EMC
TEST REPORT

Report No.: TS13090119-EME

Model No.: LK500Ui/Ri/Ei

Issued Date: Jan. 09, 2014

Applicant: **Tung Keng Enterprise Co., Ltd**
No. 1, Lane 160, Sec. 2, Tan-Fu Road, Tan-Tzu Dist., Taichung, Taiwan

Test Method/ Standard: **FCC Part 15 Subpart C Section §15.205, §15.207, §15.209, §15.247, DA 00-705 and ANSI C63.4:2003**

Registration No.: **93910**

Test By: **Intertek Testing Services Taiwan Ltd.**
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Testing Laboratory
0597

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Summary of Tests

Test Item	Reference	Results
20dB Bandwidth Test	15.247(a)(1)	Pass
Carrier Frequency Separation Test	15.247(a)(1)	Pass
Number of Hopping Frequencies Test	15.247(a)(1)	Pass
Time of Occupancy (Dwell Time) Test	15.247(a)(1)(iii)	Pass
Maximum Output Power Test	15.247(b)	Pass
RF Antenna Conducted Spurious Test	15.247(d)	Pass
Radiated Spurious Emission Test	15.205, 15.209	Pass
Emission on the Band Edge Test	15.247(d)	Pass
AC Power Line Conducted Emission Test	15.207	Pass

1. General Information

1.1 Identification of the EUT

Product:	Console for Sporting Goods
Model No.:	LK500Ui/Ri/Ei
FCC ID:	PHGLK001
Frequency Range:	2402MHz~2480MHz
Total Hopping Channel No:	79 channels
Frequency of Each Channel:	2402+1k MHz, k＝0~78
Type of Modulation:	GFSK
Rated Power:	DC 9 V
Power Cord:	N/A
Data Cable:	N/A
Sample Received:	Sep. 27, 2013
Test Date(s):	Oct. 15, 2013 ~ Oct. 17, 2013
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Note 2:	When determining the test conclusion, the Measurement Uncertainty of test has been considered.

1.2 Antenna Description

The EUT uses a permanently connected antenna.

Antenna Gain	: 3.07 dBi
Antenna Type	: Chip Antenna
Connector Type	: Fixed

2. Test Specifications

2.1 Test Standard

The EUT was performed according to the procedures in FCC Part 15 Subpart C Section §15.205, §15.207, §15.209, §15.247, DA 00-705 and ANSI C63.4:2003.

The test of radiated measurements according to FCC Part15 Section 15.33(a) had been conducted and the field strength of this frequency band was all meet limit requirement, thus we evaluate the EUT pass the specified test.

2.2 Operation Mode

The EUT is supplied DC 9 V from adapter (Test voltage: 120Vac, 60 Hz).

TX-MODE based on “RfReguration test tool” to execute, and the connection corresponds with address on the BT module.

2.3 Peripherals equipment

Peripherals	Model No.	Serial No.	Description of Data Cable
Adapter	AD48-0901000DU	N/A	N/A

2.4 Measurement Uncertainty

Measurement uncertainty was calculated in accordance with TR 100 028-1

Parameter	Uncertainty		
Radiated Emission	Below 1 GHz	Vertical	3.90 dB
		Horizontal	3.86 dB
	Above 1 GHz	Vertical	5.74 dB
		Horizontal	5.55 dB
Conducted Emission	2.08 dB		

This uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level using a coverage factor of *k*=2.

2.5 Test Equipment

Equipment	Brand	Model No.	Serial No.	Calibration Date	Next Calibration Date
EMI Test Receiver	Rohde & Schwarz	ESCI	100018	2012/11/30	2013/11/29
Spectrum Analyzer	Rohde&schwarz	FSP30	100137	2013/06/21	2014/06/20
Spectrum Analyzer	Rohde&schwarz	FSEK30	100186	2013/01/23	2014/01/22
Horn Antenna (1-18G)	Schwarzbeck	BBHA 9120 D	9120D-456	2012/09/03	2014/09/02
Horn Antenna (14-42G)	SHWARZBECK	BBHA 9170	BBHA9170159	2012/09/05	2014/09/04
Broadband Antenna	SCHWARZBECK	VULB 9168	9168-172	2013/08/08	2015/08/07
Loop Antenna	RolfHeine	LA-285	02/10033	2012/03/20	2014/03/19
Pre-Amplifier	MITEQ	AFS44-00102650--42-10P-44	1495287	2011/10/27	2013/10/26
Pre-Amplifier	MITEQ	JS4-26004000--27-8A	828825	2012/09/18	2014/09/17
Power Meter	Anritsu	ML2495A	0844001	2013/10/10	2014/10/09
Power Senor	Anritsu	MA2411B	0738452	2013/10/10	2014/10/09
Temperature& Humidity Test Chamber	TERCHY	MHU-225LRU (SA)	950838	2013/06/14	2014/06/13
Two-Line V-Network	Rohde&schwarz	ESH3-Z5	838979/014	2013/10/12	2014/10/11
Singal Analyzer	Agilent	N9030A	MY51380492	2013/09/19	2014/09/18
DC Source	Agilent	E3631A	N/A	N/A	N/A

Note: The above equipments are within the valid calibration period.

3. 20dB Bandwidth Test

3.1 Operating Environment

Temperature:	24	℃
Relative Humidity:	55	%
Atmospheric Pressure:	1008	hPa
Test Date:	Oct. 17, 2013	

3.2 Test Setup & Procedure

The test procedure was according to FCC measurement guidelines DA 00-705.

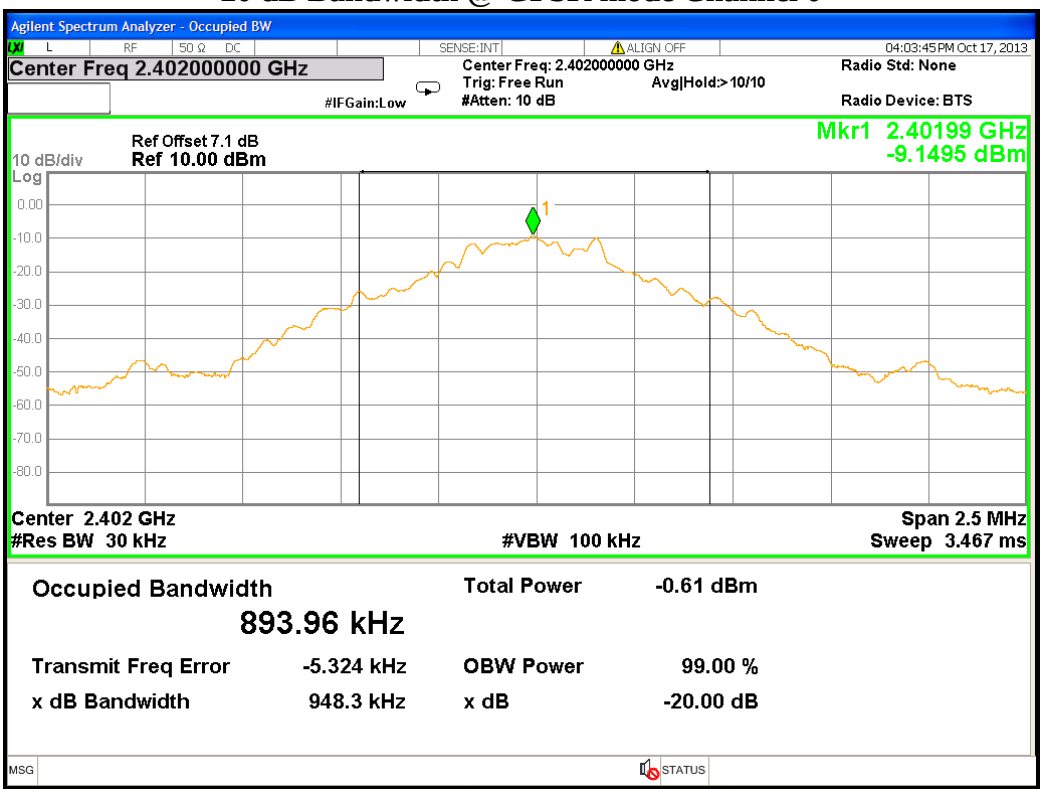
The 20dB bandwidth per FCC §15.247(a)(1) was measured using a 50 ohm spectrum analyzer with the resolutions bandwidth set≧1% of 20dB Bandwidth, the video bandwidth ≧ RBW, and the SPAN may equal to approximately 2 to 3 times the 20dB bandwidth. The test was performed at 3 channels (lowest, middle and highest channel). The maximum 20dB modulation bandwidth is in the following Table.

3.3 Measured Data of Modulated Bandwidth Test Results

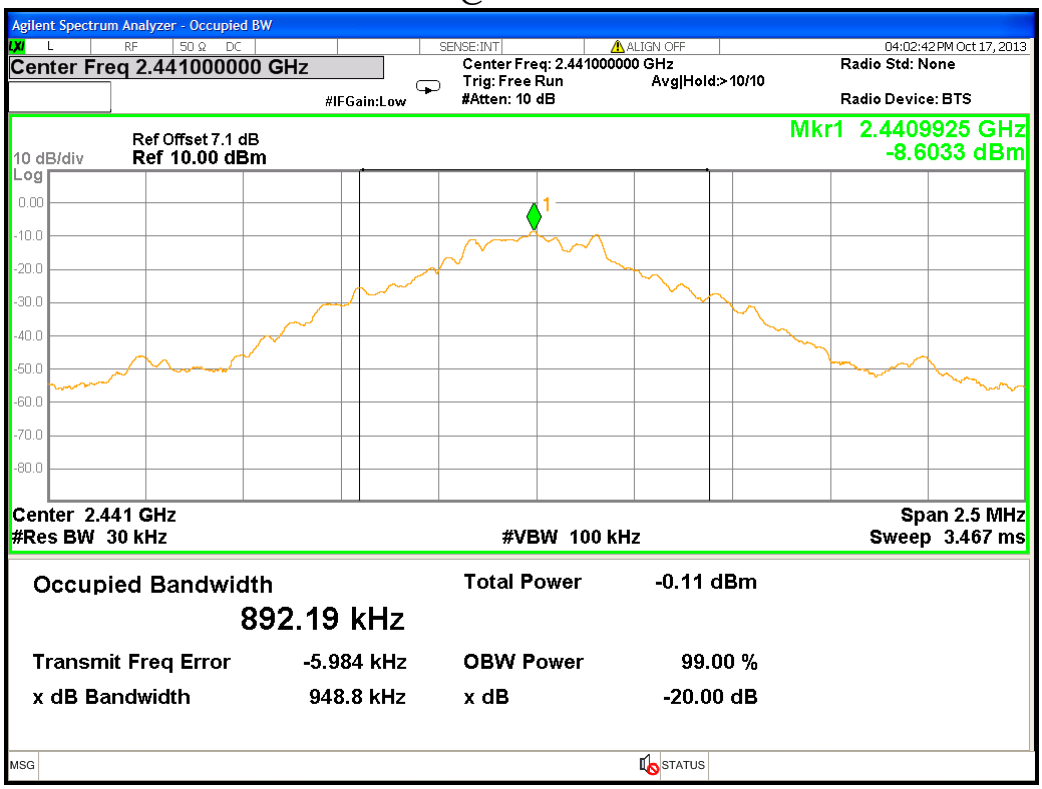
Mode	Channel	Frequency (MHz)	20dB Bandwidth (MHz)
GFSK	0	2402	0.9483
	39	2441	0.9488
	78	2480	0.9487

Please see the plot below.

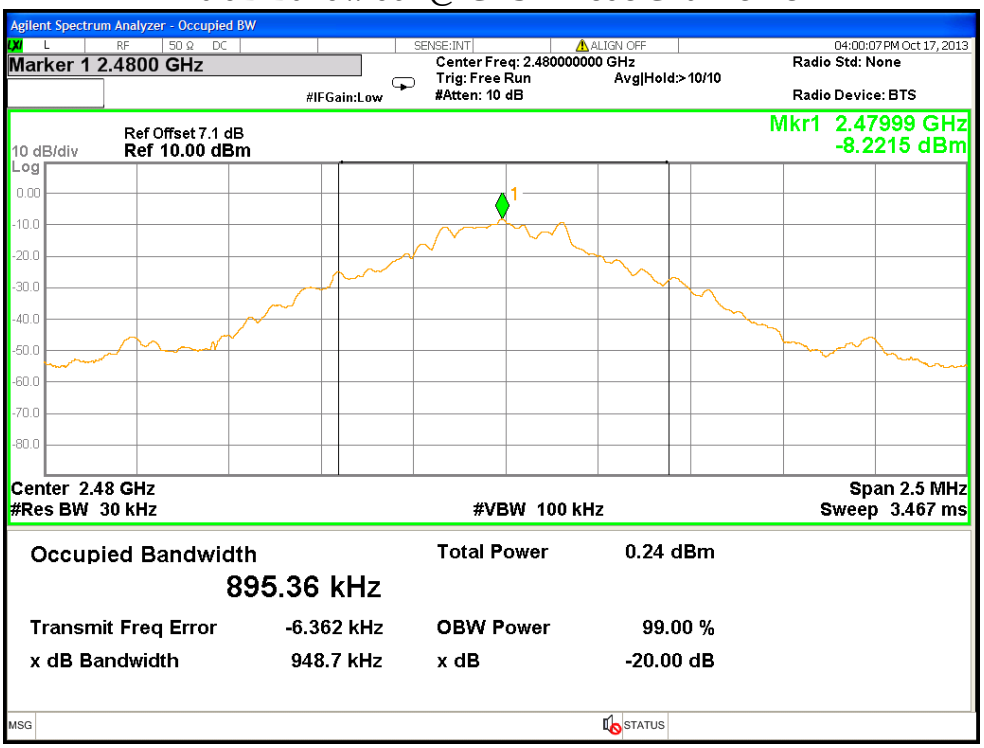
20 dB Bandwidth @ GFSK mode Channel 0



20 dB Bandwidth @ GFSK mode Channel 39



20 dB Bandwidth @ GFSK mode Channel 78



4. Carrier Frequency Separation Test

4.1 Operating Environment

Temperature:	24	℃
Relative Humidity:	55	%
Atmospheric Pressure:	1008	hPa
Test Date:	Oct. 17, 2013	

4.2 Test Setup & Procedure

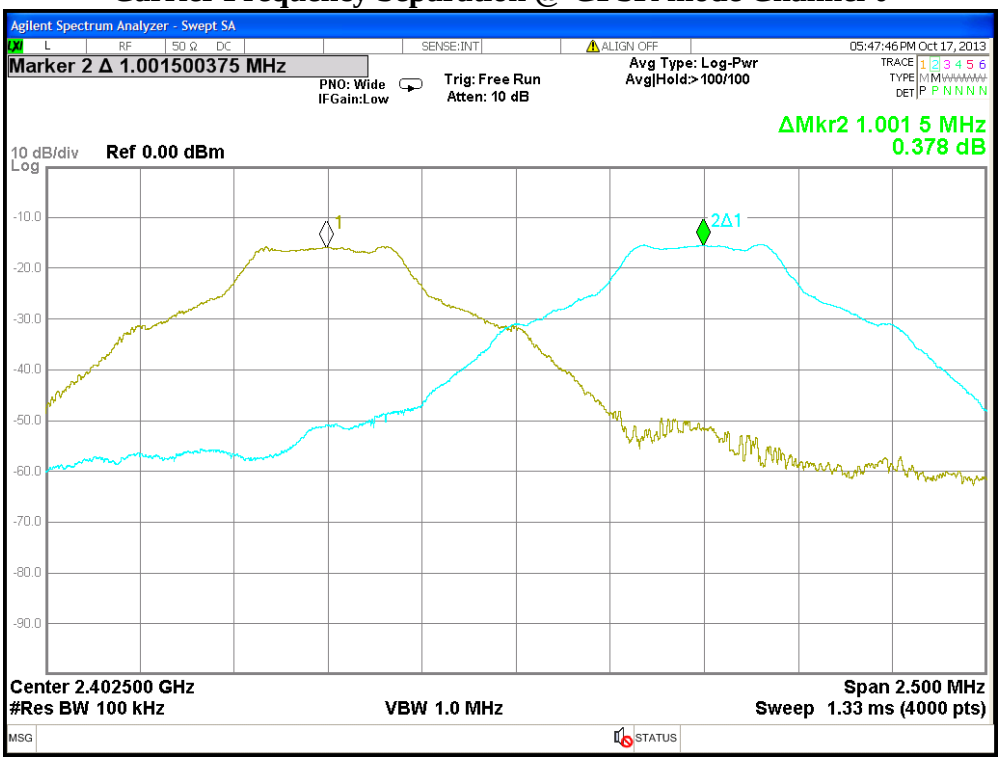
The test procedure was according to FCC measurement guidelines DA 00-705.
The carrier frequency separation per FCC §15.247(a)(1) was measured using a 50 ohm spectrum analyzer with the resolutions bandwidth set at ≧ 1% of the span, the video bandwidth ≧ RBW, and the SPAN was wide enough to capture the peaks of two adjacent channels. The carrier frequency separation result is in the following Table.

4.3 Measured Data of Carrier Frequency Separation Test Results

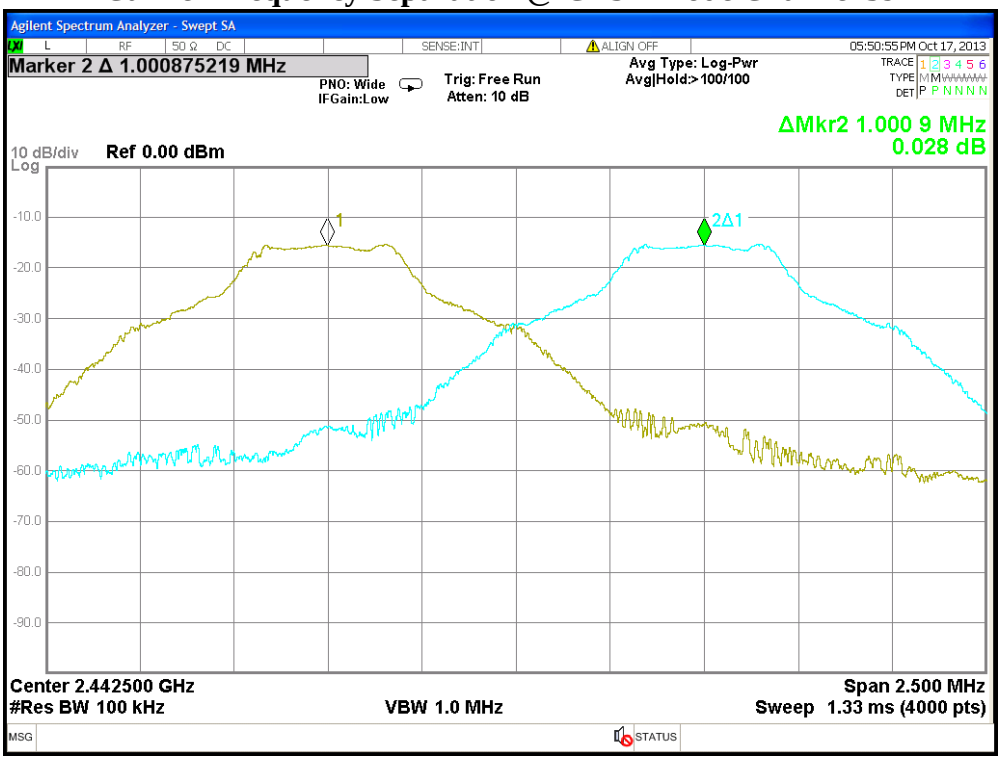
Mode	Channel	Frequency (MHz)	Adjacent channel separation (MHz)	20dB down Bandwidth (MHz)	Minimum limit 20dB BW*2/3(kHz)
GFSK	0	2402	1.0015	0.9483	0.63
	39	2441	1.0009	0.9488	0.63
	78	2480	1.0004	0.9487	0.63

Please see the spectrum plots of worst value below.

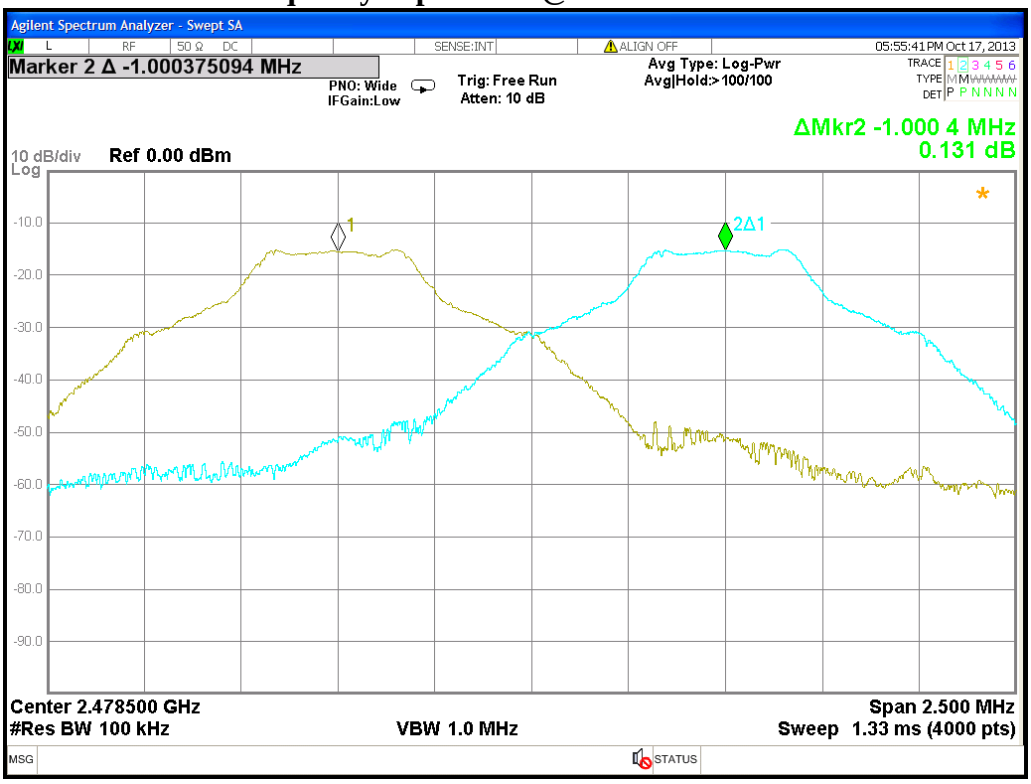
Carrier Frequency Separation @ GFSK mode Channel 0



Carrier Frequency Separation @ GFSK mode Channel 39



Carrier Frequency Separation @ GFSK mode Channel 78



5. Number of Hopping Frequencies Test

5.1 Operating Environment

Temperature:	24	℃
Relative Humidity:	55	%
Atmospheric Pressure:	1008	hPa
Test Date:	Oct. 17, 2013	

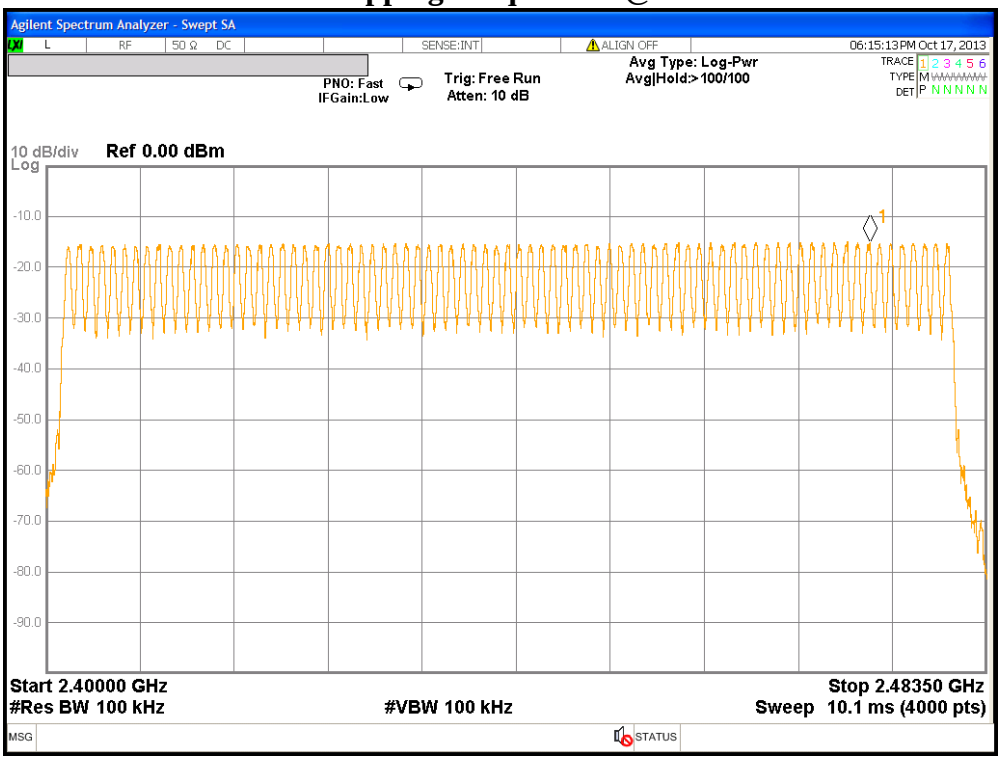
5.2 Test Setup & Procedure

The test procedure was according to FCC measurement guidelines DA 00-705.
The number of hopping frequencies per FCC §15.247(a)(1) was measured using a 50 ohm spectrum analyzer with the resolutions bandwidth set at ≧1% of the span, the video bandwidth ≧ RBW, and the SPAN was the frequency band of operation. The carrier frequency separation result is in the following Table.

5.3 Measured Data of Number of Hopping Frequencies Test Results

Frequency Range (MHz)	Hopping Channels
2402~2480	79

Number of Hopping Frequencies @ GFSK mode



6. Time of Occupancy (Dwell Time)

6.1 Operating Environment

Temperature:	24	℃
Relative Humidity:	55	%
Atmospheric Pressure:	1008	hPa
Test Date:	Oct. 17, 2013	

6.2 Test Setup & Procedure

The test procedure was according to FCC measurement guidelines DA 00-705.

The time of occupancy (dwell time) per FCC §15.247(a)(1) was measured using a 50 ohm spectrum analyzer with the resolutions bandwidth set at 1MHz, the video bandwidth ≧ RBW, and the zero span function of spectrum analyzer was enable. The EUT has its hopping function enable.

6.3 Measured Data of Maximum Output Power Test Results

The total sweep time is 0.4×79 Channels =31.6 seconds
Due to the number of hops in the 31.6s sweep, we determined to reduce the sweep time to 5s, count the number of hops and multiply by 6.32. The total number of hops will be multiplied by the measured time of one pulse.

GFSK Mode:

Time of occupancy (dwell time) for DH1

Number of Hops in 5s= 51, Total Number of Hops in 31.6s = 51(6.32) =322.32

Single Pulse Width = 0.3943 ms

Dwell time = Pulse Width * 322.32 = 127.0908 ms

Time of occupancy (dwell time) for DH3

Number of Hops in 5s=28, Total Number of Hops in 31.6s = 28(6.32) =176.69

Single Pulse Width = 1.64ms

Dwell time = Pulse Width * 176.69= 290.2144 ms

Time of occupancy (dwell time) for DH5

Number of Hops in 5s=19, Total Number of Hops in 31.6s = 19(6.32) =120.08

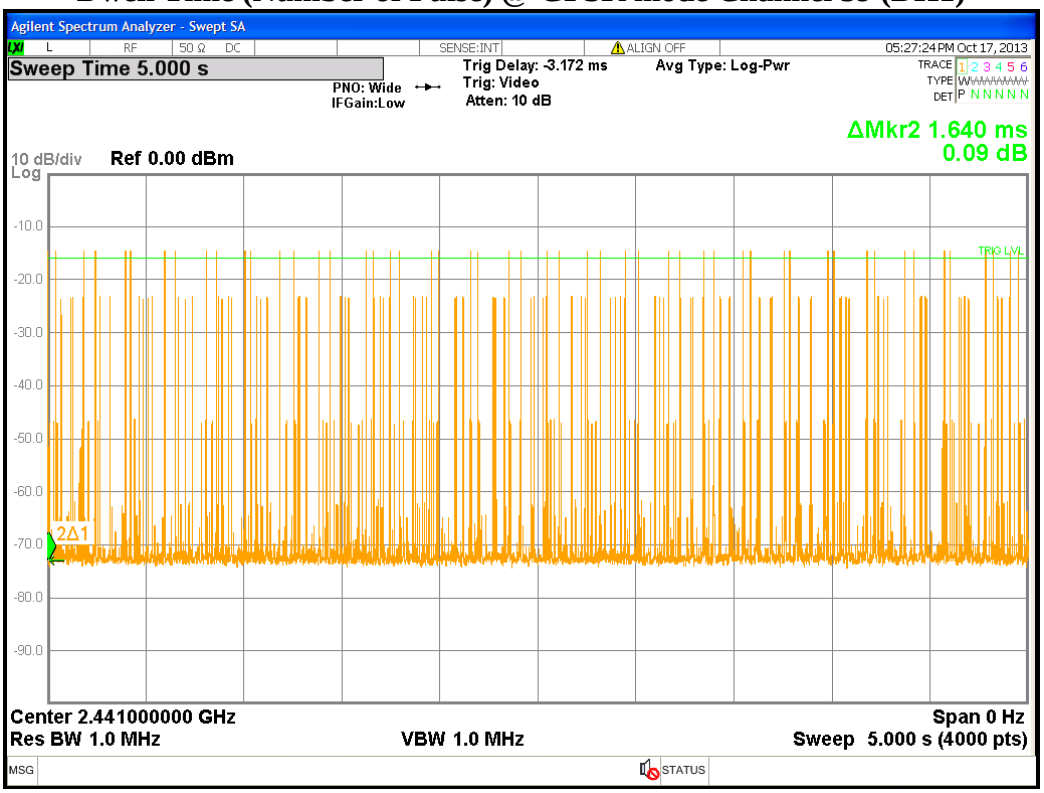
Single Pulse Width = 2.891ms

Dwell time = Pulse Width * 120.08= 347.15128 ms

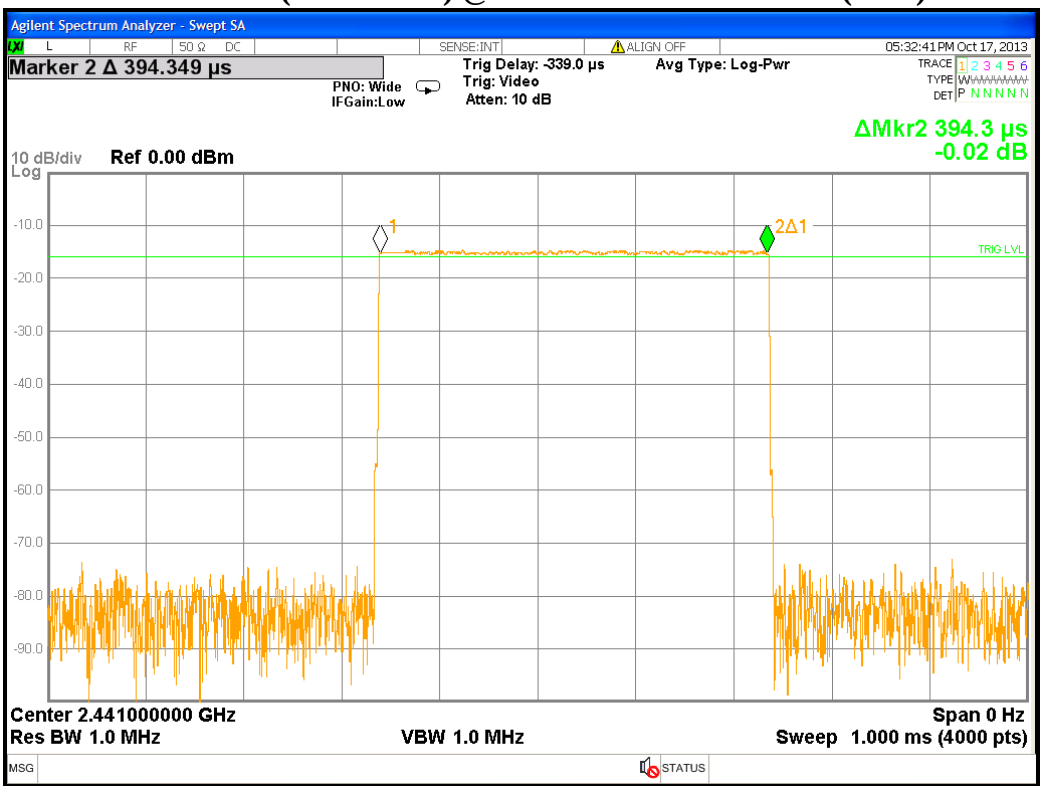
Mode	Packet Type	Pulse Duration (ms)	Number of Pulse	Measure Time (s)	Dwell Time (ms)	Limit (ms)
GFSK	DH1	0.39	51	5	127.09	400
	DH3	1.64	28	5	290.21	400
	DH5	2.89	19	5	347.15	400

Please see the plots below.

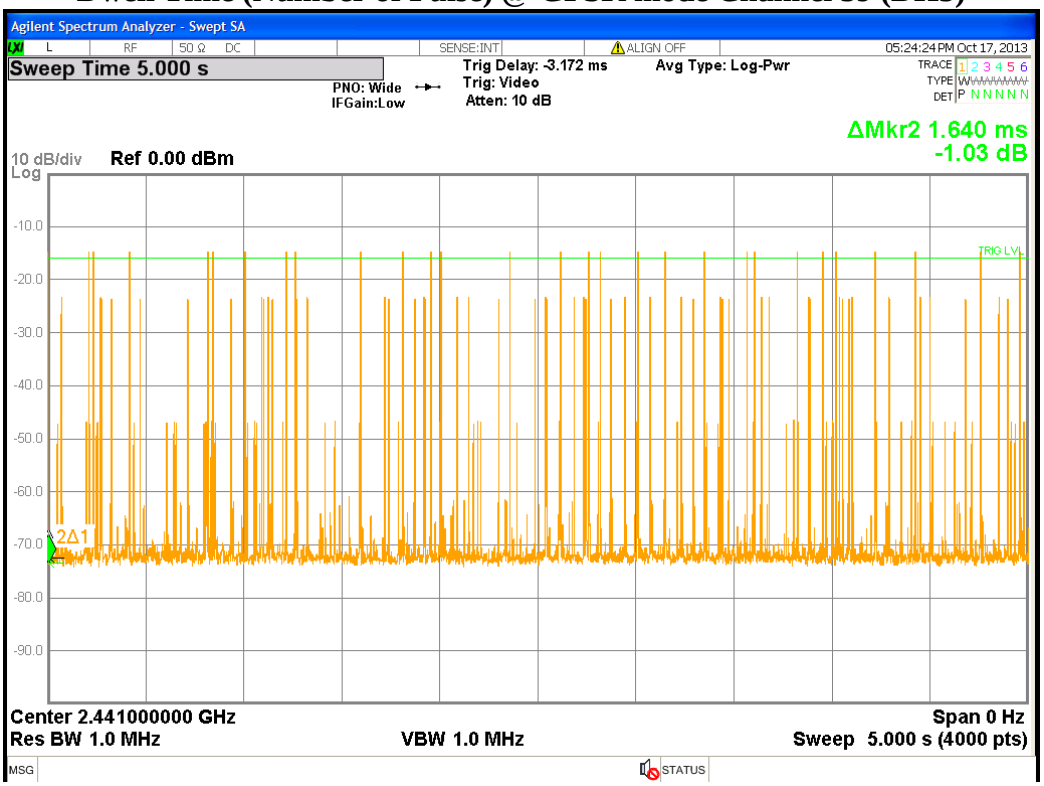
Dwell Time (Number of Pulse) @ GFSK mode Channel 39 (DH1)



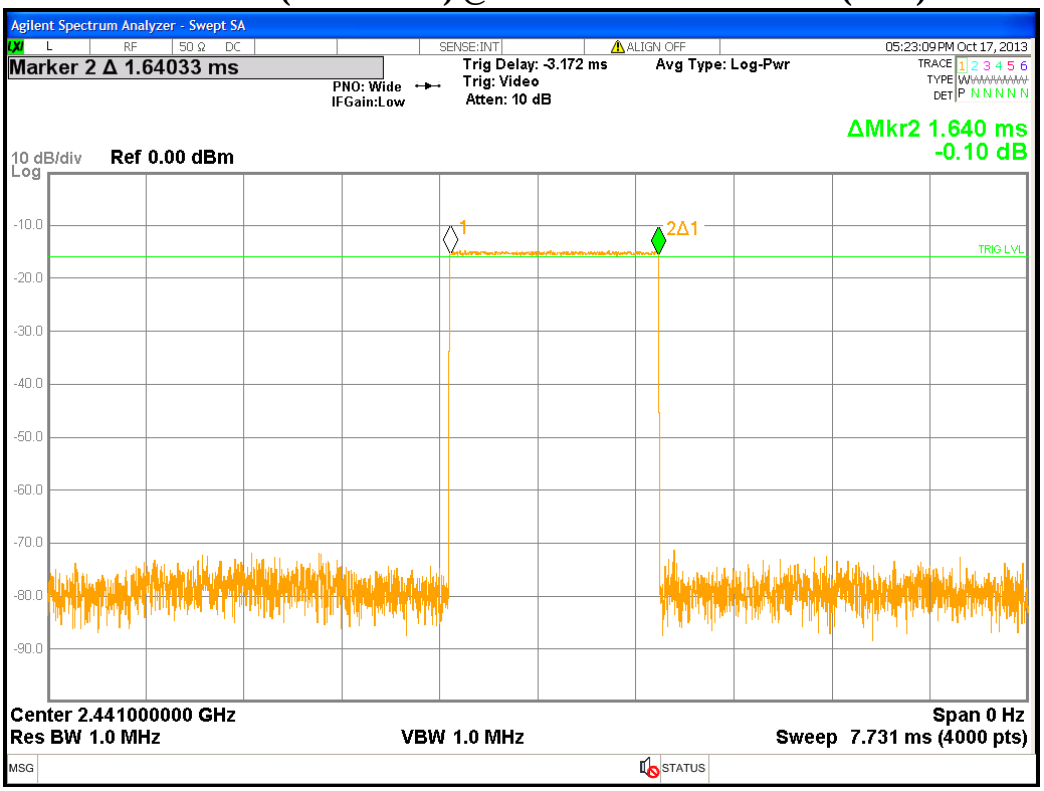
Dwell Time (Pulse Time) @ GFSK mode Channel 39 (DH1)



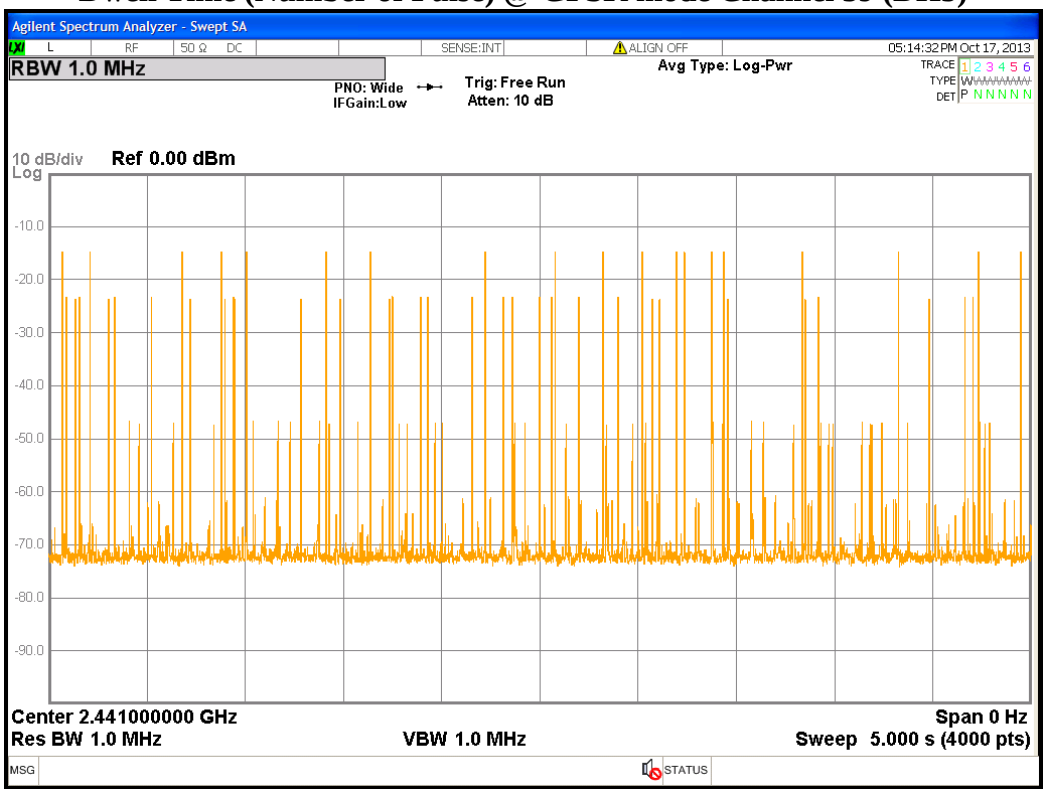
Dwell Time (Number of Pulse) @ GFSK mode Channel 39 (DH3)



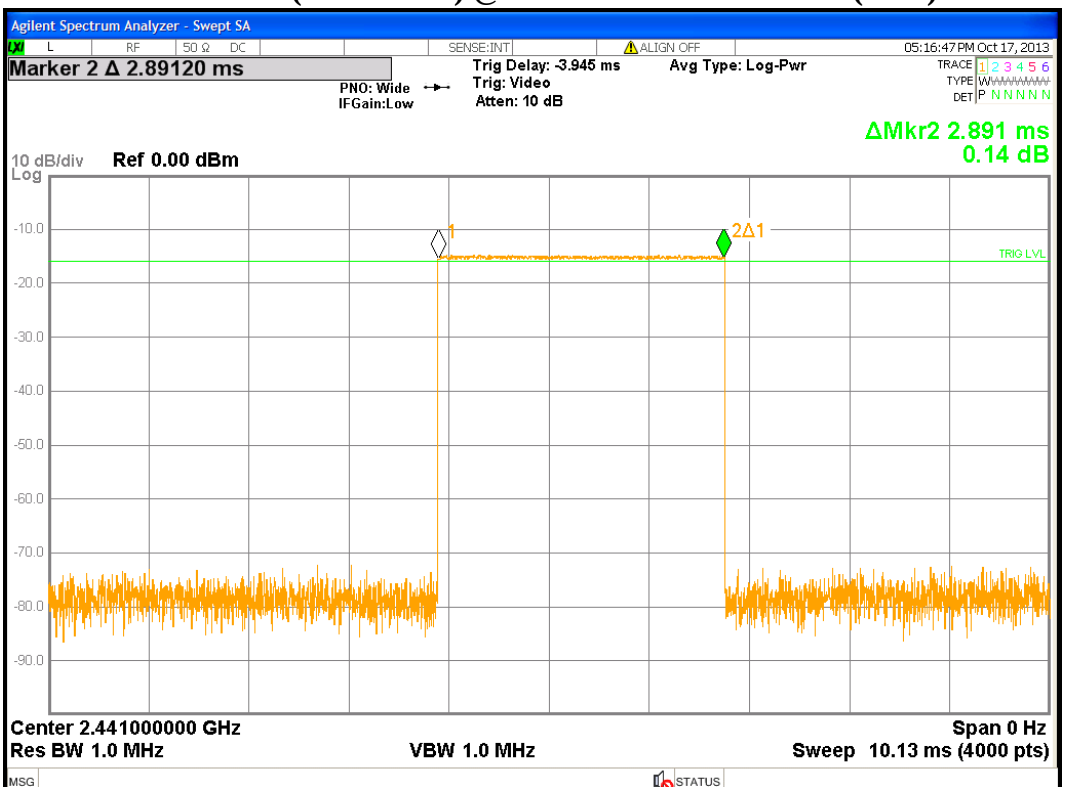
Dwell Time (Pulse Time) @ GFSK mode Channel 39 (DH3)



Dwell Time (Number of Pulse) @ GFSK mode Channel 39 (DH5)



Dwell Time (Pulse Time) @ GFSK mode Channel 39 (DH5)



7. Maximum Output Power Test

7.1 Operating Environment

Temperature:	24	℃
Relative Humidity:	55	%
Atmospheric Pressure:	1008	hPa
Test Date:	Oct. 17, 2013	

7.2 Test Setup & Procedure

The test procedure was according to FCC measurement guidelines DA 00-705.
The power output per FCC §15.247(b) was measured on the EUT using a 50 ohm SMA cable connected to peak power meter via power sensor. Power was read directly and cable loss correction (2 dB) was added to the reading to obtain power at the EUT antenna terminals. The test was performed at 3 channels (lowest, middle and highest channel).

7.3 Measured Data of Maximum Output Power Test Results

Mode	Channel	Frequency (MHz)	Output Power (dBm) PK	Total Power (mW) PK	Limit (dBm)	Margin (dB)
GFSK	0	2402	-7.11	0.19	30	-37.11
	39	2441	-6.37	0.23	30	-36.37
	78	2480	-6.46	0.23	30	-36.46

8. RF Antenna Conducted Spurious Test

8.1 Operating Environment

Temperature:	24	℃
Relative Humidity:	55	%
Atmospheric Pressure:	1008	hPa
Test Date:	Oct. 17, 2013	

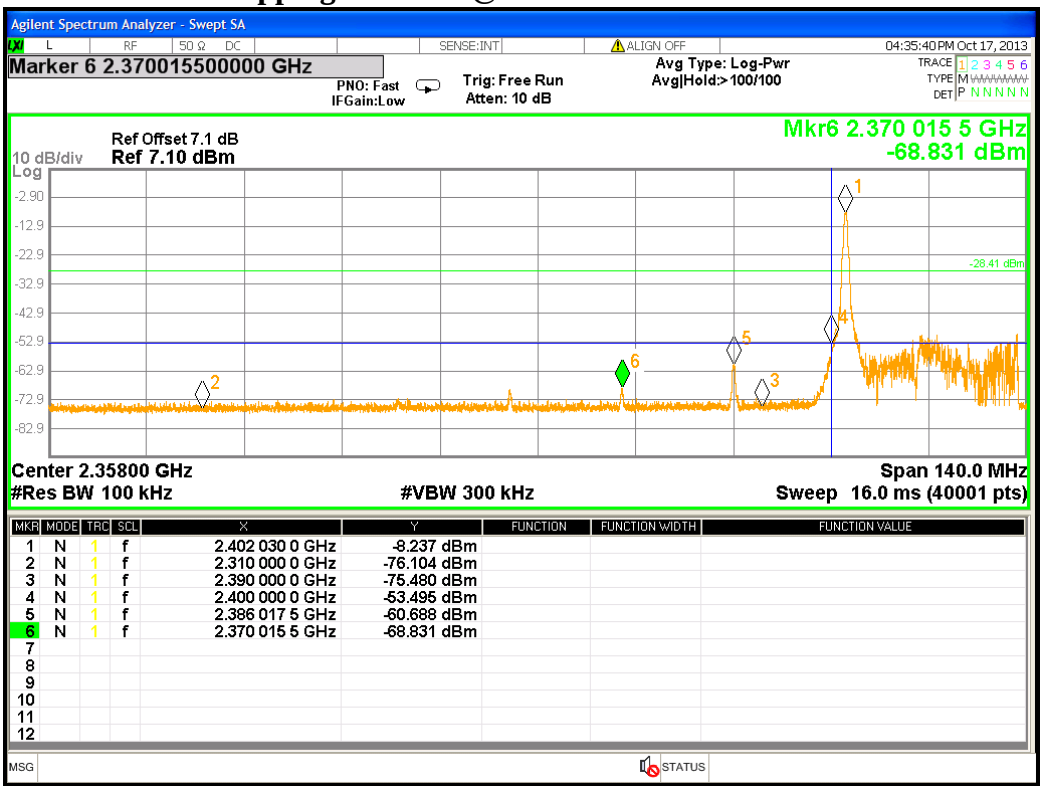
8.2 Test Setup & Procedure

The test procedure was according to FCC measurement guidelines DA 00-705.

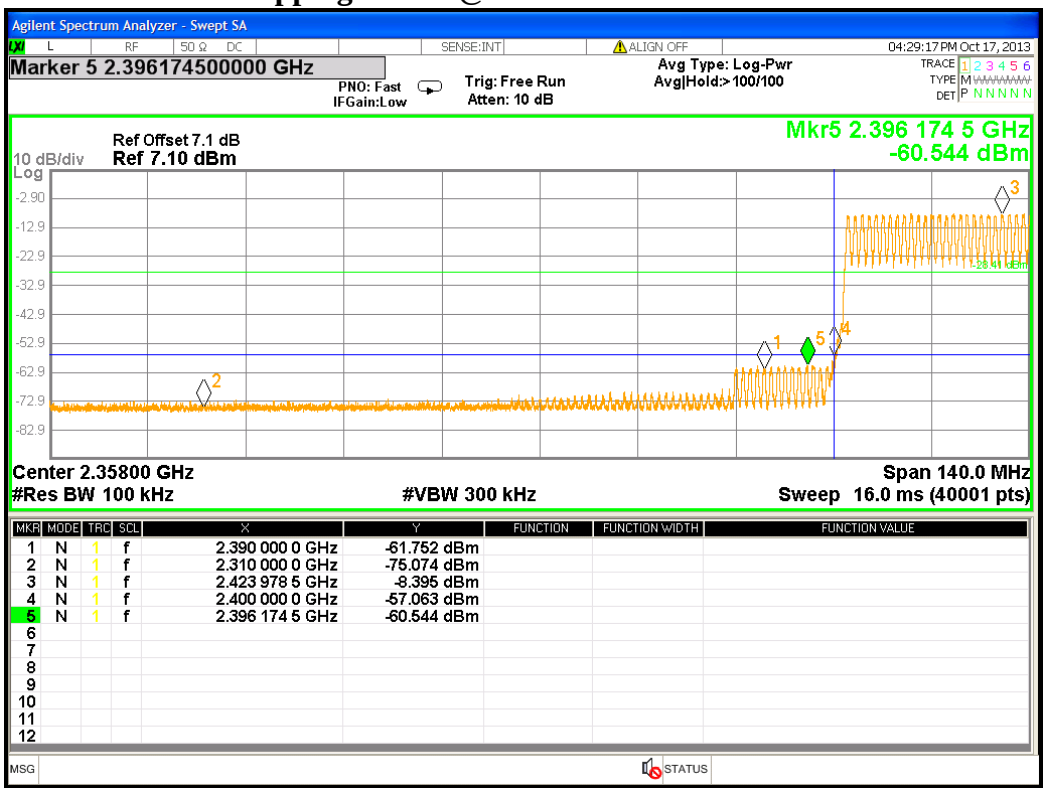
The measurements were performed from 30MHz to 25GHz RF antenna conducted per FCC 15.247 (c) was measured from the EUT antenna port using a 50ohm spectrum analyzer with the resolution bandwidth set at 100 kHz, and the video bandwidth set at 100 kHz.
Harmonics and spurious noise must be at least 20dB down from the highest emission level within the authorized band as measured with a 100 kHz RBW.

8.3 Measured Data of the Highest RF Antenna Conducted Spurious Test Results

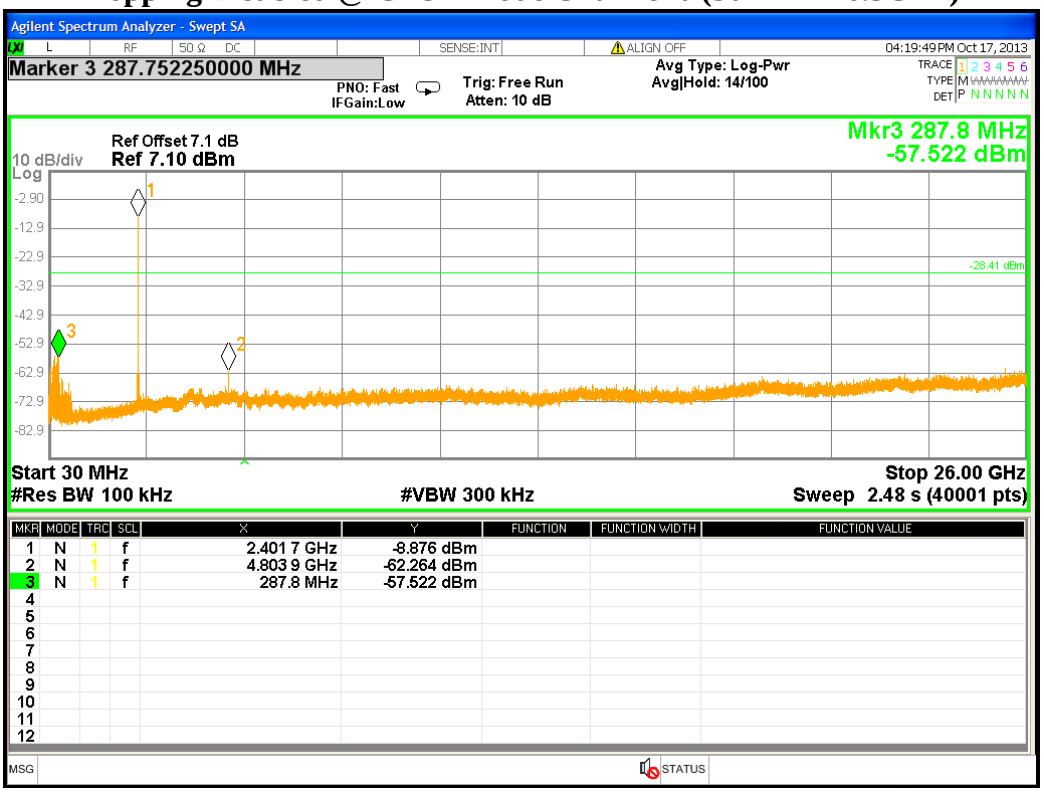
Hopping Disabled @ GFSK mode Channel 0



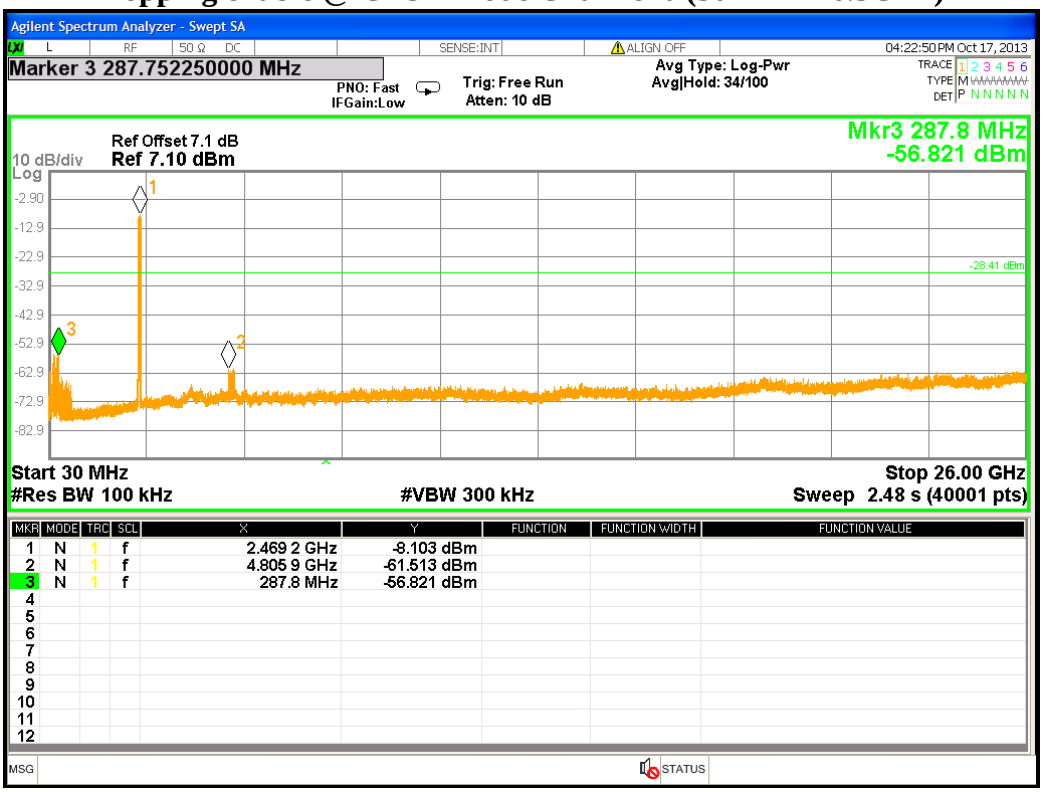
Hopping enable @ GFSK mode Channel 0



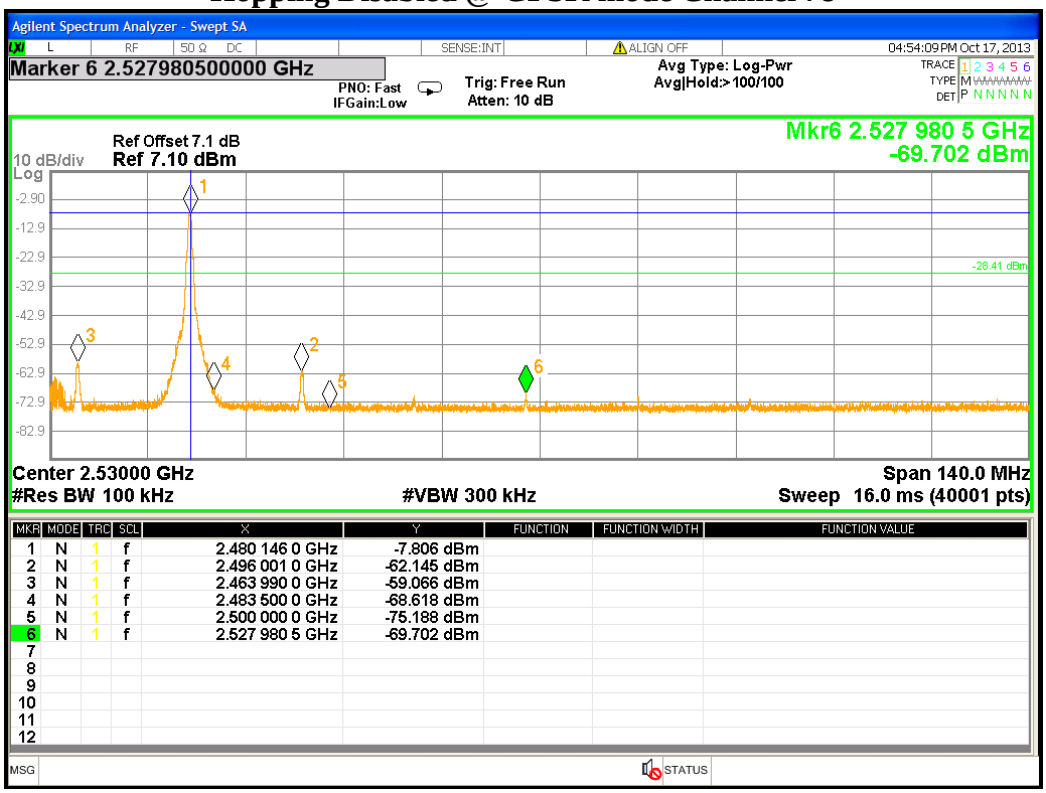
Hopping Disabled @ GFSK mode Channel 0 (30MHz~26.5GHz)



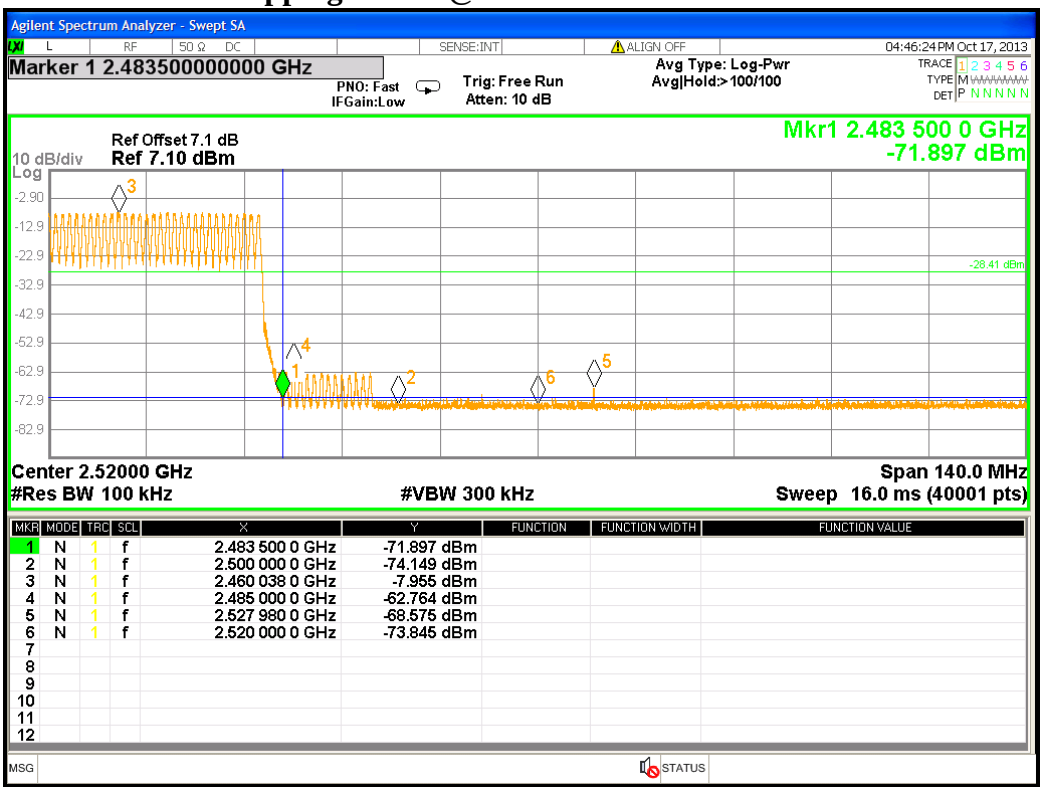
Hopping enable @ GFSK mode Channel 0 (30MHz~26.5GHz)



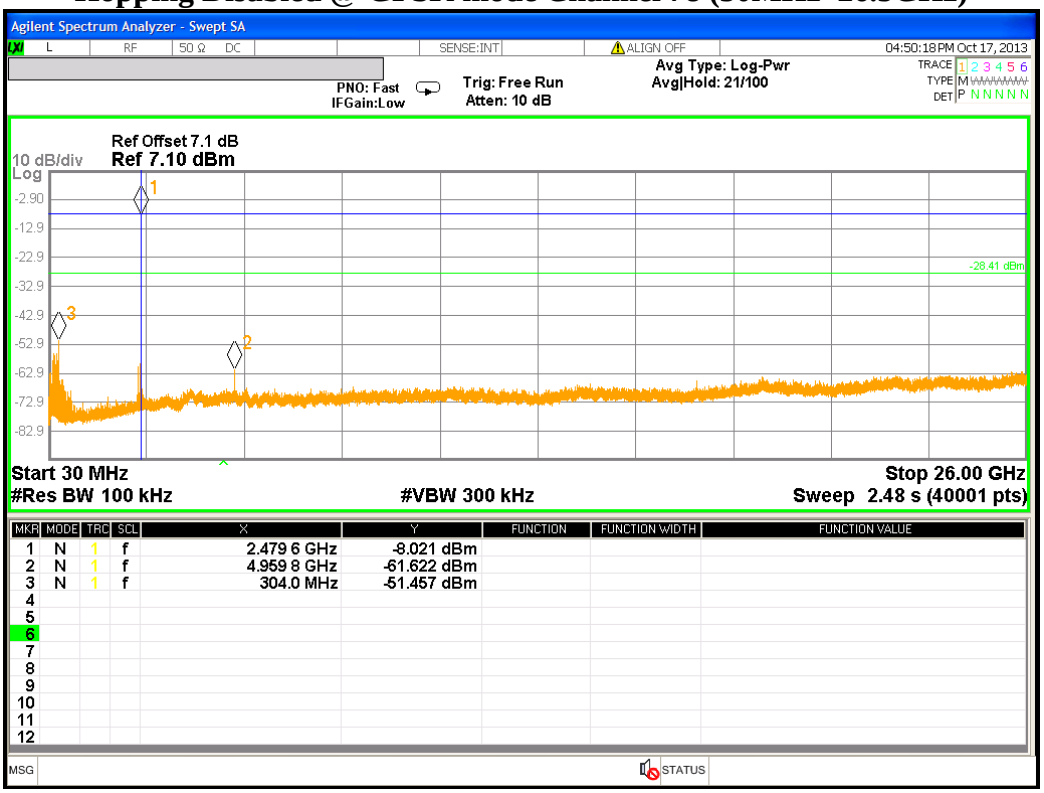
Hopping Disabled @ GFSK mode Channel 78



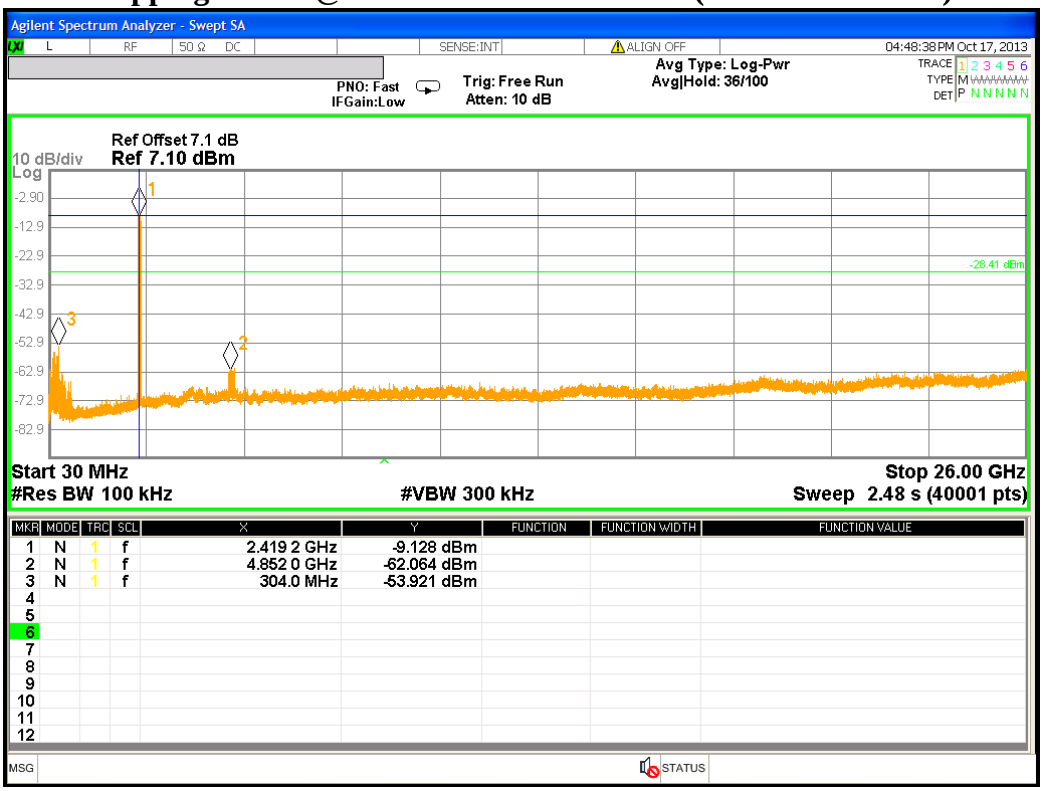
Hopping enable @ GFSK mode Channel 78



Hopping Disabled @ GFSK mode Channel 78 (30MHz~26.5GHz)



Hopping enable @ GFSK mode Channel 78 (30MHz~26.5GHz)



9. Radiated Emission Test

9.1 Operating Environment

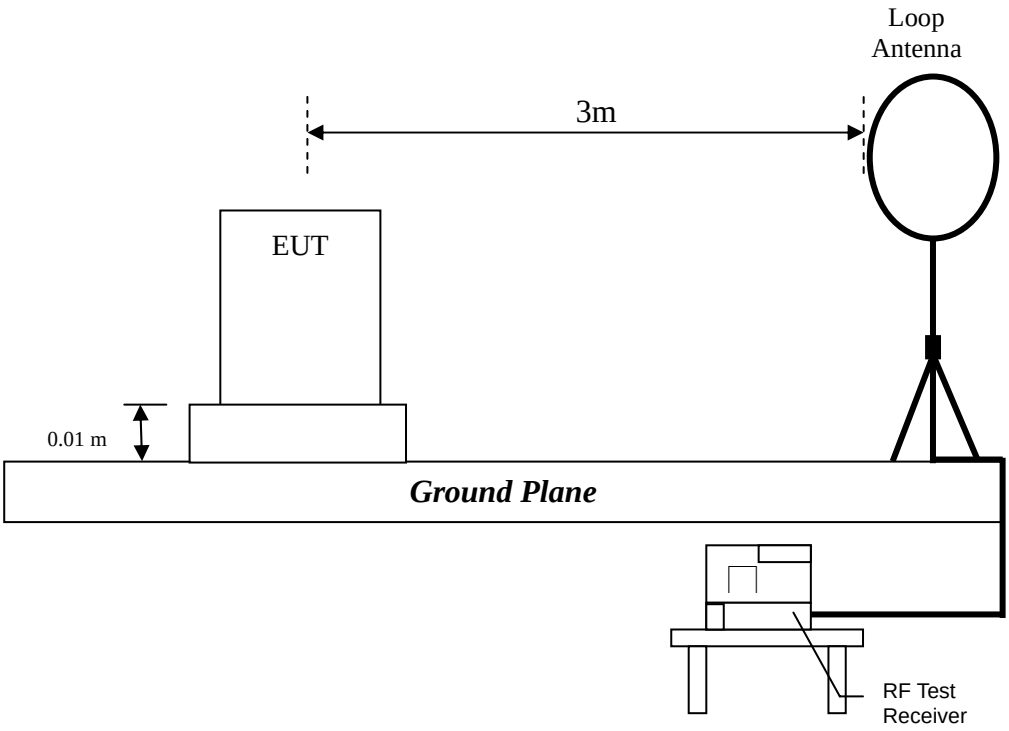
Temperature:	25	℃
Relative Humidity:	50	%
Atmospheric Pressure:	1008	hPa
Test Date:	Oct. 15, 2013	

9.2 Test Setup & Procedure

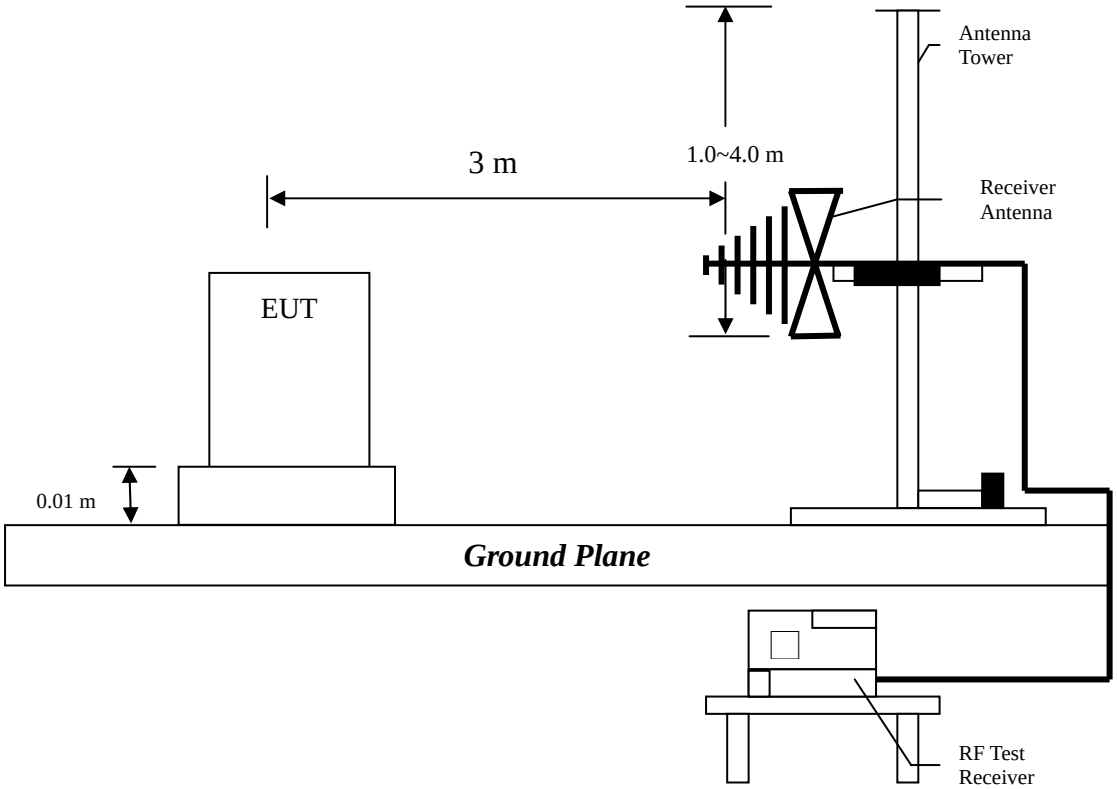
The test procedure was according to FCC measurement guidelines DA 00-705 and ANSI C63.4/2003.

The Diagram below shows the test setup, which is utilized to make these measurements.

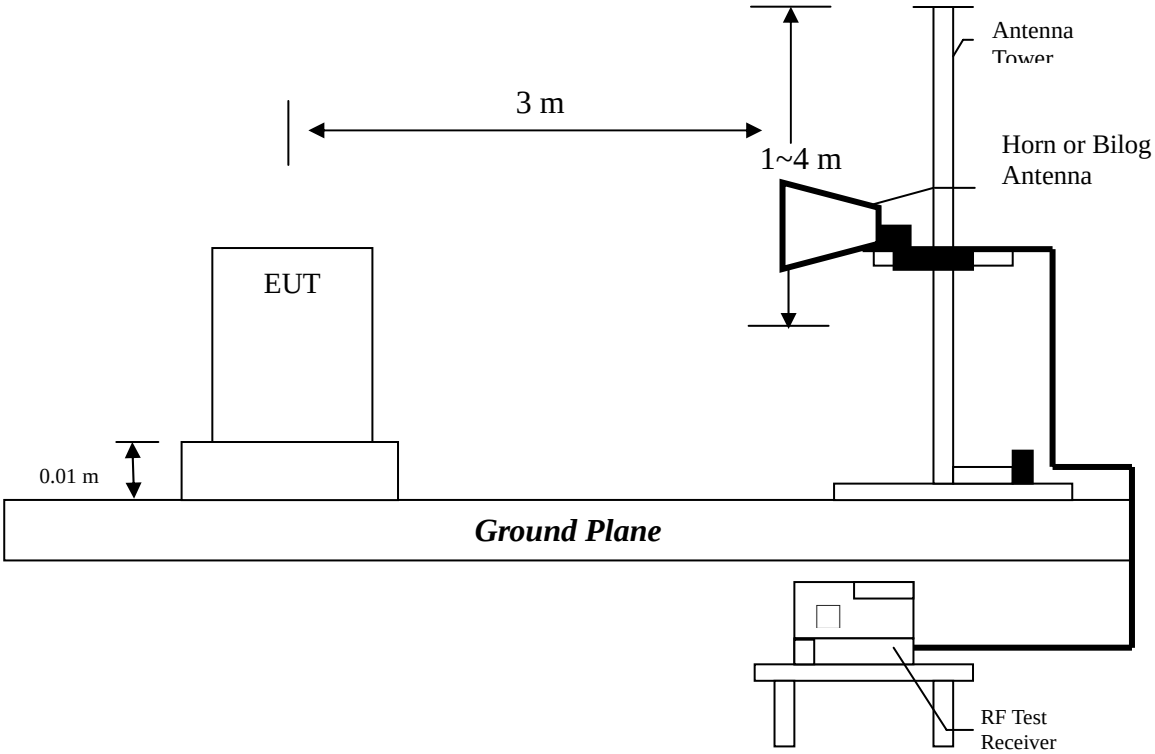
Radiated emission from 9kHz to 30MHz uses Loop Antenna:



Radiated emission from 30MHz to 1GHz uses Bilog Antenna:



Radiated emission above 1GHz uses Horn Antenna:



The signal is maximized through rotation and placement in the three orthogonal axes. According to §15.33(a), the spectrum shall be investigated from the lowest radio frequency signal generated in the device, to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower. Spectrum Analyzer Resolution Bandwidth is 100kHz or greater for frequencies 30MHz to 1GHz, 1MHz – for frequencies above 1GHz.

The EUT for testing is arranged on a 10cm board. If some peripherals apply to the EUT, the peripherals will be connected to EUT and the whole system. During the test, all cables were arranged to produce worst-case emissions. The signal is maximized through rotation. The height of antenna and polarization is changing constantly for exploring for maximum signal level. The height of antenna can be up to 4 meters and down to 1 meter.

The measurement for radiated emission will be done at the distance of three meters unless the signal level is too low to measure at that distance. In the case of the reading under noise floor, a pre-amplifier is used and/or the test is conducted at a closer distance. And then all readings are extrapolated back to the equivalent 3 meter reading using inverse scaling with distance.

The EUT configuration refers to the “Radiated emission test set-up photo.pdf”.

9.3 Emission Limits

The spurious Emission shall test through the 10th harmonic. 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).

Frequency (MHz)	Field Strength (microvolts/meter)
0.009~0.490	2400/F(kHz)
0.490~1.705	2400/F(kHz)
1.705~30	30
30-88	100
88-216	150
216-960	200
Above 960	500

Remark:
1. In the above table, the tighter limit applies at the band edges.
2. Distance refers to the distance in meters between the measuring instrument antenna and the closed point of any part of the device or system

9.4 Radiated Spurious Emission Test Data

9.4.1Measurement results: frequency range from 9 kHz to 30MHz

Frequency (kHz)	Detector	Corrected Factor (dB/m)	Reading (dBuV)	Emission (dBuV)	Limit (dBuV)	Margin (dB)
30	AV	-7.30	32.36	25.06	38.10	-13.04
350	AV	-68.90	34.20	-34.70	16.72	-51.42
710	QP	-35.20	31.39	-3.81	29.54	-33.35
12000	QP	-70.35	31.65	-38.70	29.54	-68.24

9.4.2 Measurement Results: Frequencies Equal to or Less than 1 GHz

The test was performed on EUT under GFSK mode. The worst case occurred at GFSK mode (DH5) Channel 0.

EUT :LK500Ui/Ri/Ei
Worst Case : GFSK mode (DH5) at Channel 0

Antenna Polariz. (V/H)	Freq. (MHz)	Receiver Detector	Corr. Factor (dB/m)	Reading (dBuV)	Corrected Level (dBuV/m)	Limit @ 3 m (dBuV/m)	Margin (dB)
Vertical	87.23	QP	8.50	21.95	30.44	40.00	-9.56
Vertical	175.50	QP	14.96	15.81	30.76	43.50	-12.74
Vertical	221.09	QP	12.08	18.87	30.95	46.00	-15.05
Vertical	242.43	QP	12.22	18.10	30.31	46.00	-15.69
Vertical	288.02	QP	13.70	20.19	33.88	46.00	-12.12
Vertical	374.35	QP	15.06	17.71	32.77	46.00	-13.23
Horizontal	89.17	QP	9.45	19.31	28.75	43.50	-14.75
Horizontal	175.50	QP	13.48	16.05	29.52	43.50	-13.98
Horizontal	198.78	QP	11.27	20.98	32.24	43.50	-11.26
Horizontal	221.09	QP	11.63	19.90	31.52	46.00	-14.48
Horizontal	288.02	QP	13.85	18.88	32.72	46.00	-13.28
Horizontal	331.67	QP	14.40	17.71	32.10	46.00	-13.90

Remark:1. Corr. Factor = Antenna Factor + Cable Loss
2. Corrected Level = Reading + Corr. Factor

9.4.3 Measurement Results: Frequency above 1GHz

EUT : LK500Ui/Ri/Ei
Test Condition : GFSK mode (DH5) at Channel 0

Frequency (MHz)	Spectrum Analyzer Detector	Antenna Polariz. (H/V)	Preamp Gain (dB)	Correction Factor (dB/m)	Reading (dBuV)	Corrected Level (dBuV/m)	Limit @ 3 m (dBuV/m)	Margin (dB)
4804.00	PK	H	39.77	0.16	45.95	46.11	54	-7.89
4804.00	PK	V	39.77	0.16	44.40	44.56	54	-9.44

Remark:
1. Correction Factor = Antenna Factor + Cable Loss– Preamp. Gain
2. The frequency measured ranges from 1GHz to 25GHz.The data value listed above which is higher than the noise floor, the others please refer to noise floor level.

EUT : LK500Ui/Ri/Ei
Test Condition : GFSK mode (DH5) at Channel 39

Frequency (MHz)	Spectrum Analyzer Detector	Antenna Polariz. (H/V)	Preamp Gain (dB)	Correction Factor (dB/m)	Reading (dBuV)	Corrected Level (dBuV/m)	Limit @ 3 m (dBuV/m)	Margin (dB)
4882.00	PK	V	39.86	0.28	45.74	46.02	54	-7.98
4882.00	PK	H	39.86	0.28	47.70	47.98	54	-6.02

Remark:
1. Correction Factor = Antenna Factor + Cable Loss– Preamp. Gain
2. The frequency measured ranges from 1GHz to 25GHz.The data value listed above which is higher than the noise floor, the others please refer to noise floor level.

EUT : LK500Ui/Ri/Ei
Test Condition : GFSK mode (DH5) at Channel 78

Frequency (MHz)	Spectrum Analyzer Detector	Antenna Polariz. (H/V)	Preamp Gain (dB)	Correction Factor (dB/m)	Reading (dBuV)	Corrected Level (dBuV/m)	Limit @ 3 m (dBuV/m)	Margin (dB)
4960.00	PK	V	39.95	0.40	41.43	41.83	54	-12.17
4960.00	PK	H	39.95	0.40	44.37	44.77	54	-9.23

Remark:
1. Correction Factor = Antenna Factor + Cable Loss– Preamp. Gain
2. The frequency measured ranges from 1GHz to 25GHz.The data value listed above which is higher than the noise floor, the others please refer to noise floor level.

10. Emission on the Band Edge §FCC 15.247(d)

Radiated emissions were invested cover the frequency range from 30 MHz to 1000 MHz using a receiver RBW of 120 kHz record QP reading, and the frequency over 1 GHz using a spectrum analyzer RBW of 1 MHz and 10 Hz VBW record Average reading. (15.209 paragraph), the Peak reading (1MHz / 3MHz; RBW / VBW) recorded also on the report.

10.1 Operating Environment

Temperature:	25	℃
Relative Humidity:	50	%
Atmospheric Pressure:	1008	hPa
Test Date:	Oct. 15, 2013	

10.2 Test Setup & Procedure

Please refer to the section 9.2 of this report.

10.3 Test Results

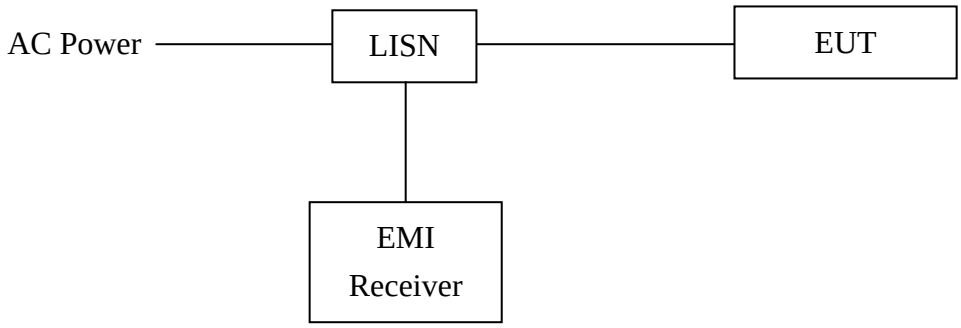
Mode	Restricted Band (MHz)	Freq. (MHz)	Spectrum Analyzer Detector	Ant. Pol. (H/V)	Preamp. Gain (dB)	Correction Factor (dB/m)	Reading (dBuV)	Corrected Level (dBuV/m)	Limit @ 3 m (dBuV/m)	Margin (dB)
GFSK	2310~2390	2338.40	PK	V	38.01	31.60	64.72	58.32	74	-15.68
		2338.40	AV	V	38.01	31.60	52.00	45.60	54	-8.40
	-	2402.00	PK	V	38.02	31.91	93.24	87.12	-	87.12
		2402.00	AV	V	38.02	31.91	83.64	77.52	-	77.52
	-	2480.00	PK	V	38.04	32.28	90.29	84.52	-	84.52
		2480.00	AV	V	38.04	32.28	81.09	75.32	-	75.32
	2483.5~2500	2483.50	PK	V	38.05	32.29	64.17	58.42	74	-15.58
		2483.50	AV	V	38.05	32.29	52.52	46.77	54	-7.23

11. Power Line Conducted Emission Test §FCC 15.207

11.1 Operating Environment

Temperature:	23	℃
Relative Humidity:	52	%
Atmospheric Pressure	1008	hPa
Test Date:	Oct. 15, 2013	

11.2 Test Setup & Procedure



The test procedure was according to ANSI C63.4/2003.

The EUT are connected to the main power through a line impedance stabilization network (LISN). This provides a 50 ohm/50uH coupling impedance for the measuring equipment. The peripheral devices are also connected to the main power through a LISN that provides a 50 ohm/50uH coupling impedance with 50 ohm termination.
Both sides (Line and Neutral) of AC line are checked for maximum conducted interference. In order to find the maximum emission, the relative positions of equipment and all of the interface cables must be changed according to ANSI C63.4/2003 on conducted measurement. The bandwidth of the field strength meter (R & S Test Receiver ESCS 30) is set at 9 kHz.

The EUT configuration refers to the “Conducted set-up photo.pdf”.

11.3 Emission Limit

Freq. (MHz)	Conducted Limit (dBuV)	
	Q.P.	Ave.
0.15~0.50	66 – 56*	56 – 46*
0.50~5.00	56	46
5.00~30.0	60	50

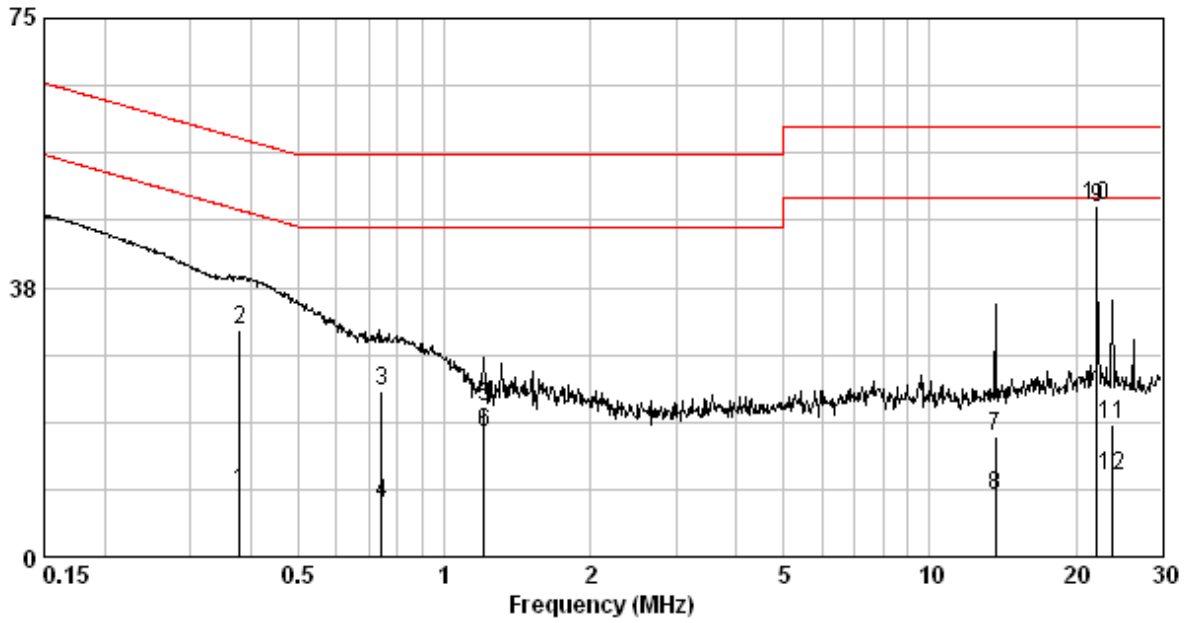
*Decreases with the logarithm of the frequency.

11.4 Power Line Conducted Emission Test Data

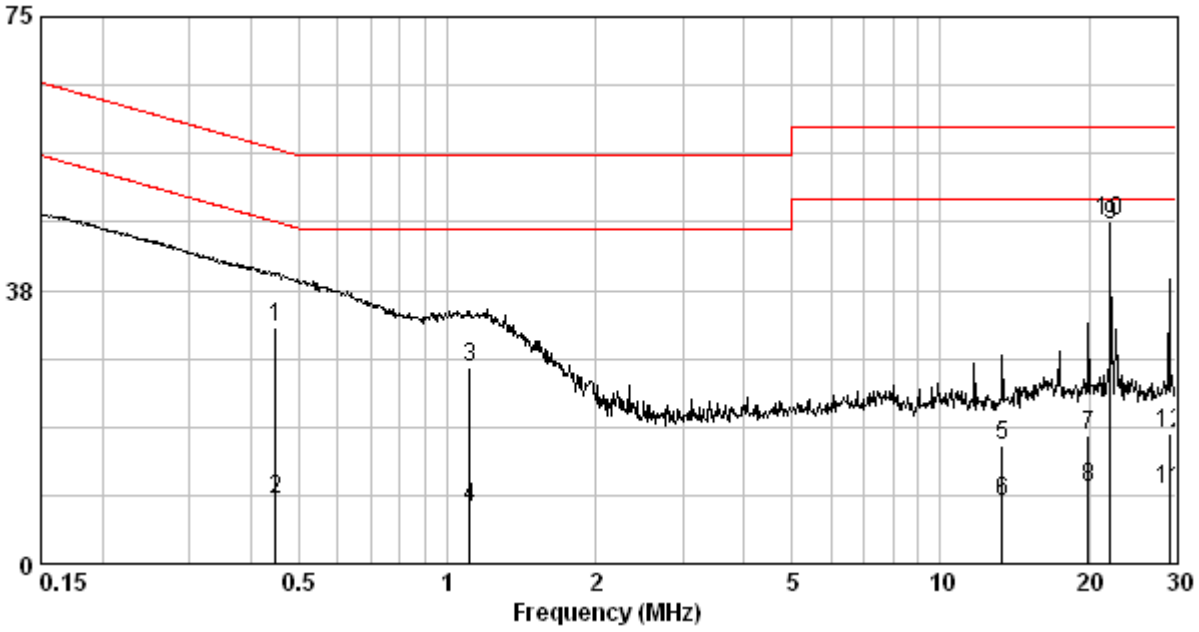
Phase: **Live Line**
Model No.: **LK500Ui**
Test Condition: **TX mode**

Frequency (MHz)	Corr. Factor (dB)	Level Qp (dBuV)	Limit Qp (dBuV)	Level Av (dBuV)	Limit Av (dBuV)	Margin (dB) Qp	Margin (dB) Av
0.379	0.32	31.54	58.30	8.99	48.30	-26.76	-39.31
0.743	0.37	23.11	56.00	7.44	46.00	-32.89	-38.56
1.210	0.44	20.91	56.00	17.32	46.00	-35.09	-28.68
13.623	1.58	16.67	60.00	8.43	50.00	-43.33	-41.57
22.123	2.09	48.78	60.00	48.68	50.00	-11.22	-1.32
23.762	2.20	18.29	60.00	11.29	50.00	-41.71	-38.71

Remark:
1. Corr. Factor (dB) = LISN Factor (dB) + Cable Loss (dB)
2. Over Limit (dB) = Level (dBuV) – Limit (dBuV)



Phase: **Neutral Line**
Model No.: **LK500Ui**
Test Condition: **TX mode**

Frequency (MHz)	Corr. Factor (dB)	Level Qp (dBuV)	Limit Qp (dBuV)	Level Av (dBuV)	Limit Av (dBuV)	Margin (dB) Qp	Margin (dB) Av
0.449	0.33	32.36	56.89	8.81	46.89	-24.53	-38.08
1.111	0.45	26.99	56.00	7.59	46.00	-29.01	-38.41
13.337	1.40	16.23	60.00	8.38	50.00	-43.77	-41.62
19.950	1.65	17.69	60.00	10.47	50.00	-42.31	-39.53
22.122	1.80	46.54	60.00	46.91	50.00	-13.46	-3.09
29.061	2.08	17.91	60.00	10.24	50.00	-42.09	-39.76

Remark:
1. Corr. Factor (dB) = LISN Factor (dB) + Cable Loss (dB)
2. Over Limit (dB) = Level (dBuV) – Limit (dBuV)