ITCR^{NG} 1.2 Locomotive Radio Installation and Field Service Guide

DCN 00006265-A

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Revision History

Revision	Date	Notes / Summary of changes
A	5/27/2025	Initial draft.

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1 Introduction

The *ITCR^{NG} Locomotive Radio Installation and Field Service Guide* provides important radio-frequency safety information, installation procedures, and servicing instructions for the Meteorcomm Interoperable Train Control (ITC) Model 65020 radio.

The Model 65020 radio is referred to in this and other documents as the ITCR^{NG} Locomotive radio. In some tables and headings it may alternatively appear without superscript as the ITCR-NG Locomotive radio.

1.1 Audience

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

- Install or replace them.
- Diagnose common problems.
- Adjust radio characteristics.
- Make simple repairs.
- 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 and Conventions Used in this Documentation

Certain terms and conventions are used throughout many ITCR^{NG} documents.

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

The term “base” refers to a network role that provides a connection to the Back Office. At present, only a Base radio can occupy the base role.

The term “remote” refers to a network role that does not provide a direct connection to the Back Office but that maintains its connection to a radio in the base role. Locomotive or Wayside radios fill the remote role.

The terms "class C address" and "class D address" refer to the IPv4 address ranges.

The term "Class C messaging" refers to the UDP-based message protocol used to broadcast short messages. Interoperable applications in the ITC interoperable messaging architecture join multicast groups to receive messages of interest.

The term "Class D messaging" refers to the TCP-based message protocol used for reliable point to point message delivery. Class D messaging is used between interoperable applications and the ITC Application Gateways. Class D messaging is also used between radios in remote areas and one or more ITC Messaging (ITCM) Connection Managers as well as bases and one or more ITCM External Link Managers.

The *ITCR^{NG} Locomotive 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 Locomotive Radio Model 65020

The following tables describe the general, transmitter and receiver specifications for the Locomotive Radio 65020.

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

Table 1-1: ITC Model Locomotive Radio 65020 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	95% non-condensing; test per S-9401
Frequency stability	±1.5 ppm over operating temperature range (+25 °C reference)
DC input voltage range	50 to 100 V Damage limit 120 VDC

Specification	Description
DC current drain	Transmit: 4 A max into 50 Ohm load, 2.5 A typical at 74 VDC Receive: 1 A max while receiving
DC power connector	MS 3102 A18-4P or equivalent
Height	9.5 in.
Width	6.2 in.
Depth	13.3 in.
Weight	17.6 lbs. (7.9 kg)
Antenna connector	Type N female
GNSS receiver	Antenna power: 0 V, 3.3 V or 5 V at 50 mA max. (3.3 V default) Antenna connector: TNC female (maximum input level: 20 dBm)
GNSS antenna	Active or passive
External interface: Ethernet (3) 10/100/1000 Mbps	Data Network ports (2) – Type RJ-45 Maintenance port - (1) Type RJ-45
LAN cable	M12 8-pin female, A-coded
External interface: USB	USB 2.0/3.0 compatible
Display	Activity/Diagnostic LEDs on front panel

Table 1-2: ITC Locomotive Radio Model 65020 Transmitter Specifications

Specification	Description
RF power output	50 W PEP Adjustable 0.5 W to 50 W PEP

Specification	Description
Output impedance	50 Ohms Operating VSWR ≤ 4:1
Modulation waveforms	16 kbps π/4 DQPSK (linear) 32 kbps π/4 DQPSK 48 kbps π/8 D8PSK 64 kbps π/8 16DAPSK
Occupied bandwidth	Meets: Part 80 Occupied BW: 2.1049 Part 90 Occupied BW: 90.209, 90.733(d)
Conducted spurious emissions	-25 dBm max
Max duty cycle rating	30%
Regulatory approvals	FCC (US) BIB65020 IC (Canada) 1300A-65020

Table 1-3: ITC Locomotive Radio Model 65020 Receiver Specifications

Specification	Description
Maximum usable sensitivity, static, BER<10^{-4}	16 kbps PI/4DQPSK -111 dBm 32 kbps PI/4DQPSK -108 dBm
Adjacent channel selectivity	70 dB @ 25 kHz offset
Spurious response rejection	65 dB
Intermodulation response rejection	65 dB
High input level (-7dBm)	BER<10^{-4}

Specification	Description
Blocking, 1MHz offset	Half rate: 80 dB Full rate: 77 dB
Number of channels simultaneously received	20
Diversity support	Two RF antenna connectors to support diversity reception

1.4 Related Documentation

For further information please see these related documents.

- *ITC Radio System Architecture*, DCN 00004692
- *ITCR^{NG} 1.2 Release Notes*, DCN 00006266
- *ITCR^{NG} API Reference*, DCN 00004474
- *ITCR^{NG} Base Radio Installation and Field Service Guide*, DCN 00006165
- *ITCR^{NG} Command Line Reference for Administration and Service (also called "CLI Reference")*, DCN 00004461
- *ITCR^{NG} Data Dictionary User Guide and Reference*, DCN 00004470
- *ITCR^{NG} Getting Started Guide*, DCN 00004686
- *ITCR^{NG} Logging User Guide and Reference*, DCN 00004469
- *ITCR^{NG} Radio Configuration Guide*, DCN 00004468
- *ITCR^{NG} Radio Management Guide*, DCN 00004463
- *ITCR^{NG} Security User Guide and Reference*, DCN 00004471
- *ITCR^{NG} Wayside Radio Installation and Field Service Guide*, DCN 00004464
- *Meteorcomm Product Compatibility Matrix*, DCN 00003775
- *RF Energy Exposure Guide*, DCN 00001235

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 Locomotive 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 0.2mW/cm^2 = 2W/m^2 vs. 10W/m^2 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 Locomotive 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 Mobile 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 Locomotive 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 Locomotive 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 Locomotive radio transmission occupies five of the FCC-defined 5 kHz channels. The lowest channel center frequency for the Locomotive 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 Locomotive radio does not transmit on those channels or their 221 MHz counterparts, 361 through 370 and 381 through 385. This corresponds to Locomotive 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.

3.2.1 Restricting Locomotive Transmission

If a Locomotive radio connects to a Base radio advertising a local channel with a restricted frequency, the Locomotive radio will transmit on that frequency. To prevent this situation, the `localInhibit` configuration parameter specifies a list of channels that the Locomotive radio will not use.

```
{
    "itcnetd" : {
        "channels" : {
            "localInhibit" : [140, 141, 142]
        }
    }
}
```

There is no need to inhibit a channel if there is no risk of connecting to a Base radio using that channel.

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 should note that all mobiles and also fixed installations transmitting between 221 and 222 MHz must limit ERP to 50 W 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 2 W.

Antennas designed for locomotives at 220 MHz generally use a rugged cast aluminum body and are top-loaded vertically polarized requiring a metal cab roof for a ground plane. They are necessarily electrically shorter than one-fourth wavelength due to vertical space limitations. Maximum antenna gain is expected to be 0 dBd = 2.5 dBi.

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 Locomotive 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

FCC rule §90.729(b) limits mobiles operating at 220 – 222 MHz to 50 W ERP, which is calculated relative to a free-space dipole with 0 dBd = 2.15 dBi gain. Because the locomotive antenna has a maximum gain equal to a dipole and the rated maximum transmitter output power is 50 W PEP, compliance with the 50 W ERP limit is assured.

If the locomotive radio antenna height is for some reason higher than 7 meters, the permitted ERP limit shall be reduced from 50 watts by 20 log10 (h/7) dB, where h is the antenna height over average terrain in meters.

3.3.2 Fixed Installation

The Locomotive radio is not intended for fixed installation.

4 Installation

The Locomotive radio satisfies the industry standard ITC requirements as part of an integrated 220 MHz radio network supporting the implementation of Positive Train Control (PTC) systems. The ITC Base, Locomotive, and Wayside radios form the transportation backbone on which a messaging application provides communication capabilities between railroad assets and their Back Offices. The ITC radio provides communication in an interoperable fashion enabling messaging to occur across railroad boundaries.

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 global navigation satellite system (GNSS) and 220 antennas.

Figure 4-1: Locomotive 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 GNSS antenna.
8. Connect the power cable.
9. Power on the radio.
10. Check front-panel LEDs.
11. View the power-on self-test (POST) results.
12. Initialize coordinated universal time (UTC) time correction data.

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	Locomotive 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.

Type	Model	Notes
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 49.
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.

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

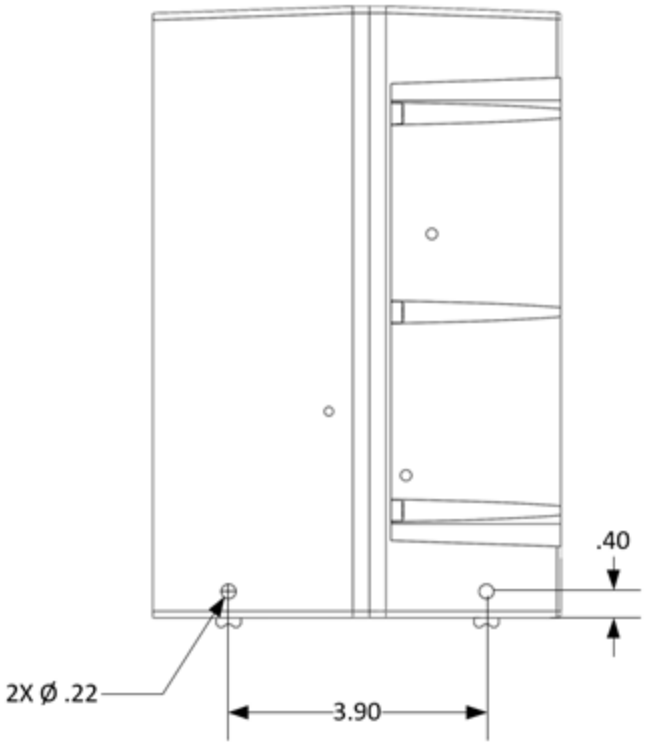
The Locomotive radio is installed in a standard LSI rack. The package includes mounting points for installation on flat surfaces. In mounting the radio, ensure that:

- the areas around the heatsink fins are not obstructed, to allow for proper airflow
- there is adequate room for cable connections
- cables are restrained to prevent kinking and stressing connectors

To mount the radio:

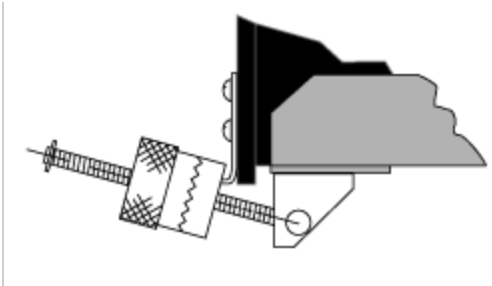
1. Slip the radio into the LSI rack tray with rear alignment dowels. Ensure that the heatsink fins are not obstructed.
2. Make sure the back of the radio is secured by two tapered pins fitting into the radio attachment holes.

Figure 4-2: Mounting measurements



3. On the front of the rack, flip the thumbscrew hold-downs up and onto the NAS attachment hooks on the front of the radio.

Figure 4-3: Mounting thumbscrew hold-down



4. Securely tighten the thumbscrew hold-downs.

4.4 Power Supply Requirements for Locomotive Radios

CAUTION! Applying an incorrect voltage outside the rated voltage range of a Locomotive radio can damage it. Confirm the voltage ratings of the radio and the power supply before applying power.

Table 4-2: Locomotive radio input power parameters

Parameter	Value
Nominal DC Power Input Voltage	74 VDC
Operational Range	50 to 100 VDC
Damage Limit	120 VDC
Current Drain (while transmitting rated power)	2.5 A typical while transmitting into 50 Ohm load, 4 A maximum

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. Failure to use an isolated power supply (for example, connecting unit directly to site batteries) would induce a ground fault at the site because the radio unit is grounded to the bungalow both through the ground lug as well as the GNSS and 220 antennas.

WARNING! Ensure the radio is grounded. Not grounding the radio could result in possible bodily injury.

The Locomotive radio is equipped with a ¼-inch grounding stud located at bottom center on the front of the unit (see the illustration in "Connecting the Antenna").

To ground the radio:

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

> **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.

3. Replace the washer and nut and tighten to 65 to 75 in-lb torque for the ¼-20 nut.

4.6 Installing Current Limiting Circuit Protection

Current-limiting circuitry must be externally supplied to each radio. A magnetic breaker with a DC voltage rating of >100 V and a current rating of 10 A is recommended. Follow the manufacturer's instructions.

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. Locomotive radios have two antenna ports.

4.7.2 Connecting the cable

The Locomotive radio is rated for 50 W peak envelope power (PEP). Sufficient termination is required to protect test equipment. The Locomotive radio uses N-type connectors for narrowband RF antennas. For transmitter testing, connect the test equipment to the TX/RX port. For receiver testing, connect the test equipment to the TX/RX port or the other RX port.

Figure 4-4: Antenna connectors

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 Locomotive radio uses a shielded CAT5 or CAT6 Ethernet cable and three RJ-45 Ethernet I/O ports, each on its own network. There are two LAN (local area network) ports and one MAINT (maintenance) port.

Figure 4-5: LAN Ethernet connections

Insert the cable into one of the LAN ports .

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

4.9 Connecting the GNSS Antenna

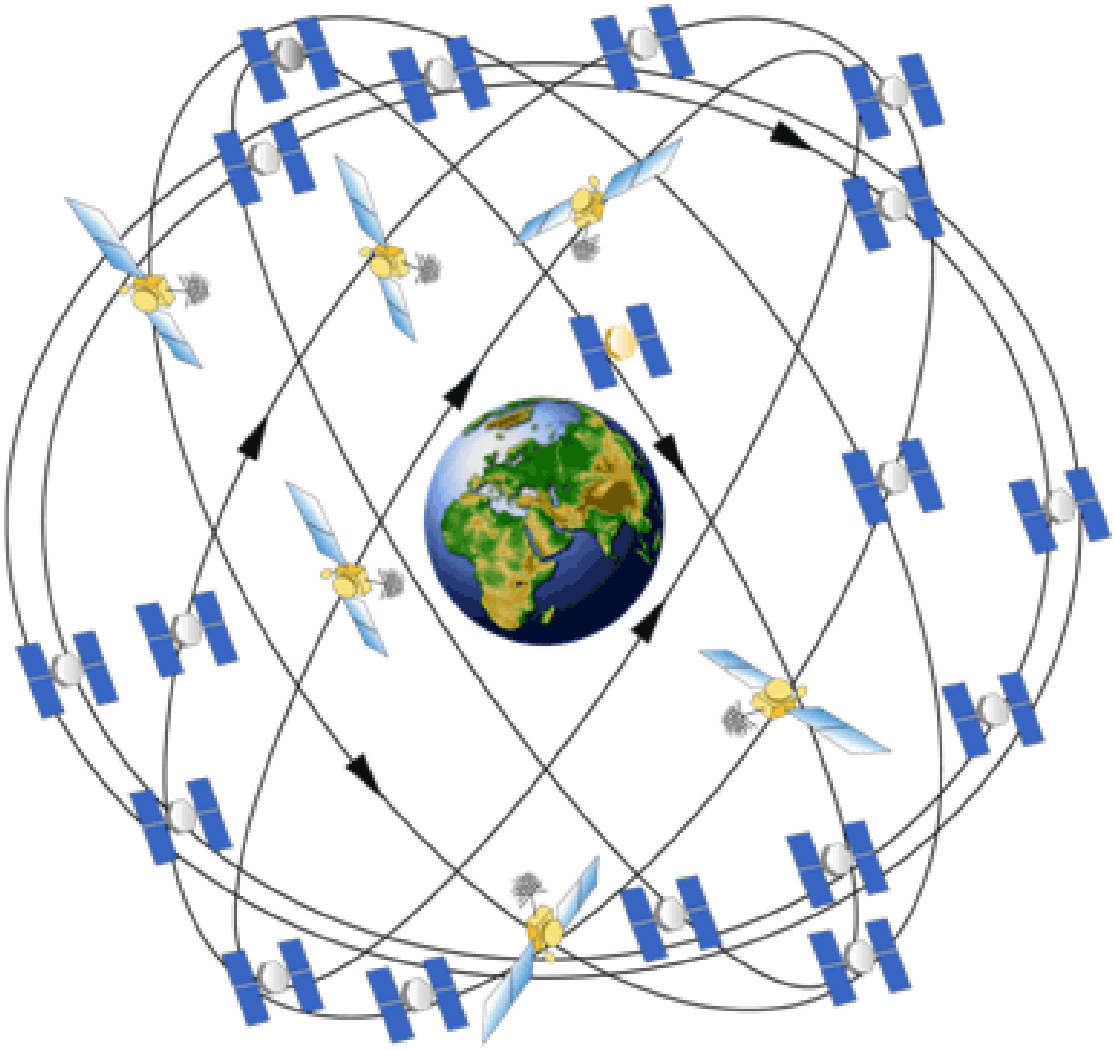
Position the GNSS antenna to avoid strong interferers that could saturate the antenna low noise amplifier or the radio GNSS receiver internal low noise amplifier. Combinations of strong interferers could mix and interfere directly with the GNSS signal quality. Test the radio GNSS with any interference source active to qualify the antenna-antenna isolation of the GNSS antenna position.

4.9.1 GNSS satellite constellation overview

The current GNSS satellite constellation is comprised of 30 active satellites in six inclined orbits, with several on-orbit spares. The GNSS satellites operate in circular, ~11-hour, 58-minute orbits at an inclination of 55 degrees, at an altitude of 20,200 km.

This type of satellite is referred to as a medium Earth orbit (MEO). It is not in geostationary orbit. This is important because unlike geostationary orbit (GEO) satellites, which are located at an altitude of 35,790 km over the equator, MEO satellites move throughout most of the sky so there is no significant preferential sky visibility sector when installing the GNSS antennas at the site. You must optimize the GNSS antenna location selection for as much sky visibility as possible, in all directions, not just south.

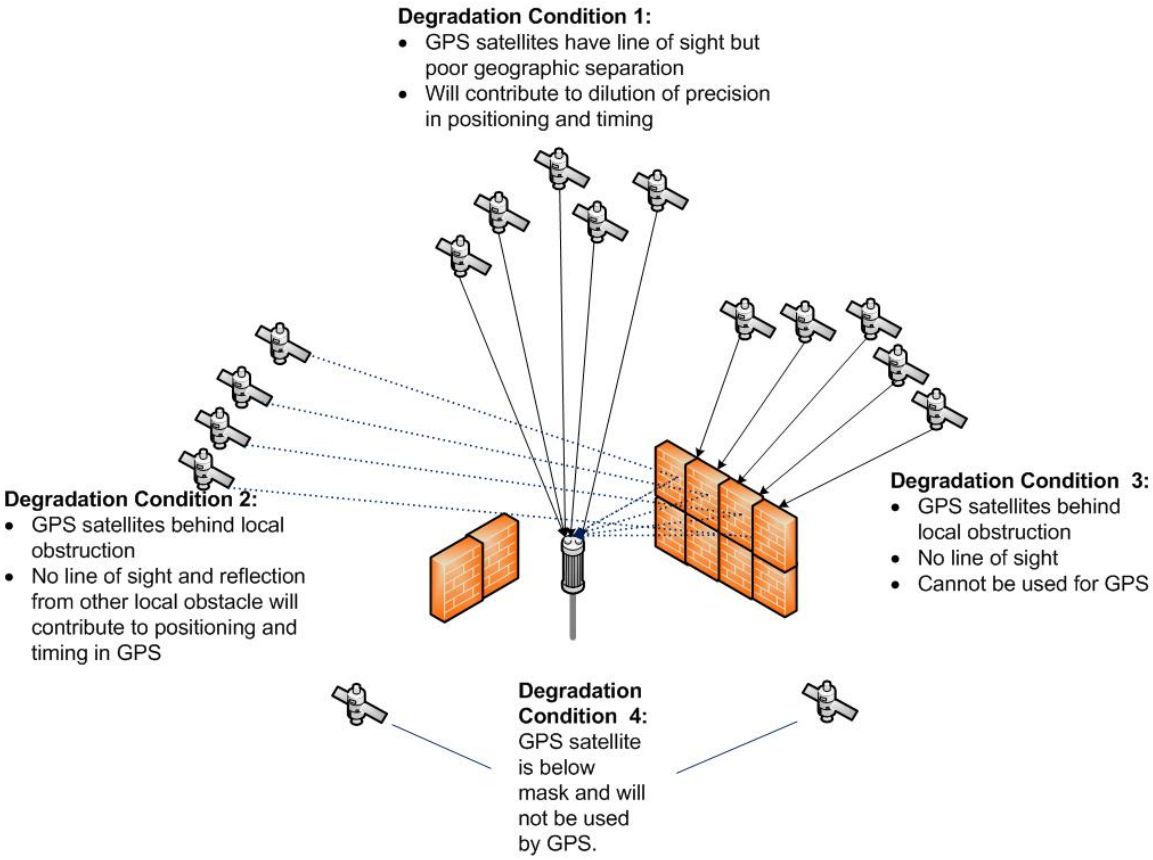
Figure 4-6: GNSS satellite constellation



4.9.2 GNSS antenna planning considerations

When determining antenna locations, you should consider several factors. The figure below illustrates four typical degradation conditions that a GNSS antenna may face.

Figure 4-7: GNSS antenna considerations



- Degradation Condition 1: Some of the satellites have a direct view to the GNSS antenna and as they move they fall behind various obstructions. There may be instances where the satellite constellation can provide replacement satellites that have unobstructed visibility. However, in the example shown, even the visible GNSS satellites have a poor geographic separation and this contributes to a poor dilution of precision (DOP).
- Degradation Condition 2: Some satellites may only have an indirect view of the GNSS antenna so that a reflected path that is longer than the direct path is all that is available. This results in an artificially long path, and timing errors are introduced, likely causing position errors during the self-survey and timing anomalies, depending on the distance of the reflecting object.
- Degradation Condition 3: Satellites that are completely obstructed have no view of the antenna and are invisible to the antenna, even though they are in the GNSS Almanac in the radio.
- Degradation Condition 4: Satellites that are below the mask angle (~10 degrees) that is set in the radio are ignored by the radio, even if they have perfect visibility of the antenna.

4.9.3 Minimize potential of GNSS antenna issues

You should optimize the GNSS antenna installation to avoid intermittent timing anomalies. In many cases, simply roof-mounting the GNSS antenna to a bungalow may not be sufficient.

The best ways to minimize impact from timing problems are to do the following:

- Install the antenna as high as is practical and as allowed by local, state, and federal laws.
- Reduce the obstruction angles by installing the antenna further from obstructions to reduce their apparent size from the perspective of the GNSS antenna:
  - Static obstructions to sky aperture include terrain, buildings, highway overpasses, flyovers, and coniferous vegetation.
  - Transient obstructions to sky aperture include vehicles, rolling stock (either moving or parked in a siding, especially at AAR Plate H), stored Conexes, and deciduous vegetation.
- Always note the format of the GNSS coordinates (for example, decimal-degrees or decimal-minutes).

4.9.3.1 Antenna separation at collocated sites

If multiple GNSS antennas are to be collocated, you should consider separation options.

This consideration stems from the use of high-gain low-noise amplifiers (LNAs) in the GNSS antenna itself. Close proximity can result in the input of one LNA detecting the output of an adjacent LNA, creating a feedback loop that may result in jitter and desensing.

Generally, active GNSS antennas should be separated by at least 6 feet, without compromising sky aperture. This is especially important at collocated sites where maintenance responsibilities of the various GNSS antennas and their transmission systems may span different departments, or even different companies. This is less of an issue with GNSS antennas installed on locomotives, where one department in a single company is responsible for the maintenance of GNSS antennas and their transmission systems.

Sometimes, due to environmental and economic constraints, optimizing the GNSS antenna location any further is not possible. In those cases, it may be more effective to reconsider which of the three available timing modes will best serve an impaired GNSS installation.

4.9.4 Connecting the GNSS antenna

The GNSS antenna connection is a threaded Neill–Concelman (TNC) female connector and always provides an active antenna voltage. If the active antenna installed exceeds either the voltage or current ability of the radio then external power must be supplied to that antenna. A DC block must be used at the radio when the additional power is supplied to avoid damage to the radio.

Figure 4-8: GNSS connector

To connect the GNSS antenna:

1. Confirm that the GNSS antenna has been verified with a network analyzer.
2. Verify the power requirement of the GNSS antenna and connect a DC block and tee in the case that external power is necessary.
3. Connect the GNSS antenna cable to the GNSS antenna input connector on the radio and tighten securely but do not overtighten. Avoid cross-threading the connector.

4.10 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 Locomotive radio operates from a 74 VDC nominal supply (50 – 100 VDC range) The Locomotive radio uses an Amphenol MS 3102 A18-4P type connector supplying 50 – 100 VDC. The power cable length should be as short as practical to minimize voltage drop.

> **Important:** The radio only operates from DC voltage and with correct polarity connections. Any application of AC voltage could damage the radio.

Figure 4-9: Example of a typical power cable

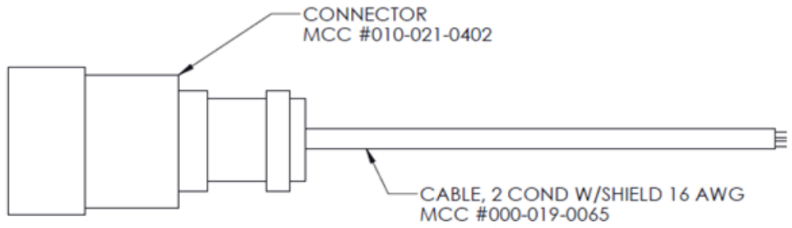
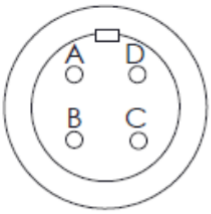


Figure 4-10: Pin out diagram



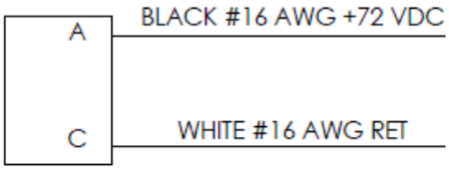


Figure 4-11: The power connector

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.

4.11 Powering On the Radio

DANGER! It is imperative that the radio's antenna connector be connected to an antenna system of the proper impedance or to an appropriate dummy load before power is connected to the radio. Not doing so may damage the radio requiring repair. Because the radio will under certain conditions begin full-rated RF transmissions without any user intervention, applying DC power to the radio without connection to a properly constructed antenna system or to a dummy load, may result in damage to the radio, cause operator injury, or violate regulatory laws regarding radio transmissions. See RF safety guidelines and antenna documentation.

To power on the radio:

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

4.12 Checking the Front Panel LEDs

The layout of the LEDs is as follows:

First row:	PWR | TX
Second row:	RFL | RX
Third row:	MSG | RFA
Fourth row:	GNSS | RDO

These indicators correspond to the following:

Power | Transmit
RF Link | Receive
Messaging | RF Antenna
GNSS | Radio

4.12.1 LEDs at Power-On

On power-on, all of the LEDs except the Power LED progress through a sequence of color displays (generally a couple of seconds each for green, white, red, green again, and amber), indicating that the operating system has booted and the radio application software is starting. The Power LED is not under software control.

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

The LEDs (except POWER) remain amber if the radio is booted to the failsafe partition upon factory reset.

4.12.2 Normal LED States

The normal states of the front panel LEDs are described in the following table.

> **Important:** Read the description of each LED below carefully. Some LEDs, such as the POWER LED, indicate a problem when they are off. Other LEDs, such as MSG (Message) and RADIO, indicate a problem when they are steady red.

Table 4-3: Normal states of front panel LEDs

Label	Description	Color
POWER	• GREEN when the power is good.	Red/Green/Amber
RF LINK	• OFF before itcnetd is running. • AMBER after first DTDMA cycle and before first remote has connected. • GREEN after one or more remotes have connected to the base. • RED if there are no remotes connected to the base. **Note:** The RF LINK LED only transitions to RED from GREEN.	Red/Green/Amber
MSG	• OFF until configured HRX servers are started. • AMBER after HRX servers are started and waiting for ELM connection on startup. • GREEN when primary and backup ELMs or CMs are connected. • RED if primary connection is lost (indicates message fault). • RED for 5 seconds if backup connection attempt fails. **Note:** The MSG LED will remain OFF if, for any reason, the radio is not configured for an HRX connection to a messaging host.	Red/Green/Amber
GNSS	• OFF after timesyncd service starts. • AMBER after GNSS initialization is complete and before radio enters Precise timesync state (or a valid GNSS UTC time is received). • GREEN when a valid GNSS fix is achieved. • RED when initial configuration is not complete within 60 seconds. • RED when the valid GNSS UTC time has not been received within 60 seconds after timesyncd service starts or 3 seconds after previous GNSS UTC time update, which occurs every second. • RED when an SBF Receiver Status is not received within 60 seconds.	Red/Green/Amber

Label	Description	Color
	• RED when GNSS antenna circuit is open or short (an overcurrent is detected); remains RED until condition is cleared (the fault condition of not receiving GNSS UTC time within 3 seconds will likely be triggered before an antenna fault condition but the LED remains RED until the next Receiver Status report, which occurs every 30 seconds, to confirm the antenna condition is cleared or not). • RED when radio discovers any health related issues causing reconfiguration or recovery; remains RED until fully recovered (i.e. Precise timesync state is entered).	
TX	• OFF initially • OFF when transmit is completed successfully • GREEN when the transmitter is active	Red/Green
RX	• OFF initially • OFF when no receiver is in RECEIVING state • GREEN when any receiver is in RECEIVING state	Red/Green
RF ANT	• OFF before itcnetd or testmoded is running. • AMBER when no transmit measurements have been made. • GREEN if VSWR is less than the threshold AND forward power is between 75% to 133% of PA power. The threshold is 4.0 (if transitioning from AMBER) or 3.0 (if transitioning from RED or GREEN). • RED when VSWR is greater than 4.0. • RED when forward power is less than 75% or more than 133% of PA power. • AMBER when no VSWR measurements have been made within 30 minutes of a good transmission.	Red/Green/Amber
RADIO	• 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	Red/Green/Amber

Label	Description	Color
	exists: • The radio is starting up and configuration and calibration have not yet been loaded. • The duration of the period when duty cycle limiting is being enforced. • Radio is configured to be in test mode. • 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.	

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.

> **Note:** The `post` command only displays the test results from the last boot up; it does not run any tests.

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 *ITCR^{NG} CLI Reference for Administration and Service*.)

4.14 Initializing UTC Time Correction Data

Following initial connection of the GNSS antenna, it may take up to 12.5 minutes (assuming nominal conditions) for the radio to obtain UTC time correction data from the GNSS satellite constellation. Prior to receiving the UTC time correction data, the GNSS receiver outputs a time value that is an integral number of seconds ahead of the correct time. The radio detects this condition and inhibits time-synchronized ITCnet transmissions in order to avoid causing network interference. Upon receipt of the UTC time correction data, the GNSS receiver reports the correct time and the radio stores the UTC time correction data in nonvolatile memory for future use in aiding the GNSS receiver.

> **Note:** A radio that is put in storage after this initialization may hold stale UTC time correction data, and may require reinitialization when placed into service.

5 Command Security

The radio is protected from unauthorized access by using cryptographically-based user authentication methods.

User authentication ensures you are someone who is allowed to run commands, change the radio's configuration settings, and update software.

The radio uses the SSH (Secure Shell) login mechanisms to restrict radio access to users with the proper authentication keys.

The following sections describe radio access in detail.

5.1 Logging On to a Radio

As there is no console terminal or external controls on the radio, all interactions with the radio are through an Ethernet-connected computer (e.g., laptop). To access the radio, the computer must have an appropriately configured terminal emulation and SSH client software plus the proper cryptographic keys. This 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, if necessary.

You may log on to a radio using SSH through one of two accounts, "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 *ITCR^{NG} 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 *ITCR^{NG} Radio Management Guide* and the `kit` command in the *ITCR^{NG} 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.

DANGER! It is imperative that the radio's antenna connector be connected to an antenna system of the proper impedance or to an appropriate dummy load before power is connected to the radio. Not doing so may damage the radio requiring repair. Because the radio will under certain conditions begin full-rated RF transmissions without any user intervention, applying DC power to the radio without connection to a properly constructed antenna system or to a dummy load, may result in damage to the radio, cause operator injury, or violate regulatory laws regarding radio transmissions. See RF safety guidelines and antenna documentation

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, grounding, Ethernet, antenna(s), and GNSS.

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

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

3. **Check the LEDs**

   Use the LEDs to determine the state of the system and whether there is a fault condition. See "Front panel LEDs" on the next page for more information.

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

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

5. **Check the state of the radio**

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

6. **Check the POST results**

   Check the output of the `post` command on the radio to ensure that no tests failed during the most recent `post`. See "View the results of the most recent POST" on the facing page for more information.

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

   Use the `config` command to query the configuration components of interest (see the *ITCR^{NG} CLI Reference*). For more information on radio configuration, see the *ITCR^{NG} 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 *ITCR^{NG} Command Line Reference*, paying particular attention to the Status and Diagnostic groups.

6.1.2 Front panel LEDs

On power-on, the front panel LEDs indicate the progress through the boot sequence.

The front panel LEDs show the general operational status of the radio after the radio conducts a POST, which it does each time the radio boots up. Table 1-2 includes a description of the function of each LED as well as the color of each LED when the radio is functioning properly.

6.1.3 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 the following output example, the `radiostate` command returns an asset state value indicating the radio's current state, including the Radio LED color, and a table listing the status of each of the radio's subcomponents.

```
Asset state: Fully Operational (Radio 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         Precise
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 Radio 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 and log in as described in "Logging On to a Radio" on page 31.
2. On the command line, enter the `radiostate` command with no arguments:

```
radiostate
```

6.1.4 View the results of the most recent POST

A POST (power-on self-test) 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 condition of the radio at the time it was last powered up.

Possible POST results are PASS, FAIL, and NOT RUN.

To display the POST results:

1. Connect to the radio.
2. On the command line, enter the `post` command with no arguments:

```
post
```

3. View the POST results list. For details about each test, see the `post` command in the *ITCR^NG Command Line Reference*.)

6.1.5 System log contents

The system log adds more debug information that you can use for POST analysis so that you can troubleshoot issues with your radios by analyzing the system log.

6.1.6 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 Locomotive Radio 65020) 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
```

If you solved the radio problem, the front panel LED that indicated a problem should now indicate normal operation. If it still indicates a problem, continue troubleshooting.

6.1.7 Factory Reset

For information about the Factory Reset procedure see "Factory Reset" in the *ITCR^NG Security User Guide and Reference*.

6.2 Radio Power Problems

Problem indicators:

- There is no power to the radio.
- The POWER LED is off.
- The radio does not transmit.
- The Fault LED is on.
- The POST results show that the internal voltages are out of range.

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 radio operating voltage (see Table 1-1).
5. Verify that any current setting on the supply (or current limiting device) is not less than the maximum current draw of the radio (see Table 1-1).
6. Replace the power cable.
7. Replace the radio. See "Replacing a Radio" on page 43.

6.3 Antenna Problems

Problem indicators:

- Transmissions from or to the radio are poor or absent.
- The radio's RF ANT LED is on.

To troubleshoot antenna issues:

1. Make sure the antenna-cable connector is securely connected to the antenna and to the radio.
2. Check the cable connector and radio connector for corrosion.
3. Check the antenna leading cable or coax for defects, breaks, or sharp bends (those with less than the cable's rated bend radius)
4. Check the lightning suppression device for shorts, faults, etc.
5. Check the antenna for any defects or breaks.
6. 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 *ITCR^{NG} Command Line Reference*).
7. Replace the cable or connector if necessary.
8. Replace the antenna if necessary.
9. Replace the lightning suppression device if necessary.
10. Check the radio output power with a nonreactive load connected.

11. If the RF ANT LED is lit, use the `vswr` command to determine why. 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,power mismatch
               Age: 1 min
              VSWR: 1.2:1
     Forward power: 55.74dBm
   Reflected power: 33.05dBm
    PA temperature: 31.9C
        PA current: 8.11A
PA driver current: 0.01A
   Battery voltage: 11.83V
```

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
```

12. Replace the radio. See "Replacing a Radio" on page 43.

6.3.1 GNSS Antenna

Check your GNSS antenna. It is recommended that your GNSS antenna supports L1, L2, and L5.

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.

- The TX LED never comes on.
- The RADIO LED is on.

To troubleshoot transmission issues:

- Make sure the radio is turned on and the green PWR LED is 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 *ITCR^{NG} Command Line Reference*).
- Check the cable connector and the radio connector for corrosion. If there is evidence of corrosion, replace the connector.
- If the STBY LED is on, 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 page 43).

6.5 Receiver Problems

Problem indicators:

- This radio stops receiving communications from another radio in the network.
- The RX LED never comes on. If there is a base attempting to communicate with the Wayside radio the RX LED should be illuminated occasionally.
- The RX LED never comes on. If there is a base attempting to communicate with the Wayside radio the RX LED should be illuminated occasionally .

To troubleshoot receiver issues:

1. Make sure the radio is turned on and the green POWER LED is on.
2. Verify that the receive frequency of this radio is within limits (see Specifications for ITC Model Locomotive Radio 65020).

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 page 43.

6.6 Ethernet Connectivity Problems

Problem indicators:

- The radio is disconnected from the network.
- The MSG LED is off.
- The link and activity indicators are off.

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" on page 43.

6.7 RF Link Problems

When the RF Link LED is on, it means that the Locomotive radio has selected and connected to a base. When the LED is off, it means the Locomotive radio is not connected to a base.

Problem indicators:

- The RF Link LED never comes on.

To troubleshoot RF link issues:

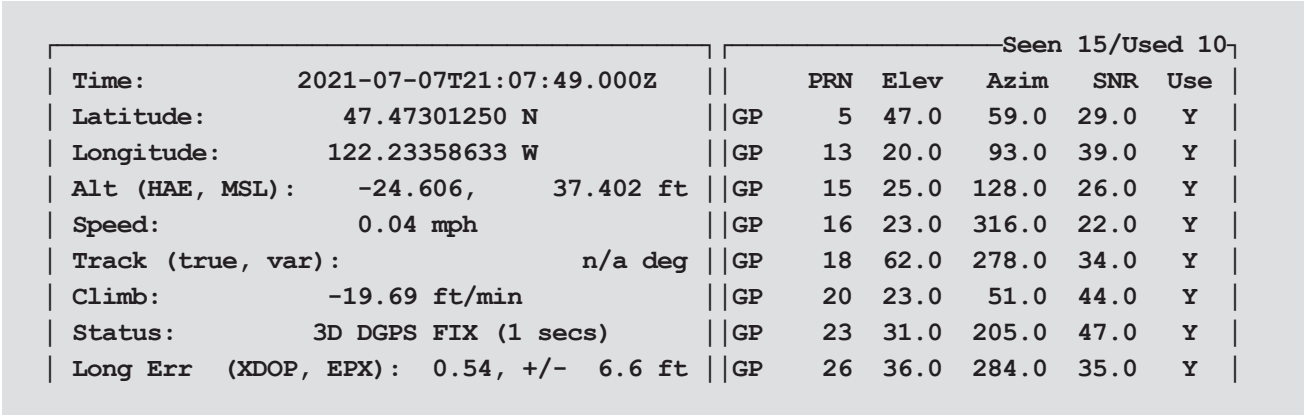
- Make sure the radio is turned on and the green PWR LED is on.
- Make sure the antenna-cable connectors are securely connected to the antenna and to the radio.
- Check the antenna for any defects or breaks.
- Check the antenna leading cable or coax for defects, breaks, or sharp bends (those with less than the cable's rated bend radius)
- Use the `radiostate` command 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.
- Replace the radio. See "Replacing a Radio" on page 43.

6.8 Time and Location Problems

The ITCR^{NG} radio's CLI commands, configuration items, and logging provide enough information to support the radio's operation within the ITCnet protocol. In particular, the CLI command `itctime` can be used to display time of day, timesync state, and day length, while the `pntinfo` command displays location along with hardware, firmware and software version numbers and other data (see the *ITCR^{NG} Command Line Reference for Administration and Service* for more information). Enabling log TS-1312 provides human-readable printout of NMEA sentences to the monitor (see the *ITCR^{NG} Logging User Guide and Reference* for more information). These data are handled by Metercomm's time synchronization service as a client application of gpsd, an open source service that interfaces with the GNSS module.

Further useful information is available through cgps, a client-side utility of gpsd that also displays NMEA sentences in real time from the GNSS module. Most of the information displayed by cgps is available in the radio's timesync-related log messages, but some users may wish to use cgps rather than the radio's time synchronization service for debugging GNSS issues. Along with NMEA sentence monitoring, the cgps output also contains a table displaying data about all the satellites the GNSS module detects, as shown in Figure 6-1, and would immediately give evidence of problems such as a broken antenna.

Figure 6-1: Partial cgps output



```
| Lat Err   (YDOP, EPY):  0.63, +/-  7.8 ft ||GP    29  67.0  128.0  43.0   Y  |
| Alt Err   (VDOP, EPV):  1.67, +/- 31.5 ft ||SB    46  35.0  189.0  36.0   Y  |
| 2D Err    (HDOP, CEP):  0.83, +/- 12.9 ft ||GP    10   2.0  213.0   0.0   N  |
| 3D Err    (PDOP, SEP):  1.86, +/- 29.0 ft ||GP    25  10.0  186.0  13.0   N  |
| Time Err  (TDOP):       1.02              ||SB    48  35.0  184.0  32.0   N  |
| Geo Err   (GDOP):       2.12              ||SB    51  33.0  160.0   0.0   N  |
| ECEF X, VX:              n/a    n/a    /s ||QZ   194  18.0  301.0  14.0   N  |
| ECEF Y, VY:              n/a    n/a    /s ||                                   |
| ECEF Z, VZ:              n/a    n/a    /s ||                                   |
| Speed Err (EPS):       +/- 10.6 mph       ||                                   |
| Track Err (EPD):         n/a              ||                                   |
| Time offset:           0.082 sec          ||                                   |
| Grid Square:            CN87vl            ||                                   |
└──────────────────────────────────────────┘└────────────────────────────────────┘
```

Review the cgps output:

1. Verify that Time is correct for UTC Time
2. Verify latitude, longitude, and altitude are correct for this location.
    a. If they match your measurements, there are no issues
    b. If they do not match your measurements, there may be a problem with the configuration loaded into the radio, if extant.
3. Check the Status field. Acceptable statuses are 2D Fix, 3D Fix, 3D DGPS Fix, and 3D RTK Fix.
4. Verify that you are seeing multiple satellites with signal-to-noise ratios (SNRs) that are greater than 30.
    a. Some satellites may have SNRs less than 30, but this would mean that those satellites are screened by vegetation, clutter, or terrain.
    b. To simplify this scenario, select a satellite with an elevation above 60 degrees, and the SNR should be in the mid 30s or higher.
    c. Consistently poor SNRs indicate a GNSS antenna location issue, or a hardware fault in the GNSS transmission system (GNSS antenna, lightning suppressor, coaxial cable segments).
    d. Satellites with a zero SNR (or no SNR at all) indicate that some satellites are completely blocked by vegetation, clutter, or terrain.
5. Verify that most of the satellites are marked as 'Y'.
    a. If most or all satellites are marked 'N', this indicates a probable issue with the configuration loaded into the radio.

For more information see the following:

- **gpsd** - https://gpsd.gitlab.io/gpsd/
- **cgps** - https://gpsd.gitlab.io/gpsd/cgps.html

6.9 Replacing a Radio

When replacing a radio in the field, follow the safety information in "Safety" on page 7. 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 antennas.
4. Disconnect the Ethernet cable(s).
5. Disconnect the GPIO connectors.
6. Disconnect the GNSS antenna.
7. Remove the ground connection from the radio.

After uninstalling the radio, follow the instructions in "Installation" on page 12 to install the replacement radio.

For radios with manually obtained GNSS coordinates, reobtain the GNSS coordinates. If you do not know how the GNSS coordinates were determined, contact your network administrator.

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

The Locomotive radio has combined tracing and logging into one function. See the *ITCR^{NG} Logging User Guide and Reference* for log definitions and the *ITCR^{NG} 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 *ITCR^{NG} 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 (identified as "Next"), 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  Next    1.0.01.06-f3-0-g0d02f54   c95c00  3    2025-03-04T00:54:18Z
mccfsA  Next    1.0.01.06-f3-0-gcca02991c 4e37f2  3    2025-03-04T00:50:05Z
linuxB  Booted  1.0.01.06-f3-0-g0d02f54   c95c00  3    2025-03-19T18:32:28Z
mccfsB  Booted  1.0.01.06-f3-0-gcca02991c 4e37f2  3    2025-03-19T18:34:34Z
linuxF          1.0.01.06-f3-0-g0d02f54   c95c00  3    2025-02-19T19:20:30Z
boot            1.0.01.06-f3-0-g0d02f54   c95c00       2025-03-19T18:30:55Z
```

8.2 Updating Software Application Images

The Locomotive 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 *ITCR^{NG} 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 *ITCR^{NG} 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 *ITCR^{NG} Radio Management Guide*.

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

   ```
   kit --add=/dev/sda/usb-drive/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.
- Keep the LED panel dust-free and viewable.
- 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.

WARNING! Before restoring power, ensure the radio's antenna connector is connected to antenna system of the proper impedance or to an appropriate dummy load.

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:

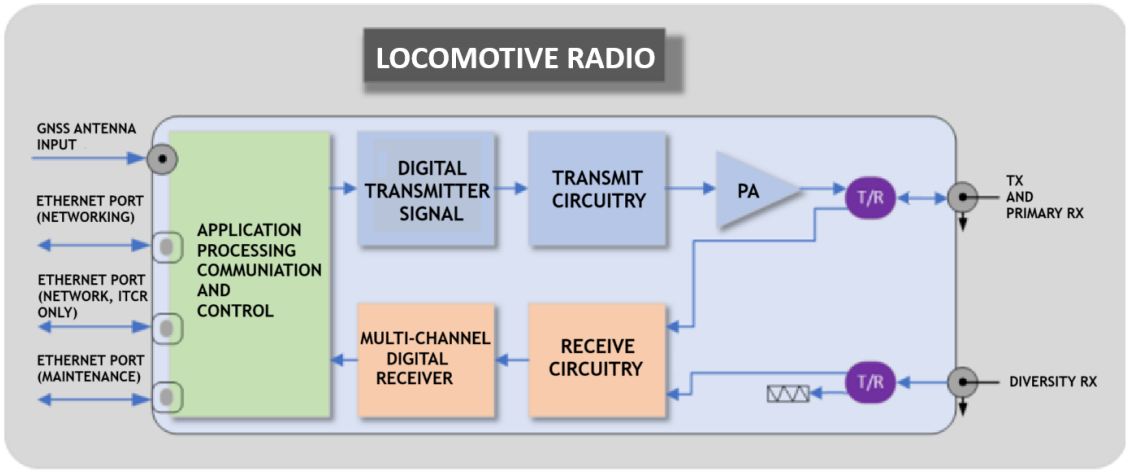
1. On the computer, click **Start**, then click **Control Panel**.
2. Click **Network and Internet**, then click **Network and Sharing Center**.
3. Click **Change adapter settings**.
4. Click **Local Area Connection**, then click **Properties**.
5. On the Networking tab, select the **Internet Protocol (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 LAN1 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: Block Diagram

Figure B-1: Locomotive radio block diagram



Appendix C: Sample Post Results

Following is an example of the output from the `post` command for the Locomotive 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      SYSMON1_Monitor_Temp              26.4C is in range
PASS      SYSMON1_5V_SYS                    5.139V is in range
PASS      SYSMON1_MB_TEMP                   21.0C is in range
PASS      SYSMON2_Monitor_Temp              27.3C is in range
PASS      SYSMON2_5V_UTIL                   5.137V is in range
PASS      SYSMON2_12V_MON                   11.068V is in range
PASS      SYSMON2_5V_UTIL_SCALED            5.196V is in range
PASS      SYSMON2_1V8_UTIL                  1.818V is in range
PASS      SYSMON2_3V3_UTIL                  3.300V is in range
PASS      SYSMON2_USB_VBUS                  5.378V is in range
PASS      SYSMON2_VTT0V6_DDR4               0.595V is in range
PASS      SYSMON2_3V3_RF                    3.319V is in range
PASS      SYSMON2_5V_RF                     5.006V is in range
PASS      PMU1_VCC_INT0V85                  0.867V is in range
PASS      PMU1_VCC_1V8                      1.789V is in range
PASS      PMU1_VCC_1V2                      1.199V is in range
PASS      PMU1_VCC_MGT1V8                   1.796V is in range
PASS      PMU1_VCC_INT0V85_TEMP             29.0C is in range
PASS      PMU1_VCC_1V8_TEMP                 29.0C is in range
PASS      PMU1_VCC_1V2_TEMP                 29.0C is in range
PASS      PMU1_VCC_MGT1V8_TEMP              29.0C is in range
PASS      PMU2_VTT0V6_DDR4                  0.597V is in range
PASS      PMU2_MGT_1V2                      1.199V is in range
PASS      PMU2_VCC_3V3_PS_HDIO              3.304V is in range
PASS      PMU2_VCC_2V5_DDR                  2.503V is in range
PASS      PMU2_MGTRA_VCC_0V85               0.835V is in range
PASS      PMU2_VTT0V6_DDR4_TEMP             25.0C is in range
PASS      PMU2_MGT_1V2_TEMP                 25.0C is in range
PASS      PMU2_VCC_3V3_PS_HDIO_TEMP         26.0C is in range
PASS      PMU2_VCC_2V5_DDR_TEMP             25.0C is in range
PASS      PMU2_MGTRA_VCC_0V85_TEMP          25.0C is in range
PASS      FIRMWARE_STATUS_RX                All tests pass
PASS      FIRMWARE_STATUS_TX                All tests pass
PASS      FIRMWARE_STATUS_LOCOMOTIVE        All tests pass
PASS      RFBOARD_EEPROM_READ               RF board EEPROM read success
```

Appendix D: Acronyms

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

Table D-1: Initialisms and acronyms

Usage	Meaning or description
A	ampere
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