TRANSMITTER REPORT

For

Codan Radio Communications

43 Erie Street
Victoria, BC
V8V 1P8, Canada

Date:	16 April 2018
Report No.:	16471-2E FCC
Revision No.:	6
Project No.:	16471
Equipment:	Cascade P25 VHF Base Station Transceiver/Amplifier 148 - 173.4MHz
Model No.:	CASC165A
FCC ID:	H4JCASC165A

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TEST REPORT		
FCC Part 90		
Report Reference No.....:	16471-2E FCC	
Report Revision History. .....:	✓ Rev. 0: Draft 26 July 2017 ✓ Rev. 1: Release 11 August 2017 ✓ Rev. 2: Released 05 September 2017 ✓ Rev. 3. Released 05October 2017 ✓ Rev. 3.1: removing LSM and HDQPSK from report ✓ Rev. 4: Released 29 January 2018 ✓ Rev. 5: removed Photos and IC information ✓ Rev. 6: removed Setup Photo Pg16; OBW corrections; Modulation Limiting corrections ✓	
Compiled by (+ signature)	David Johanson	
Approved by (+ signature).....	Jeremy Lee	
Date of issue.....:	16 April 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.....:	Codan Radio Communications	
Address .....:	43 Erie Street Victoria, BC V8V 1P8, Canada	
Contact Person.....:	Mike Cyr, Compliance Engineer	
Manufacturer's Name .....:	Codan Radio Communications	
Address .....:	43 Erie Street Victoria, BC V8V 1P8, Canada	
Test specification:		
Standard (s).....:	➢ FCC Part 2, 90; 2017	
Test procedure .....:	➢ ANSI C63.4:2014; ANSI TIA-603-E; TIA-102.CAAA-D ➢ TIA-102.CAAB-C	
Non-standard test method……..:	N/A	
Test item description .....:	Cascade P25 VHF Base Station Transceiver and Amplifier	
Trade Mark .....:	Cascade	
Model/Type reference .....:	CASC165A	

FCC ID	H4JCASC165A
Serial Numbers.....:	Transceiver: 271792 Amplifier: 271791
Ratings .....:	-48Vdc 10Amps
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 .....:	17 May 2017
Date (s) of performance of tests.....:	17 May to 01 October 2017

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 refer to Labtest test report:

“16471-1E_rev1_Codan.pdf”

The Test Setup photos have been removed from this report to comply with the clients Short Term Confidentiality Request. The Test Setup Photos are available in a separate file:

“H4JCASC165A - Test Setup.pdf”

Equipment Description

General product information:
The CODAN Cascade is a next-generation P25 base station/repeater that offers the only integrated system-in-a-box solution on the market. This all inclusive package features a modular design allowing for up to two 100W P25 repeaters mounted inside a 4RU sub-rack complete with P25 DFSI network interface and power supply.

This EUT was tested with 1 x Power Supply Module, 1 x transceiver Module and 1 x Power Amplifier (PA) Module all mounted in a sub rack with a front panel fan assembly. (consisting of: CASC-TR-01-165 (Transceiver) and CASC-PA-00-165 (Power Amplifier)). It is designed for the VHF bands 148 to 173.4MHz.

The frequency range, available channels and transmission power are preprogrammed and restricted by the factory at the time of purchase, based on the client's license.

Modulations:
• P25 Phase 1: C4FM (Constant Envelope)
• FM Analog: NB (Constant Envelope)

Emission Designations:
• FM Analog: 11K0F3E (NB Voice)
• P25 Phase I (C4FM) : 8K10F1D, 8K10F1E, 8K10F1W, 8K10F7W

EUT Internal Operating Frequencies

Multiple frequencies

Power Interface

Mode #	Voltage (V)	Current (A)	Power (W)	Frequency (DC/AC-Hz)	Phases (#)	Comments
1	-48	8	400	DC	0	

Client Equipment Used During Test

Use*	Product Type	Manufacturer	Model	Comments
EUT	Cascade	Codan	CASC165A	
AE	Computer	HP	EiteBook	Custom interface software
AE	Power Supply	GW Instek	PSW 80-40.5	

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

Software and Firmware

Use*	Description	Version
AE	Cascade Radio Platform	0.0.22
EUT	Cascade Firmware	10-20

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

Input/Output Ports

Port #	Name	Type*	Cable Max. >3m	Cable Shielded	Comments
0	Power	DC	100m	No	
1	Ethernet	TP	100m	No	
2	RF Out	RF	100m	Yes	Antenna Port
3	Ext. Ref	RF	100m	Yes	
4	RX1	RF	100m	Yes	
5	1 PPS	RF	100m	Yes	
6	GPIO	I/O	3m	No	Not used

*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 in Receive mode
3	Transmitter ON – Low Power 10 watts
4	Transmitter ON – High Power 100 watts

EUT Configuration Modes

Mode #	Description
1	• Connected to laptop with power On; RF Cable terminated to Load or Attenuator as needed; RF1 is terminated; Unit is grounded

Modifications Required for Compliance

None.

Test Equipment Verified for function

Model #	Description	Checked Function	Results
N9038A	EMI Receiver	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

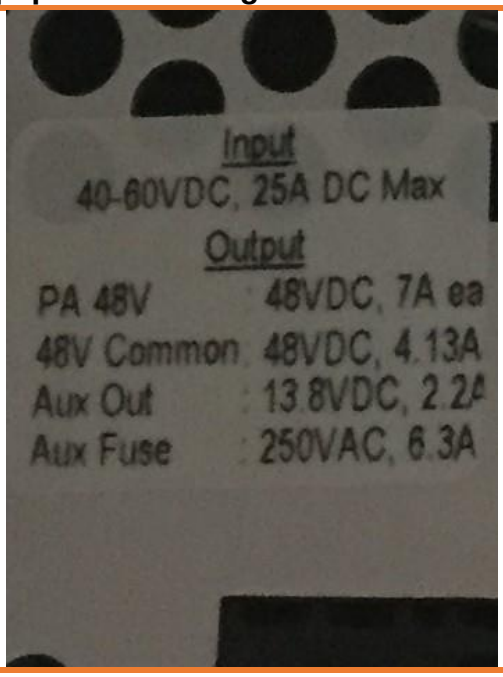
Measurement Uncertainty

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%.

Equipment Marking Plate



You should refer to the clause of FCC Part 2 Section 2.925 and FCC Part 15 Section 15.19 for information to be contained on the label as well as information about the label. Any other statements or labelling requirements may appear on a separate label at the option of the applicant/grantee.

According to FCC Section 15.19(a)(3), the following statement must be including on the identification label:

> This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Note: Some jurisdictions in Canada require Cautions and Warnings to also be in French. It is the responsibility of the Manufacturer to provide bilingual markings, where applicable, in accordance with the requirements of the local regulatory authorities. It is the responsibility of the Manufacturer to determine this requirement and have bilingual wording added to the "Markings".

Result Summary

The Compliance Status is a judgment based on the direct measurements and calculated highest emissions to appropriate standard limits. Measurement uncertainty values, provided on calibration certificates, were not be used in the judgment of the final status of compliance.

FCC Part 2, and Part 90			
Test Type	**Regulation**	**Result/Comment**	**Compliance Status**
Carrier Output Power (Conducted)	FCC Part 2 2.1046(a)	125Watt Max 100Watt Nom	PASS
Unwanted Emissions (Transmitter Conducted)	FCC Part 2 2.1046(a) FCC Part 90 90.210	< -80dBm	PASS
Field Strength of Spurious Radiation	FCC Part 2 2.1053 (a) FCC Part 90 90.210	< -80dBm	PASS
Emission Masks (Occupied Bandwidth)	FCC Part 2 2.1049 (c) (1) FCC Part 90 90.210	< 12.5kHz	PASS
99% Occupied Bandwidth	FCC Part 2.1049	< 10kHz	PASS
90.214 5.9 Transient Frequency Behavior	FCC Part 90 90.214	< 100Hz	PASS
Audio Frequency Response	FCC Part 2 2.1047(a)	complies	PASS
Modulation Limiting	FCC Part 2 2.1047(b)	complies	PASS
Frequency Stability (Temperature Variation)	FCC Part 2 2.1055(a) (1) FCC Part 90 90.213(a)	< 57Hz	PASS
Frequency Stability (Voltage Variation)	FCC Part 2 2.1055(d) (1) FCC Part 90 90.213(a)	< 12Hz	PASS

Carrier Output Power (Conducted)

Governing Doc	FCC Part 2 2.1046(a)	Room Temperature (°C)	25.8
Basic Standard	ANSI TIA-603-E TIA-102.CAAA-D	Relative Humidity (%)	35
Test Location	Richmond	Barometric Pressure (kPa)	101.4
Test Engineer	David Johanson	Date	24 May 2017
EUT Voltage	☒ -48Vdc		

Test Equipment Used	Manufacturer	Model	Identifier	Calibration	Calibration due
Power Meter	Agilent	N1911A	601	29-Dec-2016	29-Dec-2017
Wideband Power Sensor	Agilent	N1921A	602	29-Dec-2016	29-Dec-2017
Attenuator(s)	As needed				

Note) NCR = No Calibration Required

Frequency Range:	☒ 148MHz-173.4MHz
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; TIA-102-CAAA-D Section 2.2.1.2

Transmitter Power was measured as the highest reading during a 60second transmission. Since the FM output level is fixed, the FM modulation was tested at 2.5kHz at 60% deviation as required by TIA-603-E

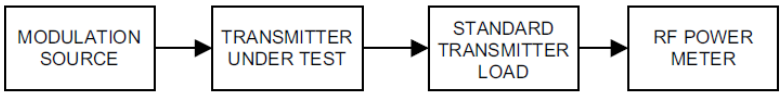
Test Result Calculation:

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.

Results

Modulation	FM 2.5KHz 60% dev.				
Meas. Freq(MHz)	Meter Reading (dBm)	Correction Factor(dB)	Emissions (dBm)	Power (Watts)	Comments
156	14.86	36.00	50.86	122	
161	14.84	36.00	50.84	121	
173.4	14.96	36.00	50.96	125	
Modulation	P25 C4FM Standard Transmitter Low Deviation Pattern				
Meas. Freq(MHz)	Meter Reading (dBm)	Correction Factor(dB)	Emissions (dBm)	Power (Watts)	Comments
156	14.80	36.00	50.80	120	
161	14.74	36.00	50.74	119	
173.4	14.91	36.00	50.91	123	

Unwanted Emissions (Transmitter Conducted)

Governing Doc	FCC Part 2 2.1046(a) FCC Part 90 90.210	Room Temperature (°C)	25.8
Basic Standard	ANSI TIA-603-E TIA-102.CAAA-D	Relative Humidity (%)	35
Test Location	Richmond	Barometric Pressure (kPa)	101.4
Test Engineer	David Johanson	Date	24 May 2017
EUT Voltage	☒ -48Vdc		

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

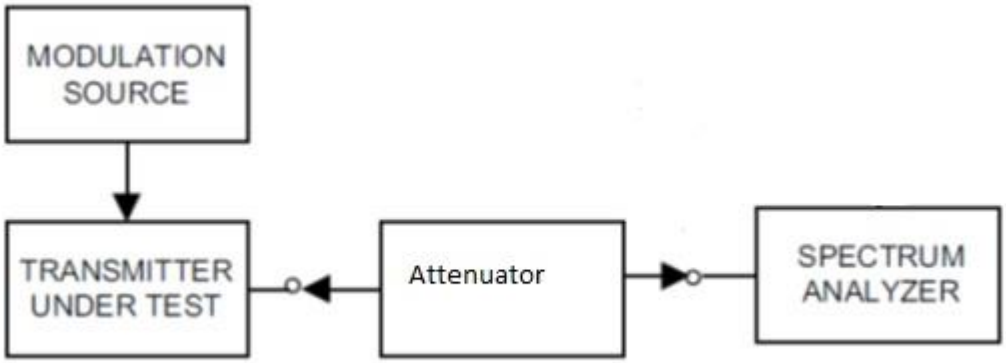
The setup and test procedure is based on ANSI/TIA-603-E for the FM Modulations; TIA-102-CAAA-D for the P25 Modulations

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	Room Temperature (°C)	23.1
Basic Standard	ANSI TIA-603-E TIA-102.CAAA-D	Relative Humidity (%)	35
Test Location	Richmond	Barometric Pressure (kPa)	100.5
Test Engineer	David Johanson	Date	21 May 2017
EUT Voltage	☒ -48Vdc		

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
Biconical Antenna	AH Systems	SAS-542	227B	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:	☒ 30-1000MHz	☐ 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

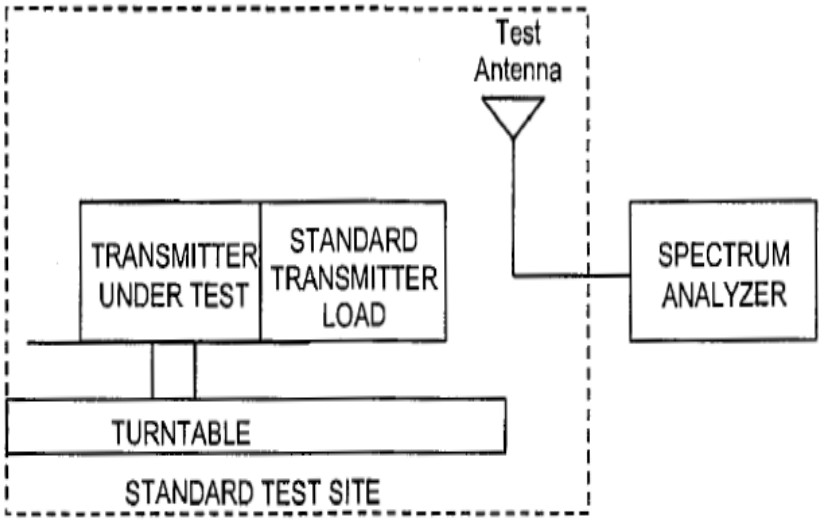
Test Method

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

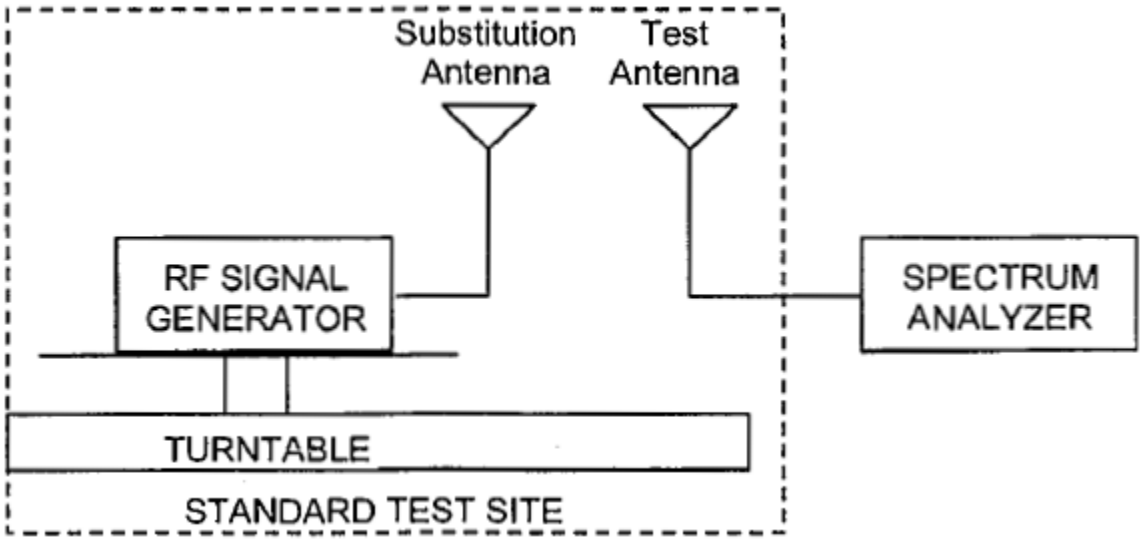
The transmitter was placed on a wooden turntable, and it was transmitting into non-radiating load which was also placed on the turntable.

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 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

The transmitter power final measurement was based on a 60 second transmission.

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.**

Results

No spurious emissions were detected when using 148 to 173.4MHz transmitters. All other emissions detected are from the Power Supply or digital circuitry
Noise floor 30 MHz to 2GHz = < -80dBm
Compliant ☒ Non-Compliant ☐

Emission Masks (Occupied Bandwidth)

Governing Doc	FCC Part 2 2.1049 (c) (1) FCC Part 90 90.210	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	09 July 2017
EUT Voltage	☒ -48Vdc		

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

Frequency Range:	☒ 30-1000MHz	☐ 150kHz-30MHz
Detector:	☒ Peak(for Prescan)	☒ Quasi-Peak(for Formal)
RBW/VBW:	☒120/300kHz	☐ 9/30kHz
Type of Facility:	☒ Testbench	
Distance:	☒ Direct	
Arrangement of EUT:	☒ Table-top only	☐ Floor-standing only ☐ Rack Mounted

Channel Bandwidth 12.5kHz must comply with mask D
99% OBW required to be measured

All modulations complied with mask D

Compliant ☒ Non-Compliant ☐

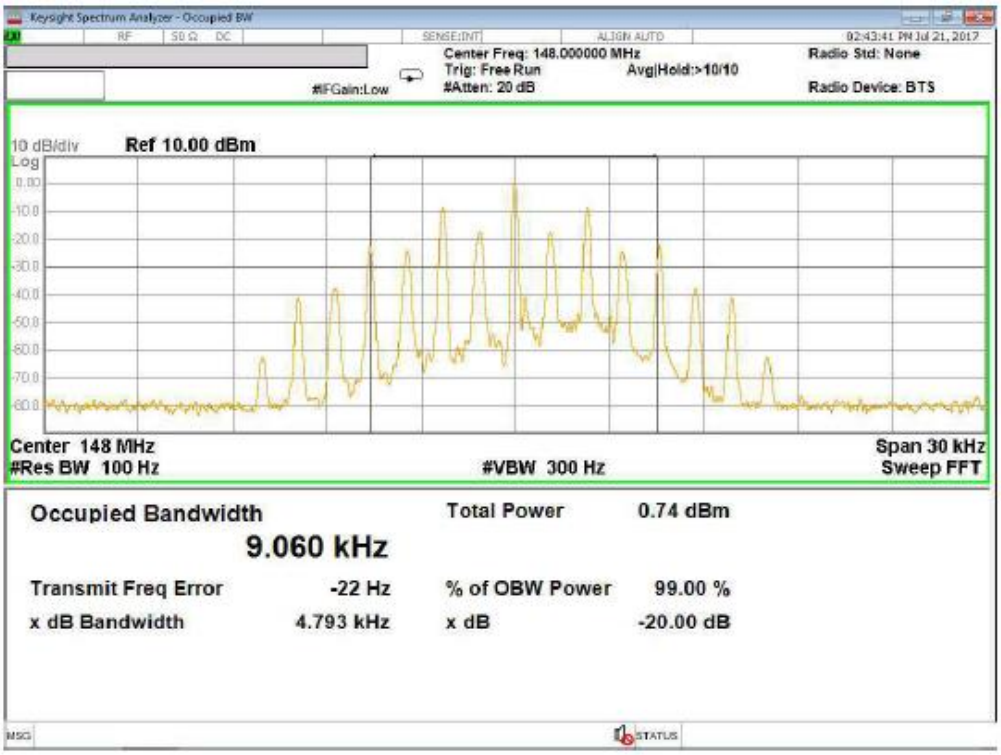
Test Method 99% OBW

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

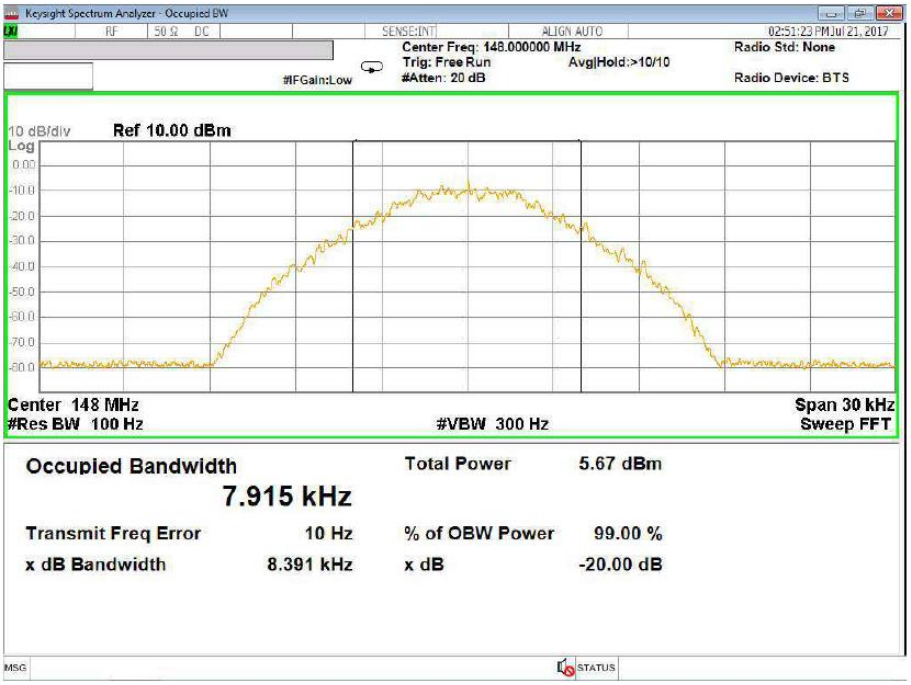
Adjust the spectrum analyzer for the following setting:
a) RBW : 100Hz (
b) VBW : 3 times the RBW

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

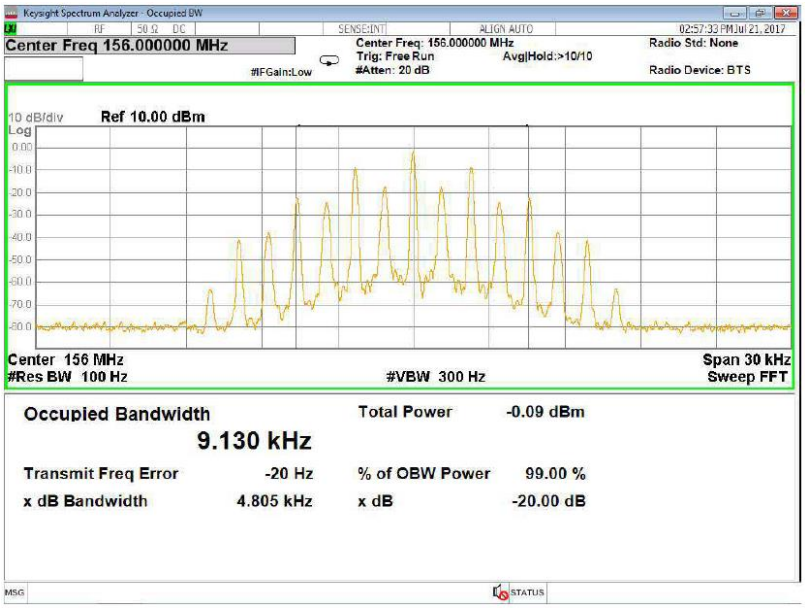
Results



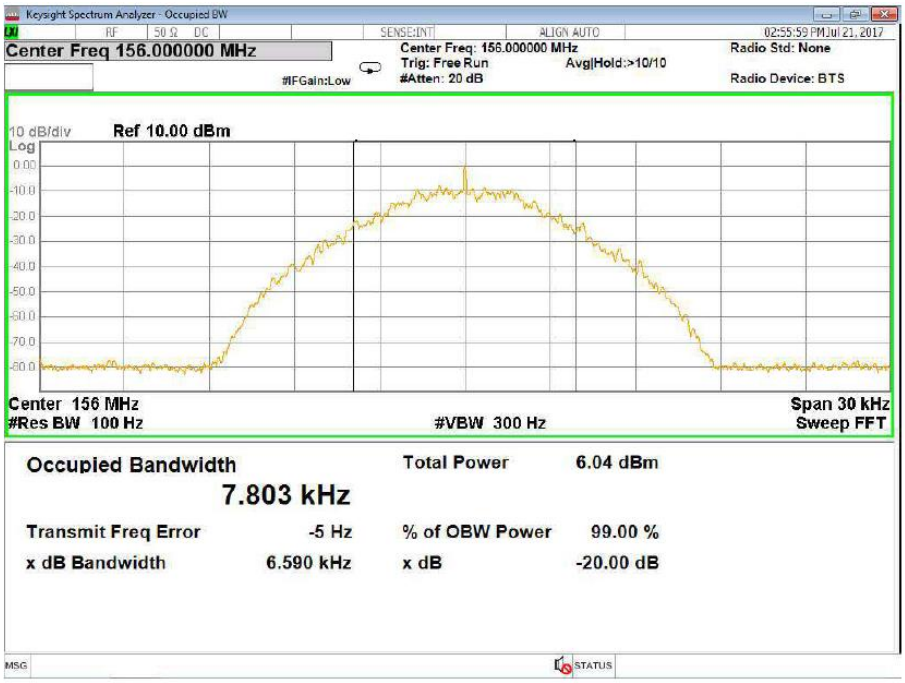
obw_156MHz_100W_FM



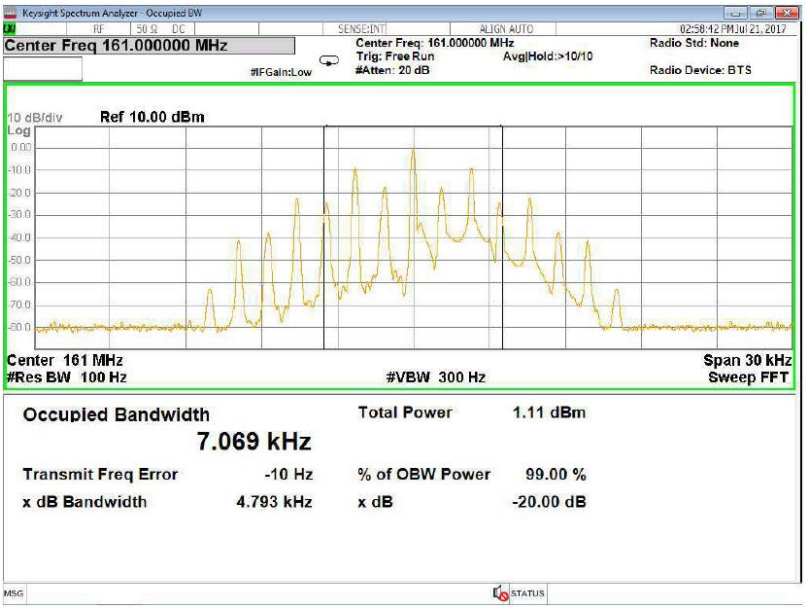
obw_156MHz_100W_C4FM



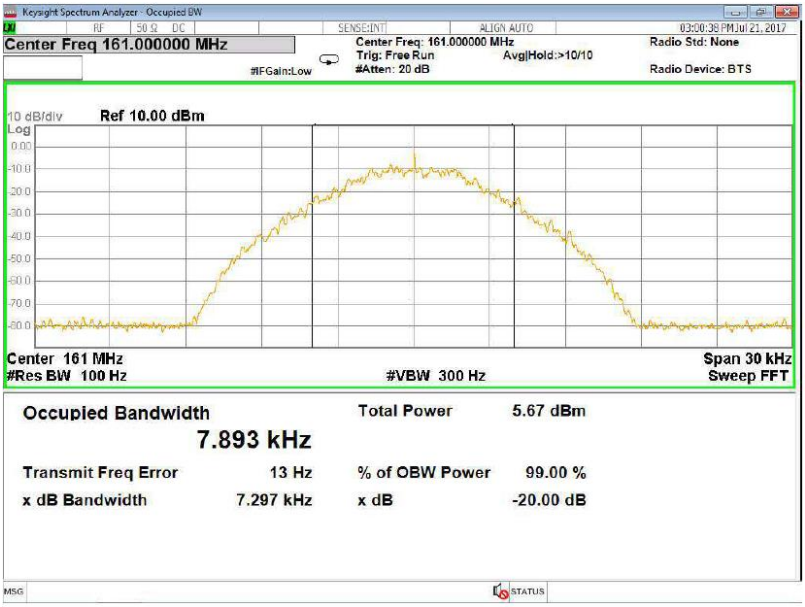
obw_156MHz_100W_FM



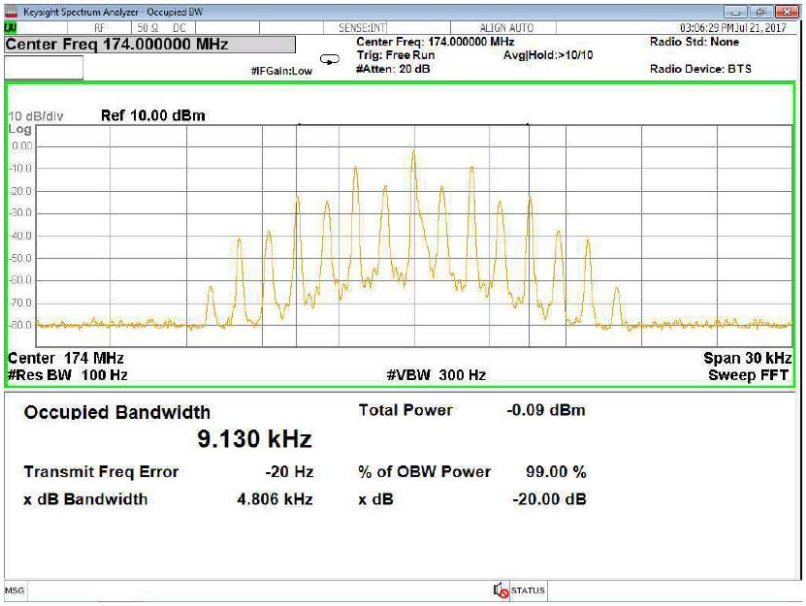
obw_156MHz_100W_C4FM



obw_161MHz_100W_FM



obw_161MHz_100W_C4FM



obw_173.4MHz_100W_FM

obw_173.4MHz_100W_C4FM

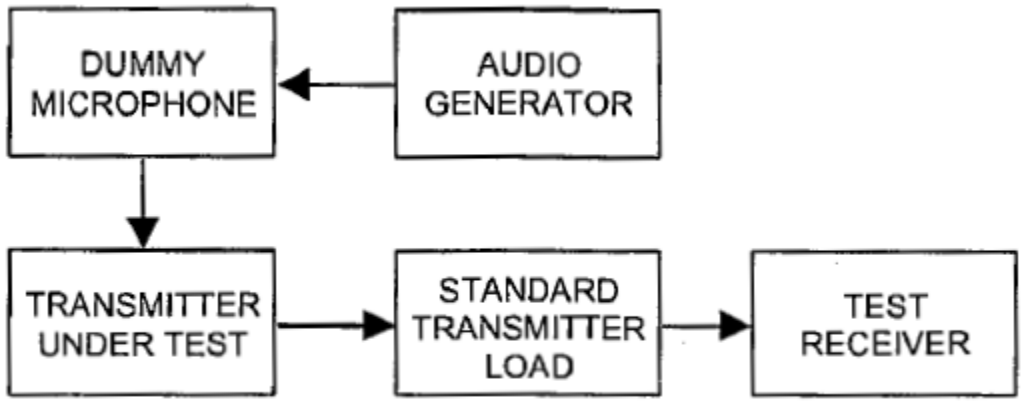
Test Method Mask D

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; TIA-102-CAAA-D for the P25 Modulations

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

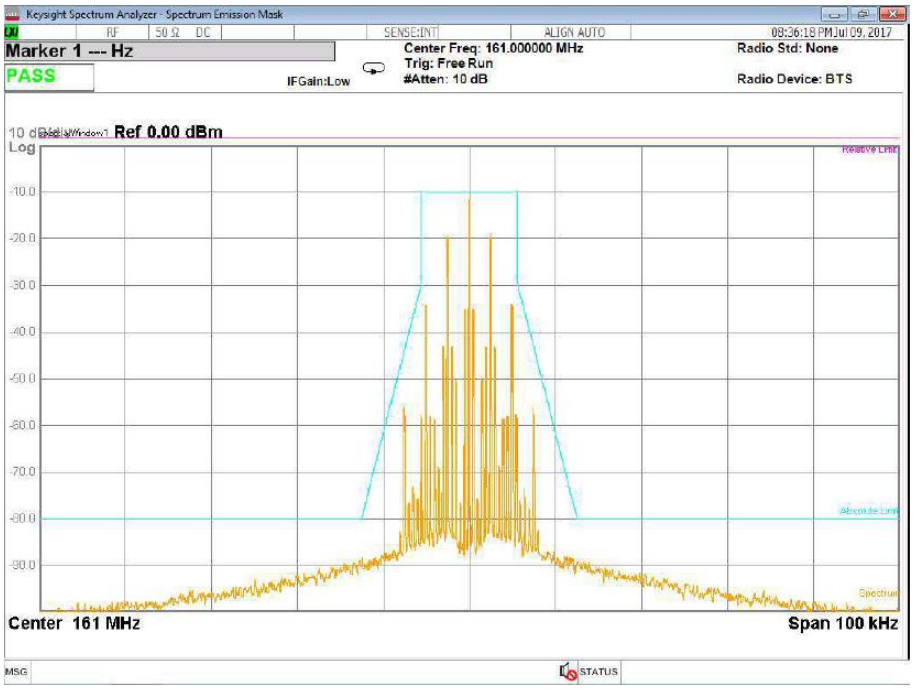
The occupied Bandwidth was measured with the Spectrum Analyzer controls set as shown on the test results.

Test setup

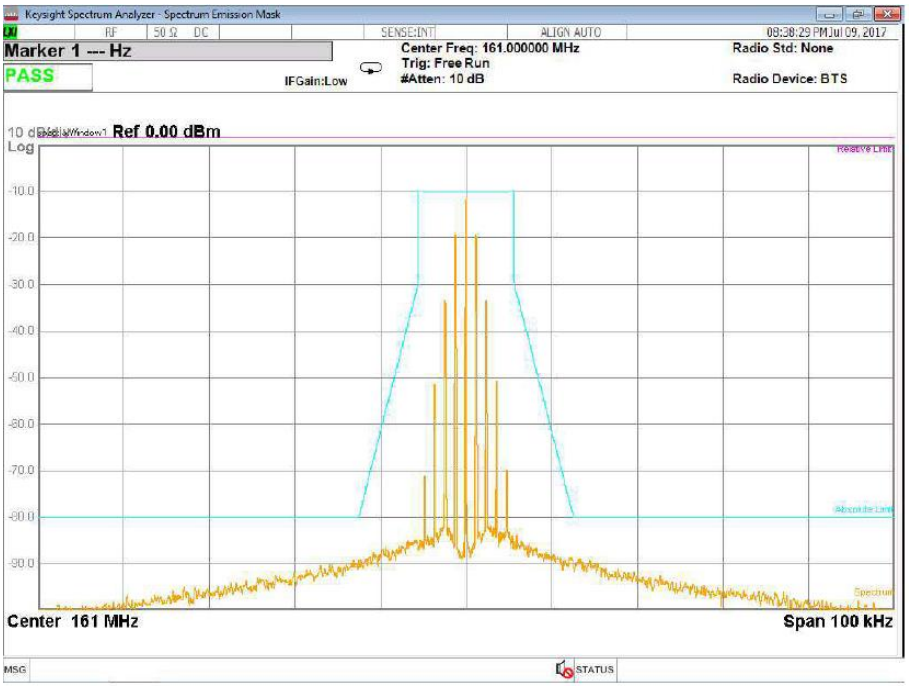


- Audio Generator and microphone are built in to the product for testing and diagnostic purposes.
- Standard Transmitter Load Attenuators were adjusted as per the TIA-603 procedures. The maximum input to the Test Receiver was -10dBm

Results



161MHz FM 2.3kHz 100Pct Deviation 12.5kHz channel (D Mask)
(-10dBm is reference Non-Modulated limit)



161MHz P25P1_C4FM_LowDev 12.5kHz channel (D Mask)
(-10dBm is reference Non-Modulated limit)

Transient Frequency Behaviour

Governing Doc	FCC Part 90 90.214	Room Temperature (°C)	23.1
Basic Standard	ANSI TIA-603-E TIA-102-CAAA-D	Relative Humidity (%)	41
Test Location	Richmond	Barometric Pressure (kPa)	100.5
Test Engineer	David Johanson	Date	18 May 2017
EUT Voltage	☒ -48Vdc		

Test Equipment Used	Manufacturer	Model	Identifier	Calibration	Calibration due
EMC Analyzer	Keysight	N9038A	702	27-Apr-2017	27-Apr-2018
Oscilloscope	Tektronix	TDS2024	021	06-Nov-2016	06-Nov-2017
Power Meter	Agilent	N1911A	601	29-Dec-2016	29-Dec-2017
Power Sensor	Agilent	N1921A	602	29-Dec-2016	29-Dec-2017
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

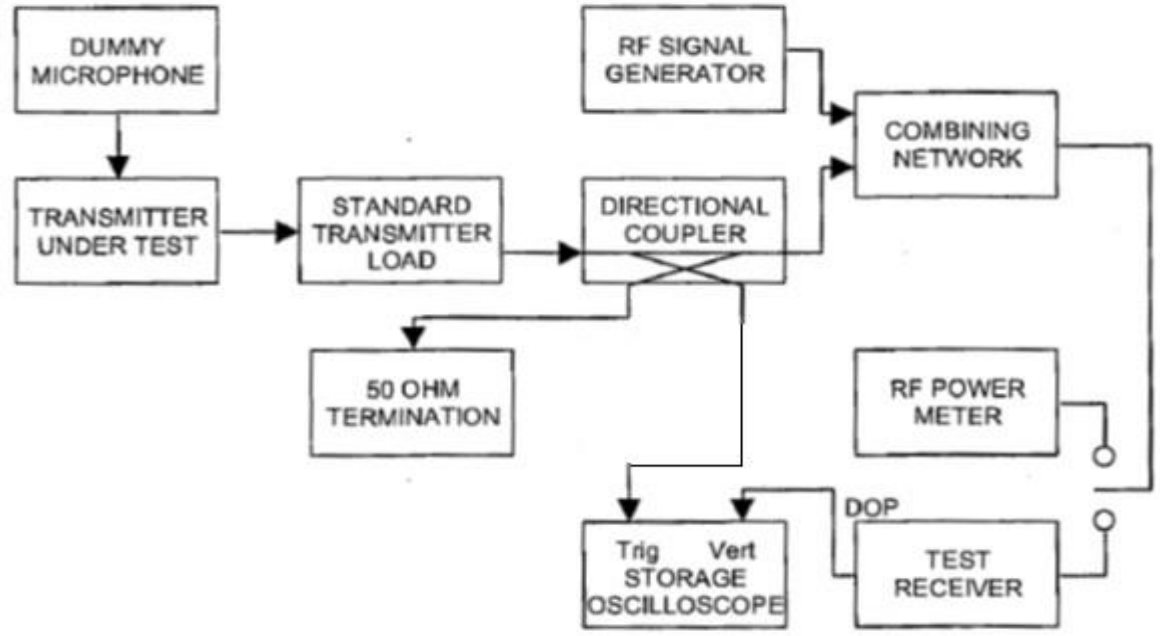
Type of Facility:	☒ Testbench
Distance:	☒ Direct
Arrangement of EUT:	☒ Table-top only

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
- 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.
- For the P25 modulations, the procedures referenced in TIA-102-CAAA were followed and are identical to the TIA-603 procedures. The only change was that the time period between t2 and t3 was captured, plotted and mean averaged to verify compliance with the limits.

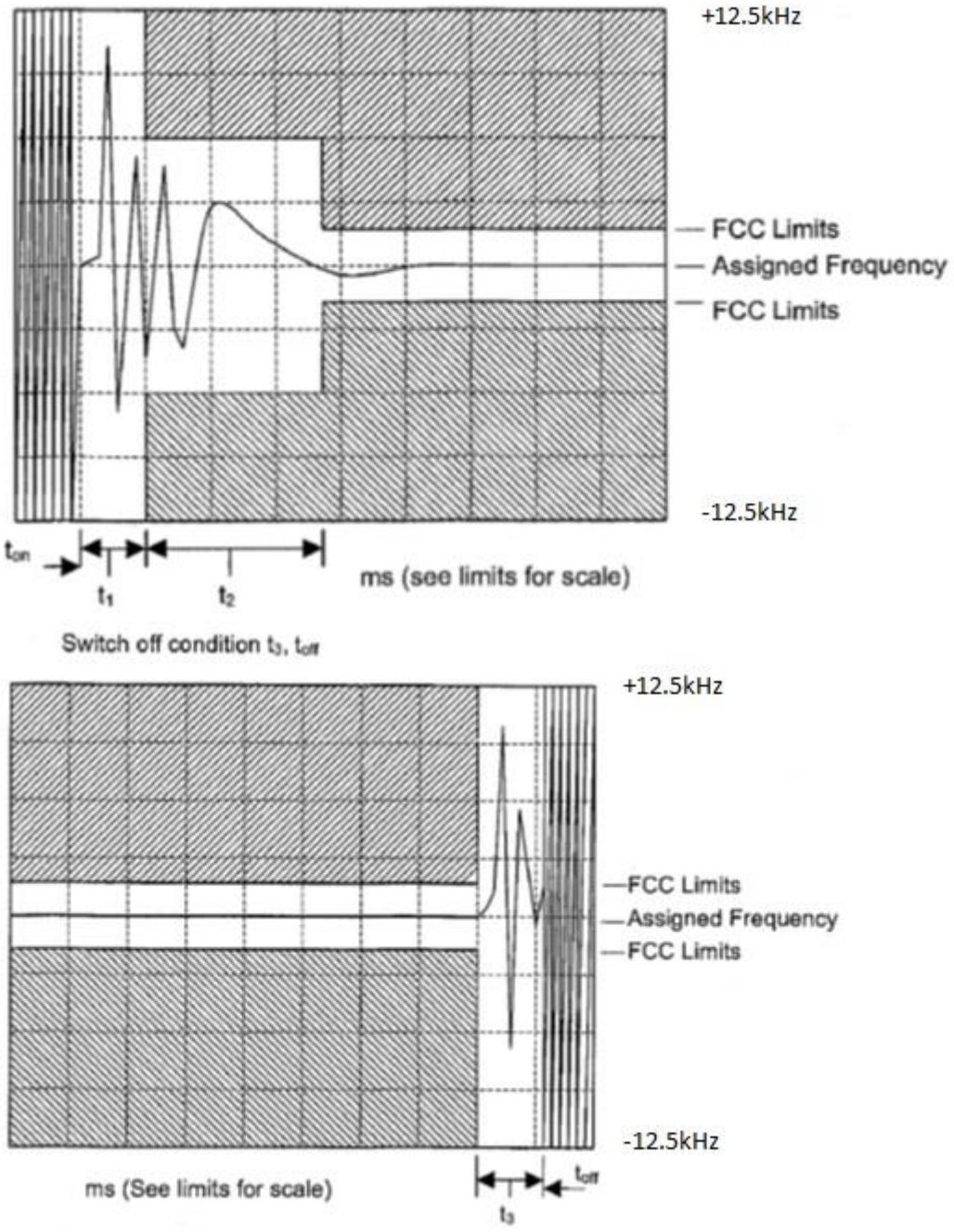
Test setup



- 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



Limits Calculations:
12.5kHz = +/-4 divisions
6.25kHz = +/-2 divisions
t2 to t3 time = (173.4MHz x 2.5ppm x +/-4div) / 12.5kHz = +/-0.14div (also = +/-86.8mV at 620mV/Div; =435Hz)

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 with 12.5kHz channels, the limits are:
-t1 = 5.0ms; t2 = 20.0ms; t3 = 5.0ms
- 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

Limits Calculations:
12.5kHz = +/-4 divisions
6.25kHz = +/-2 divisions
t2 to t3 time = (173.4MHz x 2.5ppm x +/-4div) / 12.5kHz = +/-0.14div (also = +/-86.8mV at 620mV/Div; =435Hz)

Limits TIA-102.CAAB for P25 Modulation

3.2.18 Transient Frequency Behavior

Applicable method of measurement and definition are described in clause 2.2.18. The standard that follows per Figure 1 and Figure 2 and Table 3-23 and applies to the mean frequency, which excludes peaks due to modulation.

Standard (47 CFR 90.214)

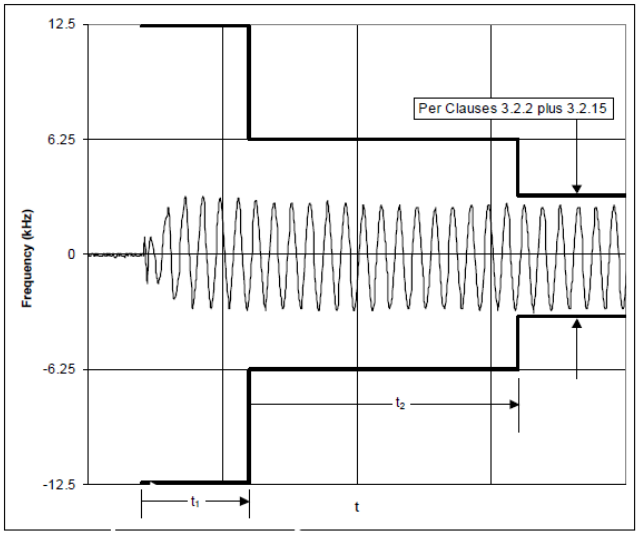


Figure 1 – Turn-on transient behavior and mean frequency limits

3.2.15 Frequency Deviation for C4FM

Applicable to C4FM transmitters only: methods of measurement and definition are described in clause 2.2.15.

Standard

High Level signal deviation shall exceed 2544 Hz but not exceed 3111 Hz.
Low Level signal deviation shall exceed 848 Hz but not exceed 1037 Hz.

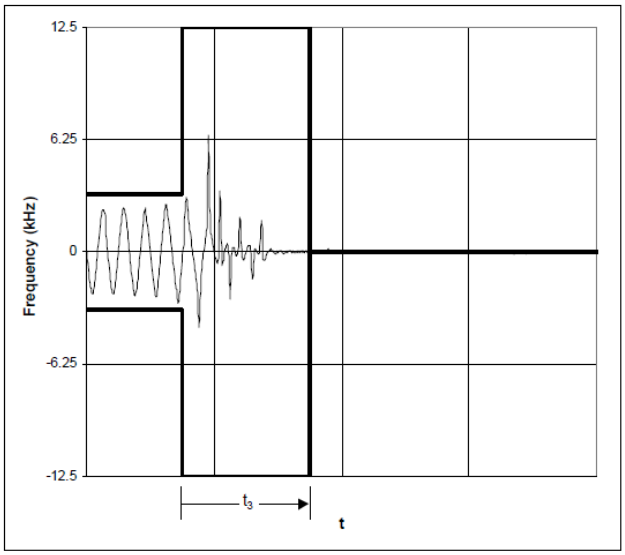


Figure 2 – Turn-o˝ ˙ransient behavior and mean frequency limits

Table 3-23. Mean transient frequency limits

	Frequency Ranges (MHz)		
Time Intervals	30 to 300	300 to 512	512 to 1000
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 mean frequency difference shall not exceed ±12.5 kHz.

During the period t_2 the mean frequency difference shall not exceed ±6.25 kHz.

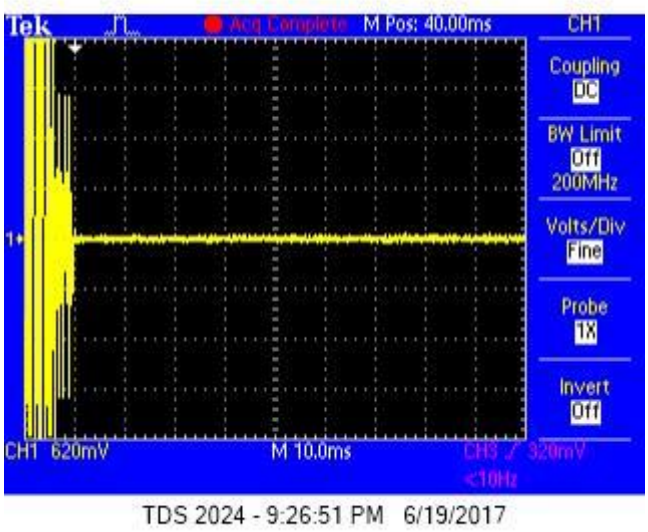
If the transmitter carrier output power rating is 6 watts or less, the mean frequency difference during t_1 and t_3 may be greater than ±12.5 kHz. The corresponding plot of frequency versus time during t_1 and t_3 shall be recorded in the test data.

For this product with 12.5kHz channels, the limits are:
-t1 = 5.0ms; t2 = 20.0ms; t3 = 5.0ms
- 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

Limits Calculations:
12.5kHz = +/-4 divisions
6.25kHz = +/-2 divisions
t2 to t3 time = (173.4MHz x 2.5ppm x +/-4div) / 12.5kHz = +/-0.14div (also = +/-103.6mV at 740mV/Div; =435Hz)

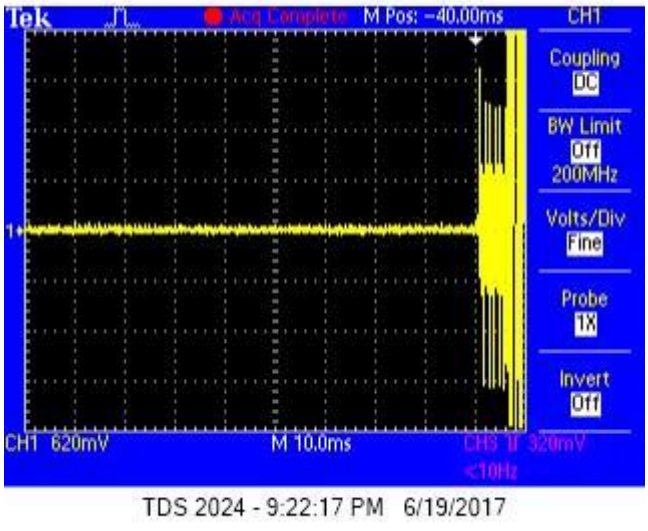
Results

173.4MHz showed the worst case results



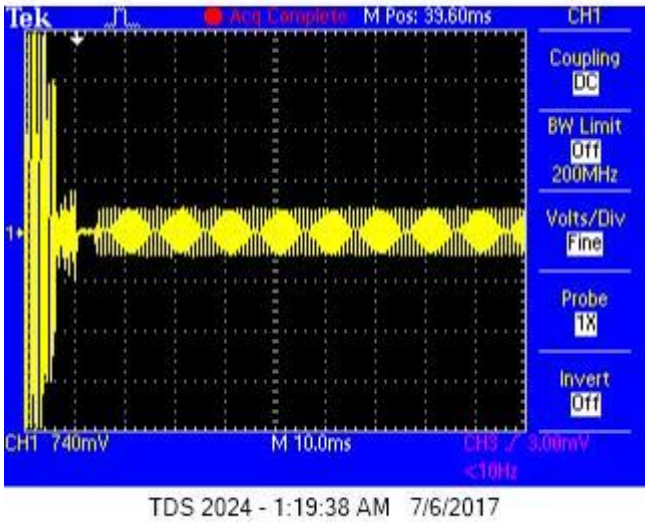
173.4MHz_100W_FM-1KHz-1PCT_transmit OFF to ON

Limits Calculations:
12.5kHz = +/-4 divisions
6.25kHz = +/-2 divisions
t2 to t3 time = (173.4MHz x 2.5ppm x +/-4div) / 12.5kHz = +/-0.14div (also = +/-86.8mV at 620mV/Div; =435Hz)



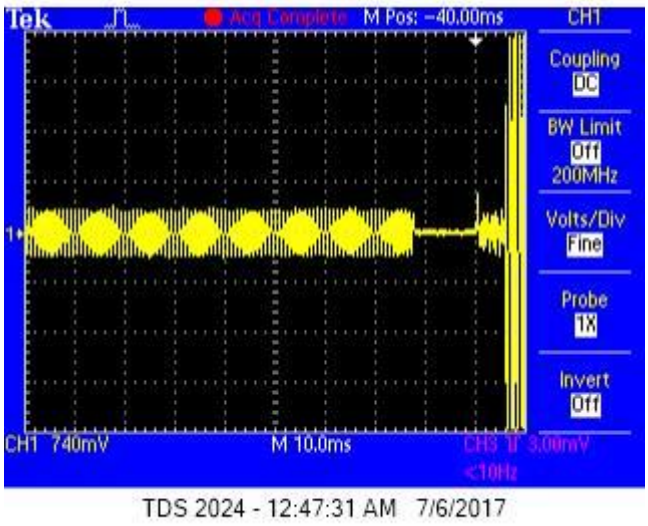
173.4MHz_100W_FM-1KhZ-1PCT_transmit ON to OFF

t2 to t3 Peak Measurement is less than 0.14div FM Modulation complies

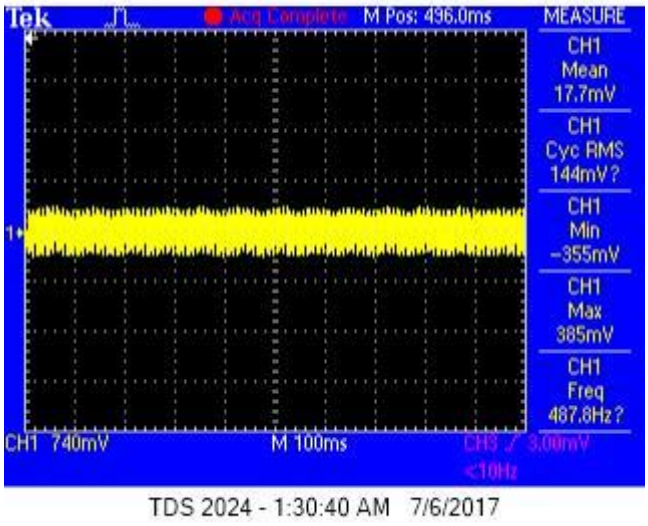


173.4MHz_100W _P25 C4FM_ OFF to ON Peak

Limits Calculations:
12.5kHz = +/-4 divisions
6.25kHz = +/-2 divisions
t2 to t3 time = (173.4MHz x 2.5ppm x +/-4div) / 12.5kHz = +/-0.14div (also = +/-103.6mV at 740mV/Div; =435Hz)



173.4MHz_100W_P25 C4FM_transmit ON to OFF Peak



173.4MHz_100W_P25 C4FM_transmit ON to OFF for t2 to t3 measurement

Limits Calculations:
12.5kHz = +/-4 divisions
6.25kHz = +/-2 divisions
t2 to t3 time = (173.4MHz x 2.5ppm x +/-4div) / 12.5kHz = +/-0.14div (also = +/-103.6mV at 740mV/Div; =435Hz)

t2 to t3 Mean Average measurement 17.7mV – P25 C4FM complies

Audio Frequency Response

Governing Doc	FCC Part 2 2.1047(a)	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	18 May 2017
EUT Voltage	☒ -48Vdc		

Test Equipment Used	Manufacturer	Model	Identifier	Calibration	Calibration due
EMC Analyzer	Keysight	N9038A	702	27-Apr-2017	27-Apr-2018
Oscilloscope	Tektronics	TDS2024	021	06-Nov-2016	06-Nov-2017

Frequency Range:	☒ 30-1000MHz
Type of Facility:	☒ Testbench
Distance:	☒ Direct
Arrangement of EUT:	☒ Table-top only ☐ Floor-standing only ☐ Rack Mounted
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

The EUT and test equipment were set up as shown on the following page.

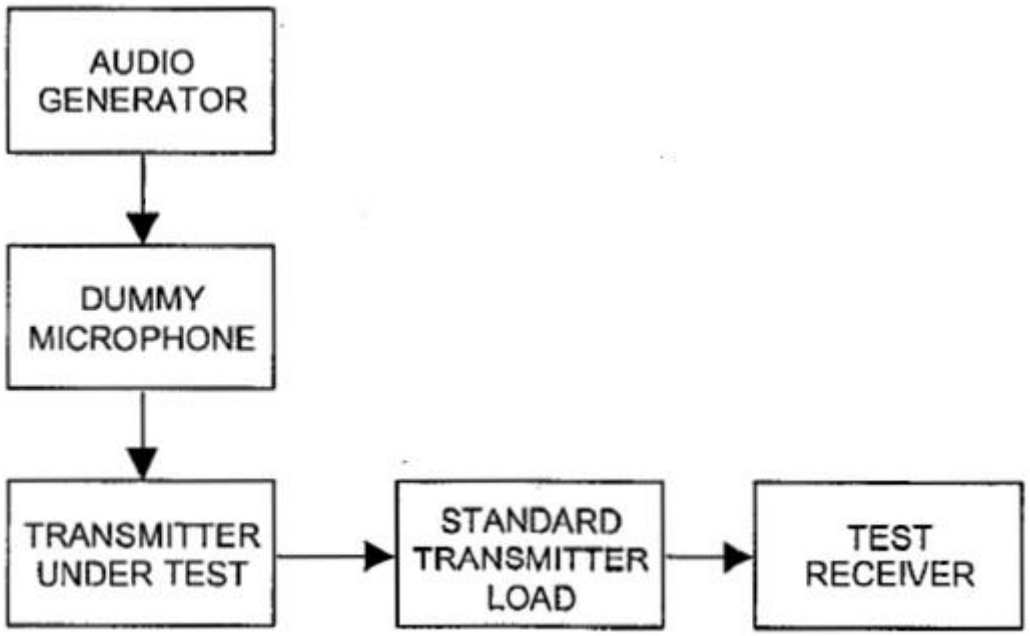
Adjust the Modulation Analyzer for the following setting:
a) High-pass filter : 50 Hz
b) Low-pass filter : 15 kHz
c) Detector : positive peak
d) Function : FM

The audio signal input was adjusted to obtain 20 % modulation at 1 kHz, and this point was taken as the 0 dB reference level.

With input levels held constant and below limiting at all frequencies, the audio signal generator was varied from 100 Hz to 5 kHz.

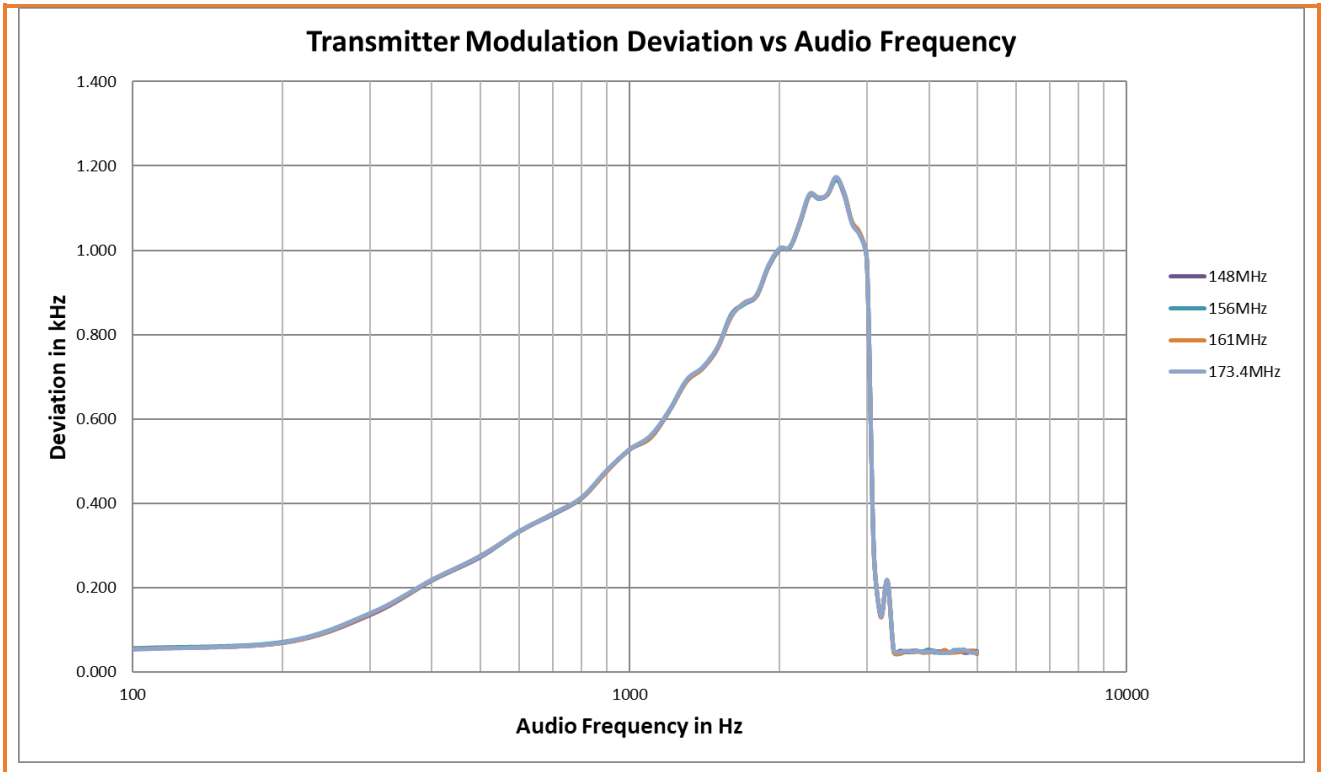
The response in dB relative to 1 kHz was then measured, using the Modulation Analyzer.

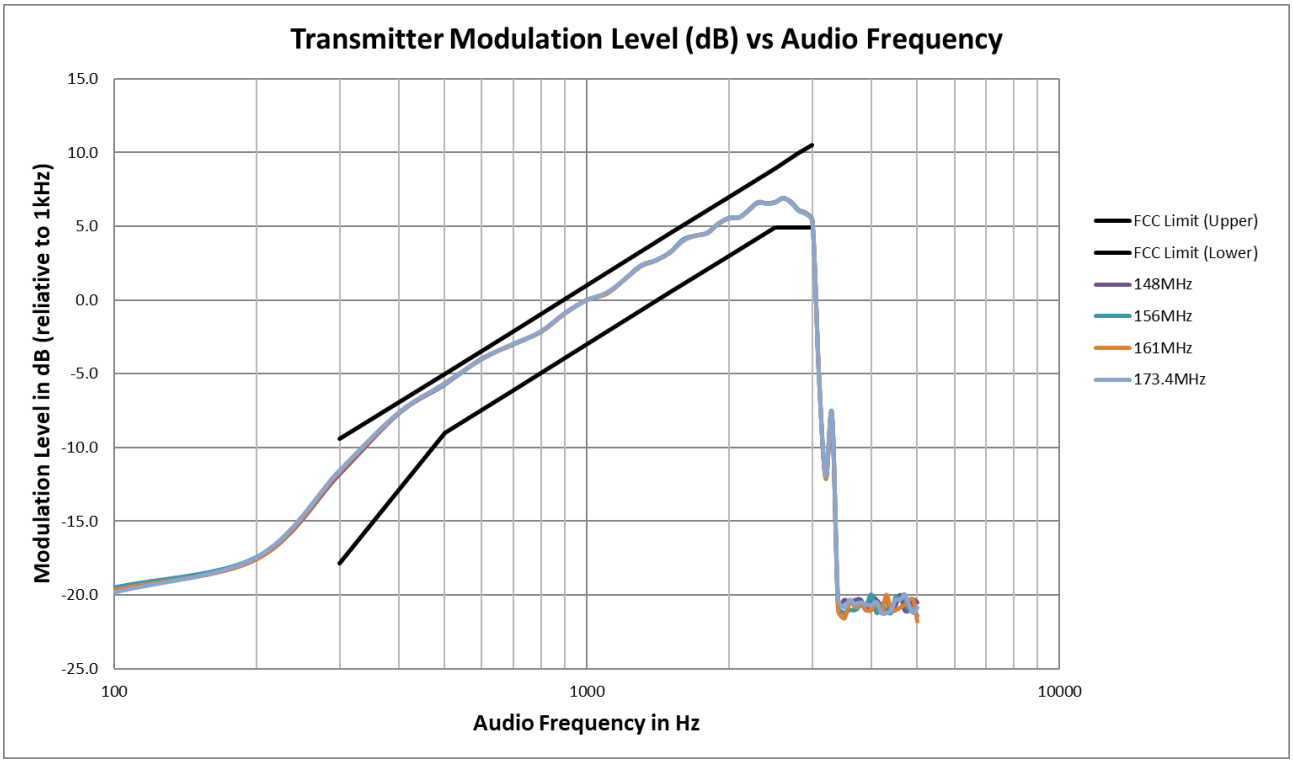
Test setup



- Audio Generator and microphone are built in to the EUT 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





Modulation Limiting

Governing Doc	FCC Part 2.1047(b)	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	29 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
Oscilloscope	Tektronics	TDS2024	021	06-Nov-2017	06-Nov-2018
Communication Test Set	Aeroflex	IFR 390	3816	23-Nov-2017	23-Nov-2018
Power Meter	Bird Electronic	4421	1626	N/A	N/A
Power Sensor	Bird Electronic	4022	1662	30-Aug-2017	30-Aug-2018

Type of Facility:	☒ Testbench
Distance:	☒ Direct
Arrangement of EUT:	☒ Table-top only ☐ Floor-standing only ☐ Rack Mounted
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

The EUT and test equipment were set up as shown on the following page.

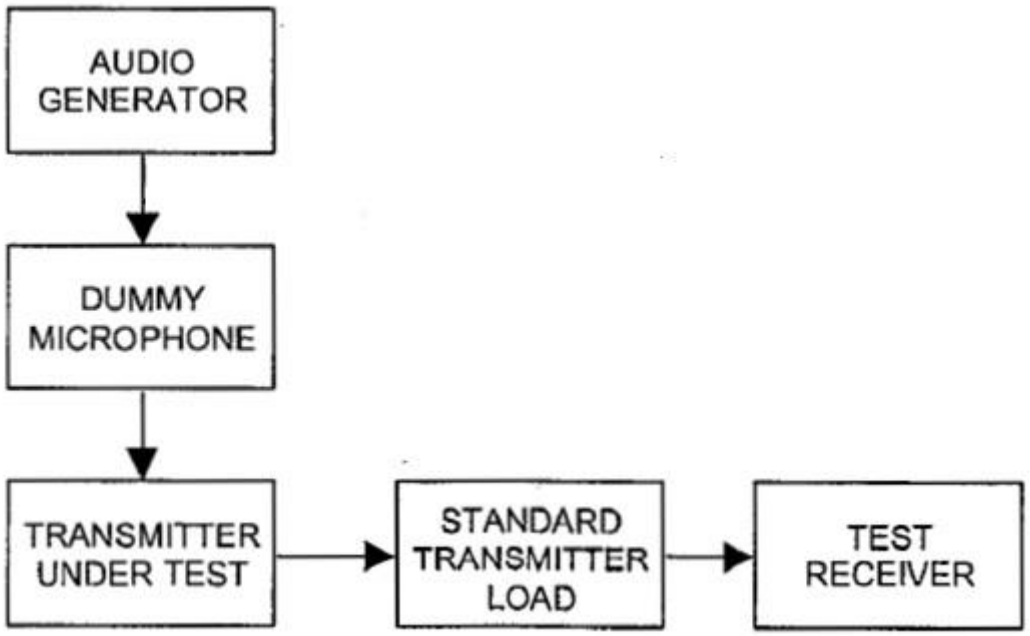
Adjust the Modulation Analyzer for the following setting:
a) High-pass filter : 50 Hz
b) Low-pass filter : 15 kHz
c) Detector : positive peak
d) Function : FM

The audio signal input was adjusted to obtain 20 % modulation at 1 kHz, and this point was taken as the 0 dB reference level.

With input levels held constant and below limiting at all frequencies, the audio signal generator was varied from 100 Hz to 5 kHz.

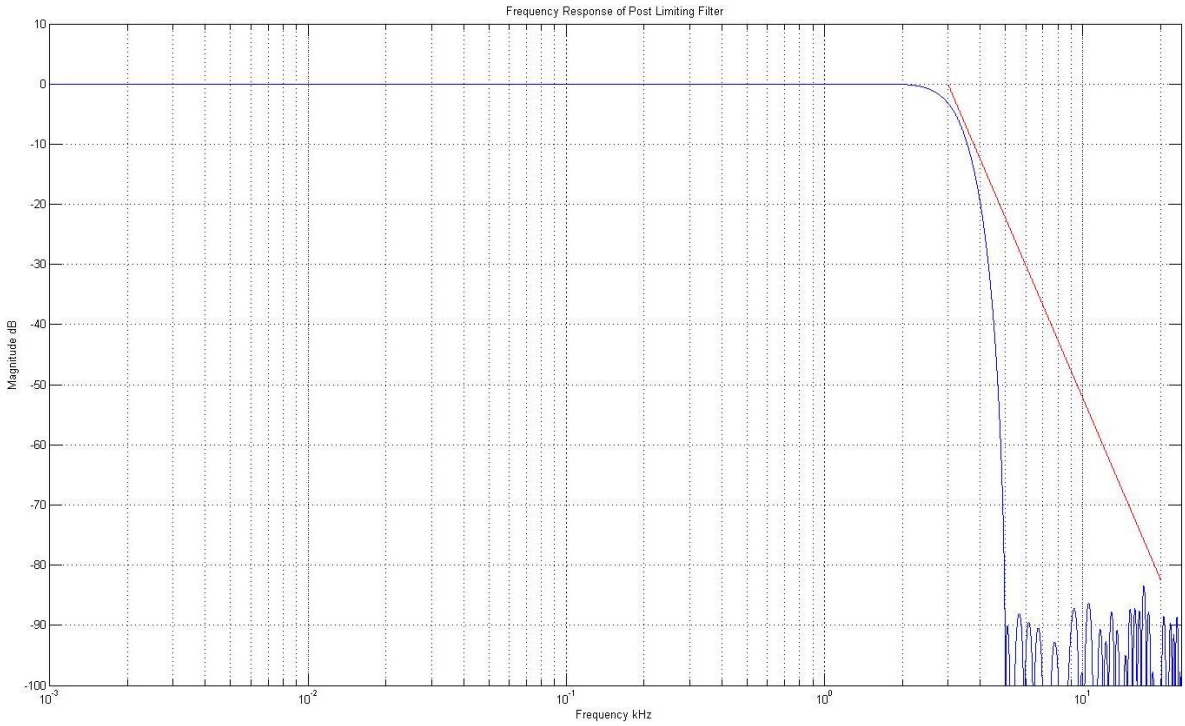
The response in dB relative to 1 kHz was then measured, using the Modulation Analyzer.

Test setup

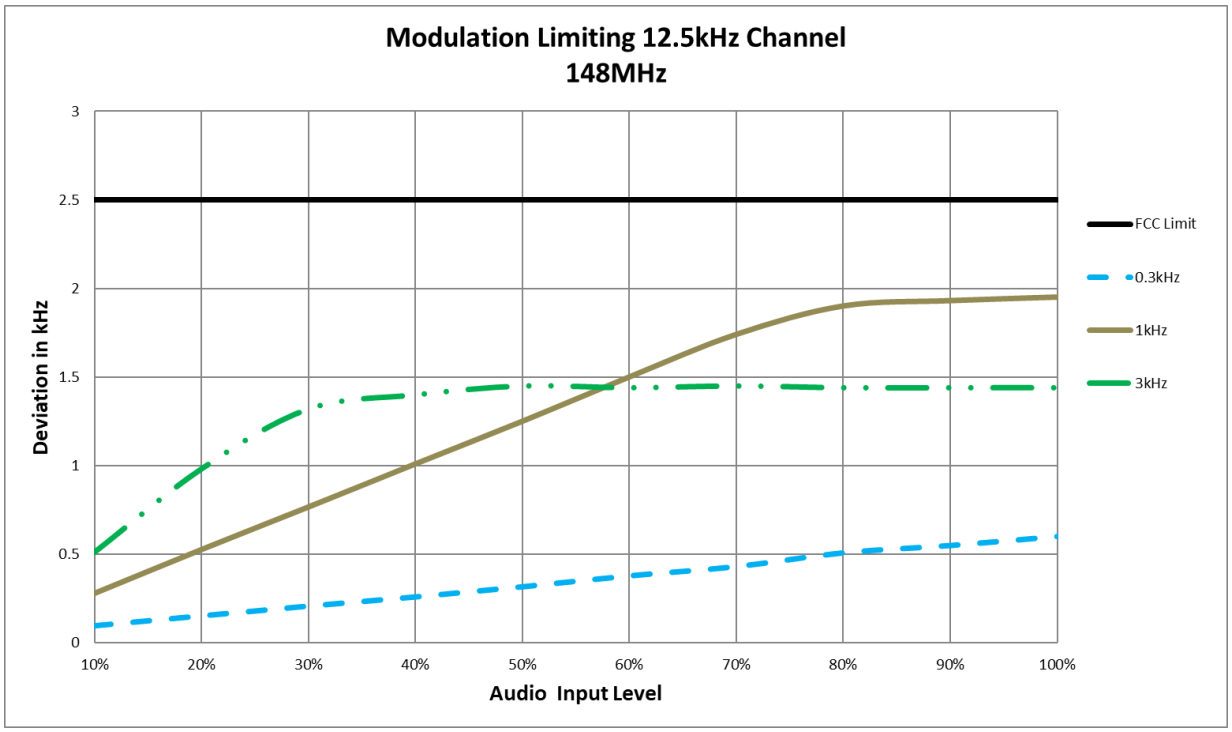


- Audio Generator and microphone are built in to the EUT for testing and diagnostic purposes.
- Standard Transmitter Load Attenuators were adjusted as per the TIA-603 procedures. The maximum input to the Test Receiver was -10dBm

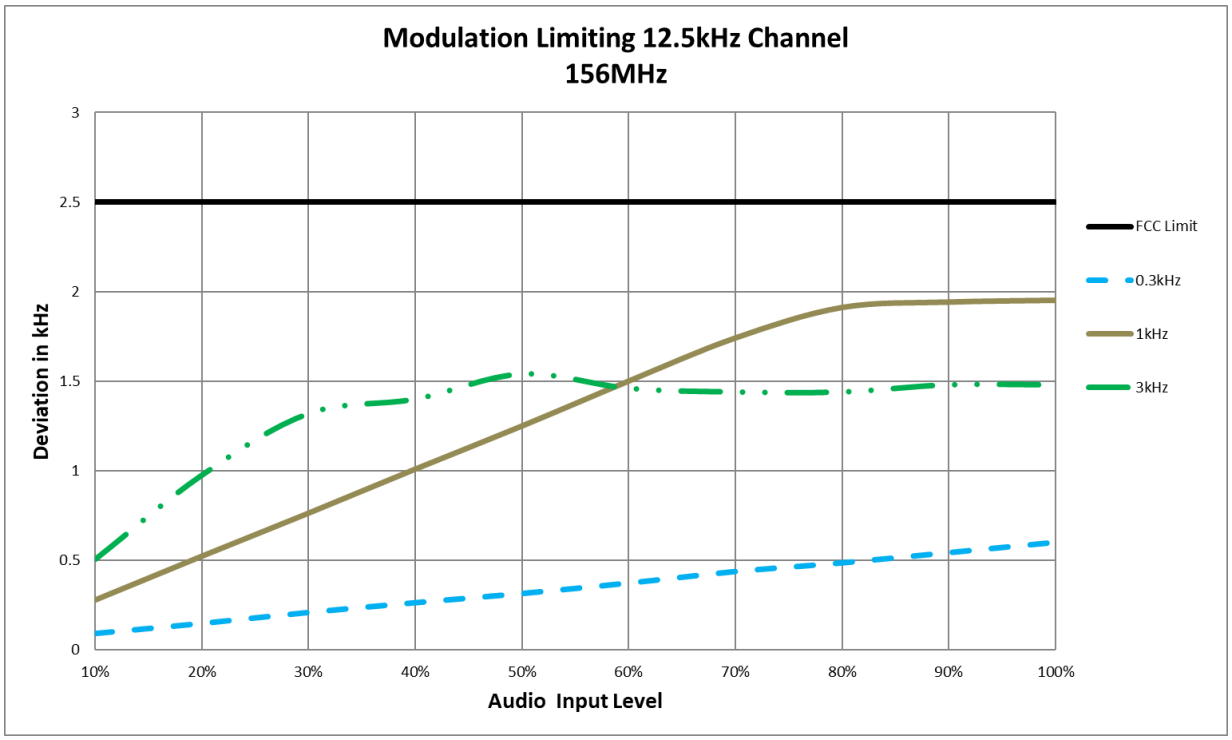
Results



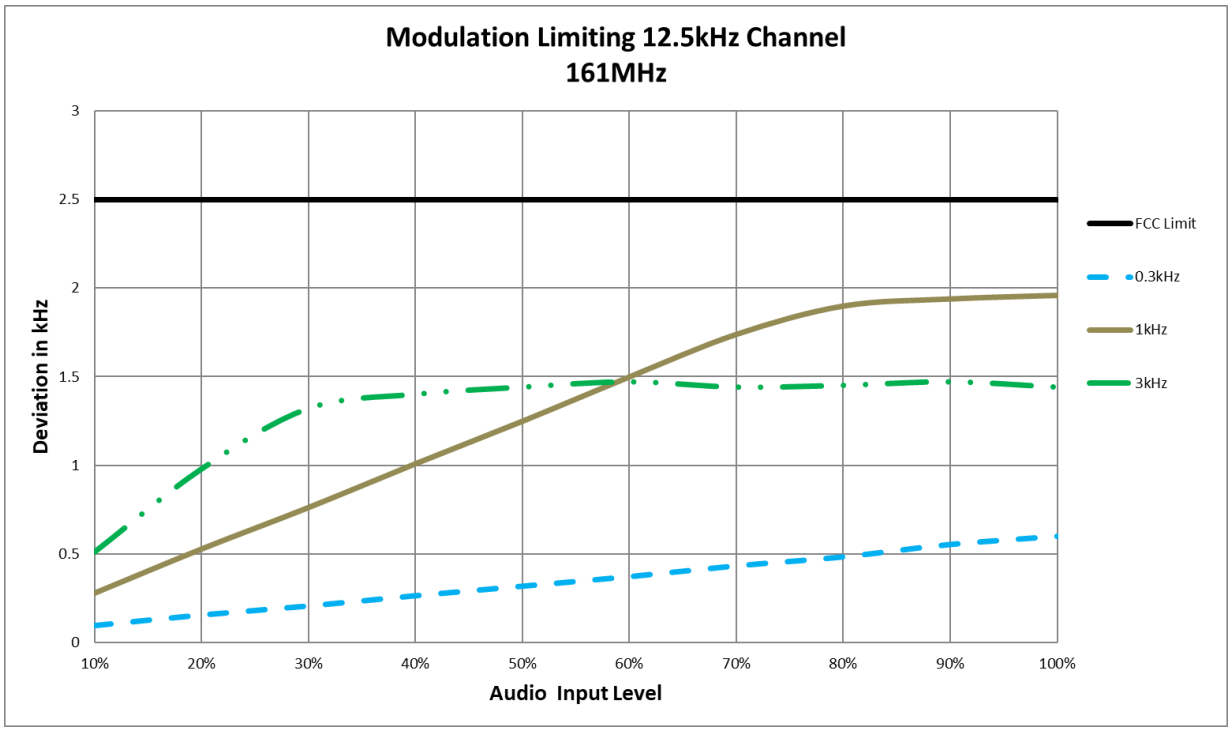
Audio Frequency	148MHz			FCC Limit
	0.3kHz	1kHz	3kHz	
Audio Input Level	Response (Deviation (kHz))	Response (Deviation (kHz))	Response (Deviation (kHz))	(kHz)
10%	0.098	0.28	0.514	2.5
20%	0.154	0.527	0.983	2.5
30%	0.209	0.767	1.32	2.5
40%	0.261	1.01	1.4	2.5
50%	0.318	1.25	1.45	2.5
60%	0.38	1.5	1.44	2.5
70%	0.432	1.74	1.45	2.5
80%	0.51	1.9	1.44	2.5
90%	0.551	1.93	1.44	2.5
100%	0.602	1.95	1.44	2.5



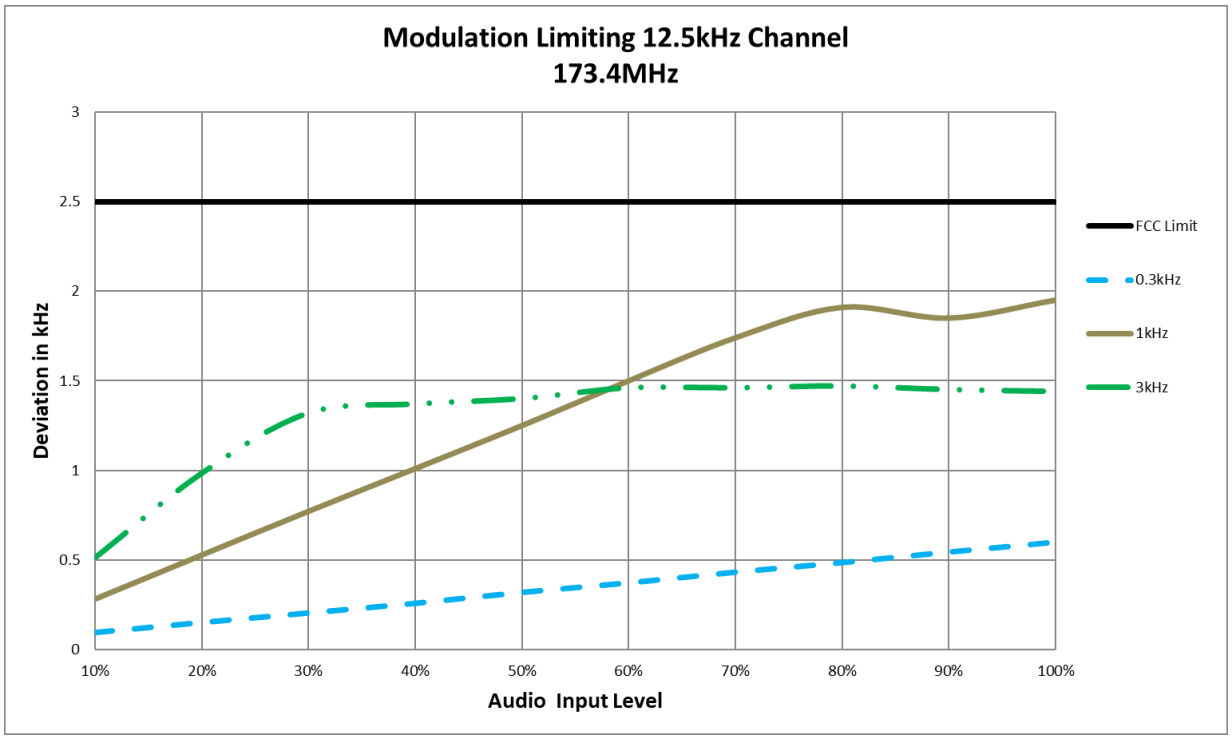
Audio Frequency	156MHz			FCC Limit
	0.3kHz	1kHz	3kHz	
Audio Input Level	Response (Deviation (kHz))	Response (Deviation (kHz))	Response (Deviation (kHz))	(kHz)
10%	0.094	0.281	0.508	2.5
20%	0.15	0.525	0.977	2.5
30%	0.211	0.765	1.32	2.5
40%	0.265	1.01	1.4	2.5
50%	0.316	1.25	1.54	2.5
60%	0.374	1.5	1.46	2.5
70%	0.438	1.74	1.44	2.5
80%	0.486	1.91	1.44	2.5
90%	0.543	1.94	1.48	2.5
100%	0.6	1.95	1.48	2.5



Audio Frequency	161MHz			FCC Limit
	0.3kHz	1kHz	3kHz	
Audio Input Level	Response (Deviation (kHz))	Response (Deviation (kHz))	Response (Deviation (kHz))	(kHz)
10%	0.095	0.28	0.511	2.5
20%	0.155	0.529	0.979	2.5
30%	0.206	0.763	1.32	2.5
40%	0.264	1.01	1.4	2.5
50%	0.318	1.25	1.44	2.5
60%	0.372	1.5	1.47	2.5
70%	0.433	1.74	1.44	2.5
80%	0.484	1.9	1.45	2.5
90%	0.554	1.94	1.47	2.5
100%	0.6	1.96	1.44	2.5



Audio Frequency	173.4MHz			FCC Limit
	0.3kHz	1kHz	3kHz	
Audio Input Level	Response (Deviation (kHz))	Response (Deviation (kHz))	Response (Deviation (kHz))	(kHz)
10%	0.097	0.282	0.516	2.5
20%	0.153	0.528	0.986	2.5
30%	0.206	0.772	1.32	2.5
40%	0.26	1.01	1.37	2.5
50%	0.321	1.25	1.4	2.5
60%	0.374	1.5	1.46	2.5
70%	0.434	1.74	1.46	2.5
80%	0.487	1.91	1.47	2.5
90%	0.546	1.85	1.45	2.5
100%	0.601	1.95	1.44	2.5



Frequency Stability (Temperature Variation)

Governing Doc	FCC Part 2 2.1055(a) (1) FCC Part 90 90.213(a)	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	18 May 2017
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	☐ 150kHz-30MHz
Detector:	☒ Peak	
RBW/VBW:	☒10/30kHz	
Type of Facility:	☒ Tabletop	
Distance:	☒ Direct	

Limit: 2.5ppm = +/- 370Hz at 156MHz

Temperature related frequency variation: -57 to +23Hz

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

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 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 transmitter and increase the temperature by 10 degrees C and repeat the test steps 3 to 8 until 60 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: 161.000000 MHz						
Temp (Deg C)	CW Mode (MHz)	FM 1kHz	C4FM	LSM	HDQPSK	
60	160.999995	160.999995	160.999997	160.999997	161.000003	
50	160.999970	160.999971	160.999971	160.999977	160.999993	
40	160.999970	160.999970	160.999970	160.999970	160.999988	
30	160.999980	160.999982	160.999980	161.000005	160.999955	
20	161.000007	161.000007	161.000007	161.000007	161.000007	
10	160.999982	160.999985	160.999982	160.999977	160.999988	
0	160.999998	160.999998	160.999998	160.999998	160.999995	
-10	160.999998	160.999998	160.999998	160.999998	161.000023	

-20	160.999993	160.999955	160.999955	160.999955	161.000003	
-30	160.999943	160.999951	160.999963	160.999963	160.999963	
Lowest Freq: 160.999943MHz ; Highest Freq: 161.0000023MHz ; Variance: -57 + 23Hz						
Limit: 2.5ppm = +/- 400Hz						
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)	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	14 July 2017
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: 2.5ppm = +/- 370Hz at 156MHz	
Voltage related frequency variation: -0 to +12Hz	
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

1) Power on the EUT in Receive mode at the nominal voltage -48.00Vdc +/-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 -36Vdc and -60Vdc 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: 161.000000 MHz at 20Deg Cel						
Voltage	CW Mode (MHz)	FM 1kHz	C4FM	LSM	HDQPSK	
-60	161.000012	161.000012	161.000012	161.000010	161.000010	
-48	161.000007	161.000007	161.000007	161.000007	161.000007	
-36	161.000007	161.000008	161.000009	161.000008	161.000008	
Lowest Freq: 161.000003MHz ; Highest Freq: 161.000002MHz ; Variance: -0 +12Hz						
Limit: 2.5ppm = +/- 400Hz						
Compliant ☒ Non-Compliant ☐						

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