
# ITC RADIOS

## WAYSIDE RADIO MANUFACTURING TEST REQUIREMENTS SPECIFICATION

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## WAYSIDE RADIO MANUFACTURING TEST REQUIREMENTS SPECIFICATION

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# 1 INTRODUCTION

## 1.1 PURPOSE

The purpose of this document is to establish the manufacturing functional test requirements for the Wayside Radio.

## 1.2 SCOPE

This document defines functional test requirements to be implemented for the Wayside radio. It does not document how the requirements are to be implemented. Such design implementation criteria is defined in a separate document. This document is intended for design engineers, and test development engineers.

## 1.3 DEFINITIONS, ACRONYMS, AND ABBREVIATIONS

| Item | Entry | Description |
|---|---|---|
| T2. 01 | MCC | Meteorcomm LLC |
| T2. 02 | CA | CalAmp Corp |
| T2. 03 | FCT | Functional Circuit Test |
| T2. 04 | PCBA | Printed Circuit Board Assembly |
| T2. 05 | VDC | Voltage Direct Current |
| T2. 06 | VAC | Voltage Alternating Current |
| T2. 07 | DUT | Device Under Test |
| T2. 08 | NA | Not Applicable |
| T2. 09 | Wayside | Wayside Radio |
| T2.10 | ITC | Interoperable Train Control |
| T2.11 | DFS | Degradation from Full Scale |
| T2.12 | ppm | parts per million |
| T2.13 | ND | Not Defined |
| T2.14 | PEP | Peak Envelope Power |
| T2.15 | VSA | Vector Signal Analyzer |
| T2.16 | N/A | Not Applicable |
| T2.17 | TBD | To Be Determined |
| T2.18 | TX | Transmit |
| T2.19 | RX | Receive |
| T2.20 | RSSI | Receive Signal Strength Indicator |

**Table 1 – Definitions, Acronyms, and Abbreviations**

## 1.4 REFERENCE DOCUMENTS

| Item | Reference Document | Doc. No. |
|---|---|---|
| T3.01 | Wayside Radio Top Level BOM | 6303000X |
| T3.02 | CLI Command Reference Document | TST-MCC-00001009-I |
| T3.03 | ITC 220MHz Radio Hardware Specification v1 4.pdf | 00001040 |
| T3.04 | 63010000-04 Test Procedure Includes Instructions for Master Board | |
| T3.05 | ITC 1 0 220 MHz Radio Hardware Performance Test Procedures | 00001434-A |
| T3.06 | Manufacturing Test Specification (MTS) Hipot & Ground Continuity Tests Wayside, Locomotive, Base Station Radio | |
| T3.07 | ITCR 1.0 Radio & PCBA Serial Numbering Scheme | 00001193-B |

**Table 2 – Reference Documents**

## 1.5 DOCUMENT OVERVIEW

This document describes the manufacturing functional test requirements for the Meteorcomm Wayside Radio. It is divided into sections:

Section 1 describes the purpose, scope, definition of acronyms and abbreviations, and references documents, and a brief overview of the document.
Section 2 presents a brief description of the radios
Section 3 presents the Tx Tuning Procedure
Section 4 describes the unit level test requirements.

The requirements are tagged with the identifier “TRS##.” As the requirement identifiers are referenced by other documents, the identifiers should NEVER be changed without understanding the work involved in bringing all documents involved to consensus.

The “ITC 220MHz Radio Hardware Specification v1 4.pdf” (ref T3.03) Appendix A & B is the source for all unit level electrical requirements. This document may tighten certain limits in manufacturing to accommodate requirements that have no allowable DFS over unit environmental conditions.

# 2 OVERALL DESCRIPTION

This ITC Radio is used as part of a larger communication system used by the railroad industry. The test strategy for the radios includes a sub level functional test for tuning and also a final level device functional test.

# 3 TEST REQUIREMENTS

## 3.1 DUT TEST SETUP

The Wayside Radio may be tested within a sealed RF enclosure when testing at the unit level. The enclosure provides shielding against other ITC radios or other products that may produce interference within the ITC band. The enclosure is recommended but not required. Other tests may be done without the RF enclosure. If the enclosure is used all instrumentation connections to the DUT shall be made through the enclosures interface panel.

In general the Radio is commanded through it's Maintenance port. A connection is made from a PC to the Maintenance port though Ethernet. ASCII commands, referred to as "CLI Commands" are sent to the radio over telnet. The radio will respond with ASCII over telnet when appropriate.

Power is applied to the radio through the Power Interface Port.

The Unit Level Receive test setup will consist of a modulated signal source that is connected to either the Primary or Diversity RF Port.

The Unit Level Transmit test setup will consist of an RF attenuator and a Vector Signal Analyzer (VSA) (or similar) that is connected to Transmit RF Port. The attenuator shall be a 50 Ohm attenuator with sufficient attenuation (> 40 dB) to protect the VSA from excessive RF levels from the 25W transmitter.

## 3.2 TRANSMITTER TUNING TEST SETUP

The Transmitter Tuning step for the Wayside radio is documented in reference T3.04. This testing is done at a sub-assembly step of radio integration where the operator has access to internal connections. The three radio PWAs are assembled into the radio chassis and the ribbon cable connecting the three PWAs is connected.

The Master Board is commanded through it's Maintenance port. A connection is made from a PC to the Maintenance port though Ethernet. ASCII commands, referred to as "CLI Commands" are sent to the radio over telnet. The radio will respond with ASCII over telnet when appropriate.

Power is applied to the radio connector (+13.6V nominal).

## 3.3 REFERENCE CLOCK TUNING TRS01

Verify that the Signal Analyzer is connected to the Transmit output of the Master Board (J20). Apply 13.6VDC to the Wayside radio and allow it to boot. Execute the commands to enable a CW tone at 220MHz.

Using the VSA spectrum analyzer output measure the frequency of the signal. Tune the XO until the frequency error is within the limit defined below. Save the setting.

| Test # | Parameter | Expected (MHz) | Min (MHz) | Max (MHz) |
|---|---|---|---|---|
| TRS01.1 | Frequency | 220.000000 | 219.999965 | 220.000035 |

Table 3 – Reference Clock Tuning TRS01

## 3.4 RF/DC BOARD BIAS LEVEL CONFIGURATION (OPEN LOOP) TRS02

Verify that the Wayside Tx cable is connected between the Master Board and RF/DC Board. Connect the Radio for TX testing per Section 3.1 Apply 13.6VDC to the Wayside radio and allow it to boot. Per reference T3.04 issue the commands to set the PA Bias and dds level, then enable the transmitter in half rate pi/4 DQPSK mode. Adjust the PA Bias through the CLI commands until the measured value is within the limits of Table 4.

| Test # | Parameter | Min | Max |
|---|---|---|---|
| TRS02.1 | PA Bias | 4.95V | 5.05V |

Table 4 – PA Bias Level Configuration TRS02

## 3.5 POWER OUTPUT TUNING TRS03

Connect the Radio for TX testing per Section 3.1. Apply 13.6VDC to the Wayside radio and allow it to boot. Load the VSA with the state specified in T3.04 (section 2.2.3.2) and send the CLI commands to set up the dds level, igain and qgain per T3.04 section 2.2.3. Execute the commands to enable the Wayside radio to produce half-rate pi/4 DQPSK Modulation at 221.1375MHz at the specified duty cycle (T3.04 section 2.2.3).

Measure power output and adjust the dds level until the power out reaches the expected level. The current draw is monitored throughout the tuning process. When finished save the calibration using the CLI command interface.

| Test # | Parameter | Expected | Min | Max |
|---|---|---|---|---|
| TRS03.1 | Current Draw | NA | NA | 10A |
| TRS03.1 | Power Out | 25W PEP (44.0dBm) | 43.8 dBm | 44.2 dBm |

Table 5 – Power Output Tuning TRS03

# 4 UNIT LEVEL TEST

## 4.1 WAYSIDE POWER SUPPLY CURRENT DRAW TRS04

The test verifies the Power Supply Current Draw with the DUT after initially powered on, when receiving, when transmitting at maximum power out, and in Power Save Mode. Note that the Power Save Mode is currently undefined for the Wayside Radio.

| Test # | DUT Status | Radio Voltage | Min Current (A) | Max Current (A) |
|---|---|---|---|---|
| TRS04.1 | Initial Power On | 13.6V | 0.4 | 1.0 |
| TRS04.2 | Receiving | 13.6V | 0.4 | 1.0 |
| TRS04.3 | Max Transmit | 13.6V | 5 | 10 |
| TRS04.4 | Power Save | 13.6V | N/A | N/A |

Table 6 – Power Supply Current Draw TRS04

## 4.2 POST TEST TRS05

This test is intended to verify that the radio has passed the internal POST.

With the unit booted up and an open telnet session, execute the CLI POST command and parse the DUT response for Pass/Fail indications. Note that the first time a unit is powered up the POST test for Serial Number verification will fail. This can be ignored as TRS08 programs and verifies the DUT Serial Number.

## 4.3 MAC ADDRESS REPORTING TEST TRS06

This test is intended to record the Ethernet MAC address for each Ethernet Port.

With the unit booted up and an open telnet session, execute the CLI command and to read each Ethernet Port's MAC address. Record the result in the Test Report.

## 4.4 SW/FW IMAGE VERIFICATION TEST TRS07

This test is intended to verify that the DUT has the correct version of CPLD code, Boot Launcher Code and Application code. It also verifies the DUT has been flashed and properly formatted with the Application load.

With the unit booted up and an open telnet session, execute the CLI commands to verify the version of the CPLD, Boot Launcher and Sprint Application Code. These versions of code are defined at the Top Level BOM – reference T3.01. Then execute the CLI commands to verify the proper formatting of the on-board flash.

The Board Type is also verified at this point, for Sprint 23.02, it should be set to “MB3”.

## 4.5 SERIAL NUMBER PROGRAMMING & VERIFICATION TEST TRS08

This test writes the DUT serial number to the radio then verifies it has been saved in the DUT.

With the unit booted up and an open telnet session, execute the CLI command to program the DUTs serial number. The serial number is bar coded on the DUT per T3.07. The serial number shall be saved to the unit then recalled to verify it was programmed correctly.

## 4.6 LED TEST TRS09

With the Radio booted, send the CLI command to enable all LEDs. The operator will verify they are all on.

Send the CLI command to disable all LEDs. The operator will verify they are all off.

## 4.7 RX RSSI Calibration TRS10

This test provides a calibration of the Rx path RSSI. Connect a Signal Generator to the Primary Receiver RF Port and generate an input signal for Full Rate DQPSK at -50 dBm, mid frequency band. Execute the commands to the maintenance port to set the radio up for Primary Receive, this will include the channel, modulation type and frequency. Poll the Wayside's RSSI and adjust the RSSI Calibration parameter until the reading is within the limits of Table 7.

| **Test #** | **Port** | **Supply Voltage** | **Modulation/ Input Level** | **Frequency (Mhz)** | **RSSI MIN (dBm)** | **RSSI MAX (dBm)** |
|---|---|---|---|---|---|---|
| TRS10.1 | RX1 (PRI) | 13.6V | π/4 DQPSK -50 dBm | 219.9125 | 49.9 | 50.1 |

**Table 7 – Receiver RSSI Calibration TRS10**

## 4.8 Primary Receiver Sensitivity Tests TRS11

Connect a Signal Generator to the Primary Receiver RF Port and generate the appropriate input signal. Execute the commands to the maintenance port to set the radio up for Primary Receive, this will include the channel, modulation type and frequency. Execute the tests in Table 8 and verify the Bit Error Rate through the appropriate CLI commands. Note: This test should report the BER as well as the RSSI value.

| Test # | Port | Supply Voltage | Modulation | Frequency (Mhz) | Input Level (dBm) | Max (BER) |
|---|---|---|---|---|---|---|
| TRS11.1 | RX1 (PRI) | Mid Voltage | π/4 DQPSK (1/2 Rate) | 217.7125 | -111 | 1E-4 |
| TRS11.2 | | | | 219.9125 | -111 | 1E-4 |
| TRS11.3 | | 13.6V | | 221.8875 | -111 | 1E-4 |
| TRS11.4 | | | π/4 DQPSK (Full Rate) | 217.7125 | -108 | 1E-4 |
| TRS11.5 | | | | 219.9125 | -108 | 1E-4 |
| TRS11.6 | | | | 221.8875 | -108 | 1E-4 |
| TRS11.7 | | | | 217.7125 | -7 | 1E-4 |
| TRS11.8 | | | | 219.9125 | -7 | 1E-4 |
| TRS11.9 | | | | 221.8875 | -7 | 1E-4 |

Table 8 – Receiver BER TRS11

## 4.9 Simultaneous Channel Test TRS12

Connect a Signal Generator to the Primary Receiver RF Port and generate the appropriate input signal. Execute the commands to the maintenance port to set the radio up for Primary Receive, this will include the channel, modulation type and frequency. Validate each of the two (2) Base Channels for BER through the appropriate CLI commands. The tests below are performed with the Base radio powered on at the mid voltage level.

| Test # | Supply Voltage | Modulation | Frequency (Mhz) | Input Level (dBm) | Max (BER) |
|---|---|---|---|---|---|
| TRS12.1 | Mid Voltage<br>13.6V | π/4 DQPSK (Half Rate) | 219.9125 | -50 | 1E-4 |

**Table 9 – Receiver, Simultaneous Channels BER TRS12**

## 4.10 Transmit Output Power Test TRS13

Connect the Radio for TX testing per Section 3.1 Execute the commands to the maintenance port to set the radio up for Transmit, this will include the modulation type, frequency, and output power indicated in the table. For each set of inputs measure the power output and compare to the limits. Validation for low power is intended to make sure the radio meets the minimum power backoff.

| Test # | Supply Voltage | Modulation | Power Setting | Frequency (Mhz) | Min (dBm) | Max (dBm) |
|---|---|---|---|---|---|---|
| TRS13.1 | Low Voltage 10.9V | π/4 DQPSK (1/2 Rate) | 25W PEP (44.0dBm) | 217.6125 | 41 | 46 |
| TRS13.2 | | | | 219.8125 | | |
| TRS13.3 | | | | 221.9875 | | |
| TRS13.4 | | | 7.5W PEP (38.75dBm) | 219.8125 | 30 | 40.8 |
| TRS13.5 | Mid Voltage 13.6V | π/4 DQPSK (1/2 Rate) | 25W PEP (44.0dBm) | 217.6125 | 43 | 45 |
| TRS13.6 | | | | 219.8125 | | |
| TRS13.7 | | | | 221.9875 | | |
| TRS13.8 | | | 7.5W PEP (38.75dBm) | 219.8125 | 30 | 39.8 |
| TRS13.9 | High Voltage 15.5V | π/4 DQPSK (1/2 Rate) | 25W PEP (44.0dBm) | 217.6125 | 41 | 46 |
| TRS13.10 | | | | 219.8125 | | |
| TRS13.11 | | | | 221.9875 | | |
| TRS13.12 | | | 7.5W PEP (38.75dBm) | 219.8125 | 30 | 40.8 |

Table 10 – Transmit Output Power Test TRS13

## 4.11 Transmit Frequency Accuracy Test TRS14

Connect the Radio for TX testing per Section 3.1 Execute the commands to the maintenance port to set the radio up for Transmit, this will include the modulation type, frequency, and output power indicated in the table. The VSA shall be setup to demodulate the signal and provide the carrier frequency offset. The value will be converted to parts-per-million (ppm) and compared to the limits.

| Test # | Supply Voltage (VDC) | Modulation | Power Setting (PEP) | Frequency (Mhz) | Min (ppm) | Max (ppm) |
|---|---|---|---|---|---|---|
| TRS14.1 | 13.6V | π/4 DQPSK (1/2 Rate) | 25W | 217.6125 | -0. 25 | +0.25 |
| | | | | 219.8125 | -0. 25 | +0.25 |
| | | | | 221.9875 | -0. 25 | +0.25 |

Table 11 – Transmit Frequency Accuracy Test TRS14

## 4.12 Transmit Error Vector Modulation Test TRS15

Connect the Radio for TX testing per Section 3.1 Execute the commands to the maintenance port to set the radio up for Transmit, this will include the modulation type, frequency, and output power indicated in the table. The VSA shall be setup to demodulate the signal and provide the EVM. The value shall be compared to the limits.

| Test # | Supply Voltage | Modulation | Power Setting | Frequency (Mhz) | Max |
|---|---|---|---|---|---|
| TRS11.1 | Low Voltage 10.9V | π/4 DQPSK (1/2 Rate) | 25W PEP (44.0dBm) | 217.6125 | 5% RMS |
| TRS15.2 | | | | 219.8125 | |
| TRS15.3 | | | | 221.9875 | |
| TRS15.4 | | | 7.5W PEP (38.75dBm) | 219.8125 | |
| TRS15.5 | Mid Voltage 13.6V | π/4 DQPSK (1/2 Rate) | 25W PEP (44.0dBm) | 217.6125 | 5% RMS |
| TRS15.6 | | | | 219.8125 | |
| TRS15.7 | | | | 221.9875 | |
| TRS15.8 | | | 7.5W PEP (38.75dBm) | 219.8125 | |
| TRS15.9 | High Voltage 15.5V | π/4 DQPSK (1/2 Rate) | 25W PEP (44.0dBm) | 217.6125 | 5% RMS |
| TRS15.10 | | | | 219.8125 | |
| TRS15.11 | | | | 221.9875 | |
| TRS15.12 | | | 7.5W PEP (38.75dBm) | 219.8125 | |

Table 12 – Transmit Modulation Error Test TRS15

## 4.13 Transmit Sideband Spectrum TRS16

Connect the Radio for TX testing per Section 3.1 Execute the commands to the maintenance port to set the radio up for Transmit, this will include the modulation type, frequency, and output power indicated in the table. The VSA shall be setup to measure the Sideband Spectrum according to the Mask defined below. Pass/Fail is reported by the VSA. This measurement shall be done at 219.8125MHz, 25W PEP, 13.6VDC, Half-rate $\pi/4$ DQPSK. The measurement is set for Max Hold using Peak Detector, a minimum of four sweeps shall be taken.

| Frequency | Rejection |
|---|---|
| kHz | dBc |
| -100 | 72 |
| -13.75 | 72 |
| -13.75 | 65 |
| -12.25 | 35 |
| -12 | 30 |
| -12 | 0 |
| 0 | 0 |
| 12 | 0 |
| 12 | 30 |
| 12.25 | 35 |
| 13.75 | 65 |
| 13.75 | 72 |
| 100 | 72 |

**Table 13 – Transmit Sideband Spectrum Mask TRS16**

## 4.14 Adjacent Channel Power Ratio TRS17

Connect the Radio for TX testing per Section 3.1 Execute the commands to the maintenance port to set the radio up for Transmit, this will include the modulation type, frequency, and output power indicated in the table. The VSA shall be setup to measure the adjacent channel power. The value shall be compared to the limits. The measurement is taken at mid-level voltage (13.6VDC).

| Test # | Modulation | Power (PEP) | Frequency(MHz) | Min (dB) |
|---|---|---|---|---|
| TRS17.1 | π/4 DQPSK (1/2 Rate) | 25W | 219.8125 | 70 |

Table 14 – Adjacent Channel Power Ratio TRS17

## 4.15 LAN and Maintenance Ethernet Port Test TRS18

Ping the LAN and Maintenance Ethernet ports and verify a correct response with no packets lost.

## 4.16 SD Card TRS19

The SD Card interface is verified during the course of Testing and Flashing the unit. Initial boot-up of the unit is done through the application resident on the SD Card. Once the unit boots and displays the SW revisions the SD Card read operations are considered validated.

A second validation of reading from the SD Card occurs when the application is written from the SD card into the radio's FLASH.

A third verification of the SD Card occurs during the POST. The POST validates SDCARD Preset, SDCARD Fail Pin and SDCARD Access.

## 4.17 GPS TRS20

The Wayside Radio GPS connectivity and DC bias are validated through an RF check and a DC Bias measurement. Connect a bias tee to the Wayside Radio GPS Port. The bias Tee shall provide a DC Block to the RF Path and a 50mA DC load from the Wayside Radio GPS Port. The Bias Tee shall not adversely affect the RF performance of the Wayside Radio GPS.

The RF Path of the Bias Tee shall be connected to a GPS Simulator capable of simulating at least 4 GPS satellite signals. Enable the GPS Simulator at a level of -130 dBm and send the CLI commands to the radio that enable GPS Messaging. The GPS Messages are parsed for the C/No ratio of the satellites and GPS Fix. The test shall be considered a pass if the GPS has a fix at -130 dBm.

The GPS DC Loading is also verified during DUT test. A Bias tee is used to provide a 50 mA load on the GPS DC output. The voltage across this load shall be 2.5V +/- 10%.

## 4.18 Temperature Sampling

A 10% sampling of PP1 radios will be tested at the temperature extremes of -40C and 70C. The tests outlined in section 5 of this document will be executed at the temperature extremes with the parametric deviations listed in the table below. Hipot, and ground continuity are not part of the Temperature testing.

The radios will be put into a temperature chamber and remain unpowered while the oven is ramped to either extreme. The units shall be soaked a minimum of two hours at the dwell temperature The radios will be put into a temperature chamber and remain unpowered while the oven is ramped to either extreme. The units shall be soaked a minimum of two hours at the dwell temperature. Continue to soak the units until the first powered up radio's Master Board device temperature is within +/-3 degrees of the target temperature. Table 15 provides the de-rating allowed at the temperature extremes.

Note that the specification for Tx ACPR and Tx Sideband Spectrum are not defined at the temperature extremes. Data will be collected on ACPR and any Tx Sideband Spectrum Failures.

| Specification | Nom Limit | DFS | OverTemp Limit |
|---|---|---|---|
| Rx Sensitivity (Half Rate) | -111dBm | 6dB | -105dBm |
| Rx Sensitivity (Full Rate) | -108dBm | 6dB | -102dBm |
| Rx Error Behavior At High | -7dBm | ND | ND |
| Tx Output Pwr (TRS16) | 25WPEP (44.0 dBm)<br><br>7.5WPEP (38.75 dBm) | +2/-3 dB | 41.0 – 46.0 dBm<br><br>30 – 40.75 dBm |
| Tx Frequency Accuracy (TRS17) | +/-0.25ppm[1] | ND | +/-1.5ppm |
| Tx EVM (TRS12) | 3% | ND | ND |
| Tx Sideband Spectrum (TRS19) | Table | ND | ND |
| Tx ACR (TRS20) | 70 dB | ND | ND |

Table 15 – DFS for Temperature Testing

1 – Note that the +/-0.25ppm Accuracy is for tuning and the specification for accuracy for the radio is +/-1.5ppm

## 4.19 ESS

TBD

## 4.20 Ground Continuity TRS21

A fully assembled Wayside Radio shall be tested for ground continuity by measuring the resistance between several contact points on the radio. The table below outlines the contact points and maximum allowable resistance.

| Test# | Chassis Contact Points | Limit |
|---|---|---|
| TRS21.1 | Ground Stud to ANT outer barrel. | < 1.0 Ω |
| TRS21.2 | Ground Stud to GPS outer barrel. | < 1.0 Ω |
| TRS21.3 | Ground Stud to CIM knobs. CIM panel must be securely closed. | < 1.0 Ω |

Table 16 – Ground Continuity Test Points TRS21

## 4.21 HiPot TRS22

The Wayside Radio is not subject to Hipot testing.