

Wireless test report – 345842-2TRFWL

Applicant:

LEGO System A/S

Product name:

Bluetooth Low Energy Transceiver

Model:

HANDSET NO.2

FCC ID:

NPI 28739

ISED Registration number:

3072A-28739

Specifications:

Low Power 0002 (LP0002) January 10, 2018

Low-power Radio-frequency Devices

Clause 3.10.1 Intentional radiators employing frequency hopping spread spectrum and digital modulation techniques

Date of issue: **June 28, 2018**

Test engineer(s): **Andrey Adelberg, Senior Wireless/EMC Specialist**

Signature:



Reviewed by: **Kevin Rose, Wireless/EMC Specialist**

Signature:



Test location(s)

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Site number	FCC: CA2040; ISED: 2040A-4 (3 m SAC)	FCC: CA2041; ISED: 2040G-5 (3 m SAC)

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 Applicant and manufacturer

Company name	LEGO System A/S
Address	Åstvej 1
City	Billund
Province/State	N/A
Postal/Zip code	7190
Country	Denmark

1.2 Test specifications

LP0002 January 10, 2018, Clause 3.10.1	Intentional radiators employing frequency hopping spread spectrum and digital modulation techniques
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1.3 Test methods

558074 D01 DTS Meas Guidance v04 (April 5, 2017)	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
ANSI C64.3 v 2003	American National Standard for Methods of Measurement of Radio- Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

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 1.5 below. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See "Summary of test results" for full details.

1.5 Exclusions

None

1.6 Test report revision history

Revision #	Date of issue	Details of changes made to test report
TRF	June 28, 2018	Original report issued

Section 2. Summary of test results

2.1 LP0002, intentional radiators test results

Part	Test description	Verdict
2.3	Conducted limits	Not applicable
3.10.1.2 (1)(A) or (B)	Maximum peak output power for frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
3.10.1.2 (1)(C)	Maximum peak output power of systems using digital modulation in the 2400–2483.5 MHz band	Pass
3.10.1.2 (2)	Maximum peak output power for frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
3.10.1.3 (1)(A)	Fixed point-to-point operation within 2.4 GHz band with directional antenna gains greater than 6 dBi	Not applicable
3.10.1.3 (1)(B)	Transmitters that emit multiple directional beams	Not applicable
3.10.1.3 (2)	Fixed point-to-point operation within 5.8 GHz band with directional antenna gains greater than 6 dBi	Not applicable
3.10.1.5	Limits on emissions outside the frequency band (Spurious emissions)	Pass
3.10.1.6 (1)(A)	Hopping channel carrier frequencies separation requirements	Not applicable
3.10.1.6 (1)(A)(a)	Frequency hopping systems operating in the 2400–2483.5 MHz band, other requirements	Not applicable
3.10.1.6 (1)(A)(b)	Frequency hopping systems operating in the 5725–5850 MHz band, other requirements	Not applicable
3.10.1.6 (2)(A)	Minimum 6 dB bandwidth for systems using digital modulation techniques	Pass
3.10.1.6 (2)(B)	Power spectral density for digitally modulated devices	Pass
3.10.1.6 (3)	Hybrid systems requirements	Not applicable

Notes: EUT is a battery-operated equipment, the testing was performed using fresh batteries.

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	June 25, 2018
Nemko sample ID number	2

3.2 EUT information

Product name	Bluetooth Low Energy Transceiver
Model	HANDSET NO.2
Serial number	N/A

3.3 Technical information

Frequency band	2400–2483.5 MHz
Frequency Min (MHz)	2402
Frequency Max (MHz)	2480
RF power Min (W)	N/A
RF power Max (W), Conducted	0.000873 (–0.59 dBm)
Field strength, Units @ distance	N/A
Measured BW (kHz) (99 %)	1048
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	GFSK
Emission classification (F1D, G1D, D1D)	F1D
Transmitter spurious, dBμV/m @ 3 m	47.46 (average) at 2483.5 MHz
Power requirements	6 V _{DC} from 4 × ‘AAA’ type of batteries
Antenna information	Integral antenna with 2.1 dBi gain

3.4 Product description and theory of operation

The device tested is a system with a central HUB which controls a motor and a LED. The system functions with a dedicated remote connection to the central HUB, or by a remote device (iOS, Android or similar) running a dedicated app connected via BLE.

3.5 EUT exercise details

EUT was connected to the Laptop and with the use of RF module software was set to transmit on the desired channels with the maximum allowed by the software output power settings.

3.6 EUT setup diagram

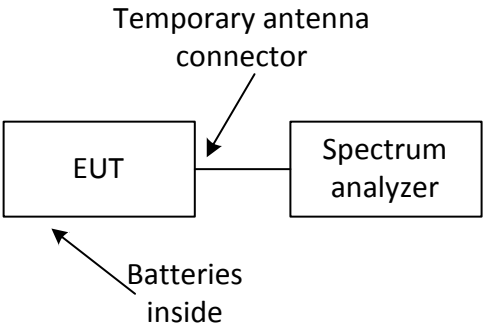


Figure 3.6-1: Setup diagram for antenna port measurements

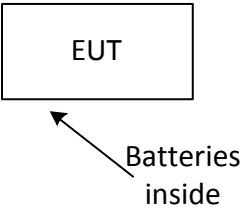


Figure 3.6-2: Setup diagram for radiated measurements

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT

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

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5. Test conditions

5.1 Atmospheric conditions

Temperature	15–30 °C
Relative humidity	20–75 %
Air pressure	860–1060 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.

5.2 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 6. Measurement uncertainty

6.1 Uncertainty of measurement

Nemko Canada Inc. has calculated measurement uncertainty and is documented in EMC/MUC/001 "Uncertainty in EMC measurements." Measurement uncertainty was calculated using the methods described in CISPR 16-4 Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainty in EMC measurements; as well as described in UKAS LAB34: The expression of Uncertainty in EMC Testing. Measurement uncertainty calculations assume a coverage factor of $K=2$ with 95% certainty.

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	Dec. 09/18
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	March 26/19
Spectrum analyzer	Rohde & Schwarz	FSU	FA001877	1 year	July 18/18
Horn with Preamp (1–18 GHz)	ETS-Lindgren	3117	FA002840	1 year	Dec. 07/18
Horn antenna (18–40 GHz)	EMCO	3116	FA001847	1 year	June 27/18
Pre-amplifier (18–26 GHz)	Narda	BBS-1826N612	FA001550	—	VOU

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

Section 8. Testing data

8.1 Clause 3.10.1.6 (2)(A) Minimum 6 dB bandwidth for systems using digital modulation techniques

8.1.1 Definitions and limits

For digitally modulated systems, the minimum 6 dB bandwidth shall be at least 500 kHz.

8.1.2 Test summary

Start date June 25, 2018

8.1.3 Observations, settings and special notes

Spectrum analyser settings:

Resolution bandwidth:	100 kHz
Video bandwidth:	$\geq 3 \times \text{RBW}$
Frequency span:	2 MHz
Detector mode:	Peak
Trace mode:	Max Hold

8.1.4 Test data

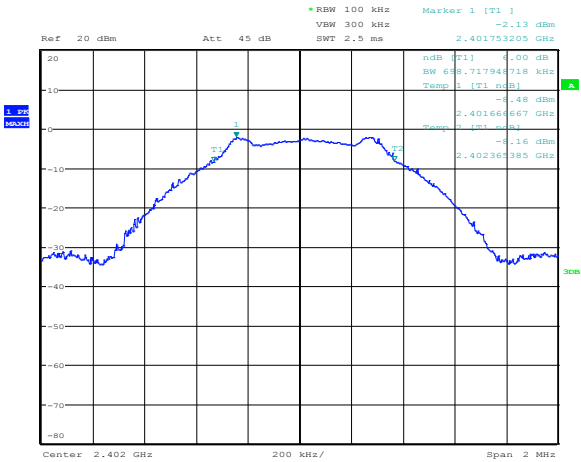
Table 8.1-1: 6 dB bandwidth results

Frequency, MHz	6 dB bandwidth, kHz	Minimum limit, kHz	Margin, kHz
2402	698.72	500.00	198.72
2440	714.74	500.00	214.74
2480	724.36	500.00	224.36

Table 8.1-2: 99 % bandwidth results

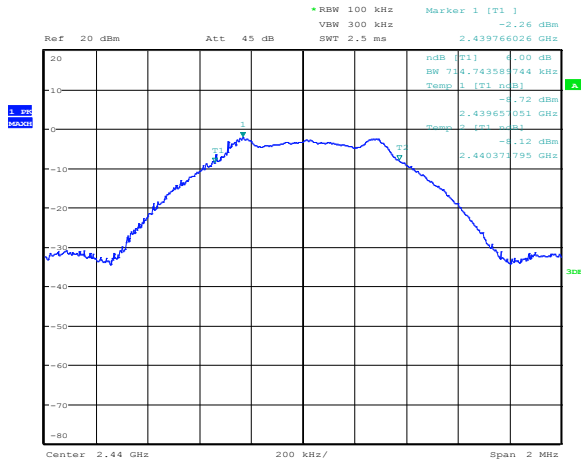
Frequency, MHz	99 % bandwidth, MHz
2402	1.048
2440	1.054
2480	1.061

Note: There is no 99% occupied bandwidth requirement, this value is reported for information only.



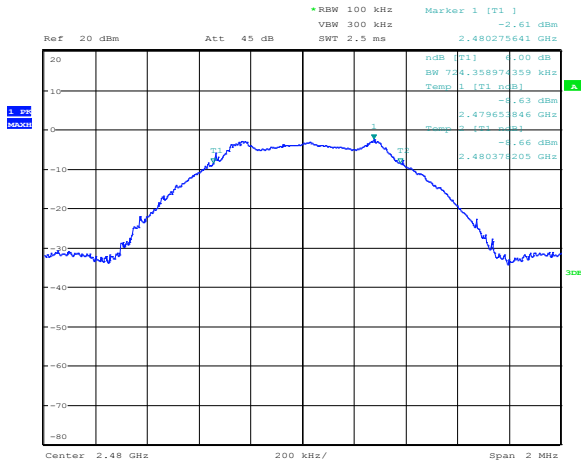
Date: 28.JUN.2018 13:09:37

Figure 8.1-1: 6 dB bandwidth on low channel



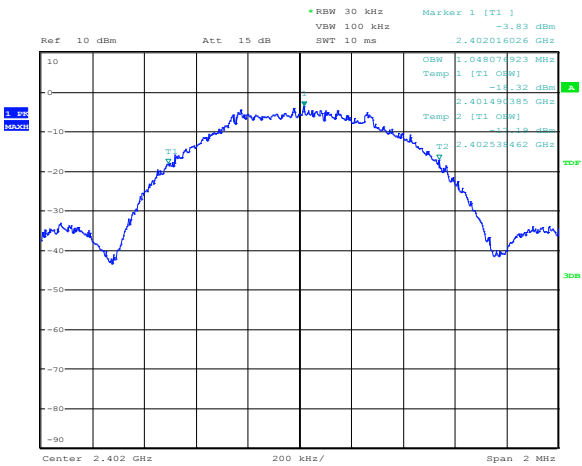
Date: 28.JUN.2018 13:11:00

Figure 8.1-2: 6 dB bandwidth on mid channel



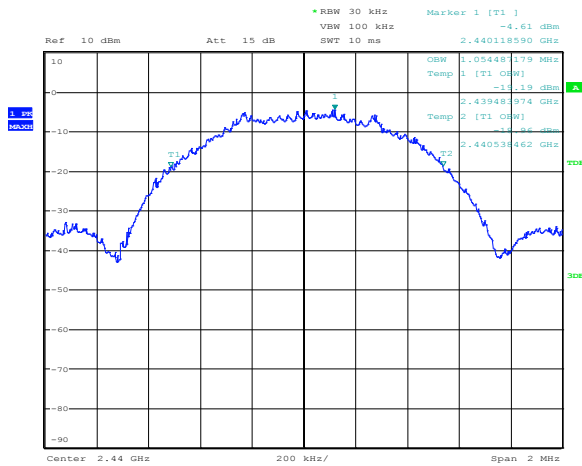
Date: 28.JUN.2018 13:11:30

Figure 8.1-3: 6 dB bandwidth on high channel



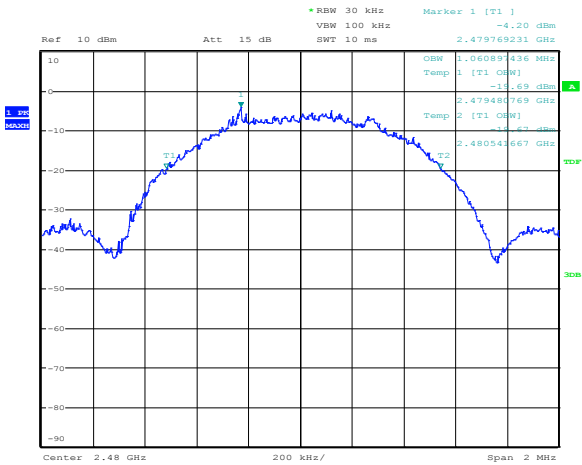
Date: 25.JUN.2018 16:19:38

Figure 8.1-4: 99 % bandwidth on low channel



Date: 25.JUN.2018 16:22:45

Figure 8.1-5: 99 % bandwidth on mid channel



Date: 25.JUN.2018 16:18:46

Figure 8.1-6: 99 % bandwidth on high channel

8.2 Clause 3.10.1.2 (1)(C) Transmitter maximum peak output power for systems using digital modulation

8.2.1 Definitions and limits

The maximum peak output power for systems using digital modulation in the 2400–2483.5 MHz band: 1 Watt (30 dBm).

3.10.1.2 (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.

3.10.1.2 (1)(A) Systems operating in the 2400–2483.5 MHz band, 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.

3.10.1.2 (2) When operating in 5725–5850 MHz and by fixed point-to-point operation, the directional gain of the transmitting antenna shall exceed 6 dBi without reducing the maximum conducted output power.

8.2.2 Test summary

Start date June 25, 2018

8.2.3 Observations, settings and special notes

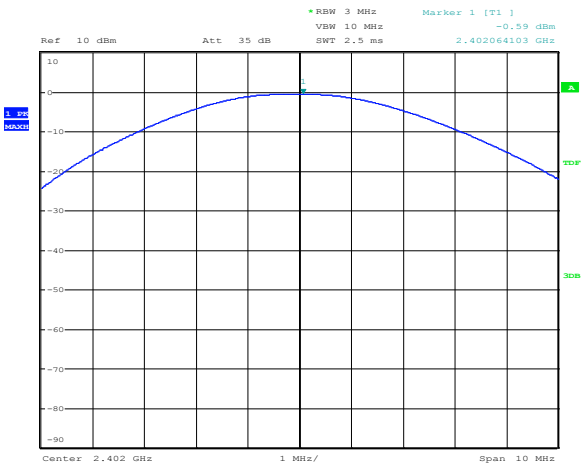
The test was performed according to DTS guidelines using Peak method. Spectrum analyzer settings were:

Resolution bandwidth:	3 MHz
Video bandwidth:	10 MHz
Detector mode:	Peak
Trace mode:	Max hold

8.2.4 Test data

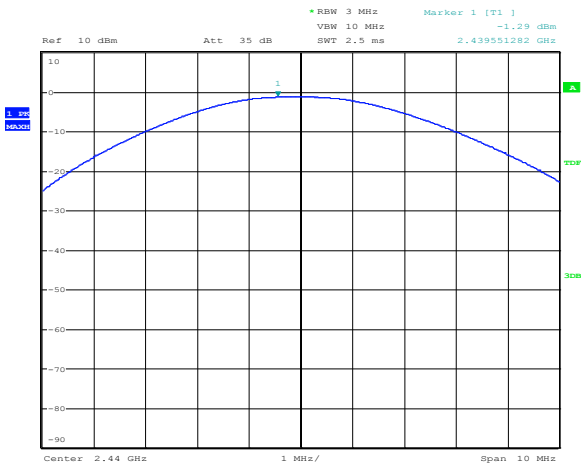
Table 8.2-1: Output power measurements results

Frequency, MHz	Conducted output power, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
	Measured	Limit					
2402	-0.59	30.00	30.59	-2.30	-2.89	36.00	38.89
2440	-1.29	30.00	31.29	-2.30	-3.59	36.00	39.59
2480	-1.44	30.00	31.44	-2.30	-3.74	36.00	39.74



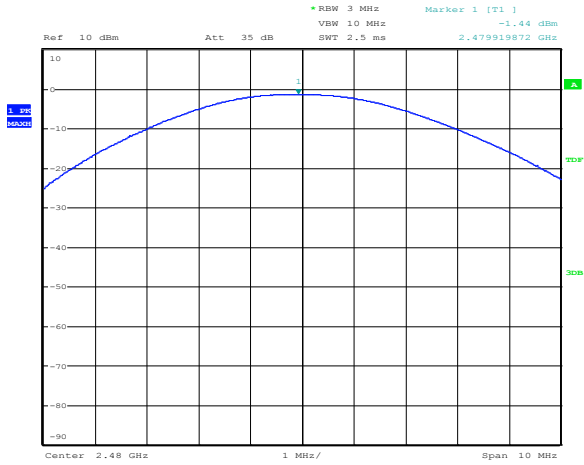
Date: 25.JUN.2018 16:15:20

Figure 8.2-1: Output power on low channel



Date: 25.JUN.2018 16:16:04

Figure 8.2-2: Output power on mid channel



Date: 25.JUN.2018 16:16:47

Figure 8.2-3: Output power on high channel

8.3 Clause 3.10.1.5 Spurious emissions

8.3.1 Definitions and limits

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:

3.10.1.5 (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.

3.10.1.5 (2) The attenuation shall be at least 30 dB when the conducted power is measured according to the paragraph (1) (C) of this section 3.10.1.2. 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.

Table 8.3-1: Section 2.8 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

Table 8.3-2: Section 2.7 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	Above 38600
162.01–167.17	2483.5–2900.0	
167.72–173.20	3260.0–3267.0	

8.3.1 Definitions and limits, continued

8.3.2 Test summary

Start date June 25, 2018

8.3.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 10th harmonic. EUT was set to transmit with 99 % duty cycle.

Cabinet radiation measurements were performed at a distance of 3 m. No emissions emanating from the RF compartment were observed more than 10 dB below the limit. Only worst case emissions were reported.

Since fundamental power was tested using peak power method, the spurious emissions outside restricted bands limit is -20 dBc/100 kHz

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

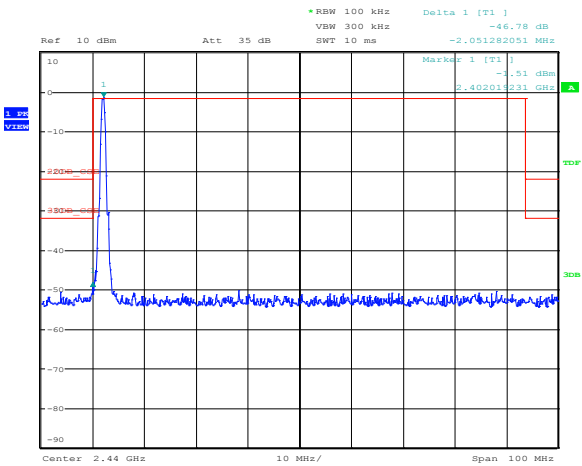
Spectrum analyser settings for average radiated measurements within restricted bands above 1 GHz:

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

Spectrum analyser settings for conducted spurious emissions outside restricted bands measurements:

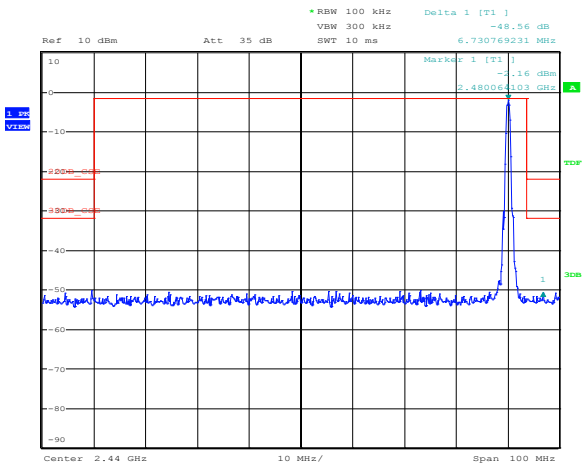
Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

8.3.4 Test data



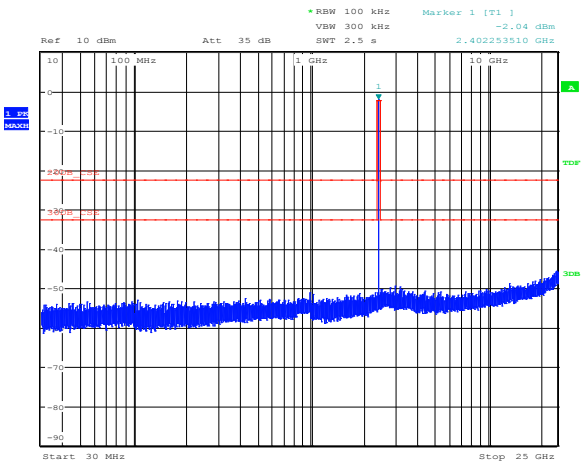
Date: 25.JUN.2018 16:14:21

Figure 8.3-1: Conducted spurious emissions outside restricted bands at the lower band edge (2400 MHz), on low channel



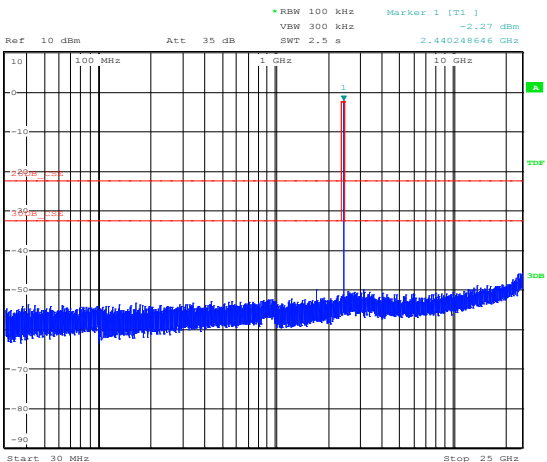
Date: 25.JUN.2018 16:13:36

Figure 8.3-2: Conducted spurious emissions outside restricted bands at the upper band edge (2483.5 MHz), on high channel



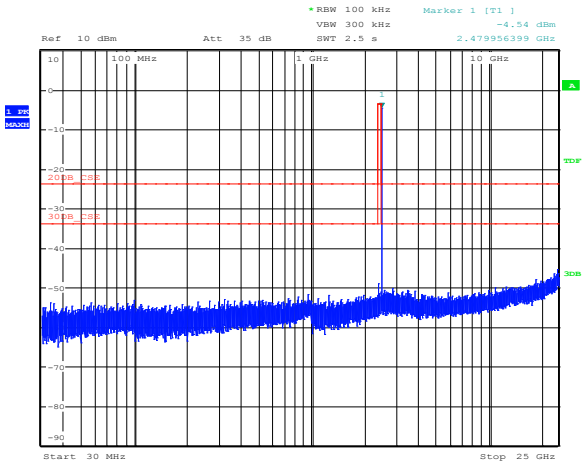
Date: 25.JUN.2018 16:10:42

Figure 8.3-3: Conducted spurious emissions outside restricted bands on low channel



Date: 25.JUN.2018 16:11:38

Figure 8.3-4: Conducted spurious emissions outside restricted bands on mid channel



Date: 25.JUN.2018 16:12:33

Figure 8.3-5: Conducted spurious emissions outside restricted bands on high channel

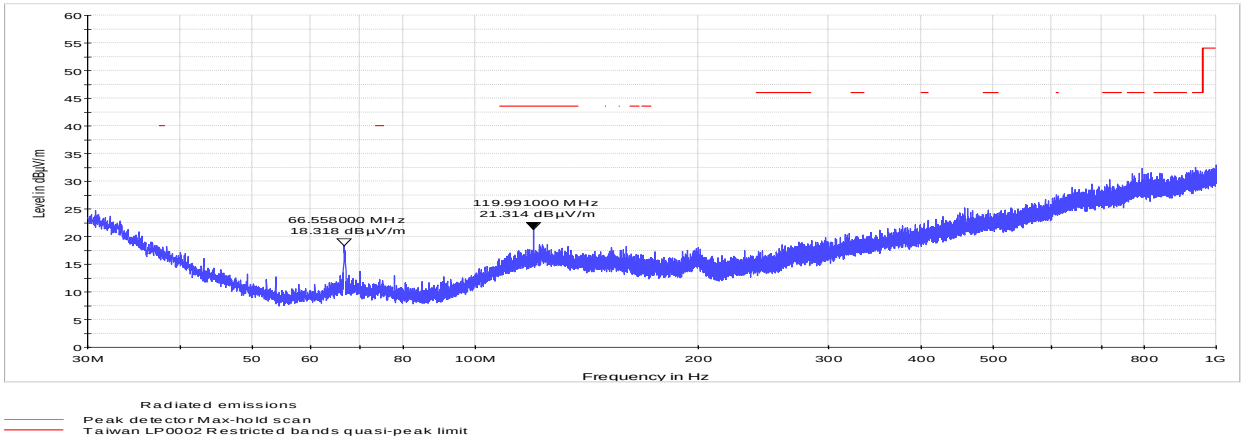


Figure 8.3-6: Radiated spurious emissions within restricted bands on low channel below 1 GHz

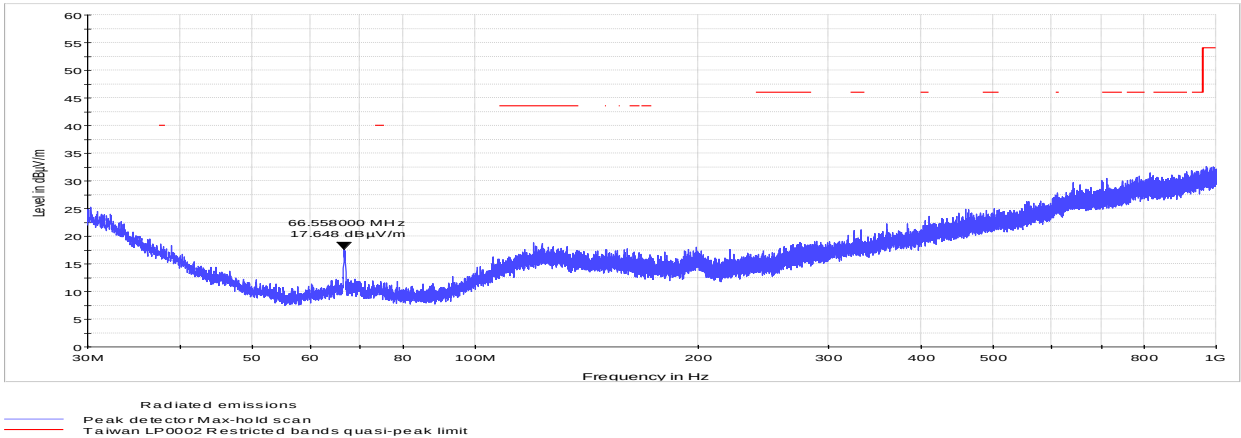


Figure 8.3-7: Radiated spurious emissions within restricted bands on mid channel below 1 GHz

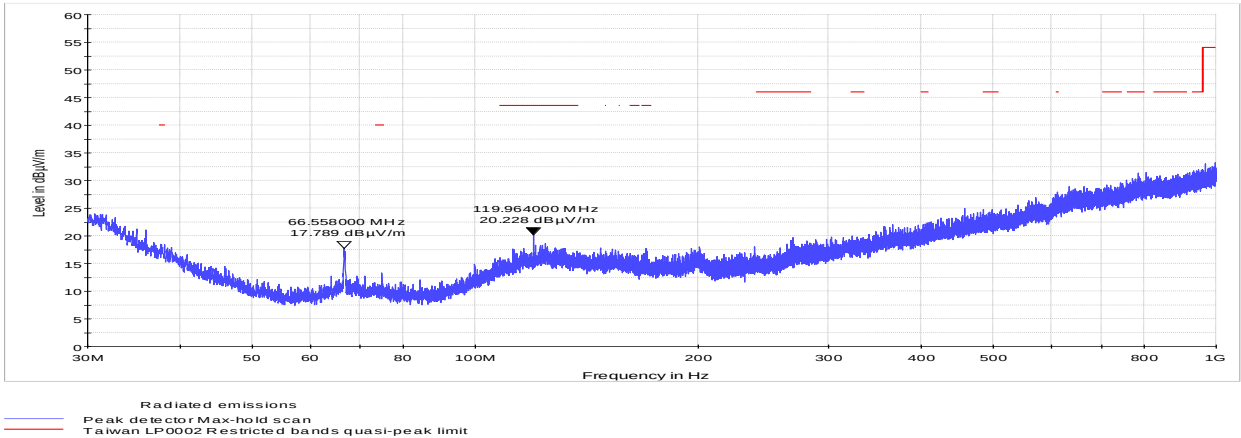


Figure 8.3-8: Radiated spurious emissions within restricted bands on high channel below 1 GHz

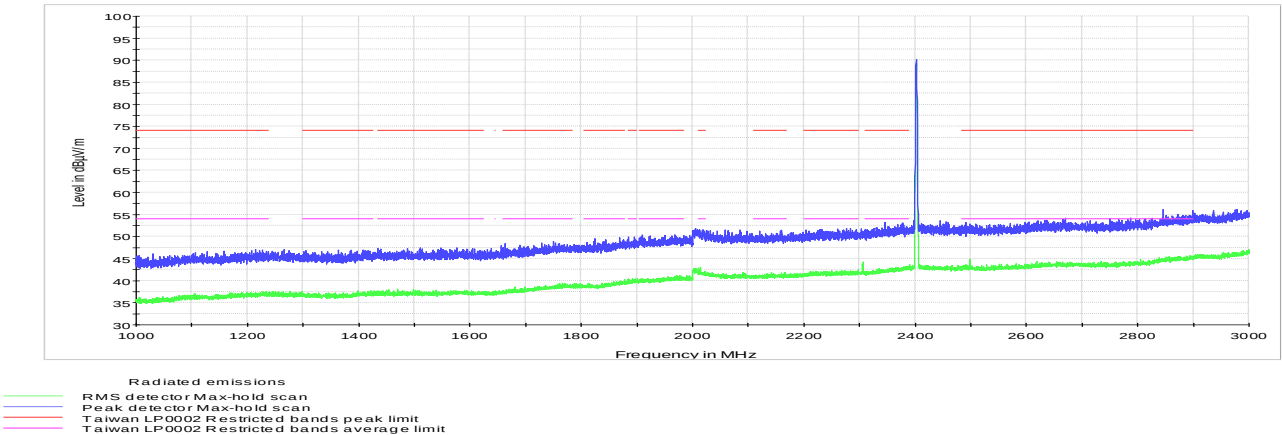


Figure 8.3-9: Radiated spurious emissions within restricted bands on low channel between 1 and 3 GHz

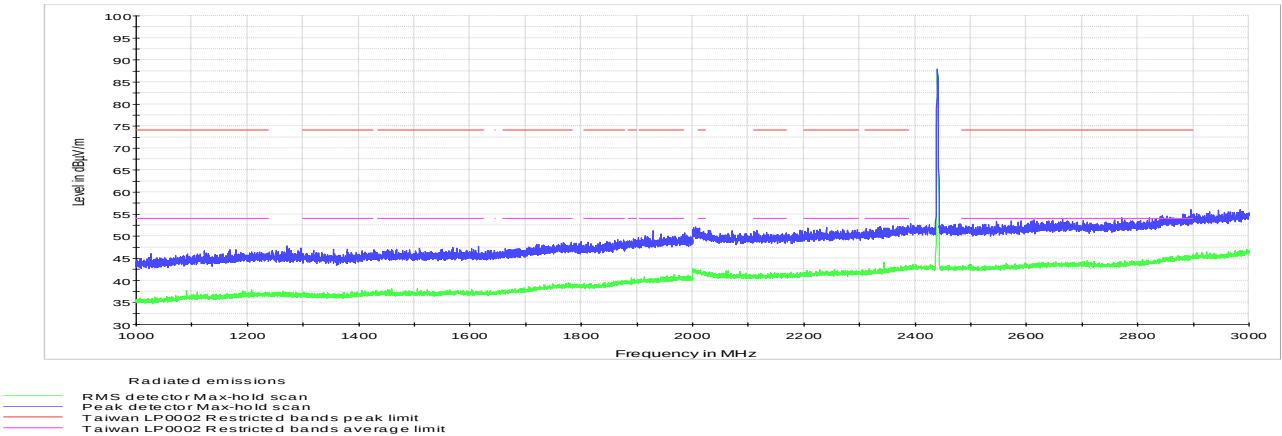


Figure 8.3-10: Radiated spurious emissions within restricted bands on mid channel between 1 and 3 GHz

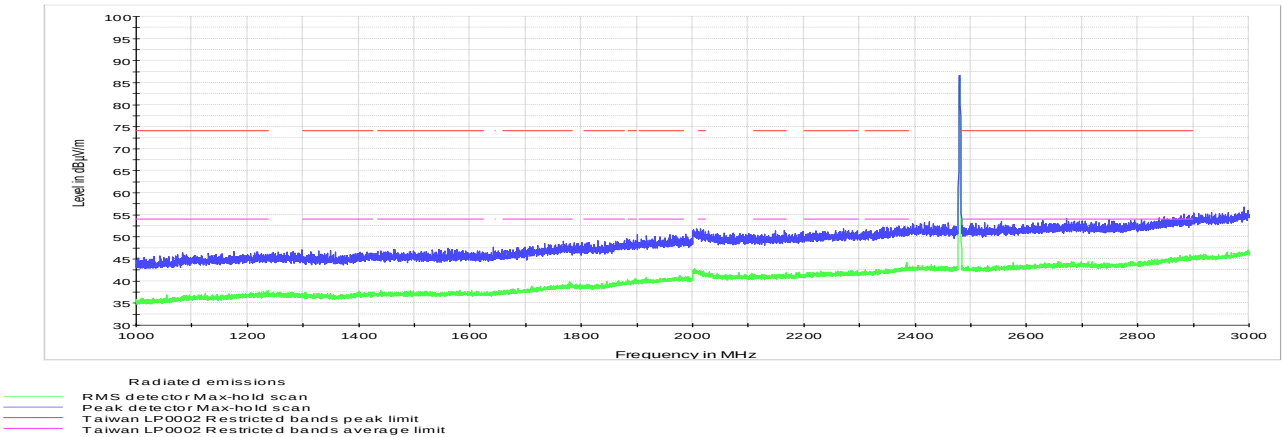


Figure 8.3-11: Radiated spurious emissions within restricted bands on high channel between 1 and 3 GHz

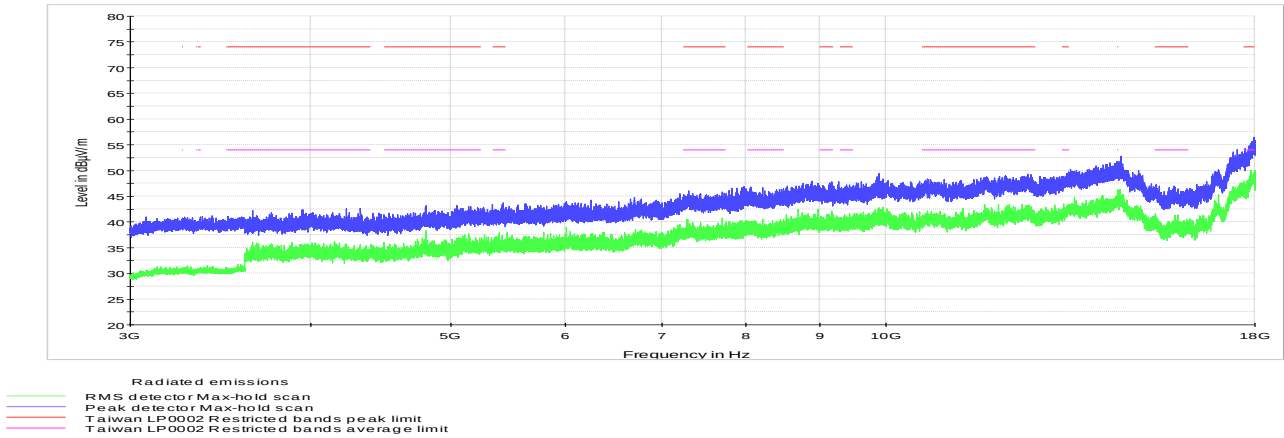


Figure 8.3-12: Radiated spurious emissions within restricted bands on low channel between 3 and 18 GHz

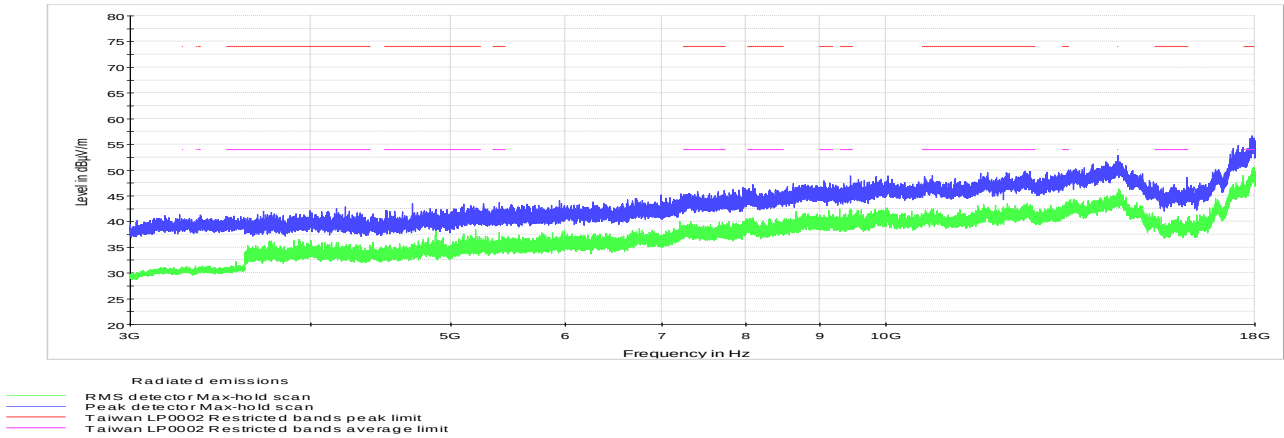


Figure 8.3-13: Radiated spurious emissions within restricted bands on mid channel between 3 and 18 GHz

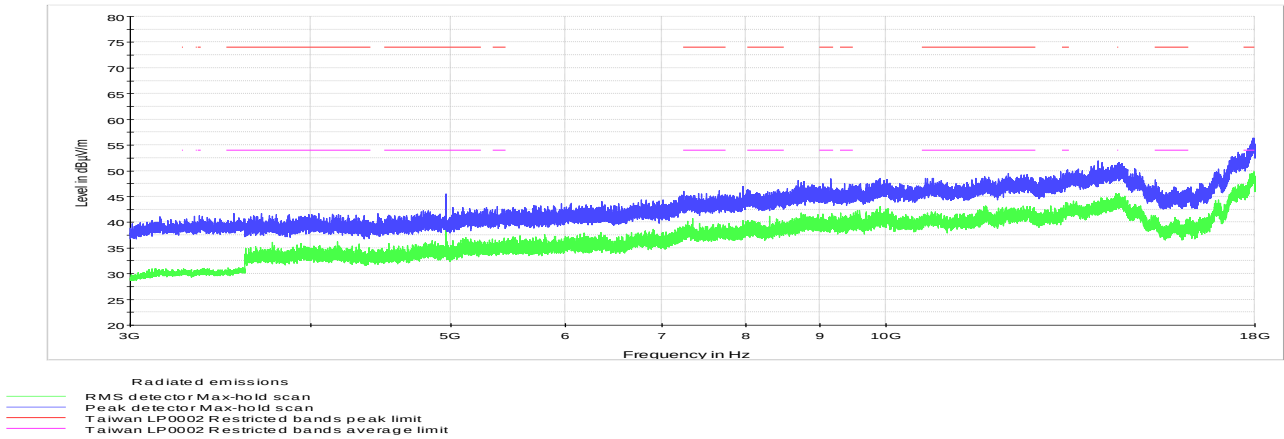


Figure 8.3-14: Radiated spurious emissions within restricted bands on high channel between 3 and 18 GHz

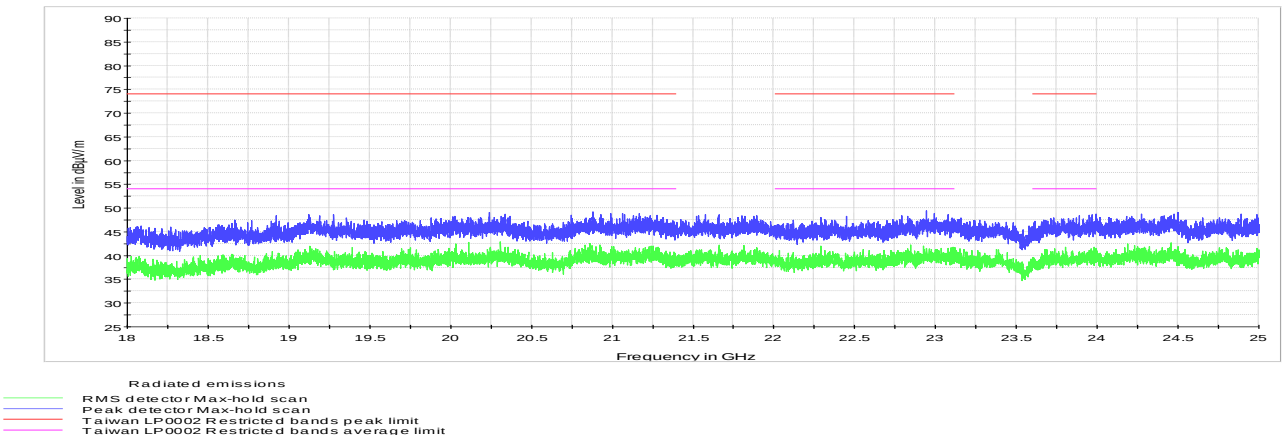


Figure 8.3-15: Radiated spurious emissions within restricted bands on low channel between 18 and 25 GHz

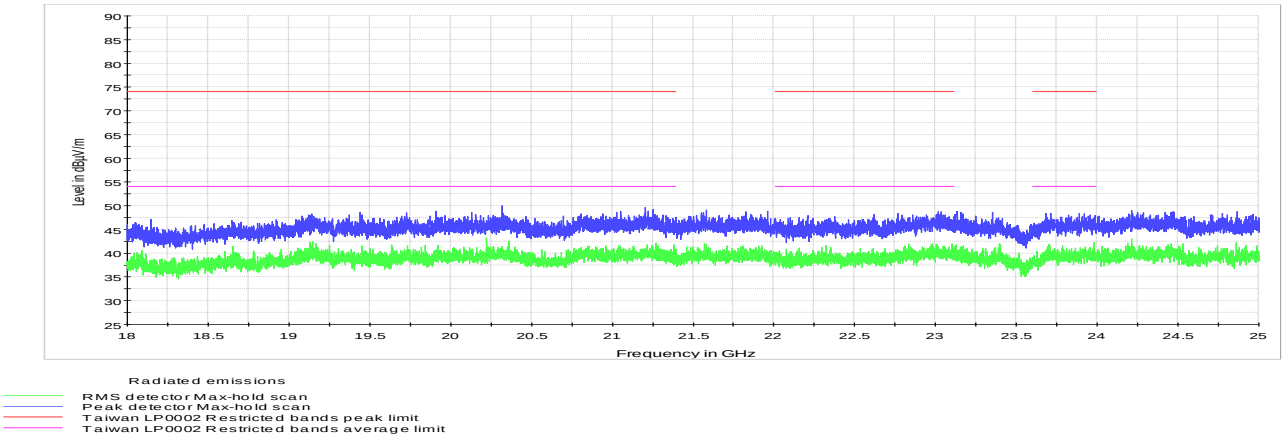


Figure 8.3-16: Radiated spurious emissions within restricted bands on mid channel between 18 and 25 GHz

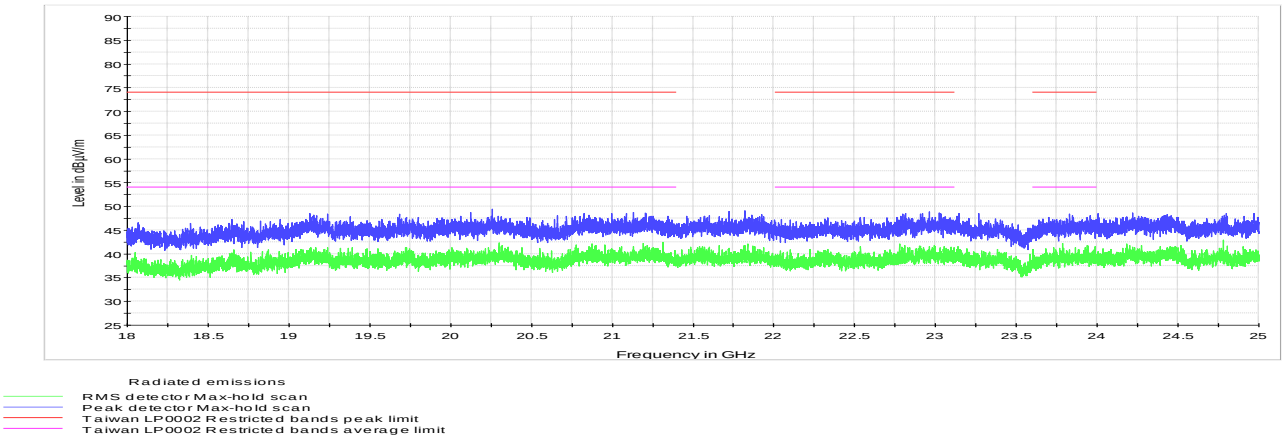


Figure 8.3-17: Radiated spurious emissions within restricted bands on high channel between 18 and 25 GHz

On the plots below limit lines are named Taiwan LP0002 restricted bands limit. For FCC and ISED the limits are the same.

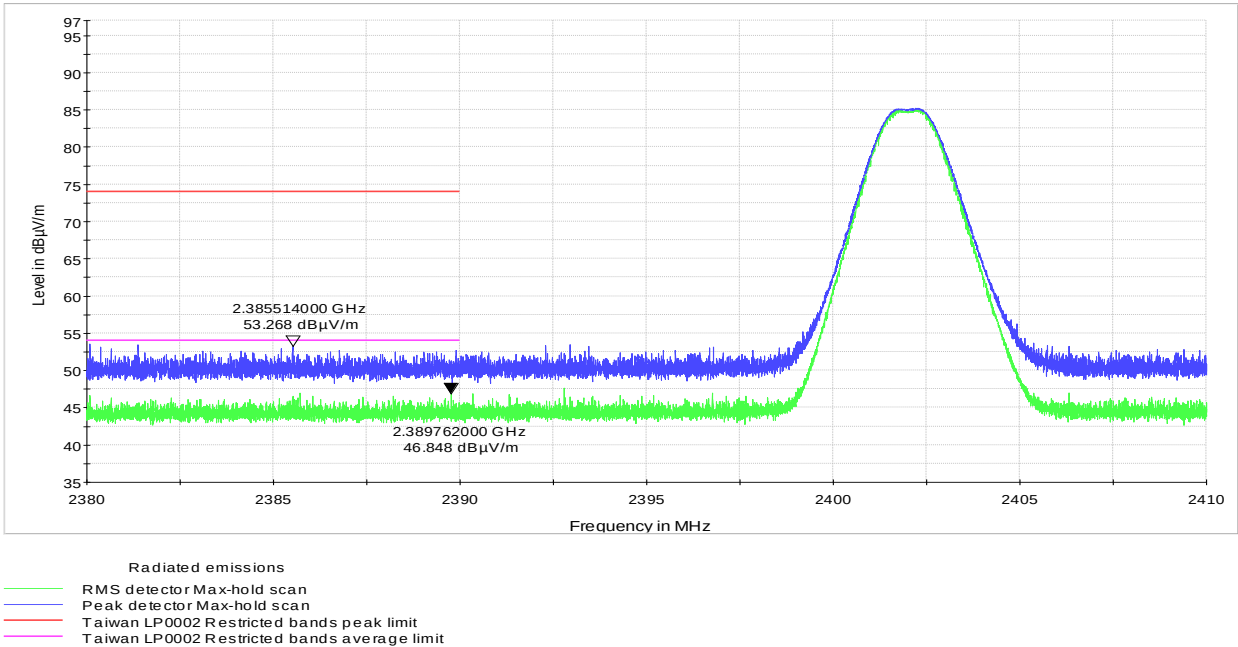


Figure 8.3-18: Radiated spurious emissions within restricted bands at the lower band edge

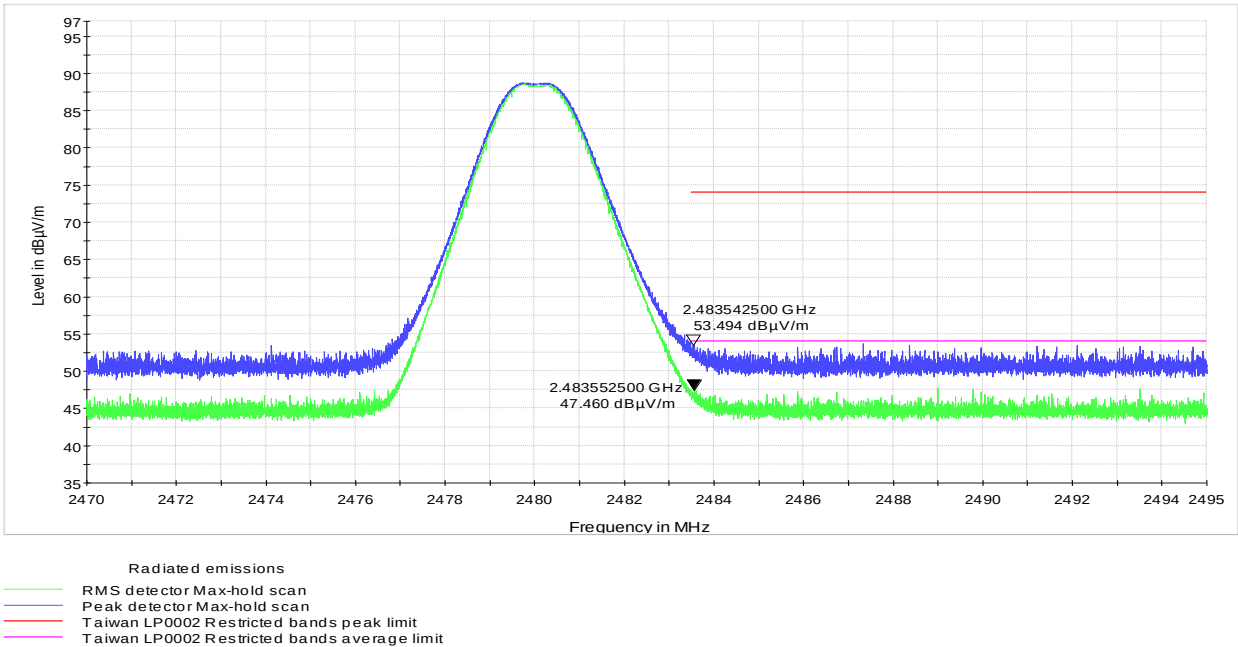


Figure 8.3-19: Radiated spurious emissions within restricted bands at the upper band edge

8.4 Clause 3.10.1.6 (2)(B) Peak power spectral density for digitally modulated devices

8.4.1 Definitions and limits

For digitally modulated systems, the peak 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.

8.4.2 Test summary

Start date June 25, 2018

8.4.3 Observations, settings and special notes

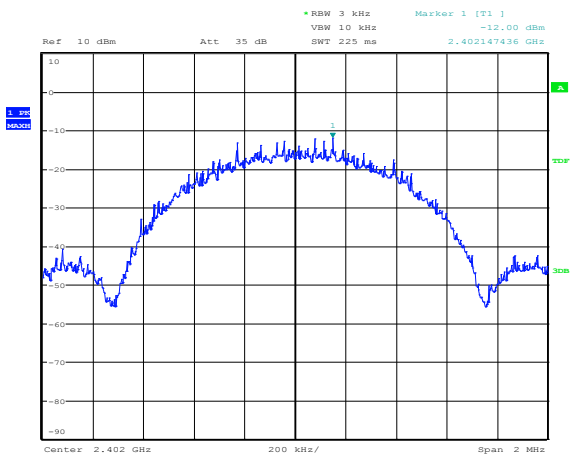
The output power was tested using peak detector, therefore PSD test was performed using method described in section 10.2 PKPSD of the 558074 D01 DTS Meas Guidance v03r01. Spectrum analyser settings:

Resolution bandwidth:	3 kHz
Video bandwidth:	$\geq 3 \times \text{RBW}$
Frequency span:	2 MHz
Detector mode:	Peak
Trace mode:	Max hold

8.4.4 Test data

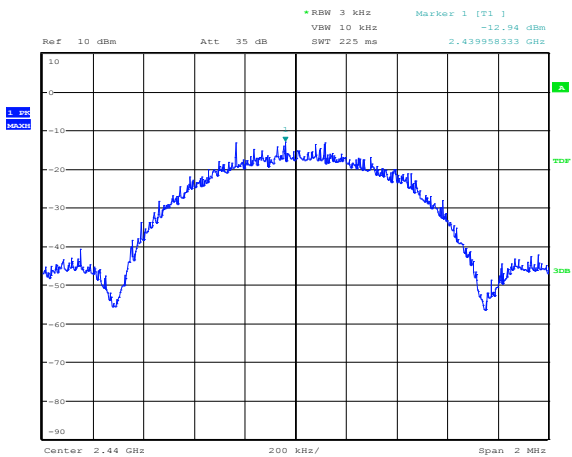
Table 8.4-1: PSD measurements results

Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
2402	-12.00	8.00	20.00
2440	-12.94	8.00	20.94
2480	-11.78	8.00	19.87



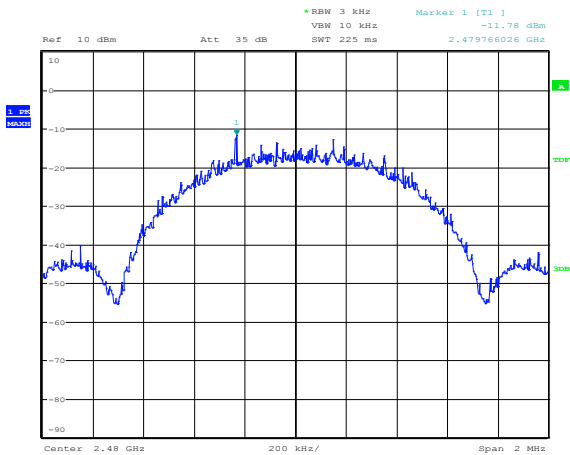
Date: 25.JUN.2018 16:25:27

Figure 8.4-1: PSD sample plot on low channel



Date: 25.JUN.2018 16:23:50

Figure 8.4-2: PSD sample plot on mid channel

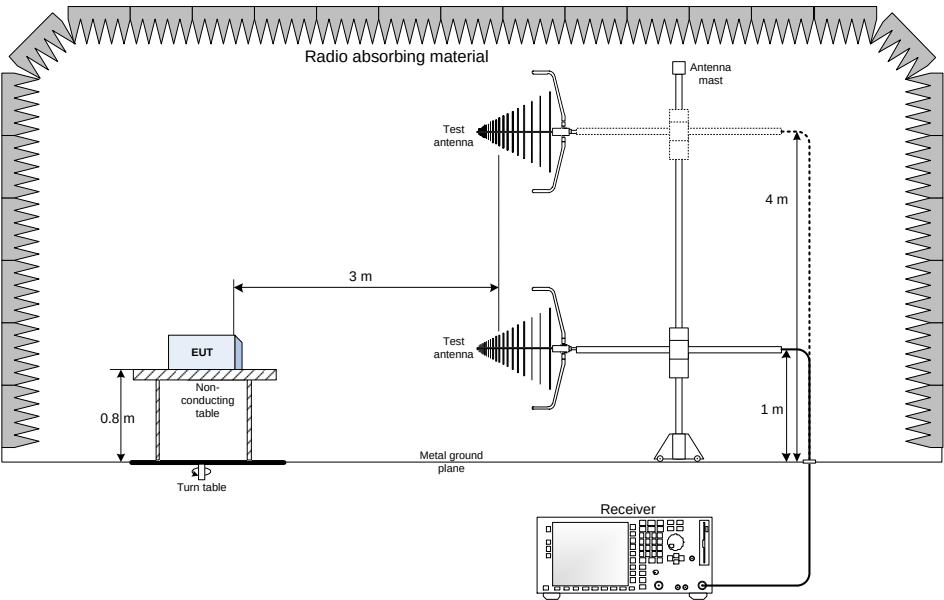


Date: 25.JUN.2018 16:24:40

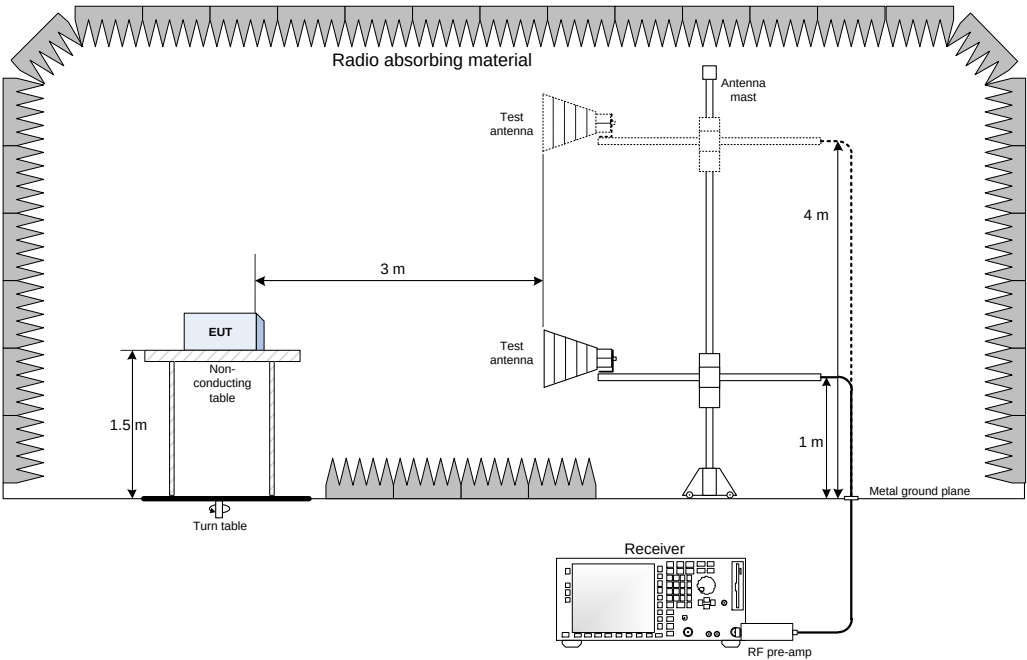
Figure 8.4-3: PSD sample plot on high channel

Section 9. Block diagrams of test set-ups

9.1 Radiated emissions set-up for frequencies below 1 GHz



9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 Antenna port set-up

