ITC 220 MHz Radio Hardware Specifications

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Revision history

Revision	Date	Summary of Changes
0.1		First draft in new template.

Acronym	Term	Definition
AAR	Association of American Railroads	Industry association for North American rail industry. A major standards-generating body.
AREMA	American Railway Engineering and Maintenance-of-Way Association	Industry association for North American rail industry. A major standards-generating body.
BO	Back Office	The IT and infrastructure support services for an organization.
BR	Base Radio	Two-way data radio designed for use at fixed base station locations.
CIM	Configuration Interface Module	A removable device used primarily to store site-specific configuration information and log files. The CIM typically is associated with an installation location and can be transferred from one radio to another to maintain application continuity. The CIM is physically an SD flash memory card.
CRs	Change Requests	Changes are reviewed/approved by the Change Control Board

Acronym	Term	Definition
		(CCB)
DFS	Degradation From Standard	Maximum allowable degradation from the specification over environmental extreme referenced to standard environmental conditions.
DQPSK	Differential Quadrature Phase Shift Keying	A linear modulation waveform that relies on the difference between successive phases of a signal rather than the absolute phase position. The DQPSK modulation has 2 bits per symbol and the symbol rate of half the bit rate.
ELM	External Link Manager	A software application that is the bridge between the ITC Messaging System and the ITC 220MHz Network.
ETSI	European Telecommunications Standards Institute	Industry association for European Telecommunications Manufacturing industry. A major standards-generating body.
FCC	Federal Communications Commission	Wired and wireless communications regulating body of the United States.
IC	Industry Canada	Wired and wireless communications regulating body of Canada.
ITC	Interoperable Train Control	A communications-based method of controlling and monitoring train movement, permitting multiple Railroads to share track and facilities.

Acronym	Term	Definition
LR	Locomotive Radio	A two-way data radio designed for use on board locomotives.
LSI	Locomotive System Integration	Generally a standard interface for objects operating on a Locomotive LAN. For the purpose of this document, LSI refers to the packaging and mounting considerations for the device.
MCU	Modular Concept Unit	Units to express sizing of LRU width, hold-down hooks and rear hold-down holes relating to LSI-compliant package.
NMS	Network Management System	This is a combination of hardware and software used to monitor and administer a computer network or networks.
PEP	Peak Envelope Power	Term for expressing the power rating of a non-constant envelope transmitter, defined as the power measured at the instant of the highest crest of the modulation envelope.
pi4DQPSK	pi/4 Differential Quadrature Phase Shift Keying	A variation of DQPSK waveform with phase transitions rotated by 45 degrees.
PPS	Pulse per Second	
RF	Radio Frequency	
TIA	Telecommunications Industry Association	Industry association for North American Telecommunications Manufacturing industry. A

Acronym	Term	Definition
		major standards-generating body.
TX	Transmit	
VDC	Volts Direct Current	
VSWR	Voltage Standing Wave Ratio	The voltage standing wave ratio is a measure of how well a load is impedance-matched to a source.
WR	Wayside Radio	Two-way data radio designed for use at fixed wayside locations.

Table of Contents

Table of Figures

Table of Tables

1. Introduction

This document provides the hardware design specification for the 220 MHz data radios being produced for the Positive Train Control (PTC) system.

1.1 Purpose

This document prescribes the electrical, mechanical, and functional details for the MCC ITC radios that are part of the 220 MHz PTC system.

Based on their intended installation location, these radios are: Locomotive, Wayside, and Base radios. Included are specifications, mechanical descriptions, and environmental requirements for each radio design. Unless explicitly stated otherwise, the specifications listed in this document apply to all three radio types.

1.2 Scope

The scope of this set of specifications is based on version 2.1 of the ITCC Scope and Requirements document with the assumption that a set of change requests (CRs) will be approved. The version of the ITC Scope and Requirements document that reflects these assumed approved CRs can be found at reference [11]. The following are the CRs that we are assuming will be approved for the purposes of the specification documents.

Table 1 - Change Requests

ID	Title
31	Define "headroom"
32	Move train initialization to release 1
34	Move download of configuration to first release
35	Remove Linux processor
36	Delay high density Locomotive requirement
37	Delay web server maintenance interface
38	Delay internal logging
39	Delay reporting to a NMS
40	Delay additional scheduling algorithms

ID	Title
41	Delay spatial diversity software
43	Change WIU Status to be variable size
47	Include GPS in wayside radios
48	Make GPS antennas required at waysides
57	Remove ambiguity from throughput requirements
58	Change Locomotive voltage to 74VDC
59	Change Locomotive power connector
60	Move Fault Indicator

Because the focus of this document is on radio construction and performance, the following is out of scope:

- Functional specifications, including functionality that crosses the boundaries of individual system components, interactions and dependencies between the ITC 220 MHz system, and parts of the larger ITC system (for example, WIUs, onboard systems, ITC Messaging System components, and so on).
- 220 MHz radio functional specifications, including details of network connections, radio interfaces, boot processes, details of radio configuration and updates, maintenance, and so on.
- ITC system architecture (beyond the 220 MHz Network) including details of the ITC Messaging System, ITC System Management and Configuration Management Approach, Wayside Systems, Onboard Systems, Back Office Systems, or wired network architecture.

The topics listed above are addressed in companion product specification documents. This includes the ITC Radio Functional Product Specification [1] and ITC Radio System Architecture Specification [2].

1.3 Historical assumptions

The following assumptions 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.
- 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 is a single federated network shared across all participating railroads. This means that any railroad can have its remote assets connect with 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 have base stations that are shared among the railroads.
- FCC Waivers submitted for the 220 MHz ITC spectrum are approved for the existing spectrum and will be submitted for any new spectrum that is acquired.

1.4 References

[1] ITC 220MHz Radio Functional Specification

[2] 220MHz System Architecture Specification

[3] AAR Standard S-5702, *Manual of Standards and Recommended Practices – Railway Electronics*, version 5.0, 3/1/2005

[4] AAR Standard S-590, *Manual of Standards and Recommended Practices – Locomotives and Locomotive Interchange Equipment*, ver5.0, 12/1/2005

[5] ANSI/TIA-603-C-2004, *Land Mobile FM or PM Communications Equipment Measurement and Performance Standards*, revision C, 12/2004

[6] ETSI EN 300 113-1-1 v1.6.1 (2007), *Electromagnetic compatibility and Radio spectrum Matters (ERM); Land Mobile Service; Radio equipment intended for the transmission of data (and/or speech) using constant or non-constant envelope modulation and having an antenna connector; Part 1: Technical characteristics and methods of measurement*

[7] Code of Federal Regulations, Title 47, Part 90 (Private Land Mobile Radio Services), Subpart T – Regulations Governing Licensing and Use of Frequencies in the 220-222 MHz Band

[8] Industry Canada RSS-119, *Radio Standards Specification - Land Mobile and Fixed Radio Transmitters and Receivers, 27.41 to 960 MHz*, Issue 6, March 25, 2000

[9] Industry Canada SRSP-512, *Standard Radio System Plan -Technical Requirements for Land Mobile and Fixed Radio Services Operating in the Band 220-222 MHz*, Issue 1, April 2006

[10] MIL-STD-810E, *Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests*

[11] Scope and Requirements, *ITC Scope and Requirements – Prod Specs Version*, version 2.1, 12/10/2009

[12] 1.0 *220 MHz Radio Hardware Performance Test Procedures*

2. Component radios

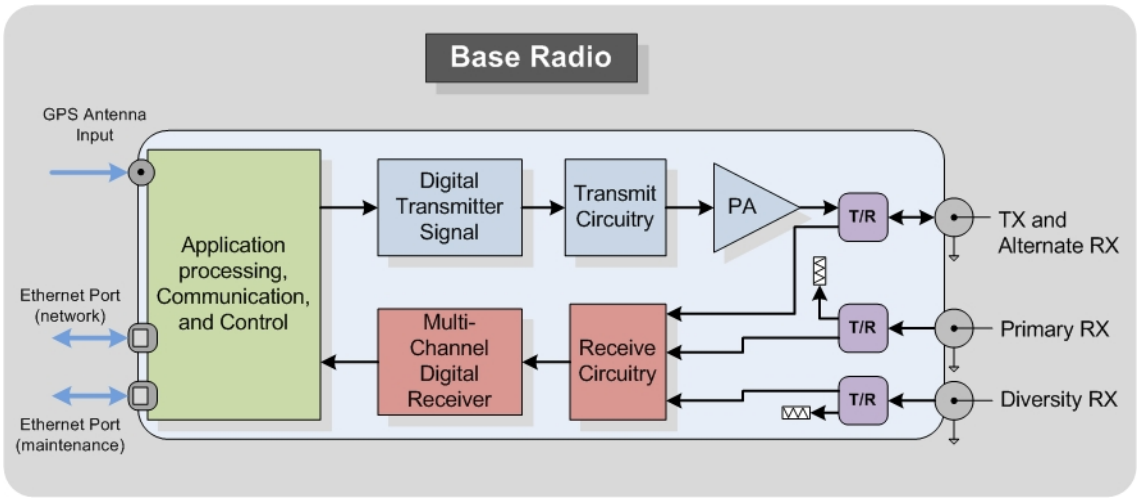
The following sections give a high-level overview of each of the three radios.

2.1 Base radio

Base radios are installed at fixed locations and provide RF connectivity between Back Office (BO) applications as well as applications running in remote areas (Locomotives and Waysides). The backhaul between the Base radio and the BO is typically a broadband connection, but may also be supported by microwave, fiber, four-wire circuit, or other types of communication links. The Base radios use Pulse per Second (PPS) signals from an onboard GPS timing chip for channel synchronization.

Base radio sites, TX power levels, and antenna characteristics are designed to provide radio coverage to all Wayside and Locomotive radios in the network. There are some areas where Base coverage of a Wayside, Locomotive, or both cannot be guaranteed.

Figure 1 - High-level Base radio block diagram



2.2 Locomotive radio

Locomotive radios are remote radios installed in the cab of locomotives and are the mobile radio elements of the ITC 220 MHz network. For normal operation within the system, a locomotive radio 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 Base radio is the best available for that Locomotive radio, the locomotive will continue to communicate with the BO through that Base.

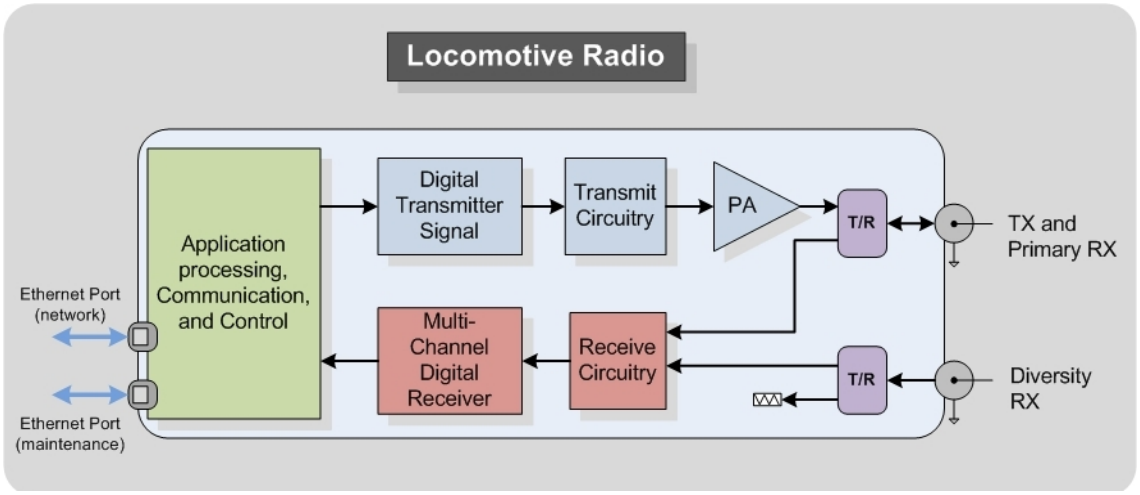
As a locomotive moves along the track, it moves out of the RF coverage of one Base and into the RF coverage of another. As this happens, the locomotive registers with the new Base. As much as possible, the system is designed with overlapping Base coverage along the tracks. Under this condition, as the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

Locomotive radios also communicate directly with Wayside radios and must do so even when there is no Base coverage. If there is no Base coverage due to a failure at the Base radio site or simply because providing Base

coverage to a particular section of track is cost prohibitive, then the Locomotive radios communicate with Wayside radios.

The Locomotive radios do not have onboard GPS like the Base and Wayside radios. Rather, the Locomotive radios are controlled by the Base radio for channel synchronization.

Figure 2 - High-level Locomotive radio block diagram

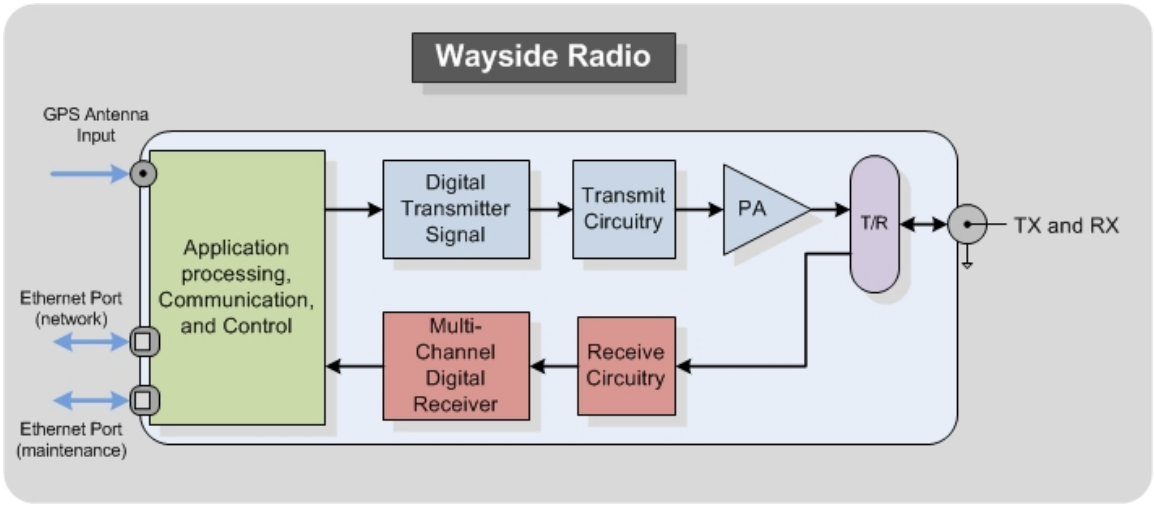


2.3 Wayside radio

Wayside radios are remote, fixed-location radios that are installed at waysides. These radios provide wayside signal status, switch position, and track integrity information to locomotives. Wayside radios also provide the ability for the wayside to communicate with the BO for maintenance and other purposes. Some Wayside radios may have access to the BO through a broadband connection. Wayside radios also use Pulse per Second (PPS) signals from an onboard GPS timing chip for channel synchronization of transmissions that are not controlled by the Base radios.

As discussed earlier, Wayside radios also communicate directly to locomotives even when there is no Base coverage due to a failure at the Base radio site or because there is no base coverage.

Figure 3 – High-level Wayside radio block diagram



3. Hardware performance specifications summary

Refer to Section 7: Electrical Requirements, Appendix A: Transmitter Specifications Limits and Test Methods, and Appendix B: Receiver Specifications Limits and Test Methods, for detailed radio performance specifications. Typical values apply for units operating at rated PEP, nominal voltage and temperature.

Table 2 – General specifications

Area	Wayside Radio	Locomotive Radio	Base Radio
Function	Half-duplex radio transceiver	Half-duplex radio transceiver	Half-duplex radio transceiver
Application of Device	Fixed (non-mobile) installations	Mobile installations	Base Station installations
Use Environment	Wayside bungalow per AAR S-5702	Vehicle interior cab per AAR S-5702	Wayside control room per AAR S-5702
Operating Temperature Range	-40° C to +70° C	-40° C to +70° C	-30° C to +70° C
DC Power Input	13.6 VDC nominal	74 VDC nominal	24 VDC or 48 VDC nominal (different power supplies)

Table 3: Transmitter Specifications

Area	Wayside Radio	Locomotive Radio	Base Radio 24 VDC	Base Radio 48 VDC
Frequency Band	217.6-222.0 MHz	217.6-222.0 MHz	217.6-222.0 MHz	217.6-222.0 MHz
Rated Power Output	25 W PEP nominal	50 W PEP nominal	75 W PEP nominal	75 W PEP nominal
Transmitter Class	Quasi-Linear	Linear	Linear	Linear
Transmitter Waveforms Supported	16 kbps pi/4DQPSK	16 kbps, 32 kbps pi/4DQPSK	16 kbps, 32 kbps pi/4DQPSK	16 kbps, 32 kbps pi/4DQPSK
Channel Spacing	25 kHz	25 kHz	25 kHz	25 kHz
TX Current Drain	7.5 A typical while transmitting into 50 ohm load. *See Table 13*.	1.8 A typical while transmitting into 50 ohm load. See Table 13.	7.5 A typical while transmitting into 50 ohm load. See Table 13.	4 A typical while transmitting into 50 ohm load. *See Table 13*
Transmitter Duty Cycle Rating	10%	30%	50%	50%

Table 4: Receiver Specifications

Area	Wayside Radio	Locomotive Radio	Base Station 24 VDC	Base Station 48 VDC
Frequency Band	217.6-222.0 MHz	217.6-222.0 MHz	217.6-222.0 MHz	217.6-222.0 MHz
Rated Static Sensitivity	*See Appendix B*	*See Appendix B*	*See Appendix B*	*See Appendix B*
Receiver Waveforms Supported	16 kbps, 32 kbps pi/4DQPSK	16 kbps, 32 kbps pi/4DQPSK	16 kbps, 32 kbps pi/4DQPSK	16 kbps, 32 kbps pi/4DQPSK

Area	Wayside Radio	Locomotive Radio	Base Station 24 VDC	Base Station 48 VDC
Channel Spacing	25 kHz	25 kHz	25 kHz	25 kHz
RX Current Drain	0.65 A typical*	0.36 A typical*	0.85 A typical*	0.41 A typical*
Power Save Mode	NA	NA	NA	NA
Number of Channels Simultaneously Received	2	16 (8 diversity receivers)	16 (8 diversity receivers)	16 (8 diversity receivers)
Diversity	Not supported	Equipped with two RF antenna connectors to support diversity reception	Equipped with two RF antenna connectors to support diversity reception	Equipped with two RX RF antenna connectors to support diversity reception
Regulatory	Complies with Parts 2, 15 and 90 of FCC rules and SRSP-512 Industry Canada requirements	Complies with Parts 2, 15 and 90 of FCC rules and SRSP-512 Industry Canada requirements	Complies with Parts 2, 15 and 90 of FCC rules and SRSP-512 Industry Canada requirements	Complies with Parts 2, 15 and 90 of FCC rules and SRSP-512 Industry Canada requirements

*Typical values apply for units operating at rated PEP, nominal voltage, and temperature.

4. Mechanical specifications

The table below provides mechanical specifications.

Table 5: Mechanical specifications

Radio	Description	Size	Weight	Fasteners	Mounting
Wayside	compact, rugged low cost	approximately 15.5W X 9.5 H X 2.0	less than 8 pounds	stainless steel	Package includes mounting points for installation on flat surfaces
Locomotive	Single LSI compliant package which implies extruded aluminum heat sink with multi-part sheet metal enclosure or machined/die-cast chassis with multi-part sheet metal enclosure	LSI rack compatible, 6xMCU maximum	Less than 22 pounds	stainless steel	Package includes mounting tabs for installation in LSI rack
Base	Single 19” EIA standard rack mount integrated package. Implies extruded aluminum heat sink with multi-part sheet metal enclosure	EIA rack height 4U (7.0” minus gap allowance) maximum height, 24” maximum depth	Less than 28 pounds	Stainless steel	• For open-frame EIA rack: Package includes removable mounting ears, with positions near radio center-of-gravity • Other mounting provisions: Mounting ears can be installed at front of unit

4.1 Materials

The table below provides more information about the product construction material specifications.

Table 6: Product construction materials

Material	Specification
Aluminum, sheet stock	5052
Aluminum, machined	6062
Aluminum, die cast	A360 or A380
Brass, sheet	UNS C26000
Stainless steel	303
Steel, sheet, cold rolled	AISI 1018-1025

4.2 Coatings

4.2.1 External surfaces

- Type: Polyurethane , powder coat paint, or plated
- Colors:
  - Sherwin Williams Carbide Black F63 B1
  - Sherwin Williams 7B Gray F63 AB

4.2.2 Undercoating and internal surfaces

Table 7 provides information about under coatings and internal surfaces.

Table 7: Undercoating and internal surfaces

Material	Plating Specification
Aluminum, sheet Aluminum, machined Aluminum, cast	Plate per MIL-DTL-5541F, Type II, Class 3 (low electrical resistance) Or Surtec® 650
Stainless steel	Passivate per ASTM A967

Material	Plating Specification
Other steels	Plate per ASTM B 633 Type II, Class Fe/Zn12, SC3 finish (trivalent chromium)
Brass	Electrodeposited Tin per ASTM B545 Class B (.0002 in. min)

4.2.3 Sealing

Employ the appropriate and necessary gasket(s) to comply with the radiated emissions and dust intrusion requirements as described in reference [3] AAR Standard S-5702.

4.3 External interface and connectors

4.3.1 Wayside radio

All interfaces are visible and accessible when the Wayside radio is installed.

Table 8 - Wayside connectors

Interface	Connector type	Location	Label
RF Antenna	Type N female	Bottom edge	ANT
GPS Antenna	TNC Female	Bottom edge	GPS
DC Power Input	Wago p/n 231-833/001-000	Bottom edge	13.6 VDC
Data Network Ethernet	RJ-45 Jack	Bottom edge	LAN
Maintenance Ethernet	RJ-45 Jack	Bottom edge	MAINT
CIM socket	SD card receptacle	Side edge	CIM

Notes:

1. The CIM-function Secure Digital (SD) flash card receptacle is accessible via retractable door on the Wayside radio front panel.

2. The mating DC power connector is Wago p/n 231-203/026-000.

4.3.2 Locomotive radio

All interfaces are visible and accessible when the Locomotive radio is mounted to the mounting surface.

Table 9 - Locomotive connectors

Interface	Connector Type	Location	Label
TX/RX1 Antenna	Type N female	Front panel	TX/RX1
Diversity RX Antenna	Type N female	Front panel	RX2
DC Power Input	MS 3102 A18-4P or equivalent (Note 1)	Front panel	74 VDC
Data Network Ethernet	M12- 8 pin female, A-coded	Front panel	LAN
Maintenance Ethernet	M12- 8 pin female, A-coded	Front panel	MAINT
CIM socket	SD card receptacle	Front panel	CIM

Notes:

1. Pin out per AREMA C&C Manual Section 22.2.1, clause H.1., with no 13.6V input.

2. The mating DC power connector (w/o external power cable) is MS 3106-E -18-4S.

3. The CIM-function Secure Digital (SD) flash card is accessible via retractable door on the Locomotive radio front panel.

4.3.3 Base Station

All interfaces are visible and accessible when the Base radio is installed in EIA open frame rack or cabinet with the doors open.

Table 10 - Base connectors

Interface	Connector Type	Location	Label
TX Antenna	Type N female	Rear panel	TX/RX
RX1 Antenna	Type N female	Rear panel	RX1
RX2 Antenna	Type N female	Rear panel	RX2
GPS Antenna	TNC Female	Rear panel	GPS
DC Power Input	Threaded posts for ring lug connection	Rear panel	24 VDC or 48 VDC
Data Network Ethernet	RJ-45	Rear panel	LAN
Maintenance Ethernet	RJ-45	Front panel	MAINT
CIM socket	SD card receptacle	Front panel	CIM

Note: The CIM-function Secure Digital (SD) flash card is accessible via a retractable door on the front panel.

4.3.4 LED indicator displays for all radios

The front panel will include LED indicators that indicate the operational status of the equipment. Refer to the ITC Radio Functional Specification for detailed description of the LED indicators operation.

Table 11 – Wayside LEDs

Label	Description	Color
POWER	Power applied	Green
TX	Transmitter on	Red
VSWR	High VSWR/Incorrect Output Power	Red

Label	Description	Color
RX	Receiving signal	Amber
DTE LINK	ELM link established	Amber
RF LINK	Radio link established	Amber
STANDBY	Standby - nonfunctional	Red
FAULT	Other fault	Red

Table 12 - Locomotive and Base LEDs

Label	Description	Color
PWR	Power applied	Green
TX	Transmitter on	Red
SWR	High VSWR/Incorrect Output Power	Red
RX	Receiving signal	Amber
DTL	ELM link established	Amber
RFL	Radio link established	Amber
STBY	Standby - nonfunctional	Red
FLT	Other fault	Red

4.3.5 Front and rear panel labeling

- Description: Silkscreen, pad print or polycarbonate laminate with PSA, white or other high contrast color lettering
- Indications: RF connections, DC power connection, CIM position, Ethernet connector locations

4.3.6 Front panel LED display

- Description: Polycarbonate laminate with PSA, black/charcoal with white lettering
- Indications: Labeling of LED indicators

4.3.7 FCC ID/IC and serial number labels

- Description: Polycarbonate laminate with PSA, black/charcoal with white lettering
- Indications: Text per FCC/IC requirements
- Placement on product: Front panel

4.3.8 Railroad serial number clearance

A location on the front panel of each product will be reserved (clear of laminate label) for the etching or stamping of Railroad-specific serial numbers.

5. Electrical requirements

5.1 Electrical construction

- Printed circuit board (PCB) substrates: FR-4 and RO4350
- PCB assemblies will conform to the RoHS lead-free directive
- All PCBs include RoHS/Pb Free and WEEE labels
- All PCBs include board revision and SN bar code labels.

5.2 DC power input – all radios

Table 13: DC power inputs - all radios

Parameter	Wayside Radio	Locomotive Radio	Base Station 24 VDC	Base Station 48 VDC
Nominal DC power input	13.6 VDC	74 VDC	24 VDC	48 VDC
Operational Range	10.9-15.5 VDC (+14%/-20%)	45-100 VDC	21-27 VDC (+/-12.5%)	42-54 VDC (+/-12.5%)
Damage Limit	17 VDC	120 VDC	30 VDC	60 VDC

Parameter	Wayside Radio	Locomotive Radio	Base Station 24 VDC	Base Station 48 VDC
Transmitter Current Drain	While transmitting into 50 ohm load: 7.5A typical* 10A max	While transmitting into 50 ohm load: 1.8A typical* 4A max	While transmitting into 50 ohm load: 7.5A typical* 11A max	While transmitting into 50 ohm load: 4A typical* 6A max
Receiver Current Drain	0.65 A typical* 1.0A max	0.36A typical* 0.50A max	0.85A typical* 1.2A max	0.41A typical* 0.6A max
External Fuse Rating	10A	7.5A	15A	10A
Overvoltage Protection	External protection required for the power amplifier. Remaining circuitry internally protected at OVP threshold	Must be supplied externally	Must be supplied externally	Must be supplied externally
Reverse Polarity	Internal reverse polarity protection will be provided, with external fuse or circuit breaker required	Internal reverse polarity protection will be provided, with external fuse or circuit breaker required	Internal reverse polarity protection will be provided, with external fuse or circuit breaker required	Internal reverse polarity protection will be provided, with external fuse or circuit breaker required

* Typical values apply to units operating at rated PEP, nominal voltage and temperature.

Note: See Reference [1] for a detailed description of radio behavior outside the allowable DC input range.

5.3 Locomotive electrical

5.3.1 DC input voltage

The Locomotive radio shall perform in accordance with the requirements of this specification when provided with an input voltage ranging from 45 VDC to 100 VDC. At any voltage outside of this range, the Locomotive radio will apply any necessary protection circuitry and may turn off.

5.3.2 Input/output isolation

The Locomotive radio DC power supply input shall withstand 500 VDC applied continuously between its input and output terminals and between any input and output terminal and its chassis. (Reference AAR S-5702, clause 5.3).

5.3.3 Voltage spikes

The DC Power input of the Locomotive radio shall dissipate voltage spikes of 5 kV peak and 90 joules of energy. (Reference AAR S-5702, clause 5.4)

5.4 Fault monitoring and diagnostics

Radio hardware will support the monitoring of the following parameters:

- Supply voltages
- Input voltage
- Internal DC converter outputs
- Forward RF power
- Reflected RF power
- RF power amplifier temperature
- Master Board temperature
- Critical event logging to non-volatile memory on Master Board
- Tachometer monitoring for fan fault monitoring (Base radio Only)

See Reference [1] for a detailed description of radio behavior as a function of internal monitoring and fault detection.

5.4.1 GPS receiver (Wayside and Base radios only)

- The unit is equipped with a GPS receiver.
- An active external antenna shall use 3.3 VDC and consume less than 50 mA.
- See Reference [1] for a detailed description of GPS functionality.

5.4.2 Cooling fan (Base radio only)

- The Base radio unit is equipped with cooling fan(s).
- Control of the fan(s) will originate at the radio Master Board.
- The cooling fan(s) will only turn on when the unit senses an ambient temperature of > +50^{o} C.
- Fan(s) includes tachometer sense for fault monitoring.
- Fan(s) are field replaceable.

5.4.3 Transmitter timeout

The radio is equipped with a hardware-controlled transmitter time out to limit the duration of each transmission. When the transmitter has been keyed for greater than 8 seconds, the timer will disable the transmitter. The transmitter can only transmit again when key has been de-asserted and re-keyed.

5.5 Electrical ratings and performance specifications

5.5.1 Transmitter-rated RF power output

See Appendix A: Transmitter specifications limits and test methods for all limits and test methods.

Table 14: Rated RF power output

Parameter	Wayside Radio	Locomotive Radio	Base Station
Conducted Carrier Output Power Rating	25 W PEP nominal	50 W PEP nominal	75 W PEP nominal
Adjustment Range	7.5 to 25 W	15 to 50 W PEP	10 to 75 W PEP

5.5.2 Receiver

See Appendix B for all limits and test methods.

5.6 Internal connectors

5.6.1 Board connectors

Board connectors will be appropriate for the intended application.

5.6.2 Serial port

An internal serial port will be accessible with radio cover removed for use in production and field service applications.

6. Environmental requirements

This section describes the environmental-condition variations induced on the equipment relative to the specified parametric degradation indicated in Appendix A: Transmitter specifications limits and test methods and Appendix B: Receiver specifications. The variations, with some exceptions, are outlined in AAR Standard S-5702 for each class of equipment.

6.1 Standard atmospheric test conditions

- Temperature: 25^{o} C
- Relative humidity: 45% to 75%
- Atmospheric pressure: 860 to 1060 mbar

Tests may be conducted at any temperature between 20^{o} C to 35^{o} C, as long as the temperature is recorded, and is held within +/-1^{o} C.

6.2 Environmental limits

Refer to S-5702, clause 3.2 for detailed descriptions, reference test procedures and test sequences.

Table 15: Environmental specifications

Ref #	Characteristic	Condition	Value
1.2.4	Temperature (ambient) S-5702 Tables 3.1, 3.2	Operating normal	WR and LR: -40°C to +70° C BR: -30°C to +70° C
1.2.5	Temperature (ambient) S-5702 Tables 3.1, 3.2	Storage	-55°C to +85° C
1.2.6		Shock	-55°C to +70° C profile per S-5702 Appendix C
		Tunnel temperature	NA
1.2.7	Humidity S-5702 Tables 3.1, 3.2 Note [1]	Operating	95% non-condensing; test per S-5702, clause 3.2.3.2
1.2.8	Humidity S-5702 Tables 3.1, 3.2 Note [1]	Storage	95% non-condensing
1.2.9	Humidity S-5702 Tables 3.1, 3.2 Note [1]	Moisture resistance	Per S-5702, clause 3.2.3.1- substituing carbon black dust with calcined petroleum coke to avoid hazardous substance use in Dust Test. The Hi-Pot test within Dust Test is not required for Wayside radios. See Note 1.
1.2.10	Shock S-5702 Tables 3.1,3.2	Shipping	See 1.2.19, "Transportability" below

Ref #	Characteristic	Condition	Value
1.2.11	Shock S-5702 Tables 3.1,3.2	Mounted	10G, 11msec (LR and WR) per S-5702, clauses 3.2.4.3.1 & 3.2.4.3.2 & Figure 3.2. Perform sinusoidal profile in Table 3.3 on BR & WR radios long enough to determine resonant frequencies, whereas the Locomotive radio will be tested per sub-clause 3.2.4.1.1
1.2.13	Salt Fog	NA	NA
1.2.14	Rain	NA	NA
1.2.15	Sand and Dust S-5702 Tables 3.1, 3.2	Operating	LR, WR & BR: Test per S-5702, *Appendix F*. Note [1]
1.1.16	Contaminants – LR only		Test per S-5702, clause 3.2.8.
1.2.18	Altitude	Operating	Per Test Method MIL-STD-810E 500.3, test guidelines I-3. - 200 to 12,000 ft from sea level Rapid decompression portion is not applicable

Ref #	Characteristic	Condition	Value
1.2.19	Transportability		Use International Safe Transit Association (ISTA) Procedure 1A 2001: Packaged-Products 150 lb (68kg) or Less to verify transportation packaging is adequate
1.2.20	Service Life		LR and BR: 80000 hours WR: 40000 hours
2.2.23	Mean Time Between Failures		All radios: 20000 hours
2.2.24	EMC S-5702 Section 4	Radiated emissions	Transmitter: see Radiated Spurious Emissions in *Appendix A*. Receiver: see Radiated Spurious Output Power in *Appendix B*.
2.2.24	EMC S-5702 Section 4	Conducted emissions	Transmitter: see Conducted Spurious Emissions in *Appendix A*. Receiver: see Conducted Spurious Output Power in *Appendix B*.
2.2.25	Immunity/Susceptibility Input power, interfaces S-5702 Sect 4.2.2.2	Operating	Level 1 Fast Transient multiburst 500 V peak per EN61001-4-4 Level 2 Transient

Ref #	Characteristic	Condition	Value
			multiburst 2 kV
2.2.26	ESD S-5702 Sect. 4.2.3	Powered Unpowered	Cards: 2 kV Panel: 6 kV Cards: 4 kV Panel: 6 kV

Note: Use of specified RJ-45 jacks and Wago-type power connectors may require exclusions due to failure after testing has been performed.

Appendix A: Transmitter specification limits and test methods

These radio parameters are subject to variation due to induced environmental conditions. Degradation from Standard (DFS) expresses the allowable degradation of the parameter over the condition range, according to the convention of TIA-603.

- BR = Base Radio
- LR = Locomotive Radio
- WR = Wayside Radio
- Test Method: Reference [12] ITC 1.0 220 MHz Radio Hardware Performance Test Procedures, document number 00001434.
- ND indicates that the allowable degradation is not defined
- None means no DFS is allowed
- NA means not applicable

		Allowable DFS over induced environmental conditions						
Transmitter Parameter	**Specification at Standard Test Conditions Note [3]**	**Wayside 10.9-15.5 VDC**	**Locomotive 45-100 VDC**	**Base 21-27 VDC**	**Base 42-54 VDC**	**Temperature**	**Humidity**	**Vibration**
Conducted Carrier Output Power	± 1.0 dB of rated	+2/-3 dB	+2/-3 dB	+2/-3 dB	+2/-3 dB	+2/-3 dB	+2/-3 dB	None, during Note [1]

		Allowable DFS over induced environmental conditions						
Transmitter Parameter	**Specification at Standard Test Conditions Note [3]**	**Wayside 10.9-15.5 VDC**	**Locomotive 45-100 VDC**	**Base 21-27 VDC**	**Base 42-54 VDC**	**Temperature**	**Humidity**	**Vibration**
Carrier Frequency Stability	± 1.5 ppm WR and LR, ± 0.1 ppm BR Frequency Calibration: ± 0.25 ppm WR and LR, ±0.025 ppm BR	None	None	None	None	None	None	None
Sideband Spectrum (Occupied Bandwidth)	Per 47CFR90.210 (f) Note [2]	ND	ND	ND	ND	ND	ND	ND
Radiated Spurious Emissions	-25 dBm max	ND	ND	ND	ND	ND	ND	ND
Conducted Spurious Emissions	-25 dBm max	ND	ND	ND	ND	ND	ND	ND

		Allowable DFS over induced environmental conditions						
Transmitter Parameter	**Specification at Standard Test Conditions Note [3]**	**Wayside 10.9-15.5 VDC**	**Locomotive 45-100 VDC**	**Base 21-27 VDC**	**Base 42-54 VDC**	**Temperature**	**Humidity**	**Vibration**
Adjacent Channel Power Ratio (full rate with 16 kHz victim bandwidth)	70 dB @ 25 kHz	NA	ND	ND	ND	ND	ND	ND
Adjacent Channel Power Ratio (half rate with 8 kHz victim bandwidth)	70 dB @ 25 kHz	ND	ND	ND	ND	ND	ND	ND
Intermodulation Attenuation	40 dB-BR only	NA	NA	ND	ND	ND	ND	ND
Transmitter Stability into VSWR	-25 dBm max spur level at 3:1 VSWR	None	None	None	None	None	None	None

Notes:

1. "During" indicates the parameter measurement takes place during the inducement of the environmental extreme.

2. Emission mask is aggregation of five (5) times Mask F per 47CFR90.733.

3. Standard Test conditions are Standard Atmospheric Test Conditions and unit power supply set to nominal DC power voltage +/-2%.

Appendix B: Receiver specification limits and test methods

These radio parameters are subject to variation due to induced environmental conditions. Degradation from Standard (DFS) expresses the allowable degradation of the parameter over the condition range, according to the convention of TIA-603.

- BR = Base Radio
- LR = Locomotive Radio
- WR = Wayside Radio
- Test Method: Reference [12] ITC 1.0 220 MHz Radio Hardware Performance Test Procedures, document number 00001434.
- ND indicates that the allowable degradation is not defined
- None means no DFS is allowed
- NA means not applicable

		Allowable DFS over induced environmental conditions						
Receiver Parameter	**Specification at Standard Test Conditions,** Note [3]	**Wayside 10.9-15.5 VDC**	**Locomotive 45-100 VDC**	**Base 21-27 VDC**	**Base 42-54 VDC**	**Temperature**	**Humidity**	**Vibration**
Radiated Spurious Output Power	Per 47 CFR 15.109	ND	ND	ND	ND	ND	ND	ND
Conducted Spurious Output Power	**Per 47 CFR 15.111**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**

		Allowable DFS over induced environmental conditions						
Receiver Parameter	**Specification at Standard Test Conditions,** Note [3]	**Wayside 10.9-15.5 VDC**	**Locomotive 45-100 VDC**	**Base 21-27 VDC**	**Base 42-54 VDC**	**Temperature**	**Humidity**	**Vibration**
Power Line Conducted Spurious Output Voltage	Per 47 CFR 15.107	ND	ND	ND	ND	ND	ND	ND
Maximum usable sensitivity, half-rate pi/4DQPSK, Static, BER<10^{-4}	-111 dBm into 50 ohms	3 dB	3 dB	3 dB	3 dB	6 dB	10 dB	None, during Note[1]
Maximum usable sensitivity, half-rate pi/4DQPSK, Static, PER<10%	-111 dBm into 50 ohms	3 dB	3 dB	3 dB	3 dB	6 dB	10 dB	None, during Note[1]
Maximum usable sensitivity, full-rate pi/4DQPSK, Static, BER<10^{-4}	-108 dBm into 50 ohms	3 dB	3 dB	3 dB	3 dB	6 dB	10 dB	None, during Note[1]
Maximum usable sensitivity, full-rate pi/4DQPSK, Static, PER<10%	-108 dBm into 50 ohms	3 dB	3 dB	3 dB	3 dB	6 dB	10 dB	None, during Note [1]

		Allowable DFS over induced environmental conditions						
Receiver Parameter	**Specification at Standard Test Conditions,** Note [3]	**Wayside 10.9-15.5 VDC**	**Locomotive 45-100 VDC**	**Base 21-27 VDC**	**Base 42-54 VDC**	**Temperature**	**Humidity**	**Vibration**
Error Behavior at High Input Levels (-7dBm)	BER$\leq 10^{-4}$	ND	ND	ND	ND	ND	ND	ND
Co-channel Rejection, half-rate pi/4DQPSK, Type 1: Desired set at 3dB above reference sensitivity.	-16 dB	ND	ND	ND	ND	ND	ND	ND
Co-channel Rejection, half-rate pi/4DQPSK, Type 2: Desired set at -90 dBm.	-11.5 dB	ND	ND	ND	ND	ND	ND	ND
Co-channel Rejection, full-rate pi/4DQPSK, Type 1: Desired set at 3dB above reference sensitivity.	-16 dB	ND	ND	ND	ND	ND	ND	ND
Co-channel Rejection, full-rate pi/4DQPSK, Type 2: Desired set at -90 dBm.	-11.5 dB	ND	ND	ND	ND	ND	ND	ND

		Allowable DFS over induced environmental conditions						
Receiver Parameter	**Specification at Standard Test Conditions,** Note [3]	**Wayside 10.9-15.5 VDC**	**Locomotive 45-100 VDC**	**Base 21-27 VDC**	**Base 42-54 VDC**	**Temperature**	**Humidity**	**Vibration**
Adjacent Channel Selectivity	70dB @ 25kHz Note [2]	6dB	6dB	6dB	6dB	12dB	12dB	ND
Spurious Response Rejection	65dB	None	None	None	None	10dB	10dB	ND
Intermodulation Response Rejection	65dB	3dB	3dB	3dB	3dB	6dB	6dB	ND
Blocking or Desensitization, Half Rate	80dB	ND	ND	ND	ND	ND	ND	ND
Blocking or Desensitization, Full Rate	77dB	ND	ND	ND	ND	ND	ND	ND
GPS Sensitivity	-130dBm, WR and BR	ND	NA	ND	ND	ND	ND	ND

Notes:

1. During indicates the parameter measurement takes place during the inducement of the environmental extreme.

2. Exceptions to adjacent channel selectivity: 63 dB @ 25 kHz on victim channel frequencies 219.1875 MHz and 219.2125 MHz.

3. Standard Test conditions are Standard Atmospheric Test Conditions and unit power supply set to nominal DC power voltage +/-2%.

Appendix C: Requirements mapping

The following table provides the mapping of the radio requirements (Reference [11]) to the Hardware Specifications in this document.

Table 16 - Requirements map

#	B	L	W	Requirement	HW Section	Notes
18	B	L	W	The radio must support 2 Ethernet I/O ports, each on its own Network.	Table 8 Table 9 Table 10	
21		L		The radio must support an 8 pole, female, M12, D coded connector for Ethernet.	Table 9	
22	B		W	The radio must support an RJ45 connector for Ethernet.	Table 8 Table 10	
23	B	L	W	The radio must support a type N connector for the narrowband RF antenna.	Table 8 Table 9 Table 10	
24			W	The radio must support a TNC connector for the GPS antenna.	Table8	
27	B			The radio must support a TNC connector for the GPS antenna.	Table 10	
28		L		The radio must support an MS 3102 A18-4P or similar connector for power.	Table 9	
29	B			The radio must support a Ring, Space, or Screw Terminal type connector for power.	Table 10	
30			W	The radio must support a low cost (Wago or equivalent) connector for power.	Table 8	

#	B	L	W	Requirement	HW Section	Notes
50	B	L	W	The radio must be able to support frequencies between 217.6 MHz and 222.0 MHz.	Table 3 Table 4	
92	B	L	W	The radio must provide external visual indications of: - Power (indication of radio being powered on) - Fault (red when a fault has been detected currently or recently) - Transmit (indication of radio transmitting) - Receive (indication of radio receiving) - VSWR (indication of VSWR exceeding limits) - Standby (indication that radio is in standby mode) - RF Link (indication that remote radio is registered to a base or that a base radio has at least 1 remote registered to it) - DTE Link (indication that radio is registered with an ELM over the wire)	Table 11 Table 12	
100	B	L	W	The radio must support a MTBF (Mean Time Between Failure) of 20,000 hours.	Table 15	
101	B	L		The radio must last for 80,000 hours of operation before needing to be replaced (assuming repairs at MTBF are OK).	Table 15	

#	B	L	W	Requirement	HW Section	Notes
102			W	The radio must last for 40,000 hours of operation before needing to be replaced (assuming repairs at MTBF are OK).	Table 15	
123	B			The radio must fit within a standard 19" rack.	Table 5	
124	B			The radio (including PA) should be no more than 24" deep.	Table 5	
125	B			The radio (including PA) should fit within a maximum of 4 RUs.	Table 5	
126		L		The radio must conform to LSI standards for packaging.	Table 5	
126.1		L		The radio (including PA) should fit within a maximum of 6 MCUs.	Table 5	
128	B			If the radio design includes a fan, it must only operate at ambient temperatures greater than 50C.	5.4.2	
130	B			The radio must be able to support a configurable power RF output up to 75WPEP (Peak Envelope Power).	Table 3 Table 14	
131		L		The radio must be able to support a configurable power RF output up to 50WPEP (Peak Envelope Power).	Table 3 Table 14	
132		L		The radio must support a nominal 74VDC (range 45V-100V) power input.	Table 2 Table 13	

#	B	L	W	Requirement	HW Section	Notes
132.1	B			The radio must support nominal 24V (range +/- 12.5%) power input.	Table 2 Table 13	
134			W	The radio must be able to support a configurable power RF output up to 30W RMS.	Table 3 Table 14	Changed to 25WPEP. (CR520
135			W	The radio must support a nominal 13.6V DC (range 10.9V-15.5V) power input.	Table 2 Table 13	
135.1			W	The radio should support an average direct draw of no more than 1 amp.	Table 13	
147	B			The radio frequency must be within 0.1 ppm of the assigned frequency.	Appendix A	
148		L	W	The radio frequency must be within 1.5 ppm of the assigned frequency.	Appendix A	
149	B	L	W	The radio design must conform to FCC FREQUENCY ALLOCATIONS AND RADIO TREATY MATTERS; GENERAL RULES AND REGULATIONS rules (listed below).	Table 4 (47CFR Part 2)	
149.1	B	L	W	The radio design must conform to FCC allocation, assignment, and use of radio frequency rules.	Table 4 (47CFR Part 2)	
149.2	B	L	W	The radio design must conform to FCC emissions rules.	Appendix A	

#	B	L	W	Requirement	HW Section	Notes
149.3	B	L	W	The radio design must conform to FCC marketing of radio frequency devices rules.	Table 4	
149.4	B	L	W	The radio design must conform to FCC equipment authorization procedures rules.	Table 4	
150	B	L	W	The radio design must conform to FCC RADIO FREQUENCY DEVICES rules (listed below).	Table 4 (47CFR Part 15)	
150.1	B	L	W	The radio design must conform to FCC general procedure rules.	Table 4 (47CFR Part 15)	
150.2	B	L	W	The radio design must conform to FCC unintentional radiators rules.	Table 4 Appendix B	
151	B	L	W	The radio design must conform to PRIVATE LAND MOBILE RADIO SERVICES rules (listed below).	Table 4 (47CFR Part 90)	
151.1	B	L	W	The radio design must conform to FCC general information rules.	Table 4 (47CFR Part 90)	
151.2	B	L	W	The radio design must conform to FCC general technical standards rules.	Table 4 (47CFR Part 90)	
151.3	B	L	W	The radio design must conform to FCC non-voice and other specialized operations rules.	Table 4 (47CFR Part 90)	
151.4	B	L	W	The radio design must conform to FCC standards for special frequencies or frequency bands rules.	Table 4 (47CFR Part 90)	

#	B	L	W	Requirement	HW Section	Notes
151.5	B	L	W	The radio design must conform to FCC operating requirements rules.	Table 4 (47CFR Part 90)	
151.6	B	L	W	The radio design must conform to FCC transmitter control rules.	Table 4 (47CFR Part 90)	
151.7	B	L	W	The radio design must conform to FCC developmental operation rules.	Table 4 (47CFR Part 90)	
151.8	B	L	W	The radio design must conform to FCC regulations governing licensing and use of frequencies in the 220-222 MHz band rules.	Table 4 (47CFR Part 90)	
154	B	L	W	The radio design must conform to applicable radio manufacturing industry specifications.	Appendix A Appendix B	
156	B	L	W	The radio design must conform to AAR specifications regarding interference from radios and processors.	Table 15	
157	B	L	W	The radio design must conform to environmental specifications from the AAR Manual of Standards and Recommended Practices.	Table 15	
158	B	L	W	The radio must be able to operate at an ambient temperature range of -40C to +70C.	Table 15	Base temperature range changed to -30C to +70C. (CR 42)

#	B	L	W	Requirement	HW Section	Notes
159		L		The radio design must conform to applicable specifications from the AAR Manual of Standards and Recommended Practices regarding device interfaces, connectors, and LSI packaging, etc. where they do not differ from other requirements.	Table 5	
160	B	L	W	The radio design must conform to applicable Canadian Telecommunications standards.	Table 4	