Report on the Radio Testing

For

Navtech Radar Ltd

on

KTS350-X

Report no. TRA-041847-45-00B

2020-06-12

Element Materials Technology Warwick Ltd.
Registered in England and Wales. Registered Office: 5 Fleet Place, London, EC4M 7RD
Company Reg No. 02536659

Report Number: TRA-041847-45-00B
Issue: B

REPORT ON THE RADIO TESTING OF A
Navtech Radar Ltd
KTS350-X
WITH RESPECT TO SPECIFICATION
FCC 47 CFR Part 90 Subpart F

TEST DATE: 2020-03-02 to 2020-04-01

Written by: David Garvey
Radio Test Engineer

Approved by: John Charters
Lab Manager

Digitally signed by John Charters
DN: cn=John Charters, o, ou=Element Materials Technology Ltd., email=john.charters@element.com, c=GB
Reason: I am approving this document
Date: 2020.06.12 14:52:04 +01'00'

Date: 2020-06-12

Element Materials Technology Warwick Ltd.
Registered in England and Wales. Registered Office: 5 Fleet Place, London, EC4M 7RD
Company Reg No. 02536659

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	2020-04-08	Original
B	2020-06-12	Updated after certification checking

2 Summary

TEST REPORT NUMBER:	TRA-041847-45-00B
WORKS ORDER NUMBER:	TRA-041847-02
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:	FCC 47 CFR Part 90 Subpart F
EQUIPMENT UNDER TEST (EUT):	KTS350-X
FCC IDENTIFIER:	S7Y-MV1K
EUT SERIAL NUMBER:	2017
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:	20108
TEST DATE:	2020-03-02 to 2020-04-01
TESTED BY:	David Garvey Element

2.1 Test Summary

Test Method and Description	*Requirement Clause* *47CFR90*	*Applicable to this equipment*	*Result / Note*
Output power	2.1046 / §90.205 Power and antenna height limits.	☒	Pass
Occupied bandwidth	2.1049 / §90.209 Bandwidth limitations.	☒	Pass
Spurious emissions at antenna terminal	2.1051 / §90.207 Types of emissions.	☒	N/A Note 3
Field strength of spurious radiation	2.1053 / §90.207 Types of emissions.	☒	Pass Note 1 Note 2
Frequency stability	2.1055 / §90.213 Frequency stability.	☒	Pass
AC power line conducted emissions	15.207	☒	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 03-11750-1-20.

Note 2: The following product was tested against the 15.209 limits as these are stricter than the 13 dBm limit as per Part 90.

Note 3: The EUT was purely radiated sample.

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).

3 Contents

4 Introduction

This report TRA-041847-45-00B presents the results of the Radio testing on a Navtech Radar Ltd, KTS350-X to specification 47 CFR Part 90 Subpart F – Radiolocation Service.

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

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 Part 90 Subpart F – Radiolocation Service.
- ANSI C63.26-2015 – American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services.
- 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: KTS350-X
- Serial Number: 02017
- Model Number: KTS350-X
- Software Revision: Not Applicable
- Build Level / Revision Number: Not Applicable

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 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 EUT does not have a separate receive mode.

7.4 EUT Radio Parameters

7.4.1 General

Frequency band:	33.4 GHz – 36 GHz
Modulation type:	FMCW
Channel spacing:	N/A (Swept RADAR signal)
ITU emission designator:	537MF0N
Declared output power:	47 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:	34 GHz to 35 GHz
Impedance:	N/A
SWR:	N/A
Gain:	35 dBi
Polarisation:	Horizontal
Beam width:	1.8˚
Environmental limits:	-30 ˚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.

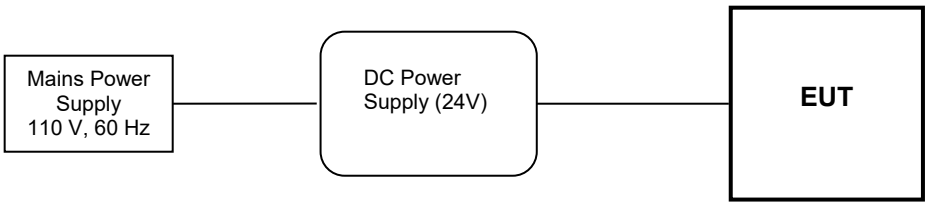
8 Modifications

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:

Photo 1 removed at the request of the applicant. The photos can be found in Element document TRA-041847-45-00B_Photographs

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

Variation of supply voltage is required to ensure stability of the declared output power. During frequency stability 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 Output power

11.1 Definition

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

11.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 3
Test Standard and Clause:	ANSI C63.26-2015, Clause 5.2
EUT Frequencies Measured:	Swept Signal / 34 GHz - 35 GHz Radar
EUT Channel Bandwidths:	537 MHz
Deviations From Standard:	None
Measurement BW:	1 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	3 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

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

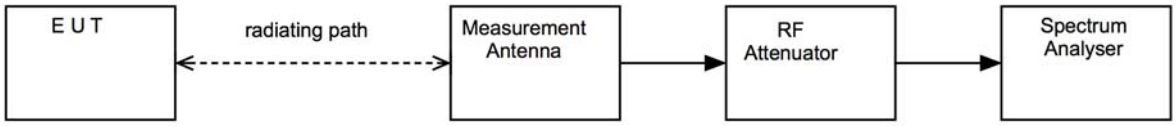
11.3 Test Limit

For measurements conducted pursuant to paragraphs (a) and (b) of this section, all calculations and methods used by the applicant for determining carrier power or peak envelope power, as appropriate, on the basis of measured power in the radio frequency load attached to the transmitter output terminals shall be shown. Under the test conditions specified, no components of the emission spectrum shall exceed the limits specified in the applicable rule parts as necessary for meeting occupied bandwidth or emission limitations.

11.4 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.

Figure iv Test Setup



11.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Ferrite Lined Chamber	Rainford	Chamber	REF2259	2020-08-03
EMI Test Receiver	R&S	ESW26	REF2235	2020-07-26
LB-180400-25-C-KF	A Info Inc	Horn Antenna	REF2245	2020-07-25
LB-180400-25-C-KF	A Info Inc	Horn Antenna	REF2246	2020-07-25
N9030A	Agilent	Spectrum Analyser	REF2167	2020-08-12
PSG E8257D	Agilent	Signal Generator	REF2168	2020-12-09

11.6 Test Results

Model	*Radome*	*Detector*	*Freq. (GHz)*	*Peak EIRP (dBm)*
KTS350-X	No	Peak	34.3	46.6
KTS350-X	Yes	Peak	34.3	45.8

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.

12 Occupied Bandwidth

12.1 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.

12.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Environmental Lab
Test Standard and Clause:	ANSI C63.26-2015, Clause 5.4
Frequency Band Measured:	33.4 GHz to 36 GHz
EUT Test Modulations:	FMCW
Deviations From Standard:	None
Measurement BW: (requirement: 1 % to 5 % OBW)	10 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	30 MHz
Measurement Span: (requirement typically 1.5 times OBW)	1 GHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 42 % RH	20 % RH to 75 % RH (as declared)
Supply: 24 Vdc	as declared

12.3 Test Limit

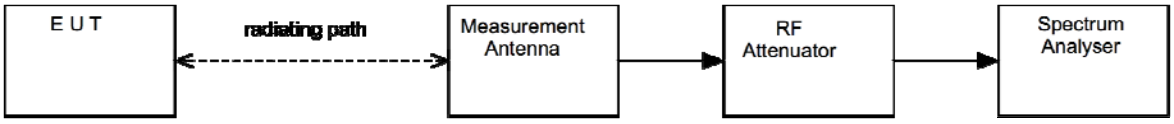
Federal Communications Commission:
Intentional radiators operating under the alternative provisions to the general emission limits, as contained in FCC 47 CFR Part 90 subpart F of this part, must be designed to ensure that the *99 %* bandwidth of the emission, is contained within the frequency band designated in the rule section under which the equipment is operated.

12.4 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 in its normal operating mode (FMCW).

Figure iii Test Setup

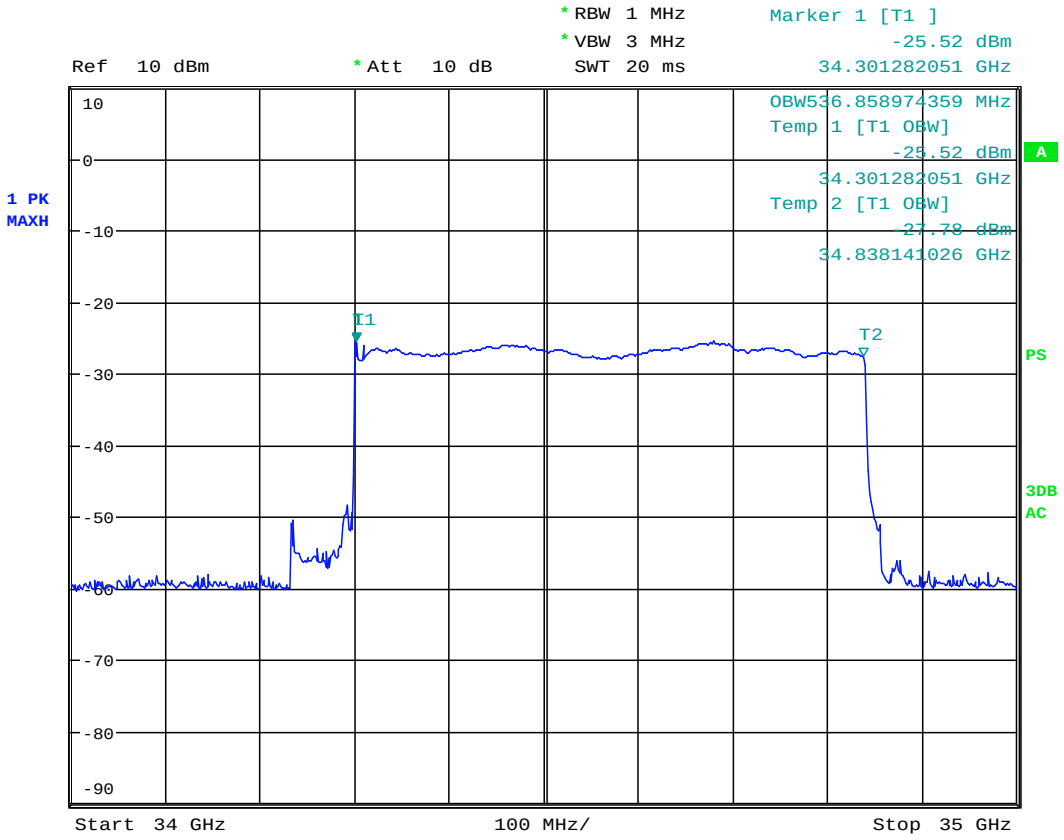


12.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESU40	R&S	Receiver	RFG701	2021-02-06
LB-180400-25-C-KF	A Info Inc	Horn Antenna	REF2246	2020-07-25
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

12.6 Test Results

FCC 2.1049 Occupied bandwidth				
Frequency (GHz)	F_L (GHz)	F_H (GHz)	99% Bandwidth (MHz)	Result
34.5678	34.301282051	34.838141026	536.858	PASS



Date: 30.MAR.2020 15:27:14

13 Radiated emissions

13.1 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.

13.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 3
Test Standard and Clause:	ANSI C63.26-2015, Clause 5.5 and 5.7
Frequencies Measured:	Swept Signal / 34 GHz - 35 GHz Radar
EUT Channel Bandwidth:	537 MHz
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: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 42 % RH	20 % RH to 75 % RH (as declared)
Supply: 24 Vdc	As declared

13.3 Test Limit

Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data shall be supplied showing the magnitude of each harmonic and other spurious emission. For this test, single sideband, independent sideband, and controlled carrier transmitters shall be modulated under the conditions specified in paragraph (c) of §2.1049, as appropriate. For equipment operating on frequencies below 890 MHz, an open field test is normally required; with the measuring instrument antenna located in the far field at all test frequencies. In the event it is either impractical or impossible to make open field measurements (e.g. a broadcast transmitter installed in a building) measurements will be accepted of the equipment as installed. Such measurements must be accompanied by a description of the site where the measurements were made showing the location of any possible source of reflections, which might distort the field strength measurements. Information submitted shall include the relative radiated power of each spurious emission with reference to the rated power output of the transmitter, assuming all emissions are radiated from half wave dipole antennas.
(b) The measurements specified in paragraph (a) of this section shall be made for the following equipment:
(1) Those in which the spurious emissions are required to be 60 dB or more below the mean power of the transmitter.
(2) All equipment operating on frequencies higher than 25 MHz.
(3) All equipment where the antenna is an integral part of, and attached directly to the transmitter.
(4) Other types of equipment as required, when deemed necessary by the Commission.

13.4 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.

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:

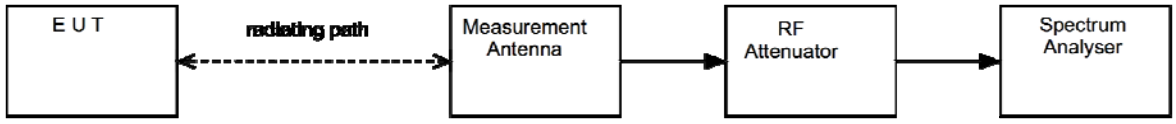
$$FS = PR + CL + AF – PA + DC – CF$$

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



13.5 Test Set-up Photograph

Photo 2 removed at the request of the applicant. The photos can be found in Element document TRA-041847-45-00B_Photographs

Photo 3 removed at the request of the applicant. The photos can be found in Element document TRA-041847-45-00B_Photographs

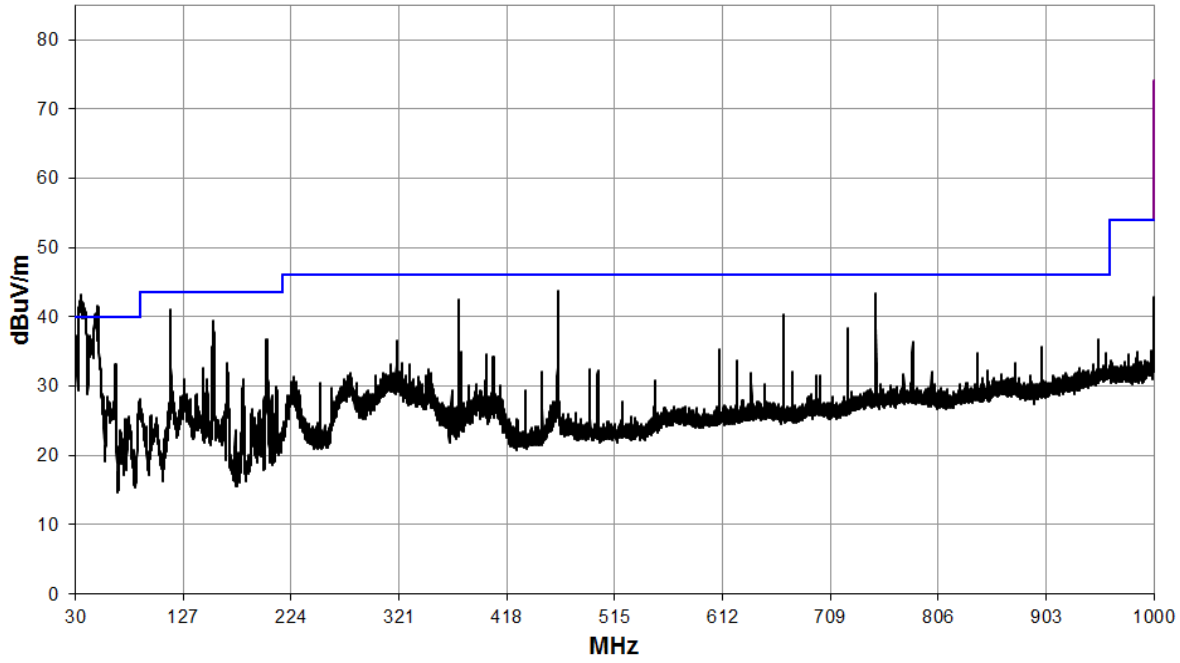
13.6 Test Equipment

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

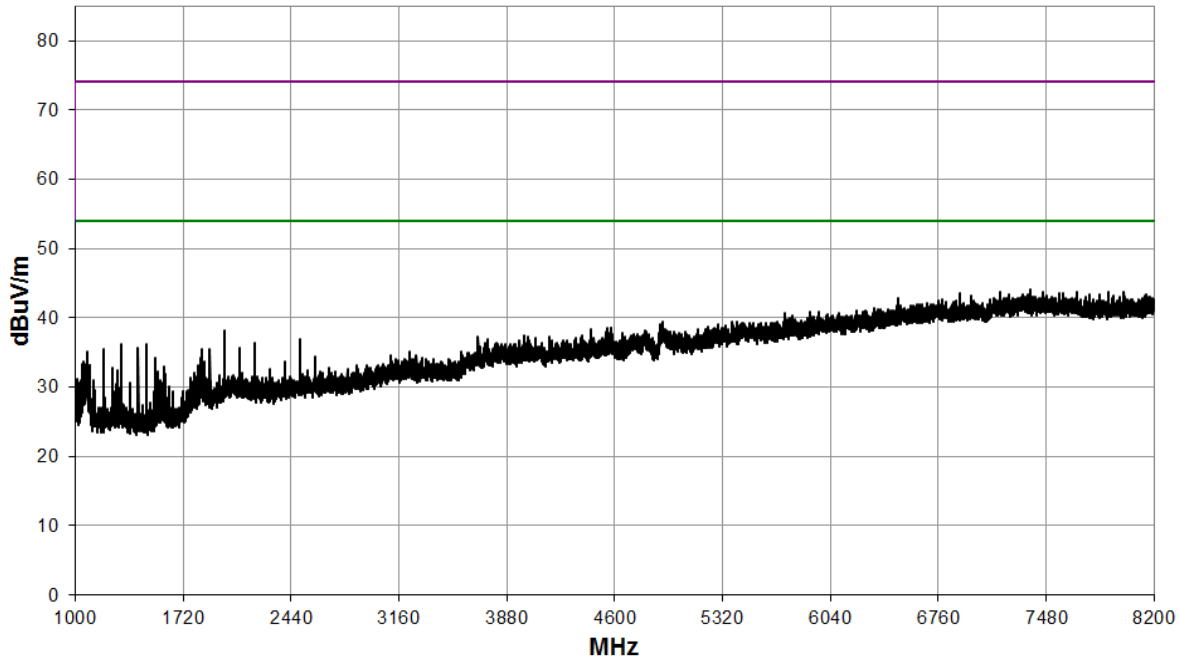
13.7 Test Results

34 GHz Radar; FMCW										
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	33.637	41.6	0.6	22.5	32.6	0.0	0.0	32.1	40.3	100
QP	50.088	49.4	0.9	15.5	32.6	0.0	0.0	33.2	45.7	100
QP	116.012	47.5	1.4	17.4	32.5	0.0	0.0	33.8	49.0	150
QP	319.008	43.3	2.4	19.1	32.5	0.0	0.0	32.3	41.2	200
QP	375.013	47.2	2.7	20.7	32.5	0.0	0.0	38.1	80.4	200
QP	464.010	48.5	3.0	23.2	32.5	0.0	0.0	42.2	128.8	200
QP	500.010	34.3	3.1	23.7	32.6	0.0	0.0	28.5	26.6	200
QP	667.012	42.4	3.6	26.3	32.6	0.0	0.0	39.7	96.6	200
QP	725.018	40.2	3.8	27.1	32.5	0.0	0.0	38.6	85.1	200
QP	899.012	32.9	4.2	28.8	31.8	0.0	0.0	34.1	50.7	200
Peak	8582.0	71.6	7.5	26.9	34.8	0.0	0.0	71.2	3630.8	5000
Average	13067.5	27.7	9.5	30.4	33.5	0.0	0.0	34.1	50.7	500
Peak	13069.4	48.3	9.5	30.4	33.5	0.0	0.0	54.7	543.3	5000
Average	17372.5	28.4	11.7	33.1	33.9	0.0	0.0	39.3	92.3	500
Peak	17375.1	44.2	11.7	33.1	33.8	0.0	0.0	55.2	575.4	5000
Peak	25747.4	68.0	7.5	34.4	32.3	-9.5	0.0	68.1	2541.0	5000
Average	25750.4	47.0	7.6	34.4	32.3	-9.5	0.0	47.2	229.1	500
Peak	30483.9	44.0	9.8	35.2	0.0	-15.6	0.0	73.4	4677.4	5000
Peak	30162.5	42.9	9.7	35.2	0.0	-15.6	0.0	72.2	4073.8	5000
Average	30158.0	12.9	9.7	35.2	0.0	-15.6	0.0	42.2	128.8	500
Average	30484.4	13.0	9.8	35.2	0.0	-15.6	0.0	42.4	131.8	500

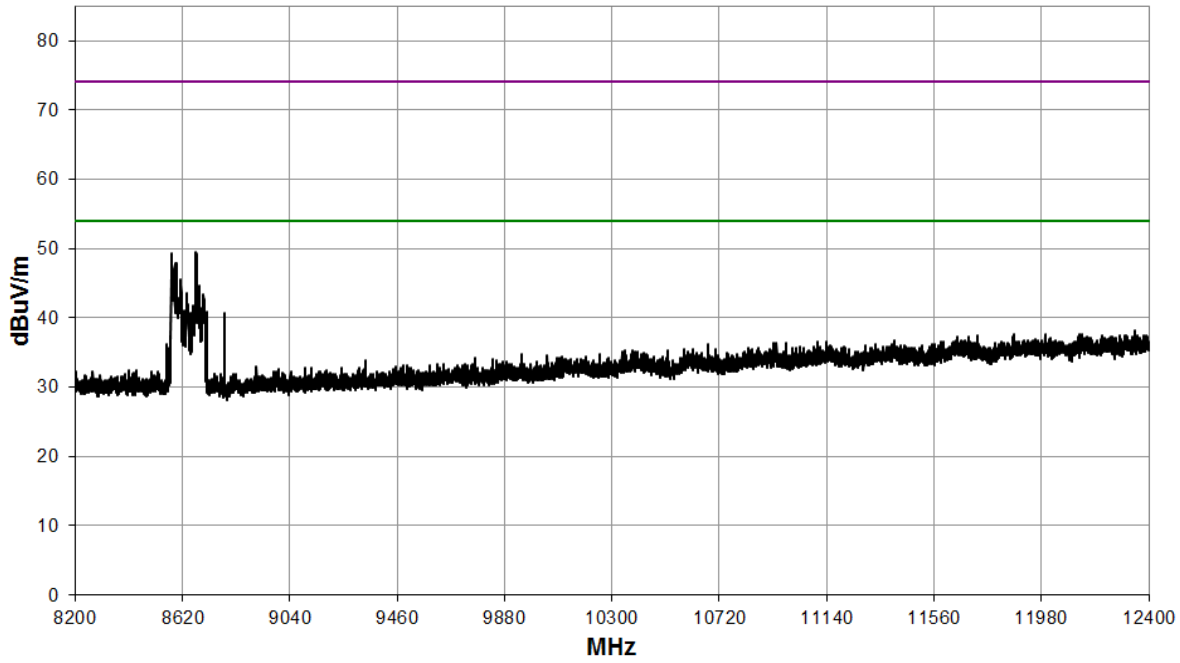
30 MHz to 1 GHz



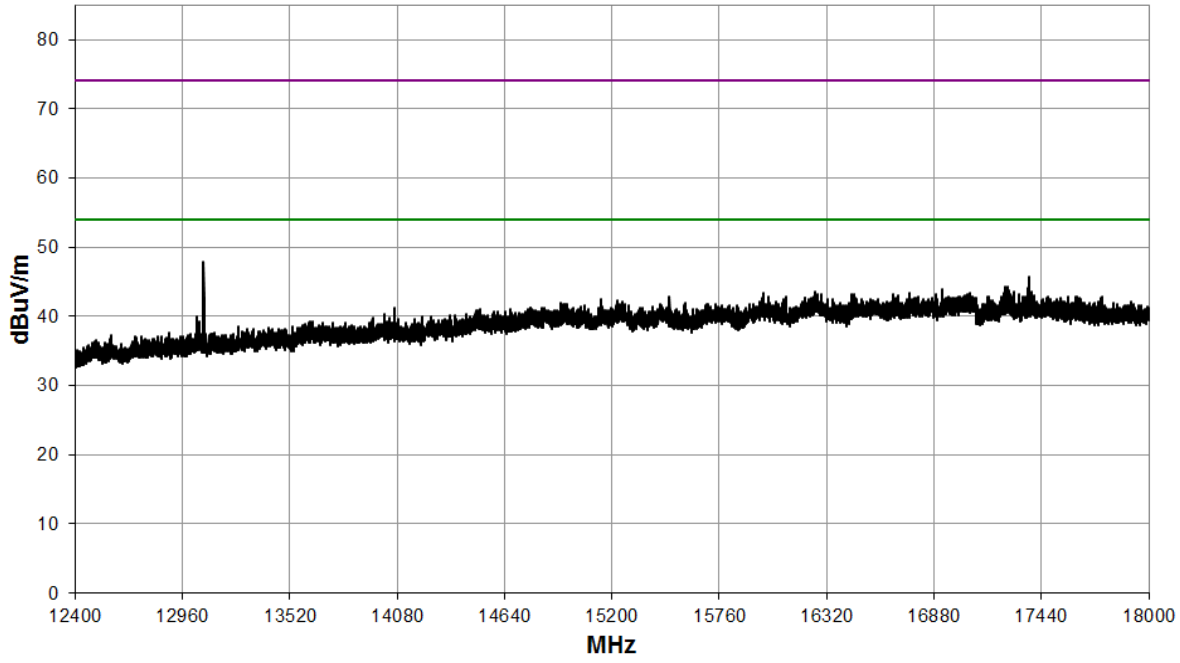
1 GHz to 8.2 GHz



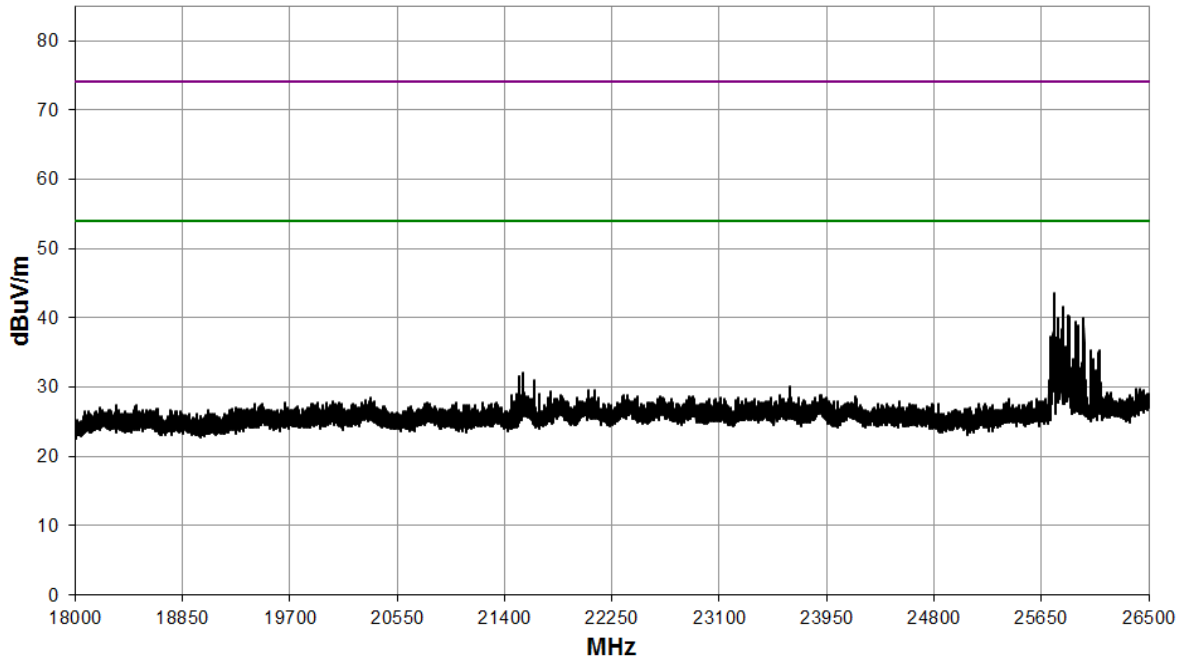
8.2 GHz to 12.4 GHz



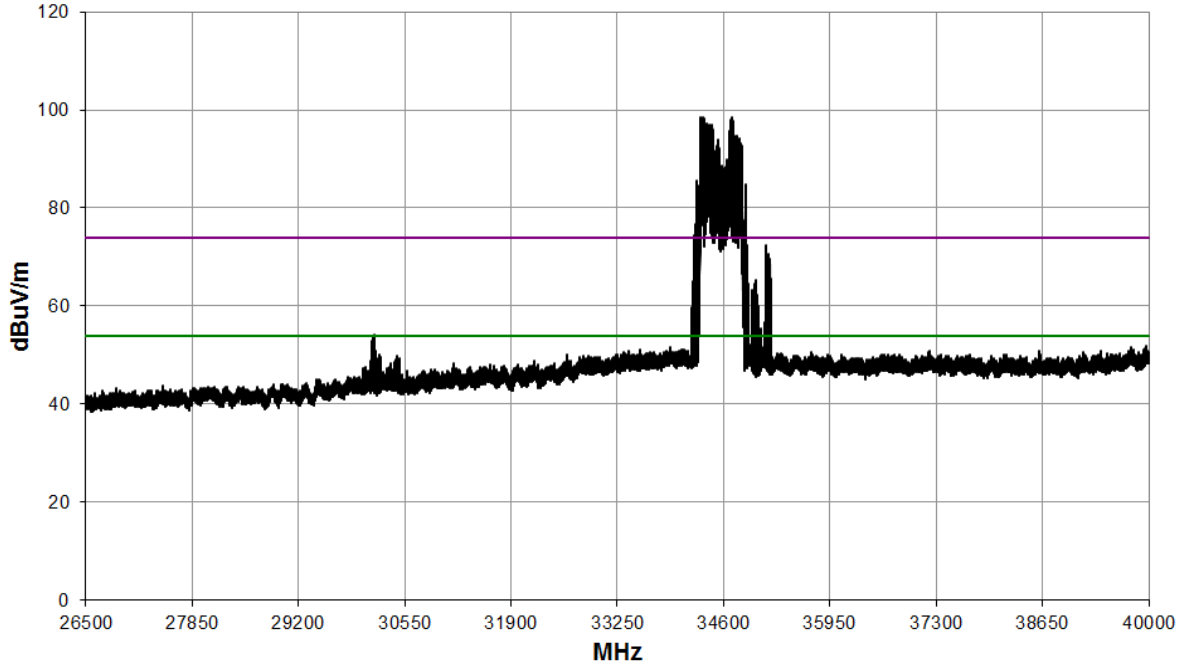
12.4 GHz to 18 GHz



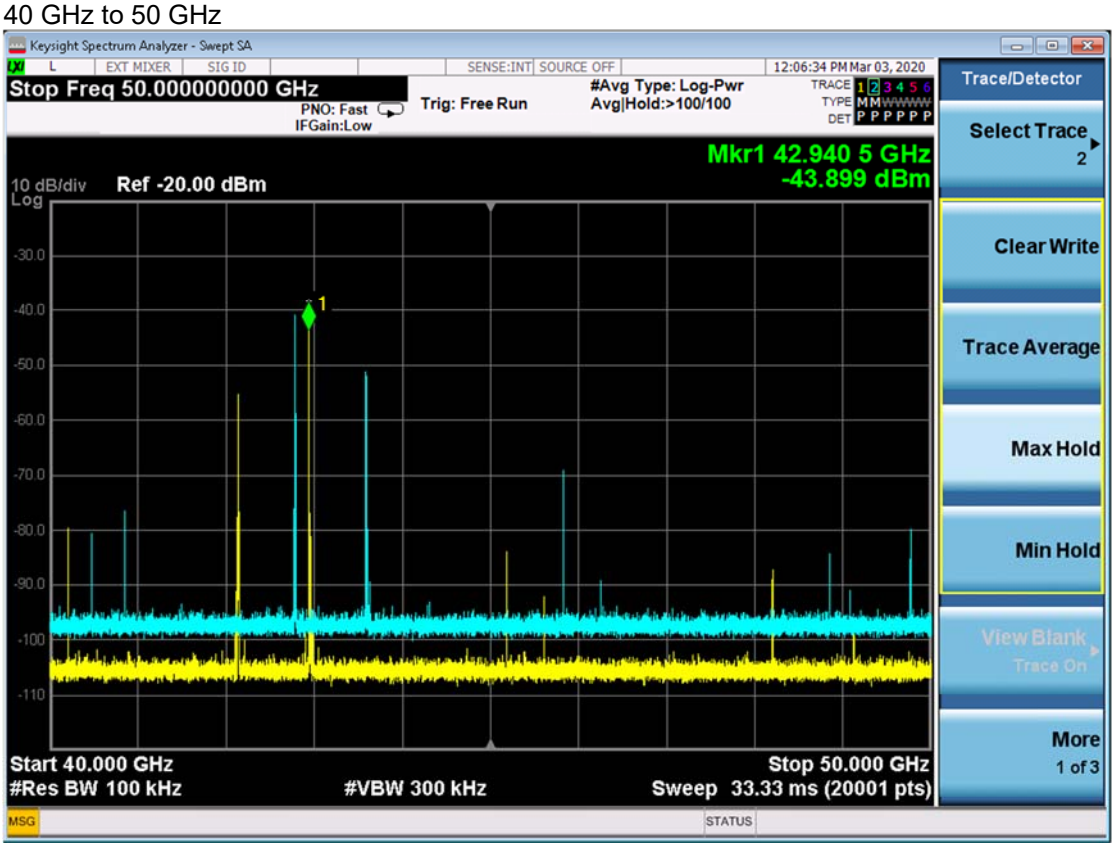
18 GHz to 26.5 GHz



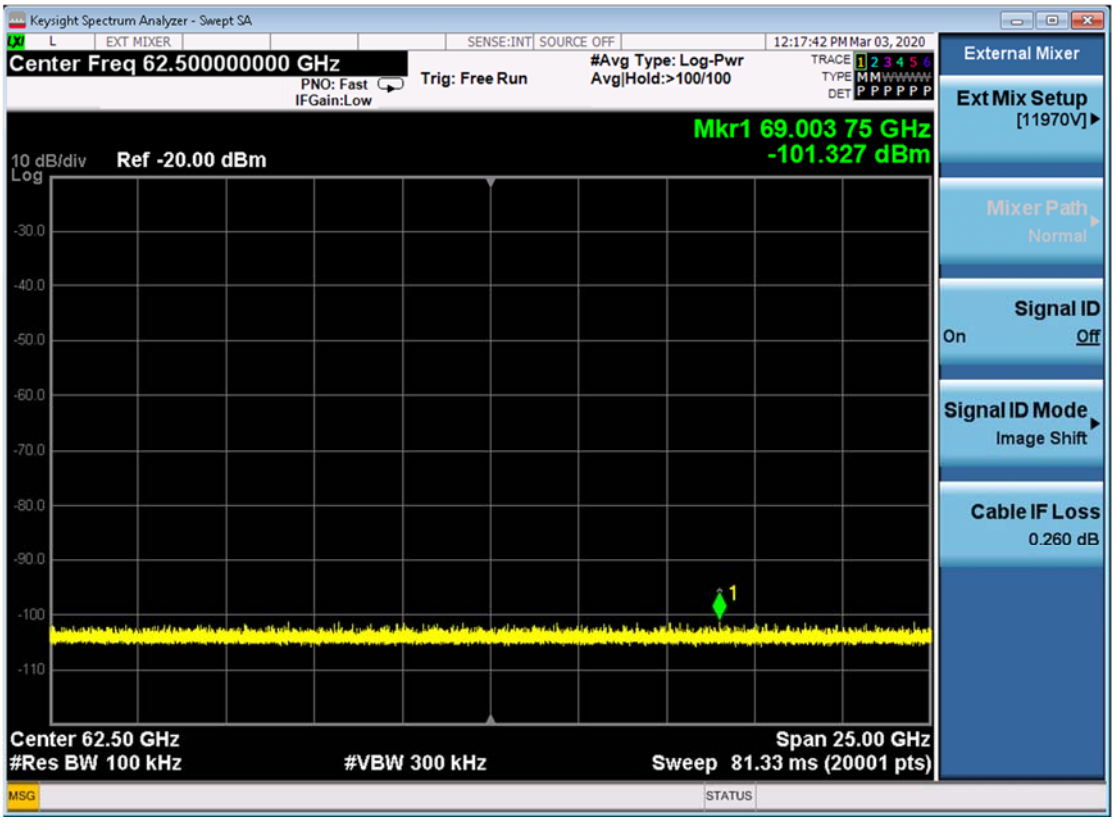
26.5 GHz to 40 GHz



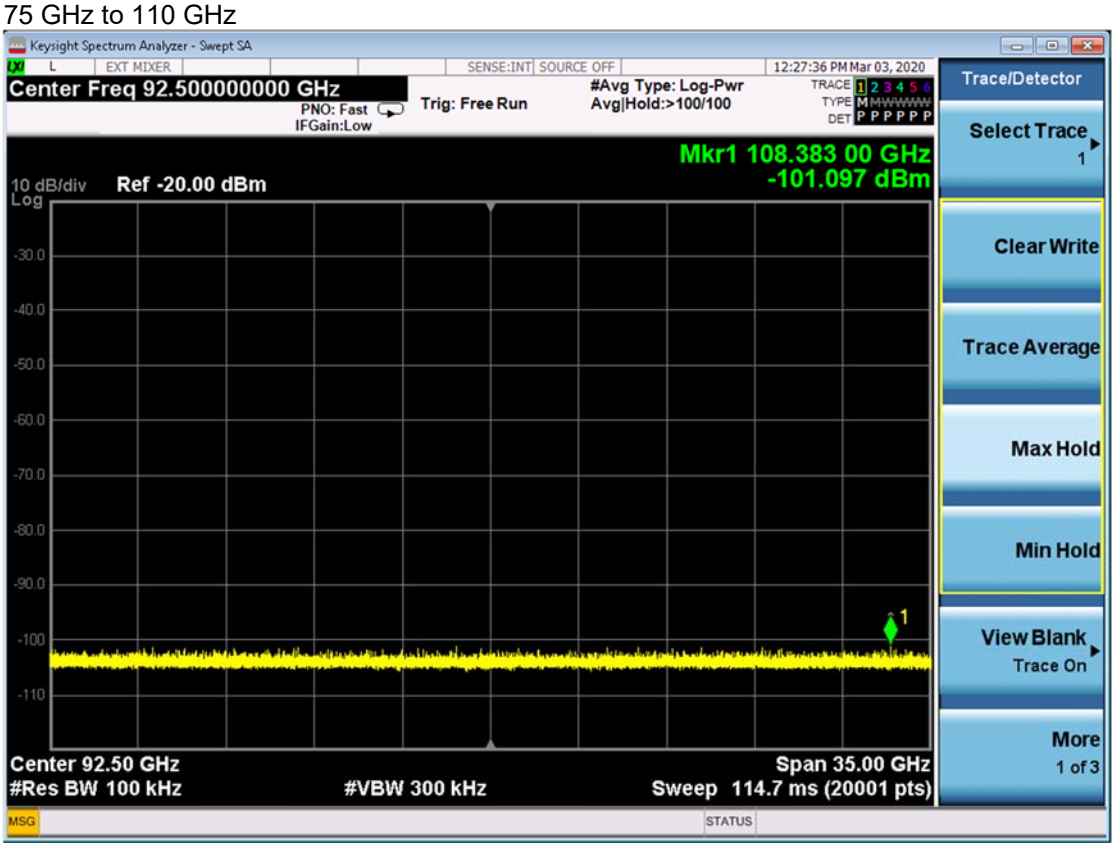
40 GHz to 50 GHz



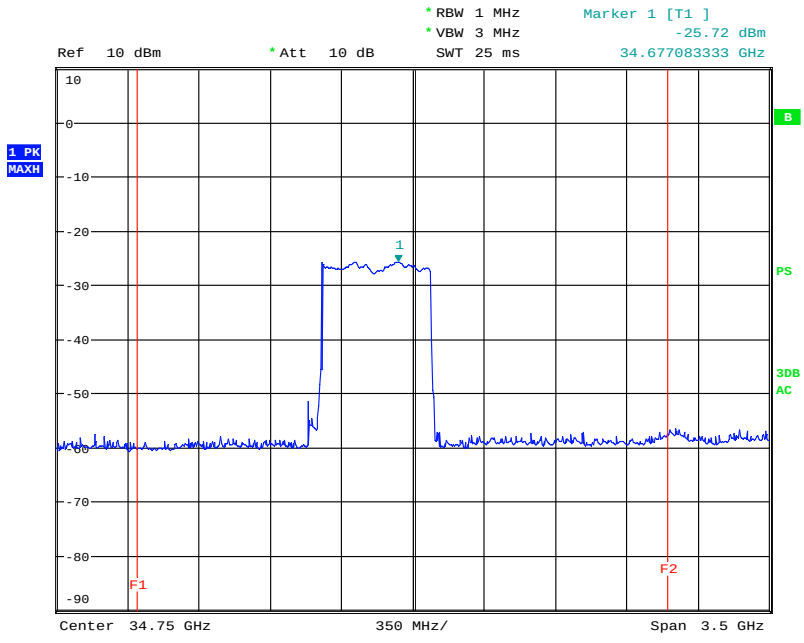
50 GHz to 75 GHz



75 GHz to 110 GHz



Band Edge Plot



Date: 30.MAR.2020 15:29:57

14 Frequency stability

14.1 Definition

Frequency stability is a measure of frequency drift due to temperature and supply voltage variations, with reference to the frequency measured at an appropriate reference temperature and the rated supply voltage.

14.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Environmental Lab
Test Standard and Clause:	ANSI C63.26-2015, Clause 5.6
Frequency Measured:	34.568 GHz
Resolution Bandwidth:	50 Hz
Video Bandwidth:	200 Hz
Frequency Span:	5 kHz
Modulation:	Off
Detector Mode:	Peak
Deviations From Standard:	EUT was left ON for the duration of the test. The upper limit of the temperature range was increased to 60 °C from 50 °C
Temperature Extreme Environment Test Range:	-30 °C to +60 °C
Voltage Extreme Environment Test Range:	24 Vdc = ±15% of Nominal;

Environmental Conditions (Normal Environment)

Temperature: 21 °C	Standard Requirement: +20 ºC
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)
Supply: 24 Vdc	as declared

14.3 Test Limit

The worst-case frequency offset determined in the test shall be added or subtracted from the values of fL and fH and the resulting frequencies must remain within the band.

The frequency band is 33.4 GHz to 36 GHz.

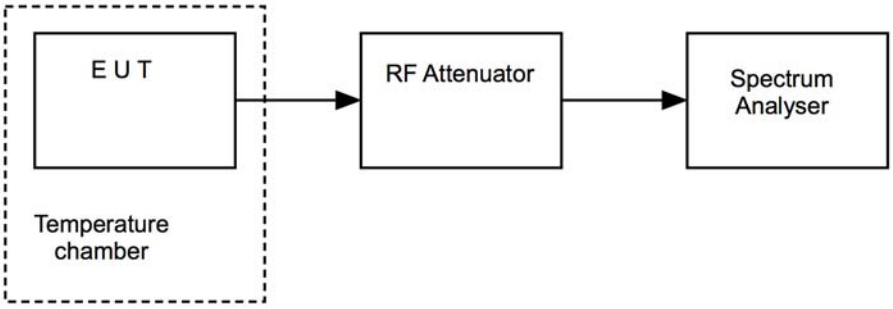
14.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure v, the frequency was measured under varying conditions of temperature and supply voltage.

The measurements were performed with EUT set in a fixed frequency mode of operation.

Measurements were made once temperature stability was achieved at each temperature.

Figure v Test Setup



14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESU40	R&S	Receiver	RFG701	2021-02-06
LB-180400-25-C-KF	A Info Inc	Horn Antenna	REF2246	2020-07-25
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

14.6 Test Results

Frequency Drift Measurement Results					
Test Environment		***Measured Frequency (MHz)***	***Frequency Drift (kHz)***	***Drift (PPM)***	***Result***
-30 °C	$V_{nominal}$	34568.306651	364.51	10.54	PASS
-20 °C	$V_{nominal}$	34568.316410	374.27	10.83	PASS
-10 °C	$V_{nominal}$	34568.263486	321.35	9.30	PASS
0 °C	$V_{nominal}$	34568.164575	222.44	6.43	PASS
+10 °C	$V_{nominal}$	34568.030321	88.18	2.55	PASS
+20 °C	$V_{minimum}$	34567.936835	-5.30	-0.15	PASS
	$V_{nominal}$	34567.942139	N/A	N/A	N/A
	$V_{maximum}$	34567.931795	-10.34	-0.30	PASS
+30 °C	$V_{nominal}$	34567.745449	-196.69	-5.69	PASS
+40 °C	$V_{nominal}$	34567.651026	-291.11	-8.42	PASS
+50 °C	$V_{nominal}$	34567.591178	-350.96	-10.15	PASS
+60 °C	$V_{nominal}$	34567.583093	-359.05	-10.39	PASS

15 AC power-line conducted emissions

15.1 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.

15.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Lab 5
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
Frequencies Measured:	Swept Signal / 34 GHz - 35 GHz Radar
EUT Channel Bandwidths:	537 MHz
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 ºC to +35 ºC (as declared)
Humidity: 40 % RH	20 % RH to 75 % RH (as declared)
Supply: 120 Vac	(as declared)

15.3 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 (dBµV)***	
	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.

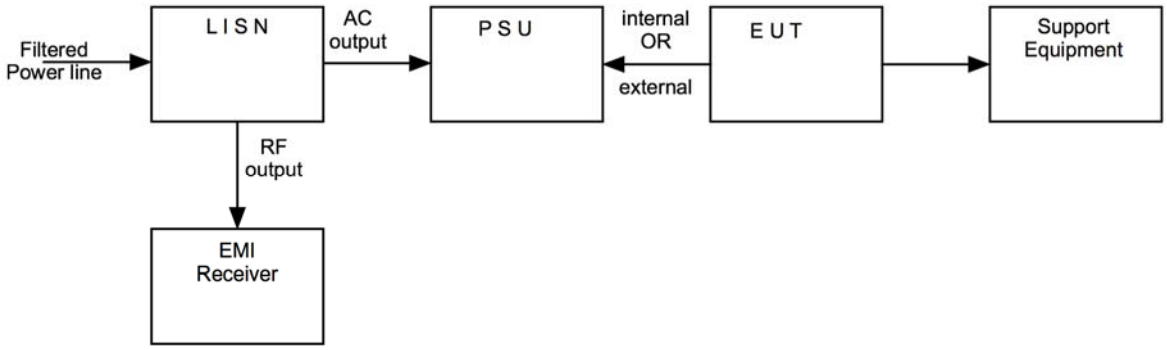
15.4 Test Method

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



15.5 Test Set-up Photograph

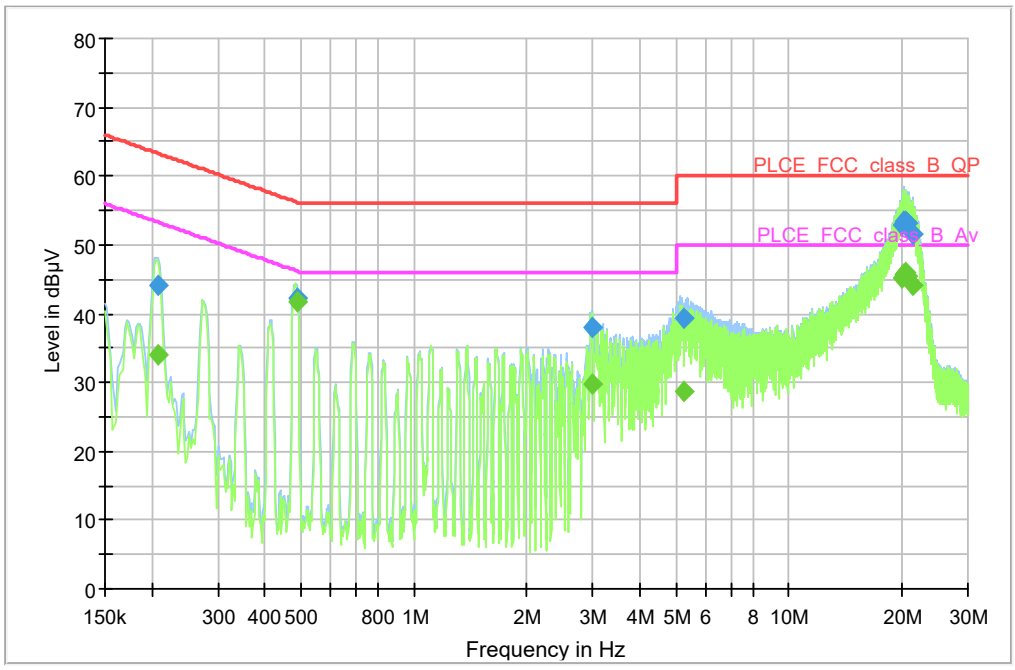
Photo 4 removed at the request of the applicant. The photos can be found in Element document TRA-041847-45-00B_Photographs

Photo 5 removed at the request of the applicant. The photos can be found in Element document TRA-041847-45-00B_Photographs

15.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESCI7	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

15.7 Test Results



15.207 Quasi Peak

Frequency (MHz)	Quasi Peak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.207275	44.2	15000.0	9.000	GND	L1	10.2	19.1	63.3
0.487725	42.4	15000.0	9.000	GND	L1	10.2	13.8	56.2
2.993475	38.1	15000.0	9.000	GND	L1	10.4	17.9	56.0
5.217500	39.4	15000.0	9.000	GND	L1	10.5	20.6	60.0
19.959000	52.8	15000.0	9.000	GND	L1	11.6	7.2	60.0
20.138500	53.1	15000.0	9.000	GND	N	11.4	6.9	60.0
20.340500	53.5	15000.0	9.000	GND	N	11.4	6.5	60.0
20.519500	53.5	15000.0	9.000	GND	N	11.4	6.5	60.0
20.795000	53.1	15000.0	9.000	GND	N	11.4	6.9	60.0
21.337500	51.6	15000.0	9.000	GND	N	11.5	8.4	60.0

15.207 Average

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.207275	34.1	15000.0	9.000	GND	L1	10.2	19.2	53.3
0.487725	41.8	15000.0	9.000	GND	L1	10.2	4.4	46.2
2.993475	29.8	15000.0	9.000	GND	L1	10.4	16.2	46.0
5.217500	28.7	15000.0	9.000	GND	L1	10.5	21.3	50.0
19.959000	45.1	15000.0	9.000	GND	L1	11.6	4.9	50.0
20.138500	45.6	15000.0	9.000	GND	N	11.4	4.4	50.0
20.340500	45.7	15000.0	9.000	GND	N	11.4	4.3	50.0
20.519500	45.9	15000.0	9.000	GND	N	11.4	4.1	50.0
20.795000	45.4	15000.0	9.000	GND	N	11.4	4.6	50.0
21.337500	44.0	15000.0	9.000	GND	N	11.5	6.0	50.0

16 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 (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 (Spectrum Analyser) = **0.265 ppm**

[6] Duty cycle

Uncertainty in test result = **7.98 %**

17 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

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

where:

S = power density
R = distance to the centre of radiation of the antenna
EIRP = EUT Maximum power

Prediction 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
34300	45.8	38018.9	1	56

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	$0.158\ f^{0.5}$	$4.21 \times 10^{-4}\ f^{0.5}$	$6.67 \times 10^{-5}\ f$	$616000/f^{1.2}$