Radio Unit Installation & Operation Guide

2012

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MiMOMax Wireless Ltd

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1   INTRODUCTION

This manual is intended for use by experienced technicians familiar with installation and operation of radio frequency linking equipment. It includes a description of the equipment, general recommendations for site engineering, and instructions for installing and configuring the MiMOMax radio.

2   OVERVIEW OF THE MIMOMAX RADIO UNIT

The MiMOMax radio products are a family of software flexible, ultra spectrally efficient, very low latency digital radio links designed for mission critical fixed long haul data linking and power protection applications. The product family includes the Network Digital Link (NDL), Optimised Protection Variant (OPV) and Multipoint Digital Link (MDL).

The radios utilise licensed narrow band radio channels and MIMO technology to provide industry leading spectral efficiencies of up to 12.8 bits/Hz/s or greater, enabling raw data rates of up to 320kb/s including link overhead (160kb/s in the OPV version) in 25kHz licensed channels.

Utilising licensed spectrum ensures that the link operates in an interference-free environment and is capable, under the right conditions, of providing a reliable low-error data transport service ($<1 \times 10^{-7}$ bit error rate).

For data linking applications the radio provides a number of industry standard data interfaces at link end points.

2.1   MIMO DIGITAL LINK GENERAL SPECIFICATIONS

Supply Voltage *	10.5V to 32V DC
Maximum Power Consumption	92W Max at 13.8V
	72W typ
Ambient Temperature Range	-25ºC to +60ºC
Mounting	2U high rack mount
	Also available as wall mount or pole mount unit
Dimensions (W x L x D)	262 x 393 x 86.5mm, Base Radio Unit
Weight	6.8kg (pole mount excluding mounting bracket)
Gross Data Rate	Up to 320kbps

* The equipment must be powered from a power supply complying with the requirements of IEC 60950-1 including compliance with sub clause 7.4 "Insulation between primary circuits and cable distribution systems".

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2.2 MECHANICAL DIMENSIONS

2.2.1 Base Radio Unit
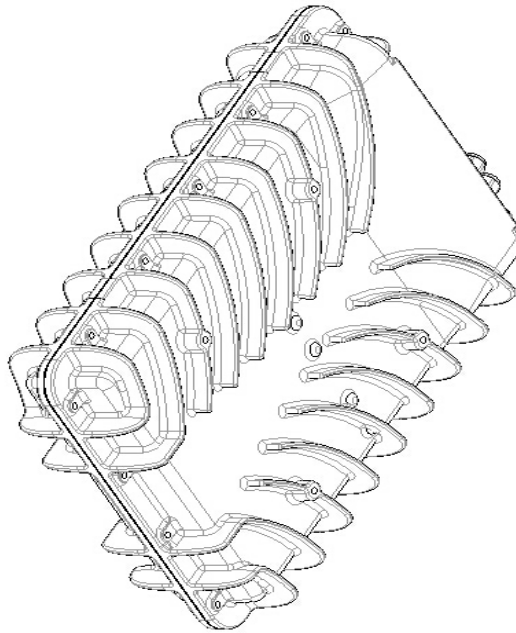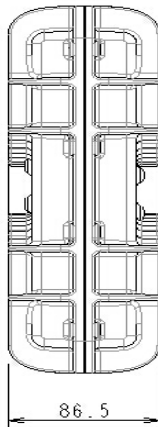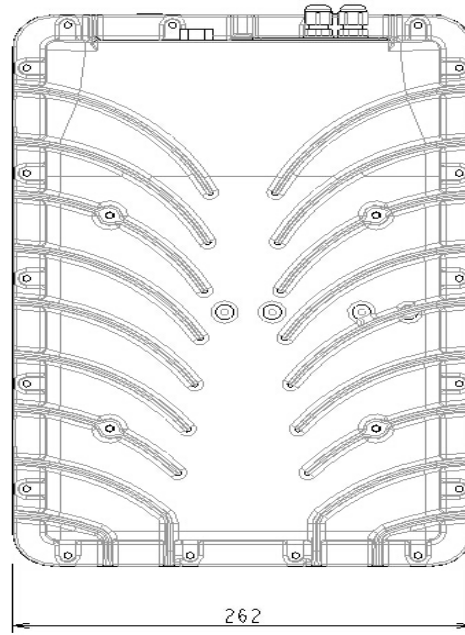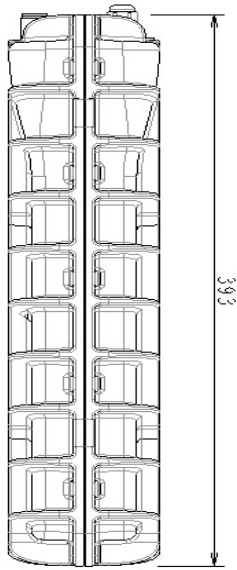
2.2.2 Rack Mount Option

2.2.3 Pole Mount Option

2.2.4 Wall Mount Option

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3   ON-SITE INSTALLATION

3.1   SITE ENGINEERING AND RECOMMENDATIONS

Prior to commissioning any fixed radio link of this nature, a full evaluation of the site and link path characteristics **must** be carried out to ensure reliable operation of the radio link under all environmental conditions. Important factors to consider and allow for include the following:

➢ Expected path loss and link budget;

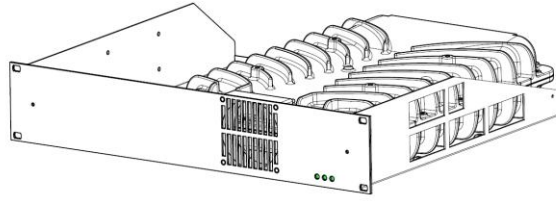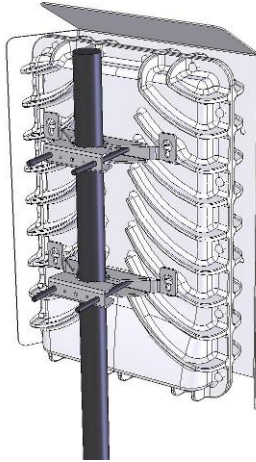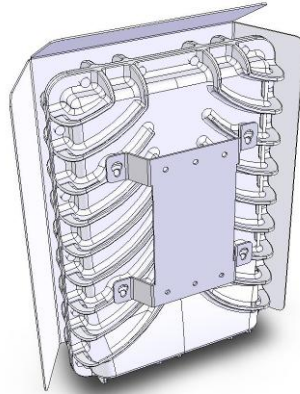➢ Multipath propagation and fading effects, including those caused by moving objects such as vehicles and aircraft in or near the link path;

➢ Obstructions (high ground, trees, buildings and structures etc.) in or near the link path (note that weather conditions can significantly affect losses caused by trees and other foliage);

➢ Potential interference from nearby radio frequency sources (these include both narrowband sources such as other radio transmitters, and wideband sources such as noise generated by other electrical equipment in the vicinity);

➢ Potential interference to other nearby radio receiving equipment as a result of normal transmitted emissions from the radio link being commissioned.

A comprehensive source of information and guidance on general site engineering issues has been published by ETSI: EG 200 053 v1.5.1, 2004/06 "Electromagnetic compatibility and Radio spectrum Matters (ERM); Radio site engineering for radio equipment and systems". It is highly recommended that this freely available ETSI document be studied in detail, in conjunction with this manual.

3.2   INSTALLING RADIO MOUNTS

3.2.1 Radio Wall Mount Kit

Included in kit:

1 x Wall mount bracket

1 x Sun shield

2 x Sun shield brackets

12 x M6x12 bolts

4 x Wall dog anchors

Tools Required:

1 x 10mm ring spanner

1 x 3mm square drive driver

1 x 5mm drill, if mounting to masonry

(A 5.5mm drill may be required for very hard masonry)

Note about radio orientation:

The radio may be mounted either indoors or outdoors (with appropriate data port seal and cable sealing glands). If mounting outdoors it is recommended to locate the radio out of direct sunlight as much as possible and to use the provided sun shield to reduce the solar gain. If the radio unit must be mounted in the sun, mount it such that the N-type connectors are closest to the wall, this is the hotter side of the unit and it will benefit from the shading.

Instructions:

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1) Fix the wall mount bracket to the wall in the desired position using the wall dog anchors (square drive), mount the bracket so the slotted mounting holes have the slots facing down (see picture below). If fixing to masonry pre drill a 5mm hole for each anchor (a 5.5mm hole may be required for very hard masonry). Do not fix to plasterboard, sheet metal or other thin material that cannot support the weight of the radio unit - if attaching through such material ensure the screws grab into the supporting studwork or a structural member.

2) Screw 4x bolts into the rear side of the radio unit, do not tighten, and leave about 3-4mm of gap between the radio unit and the bolt head.

3) Attach the radio unit to the wall mount bracket by inserting the exposed bolt heads through the holes in the bracket and slide down so it locks in position. Ensure the connectors are facing downward

4) Tighten the 4 bolts on the rear of the unit with a ring spanner.

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5) If sun shield is required then bolt the two sun shield brackets to the radio unit using four M6x12 bolts. Bolt the sun shield to the brackets using another four M6x12 bolts. Ensure the sun shield is correctly orientated so that it does not cover the radio unit connectors.

3.3   UNIT POWER CONSIDERATIONS

3.3.1 Essential Power Requirements

Voltage Range

The Radio Unit (RU) operates with a DC supply in the range of 10.5 to 32V. This means that the voltage must not rise above 32V under idle conditions or fall below 10.5V at full load.

Static Power Input

The typical power drawn is about 72W (maximum 100W) when the two transmitter channels are operating at full power. The power drawn via the internal switching regulators is nearly independent of supply voltage, except for some additional converter loss at the bottom end of the voltage range, so that the input current to the RU is almost inversely proportional to supply voltage, e.g. 6A at 12V or 3A at 24V. This is a consideration when the power source is remote from the RU and cable loss is a factor.

Starting Current

At start-up, the supply is required to charge high-capacitance filters in the regulator system and if the source is a regulated power supply, one should be selected with a constant-current limiting characteristic. Commonly available regulated power supplies that have fold-back type current limiting are unsuitable as they go into a latch-up state that does not recover. Where non-interruptible power is required a float-charged battery may be used. Once the input voltage has risen to where the switching regulators of the RU begin to operate, longer-period current limiting is provided by the switching regulators themselves.

Supply Polarity and Grounding

The negative connection of the power supply is internally bonded to the case of the RU, which must be grounded through an external earth strap, e.g. to the local rack frame. The latter should be part of a well-designed station grounding system. This internal grounding is designed for EMC and transient protection currents. In order to avoid continuous internal direct currents, which could be damaging, the external supply circuit should either be isolated from ground or grounded at the same point as the RU (

Figure 1 - Earth Strap (Green Cable) Location on RU Casting). The RU casting is tapped to take an M6 x 10mm screw.

Figure 1 - Earth Strap (Green Cable) Location on RU Casting

The standard DC power cable supplied with an RU is twin 1.5mm (16AWG), approximately 2m long, terminated at the RU end with a sealed Positronic Frontrunner connector. This cable is wired to pins 1 (positive) and 3 of the plug, which employs crimp-terminal socket contacts. Pin 2 is unconnected in the plug, although in the RU receptacle it is internally grounded to the case, as in Figure 2 below.
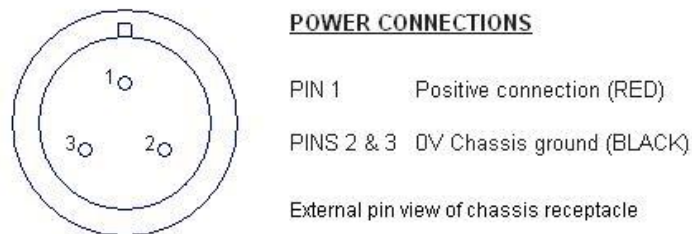

POWER CONNECTIONS

PIN 1   Positive connection (RED)

PINS 2 & 3   0V Chassis ground (BLACK)

External pin view of chassis receptacle

Figure 2 - Power Cable Connection Diagram

Supply Noise

Notwithstanding the EMC provisions in the equipment, power wiring from the DC source should not be shared with other equipment that may introduce excessive noise. Nor should the power cables to the RU be run alongside cables that connect to other equipment that may produce high current noise or transients, e.g. power relays.

Extending the DC Voltage Range

The current MiMOMax RUs are designed for nominal 12-24V supplies with negative ground only. When it is required to operate the RU from a system with positive ground or from, for example, a 48V system with either a positive or a negative ground, it is necessary to use an external DC-DC converter that also provides isolation. One such unit that has been employed is the ETA-USA VTE24SC48, sold in Australasia as the PowerBox PBIH-4824R. It has a DC

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input range of 38 to 63V and an output rating of 24V at 7A (nominally 150W) and also has the current limiting profile described above, that is needed to meet starting current requirements. Its specified isolation is 1500V ac at the input and 500V ac between output and frame.

Operating from AC Mains

AC-DC "desktop" power supplies are generally available with the required power rating but not all of these have output isolation from supply ground. Whether this is necessary or not depends on local supply noise and ground considerations. As this type of supply is typically intended for the consumer entertainment market, some countries now require the unit to meet minimum efficiency standards. Units that have been found to meet the requirements, which include the output current limiting characteristics described above, are the Switchbox Model PUP150-14 (non-isolated) and Model PMP150-14 (isolated), The latter is specified as a medical grade device. Both units provide 24V DC output at up to 150W and are sold in Australasia under the PowerBox brand.

Power for Accessory Units

The current range of MiMOMax accessory units, such as network interface or multiplexer units, may typically be mounted either remotely or close to the RU, e.g. in the rack tray alongside the radio. They are relatively low power and designed to be operated from any supply voltage in the range of 10 to 64V DC. Their supply connections are fully isolated (to 1500V rms), so that they may be operated from the same supply as the RU or a different one, without any concern for potential differences between the supplies (but there is still a need to consider grounding in relation to signal connections). Noise considerations still apply, as stated above.

System Mounting Configurations

Three typical mounting configurations are shown in Figure 3- Typical Pole and Rack Mounting Options for the Radio Unit. Of these, (a) has the lowest RF losses and the highest efficiency of power supply to the RU. However, pole mounting of the battery equipment may be considered a disadvantage from a mechanical or installation viewpoint. In (b), the RF losses are still low but the DC power losses are highest, whilst in (c) the DC losses are minimised at the expense of RF performance.
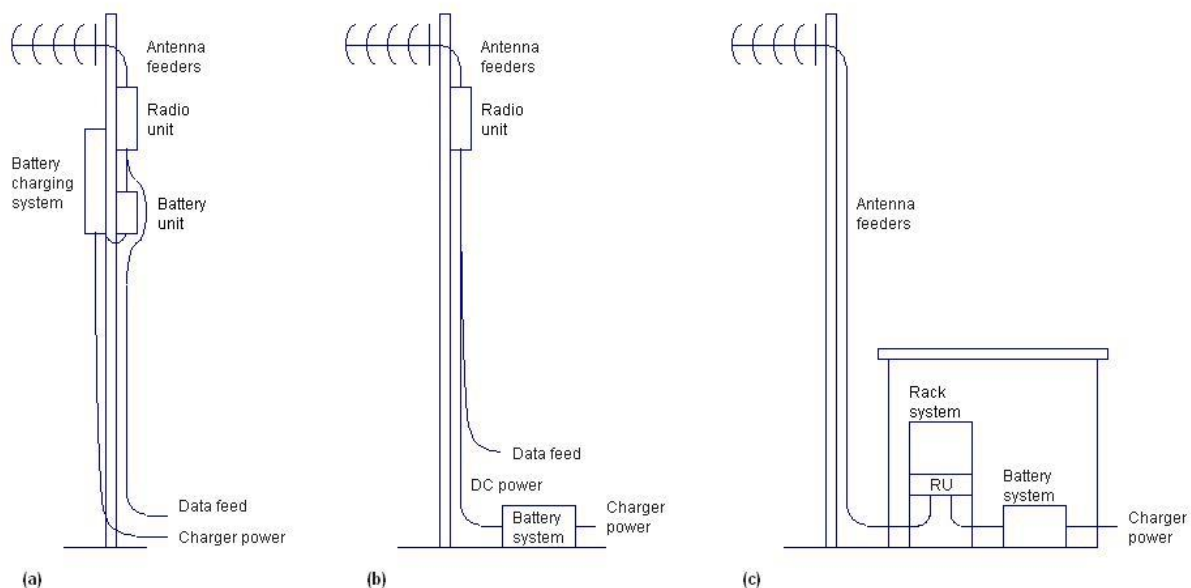

Figure 3- Typical Pole and Rack Mounting Options for the Radio Unit

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Choice of Power Cable Size

For longer distances to the power source, as would be encountered in the system mounting arrangement of Figure 3- Typical Pole and Rack Mounting Options for the Radio Unit (b), the power cable should be of a suitable gauge to not only provide a voltage at the RU within the required limits, as stated above, but achieve efficient and stable power transfer as detailed below.

In normal operation, the RU is essentially a constant-power device as seen at the DC input. For a given supply voltage, cable resistance and power consumption, the DC terminal voltage V_T at the RU is given by a quadratic equation, the solution of which is:

$$V_T = \tfrac{1}{2}(V_B \pm \sqrt{(V_B^2 - 4.P.R_L)}) \quad \text{where } V_B \text{ is source voltage, P is radio power and } R_L \text{ is line resistance.}$$

This shows that (a) R_L must be less than $V_B^2 /4.P$ and (b) that V_T could have either of two values. However, in practice, the higher current value will be precluded by the internal current limit of the radio. One should choose a cable resistance value that is significantly less than the limiting value of R_L that is calculated for the worst-case power requirement of the RU, which is approximately 100W.

The following example is for a nominal 24V battery supply and a power cable length of 100m, which is the maximum recommended length for power and signal cables to the RU. Allowing for a battery voltage to discharge to, say, 20V in the event of a mains failure, the limiting value of R_L for 100W RU power is 1.0Ω.

From wire tables, a 100m loop of 11AWG wire has a resistance of 0.8264Ω and 10AWG a resistance of 0.6554Ω, without taking heating into account. Using the latter figure in the above equation gives a value for the RU input voltage V_T of 15.9V. At the RU input, the current is 6.3A and the cable loss is 26W, giving a power efficiency of the cable feed of 79%.

The above is an extreme case and with a normally charged battery the current will be far lower and the cable feed efficiency correspondingly higher. Also, the typical power consumption of the radio is much less, at 72W.

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3.3   INSTALLING ANTENNA

3.3.1 Bi-Quad Diversity Directional-Loop Yagi Antenna

Antenna Overview:

The loop Yagi is a directional dual-polarised antenna containing both vertical and horizontal radiating elements in the same structure. The antenna is made of aluminium and fibreglass with stainless steel mounting brackets and bolts. It is weather resistant and designed for use in outdoor situations. Mounting brackets are included to fit poles from 20mm to 50mm in diameter. The antenna is equipped with two 2m coax "tails" and connectors for interfacing to the radio equipment or intermediate coaxial feeders.
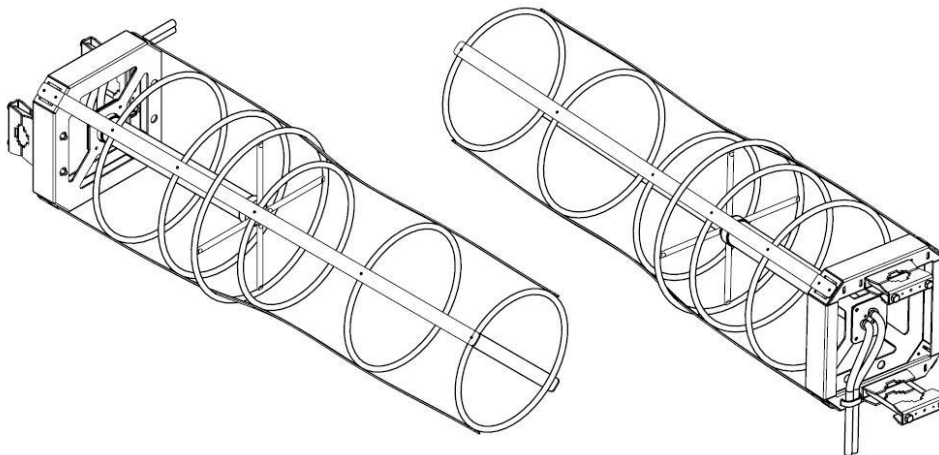
Technical Specifications:

Polarisation	Horizontal and vertical with separate feeds
Antenna Gain	>10dBi (typ 11.5dBi)
Beam Width, -3dB (parallel to polarisation plane)	48° nominal
(perpendicular to polarisation plane)	52° nominal
Front-to-Back Ratio	>15dB
Frequency Bandwidth (>15dB return loss)	>20MHz
Connector Arrangement	2 x male type N connector on 1.5m tails of RG213 coaxial cable*
Mounting (Pole)	Twin vertically spaced clamps for attachment to 25-55 mm mounting pipe
Dimensions W x H x L (Direction of Propagation)	250 x 250 x 850 mm
Weight	2.5 kg, including coax tails and mounting brackets

Note that although the male type connector is the default, female type connectors are able to be ordered should they be required. Please contact MiMOMax Wireless Ltd for more information.

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Package Contents:

1x Loop Yagi Antenna with 2 mounting brackets and 2x 2m coax

2x removable mounting brackets

4x stainless steel mounting bolts

Installation Guidelines:

Mounting location: The antenna is designed to create a directional radiation pattern. To achieve the expected pattern and gain it should be mounted clear of any local obstructions to the front or close to the sides. Generally the higher an antenna is above the ground the better it performs. A minimum of 2m above the roof line and away from all power lines and obstructions is a good general rule.

Minimum Safe Distance from Antenna: To comply with safety requirements for human RF exposure in the USA, Canada and other countries, no person shall be permitted to remain in the vicinity of the antenna of an operational MiMOMax system at distances closer than the following:

Controlled/occupational use: 1.5m.

General public: 3m.

The above distances are based on actual measured field strengths under worst-case conditions, i.e. continuous exposure of a person located directly in front of the antenna in the main radiation lobe, with a system operating at maximum power and 100% duty cycle.

Pole Installation: The antenna is designed to mount on a pole of 25–55mm diameter. The pole must be weatherproof and strong enough to support the antenna during wind gusts. Generally, the antenna and pole should be located as close to the radio equipment as possible - long cable runs increase the signal loss. If the radio equipment is located indoors, extension coax cables will be required for the cable run from the radio equipment to the antenna.

Orientation: The Yagi antenna is directional. To achieve best performance, it must be oriented such that the central axis points directly towards the antenna at the other end of the radio link path.

Direction of Radio Energy

Loop Yagi Antenna
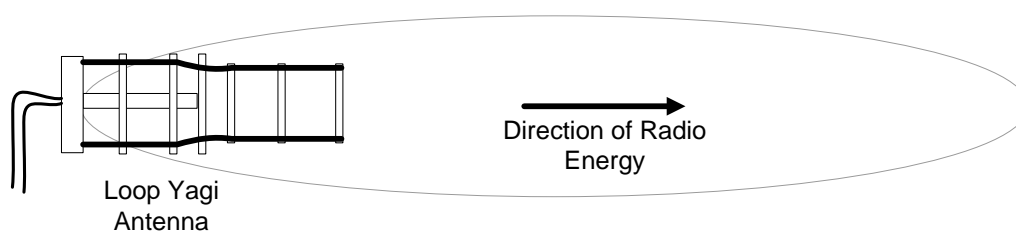
Antenna Installation:

Tools and equipment required

> ➢ 10mm spanner or socket
> ➢ Self-vulcanising rubber tape

Step 1 Remove the 4x mounting bolts and 2x removable brackets from the antenna.

Step 2 Place antenna on pole and reattach mounting brackets and bolts. Note the "this side down" label - this is to ensure the drain holes are located downwards and the coax cables exit at the bottom of the antenna.

Step 3 Move the antenna to the correct height on the pole so that it has line of sight to the antenna at the other end of the link, and with its central axis aligned to the other antenna preferably to within ±5⁰. If the other antenna isn't visible use a map & compass (**note:** be aware that nearby large ferrous objects such as antenna towers can cause erroneous compass readings) or find a landmark in the foreground that is on the signal path and point it towards that. Tighten mounting bolts equally so the mounting bracket clamps evenly.

Step 4 Once the connections to the cable feeds have been made it is highly recommended that they are waterproofed using self-vulcanising rubber tape or similar. Follow the manufacturer's instructions for applying the tape.

Note: **Do not** cut the cable ties holding the coax to the antenna frame - it is required for cable strain relief.

3.4   ENVIRONMENTAL AND SAFETY

3.4.1 Grounding

On site ground networks must be created in accordance with ITU-T recommendation K.27: Protection against Interference; Bonding Configuration and Earthing inside a telecommunications building.

3.5.2 Lightning protection

This aspect is very important to assure the protection of the tower, antennae and the radio equipment hardware.

The following diagram show the technique recommended for tower protection, antennae, feeder and RF hardware protection.

Adequate lightning protection is dependent on the effectiveness of the station earth point.

This diagram shows a recommended feeder earthing and discharge protection scenario. Feeder earthing kits are placed at the antenna adjacent to the feeder connector, where the feeder leaves the base if the tower and where the feeder enters the building structure. This is a 3 point earthing concept. If earthing kits supplies are limited or connection to an earth point is difficult, the order of importance of the earthing locations is as follows.
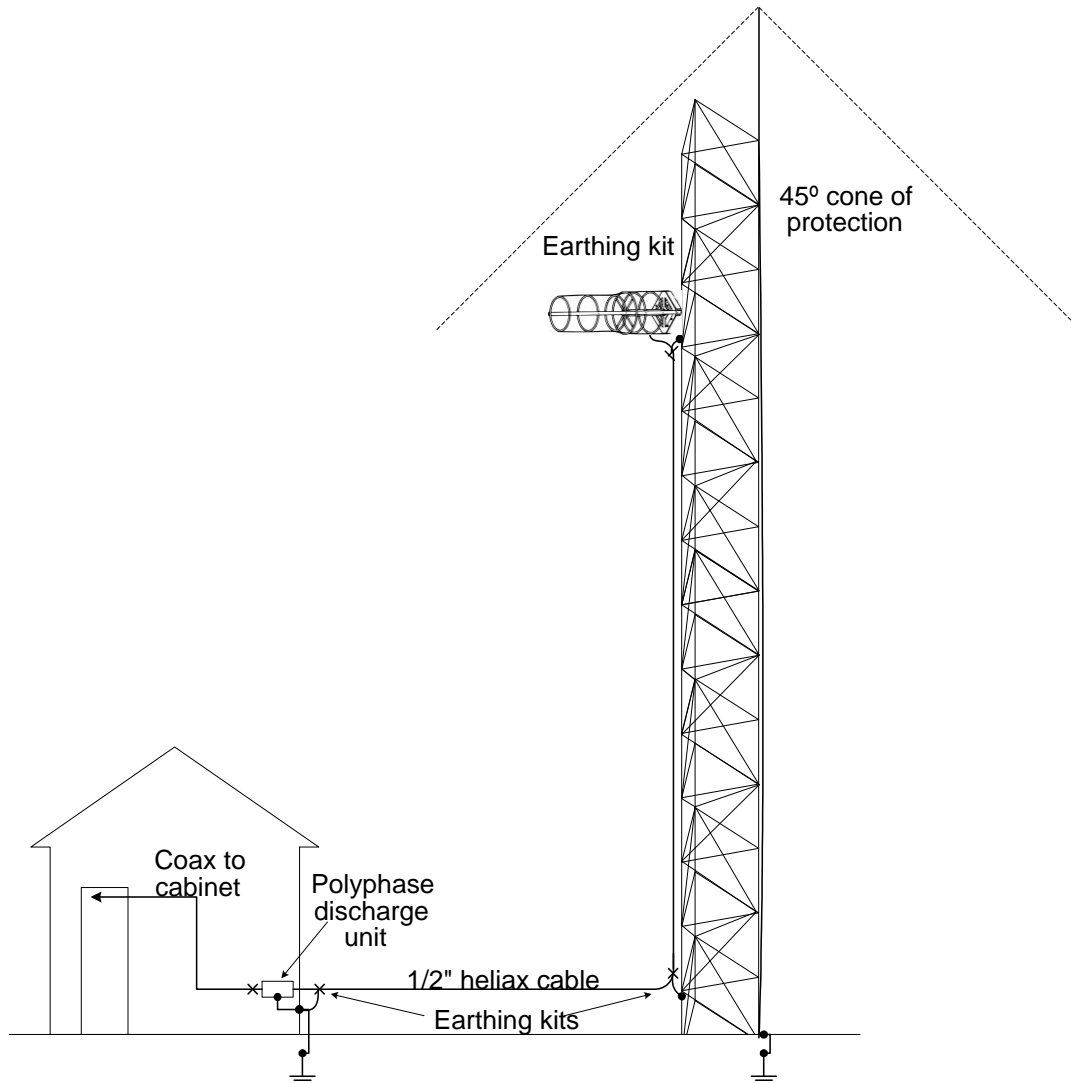
(a) For a top mounted antenna acting for lightning protection:

1. At antenna connection point.
2. At the tower base.
3. At the entry to the building.

(b) For a general mounting of antenna:

1. At the entry to the building.
2. At the tower base.
3. At the antenna connector.

The Polyphaser discharge unit is very important to release high voltage charges developed between the cable inner and outer. There are two types supplied, a transmitting and a receiving variant. The transmitting variant is the larger. It is very important that these functions

do not become confused because the lower discharge potential rating for the receiver unit will be triggered by transmitting voltages. This will cause a high VSWR and poor coverage.

3.5.3 Equipment ventilation

The radio (rack mount option) should be installed preferably in a dry, dust-free room. It is recommended that a thermal study be carried out for each site to check and ensure that thermal conditions within the cabinets do not raise the ambient temperature of the radio above its operating limit. If the temperature of the site can range beyond the operating limits, the site enclosure must have air conditioning or a forced air system installed to stabilise these excursions.

Note: Equipment cooling in the rack mount configuration relies on the front panel cooling fan. It is important to ensure that the panel fan inlet is unobstructed and that the fan is operating correctly.

3.6 CONNECTING UP THE RADIO
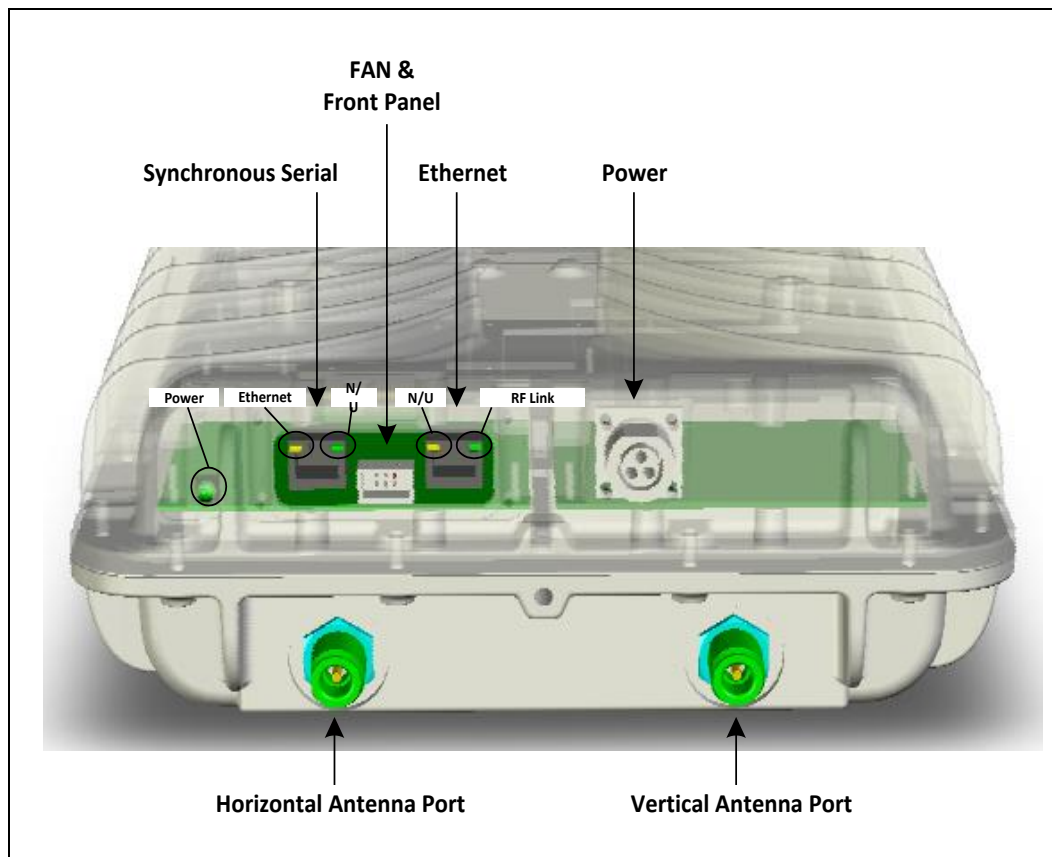
Radio Unit with Synchronous Serial Interface (DIFII) Option - Connector and LED layout

Note: It is important to connect the appropriate antenna feeder to the appropriate port on the radio.

Please refer to the Digital Interface Manual for detailed information on the operation of the Radio Units Ethernet serial and alarm ports. This document is available in the documentation section on the MiMOMax website.

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4   RADIO CONFIGURATION

MiMOMax radios use a built in web configuration package called CCMS. Tasks that can be performed via the CCMS include:

> ➢ Changing Passwords
>
> ➢ Monitoring Radio Performance
>
> ➢ Configuring Radio Link
>
> ➢ Updating RF Modem Parameters
>
> ➢ Changing a Radio's IP Settings
>
> ➢ Synchronous Serial Parameters
>
> ➢ Performing Software Upgrades
>
> ➢ Enabling/ Disabling SFEs
>
> ➢ Configuring SNMP
>
> ➢ Programming Power Levels
>
> ➢ Programming Frequency

4.1   SETUP

MiMOMax radios are often preconfigured with an IP address specified by the customer when the radio is ordered. If no IP address has been assigned, the default is 192.168.0.1/24. Additionally MiMOMax radios will broadcast 3 gratuitous ARPs to advertise the IP address when the radio boots up.

Figure 4 - MiMOMax Logon

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To logon to the radio, press the "log into System" button. MiMOMax radios have two levels of access (user and tech). The default login credentials are:

Username	Default password
user	User
tech	Tech

Figure 5 - Default Login Credentials

See section 4.8 for more information on changing the default passwords.

4.2   SYSTEM INFORMATION AND CONFIGURATION

The System configuration page (Figure 6 - System Configuration Page) is where one can set the system related items. Most of these will have been set in the factory prior to shipping.

Figure 6 - System Configuration Page

To configure a radio, one should set the following items:

1. Give the system a descriptive name that can be used to identify the radio for example, "SS test radio 1" in Figure 6 - System Configuration Page.

2. Set the desired modulation order and whether adaptive modulation (MCAM) is enabled or not. Note that the M-CAM and QAM256 features are software add-ons.

    The adaptive modulation (M-CAM) feature, when enabled, allows the RF modulation logic to step up or down depending on the quality of the received signal. It traverses from QPSK through to the maximum modulation order and visa versa depending on RF channel conditions.

    If this feature is disabled, the RF modulation logic will stay on the set maximum modulation independent of signal quality. M-CAM typically allows for better utilisation of the channel as the modulation order is adapted as channel conditions change. In some circumstances this may not be desirable (e.g. differential line protection, where fixed bandwidth and latency is required).

    QPSK will provide 64kbit/sec, QAM16 128kbit/sec, QAM64 197kbit/sec and QAM256 256kbit/sec user data rates in 25 kHz licensed channels.

3. The link retry timeout is set to 6 for a slave unit or 200 for a master unit. It does not matter which end of a link is slave or master as long as each end is different – this is usually set in the factory.

4. Set the low voltage notification level. An SNMP trap can be sent if the input voltage dips below this value. MiMOMax radios can operate down to 10.5V DC. A value of 11V for a 12V system or 22V for a 24V system may be appropriate. Note that the SNMP features are software add-ons. Refer to Figure 24 - Software Feature Request Page.

5. Set the low signal threshold which can be used to trigger an SNMP trap to be sent.

6. Set the high temperature level which can be used to trigger an SNMP trap to be sent.

7. The "Auto refresh" feature refers to web pages in the CCMS auto refreshing. For example, the monitoring page can refresh every few seconds if enabled. On low bandwidth links or busy networks, this option is best disabled.

8. Press the "Save" button to save the changes. "Cancel" will revert to the original settings. Once the settings are saved, they can be activated by clicking on "Apply changes" on the Control Panel page.

4.3   SYSTEM INFORMATION

The system information page (Figure 7 - System Information) shows various version numbers of software and hardware. The most notable items are the software version and the backup (Inactive partition) software version.

Figure 7 - System Information

4.4   NETWORKING

MiMOMax linking radios can run in two network configurations:

➢ Layer II Ethernet Bridge
➢ Layer III Router

Layer II networking makes for easy network setup, but can be problematic in larger networks where broadcast traffic needs to be isolated.

To setup IP networking, click on "Network" (Figure 8- Network Configuration Page). Firstly setup the desired IP address, subnet mask and default gateway. Be sure to note the IP address down if it is changed. All MiMOMax radios broadcast 3 gratuitous ARPs when booting up to advertise the IP address, this can be used in conjunction with a packet capturing program to find the IP address should it be unknown.

MiMOMax radios have a real-time clock that can be synchronised with a Network Time Protocol (NTP) server. Time is used for logging purposes only. To use an NTP server, enter the NTP server's IP address in the NTP server field.

Next, select if the radio should function as a layer II bridge or layer III router. To enable layer III router mode, disable "Network bridge" (Figure 8- Network Configuration Page). When running in router mode, an IP address for the air interface needs to be specified. The air IP addresses should be on completely different subnet (for example 192.168.x.x). If running in layer III mode, the default gateway address could be the air interface of the remote radio.

MiMOMax radios also have an optional SNMPv3 service that can allow various parameters to be read from the radio. For details of what can be read from your radio, click on "SNMP base MIB" and "SNMP MIB" in the control panel. Note that the SNMP service is an optional "software feature enable" (SFE), to enable this feature Figure 24 - Software Feature Request Page.

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The following traps (notifications) can be sent by the radio if SNMP is enabled.

1.   Low Input Voltage Notification

This notification is sent if the system detects that the input voltage goes below a set threshold.

2.   Low Signal Level Notification

This notification is sent if the system detects that the RSSI (Received Signal Strength Indicator) has gone below a set level.

3.   High Temperature Notification

This notification is sent if the system detects that the temperature on the radio has exceeded a set threshold.

The thresholds for these traps are set on the system configuration page, 21.

The SNMP service can be enabled by selecting "Enabled" from the drop down menu. A username and password also needs to be provided that will be used for authenticating SNMP clients connecting to the radio. The various traps can also be enabled / disabled.

Once the networking options have been entered, click "Save", this will save the options to the radio's internal database. To activate the changes, click on "Apply changes" in the control panel. If the radio's IP address has been changed, you may need to change you computer's IP address to match the radio's new subnet.

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Figure 8- Network Configuration Page

Static routes can be added to the radio should the radio need to communicate with routers other than the default gateway. These can be added on the static routes configuration page (Figure 9 - Static Routing Page). Enter the destination network, netmask and gateway address and then click "Save". To delete a route, check the "Del" checkbox and then click "Save". To activate the route changes, click on "Apply changes" in the control panel.

Figure 9 - Static Routing Page

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4.5 RF SETTINGS

MiMOMax radios feature internal duplexers for full duplex low latency communication on a frequency pair. The duplexers are factory tuned for a specific frequency range, requiring the transmit and receive frequencies to also be factory set. These frequencies can be viewed on the RF TX and RF page. This page also allows for internal 20dB receive attenuators to be enabled should they be needed due to very high receive levels or for interference trouble shooting.

The transmitter power can be configured to suit users' needs. Users can specify the required power in the item "User Transmitter Power". Users can use either dBm or mW by selecting the dBm or the the mW of the transmitter power unit.

As with all options, to save changes press the "Save" button and then to activate the changes, click "Apply changes" in the control panel.

Figure 10 – Transmitter and Receiver Configuration Page

4.6   SERIAL INTERFACES

OPV (Optimised Protection Variant) versions of the NDL (Network Digital Link) family of products contain a synchronous serial port that supports the following standards:

- ➢ RS422
- ➢ X.21
- ➢ V.35
- ➢ G.703

The desired serial standard is usually specified when the radio is ordered and set in the hardware and software in the factory

Should any changes need to be made to the synchronous serial setting, click on "Serial Interface".

It is advised to consult the MiMOMax application notes for details on interfacing various synchronous serial products to the OPV radios.

4.7   TERMINAL SERVER CONFIGURATION

Radio units equipped with a DIF3 (Digital Interface version 3) module have two RS232 ports which can be communicated with over IP via the radio unit's built in terminal server. The terminal server communicates over TCP/IP in "raw" mode.   Free PC software such as "PuTTy" can be used to communicate with the terminal server. SCADA software can also be configured to communicate with serial RTUs via the terminal server.   PC software that is designed to communicate with a serial device (e.g. a Recloser) can be configured to use a virtual serial port via a "com port redirector", such as Eltima Software's "Serial to Ethernet Connector". This allows remote configuration / debug over the IP network.

Each RS232 port has its own terminal server.   By default these servers run on TCP ports 10001 and 10002.   The two terminal servers must run on different TCP ports and are not allowed to use ports reserved for other services that run on the radio units, e.g. ports 80, 443, 23, 22. The CCMS will produce an error if an incorrect port is specified. The terminal server and serial port setting can be seen in Figure 11 - Terminal Server Configuration.

In addition to enabling and disabling the terminal server and setting the TCP port number, the *gap time* can be set. The *gap time* is a delay in the terminal server reading the serial port buffer from when data is first available. This has the effect of holding off until more than 1 byte of serial data is available and makes for better utilisation of network resource.

The serial port settings include:

- ➢ BAUD rate
- ➢ Data bits
- ➢ Parity bits
- ➢ Stop bits

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Typical settings are 9600, 8 data bits, no parity bits, 1 stop bit (9600 8N1).

Figure 11 - Terminal Server Configuration

4.8 CHANGING PASSWORDS

Passwords are used to secure access for the "user" and "tech" logins. In addition to "tech" being able to change the "tech" password, "tech" may also change the "user" password.

To change a password, click on "Change Passwords" under "System" and then do the following (Figure 12- Password Page):

1. Type the intended password into the column labelled "Password" and retype the password into the column labelled "Retype Password".

2. Click "Save" to save the changes

3. Click on "Apply Changes" in the Control Panel to activate the new passwords.

Figure 12- Password Page

5   MDL

5.1   SYSTEM OVERVIEW

The MDL is a point to multi-point system consisting of a BRU (Base Radio Unit) and multiple RRUs (Remote Radio Unit). The base may in turn be linked to the core network via point-to-point NDL (Network Digital Link) radios. See Figure 13 - MDL System
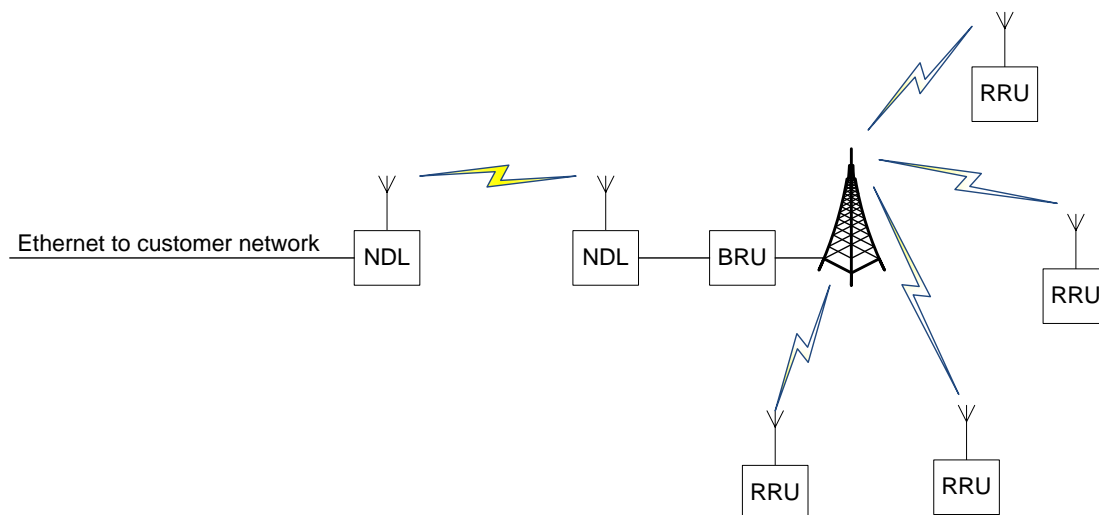

Figure 13 - MDL System

5.2   MDL IP NETWORK OVERVIEW

The MDL system works at layer III of the OSI network model. Each radio unit contains a routing engine. From an IP point of view, each radio unit has two Ethernet interfaces (1 wired and 1 air interface). The example in Figure 14 - Radio as Network Router shows the interfaces and addresses, the air interface is on the 192.168.1.0/24 subnet with IP address 192.168.1.1 and the wired interface is on the 192.168.2.0/24 subnet with an IP address of 192.168.2.1.
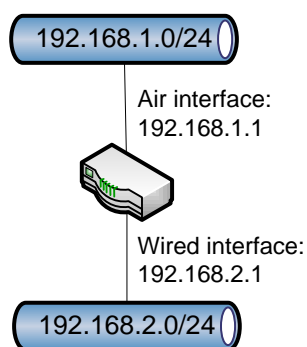

Figure 14 - Radio as Network Router

A layer III architecture has the advantage that broadcast traffic from devices connected to the Radio Units cannot travel over the air. This saves network resource.

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The MDL is full duplex, i.e. packets are transferred up and down from the base at the same time. The MDL uses a random access protocol so that RRUs can transmit their data as soon as an uplink time slot becomes available. A back-off period is used if multiple RRUs try and transmit in the same time slot.

Each RRU has a LLID (Logical Link ID). The LLID is used by the MDL MAC (Media Access Control layer) to identify each remote radio unit to the BRU. Each RRU must have a unique LLID.

An example of an MDL network can be seen in Figure 15 - MDL Network Example. In this example, the MDL consists of a base radio and 4 Remote Radio Units. Each radio unit is represented as a router. The base radio unit connects to the customer network, 172.31.0.0/16 in this example. The RRUs and BRU communicate with each other via the 192.168.1.0/24 subnet. All "air interfaces" in the MDL system are on this subnet. Finally, each Remote Radio Unit is connected to a subnet that contains other IP devices. The MDL provides IP network connectivity to these network devices on the edge of the network.
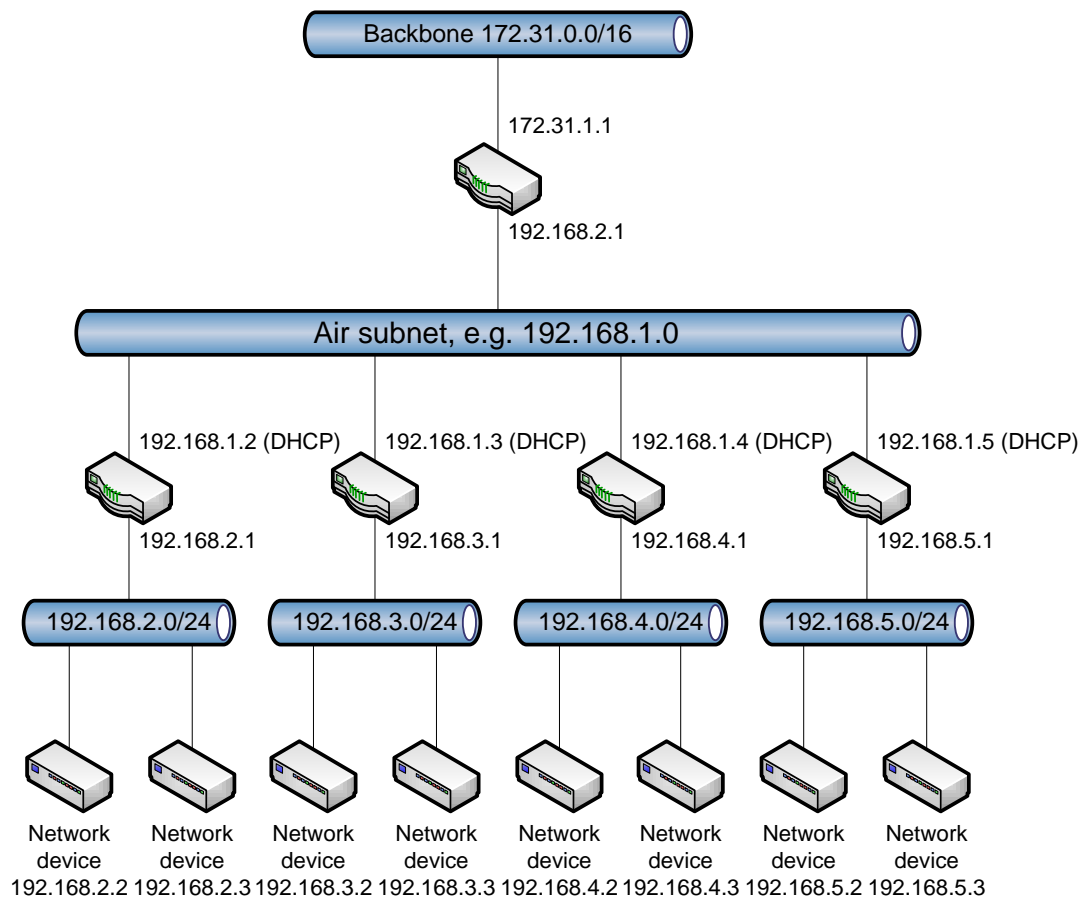
Figure 15 - MDL Network Example

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5.3 CONFIGURATION

5.3.1 Configuring the BRU

The first things to set can be found on the BRU system configuration page, Figure 16 - BRU System Configuration Page. The following items should be set:

➤ **Unit Name,** this should be set to something that distinguishes it from other radio units. A geographical name is often useful.
➤ **Date and time** makes the log files more meaningful; this does not need to be set if you have a NTP (Network Time Protocol) server in your network. Note that the radios operate on UTC (i.e. not local time) time when synchronising with an NTP server.
➤ **Maximum modulation**; this is the maximum receive modulation. i.e. the maximum that the BRU will allow RRUs to transmit at. It should be set to QAM256 if the "nitro" option has been purchased and QAM64 if the "nitro" option has not been purchased. The system will automatically lower the modulation order if channel conditions don't support the higher modulation orders for a particular RRU. It can also be set to lower modulation orders for diagnostic purposes.
➤ **Voltage / temperature thresholds**; these are the levels that can be used to trigger SNMP traps (i.e. alarm conditions)
➤ **Temperature to turn fan on**; this only applies to rack mount models and can be left as default.
➤ **Time for RRU to be considered down**; if the BRU has not received a transmission from an RRU for more than this time it will be considered down. This option is very useful when equipment connected to an RRU is expected to transmit on a regular interval or when the OSPF option is enabled.
➤ **Time for RRU to be removed from system**; if the BRU has not received a transmission from an RRU for more than this time, it can be considered to be no longer part of the system. This will prevent the RRU from appearing on the diagnostics pages. Should the RRU join the network again, it will be automatically added back to the diagnostics pages.
➤ **Monitoring auto refresh**; when viewing the diagnostics pages, the pages can auto refresh every few seconds. This can generate excess network traffic; especially when web browsers are left viewing the CCMS by accident. For this reason the option is off by default.

Figure 16 - BRU System Configuration Page

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Next, the IP networking options can be configured on the "Network, Local" page, Figure 17-BRU Network Settings Page

The radio's IP address, netmask and default gateway can be set on this page.

> The *NTP server IP* address should be set if an NTP server is available. This is very useful for accurate time when examining log files.
> The *Air IP address* and *Netmask* refer to the air Ethernet interface and must be set such that the air interface is on a different subnet to that of the wired Ethernet interface.
> The Air IP addresses on the RRUs are set via the DHCP protocol. A range of IP addresses must be set. This range must fall within the subnet configured for the air interface and must not include the IP address of the BRU air interface.

Figure 17- BRU Network Settings Page

Next, each RRU must be added to the "RRU Members page" on the BRU if OSPF is not enabled, Figure 18 - RRU Member's Page (on the BRU). This is needed so that the BRU can add the required routes to the subnets behind each RRU (i.e. subnets on the wired interface of the RRU). Multiple subnets can be specified for each RRU if multiple subnets exist. Each RRU needs to be on a unique subnet. The RRU's air interface MAC address needs to be specified along with the network details. The RRU's air interface MAC address can be found on the sticker on the RRU or on the system information page in the RRU's CCMS. Note that the example has only one RRU present, but every RRU must appear in this list at least once, the exception is if OSPF is enabled. The present software version (6.0) does not allow a mixture of OSPF enabled and non-OSPF enabled RRUs in a system. All units must be enabled for OSPF if this option is used.

Figure 18 - RRU Member's Page (on the BRU)

5.3.2 CONFIGURING THE RRUS

The RRU system configuration is similar to the BRUs with the addition of the logical link ID, Figure 19- RRU System Configuration Page. Each RRU must have a unique LLID. The LLID can be any number between 3 and 1020. A useful convention can be to set the LLID equal to a significant octet of the RRU's wired interface IP address. For example if 10 RRUs have subnets ranging from 172.31.100.0/24 to 172.31.109.0/24, then LLIDs of 100, 101, 102 …. 109 could be used.
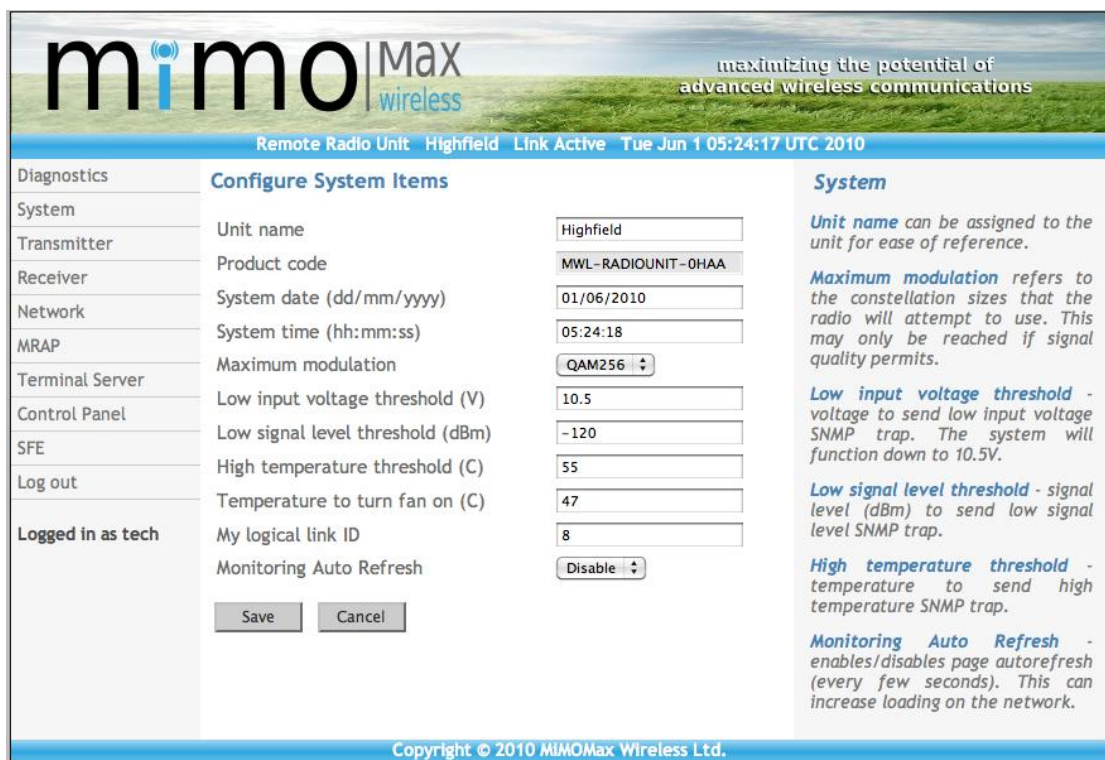

Figure 19- RRU System Configuration Page

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The Maximum modulation is the maximum modulation that the RRU can receive. Even though the BRU may be capable of higher modulation orders, the BRU will not transmit in a modulation order in excess of what the RRU is set to.

The RRU network settings page, as seen in Figure 20- RRU Network Settings Page is similar to the BRU page. All comments from the BRU apply to the RRU.
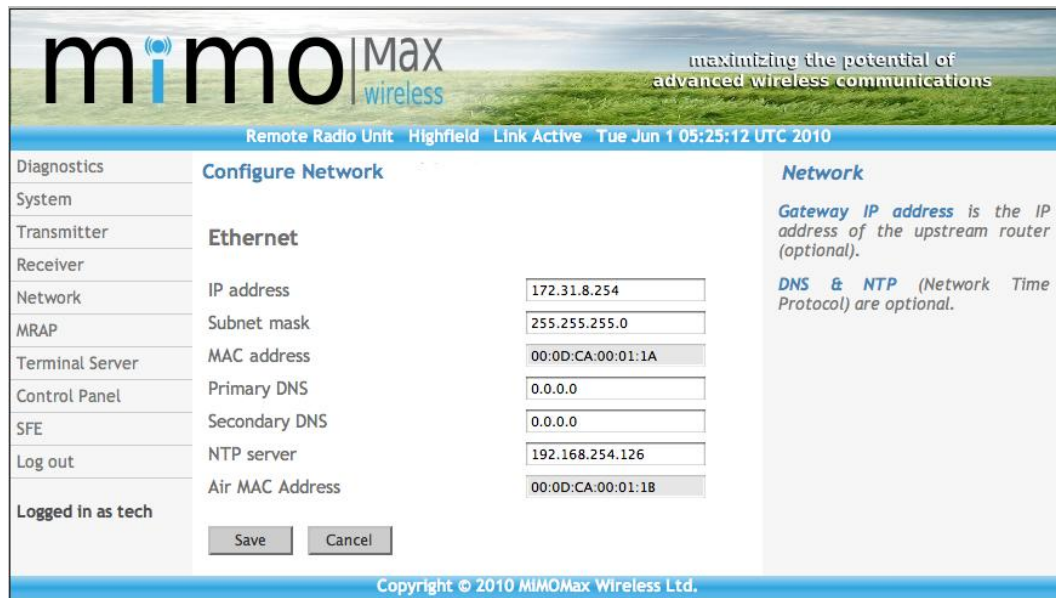

Figure 20- RRU Network Settings Page

5.4   SYSTEM INFORMATION

5.4.1 BRU

The signal levels and signal qualities for each received RRU can found on the "RRU Link Status" page (on the Diagnostics menu). This page shows the signal quality and signal level received from the last transmission from each RRU (specified by LLID). As each radio has two receivers and two transmitters, signal quality and received signal levels are shown for both transceivers. Each row appears in green if the BRU has received a transmission from the RRU in less than the down time specified on the system configuration page. A RRU is removed from this list if it has been down for more than the time specified in the dead time on the system configuration page. The example in Figure 21- RRU Signals Quality Pages shows 8 RRUs, one of which (llid = 12) has not been heard from and is considered down.

Figure 21- RRU Signals Quality Page

Figure 22 - BRU Current Values Page

The BRU Current values page, Figure 22 - BRU Current Values Page contains various counters, temperatures, uptime etc. The GRE interface stats will only appear if a GRE interface has been configured for OSPF monitoring purposes.

5.4.2 RRUs

The RRU "Current values page", can be seen in Figure 23 - RRU Current Values Page. This page contains various counters and statistics. The most useful are the received frames and received frames in error. This error counter gives a measure of the downlink performance. The signal quality and signal levels are also useful when measuring the signal path from BRU to RRU.

Figure 23 - RRU Current Values Page

6. SOFTWARE FEATURE ENABLERS

The MiMOMax Software Feature Enablers (SFEs) are configurable via the CCMS. This allows users field level access to configuration, calibration, and alarm functions. The CCMS has three optional modes of operation: Local, Remote, and Remote-Over-The-Air

1. Local CCMS

This allows local access to the CCMS web application via the Ethernet port of the local radio modem link. The application is self-documenting and allows restricted control of the local radio modem.

2. Remote CCMS / Over-the-Air Configuration (OTAC)

Remote CCMS enables access through both the local Ethernet port and over the air link (WAN). This allows Over-The-Air-Configuration (OTAC) of the remote radio link and often replaces the need to travel to both radio sites.

3. Over-the-Air Programming (OTAP)

OTAP allows the user to perform complete software and database updates or upgrades remotely via the radio link. With this feature enabled, the operating and application software can all be upgraded over the air (OTAP). There is a fall back fail safe, should an error occur during the re-programming process.

Left alone the radios will revert to the last known working version of the software and re-establish the link. Without this feature, the software and database on the radio can only be updated or upgraded locally via the wired Ethernet port.

4. Nitro QAM Boost

This feature allows the RF modulation logic to go up to the full QAM256 giving a boost in data throughput, to reach a user data rate of up to 256kbit/sec (320kbit/sec air speed).

5. SNMP Support

MiMOMax radios can be accessed via SNMP (Simple Network Management Protocol) for network monitoring purposes. The radio can also send various traps or notifications via SNMP to a configured SNMP manager on the network.

6. DNP3 (Distributed Network Protocol V3) Support

MiMOMax radios can now be accessed via DNP3 (Distributed Network Protocol version 3) for network monitoring purposes. Various DNP3 points can be added/removed easily using CCMS depending on the user's monitoring needs. Using DNP3, MiMOMax radio can also be configured to have unsolicited events enabled/disabled by default. The implementation is fully compliant with DNP 3.0 Subset Definition Level 3 and contains significant functionality beyond Subset Level 3. DNP3 has been adopted by Substation Committee of the IEEE Power Society (1379-2000) as a recommended practice for implementing SCADA Master- RTU/IED communication links.

7. Data Logging

This feature can be used for monitoring the system performance over the previous 48-hour period. With this feature, a CSV (Comma-Separated Values) data file will be available for

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download on the Control Panel page that can be downloaded for a more detailed performance monitoring.

8. Out-Station Licenses

This software enables a Radio Base Station (BRU) to support a specified number of Remote Radio Out-Stations (RRU). The number* of RRU licensed depends on the application requirements.

One BRU can support up to 1020 RRUs

9. Terminal Server

The Terminal Server software supports up to two RS-232 ports*. The terminal server packs the serial data into IP packets for transport across IP networks.

Please note the terminal server only supports the MiMOMax NDL & MDL

10. MiMOMax Cognitive Adaptive Modulation (M-CAM)

This feature, when enabled, allows the RF modulation logic to step up or down depending on the quality of the received signal. It traverses from QPSK through to the maximum modulation order and vice versa depending on RF channel conditions.

If this feature is disabled, the RF modulation logic will stay on the set maximum modulation independent of signal quality. M-CAM typically allows for better utilisation of the channel as the modulation order is adapted as channel conditions change. In some circumstances this may be not be desirable (e.g. differential line protection, where fixed bandwidth and latency is required).

11. MiMOMax Routing Adaptation Protocol (M-RAP)

M-RAP is an optional suite of protocols that provide dynamic re-routing. This allows communications to continue in the event of a failure if alternate communications links exist. Protocols include:

> **OSPF** (Open Shortest Path First) is used at a WAN level to determine the shortest path to between two sites. OSPF then selects an alternate path, ensuring that communication continues

> **VRRP** (Virtual Router Redundancy Protocol) is used at a LAN level to ensure that devices on a LAN have redundant local gateways. In the event of a failure, the remaining MiMOMax routers elect a new default gateway to ensure that devices on the local network can continue communicating with the WAN.

> GRE (Generic Route Encapsulation) is used to transfer OSPF monitoring statistics to a central monitoring server

11. MiMOMax Data Acceleration Protocol (M-DAP)

MiMOMax Data Acceleration Protocols (M-DAP) is designed to dramatically enhance VoIP and other real-time applications. M-DAP achieve a significant increase in capacity and quality by the following mechanisms:

- ➢ Header compression
- ➢ Quality of Service
- ➢ Payload compression (future)
- ➢ Traffic Classifier

12.   MiMOMax Power on Demand (M-PoD)

This is a unique power saving feature, which promptly turns on (<100ms link establishment time) the remote end of a radio unit transmitter only when there is data to be transmitted between RUs. The M-PoD is specifically designed for the NDL.

This feature is suited to remote sites where power consumption is an issue. It also supports cascaded links. M-PoD automatically and rapidly turns on the transmitter by promptly keying it up from idle mode in typically 80 ms to enable over-the-link data transmission. Once it is completed, the M-PoD ensures that the transmitter will stay active for a programmable time period between 1 and 255 seconds.

During this time, the M-PoD confirms that all data is processed before automatically deactivating the transmitter. The stand-by power consumption in idle mode is typically 8 W. MiMOMax also offers low power options for links that have to run continuously on shorter paths thereby further reducing the power consumption to less than 55W @ + 26 dBm and less than 40W @ + 23 dBm power output.

13. MiMOMax Security (M-SEC)

M-SEC provides support for secure network access to MiMOMax radios for configuration and enables a packet filtering firewall called Stateful Packet Inspection (SPI).

15. Diversity Enabled (future option)

Diversity software enabler offers a license for the 0x2 Diversity Receiver (Rx) to function and provide additional Rx in a link. The 0x2 MiMO Rx provides additional spatial diversity, which increases reception and lowers the probability of data loss under severe fading conditions.

6.1   SOFTWARE FEATURE REQUEST

The SFE page allows the user to request that additional features are enabled. Figure 24 - Software Feature Request Page. This process is described below:

1.   The user clicks on the drop-down selection menu opposite to a particular feature or features and sets it to "Enabled".

2.   The user then clicks the "Submit" button in order to create a file containing the request. The SFE page will reload and will then display a message that the process is complete and an instruction to the user about what to do next.

3. A new button called "Download SFE" also appears at the bottom of the page. The user must click this button in order to download the generated file and then send it to the nearest MiMOMax Business Centre.

4. Once the features are purchased, MiMOMax Wireless will send the customer an SFE update file in order to enable the features on the radio.
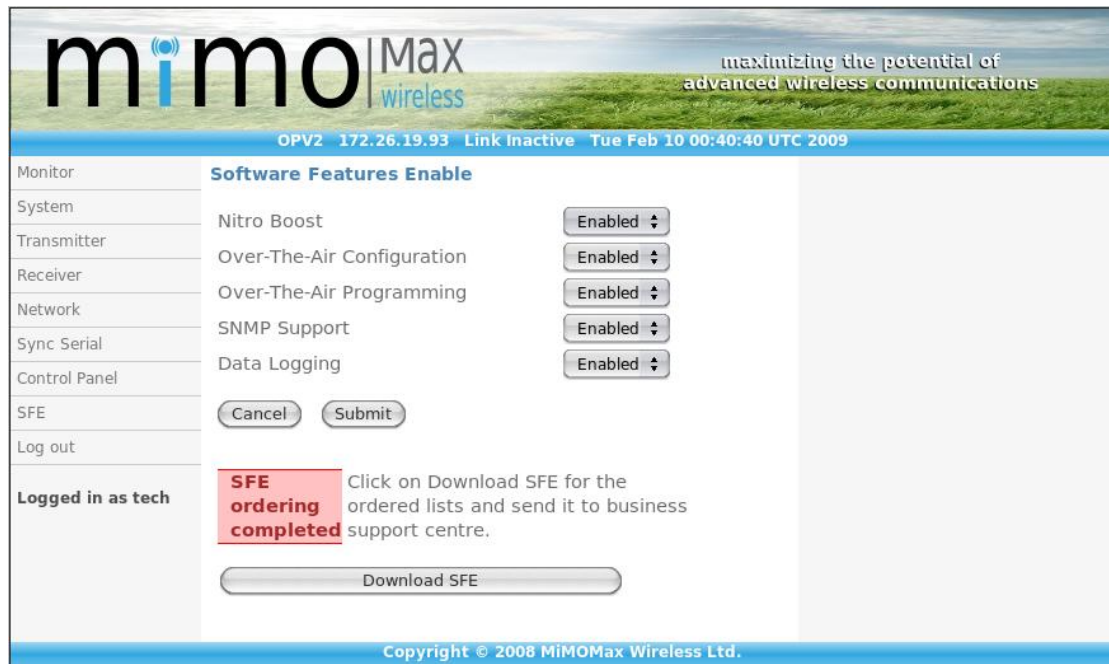

Figure 24 - Software Feature Request Page

In addition, users have the choice to enable or to disable the Express Forward (EF). By selecting Disabled of the item "Express Forward", the EF facilities in kernel will be turned off and resulting in all EF bandwidth to be shared among AF1, AF2, AF3 , AF4 and BE.

7   ADVANCED TOPICS

7.1 MONITORING AND DIAGNOSTICS

This section is aimed at diagnosing poor radio link performance on a link that was previously known to be good. A radio link may perform badly due to poor signal or a fault. The following set of steps will endeavour to discover and solve the source of the problem.

Step 1

The first thing to check is if one can logon to the radio:

Point a web browser to the radio's IP address. This can be done remotely or locally with a laptop (ensure that the laptop has an IP address on the same subnet as the radio).

If the radio is online, one should be presented with a logon screen (Figure 25 - Logon Page).

Figure 25 - Logon Page

- ➢ Logon as user "tech" (The default password is "tech").
- ➢ If one can't logon to the radio then:
  - Ensure that power is on and verifying that the power LED is on.
  - Verify that the Ethernet LED flashes in the presence of network traffic.
  - Ensure that there is IP connectivity to the previous router in the network or logon to the radio locally.
  - The status LED will be on if there is an RF link to the remote end of the link.
  - If one can't login locally then please contact MiMOMax for service

Step 2

Click on the monitoring menu item. One should see a screen similar to the one in Figure 26 - System Monitoring Page.**Error! Reference source not found.**

Figure 26 - System Monitoring Page

➢ Items to check are:
- **Link State** (in the banner at the top of the page): "Not active", indicates that there is no communication with the radio on the other end of the link.
- **Signal Quality** (Should be higher than 50%): Signal quality is a measure of how much noise is on the channel. A 70% signal quality will not usually result in any more bit errors than a 90% signal. It is purely a measure of channel performance. A very low signal quality is usually an indication of interference.
- **RSSI** (Should not be below -97dBm). For OPV or greater (see product data sheet)
- **Errors on the Air Interface** (Errors are to be expected on a radio channel, but a high error rate indicates a problem, probably related to poor RF conditions).
- **Uptime** (An unexpectedly short uptime indicates an unexpected reboot).
- **High Transmitter Temperature (90°C+)**
- **Low Input Voltage** (less than 10.5VDC)

If signal levels are bad on one end only, it either indicates a faulty transmitter at the far end or a faulty receiver at the near end. If the signal levels are bad at both ends, check the antennas and antenna feeds.

Errors on a synchronous serial connection with good signal level, good signal quality and few air interface errors could be a result of noise on the synchronous serial cable or missing terminators on the connected equipment on long cable runs.

7.2 LONG TERM MONITORING

There are two primary methods of long term monitoring, the data log file and the event or constellation capture utility.

The Data log contains various engineering parameters for 48 hours at a 1 minute sample resolution. These can be downloaded in CSV format from the control panel, by clicking on "Data log".

The event (constellation) capture utility is used to debug the RF link. The information it capturers can be used to help identify if fading or interference is effecting the path. The raw data requires processing and analysis; this is generally undertaken by MiMOMax support.

The capture utility has the ability to log the lead up to an event. It achieves this by continually recording the currently transmitted symbols in to a circular buffer. This buffer stores the preceding 500ms of symbols (on a 25 KHz system). If a trigger event occurs, the buffer content is copied to memory (RAM) for later download. There is sufficient memory allocated for 25 capture events. Once the memory reaches capacity, the oldest events will be overwritten.

The Control panel has a button, "All logs and databases" that generates a file containing the above logs as well as the radios databases. MiMOMax technical support will generally request this file to determine how a radio is configured and performing.

7.3 SOFTWARE UPGRADE

A software upgrade is usually done locally via the wired Ethernet connection to the radio device. However, if the optional Over-The-Air Programming (OTAP) feature is enabled, the process can also be done remotely via the MiMOMax link.

The following steps described here are common to the following products: OPV, LRU, BRU and RRU. The screen-shots were taken during an RRU software upgrade.

1.   MiMOMax will have provided the user with a file whose filename resembles: mdl_rru_software_5.bz2. This file is for an RRU product and is version 5 of the software. The file is securely compressed and encrypted and can not be used on any other products other than an RRU.

The user needs to login to CCMS as Technician (username "tech") and navigate to the Control Panel page (Figure 27 - Control Panel).

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Figure 27 - Control Panel

The user clicks on the browse button next to the "File to be uploaded: " text box to find the software image.

Click the "Upload File" button to upload the file. A message will then inform the user whether the upload was successful or not.

The user will need to scroll down to the "System Upgrade Operations" section of the Control Panel page and click on the "Upgrade Software" button (Figure 28 - Control Panel)
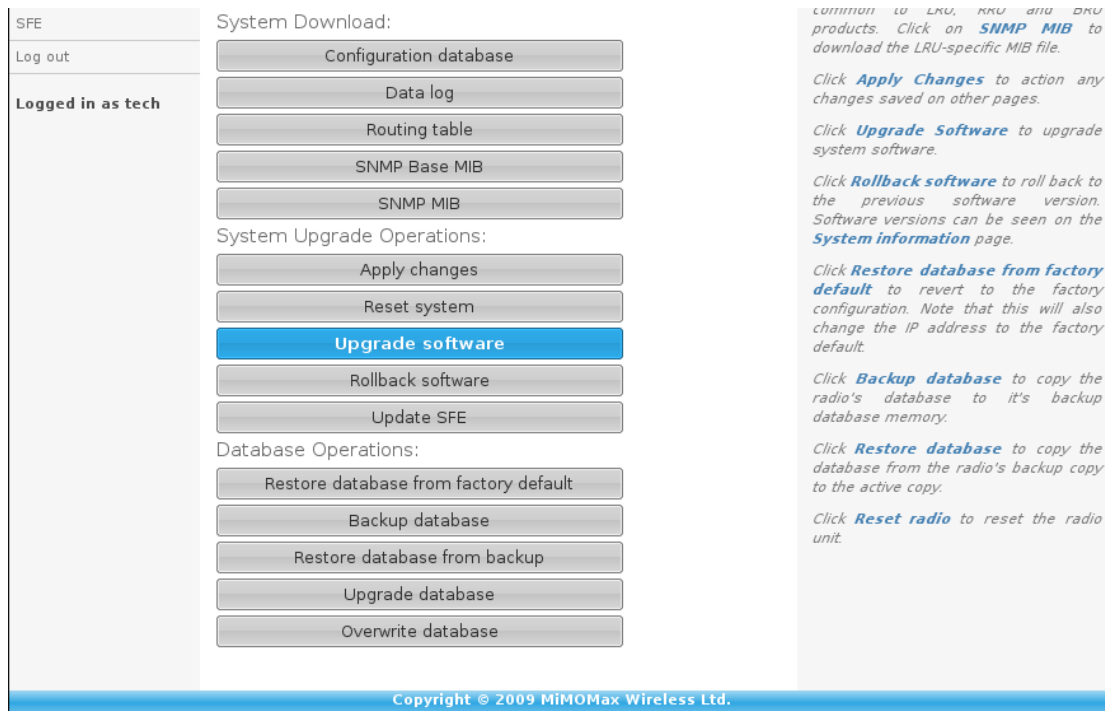
Figure 28 - Control Panel

Once the upgrade process is started, the user will be redirected to a self-reloading page that shows the process status. It reloads every 5 seconds. Figure 29 - Software Update Progress Page
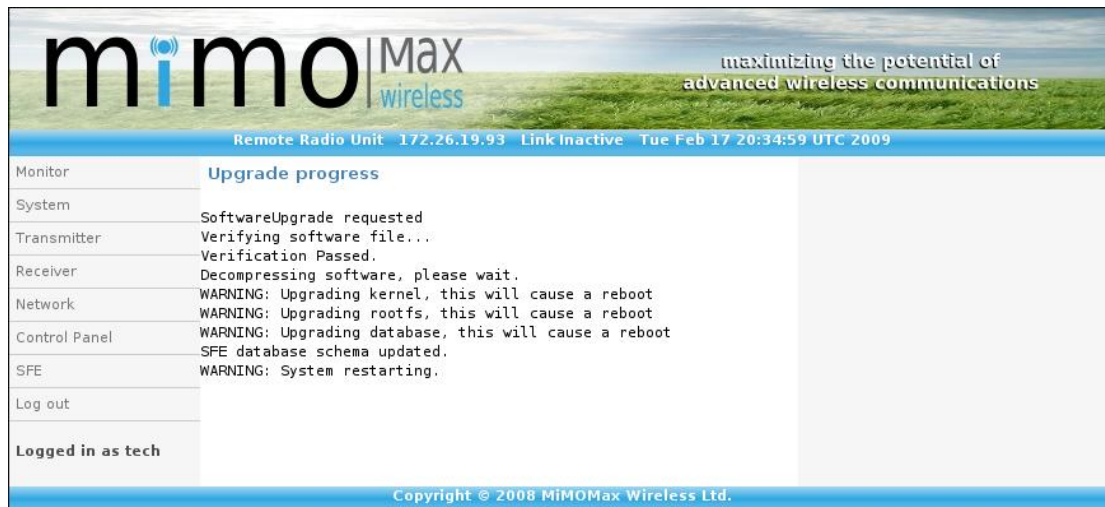

Figure 29 - Software Update Progress Page

3.   The system will automatically reboot when the upgrade is done. The upgrade process takes about 3 minutes to complete plus 2 minutes for reboot for a total of 5 minutes downtime.

This same process can be used to downgrade the running software. Use the software image with the older version and follow the steps as outlined above.

7.4 SOFTWARE ROLLBACK

The system stores two independent copies of the software image. When the software is upgraded, the new software is copied to the inactive memory partition. In other words, the currently running software is kept intact. After the software upgrade process, the memory banks are swapped such that the previous active partition becomes the inactive partition and vice versa.

If the user needs to go back to the previously running version of the software, the button called "Rollback software" under the Control Panel page is used for this purpose.

When the "Rollback software" button is pressed, the radio immediately shuts down and reboots using the other memory bank.

7.5 SFE UPDATE

When a customer is given an SFE update file from MiMOMax Wireless, an SFE update process needs to be done in order to apply the SFE changes. This process is described below:

1.   The SFE file needs to be uploaded to the specific radio it is meant for. This SFE file cannot be used on other radio units. The file upload facility is found on the Control Panel page.

Once the file is uploaded, the user needs to click on "Update SFE" button on the Control Panel page in order to apply the SFE changes. The process takes a few seconds to complete and once done, the features requested should then be "Enabled" as shown on the SFE page. See Figure 30 - Software Feature Update Status Page.

Figure 30 - Software Feature Update Status Page

7.6 DATABASE OPERATIONS

The database on a MiMOMax radio stores all configuration parameters for the radio. The database is separated from the software so that configuration settings will survive a software upgrade. In other words, even if the radio's software is upgraded or changed multiple times, the configuration settings remain intact.

The user can also download the database file for backup purposes. Additionally, the radio can also keep a backup of the database internally.

The usual time when the user will need to upgrade the database is when a previous software upgrade requires it. It is important for the software and the database to be synchronized for correct operation.

A technician can choose from among the different database operation options:

1.   Restore Database from Factory Default

This operation will reload the factory-set configuration and reboot the radio.

2.   Backup Database

This operation signals the radio to create a backup of the current configuration internally. The backup database is stored in non-volatile memory and is persistent when the radio is rebooted or powered down.

3.   Restore Database from Backup

This operation will reload the configuration from the backup stored internally in the radio. This also causes the radio to reboot so that the new settings are applied.

4.   Upgrade Database

This operation will upgrade the current database. It is important to note that a database upgrade does not necessarily affect the current configuration settings. It only means that the database version or schema is upgraded and the relevant values are retained.

5.   Overwrite Database

This operation will overwrite the database on the radio which means that all the values are overwritten with new ones. The database file used in this operation should be a database file that is specific to the radio, otherwise the operation will fail. This file is usually the result of downloading the database file from the radio by clicking on the "Configuration database" button under the "System Download" section of the "Control Panel" page.

7.7 UPGRADING THE DATABASE

The database upgrade process is similar to the software upgrade process.

1. MiMOMax will have provided the user with the appropriate database upgrade file where the filename resembles: ndl_opv2_db_1.3.bz2. It is a securely compressed and encrypted file and can only be used for the appropriate product range. In this case, this applies to any OPV series 2 (OPV2) products.

2. Login as Technician (username "tech") in CCMS and navigate to the "Control Panel" page.

3. Upload the file by clicking on the browse button next to the "File to be uploaded:" text box. Select the file provided.

4. Click on the "Upload file" button. Once the upload is complete, a message will with appear indicating success or failure.

5. Scroll down to the "Database operations" section of the "Control Panel" page and then click on "Upgrade database". Once the radio has verified the file it will then apply the upgrade and reboot the radio. The radio should be back up after 2 minutes.

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