METEORCOMM LLC

# ITCR Wayside Radio User's Manual and Installation Instructions

Applicable Model: 63010

Note: The final version of this manual will include a French translation of the notices to user in Sections 2 and 3.

# Revision History

| Revision | Date | Summary of Changes | Contributor |
|---|---|---|---|
| 0.1 | | Initial draft. | Jeff Lawrence |
| 0.2 | | Changes by Jeff Lawrence | Jeff Lawrence |
| 0.3 | 08/29/2011 | Added Notices to user, renamed and edited for FCC submission | Fred Cleveland |
| 0.4 | 09/08/2011 | Fixed errors and omissions. | Fred Cleveland |
| 0.5 | 10/04/2011 | Expanded and edited in response to examiner comments. | Fred Cleveland |
| 0.6 | 10/06/2011 | Corrected voltages. | Fred Cleveland<br>Tim Blom |
| 0.7 | 10/20/2011 | Revised Section 2.2, 3.3 and 5.4 | Fred Cleveland |

# Table of Contents

# 1. Overview

This document provides information required for the operation and verification of the Meteorcomm Interoperable Train Control Radio Network (ITCR) Wayside radios.

## 1.1 Applicable Radio Models and Identifiers

This document applies to the Wayside radio model listed below along with its regulatory identifiers.

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|---|
| Model: 63010<br>FCC ID: BIB63010<br>IC: 1300A-63010 |

## 1.2 General Description

The Wayside radio is designed to satisfy the industry standard Positive Train Control (PTC) requirements as part of an integrated 220 MHz radio network. The Base radio, Locomotive radio, and Wayside radio form the transportation backbone on which a messaging application provides communication capabilities between railroad assets and their back offices. The ITCR is designed to provide communication in an inter-operable fashion enabling messaging to occur across railroad boundaries.

When applied as a mobile station, this radio will be mounted in mobile maintenance vehicles such as pickup trucks. It will actively join the ITC network only when maintenance vehicles are driven on the rails.

The Wayside radio is normally positioned on railroad property in an equipment box or bungalow close to the active rails. When used as a wayside station, its mission is to provide wireless transmission of local track and trackside equipment where it is mounted. Its radio messages are actively monitored by locomotives in the vicinity that may be headed in its direction. It also normally associates with a nearby base station. The base station backhauls the wayside transmission for various monitoring and control purposes at the railroad central office. It is normally interfaced to a Wayside Interface Unit (WIU) via its LAN ethernet port. The WIU terminates all local wayside equipment such as switches, signals, track continuity circuits and several other possible track condition indicators. The WIU formats the status information into a short message called an aspect. The aspect is sent to the Wayside radio for packetized RF transmission.

## 1.3 Chassis

Wayside radios are housed in electrically sealed metal cases. The Wayside radio dimensions are approximately 15.5W X 9.5 H X 2.0D. It weighs less than 8 lbs.

All input/output ports are grounded and/or shielded. In addition, best engineering practices have been employed with respect to internal shielding, unit assembly and PCB design in an effort to minimize potential sources of unwanted radiated emissions.

## 1.4 Ports and Ethernet Connectors

The Wayside radio has two RJ45 Ethernet I/O ports, marked LAN and MAINT, each on its own network.

## 1.5 Power Connectors

The Wayside radio power input connector is a Wago type for 13.6 VDC nominal, min 10.9 VDC and max 15.5 VDC.

## 1.6 Antenna Connectors

The 30W PEP rated 220-222 MHz wayside radio transmitter has an N-type antenna connector and expects a nominal 50 ohm resistive load, max VSWR 3:1. It also has a TNC connector for the GPS antenna. The GPS antenna can be active (3.3Vdc, 50mA max) or passive.

# 2. Important Information for the User

## 2.1 Transmitter Warm-Up Period.

The wayside transmitter uses a temperature compensated crystal oscillator (TCXO) to achieve frequency accuracy and stability. No warm-up period is required beyond the built-in radio startup delays.

## 2.2 Limiting RF Exposure

**Please refer to the RF Energy Exposure Guide packed 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 rules that when followed, limit human exposure to radio frequency energy to acceptable levels. Note that the RF Energy Exposure Guide calculates the larger lateral safe distances for an uncontrolled environment. Obeying these limits will protect both railroad employees and the general public.

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.

This transmitter is intended to be operated with a fixed or mobile antenna in an Occupational/Controlled Exposure environment per FCC OET 65 or Controlled Use Environment per IC RSS-102. Maximum Permitted Exposure (MPE) limit for devices in the presence of the general public in the 100-300 MHz range is 0.2 $mW/cm^2$ = 2 $W/m^2$.

The tables in the RF Energy Exposure Guide list the calculated lateral distances to be maintained between the general public and an operational Wayside transmitter antenna for two antenna types and gains and for both fixed and mobile applications.

The transmitter power is adjustable to accommodate the various installations of this product. Once the authorized ERP, antenna gain and the losses from feed line, connectors and any inline RF filters are known, the transmitter power must be evaluated and if necessary, set to a value that will ensure that the authorized ERP and RF exposure requirements are met. Example ERP calculations are provided further below.

## 2.3 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.
- Install antennas in accordance with the manufacturer's instructions.
- Disable the transmitter when installing or servicing its antenna or transmission line.
- Refer to the RF Energy Exposure Guide for specific guidelines regarding the siting and installation of mobile and fixed antennas.
- Acceptable mobile and fixed antenna types are listed in the tables 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 and may violate FCC or IC regulations. Contact Meteorcomm before using other antennas.
- Maintain a safe distance from energized transmitting antennas. See above.

## 2.4 RF Interference to Residential Receivers (Part 15)

**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 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 the following measures:

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

## 2.5 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. Wayside 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.

## 3.1 Wayside Channelization and Frequency Range

The Wayside radio 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 wayside transmission occupies five of the FCC-defined 5 kHz channels. The lowest Wayside radio channel center frequency is in the center of FCC channel 3 and the next is FCC channel 8, then 13, 18, etc., up to the highest in the center of channel 398.

## 3.2 Wayside 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 161-170 and 181-185. Therefore, the wayside radio may not transmit on those channels or their 221 MHz counterparts, 361-370 and 381-385. This corresponds to wayside 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.

## 3.3 Wayside 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 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 means for the licensee to determine effective radiated power (ERP) and comply with regulatory power limits.

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

Licensees should note that all mobiles and also fixed installations transmitting between 221 and 222 MHz must limit effective radiated power (ERP) to 50W or 10*log(50) + 30 = 47dBm 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 196-200 at 220.975 to 221.000 MHz is 2 watts.

The allowable transmitter peak envelope power output in dBm is determined by subtracting the antenna gain in dBi from 49.15, then adding the loss from the antenna feedline and connectors. If the result is greater than or equal to 44.85 dBm = 14.85 dBW then the maximum power output of the Wayside transmitter can be used. If the value is less than 44.85 dBm, then the transmitter output power must be reduced to the calculated value.

Mobile Installation: As an example of a mobile installation, consider a vertical half wave ground plane on a vehicle metal rooftop. In an ideal installation the antenna gain = 2.4 dBd = 4.55 dBi. Ignoring connector losses, feedline loss is at least 0.6 dB for 10 feet of Times Microwave LMR-195 Ultra Flex coaxial cable. Transmitter power output *limit* = 47-2.4+0.6 = 45.2 dBm PEP and therefore the system is compliant with the 50W ERP limit. The actual ERP in this case is 10^(14.85+2.4-0.6) = 46.2 W. This installation is not allowed to transmit on FCC channels 196-200 because the maximum ERP is greater than 2 watts.

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

Once the allowable ERP is determined by applying all power-restrictive rules from above and the antenna gain is known, the transmitter peak envelope power output feeding the transmission line is determined by subtracting the antenna gain in dBd from the ERP and adding the loss from the antenna feedline and connectors plus the loss from any external inline power sensors, combiners, filters or lightning arresters. If the net value is greater than or equal to 44.85 dBm, then the maximum power of the Wayside transmitter can be used. If the value is less than 44.85 dBm, then the transmitter output power must be reduced to the net value.

Example for the 50W ERP fixed case: Antenna gain = 2.9 dBd and feedline loss is at least 0.5 dB for 25 feet of Times Microwave LMR-400 coax plus 0.4 dB for inline lightning arrester and three connectors. Assuming no other losses, the transmitter power output *limit* = 47-2.9+0.9 = 45 dBm PEP. In this case, the actual Wayside ERP is 44.85+2.9-0.9 dBm = 46.85 dBm = 48.4 W PEP and therefore the system is compliant with the 50W ERP limit. This installation is not allowed to transmit on FCC channels 196-200 because the maximum ERP is greater than 2 watts.

# 4. Setup and Configuration for the Wayside Radio

Set up physical connections with the following:

- DC Power
- Ethernet
  RF output termination

The sections below identify each of the physical connections.

## 4.1 Power Supply

Wayside radios operate at 13.6Vdc input. Table 1 describes the power supply requirements.

**Caution:** Applying an incorrect voltage to a Wayside radio can cause damage. Confirm the voltage of the radio and the power supply before

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|---|
| applying power. |

**Table 1 Wayside Radio Power Parameters**

| Parameter | Wayside Radio |
|---|---|
| Nominal DC Power Input Voltage | 13.6Vdc |
| Operational Range | 10.9-15.5Vdc (+14%/-20%) |
| Damage limit | 17Vdc |
| Current Drain (while transmitting rated power) | 10A max while transmitting into 50 ohm load |

## 4.2 Ethernet Connection

Wayside radios use a standard CAT5 Ethernet cable connected between a PC and the maintenance port of the radio. Configure the PC network card with a fixed IP address of 10.10.1.254.

You will use XtermW, a Meteorcomm terminal emulation program, to connect with and control the radio via commands issued at command prompts.

## 4.3 RF Output Termination

The Wayside radio is rated for 30W PEP. Sufficient termination is required to protect test equipment. For transmitter and receiver testing, connect the test equipment to the port labeled “ANT”. See further instructions below.

# 5. Tuning the Wayside Radio

There are three parameters to test and potentially tune before/during RF testing:

- 
- Master reference crystal oscillator frequency
- RF output power
- RF output channel

Factory technicians tune the master reference crystal oscillator and set the RF gain for maximum rated output power. You may have to adjust the three parameters before or during RF testing by entering commands using XtermW or another terminal emulation program.

## 5.1 Equipment Required

1. 10A DC power supply at rated voltage of wayside radio, nominally 13.6 VDC.
2. Personal computer with Ethernet network adapter and Meteorcomm XtermW or equivalent terminal program installed.
3. 30 dB 50W RF power attenuator.
4. Vector spectrum analyzer for power and frequency measurements.
5. Optional 8+ digit frequency counter for frequency measurements.
6. High stability time base accurate to 0.1 ppm. Can be internal to items 4 and 5.

## 5.2 Set up the Radio for Testing

1. Adjust a 10A DC power supply to 13.6 VDC and then disable its output. Observing polarity of the power supply terminals, connect the wayside power cable between the radio power connector and the power supply.
2. Connect one end of a CAT5 ethernet cable to the RJ-45 radio port labeled MAINT. Connect the other end to a computer network card. The default radio IP address is 10.10.1.254. Set the IP address of the computer network card to a compatible fixed address such as 10.10.1.1. The computer should have Meteorcomm XtermW or a similar terminal emulation program installed.

3. Apply power to the radio. Wait 30 seconds to open an XtermW session. Use the Edit/Configure Port window to set Port Type = TCP/IP, Protocol = Stream, TCP/IP Settings Host = 10.10.1.254, Port 4000. Select Device Type = MCC 6100 SDR (which also applies to ITC radios). Return Character = CR, Data Format = ASCII.
4. Attach a 50W 30 dB RF attenuator to the TX/RX1 N-type antenna connector. Attach an (e.g., Agilent MXA or PXA) vector spectrum analyzer or similar to the transmitter port for power and frequency measurements. The VSA should contain either a precision stability reference oscillator or attach an external rubidium reference to the VSA external reference input.

## 5.3 Measure and Calibrate Reference Crystal Oscillator Frequency

The instructions below allow you to change the factory calibration settings for the master reference oscillator crystal.

**To check the master reference crystal oscillator frequency calibration:**

1. Open an XtermW session.
2. Put the radio into test mode by typing:

```
dsp,watchdog,off
dsp_mode,test
```

3. Reduce output power to approximately 2W by typing:

```
cal,set,ddslevel, 100
```

4. Begin transmitting a test tone directly on the carrier frequency:

```
l1_test,stop
l1_test,set,txmod,cw
l1_test,set,txfreq,220012500
l1_test,start,tx
```

5. Use the frequency counter or frequency counting marker on the VSA to measure the output frequency. The measured value is the actual carrier frequency. The carrier frequency is normally well within 352 Hz (1.5 ppm) of the center frequency of the channel.
6. Alternate to the test tone: Substitute the following π/4-DQPSK modulation command for the second line in step 4.

```
l1_test,set,txmod,dqpsk_half
```

7. Set the VSA to the center frequency of the channel and set it to demodulate the 8 ksym/second π/4-DQPSK emission and measure the error frequency which is referenced to the VSA center frequency.

**To adjust the master crystal reference oscillator parameters:**

1. First, check the factory default setting for the crystal reference parameter by typing

   ```
   cal
   ```

2. Note the value for "xo" in the cal factors table that is displayed.

3. At the XtermW command line, type:

   ```
   cal,set,xo,xx
   ```

where xx is some value close to the original factory set value.

4. Use trial and error to determine the set point for the xo value to achieve the desired carrier frequency accuracy.

**To reset the XO tuning parameter to the factory setting:**

Power cycle the radio.

## 5.4 Measure and Adjust Output Power

**Caution:** Avoid unnecessary adjustments. Exercise caution when setting ddslevel or other power output controls as damage to the radio can occur if they are set too high.

The wayside radio is rated for 30W PEP. To achieve this power radios are pre-calibrated at the factory. If additional tuning is required, use an appropriate method to measure PEP for a π/4-DQPSK signal and slowly increase/decrease ddslevel level from its nominal set point, as determined by issuing the command 'cal'.

**To measure and adjust output power:**

1. At the XtermW command line, begin transmitting a π/4-DQPSK signal by typing:

```
l1_test,stop
l1_test,set,txmod,dqpsk_half
l1_test,start,tx
```

2. View the calibration settings by typing:

```
cal
```

3. Observe the value for ddslevel.

4. Tune the VSA to the center of the channel frequency and select the CCDF function to measure the peak (envelope) power, average power and peak to average ratio. Note that the peak envelope power is used for determining ERP.

5. The power can be modified by typing:

```
l1_test,stop
cal,set,ddslevel,xxx
l1_test,start,tx
```

While monitoring the output power, the value xxx should be increased a small amount to increase output power or vice versa.

## 5.5 Check and Adjust RF Output Channel

You can adjust the RF output channel by stopping transmission, setting transmission frequency, and then starting transmission again.

**To adjust RF output channel:**

1. Tune the radio to the bottom channel (220.0125MHz) by typing:

```
l1_test,stop
l1_test,set,txfreq,220012500
l1_test,start,tx
```

2. Tune the radio to the mid-channel (221.0125MHz) by typing:

```
l1_test,stop,
l1_test,set,txfreq,221012500
l1_test,start,tx
```

3. Tune the radio to the high channel (221.9875MHz) by typing:

```
l1_test,stop
l1_test,set,txfreq,221987500
l1_test,start,tx
```

# 6. Operations

## 6.1 Restore Factory Settings

**To restore factory settings without cycling the radio:**

- At the XtermW command prompt, type:

  `factory`

## 6.2 Display Software and Firmware Revision Numbers

**To display what software and firmware versions are installed on your radio:**

- At the XtermW command prompt, type:

  `rev`

## 6.3 Display Radio Identification Information

This section provides you with commands to display serial number and identification information.

**To display serial number information:**

- At the XtermW command prompt, type:

  `serialnumber`

**To show current ID setting:**

- At the XtermW command prompt, type:

  `ID`