

Report on the Radio Testing
For
Navtech Radar Ltd
on
HDR100 Radar
Report no. TRA-044480-45-00C
2020-06-16

RF922 5.0

Report Number: TRA-044480-45-00C
Issue: C

REPORT ON THE RADIO TESTING OF A
Navtech Radar Ltd
HDR100 Radar
WITH RESPECT TO SPECIFICATION
FCC 47CFR 95 Subpart M

TEST DATE: 2020-03-11 to 2020-03-27

Written by:



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Radio Test Engineer

Approved by:

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Lab Manager

Date: 2020-06-16

Disclaimers:

- [1] THIS DOCUMENT MAY BE REPRODUCED ONLY IN ITS ENTIRETY AND WITHOUT CHANGE
- [2] THE RESULTS CONTAINED IN THIS DOCUMENT RELATE ONLY TO THE ITEM(S) TESTED

RF922 5.0

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	2020-06-09	Original
B	2020-06-10	Added the CIR models on page 10
C	2020-06-16	Corrected typo on ITU Emission designator and added C63.26-2015 standard

2 Summary

TEST REPORT NUMBER:	TRA-044480-45-00C
WORKS ORDER NUMBER:	TRA-044480-02
PURPOSE OF TEST:	USA: Testing of radio frequency equipment per the relevant authorization procedure of chapter 47 of CFR (code of federal regulations) Part 2, subpart J.
TEST SPECIFICATION:	47CFR95 Subpart M
EQUIPMENT UNDER TEST (EUT):	HDR100 Radar
FCC IDENTIFIER:	S7Y-MV1
EUT SERIAL NUMBER:	1232
MANUFACTURER/AGENT:	Navtech Radar Ltd
ADDRESS:	16 Home Farm Ardington Wantage Oxfordshire OX12 8PD United Kingdom
CLIENT CONTACT:	Rick Poulton ☎ 01235 433592 ✉ richard.poulton@navtechradar.com
ORDER NUMBER:	20446
TEST DATE:	2020-03-11 to 2020-03-27
TESTED BY:	David Garvey Element

2.1 Test Summary

Test Method and Description	Requirement Clause	Applicable to this equipment	Result / Note
	47CFR95		
Radiated spurious emissions	95.3379(a)	☒	Pass Note 1
AC power line conducted emissions	15.207	☒	Pass
Occupied bandwidth	95.3379(b)	☒	Pass
Field strength of fundamental	95.3367 (a) 95.3367 (b)	☒	Pass

Notes:

Note 1: Emission only performed to 110 GHz. The radiated spurious emissions above 110 GHz was performed by RN Electronics. The report number by RN Electronics is 05-11243-1-20.

The results contained in this report relate only to the items tested, in the condition at time of test, and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

The apparatus was set up and exercised using the configurations, modes of operation and arrangements defined in this report only. Any modifications made are identified in Section 8 of this report.

Particular operating modes, apparatus monitoring methods and performance criteria required by the standards tested to have been performed except where identified in Section 5.2 of this test report (Deviations from Test Standards).

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4 Introduction

This report TRA-044480-45-00C presents the results of the Radio testing on a Navtech Radar Ltd, HDR100 Radar to specification 47CFR95 Personal Radio Services.

The testing was carried out for Navtech Radar Ltd by Element, at the address detailed below.

☒	Element Hull Unit E South Orbital Trading Park Hedon Road Hull HU9 1NJ UK	☐	Element North West Unit 1 Pendle Place Skemersdale West Lancashire WN8 9PN UK
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This report details the configuration of the equipment, the test methods used and any relevant modifications where appropriate.

All test and measurement equipment under the control of the laboratory and requiring calibration is subject to an established programme and procedures to control and maintain measurement standards. The quality management system meets the principles of ISO 9001, and has quality control procedures for monitoring the validity of tests undertaken. Records and sufficient detail are retained to establish an audit trail of calibration records relating to its test results for a defined period. Under control of the established calibration programme, key quantities or values of the test & measurement instrumentation are within specification and comply with the relevant traceable internationally recognised and appropriate standard specifications, which are UKAS calibrated as such where these properties have a significant effect on results. Participation in inter-laboratory comparisons and proficiency testing ensures satisfactory correlation of results conform to Elements own procedures, as well as statistical techniques for analysis of test data providing the appropriate confidence in measurements.

Throughout this report EUT denotes equipment under test.

FCC Site Listing:

Element is accredited for the above sites under the US-EU MRA, Designation number UK0009.

The test site requirements of ANSI C63.4-2014 are met up to 1 GHz.

The test site SVSWR requirements of CISPR 16-1-4:2010 are met over the frequency range 1 GHz to 18 GHz.

5 Test Specifications

5.1 Normative References

- FCC 47 CFR Ch. I – Part 95 – Personal Radio Services.
- ANSI C63.26-2015 – American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services.
- ANSI C63.10-2013 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- ANSI C63.4-2014 – 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.

5.2 Deviations from Test Standards

The temperature range over which the EUT performance was assessed was wider than that required by the specification at the client's request.

This test report only covers emission up to 110 GHz.

6 Glossary of Terms

§	denotes a section reference from the standard, not this document
AC	Alternating Current
ANSI	American National Standards Institute
BW	bandwidth
C	Celsius
CFR	Code of Federal Regulations
CW	Continuous Wave
dB	decibel
dBm	dB relative to 1 milliwatt
DC	Direct Current
DSSS	Direct Sequence Spread Spectrum
EIRP	Equivalent Isotropically Radiated Power
ERP	Effective Radiated Power
EUT	Equipment Under Test
FCC	Federal Communications Commission
FHSS	Frequency Hopping Spread Spectrum
Hz	hertz
IC	Industry Canada
ITU	International Telecommunication Union
LBT	Listen Before Talk
m	metre
max	maximum
MIMO	Multiple Input and Multiple Output
min	minimum
MRA	Mutual Recognition Agreement
N/A	Not Applicable
PCB	Printed Circuit Board
PDF	Portable Document Format
Pt-mpt	Point-to-multipoint
Pt-pt	Point-to-point
RF	Radio Frequency
RH	Relative Humidity
RMS	Root Mean Square
Rx	receiver
s	second
SVSWR	Site Voltage Standing Wave Ratio
Tx	transmitter
UKAS	United Kingdom Accreditation Service
V	volt
W	watt
Ω	ohm

7 Equipment Under Test

7.1 EUT Identification

- Name: HDR100 Radar
- Serial Number: 1232
- Model Number: HDR100/CIR/CTS350-X Series
- Software Revision: Not Applicable
- Build Level / Revision Number: Not Applicable

Two different antenna were tested which have minor differences in beam shape.

Antenna sample #1. This has an Azimuth x Elevation beam width of $1.8^\circ \times 1.8^\circ$, but has a fill in area below the horizontal plane.

Antenna sample #2. This has an Azimuth x Elevation beam width of $1.8^\circ \times 1.8^\circ$, but has no fill in below the horizontal plane resulting in marginally higher gain.

Models marketed to the ground surveillance applications are electronically identical, with all RF measurements applicable to all. The models are marketed based on the following format: HDR1yz. This is defined as:

- y: This is an instrumented range designator. The transmitted power is identical, but the range data reported by the radar is altered in software based on the unit purchased.
- z: This represents rotation speed of the radar and can be 1, 2 or 4Hz.

Models marketed to Industrial applications are electronically identical and are marketed based on the following format: CIRyyz-X

This is defined as:

- yy: This is a 2 digit instrumented range designator. For example, 05 represents 50m instrumented range, where as 50 would represent 500m
- z: This represents rotation speed of the radar and can be 1, 2 or 4Hz.

7.2 System Equipment

Equipment listed below forms part of the overall test setup and is required for equipment functionality and/or monitoring during testing. The compliance levels achieved in this report relate only to the EUT and not items given in the following list.

Not Applicable – No support/monitoring equipment required.

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for transmit tests was as follows:

The EUT was operating with a swept frequency transmission. For radiated spurious measurements, the EUT was operating in normal mode with a rotating antenna assembly. For all other tests, the EUT was operating in staring mode with a stationary antenna assembly lined up with the measurement antenna.

7.3.2 Reception

The mode of operation for receive tests was as follows:

The EUT does not have a separate receive mode.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	76 GHz – 77 GHz
Modulation type(s):	FMCW
Channel spacing:	N/A (Swept RADAR signal)
ITU emission designator(s):	1G00F0N
Declared output power(s):	43 dBm
Warning against use of alternative antennas in user manual:	N/A Not possible to use other antennas
Nominal Supply Voltage:	24 Vdc
Method of prevention of use on non-US / non-Canadian frequencies:	N/A
Duty cycle:	0.5% when rotating

7.4.2 Antennas

Type:	Custom pseudo optical horn lens assembly
Frequency range:	76 GHz to 77 GHz
Impedance:	N/A
SWR:	N/A
Gain:	With Fill in: 35 dBi Without Fill in: 38 dBi
Polarisation:	Horizontal
Beam width:	1.8°
Connector type:	N/A (not customer accessible)
Length:	N/A
Weight:	N/A
Environmental limits:	-20 °C to 60 °C
Mounting:	Internally mounted to a rotating assembly

7.5 EUT Description

The EUT is a Radar Unit for a variety of functions, including vehicle automation, localisation and navigation as well as ground based applications for detecting ground targets such as vehicles, debris and pedestrians.

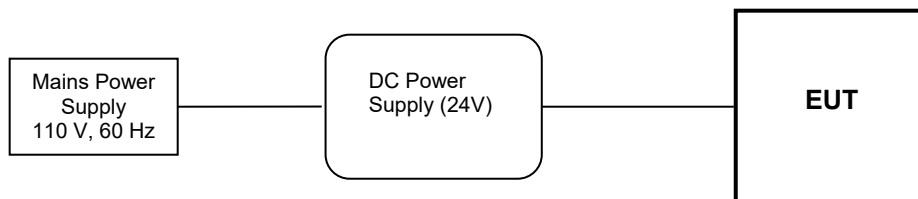
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

9.1 Block Diagram

The following diagram shows basic EUT interconnections:



9.2 General Set-up Photograph

The following photograph shows basic EUT set-up:



9.3 Measurement software

Where applicable, the following software was used to perform measurements contained within this report.

Element Emissions R5 (See Note)

Note:

The version of the Element software used is recorded in the results sheets contained within this report.

10 General Technical Parameters

10.1 Normal Conditions

The EUT was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was 24 Vdc from the provided adaptor which was powered from 110 Vac, 60 Hz, from the mains.

10.2 Varying Test Conditions

There are no specific frequency stability requirements for the type of device. The results contained in this report demonstrate that the occupied bandwidth is contained within the authorised band and the manufacturer has declared sufficient frequency stability (refer to section 7.4).

Variation of supply voltage is required to ensure stability of the declared output power. During carrier power testing the following variations were made:

	Category	Nominal	Variation
☐	Mains	110 Vac +/- 2 %	85 % and 115 %
☐	Battery	New battery	N/A
☒	Power Supply	24 Vdc	85 % and 115 %

11 Radiated emissions

11.1 Definitions

Out-of-band emissions

Emissions on a frequency or frequencies immediately outside the necessary bandwidth which result from the modulation process, but exclude spurious emissions.

Spurious emissions

Emissions on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

Restricted bands

A frequency band in which intentional radiators are permitted to radiate only spurious emissions but not fundamental signals.

11.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 3
Test Standard and Clause:	ANSI C63.26-2015, Clause 5.5
EUT Channels / Frequencies Measured:	Full band
EUT Channel Bandwidths:	1 GHz
Deviations From Standard:	None
Measurement BW:	30 MHz to 1 GHz: 120 kHz Above 1 GHz: 1 MHz
Measurement Detector:	Up to 1 GHz: quasi-peak Above 1 GHz: RMS average and Peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 42 % RH	20 % RH to 75 % RH (as declared)
Supply: 24 Vdc	As declared

11.3 Test Limit

Radiated emissions below 40 GHz shall not exceed the general field strength limits listed in FCC 47CFR95.3379 (a) (1) {see table below}.

General Field Strength Limits for License-Exempt Transmitters at Frequencies above 30 MHz

Frequency (MHz)	Field Strength ($\mu\text{V/m}$ at 3 m)
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

n.b. per FCC 47CFR15.35(b), peak limit is 20 dB above average.

Radiated emissions outside of the operating band and between 40 GHz and 200 GHz shall not exceed 600pW/cm² at a distance of 3 meters from the exterior surface of the radiating structure.

Radiated emissions above 200 GHz shall not exceed 1000 pW/cm² at a distance of 3 meters from the exterior surface of the radiating structure.

The spectrum shall be investigated up to 231 GHz.

11.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure i, the emissions from the EUT were measured on a spectrum analyzer / EMI receiver.

Radiated electromagnetic emissions from the EUT are checked first by preview scans. Preview scans for all spectrum and modulation characteristics are checked, using a peak detector and where applicable worst-case determined for function, operation, orientation, etc. for both vertical and horizontal polarisations. Pre-scan plots are shown with a peak detector and 100 kHz RBW.

If the EUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.10 are followed. Alternatively, a layout closest to normal use (as declared by the provider) is employed, (see EUT setup photographs for more detail).

Emissions between 30 MHz and 1 GHz are measured using calibrated broadband antennas. Emissions above 1 GHz are characterized using standard gain horn antennas. Pre-amplifiers and filters are used where required. Care is taken to ensure that test receiver resolution bandwidth, video bandwidth and detector type(s) meet the regulatory requirements.

For both horizontal and vertical polarizations, the EUT is then rotated through 360 degrees in azimuth until the highest emission is detected. At the previously determined azimuth the test antenna is raised and lowered from 1 to 4 m in height until a maximum emission level is detected, this maximum value is recorded.

Power values measured on the test receiver / analyzer are converted to field strength, FS, in dBμV/m at the regulatory distance, using:

$$FS = PR + CL + AF - PA + DC - CF$$

Where,

PR is the power recorded on the receiver / spectrum analyzer in dBμV;

CL is the cable loss in dB;

AF is the test antenna factor in dB/m;

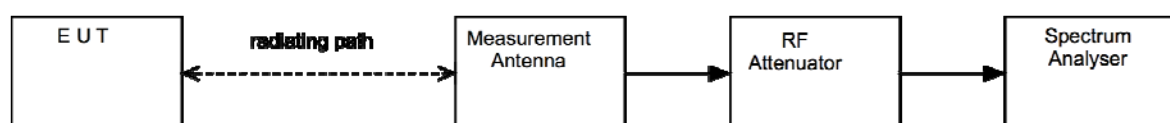
PA is the pre-amplifier gain in dB (where used);

DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);

CF is the distance factor in dB (where measurement distance different to limit distance);

This field strength value is then compared with the regulatory limit.

Figure i Test Setup



11.5 Test Set-up Photograph



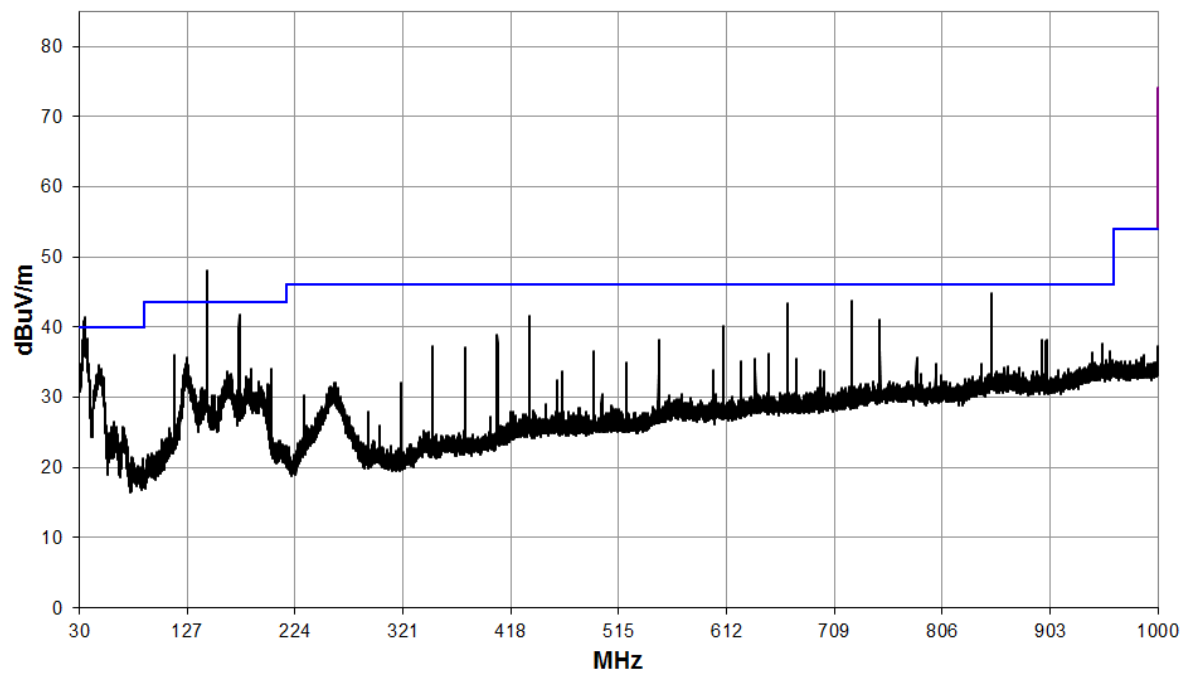
11.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Ferrite Lined Chamber	Rainford	Chamber	REF2259	2020-08-03
N9030A	Agilent	Spectrum Analyser	REF2167	2020-08-12
Bilog Antenna	Chase	CBL6111B	REF2218	2021-10-23
Horn Antenna	A Info Inc	LB-10180-NF	REF2241	2020-07-13
LB-90-25-C2-SF	A Info Inc	Horn Antenna	REF2243	2020-07-16
LB-62-25-C-SF	A Info Inc	Horn Antenna	REF2244	2020-07-16
LB-180400-25-C-KF	A Info Inc	Horn Antenna	REF2246	2020-07-25
Pre-Amp (9kHz – 1GHz)	Sonoma	310	REF927	2020-05-29
Pre-Amp (1 – 26.5GHz)	Agilent	8449B	REF913	2021-02-05
11970Q	Agilent	Harmonic Mixer (33-50)	U365	2022-05-17
11970V	Agilent	Harmonic Mixer (50-75)	U366	2022-05-17
11970W	Agilent	Harmonic Mixer (75-110)	U367	2022-05-17
ESU40	R&S	Receiver	RFG701	2021-02-06
Emissions R5	Element	Radiated Test Software	REF9000	Cal not required

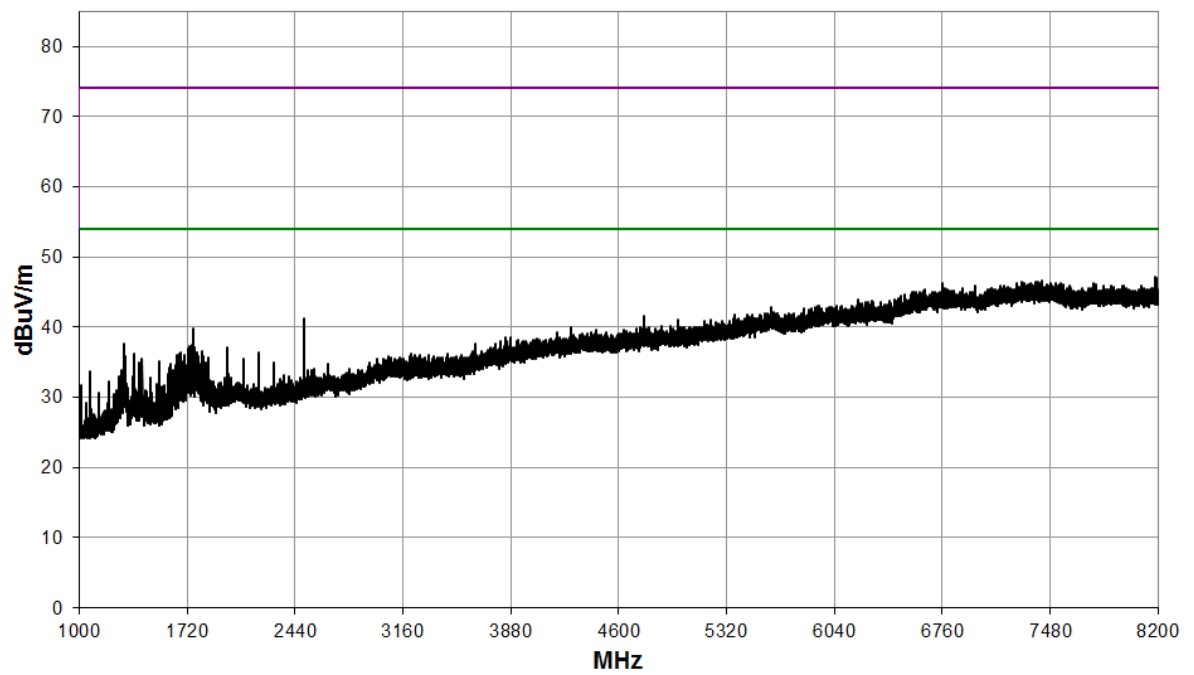
11.7 Test Results

77 GHz Radar; FMCW; With Fill In										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
QP	33.6	10.4	0.6	22.5	0.0	0.0	0.0	33.5	47.3	100
QP	48.6	12.6	0.9	16.0	0.0	0.0	0.0	29.5	29.9	100
QP	116.0	18.0	1.4	17.4	0.0	0.0	0.0	36.8	69.2	150
QP	125.7	8.7	1.5	17.8	0.0	0.0	0.0	28.0	25.1	150
QP	145.0	23.0	1.6	17.4	0.0	0.0	0.0	42.0	125.9	150
QP	174.0	23.5	1.7	15.3	0.0	0.0	0.0	40.5	105.9	150
QP	203.0	12.8	1.8	15.3	0.0	0.0	0.0	29.9	31.3	150
QP	261.0	7.2	2.2	19.7	0.0	0.0	0.0	29.1	28.5	200
QP	319.0	8.9	2.4	19.1	0.0	0.0	0.0	30.4	33.1	200
QP	348.0	8.7	2.6	20.1	0.0	0.0	0.0	31.4	37.2	200
QP	377.0	9.9	2.7	20.8	0.0	0.0	0.0	33.4	46.8	200
QP	406.0	14.4	2.8	21.9	0.0	0.0	0.0	39.1	90.2	200
QP	435.0	13.9	2.9	22.6	0.0	0.0	0.0	39.4	93.3	200
QP	493.0	6.7	3.1	23.6	0.0	0.0	0.0	33.4	46.8	200
QP	551.0	6.9	3.3	25.1	0.0	0.0	0.0	35.3	58.2	200
QP	609.0	9.2	3.5	25.6	0.0	0.0	0.0	38.3	82.2	200
QP	667.0	13.3	3.6	26.3	0.0	0.0	0.0	43.2	144.5	200
QP	725.0	8.9	3.8	27.1	0.0	0.0	0.0	39.8	97.7	200
QP	750.0	9.0	3.8	28.0	0.0	0.0	0.0	40.8	109.7	200
QP	850.0	9.3	4.1	28.9	0.0	0.0	0.0	42.3	130.3	200
QP	899.0	2.1	4.2	28.8	0.0	0.0	0.0	35.1	56.8	200
AV	1299.9	8.2	2.6	25.1	0.0	0.0	0.0	35.9	62.4	500
AV	2500.0	9.0	3.7	28.6	0.0	0.0	0.0	41.3	116.1	500
AV	4773.8	-4.3	5.4	33.4	0.0	0.0	0.0	34.5	53.1	500
PK	9533.2	34.7	8.0	27.4	0.0	0.0	0.0	70.1	3198.9	5000
PK	14322.0	49.5	10.4	31.3	33.2	0.0	0.0	58.0	794.3	5000
AV	14422.8	28.2	10.5	31.4	33.3	0.0	0.0	36.8	69.2	500
PK	19227.4	60.4	5.1	33.2	33.3	0.0	-9.5	55.9	623.7	5000

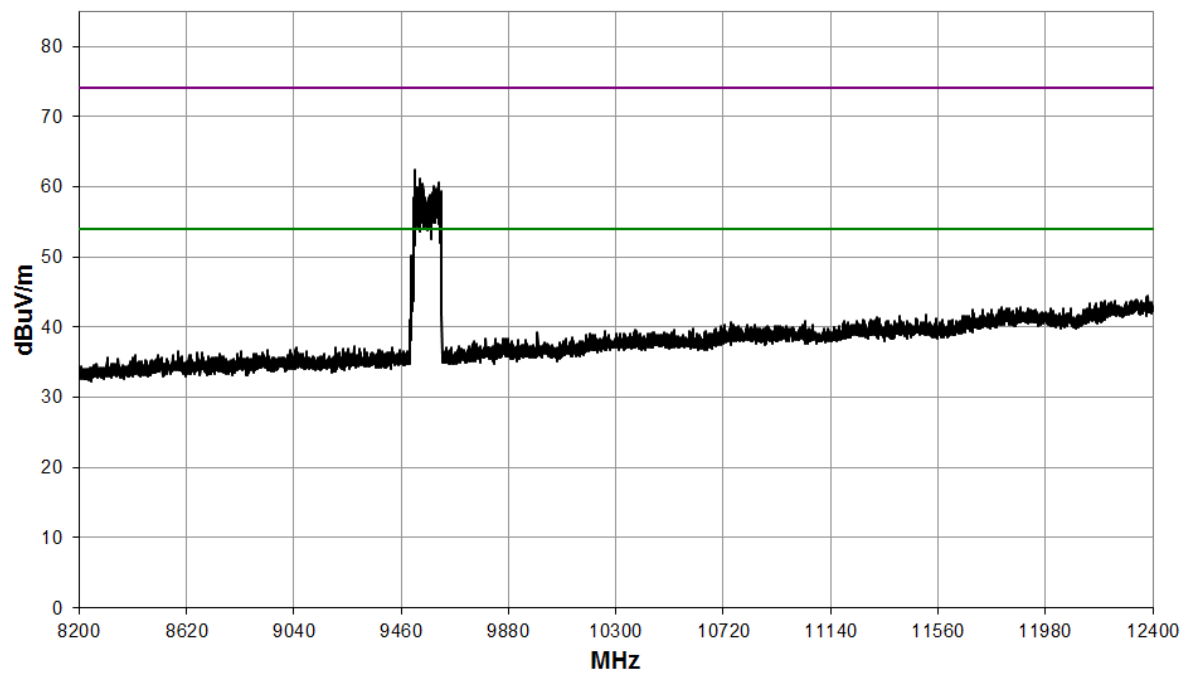
30 MHz to 1 GHz



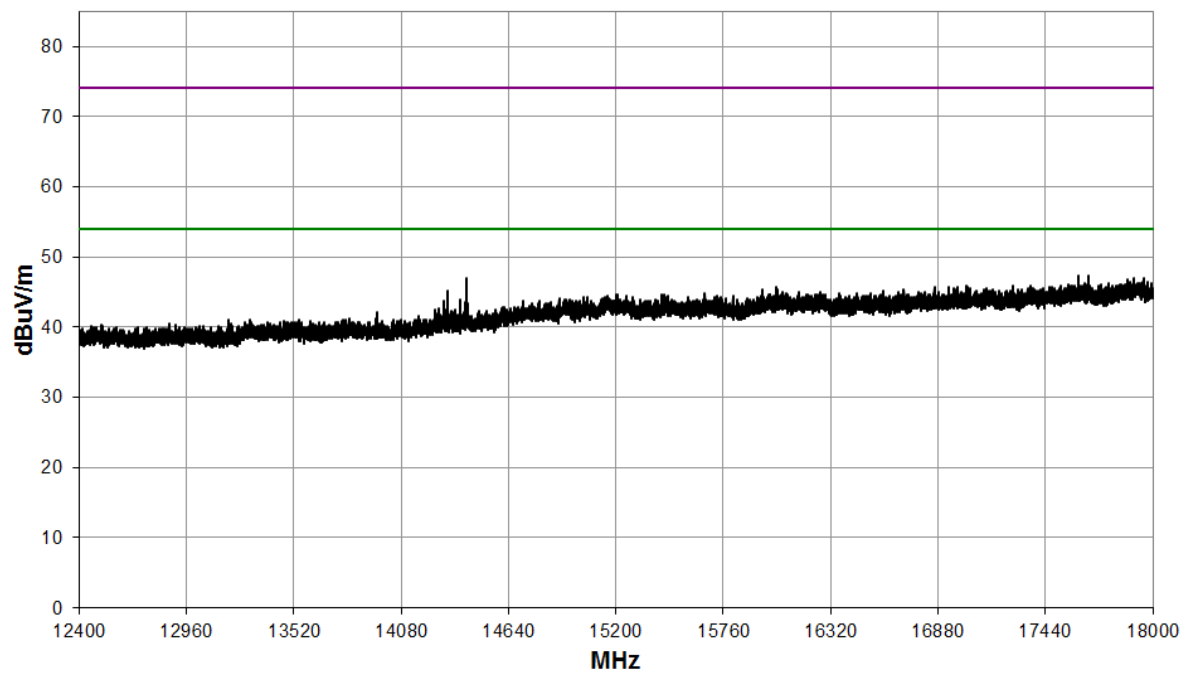
1 GHz to 8.2 GHz



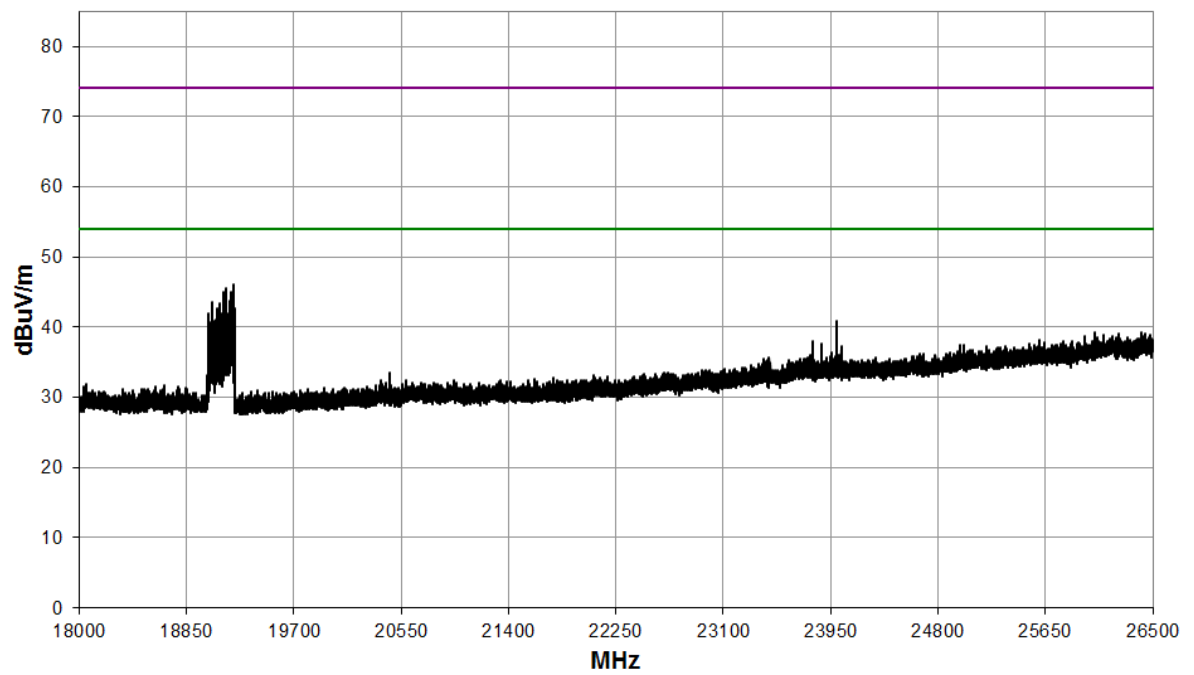
8.2 GHz to 12.4 GHz



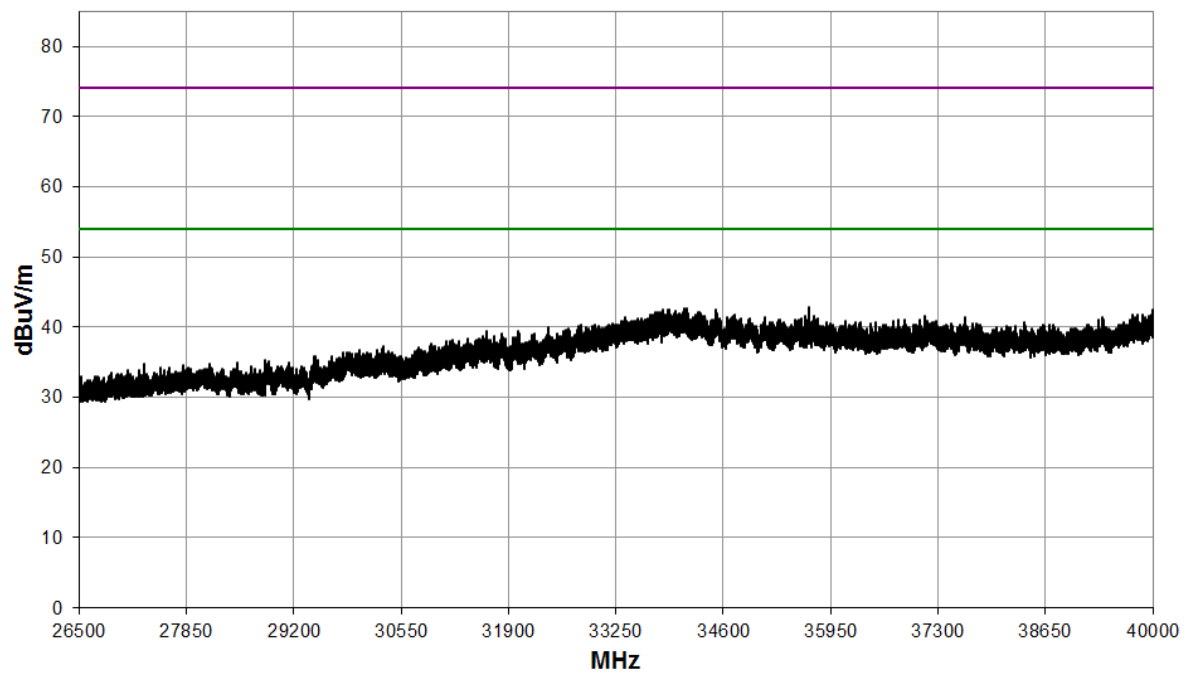
12.4 GHz to 18 GHz



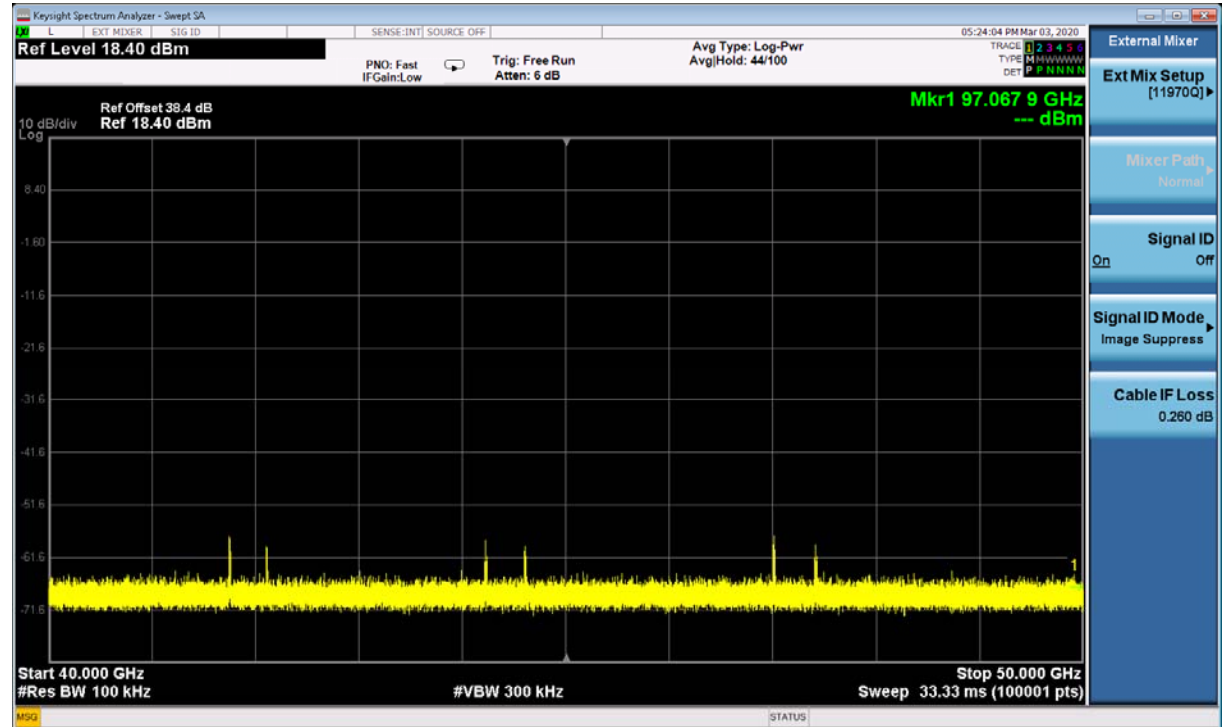
18 GHz to 26.5 GHz



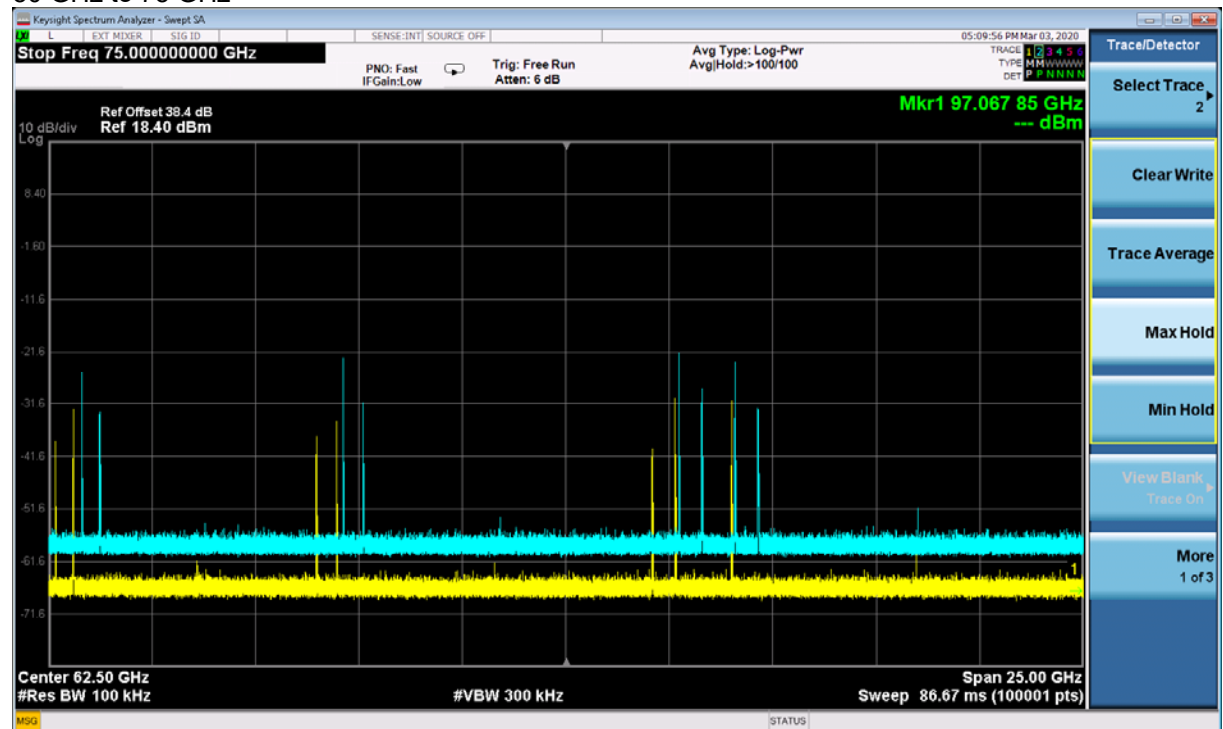
26.5 GHz to 40 GHz



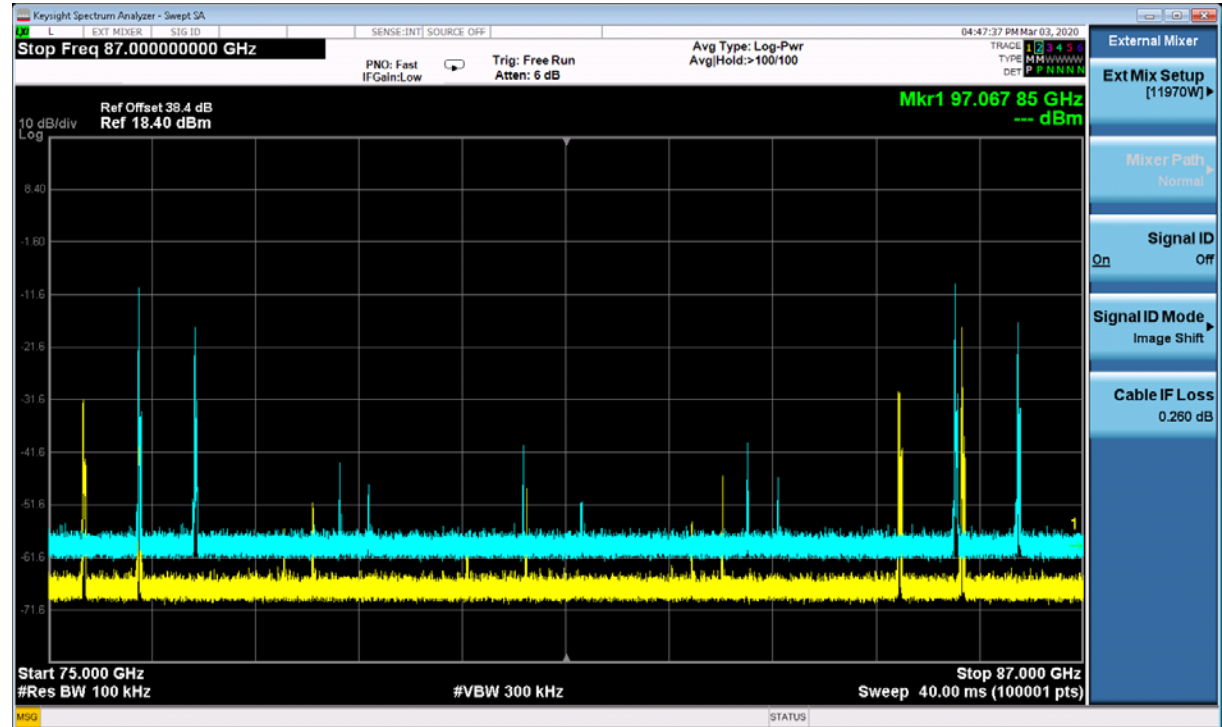
40 GHz to 50 GHz



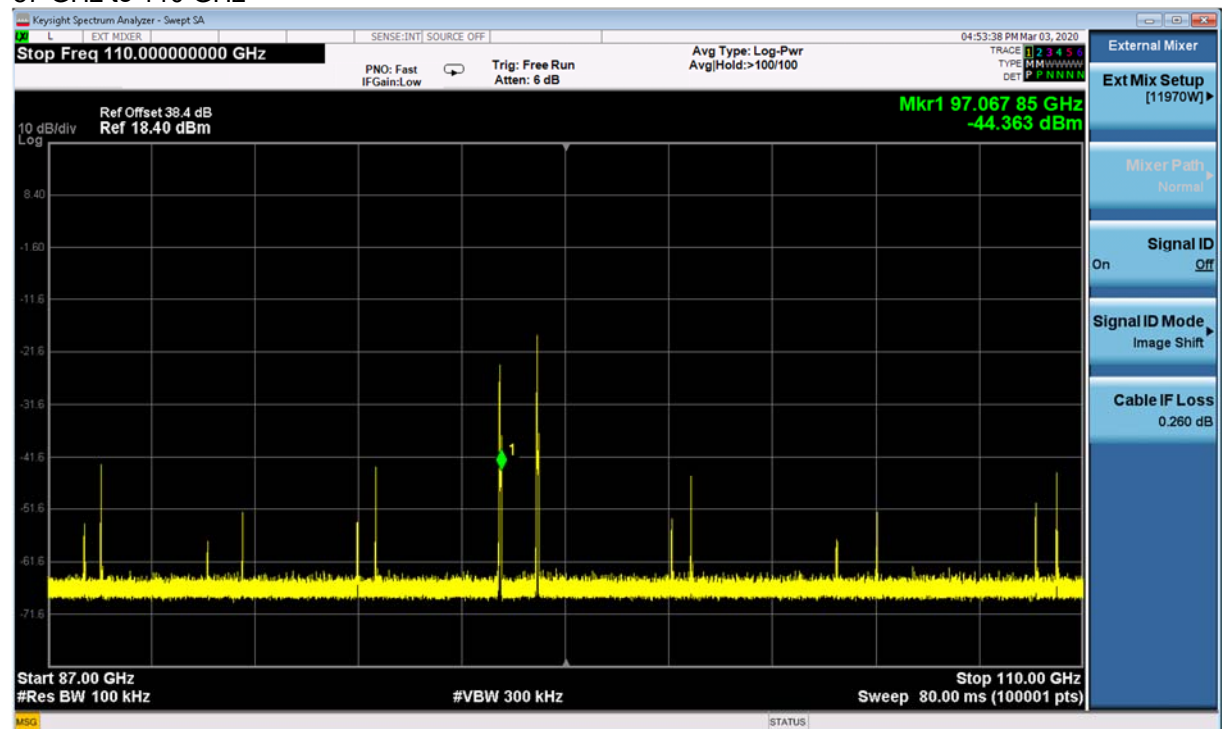
50 GHz to 75 GHz



75 GHz to 87 GHz

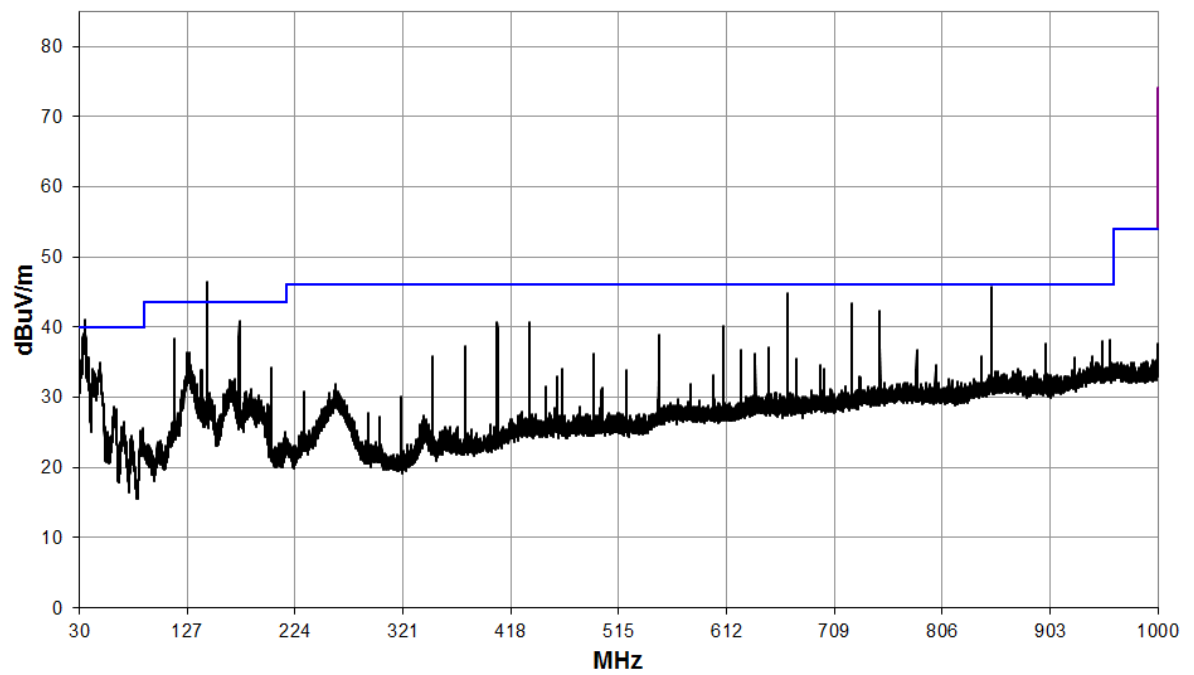


87 GHz to 110 GHz

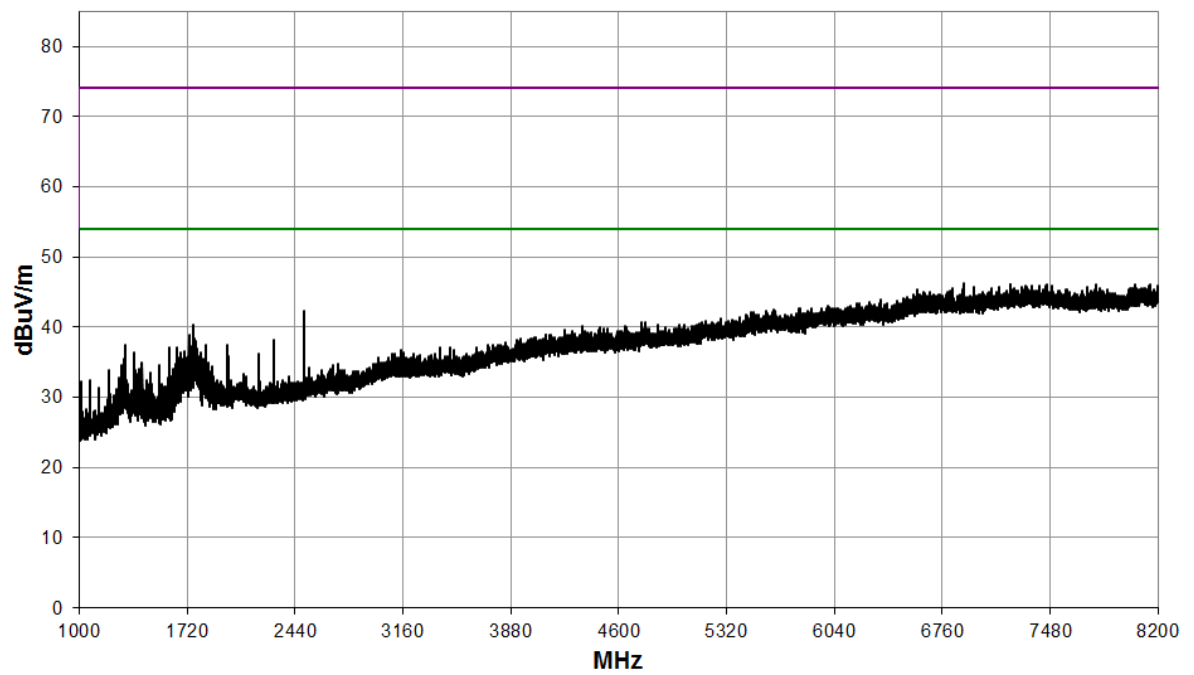


77 GHz Radar; FMCW; With No Fill In										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
QP	35.3	12.2	0.7	21.6	0.0	0.0	0.0	34.6	53.7	100
QP	48.6	12.6	0.9	16.0	0.0	0.0	0.0	29.5	29.9	100
QP	116.0	17.5	1.4	17.4	0.0	0.0	0.0	36.3	65.3	150
QP	128.5	10.3	1.5	17.8	0.0	0.0	0.0	29.6	30.2	150
QP	145.0	23.1	1.6	17.4	0.0	0.0	0.0	42.1	127.4	150
QP	174.0	23.0	1.7	15.3	0.0	0.0	0.0	40.0	100.0	150
QP	203.0	14.8	1.8	15.3	0.0	0.0	0.0	31.9	39.4	150
QP	261.0	7.2	2.2	19.7	0.0	0.0	0.0	29.1	28.5	200
QP	319.0	8.9	2.4	19.1	0.0	0.0	0.0	30.4	33.1	200
QP	348.0	10.2	2.6	20.1	0.0	0.0	0.0	32.9	44.2	200
QP	377.0	8.7	2.7	20.8	0.0	0.0	0.0	32.2	40.7	200
QP	406.0	13.8	2.8	21.9	0.0	0.0	0.0	38.5	84.1	200
QP	435.0	14.0	2.9	22.6	0.0	0.0	0.0	39.5	94.4	200
QP	493.0	6.6	3.1	23.6	0.0	0.0	0.0	33.3	46.3	200
QP	551.0	7.9	3.3	25.1	0.0	0.0	0.0	36.3	65.3	200
QP	609.0	7.0	3.5	25.6	0.0	0.0	0.0	36.1	63.8	200
QP	667.0	12.7	3.6	26.3	0.0	0.0	0.0	42.6	134.9	200
QP	725.0	13.4	3.8	27.1	0.0	0.0	0.0	44.3	164.1	200
QP	750.0	12.5	3.8	28.0	0.0	0.0	0.0	44.3	164.1	200
QP	850.0	9.5	4.1	28.9	0.0	0.0	0.0	42.5	133.4	200
QP	899.0	1.5	4.2	28.8	0.0	0.0	0.0	34.5	53.1	200
QP	957.0	-1.8	4.4	30.7	0.0	0.0	0.0	33.3	46.3	200
AV	1767.9	6.1	3.1	25.7	0.0	0.0	0.0	34.9	55.6	500
AV	2499.8	8.1	3.7	28.6	0.0	0.0	0.0	40.4	104.7	500
AV	4778.1	-4.0	5.4	33.3	0.0	0.0	0.0	34.7	54.3	500
PK	9511.7	33.1	8.0	27.4	0.0	0.0	0.0	68.5	2660.7	5000
PK	14284.0	50.3	10.4	31.2	33.1	0.0	0.0	58.8	871.0	5000
AV	14379.6	28.1	10.5	31.3	33.2	0.0	0.0	36.7	68.4	500
PK	19219.7	61.5	5.1	33.2	33.3	0.0	-9.5	57.0	707.9	5000

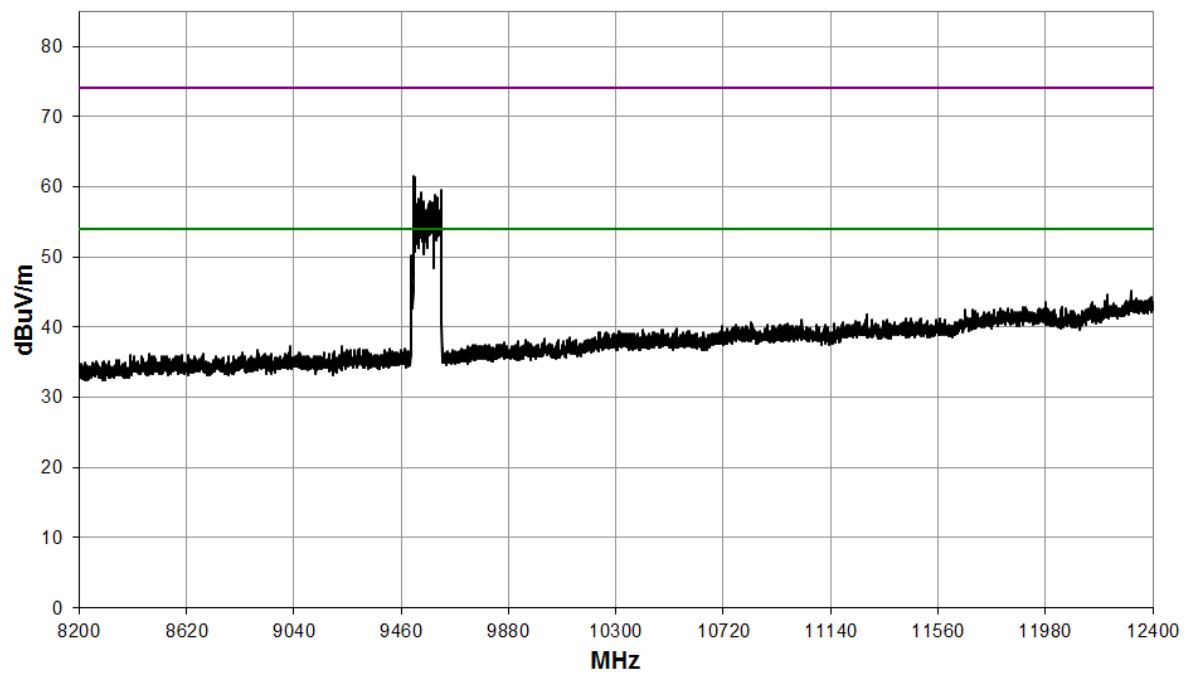
30 MHz to 1 GHz



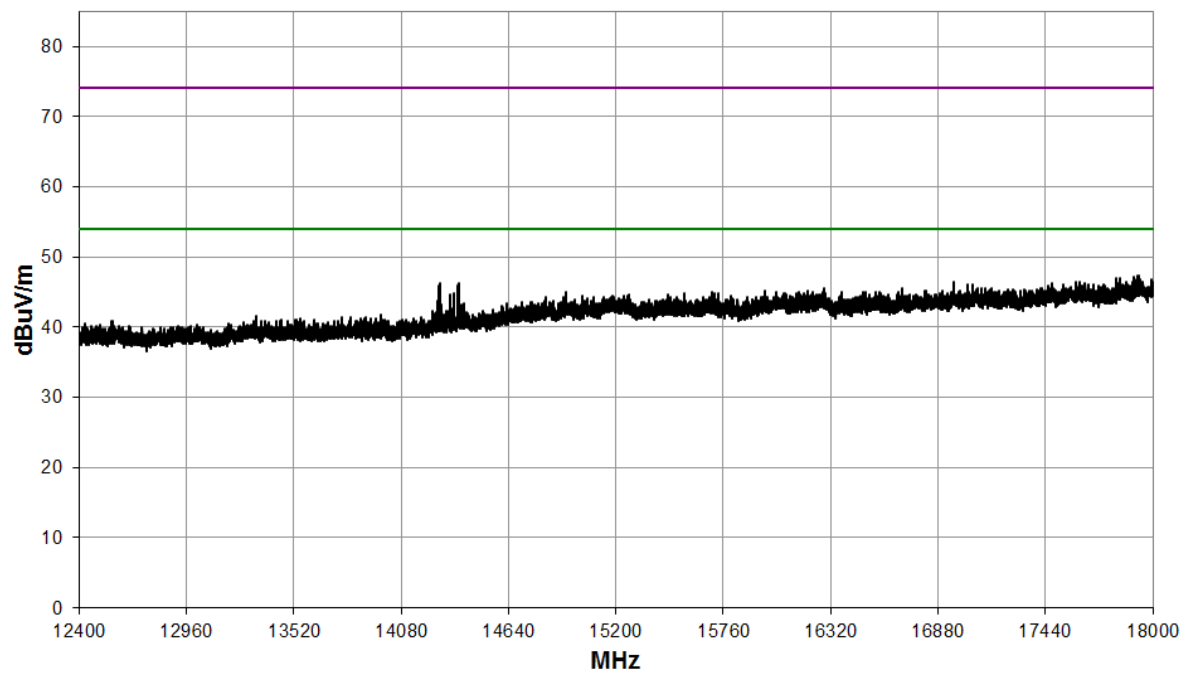
1 GHz to 8.2 GHz



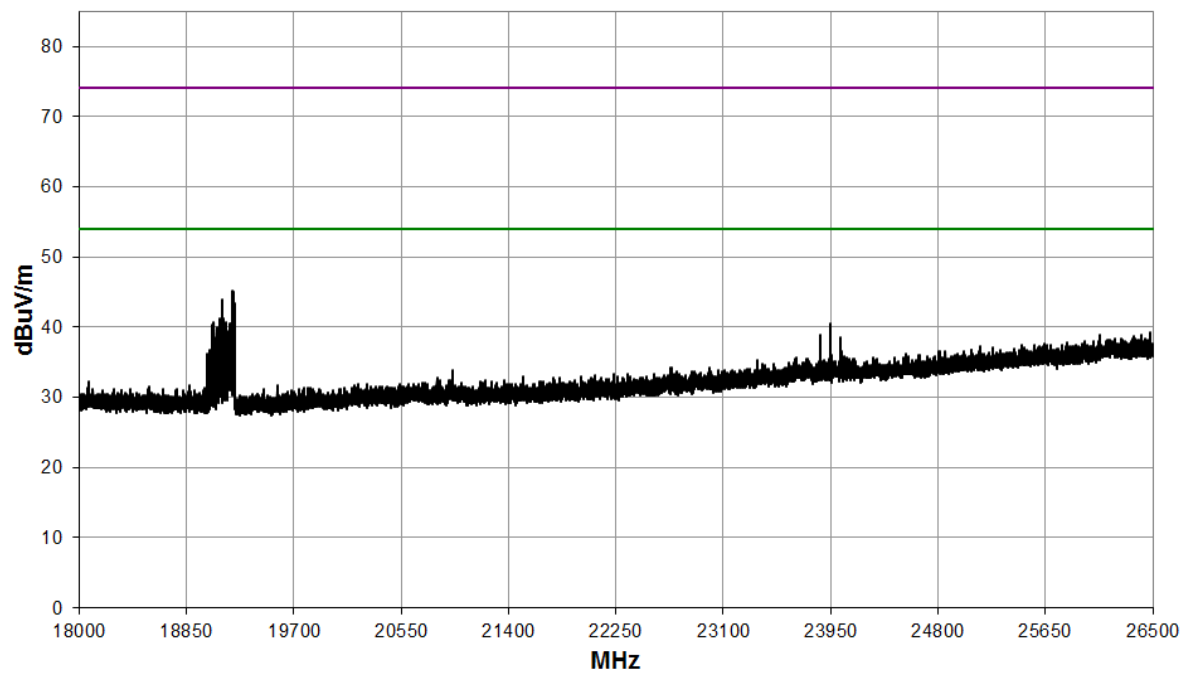
8.2 GHz to 12.4 GHz



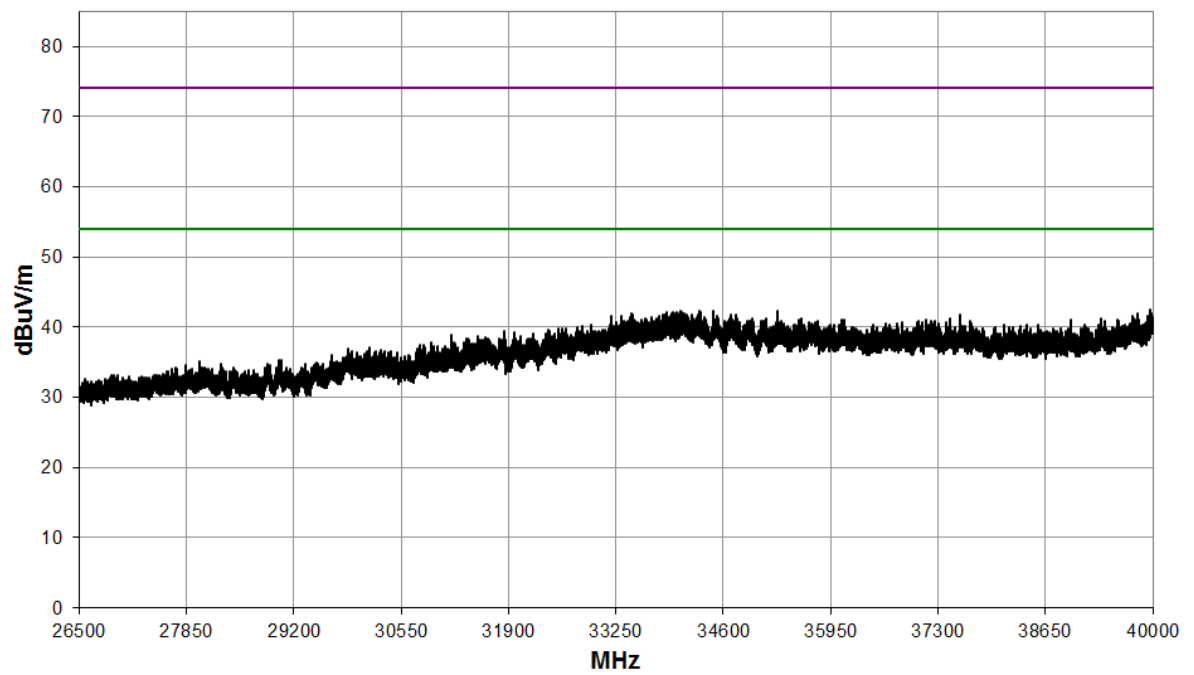
12.4 GHz to 18 GHz



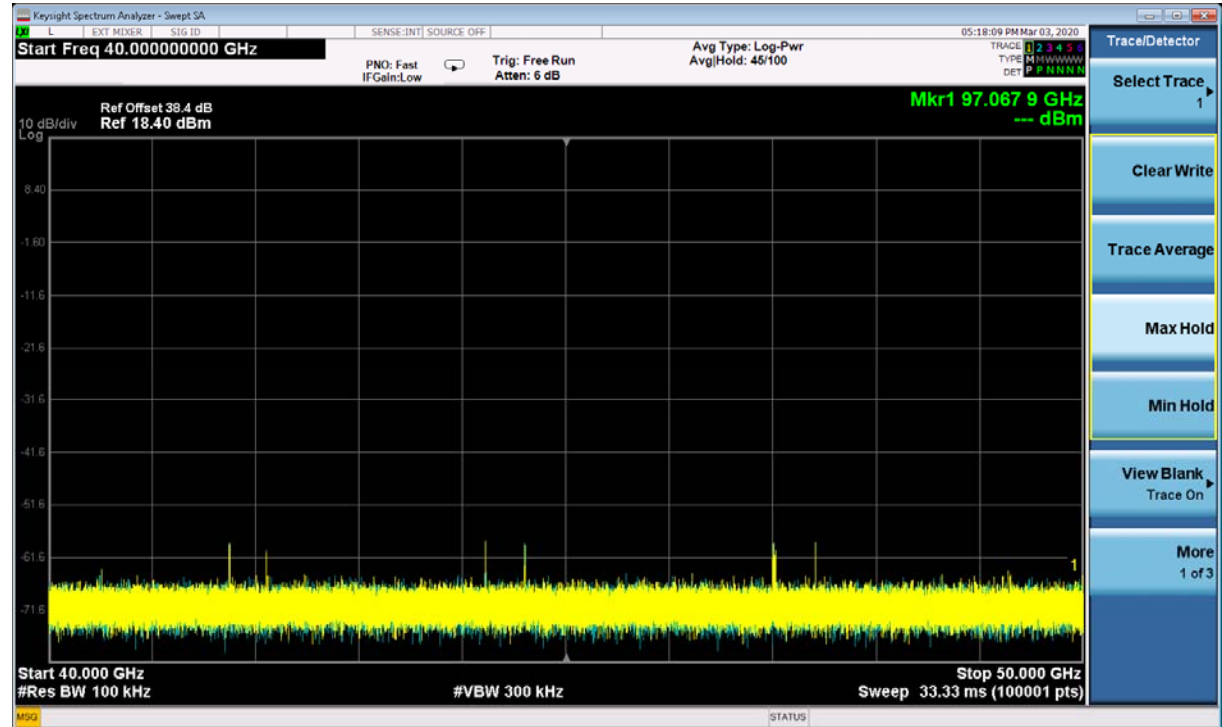
18 GHz to 26.5 GHz



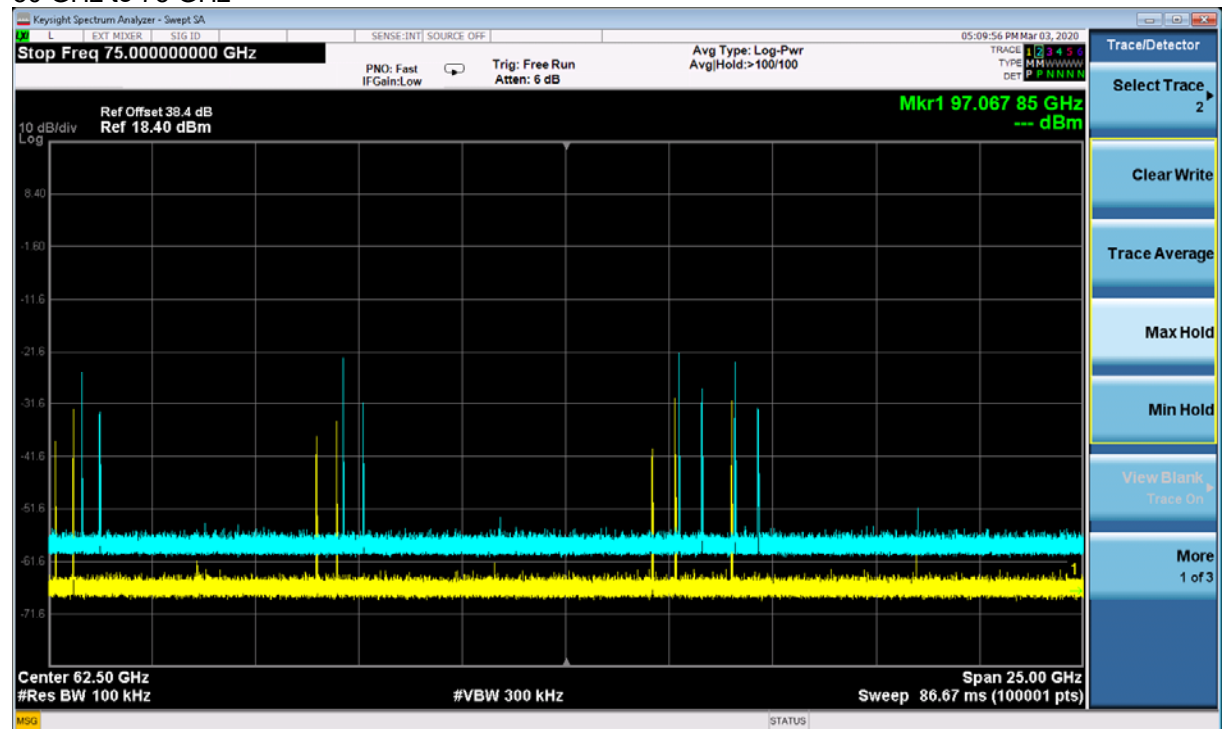
26.5 GHz to 40 GHz



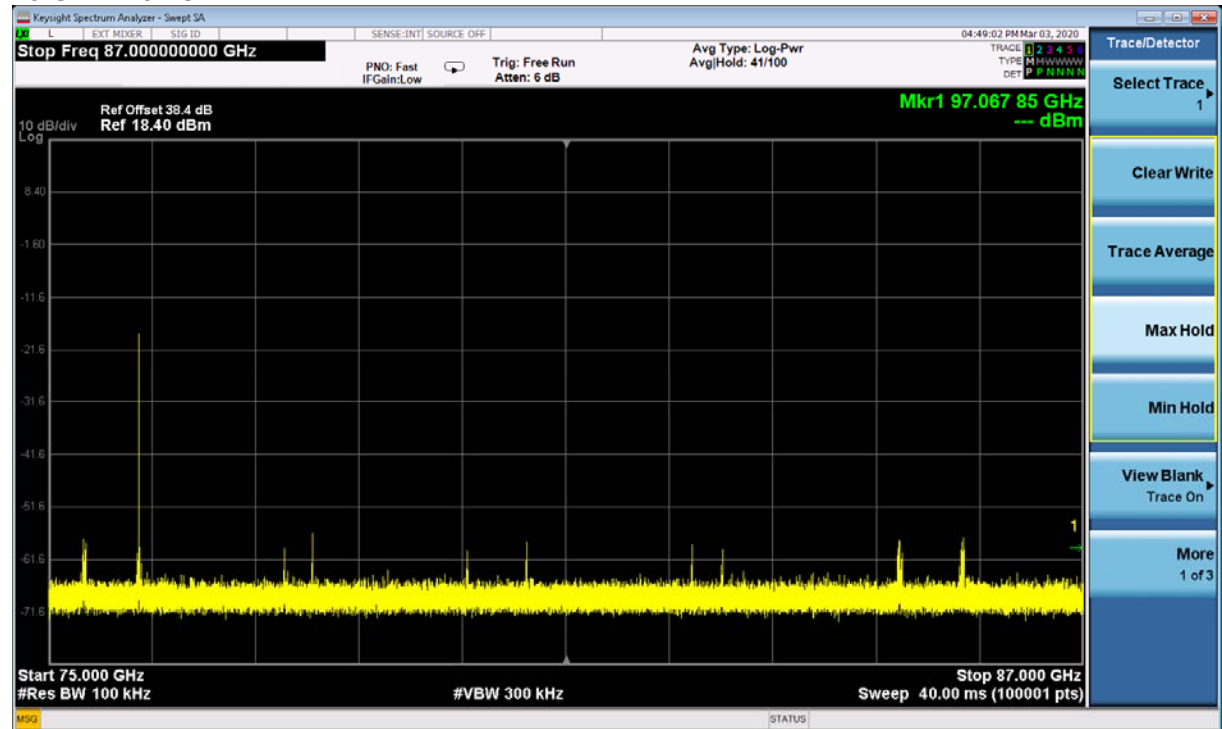
40 GHz to 50 GHz



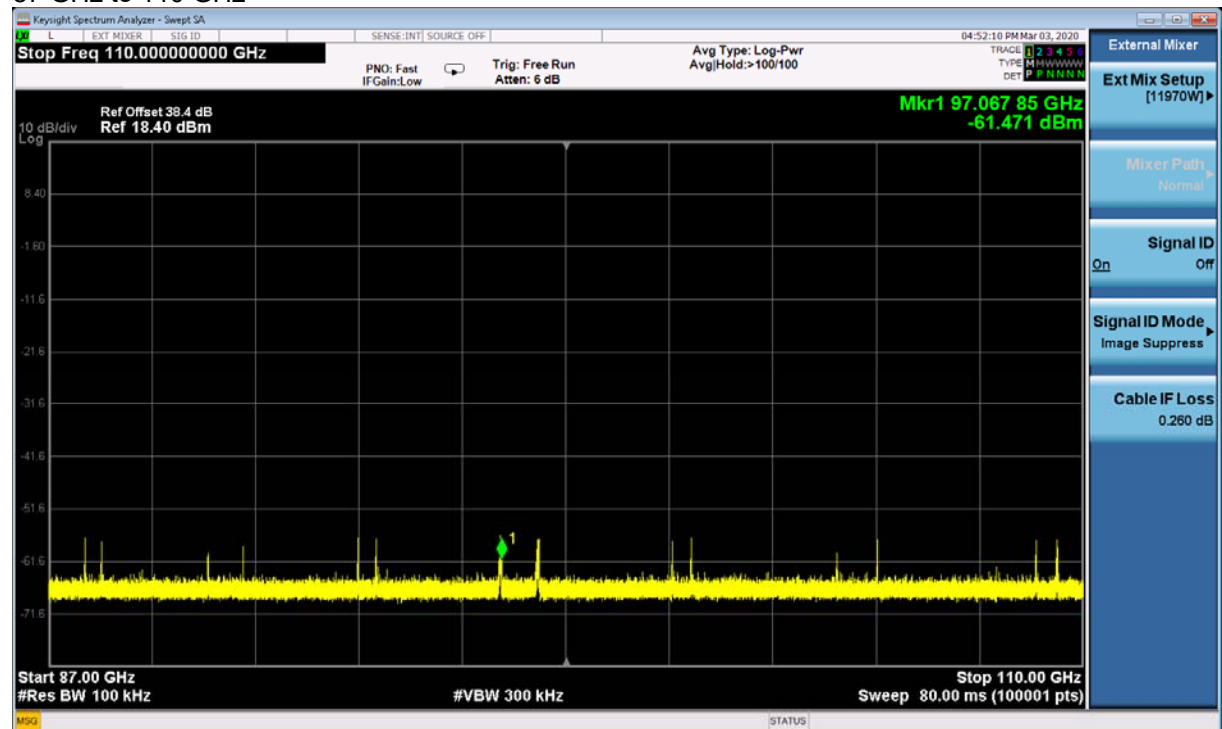
50 GHz to 75 GHz



75 GHz to 87 GHz



87 GHz to 110 GHz



12 AC power-line conducted emissions

12.1 Definition

Line-to-ground radio-noise voltage that is conducted from all of the EUT current-carrying power input terminals that are directly (or indirectly via separate transformers or power supplies) connected to a public power network.

12.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab 5
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels:	Swept Signal / 76 GHz - 77 GHz Radar
EUT Channel Bandwidths:	1 GHz
EUT Modulation:	FMCW
Deviations From Standard:	None
Measurement BW:	9 kHz
Measurement Detectors:	Quasi-Peak and Average, RMS

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 44 % RH	20 % RH to 75 % RH (as declared)
Supply: 110 Vac	As declared

12.3 Test Limit

A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz, shall not exceed the limits in Table 3.

Table 3 – AC Power Line Conducted Emission Limits

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

*The level decreases linearly with the logarithm of the frequency.

**A linear average detector is required.

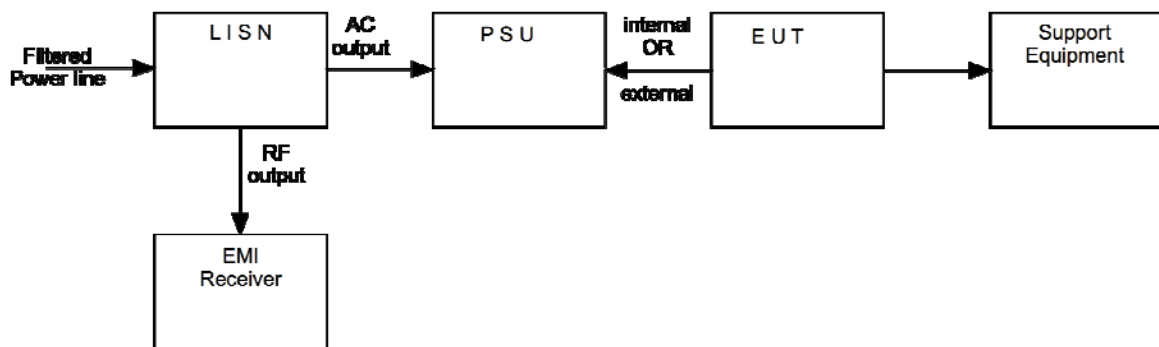
12.4 Test Method

With the EUT setup in a screened room, as per section 9 of this report and connected as per Figure ii, the power line emissions were measured on a spectrum analyzer / EMI receiver.

AC power line conducted emissions from the EUT are checked first by preview scans with peak and average detectors covering both live and neutral lines. A spectrum analyzer is used to determine if any periodic emissions are present.

Formal measurements using the correct detector(s) and bandwidth are made on frequencies identified from the preview scans. Final measurements were performed with EUT set at its maximum duty in transmit and receive modes.

Figure ii Test Setup



12.5 Test Set-up Photograph

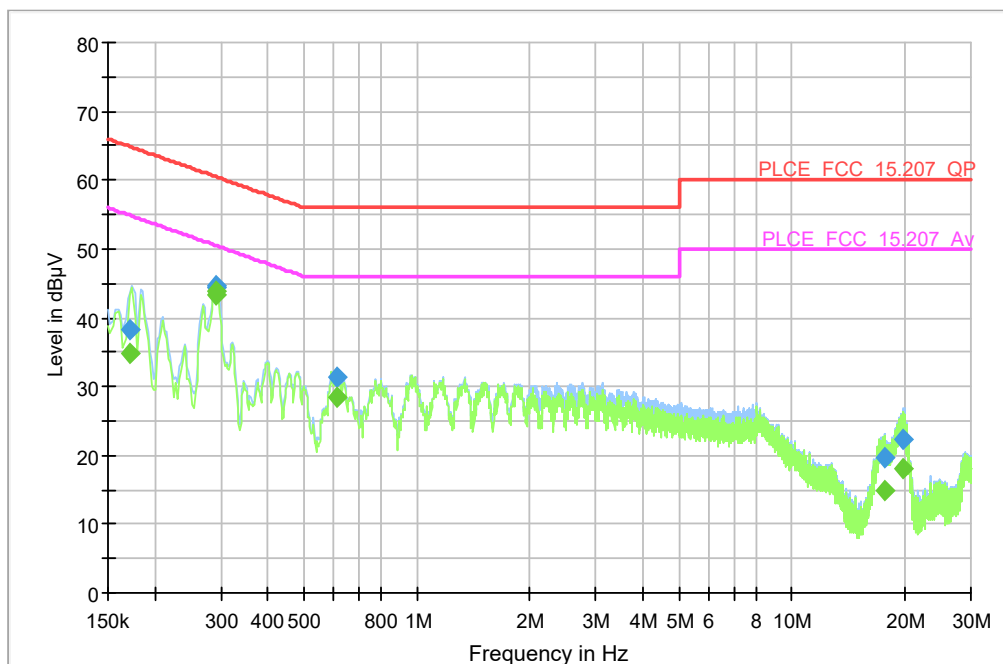




12.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESC17	R&S	Measuring Receiver	RFG715	2021-11-10
ESH3-Z2	R&S	Pulse Limiter	RFG680	2020-06-01
ESH3-Z5	R&S	LISN	RFG189	2020-07-22

12.7 Test Results



Final Result 1

Frequency (MHz)	Quasi Peak (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)
0.171750	38.2	15000.0	9.000	GND	L1	10.2	26.6	64.9
0.291325	44.5	15000.0	9.000	GND	L1	10.2	16.0	60.5
0.292150	44.6	15000.0	9.000	GND	N	10.2	15.9	60.5
0.612850	31.3	15000.0	9.000	GND	L1	10.2	24.7	56.0
17.628500	19.6	15000.0	9.000	GND	L1	11.5	40.4	60.0
19.879000	22.4	15000.0	9.000	GND	N	11.4	37.6	60.0

Final Result 2

Frequency (MHz)	Average (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)
0.171750	34.8	15000.0	9.000	GND	L1	10.2	20.1	54.9
0.291325	43.4	15000.0	9.000	GND	L1	10.2	7.1	50.5
0.292150	43.8	15000.0	9.000	GND	N	10.2	6.6	50.5
0.612850	28.4	15000.0	9.000	GND	L1	10.2	17.6	46.0
17.628500	14.9	15000.0	9.000	GND	L1	11.5	35.1	50.0
19.879000	18.1	15000.0	9.000	GND	N	11.4	31.9	50.0

13 Occupied Bandwidth

13.1 Definitions

Occupied bandwidth

The width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to 0.5 % of the emitted power. This is also known as the *99 % emission bandwidth*. For transmitters in which there are multiple carriers, contiguous or non-contiguous in frequency, the occupied bandwidth is to be the sum of the occupied bandwidths of the individual carriers.

13.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Environmental Lab
Test Standard and Clause:	ANSI C63.26-2015, Clause 5.4
EUT Channels / Frequencies Measured:	Swept Frequency
Deviations From Standard:	None
Measurement BW: (requirement: 1 % to 5 % OBW)	1 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	3 MHz
Measurement Span: (requirement 2 to 5 times OBW)	1.5 GHz
Measurement Detector:	Peak
Temperature Extreme Environment Test Range:	-20 °C to +60 °C (as declared)
Voltage Extreme Environment Test Range:	20.4 Vdc to 27.6 Vdc

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C
Humidity: 42 % RH	20 % RH to 75 % RH
Supply: 24 V dc	As declared

13.3 Test Limit

Federal Communications Commission:

§ 2.202 a) *Occupied Bandwidth*. The frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total means power radiated by a given emission.

§ 95.3379 b) Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the temperature range -20 to +50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

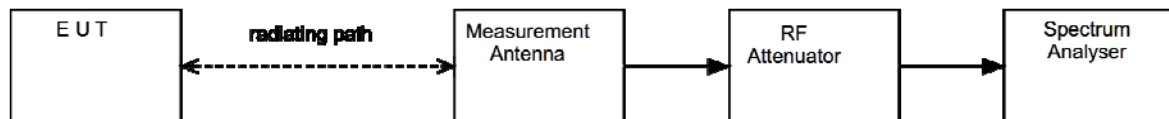
The frequency band covered by § 95.3379 is 76-81 GHz.

13.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iii, the bandwidth of the EUT was measured on a spectrum analyser.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst-case configuration in each bandwidth.

Figure iii Test Setup



13.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
N9030A	Agilent	Spectrum Analyser	REF216 7	2020-08-12
11970W	Agilent	Harmonic Mixer (75-110)	U367	2022-05-17
34405A	Agilent	Multimeter	REF887	2020-10-07
JTS/WIR/1/01	JTS	Walk in Environmental Chamber	RFG770	2021-03-20
PSU/THR/1/06	Thurlby	Power Supply	RFG113	Cal with REF887

13.6 Test Results

The operating frequency range of the swept signal was measured using the Spectrum Analysers Signal Ident mode and the mixer/antenna combination which was lined up with the EUT's antenna, the EUT was set to transmit swept signals in staring mode (antenna array not rotating).

Measurements were carried out over the temperature range -20 °C to 60 °C at the client's request (47 CFR 95.3379 (b) gives the range -20 °C to 50 °C).

FCC 95.3379 (b). EUT in Swept mode				
Test Environment		F_L (GHz)	F_H (GHz)	Result
Temperature	(GHz)			
-20 °C	V _{nominal}	76.0595	76.9410	PASS
-10 °C	V _{nominal}	76.0595	76.9405	PASS
0 °C	V _{nominal}	76.0595	76.9405	PASS
+10 °C	V _{nominal}	76.0605	76.9400	PASS
+20 °C	V _{minimum}	76.0610	76.9400	PASS
	V _{nominal}	76.0610	76.9400	PASS
	V _{maximum}	76.0610	76.9400	PASS
+30 °C	V _{nominal}	76.0610	79.9400	PASS
+40 °C	V _{nominal}	76.0610	76.9400	PASS
+50 °C	V _{nominal}	76.0610	76.9400	PASS
+56 °C	V _{nominal}	76.0610	76.9400	PASS

100% occupied bandwidth is fully located within the assigned transmit band of 76.0 GHz to 81.0 GHz.

14 Transmitter output power (fundamental radiated emission)

14.1 Definition

The RF power dissipated in the standard output termination when operating under the rated duty cycle selected by the applicant for approval.

14.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 3
Test Standard and Clause:	ANSI C63.26-2015, Clause 5.1 / 5.2
EUT Channels:	Full band with FMCW
EUT Channel Bandwidths:	1 GHz
Deviations From Standard:	None
Measurement BW:	1 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	3 MHz
Measurement Detector:	Up to 1 GHz: Quasi-peak Above 1 GHz: Average RMS and Peak
Voltage Extreme Environment Test Range:	85 % and 115 % of Nominal (FCC only requirement);

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 42 % RH	20 % RH to 75 % RH (as declared)

14.3 Test Limit

The average power of any emission within the bands specified shall not exceed an EIRP of 50dBm.

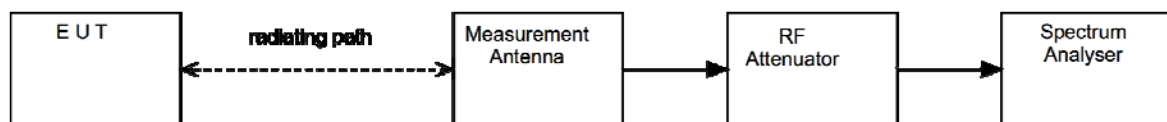
The peak power of any emission within the band 76-77 GHz shall not exceed an EIRP of 55dBm.

14.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iv, the resolution bandwidth of the spectrum analyser was increased above the EUT occupied bandwidth and the peak emission data noted.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst-case configuration in each bandwidth.

Figure iv Test Setup



14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Ferrite Lined Chamber	Rainford	Chamber	REF2259	2020-08-03
11970W	Agilent	Harmonic Mixer (75-110)	U367	2022-05-17
N9030A	Agilent	Spectrum Analyser	REF2167	2020-08-12
PSG E8257D	Agilent	Signal Generator	REF2168	2019-11-22

14.6 Test Results

Model	Radome	Frequency (GHz)	Peak EIRP (dBm)	Peak Limit (dBm)	Average EIRP (dBm)	Average Limit (dBm)
HDR100 with fill in	No	76.07	46.6	55.0	33.4	50.0
HDR100 with fill in	Yes	76.07	45.6	55.0	32.4	50.0
HDR100 without fill in	No	76.07	48.7	55.0	37.2	50.0
HDR100 without fill in	Yes	76.07	48.1	55.0	36.7	50.0

Measurements were initially made with the Radome removed to facilitate maximising the signal by lining up the EUT antenna with the measurement antenna. Measurements were then carried out with the Radome fitted to represent actual conditions of use.

15 Measurement Uncertainty

Calculated Measurement Uncertainties

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence:

[1] Carrier power

Uncertainty in test result (Power Meter) = **1.08 dB**

Uncertainty in test result (Spectrum Analyser) = **2.48 dB**

[2] Spurious emissions

Uncertainty in test result (30 MHz to 1 GHz) = **4.6 dB**

Uncertainty in test result (1 GHz to 18 GHz) = **4.7 dB**

[3] AC power line conducted emissions

Uncertainty in test result = **3.4 dB**

[4] Occupied bandwidth

Uncertainty in test result = **15.5 %**

[5] Maximum frequency error

Uncertainty in test result (Power Meter) = **0.113 ppm**

Uncertainty in test result (Spectrum Analyser) = **0.265 ppm**

[6] Duty cycle

Uncertainty in test result = **7.98 %**

16 MPE Calculation

RADIO FREQUENCY RADIATION EXPOSURE

KDB 447498

47 CFR §§1.1307 and 2.1091

Radio frequency radiation exposure evaluation.

Mobile devices that operate under CFR47 Part 90 are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use if they operate at frequencies of 1.5 GHz or below and their effective radiated power (ERP) is 1.5 watts or more for FCC requirements.

Prediction of MPE limit at a given distance

$$S = \frac{EIRP}{4 \pi R^2} \quad \text{re - arranged} \quad R = \sqrt{\frac{EIRP}{S 4 \pi}}$$

where:

S = power density

R = distance to the centre of radiation of the antenna

EIRP = EUT Maximum power

Frequency (MHz)	Maximum EIRP (dBm)	Maximum EIRP (mW)	Power density limit (S) (mW/cm ²)	Distance (R) cm required to be less than (S) mW/cm ²
76070	14.2	26.30	1	1.5

The client declared that the transceiver will not transmit until the unit is rotating and that there is a safety shut off that stops the transceiver transmitting if rotation is stopped for any reason. Accordingly, a duty cycle of $1.8^\circ/360^\circ \Rightarrow 0.5\%$ was used in the MPE assessment.

Duty cycle correction for antenna rotation of 0.5 %
 $37.2 \text{ dBm} + (10\log(0.5/100)) = 14.2 \text{ dBm Av EIRP}$

LIMITS

FCC LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

(B) Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m ²)	Averaging Time $ E ^2$, $ H ^2$ or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	(180/f ₂)*	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

f = frequency in MHz *Plane-wave equivalent power density

RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m ²)	Averaging Time (minutes)
0.003-1	280	2.19	-	6
1-10	280/f	2.19/f	-	6
10-30	28	2.19/f	-	6
30-300	28	0.073	2	6
300-1500	$1.585 f^{0.5}$	$0.0042 f^{0.5}$	f/150	6
1500-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	616000/f ^{1.2}
150000-300000	$0.158 f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	616000/f ^{1.2}