic Radio Setup:

Modulation: High Speed Mode (QAM)

Bandwidth: 25 kHz

Transmit Data Rate: Auto kbits/s

Base Data Rate: 32 kbits/s

Transmit Power Level: 40 dBm (Average: 4.0W, Peak: 13.5W)

Transmit Frequency: 472.100000 (400.0000 - 480.0000) MHz

Receive Frequency: 472.100000 (400.0000 - 480.0000) MHz

System Size: 10 clients ?

System Size matches number of Clients connected to this repeater.

415U-E-BSR specific Items

Some items are specific to the 415U-E-BSR. These are described here. To configure the repeater, click “Full Configuration” under “Advanced” tab, and then select “Network”. The items that need to be configured for the redundant repeater are at the bottom of the page in the section “Redundant Repeater Operation:”.

Redundant Repeater Operation:

- Enable Redundant Repeater Mode ?
- DI1 selects Primary ?
- Set Primary Mode at Boot ?

Enable Redundant Repeater Mode: This selects the correct mode for the 415U-E-BSR. If you do not check this, then the two repeaters will operate as independent repeaters and remote devices will arbitrarily select one or the other repeater for connection.

DI1 selects Primary: Check this to enable the local control from the front panel switch. If you don’t select this, then the repeater will only operate in remote control mode. The front panel switch will be available in register 10001 for the remote master to read and act on, but it will not select the primary repeater.

Set Primary Mode at Boot: You can select this on one repeater if you want this repeater to automatically become primary at power-on.

Note: You can also use the fail-safe feature to manage the repeater mode if it loses communication with the master. If you use the failsafe feature then leave “Set Primary Mode at Boot” unchecked.

Connecting to the device’s USB port

The USB port for each repeater is located on the front panel marked “Config”. To connect, you need an USB cable (USB-A to USB-B) for connecting from your computer to the repeater’s USB-B port.

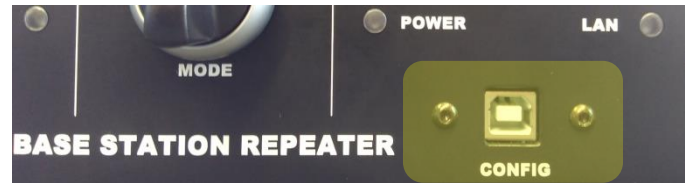


Figure 5 – USB Config Port

If this is the first time you have used your computer to connect to an ELPRO device through the USB port, then you will need to install the USB driver file from the product’s internet website. This is available from the same location that you downloaded this user manual. Downloadable from the following link.

<https://desk.zoho.com/portal/elprotech/en/kb/articles/elpro-usb-drivers>

You will also need to know the username/password configured for the device. If the device is new out-of-the-box you can use the default settings. Otherwise, you need to use the settings you configured to the device previously.

Follow the procedure for your version of windows to install the device driver. Instructions will be included with the downloaded driver file.

Power on the repeater and wait for the device to finish booting and for the “POWER” LED to go solid green (about 1 minute).

Plug in the USB cable and wait for your computer to recognize the new USB device. The new device will identify as a “415U-E”.

Once the driver is installed, you will have an additional Network Adapter in your device manager list.

“Elpro 415U-E USB Ethernet/ RNDIS Interface”

Configure this Network Adapter for IP address 192.168.111.1 (refer to section “Configuring PC networking settings” below for more detail)

Open your web browser (recommended Internet Explorer version 10 or later) and type “http://192.168.111.1” into the browser bar. Both of the repeaters have the same IP address when using the USB port. The repeater responds with a username and password box.

Type the username and password. The default username is “user” and the default password is “user”.

This connects you to the home page of the Web-based configuration utility (see Figure 4 - Web Configuration). This utility allows you to manage wireless connection links between all modules in the system through a standard browser, such as Microsoft® Internet Explorer®.

Connecting to the Device’s Ethernet port

The Ethernet port is located on the rear panel. In a normal installation, you can connect to a spare port on the Ethernet switch (Refer Figure 2). To connect, you need an Ethernet cable for connecting to the Ethernet port. You also need to know the device’s IP Address and the username/ password configured for the device.



Figure 6 - Ethernet Port

The module’s default settings are as follows:

- IP Address 192.168.0.1XX
(Shown on the printed label on the rear panel below the Ethernet port)
- Subnet Mask 255.255.255.0
- User Name user
- Password user

Once you have the device’s IP address and password:

- Connect an Ethernet cable between the repeater’s Ethernet port (or a port on the network switch) and the PC.
- Configure your PC networking settings to be on the same network as the device. For instructions on how to do this, see “Configuring PC networking settings” below.
- Open your web browser (recommended Internet Explorer version 10 or later) and type “http://” followed by the IP address of the module and press Enter.

The module responds with a username and password box.

- Type the username and password. The default username is “user”, and the default password is “user”.

This connects you to the home page of the Web-based configuration utility (see Figure 4). This utility allows you to manage wireless connection links between all modules in the system through a standard browser, such as Microsoft® Internet Explorer®.

Configuring PC networking settings

If you are unable to connect to the device through the Ethernet or the USB connection, use this guide to ensure you have your PC configured correctly.

(The following description is for Windows 7. Other operating systems have similar settings)

On the PC, open Control Panel, then select **Network and Sharing Center**.

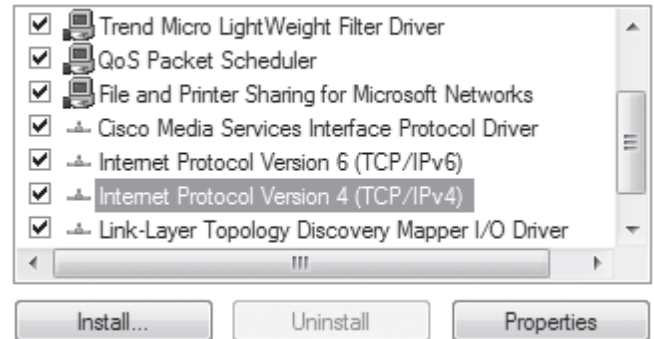
Click “**Change Adapter Settings**” on the left of the screen. You should see a list of available network adapters.

Find the correct network connection in the list. For Ethernet, this will normally be “Local Area Connection”. For the USB port, this will be “ELPRO 415U-E USB Ethernet/RNDIS”

Right click on the network connection and select **Properties** from the context menu.

Select “**Internet Protocol Version 4 (TCP/IPv4)**” and click on **Properties**.

This connection uses the following items:



On the General tab, select **Use the following IP address**: For Ethernet enter IP address 192.168.0.1.

Verify the connection to the module by using the “ping” command. Start a command window (click **Start** menu and type “command” into the search box). At the command prompt, type “ping <IP Address>”. If you have not altered the default connection settings, then the IP address will be the address printed on the label under the Ethernet port. For USB, the IP Address is always 192.168.111.1.

Remote Control and Status Monitoring

The 415U-E-BSR is designed to operate with a SCADA, HMI, or DCS system. This lets you monitor the status of the two repeaters, and lets you control which repeater is the primary. You can access the control and status registers using Modbus TCP protocol over the Ethernet ports on the rear panel.

Note: The default IP addresses of the two repeaters are printed on the rear panel under the corresponding Ethernet port.

Repeater Control Register

Each repeater contains a Modbus register allocated to setting that repeater to be primary. You can set the repeater to be primary by setting this register ON.

Register	Function
401	Remote Control. Set ON to Switch the repeater to primary mode

The repeater reads the status of this register, and the status of the mode switch (see below register 10001). If either is ON, then the repeater is set to primary mode.

Repeater Status Registers

Each repeater contains a set of registers indicating the status of the repeater, any hard alarms, and information about the connected remotes.

Register	Indication
10001	The mode switch has this repeater selected. Note: You need to configure the repeater to change to primary when this input is active.

10401	This repeater is in primary mode
10402	Hard Fault Alarm – RF Power Amplifier Temperature
10403	Hard Fault Alarm – Radio internal Fault
10404	Hard Fault Alarm – RF Frequency lock error
10405	Hard Fault Alarm – Antenna VSWR Alarm
32000	Number of connected devices

You can monitor these registers from your remote master to provide additional status information about the repeaters.

There are additional diagnostic registers that you can retrieve to get a more complete picture of how the repeater is functioning. These are listed in the section “Modbus Register Diagnostics” below.

Using Fail-Safe on loss of Remote Master

If the remote master fails, or if communication is lost, then the last setting from the master will set the primary repeater. You won't be able to switch the primary repeater over using the local Mode switch. To overcome this behavior, you can add a failsafe item to each repeater so that the remote-control register reverts to OFF a fixed time after it is last written from the remote master. You configure the fail-safe under Advanced section on the devices' web configuration menu.

The first example below configures the repeater to start in primary mode. It initializes register 401 to ON (Startup value = 1) at startup and turns it OFF ten minutes (600s) after the last time it is written – either by the remote master or from the initial startup.

Fail Safe Blocks:

#	First Register	Count	Timeout (s)	Initialise at Start ?	Startup Value ?	Invalidate on Fail ?	Fail Value ?
1	401	1	600	<input checked="" type="checkbox"/>	1	<input type="checkbox"/>	0

Figure 7 - Start up as Primary.

The second example configures the repeater to start in secondary mode. It initializes register 401 to OFF (Startup value = 0). It still sets the same timeout for writes from the remote master.

#	First Register	Count	Timeout (s)	Initialise at Start ?	Startup Value ?	Invalidate on Fail ?	Fail Value ?
1	401	1	600	<input checked="" type="checkbox"/>	0	<input type="checkbox"/>	0

Figure 8 - Start up as Secondary.

If the remote master stops updating the primary repeater, then after 10 minutes both repeaters will revert to secondary mode. The front panel mode switch can then be used to select which repeater should be primary.

Combining Local and Remote Control

If you need to implement a system which allows both local control (through the Mode switch) and remote control (from a remote master such as SCADA), then you need to implement some additional logic in the remote master to ensure both repeaters don't get set to primary at the same time. Refer to Figure 9 - Remote

Master Logic below.

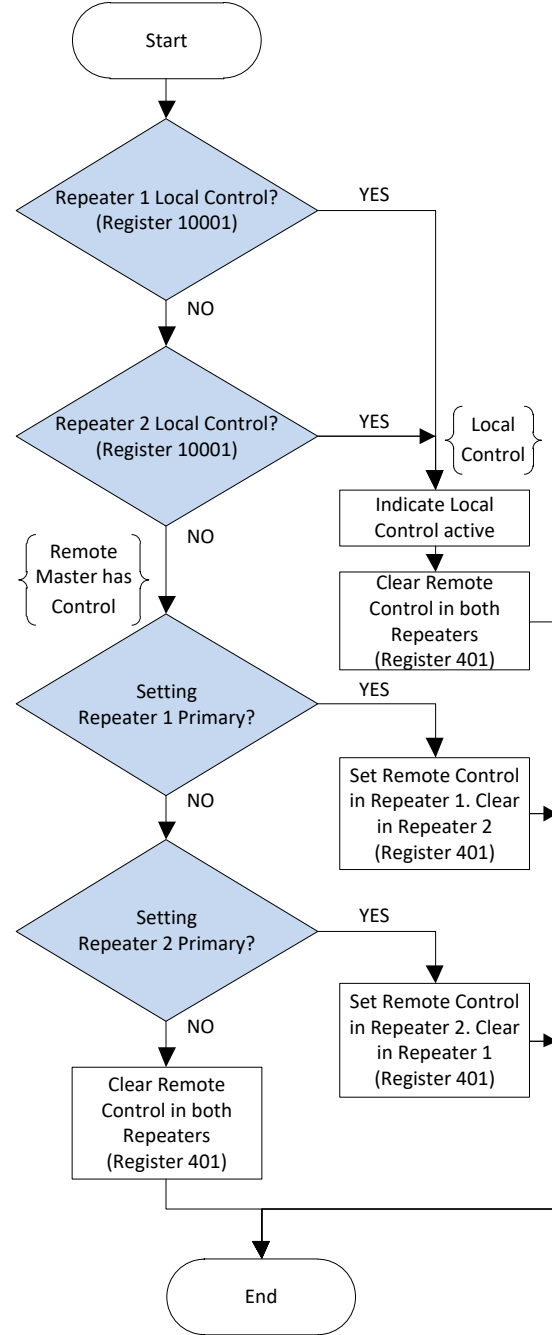


Figure 9 - Remote Master Logic

The remote master monitors the status of the mode switch (register 10001) on each repeater, and if either is selected, then it should disable the remote-control register (register 401). When the mode switch returns to the Remote-control position (Register 10001 is OFF on both repeaters), the remote master should re-enable the remote control for the current primary (register 401).

Diagnostics

The 415U-E-BSR provides an extensive range of diagnostic features to help understand the state of the system.

Web Page Diagnostics

Web-page diagnostics are accessible through a web browser from the repeaters' main pages. Refer to section “Main Configuration

Page” above for more information on accessing the web-page diagnostics. Refer to the 415U-E User manual sections 5.4 “Statistics” through 5.7 “Network Diagnostics” for instructions on using the web-page diagnostics.

Modbus Register Diagnostics

The repeaters also provide comprehensive diagnostics through Modbus registers that can be read by the remote master. The following table describes these diagnostic registers.

Digital Input Registers (Bits)

Address Range	Description
10001	Front panel Mode Switch Status (ON for selected)
10003	Set-point status for Supply Voltage (Refer 415U-E User manual)
10401	Primary Mode Indication
10402 – 10405	Radio Hard Fault Status Flags
10402	RF PA Over Temperature
10403	Radio General Hardware fault
10404	RF PLL Frequency Lock Error
10405	Antenna VSWR fault

Input Registers (Words)

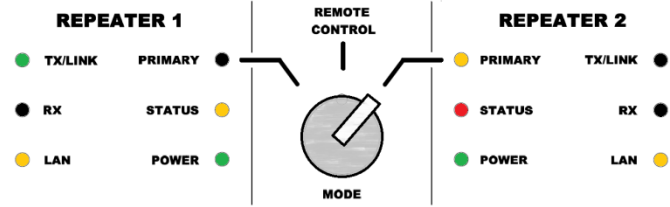
Address Range	Description
30002	Supply Voltage: 16384 => 8V. 49152 => 40V
30401	RSSI: When configured as a Repeater, or Manual Client, the RSSI of the connected upstream device in -dBm
30402	Connected Time: When configured as a Repeater, or Manual Client, the time (in hours) that the connection to the upstream device has been made.
30403	Generation Count: When configured as a Repeater, or Manual Client, the generation count of the connection to the upstream device. This is the number of times the upstream connection has been lost and re-established
30404 – 30405	Upstream IP Address: When configured as a Repeater, or Manual Client, the IP Address of the upstream device.
	Most Significant Byte High byte of Register 30404
	Second Byte Low byte of Register 30404
	Third Byte High byte of register 30405
	Least Significant Byte Low byte of register 30405
30407 – 30408	Radio Transmit Frequency (in Hz). 32-bit. Most significant word at lower (odd) address.
30409 – 30410	Radio Receive Frequency (Same as Transmit Frequency)

Address Range	Description
30411	Module uptime: The time (in hours) that this module has been up and running
30412	Channel Utilization % (average of last 60 seconds)
30413	Background Noise in (-) dBm. (Average of last 60 seconds)
30414	Tx retry % (average of last 60 seconds): The percentage of total transmissions that required at least one retry
30415	Tx failed % (average of last 60 seconds): The percentage of total transmissions that failed to get an acknowledgement after all retries exhausted.
30416 – 30419	Channel Utilization, Background noise, Tx Retry % and Tx Failed % (average of the last 60 minutes)
30420 – 30423	Channel Utilization, Background noise, Tx Retry % and Tx Failed % (average of the last 60 hours)
30494 – 30500	Internal information registers: serial number, firmware version and patch level
30494	First four digits of serial number (Encodes Manufacture Month & Year
30495	Next three digits of serial number (Encodes Manufactured Firmware version)
30496	Remaining four digits of the serial number
30497	First part of Current Firmware version
30498	Second part of Current Firmware version
30499	Third part of Current firmware version
30500	Patch Level of current firmware version
32000	Number of downstream Connected sites (Repeaters, Remotes, or Mesh Nodes).
32001 - 32255	RSSI List: When configured as a Base, Repeater, or Manual AP. The RSSI of each connected downstream is added to an I/O register according to the last byte of that device’s IP Address. For example, a downstream device with IP Address 192.168.0.199 will have its RSSI stored in I/O register 32000 + 199 = 32199. If no device is connected with that IP address, the corresponding register has the value Zero.

LED Diagnostic Charts

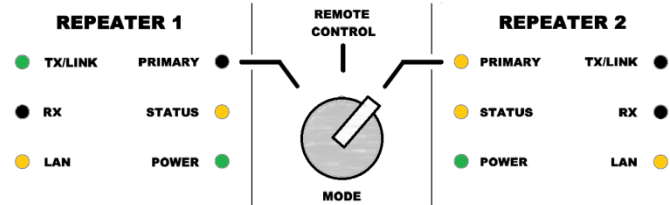
The front panel LEDs provide a quick diagnostic on the status of the repeaters. Refer to the charts below for some examples of typical LED patterns and the associated diagnosis.

Example 1 – Repeater hard fault



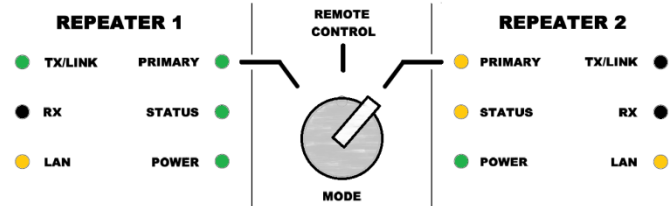
In this example, Repeater 1 is selected as secondary (Primary LED is off), but it is operating as the repeater for at least some remotes (Status LED is orange). Repeater 2 is selected as primary but has a fault (Primary LED Orange). It has hard fault (Status LED RED). Check the diagnostic registers to find the cause of the hard fault.

Example 2 – Repeater soft fault



In this example, Repeater 1 is selected as secondary (Primary LED is off), but it is operating as the repeater for at least some remotes (Status LED is orange). Repeater 2 is selected as primary but has a fault (Primary LED Orange). It has no remote sites using it as a repeater (Status LED Orange). This indicates a problem with Repeater 1 which is *not* a hard fault. Check for configuration issues, and for hardware issues related to Repeater 2.

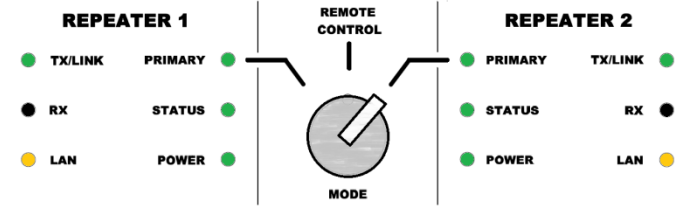
Example 3 – Both Repeaters Primary



In this example, both Repeaters are selected as primary (Both have Primary LED on). Repeater 2 is selected by the local mode control switch. Repeater 1 is selected by the remote master. Repeater 2 has a soft fault (Primary LED Orange) indicating no remotes connected (Status LED Orange). This situation arises if the remote master does not correctly manage the local mode control switch. When two repeaters are set to primary, the remotes will remain connected to their original repeater. Check that the remote master correctly manages the local mode control switch – see “Using Fail-Safe on loss

of Remote Master” above. If communications has been lost to the remote master, then you need to wait until the remote control register has timed out – see “Using Fail-Safe on loss of Remote Master” above.

Example 4 – Both Repeaters Primary



This example is similar to example 3 above, except in this case both repeaters have *some* connected remotes. This can happen if remote sites are re-started while both repeaters are set to primary. The remotes will arbitrarily select one of the primary repeaters when they restart. Make the same checks as in Example 3 above.

Maintenance

Firmware Update

The firmware update procedure is described in the 415U-E User Manual. When performing a firmware update, note the following.

- You need to update the firmware in both repeaters separately. You can do this both at once if you have two flash drives, or you can do it one-at a time.
- The firmware update progress is displayed on the POWER Led on the front panel, which flashes Orange, red, and green.
- The USB-A port is the “Service” port on the back of the module.



Fuse

The 415U-E-BSR incorporates a separate fuse for each repeater. The type for this fuse is 3AG 5AT (5 Amp Slow blow).

Dust Filters

The 415U-E-BSR incorporates two high-capacity fans to provide active cooling to the repeaters’ heat sinks when operating at high duty cycle. The fans incorporate dust filters to minimize the dust that enters the cabinet. You can remove the dust filters by undoing the four cap nuts retaining each filter on the front panel.

You should remove and clean the dust filters on a 3-month schedule. If your 415U-E-BSR is installed in a dusty environment, you should increase your cleaning schedule to monthly.

Appendix A – Specifications

SPECIFICATION	DESCRIPTION																																
Transmitter and Receiver																																	
Frequency	340–400 MHz 400–480 MHz																																
Transmit power—peak	10 mW–10 W (+40 dBm) configurable																																
Transmit power	QPSK 4 W (+36 dBm) 16-QAM, 64 QAM 2.5 W (+34 dBm) 2-FSK, 4-FSK 10 W (+40 dBm)																																
Modulation	QPSK, 16-QAM, 64-QAM 2-FSK or 4-FSK (compatibility mode)																																
Receiver Sensitivity	QPSK-FEC –116 dBm QPSK –113 dBm 16-QAM –104 dBm 64-QAM –97 dBm 2-FSK –110 dBm 4-FSK –102 dBm																																
BER	1 x 10 ⁻⁵																																
Channel spacing	6.25, 12.5, 25.0 kHz (software configurable)																																
Data rate raw No compression	<table border="1"> <thead> <tr> <th>Encoding</th> <th colspan="3">Channel</th> </tr> <tr> <th></th> <th>6.25 kHz</th> <th>12.5 kHz</th> <th>25.0 kHz</th> </tr> </thead> <tbody> <tr> <td>QPSK-FEC</td> <td>4 kbps</td> <td>8 kbps</td> <td>16 kbps</td> </tr> <tr> <td>QPSK</td> <td>8 kbps</td> <td>16 kbps</td> <td>32 kbps</td> </tr> <tr> <td>16-QAM</td> <td>16 kbps</td> <td>32 kbps</td> <td>64 kbps</td> </tr> <tr> <td>64-QAM</td> <td>24 kbps</td> <td>48 kbps</td> <td>96 kbps</td> </tr> <tr> <td>2-FSK</td> <td>4.8 kbps</td> <td>9.6 kbps</td> <td></td> </tr> <tr> <td>4-FSK</td> <td>9.6 kbps</td> <td>19.2 kbps</td> <td></td> </tr> </tbody> </table>	Encoding	Channel				6.25 kHz	12.5 kHz	25.0 kHz	QPSK-FEC	4 kbps	8 kbps	16 kbps	QPSK	8 kbps	16 kbps	32 kbps	16-QAM	16 kbps	32 kbps	64 kbps	64-QAM	24 kbps	48 kbps	96 kbps	2-FSK	4.8 kbps	9.6 kbps		4-FSK	9.6 kbps	19.2 kbps	
Encoding	Channel																																
	6.25 kHz	12.5 kHz	25.0 kHz																														
QPSK-FEC	4 kbps	8 kbps	16 kbps																														
QPSK	8 kbps	16 kbps	32 kbps																														
16-QAM	16 kbps	32 kbps	64 kbps																														
64-QAM	24 kbps	48 kbps	96 kbps																														
2-FSK	4.8 kbps	9.6 kbps																															
4-FSK	9.6 kbps	19.2 kbps																															
Typical data throughput	64-QAM 45 kbps 80 kbps 140 kbps																																
Typical Range (LoS)	62 miles (100 km) at 4 W 10 miles (16 km) at 0.5 W																																
Antenna Connector	Half Duplex - 2 x N-Type Female Full Duplex - 4 x N-Type Female																																
Environmental																																	
Ambient Temperature	-30°C to +60°C																																
Elevation	500m BSL to 2000m ASL																																
Humidity	0% to 90% Non-Condensing																																
Protocols and Configuration																																	
System address	ESSID; 1 to 31-character text string																																
Protocols supported	TCP/IP, UDP, ARP, Radius/802.1x, DHCP, DNS, PPP, ICMP, HTTP, FTP, TFTP, TELNET, Modbus RTU and Modbus TCP																																
Network parameters	Base station, Repeater, Remote for large fixed and roaming station networks, redundant radio paths, automatic selection of radio paths, prioritization of traffic flows, bandwidth efficiency features, bandwidth utilization, routing, bridging, VLAN																																
User configuration	Network access: Ethernet																																

	Remote access: Over the air
Security	WPA-PSK, WPA-Enterprise, password protected. AES 256 Bit
Address filtering	IP address, whitelist/blacklist MAC address, whitelist/blacklist ARP filtering, whitelist/blacklist

Indications & Diagnostics	
LED Indication	Radio 1 - Power/OK, RX, TX/Link, Status, LAN Radio 2 - Power/OK, RX, TX/Link, Status, LAN
Reported diagnostics	
Network management	Optional Network Management system Modbus TCP Status registers
Radio Diagnostics	Link indication, RSSI, Utilization, Channel Survey, Radio Statistics
I/O & Alarms	Alarms accessible via Modbus registers Additional IO expansion available as option
Connections	
LAN	2 x 10/100 BaseT auto-MDIX RJ45,
USB	2 x USB-B RNDIS Maintenance port 2 x USB-A for Firmware update
Operation	
Modes	Redundant Base station, Repeater or Remote
	Selectable AUTO/Primary/Secondary
Compliance	
EMC	FCC CFR47 Part 15; EN 301 489-3; EN 301 489-5
RF (radio)	FCC CFR47 Part 90; IC RSS 119; EN 300 113; EN 300 220; AS/NZS4295
Safety	EN/IEC 60950-1
Power Supply	
Nominal supply	12 – 24Vdc, under/over voltage protection
	12Vdc 24Vdc
Average current draw	880mA 550mA
Transmit current draw	2.3A 1.7A
Supply protection	Over voltage & current protection
Optional	Redundant AC supplies
General	
Housing	Powder coated high grade steel, Aluminum front and rear panels.
Terminal blocks	Removable, max. conductor 13 AWG (2.5 mm ²)
Mounting options	19" Rack mountable (wall mount cabinet options available)
Enclosure size	19" 2U enclosure 90x490x300 (HxWxD mm) 19" 4U enclosure 180x490x300 (HxWxD mm)
Weight	5.5kg (Product Only) 7.0kg (Packaged)

Appendix B – GNU General Public License

Version 2, June 1991

Copyright (C) 1989, 1991 Free Software Foundation, Inc.

51 Franklin Street, Fifth Floor, Boston, MA 02110-1301, USA

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Preamble

The licenses for most software are designed to take away your freedom to share and change it. By contrast, the GNU General Public License is intended to guarantee your freedom to share and change free software--to make sure the software is free for all its users. This General Public License applies to most of the Free Software Foundation's software and to any other program whose authors commit to using it. (Some other Free Software Foundation software is covered by the GNU Lesser General Public License instead.) You can apply it to your programs, too.

When we speak of free software, we are referring to freedom, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for this service if you wish), that you receive source code or can get it if you want it, that you can change the software or use pieces of it in new free programs; and that you know you can do these things.

To protect your rights, we need to make restrictions that forbid anyone to deny you these rights or to ask you to surrender the rights. These restrictions translate to certain responsibilities for you if you distribute copies of the software, or if you modify it.

For example, if you distribute copies of such a program, whether gratis or for a fee, you must give the recipients all the rights that you have. You must make sure that they, too, receive or can get the source code. And you must show them these terms so they know their rights.

We protect your rights with two steps: (1) copyright the software, and (2) offer you this license which gives you legal permission to copy, distribute and/or modify the software.

Also, for each author's protection and ours, we want to make certain that everyone understands that there is no warranty for this free software. If the software is modified by someone else and passed on, we want its recipients to know that what they have is not the original, so that any problems introduced by others will not reflect on the original authors' reputations.

Finally, any free program is threatened constantly by software patents. We wish to avoid the danger that redistributors of a free program will individually obtain patent licenses, in effect making the program proprietary. To prevent this, we have made it clear that any patent must be licensed for everyone's free use or not licensed at all.

The precise terms and conditions for copying, distribution and modification follow.

TERMS AND CONDITIONS FOR COPYING, DISTRIBUTION AND MODIFICATION

0. This License applies to any program or other work which contains a notice placed by the copyright holder saying it may be distributed under the terms of this General Public License. The "Program", below, refers to any such program or work, and a "work based on the Program" means either the Program or any derivative work under copyright law: that is to say, a work containing the Program or a portion of it, either verbatim or with modifications and/or translated into another language. (Hereinafter, translation is included without limitation in the term "modification".) Each licensee is addressed as "you".

Activities other than copying, distribution and modification are not covered by this License; they are outside its scope. The act of running the Program is not restricted, and the output from the Program is covered only if its contents constitute a work based on the Program (independent of having been made by running the Program). Whether that is true depends on what the Program does.

1. You may copy and distribute verbatim copies of the Program's source code as you receive it, in any medium, provided that you conspicuously and appropriately publish on each copy an appropriate copyright notice and disclaimer of warranty; keep intact all the notices that refer to this License and to the absence of any warranty; and give any other recipients of the Program a copy of this License along with the Program.

You may charge a fee for the physical act of transferring a copy, and you may at your option offer warranty protection in exchange for a fee.

2. You may modify your copy or copies of the Program or any portion of it, thus forming a work based on the Program, and copy and distribute such modifications or work under the terms of Section 1 above, provided that you also meet all of these conditions:

a) You must cause the modified files to carry prominent notices stating that you changed the files and the date of any change.

b) You must cause any work that you distribute or publish, that in whole or in part contains or is derived from the Program or any part thereof, to be licensed as a whole at no charge to all third parties under the terms of this License.

c) If the modified program normally reads commands interactively when run, you must cause it, when started running for such interactive use in the most ordinary way, to print or display an announcement including an appropriate copyright notice and a notice that there is no warranty (or else, saying that you provide a warranty) and that users may redistribute the program under these conditions, and telling the user how to view a copy of this License. (Exception: if the Program itself is interactive but does not normally print such an announcement, your work based on the Program is not required to print an announcement.)

These requirements apply to the modified work as a whole. If identifiable sections of that work are not derived from the Program, and can be reasonably considered independent and separate works in themselves, then this License, and its terms, do not apply to those sections when you distribute them as separate works. But when you distribute the same sections as part of a whole which is a work based on the Program, the distribution of the whole must be on the terms of this License, whose permissions for other licensees extend to the entire whole, and thus to each and every part regardless of who wrote it.

Thus, it is not the intent of this section to claim rights or contest your rights to work written entirely by you; rather, the intent is to exercise the right to control the distribution of derivative or collective works based on the Program.

In addition, mere aggregation of another work not based on the Program with the Program (or with a work based on the Program) on a volume of a storage or distribution medium does not bring the other work under the scope of this License.

3. You may copy and distribute the Program (or a work based on it, under Section 2) in object code or executable form under the terms of Sections 1 and 2 above provided that you also do one of the following:

- a) Accompany it with the complete corresponding machine-readable source code, which must be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange; or,
- b) Accompany it with a written offer, valid for at least three years, to give any third party, for a charge no more than your cost of physically performing source distribution, a complete machine-readable copy of the corresponding source code, to be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange; or,
- c) Accompany it with the information you received as to the offer to distribute corresponding source code. (This alternative is allowed only for noncommercial distribution and only if you received the program in object code or executable form with such an offer, in accord with Subsection b above.)

The source code for a work means the preferred form of the work for making modifications to it. For an executable work, complete source code means all the source code for all modules it contains, plus any associated interface definition files, plus the scripts used to control compilation and installation of the executable. However, as a special exception, the source code distributed need not include anything that is normally distributed (in either source or binary form) with the major components (compiler, kernel, and so on) of the operating system on which the executable runs, unless that component itself accompanies the executable.

If distribution of executable or object code is made by offering access to copy from a designated place, then offering equivalent access to copy the source code from the same place counts as distribution of the source code, even though third parties are not compelled to copy the source along with the object code.

4. You may not copy, modify, sublicense, or distribute the Program except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense or distribute the Program is void, and will automatically terminate your rights under this License. However, parties who have received copies, or rights, from you under this License will not have their licenses terminated so long as such parties remain in full compliance.
5. You are not required to accept this License, since you have not signed it. However, nothing else grants you permission to modify or distribute the Program or its derivative works. These actions are prohibited by law if you do not accept this License. Therefore, by modifying or distributing the Program (or any work based on the Program), you indicate your acceptance of this License to do so, and all its terms and conditions for copying, distributing or modifying the Program or works based on it.
6. Each time you redistribute the Program (or any work based on the Program), the recipient automatically receives a license from the original licensor to copy, distribute or modify the Program subject to these terms and conditions. You may not impose any further restrictions on the recipients' exercise of the rights granted herein. You are not responsible for enforcing compliance by third parties to this License.
7. If, as a consequence of a court judgment or allegation of patent infringement or for any other reason (not limited to patent issues), conditions are imposed on you (whether by court order, agreement or otherwise) that contradict the conditions of this License, they do not excuse you from the conditions of this License. If you cannot distribute so as to satisfy simultaneously your obligations under this License and any other pertinent obligations, then as a consequence you may not distribute the Program at all. For example, if a patent license would not permit royalty-free redistribution of the Program by all those who receive copies directly or indirectly through you, then the only way you could satisfy both it and this License would be to refrain entirely from distribution of the Program.

If any portion of this section is held invalid or unenforceable under any particular circumstance, the balance of the section is intended to apply and the section as a whole is intended to apply in other circumstances.

It is not the purpose of this section to induce you to infringe any patents or other property right claims or to contest validity of any such claims; this section has the sole purpose of protecting the integrity of the free software distribution system, which is implemented by public license practices. Many people have made generous contributions to the wide range of software distributed through that system in reliance on consistent application of that system; it is up to the author/donor to decide if he or she is willing to distribute software through any other system and a licensee cannot impose that choice.

This section is intended to make thoroughly clear what is believed to be a consequence of the rest of this License.

8. If the distribution and/or use of the Program is restricted in certain countries either by patents or by copyrighted interfaces, the original copyright holder who places the Program under this License may add an explicit geographical distribution limitation excluding those countries, so that distribution is permitted only in or among countries not thus excluded. In such case, this License incorporates the limitation as if written in the body of this License.
9. The Free Software Foundation may publish revised and/or new versions of the General Public License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns.
Each version is given a distinguishing version number. If the Program specifies a version number of this License which applies to it and "any later version", you have the option of following the terms and conditions either of that version or of any later version published by the Free Software Foundation. If the Program does not specify a version number of this License, you may choose any version ever published by the Free Software Foundation.
10. If you wish to incorporate parts of the Program into other free programs whose distribution conditions are different, write to the author to ask for permission. For software which is copyrighted by the Free Software Foundation, write to the Free Software Foundation; we sometimes make exceptions for this. Our decision will be guided by the two goals of preserving the free status of all derivatives of our free software and of promoting the sharing and reuse of software generally.

NO WARRANTY

11. BECAUSE THE PROGRAM IS LICENSED FREE OF CHARGE, THERE IS NO WARRANTY FOR THE PROGRAM, TO THE EXTENT PERMITTED BY APPLICABLE LAW. EXCEPT WHEN OTHERWISE STATED IN WRITING THE COPYRIGHT HOLDERS AND/OR OTHER PARTIES PROVIDE THE PROGRAM "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THE PROGRAM IS WITH YOU. SHOULD THE PROGRAM PROVE DEFECTIVE, YOU ASSUME THE COST OF ALL NECESSARY SERVICING, REPAIR OR CORRECTION.

12. IN NO EVENT UNLESS REQUIRED BY APPLICABLE LAW OR AGREED TO IN WRITING WILL ANY COPYRIGHT HOLDER, OR ANY OTHER PARTY WHO MAY MODIFY AND/OR REDISTRIBUTE THE PROGRAM AS PERMITTED ABOVE, BE LIABLE TO YOU FOR DAMAGES, INCLUDING ANY GENERAL, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE PROGRAM (INCLUDING BUT NOT LIMITED TO LOSS OF DATA OR DATA BEING RENDERED INACCURATE OR LOSSES SUSTAINED BY YOU OR THIRD PARTIES OR A FAILURE OF THE PROGRAM TO OPERATE WITH ANY OTHER PROGRAMS), EVEN IF SUCH HOLDER OR OTHER PARTY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.