ENGINEERING TEST REPORT

Pico 900MHz 1W FHSS / 400MHz 2W License Band Module
Model: p400
FCC ID: NS914P400

Applicant:

Microhard Systems Inc.
150 Country Hills Landing NW
Calgary, Alberta
Canada T3K 5P3

Tested in Accordance With

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

UltraTech's File No.: MCRS-069F90

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 Issued Date: September 2, 2014	Tested by: Hung Trinh Test Dates: May 9 – September 2, 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

3000 Bristol Circle, Oakville, Ontario, Canada, L6H 6G4
Tel.: (905) 829-1570 Fax.: (905) 829-8050
Website: www.ultratech-labs.com, Email: vic@ultratech-labs.com, Email: tri@ultratech-labs.com

91038	1309	Industry Canada Industrie Canada Approved Test Facility 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 and 90
Title:	Code of Federal Regulations (CFR), Title 47 –Telecommunication, Part 90 Private land mobile radio services
Purpose of Test:	To gain FCC Equipment Authorization for Radio operating in Part 90.
Test Procedures:	Both conducted and radiated emissions measurements were conducted in accordance with TIA/EIA Standard TIA-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, Title 47 – 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
CISPR 22 & EN 55022	2008-09, Edition 6.0 2006	Information Technology Equipment - Radio Disturbance Characteristics - Limits and Methods of Measurement
CISPR 16-1-1 +A1 +A2	2006 2006 2007	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-1: Measuring Apparatus
CISPR 16-1-2 +A1 +A2	2003 2004 2006	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-2: Conducted disturbances

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

APPLICANT	
Name:	Microhard Systems Inc.
Address:	150 Country Hills Landing NW Calgary, Alberta Canada T3K 5P3
Contact Person:	Mr. Hany Shenouda Phone #: 403 248-0028 Fax #: 403 248 2762 Email Address: shenouda@microhardcorp.com

MANUFACTURER	
Name:	Microhard Systems Inc.
Address:	150 Country Hills Landing NW Calgary, Alberta Canada T3K 5P3
Contact Person:	Mr. Hany Shenouda Phone #: 403 248-0028 Fax #: 403 248-2762 Email Address: shenouda@microhardcorp.com

2.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

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

Brand Name:	Microhard Systems Inc.
Product Name:	Pico 900MHz 1W FHSS / 400MHz 2W License Band Module
Model Name or Number:	p400
Serial Number:	Test sample
Type of Equipment:	Licensed Non-Broadcast Station Transmitter
External Power Supply:	3.3VDC Nominal
Transmitting/Receiving Antenna Type:	Non-integral
Primary User Functions of EUT:	OEM module

2.3. EUT'S TECHNICAL SPECIFICATIONS

Transmitter	
Equipment Type:	Mobile Fixed, Base Station
Intended Operating Environment:	Residential Commercial, industrial or business environment
Power Supply Requirement:	3.3 VDC
RF Output Power Rating:	0.1 to 2 Watts
Operating Frequency Range:	410 - 480 MHz
RF Output Impedance:	50 Ω
Channel Spacing:	12.5 kHz and 6.25 kHz
Occupied Bandwidth (99%):	• 7.76 kHz (for 12.5 kHz Channel Spacing) • 3.93 kHz (for 6.25 kHz Channel Spacing)
Emission Designation*:	7K76F1D, 3K93F1D
Antenna Connector Type:	UFL

*For Digital Modulation the measured 99% occupied bandwidth was used instead of Carson's rule.

Digital (6.25 kHz Channelization, Digital Data):
Emission Designator: 3K92F1D

Digital (12.5 kHz Channelization, Digital Data):
Emission Designator: 7K75F1D

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	RF IN/OUT Port	1	UFL	Shielded coaxial cable with unique coupling connectors
2	DC Supply & I/O Port	1	Pin Header	No cable, direct connection

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 Jig
Brand name:	Microhard Systems Inc.
Model Name or Number:	N/A
Connected to EUT’s Port:	I/O Port

Ancillary Equipment # 2	
Description:	AC/DC Adapter
Brand name:	GVE
Model Name or Number:	GM36-240100-1
Connected to EUT’s Port:	Test Jig of the EUT

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
Humidity:	51%
Pressure:	102 kPa
Power Input Source:	3.3VDC

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 Jig
Transmitter Test Antenna:	The EUT is tested with the antenna port terminated to a 50 Ω RF Load.

Transmitter Test Signals	
Frequency Band(s):	410 - 480 MHz
Test Frequencies:	410.05 MHz, 450.05 MHz, 469.95 MHz
Transmitter Wanted Output Test Signals:	
Transmitter Power (measured maximum output power):	2 W High and 0.1 W Low
Normal Test Modulation:	2 level / 4 level FSK
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 & 90.205	RF Power Output	Yes
2.1047(a)	Modulation Characteristics - Audio Frequency Response	N/A
2.1047(b)	Modulation Characteristics - Modulation Limiting	Yes
2.1049, 90.209 & 90.210	Occupied Bandwidth and Emission Masks	Yes
2.1051, 2.1057 & 90.210	Spurious Emissions at Antenna Terminal	Yes
2.1053, 2. 1057 & 90.210	Field Strength of Spurious Emissions	Yes
2.1055, 90.213 & 90.539	Frequency Stability	Yes
90.214	Transient Frequency Behavior	Yes
1.1307, 1.1310 & 2.1091	RF Exposure Limit	Yes
15.107	AC Power Line Conducted Emissions	Yes

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None.

4.4. DEVIATION OF STANDARD TEST PROCEDURES

None.

EXHIBIT 5. TEST DATA

5.1. RF POWER OUTPUT [§§ 2.1046 & 90.205]

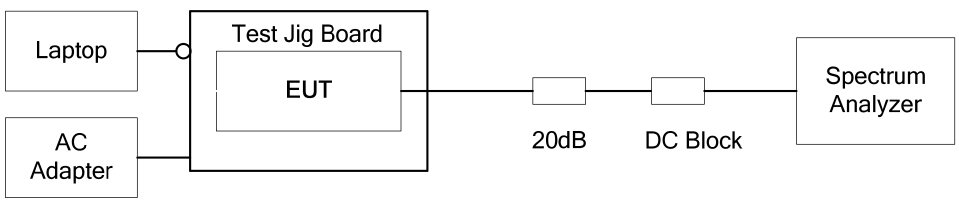
5.1.1. Limits

Refer to FCC 47 CFR 90.205 for specification details.

5.1.2. Method of Measurements

Refer to Exhibit 8, Section 8.1 (Conducted) and 8.2 (Radiated) of this report for measurement details

5.1.3. Test Arrangement



5.1.4. Test Data

Conducted Output Power for High Power Setting

Operating Power Setting	Software Power Setting	Modulation Scheme	Channel Spacing (kHz)	Data Rate (kbps)	Frequency (MHz)	Measured Average Output (dBm)	Power Rating (dBm)
High Power (33 dBm)	63	2-Level FSK	6.25	3.6	410.05	32.75	33
					450.05	32.90	33
					469.95	32.95	33
			12.5	9.6	410.05	32.79	33
					450.05	32.92	33
					469.95	32.89	33
		4-Level FSK	6.25	4.8	410.05	32.76	33
					450.05	32.96	33
					469.95	32.99	33
			12.5	9.6	410.05	32.89	33
					450.05	32.88	33
					469.95	32.74	33

Conducted Output Power for Low Power Setting

Operating Power Setting	Software Power Setting	Modulation Scheme	Channel Spacing (kHz)	Data Rate (kbps)	Frequency (MHz)	Measured Average Output (dBm)	Power Rating (dBm)
Low Power (20 dBm)	3	2-Level FSK	6.25	3.6	410.05	20.86	20
					450.05	17.63	20
					469.95	15.40	20
			12.5	9.6	410.05	20.87	20
					450.05	17.64	20
					469.95	15.46	20
		4-Level FSK	6.25	4.8	410.05	20.80	20
					450.05	17.75	20
					469.95	15.54	20
			12.5	9.6	410.05	20.85	20
					450.05	17.72	20
					469.95	15.58	20

5.2. MODULATION CHARACTERISTICS - MODULATION LIMITING [§ 2.1047 (b)]

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:

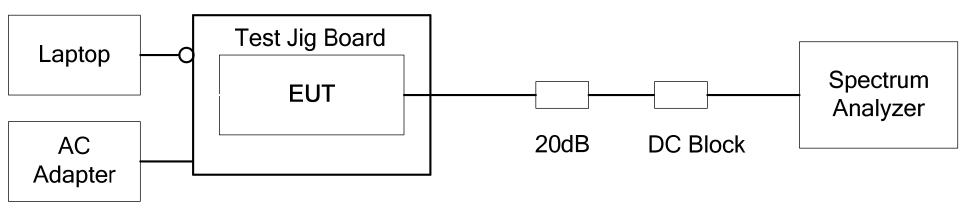
- 1.25 kHz for 6.25 kHz Channel Spacing System
- 2.5 kKHz for 12.5 kHz Channel Spacing System
- 5 kHz for 25 kHz Channel Spacing System

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)
2-Level FSK	9.6 kbps random data	3.2
4-Level FSK	9.6 kbps random data	6.2

5.2.4.2. Data Modulation Limiting for 6.25 kHz Channel Spacing Operation

Operating Mode	Data Rate	Peak Frequency Deviation (kHz)
2-Level FSK	3.6 kbps random data	2.7
4-Level FSK	4.8 kbps random data	4.4

5.3. OCCUPIED BANDWIDTH & EMISSION MASK [§§ 2.1049, 90.209 & 90.210]

5.3.1. Limits

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

Frequency band (MHz)	Channel spacing (kHz)	Authorized bandwidth (kHz)	Applicable Emission Masks	
			Mask for equipment with Audio low pass filter	Mask for equipment without audio low pass filter
[2,4] 421-512	[1] 6.25	[1,3] 20/11.25/6	B, D, or E	C, D, or E

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

[2] Bandwidths 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.

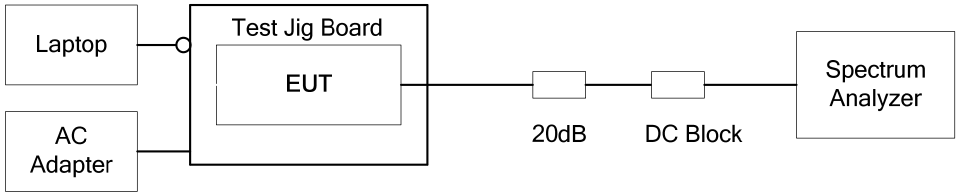
[3] Operations using equipment designed to operate with a 25 kHz channel bandwidth will be authorized a 20 kHz bandwidth. Operations using equipment designed to operate with a 12.5 kHz channel bandwidth will be authorized a 11.25 kHz bandwidth. Operations using equipment designed to operate with a 6.25 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).

[4] Equipment 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.

5.3.2. Method of Measurements

Refer to Section **Error! Reference source not found.** of this report for measurement details.

5.3.3. Test Arrangement



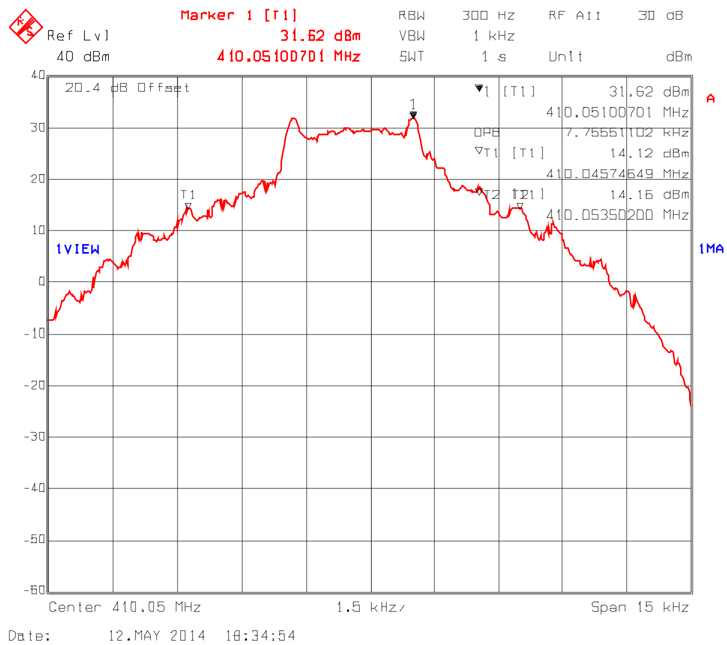
5.3.4. Test Data

5.3.4.1. 99% Occupied Bandwidth

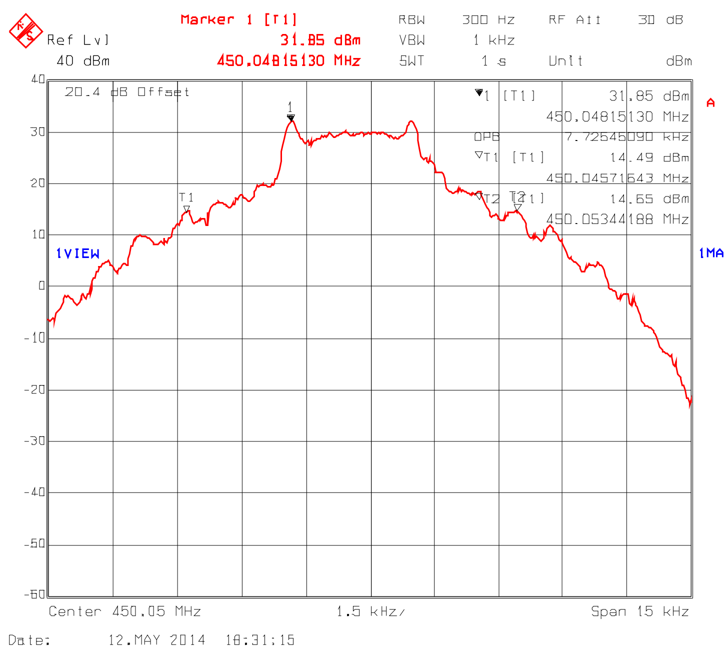
Channel Spacing (KHz)	Modulation	Frequency (MHz)	*Measured 99% OBW at Maximum Freq. Deviation (KHz)	Maximum Authorized Bandwidth (KHz)
12.5	2-Level FSK 9.6 kbps data rate	406.20	7.76	11.25
		450.05	7.73	11.25
		469.95	7.76	11.25
6.25	2-Level FSK 3.6 kbps data rate	406.20	3.93	6
		450.05	3.91	6
		469.95	3.91	6
12.5	4-Level FSK 9.6 kbps data rate	406.20	7.39	11.25
		450.05	7.36	11.25
		469.95	7.33	11.25
6.25	4-Level FSK 4.8 kbps data rate	406.20	3.40	6
		450.05	3.45	6
		469.95	3.46	6
Note: 99% Occupied Bandwidth measurements were done using the built-in auto function of the analyzer.				

*Refer to the following test data plots for detail.

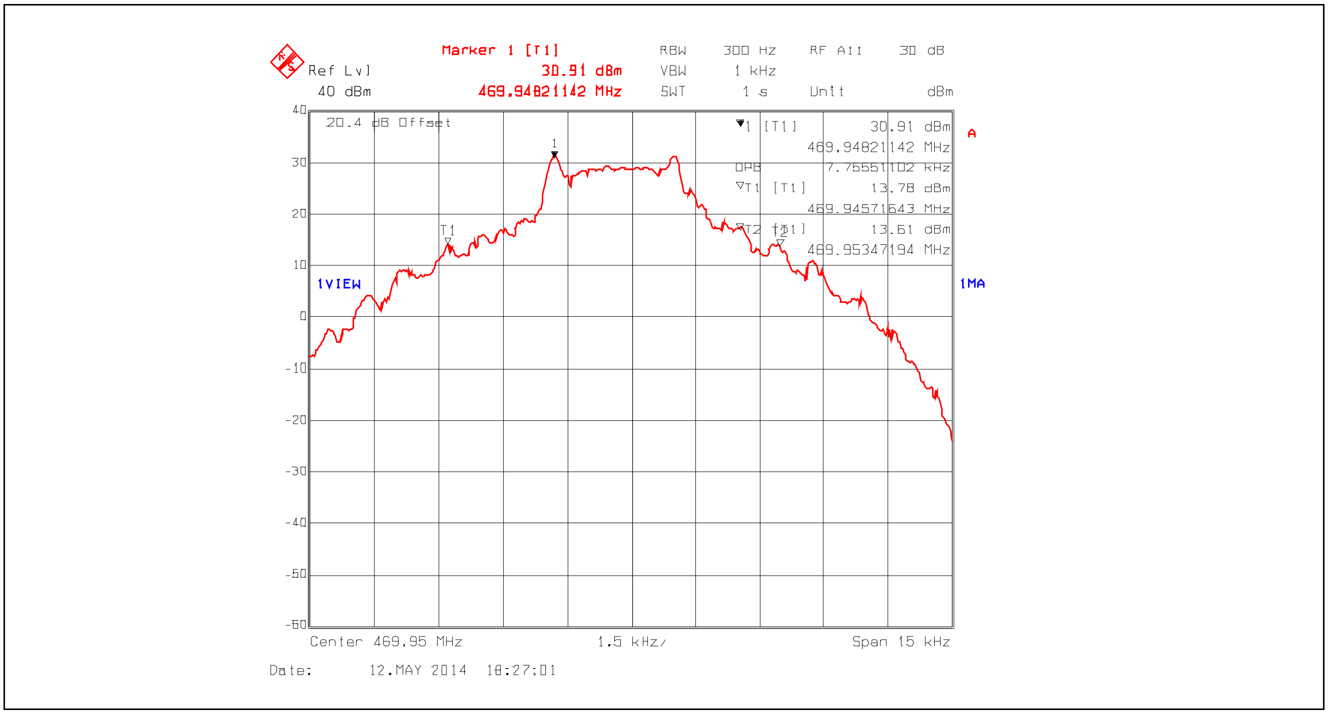
Plot 5.3.4.1.1. 99% Occupied Bandwidth, 12.5 kHz Channel Spacing, 2-Level FSK at 9.6 kbps data rate, 410.05 MHz



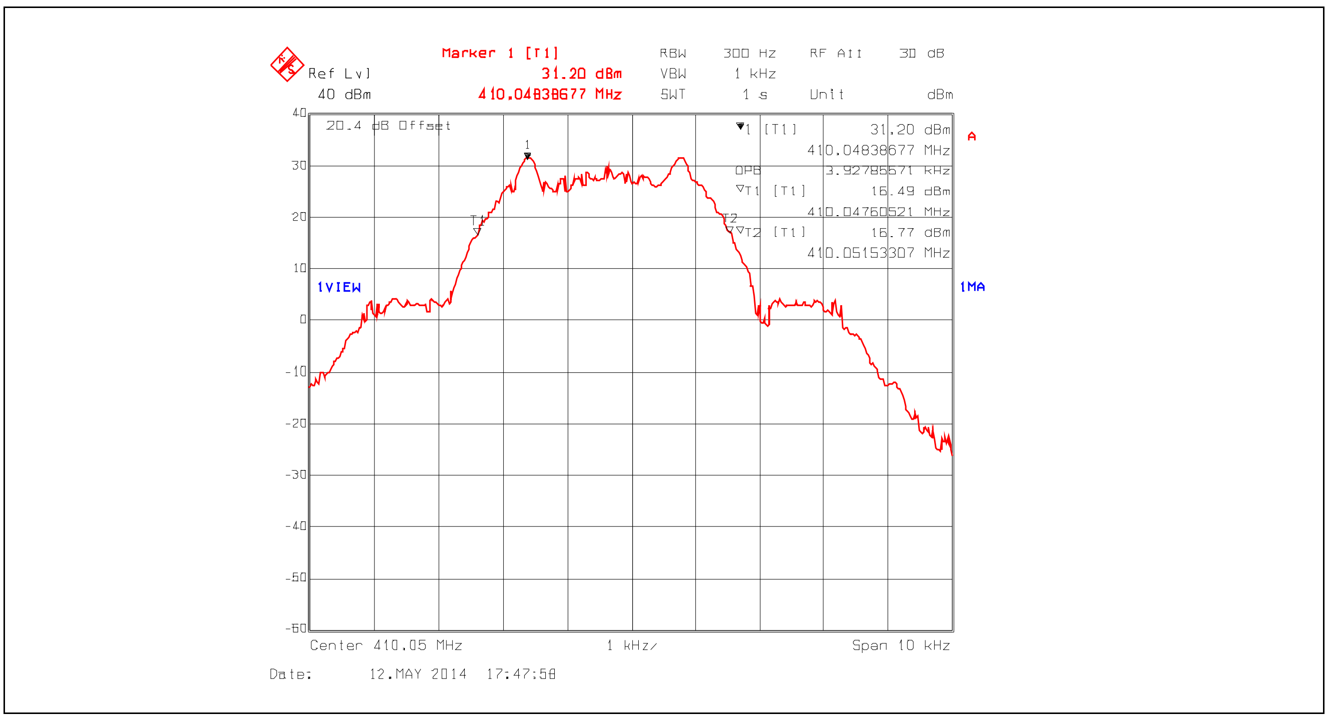
Plot 5.3.4.1.2. 99% Occupied Bandwidth, 12.5 kHz Channel Spacing, 2-Level FSK at 9.6 kbps data rate, 450.05 MHz



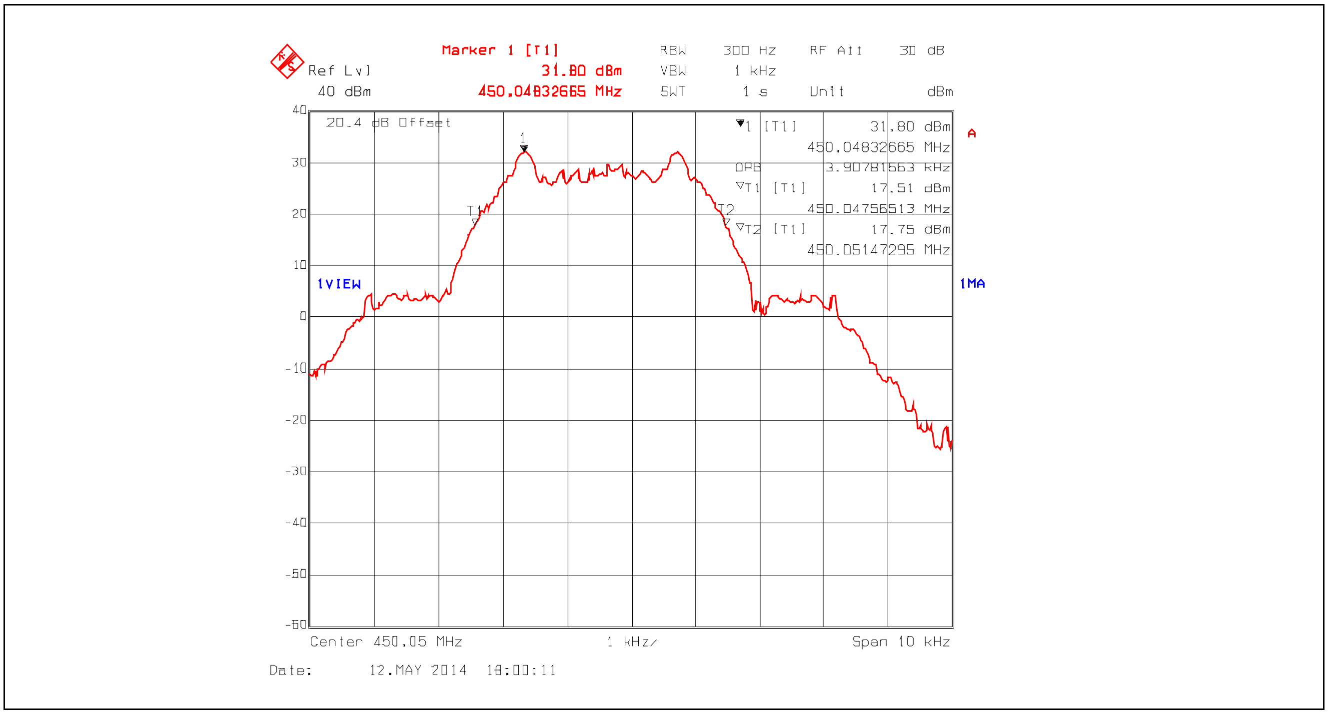
Plot 5.3.4.1.3. 99% Occupied Bandwidth, 12.5 kHz Channel Spacing, 2-Level FSK at 9.6 kbps data rate, 469.95 MHz



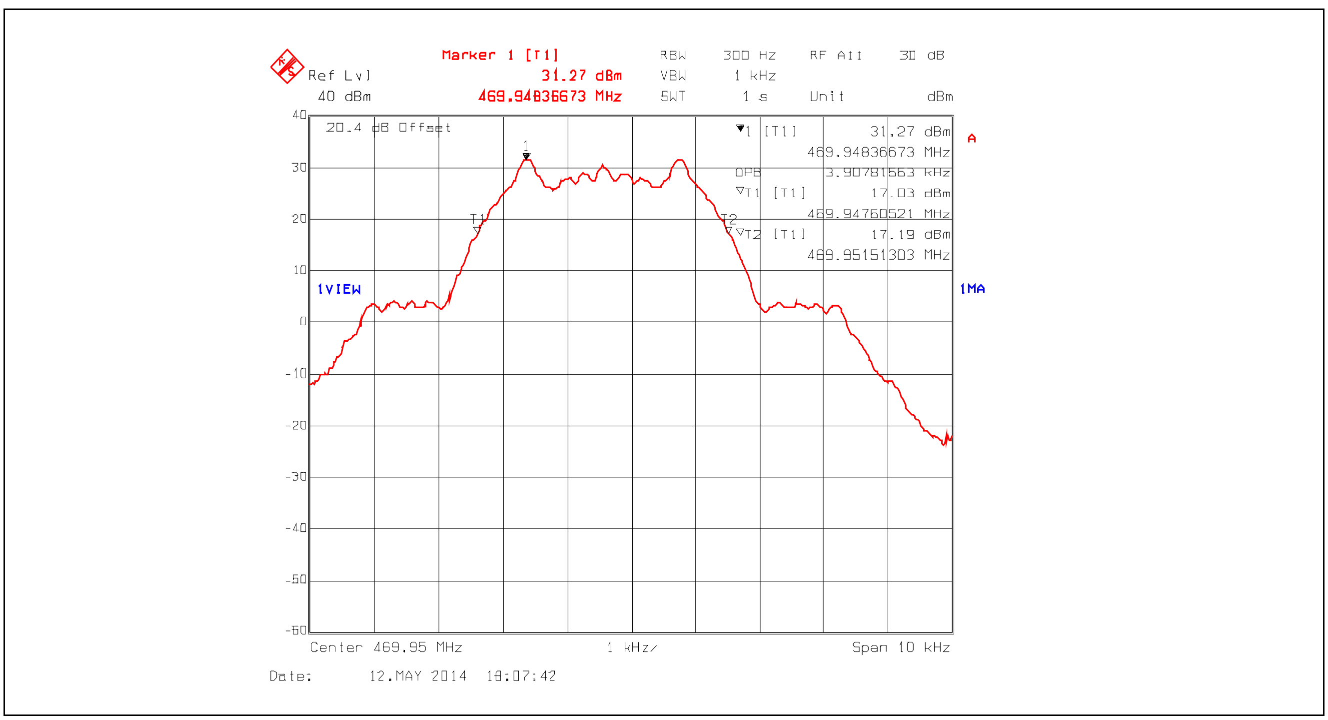
Plot 5.3.4.1.4. 99% Occupied Bandwidth, 6.25 kHz Channel Spacing, 2-Level FSK at 3.6 kbps data rate, 410.05 MHz



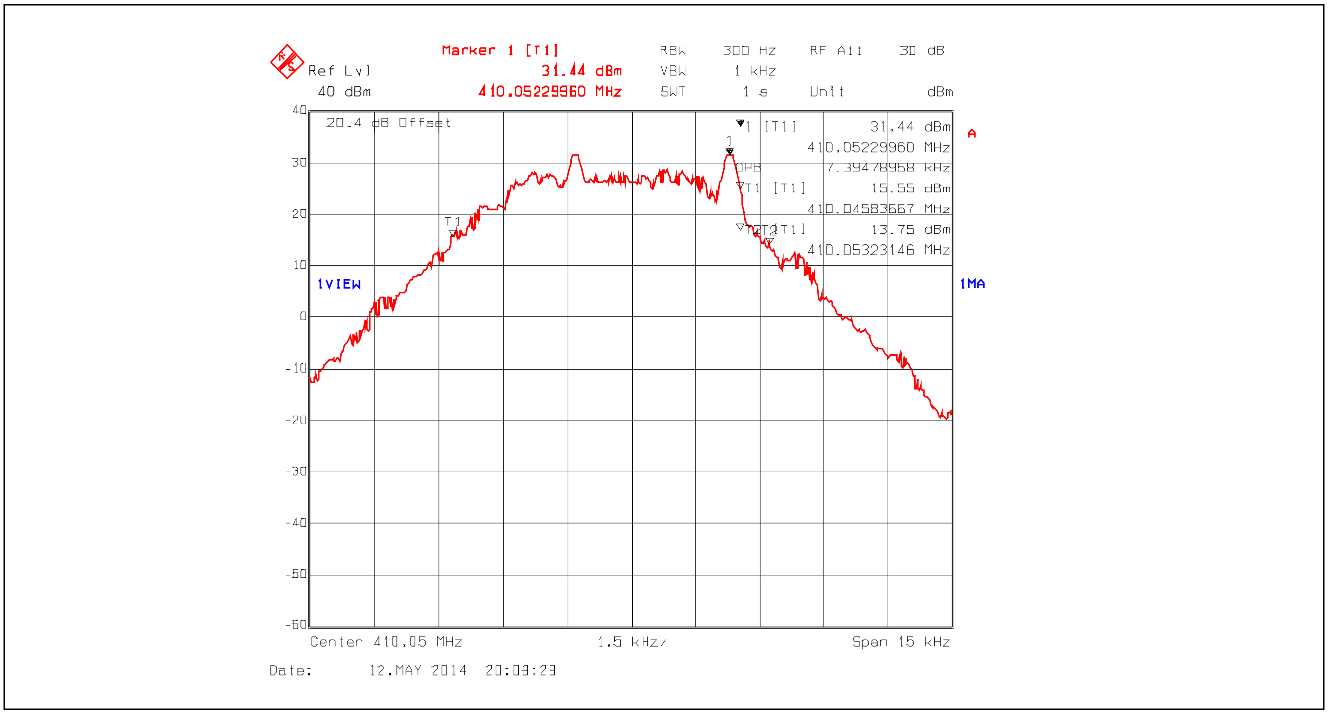
Plot 5.3.4.1.5. 99% Occupied Bandwidth, 6.25 kHz Channel Spacing, 2-Level FSK at 3.6 kbps data rate, 450.05 MHz



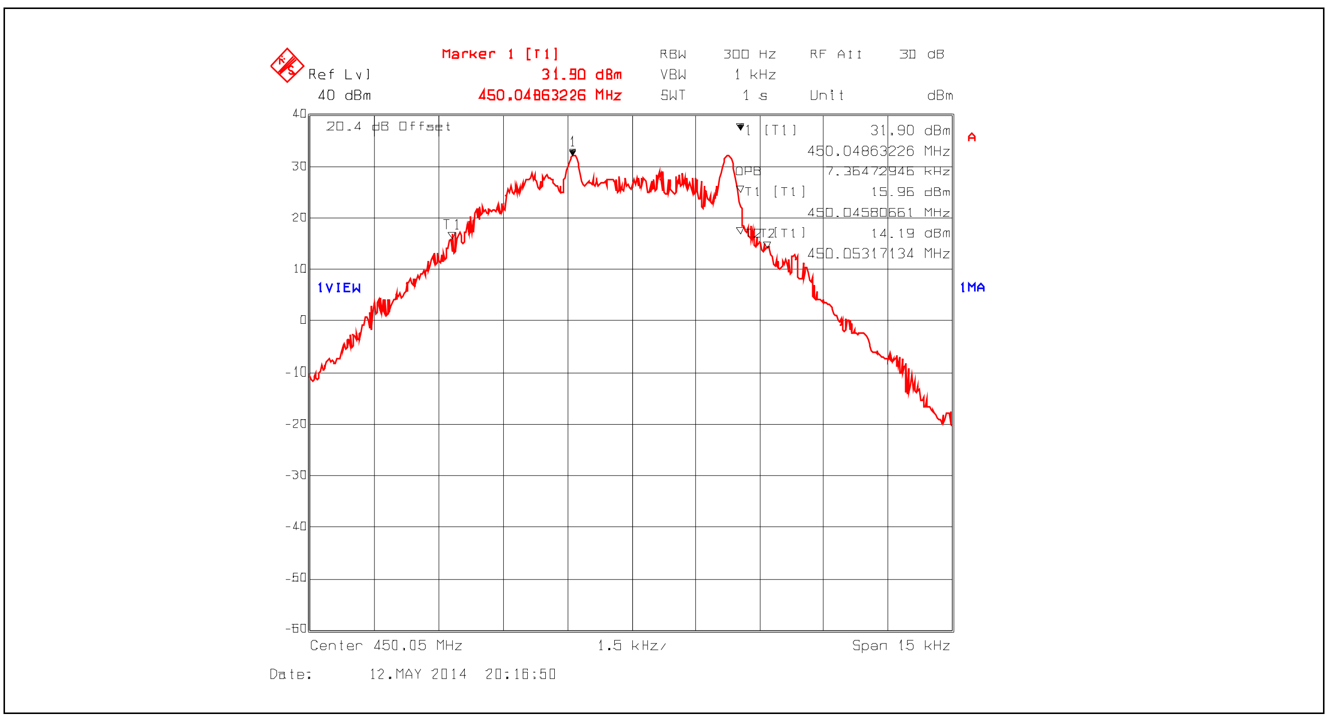
Plot 5.3.4.1.6. 99% Occupied Bandwidth, 6.25 kHz Channel Spacing, 2-Level FSK at 3.6 kbps data rate, 469.95 MHz



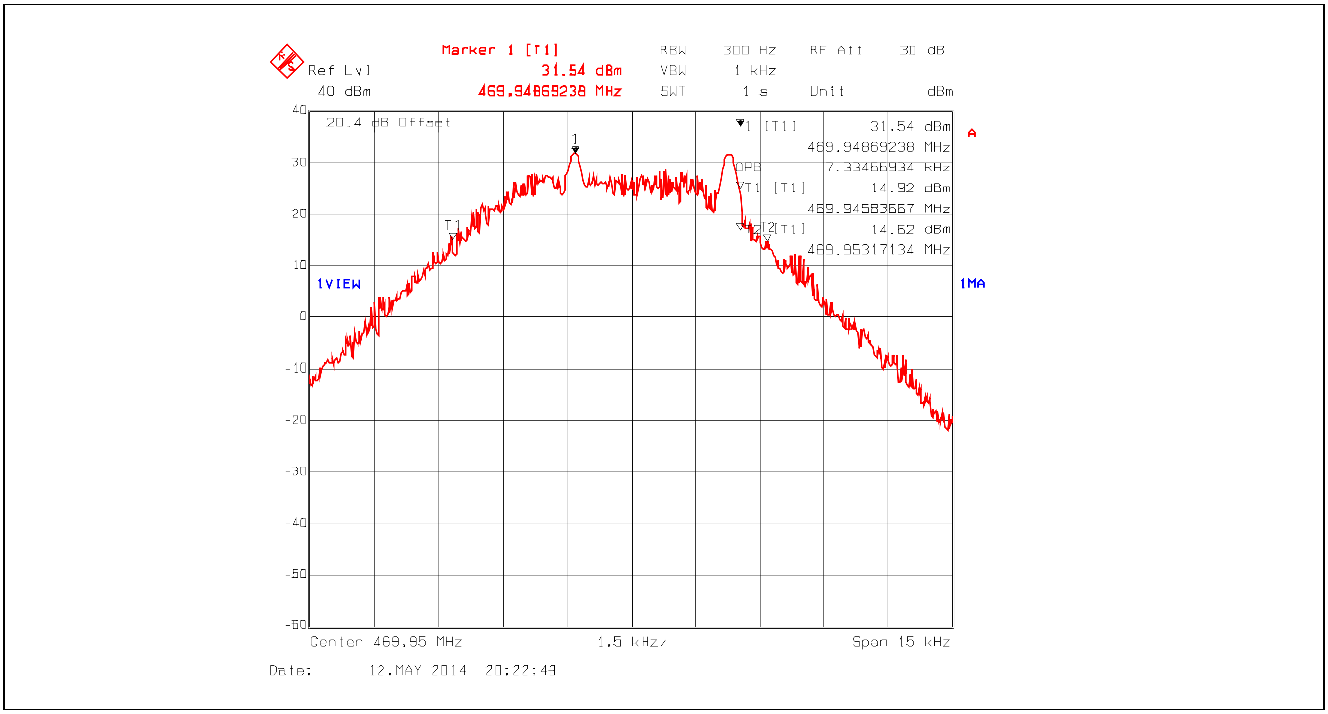
Plot 5.3.4.1.7. 99% Occupied Bandwidth, 12.5 kHz Channel Spacing, 4-Level FSK at 9.6 kbps data rate, 410.05 MHz



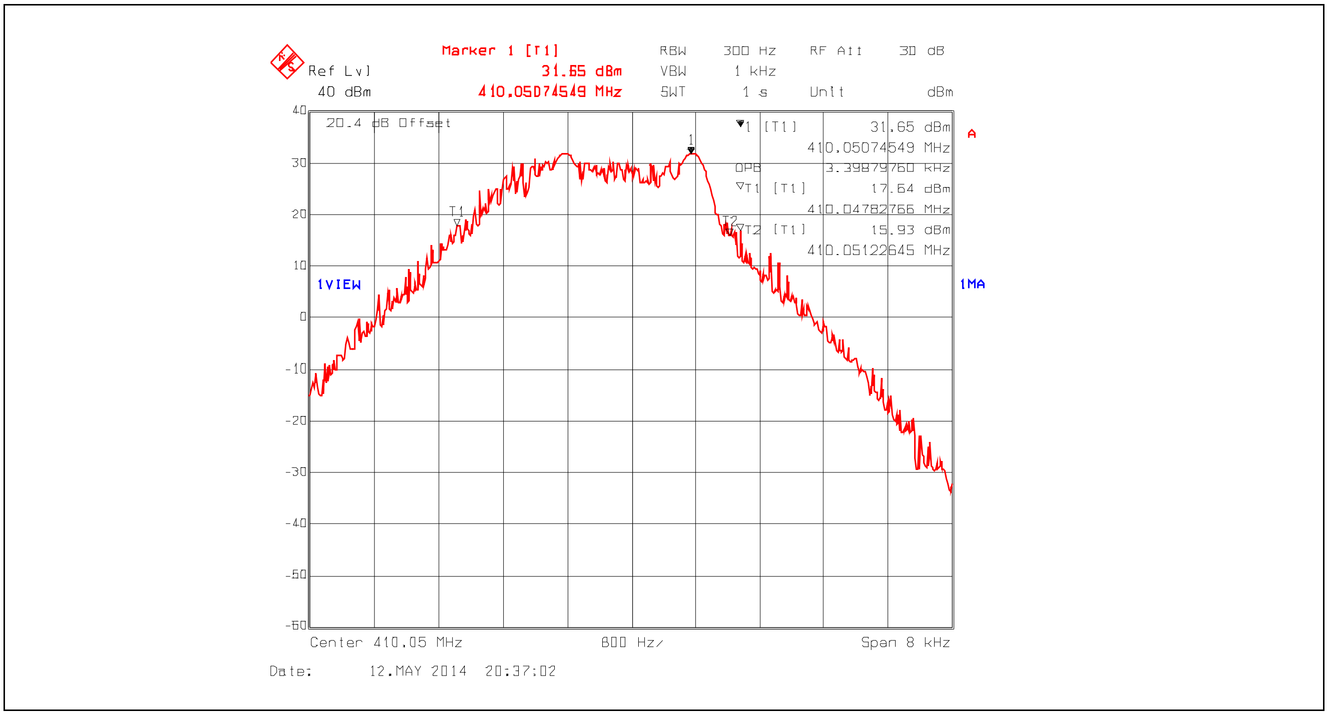
Plot 5.3.4.1.8. 99% Occupied Bandwidth, 12.5 kHz Channel Spacing, 4-Level FSK at 9.6 kbps data rate, 450.05 MHz



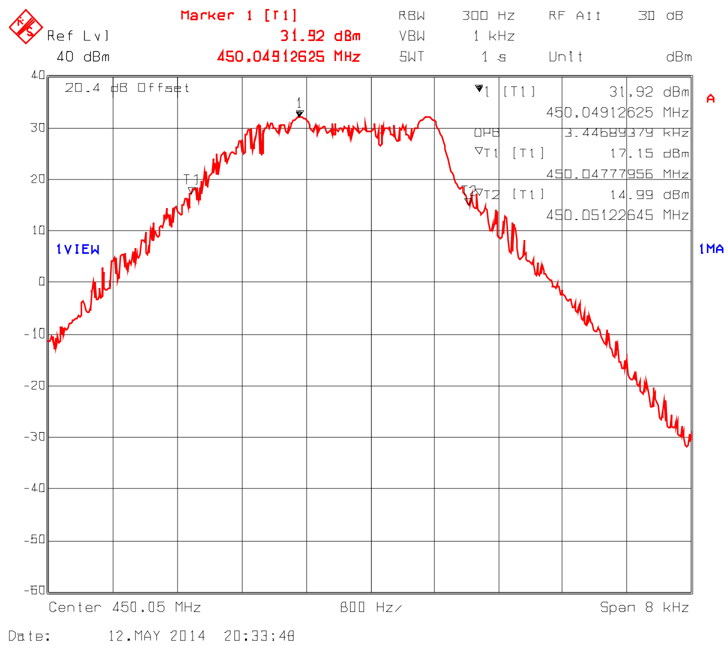
Plot 5.3.4.1.9. 99% Occupied Bandwidth, 12.5 kHz Channel Spacing, 4-Level FSK at 9.6 kbps data rate, 469.95 MHz



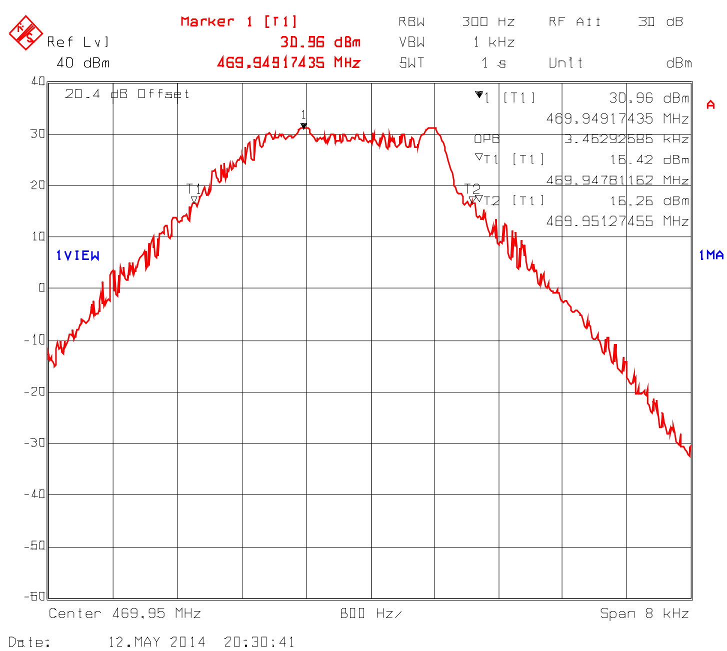
Plot 5.3.4.1.10. 99% Occupied Bandwidth, 6.25 kHz Channel Spacing, 4-Level FSK at 4.8 kbps data rate, 410.05 MHz



Plot 5.3.4.1.11. 99% Occupied Bandwidth, 6.25 kHz Channel Spacing, 4-Level FSK at 4.8 kbps data rate, 450.05 MHz

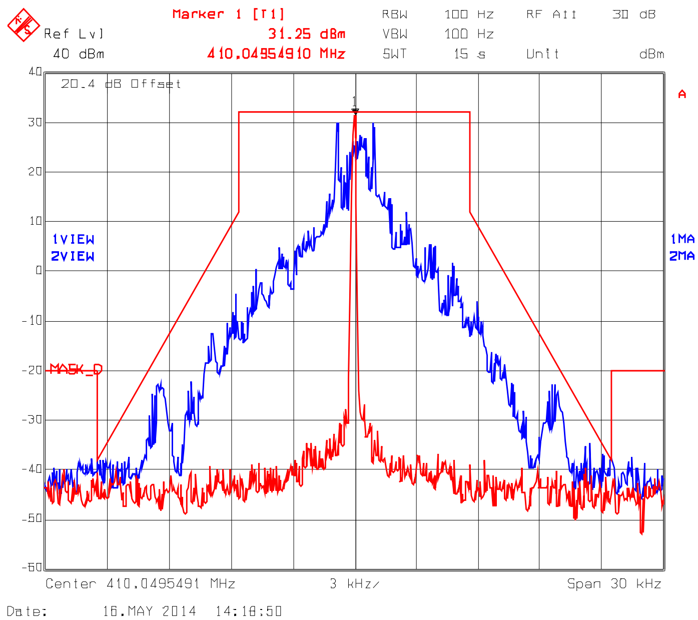


Plot 5.3.4.1.12. 99% Occupied Bandwidth, 6.25 kHz Channel Spacing, 4-Level FSK at 4.8 kbps data rate, 469.95 MHz

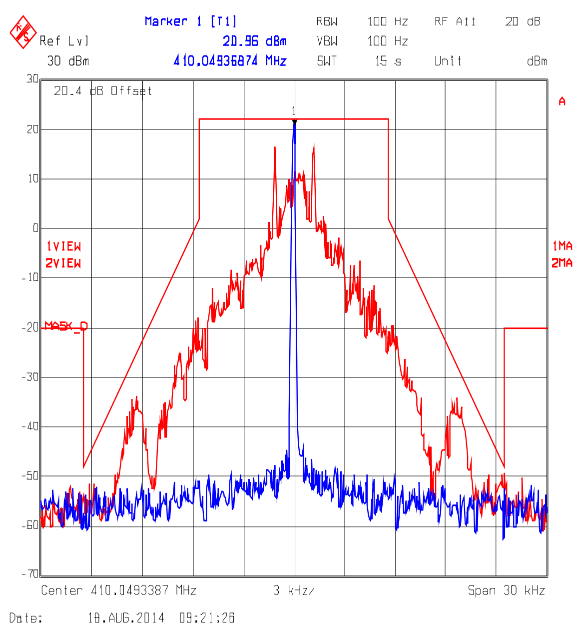


5.3.4.2. Emission Masks

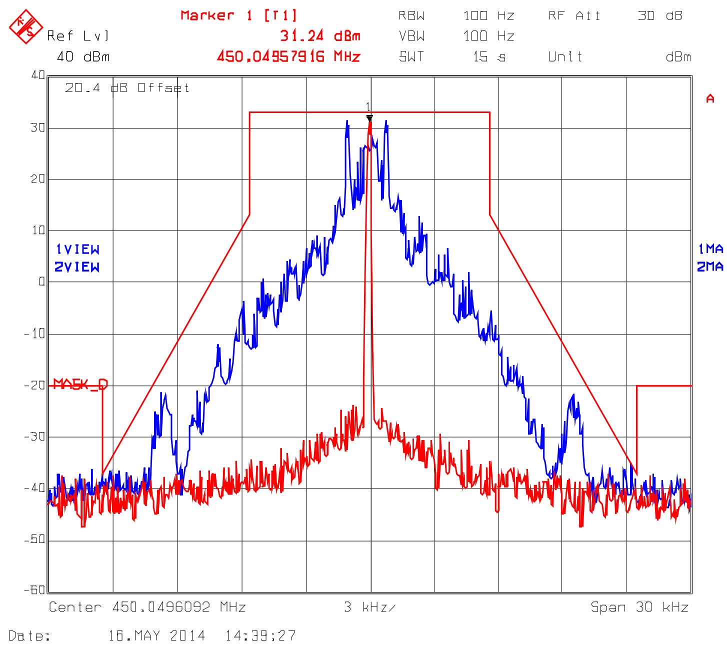
Plot 5.3.4.2.1. Emission Mask D, 2-Level FSK at 9.6 kbps data rate, High Power, 410.05 MHz



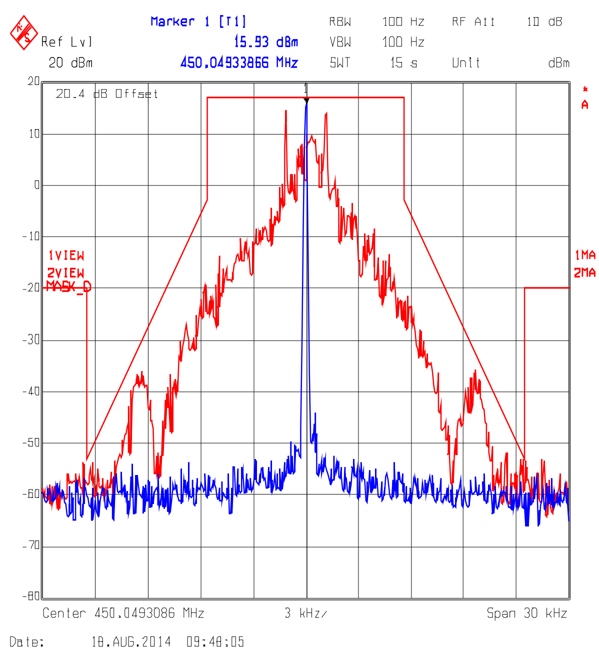
Plot 5.3.4.2.2. Emission Mask D, 2-Level FSK at 9.6 kbps data rate, Low Power, 410.05 MHz



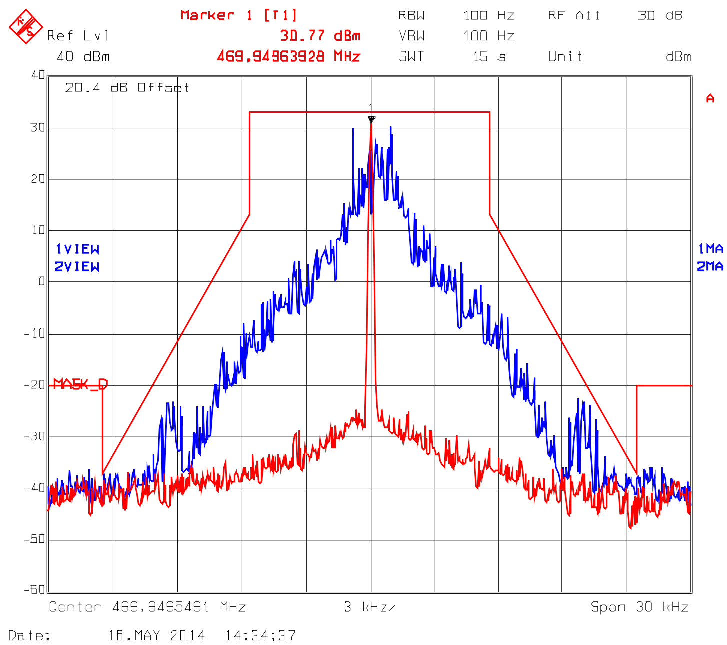
Plot 5.3.4.2.3. Emission Mask D, 2-Level FSK at 9.6 kbps data rate, High Power, 450.05 MHz



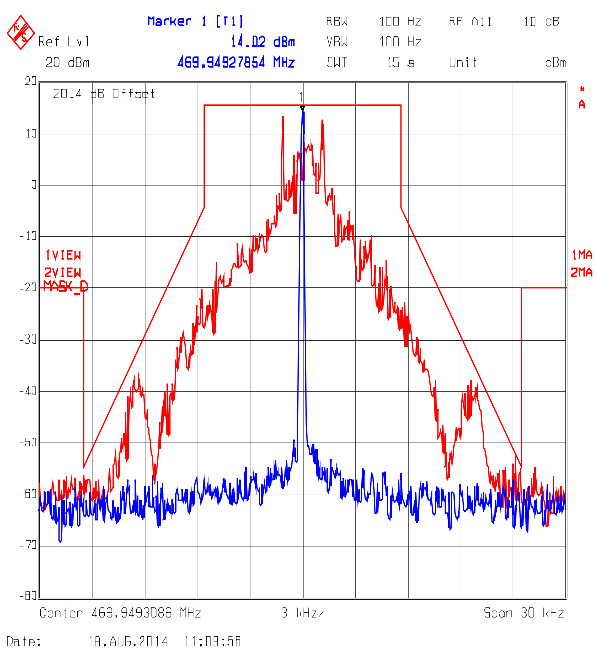
Plot 5.3.4.2.4. Emission Mask D, 2-Level FSK at 9.6 kbps data rate, Low Power, 450.05MHz



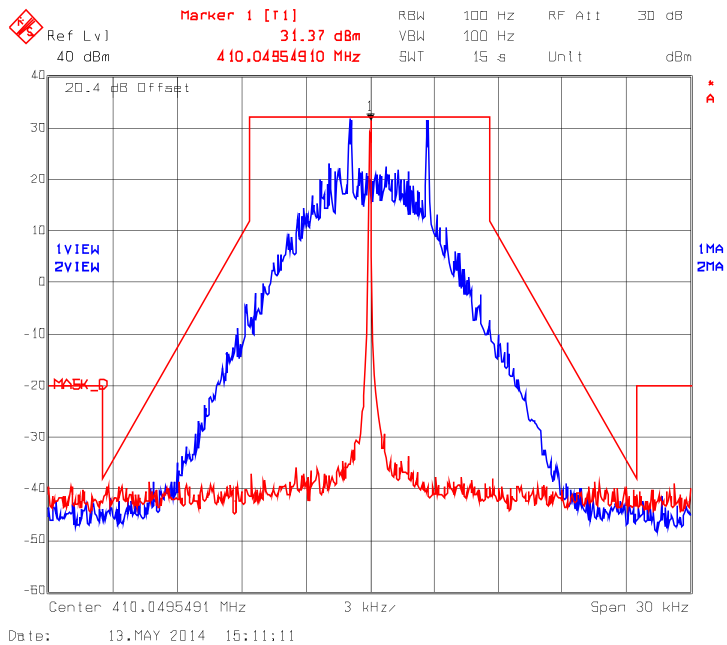
Plot 5.3.4.2.5. Emission Mask D, 2-Level FSK at 9.6 kbps data rate, High Power, 469.95 MHz



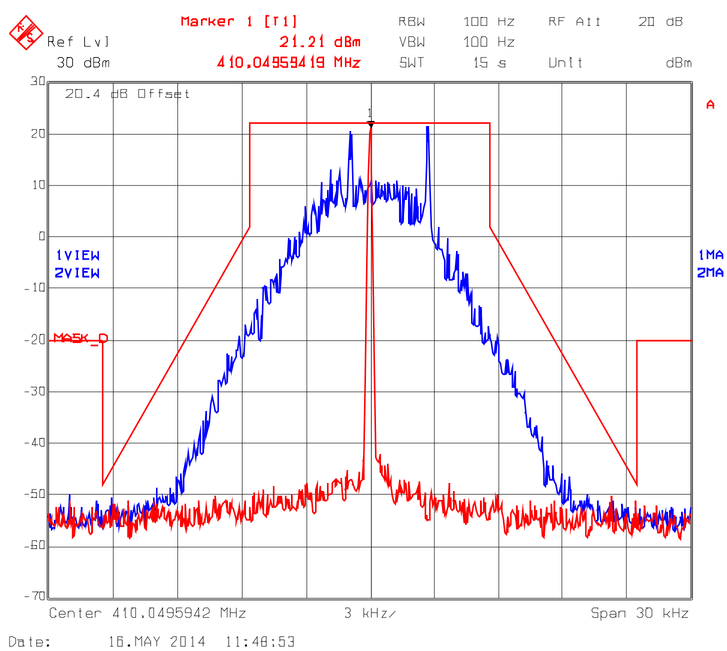
Plot 5.3.4.2.6. Emission Mask D, 2-Level FSK at 9.6 kbps data rate, Low Power, 469.95 MHz



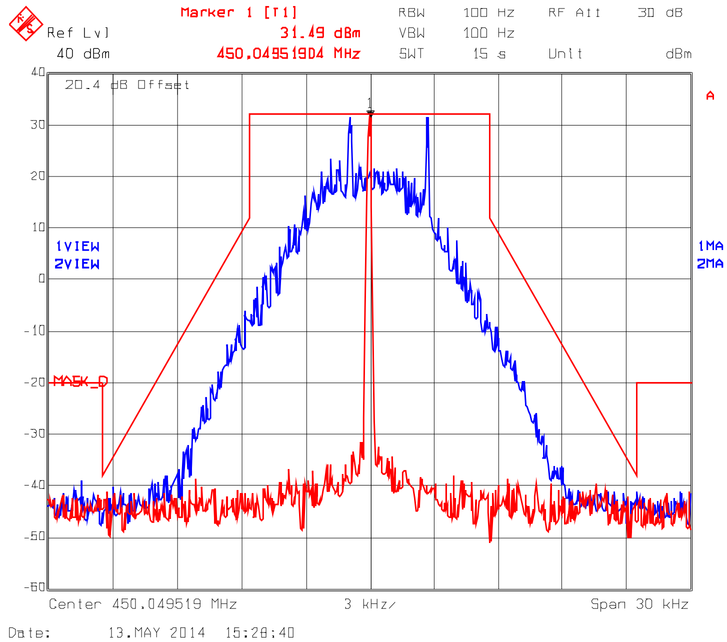
Plot 5.3.4.2.7. Emission Mask D, 4-Level FSK at 9.6 kbps data rate, High Power, 410.05 MHz



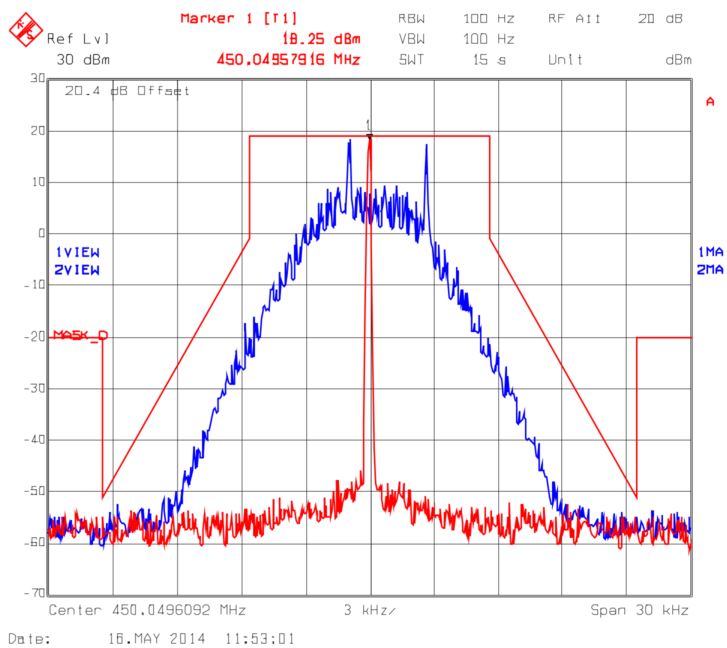
Plot 5.3.4.2.8. Emission Mask D, 4-Level FSK at 9.6 kbps data rate, Low Power, 410.05 MHz



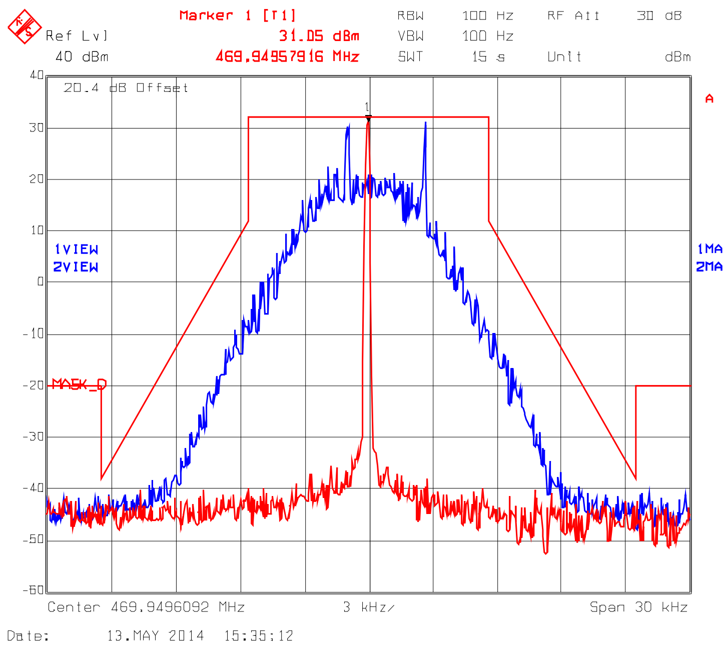
Plot 5.3.4.2.9. Emission Mask D, 4-Level FSK at 9.6 kbps data rate, High Power, 450.05 MHz



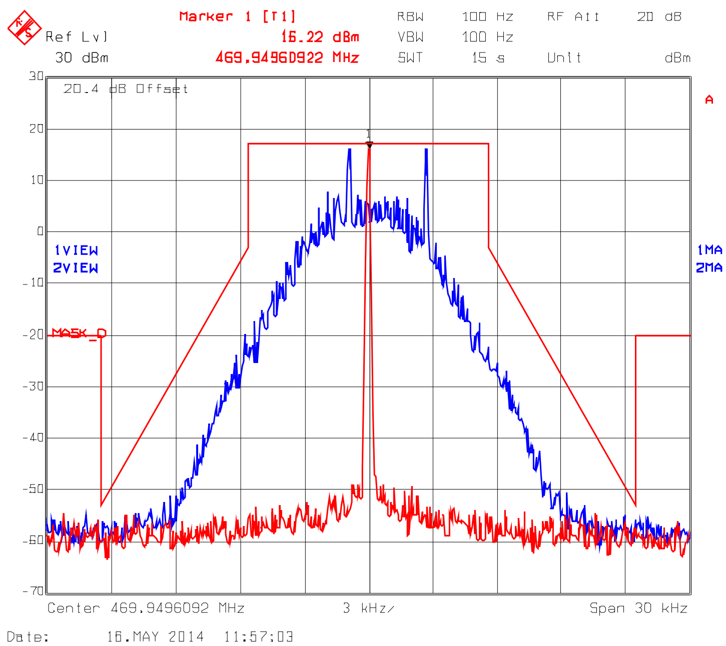
Plot 5.3.4.2.10. Emission Mask D, 4-Level FSK at 9.6 kbps data rate, Low Power, 450.05MHz



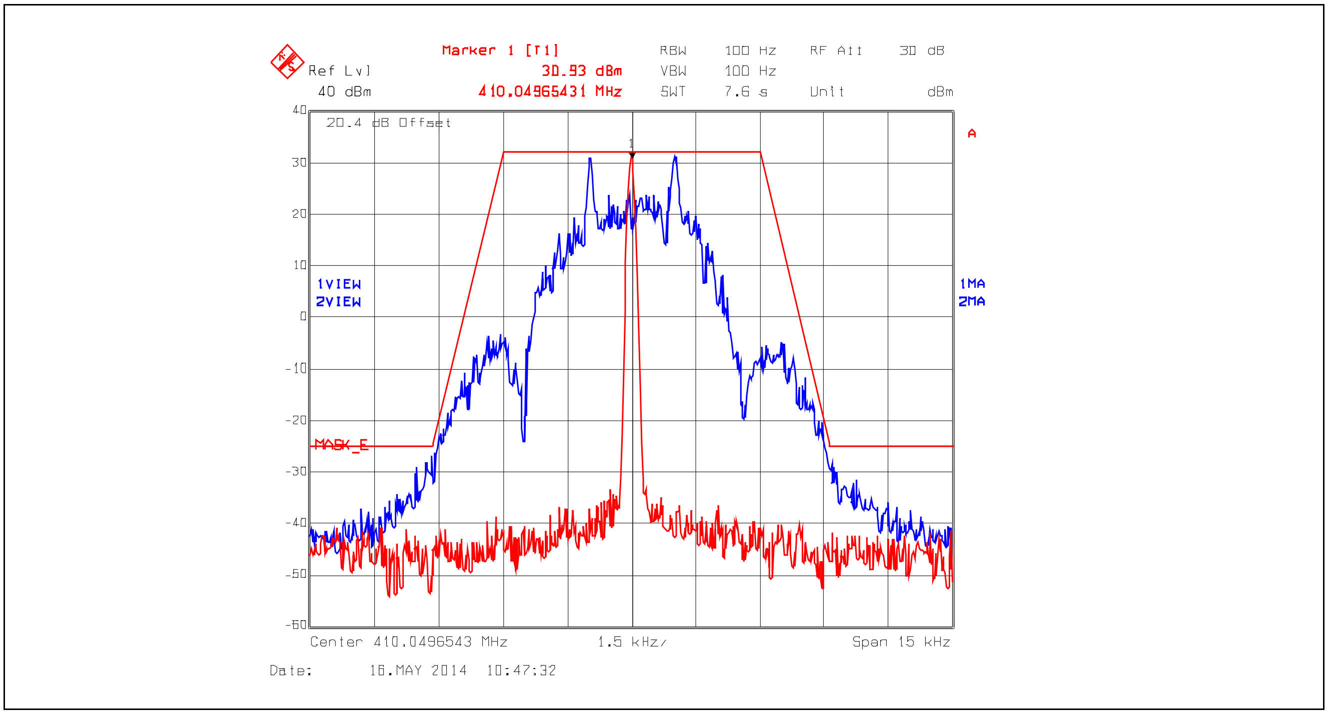
Plot 5.3.4.2.11. Emission Mask D, 4-Level FSK at 9.6 kbps data rate, High Power, 469.95 MHz



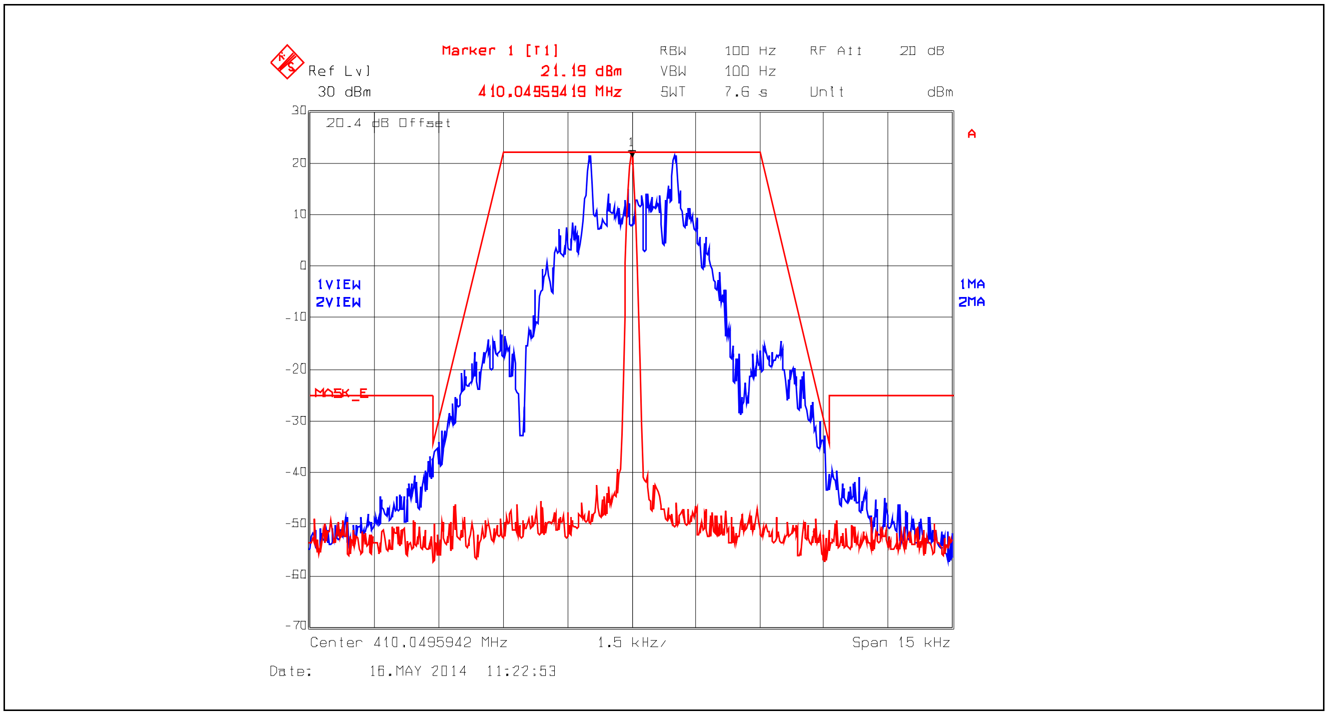
Plot 5.3.4.2.12. Emission Mask D, 4-Level FSK at 9.6 kbps data rate, Low Power, 469.95 MHz



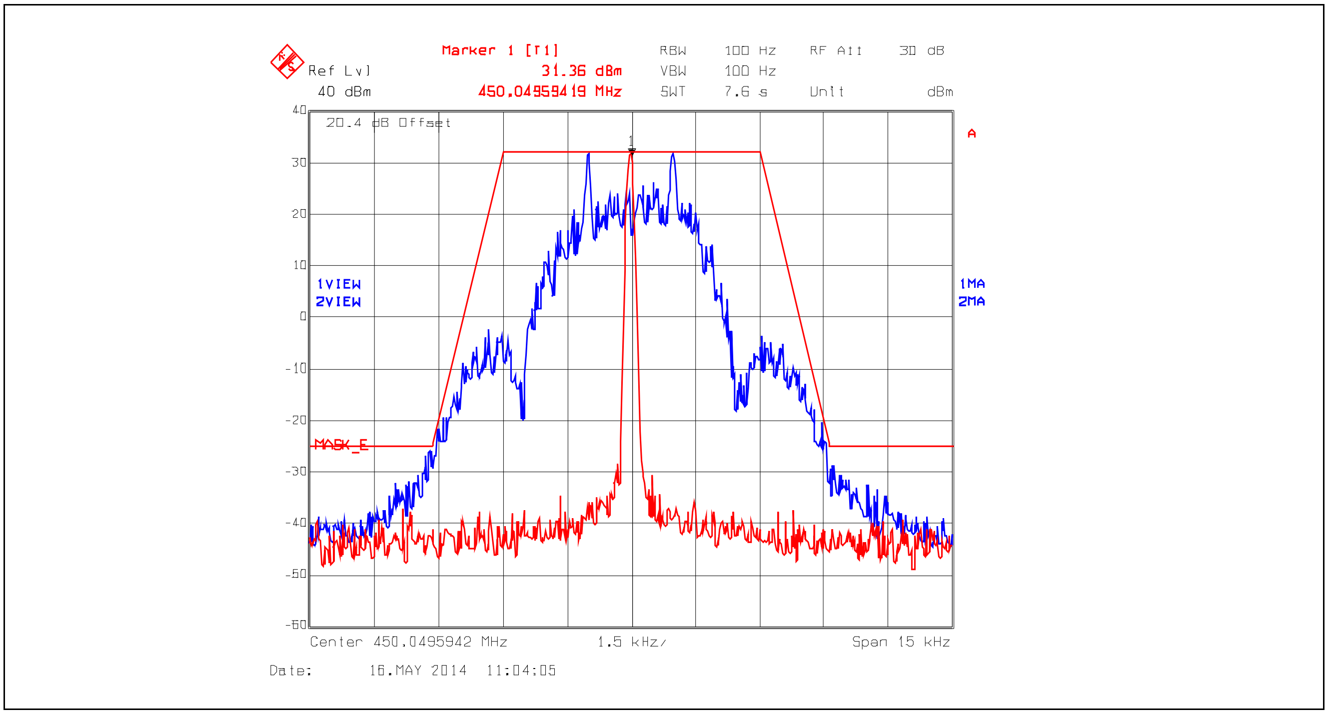
Plot 5.3.4.2.13. Emission Mask E, 2-Level FSK at 3.6 kbps data rate, High Power, 410.05 MHz



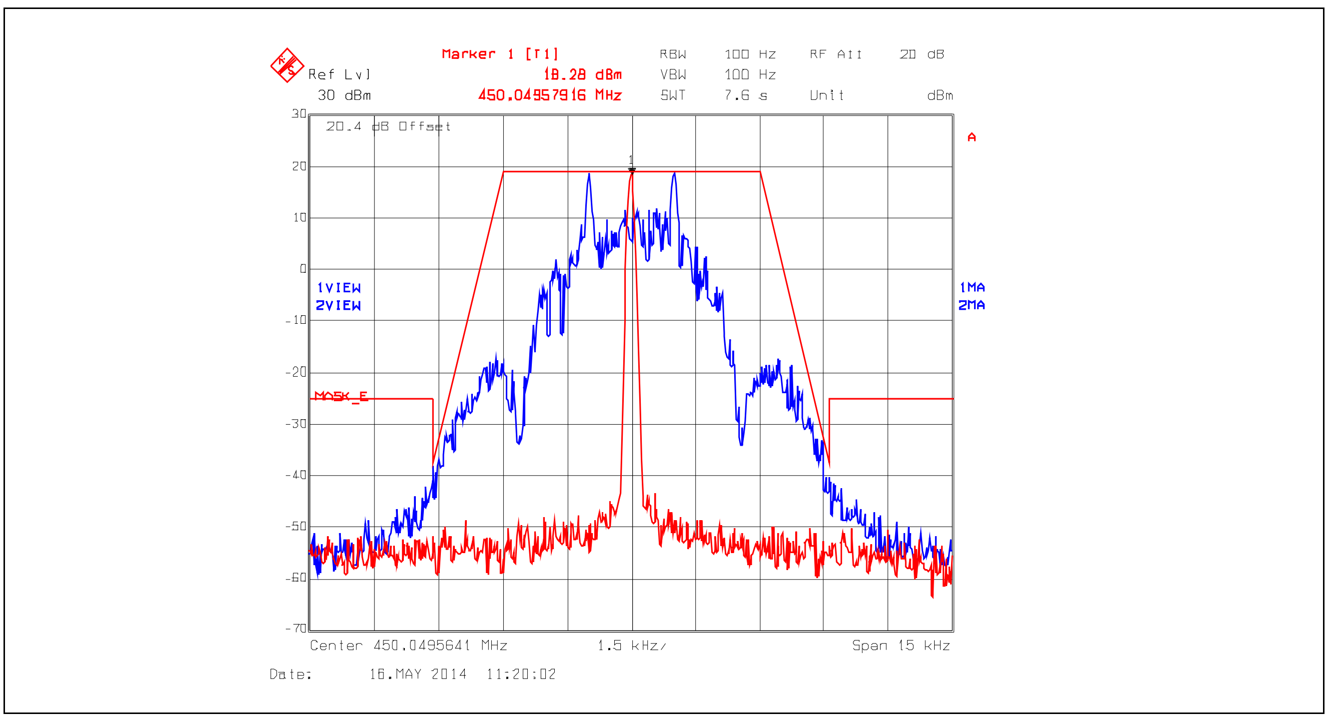
Plot 5.3.4.2.14. Emission Mask E, 2-Level FSK at 3.6 kbps data rate, Low Power, 410.05 MHz



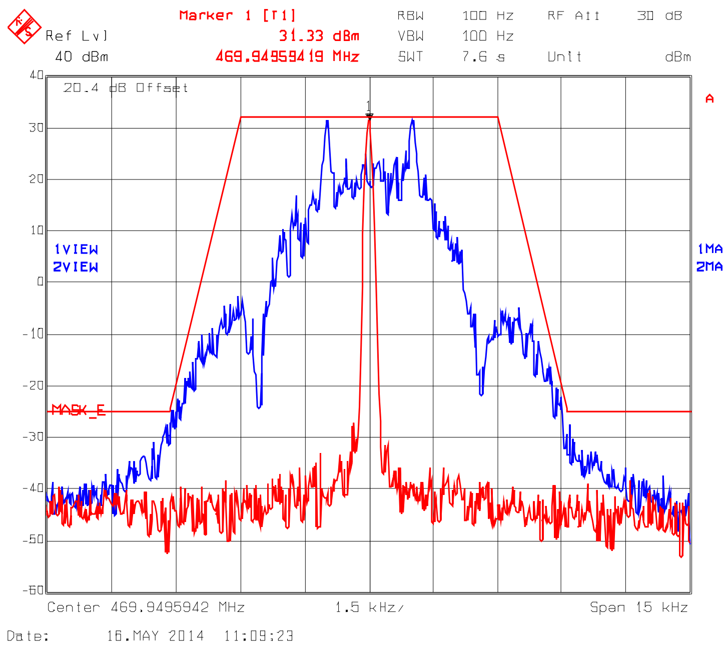
Plot 5.3.4.2.15. Emission Mask E, 2-Level FSK at 3.6 kbps data rate, High Power, 450.05 MHz



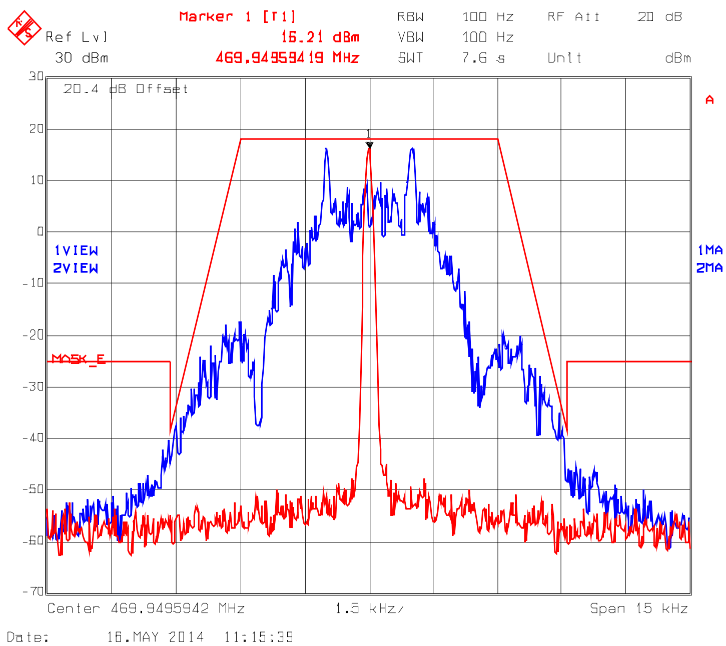
Plot 5.3.4.2.16. Emission Mask E, 2-Level FSK at 3.6 kbps data rate, Low Power, 450.05MHz



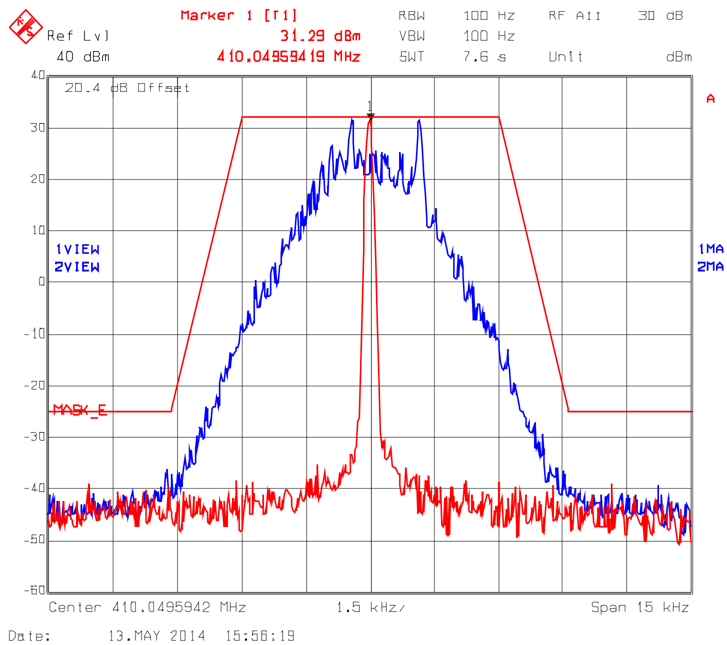
Plot 5.3.4.2.17. Emission Mask E, 2-Level FSK at 3.6 kbps data rate, High Power, 469.95 MHz



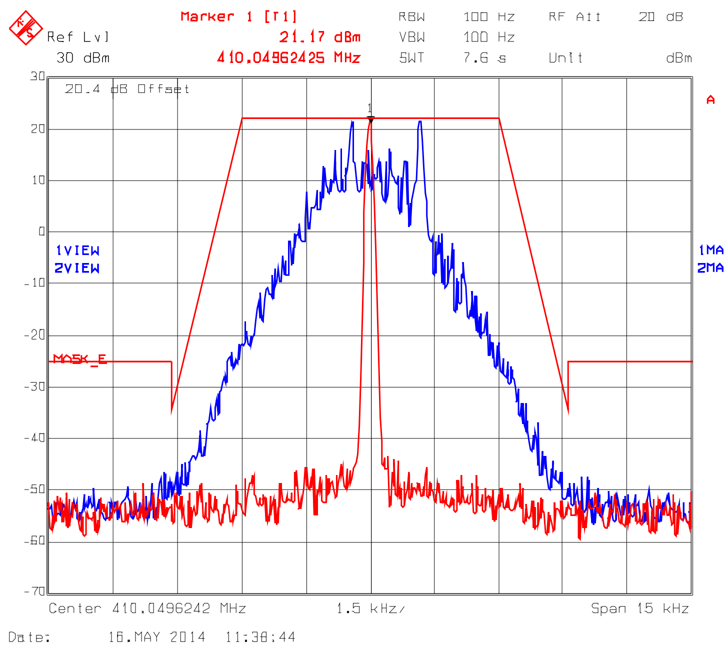
Plot 5.3.4.2.18. Emission Mask E, 2-Level FSK at 3.6 kbps data rate, Low Power, 469.95 MHz



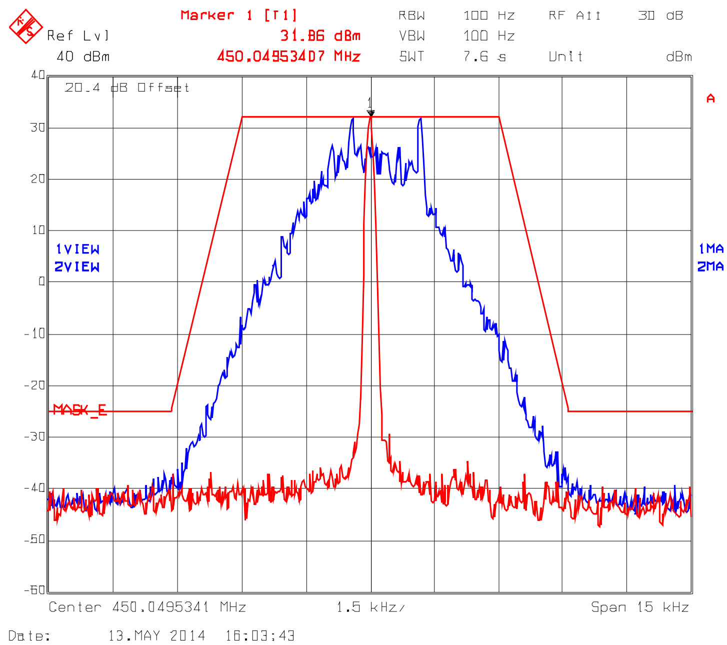
Plot 5.3.4.2.19. Emission Mask E, 4-Level FSK at 4.8 kbps data rate, High Power, 410.05 MHz



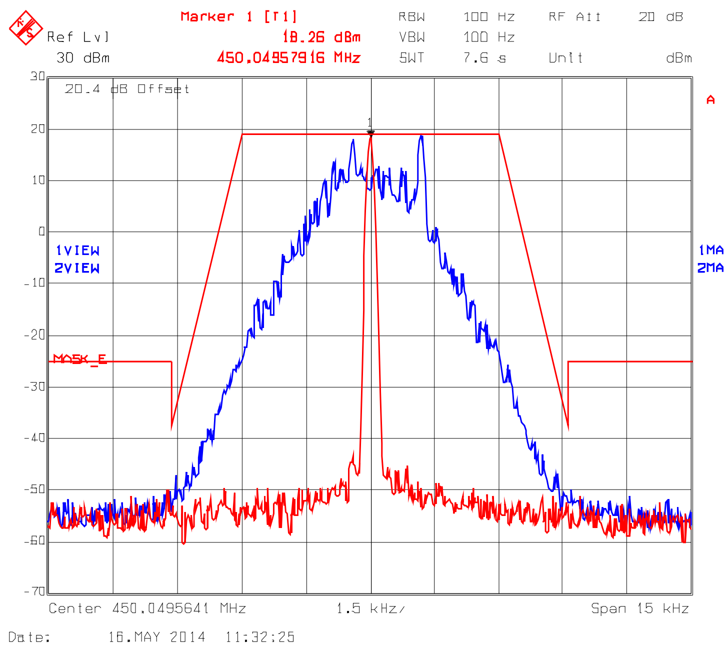
Plot 5.3.4.2.20. Emission Mask E, 4-Level FSK at 4.8 kbps data rate, Low Power, 410.05 MHz



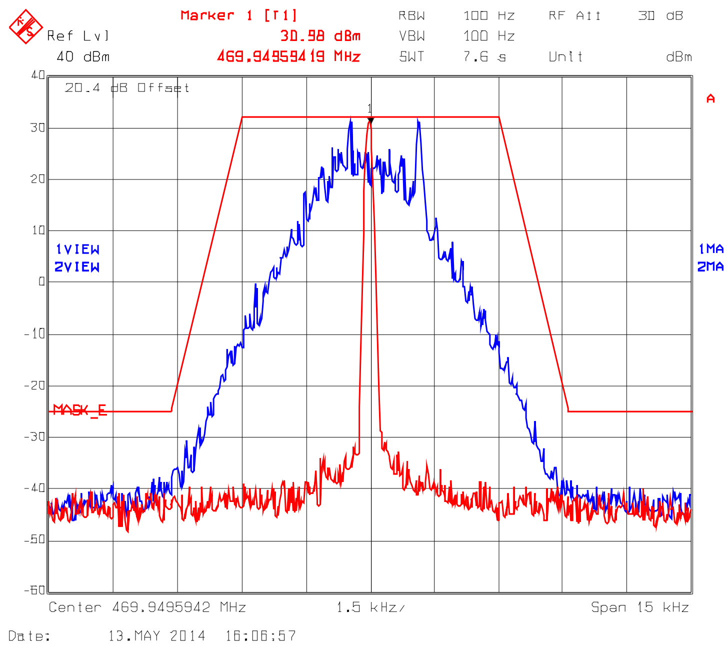
Plot 5.3.4.2.21. Emission Mask E, 4-Level FSK at 4.8 kbps data rate, High Power, 450.05 MHz



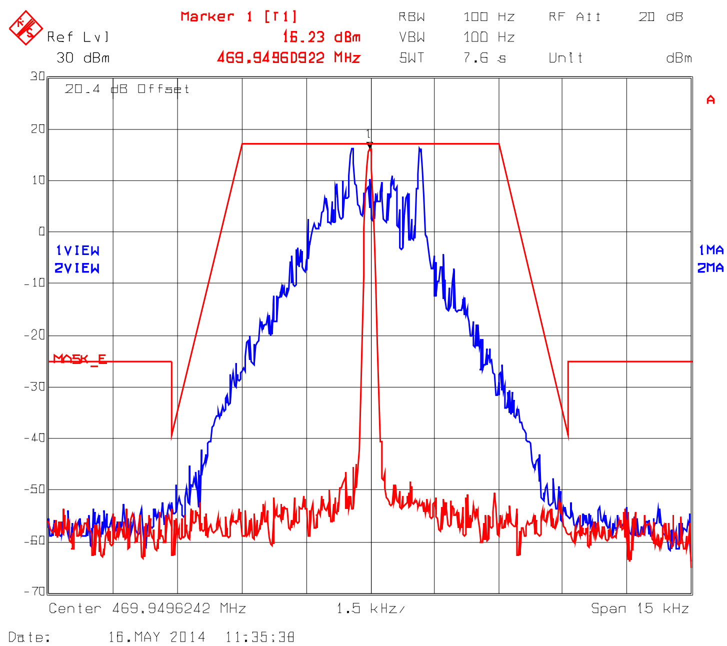
Plot 5.3.4.2.22. Emission Mask E, 4-Level FSK at 4.8 kbps data rate, Low Power, 450.05MHz



Plot 5.3.4.2.23. Emission Mask E, 4-Level FSK at 4.8 kbps data rate, High Power, 469.95 MHz



Plot 5.3.4.2.24. Emission Mask E, 4-Level FSK at 4.8 kbps data rate, Low Power, 469.95 MHz



5.4. TRANSMITTER ANTENNA POWER SPURIOUS/HARMONIC CONDUCTED EMISSIONS [§§ 2.1051 & 2.1057 & 90.210]

5.4.1. Limits

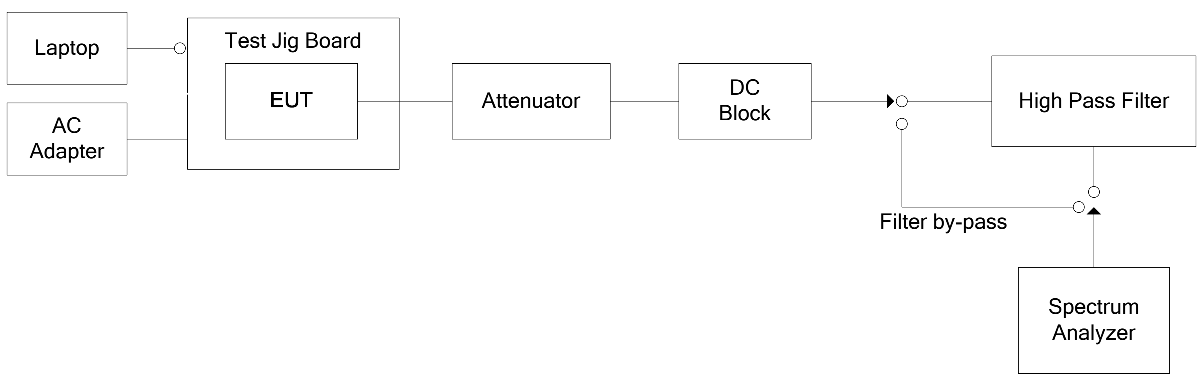
Emissions shall be attenuated below the mean output power of the transmitter as follows:

FCC Rules	Frequency Range	Attenuation Limit (dBc)
90.210(d)	10 MHz or lowest radio frequency signal generated in the device to the tenth harmonic of the highest fundamental frequency.	At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.
90.210(e)	10 MHz or lowest radio frequency signal generated in the device to the tenth harmonic of the highest fundamental frequency.	At least 55 + 10 log (P) or 65 dB, whichever is the lesser attenuation.

5.4.2. Method of Measurements

Refer to Exhibit 8 Section 8.5 of this report for measurement details

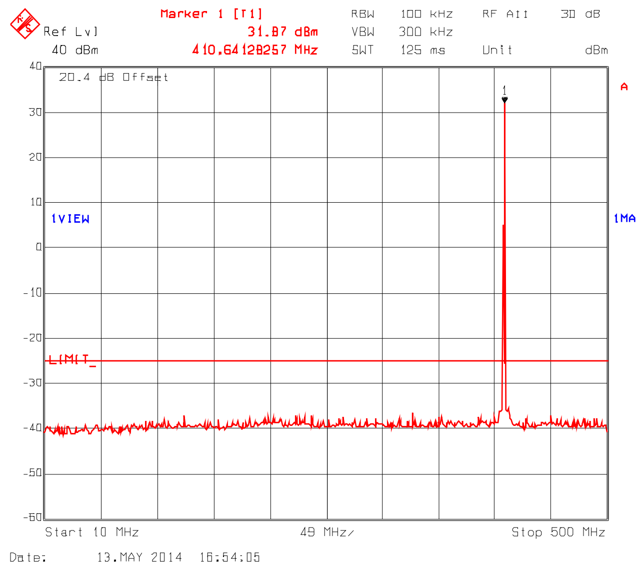
5.4.3. Test Arrangement



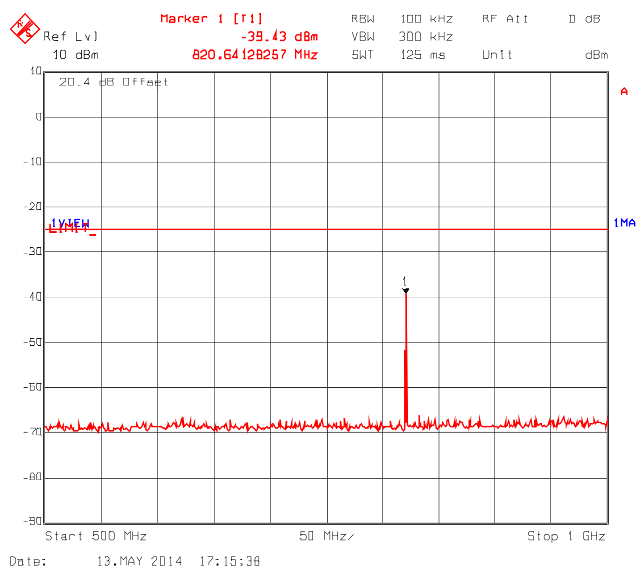
5.4.4. Test Data

The following test results are the final worst-case measurements derived from exploratory tests, performed with EUT operating at 6.25 kHz channel spacing and 4-Level FSK at 4.8 kbps data rate.

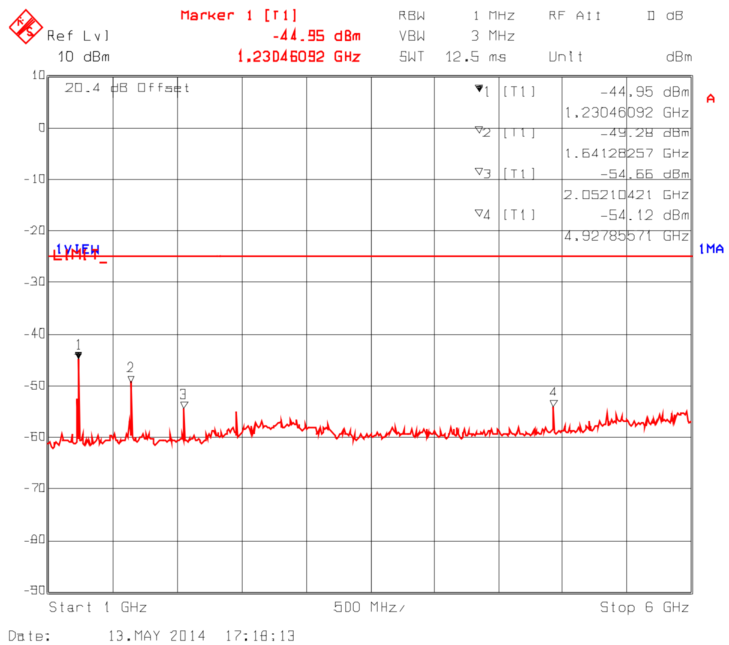
Plot 5.4.4.1. Conducted Transmitter Spurious Emissions, High Power, 410.05 MHz, 10 MHz - 500 MHz



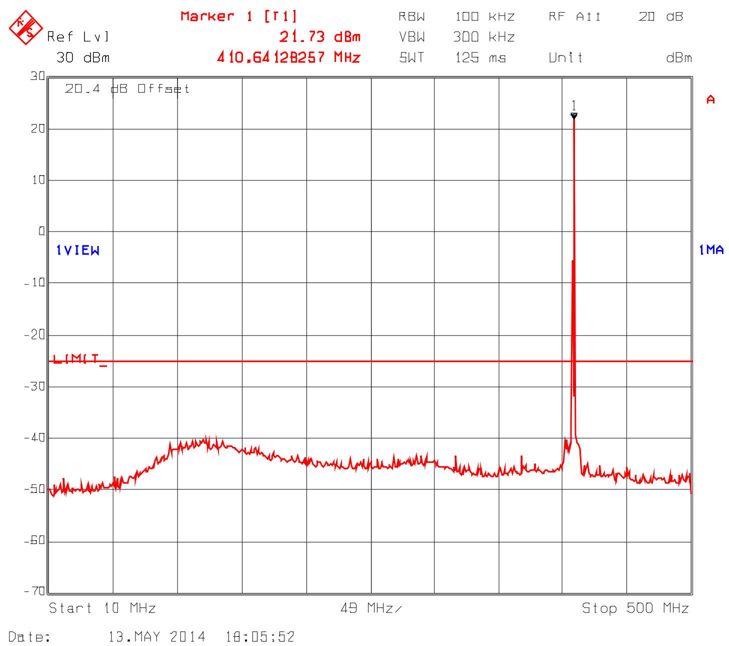
Plot 5.4.4.2. Conducted Transmitter Spurious Emissions, High Power, 410.05 MHz, 500 MHz – 1 GHz



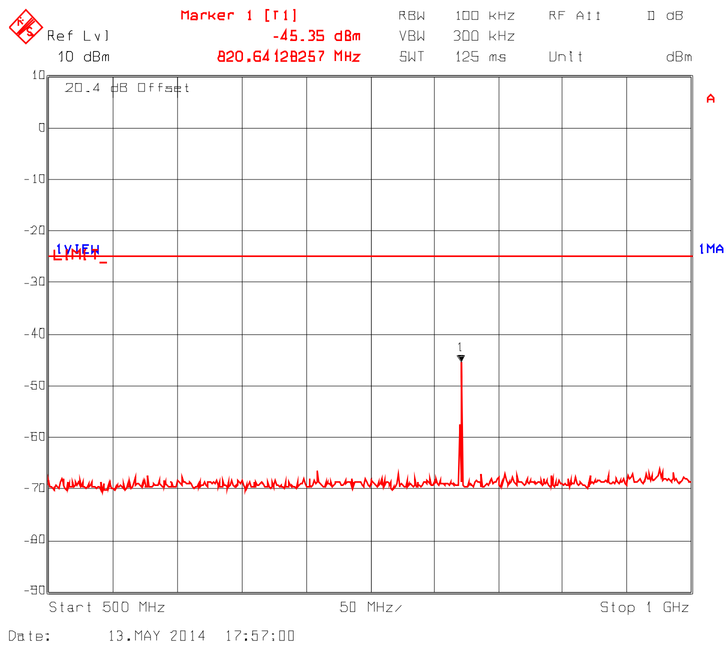
Plot 5.4.4.3. Conducted Transmitter Spurious Emissions, High Power, 410.05 MHz, 1 GHz – 6 GHz



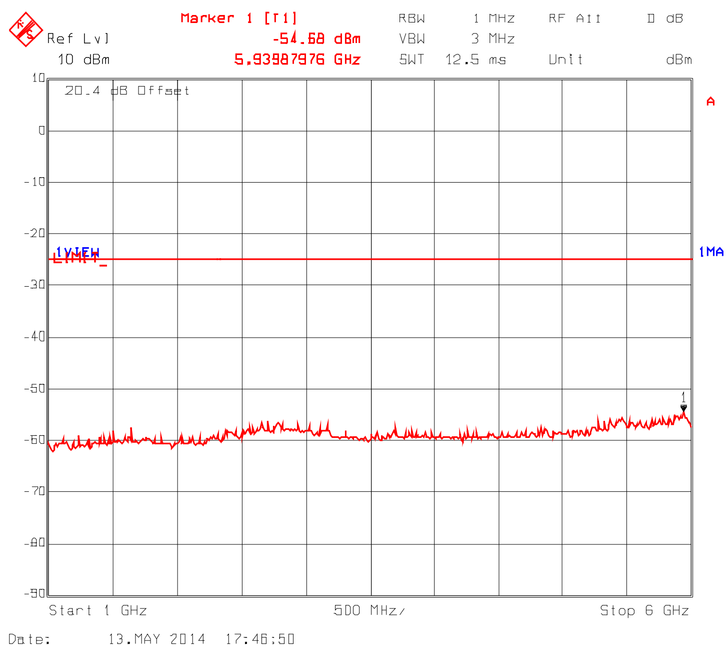
Plot 5.4.4.4. Conducted Transmitter Spurious Emissions, Low Power, 410.05 MHz, 10 MHz - 500 MHz



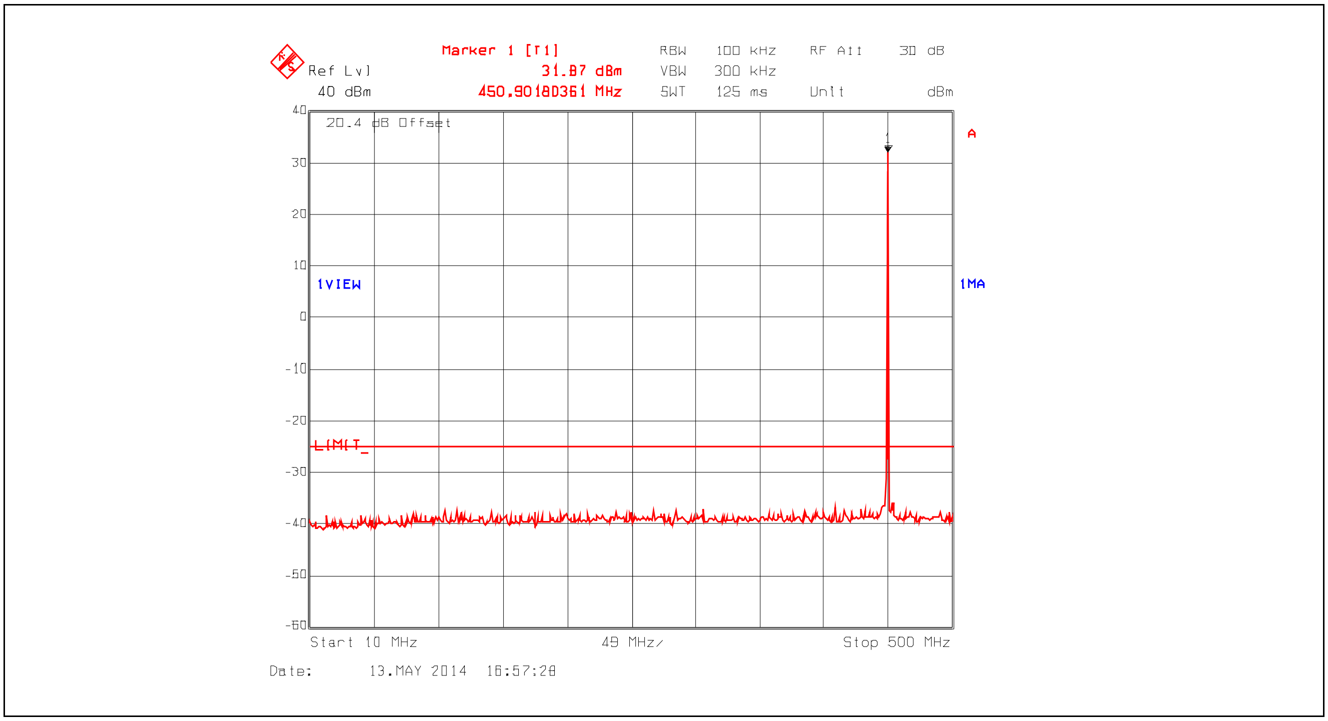
Plot 5.4.4.5. Conducted Transmitter Spurious Emissions, Low Power, 410.05 MHz, 500 MHz – 1 GHz



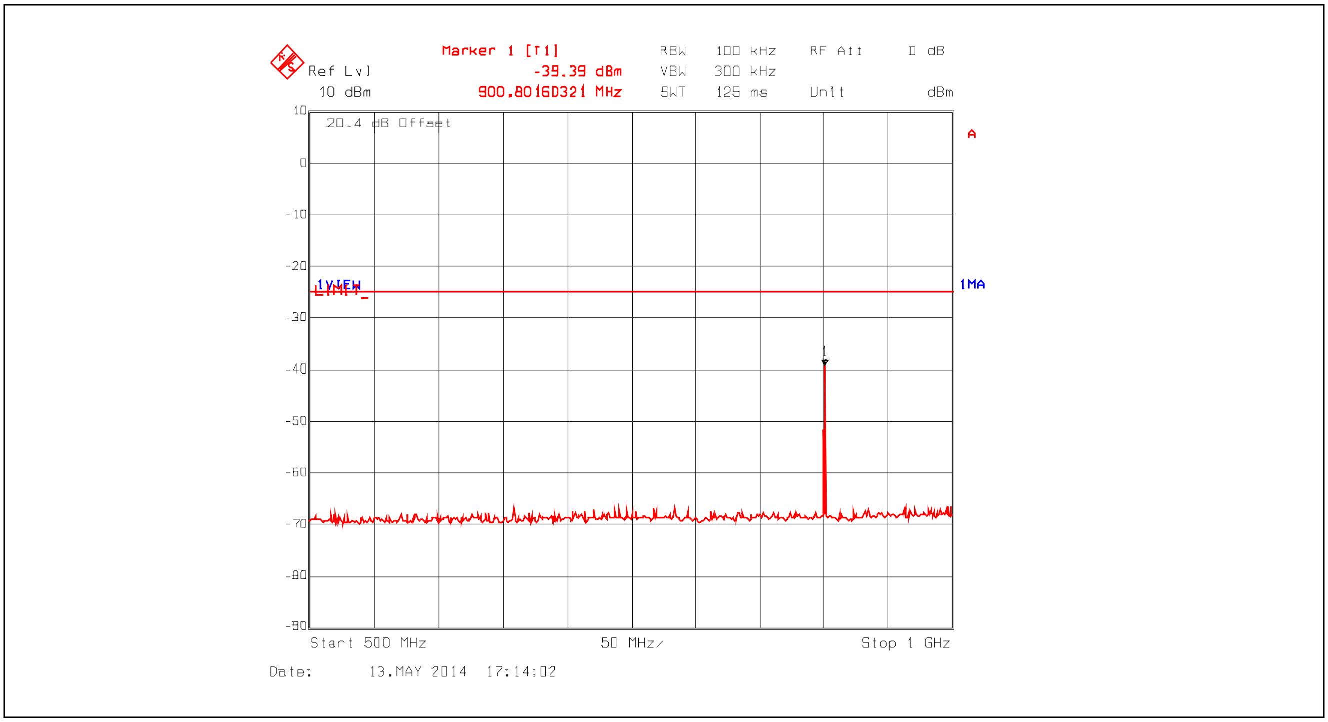
Plot 5.4.4.6. Conducted Transmitter Spurious Emissions, Low Power, 410.05 MHz, 1 GHz – 6 GHz



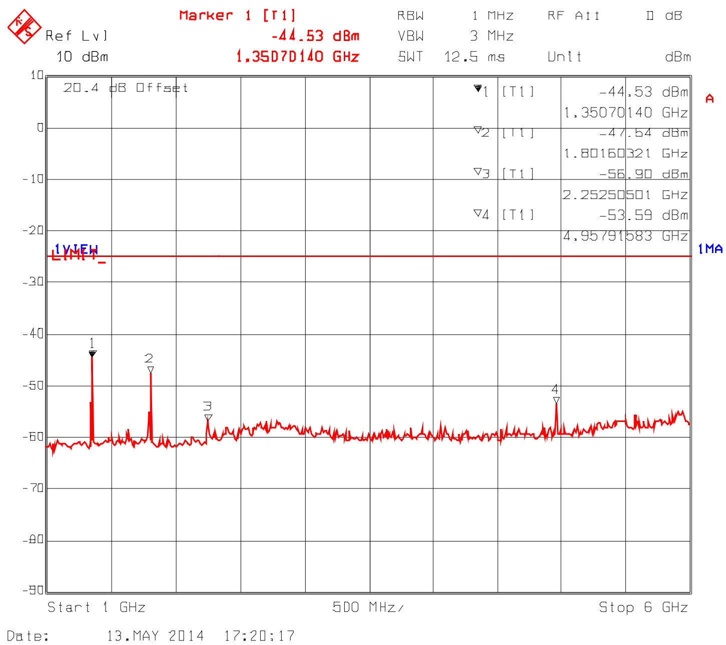
Plot 5.4.4.7. Conducted Transmitter Spurious Emissions, High Power, 450.05 MHz, 10 MHz - 500 MHz



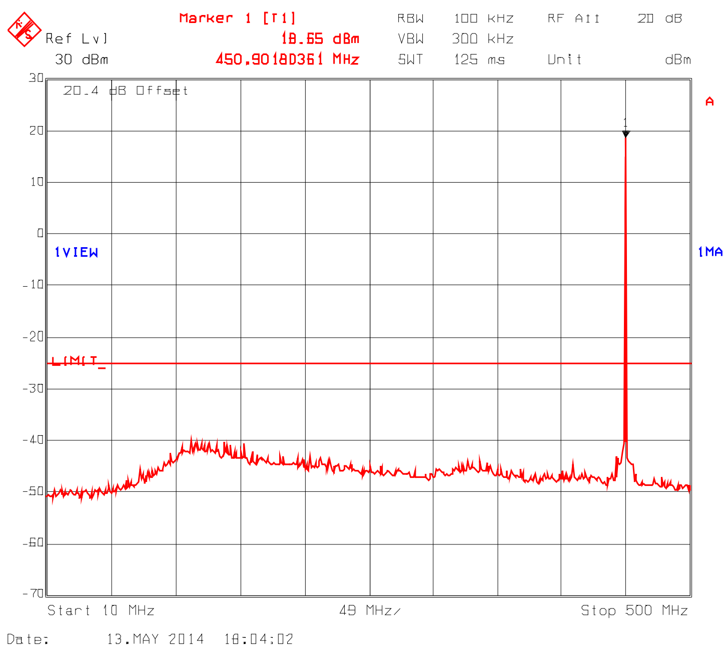
Plot 5.4.4.8. Conducted Transmitter Spurious Emissions, High Power, 450.05 MHz, 500 MHz – 1 GHz



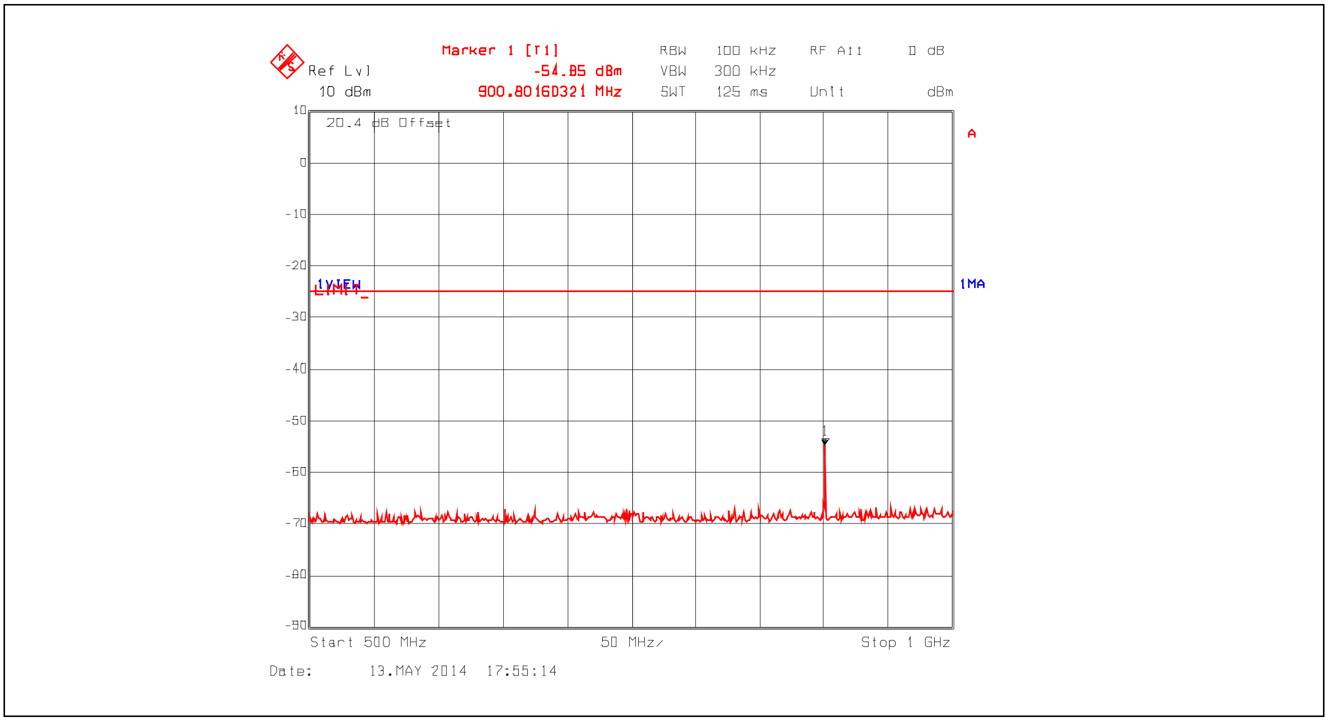
Plot 5.4.4.9. Conducted Transmitter Spurious Emissions, High Power, 450.05 MHz, 1 GHz – 6 GHz



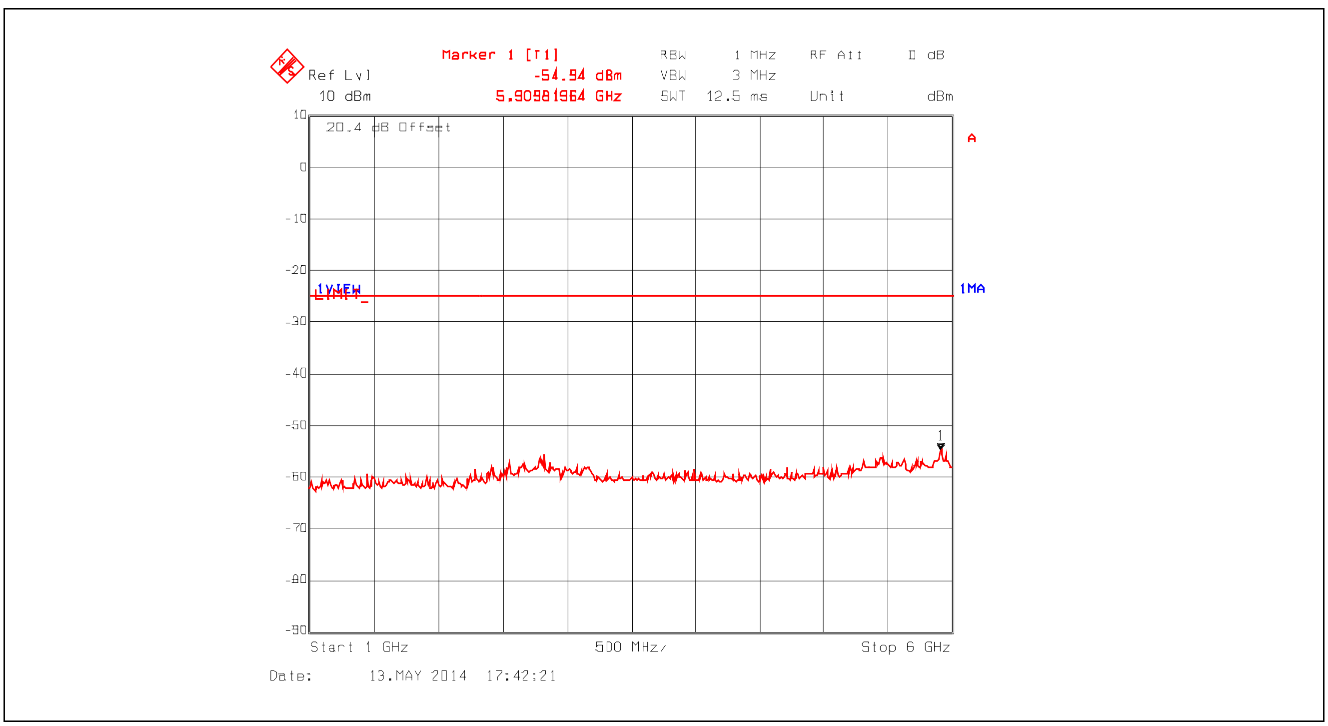
Plot 5.4.4.10. Conducted Transmitter Spurious Emissions, Low Power, 450.05 MHz, 10 MHz - 500 MHz



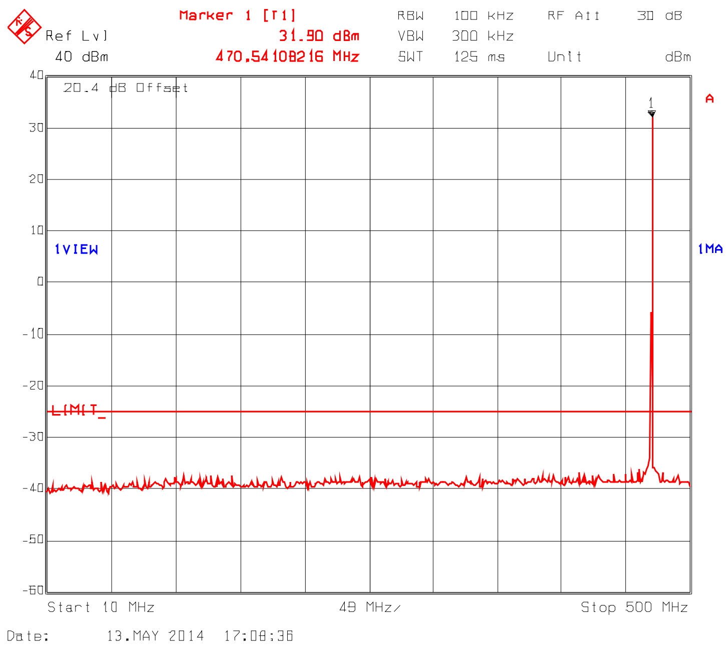
Plot 5.4.4.11. Conducted Transmitter Spurious Emissions, Low Power, 450.05 MHz, 500 MHz – 1 GHz



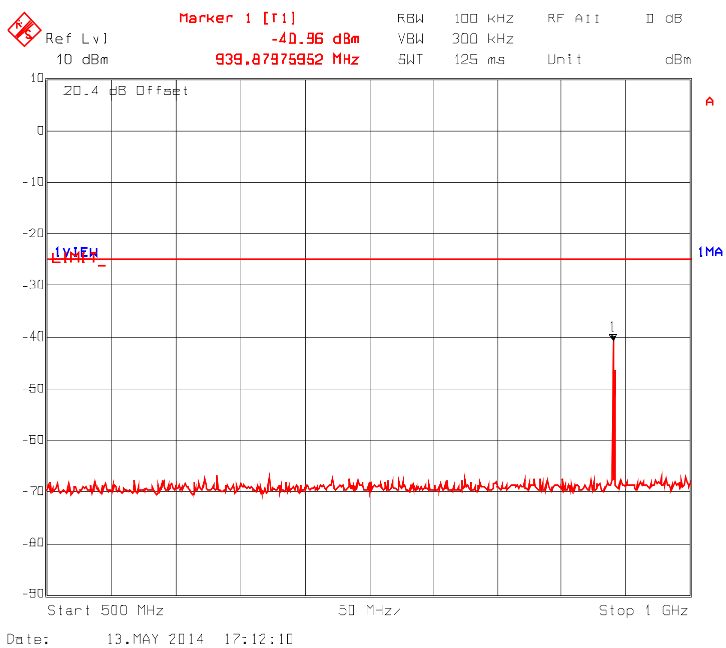
Plot 5.4.4.12. Conducted Transmitter Spurious Emissions, Low Power, 450.05 MHz, 1 GHz – 6 GHz



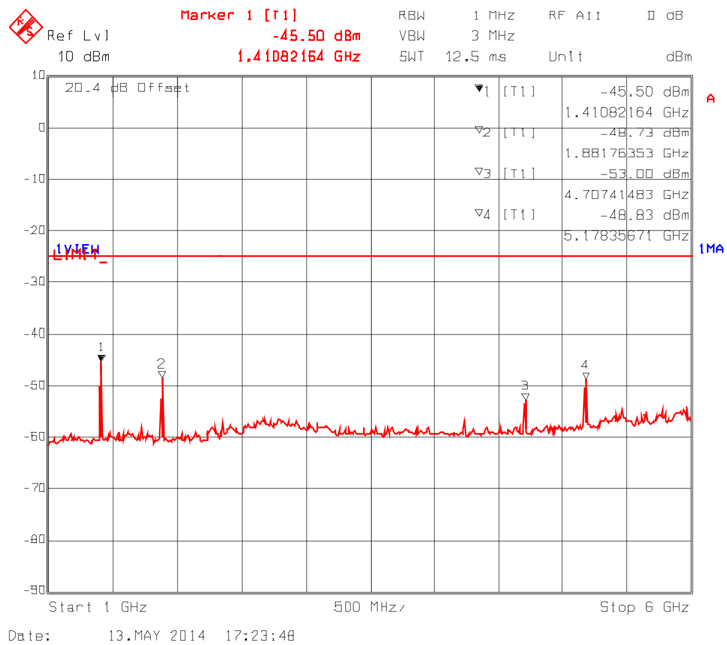
Plot 5.4.4.13. Conducted Transmitter Spurious Emissions, High Power, 469.95 MHz, 10 MHz - 500 MHz



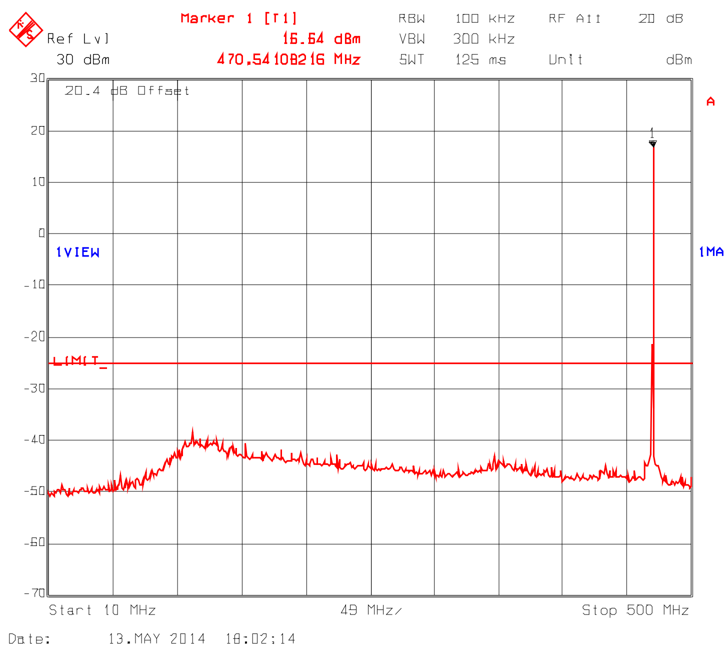
Plot 5.4.4.14. Conducted Transmitter Spurious Emissions, High Power, 469.95 MHz, 500 MHz – 1 GHz



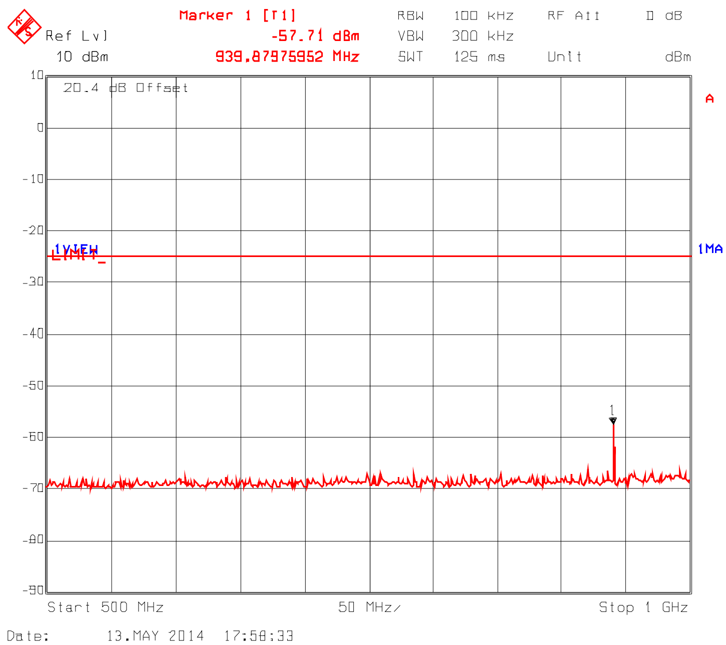
Plot 5.4.4.15. Conducted Transmitter Spurious Emissions, High Power, 469.95 MHz, 1 GHz – 6 GHz



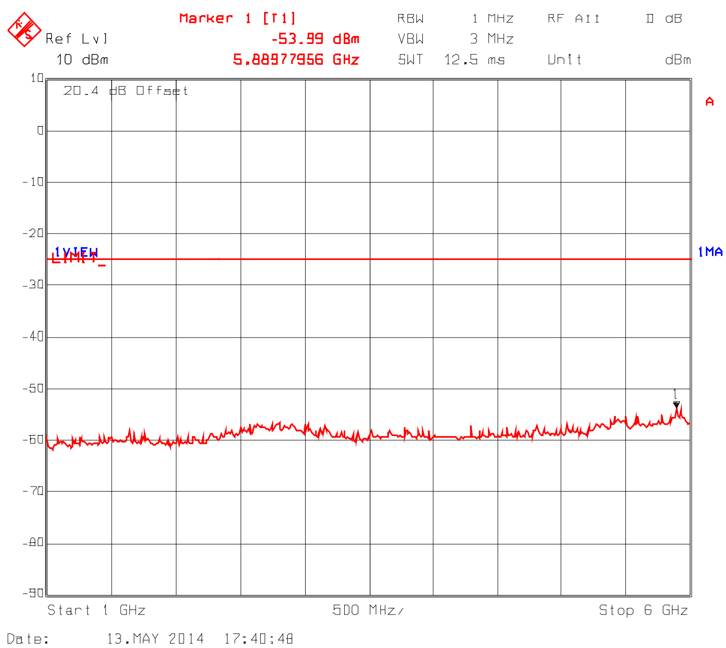
Plot 5.4.4.16. Conducted Transmitter Spurious Emissions, Low Power, 469.95 MHz, 10 MHz - 500 MHz



Plot 5.4.4.17. Conducted Transmitter Spurious Emissions, Low Power, 469.95 MHz, 500 MHz – 1 GHz



Plot 5.4.4.18. Conducted Transmitter Spurious Emissions, Low Power, 469.95 MHz, 1 GHz – 6 GHz



5.5. TRANSMITTER SPURIOUS/HARMONIC RADIATED EMISSIONS [§§ 2.1053, 2.1057 & 90.210]

5.5.1. Limits

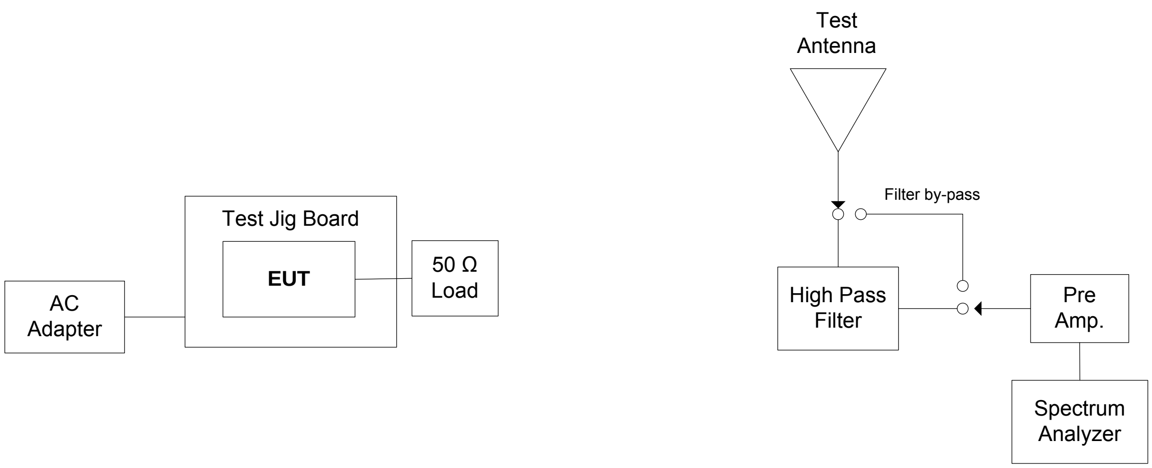
Emissions shall be attenuated below the mean output power of the transmitter as follows:

FCC Rules	Frequency Range	Attenuation Limit (dBc)
90.210(d)	10 MHz or lowest radio frequency signal generated in the device to the tenth harmonic of the highest fundamental frequency.	At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.
90.210(e)	10 MHz or lowest radio frequency signal generated in the device to the tenth harmonic of the highest fundamental frequency.	At least 55 + 10 log (P) or 65 dB, whichever is the lesser attenuation.

5.5.2. Method of Measurements

Refer to Exhibit 8 Section 8.2 of this report for measurement details.

5.5.3. Test Arrangement



5.5.4. Test Data

Remarks:

- The emissions were scanned from 30 MHz to 10th harmonics; all spurious emissions that are in excess of 20dB below the specified limit shall be recorded.
- EUT shall be tested in three orthogonal positions.
- The following test results are the final worst-case measurements derived from exploratory tests, performed with EUT unmodulated.

Carrier Frequency (MHz): 410.05
Power (dBm): 33
Limit (dBm): -25

Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP (dBm)	Limit (dBm)	Margin (dB)
820.10	56.38	Peak	V	-39.69	-25	-14.7

Carrier Frequency (MHz): 450.05
Power (dBm): 33
Limit (dBm): -25

Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP (dBm)	Limit (dBm)	Margin (dB)
30 - 5000	*	Peak	H/V	*	-25	*

* Spurious emissions are more than 20 dB below the specified limit.

Carrier Frequency (MHz): 469.95
Power (dBm): 33
Limit (dBm): -25

Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP (dBm)	Limit (dBm)	Margin (dB)
30 - 5000	*	Peak	H/V	*	-25	*

* Spurious emissions are more than 20 dB below the specified limit.

5.6. FREQUECNY STABILITY [§§ 2.1055 & 90.213]

5.6.1. Limits

See § 90.213 - Minimum Frequency Stability

Frequency range (MHz)	Minimum Frequency Stability (ppm)		
	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

[1] In 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.

[2] In 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.

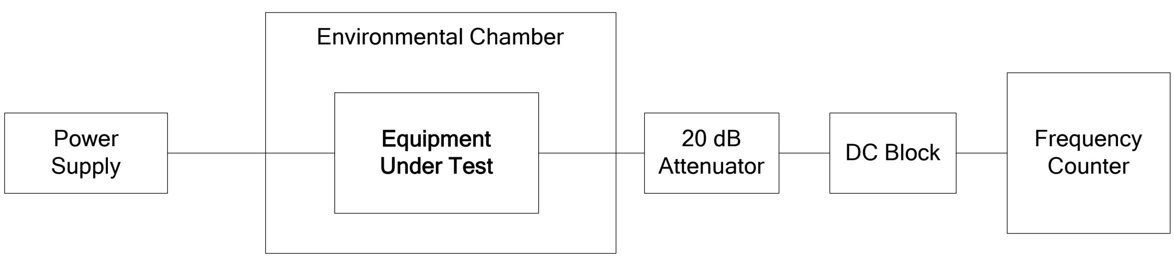
[3] Paging transmitters operating on paging-only frequencies must operate with frequency stability of 5 ppm in the 150-174 MHz band and 2.5 ppm in the 421-512 MHz band.

[4] Control 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

Center Frequency:	410.05 MHz
Full Power Level:	33 dBm
Frequency Tolerance Limit (Worst Case):	±0.5 ppm or 205 Hz
Max. Frequency Tolerance Measured:	143 Hz or 0.35 ppm
Input Voltage Rating:	12 VDC to Test Jig

Ambient Temperature (°C)	**Frequency Drift (Hz)**		
	Supply Voltage 12.5 VDC	**Supply Voltage 10.2 VDC**	**Supply Voltage 13.8 VDC**
-30	+56	--	--
-20	+44	--	--
-10	+31	--	--
0	+39	--	--
10	+16	--	--
20	0	-11	-3
30	-104	--	--
40	-44	--	--
50	-143	--	--
60	-114	--	--

5.7. TRANSIENT FREQUENCY BEHAVIOR [§ 90.214]

5.7.1. Limits

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

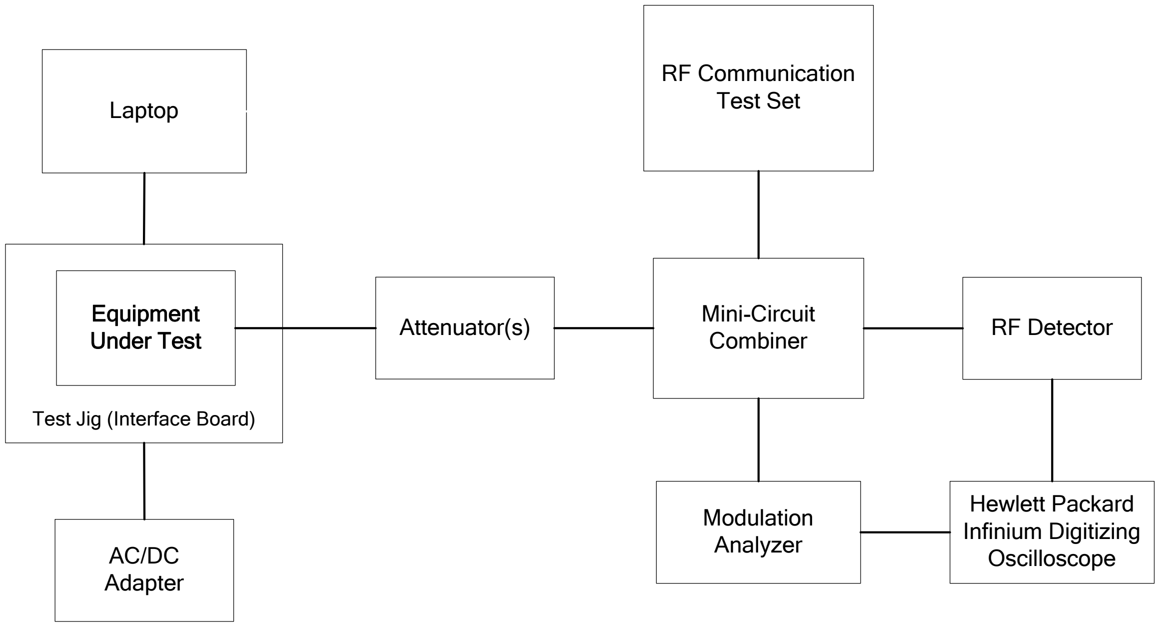
Time intervals [1, 2]	Maximum frequency difference [3]	All equipment	
		150 to 174 MHz	421 to 512MHz
Transient Frequency Behavior for Equipment Designed to Operate on 25 kHz Channels			
t_1 [4] ……………………….. t_2 ………………………… t_3 [4] ………………………..	± 25.0 KHz ± 12.5 KHz ± 25.0 KHz	5.0 ms 20.0 ms 5.0 ms	10.0 ms 25.0 ms 10.0 ms
Transient Frequency Behavior for Equipment Designed to Operate on 12.5 kHz Channels			
t_1 [4] ……………………….. t_2 ………………………… t_3 [4] ………………………..	± 12.5 KHz ± 6.25 KHz ± 12.5 KHz	5.0 ms 20.0 ms 5.0 ms	10.0 ms 25.0 ms 10.0 ms
Transient Frequency Behavior for Equipment Designed to Operate on 6.25 kHz Channels			
t_1 [4] ……………………….. t_2 ………………………… t_3 [4] ………………………..	±6.25 KHz ±3.125 KHz ±6.25 KHz	5.0 ms 20.0 ms 5.0 ms	10.0 ms 25.0 ms 10.0 ms

1. t_{on} is the instant when a 1 kHz test signal is completely suppressed, including any capture time due to phasing.
   t_1 is the time period immediately following t_{on}.
   t_2 is the time period immediately following t_1.
   t_3 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.
2. During the time from the end of t_2 to the beginning of t_3, the frequency difference must not exceed the limits specified in § 90.213.
3. Difference between the actual transmitter frequency and the assigned transmitter frequency.
4. 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

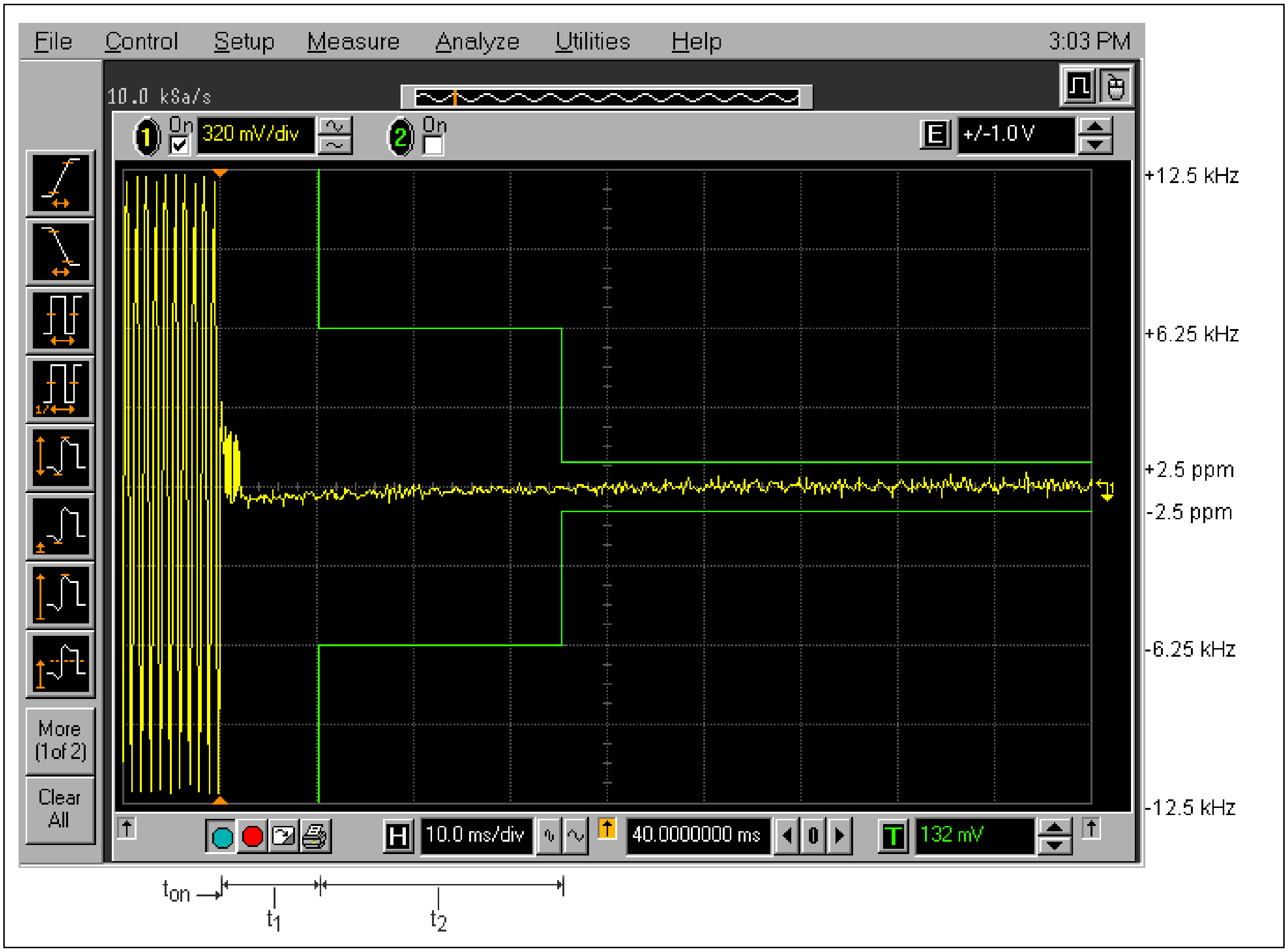
Refer to Section 8.6 of this test report and ANSI/TIA/EIA-603-D-2010, Section 2.2.19.

5.7.3. Test Arrangement

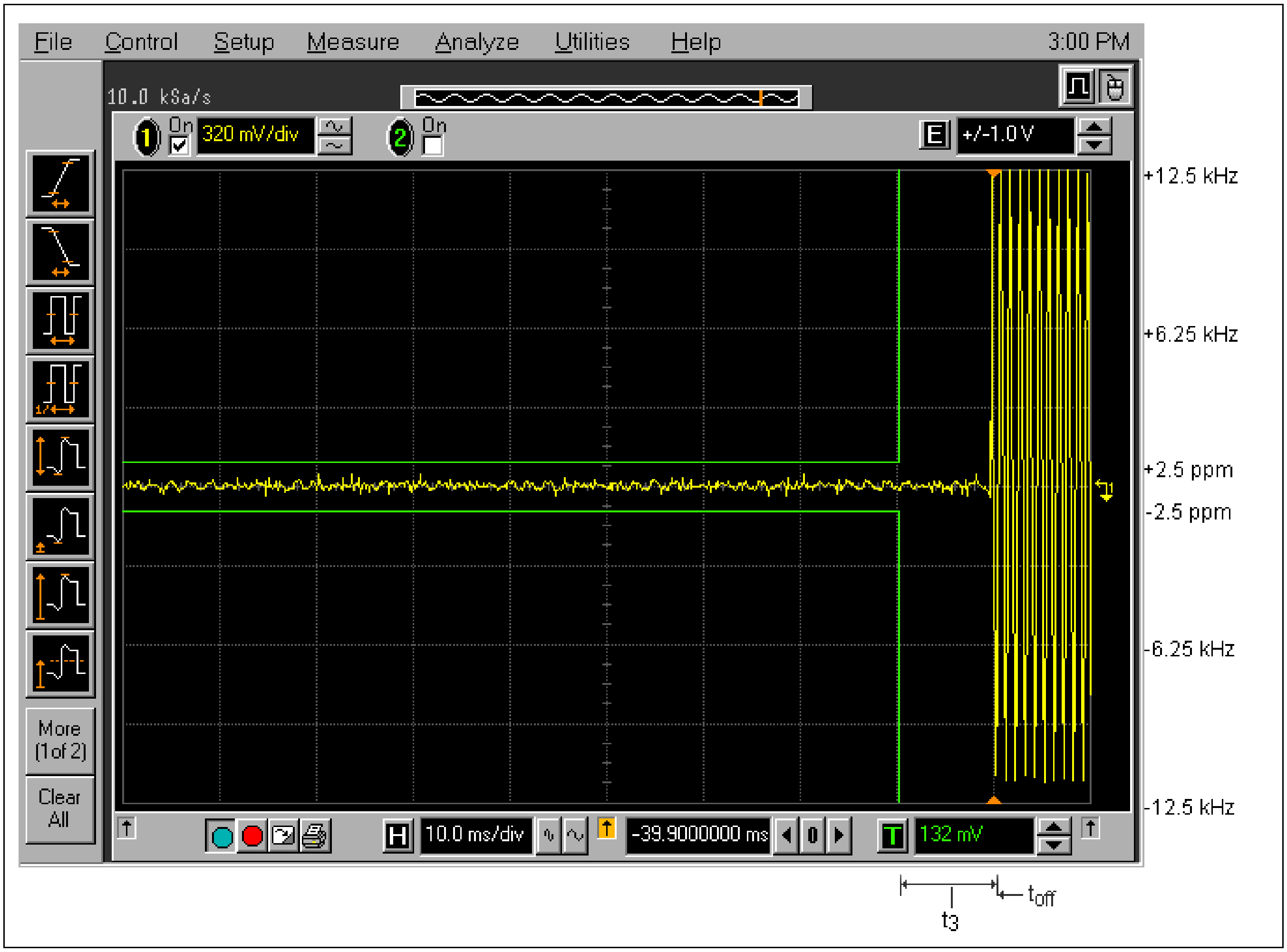


5.7.4. Test Data

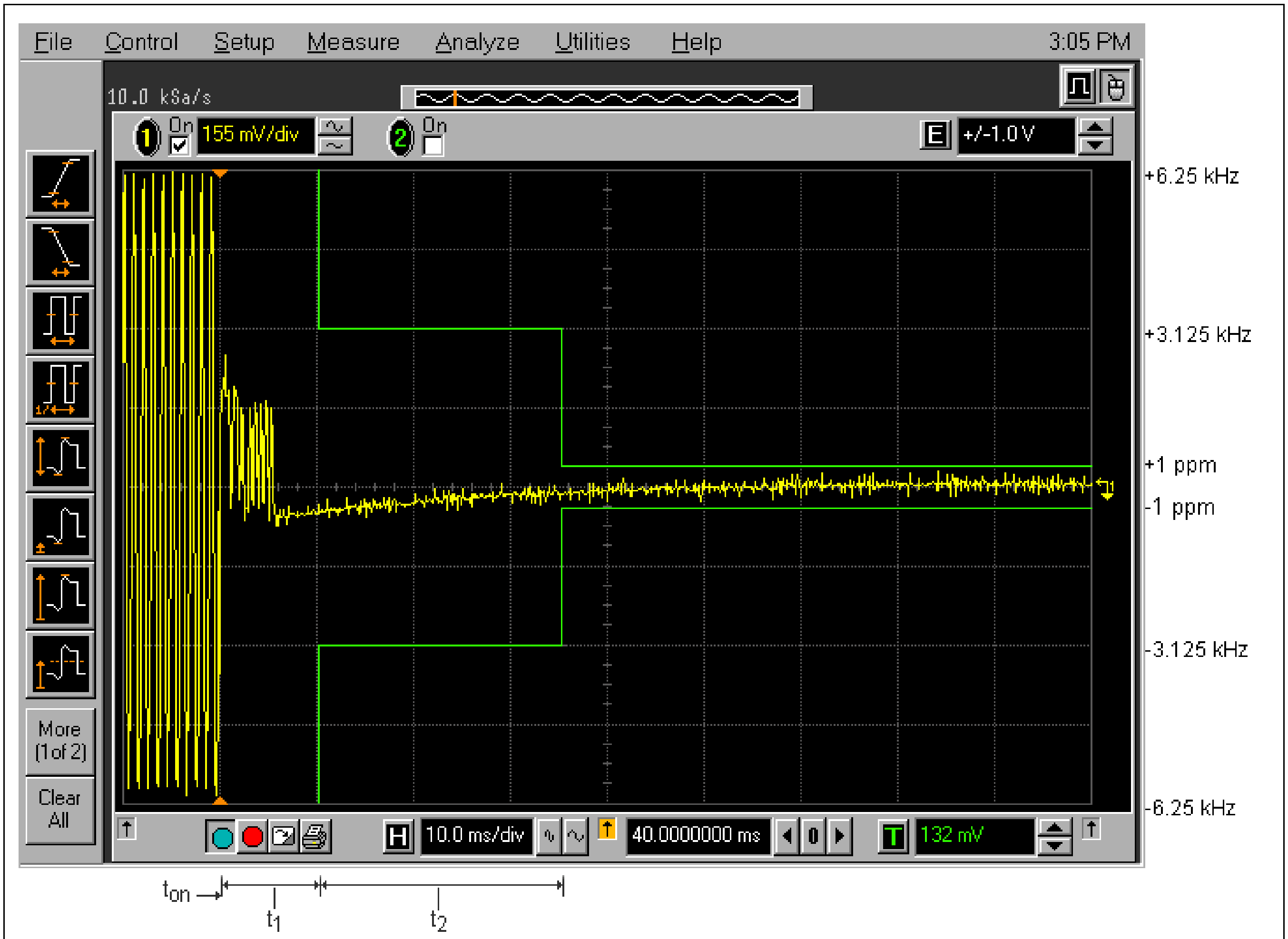
Plot 5.7.4.1. Transient Frequency Behavior on 12.5 kHz Channel Spacing
Test Frequency: 410.05 MHz; Power: 2 W; Test Conditions: Switch on condition t_{on}, t_1, and t_2



Plot 5.7.4.2. Transient Frequency Behavior on 12.5 kHz Channel Spacing
Test Frequency: 410.05 MHz; Power: 2 W; Test Conditions: Switch off condition t_3, t_{off}



Plot 5.7.4.3. Transient Frequency Behavior on 6.25 kHz Channel Spacing
Test Frequency: 410.05 MHz; Power: 2 W; Test Conditions: Switch on condition t_{on}, t_1, and t_2



Plot 5.7.4.4. Transient Frequency Behavior on 6.25 kHz Channel Spacing
Test Frequency: 410.05 MHz; Power: 2 W; Test Conditions: Switch off condition t_3, t_{off}

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/cm^2
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

Maximum RF Power conducted, **$P_{conducted}$[dBm]:**	33	
Antenna Gain, **G[dBi]**:	0	10
Maximum EIRP, **P_{EIRP}[dBm]**:	33	43
MPE Limit for General Population/Uncontrolled Exposure, $S_{controlled}$[mW/cm^2]:	0.27	
Calculated RF Safety Distance for General Population/Uncontrolled Exposure, $r_{safety\_controlled}$[cm]:	24 cm	76.7 cm

5.9. POWER LINE CONDUCTED EMISSIONS [§ 15.107]

5.9.1. Limits

The equipment shall meet the limits of the following table:

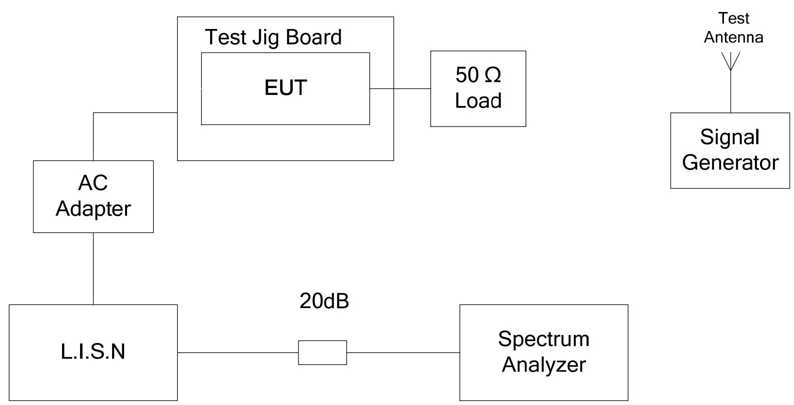
Frequency of emission (MHz)	Conducted Limits (dBμV)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

*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.

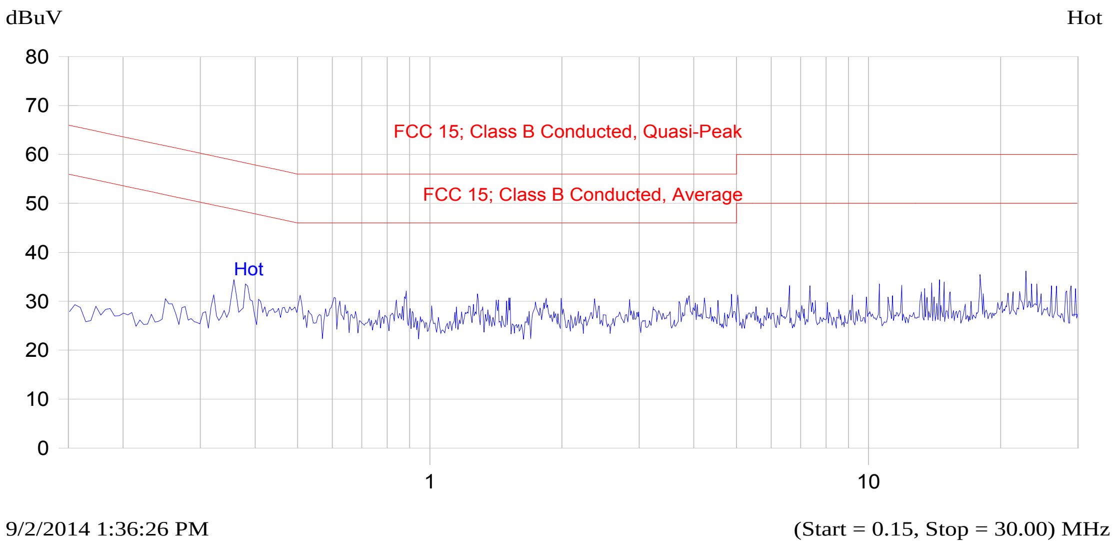
5.9.2. Test Arrangement



5.9.3. Test Data

Plot 5.9.3.1. Power Line Conducted Emissions (Tx Mode)
Line Voltage: 120 VAC; Line Tested: Hot

Current Graph

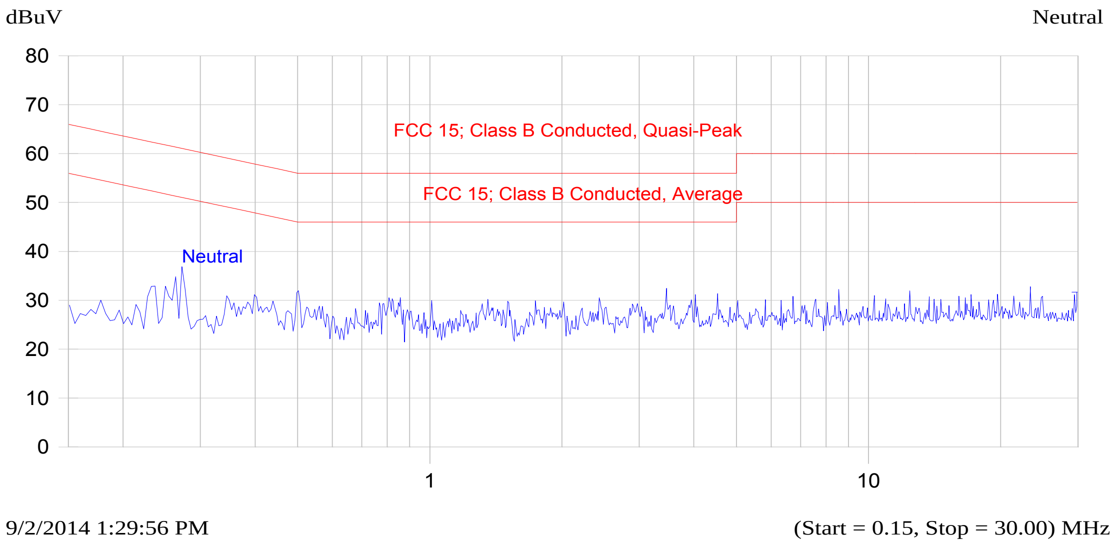


Current List

Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP Limit dB	Avg dBuV	Delta Avg-Avg Limit dB	Trace Name
0.352	33.6	27.1	-33.1	18.2	-32.0	Hot
0.608	28.7	25.0	-31.0	17.8	-28.2	Hot
6.604	27.6	21.8	-38.2	14.9	-35.1	Hot
17.940	29.9	21.6	-38.4	14.2	-35.8	Hot
22.813	29.5	24.0	-36.0	17.4	-32.6	Hot

Plot 5.9.3.2. Power Line Conducted Emissions (Tx Mode)
Line Voltage: 120 VAC; Line Tested: Neutral

Current Graph

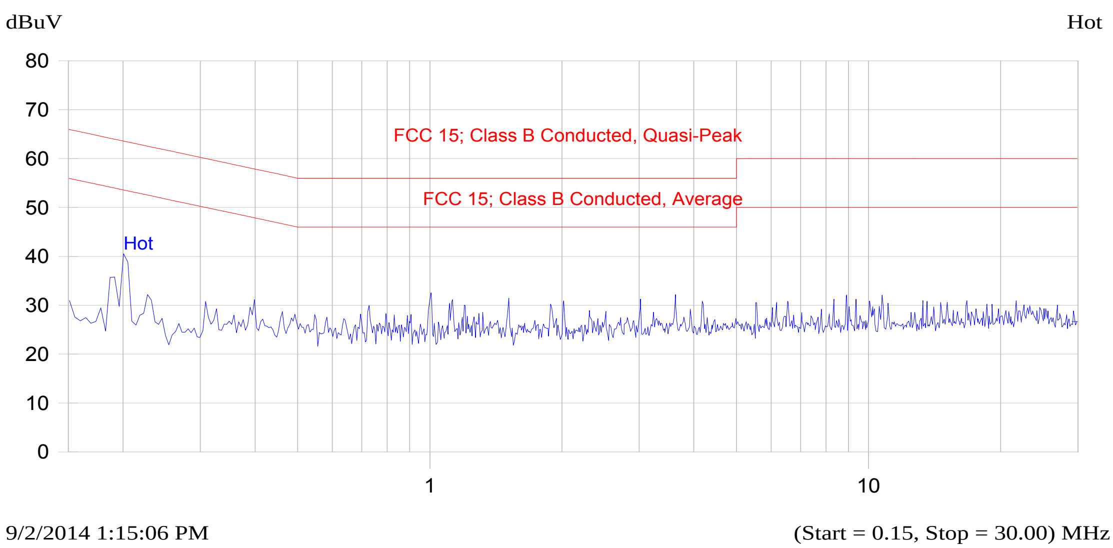


Current List

Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP Limit dB	Avg dBuV	Delta Avg-Avg Limit dB	Trace Name
0.270	36.5	29.0	-33.5	16.5	-36.0	Neutral
0.497	31.6	27.2	-28.9	19.9	-26.2	Neutral
3.462	30.7	22.9	-33.1	15.9	-30.1	Neutral

Plot 5.9.3.3. Power Line Conducted Emissions (Rx Mode)
Line Voltage: 120 VAC; Line Tested: Hot

Current Graph

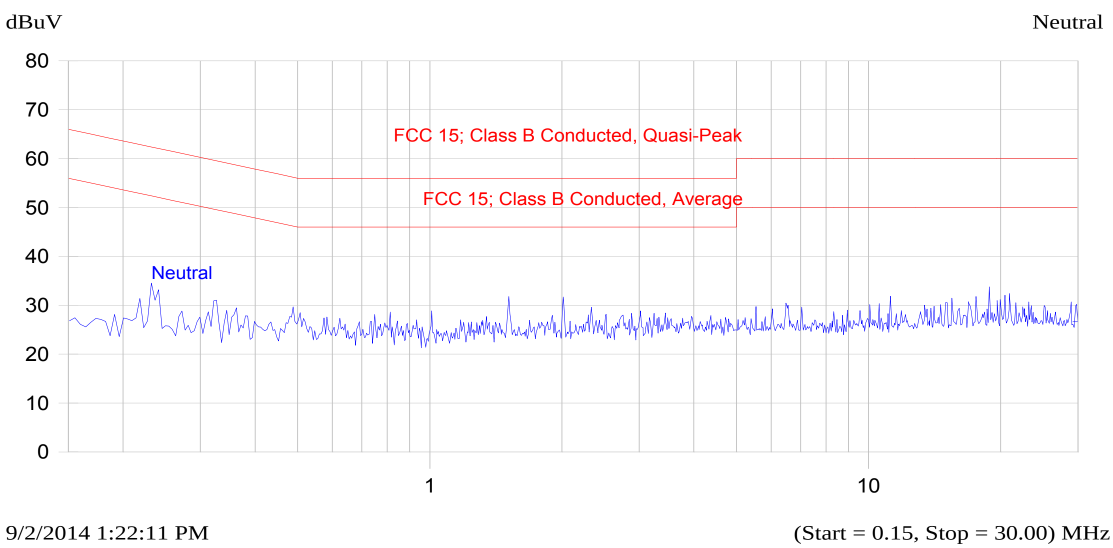


Current List

Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP Limit dB	Avg dBuV	Delta Avg-Avg Limit dB	Trace Name
0.203	42.0	34.1	-30.4	19.8	-34.7	Hot
0.215	40.7	32.2	-31.9	19.2	-34.9	Hot
0.996	30.2	21.2	-34.8	13.1	-32.9	Hot

Plot 5.9.3.4. Power Line Conducted Emissions (Rx Mode)
Line Voltage: 120 VAC; Line Tested: Neutral

Current Graph



Current List

Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP Limit dB	Avg dBuV	Delta Avg-Avg Limit dB	Trace Name
0.232	36.2	28.3	-35.3	17.5	-36.1	Neutral
0.315	31.2	24.2	-37.0	16.3	-34.9	Neutral
1.512	30.7	27.6	-28.4	24.9	-21.1	Neutral
2.012	34.3	29.1	-26.9	26.9	-19.1	Neutral

EXHIBIT 6. TEST EQUIPMENTS LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Operating Range	Cal. Due Date
Environmental Chamber	Envirotronics	SSH32C	11994847-S-11059	-60 to 177 °C	01 May 2015
Frequency Counter	EIP	545A	02683	10 Hz – 18 GHz	07 Apr 2015
DC Block	Hewlett Packard	11742A	12460	0.045 – 26.5 GHz	Cal on use
Attenuator	Weinschel	46-20-34	BS5681	DC – 18 GHz	Cal on use
DC Power Supply	Tenma	72-7295	490300270	1 – 40 Vdc	Cal on use
Peak Power Analyzer	Hewlett Packard	8990A	3314A00602	0.5 - 40 GHz	30 Oct 2014
Peak Power Sensor	Hewlett Packard	84814A	3205A00175	0.5 - 40 GHz	30 Oct 2014
Spectrum Analyzer	Rohde & Schwarz	FSEK30	100077	20 Hz – 40 GHz	08 Nov 2014
High Pass Filter	Mini-Circuits	SHP-800	10425	Cut off 400 MHz	Cal. on use
RF Amplifier	Hewlett Packard	84498	3008A00769	1 – 26.5 GHz	19 Jun 2015
RF Amplifier	Hewlett Packard	8447F	2805A03287	0.1 – 1300 MHz	15 Mar 2015
DC Power Supply	Tenma	72-7295	490300297	1 – 40 Vdc	Cal on use
Biconi-Log Antenna	EMCO	3142C	26873	26 – 3000 MHz	14 Apr 2015
Horn Antenna	EMCO	3155	5955	1 – 18 GHz	26 Mar 2015
Horn Antenna	EMCO	3155	5061	1 – 18 GHz	08 Oct 2014
Dipole Antenna	EMCO	3121C	434	30 – 1000 MHz	12 May 2016
RF Communication Test set	Hewlett Packard	8920B	US39064699	30 - 1000 MHz	03 Feb 2015
Modulation Analyzer	Hewlett Packard	8901B	3226A04606	150 kHz – 1300 MHz	29 Jan 2015
RF detector	Pasternack	PE8000-50	-	10 MHz – 1 GHz	Cal on use
Infinium Digital Oscilloscope	Hewlett Packard	54801A	US38380192	DC–500 MHz	16 Jun 2015
Combiner	Mini Circuit	ZFSC-3-4	15542	1 MHz - 1 GHz	Cal on use
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	Schwarzbeck	NSLK8127	8127276	0.01 -30 MHz	25 Mar 2015
EMI Receiver	Rohde & Schwarz	ESU40	100037	20 Hz – 40 GHz	5 Apr 2015
RF Amplifier	AH System	PAM-0118	225	20 MHz – 18 GHz	7 Apr 2015
Signal Generator	Hewlett Packard	8648C	3443U00391	100 kHz – 3200 MHz	11 Feb 2015

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:** $u_c(y) = \sqrt{\sum_{I=1}^{m} u_i^2(y)}$	**$\pm$ 1.44**	**$\pm$ 1.8**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**$\pm$ 2.89**	**$\pm$ 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:** $u_c(y) = \sqrt{\sum_{I=1}^{m} u_i^2(y)}$	**$\pm$ 2.39**	**$\pm$ 2.6**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**$\pm$ 4.79**	**$\pm$ 5.2**

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

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

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).
- I f 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 = Tx on / (Tx on + 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.

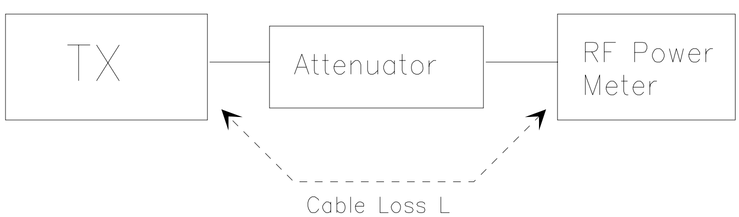
Step 2: Calculation of Average EIRP. See Figure 1

- 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:

EIRP = A + G + 10log(1/x)

{X = 1 for continuous transmission => 10log(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 (dBμV/m) = Reading (dBμV) + 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^o 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 dB
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

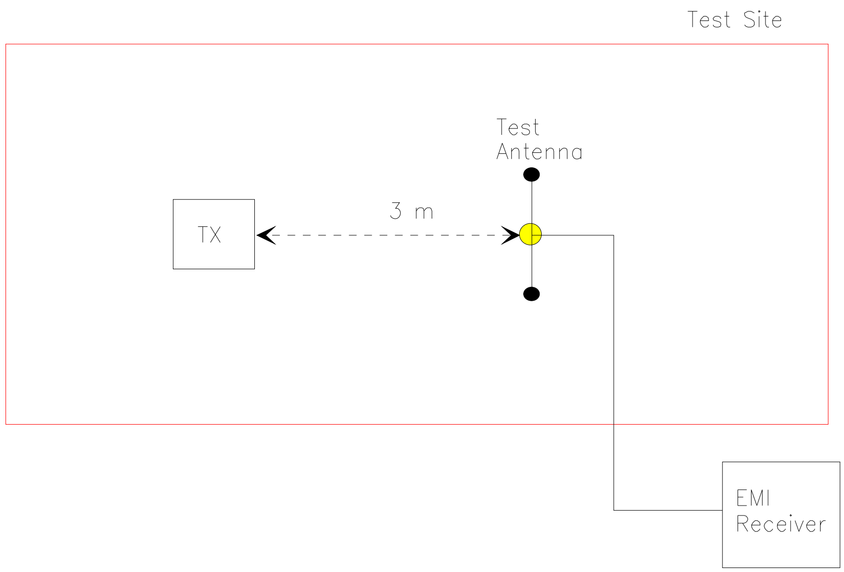
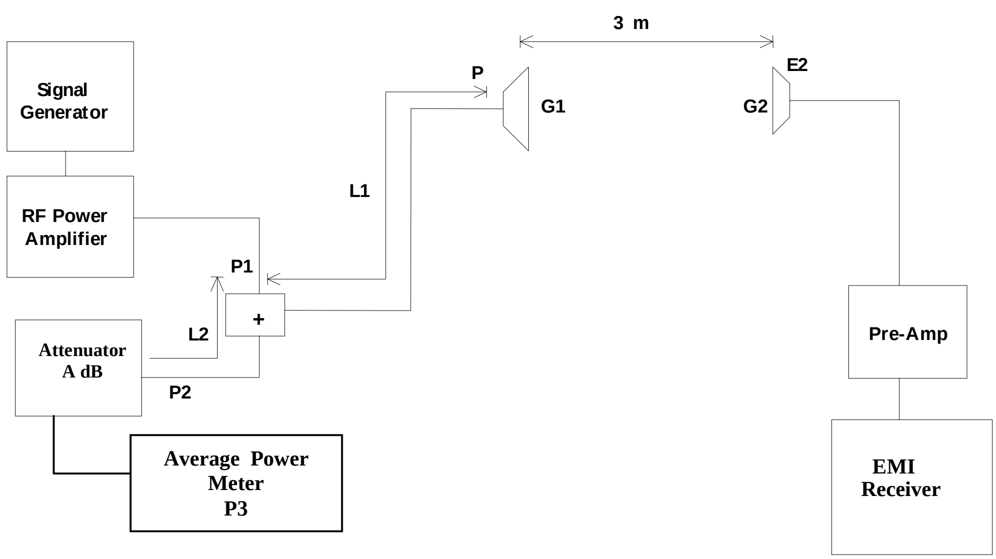


Figure 3



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).

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.: $\pm$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 10^{th} 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.