

TEST REPORT

Testing Laboratory:

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Test Report Number: SKT-RFC-220001

Date of issue: January 10, 2022

Applicant:

AISOLUTION CO., LTD.

28-4, Samyang-ro 29-gil, Gangbuk-gu, Seoul, 01194, South Korea

Manufacturer:

AISOLUTION CO., LTD.

28-4, Samyang-ro 29-gil, Gangbuk-gu, Seoul, 01194, South Korea

Product:

KDC80 Bluetooth Barcode Scanner

Model:

KDC80

FCC ID:

VH9-KDC80

Project number:

SKTEU21-1466

EUT received:

December 3, 2021

Applied standards:

ANSI C63.10-2013 and ANSI C63.4-2014

558074 D01 DTS Meas Guidance v05r02

Rule parts:

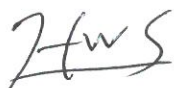
FCC Part 15 Subpart C - Intentional radiators

Equipment Class:

DTS - Part 15 Digital Transmission System

Remarks to the standards: None

The above equipment has been tested by SK Tech Co., Ltd., and found compliance with the requirements set forth in the technical standards mentioned above. The results of testing in this report apply only to the product or system, which was tested.



Wonsik Ham / **Testing Engineer**



Jongsoo Yoon / **Technical Manager**

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Revision History of Test Report

Rev.	Revisions	Effect page	Approved by	Date
-	Initial issue	All	Jongsoo Yoon	Jan. 10, 2022



TABLE OF CONTENTS

1	Summary of test results	4
2	Description of equipment under test (EUT)	5
3	Test and measurement conditions	6
	3.1. Test configuration (arrangement of EUT)	6
	3.2. Description of support units (accessory equipment).....	6
	3.3. Interconnection and I/O cables	6
	3.4. Measurement Uncertainty (<i>U</i>)	7
	3.5. Test date	7
4	Facilities and accreditations	8
	4.1. Facilities.....	8
	4.2. Accreditations	8
	4.3. List of test and measurement instruments.....	8
5	Test and measurements	9
	5.1. Antenna requirement	9
	5.2. 6 dB bandwidth.....	10
	5.3. Maximum peak output power	13
	5.4. Spurious emissions, Band edge, and Restricted bands.....	16
	5.5. Peak power spectral density.....	45
	5.6. AC power line Conducted emissions	48



1 Summary of test results

Requirement	CFR 47 Section	Result
Antenna Requirement	15.203, 15.247(b)(4)	Meets the requirements
6dB Bandwidth	15.247(a)(2)	Meets the requirements
Maximum Peak Output Power	15.247(b)(3), (4)	Meets the requirements
Spurious Emission, Band Edge, and Restricted bands	15.247(d), 15.205(a), 15.209(a)	Meets the requirements
Peak Power Spectral Density	15.247(e)	Meets the requirements
AC power line Conducted emission	15.207(a)	Meets the requirements



2 Description of equipment under test (EUT)

Product: KDC80 Bluetooth Barcode Scanner
Model: **KDC80**
Serial number: None (prototype)

Model differences:

Model name	Difference	Tested (checked)
KDC80	fully tested model that was provided by the applicant	☒

Technical data:

Power source	DC 3.7 V (Battery)
Local Oscillator or X-Tal	32 MHz
Transmit Frequency	2402 MHz ~ 2480 MHz (40 channels, Bluetooth LE only)
Antenna Type	Integral Chip antenna
Type of Modulation	GFSK
RF Output power	-1.9 dBm (measured conducted RF power)

I/O port	Type	Q'ty	Remark
USB	USB (Type C)	1	

Modification of EUT during the compliance testing: none

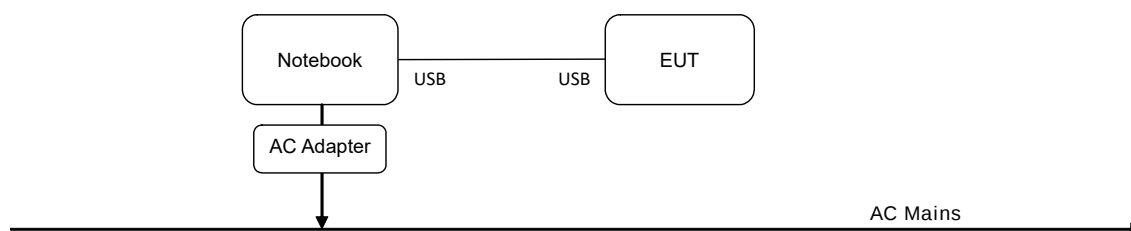


3 Test and measurement conditions

3.1. Test configuration (arrangement of EUT)

Two test samples were provided for the radiated measurements and for the conducted measurements.

The measurements were taken in continuously transmitting the burst signals. For controlling the EUT, the test software (nRF_DTM v0.10.2) and the control cable were provided by the applicant. All the tests were performed while the test sample was powered from the internal battery.



3.2. Description of support units (accessory equipment)

The following support units or accessories were used to form a representative test configuration during the tests.

#	Equipment	Manufacturer	Model No.	Serial No.
1	Notebook	Lenovo	ThinkPad X1 Carbon Gen 9	N/A
2	AC Adapter (Notebook)	Lite-On Techonology (CHANG ZHOU) Co., Ltd	ADP-60ZH	N/A

3.3. Interconnection and I/O cables

The following support units or accessories were used to form a representative test configuration during the tests.

#	Start		End		Cable	
	Name	I/O port	Name	I/O port	length (m)	shielded (Y/N)
1	EUT	USB	Notebook	USB	1.0	Y
2	Notebook	DC Input	AC Adapter	DC Output	1.7	N
3	AC Adapter	AC Input	AC Mains	AC Mains	1.8	N

Note: 1) All the equipments were placed in the worst-case configuration to maximize the emission during the test.
2) Grounding was established in accordance with the manufacturer's requirements and conditions for the intended use.



3.4. Measurement Uncertainty (U)

Measurement Item	Combined Standard Uncertainty U_c	Expanded Uncertainty $U = k \times U_c (k = 2)$
Conducted RF power	± 0.64 dB	± 1.28 dB
Conducted emissions	± 1.4 dB	± 2.8 dB
Radiated emissions (9 kHz to 30 MHz)	± 1.45 dB	± 2.9 dB
Radiated emissions (30 MHz to 1000 MHz)	± 2.5 dB	± 5.0 dB
Radiated emissions (above 1 GHz)	± 2.5 dB	± 5.0 dB

3.5. Test date

Date Tested	December 22, 2021 – January 4, 2022
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4 Facilities and accreditations

4.1. Facilities

All of the measurements described in this report were performed at SK Tech Co., Ltd

Site I: 88, Geulgaetul-ro 81beon-gil, Wabu-eup, Namyangju-si, Gyeonggi-do, Korea

Site II: 124-8, Geulgaetul-ro, Wabu-eup, Namyangju-si, Gyeonggi-do, Korea

The sites are constructed in conformance with the requirements of ANSI C63.4 and CISPR 16-1-4. The sites comply with the Normalized Site Attenuation requirements given in ANSI C63.4, and site VSWR requirements specified in CISPR 16-1-4. The measuring apparatus and ancillary equipment conform to CISPR 16-1 series.

4.2. Accreditations

The laboratory has been also notified to FCC by RRA as a Conformity Assessment Body, and designated to perform compliance testing on equipment subject to Supplier's Declaration of Conformity (SDoC) and Certification under Parts 15 and 18 of the FCC Rules.

Designation No. KR0007

4.3. List of test and measurement instruments

No	Description	Model	Manufacturer	Serial No.	Cal. due	Use
1	Spectrum Analyzer	E4440A	Agilent	MY46186322	2022.05.26	☒
2	EMI Test Receiver	ESR26	Rohde&Schwarz	101441	2022.05.26	☒
3	EMI Test Receiver	PMM9010F	Narda	020WW40105	2022.01.28	☒
4	Pulse limiter	ESH3-Z2	Rohde&Schwarz	100604	2022.05.24	☒
5	AMN (LISN)	ENV 216	Rohde&Schwarz	102047	2022.01.28	☒
6	AMN (LISN)	FCC-LISN-50-32-2-01-480V	FCC	141455	2022.05.24	
7	Pre-amplifier (30 MHz - 1 GHz)	MLA-10K01-B01-27	TSJ	2005350	2022.05.26	☒
8	Pre-amplifier (1 GHz - 18 GHz)	AFS44-00101800-25-10P-44	MITEQ	1116321	2022.05.24	☒
9	Pre-amplifier (18 GHz - 26.5 GHz)	MLA-18265-J01-35	TSJ	8490	2022.02.23	☒
10	Attenuator (10dB)	8491B	HP	38067	2022.05.26	☒
11	Attenuator (6dB)	18N5W	API Technology	-	2022.06.24	☒
12	High Pass Filter	WHKX 3.0/18G-12SS	Wainwright	8	2022.05.27	☒
13	Loop Antenna	HFH2-Z2E	Rohde&Schwarz	100883	2022.12.16	☒
14	BILOG Broadband Antenna	VULB9168	Schwarzbeck	9168-230	2022.06.24	☒
15	Horn Antenna (1 GHz - 18 GHz)	3117	ETS-LINDGREN	00205960	2022.06.23	☒
16	Horn Antenna (15 GHz - 40 GHz)	BBHA9170	Schwarzbeck	BBHA9170318	2022.06.01	☒
17	Signal Generator	SMB100A	Rohde&Schwarz	180704	2022.02.24	
18	DC Power Supply	6633A	HP	2838A-01000	2022.05.25	
19	Digital Thermo-Hygrometer	608-H1	Testo	41383411	2022.06.03	☒
20	Temperature/Humidity Chamber	DJ-THC02	DAE JIN ENG	06071	2022.05.25	

5 Test and measurements

5.1. Antenna requirement

5.1.1 Regulation

According to §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.

And according to §15.247(b)(4), the conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, 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.

5.1.2 Result:

PASS

The EUT has the internal Chip antenna with the directional gain of 3.14 dBi, and meets the requirements of this section.



5.2. 6 dB bandwidth

5.2.1 Regulation

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

5.2.2 Test Procedure

The 6 dB bandwidth was measured with the following setting according to KDB 559074 D01 DTS Meas Guidance v05r02.

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. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

5.2.3 Test Results:

PASS

Table 1: Measured values of the 6dB Bandwidth (Bluetooth LE 1 Mbps)

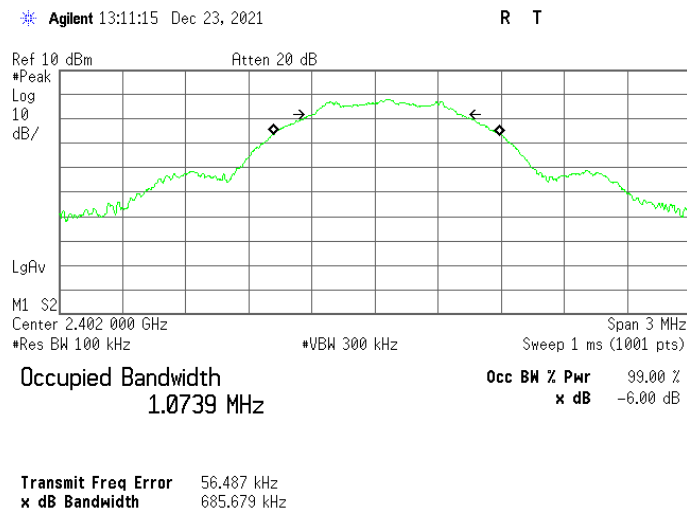
Operating frequency	Occupied Bandwidth (99 %)	6 dB Bandwidth	Limit
2402 MHz	1.0739 MHz	685.679 kHz	≥ 500 kHz
2442 MHz	1.0754 MHz	688.917 kHz	≥ 500 kHz
2480 MHz	1.0749 MHz	686.173 kHz	≥ 500 kHz

Table 2: Measured values of the 6dB Bandwidth (Bluetooth LE 2 Mbps)

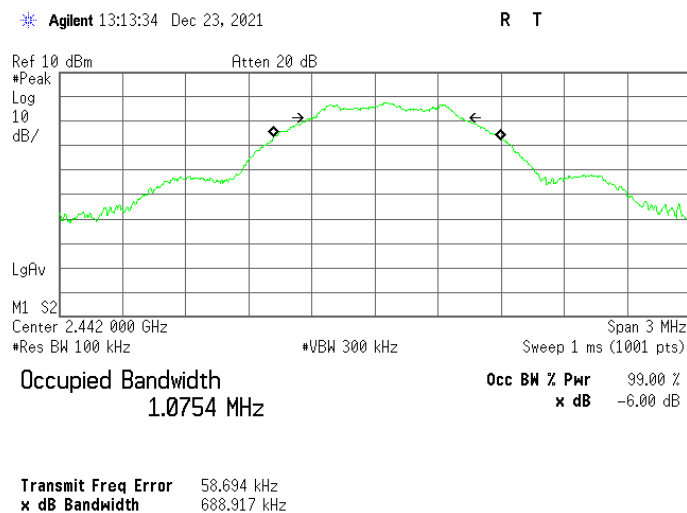
Operating frequency	Occupied Bandwidth (99 %)	6 dB Bandwidth	Limit
2402 MHz	2.0645 MHz	1.147 MHz	≥ 500 kHz
2442 MHz	2.0728 MHz	1.151 MHz	≥ 500 kHz
2480 MHz	2.0702 MHz	1.147 MHz	≥ 500 kHz

Figure 1. Plot of the 6dB Bandwidth & Occupied Bandwidth (99%)

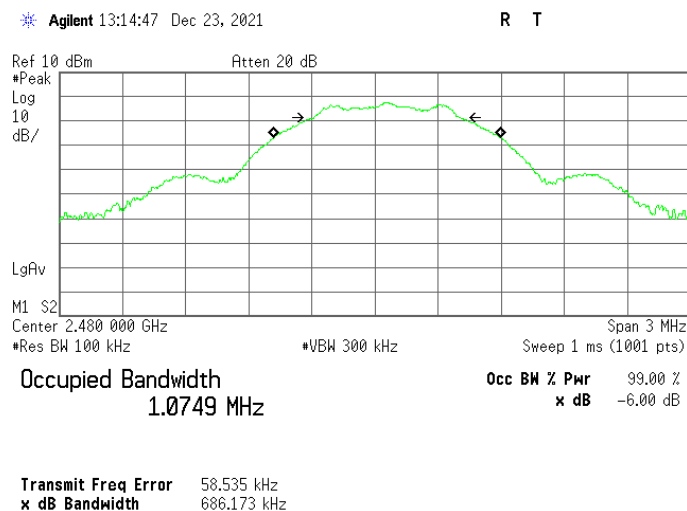
Operating at the lowest frequency (Bluetooth LE 1 Mbps, 2402 MHz)



Operating at the middle frequency (Bluetooth LE 1 Mbps, 2442 MHz)

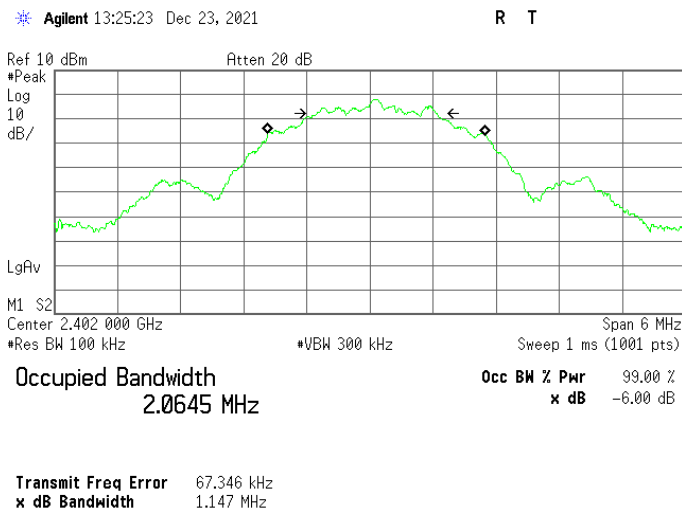


Operating at the highest frequency (Bluetooth LE 1 Mbps, 2480 MHz)

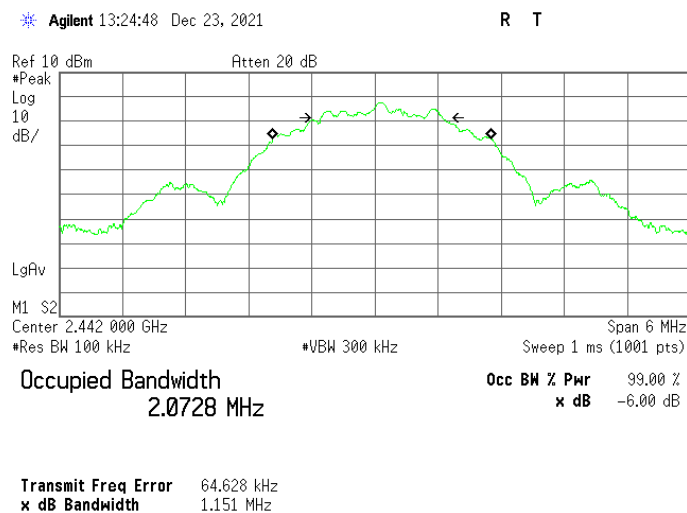




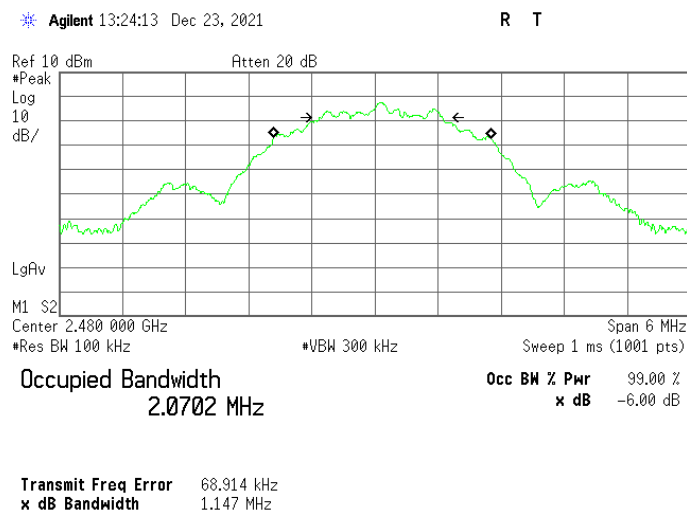
Operating at the lowest frequency (Bluetooth LE 2 Mbps, 2402 MHz)



Operating at the middle frequency (Bluetooth LE 2 Mbps, 2442 MHz)



Operating at the highest frequency (Bluetooth LE 2 Mbps, 2480 MHz)





5.3. Maximum peak output power

5.3.1 Regulation

According to §15.247(b)(3), for systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

According to §15.247(b)(4), the conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, 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.

5.3.2 Test Procedure

1. Set the RBW $\geq$ DTS bandwidth.
2. Set the VBW $\geq 3 \times$ RBW.
3. Set the span $\geq 3 \times$ 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.

5.3.3 Test Results:

PASS

Table 3: Measured values of the Maximum Peak Conducted Output Power (Bluetooth LE 1 Mbps)

Operating frequency	PEAK POWER		Limit
	[dBm]	[W]	
2402 MHz	-1.93	0.000 64	1 W
2442 MHz	-2.37	0.000 58	1 W
2480 MHz	-2.56	0.000 55	1 W

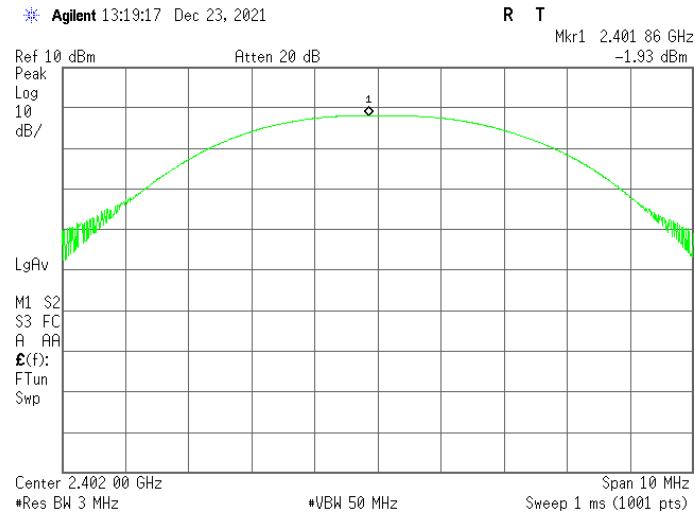
Table 4: Measured values of the Maximum Peak Conducted Output Power (Bluetooth LE 2 Mbps)

Operating frequency	PEAK POWER		Limit
	[dBm]	[W]	
2402 MHz	-1.90	0.000 65	1 W
2442 MHz	-2.33	0.000 58	1 W
2480 MHz	-2.52	0.000 56	1 W

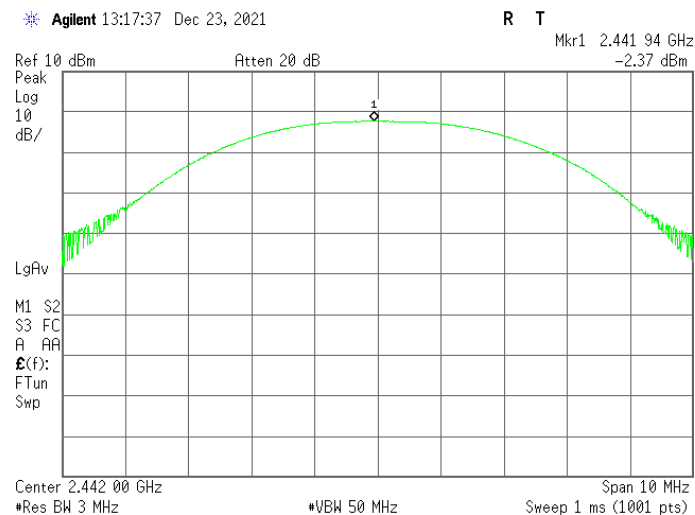
Figure 2. Plot of the Maximum Peak Conducted Output Power

During the measurements, the insertion loss of the cable loss and the external attenuator (10 dB) was corrected in the spectrum analyzer.

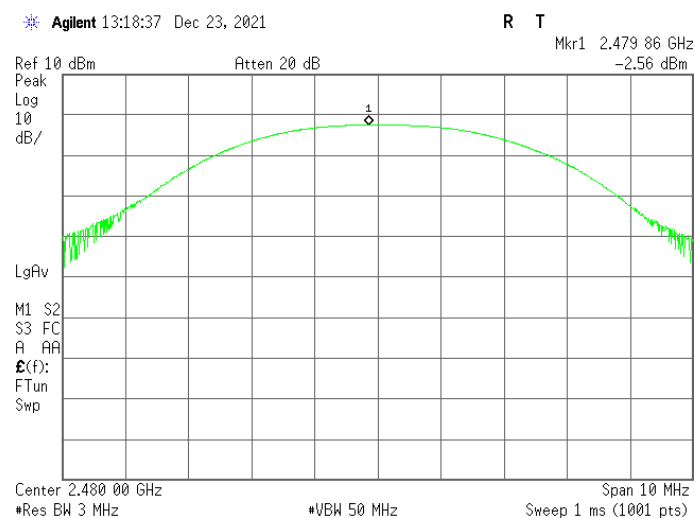
Operating at the lowest frequency (Bluetooth LE 1 Mbps, 2402 MHz)



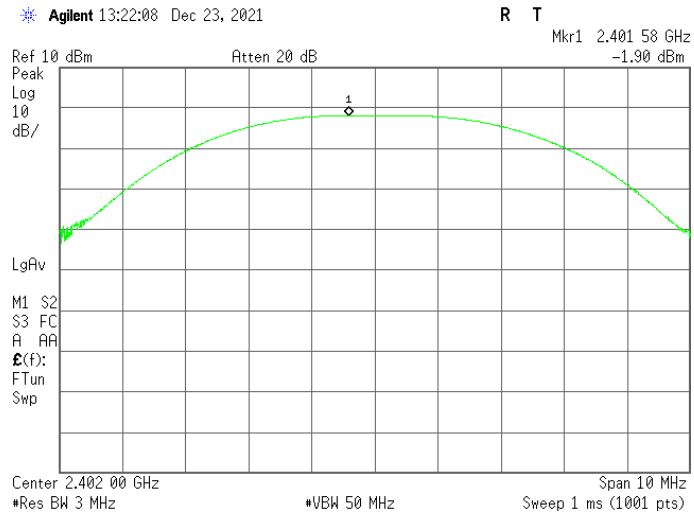
Operating at the middle frequency (Bluetooth LE 1 Mbps, 2442 MHz)



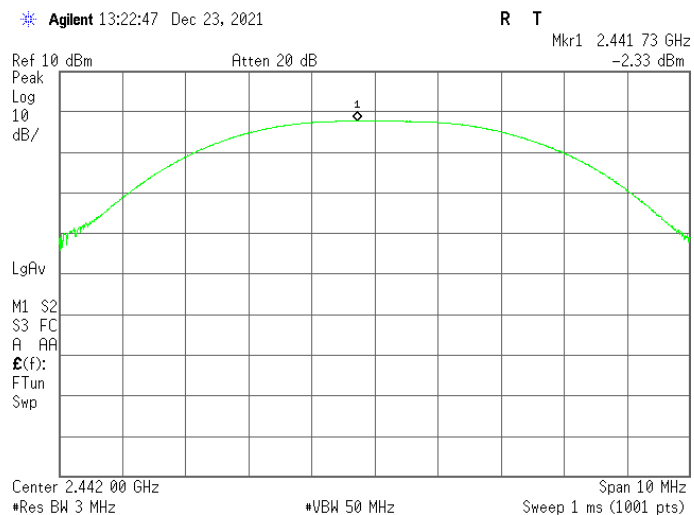
Operating at the highest frequency (Bluetooth LE 1 Mbps, 2480 MHz)



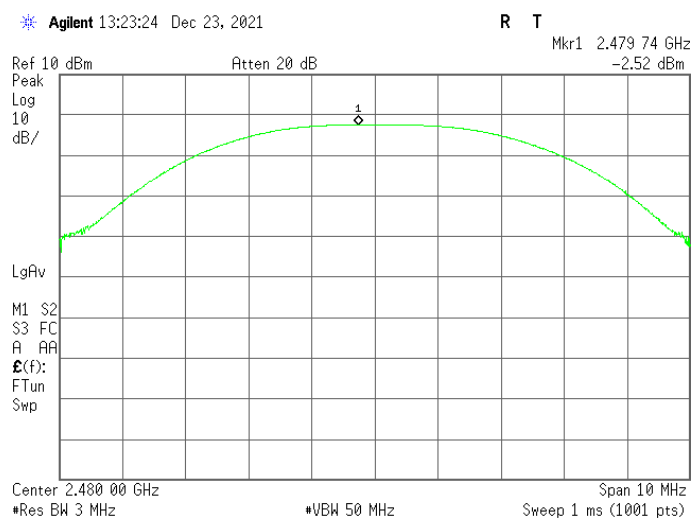
Operating at the lowest frequency (Bluetooth LE 2 Mbps, 2402 MHz)



Operating at the middle frequency (Bluetooth LE 2 Mbps, 2442 MHz)



Operating at the highest frequency (Bluetooth LE 2 Mbps, 2480 MHz)





5.4. Spurious emissions, Band edge, and Restricted bands

5.4.1 Regulation

According to §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)), the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field strength limit ($\mu\text{V}/\text{m}$)	Field strength limit (dB $\mu\text{V}/\text{m}$)	Measurement distance (m)
0.009 - 0.490	2400/F (kHz)	48.5 - 13.8	300
0.490 - 1.705	24000/F (kHz)	33.6 - 23.0	30
1.705 - 30.0	30	29.5	30
30 – 88	100	40.0	3
88 – 216	150	43.5	3
216 – 960	200	46.0	3
Above 960	500	54.0	3

***Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§15.231 and 15.241.*

5.4.2 Test Procedure

1) Band-edge measurements for RF conducted emissions

1. Set the spectrum analyzer as follows:

Span = wide enough to capture the peak level of the emission operating on the channel closest to the band-edge, as well as any modulation products which fall outside of the authorized band of operation

RBW $\geq$ 1 % of spectrum analyzer display span

VBW $\geq$ 3 x RBW

Sweep = auto

Detector function = peak

Trace = max hold

2. Allow the trace to stabilize. Set the marker on the emission at the band-edge, or on the highest modulation product outside of the band, if this level is greater than that at the band-edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.
3. Now, using the same instrument settings, enable the hopping function of the EUT. Allow the trace to stabilize. Follow the same procedure listed above to determine if any spurious emissions caused by the hopping function also comply with the specified limit.



2) Spurious RF Conducted Emissions:

1. Set the spectrum analyzer as follows:

Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic.

Typically, several plots are required to cover this entire span.

RBW = 100 kHz

VBW $\geq 3 \times$ RBW

Sweep = auto

Detector function = peak

Trace = max hold

2. Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded.

3) Spurious Radiated Emissions:

1. The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions in an anechoic chamber at a distance of 3 meters or 1 meter if applicable.
2. The EUT was placed on the top of the 0.8-meter height (or 1.5 meter height for above 1 GHz). To find the maximum emission levels, the height of a measuring antenna was changed and the turntable was rotated (0° to 360°).
3. The antenna polarization was also changed from vertical to horizontal. The spectrum was scanned from 9 kHz to 30 MHz using the loop antenna, from 30 to 1000 MHz using the Bilog broadband antenna, and from 1 GHz to tenth harmonic of the highest fundamental frequency using the horn antenna.
4. To increase the overall measurement sensitivity, the closer test distances and/or narrower bandwidths may be used. If the closer measurement distance (1 meter) were used, the beamwidth of the measuring antenna versus size of the EUT was taken into account.
5. To obtain the final measurement data, each frequency found during preliminary measurements was re-examined and investigated. The test receiver was set up to average, peak, and quasi-peak detector function with specified bandwidth. It was attempted to maximize the emission, by varying the configuration of the EUT and the cables routing.
6. The EUT is situated in three orthogonal planes (if appropriate)
7. If the emission on which a radiated measurement must be made is located at the edge of the authorized band of operation, then the alternative "marker-delta" method may be employed.

4) Marker-Delta Method at the edge of the authorized band of operation:

1. Perform an in-band field strength measurement of the fundamental emission using the RBW and detector function specified in 6.3 and 6.4, 6.5, or 6.6, as applicable, and the appropriate regulatory requirements for the frequency being measured.
2. Choose a spectrum analyzer span that encompasses both the peak of the fundamental emission and the band-edge emission under investigation. Set the analyzer RBW to approximately 1 % to 5 % of the total span, unless otherwise specified, with a video bandwidth equal to or greater than the RBW. Record the peak levels of the fundamental emission and the relevant band-edge emission (i.e., run several sweeps in peak hold mode). Observe the stored trace and measure the amplitude delta between the peak of the fundamental and the peak of the band-edge emission. This is not an absolute field strength measurement; it is only a relative measurement to determine the amount by which the emission drops at the band edge relative to the highest fundamental emission level.
3. Subtract the delta measured in b) from the field strengths measured in a). The resultant field strengths (CISPR QP, average, or peak, as appropriate) are then used to determine band-edge compliance of the restricted bands, described in 5.9.
4. The above "delta" measurement technique may be used for measuring emissions that are up to two "standard" bandwidths away from the band edge, where a "standard" bandwidth is the bandwidth specified by 4.2.3.2 for the frequency being measured. For example, band-edge measurements in the restricted band that begins at 2483.5 MHz require a measurement bandwidth of at least 1 MHz. Therefore the "delta" technique for measuring emissions up to 2 MHz removed from the band edge may be used. Radiated emissions that are removed by more than two "standard" bandwidths shall be measured in the conventional manner.

Measurement software: TEPTO-DV/RE_Version: 3.1.0044



5.4.3 Test Results:

PASS

Table 5: Measured values of the Field strength (for the frequency below 30 MHz)

Freq. (kHz)	RBW (kHz)	Reading (dBμV)			AF (dB/m)	CL (dB)	Actual (dBμV/m)			Limit (at 3m) (dBμV/m)			Margin (dB)			Remark
		PK	AV	QP			PK	AV	QP	PK	AV	QP	PK	AV	QP	
																No Radiated Spurious Emissions Found

AF and CL: antenna factor and cable loss

Actual (dBμV/m) = Reading + AF + CL

Margin (dB) = Limit – Actual

Note: These test results were measured at the 3 m distance

Table 6: Measured values of the Field strength (for the frequency from 30 MHz to 1 GHz)

Operating at the lowest frequency (Bluetooth LE 1 Mbps, 2402 MHz)

Frequency (MHz)	Pol. (V/H)	Height (m)	Reading (dBμV)	AMP (dB)	AF (dB/m)	CL (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Remark
59.600	V	1.01	35.8	30.6	19.1	1.0	25.3	40.0	14.7	X-axis
114.446	V	1.02	38.2	30.1	16.0	1.5	25.6	43.5	17.9	
168.187	V	1.08	39.3	29.7	18.2	1.8	29.6	43.5	13.9	
252.952	H	1.13	35.1	29.7	17.8	2.2	25.4	46.0	20.6	
655.008	V	1.01	21.5	30.8	26.3	3.5	20.5	46.0	25.5	
59.744	V	1.00	36.1	30.6	19.1	1.0	25.6	40.0	14.4	Y-axis
112.528	V	1.16	40.8	30.1	15.8	1.4	27.9	43.5	15.6	
169.292	H	2.21	38.2	29.7	18.1	1.8	28.4	43.5	15.1	
670.933	V	1.13	20.9	31.0	26.4	3.5	19.8	46.0	26.2	
30.434	V	1.02	35.1	30.9	18.2	0.8	23.2	40.0	16.8	Z-axis
159.676	H	1.30	37.7	29.7	18.8	1.7	28.5	43.5	15.0	
263.956	H	1.01	38.6	29.8	18.2	2.2	29.2	46.0	16.8	
375.285	H	1.11	26.2	30.5	21.0	2.6	19.3	46.0	26.7	
654.175	V	1.01	23.9	30.8	26.3	3.5	22.9	46.0	23.1	

V/H: Vertical / Horizontal polarization

AMP, AF and CL: pre-amplifier gain, antenna factor and cable loss

Actual = Reading - AMP + AF + CL

Margin = Limit - Actual



Operating at the middle frequency (Bluetooth LE 1 Mbps, 2442 MHz)

Frequency (MHz)	Pol. (V/H)	Height (m)	Reading (dBμV)	AMP (dB)	AF (dB/m)	CL (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Remark
59.232	V	1.00	36.6	30.6	19.1	1.0	26.1	40.0	13.9	X-axis
113.578	V	1.24	38.8	30.1	15.9	1.4	26.0	43.5	17.5	
169.383	V	1.05	39.4	29.7	18.1	1.8	29.6	43.5	13.9	
358.270	H	1.00	24.9	30.4	20.6	2.6	17.7	46.0	28.3	
59.438	V	1.00	36.8	30.6	19.1	1.0	26.3	40.0	13.7	Y-axis
113.014	V	1.11	40.3	30.1	15.9	1.4	27.5	43.5	16.0	
167.468	H	1.79	39.7	29.7	18.3	1.8	30.1	43.5	13.4	
358.091	H	1.02	26.5	30.4	20.6	2.6	19.3	46.0	26.7	
672.844	V	1.01	21.3	31.0	26.5	3.5	20.3	46.0	25.7	
30.941	V	1.08	35.8	30.9	18.2	0.8	23.9	40.0	16.1	Z-axis
159.763	H	1.93	35.7	29.7	18.8	1.7	26.5	43.5	17.0	
368.235	H	1.01	26.5	30.5	20.8	2.6	19.4	46.0	26.6	
635.202	V	1.02	22.9	30.7	26.1	3.4	21.7	46.0	24.3	

V/H: Vertical / Horizontal polarization

AMP, AF and CL: pre-amplifier gain, antenna factor and cable loss

Actual = Reading - AMP + AF + CL

Margin = Limit - Actual

Operating at the highest frequency (Bluetooth LE 1 Mbps, 2480 MHz)

Frequency (MHz)	Pol. (V/H)	Height (m)	Reading (dBμV)	AMP (dB)	AF (dB/m)	CL (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Remark
59.550	V	1.16	36.0	30.6	19.1	1.0	25.5	40.0	14.5	X-axis
117.936	V	1.41	36.8	30.0	16.3	1.5	24.6	43.5	18.9	
167.463	H	1.44	40.4	29.7	18.3	1.8	30.8	43.5	12.7	
669.957	V	1.46	20.2	31.0	26.4	3.5	19.1	46.0	26.9	
32.512	V	1.24	37.7	30.9	18.3	0.8	25.9	40.0	14.1	Y-axis
99.002	V	1.13	37.5	30.2	14.6	1.3	23.2	43.5	20.3	
167.771	H	2.31	38.1	29.7	18.3	1.8	28.5	43.5	15.0	
560.780	V	1.01	26.7	30.5	25.0	3.2	24.4	46.0	21.6	
655.795	V	1.49	22.0	30.8	26.3	3.5	21.0	46.0	25.0	
32.802	V	2.18	32.1	30.9	18.3	0.8	20.3	40.0	19.7	Z-axis
110.519	V	1.22	36.7	30.1	15.6	1.4	23.6	43.5	19.9	
159.507	H	2.04	36.7	29.7	18.8	1.7	27.5	43.5	16.0	
366.137	H	1.11	26.9	30.4	20.8	2.6	19.9	46.0	26.1	

V/H: Vertical / Horizontal polarization

AMP, AF and CL: pre-amplifier gain, antenna factor and cable loss

Actual = Reading - AMP + AF + CL

Margin = Limit - Actual



Operating at the middle frequency (Bluetooth LE 2 Mbps, 2402 MHz)

Frequency (MHz)	Pol. (V/H)	Height (m)	Reading (dBμV)	AMP (dB)	AF (dB/m)	CL (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Remark
58.799	V	1.01	35.6	30.6	19.2	1.0	25.2	40.0	14.8	X-axis
116.961	V	1.02	38.2	30.0	16.2	1.5	25.9	43.5	17.6	
168.502	H	1.85	40.1	29.7	18.2	1.8	30.4	43.5	13.1	
655.036	H	1.27	22.0	30.8	26.3	3.5	21.0	46.0	25.0	
32.535	V	1.22	35.6	30.9	18.3	0.8	23.8	40.0	16.2	Y-axis
98.825	V	1.49	35.0	30.2	14.6	1.3	20.7	43.5	22.8	
167.413	H	1.93	36.7	29.7	18.3	1.8	27.1	43.5	16.4	
655.063	H	1.24	23.4	30.8	26.3	3.5	22.4	46.0	23.6	
32.589	V	1.35	34.3	30.9	18.3	0.8	22.5	40.0	17.5	Z-axis
160.107	H	3.74	33.0	29.7	18.8	1.7	23.8	43.5	19.7	
263.801	H	1.24	37.6	29.8	18.2	2.2	28.2	46.0	17.8	
644.685	V	1.05	23.4	30.8	26.2	3.4	22.2	46.0	23.8	

V/H: Vertical / Horizontal polarization

AMP, AF and CL: pre-amplifier gain, antenna factor and cable loss

Actual = Reading - AMP + AF + CL

Margin = Limit - Actual

Operating at the highest frequency (Bluetooth LE 2 Mbps, 2442 MHz)

Frequency (MHz)	Pol. (V/H)	Height (m)	Reading (dBμV)	AMP (dB)	AF (dB/m)	CL (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Remark
59.304	V	1.00	36.5	30.6	19.1	1.0	26.0	40.0	14.0	X-axis
117.144	V	1.05	38.1	30.0	16.2	1.5	25.8	43.5	17.7	
168.400	H	2.01	41.0	29.7	18.2	1.8	31.3	43.5	12.2	
659.887	V	1.00	21.6	30.9	26.3	3.5	20.5	46.0	25.5	
31.294	V	1.27	35.5	30.9	18.3	0.8	23.7	40.0	16.3	Y-axis
167.624	H	2.69	36.1	29.7	18.3	1.8	26.5	43.5	17.0	
559.377	V	1.01	25.7	30.5	24.9	3.2	23.3	46.0	22.7	
650.296	H	1.27	22.9	30.8	26.3	3.5	21.9	46.0	24.1	
30.506	V	2.45	30.9	30.9	18.2	0.8	19.0	40.0	21.0	Z-axis
159.098	H	1.96	36.1	29.7	18.8	1.7	26.9	43.5	16.6	
263.854	V	1.00	37.1	29.8	18.2	2.2	27.7	46.0	18.3	
371.129	H	1.08	25.4	30.5	20.9	2.6	18.4	46.0	27.6	

V/H: Vertical / Horizontal polarization

AMP, AF and CL: pre-amplifier gain, antenna factor and cable loss

Actual = Reading - AMP + AF + CL

Margin = Limit - Actual



Operating at the middle frequency (Bluetooth LE 2 Mbps, 2480 MHz)

Frequency (MHz)	Pol. (V/H)	Height (m)	Reading (dBμV)	AMP (dB)	AF (dB/m)	CL (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Remark
59.504	V	1.01	36.0	30.6	19.1	1.0	25.5	40.0	14.5	X-axis
115.790	V	1.16	38.6	30.0	16.1	1.5	26.2	43.5	17.3	
168.293	V	1.00	39.7	29.7	18.2	1.8	30.0	43.5	13.5	
359.172	H	1.11	27.4	30.4	20.6	2.6	20.2	46.0	25.8	
32.470	V	1.30	34.9	30.9	18.3	0.8	23.1	40.0	16.9	Y-axis
50.729	V	1.02	33.3	30.6	19.6	0.9	23.2	40.0	16.8	
167.765	H	1.93	36.6	29.7	18.3	1.8	27.0	43.5	16.5	
560.709	V	1.05	26.4	30.5	25.0	3.2	24.1	46.0	21.9	
656.349	V	1.00	23.9	30.8	26.3	3.5	22.9	46.0	23.1	
32.746	V	2.26	31.8	30.9	18.3	0.8	20.0	40.0	20.0	Z-axis
159.982	H	1.76	37.7	29.7	18.8	1.7	28.5	43.5	15.0	
263.818	V	1.02	37.7	29.8	18.2	2.2	28.3	46.0	17.7	
372.593	H	1.02	27.9	30.5	20.9	2.6	20.9	46.0	25.1	
663.641	V	1.00	23.0	30.9	26.4	3.5	22.0	46.0	24.0	

V/H: Vertical / Horizontal polarization

AMP, AF and CL: pre-amplifier gain, antenna factor and cable loss

Actual = Reading - AMP + AF + CL

Margin = Limit - Actual



Table 7: Measured values of the Field strength (for the frequency above 1 GHz)

Frequency (MHz)	Pol. (V/H)	Height (m)	Reading (dBμV)		AMP (dB)	ATT (dB)	AF (dB/m)	CL (dB)	Actual (dBμV/m)		Limit (dBμV/m)		Margin (dB)	
			PK	AV					PK	AV	PK	AV	PK	AV
		No Radiated Spurious Emissions Found												

V/H: Vertical / Horizontal polarization

AMP, AF, CL and ATT: pre-amplifier gain, antenna factor, cable loss and attenuator/filter loss if used

Actual = Reading - AMP + ATT + AF + CL

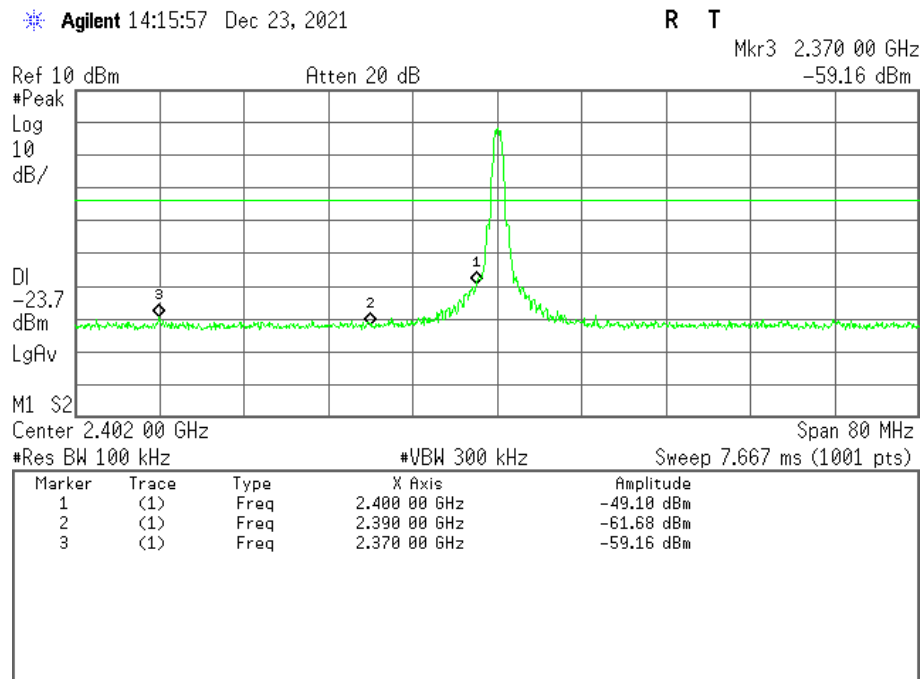
Margin = Limit - Actual



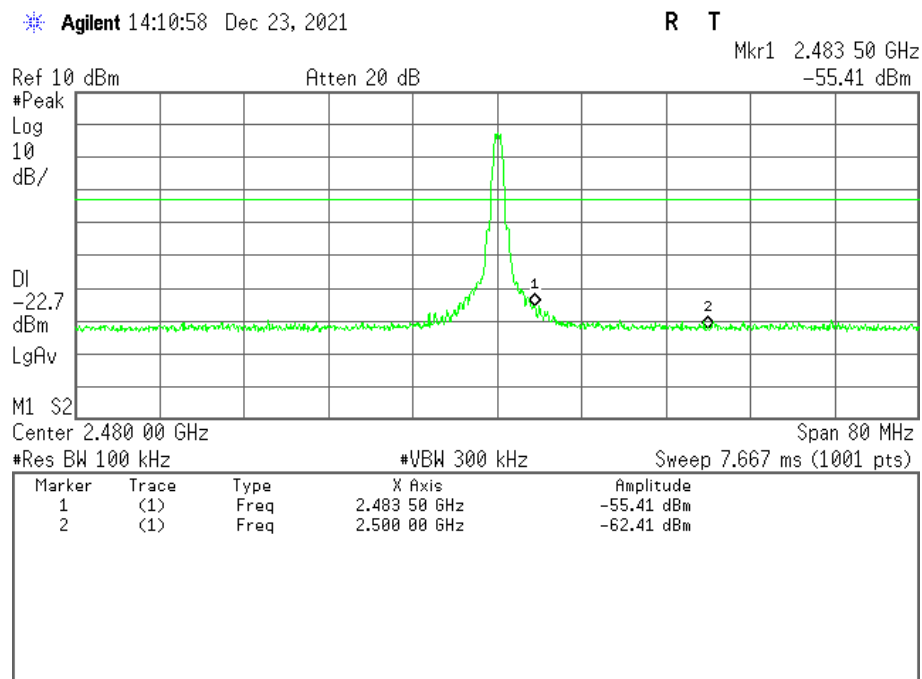
Figure 3. Plot of the Band Edge (Conducted measurements)

During the measurements, the insertion loss of the cable loss and the external attenuator (10 dB) was corrected in the spectrum analyzer.

Operating at the lowest frequency (Bluetooth LE 1 Mbps, 2402 MHz)

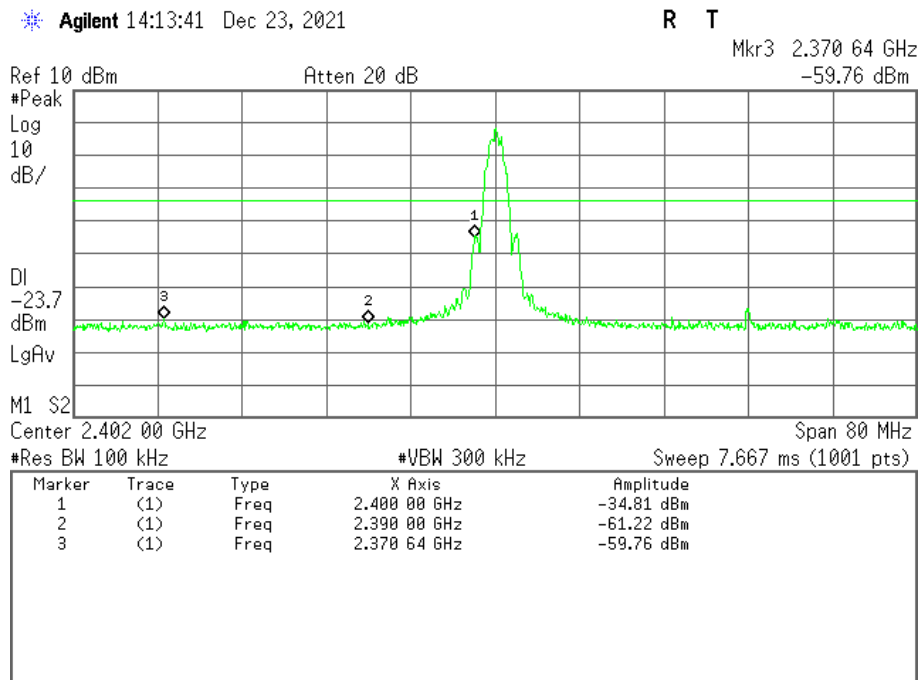


Operating at the highest frequency (Bluetooth LE 1 Mbps, 2480 MHz)





Operating at the lowest frequency (Bluetooth LE 2 Mbps, 2402 MHz)



Operating at the highest frequency (Bluetooth LE 2 Mbps, 2480 MHz)

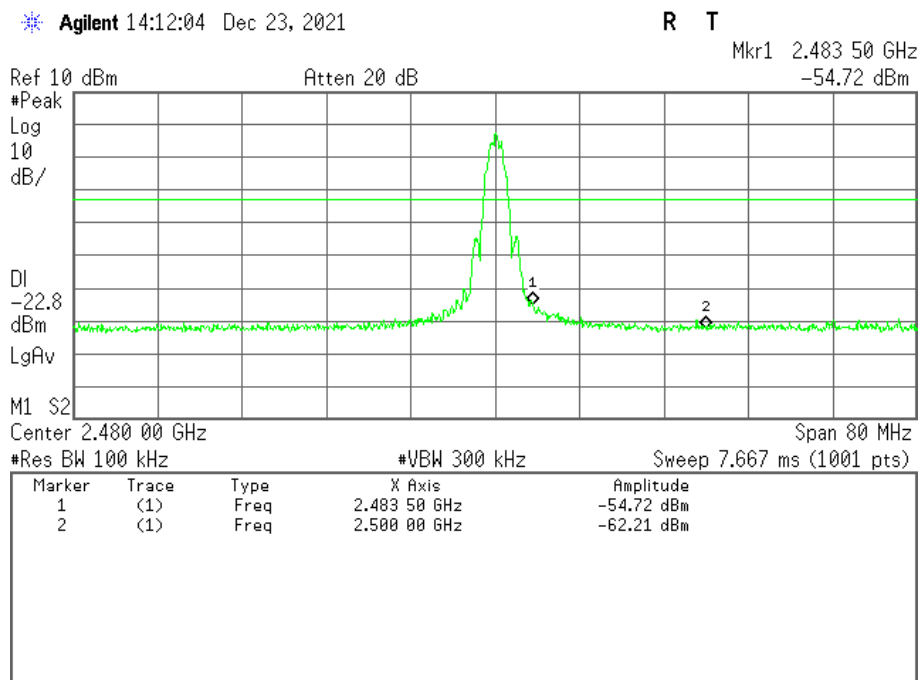


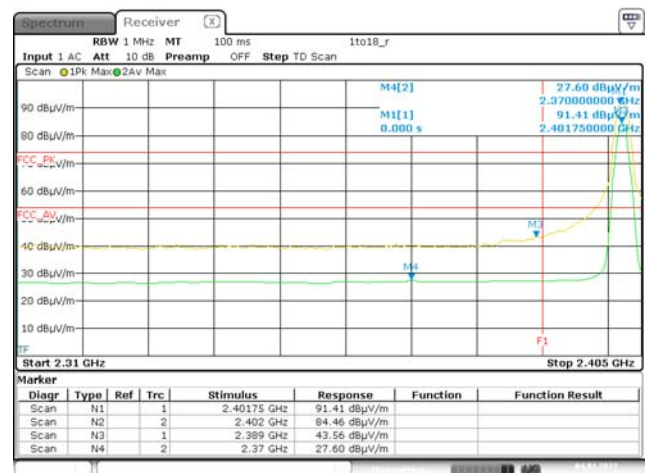
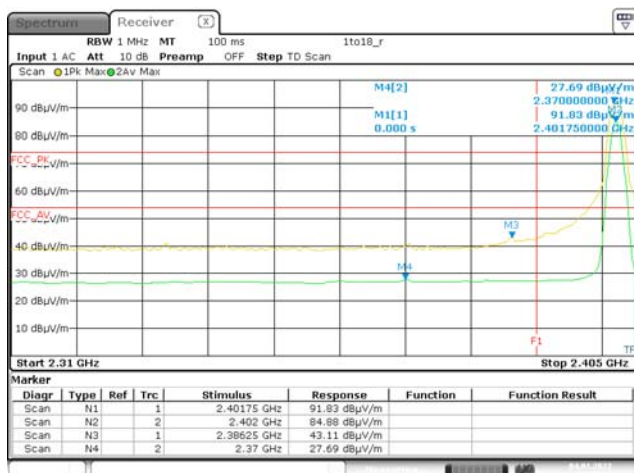
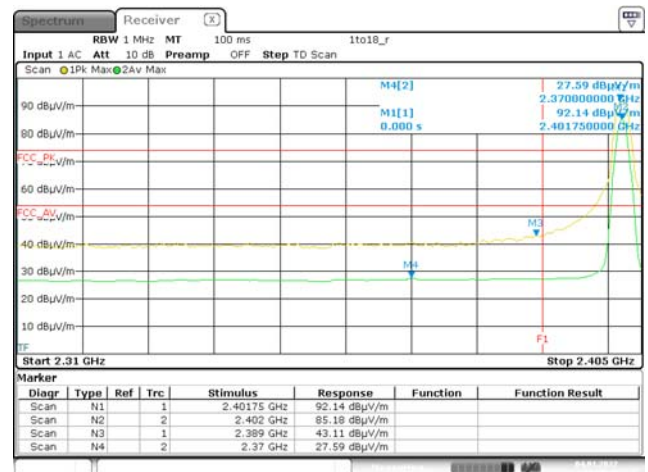
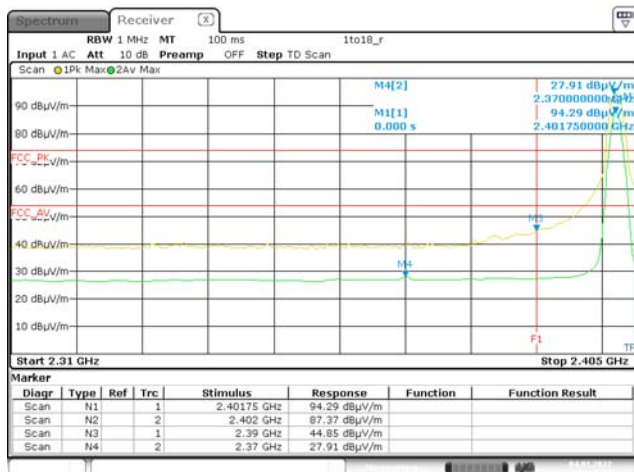
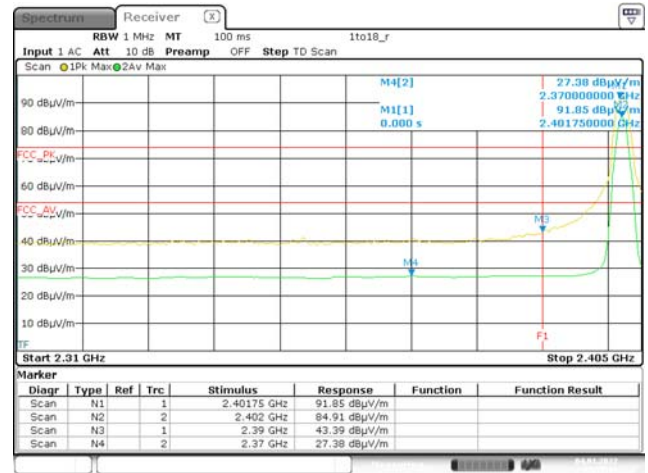
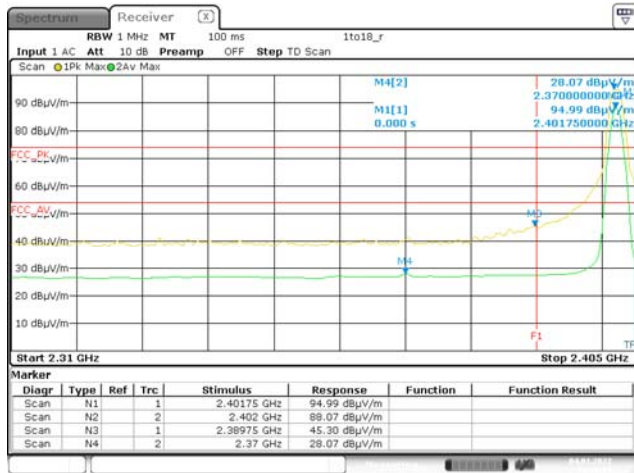


Figure 4. Plot of the Band Edge (Radiated measurements; the measurement distance is 3 meters)

Operating at the lowest frequency (Bluetooth LE 1 Mbps, 2402 MHz)

Horizontal (X, Y and Z-axis)

Vertical (X, Y and Z-axis)

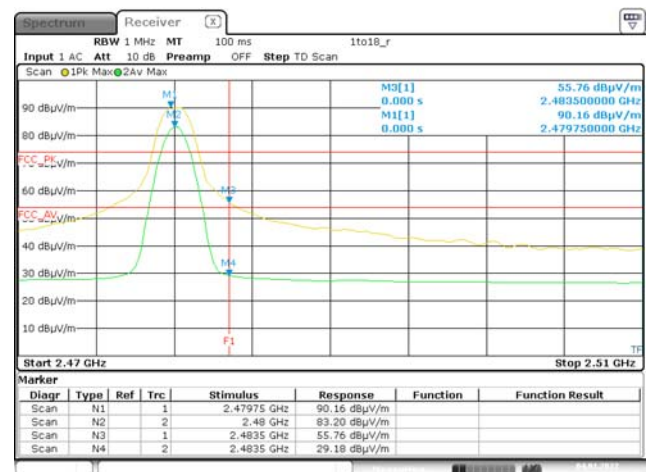
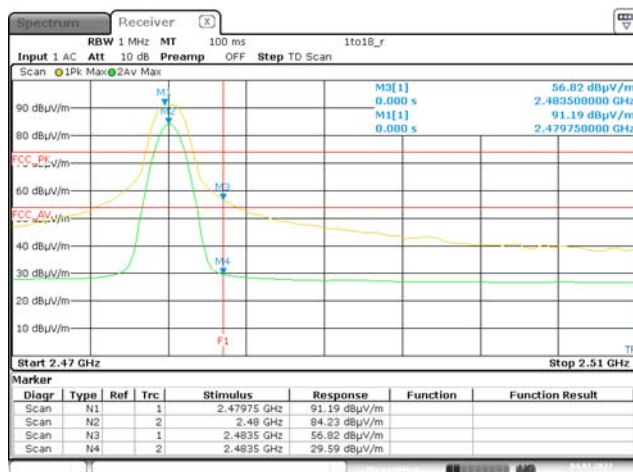
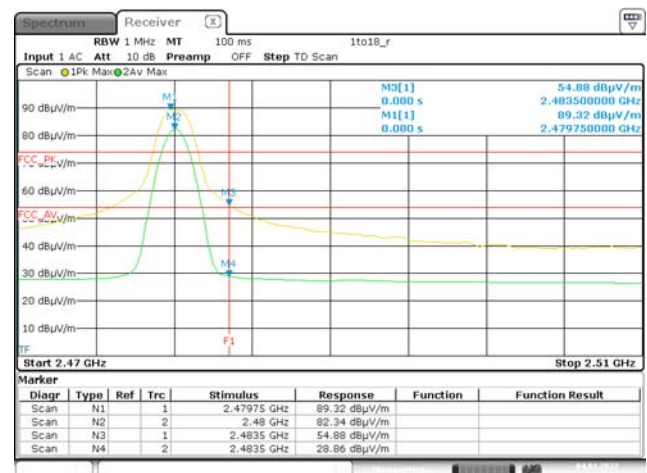
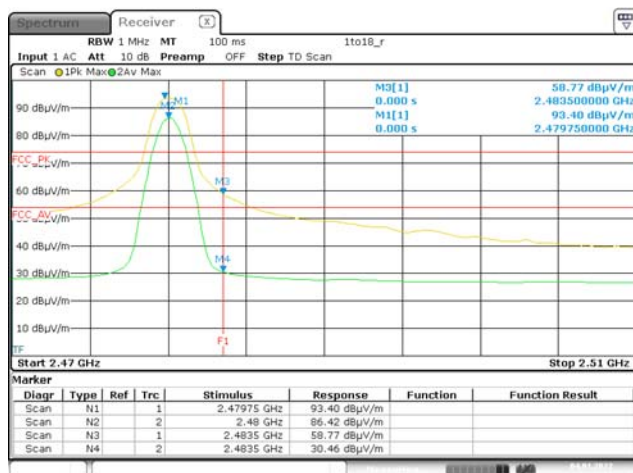
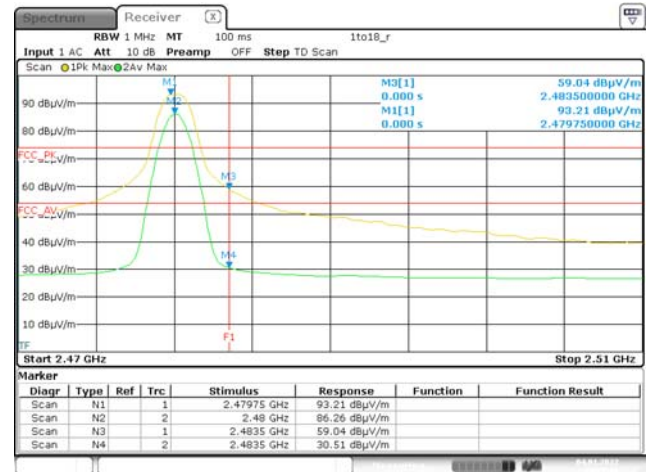
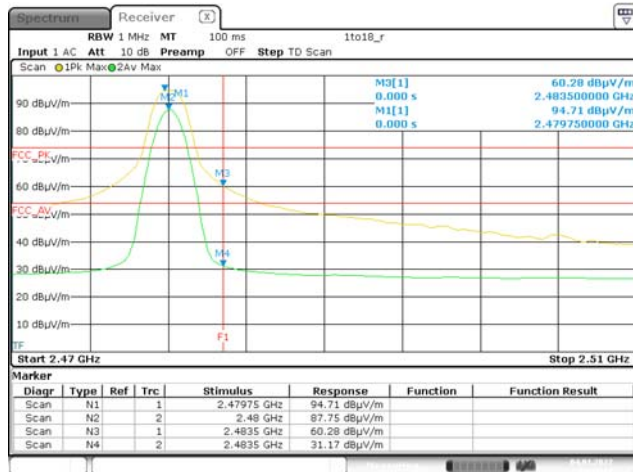




Operating at the highest frequency (Bluetooth LE 1 Mbps, 2480 MHz)

Horizontal (X, Y and Z-axis)

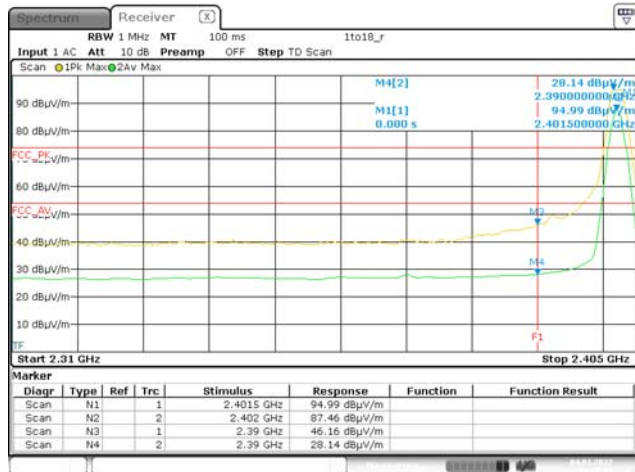
Vertical (X, Y and Z-axis)



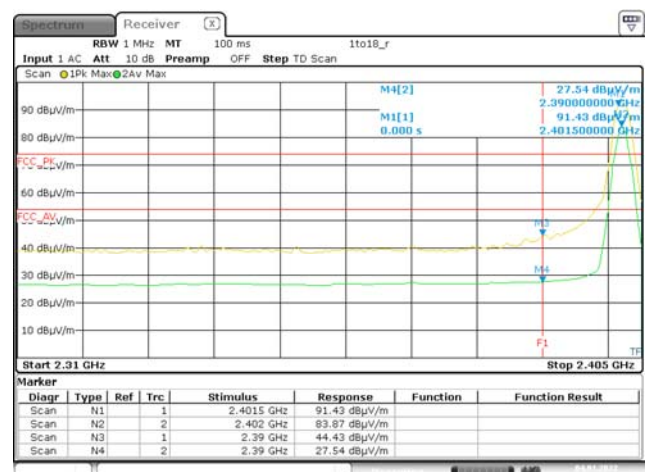
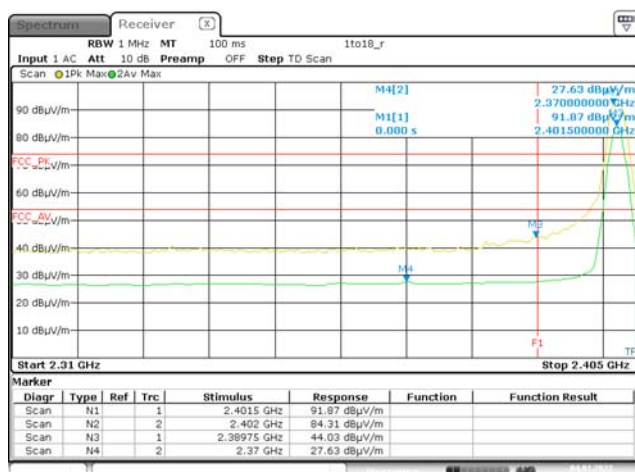
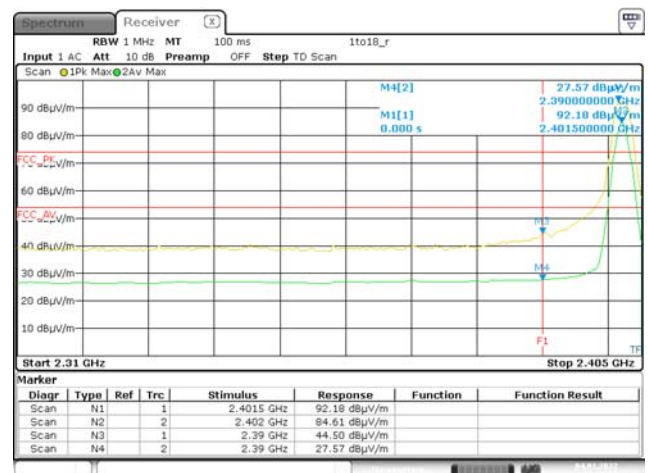
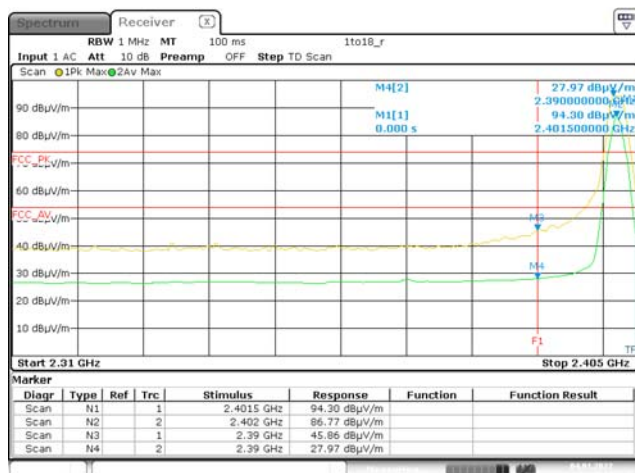
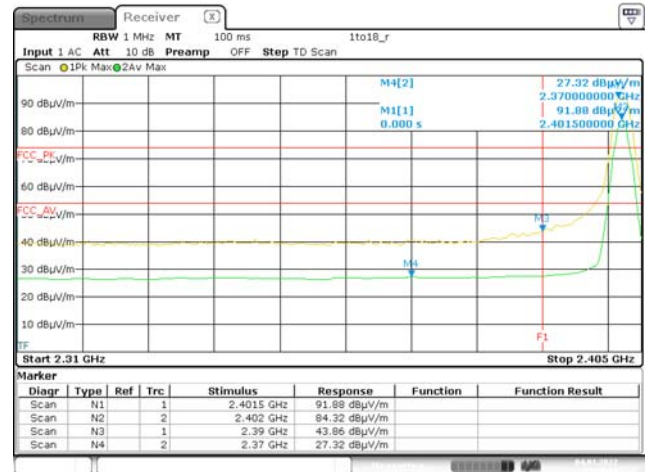


Operating at the highest frequency (Bluetooth LE 2 Mbps, 2402 MHz)

Horizontal (X, Y and Z-axis)



Vertical (X, Y and Z-axis)





Operating at the highest frequency (Bluetooth LE 2 Mbps, 2480 MHz)

Horizontal (X, Y and Z-axis)

Vertical (X, Y and Z-axis)

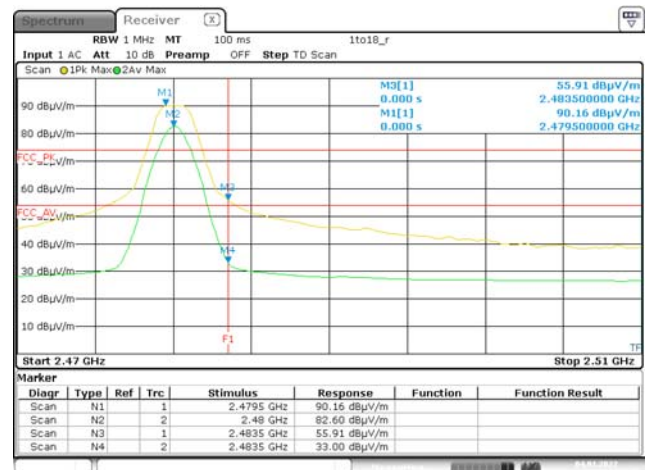
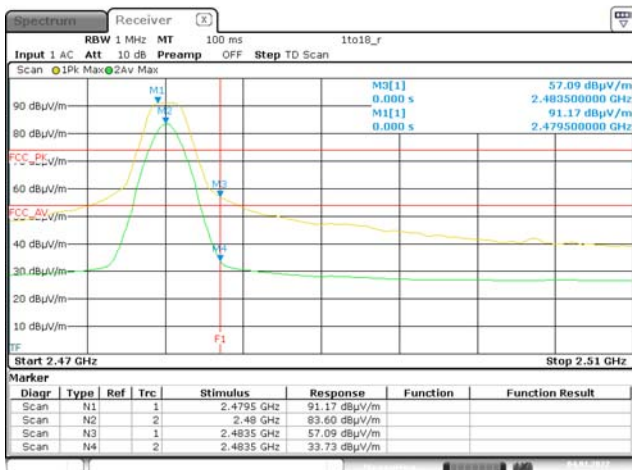
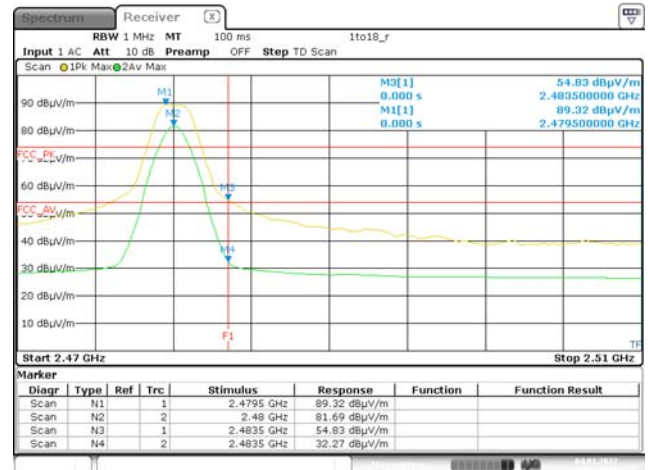
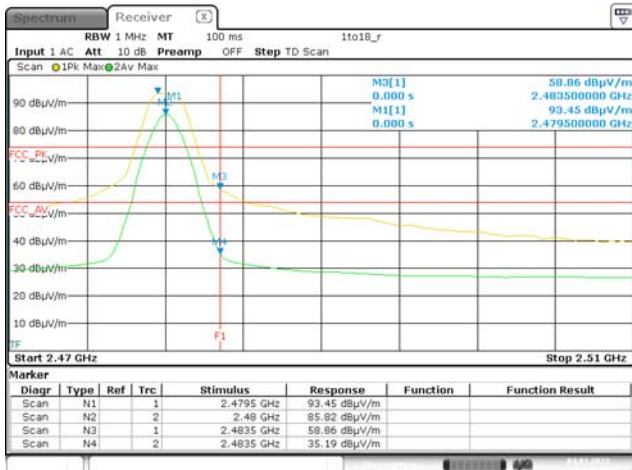
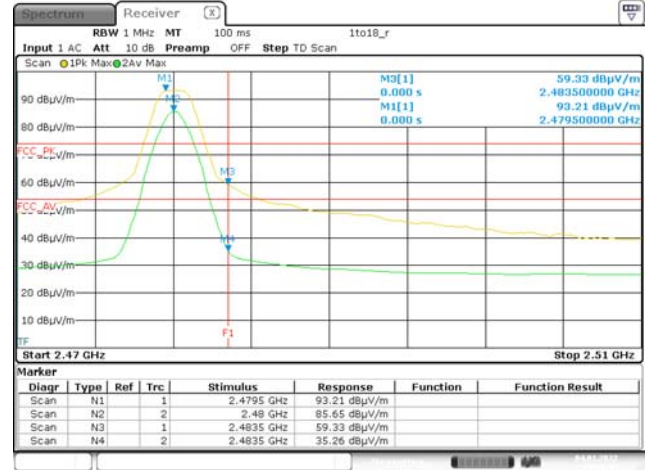
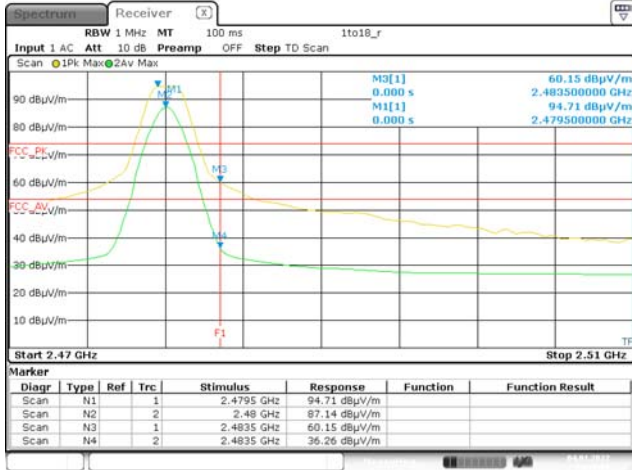
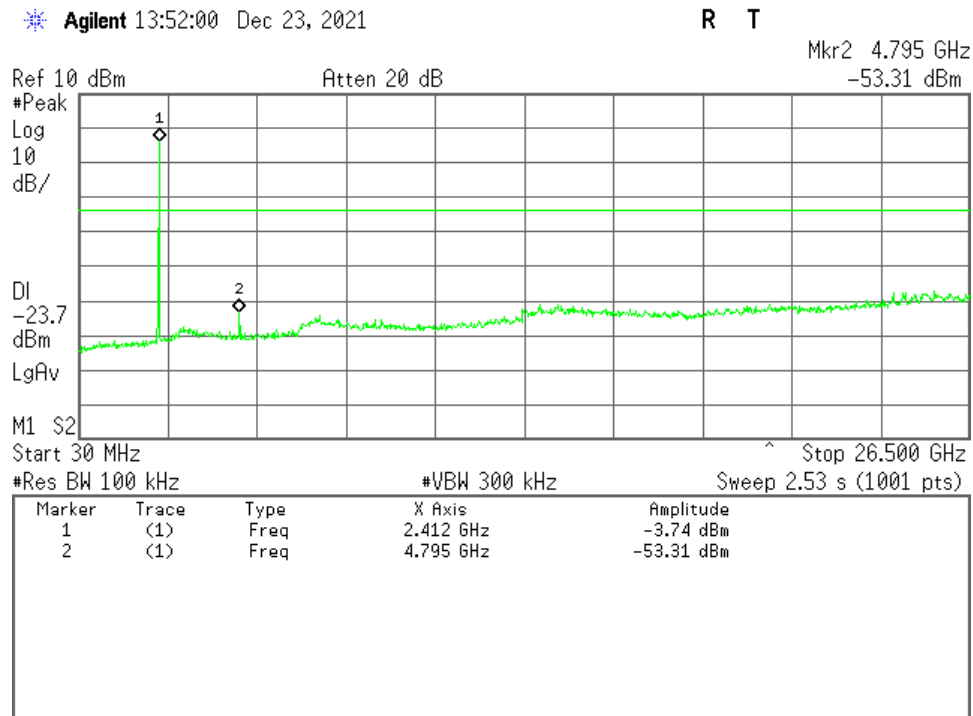




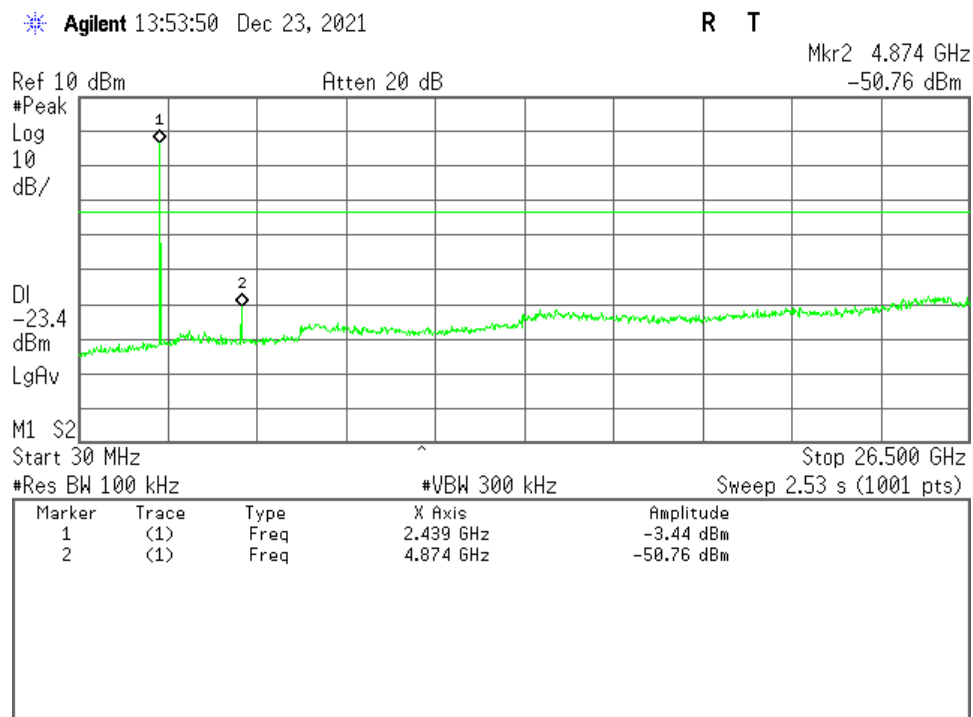
Figure 5. Spurious RF conducted emissions

During the measurements, the insertion loss of the cable loss and the external attenuator (10 dB) was corrected in the spectrum analyzer. The DL line on the plot was used as the limit 20 dB below the highest level of the desired power in the 100 kHz bandwidth.

Operating at the lowest frequency (Bluetooth LE 1 Mbps, 2402 MHz)



Operating at the middle frequency (Bluetooth LE 1 Mbps, 2442 MHz)



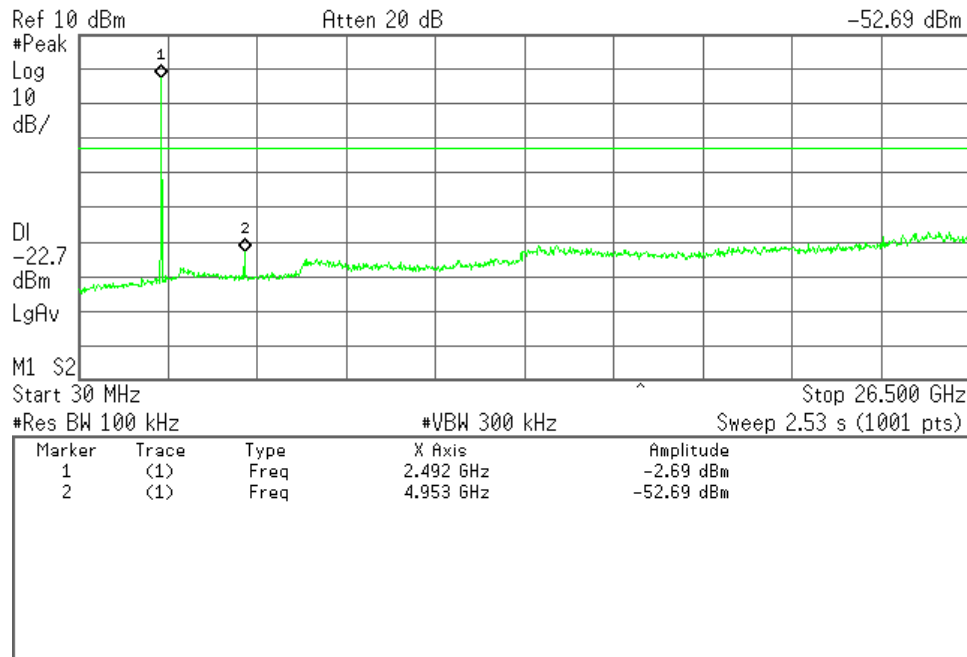


Operating at the highest frequency (Bluetooth LE 1 Mbps, 2480 MHz)

Agilent 14:08:17 Dec 23, 2021

R T

Mkr2 4.953 GHz
-52.69 dBm

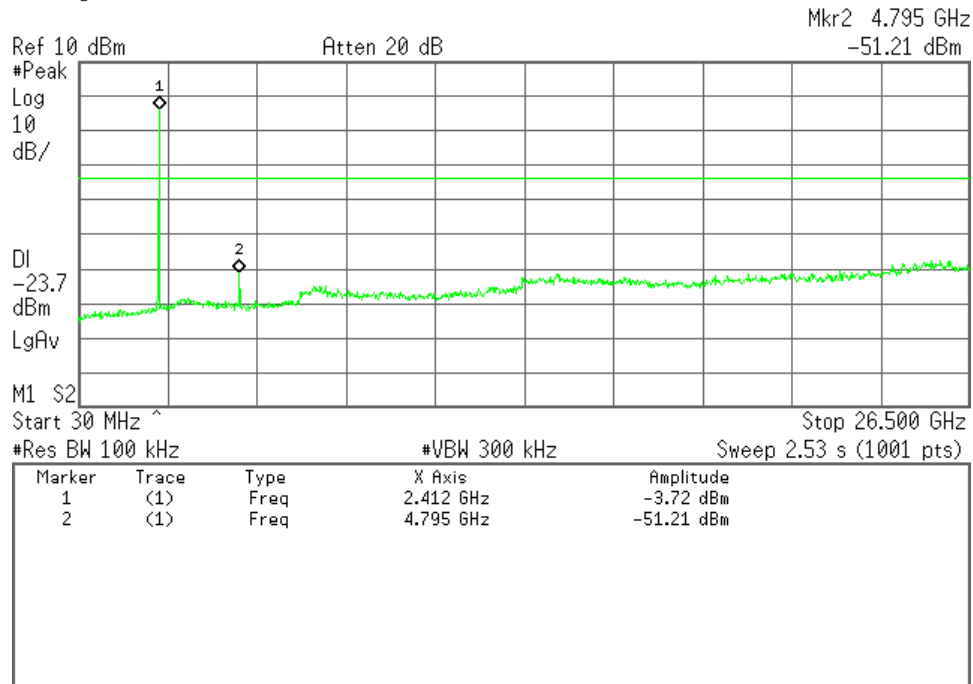




Operating at the lowest frequency (Bluetooth LE 2 Mbps, 2402 MHz)

Agilent 13:49:04 Dec 23, 2021

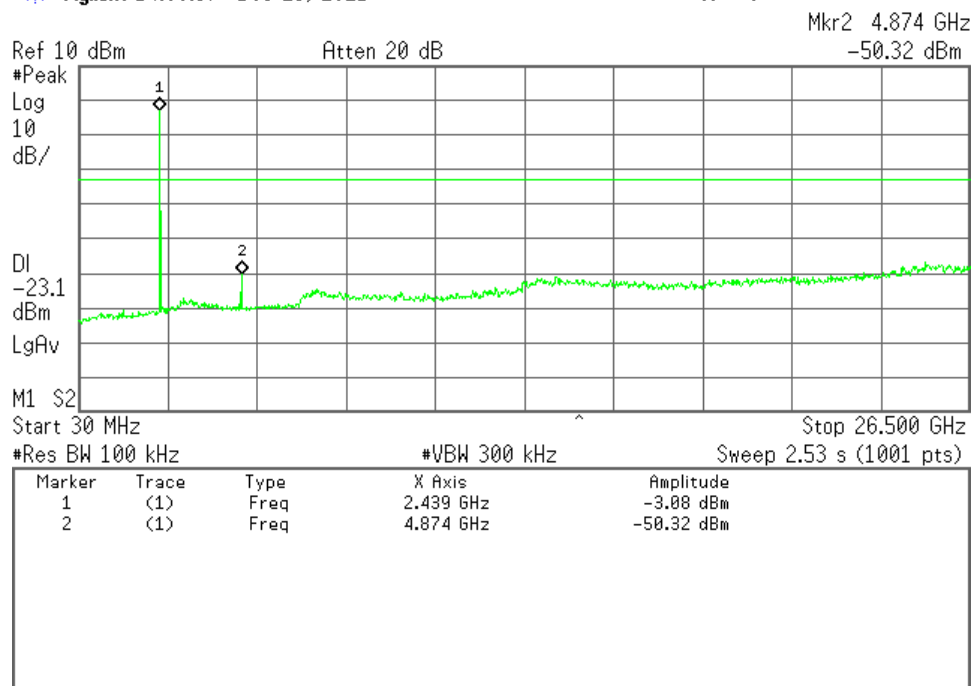
R T



Operating at the middle frequency (Bluetooth LE 2 Mbps, 2442 MHz)

Agilent 14:00:37 Dec 23, 2021

R T





Operating at the highest frequency (Bluetooth LE 2 Mbps, 2480 MHz)

Agilent 14:05:12 Dec 23, 2021

R T

Mkr2 4.953 GHz
-51.16 dBm

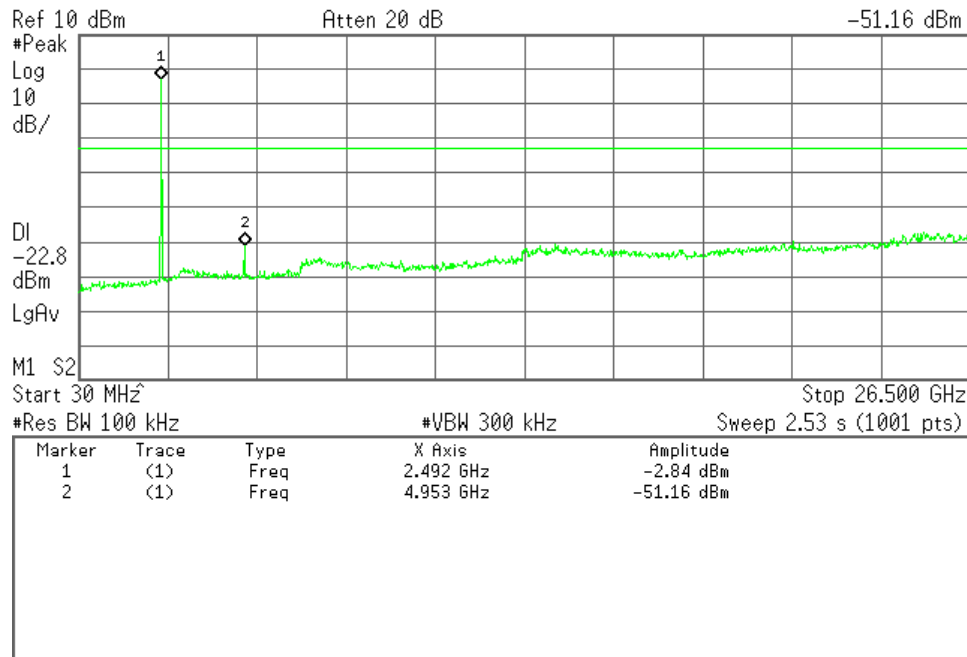
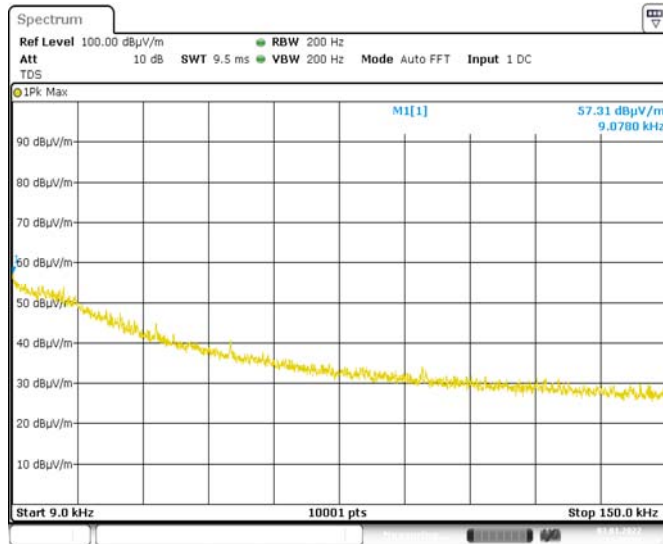


Figure 6. Emission plot for the preliminary radiated measurements

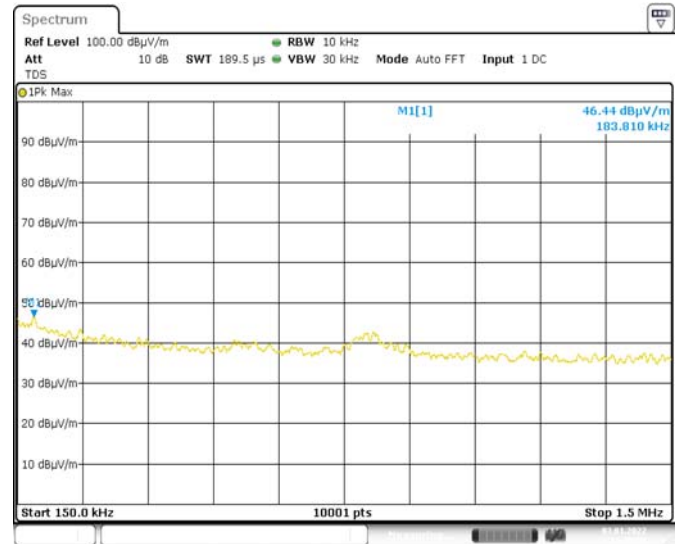
The worst-case plots were attached

Operating at the lowest frequency (Bluetooth LE 1 Mbps, 2402 MHz)

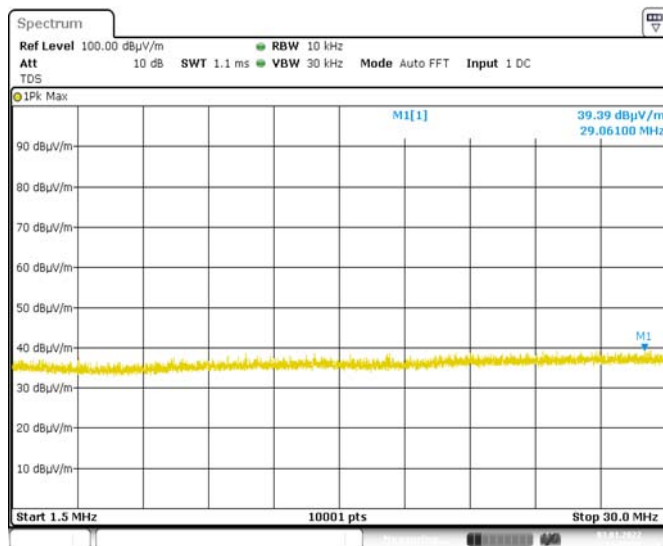
Measurement frequency range: 9 kHz to 150 kHz



Measurement frequency range: 150 kHz to 1.5 MHz



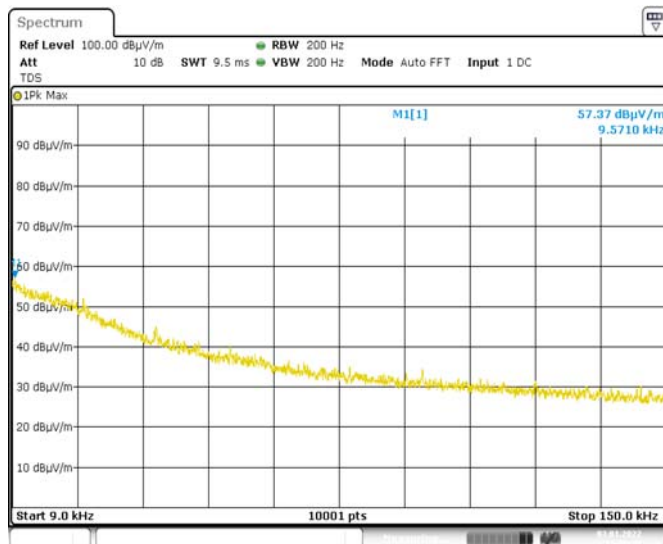
Measurement frequency range: 1.5 MHz to 30 MHz



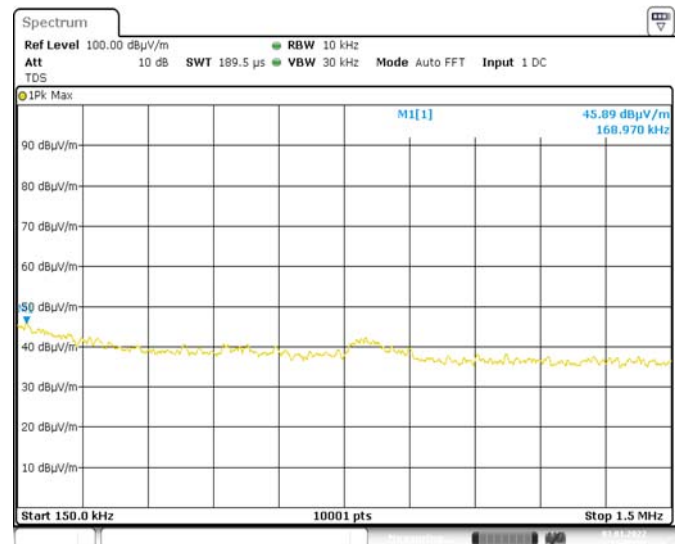
Remark: During the measurements, the insertion loss of antenna factor and cable loss was corrected in the spectrum analyzer.

Operating at the highest frequency (Bluetooth LE 1 Mbps, 2480 MHz)

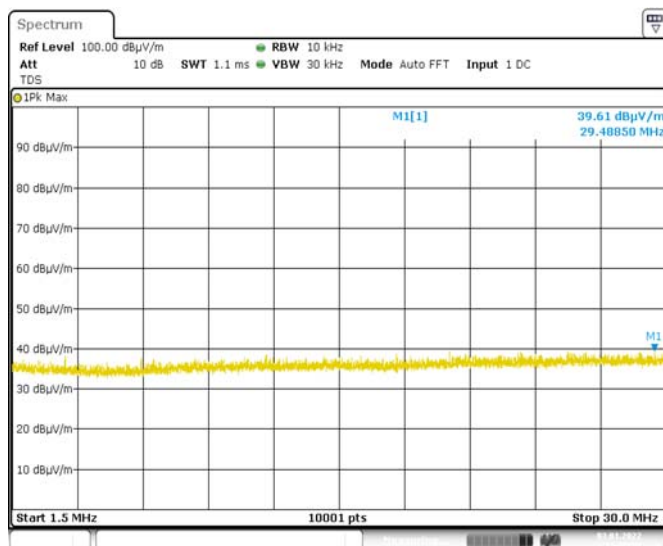
Measurement frequency range: 9 kHz to 150 kHz



Measurement frequency range: 150 kHz to 1.5 MHz



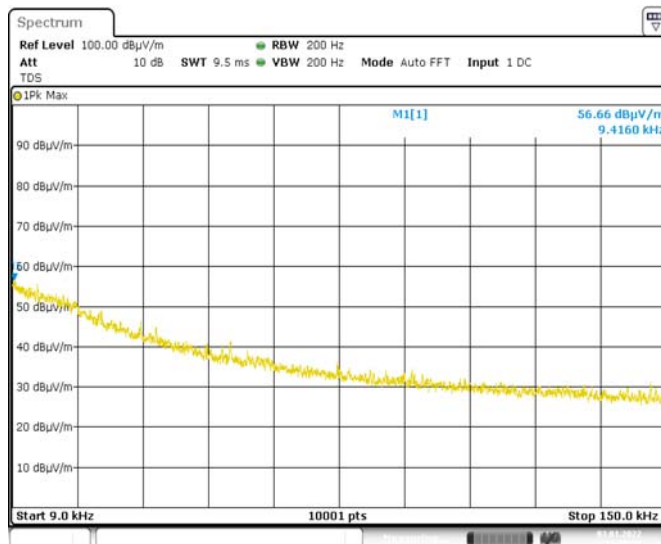
Measurement frequency range: 1.5 MHz to 30 MHz



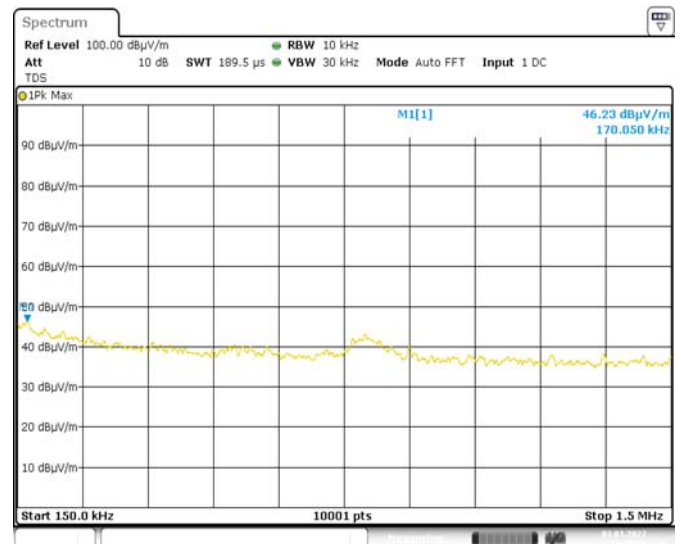
Remark: During the measurements, the insertion loss of antenna factor and cable loss was corrected in the spectrum analyzer.

Operating at the highest frequency (Bluetooth LE 2 Mbps, 2402 MHz)

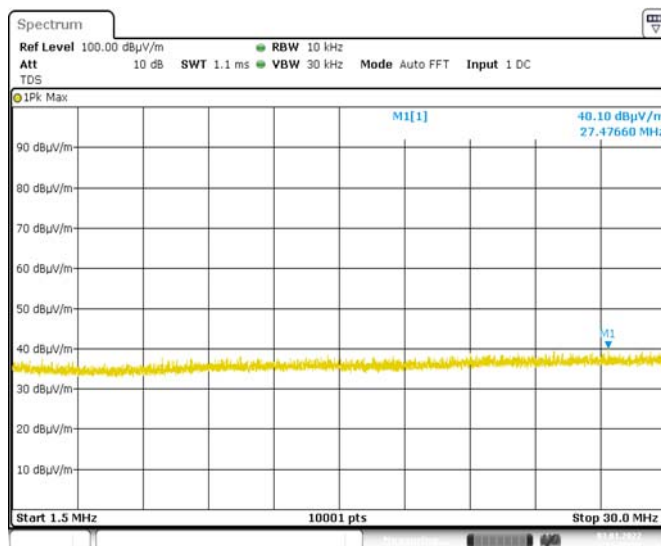
Measurement frequency range: 9 kHz to 150 kHz



Measurement frequency range: 150 kHz to 1.5 MHz



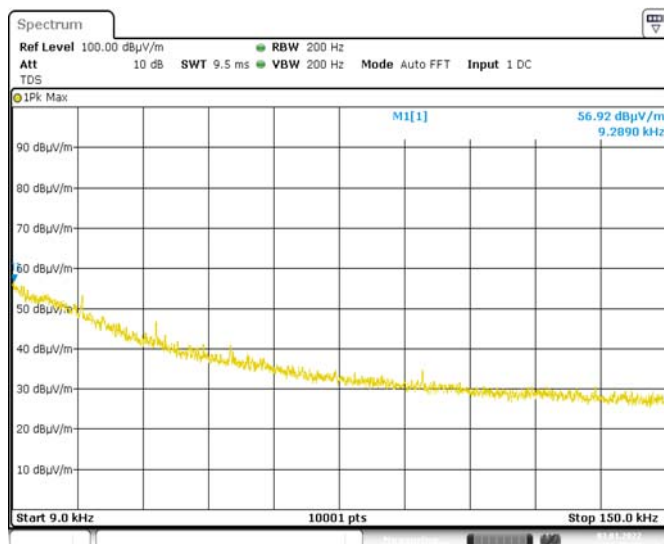
Measurement frequency range: 1.5 MHz to 30 MHz



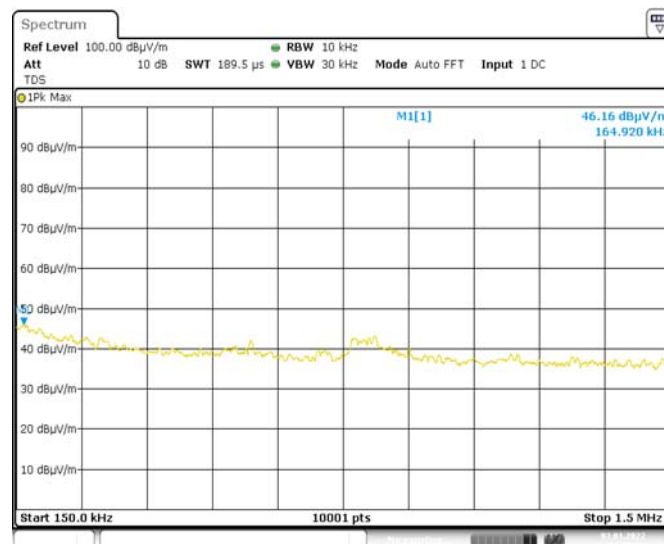
Remark: During the measurements, the insertion loss of antenna factor and cable loss was corrected in the spectrum analyzer.

Operating at the highest frequency (Bluetooth LE 2 Mbps, 2480 MHz)

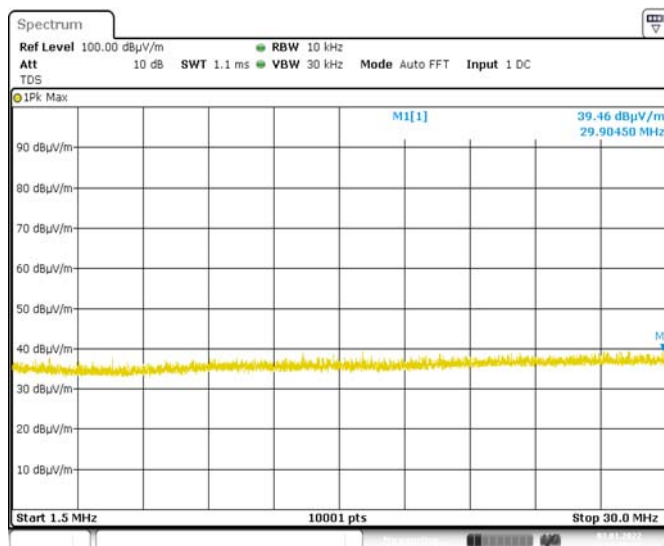
Measurement frequency range: 9 kHz to 150 kHz



Measurement frequency range: 150 kHz to 1.5 MHz



Measurement frequency range: 1.5 MHz to 30 MHz

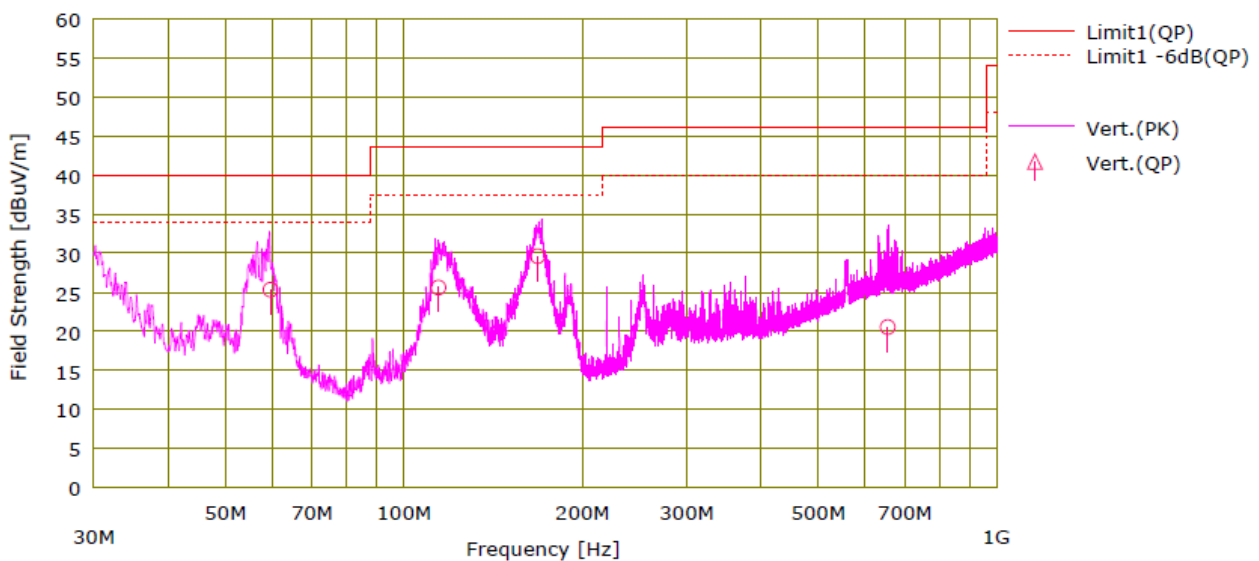
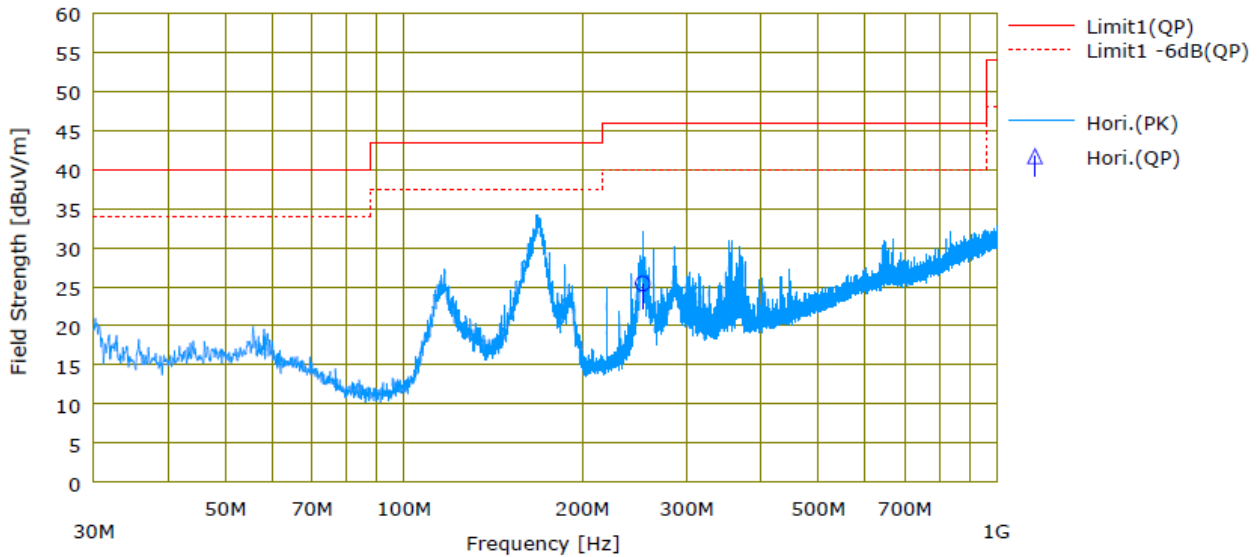


Remark: During the measurements, the insertion loss of antenna factor and cable loss was corrected in the spectrum analyzer.



Operating at the lowest frequency (Bluetooth LE 1 Mbps, 2402 MHz)

Measurement frequency range: 30 MHz to 1 GHz

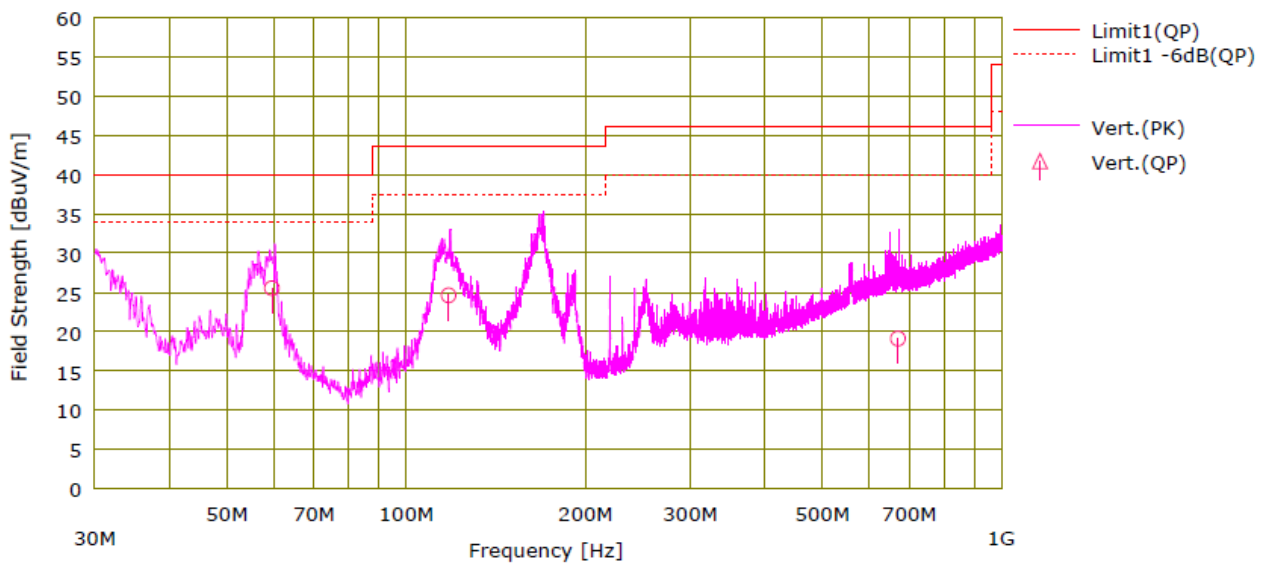
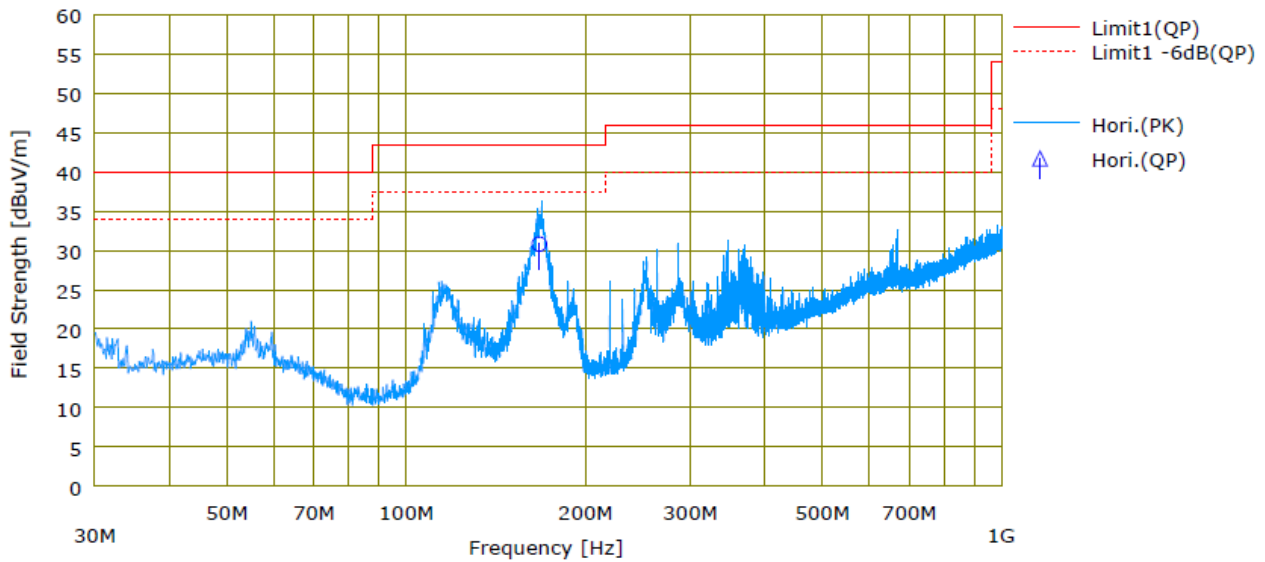


Remark: During the measurements, the insertion loss of antenna factor and cable loss was corrected in the spectrum analyzer.



Operating at the highest frequency (Bluetooth LE 1 Mbps, 2480 MHz)

Measurement frequency range: 30 MHz to 1 GHz

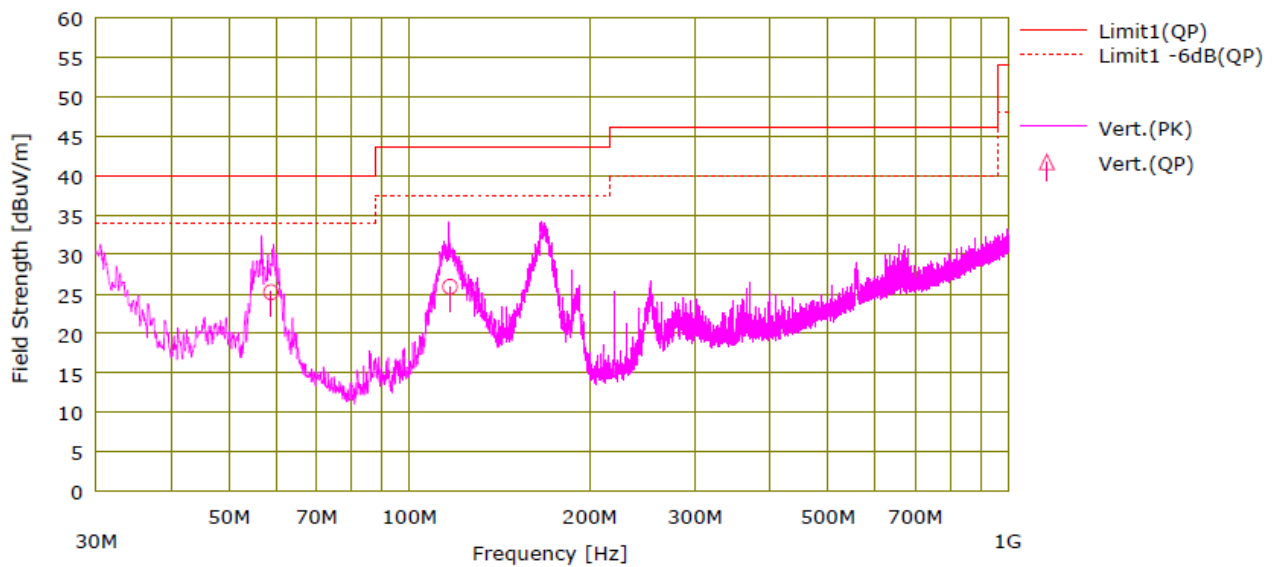
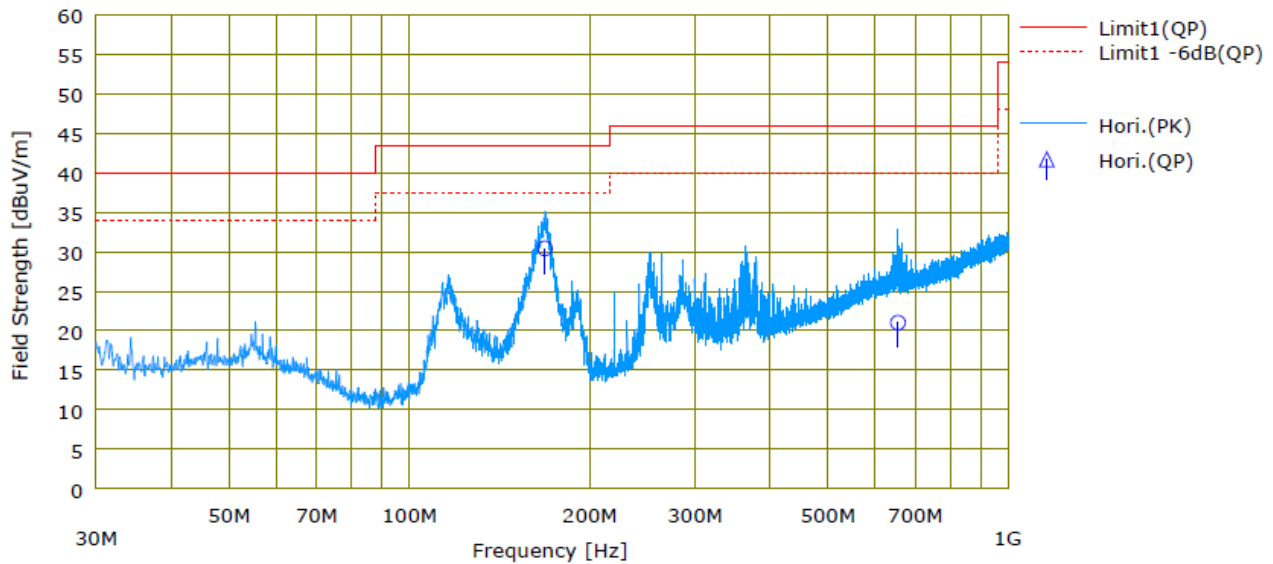


Remark: During the measurements, the insertion loss of antenna factor and cable loss was corrected in the spectrum analyzer.



Operating at the lowest frequency (Bluetooth LE 2 Mbps, 2402 MHz)

Measurement frequency range: 30 MHz to 1 GHz

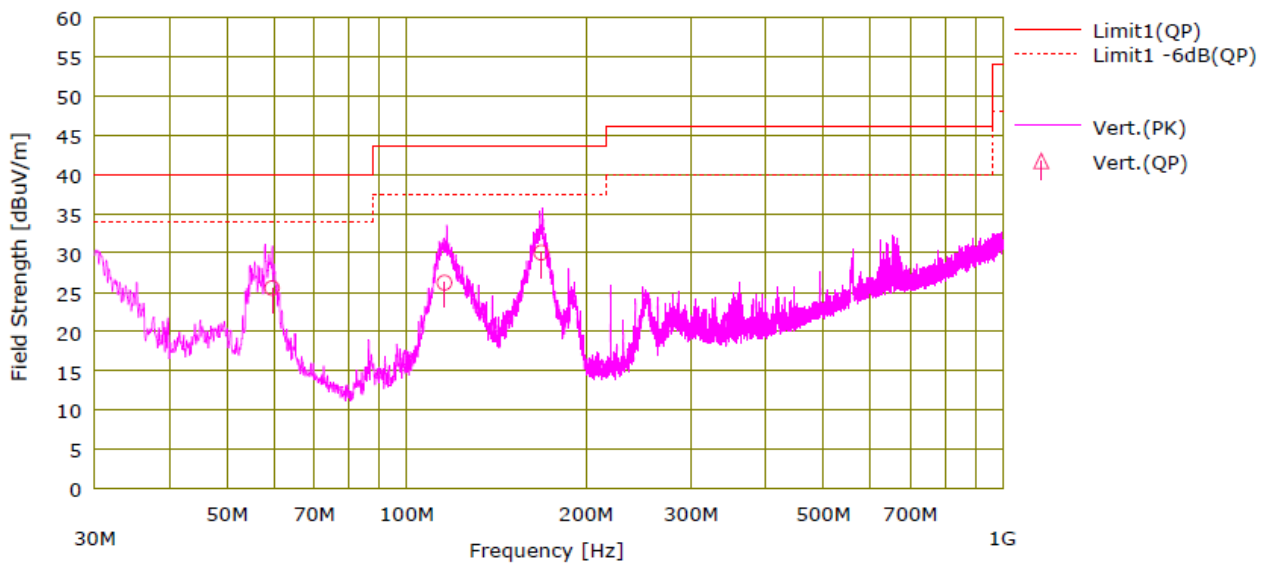
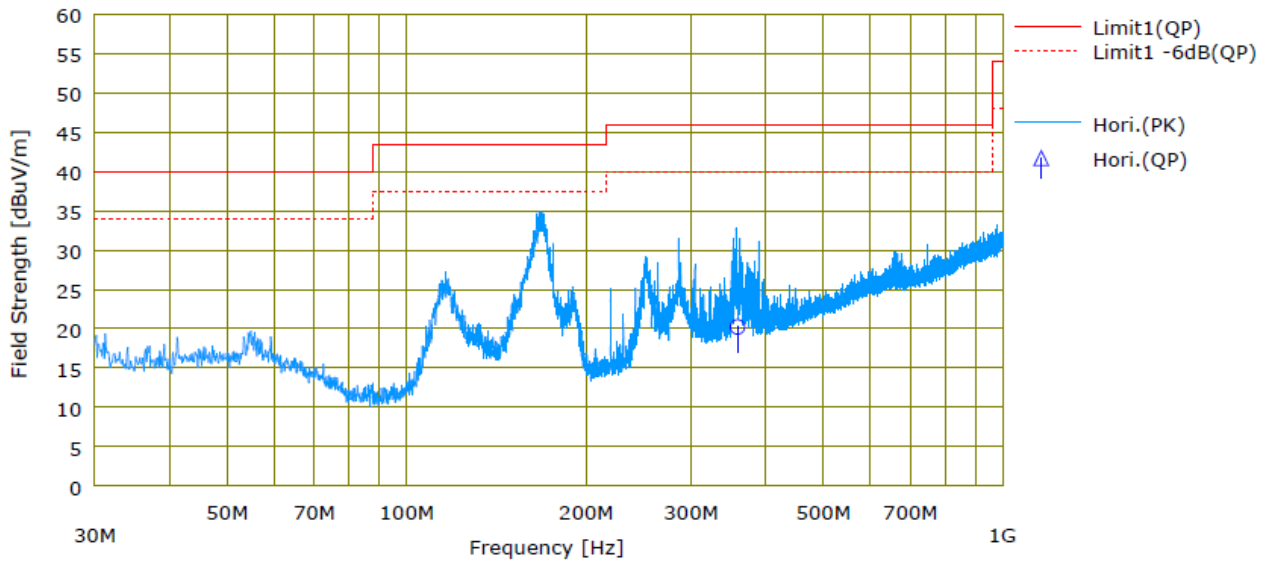


Remark: During the measurements, the insertion loss of antenna factor and cable loss was corrected in the spectrum analyzer.



Operating at the highest frequency (Bluetooth LE 2 Mbps, 2480 MHz)

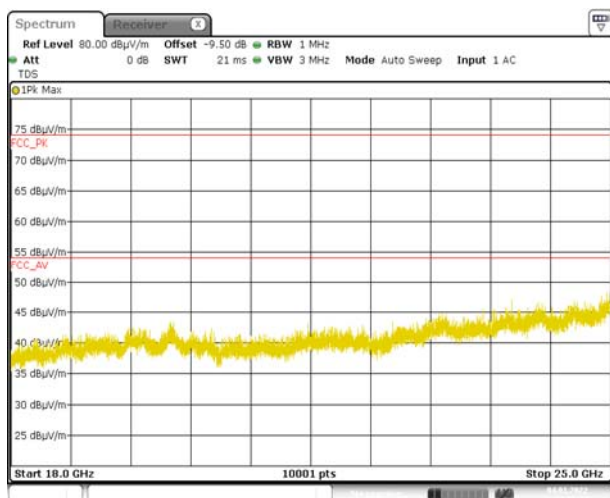
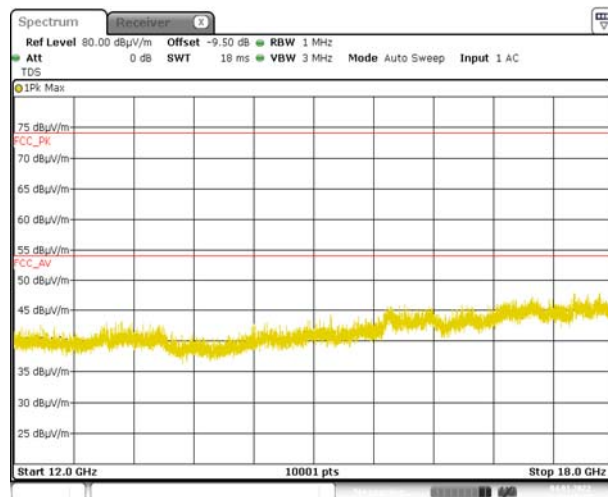
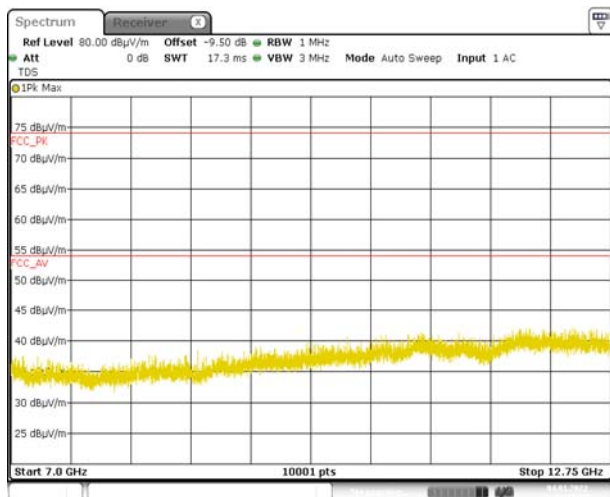
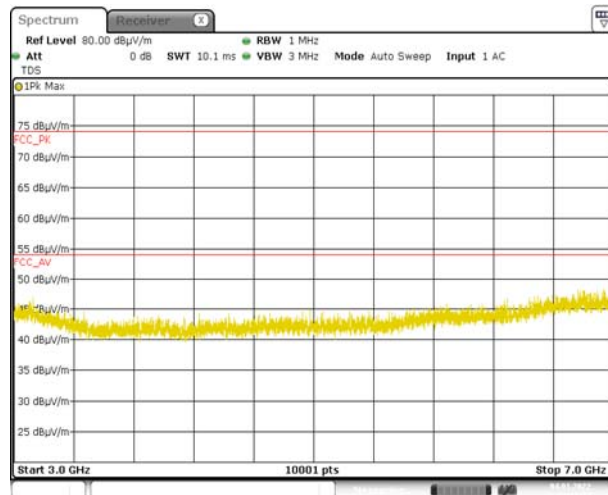
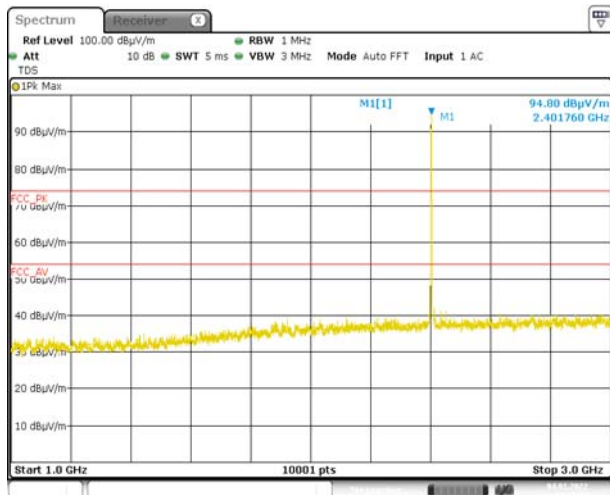
Measurement frequency range: 30 MHz to 1 GHz



Remark: During the measurements, the insertion loss of antenna factor and cable loss was corrected in the spectrum analyzer.

Operating at the lowest frequency (Bluetooth LE 1 Mbps, 2402 MHz)

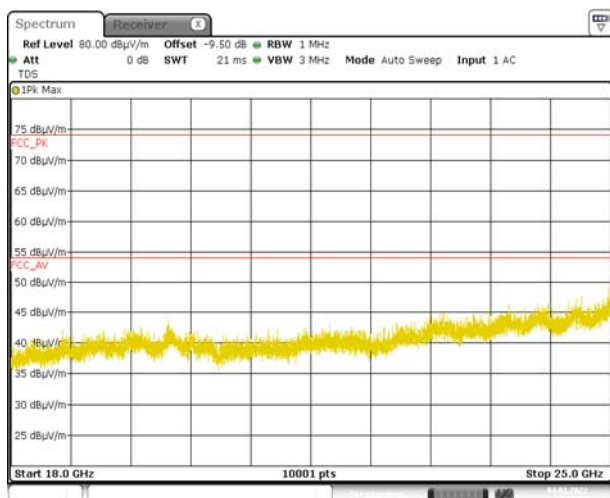
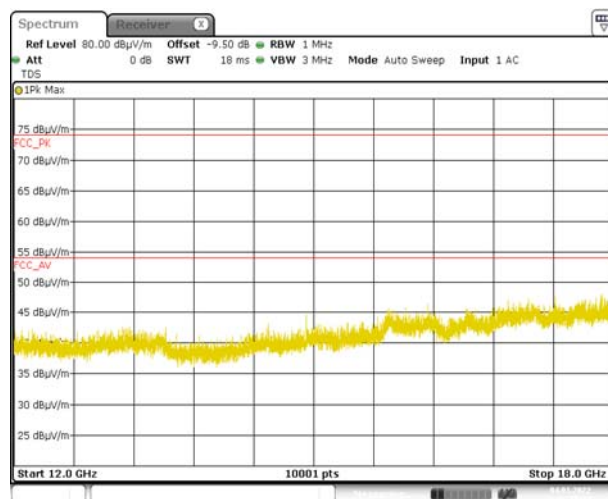
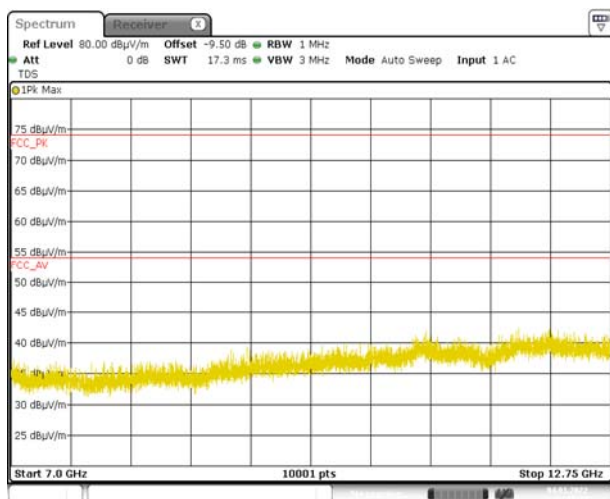
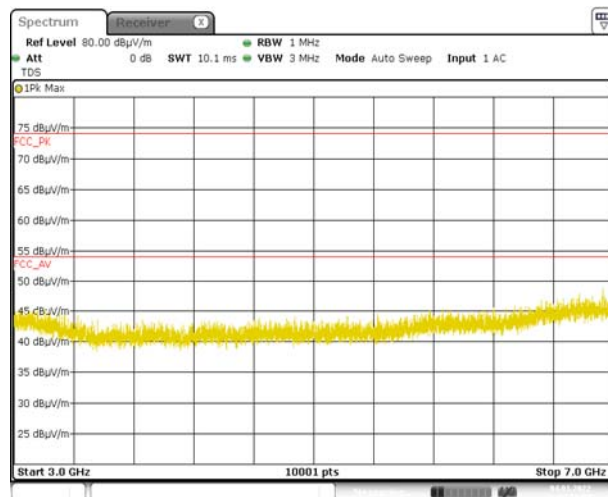
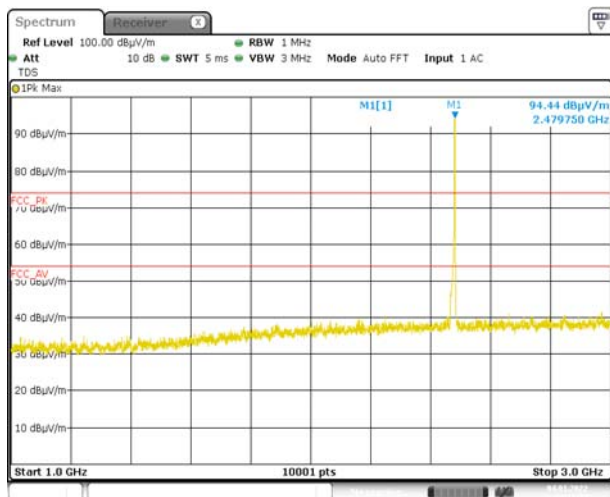
Measurement frequency range: above 1 GHz



Remark: During the measurements, the insertion loss of antenna factor and cable loss was corrected in the spectrum analyzer. During the measurements from 7 GHz to 25 GHz, the distance factor (a distance of 1 meter) was compensated as Offset -9.5 dB.

Operating at the highest frequency (Bluetooth LE 1 Mbps, 2480 MHz)

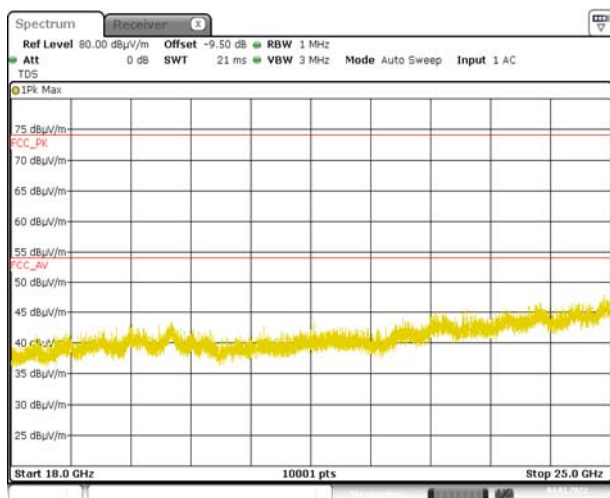
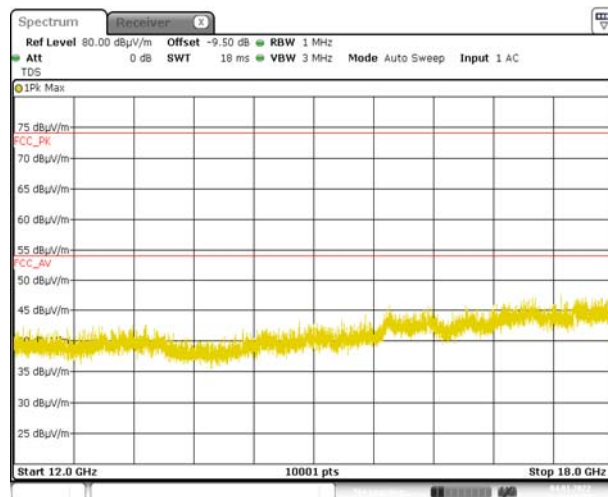
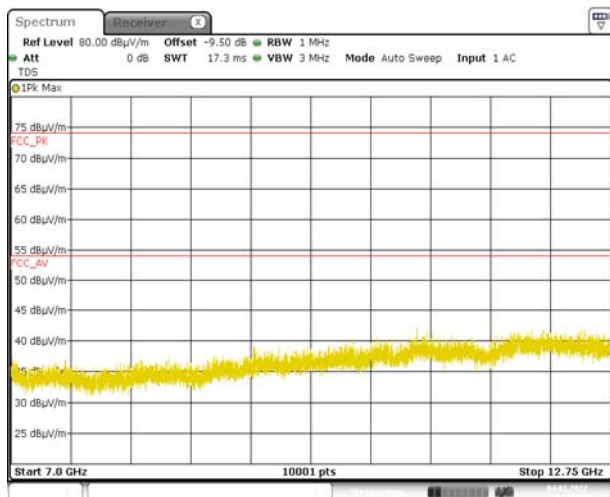
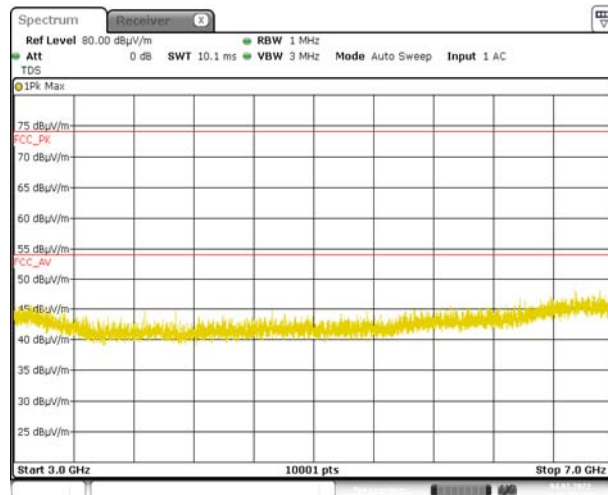
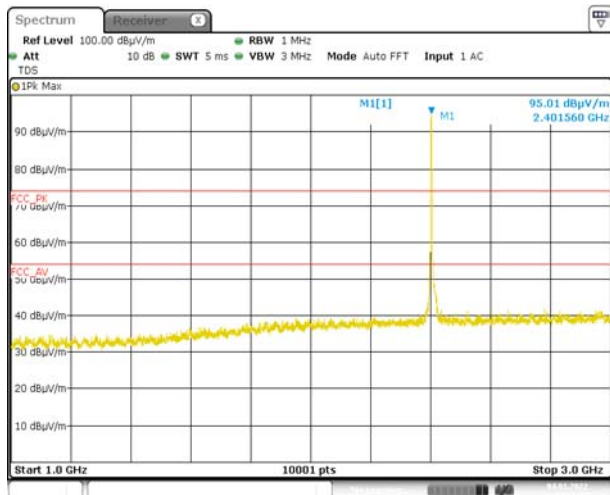
Measurement frequency range: above 1 GHz



Remark: During the measurements, the insertion loss of antenna factor and cable loss was corrected in the spectrum analyzer. During the measurements from 7 GHz to 25 GHz, the distance factor (a distance of 1 meter) was compensated as Offset -9.5 dB.

Operating at the lowest frequency (Bluetooth LE 2 Mbps, 2402 MHz)

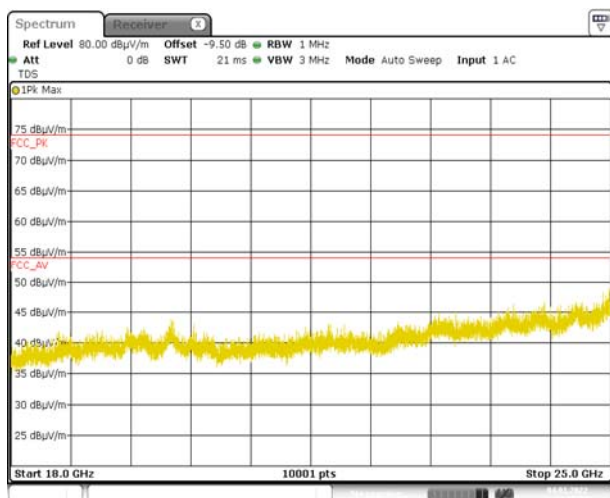
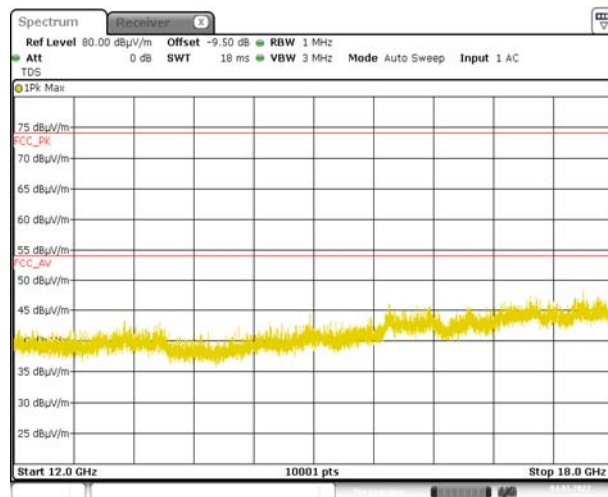
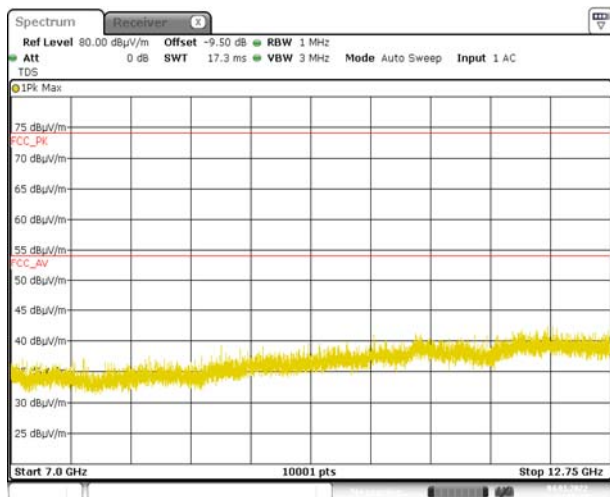
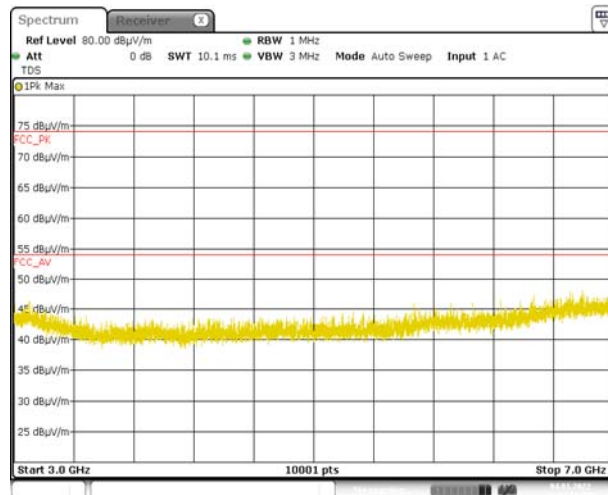
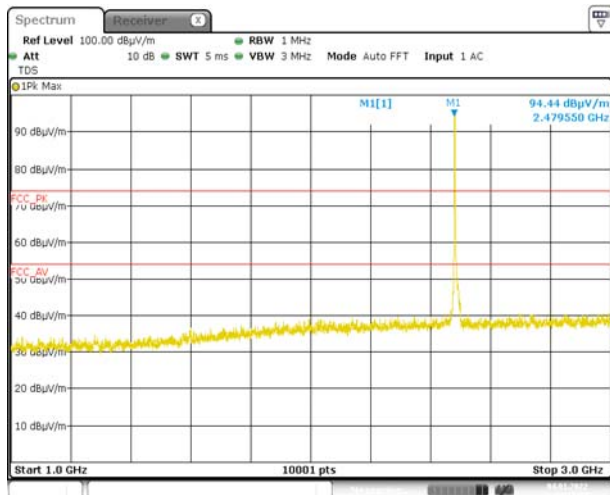
Measurement frequency range: above 1 GHz



Remark: During the measurements, the insertion loss of antenna factor and cable loss was corrected in the spectrum analyzer. During the measurements from 7 GHz to 25 GHz, the distance factor (a distance of 1 meter) was compensated as Offset -9.5 dB.

Operating at the highest frequency (Bluetooth LE 2 Mbps, 2480 MHz)

Measurement frequency range: above 1 GHz



Remark: During the measurements, the insertion loss of antenna factor and cable loss was corrected in the spectrum analyzer. During the measurements from 7 GHz to 25 GHz, the distance factor (a distance of 1 meter) was compensated as Offset -9.5 dB.



5.5. Peak power spectral density

5.5.1 Regulation

According to §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 shall be used to determine the power spectral density.

5.5.2 Test Procedure(peak PSD)

Set the spectrum analyzer as follows:

1. Set analyzer center frequency to DTS channel center 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.

5.5.3 Test Results:

PASS

Table 8: Measured values of the Peak Power Spectral Density (Bluetooth LE 1 Mbps)

Modulation	Operating frequency	PSD/3 kHz (dBm)	Limit (dBm)
GFSK	2402 MHz	-17.08	8
	2442 MHz	-17.46	8
	2480 MHz	-17.66	8

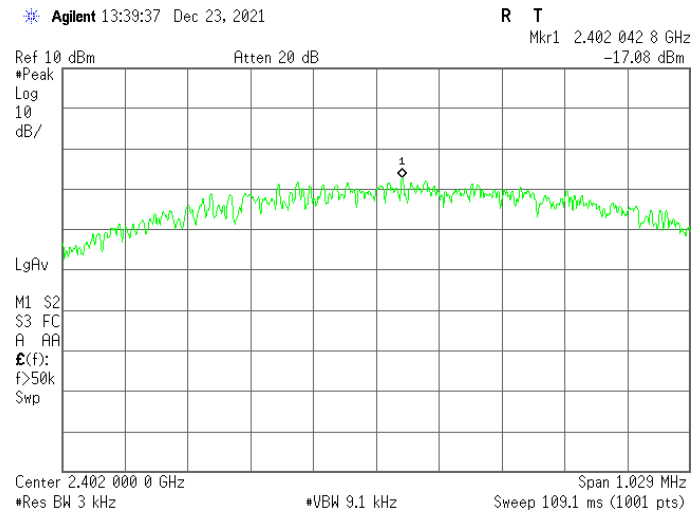
Table 9: Measured values of the Peak Power Spectral Density (Bluetooth LE 2 Mbps)

Modulation	Operating frequency	PSD/3 kHz (dBm)	Limit (dBm)
GFSK	2402 MHz	-19.72	8
	2442 MHz	-20.17	8
	2480 MHz	-20.34	8

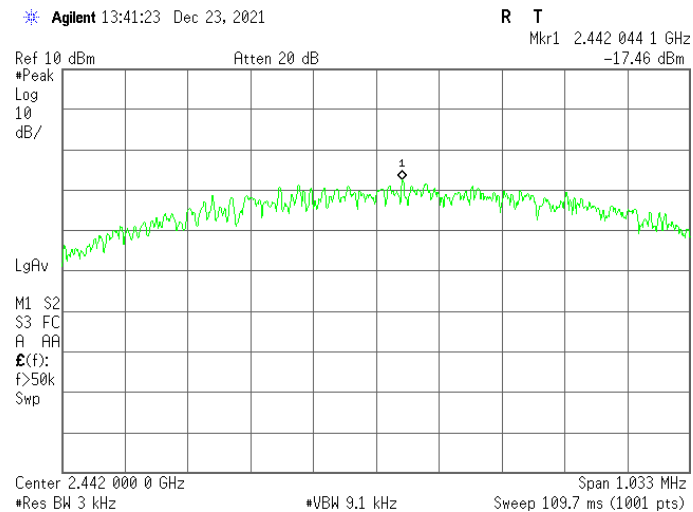
Figure 7. Plot of the Peak Power Spectral Density

During the measurements, the insertion loss of the cable loss and the external attenuator (10 dB) was corrected in the spectrum analyzer.

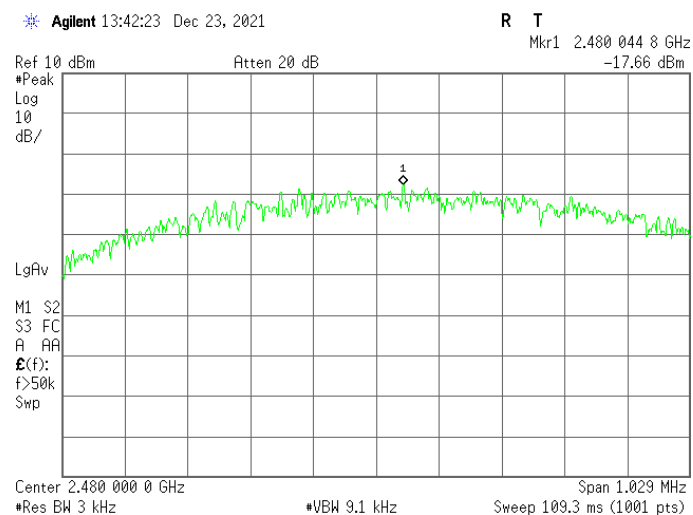
Operating at the lowest frequency (Bluetooth LE 1 Mbps, 2402 MHz)



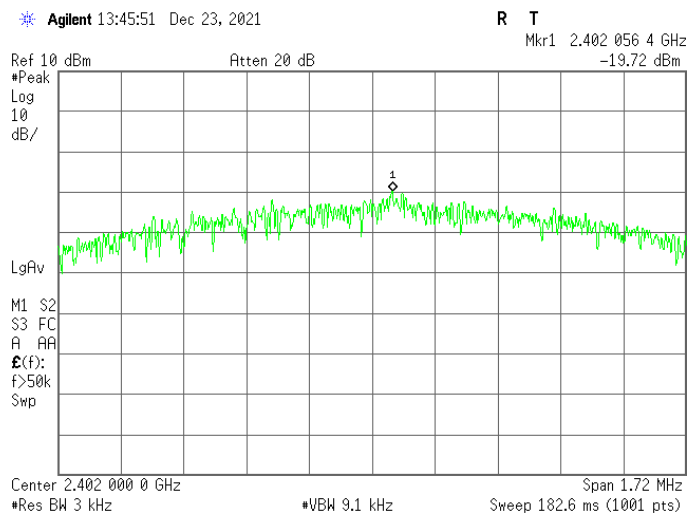
Operating at the middle frequency (Bluetooth LE 1 Mbps, 2442 MHz)



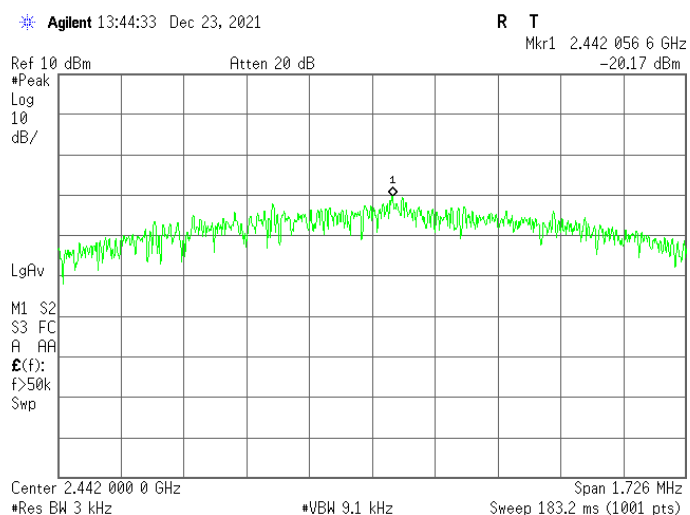
Operating at the highest frequency (Bluetooth LE 1 Mbps, 2480 MHz)



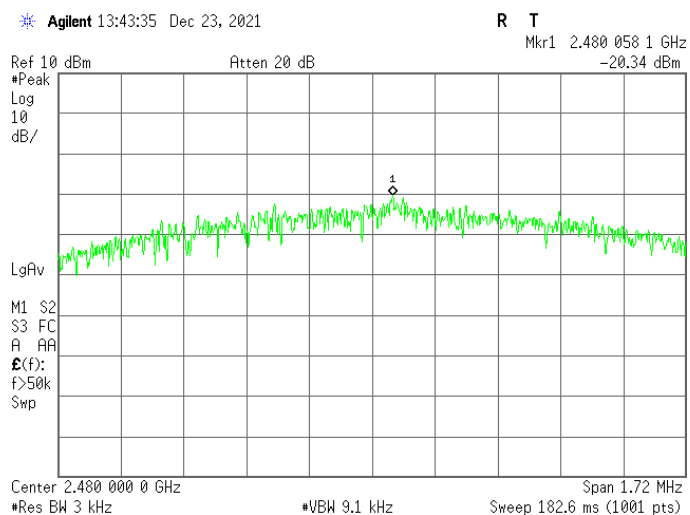
Operating at the lowest frequency (Bluetooth LE 2 Mbps, 2402 MHz)



Operating at the middle frequency (Bluetooth LE 2 Mbps, 2442 MHz)



Operating at the highest frequency (Bluetooth LE 2 Mbps, 2480 MHz)





5.6. AC power line Conducted emissions

5.6.1 Regulation

FCC 47CFR15 – 15.207(a)

According to §15.207(a), for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 Ω 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.

Frequency of emission (MHz)	Conducted limit (dB μ V)	
	Quasi-peak	Average
0.15 – 0.5	66 to 56 *	56 to 46 *
0.5 – 5	56	46
5 – 30	60	50

* Decreases with the logarithm of the frequency.

5.6.2 Test Procedure

1. The EUT and supporting equipment including all I/O cables were set up as per the test configuration to simulate typical usage. If the EUT is a table top system, a wooden table with a height of 0.8 meters is used and is placed on the ground plane. If the EUT is a floor standing equipment, it is placed on the ground plane, which has about 10 mm non-conductive covering to insulate the EUT from the ground plane.
2. Each current-carrying conductor of the EUT power cord(s), except the ground (safety) conductor(s) was individually connected through a 50 Ω /50 μ H line impedance stabilization network (LISN) to the input power mains. Emissions were measured on each current carrying line of the EUT using an EMI Test Receiver connected to the LISN powering the EUT.
3. Exploratory measurements were made to identify the frequency of the emission that had the highest amplitude relative to the limit by operating the EUT in a range of typical modes of operation, cable position, and with a typical system equipment configuration and arrangement. Based on the exploratory tests of the EUT, the one EUT cable configuration and arrangement and mode of operation that had produced the emission with the highest amplitude relative to the limit was selected for the final measurement.
4. The final test on all current-carrying conductors of all of the power cords to the equipment that comprises the EUT (but not the cords associated with other non-EUT equipment in the system) was then performed over the frequency range of 0.15 MHz to 30 MHz.
5. The measurements were made with the detector set to peak mode, quasi-peak mode and average mode within a bandwidth of 9 kHz.

Measurement software: PMM Emission Suite Version: 2.31



5.6.3 Test Results:

PASS

Table 10: Measured values of the Conducted Emissions – (Bluetooth LE 1 Mbps, 2442 MHz)

Frequency (MHz)	Line (L/N)	CF (dB)	CL (dB)	Actual (dBμV)		Limit (dBμV)		Margin (dB)	
				QP	AV	QP	AV	QP	AV
0.1520	L	9.52	9.90	52.15	36.49	65.89	55.89	13.74	19.40
0.1541	L	9.52	9.90	51.85	36.15	65.78	55.78	13.93	19.63
13.3996	N	9.62	10.18	34.38	29.45	60.00	50.00	25.62	20.55
15.5039	L	9.62	10.21	37.15	28.60	60.00	50.00	22.85	21.40
16.8106	N	9.62	10.23	39.74	31.60	60.00	50.00	20.26	18.40
16.9292	L	9.61	10.23	43.66	33.46	60.00	50.00	16.34	16.54

Table 11: Measured values of the Conducted Emissions – (Bluetooth LE 2 Mbps, 2442 MHz)

Frequency (MHz)	Line (L/N)	CF (dB)	CL (dB)	Actual (dBμV)		Limit (dBμV)		Margin (dB)	
				QP	AV	QP	AV	QP	AV
0.1500	L	9.52	9.90	49.84	33.74	66.00	56.00	16.16	22.26
0.1541	L	9.52	9.90	49.19	33.28	65.78	55.78	16.59	22.50
7.2400	L	9.59	10.10	31.86	23.48	60.00	50.00	28.14	26.52
13.3996	N	9.62	10.18	34.19	28.89	60.00	50.00	25.81	21.11
14.9108	L	9.62	10.20	33.24	25.93	60.00	50.00	26.76	24.07
16.7779	N	9.62	10.22	39.51	29.95	60.00	50.00	20.49	20.05
16.8515	L	9.61	10.23	42.86	31.50	60.00	50.00	17.14	18.50

Note: 1) L/N: Line / Neutral

2) CF and CL: correction factor (LISN) and cable loss including the insertion loss of Pulse Limiter

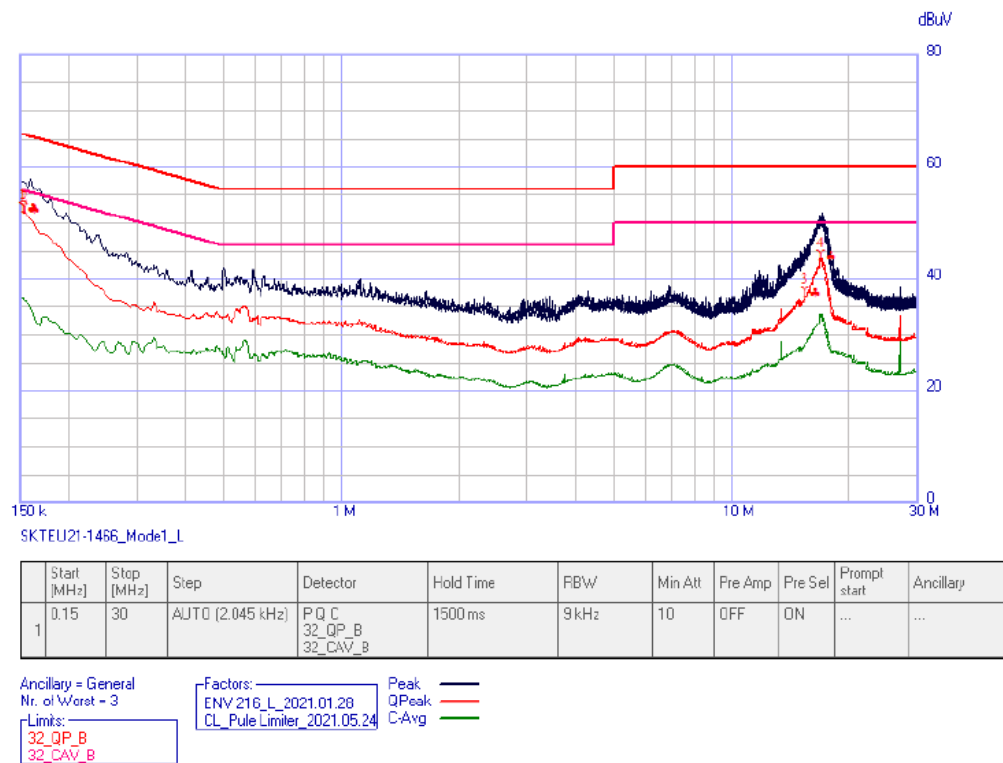
3) Actual = Final measured values after containing CF and CL

4) Margin = Limit - Actual

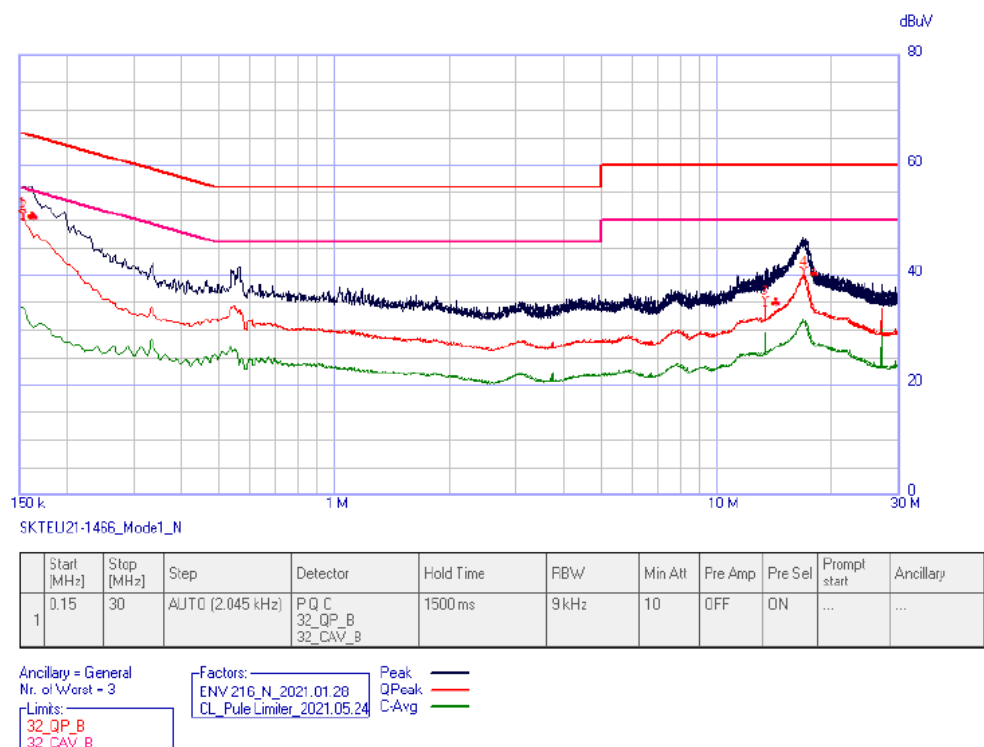


Plot of the Conducted Emissions - Bluetooth LE 1 Mbps, 2442 MHz

Line – PE



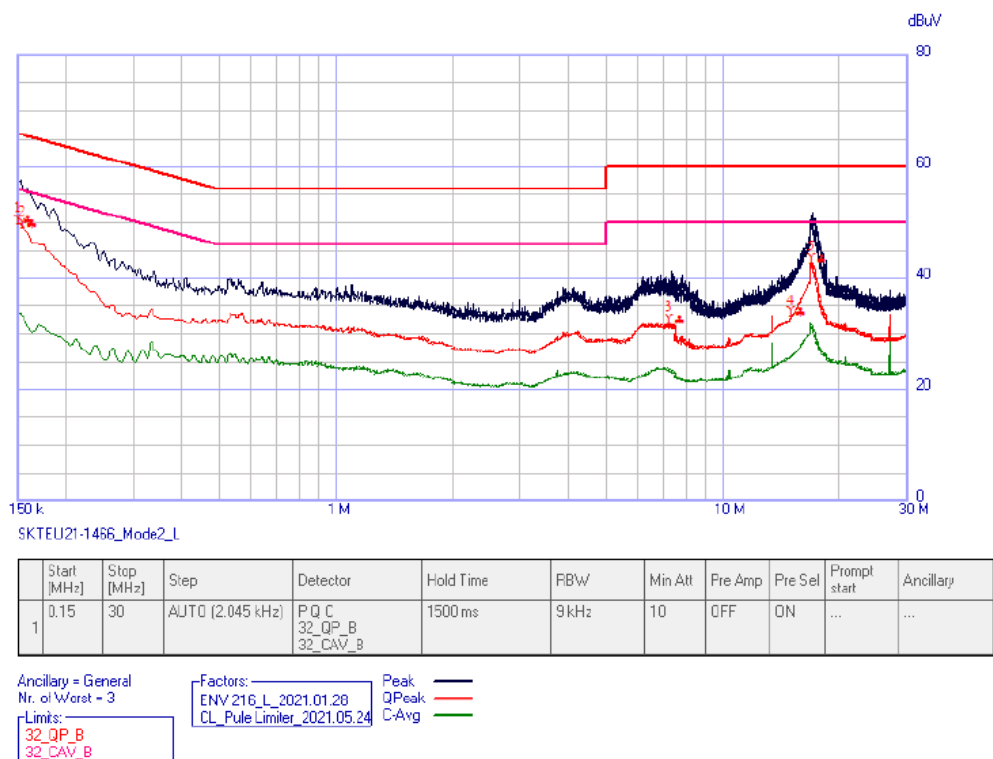
Neutral – PE





Plot of the Conducted Emissions - Bluetooth LE 2 Mbps, 2442 MHz

Line – PE



Neutral – PE

