LSR a Laird Business
ACCREDITED
TESTING CERT #1255.01
W66 N220 Commerce Court ● Cedarburg, WI 53012 USA ● Phone: 262.375.4400 ● Fax: 262.375.4248 ● www.lsr.com

ENGINEERING TEST REPORT # 316051
LSR Job #: C-2393

Compliance Testing of:

Sterling-LWB

Test Date(s):

March 9th to July 11th, 2016

Prepared For:

Attention: Josh Bablitch
LS Research
W66 N220 Commerce Court
Cedarburg, WI 53012

This Test Report is issued under the Authority of:
Coty Hammerer, EMC Engineer

Signature: Coty Hammerer Date: 7-21-16

Quality Assurance:	**Report by:**
Adam Alger, Quality Systems Engineer	Coty Hammerer, EMC Engineer
Signature: Adam O Alger Date: 7-21-16	Signature: Coty Hammerer Date: 7-21-16

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LS Research, LLC in Review

As an EMC Testing Laboratory, our Accreditation and Assessments are recognized through the following:

TESTING CERT #1255.01

A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025: 2005 with Electrical (EMC) Scope of Accreditation
A2LA Certificate Number: 1255.01

Federal Communications Commission (FCC) – USA

Listing of 3 Meter Semi-Anechoic Chamber based on Title 47 CFR – Part 2.948
FCC Registration Number: 90756

Industrie Canada Industry Canada

Industry Canada

On file, Semi-Anechoic Chamber based on RSS-GEN – Issue 4
File Number: IC 3088A-2
On file, 3 Meter Semi-Anechoic Chamber based on RSS-GEN – Issue 4
File Number: IC 3088A-3

1.0 Summary of Test Report

Between March and June of 2016 the EUT, Sterling-LWB, was tested and MEETS the following ETSI EN 300 328 v1.9.1 requirements:

EN 300 328 Technical Requirement Section	EN 300 328 Technical Requirement Description	EN 300 328 Test Procedure Section Used	Test Repot Section	Note
4.3.1.2 4.3.2.2	RF Output Power	5.3.2	C.1.1 C.2.1	(1,2)
4.3.2.3	Power spectral density	5.3.3	C.2.2	Only for modulations other than FHSS (2)
4.3.1.3 4.3.2.4	Duty Cycle, Tx-Sequence, Tx-gap	5.3.2	N/A (C.1.2, C.2.3)	Only for non-adaptive equipment
4.3.1.4	Accumulated Transmit time, Minimum Frequency Occupation & Hopping Sequence	5.3.4	C.1.3	Only for FHSS Equipment (2)
4.3.1.5	Hopping Frequency Separation	5.3.5	C.1.4	Only for FHSS Equipment (2)
4.3.1.6 4.3.2.5	Medium Utilization	5.3.2	N/A (C.1.5, C.2.4)	Only for non-adaptive equipment
4.3.1.7 4.3.2.6	Adaptivity	5.3.7	C.2.5	Only for adaptive equipment (2)
4.3.1.8 4.3.2.7	Occupied Channel Bandwidth	5.3.8	C.1.7 C.2.6	(2)
4.3.1.9 4.3.2.8	Transmitter unwanted emissions in the OOB domain	5.3.9	C.1.8 C.2.7	(2)
4.3.1.10 4.3.2.9	Transmitter unwanted emissions in the spurious domain	5.3.10	C.1.9 C.2.8	(2,3)
4.3.1.11 4.3.2.10	Receiver spurious emissions	5.3.11	C.1.10 C.2.9	(2,3)
4.3.1.12 4.3.2.11	Receiver blocking	5.3.7	C.2.10	Only for adaptive equipment (2)
4.3.1.13 4.3.2.12	Geo-location capability	N/A	N/A	(4)

Note 0: Gray does not apply to EUT
Note 1: Tested with normal and extreme conditions
Note 2: RF Conducted Measurement
Note 3: Radiated Measurement
Note 4: Manufacturer declares equipment does not have geo-location capability

2.0 Test Facilities

All testing was performed at:

LS Research, LLC
W66 N220 Commerce Court
Cedarburg, Wisconsin, 53012 USA

LS Research, LLC is accredited by A2LA (American Association for Laboratory Accreditation) to the requirements of ISO/IEC 17025, 2005 "General Requirements for the Competence of Calibration and Testing Laboratories".LS Research, LLC's scope of accreditation includes all test methods listed herein, unless otherwise noted.

3.0 Client Information

Manufacturer Name:	LS Research
Address:	W66 N220 Commerce Court, Cedarburg, WI 53012
Contact Person:	Josh Bablitch

3.1 Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	Sterling-LWB
Model Number:	Sterling-LWB
Serial Number:	15, 23, 26, 29, 32, 42, 47

3.2 Product Description

The Sterling-LWB is a multi-standard module with support for WLAN (802.11 b/g/n), and Bluetooth V2.1 and Bluetooth 4.0 & 4.1 with multiple antenna options.

This device has been designed to operate with the antenna listed below, and having a maximum gain of 2.0 dBi. The required antenna impedance is 50 ohms.

Chip Antenna: Johanson Part # 2450AT18D0100 Peak Gain 1.5 dBi

U.FL Antenna port utilizes the following antenna options:

LSR 2.4 GHz Dipole Antenna 2dBi
LSR 2.4 GHz FlexPIFA 2dBi
LSR 2.4 GHz FlexNotch 2dBi

3.3 Modifications Incorporated In the EUT for Compliance Purposes

None noted at time of test

3.4 Deviations & Exclusions from Test Specifications

None noted at time of test

4.0 Conditions of Test

Environmental:

Temperature: 20-25º C
Relative Humidity: 30-60%
Atmospheric Pressure: 86-106 kPa

Supply to EUT: 3.3 VDC, via a bench top power supply.

Extreme Environmental:

Temperature: -40°C to +85°C

5.0 Test Equipment

All test equipment is calibrated by a calibration laboratory accredited to the requirements of ISO 17025. For a complete list of test equipment and calibration dates, see Appendix A. Unless otherwise noted, resolution bandwidth of measuring instrument used during testing for given frequency range, see below.

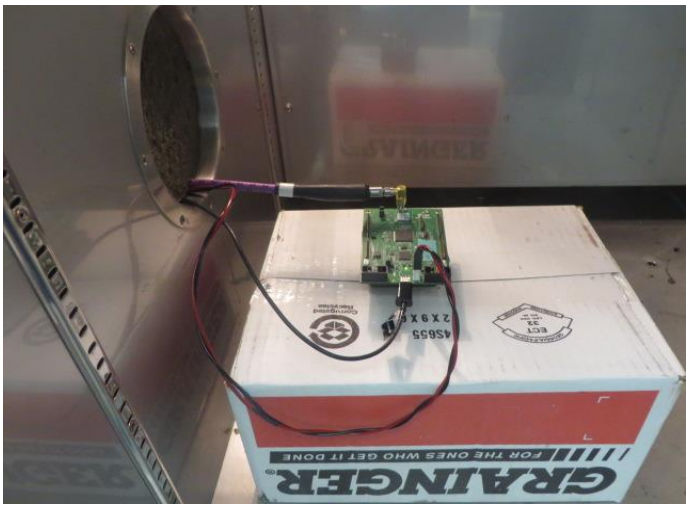
6.0 Conformance Summary

The EUT was found to MEET the requirements as described within the specification of ETSI EN 300 328 v1.9.1.

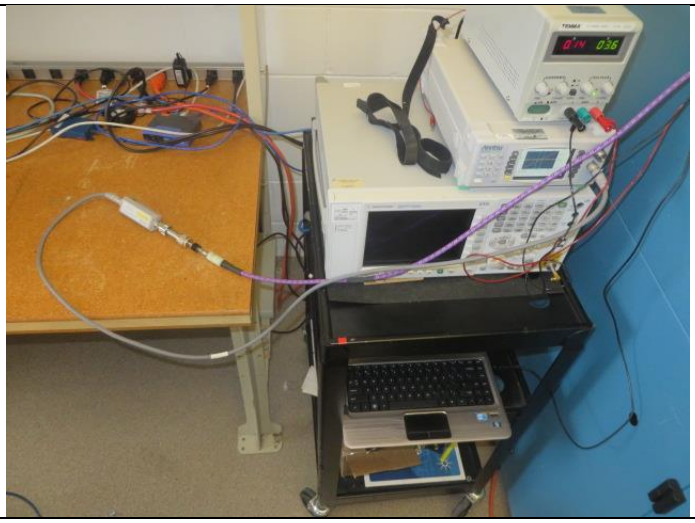
If some emissions are seen to be within 3 dB of their respective limits:
As these levels are within the tolerances of the test equipment and site employed, there is a possibility that this unit, or a similar unit selected out of production may not meet the required limit specification if tested by another agency.

LS Research, LLC certifies that the data contained herein was taken under conditions that meet or exceed the requirements of the test specifications. The results in this Test Report apply only to the item(s) tested on the above-specified dates. Any modifications made to the EUT subsequent to the indicated test date(s) will invalidate the data herein, and void this certification.

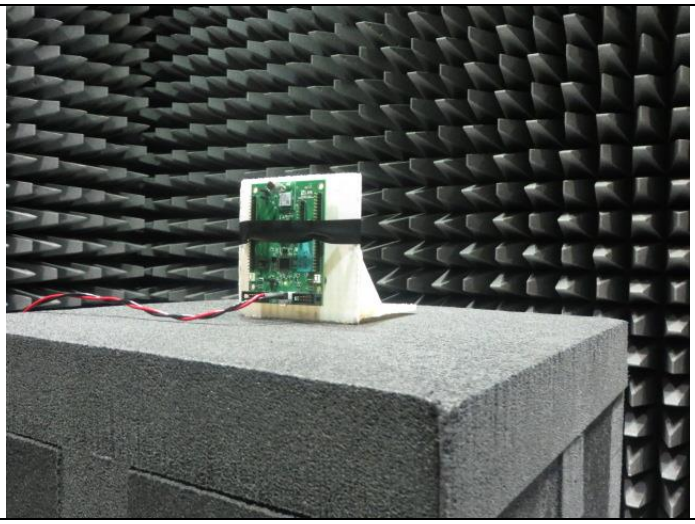
Appendix A – Test Equipment and Setup



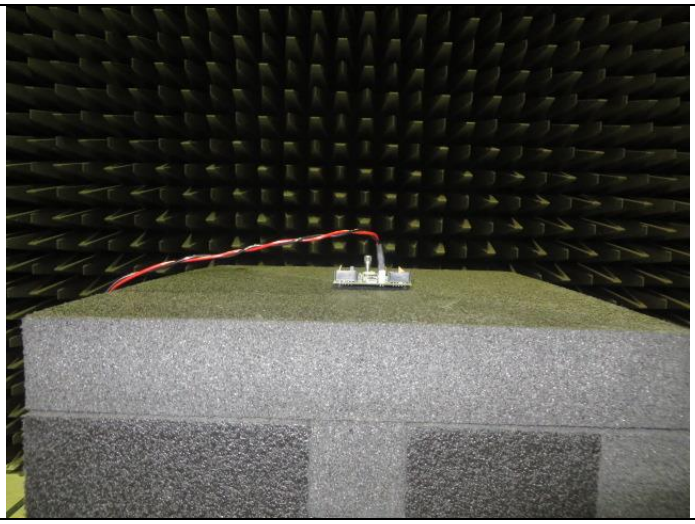
Conducted measurement



Conducted measurement

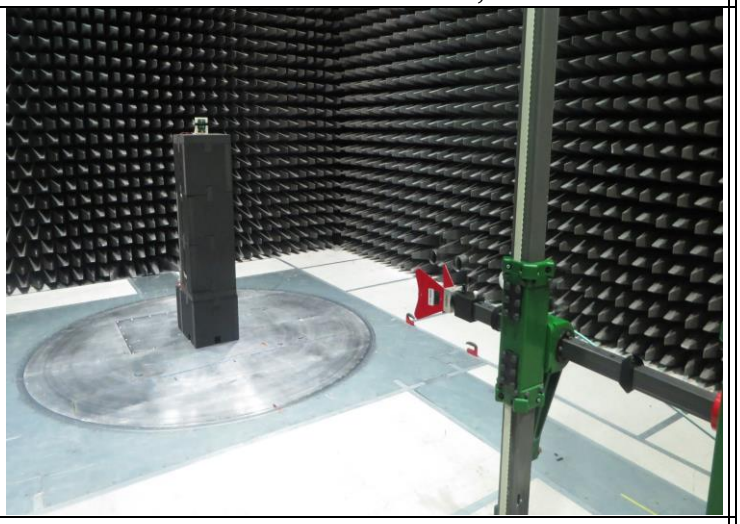


Radiated measurement, vertical



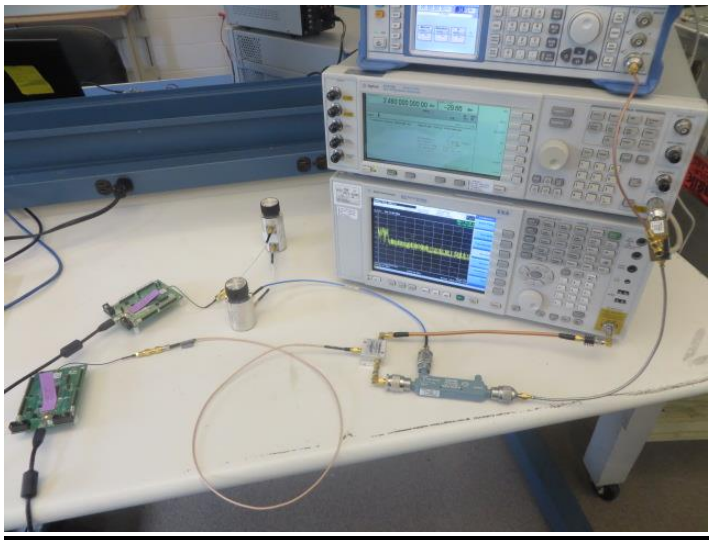
Radiated measurement, Flat

Radiated measurement, side



Radiated measurement

Adaptivity Test setup



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Date : 9-Mar-2016 Type Test : Adaptivity WLAN & Bluetooth Job # : C-2393

Prepared By: Coty Hammerer Customer : LSR Quote #: 316051

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960077	DC Power Supply	GW Instek	GPS-3030DD	EJ810521	Verification	Verification	System
2	EE 960086	40GHz Signal Generator	Rohde & Sch.	SMB100A	1406.600K03	11/18/2015	11/18/2016	Active Calibration
3	CC 000314C	Vector Signal Generator	Agilent	E4438C	US 41469143	4/29/2015	4/29/2017	Active Calibration
4	EE 960092	Directional Coupler 10dB Attenuator 1-12.4GHz	narda	3202B-10	12276	3/2/2016	3/2/2017	Active Calibration
5	EE 960093	Power Splitter/Combiner 1-10 GHz	mini-circuits	ZFSC-2-10G	SF702900616	3/3/2016	3/3/2017	Active Calibration
6	EE 960087	44GHz EXA Spectrum Analyzer	Agilent	N9010A	MY53400296	12/18/2015	12/18/2016	Active Calibration
7	EE 960094	Power Splitter/Combiner 1-10 GHz	mini-circuits	ZFSC-2-10G	SF441900526	3/3/2016	3/3/2017	Active Calibration

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Date : 9-Mar-2016 Type Test : Conducted Measurements Job # : C-2393

Prepared By: Coty Hammerer Customer : LSR Quote #: 316051

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960087	44GHz EXA Spectrum Analyzer	Agilent	N9010A	MY53400296	12/18/2015	12/18/2016	Active Calibration
2	EE 960077	DC Power Supply	GW Instek	GPS-3030DD	EJ810521	Verification	Verification	System
3	EE 960090	Power Meter	Anritsu	ML2495A	1335006	3/25/2015	3/25/2016	Active Calibration
4	EE 960091	Power Sensor (For Power Meter ML2495A (EE	Anritsu	MA2491A	1249277	3/25/2016	3/25/2017	Active Calibration
5	AA 960143	Phaseflex	Gore	EKD01D01048.0	5546519	6/26/2015	6/26/2017	Active Calibration
6	EE 960088	8GHz MXE Spectrum Analyzer	Agilent	N9038A	MY51210138	2/24/2016	2/24/2017	Active Calibration
7	EE 960081	24V/15A DC Power Supply	Tenma	72-7700	1001514	Verification	Verification	System
8	EE 960082	20V/5A DC Power Supply	Tenma	72-8350	G251003005	Verification	Verification	System
9	AA 960144	Phaseflex	Gore	EKD01D010720	5800373	Verification	Verification	System

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Date : 9-Mar-2016 Type Test : Radiated Emissions Radio EMC Job # : C-2393

Prepared By: Coty Hammerer Customer : LSR Quote #: 316051

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960085	N9038A MXE 26.5GHz Receiver	Agilent	N9038A	MY51210148	5/6/2015	5/6/2016	Active Calibration
2	AA 960158	Double Ridge Horn Antenna	ETS Lindgren	3117	109300	2/4/2016	2/4/2017	Active Calibration
3	EE 960159	0.8 - 21GHz LNA	Mini-Circuits	ZVA-213X-S+	40201429	2/4/2016	2/4/2017	Active Calibration
4	AA 960162	EM Series Cable	MegaPhase	EM26-S1S1-120	12024301001	6/30/2015	6/30/2016	Active Calibration
5	AA 960144	Phaseflex	Gore	EKD01D010720	5800373	Verification	Verification	System
6	AA 960005	Biconical Antenna	EMCO	93110B	9601-2280	1/14/2016	1/14/2017	Active Calibration
7	RE 16002	PXA Spectrum Analyzer 26.5 GHz	Keysight	N9030A	MY54490691	2/23/2016	2/23/2017	Active Calibration
8	EE 960085	N9038A MXE 26.5GHz Receiver	Agilent	N9038A	MY51210148	5/6/2015	5/6/2016	Active Calibration
9	AA 960153	2.4GHz High Pass Filter	K/M	HPF-L-14186	7272-04	4/15/2015	4/15/2016	Active Calibration
10	AA 960162	EM Series Cable	MegaPhase	EM26-S1S1-120	12024301001	6/30/2015	6/30/2016	Active Calibration
11	EE 960077	DC Power Supply	GW Instek	GPS-3030DD	EJ810521	Verification	Verification	System
12	AA 960078	Log Periodic Antenna	EMCO	93146	9701-4855	2/17/2016	2/17/2017	Active Calibration
13	AA 960150	Biconical Antenna	ETS	3110B	0003-3346	2/1/2016	2/1/2017	Active Calibration
14	EE 960081	24V/15A DC Power Supply	Tenma	72-7700	1001514	Verification	Verification	System

Appendix B – General Description of Measurement

B.1 – RF Conducted measurements

Test Location	LS Research, LLC
Standard	ETSI EN 300 328 v1.9.1
Section	Appendix C
General Description of Measurement	A direct measurement of the transmitted signal was performed at the antenna port of the EUT via a cable connection to a spectrum analyzer. An attenuator was placed in series with the cable to protect the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings there by allowing direct measurements, without the need for any further corrections. The EUT was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source.

B.2 – Radiated Emissions

Standard	ETSI EN 300 328 v1.9.1			
Section	Annex B and Annex C			
Test Location	LS Research, LLC - FCC Listed 3 meter Semi-Anechoic Chamber			
Test Distance	3 meter			
EUT Placement	150 cm height non-conductive table above reference ground plane			
Frequency Range of Measurement	Biconical: 30-200 MHz	Log Periodic Dipole Array: 200-1000 MHz	Double-Ridged Waveguide Horn: 1-18 GHz	
Description of Radiated Measurement	1) The antenna, cable, pre-amp, and other necessary measurement system correction factors are loaded onto the EMI receiver / spectrum analyzer when the measurements are performed. The data is gathered and reported as the corrected values. 2) The EUT is placed on a non-conductive pedestal centered on a turn-table in the test location with the antenna at the test distance from the EUT 3) Maximum radiated RF emissions are determined by rotation of azimuth and scanning the sense antenna between 1 and 4 meters in height using both horizontal and vertical antenna polarities. Maximized levels are manually noted at degree values of azimuth and at sense antenna height.			
Description of Substitution Measurement	1) The EUT is replaced by an antenna of known gain connected to a calibrated signal source. 2) The antenna is oriented in the polarization of the receive antenna. 3) The frequency if the signal generator is adjusted to the measurement frequency. 4) The test antenna is raised and lowered to ensure maximum signal is received. 5) The input signal to the substitution antenna is adjusted in level until an equal or known related level to that detected from the transmitter is obtained in the test receiver. Or the equation EIRP [dBm] = E [dBµV/m] +20*log(D[meters]) - 104.77 was utilized.			
Example Calculations	Reported Measurement data = Raw receiver measurement + Antenna Correction Factor + Cable factor (dB) - amplification factor (when applicable) + Additional factor (when applicable)			

Appendix C – Test Data

C.1 – Frequency Hopping Equipment

C.1.1 – RF Output Power

Manufacturer	LS Research
Date	May 23rd to June 3rd 2016
Operator	Coty Hammerer
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.1.2 – Limit: e.i.r.p 20 dBm
Test Procedure Section	5.3.2 – Conducted measurement (power meter)
Additional Notes	1. Nominal and Extreme temperature Conditions 2. Manufacturer declared antenna gain + 2.0 dBi 3. Device in hopping mode

Measured Output Power

Bluetooth								
Temp (°C)	Channel (MHz)	Rate	A	G	Y	P	Limit (dBm)	Margin (dBm)
85	Hopping	GFSK	7.16	2.0	0.0	9.2	20.0	10.8
85	Hopping	EDR2	3.00	2.0	0.0	5.0	20.0	15.0
85	Hopping	EDR3	3.00	2.0	0.0	5.0	20.0	15.0

Temp (°C)	Channel (MHz)	Rate	A	G	Y	P	Limit (dBm)	Margin (dBm)
-40	Hopping	GFSK	8.93	2.0	0.0	10.9	20.0	9.1
-40	Hopping	EDR2	7.36	2.0	0.0	9.4	20.0	10.6
-40	Hopping	EDR3	7.18	2.0	0.0	9.2	20.0	10.8

Temp (°C)	Channel (MHz)	Rate	A	G	Y	P	Limit (dBm)	Margin (dBm)
22.2	Hopping	GFSK	7.68	2.0	0.0	9.7	20.0	10.3
22.2	Hopping	EDR2	3.01	2.0	0.0	5.0	20.0	15.0
22.2	Hopping	EDR3	3.04	2.0	0.0	5.0	20.0	15.0

RF Output Power Calculation:

P = A + G

P: Output Power EIRP
A: Measured Output Power (dbm)
G: Stated antenna gain (dBi)
Y: Beamforming gain (dB)

Maximum RF Output Power EIRP:
P = 8.93 + 2.0 = 10.93 dBm EIRP

C.1.2 – Duty Cycle, Tx-sequence, Tx-gap

Manufacturer	LS Research
Date	N/A
Operator	N/A
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.1.3
Test Procedure Section	5.3.2.2.1.3
Additional Notes	Only applicable to non-adaptive equipment with EIRP greater than 10 dBm

C.1.3 – Accumulated Transmit time, Frequency Occupation and Hopping Sequence

Manufacturer	LS Research
Date	5-25-16
Operator	Coty Hammerer
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.1.4 – Adaptive frequency hopping systems
Test Procedure Section	5.3.4.2 – Conducted measurement (spectrum analyzer)
Additional Notes	1.Device in hopping mode

Requirement: The maximum accumulated dwell time on any hopping frequency shall be 400 ms within any period of 400 ms multiplied by the minimum number of hopping frequencies (N) that have to be used.

400 ms * (20 minimum channels) = 8 seconds

14.4 ms accumulated dwell time in 1s second (shown in plot below) * 8 = 115.2 ms < 400 ms

Requirement: The hopping sequence(s) shall contain at least N hopping frequencies at all times, where N is 15 or 15 divided by the minimum Hopping Frequency Separation in MHz, whichever is greater.

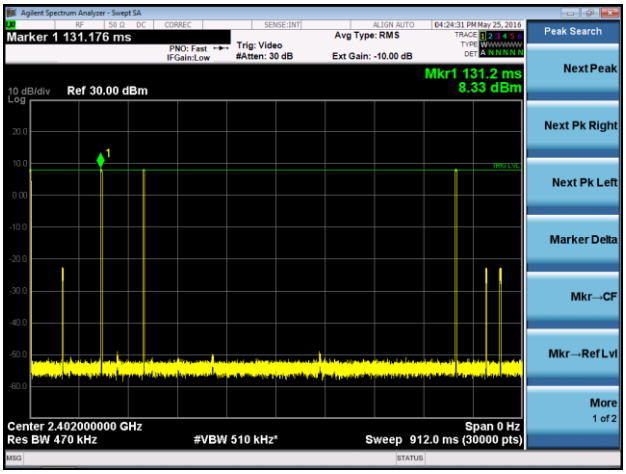
Device is IEEE defined Bluetooth using a minimum of 20 channels.

Note: The maximum dwell time above was seen in the GFSK mode

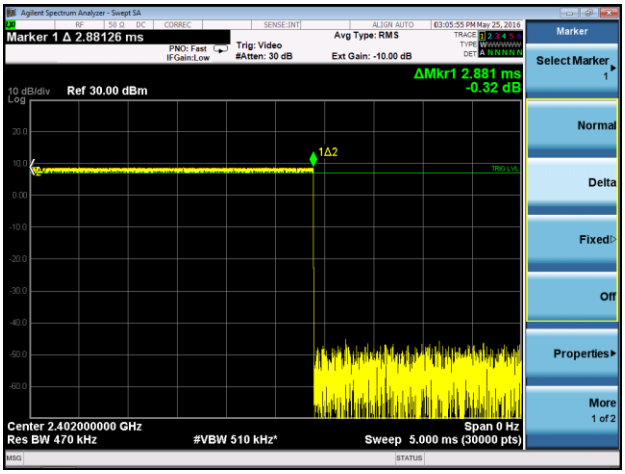
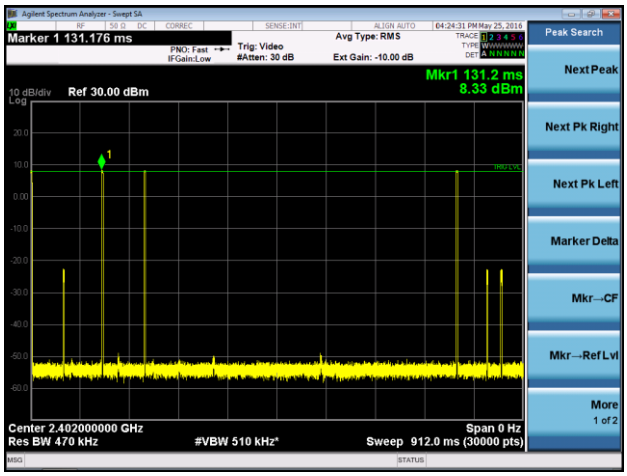
Requirement: The Minimum Frequency Occupation Time shall be equal to one dwell time within a period not exceeding four times the product of the dwell time per hop and the number of hopping frequencies in use.

(2.884 ms dwell time per hop * 79 hopping frequencies in use) *4 = 911.34 ms

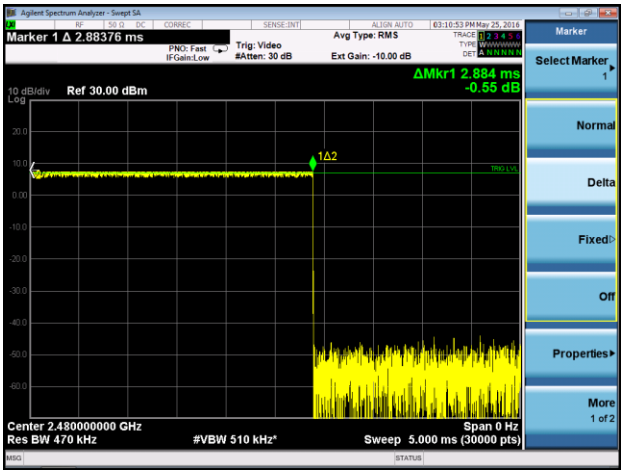
Device uses frequency several times in that period as seen is plot below



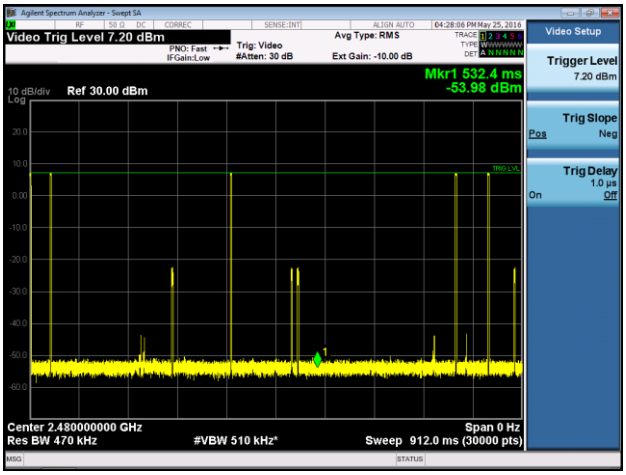
Low Channel

	
Dwell Time = 2.881 ms < 400 ms per hop	11.5 ms accumulated dwell time in 0.912 seconds

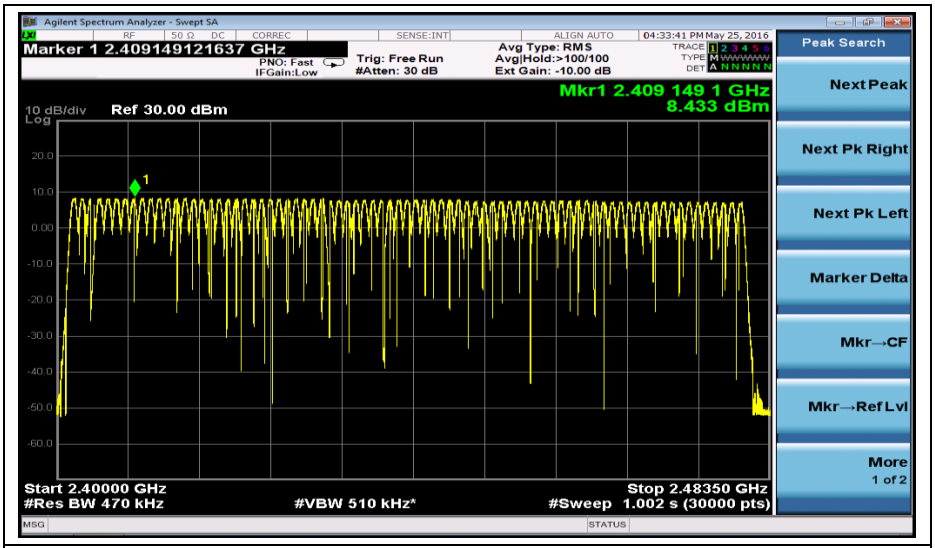
High Channel



Dwell Time = 2.884 ms < 400 ms per hop



14.4 ms accumulated dwell time in 0.912 seconds

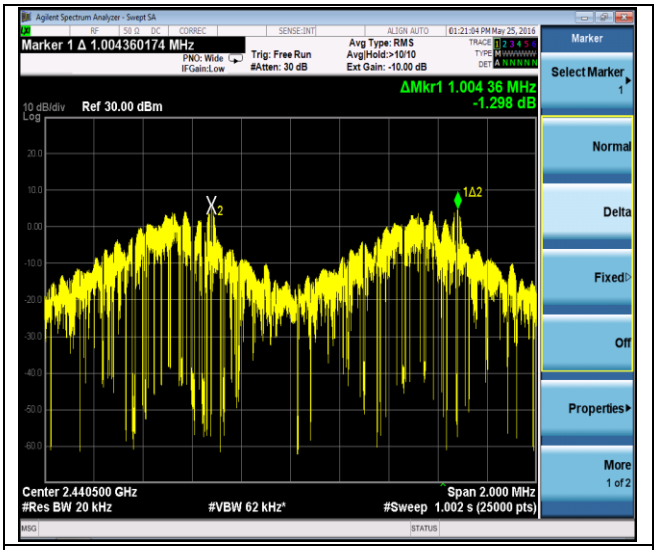


79 channels

Total channels = 79 channels > 70%

C.1.4 – Hopping Frequency Separation

Manufacturer	LS Research
Date	5-25-16
Operator	Coty Hammerer
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.1.5 – Adaptive frequency hopping systems: 100 kHz
Test Procedure Section	5.3.5 – Conducted measurement
Additional Notes	Adaptive Frequency Hopping equipment



Hopping Separation = 1.004 MHz

C.1.5 – Medium Utilisation (MU) Factor

Manufacturer	N/A
Date	N/A
Operator	N/A
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.8.1
Technical Requirement Section	4.3.1.6
Test Procedure Section	5.3.2.2.1.4
Additional Notes	Only applicable to non-adaptive equipment with EIRP greater than 10 dBm

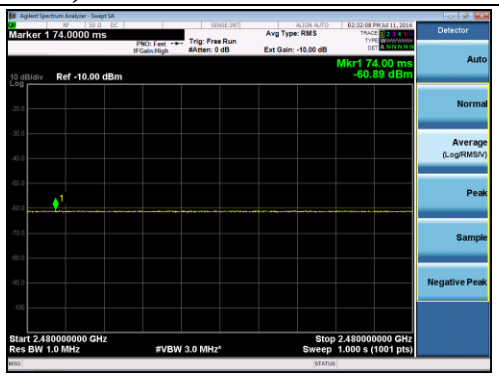
C.1.6 – Adaptivity (Adaptive Frequency Hopping)

Manufacturer	LS Research
Date	6/10/16 – 7/11/16
Operator	Michael Hintzke, Coty Hammerer
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.1.7
Test Procedure Section	5.3.7
Additional Notes	N/A

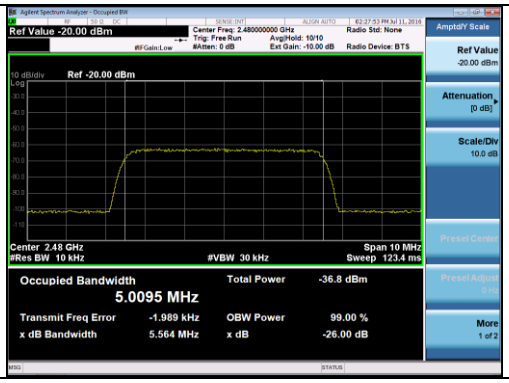
Threshold level for compliance (TL) = -70 dBm/MHz + 20 – Pout e.i.r.p (dBm)

TL = -70 +20 – (10.9) = **- 60.9 dBm / MHz**

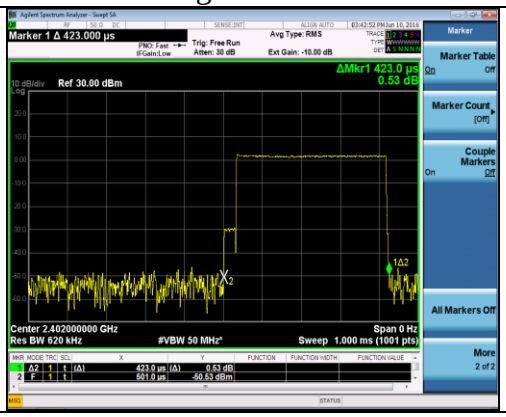
Interference threshold as presented to input of UUT:
(Signal generator 1 level ~ -43.0 dBm with AWGN signal resulting in a level of -60.9 dBm / MHz at input of UUT)



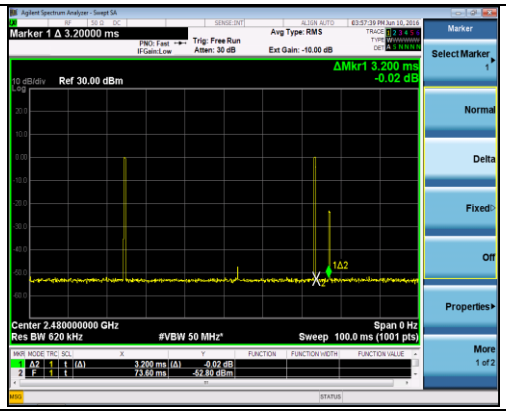
High Channel



99% BW



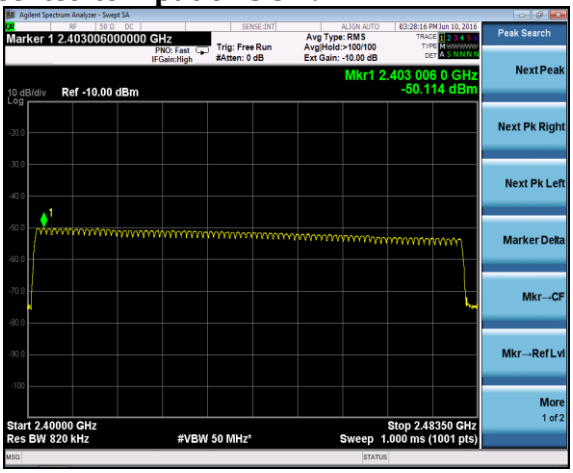
Channel Occupancy



Idle Period

Note: Only High Channel shown.

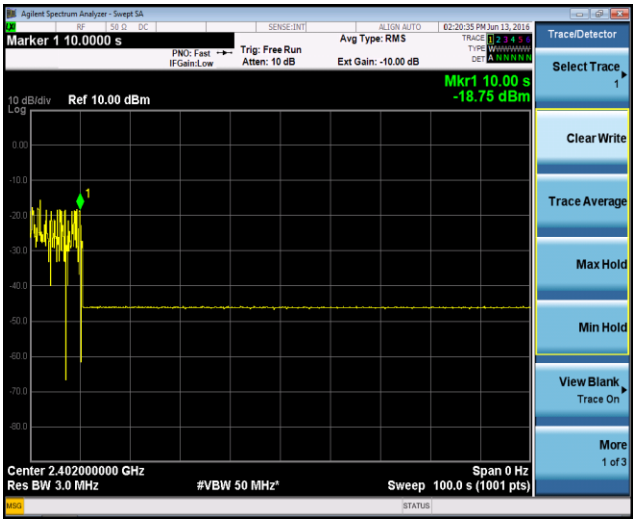
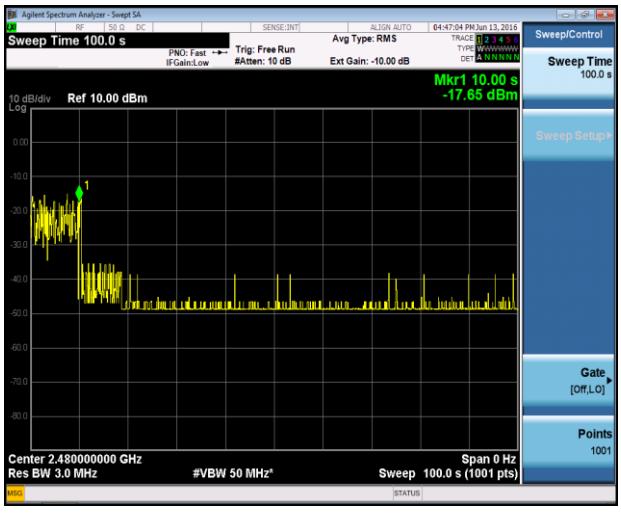
Level of companion as presented to input of UUT:



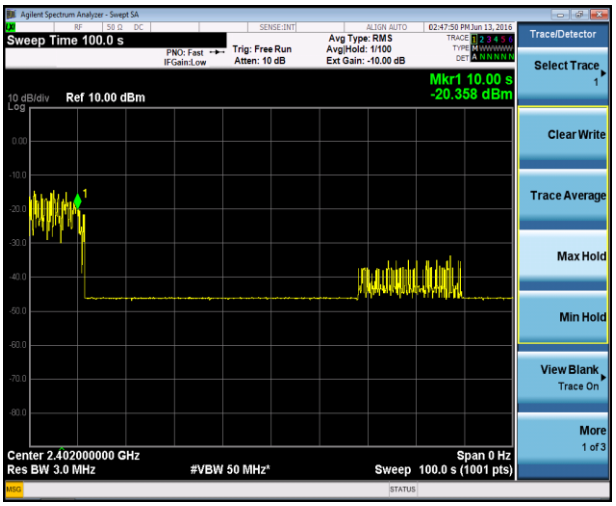
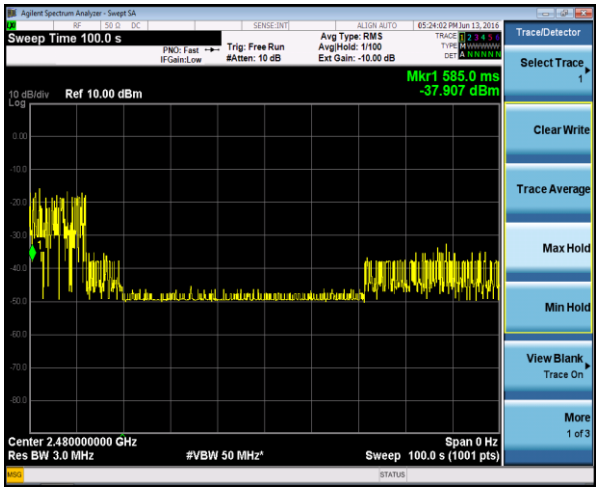
Level of blocking signal as presented to input of UUT:
(Signal generator 2 level = -27.10 dBm CW with loss through measurement system resulting in a level of ~ -35.0 dBm at input of UUT which is per standard; table 6).

	
Low Channel	High Channel

Interference added:
-Normal traffic for 10 seconds
-Signal generator 1 (AWGN) added 10.0 second into sweep
-No subsequent transmissions on channel
-Plot shows short control and signaling transmissions that are reduced in amplitude

	
Low Channel	High Channel

Blocking added:
-AWGN signal still present
-Signal generator 2 (CW) added 10.0 second into sweep

	
Low Channel	High Channel

C.1.7 – Occupied Channel Bandwidth

Manufacturer	LS Research
Date	5/23/16
Operator	Coty Hammerer
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.1.8
Test Procedure Section	5.3.8 – Conducted measurement
Additional Notes	Hopping mode disabled (single channel continuous transmit)

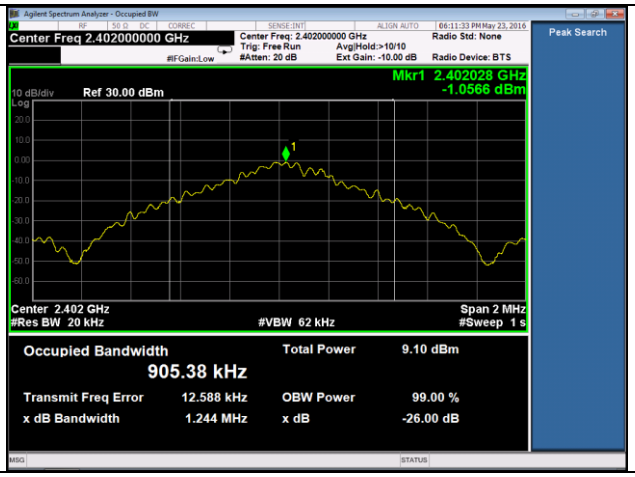
Table

GFSK		
Temp (°C)	Channel (MHz)	99% BW(MHz)
22.8	2402.0	0.91
	2480.0	0.91

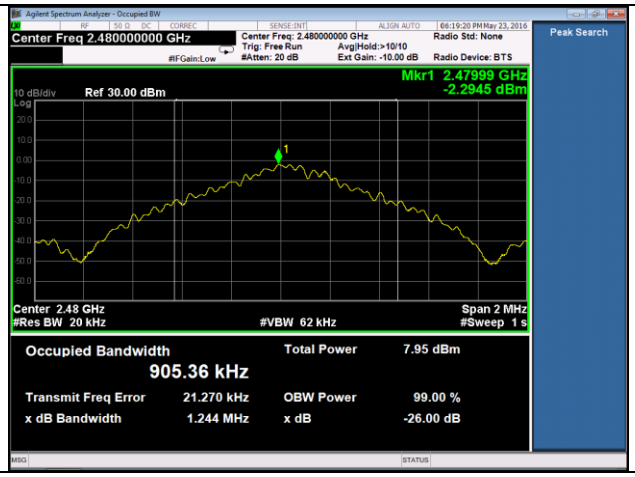
EDR2		
Temp (°C)	Channel (MHz)	99% BW(MHz)
22.8	2402.0	1.22
	2480.0	1.22

EDR3		
Temp (°C)	Channel (MHz)	99% BW(MHz)
22.8	2402.0	1.23
	2480.0	1.23

GFSK

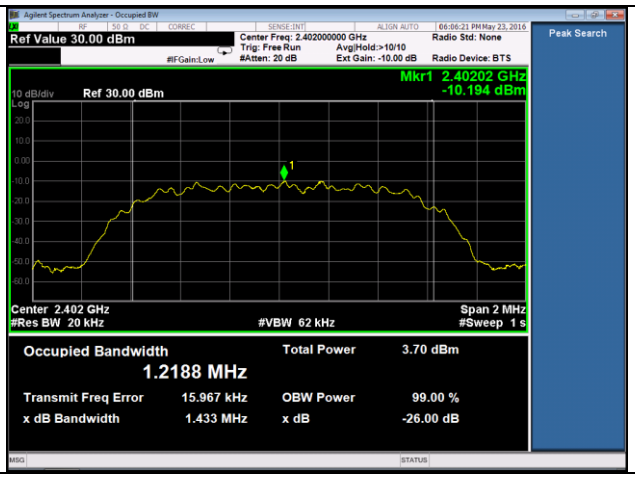


Low channel

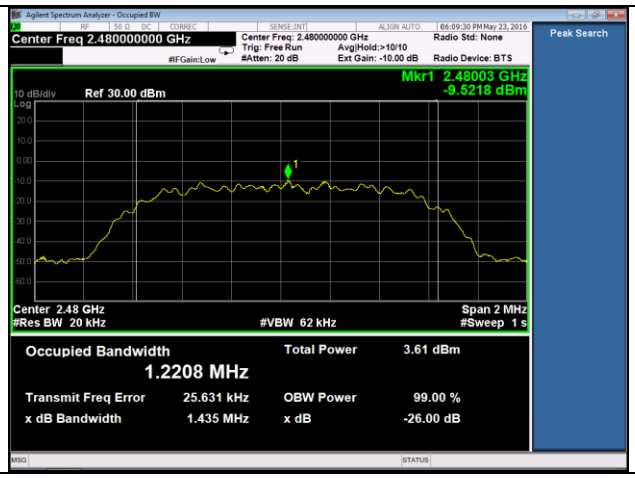


High channel

EDR2

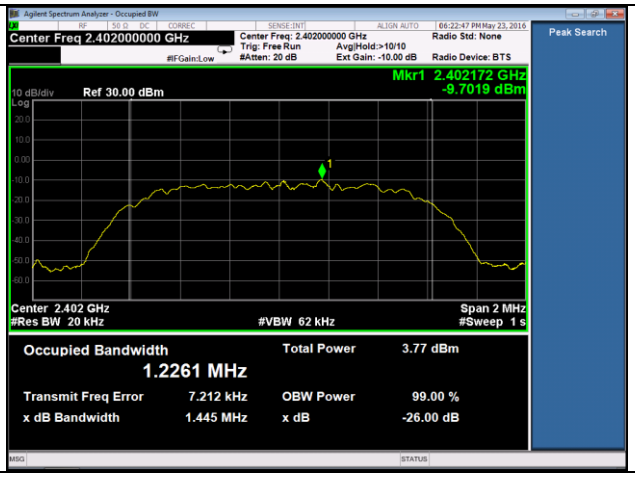


Low channel

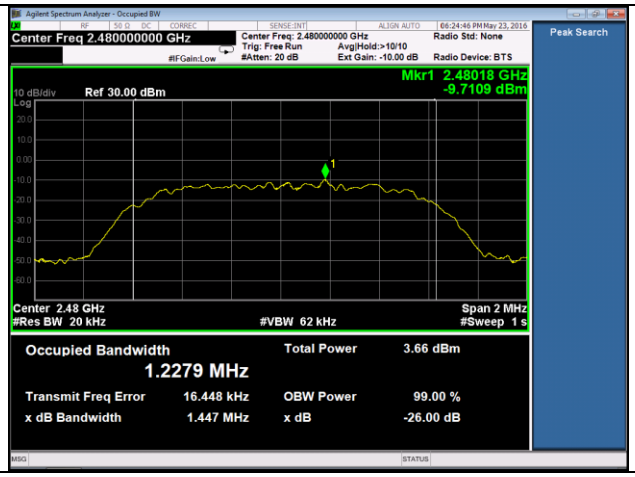


High channel

EDR3



Low channel



High channel

C.1.8 – Transmitter unwanted emissions in the out-of-band domain

Manufacturer	LS Research
Date	5/24/16
Operator	Coty Hammerer
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.1.9
Test Procedure Section	5.3.9 – Conducted measurement
Additional Notes	1. Hopping mode 2. Normal conditions 3. Used ACP function of spectrum analyzer.

Normal temperature:

GFSK											
Temp (°C)	Channel (MHz)	Mask1 power (dBm)	Antenna Gain (dBi)	Corrected Mask1 power (dBm)	Mask1 Limit (dBm)	Mask1 Margin (dBm)	Mask2 power (dBm)	Antenna Gain (dBi)	Corrected Mask2 power (dBm)	Mask2 Limit (dBm)	Mask2 Margin (dBm)
22.7	2402.0	-43.1	2.0	-41.1	-10.0	31.1	-46.3	2.0	-46.1	-20.0	26.1
	2480.0	-46.3	2.0	-44.3	-10.0	34.3	-46.4	2.0	-46.2	-20.0	26.2

EDR2											
Temp (°C)	Channel (MHz)	Mask1 power (dBm)	Antenna Gain (dBi)	Corrected Mask1 power (dBm)	Mask1 Limit (dBm)	Mask1 Margin (dBm)	Mask2 power (dBm)	Antenna Gain (dBi)	Corrected Mask2 power (dBm)	Mask2 Limit (dBm)	Mask2 Margin (dBm)
22.7	2402.0	-40.9	2.0	-38.9	-10.0	28.9	-45.0	2.0	-43.0	-20.0	23.0
	2480.0	-45.7	2.0	-43.7	-10.0	33.7	-45.0	2.0	-43.0	-20.0	23.0

EDR3											
Temp (°C)	Channel (MHz)	Mask1 power (dBm)	Antenna Gain (dBi)	Corrected Mask1 power (dBm)	Mask1 Limit (dBm)	Mask1 Margin (dBm)	Mask2 power (dBm)	Antenna Gain (dBi)	Corrected Mask2 power (dBm)	Mask2 Limit (dBm)	Mask2 Margin (dBm)
22.7	2402.0	-40.8	2.0	-38.8	-10.0	28.8	-44.8	2.0	-42.8	-20.0	22.8
	2480.0	-45.6	2.0	-43.6	-10.0	33.6	-44.8	2.0	-42.8	-20.0	22.8

Normal Conditions

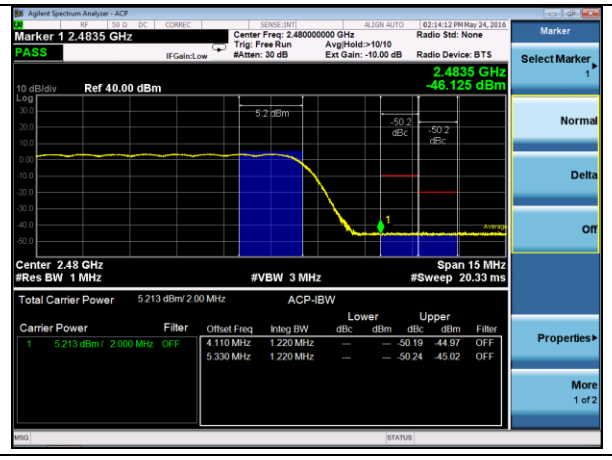
GFSK

Lower band-edge

Upper band-edge

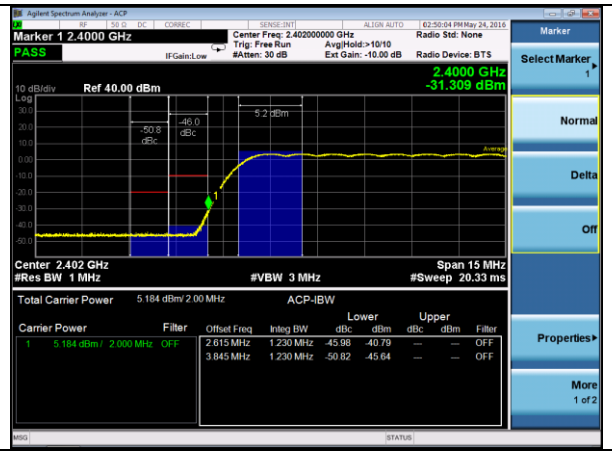
EDR 2

Lower band-edge



Upper band-edge

EDR 3



Lower band-edge

Upper band-edge

C.1.9 – Transmitter unwanted emissions in the spurious domain

Manufacturer	LS Research
Date	March 9th – May 27th, 2016
Operator	Coty Hammerer, Kimberly Bay
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.1.10
Test Procedure Section	5.3.10 –Radiated and Conducted Measurements
Additional Notes	1. Three orthogonal positions of device measured radiated. 2. Final measurements used test procedure.

Radiated Measurements

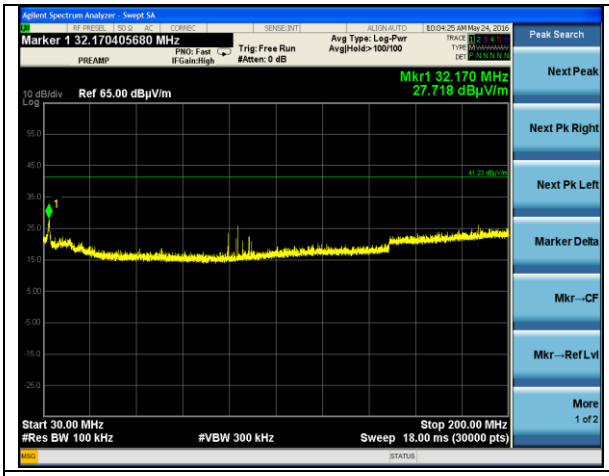
Note: Highest Emissions measured are reflected in the below plots, Low and High Channel plots and measurements were recorded.

Chip Antenna

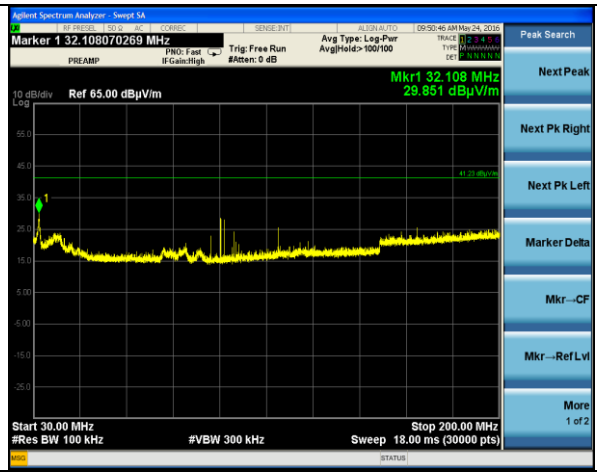
A. 30 MHz to 1000 MHz

Note: Emissions seen within this range were determined not to be a function of the radio.

30 to 200 MHz

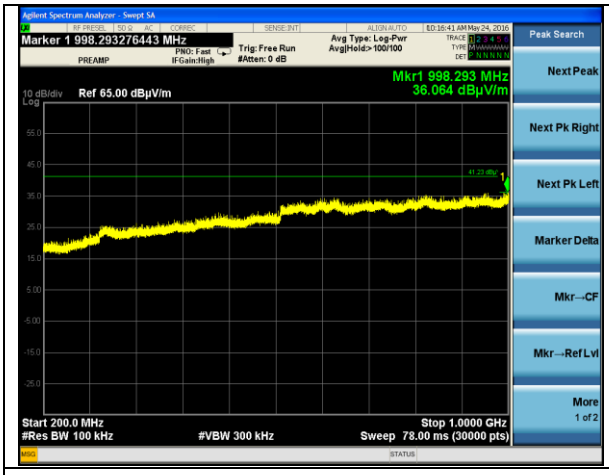


Horizontal

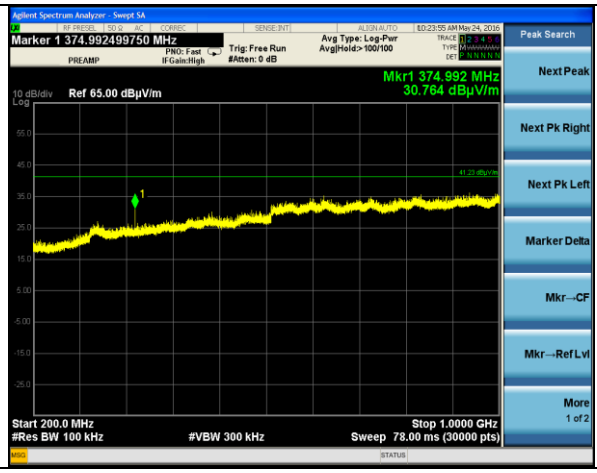


Vertical

200 to 1000 MHz



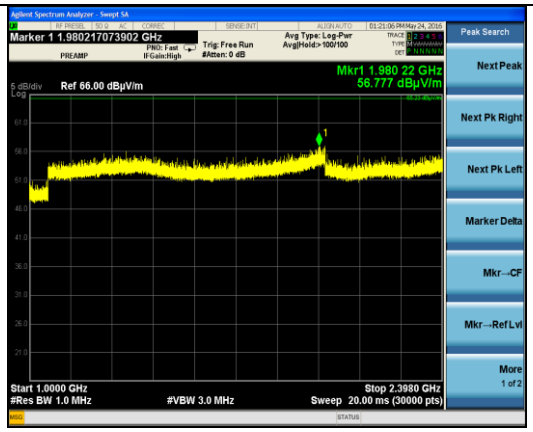
Horizontal



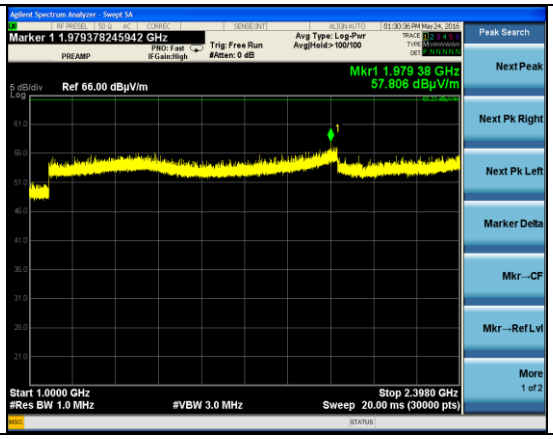
Vertical

B. 1000 MHz to 12750 MHz

1000 to 2398 MHz

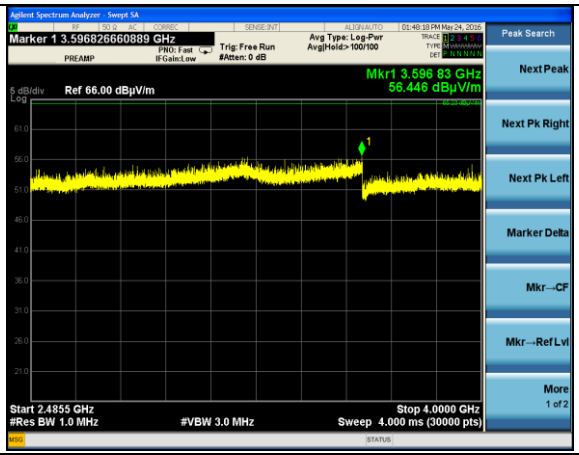


Horizontal

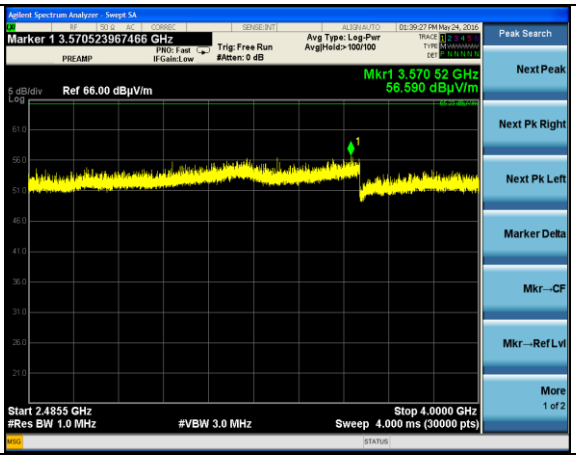


Vertical

2485.5 to 4000 MHz

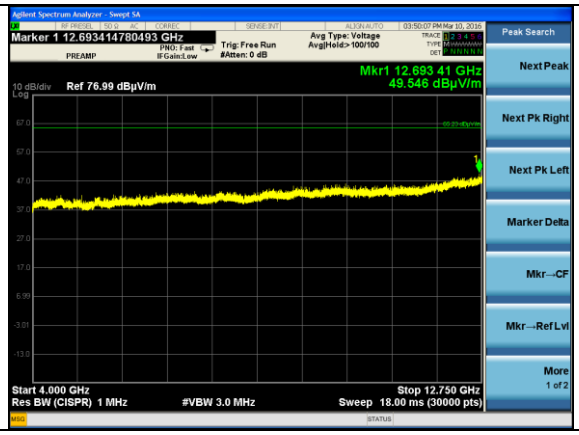


Horizontal

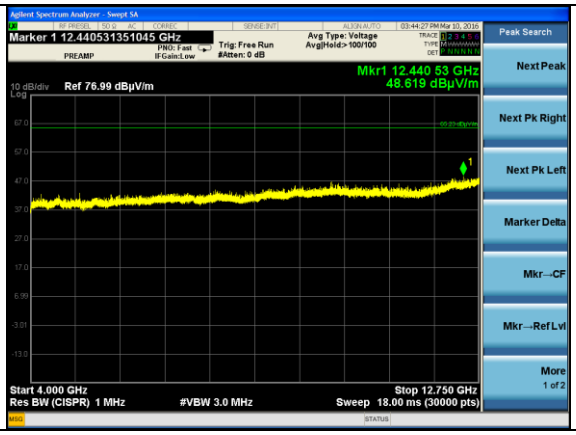


Vertical

4000 to 12750 MHz



Horizontal



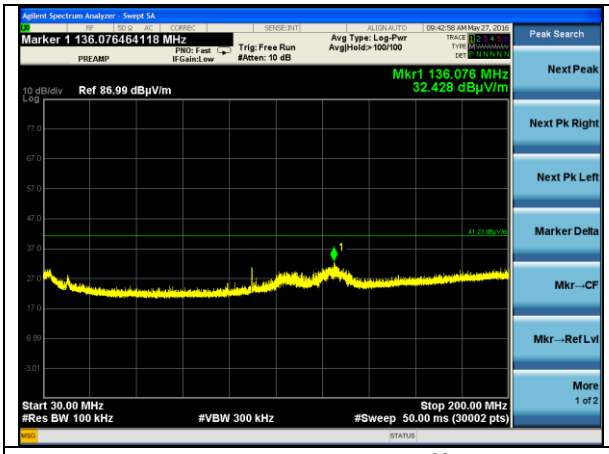
Vertical

Antenna Port Terminated

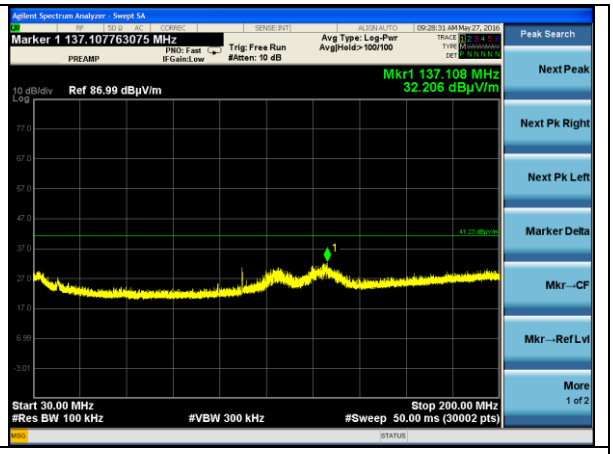
C. 30 MHz to 1000 MHz

Note: Emissions seen within this range was determined not to be a function of the radio.

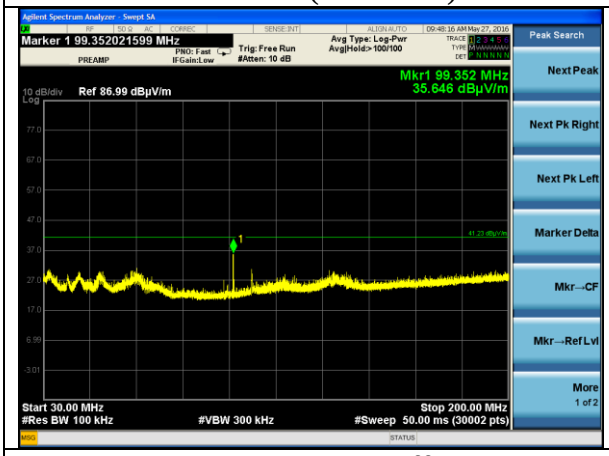
30 to 200 MHz



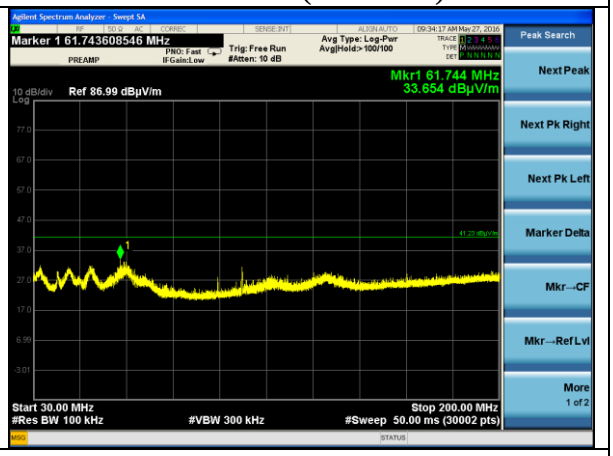
Horizontal (Radio Off)



Horizontal (Radio On)

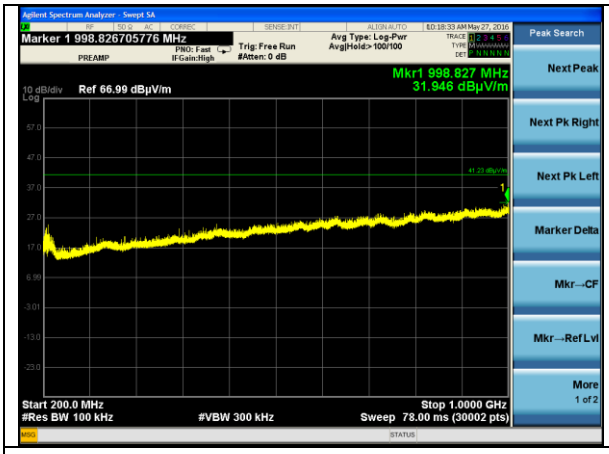


Vertical (Radio Off)



Vertical (Radio On)

200 to 1000 MHz

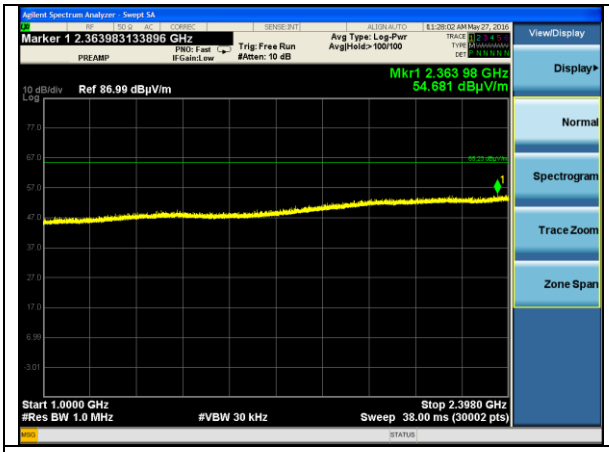


Horizontal

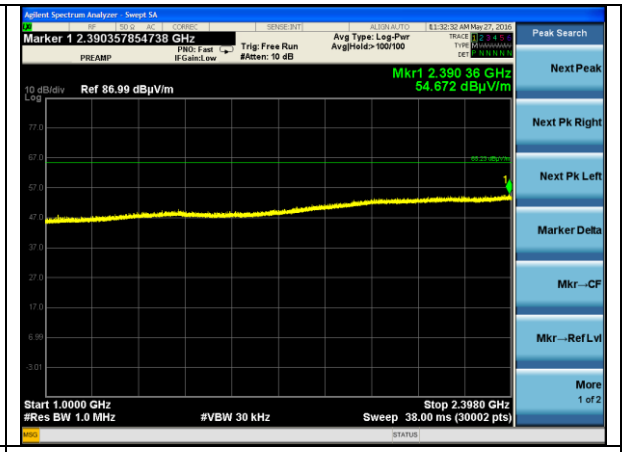
Vertical

D. 1000 MHz to 12750 MHz

1000 to 2398 MHz



Horizontal (Reduced VBW)



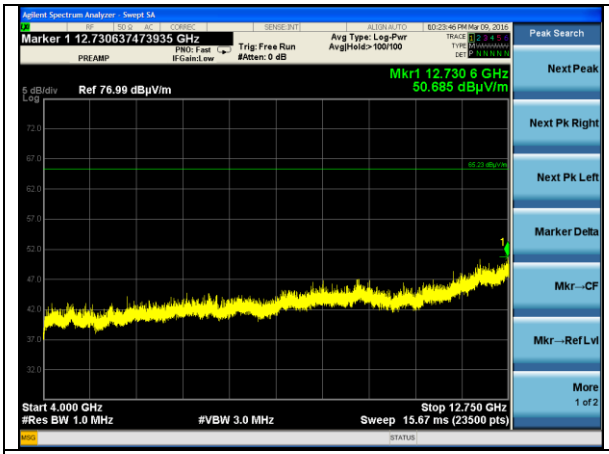
Vertical (Reduced VBW)

2485.5 to 4000 MHz

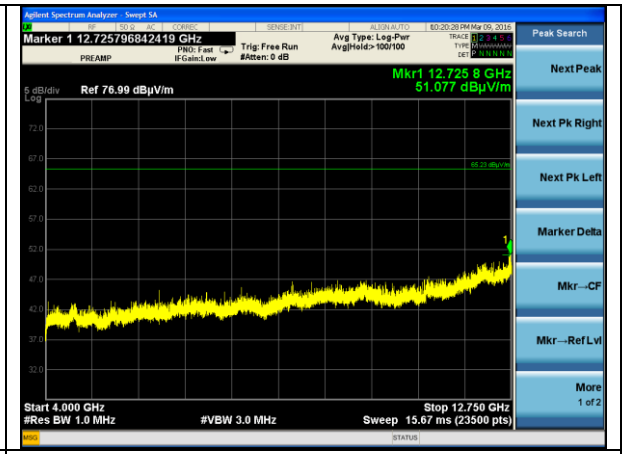
Horizontal (Reduced VBW)

Vertical (Reduced VBW)

4000 to 12750 MHz



Horizontal

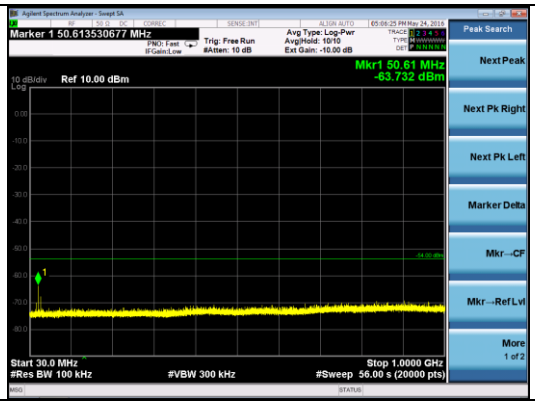


Vertical

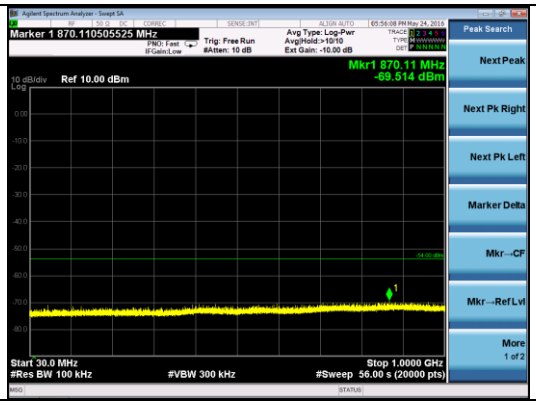
Conducted Measurements

Note: GFSK mode showed highest emissions and is displayed below:

30 to 1000 MHz

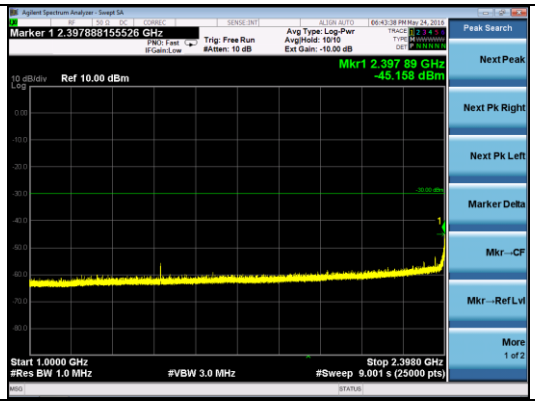


Low Channel (2402 MHz)

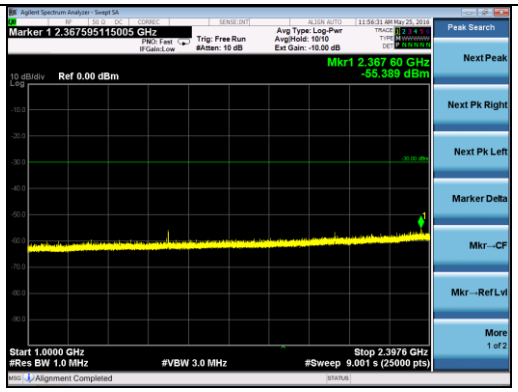


High Channel (2480 MHz)

1000 to 2398 MHz

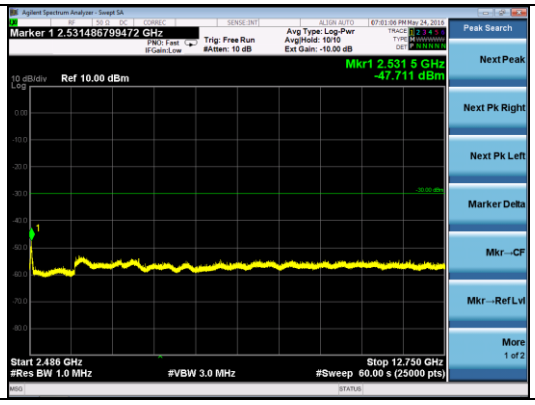


Low Channel (2402 MHz)

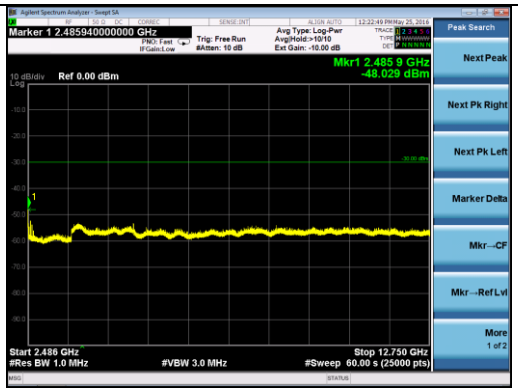


High Channel (2480 MHz)

2486 to 12750 MHz



Low Channel (2402 MHz)



High Channel (2480 MHz)

C.1.10 – Receiver spurious emissions

Manufacturer	LS Research
Date	March 9th – May 27th, 2016
Operator	Coty Hammerer, Kimberly Bay, John Johnston
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.1.11
Test Procedure Section	5.3.11 - Conducted and Radiated Measurements
Additional Notes	1. Three orthogonal positions of device measured radiated. 2. Final measurements used test procedure.

Radiated Emissions

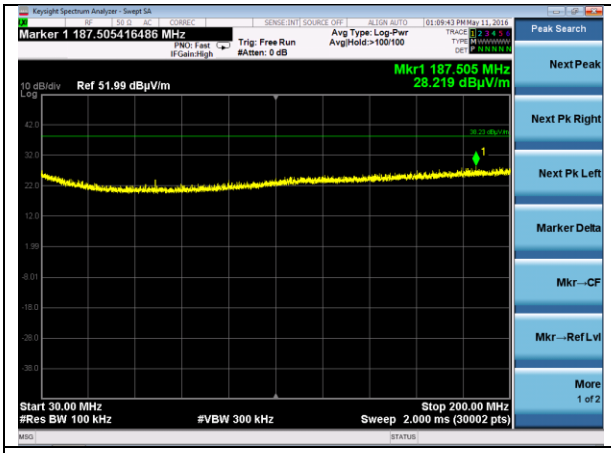
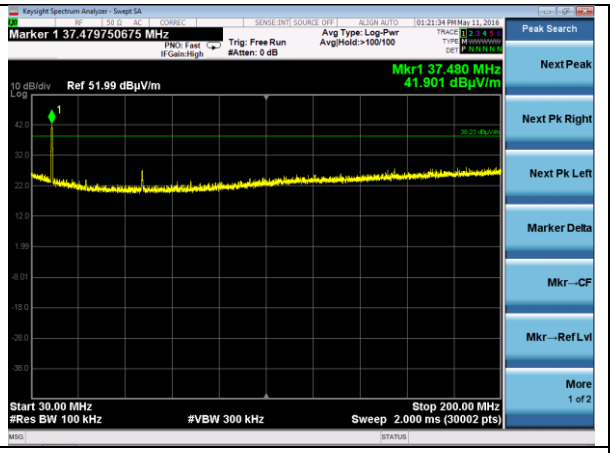
Note: Highest Emissions measured are reflected in the below plots, Low and High Channel plots and measurements were recorded.

Chip Antenna

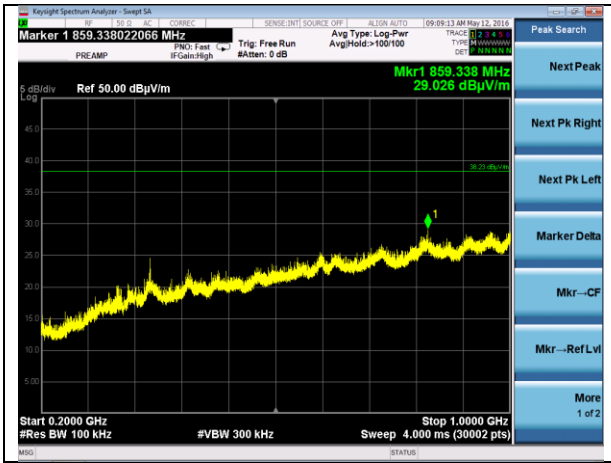
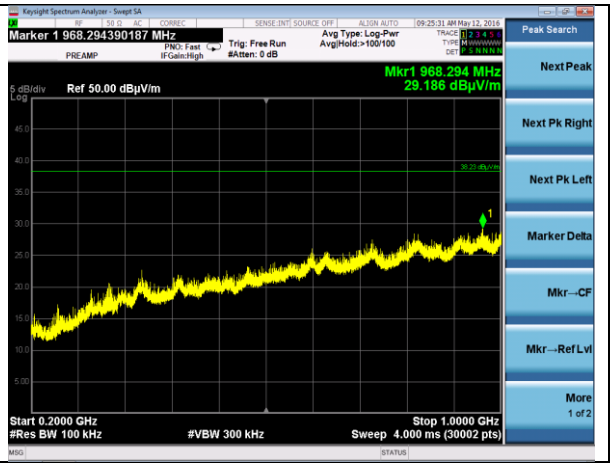
A. 30 MHz to 1000 MHz

Note: Emissions seen within this range were determined not to be a function of the radio.

30 to 200 MHz

	
Horizontal	Vertical

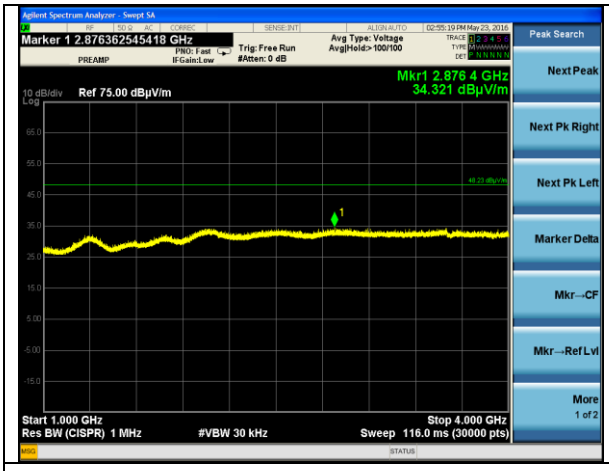
200 to 1000 MHz

	
Horizontal	Vertical

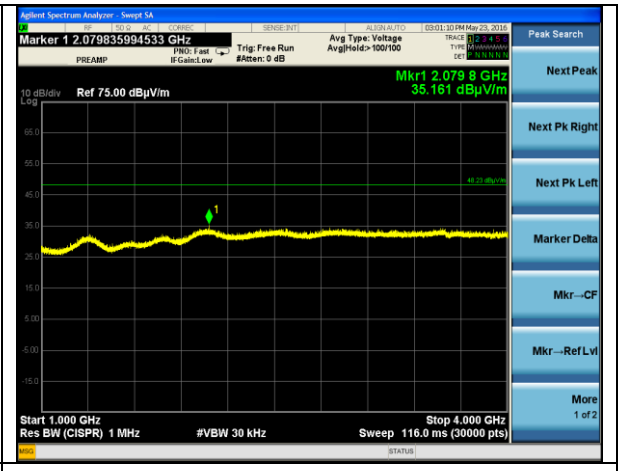
B. 1000 MHz to 12750 MHz

Frequency (MHz)	EUT Position	Polarization	Height (m)	Azimuth (°)	Field Strength (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)
2408.15	Vert.	Vert.	1.50	0	27.32	48.23	20.91
3576.09	Vert.	Hor.	1.50	0	27.85	48.23	20.38
2558.60	Vert.	Vert.	1.50	0	27.63	48.23	20.60
2804.20	Vert.	Hor.	1.50	0	27.38	48.23	20.85

1000 to 4000 MHz

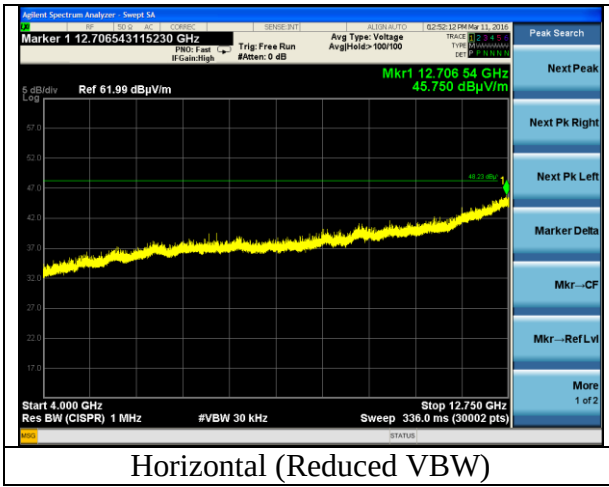


Horizontal (Reduced VBW)

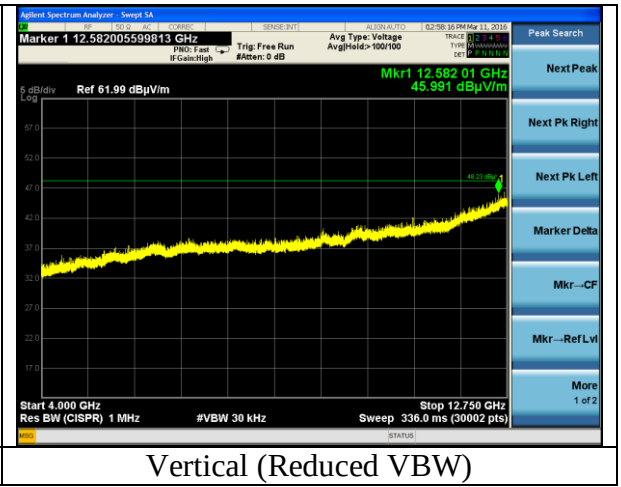


Vertical (Reduced VBW)

4000 to 12750 MHz



Horizontal (Reduced VBW)



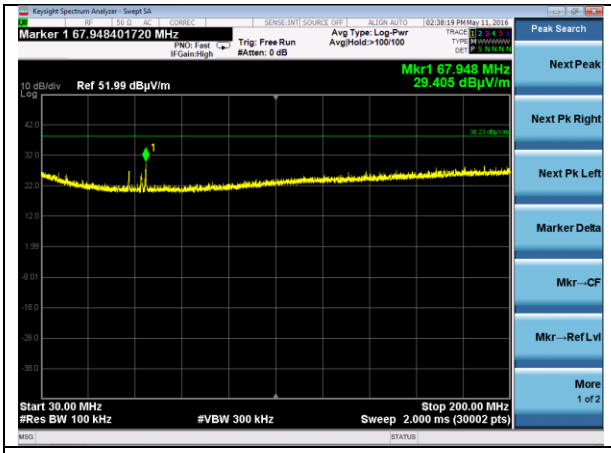
Vertical (Reduced VBW)

Antenna Port Terminated

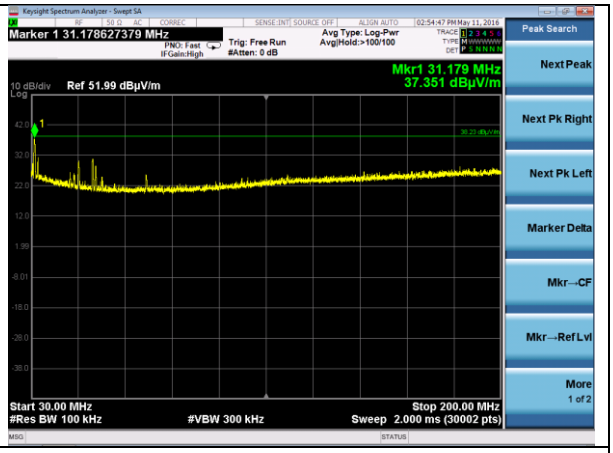
A. 30 MHz to 1000 MHz

Note: Emissions seen within this range were determined not to be a function of the radio.

30 to 200 MHz



Horizontal



Vertical

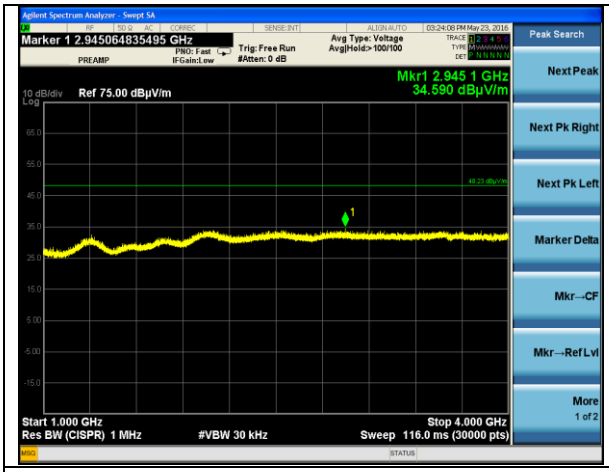
200 to 1000 MHz

Horizontal

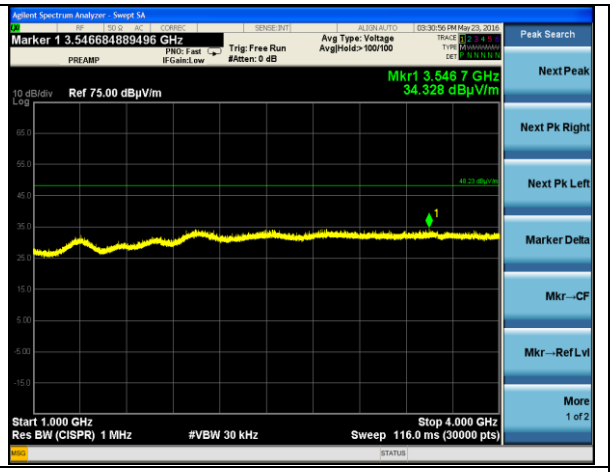
Vertical

B. 1000 MHz to 12750 MHz

1000 to 4000 MHz

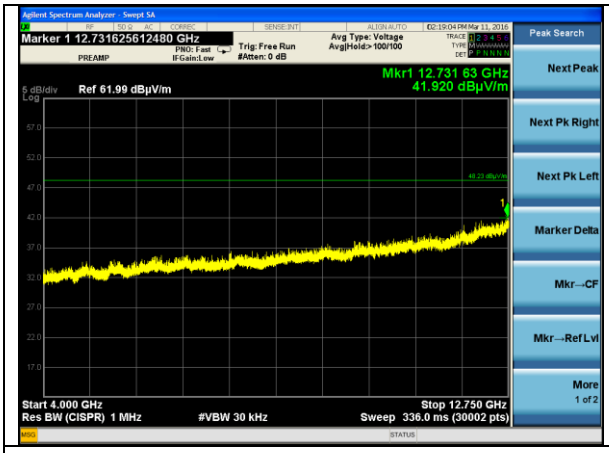


Horizontal (Reduced VBW)

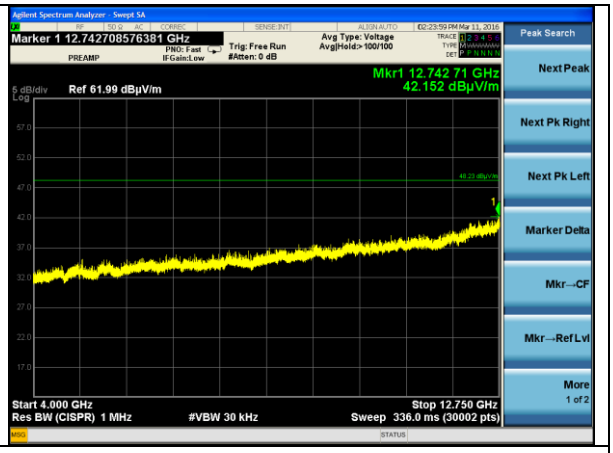


Vertical (Reduced VBW)

4000 to 12750 MHz



Horizontal (Reduced VBW)



Vertical (Reduced VBW)

C.1.11 – Receiver Blocking

Manufacturer	LS Research
Date	N/A
Operator	N/A
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.1.12
Test Procedure Section	5.3.7
Additional Notes	See section C.1.6 of this report as it is part of the Adaptivity procedure to show compliance to this requirement. (Adding the blocking signal)

Table 3: Receiver Blocking parameters

Equipment Type (LBT/non- LBT)	Wanted signal mean power from companion device	Blocking signal frequency [MHz]	Blocking signal power [dBm]	Type of interfering signal
LBT	sufficient to maintain the link (see note 2)	2 395 or 2 488,5 (see note 1)	-35	CW
Non-LBT	-30 dBm			

NOTE 1: The highest blocking frequency shall be used for testing hopping frequencies within the range 2 400 MHz to 2 442 MHz, while the lowest blocking frequency shall be used for testing hopping frequencies within the range 2 442 MHz to 2 483,5 MHz. See clause 5.3.7.1.
NOTE 2: A typical value which can be used in most cases is -50 dBm/MHz.

C.1.12 – Geo-location capability

Manufacturer	LS Research
Date	N/A
Operator	N/A
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.1.13
Test Procedure Section	5.3.7
Additional Notes	Manufacturer declares equipment does not have geo-location capability

C.2 – Wide Band Modulation Equipment

C.2.1 – RF Output Power

Manufacturer	LS Research
Date	March 9th – March 17th, 2016
Operator	Coty Hammerer, John Johnston
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.2.2 – Limit: e.i.r.p 20 dBm
Test Procedure Section	5.3.2 – Conducted measurement (power meter)
Additional Notes	1. Nominal and Extreme Conditions 2. Manufacturer declared peak antenna gain + 2.0 dBi 3. Continuous transmit on single channel

RF Output Power Calculation:

(P = A + G + Y)

P: Output Power EIRP
A: Measured Output Power (dbm)
G: Stated antenna gain (dBi)
Y: Beamforming gain (dB) – not applicable

Maximum RF Output Power EIRP:

BLE
P = 9.4 dBm EIRP (at -40°C)

WLAN
802.11b: P = 19.5 dBm EIRP (at 85°C)
802.11g: P = 17 dBm EIRP (at 22.2°C)
802.11n HT20: P = 16.0 dBm EIRP (at 22.2°C)

WLAN

A. 802.11b

1MBPS							
Temp (°C)	Channel (MHz)	A	G	Y	P	Limit (dBm)	Margin (dBm)
-40	2412.0	16.4	2.0	0.0	18.4	20.0	1.6
	2437.0	16.6	2.0	0.0	18.6	20.0	1.4
	2472.0	14.4	2.0	0.0	16.4	20.0	3.6
22.2	2412.0	14.6	2.0	0.0	16.6	20.0	3.4
	2437.0	15.0	2.0	0.0	17.0	20.0	3.0
	2472.0	14.5	2.0	0.0	16.5	20.0	3.5
85	2412.0	17.0	2.0	0.0	19.0	20.0	1.0
	2437.0	17.4	2.0	0.0	19.4	20.0	0.6
	2472.0	15.1	2.0	0.0	17.1	20.0	2.9

11MBPS							
Temp (°C)	Channel (MHz)	A	G	Y	P	Limit (dBm)	Margin (dBm)
-40	2412.0	16.5	2.0	0.0	18.5	20.0	1.5
	2437.0	16.8	2.0	0.0	18.8	20.0	1.2
	2472.0	14.6	2.0	0.0	16.6	20.0	3.4
22.2	2412.0	14.9	2.0	0.0	16.9	20.0	3.1
	2437.0	15.1	2.0	0.0	17.1	20.0	3.0
	2472.0	14.6	2.0	0.0	16.6	20.0	3.5
85	2412.0	17.3	2.0	0.0	19.3	20.0	0.7
	2437.0	17.5	2.0	0.0	19.5	20.0	0.5
	2472.0	15.1	2.0	0.0	17.1	20.0	2.9

B. 802.11g

6MBPS							
Temp (°C)	Channel (MHz)	A	G	Y	P	Limit (dBm)	Margin (dBm)
-40	2412.0	13.6	2.0	0.0	15.6	20.0	4.4
	2437.0	13.7	2.0	0.0	15.7	20.0	4.3
	2472.0	13.5	2.0	0.0	15.5	20.0	4.5
22.2	2412.0	14.6	2.0	0.0	16.6	20.0	3.4
	2437.0	14.4	2.0	0.0	16.4	20.0	3.6
	2472.0	13.4	2.0	0.0	15.4	20.0	4.6
85	2412.0	14.0	2.0	0.0	16.0	20.0	4.0
	2437.0	13.9	2.0	0.0	15.9	20.0	4.1
	2472.0	14.2	2.0	0.0	16.2	20.0	3.8

54MBPS							
Temp (°C)	Channel (MHz)	A	G	Y	P	Limit (dBm)	Margin (dBm)
-40	2412.0	13.6	2.0	0.0	15.6	20.0	4.4
	2437.0	13.6	2.0	0.0	15.6	20.0	4.4
	2472.0	13.7	2.0	0.0	15.7	20.0	4.3
22.2	2412.0	15.0	2.0	0.0	17.0	20.0	3.0
	2437.0	14.4	2.0	0.0	16.4	20.0	3.6
	2472.0	13.7	2.0	0.0	15.7	20.0	4.3
85	2412.0	14.3	2.0	0.0	16.3	20.0	3.7
	2437.0	14.3	2.0	0.0	16.3	20.0	3.7
	2472.0	14.0	2.0	0.0	16.0	20.0	4.1

C. 802.11n HT20

MCS0							
Temp (°C)	Channel (MHz)	A	G	Y	P	Limit (dBm)	Margin (dBm)
-40	2412.0	11.4	2.0	0.0	13.4	20.0	6.6
	2437.0	11.8	2.0	0.0	13.8	20.0	6.2
	2472.0	11.5	2.0	0.0	13.5	20.0	6.5
22.2	2412.0	14.0	2.0	0.0	16.0	20.0	4.0
	2437.0	13.9	2.0	0.0	15.9	20.0	4.1
	2472.0	11.6	2.0	0.0	13.6	20.0	6.5
85	2412.0	12.4	2.0	0.0	14.4	20.0	5.6
	2437.0	12.3	2.0	0.0	14.3	20.0	5.8
	2472.0	12.3	2.0	0.0	14.3	20.0	5.7

MCS7							
Temp (°C)	Channel (MHz)	A	G	Y	P	Limit (dBm)	Margin (dBm)
-40	2412.0	11.9	2.0	0.0	13.9	20.0	6.1
	2437.0	11.9	2.0	0.0	13.9	20.0	6.1
	2472.0	11.7	2.0	0.0	13.7	20.0	6.4
22.2	2412.0	13.2	2.0	0.0	15.2	20.0	4.8
	2437.0	12.6	2.0	0.0	14.6	20.0	5.4
	2472.0	11.9	2.0	0.0	13.9	20.0	6.1
85	2412.0	12.4	2.0	0.0	14.4	20.0	5.6
	2437.0	12.5	2.0	0.0	14.5	20.0	5.5
	2472.0	12.1	2.0	0.0	14.1	20.0	5.9

BLE

BLE							
Temp (°C)	Channel (MHz)	A	G	Y	P	Limit (dBm)	Margin (dBm)
-40	2402.0	7.4	2.0	0.0	9.4	20.0	10.6
	2440.0	6.2	2.0	0.0	8.2	20.0	11.8
	2480.0	5.4	2.0	0.0	7.4	20.0	12.7
22.2	2402.0	7.3	2.0	0.0	9.3	20.0	10.7
	2440.0	6.9	2.0	0.0	8.9	20.0	11.2
	2480.0	6.2	2.0	0.0	8.2	20.0	11.9
85	2402.0	7.1	2.0	0.0	9.1	20.0	10.9
	2440.0	6.7	2.0	0.0	8.7	20.0	11.3
	2480.0	5.8	2.0	0.0	7.8	20.0	12.2

C.2.2 – Power Spectral Density

Manufacturer	LS Research
Date	March 15th – May 18th, 2016
Operator	John Johnston
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.2.3 – Limit 10 dBm / MHz (EIRP)
Test Procedure Section	5.3.3
Additional Notes	1. Calculation of PSD based on EIRP values at normal temperature.

BLE

BLE				
Temp (°C)	Channel (MHz)	PSD (dBm)	Limit (dBm)	Margin (dBm)
22.2	2402.0	9.3	10.0	0.7
	2440.0	8.8	10.0	1.2
	2480.0	8.1	10.0	1.9

WLAN

A. 802.11b

1MBPS				
Temp (°C)	Channel (MHz)	PSD (dBm)	Limit (dBm)	Margin (dBm)
22.2	2412.0	8.6	10.0	1.4
	2437.0	9.1	10.0	0.9
	2472.0	8.8	10.0	1.2

11MBPS				
Temp (°C)	Channel (MHz)	PSD (dBm)	Limit (dBm)	Margin (dBm)
22.2	2412.0	8.5	10.0	1.5
	2437.0	8.7	10.0	1.3
	2472.0	8.3	10.0	1.7

B. 802.11g

6MBPS				
Temp (°C)	Channel (MHz)	PSD (dBm)	Limit (dBm)	Margin (dBm)
22.2	2412.0	5.9	10.0	4.1
	2437.0	5.7	10.0	4.3
	2472.0	4.7	10.0	5.3

54MBPS				
Temp (°C)	Channel (MHz)	PSD (dBm)	Limit (dBm)	Margin (dBm)
22.2	2412.0	6.4	10.0	3.6
	2437.0	5.8	10.0	4.2
	2472.0	5.1	10.0	4.9

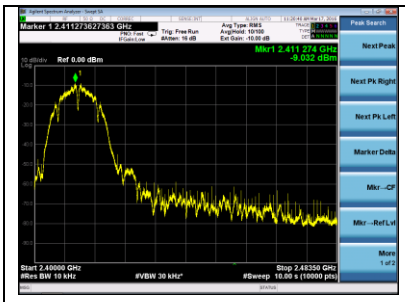
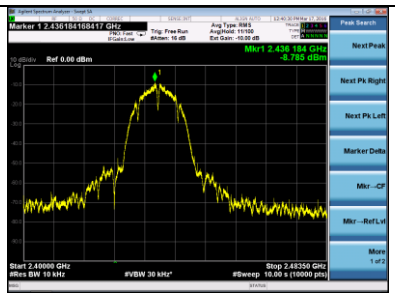
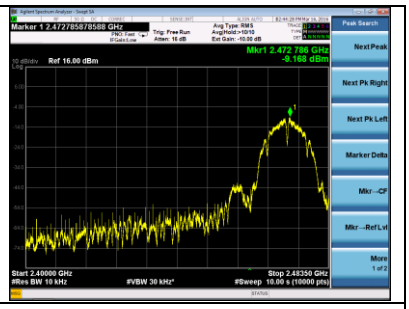
C. 802.11n HT20

MCS0				
Temp (°C)	Channel (MHz)	PSD (dBm)	Limit (dBm)	Margin (dBm)
22.2	2412.0	5.1	10.0	4.9
	2437.0	5.1	10.0	4.9
	2472.0	2.7	10.0	7.3

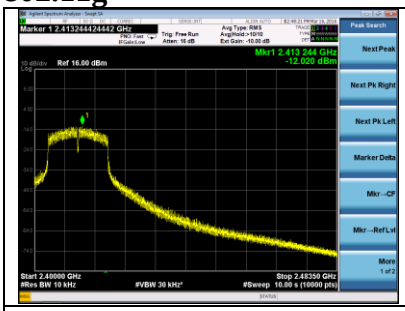
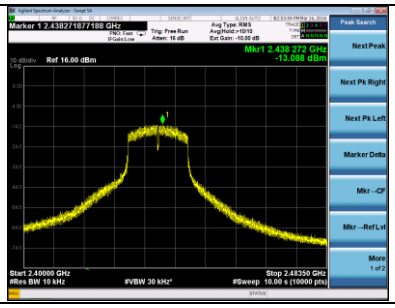
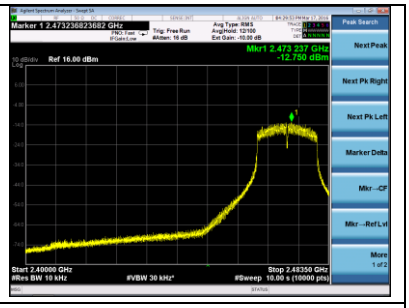
MCS7				
Temp (°C)	Channel (MHz)	PSD (dBm)	Limit (dBm)	Margin (dBm)
22.2	2412.0	4.4	10.0	5.6
	2437.0	3.8	10.0	6.2
	2472.0	3.1	10.0	6.9

Screen captures:

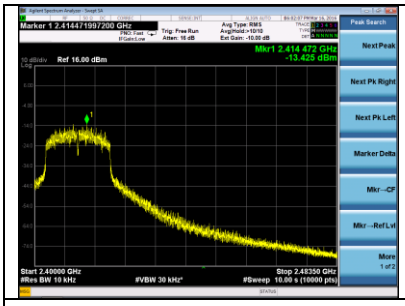
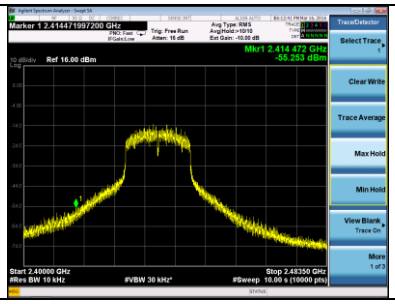
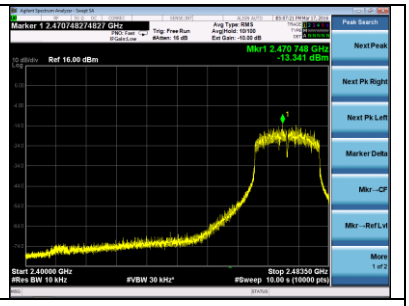
802.11b

		
Low Channel	**Middle Channel**	**High channel**

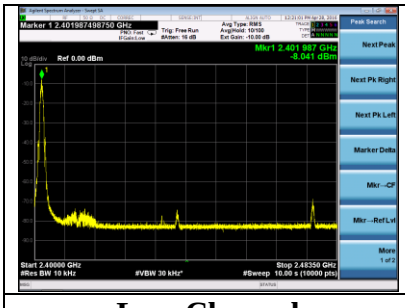
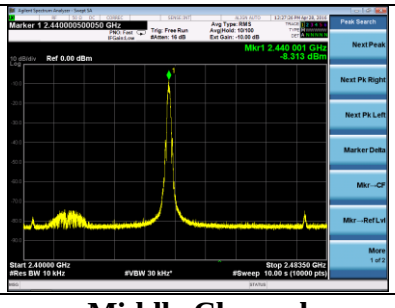
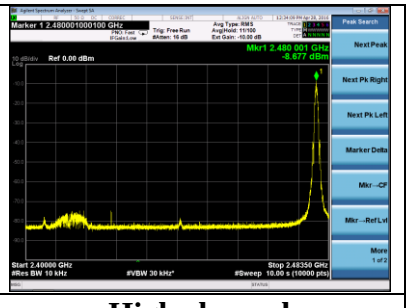
802.11g

		
Low Channel	**Middle Channel**	**High channel**

802.11n HT 20

		
Low Channel	**Middle Channel**	**High channel**

BLE

		
Low Channel	**Middle Channel**	**High channel**

C.2.3 – Duty Cycle, Tx-sequence, Tx-gap

Manufacturer	LS Research
Date	N/A
Operator	N/A
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.2.4
Test Procedure Section	5.3.2.2.1.3
Additional Notes	Only applicable to non-adaptive equipment with EIRP greater than 10 dBm

C.2.4 – Medium Utilisation (MU) Factor

Manufacturer	LS Research
Date	N/A
Operator	N/A
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.2.5
Test Procedure Section	5.3.2.2.1.4
Additional Notes	Only applicable to non-adaptive equipment with EIRP greater than 10 dBm

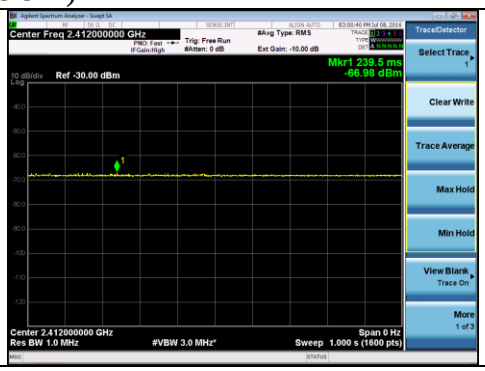
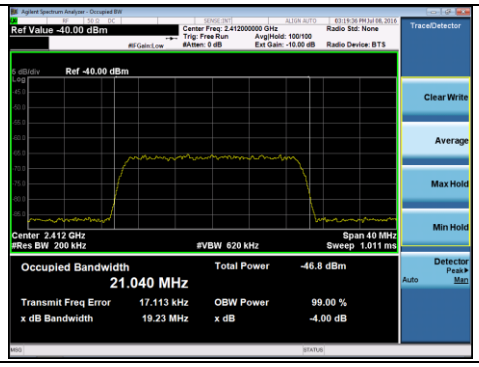
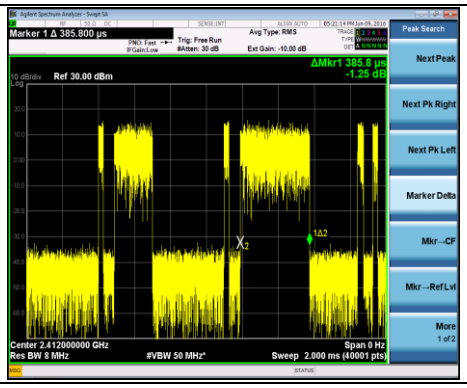
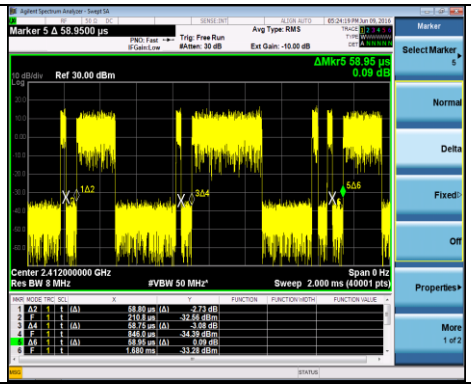
C.2.5 – Adaptivity

Manufacturer	LS Research
Date	6/8/16 – 7/11/16
Operator	Michael Hintzke, Coty Hammerer
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.2.6.3.2.3 – LBT Based DAA (Load Based Equipment)
Test Procedure Section	5.3.7.2.1.3
Additional Notes	None

Threshold level for compliance (TL) = -70 dBm/MHz + 20 – Pout e.i.r.p (dBm)

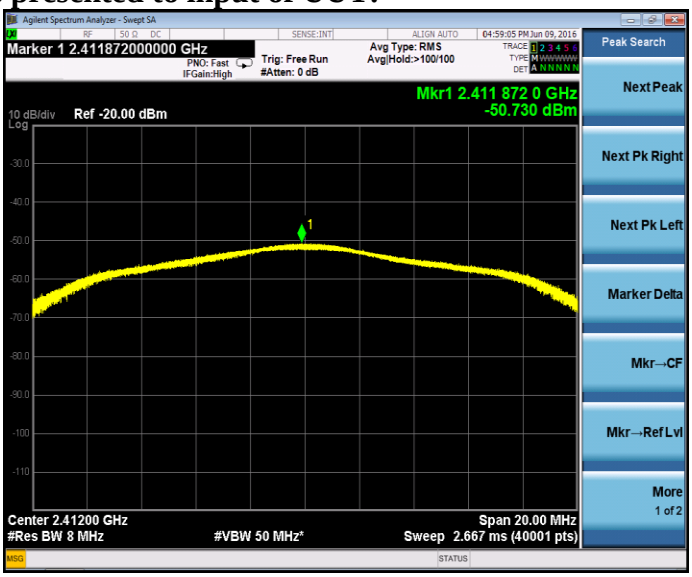
TL = -70 +20 – (17.0) = **- 67.0 dBm / MHz**

Interference threshold as presented to input of UUT:
(Signal generator 1 level = -43.5 dBm with AWGN signal resulting in a level of -70.0 dBm / MHz at input of UUT)

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>Low Channel</td><td>99% BW</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Channel Occupancy</td><td>Idle Period</td></tr>
</table>

Note: Only Low Channel shown.

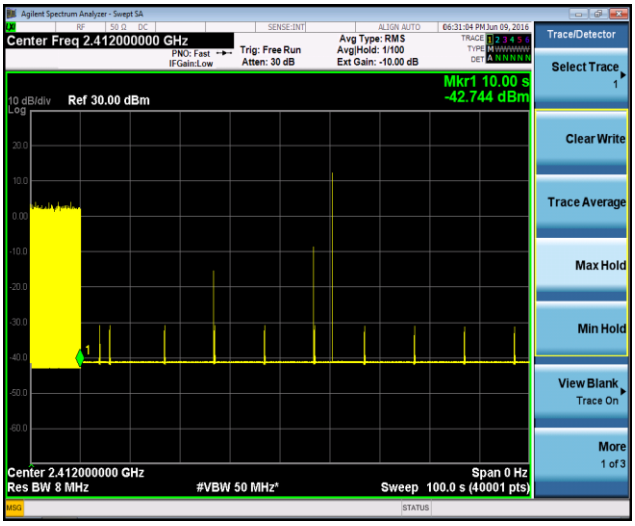
Level of companion as presented to input of UUT:



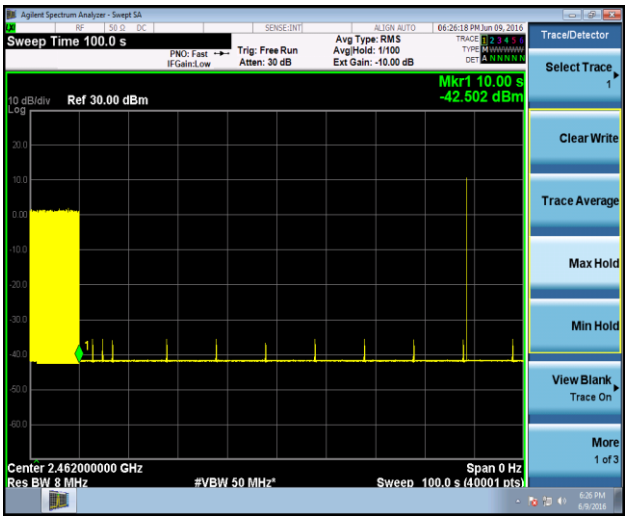
Level of blocking signal as presented to input of UUT:
(Signal generator 2 level = -23.0 dBm CW with loss through measurement system resulting in a level of ~ -35.0 dBm at input of UUT which is per standard; table 6).

	
Low Channel	High Channel

Interference added:
-Normal traffic for 10 seconds
-Signal generator 1 (AWGN) added 10.0 second into sweep
-No subsequent transmissions on channel
-Plot shows short control and signaling transmissions that are reduced in amplitude

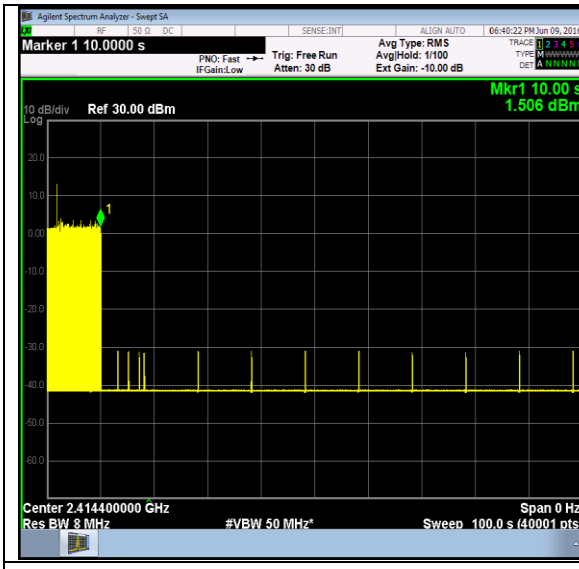


Low Channel

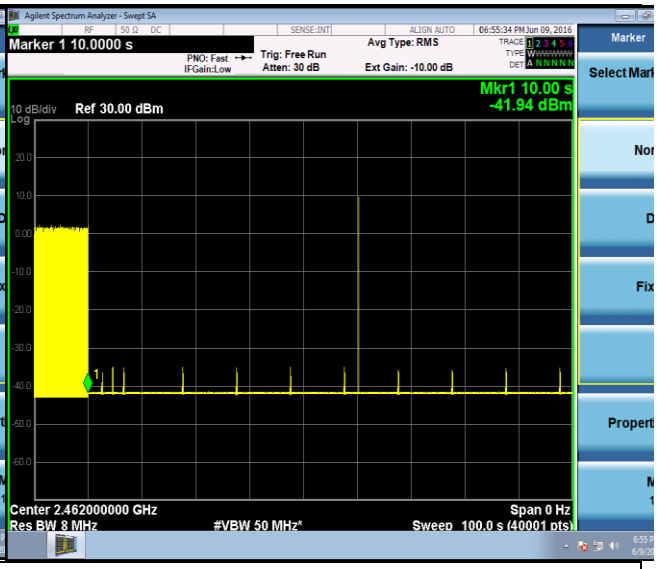


High Channel

Blocking added:
-AWGN signal still present
-Signal generator 2 (CW) added 10.0 second into sweep



Low Channel



High Channel

C.2.6 – Occupied Channel Bandwidth

Manufacturer	LS Research
Date	3/10/16
Operator	Kimberly Bay
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.2.7
Test Procedure Section	5.3.8 – Conducted measurement
Additional Notes	Continuous transmit single channel

BLE

BLE		
Temp (°C)	Channel (MHz)	99% BW(MHz)
22.2	2402.0	1.07
	2480.0	1.07

WLAN

A. 802.11b

1MBPS		
Temp (°C)	Channel (MHz)	99% BW(MHz)
22.2	2412.0	13.75
	2472.0	13.91

11MBPS		
Temp (°C)	Channel (MHz)	99% BW(MHz)
22.2	2412.0	13.78
	2472.0	13.80

B. 802.11g

6MBPS		
Temp (°C)	Channel (MHz)	99% BW(MHz)
22.2	2412.0	16.40
	2472.0	16.37

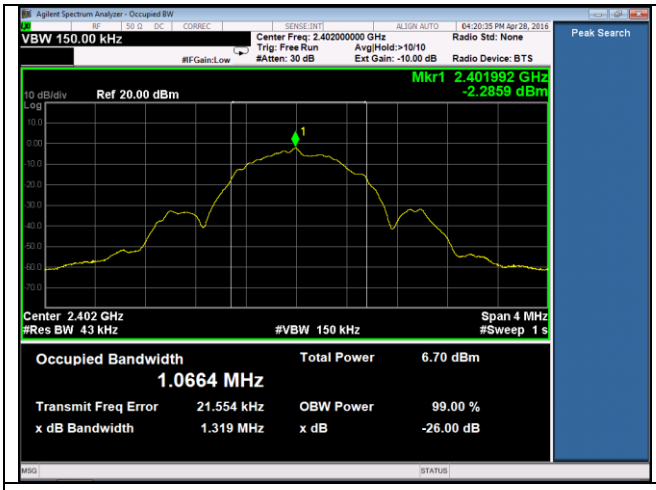
54MBPS		
Temp (°C)	Channel (MHz)	99% BW(MHz)
22.2	2412.0	16.38
	2472.0	16.36

C. 802.11n HT20

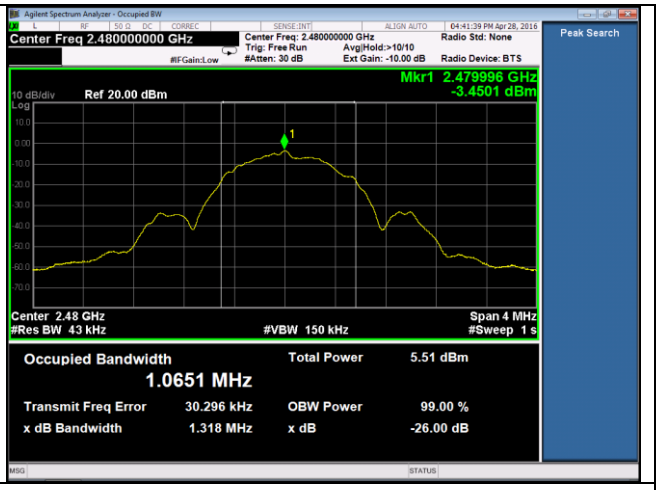
MCS0		
Temp (°C)	Channel (MHz)	99% BW(MHz)
22.2	2412.0	17.55
	2472.0	17.52

MCS7		
Temp (°C)	Channel (MHz)	99% BW(MHz)
22.2	2412.0	17.45
	2472.0	17.43

BLE



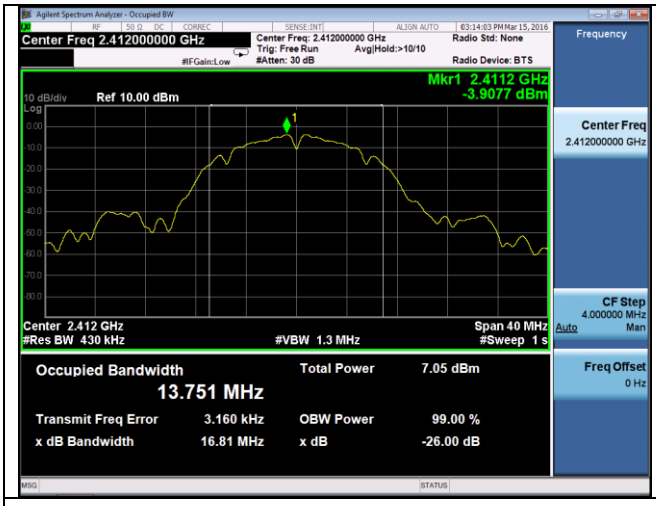
Low channel



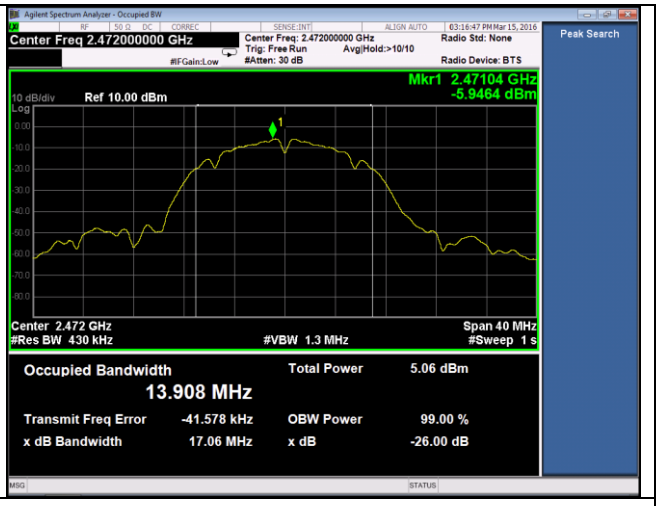
High channel

WLAN

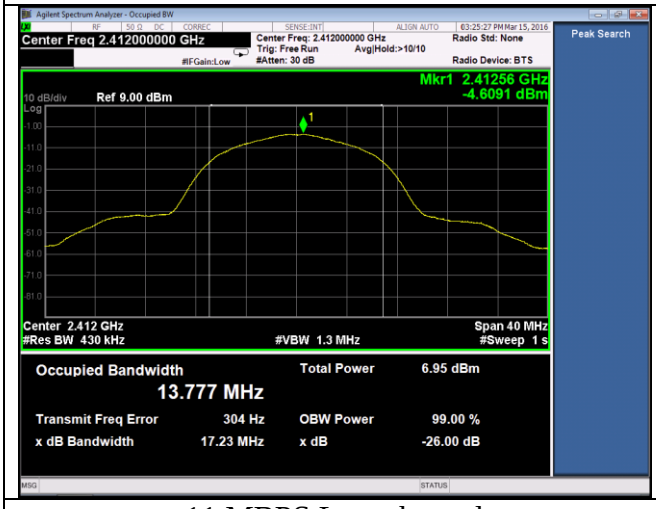
802.11b



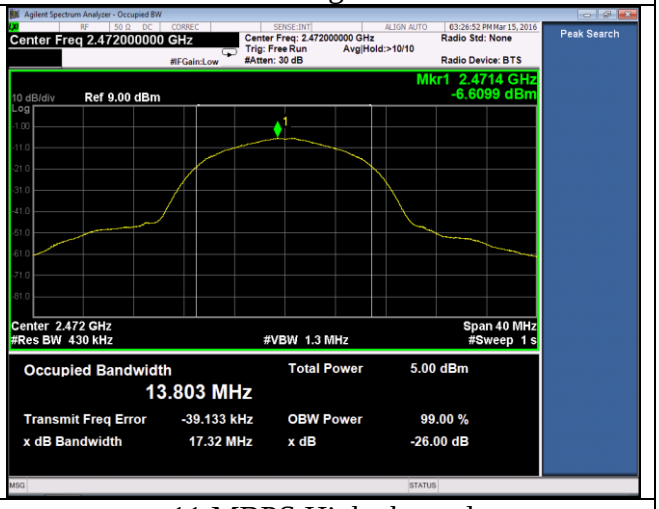
1 MBPS Low channel



1 MBPS High channel

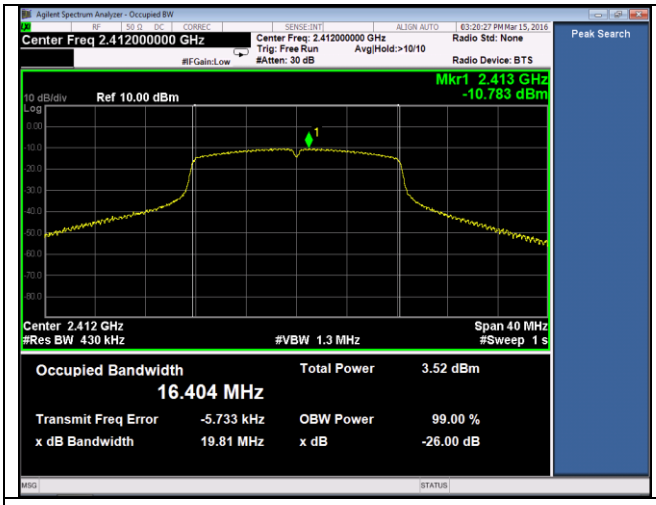


11 MBPS Low channel

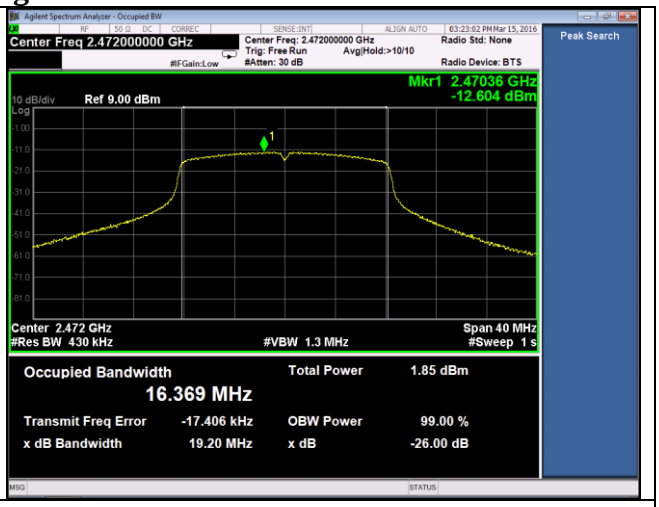


11 MBPS High channel

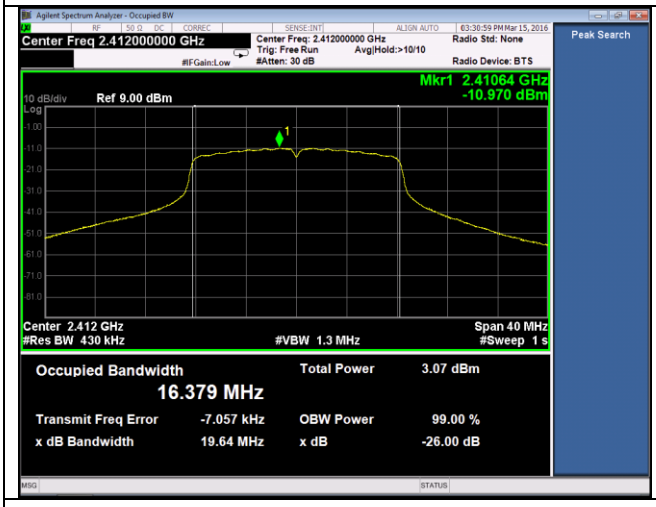
802.11g



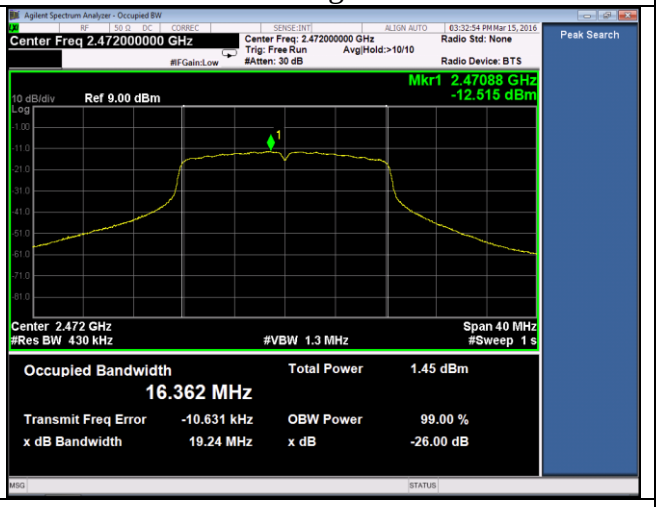
6 MBPS Low channel



6 MBPS High channel

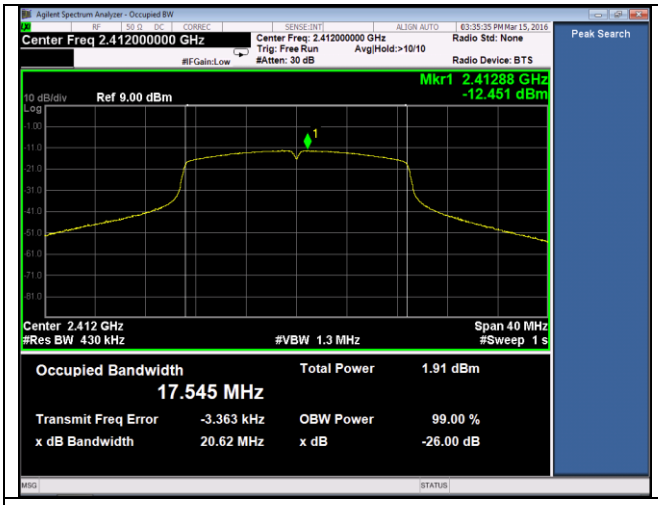


54 MBPS Low channel

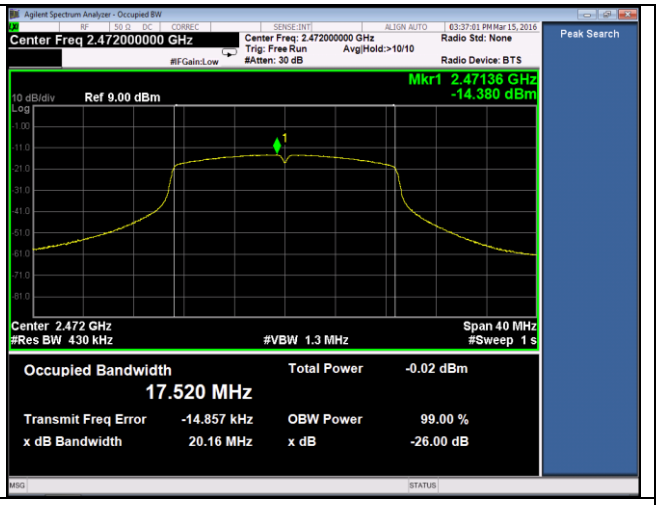


54 MBPS High channel

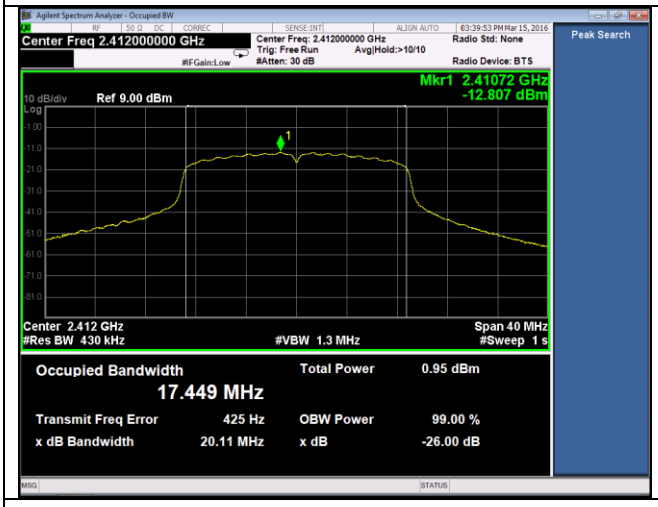
802.11n HT20



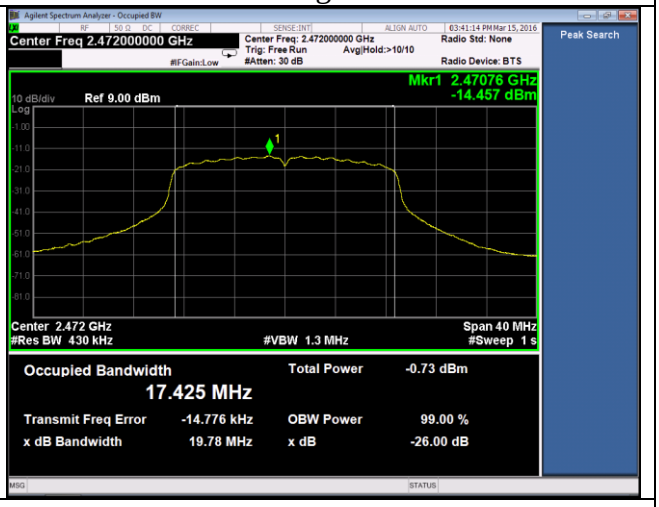
MCS0 Low channel



MCS0 High channel



MCS7 Low channel



MCS7 High channel

C.2.7 – Transmitter unwanted emissions in the out-of-band domain

Manufacturer	LS Research
Date	March 18th – May 19th, 2016
Operator	John Johnston
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.2.8
Test Procedure Section	5.3.9 – Conducted measurement
Additional Notes	1. Normal conditions 2. Used ACP function of spectrum analyzer

Normal Temperature:

BLE

BLE											
Temp (°C)	Channel (MHz)	Mask1 power (dBm)	Antenna Gain (dBi)	Corrected Mask1 power (dBm)	Mask1 Limit (dBm)	Mask1 Margin (dBm)	Mask2 power (dBm)	Antenna Gain (dBi)	Corrected Mask2 power (dBm)	Mask2 Limit (dBm)	Mask2 Margin (dBm)
22.2	2402.0	-48.4	2.0	-46.4	-10.0	36.4	-48.5	2.0	-46.5	-20.0	26.5
	2480.0	-48.1	2.0	-46.1	-10.0	36.1	-48.1	2.0	-46.1	-20.0	26.1

WLAN

A. 802.11b

1MBPS											
Temp (°C)	Channel (MHz)	Mask1 power (dBm)	Antenna Gain (dBi)	Corrected Mask1 power (dBm)	Mask1 Limit (dBm)	Mask1 Margin (dBm)	Mask2 power (dBm)	Antenna Gain (dBi)	Corrected Mask2 power (dBm)	Mask2 Limit (dBm)	Mask2 Margin (dBm)
22.2	Low Edge	-22.2	2.0	-20.2	-10.0	10.2	-29.3	2.0	-27.3	-20.0	7.3
	Upper Edge	-27.3	2.0	-25.3	-10.0	15.3	-31.3	2.0	-29.3	-20.0	9.3

11MBPS											
Temp (°C)	Channel (MHz)	Mask1 power (dBm)	Antenna Gain (dBi)	Corrected Mask1 power (dBm)	Mask1 Limit (dBm)	Mask1 Margin (dBm)	Mask2 power (dBm)	Antenna Gain (dBi)	Corrected Mask2 power (dBm)	Mask2 Limit (dBm)	Mask2 Margin (dBm)
22.2	Low Edge	-22.7	2.0	-20.7	-10.0	10.7	-30.3	2.0	-28.3	-20.0	8.3
	Upper Edge	-26.8	2.0	-24.8	-10.0	14.8	-31.6	2.0	-29.6	-20.0	9.6

B. 802.11g

6MBPS											
Temp (°C)	Channel (MHz)	Mask1 power (dBm)	Antenna Gain (dBi)	Corrected Mask1 power (dBm)	Mask1 Limit (dBm)	Mask1 Margin (dBm)	Mask2 power (dBm)	Antenna Gain (dBi)	Corrected Mask2 power (dBm)	Mask2 Limit (dBm)	Mask2 Margin (dBm)
22.2	Low Edge	-12.9	2.0	-10.9	-10.0	0.9	-25.4	2.0	-23.4	-20.0	3.4
	Upper Edge	-13.0	2.0	-11.0	-10.0	1.0	-26.7	2.0	-24.7	-20.0	4.7

54MBPS											
Temp (°C)	Channel (MHz)	Mask1 power (dBm)	Antenna Gain (dBi)	Corrected Mask1 power (dBm)	Mask1 Limit (dBm)	Mask1 Margin (dBm)	Mask2 power (dBm)	Antenna Gain (dBi)	Corrected Mask2 power (dBm)	Mask2 Limit (dBm)	Mask2 Margin (dBm)
22.2	Low Edge	-14.1	2.0	-12.1	-10.0	2.1	-27.0	2.0	-25.0	-20.0	5.0
	Upper Edge	-15.3	2.0	-13.3	-10.0	3.3	-30.1	2.0	-28.1	-20.0	8.1

C. 802.11n HT20

MCS0											
Temp (°C)	Channel (MHz)	Mask1 power (dBm)	Antenna Gain (dBi)	Corrected Mask1 power (dBm)	Mask1 Limit (dBm)	Mask1 Margin (dBm)	Mask2 power (dBm)	Antenna Gain (dBi)	Corrected Mask2 power (dBm)	Mask2 Limit (dBm)	Mask2 Margin (dBm)
22.2	Low Edge	-14.3	2.0	-12.3	-10.0	2.3	-28.8	2.0	-26.8	-20.0	6.8
	Upper Edge	-12.7	2.0	-10.7	-10.0	0.7	-26.5	2.0	-24.5	-20.0	4.5

MCS7											
Temp (°C)	Channel (MHz)	Mask1 power (dBm)	Antenna Gain (dBi)	Corrected Mask1 power (dBm)	Mask1 Limit (dBm)	Mask1 Margin (dBm)	Mask2 power (dBm)	Antenna Gain (dBi)	Corrected Mask2 power (dBm)	Mask2 Limit (dBm)	Mask2 Margin (dBm)
22.2	Low Edge	-14.3	2.0	-12.3	-10.0	2.3	-28.8	2.0	-26.8	-20.0	6.8
	Upper Edge	-14.5	2.0	-12.5	-10.0	2.5	-27.0	2.0	-25.0	-20.0	5.0

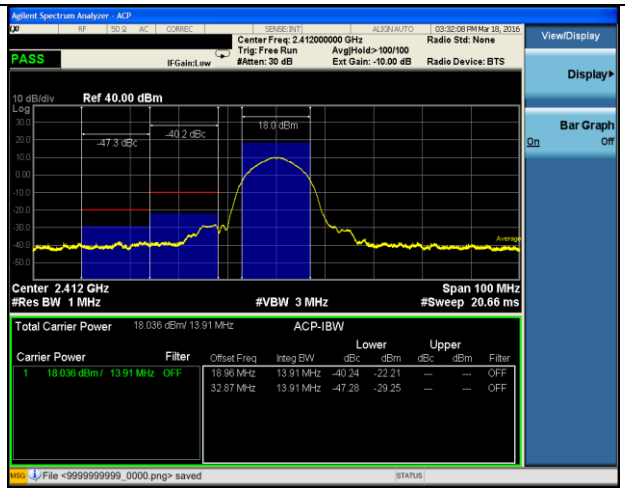
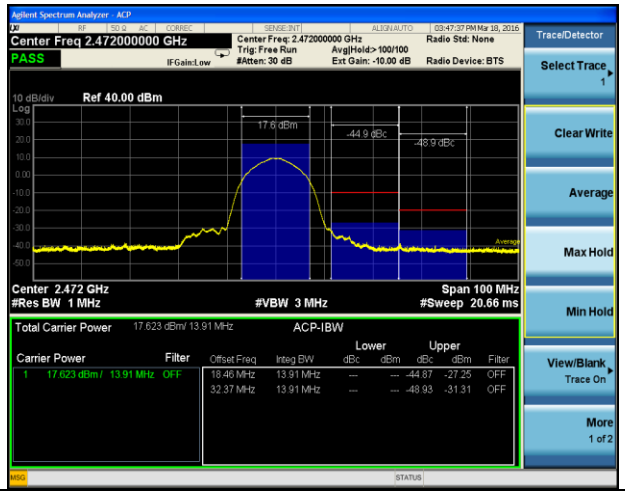
Screen Captures

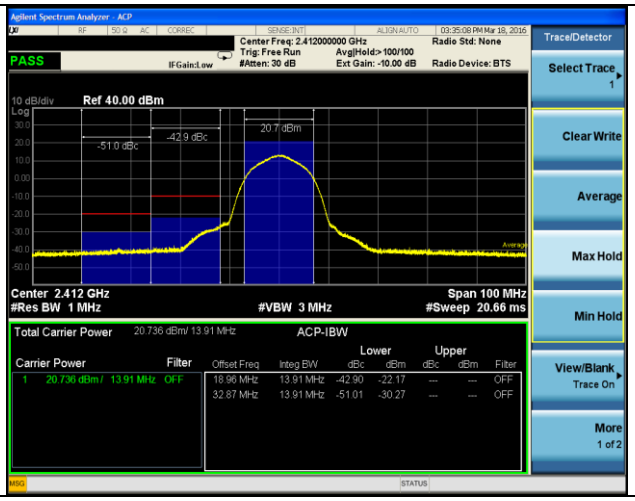
BLE

	
Lower Band-edge	**Upper band-edge**

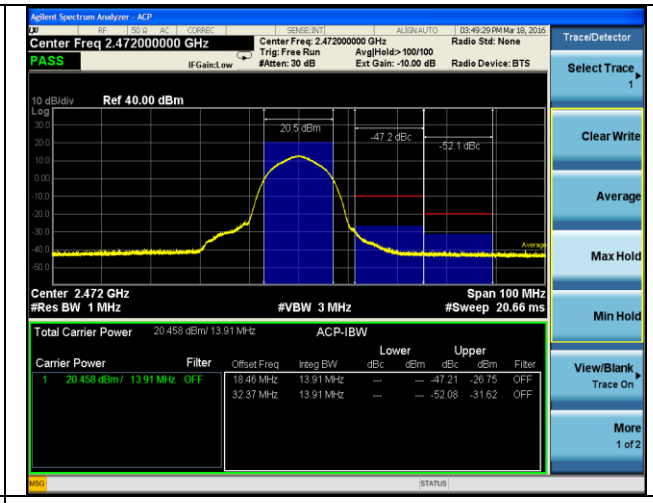
WLAN

A. 802.11b

	
1 MBPS Lower Band-edge	**1 MBPS Upper band-edge**

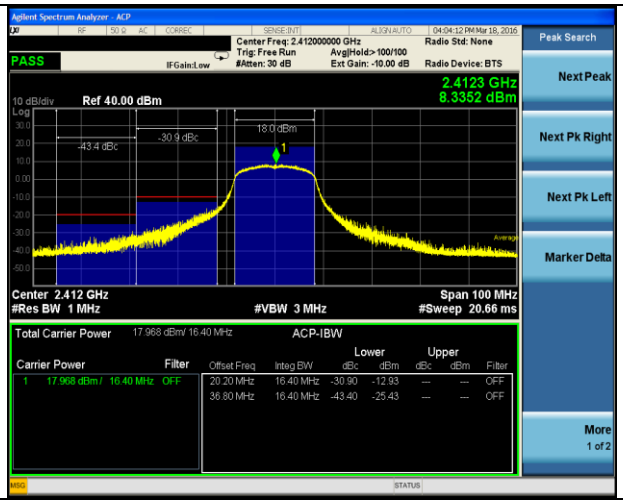


11 MBPS Lower Band-edge

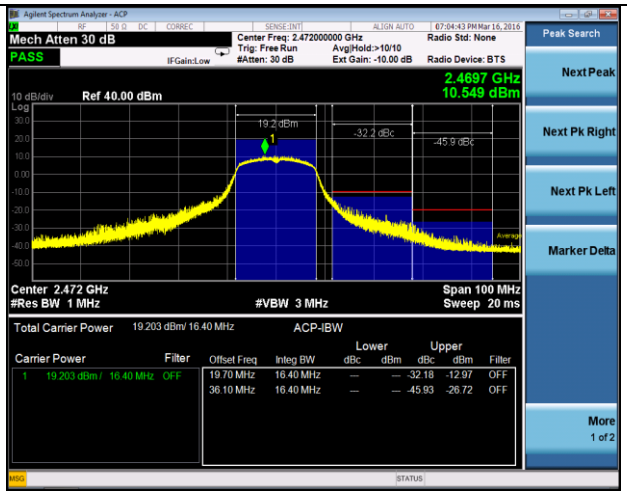


11 MBPS Upper band-edge

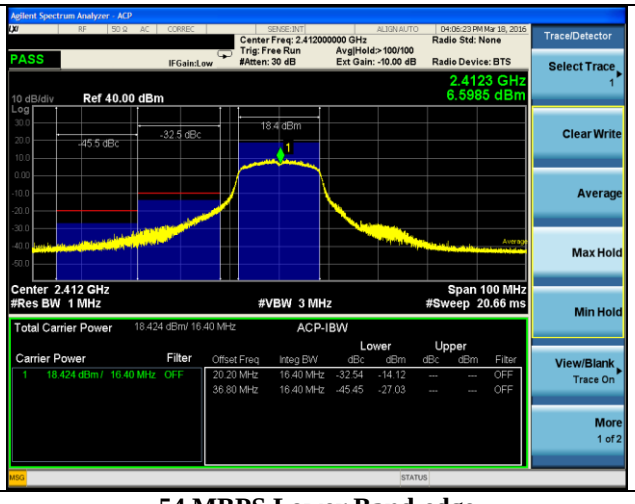
B. 802.11g



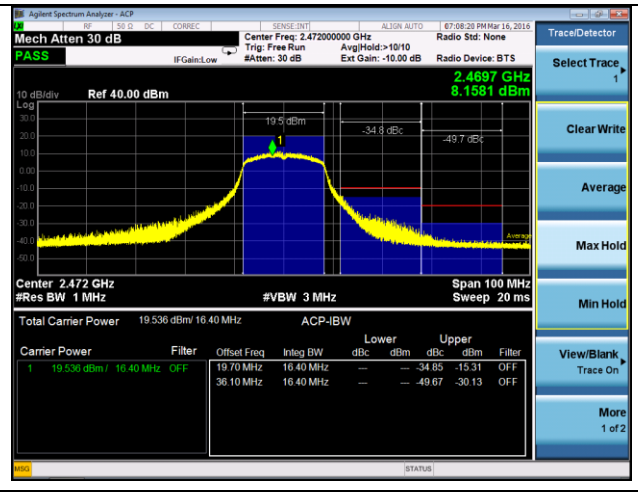
6 MBPS Lower Band-edge



6 MBPS Upper band-edge

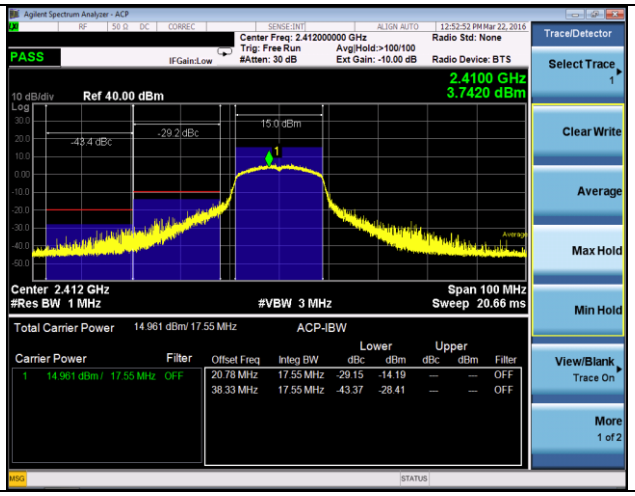


54 MBPS Lower Band-edge

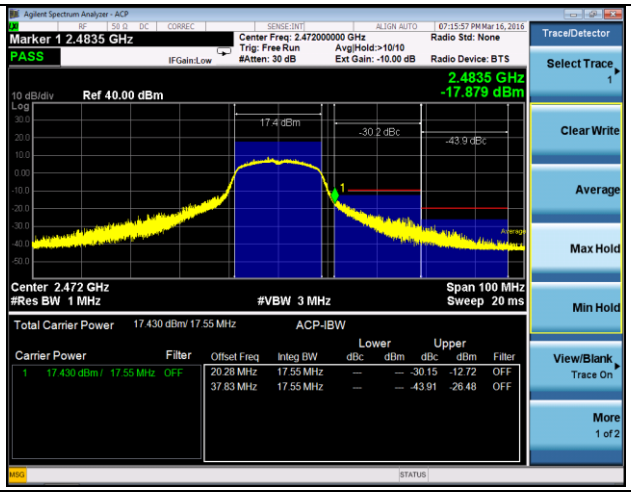


54 MBPS Upper band-edge

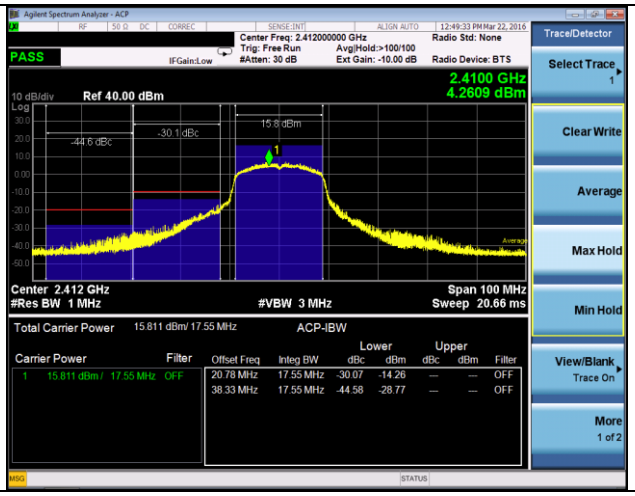
C. 802.11n HT20



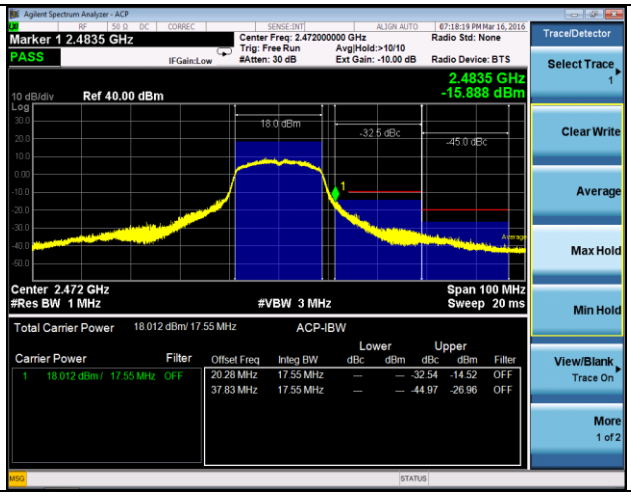
MCS0 Lower Band-edge



MCS0 Upper band-edge



MCS7 Lower Band-edge



MCS7 Upper band-edge

C.2.8 – Transmitter unwanted emissions in the spurious domain

Manufacturer	LS Research
Date	March 9th – May 27th, 2016
Operator	Kimberly Bay, Coty Hammerer, Shane Dock
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.2.9
Test Procedure Section	5.3.10 –Radiated Measurements
Additional Notes	1. See section C1.9 of the report for BLE transmitter spurious measurements, classic Bluetooth measurements are leveraged for BLE due to higher output power and similar spectral characteristics. 2. Three orthogonal positions of device measured radiated.

Radiated Measurements (WLAN):

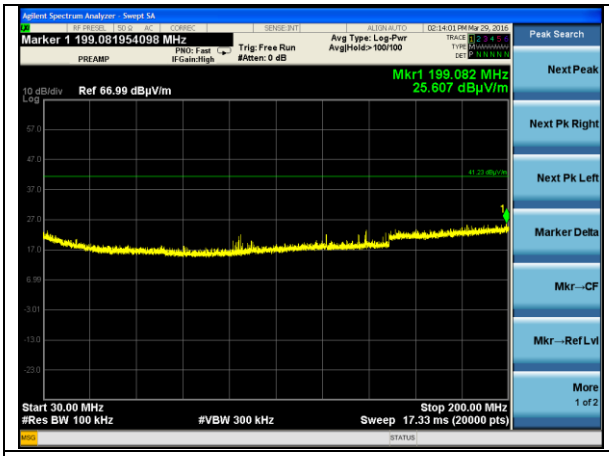
Note: Highest Emissions measured are reflected in the below plots, Low and High Channel plots and measurements were recorded.

Chip Antenna

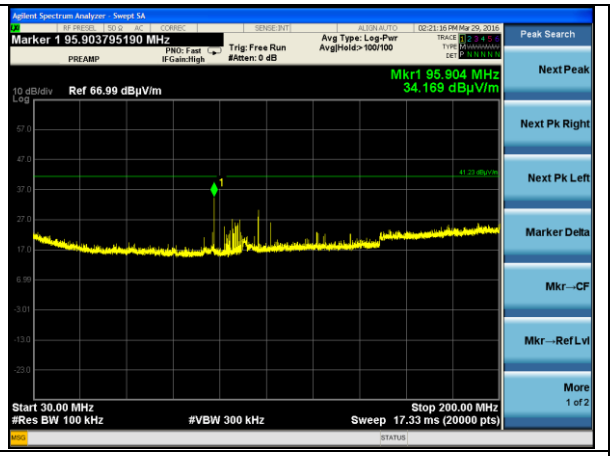
A. 30 MHz to 1000 MHz

Note: Emissions seen within this range was determined not to be a function of the radio.

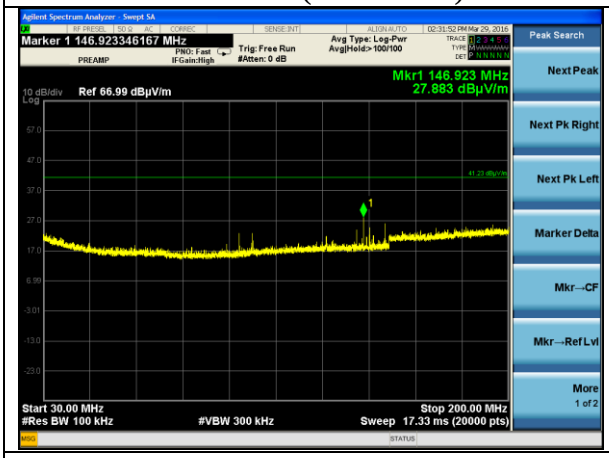
30 to 200 MHz



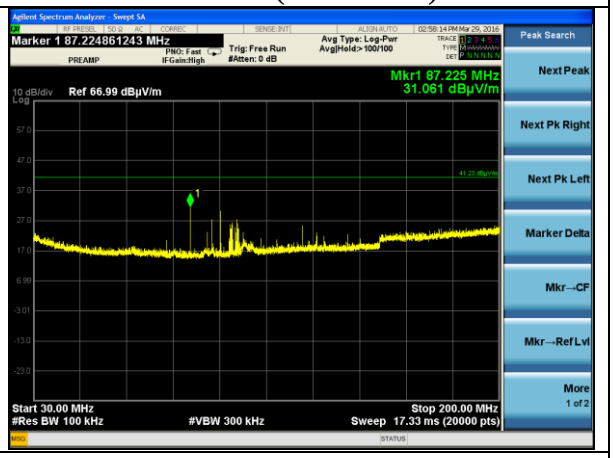
Horizontal (Radio OFF)



Vertical (Radio OFF)

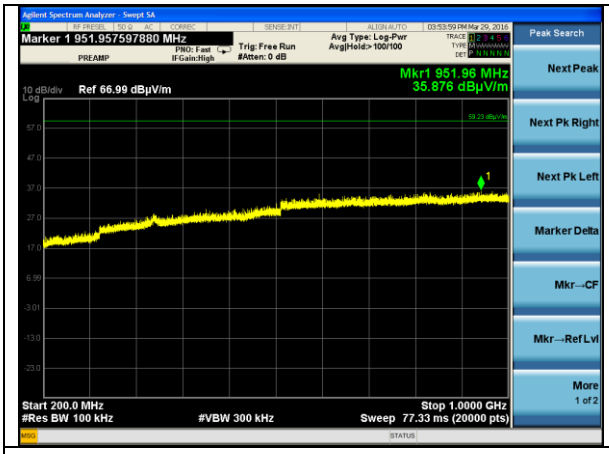
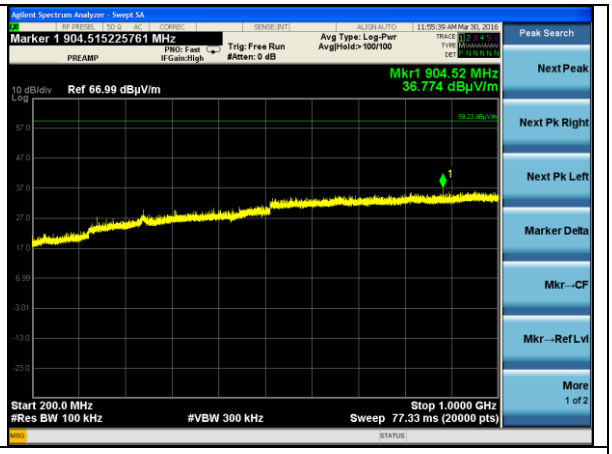


Horizontal (Radio ON)



Vertical (Radio ON)

200 to 1000 MHz

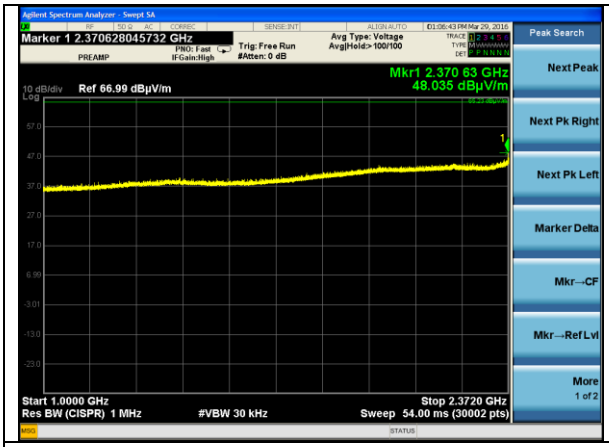
	
Horizontal	Vertical

Note: The display line in the above plots indicates the limit with respect to the highest peak found. All other measurements are noise floor and meet the limits of Table 4 in ETSI 300 328 V1.9.1.

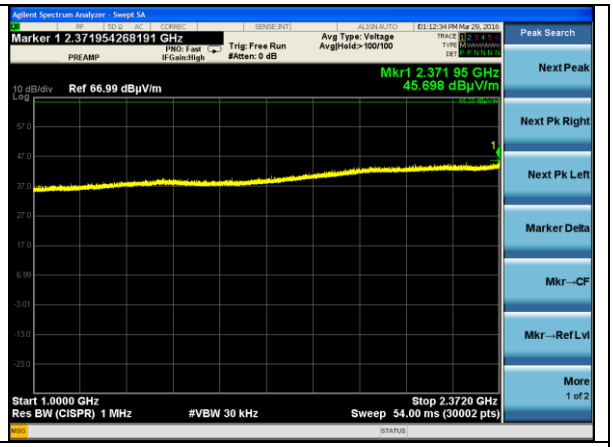
B. 1000 MHz to 12750 MHz

Note: Plots presented are those when in 802.11b (1MBPS) since it was determined that it is the worst case combination of modulation and output power.

1000 to 2372 MHz

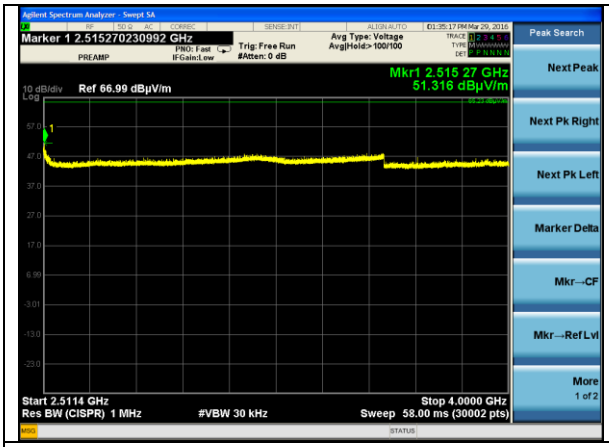


Horizontal (Reduced VBW)

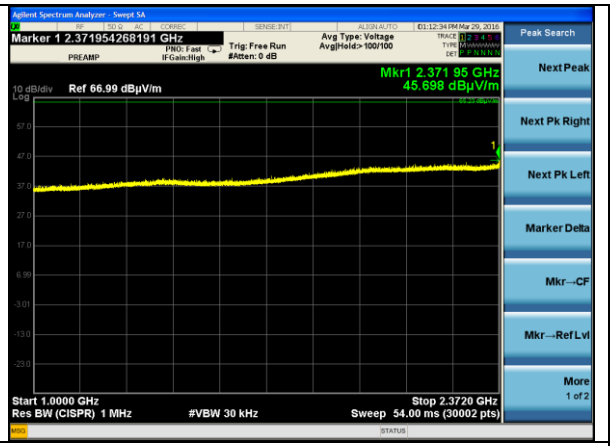


Vertical (Reduced VBW)

2511.4 to 4000 MHz

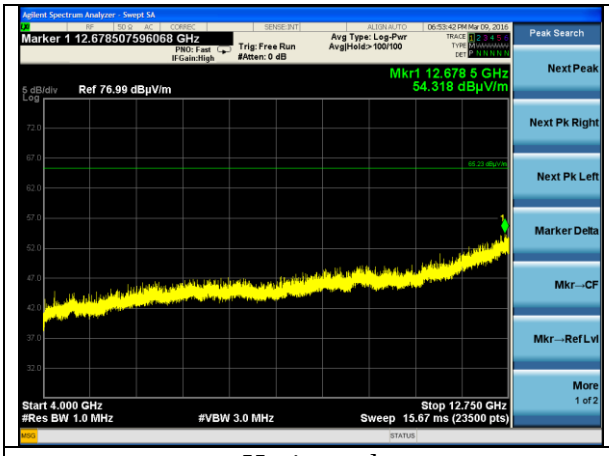


Horizontal (Reduced VBW)

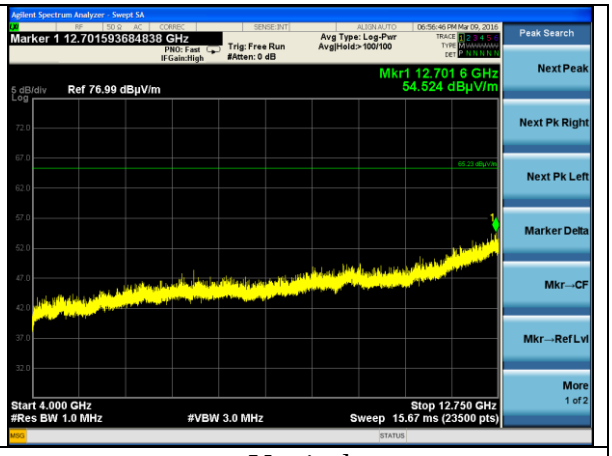


Vertical (Reduced VBW)

4000 to 12750 MHz



Horizontal



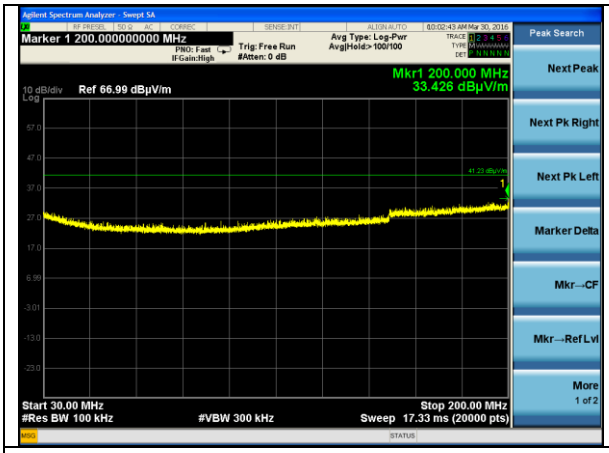
Vertical

Antenna Port Terminated

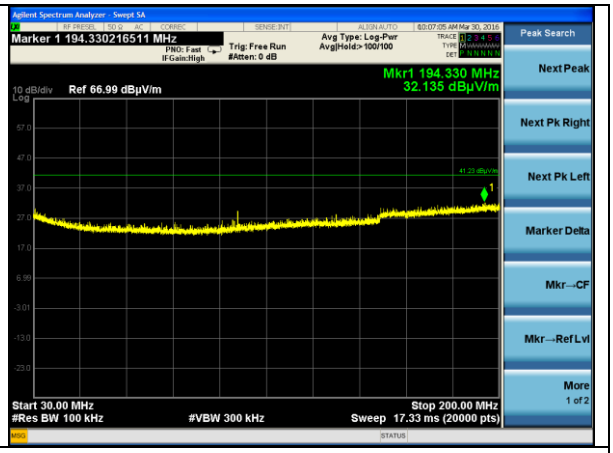
C. 30 MHz to 1000 MHz

Note: Emissions seen within this range was determined not to be a function of the radio.

30 to 200 MHz

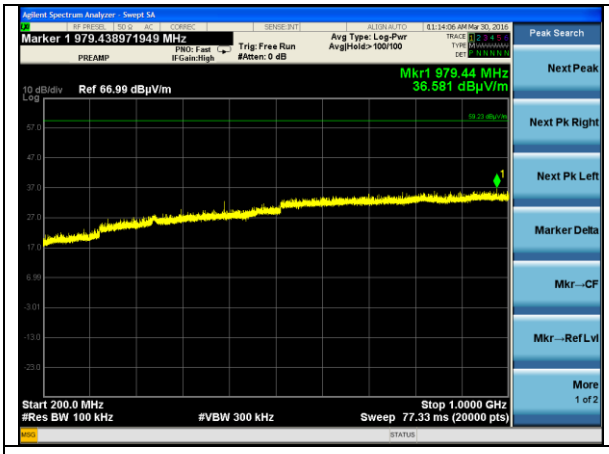


Horizontal



Vertical

200 to 1000 MHz



Horizontal

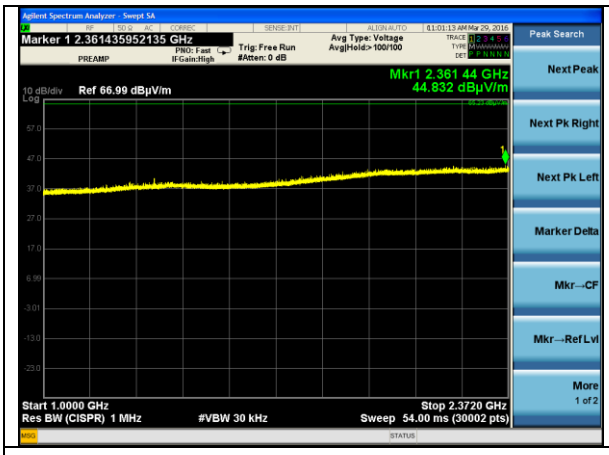
Vertical

Note: The display line in the above plots indicates the limit with respect to the highest peak found. All other measurements are noise floor and meet the limits of Table 4 in ETSI 300 328 V1.9.1.

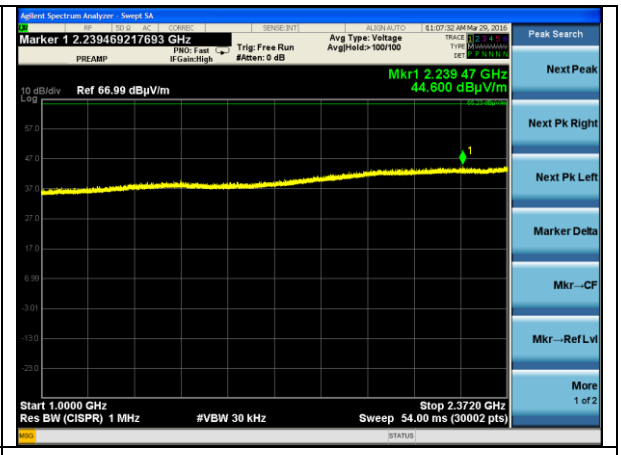
D. 1000 MHz to 12750 MHz

Note: Plots presented are those when in 802.1b (1MBPS) since it was determined that it is the worst case combination of modulation and output power.

1000 to 2372 MHz

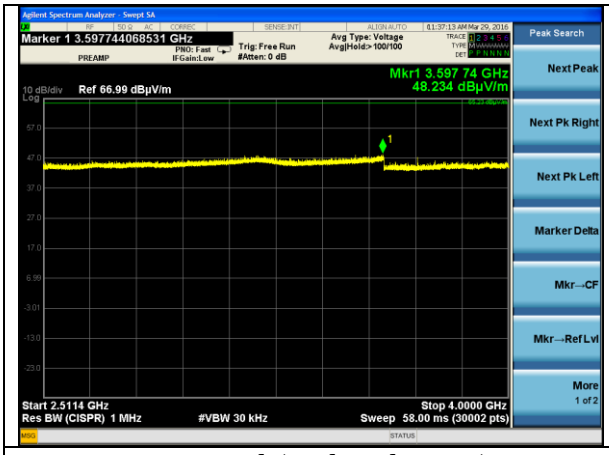


Horizontal (Reduced VBW)

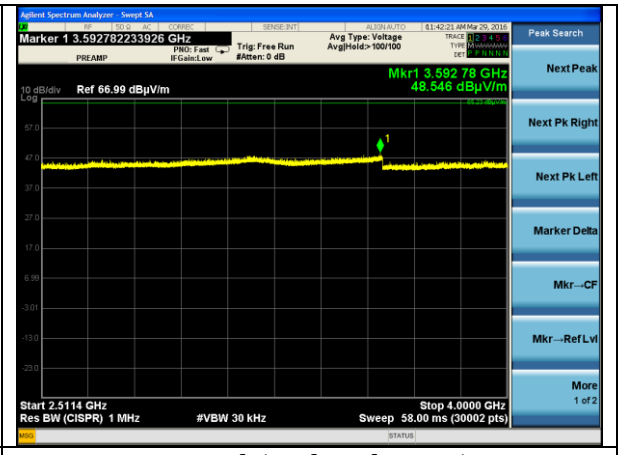


Vertical (Reduced VBW)

2511.4 to 4000 MHz

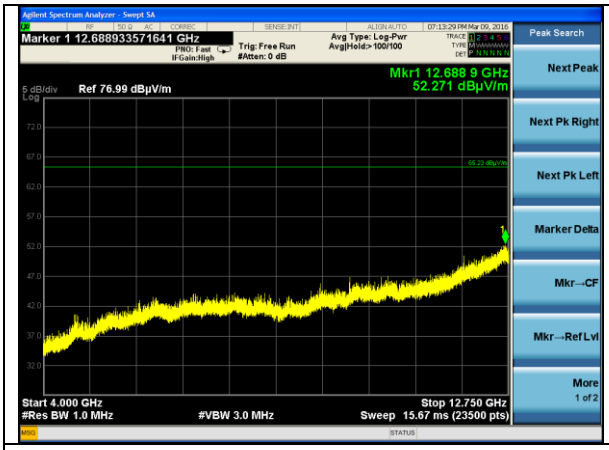


Horizontal (Reduced VBW)

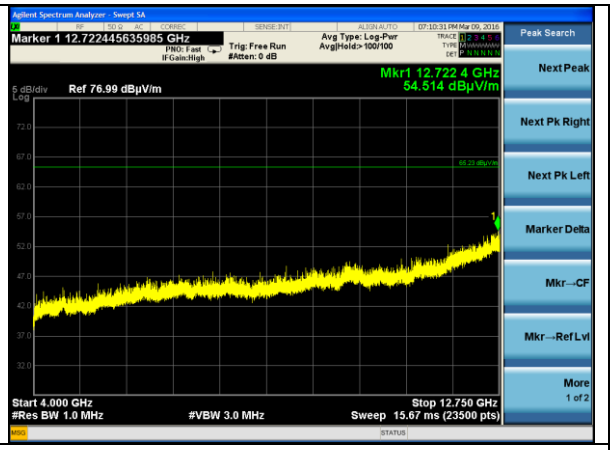


Vertical (Reduced VBW)

4000 to 12750 MHz



Horizontal



Vertical

C.2.9 – Receiver spurious emissions

Manufacturer	LS Research
Date	March 9th - May 27th, 2016
Operator	Kimberly Bay, Coty Hammerer
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.2.10
Test Procedure Section	5.3.11 - Conducted and Radiated Measurements
Additional Notes	1. See section C1.10 of the report for BLE transmitter spurious measurements, classic Bluetooth measurements are leveraged for BLE due to higher output power. 2. Three orthogonal positions of device measured radiated. 3. Reduced VBW utilized to reduce noise floor for identifying emissions. Final measurements use test procedure.

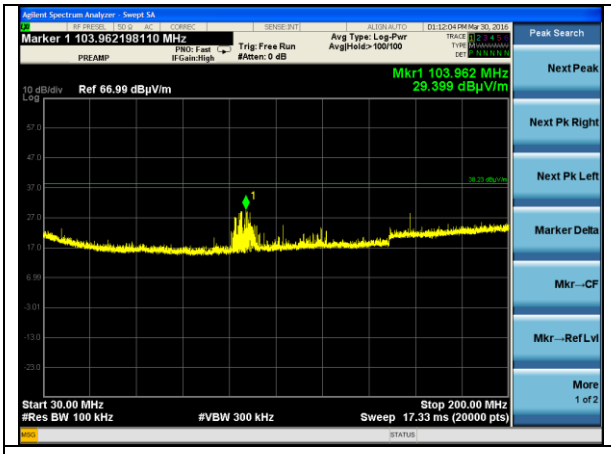
Radiated Emissions (WLAN):

Note: Highest Emissions measured are reflected in the below plots, Low and High Channel plots and measurements were recorded.

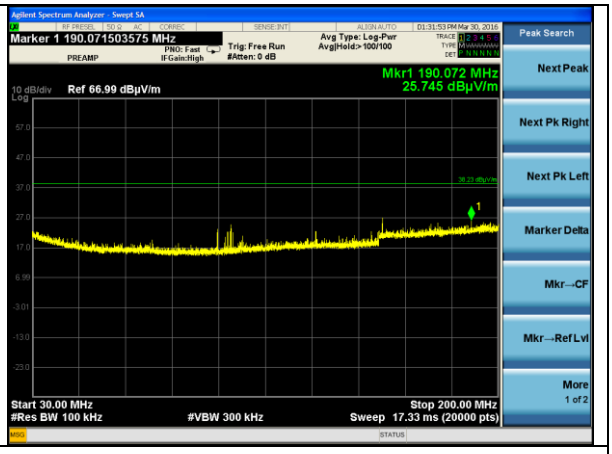
Chip Antenna

A. 30 MHz to 1000 MHz

30 to 200 MHz

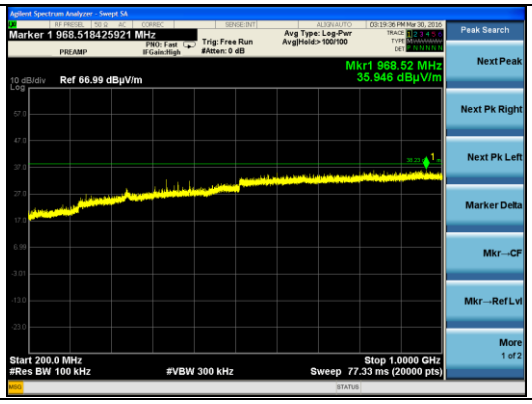


Horizontal

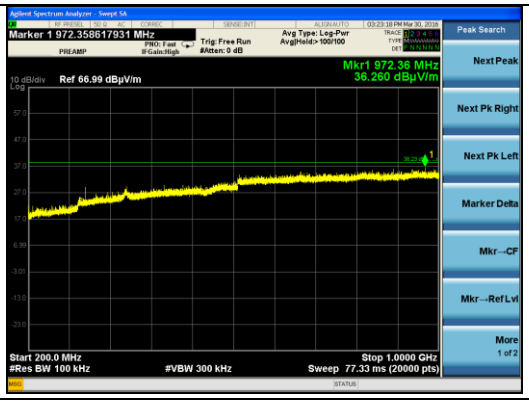


Vertical

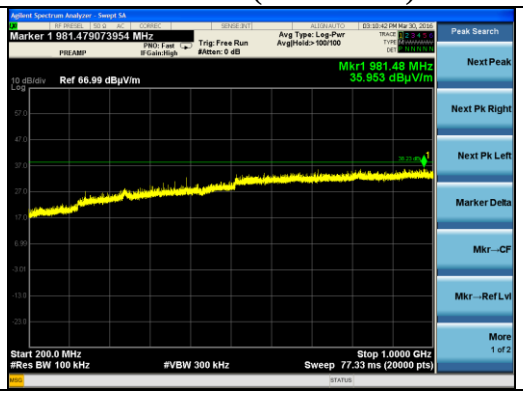
200 to 1000 MHz



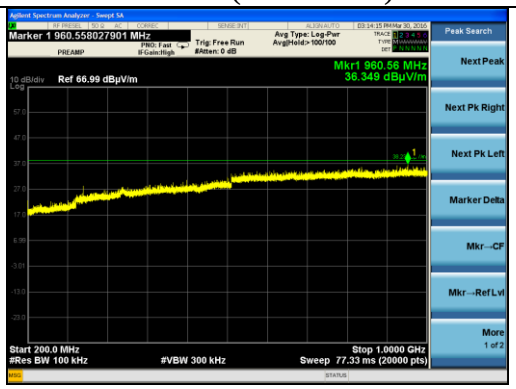
Horizontal (Radio OFF)



Vertical (Radio OFF)



Horizontal (Radio ON)



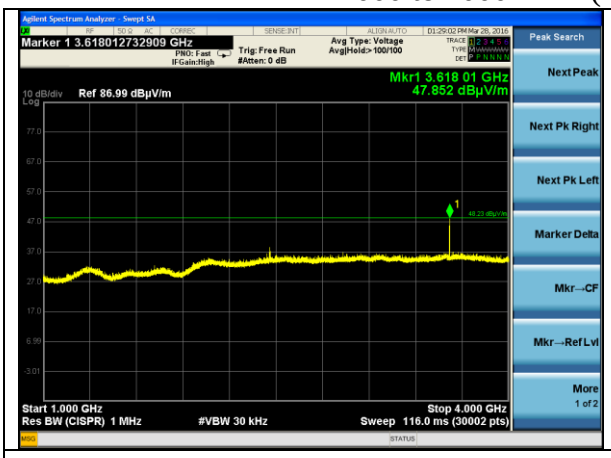
Vertical (Radio ON)

B. 1000 MHz to 12750 MHz

Procedure: 5.3.11.2.1.3
Substitution Method: C.3

Frequency (MHz)	Height (m)	Azimuth (degree)	Sig. Gen Power (dBm)	Cable Loss (dB)	Antenna Gain (dBi)	Power (dBm)	Limit (dBm)	Margin (dB)	Ant. Pol	Channel	Notes
7416.0	1.35	0.00	-65.50	-1.75	11.01	-56.24	-47.00	9.24	H	13	Chip
7416.0	1.46	0.00	-70.20	-1.75	11.01	-60.94	-47.00	13.94	V	13	Chip
7236.0	1.41	0.00	-75.00	-1.75	11.10	-65.65	-47.00	18.65	H	13	Port Term.
3600.0	1.38	0.00	-79.00	-1.75	11.10	-69.65	-47.00	22.65	V	13	Port Term.
3618.0	1.11	0.00	-57.00	-1.07	9.87	-48.20	-47.00	1.20	H	1	Chip
3618.0	1.38	0.00	-57.80	-1.07	9.87	-49.00	-47.00	2.00	V	1	Chip
3708.0	1.19	0.00	-60.00	-1.07	9.62	-51.45	-47.00	4.45	H	13	Chip
3708.0	1.68	0.00	-61.60	-1.07	9.62	-53.05	-47.00	6.05	V	13	Chip

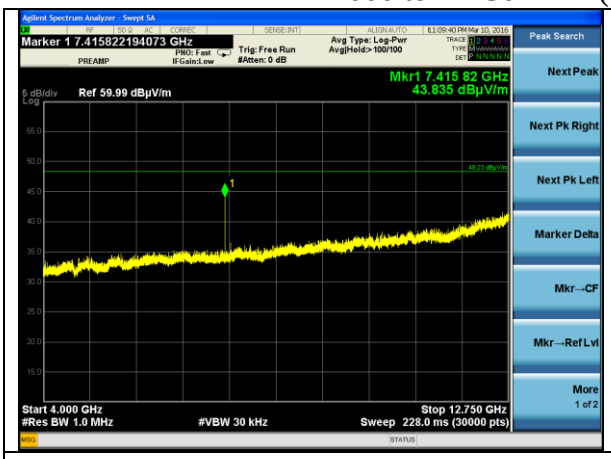
1000 to 4000 MHz (Reduced bandwidth)



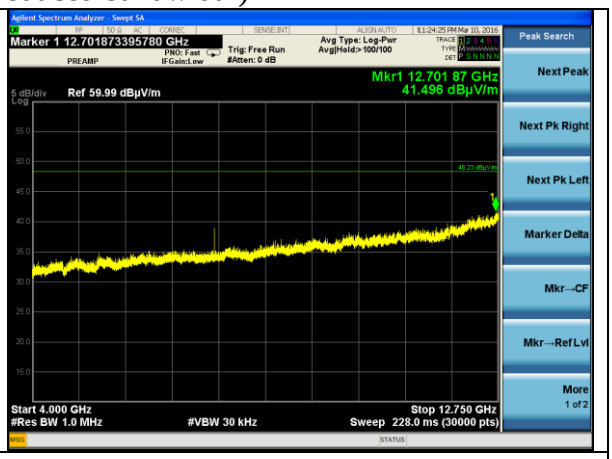
Horizontal

Vertical

4000 to 12750 MHz (Reduced bandwidth)



Horizontal

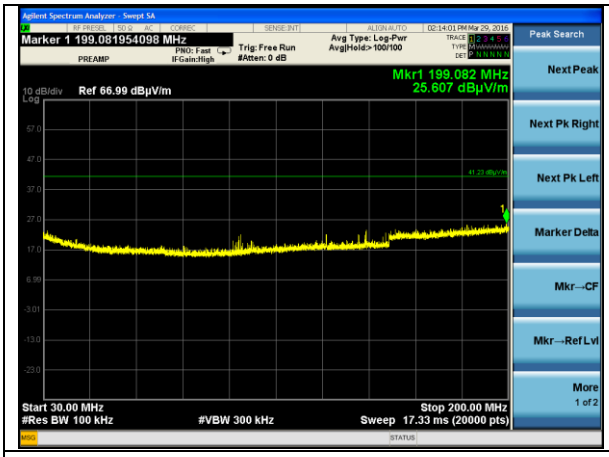


Vertical

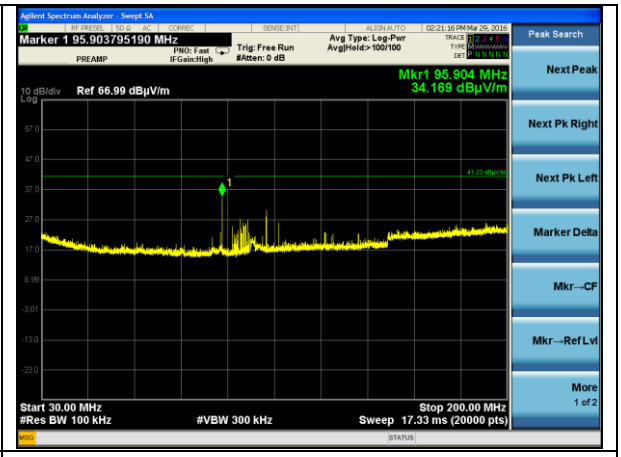
Antenna Port Terminated

C. 30 MHz to 1000 MHz

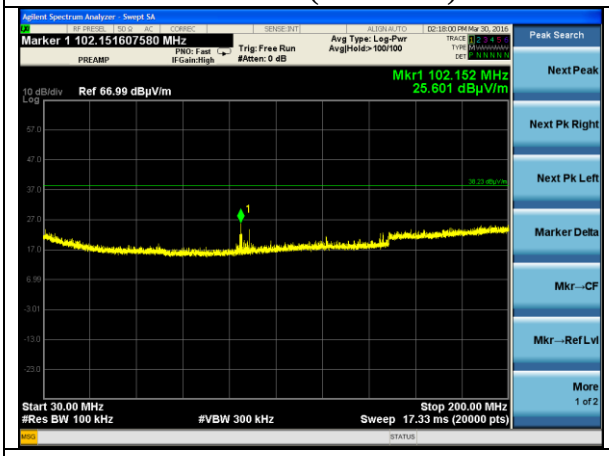
30 to 200 MHz



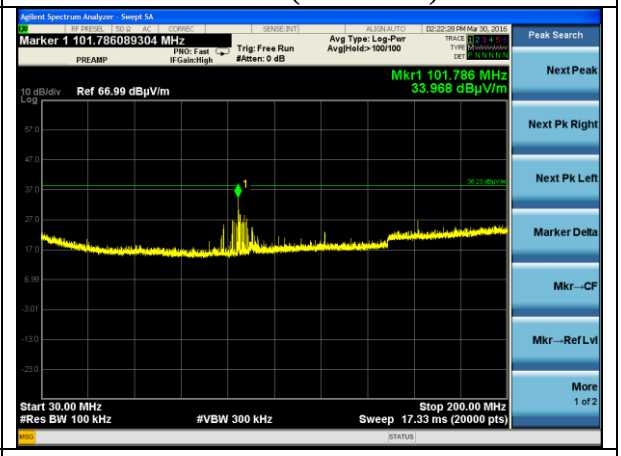
Horizontal (Radio Off)



Vertical (Radio Off)

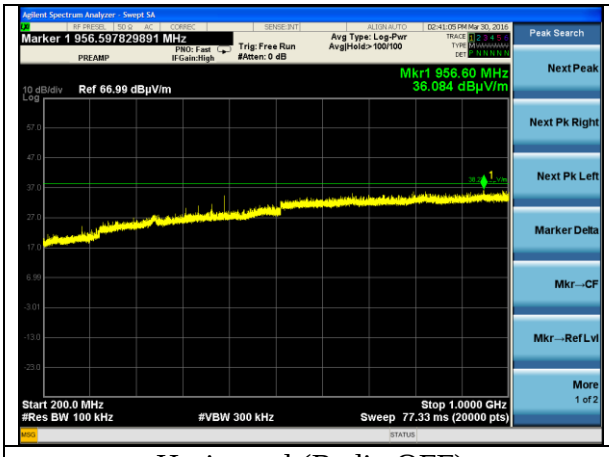


Horizontal (Radio ON)



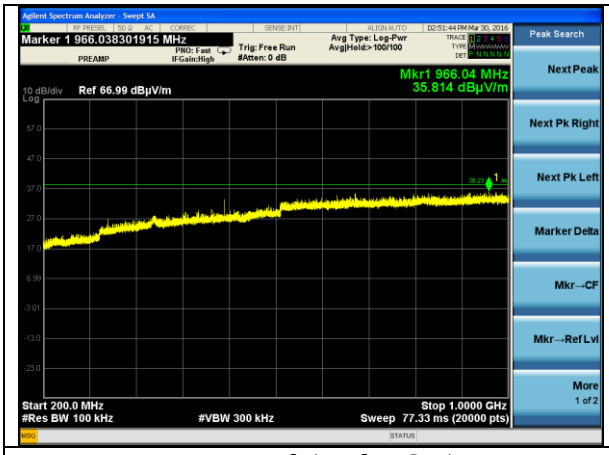
Vertical (Radio ON)

200 to 1000 MHz



Horizontal (Radio OFF)

Vertical (Radio OFF)

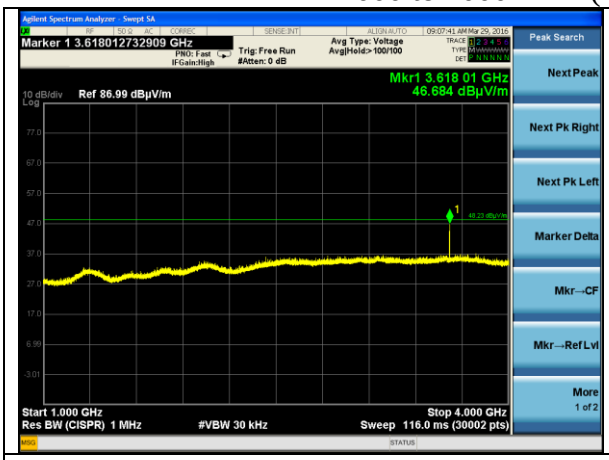


Horizontal (Radio ON)

Vertical (Radio ON)

D. 1000 MHz to 12750 MHz

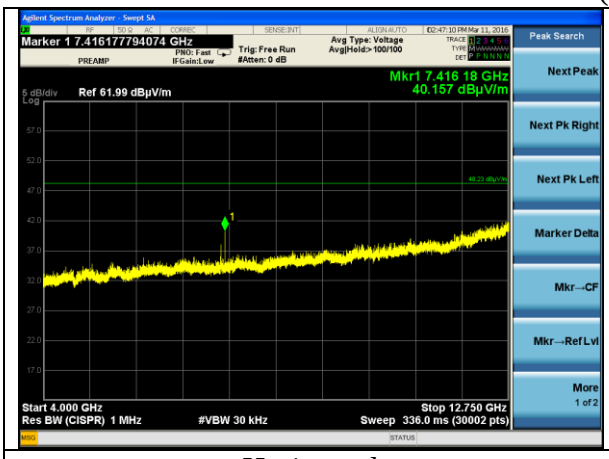
1000 to 4000 MHz (Reduced bandwidth)



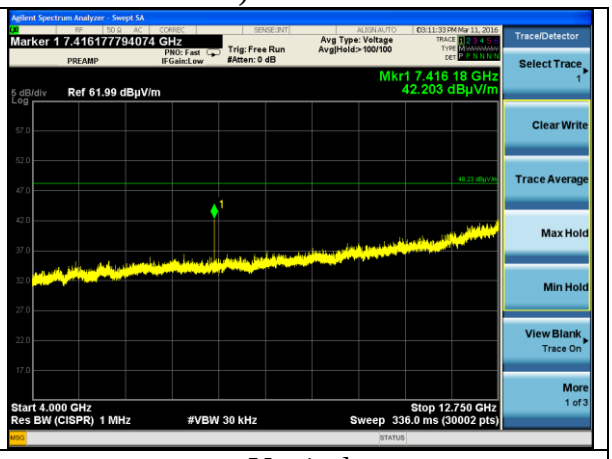
Horizontal

Vertical

4000 to 12750 MHz (Reduced bandwidth)



Horizontal



Vertical

C.2.10 – Receiver Blocking

Manufacturer	LS Research
Date	N/A
Operator	Michael Hintzke
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.2.11
Test Procedure Section	5.3.7 (Part of Adaptivity procedure)
Additional Notes	See section C.2.5 of this report as it is part of the Adaptivity procedure to show compliance to this requirement. (Adding the blocking signal)

Table 6: Receiver Blocking parameters

Equipment Type (LBT / non- LBT)	Wanted signal mean power from companion device	Blocking signal frequency [MHz]	Blocking signal power [dBm]	Type of interfering signal
LBT	sufficient to maintain the link (see note 2)	2 395 or 2 488,5 (see note 1)	-35	CW
Non-LBT	-30 dBm			
NOTE 1: The highest blocking frequency shall be used for testing operating channels within the range 2 400 MHz to 2 442 MHz, while the lowest blocking frequency shall be used for testing operating channels within the range 2 442 MHz to 2 483,5 MHz. See clause 5.3.7.1.				
NOTE 2: A typical value which can be used in most cases is -50 dBm/MHz.				

C.2.11 – Geo-location capability

Manufacturer	LS Research
Date	N/A
Operator	N/A
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Standard	ETSI EN 300 328 v1.9.1
Technical Requirement Section	4.3.2.12
Test Procedure Section	5.3.7
Additional Notes	Manufacturer declares equipment does not have geo-location capability

Appendix D - Uncertainty Summary

Table of Expanded Uncertainty Values, (K=2) for Specified Measurements

	PARAMETER	ETSI ± Uncertainty	LSR ± Uncertainty
1	Radio Frequency, from F0	$\pm 1x10^{-5}$	$\pm 1.3x10^{-7}$
2	Total RF conducted Power	±1.5 dB	±1.38 dB
3	RF conducted power density	±3.0 dB	±1.38 dB
4	Conducted spurious emissions	±3.0 dB	±1.38 dB
5	Radiated emissions	±6.0 dB	±4.87 dB
6	Temperature	±1° C	±0.64° C
7	Humidity	±5 %	±2.9 %
8	DC voltage	±3 %	±0.03 %
9	Low frequency voltage	±3 %	±0.1 %

Appendix E - References

Publication	Year	Title
ETSI EN 300 328 v1.9.1	(2015-02)	Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz ISM band and using wide band modulation techniques; Harmonized EN covering essential requirements under article 3.2 of the R&TTE Directive

END OF REPORT

Date	Version	Comments	Person
6/24/16	V0	Initial Draft Release	Coty
7/5/16	V1	Internal Review Comments Addressed	Coty
7/17/16	V2	Internal Review Comments Addressed	Coty
7/21/16	V3	Final Version	Coty