

Report on the Radio Testing  
For  
AGD Systems Ltd  
on  
326  
Report no. TRA-043537-45-01B  
2 April 2020

RF923 5.0

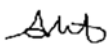


Report Number: TRA-043537-45-01B  
Issue: B

REPORT ON THE RADIO TESTING OF A  
AGD Systems Ltd  
326  
WITH RESPECT TO SPECIFICATION  
FCC 47CFR 15.245

TEST DATE: 2019-12-23 to 2020-01-07

Tested by: A Tosif & A Wong

Written by: 

A Tosif  
Radio Test Engineers

Approved by:

J Charters  
Lab Manager

Date: 2 April 2020

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

## 1 Revision Record

| <i>Issue Number</i> | <i>Issue Date</i> | <i>Revision History</i> |
|---------------------|-------------------|-------------------------|
| A                   | 24 January 2020   | Original                |
| B                   | 2 April 2020      | Section 14.6 updated    |
|                     |                   |                         |

## 2 Summary

|                             |                                                                                                                 |
|-----------------------------|-----------------------------------------------------------------------------------------------------------------|
| TEST REPORT NUMBER:         | TRA-043537-45-01B                                                                                               |
| WORKS ORDER NUMBER:         | TRA-043537-00                                                                                                   |
| PURPOSE OF TEST:            | Certification                                                                                                   |
| TEST SPECIFICATION:         | 47CFR15.245                                                                                                     |
| EQUIPMENT UNDER TEST (EUT): | 326                                                                                                             |
| FCC IDENTIFIER:             | WH3326505                                                                                                       |
| MANUFACTURER/AGENT:         | AGD Systems Ltd                                                                                                 |
| ADDRESS:                    | White Lion House<br>Gloucester Road<br>Staverton<br>Cheltenham<br>Gloucestershire<br>GL51 0TF<br>United Kingdom |
| CLIENT CONTACT:             | Richard Ellis<br>☎ +44 (0) 1452 854212<br>✉ richard.ellis@agd-systems.com                                       |
| ORDER NUMBER:               | 404826                                                                                                          |
| TEST DATE:                  | 2019-12-23 to 2020-01-07                                                                                        |
| TESTED BY:                  | A Tosif & A Wong<br>Element                                                                                     |

## 2.1 Test Summary

| <i>Test Method and Description</i> | <i>Requirement<br/>Clause<br/>47CFR15</i> | <i>Applicable to<br/>this equipment</i> | <i>Result</i> |
|------------------------------------|-------------------------------------------|-----------------------------------------|---------------|
| Radiated spurious emissions        | 15.245(b)                                 | <input checked="" type="checkbox"/>     | Pass          |
| AC power line conducted emissions  | 15.207                                    | <input checked="" type="checkbox"/>     | Pass          |
| Occupied bandwidth                 | 15.215(c)                                 | <input checked="" type="checkbox"/>     | Pass          |
| Field strength of fundamental      | 15.245(b)                                 | <input checked="" type="checkbox"/>     | Pass          |

### Notes:

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-043537-45-01B presents the results of the Radio testing on a AGD Systems Ltd, 326 to specification 47CFR15 Radio Frequency Devices.

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

|                                     |                                                                                             |                          |                                                                                                    |
|-------------------------------------|---------------------------------------------------------------------------------------------|--------------------------|----------------------------------------------------------------------------------------------------|
| <input checked="" type="checkbox"/> | Element Hull<br>Unit E<br>South Orbital Trading Park<br>Hedon Road<br>Hull<br>HU9 1NJ<br>UK | <input type="checkbox"/> | Element Skelmersdale<br>Unit 1<br>Pendle Place<br>Skelmersdale<br>West Lancashire<br>WN8 9PN<br>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.

IC Registration Number:

Element Hull 3483A

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 15 – Radio Frequency Devices.
- 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**

There were no deviations from the test standard.

## 6 Glossary of Terms

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

## 7 Equipment under Test

### 7.1 EUT Identification

- Name: 326
- Model Number: 326-500-021
- Software Revision: MI-197 Ver 4
- Build Level / Revision Number: Prototype
- Serial Number: 114856-0023

### 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.

*Laptop PC*

*Bench-top Power Supply*

### 7.3 EUT Mode of Operation

The EUT was placed in a continuous transmit mode on channel 1 and 2. Both channels are centred on 24.125 GHz with a 70 MHz bandwidth. The difference is the direction of the sweep of the FMCW modulation.

### 7.4 EUT Radio Parameters

|                                |                          |
|--------------------------------|--------------------------|
| <b>Frequency of operation:</b> | 24.125 GHz               |
| <b>Modulation type:</b>        | FMCW                     |
| <b>Nominal Supply Voltage:</b> | 12 Vdc - 24 Vdc & 24 Vac |
| <b>Duty cycle:</b>             | 100 %                    |

### 7.5 EUT Description

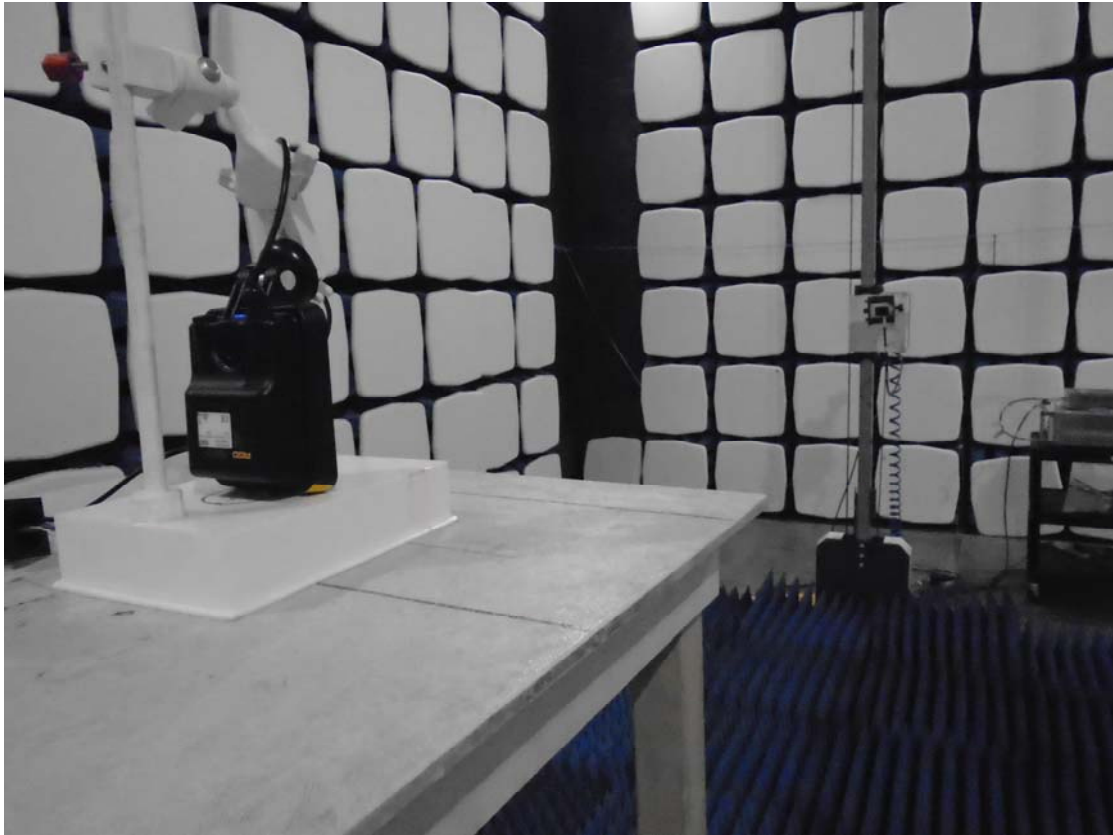
The EUT is a pedestrian detector that uses 24 GHz radar for use in pedestrian crossings.

## **8 Modifications**

No modifications were performed during this assessment.

## 9 EUT Test Setup Photographs

The following photograph shows basic EUT set-up:



### 9.1 Measurement software

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

*Element Emissions R5*

## 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. Unless otherwise stated in a specific section, the normal power source applied was 24 Vdc.

### 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.

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

| <i>Type</i> | <i>Nominal</i> | <i>Variation</i>    |
|-------------|----------------|---------------------|
| DC          | 12 – 24 Vdc    | 10.2 Vdc & 27.6 Vdc |
| AC          | 24 Vac         | 20.4 Vac & 27.6 Vac |

## 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 2                                               |
| Test Standard and Clause: | ANSI C63.10-2013, Clause 6.5 and 6.6                         |
| Frequencies Measured:     | 24.125 GHz                                                   |
| EUT Channel Bandwidth:    | 70 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<br>Above 1 GHz: RMS average and Peak |

#### **Environmental Conditions (Normal Environment)**

|                    |                                  |
|--------------------|----------------------------------|
| Temperature: 20 °C | +15 °C to +35 °C (as declared)   |
| Humidity: 39 % RH  | 20 % RH to 75 % RH (as declared) |
| Supply: 24 Vdc     | As declared                      |

### 11.3 Test Limit

The average field strength of emissions measured at 3 m shall not exceed:

- (a) 2500 mV/m for fundamental emission; and
- (b) 25 mV/m for harmonic emissions for devices operating in the 24.075 GHz - 24.175 GHz band

Harmonic emissions falling into restricted bands and which are below 17.7 GHz shall meet the general field strength limits.

Harmonic emissions falling into restricted bands which are at and above 17.7 GHz shall not exceed the following strength limits measured at a distance of 3 m:

- (a) 25 mV/m for the second and third harmonic emissions of devices operating in the band 24.075-24.175 GHz; and
- (b) 7.5 mV/m for all other devices.

Emissions radiated outside of these specified operating frequency bands, except for harmonic emissions, shall be attenuated by at least 50 dB below the level of the fundamental emissions or to the general field strength limits specified, whichever is less stringent.

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

| <i>Frequency<br/>(MHz)</i> | <i>Field Strength<br/>(<math>\mu</math>V/m at 3 m)</i> |
|----------------------------|--------------------------------------------------------|
| 30 to 88                   | 100                                                    |
| 88 to 216                  | 150                                                    |
| 216 to 960                 | 200                                                    |
| Above 960                  | 500                                                    |

n.b. peak limit is 20 dB above average.

#### **11.4 Test Method**

With the EUT 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 dB $\mu$ V/m at the regulatory distance, using:

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

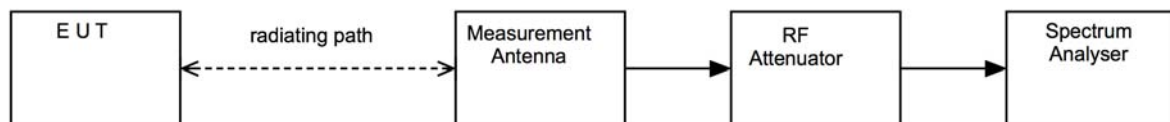
Where,

PR is the power recorded on the receiver / spectrum analyzer in dB $\mu$ V;  
 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**



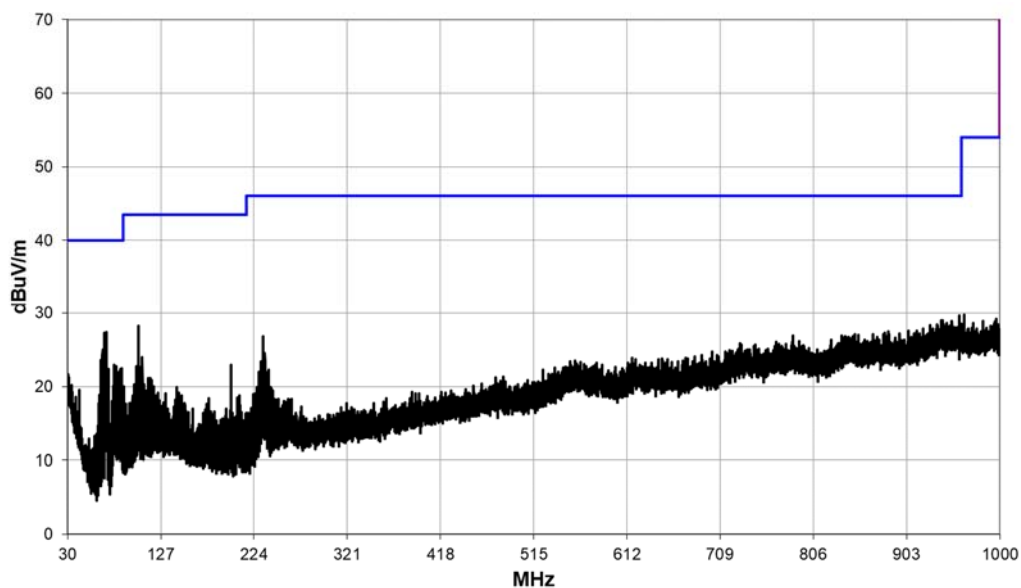
### 11.5 Test Equipment

| <i>Equipment Type</i> | <i>Manufacturer</i> | <i>Equipment Description</i> | <i>Element No</i> | <i>Due For Calibration</i> |
|-----------------------|---------------------|------------------------------|-------------------|----------------------------|
| CBL6111B              | Chase               | Bilog Antenna                | REF2233           | 2020-08-17                 |
| 3115                  | EMCO                | Horn Antenna                 | RFG129            | 2020-02-12                 |
| QSH20S20S             | Q-Par               | Horn Antenna                 | RFG629            | 2021-10-09                 |
| LB-180400-25-C-KF     | A Info Inc          | Horn Antenna                 | REF2246           | 2020-07-25                 |
| ATS                   | Rainford            | Ferrite Lined Chamber        | REF886            | 2020-07-29                 |
| ESU40                 | R&S                 | Receiver                     | RFG701            | 2020-01-18                 |
| N9030A                | Agilent             | Spectrum Analyser            | REF2167           | 2020-08-12                 |
| 11970Q                | Agilent             | Harmonic Mixer (33-50)       | U365              | 2022-05-06                 |
| 11970V                | Agilent             | Harmonic Mixer (50-75)       | U366              | 2022-05-06                 |
| 11970W                | Agilent             | Harmonic Mixer (75-110)      | U367              | 2022-05-17                 |
| 25240-20              | Flann               | Standard Gain Horn (50-75)   | U368              | 2020-05-05                 |
| 27240-20              | Flann               | Standard Gain Horn (75-110)  | U369              | 2020-05-04                 |
| 23240-20              | Flann               | Standard Gain Horn 33-50     | L264A             | 2020-05-17                 |
| 310                   | Sonoma              | Pre-Amp (9 kHz - 1 GHz)      | REF927            | 2020-05-29                 |
| 8449B                 | Agilent             | Pre-Amp (1 - 26.5 GHz)       | REF913            | 2020-02-06                 |
| Emissions R5          | Element             | Radiated Test Software       | REF9000           | N/A                        |

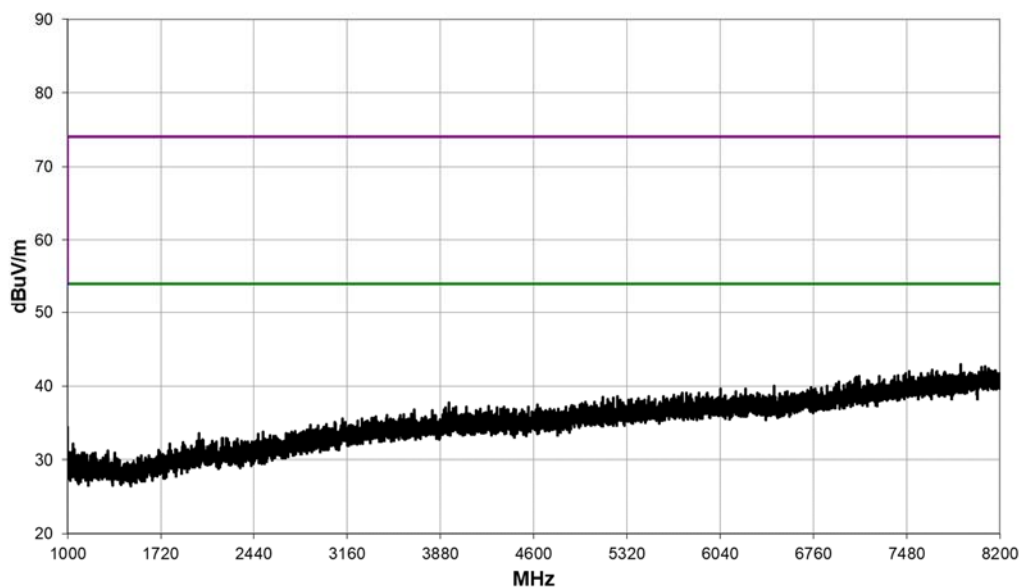
## 11.6 Test Results

| Channel 1; Frequency: 24.125 GHz                                                                                                                                                              |                 |                        |             |                               |                             |                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|------------------------|-------------|-------------------------------|-----------------------------|--------------------|
| Detector                                                                                                                                                                                      | Frequency (MHz) | Amplitude (dB $\mu$ V) | Factor (dB) | Emission level (dB $\mu$ V/m) | Field Strength ( $\mu$ V/m) | Limit ( $\mu$ V/m) |
| Quasi peak                                                                                                                                                                                    | 66.3            | 48.5                   | -19.8       | 28.7                          | 27.2                        | 100.0              |
| Quasi peak                                                                                                                                                                                    | 68.3            | 50.3                   | -19.5       | 30.8                          | 34.7                        | 100.0              |
| Quasi peak                                                                                                                                                                                    | 69.3            | 45.5                   | -19.4       | 26.1                          | 20.2                        | 100.0              |
| Quasi peak                                                                                                                                                                                    | 70.4            | 49.2                   | -19.2       | 30.0                          | 31.6                        | 100.0              |
| Quasi peak                                                                                                                                                                                    | 78.4            | 42.4                   | -17.9       | 24.5                          | 16.8                        | 100.0              |
| Quasi peak                                                                                                                                                                                    | 82.4            | 40.6                   | -17.4       | 23.2                          | 14.5                        | 100.0              |
| Quasi peak                                                                                                                                                                                    | 84.4            | 41.4                   | -17.0       | 24.4                          | 16.6                        | 100.0              |
| Quasi peak                                                                                                                                                                                    | 233.1           | 40.5                   | -14.8       | 25.7                          | 19.3                        | 200.0              |
| Radiated Spurious Emission investigations have been performed up to 100 GHz,<br>No Further Significant Emissions Within 20 dB of Limit or above the measurement system noise floor were found |                 |                        |             |                               |                             |                    |

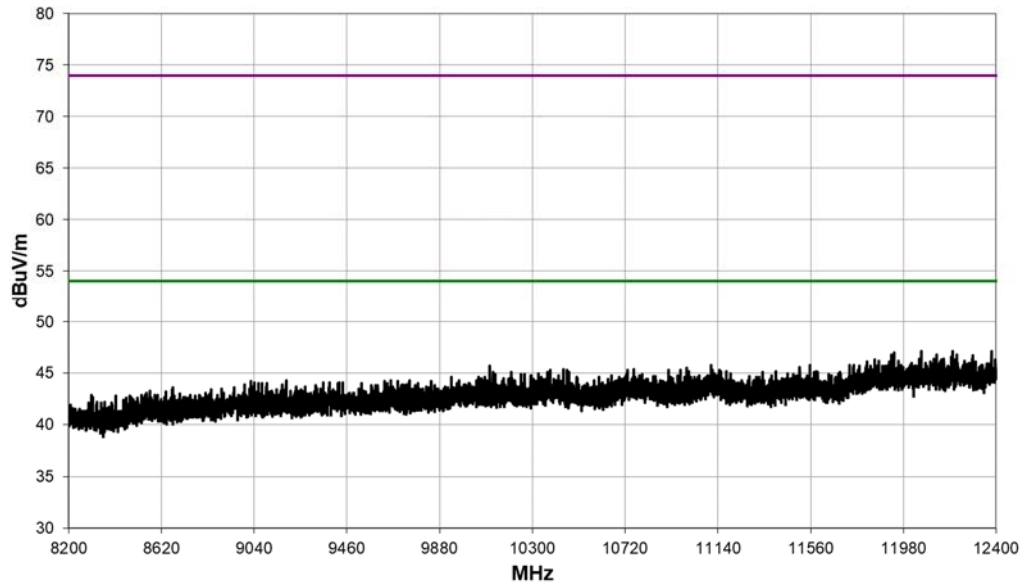
### 30 MHz to 1 GHz



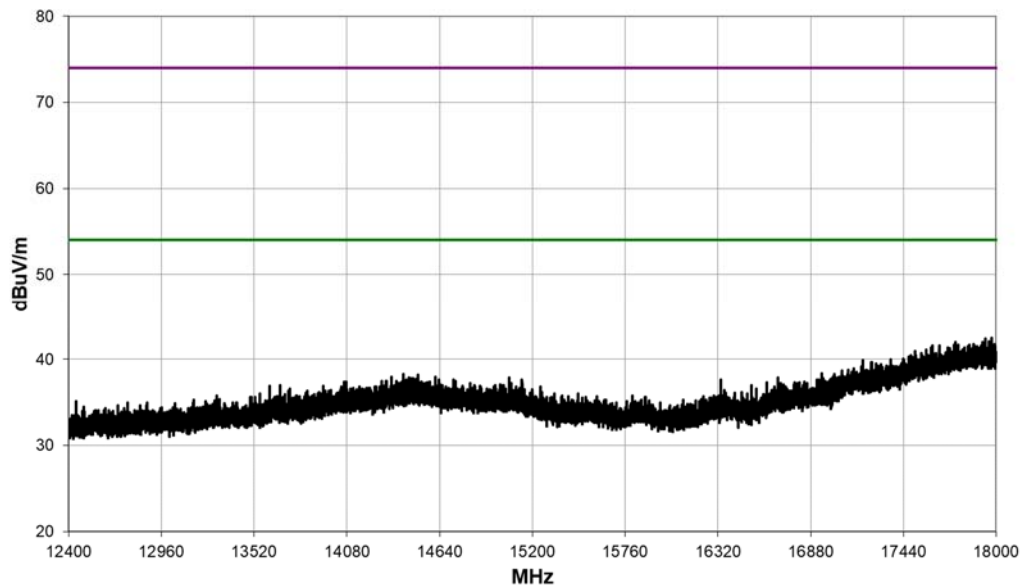
### 1 GHz to 8.2 GHz



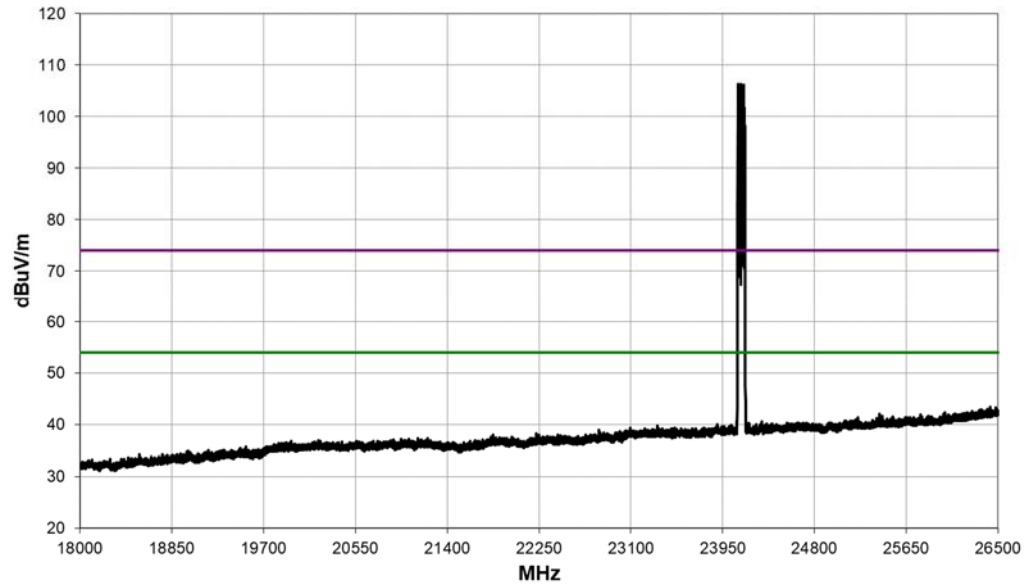
## 8.2 GHz to 12.4 GHz



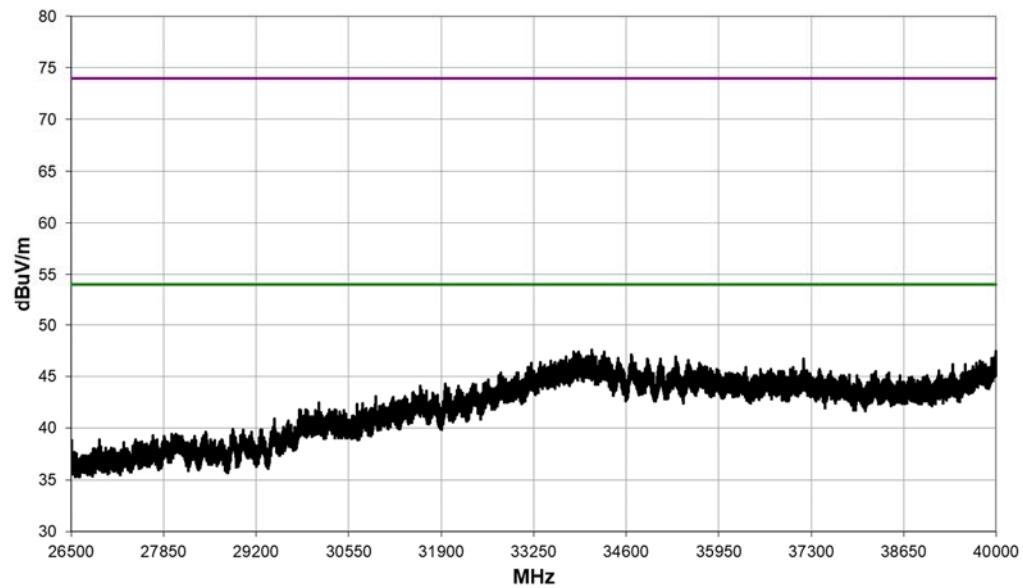
## 12.4 GHz to 18 GHz



## 18 GHz to 26.5 GHz



## 26.5 GHz to 40 GHz



# Band Edge



\* RBW 1 MHz

Marker 1 [T1 ]

\* VBW 3 MHz

57.93 dBμV/m

SWT 20 ms

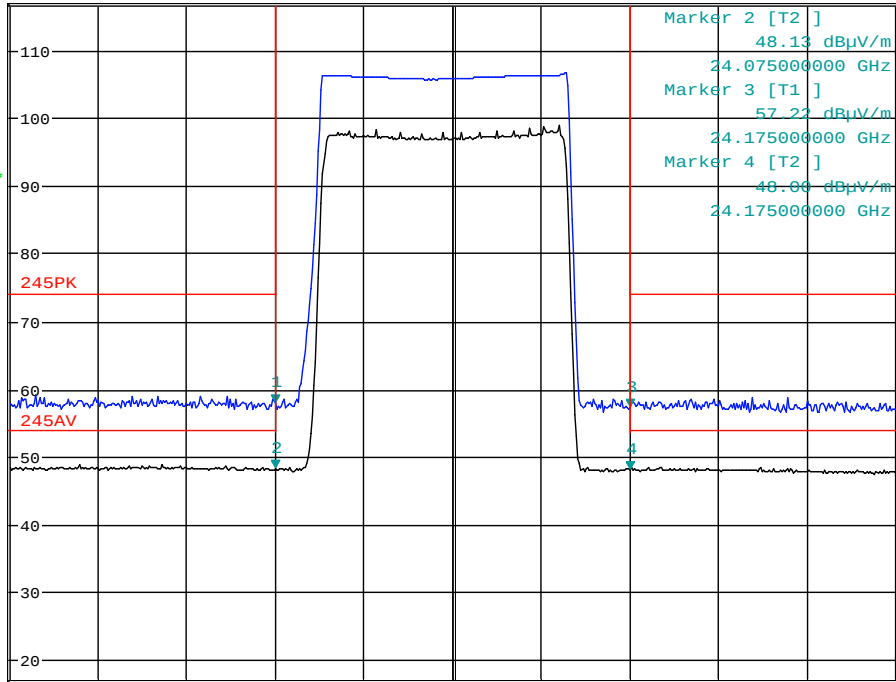
24.075000000 GHz

Ref 117 dBμV/m

\* Att 5 dB

1 PK  
MAXH

2 AV  
MAXH



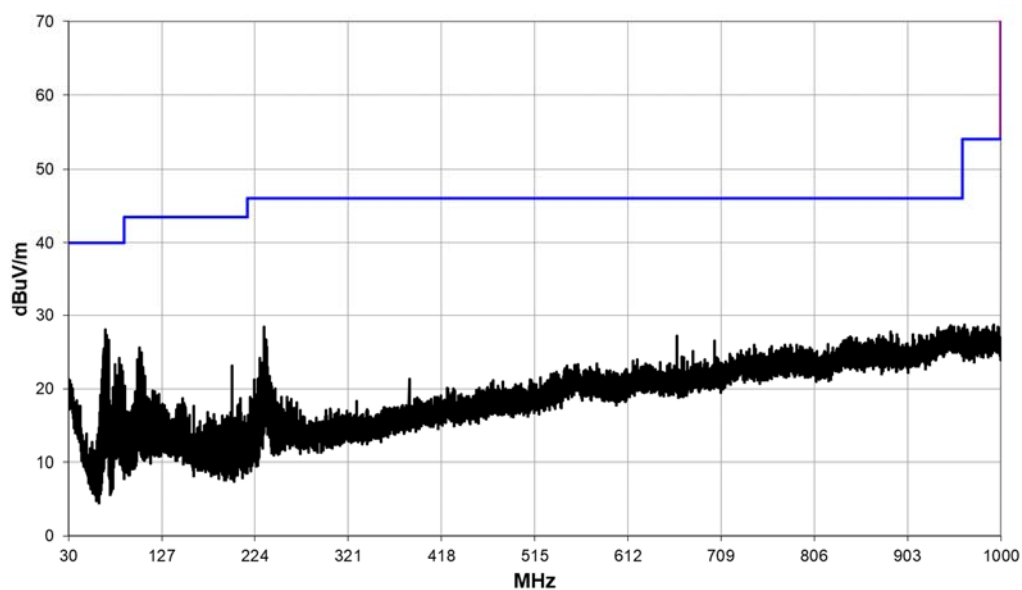
Center 24.125 GHz

25 MHz/

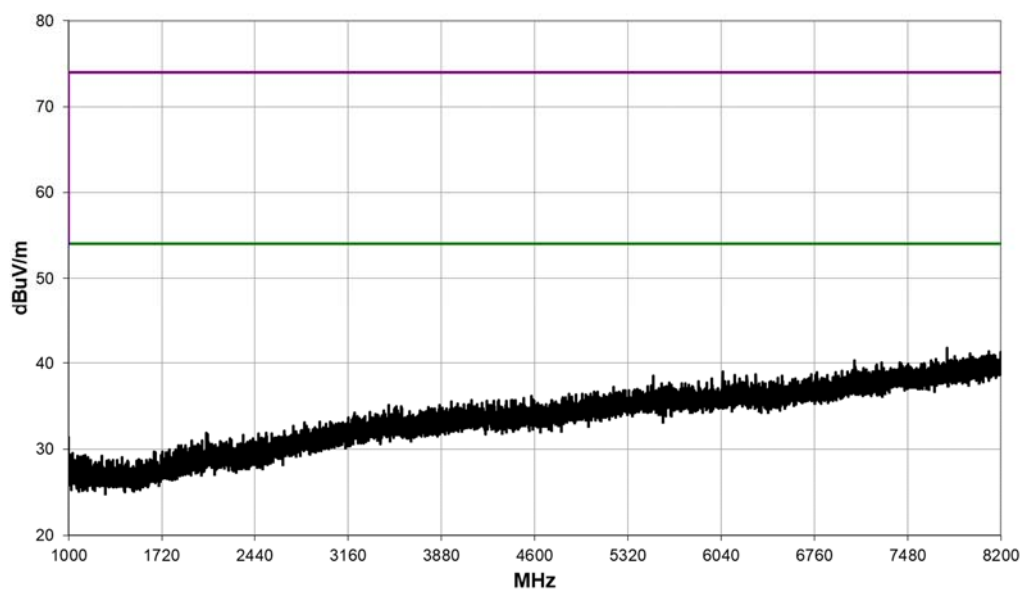
Span 250 MHz

| Channel 2; Frequency: 24.125 GHz                                                                                                                                                              |                 |                        |             |                               |                             |                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|------------------------|-------------|-------------------------------|-----------------------------|--------------------|
| Detector                                                                                                                                                                                      | Frequency (MHz) | Amplitude (dB $\mu$ V) | Factor (dB) | Emission level (dB $\mu$ V/m) | Field Strength ( $\mu$ V/m) | Limit ( $\mu$ V/m) |
| Quasi peak                                                                                                                                                                                    | 66.3            | 48.5                   | -19.8       | 28.7                          | 27.2                        | 100.0              |
| Quasi peak                                                                                                                                                                                    | 68.3            | 50.3                   | -19.5       | 30.8                          | 34.7                        | 100.0              |
| Quasi peak                                                                                                                                                                                    | 69.3            | 45.5                   | -19.4       | 26.1                          | 20.2                        | 100.0              |
| Quasi peak                                                                                                                                                                                    | 70.4            | 49.2                   | -19.2       | 30.0                          | 31.6                        | 100.0              |
| Quasi peak                                                                                                                                                                                    | 78.4            | 42.4                   | -17.9       | 24.5                          | 16.8                        | 100.0              |
| Quasi peak                                                                                                                                                                                    | 82.4            | 40.6                   | -17.4       | 23.2                          | 14.5                        | 100.0              |
| Quasi peak                                                                                                                                                                                    | 84.4            | 41.4                   | -17.0       | 24.4                          | 16.6                        | 100.0              |
| Quasi peak                                                                                                                                                                                    | 233.1           | 40.5                   | -14.8       | 25.7                          | 19.3                        | 200.0              |
| Radiated Spurious Emission investigations have been performed up to 100 GHz,<br>No Further Significant Emissions Within 20 dB of Limit or above the measurement system noise floor were found |                 |                        |             |                               |                             |                    |

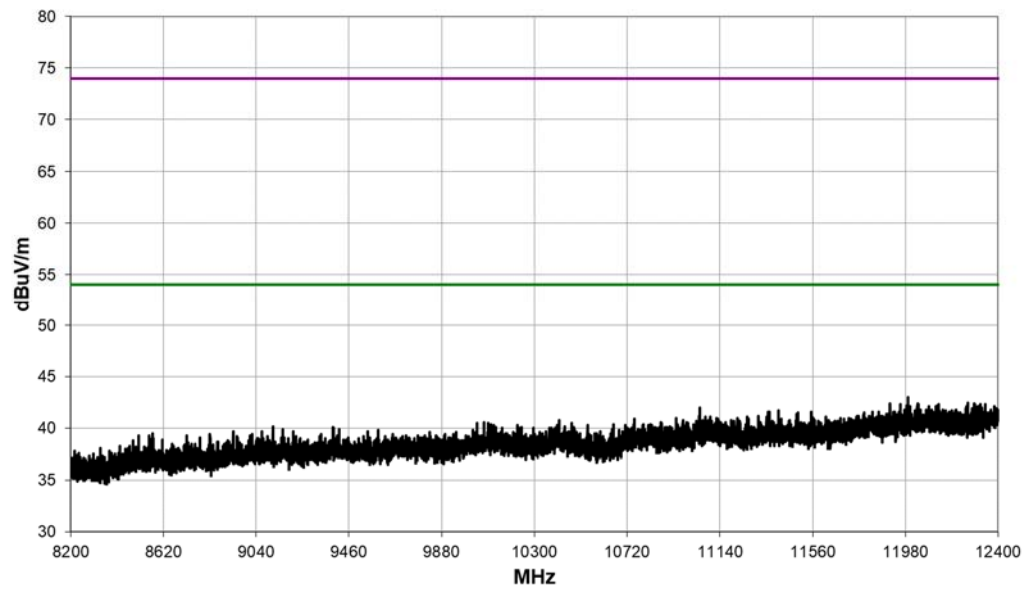
## 30 MHz to 1 GHz



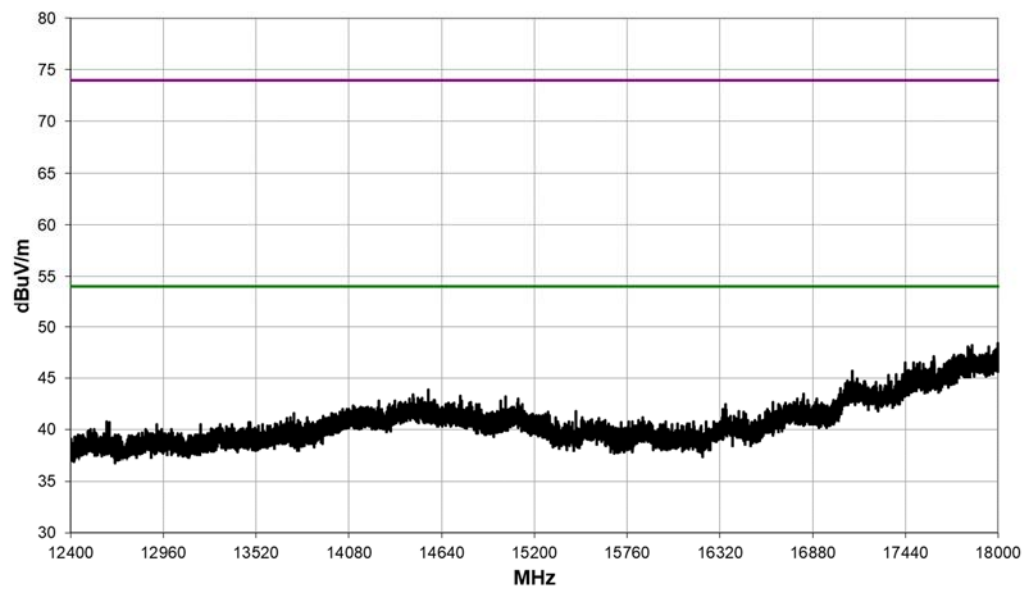
## 1 GHz to 8.2 GHz



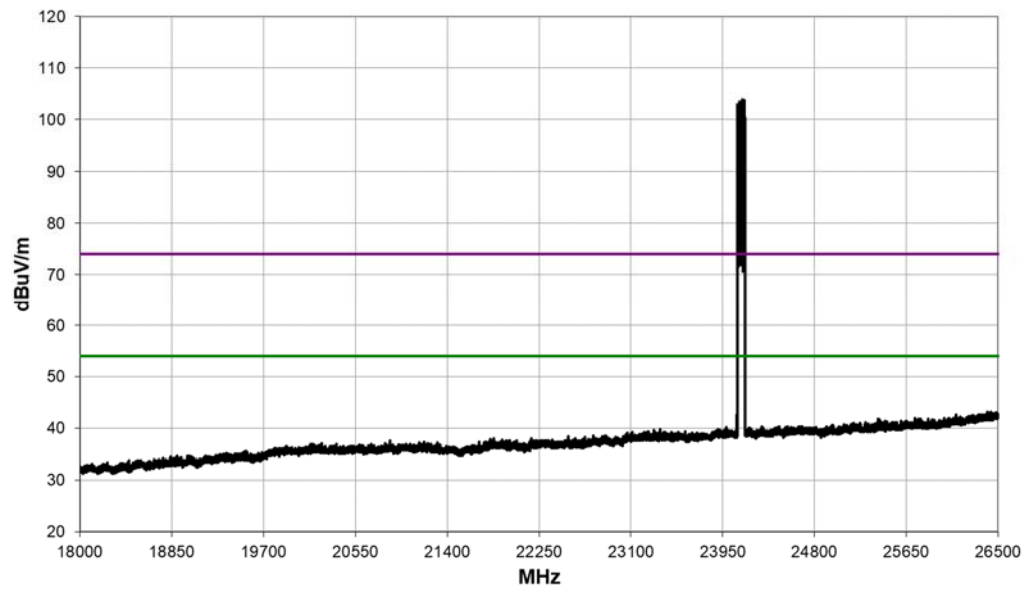
## 8.2 GHz to 12.4 GHz



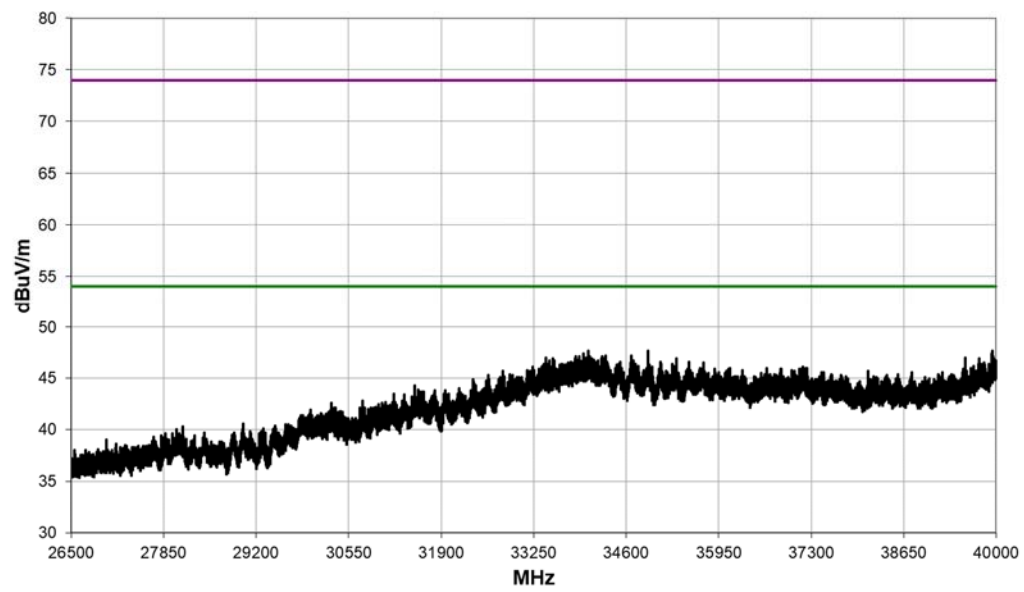
## 12.4 GHz to 18 GHz



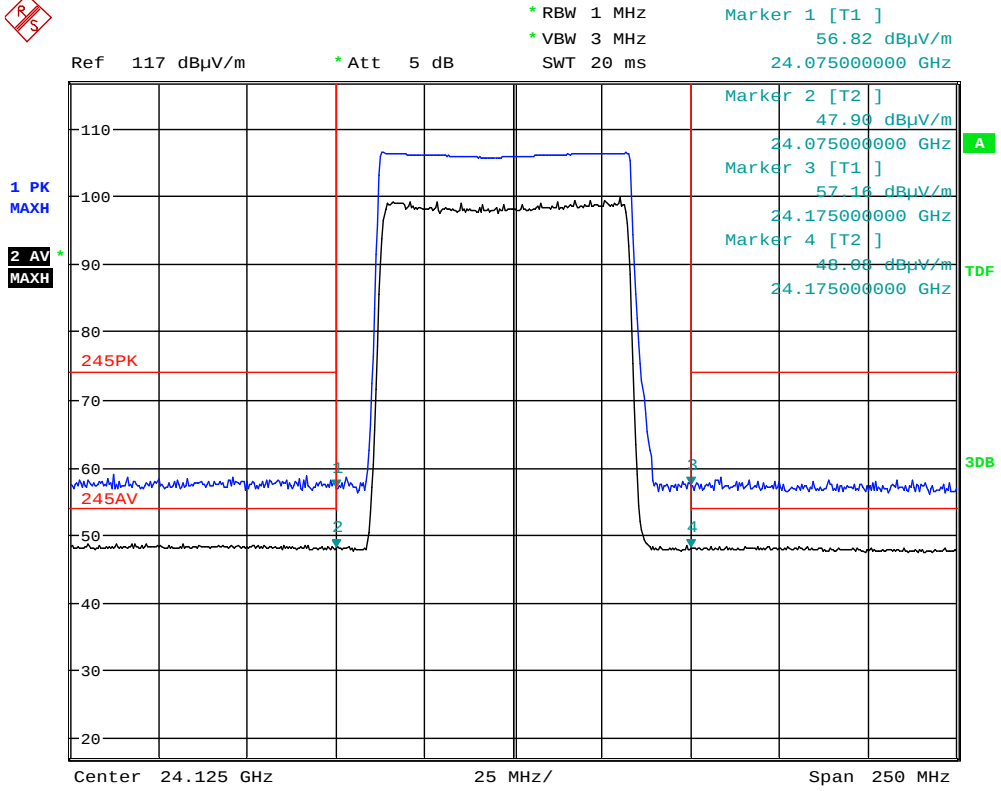
## 18 GHz to 26.5 GHz



## 26.5 GHz to 40 GHz



# Band Edge



## 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:             | Screen Room 2                |
| Test Standard and Clause: | ANSI C63.10-2013, Clause 6.2 |
| EUT Frequency Measured:   | 24.125 GHz                   |
| Deviations From Standard: | None                         |
| Measurement Detectors:    | Quasi-Peak and Average       |

### Environmental Conditions (Normal Environment)

|                    |                                  |
|--------------------|----------------------------------|
| Temperature: 22 °C | +15 °C to +35 °C (as declared)   |
| Humidity: 38 % RH  | 20 % RH to 75 % RH (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<br>(MHz) | Conducted limit<br>(dB $\mu$ 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.

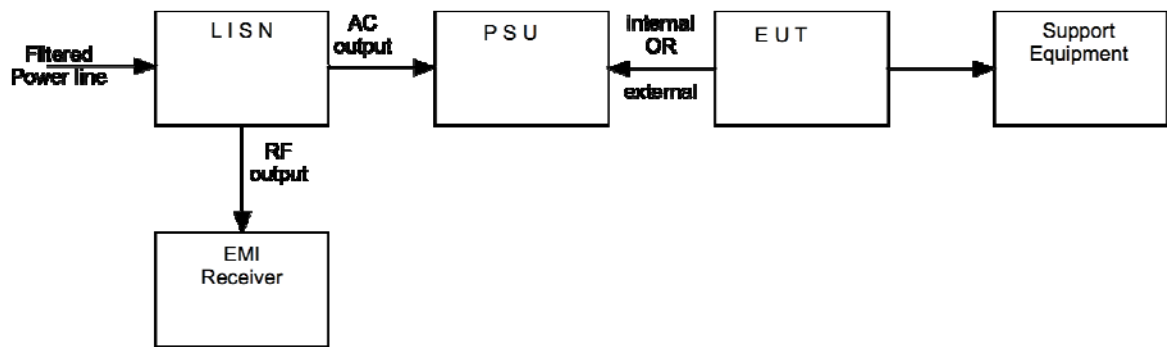
\*\*A linear average detector is required.

### 12.4 Test Method

With the EUT setup in a screened room, as per 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 mode.

**Figure ii Test Setup**

### 12.5 Test Set-up Photograph

12 Vdc and 24 Vdc Set-up Photograph



## 24 Vac Set-up Photograph



## 12.6 Test Equipment

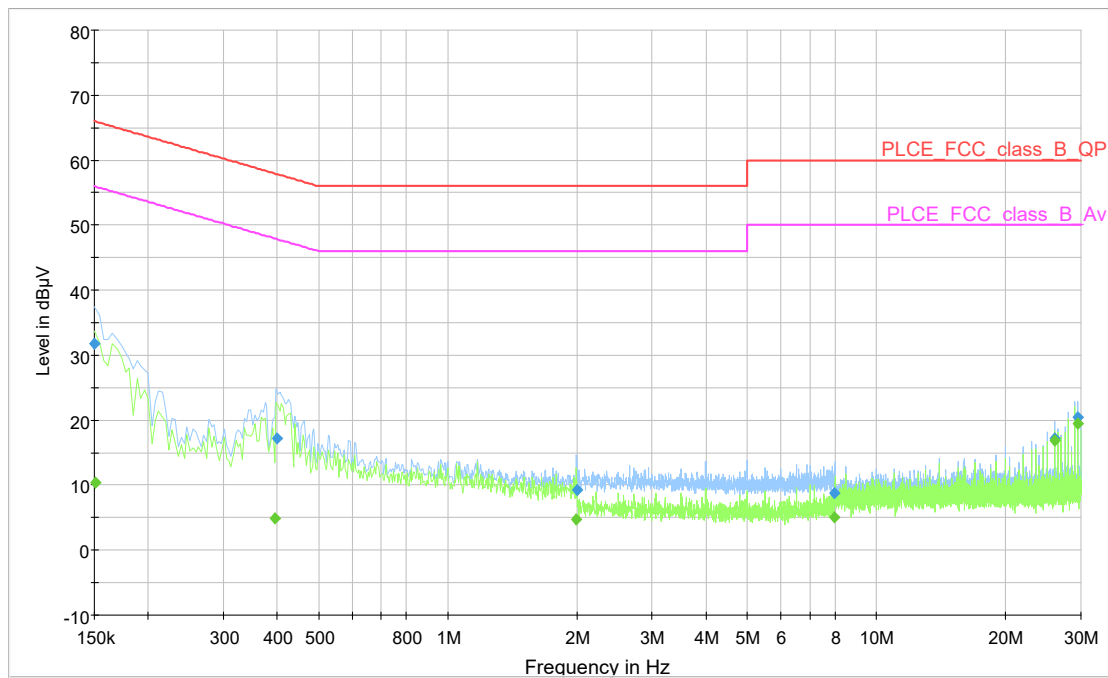
| <i><b>Equipment<br/>Description</b></i> | <i><b>Manufacturer</b></i> | <i><b>Equipment<br/>Type</b></i> | <i><b>Element<br/>No</b></i> | <i><b>Due For<br/>Calibration</b></i> |
|-----------------------------------------|----------------------------|----------------------------------|------------------------------|---------------------------------------|
| Receiver                                | R&S                        | ESU40                            | RFG701                       | 2020-01-18                            |
| LISN                                    | R&S                        | ESH3-Z5                          | RFG732                       | 2020-05-28                            |
| Pulse Limiter                           | R&S                        | ESH3-Z2                          | RFG674                       | 2020-04-15                            |

## 12.7 Test Results

### 12 Vdc Supply

| Results measured using the quasi-peak detector |                 |           |               |                            |             |                |
|------------------------------------------------|-----------------|-----------|---------------|----------------------------|-------------|----------------|
| Reference Number                               | Frequency (MHz) | Conductor | Result (dBuV) | Specification Limit (dBuV) | Margin (dB) | Result Summary |
| 1                                              | 0.150           | N         | 31.7          | 66.0                       | 34.3        | PASS           |
| 2                                              | 0.400           | N         | 17.3          | 57.9                       | 40.6        | PASS           |
| 3                                              | 2.000           | L1        | 9.2           | 56.0                       | 46.8        | PASS           |
| 4                                              | 7.999           | L1        | 8.7           | 60.0                       | 51.3        | PASS           |
| 5                                              | 25.998          | L1        | 17.1          | 60.0                       | 42.9        | PASS           |
| 6                                              | 29.499          | N         | 20.4          | 60.0                       | 39.6        | PASS           |

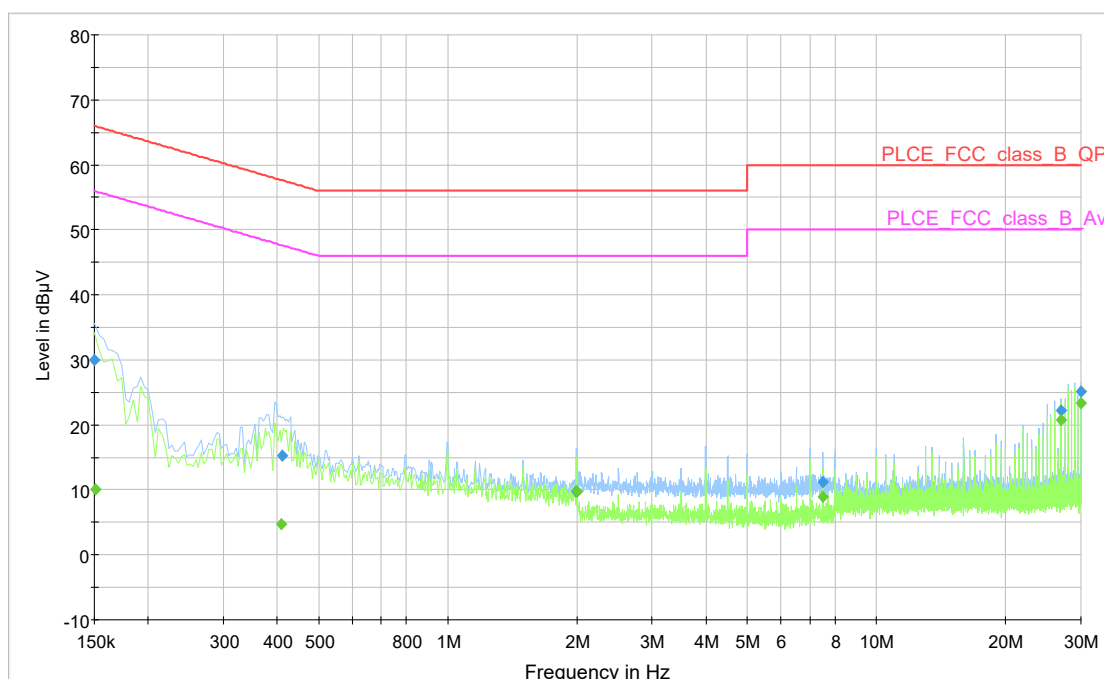
| Results measured using the average detector |                 |           |               |                            |             |                |
|---------------------------------------------|-----------------|-----------|---------------|----------------------------|-------------|----------------|
| Reference Number                            | Frequency (MHz) | Conductor | Result (dBuV) | Specification Limit (dBuV) | Margin (dB) | Result Summary |
| 1                                           | 0.151           | N         | 10.4          | 56.0                       | 45.5        | PASS           |
| 2                                           | 0.395           | N         | 5.0           | 48.0                       | 43.0        | PASS           |
| 3                                           | 1.999           | L1        | 4.7           | 46.0                       | 41.3        | PASS           |
| 4                                           | 7.998           | N         | 5.0           | 50.0                       | 45.0        | PASS           |
| 5                                           | 25.999          | N         | 16.9          | 50.0                       | 33.1        | PASS           |
| 6                                           | 29.498          | N         | 19.5          | 50.0                       | 30.5        | PASS           |



**24 Vdc Supply**

| <i>Results measured using the quasi-peak detector</i> |                        |                  |                      |                                   |                    |                       |
|-------------------------------------------------------|------------------------|------------------|----------------------|-----------------------------------|--------------------|-----------------------|
| <b>Reference Number</b>                               | <b>Frequency (MHz)</b> | <b>Conductor</b> | <b>Result (dBuV)</b> | <b>Specification Limit (dBuV)</b> | <b>Margin (dB)</b> | <b>Result Summary</b> |
| 1                                                     | 0.150                  | N                | 30.0                 | 66.0                              | 36.0               | PASS                  |
| 2                                                     | 0.412                  | N                | 15.3                 | 57.6                              | 42.3               | PASS                  |
| 3                                                     | 1.997                  | N                | 9.8                  | 56.0                              | 46.2               | PASS                  |
| 4                                                     | 7.500                  | L1               | 11.2                 | 60.0                              | 48.8               | PASS                  |
| 5                                                     | 26.999                 | N                | 22.3                 | 60.0                              | 37.7               | PASS                  |
| 6                                                     | 30.000                 | N                | 25.1                 | 60.0                              | 34.9               | PASS                  |

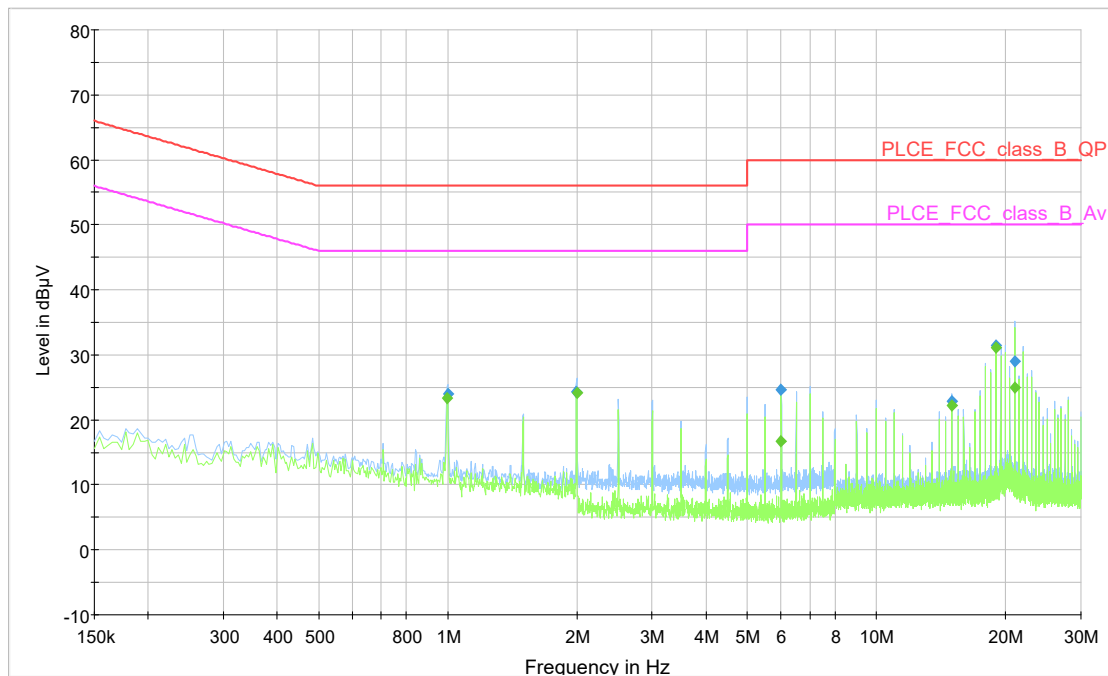
| <i>Results measured using the average detector</i> |                        |                  |                      |                                   |                    |                       |
|----------------------------------------------------|------------------------|------------------|----------------------|-----------------------------------|--------------------|-----------------------|
| <b>Reference Number</b>                            | <b>Frequency (MHz)</b> | <b>Conductor</b> | <b>Result (dBuV)</b> | <b>Specification Limit (dBuV)</b> | <b>Margin (dB)</b> | <b>Result Summary</b> |
| 1                                                  | 0.151                  | N                | 10.0                 | 56.0                              | 45.9               | PASS                  |
| 2                                                  | 0.408                  | N                | 4.7                  | 47.7                              | 43.0               | PASS                  |
| 3                                                  | 2.000                  | N                | 9.7                  | 46.0                              | 36.3               | PASS                  |
| 4                                                  | 7.500                  | L1               | 9.0                  | 50.0                              | 41.0               | PASS                  |
| 5                                                  | 27.000                 | N                | 20.8                 | 50.0                              | 29.2               | PASS                  |
| 6                                                  | 30.000                 | N                | 23.3                 | 50.0                              | 26.7               | PASS                  |



**24 Vac Supply**

| <i>Results measured using the quasi-peak detector</i> |                        |                  |                      |                                   |                    |                       |
|-------------------------------------------------------|------------------------|------------------|----------------------|-----------------------------------|--------------------|-----------------------|
| <i>Reference Number</i>                               | <i>Frequency (MHz)</i> | <i>Conductor</i> | <i>Result (dBuV)</i> | <i>Specification Limit (dBuV)</i> | <i>Margin (dB)</i> | <i>Result Summary</i> |
| 1                                                     | 1.000                  | N                | 24.0                 | 56.0                              | 32.0               | PASS                  |
| 2                                                     | 1.999                  | N                | 24.4                 | 56.0                              | 31.6               | PASS                  |
| 3                                                     | 6.000                  | N                | 24.6                 | 60.0                              | 35.4               | PASS                  |
| 4                                                     | 15.000                 | L1               | 22.9                 | 60.0                              | 37.1               | PASS                  |
| 5                                                     | 19.000                 | L1               | 31.4                 | 60.0                              | 28.6               | PASS                  |
| 6                                                     | 21.001                 | L1               | 29.1                 | 60.0                              | 30.9               | PASS                  |

| <i>Results measured using the average detector</i> |                        |                  |                      |                                   |                    |                       |
|----------------------------------------------------|------------------------|------------------|----------------------|-----------------------------------|--------------------|-----------------------|
| <i>Reference Number</i>                            | <i>Frequency (MHz)</i> | <i>Conductor</i> | <i>Result (dBuV)</i> | <i>Specification Limit (dBuV)</i> | <i>Margin (dB)</i> | <i>Result Summary</i> |
| 1                                                  | 0.999                  | N                | 23.4                 | 46.0                              | 22.6               | PASS                  |
| 2                                                  | 2.000                  | N                | 24.2                 | 46.0                              | 21.8               | PASS                  |
| 3                                                  | 5.995                  | N                | 16.7                 | 50.0                              | 33.3               | PASS                  |
| 4                                                  | 15.000                 | L1               | 22.2                 | 50.0                              | 27.8               | PASS                  |
| 5                                                  | 19.000                 | L1               | 31.1                 | 50.0                              | 18.9               | PASS                  |
| 6                                                  | 21.000                 | L1               | 25.0                 | 50.0                              | 25.0               | PASS                  |



## 13 Occupied Bandwidth

### 13.1 Definitions

The emission bandwidth (x dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated x dB below the maximum in-band spectral density of the modulated signal.

### 13.2 Test Parameters

|                             |                              |
|-----------------------------|------------------------------|
| Test Location:              | Element Hull                 |
| Test Chamber:               | Wireless Lab 2               |
| Test Standard and Clause:   | ANSI C63.10-2013, Clause 6.9 |
| EUT Frequency Measured:     | 24.125 GHz                   |
| Deviations From Standard:   | None                         |
| Measurement BW:             | 1 MHz                        |
| Spectrum Analyzer Video BW: | 3 MHz                        |
| Measurement Span:           | 200 MHz                      |
| Measurement Detector:       | Peak                         |

### Environmental Conditions (Normal Environment)

|                    |                                  |
|--------------------|----------------------------------|
| Temperature: 20 °C | +15 °C to +35 °C (as declared)   |
| Humidity: 37 % RH  | 20 % RH to 75 % RH (as declared) |

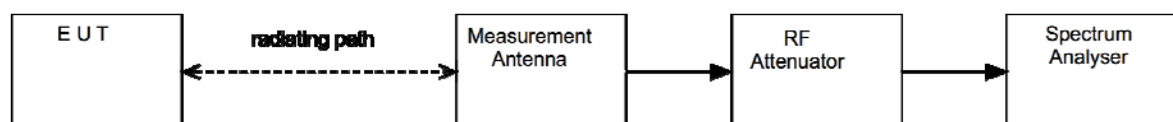
### 13.3 Test Limit

Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated.

### 13.4 Test Method

With the EUT connected as per Figure iii, the bandwidth of the EUT was measured on a spectrum analyser.

**Figure iii Test Setup**

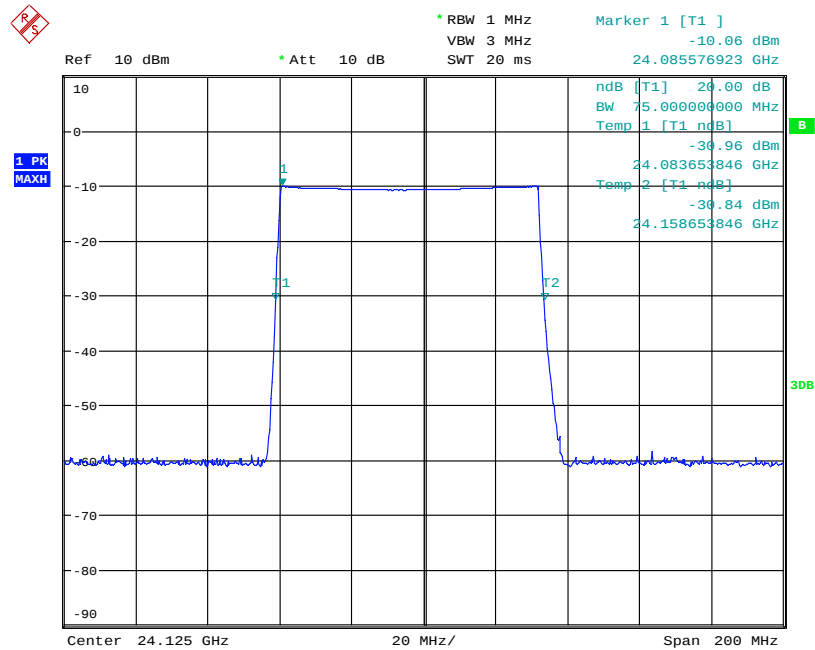


### 13.5 Test Equipment

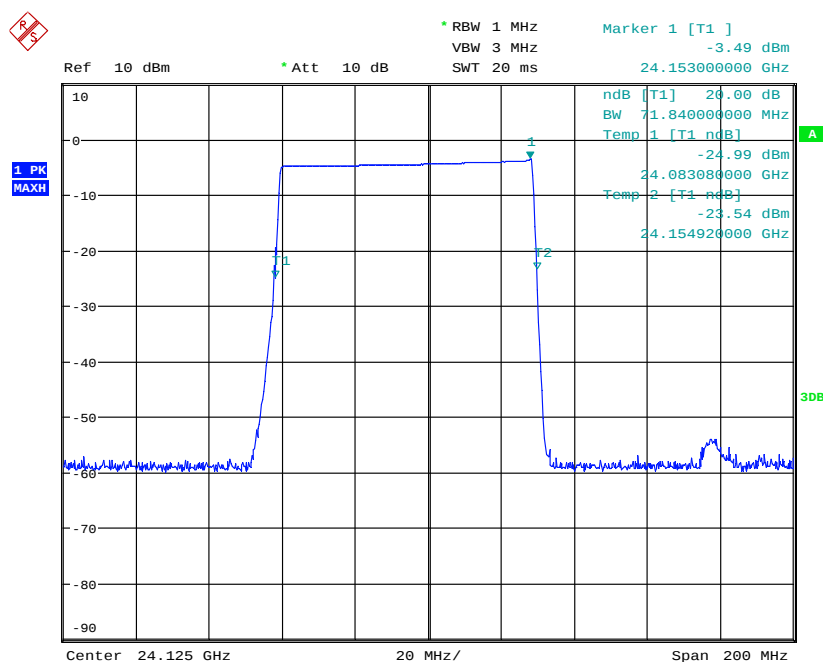
| Equipment Type    | Manufacturer | Equipment Description | Element No | Due For Calibration |
|-------------------|--------------|-----------------------|------------|---------------------|
| LB-180400-25-C-KF | A Info Inc   | Horn Antenna          | REF2245    | 2020-07-25          |
| FSU26             | R&S          | Spectrum Analyser     | REF909     | 2020-06-21          |

### 13.6 Test Results

| Channel: 1              |             |             |                       |        |
|-------------------------|-------------|-------------|-----------------------|--------|
| Channel Frequency (GHz) | $F_L$ (GHz) | $F_H$ (GHz) | 20 dB Bandwidth (MHz) | Result |
| 24.125                  | 24.083654   | 24.158654   | 75.000                | PASS   |



| Channel: 2              |             |             |                       |        |
|-------------------------|-------------|-------------|-----------------------|--------|
| Channel Frequency (GHz) | $F_L$ (GHz) | $F_H$ (GHz) | 20 dB Bandwidth (MHz) | Result |
| 24.125                  | 24.083080   | 24.154920   | 71.840                | PASS   |



## 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 1                     |
| Test Standard and Clause: | ANSI C63.10-2013, Clause 6.5 / 6.6 |
| EUT Frequency Measured:   | 24.125 GHz                         |
| Deviations From Standard: | None                               |
| Measurement Detector:     | Average RMS and Peak               |

### Environmental Conditions (Normal Environment)

|                    |                                  |
|--------------------|----------------------------------|
| Temperature: 23 °C | +15 °C to +35 °C (as declared)   |
| Humidity: 34 % RH  | 20 % RH to 75 % RH (as declared) |

### 14.3 Test Limit

The field strength measured at 3 meters shall not exceed the limit in the following table:

| Field Strength Limits              |                                     |                 |
|------------------------------------|-------------------------------------|-----------------|
| <i>Fundamental frequency (GHz)</i> | <i>Field strength (mV/m at 3 m)</i> | <i>Detector</i> |
| 24.00 to 24.25                     | 2500                                | Average, RMS    |

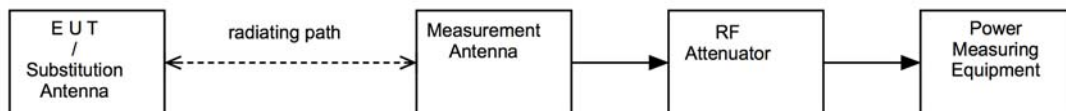
n.b. peak limit is 20 dB above average.

#### 14.4 Test Method

With the EUT connected as per Figure iv, the peak and average power was measured on the power meter.

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

| <i>Equipment Description</i> | <i>Manufacturer</i> | <i>Equipment Type</i> | <i>Element No</i> | <i>Due For Calibration</i> |
|------------------------------|---------------------|-----------------------|-------------------|----------------------------|
| Ferrite Lined Chamber        | Rainford            | ATS                   | REF886            | 2020-07-29                 |
| Pre-Amp (1 - 26.5 GHz)       | Agilent             | 8449B                 | REF913            | 2020-02-06                 |
| Horn Antenna                 | A Info Inc          | LB-180400-25-C-KF     | REF2246           | 2020-07-25                 |
| Power Meter                  | Agilent             | N1911A                | REF836            | 2020-08-28                 |
| Power Sensor                 | Agilent             | N1922A                | REF835            | 2020-08-28                 |

#### 14.6 Test Results

| <i>Channel: 1</i> |                                |                               |                        |                              |                          |                                |                              |               |
|-------------------|--------------------------------|-------------------------------|------------------------|------------------------------|--------------------------|--------------------------------|------------------------------|---------------|
| <i>Detector</i>   | <i>Channel Frequency (MHz)</i> | <i>Meas'd Emission (dBμV)</i> | <i>Cable Loss (dB)</i> | <i>Antenna Factor (dB/m)</i> | <i>Pre-amp Gain (dB)</i> | <i>Field Strength (dBμV/m)</i> | <i>Field Strength (mV/m)</i> | <i>Result</i> |
| Peak              | 24125.0                        | 98.0                          | 11.7                   | 34.0                         | 34.4                     | 109.3                          | 291.7                        | PASS          |
| Average           | 24125.0                        | 97.5                          | 11.7                   | 34.0                         | 34.4                     | 108.8                          | 275.4                        | PASS          |

| <i>Channel: 2</i> |                                |                               |                        |                              |                          |                                |                              |               |
|-------------------|--------------------------------|-------------------------------|------------------------|------------------------------|--------------------------|--------------------------------|------------------------------|---------------|
| <i>Detector</i>   | <i>Channel Frequency (MHz)</i> | <i>Meas'd Emission (dBμV)</i> | <i>Cable Loss (dB)</i> | <i>Antenna Factor (dB/m)</i> | <i>Pre-amp Gain (dB)</i> | <i>Field Strength (dBμV/m)</i> | <i>Field Strength (mV/m)</i> | <i>Result</i> |
| Peak              | 24125.0                        | 98.0                          | 11.7                   | 34.0                         | 34.4                     | 109.3                          | 291.7                        | PASS          |
| Average           | 24125.0                        | 97.6                          | 11.7                   | 34.0                         | 34.4                     | 108.9                          | 278.6                        | PASS          |

## 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%**