

RADIO TEST REPORT

Product : PCIE 802.11a/b/g/n/ac/ax 2.4GHz/5GHz+USB/UART BT 5.2 module

Model Name : ACB-QCA6391

Series Model : ACB-QCA6391-WX1, ACB-QCA6391-WX2,
ACB-QCA6391-WX4, ACB-QCA6391-WX5,
ACB-QCA6391-WI1, ACB-QCA6391-WI2,
ACB-QCA6391-WI4, ACB-QCA6391-WI5

FCC ID : 2AE3B-ACB-QCA6391

Test Regulation : FCC 47 CFR Part 15 Subpart C (Section 15.247)

Received Date : 2021/5/18

Test Date : 2023/6/1 ~ 2023/8/16

Issued Date : 2023/9/12

Applicant : VOXMICRO LTD
20955 Pathfinder Rd., STE 100, Diamond Bar, California
91765, USA

Issued By : Underwriters Laboratories Taiwan Co., Ltd.
Building A, B and E, No. 372-7, Sec. 4, Zhongxing Rd.,
Zhudong Township, Hsinchu County, Taiwan



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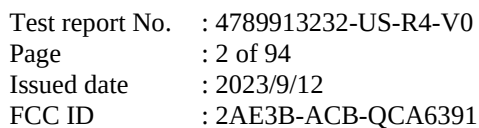
Underwriters Laboratories Taiwan Co., Ltd.

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Doc No: Form-ULID-004737 (DCS:17-EM-F0876) / 6.1



Original Test Report No.: 4789913232-US-R4-V0

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Table of Contents

1. Attestation of Test Results.....	4
2. Summary of Test Results.....	5
3. Test Methodology and Reference Procedures	6
4. Facilities and Accreditation.....	6
5. Measurement Uncertainty.....	7
6. Equipment under Test	8
6.1. Description of EUT	8
6.2. Channel List.....	9
6.3. Test Condition	10
6.4. Description of Available Antennas.....	11
6.5. Test Mode Applicability and Tested Channel Detail	12
6.6. Duty cycle.....	13
7. Test Equipment.....	14
8. Description of Test Setup.....	16
9. Test Results	18
9.1. 6dB Bandwidth	18
9.2. Conducted Output Power.....	21
9.3. Power Spectral Density	23
9.4. Conducted Out of Band Emission	26
9.5. Radiated Spurious Emission.....	33
9.6. AC Power Line Conducted Emission.....	91

1. Attestation of Test Results

APPLICANT: VOXMICRO LTD
20955 Pathfinder Rd., STE 100, Diamond Bar, California 91765, USA

MANUFACTURER: VOXMICRO LTD
8F.-3, No.5, Aly. 22, Ln. 513, Rueiguang Rd., Neihu Dist., Taipei City 114, Taiwan

EUT DESCRIPTION: PCIE 802.11a/b/g/n/ac/ax 2.4GHz/5GHz+USB/UART BT 5.2 module

BRAND: AIRETOS

MODEL: ACB-QCA6391

SERIES MODEL: ACB-QCA6391-WX1, ACB-QCA6391-WX2,
ACB-QCA6391-WX4, ACB-QCA6391-WX5,
ACB-QCA6391-WI1, ACB-QCA6391-WI2,
ACB-QCA6391-WI4, ACB-QCA6391-WI5

SAMPLE STAGE: Design Verification Test sample

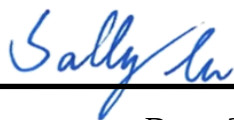
DATE of TESTED: 2023/6/1 ~ 2023/8/16

APPLICABLE STANDARDS	
STANDARD	Test Results
FCC 47 CFR PART 15 Subpart C (Section 15.247)	PASS

Underwriters Laboratories Taiwan Co., Ltd. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by Underwriters Laboratories Taiwan Co., Ltd. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by Underwriters Laboratories Taiwan Co., Ltd. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by Underwriters Laboratories Taiwan Co., Ltd. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

Prepared By:



Sally Lu
Project Handler

Date : 2023/9/12

Approved and Authorized By:



Eric Lee
Senior Laboratory Engineer

Date : 2023/9/12

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2. Summary of Test Results

Summary of Test Results		
FCC Clause	Test Items	Result
15.247(a)(2)	6dB Bandwidth	PASS
15.247(b)	Conducted Output Power	PASS
15.247(e)	Power Spectral Density	PASS
15.247(d)	Antenna Port Emission	PASS
15.205 / 15.209 / 15.247(d)	Radiated Emissions and Band Edge Measurement	PASS
15.207	AC Power Conducted Emission	PASS
15.203	Antenna Requirement	PASS

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3. Test Methodology and Reference Procedures

The tests documented in this report were performed in accordance with 47 CFR FCC Part 2, KDB558074 D01 Meas Guidance v05r02, KDB414788 D01 Radiated Test Site v01r01, ANSI C63.10-2013.

4. Facilities and Accreditation

Test Location	Underwriters Laboratories Taiwan Co., Ltd.
Address	Building A, B and E, No. 372-7, Sec. 4, Zhongxing Rd., Zhudong Township, Hsinchu County, Taiwan
Accreditation Certificate	Underwriters Laboratories Taiwan Co., Ltd. is accredited by TAF, Laboratory Code 3398.

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5. Measurement Uncertainty

For statement of conformity, accuracy method (Section 8.2.4 and 8.2.5 of ISO Guide 98-4) was applied as decision rule for measurement in this test report.

The following uncertainties have been calculated to provide a confidence level of 95 % using a coverage factor $k=2$.

Determining compliance based on the results of the compliance measurement, not considering measurement instrumentation uncertainty.

Measurement	Frequency	Uncertainty
Conducted disturbance at mains terminals ports	150kHz ~ 30MHz	± 3.1 dB
RF Conducted	9 kHz - 40GHz	± 2.3 dB
Radiated disturbance below 30MHz	9 kHz - 30 MHz	± 3.2 dB
Radiated disturbance below 1 GHz	30MHz ~ 1GHz	± 6.1 dB
Radiated disturbance above 1 GHz	1GHz ~ 40GHz	± 5.1 dB

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6. Equipment under Test

6.1. Description of EUT

Product	PCIE 802.11a/b/g/n/ac/ax 2.4GHz/5GHz+USB/UART BT 5.2 module
Brand Name	AIRETOS
Model Name	ACB-QCA6391
Series Model	ACB-QCA6391-WX1, ACB-QCA6391-WX2, ACB-QCA6391-WX4, ACB-QCA6391-WX5, ACB-QCA6391-WI1, ACB-QCA6391-WI2, ACB-QCA6391-WI4, ACB-QCA6391-WI5
Operating Frequency	2402MHz ~ 2480MHz
Modulation	GFSK
Transfer Rate	Up to 2 Mbps
Number of Channel	40
Maximum Output Power	6.13 dBm
Normal Voltage	3.7Vdc
S/N	E63B
Sample ID	3920615

Note:

- The models difference table as below:

Brand	Model	Difference
AIRETOS	ACB-QCA6391	-
	ACB-QCA6391-WX1	Market assignment classification for application and grade finish
	ACB-QCA6391-WX2	
	ACB-QCA6391-WX4	
	ACB-QCA6391-WX5	
	ACB-QCA6391-WI1	
	ACB-QCA6391-WI2	
	ACB-QCA6391-WI4	
	ACB-QCA6391-WI5	

- The above EUT information is declared by manufacturer and for more detailed features description, please refer the manufacturer's or user's manual, the laboratory shall not be held responsible.

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6.2. Channel List

40 channels are provided to this EUT:

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2402	10	2422	20	2442	30	2462
1	2404	11	2424	21	2444	31	2464
2	2406	12	2426	22	2446	32	2466
3	2408	13	2428	23	2448	33	2468
4	2410	14	2430	24	2450	34	2470
5	2412	15	2432	25	2452	35	2472
6	2414	16	2434	26	2454	36	2474
7	2416	17	2436	27	2456	37	2476
8	2418	18	2438	28	2458	38	2478
9	2420	19	2440	29	2460	39	2480

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6.3. Test Condition

Test Item	Test Site No.	Environmental Condition	Input Power	Test Date	Tested by
Antenna Port Conducted Measurement	SR4	20~26°C/ 62~68%RH	3.7Vdc	2023/06/01~ 2023/08/16	WaterNil Guan
Radiated Spurious Emission	966-2	20~26°C/ 62~68%RH	3.7Vdc	2023/06/01~ 2023/08/16	WaterNil Guan
AC power Line Conducted Emission	SR1	20~26°C/ 62~68%RH	3.7Vdc	2023/06/01~ 2023/08/16	WaterNil Guan

FCC Test Firm Registration Number: 498077

Sample Calculation:

Antenna Port Conducted Measurement:

- Where relevant, the follow sample calculation is provided:
Result Value (dBm) = Reading Value (dBm) + Attenuator Factor (dB) + Cable Loss (dB).
Example: Result Value (10dBm) = Reading Value (-2dBm) + Attenuator Factor (10dB) + Cable Loss(2dB).
*Test plot only shown the “Result Value”.

Radiated Spurious Emission:

- Where relevant, the follow sample calculation is provided:
Result Value (dBuV/m) = Reading Value (dBuV) + Correction Factor (dB/m).
Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Loss (dB) - Preamp Factor (dB).
Example: Result Value (34.5dBuV/m) = Reading Value (40.1dBuV) + Antenna Factor (18.7dB/m) + Cable Loss (4.2dB) - Preamp Factor (28.5dB).

AC power Line Conducted Emission:

- Where relevant, the follow sample calculation is provided:
Result Value (dBuV) = Reading Value (dBuV) + Correction Factor (dB).
Correction Factor (dB) = Insertion loss(dB) + Cable loss(dB).
Example: Result Value (53.7dBuV) = Reading Value (35.1dBuV) + Insertion loss(18.1dB) + Cable loss(0.5dB).

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6.4. Description of Available Antennas

Ant. No.	Transmitter Circuit	Brand Name	Model Name	Ant. Type	Maximum Gain (dBi)	Remark
1	Chain (0)	ethertronics	M830520	Chip	2.4GHz:1 5GHz: 2.6	UFL
2	Chain (0)	OXFORDTEC	WAFH-2DBI-15	FPC	2.4GHz: 2.7 5GHz: 2.6	UFL
3	Chain (0)	OXFORDTEC	WAND2DBI-SMA	Dipole	2.4GHz: 2 5GHz: 3	RP-SMA
4	Chain (0)	OXFORDTEC	WAND5DBI-SMA	Dipole	2.4GHz:3 5GHz: 5	RP-SMA
5	Chain (0)	OXFORDTEC	WAPH2DB4-15	PCB	2.4GHz:2.18 5GHz: 2.69	UFL

Note: The above antenna information was provided from customer and for more detailed features description, please refer the manufacturer's specification or user's manual, the laboratory shall not be held responsible.

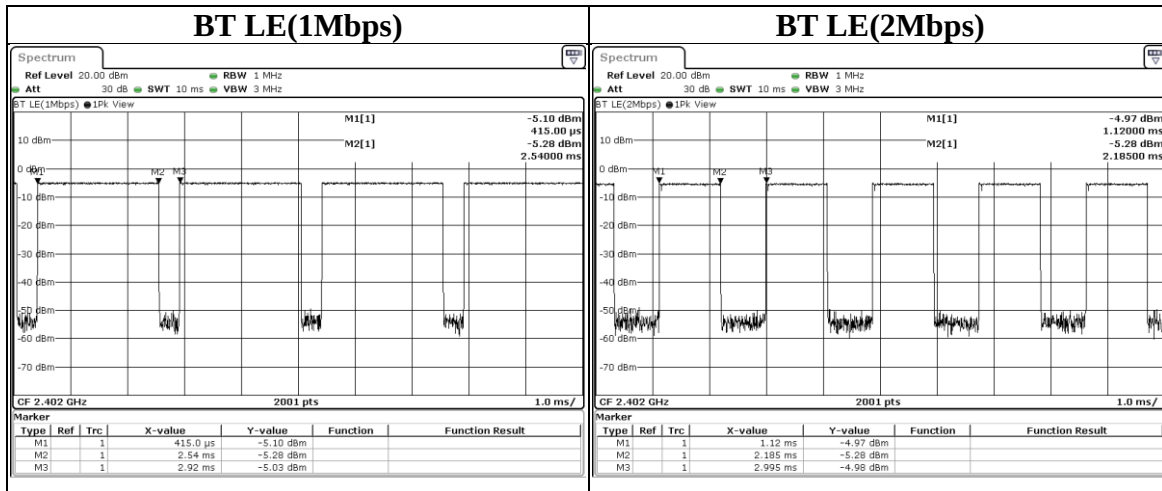
6.5. Test Mode Applicability and Tested Channel Detail

- For AC power line conducted emissions, the pre-scan has been determined by AC power 120Vac/60Hz (worst case)
- The fundamental of the antennas(M830520, WAFH-2DBI-15, WAND2DBI-SMA, WAND5DBI-SMA, and WAPH2DB4-15) were investigated in three orthogonal axes X-Y/Y-Z/X-Z. The M830520 and WAFH-2DBI-15 determined that the X-Y axis was the worst-case; and the WAND2DBI-SMA, WAND5DBI-SMA, and WAPH2DB4-15 determined that the Y-Z axis was the worst-case. Therefore, all of the final radiated testing was performed with the worst case to execute the test.
- The antennas No.3/ No.4 has the same type, therefore, the highest gain was determined antenna No.4 worst-case, the Antenna No.4 was selected for the final radiated testing.
- The antennas No.4 has the highest gain, the following conducted tests are all carried out using this antenna.
- For Antenna Port Conducted Measurement, this item includes all test value of each mode, but only includes spectrum plot of worst value of each mode.
- For below 30MHz testing, investigation was done on three antenna orientations (parallel, perpendicular, and ground-parallel), parallel and perpendicular are the worst orientations, therefore testing was performed on these two orientations only.
- For below 1 GHz radiated emission and AC power line conducted emission have performed all modes of operation were investigated and the worst-case emissions are reported.
- Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

Test Item	Modulation Type	Available Channel	Test Channel	Data Rate
Radiated Emissions	GFSK	0 to 39	0,19,39	1 Mbps
	GFSK			2 Mbps
Radiated Emissions (Below 1GHz)	GFSK	0 to 39	0	2 Mbps
AC Power Line Conducted Emission	GFSK	0 to 39	0	1 Mbps
	GFSK		0	2 Mbps
Antenna Port Conducted Measurement	GFSK	0 to 39	0,19,39	1 Mbps
	GFSK			2 Mbps

6.6. Duty cycle

Mode	On Time (ms)	On+Off Time (ms)	Duty Cycle	Duty Factor (dB)	VBW Set (above 1GHz)
BT LE(1Mbps)	2.125	2.505	0.8483	0.71	510Hz
BT LE(2Mbps)	1.065	1.875	0.5680	2.46	1kHz



7. Test Equipment

Test Equipment List					
Equipment	Manufacturer	Model No.	Serial No.	Cal. Date	Expired date
Radiated Spurious Emission					
Spectrum Analyzer	Keysight	N9010A	MY56070827	2023/4/7	2024/4/6
EMI Test Receiver	Rohde & Schwarz	ESR7	101754	2022/12/13	2023/12/12
Loop Antenna	ETS lindgren	6502	00213440	2023/1/4	2024/1/3
Trilog-Broadband Antenna with 5dB Attenuator	Schwarzbeck & EMCI	VULB 9168 & N-6-05	774 & AT-N0538	2023/2/13	2024/2/12
Horn Antenna (1-18 GHz)	Schwarzbeck	BBHA 9120 D	01690	2022/12/21	2023/12/20
Horn Antenna (18-40 GHz)	Schwarzbeck	BBHA 9170	781	2022/12/30	2023/12/29
Preamplifier (30-1000 MHz)	EMCI	EMC330E	980404	2023/5/24	2024/5/23
Preamplifier (1-18 GHz)	EMCI	EMC051835BE	980406	2023/2/17	2024/2/16
Preamplifier (18-40GHz)	EMCI	EMC184040SEE	980426	2023/5/9	2024/5/8
Cables	Hanyitek	K1K50-UP0264-K1K50-2500	170214-4 & 170425-2	2022/12/1	2023/11/30
Cables	Hanyitek	K1K50-UP0264-K1K50-2500	170214-1 & 170214-2	2022/12/1	2023/11/30
Antenna Port Conducted Measurement					
Spectrum Analyzer	Rohde & Schwarz	FSV40	101490	2022/9/12	2023/9/11
Attenuator	EMCI	EMC-40ATK2W10	17002	2022/12/9	2023/12/8
Pulse Power Sensor	Anritsu	MA2411B	1531202	2023/1/4	2024/1/3
Power Meter	Anritsu	ML2495A	1645002	2023/1/4	2024/1/3

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Test Equipment List					
Equipment	Manufacturer	Model No.	Serial No.	Cal. Date	Expired date
Antenna Port Conducted Measurement					
Spectrum Analyzer	Keysight	N9010A	MY56070834	2022/10/24	2023/10/23
Pulse Power Sensor	Anritsu	MA2411B	1531202	2023/1/4	2024/1/3
Power Meter	Anritsu	ML2495A	1645002	2023/1/4	2024/1/3

UL Software		
Description	Name	Version
Radiated measurement	e3	6.191211 (V6)
Conducted measurement	RF-Conducted-FCC 15247	ver 1.0
AC power Line Conducted Emission	EZ_EMF	UL-3A1.2

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8. Description of Test Setup

Support Equipment

ID	Equipment	Brand Name	Model Name	S/N	Remark
A	Laptop	Lenovo	T460	PC0FWU5Y	Provide by Lab
B	Mini PCI-E to ExpressCard board	PHIYO TECH	ExpressCard Extender	19	Provide by Client
C	Adapter	Phihong	PSAA12A-120L6	N/A	Provide by Client

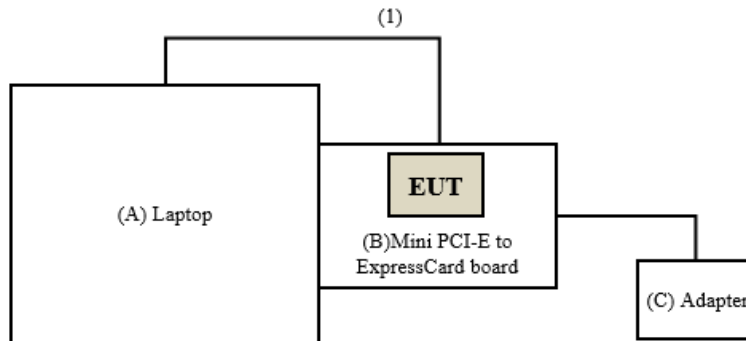
I/O Cables

ID	Equipment	Brand Name	Model Name	Length (m)	Remark
1	Micro USB Cable	fujiei	US0082	1	Provide by Client

Test Setup

Controlled using a bespoke application (QSPR_Version 5.0-00197) on a test Notebook. The application was used to enable a continuous transmission mode and to select the test channels, data rates, modulation schemes and power setting as required.

Setup Diagram for Test



Under Table

Remote Site

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9. Test Results

9.1. 6dB Bandwidth

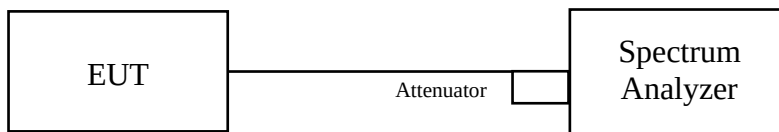
Requirements

The minimum 6 dB bandwidth shall be at least 500 kHz.

Test procedure

- Set resolution bandwidth (RBW) = 100kHz
- Set the video bandwidth (VBW) $\geq 3 \times$ RBW, Detector = Peak.
- Trace mode = max hold.
- Sweep = auto couple.
- Measure the maximum width of the emission that is constrained by the frequencies associated with the two amplitude points (upper and lower) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

Test Setup



The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

Test Data

Mode	CH	Freq (MHz)	6dB BW (MHz)	Limit (MHz)	Result
BT LE(1Mbps)	0	2402	0.662	0.5	PASS
BT LE(1Mbps)	19	2440	0.660	0.5	PASS
BT LE(1Mbps)	39	2480	0.663	0.5	PASS
BT LE(2Mbps)	0	2402	1.133	0.5	PASS
BT LE(2Mbps)	19	2440	1.153	0.5	PASS
BT LE(2Mbps)	39	2480	1.146	0.5	PASS

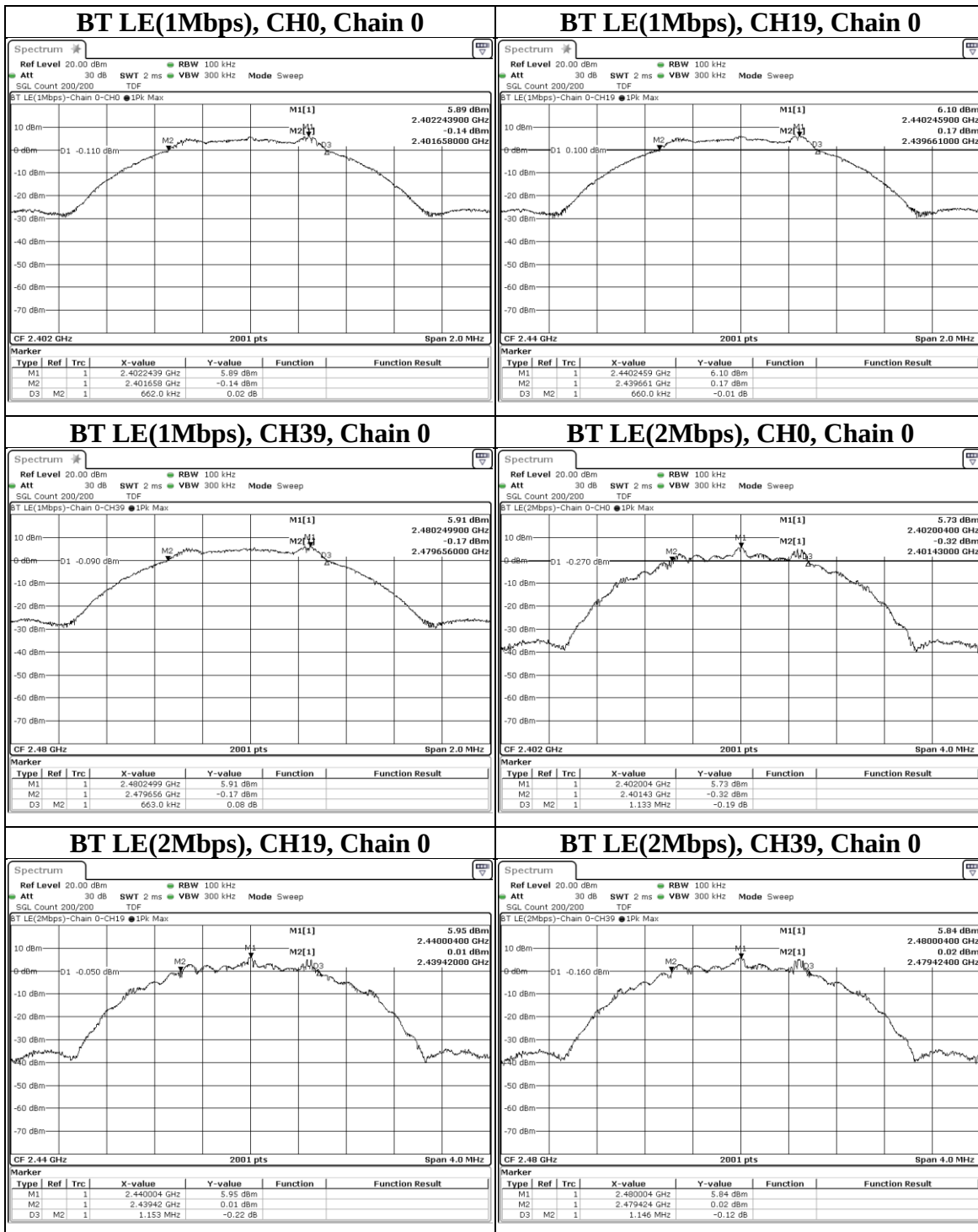
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9.2. Conducted Output Power

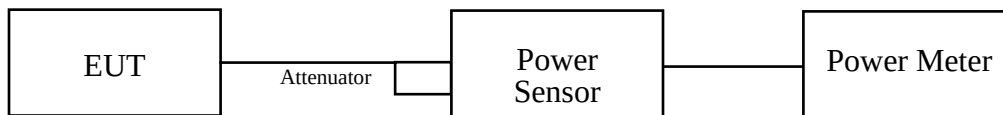
Requirements

For systems using digital modulation in the 2400-2483.5 MHz bands: 1 Watt.

Test Procedure

A peak power sensor was used on the output port of the EUT. A power meter was used to read the response of the peak power sensor. Record the power level.

Test Setup



The loss between RF output port of the EUT and the input port of the Power Meter has been taken into consideration.

Test Data

Peak Power

BT LE_1Mbps

Channel	Frequency (MHz)	Peak Power (mW)	Peak Power (dBm)	Limit (dBm)	Pass/Fail
0	2402	3.767	5.76	30	PASS
19	2440	3.963	5.98	30	PASS
39	2480	3.864	5.87	30	PASS

BT LE_2Mbps

Channel	Frequency (MHz)	Peak Power (mW)	Peak Power (dBm)	Limit (dBm)	Pass/Fail
0	2402	4.102	6.13	30	PASS
19	2440	4.093	6.12	30	PASS
39	2480	3.99	6.01	30	PASS

Average Power (Reference Only)

BT LE_1Mbps

Channel	Frequency (MHz)	Average Power (mW)	Average Power (dBm)
0	2402	3.388	5.30
19	2440	3.565	5.52
39	2480	3.436	5.36

BT LE_2Mbps

Channel	Frequency (MHz)	Average Power (mW)	Average Power (dBm)
0	2402	3.573	5.53
19	2440	3.556	5.51
39	2480	3.459	5.39

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9.3. Power Spectral Density

Requirements

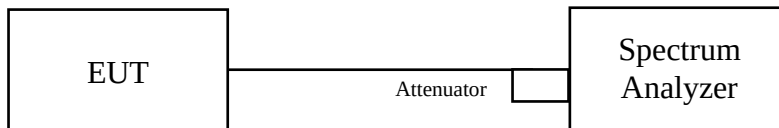
The Maximum of Power Spectral Density Measurement is 8dBm in any 3 kHz.

Test procedure

For Peak power

- a. Set analyzer center frequency to DTS channel center frequency.
- b. Set the span to 1.5 times the DTS bandwidth.
- c. Set the RBW to: $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$.
- d. Set the VBW $\geq 3 \times \text{RBW}$.
- e. Detector = peak.
- f. Sweep time = auto couple.
- g. Trace mode = max hold.
- h. Allow trace to fully stabilize.
- i. Use the peak marker function to determine the maximum amplitude level within the RBW.
- a. the average PSD during the actual transmission time.

Test Setup



The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

Test Data

Mode	CH	Freq (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Result
BT LE(1Mbps)	0	2402	-15.75	8	PASS
BT LE(1Mbps)	19	2440	-15.39	8	PASS
BT LE(1Mbps)	39	2480	-15.48	8	PASS
BT LE(2Mbps)	0	2402	-19.38	8	PASS
BT LE(2Mbps)	19	2440	-19.43	8	PASS
BT LE(2Mbps)	39	2480	-19.5	8	PASS

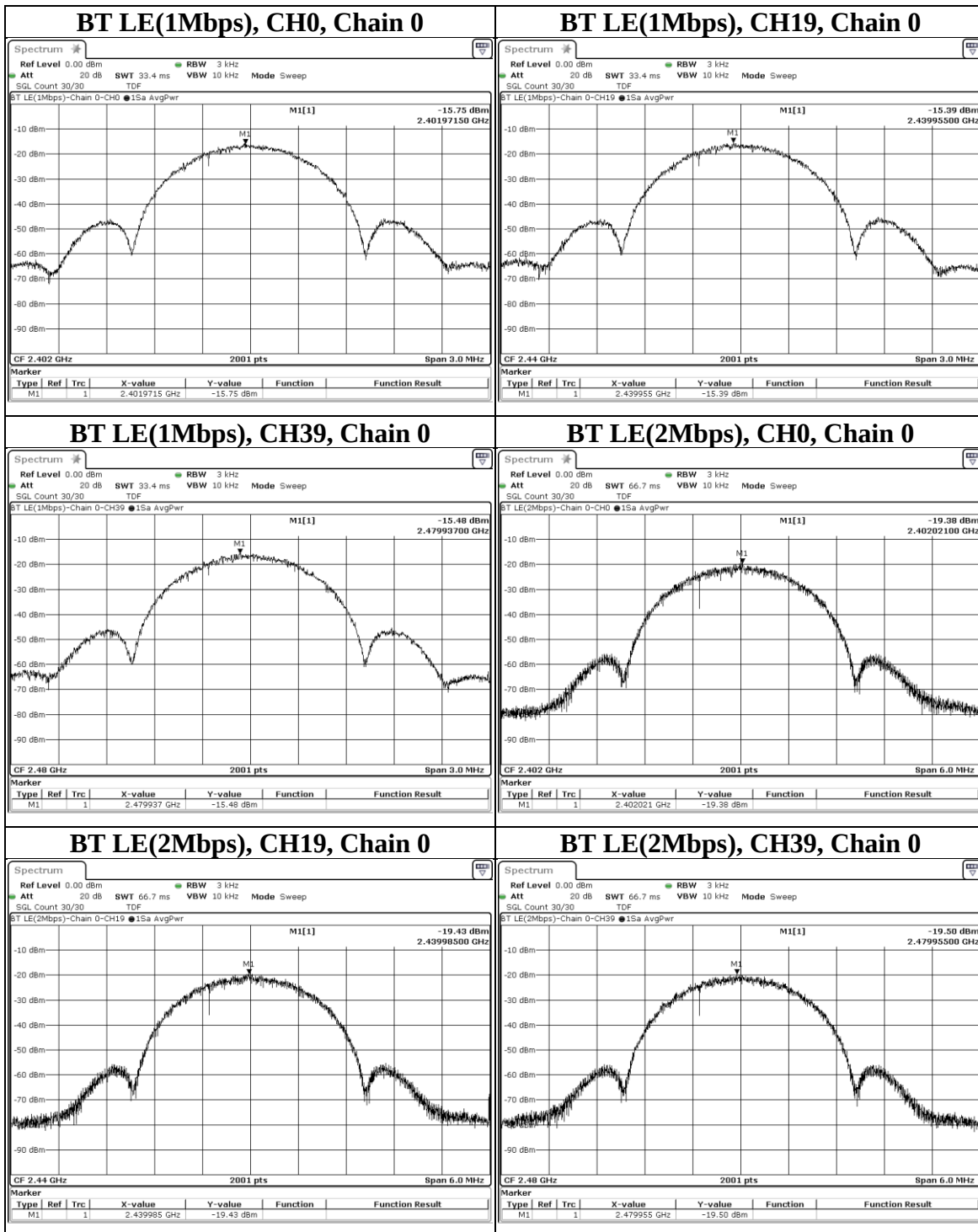
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9.4. Conducted Out of Band Emission

Requirements

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.

Test procedure

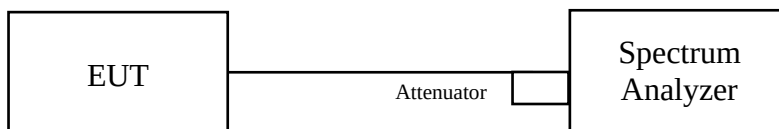
Measurement Procedure REF

- Set the RBW = 100 kHz.
- Set the VBW $\geq$ 300 kHz.
- Set the span to 1.5 times the DTS bandwidth.
- Detector = peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum power level in any 100 kHz band segment within the fundamental EBW.

Measurement Procedure OOBE

- Set RBW = 100 kHz.
- Set VBW $\geq$ 300 kHz.
- Detector = peak.
- Sweep = auto couple.
- Trace Mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum amplitude level.

Test Setup



The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

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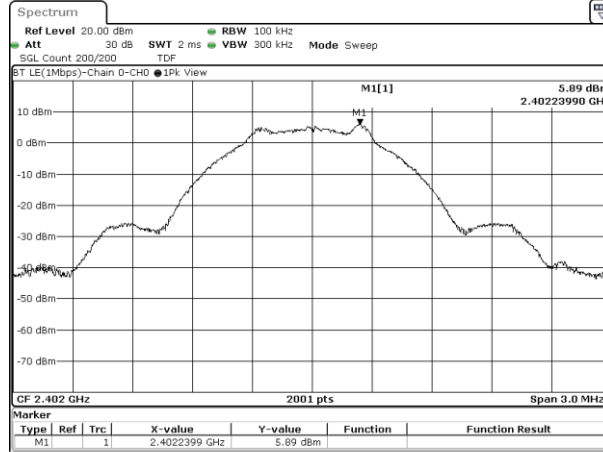
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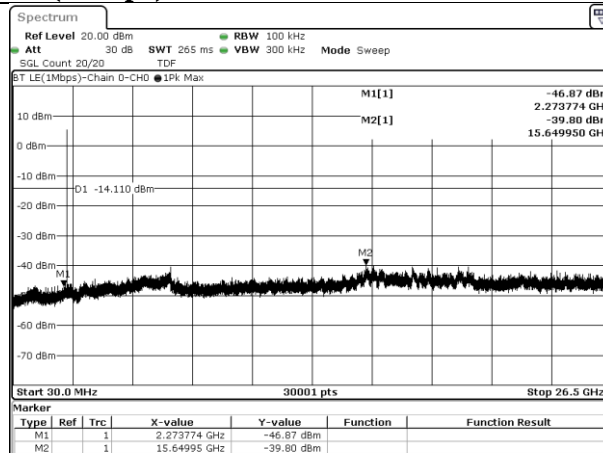
Doc No: Form-ULID-004737 (DCS:17-EM-F0876) / 6.1

Test Data

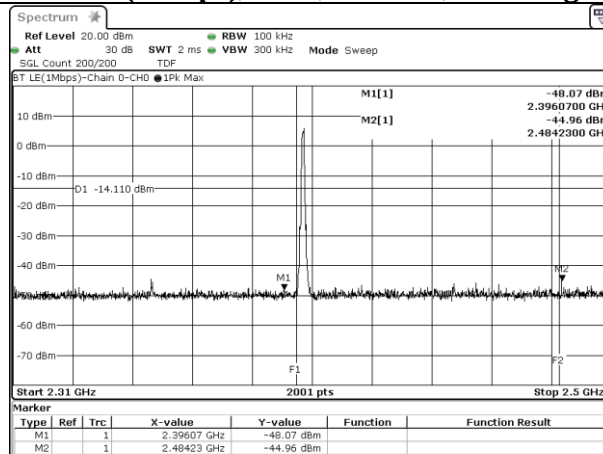
BT LE(1Mbps), CH0, Chain 0, Reference



BT LE(1Mbps), CH0, Chain 0, Conducted Emission



BT LE(1Mbps), CH0, Chain 0, Bandedge



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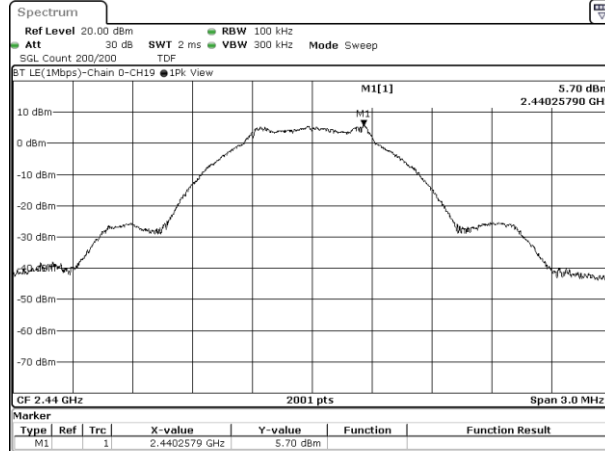
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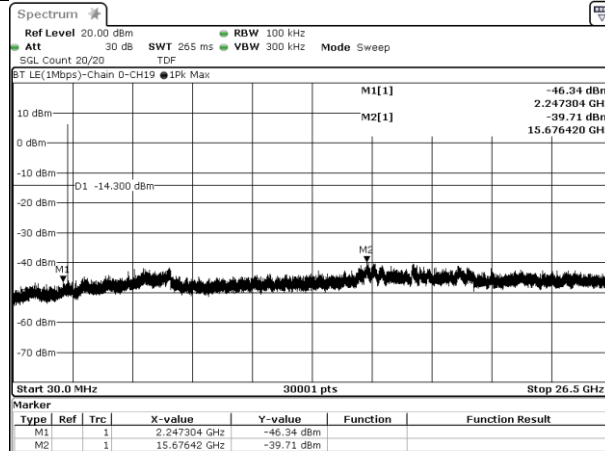
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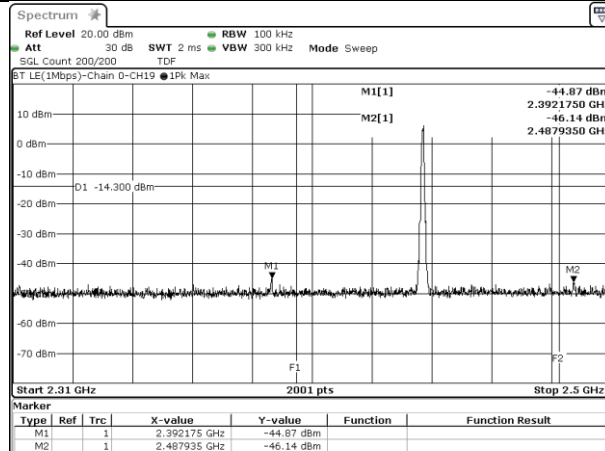
BT LE(1Mbps), CH19, Chain 0, Reference



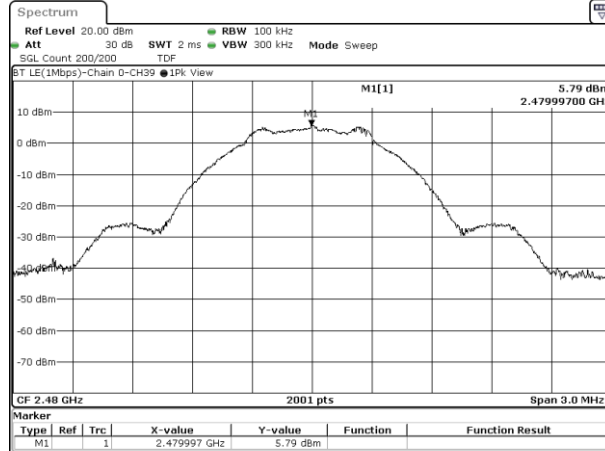
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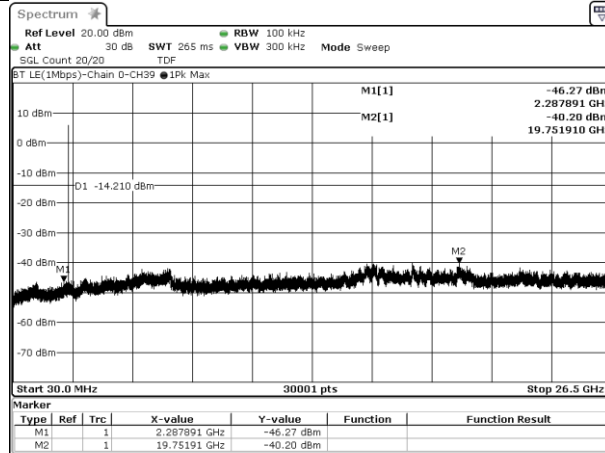
BT LE(1Mbps), CH19, Chain 0, Bandedge



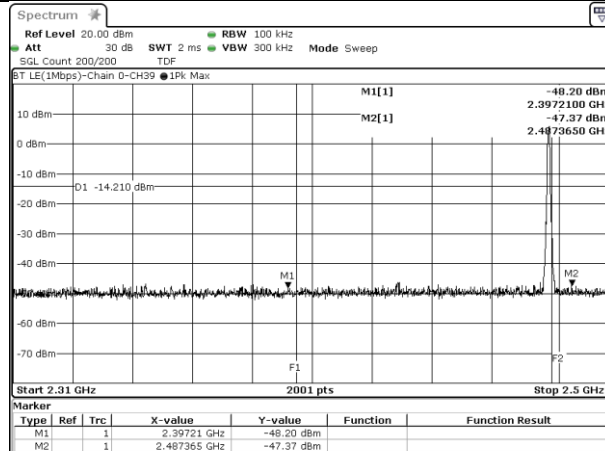
BT LE(1Mbps), CH39, Chain 0, Reference



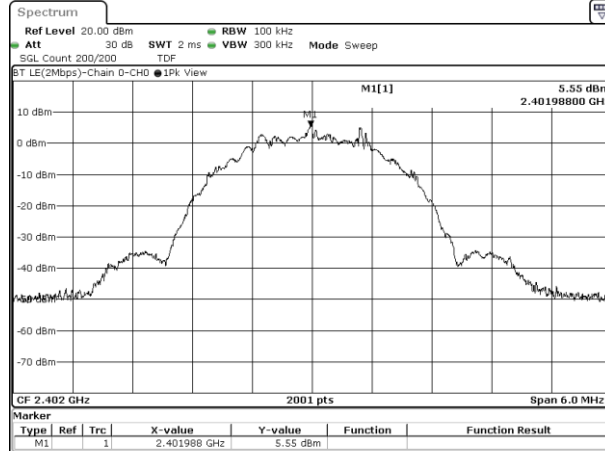
BT LE(1Mbps), CH39, Chain 0, Conducted Emission



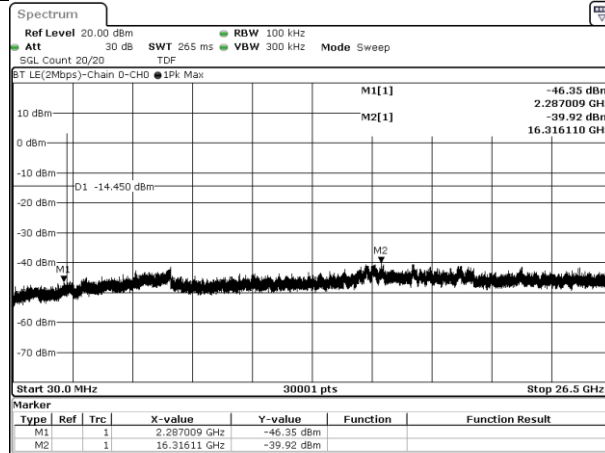
BT LE(1Mbps), CH39, Chain 0, Bandedge



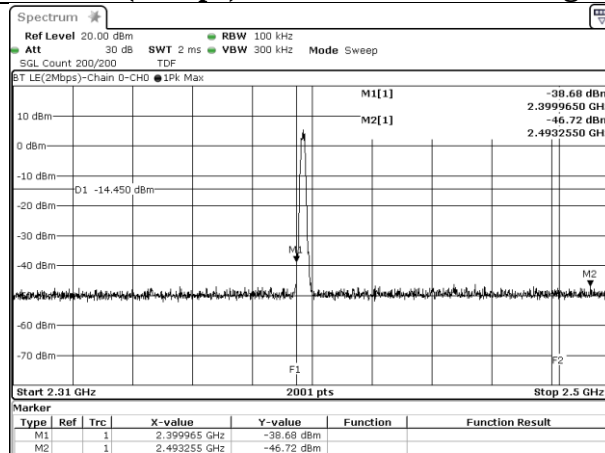
BT LE(2Mbps), CH0, Chain 0, Reference



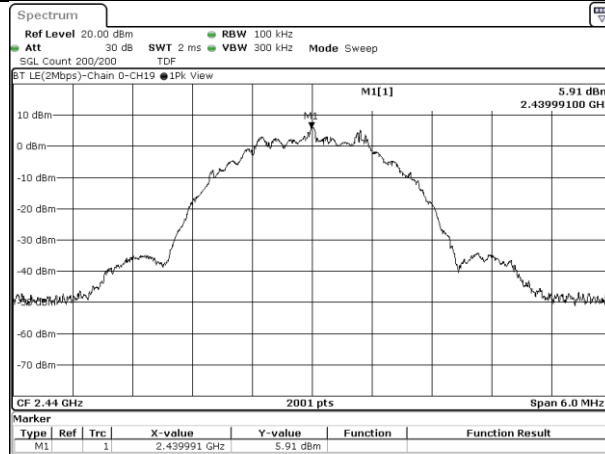
BT LE(2Mbps), CH0, Chain 0, Conducted Emission



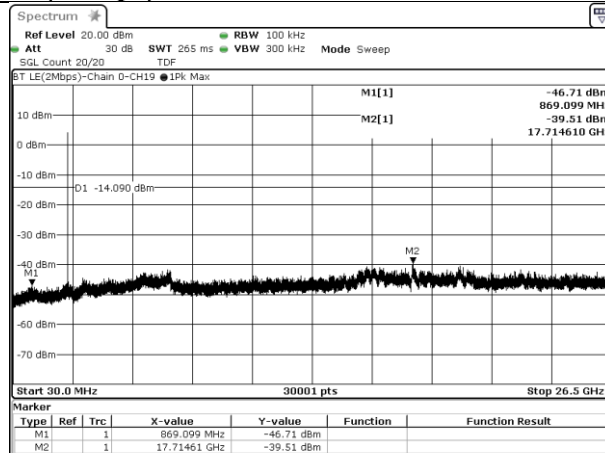
BT LE(2Mbps), CH0, Chain 0, Bandedge



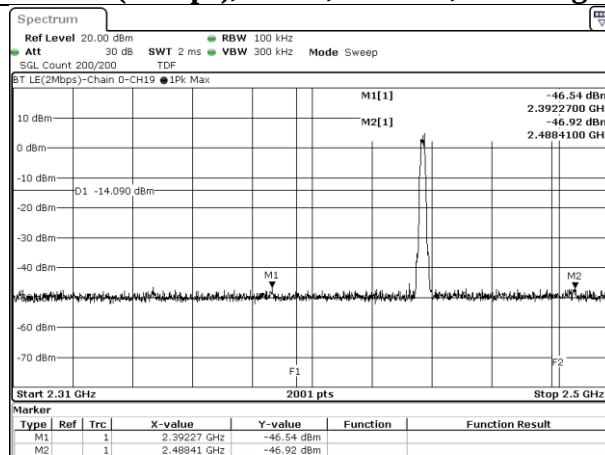
BT LE(2Mbps), CH19, Chain 0, Reference



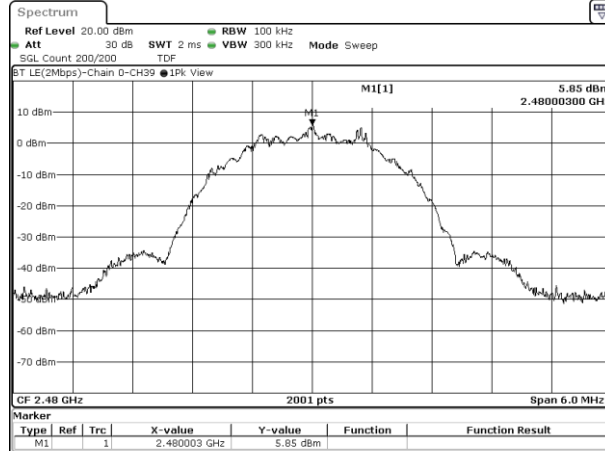
BT LE(2Mbps), CH19, Chain 0, Conducted Emission



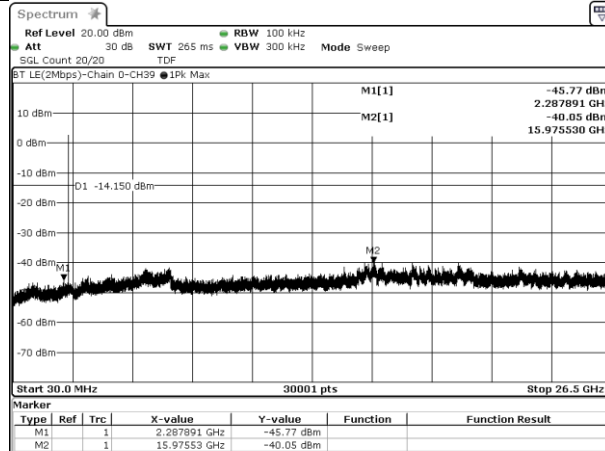
BT LE(2Mbps), CH19, Chain 0, Bandedge



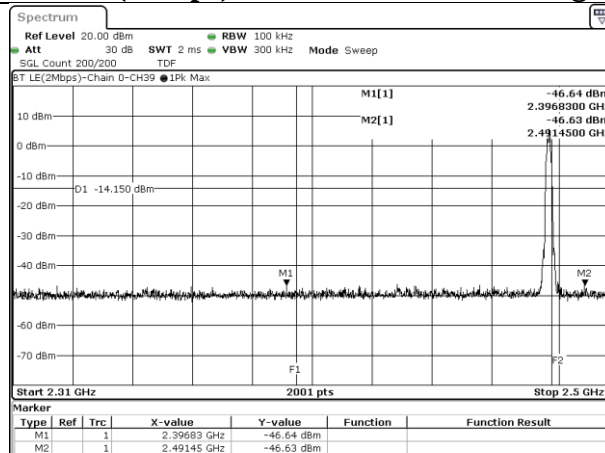
BT LE(2Mbps), CH39, Chain 0, Reference



BT LE(2Mbps), CH39, Chain 0, Conducted Emission



BT LE(2Mbps), CH39, Chain 0, Bandedge



9.5. Radiated Spurious Emission

Requirements

Radiated emissions which fall in the restricted bands must comply with the radiated emission limits specified as below table. Other emissions shall be at least 20dB below the highest level of the desired power:

Frequency(MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

NOTE:

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 log Emission level (uV/m).
3. For frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20dB under any condition of modulation.

Test Procedures

[For 9 kHz ~ 30 MHz]

- a. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter chamber room. The table was rotated 360 degrees to determine the position of the highest radiation.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. Parallel, perpendicular, and ground-parallel orientations of the antenna are set to make the measurement.
- d. For each suspected emission, the EUT was arranged to its worst case and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
- e. For measurement below 30MHz, the initial step in collecting conducted emission data is a spectrum analyzer peak detector mode pre-scanning the measurement frequency range. Significant peaks are then marked and then Quasi Peak detector mode re-measured. If the emission level of the EUT measured by the peak detector is lower than the applicable limit, the peak emission level will be reported. Otherwise, the emission measurement will be repeated using the quasi-peak detector and reported.

NOTE:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 9kHz at frequency below 30MHz.

[For above 30 MHz]

- a. The EUT was placed on the top of a rotating table 0.8 meters (for 30MHz ~ 1GHz) / 1.5 meters (for above 1GHz) above the ground at 3 meter chamber room for test. The table was rotated 360 degrees to determine the position of the highest radiation.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. The height of antenna is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
- d. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
- e. For measurement below 1GHz, the initial step in collecting conducted emission data is a spectrum analyzer peak detector mode pre-scanning the measurement frequency range. Significant peaks are then marked and then Quasi Peak detector mode re-measured. If the emission level of the EUT measured by the peak detector is lower than the applicable limit, the peak emission level will be reported. Otherwise, the emission measurement will be repeated using the quasi-peak detector and reported.
- f. The test-receiver system was set to peak and average detects function and specified bandwidth with maximum hold mode when the test frequency is above 1 GHz. If the peak reading value also meets average limit, measurement with the average detector is unnecessary.

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Note:

- a. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Quasi-peak detection (QP) at frequency below 1GHz.
- b. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 MHz for Peak detection (PK) at frequency above 1GHz.
- c. The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and the video bandwidth is $\geq 1/T$ (Duty cycle < 98%) or 10Hz (Duty cycle $\geq 98\%$) for Average detection (AV) at frequency above 1GHz.

Configuration	Average	
	RBW	VBW
Bluetooth LE	1MHz	Refer to section 6.6 for duty cycle.

- d. All modes of operation were investigated (includes all external accessories) and the worst-case emissions are reported, the other emission levels were low against the limit.
- e. Test data of Result value (dBuV/m) = Reading value (dBuV/m) + Correction Factor (dB/m).
- f. Test data of Margin(dB) = Result value (dBuV/m) - Limit value (dBuV/m).
- g. Test data of Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Loss (dB) - Preamp Factor (dB).
- h. Test data of Notation "@" = Fundamental Frequency
- i. Test data of Notation "*" = The peak result under 20 dB above and complies with AVG limit, AVG result is deemed to comply with AVG limit.

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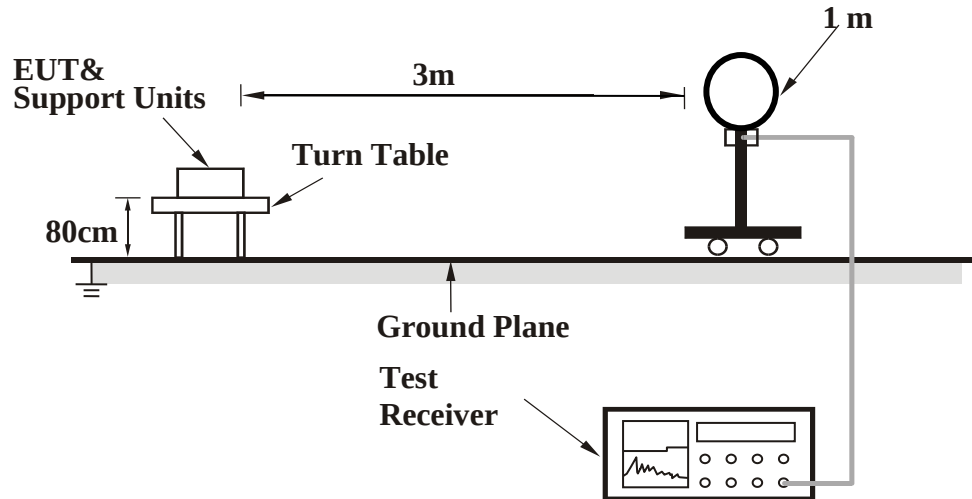
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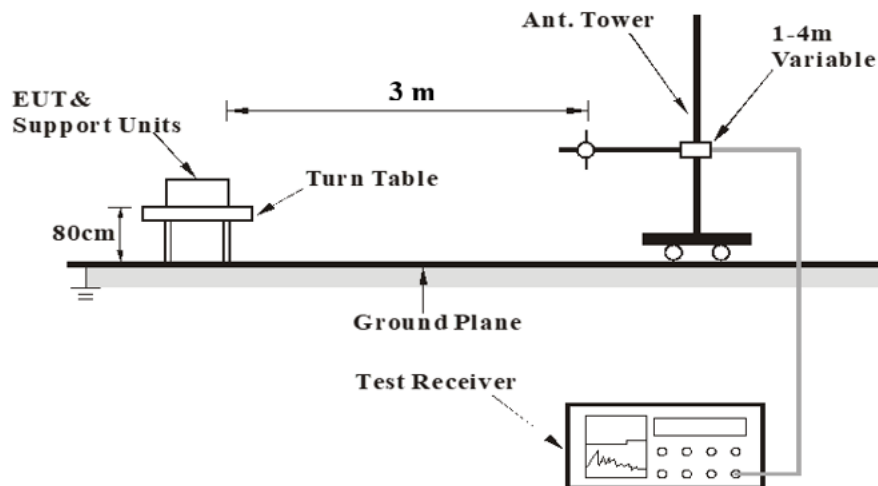
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Test Setup

<Frequency Range 9 kHz ~ 30 MHz>



<Frequency Range 30 MHz ~ 1 GHz >



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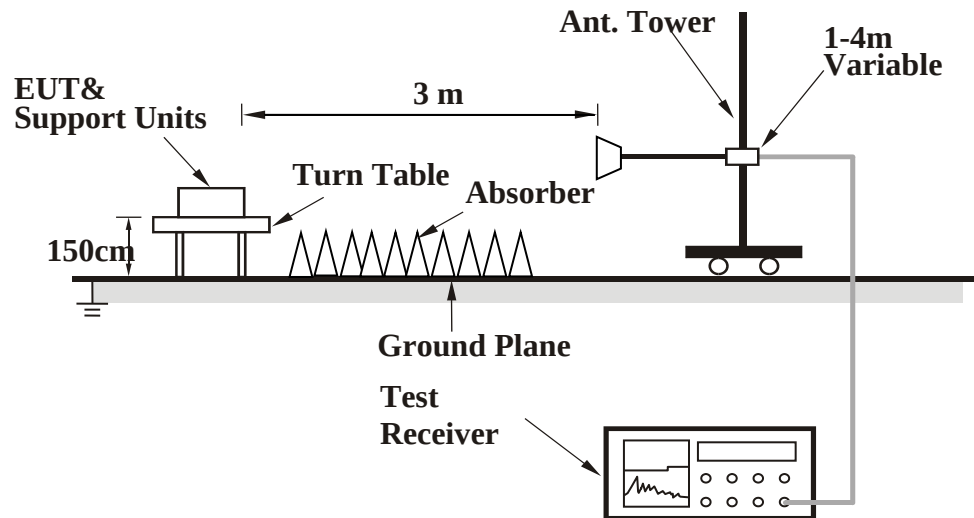
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<Frequency Range above 1 GHz>



For the actual test configuration, please refer to the Setup Configurations.

Test Data

Chip Antenna

Above 1 GHz

Mode	BT-LE-1Mbps	Channel	0
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Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		2354.08	33.29	11.94	45.23	54	-8.77	AVG
		2366.62	41.45	11.91	53.36	74	-20.64	PK
	@	2402	91.91	11.85	103.76	N/A	N/A	PK
	@	2402	91.33	11.85	103.18	N/A	N/A	AVG
	*	4804	36.94	2.14	39.08	74	-34.92	PK
Vertical		2353.89	31.05	11.94	42.99	54	-11.01	AVG
		2372.89	40.74	11.9	52.64	74	-21.36	PK
	@	2402	81.74	11.85	93.59	N/A	N/A	PK
	@	2402	81.21	11.85	93.06	N/A	N/A	AVG
	*	4804	36.59	2.14	38.73	74	-35.27	PK

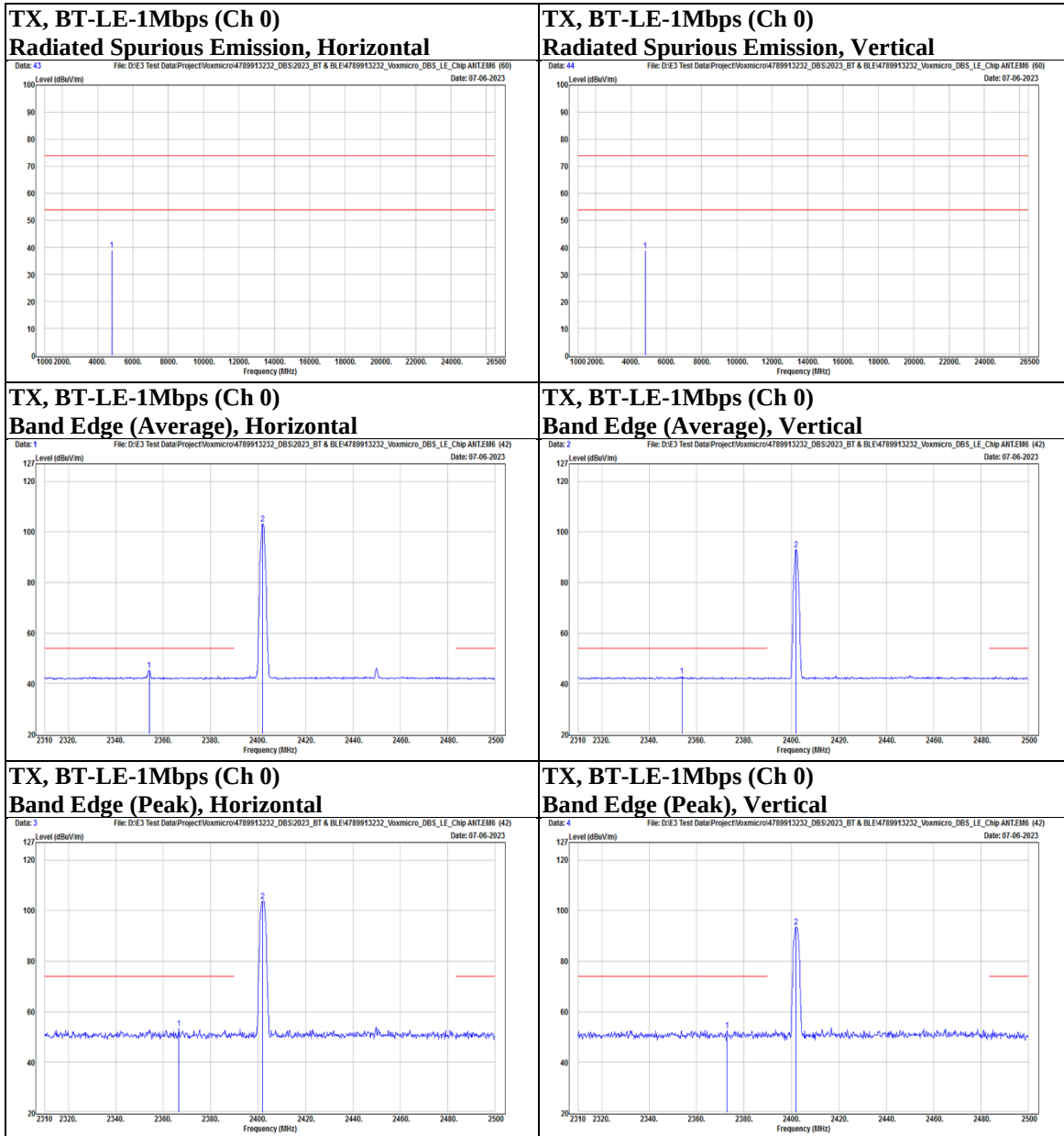
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Mode	BT-LE-1Mbps	Channel	19
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Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		2312.09	33.51	11.96	45.47	54	-8.53	AVG
		2341.16	41.17	11.96	53.13	74	-20.87	PK
	@	2440	90.8	11.99	102.79	N/A	N/A	PK
	@	2440	90.28	11.99	102.27	N/A	N/A	AVG
		2488.03	32.47	11.79	44.26	54	-9.74	AVG
		2489.93	41.3	11.77	53.07	74	-20.93	PK
	*	4880	36.92	2.21	39.13	74	-34.87	PK
	*	7320	33.18	10.25	43.43	74	-30.57	PK
Vertical		2334.51	41.34	11.95	53.29	74	-20.71	PK
		2346.48	30.79	11.96	42.75	54	-11.25	AVG
	@	2440	83.12	11.99	95.11	N/A	N/A	PK
	@	2440	82.58	11.99	94.57	N/A	N/A	AVG
		2494.87	30.8	11.74	42.54	54	-11.46	AVG
		2500	40.39	11.71	52.1	74	-21.9	PK
	*	4880	36.56	2.21	38.77	74	-35.23	PK
	*	7320	33.11	10.25	43.36	74	-30.64	PK

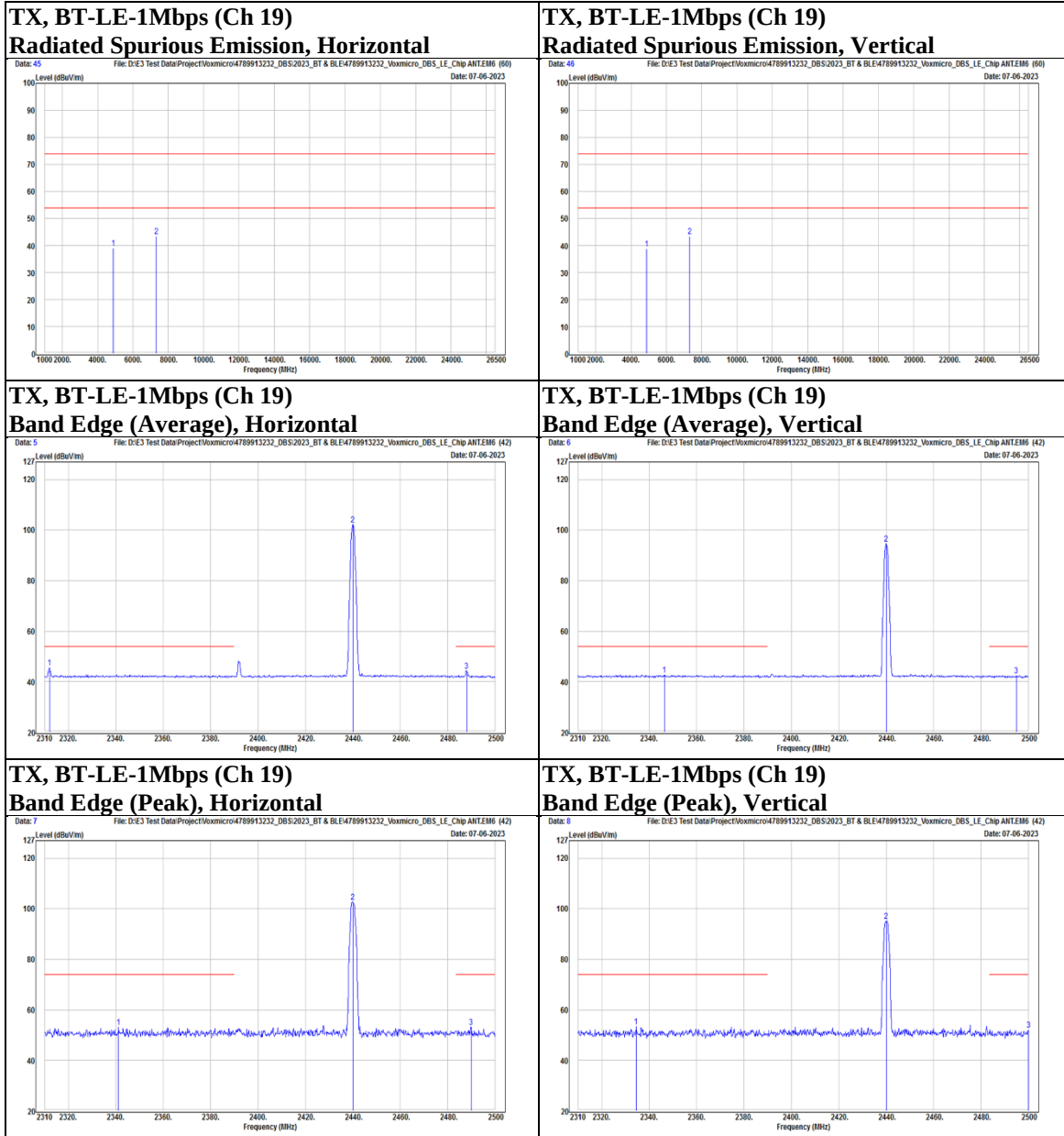
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Mode	BT-LE-1Mbps	Channel	39
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Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal	@	2480	86.25	11.83	98.08	N/A	N/A	PK
	@	2480	85.7	11.83	97.53	N/A	N/A	AVG
		2487.46	31.06	11.79	42.85	54	-11.15	AVG
		2497.15	40.55	11.72	52.27	74	-21.73	PK
	*	4960	36.73	2.3	39.03	74	-34.97	PK
	*	7440	33.05	10.69	43.74	74	-30.26	PK
Vertical	@	2480	81.35	11.83	93.18	N/A	N/A	PK
	@	2480	80.74	11.83	92.57	N/A	N/A	AVG
		2487.65	30.77	11.79	42.56	54	-11.44	AVG
		2497.34	40.36	11.73	52.09	74	-21.91	PK
	*	4960	36.66	2.3	38.96	74	-35.04	PK
	*	7440	32.73	10.69	43.42	74	-30.58	PK

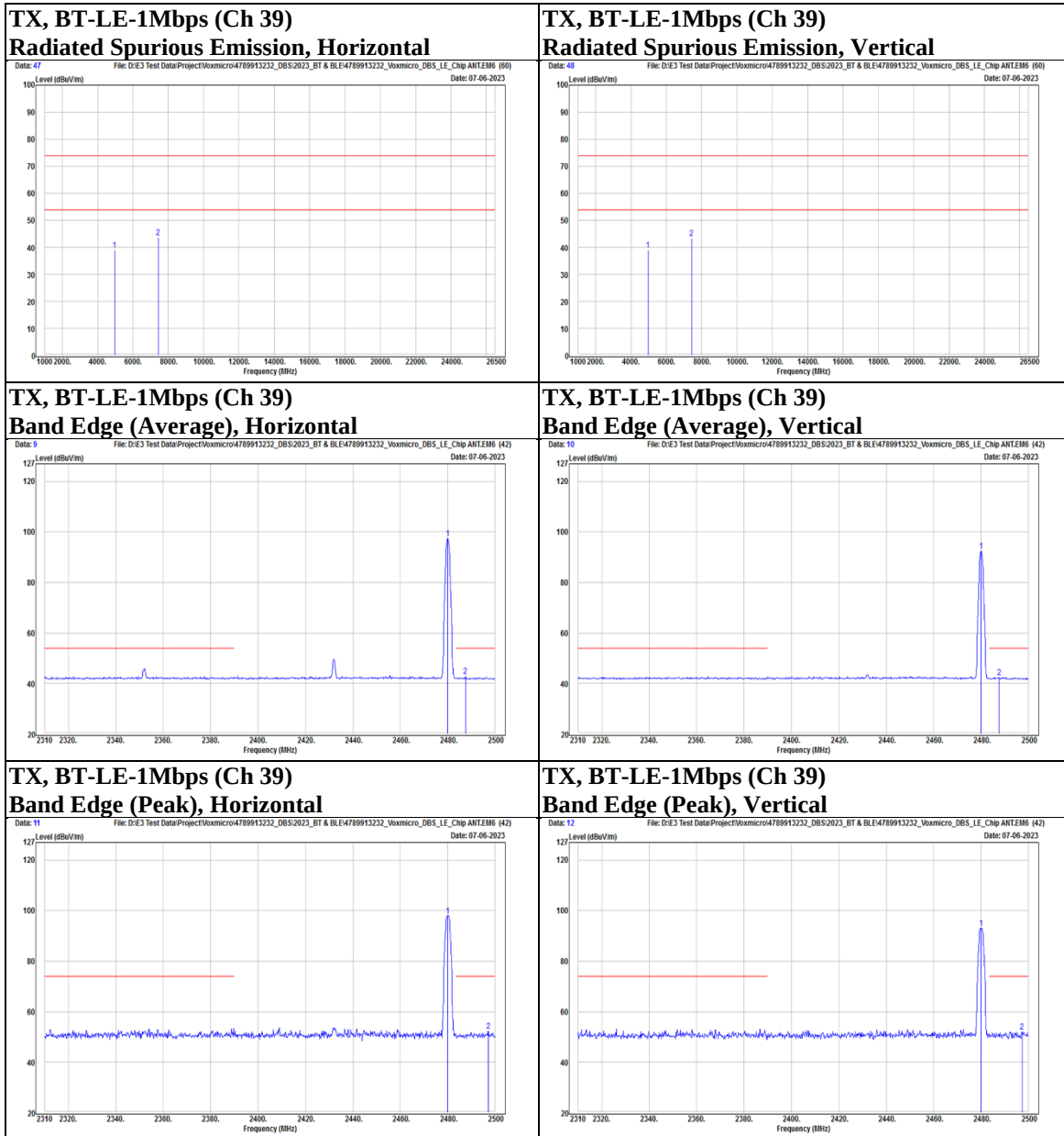
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Mode	BT-LE-2Mbps	Channel	0
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Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		2338.5	41.06	11.95	53.01	74	-20.99	PK
		2353.7	32.84	11.95	44.79	54	-9.21	AVG
	@	2402	91.43	11.85	103.28	N/A	N/A	PK
	@	2402	90.04	11.85	101.89	N/A	N/A	AVG
	*	4804	36.94	2.14	39.08	74	-34.92	PK
Vertical		2338.69	41.84	11.95	53.79	74	-20.21	PK
		2354.65	30.91	11.94	42.85	54	-11.15	AVG
	@	2402	81.31	11.85	93.16	N/A	N/A	PK
	@	2402	79.6	11.85	91.45	N/A	N/A	AVG
	*	4804	36.61	2.14	38.75	74	-35.25	PK

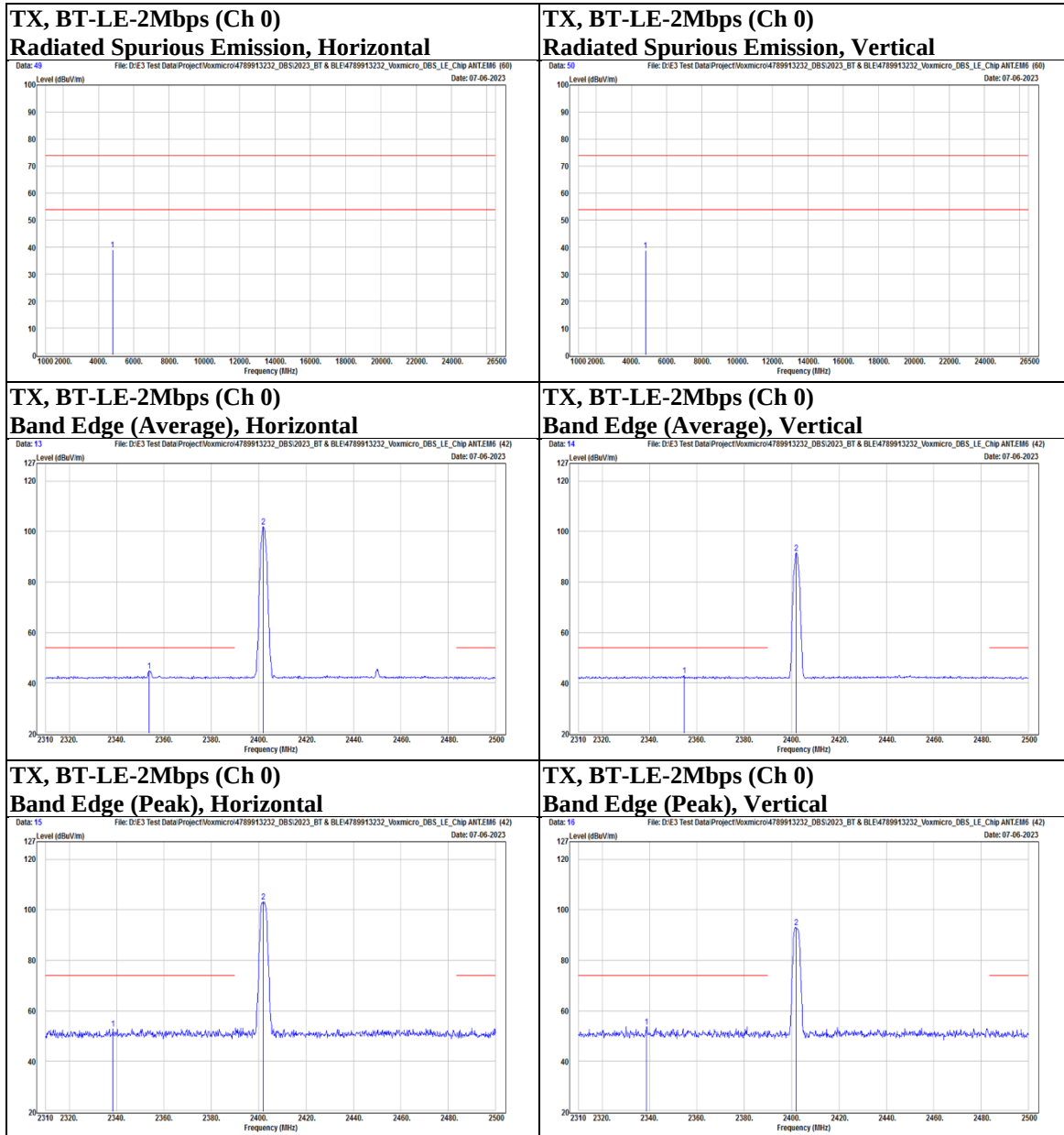
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Mode	BT-LE-2Mbps	Channel	19
------	-------------	---------	----

Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		2310.57	41.16	11.96	53.12	74	-20.88	PK
		2312.09	32.77	11.96	44.73	54	-9.27	AVG
	@	2440	90.3	11.99	102.29	N/A	N/A	PK
	@	2440	88.96	11.99	100.95	N/A	N/A	AVG
		2487.27	40.82	11.79	52.61	74	-21.39	PK
		2487.84	31.66	11.79	43.45	54	-10.55	AVG
	*	4880	36.83	2.21	39.04	74	-34.96	PK
	*	7320	33.78	10.25	44.03	74	-29.97	PK
Vertical		2329	41.1	11.95	53.05	74	-20.95	PK
		2345.91	30.73	11.96	42.69	54	-11.31	AVG
	@	2440	82.64	11.99	94.63	N/A	N/A	PK
	@	2440	81.08	11.99	93.07	N/A	N/A	AVG
		2490.88	30.94	11.76	42.7	54	-11.3	AVG
		2493.54	40.87	11.75	52.62	74	-21.38	PK
	*	4880	36.02	2.21	38.23	74	-35.77	PK
	*	7320	33.17	10.25	43.42	74	-30.58	PK

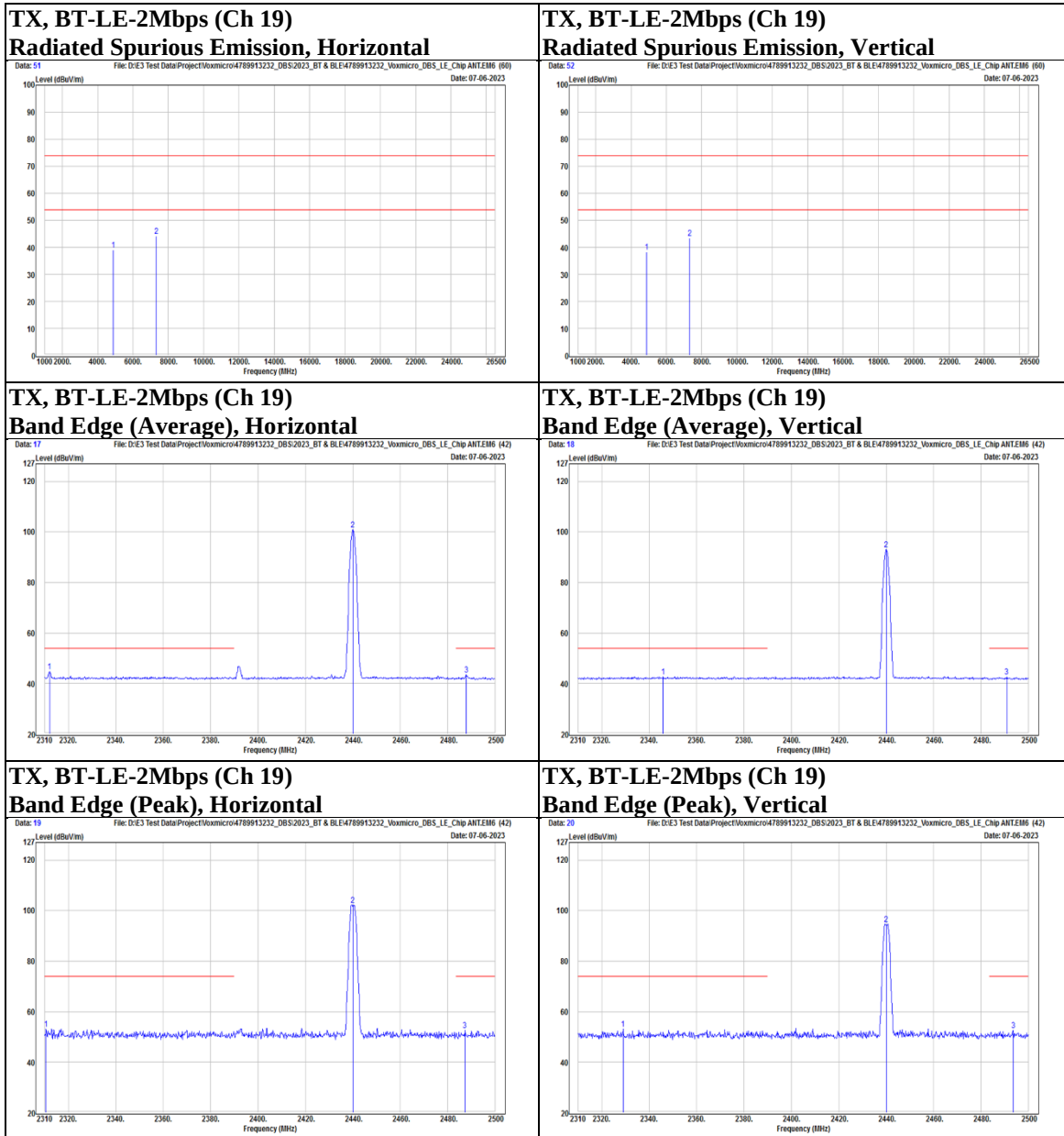
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Mode	BT-LE-2Mbps	Channel	39
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Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal	@	2480	86.38	11.83	98.21	N/A	N/A	PK
	@	2480	84.36	11.83	96.19	N/A	N/A	AVG
		2485.56	30.64	11.8	42.44	54	-11.56	AVG
		2488.03	41.03	11.79	52.82	74	-21.18	PK
	*	4960	36.19	2.3	38.49	74	-35.51	PK
	*	7440	33.7	10.69	44.39	74	-29.61	PK
Vertical	@	2480	81.33	11.83	93.16	N/A	N/A	PK
	@	2480	79.09	11.83	90.92	N/A	N/A	AVG
		2487.46	40.38	11.79	52.17	74	-21.83	PK
		2494.11	30.92	11.75	42.67	54	-11.33	AVG
	*	4960	36.94	2.3	39.24	74	-34.76	PK
	*	7440	33.42	10.69	44.11	74	-29.89	PK

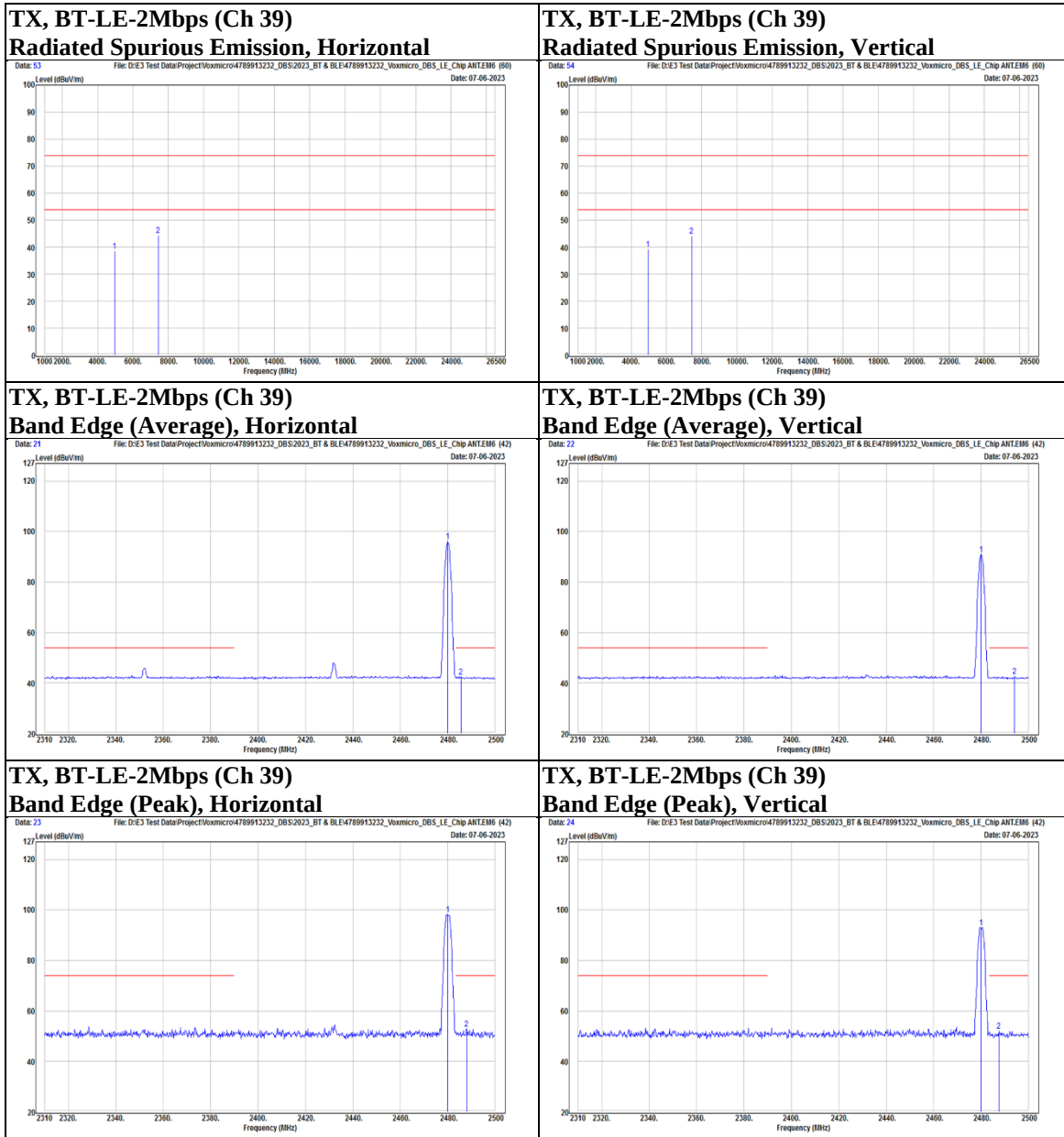
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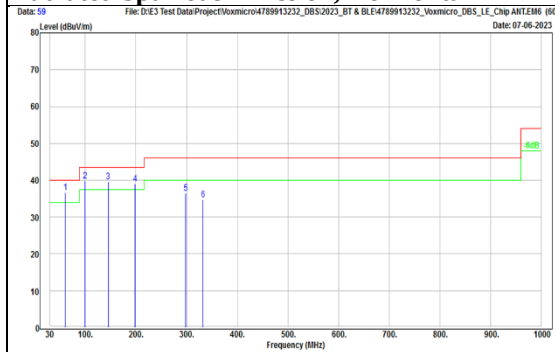
Below 1 GHz

Mode	BT-LE-2Mbps	Channel	0
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Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		61.04	49	-12.32	36.68	40	-3.32	PK
		99.84	56.37	-16.65	39.72	43.5	-3.78	PK
		145.43	51.8	-12.25	39.55	43.5	-3.95	PK
		198.78	53.89	-14.82	39.07	43.5	-4.43	PK
		298.69	47.1	-10.67	36.43	46	-9.57	PK
		332.64	44.16	-9.45	34.71	46	-11.29	PK
Vertical		62.01	48.48	-12.49	35.99	40	-4.01	PK
		84.32	50.47	-17.33	33.14	40	-6.86	PK
		140.58	45.92	-12.62	33.3	43.5	-10.2	PK
		159.98	43.66	-11.78	31.88	43.5	-11.62	PK
		298.69	44.27	-10.67	33.6	46	-12.4	PK
		332.64	43.19	-9.45	33.74	46	-12.26	PK

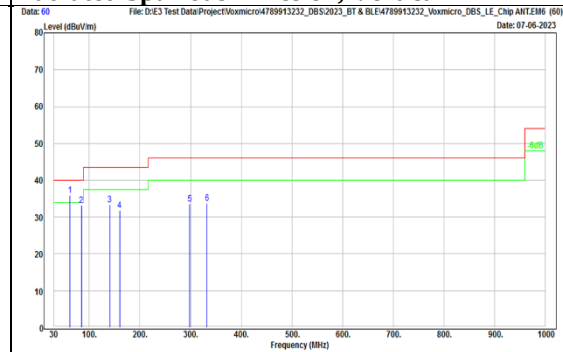
TX, BT-LE-2Mbps (Ch 0)

Radiated Spurious Emission, Horizontal



TX, BT-LE-2Mbps (Ch 0)

Radiated Spurious Emission, Vertical



FPC Antenna

Above 1 GHz

Mode	BT-LE-1Mbps	Channel	0
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Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		2330.9	42.11	11.96	54.07	74	-19.93	PK
		2353.89	31.89	11.94	43.83	54	-10.17	AVG
	@	2402	83.5	11.85	95.35	N/A	N/A	PK
	@	2402	83.16	11.85	95.01	N/A	N/A	AVG
	*	4804	37.75	2.14	39.89	74	-34.11	PK
Vertical		2325.96	41.45	11.96	53.41	74	-20.59	PK
		2354.08	31.26	11.94	43.2	54	-10.8	AVG
	@	2402	80.23	11.85	92.08	N/A	N/A	PK
	@	2402	79.62	11.85	91.47	N/A	N/A	AVG
	*	4804	37.12	2.14	39.26	74	-34.74	PK

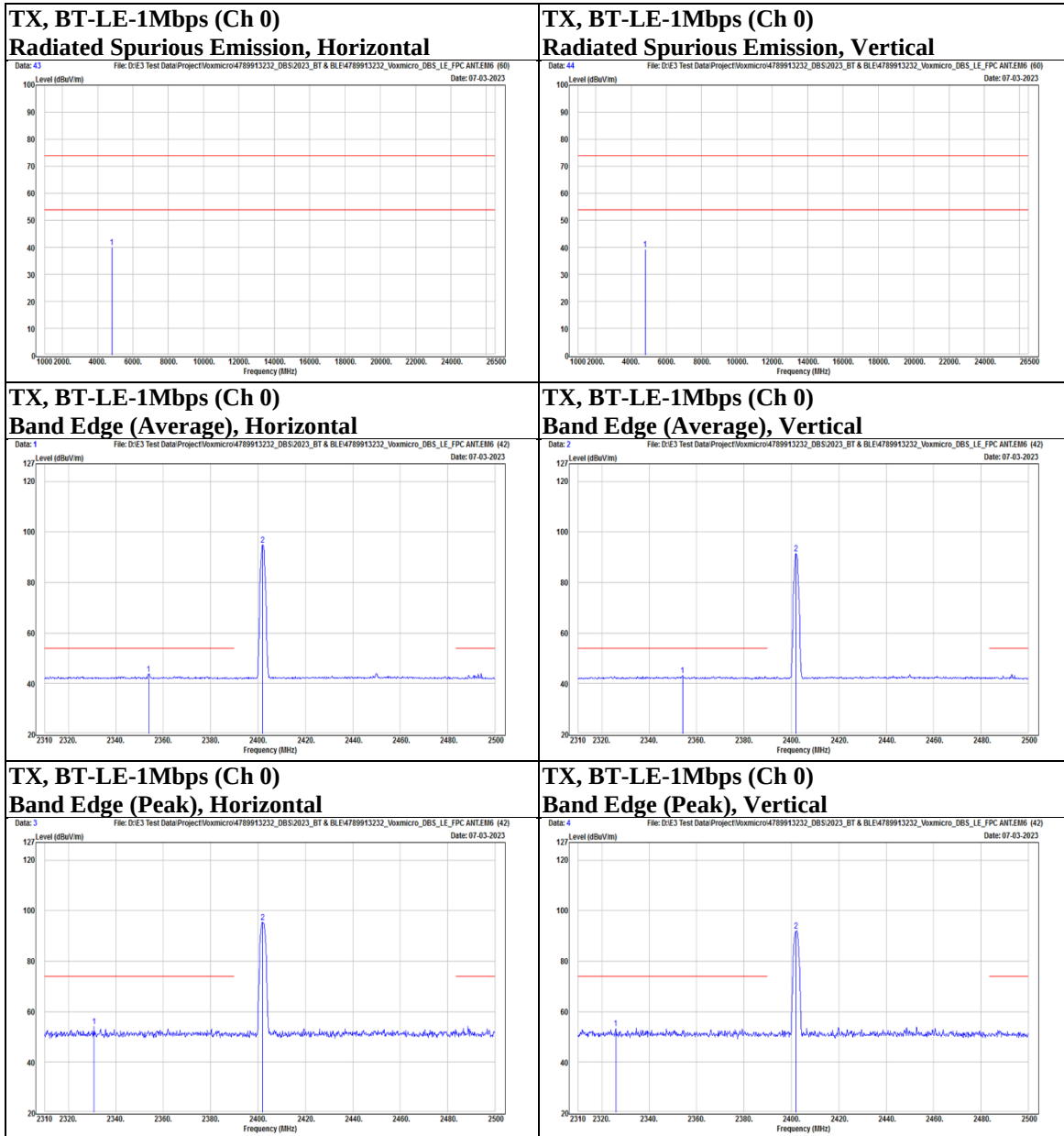
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Mode	BT-LE-1Mbps	Channel	19
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Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		2311.9	31.33	11.96	43.29	54	-10.71	AVG
		2354.27	41.63	11.94	53.57	74	-20.43	PK
	@	2440	84.06	11.99	96.05	N/A	N/A	PK
	@	2440	83.65	11.99	95.64	N/A	N/A	AVG
		2489.17	33.06	11.78	44.84	54	-9.16	AVG
		2494.11	45.16	11.75	56.91	74	-17.09	PK
	*	4880	36.2	2.21	38.41	74	-35.59	PK
	*	7320	34.81	10.25	45.06	74	-28.94	PK
Vertical		2327.48	30.95	11.96	42.91	54	-11.09	AVG
		2332.23	41.42	11.96	53.38	74	-20.62	PK
	@	2440	81.04	11.99	93.03	N/A	N/A	PK
	@	2440	80.37	11.99	92.36	N/A	N/A	AVG
		2486.32	41.64	11.79	53.43	74	-20.57	PK
		2489.36	32.13	11.78	43.91	54	-10.09	AVG
	*	4880	37.08	2.21	39.29	74	-34.71	PK
	*	7320	33.82	10.25	44.07	74	-29.93	PK

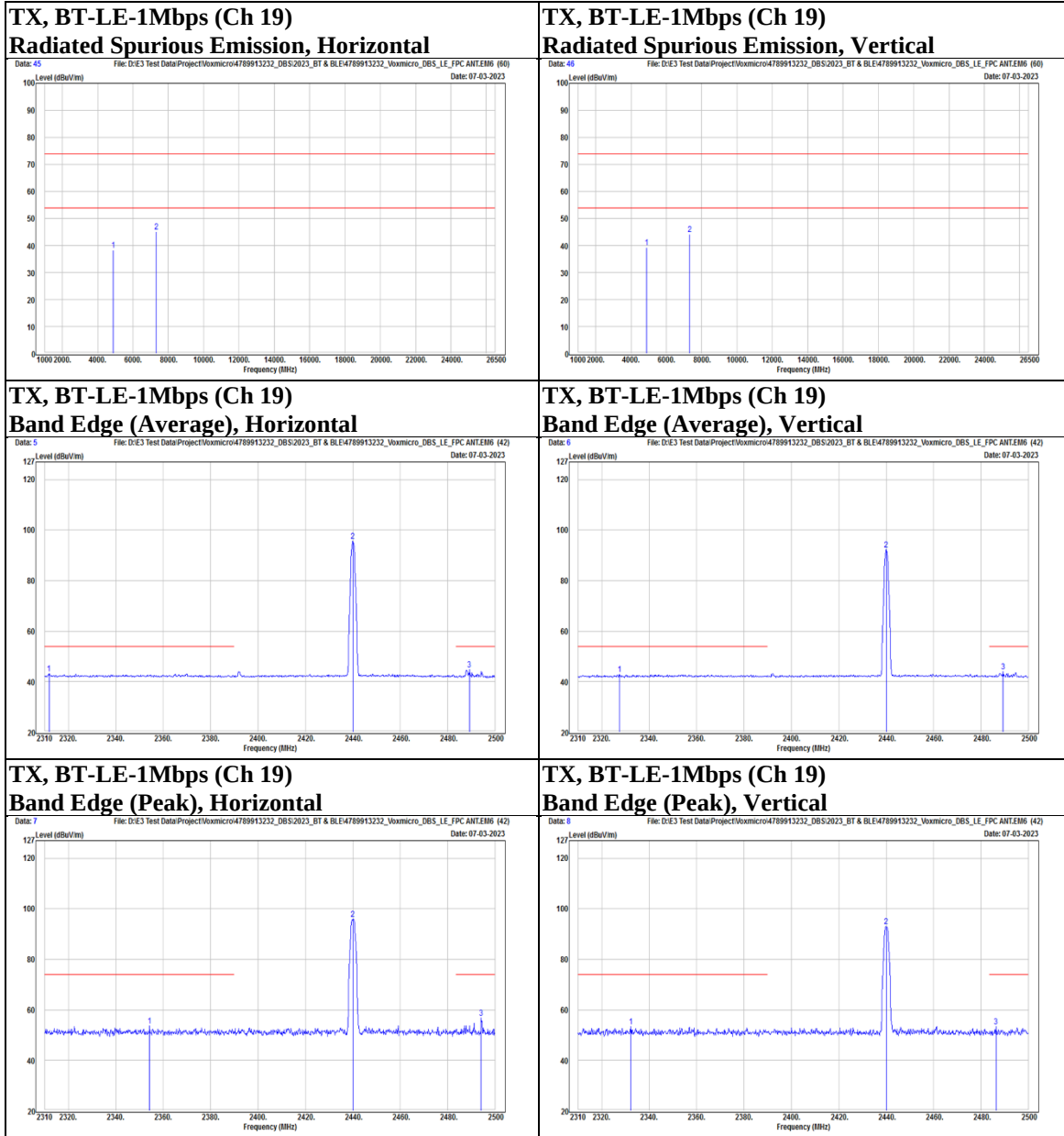
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Mode	BT-LE-1Mbps	Channel	39
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Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal	@	2480	84.62	11.83	96.45	N/A	N/A	PK
	@	2480	83.83	11.83	95.66	N/A	N/A	AVG
		2489.55	33.03	11.77	44.8	54	-9.2	AVG
		2492.4	45.07	11.76	56.83	74	-17.17	PK
	*	4960	37.1	2.3	39.4	74	-34.6	PK
	*	7440	33.06	10.69	43.75	74	-30.25	PK
Vertical	@	2480	81.5	11.83	93.33	N/A	N/A	PK
	@	2480	80.95	11.83	92.78	N/A	N/A	AVG
		2489.55	42.07	11.77	53.84	74	-20.16	PK
		2493.92	31.59	11.75	43.34	54	-10.66	AVG
	*	4960	36.44	2.3	38.74	74	-35.26	PK
	*	7440	33.27	10.69	43.96	74	-30.04	PK

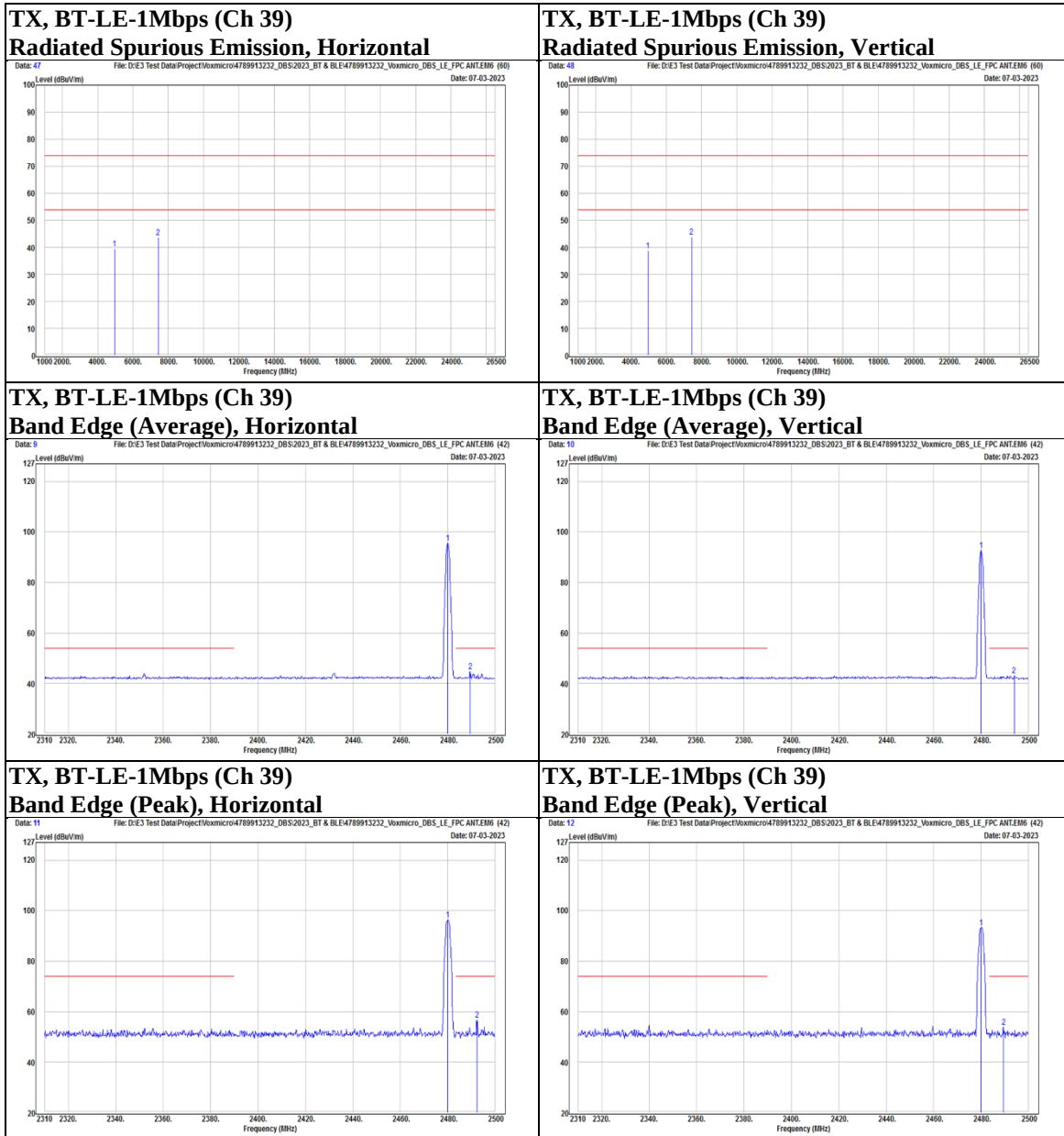
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Mode	BT-LE-2Mbps	Channel	0
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Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		2324.44	42.78	11.95	54.73	74	-19.27	PK
		2354.27	31.56	11.94	43.5	54	-10.5	AVG
	@	2402	83.3	11.85	95.15	N/A	N/A	PK
	@	2402	81.83	11.85	93.68	N/A	N/A	AVG
	*	4804	36.5	2.14	38.64	74	-35.36	PK
Vertical		2322.54	30.87	11.95	42.82	54	-11.18	AVG
		2350.09	41.9	11.95	53.85	74	-20.15	PK
	@	2402	80.08	11.85	91.93	N/A	N/A	PK
	@	2402	78.23	11.85	90.08	N/A	N/A	AVG
	*	4804	36.59	2.14	38.73	74	-35.27	PK

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