

FCC Part 15.247 RF TEST REPORT



Test Report Number.....	PFE-18100201-LC-FCC-RF-LEAP Rev1.1
Applicant.....	Phase IV Engineering 
Applicant Address.....	2820 Wilderness Place Suite C, Boulder, CO 80301
Product Name.....	Leap 2.4GHz RF Module
Model Number.....	44-100312-00, 44-100312-01
FCC ID.....	N4TLEAP1000
Date of EUT received.....	10/18/2018
Date of Test.....	10/18/2018-11/14/2018
Report Issue Date.....	11/20/2018
Test Standards.....	47CFR Part 15.247: 2018

Issued By:

Vista Laboratories

1261 Puerta Del Sol, San Clemente, CA 92673 USA

www.vista-compliance.com

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Tested by:



Sherwin Lee/Test Engineer

Approved By:



David Zhang/Technical Manager

Report Number:	PFE-18100201-LC-FCC-RF-LEAP Rev1.1
Product:	Leap 2.4GHz RF Module
Model Number:	44-100312-00, 44-100312-01



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REVISION HISTORY

Revision	Issue Date	Description	Note
Original	11/06/2018	Original release	N/A
Rev1.0	11/14/2018	Add below 30MHz test data and update equipment information, etc.	N/A
Rev1.1	11/20/2018	Update EUT information and procedure description	N/A

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1 General Information

1.1 Applicant

Applicant:	Phase IV Engineering
Applicant address:	2820 Wilderness Place Suite C, Boulder, CO 80301
Manufacturer:	Phase IV Engineering
Manufacturer Address:	2820 Wilderness Place Suite C, Boulder, CO 80301

1.2 Product information

Product Name	LEAP 2.4GHz RF Module
Model Number	On-board antenna version model: 44-100312-00 Off-board antenna version model: 44-100312-01
Serial Number	N/A
Frequency Band	2405-2470MHz
Type of modulation	DSSS
Equipment Class/ Category	DTS
Maximum output power	18.532 dBm
Antenna Information	Internal PIFA Antenna (Amotech #AMAN301512ST01), Gain: 3.4 dBi Folded Dipole Long (#ANT-2.4-CW-HW), Gain: 3.2 dBi Folded Dipole Short (#W24-RSMA-M), Gain: 2.15 dBi Monopole (#HG2407RD-RSP), Gain: 7 dBi Yagi (#HG2412SY-NF), Gain: 12 dBi
Clock Frequencies	N/A
Port/Connectors	U.FL
Input Power	3.3 VDC
Power Adapter Manu/Model	N/A
Power Adapter SN	N/A
Hardware version	Rev2.3
Software version	N/A
Simultaneous Transmission	N/A
Additional Info	This radio module has two hardware version, one with on-board chip antenna and the other one with off-board external antennas. 4 different external antennas were tested. On-board antenna version is with C20, L3 and L4 populated which serve as impedance matching, RF path selection and filtering purpose; these components are not required for Off-board antenna version thus being removed. An FCC inquiry (Tracking Number 923500) was sent to FCC and response was received to confirm that both hardware version can be certified with an original filing.

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1.3 Power level setting

Antenna	Channel	Frequency (MHz)	Power Level Setting
Internal PIFA Antenna	1-24	2405-2470	20
Folded Dipole Long	1-24	2405-2470	20
Folded Dipole Short	1-24	2405-2470	20
Monopole	1-24	2405-2470	20
Yagi	1-23	2405-2465	20
Yagi	24	2470	15

Note: Power level setting for Yagi antenna at 2470MHz is 15 only in order to meet FCC restricted band edge requirement. Applicant shall ensure the correct setting is used by end user.

1.4 Test standard and method

Test standard	47CFR Part 15.247: 2018
Test method	ANSI C63.10: 2013 558074 D01 15.247 Meas Guidance v05

1.5 Test purpose and statement

The purpose of this test report is intended to demonstrate the compliance of product listed in section 1.2, received from company listed in section 1.1, to the requirements of standard and method listed in section 1.3. Based on our test results, we conclude that the product tested complies with the requirements of the standards indicated.

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2 Test site information

Lab performing tests	Vista Laboratories
Lab Address	1261 Puerta Del Sol, San Clemente, CA 92673 USA
Phone Number	+1 (949) 393-1123
Website	www.vista-compliance.com

Test condition	Test Engineer	Test Environment	Test Date
RF conducted	Sherwin Lee	23.5°C / 58.2%/996 mbar	10/18/2018 – 10/26/2018
Radiated	Sherwin Lee	23.5°C / 58.2%/996 mbar	10/18/2018 – 11/14/2018

3 Modification of EUT

For RF conducted measurement purposes, the internal antenna port of the test sample was removed and replaced with an external SMA connector; the external antenna port was unmodified because it has a direct port to connect to. A short serial wire cable was soldered onto the PCB for sending commands from the laptop to the EUT to enable RF testing mode; the special test firmware is used for testing purpose.

For radiated measurement, a short serial wire cable was soldered onto the PCB for sending commands from the laptop to EUT to enable RF test mode; the special test firmware is used for testing purpose. No other physical modification was made.

4 Test configuration and operation

4.1 EUT test configuration

The EUT is powered by a 3.3 VDC power supply. It is connected to a test laptop through a serial cable and receives test commands for RF measurement. Radio test software is used to send commands to EUT to enable the RF test mode.

4.2 EUT test mode

Radio	Channel	Data Rates	Frequency (MHz)
2.4 GHz Transceiver	1 (Low)	250 kbps	2405
2.4 GHz Transceiver	18 (Mid)	250 kbps	2440
2.4 GHz Transceiver	24 (High)	250 kbps	2470

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4.3 Supporting Equipment

Index	Description	Model	S/N	Brand	Remark
1	Laptop	P29G003	G1H5102	Dell	N/A
2	DC Power Supply	DP712	DP7B194900487	RIGOL	N/A

4.4 EUT setup diagram



4.5 EUT operation

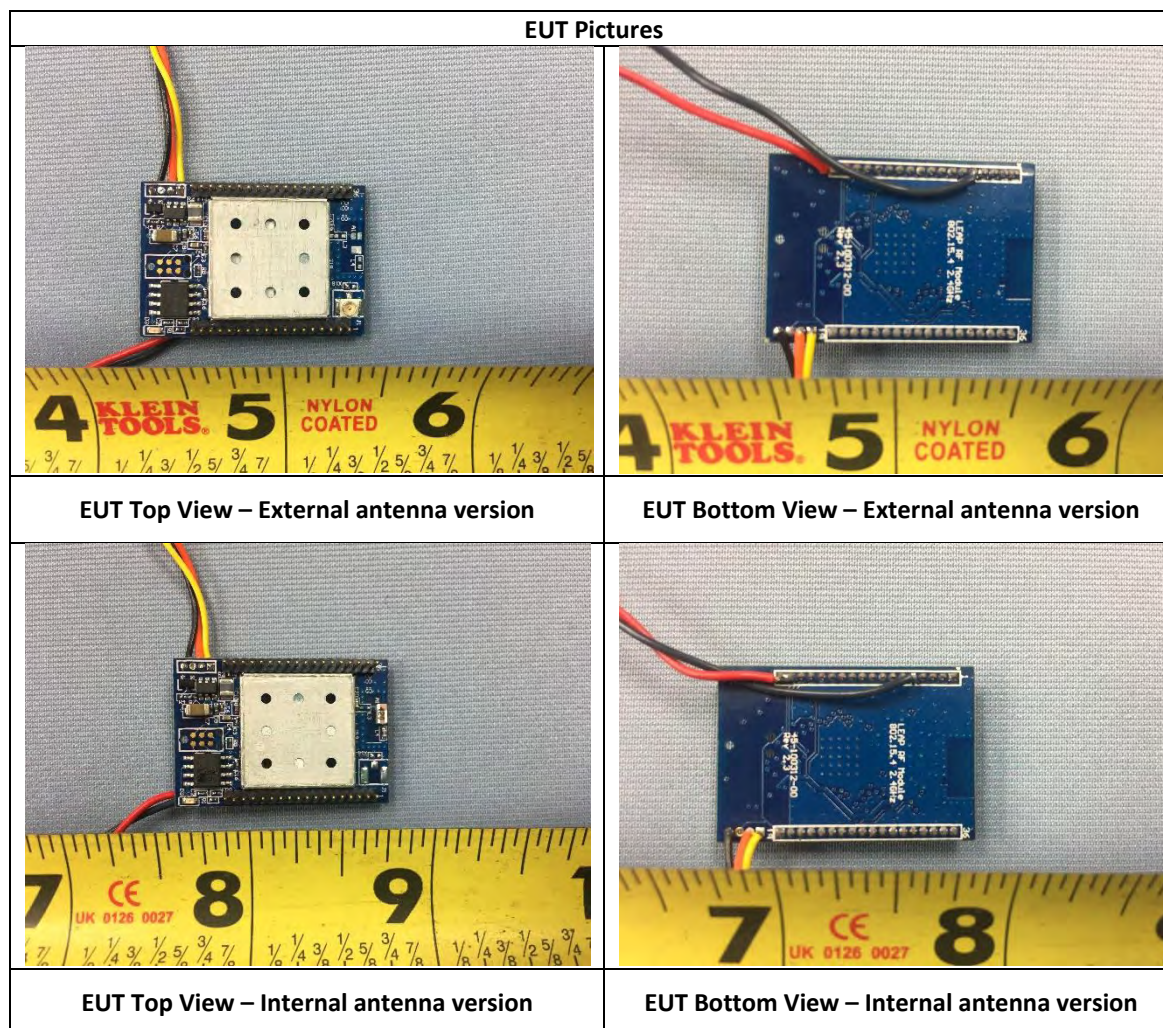
Radio test software is used to send command to EUT to enable the RF test mode.

4.6 Test software

Index	Description	Remark
1	RadioTest.exe	Serial utility software to send command to device for running RF test mode.
2	EMISoft Vasona 6.0049	EMC/Spurious emission test software used during testing

5 EUT and test setup pictures

5.1 EUT pictures

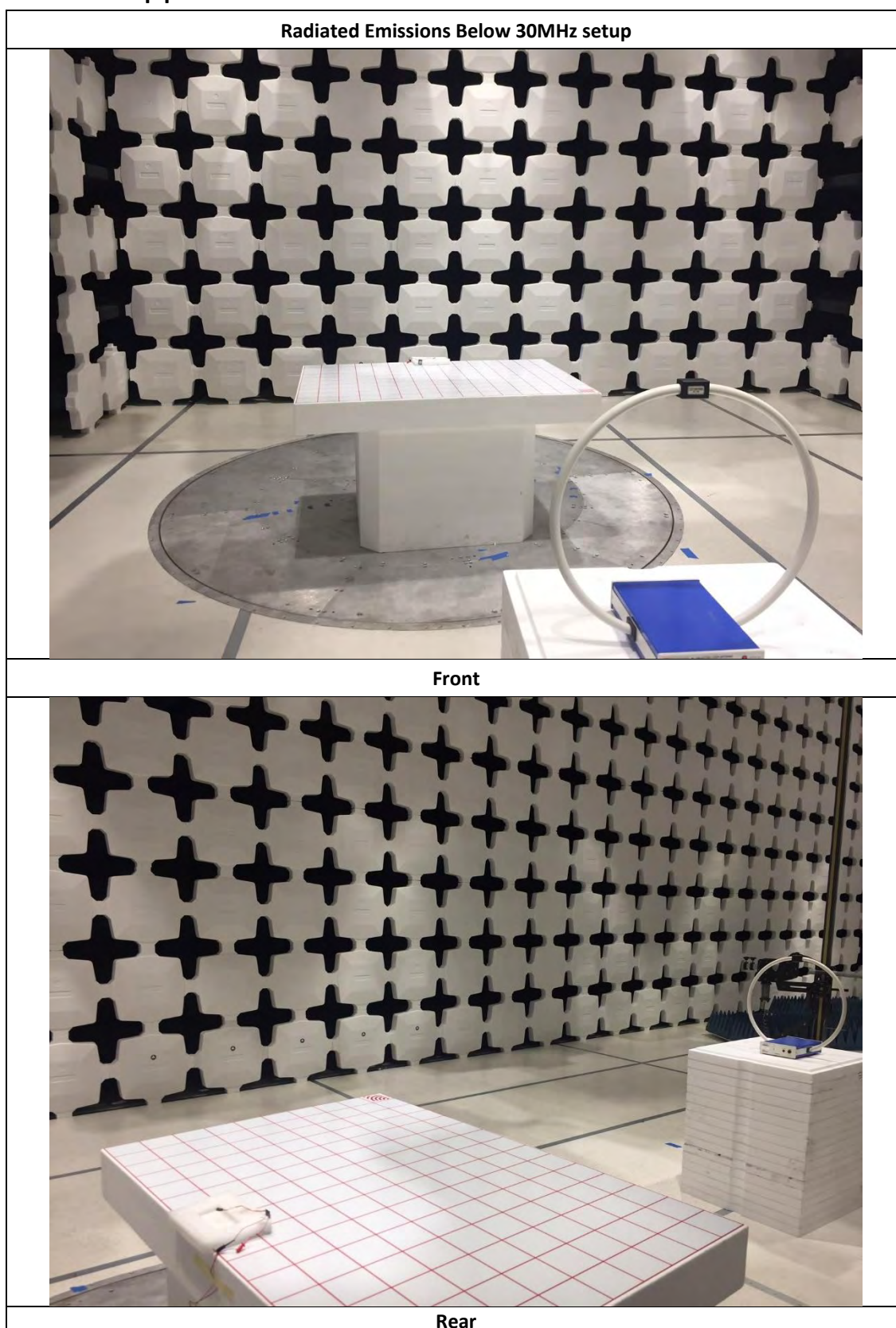


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External Antenna	
Yagi antenna (with U.FL connector)	Monopole antenna (with RP-SMA connector)
Folded Dipole, Long (with RP-SMA connector)	Folded Dipole, Short (with RP-SMA connector)
RF coupling cable (RP-SMA connector) - Front	RF coupling cable (RP-SMA connector) - Top

5.2 EUT test setup pictures



Report Number: PFE-18100201-LC-FCC-RF-LEAP Rev1.1

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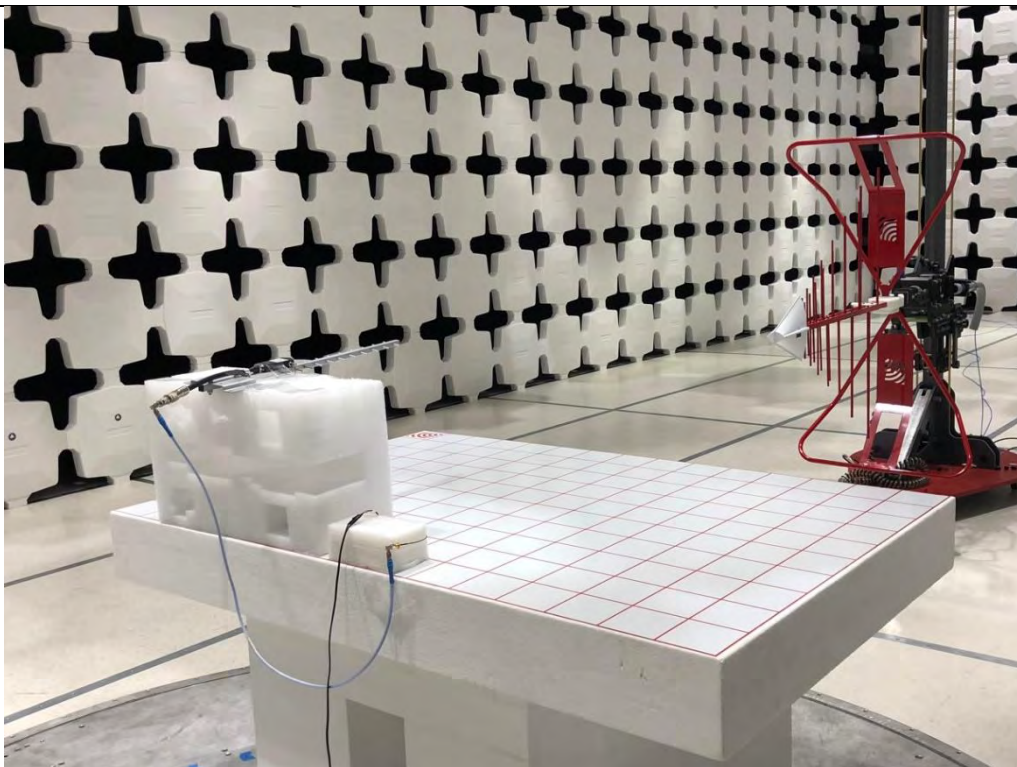


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Radiated Emissions Below 1GHz setup (Yagi antenna)



Front



Rear

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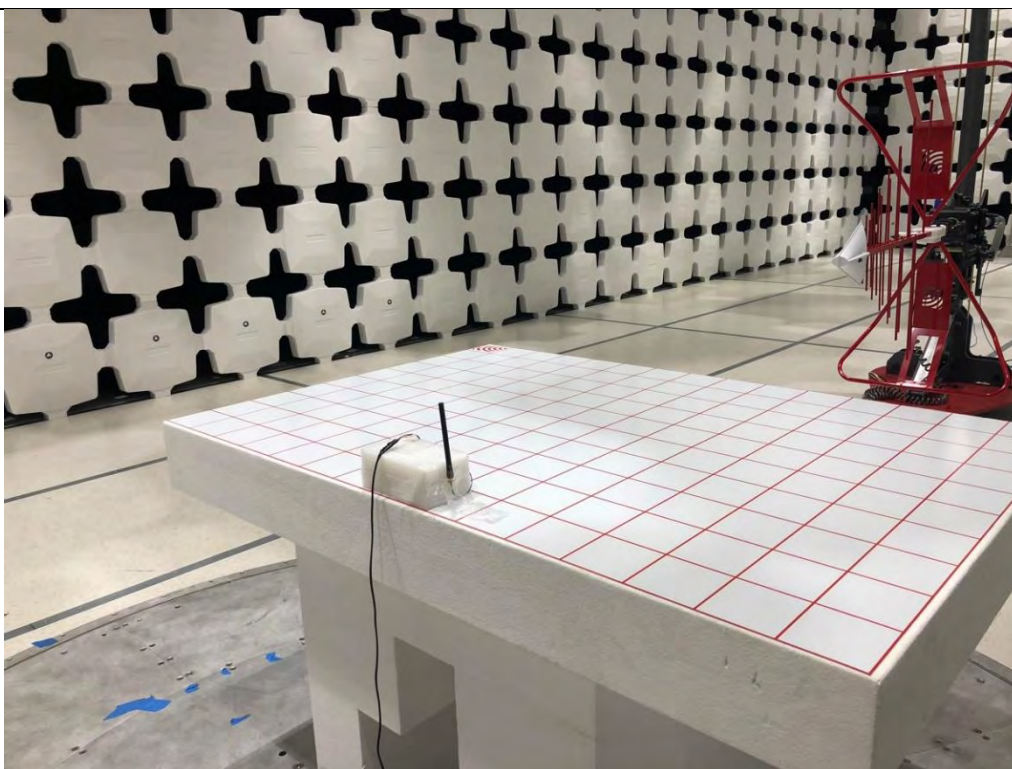


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Radiated Emissions Below 1GHz setup (monopole antenna)



Front



Rear

Report Number: PFE-18100201-LC-FCC-RF-LEAP Rev1.1

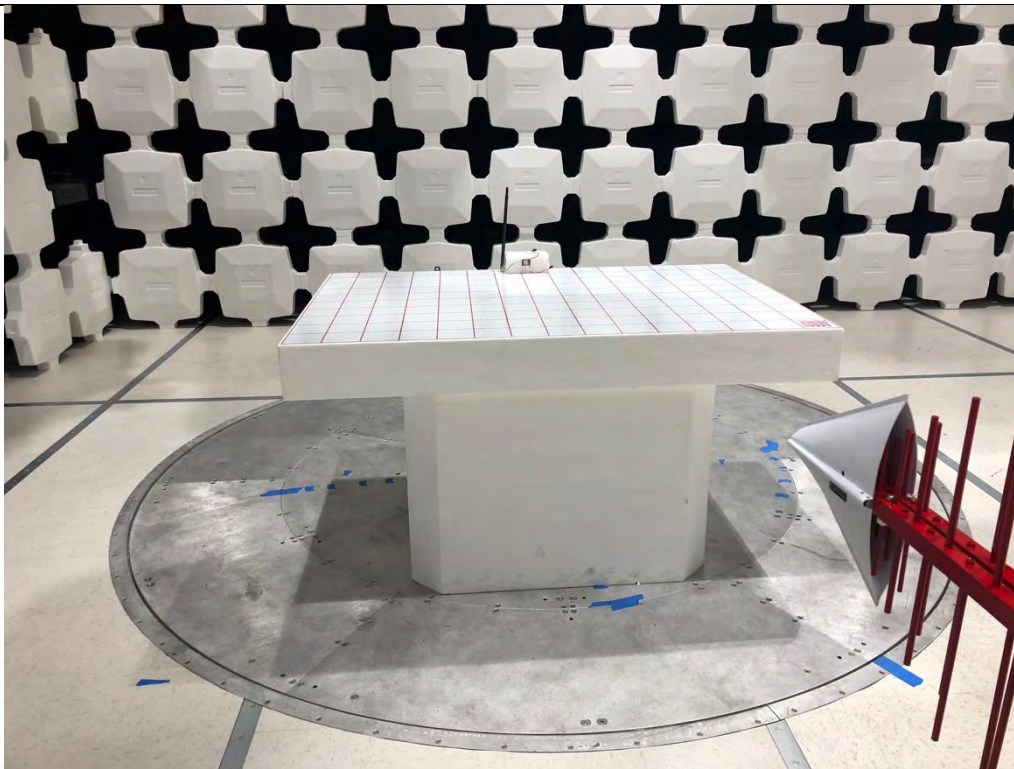
Product: Leap 2.4GHz RF Module

Model Number: 44-100312-00, 44-100312-01

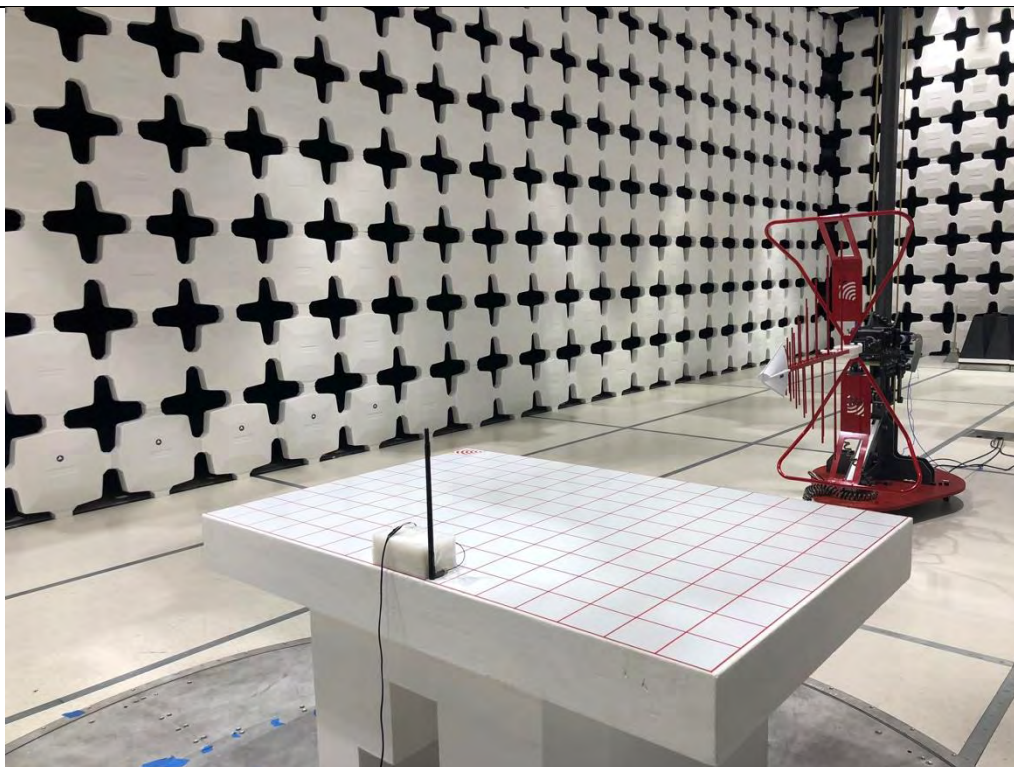


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Radiated Emissions Below 1GHz setup (folded dipole antenna, long)



Front



Rear

Report Number: PFE-18100201-LC-FCC-RF-LEAP Rev1.1

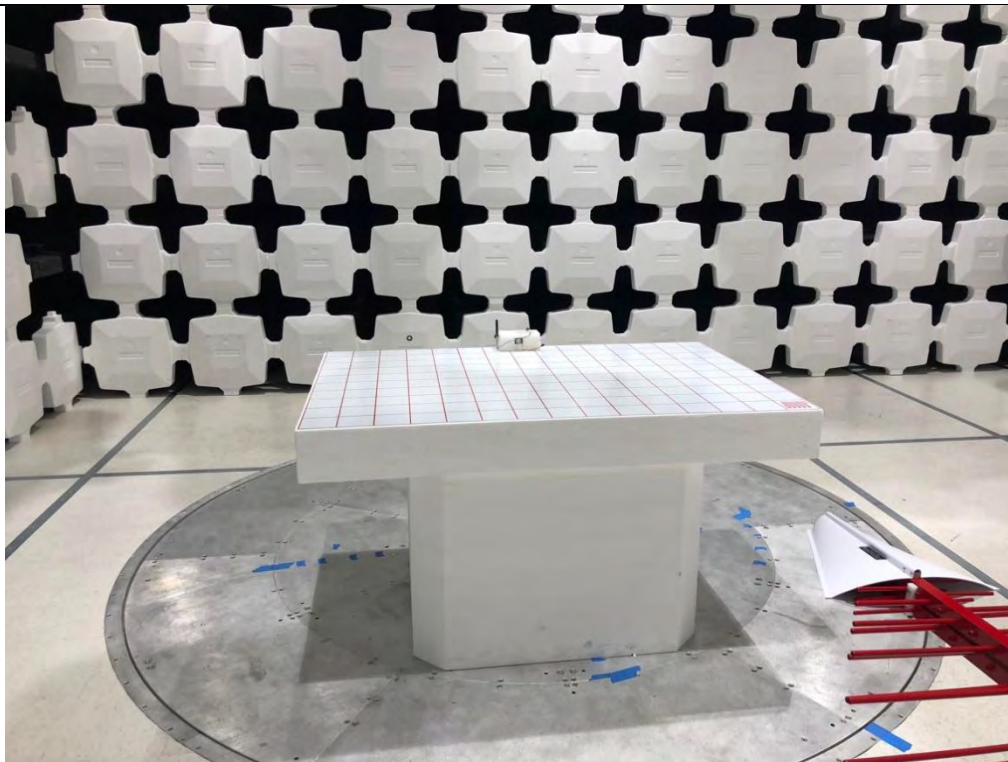
Product: Leap 2.4GHz RF Module

Model Number: 44-100312-00, 44-100312-01

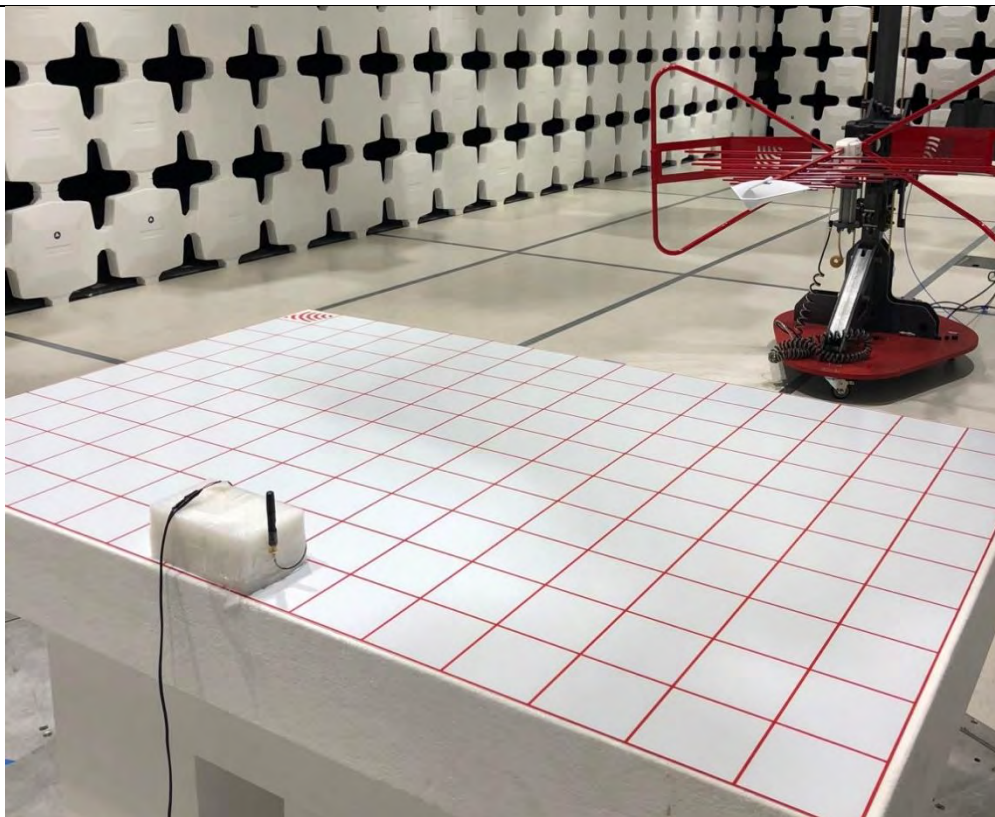


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Radiated Emissions Below 1GHz setup (folded dipole antenna, short)



Front



Rear

Report Number: PFE-18100201-LC-FCC-RF-LEAP Rev1.1

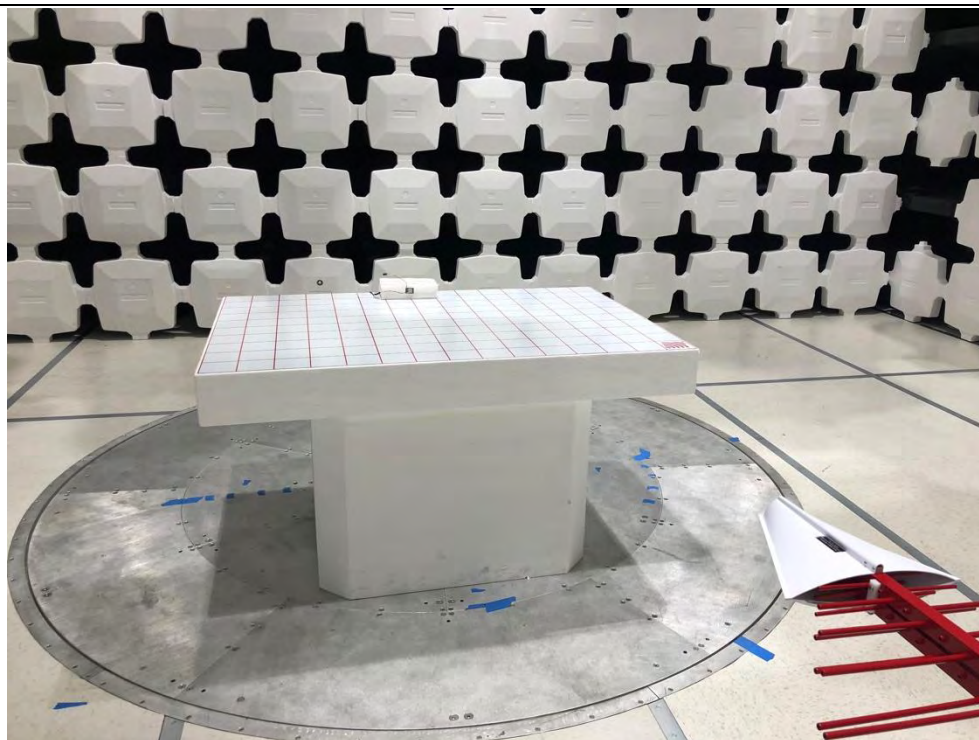
Product: Leap 2.4GHz RF Module

Model Number: 44-100312-00, 44-100312-01

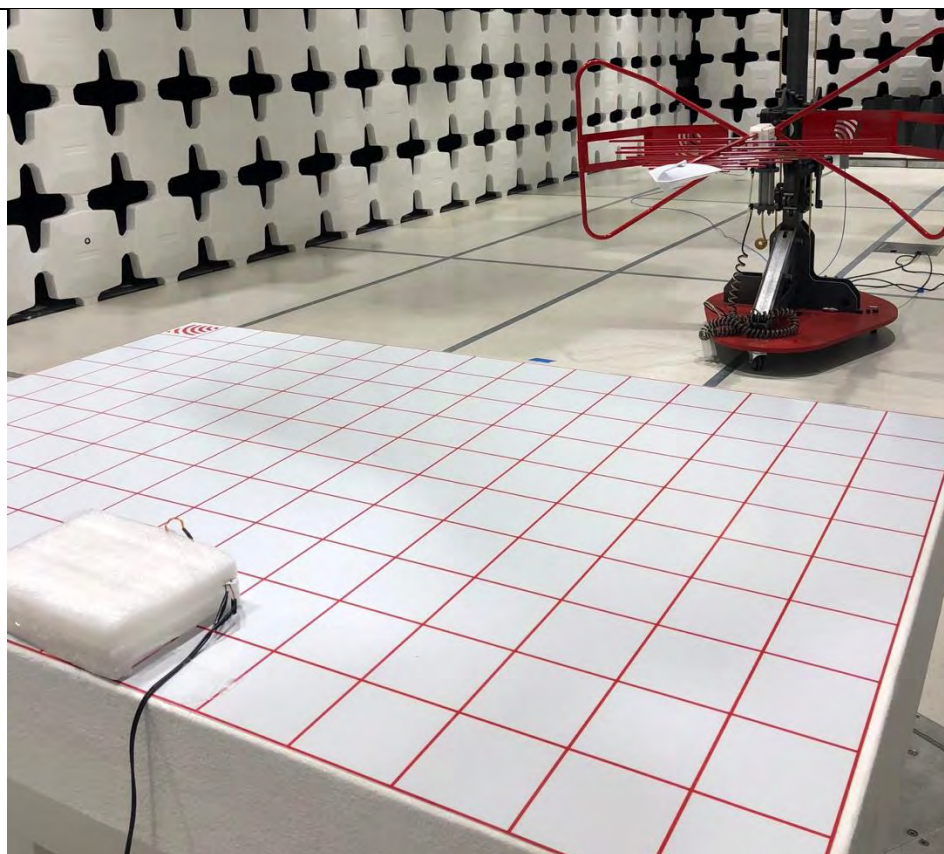


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Radiated Emissions Below 1GHz setup (internal antenna)

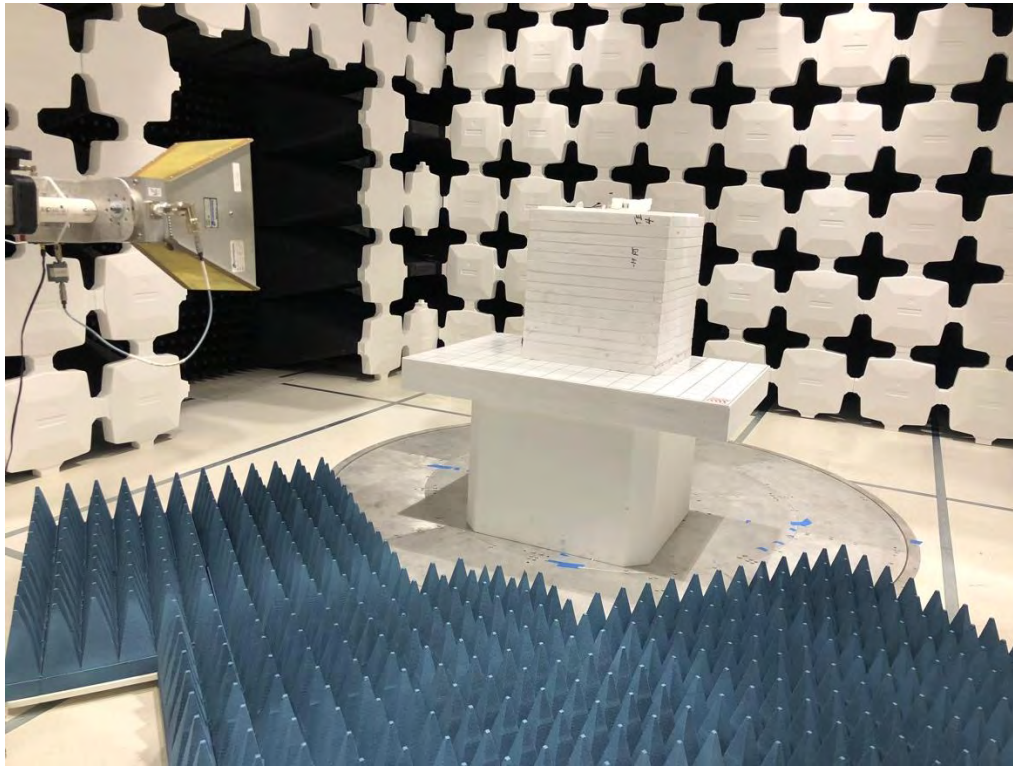


Front

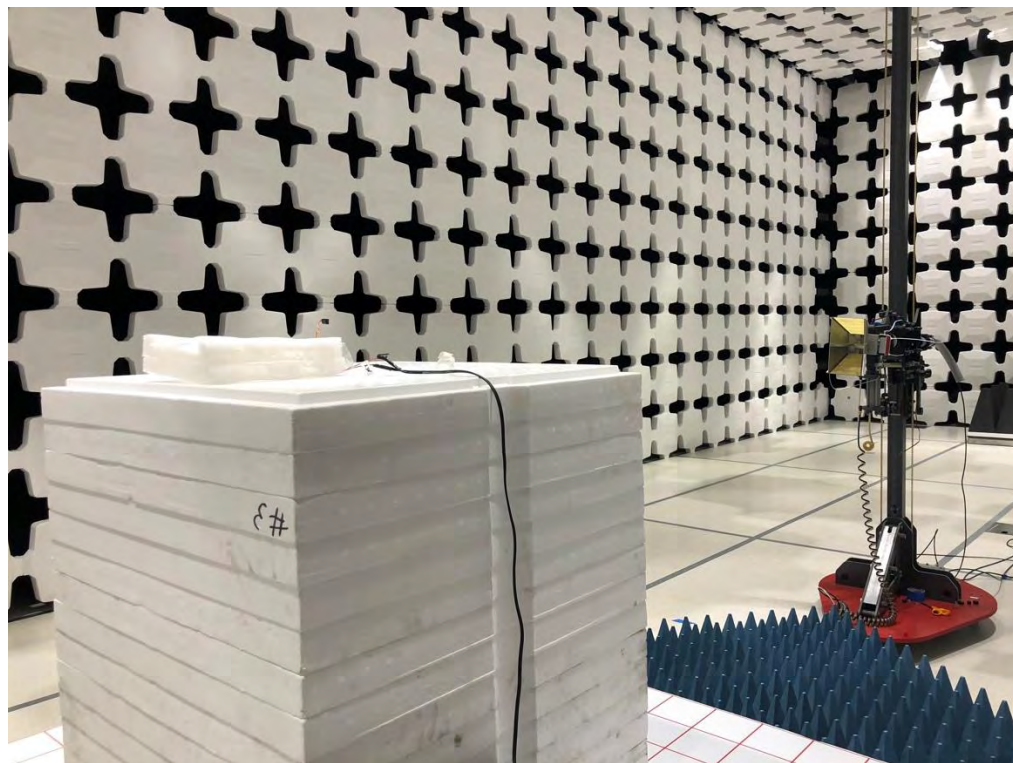


Rear

Radiated Emissions Above 1GHz setup (internal antenna)



Front



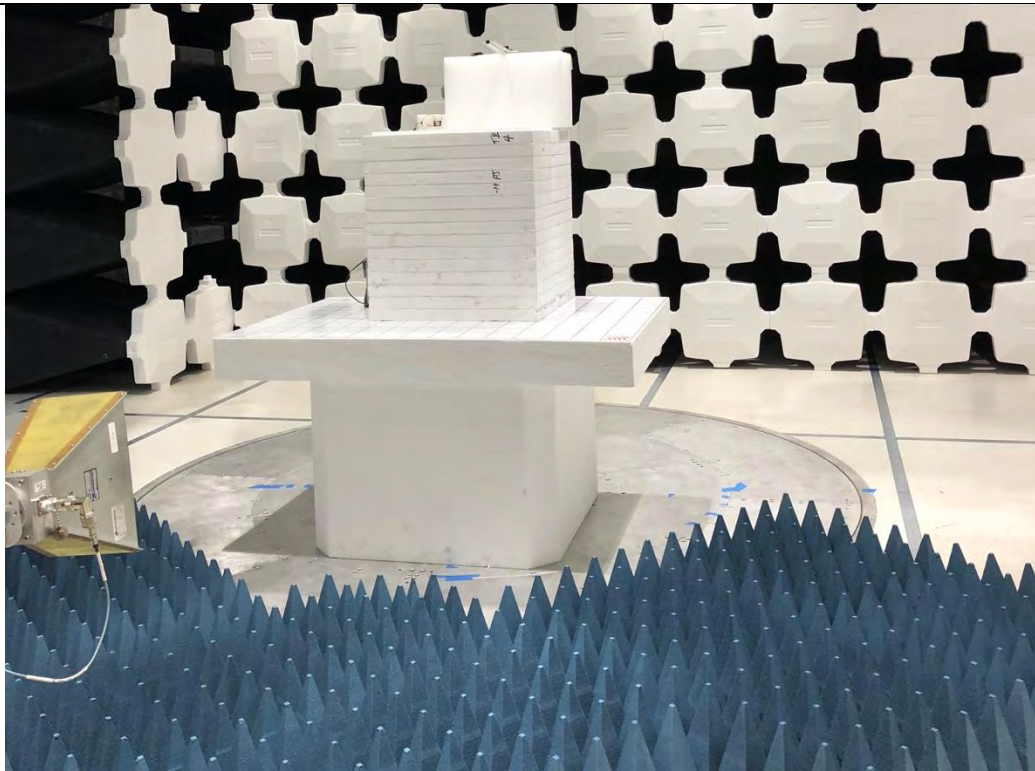
Rear

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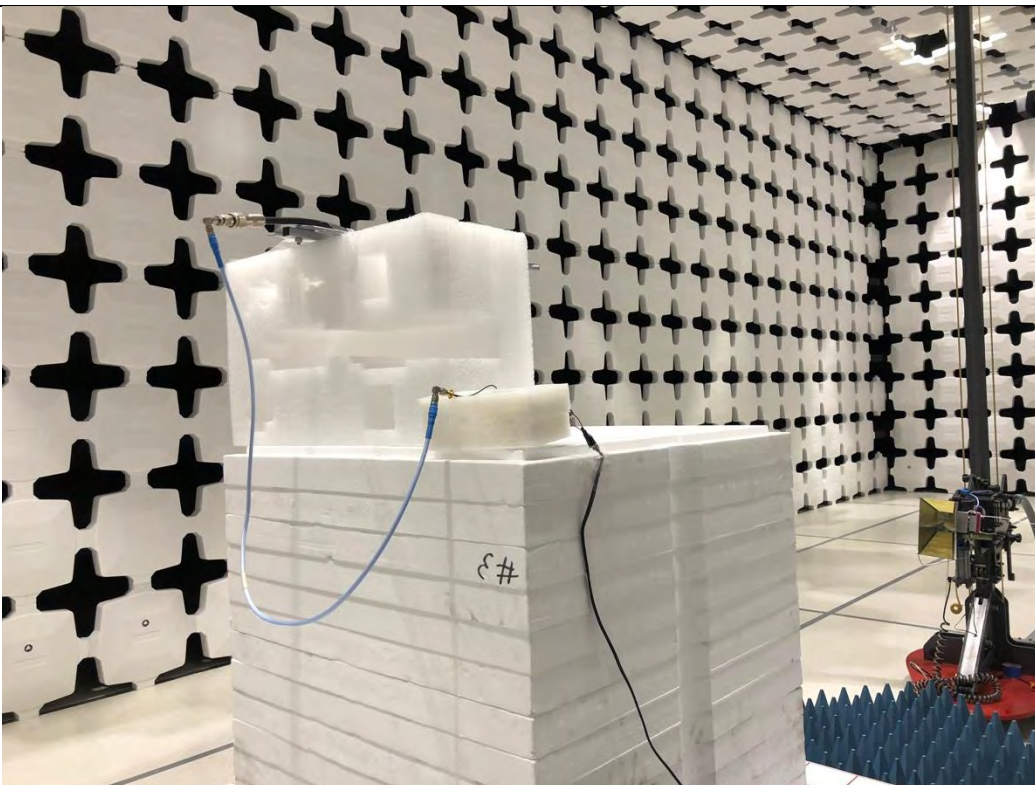


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Radiated Emissions Above 1GHz setup (Yagi antenna)



Front



Rear

Report Number: PFE-18100201-LC-FCC-RF-LEAP Rev1.1

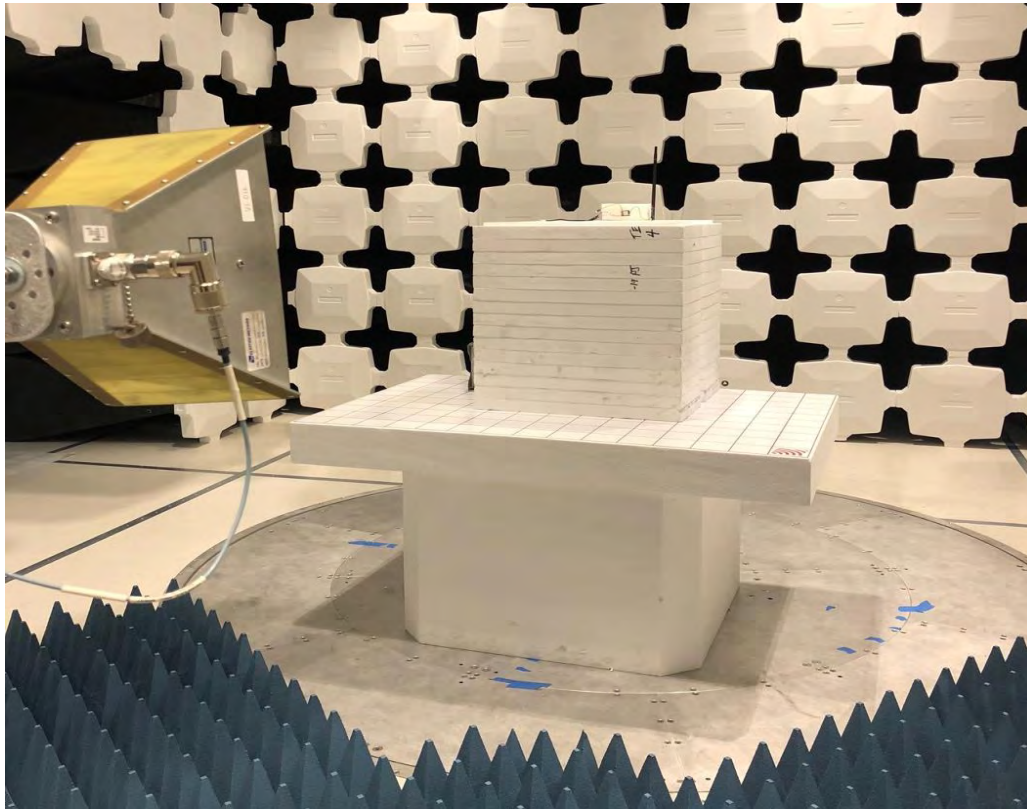
Product: Leap 2.4GHz RF Module

Model Number: 44-100312-00, 44-100312-01

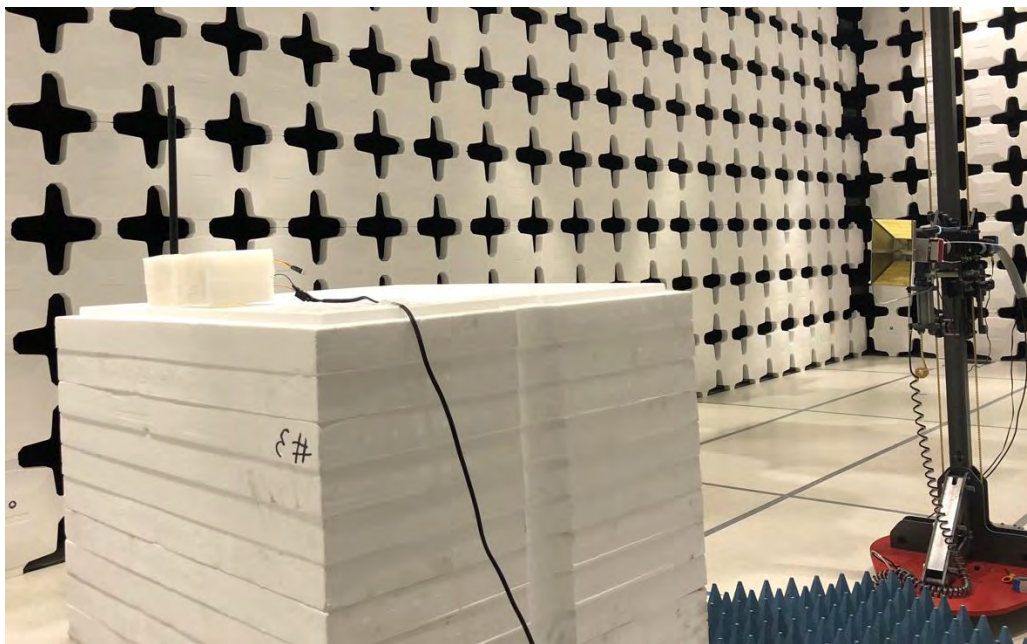


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Radiated Emissions Above 1GHz setup (folded dipole, long)

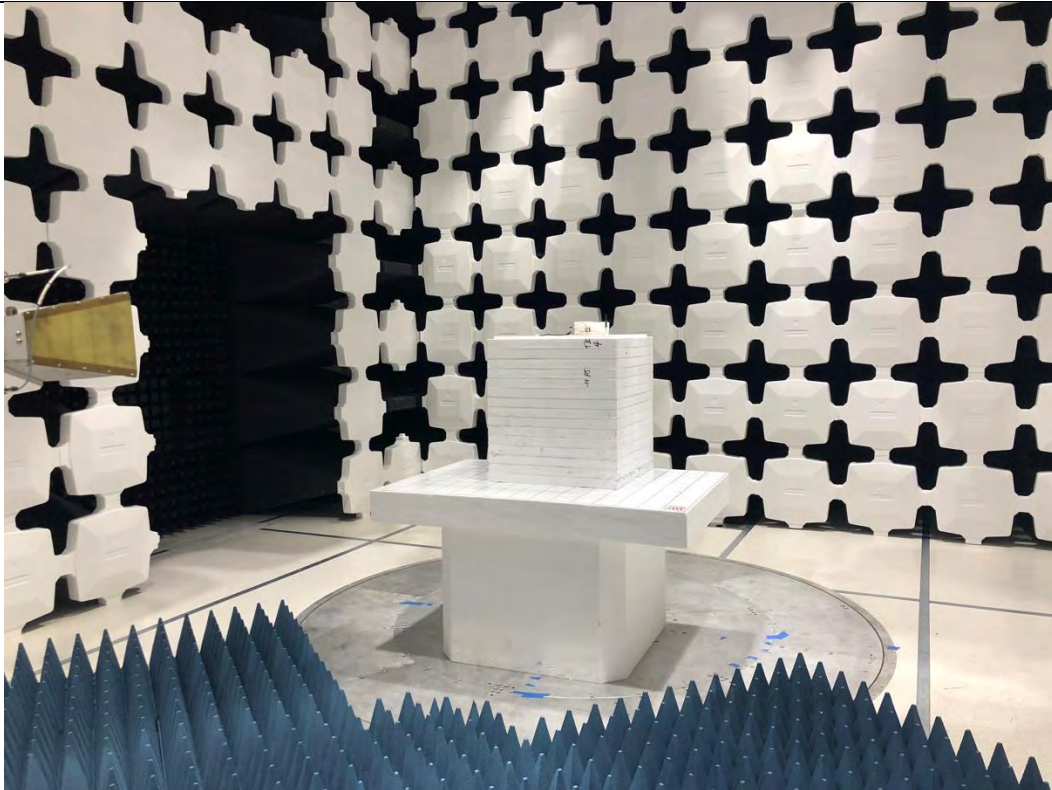


Front

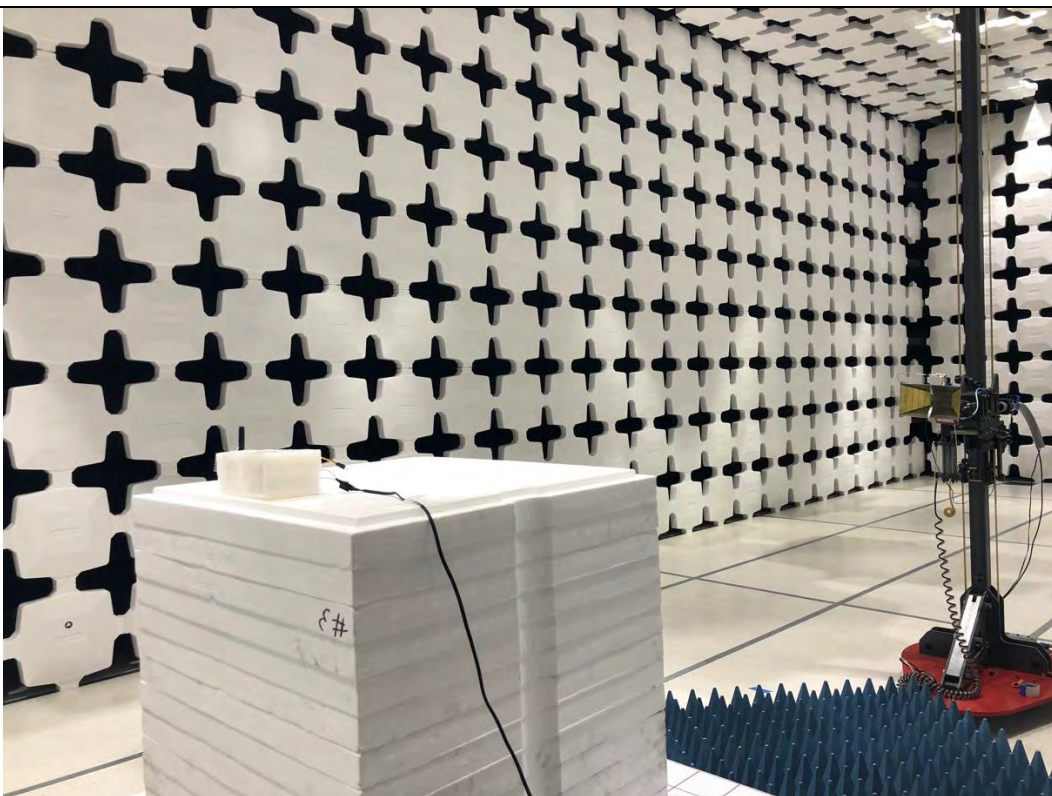


Rear

Radiated Emissions Above 1GHz setup (folded dipole, short)



Front

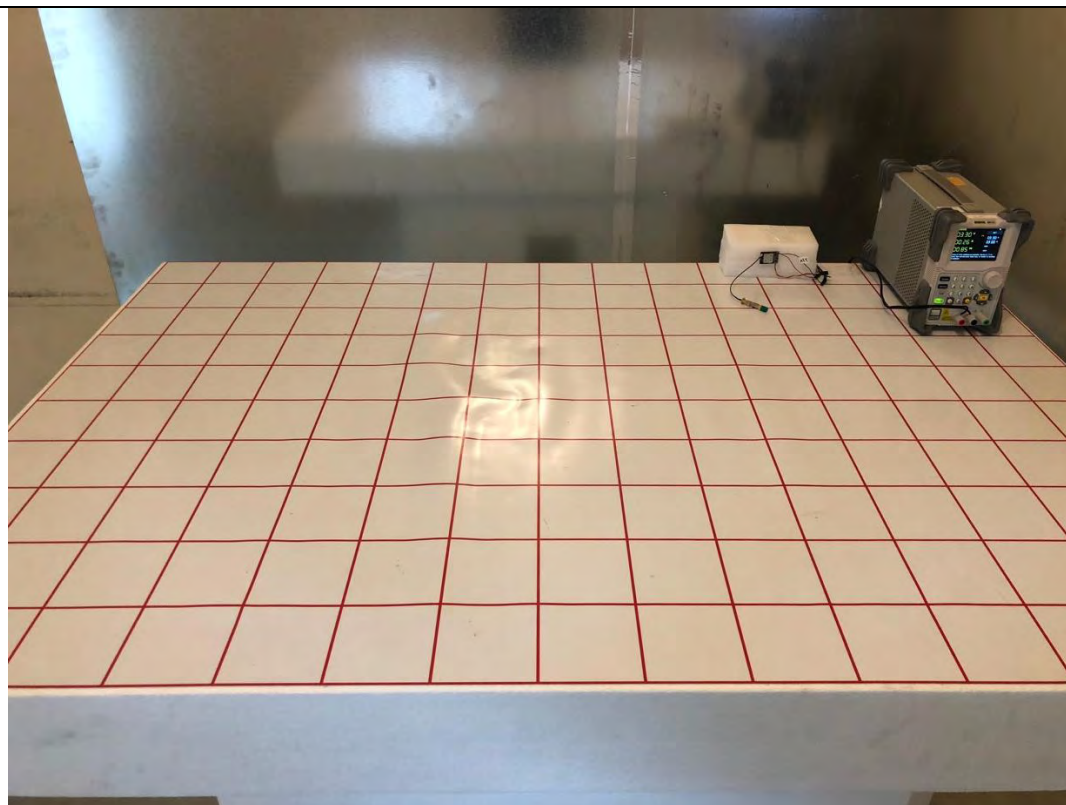


Rear

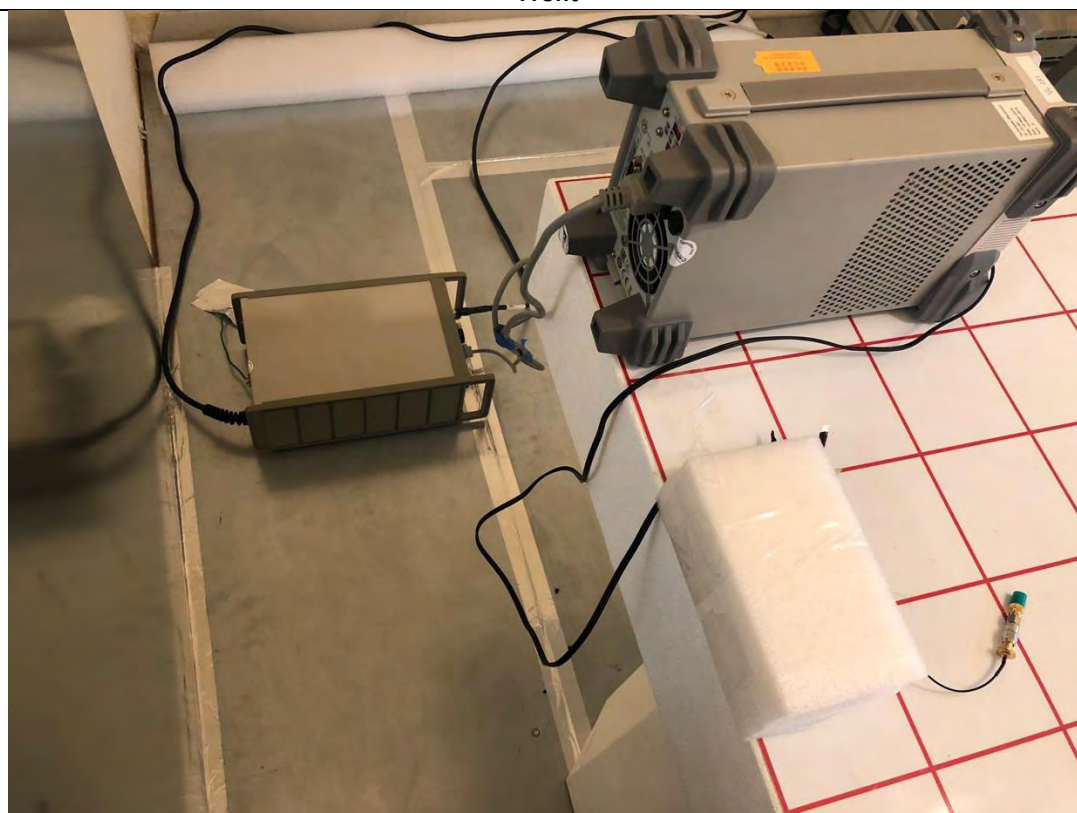
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Conducted Emissions



Front



Rear

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6 Test Summary

FCC Rules	Test Item	Test standard	Section in report	Verdict
§15.203	Antenna Requirement	47CFR Part 15.247	8.1	Pass
§15.247 (a)(2)	DTS (6 dB) Channel Bandwidth	47CFR Part 15.247	8.2	Pass
§15.247(b)(3)	Conducted Maximum Output Power	47CFR Part 15.247	8.3	Pass
§15.247(e)	Power Spectral Density	47CFR Part 15.247	8.4	Pass
§15.247(d)	Conducted Band-Edge & Unwanted Emissions	47CFR Part 15.247	8.5	Pass
§15.205, §15.209, §15.247(d)	Radiated Emissions & Unwanted Emissions into Restricted Frequency Bands	47CFR Part 15.247	8.6	Pass
§15.207 (a)	AC Power Line Conducted Emissions	47CFR Part 15.207	8.7	Pass

Note: N/A

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7 Uncertainty of Measurement

Test item	Measurement Uncertainty (dB)
RF Output Power (Conducted)	±1.2 dB
Power Spectral Density	±0.9 dB
Unwanted Emission (Conducted)	±2.6 dB
Occupied Channel Bandwidth	±5 %
Radiated Emission (9KHz-30MHz)	±3.5 dB
Radiated Emission (30MHz-1GHz)	±4.6 dB
Radiated Emission (1-18GHz)	±4.9 dB
Radiated Emission (18-40GHz)	±3.5 dB
Conducted Emissions (150KHz-30MHz)	±3.6 dB

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8 Test summary and result

8.1 Antenna Requirement

8.1.1 Requirement

Per § 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

8.1.2 Result

Analysis:

The EUT has an option of using the internal antenna, or an external antenna.

- For the internal antenna version, the EUT uses an Amotech PIFA chip antenna that is soldered and permanently attached onto the PCB.
- For the external antenna version, the EUT has a provision for connection to an external antenna, using a unique U.FL connector, and was tested with a Yagi, monopole, and folded dipole antennas provided by the applicant. No other external antennas are to be used with the EUT.
- All dipoles antennas will be equipped with unique RP-SMA connector. RF cables with unique RP-SMA and U.FL connector will be used to provide coupling between antenna and module.
- For Yagi antenna, it will have an adapter and RF cable permanently connected with industrial epoxy, "Loctite" or solder to make the connection permanent prior to delivering to OEM Integrator or Host Manufacturer. the connector type on the final assembly will be U.FL.

Conclusion:

EUT complies with antenna requirement in § 15.203.

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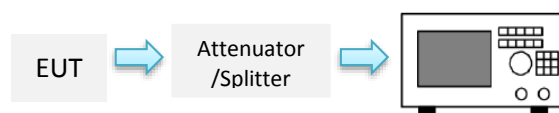


8.2 DTS (6 dB) Bandwidth

8.2.1 Requirement

Per § 15.247 (a)(2), systems using digital modulation techniques may operate in the 902-928MHz, 2400-2483.5MHz, and 5725-5850MHz bands. The minimum 6 dB bandwidth shall be at least 500 KHz.

8.2.2 Test setup



8.2.3 Test Procedure

According to section 8.2, option 2, in KDB 558074 D01 DTS Meas Guidance v05 and subclause 11.8 of ANSI C63.10-2013:

The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW $\geq 3 \times$ RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this capability, care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be ≥ 6 dB.

1. Set RBW = 100 kHz.
2. Set the video bandwidth (VBW) $\geq 3 \times$ RBW.
3. Detector = Peak.
4. Trace mode = max hold.
5. Sweep = auto couple.
6. Allow the trace to stabilize.
7. Use automatic bandwidth measurement capability on instrument to obtain BW result.

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8.2.4 Test Result

External Antenna version

Radio	Output Power Setting	Test Frequency (MHz)	Measured Bandwidth (KHz)	Minimum Bandwidth (KHz)	Result
2.4 GHz	20	2405	1675	500	Pass
	20	2440	1674	500	Pass
	20	2470	1677	500	Pass
	15*	2470	1674	500	Pass

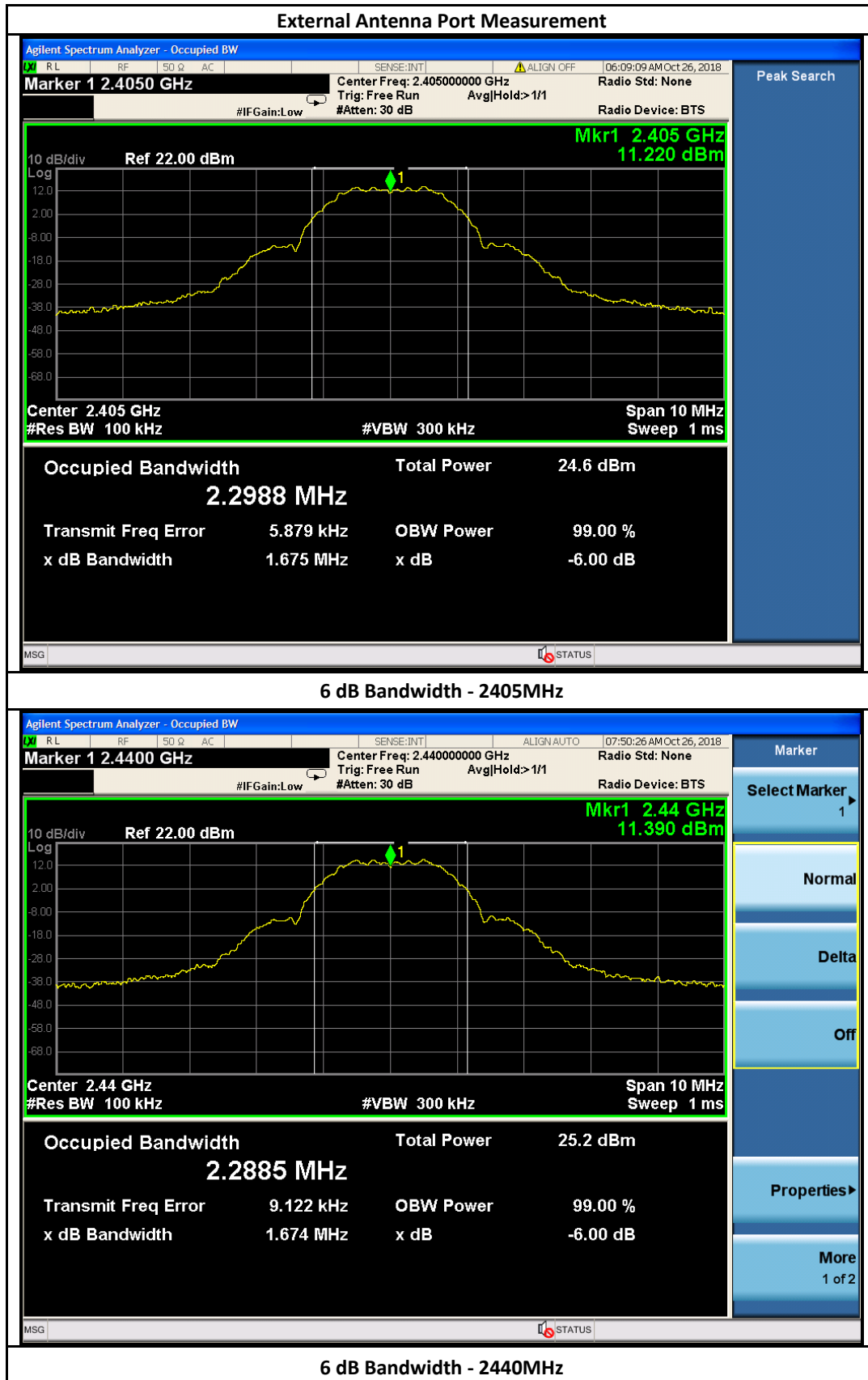
*The lower output power setting is to be used for the Yagi antenna only at 2470MHz.

Internal Antenna version

Radio	Output Power Setting	Test Frequency (MHz)	Measured Bandwidth (KHz)	Minimum Bandwidth (KHz)	Result
2.4 GHz	20	2405	1680	500	Pass
	20	2440	1677	500	Pass
	20	2470	1675	500	Pass



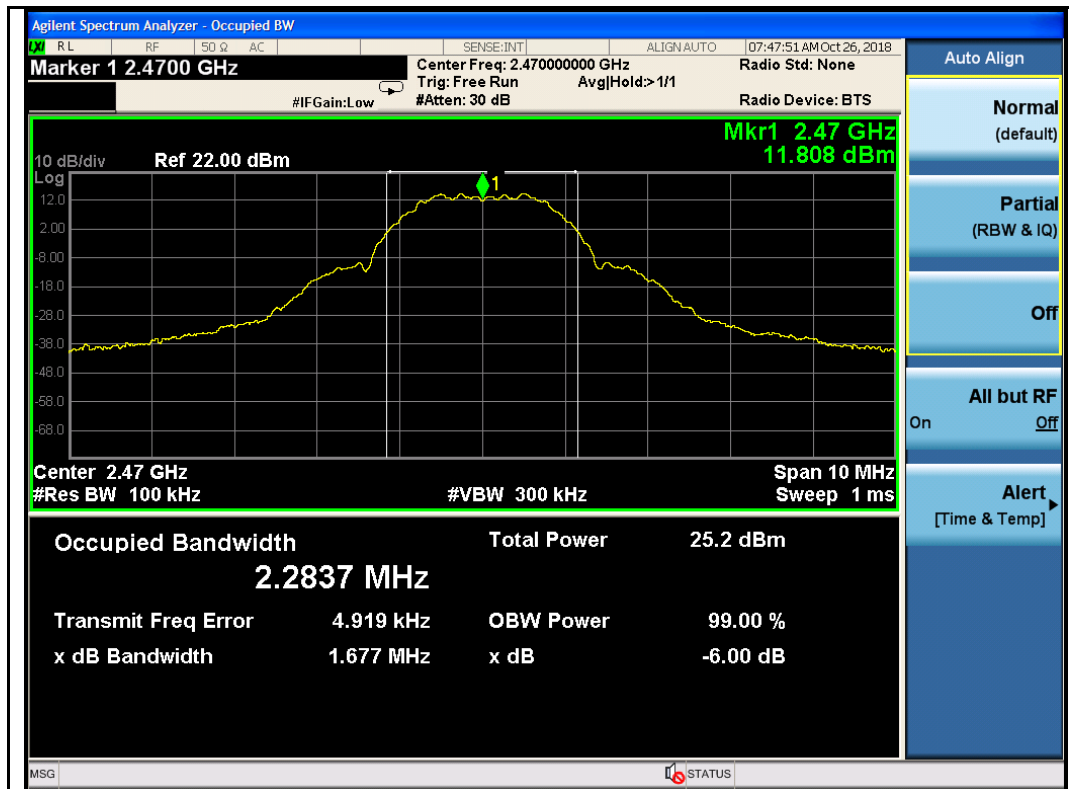
8.2.5 Test Plots



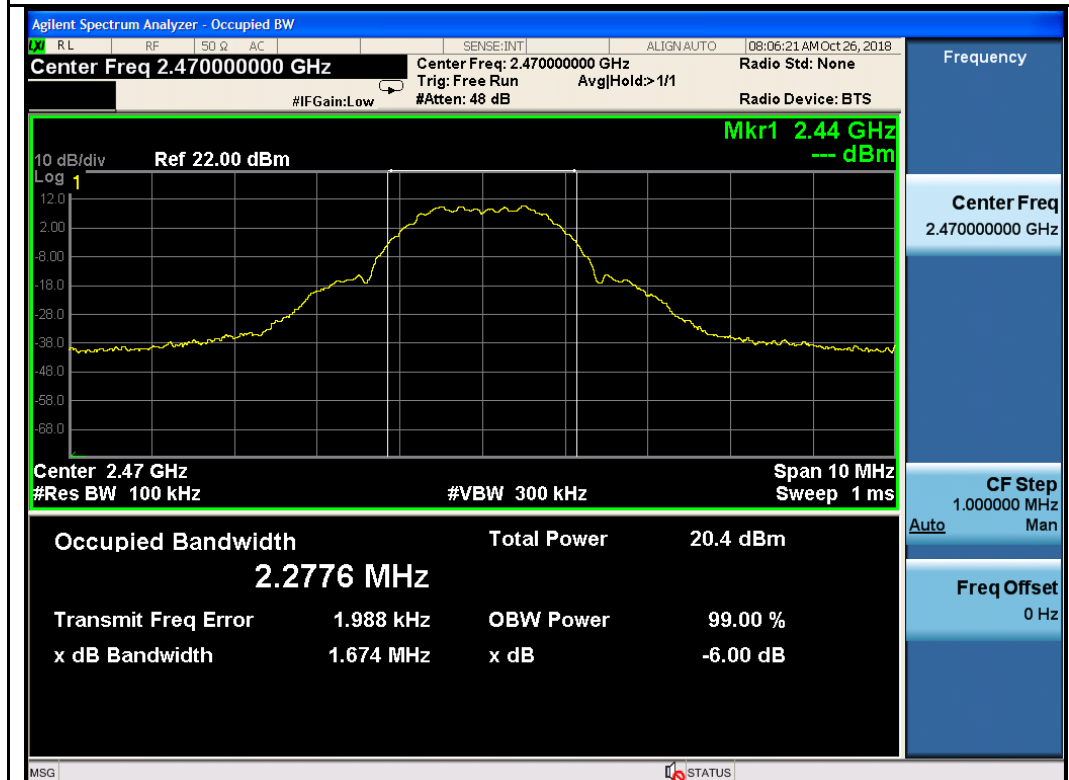
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6 dB Bandwidth - 2470MHz



6 dB Bandwidth - 2470MHz (15 dBm output power level setting for Yagi antenna)



Electromagnetic Compatibility
Radio Frequency
Product Certification
International Approval

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San Clemente, CA, 92673
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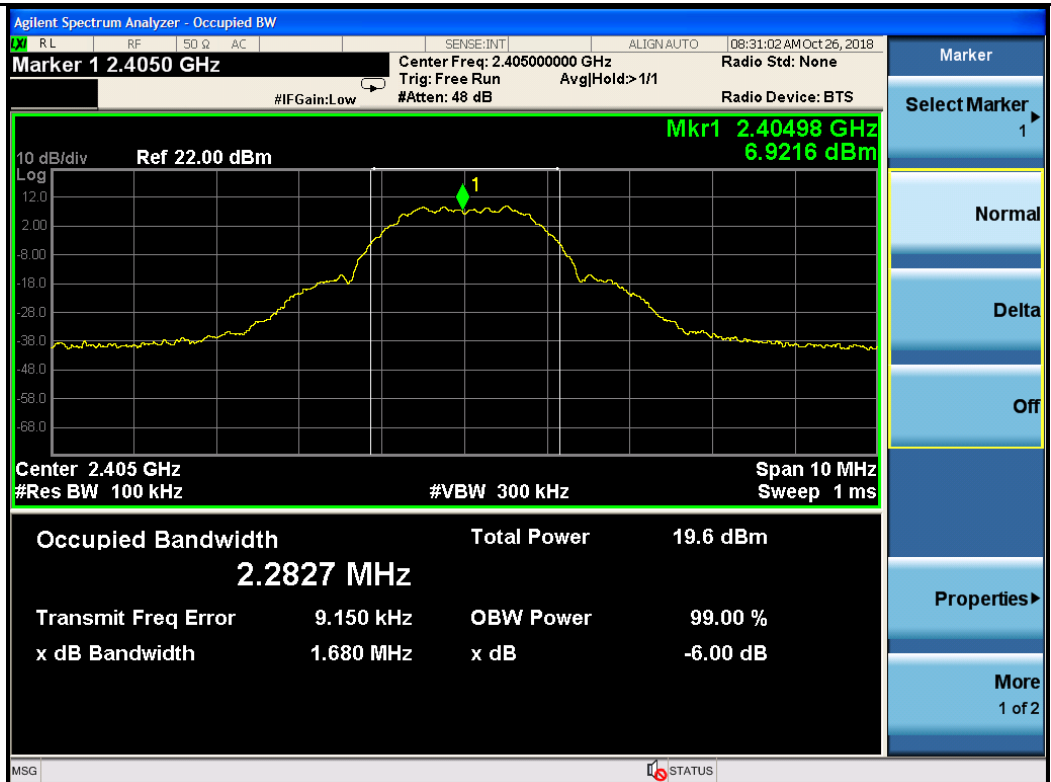
Model Number: 44-100312-00, 44-100312-01



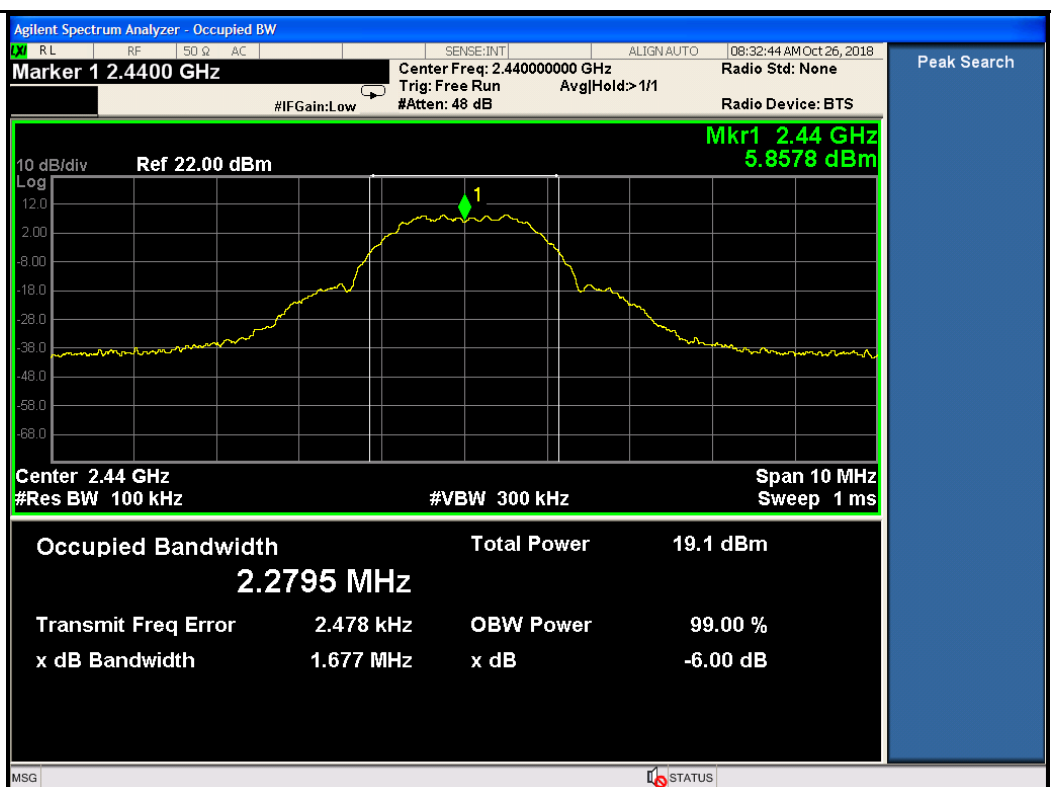
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Testing Cert #4848-01

Internal Antenna Port Measurement



6 dB Bandwidth - 2405MHz



6 dB Bandwidth - 2440MHz



Electromagnetic Compatibility
Radio Frequency
Product Certification
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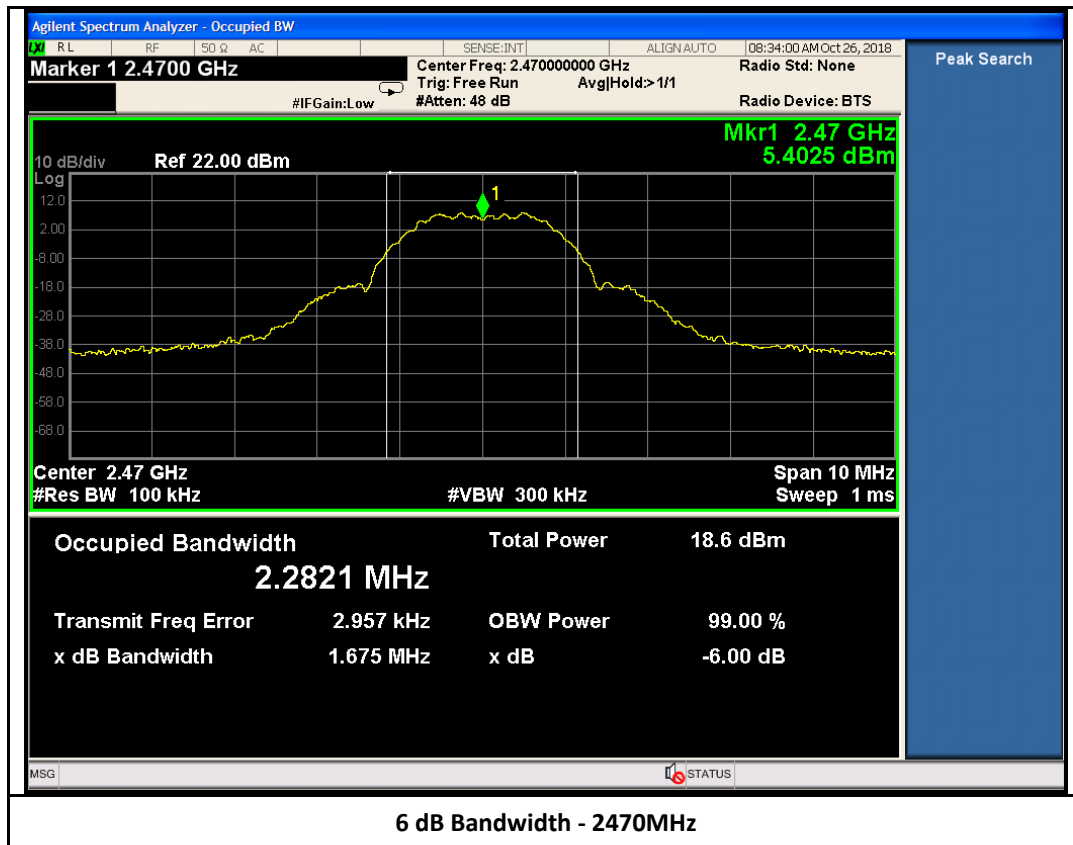
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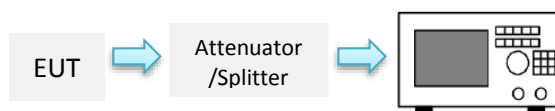
8.3 Maximum Output Power

8.3.1 Requirement

Per § 15.247 (b)(3), for systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: the maximum output power is 1 Watt.

Per § 15.247 (b)(4), if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

8.3.2 Test setup



8.3.3 Test Procedure

According to section 8.3.1.1 RBW ≥ DTS bandwidth, in KDB 558074 D01 DTS Meas Guidance v05 and subclause 11.9.1.1 of ANSI C63.10-2013:

1. Set the RBW ≥ DTS bandwidth.
2. Set VBW ≥ 3 X RBW.
3. Set span ≥ 3 X RBW
4. Sweep time = auto couple.
5. Detector = peak.
6. Trace mode = max hold.
7. Allow trace to fully stabilize.
8. Use peak marker function to determine the peak amplitude level.

8.3.4 Conducted output power limit calculation

Per FCC requirement, if antenna gain exceeds 6 dBi, conducted output power limit shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Antenna type	Antenna gain (dBi)	Amount exceeding 6 dBi (dB)	Original output power limit (dBm)	New output power limit (dBm)
Internal PIFA	3.4	N/A	30	30
Folded Dipole Long	3.2	N/A	30	30
Folded Dipole Short	2.15	N/A	30	30
Monopole	7	1	30	29
Yagi	12	6	30	24

8.3.5 Test Result

Folded Dipole Antennas

Radio	Output Power Setting	Test Frequency (MHz)	Measured Output Power (dBm)	Maximum Output Power (dBm)	Result
2.4 GHz	20 dB	2405	18.047	30	Pass
	20 dB	2440	18.446	30	Pass
	20 dB	2470	18.532	30	Pass

Yagi Antenna

Radio	Output Power Setting	Test Frequency (MHz)	Measured Output Power (dBm)	Maximum Output Power (dBm)	Result
2.4 GHz	20 dB	2405	18.047	24	Pass
	20 dB	2440	18.446	24	Pass
	15 dB	2470	13.591	24	Pass

Monopole Antenna

Radio	Output Power Setting	Test Frequency (MHz)	Measured Output Power (dBm)	Maximum Output Power (dBm)	Result
2.4 GHz	20 dB	2405	18.047	29	Pass
	20 dB	2440	18.446	29	Pass
	20 dB	2470	18.532	29	Pass

Internal Antenna

Radio	Output Power Setting	Test Frequency (MHz)	Measured Output Power (dBm)	Maximum Output Power (dBm)	Result
2.4 GHz Module	20 dB	2405	15.279	30	Pass
	20 dB	2440	15.019	30	Pass
	20 dB	2470	14.785	30	Pass

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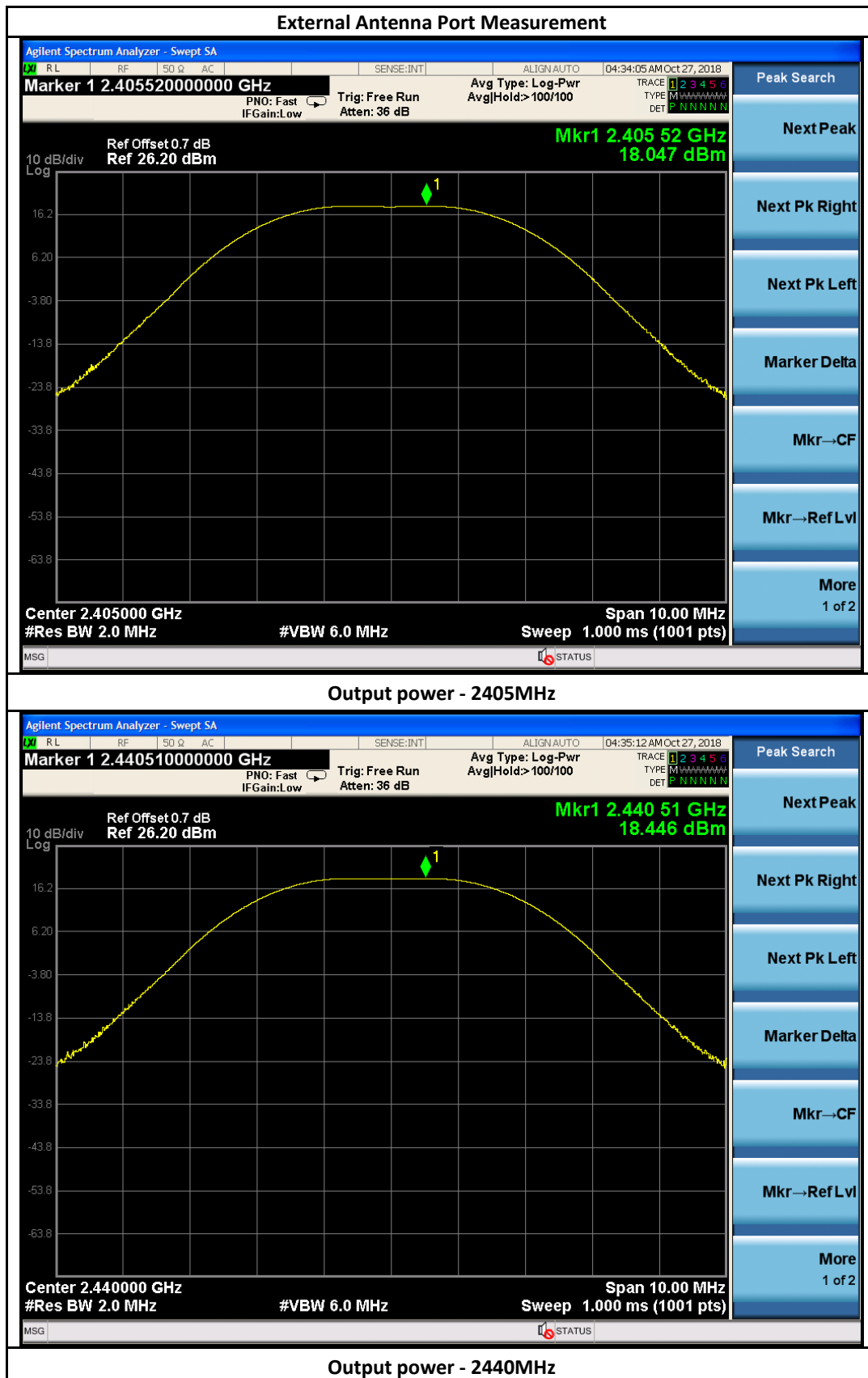
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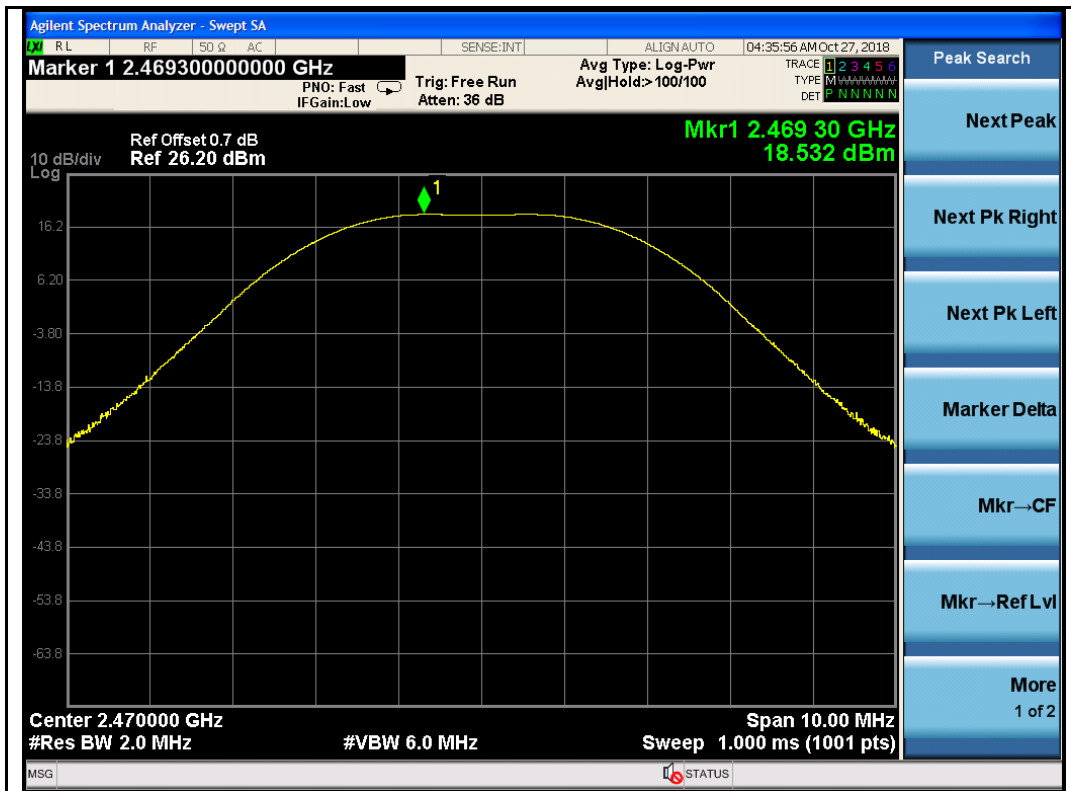
8.3.6 Test Plots



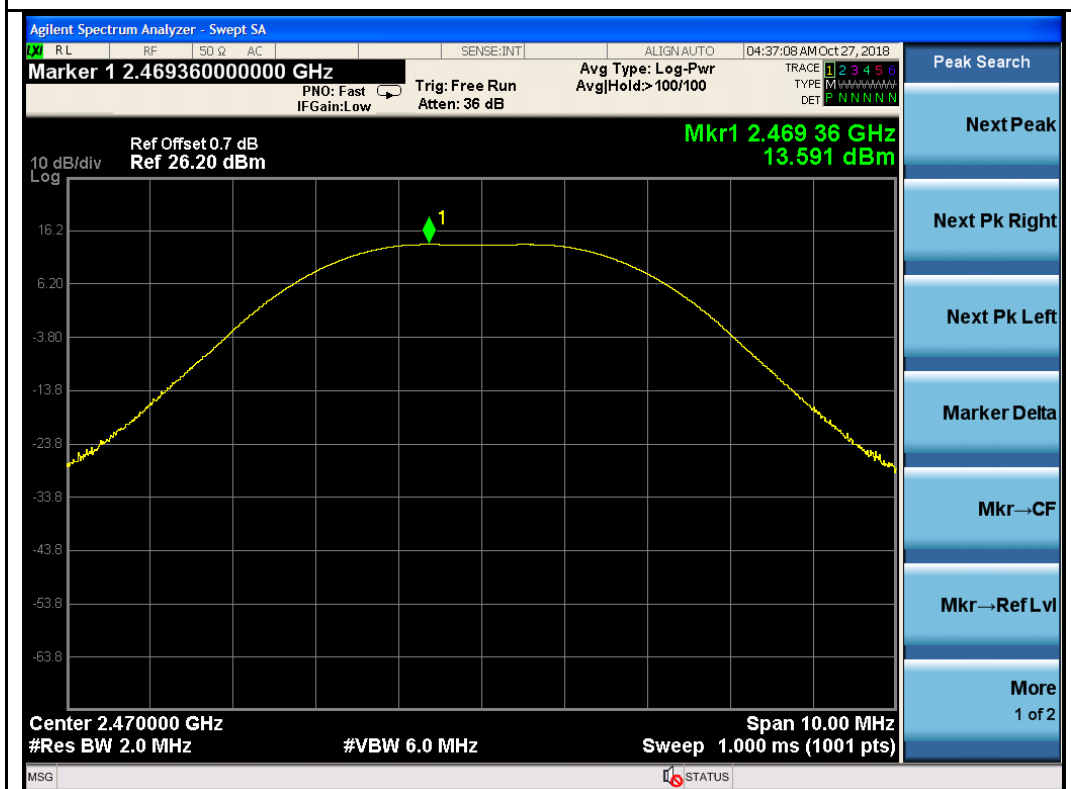
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Output power - 2470MHz



Output power - 2470MHz (15 dBm output power level setting for Yagi antenna)



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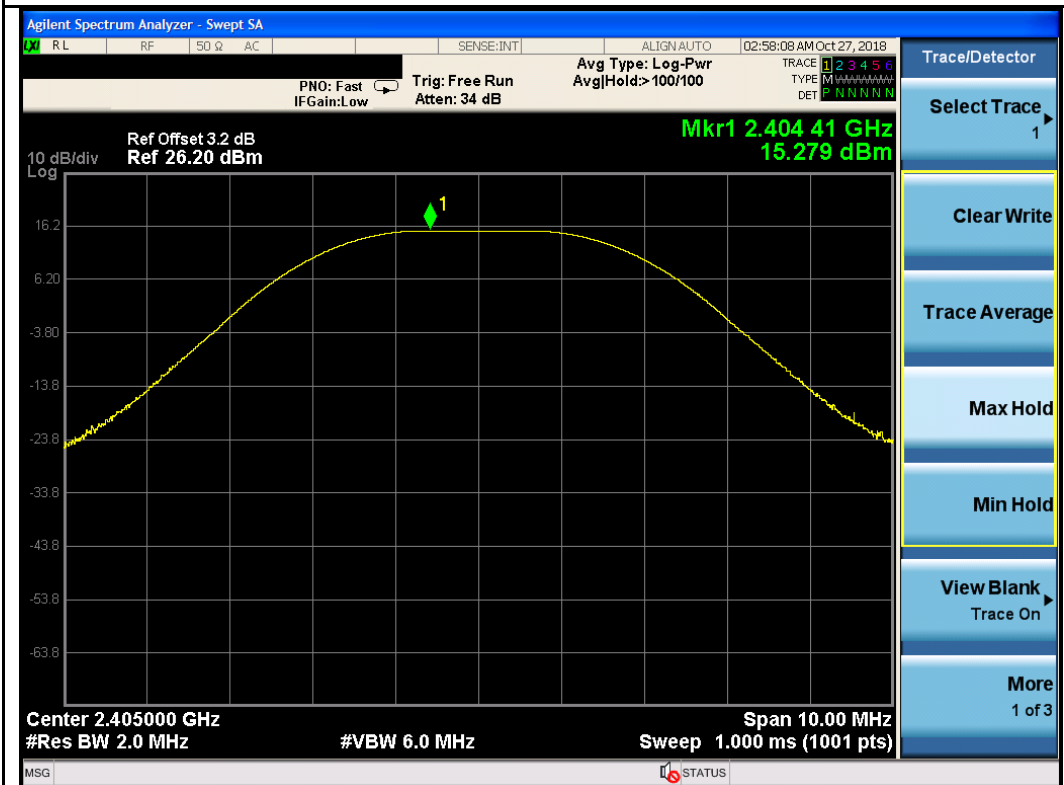
Model Number: 44-100312-00, 44-100312-01



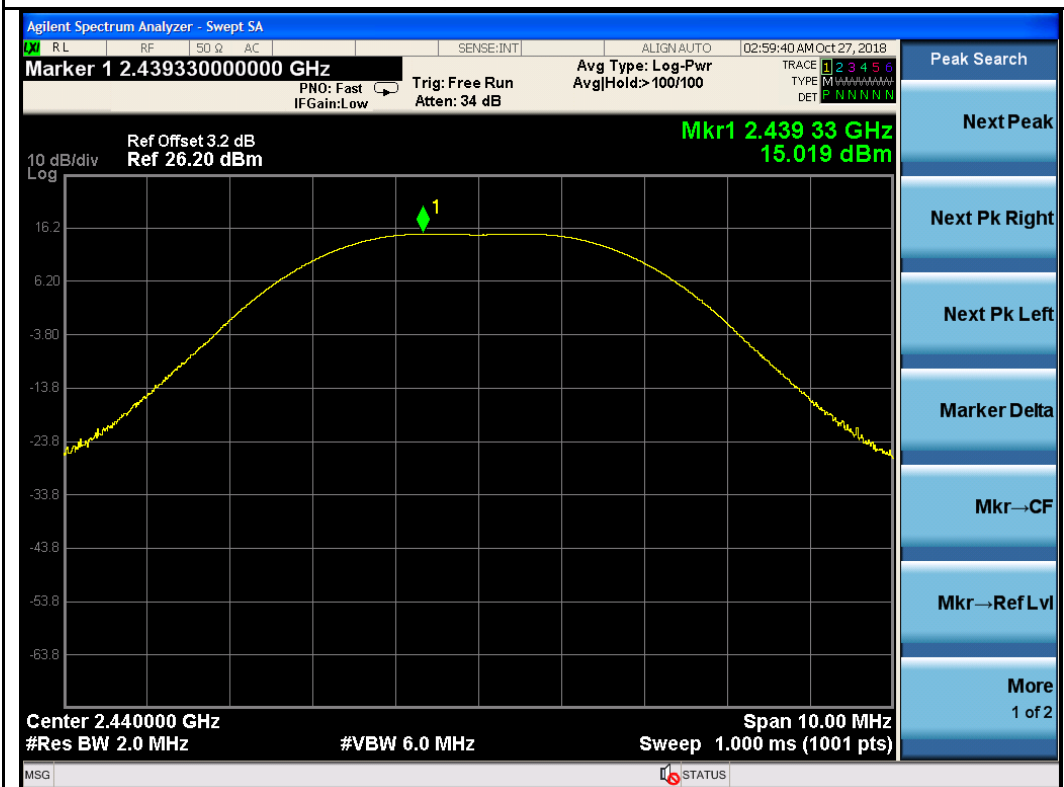
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Internal Antenna Port Measurement



Output power - 2405MHz

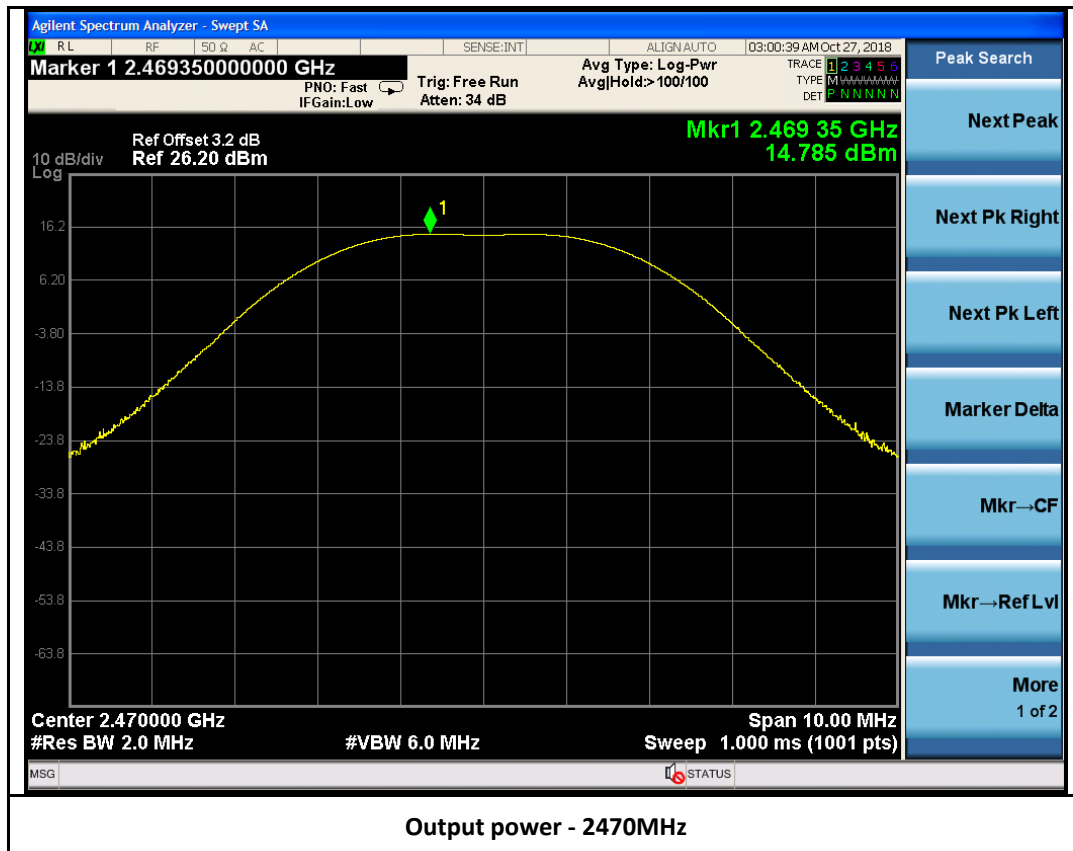


Output power - 2440MHz



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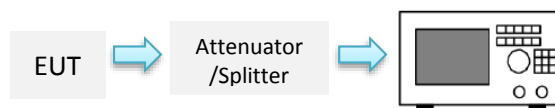


8.4 Power Spectral Density

8.4.1 Requirement

Per § 15.247 (e), for digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power is used to determine the power spectral density.

8.4.2 Test setup



8.4.3 Test Procedure

According to section 8.4 in KDB 558074 D01 DTS Meas Guidance v05 and subclause 11.10.2 PKPSD of ANSI C63.10-2013:

1. Set analyser centre frequency to DTS channel centre frequency.
2. Set the span to 1.5 X DTS bandwidth.
3. Set the RBW to: $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$.
4. Set the VBW $\geq 3 \times \text{RBW}$.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level within the RBW.
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

8.4.4 Power spectral density limit calculation

Per FCC requirement, if antenna gain exceeds 6 dBi, PSD limit shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Antenna type	Antenna gain (dBi)	Amount exceeding 6 dBi (dB)	Original PSD limit (dBm/3KHz)	New PSD limit (dBm/3KHz)
Internal PIFA	3.4	N/A	8	8
Folded Dipole Long	3.2	N/A	8	8
Folded Dipole Short	2.15	N/A	8	8
Monopole	7	1	8	7
Yagi	12	6	8	2

8.4.5 Test Result

Folded Dipole Antennas

Radio	Output Power Setting	Test Frequency (MHz)	Measured Output Power (dBm/3KHz)	Maximum Output Power (dBm/3KHz)	Result
2.4 GHz	20 dB	2405	1.614	8	Pass
	20 dB	2440	1.712	8	Pass
	20 dB	2470	2.052	8	Pass

Monopole Antenna

Radio	Output Power Setting	Test Frequency (MHz)	Measured Output Power (dBm/3KHz)	Maximum Output Power (dBm/3KHz)	Result
2.4 GHz	20 dB	2405	1.614	7	Pass
	20 dB	2440	1.712	7	Pass
	20 dB	2470	2.052	7	Pass

Yagi Antenna

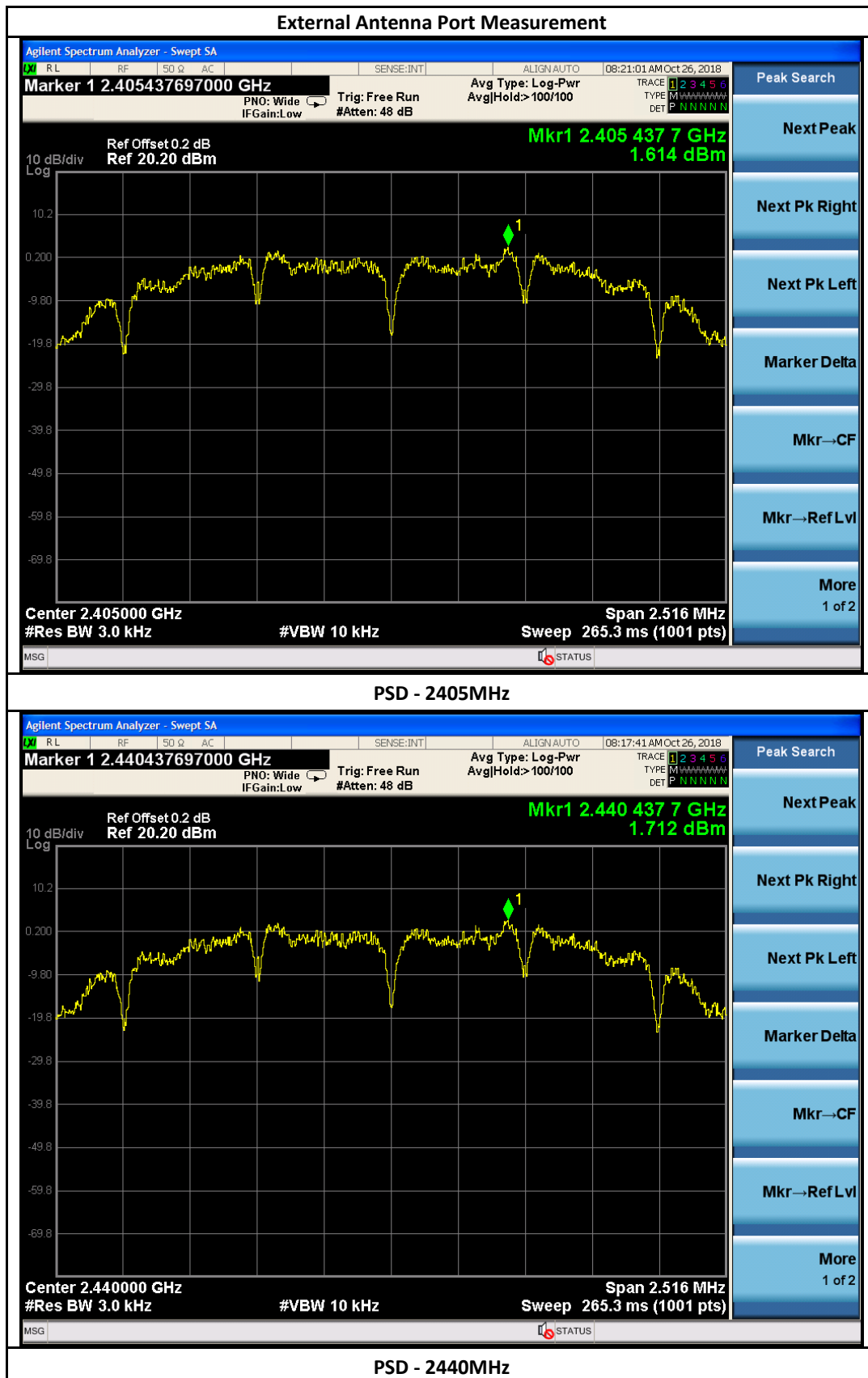
Radio	Output Power Setting	Test Frequency (MHz)	Measured Output Power (dBm/3KHz)	Maximum Output Power (dBm/3KHz)	Result
2.4 GHz	20 dB	2405	1.614	2	Pass
	20 dB	2440	1.712	2	Pass
	15 dB	2470	-1.840	2	Pass

Internal Antenna

Radio	Output Power Setting	Test Frequency (MHz)	Measured Output Power (dBm/3KHz)	Maximum Output Power (dBm/3KHz)	Result
2.4 GHz	20 dB	2405	0.196	8	Pass
	20 dB	2440	0.008	8	Pass
	20 dB	2470	-0.295	8	Pass



8.4.6 Test Plots



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PSD - 2470MHz



PSD - 2470MHz (15 dBm output power level setting for Yagi antenna)



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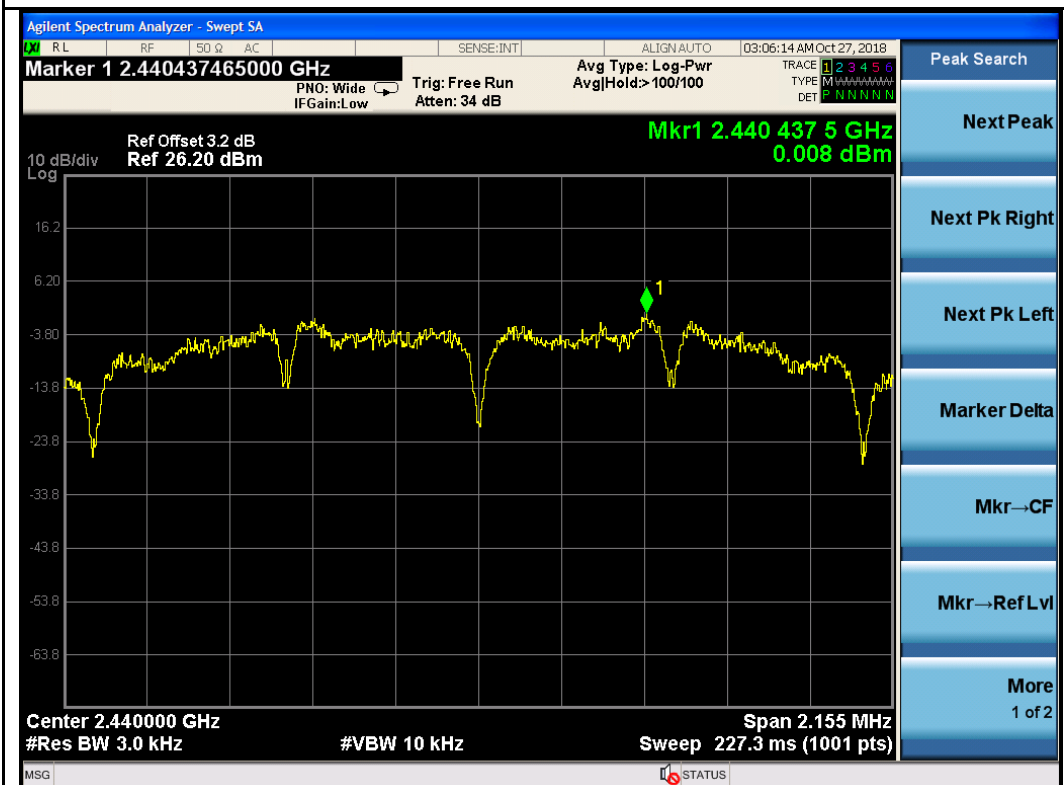
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PSD - 2405MHz



PSD - 2440MHz

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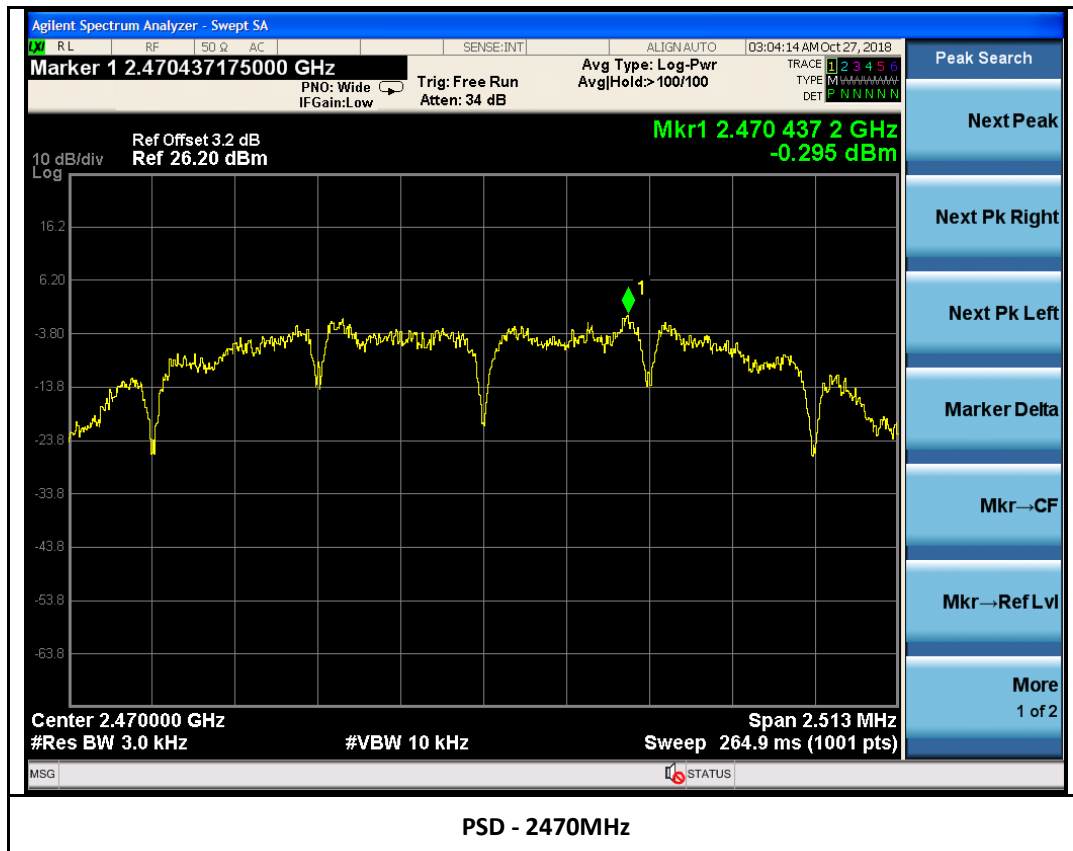
Product: Leap 2.4GHz RF Module

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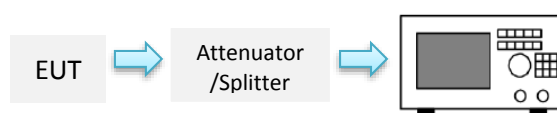


8.5 Conducted Band-Edge & Unwanted Emissions Measurement

8.5.1 Requirement

Per § 15.247 (d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

8.5.2 Test setup



8.5.3 Test Procedure

According to section 8.5 Emission level measurement, in KDB 558074 D01 DTS Meas Guidance v05 and subclause 11.11.3 in ANSI C63.10-2013:

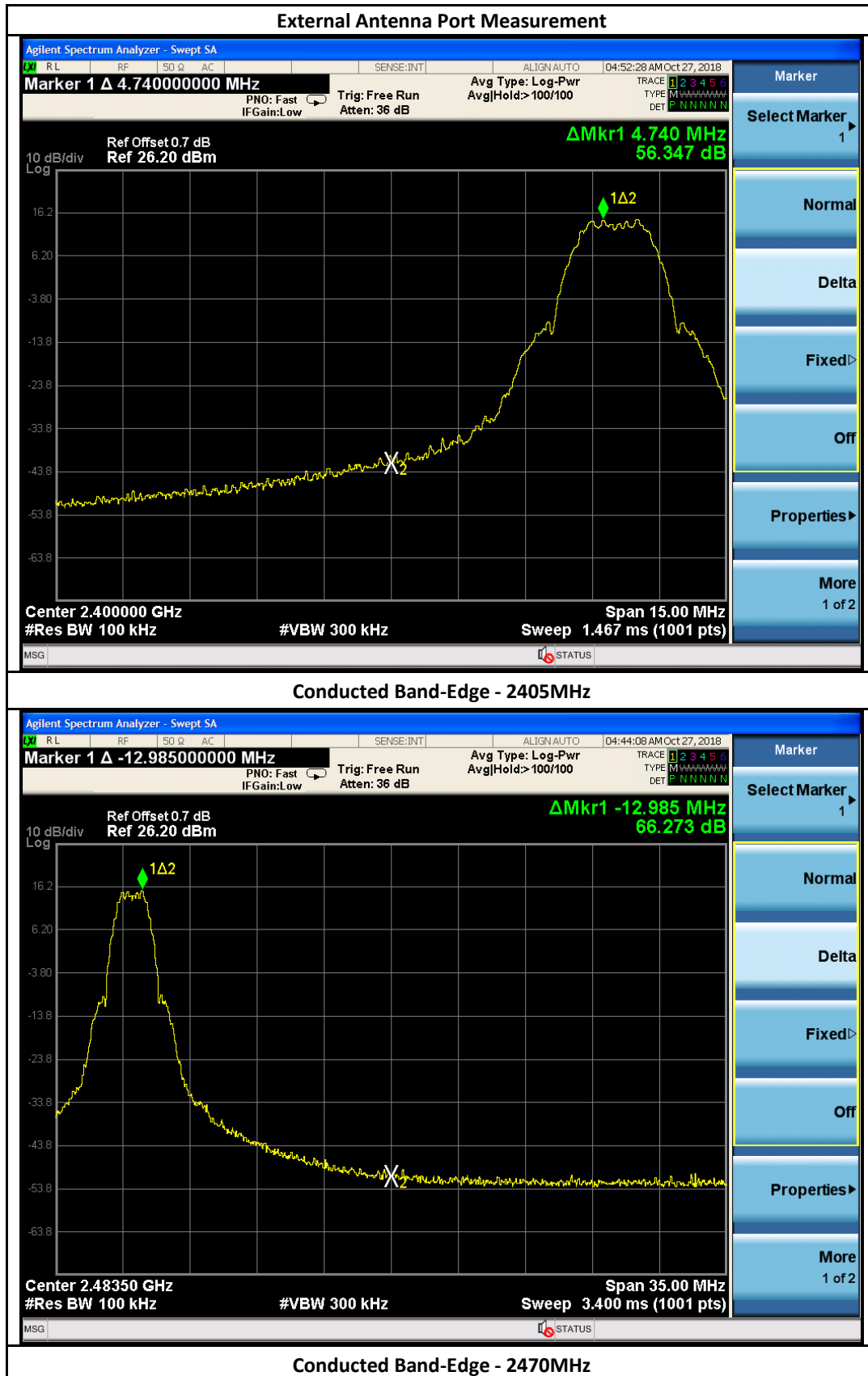
1. Set the center frequency and span to encompass frequency range to be measured.
2. Set the RBW = 100 kHz.
3. Set the VBW $\geq 3 \times$ RBW.
4. Detector = peak.
5. Sweep time = auto couple.
6. Trace mode = max hold.
7. Allow trace to fully stabilize.
8. Use the peak marker function to determine the maximum amplitude level.

8.5.4 Test Result

See test plots



8.5.5 Test Plots



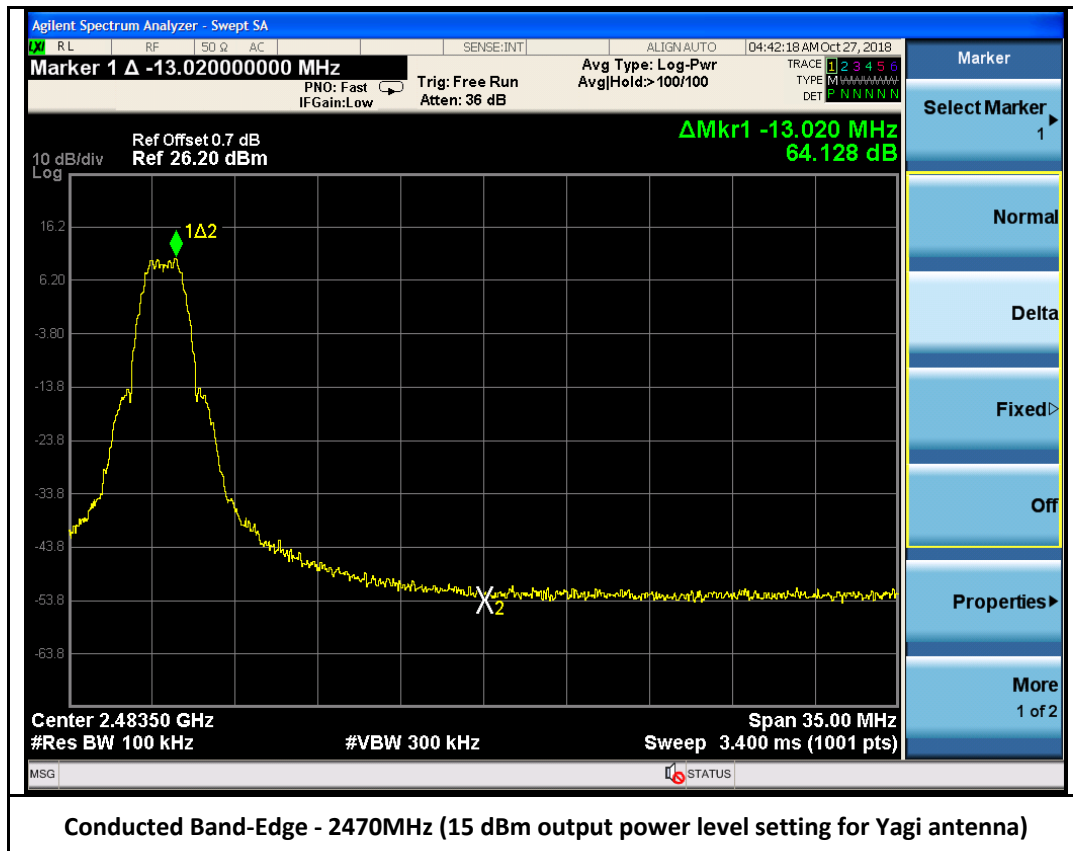
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Conducted Unwanted Emission - 2405MHz



Conducted Unwanted Emission - 2440MHz



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Conducted Unwanted Emission - 2470MHz



Conducted Unwanted Emission - 2470MHz (15 dBm output power level setting for Yagi antenna)



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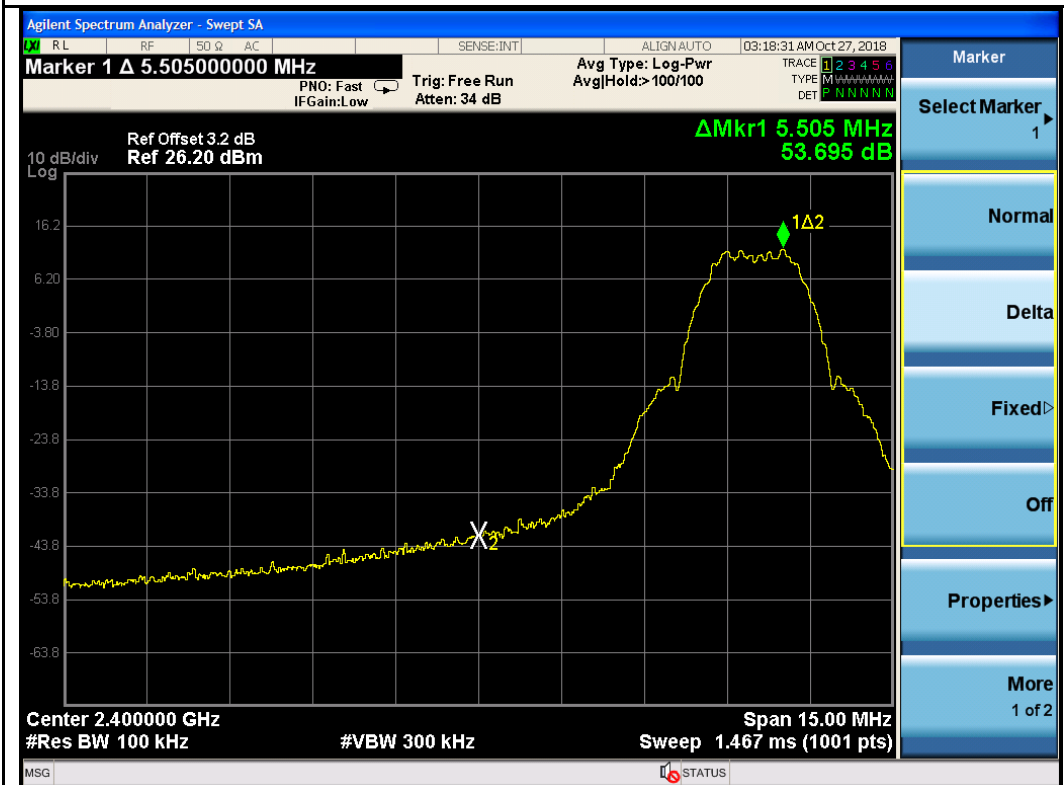
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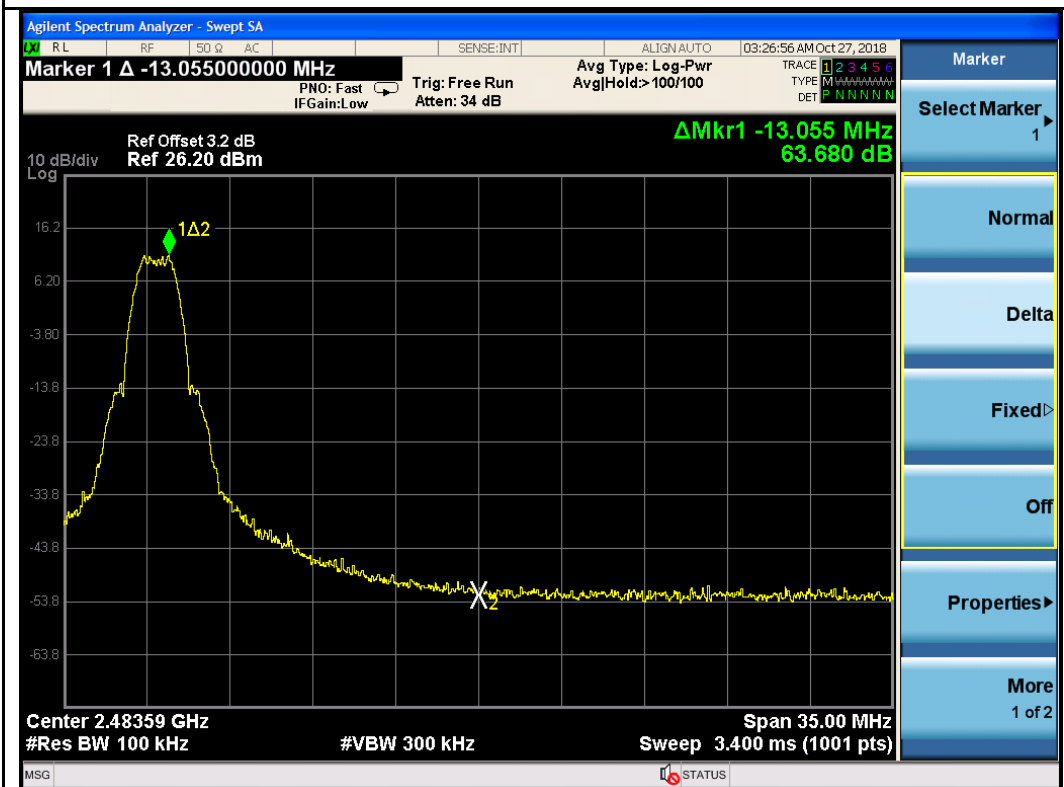


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Internal Antenna Port Measurement



Conducted Band-Edge - 2405MHz



Conducted Band-Edge - 2470MHz



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Conducted Unwanted Emission - 2405MHz



Conducted Unwanted Emission - 2440MHz



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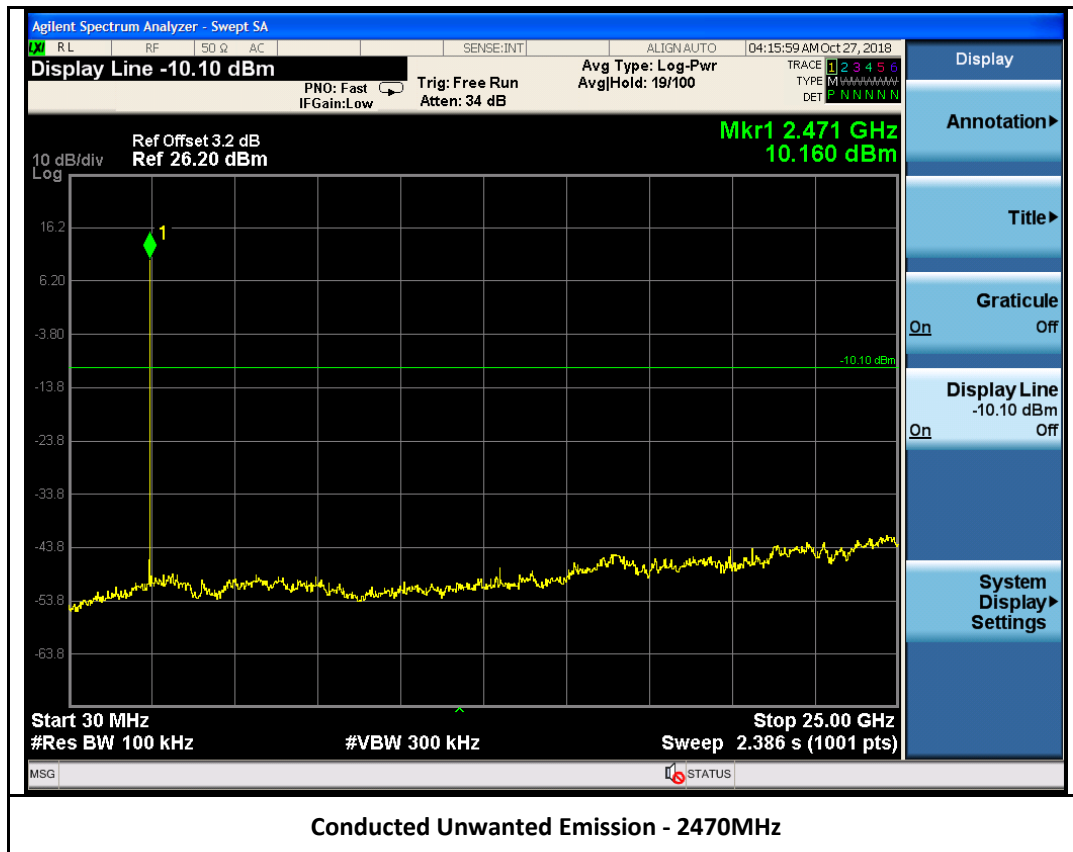
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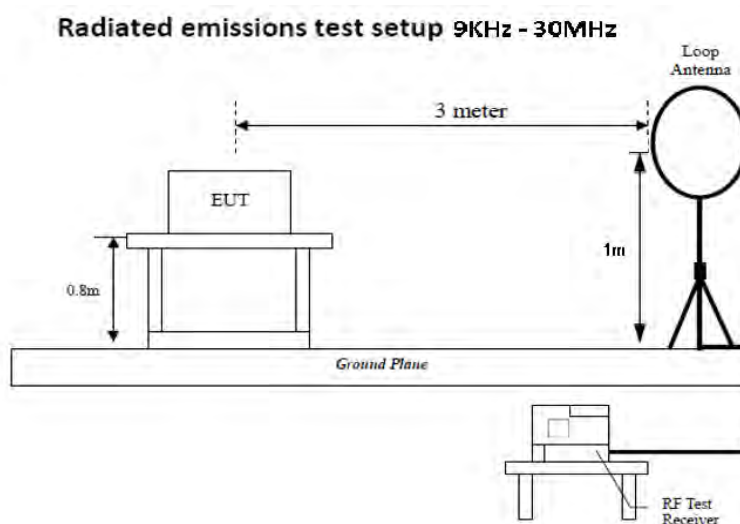
8.6 Radiated Band-Edge & Spurious Emissions into Restricted Frequency Bands

8.6.1 Requirement

Per § 15.247 (d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Frequency range (MHz)	Field Strength ($\mu\text{V/m}$)
0.009~0.490	2400/F(KHz)
0.490~1.705	24000/F(KHz)
1.705~30.0	30
30 – 88	100
88 – 216	150
216 960	200
Above 960	500

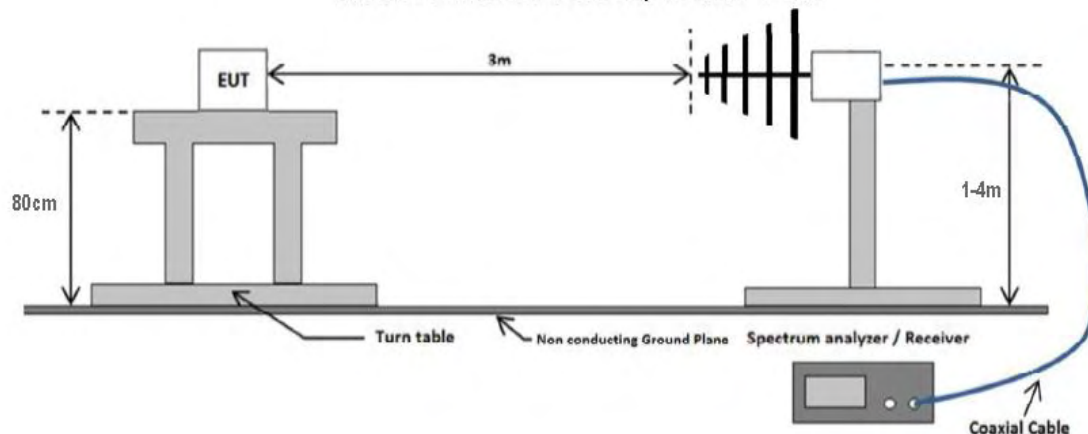
8.6.2 Test setup



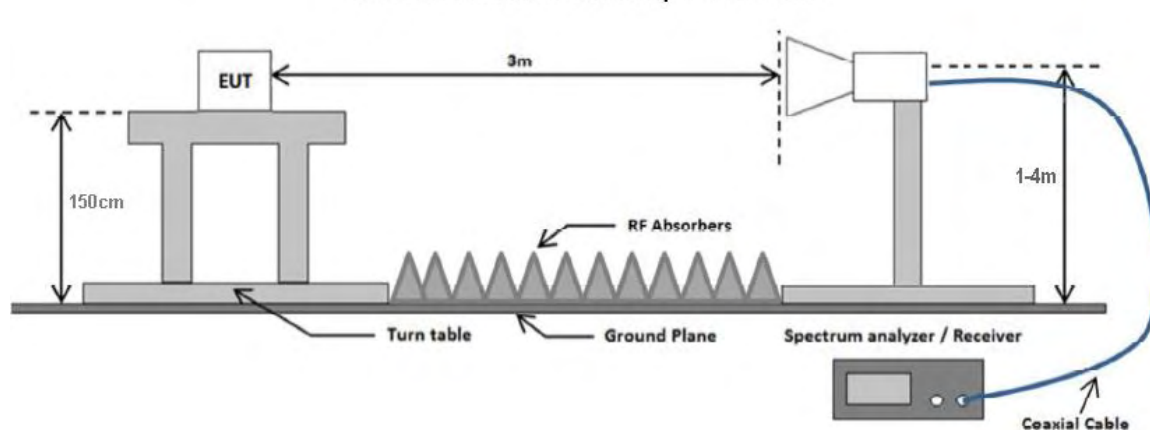
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Radiated emissions test setup 30 MHz - 1 GHz



Radiated emissions test setup above 1 GHz



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8.6.3 Test Procedure

According to section 8.6 in KDB 558074 D01 DTS Meas Guidance v05 and subclause 11.12.2.7 Radiated spurious emission measurements in ANSI C62.10-2013 as well as the procedures for maximizing and measuring radiated emissions that are described in ANSI C63.10 was followed. Boresight antenna mast was used during the scanning to point to EUT to maximize the emission. The process will be repeated in 3 EUT orientations.

1. The EUT was switched on and allowed to warm up to its normal operating condition.
2. The test was carried out at the selected frequency points obtained from the EUT characterization. Maximization of the emissions, was carried out by rotating the EUT, changing the antenna polarization, and adjusting the antenna height in the following manner:
 - a. Vertical or horizontal polarization (whichever gave the higher emission level over a full rotation of the EUT) was chosen.
 - b. The EUT was then rotated to the direction that gave the maximum emission.
 - c. Finally, the antenna height was adjusted to the height that gave the maximum emission.
3. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 300 Hz for frequency below 150KHz.
4. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 10 kHz for frequency between 150KHz – 30MHz.
5. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Quasi-Peak detection at frequency between 30MHz - 1GHz.
6. The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and video bandwidth is 3MHz with Peak detection for Peak and average measurement at frequency above 1GHz.
7. Steps 2 and 3 were repeated for the next frequency point, until all selected frequency points were measured.

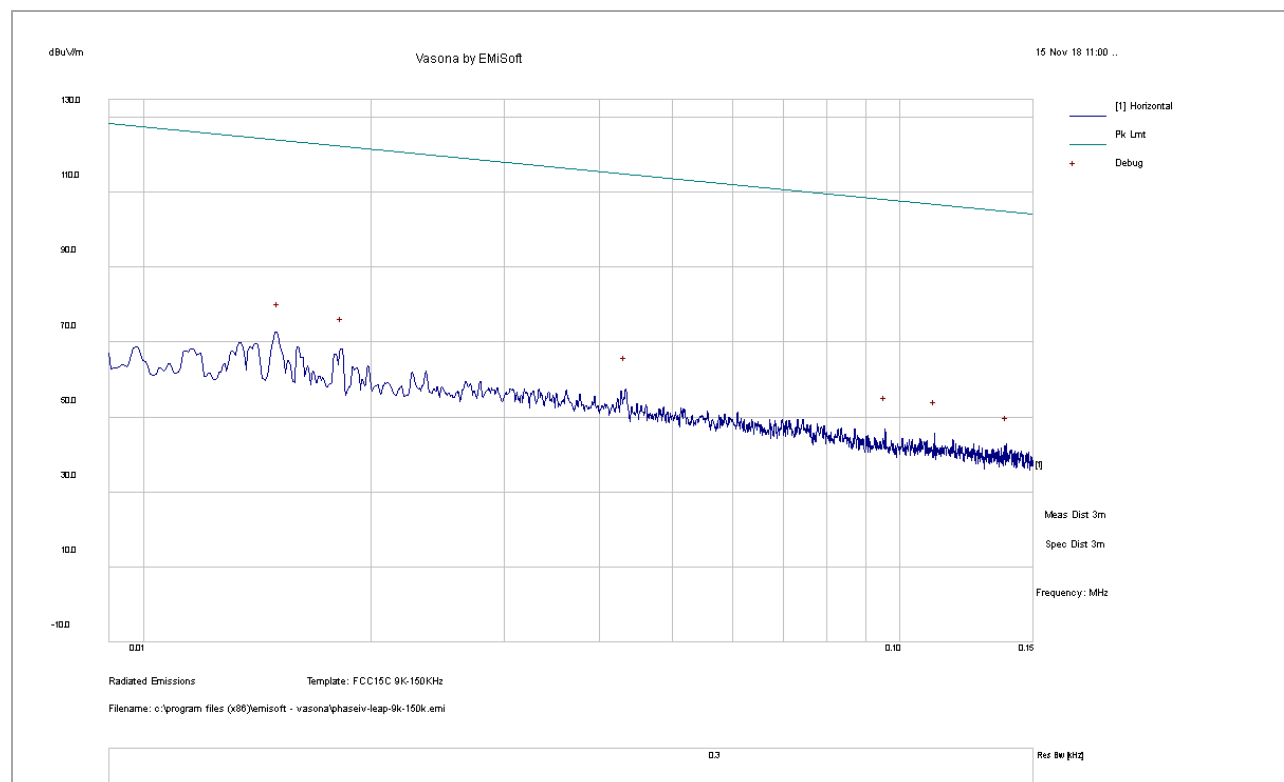
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8.6.4 Test Result

9KHz – 150KHz test result

Test Standard:	47CFR 15.209	Mode:	2440MHz
Frequency Range:	Below 150KHz	Test Date:	11/14/2018
Antenna Type/Polarity:	Loop / 0 deg & 90 deg	Test Personnel:	Sherwin Lee
Remark:	Internal antenna	Test Result:	Pass



Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
0.015	60.54	0.35	10.84	71.73	PK	0	100	182	124.05	-52.32
0.018	56.28	0.37	11.16	67.81	PK	0	100	12	122.35	-54.54
0.043	43.87	0.46	13.04	57.36	PK	0	100	10	114.86	-57.50
0.096	35.33	0.54	10.78	46.65	PK	0	100	0	108.00	-61.35
0.111	34.04	0.55	11.00	45.59	PK	0	100	38	106.69	-61.10
0.138	29.81	0.57	11.00	41.38	PK	0	100	90	104.79	-63.41

Note: 1) Both 0 deg and 90 deg setup of the loop antenna have been verified and the worst case result is presented here.

2) All different antenna versions have been verified and the worst case result is presented here.

3) EUT was tested in 3 orientations.



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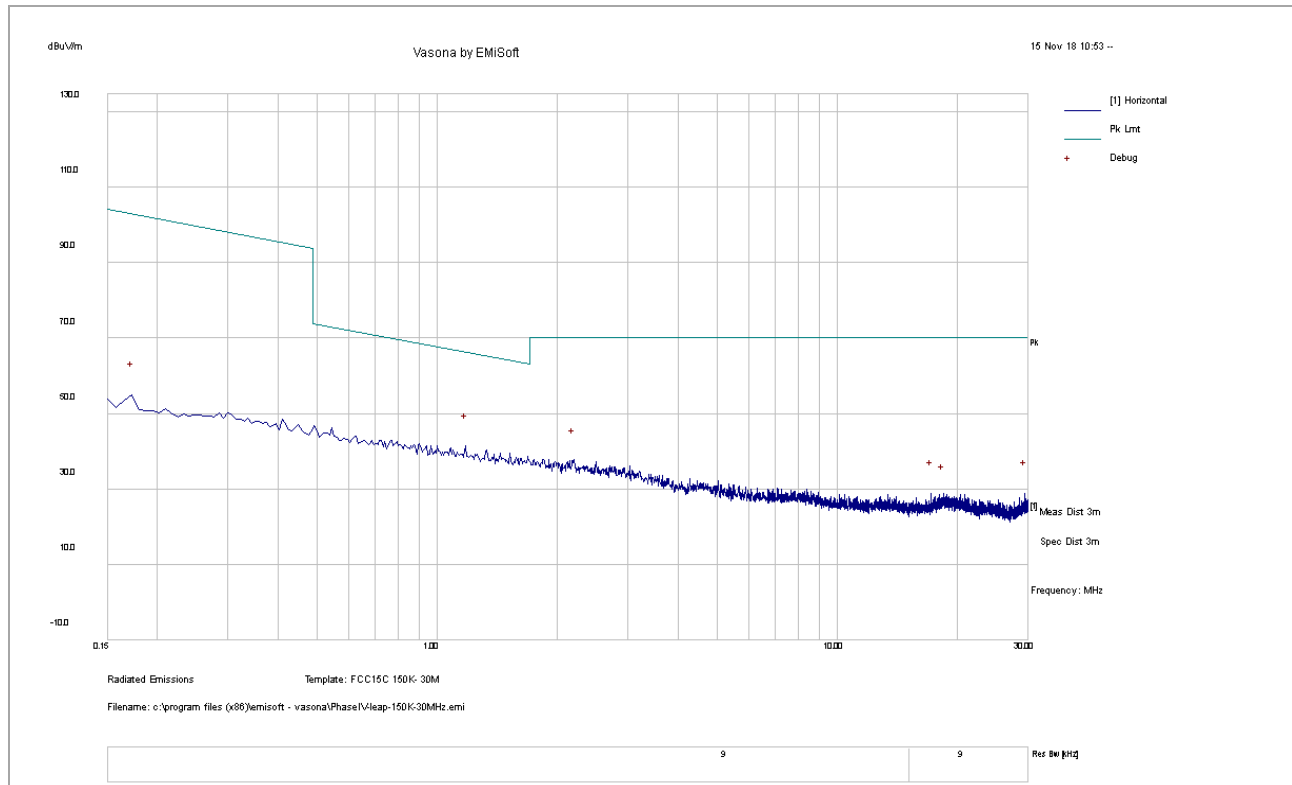
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150KHz – 30MHz test result

Test Standard:	47CFR 15.209	Mode:	2440MHz
Frequency Range:	150KHz – 30MHz	Test Date:	11/14/2018
Antenna Type/Polarity:	Loop / 0 deg & 90 deg	Test Personnel:	Sherwin Lee
Remark:	N/A	Test Result:	Pass



Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
0.173	43.25	0.60	11.00	54.85	PK	0	100	62	102.84	-47.99
1.179	27.48	0.79	12.97	41.24	PK	0	100	88	66.17	-24.93
2.184	23.15	0.85	13.18	37.18	PK	0	100	13	70.00	-32.82
17.180	13.54	1.60	13.61	28.76	PK	0	100	102	70.00	-41.24
18.399	12.10	1.68	13.92	27.70	PK	0	100	9	70.00	-42.30
29.416	14.98	2.20	11.49	28.67	PK	0	100	360	70.00	-41.33

Note: 1) Both 0 deg and 90 deg setup of the loop antenna have been verified and the worst case result is presented here.

2) All different antenna versions have been verified and the worst case result is presented here.

3) EUT was tested in 3 orientations.



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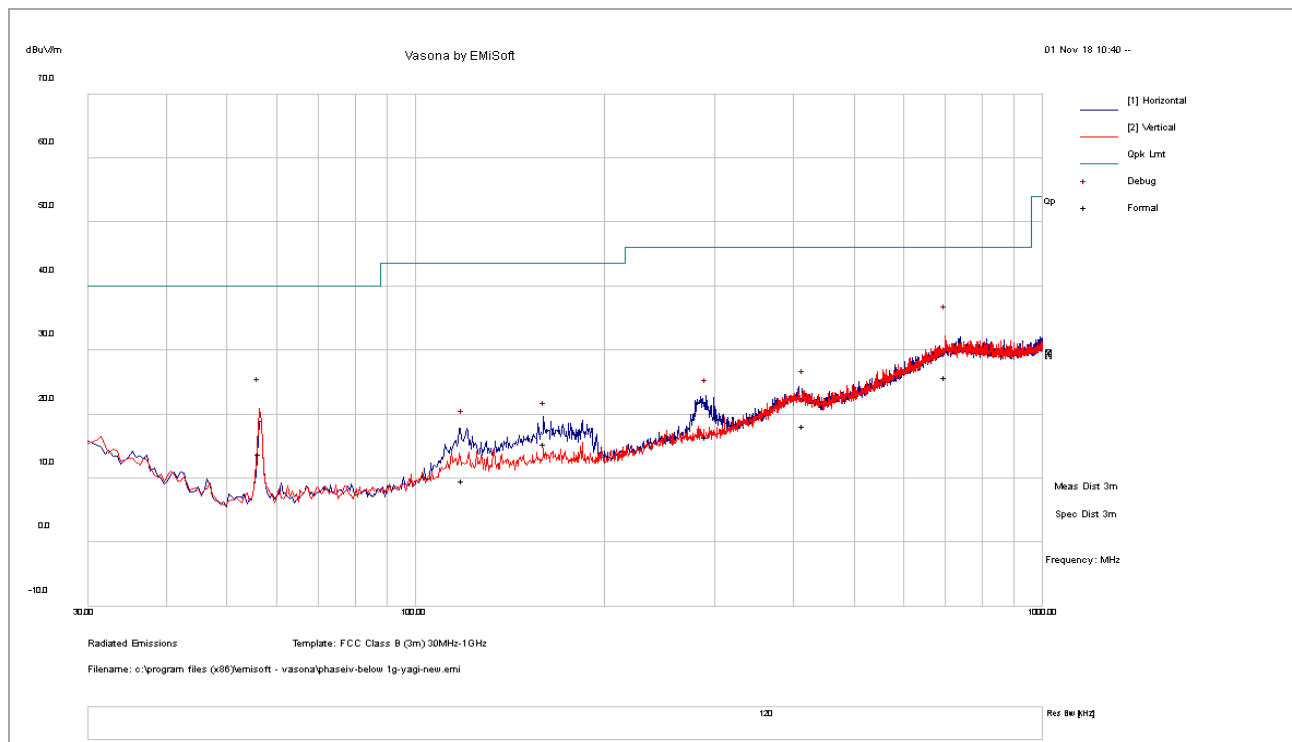
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30-1000MHz test result for Yagi antenna

Test Standard:	47CFR 15.209	Mode:	2440MHz
Frequency Range:	30-1000MHz	Test Date:	11/01/2018
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Personnel:	Sherwin Lee
Remark:	N/A	Test Result:	Pass



Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
56.43	35.71	2.93	-24.71	13.92	QP	V	399	286	40	-26.08
118.93	29.05	3.86	-23.19	9.71	QP	H	384	57	43.5	-33.79
160.85	33.34	4.36	-22.34	15.36	QP	H	119	62	43.5	-28.14
290.59	29.75	5.6	-18.82	16.54	QP	H	150	354	46	-29.46
414.71	25.57	6.32	-13.64	18.25	QP	H	224	44	46	-27.75
700.03	24.98	7.31	-6.43	25.87	QP	V	324	28	46	-20.13

Note: For below 1GHz, all different channel and modes were verified but only the worst case result is shown here. EUT was tested in 3 orientations.



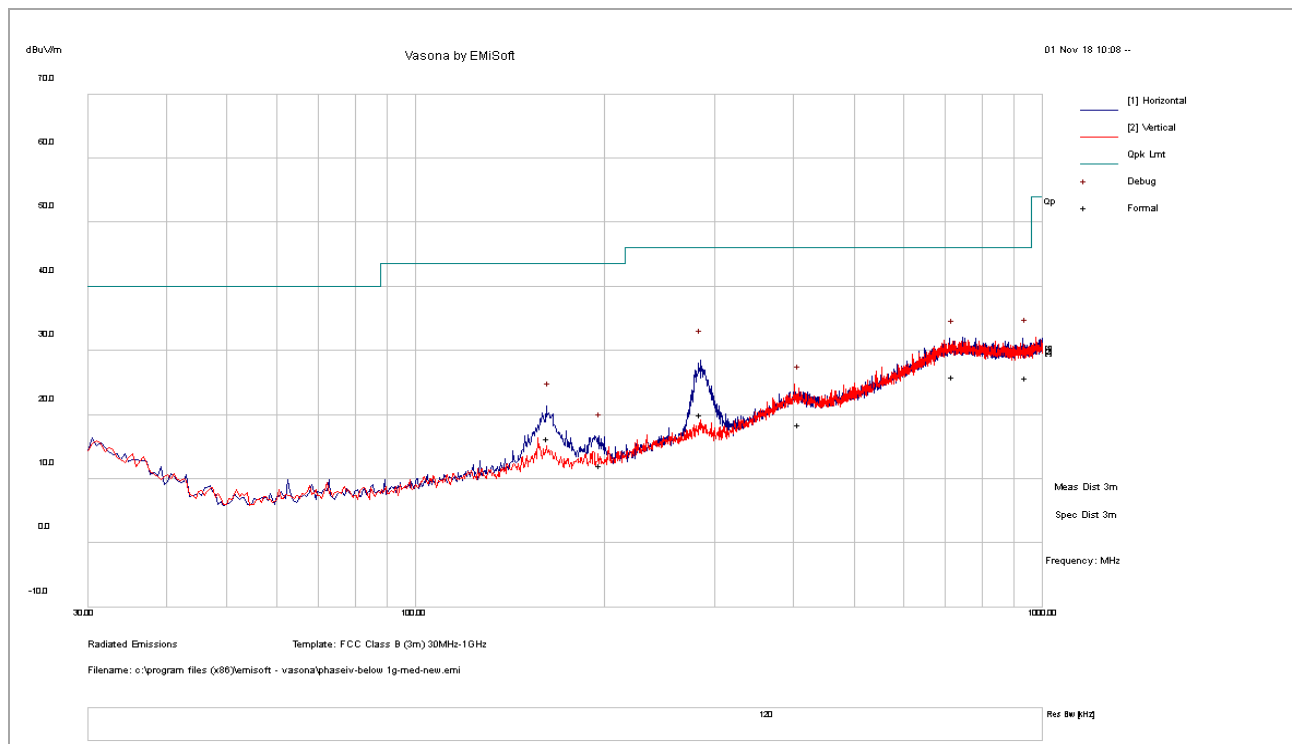
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San Clemente, CA, 92673
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30-1000MHz test result for monopole antenna

Test Standard:	47CFR 15.209	Mode:	2440MHz
Frequency Range:	30-1000MHz	Test Date:	11/01/2018
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Personnel:	Sherwin Lee
Remark:	N/A	Test Result:	Pass



Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
162.81	34.21	4.38	-22.31	16.27	QP	H	188	170	43.5	-27.23
196.87	29.33	4.7	-21.85	12.19	QP	H	115	26	43.5	-31.31
284.40	33.46	5.55	-18.88	20.14	QP	H	152	356	46	-25.86
408.04	25.65	6.34	-13.54	18.45	QP	V	280	136	46	-27.55
719.31	25.23	7.3	-6.5	26.03	QP	H	314	317	46	-19.97
940.52	24.88	7.77	-6.79	25.85	QP	H	321	198	46	-20.15

Note: For below 1GHz, all different channel and modes were verified but only the worst case result is shown here. EUT was tested in 3 orientations

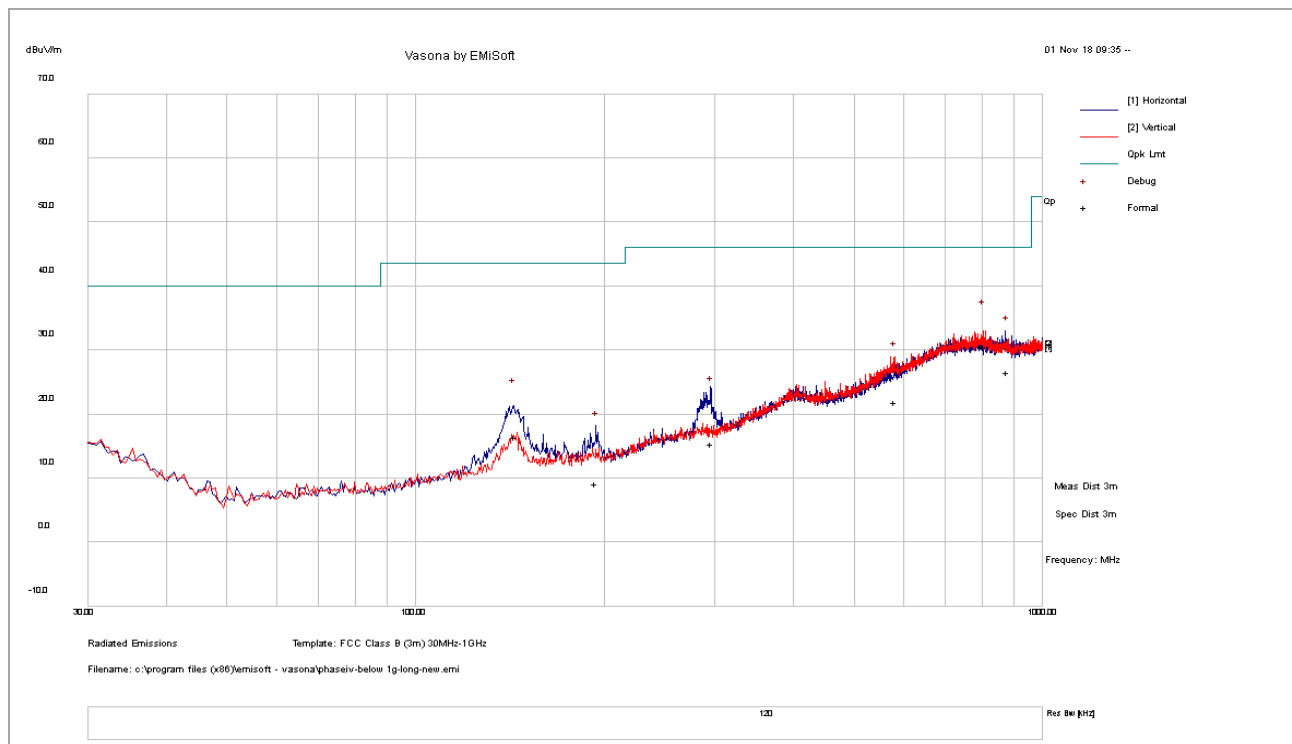
Report Number: PFE-18100201-LC-FCC-RF-LEAP Rev1.1
Product: Leap 2.4GHz RF Module
Model Number: 44-100312-00, 44-100312-01



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30-1000MHz test result for folded dipole (long) antenna

Test Standard:	47CFR 15.209	Mode:	2440MHz
Frequency Range:	30-1000MHz	Test Date:	11/01/2018
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Personnel:	Sherwin Lee
Remark:	N/A	Test Result:	Pass



Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
144.03	34.88	4.18	-22.63	16.42	QP	H	257	192	43.5	-27.08
194.29	26.34	4.68	-21.88	9.15	QP	H	350	0	43.5	-34.35
297.18	28.48	5.66	-18.75	15.39	QP	H	129	101	46	-30.61
580.86	25.35	6.97	-10.41	21.92	QP	H	228	86	46	-24.08
805.29	30.22	7.26	-6.79	30.69	QP	V	149	70	46	-15.31
878.38	26.16	7.53	-7.14	26.56	QP	H	103	300	46	-19.44

Note: For below 1GHz, all different channel and modes were verified but only the worst case result is shown here. EUT was tested in 3 orientations



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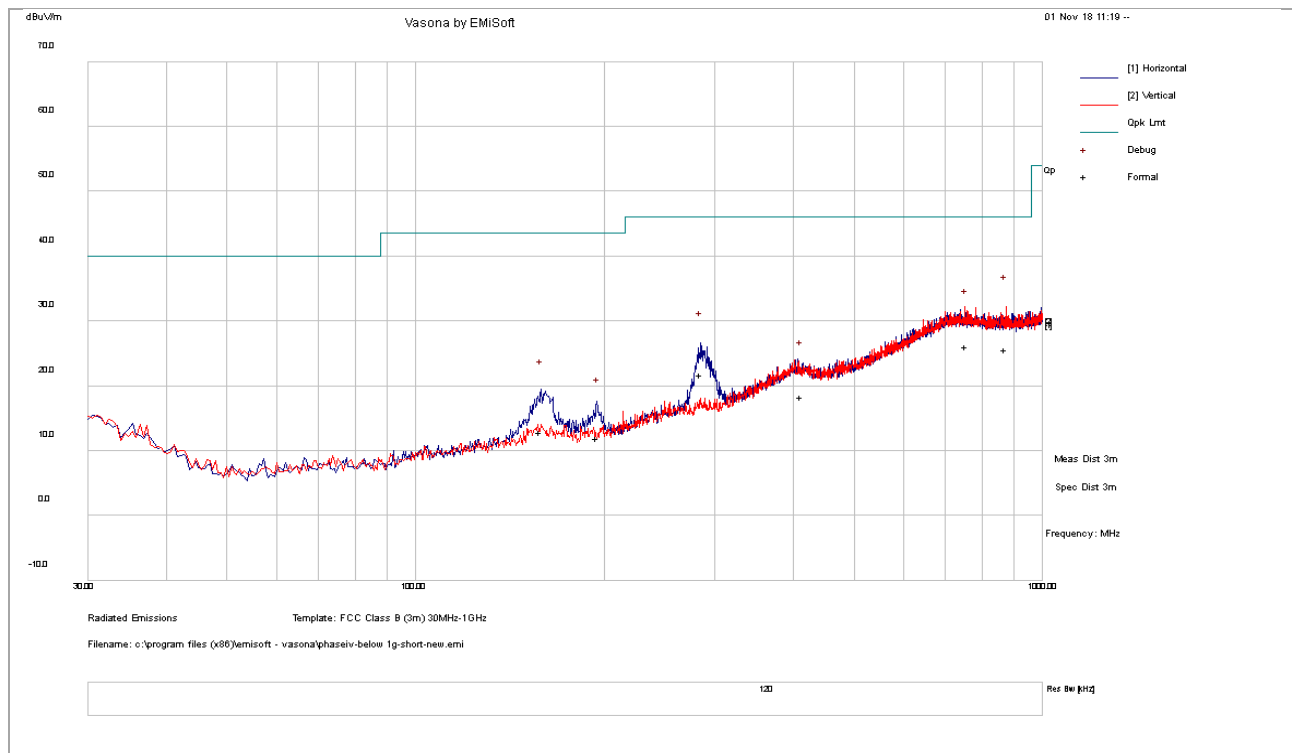
Report Number: PFE-18100201-LC-FCC-RF-LEAP Rev1.1
Product: Leap 2.4GHz RF Module
Model Number: 44-100312-00, 44-100312-01



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30-1000MHz test result for folded dipole (short) antenna

Test Standard:	47CFR 15.209	Mode:	2440MHz
Frequency Range:	30-1000MHz	Test Date:	10/20/2018
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Personnel:	Sherwin Lee
Remark:	N/A	Test Result:	Pass



Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
158.14	31	4.34	-22.39	12.95	QP	H	258	41	43.5	-30.55
195.04	29.09	4.69	-21.87	11.91	QP	H	108	0	43.5	-31.59
284.92	35.06	5.56	-18.88	21.74	QP	H	101	105	46	-24.26
412.05	25.55	6.33	-13.6	18.28	QP	H	103	0	46	-27.72
754.01	25.46	7.28	-6.62	26.12	QP	H	202	132	46	-19.88
872.81	25.19	7.51	-7.11	25.59	QP	V	128	349	46	-20.41

Note: For below 1GHz, all different channel and modes were verified but only the worst case result is shown here. EUT was tested in 3 orientations



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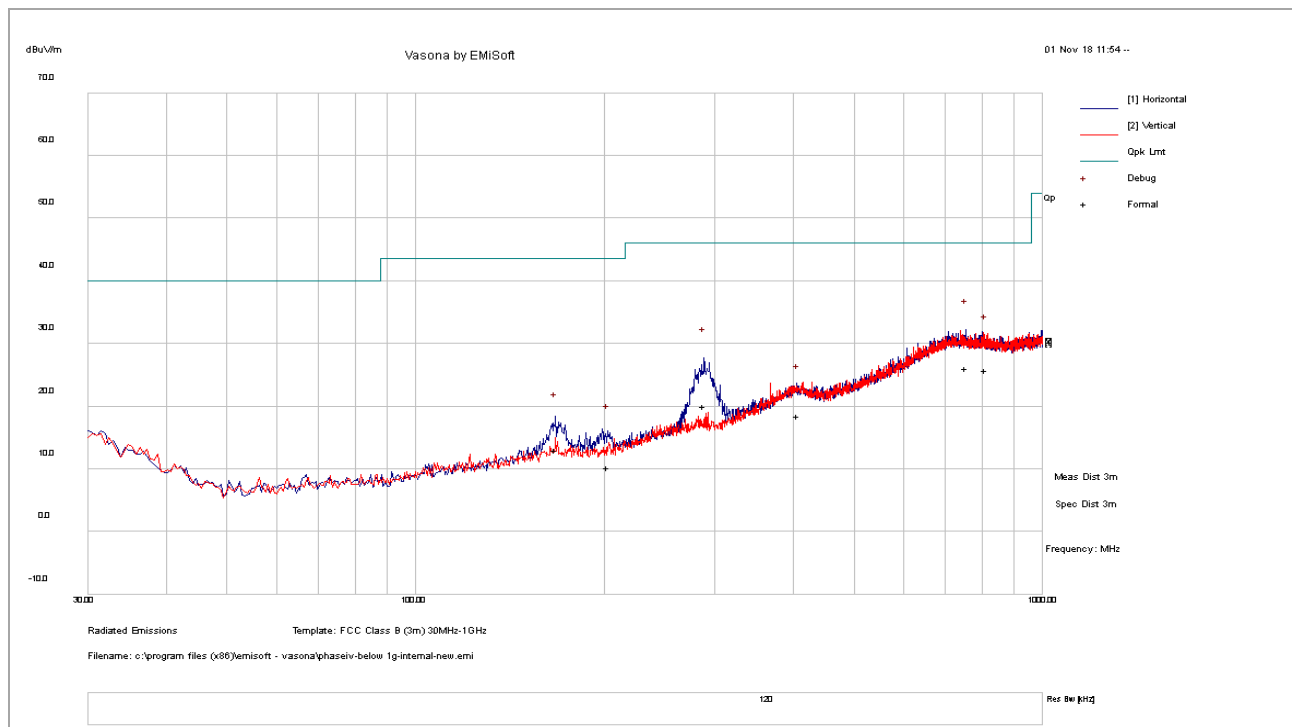
Report Number: PFE-18100201-LC-FCC-RF-LEAP Rev1.1
Product: Leap 2.4GHz RF Module
Model Number: 44-100312-00, 44-100312-01



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30-1000MHz test result for internal antenna

Test Standard:	47CFR 15.209	Mode:	2440MHz
Frequency Range:	30-1000MHz	Test Date:	10/20/2018
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Personnel:	Sherwin Lee
Remark:	N/A	Test Result:	Pass



Frequency MHz	Raw dB	Cable dB	AF dB	Level dBuV/m	Det	Pol deg	Height cm	Table cm	Limit dBuV/m	Margin dB
167.04	30.94	4.43	-22.25	13.11	QP	H	124	14	43.5	-30.39
202.67	27.19	4.76	-21.65	10.3	QP	H	272	360	43.5	-33.2
288.03	33.31	5.58	-18.84	20.05	QP	H	155	1	46	-25.95
406.96	25.63	6.35	-13.53	18.45	QP	H	127	40	46	-27.55
754.09	25.46	7.27	-6.62	26.11	QP	H	169	46	46	-19.89
813.23	25.3	7.29	-6.83	25.76	QP	H	376	129	46	-20.24

Note: For below 1GHz, all different channel and modes were verified but only the worst case result is shown here. EUT was tested in 3 orientations



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Report Number:	PFE-18100201-LC-FCC-RF-LEAP Rev1.1
Product:	Leap 2.4GHz RF Module
Model Number:	44-100312-00, 44-100312-01



1GHz – 25GHz Test Result for Internal Antenna

Test Mode: 2405MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
1276.14	44.84	4.09	-11.7	37.23	Peak	V	299	287	74	-36.77	Pass
1276.14	31.15	4.09	-11.7	23.54	Average	V	299	287	54	-30.46	Pass
4813.11	38.81	6.87	-5.53	40.15	Peak	V	185	95	74	-33.85	Pass
4813.11	27.22	6.87	-5.53	28.56	Average	V	185	95	54	-25.44	Pass
13809.19	33.61	13.58	5.57	52.75	Peak	V	280	200	74	-21.25	Pass
13809.19	21.36	13.58	5.57	40.51	Average	V	280	200	54	-13.5	Pass
14340.84	32.56	14.5	8.36	55.42	Peak	H	100	280	74	-18.58	Pass
14340.84	20.34	14.5	8.36	43.2	Average	H	100	280	54	-10.8	Pass

Test Mode: 2440MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
1224.31	50.51	4	-11.86	42.65	Peak	H	144	102	74	-31.35	Pass
1224.31	32.73	4	-11.86	24.87	Average	H	144	102	54	-29.14	Pass
4878.99	46.14	6.89	-5.55	47.49	Peak	H	104	289	74	-26.51	Pass
4878.99	36.68	6.89	-5.55	38.03	Average	H	104	289	54	-15.97	Pass
14343.37	31.77	14.5	8.37	54.64	Peak	H	109	27	74	-19.36	Pass
14343.37	20.25	14.5	8.37	43.12	Peak	H	109	27	54	-10.88	Pass

Test Mode: 2470MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
1225.32	18.17	4	-11.86	10.31	Peak	V	302	103	74	-63.69	Pass
1225.32	6	4	-11.86	-1.86	Peak	V	302	103	54	-55.86	Pass
13807.21	33.23	13.58	5.56	52.37	Peak	V	140	216	74	-21.63	Pass
13807.21	21.54	13.58	5.56	40.68	Average	V	140	216	54	-13.32	Pass
14347.29	30.97	14.51	8.38	53.86	Peak	H	158	289	74	-20.14	Pass
14347.29	19.81	14.51	8.38	42.7	Average	H	158	289	54	-11.3	Pass
17482.32	17.49	17.15	10.97	45.62	Peak	H	338	24	74	-28.39	Pass
17482.32	5.74	17.15	10.97	33.86	Peak	H	338	24	54	-20.14	Pass

Note: EUT was tested in 3 orientations



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Report Number:	PFE-18100201-LC-FCC-RF-LEAP Rev1.1
Product:	Leap 2.4GHz RF Module
Model Number:	44-100312-00, 44-100312-01



1GHz – 25GHz Test Result for Yagi Antenna

Test Mode: 2405MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
14346.73	32.31	14.51	8.38	55.2	Peak	H	380	219	74	-18.8	Pass
14346.73	19.9	14.51	8.38	42.79	Average	H	380	219	54	-11.21	Pass
17183.03	21.62	16.78	10.65	49.05	Peak	V	201	247	74	-24.95	Pass
17183.03	9.61	16.78	10.65	37.04	Average	V	201	247	54	-16.96	Pass

Test Mode: 2440MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
14335.48	32.73	14.48	8.35	55.56	Peak	H	294	360	74	-18.44	Pass
14335.48	20.39	14.48	8.35	43.22	Average	H	294	360	54	-10.78	Pass
17490.32	21.63	17.16	11.08	49.87	Peak	V	104	262	74	-24.13	Pass
17490.32	9.78	17.16	11.08	38.02	Average	V	104	262	54	-15.98	Pass

Test Mode: 2470MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
11073.57	34.68	12.59	2.6	49.87	Peak	H	151	18	74	-24.13	Pass
11073.57	22.69	12.59	2.6	37.89	Average	H	151	18	54	-16.12	Pass
14334.19	32.52	14.48	8.34	55.35	Peak	V	224	257	74	-18.65	Pass
14334.19	20.27	14.48	8.34	43.1	Average	V	224	257	54	-10.9	Pass

Note: EUT was tested in 3 orientations

Report Number:	PFE-18100201-LC-FCC-RF-LEAP Rev1.1
Product:	Leap 2.4GHz RF Module
Model Number:	44-100312-00, 44-100312-01



1GHz – 25GHz Test Result for Folded Dipole Antenna (Long)

Test Mode: 2405MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
4809.03	48.3	6.87	-5.53	49.64	Peak	H	178	292	74	-24.36	Pass
4809.03	40.2	6.87	-5.53	41.54	Average	H	178	292	54	-12.46	Pass
14346.54	31.99	14.51	8.38	54.88	Peak	H	222	328	74	-19.12	Pass
14346.54	19.73	14.51	8.38	42.62	Average	H	222	328	54	-11.38	Pass
14558.51	30.85	15.02	7.11	52.99	Peak	V	294	232	74	-21.01	Pass
14558.51	18.87	15.02	7.11	41.01	Average	V	294	232	54	-12.99	Pass

Test Mode: 2440MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
1329.67	43.82	4.18	-11.7	36.31	Peak	V	334	54	74	-37.69	Pass
1329.67	32.5	4.18	-11.7	24.99	Average	V	334	54	54	-29.01	Pass
4878.68	47.01	6.89	-5.55	48.35	Peak	H	100	276	74	-25.65	Pass
4878.68	37	6.89	-5.55	38.35	Average	H	100	276	54	-15.66	Pass
14333.61	32.18	14.48	8.34	55	Peak	V	160	286	74	-19	Pass
14333.61	20.13	14.48	8.34	42.95	Average	V	160	286	54	-11.05	Pass

Test Mode: 2470MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
1275.88	48.42	4.09	-11.7	40.82	Peak	V	312	301	74	-33.18	Pass
1275.88	32.18	4.09	-11.7	24.58	Average	V	312	301	54	-29.42	Pass
4965.79	39.62	6.91	-5.68	40.84	Peak	V	131	308	74	-33.16	Pass
4965.79	28.02	6.91	-5.68	29.24	Average	V	131	308	54	-24.76	Pass
14261.72	30.35	14.3	8.12	52.77	Peak	V	310	203	74	-21.23	Pass
14261.72	18.08	14.3	8.12	40.51	Average	V	310	203	54	-13.49	Pass
14715.82	29.93	15.4	6.09	51.42	Peak	H	240	0	74	-22.58	Pass
14715.82	17.12	15.4	6.09	38.6	Average	H	240	0	54	-15.4	Pass

Note: EUT was tested in 3 orientations

Report Number:	PFE-18100201-LC-FCC-RF-LEAP Rev1.1
Product:	Leap 2.4GHz RF Module
Model Number:	44-100312-00, 44-100312-01



1GHz – 25GHz Test Result for Folded Dipole Antenna (Short)

Test Mode: 2405MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
1224.29	57.16	4	-11.86	49.3	Peak	V	115	275	74	-24.7	Pass
1224.29	33.23	4	-11.86	25.37	Average	V	115	275	54	-28.63	Pass
4809.04	46.89	6.87	-5.53	48.23	Peak	V	125	344	74	-25.78	Pass
4809.04	38.41	6.87	-5.53	39.75	Average	V	125	344	54	-14.25	Pass
14334.03	32.71	14.48	8.34	55.53	Peak	H	400	274	74	-18.47	Pass
14334.03	20.33	14.48	8.34	43.16	Average	H	400	274	54	-10.84	Pass

Test Mode: 2440MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
1224.37	45.1	4	-11.86	37.24	Peak	V	377	294	74	-36.77	Pass
1224.37	32.6	4	-11.86	24.74	Average	V	377	294	54	-29.27	Pass
4878.82	49.33	6.89	-5.55	50.67	Peak	V	100	324	74	-23.33	Pass
4878.82	40.29	6.89	-5.55	41.63	Average	V	100	324	54	-12.37	Pass
14333.22	32.03	14.48	8.34	54.85	Peak	H	336	307	74	-19.15	Pass
14333.22	20.19	14.48	8.34	43.01	Average	H	336	307	54	-10.99	Pass

Test Mode: 2470MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
1977.94	45.4	4.44	-10.59	39.25	Peak	H	333	352	74	-34.75	Pass
1977.94	33.4	4.44	-10.59	27.26	Average	H	333	352	54	-26.74	Pass
4961.79	43.09	6.91	-5.7	44.31	Peak	V	108	150	74	-29.7	Pass
4961.79	31.58	6.91	-5.7	32.8	Average	V	108	150	54	-21.2	Pass
14335.33	32.3	14.48	8.35	55.13	Peak	H	372	0	74	-18.87	Pass
14335.33	20.35	14.48	8.35	43.18	Average	H	372	0	54	-10.82	Pass

Note: EUT was tested in 3 orientations

Report Number:	PFE-18100201-LC-FCC-RF-LEAP Rev1.1
Product:	Leap 2.4GHz RF Module
Model Number:	44-100312-00, 44-100312-01



1GHz – 25GHz Test Result for Folded Dipole Antenna (Long)

Test Mode: 2405MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
4813.07	27.08	6.87	-5.53	28.42	Average	V	175	243	54	-25.58	Pass
4813.07	38.73	6.87	-5.53	40.07	Peak	V	175	243	74	-33.93	Pass
14344.9	19.8	14.51	8.37	42.68	Average	H	156	345	54	-11.32	Pass
14344.9	32.16	14.51	8.37	55.04	Peak	H	156	345	74	-18.96	Pass
14495.33	17.85	14.87	7.61	40.33	Average	H	306	174	54	-13.67	Pass
14495.33	29.98	14.87	7.61	52.46	Peak	H	306	174	74	-21.54	Pass

Test Mode: 2440MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
1320.54	33.94	4.17	-11.67	26.44	Average	V	171	307	54	-27.56	Pass
1320.54	48.75	4.17	-11.67	41.25	Peak	V	171	307	74	-32.75	Pass
4878.9	38	6.89	-5.55	39.34	Average	V	101	327	54	-14.66	Pass
4878.9	47.1	6.89	-5.55	48.44	Peak	V	101	327	74	-25.56	Pass
14332.6	34.5	26.7	8.34	49.52	Average	H	125	294	54	-4.48	Pass
14332.6	31.61	14.48	8.34	54.43	Peak	H	125	294	74	-19.57	Pass
14494.98	17.83	14.87	7.61	40.31	Average	H	281	13	54	-13.69	Pass
14494.98	29.76	14.87	7.61	52.24	Peak	H	281	13	74	-21.76	Pass

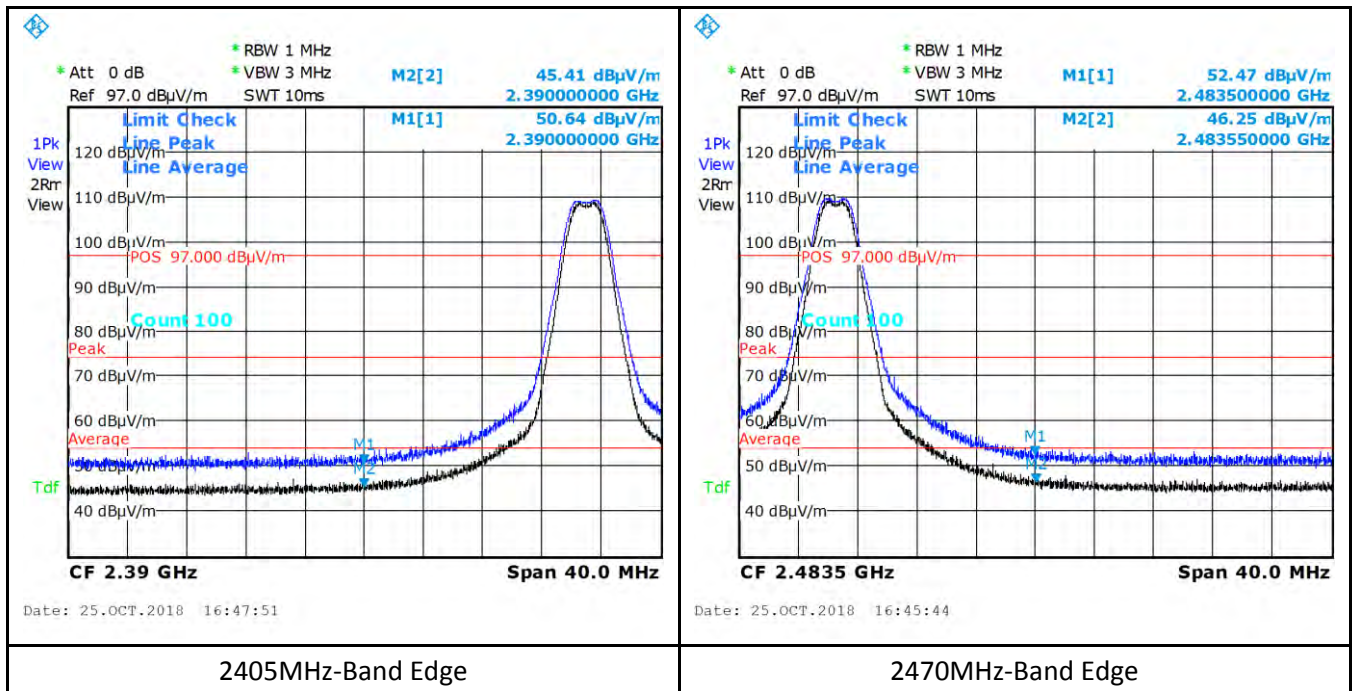
Test Mode: 2470MHz

Freq. MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Meas. Type	Pol	Hgt cm	Deg	Limit dBuV/m	Margin dB	Pass /Fail
1625.26	43.61	4.45	-11.89	36.18	Peak	V	138	55	74	-37.82	Pass
1625.26	31.11	4.45	-11.89	23.68	Average	V	138	55	54	-30.32	Pass
4961.56	44.93	6.91	-5.7	46.14	Peak	V	113	339	74	-27.86	Pass
4961.56	34.25	6.91	-5.7	35.46	Average	V	113	339	54	-18.54	Pass
14322.8	31.19	14.45	8.31	53.96	Peak	H	323	33	74	-20.04	Pass
14322.8	19.04	14.45	8.31	41.8	Average	H	323	33	54	-12.2	Pass

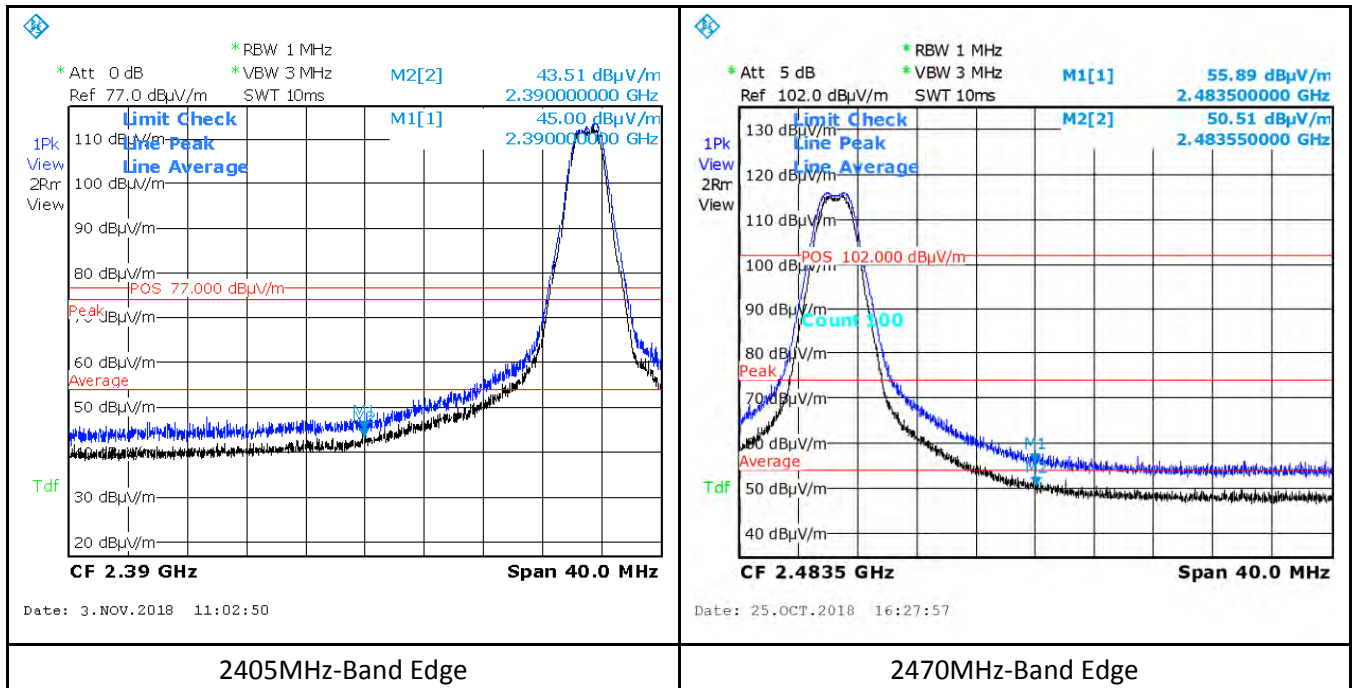
Note: EUT was tested in 3 orientations



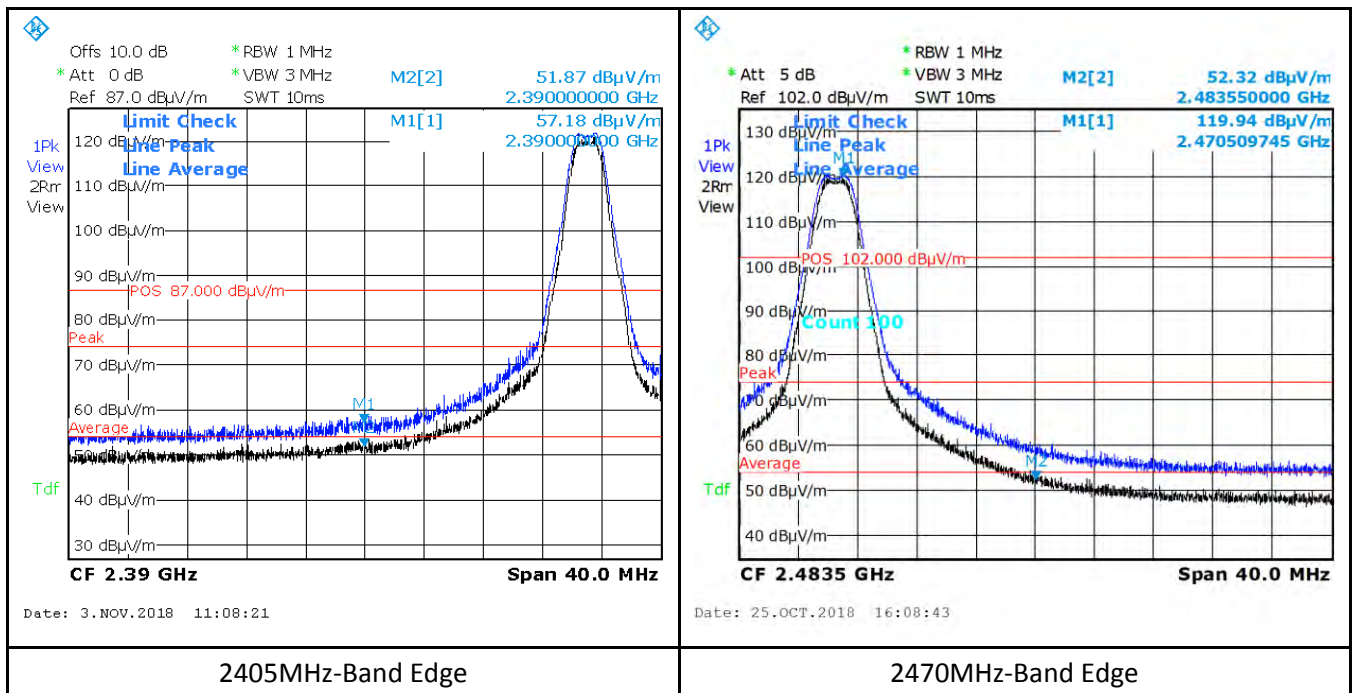
Radiated Band Edge Measurement Result for Internal Antenna



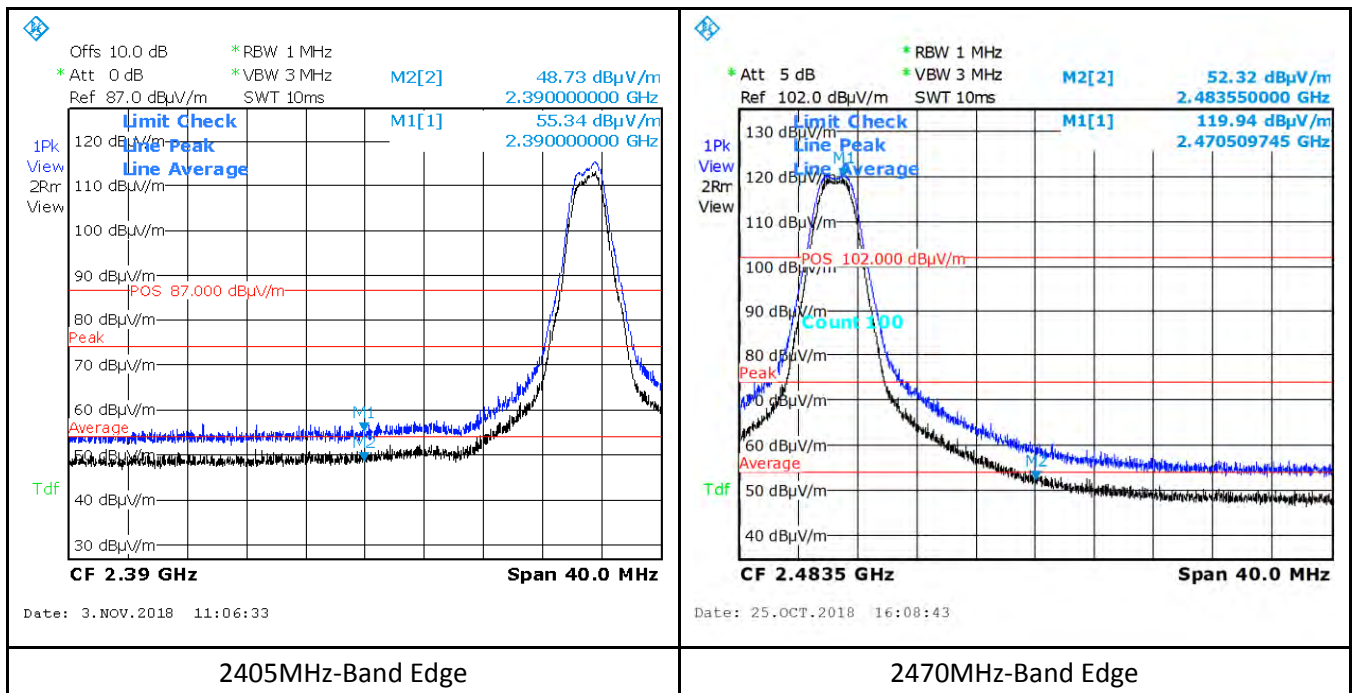
Radiated Band Edge Measurement Result for Monopole Antenna



Radiated Band Edge Measurement Result for Yagi Antenna

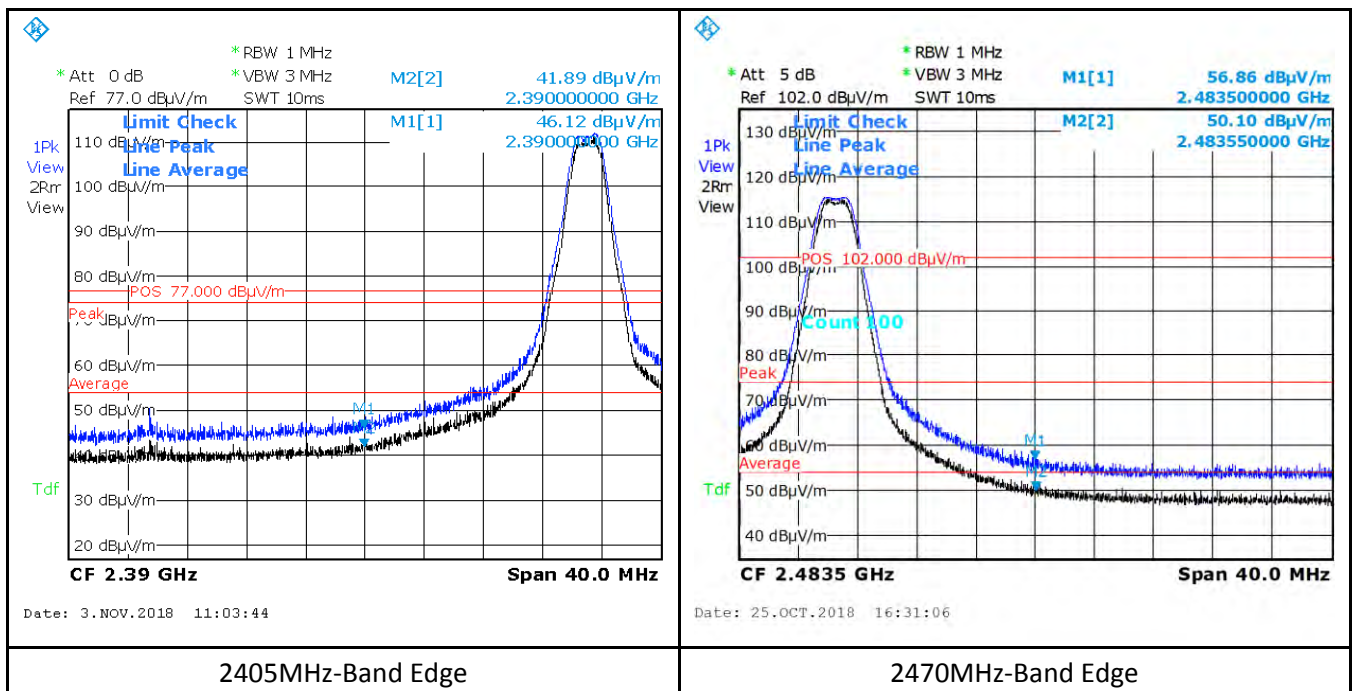


Radiated Band Edge Measurement Result for Folded Dipole Antenna (Long)



Note: Both Horizontal and vertical polarities were investigated.

Radiated Band Edge Measurement Result for Folded Dipole Antenna (Short)



Note: Both Horizontal and vertical polarities were investigated.

8.7 Conducted Emissions

8.7.1 Requirement

Per § 15.207 (a), an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Limits for Conducted Emissions at the Mains Ports

Section	Frequency ranges (MHz)	Limit (dBuV)	
		QP	Average
Class B devices	0.15 – 0.5	66 – 56	56 – 46
	0.5 – 5	56	46
	5 - 30	60	50

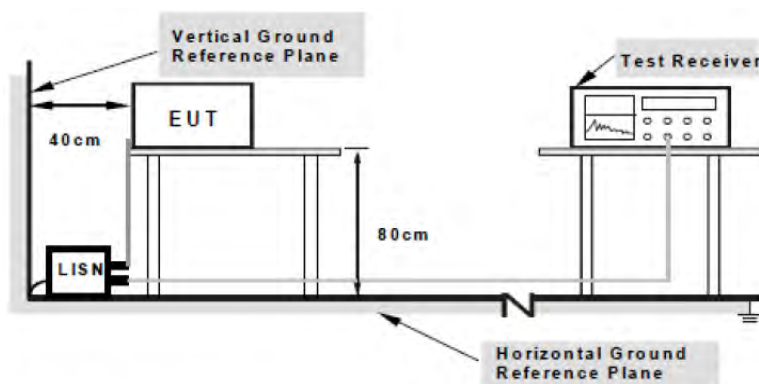
NOTE 1 The lower limit shall apply at the transition frequencies.

Limits for Conducted Emissions at the Telecommunication Ports

Section	Frequency ranges (MHz)	Limit (dBuV)	
		QP	Average
Class B devices	0.15 – 0.5	85 – 74	74 – 64
	0.5 – 5	74	64

NOTE 1 The limits decrease linearly with the logarithm of the frequency in the range 0.15 MHz to 0.5 MHz
NOTE 2 The voltage disturbance limits are derived for use with an impedance stabilization network (ISN) which presents a common mode (asymmetric mode) impedance of 150 Ω to the telecommunication port under test (conversion factor is 20 log₁₀ 150 / I = 44 dB).

8.7.2 Test setup



Note: 1. Support units were connected to second LISN.
2. Both of LISNs (AMN) are 80cm from EUT and at least 80cm from other units and other metal planes support units.

Report Number:	PFE-18100201-LC-FCC-RF-LEAP Rev1.1
Product:	Leap 2.4GHz RF Module
Model Number:	44-100312-00, 44-100312-01



8.7.3 Test Procedure

1. The EUT and supporting equipment were set up in accordance with the requirements of the standard on top of a 1.5m x 1m x 0.8m high, non-metallic table.
2. The power supply for the EUT was fed through a 50Ω/50μH EUT LISN, connected to filtered mains.
3. The RF OUT of the EUT LISN was connected to the EMI test receiver via a low-loss coaxial cable.
4. All other supporting equipment was powered separately from another main supply.
5. The EUT was switched on and allowed to warm up to its normal operating condition.
6. A scan was made on the NEUTRAL line (for AC mains) or Earth line (for DC power) over the required frequency range using an EMI test receiver.
7. High peaks, relative to the limit line, were then selected.
8. The EMI test receiver was then tuned to the selected frequencies and the necessary measurements made with a receiver bandwidth setting of 10 kHz. For FCC tests, only Quasi-peak measurements were made; while for CISPR/EN tests, both Quasi-peak and Average measurements were made
9. All possible modes of operation were investigated. Only the worst case emissions were measured and reported. All other emissions were relatively insignificant.

Note:

- 1) The AC line conducted emission was tested with antenna port terminated.
- 2) The AC line conducted emission was verified on both version boards and the worst case result tested with external antenna version is presented here.

Report Number: PFE-18100201-LC-FCC-RF-LEAP Rev1.1
Product: Leap 2.4GHz RF Module
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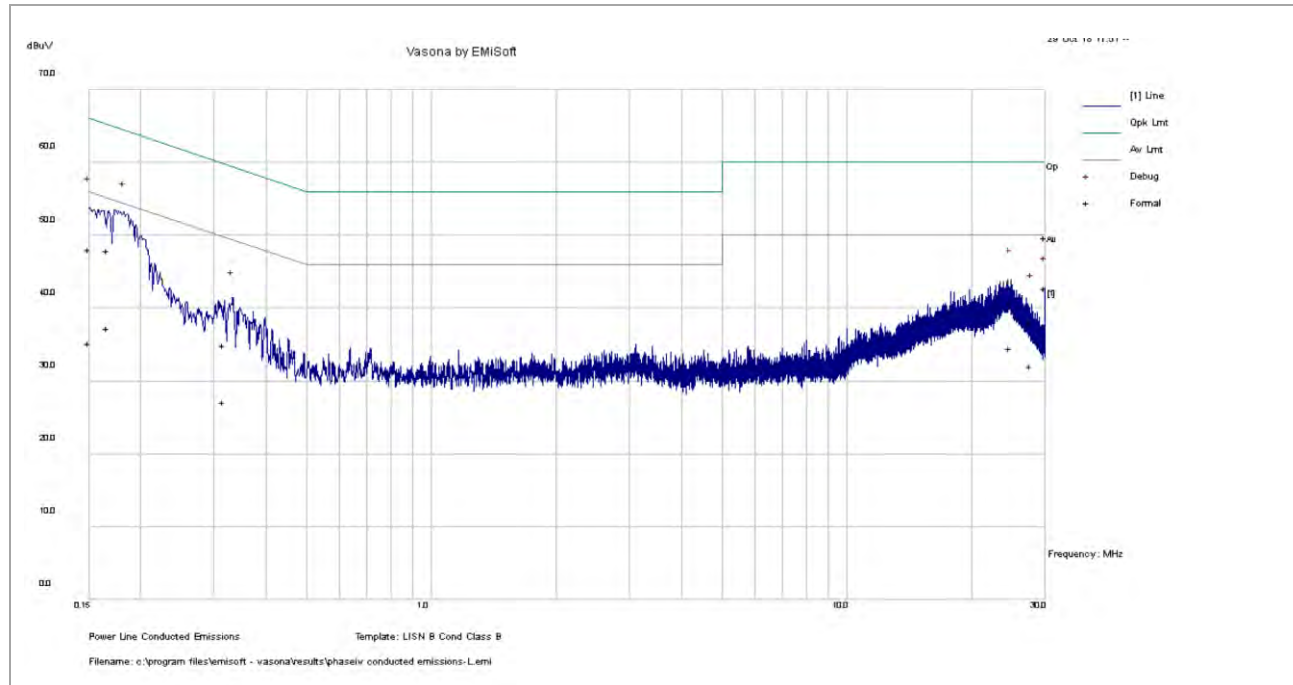
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8.7.4 Test Result

Live Line

Test Standard:	47CFR 15.207	Mode:	Line
Frequency Range:	0.15-30MHz	Test Date:	10/29/2018
Antenna Type/Polarity:	N/A	Test Personnel:	Sherwin Lee
Remark:	External antenna version	Test Result:	Pass



Frequency (MHz)	Raw (dBuV)	Cable Loss (dB)	Factors (dB)	Level (dBuV/m)	Meas. Type	Line	Limit (dBuV/m)	Margin (dB)	Pass /Fail
0.15	24.9	10.1	0.3	35.2	AV	Line	56	-20.8	Pass
0.15	37.78	10.07	0.25	48.11	QP	Line	65.99	-17.89	Pass
0.16	27	10.1	0.3	37.3	AV	Line	55.1	-17.8	Pass
0.16	37.53	10.08	0.25	47.86	QP	Line	65.11	-17.25	Pass
0.31	16.78	10.09	0.27	27.14	AV	Line	49.79	-22.65	Pass
0.31	24.57	10.09	0.27	34.93	QP	Line	59.79	-24.86	Pass
24.74	15	10.85	14.77	40.62	QP	Line	60	-19.38	Pass
24.74	8.85	10.85	14.77	34.46	AV	Line	50	-15.54	Pass
27.80	13.19	10.89	13.86	37.94	QP	Line	60	-22.06	Pass
27.80	7.36	10.89	13.86	32.11	AV	Line	50	-17.89	Pass
29.99	19.1	10.93	12.72	42.76	AV	Line	50	-7.24	Pass
29.99	26.07	10.93	12.72	49.72	QP	Line	60	-10.28	Pass



Electromagnetic Compatibility
 Radio Frequency
 Product Certification
 International Approval

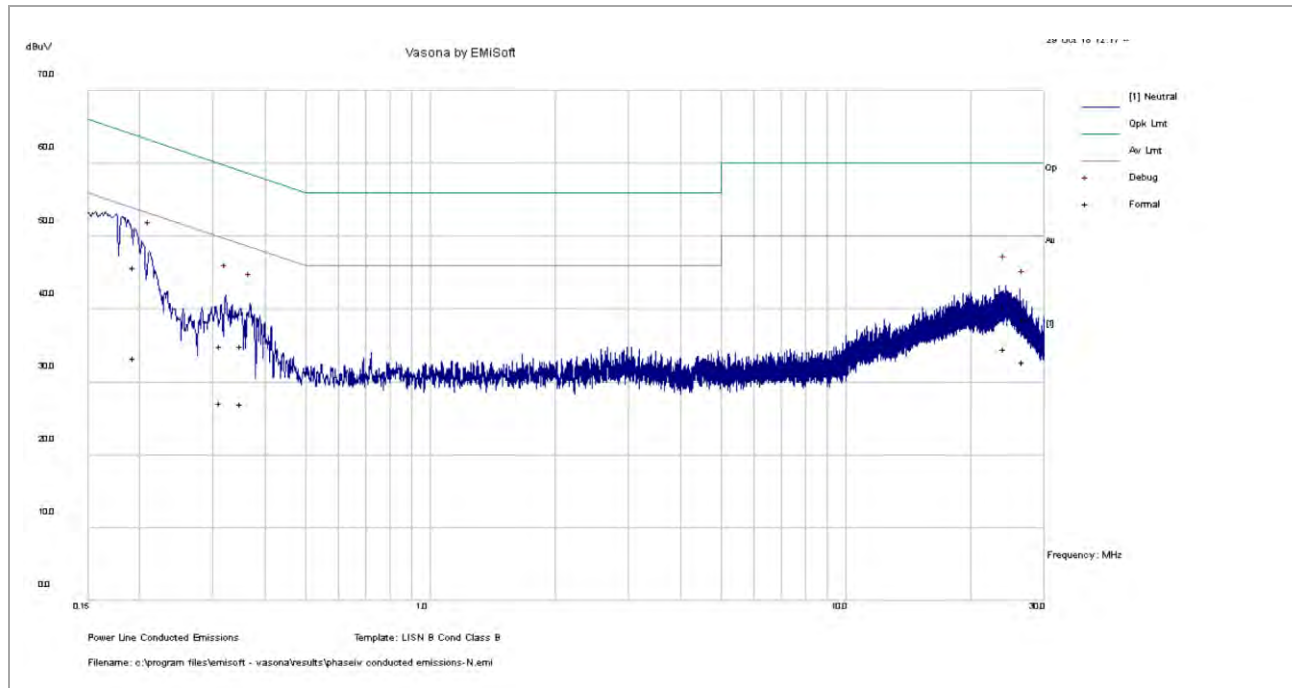
1261 Puerta Del Sol
 San Clemente, CA, 92673
 +1 (949) 393-1123
www.vista-compliance.com

Report Number:	PFE-18100201-LC-FCC-RF-LEAP Rev1.1
Product:	Leap 2.4GHz RF Module
Model Number:	44-100312-00, 44-100312-01



Neutral Line

Test Standard:	47CFR 15.207	Mode:	Neutral
Frequency Range:	0.15-30MHz	Test Date:	10/29/2018
Antenna Type/Polarity:	N/A	Test Personnel:	Sherwin Lee
Remark:	External antenna version	Test Result:	Pass



Frequency (MHz)	Raw (dBuV)	Cable Loss (dB)	Factor s (dB)	Level (dBuV/m)	Meas. Type	Line	Limit (dBuV/m)	Margin (dB)	Pass /Fail
0.19	35.43	10.08	0.26	45.76	QP	Neutral	63.89	-18.13	Pass
0.19	23	10.1	0.3	33.3	AV	Neutral	53.9	-20.6	Pass
0.31	24.54	10.09	0.27	34.9	QP	Neutral	59.89	-24.99	Pass
0.31	16.8	10.09	0.27	27.16	AV	Neutral	49.89	-22.73	Pass
0.35	24.6	10.1	0.27	34.96	QP	Neutral	58.95	-23.99	Pass
0.35	16.69	10.1	0.27	27.06	AV	Neutral	48.95	-21.89	Pass
24.14	14.63	10.84	14.99	40.46	QP	Neutral	60	-19.54	Pass
24.14	8.63	10.84	14.99	34.45	AV	Neutral	50	-15.55	Pass
26.68	13.49	10.87	14.26	38.62	QP	Neutral	60	-21.38	Pass
26.68	7.64	10.87	14.26	32.78	AV	Neutral	50	-17.22	Pass



9 Test instrument list

Equipment	Manufacturer	Model	Serial Number	Cal. Date	Cal. Due
Semi-Anechoic Chamber	ETS-Lindgren	10M	VL001	5/11/2018	5/11/2019
Shielding Control Room	ETS-Lindgren	Series 81	VL006	N/A	N/A
Spectrum Analyzer	Keysight	N9020A	MY50110074	5/4/2018	5/4/2019
EMC Test Receiver	R&S	ESL6	100230	5/7/2018	5/7/2019
LISN (9KHz – 30MHz)	EMCO	3816/2	9705-1066	5/4/2018	5/4/2019
Bi-Log Antenna	ETS-Lindgren	3142E	217921	11/15/2017	11/15/2018
Horn Antenna (1-18GHz)	Electro-Metrics	EM-6961	6292	5/2/2018	5/2/2019
Horn Antenna (18-40GHz)	Com-Power	AH-840	101109	5/2/2018	5/2/2019
Preamplifier	RF Bay, Inc.	LPA-10-20	11180621	5/10/2018	5/10/2019
True RMS Multi-meter	UNI-T	UT181A	C173014829	5/10/2018	5/10/2019
Temp / Humidity / Pressure Meter	PCE Instruments	PCE-THB 40	R062028	5/9/2018	5/9/2019
RF Attenuator	Pasternack	PE7005-3	VL061	5/10/2018	5/10/2019
Preamplifier 100KHz - 40GHz	Aeroflex	33711-392- 77150-11	064	5/10/2018	5/10/2019
EM Center Control	ETS-Lindgren	7006-001	160136	N/A	N/A
Turn Table	ETS-Lindgren	2181-3.03	VL002	N/A	N/A
Boresight Antenna Tower	ETS-Lindgren	2171B	VL003	N/A	N/A
Loop Antenna (9k-30MHz)	Com-Power	AL-130	121012	5/9/2018	5/9/2019
RE test cable(below 6GHz)	Vista	RE-6GHz-01	RE-6GHz-01	5/10/2018	5/10/2019
RE test cable (1-18GHz)	PhaseTrack	II-240	RE-18GHz-01	5/10/2018	5/10/2019
RE test cable (>18GHz)	Sucoflex	104	344903/4	5/10/2018	5/10/2019
Pulse limiter	Com-Power	LIT-930A	531727	5/15/2018	5/15/2019
CE test cable #1	FIRST RF	FRF-C-1002-001	CE-6GHz-01	5/10/2018	5/10/2019
CE test cable#2	FIRST RF	FRF-C-1002-001	CE-6GHz-02	5/9/2018	5/9/2019