



**ITCR Base Radio
User's Manual and Installation
Instructions**

Applicable Models: 63030-24, 63030-48

Revision History

| Revision | Date | Summary of Changes |
|----------|------------|--|
| 0.1 | | Initial draft. |
| 0.2 | | Changes by Neil Ross. |
| 0.3 | 8/29/2011 | Add notices to user and expanded RF exposure Information. General editing. |
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1. Overview

This document provides important radio frequency safety information and instructions for the basic operation and adjustment of the Base station radio. This document pertains to Meteorcomm Interoperable Train Control Radio Network (ITCR) Base radio models, numbers 63030-24 and 63030-48. Operation of these two models is identical except for input power requirements of 24 Vdc and 48 Vdc, respectively.

1.1 Applicable Radio Models and Identifiers

This document applies to two Base radio models listed below along with their regulatory identifiers. These two models differ only in their power supply input voltage and associated power supply circuits.

| | |
|---|---|
| Model: 63030-24 FCC ID: BIB63030-24 IC: 1300A-6303024 | Model: 63030-48 FCC ID: BIB63030-48 IC: 1300A-6303048 |
|---|---|

1.2 General Description

Meteorcomm Base radios are 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 interoperable fashion enabling messaging to occur across railroad boundaries.

The Base station radio is normally positioned inside an equipment hut or other unoccupied building at the base of an antenna tower, all within access-controlled property that is generally located away from residential areas. The equipment is installed, serviced and maintained only by professional telecommunications workers.

The Base communicates via packetized messages in a half duplex manner meaning that transmission and reception are not simultaneous. The Base organizes

transmissions into three second superframes by using slotted TDMA in the majority of the frame followed by collision sense multiple access (CSMA) in the remainder of the frame. Packet radio messages are passed between Base and mobiles (primarily locomotives but may also include maintenance equipment on the rails) and from Wayside (rail monitoring and control points) stations. The Base radio is also in two-way communication with the back office of the owner railroad company via its ethernet LAN port. Back offices of owner railroads are also linked to support foreign railroad traffic on a given railroad company's track.

1.3 Chassis

Base radios are housed in electrically sealed metal cases. The Base radio fits within a standard 19" rack mount and has a maximum depth of 24 inches and a height rack of 4 RUs, weighing less than 25 lbs.

It contains fans with a temperature sensor that can be set to turn on at a configurable temperature.

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 Base radio supports two RJ45 Ethernet I/O ports, each on its own network.

1.5 Power Connectors

The Base radio has two studs (marked '+' and '-') to support the connection of power cables. See input power requirements further below.

1.6 Antenna Connectors

The 50W PEP rated Base radio supports 50-ohm resistive loads using N-type connectors for narrowband RF antenna(s), max VSWR 3:1. The connector marked TX/RX should be routed to the transmit or transmit/receive antenna. The connectors marked RX1 and RX2 are provided for optional use of separate receiving antennas.

The Base also has a TNC connector for the GPS receiver 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 Base transmitter uses a precision oven-controlled crystal oscillator (OCXO). The OCXO warm-up period is one minute minimum after application of input power before any transmission should commence.

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 although the Base station is 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 Base transmitter 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. 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 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 non-residential buildings that are generally unoccupied except while servicing the equipment therein.

The table in the RF Energy Exposure Guide lists the calculated lateral distances to be maintained between the general public and an operational Base transmitter antenna for two antenna types suitable for fixed Base 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.

2.3 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 title Base Radiated Power Limits further below provides additional information on how to comply with ERP limits.
- Refer to the RF Energy Exposure Guide for specific guidelines regarding the siting and installation of fixed antennas.
- Acceptable fixed antenna types 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. Refer to the table of safe distances for Base radios in the RF Energy Exposure Guide packed with each radio.
- 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.

2.4 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 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. Base Transmitter Operation

It is the responsibility of the licensee to operate this radio transmitter in compliance with the terms of the license and FCC or Industry Canada service rules for 220-222 MHz, i.e., FCC Rules Part 90T and Industry Canada SRSP-512, or in the U.S. only, operation on 217.6-218 and 219-220 MHz frequencies is subject to FCC Rules Part 80.

3.1 Base Radio Channelization and Frequency Range

The Base radio can be licensed and configured to transmit on any one of 80 selectable 25-kHz spaced channels ranging from 220.0125 to 221.9875 MHz inclusive in the 220-222 MHz Radio Service defined by Part 90 Subpart T. 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 Base radio transmission occupies five of the FCC-defined 5-kHz channels. The lowest Base radio channel center frequency 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.

In the USA only, the radio can be licensed and configured to operate on 56 additional (Part 80) frequencies in the ranges 217.6125 to 217.9875 MHz and 219.0125 to 219.9875 MHz.

3.2 Base 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 Base radio may not transmit on those channels or their 221 MHz counterparts, 361-370 and 381-385. This corresponds to Base 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 Base 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 Parts 80 and 90 or Industry Canada SRSP-512 §6.3, as applicable.

Important: The following supplementary antenna system information discusses means for the licensee to comply with regulatory power limits.

Licensees must comply with the specific power vs. HAAT limitations for fixed base stations. U.S. and Canadian power limits differ in this regard.

Licensees should also note that fixed installations transmitting between 221 and 222 MHz must limit effective radiated power (ERP) to 50W or $10 \cdot \log(50) + 30 = 47\text{dBm}$

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.

Common single element fixed station antennas typically exhibit 2.1 to 5 dBi (0 to 2.9 dBd) gain and being vertically polarized, are usually omnidirectional. Multi-element antennas are designed to concentrate RF radiated power toward the horizon and away from the sky and the earth and depending on the design criteria provide azimuthal gain directivity that decreases ERP in the direction of other base stations or increases ERP in a specific direction. They may also be used to make up for large losses between transmitter and antenna. The isotropic gain of a commonly-used two-element exposed dipole antenna is typically 7 to 8 dBi.

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 dBi from the EIRP and adding the loss from the antenna feedline and connectors plus the loss from any combiners, cavity filters or lightning arresters. If the net value is greater than or equal to 48.75 dBm, then the 75W maximum power of the Base transmitter can be used. If the value is less than 48.75 dBm, then the transmitter output power should be reduced to the net value. Example for the 50W ERP case: Antenna gain = 8 dBi, feedline and connector loss = 2 dB. Assuming no other losses, the transmitter power output limit = $49.15 - 8 + 2 = 43.15$ dBm PEP or 20.7 W PEP. In this case, the Base RF output power should be adjusted to 20.7 W PEP or less.

If the calculated transmitter power limit is less than the minimum Base rated power of 10W PEP = 40 dBm PEP, then an external RF attenuator would be inserted in the feed line to increase the loss between transmitter to achieve compliance.

4. Setup and Configuration for the Base 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 Input Power

A label on the radio chassis indicates the rated voltage of the Base radio: 24 or 48V. The table below describes the power supply requirements for each type.



Caution: Applying an incorrect voltage outside the rated voltage range of a Base radio can damage it. Confirm the voltage ratings of the radio and the power supply before applying power.

Table 1. Base Radio Input Power Parameters

| Parameter | Base Radio | |
|--|---|--|
| | 24VDC radio version | 48VDC radio version |
| Nominal DC Power Input Voltage | 24VDC radio version | 48VDC radio version |
| Operational Range | 21-27 Vdc (+/-12.5%) | 42-54 Vdc (+/-12.5%) |
| Damage limit | 30VDC | 60VDC |
| Current Drain (while transmitting rated power) | 11A peak max with 50 ohm load 7.5A for max average operating current | 6A peak max with 50 ohm load 4A for max average operating current |

4.2 Ethernet Connection

Base 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 Base radio is rated for 75W PEP max into a 50 ohm resistive load. Base radios have a single TX/RX port with two additional ports for receiving only. For transmitter testing, connect the test equipment to the port labeled "TX/RX." A suitable RF power attenuator should be used to protect test equipment.

5. Tuning the Base 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 any other terminal emulation program.

5.1 Equipment Required

1. 10A DC power supply at rated voltage of Base radio.
2. Personal computer with ethernet network adapter and Meteorcomm XtermW or equivalent terminal program installed.
3. 30 dB 100W RF power attenuator.
4. Vector spectrum analyzer for power and frequency measurements.
5. Optional 8+ digit frequency counter for frequency measurements.
6. External high stability time base (e.g., rubidium) accurate to 0.01 ppm. Can be internal to items 4 and 5.

5.2 Set up the Radio for Testing

1. Connect a cable that has a CAT5 ethernet connector on one end and an 8-pin M12 cable connector on the other end (MCC P/N 14001627-01). Connect the M12 connector to the 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.
2. Find the input voltage rating marking on the radio chassis near the power input terminal block. It is either 24VDC or 48VDC. Adjust a 10A DC power supply to the proper voltage; then disable its output. Observing polarity markings connect the power supply between the radio power terminals and the power supply.
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 100W 30 dB RF attenuator to the TX/RX 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 Parameters

The instructions below allow you to change the factory calibration settings for the master reference oscillator crystal. The new setting is stored in volatile memory and will revert to factory settings when the radio is powered off and then on.

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, idle
dsp_mode, test
```
3. Reduce output power to approximately 2W by typing:

```
cal, set, igain, -1000
cal, set, qgain, -1000
```
4. Begin transmitting a test tone offset +8kHz from the carrier:

```
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 exactly 8 kHz greater than the actual carrier frequency. The carrier frequency is normally well within 22 Hz (0.1 ppm) of the carrier frequency.
6. Alternate to the test tone: Substitute the following $\pi/4$ -DQPSK modulation command for the second line in step 4.

```
l1_test, set, txmod, dqpsk
```

7. Set the VSA to the center frequency of the channel and set it to demodulate the 16 ksym/second $\pi/4$ -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 I and Q gain values as damage to the radio can occur if gains are set too high.

Base radios are rated for 75W PEP. To achieve this power radios are pre-calibrated at the factory. If additional tuning is required, use an appropriate method to determine PEP for a $\pi/4$ -DQPSK signal. The CCDF function on the VSA is recommended for peak power measurement. Slowly increase/decrease I and Q gain levels from their nominal set point, as determined by issuing the command 'cal'.

A step of 100 points (for example, -250 to -150) is approximately equivalent to an increase of 2dB in power.

To measure and adjust output power:

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

```
dsp, watchdog, off
dsp_mode, test
ll_test, stop
ll_test, set, txmod, dqpsk
ll_test, start, tx
```

2. View the calibration settings by typing:

```
cal
```

3. Note the values for igain and qgain. They are normally matched.
4. Increase the output level by entering larger matched values or reduce output level using smaller matched values. Use cal command in between to verify the new settings.

```
cal, set, igain, xxxx
cal, set, qgain, xxxx
```

5. Tune the VSA to the center of the channel frequency and use the CCDF function to measure the peak envelope power, average power and peak to average ratio.

5.5 Check and Adjust RF Output Channel Frequency

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:

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

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

```
ll_test, stop,
ll_test, set, txfreq, 221012500
ll_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
```

- Note that in the USA the bottom and middle frequencies are 217.6125 MHz and 219.8125 MHz.

6. Operations

This section provides commands used during normal operation of the Base radio.

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
```