ITC 1.0 Radio Manufacturing Test Plan (PP1/PP2): Wayside, Base, and Locomotive

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Revision History

Revision	Date	Summary of Changes
1.0	01/04/2013	First draft of FRA grant document 2648-A
2.0	01/21/2013	Revised to reflect PP1/PP2 builds, rtl Redo

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1. Introduction

1.1 Purpose

This document outlines the test strategy and testing required for the PP1/PP2 ITC Wayside Radio, Base Radio, and the Locomotive Radio at the Contract Manufacturers (CM). The testing is based on demonstrating that each product shipped from the CM is properly configured and calibrated, meets product specifications, and is free of defects.

1.2 Scope

This test plan addresses the testing of the UUT during and following the manufacturing process. The tests outlined with this document are intended to detect process problems within manufacturing. These tests are not intended to be "type" tests. (Note: Type tests are defined as tests, which are intended to be one-time test of a representative product that will be manufactured. Type tests are typically performed for either design verification or for certification evaluation). Therefore, embedded product software and algorithms are not tested by the test methods outlined within this test plan. However, the unit test does check functionality of the software in the product.

1.3 References

Table 1: References

Description	Document Number
Base Manufacturing Test Requirements Specification	00002627-A
ITC Base Station Radio Product Description	00001064-A
ITC Locomotive Radio Product Description	00001065-A
ITC Wayside Radio Product Description	00001063-A
ITC 220MHz Radio Functional Product Specification – Product Release	00002575-A (formerly 00001056-A)
ITC 220MHz Radio Hardware Specification – Product Release 1.0	00002585-A (formerly 00001040-A)
ITC 220MHz Radio System Architecture Specification	00002542-A (formerly 00001049-C)
Locomotive Manufacturing Test Requirements Specification	00002626-A
Test Strategy Development	00002635-A
Wayside Radio Manufacturing Test Requirements Specification	00002617-A

1.4 Acronyms and Definitions

Table 2: Acronyms and Definitions

Acronym/Term	Term	Definition
AOI	Automated Optical Inspection	
AQL	Acceptable Quality Limit	
AXI	Automated X-Ray Inspection Laminography	
BOM	Build Of Material	
BST	Boundary Scan Test	
CM	Contract Manufacturer	
EMS	Electronic Manufacturing Services	

Acronym/Term	Term	Definition
FPT	Flying Probe Test	
HW	Hardware	
IQA	Incoming Quality Assurance	
ITC	Interoperable Train Control	
MCC	Meteorcomm, LLC	This also includes design partners.
MCC TE	Meteorcomm Test Engineering	
OBA	Out of Box Audit	
OEM	Original Equipment Manufacturer	
ORT	On-going Reliability Test	
PA	Power Amplifier	
PCBA	Printed Circuit Board Assembly	Same as PWA (Printed Wire Assembly)
PCBA-FT	PCBA Functional Test	
PCB	Printed Circuit Board	Same as PWL (Printed Wire List)
PEP	Peak Envelope Power	
POST	Power On Self Test	
PP1	Pre Production 1 build	
PP2	Pre Production 2 build	
PWA	Printed Wire Assembly	
PCA	Printed Circuit Assembly	
QA	Quality Assurance	
SW	Software	
TBD	To Be Decided	
TE	Test Engineering	
TCXO	Temperature Compensated Oscillator	
UUT	Unit Under Test	

1.5 Product Overview

The PP1/PP2 products to be manufactured and tested at the CM will be the Wayside Radio, Base Radio, and the Locomotive Radio.

1.5.1 Major Components

Table 3: Product Component Summary

Product	ID	Major Components	Notes
Wayside Radio	1	Master PCBA	Different bare board than Base and Locomotive Radio
	2	T-R Switch/LPF PCBA	
	3	RF/DC Power PCBA	13.6VDC Input
	4	RF PA Module	Module mounted on the chassis
Base Radio	1	*Master PCBA	Uses same bare board as Locomotive with different component stuffing option.
	2	Front End PCBA	
	3	PA-Mod PCBA	
	4	*LED PCBA	Uses same bare board as Locomotive
	5	Ethernet PCBA	Final assembly uses two
	6A	24V Power Supply Assembly	Base Radio is assembled with either 24VDC or 48VDC supply.
	6B	48V Power Supply Assembly	
Locomotive Radio	1	*Master PCBA	Uses same bare board as Base Radio with different component stuffing option.
	2	Front End PCBA	
	3	PA-Mod PCBA	
	4	*LED PCBA	Uses same bare board as Base Radio
	5	Power Supply	+74 VDC Input

* Bare board is common in Base and Locomotive Radio with different BOM.

2. Test Strategy

The test strategy for the ITC Wayside Radio, Base Radio, and the Locomotive Radio is based on demonstrating that each product shipped to our customers is properly configured and calibrated, meets product

specifications, and is free of defects. To achieve this strategy, several test schemas are integrated in a hierarchy fashion progressing from the component level to the system level as the product passes through the production process phases.

Appropriate test locations will be identified within the production flow to define the optimum combination of tests to apply. The objective is to detect faults at the lowest possible level, preventing defects from reaching the next assembly, where detection is more difficult and the consequences of failure more severe.

2.1 Test Team

2.1.1 Test Team Composition

Manufacturing test systems will be developed by a team composed of MCC (including design teams), CM, and third party test system vendor personnel. While all parties will share accountability for various aspects of the project, ultimate ownership and leadership will reside with MCC personnel.

- MCC will own all Manufacturing Test Requirement Specification (TRS) documents.
- MCC will oversee test engineering activities and manage the overall project.

2.1.2 Test Team Roles and Responsibilities

All team members will work together to architect an end to end solution that best meets the project's needs, given all schedule, budget, and technical considerations. Project needs will be evaluated against the known available resources at MCC, CMs, contractors and third party vendors. A gap analysis will be provided to map residual open areas to new resources.

- All MCC personnel will work together to manage a host of outside resources working on each test stage to help with test system HW/SW development, documentation, etc.

Table 4: Test Activities and Deliverables

Test	Team	Activities	Deliverables
Bare Board Testing	CM Board house	CM will coordinate board house to have 100% bare board test. CM will coordinate board house to implement controlled impedance testing on a QA sample.	Boards are tested prior to component placement.
AOI	CM	CM develops AOI testing and data collection system.	AOI test and data collection in place at factory.
AXI	CM	CM develops AXI testing and data collection system.	AXI test and data collection in place at factory.
IQA	CM	CM may develop tests for subassemblies if needed. CM finds location to archive C of C.	Established IQA Inspection in place at factory.
Programming Devices	CM	CPLD & FLASH memory are preprogrammed prior to attachment to bare board.	CPLD & FLASH memory comes preprogrammed for board assembly in production line.

Test	Team	Activities	Deliverables
Flying Probe Test (FPT)	CM	CM generates FPT program for shorts, opens, components, etc.	FPT Test and data collection in place for preproduction build.
Boundary Scan Test (BST)	3rd party with JTAG Boundary Scan Expertise	Develops JTAG BST for Wayside, Base, and Locomotive Master boards.	Standalone station for JTAG Boundary Scan Testing.
PCBA-Functional Test (PCBA-FT)	CM	Implement test on production line.	PCBA-FT and data collection in place for preproduction build. PCBA-FT to be validated during preproduction build. BOM, schematics, software, and documentation on building PCBA-FT testers.
	MCC	Outlines test and methodology to be performed at PCBA-FT Test. Build automated test system using off the shelf equipment and test software. Automated test system needs to be developed using older PCBA versions. Assist CM on test implementation on production line.	
PA Bias Calibration	CM	Implement tests on production line.	PA Bias Calibration in place for preproduction build.
	MCC	Outlines test and methodology to be performed at PA Bias calibration. Assist CM on test implementation on production line.	
Hipot Test and Ground Test	CM	Implement tests on production line.	Hipot/Ground Test and data collection in place for preproduction build.
	MCC	Outlines test and methodology to be performed at Hipot Test and Ground Test. These may be manual tests. Assist CM on test implementation on production line.	

Test	Team	Activities	Deliverables
Unit Test	CM	Implement test on production line.	Unit Test and data collection in place for preproduction build. Unit Test to be validated during preproduction build. BOM, schematics, software, and documentation on building Unit Test testers.
	MCC	Outlines test and methodology to be performed at Unit Test. Build automated test system (ATS) using off the shelf equipment and test software. Automated test system needs to be developed using older radio version. Assist CM on test implementation on production line.	
Environmental Stress Screen (ESS)	CM	Provide space, power, and compress air to implement test on production line.	Stress Screen and data collection in place for preproduction build. Stress Screen to be validated during preproduction build. BOM, schematics, software, and documentation on building test system used in Stress Screen.
	MCC	Outlines test and methodology to be performed at Stress Screen. Implement Stress Screen using test system using off the shelf equipment and test software. Assist CM on test implementation on production line.	
Out of Box Audit (OBA)	CM	Develop OBA with MCC Test Engineer.	OBA and data collection in place for preproduction build.
	MCC Test Engineer	Works with CM to develop a final version.	

2.2 General Requirements

2.2.1 Test System General Requirements

- Test systems will be developed and implemented concurrent to the product development.
- Test systems will use off the shelf equipment and software.
- Test system design will be robust. All cables used for interfacing the UUT to the test system can be easily replaced without opening the test system.
- Test Equipment used in measurements should have sufficient accuracy to make the measurements.
  - Test System Documentation should be in a hierarchical approach to facilitate ease of readability and to facilitate easy duplication of Test System.
    - Complete BOMs
    - Mechanical drawings
    - Schematics
    - Calibration/Verification procedures
    - Software and development environment
  - Test System Validation report should include the following:

    Requirements and Test Limit Verification

    - Verify operator needs to be trained and certified.
    - Verify tests are checked against MCC Manufacturing Test Requirement Specification (TRS).
    - Verify instrument accuracy and range meets the test limit tolerance.
    - Order of test steps is adequate to produce good units.

    Equipment Installation/Qualification

    - Calibration, verification, maintenance documentation is released.
    - Specifications and drawings for test equipment and fixtures are released.
    - Software is released.

Performance Qualification

- Test system, test equipment, and test fixtures are calibrated and under calibration control.
- Test system is executing correct software revision and configuration.
- Verify integrity of automated test measurement with external test equipment.
- Verify Repeatability & Reproducibility – Gage Repeatability and Reproducibility (GRR) – consider sample size, Pass/Fail criteria.
- Verify Test Challenge – Verify Test system can identify failures (fault insertion).

- Test equipment capacity will be sufficent to meet PP1/PP2 build schedule.
- All Test data (e.g. manual and automated tests) will be captured electronically. Test data will include operation, test steps, values, pass/fail, test system ID, test operator ID, pallet ID (as applicable), etc.
- CM Shop Floor Control will control the flow of product through Work In Progress (WIP).
- Verify Product handling equipment (trays to hold unit in place during test) does not cause scratches or cosmetic damage.

2.2.2 Assumptions

- PCBAs and Radio units are available for test development.
- CM will use older PCBAs and Radios F1/F2 versions for initial test development.
- PCBA CAD and assembly drawings are available for AOI, AXI, FPT and Board Functional Test development. Assembly drawings and product specifications are available for Unit Test.

2.3 Return and Repair (RnR)

2.3.1 Return and Repair (RnR)

The returns process will not be available at PP1/PP2 launch. The remanufacturing processes may be developed after initial production

launch. The CM will determine Remanufacturing devices will be sent to the production area where they will be disassembled or reassembled, as necessary, on a dedicated remanufacturing station. The CM Manufacturing Engineering will establish processes for handling returned new and used products.

3. Manufacturing Test Descriptions

The primary purpose of the identified test methods is to provide information about the manufacturing process. Each test method will accomplish this as follows:

3.1 Incoming Quality Assurance

Performed at: The CM

Implemented by: The CM

Incoming Quality Assurance (IQA) tests certain received components and sub-assemblies to assure they are within manufacturer's specifications. This testing is typically performed on a sample Acceptable Quality Limit (AQL) basis. Alternately, IQA may receive tested components from manufacturers with a Certification of Compliance (C of C) or Certification of Analysis (C of A) providing proof of testing. CM must have a data retention plan that MCC reviews.

3.1.1 Wayside Radio

- Tested RF PA Modules, with C of C and test data for each module, shall be provided by the vendor. The C of C and test data will be archived.

3.1.2 Base Radio

- Tested DC to DC Power Modules (24 VDC=>28 VDC), with C of C and test data for each module, shall be provided by the vendor. The DC to DC Power Modules are used in the 24V Power Supply board. The C of C and test data will be archived.
- Tested DC to DC Power Modules (48 VDC=>28 VDC), with C of C and test data for each module, shall be provided by the vendor. The DC to DC

Power Modules are used in the 48V Power Supply board. The C of C and test data will be archived.

3.1.3 Locomotive Radio

- Tested DC to DC Power Modules (72 VDC=>28 VDC), with C of C and test data for each module, shall be provided by the vendor. The DC to DC Power Modules are used in the Power Supply board. The C of C and test data will be archived.

3.2 Test Summary

Table 5: Summary of Tests

ID	Major Components	Certificate of Compliance	Bare Board Electrical Net (100% sample)	Controlled Impedance (AQL% sample)	*Automated Optical Inspection (AOI) (100% sample)	*Automated X-Ray Inspection (AXI) (100% sample)	*Flying Probe Test (FPT) (100%)	JTAG Boundary Scan (100%)	PCBA Functional Test (100%)	PA Bias Calibration (100%)	Hipot Test (100%)	Ground Test (100%)	Unit Test (100%)	Environmental Stress Screen(ESS) (AQL% sample)	Out of Box Audit (OBA) (AQL% sample)
	Wayside Radio														
1	Master PCBA		X	X	X	X	X	X	X						
2	T-R Switch/LPF PCBA		X	X	X										
3	RF/DC Power PCBA		X	X	X										
4	RF PA Module	X													
5	Sub Assembly									X					
6	Final Assembly											X	X	X	X
	Base Radio														
1	Master PCBA		X	X	X	X	X	X	X						
2	Front End PCBA		X	X	X										
3	PA-Mod PCBA		X	X	X										
4	LED PCBA		X	X	X										
5	Ethernet PCBA		X	X	X										
6A	24V Power Supply PCBA		X	X	X				X						
6B	48V Power Supply PCBA		X	X	X				X						
7	Sub Assembly									X					
8	Final Assembly											X	X	X	X

ID	Major Components	Certificate of Compliance	Bare Board Electrical Net (100% sample)	Controlled Impedance (AQL% sample)	*Automated Optical Inspection (AOI) (100% sample)	*Automated X-Ray Inspection (AXI) (100% sample)	*Flying Probe Test (FPT) (100%)	JTAG Boundary Scan (100%)	PCBA Functional Test (100%)	PA Bias Calibration (100%)	Hipot Test (100%)	Ground Test (100%)	Unit Test (100%)	Environmental Stress Screen(ESS) (AQL% sample)	Out of Box Audit (OBA) (AQL% sample)
	Wayside Radio														
	Locomotive Radio														
1	Master PCBA		X	X	X	X	X	X	X						
2	Front End PCBA		X	X	X										
3	PA-Mod PCBA		X	X	X										
4	LED PCBA		X	X	X										
5	Power Supply		X	X	X										
6	Sub Assembly									X					
7	Final Assembly										X	X	X	X	X

Notes:

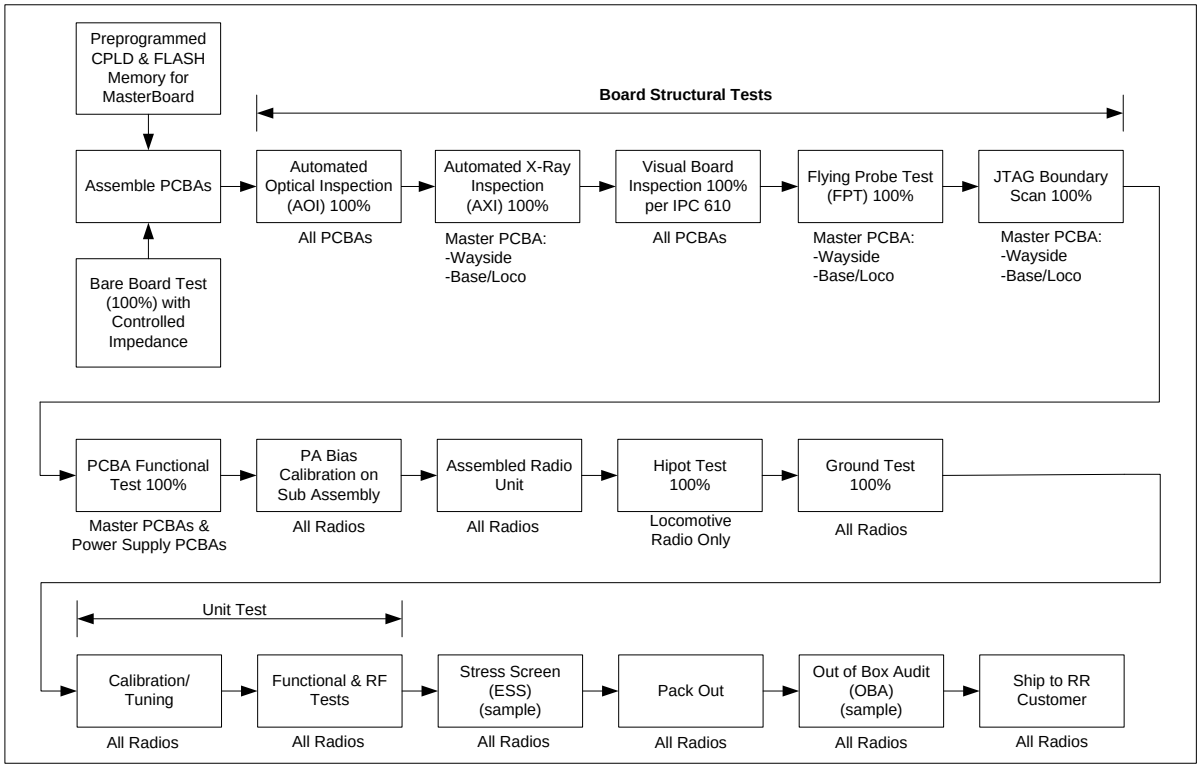
1) * AOI, Xray, and FPT to be balanced for test coverage for PCBA structural defect coverage.

2) 3D X-Ray for BGAs and similar devices only

3) Master PCBAs to get FPT testing 100%, including JTAG

4) All connectors and indicators must be tested at the device level for proper function

Figure 1: Product Flow Chart



3.3 Bare Board Testing

Performed at: The CM/OEM board supplier's factory

Test Coverage: MCC board drawings calls out test requirements

Implemented by: The CM or OEM board supplier

- Testing is performed on all bare boards to confirm no shorts/open on board's electrical net.
- Testing of controlled impedance, using IPC 2141A, on the bare boards will be conducted on a QA sample basis.
- Refer to Table 5: Summary of Tests for complete listing of boards for testing.

3.4 Automated Optical Inspection (AOI) & Visual Inspection

Performed at: The CM

Test Coverage: Provided by the CM

Implemented by: The CM

Automated Optical Testing shall be performed on populated Printed Circuit Board Assemblies (PCBAs). Visual inspection, per IPC 610, Class 2, will be performed on all boards with fine pitch SMT components.

- Refer to Table 5: Summary of Tests for complete listing of boards for testing.
- CM will provide test coverage report.

3.5 Automated X-Ray Inspection (AXI) Laminography

Performed at: The CM

Test Coverage: Provided by the CM

Implemented by: The CM

Automated X-Ray Laminography shall be performed on populated Printed Circuit Board Assemblies (PCBAs) containing Ball Grid Array (BGA) components where visual inspection is limited. 3-D X-Ray is preferred. From previous Engineering builds, 2-D AXI was not able to detect all unconnected connections on Ball Grid Array devices.

- Master Boards for Wayside, Base, and Locomotive Radios shall require AXI.
- CM will provide test coverage report.

3.6 Flying Probe Test (FPT)

Performed at: The CM

Test Coverage: Provided by the CM

Implemented by: The CM

- Flying Probe Test (FPT) shall be performed on populated Master Board Printed Circuit Board Assemblies (PCBAs) to determine shorts/open, wrong components, part orientation, and component value tolerance.
- Master Boards for Wayside, Base, and Locomotive Radios shall require FPT.

3.7 JTAG Boundary Scan Station

Performed at: The CM

Test Coverage: JTAG test program is developed by 3rd party vendor.

Implemented by: The CM

- JTAG Boundary Scan Test will be implemented on a standalone station.
- Boundary Scan tests may be performed at ICT to confirm ICs, with high pin count, to determine shorts/opens and interconnectivity where nail access is limited. These devices include the Coldfire Microprocessor, DSP, FPGA, and CPLD on the Master board.

3.8 PCBA Functional Test (PCBA FT)

Performed at: The CM.

TRS: Developed by MCC

Implemented by: MCC

Board Functional Testing is used to detect parametric faults that are not detectable using static test methods such as FPT. This method of testing typically uses a Hot Mock Up fixture, however, application and measurement of signals should be performed through edge connectors on the circuit board where possible.

The TRS documentation shall provide test limits and pass/fail criteria.

3.8.1 Wayside PCBA Functional Tests

- Master PCBA
  - Verify Power Rail voltages
  - Verify PCBA current draw
  - Verify Power ON Self Test (POST) passes
  - Verify Clocks
  - Verify Ethernet Ports Functionality and LED Indicators
  - Verify SD Card Port
  - Verify External LEDs indicators
  - Verify Temperature Sensor circuitry
  - Temperature Compensated Oscillator (TCXO) calibration

3.8.2 Base/Locomotive Radio PCBA Functional Tests

- Master PCBA – Base/Locomotive Radio
  - Verify Power Rail voltages
  - Verify PCBA current draw
  - Verify Power ON Self Test (POST) passes
  - Verify Clocks
  - Verify Ethernet Ports Functionality and LED Indicators
  - Verify SD Card Port
  - Verify LED Display Board Interface
  - Verify Temperature Sensor circuitry
- Power Supply PCBA – 74V Locomotive Radio, 24V and 48V Base Radio
  - Verify Power Supply current draw
  - Verify 28V Supply regulation
  - Verify 12V Supply regulation
  - Verify Temperature sensor circuits: 12V and 28V converters

3.9 PA Bias Calibration

Performed at: The CM.

TRS: Developed by MCC

Implemented by: MCC

The PA board and power supply board are assembled into a subassembly. The PA Bias Calibration is used to set the RF Power Amplifier (PA) at quiescent operating condition.

The TRS documentation shall provide test limits and pass/fail criteria.

3.9.1 Wayside PA Bias Calibration

- The RF/DC Board Bias Level is adjusted for an open loop PA condition.

3.9.2 Base/Locomotive Radio PA Bias

- The PA/Mod IDQ currents will be adjusted for a quiescent

3.10 Hipot Test and Ground Test

Performed at: The CM

TRS: Developed by MCC

Implemented by: MCC

The purpose of the Hipot test is to ensure a good isolation between the parts of a circuit. Having good isolation helps to guarantee the safety and quality of electrical circuits. Hipot tests are helpful in finding nicked or crushed insulation, stray wire strands or braided shielding, conductive or corrosive contaminants around the conductors, terminal spacing problems, and tolerance errors in IDC cables. All of these conditions might cause a UUT to fail.

The purpose of a Ground test is to ensure any exposed metal on the chassis (screws, connectors, etc.) is electrically connected.

The TRS documentation shall provide test limits and pass/fail criteria.

- Wayside Radio: Hipot Testing is not required. Ground Testing is performed on a buttoned up Unit.
- Base Radio: Hipot Testing is not required. Ground Testing is performed on a buttoned up Unit.
- Locomotive Radio: Hipot Testing and Ground Testing are required. Hipot Testing is performed on Unit that has buttoned up after its Calibration/Tuning step. Testing will continue to confirm no damage occurred to the Unit after Hipot Testing.

3.11 Unit Test

Performed at: The CM

TRS: Developed by MCC

Implemented by: MCC

The radio at this stage is a final assembly unit. This test is used to detect interconnect errors between circuit boards and subassemblies, and to detect problems due to interactions between circuits. Calibration steps are also performed to setup the Transmitter RF output and frequency.

The testing at the unit level at the CM site is necessary to find defects not observable at any type of board level testing.

The TRS documentation shall provide test limits and pass/fail criteria.

3.11.1 Calibration/Tuning

- Wayside Radio Calibration/Tuning
  - Output RF power is calibrated.
  - The Peak Envelope Power (PEP) is measured and calibration constants recorded.
- Base/Locomotive Radio Calibration/Tuning
  - An open loop PA check and closed loop PA check is performed to include a quick power on/current draw test and to measure the RF output power with DQPSK modulation transmission.

- The LO leakage tuning involves tuning the IDC and QDC baseband tuning parameters until the desired LO leakage is achieved. The calibration value is stored in the Master board.
- The CML phase tuning involves adjusting the CML phase until the desired result is achieved. The calibration value is stored in the Master board.
- The power output tuning involves adjusting the I and Q gain values until the desired power output is achieved. The calibration value is stored in the Master board.
- The reference clock tuning involves adjusting the XO setting until the desired relative frequency error is achieved. The calibration value is stored in the Master board.

3.11.2 Functional Tests

- Power consumption
- Communication Ports (E-net)
- GPS receiver interface
- LED Display
- MAC EEPROM
- PA/MOD board ADC
- SPI interface checkout
- SD-Card interface
- Fan functionality (Base Radio Only)
- Temperature Sensors

3.11.3 Radio Transmitter Tests

- Conducted Carrier Output Power
- Carrier Frequency Stability (TCXO calibration(Board))
- Sideband Spectrum
- Adjacent Channel Power Ratio
- Transmitter Current Drain
- Modulation Accuracy / Error Vector Magnitude

3.11.4 Radio Receiver Tests

- Static Reference Sensitivity
- Error Behavior at high input levels

3.12 Environmental Stress Screen

Performed at: The CM

TRS: Developed by MCC

Implemented by: MCC

Stress Screen is a process performed on sub-assemblies and/or completed units to prevent latent (hidden) defects from reaching the customer. These defects typically involve a stress concentrator, which is why they will become Out-of-Box or Early-life (first 90 days) failures. By applying stress (much greater than shipping and initial use), these latent defects get precipitated and become patent (visible) to test. Without stress, they may remain hidden to factory test and be found by customers.

OEM modules may contain latent defects. PCB assemblies may be susceptible to damage from shipping, storage, and handling. Highly stressed components (high voltage or high current) typically do not have huge design margin; they are not able to be sufficiently derated. Variations in strength from batch to batch may cause some weak components to escape into our supply chain. Additionally, manufacturing assembly defects can be inserted by our own processes.

Mechanical defects such as bad solder joints or loose hardware require temperature cycles and/or vibration to exercise them to failure. Electrical tolerance stack ups and insufficient margins require worst case operational conditions, at elevated temperature. An efficient Stress Screen combines the stresses that target a particular product's susceptibilities.

Stress Screen may include the following tests to the UUT:

- Temperature cycling
- Vibration Testing
- Transmit into RF Load
- Receiver testing – Set up to receive data and check Bit Error Rate (BER)
- Exercise Ethernet communications

3.13 Out of Box Audit (OBA)

Performed at: The CM

Test Coverage: Developed jointly by MCC and CM

Implemented by: The CM

The purpose of the OBA is to ensure the unit has gone through all the manufacturing or test process, the unit has passed through all the test process, and the unit is in good quality. The audit may include the following steps:

- Unit checks
  - Confirm unit has passed through the test process
  - Power up Unit to confirm POST passed
  - Verify software version and configuration is properly loaded
  - Verify LED Display
  - Verify SD-Card
  - Verify Fan functionality (Base Radio Only)
  - Verify Labels has been placed in proper location on Unit
  - Verify no cosmetic defects, cracks, and contaminants on unit
  - Verify no rattling of loose components when Unit is shaken
- Shipping package
  - Items are placed in proper location
  - Contains correct manuals and documentation
  - Contains correct accessories, tools, etc.
  - Labels from unit match labels outside of box

3.14 Data Base

- Collects all test data in Unit Test
  - Retrieve test data on a Unit
  - Test data can be exported to Excel
- Data can be used to perform standard analysis
  - Statistical Analysis: Cpk, StdDev, Mean, etc.
  - Failure Pareto charts
  - First Pass Yields, Second Pass Yields
- Integrates with CM Shop Floor Control system