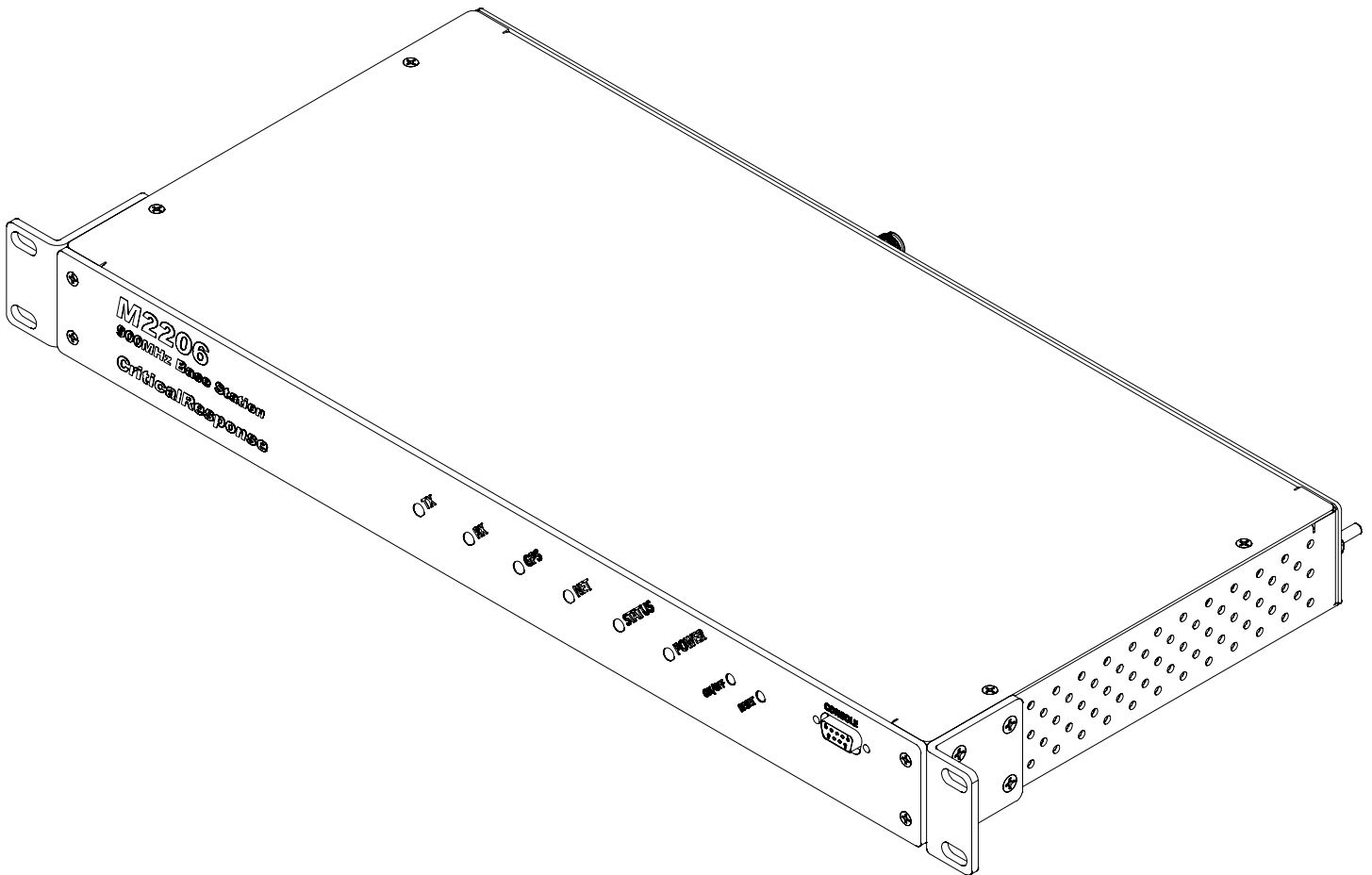


M220X Series Base Transceiver User Manual

***M2205 800MHz Base Transceiver
M2206 900MHz Base Transceiver***



Part Number CRS-DOC-M220X-UM
Version 1.2

Critical Response Systems, Inc.
1123 Zonolite Road NE Suite 8A
Atlanta, GA 30306-2015

www.criticalresponse.com

Copyright © 2019, Critical Response Systems, Inc.
All Rights Reserved.

Notice

While reasonable efforts have been made to assure the accuracy of this document, Critical Response Systems (CRS) assumes no liability resulting from any inaccuracies or omissions in this document, or from use of the information obtained herein. The information in this document has been carefully checked and is believed to be entirely reliable. However, no responsibility is assumed for inaccuracies or omissions. CRS reserves the right to make changes to any products and specifications described herein and reserves the right to revise this document and to make changes from time to time in content hereof with no obligation to notify any person of revisions or changes. CRS does not assume any liability arising out of the application or use of any product, software, or circuit described herein; neither does it convey license under its patent rights or the rights of others.

Copyrights

This document and the CRS products described in this document may be, include, or describe copyrighted CRS material, such as computer programs stored in semiconductor memories or other media. Laws in the United States and other countries preserve for CRS and its licensors certain exclusive rights for copyrighted material, including the exclusive right to copy, reproduce in any form, distribute and make derivative works of the copyrighted material. Accordingly, any copyrighted material of CRS and its licensors contained herein or in the CRS products described in this document may not be copied, reproduced, distributed, merged or modified in any manner without the express written permission of CRS. Furthermore, the purchase of CRS products shall not be deemed to grant either directly or by implication, estoppel, or otherwise, any license under the copyrights, patents or patent applications of CRS, as arises by operation of law in the sale of a product.

Patents

The material in this document is protected by multiple patents. Please see www.criticalresponse.com/patents for more information. Patent pending.

Computer Software Copyrights

The CRS and 3rd party supplied software products described in this document may include copyrighted CRS and other 3rd party supplied computer programs stored in semiconductor memories or other media. Laws in the US and other countries preserve for CRS and other 3rd party supplied software certain exclusive rights for copyrighted computer programs, including the exclusive right to copy or reproduce in any form the copyrighted computer program. Accordingly, any copyrighted CRS or other 3rd party supplied software contained in the CRS products described in this instruction manual may not be copied (reverse engineered) or reproduced in any manner without the express written permission of CRS or the 3rd party supplier. Furthermore, the purchase of CRS products shall not be deemed to grant either directly or by implication, estoppel, or otherwise, any license under the copyrights, patents or patent applications of CRS or other 3rd party supplied software, except for the normal non-exclusive, royalty free license to use that arises by operation of law in the sale of a product.

License Agreements

The software and products described in this document is the property of CRS and its licensors. It is furnished by express license agreement only and may be used only in accordance with the terms of such an agreement.

Copyrighted Materials

Software and documentation are copyrighted materials. Making unauthorized copies is prohibited by law. No part of the software or documentation may be reproduced, transmitted, transcribed, stored in a retrieval system, or translated into any language or computer language, in any form or by any means, without prior written permission of CRS.

High Risk Materials

Components, units, or third-party products used in the product described herein are NOT fault-tolerant and are NOT designed, manufactured, or intended for use as on-line control equipment in the following hazardous environments requiring fail-safe controls: the operation of Nuclear Facilities, Aircraft Navigation or Aircraft Communication Systems, Air Traffic Control, Life Support, or Weapons Systems (High Risk Activities). CRS and its supplier(s) specifically disclaim any expressed or implied warranty of fitness for such High Risk Activities.

In some cases, CRS components may be promoted specifically to facilitate safety-related applications. With such components, CRS's goal is to help enable customers to design and create solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

Trademarks

Critical Response Systems and *locast* are trademarks of *Critical Response Systems, Inc.* All other product or service names are the property of their respective owners.

THE SPECIFICATIONS AND INFORMATION REGARDING THE PRODUCTS IN THIS MANUAL ARE SUBJECT TO CHANGE WITHOUT NOTICE. ALL STATEMENTS, INFORMATION, AND RECOMMENDATIONS IN THIS MANUAL ARE BELIEVED TO BE ACCURATE BUT ARE PRESENTED WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED. USERS MUST TAKE FULL RESPONSIBILITY FOR THEIR APPLICATION OF ANY PRODUCTS.

THE SOFTWARE LICENSE AND LIMITED WARRANTY FOR THE ACCOMPANYING PRODUCT ARE SET FORTH IN THE INFORMATION PACKET THAT SHIPPED WITH THE PRODUCT AND ARE INCORPORATED HEREIN BY THIS REFERENCE. IF YOU ARE UNABLE TO LOCATE THE SOFTWARE LICENSE OR LIMITED WARRANTY, CONTACT YOUR CRS REPRESENTATIVE FOR A COPY.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio-frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case users will be required to correct the interference at their own expense.

Modifying the equipment without CRS's written authorization may result in the equipment no longer complying with FCC requirements for Class A digital devices. In that event, your right to use the equipment may be limited by FCC regulations, and you may be required to correct any interference to radio or television communications at your own expense.

NOTWITHSTANDING ANY OTHER WARRANTY HEREIN, ALL DOCUMENT FILES AND SOFTWARE OF THESE SUPPLIERS ARE PROVIDED "AS IS" WITH ALL FAULTS. CRS AND THE ABOVE-NAMED SUPPLIERS DISCLAIM ALL WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING, WITHOUT LIMITATION, THOSE OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT OR ARISING FROM A COURSE OF DEALING, USAGE, OR TRADE PRACTICE.

IN NO EVENT SHALL CRS OR ITS SUPPLIERS BE LIABLE FOR ANY INDIRECT, SPECIAL, CONSEQUENTIAL, OR INCIDENTAL DAMAGES, INCLUDING, WITHOUT LIMITATION, LOST PROFITS OR LOSS OR DAMAGE TO DATA ARISING OUT OF THE USE OR INABILITY TO USE THIS MANUAL, EVEN IF CRS OR ITS SUPPLIERS HAVE BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

Sparkgap, the Sparkgap logo, Critical Response Systems, and the Critical Response Systems logo are registered trademarks of CRS. locast and the locast logo are trademarks of CRS.

All other trademarks mentioned in this document or web site are the property of their respective owners. The use of the word partner does not imply a partnership relationship between CRS and any other company.

M220X User Manual
Copyright © 2018-2019 Critical Response Systems, Inc.
All rights reserved.

Preface

The M220X series of locast base transceivers in 800MHz and 900MHz bands. Together with an locast control stack, one or more M220X-series base transceivers provide high-performance LPWAN services to fixed and mobile nodes equipped with compliant locast node transceivers.

Audience

This guide is intended for personnel whose responsibilities include:

- Radio system specification, engineering and support,
- Radio system integration,
- Dispatch and call center integration.

Prerequisites

The M220X is both a network appliance and a base radio transceiver. This document assumes the reader has experience with land mobile radio and radio base stations, as well as some experience with the CentOS 7 operating system and network administration. The following publications may be useful references in these areas:

Blokdyk, Gerard. *Land mobile radio system: A Complete Guide*. CreateSpace Independent Publishing Platform, 2018.

Neil, Nathan James. *Learning CentOS: A Beginners Guide to Learning Linux*. CreateSpace Independent Publishing Platform, 2016.

Motorola. *STANDARDS AND GUIDELINES FOR COMMUNICATION SITES*. Motorola, 2005.

Notes, Cautions, and Warnings

The M220X transmits RF energy and operates in an environment typical of a radio site, both of which demand special care by personnel. M220X units should be installed and maintained by trained personnel. Throughout this manual, cautions, and warnings are marked with the following symbols:



This symbol indicates that the reader should take note. Notes contain useful suggestions, references to other documents, or helpful hints.



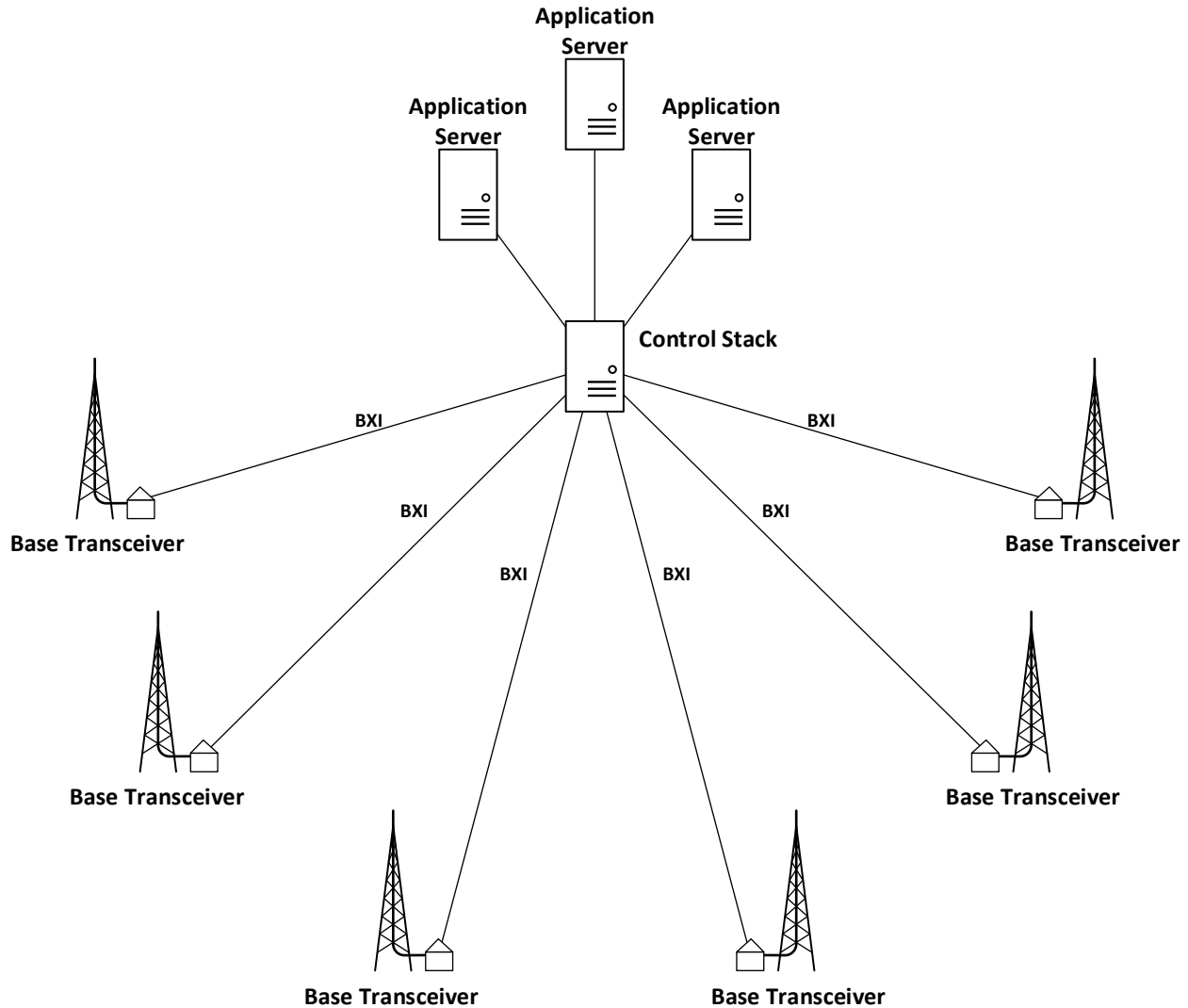
This symbol indicates the reader *must be careful* to avoid damage to equipment, interruption of service, or loss of data.



This symbol indicates *danger*. The reader must take care to avoid bodily injury, equipment damage, interruption of service, or loss of data.

1 Overview

1.1 Network Reference Model

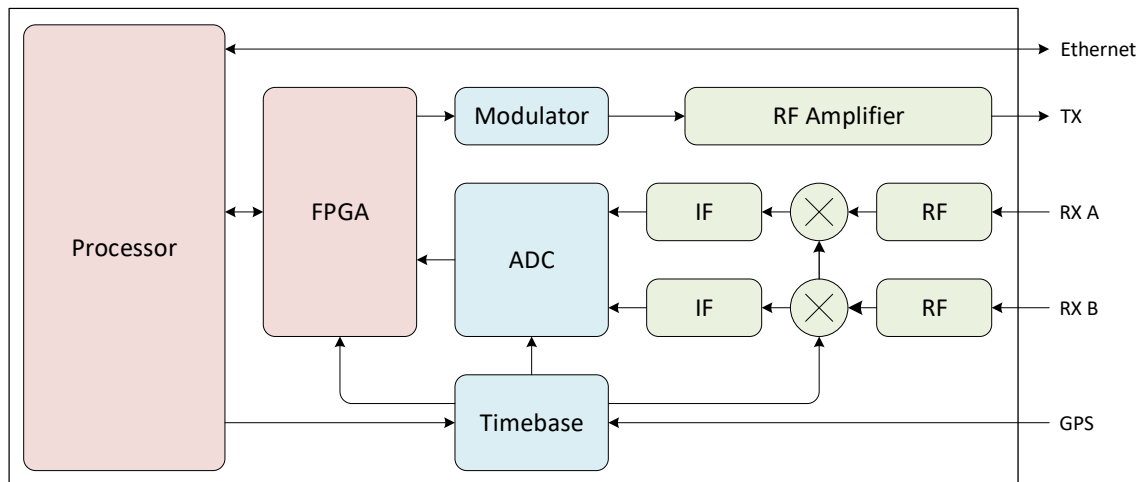


The M220X series base transceiver is designed to operate as part of an [locast](#) network. locast networks include a *control stack*, one or more *base transceivers* (such as the M220X), and tens to millions of remote *nodes*. Generally, base transceivers provide a sector of coverage, or part of a sector, and communicate with the control stack using the BXI interface.

This user manual concerns the M220X series base transceiver, 1RU rack-mount units containing an RF transmitter, an RF receiver, a GPS timing interface, and an Ethernet interface. These units connect to a control stack using TCP/IP, and they transmit and receive radio frames to and from node transceivers.

2 Theory of Operation

The M220X is capable of simultaneous transmission and reception of data on one forward channel and one reverse channel. An M220X may be installed in a tower site shelter or radio room, in a 19" rack, connected to transmit and receive antenna feed lines. It can also operate as a low-power indoor unit with antennas directly fixed to the unit.



The M220X includes 5 major subsystems: a receiver, a transmitter, a timebase, an FPGA, and a Processor. These subsystems are integrated together onto two PCB assemblies and packaged in a 1RU rackmount aluminum enclosure. During normal operation, the M220X connects to receive and transmit antennas, which may be diplexed together, a GPS antenna, and Ethernet fabric with an IP path to the system controller. Optionally, for high power transmission, the M220X may be connected to a power amplifier. In this case, a companion data connection is also required between the PA and the M220X.

2.1 CPU

The M220X CPU is a SMARC 2.0 Linux computing node mounted on a custom carrier board, which includes a supervisory microcontroller plus additional supervisory and support circuitry. The CPU runs the CentOS 7 operating system, plus a custom m220x kernel module and m220x systemd unit. The CPU communicates with the supervisory microcontroller using SPI, and communicates with the FPGA using PCI Express.

2.2 FPGA

The FPGA connects to the CPU using PCI Express and provides the main interface between the CPU and radio circuitry. The FPGA contains two asynchronous clock domains, a 100MHz PCI Express domain and a 28.8MHz radio domain. The radio domain is clocked by the Clock section, and the CPU domain is clocked by the PCIe reference clock from the CPU module.

The PCI Express domain is built from a MicroBlaze processor, a PCI Express core, and associated AXI infrastructure. It accepts and executes commands from the CPU and sends information to the CPU.

The radio domain is divided into transmitter and receiver support blocks. The transmitter block receives baseband data from the Processor, times it, and sends it to the Modulator as I2S data. The receiver samples the 45MHz IF at 14.4MHz, creating a 1.8MHz digital IF. It then filters this signal, mixes it digitally, and demodulates it into baseband data.

The FPGA also contains support for the Timebase subsystem and other functions.

2.3 Receiver

The receiver includes two double-heterodyne receivers arranged in parallel for microdiversity. The RF, RF mixer, and First IF sections are implemented with analog circuitry. The second mixer, filter, and demodulator are implemented digitally in the FPGA.

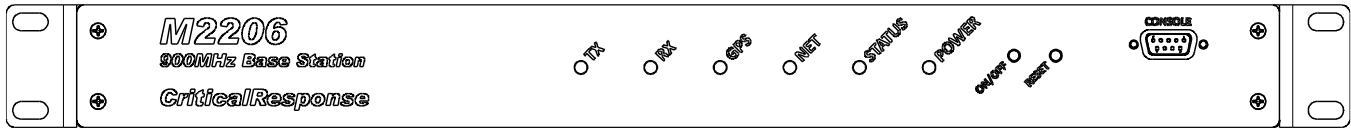
2.4 Transmitter

The transmitter includes a digital direct RF modulator followed by filtering and amplification.

2.5 Timebase

The Timebase includes an 100MHz OCXO and clock distribution system. Using the 1PPS signal from the GPS, the Processor disciplines the oscillator to within 20 parts per billion. The subsystem phase locks this frequency into separate frequencies, which drive the ADC sampling rate, the receive mixer local oscillator, the transmit carrier frequency, and the radio domain of the FPGA.

3 Front Panel



The M220X front panel contains six indicators, an on/off button, a reset button, and a console serial port.

3.1 Console Port

The console port provides a 38400,N,8,1 serial connection to the Linux shell.

3.2 Reset Button

The **Reset Button** resets the system. Holding this button down for 3 seconds forces a warm reboot of the unit.

3.3 On/Off Button

The **On/Off Button** turns the unit on and off. Holding this button down for three seconds boots a powered-down unit or shuts down a running unit. To turn the M220X on, press and hold the **ON/OFF Button** until the **POWER** indicator illuminates, then release it. The M220X will continue through the boot process and begin normal operation. To turn the M220X off, again press and hold the **ON/OFF Button** until the **STATUS** indicator begins to flash yellow, then release it; once the shutdown process is complete, the unit will power itself off.



The M220X can only be powered off with the ON/OFF button. Attempting to turn the unit off through the Linux shell will simply reboot the unit, affecting a cold reboot. Prior to detaching the power cord, the unit should always be turned off with the ON/OFF Button.

3.4 Indicators

The front panel includes 6 LED indicators, Power, Status, Net, GPS, TX, and RX. Generally, green or darkened indicators mean the system is in good health. Yellow indicators convey a marginal, but still acceptable condition, and red indicators mean the system is not operating normally. The exception to this is the RX indicator which flashes yellow and red to indicate radio packet forward error correction.

3.4.1 Power

The power indicator shows the status of the internal voltage rails.

Color	Flash Rate	Meaning
Red	Solid	Voltage is out of tolerance
Yellow	Solid	Voltage is in tolerance but marginal
Green	Solid	Voltage is in tolerance

3.4.2 Status

The **Status** indicator shows the general health of the unit, as follows:

Color	Flash Rate	Meaning
Yellow	1 Hz	Hardware boot
Yellow	2 Hz	OS booting or shutting down
Green	Solid	System operating normally
Yellow	Solid	Minor alarm condition
Red	Solid	Major alarm condition

3.4.3 Net

The **Net** indicator shows network status and activity. Under normal operations, the indicator flashes green corresponding to network activity. When the unit cannot communicate with the system controller, it glows yellow.

3.4.4 GPS

The **GPS** indicator shows status and activity of the GPS subsystem, as follows:

Color	Flash Rate	Meaning
Red	Solid	No GPS signal; oscillator not locked.
Red	1 Hz	GPS signal not locked; oscillator not locked.
Yellow	1 Hz	GPS signal acquired; oscillator not locked
Green	1 Hz	GPS signal acquired; oscillator locked

3.4.5 RX

The **RX** indicator flashes green when an RF packet is received without error, and yellow if the packet is received with a correctable error. The RX indicator flashes red if an RF packet is received with uncorrectable errors, although reception of badly corrupted packets may be ignored with no flash at all.

3.4.6 TX

The **TX** indicator illuminates green as the transmitter transmits a frame. If the transmitter is inhibited, the TX indicator will show solid yellow. Upon detection of out-of-range reflection or VSWR, the TX indicator will show red briefly and then transmission will stop.

4 Rear Panel



The rear panel contains the 8 physical ports needed by the M220X for normal operation.

4.1 AC Power

The **AC Power** port is an IEC320-C14 male connector with integrated 5x20mm 3A fuse and EMI filter. For proper operation, M220X requires 90-264VAC at 50Hz or 60Hz, and draws an average of 50 watts.

4.2 Ground Stud

The Ground Stud is a #8 stud that provides a secure mechanical and electrical connection to the M220X enclosure. This should be connected to the site main ground bus bar.

4.3 ETHERNET

The **ETHERNET** port is a RJ45 connector supporting gigabit Ethernet connectivity. Using Cat 5 or Cat 6 cable, this port must be connected to a local Ethernet switch or router with an IP path to the system controller.



As per section 6, the Ethernet port should not be connected until the M220X is configured. Connecting the M220X to the network before the unit is properly configured may result in unexpected or erroneous operation.

4.4 RX A and RX B

The **RX A** and **RX B** ports are 50Ω SMA female connectors carrying the receive RF signal from an external base antenna or low noise amplifier into the M220X. Both RX A and RX B expect the same signal and RF channel; diversity circuitry and logic combine these two signals into a single, digitally enhanced signal.



The RX A and RX B ports should be protected from ESD and high input levels, during connection and disconnection of cables and at all other times. ESD or any input signal over +10dBm may damage or degrade the unit.

4.5 TX

The **TX** port is a 50Ω SMA female connector carrying the transmit RF signal from the M220X to a base transceiver antenna, combiner, or power amplifier. The M220X has two main transmitter modes, Standalone Mode and External PA Mode.



The TX port should be protected from ESD during connection and disconnection of cables and at all other times. ESD may damage or degrade the unit.

4.5.1 Standalone Mode

For standalone low-power operation, the M220X **TX** port is connected directly to a base transceiver antenna. In this configuration, the unit can generate a maximum of +24dBm, or 0.25W. The **PA STATUS/CONTROL** port should be left unconnected for proper operation in standalone mode.

4.5.2 External PA Mode

For high-power operation, the M220X can connect to an external power amplifier (PA), which can provide several hundred watts of output. In this case, the M220X **TX** port is connected to the PA input port, and the M220X **PA STATUS/CONTROL** port is connected to the PA monitor port using a specialized cable suited to the PA (summarized in 4.5.2.1 and 4.5.2.2).



The power amplifier and PA cable must be correctly matched, and securely fastened to both the M220X and the power amplifier before power is applied. Failing to follow this procedure can result in damaged equipment and/or hazardous conditions.

4.5.2.1 Power Amplifiers for M2205

Cable Part Number	PA Vendor	PA Part Number	Maximum Transmit Power
33CRS-M220X-PAC1	CRS	CRS-M2213	30W
CRS-M220X-PAC3	TPL	PA8-2EG-HMS	250W
CRS-M220X-PAC3	TPL	PA8-2EF-LMS	125W

4.5.2.2 Power Amplifiers for M2206

Cable Part Number	PA Vendor	PA Part Number	Maximum Transmit Power
CRS-M220X-PAC1	CRS	CRS-M2213	30W
CRS-M220X-PAC2	Crescend	P25-R2L3-PS-C8-001	250W
CRS-M220X-PAC3	TPL	PA8-2EG-HMS	250W
CRS-M220X-PAC3	TPL	PA8-2EF-LMS	125W

4.6 GPS

The M220X requires a Global Positioning System (GPS) receiver connected to either the **GPS A** or **GPS B** port. The **GPS A** port connects to an external active antenna using a coaxial cable. The **GPS B** port connects to an external smart antenna using a data cable. In both cases, the GPS antenna should be mounted outdoors with a 360° view of the sky.

4.6.1 GPS A

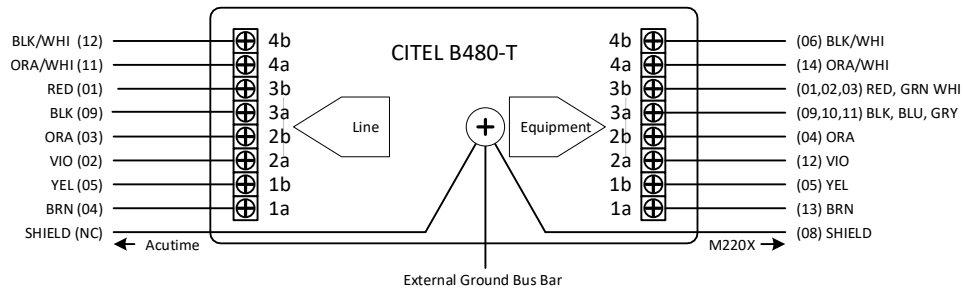
The **GPS A** port connects to a remote active antenna such as the Trimble Bullet 360 (101155-00) using a 50Ω coaxial cable. The coaxial cable passes 5V DC to the antenna and receives GPS signals from the antenna, and must be protected with a PolyPhaser DGXZ+06NFN-B or equivalent surge protector at the site external ground bus bar.

4.6.2 GPS B

The GPS B port connects to a remote Acutime series smart antenna such as the Trimble Acutime 360 (Trimble 106406-00), using a multiple conductor data cable. The cable contains 3 twisted pairs plus DC power, and must be protected with a Citel B480-T or equivalent surge protector at the site external ground bus bar.

The **GPS B** port is a DB15 female connector. The smart antenna cable is a circular 12-pin Deutsch connector. The cable between them is split and wired into a Citel B450-T or equivalent surge protector.

Acutime		Acutime Signal Description	M220X	
Pin	Color		Color	Pin
1	Red	DC Power (+12V)	Red, Green, White	1,2,3
2	Violet	Port B Receive -	Violet	12
3	Orange	Port B Receive +	Orange	4
4	Brown	Port B Transmit -	Brown	13
5	Yellow	Port B Transmit +	Yellow	5
6	White	Port A Receive -		N/C
7	Slate	Port A Receive +		N/C
8	Green	Port A Transmit -		N/C
9	Black	DC Power (0V)	Black	9, 10,11
10	Blue	Port A Transmit +	Blue	N/C
11	Orange/White	Time Mark +	Black/White	6
12	Black/White	Time Mark -	Orange/White	14
N/C	Shield	Ground	Shield	8



5 Preparing for Installation

5.1 General Safety Precautions

Read the warnings in this section before installing or working on the system.



Only trained and qualified personnel should attempt to install or replace the M220X. They should familiarize themselves with this manual and the R56 standard before installing the M220X.



Before working on equipment that is connected to power lines, such as the M220X or other equipment in the rack, personnel must remove jewelry (including rings, necklaces, and watches). Metal objects will heat up quickly if they touch power lines and can cause serious burns as well as equipment damage.

5.2 Grounding

The M220X ground lug as well as ground lugs of other equipment in the rack, as well as the rack itself, must connect securely to the site main ground bus bar. Connections between the rack and outdoor antennas must include in-line lightning arrestors mechanically clamped to the external ground bus. The M220X and its rack must be correctly grounded before connecting power or RF.



Failure to observe proper grounding convention can result in poor RF performance, radio frequency interference (RFI), or equipment damage.



When installing the M220XX, the ground must always be securely connected first. When removing or replacing an M220X, the ground must always be disconnected last. Failure to do this may result in bodily injury or damage to equipment.

5.3 A/C Power

A single electrical panel must power the entire M220X rack. The safety ground of the power panel must clamp to the site main ground bus bar, and the panel must have lightning protection. All panel circuit breakers must be sized correctly, the total current required by the panel must not exceed 2/3 of the branch current rating. All receptacles must include hot, neutral and ground conductors of at least 14 gauge. The ground connection from the panel to the rack must be a dedicated wire; conduit ground is not permitted.

5.4 ESD Consideration

Electrostatic discharge (ESD) can damage the M220X. In particular, the **RX A**, **RX B**, **TX**, and **GPS** ports may be particularly susceptible to damage from ESD. Whenever installing, removing, or replacing an M220X, the following steps should be taken to avoid damaging the unit:

- Ensure the M220X is electrically connected to the site main ground bus bar,
- Wear an anti-static wrist strap, ensure it makes good skin contact, and clip the ground line to the M220X grounding stud
- If no wrist strap is available, touch the M220X ground stud before beginning work.



The M220X RF ports (**TX**, **RX A**, and **RX B**) are extremely susceptible to ESD. Please take care when working with these ports.

5.5 RF Energy Awareness

For installations using a power amplifier, personnel must consider issues related to safe RF exposure levels. Personnel should have knowledge of the power amplifier, cables, and antenna systems, and should be aware of best practice concerning high field exposure. The following links may provide additional information:

<https://www.fcc.gov/engineering-technology/electromagnetic-compatibility-division/radio-frequency-safety/faq/rf-safety>

<https://www.osha.gov/SLTC/radiofrequencyradiation/index.html>

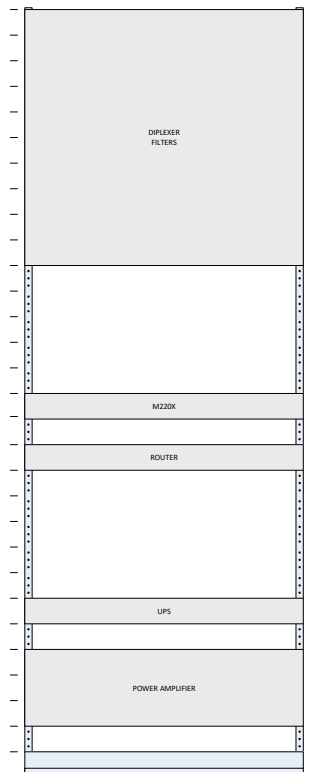
5.6 Rack Location Planning

The rack should be located in a stable, secure area, free of movement and vibration. The floor should be able to easily support the loaded weight of the rack. The rack should provide service access to the front and back of the M220X. The rack and cables should be located away from foot traffic, in an area free of excess heat, dust, and smoke, and generally in compliance with section 11.2.

The M220X requires an air temperature below 40°C (104°F). Three internal, DC-powered exhaust warm air from the left side of the chassis and draw in cool air from the right side of the chassis, cooling the M220X interior. To ensure adequate cooling, provide at least 3 inches of space on either side of the M220X.

5.7 Rack Component Planning

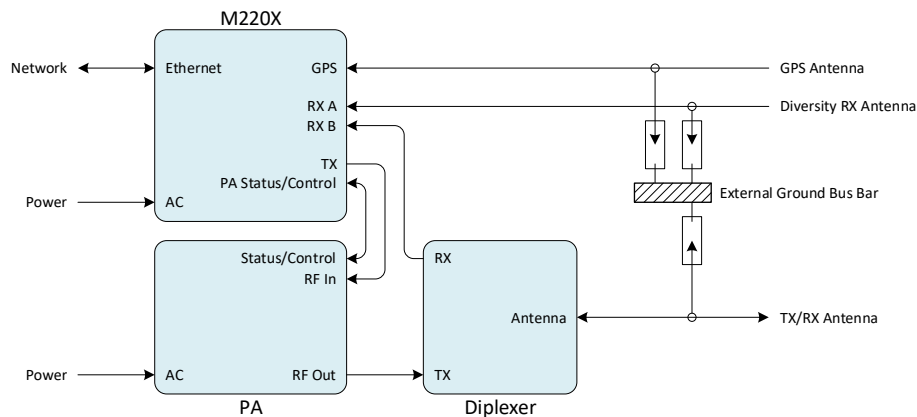
To avoid hazards associated with uneven mechanical loading of the rack, plan your installation so that the weight of the equipment is evenly distributed in the rack. Where possible (within the limitations of equipment and cabling), mount the heaviest units near the bottom of the rack. Also, keeping physical space between the M220X and any power amplifier will generally help receiver performance. Often, a reasonable approach is to place the power amplifier near the bottom of the rack, filters and diplexers near the top of the rack, and the M220X and other components near the middle.



6 Installing the M220X

The M220X is designed to be mounted in a 19" rack. Alternatively, the unit may also sit on a shelf or desk, but this is only recommended if all antennas, including the GPS antenna, are indoors and close to the unit.

In many cases, the M220X is part of a larger base site installation, which may also include a power amplifier, one or more base transceiver antennas, lightning protection, a diplexer, feed lines, jumpers, cavity filters, power, and IP network infrastructure. As per the Motorola R56 standard, all antenna lines as well as the GPS lines must be properly protected with a surge suppressor clamped to the site *external ground bus bar*, and the equipment rack must be grounded to the site *main ground bus bar*. The M220X ground stud must be connected to the site main ground bus bar along with ground lugs of all other equipment in the rack, using 14GA wire cut to the shortest possible length. In most cases, the rack itself (e.g., CPI 55053-703) should be electrically isolated from the floor using a CPI 10605-019 or equivalent isolation system.



6.1 Installing the Electrical Circuit

An outlet box containing two single phase circuits must be installed in close proximity to the equipment rack as per section 5.3. Ideally, the outlet box will use NEMA L5-20 compliant ("twist lock") receptacles, although NEMA 5-15 may be acceptable if security permits.

6.2 Installing the Rack System

The rack system (e.g., CPI 55053-703) should be securely bolted to the floor with an isolation kit (e.g., CPI 10605-019). If necessary, a local bus bar (e.g., CPI 10622-010) should be mounted to the wall near the rack, and mechanically and electrically clamped to the site main ground.

6.3 Installing the Rack Components

The M220X and other components should be mounted securely in the rack, using the supplied bolts and mounting ears. Grounding studs and lugs of all equipment in the rack should be securely connected to ground.



The M220X uses side-to-side ventilation for cooling. It requires a minimum of 3" clearance on the left and right side for proper cooling and air flow. Installing without this clearance will result in overheating and unreliable operation.

6.4 Connecting the RF Ports

The M220X **RX A**, **RX B**, and **TX** ports should be connected as per the site design. If a power amplifier is used, the power amplifier should be connected to the PA STATUS/CONTOL port using the correct cable.

6.5 Connecting Power and Turning on the M220X

Connect the A/C Power port to A/C voltage. Press and hold the ON/OFF button for approximately 3 seconds, until the POWER indicator turns on. The POWER and STATUS units will cycle through the boot process and the STATUS indicator will finally turn green to indicate the unit has booted.

6.6 Changing Root Password and Creating Users

Immediately up boot, you should change root password using the **passwd** command and create additional user accounts as necessary using the **adduser** command.

```
# passwd
# adduser user1
# passwd user1
# adduser user2
# passwd user2
```

6.7 Configuring the Ethernet Interface

Once the password is changed, you should configure the ethernet port according to your site IP plan using the **nmtui** utility. Alternatively, you may edit configuration files directly or take other steps based on your own procedures.

```
# nmtui edit eth0
```

6.8 Rebooting the System

Once the root password is changed, users are created, and the ethernet port is configured, you should reboot the system again as follows:

```
# shutdown -r now
```

6.9 Connecting the Ethernet Port

After the system restarts, it should be connected to the Ethernet network. Verify the LED lights on the connector and the NET indicator on the front panel show proper operation.

6.10 Updating the Software

Once the network is connected, log in again through the console port or through SSH using the new root password. Once you see the command prompt, update system software using the YUM command:

```
# yum update
```


7 M220X Configuration

M220X configuration file describes the physical transceiver operating parameters for the M220X. These include parameters for filters, cable loss, and transmit power. This file can be edited through the shell, using a text editor, or set up parameter by parameter through the CLI. It can also be edited remotely from a Windows 10 PC using the Sparkgap Administrator.

7.1 site_name

This string value contains the human readable name of the site.

7.2 system_name

This string value contains the name of the system to which the M220X belongs.

7.3 transmitter

7.3.1 enable

This numeric value enables the transmitter if it is non-zero, or disables the transmitter if it is zero. The default value is zero.

7.3.2 power

This numeric value specifies the final output power, in watts, as measured at the **TX** Port or the Power Amplifier output port.

7.3.3 line_loss

This floating point value describes the net loss from the **TX** Port or Power Amplifier output port to the transmit antenna, cables, duplexer, filter, etc, in dB.

7.3.4 filter

This object describes any harmonic or band pass filters in the transmit path. The absence of this node implies no filter is present.

7.3.4.1 center

This integer value represents the center of the passband in Hz.

7.3.4.2 bandwidth

This integer value represents the width of the passband in Hz.

7.4 receiver

The receive object describes the receiver.

7.4.1 noise_threshold

This floating point value sets the noise maximum noise level allowed at the **RX A** or **RX B** ports. A noise level higher than this value will trigger an alarm.

7.4.2 enable

This integer value enables the receiver if it is non-zero, or disables the receiver if it is zero. The default value is zero.

7.4.3 filter

This object describes any preselection filter in the receive path. The absence of this node implies no filter is present.

7.4.3.1 center

This integer value represents the center of the passband in Hz.

7.4.3.2 bandwidth

This integer value represents the width of the passband in Hz.

7.4.4 line_loss_a

This floating point value describes the net loss from the receiver B antenna to the **RX A** port, in dB, including amplifiers, cables, duplexer, filter, etc. If the overall effect is a net loss, this value is positive. If the overall value is a net gain, the value is negative.

7.4.5 line_loss_b

This floating point value describes the net loss from the receiver B antenna to the **RX B** port, in dB, including amplifiers, cables, duplexer, filter, etc. If the overall effect is a net loss, this value is positive. If the overall value is a net gain, the value is negative.

8 SNMP

In addition to standard CentOS related mibs, the M220X software also make 1.3.6.1.4.1.12015.100 available for transceiver-specific data.

9 BXI

Base Transceiver Interface (BXI) is the TCP/IP protocol used by a control stack to communicate with base transceivers including the M220X series. During normal operation, the control stack makes a BXI connection to the M220X, then begins sending forward channel frames and receiving reverse-channel packets.

10 SSH and Console

An administrator can make a shell connection to the M220X using either SSH or the CONSOLE port on the front panel. Through the shell, a user may modify configuration, view logs, restart the system, or perform diagnostics and troubleshooting.

10.1 systemctl

The main operating software for the M220X is the systemd unit, *m220xd*. The systemctl command may be used to start or stop the unit, or view its status.



Stopping or disabling the m220xd unit will stop operation of the GPS, transmitter, and receiver. This should only be done by trained service personnel.

10.2 Log View

The lv2 command line allows the user to view logs in real time from the shell. Typing lv2 shows command-related help.

10.3 Command Line Interface

The shell command m220x launches a command line interface (CLI) that allows the user to view status, calibrate, and troubleshoot the M220X. It is invoked from the shell by typing the command m220x. The CLI provides some basic information about the system and then prompts the user to enter a CLI command.

```
# m220x

M220X Command Line Interface

M2206 S/N 18110201
Software Version 1.2.0 Build 239
Hardware Version 1.0
FPGA Revision 1.2.2 Build 110

Unit Running
No Alarms

M220X> █
```

10.3.1 test

The test command stops normal base transceiver operation and begins a test in the background.

10.3.1.1 test tx <frequency> <power>

This command transmits a sine wave at a particular frequency and output power. The test continues until the user executes the test stop command or another test command.

```
M220X> test tx 931000000 0.25w
```

```
Test running.  
Now transmitting unmodulated carrier on 931000000Hz at 0.25W (+24dBm)  
Type test stop to resume normal operation.
```

```
M220X> █
```

10.3.1.2 test tx <modulation> <frequency> <power>

This command begins transmission pseudorandom symbols at a particular modulation, frequency, and power. The modulation parameter accepts *frame*, which sends a properly encoded iocast frames containing random data, or *raw*, which transmits random symbols with no framing. The test continues until the user executes the test stop command or another test command.

```
M220X> test tx i9600 931000000 0.25w
```

```
Test running.  
Now transmitting i9600 data on 931000000Hz at 0.25W (+24dBm)  
Type test stop to resume normal operation.
```

```
M220X> █
```

10.3.1.3 test stop

This command stops all tests in progress.

```
M220X> test tx 931000000 0.25w
```

```
Test stopped. Normal operation resumed.
```

```
M220X> █
```

10.3.2 calibrate

10.3.2.1 calibrate rx <port> <frequency>

This command calibrates the receiver. Before executing this command, the technician should connect a signal source to one of the receiver ports, A or B. The signal generator should generate a sine wave of frequency <frequency> at a level of -50dBm. This command will run for approximately 10 seconds and calibrate the receiver gain and AGC values.

```
M220X> calibrate rx a 897000000
```

```
Begin calibration.
```

```
Please connect signal source to the RX A port, configured for an  
Unmodulated carrier at 897000000Hz at a power level of -50dBm. Once  
This is ready, please hit ENTER:
```

```
Calibration in progress. Please wait...
```

```
Calibration Complete. Normal operation resumed.
```

```
M220X> █
```

10.3.2.2 Calibrate tx <frequency>

This command calibrates the transmitter. Before executing this command, the technician should connect a flow-through power meter to the transmitter port TX, in line with a 50 ohm terminator. Once the user types the command, the cli will query the user for the power level several times.

```
M220X> calibrate tx 931000000
```

```
Begin calibration.
```

```
Step 1: Please enter the current power measured at TX port: 0.237W
```

```
Step 2: Please enter the current power measured at TX port: 0.221W
```

```
Step 3: Please enter the current power measured at TX port: 0.209W
```

```
.
```

```
.
```

```
Step 16: Please enter the current power measured at TX port: 0.091W
```

```
Calibration Complete. Normal operation resumed.
```

```
M220X> █
```

10.3.3 Alarm

The alarm command displays or clears current alarms.

10.3.3.1 alarm show

This command shows a list of active alarms.

10.3.3.2 alarm clear

This command clears all active alarms.

10.3.3.3 alarm test

This command generates a test alarm

10.3.4 config

The config command sets or displays the current configuration of the M220X.

10.3.4.1 config display

This command displays the current configuration file.

10.3.4.2 config set <parameter> <value>

This command sets a configuration value.

```
M220X> config set transmitter.enable 1
```

```
Parameter Set.
```

```
M220X> █
```

10.3.5 exit

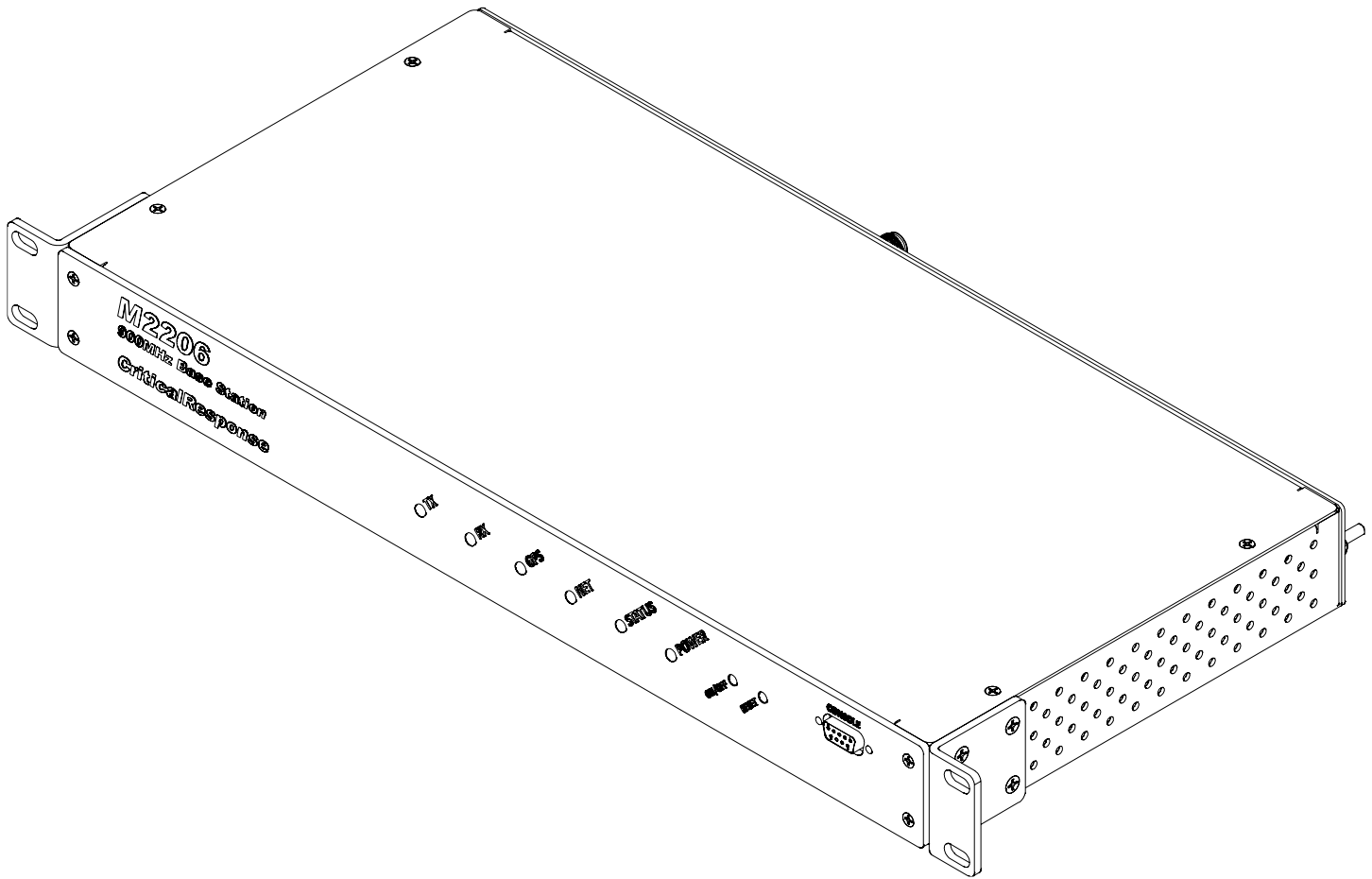
This command exits the CLI and re-enters the Linux shell.

```
M220X> exit
```

```
Exiting M2206 CLI..
```

```
# █
```

11 Product Specifications



11.1 Physical Characteristics

Dimensions	19" × 1.75" × 8"
Weight	6lbs
Mounting	1U 19" EIA Rack Space

11.2 Environmental

Operating Temperature	-30°C to +50°C
Storage Temperature	-40°C to +85°C
Humidity	5% to 95% non-condensing
Altitude	10,000 feet maximum

11.3 Power Supply

Voltage	90-264VAC
Frequency	50Hz or 60Hz

Power Used	35-50W
Connector	IEC320-C14 and #8 threaded ground stud

11.4 Transmitter

11.4.1 M2205

Output Power	+17dBm to +24dBm
Frequency Range	851 to 860MHz
Carrier Accuracy	±10 ppb
Modulation Accuracy	±100Hz
Emission Mask	§90.210(d)
Emission Designator	7X60FXD
Modulation	locast 4FSK (see ETSI TS 102 361-1 V2.4.1, section 10.2.2)
Output	SMA Female 50Ω

11.4.2 M2206

Output Power	+20dBm to +24dBm
Frequency Range	928 to 942MHz
Carrier Accuracy	±10 ppb
Modulation Accuracy	±100Hz
Emission Mask	§90.210(d) §24.133(2) §22.359(b)(2)
Emission Designator	7X60FXD
Modulation	locast 4FSK (see ETSI TS 102 361-1 V2.4.1, section 10.2.2)
Output	SMA Female 50Ω

11.5 Receiver**11.5.1 M2205**

Input Level	-130dBm to -60dBm
Frequency Range	806 to 815MHz
Carrier Accuracy	±10 ppb
Channel Width	10KHz
Selectivity	-65 dB @ 12.5KHz EIA SINAD
Sensitivity	90% packet recovery at -119 dBm
Modulation Acceptance	±2.5KHz
Input	SMA Female 50Ω

11.5.2 M2206

Input Level	-130dBm to -60dBm
Frequency Range	896 to 902MHz
Carrier Accuracy	±10 ppb
Channel Width	10KHz
Selectivity	-65 dB @ 12.5KHz EIA SINAD
Sensitivity	90% packet recovery at -119 dBm
Modulation Acceptance	±2.5KHz
Input	SMA Female 50Ω

11.6 Ordering Information

The M220X series use the following part number format:

CRS-M220①-②-③

	Value	Description
① Frequency option	5	851-860/806-815MHz
	6	928-942/896-902MHz
② GPS option	A	GPS ports A and B
	B	GPS port B only
③ Air protocol option	I	IOCAST

Part Number	Return Frequency	Forward Frequency	Air Protocols	GPS Ports
CRS-M2205-A-I	806-815MHz	851-860MHz	locast	A & B
CRS-M2205-B-I	806-815MHz	851-860MHz	locast	B Only
CRS-M2206-A-I	896-902MHz	928-942MHz	locast	A & B
CRS-M2206-B-I	896-902MHz	928-942MHz	locast	B Only