



ITC 220 Locomotive Transceiver

HIGH PERFORMANCE WIRELESS FOR RAILROAD PTC



Installation Guide
PN 133971 Rev. A
Revised July 2012

REVISION HISTORY

REV	DATE	REVISION DETAILS
A	July 2012	Initial release. Part number 133971.

Important Notice

Because of the nature of wireless communication, transmission and reception of data can never be guaranteed. Data may be delayed, corrupted (i.e. have errors), or be totally lost. Significant delays or losses of data are rare when wireless devices such as CalAmp provides are used in a normal manner with a well-constructed network. These products should not be used in situations where failure to transmit or receive data could result in damage of any kind to the user or any other party, including but not limited to personal injury or death, or loss of property. CalAmp accepts no responsibility for damages of any kind resulting from delays or errors in data transmitted or received using the ITC 220 Base Station, Locomotive, or Wayside Transceiver, or for failure to transmit or receive such data.

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RF Exposure Compliance Requirements



RF Exposure

The ITC 220 Base Station, Locomotive, and Wayside Transceivers are intended for use in the railroad industry as Interoperable Train Control (ITC) Radio (ITCR), which is an important component of Positive Train Control (PTC). The ITC 220 Base station, Locomotive, and Wayside Transceiver units must be professionally installed and must ensure a minimum separation distance between the antenna or radiating structure and any person. Refer to Table 1 and 2 on pages 3 and 4 of the *RF Energy Exposure Guide for ITC 220 Base Station, Locomotive, and Wayside Transceivers Installed in Vehicles or at Fixed Sites* for

recommended minimum lateral distance, as applicable for the antenna application, type of antenna, and transmitting power.

Radio Transceiver Model	Antenna application	Section and applicable table
ITC 220 Base Station Transceiver	Fixed installation	Section 6 Fixed Installations; Table 2 on Page 5
ITC 220 Locomotive Transceiver	Mobile installation	Section 4 Mobile Installations; Table 1 on Page 3
ITC 220 Wayside Transceiver	Fixed installation	Section 6 Fixed Installations; Table 2 on Page 5
ITC 220 Wayside Transceiver	Mobile installation	Section 4 Mobile Installations; Table 1 on Page 3

It is the responsibility of the user to guarantee compliance with the FCC MPE regulations when operating this device in a way other than described above. The installer of this equipment must ensure the antenna is located or pointed such that it does not emit an RF field in excess of Health Canada limits for the general population.

ITC 220 Base Station, Locomotive, and Wayside Transceivers use a low power radio frequency transmitter. The concentrated energy from an antenna may pose a health hazard. People should not be in front of the antenna when the transmitter is operating.

Recommended safety guidelines for the human exposure to radio frequency electromagnetic energy are contained in the Canadian Safety Code 6 (available from Health Canada), the Federal Communications Commission (FCC) Bulletin 65 and the Council of the European Union's Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (1999/519/EC).

Any changes or modifications not expressly approved by the party responsible for compliance (in the country where used) could void the user's authority to operate the equipment.

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1 OVERVIEW

This *ITC 220 Locomotive Transceiver Installation Guide* provides important electrical safety and radio-frequency compliance information, operation and routine maintenance instructions, and installation and troubleshooting procedures for CalAmp ITC 220 Locomotive Transceivers.

This manual provides essential information for personnel who perform the following on the Locomotive Transceiver:

- Operation and routine maintenance (Chapters 1–5; Appendix A)
- Installation and verification of operation (Chapters 1–6; Appendices A–B)
- Basic troubleshooting (Chapters 1–7; Appendices A–B)

Prerequisites for users of this manual who perform the above include:

- Ability to work with standard radio-frequency (RF) equipment, including knowledge of how to prevent personal injury and equipment damage.
- Ability to install LSI-rack compatible components into an LSI rack inside the compartment of a locomotive cab.
- Familiarity with means to limit RF exposure from antennas and familiarity with the *RF Energy Exposure Guide for ITC 220 Base Station, Locomotive, and Wayside Transceivers Installed in Vehicles or at Fixed Sites*.

1.1 GENERAL DESCRIPTION

Positive Train Control (PTC) is a technology solution that prevents train-to-train collisions, over-speed derailments, movement of a train through a switch left in the wrong position, and incursion of trains into maintenance of way work limits. Interoperable Train Control (ITC) defines industry-standard messaging and communication protocols that support PTC and ensure interoperability between components.

CalAmp's line of ITC 220 Radio Transceivers for locomotive, base station, and wayside applications are manufactured specifically for use by North American Railroads for PTC applications. Operating between 217.6 and 222 MHz, these multi-channel software-defined radio transceivers meet railroad requirements for ITC and are designed to meet relevant railroad specifications for operation in the harshest environments. With high power capacity, CalAmp's ITC 220 Radio Transceivers provide wireless packet data transport between locomotives, base stations, and wayside locations.

Locomotive Transceivers are remote radios installed in the cab of locomotives and are the mobile element of the ITC 220 network. A Locomotive Transceiver communicates with the Back Office through a Base Station over a 220 MHz RF link. To establish this link, a Locomotive transceiver registers with the Base transceiver. As long as the Base is the best link available, the locomotive will continue to communicate with the Back Office through that Base. The Base Station Transceiver, Locomotive Transceiver, and Wayside Transceiver form the transportation backbone on which a messaging application provides communication capabilities between railroad assets and their back offices.

Experience the advantage of high performance reliability designed to meet:

- AAR Standard S-5702
- ANSI/TIA-603-C-2004
- MIL-STD-810E
- American Recovery and Reinvestment Act – Buy American Provision

1.2 OPERATIONAL CHARACTERISTICS

ITC 220 Locomotive Transceivers are designed to satisfy the industry-standard ITC requirements as part of an integrated 220 MHz radio (ITCR) network supporting the implementation of PTC systems. These Locomotive Transceivers are designed to provide communication in an interoperable fashion enabling messages to occur across railroad boundaries.

All input and output ports are grounded or shielded. Internal shielding is used within the unit assembly and PCB design minimizes potential sources of unwanted radio emissions.

CalAmp ITC 220 Locomotive Transceivers have the following operational characteristics. (Specifications are subject to change without notice.)

General

Frequency Range:	217.6-222.0 MHz
Channel Spacing:	25 kHz
Temperature Range:	Operating: -40°C to +70°C Storage: -55°C to +85°C
Operating Humidity:	0 - 95% non-condensing
Frequency Stability:	+/- 1.5 ppm over operating temperature range
DC Input Voltage Range:	45-100 VDC; Damage limit 120 VDC
DC Current Drain:	Transmit: 4 A (peak) max into 50 ohm load, 1.8 A typical; Receive: 0.5 A max. while receiving
DC Power Connector:	MS 3102 A18-4P or equivalent
Size:	LSI rack compatible, 5×MCU max.
Weight:	< 22 lbs. (10 kg)
Antenna Connector:	Two (2) Type N female: One (1) TX/RX1 (transmit / primary receive), One (1) RX2 (diversity)
External Interface:	Two (2) Ethernet: One (1) data network port, M12 - 8 pin female; One (1) maintenance port, M12 - 8 pin female
Configuration Interface Module (CIM):	SD Card
Display:	Activity and diagnostic LEDs on front panel
Regulatory:	Complies with FCC Parts 2, 15, and 90; Industry Canada SRSP-512

Transmitter

RF Power Output:	50 W PEP; adjustable to 15-50 W PEP
Output Impedance:	50 Ohms; Operating VSWR < 3:1
Modulation Waveforms:	16 kbps pi/4DQPSK (linear); 32 kbps pi/4DQPSK (linear)
Occupied Bandwidth:	Meets 47CFR90.210 (f), five aggregated channels
Modulation Designators:	16 kbps: 8K90DXW; 32 kbps: 17K8DXW
Conducted Spurious Emissions:	-25 dBm max.
Max. Duty Cycle Rating:	30 %

Receiver

Maximum Usable Sensitivity, Static BER<10 ⁻⁴ :	16 kbps -111 dBm; 32 kbps -108 dBm
Adjacent Channel Selectivity:	70 dB at 25 kHz offset
Spurious Response Rejection:	70 dB
Intermodulation Response Rejection:	65 dB
High Input Level (-7 dBm)	BER<10 ⁻⁴
Blocking (1 MHz Offset)	80 dB
Number of Simultaneous Receiver Channels:	Sixteen (16) paired as eight (8) diversity; seven (7) 16 kbps; one (1) auto 16 kbps/32 kbps

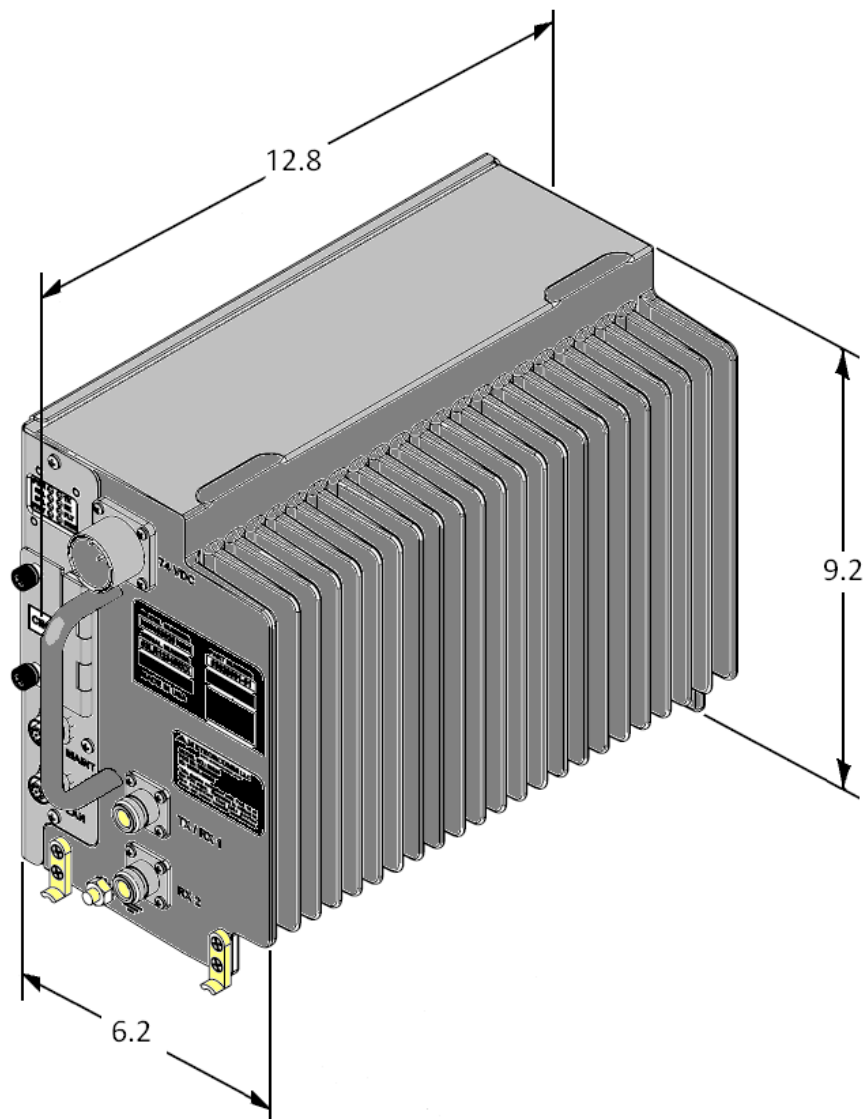
1.3 PHYSICAL DESCRIPTION

The ITC 220 Locomotive Transceiver is housed in a rugged 5×MCU LSI rack-compatible chassis for simple installation. The unit is designed to operate in an extended temperature range and provide worry-free operation.

1.3.1 DIMENSIONS

Overall dimensions of the ITC 220 Locomotive Transceiver are 6.2 in. width × 9.2 in. height × 12.8 in. depth, as shown in Figure 1, which follows.

Figure 1 ITC 220 Locomotive Transceiver overall dimensions



(Dimensions shown are in inches.)

1.3.2 CONNECTIONS

All physical connections and interfaces are located on the front panel of the Locomotive Transceiver.

The following figure and table illustrate the ports and connectors on the Locomotive Transceiver front panel.

Figure 2 Locomotive Transceiver ports and connectors

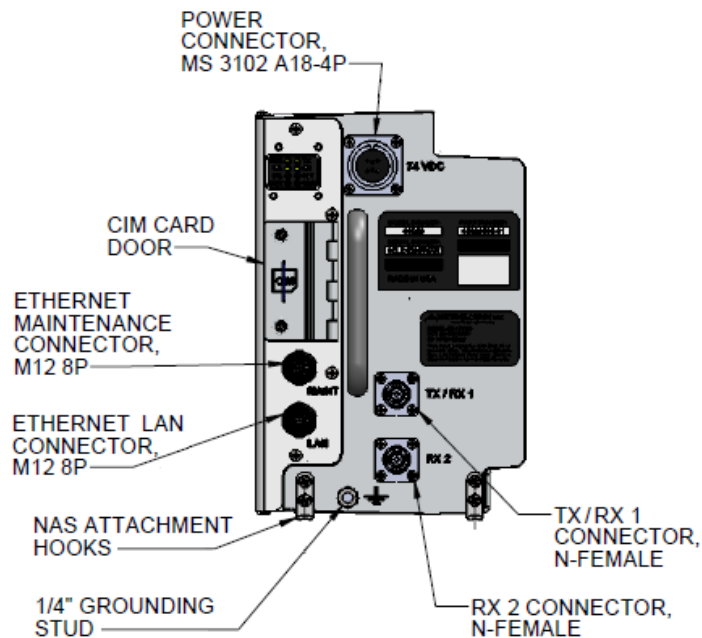


Table 1 Locomotive Transceiver front panel interface connections

Interface	Connector Type	Label
TX/RX1 Antenna	Type N female	TX/RX1
Diversity RX Antenna	Type N female	RX2
DC Power Input	MS-3102 A18-4P or equivalent	74 VDC PWR IN
Data Network Ethernet	M12 - 8 pin female, A-coded	LAN
Maintenance Ethernet	M12 - 8 pin female, A-coded	MAINT
CIM socket	SD memory card receptacle	CIM
Ground connection	Threaded post (stud) for ring lug connection	⏏

1.4 RELATED DOCUMENTS

Other documents related to this *ITC 220 Locomotive Transceiver Installation Guide* include:

- *ITC 220 Base Station Transceiver Installation Guide; CalAmp PN 133991*
- *ITC 220 Wayside Transceiver Installation Guide; CalAmp PN 133981*
- *RF Energy Exposure Guide for ITC 220 Base Station, Locomotive, and Wayside Transceivers Installed in Vehicles or at Fixed Sites; CalAmp PN 134069*

2 FOLLOW ESTABLISHED SAFETY GUIDELINES

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

To reduce the risk of electric shock:

- Follow your employer's established electrical safety guidelines.
- Disconnect power from the transceiver before removing the cover.
- Be aware that removing the cover of the radio transceiver may expose you to dangerous voltages or other risks. Avoid making internal adjustments to the radio transceiver when you are alone.
- Avoid contact with a radio's electrical components. Electric shock from voltages present with the radio transceiver are potentially fatal.
- Reassemble radio transceivers correctly. Incorrect reassembly of a radio transceiver can cause a harmful electric shock to anyone who handles it.

3 IMPORTANT INFORMATION FOR THE USER

3.1 LIMITING RF EXPOSURE



Caution – Please refer to the *RF Energy Exposure Guide for ITC 220 Base Station, Locomotive, and Wayside Transceivers Installed in Vehicles or at Fixed Sites* that is packaged with each Base Station and Locomotive Transceiver and available online or by request for specific information regarding safe distances that must be maintained between personnel and energized transmitting antennas.

The information in the *RF Energy Exposure Guide for ITC 220 Base Station, Locomotive, and Wayside Transceivers Installed in Vehicles or at Fixed Sites (RF Energy Exposure Guide)* is determined from FCC and Industry Canada rules that, when followed, limit human exposure to radio frequency energy to acceptable levels. Note that although the transceiver and antenna are expected to 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 general public.

The Locomotive Transceiver is intended to be operated with a fixed antenna in an Occupational/Controlled Exposure environment per FCC 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 $0.2 \text{ mW/cm}^2 = 2 \text{ W/m}^2$ vs. 10 W/m^2 in a controlled-exposure environment.

This radio transceiver 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. Base station antennas must be positioned on towers or nonresidential buildings that are generally unoccupied except while servicing the equipment therein.

Table 1 in Section 4 of the *RF Energy Exposure Guide* lists the calculated lateral distance to be maintained between the general public and an operational transmitter antenna for the type of antenna typically used in locomotive applications.



Note – RF exposure compliance at 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

3.2 FIXED ANTENNA GUIDELINES

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

- The licensee is required to 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. The section titled “[Locomotive-Radiated Power Limits](#),” which follows, provides additional information on how to comply with ERP limits.
- Refer to the *RF Energy Exposure Guide*, which is packaged with each Base Station and Locomotive Transceiver and available online or by request, for specific guidelines regarding placement and installation of fixed antennas.
- Acceptable fixed-antenna types are listed in the Rated Power and Recommended Lateral 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. Refer to the table of safe distances for Base radios in the *RF Energy Exposure Guide*.
- Unauthorized antennas, equipment modifications, or attachments could invalidate any equipment warranty or authority to transmit. Modification could damage the radio transceiver and may violate FCC or IC regulations. Contact CalAmp before using other antennas.

3.3 RF INTERFERENCE TO RESIDENTIAL RECEIVERS

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

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment to an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

3.4 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.

4 LOCOMOTIVE TRANSMITTER OPERATION

It is the responsibility of 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.

4.1 LOCOMOTIVE TRANSCEIVER CHANNELIZATION AND FREQUENCY RANGE

The Locomotive Transceiver can be configured 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 radio channel center frequency is in the center of FCC channel 3 and the next is centered on FCC channel 8, then 13, 18, and so on, up to the highest, which is centered with FCC channel 398.

4.2 LOCOMOTIVE 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 exceptions of FCC channels 161-170 and 181-185. Therefore, the radio may not transmit on those channels or their 221 MHz counterparts, 361-370 and 381-385. This corresponds to frequencies 220.8125, 220.8375, 220.9125, 221.8125, 221.8375, and 221.9125 MHz.

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

4.3 LOCOMOTIVE-RADIATED POWER LIMITS



It is the responsibility of the licensee to comply with the effective radiated power limits based on operating frequency, geographic location, and effective antenna height specified 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 means for the licensee to determine effective radio power (ERP) and to comply with regulatory power limits.

Licensees should also note that mobile radios must limit effective radiated power (ERP) to 50 W or $10\log(50) + 30 = 47$ dBm PEP referenced to the 2.15 dBi gain of a dipole. The EIRP for this case is 49.15 dBm. Also note that the maximum ERP on FCC/IC channels 196-200 at 220.975 to 221.000 MHz is 2 watts.

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 at 0 dBd – 2.15 dB.

FCC rule §90.729(b) limits mobile operation at 220-222 MHz to 50 W ERP, which is calculated relative to a free-space dipole with 0 dBd = 2.15 dBi gain. Since 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.

The actual power will be less than 50 W ERP when the feedline and filter losses between transmitter and antenna are taken into account. Minimum feedline loss is expected to be 0.5 dB and an inline 160 MHz reject filter adds 0.7 dB loss for a total loss of 1.2 dB. The actual ERP is therefore $47 - 1.2 = 45.8$ dBm = 38 watts. The transmitter installation cannot be operated on FCC channels 196-200 due to the 2 W limitation.

5 ROUTINE MAINTENANCE

After installation, the Locomotive Transceiver requires the following routine maintenance periodically.

- Remove dust and obstructions from heat-sink fins.
- Ensure that the unit is not subjected to excessive heat from adjacent equipment;
- Make sure that the unit is securely mounted and supported, with specified clearance maintained above and below heat sink fins.
- Restrain cables to prevent stress on connectors.
- Make sure that the SD memory card (CIM) door is securely closed.
- Keep the indicator-LED panel dust-free and LEDs viewable.

6 INSTALLATION

The Locomotive Transceiver is housed in a die-cast chassis that is designed to be mounted in an LSI rack (or equivalent) and occupy less than 6×MCUs. The unit weighs less than 22 lbs. (10 kg). Overall dimensions are 6.2 in (6×MCU) width × 9.2 in height × 12.8 in depth.

Installation of the Locomotive Transceiver consists of these steps:

1. Unpack and inspect the unit (section 6.2).
2. Confirm the SD memory card (CIM) is installed and seated (section 6.3).
3. Mount the unit (section 6.4).
4. Ground the unit (section 6.5).
5. Install current-limiting protection (section 6.6).
6. Connect the narrowband RF antennas (section 6.7).
7. Connect the Ethernet cable (section 6.8).
8. Connect the power cable (section 6.9).
9. Power on the unit (section 6.10).

At the conclusion of installation, you will verify that the Locomotive Transceiver is operational by doing the following:

1. Observe the operation of the LEDs in the transceiver front panel (section 6.10.1).
2. Verify that the LAN Ethernet port is operational (section 6.10.2).

Following sections describe each of the above steps in detail. This guide also contains a brief [Troubleshooting](#) chapter for help with common problems that may occur when installing a Locomotive Transceiver.

6.1 REQUIRED EQUIPMENT

Following is a list of equipment required to install the Locomotive Transceiver. It is expected the user is familiar with the pieces of test equipment listed below. Instructions on how to use the following equipment are beyond the scope of this document.

Table 2 Required equipment

Type	Model	Notes
Clip-on ammeter		
Digital volt meter		
Portable power meter		
Laptop with ITC setup diagnostic software installed and running		
Ethernet cable(s)	Category 5 or better	Ethernet cables used with the Locomotive Transceiver must be terminated one end with M12 - 8 pin male connectors one end to connect with ports on Transceiver, and RJ-45 connectors or suitable to connect with computer Ethernet ports at other end.
Torque wrench with 65-75 in.·lb. capacity		
Cable ties as required		
Crimping tool		

6.2 UNPACK AND INSPECT THE UNIT

Unpack and inspect the Locomotive Transceiver. Note any damage that may have resulted from shipping, including dents or loose parts. Note any damage or discrepancies between the contents in the shipping container and the packing list.

- If you detect damage or if the contents do not match the invoice, then note the defect and contact the manufacturer.
- If you do not detect any damage and the shipping invoice matches the contents, then continue with installation.

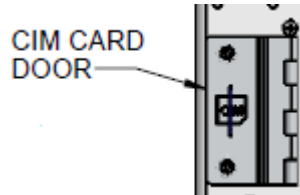
6.3 CONFIRM SD MEMORY CARD (CIM) IS INSTALLED AND SEATED

Note: The SD memory card must be inserted in the orientation shown on the door.

To confirm CIM card is installed and seated:

- Open the CIM door to ensure the SD memory card is present in the CIM socket.
- Push the SD memory card once to release it.
- Push the SD memory card again to ensure it is seated in the socket.
- Once confirmed, close and secure the CIM door.

Figure 3 CIM card door on a Locomotive Transceiver



6.4 MOUNT THE LOCOMOTIVE TRANSCEIVER

The Locomotive Transceiver is installed in a standard LSI rack. The package includes mounting points for installation on flat surfaces.

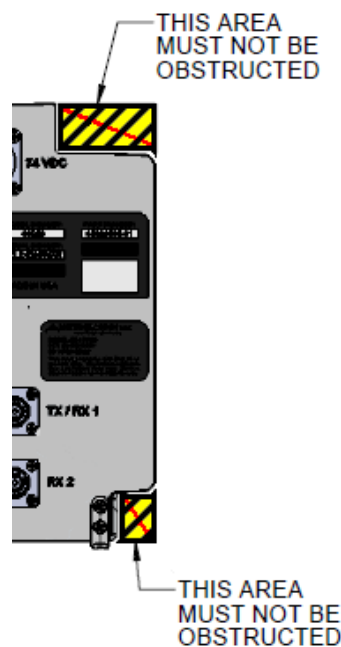
Ensure that:

- The areas around the heat-sink fins are not obstructed to allow for proper airflow.
- There is adequate space to access the CIM (SD memory card).
- There is adequate space for cable connections.
- Cables are restrained to prevent kinking and stressing connectors.

To mount the Locomotive Transceiver

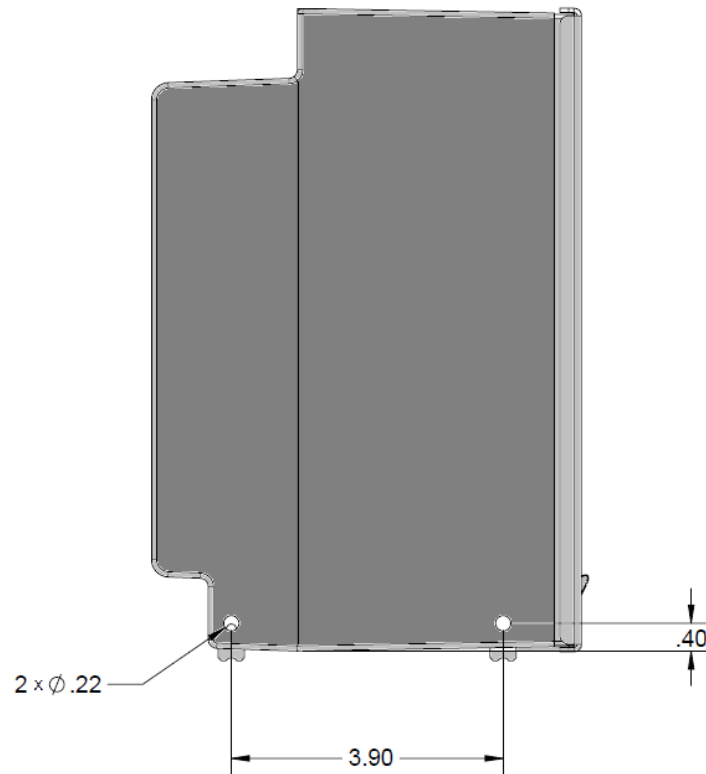
1. Slide the transceiver into the LSI rack tray with rear alignment dowels. Ensure that the heat-sink fins are not obstructed.

Figure 4 Areas must not be obstructed



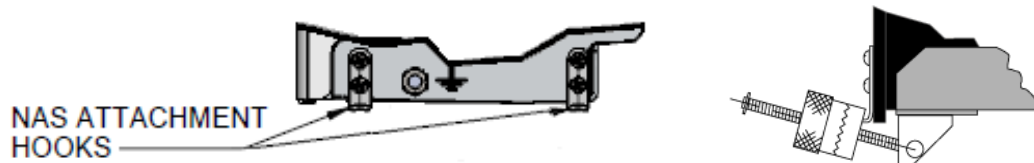
2. Make sure the back of the transceiver is secured by two tapered pins fitting into the attachment holes in the rear flange of the transceiver chassis.

Figure 5 Location of attachment holes in rear flange of transceiver chassis



3. On the front of the rack, flip the thumbscrew hold-downs up and onto the NAS attachment hooks attached to the front of the transceiver chassis.

Figure 6 NAS Attachment hooks and thumbscrews



4. Securely tighten the hold-downs.

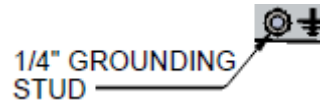
After mounting, ensure that:

- Equipment that produces substantial heat is not installed below the Locomotive Transceiver.
- Unit is secured with thumbscrews on attaching hooks.
- There is adequate space to access the CIM (SD memory card).
- There is adequate space for cable connections.
- Cables are restrained to prevent kinking and stressing connectors.

6.5 GROUND THE RADIO TRANSCEIVER CHASSIS

The Locomotive Transceiver has a 1/4 inch grounding stud at the bottom of the unit (located below the antenna connections and directly under the handle).

Figure 7 Grounding stud



To ground the Locomotive Transceiver:

1. Remove the nut and internal-tooth lock washer from the grounding stud.
2. Connect grounding wire with 1/4 inch ring lug from locomotive ground to the grounding stud.
3. Reinstall the internal-tooth lock washer and nut, removed earlier, and tighten outer nut to a maximum torque of 65-75 in.-lbs. for a 1/4-20 nut.

6.6 CONNECT CURRENT-LIMITING CIRCUIT PROTECTION

You must provide circuit protection externally to each transceiver. We recommend a magnetic breaker with a DC voltage rating greater than 100 V and 10 A current rating. Follow the manufacturer's instructions. The table below describes power supply requirements, operational ranges, and damage limits for the Locomotive Transceiver.

Table 3 Locomotive Transceiver input power parameters with operational ranges and damage limits

Parameter	Value
Nominal DC Power Input Voltage	74 VDC
Operational range	45-100 VDC
Damage limit	120 VDC

6.7 CONNECT RF ANTENNAS

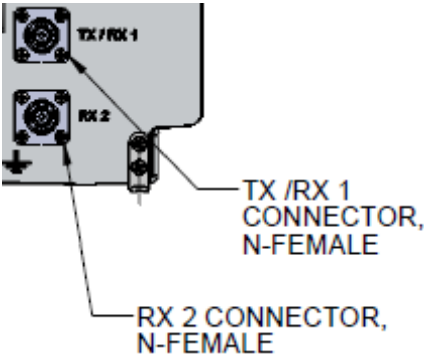
6.7.1 ANTENNA PLANNING

Antenna planning takes place before installation begins. You should already know how many antennas have been installed for the locomotive. The transceiver is designed to operate into a 50 Ohm load. Locomotive transceivers can have either of two possible antenna configurations. See [APPENDIX B — Possible Antenna Configurations](#) for more information.

6.7.2 CONNECT ANTENNA CABLE(S) FOR NARROWBAND RF ANTENNA(S)

The Locomotive Transceiver is rated for 50 W peak envelope power (PEP). Locomotive Transceivers have one combined TX/RX port and one additional port for receiving only, both of which have Type N female connectors for narrowband RF antennas. Terminate and cover any unused port with 50 Ohms termination.

Figure 8 Narrowband RF antenna connections at the rear of the Locomotive Transceiver



To connect the cables:

1. Run the cables into the rack.
2. Connect each antenna cable to the appropriate antenna input connector of the unit. (See [APPENDIX B — Possible Antenna Configurations](#) for more specific information, if necessary.) Tighten securely, but **do not over-tighten**. Use caution to avoid cross-threading the connector.
3. Terminate and cover unused port, if applicable, with 50 Ohms termination.
4. Restrain cables while observing the cable manufacturer’s minimum bend radius recommendations.

6.8 CONNECT THE ETHERNET CABLE

The Locomotive Transceiver features two 8-pole female M12 A-coded connectors for Ethernet. One is for LAN communications and the other is for the MAINT port of the transceiver. The LAN Ethernet connection is required for normal transceiver operation. The MAINT port is for performing maintenance on the unit.

Figure 9 M12 Ethernet cable connection

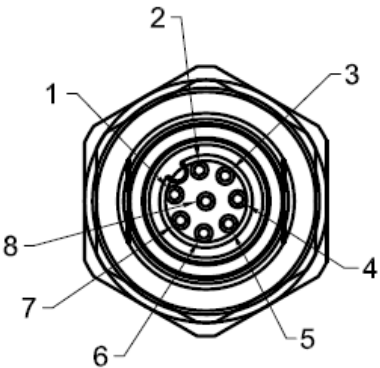


Table 4 M12 connector pinout

Pin	Purpose	Pin	Purpose	Pin	Purpose	Pin	Purpose
1	Reserved	3	Reserved	5	Receive +	7	Reserved
2	Reserved	4	Transmit –	6	Transmit +	8	Receive –

To connect the Ethernet cable

1. Checking the orientation of the pin and slot beforehand, insert the cable into the LAN connection port of the Locomotive Transceiver.
2. Rotate the entire connector until the locator pin engages in its slot. Carefully align the connectors and screw until finger-tight.

6.9 CONNECT THE POWER CABLE



Warning – Applying an incorrect voltage to a Locomotive Transceiver can cause damage. Confirm the voltage rating of the Transceiver and power source before applying power.

Locomotive Transceivers operate nominally at 74 VDC with an input range of 45-100 VDC. The Locomotive Transceiver uses an MS 3102 A18-4P connector for power. Using shielded 16 AWG cable is suggested.

Figure 10 Power connector of the Locomotive Transceiver

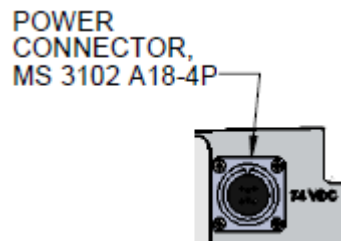
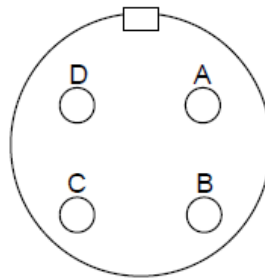


Figure 11 Power connector pin-out detail

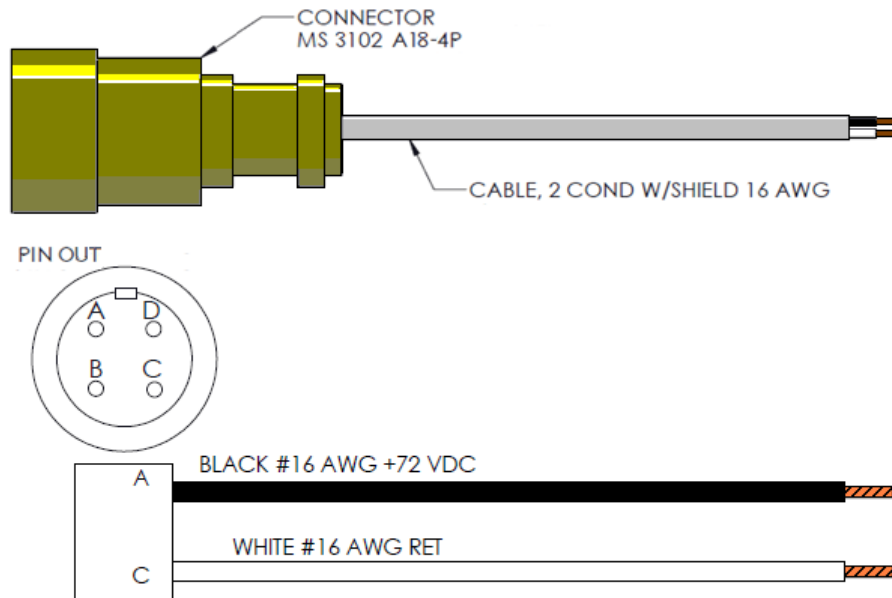


To connect the power cable:

Important! The transceiver does not have a power switch. Applying power at the power connector of the Locomotive Transceiver powers it on. Do not connect the transceiver to power until instructed to do so later in these instructions. Verify that the power is off before connecting the unit to a power source.

1. Confirm proper grounding.
2. Verify the ground bond from the ground lug on the transceiver through external surge protection.
3. Run the power cable through the rack.
4. Connect the connector onto the transceiver power port and hand-tighten.

Figure 12 Power cable for Locomotive Transceiver



6.10 POWER ON THE TRANSCEIVER



Caution – Power should never be applied to any system unless the user is acutely aware of his intentions and the environment in which the unit is operating. Applying power to an improperly-terminated radio transceiver could result in damage to the radio transceiver, cause operator injury, or violate regulatory laws regarding radio transceiver transmissions as radios will begin transmitting full-rated power without any user intervention under certain conditions.

Initial power-on of the radio transceiver:

1. Confirm that all radio transceiver connections are secure.
2. Power on the transceiver.
3. Ensure the breaker did not trip on startup.



Caution – Take care to not power-cycle the transceiver off and on repeatedly within four minutes of powering it on. Subjecting the transceiver to three or more successive power cycles within four minutes can cause a reboot error. If a reboot error occurs, remove power, replace the SD card, and then apply power and allow the transceiver to boot up normally without power interruptions.

6.10.1 LED DIAGNOSTICS

A blinking PWR (Power) LED on the front panel indicates that the boot sequence has completed. The system becomes active within about 25 seconds.

The front panel LEDs show the general operational status of the transceiver after it has conducted a POST, which it does each time it boots up. [Table 5 Front panel LEDs](#) includes a description of the function of each LED as well as the color of each LED when the transceiver is functioning properly.

Note: If a problem occurs *after* the transceiver boots up, the front panel LEDs indicate the problem only after a reboot of the transceiver (provided the problem persists).

Read the description of each LED carefully. Some LEDs, such as the PWR LED, indicate a problem when they are off. Other LEDs, such as the FLT (Fault) and SWR, indicate a problem when they are lit.

Table 5 Front panel LEDs

Label	Description	Color
PWR	Power — Blinking green LED indicates that the unit is on.	Green
TX	Illuminates when the radio transmitter is keyed.	Red
SWR	Illuminates when the VSWR of the TX port exceeds approximately 3:1 or if the TX forward power is not within 25% of the RF output power setting.	Red
RX	Illuminates when the transceiver is receiving a valid 220 MHz PTC signal.	Amber
DTL	DTE Link — Illuminates when the transceiver establishes a connection to a Communication Manager (CM) through the Ethernet network port.	Amber
RFL	RF Link — Illuminates when an RF link is established between two radios.	Amber
STBY	Standby — Illuminates when the transceiver is in standby mode, indicating TX is disabled.	Red
FLT	<p>Fault — When illuminated, it indicates a variety of fault conditions not indicated by other LEDs.</p> <p>Possible faults indicated by the Fault LED include:</p> <ul style="list-style-type: none">• One or more internal radio supply voltages are below the minimum threshold.• The extended DC voltage to the transceiver is outside of the acceptable range.• One or more of the transceiver's internal sensors is indicating a temperature exceeding the allowable threshold.• The transceiver failed one or more self tests at power on.• TX forward power is not within 25% of the RF output power setting.• The CIM script file is not present or has invalid or corrupt data. <p>Information for resolving possible power supply or CIM problems are provided in the Troubleshooting chapter.</p>	Red

6.10.2 VERIFY LAN ETHERNET PORT IS OPERATIONAL

Configure the Ethernet port (or second Ethernet port) of the test computer for connection to the Transceiver LAN port, then connect an Ethernet cable to connect these ports. The test computer should display an active network connection on the port (indicated in the System Tray in Windows XP) within 60 seconds.

7 TROUBLESHOOTING

This section describes common problems, their possible causes, and likely solutions. It covers the following problems:

- Power
- SD memory card
- Antenna
- Transmission
- Reception
- Ethernet connectivity
- RF link

In each of the following sections, a troubleshooting table lists solutions to these problems in the order you should try them. Solutions that require more than one step are described in detail in Transceiver test and adjustment procedures.

7.1 GUIDELINES FOR TROUBLESHOOTING COMMON PROBLEMS

Always check these items first when a transceiver problem occurs.

- **Check physical connections.**

Make sure that all physical connections to the transceiver are secure. This includes: Ethernet (LAN port), power, narrowband RF antennas, and GPS.

- **Check that the SD card is present, seated, and contains a valid CIM script file.**

Make sure that there is an SD card installed and seated that contains a valid CIM script file. Without an SD card present and without a valid CIM script, the transceiver will not transmit and will continually reboot every few minutes.

- **Check the LEDs.**

Use the LEDs to determine the state of the system and whether there is a fault condition. See [LED Diagnostics](#) for more information.

7.2 POWER PROBLEMS

Problem indicators:

- There is no power to the transceiver — as indicated by the green PWR (Power) LED does not illuminate or blink.
- The transceiver does not transmit.
- Internal voltages are low as evidenced by low output power.

To troubleshoot transceiver power issues:

1. Make sure the power cable connectors are securely connected to the power supply and to the transceiver.
2. Make sure the power cable polarity is correct: the black wire is connected to the unit's positive (+) terminal and the white wire is connected to the return (–) terminal. See [Figure 12 Power cable](#).
3. Check that the power supply is turned on. If it is off, then turn it on. Verify that the breaker does not trip on power up.

4. Adjust the power supply to within the rated operating voltage.
5. Verify that the current limit on the power supply meets the maximum current draw.

Table 6 Locomotive Transceiver input power parameters

Parameter	Value
Nominal DC Power Input Voltage	74 VDC
Operational range	45-100 VDC
Damage limit	120 VDC
Current draw (while transmitting rated power)	1.8 A at 74 VDC — typical while transmitting into 50 Ohm load.

6. Replace the power cable.
7. Replace the transceiver. When replacing a transceiver, if the SD card contains a valid CIM script, remove the SD memory card from the nonworking transceiver and insert and seat it in the replacement transceiver. The replacement transceiver will use the CIM script on the SD memory card and its configuration will be the same as the original transceiver.

7.3 SD MEMORY CARD PROBLEMS

SD memory card problems are one type of problem that can cause the Fault LED to illuminate.

To troubleshoot SD memory card issues:

1. Check to make sure the SD memory card is present. See [Confirm SD Memory Card \(CIM\) is Installed and Seated](#). If it is missing or defective, replace it with a new SD card that contains a valid CIM script file.
2. If the transceiver reboots every few minutes, turn off transceiver power, re-seat the SD memory card, and then power the transceiver.
3. If the above does not remedy the problem, replace the SD memory card with one that contains a valid CIM script.
4. If replacing the SD memory card and restarting the transceiver does not turn off the Fault LED then replace the transceiver.

7.4 ANTENNA PROBLEMS

Antenna problem indicators:

- Transmissions from or to the transceiver are poor or absent.
- The transceiver's SWR LED illuminates.

To troubleshoot antenna issues:

1. Make sure the antenna cable connectors are securely connected to the antenna and to the transceiver. If there is an unused antenna connector, make sure it is properly terminated.

2. Check the antenna and antenna cable for any defects or breaks.
3. Check the cable connector and radio connector for corrosion.
4. Check cable continuity.
5. Replace the cable or connector.
6. Replace the antenna.
7. Check the transmitter output power without the antenna connected.
8. Replace the transceiver. When replacing a transceiver, if the SD card contains a valid CIM script, remove the SD memory card from the nonworking transceiver and insert and seat it in the replacement transceiver. The replacement transceiver will use the CIM script on the SD memory card and its configuration will be the same as the original transceiver.

7.5 TRANSMISSION PROBLEMS

Problem indicators:

- Transmissions from the transceiver are weak or intermittent.
- A transceiver in the network stops receiving expected communications from the transceiver.
- The TX LED does not illuminate or blink.

To troubleshoot transmission issues:

1. Make sure the transceiver is turned on and the green PWR LED illuminates and blinks.
2. Check the cable connector and the radio connector for corrosion. If there is evidence of corrosion, then replace the connector.
3. Check to confirm the transceiver unit is not overheated.
4. Inspect the SD memory card to ensure it is seated properly in the CIM socket in the orientation shown on the door and is not damaged.
5. Make sure there is a valid CIM script file loaded from the SD card. Without an SD card present and without a valid CIM script, the transceiver will not transmit and will continually reboot every few minutes.
6. Make sure the antenna cable connectors are securely connected to the antenna and to the radio connectors.
7. Adjust the power output higher and lower to verify the transmission is controllable.
8. Monitor the current supplied by the power supply to confirm the current drawn is consistent with like transceiver units operating under similar conditions.
9. Check the antenna for any defects or breaks.
10. Adjust the power supply voltage, if necessary. If the power supply voltage is too low, the transceiver might stop transmitting.
11. Replace the cable or connector.

12. Replace the transceiver. When replacing a transceiver, if the SD card contains a valid CIM script, remove the SD memory card from the nonworking transceiver and insert and seat it in the replacement transceiver. The replacement transceiver will use the CIM script on the SD memory card and its configuration will be the same as the original transceiver.

7.6 RECEPTION PROBLEMS

Problem indicators

- A transceiver in the network stops receiving communications from another transceiver.
- The RX LED does not illuminate or blink.

To troubleshoot receiver issues:

1. Make sure the transceiver is turned on and the green PWR LED illuminates and blinks.
2. Verify the transmit frequency is within limits. See [Operational Characteristics](#).
3. Verify the antenna cable connectors are securely connected to the antenna and the transceiver.
4. Verify each antenna is connected to the appropriate antenna input connector. Terminate unused connector, if applicable. (See [APPENDIX B — Possible Antenna Configurations](#) for more specific information, if necessary.)
5. Check the cable connector and transceiver connector for corrosion.
6. Replace the cable or connector.
7. Check the antenna for any defects or breaks.
8. Replace the transceiver. When replacing a transceiver, if the SD card contains a valid CIM script, remove the SD memory card from the nonworking transceiver and insert and seat it in the replacement transceiver. The replacement transceiver will use the CIM script on the SD memory card and its configuration will be the same as the original transceiver.

7.7 ETHERNET CONNECTIVITY PROBLEMS

Problem indicators:

- The unit does not connect to the Ethernet network.
- The DTE Link LED does not illuminate or blink.

To troubleshoot network connectivity issues:

1. Check network activity using a computer. If the network is down, persons responsible for the network administration will need to restore network operation.
2. Make sure the Ethernet cable is securely connected to the transceiver LAN port.
3. Verify external network equipment is functioning properly.
4. Replace the Ethernet cable.

5. Replace the transceiver. When replacing a transceiver, if the SD card contains a valid CIM script, remove the SD memory card from the nonworking transceiver and insert and seat it in the replacement transceiver. The replacement transceiver will use the CIM script on the SD memory card and its configuration will be the same as the original transceiver.

7.8 RF LINK PROBLEMS

When the RF Link LED is on, it means that the Locomotive transceiver has selected and connected to a Base Station transceiver. When the LED is off, it probably means the Locomotive transceiver detects one or more Base Station transceivers but has not selected one.

Problem indicators:

- The RFL (RF Link) LED does not illuminate or blink.

To troubleshoot RF link issues:

1. Check the antenna for any defects or breaks.
2. Make sure the transceiver is turned on and the green PWR LED illuminates and blinks.
3. Make sure the antenna cable connectors are securely connected to the antenna and to the transceiver.
4. Inspect the SD memory card to ensure it is not damaged and is seated properly in the CIM socket.
5. Make sure there is a valid CIM script file loaded from the SD card. Without an SD card present and without a valid CIM script, the transceiver will not transmit and will continually reboot every few minutes.
6. Replace the transceiver. When replacing a transceiver, if the SD card contains a valid CIM script, remove the SD memory card from the nonworking transceiver and insert and seat it in the replacement transceiver. The replacement transceiver will use the CIM script on the SD memory card and its configuration will be the same as the original transceiver.

APPENDIX A — ABBREVIATIONS AND DEFINITIONS

A: Ampere, or Amp; measure of electric current

AWG: American Wire Gauge (a measure of wire diameter)

BER: Bit Error Rate

CIM: Configuration Interface Module

cm: Centimeter

Common Channel: A CSMA-operated channel common to all Base Station, Locomotive, and Wayside Transceivers in the system. Every radio transceiver in the system should have the same common channel.

CSMA: Carrier Sense Multiple Access

CW: Constant Wave

dB: Decibel

dBd: Decibel, dipole

dB_i: Decibel, isotropic

dBm: Decibel, referenced to one milliwatt

DC: Direct Current

DCE: Data Communication Equipment

DTDMA: Dynamic Time Division Multiple Access

DOP: Dilution of Precision

DQPSK: Differential Quaternary Phase-Shift Keying

EIA: Electronic Industries Alliance

EIRP: Equivalent Isotropically Radiated Power

ERP: Effective Radiated Power

EVM: Error Vector Magnitude

FCC: Federal Communications Commission (U.S.)

FRA: Federal Railroad Administration (U.S.)

FTDMA: Fixed Time Division Multiple Access

GPS: Global Positioning System

HAAT: Height Above Average Terrain

IC: Industry Canada (Canada)

ITC: Interoperable Train Control

ITCR: Interoperable Train Control Radio

kbps: Kilobits per Second

LAN: Local Area Network

LOS: Line of Sight

Local Channel: A frequency assigned to each Base Transceiver (DTDMA and FTDMA) and Wayside Transceiver (FTDMA)

LSI: Locomotive System Integration

m: Meter

Mbps: Megabits Per Second

MEO: Medium Earth Orbit

MHz: Megahertz

MPE: Maximum Permissible Exposure

MSGPS: Multi-Satellite Global Positioning System

mW: Milliwatt

NAS: An attachment system for LSI rack compatible components that utilizes alignment pins, attachment hooks, and thumbscrews

NIC: Network Interface Card or Network Interface Controller

PC: Personal Computer

PCA: Printed Circuit Assembly

PCB: Printed Circuit Board

PEP: Peak Envelope Power

PER: Packet Error Rate

POST: Power On Self Test

PPM: Parts Per Million

PSK: Phase Shift Keying

PSWR: Power Standing Wave Ratio

PTC: Positive Train Control

Radio ID: Radio Identifier; A unique identifier assigned to each radio transceiver in the system

RF: Radio Frequency

RSSI: Received Signal Strength Indicator

RTCS: Radio Test Control Simulator

RX: Receive

SAR: Specific Absorption Rate

SD memory card: Secure Digital memory card

SMA connector: SubMiniature version A connector

SRSP: Standard Radio System Plan (Canada)

TCP/IP: Transmission Control Protocol / Internet Protocol

TCXO: Temperature-Compensated Crystal Oscillator

TNC connector: Threaded Neill-Concelman connector

TX: Transmit

U: Unit measure of height for rack-mounted equipment, defined 44.5 mm (approximately 1¾ in) for rack-mounted equipment that conforms to EIA 19-inch rack standards

UUT: Unit Under Test

VDC: Voltage, Direct Current

VSWR: Voltage Standing Wave Ratio

W: Watt

XtermW: The terminal-emulation application used for configuring and testing ITC 220 Transceivers

APPENDIX B — POSSIBLE ANTENNA CONFIGURATIONS

The ITC 220 Locomotive Transceiver allows for two possible RF antenna configurations.

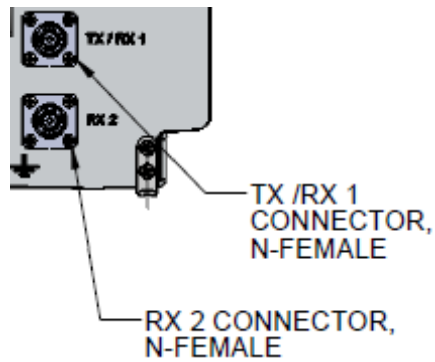
- **Single-antenna configuration**

The antenna is connected to the primary receive port, which is the TX/RX1 port. Terminate the other port RX2 with 50 Ohm termination.

- **Two-antenna configuration**

One antenna is connected to the primary receive port, TX/RX1. A second antenna is connected to the diversity port, RX2.

Figure 13 Narrowband RF antenna connections at the rear of the Locomotive Transceiver



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