METEORCOMM LLC

ITCR 1.0 Functional Product Specification

Document Revision: 1.0
Document Number: 00002575-A

.

Document Number: 00002575- A

Revision history

Revision	Date	Summary of Changes
1.0	12/10/2012	First draft in new template.

Table of Contents

Table of Figures

Table of Tables

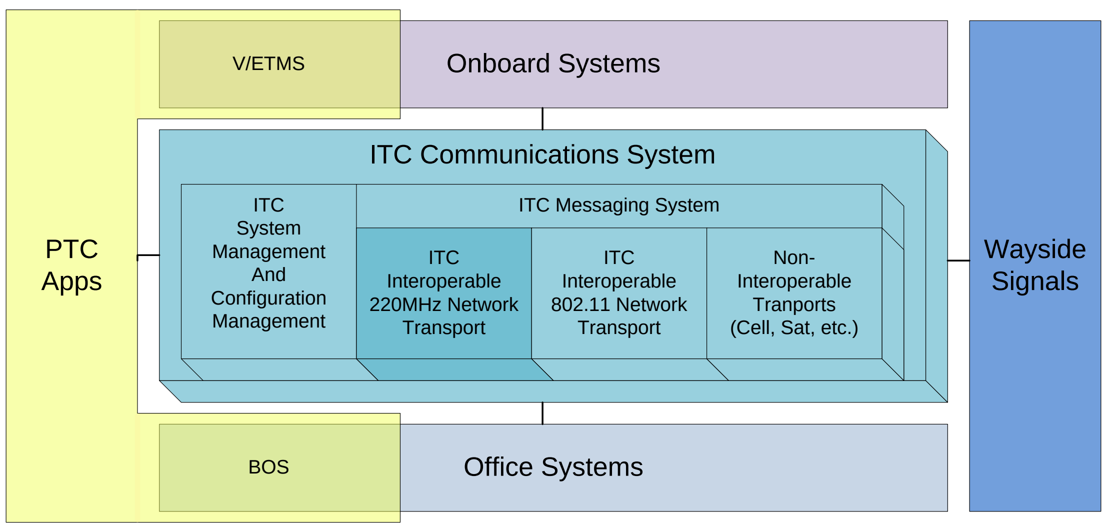
1. Introduction

1.1 Overview

This document is one of three documents in a set of specification documents that describe the ITC 220 MHz Network. This network provides communications for Positive Train Control (PTC) and is composed of 220 MHz data radios designed specifically for this application.

The following diagram places the ITC 220 MHz Network in the larger Interoperable Train Control System context.

Figure 1: ITC system components



The 220 MHz Network is the only nationwide interoperable transport within the ITC Messaging System. The other interoperable transport, 802.11, will only be available in limited coverage areas such as yards or terminals. Other message transport networks will be supported by the ITC Messaging System but will not be directly interoperable. Rather, they will be made effectively interoperable through the Messaging System's ability to route messages between back offices. As part of the messaging system, these transport networks provide data communication services between back

office, locomotive, and wayside areas. Their primary purpose is to transport PTC messages between these areas.

1.1.1.1 Purpose

These documents are primarily for use by Railroads as a description of the 220 MHz Network functionality and the products that make up the network. They can be used

- to provide information to support RF network engineering,
- as a detailed description of what the products will do,
- for customer review of the features and functionality contained in Product Release 1.0, and;
- to outline the parameters of acceptance tests.

These documents will also be used internally by the Communication System Integrator and Vendors to drive product development. Finally, they can be used to provide context to a radio manufacturer. By themselves, these specification documents are insufficient as test requirements or product design requirements and are not to be used as such.

1.2 Organization

The content of these documents are split into the following three areas.

- ITC 220 MHz Radio System Architecture Specification
- ITC 220 MHz Radio Functional Specification
- ITC 220 MHz Radio Hardware Specification

The System Architecture Specification document addresses system level aspects of the ITC 220 MHz network. The Functional Specification document addresses the functionality provided by the radios and software that make up the 220 MHz network. The Hardware Specification document addresses the electrical, mechanical, and RF characteristics of the radios.

1.3 Scope

The scope of this set of specification documents is based on version 0.3 of the ITCC Radio Requirements Baseline document (reference [1]).

1.4 Assumptions

The following assumptions have helped to drive the specifications.

- A key driver of the 220 MHz Network design is efficient use of the available spectrum for PTC message traffic. As such, the design is optimized with a focus on the specific needs of PTC.
- In order to deploy the initial product release in a timely manner, the initial release focuses on delivering critical and core functionality. Software functionality which was not deemed critical or core has been deferred to future releases.
- The ITC Communications system will be a single federated network shared across all participating railroads. This means that any railroad can have its remote assets connect and make use of any other railroad's base station assets.
- To reduce unnecessary overlapping coverage, and to make the most efficient use of the available 220 MHz spectrum, some portions of the PTC 220 MHz network will have base stations that are shared amongst the railroads.
- FCC Waivers submitted for the 220 MHz ITC spectrum will be approved for the existing spectrum and for any new spectrum that is acquired.

1.5 Acronyms

Acronym	Description
AAR	Association of American Railroads
BO	Back Office
CSMA	Carrier Sense Multiple Access
DHCP	Dynamic Host Control Protocol
DQPSK	Differential Quadrature Phase Shift Keying
ELM	External Link Manager
FDMA	Frequency Division Multiple Access
FM	Frequency Modulation
FW	Firmware
HRX	Host Radio Exchange

HW	Hardware
IP	Internet Protocol
ITC	Interoperable Train Control
MAC	Media Access Control
NMS	Network Management System
OTA	Over the Air
PTC	Positive Train Control
Remote	Generic term for locomotive and wayside radios
RF	Radio Frequency
SNMP	Small Network Management Protocol
SW	Software
TDMA	Time Division Multiple Access

1.6 References

[1] ITCC Radio Requirements Baseline, REQ-PTC-00001007-F, 3/18/2011.

[2] ITC 220 MHz Radio Hardware Specification, Product Release 1.0.

[3] ITC 220 MHz Radio System Architecture Specification, Product Release 1.0.

[4] ITCM 1.0 HRX Specifications, DCN: 00001043-C, v0.98.

2. Functional specification purpose and scope

This document specifies the functional details of the MCC ITC radios that are part of the 220 MHz Positive Train Control (PTC) system. Within that system there are three distinct 220 MHz radio types to which this specification applies. Based on their intended installation location, these radios are referred to as wayside, locomotive, and base. Unless explicitly stated otherwise, the specifications listed in this document apply to all three radio types.

The focus of this document is on radio functionality and usage. As such, the following are out of scope.

- 220 MHz Radio hardware specifications, RF performance, and mechanical packaging
- ITC system architecture, messaging protocol, and air interface
- ITC System Management and Configuration Management Approach, Wayside Systems, Onboard Systems, Back Office Systems, or wired network architecture

2.1 Document organization

This document is organized as follows:

- Overview and background
- Basic/essential radio elements
- Radio setup and maintenance mode
- Radio operational performance

3. Overview

3.1 220 MHz ITC radios

The 220 MHz PTC system uses three different radio types: wayside, locomotive, and base, each addressing different operational environments and RF link requirements. Due to the radios' architecture and design, these radios are commonly referred to as software defined radios (SDRs). The MCC ITC SDR radios employ one specific modulation schemes, π/4 DQPSK, and operate in the 220 MHz frequency band on narrowband 25 kHz channels. The radios implement the π/4 DQPSK modulation with two different symbol rates, 8 ksymbols/s and 16 ksymbols/s, utilizing the same 25 kHz channel. These characteristics are summarized in Table 1. Details of the electrical, mechanical, and RF specifications for these radios can be found in reference [2].

Table 1: Basic characteristics of ITC 220 MHz radios

	Wayside Radio	**Locomotive Radio**	**Base Radio**
Application	Fixed remote installations	Mobile remote installations	Base station installations
Frequency Band	217.6 - 222.0 MHz	217.6 - 222.0 MHz	217.6 - 222.0 MHz
TX Modulation	π/4DQPSK, 16kbps	π/4DQPSK, 16kbps π/4DQPSK, 32kbps	π/4DQPSK, 16kbps π/4DQPSK, 32kbps
RX Modulation	π/4DQPSK, 16kbps π/4DQPSK, 32kbps	π/4DQPSK, 16kbps π/4DQPSK, 32kbps	π/4DQPSK, 16kbps π/4DQPSK, 32kbps
Channel Spacing	25kHz	25kHz	25kHz

Top-level block diagrams of the locomotive, base, and wayside radios are shown in Figure 2, Figure 3, and Figure 4 respectively. The radios can simultaneously transmit only on a single frequency channel, but are capable of multichannel operation on receive. The number of receive channels for each radio type is summarized in Table 2. The interfaces to these radios include Ethernet data ports, GPS antenna, and RF transmit and receive connectors, a summary of which is given in Table 3.

Table 2: Receive channel summary

Radio Type	**Primary Receive Channels**	**Diversity Receive Channels**
Wayside	2	0
Locomotive	8	8
Base	8	8

Table 3: External interface summary

Radio Type	Ethernet Ports	GPS Antenna Inputs	Separate RX Connectors	Combination TX/RX Connectors
Wayside	2	1	0	1
Locomotive	2	0	1	1
Base	2	1	2	1

Figure 2 Locomotive radio block diagram

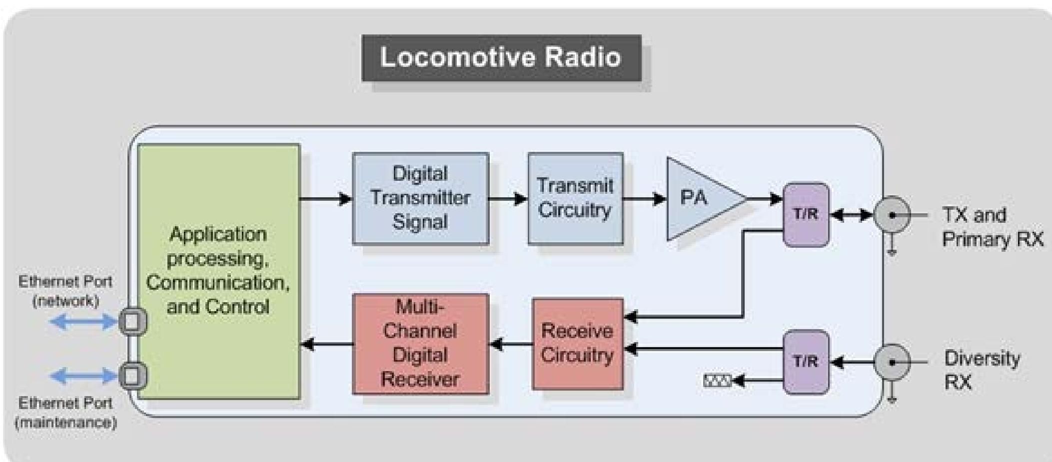
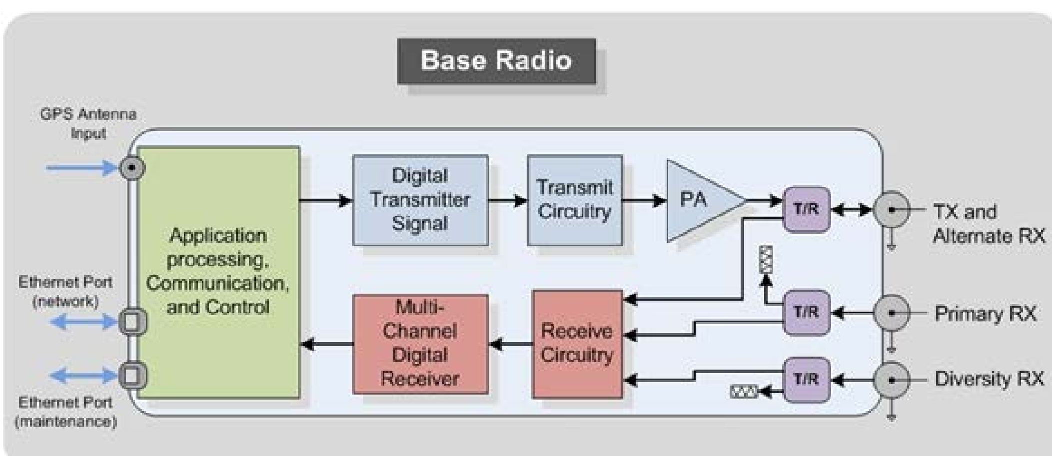
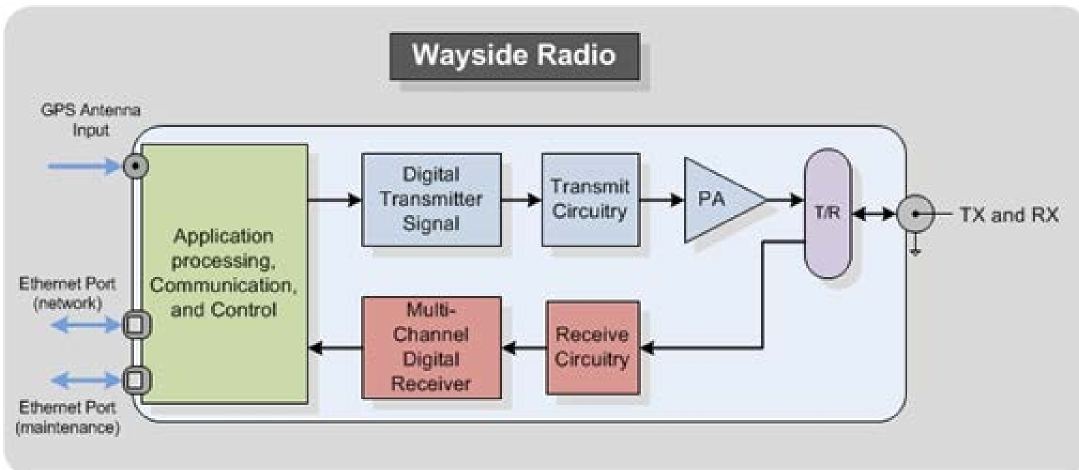


Figure 3: Base radio block diagram



The three base radio antenna connectors provide flexibility at base installations by allowing separate transmit and receive antennas, including diversity, to be used if desired. Diversity reception is supported only by radio hardware, and required radio software implementation will be part of future software releases.

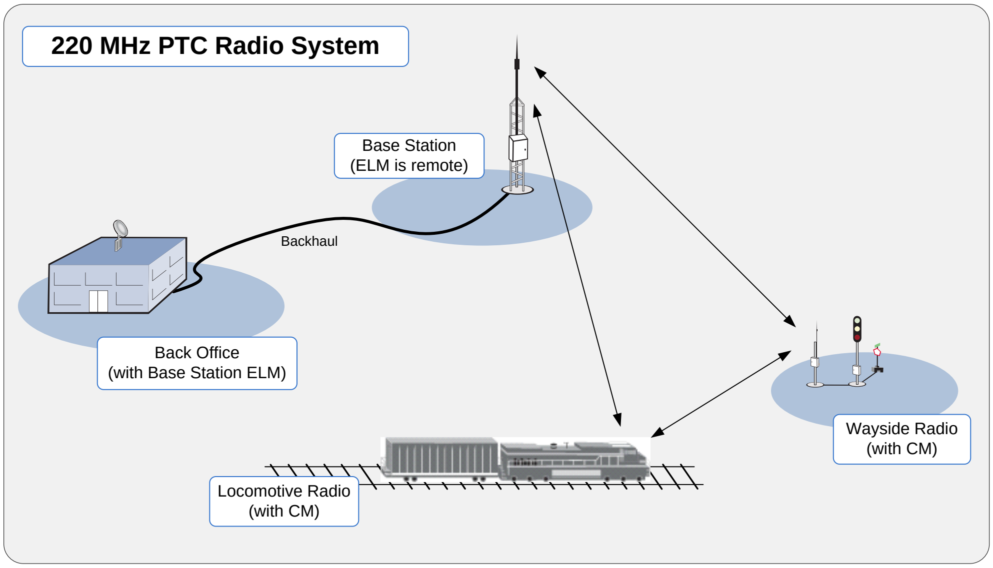
Figure 4: Wayside radio block diagram



3.2 220 MHz PTC system overview

A system overview diagram of the 220 MHz PTC RF communication system is shown in Figure 5. Each radio communicates with the ITC network through External Link Manager (ELM) or Connection Manager (CM). Both ELMs and CMs reside on a processor platform outside of the radio. For the locomotive and wayside radios the CM runs on a local platform such as a WIU. For base radios the ELM resides on a server in the back office (BO).

Figure 5: Top level ITC radio system diagram



The radios communicate over the air in half duplex (or TDD) mode using an MCC proprietary air interface known as ITCnet. This air interface is a combination of FDMA, TDMA, and CSMA. More detailed information about ITCnet can be found in reference [3].

3.2.1 External link manager

The 220 MHz Radio External link manager (ELM) or Connection manager (CM) provides an interface or bridge between an ITC radio and the rest of the ITC system. ITC 220 MHz radios always connect to an ELM or a CM through an Ethernet connection and use an MCC proprietary protocol called HRX. A brief description of the HRX protocol is included in reference [3].

The ELM and the CM have three primary functions:

- Protocol Translation – Provide a messaging bridge between the ITC Messaging protocol and the ITC 220 MHz radio wireline protocol.
- Routing - Route messages that are incoming from other ITC Messaging components to ITC 220 MHz radios.
- Mobility - When a mobile remote moves from one base to another base, update routing tables as necessary for the new message path and flush the old path.

3.2.2 Base radios

Base radios are installed at fixed locations and provide RF connectivity between BO applications and locomotives and between the BO and waysides. The backhaul between the base radio and the BO is typically a broadband landline, but may also be accomplished with point-to-point microwave, fiber, or 4-wire circuit land line.

Base radio sites, TX power levels, and antenna characteristics are designed to provide radio coverage to all waysides and operational locomotives in the system. Though this is typically the case, there are some areas where base coverage of a wayside, locomotive, or both cannot be guaranteed.

3.2.3 Wayside radios

Wayside radios are remote, fixed location radios installed at waysides. These radios provide wayside equipment status information to the BO and to locomotives. Some waysides, but not all, have access to the BO through a broadband connection.

All wayside radios interface to the wayside equipment through a wayside interface unit (WIU). The WIU provides a layer of abstraction between the various types of wayside equipment interfaces and the wayside radio. Communication between a wayside radio and the WIU is via Ethernet using the radio's network port.

Wayside radios send wayside status messages to nearby locomotives and respond to status queries from locomotives. Wayside radios may also communicate with the BO through a base radio for administrative purposes such as software or configuration updates or other system management purposes.

3.2.4 Locomotive radios

Locomotive radios are installed in the cab of locomotives and are the mobile radio element of the 220 MHz PTC system. For normal operation within the PTC system, a locomotive communicates with the BO through a base radio over a 220 MHz RF link. To establish this link a locomotive radio registers with a base radio. As long as the locomotive is within the base radio's coverage area, the locomotive will continue to communicate with the BO through that base.

As a locomotive moves along the track it moves out of the RF coverage of one base and into the RF coverage of another. When this happens the locomotive registers with the new base. As much as possible, the system is designed with overlapping base coverage along the tracks. Under this condition, as the locomotive moves down the track, the locomotive radio must decide when to drop communication with one base and register with the next. This decision is based on a number of criteria and is discussed in more detail later in the document.

Locomotive radios also communicate waysides and must do so even when there is no base coverage. This may arise due to a failure at the base radio site or simply that providing base coverage to a particular section of track is impractical.

4. Physical network connections

There are two Ethernet ports on each radio: a network port and a maintenance port. These ports support both 10BaseT and 100BaseT operations. A unique 48-bit MAC address is assigned to each interface at the time of radio manufacture. When another Ethernet device or network is connected to one of these ports, the physical connection status is detected automatically and the link parameters are auto-negotiated.

The radio reports the status and statistics of both Ethernet ports when queried. The statistics contain: link state (connected/not connected), link speed & duplex state, and transmitted and received bytes.

4.1 Network port

The network port provides the physical connection between an ELM and an ITC radio. This may be as part of the local network, such as in a locomotive cab or in a wayside bungalow, or a connection to a wide area network such as between the base and the BO. All 220 MHz communication traffic flows by default through the network port. The network port can be configured to be using either static IP addresses or DHCP. The network port can also be used as a maintenance port as described in the following section.

4.2 Maintenance Port

The maintenance port provides local access to the radio. This is used for monitoring radio activity, performing maintenance, firmware updates, and diagnostic testing. In addition, for external logging of radio data and message traffic, the logging device such as a laptop computer connects to the radio via the maintenance port. The maintenance port is configured to have a built in DHCP server by default. The maintenance port can also operate as a network port as described in the previous section if configured to do so.

4.3 DHCP and IP Address Assignment

The dynamic host control protocol (DHCP) automates the dynamic assignment of network parameters for devices in an IP network. Each of the two Ethernet ports in an ITC radio can be configured to operate as a DHCP client or as a DHCP server.

4.3.1 DHCP Client

When an ITC radio that has an Ethernet port configured as a DHCP client is connected to a network, the radio attempts to obtain a network configuration for that port by broadcasting a query to an accessible DHCP server. The DHCP server responds by assigning an IP address and other IP configuration parameters to that port.

4.3.2 DHCP Server

For an ITC radio Ethernet port configured as a DHCP Server, if another network device is connected to that port on the radio, the radio assigns an IP address and other parameters to the device. The radio Ethernet port itself must have a static IP address when it operates in DHCP server mode.

4.3.3 Static IP Address

In lieu of using DHCP, either or both Ethernets ports can be configured to use a static IP address.

4.3.4 Default Configuration

The default IP configuration in the ITC radio software is as follows:

Network Port (E2): DHCP disabled, Static IP, 10.10.2.254, Netmask: 255.255.255.0

Maintenance Port (E1): DHCP disabled,Static IP, 10.10.1.254, Netmask: 255.255.255.0

5. User Interface

5.1 Front Panel LEDs

Front panel LED indicators provide general information on the operational status of the radio. The function of each LED is described in Table 4.

Table 4: Front panel LED functionality

LED[1]	Description[2]	Color
Power	Constant illumination indicates normal radio operation.	GREEN
Fault[3]	When illuminated, it indicates a variety of fault conditions[4] not indicated by other LEDs	RED
Transmit	Illuminated when the radio is keyed.	RED
Receive	Illuminated when the radio is receiving a valid 220 MHz PTC signal.	AMBER
VSWR[3]	Illuminated when the VSWR of the TX port exceeds approximately 3:1. Illuminated if the TX forward power is not within 25% of the RF output power setting.	RED
Standby	When illuminated, the radio is in standby mode and the TX is disabled.	RED
RF Link	Refers to RF Link. Illuminated when an RF link has been established between two radios.	AMBER
Data Terminal Link (DTL)	Illuminated when the radio has a connection to an ELM through the Ethernet network port.	AMBER

[1] If for any reason the radio is reset, LED status is not preserved

[2] During certain operations such as power up initialization and firmware upgrades, special blink sequences indicate progress.

[3]

[4] Faults indicated by the fault LED:

- One or more internal radio supply voltages is below minimum thresholds
- The external DC voltage to the radio is outside of the acceptable range
- One or more of the radios internal sensors is indicating a temperature exceeding the allowable threshold
- The radio failed one or more self tests during boot up
- TX forward power is not within 25% of the RF output power setting
- Base or wayside radio does not have a GPS fix
- CIM not present or it has invalid or corrupt data

5.2 Radio access

It is possible to initiate actions including configuration changes and retrieve status information through either the maintenance port or the network port. TCP servers on these ports accept connections. In addition the radio may be accessed via remote command over the RF network.

5.2.1 User Authorization

If password protection has been enabled, the radio configuration and some specific radio commands are password protected. A maintenance password entry initiates a login session that has user privileges for radio configuration change. Alternatively, a superuser login session, which requires another password, is required for specific radio commands.

The session will remain active as long as there is activity on the access port. The session terminates when the user explicitly logs out or after a period of 10 minutes of inactivity. For security, passwords are not echoed on entry and are not displayed in any status report. Any command that affects radio configuration will be rejected if the user is not logged in. Many status queries do not require either type login.

The same conditions apply to remote commands received over the RF network.

5.3 Network and Maintenance Port Interface

5.3.1 Accessing

A TCP/IP session can be initiated from any address capable of reaching the radio ports IP address. A proprietary terminal software, XtermW, is available to make this connection.

5.3.2 Command Line Interface

The command line interface allows entry of commands to initiate actions, configure parameters, and retrieve status information. Commands consist of a command name, optionally followed by parameters separated by commas. Command entries, along with any response, are echoed to the console. Passwords however are masked. Users who enter commands which require a password are given an access error message if they are not logged in. The HELP command is provided to give concise descriptions of the syntax and use of all user commands.

Table 5 below contains a sampling of the supported commands with brief descriptions:

Table 5: Common commands

Command	Description
ASSIGN	Query or configure assignment of tasks to ports
BOOT	Restart the radio
CHANNEL	Query or configure channel table
CONFIG	Display basic parameters of radio
FACTORY	Restore factory default settings
HELP	Provide command list or help on a specific command
IPCONFIG	Query or configure IP settings
LINKSTAT	Query RF network link statistics
LOGON	Initiate password protected command session
LOGOFF	Exit command session
MESSAGE	Compose and send a text message
PING	Test IP connectivity
REMCMD	Send a command to a different radio and display response
REV	Display software revision information
SAVE	Save modified configuration data in nonvolatile memory
STAT	Display basic radio status information

6. GPS

There is an embedded GPS receiver module in the wayside and base radios. This module provides critical timing information to the radios needed for time slot synchronization and proper operation of the 220 MHz PTC air interface. As long as the GPS module has a lock on at least one satellite, the GPS module will continue to provide timing information to the radio. For operation with a single satellite, the radio must know its surveyed position with 300 meters or better accuracy. This implies that only stationary units can maintain timing with a single satellite.

The radio reports number of GPS satellites it has synchronized itself to when queried. The radio also reports its location and time when queried, independent of whether it has GPS module attached to it or not.

6.1 Loss of GPS Signal

If the GPS module loses all satellite lock the radio will lose GPS time synchronization. When this occurs, a wayside radio will continue to operate normally for a minimum of 5 minutes after loss of GPS time synch. Base radios have better accuracy oscillators that can maintain required synchronization up to an hour after GPS signal loss.

At the point where after GPS time sync loss the radio time synchronization has become too unreliable, periodical wayside status (FTDMA) transmissions need to be stopped. In case of a base radio, it also needs to cease all unicast (DTDMA) transmissions with its connected remotes. Wayside radios can retain base radio connections (DTDMA) even without accurate timing, and both base and wayside radios can continue with their CSMA transmissions. The radios indicate their impaired ability to transmit by illuminating the standby led indicator.

6.2 Real Time Clock

Each radio contains a real time clock (RTC). In the base and wayside radios the RTC is periodically set by time information from the on-board GPS module. Locomotive radios obtain time and date information from the local network, which in turn is used to periodically set the RTC.

If DC power to the radio is interrupted, the RTC will continue to maintain accurate time for at least 24 hours. This is accomplished using a large value capacitor to maintain the proper operating voltage on the RTC.

6.3 Locomotive Radio Position

Unlike base and wayside radios, locomotive radios will not have GPS. Locomotive radios obtain their position externally via Class C interface.

7. External Link Manager (ELM) and Connection Manager (CM)

The ITC Messaging system is a connectionless system through which interoperable applications, which may be operating in different local networks, communicate with. ELMs and CMs are end points that connect the messaging system to different data transport mechanisms, including the ITC 220 MHz radios. The 220 MHz radios interface with ELM/CM using HRX protocol (reference [4]).

The radio reports HRX connection status when queried.

8. Radio Boot Up

When power is applied or the radio is reset, an initialization process occurs. This includes some self-test functions, the initialization of various hardware modules, and loading of the operating system firmware and radio configuration. The LED indicators on the front panel show progress through this process. Normal radio operation does not commence until this process is complete. The radio stores and is able to tell the last time it was booted-up or rebooted.

The radio also maintains and increments a boot-up counter, which is able to maintain count how many times the radio has successfully booted-up. The value of this counter can be queried from the radio.

8.1 Radio Initialization Process

A summary of the radio initialization process is given in Table 6. If no configuration changes occurred, this process typically completes in less than a minute. If configuration changes were made, then the process can take several minutes and may require the radio to restart the initialization process.

Table 6: ITC radio initialization process

Process Step	Description
1	Main processor goes through boot and firmware is loaded into memory
2	Main processor initiates self test routines
3	The internal alert log is updated indicating a radio boot was initiated.
4	If any of the self tests fail, the alert log is updated accordingly and the front panel fault LED is illuminated.
5	If no faults were found during self test, a radio configuration check is made. If the configuration information stored on the CIM is different from what was used the last time the radio booted, a configuration update is initiated.
6	Once the boot process is complete, the radio checks to ensure that no over temperature conditions exist within the radio. If no over temperature conditions are detected, the TX is turned on and wayside and locomotive radios will attempt to register with a base station. If this is successful the RF Link (RFL) LED is illuminated on both the remote radio (wayside or locomotive) and the base.

8.2 Radio Startup Hold-off Time

ITC base radios have oven controlled oscillators that take time to warm up before reaching proper operating temperature and frequency stability. The worst case warm-up time is 30 seconds assuming ambient temperature of -40°C. The radio measures time elapsed since it was booted up, and inhibits all radio transmissions before 30 seconds have passed.

8.3 Self Test

Table 7 below summarizes the self tests that occur at radio startup. If possible, any self tests that fail generate an alert and cause the front panel fault LED to be illuminated.

Table 7: ITC radio self test

Test	Description
RAM	Dynamic RAM is tested for correct operation.
Image	The firmware image is checked for corruption. Failure at this point can result in automatic rollback.
CONFIG	The internally stored configuration parameters are checked for corruption. Failure at this point will cause the radio to restore a factory default state.
CIM	A test is performed to ensure that the CIM is present and can be read. Radio configuration is also checked to ensure that it matches the CIM.
DC Voltage	Voltage levels of all internal power supplies are tested to ensure they are within the allowable range.
Firmware Operation	A hardware watchdog timer ensures that the firmware is running properly. If the radio fails to start up properly it will reset within 45 seconds. Failure subsequent to startup will also cause a reset.

8.4 Triggering a Radio Reset

A radio reset and initialization can occur for multiple reasons. These are summarized in Table 8.

Table 8: Summary of radio initialization triggers

Reset	Description
Power Cycle	DC power to the radio is interrupted or initial radio power up
SW Initiated	A re-initialization of the radio can be triggered automatically by the SW: This may happen at the end of a radio initialization sequence

Reset	Description
	in which a configuration update occurred. The radio performs a SW update, and reboots to the new software. The radio SW identifies an operational issue that can be corrected by radio initialization.
HW Initiated	Special power supply management circuitry in the radio detects a low supply voltage condition and forces a reset. When this occurs the radio is held in a reset condition until the low voltage condition is no longer present. To avoid toggling the radio between reset and boot up, the radio is held in reset for 0.5 seconds after a return to normal supply voltage levels.
Manual	An operator or site engineer sends a command to the radio triggering a SW reset.

9. Radio Configuration Parameters

9.1 Configuration Information Module (CIM)

Each radio contains a configuration information module (CIM). This is a removable memory device in the form of an SD card. The CIM stores the following information.

- Site specific information
- Radio configuration data

9.1.1 CIM Signature

When the radio is configured from the CIM, a signature is computed and stored in nonvolatile memory in the radio. This signature is updated whenever the configuration parameters on the CIM are modified.

9.1.2 Configuration from CIM

When a radio is reset or is powered up, the radio compares the CIM signature stored in memory to the signature on the CIM. If the signatures differ, the radio is reconfigured from the configuration information stored in the CIM.

9.1.3 Radio Operation without Access to the CIM

In order for a radio to go online after power up, a CIM with valid configuration data must be installed in the radio.

Once the radio is operational, access to the CIM is not required. If access to a CIM becomes unavailable the radio will continue to operate normally. However, if the radio is power cycled, lack of access to a CIM will prevent the radio from coming on line.

9.2 Radio Configuration Parameters

Radio configuration parameter information is stored on the CIM. There are three separate configuration parameter files, only one of which is used at a time. The purpose of these files is summarized in Table 9.

Table 9: Summary of radio configuration file functions

File	Description
Current Configuration Parameter Settings	Current set of radio configuration parameter values used by the radio. This set of configuration parameter values is copied into radio memory at the time of boot up.
Rollback Configuration parameter Settings	Backup set of configuration values. These values are used if a rollback to a previous version of the radio configuration is desired.
Factory Default	Set of configuration values that are set at the time of radio manufacture. These values are locked and cannot be altered.

9.3 Configurable Parameters

Parameters are considered configurable if they can be explicitly changed by a command or loaded from a file, they can be saved permanently, and they affect radio operation.

9.3.1 Configurable Parameter Overview

Some of the more fundamental configurable parameters are described briefly below:

9.3.1.1 Identification

Several configuration parameters identify the individual radio including the radio ID, customer ID, site name, and serial number.

9.3.1.2 Basic RF Configuration

The RF operation of the radio is configurable. ITC channel numbers, which are used in frequency channel configuration, are pre-defined in the radio. The transmit power is also configurable. Various network parameters or parameters that control the selection of base stations are configurable.

9.3.1.3 I/O Configuration

In addition the network parameters of Ethernet connections are configurable including IP address, subnet mask, default router, and DHCP configuration.

9.3.1.4 Security Features

The selection of which parameters are locked and the use of passwords are configurable.

9.3.1.5 Time

The time and date may be adjusted. Time and date are maintained by an internal clock. The time zone is also configurable to be used as an offset to between the internal time and the time displayed. Also the method used to maintain synchronization is configurable. For example time can rely on the internal clock only or time can be synchronized to a base station or a GPS receiver.

9.3.1.6 *Diagnostic Information*

The types of diagnostic information generated, the level of detail, and where it is stored or routed is all configurable.

9.4 Security Features

9.4.1 Locked Parameters

Certain critical parameters can be locked. This is done by setting the corresponding lock parameter in the configuration file. As long as they remain locked, locked parameters cannot be changed. Also, locked parameters are not restored to a default state either by configuration or firmware updates or by explicit request.

9.4.2 Password Protection

Password protection can be enabled for maintenance functions. .If password protection is enabled, radio configuration changing functions are unavailable without user login.

9.5 Detailed Configurable Parameter List

The configurable radio parameters are described in Table 10 and Table 11.

Table 10 includes the parameters required by an ITC 220 MHz radio that are most likely to be of interest to users and maintainers. Table 11 includes the parameters which generally use default values and are the same for most or all of the radios within the network.

Table 10: Common ITC configurable parameters

Name	Descriptive Notes
	BASIC ITC NETWORK CONFIGURATION RELATED
Radio ID	The radio ID is a 24-bit number (2-16777215) used to uniquely identify radios within an ITC network for the purposes of routing. Each radio within a network must be assigned a unique radio ID. Changing this id will cause the radio to restart.
Site Name	The site name is a text string of up to 32 characters used to identify the site at which the radio is installed. This parameter is for use by customer applications. If used it is recommended that unique names be used.
Customer ID	The customer ID is an integer value (1-65535) used to identify the customer network in which the radio is operating. This parameter is for use by customer applications.
TX RF Power Level	The RF transmit power is settable up to maximum capability of the radio. Most radios will be set the same as other radios of the same type but adjustments can be made for special conditions to limit range or interference or reduce power consumption.
RF Channel Parameters	The channel table provides an association between channel numbers and channel attributes including receive frequency, and transmit frequency. Radios within a network should use consistent channel tables and to that end commonly used channels will be predefined.
Common Channel Frequency	The channel number of the common channel used to advertise base station availability and for certain peer-to-peer CSMA message traffic.
Base TX Frequency	The channel number of the primary transmit channel for a base For a remote this channel may change if a different base is selected but this must be configured for a base.
Fixed Time Slot Channel Number	The channel number of the channel on which messages are sent in fixed time slots. Generally fixed times slots are used for wayside status data. Radios that do not have fixed slots configured (most non-wayside radios) do not require this channel to be configured.

Name	Descriptive Notes
Common Base Beacon Interval	Base stations periodically transmit a common base probe to advertise their presence on the common channel. The nominal interval between probes is configurable in seconds.
Local Base Beacon Active/Inactive	If enabled by this parameter, base stations transmit a base beacon packet to advertise their presence on the local channel.
Local Base Beacon Interval	The minimum interval between base beacons transmitted on the local channel by a base station
Remote Radio Heartbeat Interval	If they do not have regular traffic, remotes maintain connectivity with base stations by transmitting check in packets at a configurable interval.
TX Duty Cycle	To enforce fairness in the system, to protect radio hardware, and to tune system performance the radio implement duty cycle limits.
Define Superframe Structure	Allows configuration of TDMA superframes. The configuration controls the overall superframe parameters of length and offset (timing relative to time of day). Base stations must also be configured to control the period, offset, and length of dynamic TDMA frames (the portion of the superframe organized by the base station) assigned to them. Stations with fixed TDMA slot assignments (generally waysides) maintain these slot assignments (length, offset, Tx frequency channel, and wayside device ID) in this structure.
	BASE SELECTION
Set Base Selection Algorithm	Several parameters control the behavior of the base selection algorithm. The algorithm used is determined by this parameter.
Set Link Quality	Minimum allowable link quality criteria for searching for a new base. This includes multiple parameters such as RSSI, message ACK ratio, and packet count.
Maximum Data Congestion	Maximum allowed congestion level criteria for searching for a new base.
Base Hold Off Time	A base that has been dropped cannot be reselected for a time out determined by hold-off.
List of Allowed Base	List of allowed bases a remote radio can connect to.

Name	Descriptive Notes
IDs	
Maximum Base Distance	Distance to a base, beyond which a remote excludes the base from consideration
	PORT RELATED
Ethernet Port 1 IP Address	Eth-1 (network data port) IP static address string. If DHCP client is enabled, this will auto configure.
Ethernet Port 2 IP Address	Eth-2 (maintenance port) IP static address string. If DHCP client is enabled, this will auto configure.
Gateway IP Address	Gateway IP static address string. If DHCP client is enabled, this may auto configure.
Subnet Mask	IP subnet masks for each physical Ethernet port. IF DHCP client is enabled, these will auto configure.
Gateway Mode	IP gateway mode determines whether the gateway address is configured statically (or dynamically)
Enable/Disable DHCP Client	DHCP enable flags control the use of DHCP clients on each port. The DHCP client allows the port to be configured by an external server.
Enable/Disable NAT	NAT/NAPT enable flags control the use of network address translation.
Setup NAT Operation	NAT/NAPT configuration data structure controls the operation of NAT/NAPT if used.
Enable/Disable DHCP Server	A DHCP server may be enabled individually on the Ethernet ports. Only IP address, mask, and gateway are provided. Configurable parameters are provided to control the operation of the server including the range of addresses provided and the lease and renew times.
DHCP Server Setup	

Name	Descriptive Notes
Data Stream Configuration	Configuration data for each of the active wireline data streams. The configuration includes role (typically TCP server), TCP port numbers, application protocol in use, and input time out. By default, a data connection compatible with an ELM and a connection to a maintenance utility will be enabled. Note that it is possible to have multiple data streams on a single physical port.
	TIME AND POSITION RELATED
Enable/Disable Ignore GPS Position Reporting	Radio may be configured to override GPS position with manually entered position In this case the GPS is used only for timing. While ITC applications may not require GPS position anyway, the GPS may be able to obtain timing with fewer satellites if it has a known fixed position.
Latitude	Manually entered latitude
Longitude	Manually entered longitude
Altitude	Manually entered altitude
	SECURITY RELATED
Enable/Disable Password Required	Maintenance session requires password
Set Password	Maintenance session password

Table 11: Infrequently changed radio configuration parameters

Name	Descriptive Notes
	BASIC ITC NETWORK CONFIGURATION RELATED
Radio Device Type	The device type (BASE or REMOTE) is normally set at the factory. Wayside and locomotive radio models default to REMOTE and base stations default to BASE. There may be some special circumstances that could require a radio to function in a non-default role. Changing the device type will cause the radio to restart.
Lock Radio ID	Locks Radio ID.
Lock Site Name	Locks site name.

Name	Descriptive Notes
Lock Customer ID	Locks customer id, serial number, DSP, FPGA, subnet, and RF power.
Lock Frequency Table	Locks channel table
Lock Current Channels	Locks currently selected channels
Enable/Disable Automatic Channel Configuration	Multichannel mode (fixed or auto). ITC radios have multiple receivers. Each receiver may be tuned to a fixed channel or the channel may be automatically configured as different channels are required (for example when changing base stations).
Receiver to be Automatically Configured	Receiver to apply auto channel configuration to
Setup Fixed Receive Frequencies	Receiver channel assignments for fixed receivers
Enable/Disable Time of Day Broadcasts	Time of day probe mode generally broadcast by base stations
Base ID Range	Reserved base ID range
Set Default Time-to-Live for Messages	The default time that a message is maintained in the radio waiting for acknowledgement (time to live).. This time is applied to Layer 3 radio to radio messages.
Base beacon count	The number of base beacons that must be received from a base station before it is declared up (added to the neighbor list).
Neighbor Timeout	A neighbor is declared down if it has not been heard from for a configured time.
Remote Radio Timeout	If no communication is received from a remote radio, including responses to check-in requests, for this configured timeout, the remote connection is considered down.
Duplicate Filtering Timeout	History file time out (for duplicate packet filtering).

Name	Descriptive Notes
CSMA Slot Allocation	CSMA slot maximum count controls the maximum amount allocated to random access slots in a base stations dynamic TDMA frame.
CSMA Minimum Slot Allocation	The cycle count between CSMA access slots determines the minimum amount allocated to random access slots in a base stations dynamic TDMA frames.
	PORT RELATED
Enable/Disable Ethernet Auto-Configure	10/100 BaseT select. Normally set to auto configure.
Set Host Mode	Behavior on loss of host connection
Host Timeout	Host connection timeout
	TIME AND POSITION RELATED
Enable/Disable GPS Time Synch	It is envisioned that base and wayside radios in the ITC network will synchronize to GPS. However this may be impractical in some instances and in situations where GPS is lost it may be necessary to specify alternate backup methods. Locomotive radios will typically synchronize to the time obtained from the Class C interface or to time of day packets transmitted by base stations.
Time Synch Source List	List of base stations that are allowable sources for a time sync
UTC Offset	UTC offset applied to GPS time
TOD Offset	Local time offset applied to TOD probes from GPS time
	SECURITY RELATED
Enable/Disable Shortened Commands	Disallow shortened commands

9.6 Configuration Parameter Updates

Radio configuration parameter changes can be accomplished either by loading in a new configuration file onto the radio or by manually making changes to individual parameters. When done manually, corresponding configuration changes need to be saved to the configuration file in the CIM. Otherwise, if the radio is reset or power cycled, those changes are lost.

9.6.1 Configuration Files

Radio configuration parameters are stored in a configuration file that resides in the CIM.

A configuration file can be loaded into the radio via the maintenance port, over the air via the 220 MHz RF link from a base radio to a remote radio using remote commands, or remotely via a broadband network connection if available.

9.6.2 User Authentication

Making changes manually to configuration parameters or loading a new configuration file on a radio requires a password.

9.6.3 Activating a New Configuration

A new configuration can be activated manually or scheduled for activation at a future time if combined with scheduled firmware update.

9.6.4 Configuration Parameter File Rollback

If desired, the radio configuration can be rolled back to the previous configuration. This can is done manually by entering a command.

9.6.5 Configuration Parameter Factory Reset

The radio configuration can be reset to the factory default settings. Doing so also resets the password.

10. SW Update

To accommodate system enhancements and modifications it is possible to load new radio software. The file that is installed on the radio in this process is called a firmware image. Firmware images can be upgraded with specific file downloads to the radio.

10.1 Firmware Image Download

Firmware image download into the radio can be done locally via the maintenance port, or remotely via a broadband network connection, if available. Once downloaded, the firmware image is validated to insure data integrity.

10.2 Firmware Image Rollover

Firmware installation can be invoked immediately after download, scheduled for an automatic rollover at some future time, or performed manually. Normal radio operation is suspended during the firmware download and upgrade process.

10.3 Firmware Image Rollback

There is sufficient memory to store multiple firmware images in the radio. In the event that the firmware update and installation process does not complete or a failure is detected during the process, the radio will automatically roll back to the previous software version. Repeated resets on the first time new firmware runs will also cause automatic rollback. Additionally, a manual rollback can be invoked.

Separate events will be recorded when a firmware image rollback is initiated, and when the rollback has completed successfully. The radio will generate an alert if the attempted rollback is detected not having been successful.

10.4 Factory Default Firmware

The radio software allows one to have up to four different firmware images stored in the non-volatile memory. The radio is supplied with a firmware image, which will occupy one of the storage locations. This original firmware image could be considered to be the factory default firmware.

When radio firmware images are upgraded, it can be done manually in such a way that this factory default firmware is preserved and will not be overwritten. Following this assumption, the radio will automatically rollback to this factory default firmware, in case it detects a problem with all other firmware images it carries and has been upgraded to. If the factory default firmware has been preserved, one can rollover to it with a manual command in the same way one can rollover to any other firmware image.

The radio handles this factory default firmware similarly to any other firmware image. There are not any specific factory default firmware related operations implemented in the radio software, nor there is any protection that preserves the original firmware image during firmware upgrades.

11. Radio Tests

Forward and reflected power and DC supply voltage are measured on every transmission. A command is provided to do a test transmission to provide fresh measurements. The radio reports forward and reflected powers and VSWR when queried.

When a bad transmitter condition prevails, such as when forward power is less than 75% of set transmit power or measured VSWR exceeds 3:1, the radio will generate an alert and illuminate the VSWR light.

11.1 Message Based Testing

From the maintenance port it is possible to compose, route, and transmit text messages or remote commands to one or more radios identified by radio ID. If the radio’s own ID is included as a destination, the message or remote command will be looped back but no RF transmission will be involved

11.1.1 Radio-Radio Loopback Test

If a remote command is received the radio will act on the command and route any response output back to the sender.

11.2 Test Commands

Table 12 describes some of the basic test commands available.

Table 12: ITC radio self test

Command	Description
REV	Displays firmware revision data
MEM	Displays memory usage
STAT	Displays the most commonly used status information including transmit forward and reflected power, supply voltage, receiver noise floor, basic packet statistics, run time and number of resets
LINKSTAT	Displays information on active RF links including radio IDs, basic link statistics, and received signal level
TXTEST	Sends a test transmission (keys the radio) and displays status including forward and reflected power and supply voltage.
REMCMD	Sends a command to a specified radio and displays the response
MESSAGE	Sends a text message to a specified radio.
IPCONFIG	Displays status of Ethernet connections
PING	Sends an echo request to an IP address and displays response status
TRACERT	Sends echo requests to an IP address and displays the route taken by the echo reply.
BOOT	Perform hardware reset.

11.3 RF Performance Test

The following RF performance tests are supported. Multiple commands may be required to setup and complete each test.

Table 13: RF performance tests

Parameter	Description
VSWR	The forward and reflected transmit power are measured internally to the radio. These values are used to compute

Parameter	Description
	a VSWR value.
Frequency Accuracy	Frequency accuracy is measured by setting the radio to output an unmodulated carrier on the TX port. Using an appropriate piece of external test equipment the frequency accuracy of the radio can be measured.
BER	A BER test of the radio receiver can be performed using an external signal generator. In order for the radio under test to lock onto the test signal, the signal generator must be programmed with the appropriate data sequence.

12. Special Operational Modes

12.1 Transmitter Limiting

The radio can inhibit all transmissions to protect the radio from damage, prevent network congestion, or ensure that regulatory requirements are met. Consequently, transmitter limiting is provided to limit the duty cycle and duration of each transmission. The transmitter is also inhibited when the temperature exceeds a threshold or the supply voltage is out of acceptable range.

12.1.1 Transmitter Key Timeout

Included in the transmitter limiting functionality is "stuck transmitter" timer that automatically un-keys the radio if a time limit is exceeded. This is implemented in the radio HW such that if necessary the transmitter will turn off independent of the radio SW.

12.2 Operation during Locomotive Crank

During locomotive crank, if the external DC supply to the radio drops below an acceptable threshold, the radio will reset.

12.3 Base radio Chassis Fan

For the base radio, a chassis fan may be used for additional forced air cooling. The fan engages when the measured temperature exceeds a configurable threshold. Base station fans are field replaceable.

12.3.1 Extreme Temperature Operation

If the temperature in the PA exceeds a critical threshold the transmitter is disabled. Once the transmitter has been disabled, there is built-in hysteresis to keep the transmitter disabled for a safety period before the radio re-enables the transmitter.

12.4 Standby Mode

The radio can be instructed to enter and exit a standby mode, during which all radio transmissions, excluding some test mode transmissions, are inhibited. Other than to transmit, the radio is able to receive and operate otherwise normally during standby.

While the radio is in standby mode, it has a special indicator LED on in its front panel. The standby status can be queried from the radio.

13. Remote Radio Base Selection

Along with other information, data contained in base beacon signals is used by remotes (i.e. locomotive and wayside radios) to select an appropriate base to associate with. Base beacon signals are broadcast in the common channel at the rate of 16 kbps. The information contained in the base beacon signal is listed in Table 14.

Table 14: Base beacon signal content

Parameter	Description
Base ID	Unique ID of the base radio sending the beacon
Base Location	Location coordinates of the base
Channel Numbers	RF frequency channel numbers of the base and six

Parameter	Description
	neighbor bases
Bit Rate	RF channel bit rate (i.e. either 16 kbps or 32 kbps)
Utilization	Parameter that denotes amount of available RF bandwidth in use

The remote radio tracks the received signal strength and the number of packets received of up to six nearby base beacon signals. In addition, for the base radio to which the remote radio is currently associated, the remote records the ratio of acknowledgements (ACKs) received to the packets transmitted. This is referred to as the A/T ratio and is an indicator of link quality. Each remote radio stores this information internally in a table, referred to as the base information table.

13.1 Base Selection Criteria

The data in the base information table and the selection criteria summarized in Table 15 are used by the remote radios to choose a base.

Base selection is based on calculated ranks for each candidate base. The final rank for each base is calculated as a product of five ranking functions that are based on distance, RSSI, base utilization, base hold-off time, and selected base preference.

The distance, RSSI, and base utilization ranking functions can produce values ranging from zero to one and can be configured as two-piece linear functions defined by three points: min, knee, max. Figure 6 shows examples of how these three ranking functions can be defined.

When the locomotive radio has moved away from a base and the base hold-off time for that base has not yet expired, its base hold-off rank is 0.01, which keeps the locomotive radio from moving back to it, but the base remains as a valid candidate in case it becomes the only choice. After the base hold-off time has expired, its base hold-off rank becomes 1.0.

The selected base preference rank has a value 1.0 for the currently selected base and a value 0.8 for all new base candidates.

In order to become a candidate for base selection, locomotive radio needs to first successfully receive a configurable number of base beacons from the candidate base.

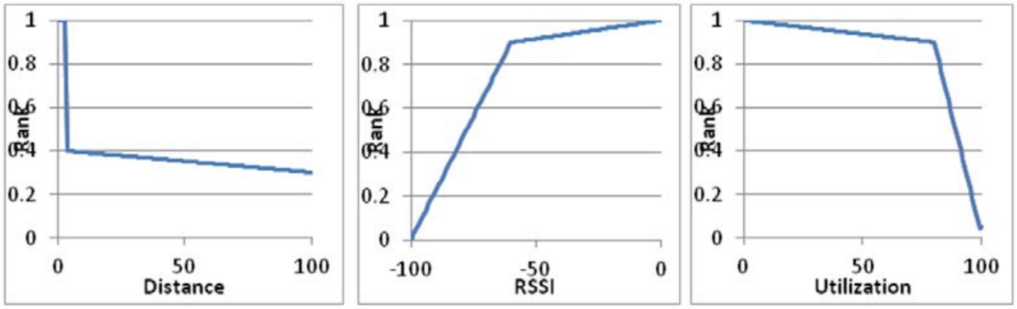
The A/T ratio of the current base controls how frequently the base reselection is considered.

A remote radio reports base stations it can hear with associated base selection criteria parameters when queried.

Table 15: Remote radio base selection criteria

Remote to Base Distance	Ranking function	Two-piece linear function defined by three points: Min, Knee, Max.
RSSI	Ranking function	Two-piece linear function defined by three points: Min, Knee, Max.
Utilization	Ranking function	Two-piece linear function defined by three points: Min, Knee, Max. Utilization rank = 1.0 for current base when its A/T > Ta
Selected Base Preference	Ranking function	Base preference rank = 1.0 for current base when its A/T > Ta Else, rank = 0.8
Base holdoff time	Ranking function	If time since connected to the base < Tb, rank = 0.01, Else, rank = 1.0 Base holdoff rank = 1.0 for current base Tb: Configurable threshold value.
A/T	Prefer to stay on current base if A/T > Ta.	Ta: Configurable threshold value.
Base Beacon Count	Ignore bases with a received base beacon count < Crx	Crx: Configurable threshold value

Figure 6: Examples of the configurable base selection ranking functions



13.2 Status after Base Selection is Complete

After a remote radio has selected a base, the configurations of the remote radio RF channels are as summarized in Table 16.

Table 16: Post base selection channel setup

RF Channel	Frequency	Bit Rate
RX1	Common frequency	16 kbps
RX2	Connected base frequency	16 and 32 kbps
Additional RX channels[5] (up to 6)	Listens to other base frequencies[6]	16 kbps
TX	Change to selected base channel	Wayside: 16 kbps Locomotive: per base beacon signal data

[5] Only applies to locomotive radios.

[6] These frequencies are included in the base beacon signal.

14. Data Logging and Radio Status

14.1 Logged Data

Radio activity can be logged and the level of detail is configurable. Data is logged to a device external to the radio via the maintenance port, streaming the log data to a maintenance terminal such as a laptop. Software in the maintenance terminal can be used to capture this data in a file.

Logged data may include:

- Commands received from the maintenance port and the corresponding responses to those commands
- Informational messages concerning radio activity including message traffic and air interface packet traffic
- Diagnostic information

The logged data is controlled by enabling various levels of traces on the radio maintenance port connection. The logging is done by the xTermW application.

14.2 Radio RF Link Quality and Status

The radio performs RF link and protocol level measurements and maintains the following statistics

- number of ITCnet messages sent and received (per radio link),
- number of unicast packets transmitted and received (per radio link),
- number of broadcast packets transmitted and received (per radio link),
- number of unicast packets not acknowledged (per radio link),
- number of segments sent and received (per radio link),
- number of segments that required forward error correction,
- number of segments that failed error correction, and
- RSSI (per radio link, measured during receiving packets).

The per radio link type measurement statistics are reset every time a radio link is started or when it is lost (and restarted). The radio reports a list of active radio links with these associated measurement statistics when queried.

14.3 Status and Diagnostic Functions

14.3.1 Configuration Status

It is possible to obtain the status of all configurable parameters through the maintenance connection except those parameters which have been specifically masked for security reasons (e.g. passwords). In addition, the radio can be queried for version information via the maintenance connection.

14.3.2 Health Monitoring

The radio monitors a number of key parameters. Some of these parameters include supply voltage, voltage under transmit load, RF power output, temperature, RF link connectivity, Ethernet link connectivity, and continuous processor operation. The radio reports the status of all these parameters when queried.

The radio tests the following power supply related voltages during power on self test

- 5 V regulated power,
- 3.3 V regulated power,
- 2.5 V regulated power,
- 1.8 V regulated power separately for ColdFire and DSP,
- 1.5 V regulated power,
- 1.2 V regulated power,
- Battery voltage input, and
- 74 V. (24 V, or 48 V) or 13.6 V input voltage (depending on whether the radio is locomotive, base, or wayside, respectively).

The input voltage is also continuously monitored to detect an under-voltage condition.

With regards to input voltage, the radio measures it during high load situations such as when the radio is transmitting. The radio inhibits radio transmissions in case the input voltage drops below certain thresholds in Table 17.

Table 17: Input voltage detection thresholds

Input voltage (Locomotive)	Input voltage (Base, assuming 24 V operation)	Input voltage (Wayside)	Resulting status/action
< 45 V	< 21 V	< 10.9 V	Low voltage error, turn off radio transmissions
Between 45 V and 100 V	Between 21 V and 27 V	Between 10.9 V and 15.5 V	No action
> 100 V	> 27 V	> 15.5 V	Detected malfunction

The base radio monitors chassis fan and various temperature sensors inside the radio chassis. The radio also controls the chassis fans by turning them on and off.

The radio monitors PA temperature with one of its temperature sensors. If the PA temperature reaches a critical threshold, the radio inhibits all transmissions. The critical temperature condition is also indicated by illuminating front panel standby and fault LEDs.

Base radios have a configurable temperature threshold for fan control. In case the fan speed goes below a low threshold while it is turned on, the radio illuminates the fault led.

Nominally the fan speed and all temperature measurements can be queried from the radio.

Service related data such as the time since last reset is maintained. Some diagnostic functions are also available through the maintenance port on request. For example there are commands to reboot the radio, reset to default configuration, send test messages, or key the radio.

14.3.3 Statistics

The radio collects and retains statistics on RF link quality and throughput as well as Ethernet links. Statistics can be reset. Statistics can be retrieved via the maintenance connection.

14.4 Sniffer Mode

The sniffer mode is a specific operational mode that allows all air interface packet traffic on the common channel, and one user specified local channel, to be logged to an external device. While in the sniffer mode the radio ceases normal operation and the transmitter is disabled.

Sniffer mode can be invoked through the command line interface locally via the maintenance port and remotely via the data port.

15. Alerts and Events

A variety of conditions can trigger either an alert or an event.

Events can either indicate minor, non-critical error conditions or conditions that can help in debugging the system operation and status in case of a future error. Alerts indicate critical error conditions that are actionable and require system maintenance attention.

Alert conditions are reported to any connected maintenance terminal console. In many instances, an alert is also indicated by the condition of the front panel LEDs.

Table 18 presents a summary of alerts supported in the radio. Also indicated are the front panel LED conditions.

Table 18: Summary of radio alerts

Alert	LED Indicator	Console Report	Description
Power Supply	FAULT	Y	Indicates the DC voltage is outside the acceptable range.

Alert	LED Indicator	Console Report	Description
Temperature[7]	FAULT	Y	Indicates internal temperature exceeds allowable threshold.
VSWR	VSWR	Y	A VSWR greater than 3:1 has been detected.
Low Power	VSWR	Y	Transmit power is less than 75% of nominal power.
GPS[8]		Y	Indicates that the 1PPS signal is not present or that the GPS data stream is invalid or missing.
Failed Self Test	FAULT	Y	In many cases a radio that fails self test will be unable to send an alert.
Failed Firmware Upgrade		Y	Any rollback is reported.
Failed Configuration Update		Y	Any rollback is reported.
Reset		Y	Indicates radio has reset.
Lost connection with ELM	FAULT	Y	Any detected lost connection is reported as an alarm.
Locomotive radio not receiving external time or position updates		Y	Locomotive radio obtains time and position via Class C interface.

15.1 Alert Log

The alert log records the self test status report at the last radio boot-up. The alert log is stored in nonvolatile memory. The alert log can be accessed and downloaded from the radio locally via the maintenance port or remotely via the network port. The log is in ASCII text format.

[7] For the base radio, a chassis fan may be used, which turns on when the measured temperature exceeds a configurable threshold.

[8] This is not an alert condition if the radio is configured to ignore the GPS data.