AR^{220DB} 1.0 Radio Installation and Field Service Guide

DCN 00006153-B

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Revision History

Revision	Date	Notes / Summary of changes
A	12/13/2024	Initial draft.
B	1/30/2025	Initial document release. Published in support of release 1.0 of AR^{220DB} 220 MHz Radio software.

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Contents

Figures

Tables

1 Introduction

The *AR220DB Radio Installation and Field Service Guide* provides important radio-frequency safety information, installation procedures, and servicing instructions for the Meteorcomm Interoperable Train Control (ITC) AR220DB radio model 70010. Throughout this and other documents the radio is referred to as the AR220DB radio and also the AR220DB radio.

1.1 Audience

This guide is intended for users who perform any of the following tasks on AR220DB radios:

- Install or replace them.
- Diagnose common problems.
- Adjust radio characteristics.
- Perform routine maintenance.

Prerequisites for users of this guide include:

- The ability to work with standard radio-frequency (RF) test equipment, including knowledge of how to prevent equipment damage or personal injury.
- The ability to measure basic transceiver performance, including RF power, frequency and receiver sensitivity, and the knowledge to analyze RF performance.
- Basic knowledge of the Linux shell.
- Knowledge of how to use an SSH client.
- Familiarity with means to limit RF exposure from antennas and familiarity with the Meteorcomm RF Energy Exposure Guide.

1.2 Some Terms Used in this Documentation

The term "Base radio" refers to the radio hardware unit and its immediately associated equipment, such as antenna and power source.

The term "base" refers to a network role that provides RF connectivity between the Back Office and locomotives and waysides. At present, only a Base radio can occupy the base role.

The term "remote" refers to a network role that does not provide a connection to the Back Office but that monitors its connection to a radio in the base role. A Locomotive or Wayside radio normally fills the remote role, but you can configure a Base radio to operate in the remote role.

The *AR220DB Radio Installation and Field Service Guide* uses Linux-style notation.

Throughout this document the names of commands and their arguments in running text, as well as examples of commands and their outputs in shaded example boxes, are printed in `fixed-width font`, as in the following example:

```
config --profile --list
```

1.3 Specifications for ITC Model AR^{220DB} Radio 70010

The following tables describe the general, transmitter and receiver specifications for the AR^{220DB} Radio 70010.

> **Note:** Specifications are subject to change without notice.

Table 1-1: ITC Model AR220DB Radio 70010 General Specifications

Specification	Description
Frequency range	217.6 to 222 MHz
Channel spacing	25 kHz
Temperature range	Operating: -40°C to +70°C Storage: -55°C to +85°C
Humidity, operating	0% to 95% noncondensing; Test per S-5702, clause 3.2.3.2
Frequency stability	±1.0 ppm 217.6125 to 219.9875 MHz ±1.5 ppm 220.0125 to 221.9875 MHz
DC input voltage range	10.9 to 15.5V Damage limit 20VDC
DC current drain (13.6VDC input)	Transmit: 10A max into 50 Ohm load, 7.5A typical Receive: 1A max while receiving
DC power connector	Wago p/n 231-833/001-000
Height	2.18 in.
Width	6.0 in.
Depth	3.57 in.
Weight	2 lbs. (0.9 kg)

Specification	Description
Antenna connector	Type N female
External interface: Ethernet 10/100 Mbps	Data Network ports (1) – Type RJ-45 Maintenance port - (1) - Type RJ-45
Display	Activity/Diagnostic LEDs

Table 1-2: ITC Model AR220DB Radio 70010 Transmitter Specifications

Specification	Description
RF power output	25W PEP Adjustable 0.25 W to 25 W PEP
Output impedance	50 ohms Operating VSWR < 4:1
Modulation waveforms	32kbps π/4 DQPSK
Occupied bandwidth	<25 kHz Meets Part 80 Occupied BW: 2.1049 and Part 90 Occupied BW: 90.209, 90.733 (d)
Conducted spurious emissions	-25dBm max
Max duty cycle rating	10%
Emission designator	17K6DXW (32kbps π/4 DQPSK)
Regulatory approvals	FCC ID BIB70010

Note: AR^{220DB} does not currently support half-rate transmissions on any channel.

Table 1-3: ITC Model AR220DB Radio 70010 Receiver Specifications

Specification	Description
Maximum usable sensitivity, static, BER<10-4	16kbps PI/4DQPSK -111dBm 32kbps PI/4DQPSK -108dBm
Adjacent channel selectivity	70dB @ 25kHz offset
Spurious response rejection	65dB
Intermodulation response rejection	65dB
Maximum destructive input level	+15dBm
High input level (-7dBm)	BER<10^{-4}
Blocking, 1MHz offset	Half rate: 80dB Full rate: 77dB
Number of channels simultaneously received	4
Diversity support	No

1.4 Release Documentation

Along with this document, the following documents are included in the release package.

- *AR220DB 1.0 Release Notes*, DCN 00006225-A
- *AR220DB Getting Started Guide*, DCN 00006154-B
- *AR220DB Security User Guide and Reference*, DCN 00006163-B
- *AR220DB Command Line Interface Reference* (also called *CLI Reference*), DCN 00006157-B
- *AR220DB Radio Configuration Guide*, DCN 00006155-B
- *AR220DB Radio Management Guide*, DCN 00006160-B
- *AR220DB API Reference*, DCN 00006159-B
- *AR220DB Data Dictionary User Guide and Reference*, DCN 00006162-B
- *AR220DB Logging User Guide and Reference*, DCN 00006156-B
- *AR220DB System Architecture*, DCN 00006224-B
- *RF Energy Exposure Guide*, DCN 00001235-J

1.5 How to Get Help

Please contact our Service Desk (https://support.meteorcomm.com/home) if you have any questions regarding this release.

We encourage you to provide feedback, comments, and suggestions so that we can improve the documentation to better meet your needs. Send your comments to the Service Desk and provide the following information:

- Document name
- Section or page number
- Software release number

2 Safety

Your employer has created safety guidelines that apply to your work environment and tasks. Please follow them. If you have questions about general on-the-job safety concerns, please consult your employer's established safety guidelines.

2.1 Electrical Safety Guidelines

To reduce the risk of electric shock:

• Follow your employer's established electrical-safety guidelines.

• Disconnect power from radio before removing the cover.

• Be aware that removing the radio cover may expose you to dangerous voltages or other risks. Avoid making internal adjustments to the radio when you are alone.

• Avoid contact with a radio's electrical components. Electric shock from voltages present within the radio is potentially fatal.

• Reassemble radios correctly. Incorrect reassembly of a radio can cause a harmful electric shock to radio handlers.

2.2 RF Safety Information

You must be aware of the following information to prevent your physical harm or death or damage to the equipment.

2.2.1 Limiting RF Exposure

CAUTION! Please see the *RF Energy Exposure Guide* that is packaged with each radio for specific information regarding safe distances that must be maintained between personnel and energized transmitting antennas.

The information in the *RF Energy Exposure Guide* is determined from FCC and Industry Canada (IC) rules that, when followed, limit human exposure to radio frequency energy to acceptable levels. Note that although the AR^{220DB} radio should be sited, installed, and maintained only by professionals in a controlled-exposure environment, the *RF Energy Exposure Guide* lists the larger lateral safe distances for an uncontrolled environment. Obeying these limits will protect both railroad employees and the public.

The transmitter should be operated with a fixed antenna in an Occupational/Controlled Exposure environment per Federal Communications Commission (FCC) Office of Engineering and Technology (OET) 65 or Controlled Use Environment per IC RSS-102. The Maximum Permitted Exposure (MPE) limit

for devices in the presence of the general public in the 100-300 MHz range is 0.2 mW/cm2 = 2W/m2 vs. 10W/m2 in a controlled-exposure environment.

This radio is intended for use by railroad employees who have full knowledge of their exposure and can exercise control over their exposure to meet FCC and IC limits. This radio device is not intended for use by consumers or the general population.

The table in the *RF Energy Exposure Guide* lists the calculated lateral distances to be maintained between the general public and an operational AR^{220DB} radio transmitter antenna for two antenna types suitable for fixed applications.

CAUTION! RF exposure compliance while servicing multiple transmitter sites must be addressed on a site-by-site basis. It is the responsibility of the licensee to ensure compliance with maximum exposure limits.

2.2.2 Antenna Guidelines

This section contains antenna information and additional notes regarding methods to limit RF exposure.

You must:

- Comply with limits on antenna location, power and effective antenna height per 47CFR Subpart T §90.701 et. seq., or Industry Canada SRSP-512 §6.3 as applicable. See section 4.3 for additional information about how to comply with ERP limits. See the *RF Energy Exposure Guide*for specific guidelines regarding the siting and installation of fixed antennas.
- Follow the acceptable fixed-antenna types that are listed in the lateral separation distance tables in the *RF Energy Exposure Guide*.
- Install antennas in accordance with the manufacturer's instructions.
- Disable the transmitter when installing or servicing its antenna or transmission line.
- Maintain a safe distance from energized transmitting antennas. See the table of safe distances for AR220DB radios in the *RF Energy Exposure Guide*, which is packaged with each radio.
- Remove any unauthorized antennas, equipment modifications, or attachments that could invalidate any equipment warranty or authority to transmit. Modification could damage the radio and may violate FCC or IC regulations. Contact Meteorcomm before using other antennas.

2.2.3 RF Interference Considerations

Notice to user: This equipment complies with Part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference.

Note: 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 the user will be required to correct the interference at his own expense.

2.2.4 Equipment Modifications

CAUTION! Any changes or modifications to this equipment not expressly approved by the party responsible for compliance (in the respective country of use) could void the user's authority to operate the equipment.

3 Transmitter Operation

It is your responsibility, as the licensee, to operate this radio transmitter in compliance with FCC and Industry Canada service rules for 220-222 MHz, namely FCC Rules Part 90 Subpart T and Industry Canada SRSP-512. It is also your responsibility to coordinate specific frequency use within a specified area with PTC-220 LLC.

3.1 Radio Channelization and Frequency Range

You can configure the AR^{220DB} radio to transmit on any one of 80 selectable 25 kHz-spaced channels ranging from 220.0125 to 221.9875 MHz inclusive. The spectrum included corresponds to all 5-kHz-wide FCC channels numbered from 1 at 220.0025 MHz to 400 at 221.9975 MHz. Each AR^{220DB} radio transmission occupies five of the FCC-defined 5 kHz channels. The lowest channel center frequency for the AR^{220DB} radio is in the center of FCC channel 3 and the next is FCC channel 8, then 13, 18, and so on, up to the highest in the center of channel 398.

3.2 Channel Restrictions

Section 90.715 of the FCC Rules lists the authorized frequencies of the 400 total 5-kHz-wide channels. According to §90.733(d), these can be aggregated into larger channel widths with the exception of FCC channels 161 through 170 and 181 through 185. Therefore, the AR^{220DB} radio does not transmit on those channels or their 221 MHz counterparts, 361 through 370 and 381 through 385. This corresponds to AR^{220DB} radio frequencies 220.8125, 220.8375, 220.9125, 221.8125, 221.8375, and 221.9125 MHz.

Please see Part 90 Subpart T and SRSP-512 for additional frequency use restrictions in Canadian and Mexican border areas.

3.3 Radiated Power Limits

WARNING! It is your responsibility, as the licensee, to comply with the effective radiated power limits based on operating frequency, geographic location, and effective antenna height set out in 47CFR Subpart T §90.701 et. seq., or Industry Canada SRSP-512 §6.3, as applicable.

> **Important:** The following supplementary antenna system information discusses methods for you, as the licensee, to determine effective radiated power (ERP) and comply with regulatory power limits.

You must comply with the specific power and antenna height limitations for fixed-antenna stations per §90.729 or SRSP-512 §6.3. Note that U.S. and Canadian power limits vs. HAAT are not identical.

You should note that all mobiles and also fixed installations transmitting between 221 and 222 MHz must limit ERP to 50W or 10*log(50) + 30 = 47 dBm peak envelope power (PEP) referenced to the 2.15

dBi gain of a dipole, unless operating under a waiver of FCC rule §90.729(b) or SRSP-512 §6.3 as applicable. The EIRP for this case is 49.15 dBm. Also note that the maximum ERP on FCC/IC channels 196 through 200 at 220.975 to 221.000 MHz is 2W.

The allowable transmitter peak envelope power output in dBm is determined by subtracting the antenna gain in dBd from 47, then adding the loss from the antenna feedline and connectors. If the result is greater than or equal to 44 dBm = 14 dBW then the maximum power output of the AR^{220DB} radio transmitter can be used. If the value is less than 44 dBm, then the transmitter output power must be reduced to the calculated value.

3.3.1 Mobile Installation

As an example of a mobile installation, consider a vertical half wave ground plane on a vehicle metal rooftop. In an ideal installation the antenna gain = 2.4 dBd = 4.55 dBi. Ignoring connector losses, feedline loss is at least 0.6 dB for 10 feet of Times Microwave LMR-195 Ultra Flex coaxial cable. Transmitter power output limit = 47-2.4 + 0.6 = 45.2 dBm PEP. Since this is higher than 44 dBm the system is compliant with the 50W ERP limit with the Wayside radio maximum transmit power. The actual ERP in this case is 10^[(14+2.4-0.6)/10]=38.0W. This installation is not allowed to transmit on FCC channels 196 through 200 because the maximum ERP is greater than 2W.

3.3.2 Fixed Installation

In a fixed installation, a common single-element exposed folded dipole antenna without reflector has 0 up to 2.9 dBd (2.1 – 5.0 dBi) azimuthal gain depending on the design.

After the allowable ERP is determined by applying all the previously listed power-restrictive rules and the antenna gain is known, the transmitter peak envelope power output feeding the transmission line is determined by subtracting the antenna gain in dBd from the ERP and adding the loss from the antenna feedline and connectors plus the loss from any external inline power sensors, combiners, filters or lightning arresters. If the net value is greater than or equal to 44 dBm, then the maximum power of the AR^{220DB} radio transmitter can be used. If the value is less than 44 dBm, then the transmitter output power must be reduced to the net value.

Example for the 50W ERP fixed case: Antenna gain = 2.9 dBd and feedline loss is at least 0.5 dB for 25 feet of Times Microwave LMR-400 coax plus 0.4 dB for inline lightning arrester and three connectors. Assuming no other losses, the transmitter power output limit = 47-2.9+0.9 = 45 dBm PEP. In this case, the actual AR^{220DB} ERP is 44+2.9-0.9 dBm = 46 dBm = 39.8W PEP and therefore the system is compliant with the 50W ERP limit. This installation is not allowed to transmit on FCC channels 196 through 200 because the maximum ERP is greater than 2W.

4 Installation

The AR^{220DB} radio satisfies the niche requirement for transporting data from the field to the Back Office.

AR^{220DB} radios are typically installed at various ancillary locations and configured as remotes to make connections with bases. The radios are meant for installation in such a way that they are protected from the elements. The radio's dimensions are approximately 6.0" wide x 2.18 in" tall x 3.57" deep and it weighs about 2 pounds.

All input/output ports are grounded and/or shielded. Internal shielding, unit assembly and printed circuit board (PCB) design are used to minimize unwanted radiated emissions.

WARNING! This radio requires an external isolated power supply to provide ground isolation between the radio and the site electronics when located with railroad signalling equipment. Failure to use an isolated power supply (for example, connecting unit directly to site batteries) could induce a ground fault at the site because the radio unit is grounded to the bungalow both through the ground lug and the 220 antenna.

Figure 4-1: AR^{220DB} radio

Radio installation consists of these steps:

1. Unpack and inspect the radio.
2. Mount the radio.
3. Ground the radio.
4. Install current-limiting circuit protection.
5. Connect the antenna.
6. Connect the Ethernet cable.
7. Connect the power cable.
8. Power on the radio.
9. Check the L1 LED.
10. View the power-on self-test (POST) results.

The following sections describe each of these steps in detail.

4.1 Equipment Required for Verification of Specification Compliance

Following is a list of equipment required to perform all of the tests described in this document. You should be familiar with the pieces of test equipment listed in the following table. Instructions about how to use the following equipment are beyond the scope of this document.

Table 4-1: Equipment required for installation and field service

Type	Model	Notes
Vector signal generator	Agilent E4438C or equivalent	Recommend option for 50VDC, 50W input protection of RF signal output port. Preprogrammed with DQPSK data packet.
Vector signal analyzer	Agilent E9010A or equivalent	
10 MHz frequency standard	Standard Research Systems model FS725 or equivalent	AR^{220DB} radio frequency adjustments require frequency standard accuracy to 0.01 ppm or better.
60 dB power attenuator/load		Consists of two pieces with 100W and 2W min. power rating.
Constant voltage DC power supply		Verify unit supports voltage and current draw required by unit under test.
Host computer with at least one Ethernet port and MobaXterm, PuTTY, or equivalent terminal program installed		If the host computer's Ethernet port has not been configured, follow the instructions in "Appendix A: Configure Computer Ethernet Interfaces " on page 37.
Wilmore DC-DC Converter 1675-12-12-15 or equivalent		The radio must be grounded to a proper isolated converter.
Clip-on ammeter		
Antenna/VSWR test kit		
Cable ties as required		
Digital volt meter		
Network analyzer		
Portable power meter		
Site tester		

4.2 Unpacking and Inspecting the Radio

When you unpack and inspect the radio, note any damage that may have resulted from shipping including dents or loose parts. Also note any damage or discrepancies between the contents in the

shipping container and the packing list.

> **Note:** The radio is shipped with a power connector (Meteorcomm [MCC] part number 010-031-0306). Please ensure it is connected to the radio and not left in the packing box.

If you detect damage or the contents do not match the invoice, make note of the defect and contact the radio manufacturer, with particular attention to the following:

- Observable damage to chassis and connectors
- Missing parts such as screws and included connectors
- Evidence of contamination including stains and odors
- Evidence of electrical stress such as plasma flashover, pitting, and arc damage

If you do not detect any damage and the shipping invoice matches the contents, continue with the installation.

4.3 Mounting the Radio

The radio cover is equipped with top and bottom mounting features. The AR^{220DB} radio should be mounted on a vertical surface with the cooling fins oriented vertically for maximum heat dissipation.

In mounting the radio, ensure that:

- Equipment that produces substantial heat is not installed below the radio.
- Each radio is secured with a minimum of two screws on the top and bottom.
- There is adequate room for cable connections.
- Cables are restrained to prevent kinking and stressing connectors.

4.4 Power Supply Requirements for AR^{220DB} Radios

CAUTION! Applying an incorrect voltage outside the rated voltage range of a AR^{220DB} radio can damage it. Confirm the voltage ratings of the radio and the power supply before applying power.

Table 4-2: AR^{220DB} radio input power parameters

Parameter	Value
Nominal DC Power Input Voltage	13.6VDC
Operational Range	10.9 – 15.5VDC
Damage Limit	20VDC
Current Drain (while transmitting rated power)	

4.5 Grounding the Radio

WARNING! This radio requires an external isolated power supply to provide ground isolation between the radio and the site electronics when located with railroad signalling equipment. Failure to use an isolated power supply (for example, connecting unit directly to site batteries) could induce a ground fault at the site because the radio unit is grounded to the bungalow both through the ground lug and the 220 antenna.

> **Note:** The radio must be grounded to a proper isolated converter such as the Wilmore DC-DC isolated converter (P/N 1675-12-12-15) or equivalent.

To ground the radio:

1. Remove the nut and washer from the grounding stud.
2. Connect the ground wire ring lug to ground.

> **Note:** Meteorcomm recommends that the gauge of the ground wire connected to the grounding stud of the radio be the same as or lower than the gauge of wire supplying power to the radio.

4.6 Installing Current Limiting Circuit Protection

External circuit protection must be supplied to each radio. If necessary, always replace the fuse with a 10A/32V-rated ATO fuse.

4.7 Connecting the Antenna

You must plan the location before you can connect the antenna.

4.7.1 Antenna planning

The radio is designed to be properly terminated to 50-Ohm resistance load. AR220DB radios have one antenna port.

4.7.2 Connecting the cable

The AR^{220DB} radio is rated for 25W peak envelope power (PEP). Sufficient termination is required to protect test equipment. The AR^{220DB} radio uses N-type connectors for narrowband RF antennas. For transmitter and receiver testing, connect the test equipment to the port labeled ANT.

Figure 4-2: Antenna connector

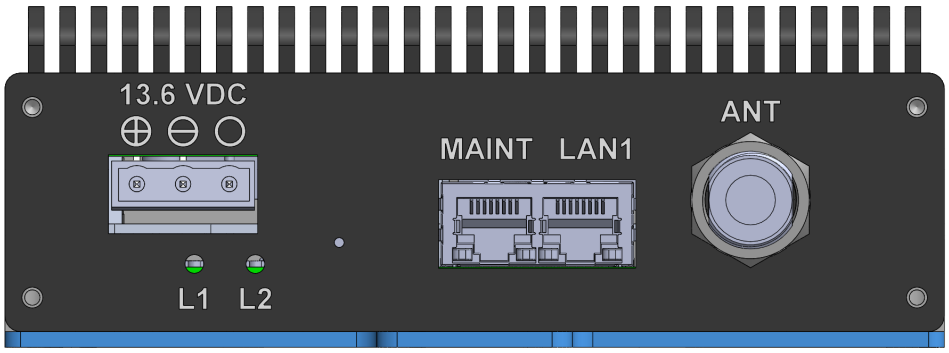
To connect the cable:

1. Perform or confirm a 220 MHz antenna voltage standing wave ratio (VSWR) test prior to connecting the antenna to the radio using an antenna/VSWR test set.
2. Slip the connector over the radio port and tighten.
3. Restrain all cables while observing the cable manufacturer's minimum bend radius requirements.

4.8 Connecting the Ethernet Cable

The AR^{220DB} radio uses a shielded CAT5 or CAT6 Ethernet cable and two RJ-45 Ethernet I/O ports, each on its own network.

Figure 4-3: Ethernet connections



Insert the cable into the port on the radio marked LAN1.

> **Note:** It is recommended that only shielded cable be used.

4.9 Connecting the Power Cable

CAUTION! Applying an incorrect voltage to a radio can cause damage. Confirm the voltage of the power supply and the polarity before applying power to the radio.

The AR^{220DB} radio operates from a 13.6VDC nominal supply (10.9 – 15.5 VDC range) isolated from other electronic equipment using a DC-DC isolated converter. The AR^{220DB} radio uses a Wago-type connector supplying 10.9 – 15.5VDC. The power cable length should be as short as practical to minimize voltage drop.

> **Important:** The radio only operates on DC voltage. Any application of AC voltage could damage the radio.

Figure 4-4: Example of a typical power cable externally fused with 10A ATO

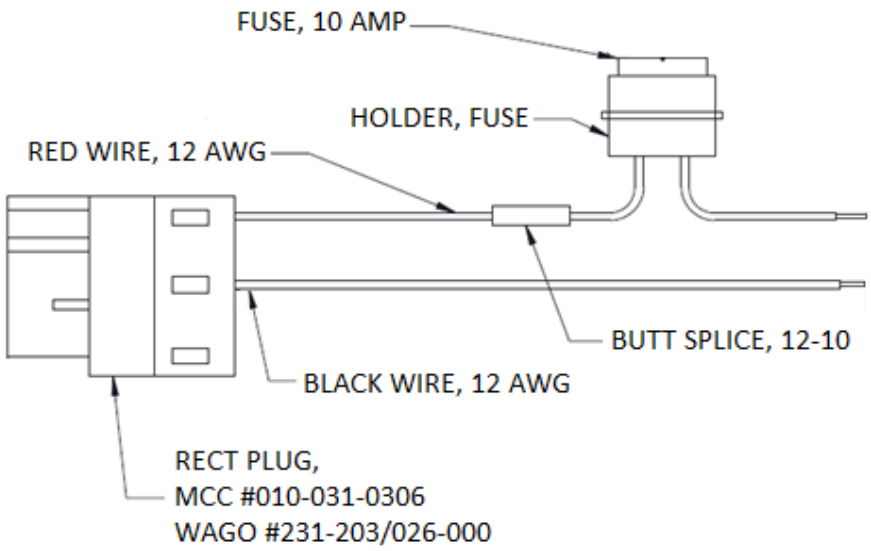
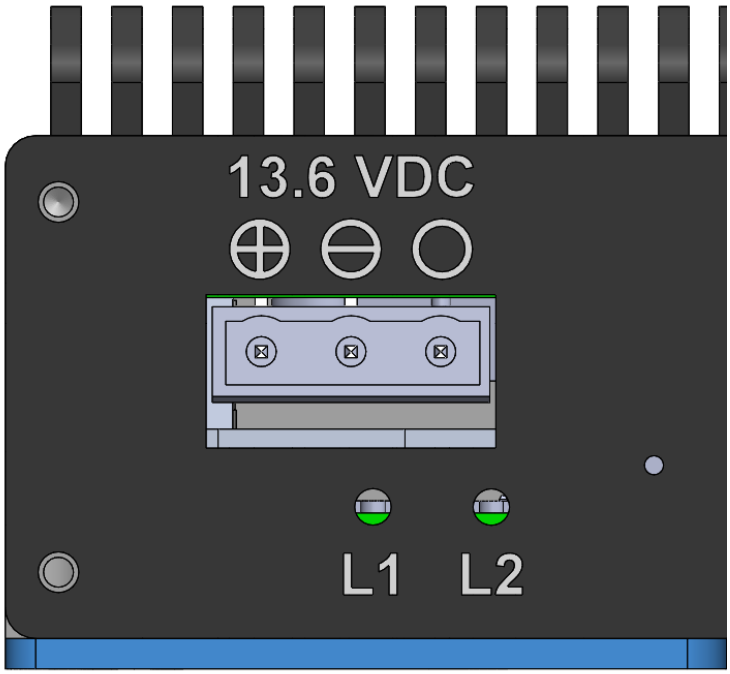


Figure 4-5: Power connector



To connect the power cable:

1. The radio does not have a power switch. Verify that the power is off before connecting the radio to a power source.
2. Confirm proper grounding.
3. Verify the ground bond from the ground lug on the radio through external surge protection.
4. Confirm that the ground lug connection has not bypassed the isolator converter.
5. Insert the connector into the slot. The connector can only fit one way. Make sure the red wire is connected to the slot marked +.

4.10 Connecting the GPIO connectors

AR^{220DB} does not support GPIO connectors.

4.11 Powering On the Radio

WARNING! You should never apply power to any radio unless you are acutely aware of your intentions and the environment in which the radio is operating. Applying power to an improperly terminated radio may result in damage to the radio, cause operator injury, or violate regulatory laws regarding radio transmissions because radios will begin transmitting full-rated power without any user intervention under certain conditions.

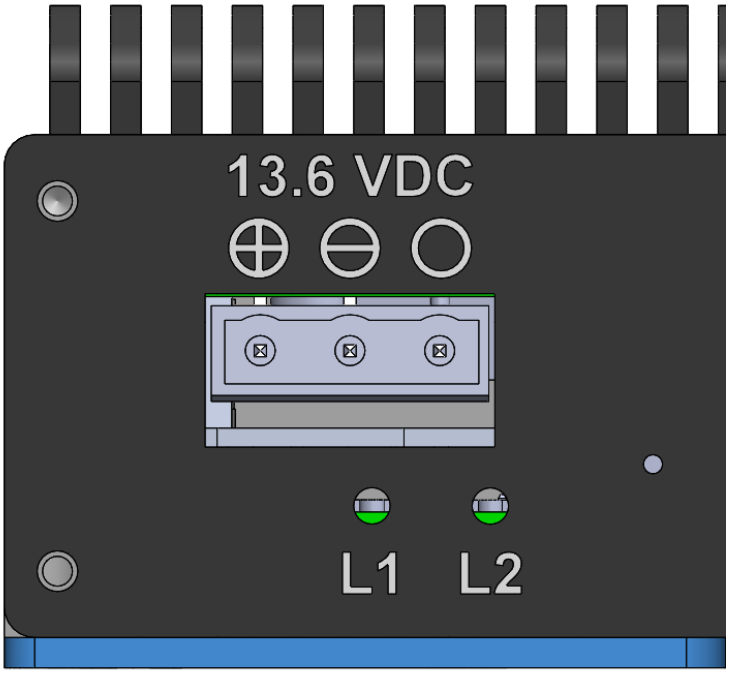
To power on the radio:

1. Confirm that all connections are tight and secure.
2. Power on the radio.

4.12 Checking the LEDs

The AR220DB has two LEDs: L1 and L2 (Power). They are located on the left side of the front face of the unit below the power connectors.

Figure 4-6: AR220DB LEDs



4.12.1 L1 LED at Power-On

On power-on, the L1 LED progresses through a sequence indicating that the operating system has booted and the radio application software is starting. The Power LED (L2) is not under software control. The progress is described in 4.12.

The following sequence is triggered by the start of the boot sequence:

- Green for a brief period, approximately 0.5 seconds.
- Off for a brief period, approximately 2.5 seconds.
- Red for a brief period, approximately 2.5 seconds.
- Green for a brief period, approximately 2.5 seconds.
- Blue for a brief period, approximately 2.5 seconds.
- White for a brief period, approximately 2.5 seconds.

The LEDs take on their normal state upon completion of the boot sequence. These are described in Table 4-3.

The LED remains white if the radio is booted to the failsafe partition upon factory reset.

4.12.2 Normal LED States

The normal states of the radio's LED s are described in the following table.

Table 4-3: Normal states of the LEDs

Label	Description	Color

L1	• OFF Initially upon radio boot until software is sufficiently running to maintain proper states.
	• OFF when a restart is requested.
	• AMBER when one or more of the following conditions exists:
	  • Configuration and calibration have not yet completed.
	  • The duration of the period when duty cycle limiting is being enforced.
	  • Radio is configured to be in test mode.
		Red/Green/Amber

Label	Description	Color

	• Transmitter is disabled (as for example with the `txdisable` command).
	• GREEN when **all** of the following conditions are met:
	  • Radio is in normal mode (itcnetd is operational).
	  • A valid configuration is loaded and calibration is locked.
	  • Transmitter is not disabled.
	• RED when **any** of the following conditions are met, regardless of above conditions:
	  • The selected configuration is invalid.
	  • Radio is not calibrated (calibration is unlocked).
	  • A required service is not running.	

L2	• GREEN when the power is good.	Green

4.13 Displaying POST Results

A power-on self-test (POST) is a series of several dozen tests that the radio quickly runs on itself each time it boots up to determine whether it has any problems or is missing any critical information. Entering the `post` command multiple times does not rerun the tests. The `post` command only reports the results of the most recent POST.

Possible POST results are: PASS, FAIL, or NOT RUN.

To display the POST results:

1. Connect to the radio.
2. On the command line, enter: `post`
3. View the POST results list. (For information about using the `post` command see the *AR^{220DB} CLI Reference for Administration and Service*.)

5 Command Security

User authentication identifies you as someone who is allowed to change the radio's configuration settings and update software.

User authentication tasks consist of:

- Logging on to a radio
- Logging off from a radio
- Managing your SSH authentication keys

The following sections describe each task in detail.

5.1 Logging On to a Radio

To log on to a radio, you must configure a computer to communicate with the radio. Your computer and terminal emulator application must satisfy the following prerequisites:

- The computer is connected to the radio's maintenance (MAINT) port.
- The Ethernet interface is configured to communicate with Transmission Control Protocol (TCP) port 22 on the radio.
- The firewall rules are configured to allow Secure Shell Protocol (SSH) access.
- The computer has native support for an SSH client or has an SSH client installed.
- The radio's SSH private key for the user account or the admin account is available to the computer's SSH client. The predefined identity files containing the private keys are in Privacy Enhancement Mail (PEM) format and may need to be converted to a different format if your SSH client does not support PEM files.

Additional prerequisites for logging on to a radio are:

- The radio has been powered.
- You have permission to enter commands that can change configuration settings.

You may log on to a radio using SSH through an account named "user" or "admin"; these account names are case sensitive. The admin account has permission to run more commands than the user account. These accounts do not have passwords, but they are authenticated through SSH using private keys provided to your SSH client.

Notes:

- You can make an unlimited number of log-on attempts without being locked out of the radio.
- More than one SSH authentication key can be associated with an account.

To log on to the radio:

1. On your computer, use your SSH client to log on to the account that you wish to use with the account's identity file. The radio uses the default SSH port, TCP port 22.
2. When you have successfully logged on to the radio, you will see the command prompt of a Linux interactive login shell.

5.2 Logging Off from a Radio

After you log on to a radio, you can log off at any time by ending the SSH session. If you have opened more than one session with the radio, ending one session will not affect the other sessions.

To log off from a radio:

1. On your computer, access your SSH client that is handling the session that you wish to end.
2. At the command prompt type:

```
exit
```

   Alternatively, enter Ctrl+D.

> **Note:** You may have to do this more than once if you have opened sub-shells.

The final command logs off the login shell and closes the SSH session.

5.3 Managing SSH Authentication Keys

Changing your SSH authentication key from the predefined key or a key you have been using for a while to a new authentication key improves radio security. If you are not sure when to change your authentication key, ask an administrator to check with your company's established procedures for guidance.

The `userkey` command can be used by the admin account to list keys. See the section "Creating New SSH Keys" in the *AR220DB Getting Started Guide* for information about how to create a new key and create a kit containing the new key. Then, if you are using MobaXterm, see the section "Kit Management" in that document for information about how to add and remove kits containing keys for the admin and user accounts. To manage kits using the command line see "Managing User Access" in the *AR220DB Radio Management Guide* and the `kit` command in the *AR220DB Command Line Reference for Administration and Service*.

The predefined keys for each user account can only be replaced by installing a kit with new SSH auth keys for the same user account.

6 Troubleshooting

This section describes common radio problems, their probable causes, and likely solutions. Problems covered in this section are those related to:

- Power
- Antenna
- Transmitter
- Receiver
- Ethernet connectivity
- RF link
- Time and location

In the following sections, solutions to a given problem are listed in the order you should try them.

6.1 Guidelines for Troubleshooting Common Problems

Always check these items first when a radio problem occurs:

1. **Check physical radio connections**

   Make sure that all physical connections to the radio are secure. This includes: power, Ethernet, and antenna.

2. **Ensure the radio is powered up**

   Ensure that the DC voltage is appropriate for the radio type and that no current limiting is set on the power supply.

3. **Determine the software version each radio is running**

   Check the result of the `apps` command to determine what revision of radio software is running.

4. **Check the state of the radio**

   Use the `radiostate` command to view the state of the radio.

5. **Check that the radio configuration is up-to-date**

   Use the `config` command to query the configuration components of interest (see the *AR^{220DB} CLI Reference*). For more information on radio configuration, see the *AR^{220DB} Radio Configuration Guide*.

6.1.1 Commonly used diagnostic commands

A number of CLI commands are available to provide information about the state of the radio, including current RF connections and software version information. You can use them to collect information that may be useful in determining why a radio connection is not performing as expected. The `radiostate` command is described below. For the full list of CLI commands, see "Commands Grouped by Function" in the *AR220DB Command Line Reference*, paying particular attention to the Status and Diagnostic groups.

6.1.2 Check the state of the radio with the radiostate command

The `radiostate` command queries the radio's operational states, composed of the asset state and the POST state. It displays the LED status and the detailed reason why the LED is in its current state.

As shown in Table 6-1, the `radiostate` command returns an asset state value indicating the radio's current state, including the L1 LED color, and a table listing the status of each of the radio's subcomponents.

Table 6-1: radiostate command response

```
Asset state: Fully Operational (L1 LED: Green)

Subcomponent             Status       Reason
-----------------------  -----------  -------------
Configuration            Good         Valid
HRX connection           Good         Connected to host
Calibration              Good         Calibration locked
Mode                     Good         itcnet operational
Tx state                 Good         Enabled
VSWR                     Good         In range
Timesync                 Good         SemiPrecise
Temperature              Good         In range
Voltage                  Good         In range
Software                 Good         All services active
Hardware                 Good         No failures
POST                     Pass         All post tests pass
```

The asset state portion of the response is a summary based on a set of criteria. Each criterion is included in the table and reported as "Good" or "Bad", depending on the criterion's value compared to a fully operational radio. Only when all criteria are designated as "Good" is the asset state shown as "Fully Operational".

The POST item in the response is a summary of the results of the power-on self-test, which is actually many discrete tests. See the `post` command for additional information regarding the results of individual tests.

The value returned for L1 LED is one of the following: Off, Red, Green, or Amber.

To view the radiostate command output:

1. Connect the computer to the radio MAINT port.
2. On the command line, enter the `radiostate` command with no arguments:

```
radiostate
```

6.1.3 Boot a radio

A radio boots up when it is powered on, when the `sysreboot` command is sent to it, or the software stops responding.

To boot a radio:

1. Power on the radio by connecting it to a power supply that meets the "DC input voltage range" specified (see Specifications for ITC Model AR220DB Radio 70010) or send the `sysreboot` command to the radio.
2. Connect the computer to the radio MAINT port.
3. On the command line, enter the `sysreboot` command with no arguments.

```
sysreboot
```

6.2 Radio Power Problems

Problem indicators:

- There is no power to the radio.
- The radio does not transmit.

To troubleshoot radio power issues:

1. Make sure the power-cable connectors are securely connected to the power supply and to the radio.
2. Make sure the power-cable polarity is correct.
3. Make sure the power supply is turned on.
4. Measure the voltage at the power-cable connector to the radio. Adjust the power supply to within the rated operating voltage.
5. Verify that current limiting on the supply is not less than the maximum current draw.
6. Replace the power cable.
7. Replace the radio. See "Replacing a Radio" on page 31.

6.3 Antenna Problems

Problem indicators:

- Transmissions from or to the radio are poor or absent.

To troubleshoot antenna issues:

1. Make sure the antenna-cable connector is securely connected to the antenna and to the radio.
2. Check the antenna for any defects or breaks, and check the antenna leading cable or coax for defects, breaks, or sharp bends (those with less than the cable's rated bend radius)
3. Check the cable connector and radio connector for corrosion.
4. Check the lightning suppression device for shorts, faults, etc.
5. Use the commands `txtest`, `canmsg`, and `vswr` to verify that there are no electrically detectable defects in the above components (for information about these commands, see the *AR^{220DB} Command Line Reference*).
6. Replace the cable or connector if necessary.
7. Replace the antenna if necessary.
8. Replace the lightning suppression device if necessary.
9. Check the radio output power with a nonreactive load connected.
10. Use the `vswr` command to determine antenna integrity. On the command line enter:

```
vswr
```

Following are examples of the response to the `vswr` command that show good and bad status.

A good status looks like this:

```
           Status: good
              Age: 1 min
             VSWR: 1.2:1
    Forward power: 43.90dBm
  Reflected power: 23.07dBm
   PA temperature: 32.0C
       PA current: 5.97A
PA driver current: 0.00A
  Battery voltage: 13.70V
```

A bad status looks like this:

```
            Status: bad
               Age: 1 min
              VSWR: 4.5:1
     Forward power: 39.96dBm
   Reflected power: 36.03dBm
    PA temperature: 33.0C
        PA current: 5.93A
PA driver current: 0.00A
  Battery voltage: 13.70V
```

11. Replace the radio. See "Replacing a Radio" on page 31.

6.4 Transmission Problems

Problem indicators:

- Transmissions from the radio are weak or intermittent.
- Another radio in the network stops receiving expected communications from this radio.

To troubleshoot transmission issues:

- Make sure the radio is turned on.
- Use the `vswr` command to confirm the power output of the last transmission and VSWR (for information about this and other commands, see the *AR^{220DB} Command Line Reference*).
- Check the cable connector and the radio connector for corrosion. If there is evidence of corrosion, replace the connector.
- Use the `txstate` command to verify that the transmitter is enabled.
- Use the `radiostate` command to check subcomponents of the radio to ensure it is in proper working condition.
- Make sure the antenna-cable connectors are securely connected to the antenna, to the lightning protector, and to the radio.
- Adjust the RF power output higher and lower to verify that the transmitter output is controllable.
- Monitor the current supplied by the power supply to confirm that the typical transmit current is drawn and the radio is not current-limited.
- Check the antenna for any defects or breaks.
- Check the antenna proximity for the presence of any large objects, permanent or transient.
- Check the power supply voltage. If the power-supply voltage is too low, the radio might stop transmitting. If current limiting is set, it may not be sufficient and may need to be adjusted.

- Replace the cable or connector.
- Replace the radio (see "Replacing a Radio" on the facing page).

6.5 Receiver Problems

Problem indicators:

- This radio stops receiving communications from another radio in the network.

To troubleshoot receiver issues:

1. Make sure the radio is turned on.
2. Verify that the receive frequency of this radio is within limits (see Specifications for ITC Model AR220DB Radio 70010).
3. Verify that the receive frequency is within the antenna's bandwidth range specification.
4. Make sure the antenna-cable connectors are securely connected to the antenna and to the radio.
5. Check the cable connector and radio connector for corrosion. If there is evidence of corrosion, replace the connector.
6. Check the antenna for any defects or breaks.
7. Replace the radio. See "Replacing a Radio" on the facing page.

6.6 Ethernet Connectivity Problems

Problem indicators:

- The radio is disconnected from the network.

To troubleshoot network connectivity issues:

1. Check network activity. If the network is down, then the problem probably is not in the radio.
2. Make sure the Ethernet cable is securely connected to the radio's Ethernet port under test.
   a. Physically inspect the cable and connectors for damage and missing pins.
   b. Inspect the Ethernet socket on the laptop and the radio for damage or "crossed fingers".
3. Verify that external equipment is functioning properly.
4. Connect your computer to radio's Ethernet port under test, send commands to the radio, and then see if the radio responds.

> **Note:** To connect the computer to the radio's Ethernet port under test, you must configure the computer's Ethernet interfaces to communicate with the radio on the same network as the port under test. If you do not know the IP address, contact your system administrator.

5. Replace the cable.
6. Replace the radio. See "Replacing a Radio" below.

6.7 RF Link Problems

Problem indicators:

- Radio does not connect to a Base radio.

To troubleshoot RF link issues:

- Make sure the radio is turned on and the green PWR LED is on.
- Make sure the antenna-cable connectors are securely connected to the antenna and to the radio.
- Check the antenna for any defects or breaks.
- Check the antenna leading cable or coax for defects, breaks, or sharp bends (those with less than the cable's rated bend radius)
- Use the `radiostate` comand to make sure there is a valid configuration loaded.
- Verify that the Base radio is transmitting. Use a signal source and perform a direct receiver test if necessary to isolate the problem.
- Make sure the AR220DB transmitter is not disabled.
- Replace the radio. See "Replacing a Radio" below.

6.8 Replacing a Radio

When replacing a radio in the field, follow the safety information in "Safety" on page 6. Inspect the installation of the radio to determine if an installation problem caused the radio to fail.

To uninstall the existing radio:

1. Power down the radio.
2. Disconnect the power cable.
3. Disconnect the antenna.
4. Disconnect the Ethernet cable(s).
5. Remove the ground connection from the radio.

After uninstalling the radio, follow the instructions in "Installation" on page 11 to install the replacement radio.

7 Real-Time Log (a.k.a "Trace") Monitoring

The AR220DB radio has combined tracing and logging into one function. See the *AR220DB Logging User Guide and Reference* for log definitions and the *AR220DB Radio Configuration Guide* for configuration instructions.

To provide a live view of log messages as they occur you can use `journalctl`. The `journalctl` utility is a standard Linux tool used to interact with logs captured by systemd. Using `journalctl` you can read, filter, and monitor logs in real time. The following briefly describes how to use `journalctl` to monitor logs in real time, but please see the `journalctl` man pages for complete details on all the uses of the utility.

In monitoring logs with `journalctl`, the most important switch is `--follow` (or `-f`), which continually prints log messages to the screen as they are produced. The following command displays all new log messages as they arrive.

```
journalctl --follow
```

8 Managing Software Application Images

From time to time, new functionality becomes available from the radio manufacturer in the form of a new software application image (also simply called an "image"). This new functionality is provided to the radio by updating the radio software.

All image management operations may be accomplished using operator commands. However, the radios also support performing some image management operations using ITC Systems Management (ITCSM) features through network connection from an application gateway. See the *AR^{220DB} Radio Configuration Guide* for information about how to configure a radio for ITCSM connectivity.

Using ITCSM features involves creating a radio software kit, as well as sending the appropriate messages to the radio in order to perform the management operations. Consult with your Back Office support team or engineers for more information about ITCSM support of your radios.

This section offers instructions for:

- Determining software image status.
- Updating radio software application images.
- Performing a manual software rollback.
- Determining whether automatic rollback has occurred.
- Maintaining multiple software application images in the radio.

8.1 Determining Software Images Status

The radio is partitioned into three areas: A, B, and F. Partitions A and B are the alternate active and backup (or *rollback*) partitions, and F is the Failsafe partition used to recover the radio.

The `apps` command lists the current active and rollback software images loaded into the radio, as shown in the example output below.

```
Slot    Status  Version                    SHA     Rem  Installed
----    ------  -------                    ---     ---  ---------
linuxA  Booted  0.1.72.06-f2-36-g475fd7c    820ab1  3    2023-04-07T15:40:42Z
mccfsA  Booted  0.1.117.01-f2-0-g1e045e19b  e9be89  3    2023-04-07T15:40:13Z
linuxB                                             3
mccfsB                                             3
linuxF          0.1.72.06-f2-36-g475fd7c    11c8d5  3    2022-01-06T03:33:30Z
boot            0.1.72.06-f2-36-g475fd7c    8a6c68       2023-04-07T15:40:03Z
```

8.2 Updating Software Application Images

The AR^{220DB} radio does not directly ingests images, but rather kits containing images that are signed for security purposes. Kits are created off the radio.

Updating the software means installing the software application kit, selecting it to be active, and then running it. This procedure can be done using the command line as shown below, or using MobaXterm as described in the "Kit Management" section of the *AR^{220DB} Getting Started Guide*. To roll back an image, see "Rolling Back an Image" on the facing page. For information about uninstalling and removing images, see the *AR^{220DB} Radio Management Guide*.

To update the radio's software application image using CLI commands:

Use the following procedure to transfer and add a software kit to the radio and install the updated software image contained in the kit.

> **Note:** You cannot schedule a software update with the command line. This can be done using ITCSM (see "Updating radio software through ITCSM" in the *AR^{220DB} Radio Management Guide*.

1. Transfer the software kit to the radio using the `kit` command with the `--add` operation.

   ```
   kit --add=/var/tmp/myKit.kit
   ```

   This command also adds the kit to the kit directory.

2. You can use the `kit` command with `--list` operation to verify that the kit is now in the kit directory.

   ```
   kit --list
   ```

   This command displays all the kit files in the kit directory, as well as whether or not each is installed, active, available to be installed, and in the rollback position.

```
Kit name        Kit ID         Available  Installed  Active     Rollback
---------       ---------      ---------  ---------  ---------  ---------
abc.kit         2              Yes        Yes        No         No
xyz.kit         4              Yes        Yes        Yes        Yes
34.kit          7              Yes        Yes        Yes        Yes
c_luffman3.kit  3              Yes        Yes        No         No
mykit.kit       Not installed  Yes        No         No         No
```

3. Install the kit using the `kit` command with the `--install` operation. The following command dispatches elements from the specified kit file to the installers.

```
kit --install=myKit.kit
```

4. Verify the contents of the installed kit. The following command queries the contents of an available kit file.

```
kit --query=myKit.kit
```

The above command receives a response indicating that the kit contains a manifest file and two RAUC bundles.

```
KitFileID        :myKit
Description      :Manifest file used for manual testing
Size of kit file :59888040 bytes
Elements:
boot.raucb
rootfs.raucb
```

5. Restart the radio.
6. Confirm the software update using the `apps` command.

8.3 Rolling Back an Image

You can manually rollback software when there are multiple images installed in the radio.

To manually roll back an image:

1. Run the `apps` command and view the list of images in the output table, noting whether the Status column for each image reports "Booted" or "Bad" or is blank.
2. Select the image listed as blank to roll back to using the `apps` CLI command with the `--select` option.

```
apps --select=b
```

3. Reboot the radio using the `sysreboot` CLI command.

8.3.1 How automatic rollback occurs

If for some reason the active image cannot boot, the backup image becomes active and is booted. If there is no backup image or it also fails, the failsafe image is run. The radio will not be fully operational running in failsafe partition.

9 Routine Maintenance

The following are maintenance items that you should perform routinely:

- Remove dust and obstructions from heatsink fins.
- Ensure that the radio is free of excessive condensation and moisture.
- Ensure that the radio is not subjected to excessive heat from adjacent equipment.
- Make sure that the radio is securely mounted and supported.
- Make sure that the cables do not bend with less than the minimum bend radius.
- Restrain cables to prevent stress on connectors.
- Remove cables during a powered-off maintenance cycle and make sure the pins do not have corrosion nor signs of thermal stress:
  - Discoloration and flaky or granular material
  - Darkened color, signs of oxidation, pitting, or plasma flashover
- Verify that cable insulation is not sliced, worn, or cracked.
- Verify that all unused connectors are covered with the appropriate dust cover.

Appendix A: Configure Computer Ethernet Interfaces

It is recommended that you use a computer with two Ethernet interfaces, Ethernet 1 and Ethernet 2, so that your computer can communicate with a radio's maintenance (MAINT) and LAN Ethernet ports at the same time. You must have a terminal emulator such as MobaXTERM or PuTTY installed on the computer and have administrative rights to configure the Ethernet interfaces.

Notes:

- The following configuration example is for directly connecting to the radio and bypassing any network infrastructure. If you cannot get direct access to the radio, contact your network administrator for instructions.
- If you are using the factory defaults, use the following example. If you are not using the factory defaults, contact your network administrator for the appropriate IP settings.
- The following procedures are intended for use with Windows 10. Consult with your network administrator if you are using a different version of Windows.

To configure the computer Ethernet interface for connecting to the radio's MAINT port:

1. On the computer, click **Start**, then click **Control Panel**.
2. Click **Network and Internet**, then click **Network and Sharing Center**.
3. Click **Change adapter settings**.
4. Click **Local Area Connection**, then click **Properties**.
5. On the Networking tab, select the **Internet Protocol (TCP/IPv4)** check box, and then click **Properties**.
6. Click **Obtain an IP address automatically**.
7. Click **OK**.

To configure the computer Ethernet interface for connecting to the radio's LAN port:

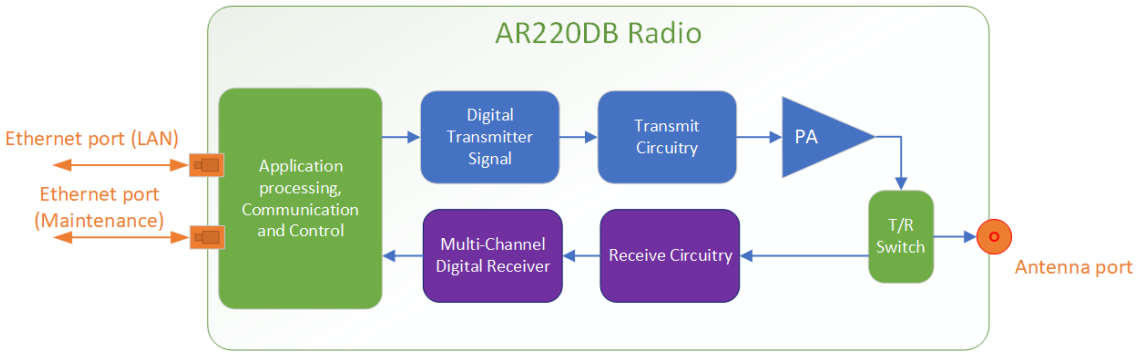
1. On the computer, click **Start**, then click **Control Panel**.
2. Click **Network and Internet**, then click **Network and Sharing Center**.
3. Click **Change adapter settings**.
4. Click **Local Area Connection**, then click **Properties**.
5. On the Networking tab, select the **Internet Protocol (TCP/IPv4)** check box, and then click **Properties**.
6. Click **Use the following IP address**.
7. In the IP address field, type 10.255.255.200.
8. In the Subnet mask field, type 255.255.255.0.
9. Click **OK**.

Appendix B: Parts List

The following part numbers are for reference only and are subject to change without notice.

[List to be provided]

Appendix C: Block Diagram



Appendix D: Sample Post Results

Following is an example of the output from the `post` command for the AR220DB radio.

```
Result    Test                                Notes
-------   ----------------------------------  -----
PASS      MAC EEPROMS                         CRC of all MACs matched
PASS      DISK LIFETIME                       0%-10% device life time used
PASS      DISK FSCK                           FSCK passed for all disks
PASS      GNSS_STATUS                         No GNSS receiver errors, RxState
= ACTIVEANTENNA
PASS      GNSS_RUNNING                        GNSS running 20 seconds
PASS      CALIBRATION LOCKED                  Calibration is locked
PASS      MAGIC TOKEN                         Magic token is initialized
PASS      CALIBRATION CRC                     Valid CRC
PASS      MAINBOARD SERIAL NUMBER             Serial Number: F2_GAN
PASS      I2C IO EXPANDER                     IO Expander accessible on I2C
bus
PASS      I2C MUX                             Mux device accessible on I2C bus
PASS      TPM SELFTEST                        001fe18b0000000096b0
PASS      Main_Board_Input_Voltage            11.081V is in range
PASS      SYSMON0_PS_Temp                     28.8C is in range
PASS      SYSMON0_PL_Temp                     28.6C is in range
PASS      SYSMON0_VCC_PSPLL0                  1.194V is in range
PASS      SYSMON0_VCC_PSBATT                  1.488V is in range
PASS      SYSMON0_VCC_INT_AMS                 0.832V is in range
PASS      SYSMON0_VCC_BRAM_AMS                0.835V is in range
PASS      SYSMON0_VCC_AUX_AMS                 1.794V is in range
PASS      SYSMON0_VCC_PSDDR_PLL               1.786V is in range
PASS      SYSMON0_VCC_PSINTFP_DDR             0.829V is in range
PASS      SYSMON0_VCC_PSINTLP                 0.825V is in range
PASS      SYSMON0_VCC_PSINTFP                 0.826V is in range
PASS      SYSMON0_VCC_PSAUX                   1.794V is in range
PASS      SYSMON0_VCC_PSDDR                   1.197V is in range
PASS      SYSMON0_VCC_PSIO3                   1.783V is in range
PASS      SYSMON0_VCC_PSIO0                   1.781V is in range
PASS      SYSMON0_VCC_PSIO1                   1.784V is in range
PASS      SYSMON0_VCC_PSIO2                   1.783V is in range
PASS      SYSMON0_VCC_PSMGTR_AVCC             0.846V is in range
PASS      SYSMON0_VCC_PSMGTR_AVTT             1.807V is in range
PASS      SYSMON0_VCC_AMS_PS                  1.786V is in range
PASS      SYSMON0_VCC_INT_PL                  0.833V is in range
PASS      SYSMON0_VCC_AUX_PL                  1.795V is in range
PASS      SYSMON0_VCC_BRAM_PL                 0.835V is in range
PASS      SYSMON0_VCC_PLINTLP                 0.832V is in range
PASS      SYSMON0_VCC_PLINTFP                 0.829V is in range
PASS      SYSMON0_VCC_PLAUX                   1.798V is in range
```

```
PASS      SYSMON0_VCC_AMS_PL                    1.790V is in range
PASS      FIRMWARE_STATUS_RX                    All tests pass
PASS      FIRMWARE_STATUS_TX                    All tests pass
PASS      RFBOARD_EEPROM_READ                   RF board EEPROM read success
```

Appendix E: Acronyms

The following table defines initialisms and acronyms used in this document.

Table E-1: Initialisms and acronyms

Usage	Meaning or description
A	amp
AWG	American wire gauge, a unit of wire diameter
cm	centimeter
CM	Connection Manager
dB	decibel
dBi	decibel, isotropic
dBm	decibel referenced to one milliwatt
DC	direct current
DOP	dilution of precision
DQPSK	differential quadrature phase-shift keying
DSP	digital signal processor
EIRP	effective isotropic radiated power
ERP	effective radiated power
EVM	error vector magnitude
FCC	Federal Communications Commission
GEO	geostationary orbit
GNSS	global navigation satellite system
IC	Industry Canada
ITC	Interoperable Train Control
ITCM	ITC Messaging
ITCR	ITC Radio
LAN	local area network
LNA	low noise amplifier
m	meter
MCC	Meteorcomm LLC
MEO	medium Earth orbit
MHz	megahertz, a unit of frequency measurement
MPE	maximum permitted exposure
mW	milliwatt
PEP	peak envelope power

Usage	Meaning or description
POST	power-on self-test
PPM	parts per million
PTC	Positive Train Control
RF	radio frequency
RU	rack unit, defined as a height of 44.5 mm
SAR	specific absorption rate
SMA	subminiature, version A, a type of connector
SNR	signal-to-noise ratio
SWR	standing wave ratio
TCP/IP	transmission control protocol/Internet protocol
TNC	Threaded Neill-Concelman, a type of connector
VDC	voltage, direct current
VSWR	voltage standing wave ratio
W	watt