



KR5 UE Relay
User Configuration & Monitoring Guide

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Overview

The document is a User Configuration and Monitoring Guide for the Kumu KR5 UE Relay.

The following SKU variants are currently supported:

SKU	Access LTE Band	Backhaul LTE Band Combinations
KR5192	B2	B2 + B12/13/17
KR5181	B3	B3 + B8/20/28
KR5261	B7	B7 + B8/20/28

This product is intended for use by a qualified network operator in compliance with local safety regulations and building codes in the country of installation.

Product Support: For Technical Support, email techsupport@kumunetworks.com

Functionality

Kumu Networks' KR5 Full Duplex Self-Backhaul LTE UE Relay (Figure 1) enables small cell LTE eNodeB's to backhaul to an LTE macro base-station with the same access frequencies used by both the small cell and the macro network.

The Relay accomplishes full-duplex operation by utilizing Kumu Networks' proprietary Self-Interference Canceller technology to suppress transmitter interference into the receive radios in real-time, such that both the Uplink and Downlink radios can be operational in the same channel at all times.

By using Full Duplex wireless backhaul, operators not only reduce frequency planning complexity but also improve spectral efficiency through channel reuse. The KR5 Relay is easy to install in a matter of minutes. It eliminates the cost of wired backhaul and minimizes operational costs by providing an easy to use network management interface.



Figure 1 - KR5 Relay

The KR5 Relay is designed to be paired with an external eNodeB. The Relay backhauls the eNodeB to another base station over the same access frequencies used by both the eNodeB and the macro network.

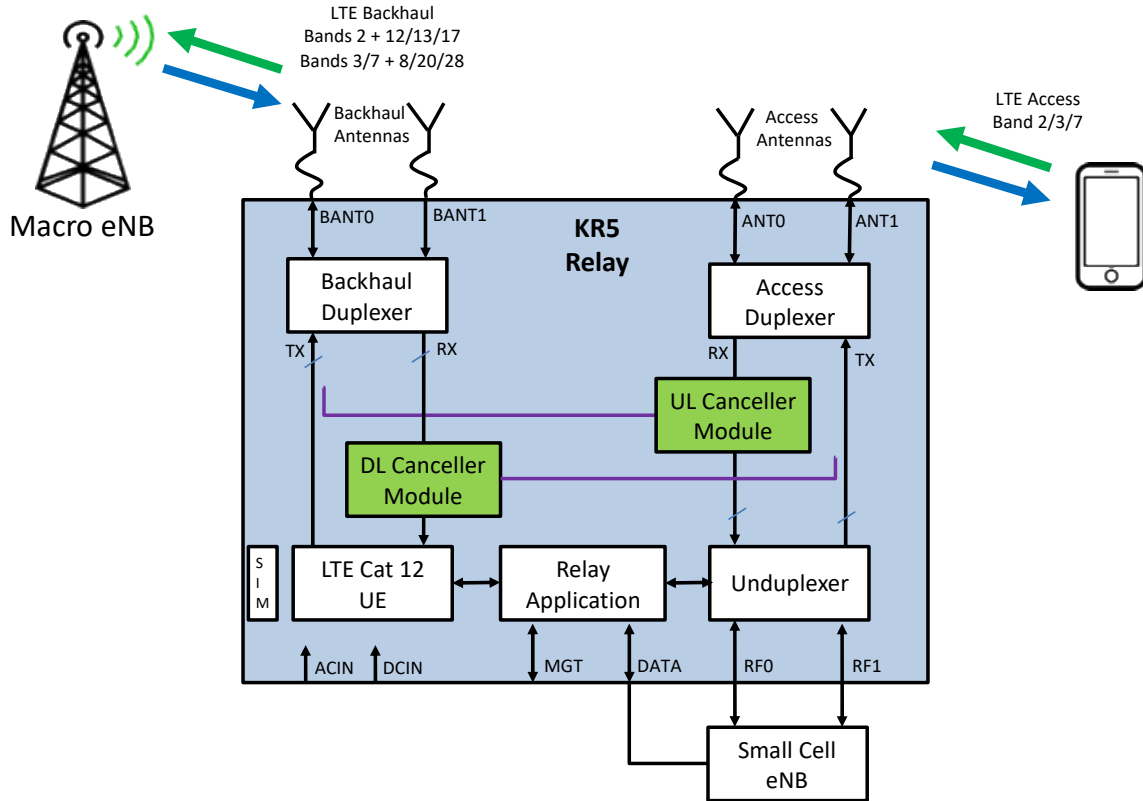


Figure 2 - System View

Features

- Simultaneous use of same channel for access and backhaul (Full-Duplex)
- SKU variants for different LTE bands
- Integrated Cat 12 LTE UE for maximum throughput on backhaul link
- Up to 2CC 30MHz Carrier Aggregation with low-band LTE for improved backhaul coverage
- Works with any LTE small cell
- eNodeB MIMO support up to 2Tx / 2Rx
- eNodeB transmit power support up to 5W per port (+37dBm)
- Transmit noise suppression in receive channel down to -85dBm with Self-Interference Cancellation
- Real-time tuning so cancellation is maintained even in presence of wireless channel variations

Interfaces

Interface	Connector	Purpose
BANT0	Nex10	Backhaul TX/RX RF I/O
BANT1	Nex10	Backhaul RX only RF Input
ANT0	Nex10	Access TX/RX RF I/O

ANT1	Nex10	Access TX/RX RF I/O
RF0	Nex10	TX/RX RF I/O to eNB
RF1	Nex10	TX/RX RF I/O to eNB
ETH1	RJ-45	Ethernet I/O to eNB/Config
ETH2	SFP/RJ-45	Ethernet I/O to eNB/Config
ACIN	Custom	90V-240VAC power supply
DCIN	Custom	-48VDC

Electrical Specifications

Specification	Description
LTE Bandwidths	5,10 & 20 MHz
Backhaul Carrier Aggregation	2CC Interband up to 30MHz
eNodeB Tx power	Up to +37 dBm (per port)
eNodeB MIMO	Up to 2Tx / 2Rx
UE Tx power	Up to +23dBm
UE MIMO	1Tx / 2Rx
Max DL Throughput (PHY)	150Mbps (20MHz) 225Mbps (20 + 10 MHz)
Antenna Isolation (Backhaul - Access)	>45dB required
Remote Operations and Maintenance	NetConf
AC Input	150W 90-254 V~ (AC), 47-63 Hz
DC Input	-48V DC

Environmental Specifications

Specification	Description
Operating temperature	-40° to 55° C
Operating humidity	5% - 100% non-condensing
Ingress protection (rain/dust)	IP65

Physical Specifications

Specification	Description
Size	18" x 10.6" x 5.8"
Weight	14.8 kg (without bracket)
Mounting	Pole or wall mounted
Safety	UL 62368
Hazardous materials	RoHS
Certifications	FCC Part 15 (US) FCC Part 24 (US) FCC Part 27 (US)

Getting Started

Setup

1. Connect a laptop to the KR5 Relay either via a switch or directly to the ETH1 (preferred) or ETH2 port on the relay.
2. Set the laptop ethernet port to DHCP (this is typically already the case)
3. Open a browser and enter `http://192.168.100.1`
4. Accept the security warning due to the self signed certificate.
5. Enter the administrator username & password. Default username for relay is **Administrator** and password is **Administrator**

You should be greeted by the Basic Status page as shown in Figure 3.

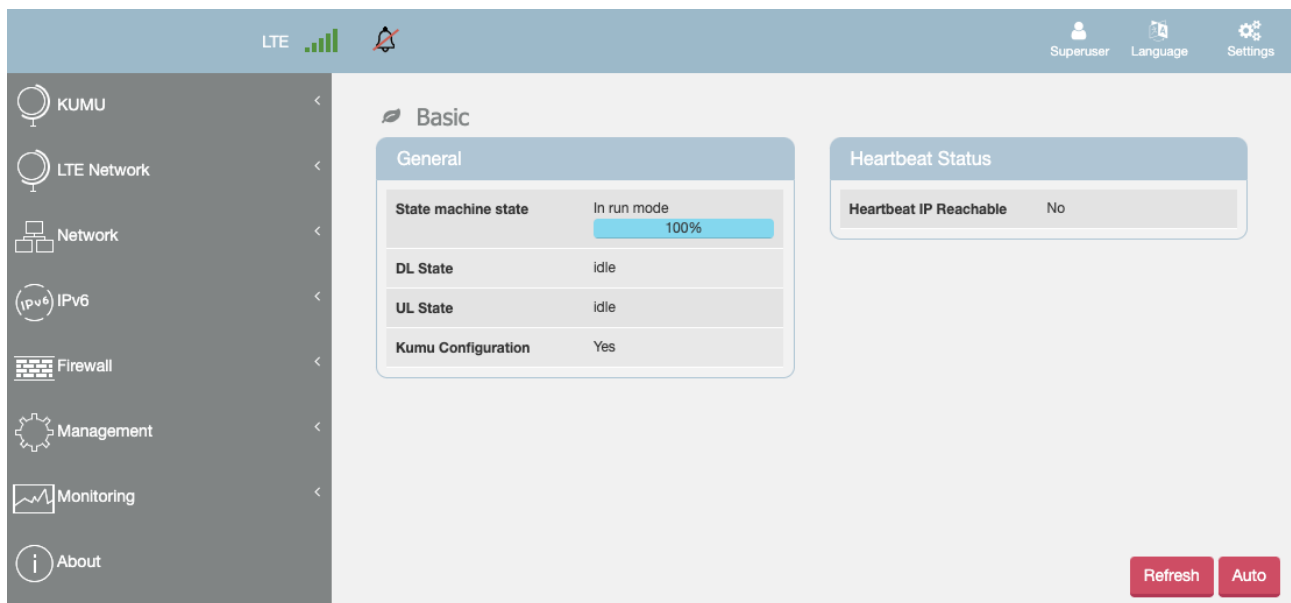


Figure 3 – KR5 Relay GUI – Top Level Menu

Configuring the Relay

RF Configuration



IMPORTANT: The cancellation modules are calibrated based on the values in the this screen. Changing the values in these fields will cause the relay to restart and recalibrate.

Select **KUMU** -> **Configuration** to get to the Kumu Configuration screen as shown in Figure 4

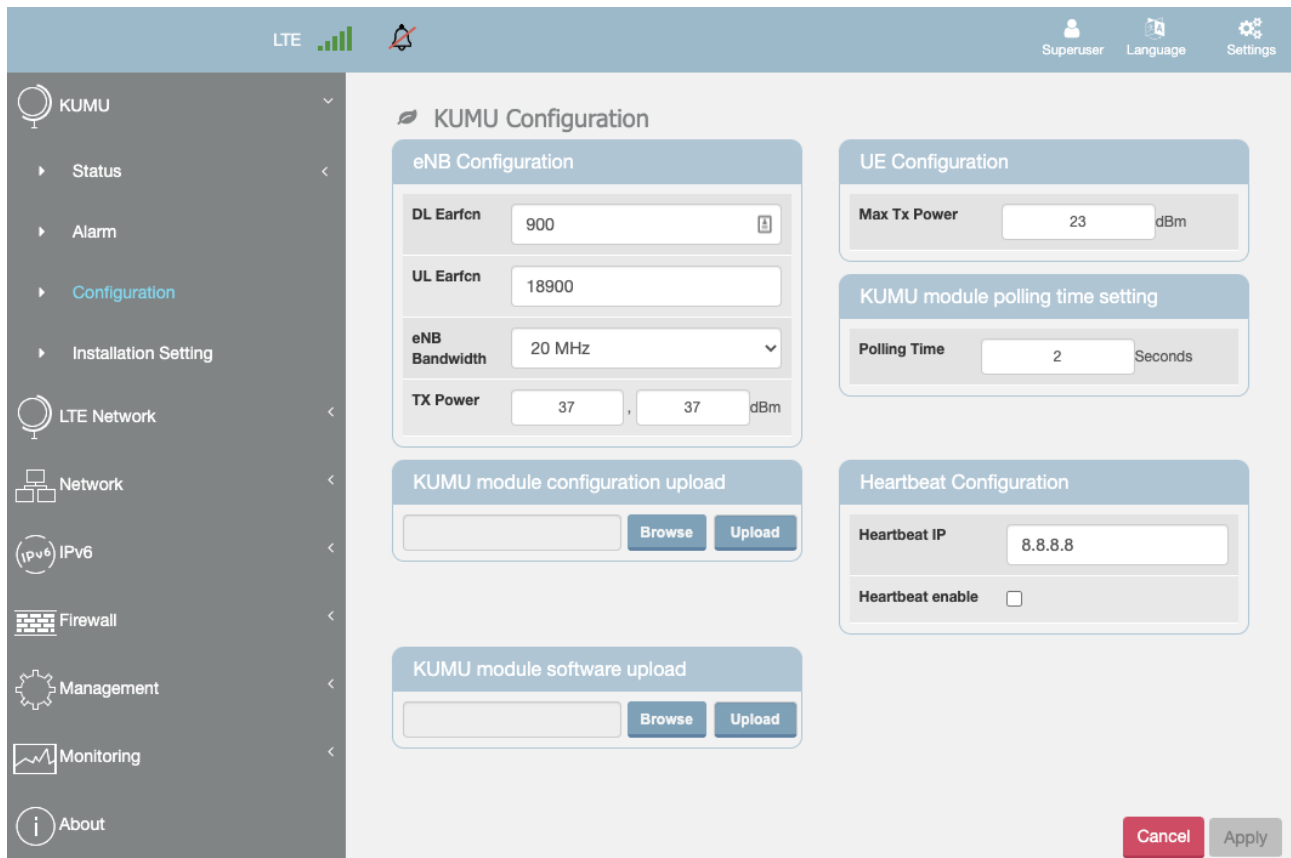


Figure 4 - KUMU Configuration Screen

Mandatory Settings

Set the **DL Earfcn** channel number that will be used by the small cell. If the small cell supports multiple bands, enter the channel number for the Band 2 channel.

Set the **UL Earfcn** channel number that will be used by the small cell. If the small cell supports multiple bands, enter the channel number for the Band 2 channel.

Setup **eNB bandwidth**. If the small cell supports multiple bands, enter the value from Band 2. Default is 20MHz. Allowed values are 5MHz,10MHz or 20MHz

Setup **TX Power** for each of the eNodeB ports. Default/Max is 37 dBm each.

Setup **Max TX Power** for the UE. Default/Max is 23 dBm.

Other Settings

The **Kumu Module Configuration Upload** should not be used by vendor unless instructed by Kumu personnel.

Leave **KUMU module polling time setting** at 2s unless instructed by Kumu

Heartbeat Configuration can be used to regularly ping an IP address to confirm connectivity. If desired:

Set **Heartbeat IP** to the IP address of the machine to be pinged

Set **Heartbeat enable** as appropriate to enable/disable

Finally, select **Apply** to save the settings. The backhaul connection may be temporarily dropped while the new settings are applied.

Site Survey / Setup



IMPORTANT: Changing values on this screen will result in the backhaul relaying re-initializing during which the backhaul connection will be lost.

Select **KUMU** -> **Installation Setting** to get to the installation screen as shown in Figure 5

The screenshot shows the 'KUMU Installation Setting' interface. On the left is a navigation menu with options: KUMU, Status, Alarm, Configuration, Installation Setting (selected), LTE Network, Network, IPv6, Firewall, Management, Monitoring, and About. The main content area is titled 'KUMU Installation Setting' and contains several sections:

- UE Mode:** A dropdown menu currently set to 'Normal Mode'.
- Detected Cell:** A table with columns: Index, DL-Earfcn, PCI, RSRP (dBm), RSRQ (dB), RSSI (dBm), CINR (dB), and PCI Lock. It shows one 'Current cell' with values: Index 800, DL-Earfcn 208, RSRP -76, RSRQ -5, RSSI -51, CINR 31, and a '+' icon for PCI Lock. A 'Survey' button is in the top right of this section.
- Release Lock Specific Cell List Timer:** A text input field containing '0' and a label 'min (0-65535)'. Below it is a red warning message: 'The time to wait before starting full band scan if none of the cells in the lock cell list is available. Enter 0 to disable rescan.'
- Lock Specific Cell:** A table with columns: Index, DL-Earfcn, PCI, and Delete. It is currently empty, with an 'Add' button in the top right.
- PCI Black List:** A table with columns: Index, PCI, and Delete. It is currently empty, with an 'Add' button in the top right.

At the bottom right of the screen are 'Cancel' and 'Apply' buttons.

Figure 5 - Installation Screen

This screen is used for antenna alignment. Set **UE Mode = Scan Mode** and **Apply**.

Monitor RSRP/RSRQ/CINR while aligning antennas for the best quality signal. Note that in dynamic environments these may change frequently

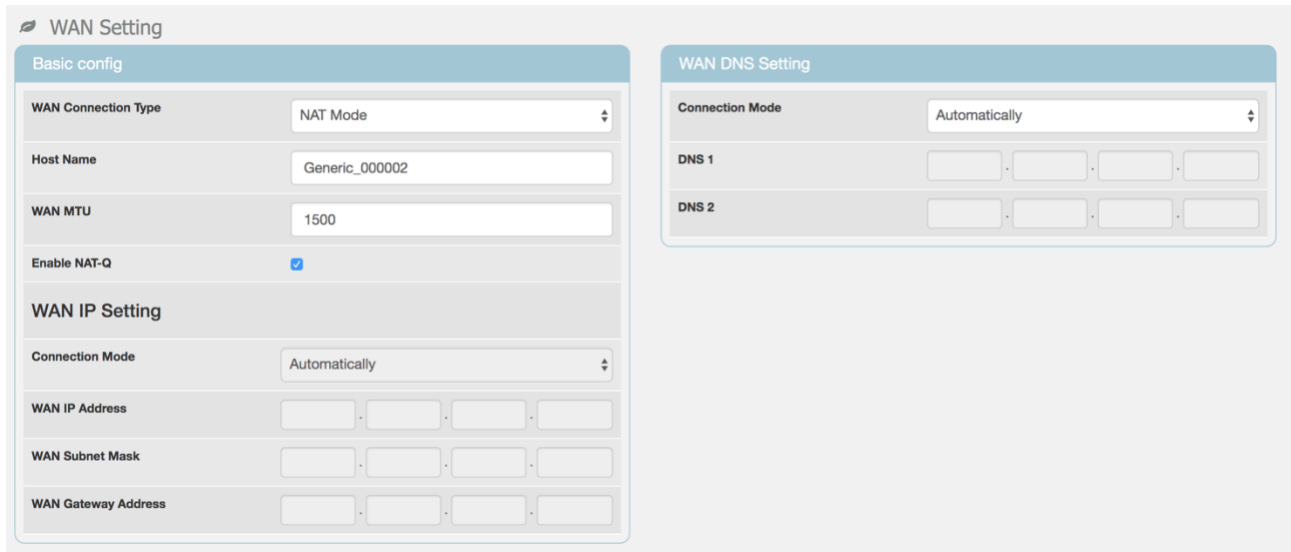
Once antennas are aligned, change **UE Mode = Normal Mode** and **Apply**.

PCI Lock can be used to lock Donor Cell if necessary. This should only be used when absolutely necessary as it will prevent the relay from roaming to other cells if the locked cell goes down, or changes it's PCI.

PCI Black List can be also used to Black List specific PCI's if necessary. In rare cases it may be needed to black list the local small cell to prevent the relay from attempting to attach to it.

Network Configuration

Select **Network -> WAN Setting** for network configurations.



The screenshot shows the 'WAN Setting' configuration page. It is divided into two main sections: 'Basic config' and 'WAN DNS Setting'.
Basic config:

- WAN Connection Type: NAT Mode (dropdown)
- Host Name: Generic_000002 (text input)
- WAN MTU: 1500 (text input)
- Enable NAT-Q:
- WAN IP Setting:**
 - Connection Mode: Automatically (dropdown)
 - WAN IP Address: [] . [] . [] . [] (text input)
 - WAN Subnet Mask: [] . [] . [] . [] (text input)
 - WAN Gateway Address: [] . [] . [] . [] (text input)

WAN DNS Setting:

- Connection Mode: Automatically (dropdown)
- DNS 1: [] . [] . [] . [] (text input)
- DNS 2: [] . [] . [] . [] (text input)

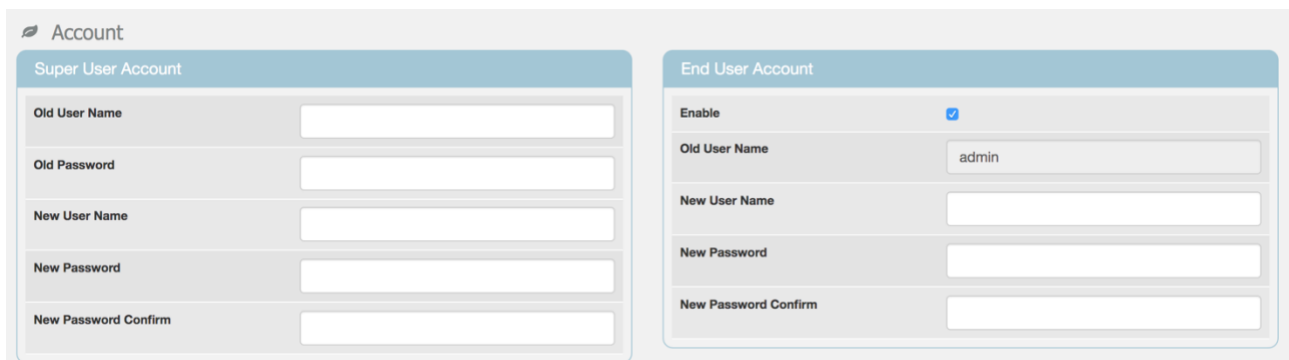
WAN MTU may need to be configured based on eNodeB preferences. Default value for WAN MTU is 1500.

Other settings should not be changed unless directed by Kumu personnel

Management

User Name & Password

Select **Management -> Account** to change default user name or password for the Relay.



The screenshot shows the 'Account' configuration page, divided into two sections: 'Super User Account' and 'End User Account'.
Super User Account:

- Old User Name: [] (text input)
- Old Password: [] (text input)
- New User Name: [] (text input)
- New Password: [] (text input)
- New Password Confirm: [] (text input)

End User Account:

- Enable:
- Old User Name: admin (text input)
- New User Name: [] (text input)
- New Password: [] (text input)
- New Password Confirm: [] (text input)

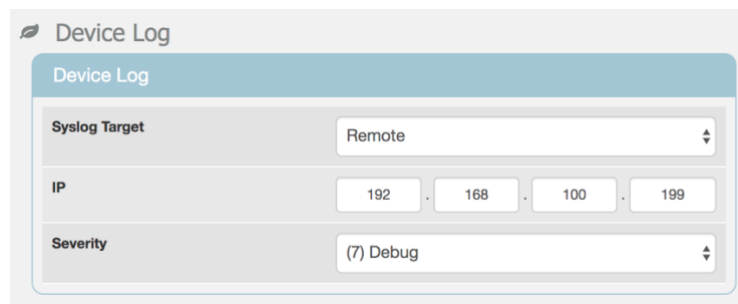
Device Log

The relay supports sending syslog messages to a remote server.

Select **Management -> Device Log** to manage device log location and contents. Default setting is that device does not generate logs.

To enable syslog logging:

1. Change **Syslog Target** to Remote
2. Enter the **IP address** of the syslog server
3. Set the **Severity level** as appropriate. It is not recommended to set this any higher than (5) Informational for regular operation.

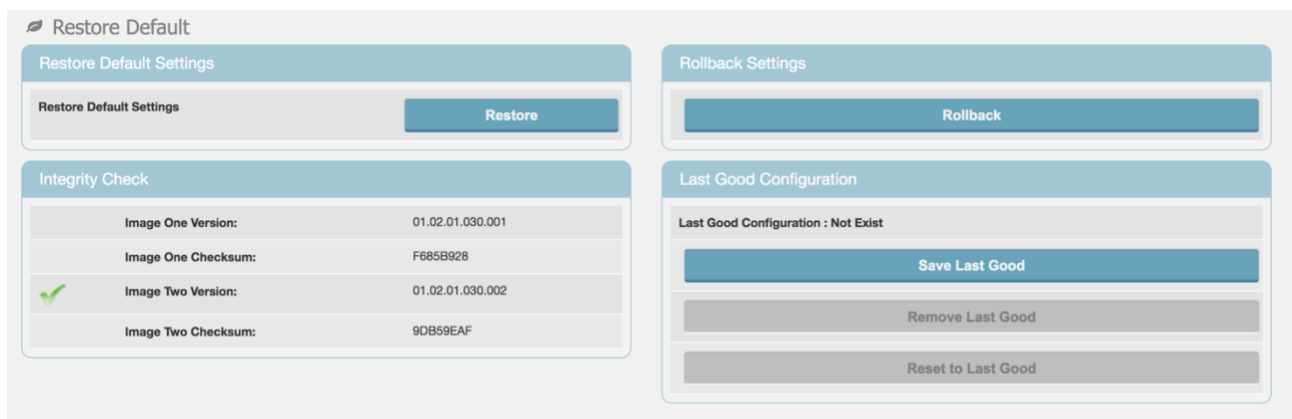


The screenshot shows the 'Device Log' configuration interface. It has a title bar 'Device Log' with a leaf icon. Below it is a 'Device Log' section with three rows: 'Syslog Target' with a dropdown menu showing 'Remote', 'IP' with four input fields containing '192', '168', '100', and '199', and 'Severity' with a dropdown menu showing '(7) Debug'.

Figure 6 - Device Log Settings

Factory Reset

Select **Management -> Restore Default** to reset Relay back to Factory Default.



The screenshot shows the 'Restore Default' configuration interface. It has a title bar 'Restore Default' with a leaf icon. Below it are four sections: 'Restore Default Settings' with a 'Restore' button, 'Rollback Settings' with a 'Rollback' button, 'Integrity Check' with a table of image versions and checksums, and 'Last Good Configuration' with 'Last Good Configuration : Not Exist' and buttons for 'Save Last Good', 'Remove Last Good', and 'Reset to Last Good'.

Image One Version:	01.02.01.030.001
Image One Checksum:	F685B928
Image Two Version:	01.02.01.030.002
Image Two Checksum:	90B59EAF

Figure 7 - Restore Default Screen

Software Upgrade / Config Backup Restore

Select **Management -> Software** to update the Relay software. This screen also shows the current Relay software version.

Select **Browse** to open a dialog and select a new software installation file (*.ipk).

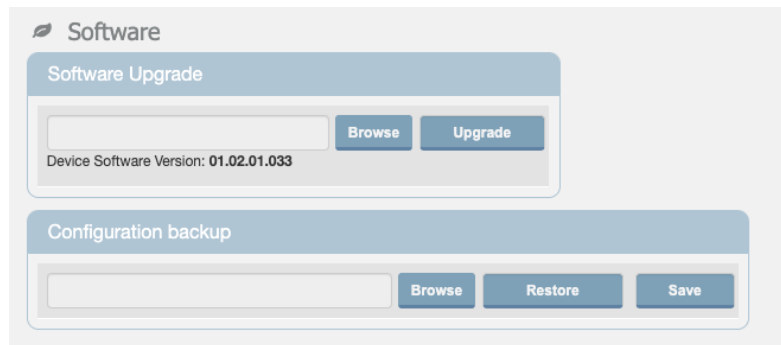


Figure 8 - Software Management Screen

This screen also offers the option to backup/restore the relay configuration.

To Backup the Configuration:

Choose **Save** to download a backup copy of the relay configuration. Enter a passphrase that will be used to secure the image.

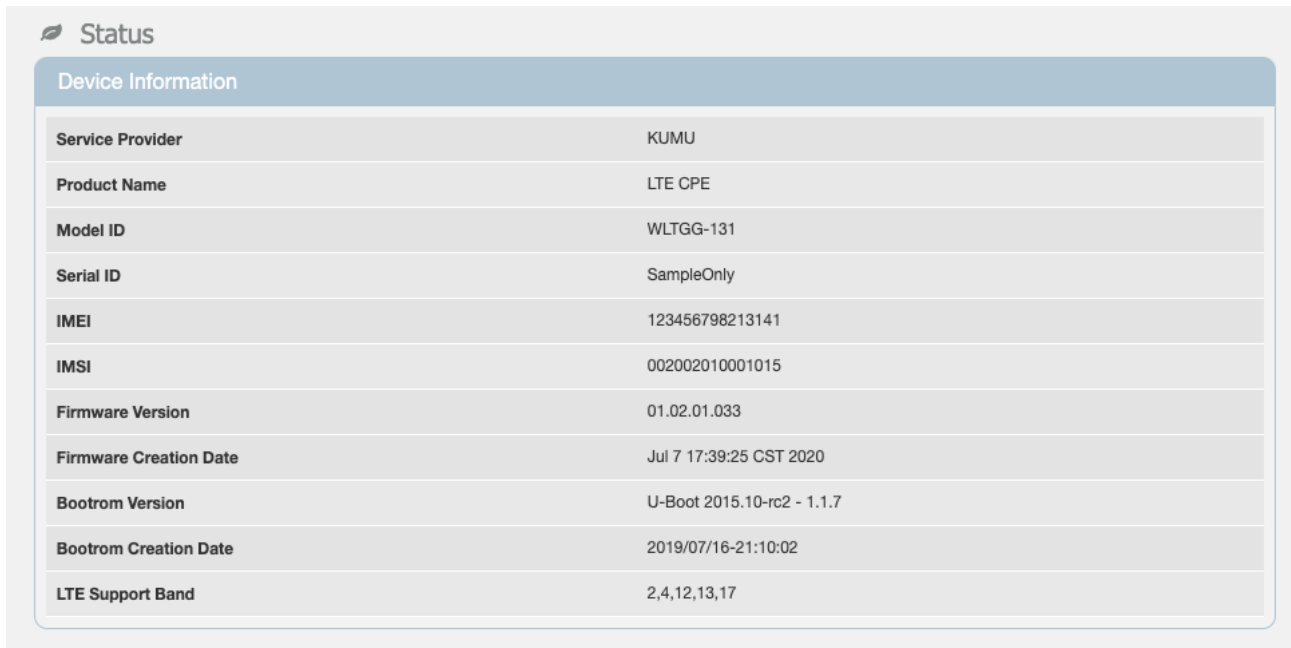
To Restore the Configuration:

Choose **Browse** to select a backup file for upload, and then **Restore** to upload to relay. Enter the passphrase that was used to secure the image

About

The KR5 Relay **About** GUI provides useful information about metrics and status of the Relay as shown in Figure 9.

Select **About** from the main menu to check Relay device information including IMEI, Firmware version and LTE Bands supported.



The screenshot shows a 'Status' screen with a 'Device Information' table. The table lists various device and firmware details.

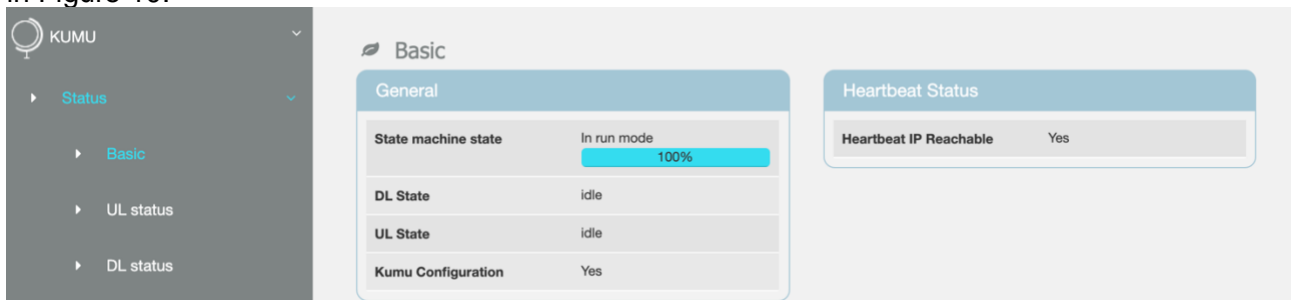
Device Information	
Service Provider	KUMU
Product Name	LTE CPE
Model ID	WLTGG-131
Serial ID	SampleOnly
IMEI	123456798213141
IMSI	002002010001015
Firmware Version	01.02.01.033
Firmware Creation Date	Jul 7 17:39:25 CST 2020
Bootrom Version	U-Boot 2015.10-rc2 - 1.1.7
Bootrom Creation Date	2019/07/16-21:10:02
LTE Support Band	2,4,12,13,17

Figure 9 - About Screen

Performance Status

Kumu Cancellation Status

Select **Kumu -> Basic** for basic status information of the Kumu cancellation technology as shown in Figure 10.



The screenshot shows a 'Basic' status screen for Kumu. It includes a sidebar menu and two main panels: 'General' and 'Heartbeat Status'.

General	
State machine state	In run mode 100%
DL State	idle
UL State	idle
Kumu Configuration	Yes

Heartbeat Status	
Heartbeat IP Reachable	Yes

Figure 10 - Kumu Basic Status Screen

State Machine State will enumerate through a number of states on power-up, or during config

changes. During normal operation it will show “in run mode” and 100%.

During normal operation both **DL State** and **UL State** will show “idle”.

At all times the **Kumu Configuration** will show “Yes”.

If any of the above do not go to the intended state within 10 minutes, check the **Alarms** screen for more information.

Heartbeat IP Reachable is user indicate that the configured Heartbeat IP can be contacted and is useful for confirming a valid IP connection.

Select **Kumu -> UL Status** or **KUMU -> DL Status** from the main menu to check detailed cancellation status, e.g. if Relay is Calibrated or is actively cancelling self-interference. This screen also confirms Relay RF setting information.

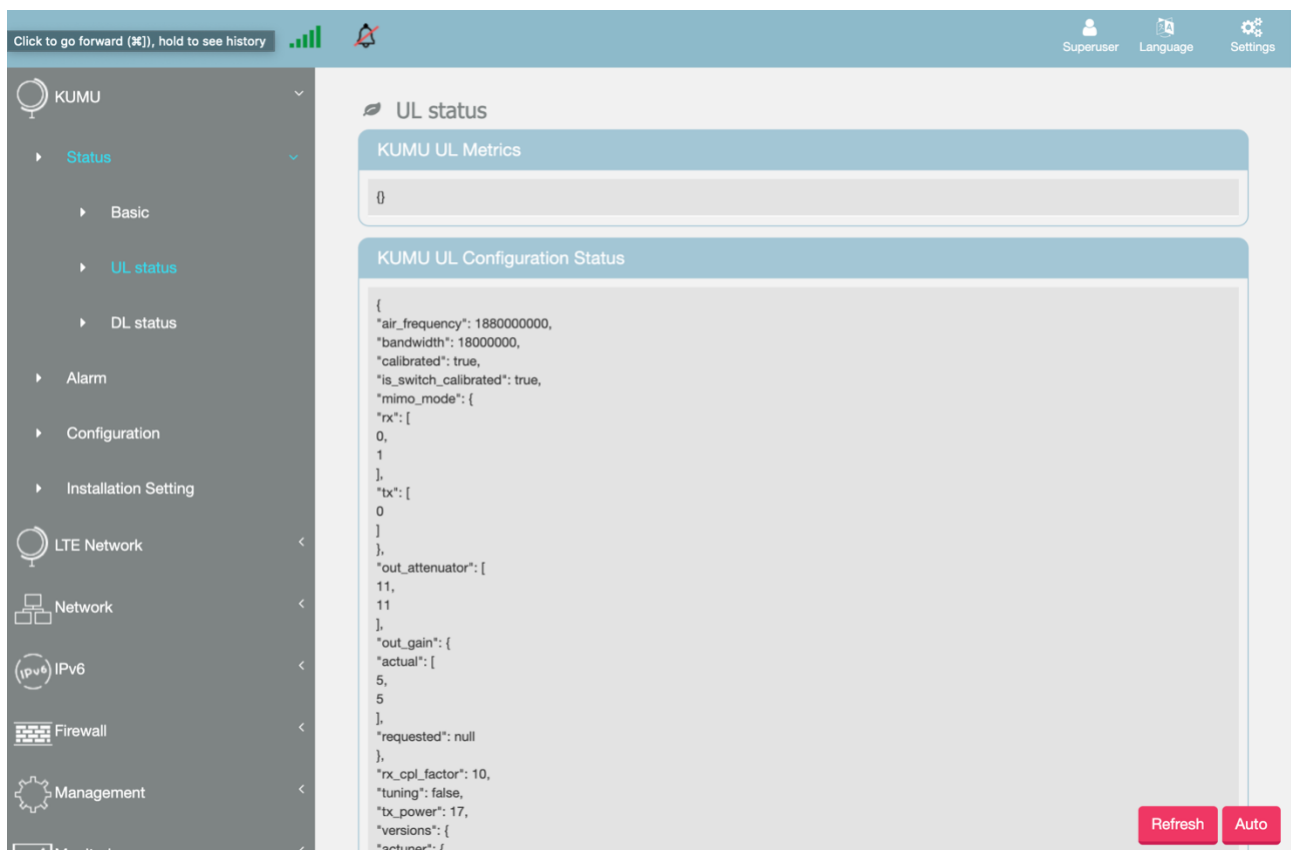


Figure 11 - Kumu Advanced Status Screen

LTE Status

Select **LTE Network -> Status -> Basic** to check connectivity status, LTE information and Uplink & Downlink status of the backhaul link as shown in Figure 12.

Status

General Information			
State	Connecting	Network Operator	00000
Technology	LTE	Connection Time	0 Seconds

LTE Information			
State	Search	RRC State	N/A
DL Frequency	0 kHz	UL Frequency	0 kHz
SINR	0 dB	RSRP	0 dBm
RSRQ	0 dB	ECI	0000000
PCI	0	eNodeB ID	00000
Cell ID	00	TX Power	0.0 dBm

UpLink Status			
Data Rate	0 kbps	TX Bytes	N/A
Packets	N/A		

DownLink Status			
Data Rate	0 kbps	RX Bytes	N/A
Packets	N/A		

Figure 12 - LTE Basic Status Screen

Select **LTE Network** -> **Status** -> **Advanced** to check LTE TX (PUSCH) and LTE RX (RSRP, SINR) information.

Advanced

LTE TX	
Path Index	PUSCH (dBm)
1	N/A
2	N/A

LTE RX		
Path Index	RSRP (dBm)	SINR (dB)
1	NA	NA
2	NA	NA
3	NA	NA
4	NA	NA

Figure 13 - LTE Advanced Status Screen

Select **LTE Network** -> **Status** -> **PDN** to check Serving Cell information.

Serving Cell Detailed Information

PDN Connection

Cid	APN Name	PDN Type	Authentication Type	Connected	IP Address
Default	apn.kumu	IPv4	NONE		192.168.200.15

Figure 14 - LTE Serving Cell Screen

Network Status

Select **Network** -> **Status** to check details on LAN and WAN configurations, as shown in Figure 15

Status

LAN Information

LAN MAC	80:02:9c:3a:ea:8c	LAN IP Address	192.168.100.1
LAN Subnet Mask	255.255.255.0	TX Bytes	6643456
RX Bytes	5380253	TX Packets	11939
RX Packets	14274	TX Drop Packets	0
RX Drop Packets	0		

WAN Information

Type	Automatically	Current MTU	1500
WAN IP Address	N/A	WAN IP Subnet Mask	N/A
WAN IP Default Gateway	N/A	DNS Server	N/A
TX Bytes	0	RX Bytes	0
TX Packets	0	RX Packets	0
TX Drop Packets	0		

Figure 15 - Network Status Screen

Select **IPv6 -> Status** to check IPv6 LAN address configuration.

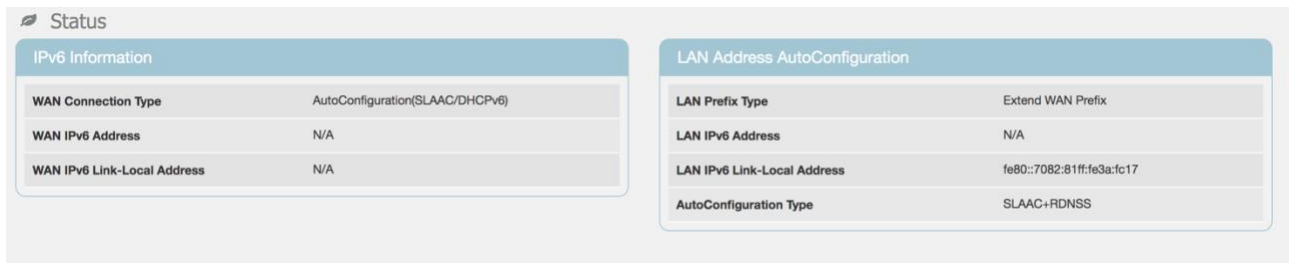


Figure 16 - IPv6 Status Screen

Advanced Settings

The KR5 Relay GUI allows advanced settings to be configured. These settings should only be changed by qualified operators if required and are not necessary to configure for most normal installations.

LTE Settings

Band Selection

Select **LTE Network -> Cell Selection** for advanced configurations including to limit bands used for backhaul.

Use the **Band** options to enable/disable bands on the backhaul link. Note that Band 4 is not supported by the current hardware and should not be enabled.

Other settings should not be used except as directed by Kumu personnel.

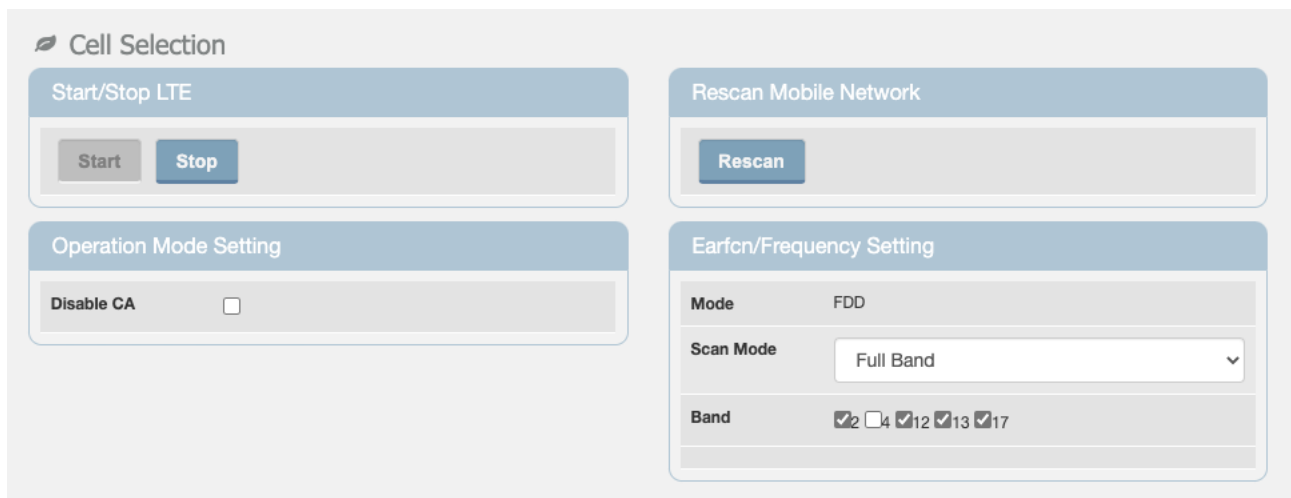


Figure 17 - Cell Selection Screen

Default PDN

Select **LTE Network -> Default PDN** for advanced Packet Data Network (PDN) connection parameters.

The screenshot shows the 'Default PDN' settings screen. It has a title bar with a leaf icon and the text 'Default PDN'. Below the title bar is a section titled 'Default PDN Connection'. This section contains four rows of settings, each with a label on the left and a dropdown menu on the right:

- APN for network attach: Auto
- Authentication Type: NONE
- PDN Type: IPv4
- IP Address Allocation: NAS SIGNALLING

Figure 18 - Default PDN Screen

Multiple PDN

Select **LTE Network -> Multiple PDN** if required for multiple Packet Data Network (PDN) connections

The screenshot shows the 'Multiple PDN' settings screen. It has a title bar with a leaf icon and the text 'Multiple PDN'. Below the title bar is a section titled 'Setting' with an 'Add +' button on the right. Below this is a table with the following columns:

Cid	PDN Type	APN Name	IP Address Allocation	Authentication Type	Username	Password	Delete
-----	----------	----------	-----------------------	---------------------	----------	----------	--------

Figure 19 - Multiple PDN Screen

SIM Card PIN (CPIN)

Select **LTE Network -> PIN** to enable PIN code check for SIM card or change the PIN. This is not a common setting as most networks no longer use SIM cards with PIN.

The screenshot shows the 'PIN' settings screen. It has a title bar with a leaf icon and the text 'PIN'. Below the title bar are two sections:

- Enable PIN:** Contains a toggle switch for 'Enable PIN Code check', which is currently turned off.
- Change PIN:** Contains a 'Change PIN' input field, a 'Change' button, and a 'Remaining Attempts' indicator showing '3'.

Network Settings

Select **Network -> LAN Setting** to setup LAN IP address or enable/disable the DHCP server.

The **LAN Settings** should NOT be changed without consulting Kumu technical support.

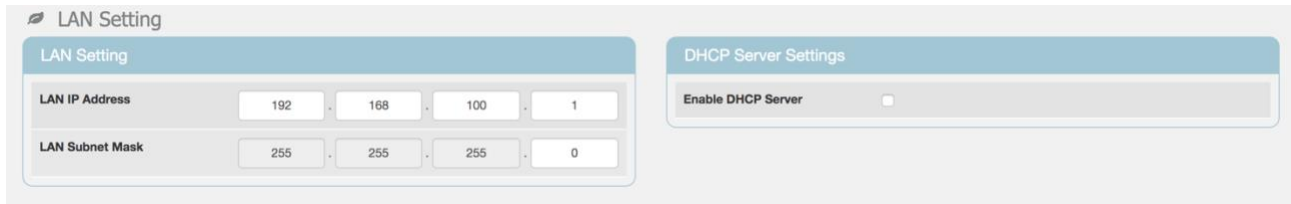


Figure 20 - LAN Settings Screen

Select **Network -> Port Forwarding** to setup port forwarding. These are not necessary for normal operation.

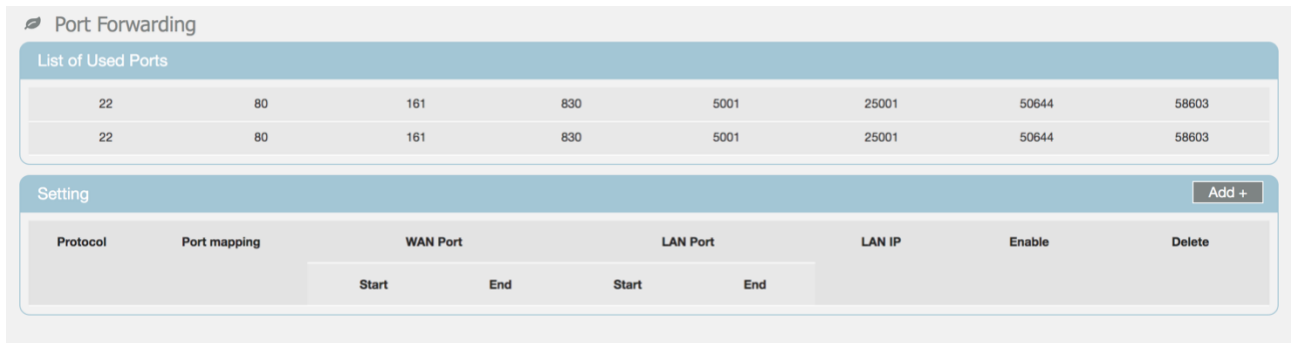


Figure 21 - Port Forwarding Screen

Select **Network -> Port Trigger** to setup port triggering. These are not necessary for normal operation

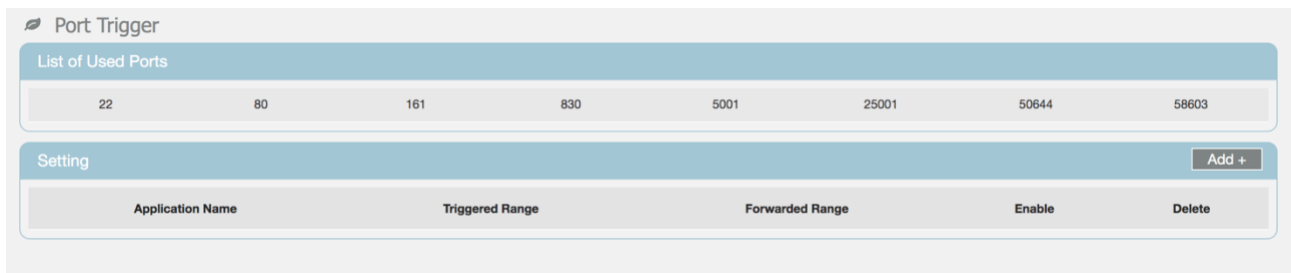


Figure 22 - Port Trigger Screen

IPv6 Settings

Select **IPv6 -> Settings** to setup Internet connection type and IPv6 LAN address settings.



Figure 23 - IPv6 Settings Screen

Firewall Settings

Select **Firewall -> Basic** to enable/disable firewall and basic firewall settings.

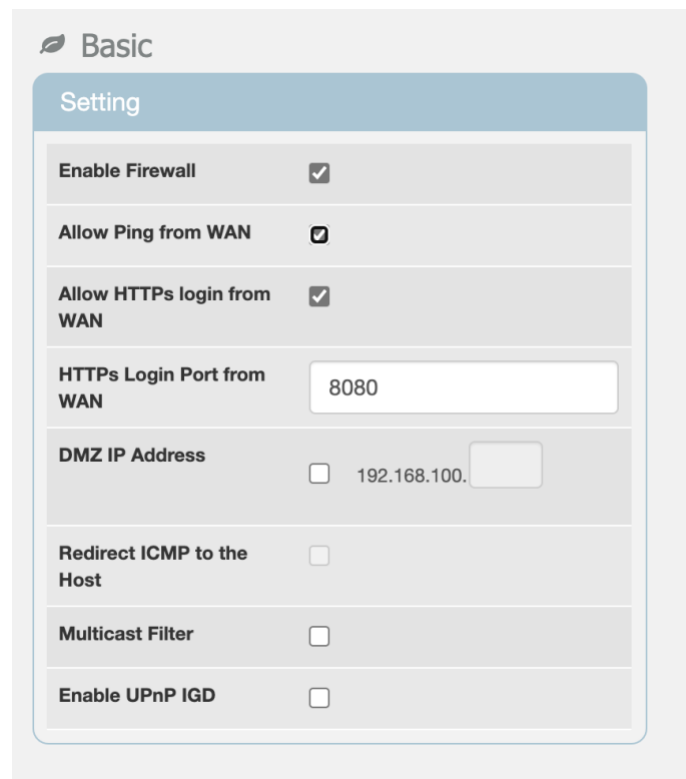


Figure 24 - Firewall Basic Settings Screen

Select **Firewall -> Access Restriction** to add access restrictions to the Relay.



Figure 25 - Firewall Access Restrictions Screen

Monitoring the Relay

Status

Select **Monitoring** -> **Status** for information on CPU Utilization, Memory Utilization, Uplink and Downlink data rates and system information like the last restart reason.

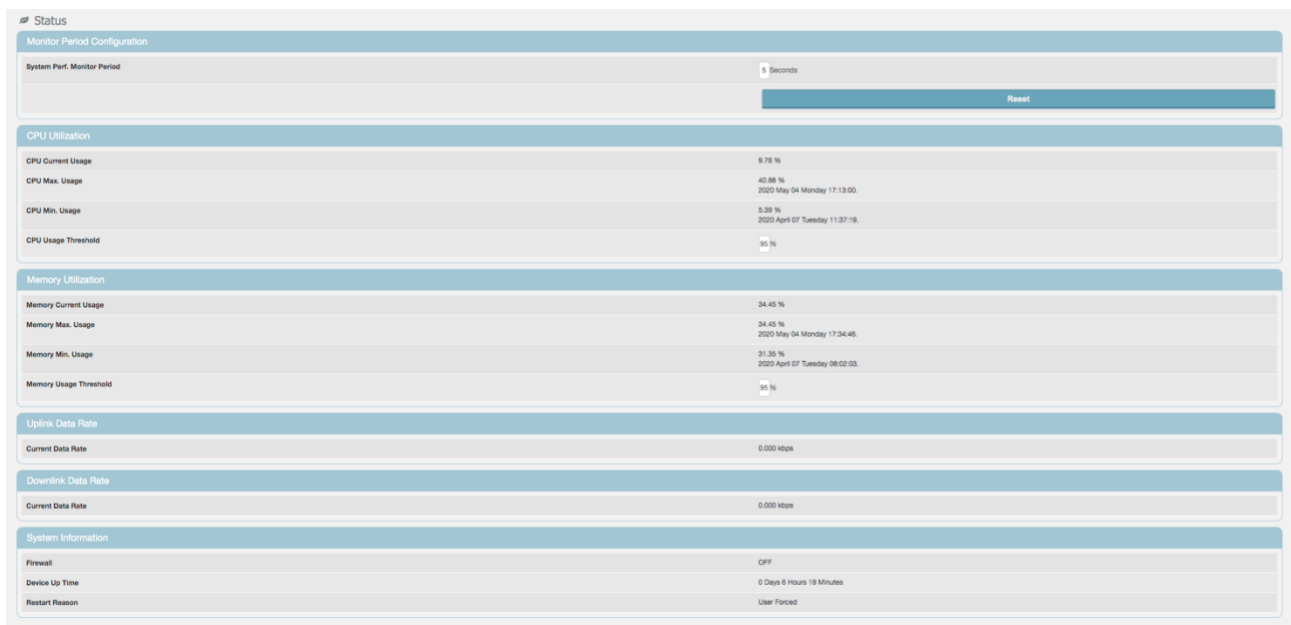


Figure 26 - Monitoring Status Screen

iPerf Utility

Select **Monitoring** -> **iPerf** to setup and perform uplink and downlink speed test.

Note that due to the performance limitations of the onboard CPU to run the iPerf application you may not be able to see full performance. Use an external speedtest tools (ex. Speedtest.net, or testmy.net) to see true backhaul performance.

The screenshot displays the Iperf web interface. At the top left, there is a logo with a leaf icon and the text "Iperf". Below this is a "Settings" section with a blue header. The settings are organized into several rows:

- Status:** Two buttons, "Enable" (highlighted in blue) and "Disabled" (grey).
- Last Measurement Date/Time:** A label with no input field.
- Server Address:** An empty text input field.
- Server Port:** A text input field containing "5001".
- Management Port:** A text input field containing "5001".
- Measurement Time:** A text input field containing "60" followed by the label "Seconds".
- Protocol Type:** A dropdown menu with "TCP" selected.
- TCP Client Number:** A text input field containing "1".

Below the settings is a "Result" section with a blue header. The content area below the header is a large, empty rectangular box.

Figure 27 - Iperf Screen

Diagnostic Tools

Select **Monitoring -> Diagnostic Tools** to setup diagnostics and observe diagnostic metrics including ping timings and counts or traceroute. Ping helps verify if system is connected to the internet or other devices while traceroute can be used to troubleshoot connection routing.

Please consult your networking support engineer for use of these tools.

Diagnostic Tools

Settings

Status

Diagnostic Type

Protocol Type

IP Address/Domain

Ping Count

Packet Size Bytes

Ping Timeout Seconds

Max Hops

Diagnostic Result

Figure 28 - Ping / Traceroute Screen

Status LED's

There are two LEDs on the side of the relay that indicate the state of the relay, as shown in Table 1.

Table 1 - LED Status and Recommended Action

Red LED	Green LED	Relay Status	Action
Flashing	Off	Booting, not connected	Wait 5 – 10 minutes for system to complete boot process.
Solid	Off	Error, not connected	Check Kumu -> Alarms
Off	Solid	Connected	No action required
Off	Off	Not connected	Check power to relay

System Alarms

Check **Kumu -> Alarms** to view current alarms, and suggested next steps.

If **State = True** then this is an active alarm. If **State = False** then the alarm condition has been cleared.

The **Message** will give details on the alarm and possible next steps.

Last-set indicates how long since this alarm was last activated.

Last-clear indicates how long since this alarm was last cleared.

Status

Relay Alarms

Name	State	Severity	Message	Last-set	Last-clear	Detail
module_severity_0	false	0	Relay failure and requires service	00:00:00	08:13:40	
module_severity_1	false	1	Relay degraded and should be serviced	00:00:00	08:13:41	
relay_api_timeout	false	1	Relay internal API failure. Power cycle and then service if not resolved	08:05:55	12:39:47	
relay_in_scan_mode	false	2	Relay is in scan_mode. Disable scan_mode and reboot for normal operation.	00:01:00	10:52:17	
module_severity_2	false	3	Relay warning	00:00:00	08:13:42	
relay_pci_lock_attach_fail	false	3	PCI locked cell is unreachable.	06:28:13	09:33:45	

DL module Alarms

Name	State	Severity	Message	Last-set	Last-clear	Detail
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UL module Alarms

Name	State	Severity	Message	Last-set	Last-clear	Detail
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Figure 29 - Alarms Screen

Note: In V33 of the Relay software many alarms will be shown with State=False that have never been activated. These alarms can be ignored.