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FCC PART 90 TEST REPORT

APPLICANT	EF JOHNSON COMPANY
	123 N State Street Waseca Minnesota 56093
FCC ID	ATH2425M70
MODEL NUMBER	242-5M70
PRODUCT DESCRIPTION	VIKING MOBILE 700/800 MHZ RADIO
STANDARD APPLIED	CFR 47 Part 90
DATE SAMPLE RECEIVED	4/25/2014
DATE TESTED	5/1/2014
REPORT ISSUE DATE	5/12/2014
TESTED BY	Nam Nguyen
APPROVED BY	Nam Nguyen
TIMCO REPORT NO.	673AUT14TestReport.docx
TEST RESULTS	☒ PASS ☐ FAIL

THE ATTACHED REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL
WITHOUT THE WRITTEN APPROVAL OF TIMCO ENGINEERING, INC.

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GENERAL REMARKS

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Summary

The device under test does:

- ☒ fulfill the general approval requirements as identified in this test report
☐ not fulfill the general approval requirements as identified in this test report

Attestations

This equipment has been tested in accordance with the standards identified in this test report. To the best of my knowledge and belief, these tests were performed using the measurement procedures described in this report.

All instrumentation and accessories used to test products for compliance to the indicated standards are calibrated regularly in accordance with ISO 17025 requirements.

I attest that the necessary measurements were made, under my supervision, at:

Timco Engineering Inc.
849 NW State Road 45
Newberry, FL 32669



Authorized Signatory Name:

Nam Nguyen
Engineering Project Manager

Date: 5/12/14

GENERAL INFORMATION

EUT Specification

EUT Description	VIKING MOBILE 700/800 MHZ RADIO
FCC ID	ATH2425M70
Model Number	242-5M70
Operating Frequency	763 to 805 MHz (25W) 806 to 869 MHz (35W)
Test Frequencies	763.0125, 799.0125, 815.0125, and 869.9875 MHz
No. of Channels	54 channel/16 zone Feature
Type of Emission	763 to 805 MHz: 11K0F3E, 8K10F1E, 8K10F1D, 8K10F7E 806 to 869 MHz: 16K0F3E, 14K0F3E, 8K10F1E, 8K10F1D, 8K10F7E
Modulation	FM, C4FM, H-CPM
EUT Power Source	☐ 110–120Vac/50– 60Hz
	☒ DC Power 12V
	☐ Battery Operated Exclusively
Test Item	☐ Prototype
	☒ Pre-Production
	☐ Production
Type of Equipment	☐ Fixed
	☒ Mobile
	☐ Portable
Test Conditions	The temperature was 26°C with a relative humidity of 50%.
Revision History to the EUT	None
Test Exercise	The EUT was placed in continuous transmit mode.
Applicable Standards	ANSI/TIA 603-D: 2010, FCC CFR 47 Part 90
Test Facility	Timco Engineering Inc. 849 NW State Road 45 Newberry, FL 32669 USA.

EQUIPMENT LIST

Device	Manufacturer	Model	Serial Number	Cal/Char Date	Due Date
Antenna: Biconnical	Eaton	94455-1	1096	05/10/13	05/10/15
Antenna: Log-Periodic	Electro-Metrics	LPA-25	1122	05/09/13	05/09/15
Antenna: Double-Ridged Horn/ETS Horn 2	ETS-Lindgren	3117	00041534	10/05/12	10/05/14
Hygro-Thermometer	Extech	445703	0602	06/20/13	06/20/15
Digital Multimeter	Fluke	77	35053830	08/22/13	08/22/15
Notch Filter	Microlab	HA-10N	NA	5/17/13	5/17/15
Notch Filter	Microlab	HA-20N	NA	5/17/13	5/17/15
Band-pass Filter	Lorch Microwave	5BRX-850	AD-1	12/7/12	12/7/14
Antenna: Double-Ridged Horn	Electro-Metrics	RGA-180	2319	06/19/12	06/19/14
Antenna: Dipole Kit	Electro-Metrics	TDA-30/1-4	152	11/01/13	11/01/15
Temperature Chamber	Tenney Engineering	TTRC	11717-7	07/03/12	07/03/14
Frequency Counter	HP	5385A	2730A03025	08/22/13	08/22/15
Power Supply	Astron	VLS-25M	9001191	03/21/13	03/21/15
3-Meter Semi-Anechoic Chamber	Panashield	N/A	N/A	12/31/13	12/31/15
EMI Test Receiver	Rohde & Schwarz	ESIB40	100274	2/15/13	2/15/15
EMI Test Receiver	Rohde & Schwarz	ESU40	100320	3/21/13	3/21/15
Software: Field Strength Program	Timco	N/A	Version 4.0	NA	NA

EMI TEST RECEIVER FIRMWARE VERSION USED

Manufacturer	Model	Receiver Firmware	BIOS Ver
Rohde & Schwarz	ESU40	4.43 SP3	V5.1-24-3
Rohde & Schwarz	ESIB40	4.34.3	3.3

Applicant: EF JOHNSON COMPANY

FCC ID: ATH2425M70

Report: E\EF JOHNSON\673AUT14\673AUT14TestReport.docx

TEST PROCEDURE

Power Line Conducted Interference: The procedure used was ANSI/TIA 603-D: 2010, using a 50uH LISN. Both lines were observed with the EUT transmitting. The bandwidth of the spectrum analyzer was 10 kHz with an appropriate sweep speed.

Bandwidth 20 dB: The measurements were made with the spectrum analyzer's resolution bandwidth (RBW) = 1 MHz and the video bandwidth (VBW) = 3 MHz and the span set as shown on plot.

Power Output: The RF power output was measured at the antenna feed point using a peak power meter.

Antenna Conducted Emissions: The RBW = 100 kHz, VBW = 300 kHz and the span set to 10.0 MHz and the spectrum was scanned from 30 MHz to the 10th harmonic of the fundamental. Above 1 GHz the resolution bandwidth was 1 MHz and the VBW = 3 MHz and the span to 50 MHz.

Radiation Interference: The test procedure used was ANSI/TIA 603-D: 2010, using an Rohde & Schwarz – EMI test receiver. The bandwidth (RBW) of the spectrum, receiver was 100 kHz up to 1 GHz and 1 MHz above 1 GHz with an appropriate sweep speed. The VBW above 1 GHz was 3 MHz. The analyzer was calibrated in dB above a microvolt at the output of the antenna.

RF POWER OUTPUT

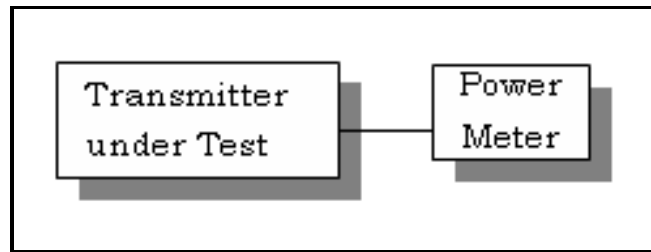
Rule Part No.: Part 2.1046(a), Part 90

Test Requirements: Manufacturer's Specification

Method of Measurement: RF power is measured by using a 50-ohm, resistive wattmeter to the RF output connector. With a nominal battery voltage (if battery operated), or a properly adjusted power supply (if not battery operated), and the transmitter properly adjusted the RF output measures:

For the device with a fixed or integral antenna, the RF power is measured as ERP. The substitution method was used. The RF output measures:

Test Setup Diagram:



Test Data: RF power of the EUT can be set at:

763 to 805 MHz: 25W

806 to 869 MHz: 35W

OUTPUT POWER:

Tuned Frequency (MHz)	Output Power(W)
763.0125	26.2
799.0125	25.7
815.0125	36.3
868.9875	34.7

Part 2.1033 (C)(8) DC Input into the final amplifier

FOR 25W POWER SETTING: $(13.6V)(6.1A) = 82.9$ Watts

FOR 35W POWER SETTING: $(13.6V)(7.8A) = 106.1$ Watts

MODULATION CHARACTERISTICS

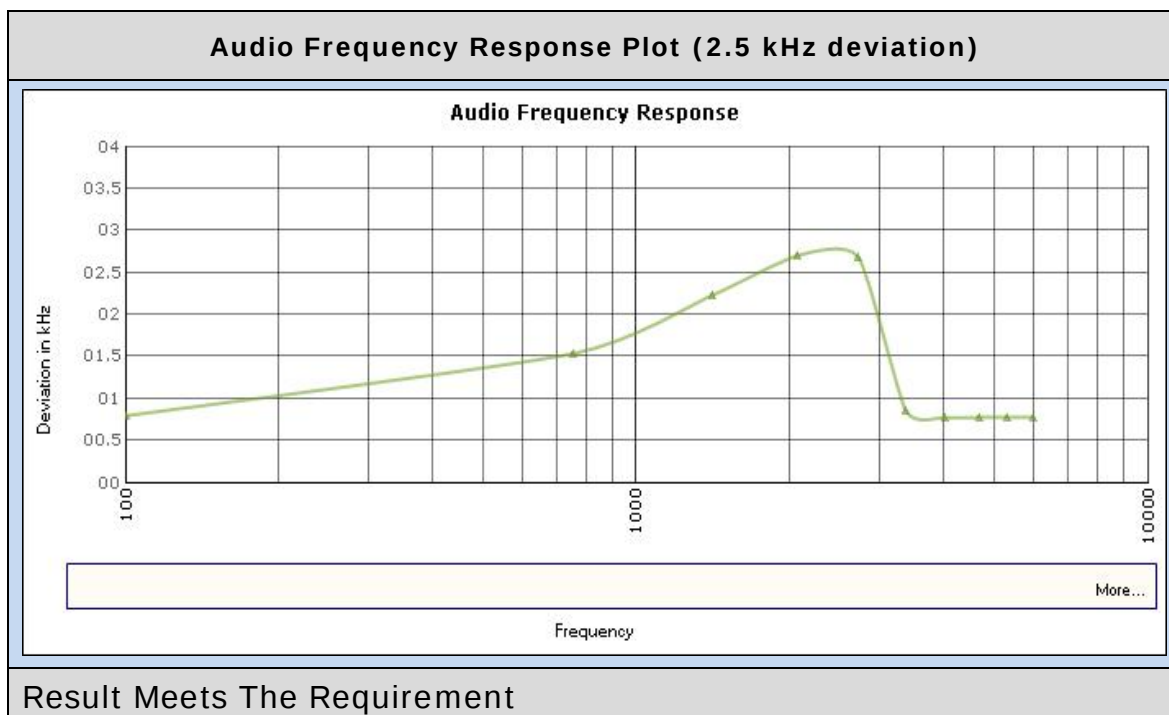
Rule Part No.: Part 2.1047(a)(b)

Test Requirements:

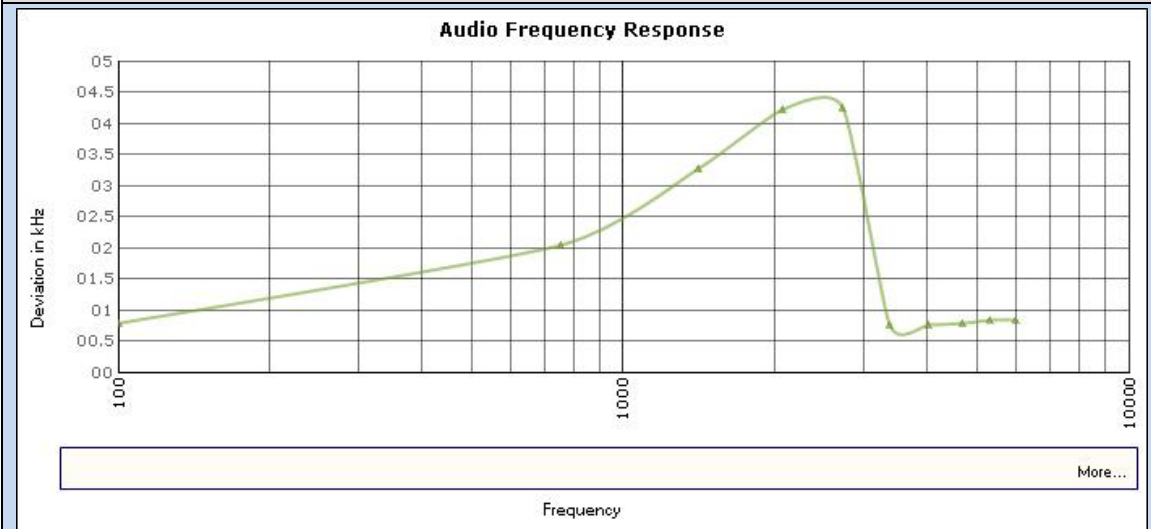
Method of Measurement:

Audio frequency response

The audio frequency response was measured in accordance with ANSI/TIA 603-D: 2010. A curve or equivalent data showing the frequency response of the audio modulating circuit over a range of 100 – 5000Hz shall be submitted. The audio frequency response curve is shown below.

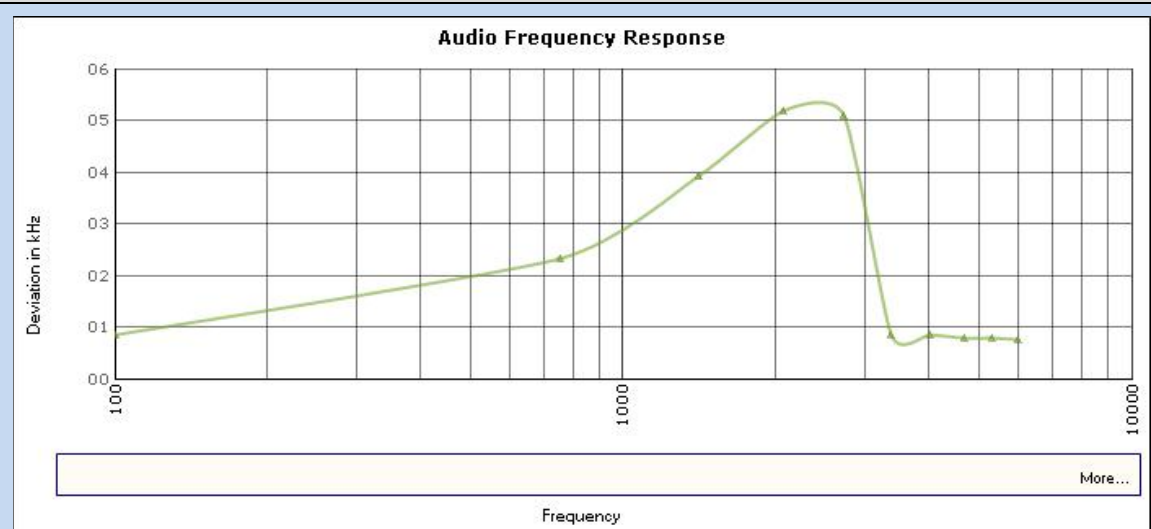


Audio Frequency Response Plot (4.0 kHz deviation)



Result Meets The Requirement

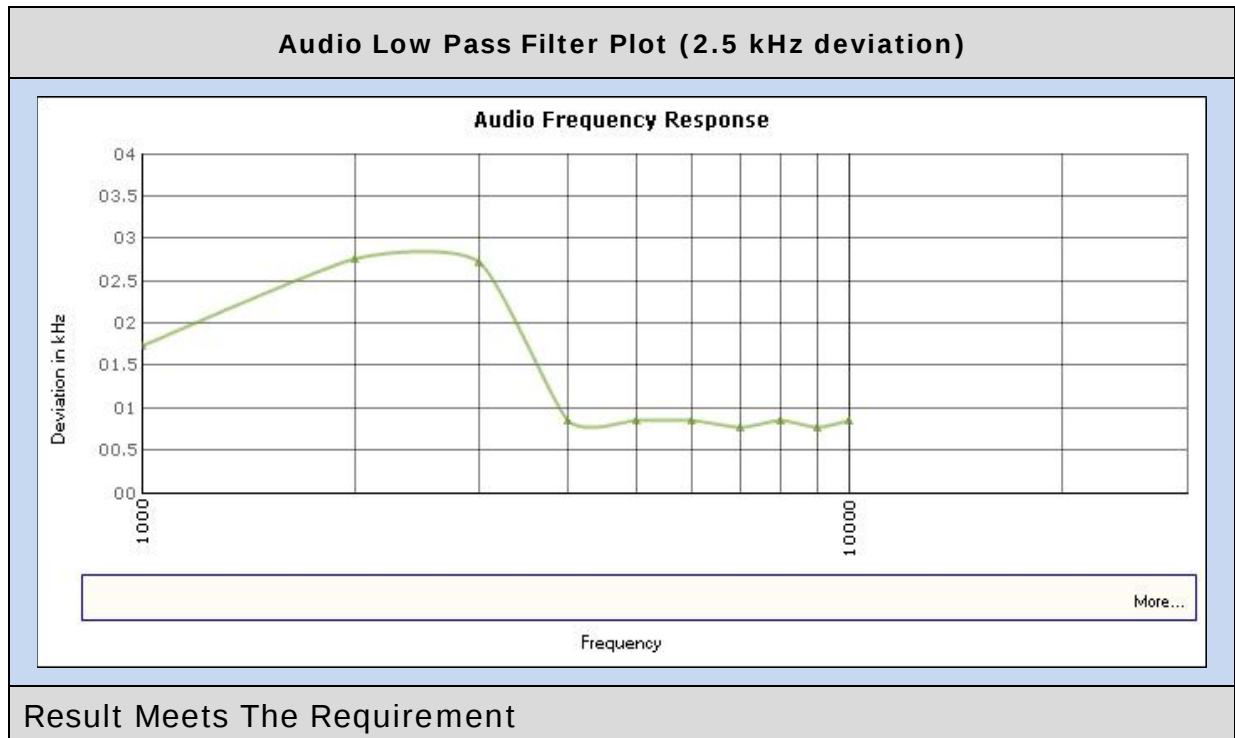
Audio Frequency Response Plot (5.0 kHz deviation)



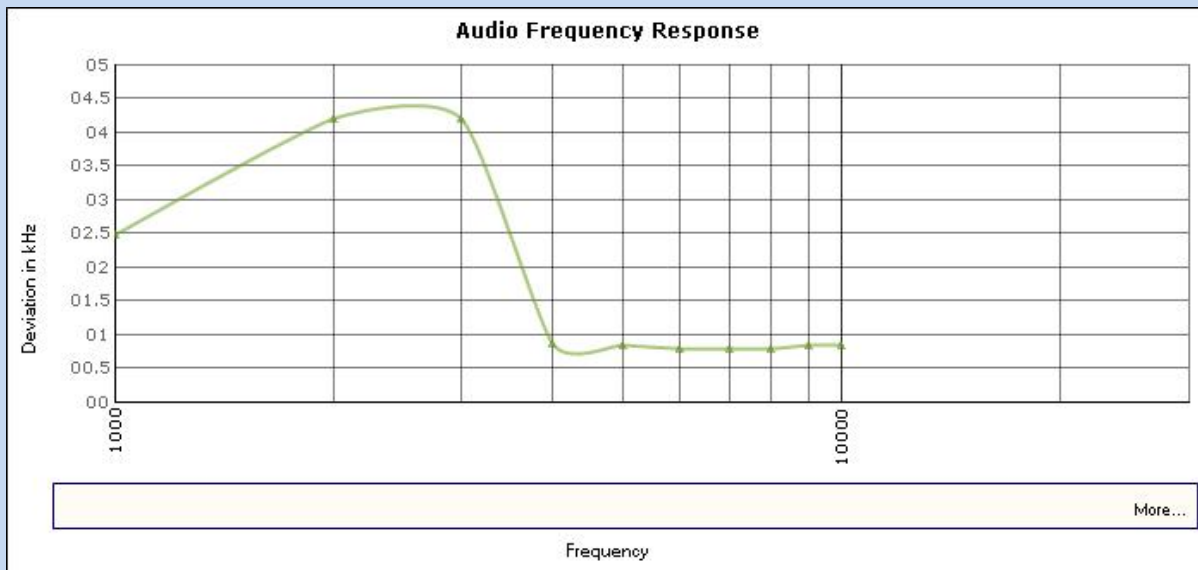
Result Meets The Requirement

VOICE MODULATED COMMUNICATION EQUIPMENT

Part 2.1047(a): For equipment required to have an audio low-pass filter, a curve showing the frequency response of the filter, or of all the circuitry installed between the modulation limiter and the modulated stage shall be submitted.

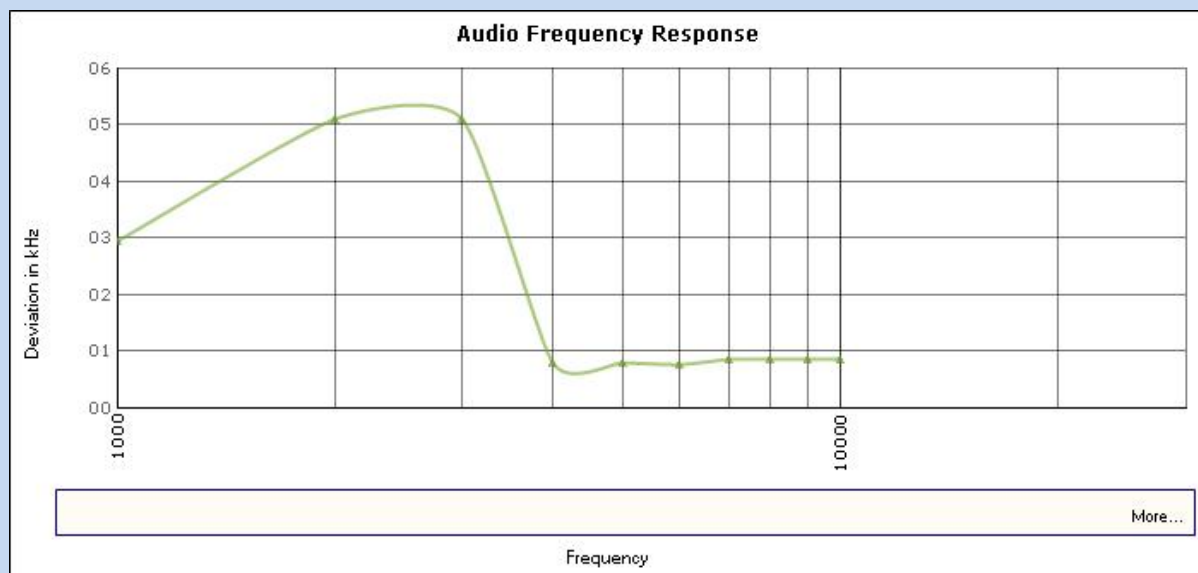


Audio Low Pass Filter Plot (4.0 kHz deviation)



Result Meets The Requirement

Audio Low Pass Filter Plot (5.0 kHz deviation)



Result Meets The Requirement

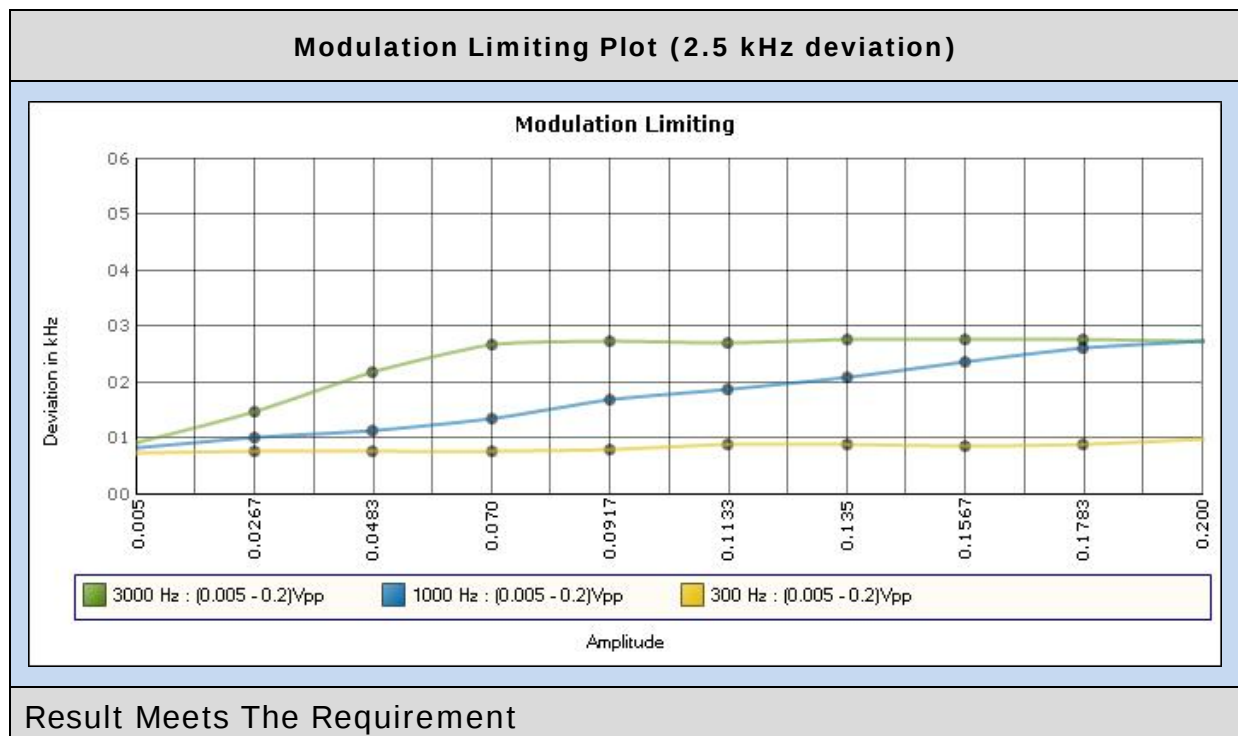
AUDIO INPUT VERSUS MODULATION

Rule Part No.: Part 2.1047(b) & 90

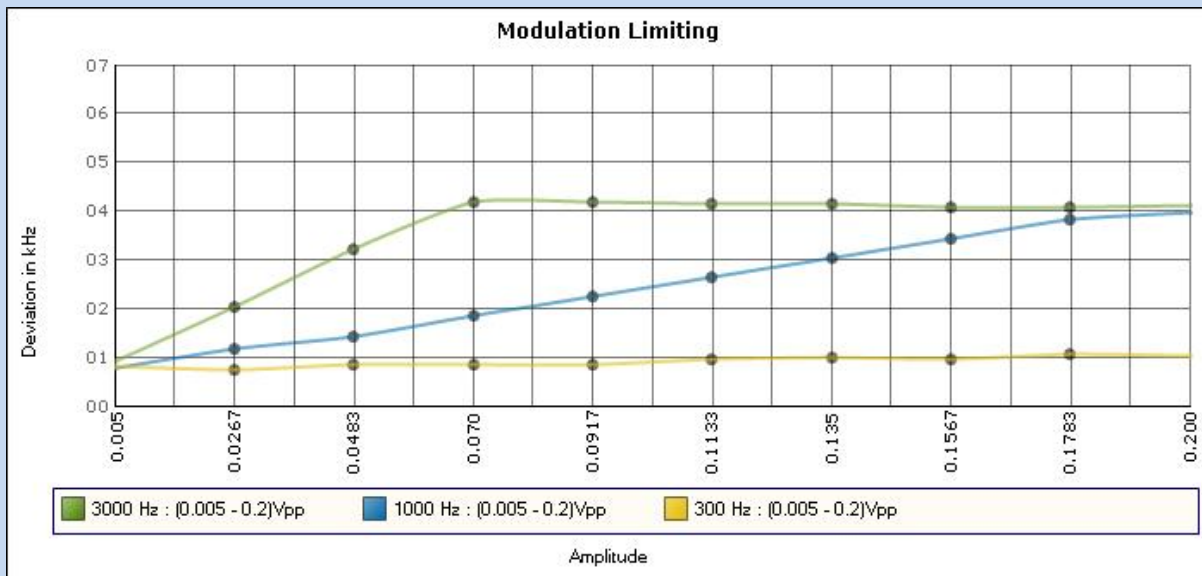
Test Requirements:

Method of Measurement: Modulation cannot exceed 100%, The audio input level needed for a particular percentage of modulation was measured in accordance with ANSI/TIA 603-D: 2010. The audio input curves versus modulation are shown below. Curves are provided for audio input frequencies of 300, 1000, and 3000 Hz.

Test data:



Modulation Limiting Plot (4.0 kHz deviation)



Result Meets The Requirement

Modulation Limiting Plot (5.0 kHz deviation)



Result Meets The Requirement

OTHER MODULATION CHARACTERISTICS

Part 2.1033(c)

Part 90.209

Part 90.207

Part 2.1033(c) (4) Type of Emission: 11K0F3E

$$B_n = 2M + 2DK$$

$$M = 3000$$

$$D = 2500$$

$$K=1$$

$$B_n = 2(3000) + 2(2500) = 11.0k$$

Part 2.1033(c) (4) Type of Emission: 14K0F3E (NPSPAC)

$$B_n = 2M + 2DK$$

$$M = 3000$$

$$D = 4000$$

$$K=1$$

$$B_n = 2(3000) + 2(4000) = 14.0k$$

Part 2.1033(c) (4) Type of Emission: 16K0F3E

$$B_n = 2M + 2DK$$

$$M = 3000$$

$$D = 5000$$

$$K=1$$

$$B_n = 2(3000) + 2(5000) = 16.0k$$

Part 2.1033(c) (4) Type of Emission: 8K10F1E, 8K10F1D, 8K10F7E

The DUT has Digital functions comply with P25 Phase 2 (TDMA)

Format: 2-slot TDMA

Modulation: 4FSK

Bandwidth: 12.5kHz

Data rate: 9,600bps (bit per second)

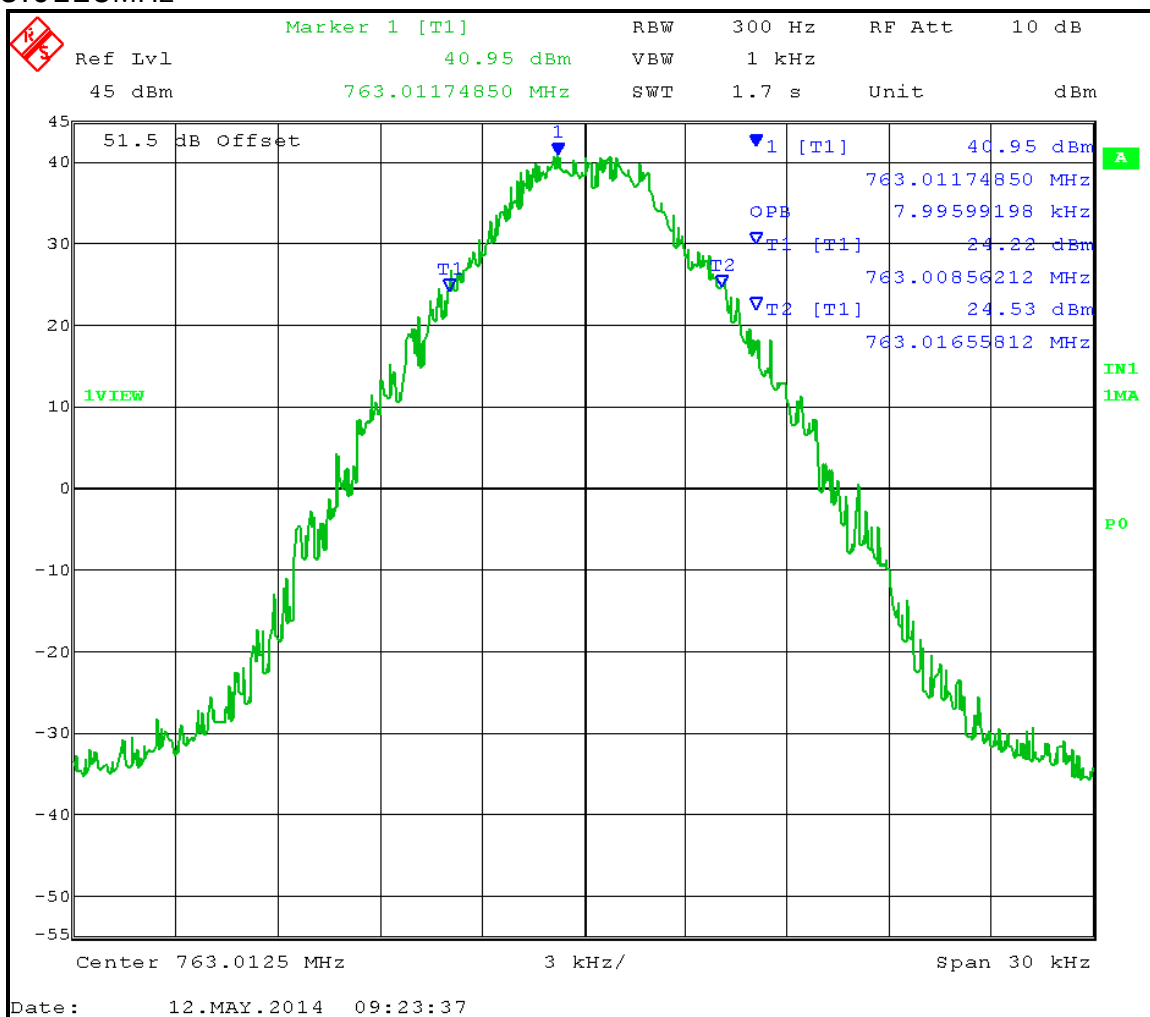
BANDWIDTH LIMITATIONS

Part 2.1049

Part 90.209

Frequency (MHz)	99% Occupied Bandwidth (kHz)
763.0125	8.00
799.0125	8.11
815.0125	8.00
868.9875	8.12

763.0125MHz

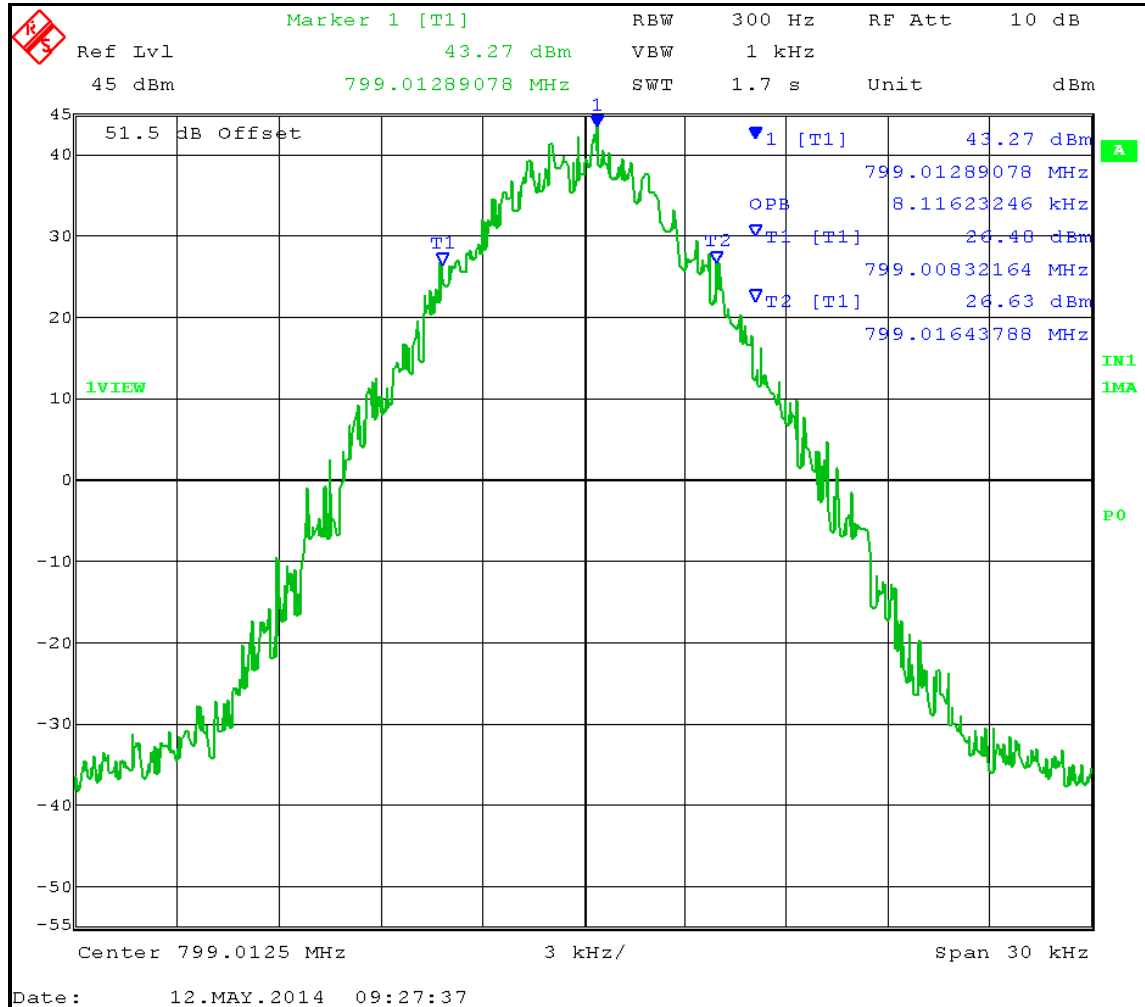


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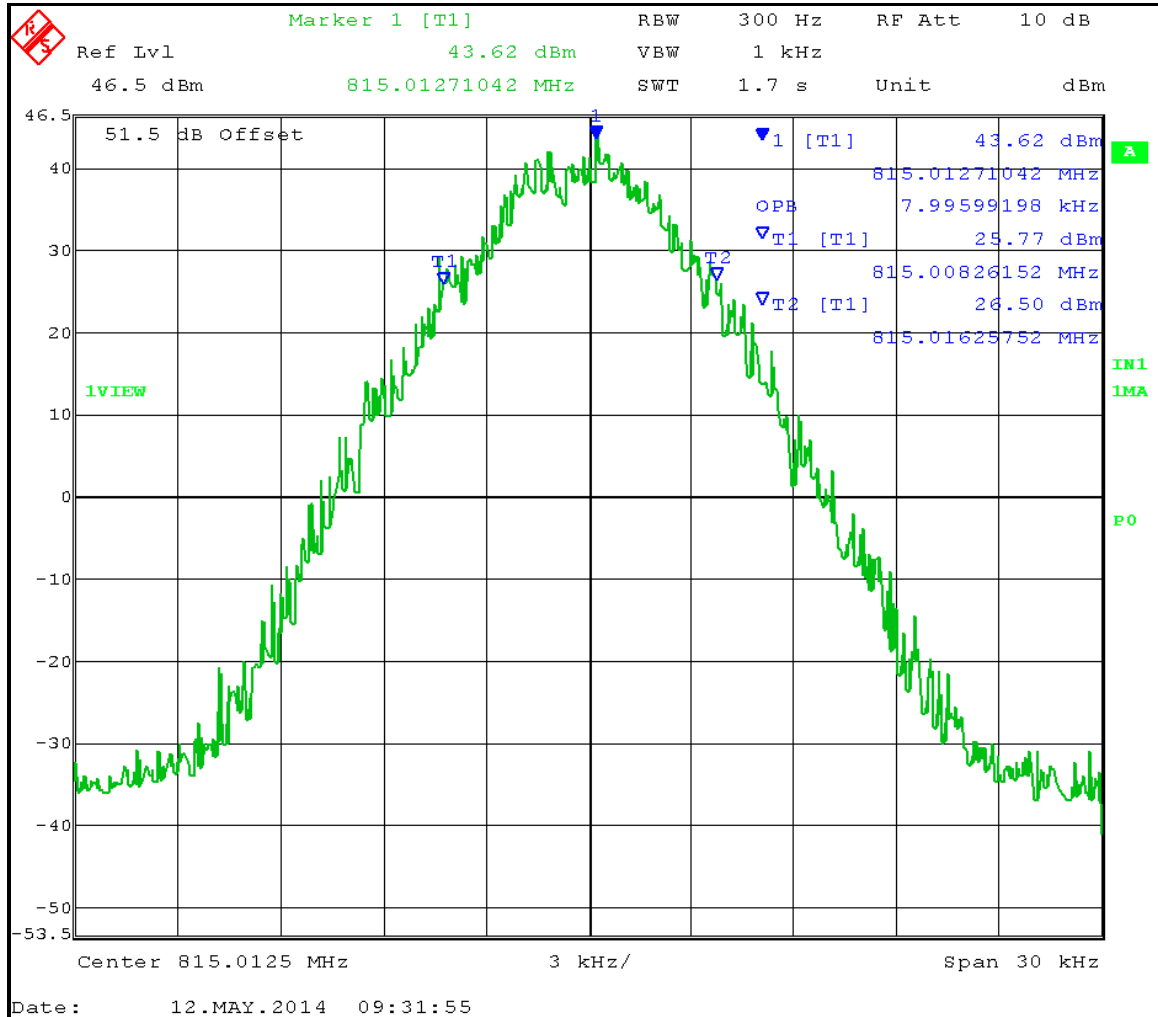
FCC ID: ATH2425M70

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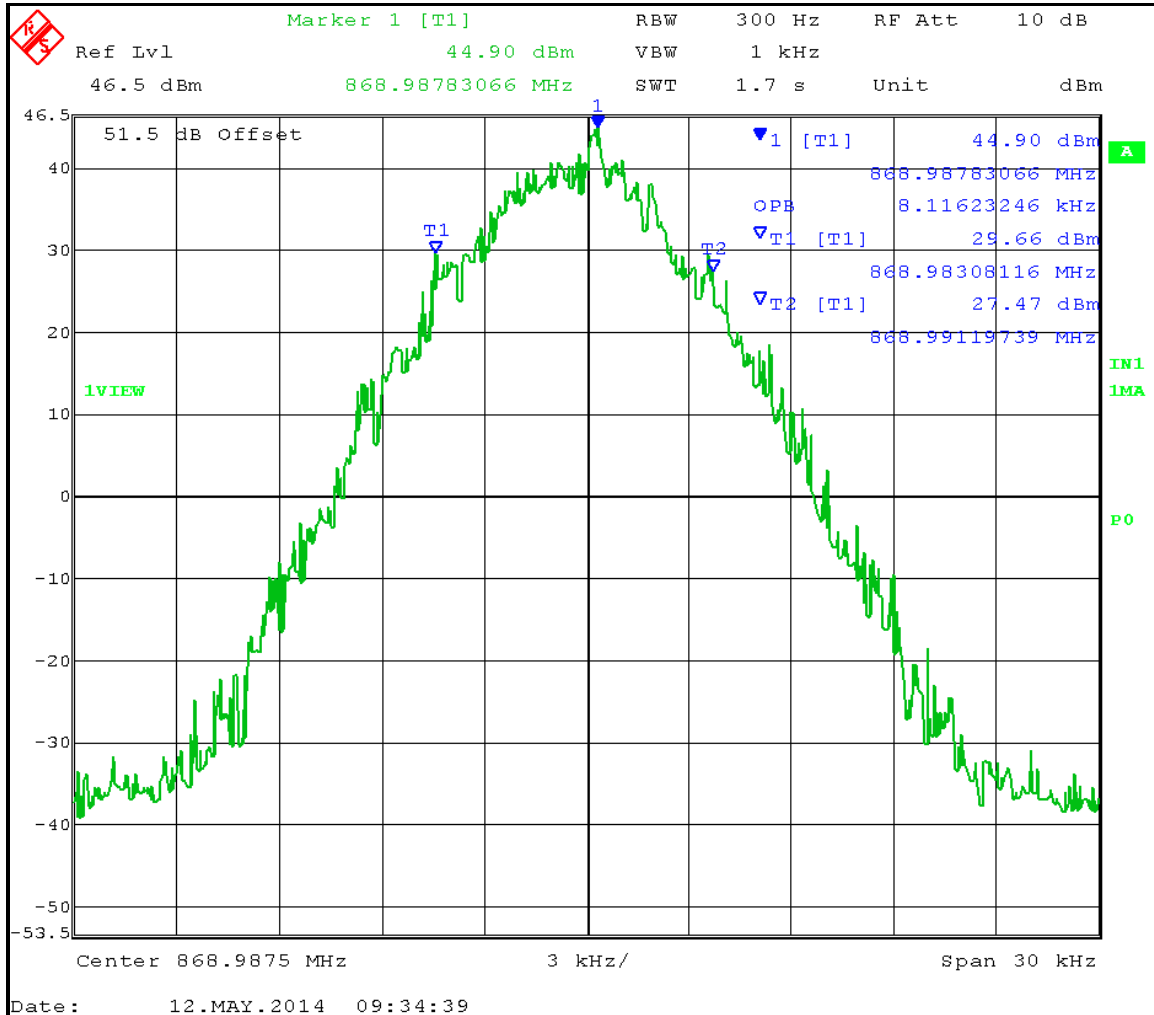
799.0125MHz



815.0125MHz



868.9875MHz



OCCUPIED BANDWIDTH

Part 2.1049(c) EMISSION BANDWIDTH:

Part 90.210(b) 25 kHz Channel Spacing

Data in the plots show that on any frequency removed from the assigned frequency by more than 50%, but not more than 100%: At least 25dB. On any frequency removed from the assigned frequency by more than 100%, but not more than 250%: At least 35 dB. On any frequency removed from the assigned frequency by more than 250%, of the authorized bandwidth: At least $43 + 10\log(P)$ dB.

Part 90.210(c) 25kHz Channel Spacing Not Equipped with a Low Pass Filter

For transmitters that are not equipped with an audio low pass filter pursuant to S90.211 (b), the power of any emission must be attenuated below the unmodulated carrier output power as follows; (1) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5 kHz but not more than 10 kHz: At least $83 \log(f_d/5)$ dB; (2) ON any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 10 kHz, but not more than 250% of the authorized bandwidth: At least $29 \log(f_d^2/11)$ dB or 50 dB, whichever is the lesser attenuation; (3) On any frequency removed from the center of the authorized bandwidth by more than 250% of the authorized bandwidth: At least $43 + 10 \log(P_o)$ dB.

Part 90.210(d) Emission Mask D - 12.5 kHz channel BW equipment.

For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:

- (1) On any frequency from the center of the authorized bandwidth f_0 to 5.625 kHz removed from f_0 : Zero dB.
- (2) On any frequency from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least $7.27 (f_d - 2.88 \text{ kHz})$ dB.
- (3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz: At least $50 + 10\log(P)$ dB or 70 dB, whichever is the lesser attenuation.

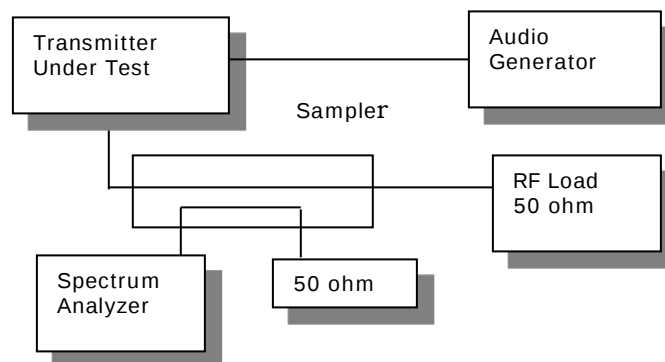
Part 90.210(e) Emission Mask E – 6.25 kHz channel BW equipment.

For transmitters designed to operate with a 6.25 kHz bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:

- (1) On any frequency from the center of the authorized bandwidth f_0 to 3.0 kHz removed from f_0 : Zero dB.
- (2) On any frequency from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 3.0 kHz but no more than 4.6 kHz: At least $30 + 16.67(f_d - 3.0 \text{ kHz})$ or $55 + 10 \log(P)$ or 65, whichever is the lesser attenuation.
- (3) On any frequency removed from the center of the authorized bandwidth by more than 4.6 kHz: At least $55 + 10 \log(P)$ dB or 65 dB, whichever is the lesser attenuation.

Method of Measurement: ANSI/TIA 603-D: 2010

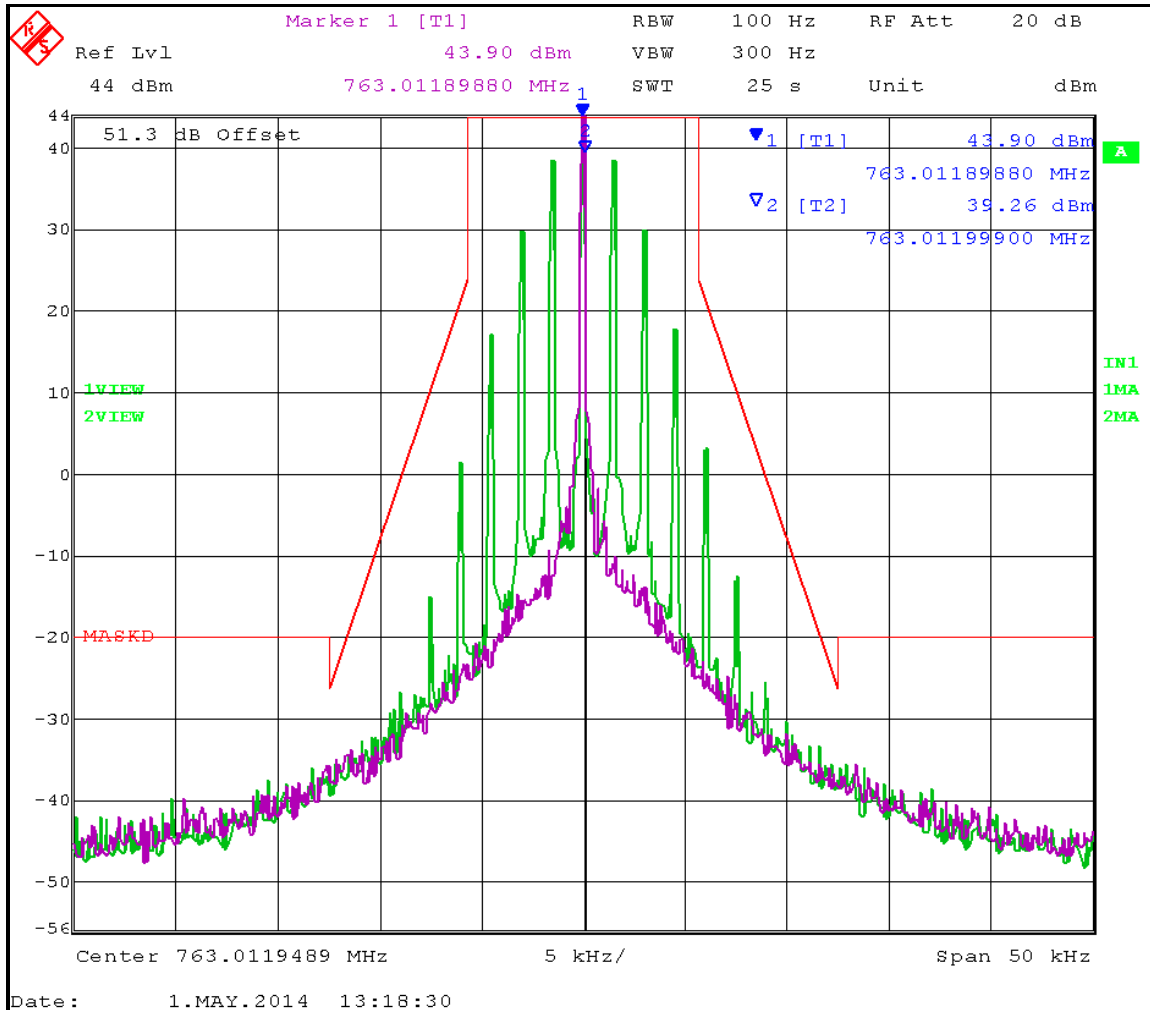
Test Setup Diagram:



Test Data: See the plots below

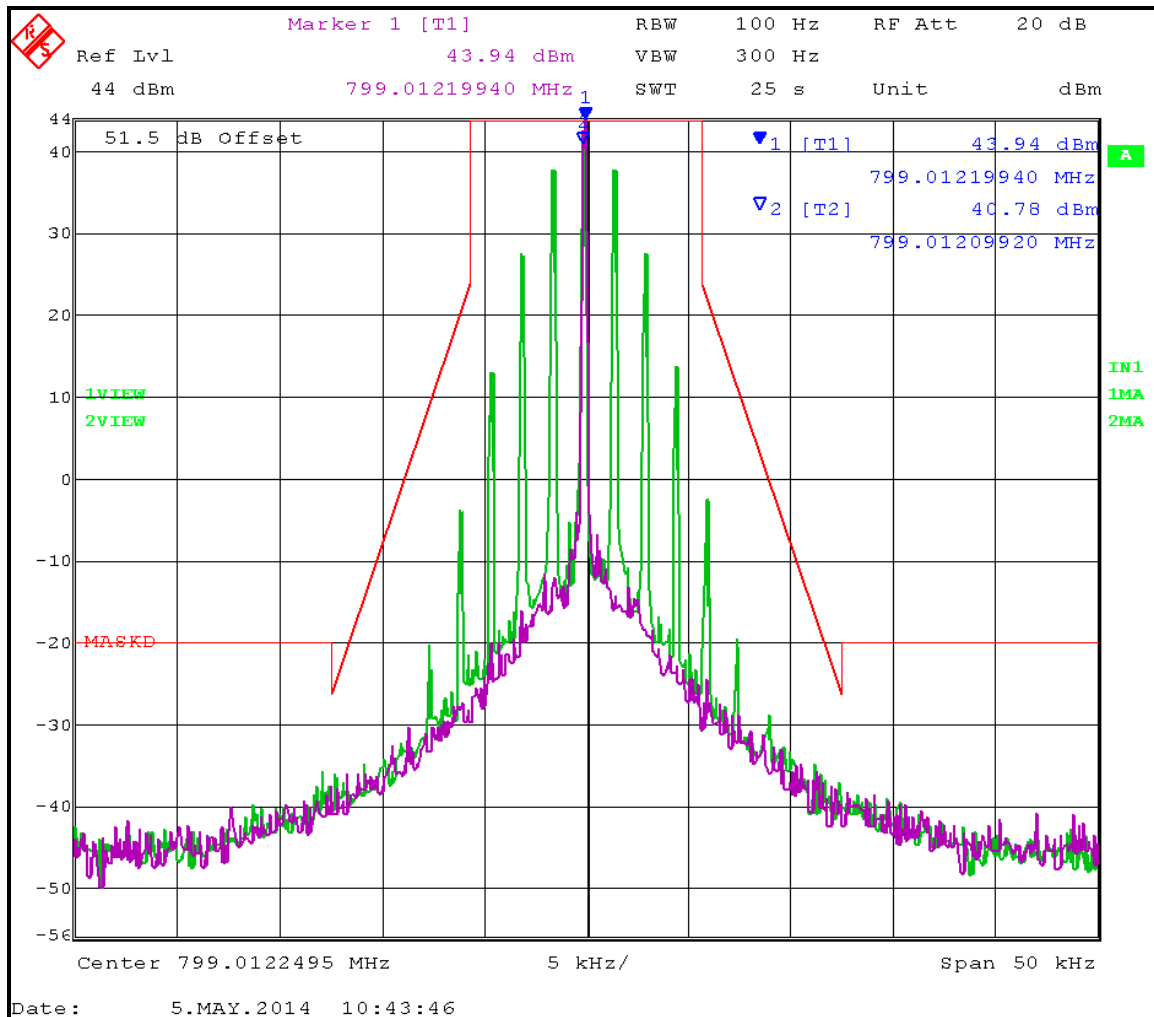
OCCUPIED BANDWIDTH PLOTS: ANALOG

Part 90.210(d) Emission Mask D - 12.5 kHz channel bandwidth - ANALOG
(2.5 kHz deviation)



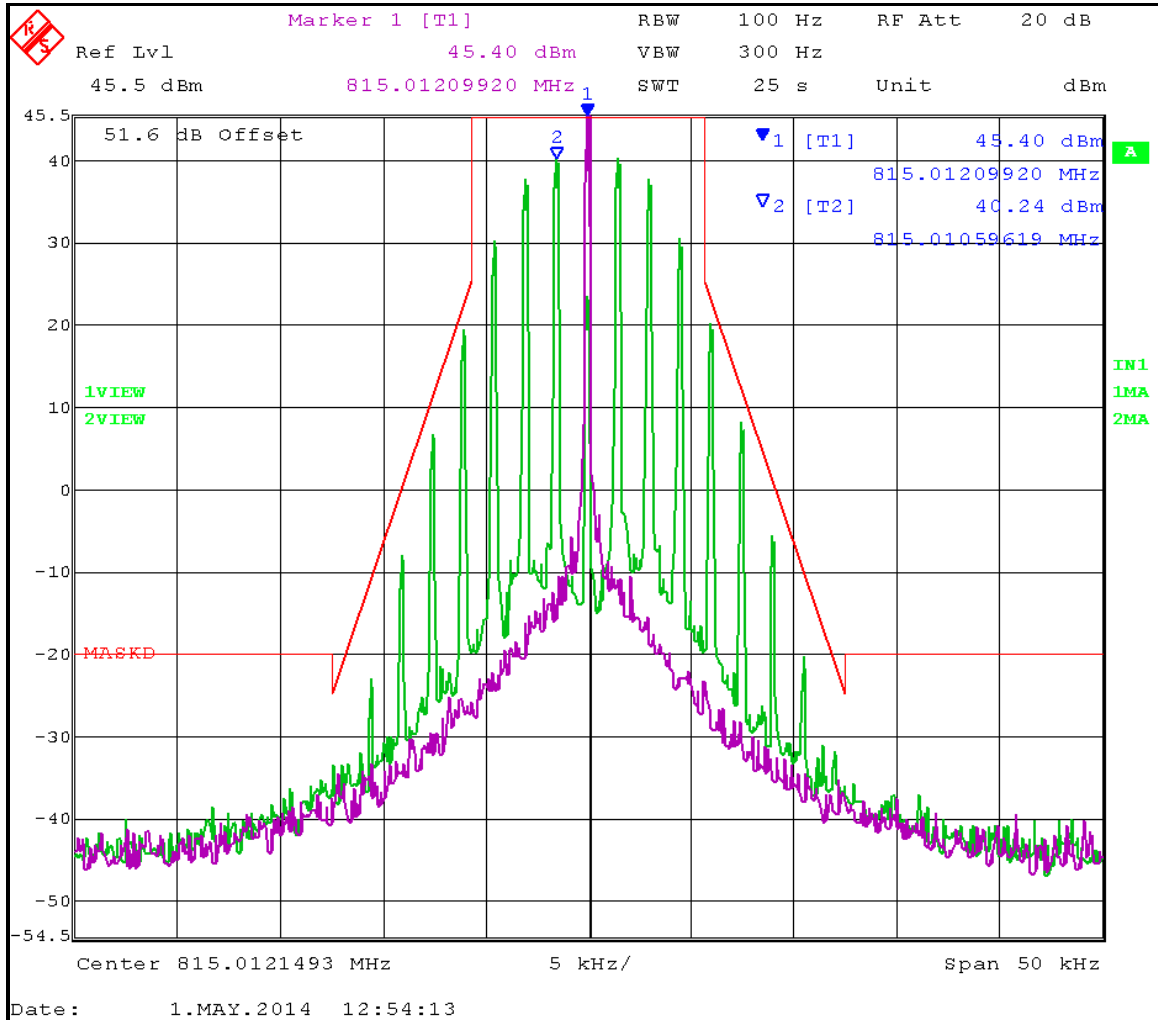
Low End of the Band (763-805 MHz): 763.0125 MHz

**Part 90.210(d) Emission Mask D - 12.5 kHz channel bandwidth - ANALOG
(2.5 kHz deviation)**



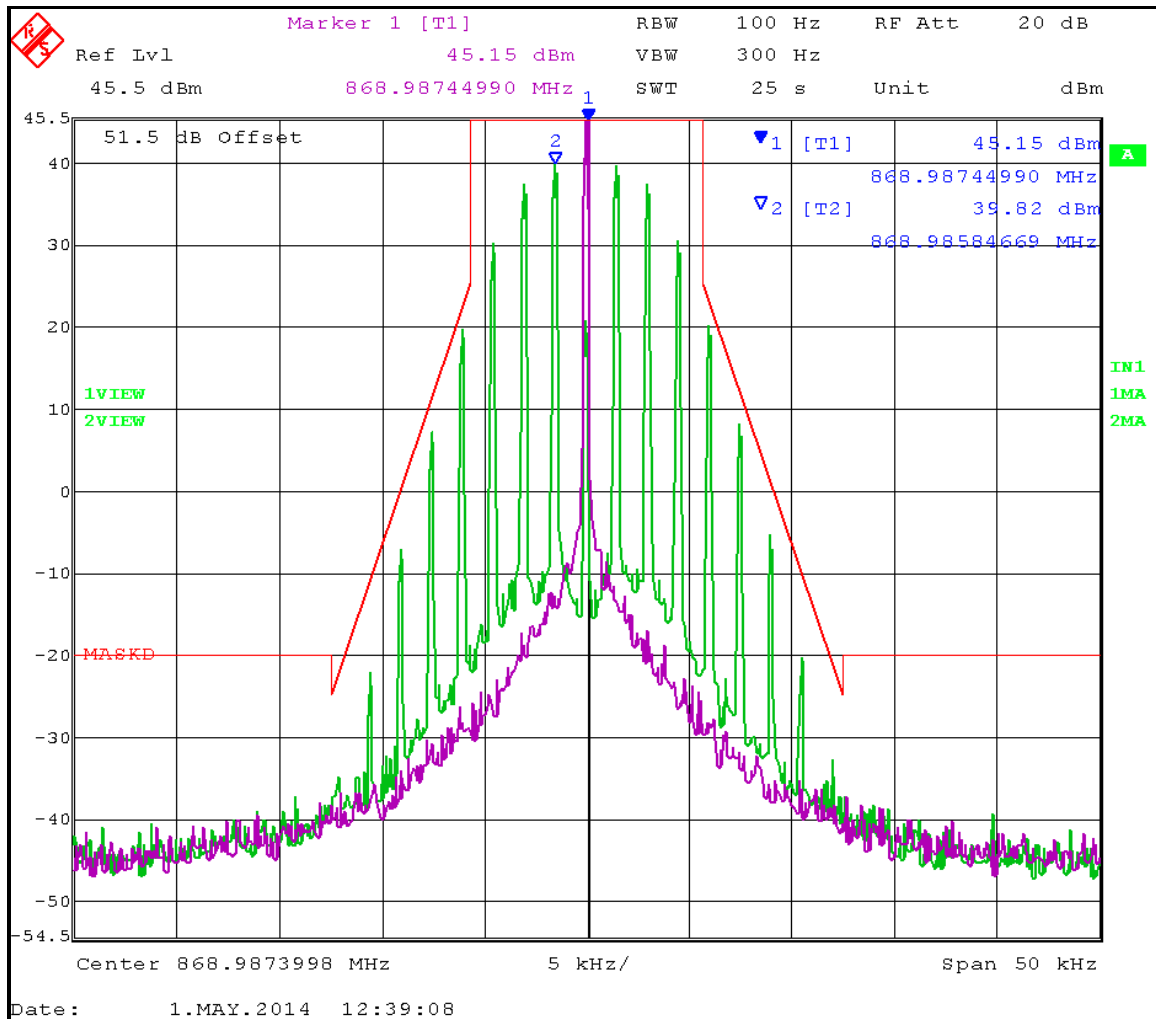
Middle of the Band (763-805 MHz): 799.0125 MHz

**Part 90.210(d) Emission Mask D - 12.5 kHz channel bandwidth - ANALOG
(4.0 kHz deviation)**



Middle of the Band (806-869 MHz): 815.0125 MHz

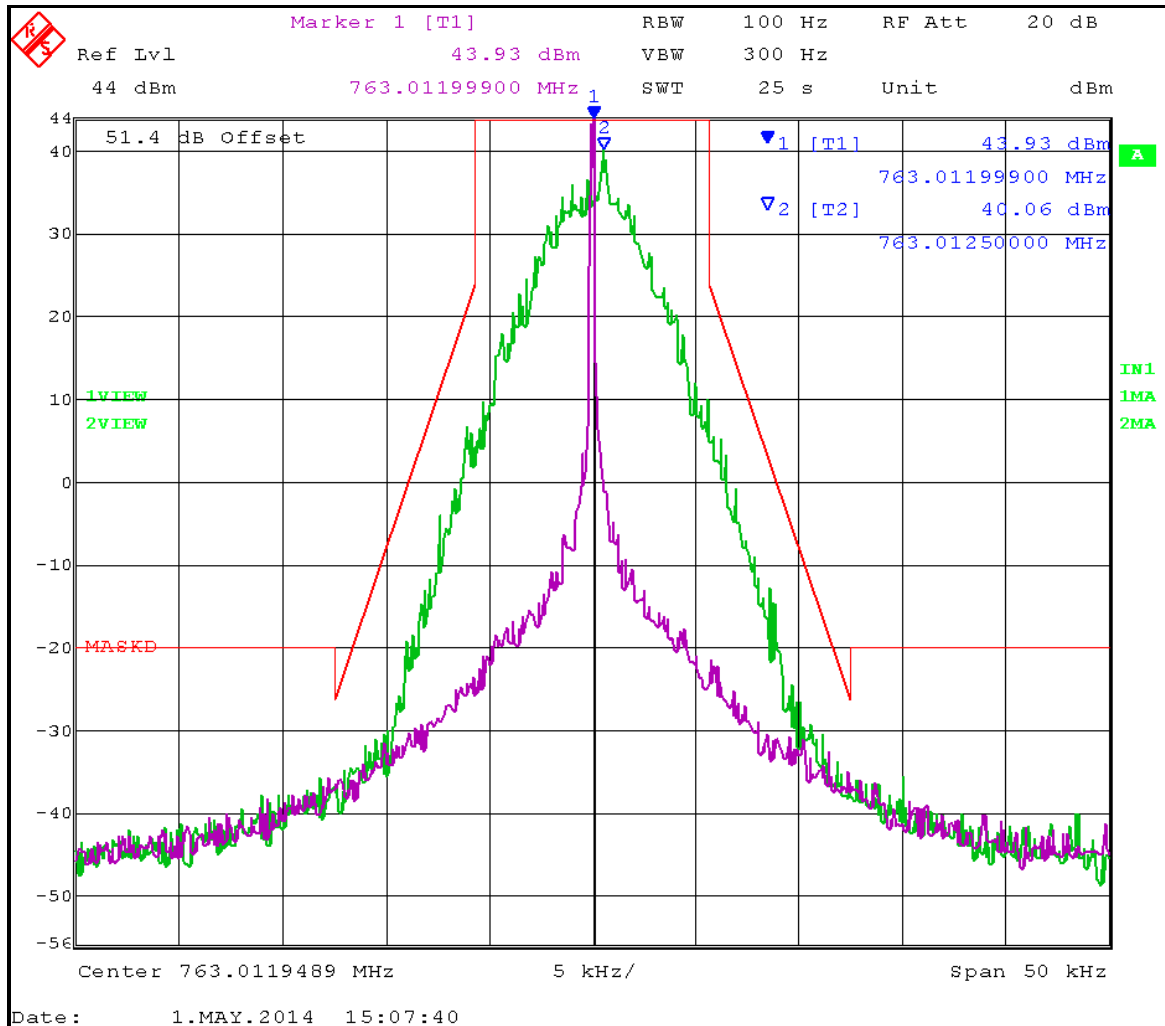
**Part 90.210(d) Emission Mask D - 12.5 kHz channel bandwidth - ANALOG
(4.0 kHz deviation)**



High End of the Band (806-869 MHz): 868.9875 MHz

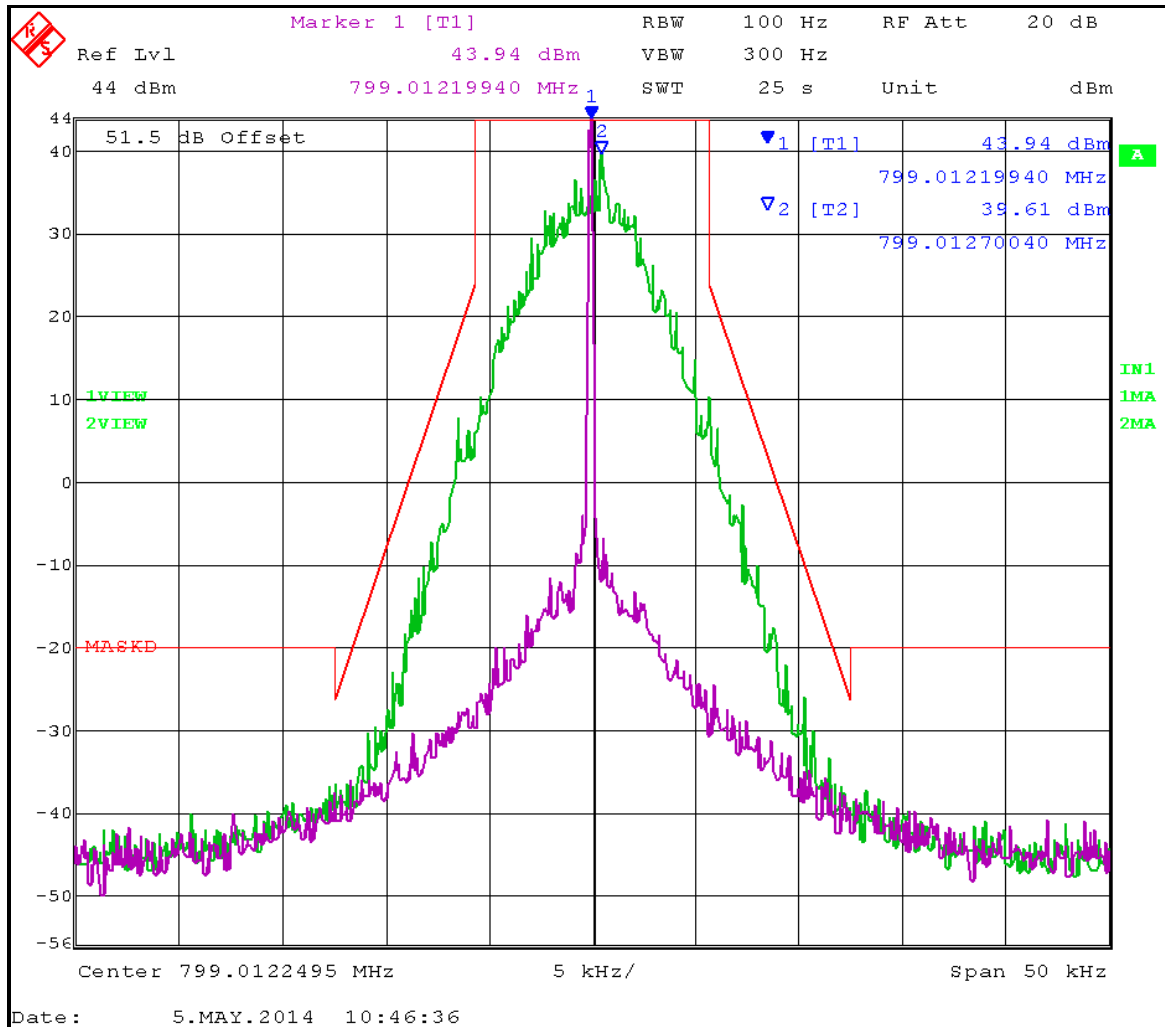
OCCUPIED BANDWIDTH PLOTS: DIGITAL

Part 90.210(d) Emission Mask D - 12.5 kHz channel bandwidth - DIGITAL



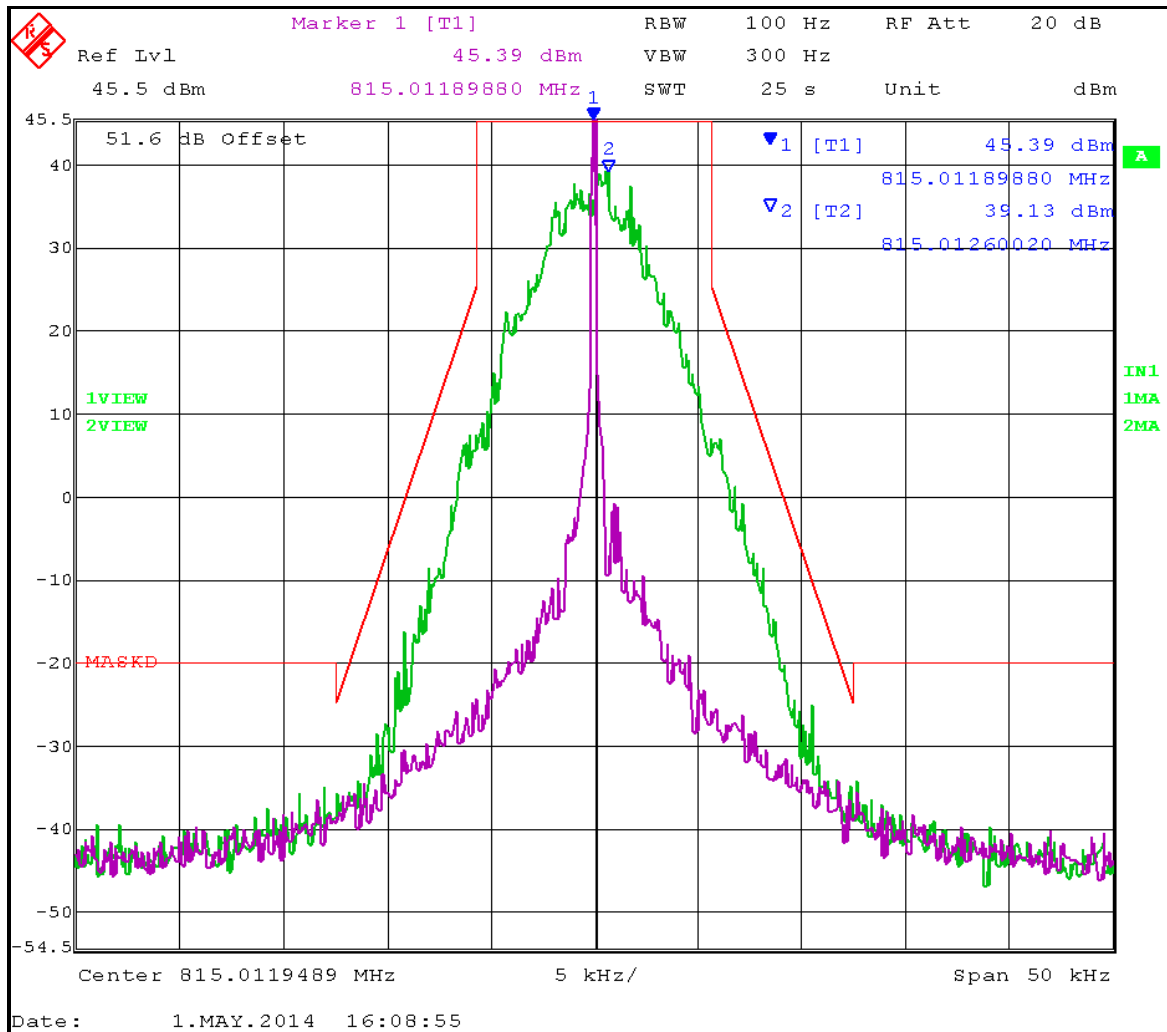
Low End of the Band (763-805 MHz): 763.0125 MHz

Part 90.210(d) Emission Mask D - 12.5 kHz channel bandwidth - DIGITAL



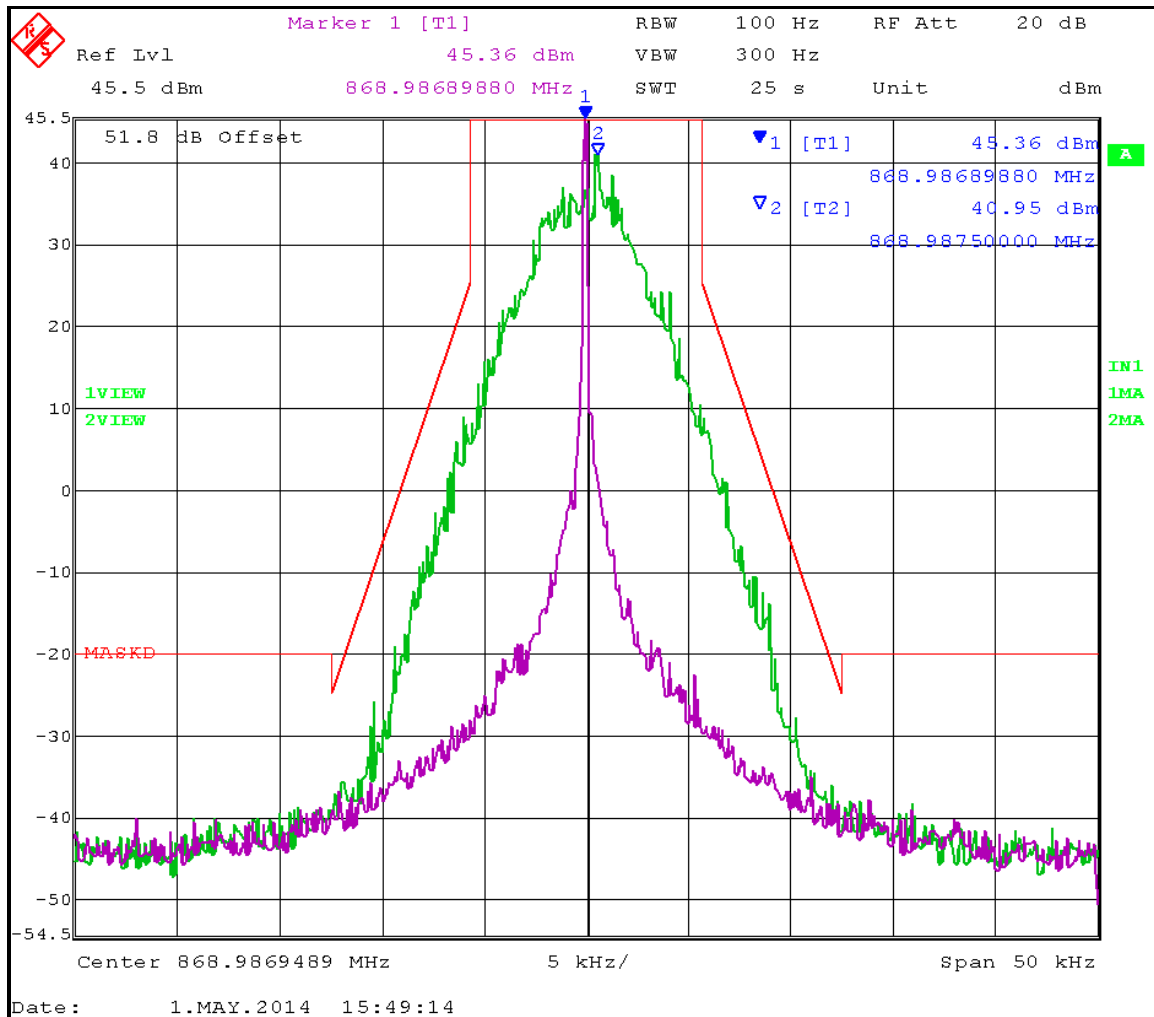
Middle of the Band (763-805 MHz): 799.0125 MHz

Part 90.210(d) Emission Mask D - 12.5 kHz channel bandwidth - DIGITAL



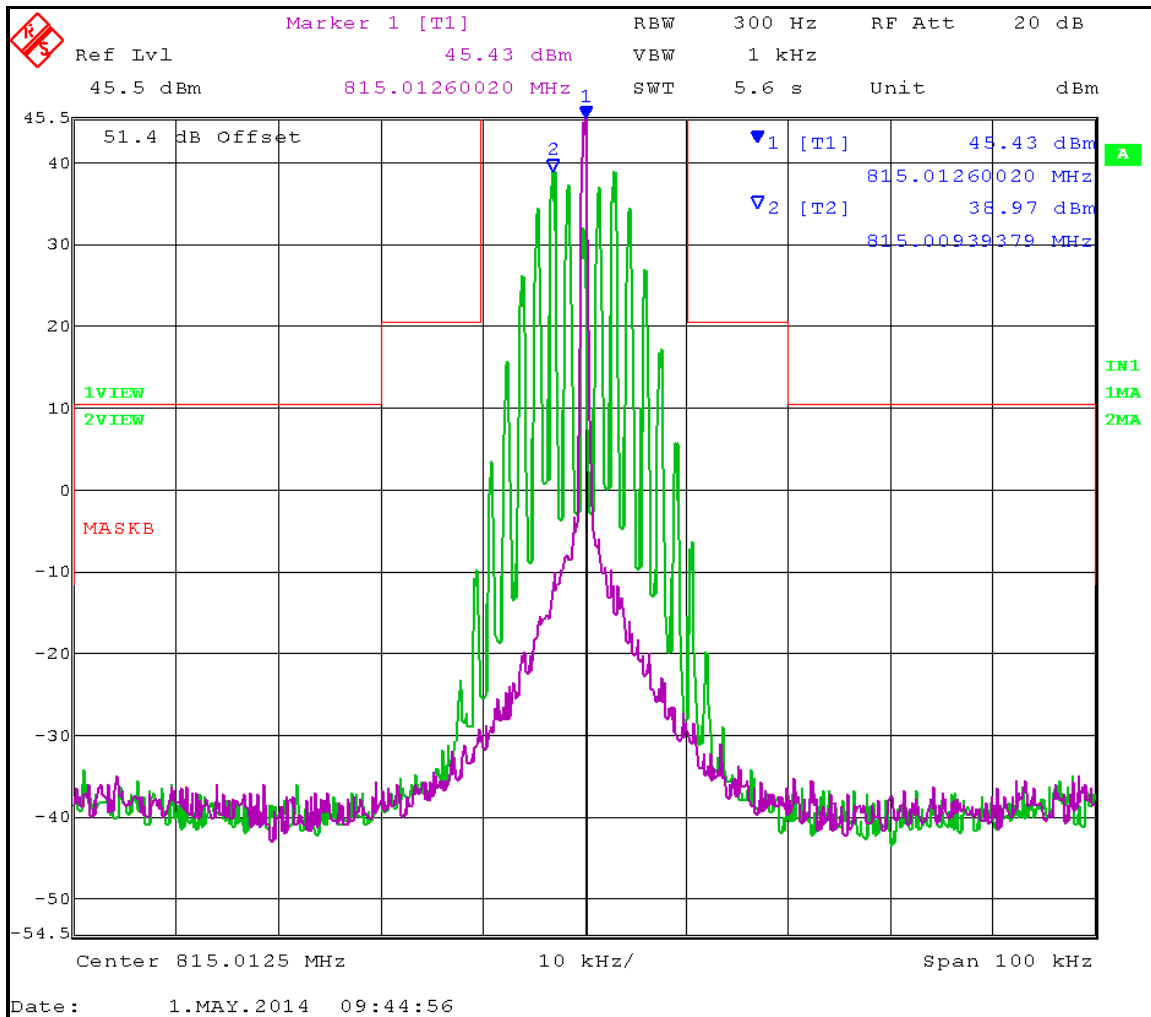
Middle of the Band (806-869 MHz): 815.0125 MHz

Part 90.210(d) Emission Mask D - 12.5 kHz channel bandwidth - DIGITAL



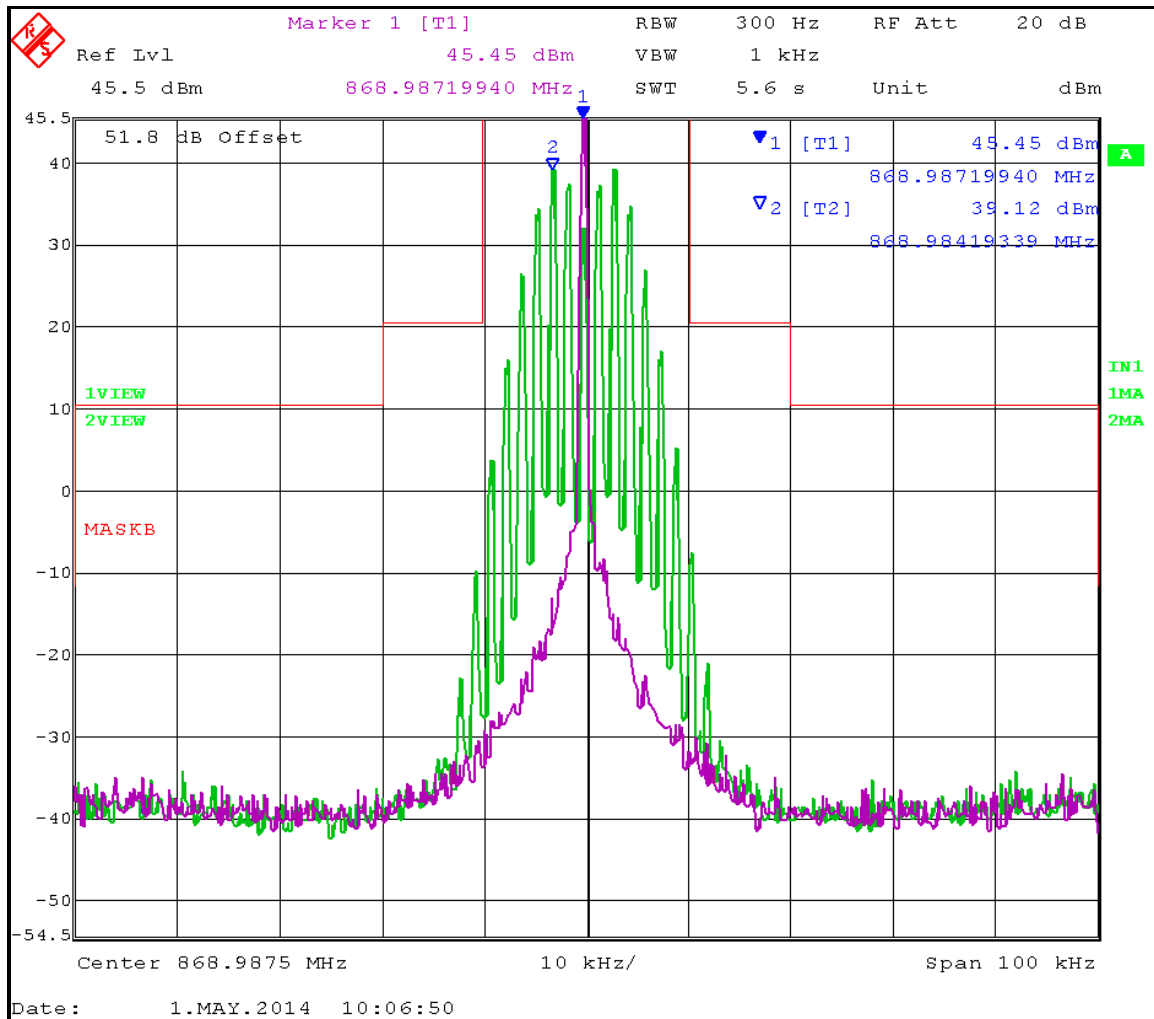
High End of the Band (806-869 MHz): 868.9875 MHz

**Part 90.210(b) Emission Mask B – 25.0 kHz channel bandwidth - ANALOG
(5.0 kHz deviation)**



Middle of the Band (806-869 MHz): 815.0125 MHz

**Part 90.210(b) Emission Mask B – 25.0 kHz channel bandwidth - ANALOG
(5.0 kHz deviation)**



High End of the Band (806-869 MHz): 868.9875 MHz

SPURIOUS EMISSIONS AT ANTENNA TERMINALS (CONDUCTED)

Rule Part No.: Part 2.1051(a)

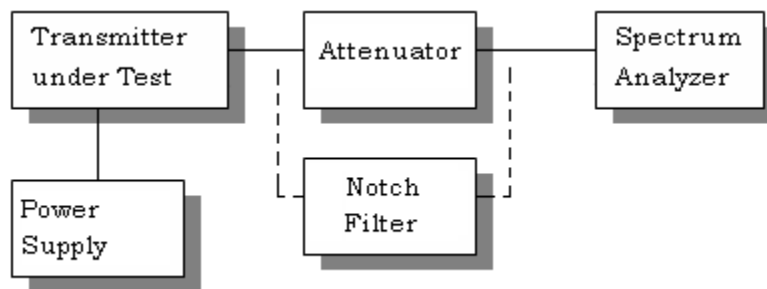
Requirements:

12.5 kHz Channel Spacing = $50 + 10 \log (25.0) = 64.0 \text{ dBc}$

12.5 kHz Channel Spacing = $50 + 10 \log (35.0) = 65.5 \text{ dBc}$

Method of Measurement: The carrier was modulated 100% using a 2500 Hz tone. The spectrum was scanned from 0.4 to at least the 10th harmonic of the fundamental. The measurements were made in accordance with standard ANSI/TIA 603-D: 2010.

Method of Measuring Conducted Spurious Emissions



Test Data:

Frequency range: 763 to 805 MHz, output power 25 W: Low End of the Band

TF	EF	dB below carrier
763.01	1526.03	73.3
	2289.04	74.3
	3052.05	73.6
	3815.06	73.2
	4578.08	73.5
	5341.09	NE
	6104.10	NE
	6867.11	NE
	7630.13	NE

Applicant: EF JOHNSON COMPANY

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Frequency range: 763 to 805 MHz, output power 25 W: Middle of the Band.

TF	EF	dB below carrier
799.01	1598.03	73.6
	2397.04	72.4
	3196.05	73.8
	3995.06	73.2
	4794.08	73.1
	5593.09	NE
	6392.10	NE
	7191.11	NE
	7990.13	NE

Frequency range: 806 to 869 MHz, output power 35 W: Middle of the Band.

TF	EF	dB below carrier
815.01	1630.03	75
	2445.04	73.2
	3260.05	75.2
	4075.06	74.3
	4890.08	74.3
	5705.09	NE
	6520.10	NE
	7335.11	NE
	8150.13	NE

Frequency range: 806 to 869 MHz, output power 35 W: High End of the Band

TF	EF	dB below carrier
868.99	1737.98	75.2
	2606.96	75
	3475.95	74.7
	4344.94	74.2
	5213.93	71.4
	6082.91	NE
	6951.90	NE
	7820.89	NE
	8689.88	NE

RESULTS: PASS

FIELD STRENGTH OF SPURIOUS EMISSIONS

Rule Parts. No.: Part 2.1053

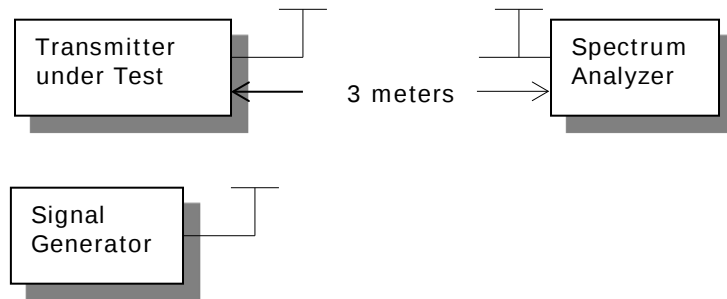
Requirements:

$$12.5\text{kHz Channel Spacing} = 50 + 10\log(25.0) = 64.0 \text{ dBc}$$

$$12.5\text{kHz Channel Spacing} = 50 + 10\log(35.0) = 65.5 \text{ dBc}$$

METHOD OF MEASUREMENT: The tabulated data shows the results of the radiated field strength emissions test. The spectrum was scanned from 30 MHz to at least the tenth harmonic of the fundamental. This test was conducted per ANSI/TIA 603-D: 2010 using the substitution method. Measurements were made at the test site of TIMCO ENGINEERING, INC. located at 849 NW State Road 45, Newberry, FL 32669.

Test Setup Diagram:



Test Data:

Frequency range: 763 to 805 MHz, output power 25 W: Low End of the Band

Emission Frequency MHz	Ant. Polarity	dB Below Carrier (dBc)
763.01	0	0
1526.03	H	84.9
2289.04	H	81.6
3052.05	V	86.2
3815.06	V	93.9
4578.08	V	93.0
5341.09	V	89.5
6104.10	H	82.8
6867.11	V	88.9
7630.13	V	89.2

Applicant: EF JOHNSON COMPANY

FCC ID: ATH2425M70

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Frequency range: 763 to 805 MHz, output power 25 W: Middle of the Band.

Emission Frequency MHz	Ant. Polarity	dB Below Carrier (dBc)
799.01	0	0
1598.03	H	80.7
2397.04	H	75.6
3196.05	V	89.0
3995.06	V	95.3
4794.08	V	97.0
5593.09	V	91.5
6392.10	V	90.8
7191.11	V	93.1
7990.13	V	94.2

Frequency range: 806 to 869 MHz, output power 35 W: Middle of the Band.

Emission Frequency MHz	Ant. Polarity	dB Below Carrier (dBc)
815.01	0	0
1630.03	H	85.6
2445.04	V	68.8
3260.05	V	81.5
4075.06	V	81.4
4890.08	V	84.9
5705.09	V	77.6
6520.10	V	88.6
7335.11	V	80.3
8150.13	V	91.8

Frequency range: 806 to 869 MHz, output power 35 W: High End of the Band

Emission Frequency MHz	Ant. Polarity	dB Below Carrier (dBc)
868.99	0	0
1737.98	H	90.8
2606.96	H	66.2
3475.95	V	78.9
4344.94	V	75.9
5213.93	H	71.4
6082.91	H	67.6
6951.90	H	73.1
7820.89	V	83.0
8689.88	V	79.2

ADJACENT CHANNEL POWER

90.543 Emission limitations.

12.5 kHz Mobile Transmitter ACP Measurement and Requirements

Offset from center frequency (kHz)	Measurement bandwidth (kHz)	ACP Measurement Reading (dBc)		Limit ACP (dBc)
		UPPER	LOWER	
9.375	6.25	-43	-43.4	-40
15.625	6.25	-77.8	-78.2	-60
21.875	6.25	-80.8	-80.8	-60
37.5	25	-73.8	-73.9	-60
62.5	25	-73.5	-73.2	-65
87.5	25	-69.4	-69	-65
150	100	-70.9	-70.5	-65
250	100	-71.4	-71.4	-65
350	100	-71.4	-71.4	-65
>400 to 12MHz	30(s)	-80.2	-80.5	-75
12 to paired rx band	30(s)	-82.6	-82.5	-75
In the paired rx band	30(s)	-110.0	-110.2	-100

FREQUENCY STABILITY

Rule Parts. No.: Part 2.1055, Part 90.213

Requirements: Temperature range requirements: -30 to +50° C.
Voltage Variation +, -15%
±2.5 PPM

Method of Measurements: ANSI/TIA 603-D: 2010.

Test Data:

Assigned Frequency (Ref. Frequency) (MHz)		799.012220
Temperature (°C)	Frequency (MHz)	Frequency Stability (PPM)
-30	799.011994	-0.28
-20	799.011972	-0.31
-10	799.012016	-0.26
0	799.012002	-0.27
+10	799.012154	-0.08
+20	799.012218	0.00
+30	799.012065	-0.19
+40	799.011831	-0.49
+50	799.011633	-0.73

Assigned Frequency (Ref. Frequency) (MHz)		158.609986
% Battery	Frequency (MHz)	Frequency Stability (PPM)
-15%	799.012217	0.00
0	799.012220	0.00
+15%	799.012215	-0.01

TRANSIENT FREQUENCY BEHAVIOR

Part 90.214 Transient Frequency Behavior

REQUIREMENTS: Transmitters designed to operate in the 150-174 MHz and 421-512 MHz frequency bands must maintain transient frequencies within the maximum transient frequencies within the maximum frequency difference limits during the time intervals indicated:

Time Intervals	Maximum frequency difference	All Equipment	
		150-174 MHz	421-512 MHz

Transient Frequency Behavior for Equipment Designed to Operate on 25 kHz Channels

t_1^4	± 25.0 kHz	5.0 ms	10.0 ms
t_2	± 12.5 kHz	20.0 ms	25.0 ms
t_3^4	± 25.0 kHz	5.0 ms	10.0 ms

Transient Frequency Behavior for Equipment Designed to Operate on 12.5 kHz Channels

t_1^4	± 12.5 kHz	5.0 ms	10.0 ms
t_2	± 6.25 kHz	20.0 ms	25.0 ms
t_3^4	± 12.5 kHz	5.0 ms	10.0 ms

Transient Frequency Behavior for Equipment Designed to Operate on 6.25 kHz Channels

t_1^4	± 6.25 kHz	5.0 ms	10.0 ms
t_2	± 3.125 kHz	20.0 ms	25.0 ms
t_3^4	± 6.25 kHz	5.0 ms	10.0 ms

Test Data:

N/A: 700/800 MHz Mobile Device.

TEST PROCEEDURE: ANSI/TIA 603-D: 2010, the levels were set as follows:

1. Using the variable attenuator the transmitter level was set to 40 dB below the test receivers maximum input level, then the transmitter was turned off.
2. With the transmitter off the signal generator was set 20dB below the level of the transmitter in the above step, this level will be maintained with the signal generator through-out the test.
3. Reduce the attenuation between the transmitter and the RF detector by 30 dB.
4. With the levels set as above, the transient frequency behavior was observed and recorded.

