FCC / IC Test Report

FOR:

Apple Inc.

Model Name:

A1657

Product Description:

Bluetooth Device with BDR, EDR and LE support

FCC ID: BCGA1657
IC ID: 579C-A1657

Per:
47 CFR Part 15.247 (DSS)
RSS-247 Issue 1 (FHSs) & RSS-Gen Issue 4

REPORT #: EMC_APPLE-166-15001_15.247_BT_Rev1

DATE: 2015-08-13

A2LA Accredited

IC recognized #
3462B-1

***CETECOM* Inc.**
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CETECOM Inc. is a Delaware Corporation with Corporation number: 2905571

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1 Assessment

The following device was evaluated against the applicable criteria specified in FCC rules Parts 15.247 of Title 47 of the Code of Federal Regulations and the relevant IC standard RSS-247.

No deviations were ascertained.

Company	Description	Model #
APPLE INC	Bluetooth Device with BDR, EDR and LE support	A1657

Responsible for Testing Laboratory:

Date	Section	Name	Signature
2015-08-13	Compliance	Franz Engert (Compliance Manager)	Digitally signed by Franz Engert DN: cn=Franz Engert, c=US, o=CETECOM, ou=Complience, email=franz.engert@cetecom.com

Responsible for the Report:

Date	Section	Name	Signature
2015-08-13	Compliance	Kris Lazarov (EMC Engineer)	Kris Lazarov Digitally signed by Kris Lazarov DN: cn=Kris Lazarov, o=CETECOM, ou, email=kris.lazarov@cetecom.com, c=US Date: 2015.08.14 11:30:32 -07'00'

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the EMC Test Report

Company Name:	CETECOM Inc.
Department:	Compliance
Address:	411 Dixon Landing Road Milpitas, CA 95035 U.S.A.
Telephone:	+1 (408) 586 6200
Fax:	+1 (408) 586 6299
Compliance Manager:	Franz Engert
Responsible Project Leader:	Kris Lazarov

2.2 Identification of the Client

Applicant's Name:	Apple Inc.
Street Address:	1 Infinite Loop
City/Zip Code	Cupertino, CA 95014
Country	USA
Contact Person:	Jacqueline Zhai
Phone No.	(408) 620-0616
e-mail:	jacqueline_zhai@apple.com

2.3 Identification of the Manufacturer

Manufacturer's Name:	Same as Applicant
Manufacturers Address:	-------
City/Zip Code	-------
Country	-------

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Model No:	A1657
HW Version :	Rev 1.0
SW Version :	(a) STFW version 0x0794 (b) BT FW version 0x0054
FCC-ID :	BCGA1657
IC-ID:	579C-A1657
HVIN:	A1657
PMN:	A1657
Product Description:	Bluetooth Device with BDR, EDR and LE support
Frequency Range / number of channels:	Nominal band: 2400 – 2483.5; Center to center: 2402(ch 0) – 2480(ch 78), 79 channels
Type(s) of Modulation:	Bluetooth Basic/EDR: GFSK, π /4 DQPSK, 8DPSK
Modes of Operation:	Hopping
Antenna Information as declared:	Inverted F antenna with max gain -1.93dBi @2412MHz
Max. declared output Powers:	Conducted Power 7.0dBm average
Power Supply/ Rated Operating Voltage Range:	lithium battery pack (dedicated) Vmin: 3.0V dc/ Vnom: 3.8V dc / Vmax: 4.3V dc
Operating Temperature Range	0 ºC to 35 ºC
Other Radios included in the device:	Bluetooth 4.2 Low Energy (BT LE)
Sample Revision	☐Prototype Unit; ☐Production Unit; ■Pre-Production

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	BDA94F6A3F3E2F9	Rev 1.0	(a) STFW version 0x0794 (b) BT FW version 0x0054	Radiated emissions and conducted measurements
2	BDA94F6A3F3E2C1	Rev 1.0	(a) STFW version 0x0794 (b) BT FW version 0x0054	AC Conducted measurements

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number
1	Laptop	Apple		
2	USB Power Adapter	Phihong	PSAI05R-050Q	P142302633A1

3.4 Test Sample Configuration

EUT Set-up #	Combination of AE used for test set up	Comments
1	EUT#1	The EUT was set to Bluetooth® test mode and connected to a CMD callbox. The measurement equipment was connected to the 50Ohm UFL port of the EUT.
2	EUT#1	The EUT was set to Bluetooth® test mode and connected to a CMD callbox. The internal antenna was connected.
3	EUT#2 + AE#1	The EUT was set to Bluetooth® test mode and connected to a CMD callbox. The internal antenna was connected. The EUT was connected to the AC mains through a Laptop.
4	EUT#2 + AE#2	The EUT was set to Bluetooth® test mode and connected to a CMD callbox. The internal antenna was connected. The EUT was connected to the AC mains through a USB charger.

3.5 Justification for Worst Case Mode of Operation

During the testing process the EUT was tested with transmitter sets on low, mid and high channels. For radiated measurements, all data in this report shows the worst case between horizontal and vertical antenna polarizations and for all orientations of the EUT.

The GFSK modulation scheme produced the highest output power (worst case) and was used in all test cases during this evaluation that define limits of power or field strength.

Modulation	Timing	Peak Power (dBm)
GFSK	DH5	7.06
8DPSK	DH5	7.06
DQPSK	DH5	6.75

GFSK DH5 package type was used for all power and emission measurements with an amplitude limit as it represents the worst case.

The occupied Bandwidth measurements were also done with 8DPSK and DQPSK modulation.

4 Subject of Investigation

The objective of the measurements done by CETECOM Inc. was to assess the performance of the EUT per the relevant requirements specified in FCC rules Part 15.247 of Title 47 of the Code of Federal Regulations and Radio Standard Specification RSS-247 Issue1 of Industry Canada.

This test report is to support a request for new equipment authorization under the FCC ID: BCGA1657;
IC ID: 579C-A1657
Testing procedures are based on Public Notice "DA 00-705: March 30, 2000" and ANSI C63.10:2013 for FHSS systems.

For Bandwidth and timing measurements packet types and modulations have been tested according to DA 00-705: March 30, 2000.

5 Measurement Results Summary

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	Fail	NA	NP	Result
§15.247(b)(1) RSS-247 5.4(2)	Maximum Peak Conducted Output Power	Nominal	GFSK DH5	■	☐	☐	☐	Complies
§15.247(d) RSS-247 5.5 RSS-Gen 8.10	Band Edge Compliance	Nominal	GFSK DH5	■	☐	☐	☐	Complies
§15.247(a)(1) RSS-247 5.1(1)	Spectrum Bandwidth	Nominal	GFSK DH5 DQPSK DH5 8DPSK DH5	■	☐	☐	☐	Complies
§15.247(a)(1) RSS-247 5.1(1)	Carrier Frequency Separation	Nominal	GFSK DH5	■	☐	☐	☐	Complies
§15.247(a)(1) RSS-247 5.1(4)	Number of Hopping Channels	Nominal	GFSK DH5	■	☐	☐	☐	Complies
§15.247(a)(1)(iii) RSS-247 5.1(4)	Time of occupancy	Nominal	GFSK DH5 max duty cycle	■	☐	☐	☐	Complies
§15.247(d) §15.209 (a) RSS-Gen 6.13	TX Spurious emissions-Radiated	Nominal	GFSK DH5	■	☐	☐	☐	Complies
§15.207(a) RSS-Gen 8.8	AC Conducted Emissions <30MHz	Nominal	GFSK DH5	■	☐	☐	☐	Complies

Note: NA= Not Applicable; NP= Not Performed.

6 Measurements

6.1 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus, with 95% confidence interval (in dB delta to result), based on a coverage factor k=1.

Radiated measurement

9 kHz to 30MHz	±2.5 dB (Magnetic Loop Antenna)
30 MHz to 1000 MHz	±2.0 dB (Biconilog Antenna)
1 GHz to 40 GHz	±2.3 dB (Horn Antenna)

Conducted measurement

150 kHz to 30 MHz	±0.7 dB (LISN)
RF conducted measurement	±0.5 dB

6.2 Environmental Conditions During Testing:

The following environmental conditions were maintained during the course of testing:

- Ambient Temperature: 20-25°C
- Relative humidity: 40-60%

6.3 Dates of Testing:

7/7/2015 - 7/31/2015

7 Measurement Procedures

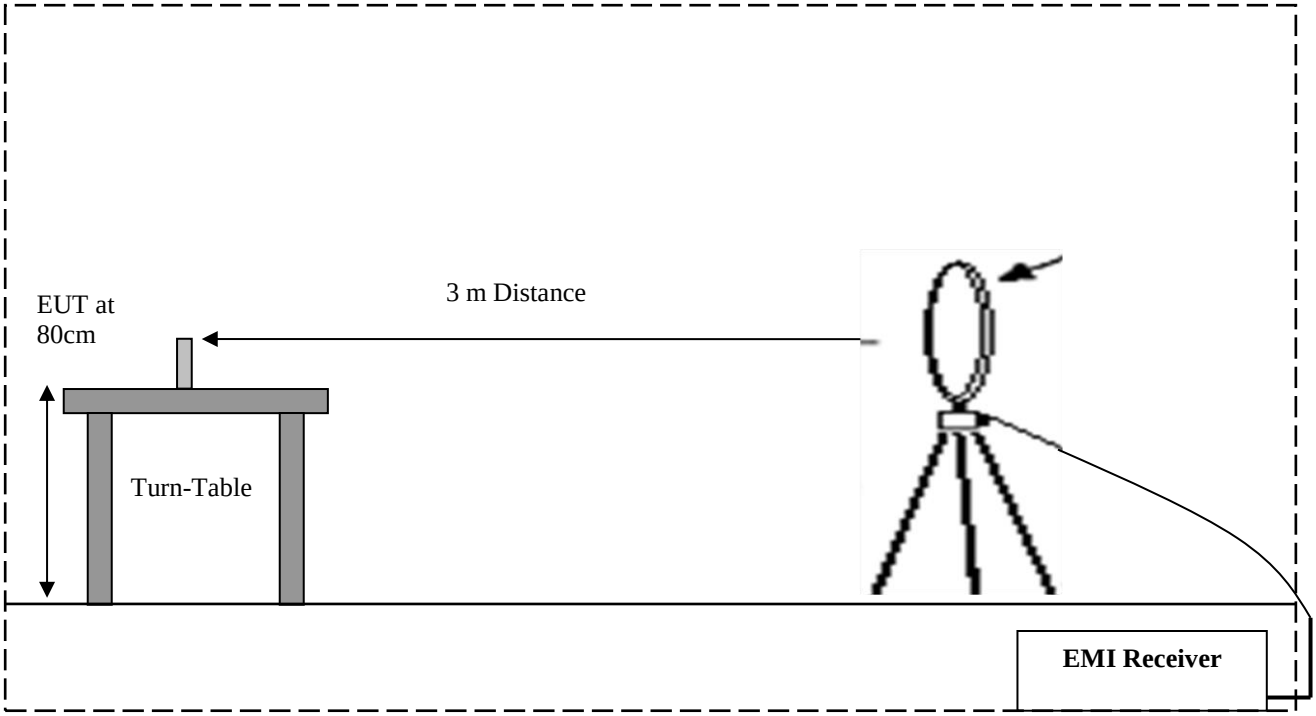
7.1 Radiated Measurement

The radiated measurement is performed according to:

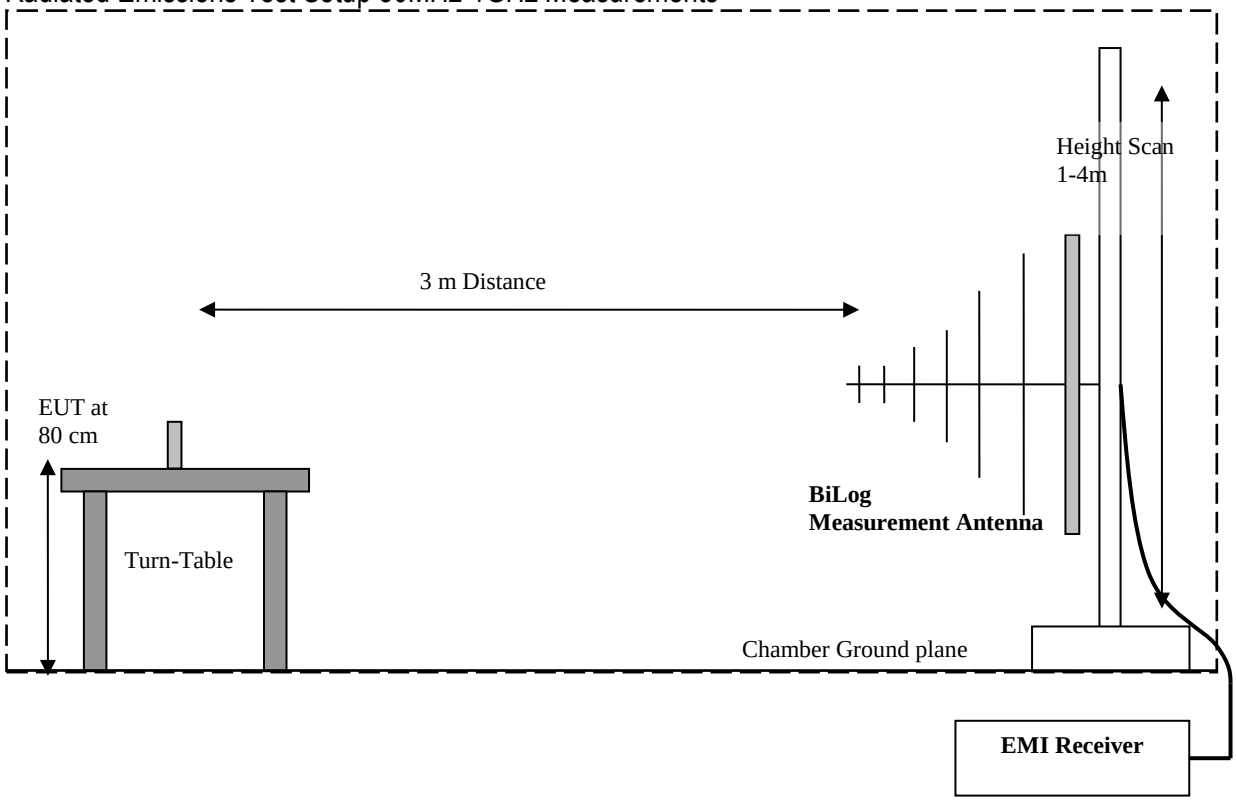
ANSI C63.10 (2013)

- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 4 positions of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to cover the 3 orthogonal axis of the EUT. A max peak detector is utilized during the exploratory measurement. The Test-SW creates an overall maximum trace for all 12 sweeps and saves the settings for each point of this trace. The maximum trace is part of the test report.
- The 10 highest emissions are selected with an automatic algorithm of EMC32 searching for peaks in the noise floor and ensuring that broadband signals are not selected multiple times.
- The maxima are then put through the final measurement and again maximized in a 90deg range of the turntable, fine search in frequency domain and height scan between 1m and 4m.
- The above procedure is repeated for all possible ways of power supply to EUT and for all supported modulations.
- In case there are no emissions above noise floor level only the maximum trace is reported as described above.
- The results are split up into up to 4 frequency ranges due to antenna bandwidth restrictions. A magnetic loop is used from 9 kHz to 30 MHz, a Biconilog antenna is used from 30 MHz to 1 GHz, and two different horn antennas are used to cover frequencies up to 40 GHz.

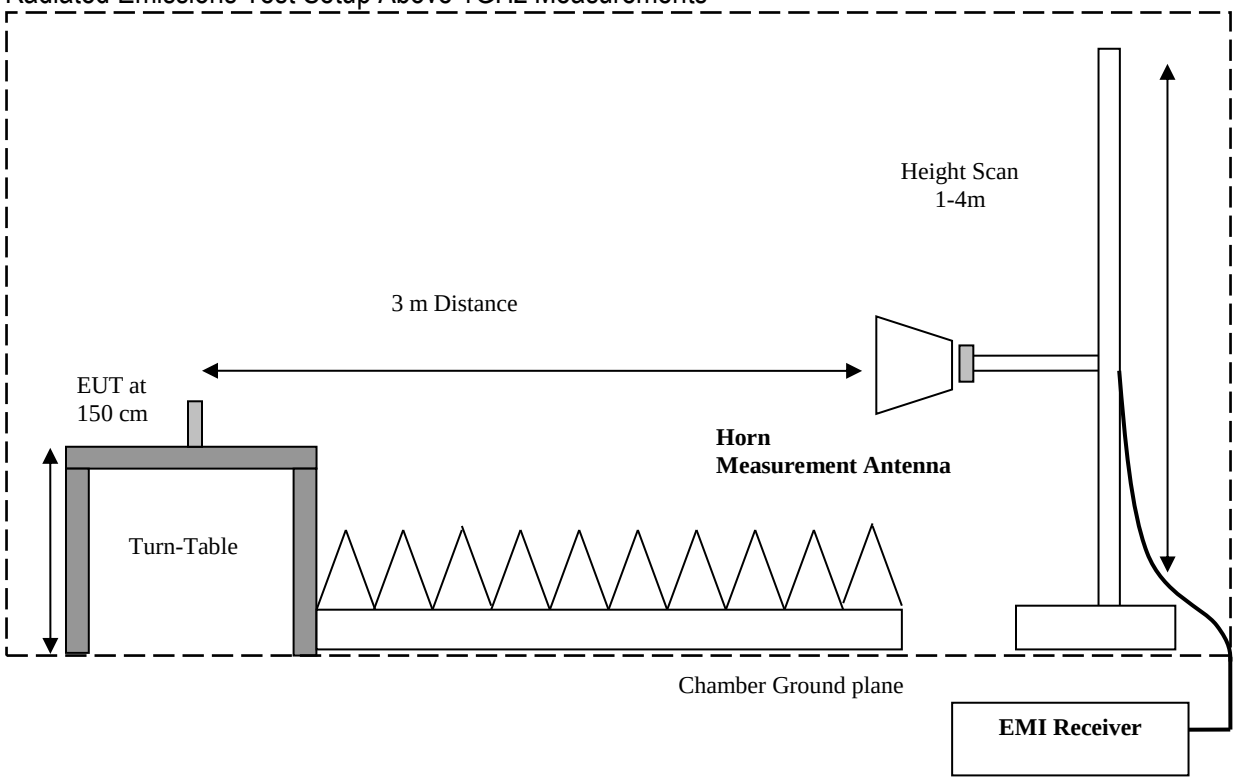
Radiated Emissions Test Setup Below 30MHz Measurements



Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup Above 1GHz Measurements



7.1.1 Sample Calculations for Field Strength Measurements

Field Strength is calculated from the Spectrum Analyzer/ Receiver readings, taking into account the following parameters:

1. Measured reading in dBµV
2. Cable Loss between the receiving antenna and SA in dB and
3. Antenna Factor in dB/m

All radiated measurement plots in this report are taken from a test SW that calculates the Field Strength based on the following equation:

FS (dBµV/m) = Measured Value on SA (dBµV)- Cable Loss (dB)+ Antenna Factor (dB/m)

Example:

Frequency (MHz)	Measured SA (dBµV)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dBµV/m)
1000	80.5	3.5	14	98.0

7.2 Power Line Conducted Measurement Procedure

AC Power Line conducted emissions measurements performed according to:

ANSI C63.10 (2013)

7.3 RF Conducted Measurement Procedure

Reference: FCC Public Notice DA 00-705:2000 (Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems).

1. Connect the equipment as shown in the above diagram.
2. Adjust the settings of the SA (Rohde-Schwarz Spectrum Analyzer) to connect the EUT at the required mode of test.
3. Measurements are to be performed with the EUT set to the low, middle and high channels and for worst case modulation schemes.

8 Test Result Data

8.1 Maximum Peak Conducted Output Power

8.1.1 Measurement according to DA 00-705:2000

Spectrum Analyzer settings:
Span = approximately 5 times the 20 dB bandwidth
RBW > the 20 dB bandwidth of the emission being measured
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold
Use the marker-peak function to set the marker to the peak of the emission.

8.1.2 Limits:

Maximum Peak Output Power:
FCC §15.247 (b)(1): 1W
IC RSS-247: 1W

8.1.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain (dBi)
22° C	1	GFSK	3.3V DC	-1.93

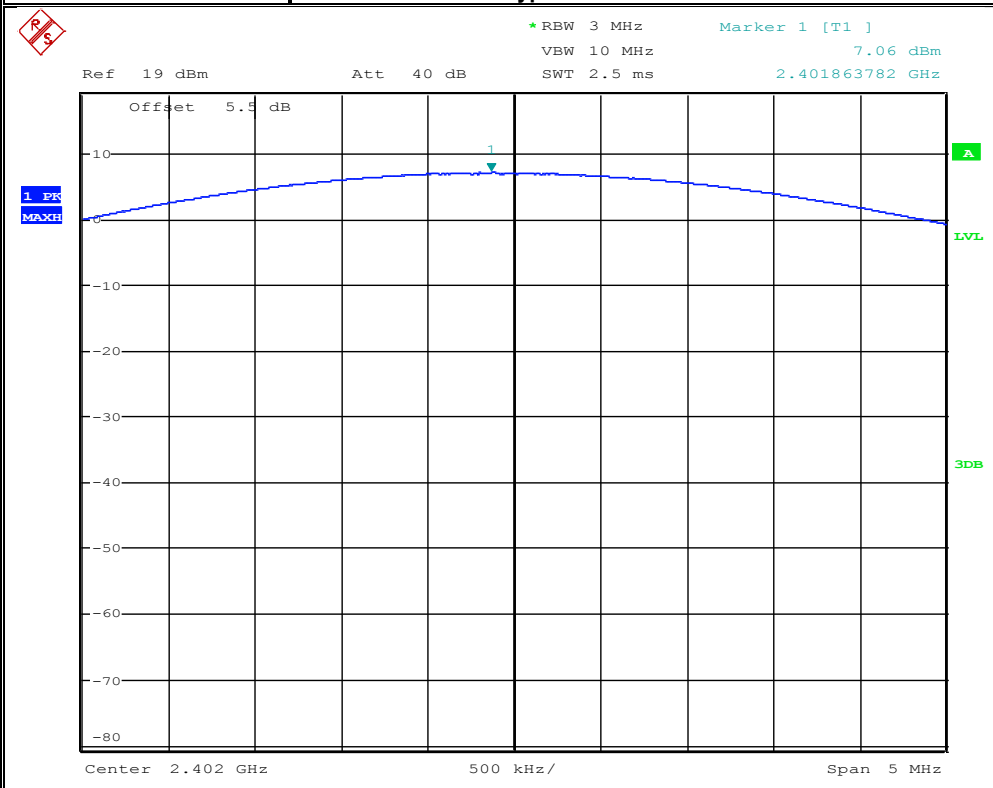
8.1.4 Measurement result:

Plot #	Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)	EIRP (dBm)	Limit (dBm)	Result
1	2402	7.06	5.13	30(Pk) / 36(EIRP)	Pass
2	2441	6.38	4.45	30(Pk) / 36(EIRP)	Pass
3	2480	6.12	4.19	30(Pk) / 36(EIRP)	Pass

8.1.5 Measurement Plots:

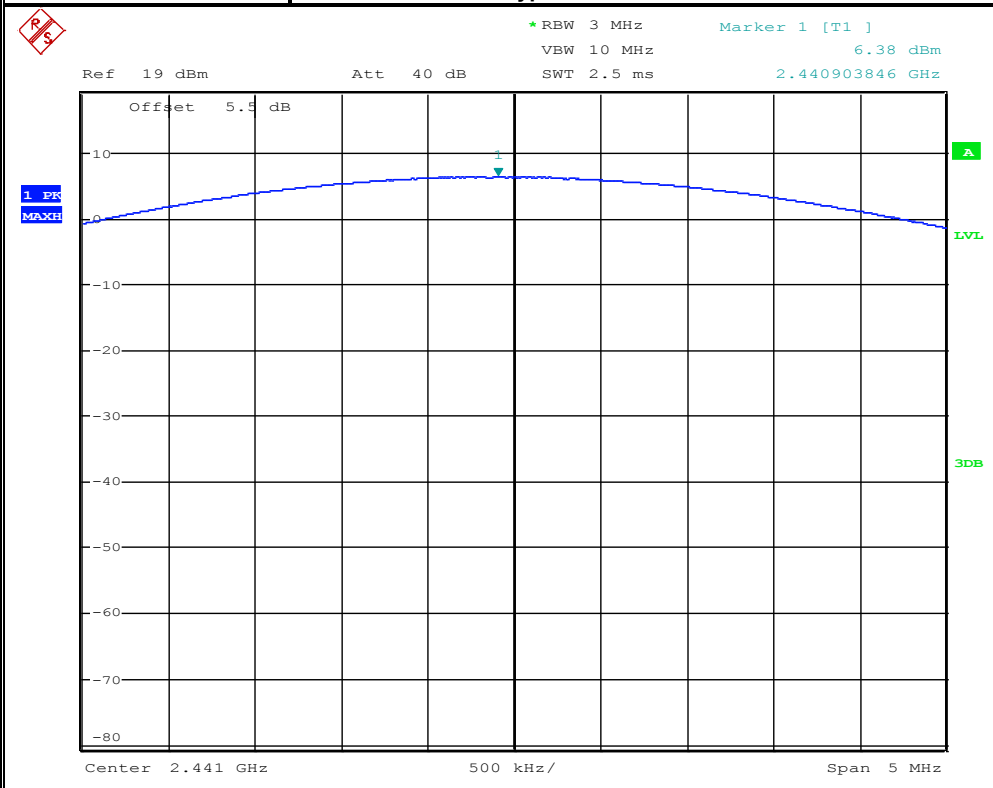
Plot #1

Ch.0 / 2402 MHz | **Modulation/Packet Type: GFSK / DH5**



Plot #2

Ch.39 / 2441 MHz | **Modulation/Packet Type: GFSK / DH5**



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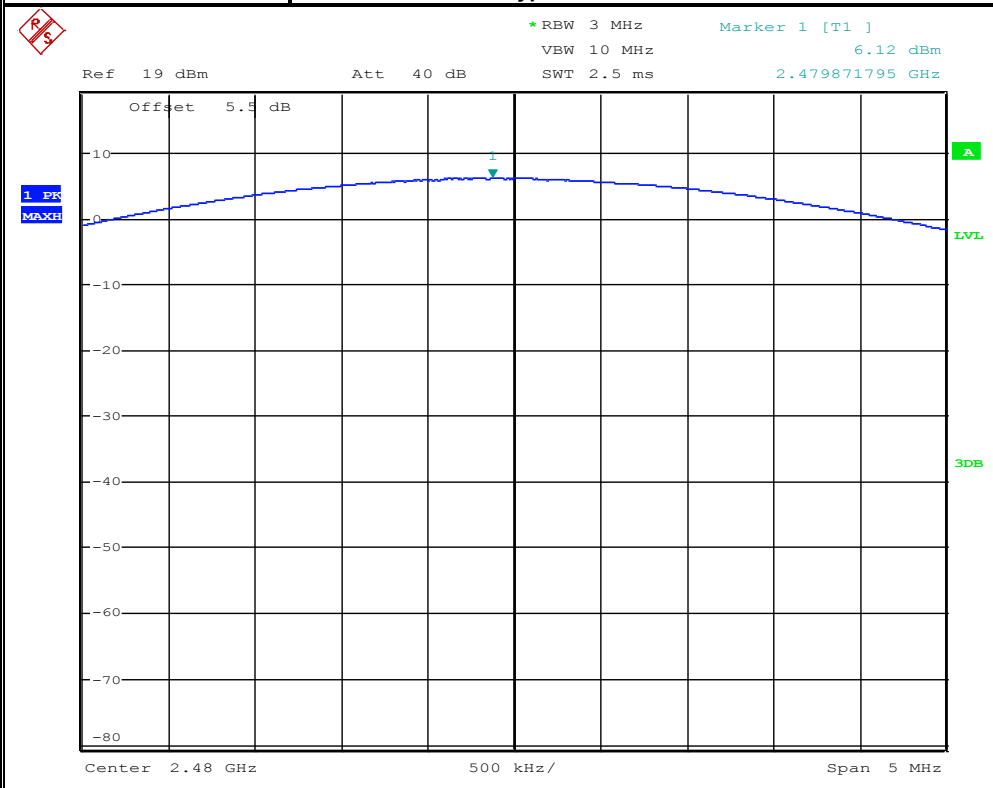
Plot #3

Ch.78 / 2480 MHz | **Modulation/Packet Type: GFSK / DH5**



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8.2 Band Edge Compliance

8.2.1 Measurement according to DA 00-705:2000

Spectrum Analyzer settings for non-restricted band edge:
Span: wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation.

RBW ≥ 1% of the span
VBW ≥ RBW
Sweep Time: Auto
Detector = peak
Trace = max hold

Allow the trace to stabilize. Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge.

Spectrum Analyzer settings for restricted band:
Peak measurements are made using a peak detector and RBW=1 MHz, VBW ≥ RBW

8.2.2 Limits restricted band §15.209 and RSS-Gen 8.10

*PEAK LIMIT= 74dBµV/m @3m =-21.23dBm
*AVG. LIMIT= 54dBµV/m @3m =-41.23dBm
Start frequency & stop frequency according to frequency range specified in the restricted band table in FCC section 15.205 & RSS-Gen 8.10
Measurements with a peak detector were used to show compliance to average limits, thus showing compliance to both peak and average limits.

(a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
[1]0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	([2])
13.36 - 13.41			

8.2.3 Limits non restricted band §15.247 and RSS-247 5.5

FCC15.247 (d)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

RSS-247 5/5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30dB instead of 20dB.

8.2.4 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna gain
22° C	1	Hopping, GFSK DH 5 fixed channel	3.3V DC	-1.93

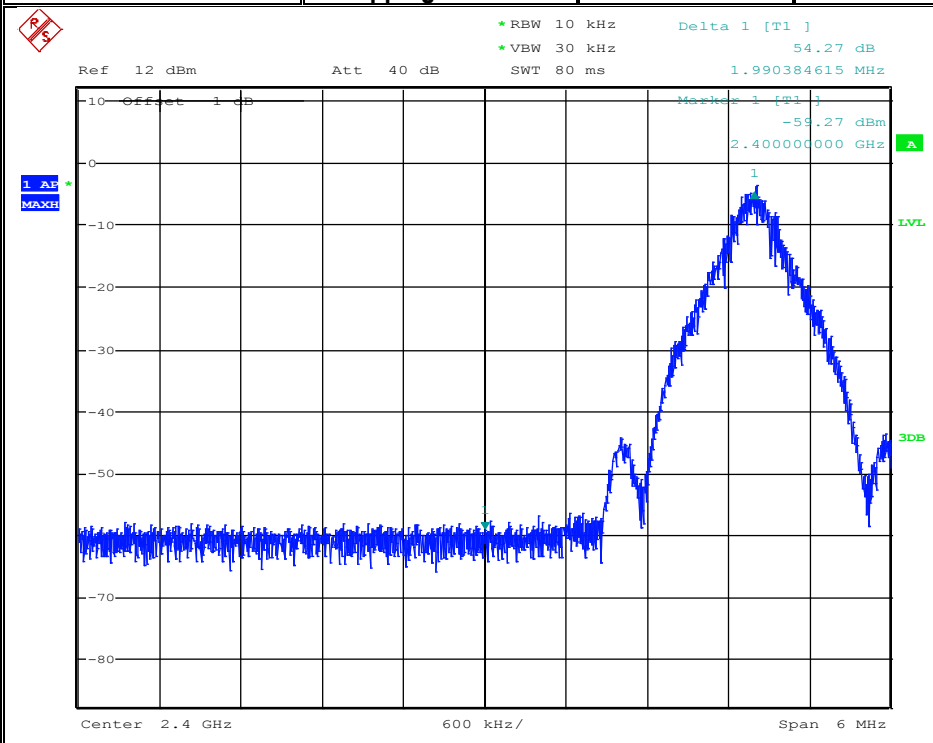
8.2.5 Measurement result:

Plot #	EUT operating mode	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
1	GFSK DH5 fixed channel	Lower, non-restricted	-54.27	20	Pass
2	GFSK DH5 Hopping	Lower, non-restricted	-52.96	20	Pass

Plot #	EUT operating mode	Band Edge	Measured value	Corrected by duty cycle	Corrected by gain	Limit (dBm)	Result
3	GFSK DH5 fixed channel	Upper restricted peak	-33.02	NA due to peak detector	-34.95	-21.23 Peak	Pass
4	GFSK DH5 Hopping	Upper restricted peak	-33.74	NA due to peak detector	-35.67	-21.23 Peak	Pass
5	GFSK DH5 fixed channel	Upper restricted average	-54.19	NA due to max hold trace	-56.12	-41.23 AVG	Pass
6	GFSK DH5 Hopping	Upper restricted average	-54.21	NA due to max hold trace	-56.14	-41.23 AVG	Pass

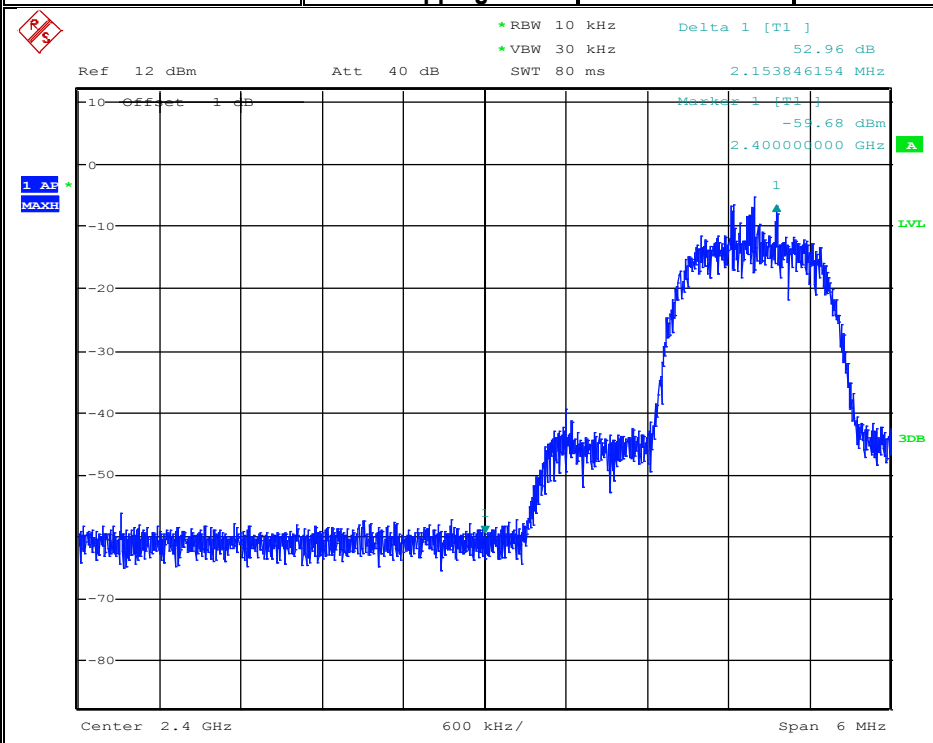
8.2.6 Measurement Plots:

Plot #1 Lower Band Edge			
Ch. Low / 2402MHz	Hopping Disabled	Peak	GFSK / DH5



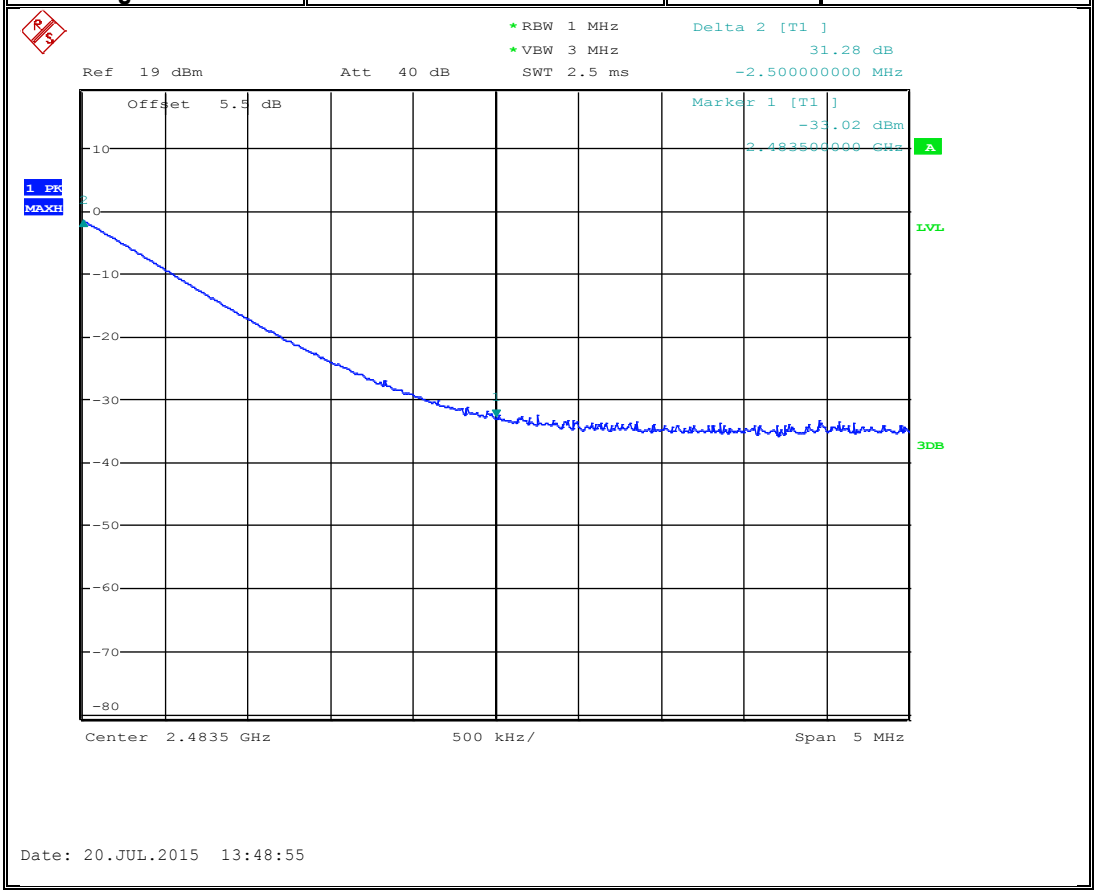
Plot #2 Lower Band Edge

Ch. Low / 2402MHz	Hopping	Peak	GFSK / DH5



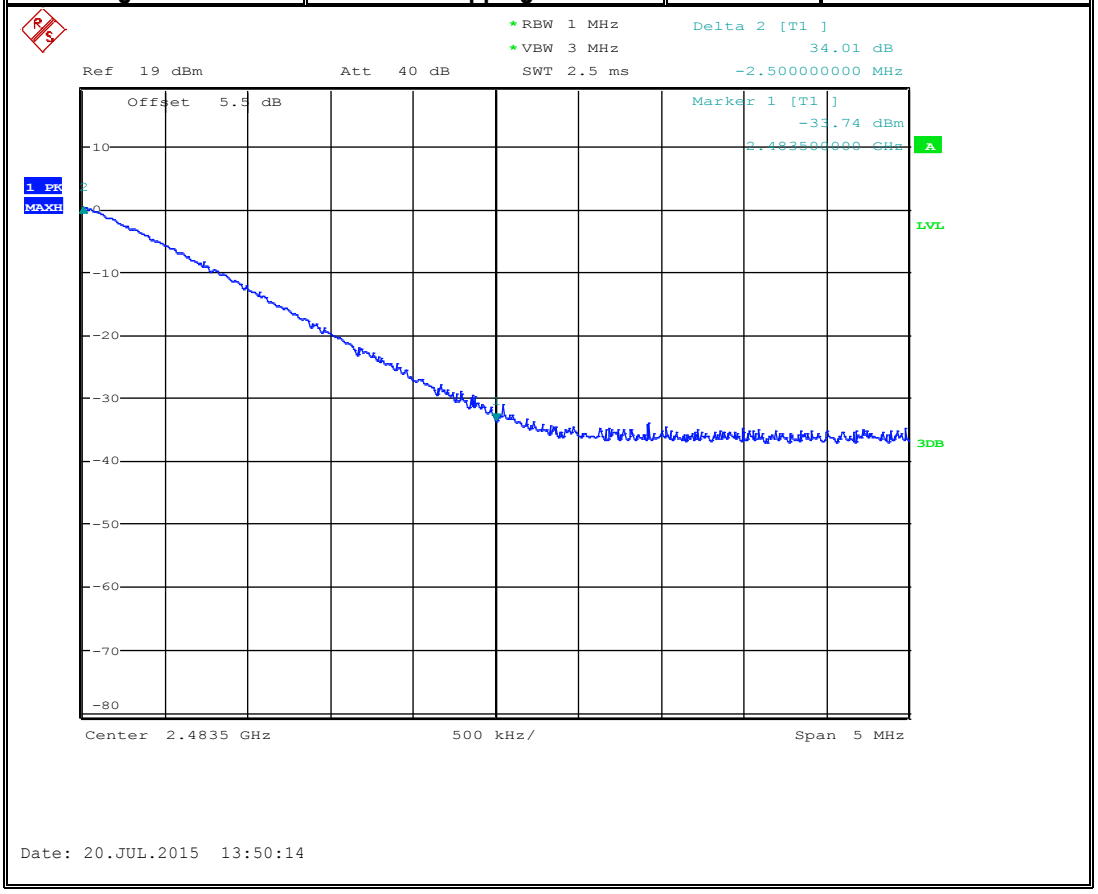
Plot #3 Upper Band Edge

Ch. High / 2480MHz	Fixed channel	Peak	GFSK / DH5



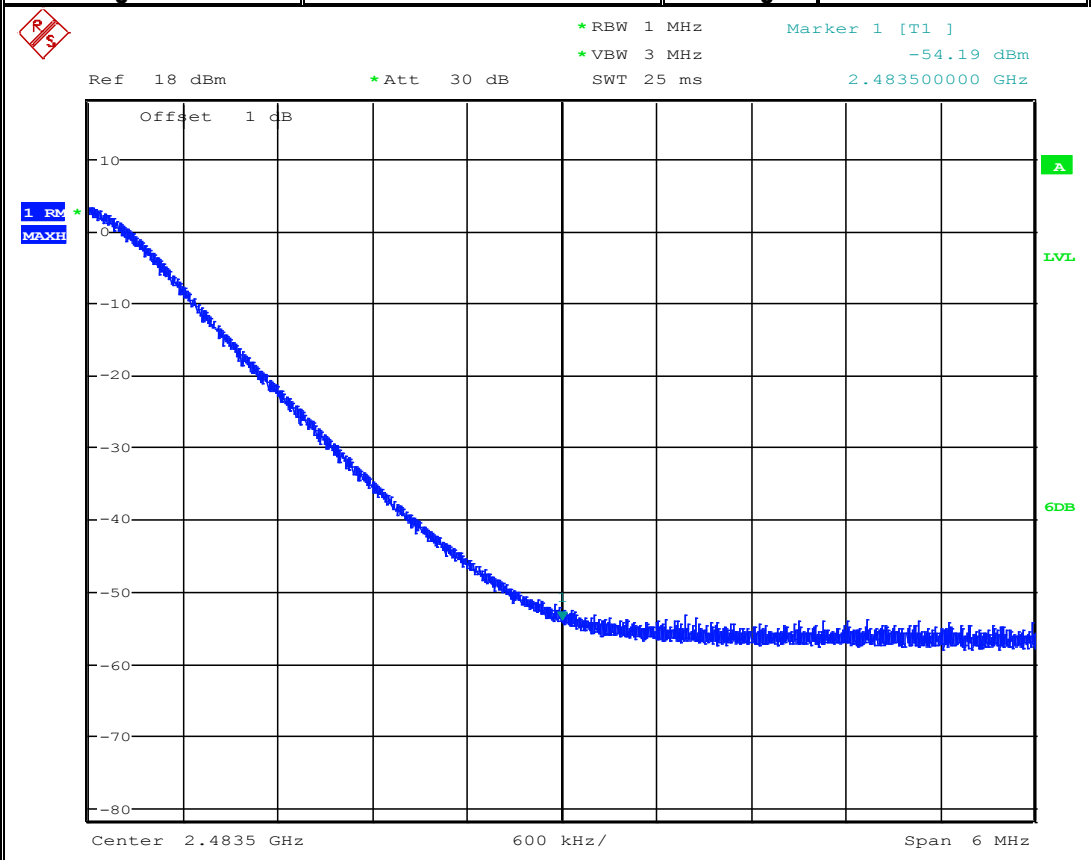
Plot #4 Upper Band Edge

Ch. High / 2480MHz	Hopping	Peak	GFSK / DH5



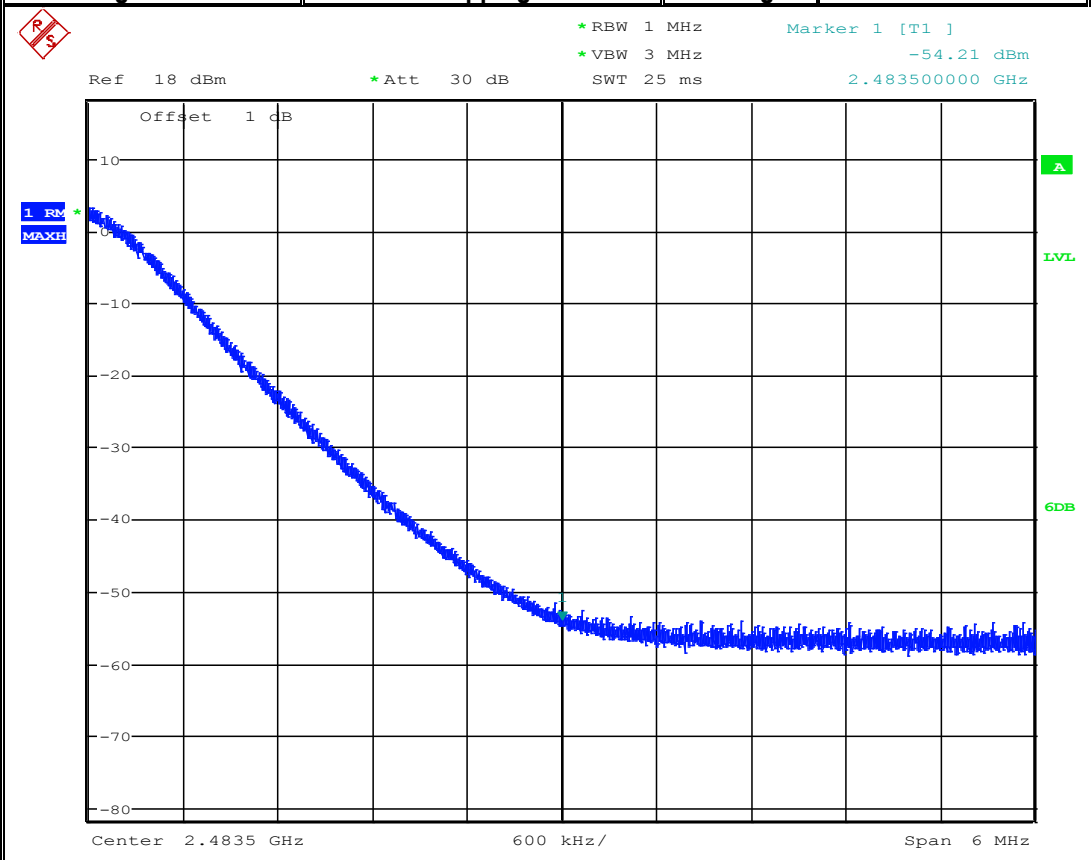
Plot #5 Upper Band Edge

Ch. High / 2480MHz	Fixed channel	Average	GFSK / DH5



Plot #6 Upper Band Edge

Ch. High / 2480MHz	Hopping	Average	GFSK / DH5



8.3 20dB Bandwidth

8.3.1 Measurement according to DA 00-705:2000

Spectrum Analyzer settings:
Span: approximately 2 to 3 times the 20 dB bandwidth, centered on the hopping channel
RBW ≥ 1% of the 20 dB bandwidth
Sweep Time: Auto
Detector = peak
Trace = max hold

8.3.2 Limits: §15.247 (a) (1), RSS-227

Frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

8.3.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22° C	1	GFSK, DQPSK, 8PSK – DH5	3.3V DC

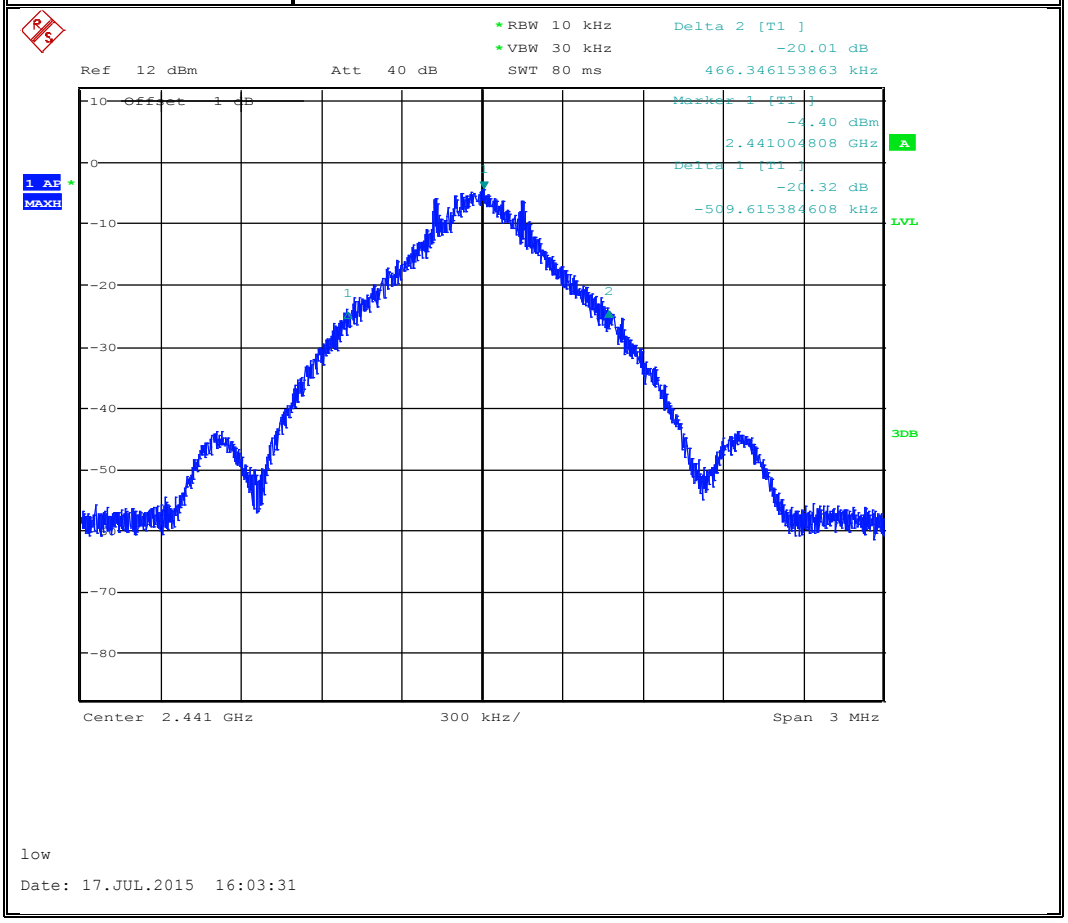
8.3.4 Measurement result:

Plot #	EUT operating mode	20 dB Bandwidth (MHz)
1	GFSK DH5 fixed channel	0.976
2	DQPSK DH5 fixed channel	1.312
3	8PSK DH5 fixed channel	1.308

8.3.5 Measurement Plots:

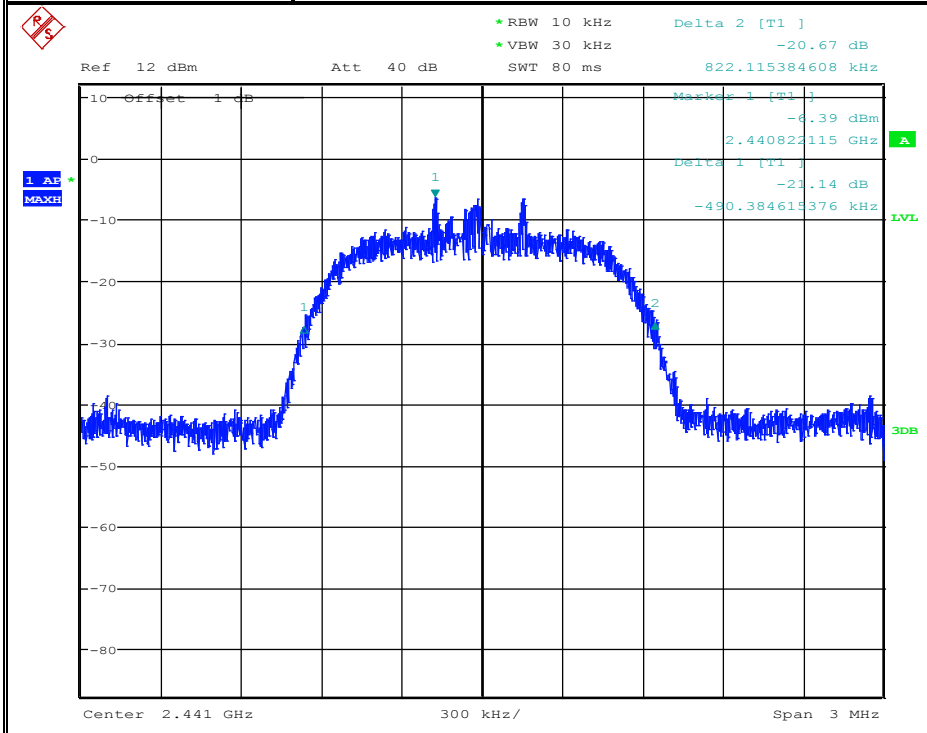
Plot #1 20dB Bandwidth

Ch Mid / 2441 MHz	Modulation: GFSK / DH5



Plot #2 20dB Bandwidth

Ch Mid / 2441 MHz	Modulation: 8DPSK / DH5



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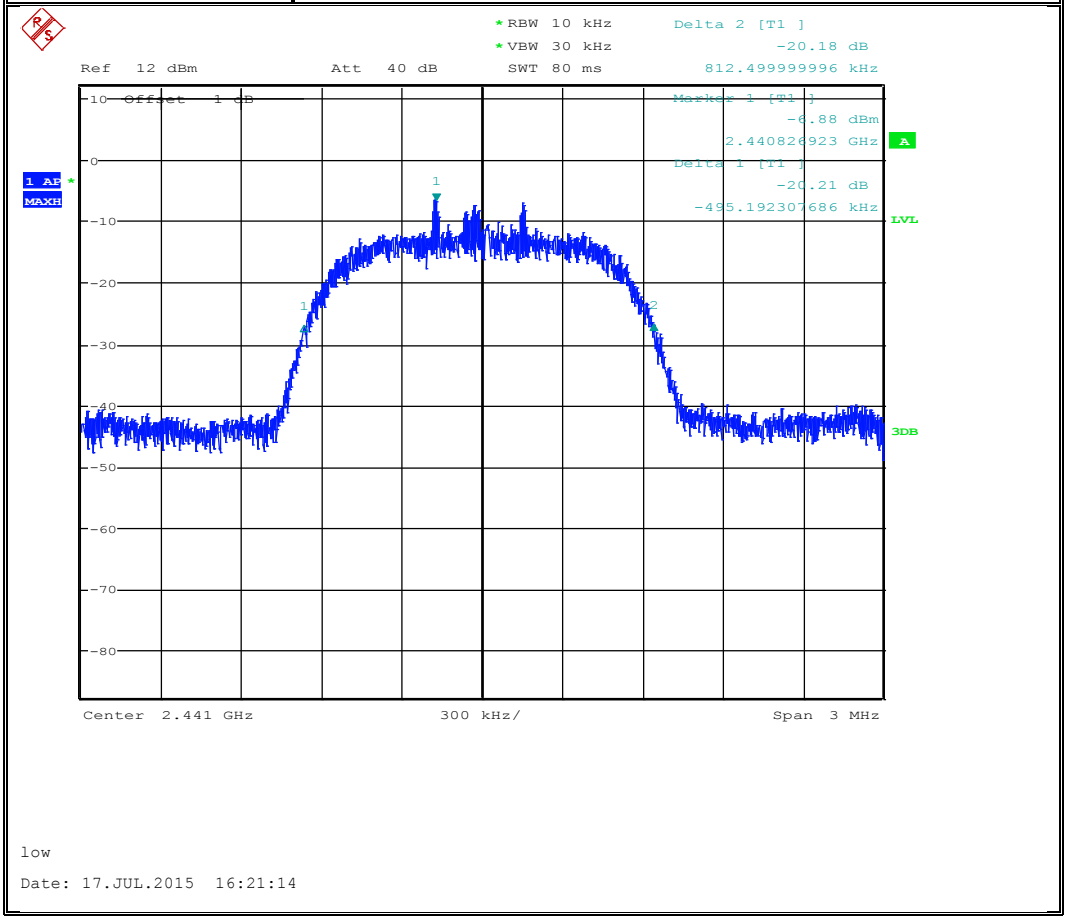
Plot #3 20dB Bandwidth

Ch Mid / 2441 MHz	Modulation: DQPSK / DH5



8.4 Carrier Frequency Separation

8.4.1 Measurement according to DA 00-705:2000

Spectrum Analyzer settings:
Span = Wide enough to capture the peaks of the two adjacent channels
RBW ≥ 1% of the span
VBW ≥ RBW or 3X
Sweep = auto
Detector function = peak
Trace = max hold
Use marker-delta function to determine the separation between the peaks of the two adjacent channels.

8.4.2 Limits: § 15.247 (a) (1) & RSS-247

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

8.4.3 Test conditions and setup:

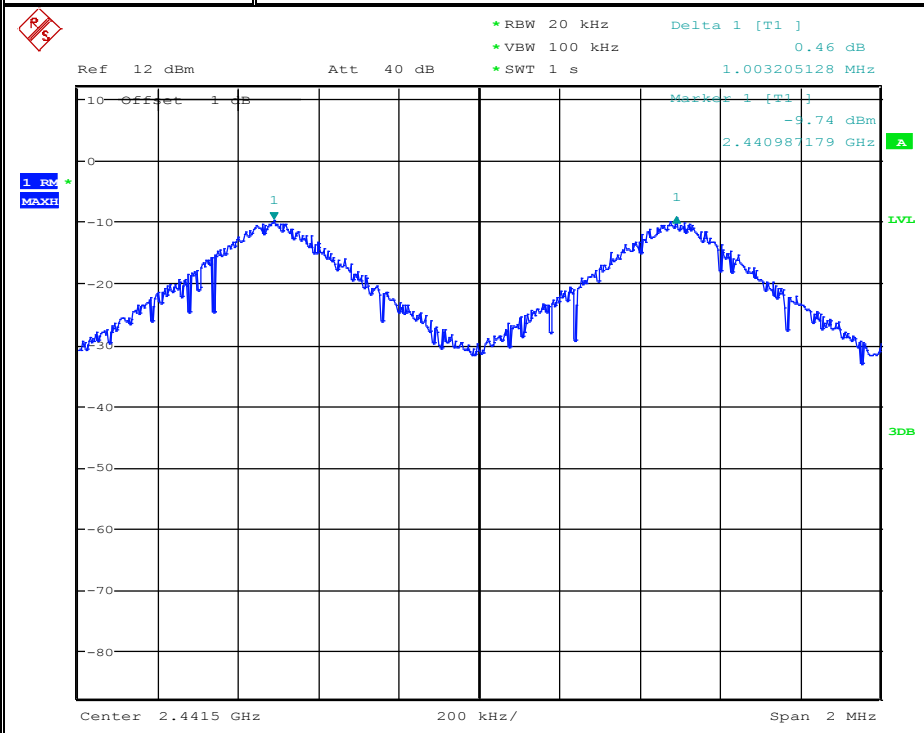
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22° C	1	GFSK DH5 hopping	3.3V DC

8.4.4 Measurement result:

Plot #	Carrier Frequency Separation (MHz)	Limit (MHz)	Result
1	1.003	> 2/3 * OBW = 0.65	Pass

8.4.5 Measurement Plots:

Carrier Frequency Separation	
Packet Type: DH5	Modulation: GFSK
Hopping On	Channel 39 & Channel 40



8.5 Number of hopping channels

8.5.1 Measurement according to DA 00-705:2000

Spectrum Analyzer settings:
Span = the entire frequency band of operation
RBW ≥ 50 KHz
VBW ≥ RBW or 3X
Sweep = auto
Detector function = peak
Trace = max hold

8.5.2 Limits:
§ 15.247 (a) (1) (ii) (iii) & RSS-227

At least 15 non-overlapping channels

8.5.3 Test conditions and setup:

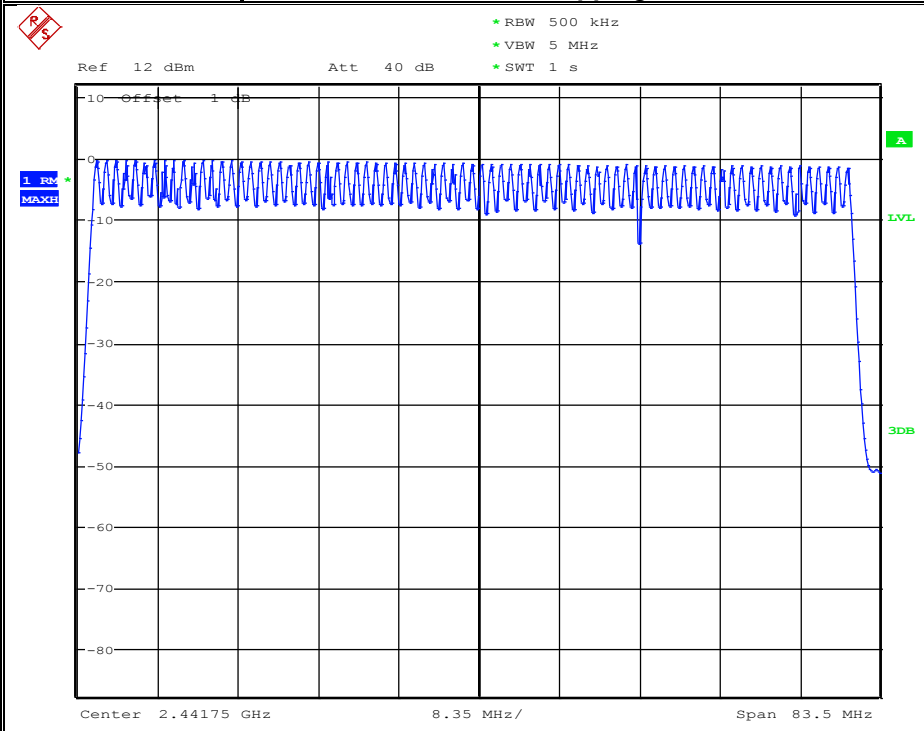
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22° C	1	GFSK DH5 hopping	3.3V DC

8.5.4 Measurement result:

Plot #	Number of Hopping Frequencies	Limit	Result
1	79	15 non-overlapping channels	Pass

8.5.5 Measurement Plots:

Number of Hopping Frequencies	
Packet Type: DH5	Modulation: GFSK
Hopping On	Total Hopping channels = 79



8.6 Time of Occupancy (Dwell Time)

8.6.1 Measurement according to DA 00-705:2000

Spectrum Analyzer settings:

Duration of Pulse Measurement
RBW= 1MHz
VBW= 3MHz
Sweep Time= 10 ms
Sweep Mode= Single
Detector=Peak
Trigger= Video

Observation Period
RBW= 1MHz
VBW= 3MHz
Sweep Time= 31.6 s
Sweep Mode= Single
Detector=Peak
Trigger= Free Run

Observation Period = 0.4s x No. of hopping channels = 0.4 x 79 = 31.6 s

8.6.2 Limits: § 15.247 (a) (1) (iii) & RSS-247

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

8.6.3 Test conditions and setup:

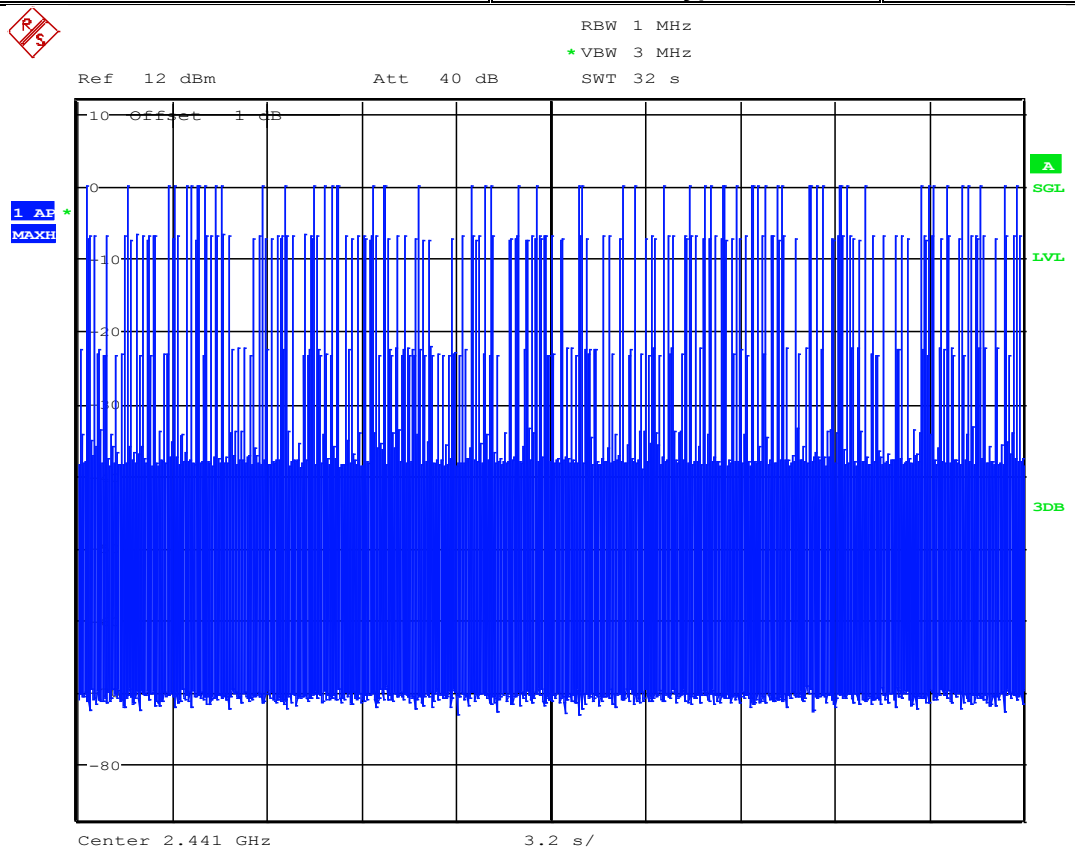
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22° C	1	GFSK DH5 hopping	3.3V DC

8.6.4 Measurement result:

Plot #	Modulation	Timing	Pulse Duration (ms)	Number of hops 31.6s	Total Dwell Time in 31.6s (ms)	Limit	Result
1	GFSK	DH5	2.89	111	321	< 400 in 31.6s	Pass

8.6.5 Measurement Plots:

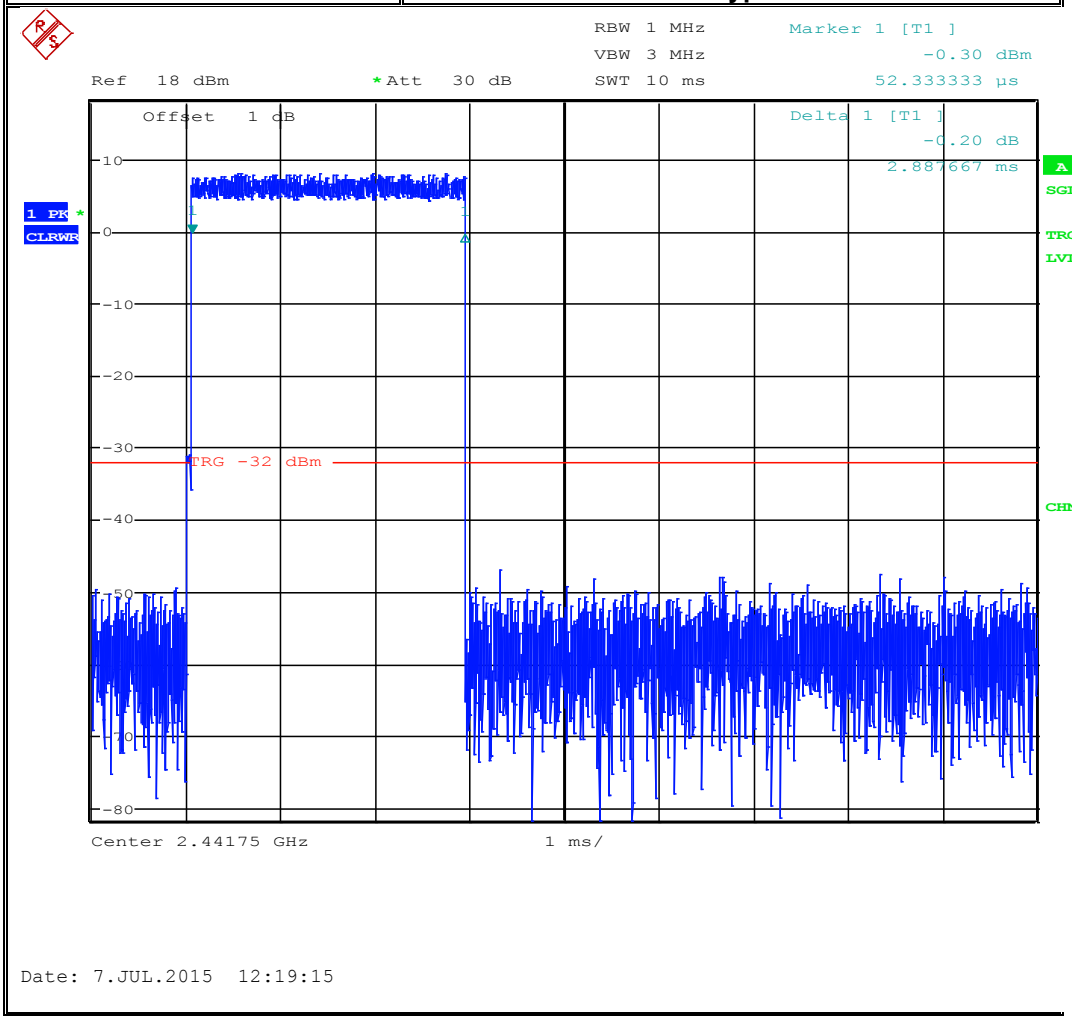
Plot #1 Transmission on Time in Observation Period (31.6s)		
Modulation: GFSK	**Packet Type: DH5**	**Number Bursts = 111**



low

Date: 17.JUL.2015 17:20:09

Pulse Duration	
Modulation: GFSK	Packet Type: DH5



8.7 Transmitter Spurious Emissions and Restricted Bands

8.7.1 Measurement according to ANSI C63.10 (2013)

Analyzer Settings:
Frequency = 9 KHz – 30 MHz
RBW = 9 KHz
Detector: Peak

Frequency = 30 MHz – 1 GHz
Detector = Peak / Quasi-Peak
RBW=120 KHz (<1GHz)

Frequency > 1 GHz
Detector = Peak / Average
RBW= 1MHz

Plots reported here represent the worst case emissions for horizontal and vertical antenna polarizations and for three orientations of the EUT. Unless mentioned otherwise, the emissions outside the limit lines in the plots are from the transmit signal.

8.7.2 Limits: §15.247/15.205/15.209 & RSS-247 / RSS-Gen 8.9/ 8.10 (restricted bands)

(a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
[1]0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	([2])
13.36 - 13.41			

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

*PEAK LIMIT= 74dBµV/m
*AVG. LIMIT= 54dBµV/m

Table 1:

Frequency of emission (MHz)	Field strength @ 3m (µV/m)	Field strength @ 3m (dBµV/m)
30–88	100	40dBµV/m
88–216	150	43.5 dBµV/m
216–960	200	46 dBµV/m
Above 960	500	54 dBµV/m

Table 2:

Frequency of emission (MHz)	Field strength (µV/m) / (dBuV/m)	Measurement Distance (m)
0.009–0.490	2400/F(kHz) / ---------	300
0.490–1.705	24000/F(kHz) / --------	30
1.705–30.0	30 / (29.5)	30

Radiated spurious emissions shall be measured for the transmit frequencies, transmit power, and data rate for the lowest, middle and highest channel in each frequency band of operation and for the highest gain antenna for each antenna type, and using the appropriate parameters and test requirements described in 5.4.
The highest (or worst-case) data rate shall be recorded for each measurement.

For testing at distance other than the specified in the standard, the limit conversion is calculated by using 40 dB/decade extrapolation factor as follow:

Conversion factor (CF) = 40 log (D/d) = 40 log (300m / 3m) = 80dB

8.7.3 Test conditions and setup:

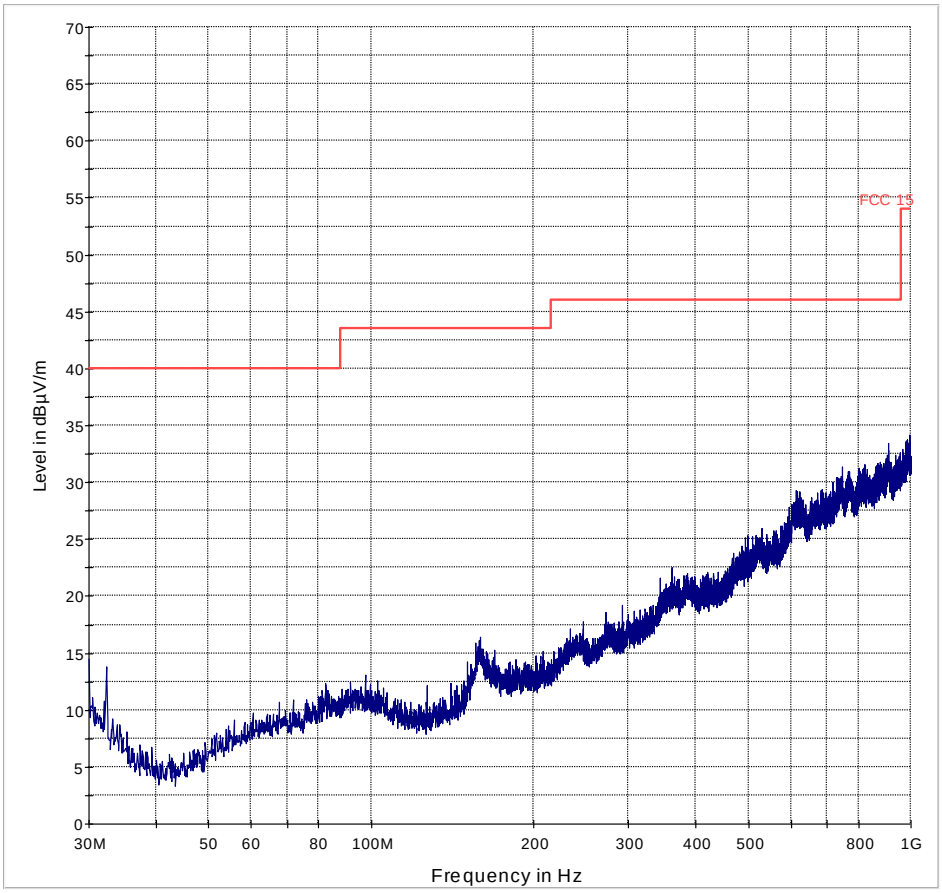
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
21.6° C	2	GFSK DH5 fixed channel	3.3V DC

8.7.4 Measurement result:

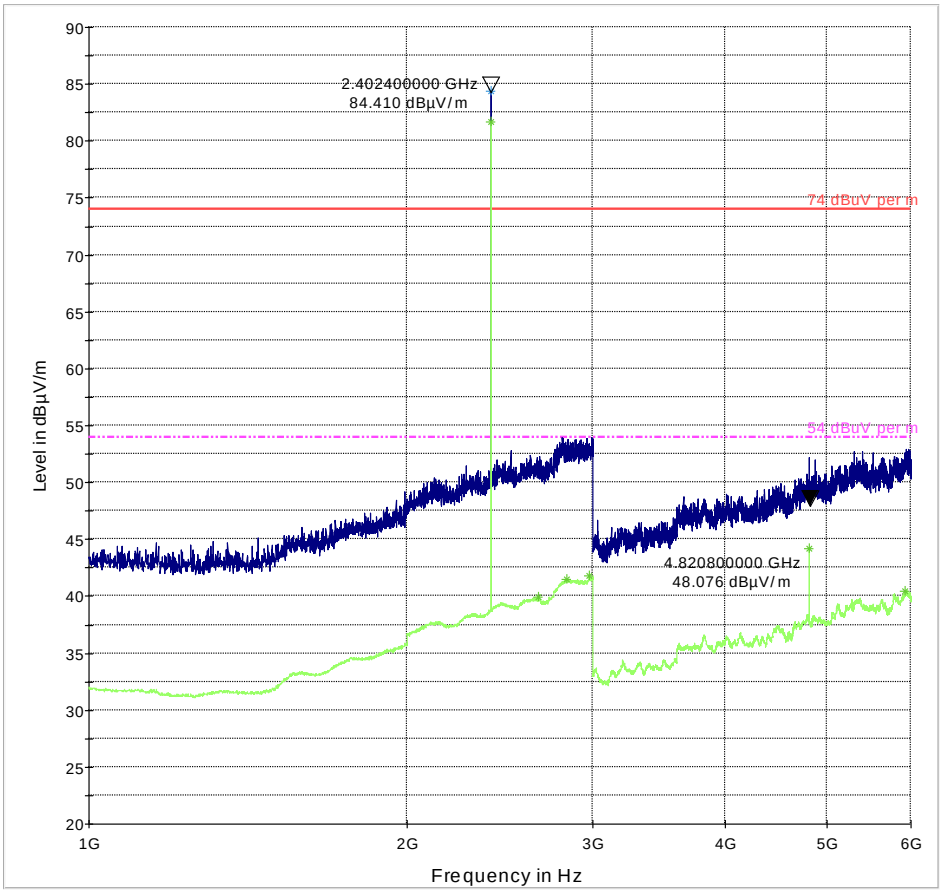
Plot #	Channel #	Scan Frequency	Limit	Result
1-3	Low	30 MHz – 18 GHz	See section 8.7.2	Pass
4-8	Mid	9 kHz – 26 GHz	See section 8.7.2	Pass
9-12	Hi	30 MHz – 18 GHz	See section 8.7.2	Pass

8.7.5 Measurement Plots:

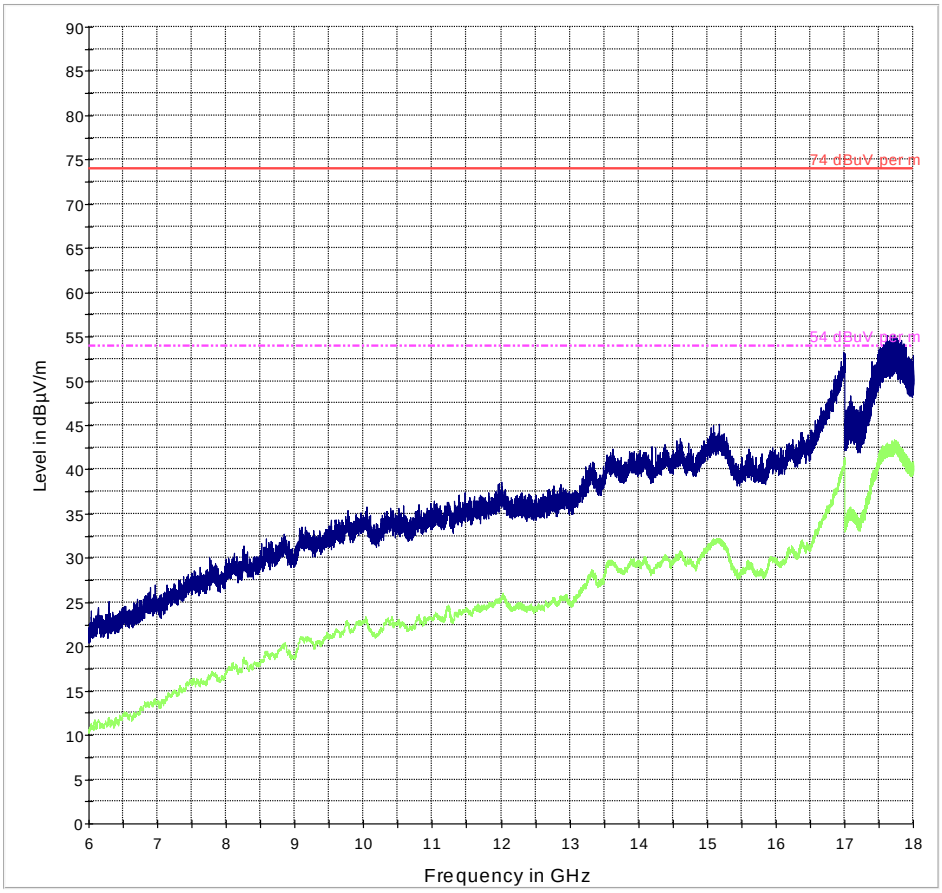
Plot #1 Radiated Emissions: 30 MHz – 1GHz		
Modulation: GFSK	**Channel: Low**	**100% Duty Cycle**



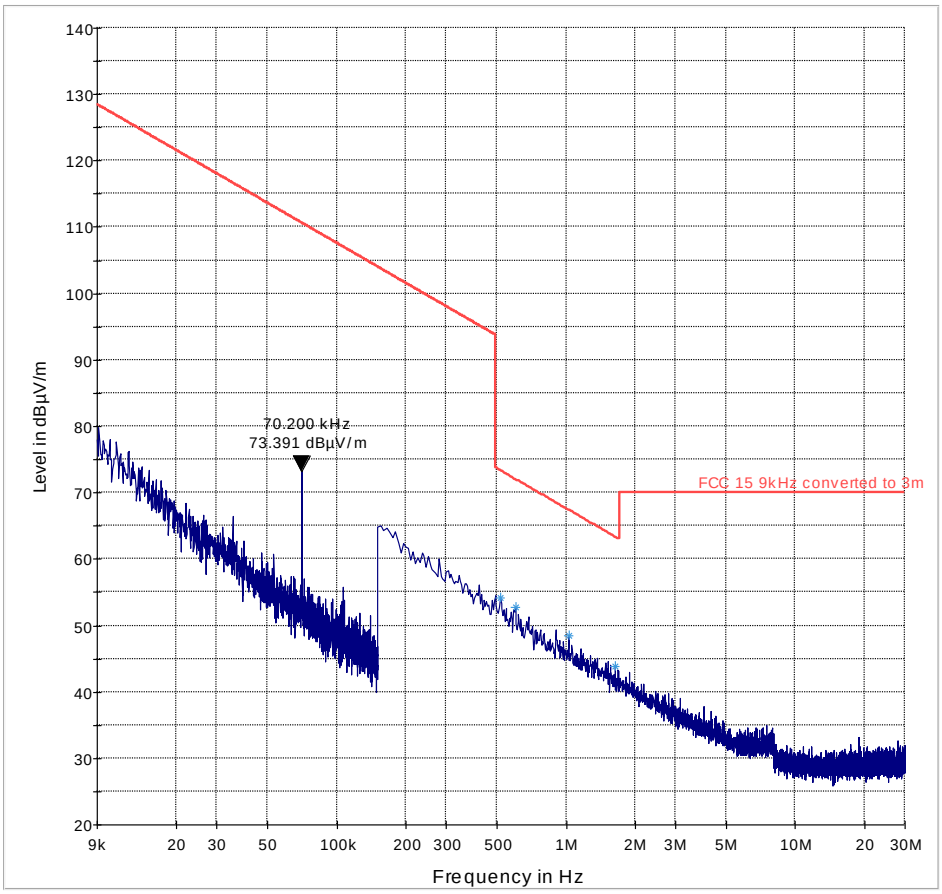
Plot # 2 Radiated Emissions: 1-6 GHz		
Modulation: GFSK	**Channel: Low**	**100% Duty Cycle**


2.402400000 GHz
84.410 dBµV/m
74 dBuV per m
54 dBuV per m
4.820800000 GHz
48.076 dBµV/m
Level in dBµV/m
Frequency in Hz
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
1G
2G
3G
4G
5G
6G

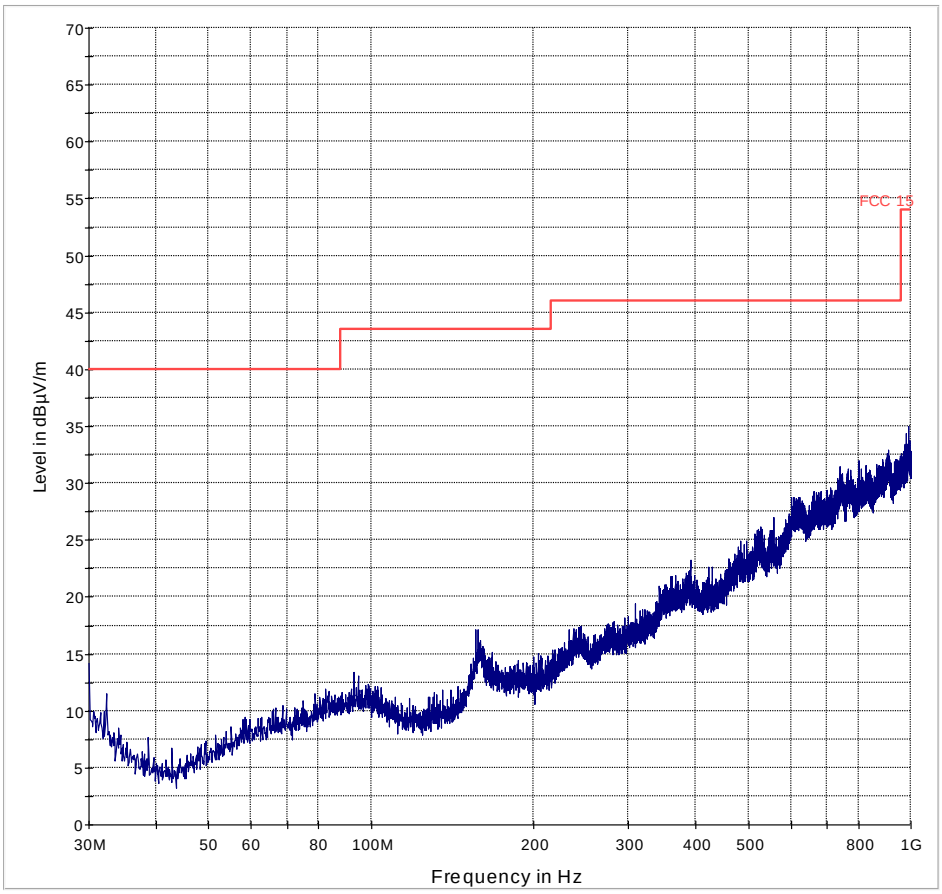
Plot # 3 Radiated Emissions: 6-18 GHz		
Modulation: GFSK	**Channel: Low**	**100% Duty Cycle**



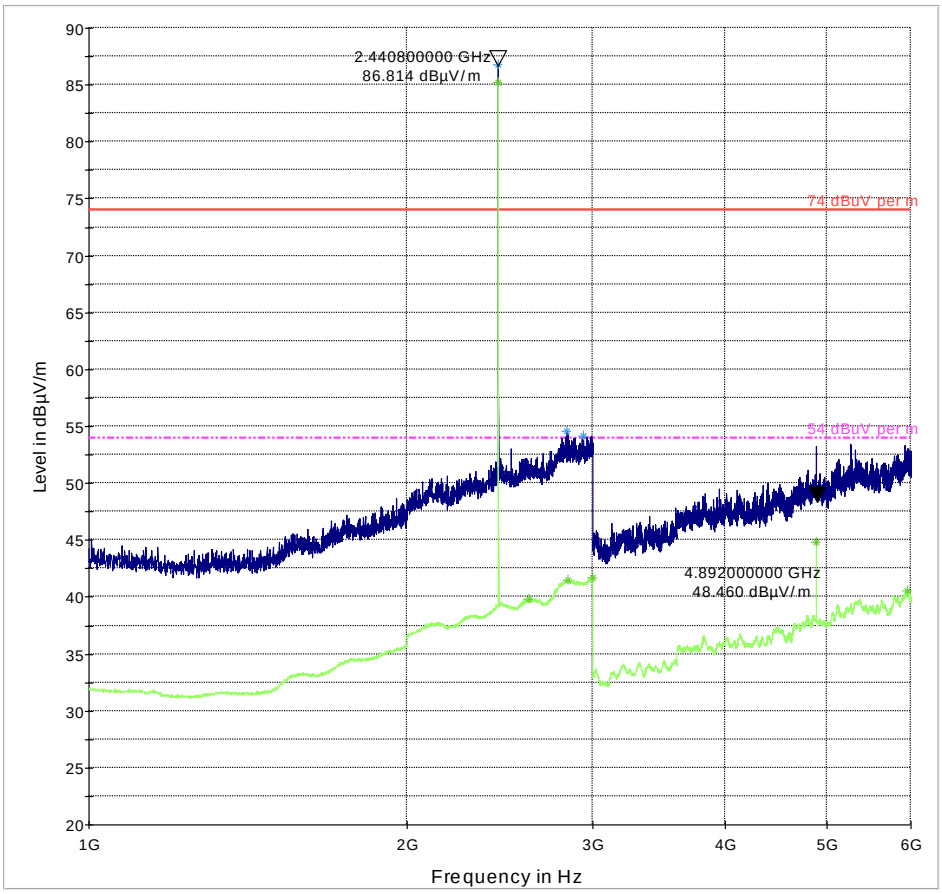
Plot # 4 Radiated Emissions: 9 KHz - 30 MHz		
Modulation: GFSK	**Channel: Mid**	**100% Duty Cycle**



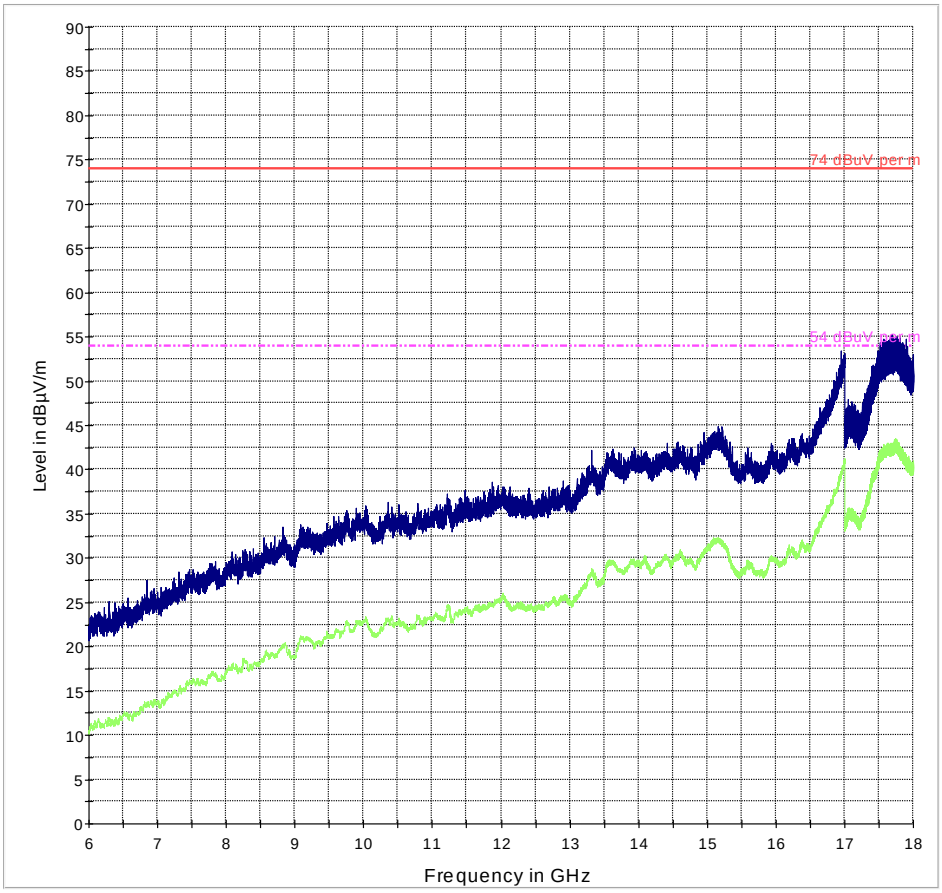
Plot #5 Radiated Emissions: 30 MHz – 1GHz		
Modulation: GFSK	**Channel: Mid**	**100% Duty Cycle**



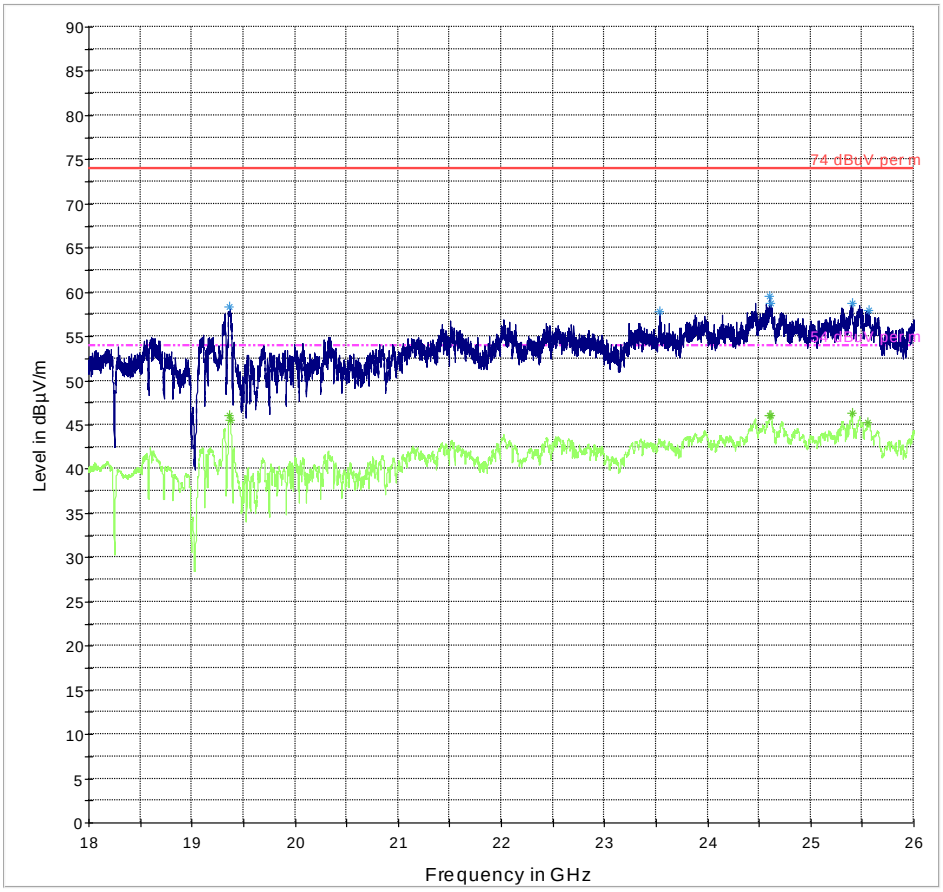
Plot #6 Radiated Emissions: 1-6 GHz		
Modulation: GFSK	**Channel: Mid**	**100% Duty Cycle**



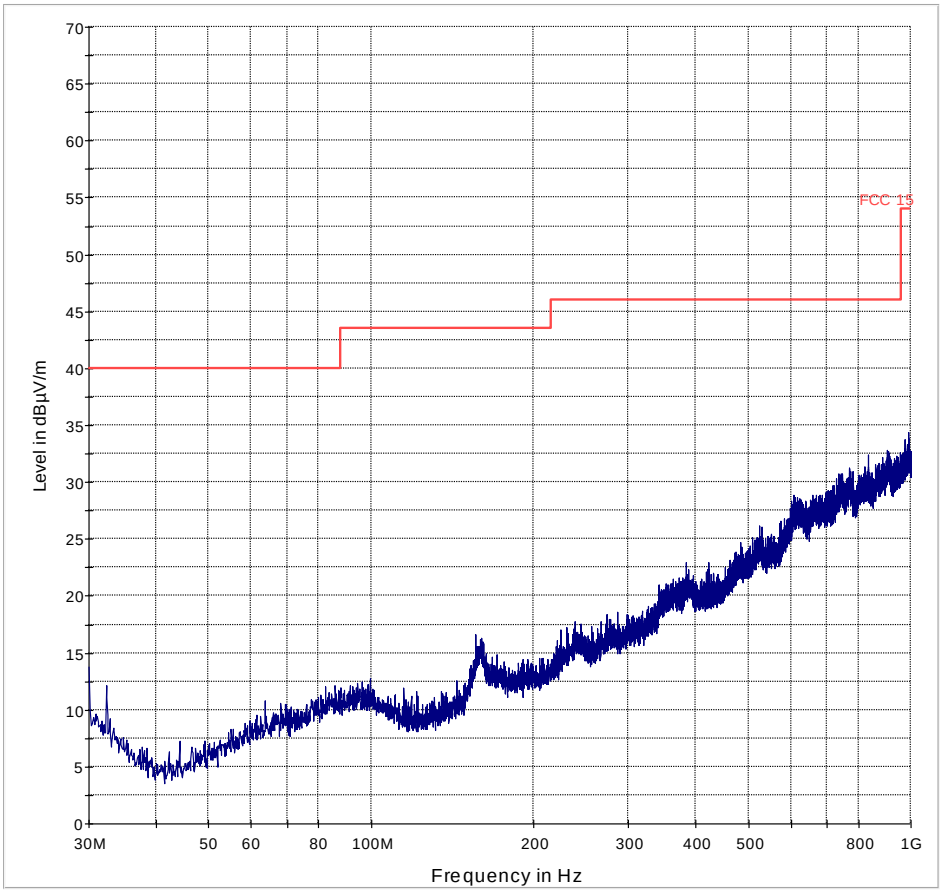
Plot #7 Radiated Emissions: 6-18 GHz		
Modulation: GFSK	**Channel: Mid**	**100% Duty Cycle**



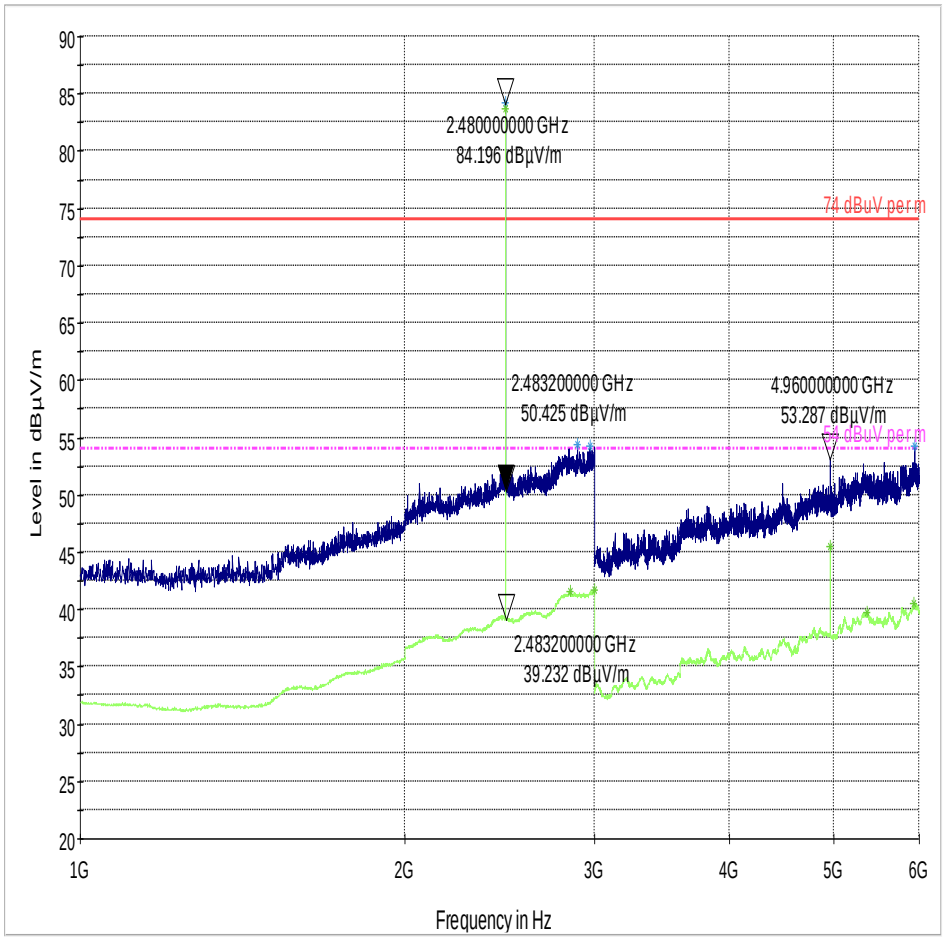
Plot #8 Radiated Emissions: 18-26 GHz		
Modulation: GFSK	**Channel: Mid**	**100% Duty Cycle**



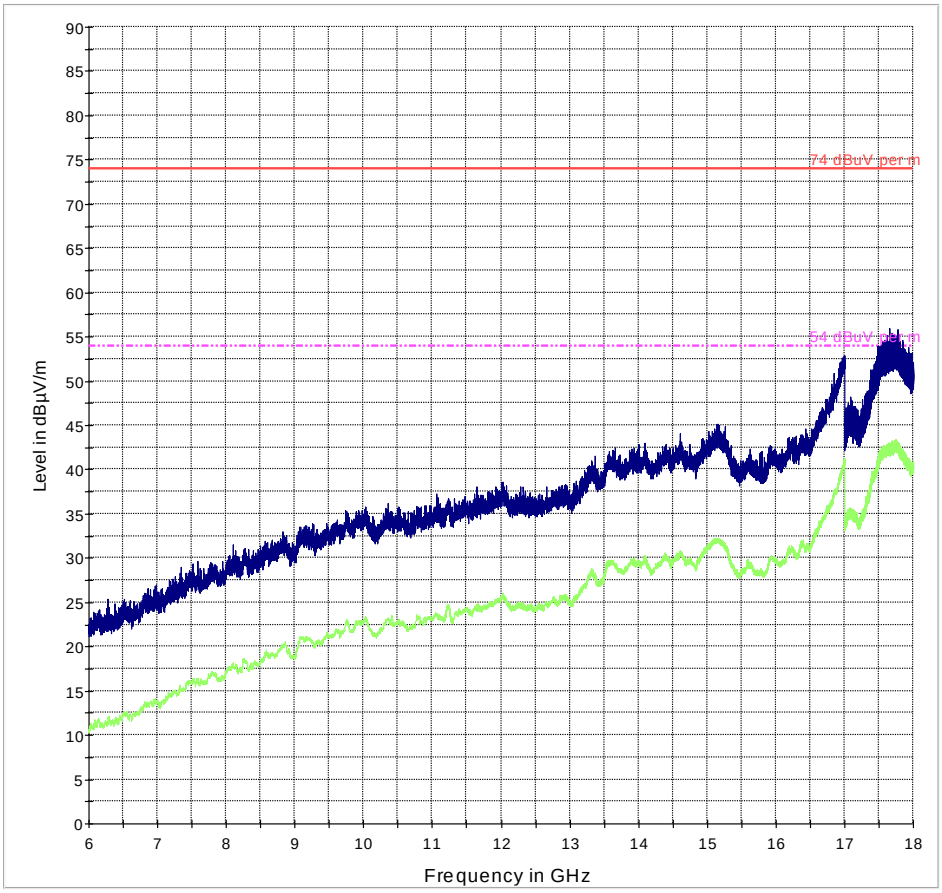
Plot #9 Radiated Emissions: 30 MHz – 1GHz		
Modulation: GFSK	**Channel: Hi**	**100% Duty Cycle**



Plot # 10 Radiated Emissions: 1-6 GHz and Restricted Bands		
Modulation: GFSK	**Channel: Hi**	**100% Duty Cycle**



Plot #11 Radiated Emissions: 6-18 GHz		
Modulation: GFSK	**Channel: Hi**	**100% Duty Cycle**



8.8 AC Power Line Conducted Emissions

8.8.1 Measurement according to ANSI C63.10 (2013)

Analyzer Settings:
RBW = 9 KHz (CISPR Bandwidth)
Detector: Peak / Average for Pre-scan
Quasi-Peak/Average for Final Measurements

8.8.2 Limits: §15.207 & RSS-Gen 8.8

(a) Except as shown in paragraphs (b) and (c) of this section of the CFR, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table (1), as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between frequency ranges.

Table 1:

Frequency of emission (MHz)	Conducted limit (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.

8.8.3 Test conditions and setup:

Ambient Temperature (C)	EUT Set-Up #	EUT operating mode	Power line (L1, L2, L3, N)	Power Input
22	3,4	Continuous TX	Line & Neutral	110V / 60Hz

8.8.4 Measurement Result:

Plot #	Port	EUT Set-Up #:	EUT operating mode	Scan Frequency	Limit	Result
1	AC Mains	3	1	150 kHz – 30 MHz	See section 8.8.2	Pass
2	AC Mains	4	1	150 kHz – 30 MHz	See section 8.8.2	Pass

8.8.5 Measurement Plots:

Plot #1

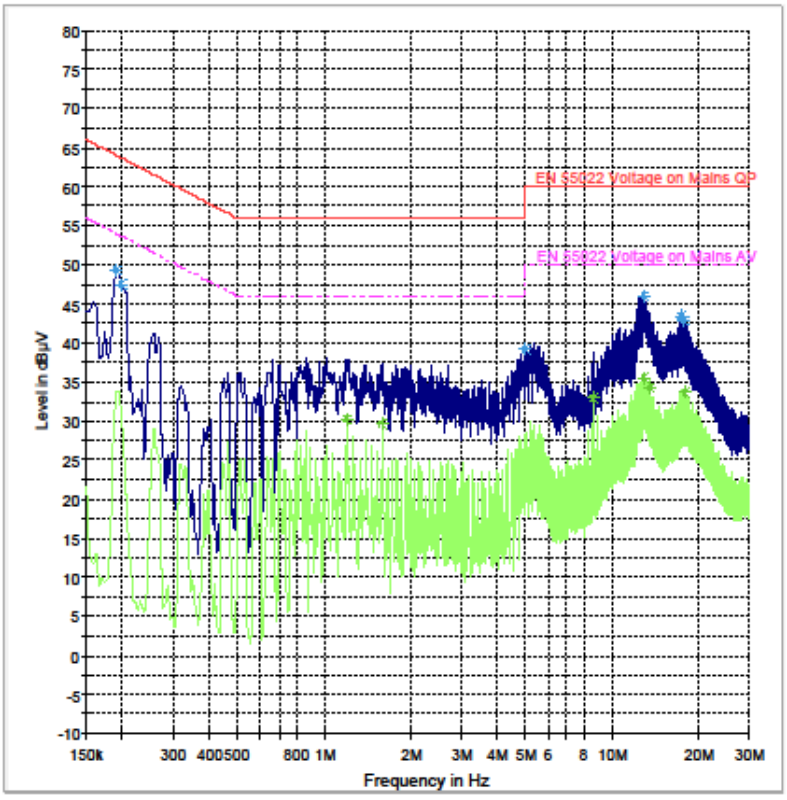
Emissions Test Data 1 / 1

EUT Information

EUT Name:	Z15
Manufacturer:	ACI
Serial Number:	BDA94F6A3F3E2C1
Hardware Rev:	
Software Rev:	
Comment:	laptop

Disclaimer: Any measurement data within 2dB from the limit line is conditional PASS/FAIL due to measurement uncertainty considerations.

CISPR 22 Mains Conducted FCC_LISN



Test Date:7/31/2015 12:39:57 Test Engineer:SMoon

Plot #2

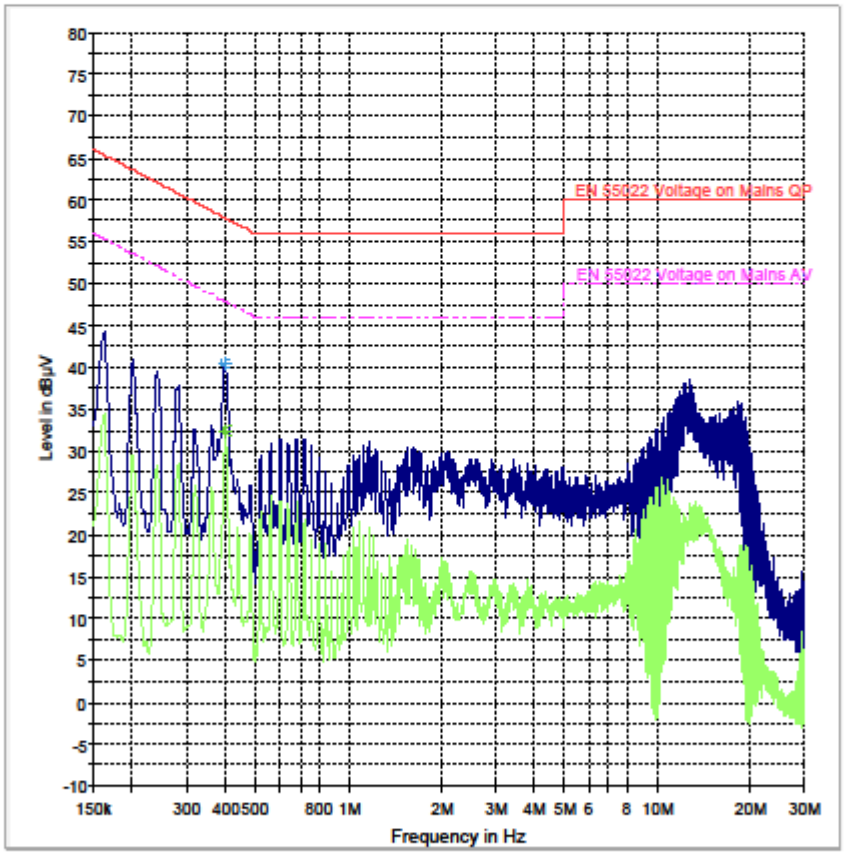
Emissions Test Data 1 / 1

EUT Information

EUT Name:	Z15
Manufacturer:	ACI
Serial Number:	BDA94F6A3F3E2C1
Hardware Rev:	
Software Rev:	
Comment:	AC

Disclaimer: Any measurement data within 2dB from the limit line is considered PASS/FAIL due to measurement uncertainty considerations.

CISPR 22 Mains Conducted FCC_LISN



Test Date:7/31/2015 12:48:52 Test Engineer:SMoon

9 Test Equipment And Ancillaries Used For Testing

No.	Equipment Name	Manufacturer	Type/model	Serial No.	Cal Date	Cal Interval
	Turn table	EMCO	2075	N/A	N/A	N/A
	MAPS Position Controller	ETS Lindgren	2092	0004-1510	N/A	N/A
	Antenna Mast	EMCO	2075	N/A	N/A	N/A
	High Pass Filter	5HC2700	Trilithic Inc.	9926013	Part of system calibration	
	High Pass Filter	4HC1600	Trilithic Inc.	9922307	Part of system calibration	
	6GHz High Pass Filter	HPM50106	Microtronics	001	Part of system calibration	
	Pre-Amplifier	JS4-00102600	Miteq	00616	Part of system calibration	
	Relay Switch Unit	Rohde&Schwarz	RSU	338964/001	N/A	N/A
	EMI Receiver/Analyzer	Rohde&Schwarz	ESU 40	100251	July 2015	2 Year
	Spectrum Analyzer	Rohde&Schwarz	FSU	200302	July 2015	2 Years
	1500MHz HP Filter	Filtek	HP12/1700	14c48	N/A	N/A
	2800 MHZ HP Filter	Filtek	HP12/2800	14C47	N/A	N/A
	Pre-Amplifier	Miteq	JS40010260	340125	N/A	N/A
	Binconilog Antenna	EMCO	3141	0005-1186	Apr 2012	4 Years
	Binconilog Antenna	ETS	3149	J000123908	Mar 2014	4 years
	Horn Antenna	EMCO	3115	35114	Mar 2012	4 Years
	Loop Antenna	EMCO	6512	00049838	Apr 2014	4 years
	LISN	R&S	ESH3-Z5	836679/003	Jun 2013	4 Years
	Fast Power Detector 5Ms/s	ETS Lindgren	7002-006	00160034	Sep 2014	2 Years

10 Revision History

Date	Report Name	Changes to report	Report prepared by
2015-07-27	EMC-APPLE-166-15001-Z15-15.247-BT	Initial Version	Franz Engert
2015-08-13	EMC-APPLE-166-15001-Z15-15.247-BT_Rev1	Updated front page requirements section to indicate DSS system. Updated section 5 Rss247 section references. Updated section Corrected section 8.2.5 Limit to (dBc,) and Band Edge to “Lower, non-restricted”.	Kris Lazarov