StreamCaster MIMO Radio

User Manual

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Revision History

Version	Date	Changes
1.0	September, 2012	Original
1.1	October 9, 2012	Minor Fixes
2.0	January 9, 2012	Updated for StreamScape 2.0
2.1	March 15, 2012	Updated Sensitivity Values. Added cable pinouts
2.2	May 23, 2013	Updated cable pinouts section
2.3	June 5, 2013	Added Tri-Color LED info
3.0	July 1, 2013	Updated for StreamScape 3.0
3.1	July 23, 2013	Minor Fixes
3.2	September 3, 2013	Added Link Characteristics
3.3	January 17, 2014	Updated Throughput in Tables 6 and 7
3.4	February 24, 2014	Updated through release SS3vb9.17
3.5	April 1, 2014	Updated to include SC3822

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1. Introduction

The StreamCaster family of MIMO radios was designed with operator ease of use in mind. Each radio is capable of operating in a multitude of configurations that are accessed via simple web pages within the radio. Settings such as transmit power, frequency, channel bandwidth, link adaptation and range control can be accessed by simply using a web browser to log into any radio within the network. This quick start user guide contains all essential information for the user to configure the StreamCaster radio and to also run an iperf network test.

2. StreamCaster Network

Each StreamCaster MIMO radio has a fixed static IP address in the 172.20.0.0 network. The radio operates as a network switch; the user equipment does not need to be on the same subnet as the radio during operation. It is possible to setup a secondary IP address on the radio if the user finds this feature convenient. Setting up a secondary IP address is useful if the user wishes to access the radio's web interface in their network.

3. Hardware Overview

3.1 StreamCaster Hardware Interface

SC3822:

Figure 1 StreamCaster 3822 Ruggedized Enclosure

1 RF channels 1-2 connectors [SMA Female]

2 USB/GPIO connector [Hirose LF10WBRB-12SD]

3 Tri-Color Status LED

- Red – Radio is in the process of booting up
- Orange – Radio is fully booted but not wirelessly connected to any other radio
- Green – Radio is wirelessly connected to at least one other radio

4 Power (9-32 VDC), Ethernet, and Serial Port connector [Hirose LF10WBRB-12PD]

SC3500/SC3800:

Figure 2 StreamCaster 3500/3800 Ruggedized Enclosure

1 RF channels 1-4 connectors [TNC Female]

2 Ethernet connector [Mighty-Mouse 801 Heavy Duty]

3 Power (9-20 VDC) and Serial Port connector [Mighty-Mouse 801 Heavy Duty]

4 Tri-Color Status LED

- Red – Radio is in the process of booting up
- Orange – Radio is fully booted but not wirelessly connected to any other radio
- Green – Radio is wirelessly connected to at least one other radio

5 Power Switch

3.2 Connector Pinouts

SC3822:

- OEM Power/Ethernet/Serial Connector: FPC Connector 1 (AYF534065). (See Figure 3 below)
- OEM USB/GPIO Connector: FPC Connector 2 (AYF532265)
- OEM LED Connector: Molex (781710003)
- Enclosure Power/Ethernet/Serial Connecter: Hirose (LF10WBRB-12PD)
- Enclosure USB/GPIO Connecter: Hirose (LF10WBRB-12SD)

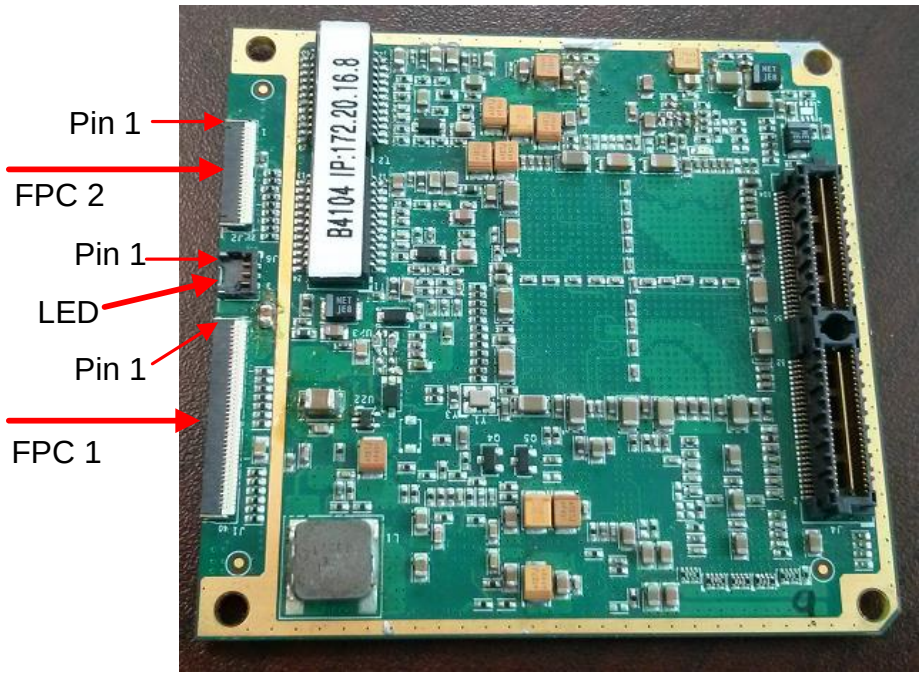


Figure 3 SC3822 Digital Board OEM Connectors

SC3500/SC3800:

- OEM Power/Ethernet/Serial Connectors: Harwin M80 8-pin male (M80-8530842). (See Figure 2 below)
- Enclosure Power/Serial Connecter: Mighty-Mouse 801 male (801-010-07NF7-10PA)
- Enclosure Ethernet Connecter: Mighty-Mouse 801 female (801-010-07NF7-10SA)

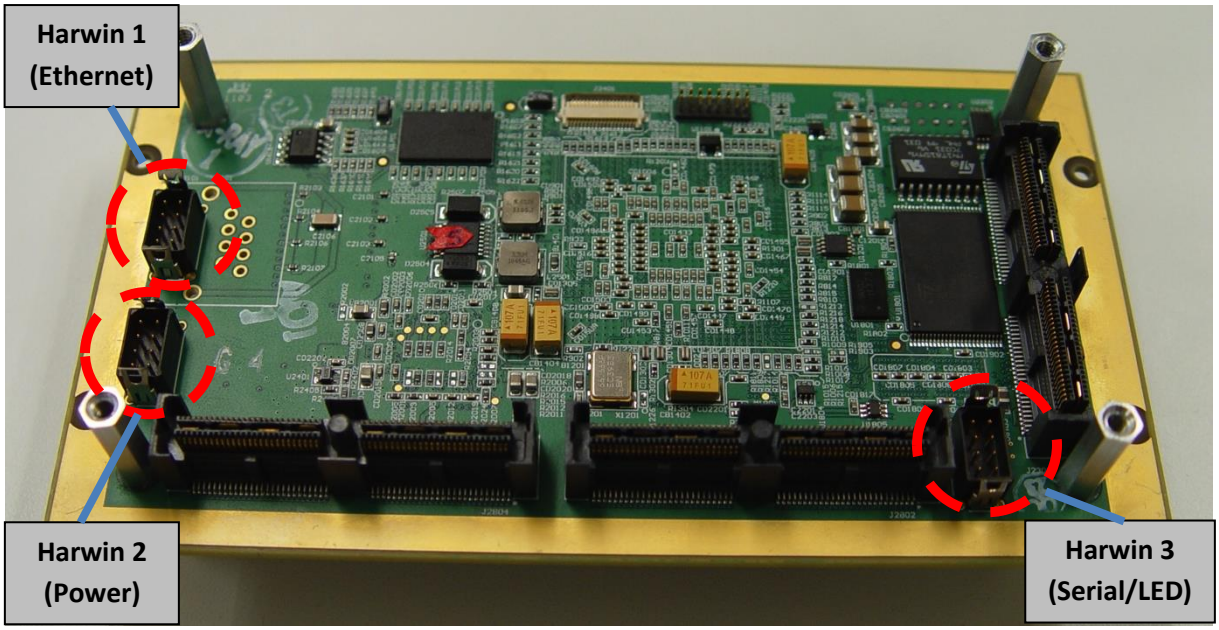


Figure 4 SC3500/SC3800 OEM Connectors

3.2.1 SC3822 Pinouts

SC3822 Power/Ethernet/Serial Connector Pinout			
Enclosure PWR/COMM (LF10WBRB-12PD)	Signal	Switchcraft Pinout (EN3C2F16X)	OEM FPC Connector 1
1	3.3V OUT	NC	21-23
2	GND IN	2	11-15
3	GND IN	2	16-20
4	VCC IN	1	1-5
5	VCC IN	1	6-10
6	100-Base T ETH0 M2N	NC	34
7	100-Base T ETH0 M2P	NC	33
8	100-Base T ETH0 M1P	NC	31
9	RS232_RXD	NC	26
10	RS232_TXD	NC	24
11	RS232_GND	NC	NC
12	100-Base T ETH0 M1N	NC	32

Table 1 SC3822 Power/Ethernet/Serial Connector Pinout

SC3822 RS-232 and PS/2 (GPS) Pinout				
RS-232	PS/2 (GPS)	Signal	Switchcraft Pinout	OEM FPC Connector 1
3	4	TxD	2	24
2	5	RxD	1	26
7	NC	RTS	4	NA
NC	2	3.3V	6	21-23
8	NC	CTS	5	NA
5	1	Ground	3	NA

Table 2 SC3822 Serial and GPS Pinout

SC3822 USB/GPIO Connector Pinout		
Enclosure USP/GPIO (LF10WBRB-12PD)	**Signal**	**OEM FPC Connector 2**
1	USB_GND	11-12
2	USB_D-	14
3	USB_5V	NC
4	NC	NC
5	GPIO1	1
6	GPIO2	2
7	GPIO3	3
8	3.3V	5-7
9	GND	8-10
10	USB_Sense	13
11	USB_D+	15
12	GPIO4	4

Table 3 SC3822 USB/GPIO Connector Pinout

SC3822 Extension Connector Pinout		
Pin #	**Signal**	**Notes**
1-6	VCC_IN	9V - 36V. These pins are directly wired to the VCC_IN on FPC 1.
7-10	GPIO1 – GPIO4	These GPIOs are directly wired to the GPIOs on FPC connector 2.
11-19	Reserved for Testing	Do Not Connect
20	CPU Reset (3.3V)	Wired to PS_SRST_EXT signal on FPC 1
21-54	Reserved for Testing	Do Not Connect
55	GND	
56	ETH1_MX4N	Second Gigabit Ethernet Interface
57	ETH1_MX4P	
58	ETH1_MX3N	
59	ETH1_MX3P	
60	ETH1_MX2N	
61	ETH1_MX2P	
62	ETH1_MX1N	
63	ETH1_MX1P	
64	GND	
65-68	Reserved for Testing	Do Not Connect

Table 4 SC3822 Extension Connector Pinout

3.2.2 SC3500/SC3800 Pinouts

SC3500/3800 Power Connector Pinout			
Enclosure Pinout (801-010-07NF7-10PA)	Signal	Switchcraft Pinout (EN3C2F16X)	OEM Harwin 2 Pinout
1	12V Power Return	2	7
2	12V Power Return	2	8
3	12V Power	1	1
4	12V Power	1	2
5	TxD	For Serial Comm.	NC
6	RxD	For Serial Comm.	NC
7	RTS	For Serial Comm.	NC
8	CTS	For Serial Comm.	NC
9	Ground	For Serial Comm.	NA
10	NC	NC	NA

Table 5 SC3500/SC3800 Power Connector Pinout

SC3500/3800 Ethernet Connector Pinout			
Enclosure Pinout (801-010-07NF7-10SA)	Signal	RJ45 Pinout	OEM Harwin 1 Pinout
1	WHT/BLU	5	5
2	WHT/BRN	7	7
3	BRN	8	8
4	ORG	2	2
5	WHT/GRN	3	3
6	WHT/ORG	1	1
7	BLU	4	4
8	GRN	6	6
9	NC	NC	NC
10	NC	NC	NC

Table 6 SC3500/SC3800 Ethernet Connector Pinout

SC3500/3800 RS-232 and PS/2 (GPS) Pinout				
RS-232	PS/2 (GPS)	Signal	Switchcraft Pinout	OEM Harwin 3 Pinout
3	4	TxD	2	1
2	5	RxD	1	2
7	NC	RTS	4	3
NC	2	NC	6	NC
8	NC	CTS	5	4
5	1	Ground	3	5
NA	NA	LED Ground	NA	6
NA	NA	Green	NA	7
NA	NA	Red	NA	8

Table 7 SC3500/SC3800 Serial and GPS Pinout

3.3 Mechanical and Operating Specifications

SC3822:

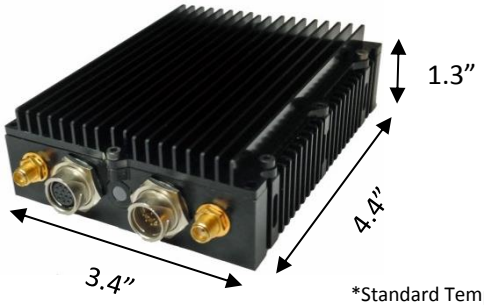
Environmental

	Standard Temperature	Extended Temperature
• **Operating Temp.**	-40° - +55° C	-40° - +65° C
• **IP Rating (Ingress Protection)**	IP-67 (Dust / Immersion in water up to 1m)*	

*Must have all connectors mated

Mechanical – Chassis

	Standard	Extended Temperature
• **Dimensions**	4.4" x 3.4" x 1.3"	4.4" x 3.4" x 2.0"
• **Weight**	1.0 Pounds	1.2 Pounds
• **Color**	a. Black anodized b. FED-STD-595B-34094 (green 383)	
• **Mounting**	4-hole mounting patterns (Through-hole)	



*Standard Temperature enclosure shown.
Extended Temp has height of 2".

Connectors

- **RF** — SMA (f) (2 each)
- **Data / Control** — Ethernet (Gigabit for OEM, 100 Base-T for Enclosed), RS232, USB
- **Power** — Hirose LF Series Circular Connector (Front Panel)
  Samtec QSH (Expansion)

Controls and Indicators

- **Status Indicator** — Tri-Color LED

Power Requirements

- **Voltage** — 9 – 32 VDC
- **Consumption** — 6W – 16W (Duty Cycle and Frequency Dependent)

Mechanical – OEM Board Stack

- **Dimensions** — 3.3" x 2.9" x 0.5" L x W x H
- **Weight** — 3 oz
- **RF Connector** — SMP (m)

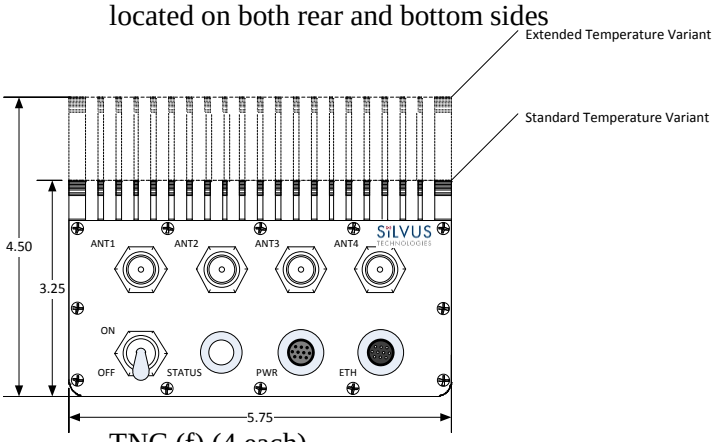
SC3500/SC3800:

Environmental

	Standard	Extended Temperature
• **Operating Temp.**	-40° - +55° C	-40° - +65° C
• **IP Rating (Ingress Protection)**	IP-67 (Dust / Immersion in water up to 1m)	

Mechanical – Chassis

	Standard	Extended Temperature
• **Dimensions**	3.25” x 5.75” x 4”	4.5” x 5.75” x 4”
• **Weight**	3.7 Pounds	4.0 Pounds
• **Color**	c. FED-STD-595B-34094 (green 383) d. Black anodized e. CARC (Chemical Agent Resistant Coating)	
• **Mounting**	4-hole mounting patterns (non-penetrating) located on both rear and bottom sides	



Connectors

- **RF** TNC (f) (4 each)
- **Data / Control** Ethernet cable, Mighty-Mouse 801 Heavy-Duty, Double-Start 10
- **Power** Mighty-Mouse 801 Heavy-Duty, Double-Start 10 conductor (m) (RS232 / GPS Support)

Controls and Indicators

- **Power** On / Off Toggle with detent
- **Status Indicator** Tri-Color LED

Power Requirements

- **Voltage** 9 – 20 VDC
- **Consumption** 12W – 22.5W (Duty Cycle and Frequency Dependent)

Mechanical – OEM Board Stack

- **Dimensions** 1.9” x 5.25” x 2.9” H x L x W
- **Weight** 8 oz
- **RF Connector** SMP (m)
- **Data Connector** Harwin M80 8-pin (m), (RS232/GPS optional)
- **Power Connector** Harwin M80 8-pin

3.3.1 SC3500/SC3800 Phase II Enclosure Mounting Pattern

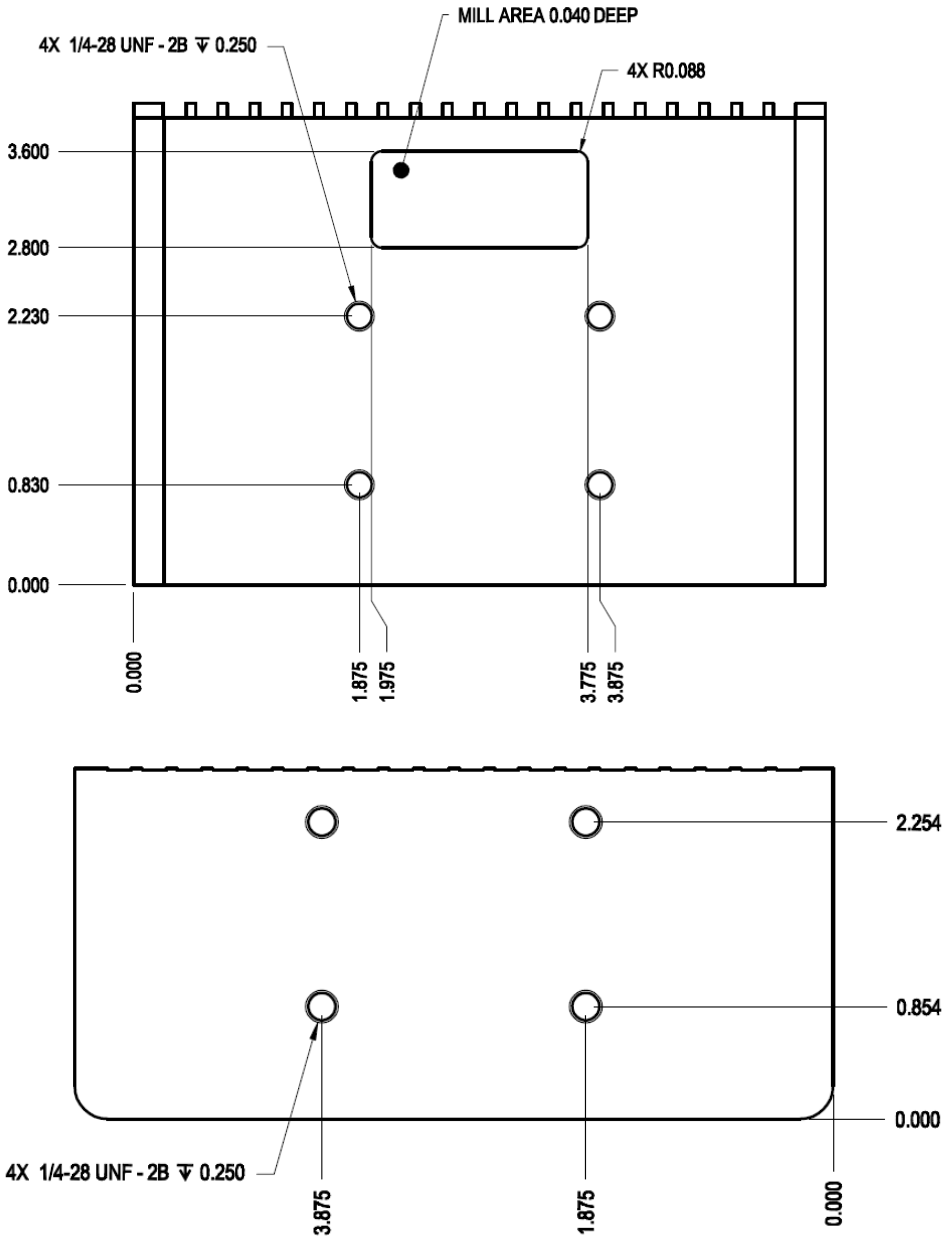


Figure 5 SC3500/SC3800 Phase II Enclosure Mounting Pattern for Back of Enclosure (top) and Bottom of Enclosure (bottom)

3.3.2 SC3500/ SC3800 Phase III Enclosure Mounting Pattern

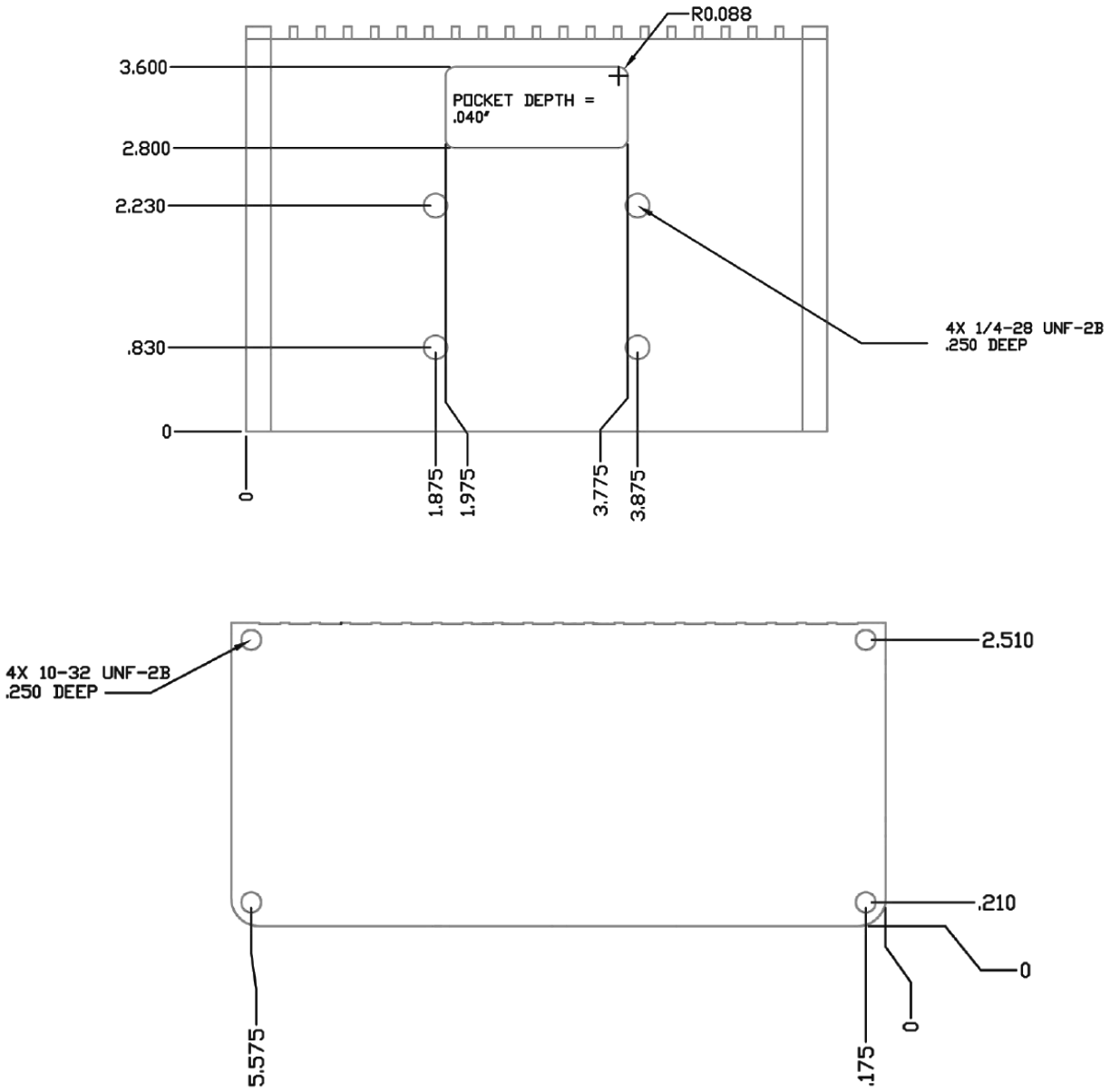


Figure 6 SC3500/SC3800 Phase III Enclosure Mounting Pattern for Back of Enclosure (top) and Bottom of Enclosure (bottom)

3.4 SC3822 Specifications

General

- **Radio Type** — MIMO Coded-OFDM
- **Subcarrier Modulation** — BPSK, QPSK, 16-QAM, 64-QAM
- **Channel Bandwidth** — 5 & 20 MHz (1.25* MHz, 2.5* MHz, 10* MHz)
- **Encryption** — DES Standard, AES 128/256 Optional (FIPS 140-2)
- **Frequency Stability** — 1 PPM over temp -40° - +85° C
- **Tuning Step Size** — 1 KHz
- **Data Rates** — 80 Mbps UDP & 65 Mbps TCP
- **MAC Protocols (Medium Access Control)** — TDMA, CSMA, TPMA
- **Error Correction** — 1/2, 2/3, 3/4, 5/6
- **Antenna Processing** — Spatial Multiplexing, Space-Time Coding, RX Eigen Beam Forming
- **No. of Spatial Streams** — 1-2
- **No. of Antennas** — 2
- **Total Power Output** — 10mW – 500mW (variable)

Performance

- **Latency** — 7 ms average
- **Sensitivity** — Varies with MCS index
  Maximum = -99 dBm (5MHz BW, MCS0)

Frequency Band Specifics

Please note, this table reflects standard frequency bands available, additional bands are frequently added as demands dictate. If your band of interest is not listed, please contact your sales person. (All bands listed in MHz)

Low Band		High Band		
UHF	400-450 *			
ISM 900	902-928 *	**1**	**C-1 Band**	4400-4700
L Band	1350-1390	**2**	**C-2 Band**	4700-4994
BAS	1980-2200 *	**3**	**C-3 Band**	4900-5275 *
Federal 'S'	2200-2500	**4**	**C-4 Band**	5727-5852
ISM2400	2400-2500 *			

Footnote: (*) in development

3.5 SC3500 Specifications

General

- **Radio Type** — MIMO Coded-OFDM
- **Subcarrier Modulation** — BPSK, QPSK, 16-QAM, 64-QAM
- **Channel Bandwidth** — 5 & 20 MHz
- **Encryption** — AES 128 or AES 256 (optional)
- **Frequency Stability** — 1 PPM over temp -40° - +85° C
- **Tuning Step Size** — 1 KHz
- **Data Rates** — 75 Mbps UDP & 60 Mbps TCP
- **MAC Protocols (Medium Access Control)** — TDMA, CSMA, TPMA
- **Error Correction** — 1/2, 2/3, 3/4, 5/6
- **Antenna Processing** — Spatial Multiplexing, Space-Time Coding, Eigen Beam Forming
- **No. of Spatial Streams** — 1-4
- **No. of Antennas** — 4
- **Total Power Output** — 10mW – 1W (variable)

Performance

- **Latency** — 7 ms average
- **Sensitivity** — Varies with MCS index
Maximum = -102 dBm (5 MHz BW, MCS 0)

Frequency Band Specifics

	S Band	C Band
Frequency Code '243541'	2.385 – 2.490 GHz	4.960 – 5.875 GHz
Frequency Code '243578'	2.427 – 2.447 GHz	5.745 – 5.830 GHz

3.6 SC3800 Specifications

General

- **Radio Type** — MIMO Coded-OFDM
- **Subcarrier Modulation** — BPSK, QPSK, 16-QAM, 64-QAM
- **Channel Bandwidth** — 5 & 20 MHz (1.25* MHz, 2.5* MHz, 10* MHz)
- **Encryption** — AES 128 or AES 256 (optional)
- **Frequency Stability** — 1 PPM over temp -40° - +85° C
- **Tuning Step Size** — 1 KHz
- **Data Rates** — 75 Mbps UDP & 60 Mbps TCP
- **MAC Protocols (Medium Access Control)** — TDMA, CSMA, TPMA
- **Error Correction** — 1/2, 2/3, 3/4, 5/6
- **Antenna Processing** — Spatial Multiplexing, Space-Time Coding, RX Eigen Beam Forming
- **No. of Spatial Streams** — 1-4
- **No. of Antennas** — 4
- **Total Power Output** — 10 mW – 1 W (variable)

Performance

- **Latency** — 7 ms average
- **Sensitivity** — Varies with MCS index
  Maximum = -102 dBm (5MHz BW, MCS 0)

Frequency Band Specifics

Please note, this table reflects standard frequency bands available, additional bands are frequently added as demands dictate. If your band of interest is not listed, please contact your sales person. (All bands listed in MHz)

Low Band		High Band		
UHF	400-450 *			
ISM 900	902-928 *	**1**	**C-1 Band**	4400-4700
L Band	1350-1390	**2**	**C-2 Band**	4700-4994
BAS	1980-2200 *	**3**	**C-3 Band**	4900-5275 *
Federal 'S'	2200-2500	**4**	**C-4 Band**	5727-5852
ISM2400	2400-2500 *			

Footnote: (*) in development

4. Web Interface

4.1 Getting Started

Connect a laptop to the StreamCaster radio using the supplied Ethernet cable and turn on the radio. Users can type "ping <IPaddress>" in order to determine whether the radio is fully booted. A web configuration will then be available by typing the radio IP address in a web browser. Please ensure that your laptop is on the same subnet as the radio (172.20.xx.xx by default). Users will be directed to the Basic Configuration page. (See **Figure 7**)

4.1.1 Basic Configuration

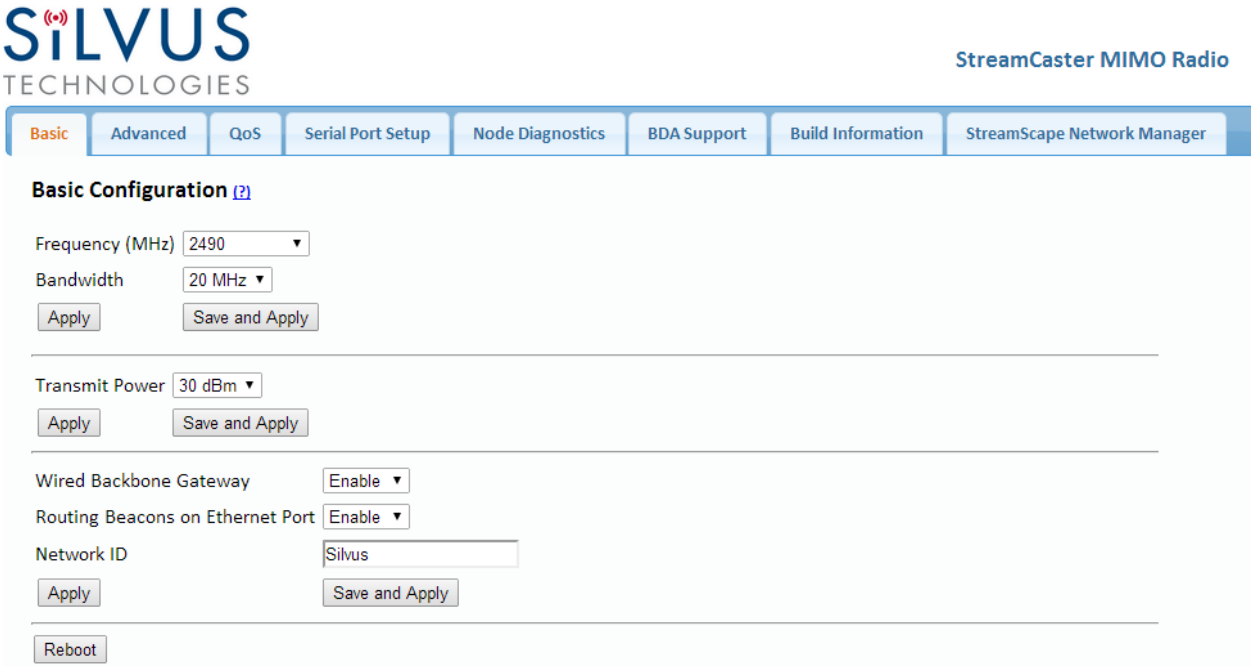


Figure 7 Basic Configuration Page

This page is used to set basic configurations. A brief description of each parameter is given below.

- **Frequency**: This defines the frequency of the signal. There is a drop-down menu for frequency selection. The frequency choices will vary depending on the StreamCaster variant you are using (SC3500 or SC3800).
- **Bandwidth**: This defines the RF bandwidth of the signal.

- **Apply**: Apply the new frequency and bandwidth values. Frequency and bandwidth will change back to the default settings after a reboot.

- **Save and Apply**: The new value for the frequency and bandwidth will be set as the default value.

- **Transmit Power**: This defines the total power of the signal (power is divided equally between the 4 ports).

- **Apply**: Apply the new transmit power value. Value will change back to the default setting after reboot.

- **Save and Apply**: Set the new transmit power as the default value.

- **Wired Backbone Gateway**: This setting pertains to wired backbone functionality (See Section 5: Wired Backbone) For normal operation, set Wired Backbone Gateway to enable. If multiple radios will be connected to a wired backbone, only one radio should be enabled as a Wired Backbone Gateway and all others on the wireline should be disabled.

- **Routing Beacons on Ethernet Port**: For radios to be able to communicate and transfer data over a wired link, routing information needs to be sent over the wireline. These packets are broadcast packets that are sent even if there is only one radio on the network. If wired backbone is not being utilized, the user can disable these routing beacons to prevent loading their local network with these routing packets.

- **Network ID**: Network ID allows for clusters of radios to operate in the same channel, but remain independent. A radio with a given Network ID will only communicate with other radios with the same Network ID.

- **Apply**: Apply the new Gateway value. Value will change back to the default setting after reboot.

- **Save and Apply**: Set the new Gateway power as the default value.

4.1.2 Advanced Configuration

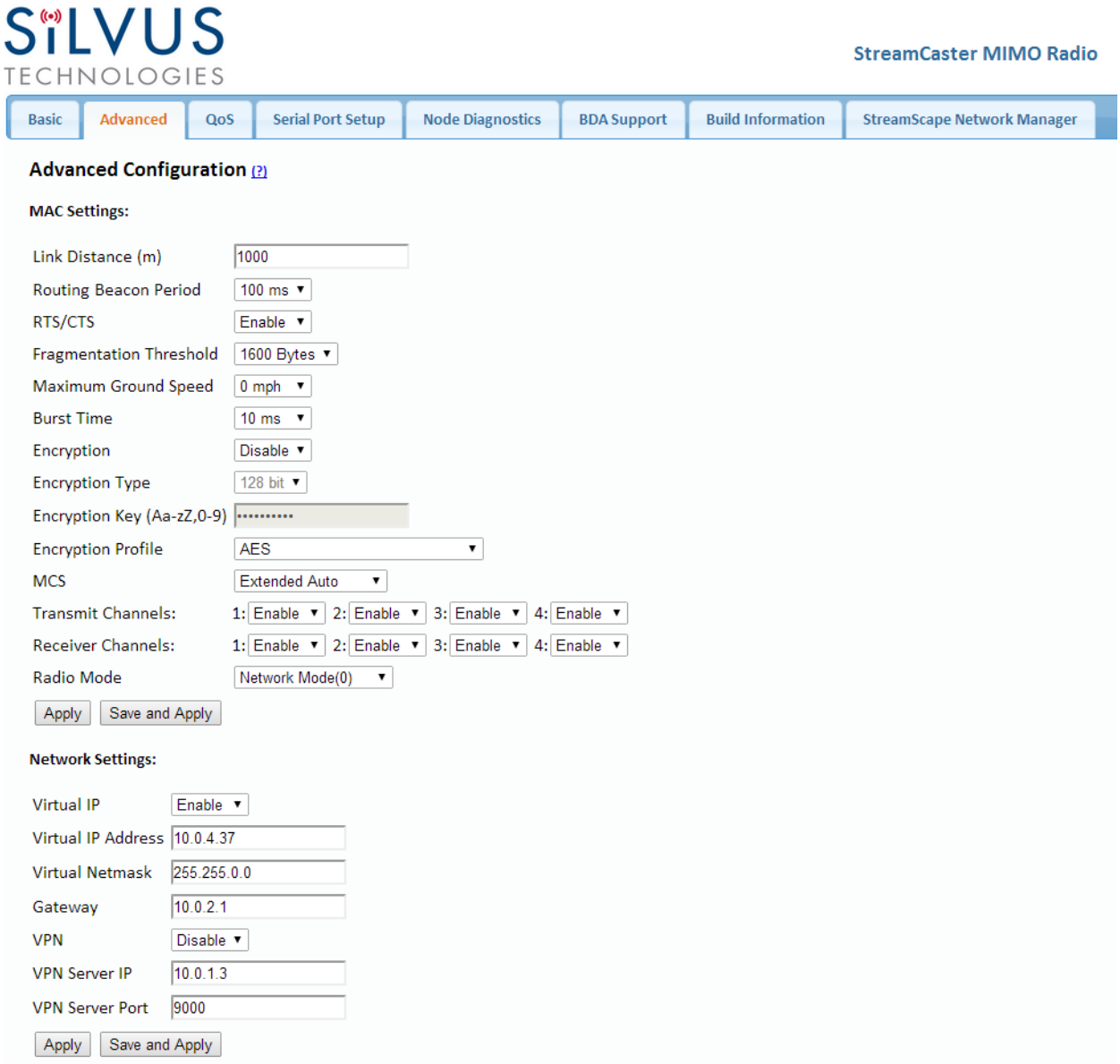


Figure 8 Advanced Configuration Page

This page is used to set advanced configurations. A brief description of each parameter is given below.

MAC Settings:

- **Link Distance**: Set to an approximate maximum distance between any two nodes in meters, e.g., 1000 for 1km (default). It is important to set the link distance to allow enough time for packets to propagate over the air. Failing to set the link distance to an approximate maximum distance can result in over the air collisions and a degradation of performance for links beyond 2 kilometers. Overestimating link distance may result in a slight degradation of link efficiency.

- **Routing Beacon Period**: Controls how often routing beacons are sent to other radios. A lower Routing Beacon Period results in faster reaction to topology changes. A lower Routing Beacon Period also adds more overhead to the network which scales with the number of nodes in the network. For larger networks, a larger Routing Beacon Period is recommended. Default value is 100ms.

- **RTS/CTS**: Enable or disable RTS/CTS (Request-to-Send/Clear-to-Send). When enabled, a node wishing to send data initiates the process by sending a request to send message. The destination node replies with a clear to send message. Any other node that receives the RTS or CTS message will refrain from sending data for a given time. This protocol helps to avoid collisions in networks consisting of 3 or more nodes. For long range point-to-point links, it may be beneficial to disable this feature.

- **Fragmentation Threshold**: Allows user to determine the minimum over-the-air packet size in bytes. Smaller packet size can improve performance in high mobility while a larger packet size will allow for more throughput. (1600 bytes default).

- **Maximum Ground Speed**: This setting improves performance in high mobility scenarios where the wireless channel may change rapidly. Setting this value to an unnecessarily high value may have an impact as high as 25 percent on overall achievable throughput.

- **Burst Time**: The burst time determines the maximum amount of time each node is allowed to transmit at once. A larger burst time will provide higher throughput at the cost of higher latency. On the other hand, a smaller burst time will provide less latency at the cost of less throughput. The throughput values shown in **Table 8** and **Table 9** assume the minimum burst time

- **Encryption**: Enable or disable AES encryption.

- **Encryption Type**: Choose between AES 128-bit and 256-bit encryption

- **Encryption Key**: Set an encryption key if encryption is enabled.

- **MCS**: Choose the modulation and coding scheme (MCS). If this is set as AUTO, the radio will dynamically cycle between a subset of the modes depending on the quality of the link. This is the recommended setting for most users and will provide the maximum

data rate that the link can support. The EXTENDED AUTO mode includes some additional modes on top of those included in the AUTO mode. EXTENDED AUTO is currently a beta feature. Due to the small increase in overhead associated with the AUTO/EXTENDED AUTO modes, in some cases it may be beneficial for the user to set the MCS to a specific value if the data rate is known. **Table 8** and **Table 9** below show the estimated UDP data rate and sensitivity for each MCS. This table assumes a 20MHz bandwidth, 1000 meter link distance and 1600 byte fragmentation threshold.

- **Transmit Channels:** Allows user to Enable or Disable each channel on the radio for TX.

- **Receiver Channels:** Allows user to Enable or Disable each channel on the radio for RX.

- **Radio Mode**: Switch between Network mode and PHY Diagnostics. If the value equals 0, it is in Network mode; if the value equals 1, it is in PHY Diagnostics. PHY Diagnostics mode is only relevant for users who wish to run diagnostic tests on the radio.

- **Apply**: Applies the new values but does not save them to flash.

- **Save and Apply**: Save the new values to flash and apply.

Network Settings:

- **Virtual IP**: Enable or Disable the Secondary IP address for the radio.

- **Virtual IP Address**: Secondary IP address for the radio. The user may set this to be on the user's IP network, e.g., 192.168.2.10. Once this secondary IP address is set, the user may access the radio web page using either the native IP address or the secondary IP address. Please note that the secondary IP address should NOT be on the 172.20.xx.xx subnet.

- **Virtual Netmask**: Netmask for the Secondary IP address, e.g. 255.255.255.0.

- **Virtual Gateway:** Gateway for local network to allow radio to connect to the internet

- **VPN:** For WAN wired backbone scenarios where radios from two different sites are connected via the internet, a public N2N server is needed to route the data. Here is an example of how to setup an N2N server on a server hosted by Amazon AWS running Ubuntu 12.04:

  Compile:
  git clone https://github.com/lukablurr/n2n_v2_fork ### downloads the code
  cd n2n_v2_fork
  export N2N_OPTION_AES=no
  make clean
  make

Execute:
./supernode -l 9000 -v

Server will be running on port 9000.

- **VPN Server IP**: IP Address of N2N VPN Server
- **VPN Server Port**: Port that the N2N VPN server is configured to listen on.
- **Apply**: Applies the new values but does not save them to flash.
- **Save and Apply**: Save the new values to flash and apply.

Modulation Modes and Receiver Sensitivity

- Note that listed sensitivity values were measured using a controlled and cabled setup. Actual results may vary by +/- 2dB. Table assumes link distance of 1000m, 10ms burst time and 1600 byte Fragmentation Threshold.
- * Modes supported under the AUTO MCS option.
- * Modes supported under the EXTENDED AUTO MCS option in addition to AUTO MCS modes. This is currently a Beta feature.
- * Modes that are not currently supported.
- All other modes are supported as a fixed MCS option

Mode	NSS	MCS	Coding Rate	PHY Throughput (Mbps)	UDP User Throughput (Mbps)	SC3500/SC3800 Sensitivity	SC3822 Sensitivity
1	1	0	BPSK 1/2	1.625	1.03	-102	-99
2	1	1	QPSK 1/2	3.25	2.06	-100	-97
3	1	2	QPSK 3/4	4.875	3.09	-97	-94
4	1	3	16-QAM 1/2	6.5	4.12	-95	-92
5	1	4	16-QAM 3/4	9.75	6.18	-92	-89
6	1	5	64 QAM 2/3	13	8.25	-87	-84
7	1	6	64 QAM 3/4	14.625	9.28	-85	-82
8	1	7	64 QAM 5/6	16.25	10.30	-80	-77
9	2	8	BPSK 1/2	3.25	2.06	-100	-97
10	2	9	QPSK 1/2	6.5	4.12	-97	-94
11	2	10	QPSK 3/4	9.75	6.18	-94	-91
12	2	11	16-QAM 1/2	13	8.25	-91	-89
13	2	12	16-QAM 3/4	19.5	12.38	-88	-85
14	2	13	64 QAM 2/3	26	16.21	-84	-81
15	2	14	64 QAM 3/4	29.25	17.62	-82	-79
16	2	15	64 QAM 5/6	32.5	18.94	-77	-74
17	3	16	BPSK 1/2	4.875	3.09	-98	N/A
18	3	17	QPSK 1/2	9.75	6.18	-95	N/A
19	3	18	QPSK 3/4	14.625	9.28	-92	N/A
20	3	19	16-QAM 1/2	19.5	12.38	-90	N/A
21	3	20	16-QAM 3/4	29.25	17.62	-86	N/A
22	3	21	64 QAM 2/3	39	21.31	-81	N/A
23	3	22	64 QAM 3/4	43.875	22.94	-79	N/A
24	3	23	64 QAM 5/6	48.75	24.42	-74	N/A
25	4	24	BPSK 1/2	6.5	4.12	-97	N/A
26	4	25	QPSK 1/2	13	8.25	-94	N/A
27	4	26	QPSK 3/4	19.5	12.38	-91	N/A
28	4	27	16-QAM 1/2	26	16.21	-88	N/A
29	4	28	16-QAM 3/4	39	21.31	-84	N/A
30	4	29	64 QAM 2/3	52	25.36	-79	N/A

Table 8 MCS vs. Sensitivity Chart (5MHz Bandwidth)

Mode	NSS	MCS	Coding Rate	PHY Throughput (Mbps)	UDP User Throughput (Mbps)	SC3500/SC3800 Sensitivity	SC3822 Sensitivity
31	1	0	BPSK 1/2	6.5	4.92	-96	-93
32	1	1	QPSK 1/2	13	9.82	-94	-91
33	1	2	QPSK 3/4	19.5	14.73	-91	-88
34	1	3	16-QAM 1/2	26	19.65	-89	-86
35	1	4	16-QAM 3/4	39	29.47	-86	-83
36	1	5	64 QAM 2/3	52	39.29	-82	-79
37	1	6	64 QAM 3/4	58.5	44.20	-80	-77
38	1	7	64 QAM 5/6	65	47.45	-78	-75
39	2	8	BPSK 1/2	13	9.82	-94	-91
40	2	9	QPSK 1/2	26	19.65	-91	-88
41	2	10	QPSK 3/4	39	29.47	-88	-85
42	2	11	16-QAM 1/2	52	39.29	-86	-83
43	2	12	16-QAM 3/4	78	57.04	-82	-79
44	2	13	64 QAM 2/3	104	75.00	-79	-76
45	2	14	64 QAM 3/4	117	75.00 (85.00 for SC3822)	-77	-74
46	2	15	64 QAM 5/6	130	75.00 (85.00 for SC3822)	-75	-72
47	3	16	BPSK 1/2	19.5	14.73	-92	N/A
48	3	17	QPSK 1/2	39	29.47	-89	N/A
49	3	18	QPSK 3/4	58.5	44.20	-86	N/A
50	3	19	16-QAM 1/2	78	59.05	-84	N/A
51	3	20	16-QAM 3/4	117	75.00	-80	N/A
52	3	21	64 QAM 2/3	156	75.00	-76	N/A
53	3	22	64 QAM 3/4	175.5	75.00	-74	N/A
54	3	23	64 QAM 5/6	195	75.00	-72	N/A
55	4	24	BPSK 1/2	26	19.65	-91	N/A
56	4	25	QPSK 1/2	52	39.29	-88	N/A
57	4	26	QPSK 3/4	78	59.05	-85	N/A
58	4	27	16-QAM 1/2	104	75.00	-82	N/A
59	4	28	16-QAM 3/4	156	75.00	-78	N/A
60	4	29	64 QAM 2/3	208	75.00	-74	N/A

Table 9 MCS vs. Sensitivity Chart (20MHz Bandwidth)

4.1.3 Quality of Service (QoS)

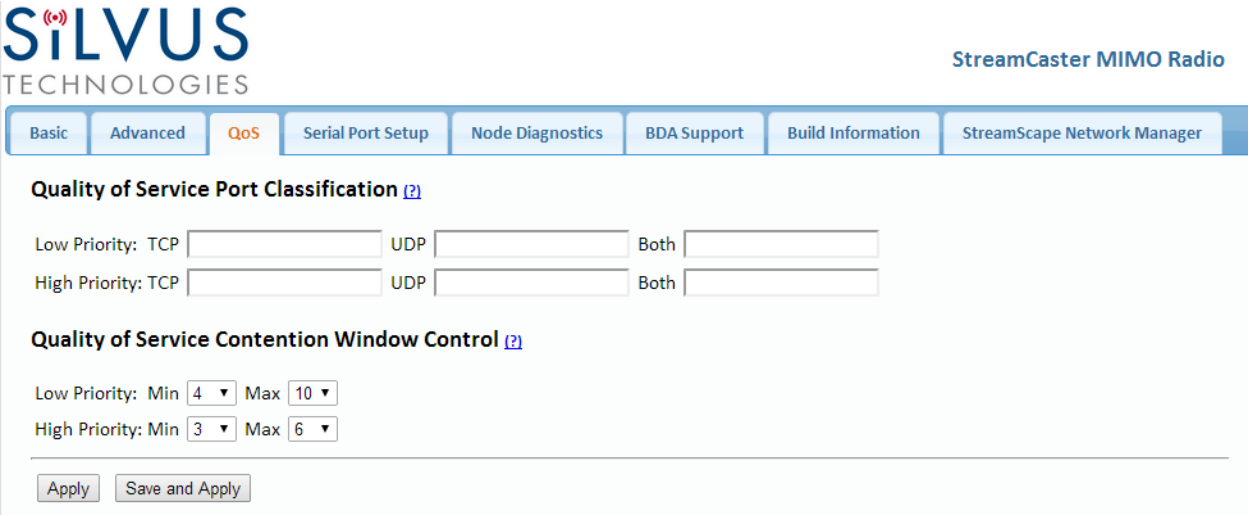


Figure 9 Quality of Service (QoS) Configuration Page

Quality of Service Port Classification:

The Quality of Service configuration page allows the user to make a distinction between low and high priority traffic transmitted through each radio. High priority traffic will always jump to the front of the queue and bypass any awaiting low priority traffic. In instances where the link cannot support the amount of data trying to be transmitted, low priority traffic may be completely shelved in order to ensure that the high priority traffic gets through.

To specify Low/High priority traffic, the user needs to simply input the port number that the traffic will be arriving on. Multiple ports of the same priority can be separated by a comma (i.e. 5001, 6001, 6002). Alternatively, the user can specify a range of ports using a dash (i.e. 5001-5006). Any combination of commas and dashes will work as well (i.e. 5001, 6001-6007, 8000). Any field can be cleared by removing the text and clicking 'Apply' or 'Save and Apply'. If unspecified, traffic is treated as Low Priority.

Quality of Service Contention Window Control:

The Quality of Service Contention Window Control tunes the aggressiveness of CSMA backoffs when collisions occur. The MAC takes random backoffs in the range [0, 2^cw_min]. Every time there is a collision/noise it will increase this cw_min by 1, until it is capped by cw_max.

E.g. 4,10 translates to random backoffs in the range [0,16] in the beginning for a packet. If the first try results in a collision, it will pick another backoff in the range [0,32], then [0,64], until [0,1024]. After successful transmission, backoff is reset to [0,16]. The default is 4,10 for low priority, and 3,6 for high priority. For larger networks, it is recommended to increase the Low Priority minimum to reduce the chance of collisions occurring.

4.1.4 Serial Port Setup

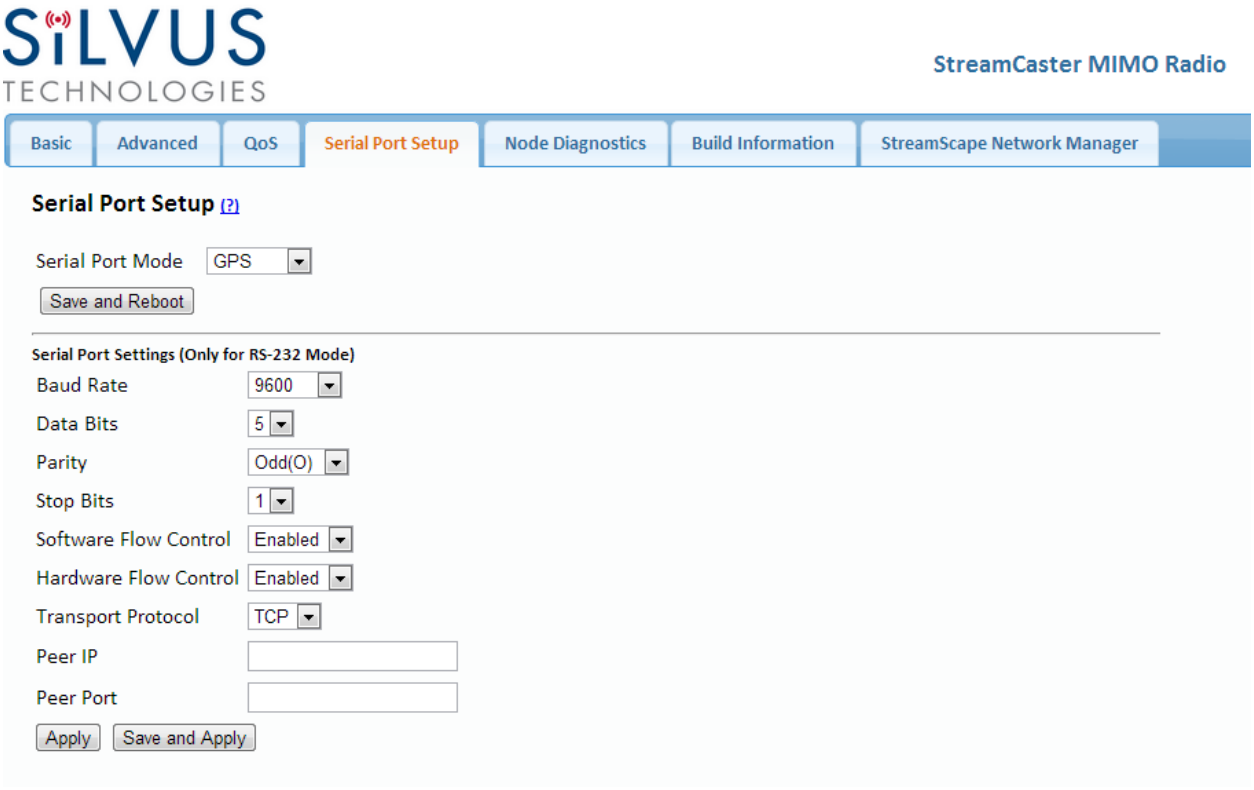


Figure 10 Serial Port Setup Configuration Page

Each StreamCaster is equipped with one user configurable serial port. A special power cable and null modem cable are required for access to the radio's serial port. A brief description of each parameter is given below.

- **Serial Port Mode**: The user can select one of four available modes for the serial port: *GPS*, *RS232*, *Console*, and *Disabled*.

    - ***GPS***: In GPS mode, an external GPS module (MR-350 GPS Receiver) can be connected to and powered from the serial port of the radio. A gpsd service daemon running on the node will make the GPS information available to any user on the network from TCP/IP port 2947. For more information on gpsd please see: http://catb.org/gpsd/

    - ***RS-232***: The RS-232 mode provides a wireless serial connection between any two serial devices connected to StreamCaster nodes on the network. In this mode, the user must configure the RS-232 protocol parameters shown in **Figure 10** above. The transport protocol for the serial data can be set as either TCP or UDP. For data that is sensitive to latency such as command and control data, UDP is recommended. For data that cannot tolerate any data loss, such as telemetry data, TCP is recommended.

- ***Console**:* The console mode is used to gain terminal access to the StreamCaster radio and is available for debug or interface purposes. The user's terminal client should be set to a baud rate of 115200 for console access to the radio.

- ***Disabled**:* This mode completely disables the serial terminal of the radio.

- **Apply**: Apply the new values but does not save them to flash.
- **Save and Apply**: Save the new values to flash and apply.

4.1.5 Node Diagnostics

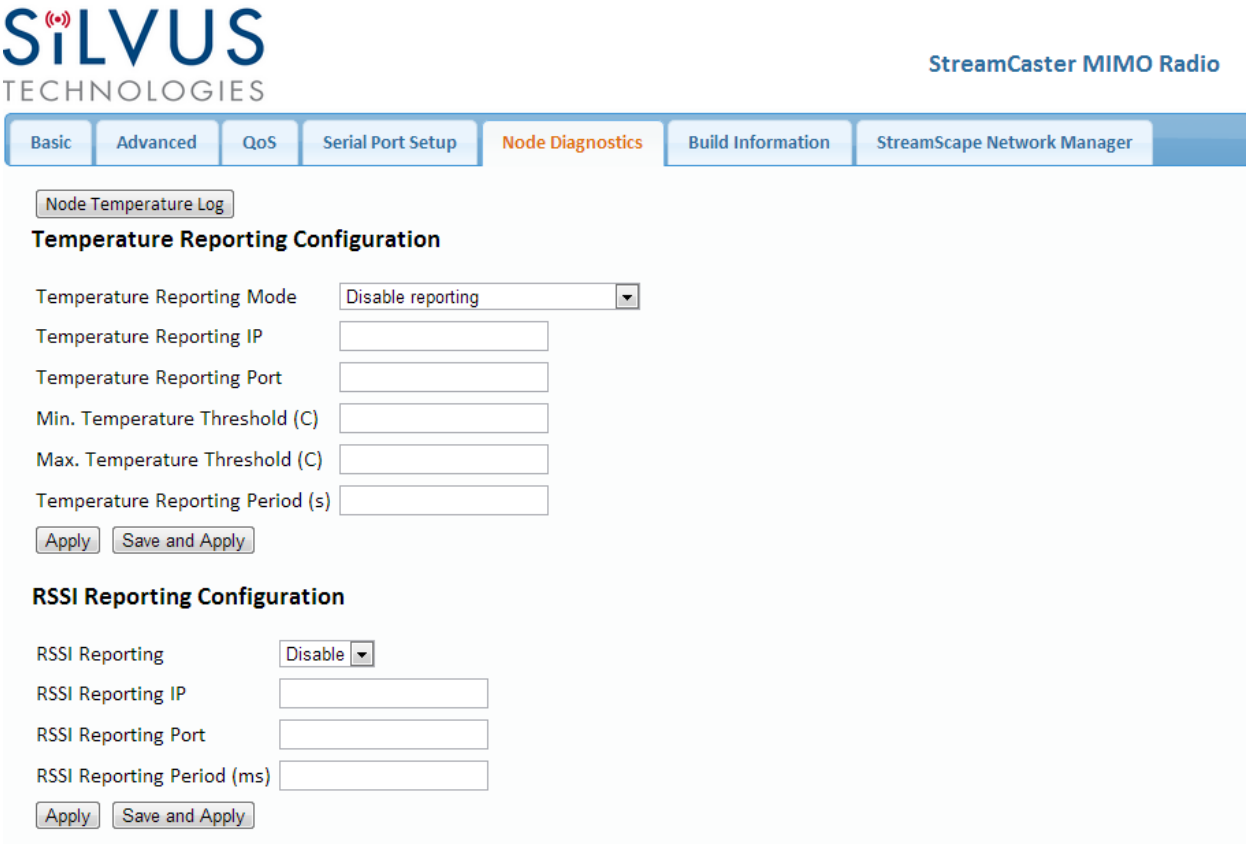


Figure 11 Node Diagnostics Configuration Page

The Node Diagnostics page allows the user to specify an IP and Port number for Temperature and RSSI (Receiver Signal Strength Indication) reports to be delivered to. This is useful for users that intend to feed this information into some other platform for analysis and recording. Section 6 gives more information on the format of streaming reports.

Temperature Thresholds:

In addition to receiving temperature reports, this page can be used to set minimum and maximum temperature thresholds for the radio. The StreamCaster™ family of radios is equipped with on board temperature sensors which are monitored to prevent overheating. Once a radio reaches the maximum temperature threshold, the radio will begin to reduce its transmission time until the temperature falls below the minimum temperature threshold. By default, the min and max values are 75C and 85C respectively.

4.1.6 BDA Support

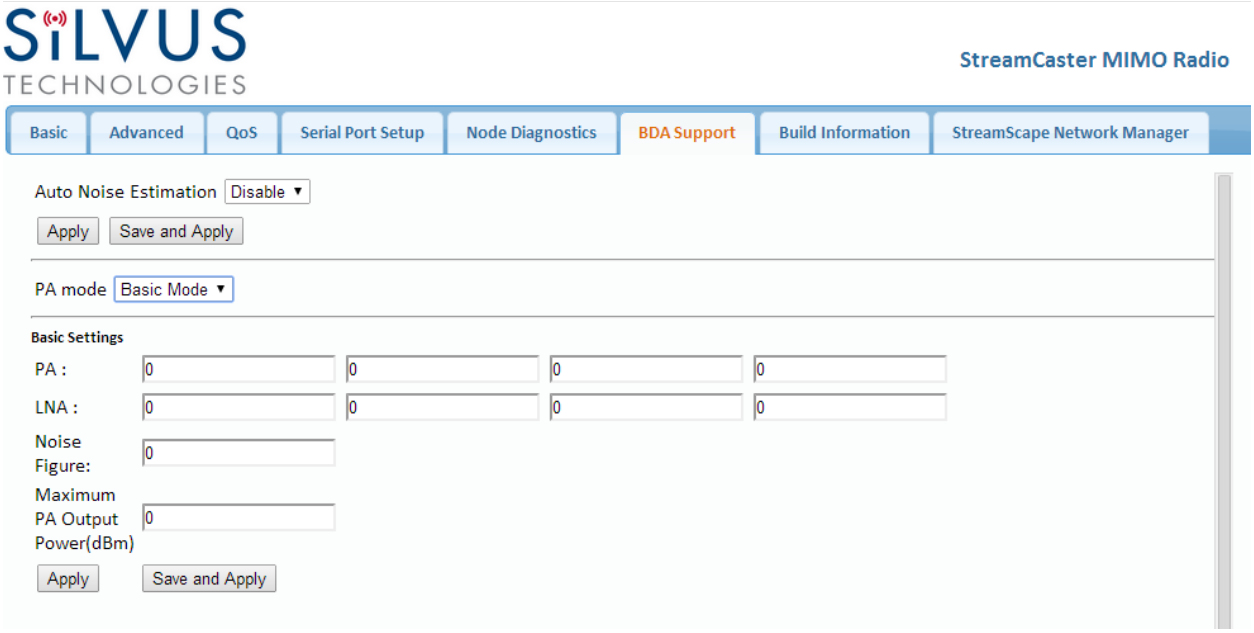


Figure 12 BDA (Bi-Directional Amplifier) Support Configuration Page

The BDA Support page is used to configure the radio to work with an external bi-directional amplifier. These settings should be configured before connecting the amplifier to the radio.

- **Auto Noise Estimation:** When enabled, the radio can automatically estimate the noise in the channel, including any amplification due to the external amplifier. It is preferred that this remain disabled and the LNA gain values be manually input further below, but if the LNA gain values are not known, this can be used instead.
- **Apply**: Apply the new values but does not save them to flash.
- **Save and Apply**: Save the new values to flash and apply.
- **PA Mode**: Either set to "No PA" when there is no amplifier present or "Basic Mode" when using an external amplifier.

Basic Settings:

- **PA**: Enter the gain (dB) for the power amplifier connected to each channel of the radio.
- **LNA**: Enter the gain (dB) for the LNA connected to each channel of the radio.
- **Noise Figure**: Enter the Noise Figure of the receive chain of each LNA.
- **Maximum PA Output Power (dBm)**: Enter the maximum output power for all PA's combined.

4.1.7 Build Information

Figure 13 Build Information

On the Build Information page a user can see information about the hardware and firmware loaded onto the radio. In addition, the user can restore the factory default settings and also upgrade the radio firmware on this page. The firmware can be upgraded by simply choosing the upgrade image from your desktop and uploading it to the radio. This field can be used to upgrade the radio root file system, linux kernel, or uboot. The upgrade system accepts the root file system image for upgrade or a tar file containing up to 3 files (uboot, kernel, rootfs) for upgrade. A radio reboot will be required after update before the changes take effect.

4.2 StreamScape Network Manager

Silvus' StreamScape Network Management Utility was designed to monitor the status of a Silvus mesh network in real-time. The graphical interface network map, shown in Figure 1, allows users to quickly and effortlessly view the network topology and configure key parameters of the network. For ease of use, the Silvus StreamScape utility is designed to be accessible from a Firefox or Chrome web browser.

4.2.1 Network Topology

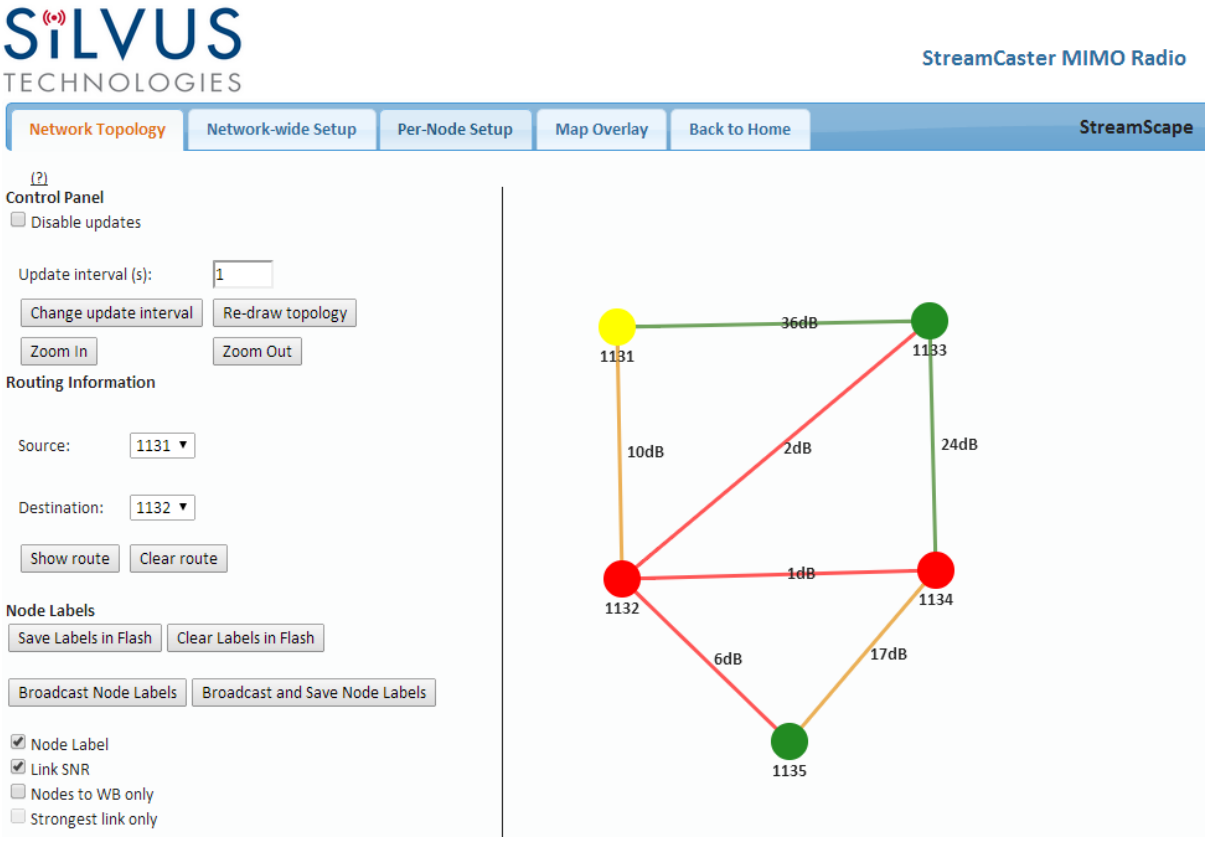


Figure 14 Silvus StreamScapeNetwork Manager

The network topology provides the user with real-time visual feedback of the network. Users will be able to determine several network characteristics at a glance with the following features:

- **Color Coded Link Health –** Color coding of each link in the network allows the user to quickly identify the weak links within a network. A link between two nodes will transition from green to yellow to red as the link weakens while also displaying the SNR of the link. This can be seen in **Figure 15**.

- **Route Health –** The Silvus StreamScape Utility will alert the user when too many packets are being routed through a single node. In such cases, a node will change from green to yellow to red as the packet queue increases (see '1131' and '1132' in **Figure 15**). This will allow the user to recognize the issue and rearrange the network accordingly.

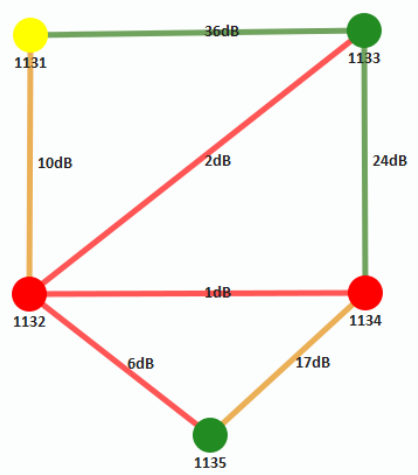


Figure 15 Example Network Topology

- **Routing Information –** The user can determine the routing path between any 2 nodes within a network by simply specifying the source and destination node in the Control Panel on the left hand side. The path will turn bold as shown in **Figure 16** for the path from '1131' to '1135'.

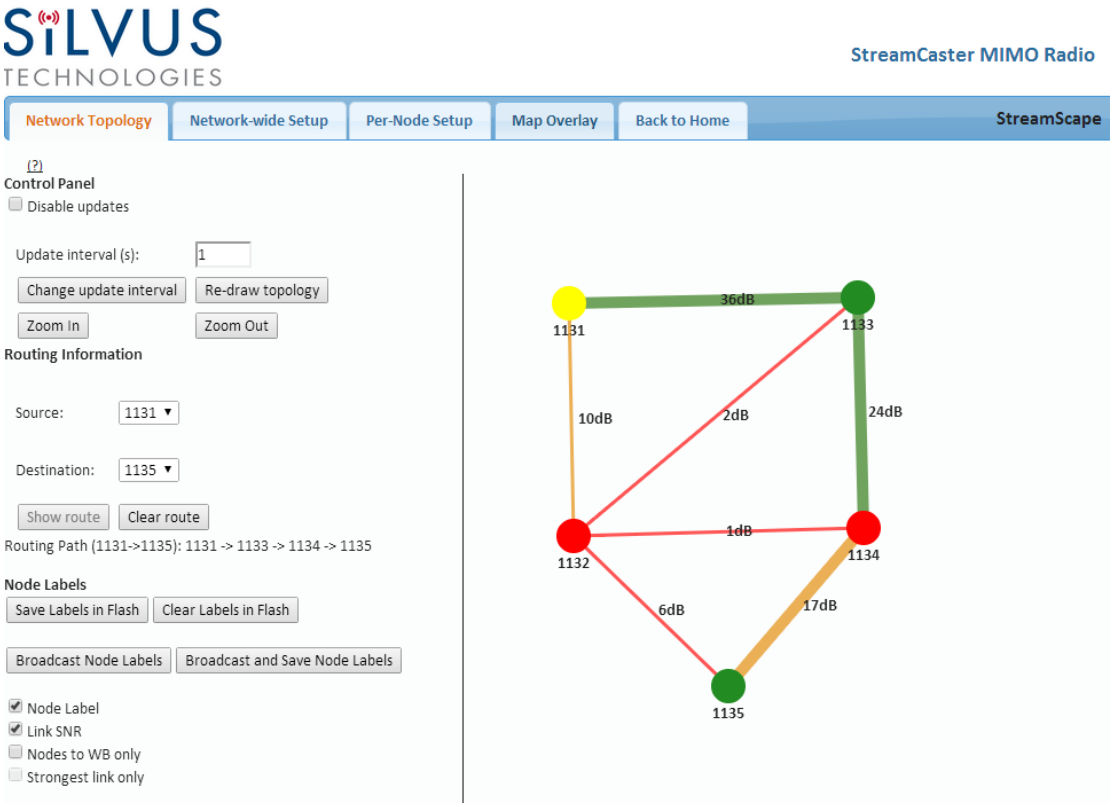


Figure 16 Routing Path

- **Custom Node Naming –** Naming each node in the network is as simple as double-clicking on the node name and typing in a new name as shown in **Figure 17**. This feature enables quick identification of nodes in the field and is especially useful in mission critical situations with many mobile assets. The user can click on the 'Save Labels in Flash' button in the left pane to store the node names to the radio's flash memory. This will store the names on the radio even after the radio is powered off. The saved labels can also be cleared back to the defaults by clicking 'Clear Labels in Flash'.

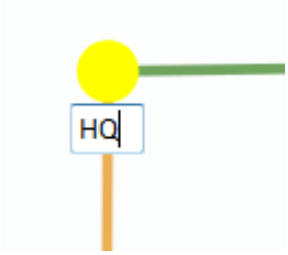


Figure 17 Custom Node Naming

- **Individual Node Characteristics –** By simply rolling the mouse over any node in the network, users can view key operating characteristics of the node. **Figure 18** shows an example of this for node '1131'. The characteristics shown are:

- **Node ID**: The unique node ID assigned to each node at time of manufacture. This cannot be changed.
- **IP**: IP address of the node.
- **Connections**: Number of direct connections to node. Each directly connected node is listed in the following format:
  <Node Name> <RX SNR> <TX MCS> <Pkts in TX Queue> <Num. of Spatial Streams> <RSSI Ch1> <RSSI Ch2> <RSSI Ch3> <RSSI Ch4>
- **Frequency:** RF center frequency of the node.
- **Bandwidth:** RF bandwidth of the node.
- **Noise Level:** Received noise level of the node.
- **Interference:** Approximate in-band interference level.
- **TX Power:** Total target transmit power of node.
- **TX Power (Actual):** Actual transmit power of node. This value may differ from the target transmit due to temperature variation or inability to transmit a clean signal with the selected MCS at the target power.
- **RTS/CTS:** Request-to-Send/Clear-to-Send enabled or disabled.
- **Fragmentation Threshold:** Chosen fragmentation threshold.
- **Virtual IP:** Secondary IP address of node (0 if none set).
- **MCS Mode:** Transmit MCS of node.
- **Link Distance:** Link distance setting of node.
- **Burst Time:** Burst time setting of node.
- **Routing Beacon Period:** Routing Beacon Period setting of node.
- **Contention Window Minimum:** Low Priority Contention Window Minimum setting of node.
- **Maximum Ground Speed:** Maximum Ground Speed setting of node.
- **Queue Size:** Number of packets currently waiting to be transmitted.

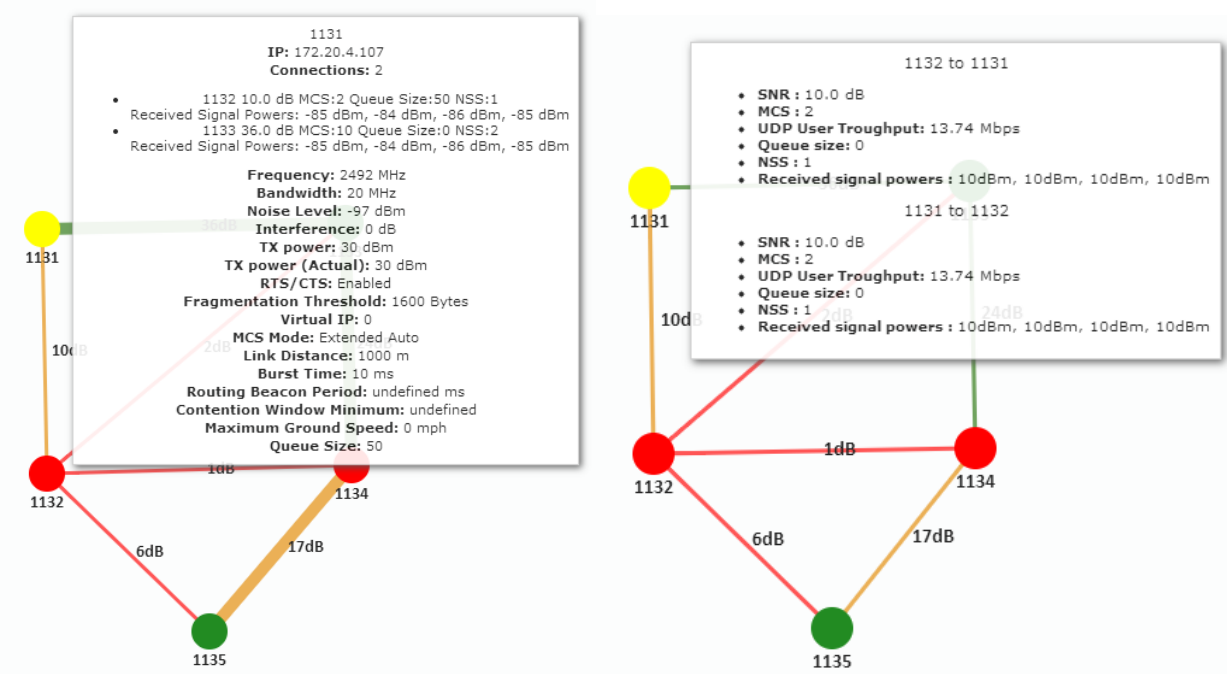


Figure 18 Individual Node Characteristics (Left), Link Characteristics (Right)

- **Link Characteristics –** By simply rolling the mouse over any link in the network, users can view key operating characteristics of that link. **Figure 18** shows an example of this for the link between node '1131' and node '1132'. The characteristics shown are:
    - **SNR**: The SNR of the link in each direction.
    - **MCS**: The MCS used to transfer data in each direction.
    - **UDP User Throughput:** The estimated UDP User Throughput available for each direction of the link. This is estimated based on the current MCS used for transmission.
    - **Queue Size:** Number of packets in TX Queue in each direction.
    - **NSS:** Number of Spatial Streams in each direction.
    - **Received Signal Powers:** Received signal power for each antenna in each direction.

4.2.2 Network-wide Setup and Multicast

Using the network-wide setup users can configure key parameters of every node in the network with just one click. Users simply need to check off the parameters they wish to be updated across the network and click on *Apply* to apply but not write new values to flash or *Save and Apply* to apply and save values to flash. The *Broadcast Update Interval* field determines how often, in seconds, the new parameters will be broadcast to the entire network. A list of all nodes will appear on the right with a check box next to each node. This box will be checked off as each node receives the update. Once all nodes have been updated, the broadcast should be stopped by clicking on *Stop Update.*

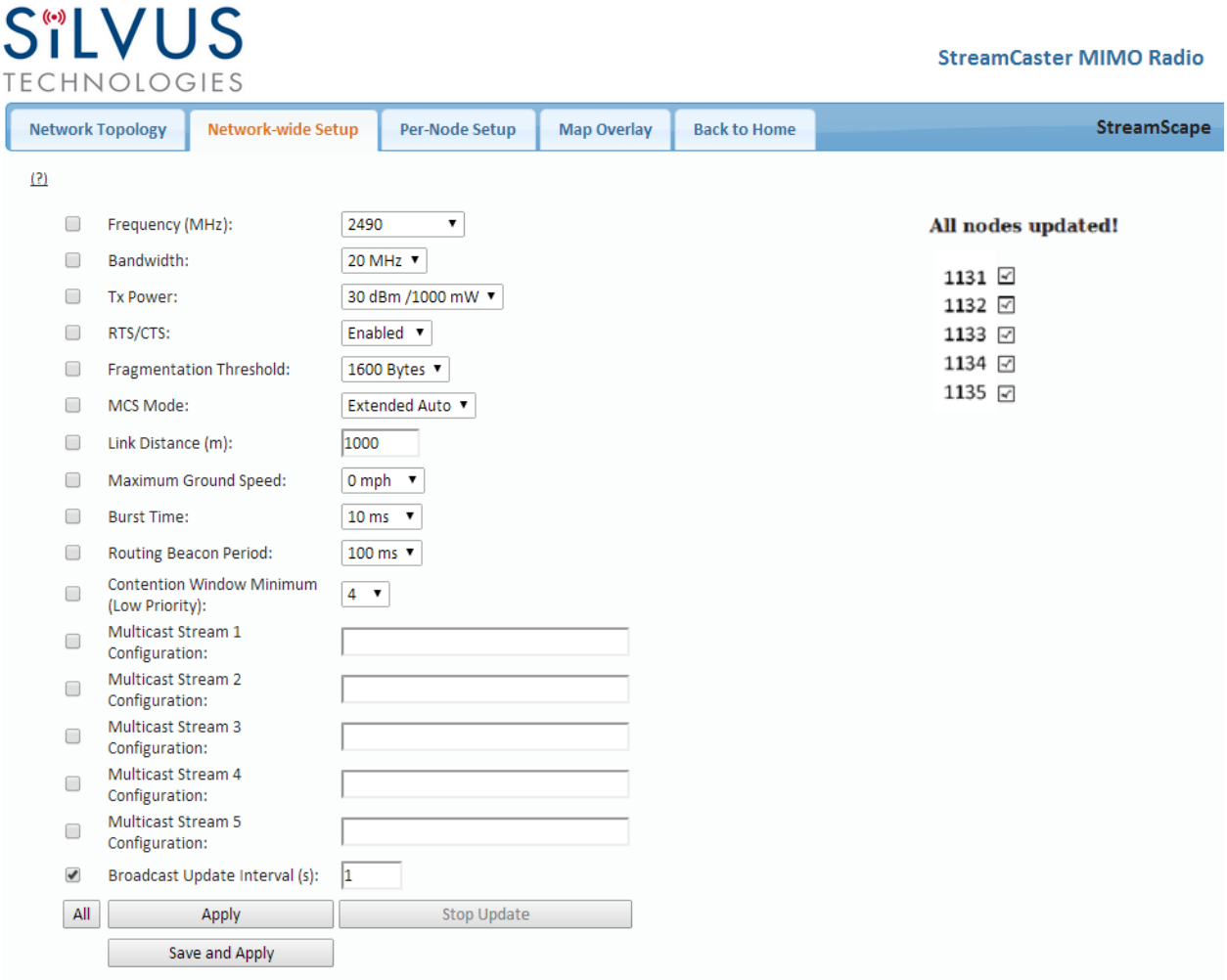


Figure 19 Network-wide Setup

4.2.2.1 Multicast

The Network Wide Setup page is also used to configure up to 5 multicast streams. By default, all multicast/broadcast flows will be sent to all radios. This configuration is only necessary if a user wishes to send multicast streams to a subset of radios on the network. The configuration string format is as follows:

Multicast_ip_address, receiver_id1, receiver_id2, … , receiver_idN

Multicast_ip_address is the multicast group address and receiver_idN are the node ids of the radios that need to receive the multicast stream. If no receivers are indicated, multicast will be sent to all radios. If there is only one receiver id = -1, the multicast stream will not be put on the air and discarded at the transmitter. This allows a quick way for the user to turn off a multicast stream from anywhere on the network.

Some Multicast examples:

Data for multicast group 224.50.50.51 will be received only by radios with node-ids 1131 and 1261:

224.50.50.51, 1131, 1261

Data for multicast group 224.50.50.51 will be received by all radios:

224.50.50.51,

Data for multicast group 224.50.50.51 will be discarded at the transmitter and not put on the air:

224.50.50.51, -1

4.2.3 Per-Node Setup

The per-node setup can be used to modify key parameters of individual nodes within the network. As shown in **Figure 20**, users will see a list of all nodes available within the network. The directly connected node is listed first with the rest ordered lexically. From here, users can click on an individual node and modify its parameters. Any parameters changed from this interface can either be applied or saved and applied.

In addition, this page can be used to upgrade a radio's firmware by simply choosing the upgrade image from your desktop and uploading it to the radio. This field can be used to upgrade the radio root file system, linux kernel, or uboot. The upgrade system accepts the root file system image for upgrade or a tar file containing up to 3 files (uboot, kernel, rootfs) for upgrade. A radio reboot will be required after update before the changes take effect.

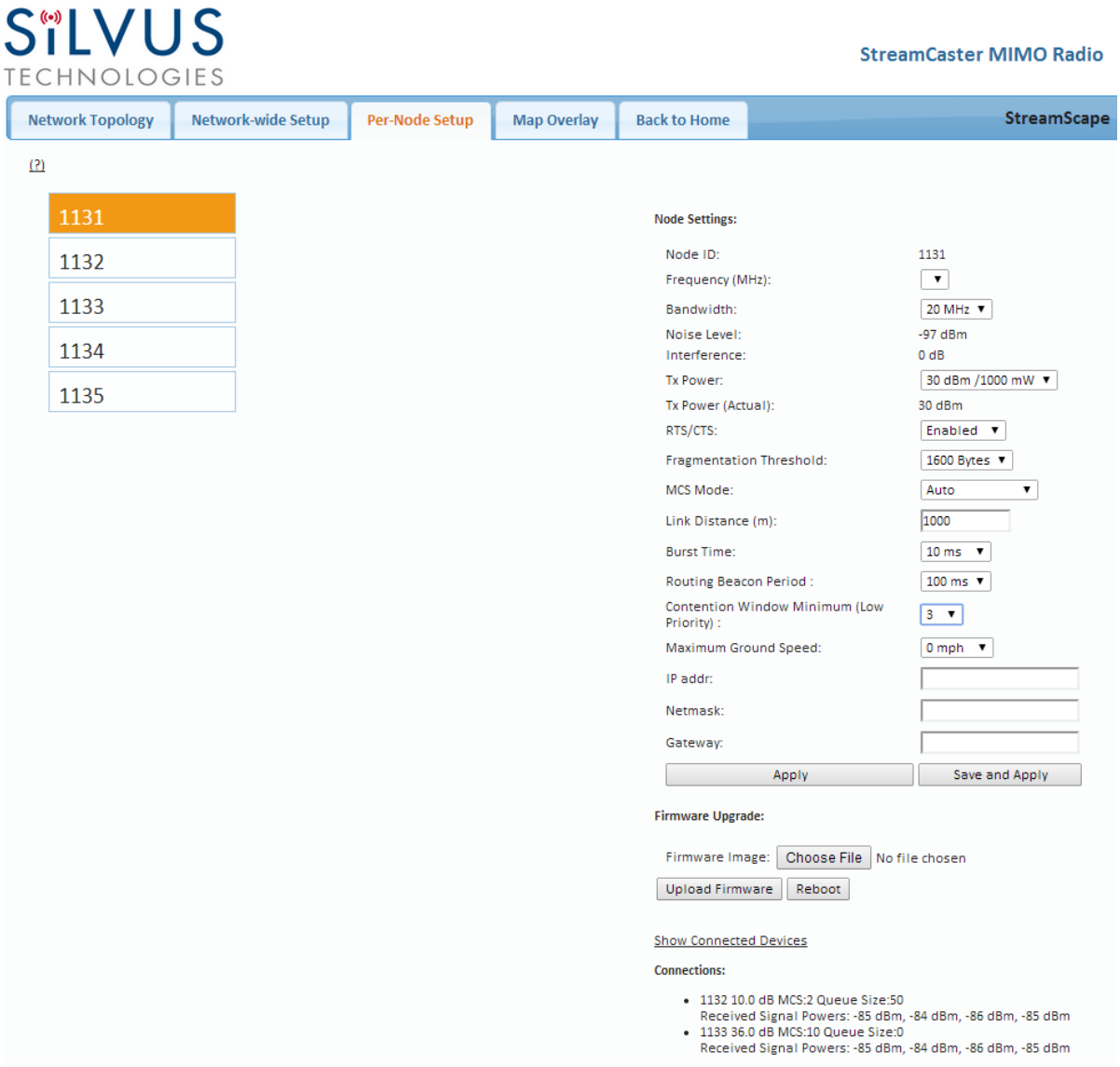


Figure 20 Per-Node Setup

4.2.4 Map Overlay

The Map Overlay page provides an easy to use method of tracking the location of nodes in real-time. Nodes with GPS modules attached will be placed on the map as shown in **Figure 21**.

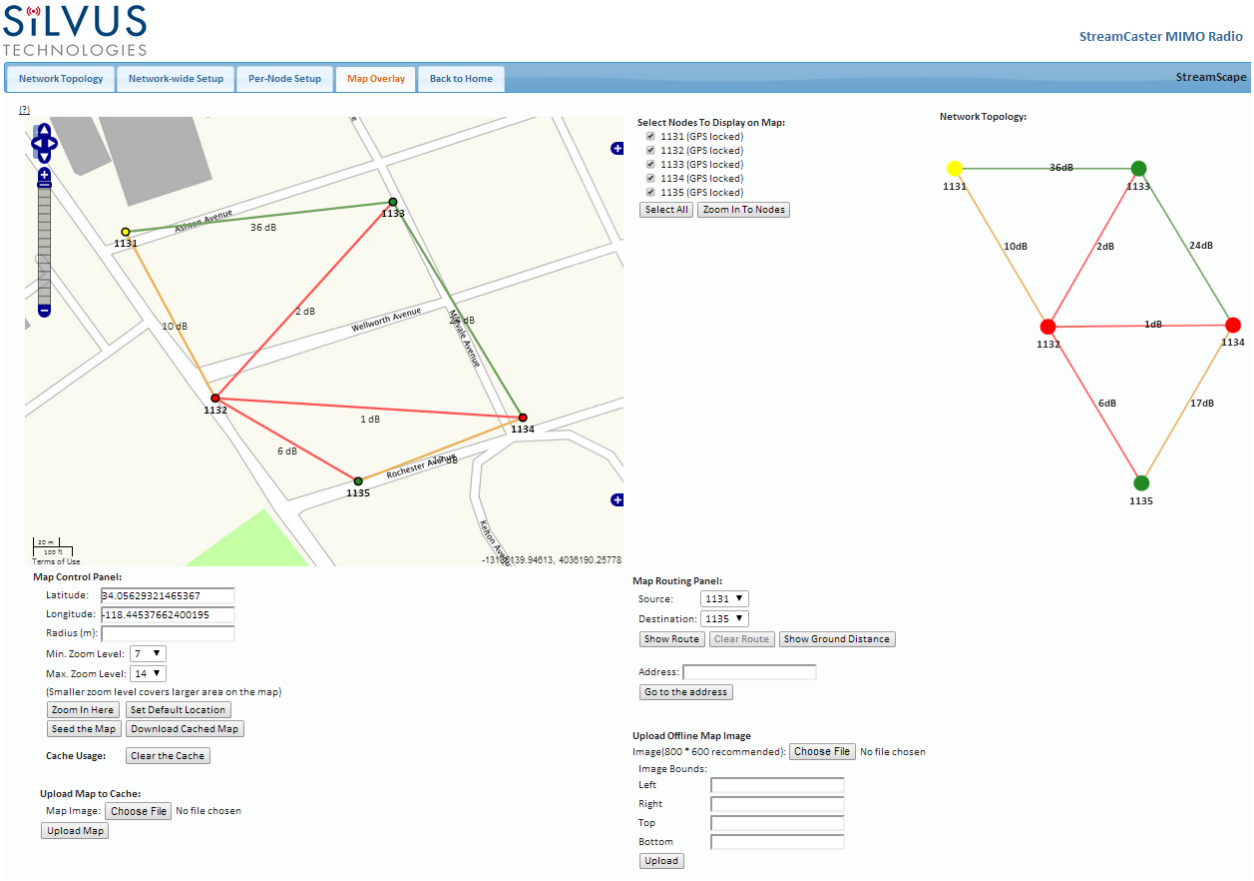


Figure 21 Map Overlay

For convenience, a small copy of the network topology is displayed on the right hand side of the page. This allows users to clearly view the network characteristics in instances where nodes are physically close to one another and difficult to distinguish on the map overlay.

4.2.4.1 Map Options

There are 3 map options currently available in the Map Overlay view. The default map is OpenStreet Maps. These maps can be saved to the radio's internal memory for offline use. For instructions to Download OpenStreet Maps into the radio, see section 4.2.4.2.

In Addition to OpenStreet Maps, Google Maps and Google Satellite are also available. This can be changed by clicking the '+' symbol at the top right of the map:

Figure 22 Google Maps

Note that Google Maps and Google Satellite require an active internet connection on the viewing computer. These maps cannot be saved for offline use.

In addition to the preset map options, the user can also upload a custom image or blueprint in place of the map.

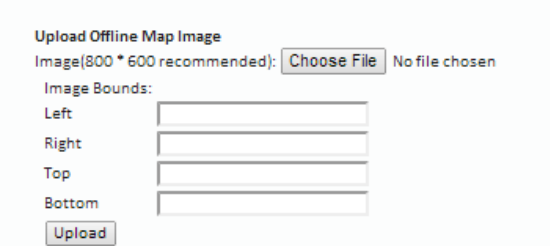


Figure 23 Offline Map Image

To upload a custom image (800 x 600 pixels recommended), first choose the file from your desktop. You will then need to provide the image bounds. These bounds will be the latitude of the left and right bounds of the image and longitude of the top and bottom bounds of the image. Once entered, click upload and there will now be a 4th option when clicking the '+' at the top left of the map overlay.

4.2.4.2 Downloading Maps

An internet connection is required to obtain map data, however, users can cache map data on a node beforehand. For map caching follow these steps:

1. Attach the radio to a laptop and open the advanced tab.
2. Set the Virtual IP address, netmask and gateway to values appropriate for your local network. Your local network should be able to access the internet.
3. Attach the radio to your local network and open the Map Overlay tab.
4. Input the address of the location you wish to download
5. You now have two options for caching map data:
    a. Zoom/pan around the area you are interested in at the zoom level you will be using. This will automatically cache the map data at this zoom level.
    b. Fill in the radius field (in meters), set the Min/Max zoom levels and click on 'Seed the Map'. This is a beta feature and will attempt to cache the entire area for all appropriate zoom levels. Users should be careful in using this feature since it may take some time and will use up the radio's available memory. For reference, a radius of ~3000m will use approximately 5 percent of the total memory.

4.2.4.3 Manual GPS for Nodes without GPS Module

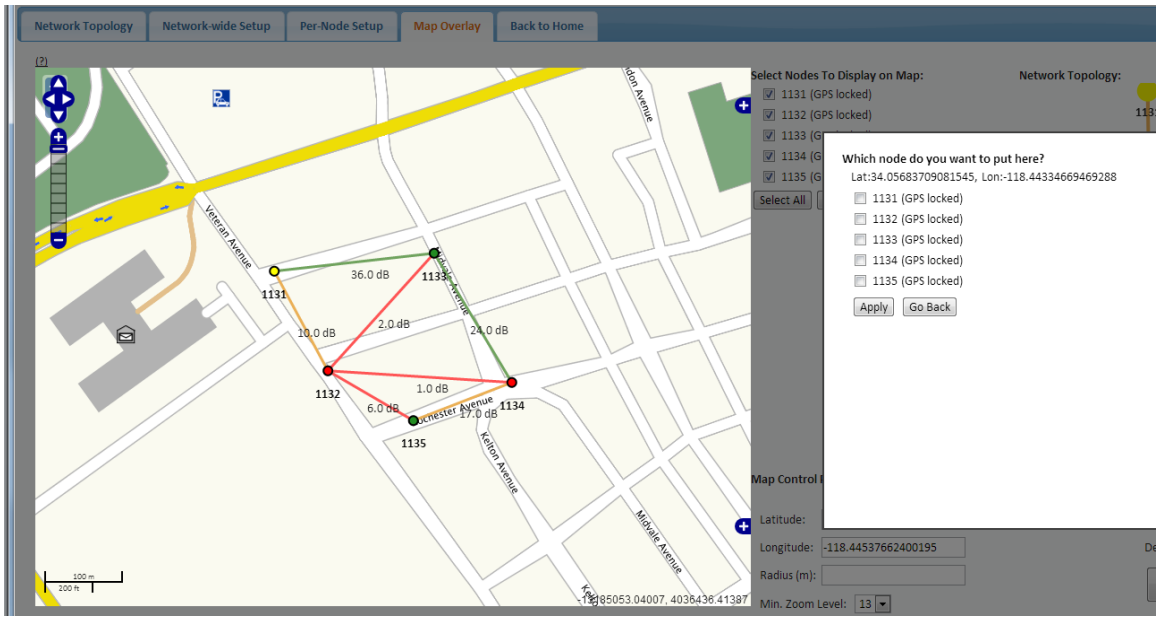


Figure 24 Placing Nodes on the Map

If there are nodes within the mesh that do not have a GPS module connected, or are located in an area with no GPS connectivity, the user can easily place the node on the map by right clicking on the desired location on the map and choosing which node to place there. These values will be ignored if GPS coordinates are available via a GPS module.

5. Wired Backbone

Wired Backbone extends the StreamCaster mesh functionality over LAN (Ethernet) and WAN (Internet) links. This feature is transparent to end-users - they do not have to re-configure their devices in any manner to use this feature.

The StreamCaster routing protocol will automatically detect and route data on wired links to preserve air bandwidth.

5.1 LAN Backbone

The LAN backbone feature allows more than one radio to be connected to a LAN.

5.1.1 Implementation

One of these radios must be configured as a "gateway" radio. This radio then begins listening promiscuously on its ethernet interface to "register" all devices on the LAN as being connected to the gateway radio. At the same time it auto-detects other non-gateway radios connected to the LAN and establishes "wired" links to them. StreamScape Web GUI will show LAN links with SNR of 150 dB to differentiate from wireless links.

The non-gateway radios do not register any devices, they merely act as relays. The gateway radio will forward traffic originating from the LAN, destined for a device attached to a wireless radio, to the non-gateway radio that is closest to the destination. Similarly, any traffic originating from a device attached to a remote wireless radio, destined to a device on the LAN will be forwarded by non-gateway radios to the gateway radio. The gateway radio will then send it to the device.

Currently we support data rates of up to 65 Mbps on the LAN without encryption. Since all LAN traffic goes via the gateway radio, this is the upper limit of all traffic that can enter or go out of the LAN from/to devices connected to wireless radios. Of course, this limit does not affect the throughput between two devices connected directly to the LAN backbone.

5.1.2 Use Case

Consider the following scenario. A business wants to do video monitoring of its grounds. High speed LAN hookups are available only in the HQ building. They want to use the StreamCaster radios on towers to provide complete coverage of the grounds. All video feeds are sent back and

displayed at the HQ. To conserve air bandwidth and possible interference to other users, we want video data to go through the high speed LAN backbone as much as possible. The below diagram shows the scenario.

Towers 1-3 are equipped with IP cameras attached to StreamCaster radios 1-3. Radios 4-6 are mounted on three sides of the HQ building with their Ethernet interfaces connected to the high speed LAN. Tower 1 can only communicate wirelessly with radio 4, Tower 3 with radio 5 and Tower 2 with radio 6. Video from Tower 1 will flow wirelessly to radio 4, then via the LAN backbone to the HQ viewer which is also attached to the LAN backbone. Even though the radios 4-6 may communicate wirelessly, they will choose to do so via the LAN backbone.

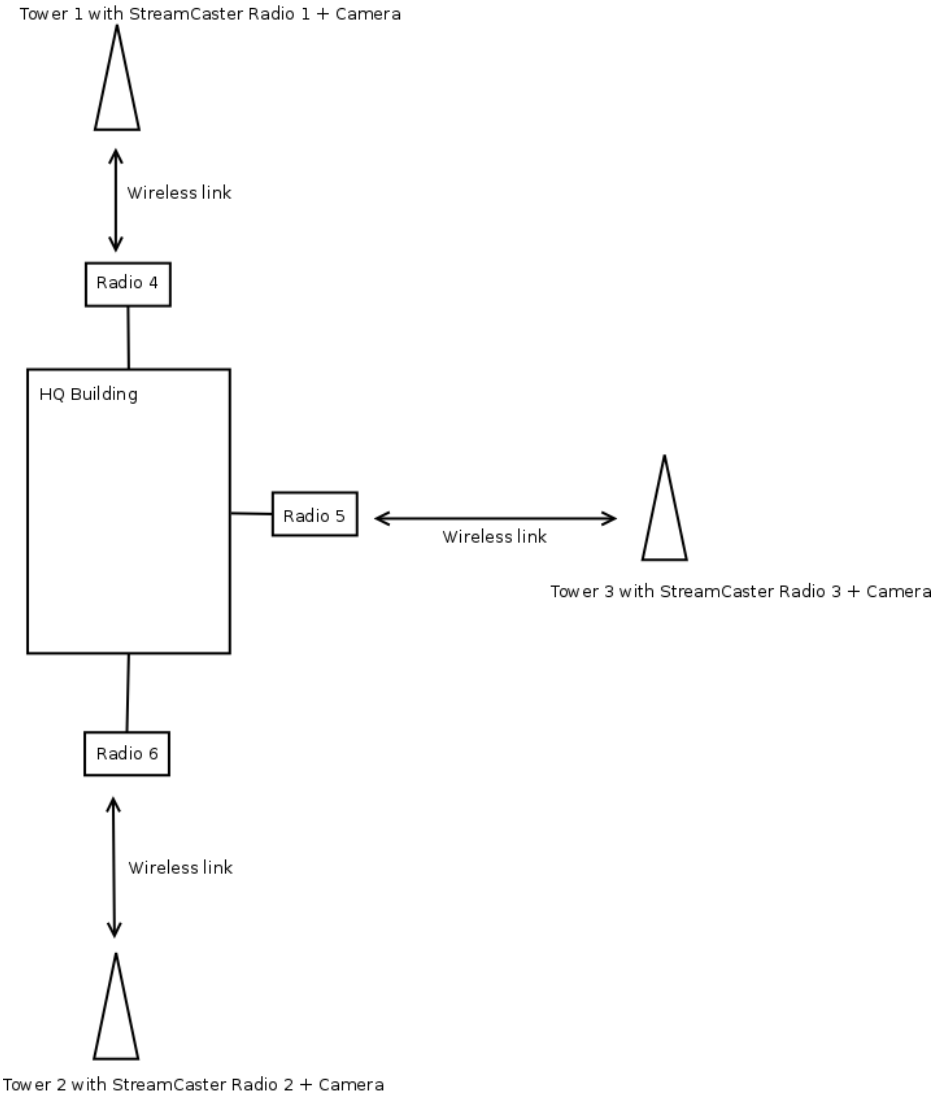


Figure 25 LAN Backbone Example

5.2 WAN Backbone with Roaming

The WAN backbone feature allows the wireless mesh network to extend over Internet links. Multiple geographically separate "sites" can be connected into one single layer 2 network as long as each site has an uplink to the Internet. The roaming feature allows mobile devices connected to StreamCaster radios to roam from one site to another without any network re-configuration.

5.2.1 Implementation

Each site wishing to become part of the wireless mesh needs to connect one StreamCaster radio to its LAN. Such a radio has to be configured to connect to a remote VPN server using the N2N protocol. Radios from multiple sites will be connected at layer 2 via the N2N VPN server creating a single broadcast domain for such nodes. By broadcasting routing packets in this domain, the nodes will auto-detect each other and establish WAN links. Such links will appear on the StreamScape GUI with a link SNR of 120 dB to differentiate from LAN links (150 dB) and wireless links.

The N2N VPN server will try to establish peer-to-peer links between the radios if it can. Under some cases (e.g. symmetric NATs), this is not possible, in which case traffic between the peers is relayed by the N2N server.

The N2N server can be hosted at any server with a public IP on the Internet. As a proof-of-concept, a server has been set up on Amazon Web Services. Currently we support up to 10 Mbps unencrypted between any two sites.

5.2.2 Use Case

Consider a military scenario where a platoon of soldiers begins its mission at an HQ, then breaks up into two groups. Each group has at least one soldier with an uplink to the Internet (provided by a 4G card). The HQ also has an uplink to the Internet. Every soldier and the HQ have a StreamCaster radio attached to their devices.

The soldiers in the two groups want seamless and transparent communication between 1) other soldiers in the same group 2) soldiers in the other group 3) back to HQ. Some lone soldiers (e.g. Soldier A with a StreamCaster radio) may break up from each group and move about on their own. As they get close to group 1, 2 or the HQ, they should be able to immediately establish communication and talk to all other soldiers in the network.

The StreamCaster radios connected to the uplinks in Group 1-2 and the HQ will automatically connect and form WAN links.

Note that the WAN and LAN backbone are complementary features. E.g. at the HQ, multiple radios can be connected to a LAN backbone so that any approaching soldier or group has a direct line of sight wireless connection to the HQ.

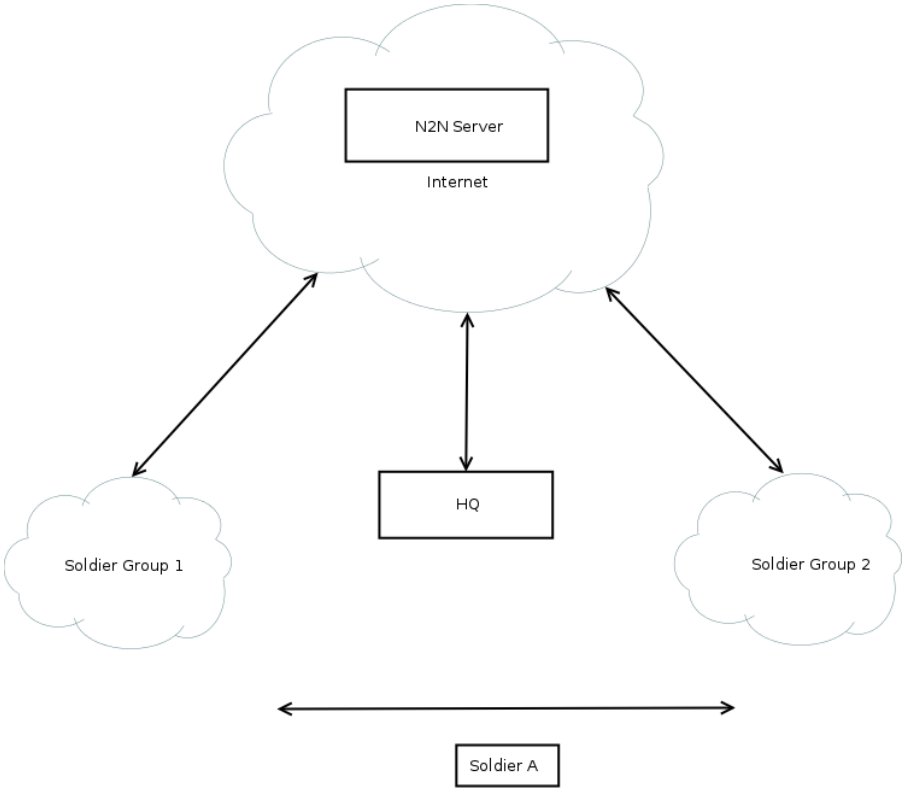


Figure 26 WAN Backbone Example

6. Streaming Response

Some users may be interested in streaming specific information from the radio e.g. rssi, noise floor, temperature, etc. After enabling the response they need using the above commands, the radio will transmit the desired information in the form of UDP packets to a specific IP address and port. The format of each report message will be in the type-length-value format as shown below:

TYPE LENGTH VALUE TYPE LENGTH VALUE …

- TYPE and LENGTH will be 16-bit unsigned integers in network-endian format.
- TYPE indicates the kind of information being transmitted. Pre-defined types are listed later in this document.
- LENGTH indicates the length of the VALUE field in bytes, including the terminating null byte.
- VALUE will be ASCII-encoded text terminated with a null byte ('\0').
- A single report will comprise of a set of type-length-value fields beginning with a "begin" report type. It will have a type which is specific to the type of report being generated, length of 1 byte and a value of an empty string (""). Note the empty string is still null terminated.
- Each report will end with an end of report which has type 1 (type = end of report, length = 1, value = "").
- **T**he empty string listed above has a NULL character and has length 1. Any length number in the streaming report includes the NULL character
- A UDP packet may contain more than one report.
- The UDP packets have a maximum size of 1400 bytes.

6.1 RSSI and Noise Floor Reporting

The type/length/value for RSSI and noise floor reporting are listed in the following table:

Report Type	Data Type	Information
5009	Empty string ""	Begin of RSSI report
5010	Float	Revision number for RSSI report
5000	Integer	Raw signal power of first antenna, represented in half dBm steps.
5001	Integer	Raw signal power of second antenna represented in half dBm steps.
5002	Integer	Raw signal power of third antenna represented in half dBm steps.
5003	Integer	Raw signal power of fourth antenna represented in half dBm steps.
5004	Integer	Raw noise power represented in half dBm steps.
5005	32-bit integer	Sync signal power (from digital domain, see note below).
5006	32-bit integer	Sync noise power (from digital domain, see note below).
5007	16-bit integer	Node ID of the radio.
5008	32-bit integer	Report sequence number, increments for every report, resets after 9999.
1	Empty string ""	End of report.

Table 10 RSSI Reporting Format

Note:

The sync noise and power (types 5005, 5006) are special values obtained after packet processing in the digital domain. They cannot be directly compared to the raw signal and noise values. To obtain an SNR from these values the user needs to run the below formula on these values:

X = sync signal power;

Y = sync noise power;

Z = (Y-X)/51

SNR_mw = (X – 12 * Z)/(64 * Z)

SNR_db = 10 * log(SNR_mw)/log(10)

SNR_db is the SNR in dB and it is averaged across all antennae.

The SNR obtained above is more accurate when the real SNR goes below 10 dB. Above 10 dB, the SNR obtained from the raw signal and noise values are more accurate.

Below is an example of the RSSI report:

Report Type	Length	Information
5009	1	""
5010	4	"1.0"
5008	5	"2333"
5000	5	"-43"
5001	5	"-31"
5002	5	"-28"
5003	5	"-66"
5004	5	"-190"
5005	8	"8604568"
5006	8	"8861322"
5007	5	"1025"
1	1	""

Table 11 Sample RSSI Report

The corresponding raw UDP dump in hexadecimal format is attached below. For the purpose of easier reading, each byte is separated by a space, and each item is separated by a new line. The real streaming report is continuous without any spaces or newlines and is currently 109 bytes long.

13 ffffff91 0 1 0
13 ffffff92 0 4 31 2e 30 0
13 ffffff90 0 5 32 33 33 33 0
13 ffffff88 0 5 20 2d 34 33 0
13 ffffff89 0 5 20 2d 33 31 0
13 ffffff8a 0 5 20 2d 32 38 0
13 ffffff8b 0 5 20 2d 36 36 0
13 ffffff8c 0 5 2d 31 39 30 0
13 ffffff8d 0 a 20 20 38 36 30 34 35 36 38 0
13 ffffff8e 0 a 20 20 38 38 36 31 33 32 32 0
13 ffffff8f 0 5 31 30 32 35 0
0 1 0 1 0

6.2 Temperature Reporting

The type, length and value for temperature reporting are listed in the following table:

Report Type	Data Type	Data
8	Empty string ""	Begin of temperature report.
9	Float	Revision number for temperature report.
2	Integer	Current Temperature on the radio.
3	Integer	Maximum Temperature reached on the radio after last booting.
4	Integer	Overheat Count: number of times the radio temperature has exceeded temp_reporting_max_threshold.
1	Empty string ""	End of report

Table 12 Temperature Reporting Format

7. Setting up an Iperf Test

7.1 Required Equipment

- Two laptops with iperf or jperf installed. It is beyond the scope of this manual to cover the installation and operation of these tools. The laptops must be on the same subnet but not necessarily the same subnet as the radios (172.20.0.0). It is not required for the user to set a secondary IP address on the radio to perform this test. It is recommended the iperf or jperf tests are first conducted between the laptops using an Ethernet switch or cross-over Ethernet cable between them to verify the laptops and iperf/jperf tools.
- Two or more StreamCaster radios properly configured.

7.2 Running Iperf Test

- Connect a laptop to one StreamCaster radio using the Ethernet cable.
- Connect the other laptop to another StreamCaster radio.
- Power up the radios and verify the radios are ready.
- At the receiver side type the following in a terminal
    - iperf –s –u -i 1
- At the transmitter side type the following in a terminal
    - iperf –c receiver_laptop_ip_address –u –i 1 –b 1M –t 60

8. Firmware Upgrade

This section describes the procedure for a firmware upgrade for the StreamCaster radios. Firmware upgrades are meant for enhancement of features or bug fixes. There are two components that may be upgraded: ***file-system*** and ***kernel***. An upgrade may be for both file-system and kernel or just one of them. Typically only a file-system upgrade is necessary.

8.1 Upgrade Requirements

- ✓ The upgrade requires a computer with an Ethernet interface with an IP address in the 172.20.0.0 subnet, e.g., 172.20.253.10. The computer must also have an ssh client. Putty is a free ssh client for Windows.
- ✓ The binary file(s). You may be provided with a checksum for the binary file(s). The checksum is a 32-hexadecimal-digit, e.g., 96eb9bda17dbff4e5961a71f5a1e3fc7. Have the binary file for the file-system or kernel upgrade ready in the computer.
- ✓ Check for the radio IP address 172.20.x.y.

8.2 Upgrading

WARNING!!! Upgrading the radio firmware is similar to a BIOS upgrade for a computer. Failure during the procedure will render the device "bricked." A bricked device will require servicing at the factory. Be sure to have the radio connected to a reliable source of power. A binary file meant for file-system upgrade must not be used for a kernel upgrade and vice-versa.

8.2.1 File-System Upgrade

1. Have the upgrade binary "upgrade.bin" on the computer. The name of the binary file is an example. You may have a binary file with a different name and extension. You may also rename the file if you find it convenient.

2. Connect the computer to the radio with an Ethernet cable.

3. Verify the connectivity with "ping"

    - **Computer prompt> ping 172.20.x.y**

4. Copy the binary file to the /tmp folder in the radio using ssh. Provide "root" as the password when requested.

    - **Computer prompt> scp upgrade.bin root@172.20.x.y:/tmp/.**

5. Login on to the radio. Provide "root" as the password when requested.

    - **Computer prompt> ssh root@172.20.x.y**

6. Change the directory to /tmp

    - **Radio prompt> cd /tmp**

7. If you have the checksum for the binary file, you may verify it now.

    - **Radio prompt> md5sum upgrade.bin**

8. Perform the upgrade. You shall see the messages "Updating rootfs, Erasing, Writing, Done." The process takes less than 30s.

    - **Radio prompt> upgrade.sh r10 upgrade.bin**

9. Power-cycle the radio for the upgrade to be complete.

8.2.2 Kernel Upgrade

1. Have the upgrade binary “upgrade.bin” on the computer. The name of the binary file is an example. You may have a binary file with a different name and extension. You may also rename the file if you find it convenient.

2. Connect the computer to the radio with an Ethernet cable.

3. Verify the connectivity with “ping”

    - **Computer prompt> ping 172.20.x.y**

4. Copy the binary file to the /tmp folder in the radio using ssh. Provide “root” as the password when requested.

    - **Computer prompt> scp upgrade.bin root@172.20.x.y:/tmp/.**

5. Login on to the radio. Provide “root” as the password when requested.

    - **Computer prompt> ssh root@172.20.x.y**

6. Change the directory to /tmp

    - **Radio prompt> cd /tmp**

7. If you have the checksum for the binary file, you may verify it now.

    - **Radio prompt> md5sum upgrade.bin**

8. Perform the upgrade. You shall see the messages “Update kernel, Erasing, Writing, Done.” The process takes less than 30s.

    - **Radio prompt> upgrade.sh k upgrade.bin**

9. Power-cycle the radio for the upgrade to be complete.

9. Precautions and Recommendations

9.1 Saving the Radio Configuration

It is very important that the radio does not lose power during any configuration changes in which the user requests a "save and apply" operation. Partial saving of the configuration to the radio due to power interruption may disable the radio requiring reprogramming at the factory. Also, please wait for a "done" feedback at the web interface before proceeding to any other configuration changes.

9.2 Network Tests

9.2.1 Ping

The "ping" command is often used for quick network connectivity and latency tests.

9.2.2 Multicast

It is recommended to turn link adaptation off if the user intends to use large amount of multicast traffic with the current release.

10. FCC Notice (SC3500U Only)

This equipment has been tested and found to comply with the limits for a class B digital device pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

* Reorient or relocate the receiving antenna.

* Increase the separation between the equipment and receiver.

* Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

* Consult the dealer or an experienced radio/TV technician for help.

In order to maintain compliance with FCC regulations, shielded cables must be used with this equipment. Operation with non-approved equipment or unshielded cables is likely to result in interference to radio and TV reception. The user is cautioned that changes and modifications made to the equipment without the approval of the manufacturer could void the user's authority to operate the equipment.

To satisfy RF exposure requirements, this device and its antennas must operate with a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.