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Identifier	Version	Author
NDHF1405-128215	2.0	Scott Straka

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APPROVALS

Signed By	Responsibility	Date/Time (GMT)
Joshua Francis	Development Approver	7/23/2012 9:16:24 PM
Dawit Belete	Reliability/SQE Engineering Approver	7/23/2012 9:17:37 PM
Farshad Esnaashari	Project Management Approver	7/24/2012 2:57:26 PM
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Holli Pheil	Development Approver	7/26/2012 12:39:31 PM

Project Name: PTM3

Authored By: Scott Straka

Version History		
Version	**Description of Change**	**Change Author**
1.0	Initial Version	Scott Straka
2.0	Route for Approval	Scott Straka

Document location: *NPD > NDHF-Design History Files > NDHF1405 XTM Instruments Platform >XTM Hardware > HW PTM*

This report utilizes MEDN-0066 Version 7.0. The protocol was written in version 7.0, and version 8.0 did not add any additional content that is not covered in this report.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 EXECUTIVE SUMMARY

Purpose:

To verify the Model 97745 Patient Therapy Manager (PTM3) meets the RF electrical design verification requirements specified in the Design Verification Test Protocol (NDHF1405-112546) and the PTM3 Product Specification NDHF 1405-111160.

Products Tested:

All testing was performed on production representative products.

Results and Conclusions:

All products tested met the requirements specified in Design Verification protocol NDHF1405-112546 as specified in NDHF1405-111160, PTM3 Product Specification. Test results are summarized below in Table 1: Summary of Results.

Table 1: Summary of Results

Test #	Test Name	Requirement	Acceptance Criteria	Data Sample Size	Pass/Fail
RF-1 (mode 1)	Tel M Receiver Sensitivity	EE296 EE305	Max PER of 1% when: -89 dBm ≤ signal level ≤ -22 dBm	222 240	PASS
RF-2 (mode 1)	Tel M Receiver Intermodulation Rejection	EE298	Max PER of 1% when IMR interferer levels ≤ 47 dB	43	PASS
RF-3 (mode 1)	Tel M Rx Adjacent Channel Rejection	EE299	Max PER of 1% when adj. ch. interferer level (100 kHz offset) ≤ 35 dB	217	PASS
RF-4 (mode 1)	Tel M Rx Alternate Channel Rejection	EE300	Max PER of 1% when alt. ch. interferer level (200 kHz offset) ≤ 44 dB	216	PASS
RF-5 (mode 1)	Tel M Rx AM Rejection	EE304	Max PER of 1% AM interferer level (1.5 MHz offset) ≤ -58 dBm	41	PASS
RF-6 (mode 1)	Tel M Rx External Spurious Response Rejection	EE303	Max PER of 1% at specified power with specified external spurious interferers	211	PASS
RF-7 (mode 1)	Tel M RSSI Linearity and	EE306 EE307	RSSI range of -109 dBm min and -55	240	PASS

	Differentiation		dBm max and differentiate -109 dBm and -106 dBm across all MICS channels	240	
RF-8 (mode 1)	Tel M Tx output Power	EE286	-16.75 ≤ Tx Power ≤ -11.25 dBm	200	PASS
RF-8 (mode 1)	Tel M Tx Adjacent Channel Power Ratio	EE291	ACPR ≤ -34 dBc	200	PASS
RF-8 (mode 1)	Tel M Tx Alternate Channel Power Ratio	EE293	AltCPR ≤ -40 dBc	200	PASS
RF-9 (mode 1)	Tel M Transmitter Error Vector Magnitude	EE388	EVM ≤ 8.4%	200	PASS
RF-9 (mode 1)	Tel M Transmitter Frequency Stability	EE284 EE285	Freq Stability ≤ +/- 12 ppm synthesizer shall tune in increments of 300 kHz from 402.15 MHz to 404.85 MHz	200 200	PASS
RF-10	Active Tel M Antenna Gain	EE308	Antenna gain ≥ -8.0 dBi	35	PASS
RF-11	Tel M Antenna Return Loss	EE309 EE310	Nominal 50 Ohm impedance Return loss ≤ -6 dB	35 35	PASS
RF-12	Active Bluetooth Antenna Efficiency	EE386	Radiation efficiency ≥ -10 dB	35	PASS
RF-13	Bluetooth Antenna Return Loss	EE316	Return loss ≤ -6 dB	35	PASS
RF-14	Bluetooth Rx Sensitivity (GFSK)	EE387	Rx Sensitivity ≤ -80 dBm	100	PASS
RF-15	Bluetooth Standard Qualification	EE241	Obtain Bluetooth 2.0 certification	1	PASS
RF-16	Tel M I/O	EE270 EE271 EE272 EE273 EE274 EE275 EE276 EE277 EE278 EE279 EE280	Meet the EE requirements listed	None	PASS

		EE281 EE282 EE283			

2 SCOPE

This document describes the Electrical Design Verification Test Report for the radio frequency (RF) aspects of the PTM3, Model 97745. All testing performed was to verify the radio performance requirements for the long distance telemetry scheme used by the PTM3, Model 97745. The Bluetooth radio, operating in the ISM band, is used to communicate between the PTM3, Model 97745 and the Intellis ENS (External Neurostimulator). In the scope of telemetry, the PTM3, Model 97745, acts as the patient therapy manager for the Intellis ENS.

3 PURPOSE / OBJECTIVES

The purpose of this document is to provide test results for applicable electrical design requirements (long distance telemetry) for the Patient Therapy Manager (PTM3), Model 97745. The PTM3, Model 97745, electronics were evaluated against these requirements using the test plan described in this document.

4 BACKGROUND

4.1 PRODUCT

The Patient Therapy Manager (PTM) is described in NDHF1405-110160 PTM Product Specification. A summary of the description is provided here for reference.

PTM3 is a handheld, battery operated, microprocessor-based programmer designed for use by clinicians and patients to provide additional control of medical therapy. Control of the therapy includes the ability to administer a predetermined quantity of boluses, permit management of stimulation, or view and acknowledge medical alarms / alerts. PTM3 Model 97745 will be used in the Intellis Test Screener.

PTM3 Model 97745 components include: a Bluetooth Module, a 2.8” display and capacitive touch panel, two AA alkaline or a Li-ion rechargeable battery pack, LED indicator lights, a system connector port, and three mechanical buttons as well as Application Specific Software.

PTM3 will use Bluetooth to communicate with the Intellis ENS.

A representative diagram of PTM3, model 97745, communication with medical devices and rechargers is represented in Figure 1.

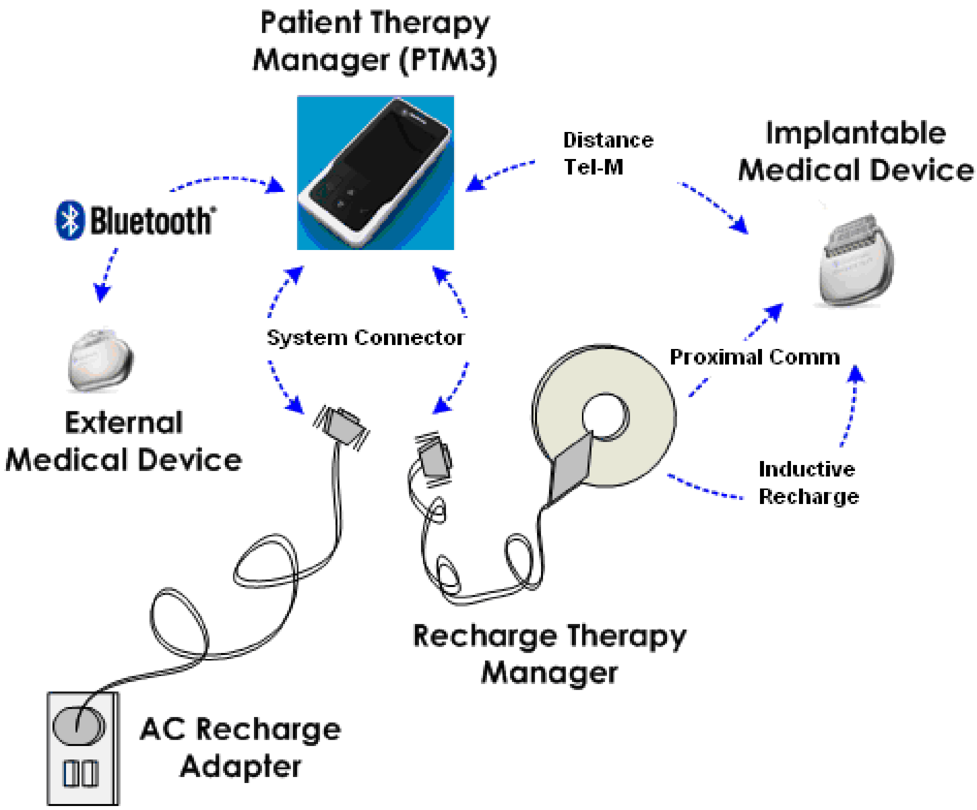


Figure 1 - PTM3, model 97745, System Illustration

5 APPLICABLE DOCUMENTS

Table 2: Table of Applicable Documents

Document Number	Version	Description
NDHF1405-112546	3.0	PTM3 Model 3537 and 97745 RF DVT Plan
NDHF1405-110160	8.0	PTM3 Product Specification
NDHF1405-112073	5.0	PTM3 Electrical Specification
M951878A001	B	Electrical Assembly, Intellis
A17245	L	Telemetry M RF Module Requirements Specification
NDHF1405-118064	4.0	PTM3 Electrical DFMEA
NDHF1405-121834	2.0	xTM Telemetry M Test Environment Verification Report
QMS1795	11.0	Neuromodulation Global Glossary
QMS1850	4.0	TLP Statistics, Monitoring, and Analysis
NDHF1205-120175	3.0	NGCP CTM2, PTM3, and RTM Supplier Manufacturing Quality Plan

Document Number	Version	Description
PCP1874	8.0	Design Verification Procedure
NDHF1405-122707	2.0	xTM Telemetry M Test Sample Justification
PCPWI1907	8.0	Electrical Design and Design Verification
NDHF1405-128216	3.0	Supporting Data for PTM3 Model 97745 RF DVT Report (NDHF1405-128215)

6 ACCEPTANCE STRATEGY

The purpose of this document and the design verification test (DVT) evaluation is to ensure the RF performance meets the requirements outlined in the electrical specifications. Acceptance criteria will be meeting the electrical requirements with 90% confidence/90% reliability. Any deviations or exceptions from the requirements or test plan procedures will be published in the DVT report with supporting rationale. Test vectors (environmental variables) will be across operating temperature range, across operating voltage range, and also across frequency channels.

7 SAMPLE SIZE JUSTIFICATION

An appropriate DUT sample size to obtain ≥ 30 variables data points will be used to demonstrate specification compliance with a 90/90 confidence/reliability. The samples to be analyzed will be the actual parametric performance measurements per each requirement (i.e. power at which Rx sensitivity is achieved, output Tx power, etc.). Part to part variation is minimized by virtue of 100% trim and calibration at manufacturing. Observed Cpk values will be analyzed in the DVT report to demonstrate 90/90 confidence reliability. Historical data and analysis contained in NDHF1405-122707 supports the sample size based off measured performance across environmental conditions rather than device to device variation.

For RF-15 Bluetooth Standard Qualification, a minimum sample size of 1 DUT is the requirement per Bluetooth SIG qualification procedures. Capability analysis does not apply to this requirement and test as this qualification effort is controlled and judged solely by the Bluetooth SIG.

8 ACRONYMS

All acronyms used within this document are defined here.

Table 3: Table of Acronym Definitions

Acronym	Description	Definition
ACPR		Adjacent Channel Power ratio
ADC		Analog to Digital Converter
AltCP		Alternate Channel Power
AltCPR		Alternate Channel Power ratio
AM		Amplitude Modulation
BPSK	Type of digital modulation scheme	Binary Phase Shift Key
CL		Confidence Level
CTM		Clinician Telemetry Module
CW	Unmodulated RF signal	Continuous Wave
DL		downlink
DUT		Device Under Test
DVT		Design Verification Test

ENS	External Neurostimulator	External Neurostimulator
EIRP	Antenna parameter	Effective Isotropic Radiated Power
EVM	Metric of the transmitter	Error Vector Magnitude
F2R1	Version of Tel M module	Fracture 2 ROM 1
F2R1	Version of Tel M module used in DVT build	Fracture 2 ROM 2
FM		Frequency Modulation
GPIB	Common interface between Labview software and test equipment	General Purpose Interface Bus
IMR		Intermodulation Rejection
LSB		Least Significant Bit
ISS	InterStim Test Screener	Interstim Test Screener
MICS	402-405 MHz frequency band	Medical Implant Communication Services (402-405 MHz)
NGCP		Next Generation Clinician Programmer
OAB	Over-Active Bladder therapy	Over-Active Bladder therapy
PCB		Printed Circuit Board
PER	Metric used to assess receiver performance	Packet Error Rate
P_{inc}		Power incident at DUT
PTM3		Patient Therapy Manager
RF		Radio Frequency
RFM	Telemetry M module that resides on PCB	RF Module
RMS	Power measurement	Root Mean Square
RSSI		Received Signal Strength Indication
Rx		Receive
Rx_{sens}		Receiver sensitivity
TRP	Antenna parameter	Total Radiated Power
Tx		Transmit
UL		uplink
USB	Common interface between computer and test equipment	Universal Serial Bus
WU_{sens}		Wakeup sensitivity

9 TEST PROCEDURE

9.1 SAMPLE CONFIGURATION

The devices to be tested will be built per controlled process, including having RF trims performed after being populated on the PTM3 printed circuit board (PCB). The units will be tested at the PCB level for most tests. This is implemented so that test points can be accessed for testing. Testing at the PCB level for conducted testing is acceptable since parametric shifts will not be experienced, due to the tests being conducted rather than radiated. The exception to this configuration is that all antenna testing will be performed in the final assembly form. This is due to the antenna tests being sensitive to the parasitic loading of the entire assembly.

9.2 TEST EQUIPMENT

Manufacturer	Model	Asset #	Calibration Due	Test Station
Agilent	E4438C	157633	15Oct2012	Rx/Tx 1
Agilent	E4438C	152061	13Oct2012	Rx/Tx 1
Agilent	E4400B	ES036522	17Oct2012	Rx/Tx 1
Agilent	E3631A	ES048744	17Sep2012	Rx/Tx 1
Sigma Systems	Temp Chamber	157548	04Apr2013	Rx/Tx 1
Agilent	N9020A MXA	157553	015Nov2012	Rx/Tx 1
Agilent	E4438C	157632	13Oct2012	Rx/Tx 2
Agilent	E4438C	152060	13Oct2012	Rx/Tx 2
Agilent	E8663D	157631	23Apr2013	Rx/Tx 2
Keithley	2400	157556	20Feb2013	Rx/Tx 2
Sigma Systems	Temp Chamber	157637	02May2013	Rx/Tx 2
Agilent	N9020A MXA	157553	15Nov2012	Rx/Tx 2
Agilent	E4438C	157750	12Oct2012	SPUR1
Agilent	E8664A	152057	10Oct2012	SPUR1
Agilent	E3631A	124550	07Mar2013	SPUR1
JFW	50SA-203	ES049089	N/A	SPUR1
Agilent	E4438C	155953	24Oct2012	SPUR2
Agilent	E8663D	157541	10Dec2012	SPUR2
Agilent	E3631A	ES048745	11Sep2012	SPUR2
JFW	50SA-203	ES043742	N/A	SPUR2

9.3 REQUIREMENTS

All Rx tests are independent and therefore are not required to be run in a specific order, however, for optimal time efficiency, Rx tests will be run in a specific order. With the exception of Rx spurious response, Rx sensitivity will be run, then subsequent interference tests with the same input parameters (i.e. channel, temp, voltage, etc.) will be run afterwards. For Rx tests, Rx attenuation will be 17 dB. All Tx tests are independent and therefore do not need to be run in a specific order and there is no time efficiency to be gained from special sequencing.

Table 4: List of Tests for PTM3 RF Design Verification Testing

Test Number	PTM Instrument Testing	Minimum Test Samples
	Tel-M Receiver Testing	
RF-1.	Receiver Sensitivity	3 DUTs
RF-2.	Receiver Intermodulation Rejection	3 DUTs
RF-3.	Receiver Adjacent Channel	3 DUTs
RF-4.	Receiver Alternate Channel Rejection	3 DUTs
RF-5.	Receiver AM Rejection	3 DUTs
RF-6.	External Spurious Response Rejection (Single Tone, Unmodulated)	3 DUTs
RF-7.	Rx RSSI Linearity and differentiation	3 DUTs
	Tel-M Transmitter Testing	
RF-8.	Transmitter Output Power, Transmitter Adjacent Channel Power Ratio, Transmitter Alternate Channel Power Ratio	3 DUTs
RF-9.	Transmitter Error Vector Magnitude & Transmitter Frequency Stability	3 DUTs
	Antenna Testing	
RF-10.	Active Tel-M Antenna Gain	7 DUTs
RF-11.	Tel-M Antenna Return Loss	7 DUTs
RF-12.	Active Bluetooth Antenna Efficiency	7 DUTs
RF-13.	Bluetooth Antenna Return Loss	7 DUTs
	Bluetooth Testing	
RF-14.	Bluetooth Rx Sensitivity (GFSK)	3 DUTs
RF-15.	Bluetooth Standard Qualification	1 DUTs
	Tel M I/O	
RF-16.	Tel M I/O	None, Datasheet inspection

9.4 REQUIREMENTS, ACCEPTANCE STRATEGY & RESULTS (REPORT ONLY)

Testing was performed on the dates listed in the table below. There were no deviations to the test protocol.

Tester	Date(s) Tested
Rx1	02Jul2012, 25Jun2012
Rx2	06Jul2012, 02Jul2012, 25Jun2012, 20Jun2012
Tx1	15Jun2012, 13Jun2012, 12Jun2012, 11Jun2012
Tx2	12Jun2012
Spur1	08Jun2012, 14Jun2012, 15Jun2012
Spur2	08Jun2012, 11Jun2012, 14Jun2012, 15Jun2012

Prior to beginning DVT testing:

1. Determine the cable loss of all RF coax cables that will be used in the test setup. (Appendix A: Measurement of RF path loss through cables)
2. Build DVT Vector files for Rx test suite, Rx spurious test suite, and Tx test suite.

9.4.1 RF-1: Receiver Sensitivity

Requirement	EETD41 Tel-M Receiver Sensitivity Verifies: EE296 The Tel M Receiver shall have a minimum Mode 1 sensitivity of -89 dBm EE305 The Tel-M Receiver shall have effective over the air maximum Rx power >= -22dBm with Rx attenuation setting.
Test Description	This test is automated in DVT. Rx attenuation = 17 dB. The antenna loss makes up the remainder of the needed loss. The receiver sensitivity test measures how low in power a Tel M signal can be received by the DUT receiver and achieve a packet error rate (PER) ≤ 1%. The test is conducted in a shielded temp chamber that provides an isolated environment from external interfering signals (e.g., WiFi, Cell phone, etc.). The DUT is powered via an external power supply such that the temperature and power supply can be variable parameters in the test. A vector signal generator is used to play back arbitrary waveforms consisting of valid framed Tel M data. After a specified number of packets, the number of received packets and packets with Reed Solomon errors are counted. From this, the PER is calculated. The calculation is: PER(%) = [(packets sent – packets received) + packet errors] / (packets sent) * 100 In this test, the interfering signal generators are not used.
Sample size:	*6 DUTs*
Acceptance Criteria	An acceptance criterion is based on successful completion of tests within specified range of error or meeting the requirements set forth.
Test Objective:	Verify device meets specified requirements.

Test Environment:

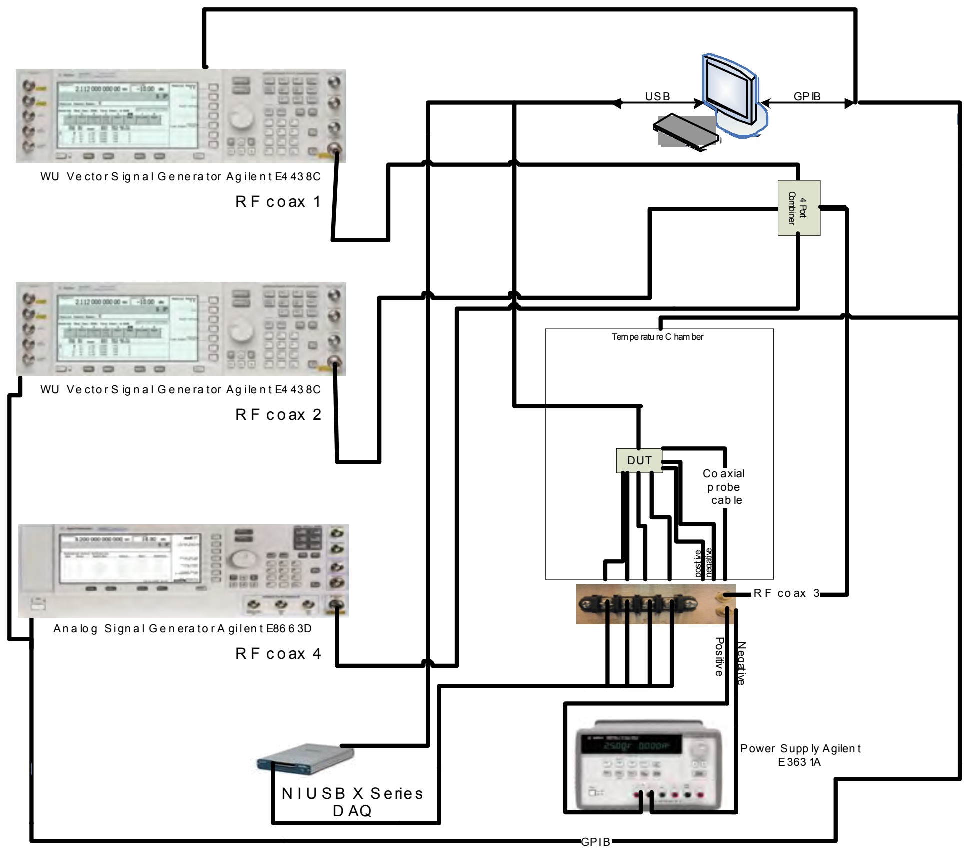


Figure 2. Test setup for receiver testing

Test Setup:

Cable connections and initial calibrations:

1. Measure the signal level at each signal generator with a power meter. Then connect the signal generators to the RF combiner. Now measure the power of each signal generator at the input of the DUT (incident at the DUT from the signal generators). Record these loss factors in the DUT .ini file for software use. These losses will compensate for inaccuracies of the signal generator output, as well as all RF losses due to routing.
2. Place the DUT inside the fixture.
3. Place the fixture inside temperature chamber
4. Connect the measured cable between the DUT and RF Combiner (RF coax 3).
5. Connect the power supply to the DUT fixture.
6. Connect up DAQ to Tel M test bus.
7. Connect GPIB and USB connections to interface with testing software

Test Procedure:

I. Initial Setup

A. Setup equipment as shown in Figure 2

II. Labview:

A. Open and run “DVT Main Menu.vi” file
B. Login with User Name and Password

C. Select “Run DVT” button
D. When prompted, select “PTM_DVT_Rx_Suite.dvt” script.
E. Select “Start” button
F. When prompted, fill in “UUT Serial Number” field and “Bench Name” field appropriately.
G. Select “OK” button.
H. Confirm that the tests have started as expected.

Test Results: All data samples PASS receiver sensitivity requirements.

Capability Analysis:

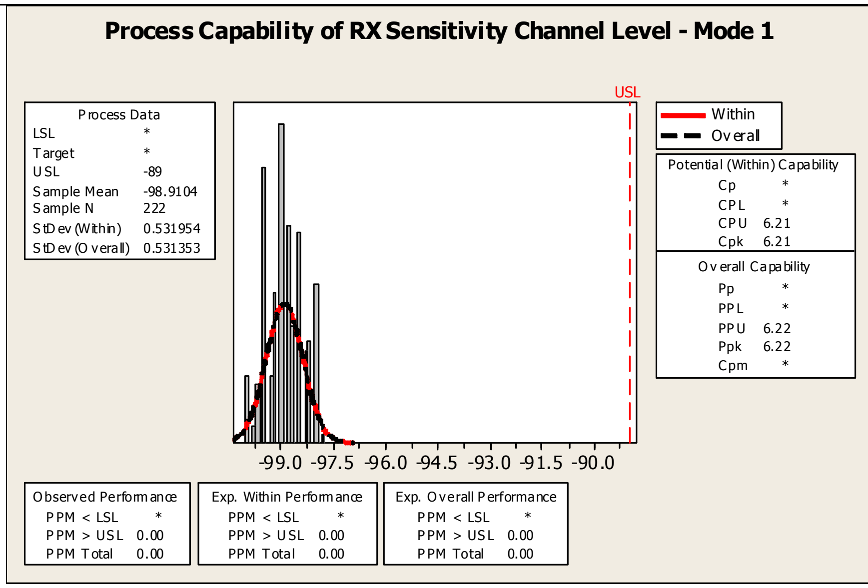


Figure 3 Capability Analysis of Receiver Sensitivity

Receiver sensitivity results in Figure 3 show higher than 99%/99% confidence/reliability in the ability of the Tel-M receiver to have a minimum Mode 1 sensitivity of -89 dBm.

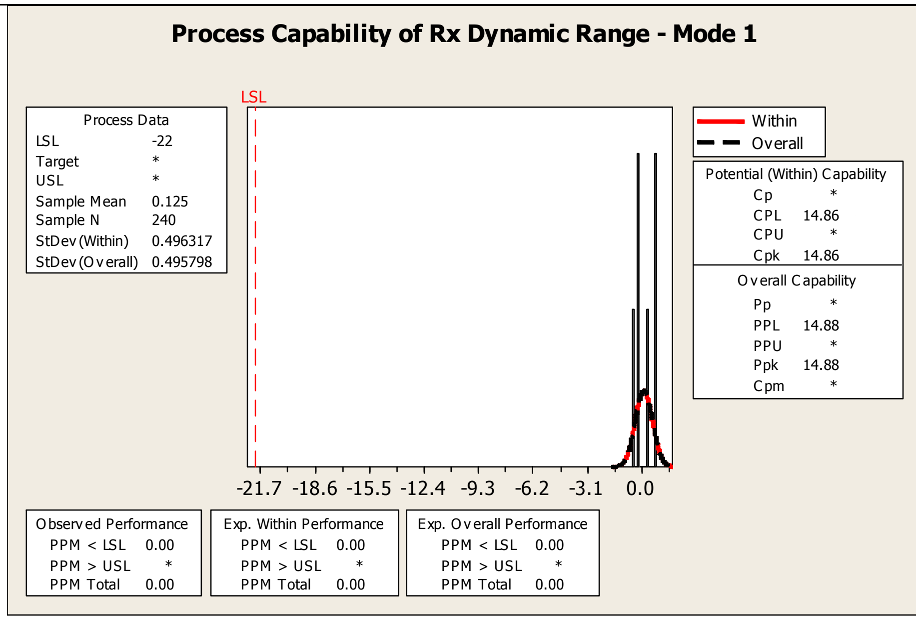


Figure 4 Capability Analysis of Mode 1 Upper Dynamic Range Level

Mode 1 Rx dynamic range results, Figure 4, show higher than 99%/99% confidence/reliability in achieving an upper level dynamic range capability that exceeds -22 dBm.

Test Data Traceability	Test data can be found in the supporting document archival file NDHF1405-128216.
Test Sample Retention	Test samples will be retained per work instructions.

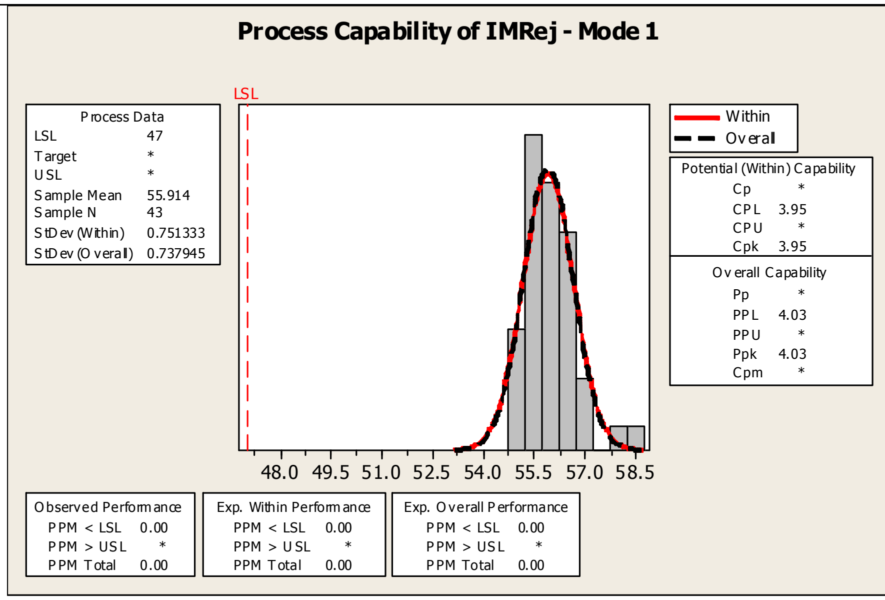
Table 5: Table of Receiver Tests

	Mode 1	
DUT channel	**Temperature (C)**	**Battery voltage (V)**
1 (402.15 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25
2 (402.45 MHz)	9.	2.3
	9	5.25
	43	2.3
	43	5.25
3 (402.75 MHz)	9	2.3

	9	5.25
	43	2.3
	43	5.25
4 (403.05 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25
5 (403.35 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25
6 (403.65 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25
7 (403.95 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25
8 (404.25 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25
9 (404.55 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25
10 (404.85 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25

9.4.2 RF-2: Receiver Intermodulation Rejection

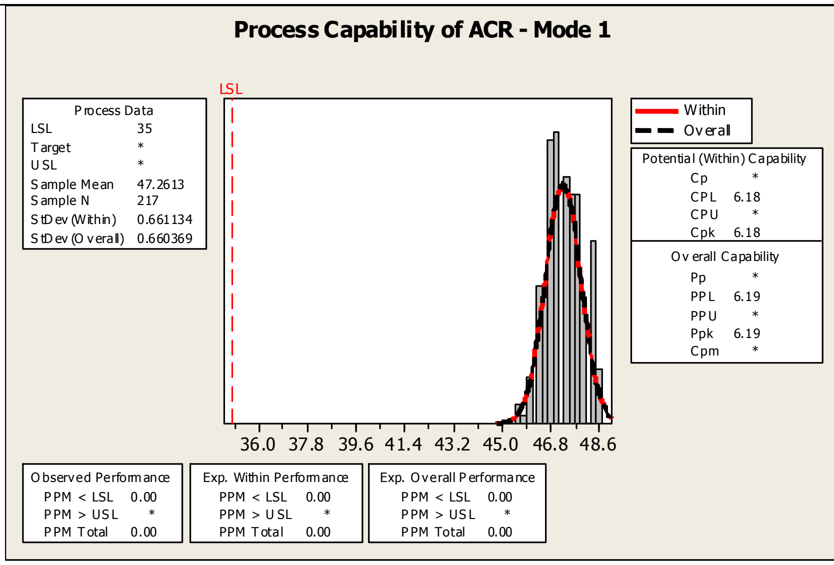
Requirements	EETD42 Tel-M Receiver Intermodulation Rejection Verifies: EE298 The Tel-M Receiver shall have minimum IM rejection of 47dB with interferers at 1.5 MHz and 3.0 MHz offset from desired signal.
Test Description	This test is automated in DVT. Rx attenuation = 17 dB. The intermodulation rejection test measures the ability of the receiver to prevent two specific interfering signal inputs from causing degradation of reception of the desired signal. The test method is loosely based on Industry standard: TIA/EIA 603-B with deviations as required for differences due to operation in the MICS band. The test setup is the same as shown in Figure 2. The desired signal is provided by a vector signal generator playing back an appropriate arbitrary waveform consisting of properly formatted Tel M frames of data modulated appropriately. The first interferer, programmed on one signal generator, is five channel spacings away (1.5 MHz) from the desired signal and is an unmodulated CW mode signal. The second interfering signal, programmed on a vector signal generator, is ten channel spacings away (3.0 MHz) from the desired signal and will have BPSK modulation (58 kbps for mode 1, 185 kbps for mode 3; alpha = 0.35, and PN23 sequence as data source). The performance measurement will be based on measuring PER degradation as the power of the interferers is increased. After a specified number of packets, the number of received packets and packets with Reed Solomon errors are counted. From this, the PER is calculated. The calculation for PER is: PER(%) = [(packets sent – packets received) + packet errors] / (packets sent) * 100
Sample size:	*6 DUTs*
Acceptance Criteria	An acceptance criterion is based on successful completion of tests within specified range of error or meeting the requirements set forth.
Test Objective:	Verify device meets specified requirements.
Test Environment:	This test is part of the receiver suite of tests. See test environment in section 9.4.1.
Test Setup:	This test is part of the receiver suite of tests. See test setup in 9.4.1.
Test Procedure:	**I. Initial setup:** Setup equipment as shown in Figure 2 **II. Labview:** A. Open and run “DVT Main Menu.vi” file B. Login with User Name and Password

	C. Select “Run DVT” button D. When prompted, select “PTM_DVT_Rx_Suite.dvt” script. E. Select “Start” button F. When prompted, fill in “UUT Serial Number” field and “Bench Name” field appropriately. G. Select “OK” button. H. Confirm that the tests have started as expected.
Test Results:	All data samples PASS intermodulation rejection requirements.
Capability Analysis:	 Figure 5 Capability Analysis of Intermodulation Rejection Receiver intermodulation rejection results in Figure 5 show higher than 99%/99% confidence/reliability in achieving a minimum rejection of 47dB.
Test Data Traceability	Test data can be found in the supporting document archival file NDHF1405-128216.
Test Sample Retention	Test samples will be retained per work instructions.

9.4.3 RF-3: RECEIVER ADJACENT CHANNEL REJECTION

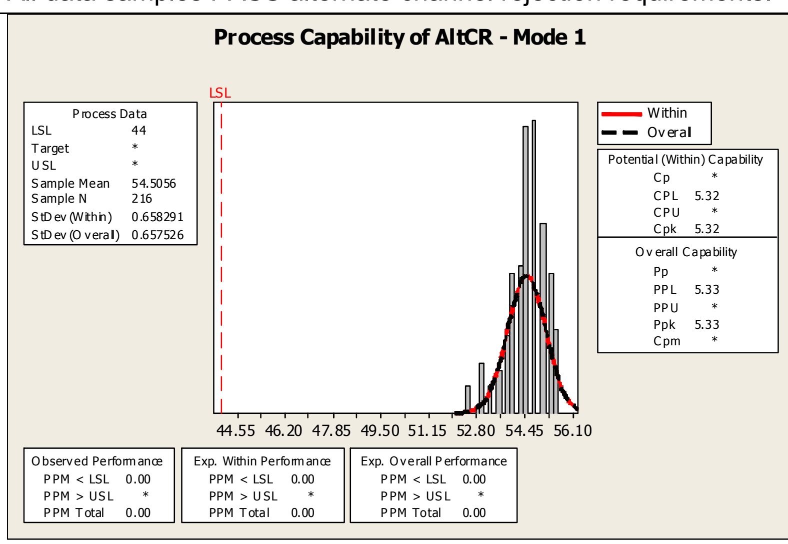
Requirements	EETD43 Tel-M Receiver Adjacent Channel Rejection Verifies: EE299 The Tel-M Receiver shall have minimum adjacent channel rejection of 35dB at 100 kHz offset.

Test Description	This test is automated in DVT. Rx attenuation = 17 dB. The adjacent channel interference rejection is a measure of the ability of a receiver to reject an interfering signal in the channel adjacent to the desired signal. The test setup is the same as shown in Figure 2. The desired signal is provided by a vector signal generator playing back an appropriate arbitrary waveform consisting of properly formatted Tel M frames of data modulated appropriately. The interferer, programmed on the vector signal generator, is offset 300 kHz from the desired signal for mode 3 and offset 100 kHz from the desired signal for mode 1 (i.e., in the adjacent channel) and will have BPSK modulation (58 kbps for mode 1, 185 kbps for mode 3; alpha = 0.35, and PN23 sequence as data source). Note that the other signal generator is not used in this test. The performance measurement will be based on measuring PER degradation as the power of the interferers is increased. After a specified number of packets, the number of received packets and packets with Reed Solomon errors are counted. From this, the PER is calculated. The calculation for PER is: PER(%) = [(packets sent – packets received) + packet errors] / (packets sent) * 100
Sample size:	*6 DUTs*
Acceptance Criteria	An acceptance criterion is based on successful completion of tests within specified range of error or meeting the requirements set forth.
Test Objective:	Verify device meets specified requirements.
Test Environment:	This test is part of the receiver suite of tests. See test environment in section 9.4.1.
Test Setup:	This test is part of the receiver suite of tests. See test setup in section 9.4.1.
Test Procedure:	I. **Initial setup:** Setup equipment as shown in Figure 2 II. **Labview:** A. Open and run “DVT Main Menu.vi” file B. Login with User Name and Password C. Select “Run DVT” button D. When prompted, select “PTM_DVT_Rx_Suite.dvt” script. E. Select “Start” button F. When prompted, fill in “UUT Serial Number” field and “Bench Name” field appropriately. G. Select “OK” button. H. Confirm that the tests have started as expected.
Test Results:	All data samples PASS adjacent channel rejection requirements.

Capability Analysis:	 Figure 6 Capability Analysis of Adjacent Channel Rejection Receiver adjacent channel rejection results in Figure 6 show higher than 99%/99% confidence/reliability in achieving a minimum rejection of 35dB.
Test Data Traceability	Test data can be found in the supporting document archival file NDHF1405-128216.
Test Sample Retention	Test samples will be retained per work instructions.

9.4.4 RF-4: RECEIVER ALTERNATE CHANNEL REJECTION

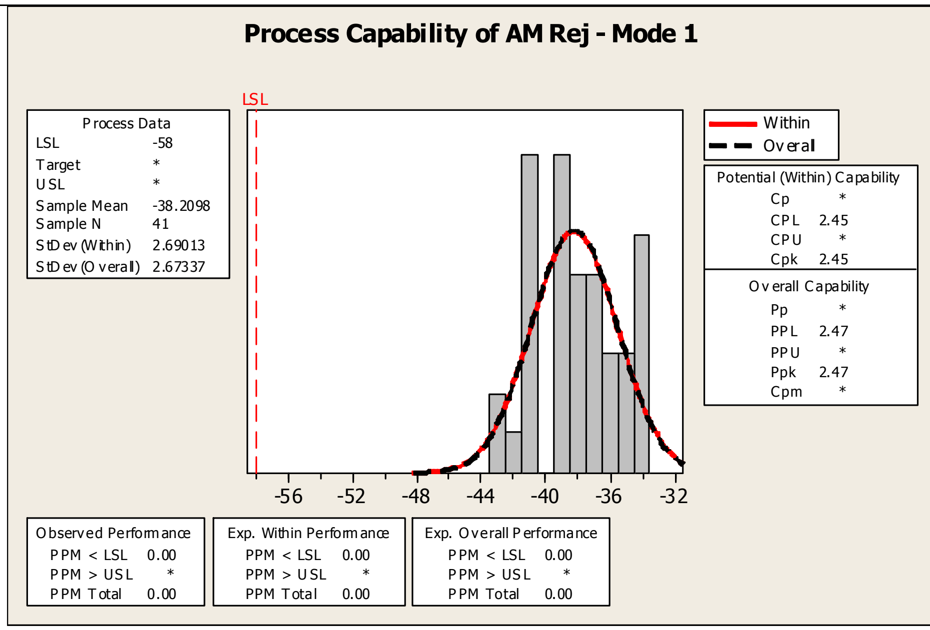
Requirements	EETD44 Tel-M Receiver Alternate Channel Rejection Verifies: EE300 The Tel-M Receiver shall have minimum alternate channel rejection of 44dB at 200 kHz offset.
Test Description	This test is automated in DVT. Rx attenuation = 17 dB. The alternate channel interference rejection is a measure of the ability of a receiver to reject an interfering signal 2 channels away from the desired signal. The test setup is the same as shown in Figure 2. The desired signal is provided by a vector signal generator playing back an appropriate arbitrary waveform consisting of properly formatted Tel M frames of data modulated appropriately. The interferer, programmed on the vector signal generator, is 600 kHz for mode 3 and 200 kHz for mode

	1 (i.e., in the alternate channel) from the desired signal and will have BPSK modulation (58 kbps for mode 1, 185 kbps for mode 3; alpha = 0.35, and PN23 sequence as data source). Note that the other signal generator is not used in this test. The performance measurement will be based on measuring PER degradation as the power of the interferers is increased. After a specified number of packets, the number of received packets and packets with Reed Solomon errors are counted. From this, the PER is calculated. The calculation for PER is: PER(%) = [(packets sent – packets received) + packet errors] / (packets sent) * 100
Sample size:	*6 DUTs*
Acceptance Criteria	An acceptance criterion is based on successful completion of tests within specified range of error or meeting the requirements set forth.
Test Objective:	Verify device meets specified requirements.
Test Environment:	This test is part of the receiver suite of tests. See test environment in section 9.4.1.
Test Setup:	This test is part of the receiver suite of tests. See test setup in section 9.4.1.
Test Procedure:	I. **Initial setup:** Setup equipment as shown in Figure 2 II. **Labview:** A. Open and run “DVT Main Menu.vi” file B. Login with User Name and Password C. Select “Run DVT” button D. When prompted, select “PTM_DVT_Rx_Suite.dvt” script. E. Select “Start” button F. When prompted, fill in “UUT Serial Number” field and “Bench Name” field appropriately. G. Select “OK” button. H. Confirm that the tests have started as expected.
Test Results:	All data samples PASS alternate channel rejection requirements.
Capability Analysis:	 Figure 7 - Capability Analysis of Alternate Channel Rejection

	Receiver alternate channel rejection results in Figure 7 show higher than 99%/99% confidence/reliability in achieving a minimum rejection of 44 dB.
Test Data Traceability	Test data can be found in the supporting document archival file NDHF1405-128216.
Test Sample Retention	Test samples will be retained per work instructions.

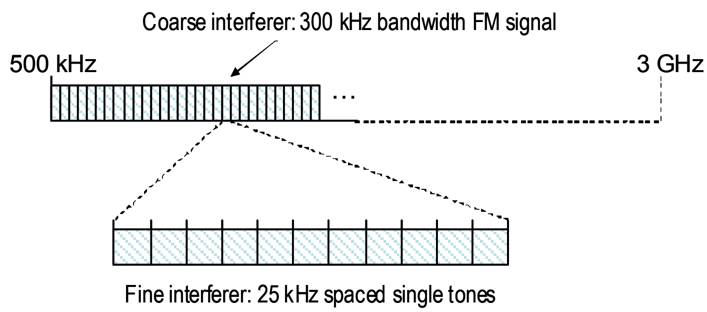
9.4.5 RF-5: Receiver AM Channel Rejection

Requirements	EETD56 Tel_M Receiver AM Channel Rejection Verifies: EE304 The Tel-M Receiver shall have AM rejection better >= -58dBm for 1.5MHz offset.
Test Description	This test is automated in DVT. Rx attenuation = 17 dB. The AM rejection is a measure of the ability of a receiver to reject an amplitude modulated interfering signal 1.5 MHz away from the desired signal. The test setup is the same as shown in Figure 2. The desired signal is provided by a vector signal generator playing back an appropriate arbitrary waveform consisting of properly formatted Tel M frames of data modulated appropriately. The interferer, programmed on a signal generator, is 1.5 MHz from the desired signal and will have 100% AM modulation at an 8 kHz rate (using sinusoidal modulation). Note that the other signal generator is not used in this test. The performance measurement will be based on measuring PER degradation as the power of the interferers is increased. After a specified number of packets, the number of received packets and packets with Reed Solomon errors are counted. From this, the PER is calculated. The calculation for PER is: PER(%) = [(packets sent – packets received) + packet errors] / (packets sent) * 100
Sample size:	*6 DUTs*
Acceptance Criteria	An acceptance criterion is based on successful completion of tests within specified range of error or meeting the requirements set forth.
Test Objective:	Verify device meets specified requirements.
Test Environment:	This test is part of the receiver suite of tests. See test environment in 9.4.1.
Test Setup:	This test is part of the receiver suite of tests. See test setup in section 9.4.1.
Test Procedure:	I. **Initial setup:** Setup equipment as shown in Figure 2

	II. **Labview:** A. Open and run “DVT Main Menu.vi” file B. Login with User Name and Password C. Select “Run DVT” button D. When prompted, select “PTM_DVT_Rx_Suite.dvt” script. E. Select “Start” button F. When prompted, fill in “UUT Serial Number” field and “Bench Name” field appropriately. G. Select “OK” button. H. Confirm that the tests have started as expected.
Test Results:	All data samples PASS AM channel rejection requirements.
Capability Analysis:	 Figure 8 Capability Analysis of AM Channel Rejection Receiver AM channel rejection results in Figure 8 show higher than 99%/99% confidence/reliability in achieving a minimum rejection of -58 dB.
Test Data Traceability	Test data can be found in the supporting document archival file NDHF1405-128216.
Test Sample Retention	Test samples will be retained per work instructions.

9.4.6 RF-6 : External Spurious Response Rejection (Single Tone, Unmodulated)

Requirements	EETD45 Tel-M External Spurious Response Rejection (Single Tone, Unmodulated)

	Verifies: EE303 The Tel-M Receiver shall have outband single tone spurious response >= -42dBm for CW interferers ranging from 500kHz to 3GHz with the following exceptions: For Mode 1: External spurious response rejection shall be >= -52 dBm for 250 kHz to 350 kHz offset, >= -50.0 dBm for 350 kHz to 450 kHz offset, >= -49.5 dBm for 450 kHz to 550 kHz offset, >= -48 dBm for 550 kHz to 650 kHz offset, >= -46.5 dBm for 650 kHz to 750 kHz offset, -45.5 dBm for 750 kHz to 850 kHz offset, >= -45 dBm for 850 kHz to 950 kHz offset, >= -44 dBm for 950 kHz to 1050 kHz offset, >= -43.5 dBm for 1050 to 1150 kHz offset, >= -43 dBm for 1150 kHz to 1250 kHz offset, >= -42.5 dBm for 1250 to 1350 kHz offset.
Test Description	This test is automated in DVT. Rx attenuation = 17 dB. The external spurious response rejection (single tone, unmodulated) verifies the ability of the receiver to prevent unwanted signals over a broad range of frequencies (500 kHz to 3 GHz) from causing degradation to the reception of the desired signal.  Figure 9. Diagram of interference strategy for single tone spurious harmonics test. The desired signal is provided by a vector signal generator playing back an appropriate arbitrary waveform consisting of properly formatted Tel M frames of data modulated appropriately. An initial interferer, a 300 kHz bandwidth FM signal, is used to perform a coarse search of the broad frequency range (Figure 9). Each region that does not meet the more stringent coarse search specification must be investigated more thoroughly to fully understand the issue. To do this, a single tone interferer is swept every 30 kHz within the frequency band identified as problematic in the coarse search. Since this test is not expected to perform differently over different modes, the coarse search will be performed with the mode 3 to take advantage of the faster data rate. The faster data rate will enable the test to be run 3 times faster than in mode 1. The fine search will be performed in mode 1 and mode 3. The performance measurement will be based on measuring PER degradation as the power of the interferers is increased. After a specified number of packets, the number of received packets and packets with Reed Solomon errors are counted. From this, the PER is calculated.

<table>
<tr><td></td><td>The calculation for PER is:

PER(%) = [(packets sent – packets received) + packet errors] / (packets sent) * 100</td></tr>
<tr><td><u>Sample size:</u></td><td>4 DUTs</td></tr>
<tr><td><u>Acceptance Criteria</u></td><td>An acceptance criterion is based on successful completion of tests within specified range of error or meeting the requirements set forth.</td></tr>
<tr><td><u>Test Objective:</u></td><td>Verify device meets specified requirements.</td></tr>
<tr><td><u>Test Environment:</u></td><td>

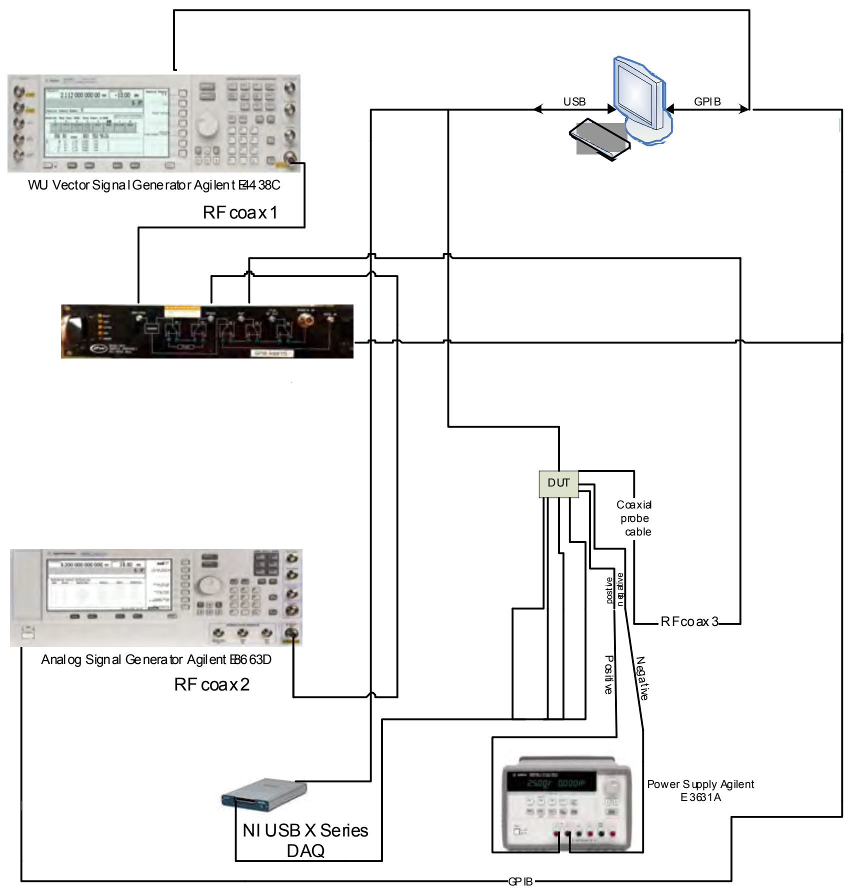
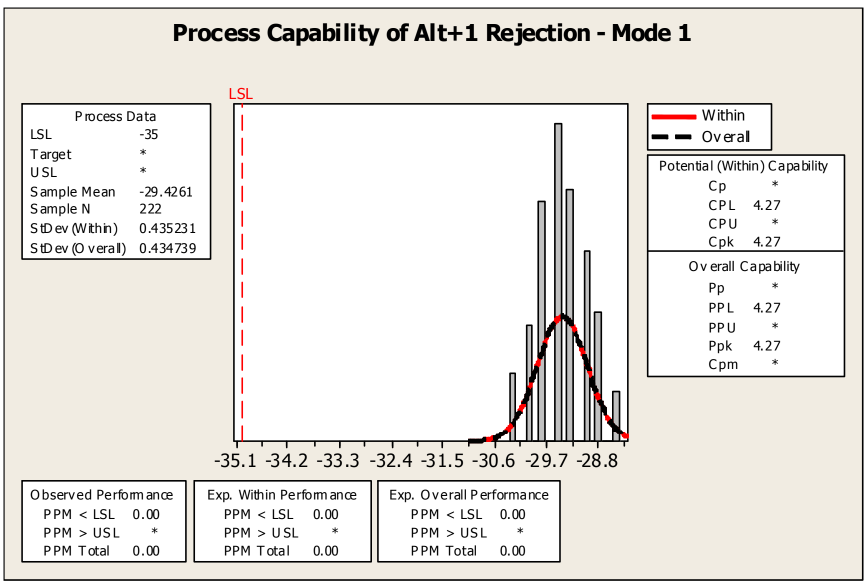


Figure 10 Test setup for Rx spurious response rejection testing</td></tr>
<tr><td><u>Test Setup:</u></td><td>See test setup in section 9.4.1.</td></tr>
<tr><td><u>Test Procedure:</u></td><td>Sweeping with a Coarse Interferer
I. Initial setup: Setup equipment as shown in Figure 2
II. Labview:
A. Open and run “DVT Main Menu.vi” file
B. Login with User Name and Password
C. Select “Run DVT” button
D. When prompted, select “PTM_DVT_Rx_Spurious_Coarse_Suite.dvt” script.
E. Select “Start” button
F. When prompted, fill in “UUT Serial Number” field and “Bench Name” field</td></tr>
</table>

	appropriately. G. Select “OK” button. H. Confirm that the tests have started as expected. *Sweeping with a Fine interferer:* I. **Initial setup:** Setup equipment as shown in Figure 2 II. **Labview:** A. Open and run “DVT Main Menu.vi” file B. Login with User Name and Password C. Select “Run DVT” button D. When prompted, select “PTM_DVT_Rx_Spurious_Fine_Suite.dvt” script. E. Select “Start” button F. When prompted, fill in “UUT Serial Number” field and “Bench Name” field appropriately. G. Select “OK” button. Confirm that the tests have started as expected.
Test Results:	All data samples PASS all Rx Spurious rejection requirements.
Capability Analysis:	 Figure 11 Capability Analysis of Rx Alt+1 Rejection

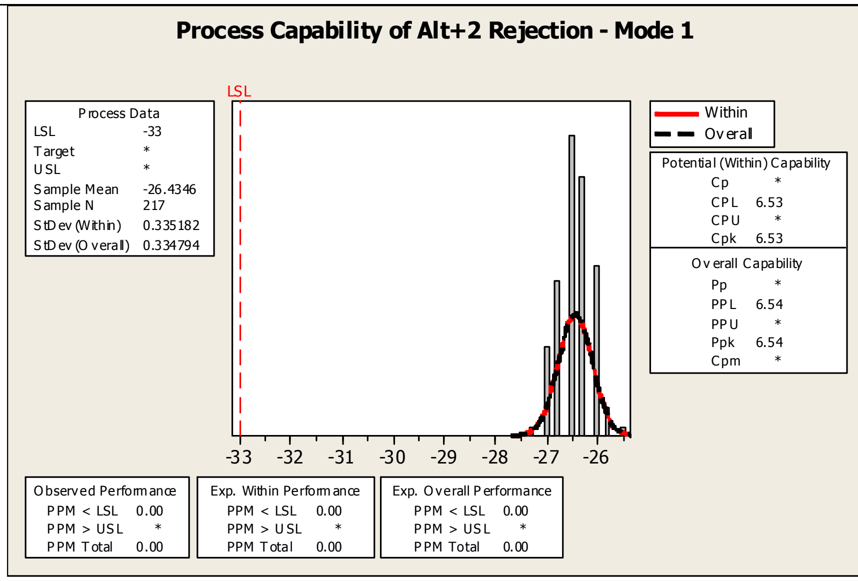


Figure 12 Capability Analysis of Rx Alt+2 Rejection

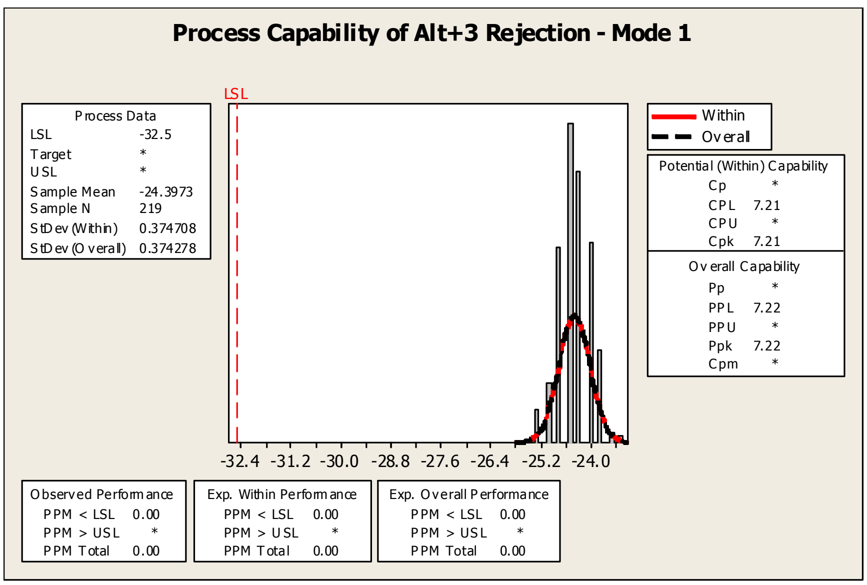


Figure 13 Capability Analysis of Rx Alt+3 Rejection

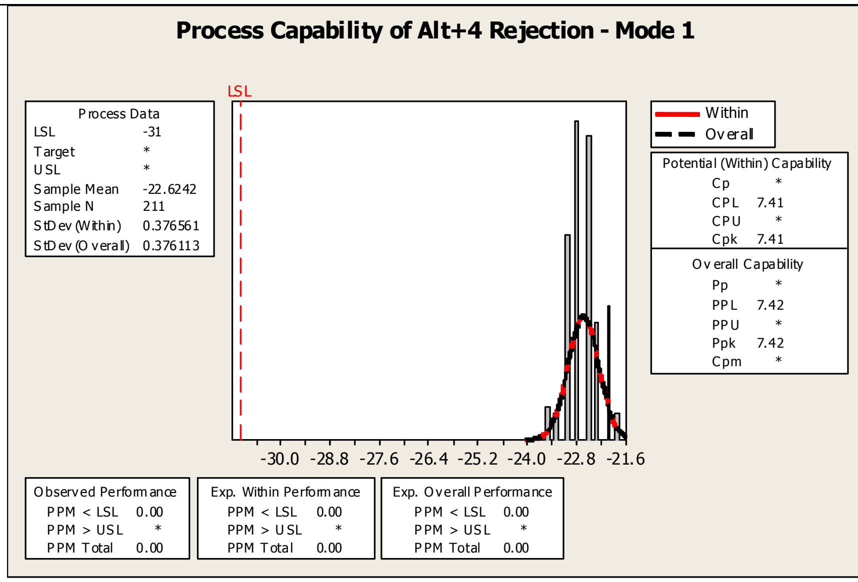


Figure 14 Capability Analysis of Rx Alt+4 Rejection

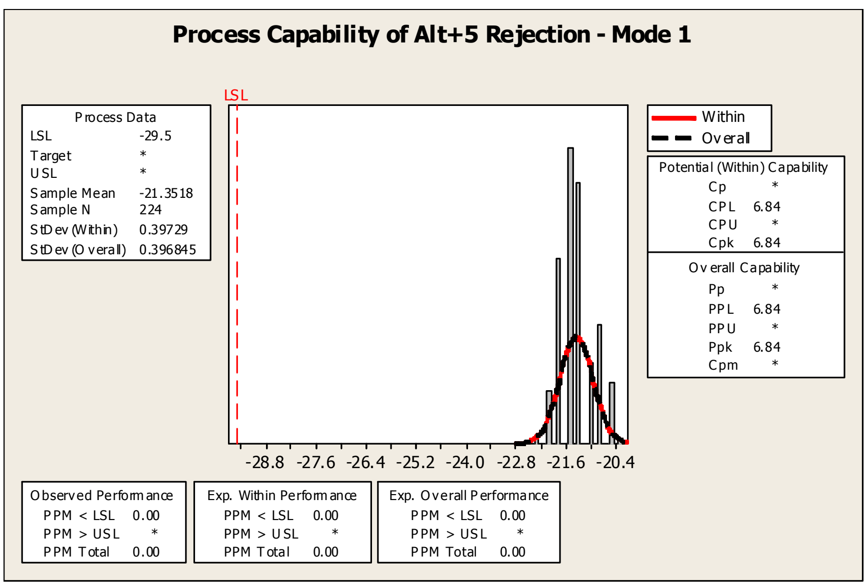


Figure 15 Capability Analysis of Rx Alt+5 Rejection

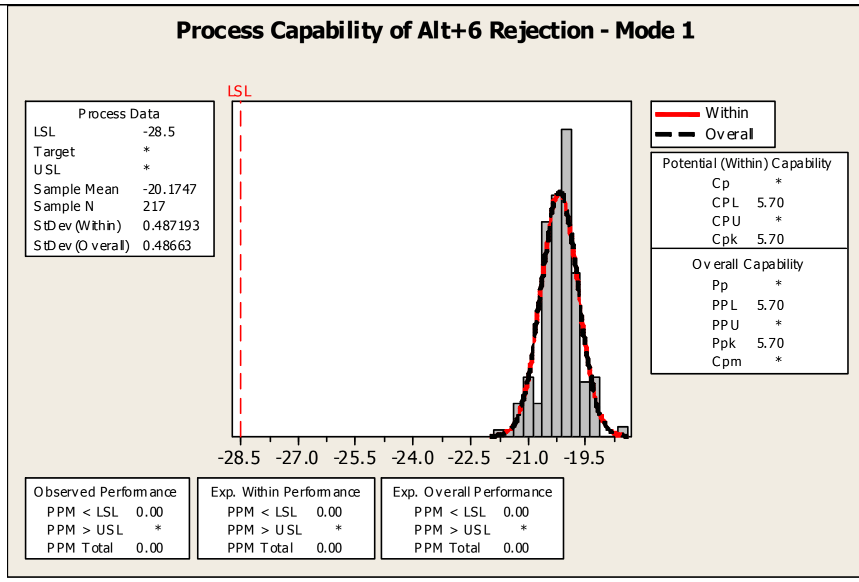


Figure 16 Capability Analysis of Rx Alt+6 Rejection

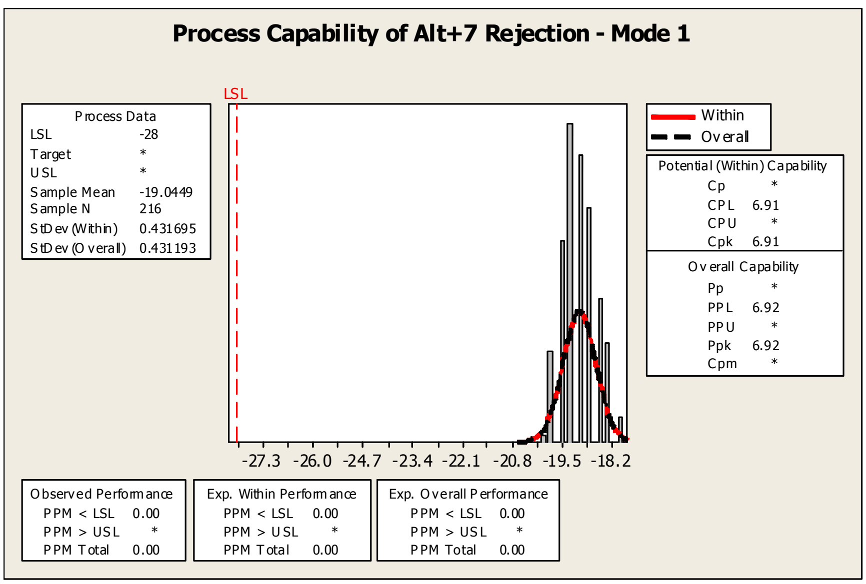


Figure 17 Capability Analysis of Rx Alt+7 Rejection

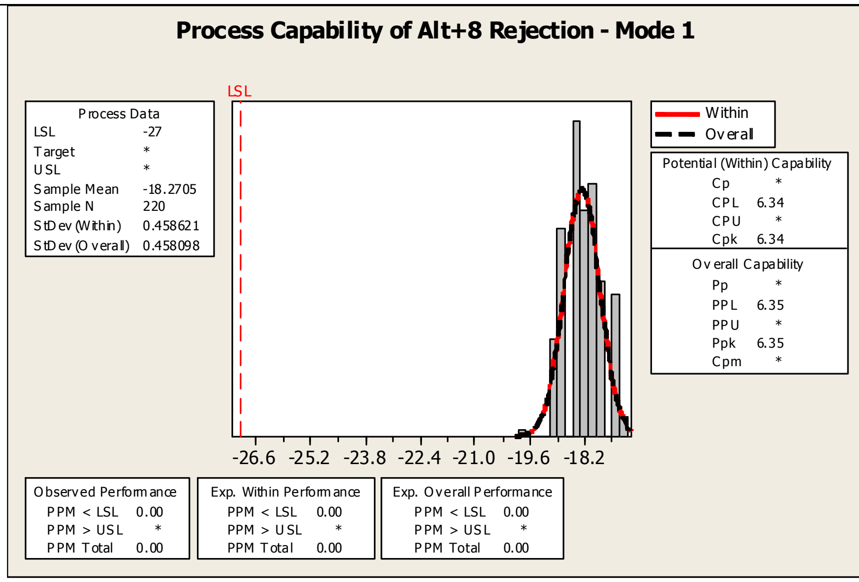


Figure 18 Capability Analysis of Rx Alt+8 Rejection

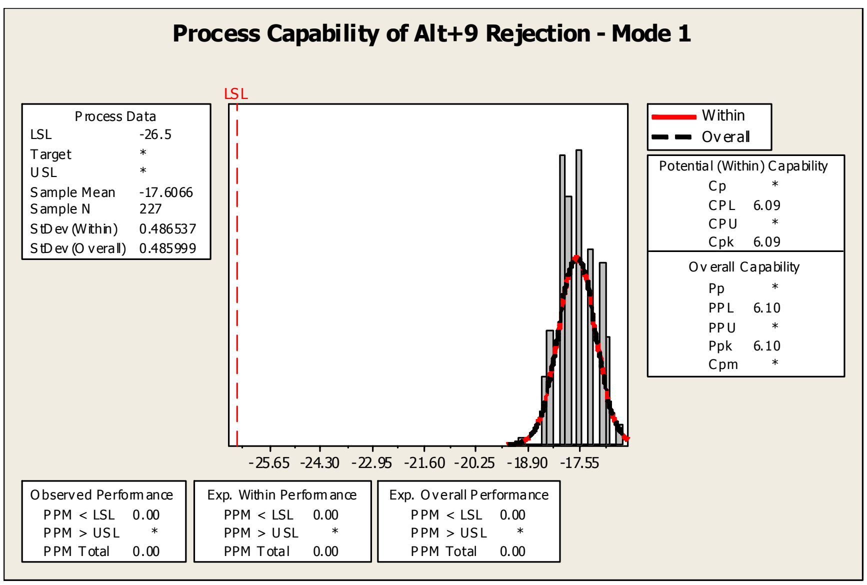


Figure 19 Capability Analysis of Rx Alt+9 Rejection

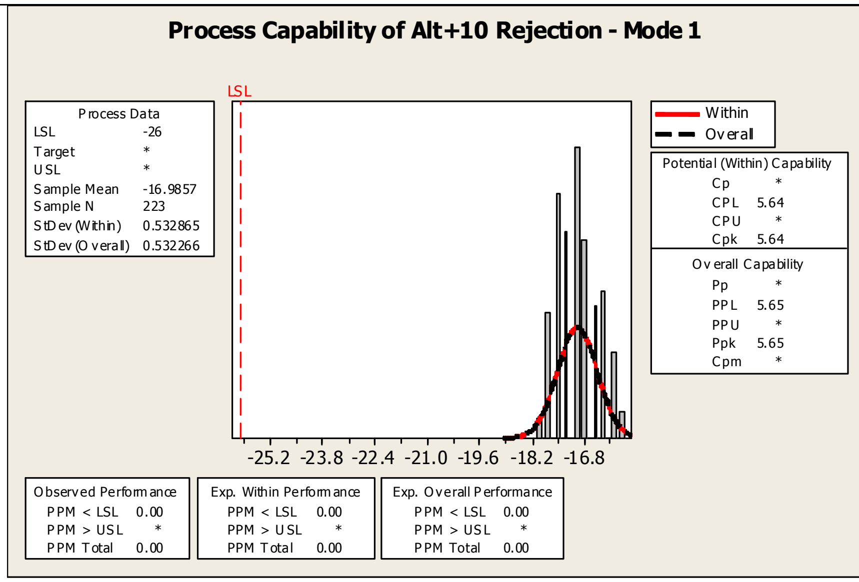


Figure 20 Capability Analysis of Rx Alt+10 Rejection

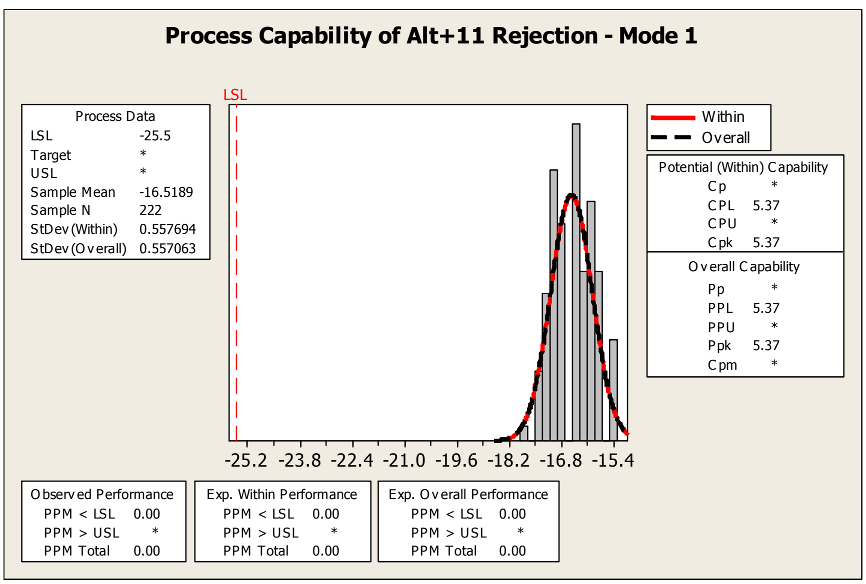


Figure 21 Capability Analysis of Rx Alt+11 Rejection

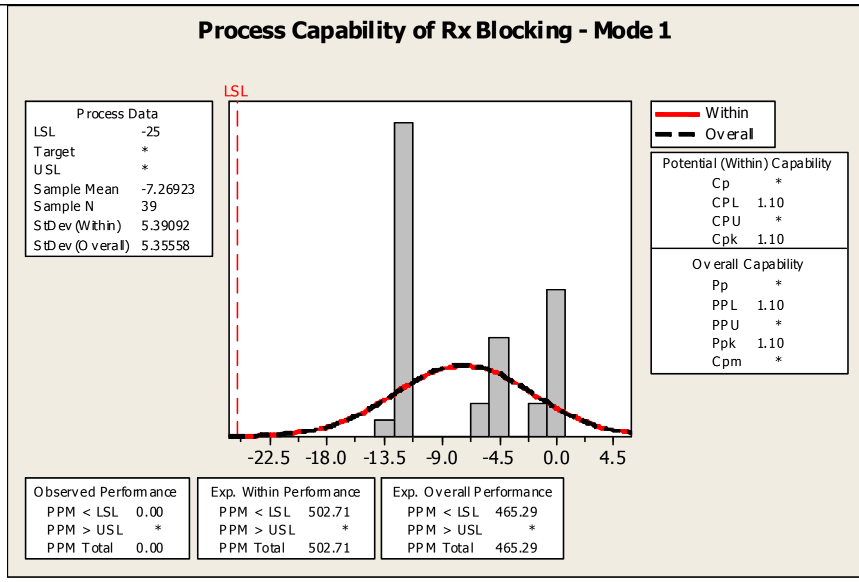


Figure 22 Capability Analysis of Rx Blocking - Mode 1

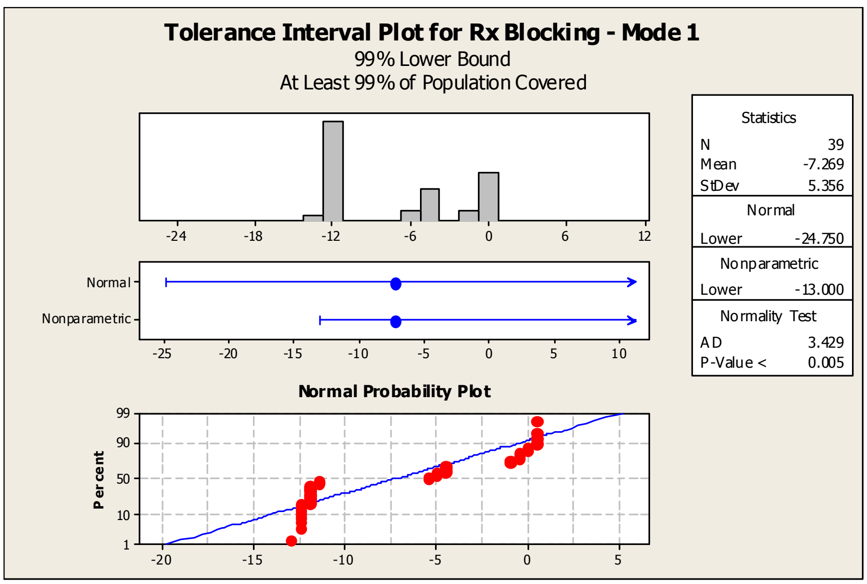


Figure 23 Tolerance Interval for Rx Blocking - Mode 1

All out of band receiver spurious response rejection results, shown in Figure 11 - Figure 21, passed with a minimum of 99%/99% confidence/reliability.

Since the in band receiver blocking daa found in Figure 22 and Figure 23 was shown to have a C_{pk} lower than 1.33, additional data analysis was conducted. The analysis showed that there is 95%/95% confidence/reliability with the resulting data to meet the specification limit using the nonparametric results shown in Figure 23. The analysis is included in the

	supporting data.
Test Data Traceability	Test data can be found in the supporting document archival file NDHF1405-128216.
Test Sample Retention	Test samples will be retained per work instructions.

Table 6: Table of Receiver Spurious Response Rejection Tests

	Mode 3, Spurious Coarse		Mode 1, Spurious Fine	
DUT channel	Temperature (C)	Battery voltage (V)	Temperature (C)	Battery voltage (V)
1 (402.15 MHz)	Ambient	3.2	Ambient	3.2
2 (402.45 MHz)	Ambient	3.2	Ambient	3.2
3 (402.75 MHz)	Ambient	3.2	Ambient	3.2
4 (403.05 MHz)	Ambient	3.2	Ambient	3.2
5 (403.35 MHz)	Ambient	3.2	Ambient	3.2
6 (403.65 MHz)	Ambient	3.2	Ambient	3.2
7 (403.95 MHz)	Ambient	3.2	Ambient	3.2
8 (404.25 MHz)	Ambient	3.2	Ambient	3.2
9 (404.55 MHz)	Ambient	3.2	Ambient	3.2
10 (404.85 MHz)	Ambient	3.2	Ambient	3.2

9.4.7 RF-7: Receiver RSSI Linearity and Differentiation

Requirements	EETD46 Tel-M Rx RSSI Linearity and Differentiation Verifies: EE306 The Tel-M Receiver shall have a minimum monotonic RSSI range of -109dBm to -55 dBm for Clear Channel Assessment (CCA) (i.e. no Rx attenuation present). EE307 The Tel-M Receiver shall be able to differentiate -109dBm and -106 dBm across all MICS channels for Clear Channel Assessment (CCA) (i.e. no Rx attenuation present).
Test Description	This test is automated in DVT. The RSSI linearity is the ability of the RSSI ADC to report back values in a monotonic fashion from -106 dBm to -55 dBm. The RSSI differentiation is the ability of the RSSI circuitry to distinguish between a signal at -109 dBm on any channel vs. a signal on any of the other ten channels whose power level is -106 dBm. The LSB of the ADC value should be greater than zero in all cases.

	The test setup is the same as shown in Figure 2. The desired signal is provided by a vector signal generator supplying a CW tone 20 kHz offset from the desired channel frequency (e.g. 402.15 MHz + 20 kHz for channel 1). The performance measurement will be based on the post processing of ADC values at the varying input power levels across channels.
Sample size:	*6 DUTs*
Acceptance Criteria	An acceptance criterion is based on successful completion of tests within specified range of error or meeting the requirements set forth.
Test Objective:	Verify device meets specified requirements.
Test Environment:	This test is part of the receiver suite of tests. See test environment in section 9.4.1.
Test Setup:	This test is part of the receiver suite of tests. See test setup in section 9.4.1.
Test Procedure:	I. **Initial setup:** Setup equipment as shown in Figure 27. II. **Labview:** A. Open and run "DVT Main Menu.vi" file B. Login with User Name and Password C. Select "Run DVT" button D. When prompted, select "PTM_DVT_Tx_Suite.dvt" script. E. Select "Start" button F. When prompted, fill in "UUT Serial Number" field and "Bench Name" field appropriately. G. Select "OK" button. I. Confirm that the tests have started as expected.
Test Results:	All test samples PASS RSSI range requirements as well as ability to differentiate between 3 dB steps of incident signal power.
Capability Analysis:	See figure below.

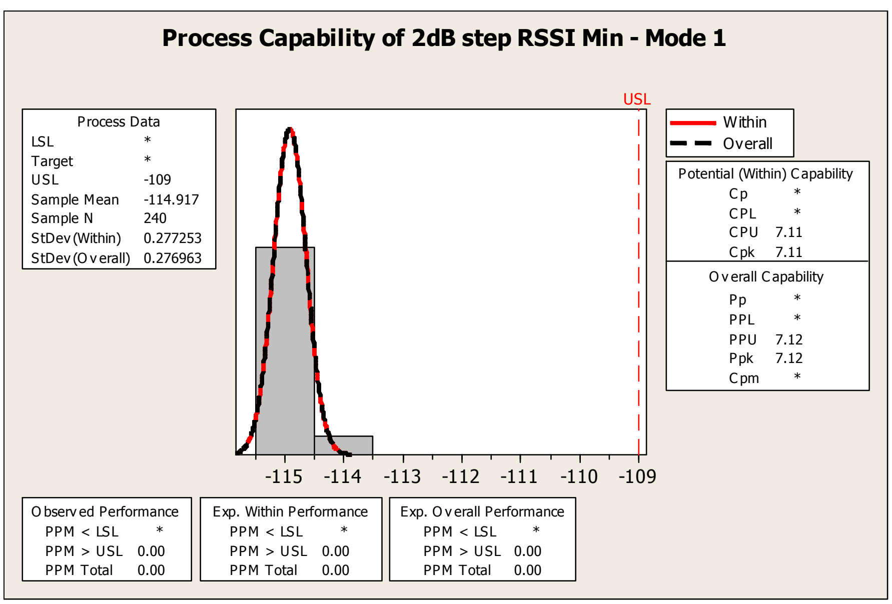
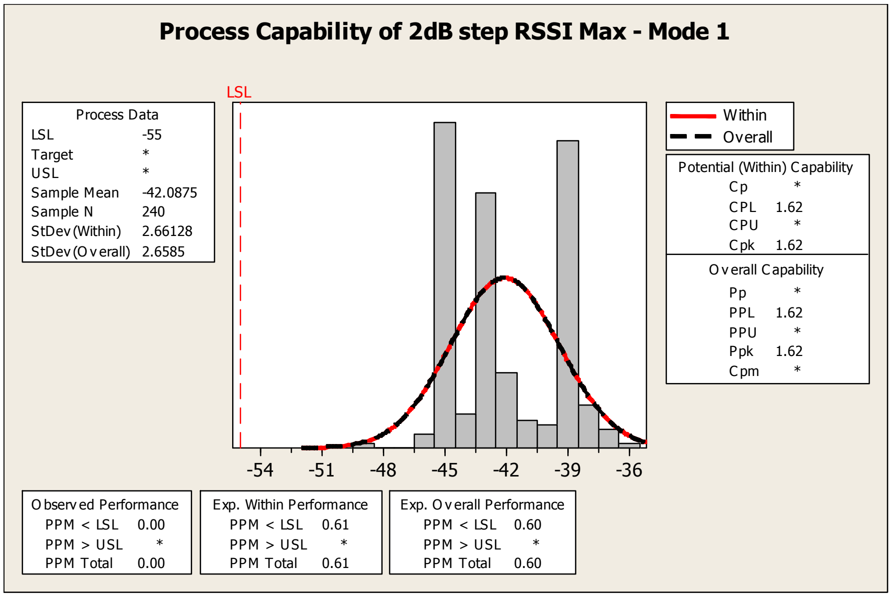
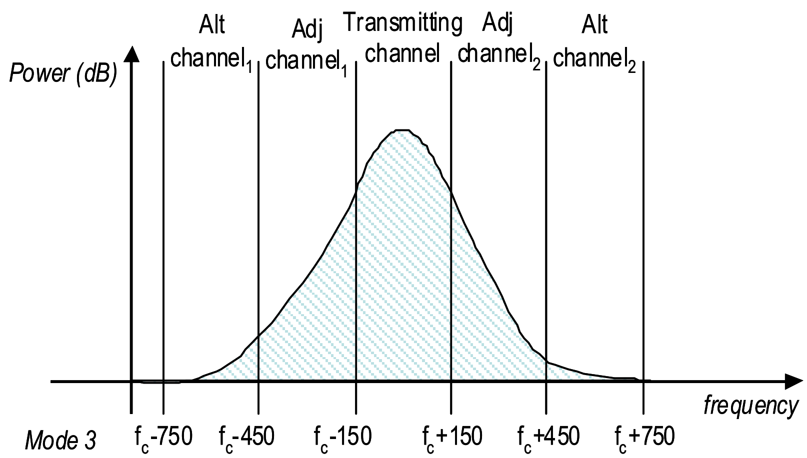


Figure 24 Capability Analysis of RSSI Lower Level Range

	 Figure 25 Capability Analysis of RSSI Upper Level Range Rx RSSI Min results, Figure 24, show higher than 99%/99% confidence/reliability in achieving the ability of differentiating a minimum signal level of -109 dBm. Rx RSSI Min results, Figure 25, show higher than 99%/99% confidence/reliability in achieving the ability of differentiating a maximum signal level of -55 dBm.
Test Data Traceability	Test data can be found in the supporting document archival file NDHF1405-128216.
Test Sample Retention	Test samples will be retained per work instructions.

9.4.8 RF-8 TRANSMIT POWER, ADJACENT CHANNEL POWER RATIO, AND ALTERNATE CHANNEL POWER RATIO

Requirements	EETD47 Tel-M Transmitter Output Power, Adjacent Channel Power Ratio, and Alternate Channel Power Ratio Verifies: EE286 The Tel-M Transmitter shall have a minimum conducted output power into a 50 ohm load of -16.25dBm and a maximum of -11.25dBm. EE291 The Tel-M Transmitter shall have minimum ACPR -34dBc. Measured at fc+/-50kHz to fc+/-150kHz. EE293 The Tel-M Transmitter shall have minimum AltCPR -40 dBc. Measured at fc+/-150kHz to

	fc+/-250kHz.
Test Description	This test is automated in DVT.  Figure 26. Mode 3 Transmit Channel Illustration This transmitter test checks the power of the transmitting channel, adjacent channels and alternate channels with respect to the specification. The transmitter power output test measures the average power output by the transmitter within the transmitting channel. The adjacent channel power ratio (ACPR) is defined as the ratio of the integrated power in the transmitting channel to the maximum of the integrated power in either of the two channels adjacent to the transmitting channel. AltCPR is similarly measured for the Alt channels as indicated in Figure 26. To execute these tests, the DUT is programmed to transmit a continuous frame of data for the appropriate mode and channel. The signal analyzer is used to measure output power, adjacent channel power, and alternate channel power.
Sample size:	*5 DUTs*
Acceptance Criteria	An acceptance criterion is based on successful completion of tests within specified range of error or meeting the requirements set forth.
Test Objective:	Verify device meets specified requirements.

Test Environment:

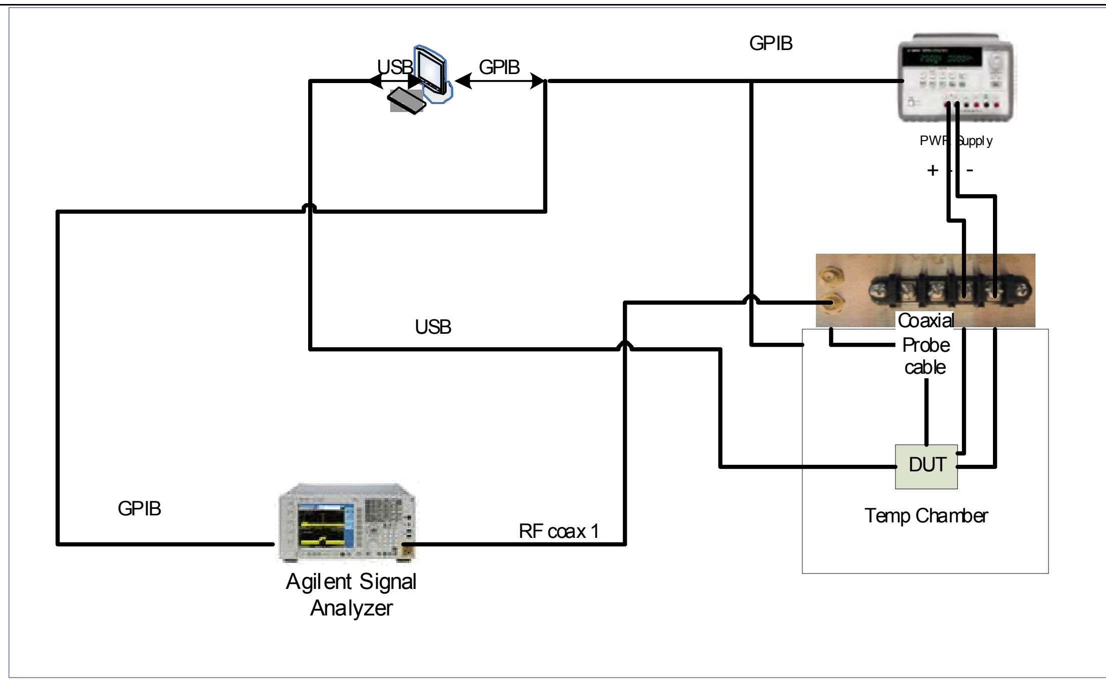


Figure 27 Test setup for Tx testing

Test Setup:

Cable connections and initial calibrations:

1. Measure the signal level at the MXA when sourcing with a known signal source (replace DUT for calibration). Record this loss factor in the DUT .ini file for software use. This losses will compensate for all RF losses due to routing.
2. Use a network analyzer to measure the same path as step 1 for a frequency range of 9 kHz to 4.06 GHz. Save the results off to "Ch5_gamma_0.00_phase_0.00_s21.csv". This file is used for out-of-band emissions loss compensation.
3. Place the DUT inside the fixture.
4. Place the fixture inside temperature chamber
5. Connect the measured cable between the DUT and RF Combiner (RF coax 1).
6. Connect the power supply to the DUT fixture.

Connect GPIB and USB connections to interface with testing software

Test Procedure:

I. **Initial setup:** Setup equipment as shown in Figure 27.

II. **Labview:**

A. Open and run "DVT Main Menu.vi" file
B. Login with User Name and Password
C. Select "Run DVT" button
D. When prompted, select "PTM_DVT_Tx_Suite.dvt" script.
E. Select "Start" button
F. When prompted, fill in "UUT Serial Number" field and "Bench Name" field appropriately.
G. Select "OK" button.
H. Confirm that the tests have started as expected.

Test Results:

All test samples PASS Tx power requirements.
All test samples PASS Tx adjacent channel power ratio requirements.
All test samples PASS Tx alternate channel power ratio requirements.

Capability

Analysis:

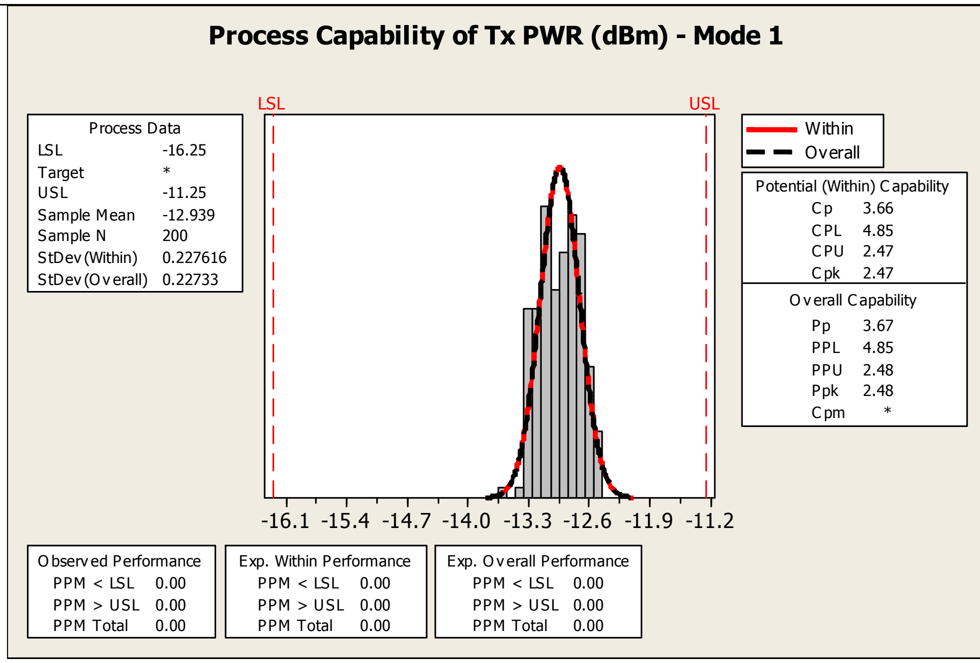


Figure 28 Capability Analysis of Transmit Power

Transmit power results in Figure 28 show higher than 99%/99% confidence/reliability in achieving the ability to transmit at a power level of -16.25 dBm minimum to -11.25 dBm maximum.

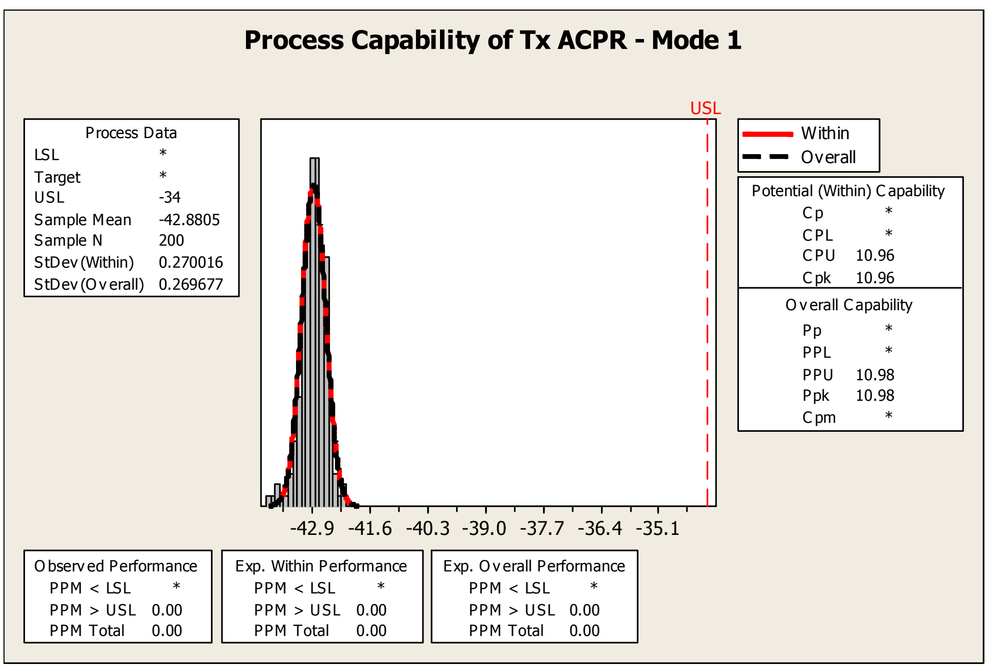


Figure 29 Capability Analysis of Adjacent Channel Power Ratio

Transmit adjacent channel power ratio (ACPR) results, Figure 29, show higher than 99%/99% confidence/reliability in achieving the ability to maintain ACPR performance of -34 dB maximum.

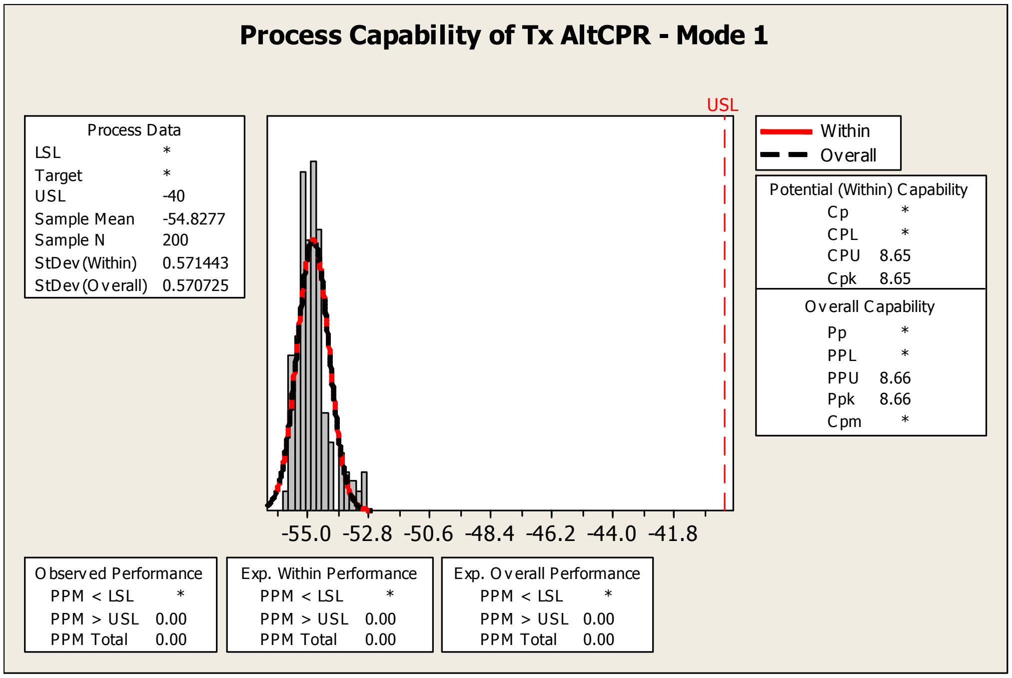


Figure 30 Capability Analysis of Alternate Channel Power Ratio

Transmit power alternate channel power ratio (AltCPR) results, Figure 30, show higher than 99%/99% confidence/reliability in achieving the ability to maintain AltCPR performance of -40 dB maximum..

Test Data Traceability	Test data can be found in the supporting document archival file NDHF1405-128216.
Test Sample Retention	Test samples will be retained per work instructions.

Table 7: Table of Transmitter Tests

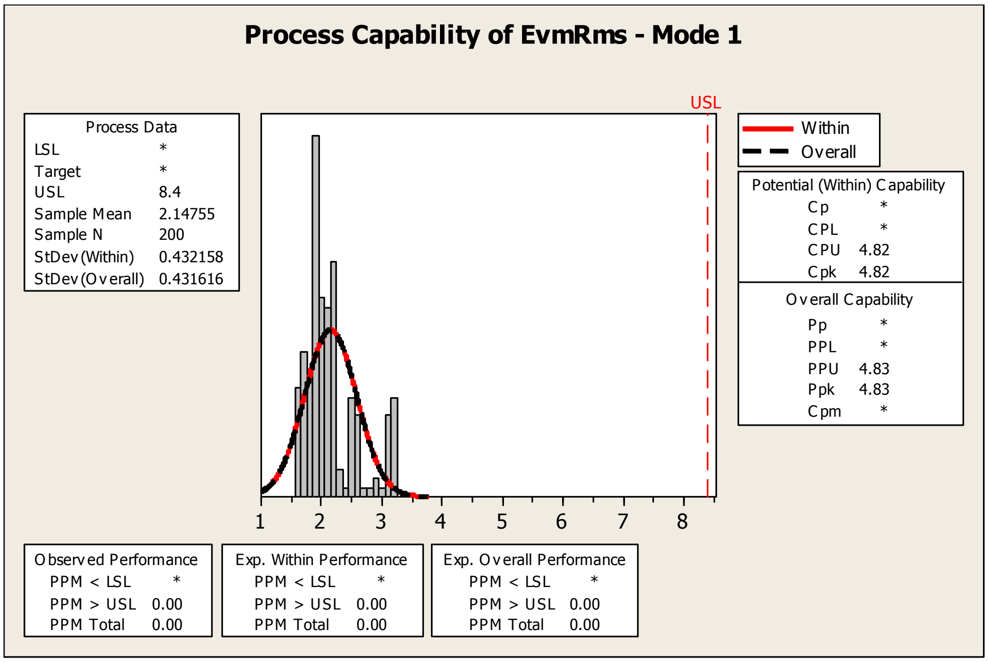
	Mode 1	
DUT channel	**Temperature (C)**	**Battery voltage (V)**
1 (402.15 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25

2 (402.45 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25
3 (402.75 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25
4 (403.05 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25
5 (403.35 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25
6 (403.65 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25
7 (403.95 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25
8 (404.25 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25
9 (404.55 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25

10 (404.85 MHz)	9	2.3
	9	5.25
	43	2.3
	43	5.25

9.4.9 RF-9 Transmitter Error Vector Magnitude & Transmitter Frequency Stability

Requirements	EETD48 Tel-M Transmitter Error Vector Magnitude & Transmitter Frequency Stability Verifies: EE284 The Tel-M RF synthesizer shall tune in increments of 300 kHz from 402.15 MHz to 404.85 MHz EE388 The Tel-M Transmitter in mode 1 shall have EVM <=8.4%. EE285 The Tel-M RF synthesizer shall have a minimum frequency stability of 12ppm.
Test Description	This test is automated in DVT. This transmitter test checks the error vector magnitude (EVM) of the transmitting signal by demodulating the DUT RF output and comparing the result to an ideal signal. From the demodulation, the frequency error can be measured. This frequency error can then be verified to meet the frequency requirements outlined in EE157. To execute these tests, the DUT is programmed to transmit a continuous frame of data for the appropriate mode and channel. The signal analyzer is used to demodulate the transmissions from the DUT and also perform the frequency accuracy measurements.
Sample size:	*5 DUTs*
Acceptance Criteria	An acceptance criterion is based on successful completion of tests within specified range of error or meeting the requirements set forth.
Test Objective:	Verify device meets specified requirements.
Test Environment:	This test is part of the transmitter suite of tests. See test environment in section 9.4.8.
Test Setup:	This test is part of the transmitter suite of tests. See test setup in section 9.4.8.
Test Procedure:	I. **Initial setup:** Setup equipment as shown in Figure 27. II. **Labview:** A. Open and run “DVT Main Menu.vi” file B. Login with User Name and Password C. Select “Run DVT” button D. When prompted, select “PTM_DVT_Tx_Suite.dvt” script. E. Select “Start” button F. When prompted, fill in “UUT Serial Number” field and “Bench Name” field appropriately.

	G. Select "OK" button. H. Confirm that the tests have started as expected.
Test Results:	All data samples PASS minimum EVM requirements. All data samples PASS synthesizer frequency requirements. All data samples PASS the synthesizer tuning resolution requirement, which was demonstrated in the synthesizer frequency stability testing.
Capability Analysis:	 Figure 31 Capability Analysis of Error Vector Magnitude Transmit error vector magnitude (EVM) results, Figure 31, show higher than 99%/99% confidence/reliability in achieving the ability to transmit with an EVM of 8.4 % maximum.

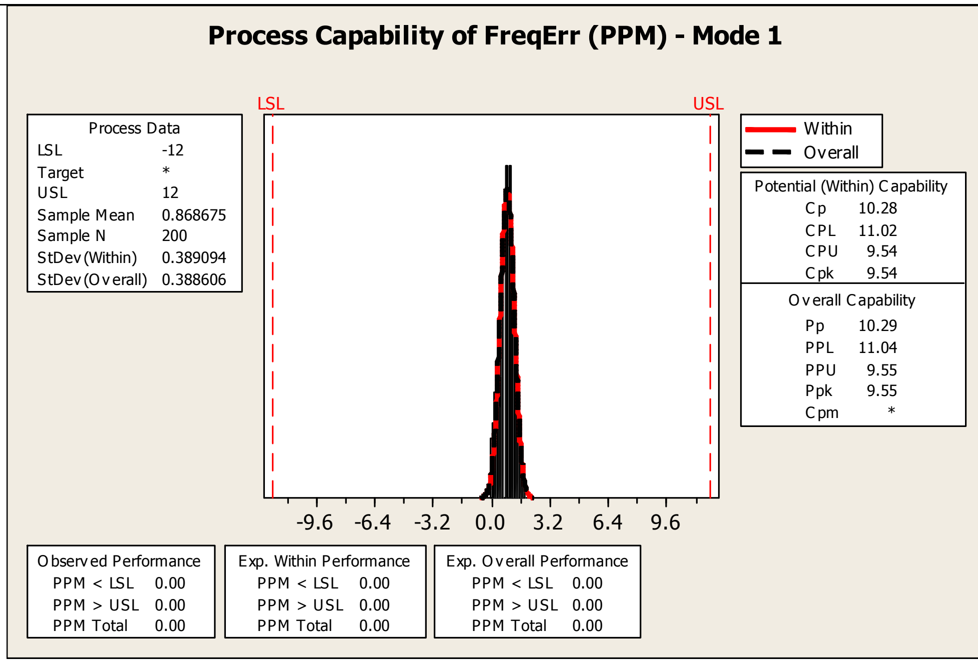


Figure 32 Capability Analysis of Frequency Stability

Transmit synthesizer error results, Figure 32, show higher than 99%/99% confidence/reliability in achieving the ability of the frequency synthesizer to maintain frequency accuracy within -12 parts per million (ppm) minimum to +12 ppm maximum.

Test Data Traceability	Test data can be found in the supporting document archival file NDHF1405-128216.
Test Sample Retention	Test samples will be retained per work instructions.

9.4.10 RF-10: Active Tel-M Antenna Gain

Requirements	EETD50 Active Tel-M Antenna Gain Verifies: EE308 The PTM3 Tel-M antenna shall have minimum gain of -8.0 dBi in free space.
Test Description	This test is done at Satimo in Atlanta, GA. For this test, a fully functional, form, fit DUT is used to check the antenna performance. The test interface is used to put the devices into a CW transmit mode. The transmitting device is placed inside the calibrated anechoic chamber at Satimo at a specified location. The test antennas are configured to receive the DUT signal. The received signals are collected through Satimo's data collection system that automates the antenna switching and accounts for calibration losses.

	The resulting measurement provides the EIRP and TRP. The gain and efficiency can be calculated from EIRP and TRP, respectively.
Sample size:	*7 DUTs*
Acceptance Criteria	An acceptance criterion is based on successful completion of tests within specified range of error or meeting the requirements set forth.
Test Objective:	Verify device meets specified requirements.
Test Environment:	 Figure 33 Zoom in picture of PTM in Star Gate with laser placement
Test Setup:	Test setup is included in the procedure
Test Procedure:	**I. Calibration** **A.** Set the laser to a location centered within the Satimo antenna Stargate **B.** Place the calibration antenna at the laser location **C.** Shut the chamber door and collect the calibration data **II. Put device in Continuous Transmit mode** A. Power up PTM B. Discover device using ActiveX OsirisGUI.

C. Run appropriate script for desired transmit channel.

III. Device Setup

A. Center the device on the laser beam.

IV. Measurement

A. Close the chamber door

B. Measure the EIRP and TRP using Satimo's data collection system

V. Iterations

A. Repeat measurements for 403.5 MHz and 404.85 MHz

VI. Analysis

A. Calculate Gain: Gain=EIRP - transmit power

B. Calculate efficiency: efficiency=TRP- transmit power

Test Results: All data samples PASS minimum antenna gain requirements.

Capability Analysis:

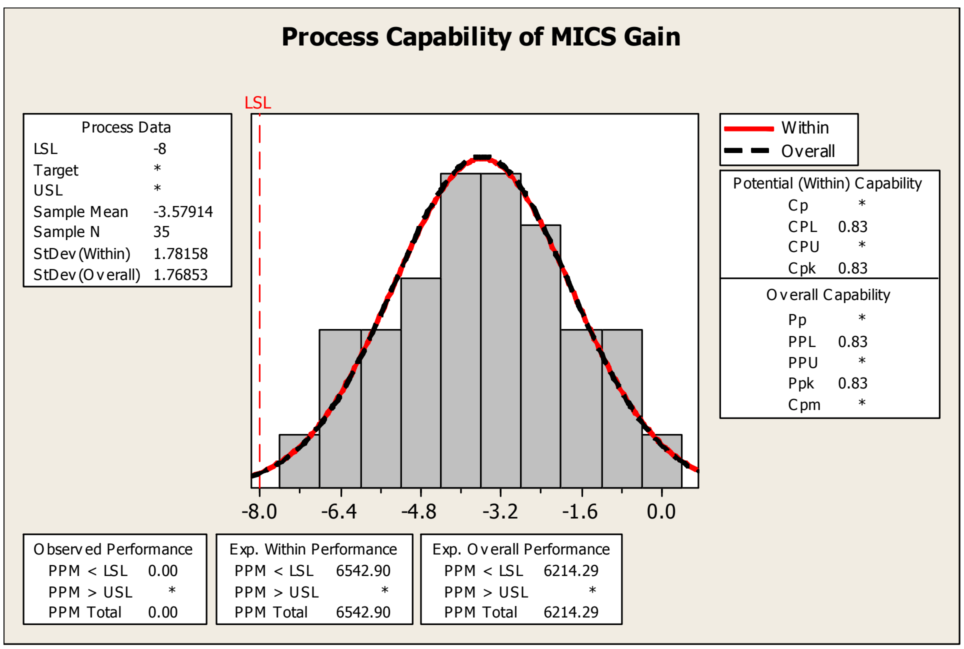


Figure 34 Capability Analysis of MICS Antenna Gain

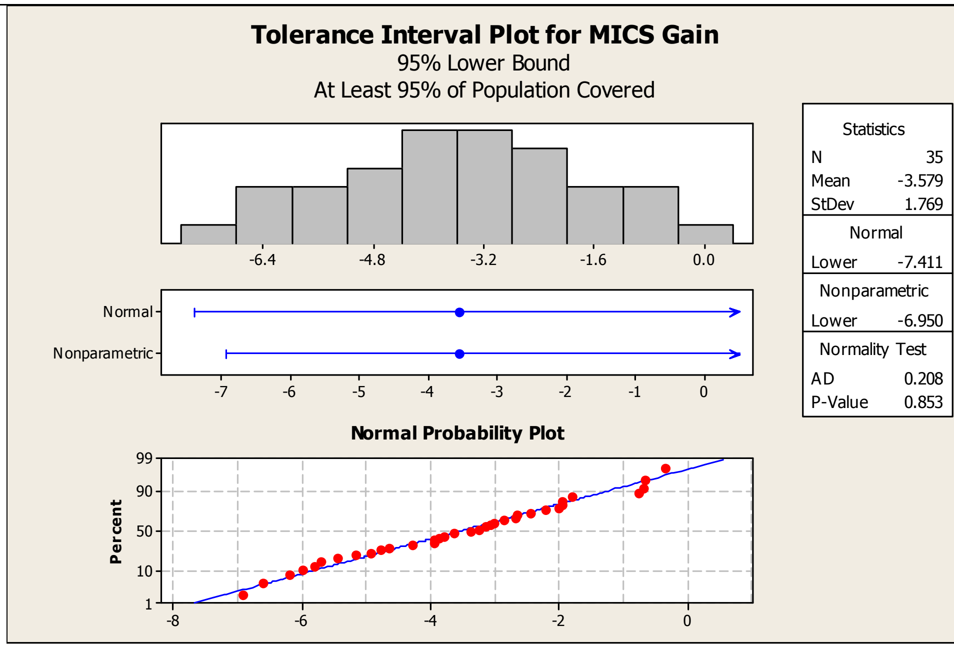


Figure 35 Tolerance Interval for MICS Antenna Gain

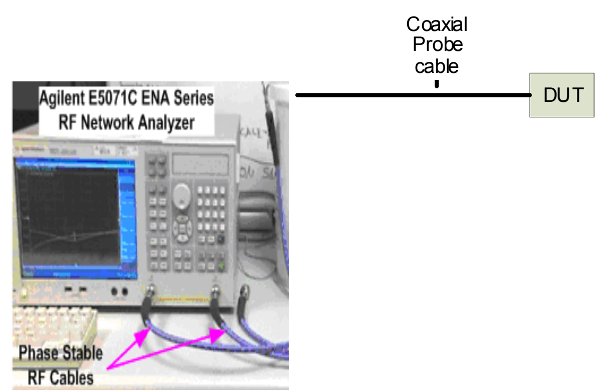
Since the Antenna Gain data found in Figure 34 was shown to have a Cpk less than 1.33, additional analysis was conducted. The analysis showed that there is 95%/95% confidence/reliability with the resulting data to meet the specification limit using the normal distribution results shown in Figure 35. The analysis is included in the supporting data file.

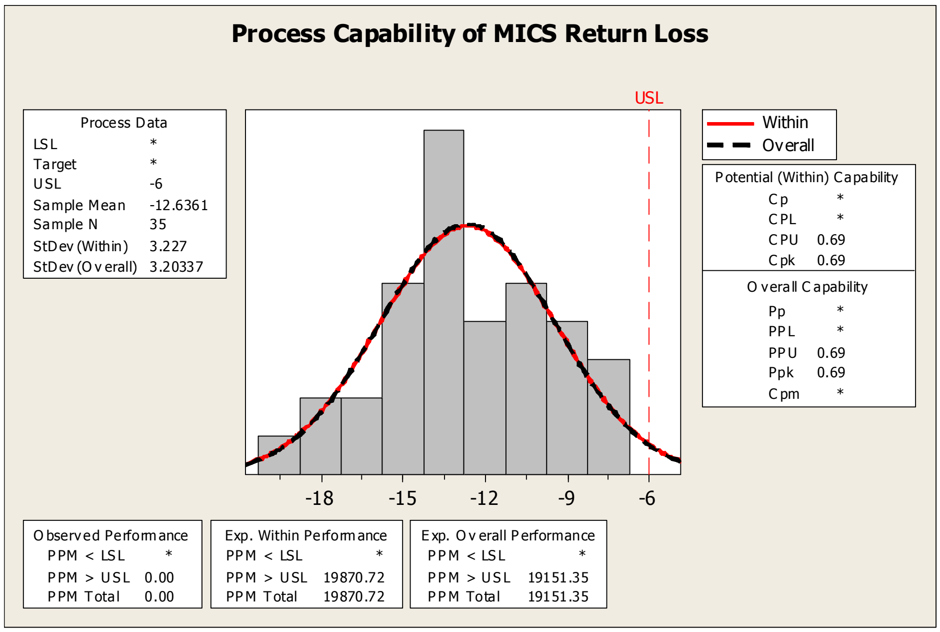
Test Data Traceability	Test data can be found in the supporting document archival file NDHF1405-128216.
Test Sample Retention	Test samples will be retained per work instructions.

Table 8 List of test cases for MICS active antenna testing

Channel	Mode	Modulation
1	Test	CW
3	Test	CW
5	Test	CW
7	Test	CW
10	Test	CW

9.4.11 RF-11: TEL-M ANTENNA RETURN LOSS

Requirements	EETD51 Tel-M Antenna Return Loss Verifies: EE309 The Tel-M antenna shall have a nominal impedance of 50 Ohms, including off module matching. EE310 The Tel-M antenna shall have return loss less than -6 dB in MICS band.
Test Description	For this test, a fully functional, form, fit DUT is used to check the antenna performance. The antenna probe connector is reversed from the normal placement so that the network analyzer will be looking into the antenna. The network analyzer frequency span is setup for a center frequency of 403.5 MHz (center of MICS band) and the span is set to 20 MHz. The number of points should be a minimum of 201 (this will provide a minimum of 100 kHz resolution). The network analyzer is then calibrated. Then the network analyzer is connected to the DUT (which is fully assembled), and return loss is measured directly. The resulting sweep is saved off to a .csv file. The resulting measurement is a direct measurement of return loss.
Sample size:	*7 DUTs*
Acceptance Criteria	An acceptance criterion is based on successful completion of tests within specified range of error or meeting the requirements set forth.
Test Objective:	Verify device meets specified requirements.
Test Environment:	 Figure 36 Return Loss Test Setup
Test Setup:	Test setup is included in the procedure
Test Procedure:	**I. Calibration** **A.** Set center frequency to 403.5 MHz. **B.** Set span to 20 MHz. **C.** Set number of points to 201. **II. Measurement**

	A. Connect network analyzer to MICS antenna 1 port of DUT B. Measure return loss of MICS antenna C. Save off return loss sweep to appropriately named .csv file (DUT serial # and antenna port should be included).
Test Results:	All data samples PASS maximum antenna return loss requirements.
Capability Analysis:	 Figure 37 Capability Analysis of Return Loss

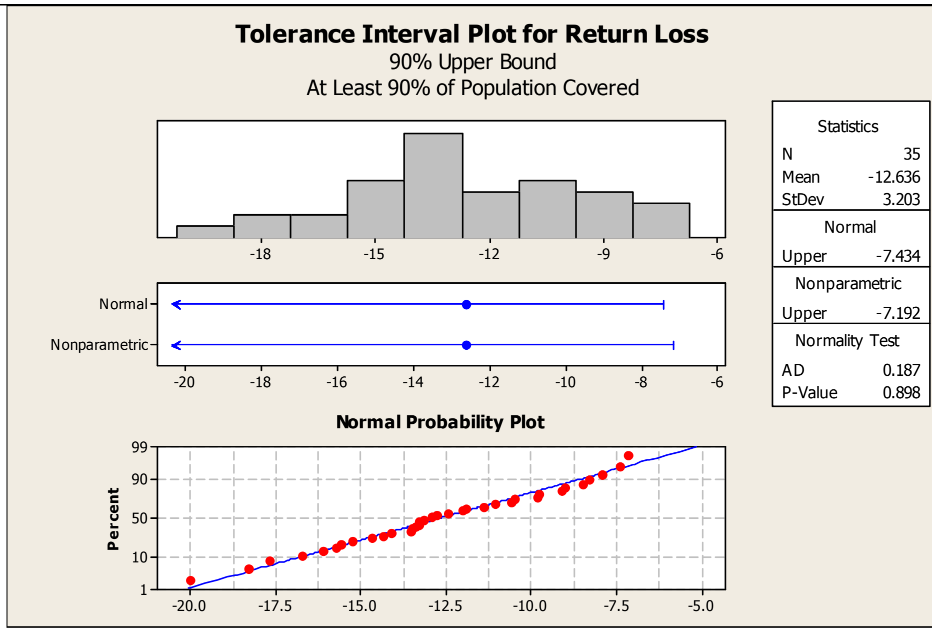


Figure 38 Tolerance Interval for Return Loss

Since the Return Loss data found in Figure 37 was shown to have a Cpk less than 1.33, additional analysis was conducted. The analysis showed that there is 90%/90% confidence/reliability with the resulting data to meet the specification limit using the nonparametric results shown in Figure 38. The analysis is included in the supporting data file.

Test Data Traceability	Test data can be found in the supporting document archival file NDHF1405-128216.
Test Sample Retention	Test samples will be retained per work instructions.

9.4.12 RF-12: Active Bluetooth Antenna Efficiency

Requirements	EETD52 Active Bluetooth Antenna Efficiency Verifies: EE386 The PTM Bluetooth antenna shall have minimum radiation efficiency of -10 dB
Test Description	This test is done at Satimo in Atlanta, GA. For this test, a fully functional, form, fit DUT is used to check the antenna performance. The test interface is used to put the devices into a CW transmit mode. The transmitting device is placed inside the calibrated anechoic chamber at Satimo at a specified location. The test antennas are configured to receive the DUT signal. The received signals are collected through Satimo's data collection system that automates the antenna switching and accounts for calibration losses. The resulting measurement provides the EIRP and TRP. The gain and efficiency can be

	calculated from EIRP and TRP, respectively.
Sample size:	7 DUTs
Acceptance Criteria	An acceptance criterion is based on successful completion of tests within specified range of error or meeting the requirements set forth.
Test Objective:	Verify device meets specified requirements.
Test Environment:	This test is part of the radiated antenna suite of tests. See test environment in section 9.4.10.
Test Setup:	Test setup is included in the procedure
Test Procedure:	**I. Calibration** A. Set the laser to a location centered within the Satimo antenna Stargate B. Place the calibration antenna at the laser location C. Shut the chamber door and collect the calibration data **II. Put device in Continuous Transmit mode** A. Power up PTM B. Discover device using ActiveX OsirisGUI. C. Run appropriate script for desired transmit channel. **III. Device Setup** A. Center the device on the laser beam. **IV. Measurement** A. Close the chamber door B. Measure the EIRP and TRP using Satimo's data collection system **V. Iterations** A. Repeat measurements for 2441.165 MHz and 2480.165 MHz **VI. Analysis** A. Calculate Gain: Gain=EIRP - transmit power B. Calculate efficiency: efficiency=TRP- transmit power
Test Results:	All data samples PASS minimum radiation efficiency requirements.
Capability Analysis:	

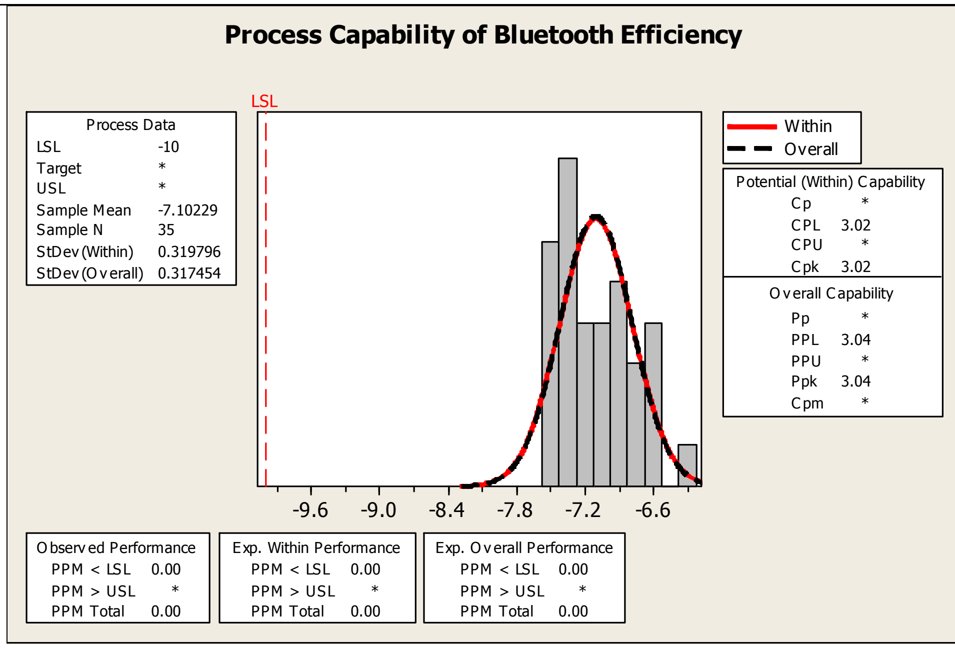


Figure 39 Capability Analysis of Radiation Efficiency of Bluetooth Antenna

Bluetooth antenna radiation efficiency results in Figure 39, show higher than 99%/99% confidence/reliability in the ability of the Bluetooth antenna to achieve a radiation efficiency of -10 dB minimum.

Test Data Traceability	Test data can be found in the supporting documents archival file NDHF1405-128216.
Test Sample Retention	Test samples will be retained per work instructions.

Table 9 List of test cases for Bluetooth active antenna testing

Channel	Frequency (MHz)	Mode	Modulation
0	2402.165	Test	CW
20	2422.165	Test	CW
39	2441.165	Test	CW
59	2461.165	Test	CW
78	2480.165	Test	CW

9.4.13 RF-13: Bluetooth Antenna Return Loss

Requirements	EETD53 Bluetooth Antenna Return Loss Verifies:

	EE316 The PTM Bluetooth transceiver antenna shall have a maximum return loss of -6 dB for frequency range between 2.4 GHz and 2.4835 GHz.
Test Description	For this test, a fully functional, form, fit DUT is used to check the antenna performance. The antenna probe connector is reversed from the normal placement so that the network analyzer will be looking into the antenna. The network analyzer frequency span is setup for a center frequency of 2441 MHz and the span is set to 200 MHz. The number of points should be a minimum of 1601. The network analyzer is then calibrated. Then the network analyzer is connected to the DUT (which is fully assembled), and return loss is measured directly. The resulting sweep is saved off to a .csv file. The resulting measurement is a direct measurement of return loss.
Sample size:	7 DUTs
Acceptance Criteria	An acceptance criterion is based on successful completion of tests within specified range of error or meeting the requirements set forth.
Test Objective:	Verify device meets specified requirements.
Test Environment:	This test is part of the radiated antenna suite of tests. See test environment in section 9.4.11.
Test Setup:	Test setup is included in the procedure
Test Procedure:	**I. Calibration** A. Set center frequency to 2441 MHz. B. Set span to 200 MHz. C. Set number of points to 1601. **II. Measurement** A. Connect network analyzer to Bluetooth antenna port of DUT B. Measure return loss of Bluetooth antenna C. Save off return loss sweep to appropriately named .csv file (DUT serial # and antenna port should be included).
Test Results:	All data samples PASS maximum antenna return loss requirements.
Capability Analysis:	

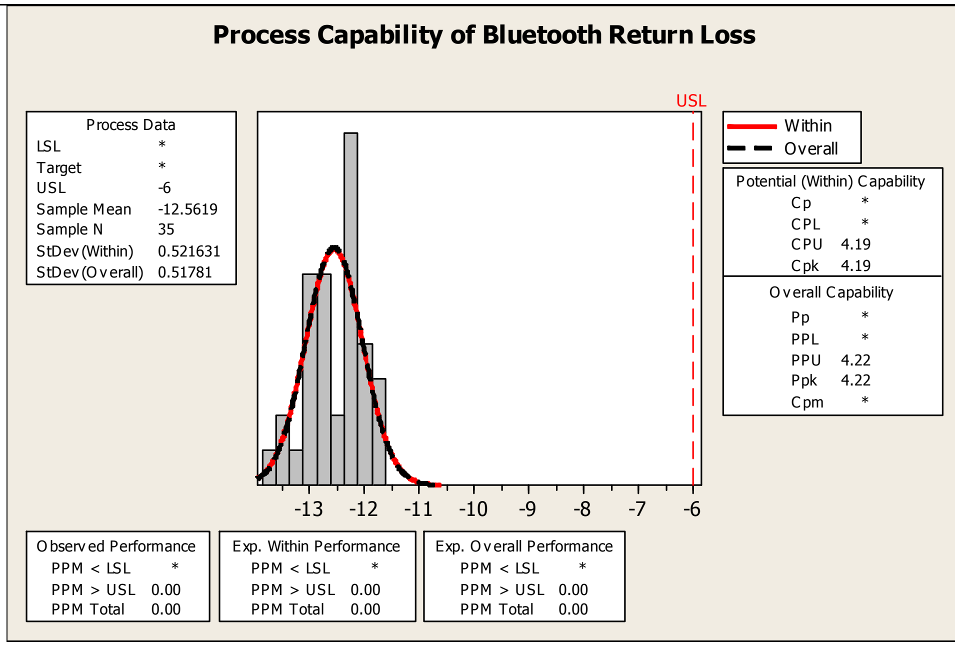


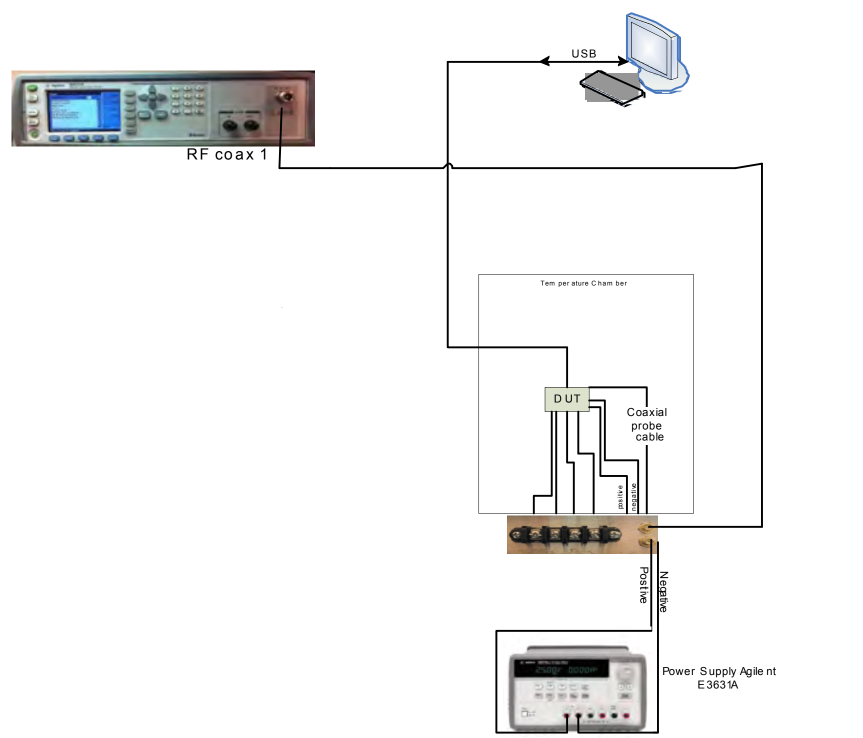
Figure 40 Capability Analysis of Return Loss of Bluetooth Antenna

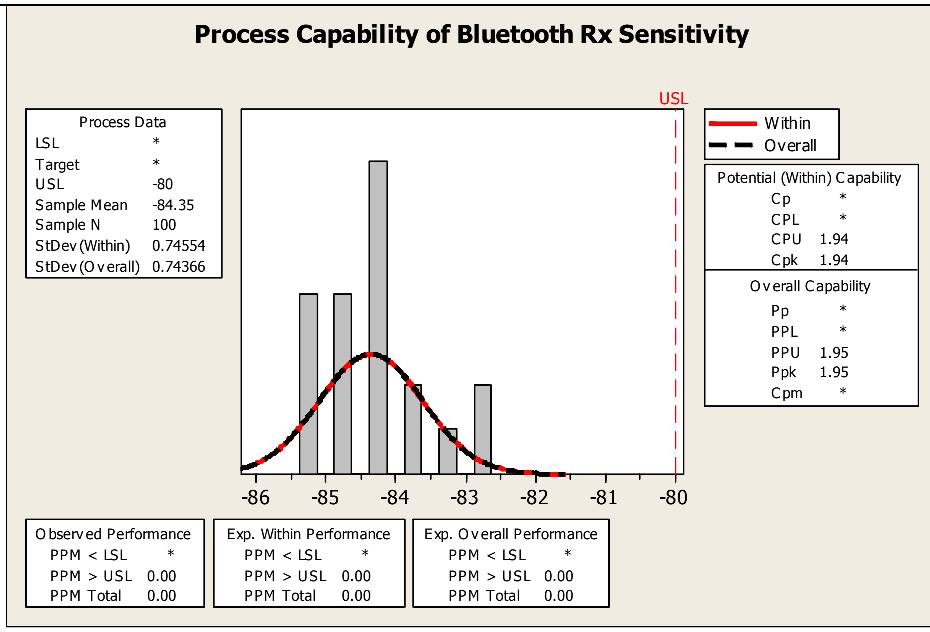
Bluetooth antenna return loss results in Figure 40 show higher than 99%/99% confidence/reliability in the ability of the Bluetooth antenna to achieve a return loss of -6 dB maximum.

Test Data Traceability	Test data can be found in the supporting document archival file NDHF1405-128216.
Test Sample Retention	Test samples will be retained per work instructions.

9.4.14 RF-14: Bluetooth Rx Sensitivity (GFSK)

Requirements	EETD54 Bluetooth Rx Sensitivity (GFSK) Verifies: EE387 The PTM Bluetooth transceiver shall have min Rx sensitivity equal or less than -80 dBm (GFSK modulation)
Test Description	The receiver sensitivity test measures how low in power a Bluetooth signal can be received by the DUT receiver and achieve a raw bit error rate (BER) ≤ 0.1%. The test is conducted in a shielded temp chamber that provides an isolated environment from external interfering signals (e.g., WiFi, Cell phone, etc.). The DUT is powered via an external power supply such that the temperature and power supply can be variable parameters in the test. A dedicated Wireless Connectivity Test Set (Agilent N40101A) is used to perform this test. After a specified number of packets, the number of received bits and bits with errors are counted.

Sample size:	5 DUTs
Acceptance Criteria	An acceptance criterion is based on successful completion of tests within specified range of error or meeting the requirements set forth.
Test Objective:	Verify device meets specified requirements.
Test Environment:	 Figure 41 Test setup for Bluetooth receiver testing
Test Setup:	**Cable connections and initial calibrations:** 1. Measure the loss of coax1. Record this loss factor and program it into the N40101A. 2. Place the DUT inside temperature chamber 3. Connect the measured coaxial cable. 4. Connect the power supply to the DUT.
Test Procedure:	**I. Calibration** A. Set channels to non frequency hopping. B. Set channels to test channel 0, 39, and 78. C. Set number of bits to send to 16e6. D. Ensure data whitening is enabled.

	E. Ensure interference is on. F. Ensure DUT has custom “Bluetooth Test Mode” firmware installed. G. Set Rx power to -85 dBm. **II. Measurement** A. Run Rx test suite. B. Record Rx results. C. Repeat steps A & B after incrementing Rx power by 1 dB until Rx sensitivity is achieved.
Test Results:	All data samples PASS minimum Bluetooth Rx sensitivity.
Capability Analysis:	 Figure 42 Capability Analysis of Bluetooth Rx Sensitivity Bluetooth Rx sensitivity results, Figure 42, show higher than 99%/99% confidence/reliability in achieving a minimum sensitivity of -80 dBm.
Test Data Traceability	Test data can be found in the supporting documents archival file NDHF1405-128216.
Test Sample Retention	Test samples will be retained per work instructions.

9.4.15 RF-15: BLUETOOTH STANDARD QUALIFICATION

Requirements	EETD55 Bluetooth Standard Qualification Verifies:

	EE241 The PTM3 electrical design shall provide a Bluetooth transceiver compliant with the Bluetooth 2.1 RF specifications as a class 1 device with a maximum output power less than +10dBm.
Test Description	This test is done at 7 Layers, Inc. located in Irvine, CA. For this test, a fully functional, form, fit DUT is provided to 7 Layers, Inc. for Bluetooth certification. 7 Layers is accredited and has Bluetooth Qualification Test Facility (BQTF) status, thus formally recognized as competent to perform "Category A" Bluetooth qualification conformance tests.
Sample size:	1 DUT
Acceptance Criteria	An acceptance criterion is based on successful completion of tests and attaining Bluetooth EDR 2.1 certification.
Test Objective:	Verify device meets specified requirements.
Test Environment:	This requirement will be tested at 7 Layers, Inc. located in Irvine, CA.
Test Setup:	Test setup is included in the procedure
Test Procedure:	**I. Calibration** A. Record the loss of the RF coaxial cable provided to 7 Layers and provide that information to them. **II. Firmware** A. Load a custom F/W version on the DUT(s) to be tested. This firmware puts the Bluetooth radio in Bluetooth test mode, rather than normal power up conditions.
Test Results:	The PTM3, Model 97745, successfully passed all Bluetooth qualification testing.
Test Data Traceability	This testing evidence can be found in the supporting documents archival file NDHF1405-128216.
Test Sample Retention	Test samples will be retained per work instructions.

9.4.16 RF-16: Tel M I/O

Requirement	EETD98 Tel M I/O Verifies: EE270 The Tel-M module digital inputs shall support a maximum 10%-90% rise time of 40 ns EE271 The Tel-M module digital inputs shall support a maximum 90%-10% fall time of 40 ns EE272 The Tel-M module digital inputs shall support a minimum logic high level voltage of DVDD-0.1V EE273 The Tel-M module digital inputs shall support a maximum logic high level voltage of DVDD

	EE274 The Tel-M module digital inputs shall support a maximum logic low level voltage of 0.3V EE275 The Tel-M SPI interface shall use nominal clock frequency 4 MHz EE276 The Tel-M SPI interface shall have a SCK duty cycle of 50% +/-10% EE277 The Tel-M SPI interface shall have SDI setup time (before SCK rising edge) >= 62ns EE278 The Tel-M SPI interface shall have SDI hold time (after SCK rising edge) >= 125ns and <= 187ns EE279 The Tel-M SPI interface shall have SDO setup time (before SCK rising edge) >= 30ns and <= 125ns EE280 The Tel-M SPI interface shall have SDO hold time (after SCK rising edge) >= 125ns and <= 187ns EE281 The Tel-M SPI interface shall have SCS duration for logic high >= 50 ns EE282 The Tel-M SPI interface shall have a delay after the last SCK falling edge and before SCS is inactive >= 125ns EE283 The Tel-M SPI interface shall have a delay after SCS is inactive and SDO going high impedance <= 62ns
Test Description	This will be verified via inspection of the Tel M module requirement (A17245).
Sample size:	*N/A*
Acceptance Criteria	An acceptance criterion is based on the Tel M module supporting the I/O requirements as stated above.
Test Objective:	Verify device meets specified requirements.
Test Environment:	N/A
Test Setup:	N/A
Test Procedure:	N/A
Test Results:	Inspection of the Telemetry M RF Module Requirements Specification (A17245) shows that the module meets the requirements set forth.
Test Data Traceability	N/A
Test Sample Retention	N/A

10 SAMPLE BUILD TRACEABILITY

S/N	Configuration/Assembly Number	Test Used	Traceability Documentation	Alterations

		On		
NLD001682N	PCBA/ M951956A001	RF-6		
NLD001607N	PCBA/ M951956A001	RF-6		
NLD001633N	PCBA/ M951956A001	RF-1 – RF-7		
NLD001759N	PCBA & HLA/ M951956A001	RF-1 – RF -9, RF-14		
NLD001726N	PCBA & HLA/ M951956A001	RF-1 – RF -9, RF-14		
NLD001725N	PCBA & HLA/ M951956A001	RF-1 – RF -9, RF-14		
NLD001776N	PCBA & HLA/ M951956A001	RF-1 – RF -9, RF-14		
NLD001754N	PCBA & HLA/ M951956A001	RF-1 – RF -9, RF-14		
NLD001630N	HLA/ M951956A001	RF-10 – RF-13		RF switches (J1-J3) reversed for RF-12 & RF-14
NLD001595N	HLA/ M951956A001	RF-10 – RF-13		RF switches (J1-J3) reversed for RF-12 &

				RF-14
NLD001667N	HLA/ M951956A001	RF-10 – RF-13		RF switches (J1-J3) reversed for RF-12 & RF-14
NLD001631N	HLA/ M951956A001	RF-10 – RF-13		RF switches (J1-J3) reversed for RF-12 & RF-14
NLD001760N	HLA/ M951956A001	RF-10 – RF-13		RF switches (J1-J3) reversed for RF-12 & RF-14
NLD001758N	HLA/ M951956A001	RF-10 – RF-13		RF switches (J1-J3) reversed for RF-12 & RF-14
NLD001747N	HLA/ M951956A001	RF-10 – RF-13		RF switches (J1-J3) reversed for RF-12 & RF-14
NLD001756N	HLA/ M951956A001	RF-15		
NLD001627N	HLA/ M951956A001	RF-15		

11 CONCLUSION

Instruments from the PTM3 Model 97745 electrical DVT build, which are production representative, were used to execute the testing in the PTM3 Model 97745 RF DVT Test Protocol. All tests passed with no modifications to the test protocol. All testing passed as described in this report and the PTM3 Model 97745 RF design is considered verified.

12 RECOMMENDATIONS

Based on the results within this report, the PTM3 Model 97745 instrument meets all RF specifications reflected in this report. The recommendation is to move forward to production release pending successful completion of all other verification testing.

13 DATA ANALYSIS

N/A

14 APPENDIX

14.1 Appendix A: Measurement of RF path loss through cables

14.1.1 Narrowband cable loss measurements

All losses due to cable connections must be accounted. Each cable must be measured using the following procedure and then the losses can be input into the Labview code to be accounted properly in the calculations.

1. Connect the suitable extension cables to network analyzer ports 1 and 2
2. Preset the Network Analyzer to get to a common and known state
3. Select a span from 200 MHz to 600 MHz
4. Perform appropriate calibration on the network analyzer using the E Cal module
5. Connect the cable(s) to the network analyzer.
6. Select Log magnitude display mode
7. Select measurement type “S21”
8. Turn on averaging and/or smoothing ON (optional)
9. Place the marker at 403 MHz
10. Read the transmission loss (in dB)
11. Enter this value into the Labview application

14.1.2 Broad Band Cable Loss Measurements

The spurious harmonics test is over a broad range of frequency. To account for the change in RF losses over frequency, all path losses (e.g., cables, connectors, and SAM3 path) must be measured across the broadband. During the test, the large frequency band (500 kHz to 3 GHz) is measured in 300 kHz increments. Table 10 breaks up the measurement to capture data at the center point of each of these 300 kHz increments. The data will be input into a table for import by the Labview application and accounting during measurements.

1. Connect the suitable extension cables to network analyzer ports 1 (and 2)
2. Preset the Network Analyzer to get to a common and known state
3. Select a span from 650 kHz to 224.75 MHz and 748 data points
4. Perform (two port) calibration on the network analyzer using the E Cal module
5. Move SW1 and SW2 in the SAM3 to position 2
6. Connect RF coax 2 between port 1 of the network analyzer and Sig Gen C on the SAM3. (Remove any circulators/isolators for this measurement since they are band limited.)
7. Connect RF coax 3 between port 2 of the network analyzer and DUT on the SAM3.
8. Select Log magnitude display mode
9. Select measurement type “S21”
10. Turn on averaging and/or smoothing ON (optional)
11. Save the data to a .csv file
12. Move SW1 and SW2 in the SAM3 to position 1.
13. Repeat steps 3-11each of the spans and data points listed in Table 10.
14. Concatenate all of the .csv files into a single file with two columns: Frequency (Hz), Path loss in dB
15. Use the Labview application to input this file for the spurious harmonics test

Table 10 Frequency spans and number of data points to create the broadband path loss table for test RF-6

start frequency (Hz)	number of data points	stop frequency (Hz)	start frequency (Hz)
100000	1601	1125000000	100000
1125000000	1601	2250000000	1125000000
2250000000	1601	3375000000	2250000000
3375000000	1601	4500000000	3375000000

14.2 Appendix B: REQUIREMENTS TRACE

Table 11 Requirements Trace from EDVT Protocol to EE Requirements

EETD Tag	Requirement text	Requirement Status	Traced-to
EETD41	Tel-M Receiver Sensitivity	Approved	EE193, EE296, EE305, EE311
EETD42	Tel-M Receiver Intermodulation Rejection	Approved	EE193, EE298, EE311
EETD43	Tel-M Receiver Adjacent Channel Rejection	Approved	EE193, EE299, EE311
EETD44	Tel-M Receiver Alternate Channel Rejection	Approved	EE193, EE300, EE311
EETD45	Tel-M External Spurious Response Rejection (Single Tone, Unmodulated)	Approved	EE303
EETD46	Tel-M Rx RSSI Linearity and Differentiation	Approved	EE193, EE306, EE307, EE311
EETD47	Tel-M Transmitter Output Power, Adjacent Channel Power Ratio, and Alternate Channel Power Ratio	Approved	EE193, EE286, EE291, EE293, EE311
EETD48	Tel-M Transmitter Error Vector Magnitude & Transmitter Frequency Stability	Approved	EE193, EE284, EE285, EE311, EE388(s)
EETD49	Tel-M Transmitter Spectral Emissions	Deleted	
EETD50	Active Tel-M Antenna Gain	Approved	EE308
EETD51	Tel-M Antenna Return Loss	Approved	EE309, EE310
EETD52	Active Bluetooth Antenna Efficiency	Approved	EE386
EETD53	Bluetooth Antenna Return Loss	Approved	EE316
EETD54	Bluetooth Rx Sensitivity (GFSK)	Approved	EE193, EE311, EE387
EETD55	Bluetooth Standard Qualification	Approved	EE193, EE311, PR34
EETD56	Tel_M Receiver AM Channel Rejection	Approved	EE193, EE304, EE311
EETD98	Tel M I/O	Approved	EE270, EE271, EE272, EE273, EE274, EE275, EE276, EE277, EE278, EE279, EE280, EE281, EE282, EE283
EETD166	AA Alkaline Batteries Current Drain	Approved	EE193, EE206, EE207, EE311, EE560, EE562
EETD167	Li-ion Battery Current Drain	Approved	EE193, EE311, EE558, EE559, EE561, EE563
EETD168	Power Supplies - 2.8V Supply	Approved	EE208, EE210, EE265, EE266
EETD169	Power Supplies - 3.3V Supply	Approved	EE211, EE213
EETD170	Battery Charger	Approved	EE194, EE197, EE200, EE311
EETD171	Reverse Polarity Protection	Approved	EE201, EE311, EE564
EETD172	Battery Voltage Measurement	Approved	EE202, EE311

EETD173	Real Time Clock (RTC) Backup Power	Approved	EE205, EE311
EETD174	Internal Memory	Approved	EE217, EE218
EETD175	External Memory	Approved	EE224, EE225
EETD176	LCD Display	Approved	EE226
EETD177	LCD Backlight Power and Control	Approved	EE204, EE215, EE311
EETD178	Capacitive Touch Panel Power	Approved	EE557
EETD179	Capacitive Touch Panel	Approved	EE227, EE311
EETD180	Audio Transducer	Approved	EE230, EE311
EETD181	Vibration Motor Operating Voltage	Approved	EE231
EETD182	Vibration Motor	Approved	EE232, EE311
EETD183	Simultaneous Vibration Motor and Audio Speaker	Approved	EE233, EE311
EETD184	Pushbuttons and Switches	Approved	EE234, EE311
EETD185	LED Indicators	Approved	EE237, EE311
EETD186	System Connector	Approved	EE257, EE258, EE260, EE262, EE263, EE264, EE311, EE317, EE318, EE565
EETD187	USB Alive	Approved	EE193, EE260, EE311

Table 12 Requirements Trace from EE Requirements to RF DVT Protocol

EE Tag	Requirement text	Requirement Status	Traced-from	Traced-to
EE193	The PTM3 electrical design shall be operational from two AA alkaline batteries or a rechargeable Li-Ion battery pack and an external 5V power supply at the system connector over a voltage range of 2.3V(-0/+50mV) to 5.0V(+/-250mV).	Approved	EETD41, EETD42, EETD43, EETD44, EETD46, EETD47, EETD48, EETD54, EETD55, EETD56, EETD166, EETD167, EETD187	PR35, PR36, PR324
EE194	The PTM3 electrical design shall provide an integrated battery charger that will operate from an input voltage of 5V +/- 250mV provided by an external power supply input at the system connector.	Approved	EETD170	PR36, PR324
EE197	The PTM3 battery charger when powered and enabled shall charge the Li-Ion rechargeable battery pack at 850mA +/- 50mA when the battery pack is at 3.5V	Approved	EETD170	PR36, PR324, PR325
EE200	The PTM3 electrical design shall provide a method of	Approved	EETD170	PR36, PR37

	communicating with the Li-Ion *rechargeable battery pack.			
EE201	The PTM3 electrical design shall provide reverse polarity protection at the battery input with a maximum reverse leakage current of 10 uA when AA alkaline batteries are installed in reverse.	Approved	EETD171	PR37, PR326
EE202	The PTM3 electrical design shall provide a method to measure battery voltage over a voltage range of 2.3 to 4.2V+/-150mV.	Approved	EETD172	PR85
EE204	The PTM3 electrical design shall provide an LCD power switch that will be controlled by the microcontroller.	Approved	EETD177	PR39, PR40, PR89
EE205	The PTM3 electrical design shall provide an RTC backup power source that shall maintain the microcontroller RTC for a minimum duration of 4 hours with the main battery removed.	Approved	EETD173	PR44
EE206	The PTM3 electrical design shall have an average battery current drain <= 4mA in STANDBY mode for a AA battery voltage range of 2.3V to 3.2V.	Approved	EETD166	PR40
EE207	The PTM3 electrical design shall have an average battery current drain <= 250mA in ACTIVE mode for a AA battery voltage range of 2.3V to 3.2V.	Approved	EETD166	PR40
EE208	The PTM3 electrical design shall provide a system power supply with an average output voltage of 2.8V for an input voltage range of 2.3V to 5.0V.	Approved	EETD168	PR35, PR36
EE210	The PTM3 system power supply shall always be enabled for a battery voltage >= 2.3V.	Approved	EETD168	PR35, PR384
EE211	The PTM3 electrical design shall provide a power supply with an average output voltage of 3.3V+/-200mV for	Approved	EETD169	PR35, PR36

	an input voltage range of 2.3 to 5.0V.			
EE213	The PTM3 3.3V supply shall be enabled and disabled by the microcontroller.	Approved	EETD169	PR35, PR36, PR39, PR40, PR327
EE215	The PTM3 LCD backlight power supply shall be able to control backlight from off to maximum brightness based on a PWM input with a duty cycle in 20% increments.	Approved	EETD177	PR35, PR36, PR89
EE217	The PTM3 microcontroller shall provide flash with a minimum capacity of 1 MBytes.	Approved	EETD174	PR42
EE218	The PTM3 microcontroller shall provide SRAM with a minimum capacity of 96 Kbytes.	Approved	EETD174	PR335
EE224	The PTM3 electrical design shall provide serial flash with a minimum capacity of 2 MBytes.	Approved	EETD175	PR42
EE225	The PTM3 electrical design shall provide external SRAM with a minimum capacity of 2 MBytes.	Approved	EETD175	PR335
EE226	The PTM3 electrical design shall provide a transflective 2.8" QVGA TFT LCD with an LED backlight.	Approved	EETD176	PR16, PR89
EE227	The PTM3 electrical design shall provide a projected capacitance touch panel that supports single touch events.	Approved	EETD179	PR89
EE230	The PTM3 audio transducer shall have a minimum sound pressure level of 60dBA measured at 10 cm at 400Hz and 600Hz.	Approved	EETD180	PR86, PR87
EE231	The PTM3 electrical design shall provide a vibration motor.	Approved	EETD181	PR86
EE232	The PTM3 electrical design shall provide a power switch that will enable and disable the vibration motor.	Approved	EETD182	PR86

EE233	The PTM3 shall support the production of audible tones and vibrations simultaneously.	Approved	EETD183	PR86
EE234	The PTM3 electrical design shall provide 3 tactile pushbuttons for therapy on/off up and down functions that can generate hardware interrupts when pressed or released.	Approved	EETD184	PR95
EE237	The PTM3 shall have two LEDs, one green and one yellow.	Approved	EETD185	PR333
EE257	The PTM3 system connector shall provide a switched battery power output that is controlled by the microcontroller.	Approved	EETD186	PR33
EE258	The PTM3 system connector shall provide a switched 3.3V power output that is controlled by the microcontroller.	Approved	EETD186	PR33
EE260	The PTM3 USB device interface shall support software boot loading of the microcontroller.	Approved	EETD186, EETD187	PR5, PR33, PR51
EE262	The PTM3 system connector shall provide 2 UARTs with a minimum data rate of 115.2 kbps.	Approved	EETD186	PR5, PR6, PR33, PR251, PR382
EE263	The PTM3 system connector shall provide an interrupt signal input.	Approved	EETD186	PR33, PR324, PR325
EE264	The PTM3 system connector shall provide a dock detect interrupt signal input.	Approved	EETD186	PR33, PR324, PR325
EE265	The Tel-M module BPFLT supply voltage shall be >= 1.85V and <=3.5V.	Approved	EETD168	PR45
EE266	The Tel-M module DVDD power supply shall be >= 1.3V and <= BPFLT supply voltage.	Approved	EETD168	PR45
EE270	The Tel-M module digital inputs shall support a maximum 10%-90% rise time of 40 ns.	Approved	EETD98	PR45
EE271	The Tel-M module digital inputs shall support a	Approved	EETD98	PR45

	maximum 90%-10% fall time of 40 ns.			
EE272	The Tel-M module digital inputs shall support a minimum logic high level voltage of DVDD - 0.1V.	Approved	EETD98	PR45
EE273	The Tel-M module digital inputs shall support a maximum logic high level voltage of DVDD.	Approved	EETD98	PR45
EE274	The Tel-M module digital inputs shall support a maximum logic low level voltage of 0.3V.	Approved	EETD98	PR45
EE275	The Tel-M SPI interface shall use a nominal clock frequency 4MHz.	Approved	EETD98	PR45
EE276	The Tel-M SPI interface shall have a SCK duty cycle of 50% +/-10%.	Approved	EETD98	PR45
EE277	The Tel-M SPI interface shall have SDI setup time (before SCK rising edge) >= 62ns.	Approved	EETD98	PR45
EE278	The Tel-M SPI interface shall have SDI hold time (after SCK rising edge) >= 125ns and <= 187ns.	Approved	EETD98	PR45
EE279	The Tel-M SPI interface shall have SDO setup time (before SCK rising edge) => 30ns and <= 125ns.	Approved	EETD98	PR45
EE280	The Tel-M SPI interface shall have SDO hold time (after SCK rising edge) >= 125ns and <= 187ns.	Approved	EETD98	PR45
EE281	The Tel-M SPI interface shall have SCS duration for logic high >= 50 ns.	Approved	EETD98	PR45
EE282	The Tel-M SPI interface shall have a delay after the last SCK falling edge and before SCS is inactive >= 125ns.	Approved	EETD98	PR45
EE283	The Tel-M SPI interface shall have a delay after SCS is inactive and SDO going high impedance <= 62ns.	Approved	EETD98	PR45
EE284	The Tel-M RF synthesizer shall tune in increments of 300 kHz from 402.15 MHz to 404.85 MHz.	Approved	EETD48	PR45

EE285	The Tel-M RF synthesizer shall have a minimum frequency stability of 12ppm.	Approved	EETD48	PR45
EE286	The Tel-M Transmitter shall have a minimum conducted output power into a 50 ohm load of -16.25dBm and a maximum of -11.25dBm.	Approved	EETD47	PR45
EE291	The Tel-M Transmitter shall have minimum ACPR -34dBc. Measured at fc+/-50kHz to fc+/-150kHz	Approved	EETD47	PR45
EE293	The Tel-M Transmitter shall have minimum AltCPR -40 dBc. Measured at fc+/-150kHz to fc+/-250kHz.	Approved	EETD47	PR45
EE296	The Tel-M Receiver shall have a minimum Mode1 sensitivity of -89dBm.	Approved	EETD41	PR45
EE298	The Tel-M Receiver shall have minimum IM rejection of 47dB with interferers at 1.5 MHz and 3.0 MHz offset from desired signal.	Approved	EETD42	PR45
EE299	The Tel-M Receiver shall have minimum adjacent channel rejection of 35dB at 100 kHz offset.	Approved	EETD43	PR45
EE300	The Tel-M Receiver shall have minimum alternate channel rejection of 44dB at 200 kHz offset.	Approved	EETD44	PR45
EE303	The Tel-M Receiver shall have outband single tone spurious response >= -42dBm for CW interferers ranging from 500kHz to 3GHz with the following exceptions: For Mode 1: External spurious response rejection shall be >= -52 dBm for 250 kHz to 350 kHz offset, >= -50.0 dBm for 350 kHz to 450 kHz offset, >= -49.5 dBm for 450 kHz to 550 kHz offset, >= -48 dBm for 550 kHz to 650 kHz offset, >= -46.5 dBm for 650 kHz to 750 kHz offset, -45.5 dBm for 750 kHz to 850 kHz offset, >= -45 dBm for	Approved	EETD45	PR45

	850 kHz to 950 kHz offset, >= -44 dBm for 950 kHz to 1050 kHz offset, >= -43.5 dBm for 1050 to 1150 kHz offset, >= -43 dBm for 1150 kHz to 1250 kHz offset, >= -42.5 dBm for 1250 to 1350 kHz offset..			
EE304	The Tel-M Receiver shall have AM rejection better >= -58dBm for 1.5MHz offset.	Approved	EETD56	PR45
EE305	The Tel-M Receiver shall have effective over the air maximum Rx power >= -22dBm with Rx attenuation setting.	Approved	EETD41	PR45
EE306	The Tel-M Receiver shall have a minimum monotonic RSSI range of -109dBm to -55 dBm for Clear Channel Assessment (CCA) (i.e. no Rx attenuation present).	Approved	EETD46	PR45
EE307	The Tel-M Receiver shall be able to differentiate -109dBm and -106 dBm across all MICS channels for Clear Channel Assessment (CCA) (i.e. no Rx attenuation present).	Approved	EETD46	PR45
EE308	The PTM3 Tel-M antenna shall have minimum gain of -8.0 dBi in free space.	Approved	EETD50	PR45
EE309	The Tel-M antenna shall have a nominal impedance of 50 ohms, including off module matching.	Approved	EETD51	PR45
EE310	The Tel-M antenna shall have return loss less than -6 dB in MICS band.	Approved	EETD51	PR45

EE311	The PTM3 electrical design shall be fully functional within the temperature range of 9+/-2 degrees Celsius to 43+/-2 degrees Celsius.	Approved	EETD41, EETD42, EETD43, EETD44, EETD46, EETD47, EETD48, EETD54, EETD55, EETD56, EETD166, EETD167, EETD170, EETD171, EETD172, EETD173, EETD177, EETD179, EETD180, EETD182, EETD183, EETD184, EETD185, EETD186, EETD187	PR73
EE316	The PTM Bluetooth transceiver antenna shall have a maximum return loss of -6 dB for frequency range between 2.4GHz and 2.4835GHz.	Approved	EETD53	PR34
EE317	The PTM3 system connector switched battery power shall be able to provide 4.5W of power to an external peripheral while in ACTIVE mode.	Approved	EETD186	PR33
EE318	The PTM3 system connector switch 3.3V power shall be able to provide 110mA of current to an external peripheral while in ACTIVE mode.	Approved	EETD186	PR33
EE386	The PTM Bluetooth antenna shall have minimum radiation efficiency of -10 dB	Approved	EETD52	
EE387	The PTM Bluetooth transceiver shall have min Rx sensitivity equal or less than -80 dBm (GFSK modulation)	Approved	EETD54	
EE388	The Tel-M Transmitter in mode 1 shall have EVM <=8.4%.	Approved	EETD48(s)	

EE557	The PTM3 electrical design shall provide a capacitive touch panel power switch that will be controlled by the microcontroller.	Approved	EETD178	
EE558	The PTM3 electrical design shall have an average battery current drain <= 2.8mA in STANDBY mode for a Li-Ion battery voltage range of 3.0V to 4.2V.	Approved	EETD167	PR39, PR327
EE559	The PTM3 electrical design shall have an average battery current drain <= 180mA in ACTIVE mode for a Li-Ion battery voltage range of 3.0V to 4.2V.	Approved	EETD167	PR39, PR327
EE560	The PTM3 electrical design shall have an average battery current drain <= 125mA in DIM mode for a AA battery voltage range of 2.3V to 3.2V.	Approved	EETD166	
EE561	The PTM3 electrical design shall have an average battery current drain <= 110mA in DIM mode for a Li-Ion battery voltage range of 3.0V to 4.2V.	Approved	EETD167	PR39, PR327
EE562	The PTM3 electrical design shall have an average battery current drain <= 100mA in DARK mode for a AA battery voltage range of 2.3V to 3.2V.	Approved	EETD166	
EE563	The PTM3 electrical design shall have an average battery current drain <= 100mA in DARK mode for a Li-Ion battery voltage range of 3.0V to 4.2V.	Approved	EETD167	PR39, PR327
EE564	When powered by the external, mains-powered supply, the PTM3 shall not cause any harm to properly inserted AA batteries	Approved	EETD171	
EE565	The PTM3 electrical design shall have a max current drain <=2.0A in ACTIVE RTM MODE for a Li-ion battery voltage of 3.3V while maintaining a minimum 3.0V on the VBAT terminals on the	Approved	EETD186	PR327

	system connector.			