

RADIO TEST REPORT – 407105-1TRFWL

Type of assessment:

Final product testing

Applicant:

LEGO System A/S

Product name:

Construction LEGO toy

Trademark:

LEGO

RF product type:

Bluetooth and BLE Transceiver

Model:

HUB NO.7

Specifications:

Low Power 0002 (LP0002) July 15, 2020, Clause 4.10.1

(低功率射頻電機技術規範)

Date of issue: August 25, 2021

Andrey Adelberg, Senior EMC/RF Specialist

Tested by



Signature

David Duchesne, EMC/RF Lab Manager

Reviewed by



Signature

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SCC File Number: 15064 (Ottawa/Almonte); 151100 (Montreal); 151097 (Cambridge)

LP0002 2018 FHSS and DTS; Date: April, 2020

Lab locations

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Test site registration	Organization	Recognition numbers and location		
	FCC/ISED	FCC: CA2040; IC: 2040A-4 (Ottawa/Almonte); FCC: CA2041; IC: 2040G-5 (Montreal); CA0101 (Cambridge)		
Website	www.nemko.com			

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contained in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

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Section 1 Report summary

1.1 Test specifications

LP0002 July 15, 2020, Clause 4.10.1 低功率射頻電機技術規範	Intentional radiators employing frequency hopping spread spectrum and digital modulation techniques. Operation within the bands 2400–2483.5 MHz and 5725–5875 MHz
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1.2 Test methods

558074 D01 15.247 Meas Guidance v05r02 (April 2, 2019)	Guidance for compliance measurements on digital transmission system, frequency hopping spread spectrum system, and hybrid system devices operating under section 15.247 of the FCC rules.
DA 00-705, Released March 30, 2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

1.3 Exclusions

None

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard except as noted in section 1.3 above. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

Determining compliance is based on the results of the compliance measurement, not taking into account measurement uncertainty, in accordance with section 1.3 of ANSI C63.10 v2013.

See “Summary of test results” for full details.

1.5 Test report revision history

Table 1.5-1: Test report revision history

Revision #	Date of issue	Details of changes made to test report
TRF	August 25, 2021	Original report issued

Section 2 Engineering considerations

2.1 Modifications incorporated in the EUT for compliance

There were no modifications performed to the EUT during this assessment.

2.2 Technical judgment

None

2.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 3 Test conditions

3.1 Atmospheric conditions

Temperature	15 °C – 35 °C
Relative humidity	20 % – 75 %
Air pressure	86 kPa (860 mbar) – 106 kPa (1060 mbar)

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

3.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages $\pm 5\%$, for which the equipment was designed.

Section 4 Measurement uncertainty

4.1 Uncertainty of measurement

UKAS Lab 34 and TIA-603-B have been used as guidance for measurement uncertainty reasonable estimations with regards to previous experience and validation of data. Nemko Canada, Inc. follows these test methods in order to satisfy ISO/IEC 17025 requirements for estimation of uncertainty of measurement for wireless products.

Measurement uncertainty budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of $K = 2$ with 95% certainty.

Table 4.1-1: Measurement uncertainty calculations

Test name	Measurement uncertainty, $\pm$ dB
All antenna port measurements	0.55
Occupied bandwidth	4.45
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78
AC power line conducted emissions	3.55

Section 5 Information provided by the applicant

5.1 Disclaimer

This section contains information provided by the applicant and has been utilized to support the test plan. Inaccurate information provided by the applicant can affect the validity of the results contained within this test report. Nemko accepts no responsibility for the information contained within this section and the impact it may have on the test plan and resulting measurements.

5.2 Applicant/Manufacture

Applicant name	LEGO System A/S
Applicant address	Aastvej 1, 7190 Billund, Denmark
Manufacture name	Same as applicant
Manufacture address	Same as applicant

5.3 EUT information

Product name	Construction LEGO toy
Model	HUB NO.7
Serial number	N/A
Hardware identity and/or version	Version C
Software identity and/or version	1.00.00.0
Power supply requirements	DC input from USB (5 V _{DC}) or internal rechargeable Lithium-Ion battery (7.3 V / 600 mA)
Product description and theory of operation	The device is a toy which controls dedicated motors, sensors and remotely control via BLE or Bluetooth classic with remote device such as iOS, Android or similar.

5.4 Radio technical information

Category of Wideband Data Transmission equipment	☒ Frequency Hopping Spread Spectrum (FHSS) equipment
	☒ Other types of Wideband Data Transmission equipment (e.g. DSSS, OFDM, etc.).
RF Product type	Bluetooth and BLE Transceiver
Frequency band	2400–2483.5 MHz
Frequency Min	2402 MHz
Frequency Max	2480 MHz
RF power Max, Conducted	1.75 dBm
Measured BW, 99% OBW	1.224 MHz
Type of modulation	BLE: GFSK and Bluetooth: GFSK, 8-DPSK, $\pi/4$ -DQPSK
Antenna information	Integral antenna, 3 dBi (max)

5.5 EUT setup details

5.5.1 Radio exercise details

Operating conditions	EUT was loaded with the special operation mode: Approval Test Mode (ATM). Modified conducted test sample was provided with an SMA connector instead of antenna.
Transmitter state	Transmitter was set into continuous mode with modulated signal at maximum power on low/mid/high channels

5.5.2 EUT setup configurations

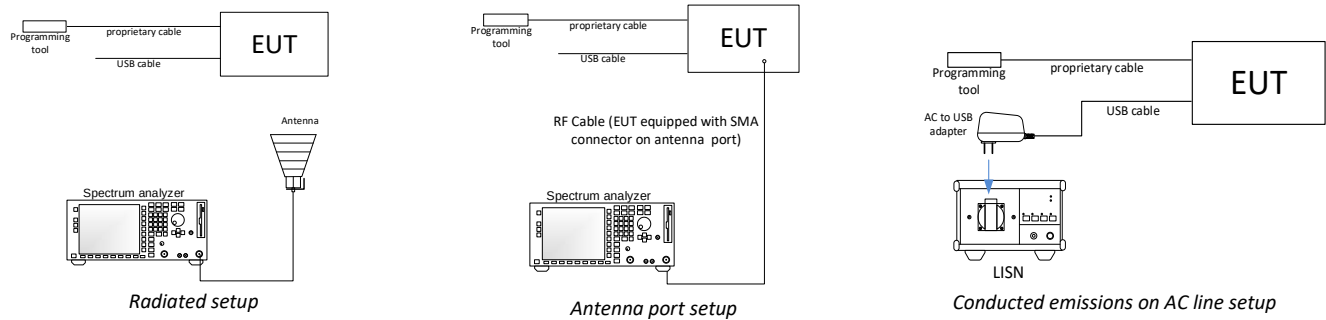


Figure 5.5-1: Setup block diagrams

Section 6 Summary of test results

6.1 Testing location

Test location (s)	Ottawa
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6.2 Testing period

Test start date	March 10, 2021	Test end date	March 10, 2021
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6.3 Sample information

Receipt date	March 9, 2021	Nemko sample ID number(s)	9 (conducted), 8 (radiated)
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6.4 Summary of test results

Table 6.4-1: LP0002:2020 requirements results

Clause	Test description	Verdict
3.3	(傳導限制值) Conducted limits	Pass
4.10.1.6 (1) (a)	(跳頻系統) Frequency Hopping Systems requirements	Pass
4.10.1.2 (1) (A)	(峰值傳導輸出功率) The maximum peak output power and EIRP for FHSS	Pass
4.10.1.6 (2) (A)	(最小6dB帶寬) Minimum 6 dB bandwidth for systems using digital modulation techniques	Pass
4.10.1.2 (1) (C)	(峰值傳導輸出功率) Maximum peak output power and EIRP for DTS	Pass
4.10.1.5	(帶外發射限制) Limits on emissions outside the frequency band	Pass
4.10.1.6 (2) (B)	(峰值传输电功率密度) Power spectral density for digitally modulated devices	Pass

Section 7 Test equipment

7.1 Test equipment list

Table 7.1-1: Equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
3 m EMI test chamber	TDK	SAC-3	FA002047	1 year	April 24, 2021
Flush mount turntable	Sunol	FM2022	FA002082	—	NCR
Controller	Sunol	SC104V	FA002060	—	NCR
Antenna mast	Sunol	TLT2	FA002061	—	NCR
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	November 6, 2021
Biconical antenna (30–300 MHz)	Sunol	BC2	FA002078	1 year	April 30, 2021
Log periodic antenna (200–5000 MHz)	Sunol	LP5	FA002077	1 year	April 30, 2021
Horn antenna (1–18 GHz)	EMCO	3115	FA000825	1 year	April 30, 2021
Horn antenna (18–40 GHz)	EMCO	3116	FA001847	1 year	May 7, 2021
Pre-amplifier (18–26 GHz)	Narda	BBS-1826N612	FA001550	—	VOU
Signal and Spectrum Analyzer	Rhode&Schwarz	FSW50	FA003267	1 year	December 7, 2021
Preamplifier (1–18 GHz)	ETS Lindgren	124334	FA002877	1 year	October 13, 2021
LISN	Rohde & Schwarz	ENV216	FA002515	1 year	January 29, 2022
61505 AC source	Chroma	61509	FA003036	—	VOU

Notes: NCR - no calibration required, VOU - verify on use

Section 8 Testing data

8.1 (傳導限制值) AC power line conducted emissions limits

8.1.1 References, definitions and limits

LP0002, Clause 3:

- 3 General requirements
- 3.3 For Low-power radio-frequency devices 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). The lower limit applies at the boundary between the frequency ranges.

Table 8.1-1: *Conducted emissions limit*

Frequency of emission, MHz	Conducted emissions 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

Notes: * - The level decreases linearly with the logarithm of the frequency.
 ** - A linear average detector is required.

8.1.2 Test summary

Verdict	Pass		
Tested by	Andrey Adelberg	Test date	March 16, 2021

8.1.3 Observations, settings and special notes

Port under test – Coupling device	AC input of USB Power adapter – Artificial Mains Network (AMN)
EUT power input during test	5 V _{DC} (via external 100–240 V _{AC} , 50/60 Hz power adapter)
EUT setup configuration	Table top
Measurement details	A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 10 dB or above the limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.
Additional notes:	– The EUT was set up as tabletop configuration per ANSI C63.10-2013 measurement procedure. – The spectral scan has been corrected with transducer factors (i.e. cable loss, LISN factors, and attenuators) for determination of compliance. Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB) – Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

Receiver settings:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average (Preview), Quasi-peak and CAverage (Final)
Trace mode	Max Hold
Measurement time	100 ms (Preview), 160 ms (Final)

8.1.4 Test data

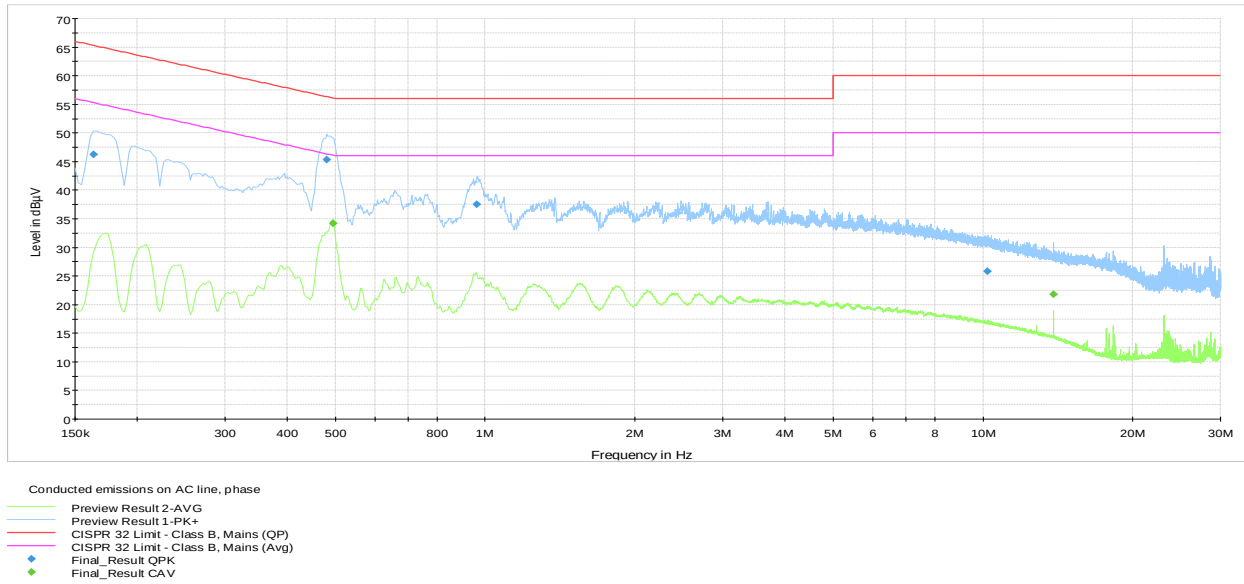
Table 8.1-2: Conducted emissions results on phase line

Frequency, MHz	Quasi-Peak result, dBμV	Quasi-Peak limit, dBμV	Quasi-Peak margin, dB	Correction factor, dB
0.164	46.27	65.28	19.01	10.20
0.481	45.32	56.33	11.01	10.10
0.962	37.58	56.00	18.42	10.00
10.196	25.83	60.00	34.17	10.00
Frequency, MHz	CAverage result, dBμV	CAverage limit, dBμV	CAverage margin, dB	Correction factor, dB
0.494	34.21	46.10	11.89	10.10
13.845	21.83	50.00	28.17	10.00

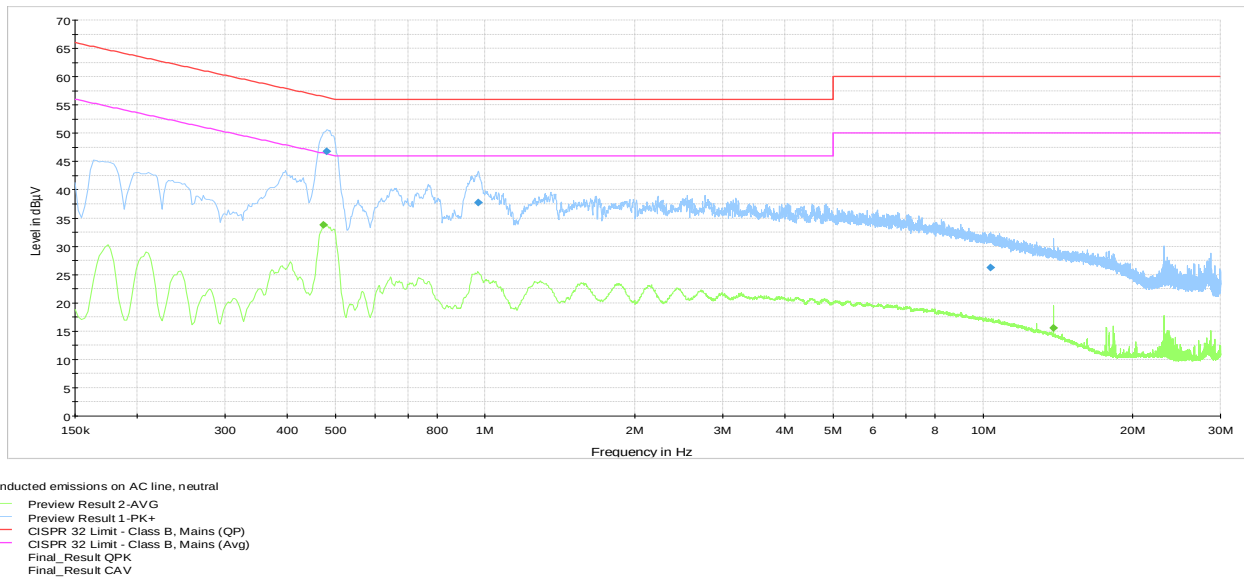
Table 8.1-3: Conducted emissions results on neutral line

Frequency, MHz	Quasi-Peak result, dBμV	Quasi-Peak limit, dBμV	Quasi-Peak margin, dB	Correction factor, dB
0.481	46.79	56.33	9.54	10.10
0.969	37.77	56.00	18.23	10.00
10.358	26.18	60.00	33.82	10.00
Frequency, MHz	CAverage result, dBμV	CAverage limit, dBμV	CAverage margin, dB	Correction factor, dB
0.474	33.76	46.44	12.68	10.10
13.845	15.58	50.00	34.42	10.00

Test data, continued



Plot 8.1-1: *Conducted emissions on phase line*



Plot 8.1-2: *Conducted emissions on neutral line*

8.2 (最小6dB带宽) Minimum 6 dB bandwidth for systems using digital modulation techniques

8.2.1 References, definitions and limits

LP0002, Clause 4.10.1.6

Other limits:

- (2) Digital modulation techniques system:
- (A) For digitally modulated systems, the minimum 6 dB bandwidth shall be at least 500 kHz.

8.2.2 Test summary

Verdict	Pass		
Tested by	Andrey Adelberg	Test date	March 10, 2021

8.2.3 Observations, settings and special notes

The test was performed as per KDB 558074, section 8.2 with reference to ANSI C63.10 subclause 11.8.
Spectrum analyser settings:

Resolution bandwidth	6 dB BW: 100 kHz; 99% OBW: 1–5% of OBW
Video bandwidth	$\geq 3 \times \text{RBW}$
Frequency span	3–5 MHz
Detector mode	Peak
Trace mode	Max Hold

8.2.4 Test data

Table 8.2-1: Occupied bandwidth results

Frequency, MHz	99% occupied bandwidth, MHz	6 dB bandwidth, MHz	Minimum 6 dB BW limit, MHz	Margin, MHz
2402	1.027	0.759	0.500	0.259
2440	1.027	0.739	0.500	0.239
2480	1.027	0.744	0.500	0.244

Test data, continued

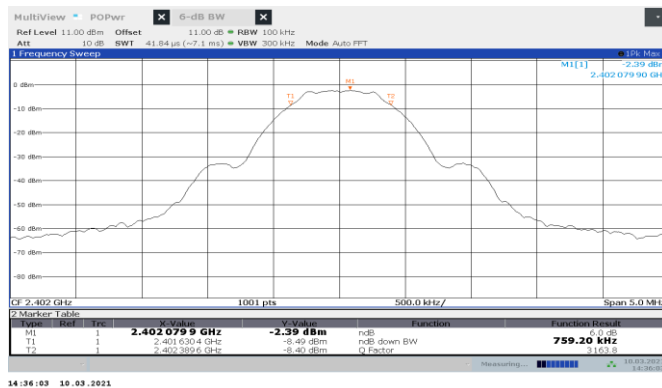


Figure 8.2-1: 6 dB bandwidth on low channel

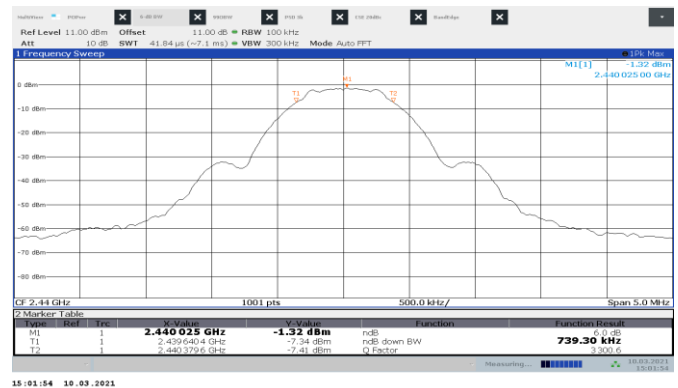


Figure 8.2-2: 6 dB bandwidth on mid channel

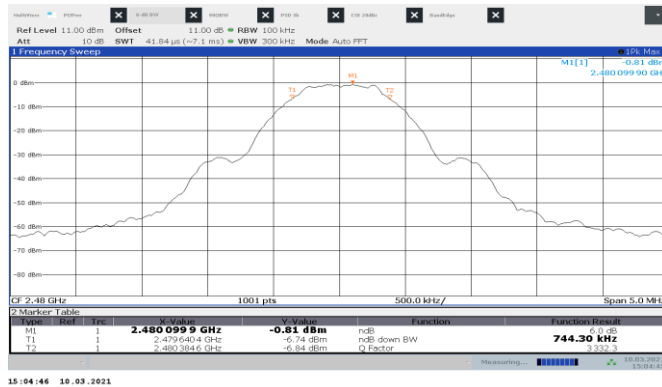


Figure 8.2-3: 6 dB bandwidth on top channel

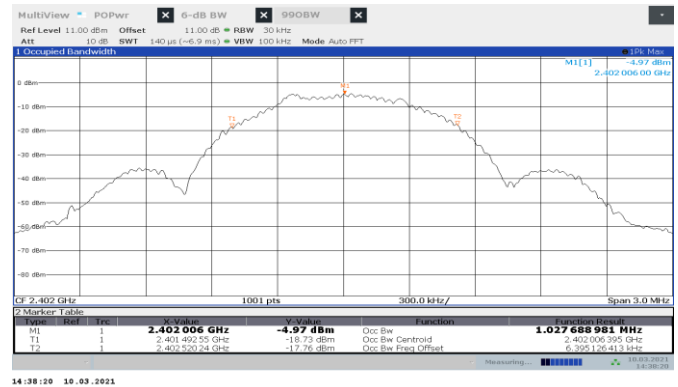


Figure 8.2-4: 99% occupied bandwidth on low channel

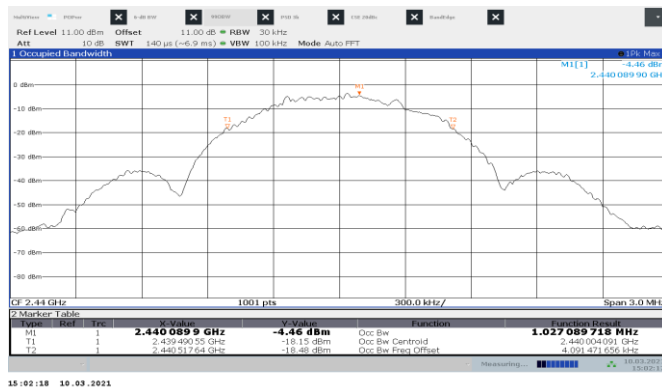


Figure 8.2-5: 99% occupied bandwidth on mid channel



Figure 8.2-6: 99% occupied bandwidth on top channel

8.3 (峰值傳導輸出功率) Maximum peak output power and EIRP for DTS (BLE)

8.3.1 References, definitions and limits

LP0002, Clause 4.10.1.2

The maximum peak output power:

- (1) Operation within 2400–2483.5 MHz
- (C) For systems using digital modulation: below 1 Watt (inclusive).

LP0002, Clause 4.10.1.3

Limits of antenna gains:

- (1) For systems operated in the 2400–2483.5 MHz:
 - (A) For fixed, point-to-point operations, the peak conducted output power of the intentional radiator shall be reduced by 1 dB for every 3 dBi when the directional gain of the antenna exceeds 6 dBi.
 - (B) Transmitters that emit multiple directional beams (including simultaneously or sequentially) for the purpose of directing signals to individual receivers or to groups of receivers shall comply with the following requirements:
 - (a) If the transmitter employs an antenna system that emits multiple directional beams but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device shall not exceed the limit specified in paragraph 4.10.1.2 of this section. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dBi that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:
 - (i) Directional gain = $10 \times \log(\text{number of array elements or staves}) + \text{the directional gain of the element or stave having the highest gain}$.
 - (ii) A lower value for the directional gain than that calculated in paragraph (i) of this section will be accepted if sufficient evidence is presented, e.g., due to shading of the array or coherence loss in the beam forming.
 - (b) If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channel(s), the power supplied to each emission beam shall be subject to the power limit specified in (a). If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the limit specified in (a). In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the limit specified in (a) by more than 8 dB. The directional gain is calculated the same as (a).
 - (c) Transmitters that emit a single directional beam shall operate under the provisions of (1) (A) and (3) of this section.
 - (3) When using the transmitting antennas with the directional gain over 6 dBi except for (1) and (2), the maximum conducted output power shall be reduced in equal quantity according to the total dBi of the antenna directional gain over 6 dBi.

8.3.2 Test summary

Verdict	Pass		
Tested by	Andrey Adelberg	Test date	March 10, 2021

8.3.3 Observations, settings and special notes

The test was performed as per KDB 558074, section 8.3 with reference to ANSI C63.10 subclause 11.9.1 (peak power). Spectrum analyser settings:

Resolution bandwidth	3 MHz
Video bandwidth	10 MHz
Frequency span	20 MHz
Detector mode	Peak
Trace mode	Max-hold

8.3.4 Test data

Table 8.3-1: Output power and EIRP results (antenna port measurement)

Frequency, MHz	Conducted output power, dBm	Output power limit, dBm	Output power margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
2402	-0.90	30.00	30.90	3.00	2.10	36.00	33.90
2440	-0.02	30.00	30.02	3.00	2.98	36.00	33.02
2480	0.97	30.00	29.03	3.00	3.97	36.00	32.03

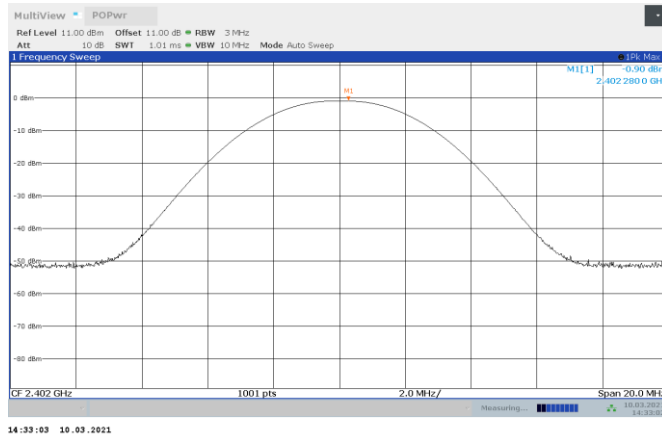


Figure 8.3-1: Output power on low channel

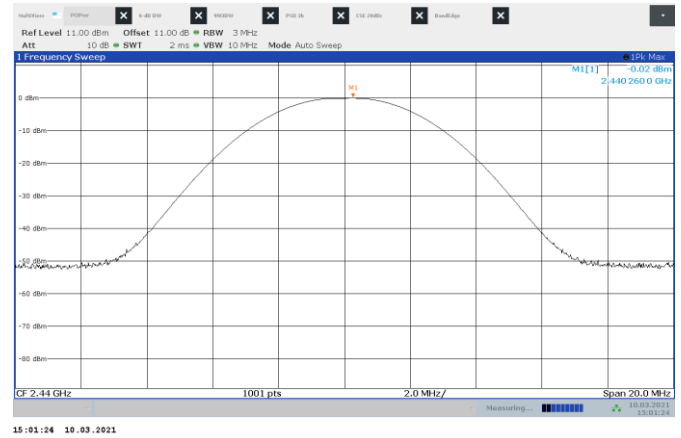


Figure 8.3-2: Output power on mid channel

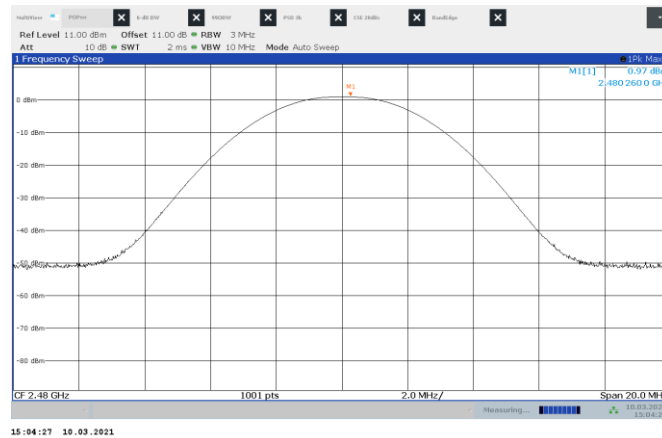


Figure 8.3-3: Output power on high channel

8.4 (峰值傳導輸出功率) The maximum peak output power and EIRP for FHSS (Bluetooth)

8.4.1 References, definitions and limits

LP0002, Clause 4.10.1.2

The maximum peak output power:

- (1) Operation within 2400–2483.5 MHz
- (A) For frequency hopping systems employing at least 75 hopping channels: below 1 Watt (inclusive).
- (B) Frequency hopping systems according to Section 4.10.1.6 (1) (A) (a) excluded by (A): below 0.125 W (inclusive).

LP0002, Clause 4.10.1.3

Limits of antenna gains:

- (1) For systems operated in the 2400–2483.5 MHz:
 - (A) For fixed, point-to-point operations, the peak conducted output power of the intentional radiator shall be reduced by 1 dB for every 3 dBi when the directional gain of the antenna exceeds 6 dBi.
 - (B) Transmitters that emit multiple directional beams (including simultaneously or sequentially) for the purpose of directing signals to individual receivers or to groups of receivers shall comply with the following requirements:
 - (a) If the transmitter employs an antenna system that emits multiple directional beams but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device shall not exceed the limit specified in paragraph 4.10.1.2 of this section. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dBi that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:
 - (i) Directional gain = $10 \times \log(\text{number of array elements or staves}) + \text{the directional gain of the element or stave having the highest gain}$.
 - (ii) A lower value for the directional gain than that calculated in paragraph (i) of this section will be accepted if sufficient evidence is presented, e.g., due to shading of the array or coherence loss in the beam forming.
 - (b) If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channel(s), the power supplied to each emission beam shall be subject to the power limit specified in (a). If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the limit specified in (a). In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the limit specified in (a) by more than 8 dB. The directional gain is calculated the same as (a).
 - (c) Transmitters that emit a single directional beam shall operate under the provisions of (1) (A) and (3) of this section.
 - (3) When using the transmitting antennas with the directional gain over 6 dBi except for (1) and (2), the maximum conducted output power shall be reduced in equal quantity according to the total dBi of the antenna directional gain over 6 dBi.

8.4.2 Test summary

Verdict	Pass		
Tested by	Andrey Adelberg	Test date	March 10, 2021

8.4.3 Observations, settings and special notes

Conducted output power was tested per ANSI C63.10 subclause 7.8.5. The hopping shall be disabled for this test. Spectrum analyser settings:

Resolution bandwidth	3 MHz
Video bandwidth	≥ RBW
Frequency span	20 MHz
Detector mode	Peak
Trace mode	Max Hold

8.4.4 Test data

Table 8.4-1: Output power and EIRP results

Modulation	Frequency, MHz	Output power, dBm	Output power limit, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
GFSK	2402	-0.97	30.00	30.97	3.00	2.03	36.00	33.97
GFSK	2441	0.08	30.00	29.92	3.00	3.08	36.00	32.92
GFSK	2480	1.03	30.00	28.97	3.00	4.03	36.00	31.97
8-DPSK	2402	-0.09	30.00	30.09	3.00	2.91	36.00	33.09
8-DPSK	2441	1.39	30.00	28.61	3.00	4.39	36.00	31.61
8-DPSK	2480	1.75	30.00	28.25	3.00	4.75	36.00	31.25
$\pi/4$ -DQPSK	2402	-0.73	30.00	30.73	3.00	2.27	36.00	33.73
$\pi/4$ -DQPSK	2441	0.27	30.00	29.73	3.00	3.27	36.00	32.73
$\pi/4$ -DQPSK	2480	1.20	30.00	28.80	3.00	4.20	36.00	31.80

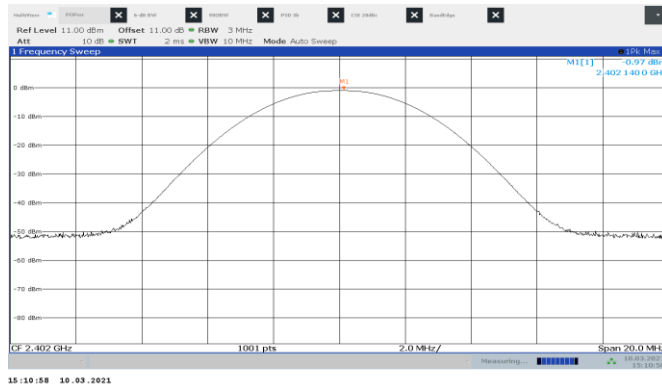


Figure 8.4-1: Output power on low channel, GFSK

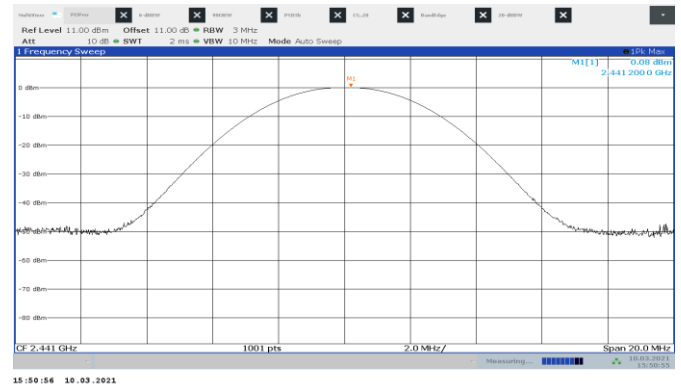


Figure 8.4-2: Output power on mid channel, GFSK

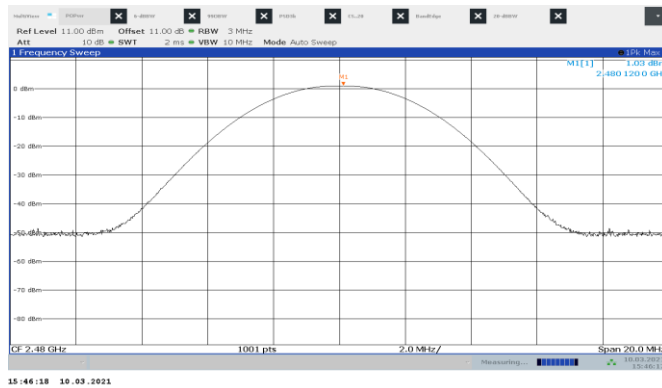


Figure 8.4-3: Output power on high channel, GFSK

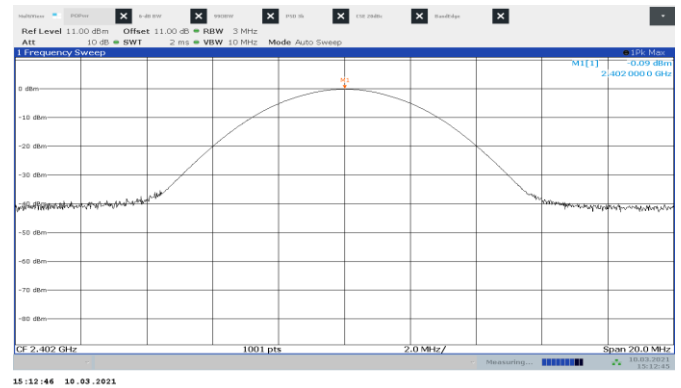


Figure 8.4-4: Output power on low channel, 8-DPSK

Test data, continued

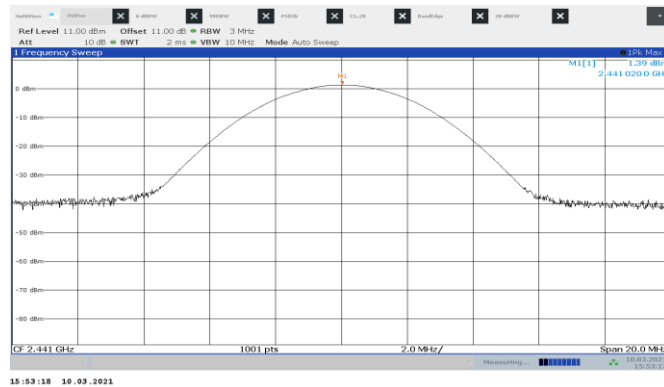


Figure 8.4-5: Output power on mid channel, 8-DPSK

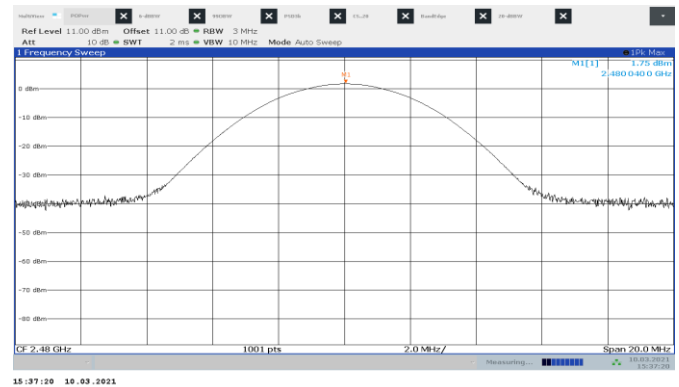


Figure 8.4-6: Output power on high channel, 8-DPSK

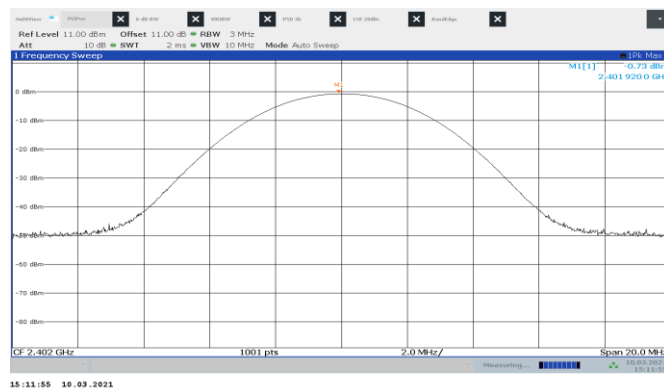


Figure 8.4-7: Output power on low channel, $\pi/4$ -DQPSK

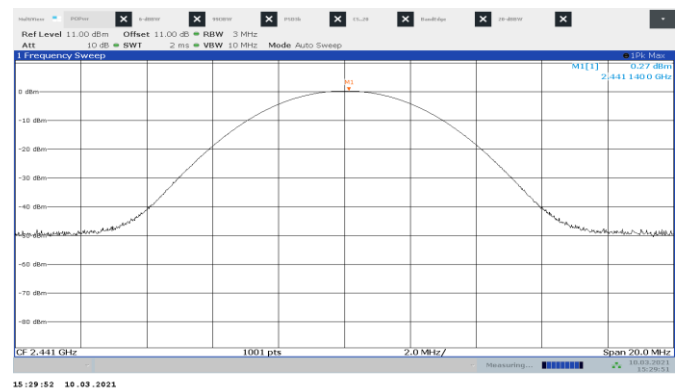


Figure 8.4-8: Output power on mid channel, $\pi/4$ -DQPSK

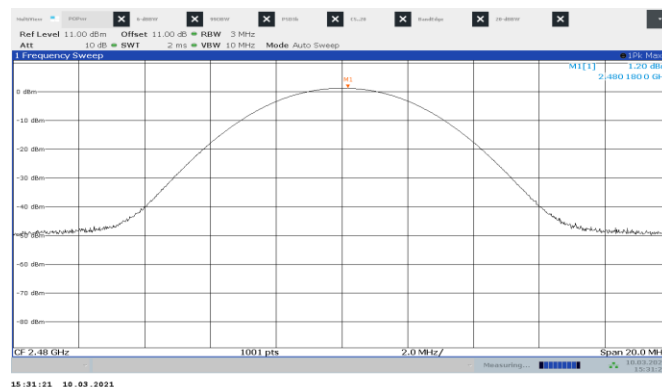


Figure 8.4-9: Output power on high channel, $\pi/4$ -DQPSK

8.5 (帶外發射限制) Limits on emissions outside the frequency band (BLE)

8.5.1 References, definitions and limits

LP0002, Clause 4.10.1.5

Limits on emissions outside the frequency band:

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 below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, the attenuation shall be as below:

- (1) The attenuation shall be at least 20 dB when the conducted power is measured according to Appendix II of this section, based on either an RF conducted or a radiated measurement.
 - (2) The attenuation shall be at least 30 dB when the conducted power is measured according to the paragraph (1) (C) of this section 4.10.1.2.
- In addition, radiated emissions that fall under Section 3.5 the restricted bands must also comply with the radiated emission limit specified in Section 3.6.

LP0002, Clause 3.5:

Additional regulations shall apply except for this standard. The fundamental frequency of any low-power radio-frequency devices shall be restricted in any of the operation bands listed below; spurious emissions shall be permitted in any of frequency band listed below and shall meet the field strength requirement of 3.6:

Table 8.5-1: Section 3.5 Restricted frequency bands

MHz	MHz	MHz
0.090–0.110	240.00–285.00	3332.0–3339.0
0.490–0.510	322.00–335.40	3345.8–3358.0
2.172–2.198	399.90–410.00	3500.0–4400.0
3.013–3.033	485.00–510.00	4500.0–5250.0
4.115–4.198	608.00–614.00	5350.0–5460.0
5.670–5.690	703.00–748.00	7250.0–7750.0
6.200–6.300	758.00–803.00	8025.0–8500.0
8.230–8.400	825.00–915.00	9000.0–9200.0
12.265–12.600	930.00–1240.0	9300.0–9500.0
13.340–13.430	1300.0–1427.0	10600–12700
14.965–15.020	1435.0–1626.5	13250–13400
16.700–16.755	1660.0–1785.0	14470–14500
19.965–20.020	1805.0–1880.0	15350–16200
25.500–25.700	1885.0–1900.0	17700–21400
37.475–38.275	1905.0–1985.0	22010–23120
73.500–75.400	2010.0–2025.0	23600–24000
108.00–138.00	2110.0–2170.0	31200–31800
149.90–150.05	2200.0–2300.0	36430–36500
156.70–156.90	2310.0–2390.0	
162.01–167.17	2483.5–2900.0	Above 38600
167.72–173.20	3260.0–3267.0	

References, definitions and limits, continued

LP0002, Clause 3.6:

Additional regulations shall apply except for this standard, the emissions from the low-power radio-frequency devices shall be less than or equal the field strength levels specified in the following table and the level of any unwanted emissions shall not exceed the level of the fundamental emission.

The tighter limit applies at the band edges.

Table 8.5-2: Section 3.6 Radiated emission limits

Frequency, MHz	Field strength of emissions		Measurement distance, m
	$\mu\text{V/m}$	$\text{dB}\mu\text{V/m}$	
0.009–0.490	2400/F	$67.6 - 20 \times \log_{10}(\text{F})$	300
0.490–1.705	24000/F	$87.6 - 20 \times \log_{10}(\text{F})$	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

Notes: In the emission table above, the tighter limit applies at the band edges. F is in kHz units
 For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test

LP0002, Clause 3.7:

The field strength radio frequency 9–90 kHz, 110–490 kHz and 1000 MHz above stipulated in the above table shall be measured according to an average detector and comply with Section 6.15.2, while others shall be measured using a CISPR quasi-peak detector.

LP0002, Clause 6.15.2:

On any frequency of frequencies above 1000 MHz, the radiated limits shown are based upon the use of measurement instrumentation employing an average detector function. When average radiated emission measurements are specified in the regulations (including emission measurements below 1000 MHz), there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit for the frequency being investigated unless a different peak emission limit is otherwise specified in the rules. Unless otherwise specified, measurements above 1000 MHz shall be undertaken using a minimum resolution bandwidth of 1 MHz.

8.5.2 Test summary

Verdict	Pass		
Tested by	Andrey Adelberg	Test date	March 10, 2021

8.5.3 Observations, settings and special notes

- As part of the current assessment, the test range of 9 kHz to 10th harmonic has been fully considered and compared to the actual frequencies utilized within the EUT. Since the EUT contains a transmitter in the GHz range, the EUT has been deemed compliant without formal testing in the 9 kHz to 30 MHz test range, therefore formal test results (tabular data and/or plots) are not provided within this test report.
- EUT was set to transmit with 100 % duty cycle.
- Radiated measurements were performed at a distance of 3 m up to 18 GHz and 1 m above 18 GHz.
- DTS emissions in non-restricted frequency bands test was performed as per KDB 558074, section 8.5 with reference to ANSI C63.10 subclause 11.11.
- Since fundamental power was tested using the maximum peak conducted output power procedure to demonstrate compliance, the spurious emissions limit is –20 dBc/100 kHz.
- DTS emissions in restricted frequency bands test was performed as per KDB 558074, section 8.6 with reference to ANSI C63.10 subclause 11.12.
- DTS band-edge emission measurements test was performed as per KDB 558074, section 8.7 with reference to ANSI C63.10 subclause 11.13.

Spectrum analyser settings for radiated measurements within restricted bands below 1 GHz:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for peak radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for average radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	10 Hz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for conducted spurious emissions measurements:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

8.5.4 Test data

Table 8.5-3: Radiated field strength measurement results

Channel	Frequency, MHz	Peak Field strength, dBμV/m		Margin, dB	Average Field strength, dBμV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2384.2	52.09	74.00	21.91	43.55	54.00	10.45
Low	12008.9	49.01	74.00	24.99	49.10	54.00	4.90
Top	2483.5	53.66	74.00	20.34	45.90	54.00	8.10
Top	14597.6	50.81	74.00	23.19	50.81	54.00	3.19

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

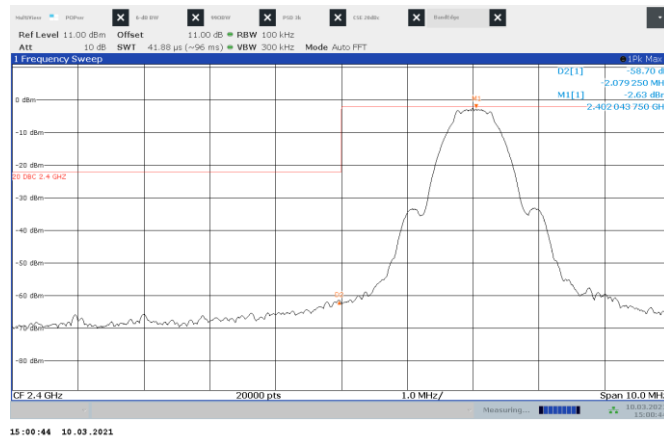


Figure 8.5-1: Band edge conducted spurious emissions at 2400 MHz

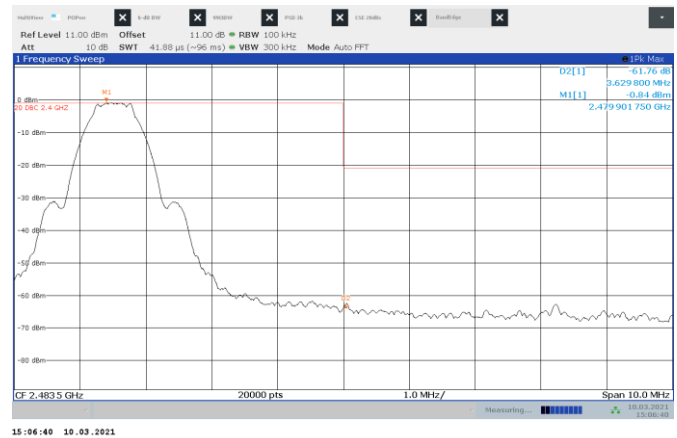


Figure 8.5-2: Band edge conducted spurious emissions at 2483.5 MHz

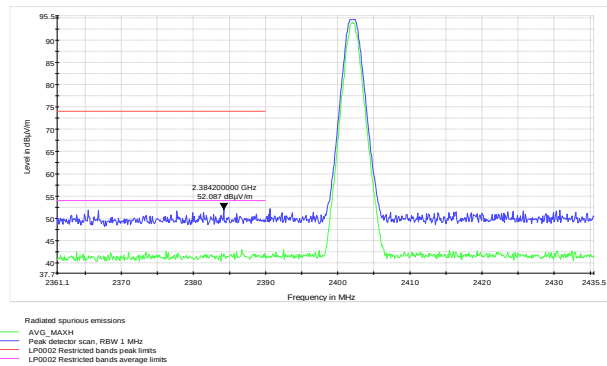


Figure 8.5-3: Band edge radiated spurious emissions at 2390 MHz

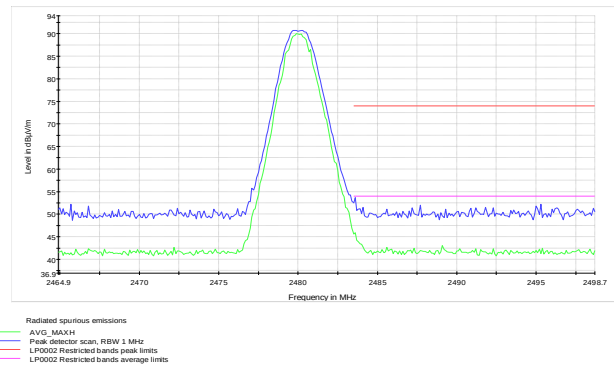


Figure 8.5-4: Band edge radiated spurious emissions at 2483.5 MHz

Test data, continued

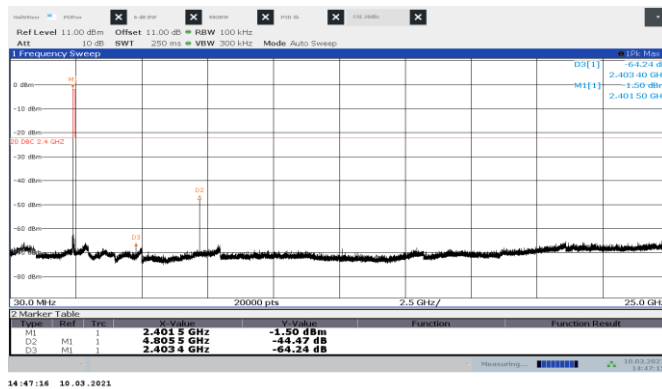


Figure 8.5-5: Conducted spurious emissions on low channel

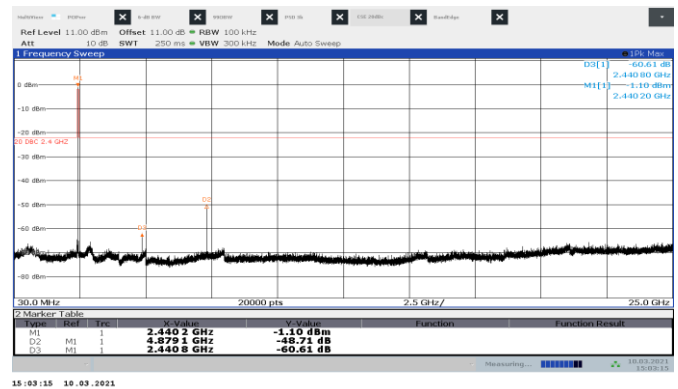


Figure 8.5-6: Conducted spurious emissions on mid channel

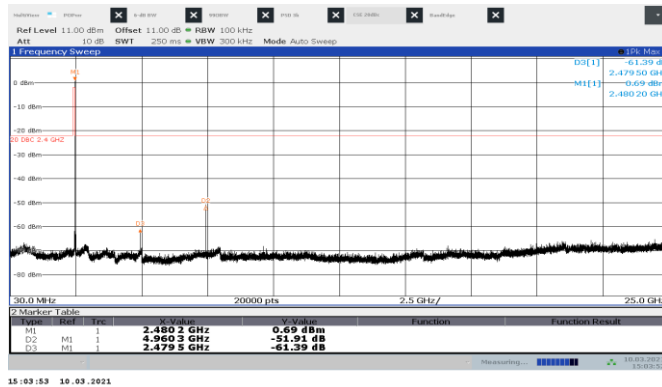


Figure 8.5-7: Conducted spurious emissions on top channel

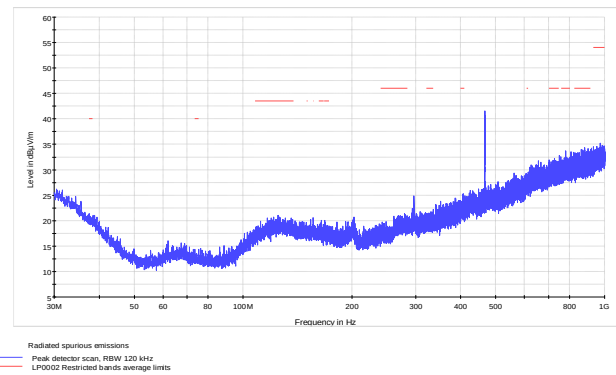


Figure 8.5-8: Radiated spurious emissions within 30–1000 MHz on low channel

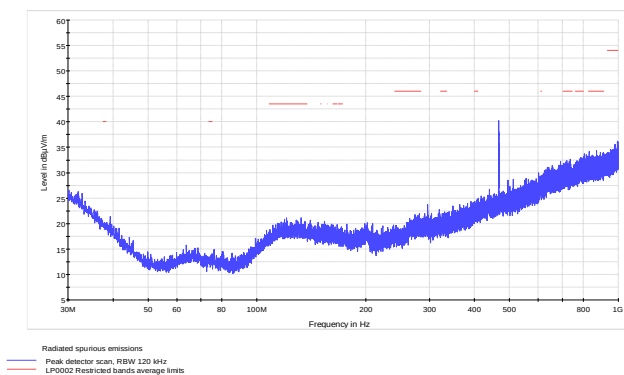


Figure 8.5-9: Radiated spurious emissions within 30–1000 MHz on mid channel

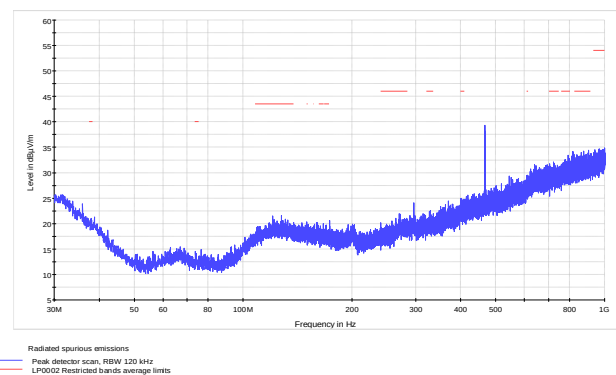


Figure 8.5-10: Radiated spurious emissions within 30–1000 MHz on top channel

Test data, continued

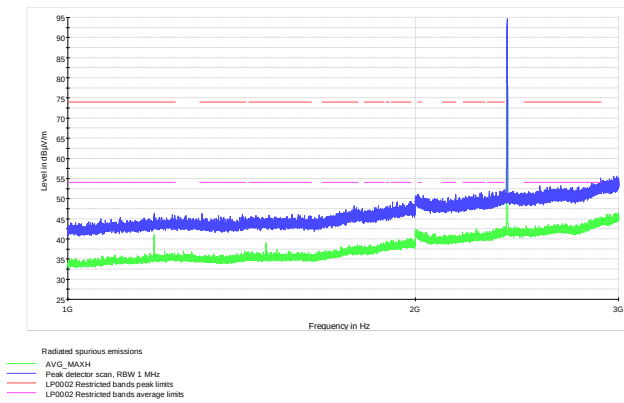


Figure 8.5-11: Radiated spurious emissions within 1–3 GHz on low channel

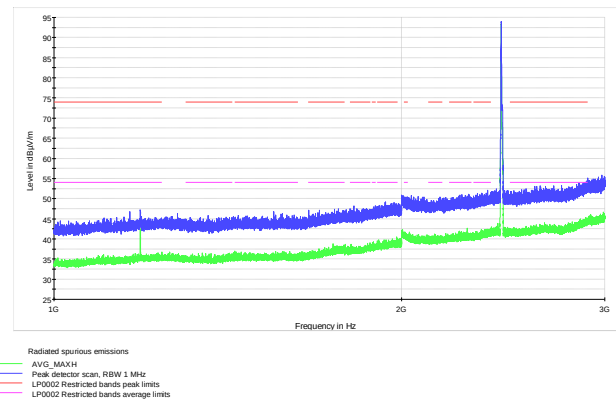


Figure 8.5-12: Radiated spurious emissions within 1–3 GHz on mid channel

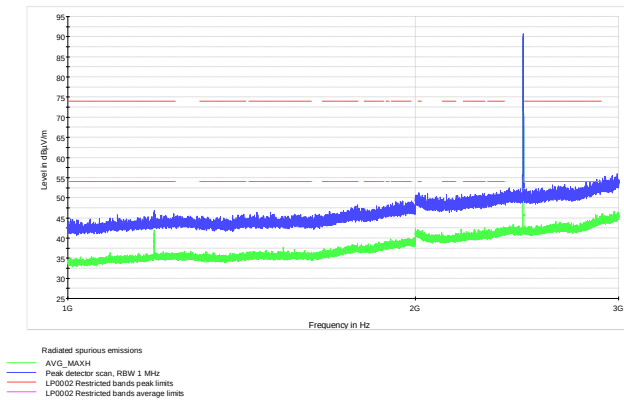


Figure 8.5-13: Radiated spurious emissions within 1–3 GHz on top channel

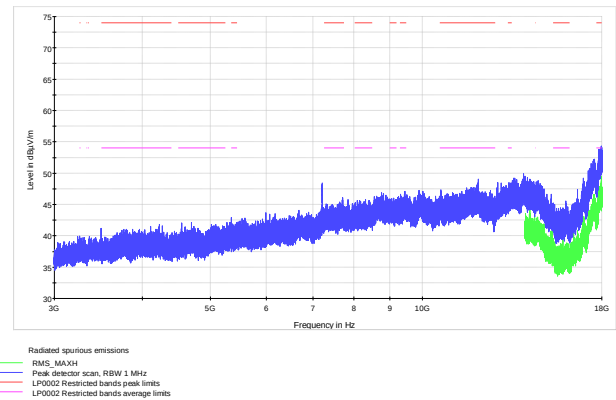


Figure 8.5-14: Radiated spurious emissions within 3–18 GHz on low channel

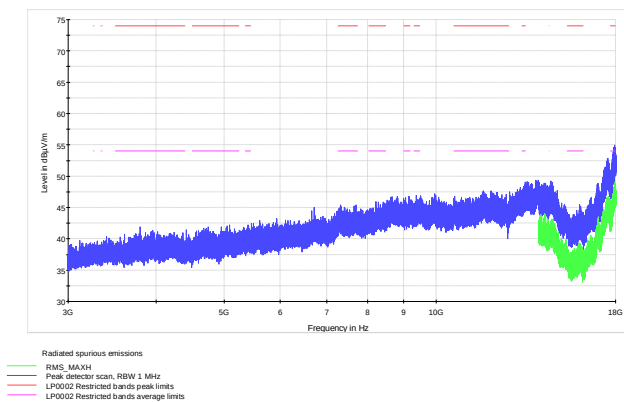


Figure 8.5-15: Radiated spurious emissions within 3–18 GHz on mid channel

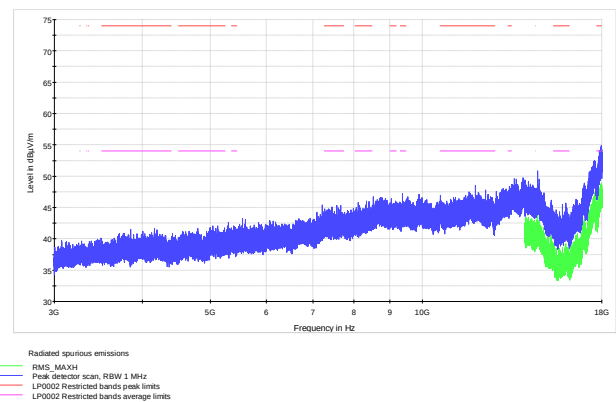


Figure 8.5-16: Radiated spurious emissions within 3–18 GHz on top channel

Test data, continued

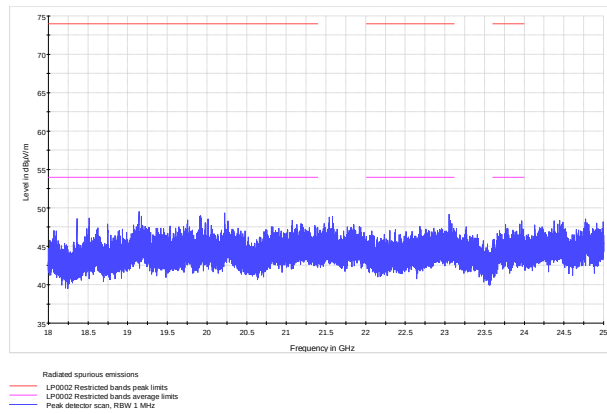


Figure 8.5-17: Radiated spurious emissions within 18–25 GHz on low channel

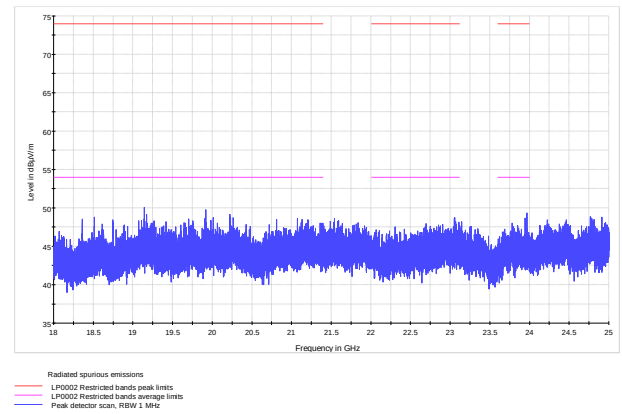


Figure 8.5-18: Radiated spurious emissions within 18–25 GHz on mid channel

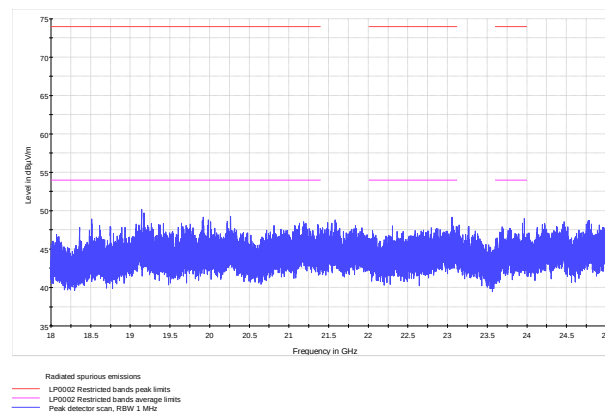


Figure 8.5-19: Radiated spurious emissions within 18–25 GHz on low channel

8.6 (帶外發射限制) Limits on emissions outside the frequency band (Bluetooth - FHSS)

8.6.1 References, definitions and limits

LP0002, Clause 4.10.1.5

Limits on emissions outside the frequency band:

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 below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, the attenuation shall be as below:

- (1) The attenuation shall be at least 20 dB when the conducted power is measured according to Appendix II of this section, based on either an RF conducted or a radiated measurement.
- (2) The attenuation shall be at least 30 dB when the conducted power is measured according to the paragraph (1) (C) of this section 4.10.1.2. In addition, radiated emissions that fall under Section 2.7 the restricted bands must also comply with the radiated emission limit specified in Section 2.8.

LP0002, Clause 3.5:

Additional regulations shall apply except for this standard. The fundamental frequency of any low-power radio-frequency devices shall be restricted in any of the operation bands listed below; spurious emissions shall be permitted in any of frequency band listed below and shall meet the field strength requirement of 3.6:

Table 8.6-1: Section 3.5 Restricted frequency bands

MHz	MHz	MHz
0.090–0.110	240.00–285.00	3332.0–3339.0
0.490–0.510	322.00–335.40	3345.8–3358.0
2.172–2.198	399.90–410.00	3500.0–4400.0
3.013–3.033	485.00–510.00	4500.0–5250.0
4.115–4.198	608.00–614.00	5350.0–5460.0
5.670–5.690	703.00–748.00	7250.0–7750.0
6.200–6.300	758.00–803.00	8025.0–8500.0
8.230–8.400	825.00–915.00	9000.0–9200.0
12.265–12.600	930.00–1240.0	9300.0–9500.0
13.340–13.430	1300.0–1427.0	10600–12700
14.965–15.020	1435.0–1626.5	13250–13400
16.700–16.755	1660.0–1785.0	14470–14500
19.965–20.020	1805.0–1880.0	15350–16200
25.500–25.700	1885.0–1900.0	17700–21400
37.475–38.275	1905.0–1985.0	22010–23120
73.500–75.400	2010.0–2025.0	23600–24000
108.00–138.00	2110.0–2170.0	31200–31800
149.90–150.05	2200.0–2300.0	36430–36500
156.70–156.90	2310.0–2390.0	
162.01–167.17	2483.5–2900.0	Above 38600
167.72–173.20	3260.0–3267.0	

References, definitions and limits, continued

LP0002, Clause 3.6:

Additional regulations shall apply except for this standard, the emissions from the low-power radio-frequency devices shall be less than or equal the field strength levels specified in the following table and the level of any unwanted emissions shall not exceed the level of the fundamental emission.

The tighter limit applies at the band edges.

Table 8.6-2: Section 3.6 Radiated emission limits

Frequency, MHz	Field strength of emissions		Measurement distance, m
	$\mu\text{V/m}$	$\text{dB}\mu\text{V/m}$	
0.009–0.490	2400/F	$67.6 - 20 \times \log_{10}(\text{F})$	300
0.490–1.705	24000/F	$87.6 - 20 \times \log_{10}(\text{F})$	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

Notes: In the emission table above, the tighter limit applies at the band edges. F is in kHz units
 For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test

LP0002, Clause 3.7:

The field strength radio frequency 9–90 kHz, 110–490 kHz and 1000 MHz above stipulated in the above table shall be measured according to an average detector and comply with Section 6.15.2, while others shall be measured using a CISPR quasi-peak detector.

LP0002, Clause 6.15.2:

On any frequency of frequencies above 1000 MHz, the radiated limits shown are based upon the use of measurement instrumentation employing an average detector function. When average radiated emission measurements are specified in the regulations (including emission measurements below 1000 MHz), there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit for the frequency being investigated unless a different peak emission limit is otherwise specified in the rules. Unless otherwise specified, measurements above 1000 MHz shall be undertaken using a minimum resolution bandwidth of 1 MHz.

8.6.2 Test summary

Verdict	Pass		
Tested by	Andrey Adelberg	Test date	March 10, 2021

8.6.3 Observations, settings and special notes

- As part of the current assessment, the test range of 9 kHz to 10th harmonic has been fully considered and compared to the actual frequencies utilized within the EUT. Since the EUT contains a transmitter in the GHz range, the EUT has been deemed compliant without formal testing in the 9 kHz to 30 MHz test range, therefore formal test results (tabular data and/or plots) are not provided within this test report.
- EUT was set to transmit with 100 % duty cycle.
- Radiated measurements were performed at a distance of 3 m up to 18 GHz and 1 m above 18 GHz.
- DTS emissions in non-restricted frequency bands test was performed as per KDB 558074, section 8.5 with reference to ANSI C63.10 subclause 11.11.
- Since fundamental power was tested using the maximum peak conducted output power procedure to demonstrate compliance, the spurious emissions limit is –20 dBc/100 kHz.
- DTS emissions in restricted frequency bands test was performed as per KDB 558074, section 8.6 with reference to ANSI C63.10 subclause 11.12.
- DTS band-edge emission measurements test was performed as per KDB 558074, section 8.7 with reference to ANSI C63.10 subclause 11.13.

Spectrum analyser settings for radiated measurements within restricted bands below 1 GHz:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for peak radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for average radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	10 Hz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for conducted spurious emissions measurements:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

8.6.4 Test data

Table 8.6-3: Radiated field strength measurement results

Channel, modulation	Frequency, MHz	Peak Field strength, dBμV/m		Margin, dB	Average Field strength, dBμV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low, GFSK	2388.2	51.32	74.00	22.68	44.34	54.00	9.66
Low, π/4-DQPSK	2388.5	51.42	74.00	22.58	43.60	54.00	10.40
Low, 8-DPSK	2389.4	51.49	74.00	22.51	44.42	54.00	9.58
Low, π/4-DQPSK	4803.6	44.36	74.00	29.64	44.36	54.00	9.64
Mid, GFSK	1187.9	46.93	74.00	27.07	46.93	54.00	7.07
Mid, π/4-DQPSK	1187.9	48.17	74.00	25.83	48.17	54.00	5.83
Mid, 8-DPSK	1187.8	47.20	74.00	26.80	47.20	54.00	6.80
Top, GFSK	2483.5	52.68	74.00	21.32	45.70	54.00	8.30
Top, π/4-DQPSK	2483.5	52.48	74.00	21.52	44.70	54.00	9.30
Top, 8-DPSK	2483.5	52.31	74.00	21.69	45.24	54.00	8.76
Top, π/4-DQPSK	4959.4	44.38	74.00	29.62	44.38	54.00	9.62

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

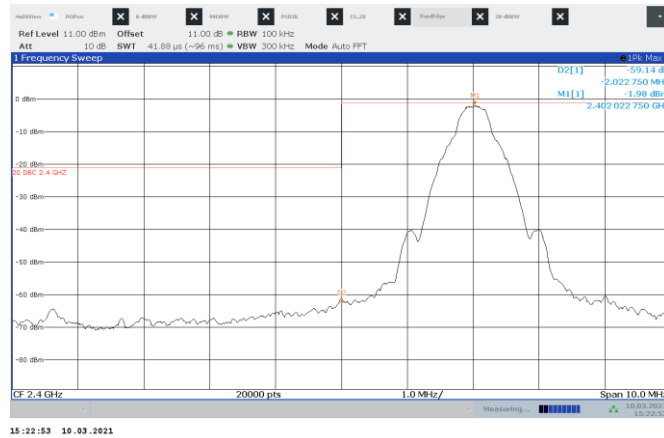


Figure 8.6-1: Band edge conducted spurious emissions at 2400 MHz, GFSK, hopping turned OFF

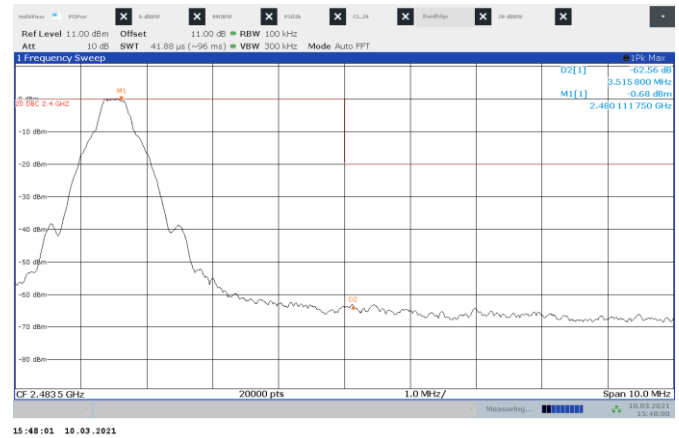


Figure 8.6-2: Band edge conducted spurious emissions at 2483.5 MHz, GFSK, hopping turned OFF

Test data, continued

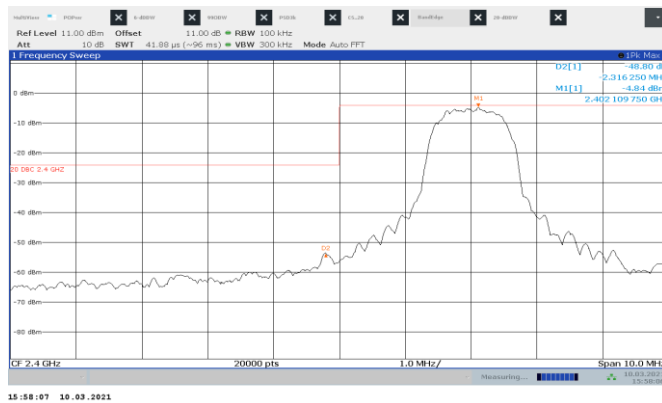


Figure 8.6-3: Band edge conducted spurious emissions at 2400 MHz, 8-DPSK, hopping turned OFF

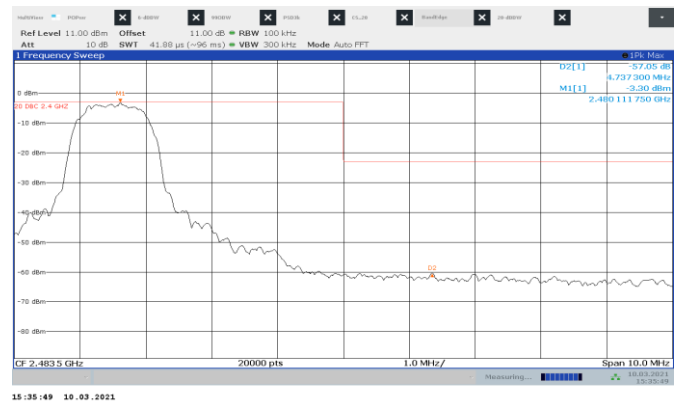


Figure 8.6-4: Band edge conducted spurious emissions at 2483.5 MHz, 8-DPSK, hopping turned OFF

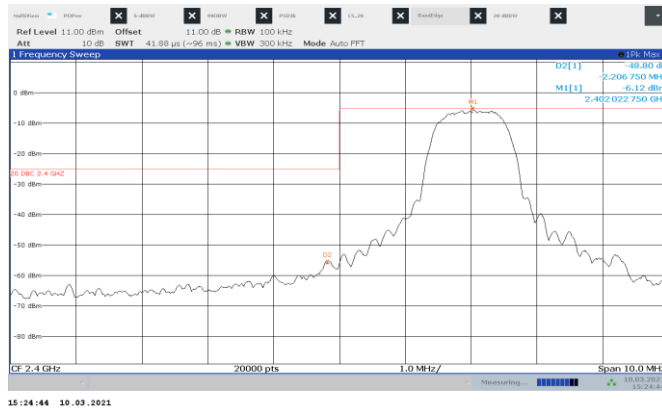


Figure 8.6-5: Band edge conducted spurious emissions at 2400 MHz, $\pi/4$ -DQPSK, hopping turned OFF

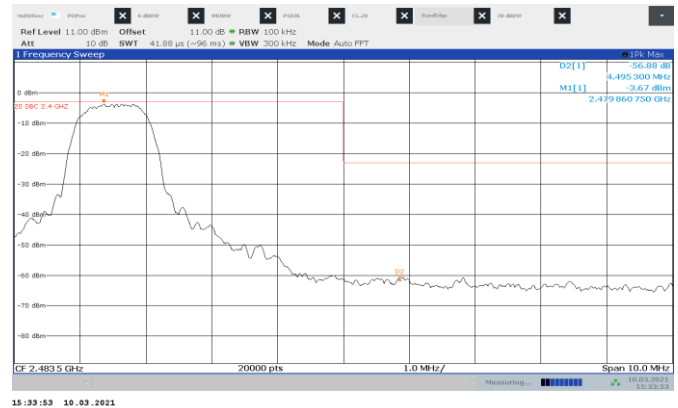


Figure 8.6-6: Band edge conducted spurious emissions at 2483.5 MHz, $\pi/4$ -DQPSK, hopping turned OFF

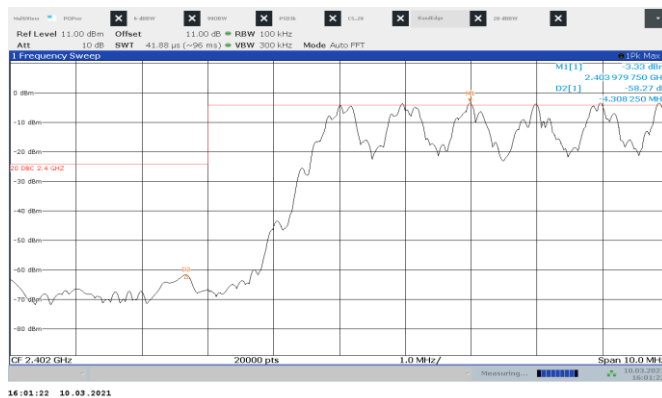


Figure 8.6-7: Band edge conducted spurious emissions at 2400 MHz, hopping turned ON, BR DH1 15 bytes

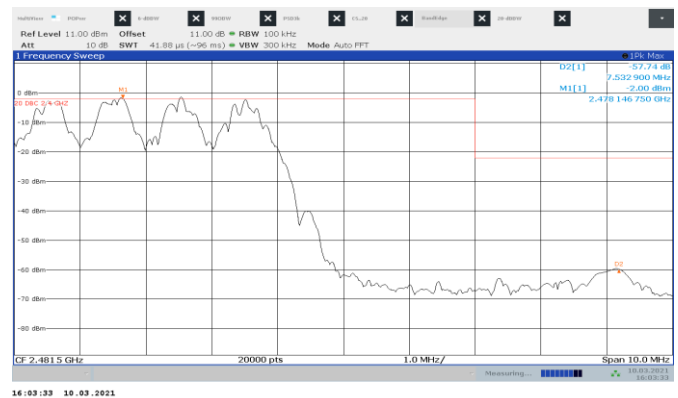


Figure 8.6-8: Band edge conducted spurious emissions at 2483.5 MHz, hopping turned ON, BR DH1 15 bytes

Test data, continued

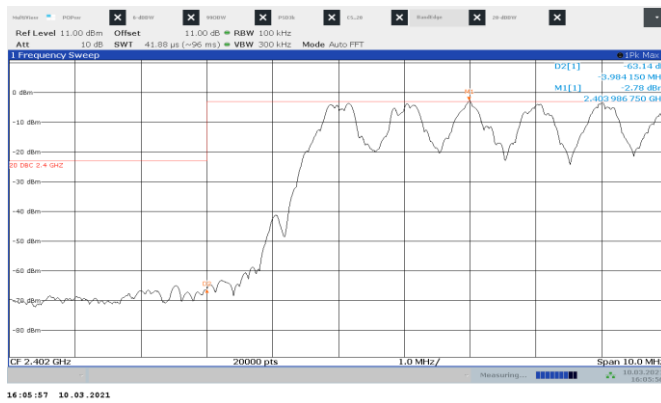


Figure 8.6-9: Band edge conducted spurious emissions at 2400 MHz, hopping turned ON, BR DH3 127 bytes

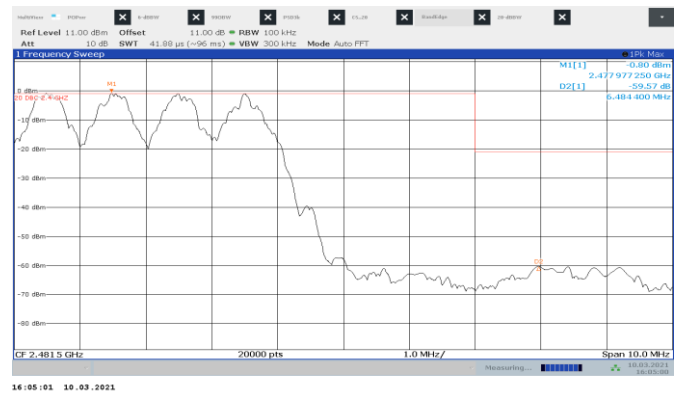


Figure 8.6-10: Band edge conducted spurious emissions at 2483.5 MHz, hopping turned ON, BR DH3 127 bytes

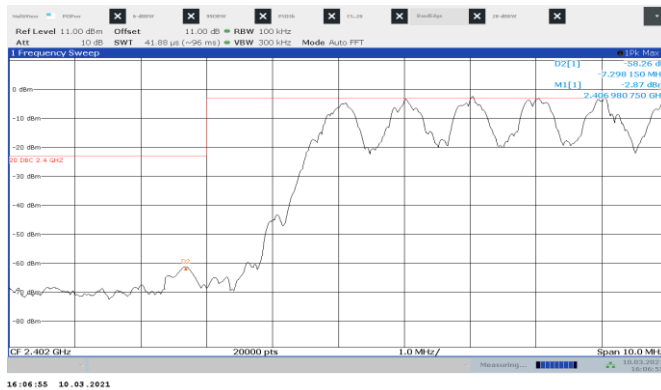


Figure 8.6-11: Band edge conducted spurious emissions at 2400 MHz, hopping turned ON, BR DH5 255 bytes

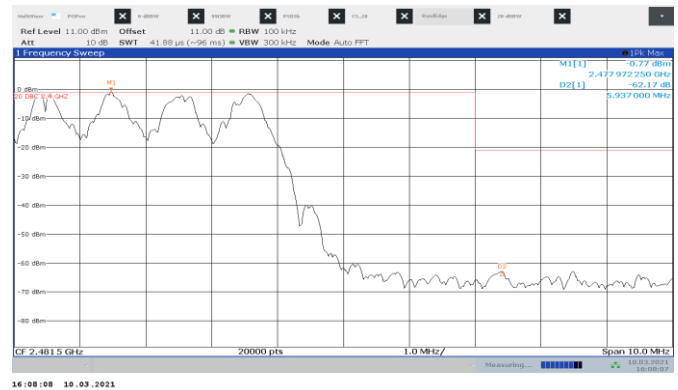


Figure 8.6-12: Band edge conducted spurious emissions at 2483.5 MHz, hopping turned ON, BR DH5 255 bytes

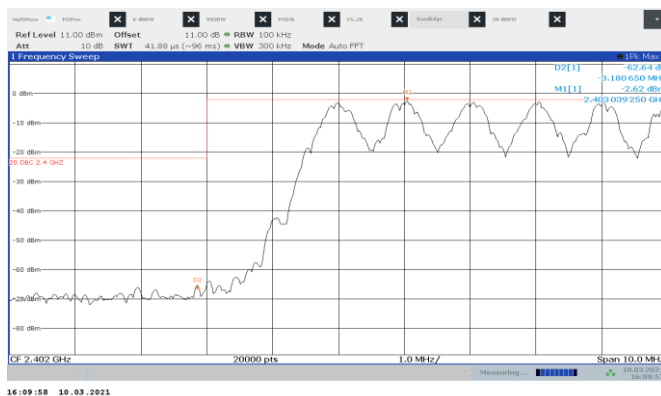


Figure 8.6-13: Band edge conducted spurious emissions at 2400 MHz, hopping turned ON, BR Long DH5 339 bytes

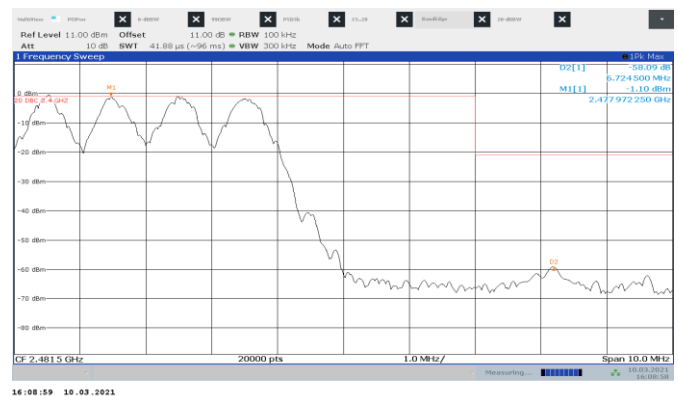


Figure 8.6-14: Band edge conducted spurious emissions at 2483.5 MHz, hopping turned ON, BR Long DH5 339 bytes

Test data, continued

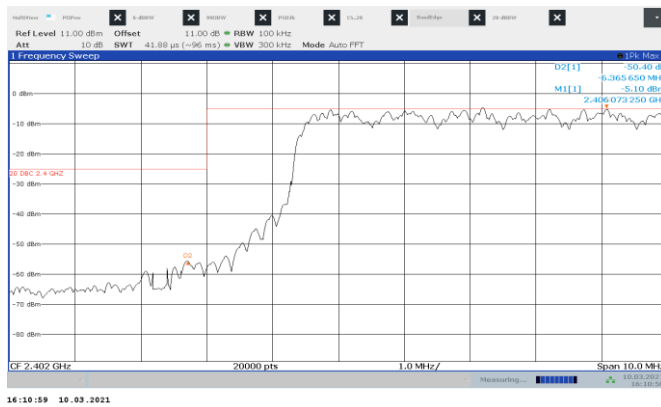


Figure 8.6-15: Band edge conducted spurious emissions at 2400 MHz, hopping turned ON, EDR2 2DH5 679 bytes

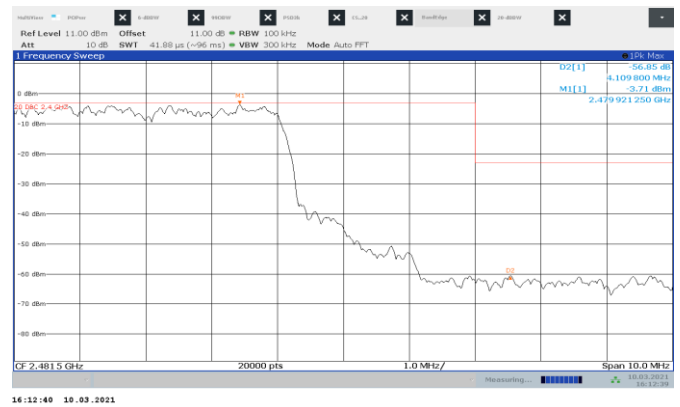


Figure 8.6-16: Band edge conducted spurious emissions at 2483.5 MHz, hopping turned ON, EDR2 2DH5 679 bytes

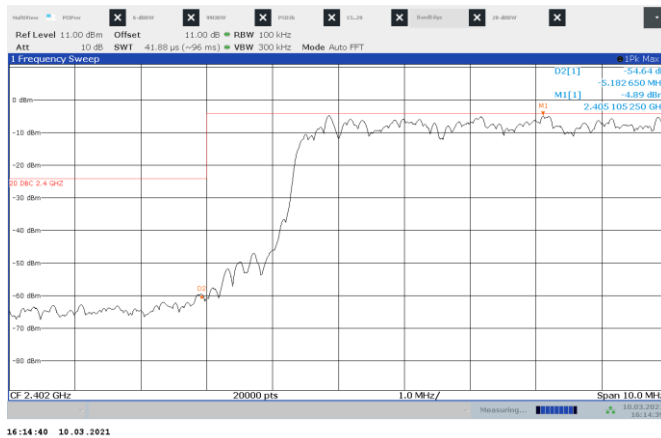


Figure 8.6-17: Band edge conducted spurious emissions at 2400 MHz, hopping turned ON, EDR3 3DH5 1021 bytes

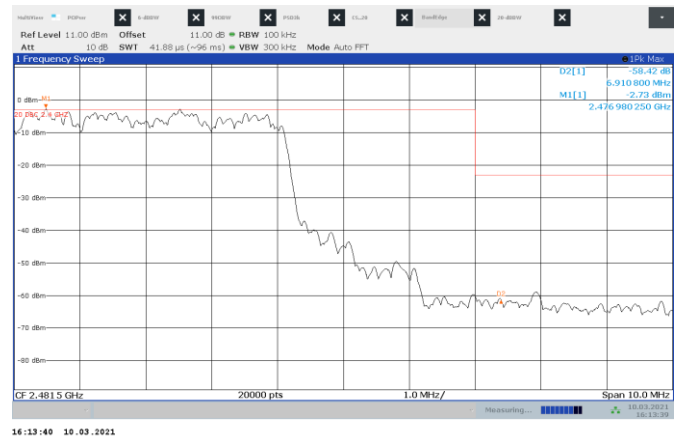


Figure 8.6-18: Band edge conducted spurious emissions at 2483.5 MHz, hopping turned ON, EDR3 3DH5 1021 bytes

Test data, continued

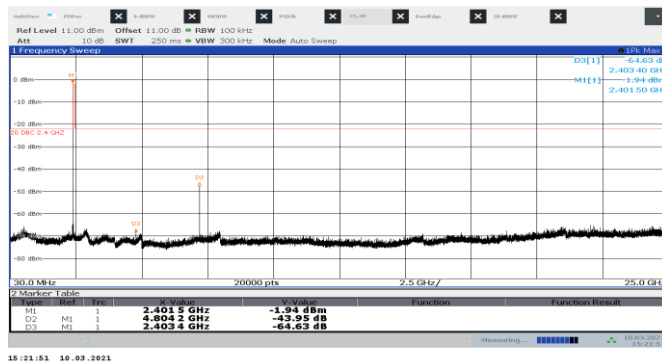


Figure 8.6-19: Conducted spurious emissions on low channel, GFSK

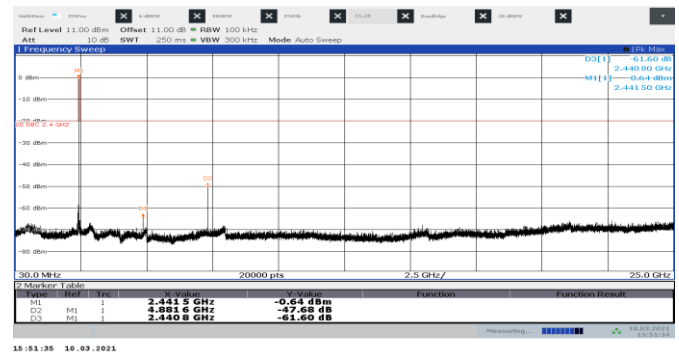


Figure 8.6-20: Conducted spurious emissions on mid channel, GFSK

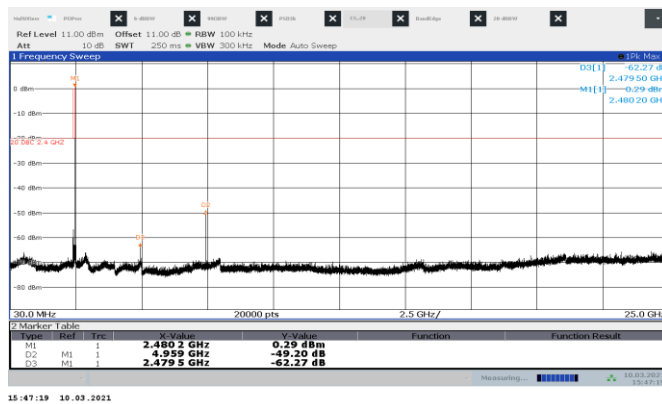


Figure 8.6-21: Conducted spurious emissions on top channel, GFSK

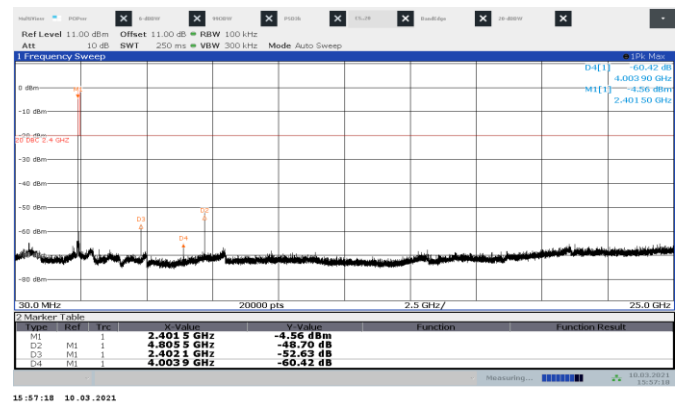


Figure 8.6-22: Conducted spurious emissions on low channel, 8-DPSK

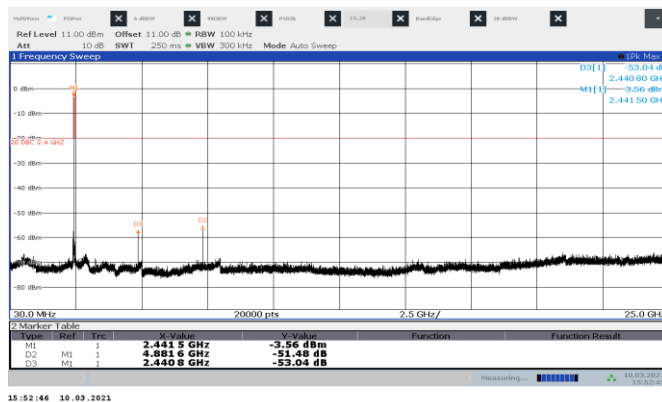


Figure 8.6-23: Conducted spurious emissions on mid channel, 8-DPSK

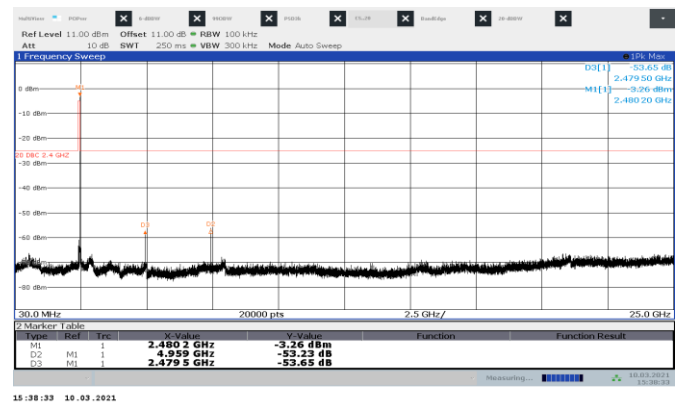


Figure 8.6-24: Conducted spurious emissions on high channel, 8-DPSK

Test data, continued

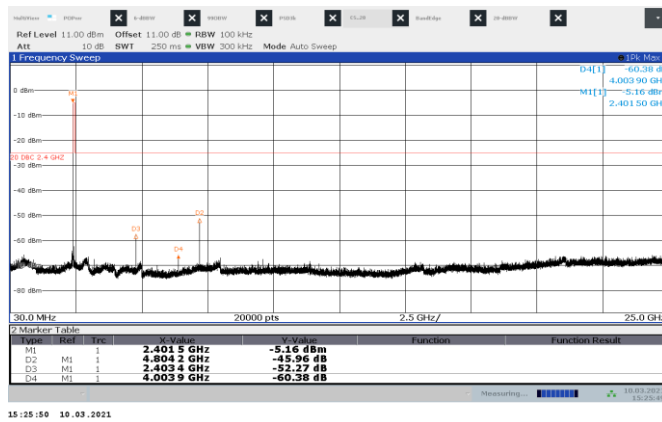


Figure 8.6-25: Conducted spurious emissions on low channel, $\pi/4$ -DQPSK

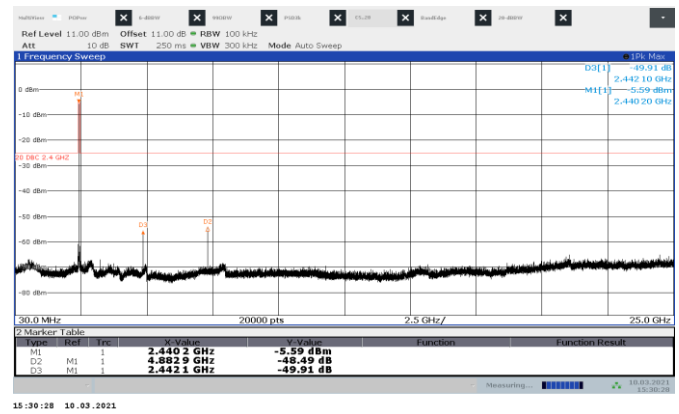


Figure 8.6-26: Conducted spurious emissions on mid channel, $\pi/4$ -DQPSK

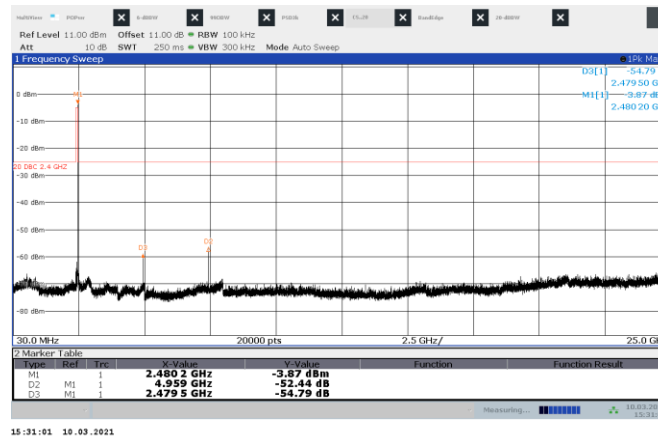


Figure 8.6-27: Conducted spurious emissions on high channel, $\pi/4$ -DQPSK

Test data, continued

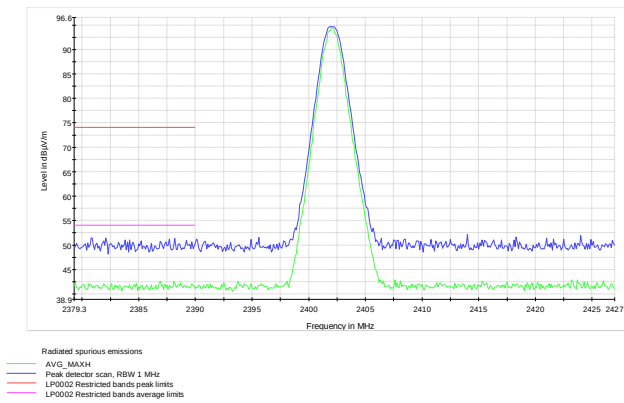


Figure 8.6-28: Band edge radiated spurious emissions at 2400 MHz, GFSK

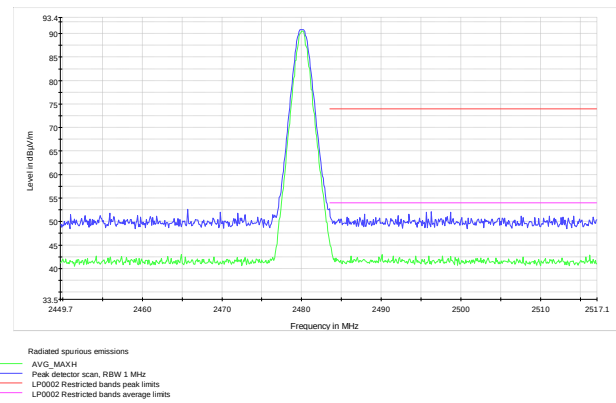


Figure 8.6-29: Band edge radiated spurious emissions at 2483.5 MHz, GFSK

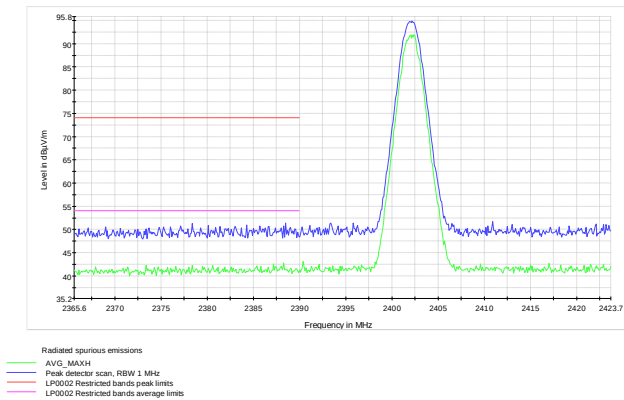
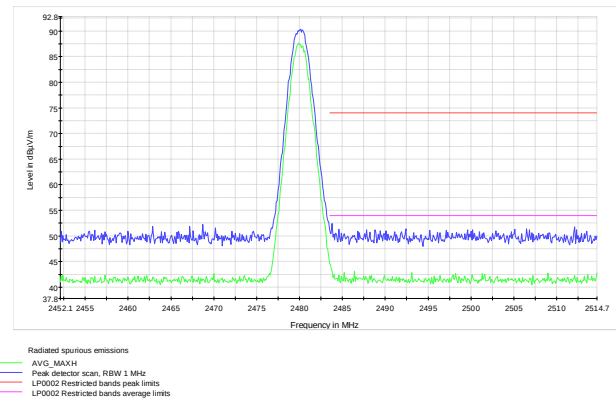
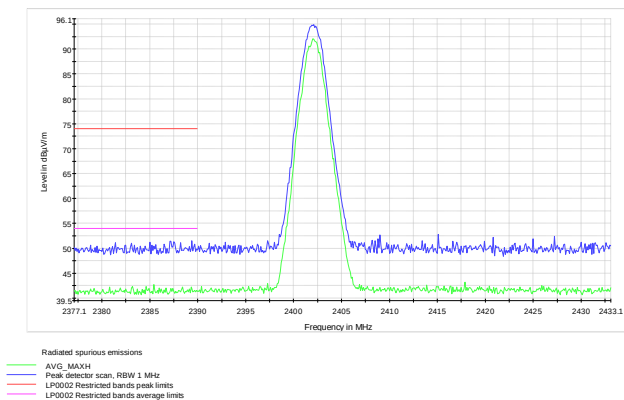

Figure 8.6-30: Band edge radiated spurious emissions at 2400 MHz, $\pi/4$ -DQPSK

Figure 8.6-31: Band edge radiated spurious emissions at 2483.5 MHz, $\pi/4$ -DQPSK


Figure 8.6-32: Band edge radiated spurious emissions at 2400 MHz, 8-DPSK

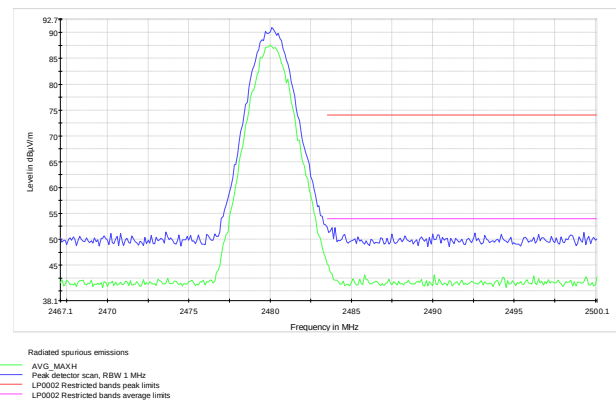


Figure 8.6-33: Band edge radiated spurious emissions at 2483.5 MHz, 8-DPSK

Test data, continued

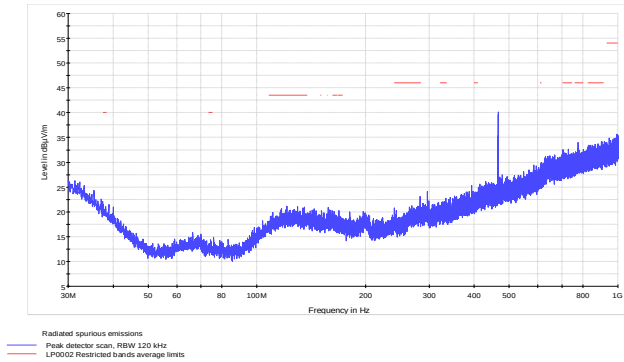


Figure 8.6-34: Radiated spurious emissions within 30–1000 MHz on low channel, GFSK

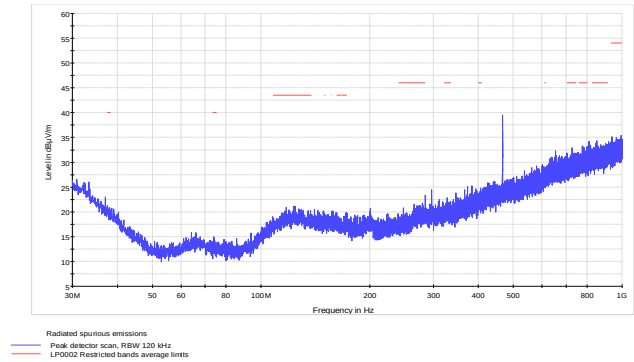


Figure 8.6-35: Radiated spurious emissions within 30–1000 MHz on mid channel, GFSK

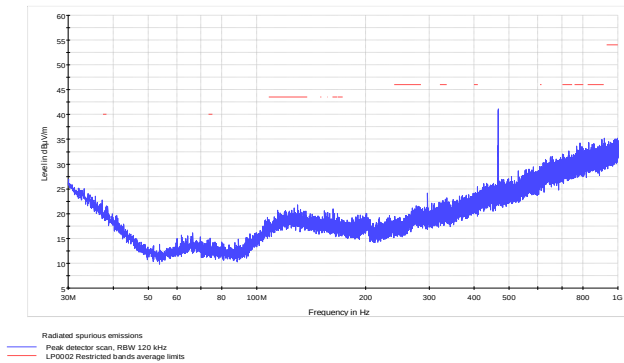


Figure 8.6-36: Radiated spurious emissions within 30–1000 MHz on top channel, GFSK

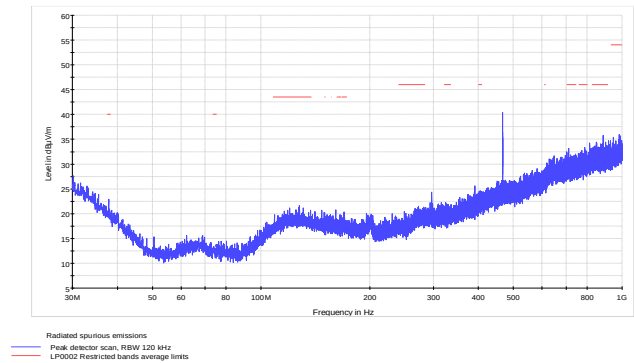


Figure 8.6-37: Radiated spurious emissions within 30–1000 MHz on low channel, $\pi/4$ -DQPSK

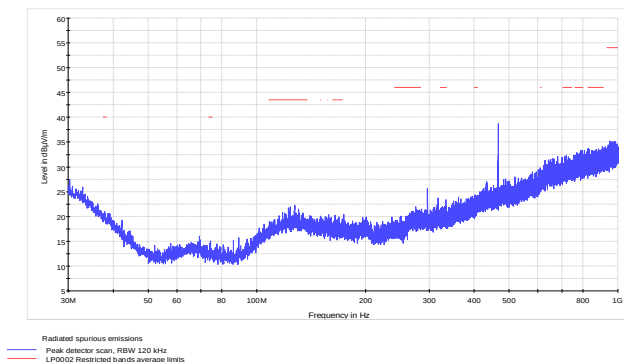


Figure 8.6-38: Radiated spurious emissions within 30–1000 MHz on mid channel, $\pi/4$ -DQPSK

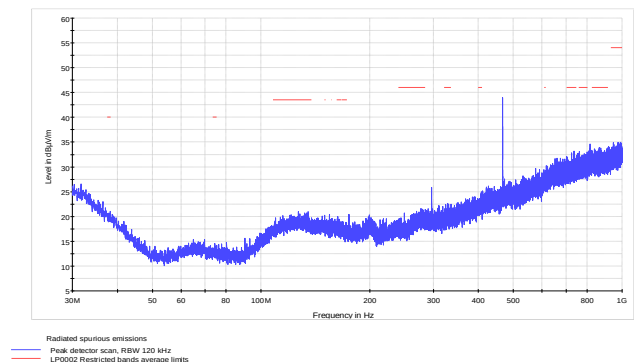


Figure 8.6-39: Radiated spurious emissions within 30–1000 MHz on top channel, $\pi/4$ -DQPSK

Test data, continued

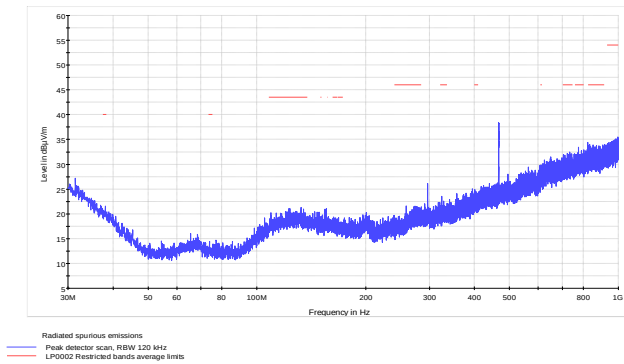


Figure 8.6-40: Radiated spurious emissions within 30–1000 MHz on low channel, 8-DPSK

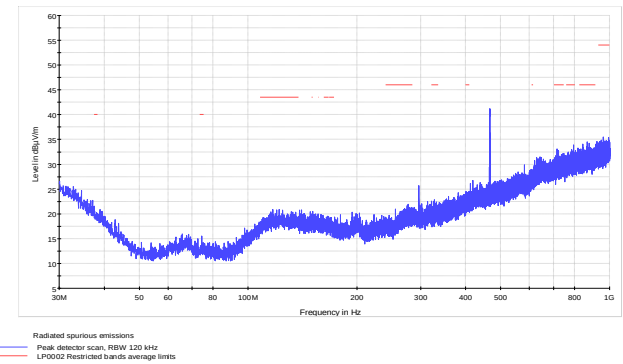


Figure 8.6-41: Radiated spurious emissions within 30–1000 MHz on mid channel, 8-DPSK

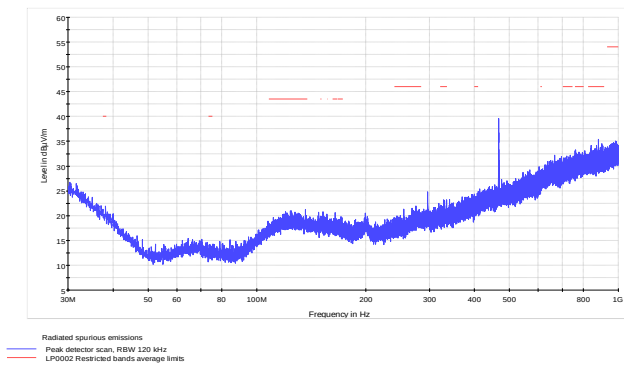


Figure 8.6-42: Radiated spurious emissions within 30–1000 MHz on top channel, 8-DPSK

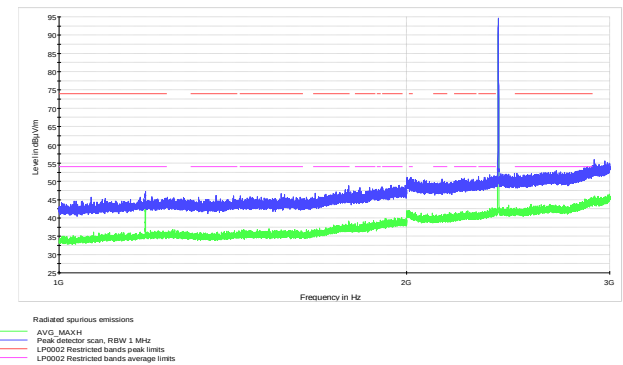


Figure 8.6-43: Radiated spurious emissions within 1–3 GHz on low channel, GFSK

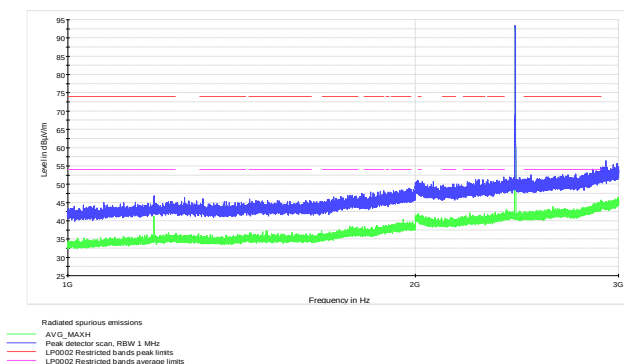


Figure 8.6-44: Radiated spurious emissions within 1–3 GHz on mid channel, GFSK

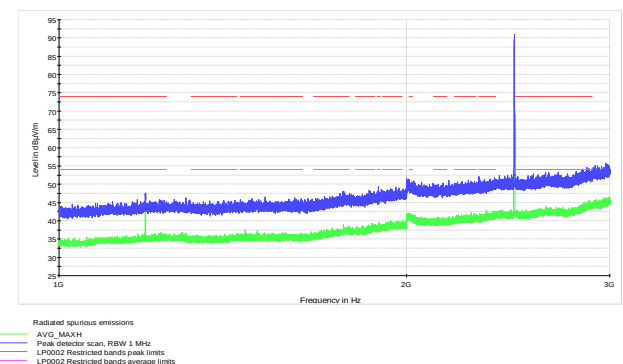


Figure 8.6-45: Radiated spurious emissions within 1–3 GHz on top channel, GFSK

Test data, continued

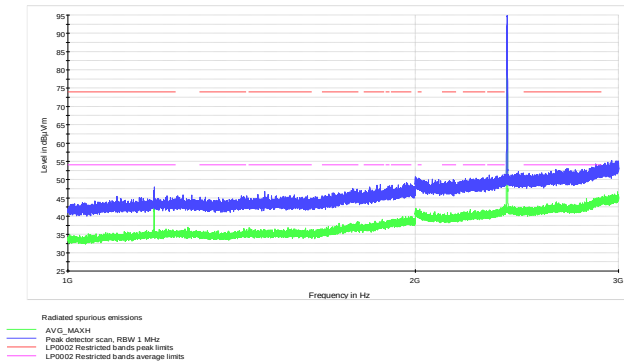


Figure 8.6-46: Radiated spurious emissions within 1–3 GHz on low channel, $\pi/4$ -DQPSK

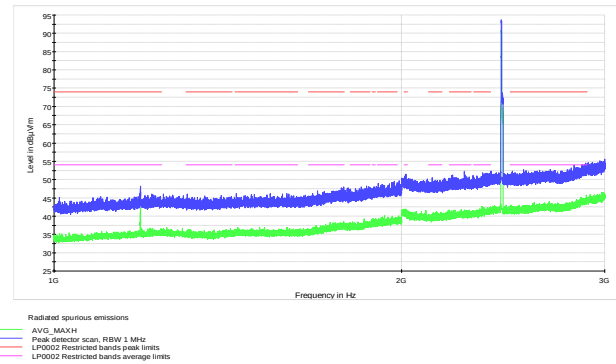


Figure 8.6-47: Radiated spurious emissions within 1–3 GHz on mid channel, $\pi/4$ -DQPSK

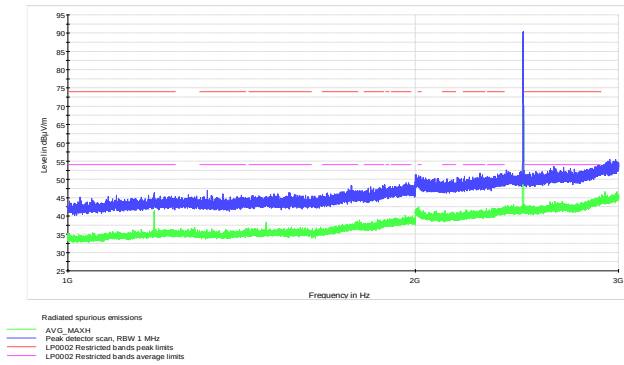


Figure 8.6-48: Radiated spurious emissions within 1–3 GHz on top channel, $\pi/4$ -DQPSK

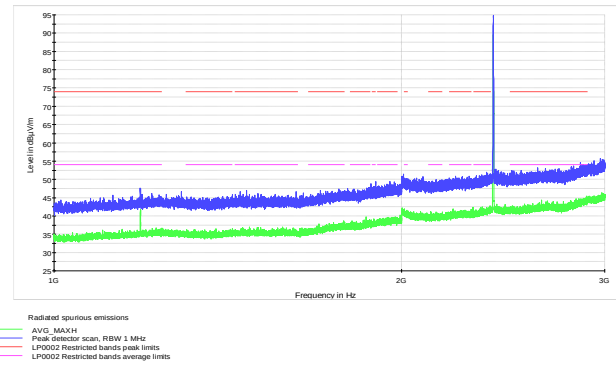


Figure 8.6-49: Radiated spurious emissions within 1–3 GHz on low channel, 8-DPSK

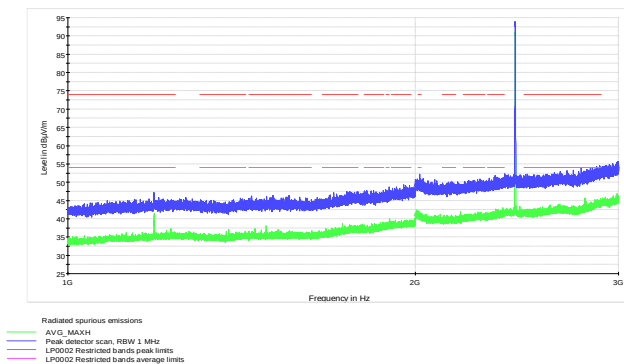


Figure 8.6-50: Radiated spurious emissions within 1–3 GHz on mid channel, 8-DPSK

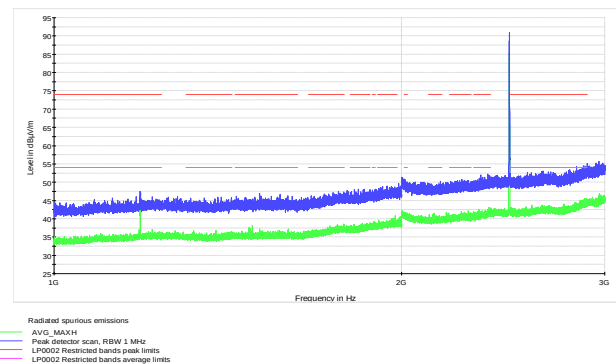


Figure 8.6-51: Radiated spurious emissions within 1–3 GHz on top channel, 8-DPSK

Test data, continued

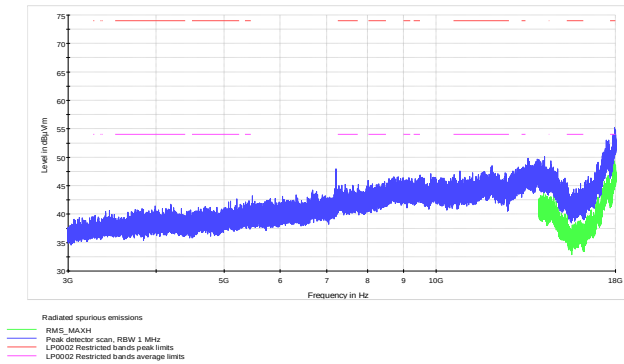


Figure 8.6-52: Radiated spurious emissions within 3–18 GHz on low channel, GFSK

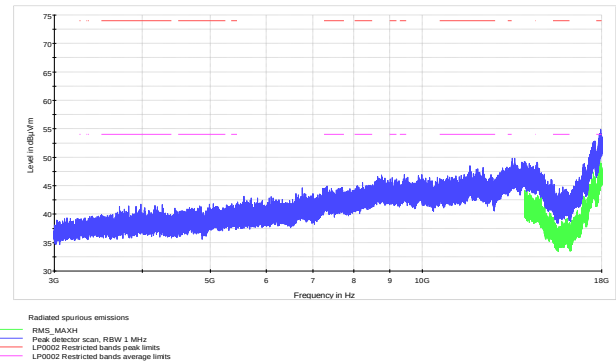


Figure 8.6-53: Radiated spurious emissions within 3–18 GHz on mid channel, GFSK

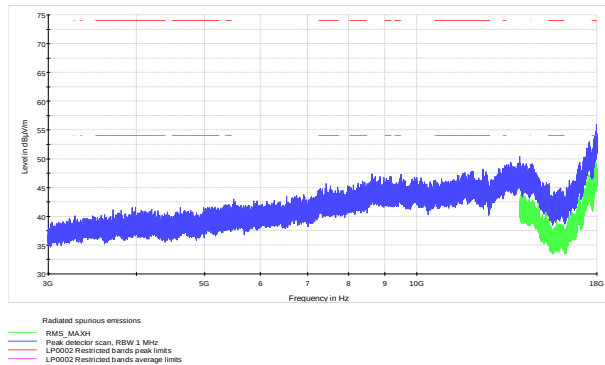


Figure 8.6-54: Radiated spurious emissions within 3–18 GHz on top channel, GFSK

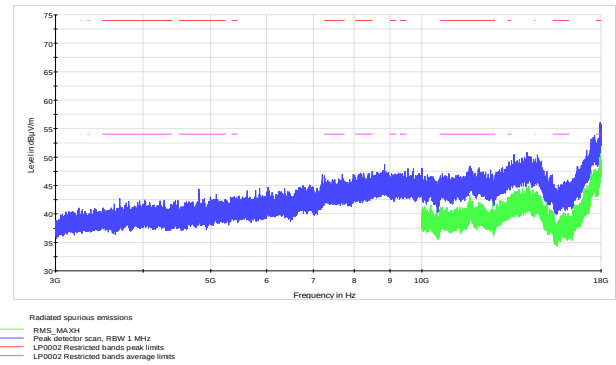


Figure 8.6-55: Radiated spurious emissions within 3–18 GHz on low channel, $\pi/4$ -DQPSK

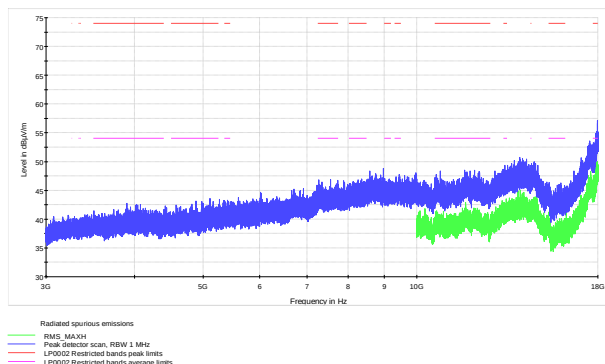


Figure 8.6-56: Radiated spurious emissions within 3–18 GHz on mid channel, $\pi/4$ -DQPSK

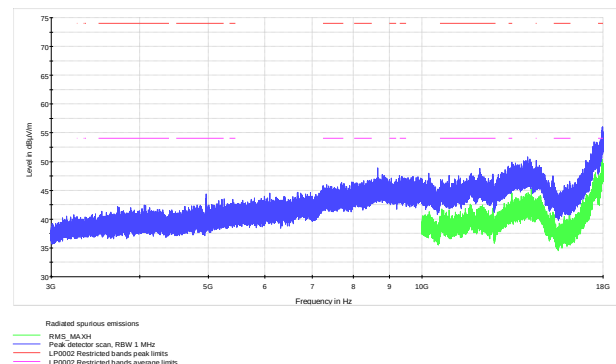


Figure 8.6-57: Radiated spurious emissions within 3–18 GHz on top channel, $\pi/4$ -DQPSK

Test data, continued

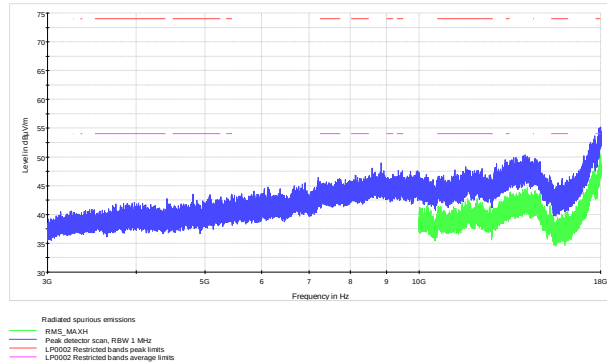


Figure 8.6-58: Radiated spurious emissions within 3–18 GHz on low channel, 8-DPSK

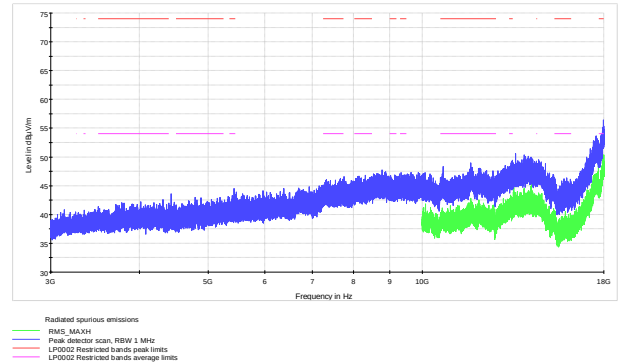


Figure 8.6-59: Radiated spurious emissions within 3–18 GHz on mid channel, 8-DPSK

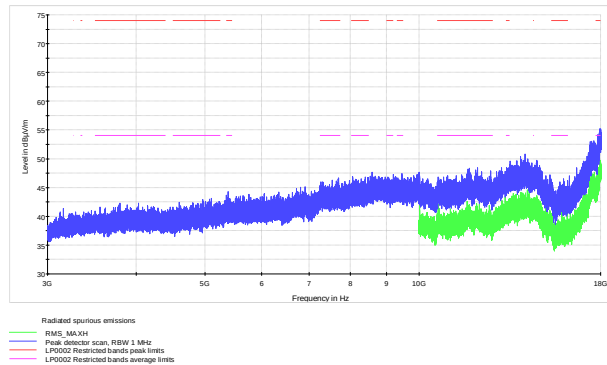


Figure 8.6-60: Radiated spurious emissions within 3–18 GHz on top channel, 8-DPSK

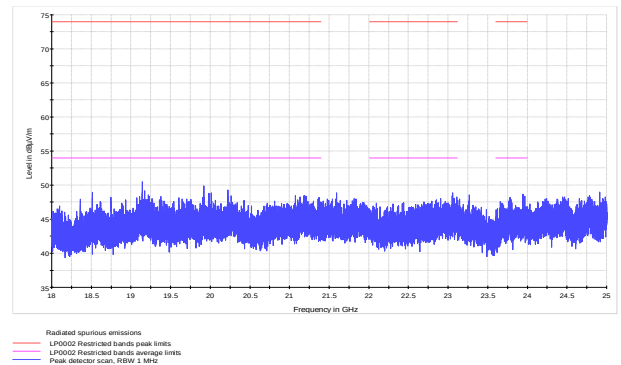


Figure 8.6-61: Radiated spurious emissions within 18–25 GHz on low channel, GFSK

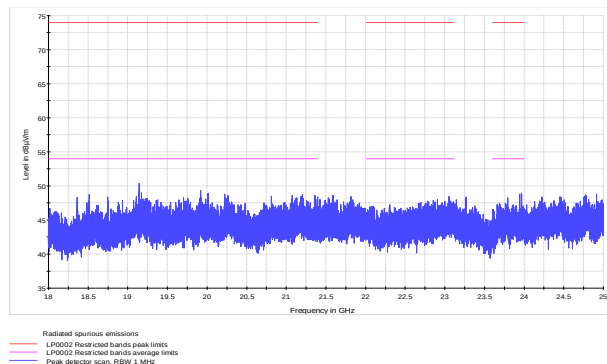


Figure 8.6-62: Radiated spurious emissions within 18–25 GHz on mid channel, GFSK

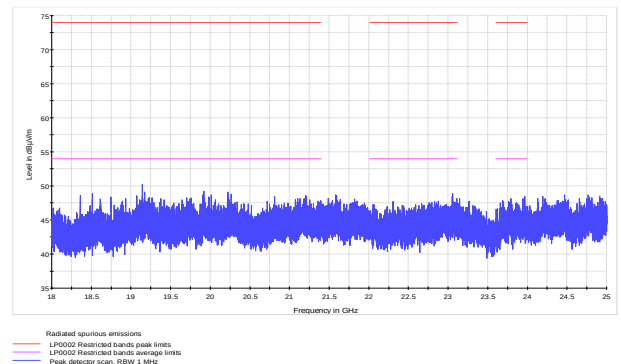


Figure 8.6-63: Radiated spurious emissions within 18–25 GHz on top channel, GFSK

Test data, continued

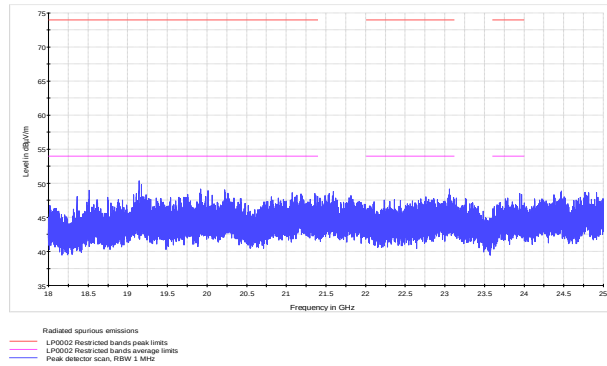


Figure 8.6-64: Radiated spurious emissions within 18–25 GHz on low channel, $\pi/4$ -DQPSK

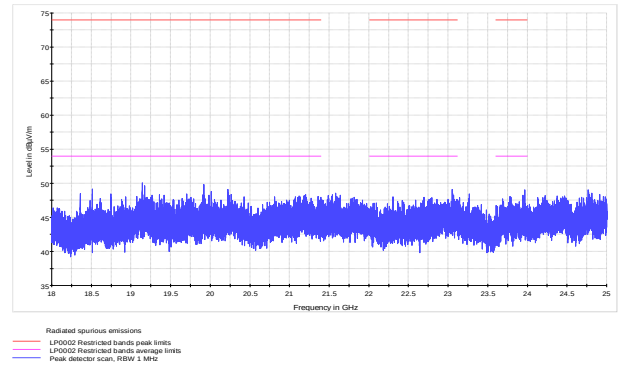


Figure 8.6-65: Radiated spurious emissions within 18–25 GHz on mid channel, $\pi/4$ -DQPSK

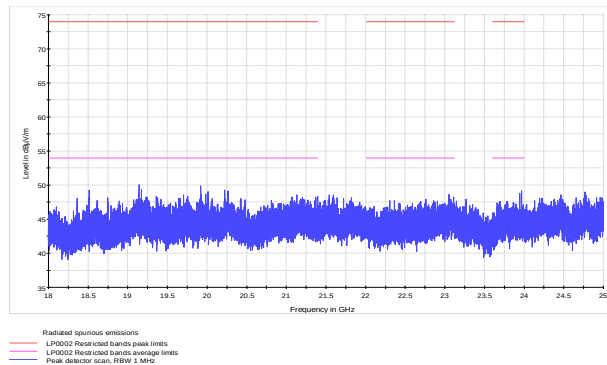


Figure 8.6-66: Radiated spurious emissions within 18–25 GHz on top channel, $\pi/4$ -DQPSK

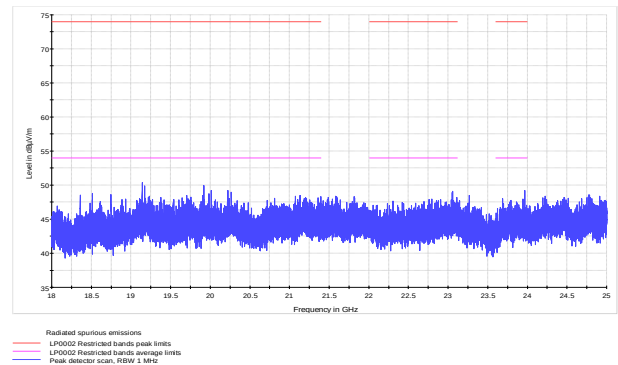


Figure 8.6-67: Radiated spurious emissions within 18–25 GHz on low channel, 8-DPSK

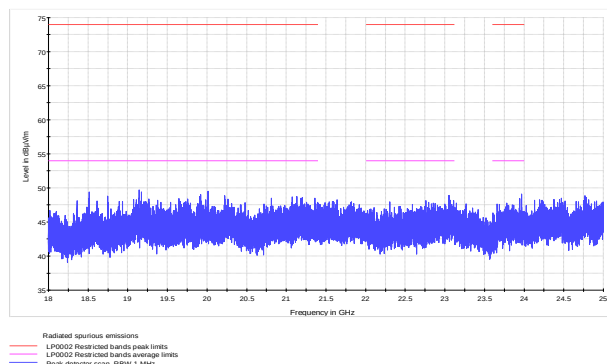


Figure 8.6-68: Radiated spurious emissions within 18–25 GHz on mid channel, 8-DPSK

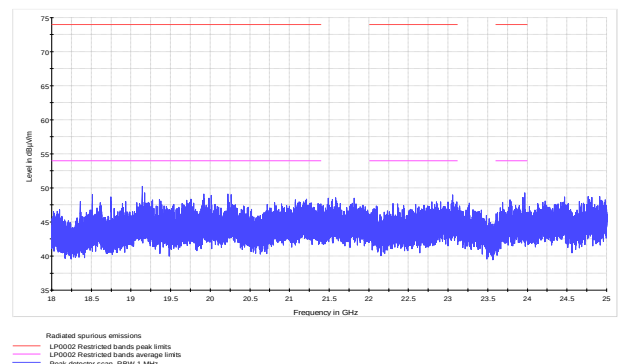


Figure 8.6-69: Radiated spurious emissions within 18–25 GHz on top channel, 8-DPSK

8.7 (跳頻系統) Frequency Hopping Systems requirements (Bluetooth)

8.7.1 References, definitions and limits

LP0002, Clause 4.10.1.6

Other limits:

- (1) Frequency hopping systems:
 - (A) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. However, frequency hopping systems with output power less than or equal to 125 mW, the intervals of hopping channel carrier frequencies shall not be less than 25 kHz or two thirds of the 20 dB bandwidth of the hopping channel, whichever is greater.
 - (a) Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 non-overlapping channels. The average time of occupancy on any channel shall be less than or equal to 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. The intelligent hopping techniques shall be used to avoid the occupancy on specific frequency hopping channel.

8.7.2 Test summary

Verdict	Pass		
Tested by	Andrey Adelberg	Test date	March 10, 2021

8.7.3 Observations, settings and special notes

Carrier frequency separation was tested per ANSI C63.10 subclause 7.8.2. Spectrum analyser settings:

Resolution bandwidth	Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
Video bandwidth	≥ RBW
Frequency span	Wide enough to capture the peaks of two adjacent channels
Detector mode	Peak
Trace mode	Max Hold

Number of hopping frequencies was tested per ANSI C63.10 subclause 7.8.3. Spectrum analyser settings:

Resolution bandwidth	To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
Video bandwidth	≥ RBW
Frequency span	The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
Detector mode	Peak
Trace mode	Max Hold

Time of occupancy (dwell time) was tested per ANSI C63.10 subclause 7.8.4. Spectrum analyser settings:

Resolution bandwidth	shall be ≤ channel spacing and where possible RBW should be set $\gg 1/T$, where T is the expected dwell time per channel.
Video bandwidth	≥ RBW
Frequency span	Zero span, centered on a hopping channel.
Detector mode	Peak
Trace mode	Max Hold

Observations, settings and special notes, continued

20 dB bandwidth was tested per ANSI C63.10 subclause 6.9.2. Spectrum analyser settings:

Resolution bandwidth	100 kHz
Video bandwidth	≥ RBW
Frequency span	3 MHz
Detector mode	Peak
Trace mode	Max Hold

8.7.4 Test data

Table 8.7-1: Occupied bandwidth results

Modulation	Frequency, MHz	99% occupied bandwidth, MHz	20 dB bandwidth, MHz
GFSK	2402	0.879	1.110
GFSK	2441	0.873	1.110
GFSK	2480	0.872	1.100
8-DPSK	2402	1.223	1.430
8-DPSK	2441	1.222	1.430
8-DPSK	2480	1.224	1.440
$\pi/4$ -DQPSK	2402	1.219	1.440
$\pi/4$ -DQPSK	2441	1.218	1.440
$\pi/4$ -DQPSK	2480	1.220	1.440

Table 8.7-2: Carrier frequency separation results

Mode of hopping operation	Carrier frequency separation, kHz
BR DH1 15 bytes	1005
BR DH3 127 bytes	1003
BR DH5 255 bytes	1003
BR Long DH5 339 bytes	1003
EDR2 2DH5 679 bytes	1008
EDR3 3DH5 1021 bytes	1003

Note: Maximum measured output power is 1.75 dBm (8-DPSK), it is less than 125 mW (21 dBm) therefore there is no minimum carrier separation limit.

Test data, continued

Table 8.7-3: Number of hopping frequencies results

Mode of hopping operation	Number of hopping frequencies	Minimum limit	Margin
BR DH1 15 bytes	79	15	64
BR DH3 127 bytes	79	15	64
BR DH5 255 bytes	79	15	64
BR Long DH5 339 bytes	79	15	64
EDR2 2DH5 679 bytes	79	15	64
EDR3 3DH5 1021 bytes	79	15	64

Table 8.7-4: Average time of occupancy results

Mode of hopping operation	Dwell time of each pulse, ms	Minimum time between RF burst on the same channel, ms	Average time of occupancy, ms	Limit, ms	Margin, ms
BR DH1 15 bytes	0.291	63.8	144.132	400.000	255.868
BR DH3 127 bytes	1.195	452.7	83.415	400.000	316.585
BR DH5 255 bytes	2.220	389.5	180.108	400.000	219.892
BR Long DH5 339 bytes	2.895	405.1	225.826	400.000	174.174
EDR2 2DH5 679 bytes	2.895	411.9	222.098	400.000	177.902
EDR3 3DH5 1021 bytes	2.895	427.9	213.793	400.000	186.207

Note: Average time of occupancy was calculated as follows: (Dwell time × 400 ms × 79 channels) / Minimum time between bursts

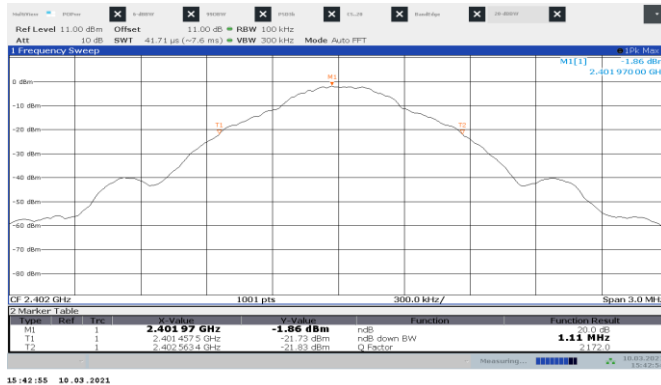


Figure 8.7-1: 20 dB bandwidth on low channel, GFSK

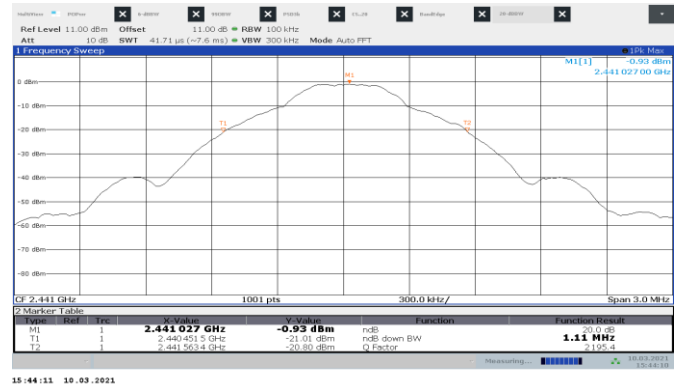


Figure 8.7-2: 20 dB bandwidth on mid channel, GFSK

Test data, continued

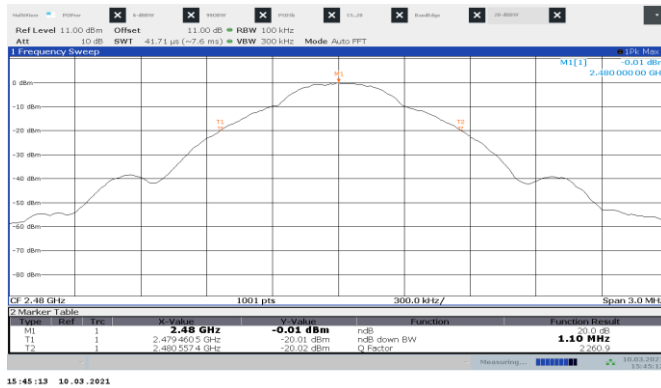


Figure 8.7-3: 20 dB bandwidth on high channel, GFSK

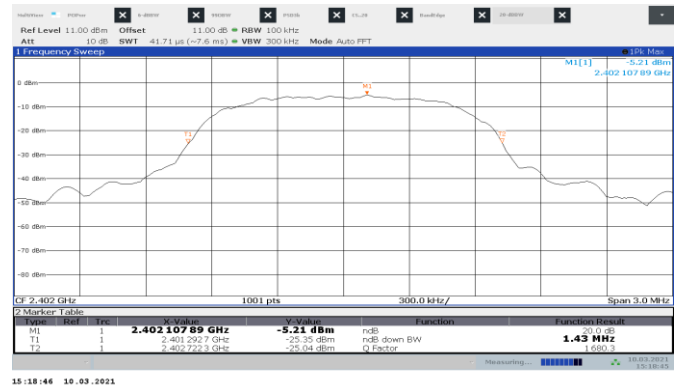


Figure 8.7-4: 20 dB bandwidth on low channel, 8-DPSK

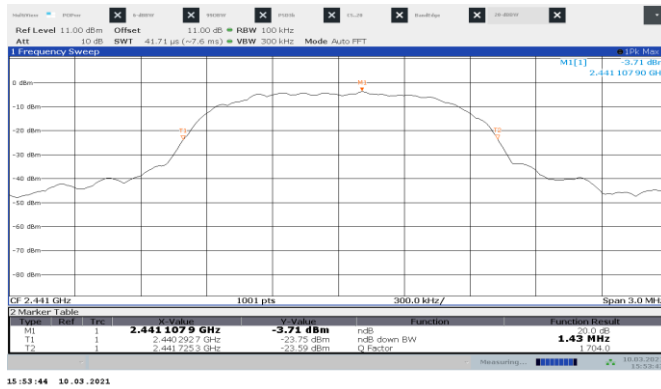


Figure 8.7-5: 20 dB bandwidth on mid channel, 8-DPSK

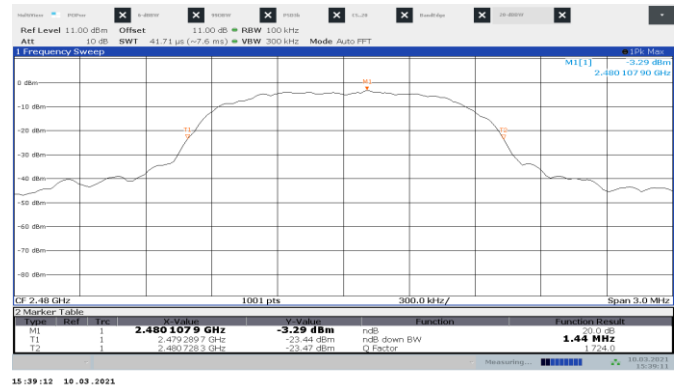


Figure 8.7-6: 20 dB bandwidth on high channel, 8-DPSK

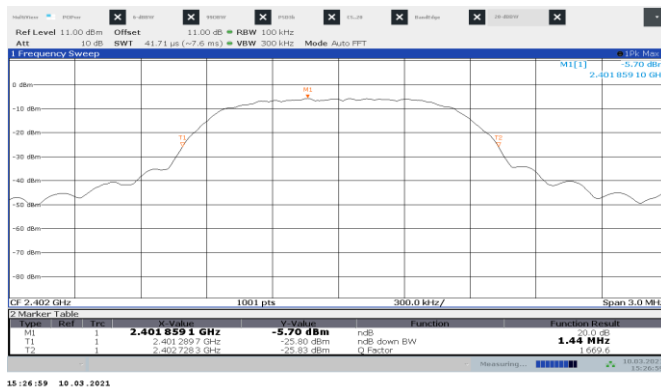


Figure 8.7-7: 20 dB bandwidth on low channel, $\pi/4$ -DQPSK

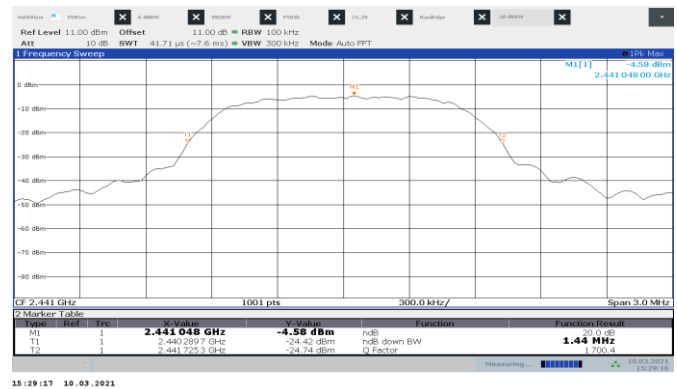


Figure 8.7-8: 20 dB bandwidth on mid channel, $\pi/4$ -DQPSK

Test data, continued

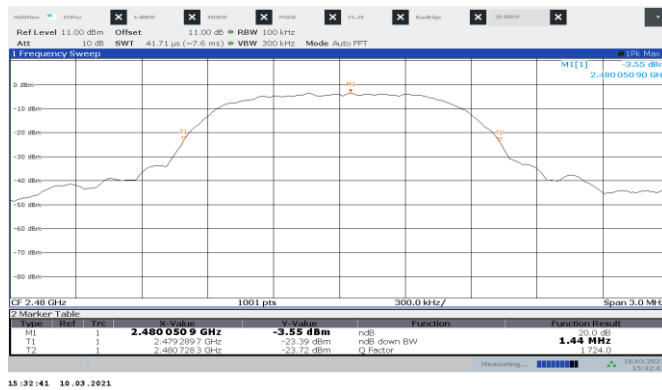
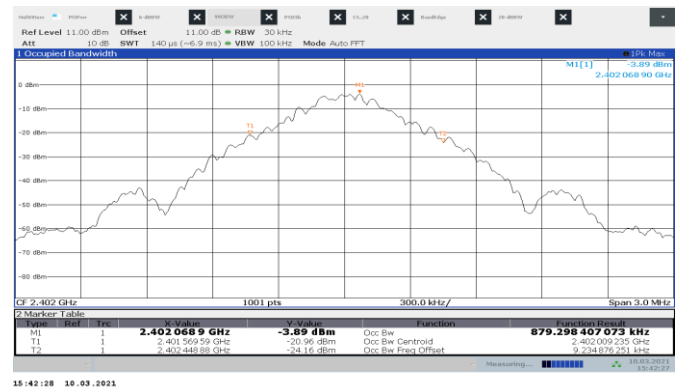

Figure 8.7-9: 20 dB bandwidth on high channel, $\pi/4$ -DQPSK


Figure 8.7-10: 99% occupied bandwidth on low channel, GFSK

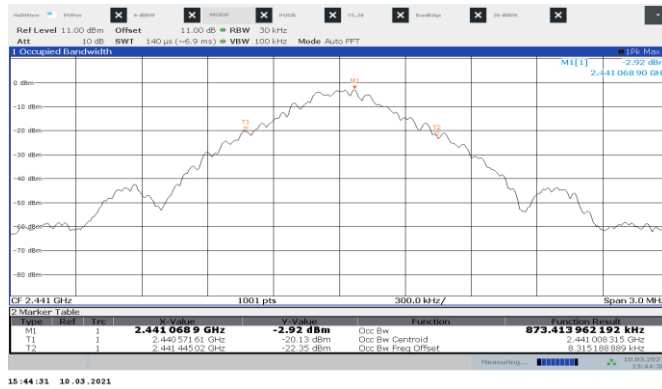


Figure 8.7-11: 99% occupied bandwidth on mid channel, GFSK

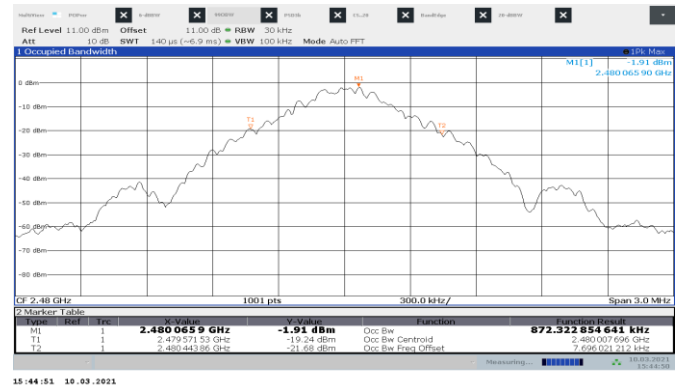


Figure 8.7-12: 99% occupied bandwidth on high channel, GFSK

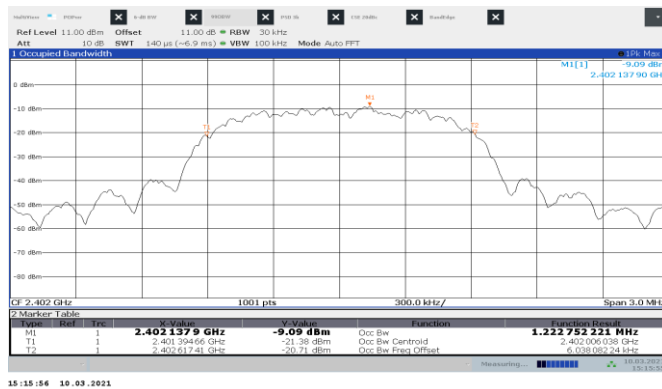


Figure 8.7-13: 99% occupied bandwidth on low channel, 8-DPSK

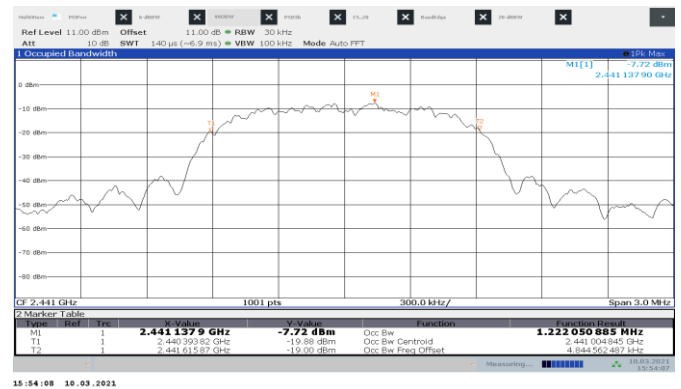


Figure 8.7-14: 99% occupied bandwidth on mid channel, 8-DPSK

Test data, continued

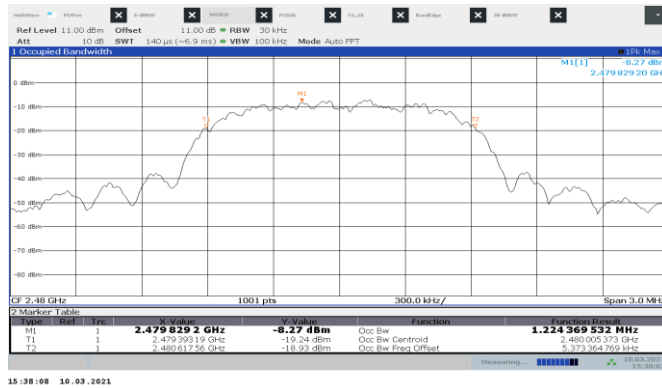


Figure 8.7-15: 99% occupied bandwidth on high channel, 8-DPSK

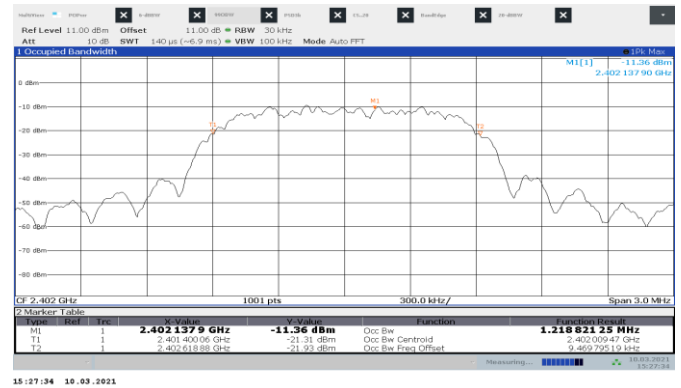


Figure 8.7-16: 99% occupied bandwidth on low channel, $\pi/4$ -DQPSK

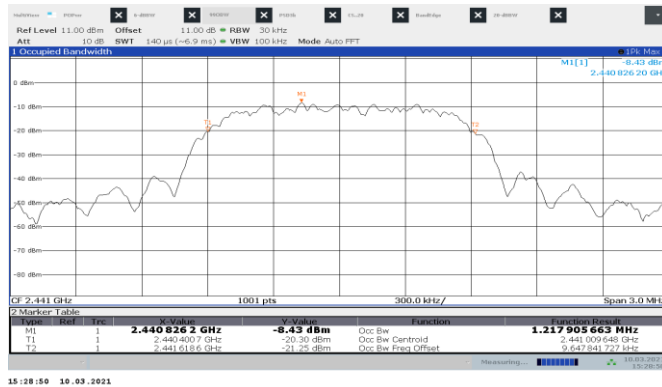


Figure 8.7-17: 99% occupied bandwidth on mid channel, $\pi/4$ -DQPSK

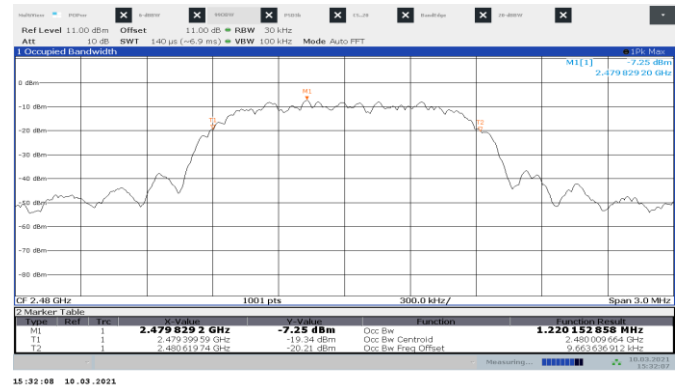


Figure 8.7-18: 99% occupied bandwidth on high channel, $\pi/4$ -DQPSK

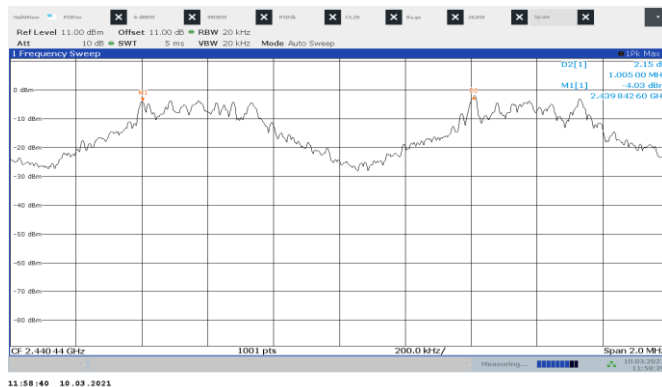


Figure 8.7-19: Carrier frequency separation, BR DH1 15 bytes

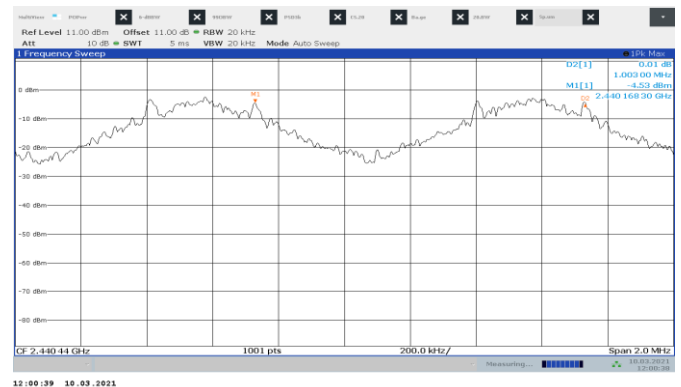


Figure 8.7-20: Carrier frequency separation, BR DH3 127 bytes

Test data, continued

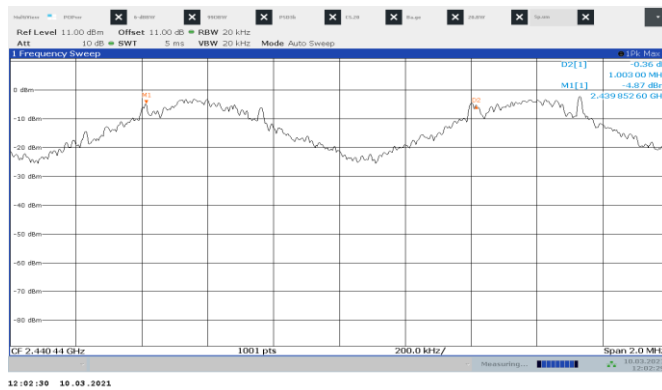


Figure 8.7-21: Carrier frequency separation, BR DH5 255 bytes

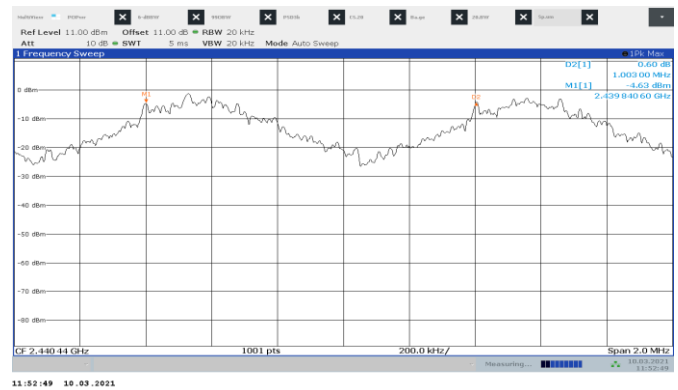


Figure 8.7-22: Carrier frequency separation, BR Long DH5 339 bytes

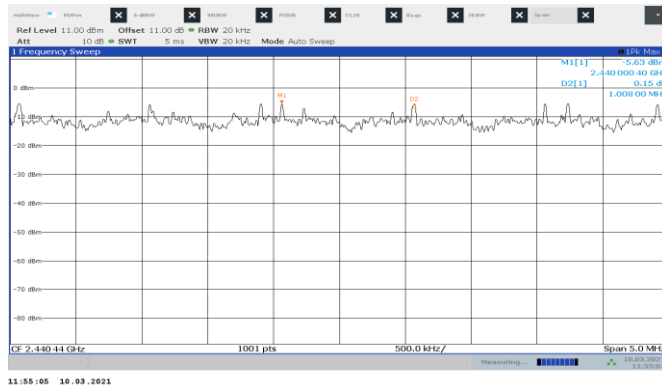


Figure 8.7-23: Carrier frequency separation, EDR2 2DH5 679 bytes

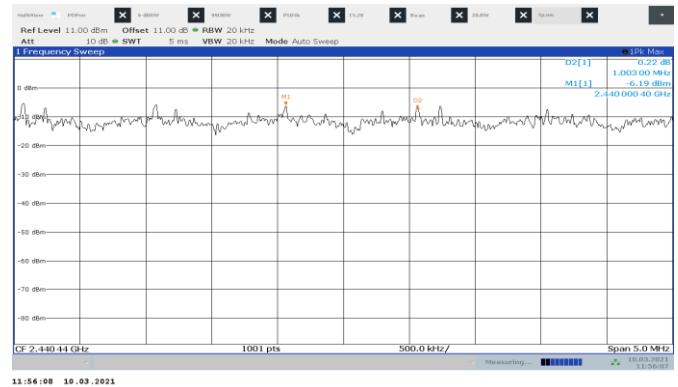


Figure 8.7-24: Carrier frequency separation, EDR3 3DH5 1021 bytes

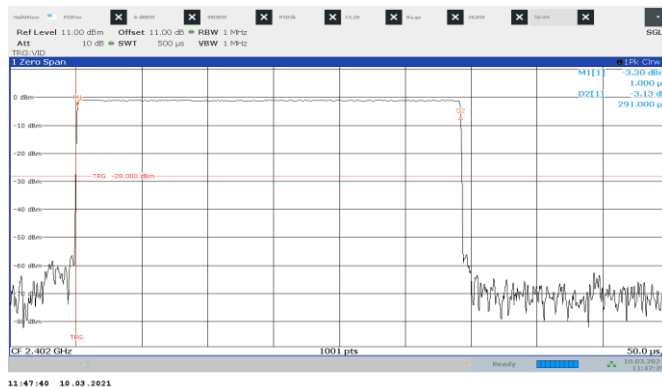


Figure 8.7-25: Burst length, BR DH1 15 bytes

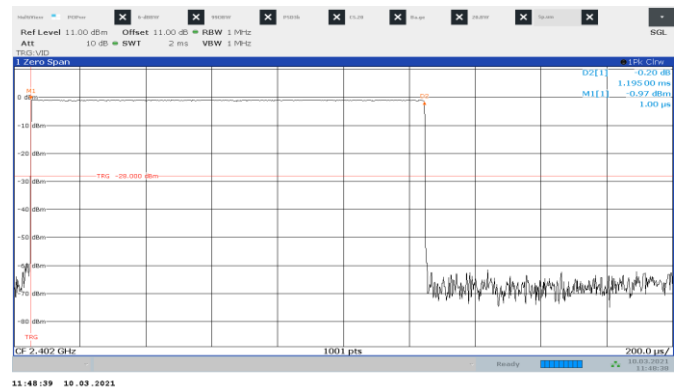


Figure 8.7-26: Burst length, BR DH3 127 bytes

Test data, continued

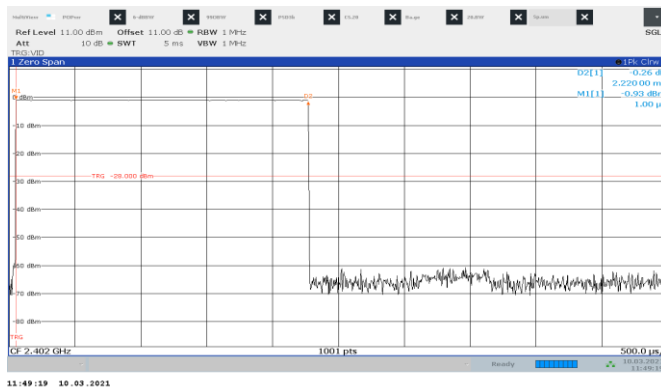


Figure 8.7-27: Burst length, BR DH5 255 bytes

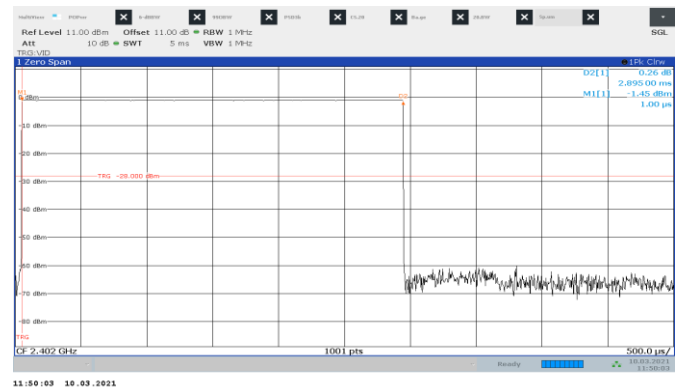


Figure 8.7-28: Burst length, BR Long DH5 339 bytes

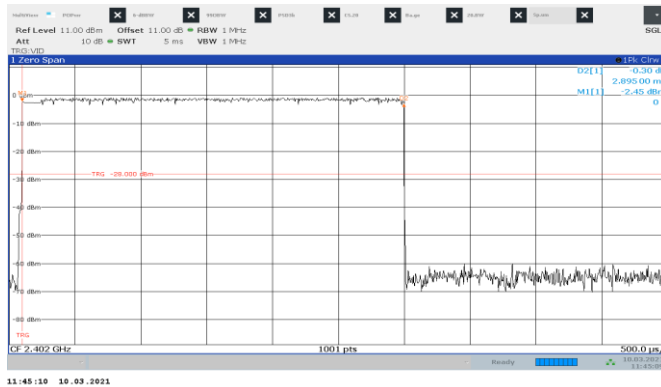


Figure 8.7-29: Burst length, EDR2 2DH5 679 bytes

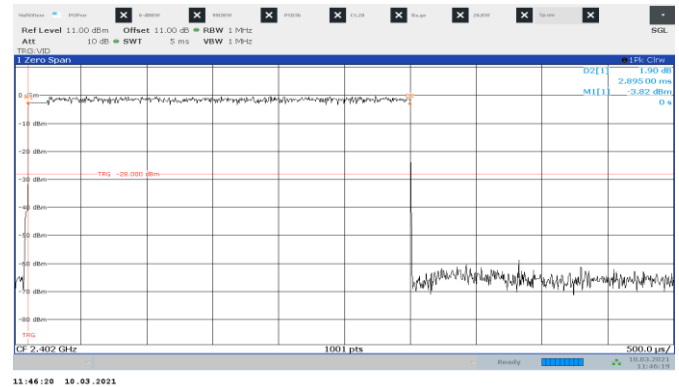


Figure 8.7-30: Burst length, EDR3 3DH5 1021 bytes

8.8 (峰值传输电功率密度) Power spectral density for digitally modulated devices (BLE)

8.8.1 References, definitions and limits

LP0002, Clause 4.10.1.6:

Other limits:

- (2) Digital modulation techniques system:
- (B) For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall be less than or equal to 8 dBm in any 3 kHz band during any time interval of continuous transmission, and shall reduce the power spectral density requirement according to the Section 4.10.1.3.

8.8.2 Test summary

Verdict	Pass		
Tested by	Andrey Adelberg	Test date	March 10, 2021

8.8.3 Observations, settings and special notes

Power spectral density test was performed as per KDB 558074, section 8.4 with reference to ANSI C63.10 subclause 11.10.

The test was performed using method PKPSD (peak PSD).

Spectrum analyser settings:

Resolution bandwidth:	3 kHz
Video bandwidth:	$\geq 3 \times \text{RBW}$
Frequency span:	10 MHz
Detector mode:	Peak
Trace mode:	Max-hold

8.8.4 Test data

Table 8.8-1: PSD results (antenna port measurement)

Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
2402	-10.86	8.00	18.86
2440	-10.15	8.00	18.15
2480	-9.21	8.00	17.21

Test data, continued

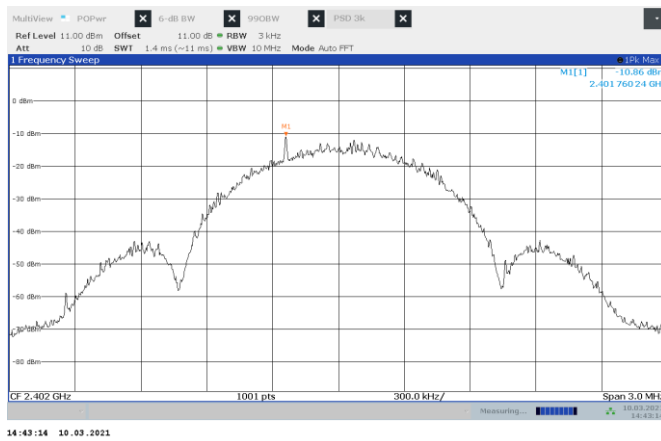


Figure 8.8-1: PSD on low channel

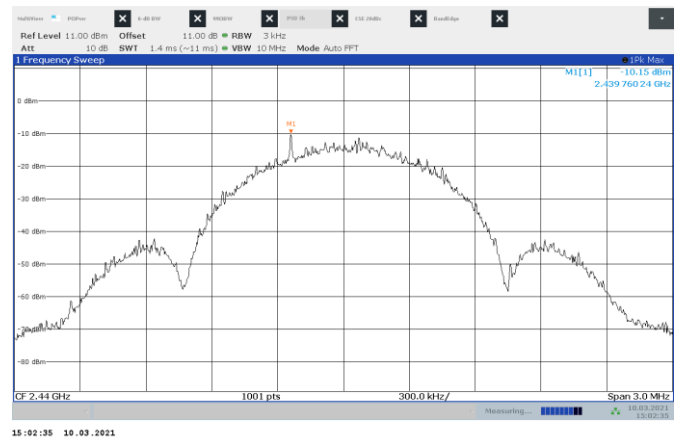


Figure 8.8-2: PSD on mid channel

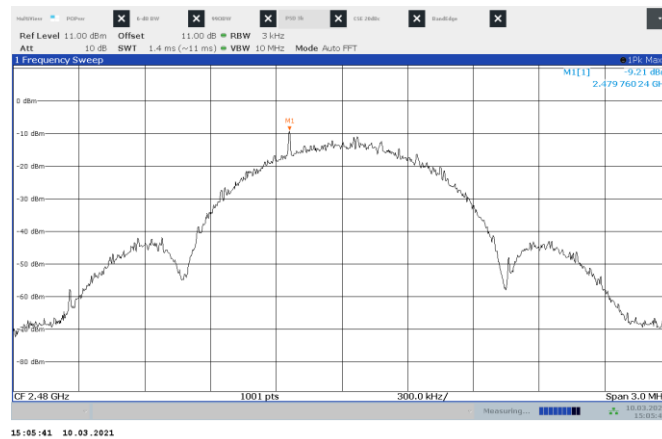


Figure 8.8-3: PSD on top channel

Section 9 EUT photos

9.1 External photos



Figure 9.1-1: Front view photo

External photos, continued



Figure 9.1-2: Back view photo

External photos, continued



Figure 9.1-3: Side view photo

External photos, continued

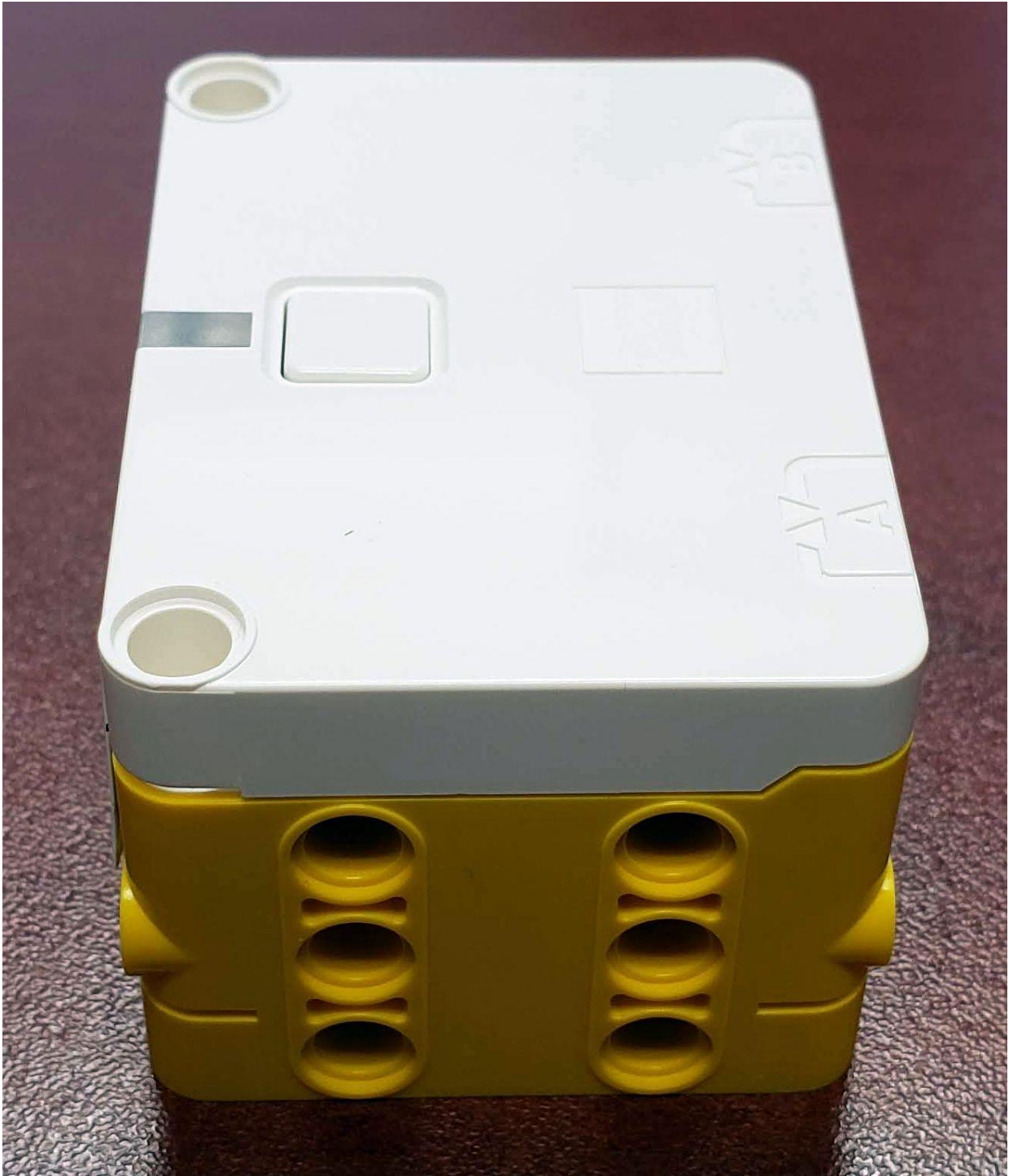


Figure 9.1-4: Side view photo

External photos, continued



Figure 9.1-5: Top view photo

External photos, continued

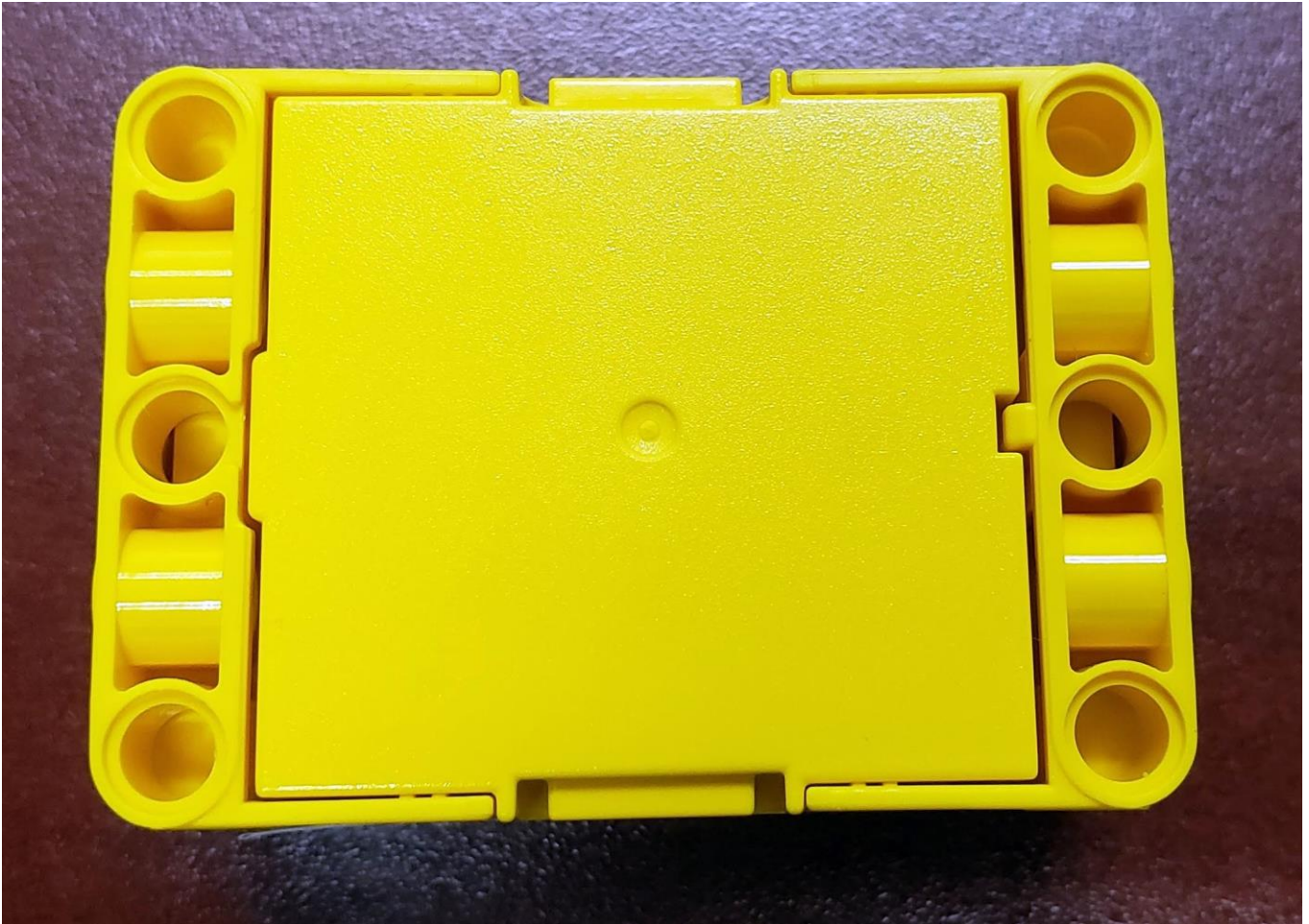


Figure 9.1-6: Bottom view photo

External photos, continued



Figure 9.1-7: Battery compartment view photo

End of the test report