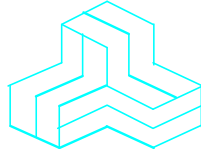


ENGINEERING TEST REPORT



UHF Narrowband Radio Module
Model: RA1202
FCC ID: H9PRA1202

Applicant:

Symbol Technologies Inc.
One Motorola Plaza
Holtsville, New York 11742
USA

Tested in Accordance With

Federal Communications Commission (FCC)
47 CFR, Parts 2, 22, 74, 80 and 90 (Subpart I)

UltraTech's File No.: TEK-737F90

This Test report is Issued under the Authority of
Tri M. Luu
Vice President of Engineering
UltraTech Group of Labs

Date: September 2, 2014

Report Prepared by: Dan Huynh

Tested by: Wei Wu

Issued Date: September 2, 2014

Test Dates: August 13 – 19 2014

- *The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.*
- *This report must not be used by the client to claim product endorsement by NVLAP or any agency of the US Government.*

UltraTech

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91038



1309



46390-2049



NVLAP LAB
CODE 200093-0



SL2-IN-E-
1119R



Korea
KCC-RRA

CA2049



TL363_B



TPTDP
DA1300

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EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	FCC Parts 2, 22, 74, 80 and 90 (Subpart I)
Title:	Code of Federal Regulations (CFR), Title 47 Telecommunication – Parts 2, 22, 74, 80 and 90 (Subpart I)
Purpose of Test:	To obtain FCC Certification Authorization for Radio operating in the Frequency Band 435-470 MHz
Test Procedures:	Both conducted and radiated emissions measurements were conducted in accordance with TIA/EIA Standard TIA/EIA-603-D – Land Mobile FM or PM Communications Equipment Measurement and performance Standards.

1.2. RELATED SUBMITTAL(S)/GRANT(S)

None

1.3. NORMATIVE REFERENCES

Publication	Year	Title
FCC CFR Parts 0-19, 80-End	2014	Code of Federal Regulations – Telecommunication
ANSI C63.4	2009	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
TIA/EIA 603, Edition D	2010	Land Mobile FM or PM Communications Equipment Measurement and Performance Standards

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

Applicant	
Name:	Symbol Technologies Inc.
Address:	One Motorola Plaza Holtsville, New York 11742 USA
Contact Person:	Mark S. Luksich Phone #: +1 (631) 738 5134 Fax #: +1 (631) 738 3318 Email Address: Mark.Luksich@motorolasolutions.com

Manufacturer	
Name:	Symbol Technologies Inc.
Address:	One Motorola Plaza Holtsville, New York 11742 USA
Contact Person:	Sada Dharwarkar Phone #: 905 812 6200 Ext. 3358 Fax #: 905 812 6301 Email Address: Sada.Dharwarkar@motorolasolutions.com

2.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

The applicant has supplied the following information (with the exception of the Date of Receipt).

Brand Name:	Symbol
Product Name:	UHF Narrowband Radio Module
Model Name or Number:	RA1202
Serial Number:	Test Sample
Type of Equipment:	Licensed Non-Broadcast Station Transmitter
Power Supply Requirement:	3.7 VDC nominal
Transmitting/Receiving Antenna Type:	Non-integral
Primary User Functions of EUT:	Transmit and receive data

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2.3. EUT'S TECHNICAL SPECIFICATIONS

Transmitter	
Equipment Type:	Mobile/Fixed
Intended Operating Environment:	Commercial, Restricted to Occupational Use only
Power Supply Requirement:	3.7 VDC nominal
RF Output Power Rating:	1 W
Operating Frequency Range:	435 - 470 MHz
RF Output Impedance:	50 Ω
Channel Spacing:	25 kHz, 12.5 kHz
Occupied Bandwidth (99%):	15.013 kHz (for 25 kHz Channel Spacing, Digital) 8.243 kHz (for 12.5 kHz Channel Spacing, Digital)
Emission Designation*:	8K24F1D, 15K0F1D
Antenna Connector Type:	HIROSE U.FL
<p>*For Digital Modulation the measured 99% occupied bandwidth was used instead of Carson's rule.</p> <p>Digital (12.5 kHz Channelization, Digital Data): Emission Designator: 8K24F1D</p> <p>Digital (25 kHz Channelization, Digital Data): Emission Designator: 15K0F1D</p>	

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2.4. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	Connector SMT Header Micro 54PIN Dual Row	1	SMT Header 54 pin	--
2	Antenna Port	1	UFL	Shielded

2.5. ANCILLARY EQUIPMENT

The EUT was tested while connected to the following representative configuration of ancillary equipment necessary to exercise the ports during tests:

Ancillary Equipment # 1	
Description:	Test Fixture
Brand name:	Symbol
Model Name or Number:	Test sample
Connected to EUT's Port:	SMT Header Micro 54PIN Dual Row

EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

3.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21°C - 24°C
Humidity:	45% to 58%
Pressure:	102 kPa
Power Input Source:	3.7 VDC nominal

3.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TEST SIGNALS

Operating Modes:	The transmitter was operated in a continuous transmission mode with the carrier modulated as specified in the Test Data.
Special Test Software:	Special software provided by the Applicant to operate the EUT at each channel frequency continuously and in the range of typical modes of operation.
Special Hardware Used:	Test Fixture
Transmitter Test Antenna:	The EUT is tested with the antenna port terminated to a 50 Ω RF Load.

Transmitter Test Signals	
Frequency Band(s):	435 - 470 MHz
Test Frequencies:	435 MHz, 450 MHz & 470 MHz
Transmitter Wanted Output Test Signals:	
Transmitter Power (measured maximum output power):	1 W
Normal Test Modulation:	Digital
Modulating signal source:	External

EXHIBIT 4. SUMMARY OF TEST RESULTS

4.1. LOCATION OF TESTS

All of the measurements described in this report were performed at Ultratech Group of Labs located in the city of Oakville, Province of Ontario, Canada.

- AC Power Line Conducted Emissions were performed in UltraTech's shielded room, 24'(L) by 16'(W) by 8'(H).
- Radiated Emissions were performed at the Ultratech's 3-10 TDK Semi-Anechoic Chamber situated in the Town of Oakville, province of Ontario. This test site been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Sec. 2.948 of the FCC Rules. The descriptions and site measurement data of the Oakville 3-10 TDK Semi-Anechoic Chamber has been filed with FCC office (FCC File No.: 91038) and Industry Canada office (Industry Canada File No.: 2049A-3). Expiry Date: 2017-04-02.

4.2. APPLICABILITY & SUMMARY OF EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Applicability (Yes/No)
2.1046, 22.565, 74.461, 80.215 & 90.205	RF Power Output	Yes
2.1047(a) & 90.242(b)(8)	Modulation Characteristics - Audio Frequency Response	N/A
2.1047(b), 74.463 & 80.213	Modulation Characteristics - Modulation Limiting	Yes
2.1049, 74.462, 80.211(f), 90.209 & 90.210	Occupied Bandwidth, Emission Limitation & Emission Mask	Yes
2.1051, 2.1057, 22.359(a), 80.211(f)(3), & 90.210	Spurious Emissions at Antenna Terminals	Yes
2.1053, 2.1057, 22.359(a), 80.211(f)(3), & 90.210	Field Strength of Spurious Emissions	Yes
2.1055, 22.355, 74.464 80.209 & 90.213	Frequency Stability	Yes
74.462(c) & 90.214	Transient Frequency Behavior	Yes
1.1307, 1.1310, 2.1091 & 2.1093	RF Exposure Limit	Yes
15.107	AC Power Line Conducted Emissions	Yes

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None.

4.3.1. DEVIATION OF STANDARD TEST PROCEDURES

None.

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EXHIBIT 5. MEASUREMENTS DATA

5.1. RF POWER OUTPUT [§§ 2.1046, 22.565, 74.461, 80.215 & 90.205]

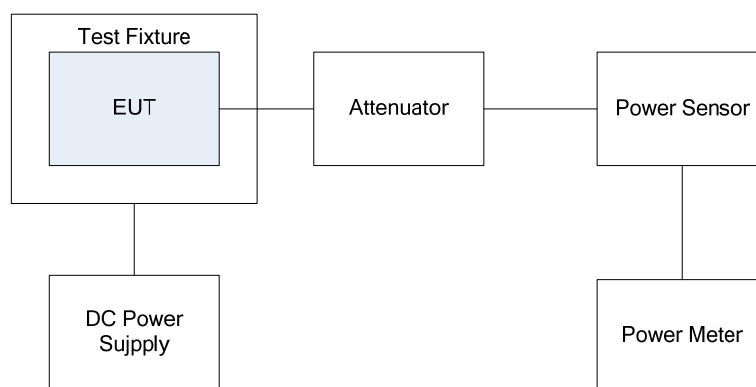
5.1.1. Limits

Refer to FCC 47 CFR 22.565, 74.461, 80.215 and 90.205 for specification details.

5.1.2. Method of Measurements

Refer to Section 8.1 (Conducted) and 8.2 (Radiated) of this report for measurement details

5.1.3. Test Arrangement



5.1.4. Test Data

Fundamental Frequency (MHz)	Measured (Average) Power		Power Rating	
	(dBm)	(W)	(dBm)	(W)
435	29.95	0.99	30	1
450	30.00	1.00	30	1
470	30.03	1.01	30	1

5.2. MODULATION LIMITING [§§ 2.1047 (b), 74.463 & 80.213]

5.2.1. Limits

§ 2.1047(b): Equipment which employs modulation limiting. A curve or family of curves showing the percentage of modulation versus the modulation input voltage shall be supplied. The information submitted shall be sufficient to show modulation limiting capability throughout the range of modulating frequencies and input modulating signal levels employed.

Recommended frequency deviation characteristics are given below:

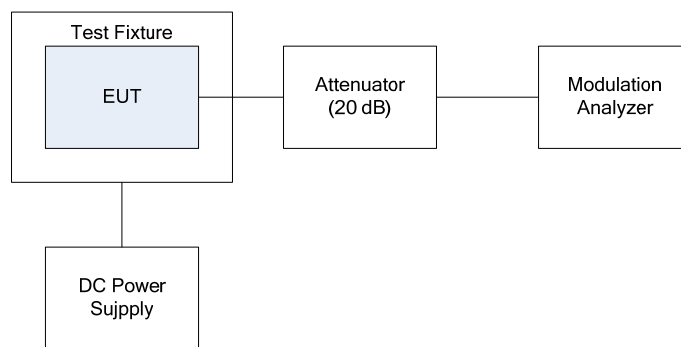
- 1.25 kHz for 6.25 kHz Channel Spacing System
- 2.5 kHz for 12.5 kHz Channel Spacing System
- 5 kHz for 25 kHz Channel Spacing System

5.2.2. Method of Measurements

For Audio Transmitter: The carrier frequency deviation was measured with the tone input signal level varied from 0 Vp to audio input rating level plus 16 dB at frequencies 0.1, 0.5, 1.0, 3.0 and 5.0 kHz. The maximum deviation was recorded at each test condition.

For Data Transmitter with Maximum Frequency Deviation set by Factory: The EUT was set at maximum frequency deviation, and its peak frequency deviation was then measured using EUT's internal random data source.

5.2.3. Test Arrangement



5.2.4. Test Data

5.2.4.1. Data Modulation Limiting for 12.5 kHz Channel Spacing Operation

Operating Mode	Data Rate	Peak Frequency Deviation (kHz)
FSK	9.6 kbps random data	3.21

5.2.4.2. Data Modulation Limiting for 25 kHz Channel Spacing Operation

Operating Mode	Data Rate	Peak Frequency Deviation (kHz)
FSK	19.2 kbps random data	7.28

5.3. OCCUPIED BANDWIDTH & EMISSION MASK [§§ 2.1049, 74.462, 80.211(f), 90.209 & 90.210]

5.3.1. Limits

§80.211(f) Emission limitations

Emissions shall be attenuated below the mean output power of the transmitter as follows:

- (1) On any frequency removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: At least 25 dB;
- (2) On any frequency removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: At least 35 dB; and
- (3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 plus $10\log_{10}$ (mean power in watts) dB.

§90.209 Bandwidth limitations

Frequency band (MHz)	Channel spacing (kHz)	Authorized bandwidth (kHz)
406-512 ²	¹ 6.25	^{1 3} 20/11.25/6

¹For stations authorized on or after August 18, 1995.

²Bandwidths for radiolocation stations in the 420-450 MHz band and for stations operating in bands subject to this footnote will be reviewed and authorized on a case-by-case basis.

³Operations using equipment designed to operate with a 25 kHz channel bandwidth will be authorized a 20 kHz bandwidth. Operations using equipment designed to operate with a 12.5 kHz channel bandwidth will be authorized a 11.25 kHz bandwidth. Operations using equipment designed to operate with a 6.25 kHz channel bandwidth will be authorized a 6 kHz bandwidth. All stations must operate on channels with a bandwidth of 12.5 kHz or less beginning January 1, 2013, unless the operations meet the efficiency standard of §90.203(j)(3).

§90.210 Emission masks

Frequency band (MHz)	Mask for equipment without audio low pass filter	Mask for equipment without audio low pass filter
421-512 ^{1 2}	B, D, or E	C, D, or E
450 paging only	B	G

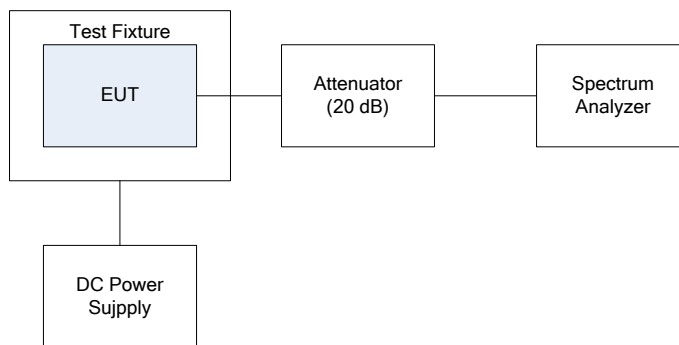
¹Equipment designed to operate with a 25 kHz channel bandwidth must meet the requirements of Emission Mask B or C, as applicable. Equipment designed to operate with a 12.5 kHz channel bandwidth must meet the requirements of Emission Mask D, and equipment designed to operate with a 6.25 kHz channel bandwidth must meet the requirements of Emission Mask E.

²Equipment may alternatively meet the Adjacent Channel Power limits of §90.221.

5.3.2. Method of Measurements

Refer to Section 8.4 of this report for measurement details.

5.3.3. Test Arrangement



5.3.4. Test Data

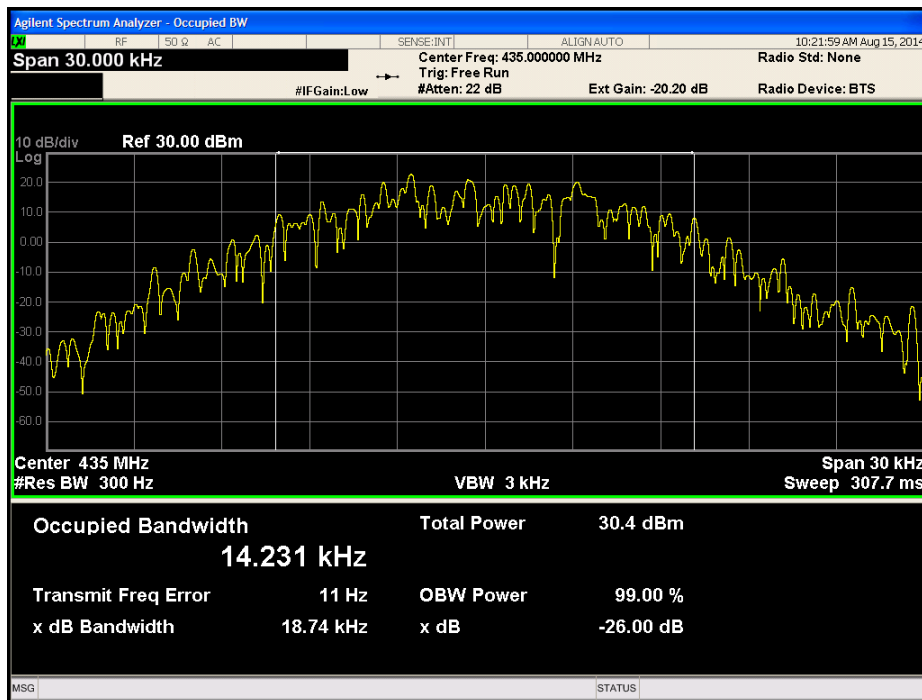
5.3.4.1. 99% Occupied Bandwidth

Frequency (MHz)	Channel Spacing (kHz)	Modulation	Measured 99% OBW at Maximum Freq. Deviation (kHz)	Maximum Authorized Bandwidth (kHz)
435	25	Digital	14.231	20
450	25	Digital	14.678	20
470	25	Digital	15.013	20
435	12.5	Digital	8.243	11.25
450	12.5	Digital	7.576	11.25
470	12.5	Digital	7.526	11.25

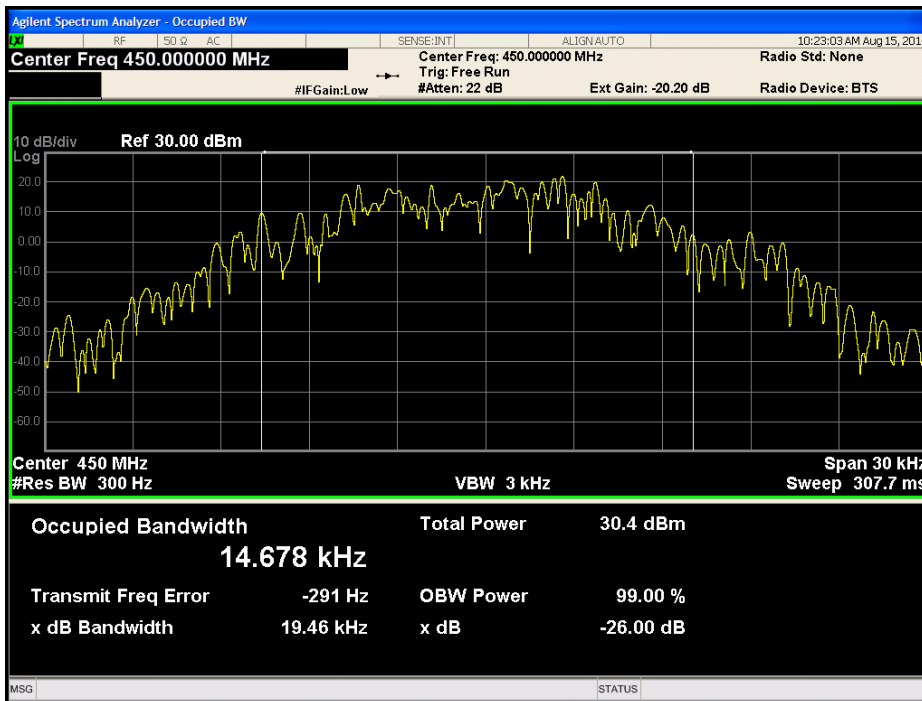
Note: 99% Occupied Bandwidth measurements were done using the built-in auto function of the analyzer.

Refer to the following test data plots for details.

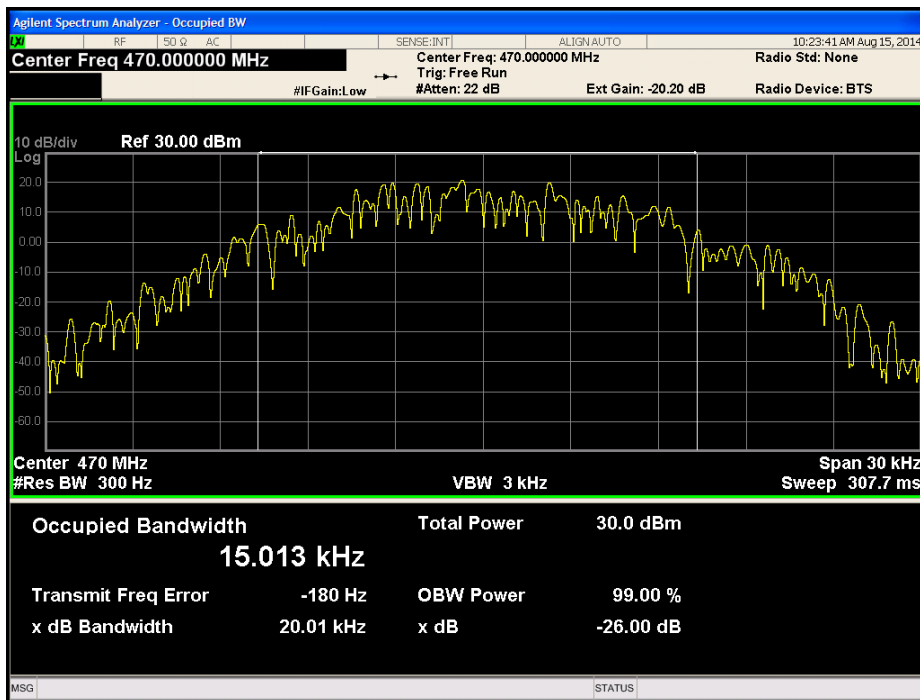
Plot 5.3.4.1.1. 99% Occupied Bandwidth for 25 kHz Channel Spacing, Digital, 435 MHz



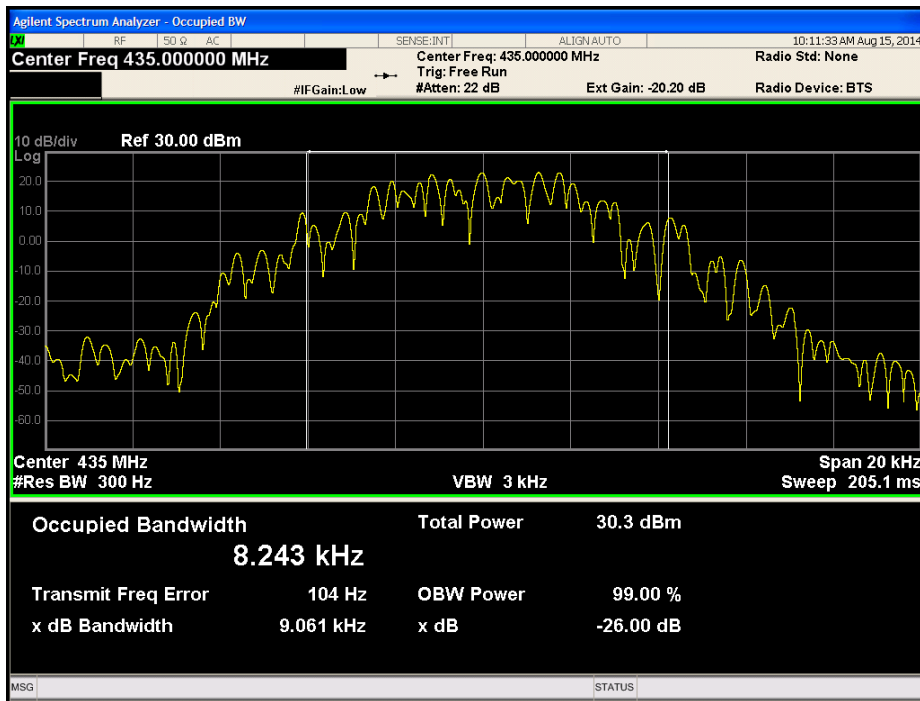
Plot 5.3.4.1.2. 99% Occupied Bandwidth for 25 kHz Channel Spacing, Digital, 450 MHz



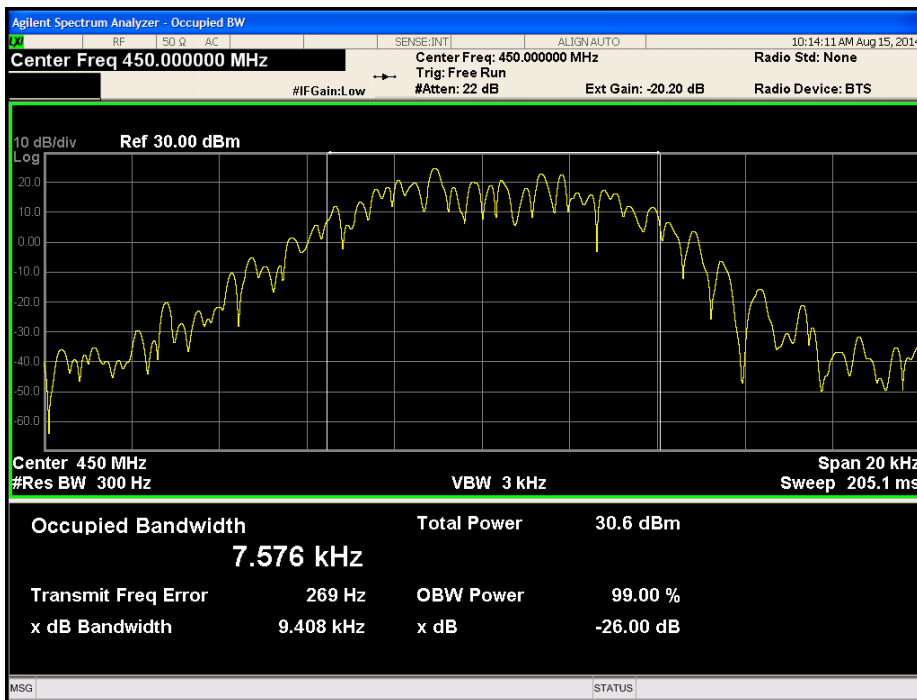
Plot 5.3.4.1.3. 99% Occupied Bandwidth for 25 kHz Channel Spacing, Digital, 470 MHz



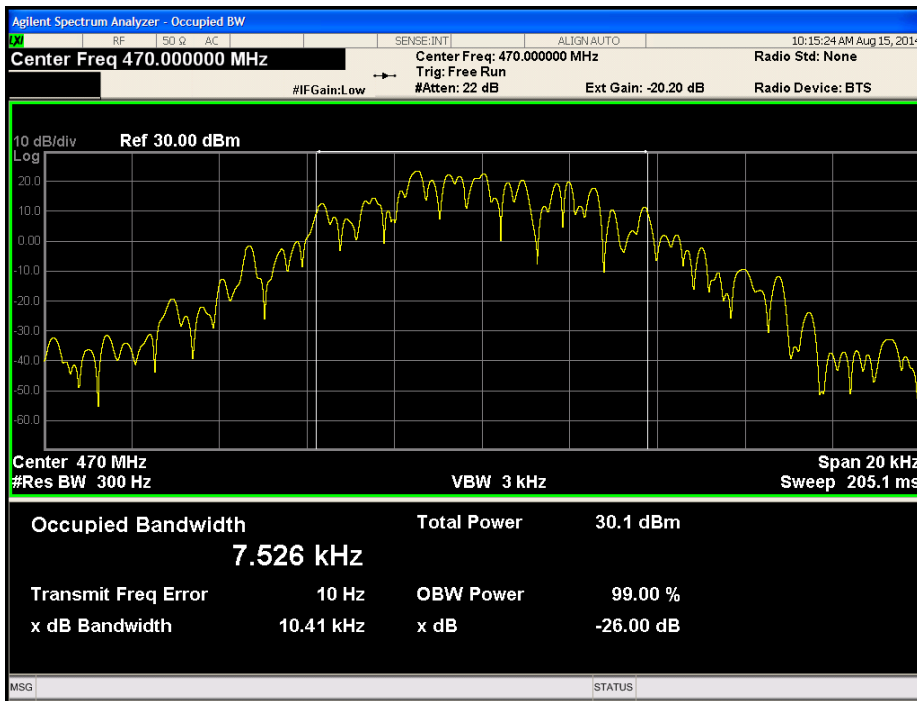
Plot 5.3.4.1.4. 99% Occupied Bandwidth for 12.5 kHz Channel Spacing, Digital, 435 MHz



Plot 5.3.4.1.5. 99% Occupied Bandwidth for 12.5 kHz Channel Spacing, Digital, 450 MHz

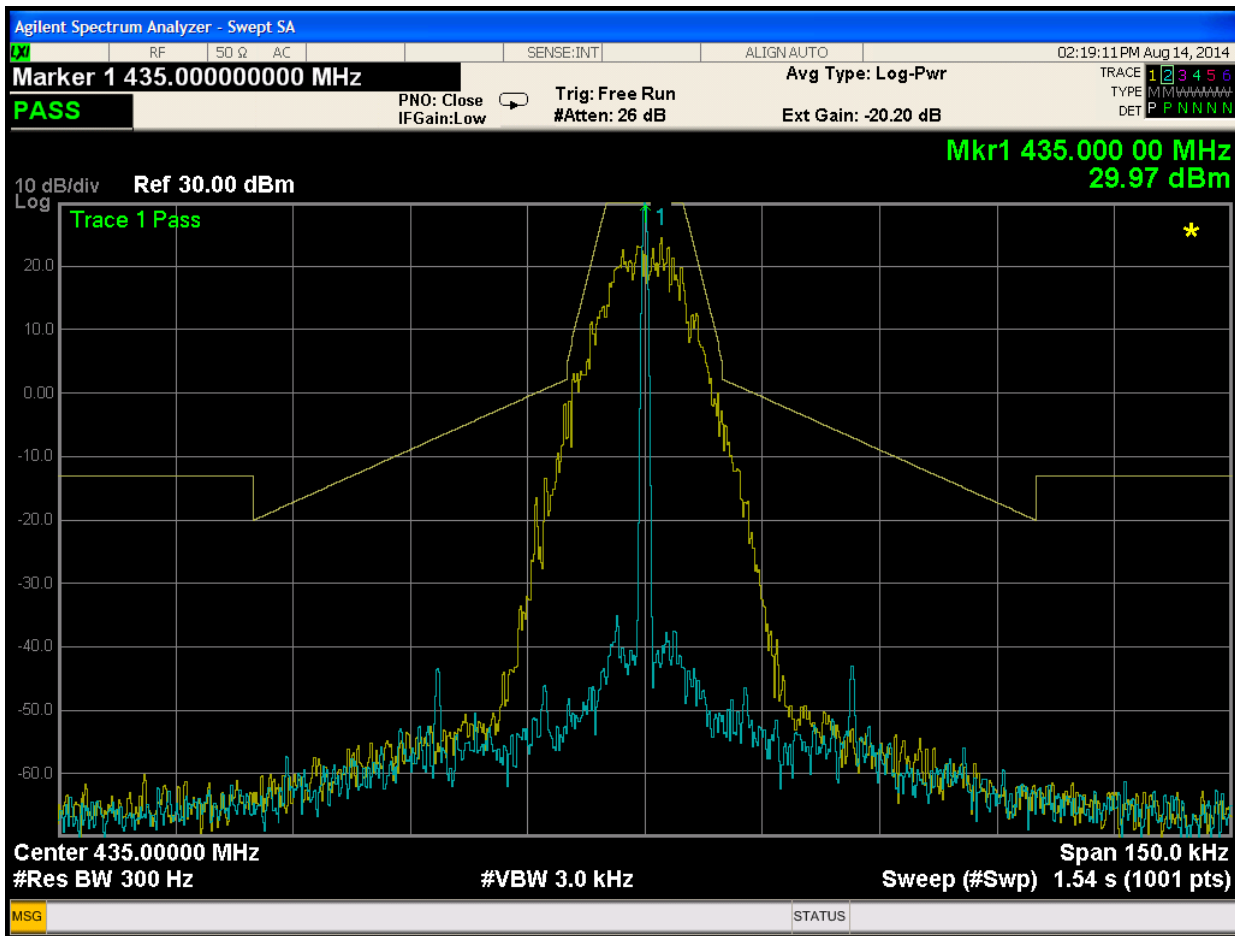


Plot 5.3.4.1.6. 99% Occupied Bandwidth for 12.5 kHz Channel Spacing, Digital, 470 MHz



5.3.4.2. Emission Mask C

Plot 5.3.4.2.1. Emission Mask C, Digital, 435 MHz



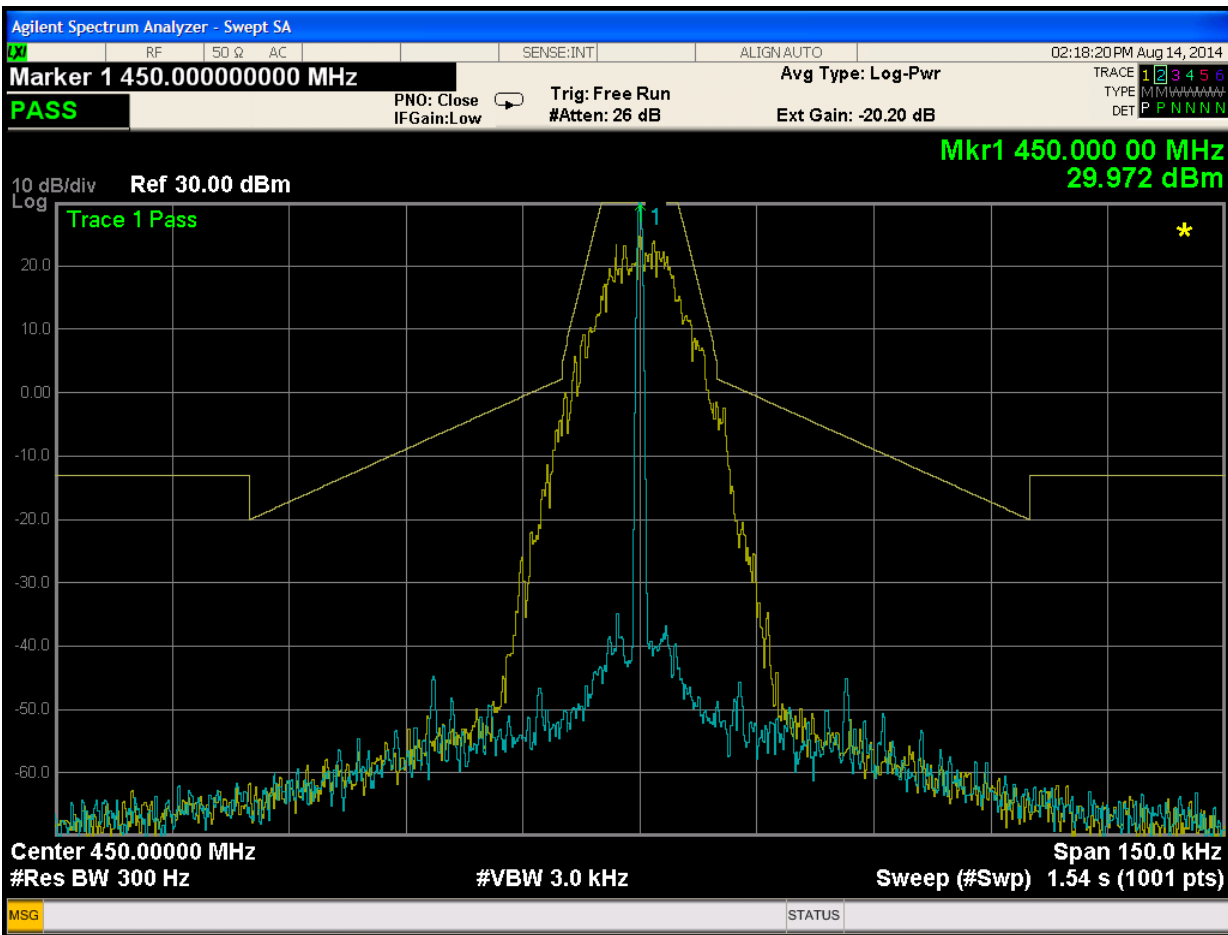
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Plot 5.3.4.2.2. Emission Mask C, Digital, 450MHz



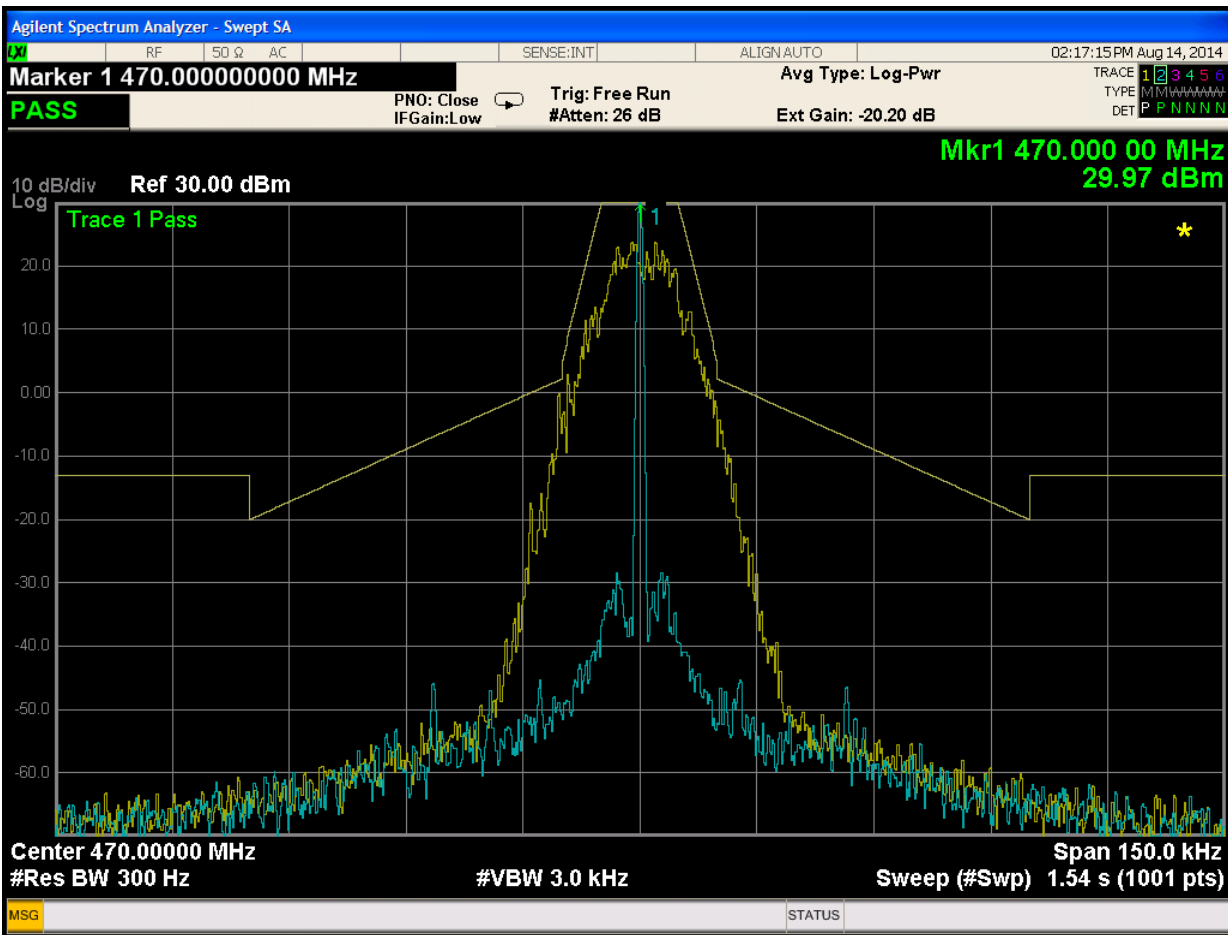
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Plot 5.3.4.2.3. Emission Mask C, Digital, 470 MHz



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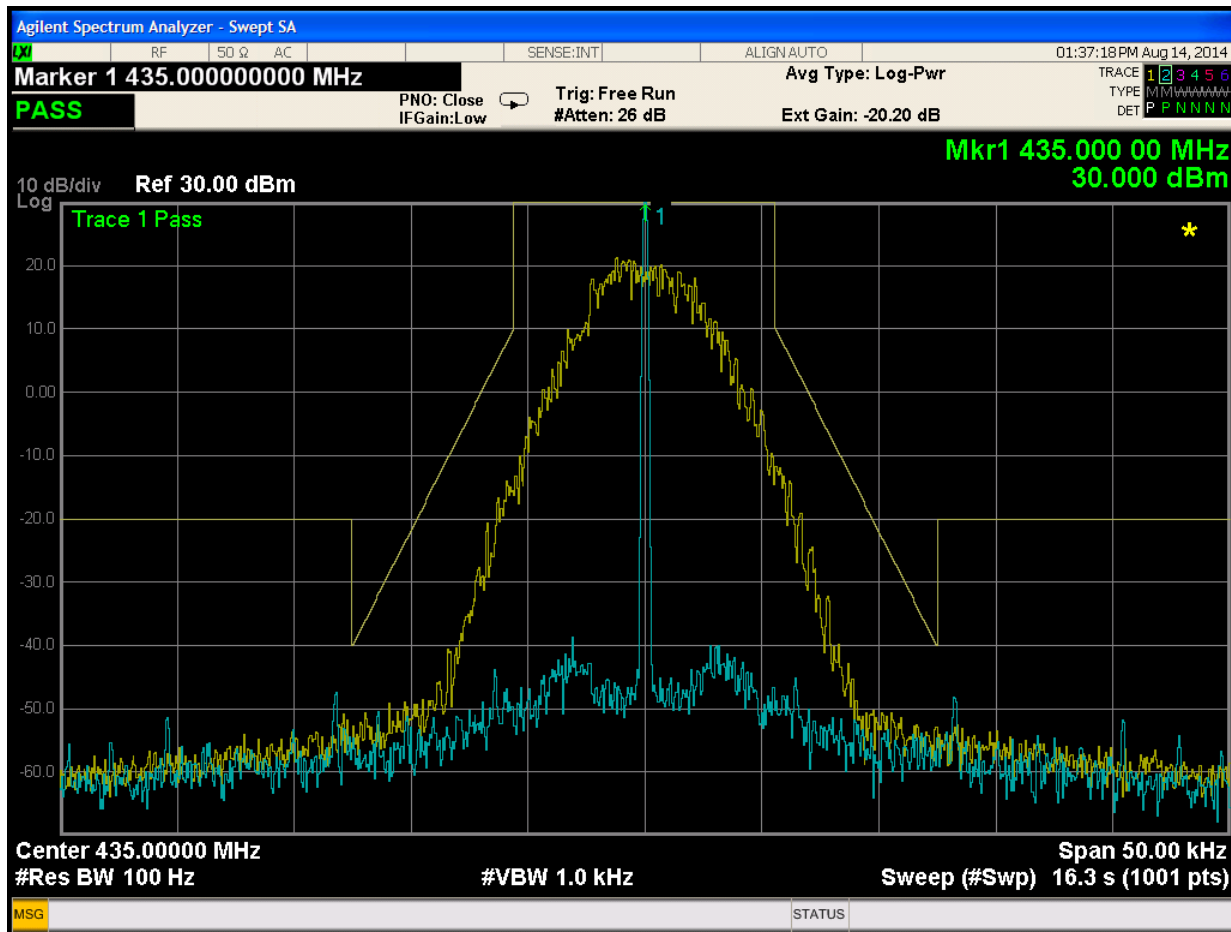
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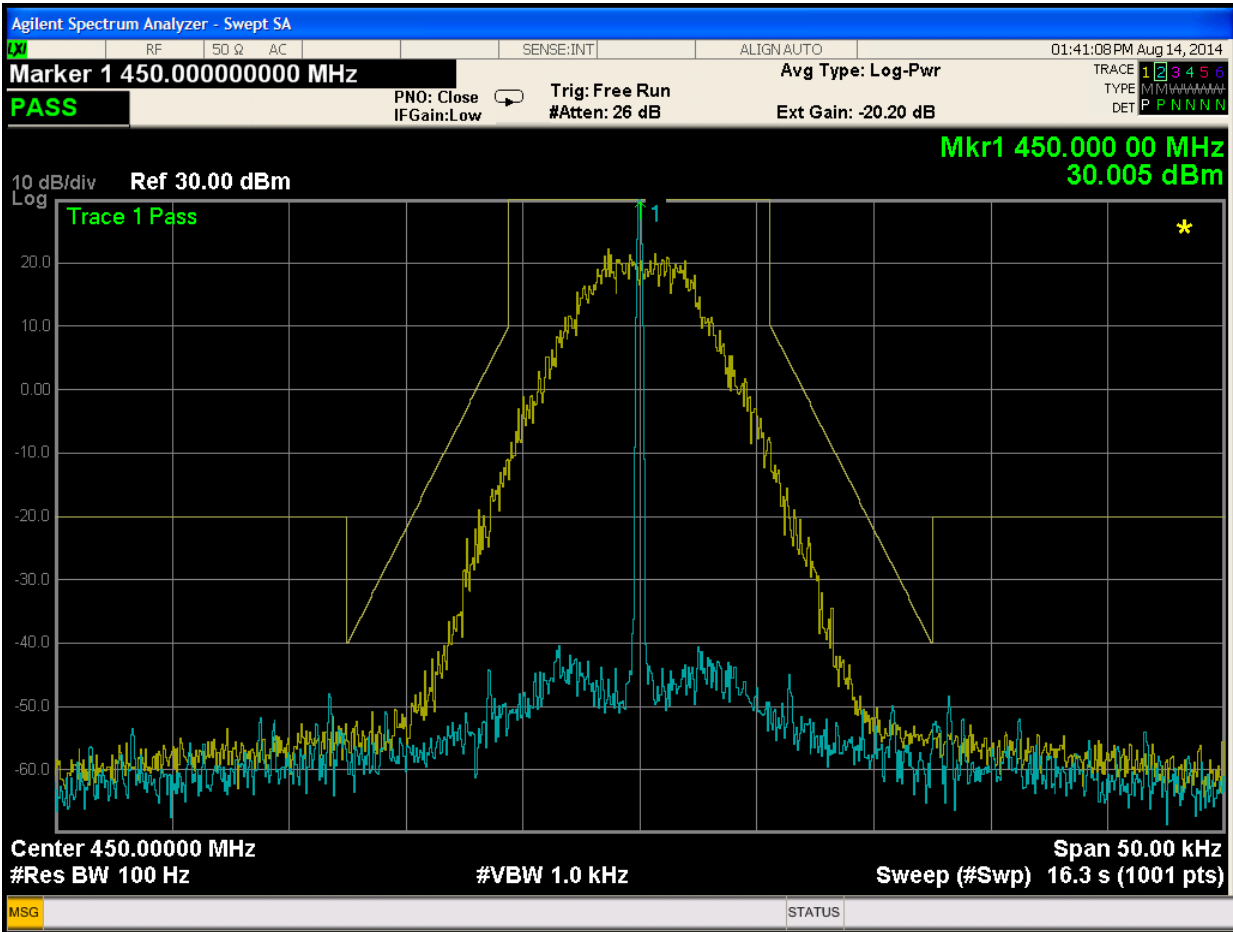
All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

5.3.4.3. Emission Mask D

Plot 5.3.4.3.1. Emission Mask D, Digital, 435 MHz



Plot 5.3.4.3.2. Emission Mask D, Digital, 450MHz



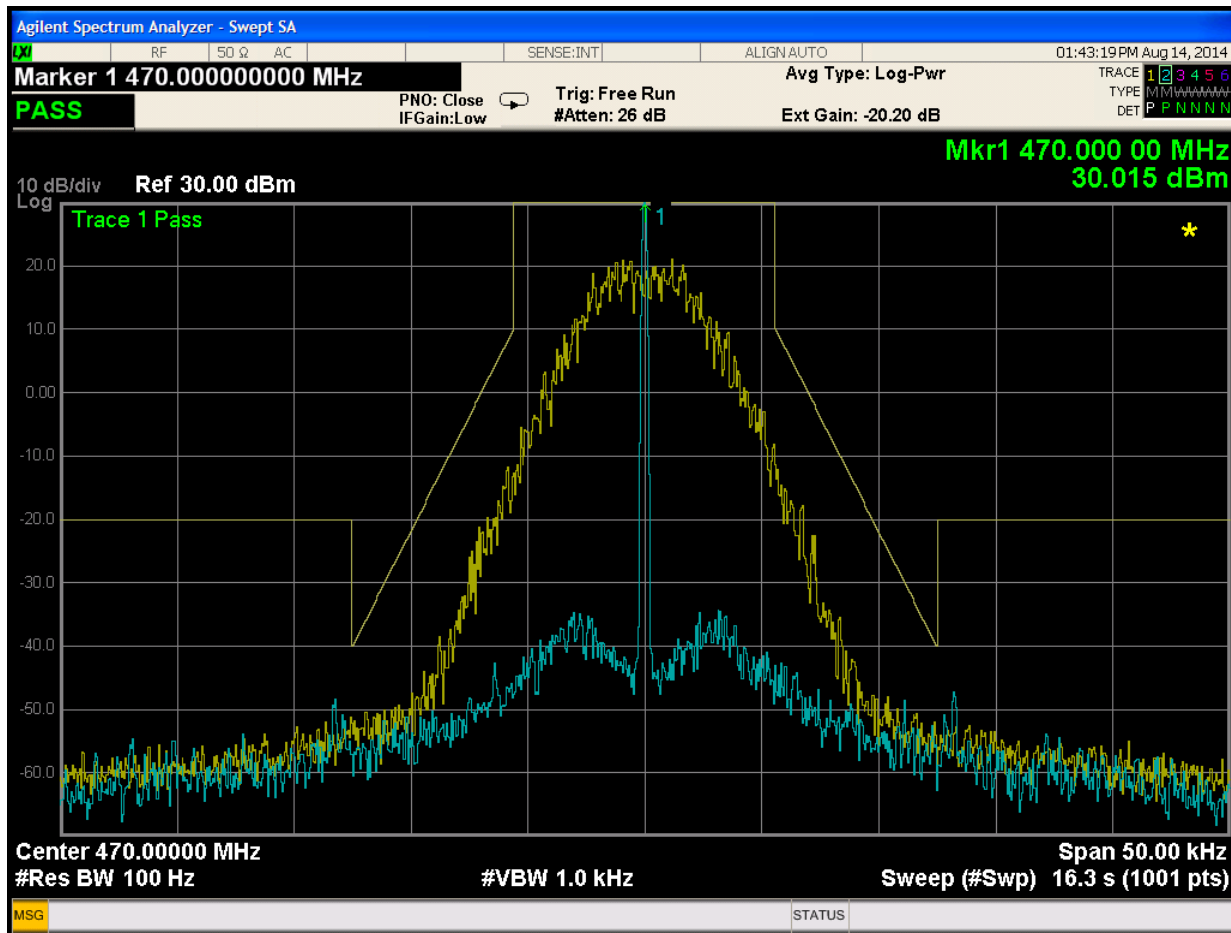
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Plot 5.3.4.3.3. Emission Mask D, Digital, 470 MHz



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File #: TEK-737F90
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5.4. SPURIOUS EMISSIONS AT ANTENNA TERMINALS [§§ 2.1051, 2.1057, 22.359(a), 74.462(c), 80.211(f)(3) & 90.210]

5.4.1. Limits

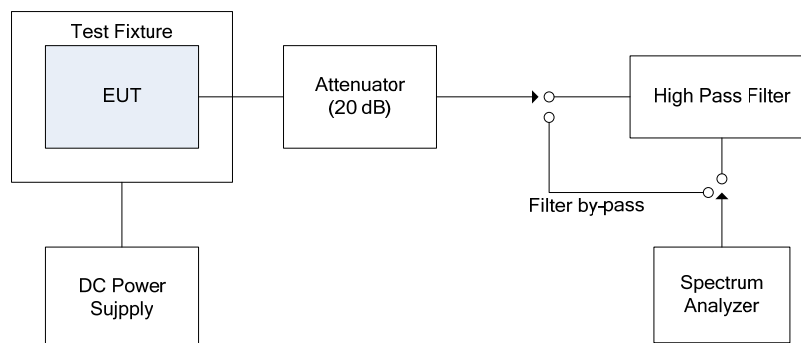
Emissions shall be attenuated below the mean output power of the transmitter as follows:

FCC Rules	Attenuation Limit (dBc)
§ 22.359(a)	At least $43 + 10 \log (P)$ dB
§74.462(c)(3)	At least 43 plus $10 \log^{10}$ (mean output power, in watts) dB
§ 80.211(f)(3),	At least $43 + 10 \log_{10}$ (mean power in watts) dB
§ 90.210(c)	At least $43 + 10 \log (P)$ dB
§ 90.210(d)	At least $50 + 10 \log (P)$ dB or 70 dB, whichever is the lesser attenuation.

5.4.2. Method of Measurements

Refer to Section 8.5 of this report for measurement details

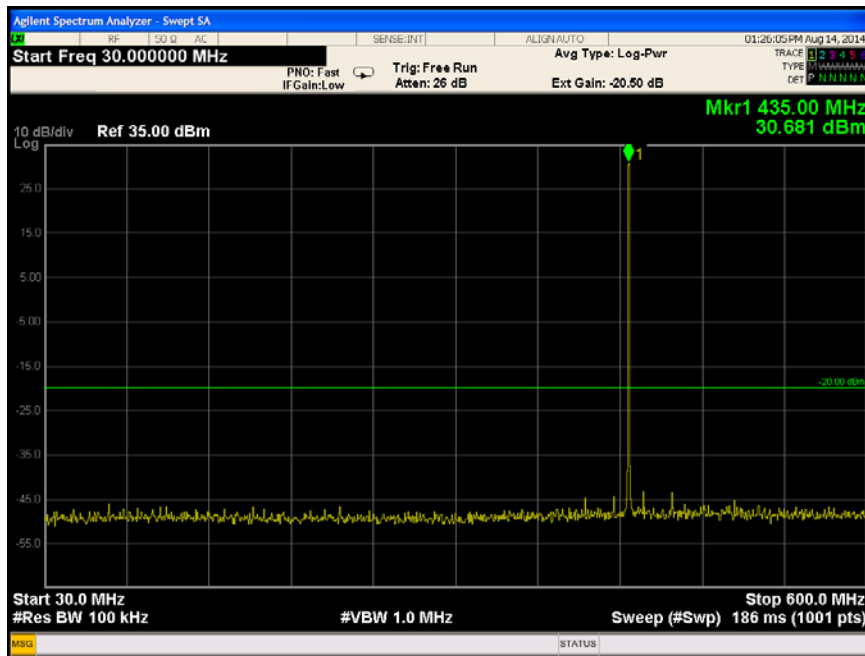
5.4.3. Test Arrangement



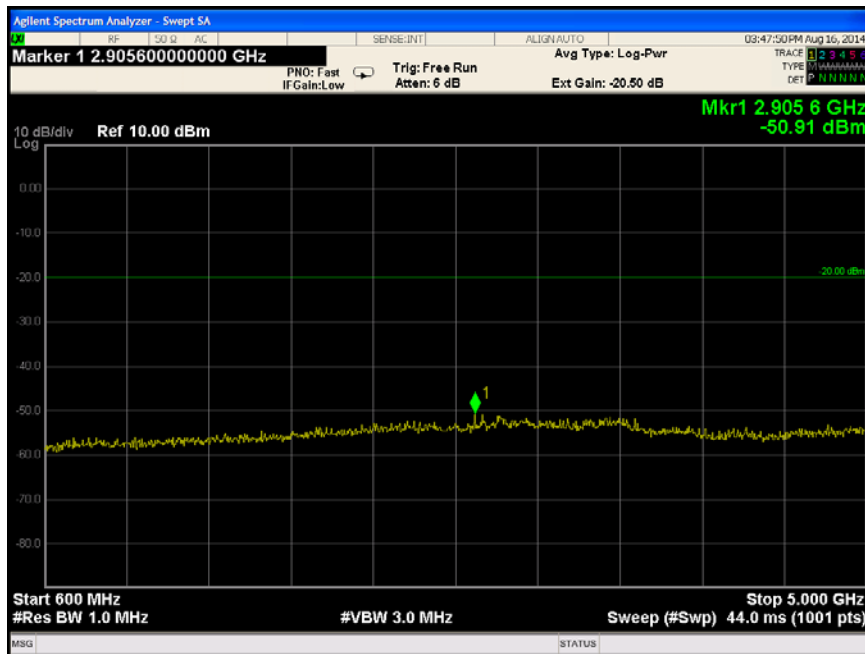
5.4.4. Test Data

Remark: Exploratory tests were conducted with modulations in the range of typical modes of operation to identify the worst-case test configuration. The worst-case test configuration for the final measurement is performed at 12.5 kHz channel spacing.

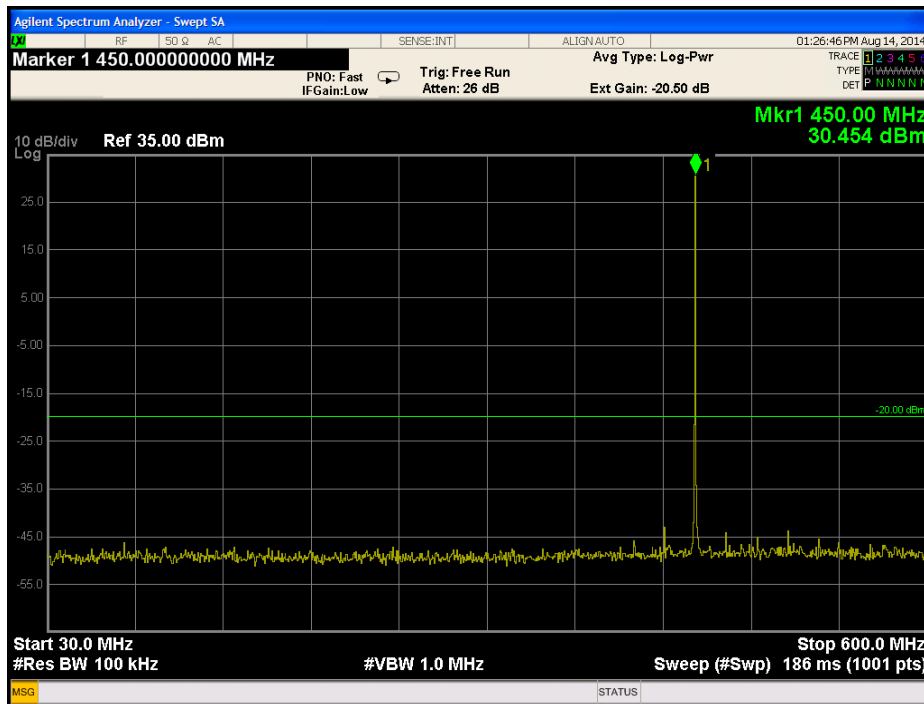
Plot 5.4.4.1. Conducted Transmitter Spurious Emissions, 435 MHz, 30 MHz – 600 MHz



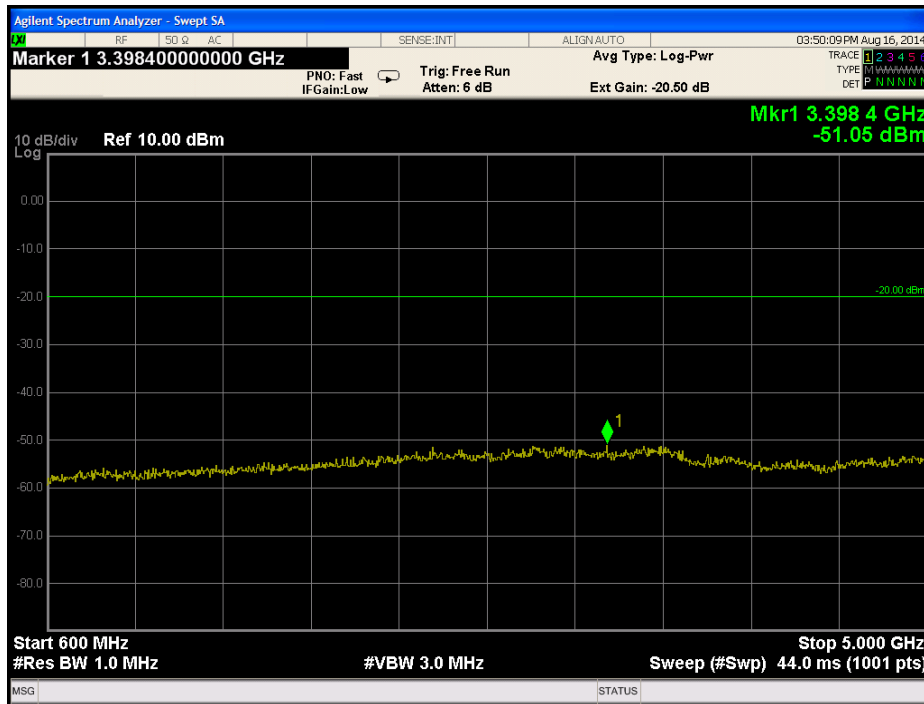
Plot 5.4.4.2. Conducted Transmitter Spurious Emissions, 435 MHz, 600 MHz – 5 GHz



Plot 5.4.4.3. Conducted Transmitter Spurious Emissions, 450 MHz, 30 MHz – 600 MHz



Plot 5.4.4.4. Conducted Transmitter Spurious Emissions, 450 MHz, 600 MHz – 5 GHz



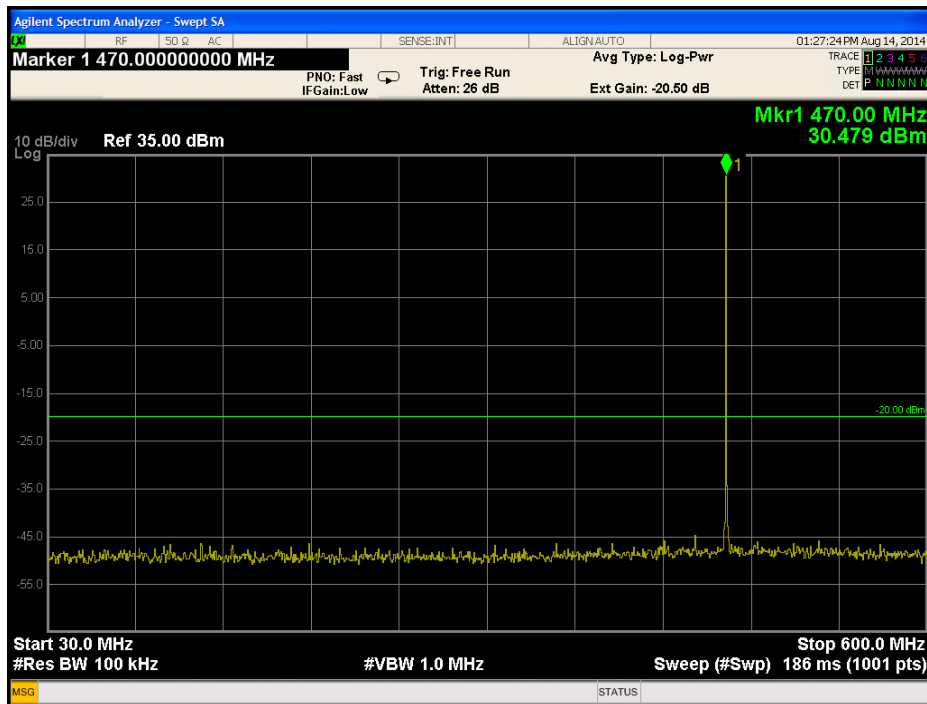
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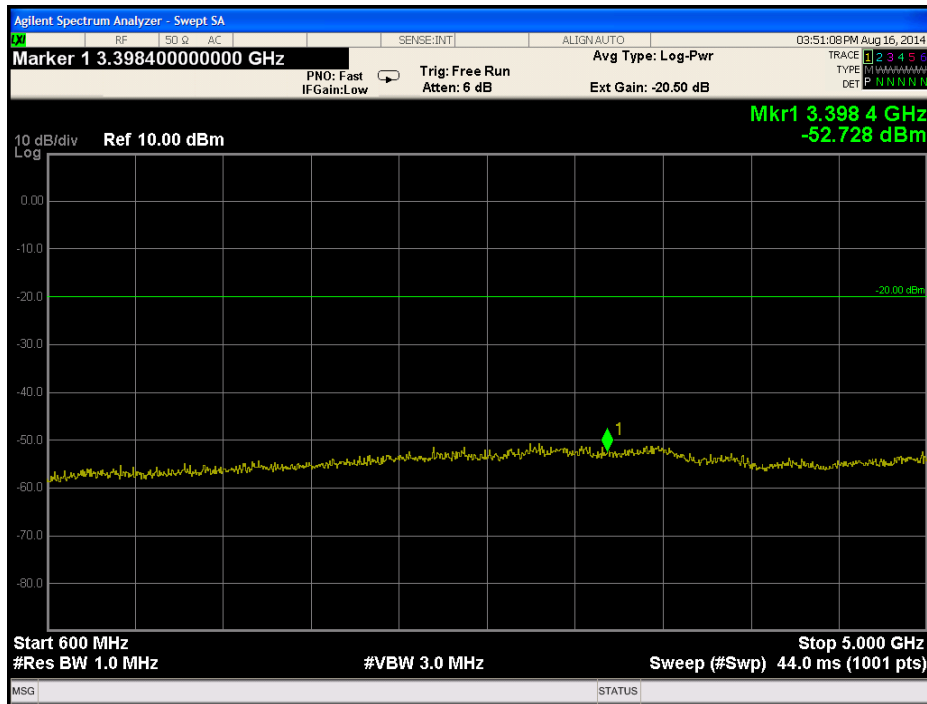
File #: TEK-737F90
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Plot 5.4.4.5. Conducted Transmitter Spurious Emissions, 470 MHz, 30 MHz – 600 MHz



Plot 5.4.4.6. Conducted Transmitter Spurious Emissions, 470 MHz, 600 MHz – 5 GHz



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5.5. FIELD STRENGTH OF SPURIOUS EMISSIONS [§§ 2.1053, 2.1057, 22.359(a), 74.462(c), 80.211(f)(3) & 90.210]

5.5.1. Limits

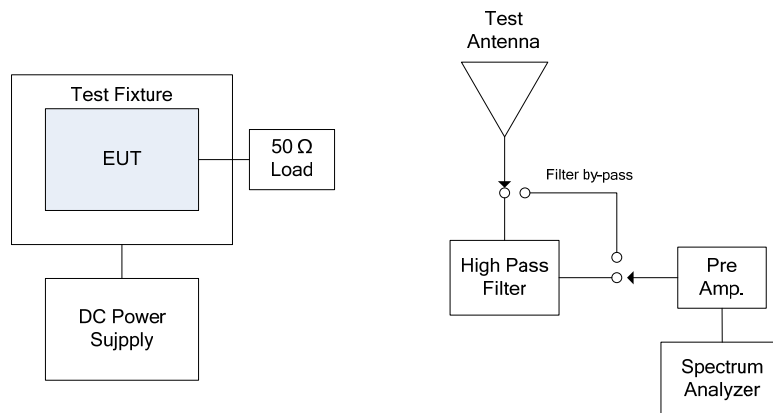
Emissions shall be attenuated below the mean output power of the transmitter as follows:

FCC Rules	Attenuation Limit (dBc)
§ 22.359(a)	At least $43 + 10 \log (P)$ dB
§74.462(c)(3)	At least 43 plus $10 \log^{10}$ (mean output power, in watts) dB
§ 80.211(f)(3),	At least $43 + 10 \log_{10}$ (mean power in watts) dB
§ 90.210(c)	At least $43 + 10 \log (P)$ dB
§ 90.210(d)	At least $50 + 10 \log (P)$ dB or 70 dB, whichever is the lesser attenuation.

5.5.2. Method of Measurements

The spurious/harmonic ERP measurements are using substitution method specified in Section 8.2 of this report.

5.5.3. Test Arrangement



5.5.4. Test Data

Remarks:

- The emissions were scanned from 30 MHz to 10th harmonics (5 GHz); all spurious emissions that are in excess of 20dB below the specified limit shall be recorded.
- The following test results are the final worst-case measurements derived from exploratory tests, performed with EUT unmodulated at 12.5 kHz channel spacing.

Test Frequency (MHz): 435						
Power conducted (dBm): 33						
Limit (dBm): -20						
Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP measured (dBm)	Limit (dBm)	Margin (dB)
30-5000	*	Peak	H/V	*	-20	*
* The amplitude of spurious emissions is more than 20 dB below the specified limit.						

Test Frequency (MHz): 450						
Power conducted (dBm): 33						
Limit (dBm): -20						
Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP Measured (dBm)	Limit (dBm)	Margin (dB)
30-5000	*	Peak	H/V	*	-20	*
* The amplitude of spurious emissions is more than 20 dB below the specified limit.						

Test Frequency (MHz): 470						
Power conducted (dBm): 33						
Limit (dBm): -20						
Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP Measured (dBm)	Limit (dBm)	Margin (dB)
30-5000	*	Peak	H/V	*	-20	*
* The amplitude of spurious emissions is more than 20 dB below the specified limit.						

5.6. FREQUENCY STABILITY [§§ 2.1055, 22.355, 74.464, 80.209 & 90.213]

5.6.1. Limits

§22.355 Frequency tolerance

Frequency Tolerance for Transmitters in the Public Mobile Services			
Frequency range (MHz)	Base, fixed (ppm)	Mobile ≤3 watts (ppm)	Mobile ≤3 watts (ppm)
50 to 450	5.0	5.0	50.0
450 to 512	2.5	5.0	5.0

§74.464 Frequency tolerance

For operations on frequencies above 25 MHz using authorized bandwidths up to 30 kHz, the licensee of a remote pickup broadcast station or system shall maintain the operating frequency of each station in compliance with the frequency tolerance requirements of §90.213 of this chapter. For all other operations, the licensee of a remote pickup broadcast station or system shall maintain the operating frequency of each station in accordance with the following:

Frequency range	Tolerance (percent)	
	Base station	Mobile station
300 to 500 MHz, all powers	.00025	.0005

§80.209 Transmitter frequency tolerances

(a) The frequency tolerance requirements applicable to transmitters in the maritime services are shown in the following table. Tolerances are given as parts in 10⁶ unless shown in Hz.

Frequency bands and categories of stations	Tolerances ¹
(7) Band 400-466 MHz:	
(i) EPIRBs operating on 406-406.1 MHz	5.
(ii) On-board stations	5.
(iii) Radiolocation and telecommand stations.	5.

¹Transmitters authorized prior to January 2, 1990, with frequency tolerances equal to or better than those required after this date will continue to be authorized in the maritime services provided they retain approval and comply with the applicable standards in this part.

§90.213 Frequency stability

Minimum Frequency Stability (ppm)			
Frequency range (MHz)	Fixed and base stations	Mobile stations	
		Over 2 watts output power	2 watts or less output power
421-512	^{1 3 4} 2.5	^{2 5}	^{2 5}

¹In the 421-512 MHz band, fixed and base stations with a 12.5 kHz channel bandwidth must have a frequency stability of 1.5 ppm. Fixed and base stations with a 6.25 kHz channel bandwidth must have a frequency stability of 0.5 ppm.

²In the 421-512 MHz band, mobile stations designed to operate with a 12.5 kHz channel bandwidth must have a frequency stability of 2.5 ppm. Mobile stations designed to operate with a 6.25 kHz channel bandwidth must have a frequency stability of 1.0 ppm.

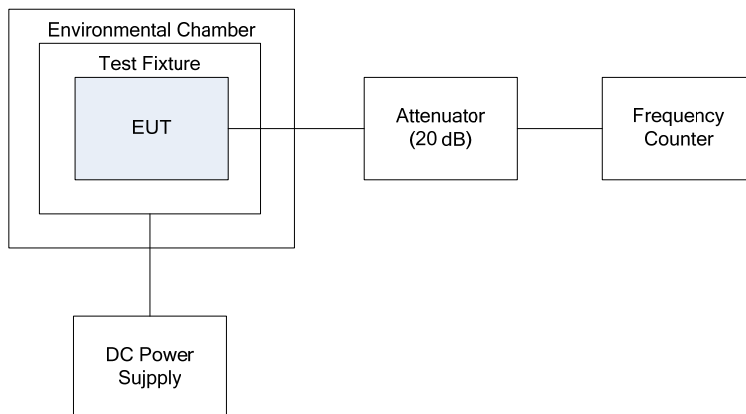
³Paging transmitters operating on paging-only frequencies must operate with frequency stability of 5 ppm in the 150-174 MHz band and 2.5 ppm in the 421-512 MHz band.

⁴Control stations may operate with the frequency tolerance specified for associated mobile frequencies.

5.6.2. Method of Measurements

Refer to Section 8.3 of this report for measurement details.

5.6.3. Test Arrangement



5.6.4. Test Data

Test Frequency:		435 MHz		
Full Power Level:		29.95 dBm		
Frequency Tolerance Limit:		± 1.5 ppm or ± 653 Hz		
Max. Frequency Tolerance Measured:		+380 Hz or 0.87 ppm		
Input Voltage Rating:		3.7 VDC (nominal)		
Ambient Temperature (°C)	Frequency Drift (Hz)			
	Supply Voltage (Nominal) 3.7 VDC	Supply Voltage (85% of Nominal) 3.2 VDC	Supply Voltage (115% of Nominal) 4.3 VDC	
-30	-212	--	--	
-20	-54	--	--	
-10	+45	--	--	
0	+45	--	--	
+10	+50	--	--	
+20	-17	-11	-15	
+30	-41	--	--	
+40	-108	--	--	
+50	-143	--	--	
+60	-141	--	--	
+70	-139	--	--	
+80	-106	--	--	
+85	+380	--	--	

5.7. TRANSIENT FREQUENCY BEHAVIOR [§§ 90.214 & 74.462(c)]

5.7.1. Limits

Transient frequencies must be within the maximum frequency difference limits during the time intervals indicated:

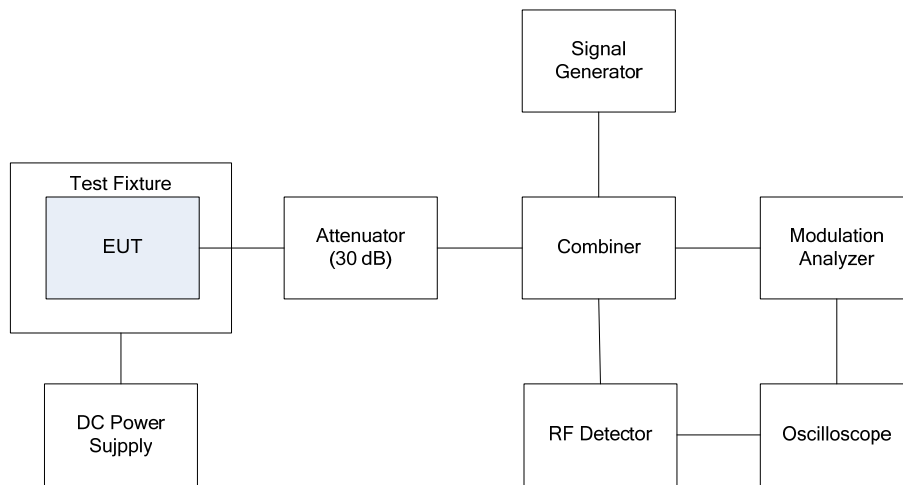
Time intervals ^{1, 2}	Maximum frequency difference ³	All equipment	
		150 to 174 MHz	421 to 512MHz
Transient Frequency Behavior for Equipment Designed to Operate on 25 KHz Channels			
t ₁ ⁴	± 25.0 KHz	5.0 ms	10.0 ms
t ₂	± 12.5 KHz	20.0 ms	25.0 ms
t ₃ ⁴	± 25.0 KHz	5.0 ms	10.0 ms
Transient Frequency Behavior 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

- t_{on} is the instant when a 1 kHz test signal is completely suppressed, including any capture time due to phasing.
 t₁ is the time period immediately following t_{on}.
 t₂ is the time period immediately following t₁.
 t₃ is the time period from the instant when the transmitter is turned off until t_{off}.
 t_{off} is the instant when the 1 kHz test signal starts to rise.
- During the time from the end of t₂ to the beginning of t₃, the frequency difference must not exceed the limits specified in § 90.213.
- Difference between the actual transmitter frequency and the assigned transmitter frequency.
- If the transmitter carrier output power rating is 6 Watts or less, the frequency difference during this time period may exceed the maximum frequency difference for this time period.

5.7.2. Method of Measurements

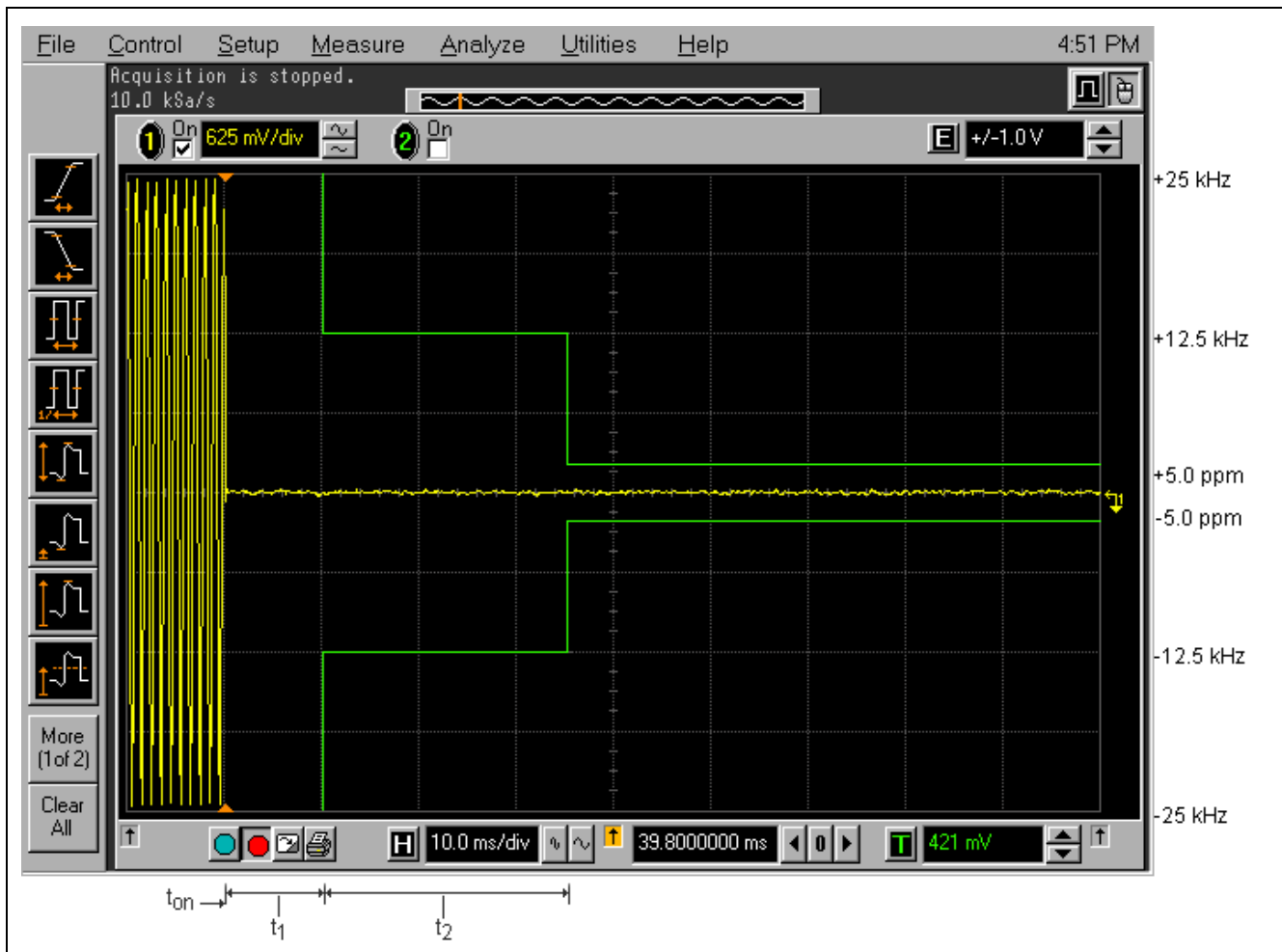
Refer to Section 8.6 of this test report and ANSI/TIA/EIA-603-D-2010, Section 2.

5.7.3. Test Arrangement



5.7.4. Test Data

Plot 5.7.4.1. Transient Frequency Behavior for 25 kHz Channel Spacing
435 MHz, Switch on condition t_{on} , t_1 , and t_2



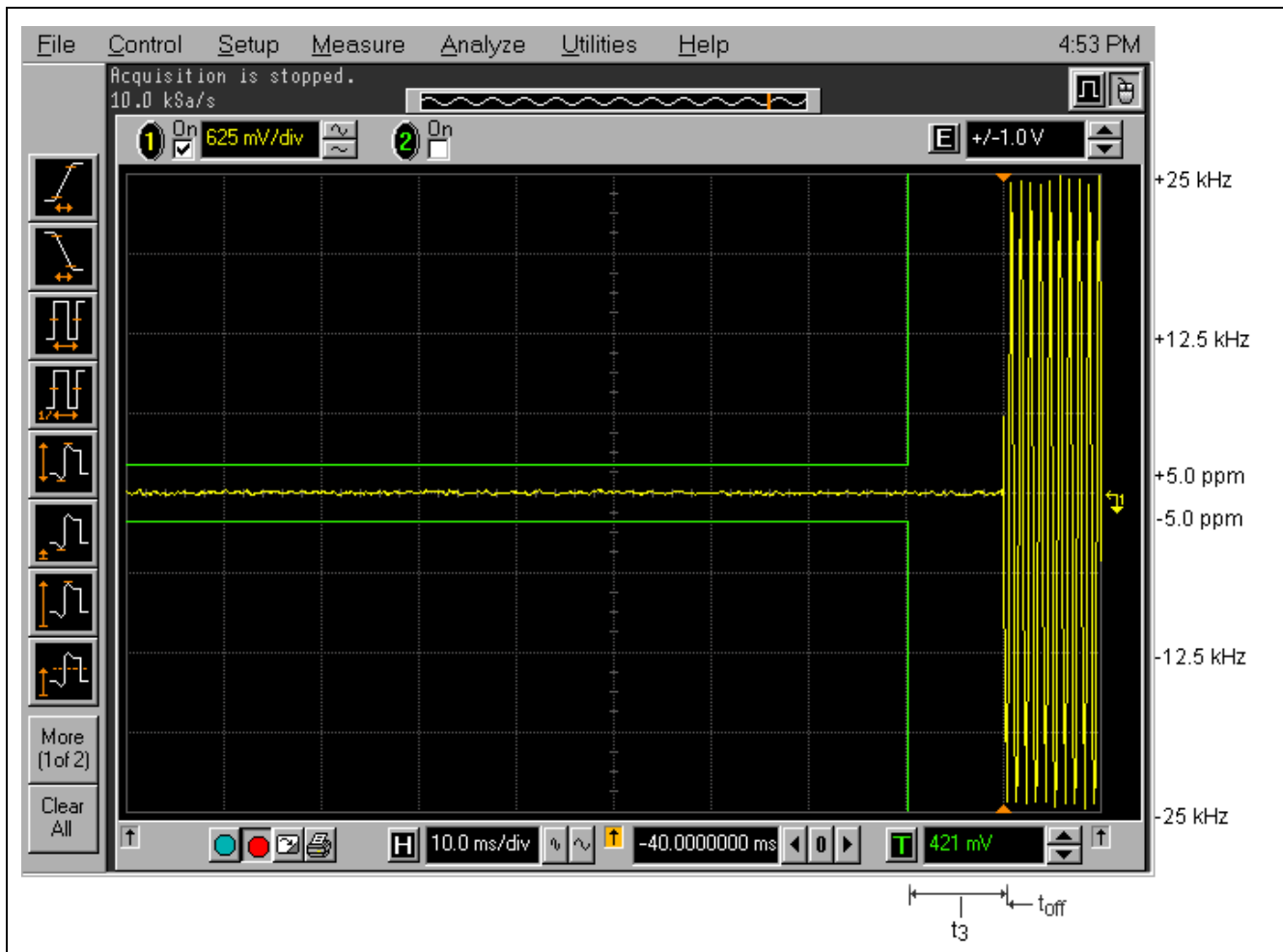
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Plot 5.7.4.2. Transient Frequency Behavior for 25 kHz Channel Spacing
435 MHz, Switch off condition t_3 , t_{off}



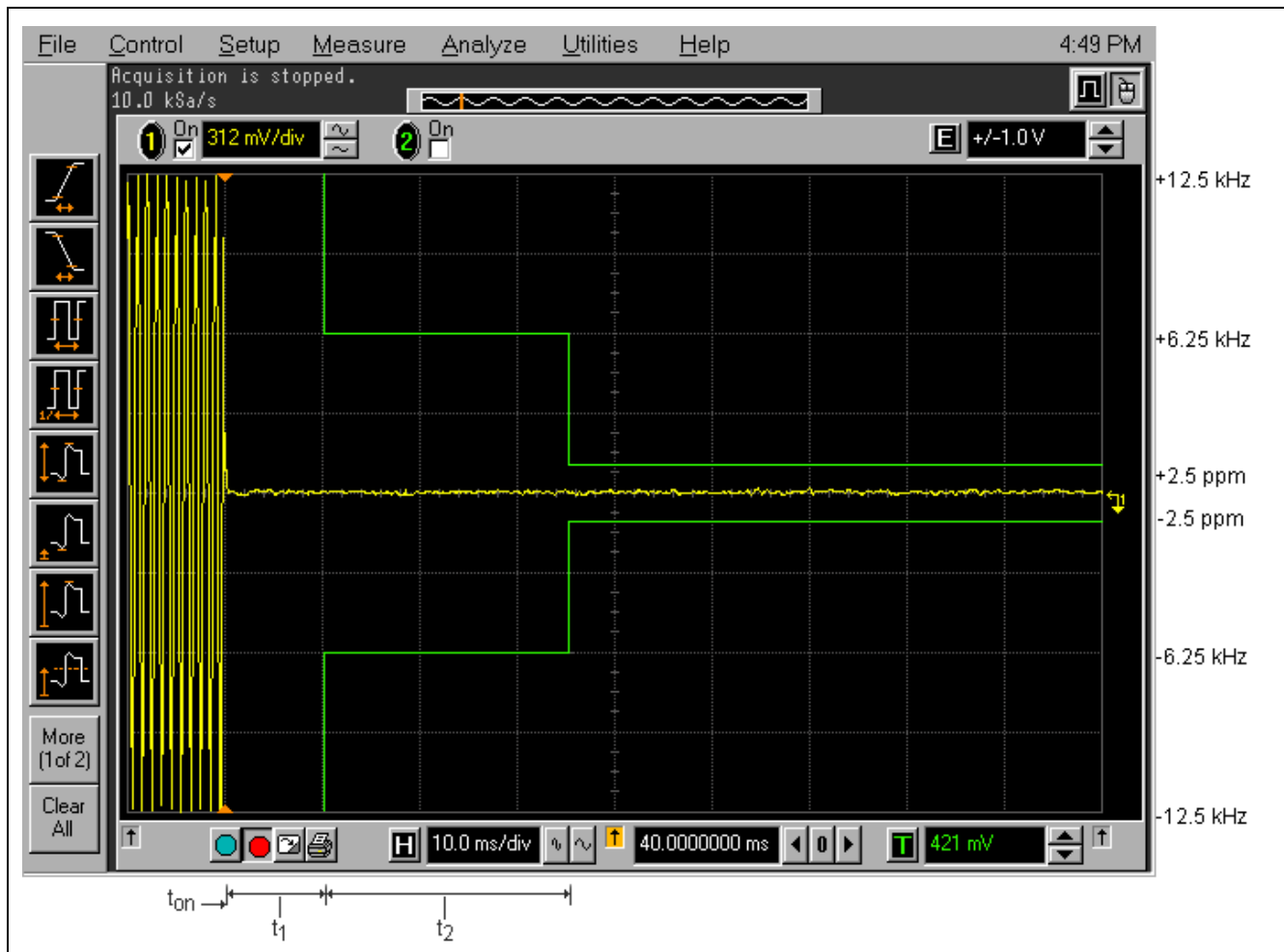
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Plot 5.7.4.3. Transient Frequency Behavior for 12.5 kHz Channel Spacing
435 MHz, Switch on condition t_{on} , t_1 , and t_2



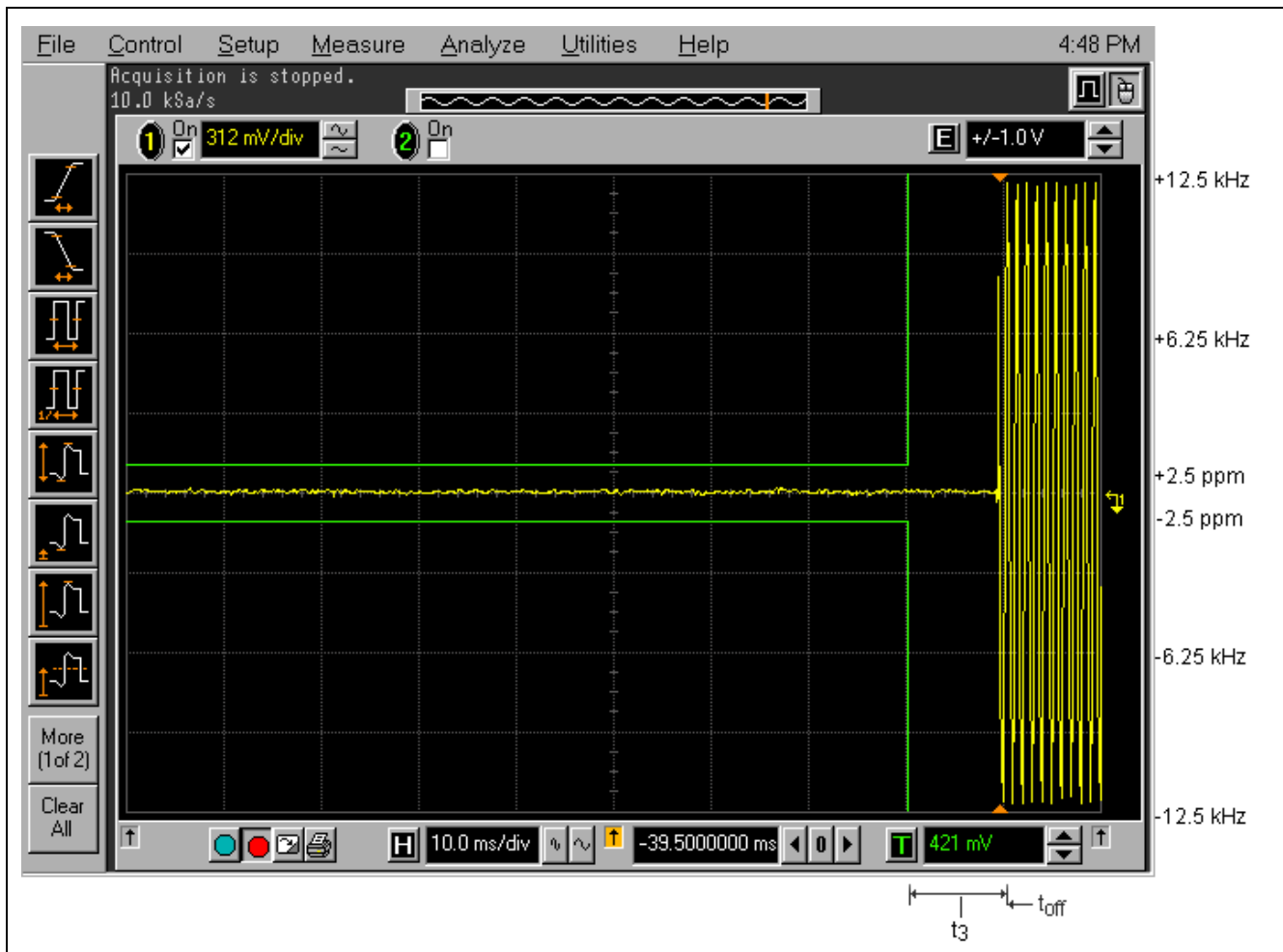
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Plot 5.7.4.4. Transient Frequency Behavior for 12.5 kHz Channel Spacing
435 MHz, Switch off condition t_3 , t_{off}



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5.8. EXPOSURE OF HUMANS TO RF FIELD [[§§ 1.1310 & 2.1091]

§ 1.1310: The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b).

Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3-3.0	614	1.63	*(100)	6
3.0-30	1842/f	4.89/f	*(900/f ²)	6
30-300	61.4	0.163	1.0	6
300-1500			f/300	6
1500-100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*(180/f ²)	30
30-300	27.5	0.073	0.2	30
300-1500			f/1500	30
1500-100,000			1.0	30

f = frequency in MHz

* = Plane-wave equivalent power density

Note 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

Note 2: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

5.8.1. Method of Measurements

Calculation Method of RF Safety Distance:

$$S = \frac{PG}{4\pi \cdot r^2} = \frac{EIRP}{4\pi \cdot r^2}$$

Where, P: power input to the antenna in mW
 EIRP: Equivalent (effective) isotropic radiated power.
 S: power density mW/cm²
 G: numeric gain of antenna relative to isotropic radiator
 r: distance to centre of radiation in cm

$$r = \sqrt{\frac{PG}{4\pi \cdot S}} = \sqrt{\frac{EIRP}{4\pi \cdot S}}$$

5.8.2. Evaluation of RF Exposure Compliance Requirements

The EUT is evaluated in stand-alone and in specific host (FCC ID: GM38516) for collocation MPE.

5.8.2.1. Stand-alone MPE Evaluation

Maximum RF Power conducted, P_{conducted}[dBm]:	30
Maximum Antenna Gain, G[dBi]:	12
Maximum EIRP, P_{EIRP}[dBm]:	42
MPE Limit for General Population/Uncontrolled Exposure, S_{controlled}[mW/cm²]:	0.29
Calculated RF Safety Distance for General Population/Uncontrolled Exposure, r_{safety_controlled}[cm]:	66 cm

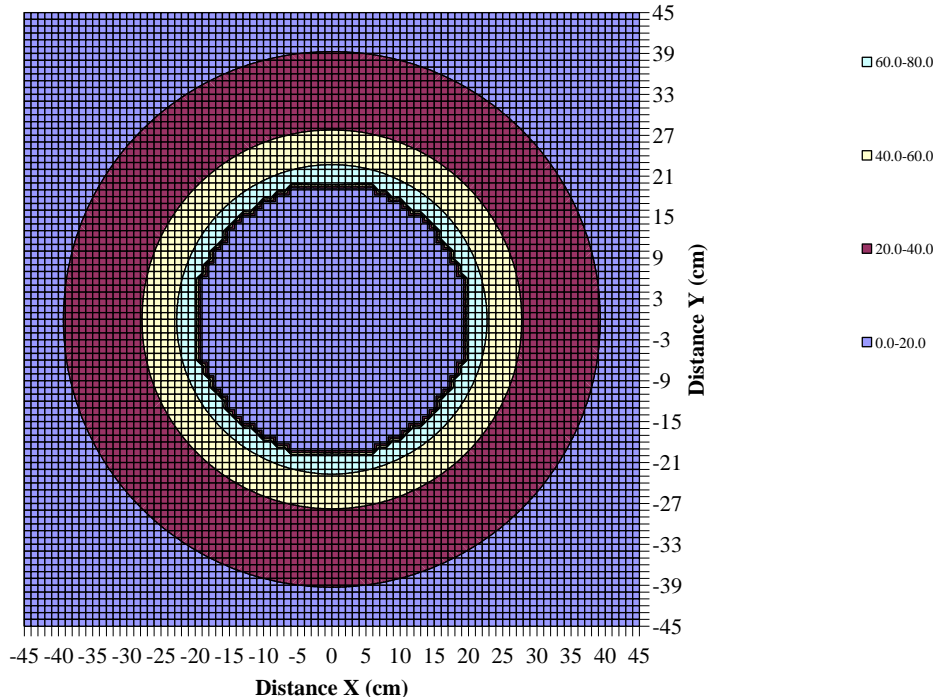
5.8.2.2. EUT Collocated with Specific Host (FCC ID: GM38516) MPE Evaluation

Using the spreadsheet for Mobile Multi-transmitter MPE Estimation from KDB 447498, below is worst case evaluation for the EUT with 0 dBi (Antenna No. 1) and the transmitters in the host device (Antenna No. 2)

Antenna No.		Total	1	2
Tx Status			On	On
Frequency	MHz		435	2412
MPE Limit	mW/cm ²		0.29	1.00
Max % MPE	%	77.0	68.6	8.4
Power	(W)	1.134	1.000	0.134
Antenna Gain	dBi		0.00	5.00
EIRP	(W)	1.42	1.000	0.424
X	(cm)		0.0	0.0
Y	(cm)		0.0	0.0
Sector			FALSE	FALSE
Arc			FALSE	FALSE
θ ₁	degs	input	-120	-120
θ ₂			60	60
θ ₁		actual	-120	-120
θ ₂			60	60

% MPE Contour

Note: The 0% contour surrounding the antennas identifies a 20 cm perimeter surrounding all active antennas



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5.9. POWER LINE CONDUCTED EMISSIONS [§ 15.107]

5.9.1. Limits

The equipment shall meet the limits of the following table:

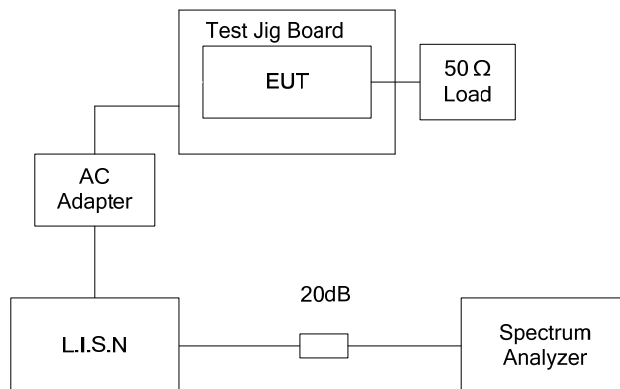
Frequency of emission (MHz)	Conducted Limits (dB μ V)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

*Decreases with the logarithm of the frequency.

5.9.1.1. Method of Measurements

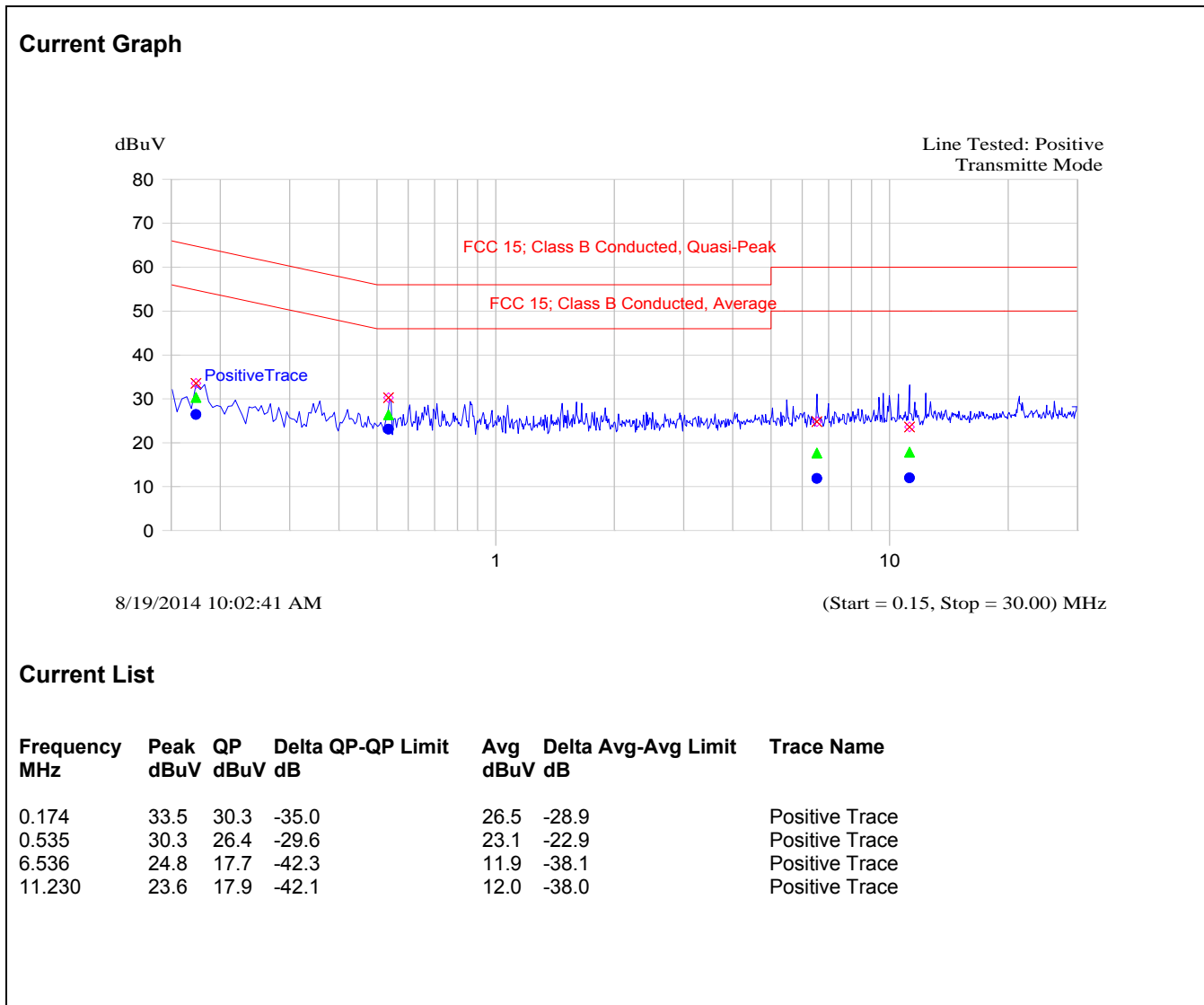
Refer to Ultratech Test Procedures ULTR-P001-2004 & ANSI C63.4-2009 for method of measurements.

5.9.2. Test Arrangement

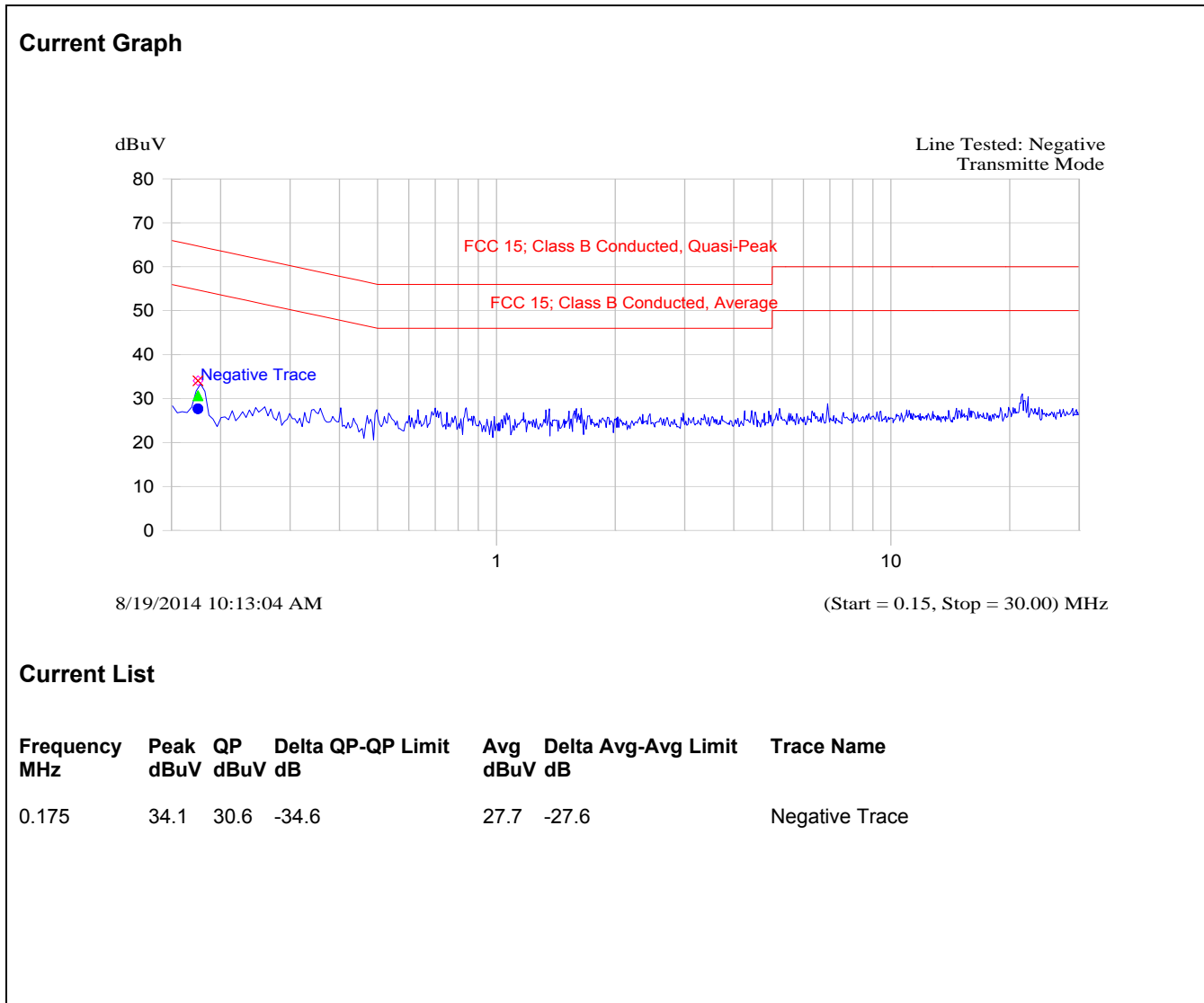


5.9.3. Test Data

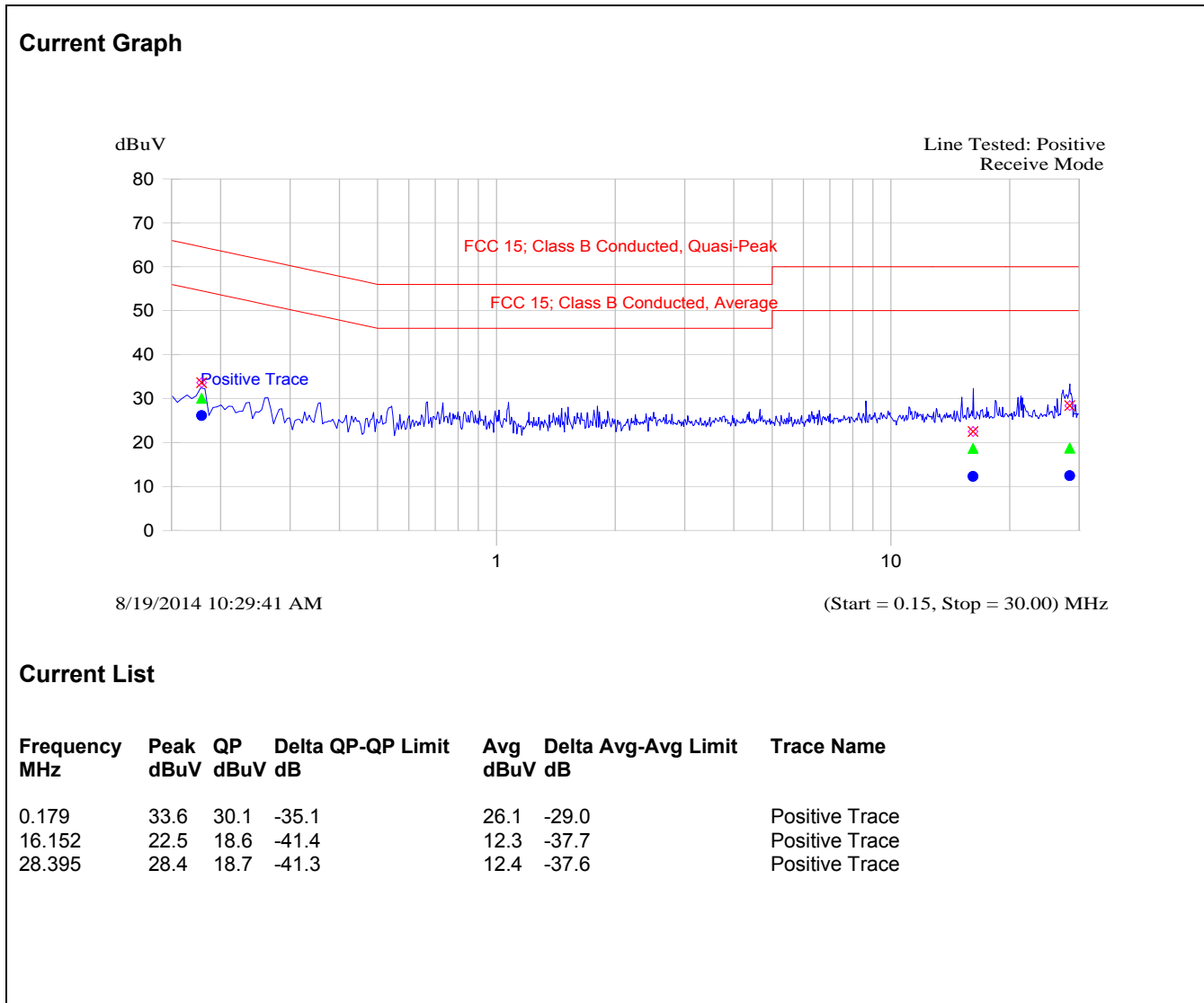
Plot 5.9.3.1. Power Line Conducted Emissions (Tx Mode)
 Line Voltage: 3.7 VDC; Line Tested: Positive



Plot 5.9.3.2. Power Line Conducted Emissions (Tx Mode)
 Line Voltage: 3.7 VDC; Line Tested: Negative



Plot 5.9.3.3. Power Line Conducted Emissions (Rx Mode)
 Line Voltage: 3.7 VDC; Line Tested: Positive



Plot 5.9.3.4. Power Line Conducted Emissions (Rx Mode)
 Line Voltage: 3.7 VDC; Line Tested: Negative

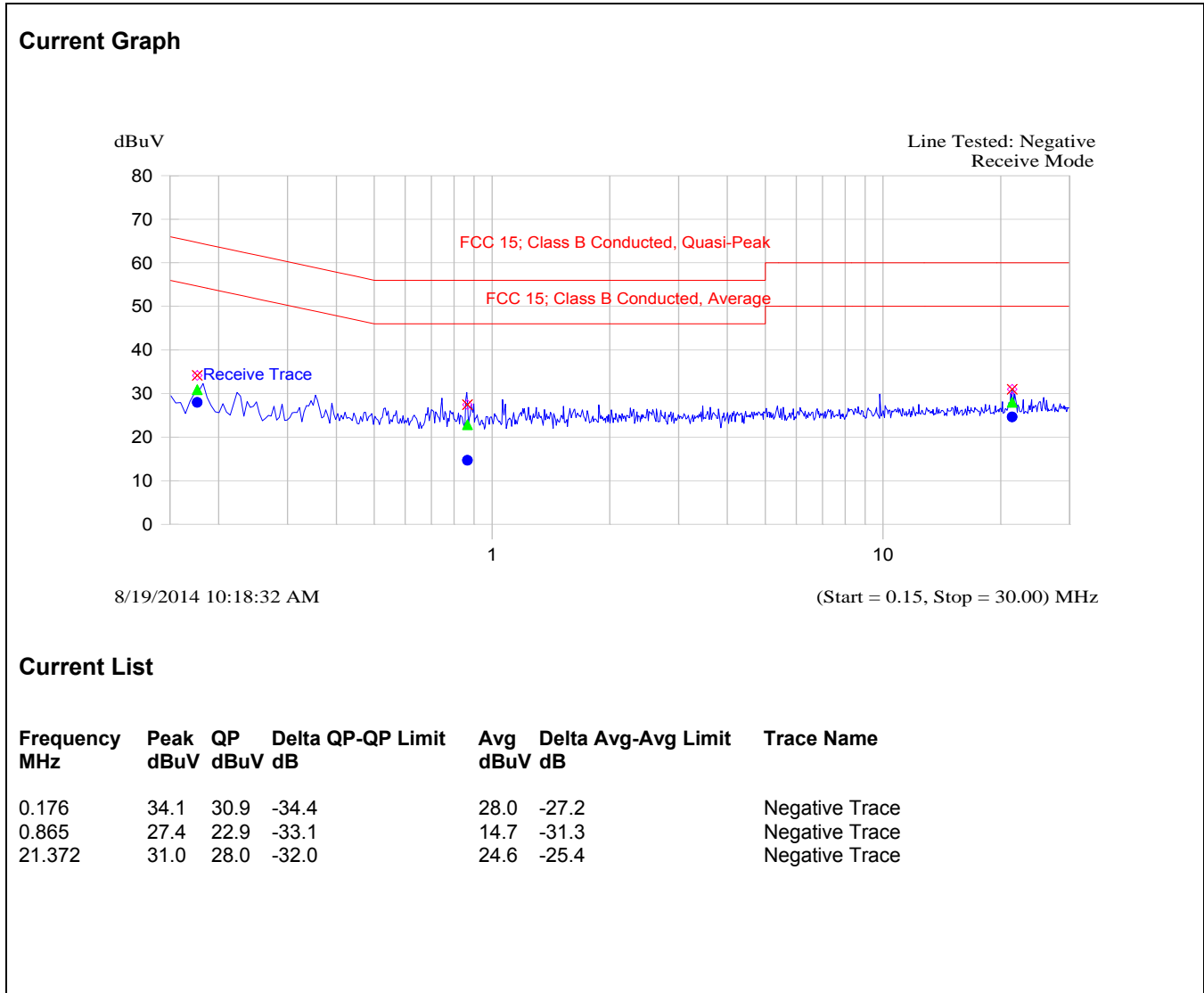


EXHIBIT 6. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Operating Range	Cal. Due Date
Spectrum Analyzer	Rohde & Schwarz	FSEK	834157/005	9 kHz – 40 GHz	03 Jan 2015
Attenuator (20dB)	Aeroflex/Weinschel	23-20-34	BH7876	DC - 18 GHz	See Note 1
High Pass Filter	Mini Circuit	SHP 250	--	Cut off 230 MHz	See Note 1
Power Meter	Hewlett Packard	438A	3008A06729	100K--50G sensor dependent	10 Apr 2015
Power Sensor	Hewlett Packard	8482A	US37295944	100 kHz - 4.2 GHz	26 Feb 2015
Environmental Chamber	Envirotronics	SSH32C	11994847-S-11059	-60 to 177 °C	16 Apr 2015
Programmable Power Supply	Rohde & Schwarz	HMP4040	1939038	0-32V DC 10A X4	See Note 1
Horn Antenna	ETS-LINDGREN	3117	119425	1 – 18 GHz	02 May 2015
Preamplifier	COM-POWER	PA-103A	161243	10 MHz – 1 GHz	30 Jun 2015
Preamplifier	COM-POWER	PA-118A	551016	500 MHz – 18 GHz	14 Nov 2014
Antenna	ETS	3148	1101	200 - 2000 MHz	14 Apr 2015
Frequency Counter	EIP	545A	2683	10 Hz - 18 GHz	07 Apr 2015
High Pass Filter	Mini Circuit	SHP 600	--	Cut off 560 MHz	See Note 1
PXA Signal Analyzer	Agilent Technoligics	N9030A	MY53120273	3 Hz - 8.4 GHz	27 Apr 2016
Combiner	Mini Circuit	ZFSC-3-4	15542	1 MHz – 1 GHz	See Note 1
RF Detector	Pasternack	PE8000-50	--	10 MHz -1 GHz	See Note 1
Infinium Digital Oscilloscope	Hewlett-Packard	54801A	US38380192	DC--500M Hz 1G sampling	16 Jun 2015
RF Synthesized Signal Generator	HP	8648C	3343U00391	100 kHz – 3200 MHz AM/ FM/ PM	03 Jan 2015
Modulation Analyzer	Hewlett Packard	8901B	3226A04606	150 kHz – 1300 MHz	29 Jan 2015
Spectrum Analyzer	Agilent	E7401A	US40240432	9 kHz - 1.5 GHz	14 Mar 2015
Attenuator	Pasternack	PE7010-20	-	DC - 2 GHz	02 Jan 2015
L.I.S.N	EMCO	3825/2R	1165	10 kHz - 30 MHz	05 Nov 2014
EMI Receiver	Rohde & Schwarz	ESU40	100037	20 Hz – 40 GHz	05 Apr 2015
Biconilog Antenna	EMCO	3142C	00026873	26 – 3000 MHz	14 Apr 2015
RF Amplifier	AH System	PAM-0118	225	20 MHz – 18 GHz	07 Apr 2015
Horn Antenna	EMCO	3115	9701-5061	1 - 18 GHz	08 Oct 2014

*Note 1: Internal Verification/Calibration check

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EXHIBIT 7. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of CISPR 16-4-2 @ IEC:2003 and JCGM 100:2008 (GUM 1995) – Guide to the Expression of Uncertainty in Measurement.

7.1. LINE CONDUCTED EMISSION MEASUREMENT UNCERTAINTY

	Line Conducted Emission Measurement Uncertainty (9 kHz – 30 MHz):	Measured	Limit
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 1.44	± 1.8
U	Expanded uncertainty U: $U = 2u_c(y)$	± 2.89	± 3.6

7.2. RADIATED EMISSION MEASUREMENT UNCERTAINTY

	Radiated Emission Measurement Uncertainty @ 3m, Horizontal (30-1000 MHz):	Measured (dB)	Limit (dB)
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 2.39	± 2.6
U	Expanded uncertainty U: $U = 2u_c(y)$	± 4.79	± 5.2

	Radiated Emission Measurement Uncertainty @ 3m, Vertical (30-1000 MHz):	Measured (dB)	Limit (dB)
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 2.39	± 2.6
U	Expanded uncertainty U: $U = 2u_c(y)$	± 4.78	± 5.2

	Radiated Emission Measurement Uncertainty @ 3 m, Horizontal & Vertical (1 – 18 GHz):	Measured (dB)	Limit (dB)
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 1.87	Under consideration
U	Expanded uncertainty U: $U = 2u_c(y)$	± 3.75	Under consideration

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All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

EXHIBIT 8. MEASUREMENT METHODS

8.1. CONDUCTED POWER MEASUREMENTS

- The following shall be applied to the combination(s) of the radio device and its intended antenna(e).
- If the RF level is user adjustable, all measurements shall be made with the highest power level available to the user for that combination.
- The following method of measurement shall apply to both conducted and radiated measurements.
- The radiated measurements are performed at the Ultratech Calibrated Open Field Test Site.
- The measurement shall be performed using normal operation of the equipment with modulation.

Test procedure shall be as follows:

Step 1: Duty Cycle measurements if the transmitter's transmission is transient

- Using a EMI Receiver with the frequency span set to 0 Hz and the sweep time set at a suitable value to capture the envelope peaks and the duty cycle of the transmitter output signal;
- The duty cycle of the transmitter, $x = \text{Tx on} / (\text{Tx on} + \text{Tx off})$ with $0 < x < 1$, is measure and recorded in the test report. For the purpose of testing, the equipment shall be operated with a duty cycle that is equal or more than 0.1.

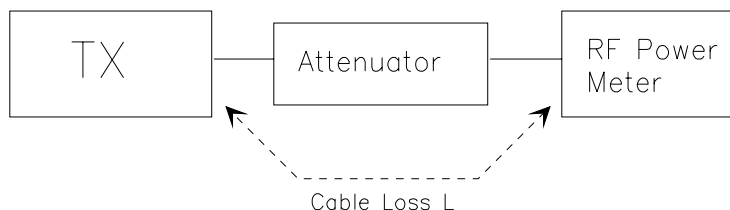
Step 2: Calculation of Average EIRP. See Figure 1

- The average output power of the transmitter shall be determined using a wideband, calibrated RF average power meter with the power sensor with an integration period that exceeds the repetition period of the transmitter by a factor 5 or more. The observed value shall be recorded as "A" (in dBm);
- The e.i.r.p. shall be calculated from the above measured power output "A", the observed duty cycle x, and the applicable antenna assembly gain "G" in dBi, according to the formula:

$$\text{EIRP} = \text{A} + \text{G} + 10\log(1/x)$$

{X = 1 for continuous transmission => $10\log(1/x) = 0$ dB}

Figure 1.



8.2. RADIATED POWER MEASUREMENTS (ERP & EIRP) USING SUBSTITUTION METHOD

8.2.1. MAXIMIZING RF EMISSION LEVEL (E-FIELD)

- (a) The measurements were performed with full rf output power and modulation.
- (b) Test was performed at listed 3m open area test site (listed with FCC, IC, ITI, NVLAP, ACA & VCCI).
- (c) The transmitter under test was placed at the specified height on a non-conducting turntable (80 cm height)
- (d) The BICONILOG antenna (20 MHz to 1 GHz) or HORN antenna (1 GHz to 18 GHz) was used for measuring.
- (e) Load an appropriate correction factors file in EMI Receiver for correcting the field strength reading level

Total Correction Factor recorded in the EMI Receiver = Cable Loss + Antenna Factor
 $E \text{ (dB}\mu\text{V/m)} = \text{Reading (dB}\mu\text{V)} + \text{Total Correction Factor (dB/m)}$

- (f) Set the EMI Receiver and #2 as follows:

Center Frequency: test frequency
Resolution BW: 100 KHz
Video BW: same
Detector Mode: positive
Average: off
Span: 3 x the signal bandwidth

- (g) The test antenna was lowered or raised from 1 to 4 meters until the maximum signal level was detected.
- (h) The transmitter was rotated through 360° about a vertical axis until a higher maximum signal was received.
- (i) The test antenna was lowered or raised again from 1 to 4 meters until a maximum was obtained. This level was recorded.
- (j) The recorded reading was corrected to the true field strength level by adding the antenna factor, cable loss and subtracting the pre-amplifier gain.
- (k) The above steps were repeated with both transmitters' antenna and test receiving antenna placed in vertical and horizontal polarization. Both readings with the antennas placed in vertical and horizontal polarization shall be recorded.
- (l) Repeat for all different test signal frequencies.

8.2.2. Measuring the EIRP of Spurious/Harmonic Emissions using Substitution Method

- (a) Set the EMI Receiver (for measuring E-Field) and Receiver #2 (for measuring EIRP) as follows:

Center Frequency: equal to the signal source
Resolution BW: 100 KHz
Video BW: VBW > RBW
Detector Mode: positive
Average: off
Span: 3 x the signal bandwidth

- (b) Load an appropriate correction factors file in EMI Receiver for correcting the field strength reading level

Total Correction Factor recorded in the EMI Receiver = Cable Loss + Antenna Factor
E (dBuV/m) = Reading (dBuV) + Total Correction Factor (dB/m)

- (c) Select the frequency and E-field levels obtained in the Section 8.2.1 for ERP/EIRP measurements.
(d) Substitute the EUT by a signal generator and one of the following transmitting antenna (substitution antenna):
♦ DIPOLE antenna for frequency from 30-1000 MHz or
♦ HORN antenna for frequency above 1 GHz }.
(e) Mount the transmitting antenna at 1.5 meter high from the ground plane.
(f) Use one of the following antenna as a receiving antenna:
♦ DIPOLE antenna for frequency from 30-1000 MHz or
♦ HORN antenna for frequency above 1 GHz }.
(g) If the DIPOLE antenna is used, tune it's elements to the frequency as specified in the calibration manual.
(h) Adjust both transmitting and receiving antenna in a VERTICAL polarization.
(i) Tune the EMI Receivers to the test frequency.
(j) Lower or raise the test antenna from 1 to 4 meters until the maximum signal level was detected.
(k) The transmitter was rotated through 360° about a vertical axis until a higher maximum signal was received.
(l) Lower or raise the test antenna from 1 to 4 meters until the maximum signal level was detected.
(m) Adjust input signal to the substitution antenna until an equal or a known related level to that detected from the transmitter was obtained in the test receiver.
(n) Record the power level read from the Average Power Meter and calculate the ERP/EIRP as follows:

$$P = P1 - L1 = (P2 + L2) - L1 = P3 + A + L2 - L1$$

$$EIRP = P + G1 = P3 + L2 - L1 + A + G1$$

$$ERP = EIRP - 2.15 \text{ dB}$$

$$\text{Total Correction factor in EMI Receiver \# 2} = L2 - L1 + G1$$

Where: P: Actual RF Power fed into the substitution antenna port after corrected.
P1: Power output from the signal generator
P2: Power measured at attenuator A input
P3: Power reading on the Average Power Meter
EIRP: EIRP after correction
ERP: ERP after correction

- (o) Adjust both transmitting and receiving antenna in a HORIZONTAL polarization, then repeat step (k) to (o)
(p) Repeat step (d) to (o) for different test frequency
(q) Repeat steps (c) to (j) with the substitution antenna oriented in horizontal polarization.
(r) Actual gain of the EUT's antenna is the difference of the measured EIRP and measured RF power at the RF port. Correct the antenna gain if necessary.

Figure 2

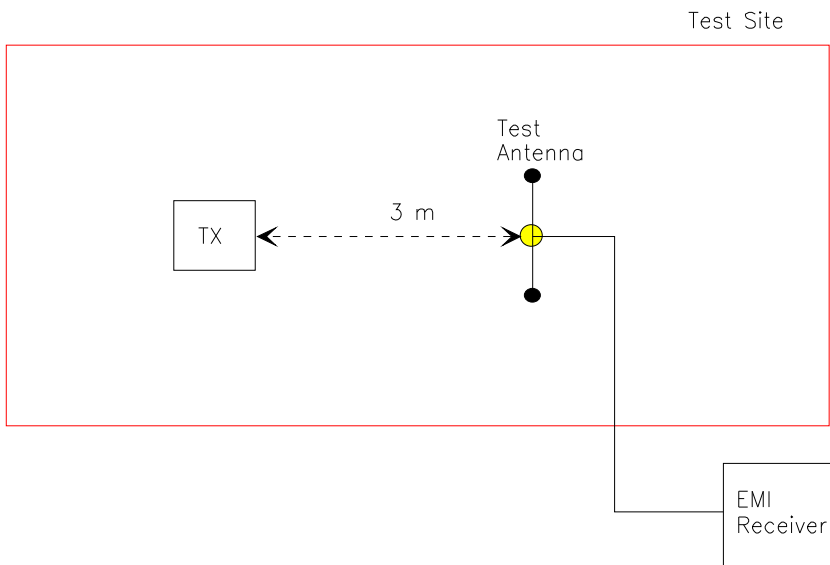
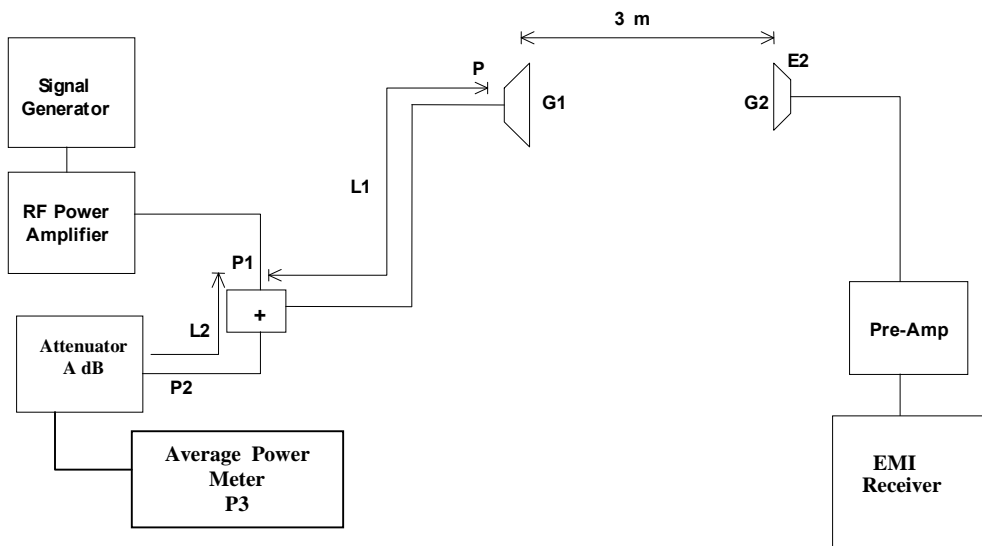


Figure 3



8.3. FREQUENCY STABILITY

Refer to FCC @ 2.1055.

- (a) The frequency stability shall be measured with variation of ambient temperature as follows: From -30 to +50 centigrade except that specified in subparagraph (2) & (3) of this paragraph.
- (b) Frequency measurements shall be made at extremes of the specified temperature range and at intervals of not more than 10 centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. The short-term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stability circuitry need be subjected to the temperature variation test.
- (d) The frequency stability supply shall be measured with variation of primary supply voltage as follows:
 - (1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.
 - (2) For hand carried, battery powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.
 - (3) The supply voltage shall be measured at the input to the cable normally provide with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.
- (e) When deemed necessary, the Commission may require tests of frequency stability under conditions in addition to those specifically set out in paragraphs (a), (b), (c) and (d) of this section. (For example, measurements showing the effect of proximity to large metal objects, or of various types of antennas, may be required for portable equipment).

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8.4. EMISSION MASK

Voice or Digital Modulation Through a Voice Input Port @ 2.1049(c)(i):- The transmitter was modulated by a 2.5 KHz tone signal at an input level 16 dB greater than that required to produce 50% modulation (e.g.: ± 2.5 KHz peak deviation at 1 KHz modulating frequency). The input level was established at the frequency of maximum response of the audio modulating circuit.

Digital Modulation Through a Data Input Port @ 2.1049(h):- Transmitters employing digital modulation techniques - when modulated by an input signal such that its amplitude and symbol rate represent the maximum rated conditions under which the equipment will be operated. The signal shall be applied through any filter networks, pseudo-random generators or other devices required in normal service. Additionally, the Emission Masks shall be shown for operation with any devices used for modifying the spectrum when such devices are operational at the discretion of the user.

The following EMI Receiver bandwidth shall be used for measurement of Emission Mask/Out-of-Band Emission Measurements:

- (1) For 25 KHz Channel Spacing: RBW = 300 Hz
- (2) For 12.5 KHz or 6.25 KHz Channel Spacings: RBW = 100 Hz

The all cases the Video Bandwidth shall be equal or greater than the measuring bandwidth.

8.5. SPURIOUS EMISSIONS (CONDUCTED)

With transmitter modulation characteristics described in Out-of-Band Emissions measurements @ 2.1049, the transmitter spurious and harmonic emissions were scanned. The spurious and harmonic emissions were measured with the EMI Receiver controls set as RBW = 30 KHz minimum , VBW \geq RBW and SWEEP TIME = AUTO). The transmitter was operated at a full rated power output, and modulated as follows:

FCC 47 CFR 2.1057 - Frequency spectrum to be investigated: The spectrum was investigated from the lowest radio generated in the equipment up to at least the 10th harmonic of the carrier frequency or to the highest frequency practicable in the present state of the art of measuring techniques, whichever is lower. Particular attention should be paid to harmonics and subharmonics of the carrier frequency. Radiation at the frequencies of multiplier stages should be checked. The amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.

FCC 47 CFR 2.1051 - Spurious Emissions at Antenna Terminal: The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of the harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in 2.1049 as appropriate. The magnitude of spurious emissions, which are attenuated more than 20 dB below the permissible value, need not be specified.

8.6. TRANSIENT FREQUENCY BEHAVIOR

1. Connect the transmitter under tests as shown in the above block diagram
2. Set the signal generator to the assigned frequency and modulate with a 1 KHz tone at ± 12.5 KHz deviation and its output level to be 50 dB below the transmitter rf output at the test receiver end.
3. Set the horizontal sweep rate on the storage scope to 10 milliseconds per division and adjust the display to continuously view the 1000 Hz tone from the Demodulator Output Port (DOP) of the Test Receiver. Adjust the vertical scale amplitude control of the scope to display the 1000 Hz at ± 4 divisions vertical Center at the display.
4. Adjust the scope so it will trigger on an increasing magnitude from the RF trigger signal of the transmitter under test when the transmitter was turned on. Set the controls to store the display.
5. The output at the DOP, due to the change in the ratio of the power between the signal generator input power and transmitter output power will, because of the capture effect of the test receiver, produce a change in display: For the first part of the sweep it will show the 1 KHz test signal. Then once the receiver's demodulator has been captured by the transmitter power, the display will show the frequency difference from the assigned frequency to the actual transmitter frequency versus time. The instant when the 1 KHz test signal is completely suppressed (including any capture time due to phasing) is considered to be t_{on} . The trace should be maintained within the allowed divisions during the period t_1 and t_2 .
6. During the time from the end of t_2 to the beginning of t_3 the frequency difference should not exceed the limits set by the FCC in Part 90.214 and the outlined in the Carrier Frequency Stability sections. The allowed limit is equal to FCC frequency tolerance limits specified in FCC 90.213.
7. Repeat the above steps when the transmitter was turned off for measuring t_3 .