



ITCR 1.0 PP-2 Radio Manufacturing Acceptance (First Article) Test Report

Final Report

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1. Introduction

This document contains the results of the Hardware Acceptance Plan tests for the Meteorcomm (MCC) 220 MHz Positive Train Control (PTC) PP-2 radios manufactured by CalAmp. The radio tests were based on the *Field Radio 3 Joint Engineering Test Acceptance Plan*, DCN 00001530-A, which provides criteria for evaluating radio performance and performed according to *Radio Hardware Performance Test Procedures*, DCN 00001434-A.

Throughout this report, the radios are noted as PP-2, which stands for 2nd Pre-production (PP-2).

Tests were conducted on the following radios:

- 5 PP-2 Locomotive radios
- 5 PP-2 Base radios
- 5 PP-2 Wayside radios

1.1 Background

PTC radios have gone through several stages of development: prototype, Field 1, Field 2, Field 3, pre-production, and production. With each iteration of the radio, MCC executes acceptance test plans to characterize radio performance and ensure that the radios comply with the *ITC 220 MHz Radio Hardware Specification*.

This document contains the results of tests relating to the PP-2 radios manufactured by CalAmp.

The following test results demonstrate the progress being made in building/producing radios that meet all specifications.

1.2 Document organization

This final report summarizes the results of the engineering testing and is organized as follows:

- The Executive Summary summarizes the testing results.
- The General section provides testing information on the voltage and temperature conditions.
- Appendix A is a list of the specific test reports for each radio and configuration.

1.3 References

- *ITC 220 MHz Radio Hardware Specification, 1.3*, DCN 00001040-E
- *Field Radio 3 Joint Engineering Test Acceptance Plan*, DCN 00001530-A
- *ITC 1.0 220 MHz Radio Hardware Performance Test Procedures*, DCN 00001434-A

1.4 Acronyms

Acronym	Description
ACPR	Adjacent Channel Power Ratio
ADC	Analog to Digital Conversion
BER	Bit Error Ratio
C4FM	Compatible 4-ary frequency modulation
CR	Change Request
DCN	Document Control Number
DQPSK	Differential Quadrature Phase Shift Keying
EIT	Enterprise Issue Tracker
ESTI	European Telecommunications Standards Institute
F2 / F3	Field radio 2 / Field radio 3
FCAL	Frequency Calibration
FRAP	Field Radio Acceptance Plan
GPS	Global Positioning System
HW	Hardware
ITC	Interoperative Train Control
JET	Joint Engineering Test
LNA	Low Noise Amplifier
MB3	Master Board 3
MCC	Meteorcomm
OCXO	Oven Controlled Crystal Oscillator
PCB	Printed Circuit Board
PP-1	1 st Pre-Production radio
PTC	Positive Train Control
Rally	MCC's defect tracking system
RCT	RMAC Communication Team
RMAC	Risk Management Advisory Committee
RX	Receive or Receiver
TCXO	Temperature Compensated Crystal Oscillator
TIA	Telecommunications Industry Association
TX	Transmit or Transmitter
VDC	Voltage Direct Current
VSWR	Voltage Standing Wave Ratio

2. Executive summary

In summary, the testing results demonstrate continued improvement in radio performance. In nearly all cases, the radios are meeting, and in some cases exceeding, radio performance specifications. A few issues have been identified that need addressing. In some cases, specifications have been updated.

Issues uncovered during acceptance testing are outlined in Table 1 and tracked in the Enterprise Issue Tracker (EIT). Software and/or firmware defects are tracked in Rally (DENNN). The following tables reference the tracking and/or defect number for each issue.

Table 1: Summary of issues

Radio	Issues	Impact	Action	Tracking #
Wayside, Base, and Locomotive	Radio failed to meet earlier Spurious Response Rejection specification.	Low probability of system impact.	A hardware filter modification has been implemented on all radios to improve analog to digital conversion. The Hardware specification also has since been changed from 70 dB to 65 dB.	TS293
Locomotive Radio	Radio failed to transmit at high temperature, poor ACPR at room temperature.	Radio may not transmit at high temperature.	Root-caused to a single isolated component failure. A manufacturing screen was put in place to catch any possible additional failures.	DE 1521

Radio	Issues	Impact	Action	Tracking #
Wayside, Base, and Locomotive	Base, Locomotive, radio not meeting target of 65 dB RX Adjacent Channel Selectivity: Like Interferer.	Possible unwanted interference affecting radio receiver performance.	Updated specification for like interferer.	RX Adjacent Channel Selectivity: Like Interferer EIT -310
Wayside, Base, and Locomotive	Base, Locomotive, and Wayside radio not meeting blocking and intermodulation	Interference from other sources may degrade radio performance.	Blocking Specification changed to 80 dB for Full Rate and 77 dB for Half Rate. The Inter-modulation Response Rejection specification has been updated to 65 dB for Base and Locomotive radios. Production screen implemented for NMIMR.	RX Intermodulation Response Rejection - EIT573 RX Blocking EIT -371

3. Radio performance measurements

Tests were conducted to evaluate the ability of the radios to transmit and receive within specific parameters defined above (*ITC 220 MHz Radio Hardware Specification, 1.3*, DCN 00001040-E). Tests were made under normal and corner (or extreme), conditions for voltage and temperature.

3.1 General

Table 2 lists the normal and high/low voltage and temperature corner conditions used for the radio tests.

Table 2: Radio test conditions

Radio	Normal Condition +25°C	Corner Conditions -30°C / +70°C
Base	24.0 VDC	21 VDC / 42 VDC
	48.0 VDC	27 VDC / 54 VDC
Radio	Normal Condition +25°C	Corner Conditions -40°C / +70°C
Locomotive	74.0 VDC	45 VDC / 100 VDC
Wayside	13.6 VDC	10.9 VDC / 15.5 VDC

3.2 PP-2 Radio performance test results

Table 3 and Table 4 describe the evaluation test results for transmitter and receiver radio parametric tests, respectively, conducted on the PP-2 radios.

Table 3: Transmitter Radio test results

TX Test	Wayside	Base	Locomotive
Conducted Carrier Output Power	PASS	PASS	PASS
Error Vector Magnitude	PASS	PASS	PASS
Sideband Spectrum	PASS	PASS	PASS
Carrier Frequency Stability	PASS	PASS	PASS
Conducted Spurious Emissions	PASS	PASS	PASS
Adjacent Channel Power Ratio	PASS	PASS	FAIL ¹
Stability into VSWR	PASS	PASS	PASS
Inter-modulation Attenuation (Base Radio only)	NA	PASS	NA

Note:

1. Evaluation determined that the root cause of Adjacent Channel Power ratio failure was a single isolated component failure and logged in Rally as DE1521. Subsequently a manufacturing screen was put in place to catch any possible additional failures.

Table 4: Receiver Radio Test Results

RX Test	Wayside	Base	Locomotive
Static Reference Sensitivity	PASS	PASS	PASS
Co-channel Rejection Type 1	PASS	PASS	PASS
Co-channel Rejection Type 2	PASS	PASS	PASS
Adjacent Channel Selectivity	FAIL ¹	PASS	FAIL ¹
Blocking	FAIL ²	FAIL ²	FAIL ²
Inter-modulation Response Rejection	PASS	FAIL ^{2,3}	FAIL ^{2,3}
Spurious Response Rejection	PASS	FAIL ⁴	PASS
Noise Floor Scan	PASS	PASS	PASS
Conducted Spurious Output Power	PASS	PASS	PASS
GPS Receiver Sensitivity	PASS	PASS	PASS
Error Behavior at High Input Level	PASS	PASS	PASS

Note:

1. Radios failed due to not meeting earlier specification of 65 dB RX Adjacent Channel Selectivity on two frequencies. This issue had been previously identified on earlier radio versions and documented as EIT 310. The Hardware Specification has since been updated and Adjacent Channel Selectivity changed to 63 dB for specific victim channel frequencies 219.1875 MHz and 219.2125 MHz.

2. Radios failed to meet earlier Blocking and Inter-modulation Response Rejection specification. These issues had been previously identified on earlier radio versions and documented as EIT 371. The Hardware Specification has since been updated and Blocking Specification changed to 80 dB for Full Rate and 77 dB for Half Rate. The Inter-modulation Response Rejection specification has been updated to 65 dB for Base and Locomotive radios.

3. Radios failed to meet earlier Inter-modulation Response (IMR) specification due to a non-monotonic response on some radios, documented as EIT 573. Production tests have since been updated to screen out any radios with this issue.

4. Radios failed to meet earlier Spurious Response Rejection specification. A hardware filter modification has been implemented on all radios to improve analog to digital conversion. The Hardware specification also has since been changed from 70 db to 65 dB.

APPENDIX A

The following documents show detailed accountings of the tests and can be found on Rally:

- TS 262 CalAmp Wayside Manufacturing Acceptance Test
- TS 273 CalAmp Locomotive Radio Manufacturing Acceptance Test
- TS282 CalAmp Wayside Rev. F Manufacturing Acceptance Test
- TS292 CalAmp Base 24V Radio Manufacturing Acceptance Test - Transmit
- TS293 CalAmp Base 24V Radio Manufacturing Acceptance Test - Receive
- TS298 CalAmp Base 48V Radio Manufacturing Acceptance Test - Transmit
- TS459 PP2 Base and Locomotive Filter Modification - Version 7