FCC Test Report

Technolog Ltd
Cello 4S, Model: Cello 4S

In accordance with FCC 47 CFR Part 24, FCC 47 CFR Part 2
(PCS 1900)

Prepared for: Technolog Ltd
Ravenstor Road, Wirksworth
DE4 4FY, United Kingdom

FCC ID: XUV2172TT2400

COMMERCIAL-IN-CONFIDENCE

Document 75953750-04 Issue 01

SIGNATURE			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Steve Marshall	Senior Engineer	Authorised Signatory	22 February 2022

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD document control rules.

ENGINEERING STATEMENT
The measurements shown in this report were made in accordance with the procedures described on test pages. All reported testing was carried out on a sample equipment to demonstrate limited compliance with FCC 47 CFR Part 24 and FCC 47 CFR Part 2. The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	Neil Rousell	22 February 2022	
Testing	Graeme Lawler	22 February 2022	

FCC Accreditation
90987 Octagon House, Fareham Test Laboratory

EXECUTIVE SUMMARY
A sample of this product was tested and found to be compliant with FCC 47 CFR Part 24: 2020 and FCC 47 CFR Part 2: 2020 for the tests detailed in section 1.3.

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1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	22-February-2022

Table 1

1.2 Introduction

Applicant	Technolog Ltd
Manufacturer	Technolog Ltd
Model Number(s)	Cello 4S
Serial Number(s)	20213128425-93-
Hardware Version(s)	2172TT2400B / 2172CG3522
Software Version(s)	4.50
Number of Samples Tested	1
Test Specification/Issue/Date	FCC 47 CFR Part 2: 2020 FCC 47 CFR Part 24: 2020
Order Number Date	PO-301292 03-November-2021
Date of Receipt of EUT	12-January-2022
Start of Test	12-January-2022
Finish of Test	03-February-2022
Name of Engineer(s)	Neil Rousell and Graeme Lawler
Related Document(s)	ANSI C63.26: 2015 KDB 971168 D01 v03r01

1.3 4

1.4 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC 47 CFR Part 24 and FCC 47 CFR Part 2 is shown below.

Section	Specification Clause		Test Description	Result	Comments/Base Standard
	FCC Part 2	FCC Part 24			
Configuration and Mode: Internal Antenna - PCS 1900					
2.1	2.1047 (d)	-	Modulation Characteristics	Declaration	
2.2	-	24.232	Equivalent Isotropic Radiated Power	Pass	
2.3	2.1053	24.238 (a)	Radiated Spurious Emissions	Pass	
Configuration and Mode: External Antenna - PCS 1900					
2.4	2.1051	24.229 and 24.238 (a)	Spurious Emissions at Band Edge	Pass	
2.2	-	24.232	Equivalent Isotropic Radiated Power	Pass	
2.5	2.1046	24.232	Maximum Conducted Output Power	Pass	
2.6	2.1055	24.235	Frequency Stability	Pass	
2.7	2.1049 (h)	24.238	26 dB Bandwidth	Satisfactory	
2.8	2.1051	24.238 (a)	Spurious Emissions at Antenna Terminals	Pass	
2.3	2.1053	24.238 (a)	Radiated Spurious Emissions	Pass	

Table 2

1.5 Application Form

Equipment Description

Technical Description: *(Please provide a brief description of the intended use of the equipment)*	Data logger for monitoring pressure and flow in a mains water distribution network. The logger sends data periodically via SMS or a data connection with a server.
Manufacturer:	Technolog Ltd
Model:	Cello 4S; CMC4/P(1)ST/IOMC12+3/2131/LTE_WW+2G
Part Number:	2172CG3522
Hardware Version:	2172TT2400B / 2172CG3522
Software Version:	4.50
FCC ID (if applicable)	XUV2172TT2400f
IC ID (if applicable)	5131A-ME910G1WW (of the integrated module)

Table 3

Intentional Radiators

Technology	PCS1900					
Frequency Band (MHz)	1900					
Conducted Declared Output Power (dBm)	29.5					
Antenna Gain (dBi)	4 (internal ant) 4.5 (external ant)					
Supported Bandwidth(s) (MHz)	As per standard.					
Modulation Scheme(s)	As per standard.					
ITU Emission Designator	As per standard.					
Bottom Frequency (MHz)	As per standard.					
Middle Frequency (MHz)	As per standard.					
Top Frequency (MHz)	As per standard.					

Table 4

Un-intentional Radiators

Highest frequency generated or used in the device or on which the device operates or tunes	3.58MHz
Lowest frequency generated or used in the device or on which the device operates or tunes	0 Hz
Class A Digital Device (Use in commercial, industrial or business environment) ☒ Class B Digital Device (Use in residential environment only) ☐	

Table 5

AC Power Source

AC supply frequency:		Hz
Voltage		V
Max current:		A
Single Phase ☐ Three Phase ☐		

Table 6

DC Power Source

Nominal voltage:		V
Extreme upper voltage:		V
Extreme lower voltage:		V
Max current:		A

Table 7

Battery Power Source

Voltage:	3.6	V
End-point voltage:	3.5	V *(Point at which the battery will terminate)*
Alkaline ☐ Leclanche ☐ Lithium ☒ Nickel Cadmium ☐ Lead Acid* ☐ **(Vehicle regulated)*		
Other ☐ Please detail:		

Table 8

Charging

Can the EUT transmit whilst being charged	Yes ☐ No ☒

Table 9

Temperature

Minimum temperature:	-20	°C
Maximum temperature:	+60	°C

Table 10

Antenna Characteristics

Antenna connector ☒			State impedance	50	Ohm
Temporary antenna connector ☐			State impedance		Ohm
Integral antenna ☒	Type:	Ceramic	Gain	2 @ 800 4 @ 1790	dBi
External antenna ☒	Type:	dipole	Gain	4.5 @ 700 & 850 5 @ 1700	dBi
For external antenna only: Standard Antenna Jack ☒ If yes, describe how user is prohibited from changing antenna (if not professional installed): Equipment is only ever professionally installed ☒ Non-standard Antenna Jack ☐					

Table 11

Ancillaries (if applicable)

MANUFACTURING DESCRIPTION		Input cable (3-way)	External antenna
MANUFACTURER		Technolog Ltd	Smarteq
TYPE		5m flying lead (unscreened)	Low profile, full dipole
PART NUMBER		CBLUT03U000	710266
SERIAL NUMBER		N/A	N/A
COUNTRY OF ORIGIN		UK	Sweden
ANCILLARIES (cont'd)			
MANUFACTURING DESCRIPTION	Input cable (12-way)	External Battery Pack	
MANUFACTURER	Technolog Ltd	Technolog Ltd	
TYPE	1.5m flying lead, unscreened cable.	3.6v primary lithium. ~400mm connection lead (unscreened)	
PART NUMBER	CBL006	2133TT3000-1	
SERIAL NUMBER	N/A	N/A	
COUNTRY OF ORIGIN	UK	UK	

Table 12

I hereby declare that the information supplied is correct and complete.

Name: Joe Sawyer
Position held: Production Engineering Manager
Date: 22 November 2021

1.6 Product Information

1.6.1 Technical Description

Data logger for monitoring pressure and flow in a mains water distribution network. The logger sends data periodically via SMS or a data connection with a server.

1.7 Deviations from the Standard

No deviations from the applicable test standard were made during testing.

1.8 EUT Modification Record

The table below details modifications made to the EUT during the test programme.

The modifications incorporated during each test are recorded on the appropriate test pages.

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
Model: Cello 4S, Serial Number: 20213128425-93			
0	As supplied by the customer	Not Applicable	Not Applicable

Table 13

1.9 Test Location

TÜV SÜD conducted the following tests at our Fareham Test Laboratory.

Test Name	Name of Engineer(s)	Accreditation
Configuration and Mode: Internal Antenna - PCS 1900		
Equivalent Isotropic Radiated Power	Graeme Lawler	UKAS
Radiated Spurious Emissions	Graeme Lawler	UKAS
Configuration and Mode: External Antenna - PCS 1900		
Spurious Emissions at Band Edge	Neil Rousell	UKAS
Equivalent Isotropic Radiated Power	Graeme Lawler	UKAS
Maximum Conducted Output Power	Neil Rousell	UKAS
Frequency Stability	Neil Rousell	UKAS
26 dB Bandwidth	Neil Rousell	UKAS
Spurious Emissions at Antenna Terminals	Neil Rousell	UKAS
Radiated Spurious Emissions	Graeme Lawler	UKAS

Table 14

Office Address:

TÜV SÜD
Octagon House
Concorde Way
Fareham
Hampshire
PO15 5RL
United Kingdom

2 Test Details

2.1 Modulation Characteristics

2.1.1 Specification Reference

FCC 47 CFR Part 2, Clause 2.1047(d)

2.1.2 Equipment Under Test and Modification State

Cello 4S

2.1.3 Date of Test

03-February-2022

2.1.4 Test Method

A declaration was made by the applicant.

2.1.5 Test Results

Internal Antenna - PCS 1900

Description Of Modulation Technique

The modulation scheme used in GSM is called Gaussian Minimum Shift Keying (GMSK). GMSK facilitates the use of narrow bandwidth and allows for both coherent and non coherent detection capabilities. It is a scheme in which the transitions from One to Zero or Zero to One do not occur quickly, but over a period of time. If pulses are transmitted quickly harmonics are transmitted. The power spectrum for a square wave is rich in harmonics, and the power within the side lobes is wasted, and can be a cause of potential interference.

A method to reduce the harmonics is to round off the edges of the pulses thus lowering the spectral components of the signal. In GSM this is done by using a Gaussian pre-filter which typically has a bandwidth of 81.25kHz. The output from the Gaussian filter then phase modulates the carrier. As there are no dramatic phase transitions of the carrier this gives a constant envelope and low spectral component output from the transmitter.

The spectral efficiency is calculated by

bit rate / Channel bandwidth = 270.83333 kbit/s / 200 kHz = 1.354 bit/s/Hz.

The bandwidth product BT = Bandwidth x bit duration = 81.25 kHz x 3.6923 micros = 0.3

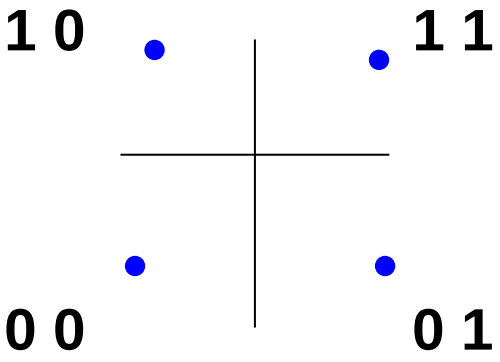
GMSK OVERVIEW

The modulation scheme used for the EUT is GMSK.

A brief overview of how GMSK works is shown below.

GMSK (Gaussian Minimum Shift Keying)

The fundamental principal behind GMSK is Phase shift keying. This splits a data stream into a series of 2-digit phase shifts, using the following phase shifts to represent data pairs.



Therefore, for the BIT sequence 0 0 1 1 1 0 0 1 The corresponding phase shift will be used

BIT SEQUENCE	0 0	1 1	1 0	01
PHASE 225º	45º	135º	315º	

This is called QPSK (Quadratic Phase Shift Keying)

<u>However</u>

There is a problem with QPSK: transition from e.g. 00 to 11 gives phase shift of 180° (π radians). This has the effect of inverting the carrier waveform and this can lead to detection errors at the receiver.

Solution: restrict phase changes to ± 90°

1. Split bitstream into 2 streams e.g.

	0 0		1 1		0 1		1 0	
I Stream	0		1		0		1	
Q stream		0		1		1		0

Table 15

2. Modulate each stream with PSK (1 = 90° or π/2, 0 = -90° or - π/2 phase shift)

I Stream	0		1		0		1	
	-π/2		-π/2		-π/2		π/2	
Q stream		0		1		1		0
		-π/2		π/2		π/2		-π/2

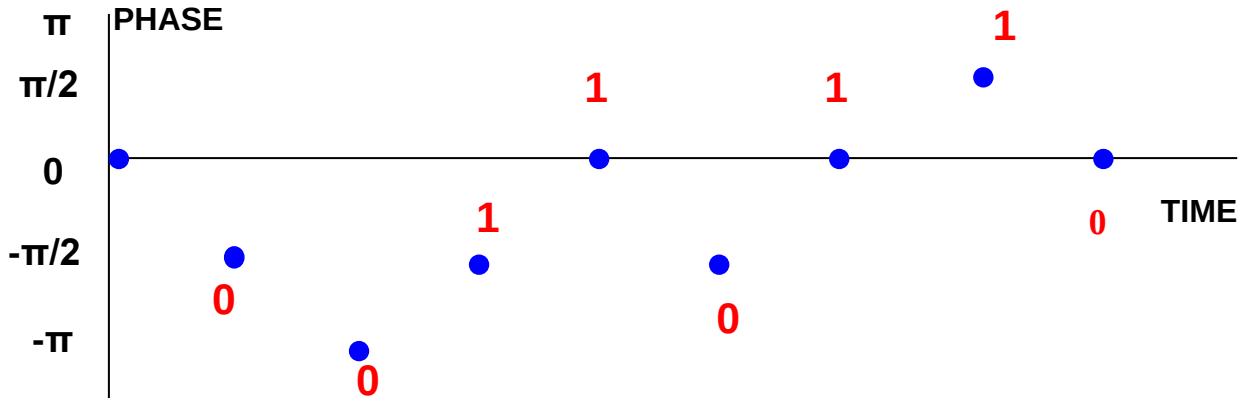
Table 16

3. Combine (add) the two PSK signals:

Combined Phase	-π/2	-π	-π/2	0	-π/2	0	π/2	0

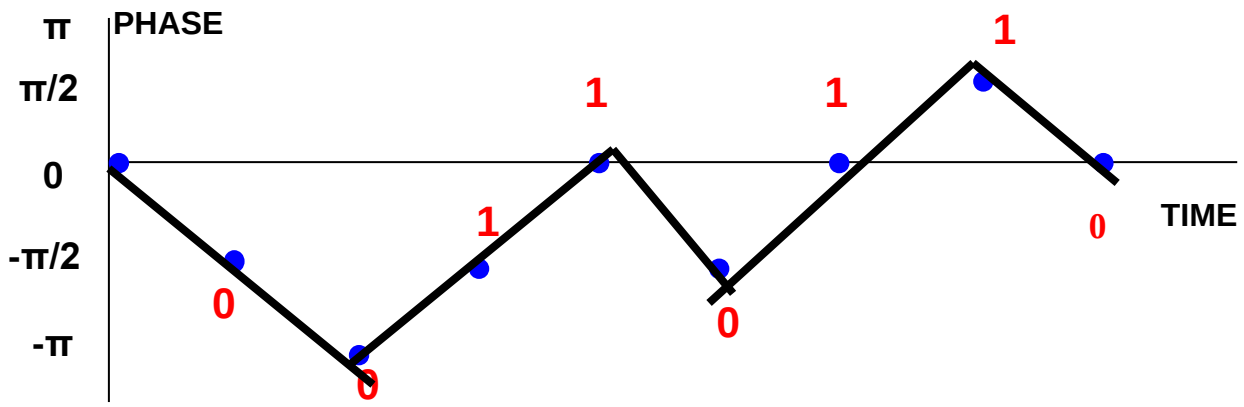
Table 17

Result: offset - QPSK, phase change is restricted to ± π/2 radians:



It would be preferable to have "gradual" changes in place between each pair of bits (Continuous-phase modulation). Replacing each “rectangular” shaped pulse (for 1 or 0) with a sinusoidal pulse can do this:

Result: Minimum Shift Keying (MSK):



<u>Gaussian Minimum Shift Keying</u>

MSK has high sidebands relative to the main lobes in the frequency domain - this can lead to interference with adjacent signals.

If the rectangular pulses corresponding to the bitstream are filtering using a Gaussian-shaped impulse response filter, we get Gaussian MSK (GMSK) - this has low sidelobes compared to MSK.

<u>Limit Clause</u>

A curve or equivalent data which shows that the equipment will meet the modulation requirements of the rules under which the equipment is to be licensed.

2.2 Equivalent Isotropic Radiated Power

2.2.1 Specification Reference

FCC 47 CFR Part 24, Clause 24.232

2.2.2 Equipment Under Test and Modification State

Cello 4S, S/N: 20213128425-93 - Modification State 0

2.2.3 Date of Test

12-January-2022 to 18-January-2022

2.2.4 Test Method

This test was performed in accordance with ANSI C63.26 clause 5.2.3.3 and 5.2.7.

2.2.5 Environmental Conditions

Ambient Temperature	20.3 - 20.4 °C
Relative Humidity	35.5 - 37.1 %

2.2.6 Test Results

Internal Antenna - PCS 1900

The worst-case mode was identified as: Single time slot uplink

Frequency (MHz)	Result	Limit	Unit
1850.2 MHz	30.38	33.01	dBm
1880.0 MHz	31.01	33.01	dBm
1909.8 MHz	30.73	33.01	dBm

Table 18 - EIRP Results

External Antenna - PCS 1900

The worst-case mode was identified as: Single time slot uplink

Frequency (MHz)	Result	Limit	Unit
1850.2	28.51	33.01	dBm
1880.0	26.96	33.01	dBm
1909.8	25.99	33.01	dBm

Table 19 - EIRP Results

FCC Part 24 Limit Clause 22.237(c)

Mobile and portable stations are limited to 2 watts EIRP and the equipment must employ a means for limiting power to the minimum necessary for successful communications.

2.2.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 12.

Instrument	Manufacturer	Type No.	TE No.	Calibration Period (months)	Calibration Expiry Date
Test Receiver	Rohde & Schwarz	ESU40	3506	12	18-Mar-2022
Wideband Radio Communication Tester	Rohde & Schwarz	CMW 500	4143	12	10-Feb-2022
Cable (K-Type to K-Type, 2 m)	Scott Cables	KPS-1501-2000-KPS	4526	6	06-Mar-2022
Emissions Software	TUV SUD	EmX V2.1.11 V.2.1.11	5125	-	Software
Cable (N-Type to N-Type, 8 m)	Teledyne	PR90-088-8MTR	5450	6	08-Mar-2022
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5481	12	31-Mar-2022
Turntable & Mast Controller	Maturo Gmbh	NCD/498/2799.01	5612	-	TU
Tilt Antenna Mast	Maturo Gmbh	TAM 4.0-P	5613	-	TU
Turntable	Maturo Gmbh	Turntable 1.5 SI-2t	5614	-	TU
Screened Room (12)	MVG	EMC-3	5621	36	11-Aug-2023

Table 20

TU – Traceability Unscheduled

2.3 Radiated Spurious Emissions

2.3.1 Specification Reference

FCC 47 CFR Part 2, Clause 2.1053
FCC 47 CFR Part 24, Clause 24.238 (a)

2.3.2 Equipment Under Test and Modification State

Cello 4S, S/N: 20213128425-93 - Modification State 0

2.3.3 Date of Test

12-January-2022 to 18-January-2022

2.3.4 Test Method

A preliminary profile of the Radiated Spurious Emissions was obtained up to the 10th harmonic by operating the EUT on a remotely controlled turntable within a semi-anechoic chamber. Measurements of emissions from the EUT were obtained with the Measurement Antenna in both Horizontal and Vertical Polarisations. The profiling produced a list of the worst-case emissions together with the EUT azimuth and antenna polarisation.

To determine the emission characteristic of the EUT above 18 GHz, the test antenna was swept over all faces of the EUT whilst observing a spectral display. The frequency of any emissions of interest was noted for formal measurement at the correct measurement distance of 3m. This procedure was repeated for all relevant transmit operating channels. Representative noise floor plots are presented above 18GHz for one channel only.

Testing was performed in accordance with ANSI C63.26, Clause 5.5.

Prescans and final measurements were performed using the direct field strength method.

Field strength measurements were performed and Clause 5.2.7 equation c)

Example calculation:

E (dBuV/m) + 20log(d) - 104.8 = EIRP (dBm) where (d) is the measurement distance.

82.2 (dBuV/m) + 20log(3) – 104.8 = EIRP (dBm)

-13.0 = EIRP (dBm)

2.3.1 Example Test Setup Diagram

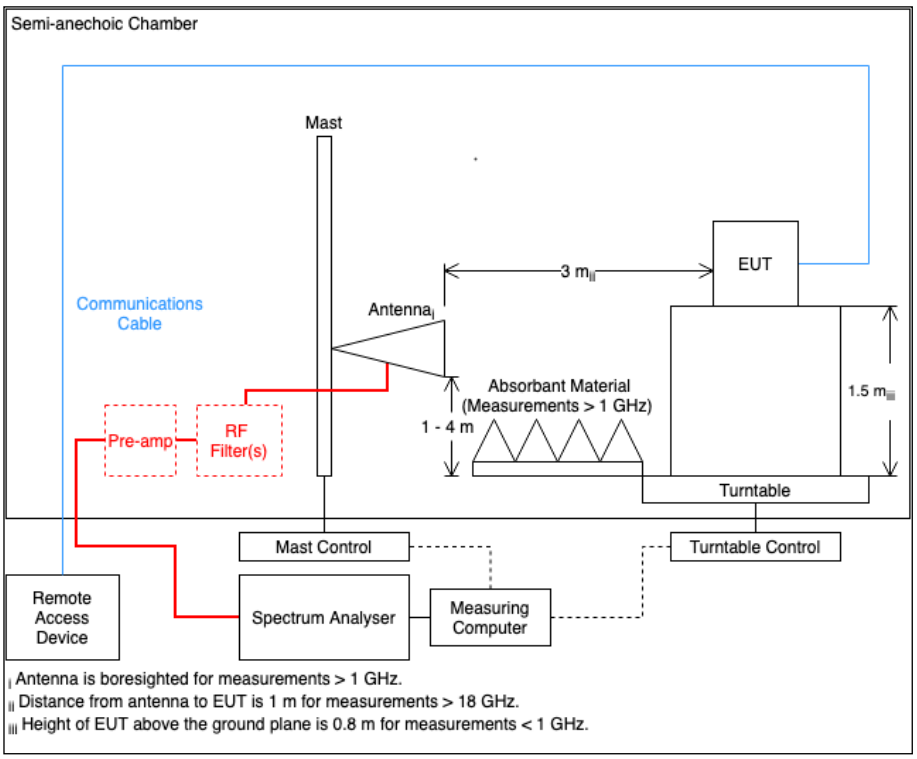


Figure 1

2.3.2 Environmental Conditions

Ambient Temperature	20.3 - 20.4 °C
Relative Humidity	35.5 - 37.1 %

2.3.3 Test Results

Internal Antenna - PCS 1900

Frequency (MHz)	Level (dBm)	Angle	Height	Polarisation	Orientation
*					

Table 21 - 1850.2 MHz

*No emissions were detected within 10 dB of the limit.

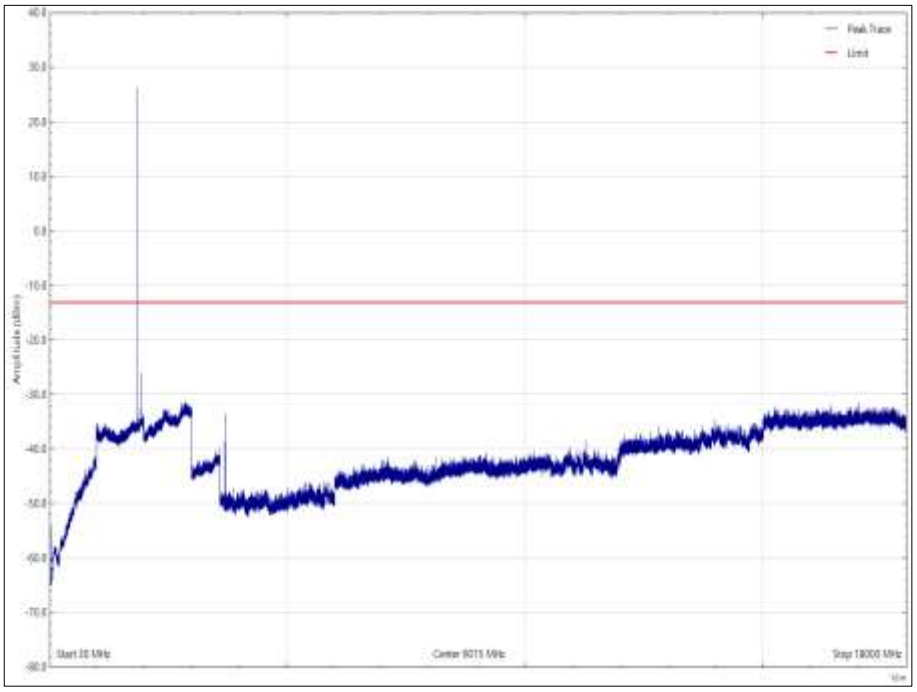


Figure 2 - 1850.2 MHz - 30 MHz to 18 GHz, Horizontal, Orientation X

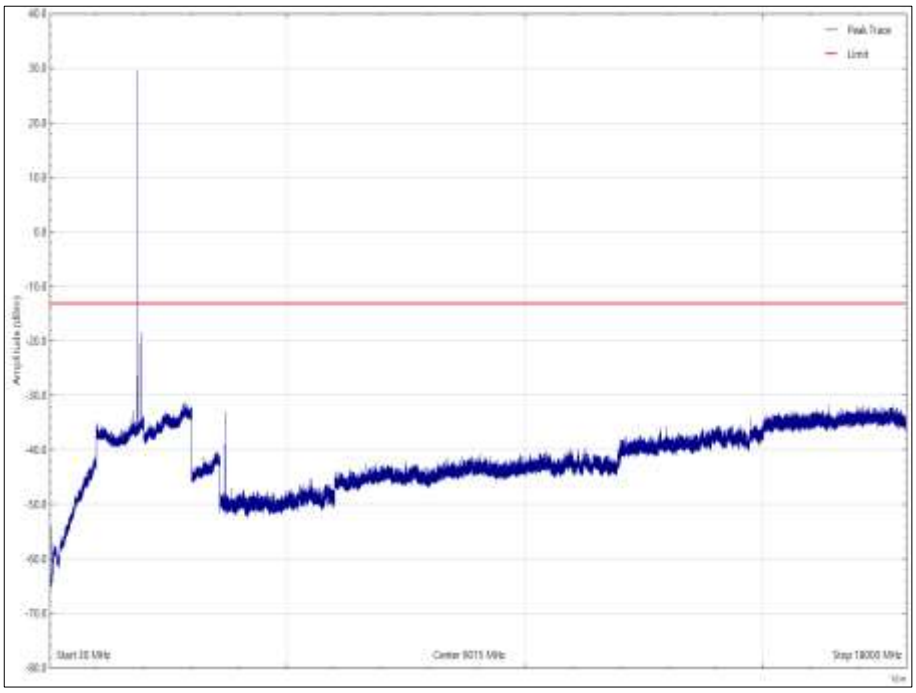


Figure 3 - 1850.2 MHz - 30 MHz to 18 GHz, Vertical, Orientation X

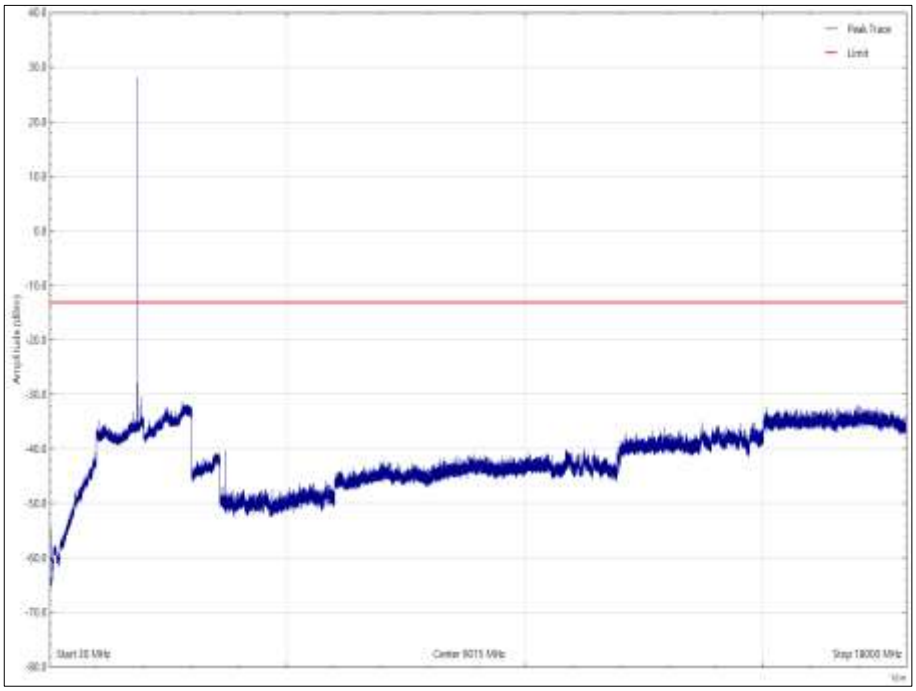


Figure 4 - 1850.2 MHz - 30 MHz to 18 GHz, Horizontal, Orientation Y

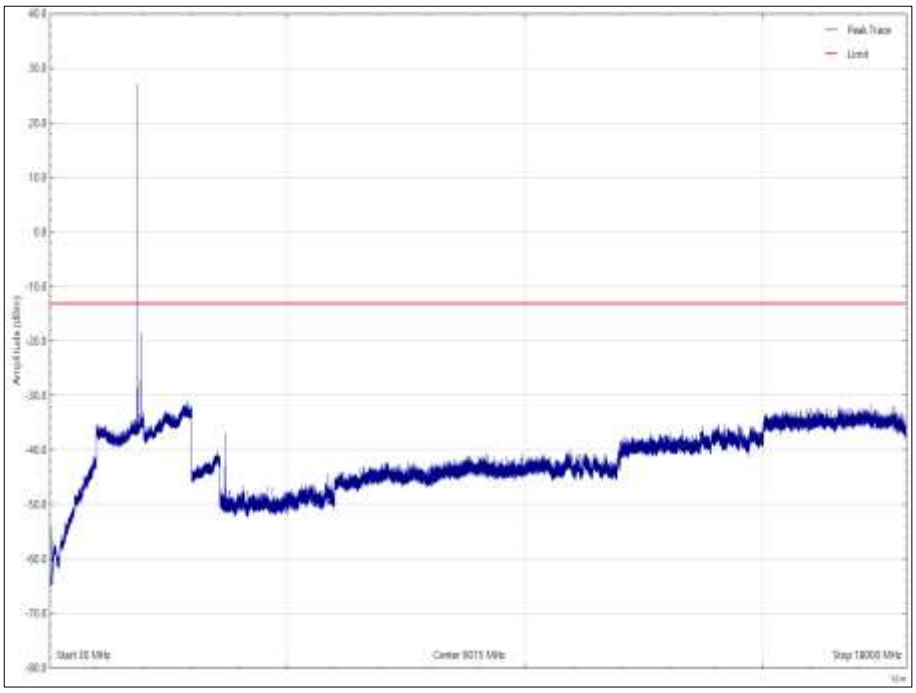


Figure 5 - 1850.2 MHz - 30 MHz to 18 GHz, Vertical, Orientation Y

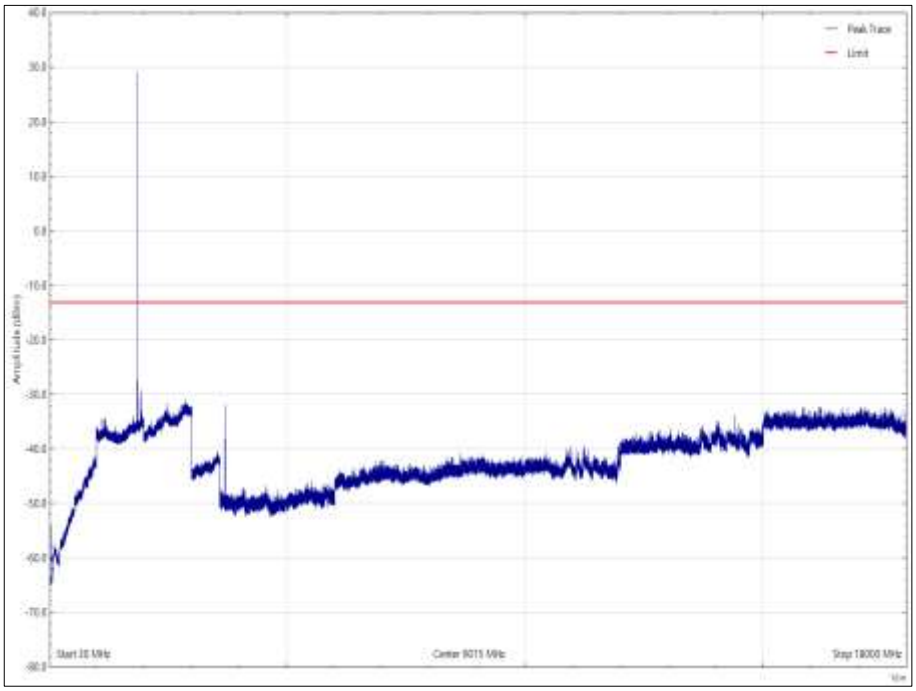


Figure 6 - 1850.2 MHz - 30 MHz to 18 GHz, Horizontal, Orientation Z

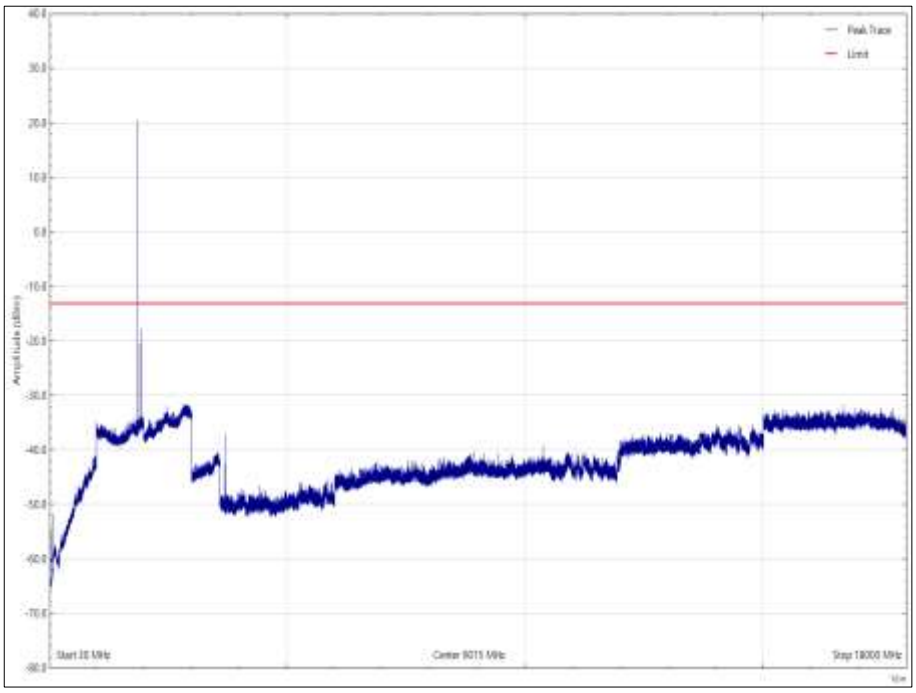


Figure 7 - 1850.2 MHz - 30 MHz to 18 GHz, Vertical, Orientation Z

Frequency (MHz)	Level (dBm)	Angle	Height	Polarisation	Orientation
*					

Table 22 - 1880.0 MHz

*No emissions were detected within 10 dB of the limit.

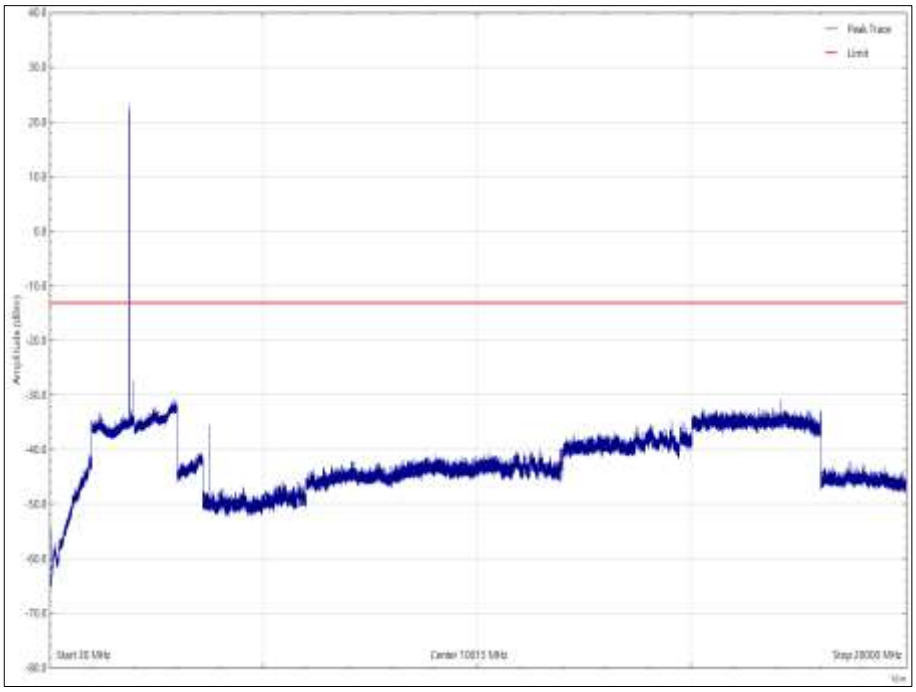


Figure 8 - 1880.0 MHz - 30 MHz to 20 GHz, Horizontal, Orientation X

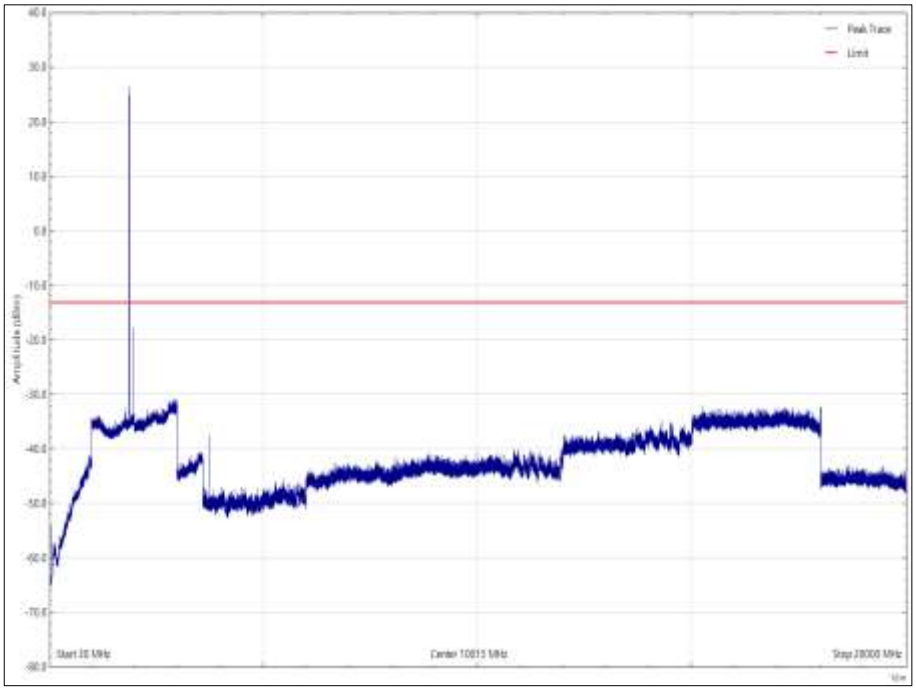


Figure 9 - 1880.0 MHz - 30 MHz to 20 GHz, Vertical, Orientation X

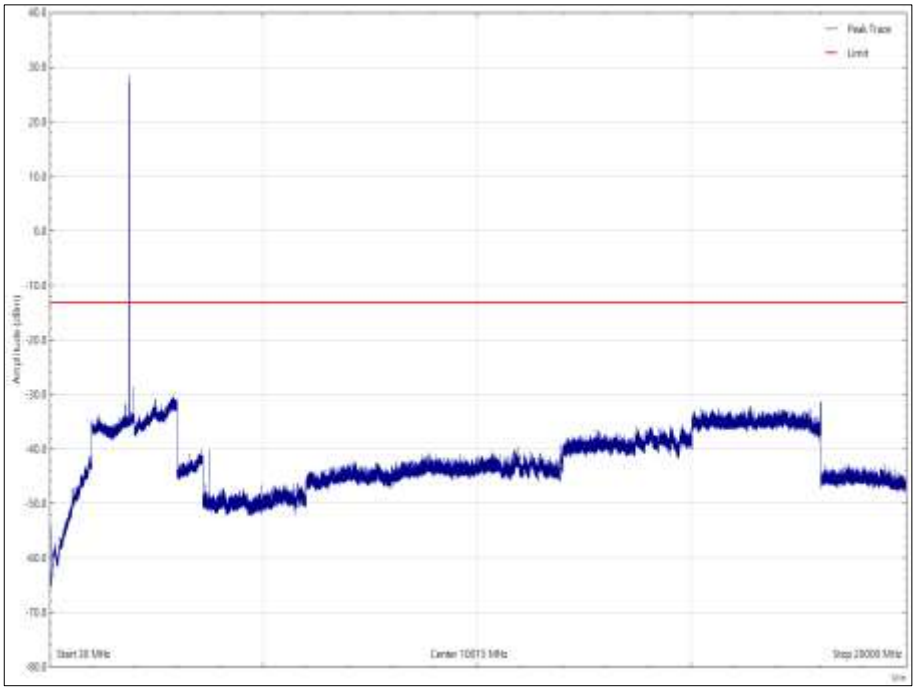


Figure 10 - 1880.0 MHz - 30 MHz to 20 GHz, Horizontal, Orientation Y

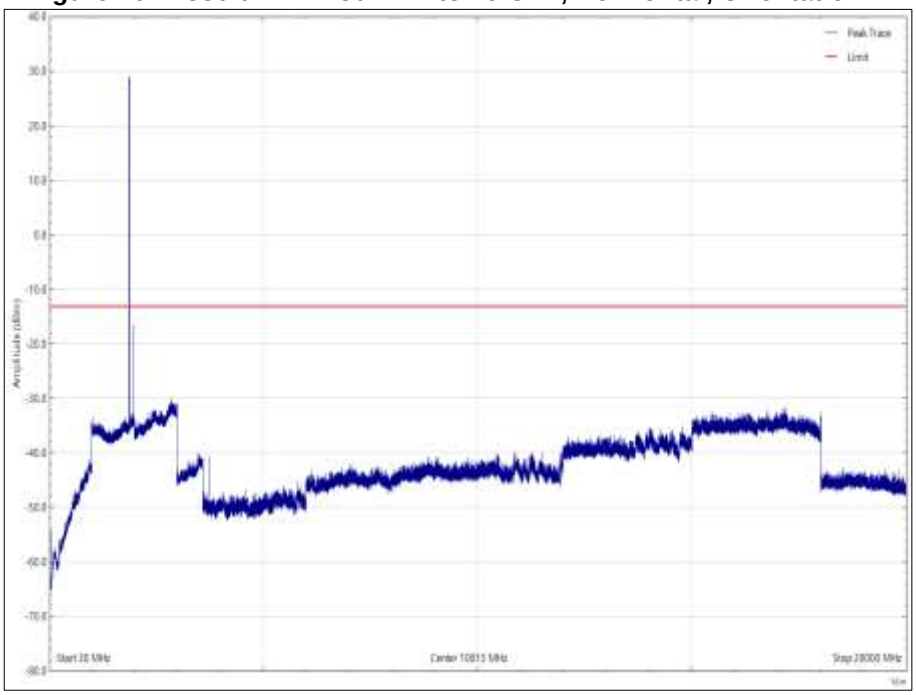


Figure 11 - 1880.0 MHz - 30 MHz to 20 GHz, Vertical, Orientation Y

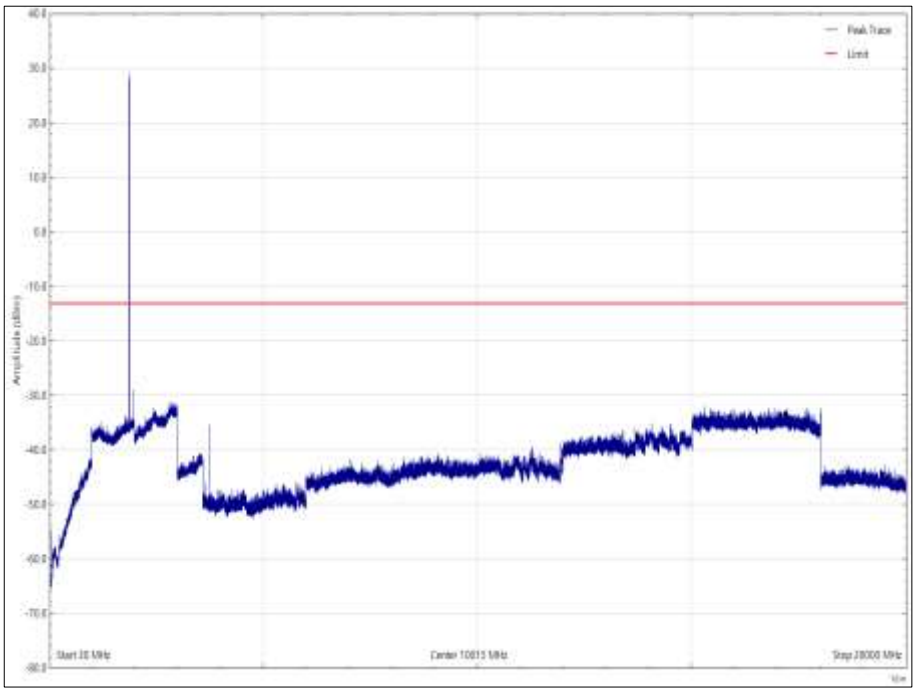


Figure 12 - 1880.0 MHz - 30 MHz to 20 GHz, Horizontal, Orientation Z

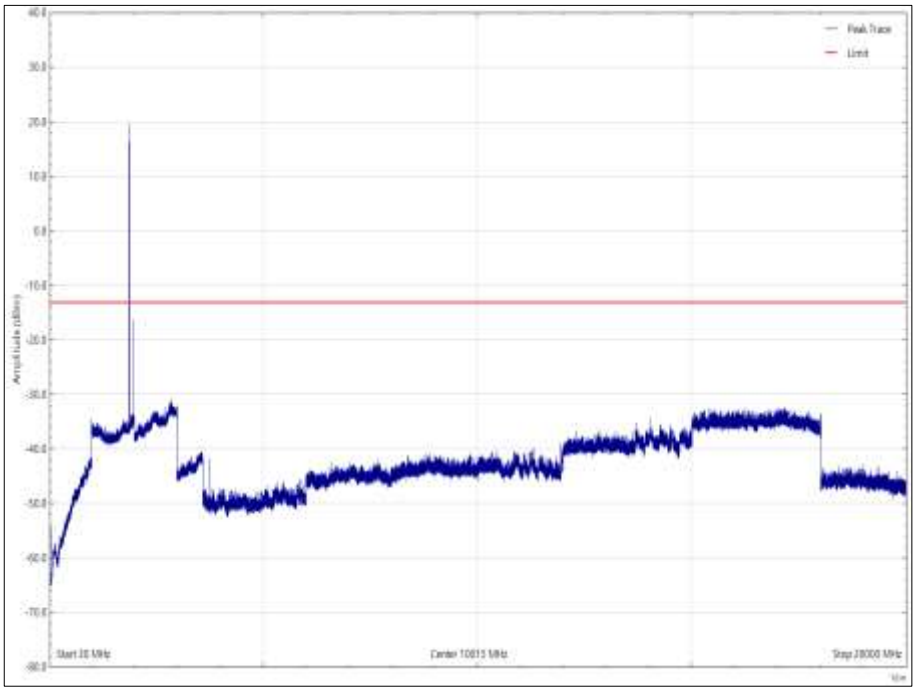


Figure 13 - 1880.0 MHz - 30 MHz to 20 GHz, Vertical, Orientation Z

Frequency (MHz)	Level (dBm)	Angle	Height	Polarisation	Orientation
*					

Table 23 – 1909.8 MHz

*No emissions were detected within 10 dB of the limit.

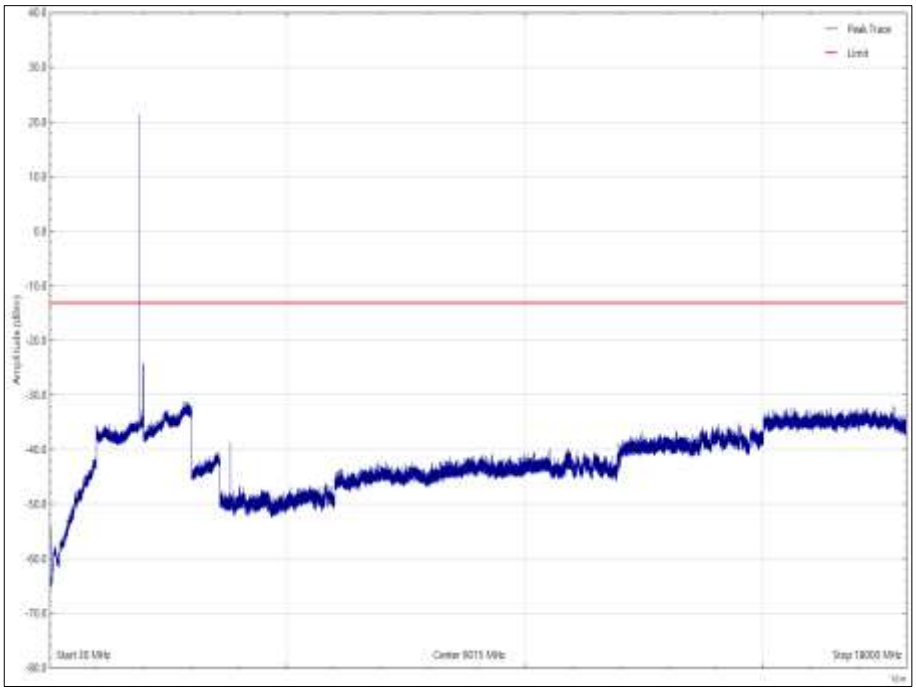


Figure 14 - 1909.8 MHz - 30 MHz to 18 GHz, Horizontal, Orientation X

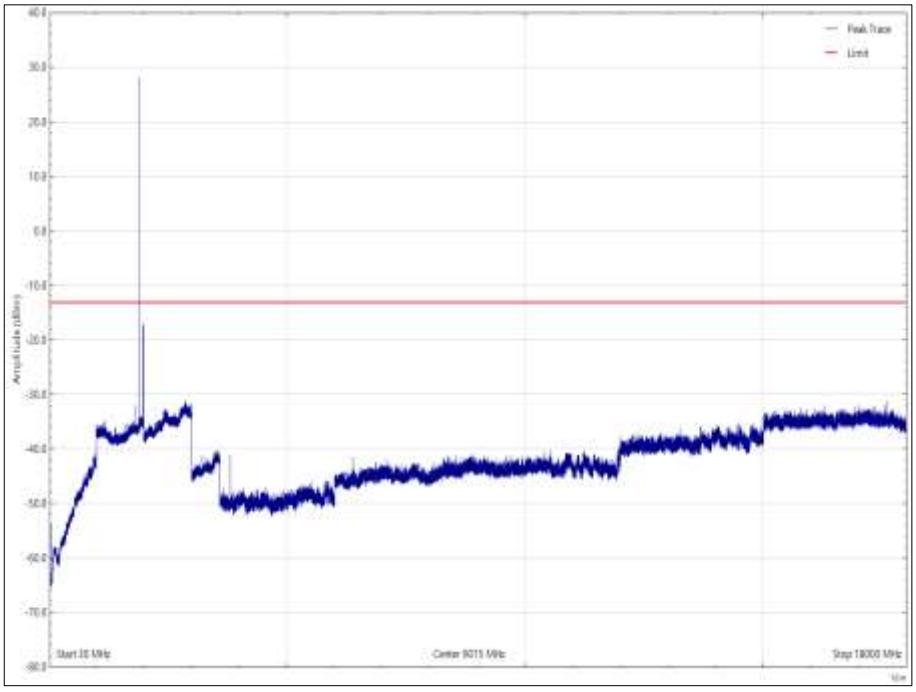


Figure 15 - 1909.8 MHz - 30 MHz to 18 GHz, Vertical, Orientation X

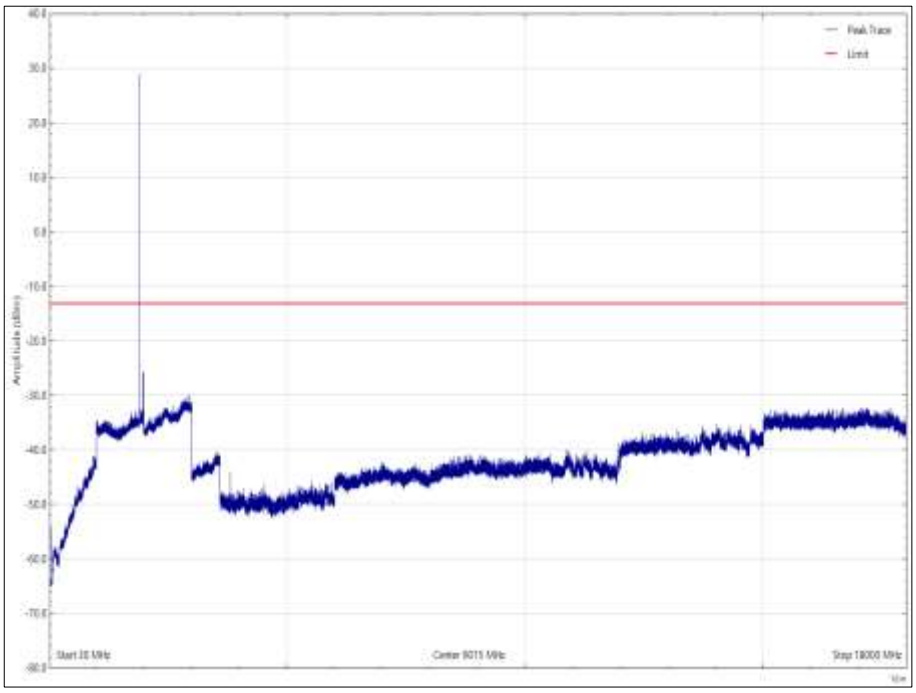


Figure 16 - 1909.8 MHz - 30 MHz to 18 GHz, Horizontal, Orientation Y

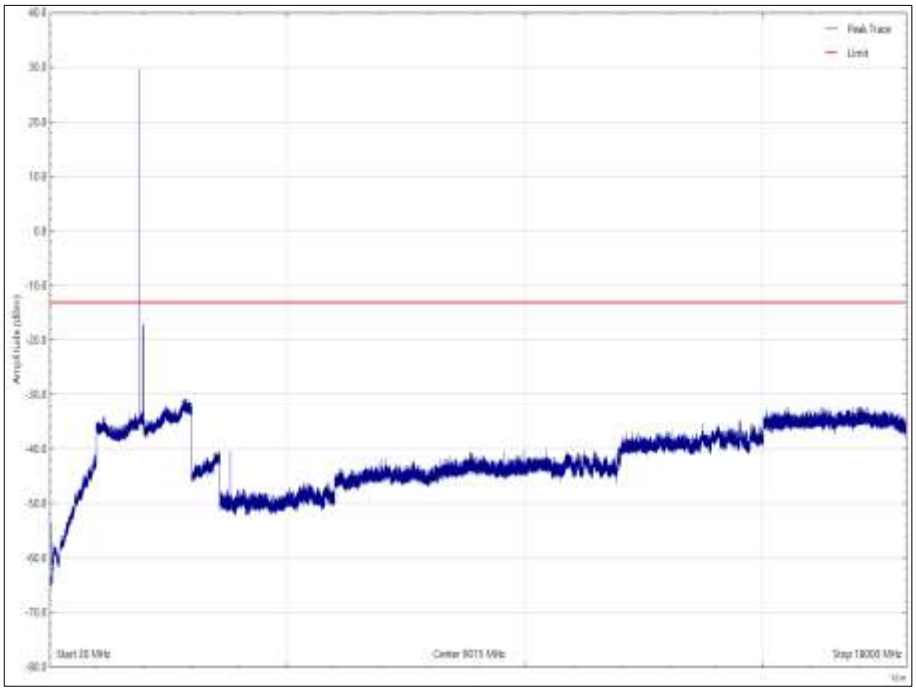


Figure 17 - 1909.8 MHz - 30 MHz to 18 GHz, Vertical, Orientation Y

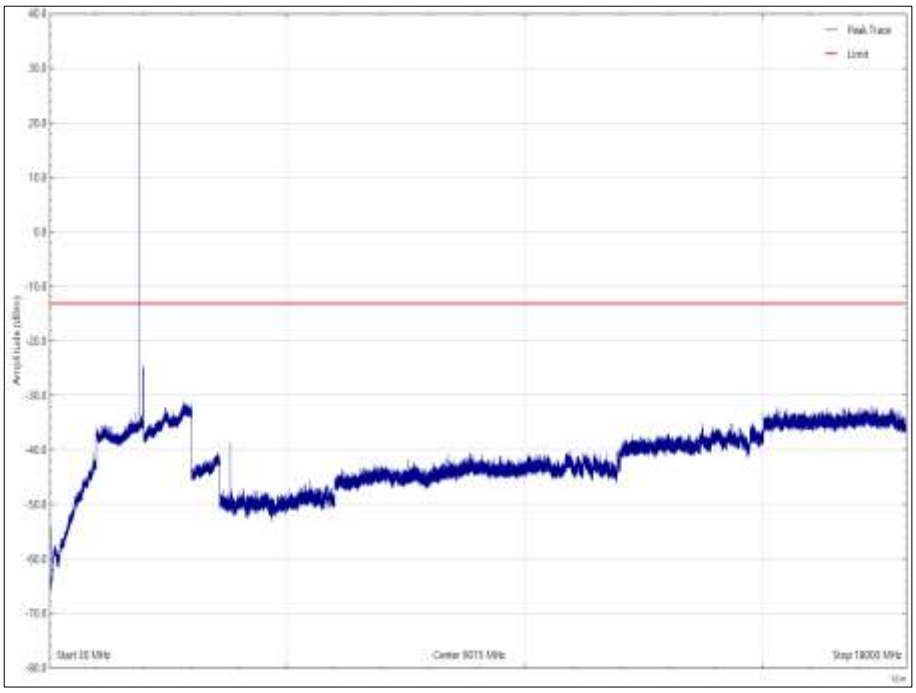


Figure 18 - 1909.8 MHz - 30 MHz to 18 GHz, Horizontal, Orientation Z

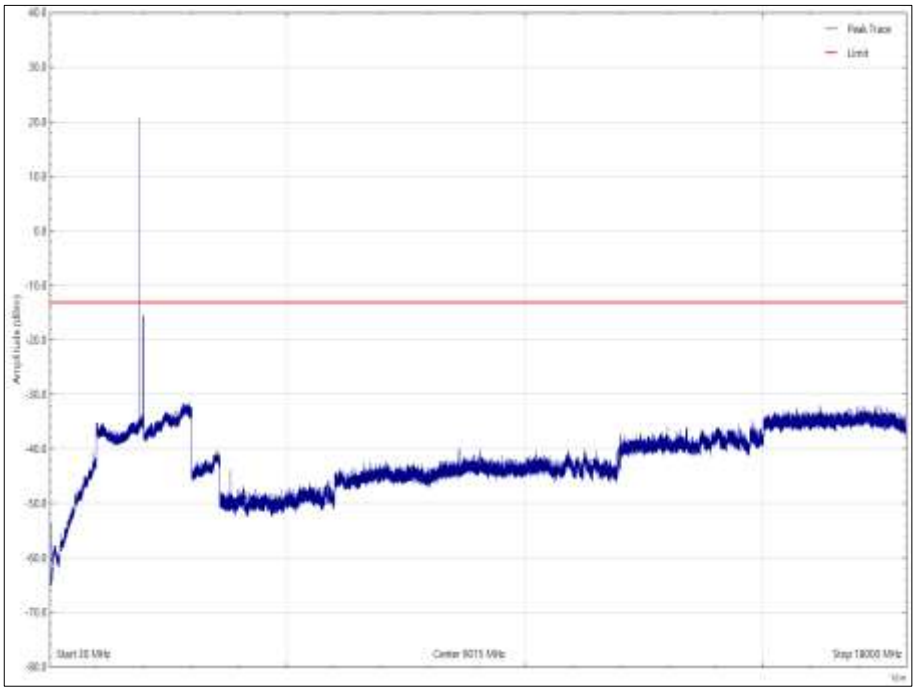


Figure 19 - 1909.8 MHz - 30 MHz to 18 GHz, Vertical, Orientation Z

<u>FCC 47 CFR Part 24, Limit Clause 24.238(a)</u>

The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log(P) dB.

External Antenna - PCS 1900

Frequency (MHz)	Level (dBm)	Angle	Height	Polarisation	Orientation
*					

Table 24 - 1850.2 MHz

*No emissions were detected within 10 dB of the limit.

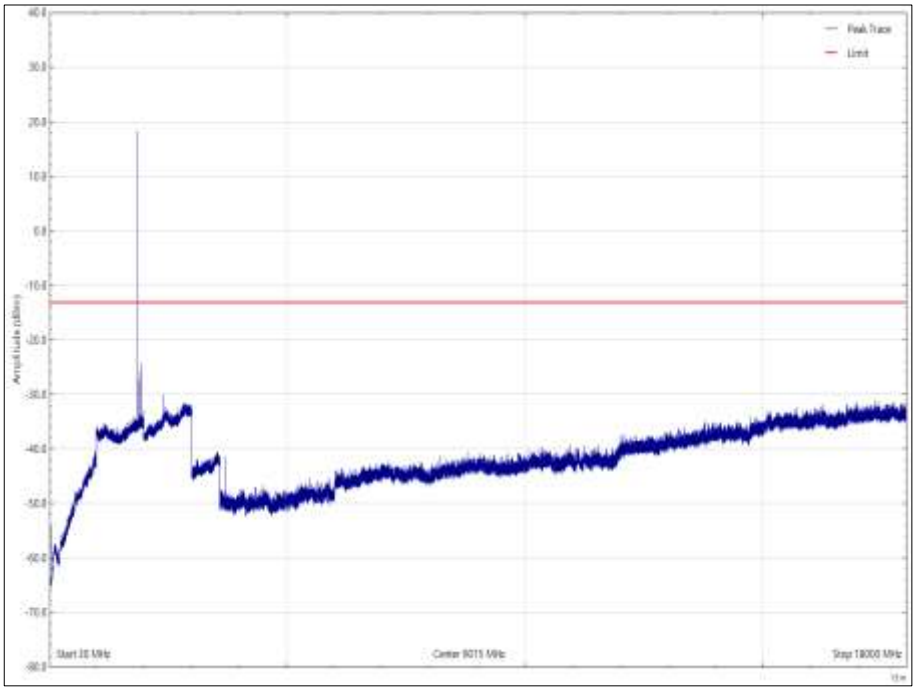


Figure 20 - 1850.2 MHz - 30 MHz to 18 GHz, Horizontal, Orientation X

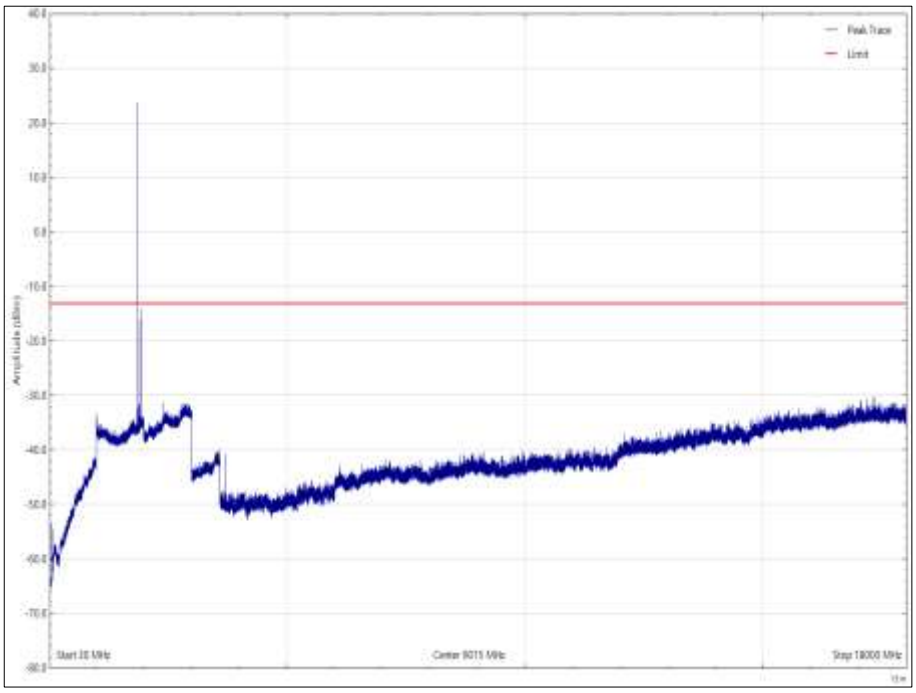


Figure 21 - 1850.2 MHz - 30 MHz to 18 GHz, Vertical, Orientation X

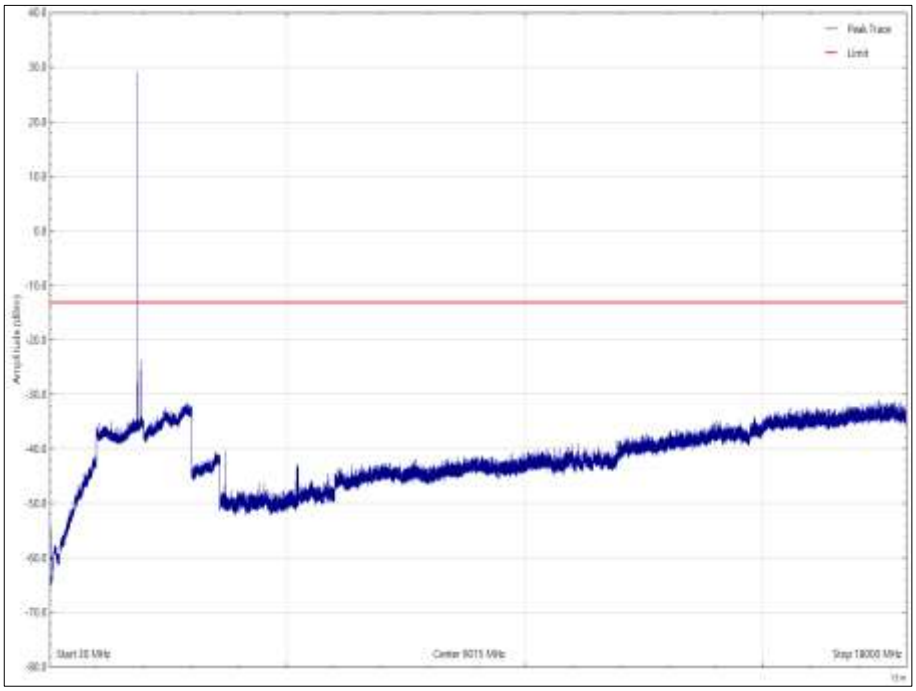


Figure 22 - 1850.2 MHz - 30 MHz to 18 GHz, Horizontal, Orientation Y

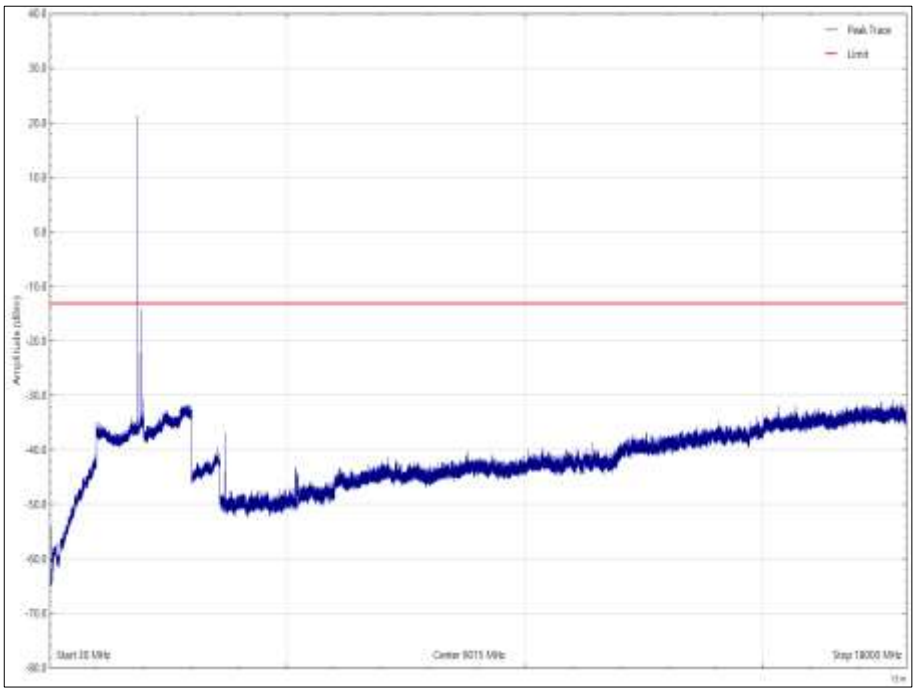


Figure 23 - 1850.2 MHz - 30 MHz to 18 GHz, Vertical, Orientation Y

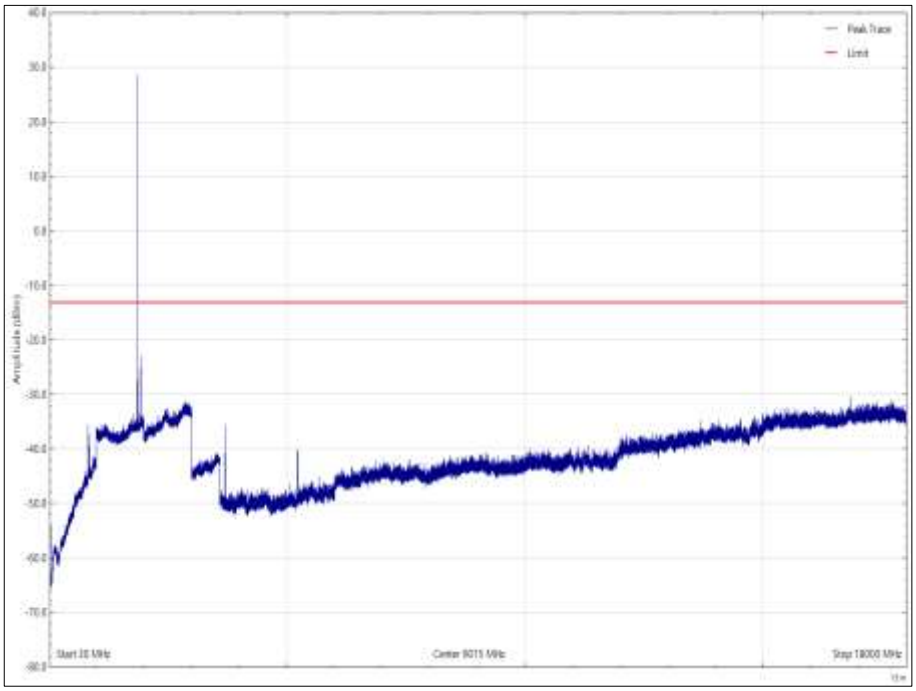


Figure 24 - 1850.2 MHz - 30 MHz to 18 GHz, Horizontal, Orientation Z

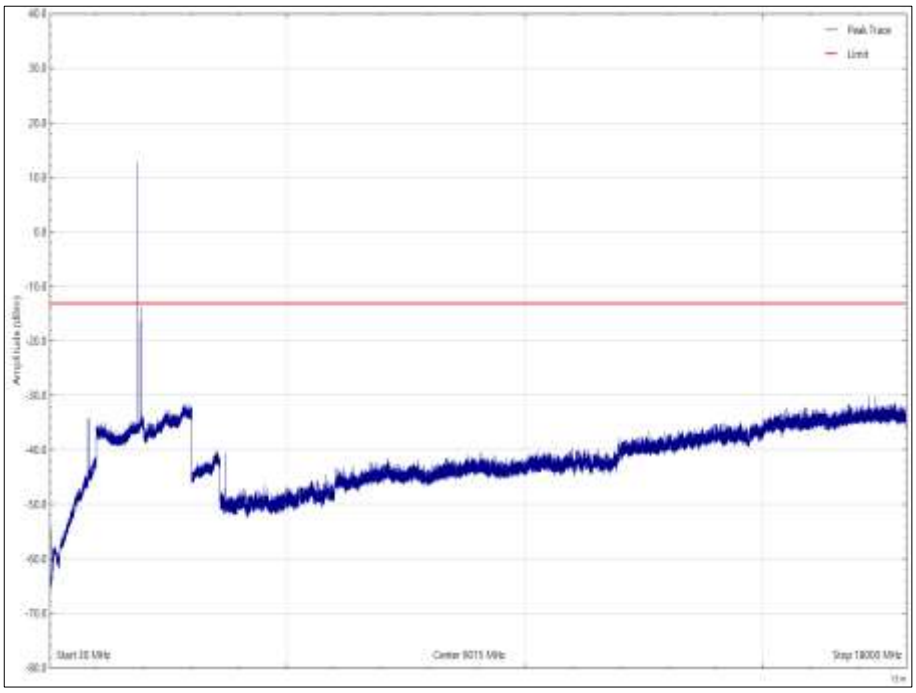


Figure 25 - 1850.2 MHz - 30 MHz to 18 GHz, Vertical, Orientation Z

Frequency (MHz)	Level (dBm)	Angle	Height	Polarisation	Orientation
*					

Table 25 - 1880.0 MHz

*No emissions were detected within 10 dB of the limit.

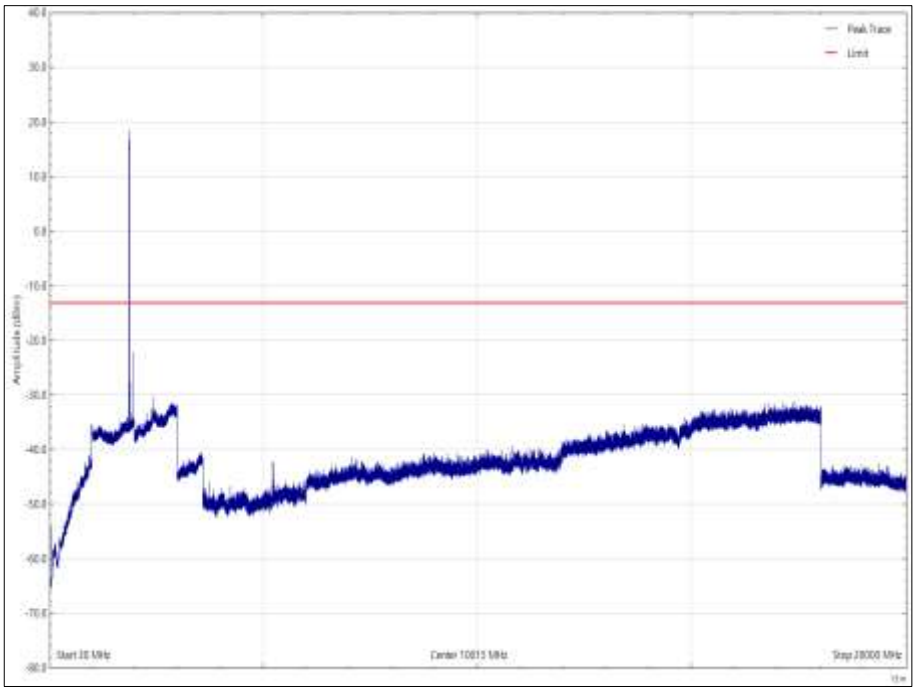


Figure 26 - 1880.0 MHz - 30 MHz to 20 GHz, Horizontal, Orientation X

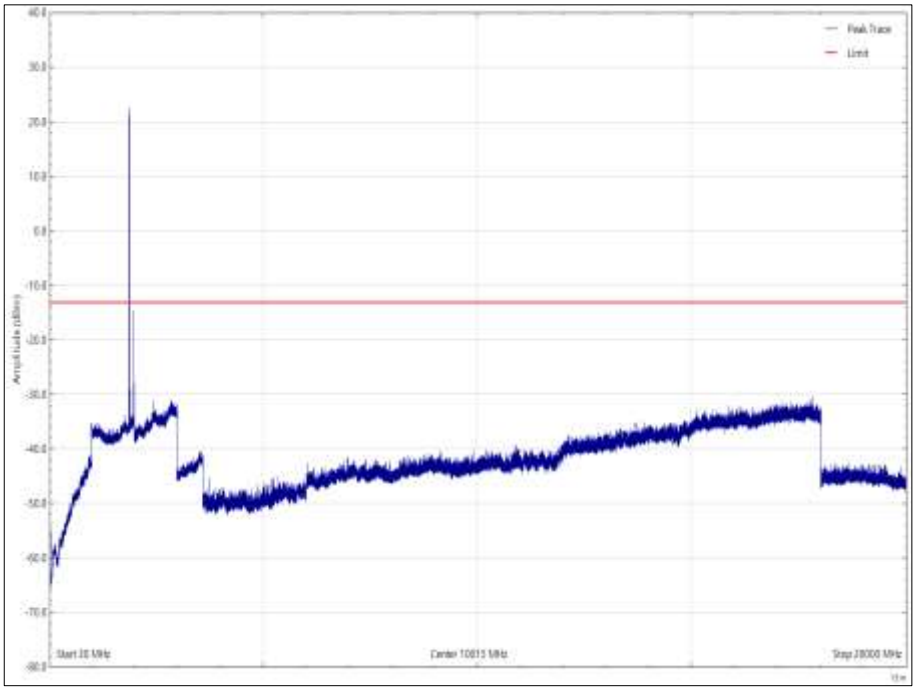


Figure 27 - 1880.0 MHz - 30 MHz to 20 GHz, Vertical, Orientation X

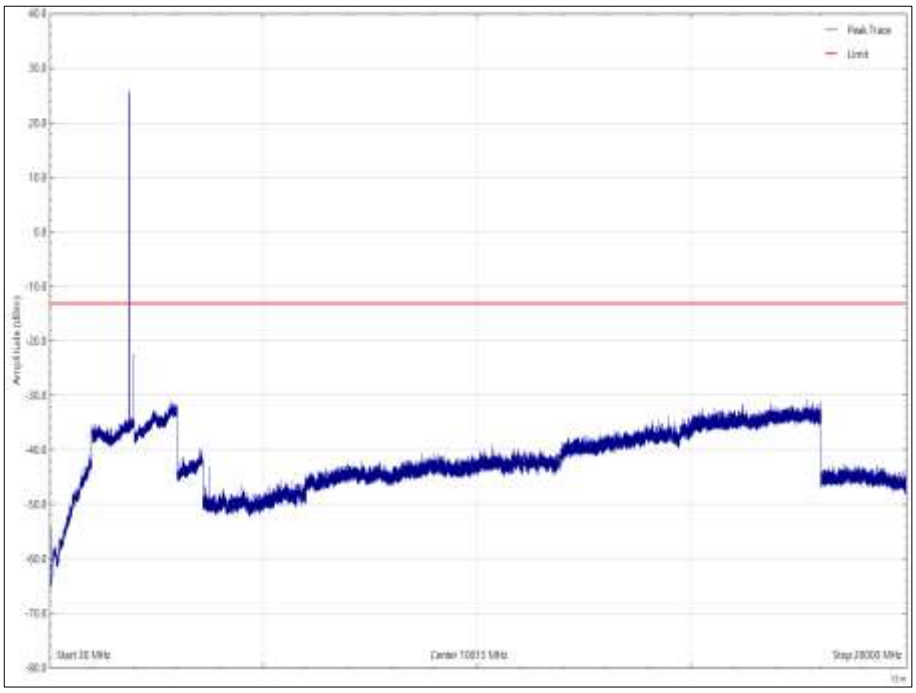


Figure 28 - 1880.0 MHz - 30 MHz to 20 GHz, Horizontal, Orientation Y

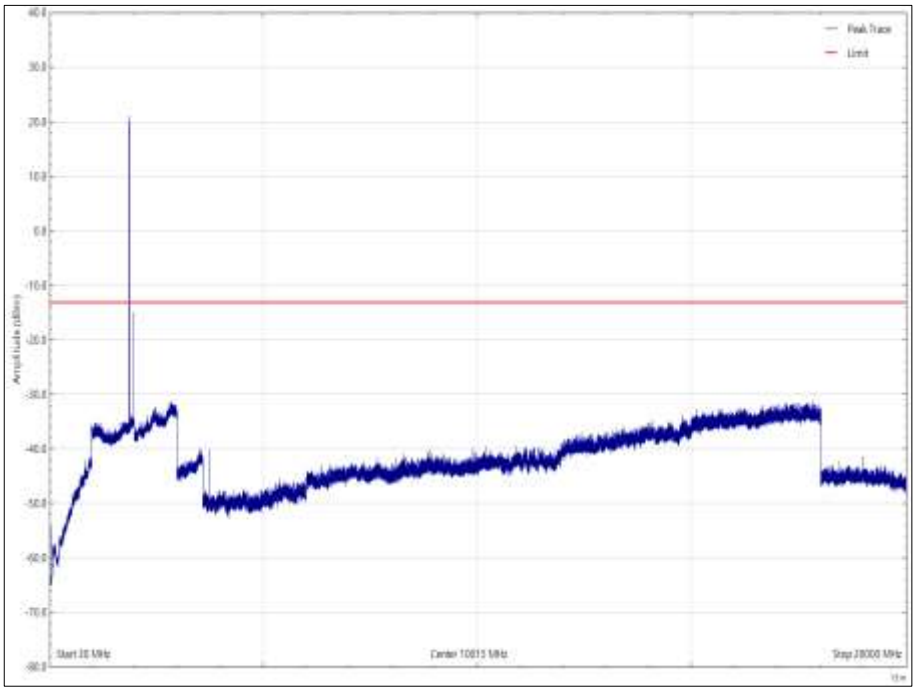


Figure 29 - 1880.0 MHz - 30 MHz to 20 GHz, Vertical, Orientation Y

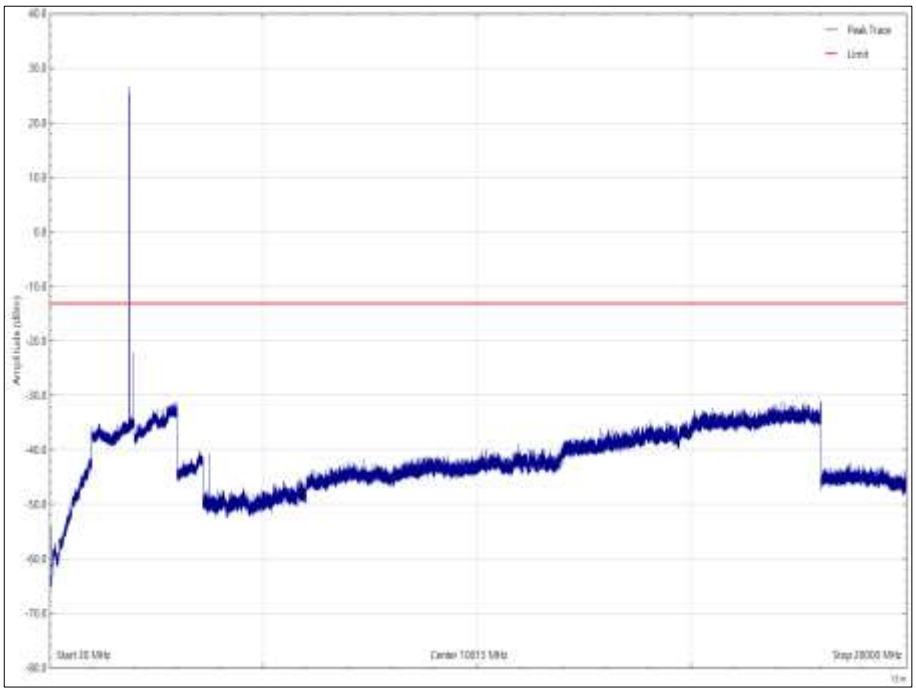


Figure 30 - 1880.0 MHz - 30 MHz to 20 GHz, Horizontal, Orientation Z

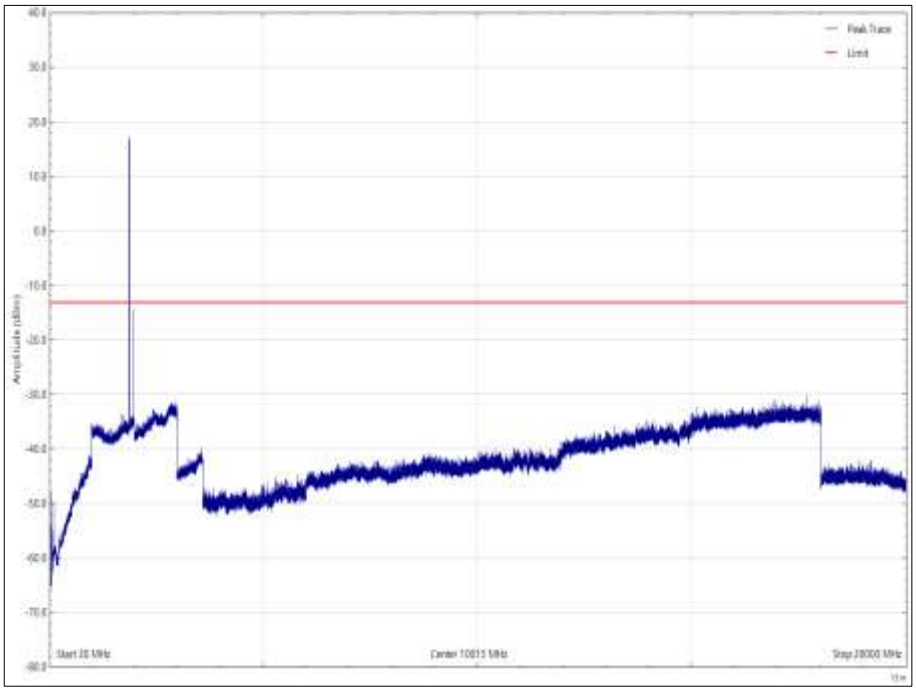


Figure 31 - 1880.0 MHz - 30 MHz to 20 GHz, Vertical, Orientation Z

Frequency (MHz)	Level (dBm)	Angle	Height	Polarisation	Orientation
*					

Table 26 – 1909.8 MHz

*No emissions were detected within 10 dB of the limit.

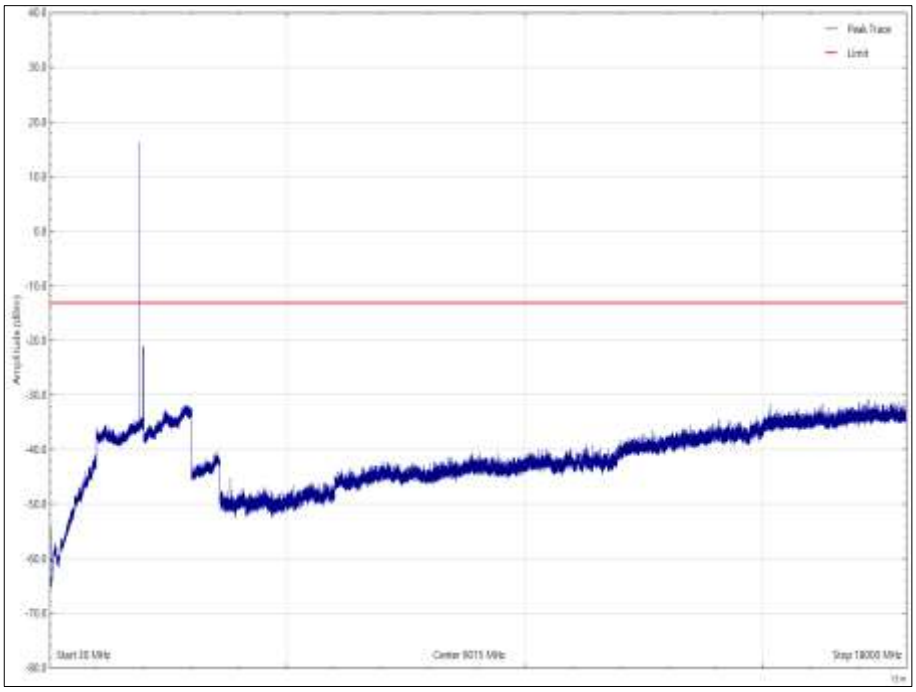


Figure 32 - 1909.8 MHz - 30 MHz to 18 GHz, Horizontal, Orientation X

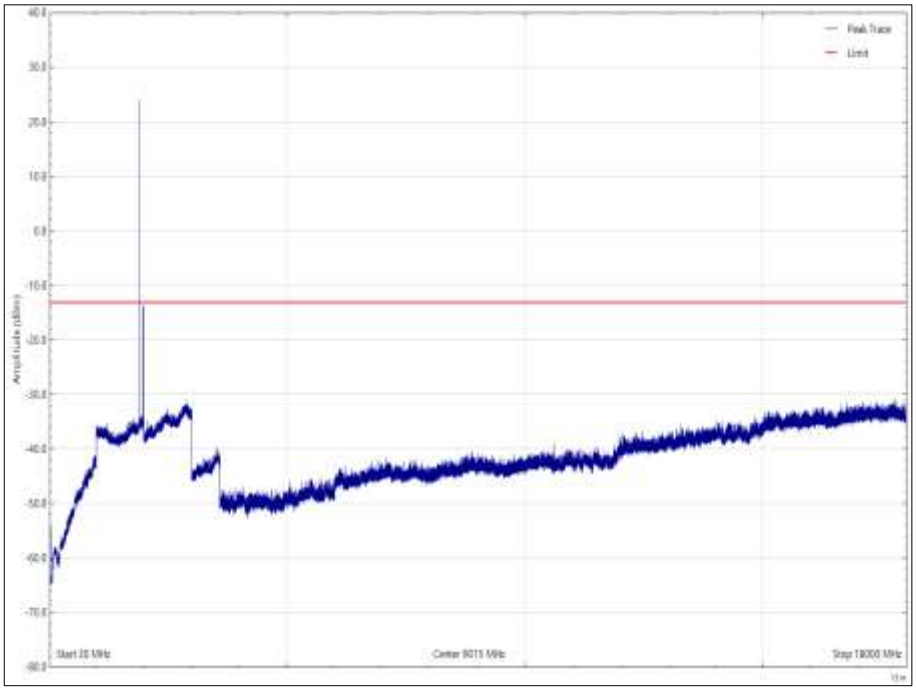


Figure 33 - 1909.8 MHz - 30 MHz to 18 GHz, Vertical, Orientation X

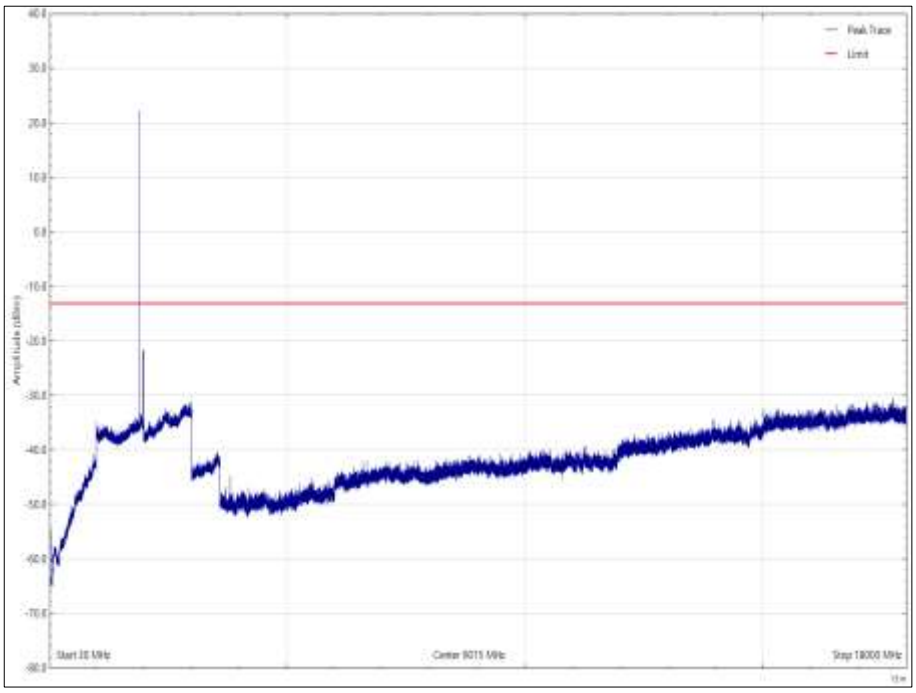


Figure 34 - 1909.8 MHz - 30 MHz to 18 GHz, Horizontal, Orientation Y

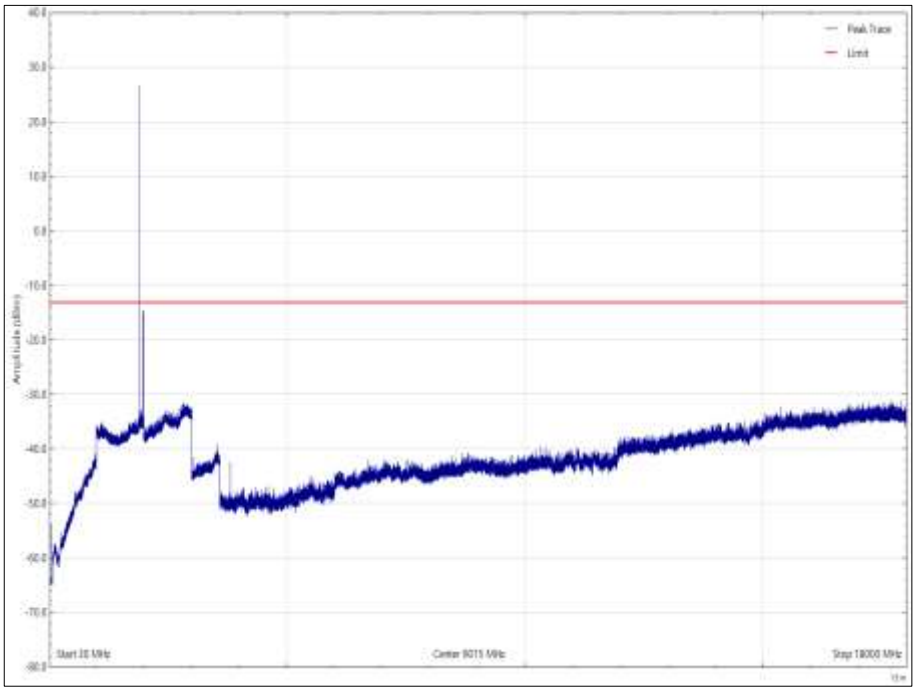


Figure 35 - 1909.8 MHz - 30 MHz to 18 GHz, Vertical, Orientation Y

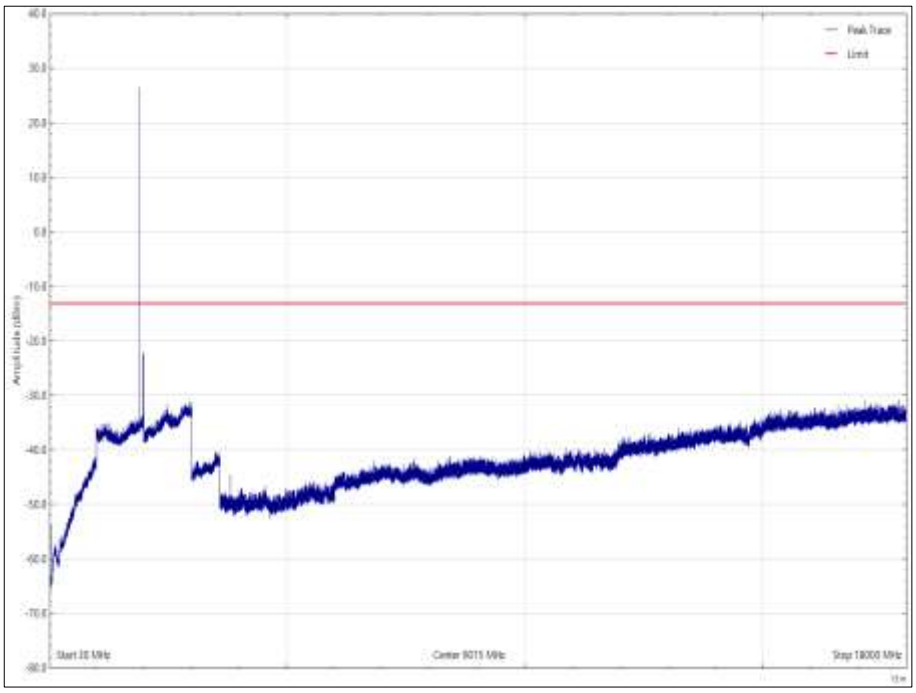


Figure 36 - 1909.8 MHz - 30 MHz to 18 GHz, Horizontal, Orientation Z

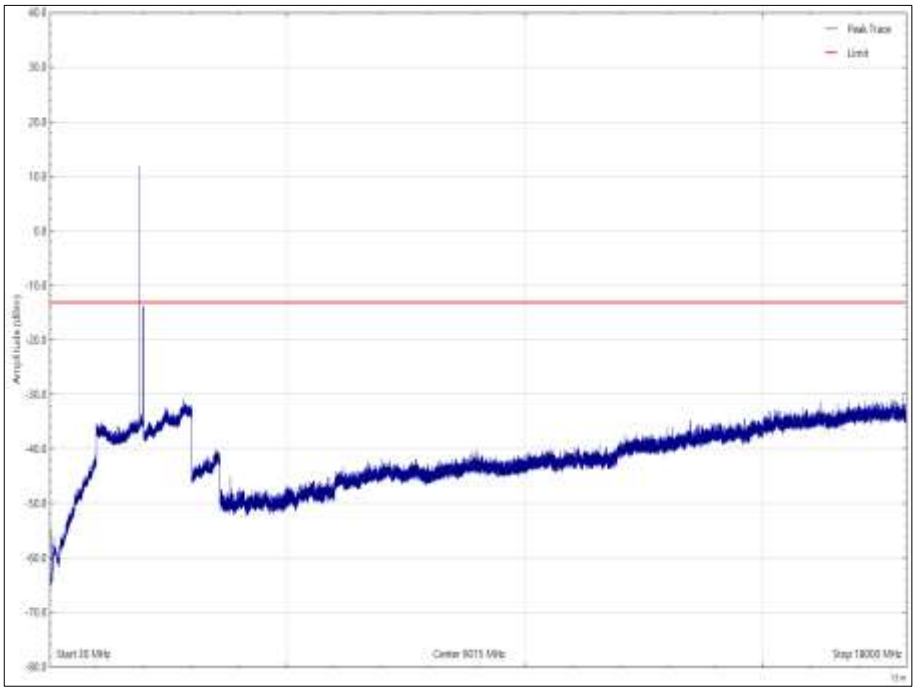


Figure 37 - 1909.8 MHz - 30 MHz to 18 GHz, Vertical, Orientation Z

<u>FCC 47 CFR Part 24, Limit Clause 24.238(a)</u>

The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log(P) dB.

2.3.4 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 12.

Instrument	Manufacturer	Type No.	TE No.	Calibration Period (months)	Calibration Expiry Date
Antenna (DRG, 18 GHz to 40 GHz)	Link Microtek Ltd	AM180HA-K-TU2	230	24	27-Jul-2022
Pre-Amplifier (18 GHz to 40 GHz)	Phase One	PSO4-0087	1534	12	02-Aug-2022
Comb Generator	Schaffner	RSG1000	3034	-	TU
Antenna (Log Periodic)	Schaffner	UPA6108	3108	12	13-Aug-2022
Test Receiver	Rohde & Schwarz	ESU40	3506	12	18-Mar-2022
Wideband Radio Communication Tester	Rohde & Schwarz	CMW 500	4143	12	10-Feb-2022
Cable (K-Type to K-Type, 2 m)	Scott Cables	KPS-1501-2000-KPS	4526	6	06-Mar-2022
Emissions Software	TUV SUD	EmX V2.1.11 V.2.1.11	5125	-	Software
Cable (N-Type to N-Type, 8 m)	Teledyne	PR90-088-8MTR	5450	6	08-Mar-2022
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5481	12	31-Mar-2022
3 GHz High pass Filter	Wainwright	WHKX12-2580-3000-18000-80SS	5548	12	07-May-2022
Antenna (DRG, 7.5 GHz to 18 GHz)	Schwarzbeck	HWRD750	5610	12	15-Oct-2022
Antenna (DRG, 1 GHz to 10 GHz)	Schwarzbeck	BBHA 9120 B	5611	12	15-Oct-2022
Turntable & Mast Controller	Maturo Gmbh	NCD/498/2799.01	5612	-	TU
Tilt Antenna Mast	Maturo Gmbh	TAM 4.0-P	5613	-	TU
Turntable	Maturo Gmbh	Turntable 1.5 SI-2t	5614	-	TU
Antenna (Bi-Log, 30 MHz to 1 GHz)	Teseq	CBL6111D	5615	24	16-Oct-2022
Screened Room (12)	MVG	EMC-3	5621	36	11-Aug-2023

Figure 38

TU – Traceability Unscheduled

2.4 Spurious Emissions at Band Edge

2.4.1 Specification Reference

FCC 47 CFR Part 2, Clause 2.1051
FCC 47 CFR Part 24, Clause 24.229 and 24.238 (a)

2.4.2 Equipment Under Test and Modification State

Cello 4S, S/N: 20213128425-93 - Modification State 0

2.4.3 Date of Test

25-January-2022

2.4.4 Test Method

The test was performed in accordance with KDB 971168 D01 v03r01, Clause 6.

2.4.5 Environmental Conditions

Ambient Temperature	23.6 °C
Relative Humidity	36.3 %

2.4.6 Test Results

External Antenna - PCS 1900

Lower Band Edge – Level (dBm)	Upper Band Edge – Level (dBm)
-30.8	-32.4

Table 27 - Band Edge Results

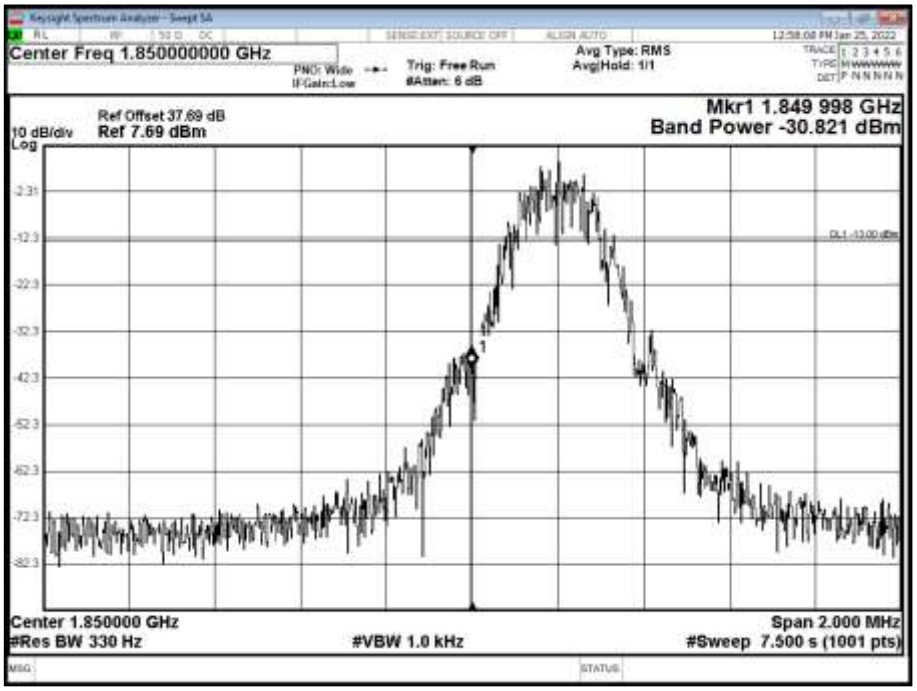


Figure 39 - Lower Band Edge

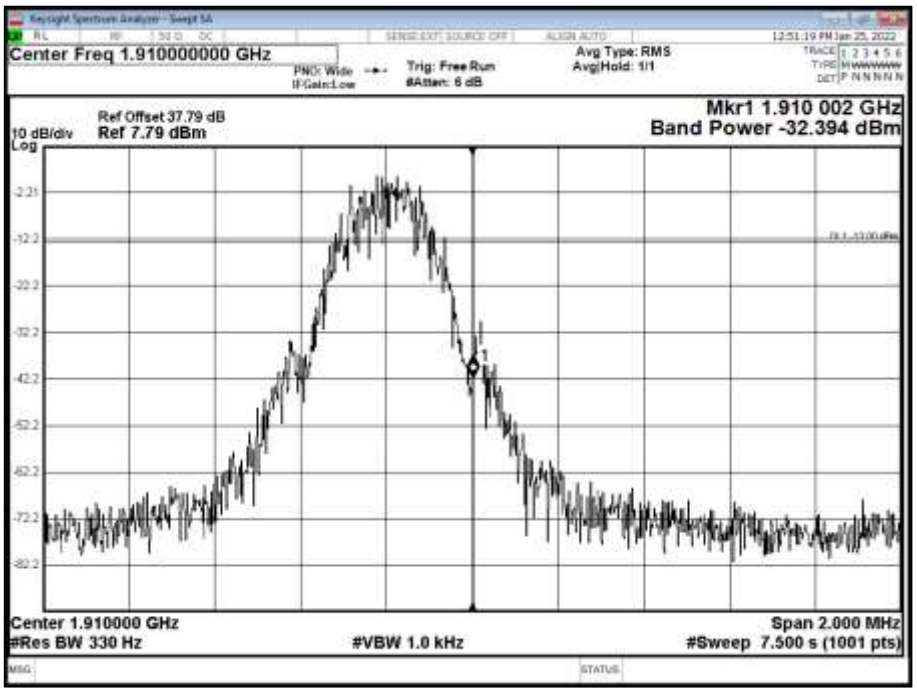


Figure 40 - Upper Band Edge

FCC Part 22 Limit Clause 24.238(a)

The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log(P) dB.

2.4.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 2.

Instrument	Manufacturer	Type No.	TE No.	Calibration Period (months)	Calibration Expiry Date
Power Splitter	Weinschel	1870A	3204	12	18-Aug-2022
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	29-Jan-2022
Wideband Radio Communication Tester	Rohde & Schwarz	CMW 500	4143	12	10-Feb-2022
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	31-Jan-2022
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	30-Jun-2022
1 metre K-Type Cable	Florida Labs	KMS-180SP-39.4-KMS	4519	12	18-Nov-2022
1 metre K-Type Cable	Florida Labs	KMS-180SP-39.4-KMS	4520	12	18-Nov-2022
PXA Signal Analyser	Keysight Technologies	N9030A	4654	12	24-Nov-2022
3.5 mm 1m Cable	Junkosha	MWX221-01000DMS	5420	12	12-Aug-2022
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5475	12	06-Apr-2022
Attenuator 5W 30dB DC-18GHz	Aaren	AT40A-4041-D18-30	5503	12	14-Apr-2022

Table 28

2.5 Maximum Conducted Output Power

2.5.1 Specification Reference

FCC 47 CFR Part 2, Clause 2.1046
FCC 47 CFR Part 24, Clause 24.232

2.5.2 Equipment Under Test and Modification State

Cello 4S, S/N: 20213128425-93 - Modification State 0

2.5.3 Date of Test

26-January-2022

2.5.4 Test Method

The test was performed in accordance with KDB 971168 D01 v03r01, Clause 5.1.1, 5.1.2, 5.2.3

2.5.5 Environmental Conditions

Ambient Temperature	23.5 °C
Relative Humidity	34.7 %

2.5.6 Test Results

External Antenna - PCS 1900

1850.2 MHz			1880.0 MHz			1909.8 MHz		
Average Power (dBm)	Average Power (W)	Peak to Average Ratio (dB)	Average Power (dBm)	Average Power (dBm)	Peak to Average Ratio (dB)	Average Power (dBm)	Average Power (W)	Peak to Average Ratio (dB)
26.6	0.457	0.8	26.5	0.447	0.7	26.1	0.407	0.7

Table 29 - Maximum Conducted Output Power

FCC 47 CFR Part 24, Limit Clause 24.232(c)

Mobile and portable stations are limited to 2 watts EIRP and the equipment must employ a means for limiting power to the minimum necessary for successful communications.

The peak-to-average ratio (PAR) of the transmission may not exceed 13 dB.

2.5.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 2.

Instrument	Manufacturer	Type No.	TE No.	Calibration Period (months)	Calibration Expiry Date
Power Splitter	Weinschel	1870A	3204	12	18-Aug-2022
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	29-Jan-2022
Wideband Radio Communication Tester	Rohde & Schwarz	CMW 500	4143	12	10-Feb-2022
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	31-Jan-2022
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	30-Jun-2022
1 metre K-Type Cable	Florida Labs	KMS-180SP-39.4-KMS	4519	12	18-Nov-2022
1 metre K-Type Cable	Florida Labs	KMS-180SP-39.4-KMS	4520	12	18-Nov-2022
PXA Signal Analyser	Keysight Technologies	N9030A	4654	12	24-Nov-2022
3.5 mm 1m Cable	Junkosha	MWX221-01000DMS	5420	12	12-Aug-2022
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5475	12	06-Apr-2022
Attenuator 5W 30dB DC-18GHz	Aaren	AT40A-4041-D18-30	5503	12	14-Apr-2022

Table 30

2.6 Frequency Stability

2.6.1 Specification Reference

FCC 47 CFR Part 2, Clause 2.1055
FCC 47 CFR Part 24, Clause 24.235

2.6.2 Equipment Under Test and Modification State

Cello 4S, S/N: 20213128425-93 - Modification State 0

2.6.3 Date of Test

25-January-2022

2.6.4 Test Method

This test was performed in accordance with FCC 47 CFR Part 2, clause 2.1055.

CMW500 Multi Evaluation measurement function was used to measure the frequency error. CMW500 was configured for an uplink frequency of 1850.2 MHz, 1880.0 MHz and 1909.8 MHz.

Note that voltage variation was not tested as the EUT could only be operated with a fitted battery.

2.6.5 Environmental Conditions

Ambient Temperature	23.6 °C
Relative Humidity	36.7 %

2.6.6 Test Results

External Antenna - PCS 1900

Temperature	Frequency Error (Hz)		
	1850.2 MHz	1880.0 MHz	1909.8 MHz
+50 °C	33.1	17.2	23.6
+40 °C	32.7	20.0	24.2
+30 °C	31.4	-19.0	25.5
+20 °C	34.4	21.1	27.1
+10 °C	38.8	26.2	32.5
0 °C	42.3	29.1	39.7
-10 °C	46.8	24.2	32.0
-20 °C	41.8	30.1	45.7
-30 °C	38.2	28.7	27.8

Table 31 - Frequency Stability Under Temperature Variations

FCC 47 CFR Part 24, Limit Clause 24.235

Fundamental emission stays within authorised frequency block.

2.6.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 2.

Instrument	Manufacturer	Type No.	TE No.	Calibration Period (months)	Calibration Expiry Date
Climatic Chamber	Votsch	VT4002	161	-	O/P Mon
Digital Temperature Indicator	Fluke	51	1385	12	02-Mar-2022
Power Splitter	Weinschel	1870A	3204	12	18-Aug-2022
Wideband Radio Communication Tester	Rohde & Schwarz	CMW 500	4143	12	10-Feb-2022
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	30-Jun-2022
1 metre K-Type Cable	Florida Labs	KMS-180SP-39.4-KMS	4519	12	18-Nov-2022
1 metre K-Type Cable	Florida Labs	KMS-180SP-39.4-KMS	4520	12	18-Nov-2022
3.5 mm 1m Cable	Junkosha	MWX221-01000DMS	5420	12	12-Aug-2022
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5475	12	06-Apr-2022
Attenuator 5W 30dB DC-18GHz	Aaren	AT40A-4041-D18-30	5503	12	14-Apr-2022

Table 32

O/P Mon – Output Monitored using calibrated equipment

2.7 26 dB Bandwidth

2.7.1 Specification Reference

FCC 47 CFR Part 2, Clause 2.1049 (h)
FCC 47 CFR Part 24, Clause 24.238

2.7.2 Equipment Under Test and Modification State

Cello 4S, S/N: 20213128425-93 - Modification State 0

2.7.3 Date of Test

25-January-2022

2.7.4 Test Method

The test was performed in accordance with KDB 971168 D01 v03r01, Clause 4.1.

2.7.5 Environmental Conditions

Ambient Temperature	23.6 °C
Relative Humidity	36.3 %

2.7.6 Test Results

External Antenna - PCS 1900

26 dB Bandwidth (kHz)		
1850.2 MHz	1880.0 MHz	1909.8 MHz
319.6	323.1	317.8

Table 33 - 26 dB Bandwidth

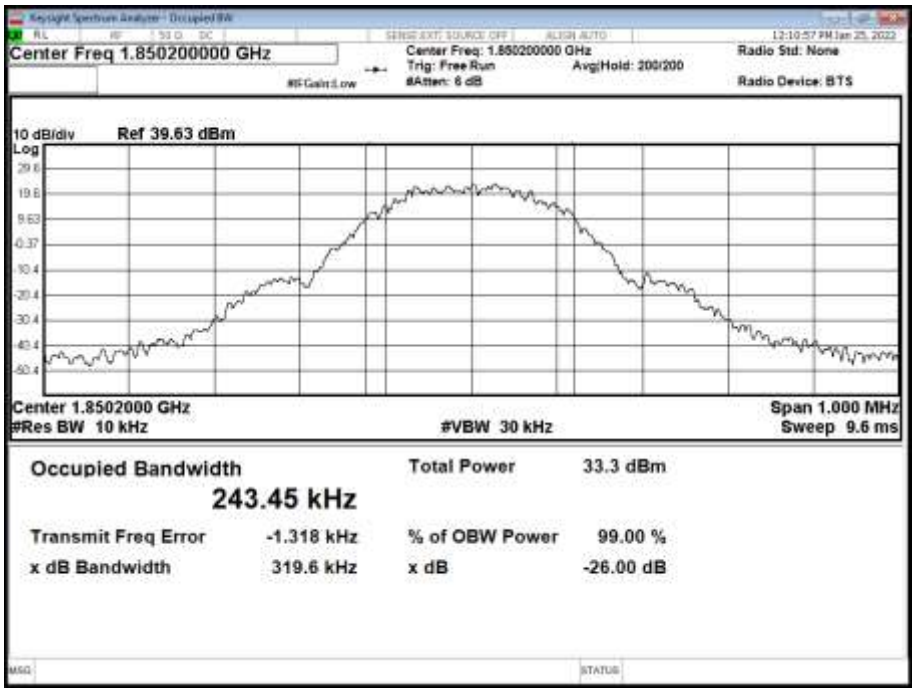


Figure 41 - 26 dB Bandwidth, 1850.2 MHz

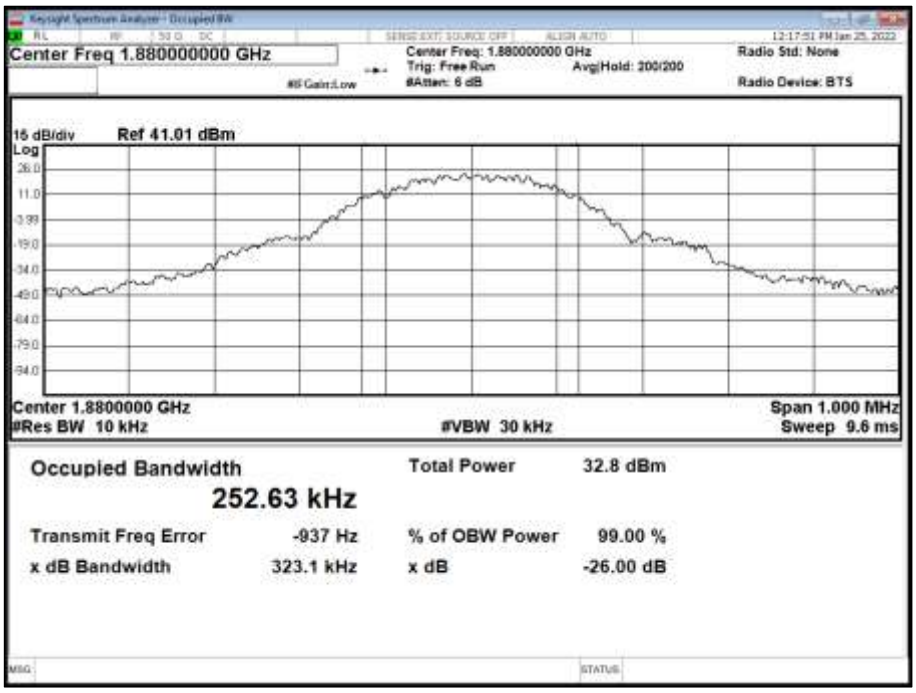


Figure 42 - 26 dB Bandwidth, 1880.0 MHz

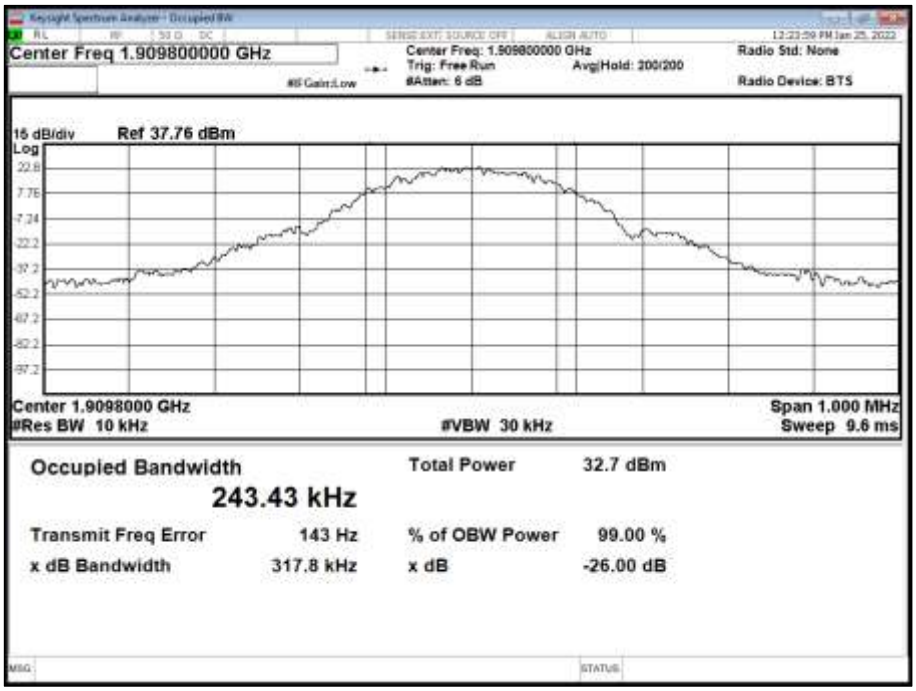


Figure 43 - 26 dB Bandwidth, 1909.8 MHz

FCC 47 CFR Part 24, Limit Clause

None Specified.

2.7.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 2.

Instrument	Manufacturer	Type No.	TE No.	Calibration Period (months)	Calibration Expiry Date
Power Splitter	Weinschel	1870A	3204	12	18-Aug-2022
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	29-Jan-2022
Wideband Radio Communication Tester	Rohde & Schwarz	CMW 500	4143	12	10-Feb-2022
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	31-Jan-2022
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	30-Jun-2022
1 metre K-Type Cable	Florida Labs	KMS-180SP-39.4-KMS	4519	12	18-Nov-2022
1 metre K-Type Cable	Florida Labs	KMS-180SP-39.4-KMS	4520	12	18-Nov-2022
PXA Signal Analyser	Keysight Technologies	N9030A	4654	12	24-Nov-2022
3.5 mm 1m Cable	Junkosha	MWX221-01000DMS	5420	12	12-Aug-2022
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5475	12	06-Apr-2022
Attenuator 5W 30dB DC-18GHz	Aaren	AT40A-4041-D18-30	5503	12	14-Apr-2022

Table 34

2.8 Spurious Emissions at Antenna Terminals

2.8.1 Specification Reference

FCC 47 CFR Part 2, Clause 2.1051
FCC 47 CFR Part 24, Clause 24.238 (a)

2.8.2 Equipment Under Test and Modification State

Cello 4S, S/N: 20213128425-93 - Modification State 0

2.8.3 Date of Test

25-January-2022

2.8.4 Test Method

The test was performed in accordance with KDB 971168 D01 v03r01, Clause 6.

Emissions exceeding the limit line on the plots below other than the fundamental, were confirmed as either the BCCH or TCH from the communications test set.

2.8.5 Environmental Conditions

Ambient Temperature	23.6 °C
Relative Humidity	36.7 %

2.8.6 Test Results

External Antenna - PCS 1900

Frequency (MHz)	Level (dBm)
*	

Table 35 - 1850.2 MHz - Conducted Emissions Results

*No emissions were detected within 10 dB of the limit.

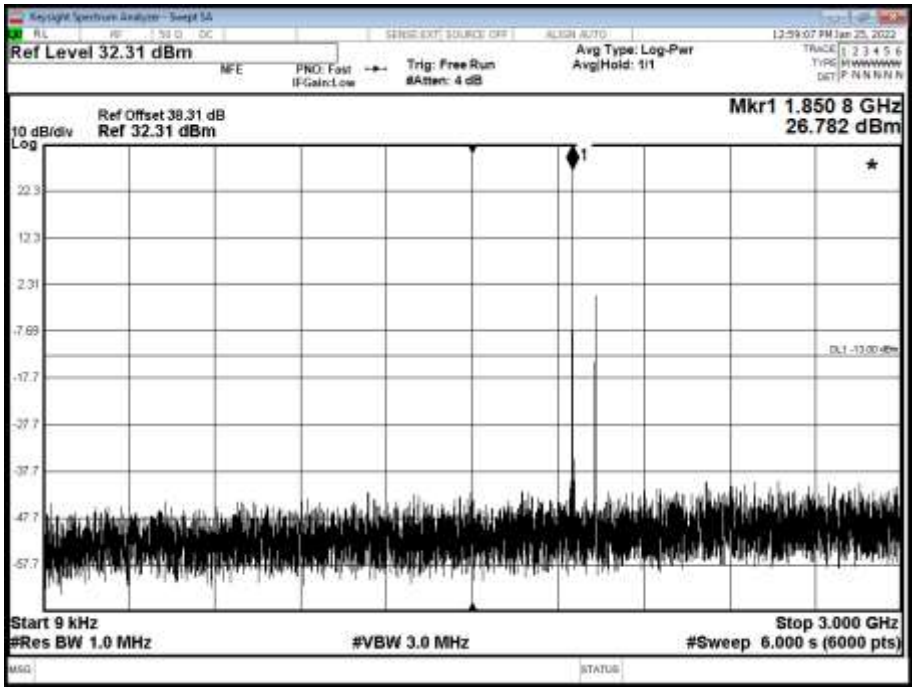


Figure 44 - 1850.2 MHz - 9 kHz to 3 GHz

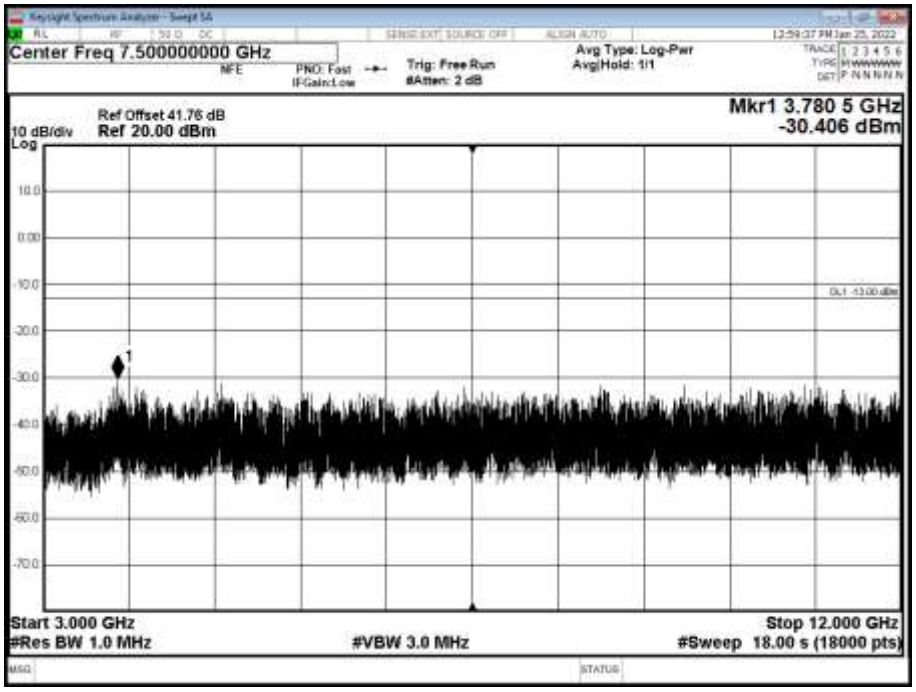


Figure 45 - 1850.2 MHz - 3 GHz to 12 GHz

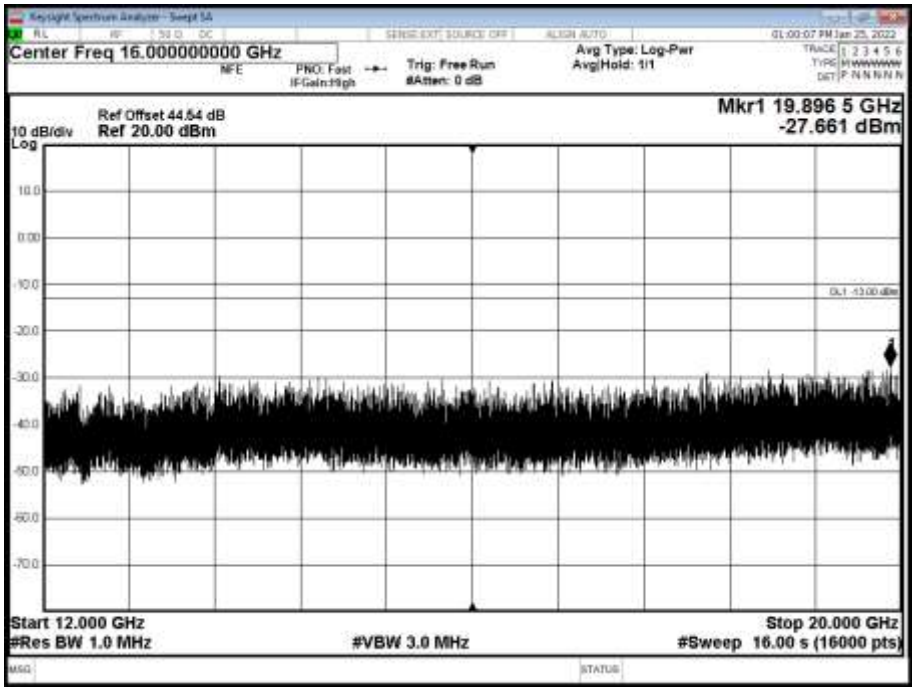


Figure 46 - 1850.2 MHz - 12 GHz to 20 GHz

Frequency (MHz)	Level (dBm)
*	

Table 36 - 1880.0 MHz - Conducted Emissions Results

*No emissions were detected within 10 dB of the limit.

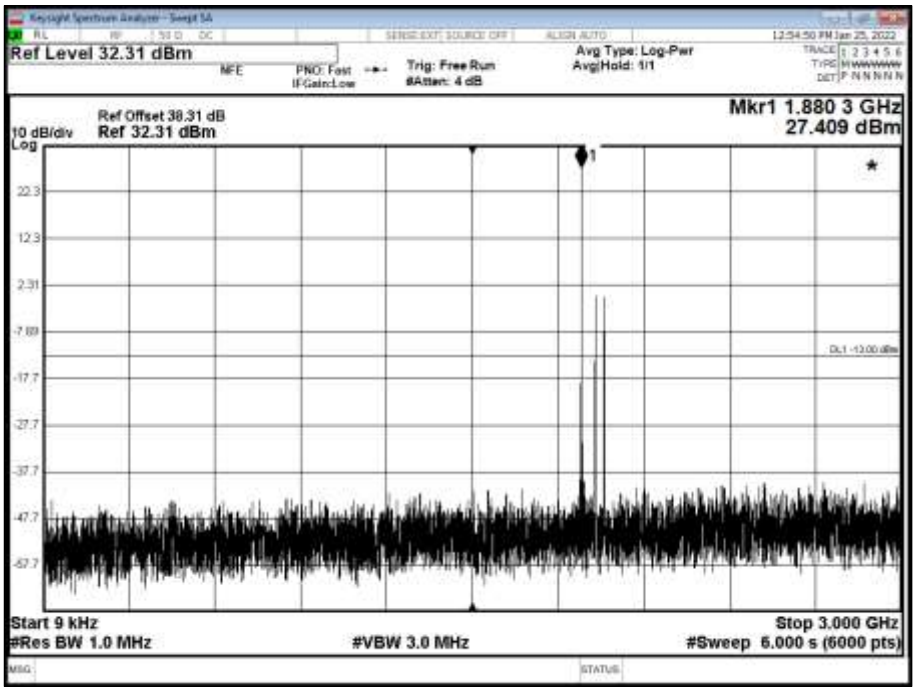


Figure 47 - 1880.0 MHz - 9 kHz to 3 GHz

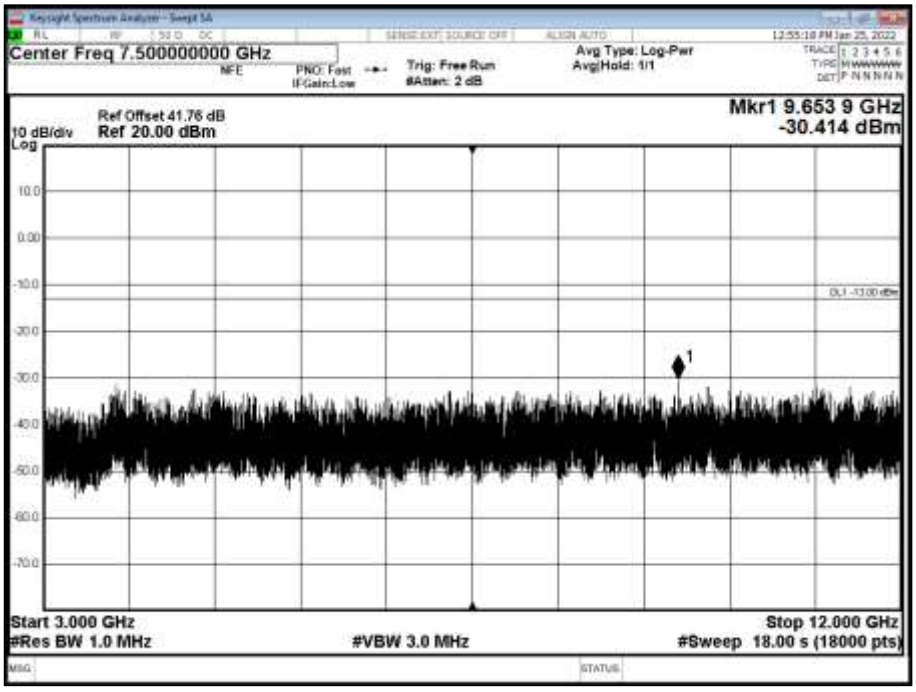


Figure 48 - 1880.0 MHz - 3 GHz to 12 GHz

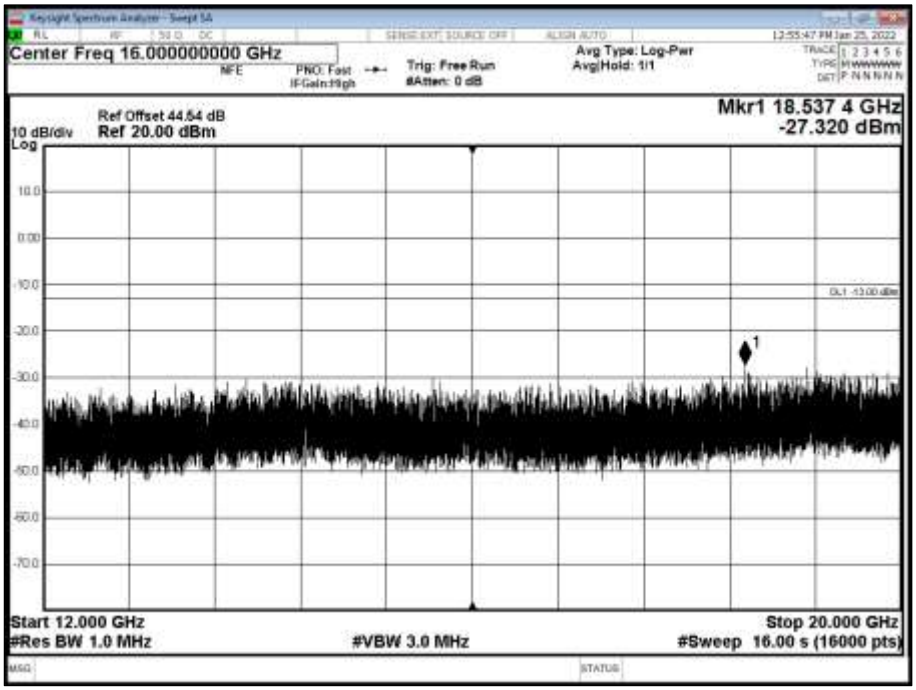


Figure 49 - 1880.0 MHz - 12 GHz to 20 GHz

Frequency (MHz)	Level (dBm)
*	

Table 37 - 1880.0 MHz - Conducted Emissions Results

*No emissions were detected within 10 dB of the limit.

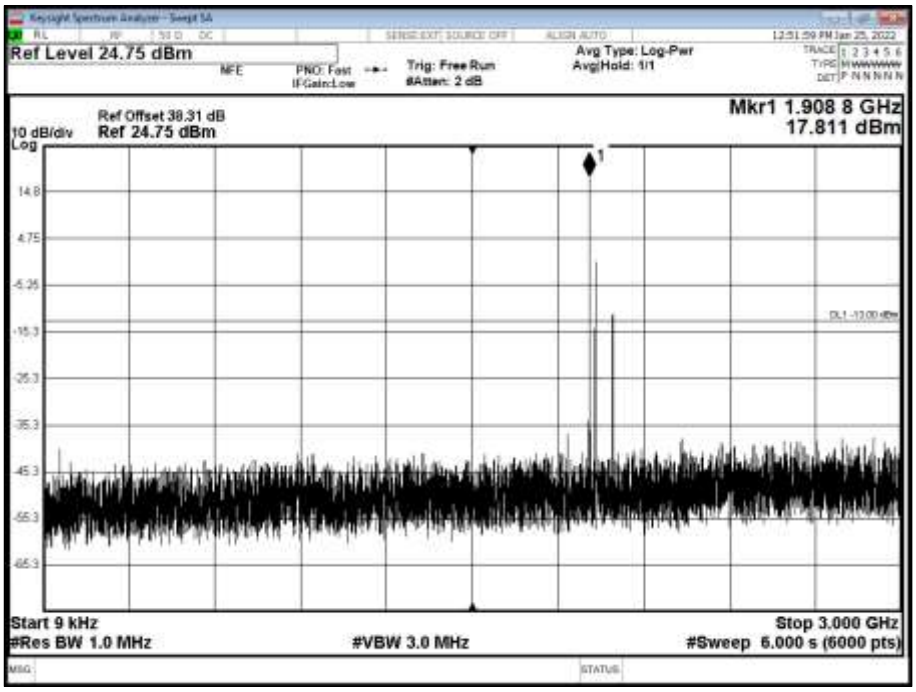


Figure 50 - 1909.8 MHz - 9 kHz to 3 GHz

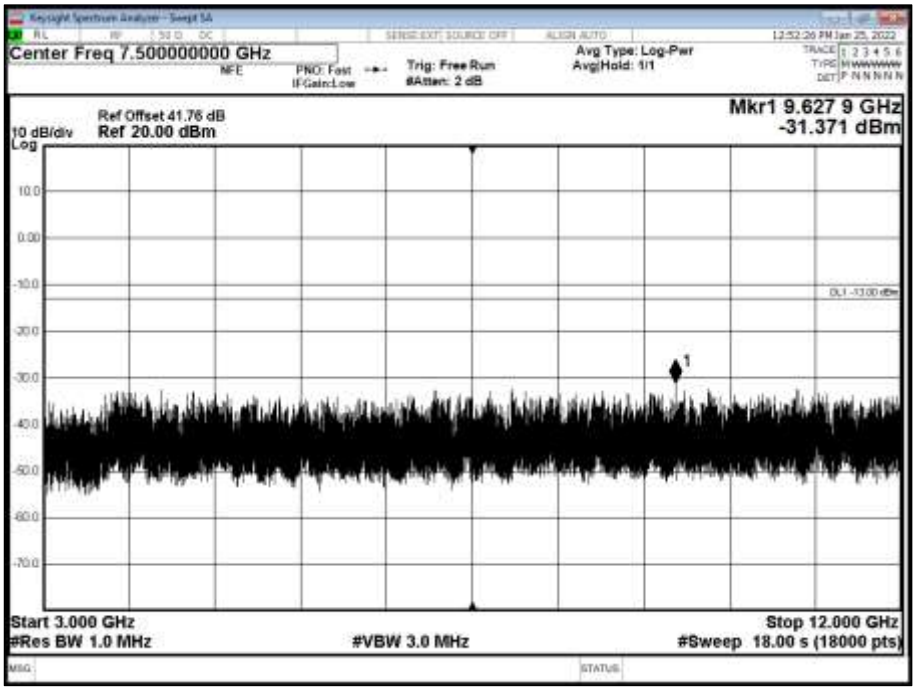


Figure 51 - 1909.8 MHz - 3 GHz to 12 GHz

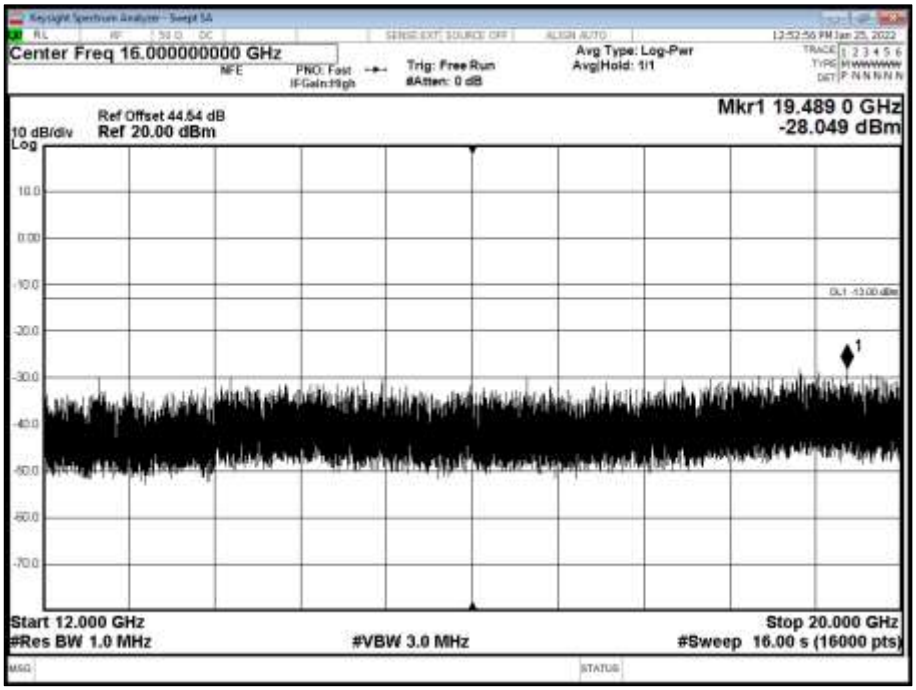


Figure 52 - 1909.8 MHz - 12 GHz to 20 GHz

FCC 47 CFR Part 24, Limit Clause 24.238(a)

The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log(P) dB.

2.8.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 2.

Instrument	Manufacturer	Type No.	TE No.	Calibration Period (months)	Calibration Expiry Date
Power Splitter	Weinschel	1870A	3204	12	18-Aug-2022
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	29-Jan-2022
Wideband Radio Communication Tester	Rohde & Schwarz	CMW 500	4143	12	10-Feb-2022
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	31-Jan-2022
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	30-Jun-2022
1 metre K-Type Cable	Florida Labs	KMS-180SP-39.4-KMS	4519	12	18-Nov-2022
1 metre K-Type Cable	Florida Labs	KMS-180SP-39.4-KMS	4520	12	18-Nov-2022
PXA Signal Analyser	Keysight Technologies	N9030A	4654	12	24-Nov-2022
3.5 mm 1m Cable	Junkosha	MWX221-01000DMS	5420	12	12-Aug-2022
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5475	12	06-Apr-2022
Attenuator 5W 30dB DC-18GHz	Aaren	AT40A-4041-D18-30	5503	12	14-Apr-2022

Table 38

3 Photographs

3.1 Test Setup Photographs

Figure 53 - 30 MHz to 1 GHz - X Orientation

Figure 54 - 30 MHz to 1 GHz - Y Orientation

Figure 55 - 30 MHz to 1 GHz - Z Orientation

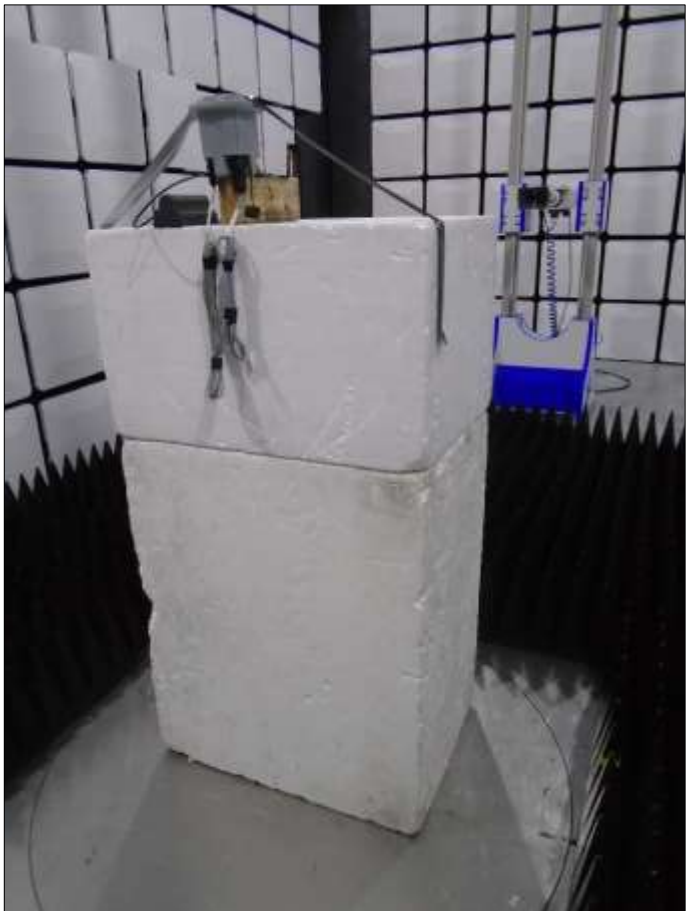


Figure 56 - 1 GHz to 18 GHz - X Orientation

Figure 57 - 1 GHz to 18 GHz - Y Orientation

Figure 58 - 1 GHz to 18 GHz - Z Orientation

Figure 59 - 18 GHz to 20 GHz - X Orientation

Figure 60 - 18 GHz to 20 GHz - X Orientation

Figure 61 - 18 GHz to 20 GHz - X Orientation

4 Measurement Uncertainty

For a 95% confidence level, the measurement uncertainties for defined systems are:

Test Name	Measurement Uncertainty
Modulation Characteristics	-
Equivalent Isotropic Radiated Power	± 3.2 dB
Radiated Spurious Emissions	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB
Spurious Emissions at Band Edge	± 3.454 dB
Maximum Conducted Output Power	± 3.2 dB
Frequency Stability	±101.1 Hz
26 dB Bandwidth	±10.14 kHz
Spurious Emissions at Antenna Terminals	± 3.454 dB

Table 39

Measurement Uncertainty Decision Rule – Accuracy Method

Determination of conformity with the specification limits is based on the decision rule according to IEC Guide 115:2007, Clause 4.4.3 and 4.5.1. (Procedure 2). The measurement results are directly compared with the test limit to determine conformance with the requirements of the standard.

Risk: The uncertainty of measurement about the measured result is negligible with regard to the final pass/fail decision. The measurement result can be directly compared with the test limit to determine conformance with the requirement (compare IEC Guide 115). The level of risk to falsely accept and falsely reject items is further described in ILAC-G8.