TRANSMITTER REPORT

For

ELPRO Technologies

9/12 Billabong St.
Stafford, QLD, Australia
4053

Date:	27 March 2018
Report No.:	16599-2E
Revision No.:	2
Project No.:	16599
Equipment:	UHF Radio Module 421 to 480MHz 10Watt
Model No.:	E2-455
FCC ID:	O9P-E2-455
IC:	3957A-E2455

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Unit 205 – 8291 92 St, Delta, BC
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Phone: 604-247-0444
Fax: 604-247-0442
www.labtestcert.com

Contents

TEST REPORT		
FCC Part 90 IC RSS-119		
Report Reference No.....:	16599-2E	
Report Revision History. .....:	✓ Rev. 0: Draft 0 19 February 2018 ✓ Rev. 1: Original Release 28 February 2018	
Compiled by (+ signature)	David Johanson	
Approved by (+ signature).....	Jeremy Lee	
Date of issue.....:	27 March 2018	
Testing Laboratory Name.....:	LabTest Certification Inc.	
Address .....:	3128-20800 Westminster HWY, Richmond, B.C. V6V 2W3 Canada	
FCC Site Registration No......:	CA5970	
IC Site Registration No. .....:	5970A-2	
Test Site Location Name ..... :	LabTest Certification Inc.	
Address ..... :	3128–20800 Westminster Hwy, Richmond, B.C. V6V 2W3 Canada	
Applicant's name.....:	ELPRO Technologies, PTY LTD.	
Address .....:	9/12 Billabong Street, Stafford, QLD 4053 Australia	
Manufacturer's Name .....:	ELPRO Technologies, PTY LTD.	
Address .....:	9/12 Billabong Street, Stafford, QLD 4053 Australia	
Test specification:		
Standard (s).....:	➢ FCC Part 2, 90; 2017 ➢ IC RSS-119 Iss 12 May 2015 ➢ IC RSS-Gen Iss 4 November 2014	
Test procedure .....:	➢ ANSI C63.4:2014; ANSI TIA-603-E	
Non-standard test method……..:	N/A	
Test item description .....:	UHF Radio Module 421 to 480MHz 10Watt	
Trade Mark .....:	EATON Powering Business Worldwide	
Model/Type reference .....:	E2-455	

FCC ID	O9P-E2-455
IC Certification	3957A-E2455
Serial Numbers.....:	ENG001
Ratings .....:	13Vdc 3Amps
Possible test case verdicts:	
- test case does not apply to the test object .....:	N/A
- test object does meet the requirement .....:	P (Pass)
- test object does not meet the requirement .....:	F (Fail)
Testing:	
Date of receipt of test item .....:	31 October 2017
Date (s) of performance of tests.....:	31 October to 02 February 2018

General remarks:

The test results presented in this report relate only to the object tested.

The results contained in this report reflect the results for this particular model and serial number. It is the responsibility of the manufacturer to ensure that all production models meet the intent of the requirements detailed within this report.

This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.
"(see Enclosure #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

Throughout this report a period "**.**" (point) is used as the decimal separator.

This test report is for the Transmitter functions only.

For digital mode test results as per FCC Part15/B and IC ICES-003, refer to Labtest test report:

"16599-1E_rev1_Elpro.pdf"

Equipment Description

General product information:

The ELPRO E2-455 UHF Wireless Module is designed to be added to a host unit. This will provide a UHF channel for communications with other devices using an FM Analog 12.5kHz channel.

This module is designed to only be used by ELPRO hosts and will not be made available to sale to other OEMS or the general public.

This EUT was tested on its own without a host unit or chassis. It was connected to a 13Vdc power supply, and a laptop using a serial port for programming the frequencies and modulations.

It is designed for the UHF bands 421 to 480MHz.

The frequency range, available channels and transmission power are pre-programmed and restricted by the factory at the time of purchase, based on the clients license.

Modulations:
• 2FSK
• 4FSK

Emission Designations:
• 2FSK Digital: 11K0F1D
• 4FSK Digital: 11K0F1D

EUT Internal Operating Frequencies

Description	Frequency	Description	Frequency
Micro Crystal	32.768kHz	Reference and Modem and IC502	16.000MHz
Micro PLL	48.00MHz	VCO (2 x Transmitter Frequency)	800-960MHz

Power Interface

Mode #	Voltage (V)	Current (A)	Power (W)	Frequency (DC/AC-Hz)	Phases (#)	Comments
1	13	2.5	40	DC	0	

Client Equipment Used During Test

Use*	Product Type	Manufacturer	Model	Comments
EUT	Transmitter	ELPRO	E2-455	
AE	Laptop	DELL	Inspiron 5559	Djohanson Labtest

Abbreviations:
EUT - Equipment Under Test,
AE - Auxiliary/Associated Equipment, or
SIM - Simulator (Not Subjected to Test)

Software and Firmware

Use*	Description	Version
AE	PuTTY.exe 64bit	0.70
EUT	E2-455 Firmware	7392

Abbreviations:
EUT - Equipment Under Test,
AE - Auxiliary/Associated Equipment, or
SIM - Simulator (Not Subjected to Test)

Input/Output Ports

Port #	Name	Type*	Cable Max.	Cable Shielded	Comments
1	Power	DC	<0.1m	No	Module will get it's power from the host through a plug-in connector
2	signals	TP	<0.1m	No	Module will get it's signals from the host through a plug-in connector
3	RF Out	RF	20m	Yes	Usually connected to an Antenna using a cable to the antenna

*Note: AC = AC Power Port DC = DC Power Port N/E = Non-Electrical
I/O = Signal Input or Output Port (Not Involved in Process Control)
TP = Telecommunication Ports

EUT Operation Modes

Mode #	Description
1	Power on
2	Communications with PC while in Receive mode
3	Transmitter ON – MaxPower 10 watts

EUT Configuration Modes

Mode #	Description
1	Connected to laptop with power On; RF Cable terminated to Load or Attenuator as needed.

Modifications Required for Compliance

Mod#	Description
	None required

Test Equipment Verified for function

Model #	Description	Checked Function	Results
N9038A	EMI Receiver	Yes	Pass
E7405A	EMC Analyzer	Yes	Pass
JB1	Antenna, 30 to 2000MHz	Yes	Pass
SAS-571	Antenna, 1 to 18GHz	Yes	Pass
MG310A	Rf Generator	Yes	Pass
N19411	Power Meter	Yes	Pass

Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests:

Parameter	Uncertainty
Radiated Emission, 30 to 6,000MHz	± 4.95 dB
Conducted Measurements, 0.15 to 30MHz	± 3.50 dB

Uncertainty figures are valid to a confidence level of 95%.

Test Result Summary

FCC Part 2, 90 and IC RSS-119			
Test Type	**Regulation**	**Result/Comment**	**Compliance Status**
Carrier Output Power (Conducted)	FCC Part 2 2.1046(a) IC RSS-119 5.4	10Watt Max	PASS
Unwanted Emissions (Transmitter Conducted)	FCC Part 2 2.1046(a) FCC Part 90 90.210 IC RSS-119 5.8	< -80dBm	PASS
Field Strength of Spurious Radiation	FCC Part 2 2.1053 (a) FCC Part 90 90.210 IC RSS-119 5.8	< -80dBm	PASS
Emission Masks (Occupied Bandwidth)	FCC Part 2 2.1049 (c) (1) FCC Part 90 90.210 IC RSS-119 5.5	MASK D < 12.5kHz	PASS
90.214 5.9 Transient Frequency Behavior	FCC Part 90 90.214 IC RSS-119 5.9	< 100Hz	PASS
Audio Frequency Response	FCC Part 2 2.1047(a)	N/A	
Modulation Limiting	FCC Part 2 2.1047(b)	N/A	
Frequency Stability (Temperature Variation)	FCC Part 2 2.1055(a) (1) FCC Part 90 90.213(a) IC RSS-119 5.3	< 178Hz	PASS
Frequency Stability (Voltage Variation)	FCC Part 2 2.1055(d) (1) FCC Part 90 90.213(a) IC RSS-119 5.3	< 178Hz	PASS
Receiver Spurious Emissions	IC RSS-Gen 7.1	< 40dBuV	PASS

Carrier Output Power (Conducted)

Governing Doc	FCC Part 2 2.1046(a) IC RSS-119 5.4	Room Temperature (°C)	23.5
Basic Standard	ANSI TIA-603-E	Relative Humidity (%)	42
Test Location	Richmond	Barometric Pressure (kPa)	101.4
Test Engineer	David Johanson	Date	12 Dec 2017
EUT Voltage	☒ 13Vdc		

Test Equipment Used	Manufacturer	Model	Identifier	Calibration	Calibration due
Power Meter	Agilent	N1911A	601	10-Sep-2017	10-Sep-2018
Power Sensor	Agilent	N1921A	602	10-Sep-2017	10-Sep-2018
Attenuator(s)	-	-	-	IHC	IHC

Note) IHC: In House Calibration

Frequency Range:	☒ 421-480MHz
Detector:	☒ Peak
Type of Facility:	☒ Test bench
Distance:	☒ Direct
Arrangement of EUT:	☒ Table-top only ☐ Floor-standing only ☐ Rack Mounted

Test Method

Test procedure is based on ANSI/TIA-603-E Section 2.2.1.2

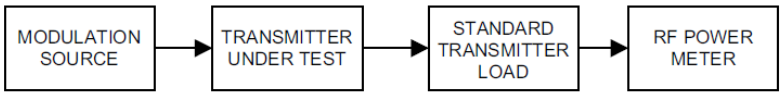
For IC RSS-119, the procedure as outlined in Section 4.1 could not be followed due to the type of device. the Modulation power was not adjustable so the Worse Case settings of Frequency and Deviation was used.

Transmitter Power was measured as the highest reading during a 60second transmission or until the power reading stabilized, which ever came first.

Test Result Calculation

RF Power (W) = (10^ (RF Power (dBm)/10))/1000
RF Power (dBm) = Power Meter reading (dBm) + Attenuator and Cable Loss (dB)

Test setup

Description of test set-up:
The EUT was placed on a test bench and connected to a Power Meter using the appropriate attenuation. The EUT was set to **Operation Mode #1 with configuration Mode #1.**    - Modulation Source is a built-in function of this EUT - Standard Transmitter Load Attenuators were adjusted as per the TIA-603 procedures. The maximum input to the Test Receiver was -10dBm

Results

Modulation	2FSK 12.5kHz. PRBS		
Meas. Freq(MHz)	Corrected Reading (dBm)	Power (Watts)	Comments
421	39.95	9.9	
450	39.59	9.1	
480	39.14	8.2	
Modulation	4FSK 12.5kHz PRBS		
Meas. Freq(MHz)	Meter Reading (dBm)	Power (Watts)	Comments
421	39.97	9.9	
450	39.59	9.1	
480	39.07	8.1	

Unwanted Emissions (Transmitter Conducted)

Governing Doc	FCC Part 2 2.1046(a) FCC Part 90 90.210 IC RSS-119 5.8	Room Temperature (°C)	23.8
Basic Standard	ANSI TIA-603-E	Relative Humidity (%)	40
Test Location	Richmond	Barometric Pressure (kPa)	101.4
Test Engineer	David Johanson	Date	15 Nov 2017
EUT Voltage	☒ 13Vdc		

Test Equipment Used	Manufacturer	Model	Identifier	Calibration	Calibration due
EMC Analyzer	Keysight	N9038A	702	27-Apr-2017	27-Apr-2018

Frequency Range:	☒ 10KHz-2000MHz	
Detector:	☒ Peak(for Prescan)	☒ Average(for Formal)
RBW/VBW:	☒120/300kHz	☒ 9/30kHz
Type of Facility:	☒ Testbench	
Distance:	☒ Direct Connection	
Arrangement of EUT:	☒ Table-top only ☐ Floor-standing only ☐ Rack Mounted	

Test Method

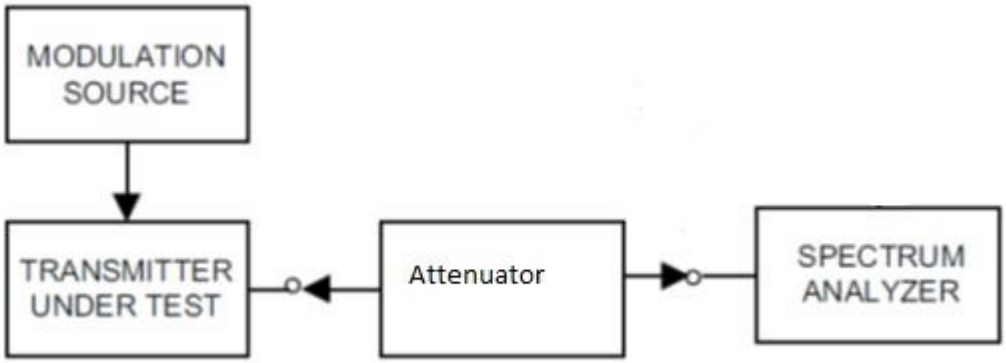
The setup and test procedure is based on ANSI/TIA-603-E for the FM Modulations

Transmitter Spurious emissions were measured as the highest reading during a 60second transmission.

Test Result Calculation
RF Power (dBm) = EMC Analyzer reading (dBm) + Attenuator and Cable Loss (dB)

Test setup

Description of test set-up:
The EUT was placed on a test bench and connected to a Power Meter using the appropriate attenuation. The EUT was set to **Operation Mode #1 with configuration Mode #1.**



- Modulation Source is a built-in function of this EUT
- Standard Transmitter Load Attenuators were adjusted as per the TIA-603 procedures. The maximum input to the Test Receiver was -10dBm
-

Results

No spurious emissions were detected on the Antenna Port 10kHz to 2GHz for all transmission frequencies and modulations.
Noise floor 30 MHz to 2GHz = < -80dBm
Compliant ☒ Non-Compliant ☐

Field Strength of Spurious Radiation

Governing Doc	FCC Part 2 2.1053 (a) FCC Part 90 90.210 IC RSS-119 5.8	Room Temperature (°C)	23.8
Basic Standard	ANSI TIA-603-E	Relative Humidity (%)	40
Test Location	Richmond	Barometric Pressure (kPa)	101.4
Test Engineer	David Johanson	Date	15 Nov 2017
EUT Voltage	☒ 13Vdc		

Test Equipment Used	Manufacturer	Model	Identifier	Calibration	Calibration due
EMC Analyzer	Keysight	N9038A	702	27-Apr-2017	27-Apr-2018
Biconilog Antenna	Sunol	JB1	371	29-Mar-2016	29-Mar-2018
1-18GHz DRG Horn Antenna	AH Systems	SAS-571	227C	29-Mar-2016	29-Mar-2018
RF Generator	Anritsu	MG3710A	707	06-Jul-2016	06-Jul-2018
EMC Shielded Enclosure	USC	USC-26	374	NCR	NCR
Note) NCR = No Calibration Required					

Frequency Range:	☒ 30-5000MHz	☐ 150kHz-30MHz	
Detector:	☒ Peak(for Prescan)	☐ Quasi-Peak(for Formal)	
RBW/VBW:	☒120/300kHz	☐ 1/3MHz	
Type of Facility:	☒ SAC	☐ OATS	☐ *in-situ*
Distance:	☒ 3meter	☐ 10meter	☐ 1meter
Arrangement of EUT:	☒ Table-top only	☐ Floor-standing only	☐ Rack Mounted

Test Method

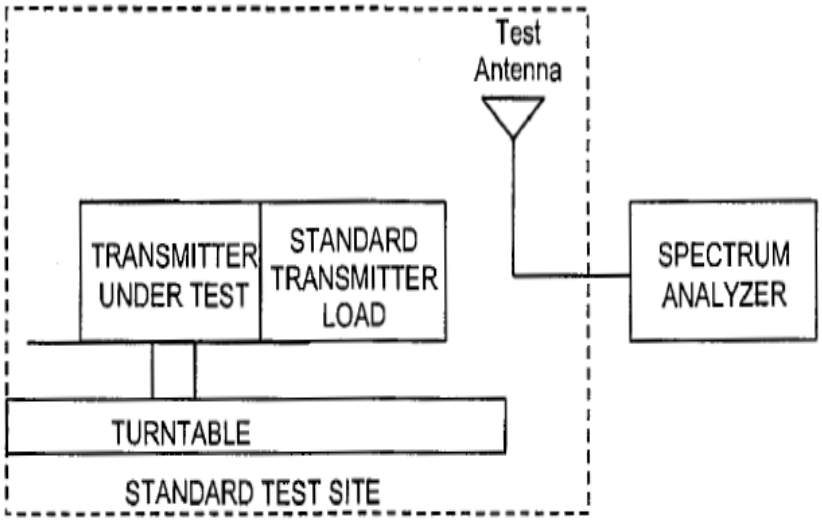
The EUT and test equipment were set up and measurements taken using procedures based on the ANSI/TIA-603-E for the FM Modulations

Adjust the spectrum analyzer for the following setting:
a) RBW : 100 kHz (< 1 GHz), 1 MHz (> 1 GHz).
b) VBW : 300 kHz (< 1 GHz), 3 MHz (> 1 GHz).
c) Detector mode : Positive Peak

The transmitter was placed on a Styrofoam turntable, and it was transmitting into non-radiating load which was also placed on the turntable.

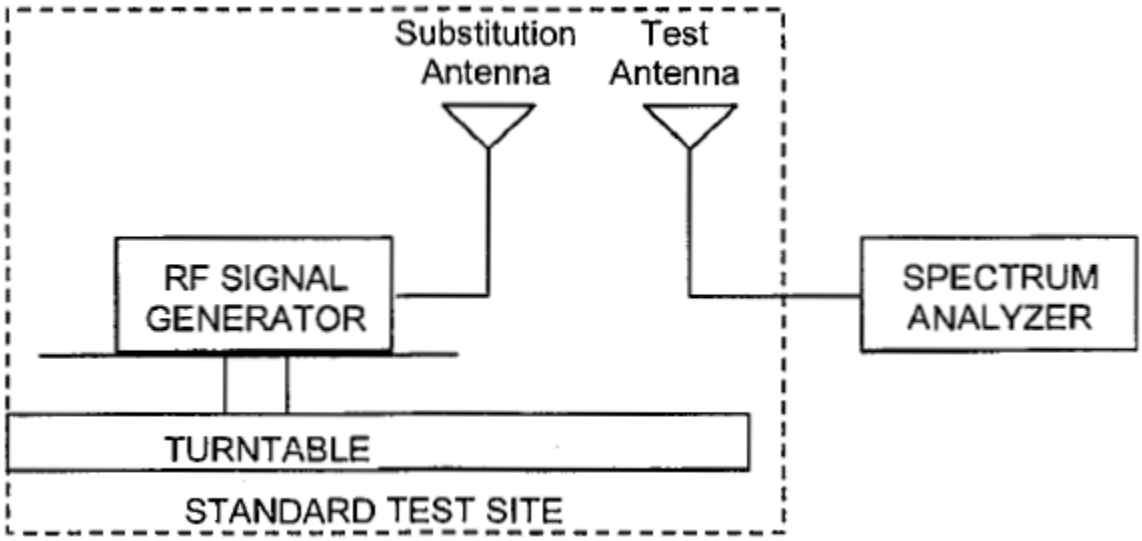
The measurement antenna was placed at a distance of 3 meters from the EUT. During the tests, the antenna height and polarization as well as EUT azimuth were varied in order to identify the maximum level of emissions from the EUT.

The transmitter power final measurement is based on a 60 second transmission, the time required to reach transmitter stability. Modulated and CW signals are investigated.



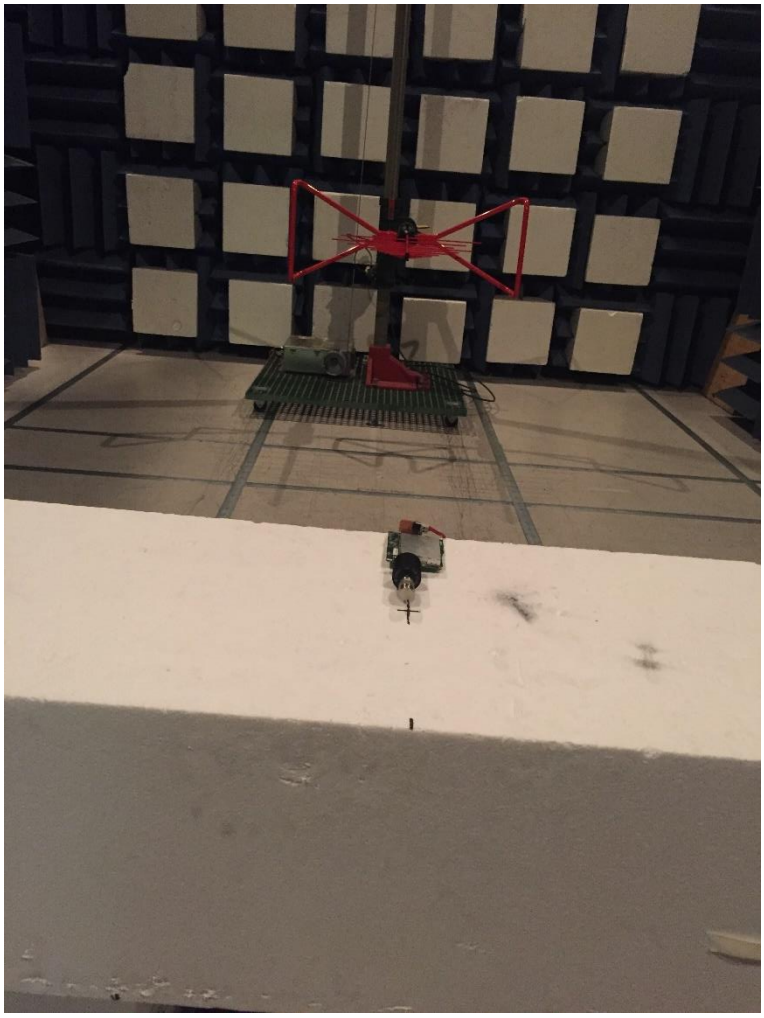
The frequency range up to tenth harmonic of the fundamental frequency was investigated.

Remove the EUT and replace it with substitution antenna. A signal generator was connected to the substitution antenna by a non-radiating cable.
The absolute levels of the spurious emissions were measured by the substitution.



Spurious emissions in dB = 10 Log (TX power in Watts/0.001) – the absolute level

Test setup

Description of test set-up:
The EUT was placed on a 0.8m non-conducting table above a ground reference plane (GRP). The EUT was set to **Operation Mode #1 with configuration Mode #1.**
30 – 1,000MHz with JB-1 Antenna: 

Results

- This product is in compliance with FCC Part 90.210 and Part 2.1057(a)(1) and (c) - All Spurious Emissions from the transmitter were greater than 20dB below the required levels and were not measured as per 2.1057(c). - No spurious emissions from the transmitter frequencies were detected. - All other emissions detected are from the Power Supply or digital circuitry
Noise floor 30 MHz to 5GHz = < -80dBm
Compliant ☒ Non-Compliant ☐

Emission Masks (Occupied Bandwidth)

Governing Doc	FCC Part 2 2.1049 (c) (1) FCC Part 90 90.210 IC RSS-119 5.5	Room Temperature (°C)	23.1
Basic Standard	ANSI TIA-603	Relative Humidity (%)	41
Test Location	Richmond	Barometric Pressure (kPa)	100.5
Test Engineer	David Johanson	Date	26 Jan 2018
EUT Voltage	☒ 13Vdc		

Test Equipment Used	Manufacturer	Model	Identifier	Calibration	Calibration due
EMI Receiver	Keysight	N9038A	702	27-Apr-2017	27-Apr-2018
EMC Analyzer	Agilent	E7405A	272	17-Jun-2017	17-Jun-2018

Frequency Range:	☒ 30-1000MHz	☐ 150kHz-30MHz
Detector:	☒ Peak(for Prescan)	☐ Quasi-Peak(for Formal)
RBW/VBW:	☐120/300kHz	☒ As specified in the test procedures
Type of Facility:	☒ Testbench	
Distance:	☒ Direct	
Arrangement of EUT:	☒ Table-top only ☐ Floor-standing only ☐ Rack Mounted	

Frequency bands in use and Investigated:

421.000 to 454.000MHz (Low Mid and High Channels Investigated)
456.00 to 462.375MHz (Low and High Channels Investigated)
462.7375 to 467.5375MHz (Low and High Channels Investigated)
467.7375 to 480MHz (Low Mid and High Channels Investigated)

Modulations in Use and Investigated:
2FSK and 4FSK Analog Modulations

VHF Channel bandwidths in Use and Investigated:
All Channels use Bandwidth 12.5kHz must comply with mask D;

Result Summary:
2FSK widest 99% OBW = 9.4kHz
4FSK widest 99% OBW = 9.1kHz

All modulations complied with mask D

Compliant ☒ Non-Compliant ☐

Test Method 99% OBW

The EUT and test equipment were set up and measurements taken using procedures from ANSI/TIA-603-E for the FM Modulations

Adjust the spectrum analyzer for the following setting:
a) RBW : 300Hz (
b) VBW : 3 times the RBW

The occupied Bandwidth was measured with the Spectrum Analyzer controls set as shown on the test results.

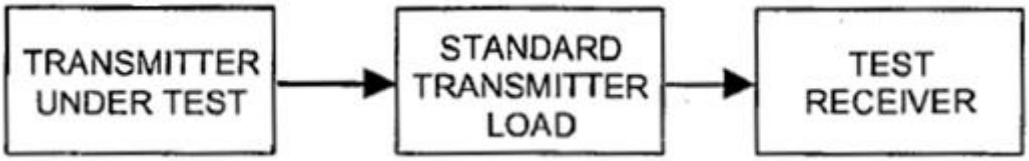
Test Method Mask D

The EUT and test equipment were set up and measurements taken using the procedures is based on ANSI/TIA-603-E for the FM Modulations.

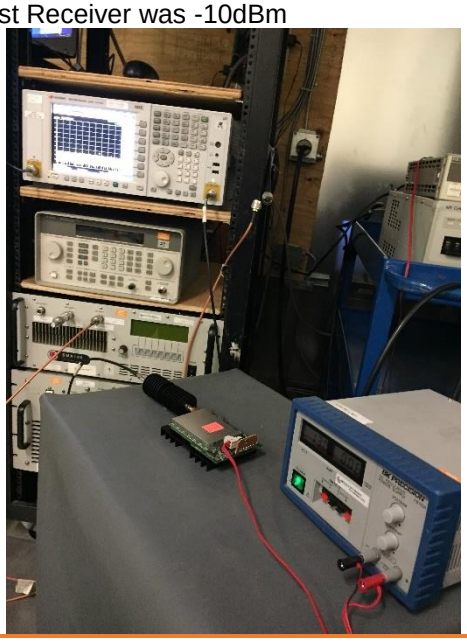
Adjust the spectrum analyzer for the following setting:
a) RBW : 100Hz
b) VBW : 10times the RBW

The occupied Bandwidth was measured with the Spectrum Analyzer controls set as shown on the test results.

Test setup

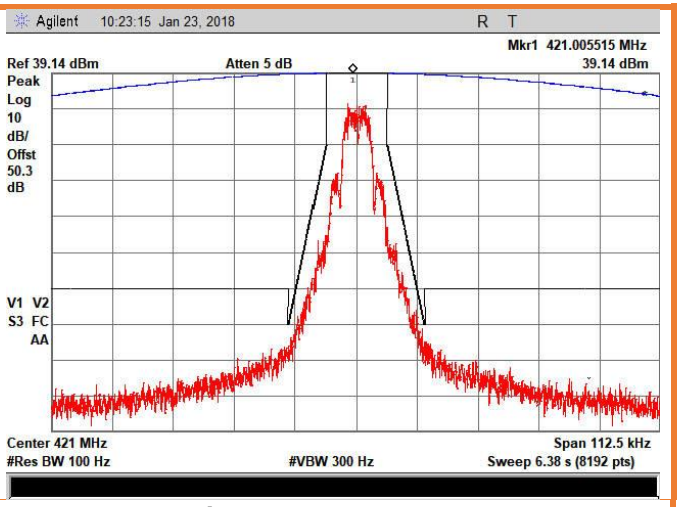


- Audio Generator and microphone are built in to the product for testing and diagnostic purposes.
- Standard Transmitter Load Attenuators were adjusted as per the TIA-603 procedures. The maximum input to the Test Receiver was -10dBm

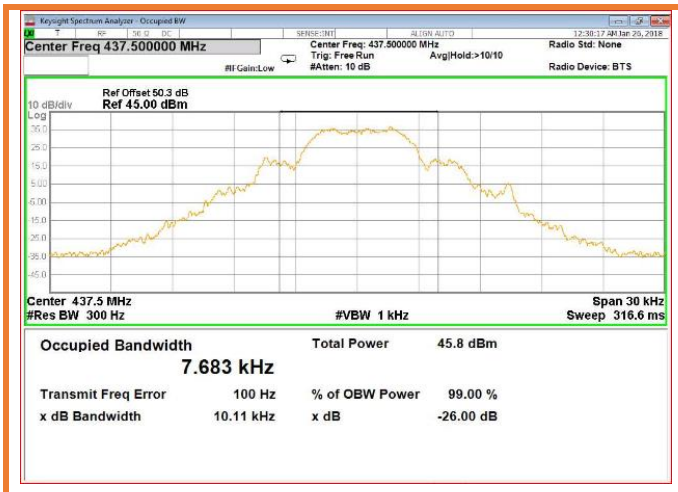


Results

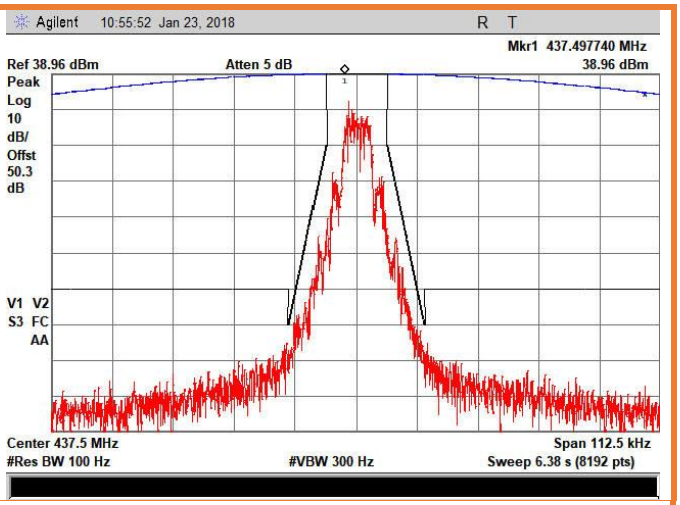
obw_421.00625MHz_2FSK



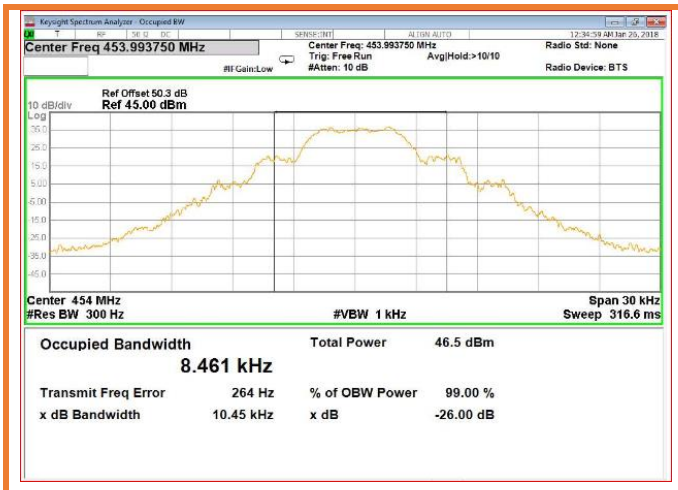
Mask D_421.00625MHz_2FSK



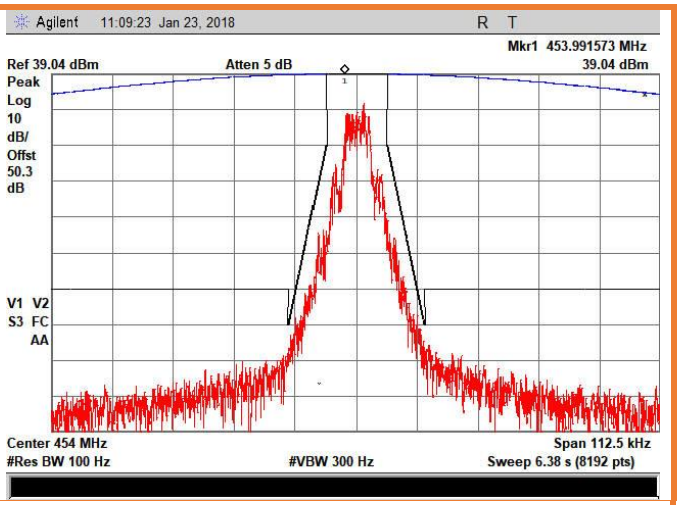
obw_437.5MHz_2FSK



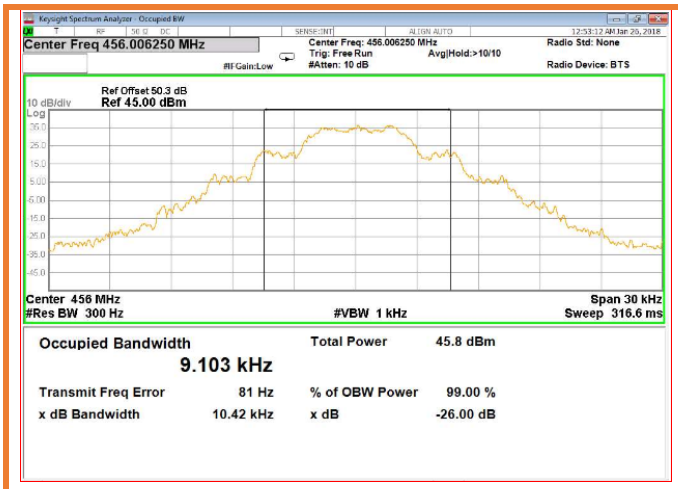
Mask D_437.5MHz_2FSK



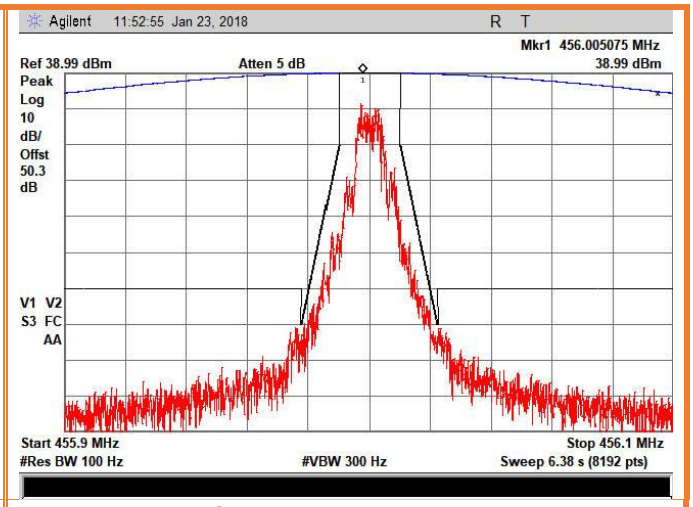
obw_453.99375MHz_2FSK



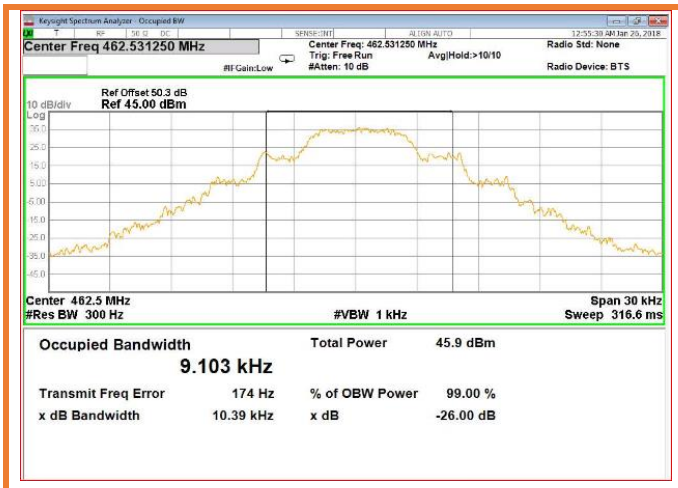
Mask D_453.99375MHz _2FSK



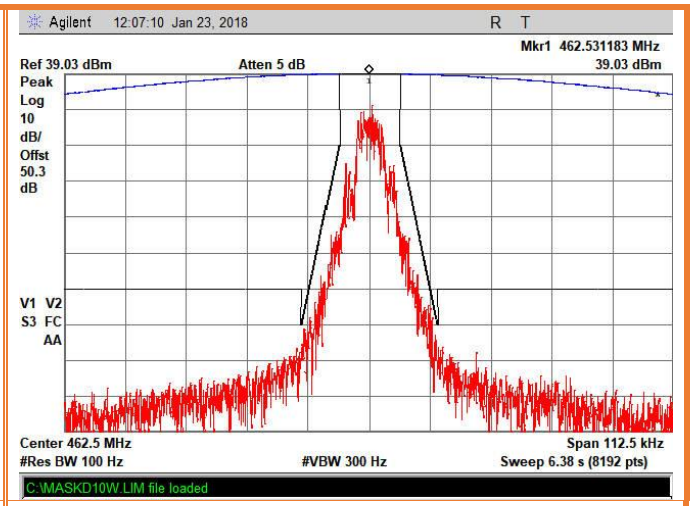
obw_456.00625MHz_2FSK



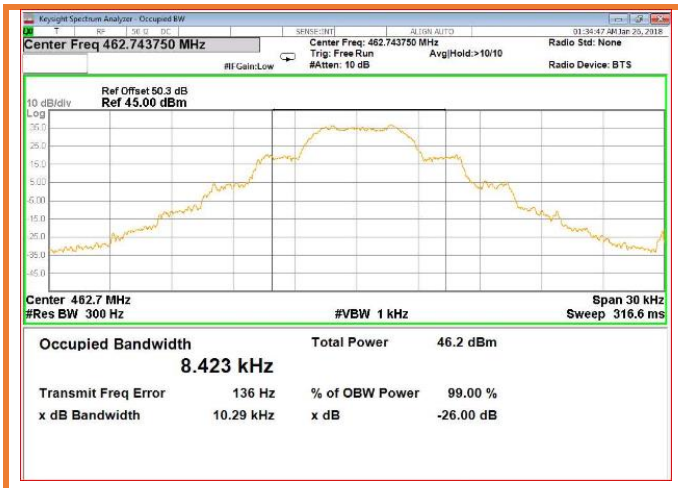
Mask D_456.00625MHz _2FSK



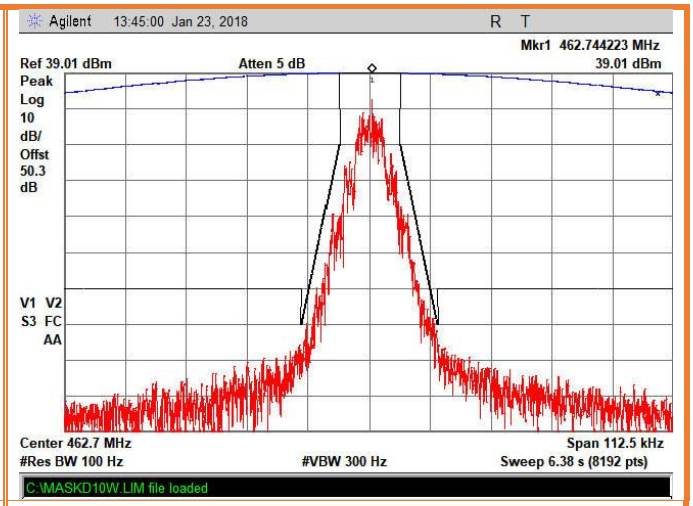
obw_462.53125MHz_2FSK



Mask D_462.53125MHz _2FSK

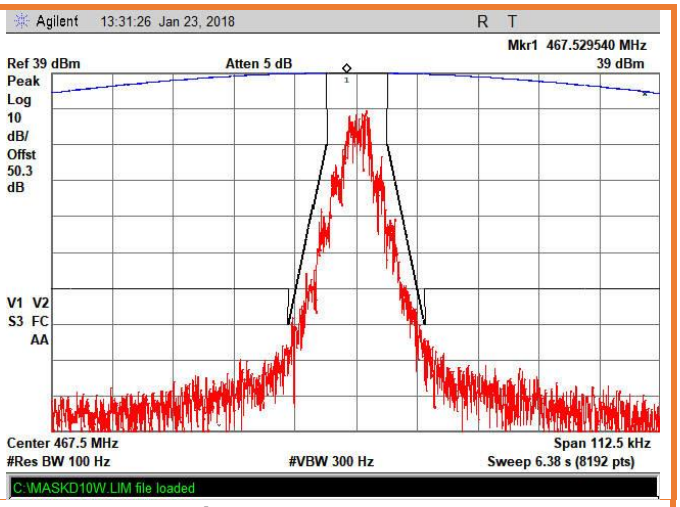


obw_462.74375MHz_2FSK

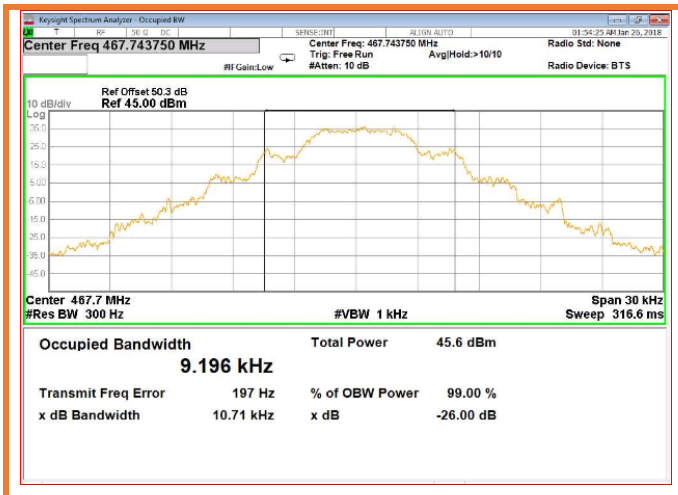


Mask D_462.74375MHz _2FSK

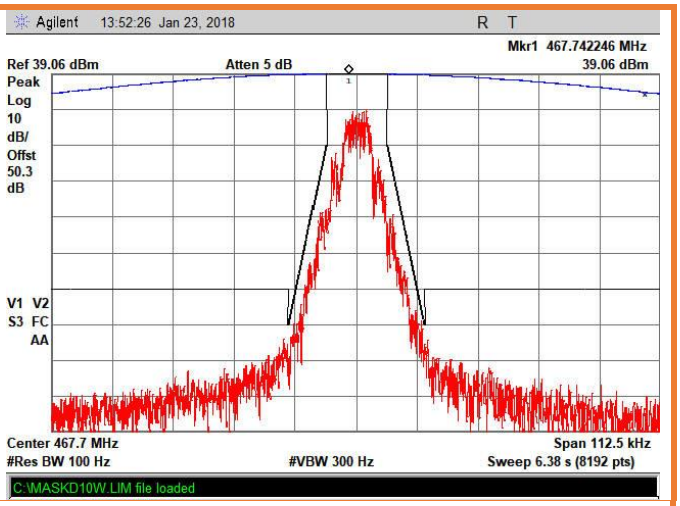
obw_467.53125MHz_2FSK



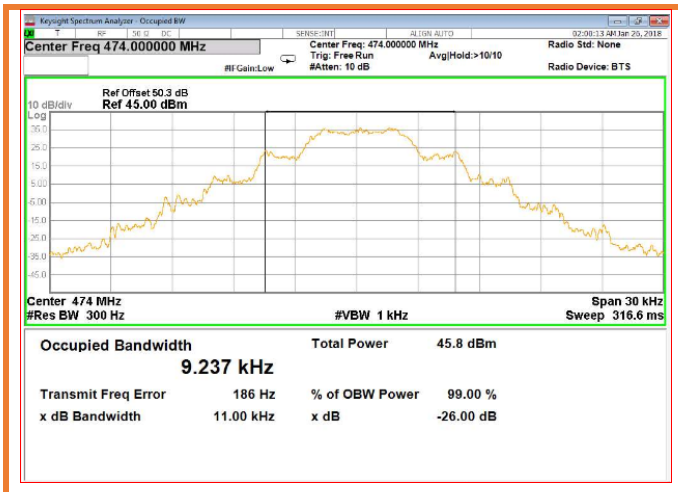
Mask D_467.53125MHz _2FSK



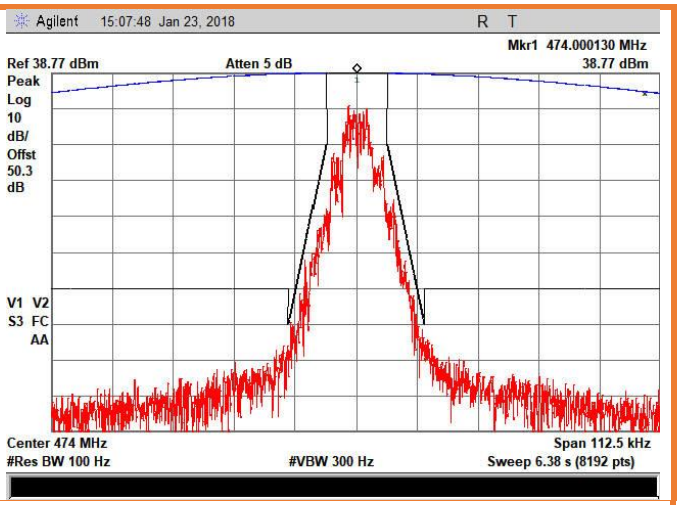
obw_467.743750MHz_2FSK



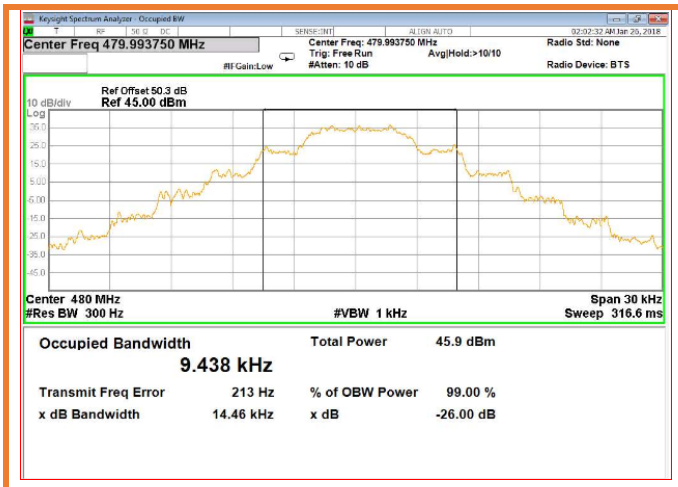
Mask D_467.74375MHz _2FSK



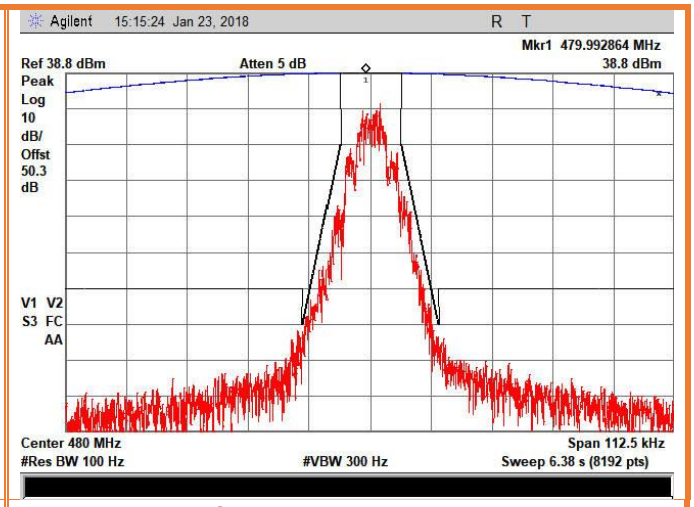
obw_474.0000MHz_2FSK



Mask D_474.0000MHz _2FSK

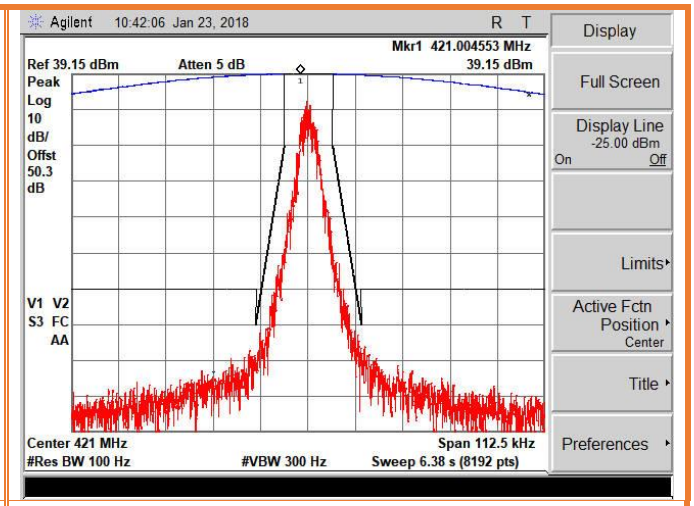


obw_479.99375MHz_2FSK

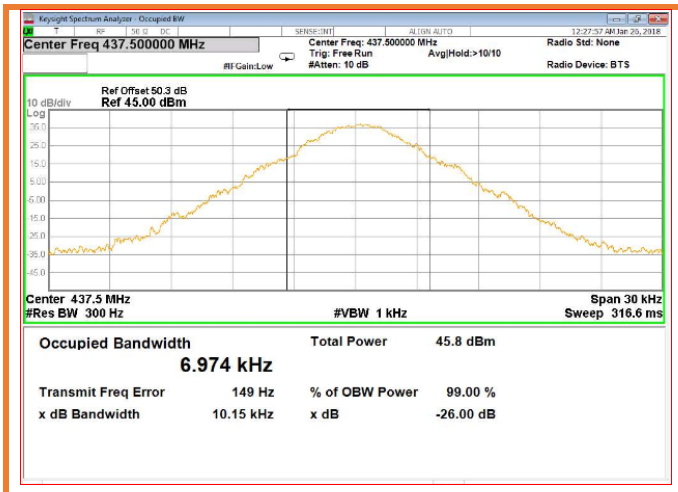


Mask D_479.99375MHz _2FSK

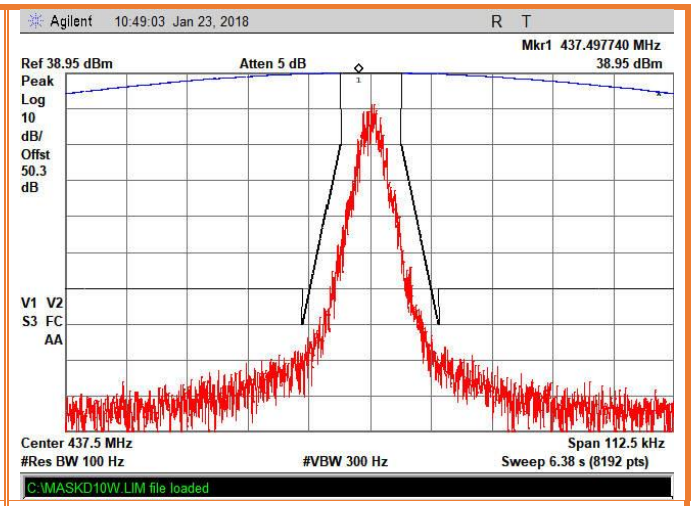
obw_421.00625MHz_4FSK



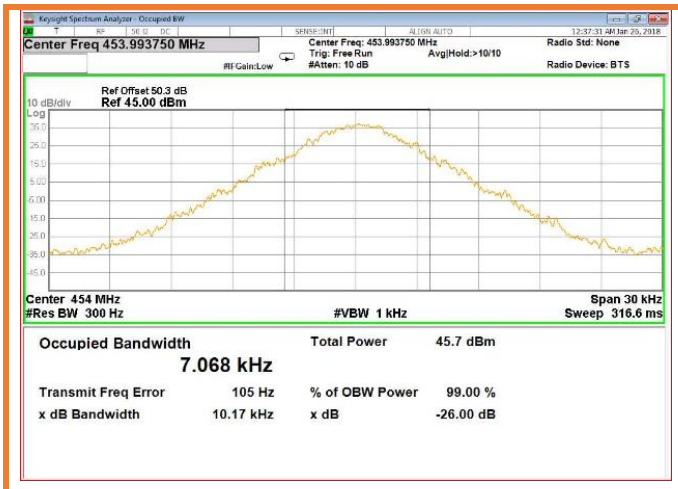
Mask D_421.00625MHz_4FSK



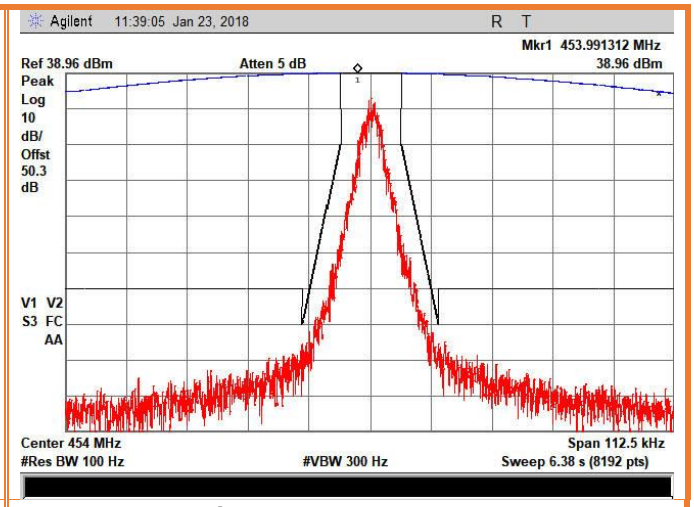
obw_437.5MHz_4FSK



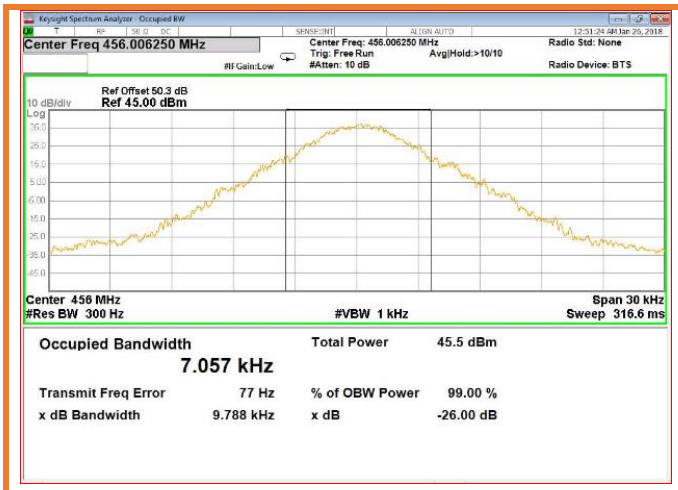
Mask D_437.5MHz_4FSK



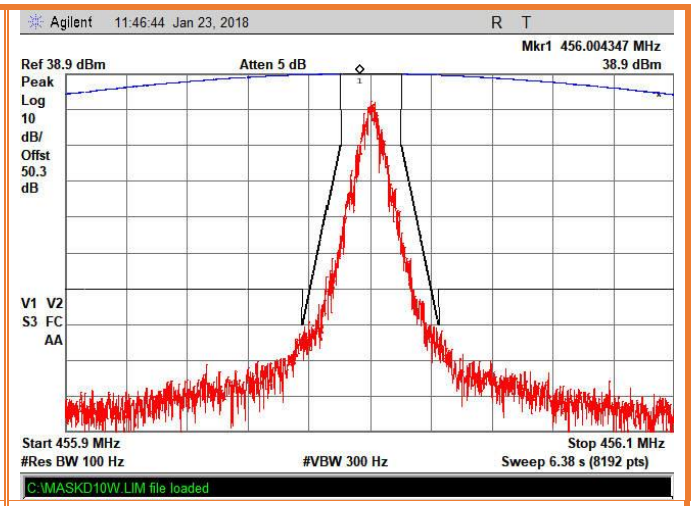
obw_453.99375MHz_4FSK



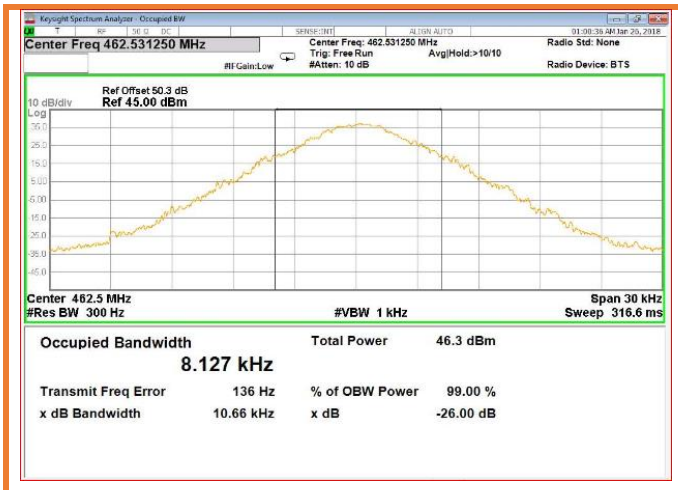
Mask D_453.99375MHz _4FSK



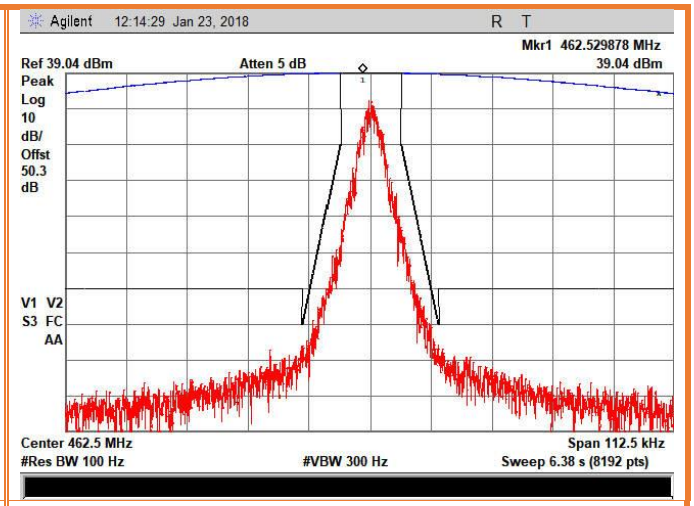
obw_456.00625MHz_4FSK



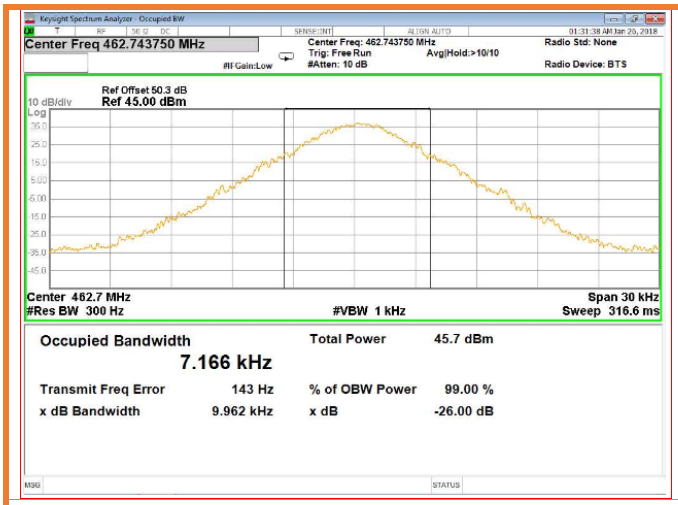
Mask D_456.00625MHz _4FSK



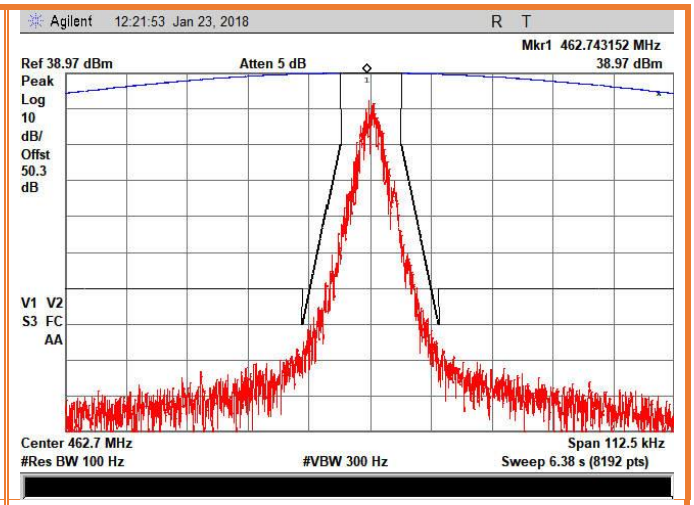
obw_462.53125MHz_4FSK



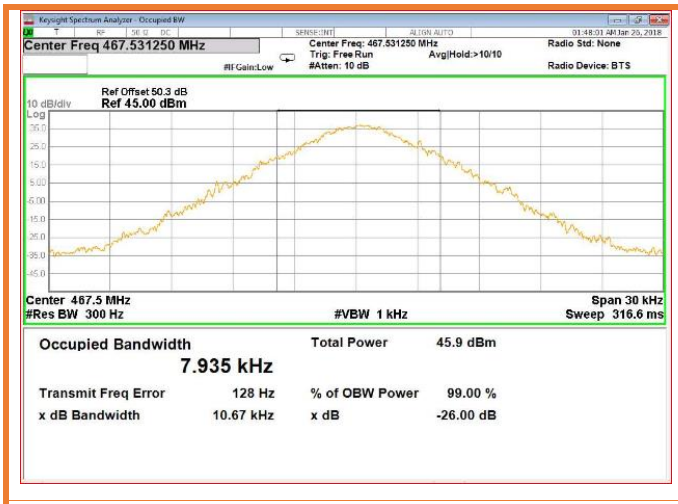
Mask D_462.53125MHz _4FSK



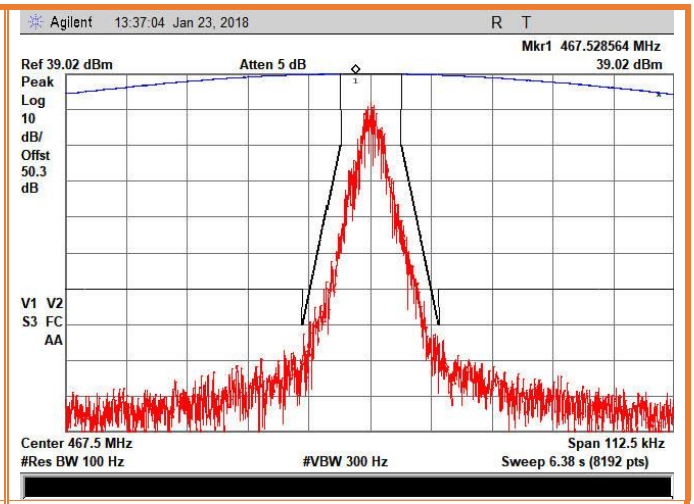
obw_462.74375MHz_4FSK



Mask D_462.74375MHz _4FSK

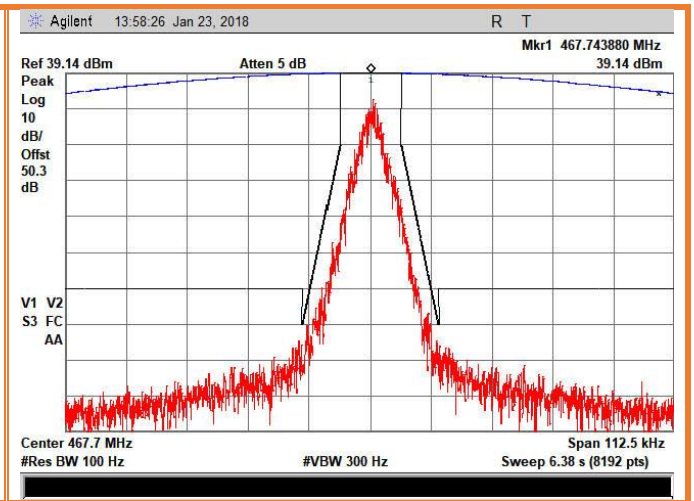


obw_467.53125MHz_4FSK

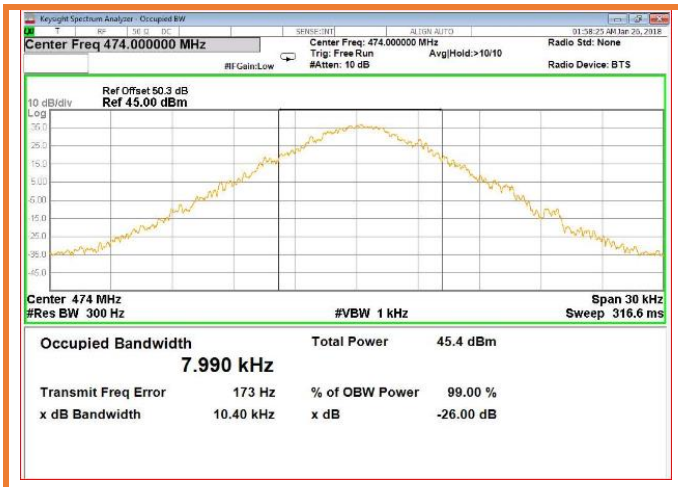


Mask D_467.53125MHz _4FSK

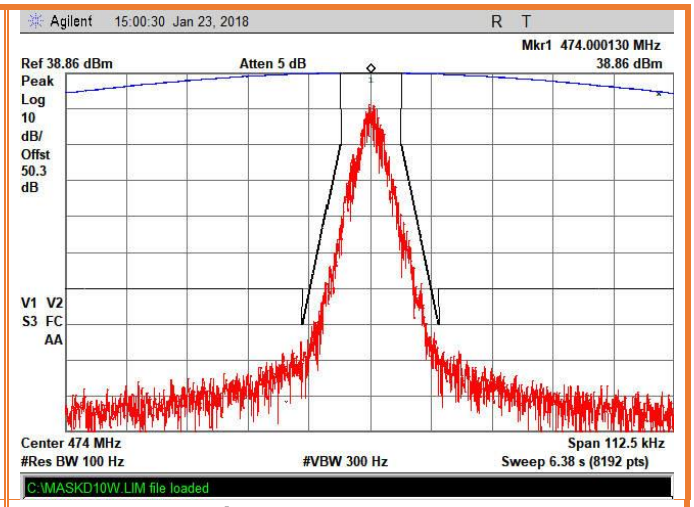
obw_467.743750MHz_4FSK



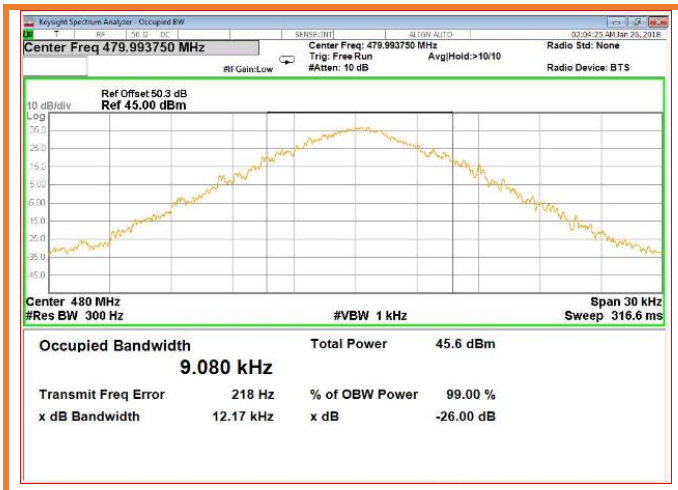
Mask D_467.743750MHz _4FSK



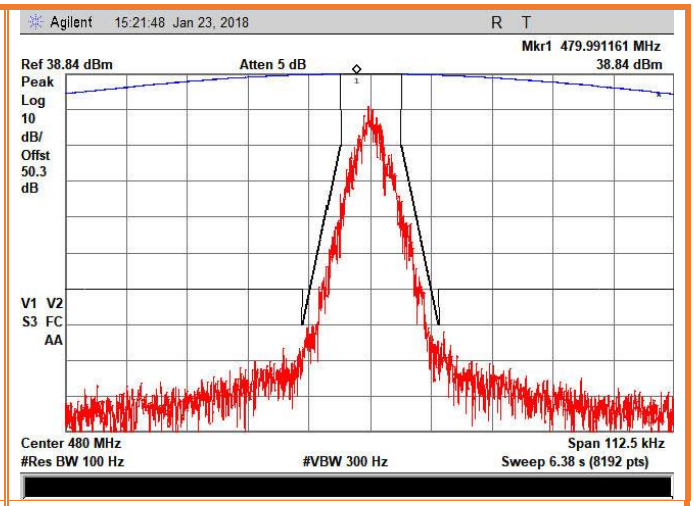
obw_474.0000MHz_4FSK



Mask D_474.0000MHz _4FSK



obw_479.99375MHz_4FSK



Mask D_479.99375MHz _4FSK

Transient Frequency Behaviour

Governing Doc	FCC Part 90 90.214 IC RSS-119 5.9	Room Temperature (°C)	23.1
Basic Standard	ANSI TIA-603-E	Relative Humidity (%)	41
Test Location	Richmond	Barometric Pressure (kPa)	100.5
Test Engineer	David Johanson	Date	28 January 2018
EUT Voltage	☒ 13Vdc		

Test Equipment Used	Manufacturer	Model	Identifier	Calibration	Calibration due
EMC Analyzer	Keysight	N9038A	702	27-Apr-2017	27-Apr-2018
Oscilloscope	Tektronix	TDS2024	021	08-Dec-2017	08-Dec-2018
Power Meter	Agilent	N1911A	601	10-Sep-2017	10-Sep-2018
Power Sensor	Agilent	N1921A	602	10-Sep-2017	10-Sep-2018
Signal Generator	Anritsu	MG3710A	707	06-Jul-2016	06-Jul-2018
Dual Directional Coupler	Werlatone	C6934-13	131	NCR	NCR
Combiner	Mini-Circuits	ZFRSC-42-S+	1440	NCR	NCR

Note) NCR = No Calibration Required

Type of Facility:	☒ Testbench
Distance:	☒ Direct
Arrangement of EUT:	☒ Table-top only

Frequency bands in use and Investigated:

421.000 to 454.000MHz (Low Mid and High Channels Investigated)
456.00 to 462.375MHz (Low and High Channels Investigated)
462.7375 to 467.5375MHz (Low and High Channels Investigated)
467.7375 to 480MHz (Low Mid and High Channels Investigated)

Modulations in Use and Investigated:
2FSK and 4FSK Analog Modulations

Result Summary:
4FSK at 450MHz is worst case representation and complies

Compliant ☒ Non-Compliant ☐

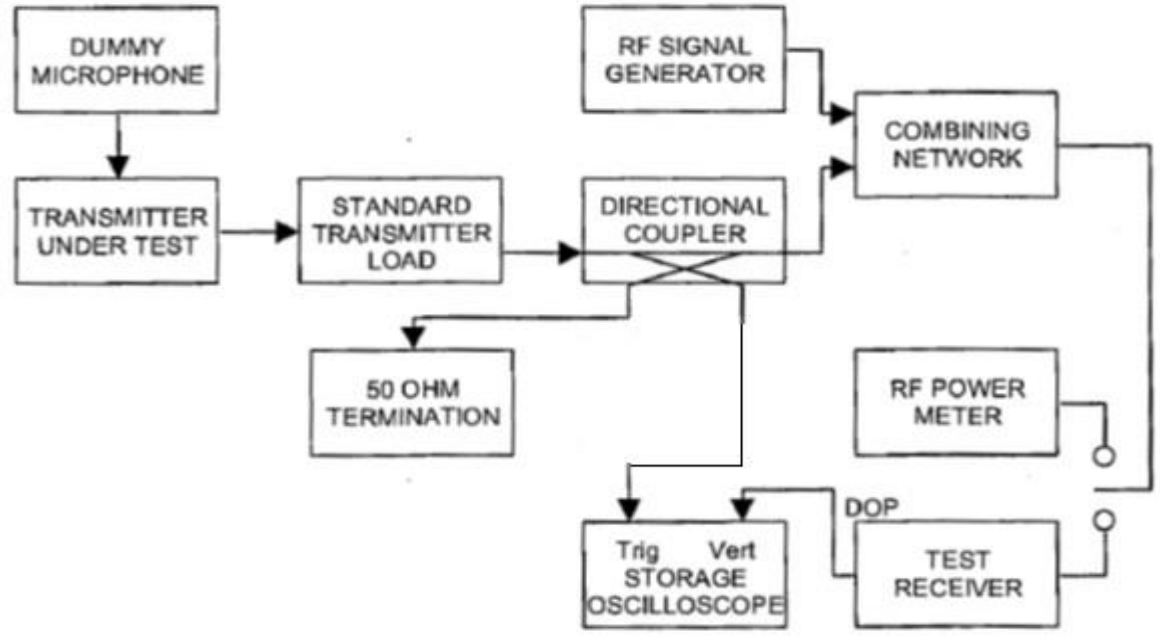
Test Method

- The EUT and test equipment were set up and measurements taken using the procedures is based on the ANSI/TIA-603-E for the FM Modulations
- The transmitter was turned on for a 60second transmission

.

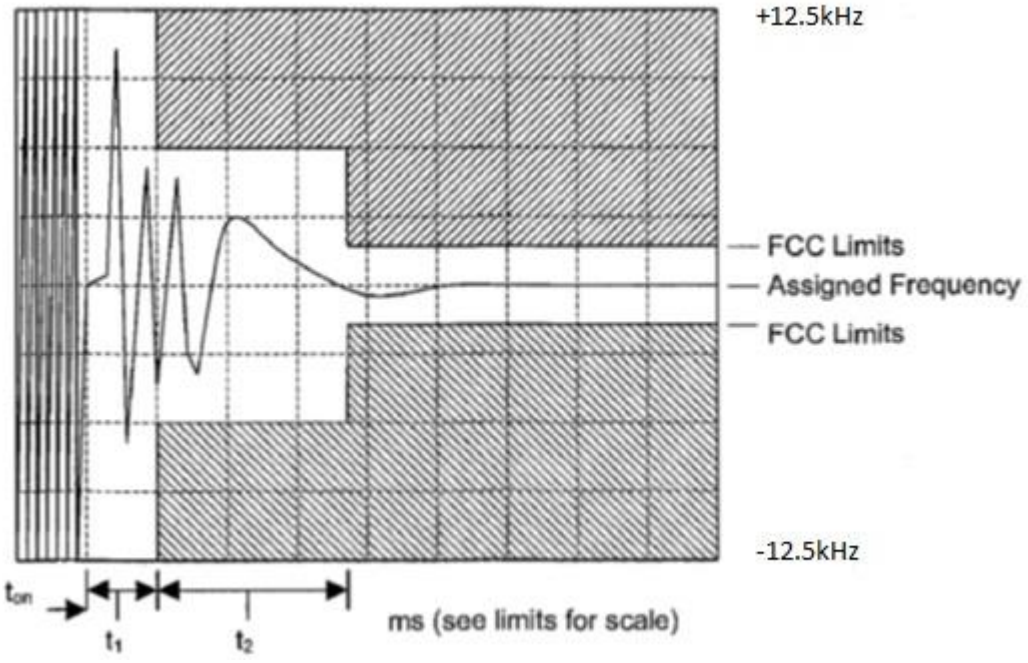
- The transmitter carrier level was measured at the output of the combiner.
- The transmitter was turned off.
- An RF signal generator (1) modulated with a 1 kHz tone at 12.5 kHz deviation, and set to the same frequency as the assigned transmitter frequency, (2) was adjusted to a level -30 dB below the level recorded in Procedure 3, as measured at the output of the combiner. This level was then fixed for the remainder of the test and is recorded at step h.
- The oscilloscope was setup using TIA-603 steps j and k as a guide, however 1000 Hz tone was adjusted at +/- 4div vertically centered on the display.
- The transmitter was turned on, and the level of the carrier at the output of the combiner was recorded as step l.
- The carrier on-time as referenced in TIA-603 steps m, n, and o was captured and plotted.
- The carrier off-time as referenced in TIA-603 steps p, q, r, and s was captured and plotted.

Test setup

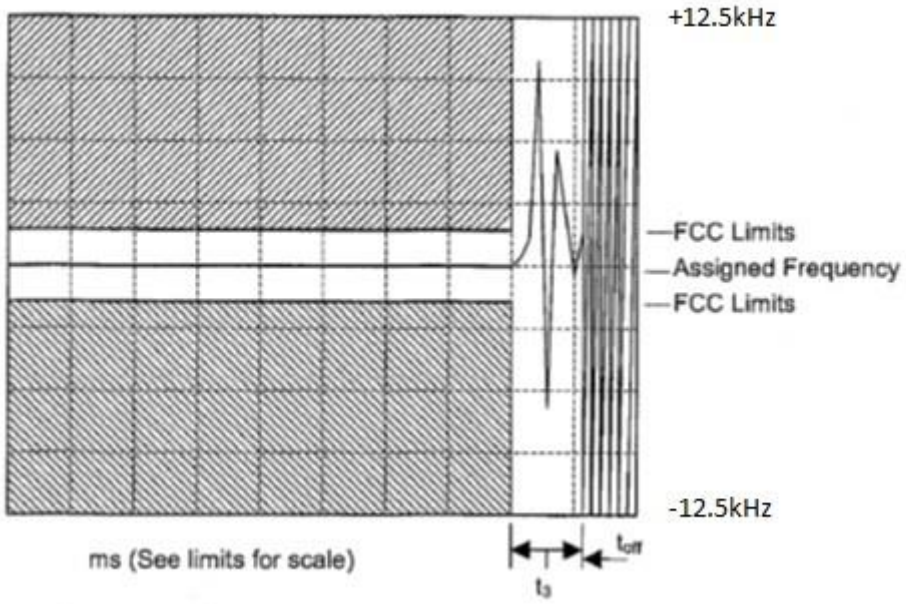


- Dummy Microphone is a built-in function of the EUT
- Standard Transmitter Load Attenuators were adjusted as per the TIA-603 procedures. The maximum input to the Test Receiver was -10dBm

Limits TIA-603-E for FM Modulation



Switch off condition t_3, t_{off}



Limits Calculations:
12.5kHz = +/-4 divisions
6.25kHz = +/-2 divisions
t2 to t3 time = (450MHz x 2.5ppm x +/-4div) / 12.5kHz = +/-0.36div

Table 51 - Transient Frequency Difference Limits

Time Interval	Max. Permitted Frequency Difference for 25 and 30 kHz Channel Bandwidth (in kHz)	Max. Permitted Frequency Difference for 12.5 and 15 kHz Channel Bandwidth (in kHz)
t_1 or t_3	25	12.5
t_2	12.5	6.25

Table 52 - Transient Duration Limits

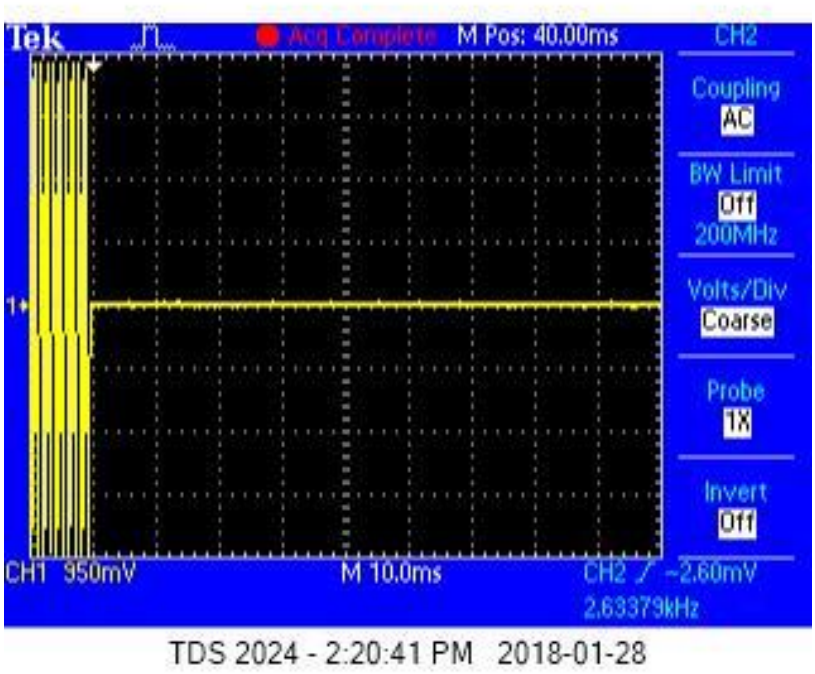
Time Intervals	Frequency Ranges (MHz)		
	30 to 174	406 to 512	806 to 940
t_1	5.0 ms	10.0 ms	20.0 ms
t_2	20.0 ms	25.0 ms	50.0 ms
t_3	5.0 ms	10.0 ms	10.0 ms

During the period t_1 and t_3, the frequency difference shall not exceed ±25 kHz.
During the period t_2, the frequency difference shall not exceed ±12.5 kHz.

For this product 421 to 480MHz with 12.5kHz channels, the timing limits are:
-t1 = 10.0ms; t2 = 20.0ms; t3 = 10.0ms
- During the period t1 and t3, the frequency difference shall not exceed +/-12.5kHz.
- During the period t2 the frequency difference shall not exceed +/-6.25kHz

The frequency limits are:
t1 and t3 area = 12.5kHz = +/-4 divisions
t2 area 6.25kHz = +/-2 divisions
t2 to t3 area = (450MHz x 2.5ppm x +/-4div) / 12.5kHz = +/-0.36div

Results



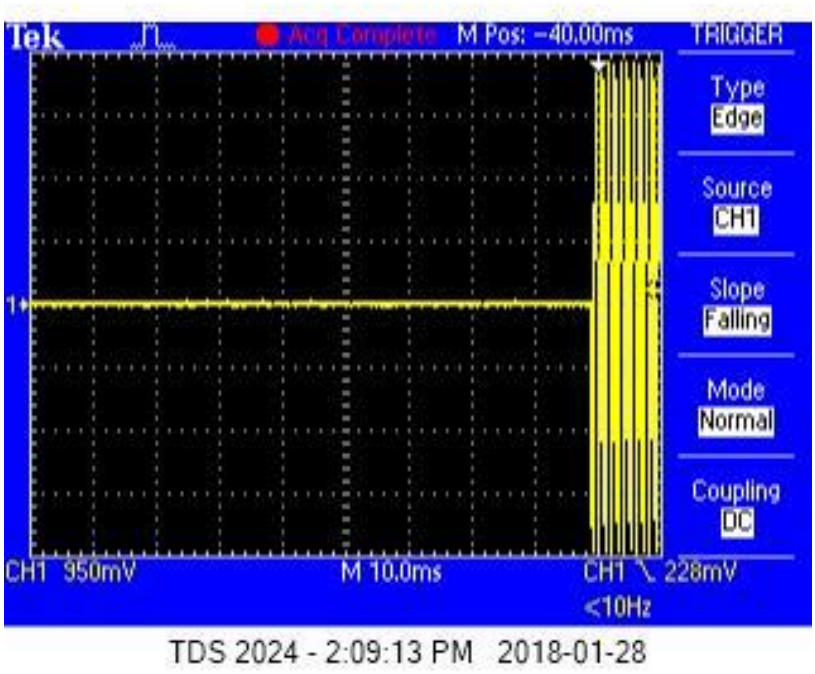
450MHz_4FSK_FM-1KHz-transmit ON to OFF

Each Horizontal Division = 10ms
Each Vertical Division = 3.125kHz

For this product 421 to 480MHz with 12.5kHz channels, the timing limits are:
-t1 = 10.0ms; t2 = 20.0ms; t3 = 10.0ms
- During the period t1 and t3, the frequency difference shall not exceed +/-12.5kHz.
- During the period t2 the frequency difference shall not exceed +/-6.25kHz

The frequency limits are:
t1 and t3 area = 12.5kHz = +/-4 divisions
t2 area 6.25kHz = +/-2 divisions
t2 to t3 area = (450MHz x 2.5ppm x +/-4div) / 12.5kHz = +/-0.36div

Results:
“On” stabilizes in less than 1ms - complies
t1 region is less than +/-0.1div – complies
t2 region is less than +/-0.1div – complies
t2 to t3 region is less than +/-0.1div - complies



450MHz_4FSK_FM-1KHz-transmit ON to OFF

For this product 421 to 480MHz with 12.5kHz channels, the timing limits are:
-t1 = 10.0ms; t2 = 20.0ms; t3 = 10.0ms
- During the period t1 and t3, the frequency difference shall not exceed +/-12.5kHz.
- During the period t2 the frequency difference shall not exceed +/-6.25kHz

The frequency limits are:
t1 and t3 area = 12.5kHz = +/-4 divisions
t2 area 6.25kHz = +/-2 divisions
t2 to t3 area = (450MHz x 2.5ppm x +/-4div) / 12.5kHz = +/-0.36div

Results:
“OFF” stabilizes in less than 1ms - complies
t3 region is less than +/-0.1div – complies
t2 to t3 region is less than +/-0.1div - complies

Frequency Stability (Temperature Variation)

Governing Doc	FCC Part 2 2.1055(a) (1) FCC Part 90 90.213(a) IC RSS-119 5.3	Room Temperature (°C)	23.1
Basic Standard	ANSI TIA-603	Relative Humidity (%)	41
Test Location	Richmond	Barometric Pressure (kPa)	100.5
Test Engineer	David Johanson	Date	31 January 2018
EUT Voltage	☒ 13Vdc		

Test Equipment Used	Manufacturer	Model	Identifier	Calibration	Calibration due
EMC Analyzer	Keysight	N9038A	702	27-Apr-2017	27-Apr-2018
Digital Multi-Meter	Fluke	77	640	17-May-2017	17-May-2018
Temperature Probe with Type K probe	Omega	HH23A	394	17-May-2017	17-May-2018

Frequency Range:	☒ 30-1000MHz	☐ 150kHz-30MHz
Detector:	☒ Peak	
RBW/VBW:	☒10/30kHz	
Type of Facility:	☒ Tabletop	
Distance:	☒ Direct	

Limit: 1.5ppm (420 to 450MHz) = +/- 630Hz at 420MHz
Limit: 2.5ppm (450 to 480MHz) = +/- 1125Hz at 450MHz

Manufacturer Temperature Limits:
-30 to +70Deg. Celsius

Results:
Temperature related frequency variation: 190Hz

Compliant ☒ Non-Compliant ☐

Test Method

The EUT and test equipment were set up and measurements taken using the procedures is based on ANSI/TIA-603-E for the FM Modulations;

1) Power on the EUT in Receive mode.
2) Set the temperature to -30 degrees C.
3) “Soak” the EUT at this temperature for 1 hour.
4) Turn on Transmitter for 60 seconds at maximum power using the FM modulation
5) Measure the output frequency at the center frequency
6) Adjust the modulation to the next modulation and wait 10 minutes.
7) Repeat steps 4 to 6 until all modulations have been measured.
8) Turn off the transmitter and increase the temperature by 10 degrees C and repeat the test steps 3 to 7 until 70 Deg Cel is completed

Test setup

- Standard Transmitter Load Attenuators were adjusted as per the TIA-603 procedures. The maximum input to the Test Receiver was -10dBm

Results

Ref Frequency: 450.000000 MHz			
Temp (Deg C)	CW Mode (MHz)	2FSK	4FSK
70	450.000135	450.000127	450.000130
60	450.000122	450.000112	450.000111
50	450.000061	450.00085	450.000098
40	450.000124	450.000116	450.000111
30	450.000139	450.000128	450.000130
20	450.000190	450.000166	450.000170
10	450.000176	450.000168	450.000163
0	450.000160	450.000153	450.000155

-10	450.000126	450.00095	450.000082	
-20	450.000067	450.000100	450.000085	
-30	450.000048	450.000062	450.000075	
Lowest Freq: 450.000048MHz; Highest Freq: 450.000178MHz; Variance: +48 to178Hz				
Limit: 1.5ppm at 420MHz to 1.5ppm at 450MHz = +/- 630Hz				
Compliant ☒ Non-Compliant ☐				

Frequency Stability (Voltage Variation)

Governing Doc	FCC Part 2 2.1055(d) (1) FCC Part 80 80.209 FCC Part 90 90.213(a) IC RSS-119 5.3	Room Temperature (°C)	21.2
Basic Standard	ANSI TIA-603	Relative Humidity (%)	52
Test Location	Richmond	Barometric Pressure (kPa)	101.5
Test Engineer	David Johanson	Date	31 January 2018
EUT Voltage	☒ -48Vdc		

Test Equipment Used	Manufacturer	Model	Identifier	Calibration	Calibration due
EMC Analyzer	Keysight	N9038A	702	27-Apr-2017	27-Apr-2018
Digital Multi-Meter	Fluke	77	640	17-May-2017	17-May-2018
Temperature Probe with Type K probe	Omega	HH23A	394	17-May-2017	17-May-2018

Frequency Range:	☒ 30-1000MHz
Detector:	☒ Peak
RBW/VBW:	☒120/300kHz
Type of Facility:	☒ Tabletop
Distance:	☒ Direct

Limit: 1.5ppm (420 to 450MHz) = +/- 630Hz at 420MHz
Limit: 2.5ppm (450 to 480MHz) = +/- 1125Hz at 450MHz

Manufacturer Voltage Limits:
+13Vdc +/- 10% (11 to 15Vdc)

Voltage related frequency variation: 178Hz

Compliant ☒ Non-Compliant ☐

Test Method

The EUT and test equipment were set up and measurements taken using the procedures is based on ANSI/TIA-603-E for the FM Modulations

1) Power on the EUT in Receive mode at the nominal voltage 13.00Vdc +/-0.01
2) Set the temperature to +20 degrees C.
3) “Soak” the EUT at this temperature for 1 hour
4) Turn on Transmitter for 30 seconds at maximum power using the FM modulation
5) Measure the output frequency at the center frequency
6) Adjust the modulation to the next modulation and wait 10 minutes
7) Repeat steps 4 to 6 until all modulations have been measured.
8) Turn off the EUT power supply and change the input voltage and repeat the test steps 3 to 8 until both 11Vdc and 15Vdc have been completed

Test setup

- Standard Transmitter Load Attenuators were adjusted as per the TIA-603 procedures. The maximum input to the Test Receiver was -10dBm

Results

Ref Frequency: 450.000000 MHz at 25Deg Cel				
Voltage	CW Mode (MHz)	2FSK	4FSK	
11	450.00146	450.000153	450.000148	
13	450.000158	450.000160	450.000178	
15	450.000135	450.000137	450.000140	
Lowest Freq: 450.000135MHz ; Highest Freq: 161.000178MHz ; Variance: 178Hz				
Limit: 1.5ppm at 420MHz to 1.5ppm at 450MHz = +/- 630Hz				
Compliant ☒ Non-Compliant ☐				

Receiver Spurious Emissions

Governing Doc	IC RSS-Gen 7.1	Room Temperature (°C)	23.1
Basic Standard	ANSI TIA-603	Relative Humidity (%)	41
Test Location	Richmond	Barometric Pressure (kPa)	100.5
Test Engineer	David Johanson	Date	15 Nov 2017
EUT Voltage	☒ 13Vdc		

Test Equipment Used	Manufacturer	Model	Identifier	Calibration	Calibration due
EMC Analyzer	Keysight	N9038A	702	27-Apr-2017	27-Apr-2018
Biconilog Antenna	Sunol	JB1	371	29-Mar-2016	29-Mar-2018
EMC Shielded Enclosure	USC	USC-26	374	NCR	NCR
AC Power Source	California Instrument	5001i	059	NCR	NCR

Note) NCR = No Calibration Required

Frequency Range:	☒ 30-1000MHz	☐ 150kHz-30MHz	
Detector:	☒ Peak(for Prescan)	☒ Quasi-Peak(for Formal)	
RBW/VBW:	☒120/300kHz	☐ 9/30kHz	
Type of Facility:	☒ SAC	☐ OATS	☐ *in-situ*
Distance:	☒ 3meter	☐ 10meter	☐ 1meter
Arrangement of EUT:	☒ Table-top only	☐ Floor-standing only	☐ Rack Mounted
Classification:	☐ Class A	☒ Class B	

All emissions detected were digital mode emissions only. No receiver based frequencies were detected.

Compliant ☒ Non-Compliant ☐

Test Method

The EUT and test equipment were set up and measurements taken using the procedures is based on the ANSI/TIA-603-E for the FM Modulations; TIA-102-CAAA-D for the P25 Modulations

Adjust the spectrum analyzer for the following setting:
a) RBW : 100 kHz (< 1 GHz), 1 MHz (> 1 GHz).
b) VBW : 300 kHz (< 1 GHz), 3 MHz (> 1 GHz).
c) Detector mode : Positive Peak

The transmitter was placed on a non-conductive turntable connected to a non-radiating load, which was also placed on the turntable.

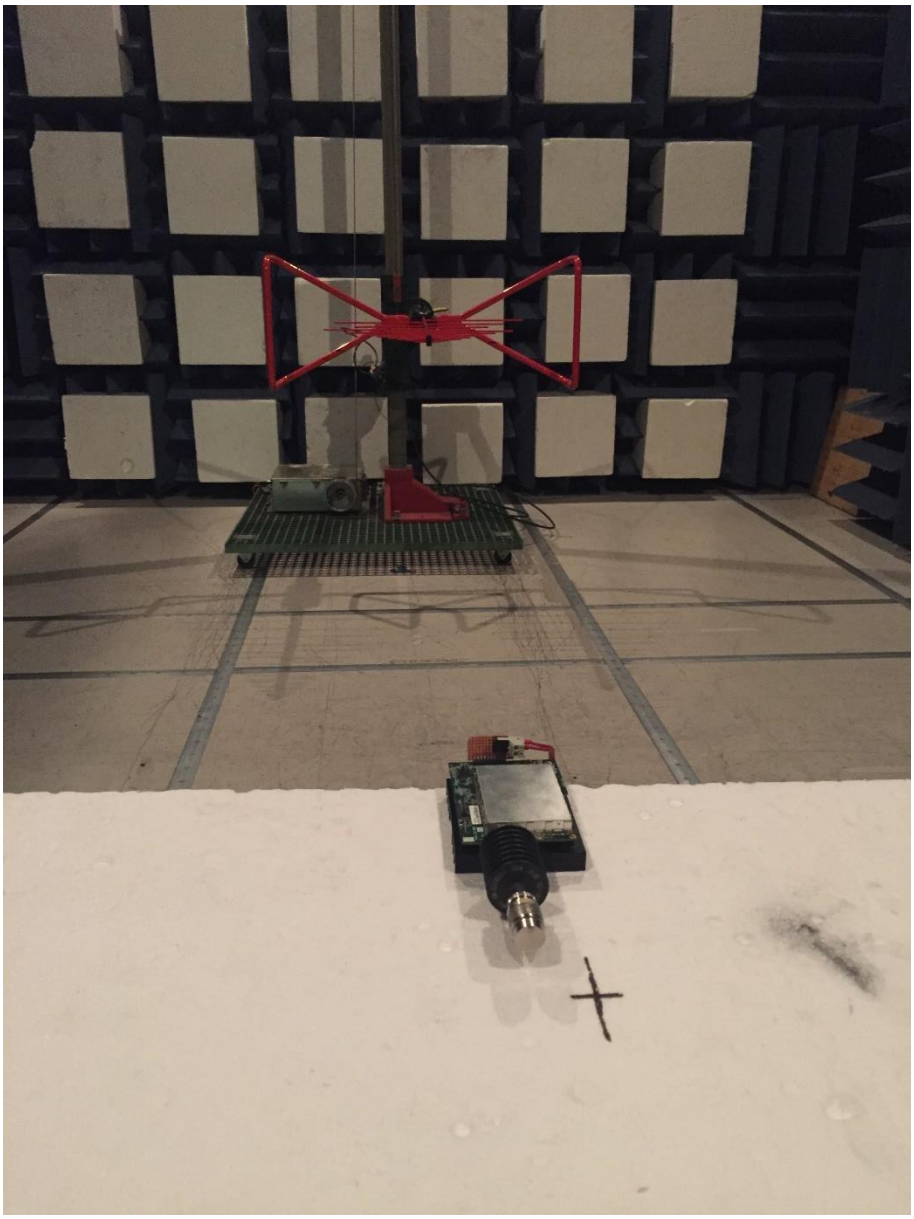
The measurement antenna was placed at a distance of 3 meters from the EUT. During the tests, the antenna height and polarization as well as EUT azimuth were varied in order to identify the maximum level of emissions from the EUT.

The Receiver frequency was selected and left in receive mode of operation. A measurement was performed for each frequency.

Test Result

Emission level (dBuV/m) = Quasi-Peak detected level (dBuV) +Cable Loss (dB) + Antenna Factor (dB/m)

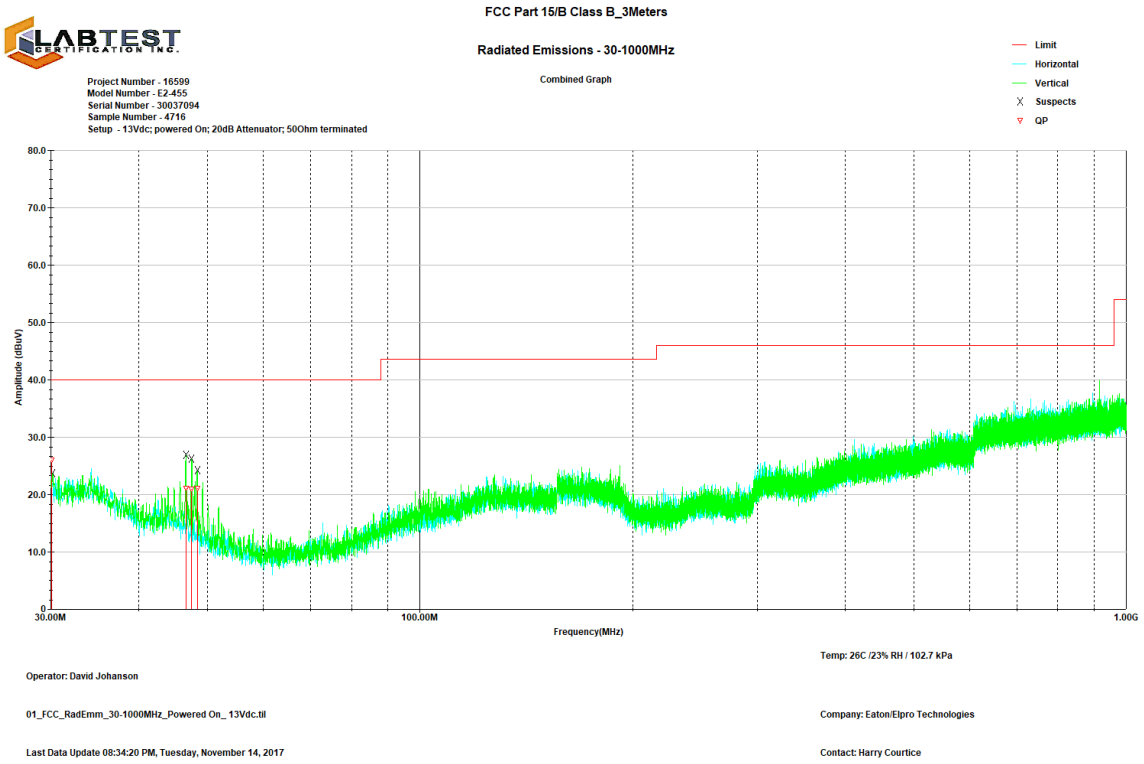
Test setup

Description of test set-up:
The EUT was placed on a 0.8m non-conducting table above a ground reference plane (GRP). The EUT was set to **Operation Mode #1 with configuration Mode #1.**
30 – 1,000MHz with JB-1 Antenna: 

Measurement Table/Graphical representation for Emission

Receiver frequency set for 450MHz.
All other Receiver frequencies produced the same data and graphs

- Graph, Combined



Top_Vertical								
Frequency	Ant Fac	Cable Fac	AZ	HGT	Peak	QP	Limit	Margin
MHz	dB	dB	Deg	cm	dBuV/m	dBuV/m	dBuV/m	dB
30.0855	17.39	0.7	145	364	29.85	25.97	40	-14.03
46.587	10.87	0.86	263	364	24.92	21.08	40	-18.92
47.4843	10.11	0.87	174	389	24.12	20.86	40	-19.14
48.3573	9.38	0.88	202	348	24.19	21.03	40	-18.97

EUT was scanned in 3 orthogonals. Flat on the table was the worst case emissions

Frequencies detected were from Digital Circuitry only. There were no other Receiver Frequencies detected, regardless of the receiver frequency setting.

No Horizontal Emissions to measure.

APPENDIX A: ISO 17025:2005 Accreditation Certificate

CERTIFICATE OF ACCREDITATION

ANSI-ASQ National Accreditation Board
500 Montgomery Street, Suite 625, Alexandria, VA 22314, 877-344-3044

This is to certify that

Labtest Certification, Inc.
3128, 20800 Westminster HWY
Richmond B.C. V6V 2W3

has been assessed by ANAB
and meets the requirements of international standard

ISO/IEC 17025:2005

while demonstrating technical competence in the field of

TESTING

Refer to the accompanying Scope of Accreditation for information regarding the types of tests to which this accreditation applies.

AT-2033
Certificate Number

ANAB Approval

Certificate Valid: 08/07/2017-03/04/2018
Version No. 004 Issued: 08/07/2017

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).

ANSI-ASQ National Accreditation Board

ANAB

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

Labtest Certification, Inc.
3128, 20800 Westminster HWY
Richmond, B.C. V6V 2W3
Kavinder Dhillon Ruben Ugarte Phone: 604-247-0444
kdhillon@labtestcert.com ruben.Ugarte@labtestcert.com
www.labtestcert.com

TESTING

Valid to: **March 4, 2018** Certificate Number: **AT-2033**

Testing performed in support of FCC DoC and Certification approval procedures

Type of Device Examples	Scope of Accreditation	Supporting FCC Guidance	Comments
Unintentional Radiators (FCC Part 15, Subpart B)	• ANSI C63.4-2014		
Industrial, Scientific, and Medical Equipment (FCC Part 18) • Consumer ISM equipment	• FCC MP-5, (February 1986)		
Intentional Radiators (FCC Part 15 Subpart C)	• ANSI C63.10-2013		
UPCS (FCC Part 15, Subpart D) •Unlicensed Personal Communication Systems devices	• ANSI C63.17-2013		
U-NII without DFS Intentional Radiators (FCC Part 15, Subpart E) •Unlicensed National Information Infrastructure Devices (U-NII without DFS)	• ANSI C63.10-2013	KDB Publication 789033	
U-NII with DFS Intentional Radiators (FCC Part 15 Subpart E) • Unlicensed National Information Infrastructure U-NII) Devices with Dynamic Frequency Selection (DFS)	• FCC KDB Publication 905462 D02 UNII DFS Compliance Procedures New Rules v01 (April 8, 2016)		
UWB Intentional Radiators (FCC Part 15, Subpart F) •Ultra-wideband Operation	• ANSI C63.10-2013		
BPL Intentional Radiators (FCC Part 15, Subpart G) •Access Broadband Over Power Line (Access BPL)	• ANSI C63.10-2013		
White Space Device Intentional Radiators (FCC Part 15, Subpart H) •White Space Devices	• ANSI C63.10-2013		

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Testing performed in support of FCC DoC and Certification approval procedures

Type of Device Examples	Scope of Accreditation	Supporting FCC Guidance	Comments
Commercial Mobile Services (FCC Licensed Radio Service Equipment) •Part 22 (cellular) •Part 24 •Part 25 (non-microwave) •Part 27	• ANSI/TIA-603-D • TIA-102.CAAA-D	KDB Publication 971168	
General Mobile Radio Services (FCC Licensed Radio Service Equipment) •Part 22 (non-cellular) •Part 90 (non-microwave) •Part 95 •Part 97 •Part 101 (non-microwave)	• ANSI/TIA-603-D • TIA-102.CAAA-D		Microwave Frequencies, as used in this part, refers to frequencies of 890 MHz and above.
Citizens Broadband Radio Services (FCC Licensed Radio Service Equipment) •Part 96	• ANSI/TIA-603-D • TIA-102.CAAA-D	KDB Publication 971168	
Maritime and Aviation Radio Services (FCC Licensed Radio Service Equipment) •Part 80 •Part 87	• ANSI/TIA-603-D		
Microwave and Millimeter Bands Radio Services (FCC Licensed Radio Service Equipment) •Part 25 •Part 74 •Part 90 (90Y, 90Z, DSRC) •Part 101	• ANSI/TIA-603-D • TIA-102.CAAA-D		
Broadcast Radio Services (FCC Licensed Radio Service Equipment) •Part 73 •Part 74 (non-microwave)	• ANSI/TIA-603-D • TIA-102.CAAA-D		
RF Exposure •Devices subject to SAR requirements	• IEEE Std 1528™-2013	KDB Publication 865664 KDB Publication 447498	
Hearing Aid Compatibility (Part 20) •HAC for Commercial mobile services	• ANSI C63.19-2007; or • ANSI C63.19-2011		

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Testing performed in support of FCC DoC and Certification approval procedures

Type of Device Examples	Scope of Accreditation	Supporting FCC Guidance	Comments
Signal Boosters (Part 20) •Wideband Consumer signal boosters •Provider-specific signal boosters •Industrial signal boosters	• FCC KDB Publication 935210 D03 Signal Booster Measurements v04(February 12,2016) • FCC KDB Publication 935210 D04 Provider Specific Booster Measurements v02 (February 12,2016) • FCC KDB Publication 935210 D05 Indus Booster Basic Meas v01r01 (February 12,2016)		

Electromagnetic Compatibility (EMC)

Test Method	Test Specification(s)	Range	Comments
Unintentional Radiators	ANSI C63.4-2003 ANSI C63.4-2009		
Radiated and Conducted Emissions	ANSI C63.4:2014; FCC OST/MP-05 (1986); ICES-001(2006); ICES-002(2013); ICES-003(2016); ICES-005(2009); CISPR 16-1-1(2015); CISPR 16-1-2(2014); CISPR 16-1-3(2006); CISPR 16-2-1(2014); CISPR 16-2-2(2010); CISPR 16-2-3(2014); CISPR 16-2-5(2008); CISPR 16-4-2(2014); EN 55016-1-1(2010); EN 55016-1-2(2014); EN 55016-1-3(2006); EN 55016-1-4(2010); EN 55016-2-1(2014); EN 55016-2-2(2011); EN 55016-2-3(2014); EN 55016-4-2(2014); CISPR 11(2012); EN 55011(2013); AS/NZS CISPR 11(2013); KN 11 (RRA Announce 2015-110, Dec, 03, 2015); VCCI V-3 (up to 6 GHz); VCCI V-5; CNS 13438	9 kHz to 40 GHz	

END OF REPORT