EMC TEST REPORT
No. 2347 FR
Issue#3: 2nd February 2021

FCC Test Report

for

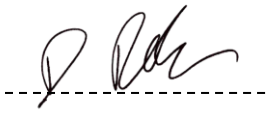
Senceive Ltd

Flat Mesh Node

Model: FM3M-LDS-IX

FCC ID: 2AMFBFM3NF
IC ID: 24373-FM3NF

Project Engineer: R. Pennell



Approval Signatory

Approved signatories: D. Tiroke ☑ A. R. Coombes ☐

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Document History:
Issue#1: 4th January 2021 was withdrawn and replaced by Issue#2: 18th January 2021 updated with editorial correction.
Issue#2: 18thJanuary 2021 was withdrawn and replaced by Issue#3: 2nd February 2021 updated with editorial correction.

1.0 DECLARATION

1.1 FCC Class A Test Report

The Equipment Under Test (EUT), as described and reported within this document, complies with part 15.205, 15.209 and 15.247 of CFR 47 FCC rules in accordance with ANSI C63.4:2014 and ANSI C63.10:2013 measurement procedure referencing the following EMC tests:-

- RADIATED EMISSIONS - Airborne, from 30.0 MHz to 26 GHz

Note: The highest associated operating frequency on the system, as declared by the manufacturer is a clock rate of 2.475 GHz.

This report relates to the sample tested and may not represent the entire population. It is valid only for the product identified, either in part or in full, to the relevant electromagnetic requirements necessary for compliance.

Eurofins Hursley is recognized by the Federal Communications Commissions (FCC) as an EMI laboratory, outside of the USA, for the measurement of radiated emissions at three metres.

1.2 Product Modifications

None to sample submitted.

2.0 EQUIPMENT & TEST DETAILS

2.1 General

Product (EUT):	Flat Mesh Node Model: FM3M-LDS-IX Serial number: 0073B0
Product mains rating:	Battery
Product build level:	Production sample
Product manufacturer:	Senceive Ltd
Customer:	Senceive Ltd 7b/7c Imperial Studios Imperial Road Fulham London SW6 2AG United kingdom
Test commissioned by:	Mr Charlie Blackham (Sulis Consultants)
EMC Test lab reference:	Eurofins Hursley Files: 2347 Sulis Consultants Test Plan: 2347 RF Test
Date EUT received:	7th October 2020
Test date(s):	7th to 16th October 2020
EMC measurement site:	Eurofins Hursley Trafalgar House, Trafalgar Close, Chandlers Ford, Hampshire
IC Canadia ID:	UK0005

2.2 EUT Description

The EUT is typically used in civil engineering and railway environment for measuring movement / stability. The EUT takes data from onboard sensors and uploads via 2.4GHz mesh network.

The device operates inside the 2400 – 2483.5 MHz band with a single bandwidth and single modulation.
The following test frequencies were used to cover the full band of operation of the device:

Test Channel	Centre Frequency (MHz)
Bottom channel	2405.0
Middle channel	2440.0
Top channel	2475.0

Table 1: Test frequencies

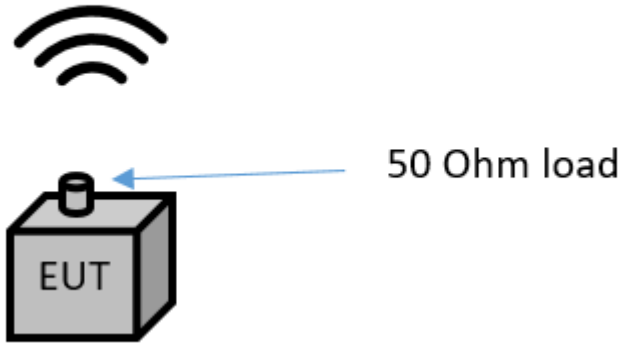
2.3 EUT Test Exerciser

Inbuilt test mode 100% duty cycle transmit

2.4 EUT Support Equipment

None.

2.5 EUT Test Configuration



2.6 Environmental Test Conditions

Temperature	22º Celsius
Relative Humidity	45%
Atmospheric Pressure	1017.9 millibars

2.7 EMC Test Equipment

#ID	CP	Manufacturer	Type	Serial Nø	Description	Calibration due date
021	1	Rohde & Schwarz	ESIB	100192	Test receiver (40GHz)	12/08/2021
053	1	HP	8449B	3008A01394	Pre-amplifier (1.0-26.5GHz)	22/10/2021
250	1	HP	8449B	3008A01077	Pre-amplifier (1.0-26.5GHz)	26/02/2021
446	1	0	Cable	0	BNC Cable	Internal
456	1	Rohde & Schwarz	ESCI7	1144573407	EMI Test Receiver	26/08/2021
466	3	Schwarzbeck	BBHA 9120 571	571	1-10GHz Horn	28/02/2022
516	1	Suhner	Cable	0	N type to sma cable for #250	23/09/2021
644	1	Intelliconnect	yellow H duty	15072	10m - 18GHz sma to N type H duty	30/10/2020
651	1	Rohde & Schwarz	ESIB 40 no.2	100262	40GHz receiver	27/11/2020
750	1	Global	CISPR16 chamber	1	11 x 7 x 6.2m	10/11/2020
761	3	Schwarzbeck	VULB9162	128	Trilog Broadband Antenna	02/03/2023
761a	3	Schwarzbeck	DGA 9552N	0	6dB attenuator for #761	02/03/2023
769	3	Schwarzbeck	BBHA 9120 C	631	2-18GHz Horn antenna (RE)	06/12/2020
776	2	IntelliConnect	C-NPS-2301-4M-NPS	I11816	4M N-TYPE 18GHz CABLE	25/04/2021
779	3	Steatite	QWH-SL-18-40-K-SG	17504	18-40GHz wideband horn antenna	11/05/2021

CP = Interval period [year] prescribed for external calibrations
Note: 'Calibration due date' means that the instrument is certified with a UKAS or traceable calibration certificate.
'Internal' means internally calibrated using Eurofins Hursley procedures

2.8 EMC Test Software

The following table shows the current EMC test equipment software used by Eurofins Hursley:

ID	Manufacturer	Description
856	R&S	EMC32 Version 10.50.10
857	Gauss	TDMI 30 Version 5.00
858	Ametek	Compliance 5 Immunity Version 5.26.48
859	EMC Partner	HARCS Version 4.22
860	Frankonia	Hurbert IEC1000-4-6 Version 1.3.0
861	Schafner	Win 2110 Version 1.27.0.3
862	EMC Partner	TEMA3000 Version 4.4.2
863	EFH	ProfilaMil Version 2.8.1
864	AFJ	CL55C Version 1.00

2.10 Radiated Emissions

Initial Scan

Radiated profile scans were taken on eight azimuths between 30.0 MHz and 25.0 GHz in both the vertical and horizontal polarities of the antennae in a semi-anechoic chamber. The resulting data obtained from these scans was used to determine subsequent measurement for final measurement evaluation.

Final Measurements

The EUT was then measured at three metres in the chamber using the pre-scan results as a guide. Emissions from the EUT were maximised by revolving the system on the turntable and moving the antennae in height and azimuth. Cable and system component positions had been investigated for maximum emissions, and the system under test represented the worst-case configuration. The highest values obtained are presented in this report.

3.0 EMISSION RESULTS

3.1 Radiated Emissions; 30MHz to 1GHz

Radiated emissions pre-scan profile measurements were taken at a distance of three metres on eight azimuths of the EUT in both horizontal and vertical antenna polarities in a semi anechoic chamber for FCC measurements.

Using the pre-scan results as a guide, each emission from the EUT was maximised. Measurements were carried out a distance of three metres in a CISPR 16-1-4 compliant semi anechoic chamber. Cable positions were then finally adjusted to produce the maximum emission levels. The EUT was tested in 3 axis and the worst case results are shown below.

3.1.1 Data; Antenna up, Bottom Channel

Emission frequency	Measured quasi-peak value	Class B specified quasi-peak limit	Pass Margin	Antenna polarity	Antenna height	Turntable azimuth	
MHz	dBµV/m	dBµV/m	dB	H/V	cm	deg	Status
37.907474	25.97	40.00	14.03	V	377.0	239.0	Pass
110.566161	25.61	43.50	17.89	H	166.0	39.0	Pass
995.599515	40.26	54.00	13.74	V	197.0	184.0	Pass

V = Vertical / H = Horizontal

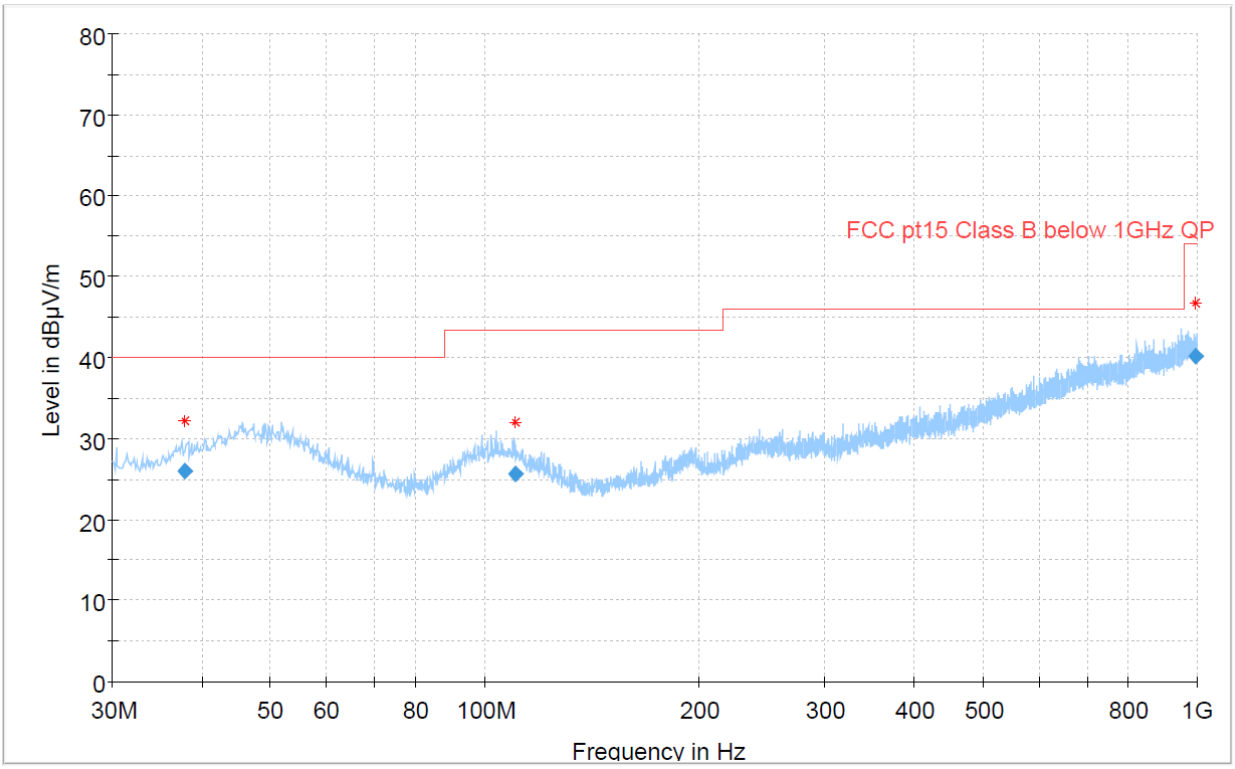
The measurements reported are the highest emissions relative to the FCC Class B limits and take into account the antenna and cable loss factors. Measurements made according to the FCC test standard and Eurofins Hursley test procedure RAD-01.

TEST ENGINEER: Malcolm Musgrave

3.1.2 Profile; Antenna up, Bottom Channel

Max hold trace with quasi-peak values (◆)

Peak measurements are shown in red (✳)



3.2 Radiated Emissions; 30MHz to 1GHz (Continued)

3.2.1 Data; Label up, Middle Channel

Emission frequency	Measured quasi-peak value	Class B specified quasi-peak limit	Pass Margin	Antenna polarity	Antenna height	Turntable azimuth	
MHz	dBµV/m	dBµV/m	dB	H/V	cm	deg	Status
251.129942	26.92	46.00	19.08	V	232.0	178.0	Pass

V = Vertical / H = Horizontal

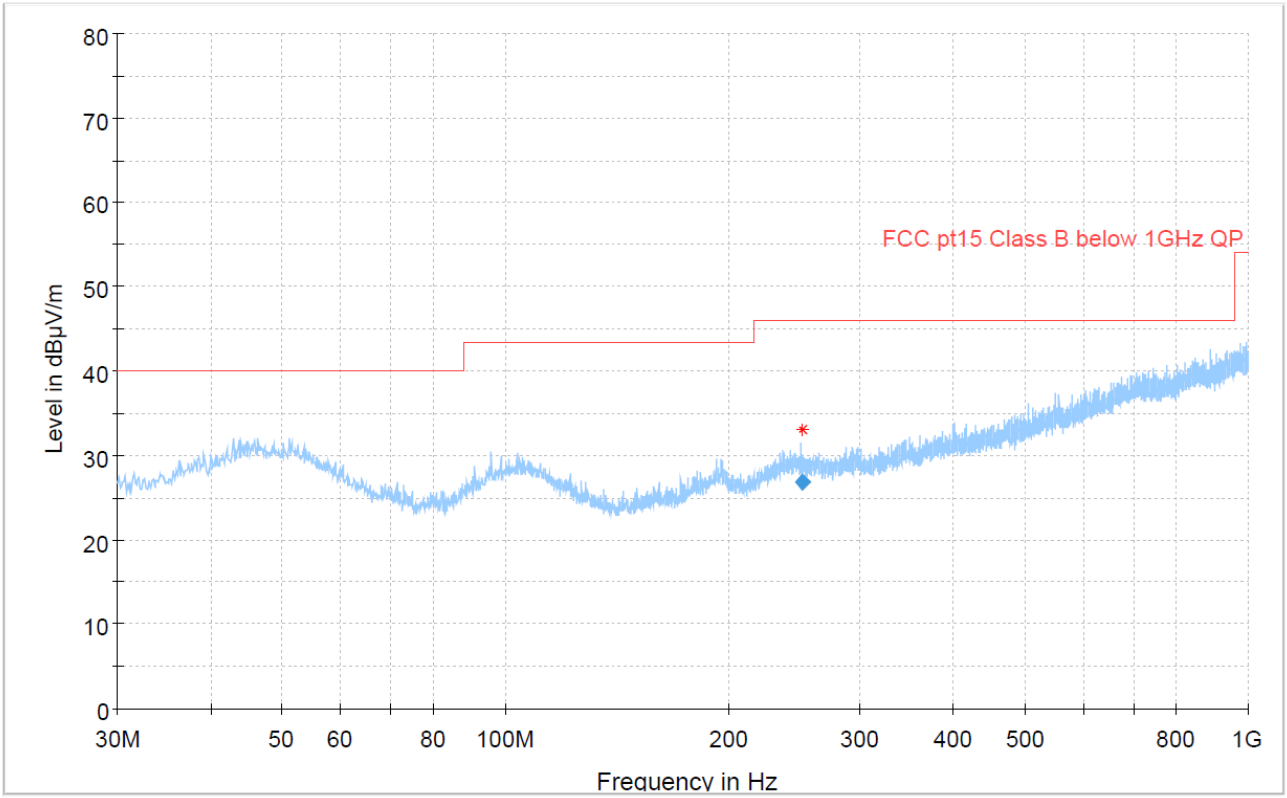
The measurements reported are the highest emissions relative to the FCC Class B limits and take into account the antenna and cable loss factors. Measurements made according to the FCC test standard and Eurofins Hursley test procedure RAD-01.

TEST ENGINEER: Richard Pennell

3.2.2 Profile; Label up, Middle Channel

Max hold trace with quasi-peak values (◆)

Peak measurements are shown in red (✳)



3.3 Radiated Emissions; 30MHz to 1GHz (Continued)

3.3.1 Data; Laser up, Top Channel

Emission frequency	Measured quasi-peak value	Class B specified quasi-peak limit	Pass Margin	Antenna polarity	Antenna height	Turntable azimuth	
MHz	dBµV/m	dBµV/m	dB	H/V	cm	deg	Status
163.403406	23.20	43.50	20.30	V	200.0	179.0	Pass
962.505671	40.18	54.00	13.82	H	249.0	123.0	Pass

V = Vertical / H = Horizontal

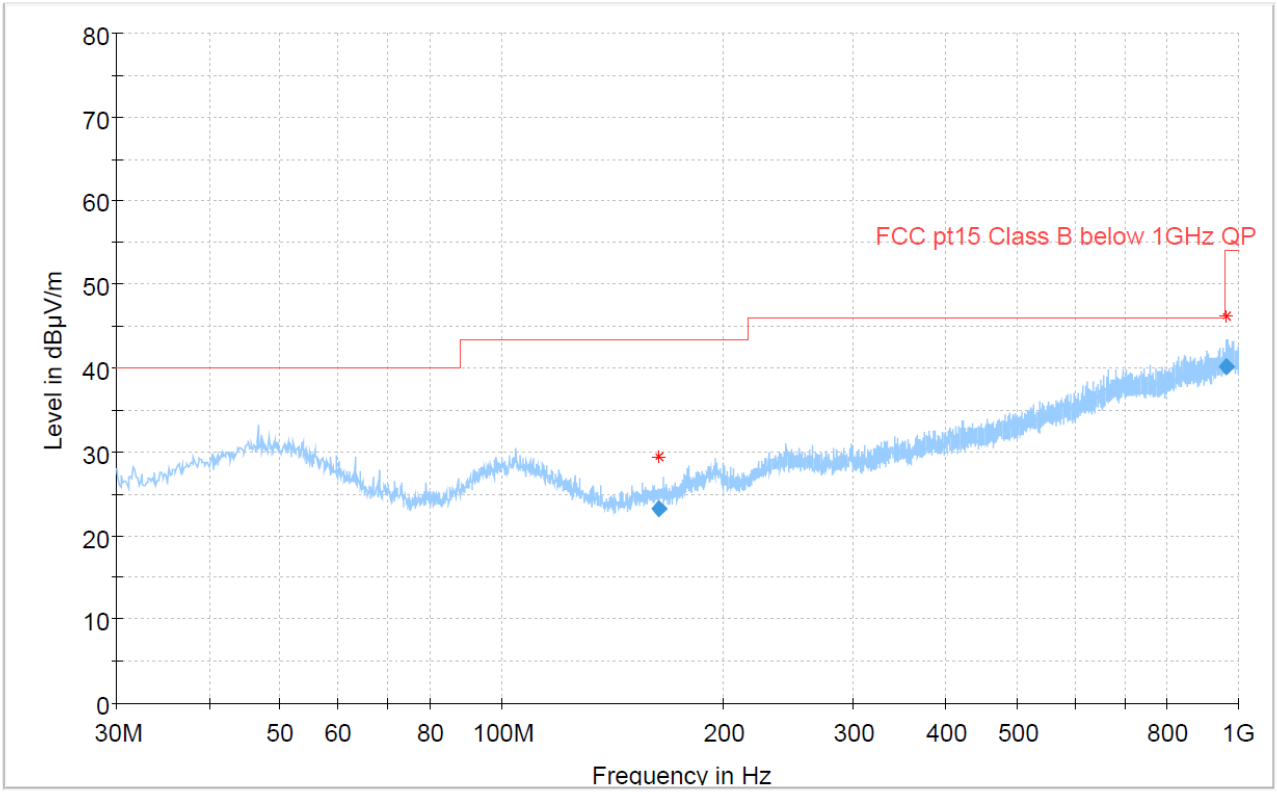
The measurements reported are the highest emissions relative to the FCC Class B limits and take into account the antenna and cable loss factors. Measurements made according to the FCC test standard and Eurofins Hursley test procedure RAD-01.

TEST ENGINEER: Richard Pennell

3.3.2 Profile; Laser up, Top Channel

Max hold trace with quasi-peak values (◆)

Peak measurements are shown in red (✳)



3.4 Radiated Emissions; 1 to 10GHz

Radiated emissions pre-scan profile measurements were taken at a distance of three metres on eight azimuths of the EUT in both horizontal and vertical antenna polarities in a semi anechoic chamber for FCC measurements.

Using the pre-scan results as a guide, each emission from the EUT was maximised. Measurements were carried out a distance of three metres in a CISPR 16-1-4 compliant semi anechoic chamber. Cable positions were then finally adjusted to produce the maximum emission levels. The EUT was tested in 3 axis and the worst-case results are recorded below.

3.4.1 Data; Node Label up, Bottom Channel

Frequency	Peak	CISPR Average	Limit	Margin	Height	Pol	Azimuth	Corr.	
MHz	dBµV/m	dBµV/m	dBµV/	dB	cm	H/V	Deg	dB/m	Status
2390.00000	---	26.37	54.00	27.63	242.0	H	99.0	-6.6	Pass
2390.00000	39.84	---	74.00	34.16	296.0	H	118.0	-6.6	Pass

V = Vertical / H = Horizontal

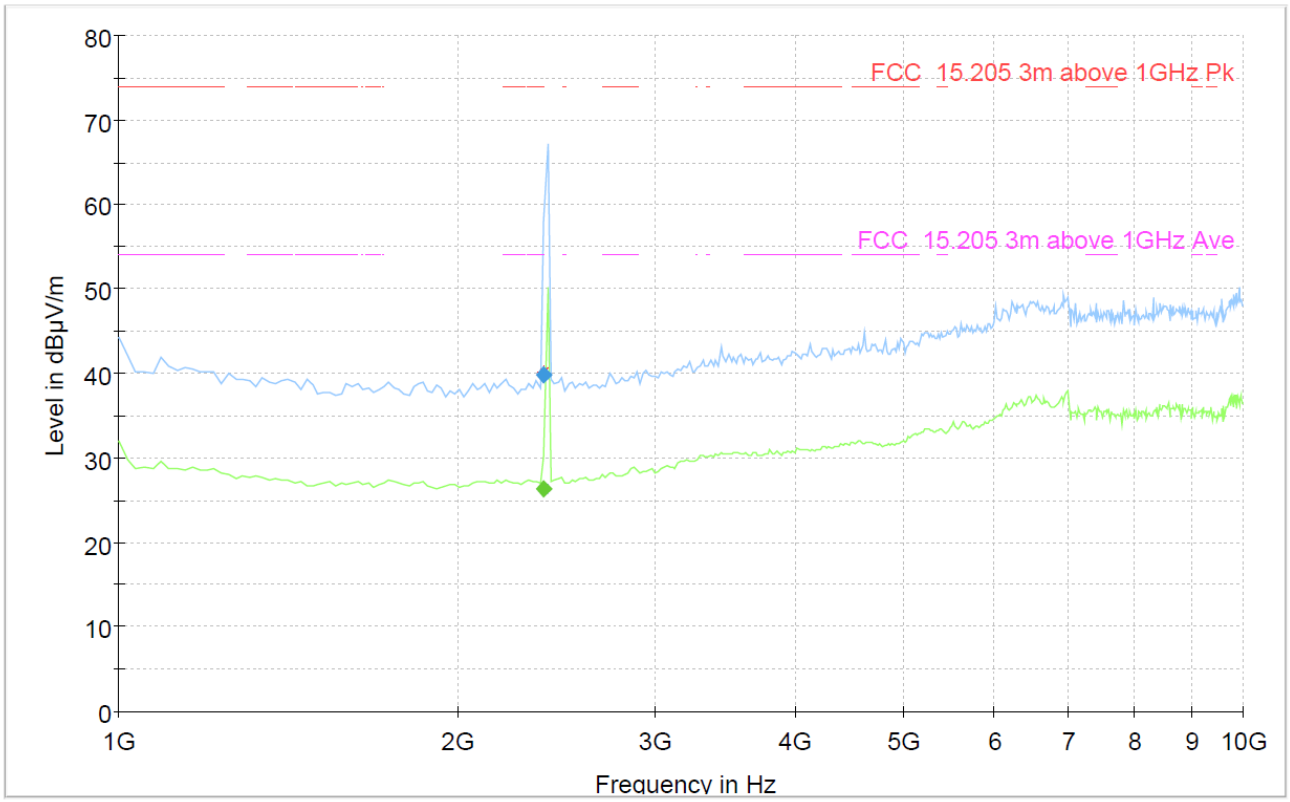
The measurements reported are the highest emissions relative to the FCC limits and take into account the antenna and cable loss factors. Measurements made according to the FCC test standard and Eurofins Hursley test procedure RHF-01.

TEST ENGINEER: Richard Pennell

3.4.2 Profile; Node Label up, Bottom Channel

Max hold trace with peak values (◆)

Max hold trace with average values (◆)



3.5 Radiated Emissions; 1 to 10GHz (Continued)

3.5.1 Data; Node Label up, Middle Channel

Frequency	Peak	CISPR Average	Limit	Margin	Height	Pol	Azimuth	Corr.	
MHz	dBµV/m	dBµV/m	dBµV/	dB	cm	H/V	Deg	dB/m	Status
No significant peaks found.									Pass

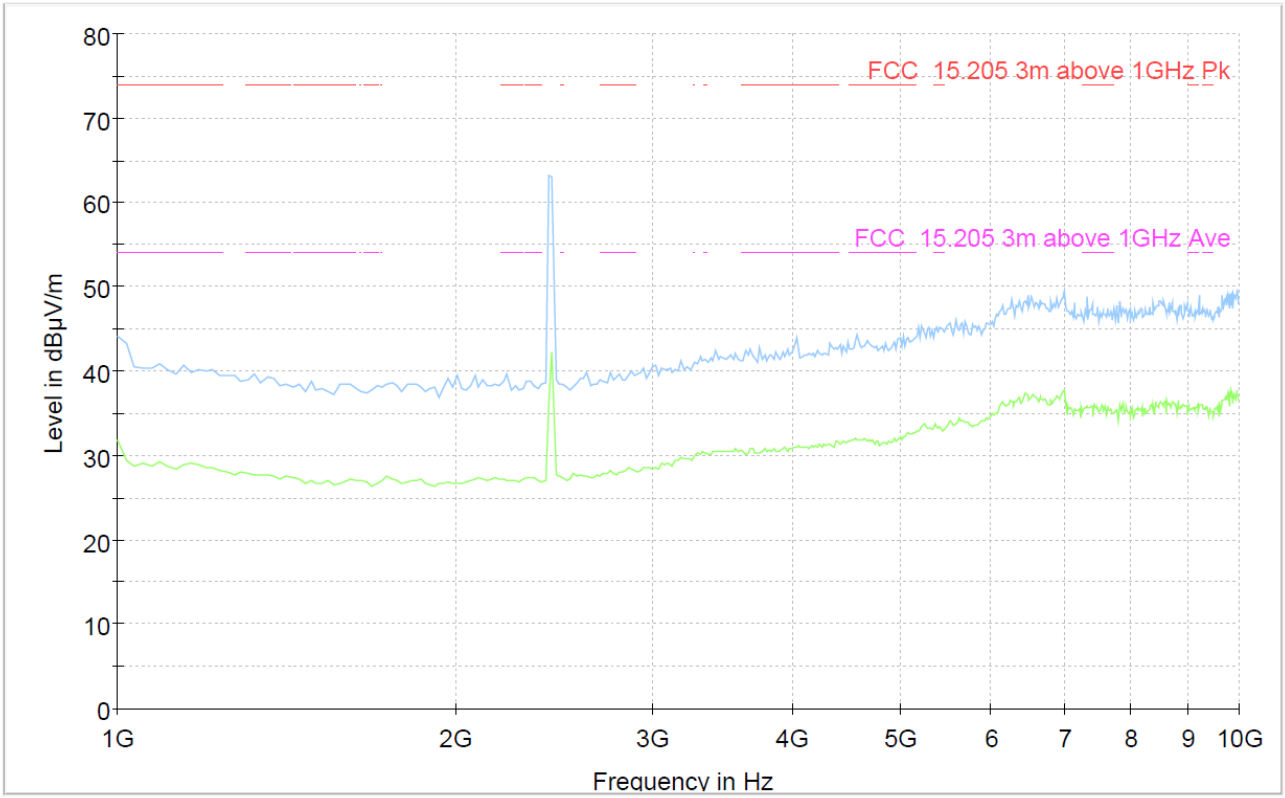
The measurements reported are the highest emissions relative to the FCC limits and take into account the antenna and cable loss factors. Measurements made according to the FCC test standard and Eurofins Hursley test procedure RHF-01.

TEST ENGINEER: Richard Pennell

3.5.2 Profile; Node Label up, Middle Channel

Max hold trace with peak values (◆)

Max hold trace with average values (◆)



3.6 Radiated Emissions; 1 to 10GHz (Continued)

3.6.1 Data; Node Label up, Top Channel

Frequency	Peak	CISPR Average	Limit	Margin	Height	Pol	Azimuth	Corr.	
MHz	dBµV/m	dBµV/m	dBµV/	dB	cm	H/V	Deg	dB/m	Status
2483.50000	---	7.20	---	---	132.0	H	155.0	-6.5	Pass
2483.50000	19.20	---	---	---	128.0	H	156.0	-6.5	Pass

V = Vertical / H = Horizontal

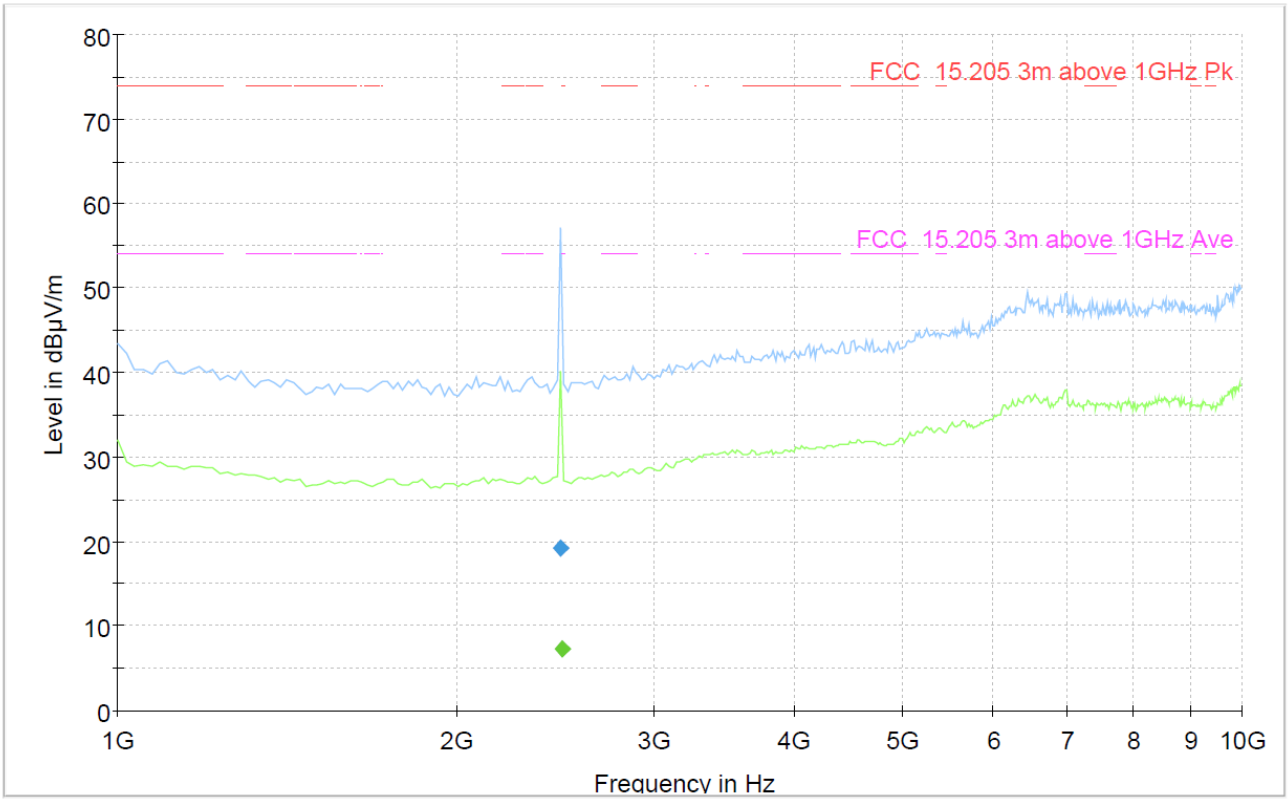
The measurements reported are the highest emissions relative to the FCC limits and take into account the antenna and cable loss factors. Measurements made according to the FCC test standard and Eurofins Hursley test procedure RHF-01.

TEST ENGINEER: Richard Pennell

3.6.2 Profile; Node Label up, Top Channel

Max hold trace with peak values (◆)

Max hold trace with average values (◆)



3.7 Radiated Emissions; 2 to 3 GHz

Radiated emissions pre-scan profile measurements were taken at a distance of three metres on eight azimuths of the EUT in both horizontal and vertical antenna polarities in a semi-anechoic chamber for FCC measurements.

Using the pre-scan results as a guide, each emission from the EUT was maximised. Measurements were carried out a distance of three metres in a CISPR 16-1-4 compliant semi-anechoic chamber. Cable positions were then finally adjusted to produce the maximum emission levels. The EUT was tested in 3 axis and the worst-case results are recorded below.

3.7.1 Data; Orientation, Label up, Top channel

Frequency	Peak	CISPR Average	Limit	Margin	Height	Pol	Azimuth	Corr.	
MHz	dBµV/	dBµV/m	dBµV/	dB	cm	H/V	Deg	dB/m	Status
2483.500000	---	7.20	54.00	46.8	132.0	H	155.0	-6.5	Pass
2483.500000	19.2.	---	74.00	54.8	128.0	H	156.0	-6.5	Pass

V = Vertical / H = Horizontal

The measurements reported are the highest emissions relative to the FCC limits and take into account the antenna and cable loss factors. Measurements made according to the FCC test standard and Eurofins Hursley test procedure RHF-01.

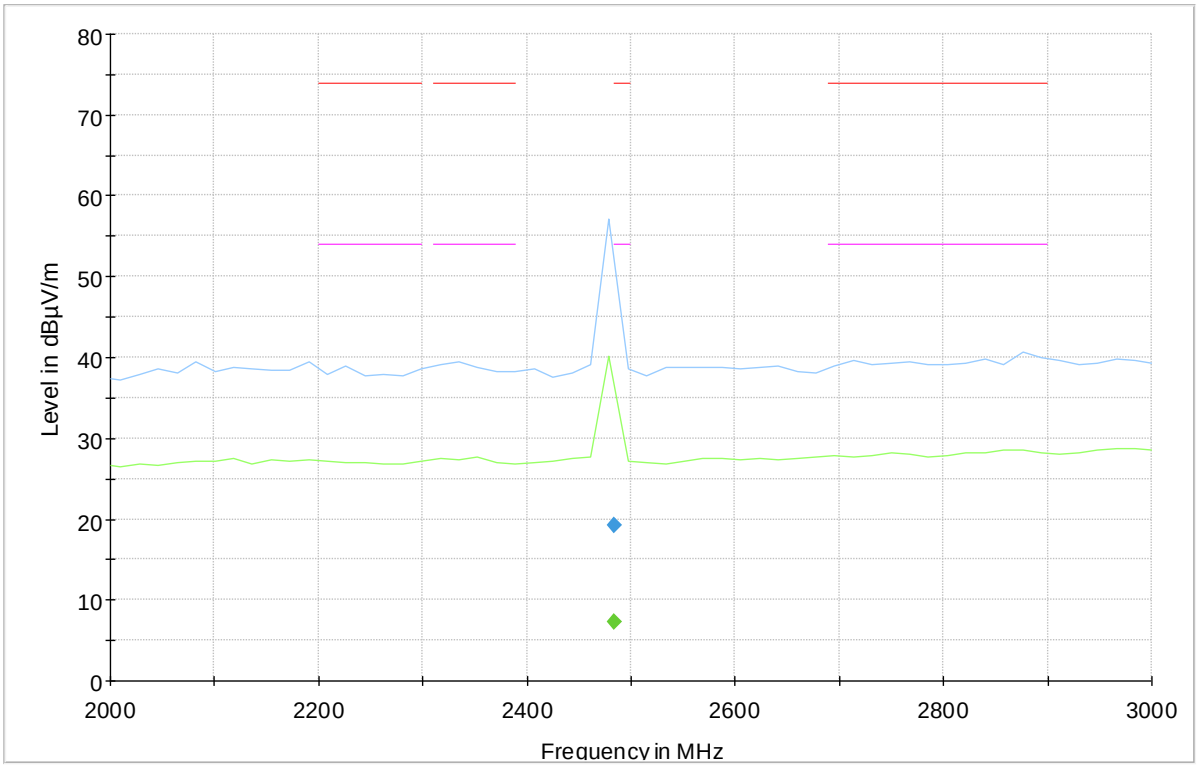
TEST ENGINEER: Richard Pennell

3.7.2 Profile; Orientation , Label up, Top channel

Max hold trace with peak values (◆)

Peak measurements are shown in red (✳)

Max hold trace with average values (◆)



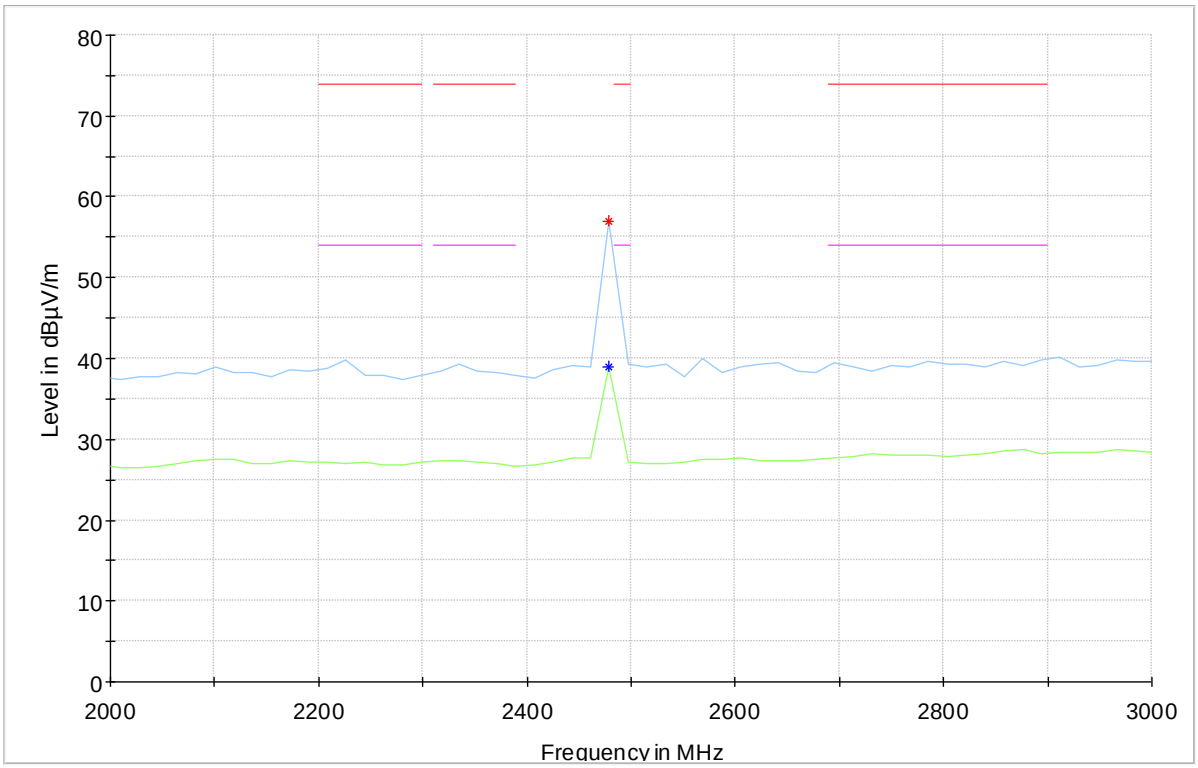
3.8 Radiated Emissions; 2 to 3 GHz (continued)

3.8.1 Profile; Orientation, Antenna up, Top channel

Max hold trace with peak values (◆)

Peak measurements are shown in red (✳)

Max hold trace with average values (◆)

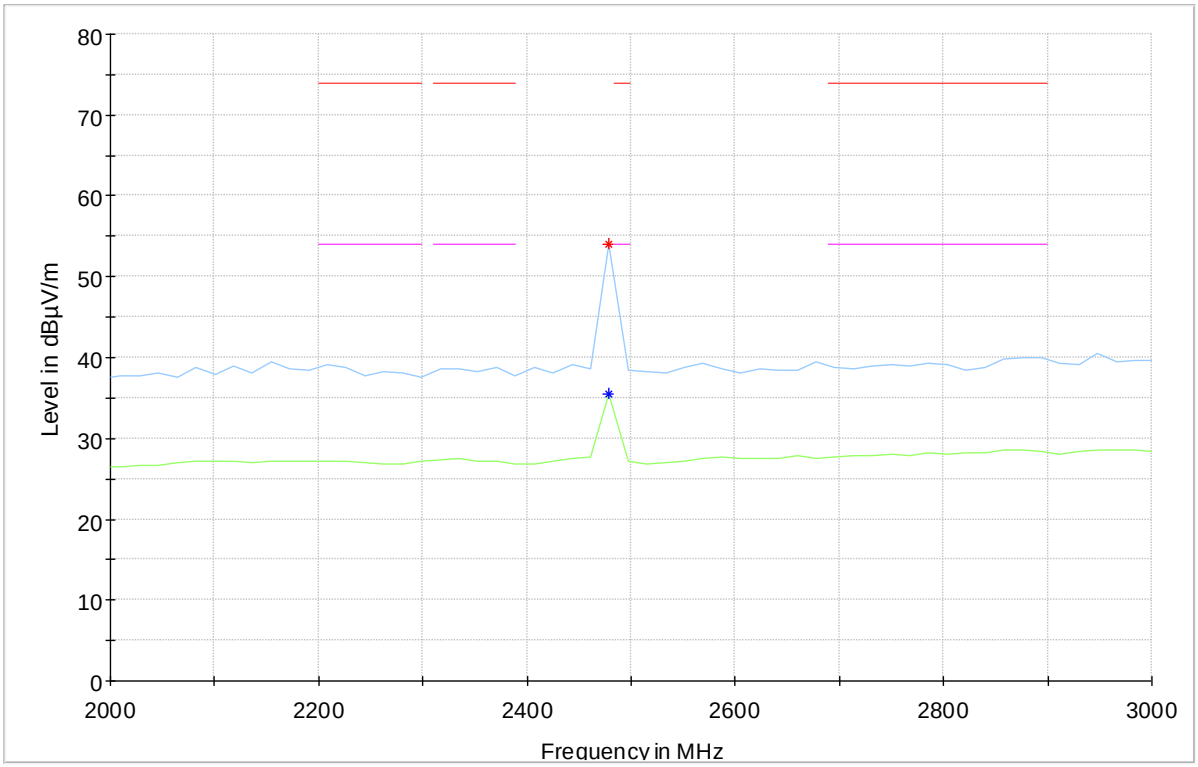


3.8.2 Profile; Orientation, Laser up, Top channel

Max hold trace with peak values (◆)

Peak measurements are shown in red (✳)

Max hold trace with average values (◆)



TEST ENGINEER: Richard Pennell

3.9 Radiated Emissions; 2 to 3 GHz (continued)

3.9.1 Data; Orientation, Label up, Top channel

Frequency	Peak	CISPR Average	Limit	Margin	Height	Pol	Azimuth	Corr.	
MHz	dBµV/	dBµV/m	dBµV/	dB	cm	H/V	Deg	dB/m	Status
2483.500000	---	7.20	54.00	46.8	132.0	H	155.0	-6.5	Pass
2483.500000	19.2.	---	74.00	54.8	128.0	H	156.0	-6.5	Pass

V = Vertical / H = Horizontal

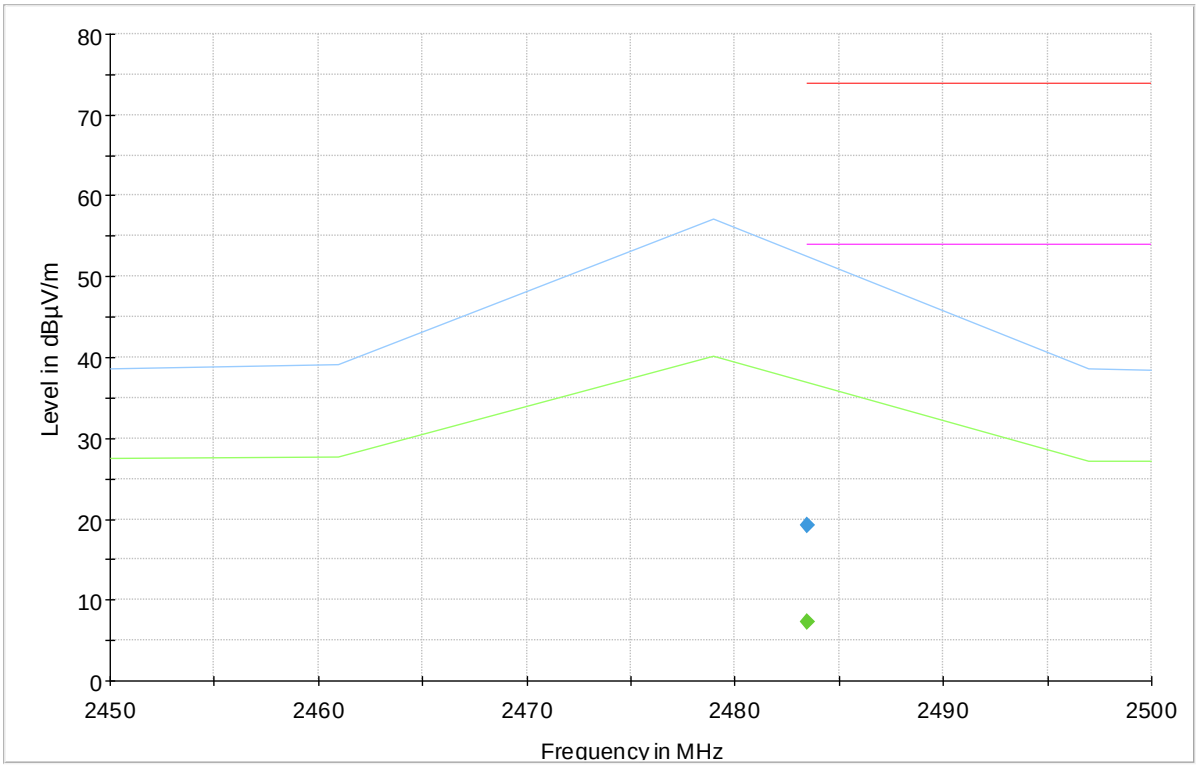
The measurements reported are the highest emissions relative to the FCC limits and take into account the antenna and cable loss factors. Measurements made according to the FCC test standard and Eurofins Hursley test procedure RHF-01.

3.9.2 Profile; Orientation, Label up, Top channel

Max hold trace with peak values (◆)

Peak measurements are shown in red (✳)

Max hold trace with average values (◆)



3.10 Radiated Emissions; 2 to 3 GHz (continued)

3.10.1 Data; Orientation, Label up, Bottom channel

Frequency	Peak	CISPR Average	Limit	Margin	Height	Pol	Azimuth	Corr.	
MHz	dBµV/	dBµV/m	dBµV/	dB	cm	H/V	Deg	dB/m	Status
2390.000000	---	26.37	54.00	27.63	242.0	H	99.0	-6.6	Pass
2390.000000	39.84.	---	74.00	34.16	296.0	H	118.0	-6.6	Pass

V = Vertical / H = Horizontal

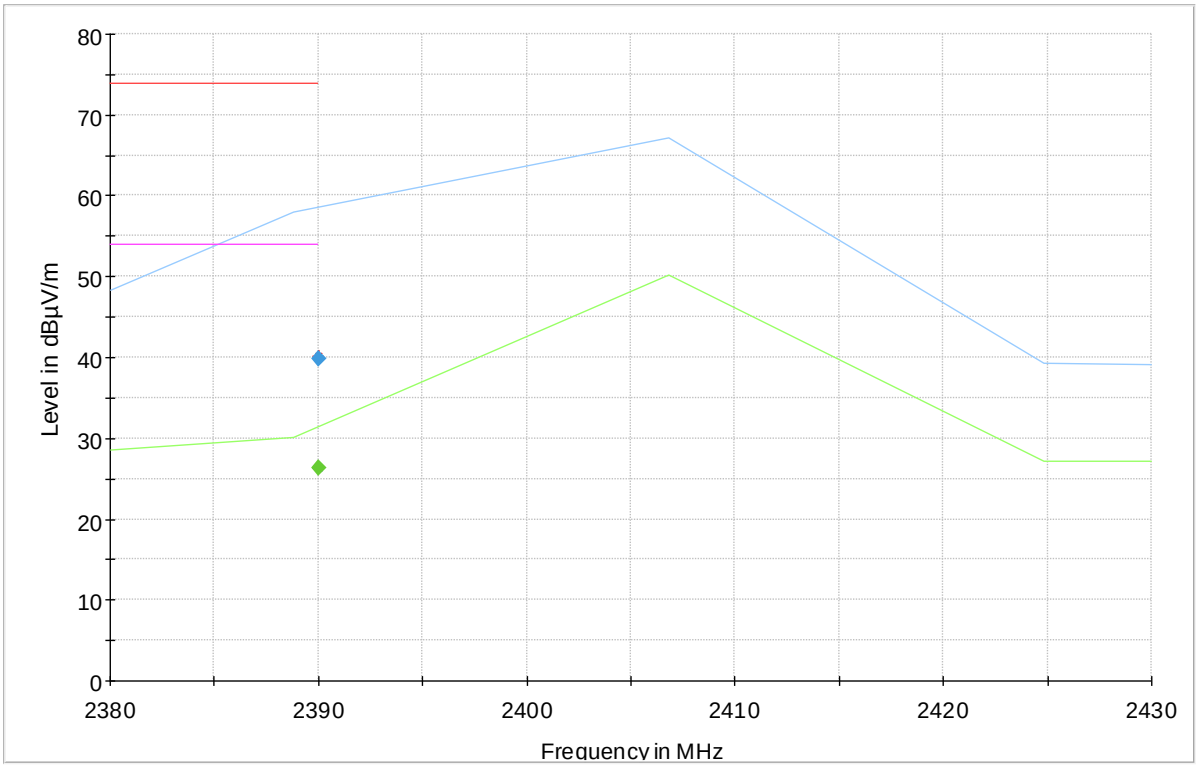
The measurements reported are the highest emissions relative to the FCC limits and take into account the antenna and cable loss factors. Measurements made according to the FCC test standard and Eurofins Hursley test procedure RHF-01.

3.10.2 Profile; Orientation, Label up, Bottom channel

Max hold trace with peak values (◆)

Peak measurements are shown in red (✳)

Max hold trace with average values (◆)



3.11 Radiated Emissions; 10 to 18 GHz

Radiated emissions pre-scan profile measurements were taken at a distance of three metres on eight azimuths of the EUT in both horizontal and vertical antenna polarities in a semi anechoic chamber for FCC measurements.

Using the pre-scan results as a guide, each emission from the EUT was maximised. Measurements were carried out a distance of three metres in a CISPR 16-1-4 compliant semi anechoic chamber. Cable positions were then finally adjusted to produce the maximum emission levels. The EUT was tested in 3 axis and the worst-case results are recorded below.

3.11.1 Data; Node Label up, Bottom Channel

Frequency	Peak	CISPR Average	Limit	Margin	Height	Pol	Azimuth	Corr.	
MHz	dBµV/	dBµV/m	dBµV/	dB	cm	H/V	Deg	dB/m	Status
14488.977956	---	47.00	54.00	7.00	278.0	V	303.0	15.3	Pass
14488.977956	60.75	---	74.00	13.25	192.0	V	10.0	15.3	Pass
16140.280561	---	48.14	54.00	5.86	313.0	V	76.0	15.1	Pass
16140.280561	61.68	---	74.00	12.32	151.0	H	320.0	15.1	Pass

V = Vertical / H = Horizontal

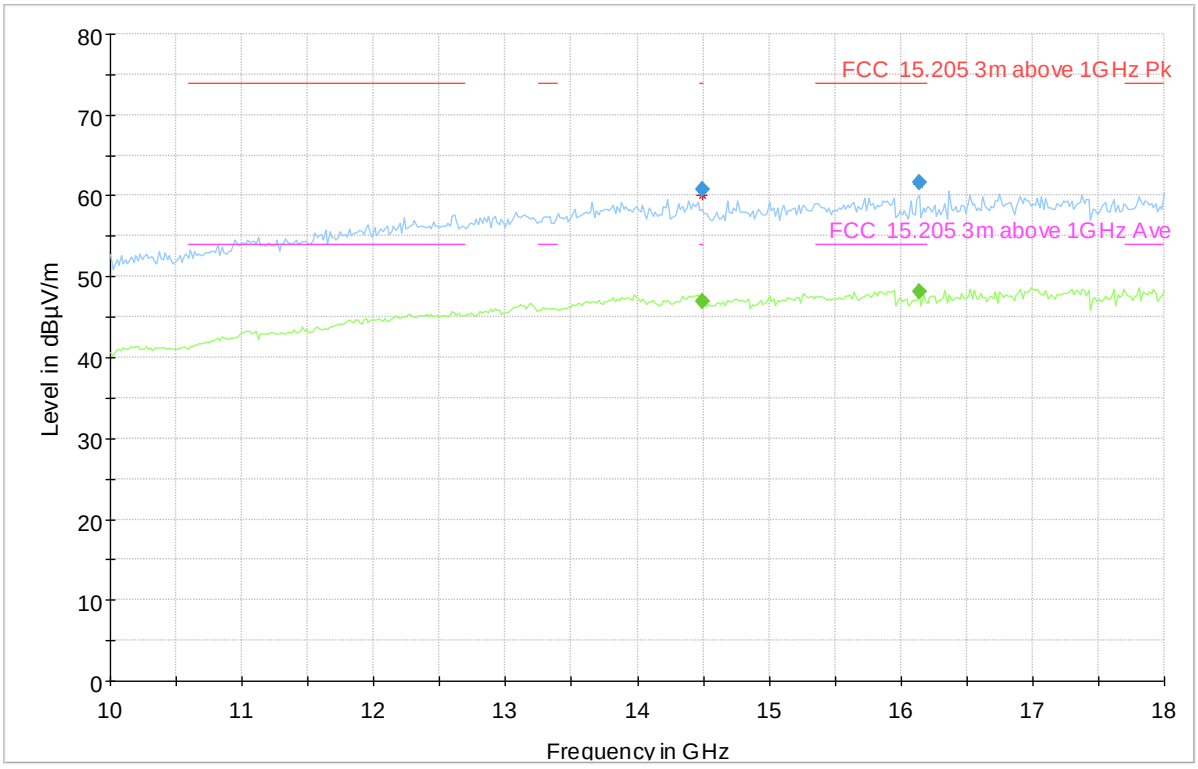
The measurements reported are the highest emissions relative to the FCC limits and take into account the antenna and cable loss factors. Measurements made according to the FCC test standard and Eurofins Hursley test procedure RHF-01.

3.11.2 Profile; Node Label up, Bottom Channel

Max hold trace with peak values (◆)

Peak measurements are shown in red (✳)

Max hold trace with average values (◆)



3.12 Radiated Emissions; 10 to 18 GHz (Continued)

3.12.1 Data; Node Label up, Middle Channel

Frequency	Peak	CISPR Average	Limit	Margin	Height	Pol	Azimuth	Corr.	
MHz	dBµV/	dBµV/m	dBµV/	dB	cm	H/V	Deg	dB/m	Status
13270.541082	---	45.48	54.00	8.52	252.0	H	44.0	14.0	Pass
13270.541082	58.85	---	74.00	15.15	238.0	H	345.0	14.0	Pass
16140.280561	61.68	---	74.00	12.32	240.0	H	45.0	15.1	Pass
16140.280561	---	48.11	54.00	5.89	115.0	V	115.0	15.1	Pass

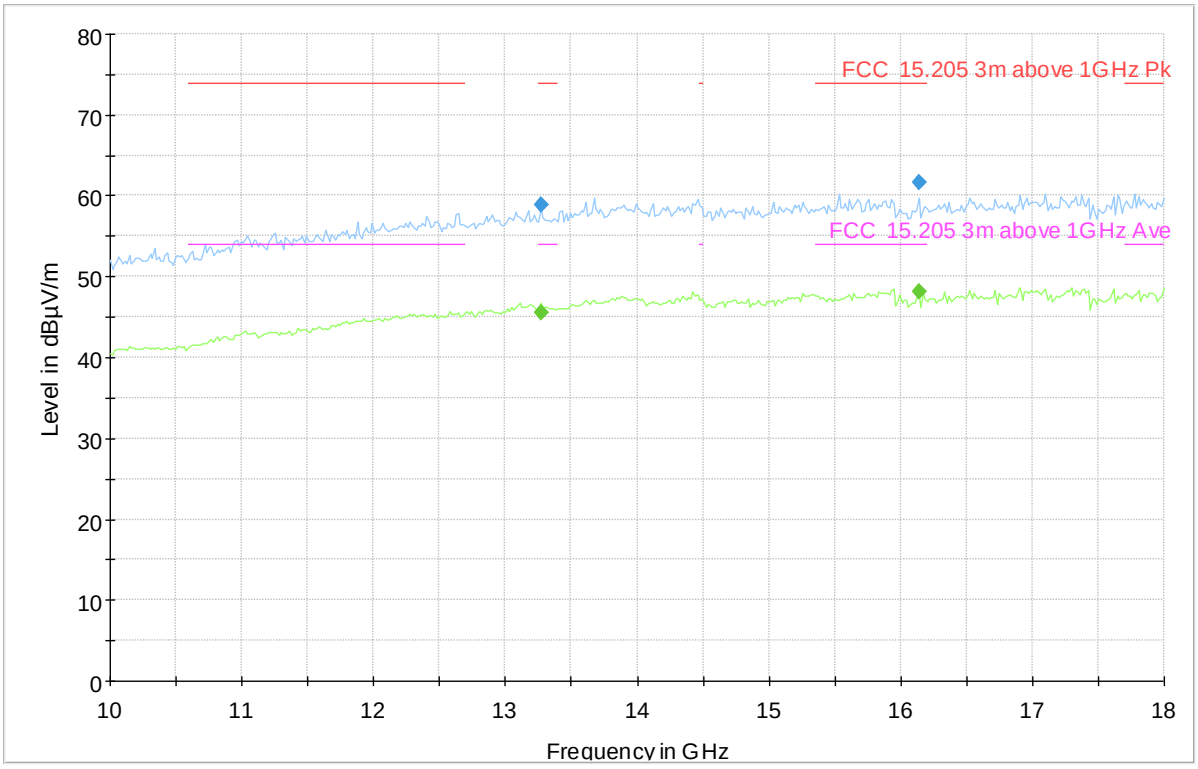
V = Vertical / H = Horizontal

The measurements reported are the highest emissions relative to the FCC limits and take into account the antenna and cable loss factors. Measurements made according to the FCC test standard and Eurofins Hursley test procedure RHF-01.

3.12.2 Profile; Node Label up, Middle Channel

Max hold trace with peak values (◆)

Max hold trace with average values (◆)



3.13 Radiated Emissions; 10 to 18 GHz (Continued)

3.13.1 Data; Node Label up, Top Channel

Frequency	Peak	CISPR Average	Limit	Margin	Height	Pol	Azimuth	Corr.	
MHz	dBµV/	dBµV/m	dBµV/	dB	cm	H/V	Deg	dB/m	Status
14488.977956	60.49	---	74.00	13.51	121.0	V	212.0	15.3	Pass
14488.977956	---	47.11	54.00	6.89	240.0	V	321.0	15.3	Pass
17807.615231	---	49.22	54.00	4.78	309.0	V	350.0	17.1	Pass
17807.615231	63.54	---	74.00	10.46	158.0	H	32.0	17.1	Pass

V = Vertical / H = Horizontal

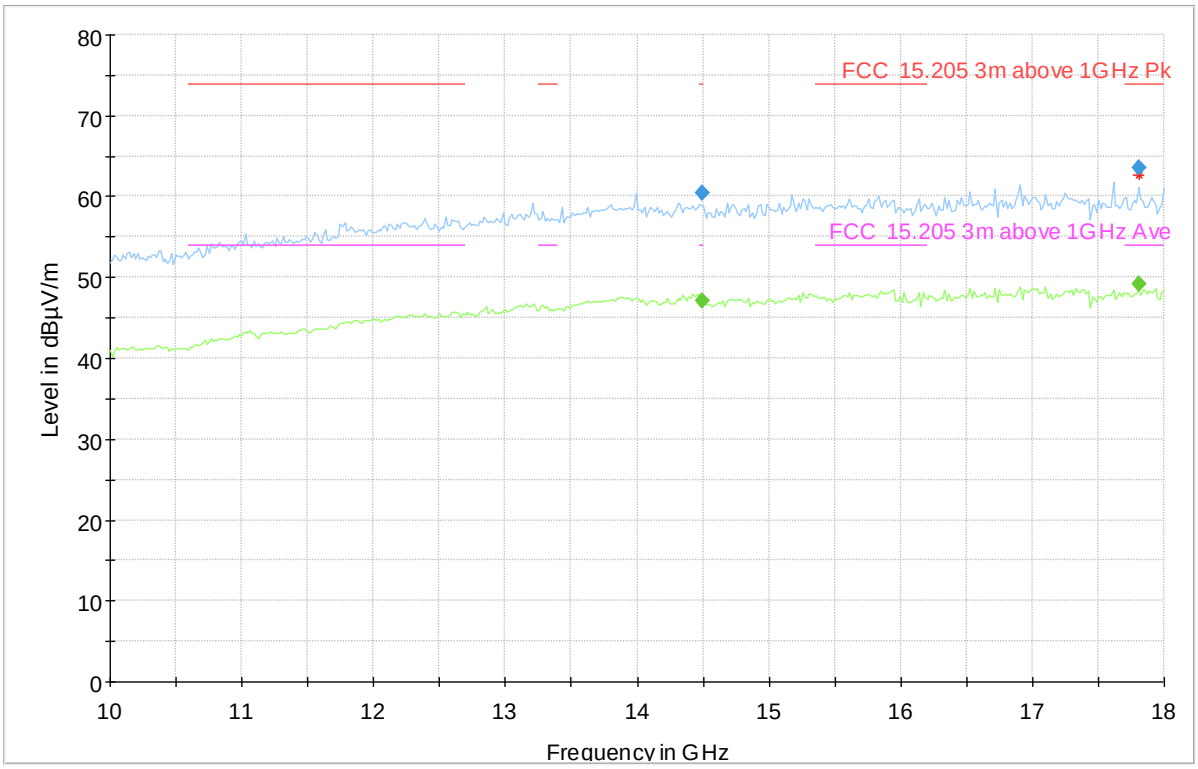
The measurements reported are the highest emissions relative to the FCC limits and take into account the antenna and cable loss factors. Measurements made according to the FCC test standard and Eurofins Hursley test procedure RHF-01.

3.13.2 Profile; Node Label up, Top Channel

Max hold trace with peak values (◆)

Peak measurements are shown in red (✳)

Max hold trace with average values (◆)



3.14 Radiated Emissions; 18 to 26 GHz

The EUT was tested in 3 axis and the worst-case results are recorded below.

3.14.1 Data; Node Antenna up, Bottom Channel

Frequency	Peak	CISPR Average	Limit	Margin	Height	Pol	Azimuth	Corr.	
MHz	dBµV/	dBµV/m	dBµV/	dB	cm	H/V	Deg	dB/m	Status
No significant peaks found									Pass

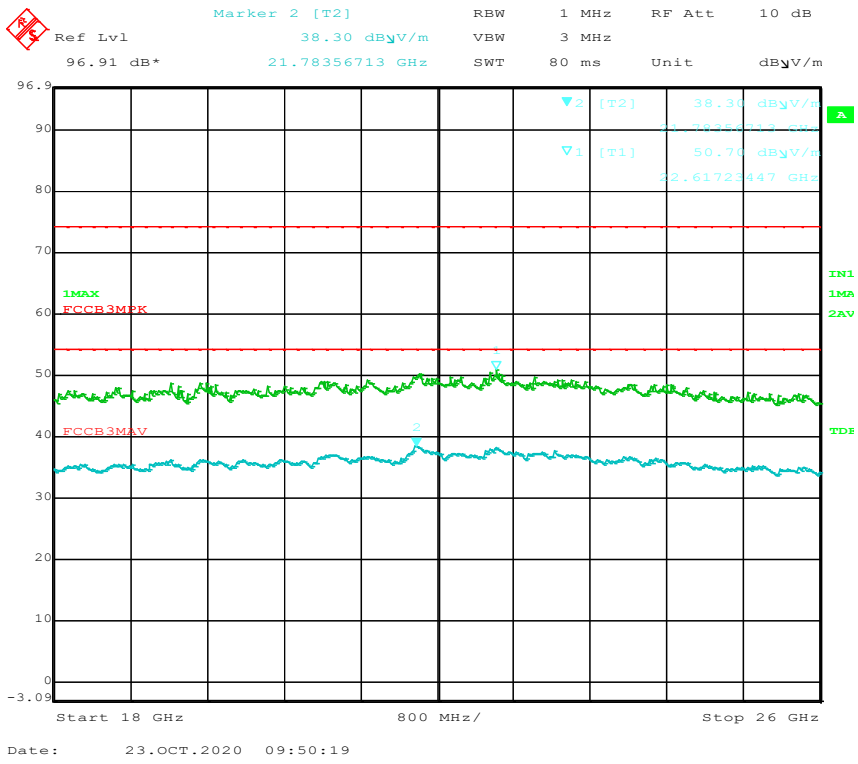
V = Vertical / H = Horizontal

The measurements reported are the highest emissions relative to the FCC limits and take into account the antenna and cable loss factors. Measurements made according to the FCC test standard and Eurofins Hursley test procedure RHF-01.

3.14.2 Profile; Node Antenna up, Bottom Channel

Max hold trace with peak values (▽)

Max hold trace with average values (▼)



3.15 Radiated Emissions; 18 to 26 GHz (Continued)

3.15.1 Data; Node Antenna up, Middle Channel

Frequency	Peak	CISPR Average	Limit	Margin	Height	Pol	Azimuth	Corr.	
MHz	dBµV/	dBµV/m	dBµV/	dB	cm	H/V	Deg	dB/m	Status
No significant peaks found									Pass

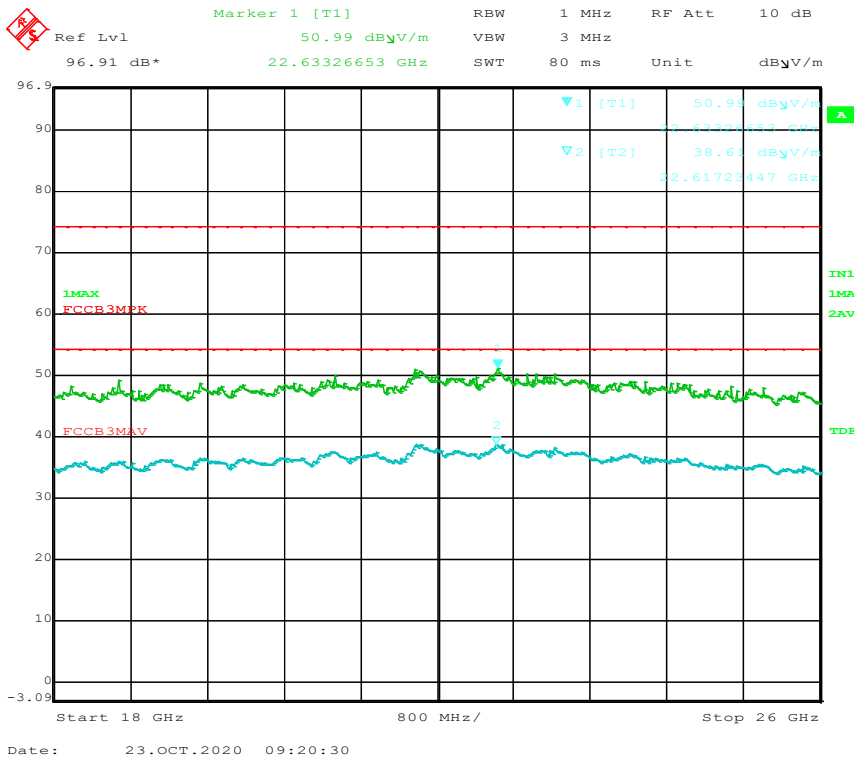
V = Vertical / H = Horizontal

The measurements reported are the highest emissions relative to the FCC limits and take into account the antenna and cable loss factors. Measurements made according to the FCC test standard and Eurofins Hursley test procedure RHF-01.

3.15.2 Profile; Node Antenna up, Middle Channel

Max hold trace with peak values (▽)

Max hold trace with average values (▼)



3.16 Radiated Emissions; 18 to 26 GHz (Continued)

3.16.1 Data; Node Antenna up, Top Channel

Frequency	Peak	CISPR Average	Limit	Margin	Height	Pol	Azimuth	Corr.	
MHz	dBµV/	dBµV/m	dBµV/	dB	cm	H/V	Deg	dB/m	Status
No significant peaks found									Pass

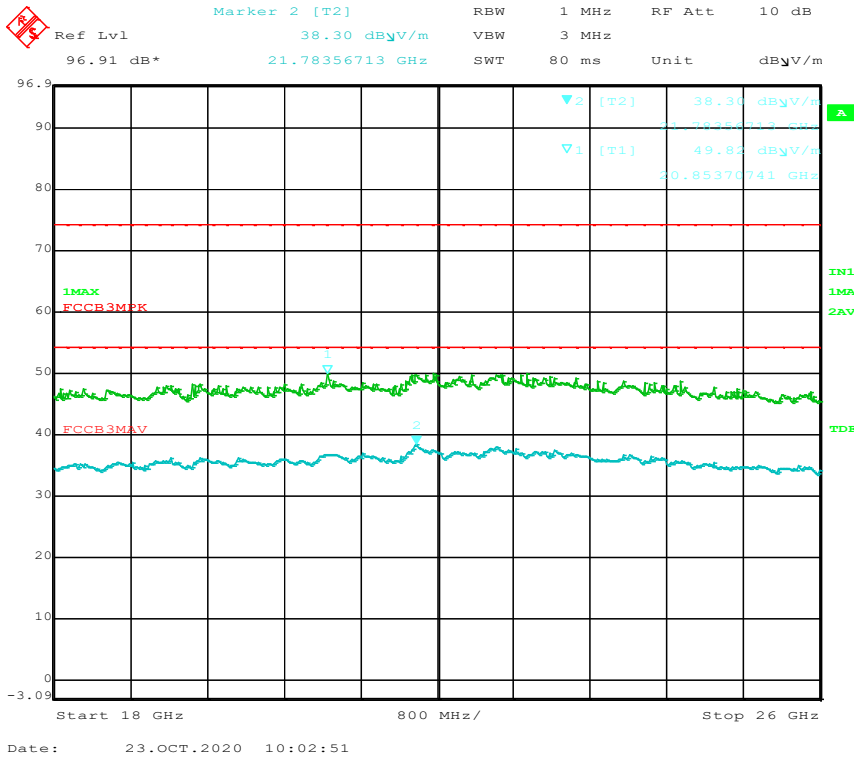
V = Vertical / H = Horizontal

The measurements reported are the highest emissions relative to the FCC limits and take into account the antenna and cable loss factors. Measurements made according to the FCC test standard and Eurofins Hursley test procedure RHF-01.

3.16.2 Profile; Node Antenna up, Top Channel

Max hold trace with peak values (▽)

Max hold trace with average values (▼)



4.0 PHOTO LOG

Emissions:

Radiated emissions

Photo Log (continued)

Emissions:

Radiated emissions

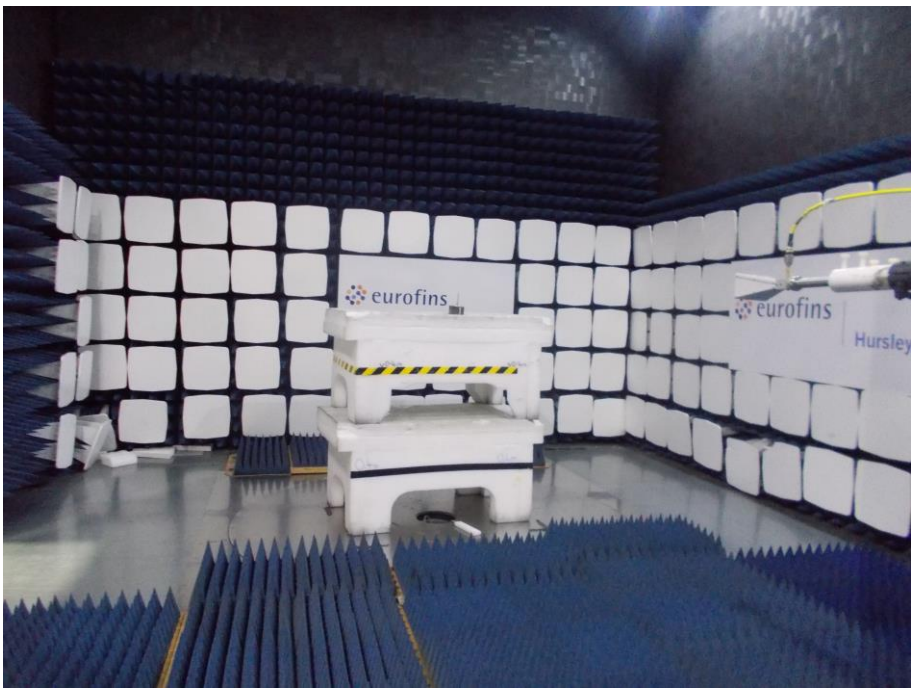
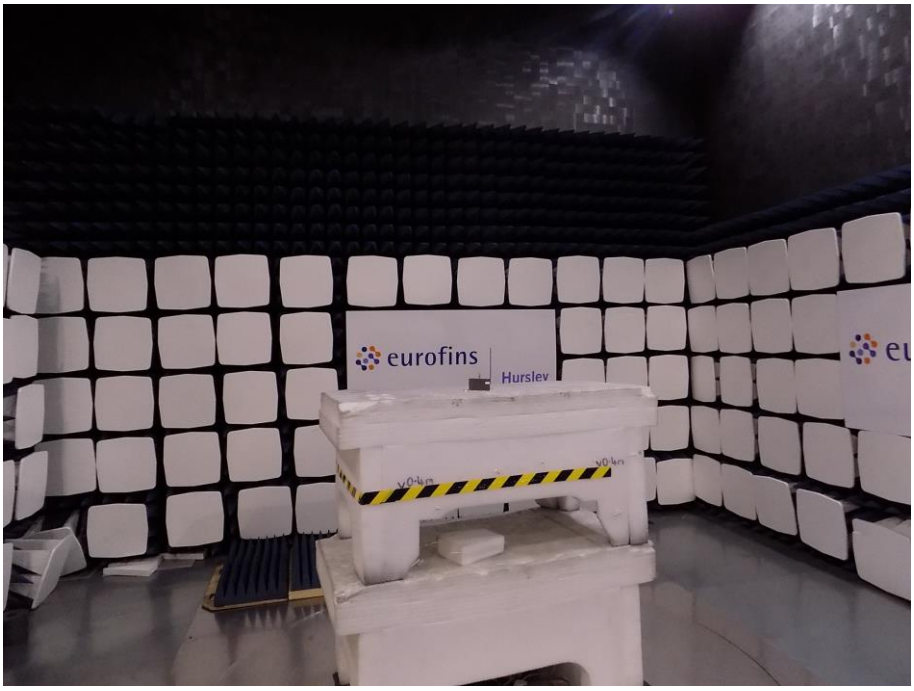


Photo Log (continued)

Emissions:

Radiated emissions



5.0 MEASUREMENT UNCERTAINTIES

Emissions tests

For all emissions tests, measurement uncertainties have been calculated in line with the requirements of CISPR 16-4-2 to give a confidence level of greater than 95%. In all cases the laboratories calculated uncertainty values (known as Ulab) are equal to or are less than the expected uncertainty values contained in CISPR 16-4-2 (known as Ucispr). Below is a list of the laboratories calculated measurement uncertainties:

Conducted emissions:

Via AMN/LISN:	±3.27 dB (9 kHz – 150 kHz), ±3.28 dB (150 kHz – 30 MHz)
Via AAN/ISN:	±4.99 dB (150 kHz – 30 MHz)
Via CVP:	±3.47 dB (150 kHz – 30 MHz)
Via CP:	±2.69 dB (150 kHz – 30 MHz)
Via 100 Ω:	±2.69 dB (150 kHz – 30 MHz)
Clicks:	±3.34 dB (150 kHz – 30 MHz)
Harmonics:	±5.82 % (100 Hz – 2 kHz)
Flicker:	±3.78 % (worst case for all parameters)

Radiated emissions:

H-Field:	±2.73 dB (9 kHz – 3 MHz), ±2.88 dB (3 MHz – 30 MHz)
D = 3.0 m (Horizontal):	±3.92 dB (30 MHz – 200 MHz), ±3.78 dB (200 MHz – 1 GHz)
D = 3.0 m (Vertical):	±3.74 dB (30 MHz – 200 MHz), ±5.06 dB (200 MHz – 1 GHz)
D = 3.0 m:	±4.50 dB (1 GHz – 6 GHz), ±4.04 dB (6 GHz – 18 GHz), ±4.27 dB (18 GHz – 40 GHz)
D = 10.0 m (Horizontal):	±4.53 dB (30 MHz – 200 MHz), ±4.61 dB (200 MHz – 1 GHz)
D = 10.0 m (Vertical):	±4.41 dB (30 MHz – 200 MHz), ±4.77 dB (200 MHz – 1 GHz)

6.0 ANNEX – CONDUCTED EMISSIONS RESULTS

6.1 Measurement Uncertainty

The uncertainty gives a 95% confidence interval in the measurement . expanded uncertainty (K=2) for the frequency range 10 MHz to 25 GHz is as follows: < ± 1.73 dB.

6.2 DTS Bandwidth

6.2.1 Measurement method

Test was conducted in accordance with ANSI C63.10 Clause 11.8 Option 1:

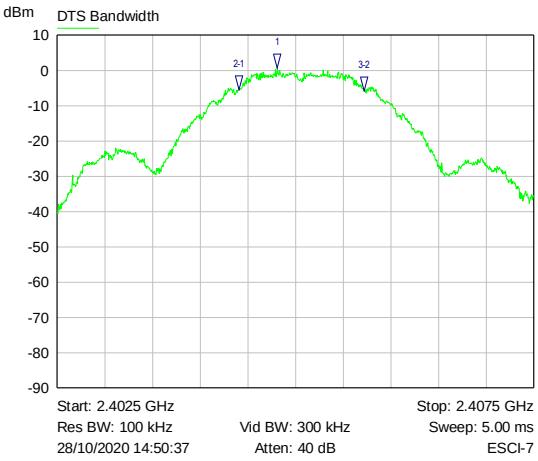
a) Set resolution bandwidth to 100 kHz
b) Set the video bandwidth to ≥ 3 x RBW
c) Detector = Peak.
d) Trace mode = max hold.
e) Sweep = auto couple.
f) Allow the trace to stabilize.
g) Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

6.2.2 Test results

Channel	6dB DTS Bandwidth (MHz)	Requirement	Result
Bottom	1.43	> 500 kHz	Pass
Middle	1.37	> 500 kHz	Pass
Top	1.32	> 500 kHz	Pass

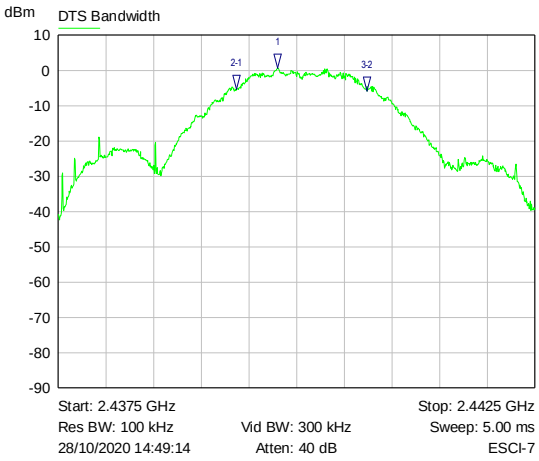
Table 6: DTS Bandwidth

6.2.3 DTS Bandwidth plots



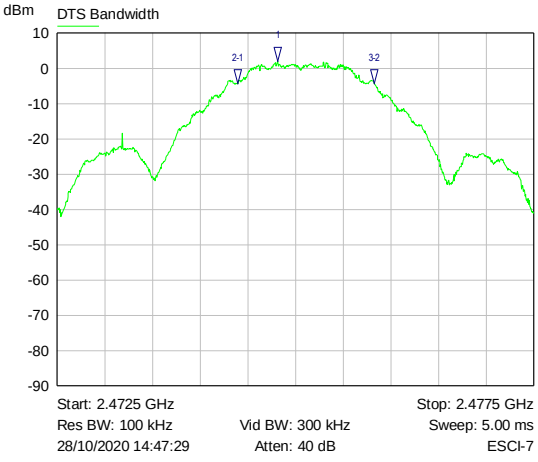
Mkr	Trace	X-Axis	Value	Notes
1	DTS Bandwidth	2.4048 GHz	0.61 dBm	
2-1	DTS Bandwidth	-400.0000 kHz	-6.13 dB	Relative to max
3-2	DTS Bandwidth	1.3150 MHz	-0.32 dB	Relative to marker 2

Bottom



Mkr	Trace	X-Axis	Value	Notes
1	DTS Bandwidth	2.4398 GHz	0.61 dBm	
2-1	DTS Bandwidth	-430.0000 kHz	-5.97 dB	Relative to max
3-2	DTS Bandwidth	1.3700 MHz	-0.41 dB	Relative to marker 2

Middle



Mkr	Trace	X-Axis	Value	Notes
1	DTS Bandwidth	2.4748 GHz	2.06 dBm	
2-1	DTS Bandwidth	-415.0000 kHz	-6.46 dB	Relative to max
3-2	DTS Bandwidth	1.4300 MHz	0.02 dB	Relative to marker 2

Top

Figure 1: DTS Bandwidth plots

6.3 Maximum Peak Conducted Output Power

6.3.1 Measurement method

As the analyser could be set RBW ≥ DTS bandwidth, the test was conducted in accordance with ANSI C63.10 Clause 11.9.1.1:

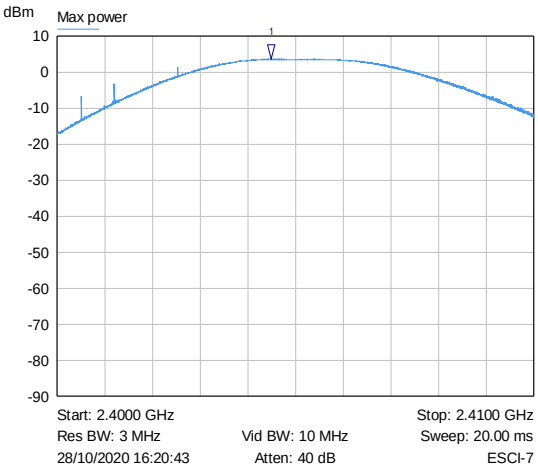
a) Set the RBW ≥ DTS bandwidth.
b) Set VBW ≥ 3 x RBW.
c) Set span ≥ 3 x RBW
d) Sweep time = auto couple.
e) Detector = peak.
f) Trace mode = max hold.
g) Allow trace to fully stabilize.
h) Use peak marker function to determine the peak amplitude level.

6.3.2 Test results

Channel	Channel Power (dBm)	Limit (dBm)	Result
Bottom	3.62	30.0	Pass
Middle	3.65	30.0	Pass
Top	4.99	30.0	Pass

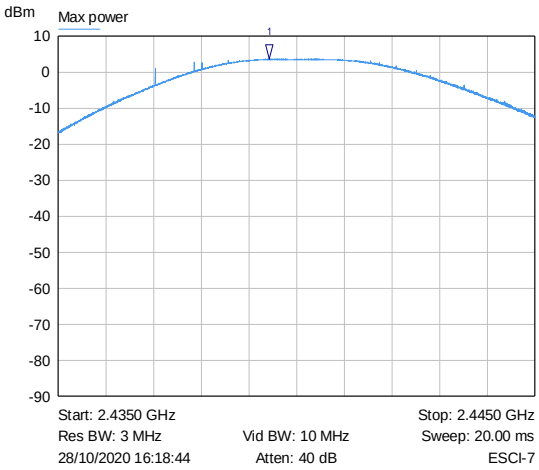
Table 7: Channel Power

6.3.3 Profile; Maximum Peak Conducted Power



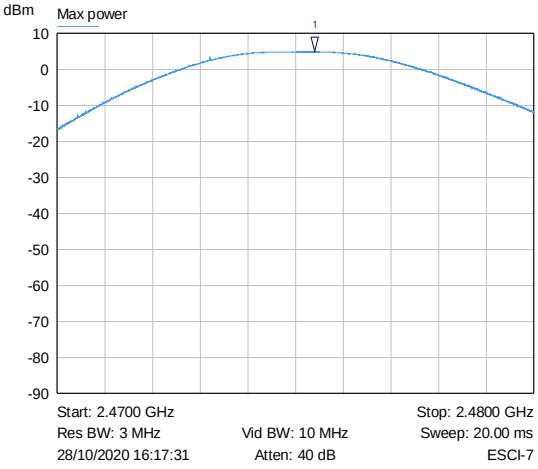
Mkr	Trace	X-Axis	Value	Notes
1	Max power	2.4045 GHz	3.62 dBm	

Bottom



Mkr	Trace	X-Axis	Value	Notes
1	Max power	2.4394 GHz	3.65 dBm	

Middle



Mkr	Trace	X-Axis	Value	Notes
1	Max power	2.4754 GHz	4.99 dBm	

Top

Figure 2: Peak Conducted Power plots

6.4 Maximum Power Spectral Density

6.4.1 Measurement method

As conducted power was measured as Maximum Peak Conducted Power, measurement was performed in accordance with ANSI C63.10 Clause 11.10.2:

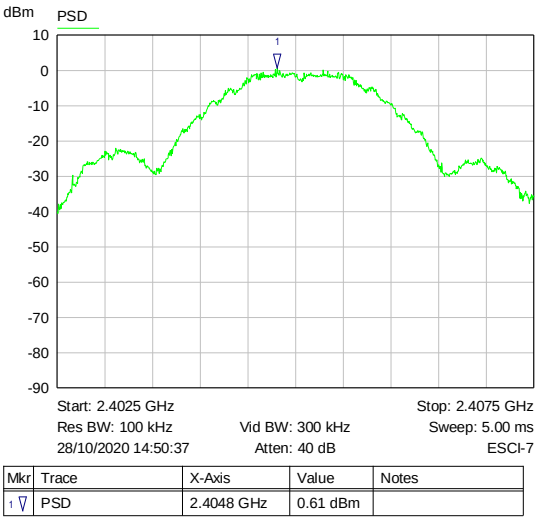
a) Set analyzer center frequency to DTS channel center frequency.
b) Set the span to 1.5 x DTS bandwidth.
c) Set the RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
d) Set the VBW ≥ 3 x RBW.
e) Detector = peak.
f) Sweep time = auto couple.
g) Trace mode = max hold.
h) Allow trace to fully stabilize.
i) Use the peak marker function to determine the maximum amplitude level within the RBW.
j) If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

6.4.2 Test results

Channel	Peak Marker reading (dBm)	Limit (dBm/3kHz)	Result
Bottom	0.61	8.0	Pass
Middle	0.61	8.0	Pass
Top	2.06	8.0	Pass

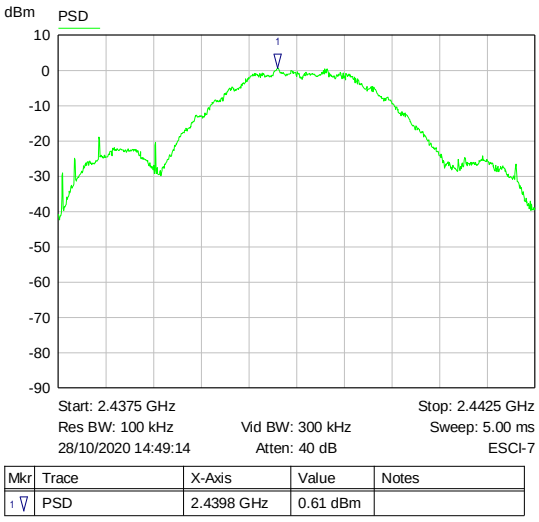
Table 8: Spectral Density results

6.4.3 Profile; Power Spectral Density



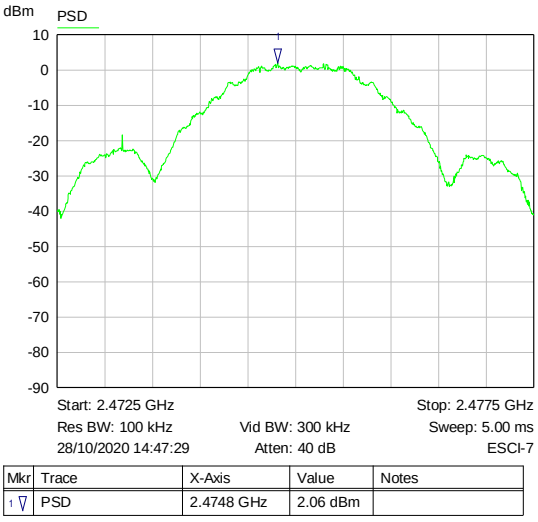
Mkr	Trace	X-Axis	Value	Notes
1	PSD	2.4048 GHz	0.61 dBm	

Bottom



Mkr	Trace	X-Axis	Value	Notes
1	PSD	2.4398 GHz	0.61 dBm	

Middle



Mkr	Trace	X-Axis	Value	Notes
1	PSD	2.4748 GHz	2.06 dBm	

Top

Figure 3: Spectral Density plots

6.5 Emissions in non-restricted frequency bands

6.5.1 Measurement method

Since peak power measurements were made using a peak detector, the same detector will be used for unwanted emissions. The unwanted emissions shall be at least 20dB lower than the wanted emission.

First, establish a reference level in accordance with ANSI C63.10 Clause 11.11.2:

a) Set instrument center frequency to DTS channel center frequency.
b) Set the span to ≥ 1.5 x DTS bandwidth.
c) Set the RBW = 100 kHz.
d) Set the VBW ≥ 3 x RBW.
e) Detector = peak.
f) Sweep time = auto couple.
g) Trace mode = max hold.
h) Allow trace to fully stabilize.
i) Use the peak marker function to determine the maximum PSD level.

Then measure the emission levels in accordance with KDB 558074 section 11.3

a) Set the center frequency and span to encompass frequency range to be measured.
b) Set the RBW = 100 kHz.
c) Set the VBW ≥ 3 x RBW.
d) Detector = peak.
e) Sweep time = auto couple.
f) Trace mode = max hold.
g) Allow trace to fully stabilize.
h) Use the peak marker function to determine the maximum amplitude level.

6.5.2 Test results

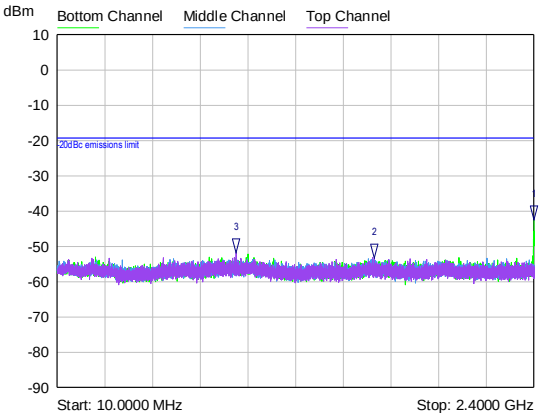
The reference trace was taken from the Power Spectral Density Measurement which used the same settings.

For ease of measurement, maximum values are reported anywhere in the frequency band of investigation, whether or not it is outside a restricted band. Further measurements in restricted bands are in the next section.

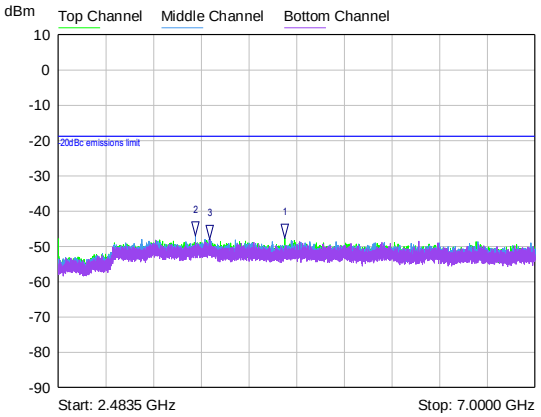
Channel	Maximum Peak level in 100 kHz RBW (dBm)	-20 dBc (dBm)	Maximum emission (dBm)	Result
Bottom	0.61	-19.39	-42.55	Pass
Middle	0.61	-19.39	-47.07	Pass
Top	2.06	-17.94	-48.02	Pass

Table 9: Emissions in non-restricted bands

6.5.3 Profile; Emissions in non-restricted frequency bands



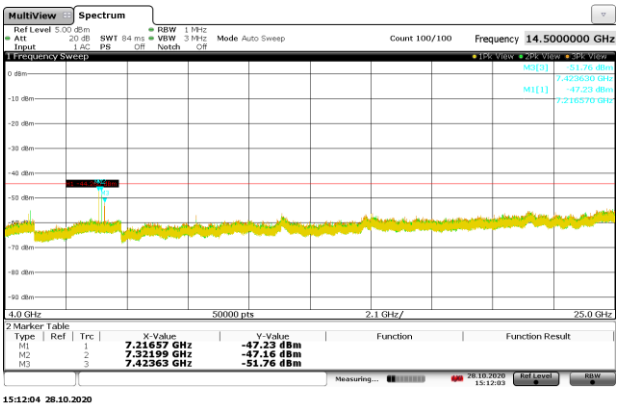
Mkr	Trace	X-Axis	Value	Notes
1	Bottom Channel	2.4000 GHz	-42.55 dBm	
2	Middle Channel	1.5985 GHz	-53.29 dBm	
3	Top Channel	906.5488 MHz	-51.91 dBm	



Mkr	Trace	X-Axis	Value	Notes
1	Top Channel	4.6277 GHz	-47.60 dBm	
2	Middle Channel	3.7814 GHz	-47.07 dBm	
3	Bottom Channel	3.9197 GHz	-48.02 dBm	

20 – 2400 MHz

2483.5 – 7000 MHz



4000 – 25000 MHz (1 MHz RBW)

Figure 4: Emissions in non-restricted frequency bands

6.6 Maximum Emissions in Restricted Band

This testing is done in two parts:

- Antenna port conducted measurement
- Radiated measurement with antenna port terminated

6.7 Conducted Antenna port

6.7.1 Measurement method

The conducted antenna port power is converted to a radiated emissions field strength limit specified in 15.209(a) as per ANSI C63.10 Clause 11.12.2:

Electric field strength, E = EIRP – 20log D + 104.8

Which can be re-written as EIRP = E + 20logD – 104.8

Since EIRP = conducted power + antenna gain + ground reflection
This can be re-written:

Max. conducted power = E + 20logD – 104.8 - antenna gain - ground reflection

If "E" is the limit, and the measurement distance taken as 3 m, the maximum conducted power can be determined as shown in the table:

Frequency range	Limit	Field strength (µV/m)	Field Strength (dBµV/m)	20logD	Antenna gain (dBi)	Ground reflection	Limit (dBm)
30 – 88 MHz	QP	100	40.0	9.54	2.0	4.7	-61.96
88 – 216 MHz	QP	150	43.5	9.54	2.0	4.7	-58.46
216 – 960 MHz	QP	200	46.0	9.54	2.0	4.7	-55.96
960 – 1000 MHz	QP	500	54.0	9.54	2.0	4.7	-47.96
> 1 GHz	Average	500	54.0	9.54	2.0	0	-43.26
> 1 GHz	Peak	Average + 20dB	74.0	9.54	2.0	0	-23.26

Table 10: Restricted band limits at antenna port

Initial measurement of antenna port emissions was performed with a peak detector as per ANSI C63.10 Clause 11.12.2.4:

a) RBW = as specified in Table 1.
b) VBW ≥ 3 x RBW.
c) Detector = Peak.
d) Sweep time = auto.
e) Trace mode = max hold.
f) Allow sweeps to continue until the trace stabilizes. (Note that the required measurement time may be longer for low duty cycle applications).

Where emissions above 1 GHz were close to the limit, these were re-measured using trace-averaging and RMS detector as per section 11.12.2.5.1:

a) RBW = 1 MHz (unless otherwise specified).
b) VBW ≥ 3 x RBW.
c) Detector = RMS, if span/(# of points in sweep) ≤ (RBW/2). Satisfying this condition may require increasing the number of points in the sweep or reducing the span. If this condition cannot be satisfied, then the detector mode shall be set to peak. (Note: 32001 measurement points used)
d) Averaging type = power (i.e., RMS).
    1) As an alternative, the detector and averaging type may be set for linear voltage averaging.
    2) Some instruments require linear display mode in order to use linear voltage averaging. Log or dB averaging shall not be used.
e) Sweep time = auto.
f) Perform a trace average of at least 100 traces.

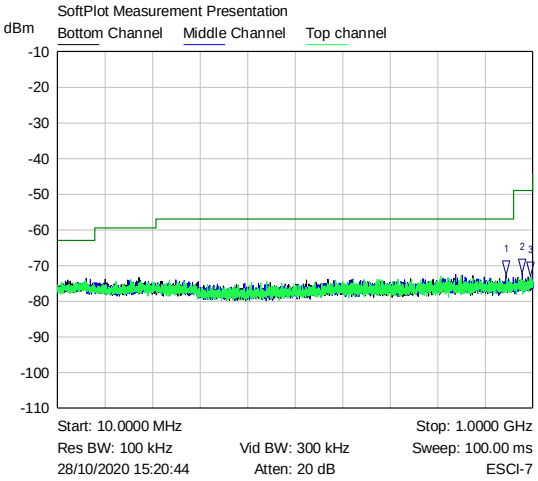
6.7.2 Test results

Maximum values for each frequency range are shown on the plots, and the worst case emissions for each channel where the emission is in a restricted band were re-measured using RMS detector and are detailed in the table below:

Channel	Frequency (MHz)	Detector	Level (dBm)	Peak limit (dBm)	Average limit (dBm)	Result
2475	2483.5	Peak	-40.05	-23.26	N/A	Pass
		RMS	-47.85	N/A	-42.26	Pass
2405	7216.57	Peak	-47.23	N/A: not in a restricted band		
		RMS	-54.02	N/A: not in a restricted band		
2440	7321.99	Peak	-47.16	-23.26	N/A	Pass
		RMS	-54.68	N/A	-43.26	Pass
2475	7423.63	Peak	-51.76	-23.26	N/A	Pass
		RMS	-60.13	N/A	-43.26	Pass

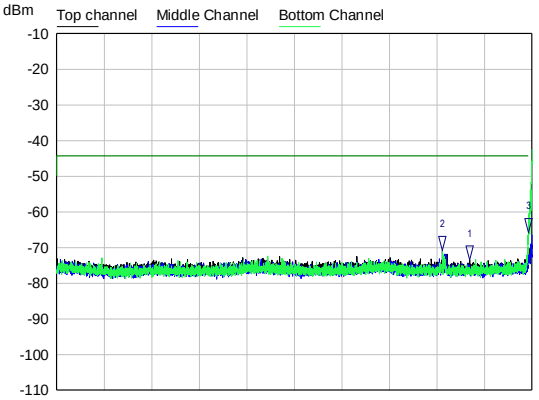
Table 11: Emissions in restricted bands

6.7.3 Emissions in restricted bands



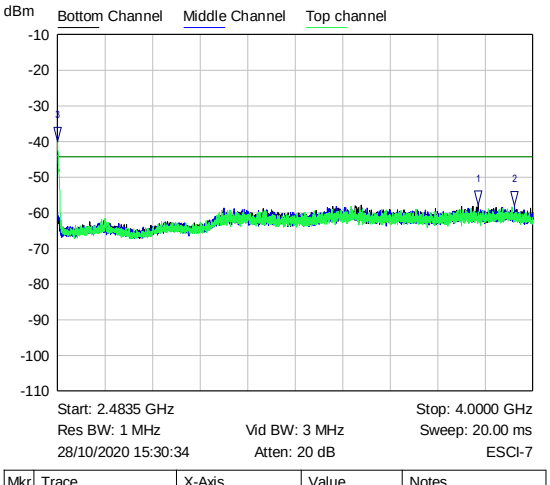
Mkr	Trace	X-Axis	Value	Notes
1	Bottom Channel	944.3125 MHz	-72.71 dBm	
2	Middle Channel	978.2200 MHz	-72.18 dBm	
3	Top channel	994.5550 MHz	-72.97 dBm	

30 – 1000 MHz (peak)



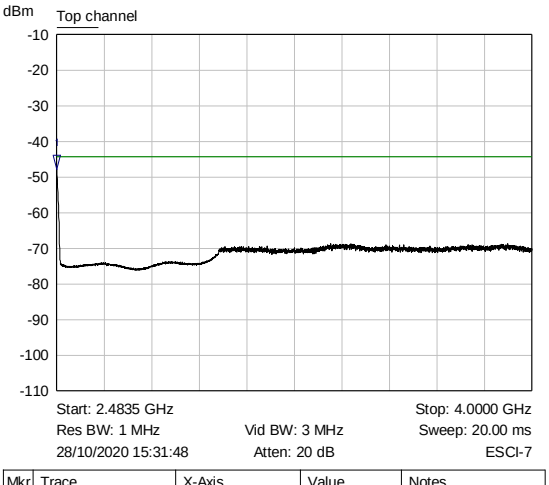
Mkr	Trace	X-Axis	Value	Notes
1	Top channel	2.2166 GHz	-73.51 dBm	
2	Middle Channel	2.1361 GHz	-70.85 dBm	
3	Bottom Channel	2.3899 GHz	-65.82 dBm	

1000 - 2390 MHz (Peak)



Mkr	Trace	X-Axis	Value	Notes
1	Bottom Channel	3.8256 GHz	-57.85 dBm	
2	Middle Channel	3.9420 GHz	-58.07 dBm	
3	Top channel	2.4835 GHz	-40.05 dBm	

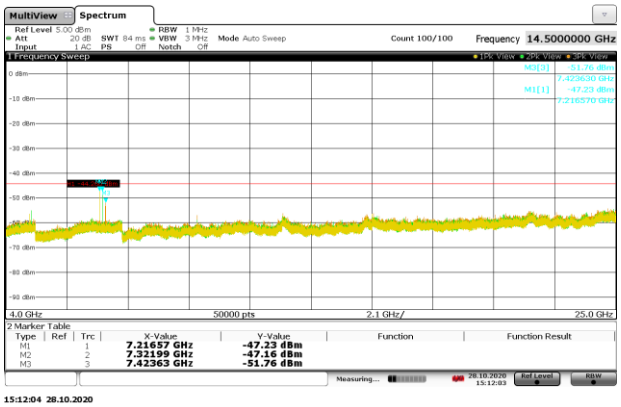
2483.5 – 4000 MHz (Peak)



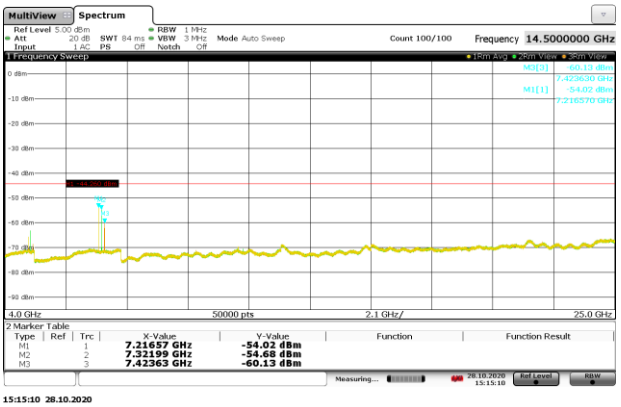
Mkr	Trace	X-Axis	Value	Notes
1	Top channel	2.4835 GHz	-47.85 dBm	RMS below Ave limit

Top channel 2483.5 – 4000 MHz (RMS)

6.7.4 Emissions in restricted frequency bands (continued)



4000 – 25000 MHz (Peak)



4000 – 25000 MHz (RMS)

Figure 6: Emissions in restricted frequency bands

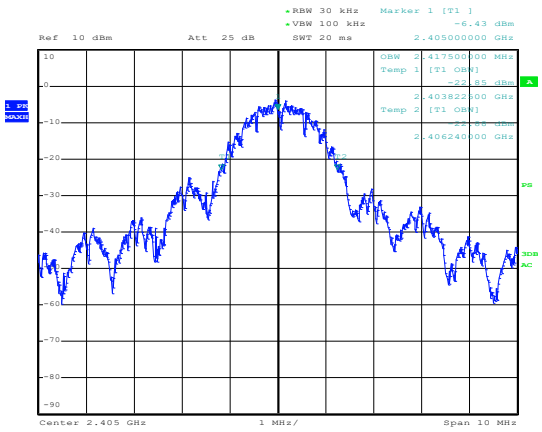
6.8 Occupied bandwidth

99% occupied bandwidth measured using the inbuilt function in the spectrum analyser

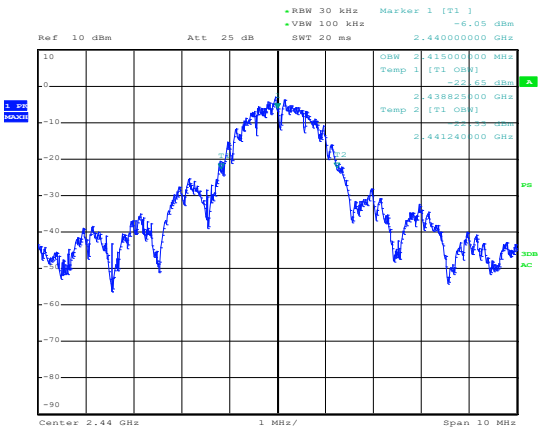
Channel	Occupied Bandwidth (MHz)	Requirement	Result
Bottom	2.418	None	For information
Middle	2.415	None	For information
Top	2.308	None	For information

Table 12: Occupied Bandwidth

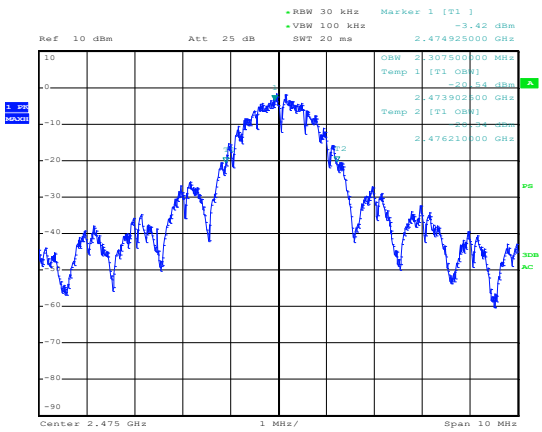
Occupied Bandwidth



Bottom



Middle



Top

Figure 7: Occupied Bandwidth

6.9 Test equipment

Description	Manufacturer	Name	Serial Number	Calibration certificate Or Calibration due
Spectrum Analyser	Rohde & Schwarz	ESCI 7	HEMC #289	16/09/2021
Spectrum Analyser	Rohde & Schwarz	ESW 44	HEMC #788	28/04/2021

Table 2: Test Equipment

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