

Report on the FCC and ISED Testing of the: Apple Inc. Model: A2159

In accordance with FCC 47 CFR Part 15B
and ICES-003



Prepared for: Apple Inc.
One Apple Park Way
Cupertino
California 95014
USA

**Add value.
Inspire trust.**

FCC ID: BCGA2159 IC: 579C-A2159

COMMERCIAL-IN-CONFIDENCE

Document Number: 75945152-09 | Issue: 02

SIGNATURE

A3: ausser

| NAME | JOB TITLE | RESPONSIBLE FOR | ISSUE DATE |
|-------------|---------------------|----------------------|--------------|
| Andy Lawson | Senior EMC Engineer | Authorised Signatory | 01 July 2019 |

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

ENGINEERING STATEMENT

The measurements shown in this report were made in accordance with the procedures described on test pages. All reported testing was carried out on a sample equipment to demonstrate limited compliance with FCC 47 CFR Part 15B and ICES-003. The sample tested was found to comply with the requirements defined in the applied rules.

SIGNATURE

James Ruth

| NAME | JOB TITLE | RESPONSIBLE FOR | ISSUE DATE |
|-------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------|--------------|
| Mohammad Malik | Shift Technician | Testing | 01 July 2019 |
| FCC Accreditation 90987 Octagon House, Fareham Test Laboratory | Industry Canada Accreditation IC2932B-1 Octagon House, Fareham Test Laboratory | | |

EXECUTIVE SUMMARY

A sample of this product was tested and found to be compliant with FCC 47 CFR Part 15B and ICES-003: 2017 and 2016.



DISCLAIMER AND COPYRIGHT

This non-binding report has been prepared by TÜV SÜD with all reasonable skill and care. The document is confidential to the potential Client and TÜV SÜD. No part of this document may be reproduced without the prior written approval of TÜV SÜD. © 2019 TÜV SÜD. This report relates only to the actual item/items tested.

ACCREDITATION

Our UKAS Accreditation does not cover opinions and interpretations and any expressed are outside the scope of our UKAS Accreditation. Results of tests not covered by our UKAS Accreditation Schedule are marked NUA (Not UKAS Accredited).

TÜV SÜD
is a trading name of TUV SUD Ltd
Registered in Scotland at East Kilbride,
Glasgow G75 0QF, United Kingdom
Registered number: SC215164

TUV SUD Ltd is a
TÜV SÜD Group Company

Phone: +44 (0) 1489 558100
Fax: +44 (0) 1489 558101
www.tuv-sud.co.uk

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



Contents

| | | |
|----------|------------------------------------------------|-----------|
| 1 | Report Summary | 2 |
| 1.1 | Report Modification Record..... | 2 |
| 1.2 | Introduction..... | 2 |
| 1.3 | Brief Summary of Results | 3 |
| 1.4 | Product Information | 4 |
| 1.5 | Deviations from the Standard..... | 4 |
| 1.6 | EUT Modification Record | 4 |
| 1.7 | Test Location..... | 5 |
| 2 | Test Details | 6 |
| 2.1 | Conducted Disturbance at Mains Terminals | 6 |
| 2.2 | Radiated Disturbance..... | 10 |
| 3 | Measurement Uncertainty | 19 |



1 Report Summary

1.1 Report Modification Record

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

| Issue | Description of Change | Date of Issue |
|-------|-----------------------|---------------|
| 1 | First Issue | 01 May 2019 |
| 2 | Removed Set-Up Photos | 01 July 2019 |

Table 1

1.2 Introduction

| | |
|-------------------------------|-------------------------------------------------|
| Applicant | Apple Inc. |
| Manufacturer | Apple Inc. |
| Model Number(s) | A2159 |
| Serial Number(s) | C02Y4006L59F |
| Hardware Version(s) | REV 1.0 |
| Software Version(s) | 18F65 |
| Number of Samples Tested | 1 |
| Test Specification/Issue/Date | FCC 47 CFR Part 15B and ICES-003: 2017 and 2016 |
| Order Number | 0540175066 |
| Date | 21-February-2019 |
| Date of Receipt of EUT | 06-February-2019 |
| Start of Test | 03-March-2019 |
| Finish of Test | 05-March-2019 |
| Name of Engineer(s) | Mohammad Malik |
| Related Document(s) | ANSI C63.4: 2014 |



1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC 47 CFR Part 15B and ICES-003 is shown below.

| Section | Specification Clause | Test Description | Result | Comments/Base Standard |
|---------------------------------|----------------------|------------------------------------------|--------|------------------------|
| Configuration and Mode: TX idle | | | | |
| 2.1 | 15.107 and 6.1 | Conducted Disturbance at Mains Terminals | Pass | ANSI C63.4: 2014 |
| 2.2 | 15.109 and 6.2 | Radiated Disturbance | Pass | ANSI C63.4: 2014 |

Table 2



1.4 Product Information

1.4.1 Technical Description

The Equipment Under Test (EUT) was a Laptop computer with Bluetooth, Bluetooth Low Energy and 802.11 a/b/g/n/ac capabilities in the 2.4 GHz and 5.0 GHz bands.

1.4.2 EUT Configuration and Rationale for Radiated Spurious Emissions

The EUT was powered and charging from 120V, 60Hz via its USB type C power adaptor.

The device's internal battery was discharged prior to testing.

The display setting on the device was set to maximum brightness, and the device was configured to ensure that the display remained active throughout testing.

The spare USB type C port on the device, was connected via ethernet to another Laptop computer located outside the test chamber that was used to remotely control the unit.

A set of wired Ear Pods were connected to the EUT

All transmitters were disabled during this testing.

1.5 Deviations from the Standard

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

1.6 EUT Modification Record

The table below details modifications made to the EUT during the test programme.
The modifications incorporated during each test are recorded on the appropriate test pages.

| Modification State | Description of Modification still fitted to EUT | Modification Fitted By | Date Modification Fitted |
|-----------------------------|-------------------------------------------------|------------------------|--------------------------|
| Serial Number: C02Y4006L59F | | | |
| 0 | As supplied by the customer | Not Applicable | Not Applicable |

Table 3



1.7 Test Location

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

| Test Name | Name of Engineer(s) | Accreditation |
|------------------------------------------|---------------------|---------------|
| Configuration and Mode: TX idle | | |
| Conducted Disturbance at Mains Terminals | Mohammad Malik | UKAS |
| Radiated Disturbance | Mohammad Malik | UKAS |

Table 4

Office Address:

Octagon House
Concorde Way
Segensworth North
Fareham
Hampshire
PO15 5RL
United Kingdom



2 Test Details

2.1 Conducted Disturbance at Mains Terminals

2.1.1 Specification Reference

FCC 47 CFR Part 15B and ICES-003, Clause 15.107 and 6.1

2.1.2 Equipment Under Test and Modification State

A2159, S/N: C02Y4006L59F - Modification State 0

2.1.3 Date of Test

03-March-2019

2.1.4 Test Method

The EUT was placed on a non-conductive table 0.8m above a reference ground plane and 0.4m away from a vertical coupling plane

All power was connected to the EUT through an Artificial Mains Network (AMN). Conducted disturbance voltage measurements on mains lines were made at the output of the AMN. The AMN was placed 0.8m from the boundary of the EUT and bonded to the reference ground plane.

2.1.5 Example Calculation

Quasi-Peak level (dB μ V) = Receiver level (dB μ V) + Correction Factor (dB)
Margin (dB) = Limit (dB μ V) – Quasi-Peak level (dB μ V)

CISPR Average level (dB μ V) = Receiver level (dB μ V) + Correction Factor (dB)
Margin (dB) = Limit (dB μ V) – CISPR Average level (dB μ V)

2.1.6 Test Setup Diagram

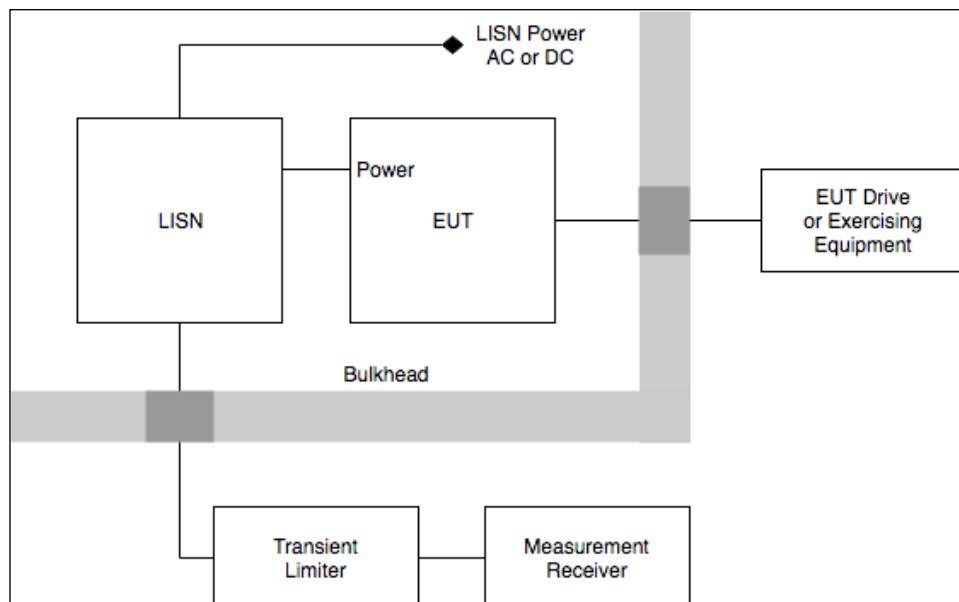


Figure 1 - Conducted Disturbance Test Setup



2.1.7 Environmental Conditions

Ambient Temperature 19.3 °C
Relative Humidity 53.3 %

2.1.8 Test Results

Results for Configuration and Mode: Unintentional Transmissions

Performance assessment of the EUT made during this test: Pass.

Detailed results are shown below.

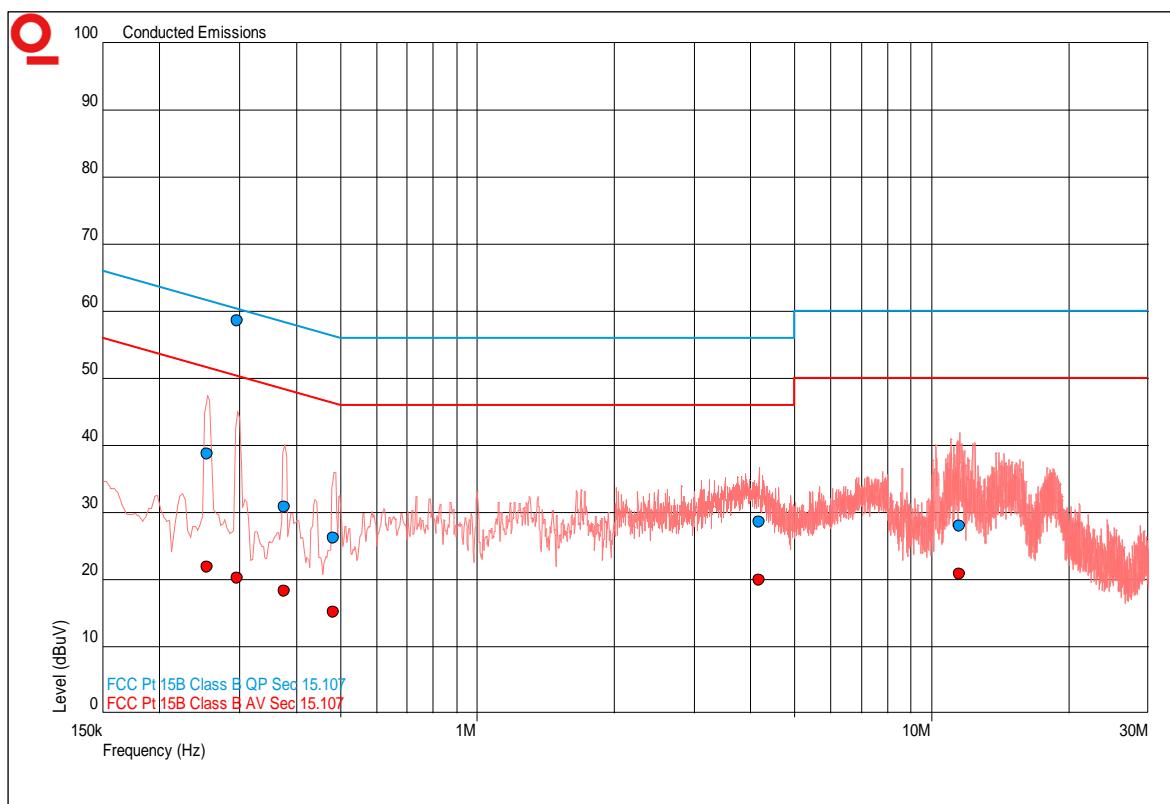


Figure 2 - Graphical Results – Live Line

| Frequency (MHz) | QP Level (dBμV) | QP Limit (dBμV) | QP Margin (dB) | CISPR AV Level (dBμV) | CISPR AV Limit (dBμV) | CISPR AV Margin (dB) |
|-----------------|-----------------|-----------------|----------------|-----------------------|-----------------------|----------------------|
| 0.254 | 38.7 | 61.6 | 22.9 | 21.9 | 51.6 | 29.8 |
| 0.296 | 58.6 | 60.3 | 1.8 | 20.2 | 50.3 | 30.2 |
| 0.377 | 30.8 | 58.3 | 27.6 | 18.3 | 48.3 | 30.0 |
| 0.484 | 26.3 | 56.3 | 30.0 | 15.1 | 46.3 | 31.2 |
| 4.168 | 28.6 | 56.0 | 27.4 | 19.9 | 46.0 | 26.1 |
| 11.514 | 28.0 | 60.0 | 32.0 | 20.8 | 50.0 | 29.2 |

Table 5

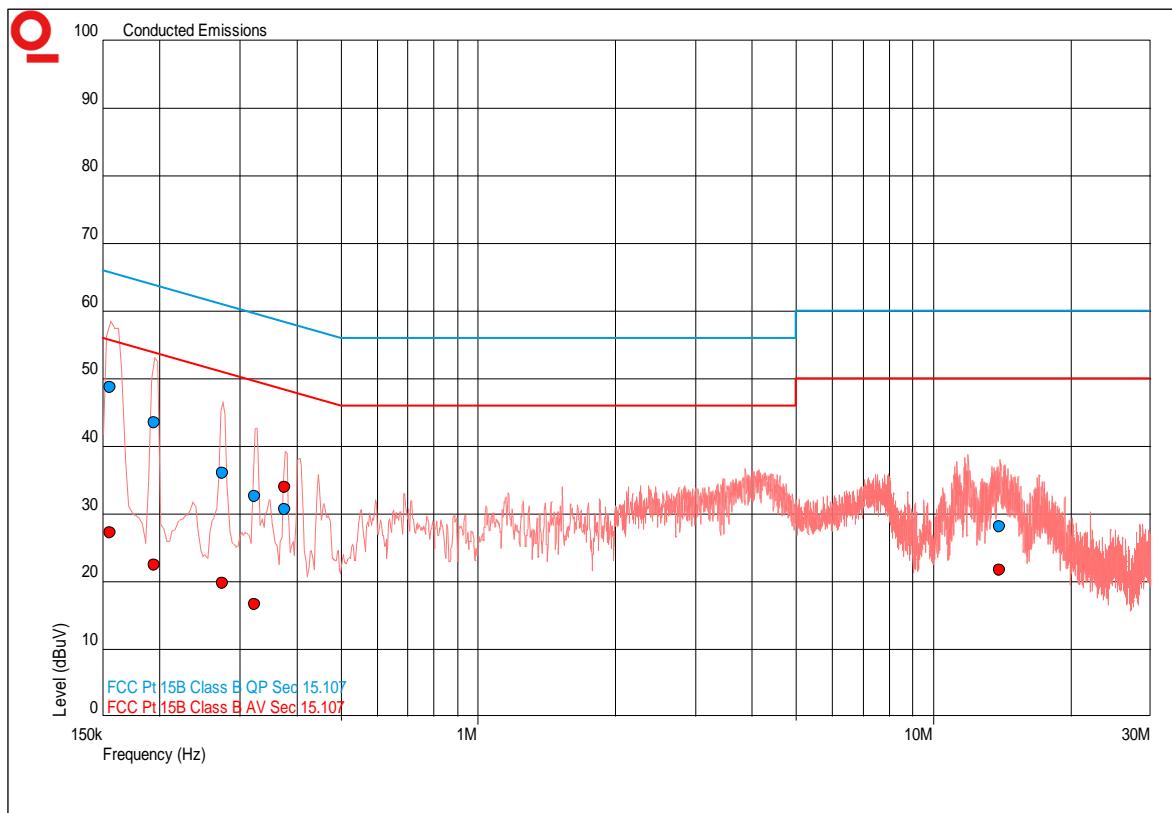


Figure 3 - Graphical Results – Neutral Line

| Frequency (MHz) | QP Level (dB μ V) | QP Limit (dB μ V) | QP Margin (dB) | CISPR AV Level (dB μ V) | CISPR AV Limit (dB μ V) | CISPR AV Margin (dB) |
|-----------------|-----------------------|-----------------------|----------------|-----------------------------|-----------------------------|----------------------|
| 0.156 | 48.7 | 65.7 | 17.0 | 27.2 | 55.7 | 28.5 |
| 0.195 | 43.6 | 63.8 | 20.3 | 22.5 | 53.8 | 31.4 |
| 0.275 | 36.1 | 61.0 | 24.8 | 19.8 | 51.0 | 31.1 |
| 0.323 | 32.6 | 59.6 | 27.1 | 16.7 | 49.6 | 32.9 |
| 0.377 | 30.6 | 58.3 | 27.7 | 33.9 | 48.3 | 14.5 |
| 13.968 | 28.1 | 60.0 | 31.9 | 21.8 | 50.0 | 28.2 |

Table 6



2.1.9 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

| Instrument | Manufacturer | Type No | TE No | Calibration Period (months) | Calibration Due |
|------------------------|-----------------|---------------|-------|-----------------------------|-----------------|
| Screened Room (5) | Rainford | Rainford | 1545 | 36 | 23-Jan-2021 |
| Compliance 5 Emissions | Teseq | V5.26.51 | 3275 | - | Software |
| EMI Test Receiver | Rohde & Schwarz | ESU40 | 3506 | 12 | 17-Dec-2019 |
| Transient Limiter | Hewlett Packard | 11947A | 15 | 12 | 26-Jul-2019 |
| LISN | Rohde & Schwarz | ESH3-Z5 | 1390 | 12 | 20-Nov-2019 |
| 8m N-Type RF Cable | Teledyne | PR90-088-8MTR | 5093 | 12 | 04-Oct-2019 |

Table 7



2.2 Radiated Disturbance

2.2.1 Specification Reference

FCC 47 CFR Part 15B and ICES-003, Clause 15.109 and 6.2

2.2.2 Equipment Under Test and Modification State

A2159, S/N: C02Y4006L59F - Modification State 0

2.2.3 Date of Test

03-March-2019 to 05-March-2019

2.2.4 Test Method

The EUT was set up in a semi-anechoic chamber on a remotely controlled turntable and placed on a non-conductive table 0.8m above a reference ground plane.

A pre-scan of the EUT emissions profile was made while varying the antenna-to-EUT azimuth, and antenna-to-EUT polarisation using a peak detector.

Measurements below 18GHz were taken at a 3m distance and measurements above 18GHz were taken at 1m distance.

Using the pre-scan list of the highest emissions detected, their bearing and associated antenna polarisation, the EUT was then formally measured using a Quasi-Peak, Peak, CISPR Average detector as appropriate.

The readings were maximized by adjusting the antenna height, polarisation and turntable azimuth, in accordance with the specification.

2.2.5 Example Calculation

Below 1GHz:

$$\begin{aligned}\text{Quasi-Peak level (dB}\mu\text{V/m)} &= \text{Receiver level (dB}\mu\text{V/m)} + \text{Correction Factor (dB)} \\ \text{Margin (dB)} &= \text{Limit (dB}\mu\text{V/m)} - \text{Quasi-Peak level (dB}\mu\text{V/m)}\end{aligned}$$

Above 1GHz:

$$\begin{aligned}\text{CISPR Average level (dB}\mu\text{V/m)} &= \text{Receiver level (dB}\mu\text{V/m)} + \text{Correction Factor (dB)} \\ \text{Margin (dB)} &= \text{Limit (dB}\mu\text{V/m)} - \text{CISPR Average level (dB}\mu\text{V/m)}\end{aligned}$$

$$\begin{aligned}\text{Peak level (dB}\mu\text{V/m)} &= \text{Receiver level (dB}\mu\text{V/m)} + \text{Correction Factor (dB)} \\ \text{Margin (dB)} &= \text{Limit (dB}\mu\text{V/m)} - \text{Peak level (dB}\mu\text{V/m)}\end{aligned}$$

2.2.6 Test Setup Diagram

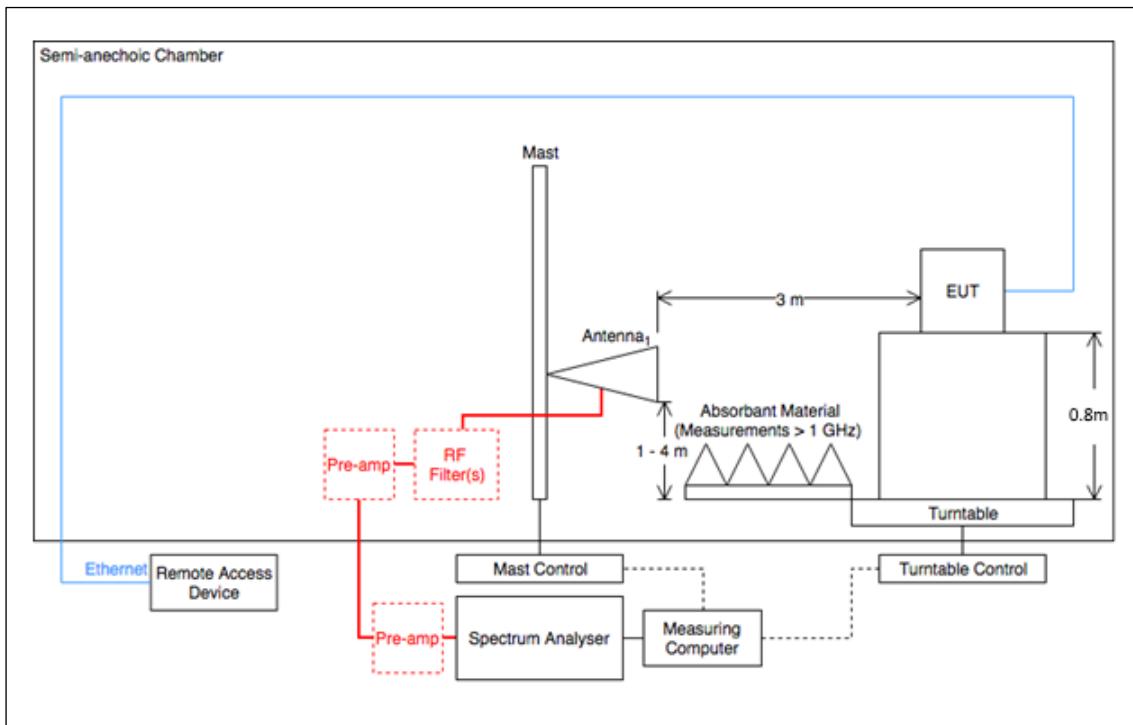


Figure 4 - Radiated Disturbance Test Setup

2.2.7 Environmental Conditions

Ambient Temperature 23.2 °C
Relative Humidity 43.0 %



2.2.8 Test Results

Results for Configuration and Mode: Unintentional Transmissions

Detailed results are shown below.

Highest frequency generated or used within the EUT: 5.9GHz
Which necessitates an upper frequency test limit of: 30GHz

| Frequency (MHz) | QP Level (dB μ V/m) | QP Limit (dB μ V/m) | QP Margin (dB) | Angle(Deg) | Height(m) | Polarity |
|-----------------|-------------------------|-------------------------|----------------|------------|-----------|----------|
| * | - | - | - | - | - | - |

Table 8 – 30 MHz to 1 GHz – Radiated Emissions Results

*No emissions were detected within 10 dB of the limit

| Frequency (GHz) | Result (dB μ V/m) | | Limit (dB μ V/m) | | Margin (dB) | |
|-----------------|-----------------------|---------------|----------------------|---------------|-------------|---------------|
| | Peak | CISPR Average | Peak | CISPR Average | Peak | CISPR Average |
| * | - | - | - | - | - | - |

Table 9 - 1GHz to 30GHz - Radiated Emissions Results

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

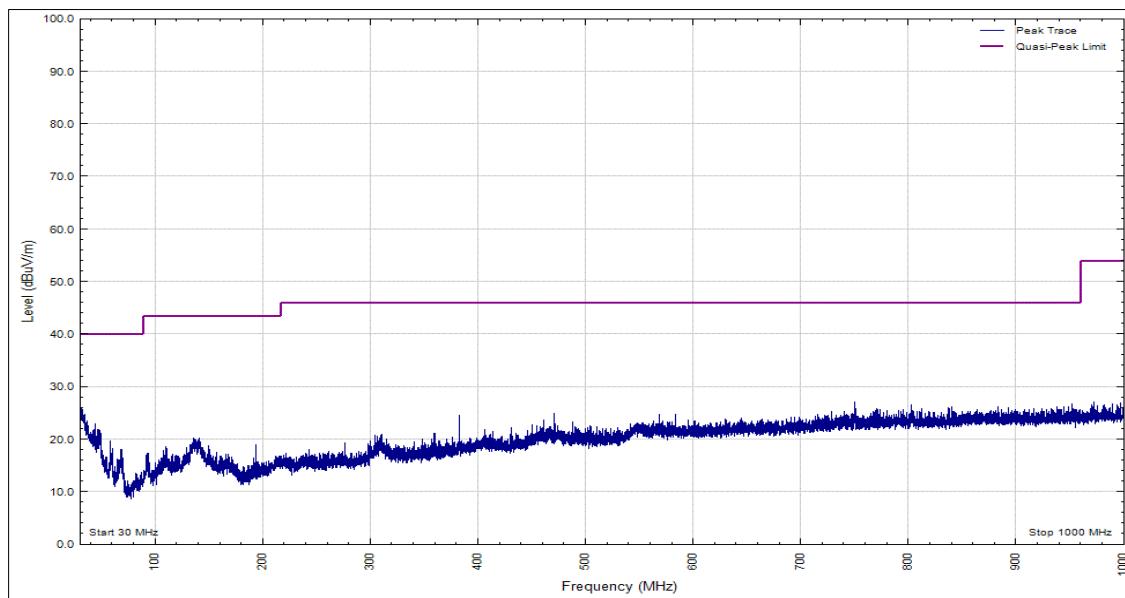


Figure 5 - Graphical Results - 30 MHz to 1 GHz – Vertical Polarity (Peak)

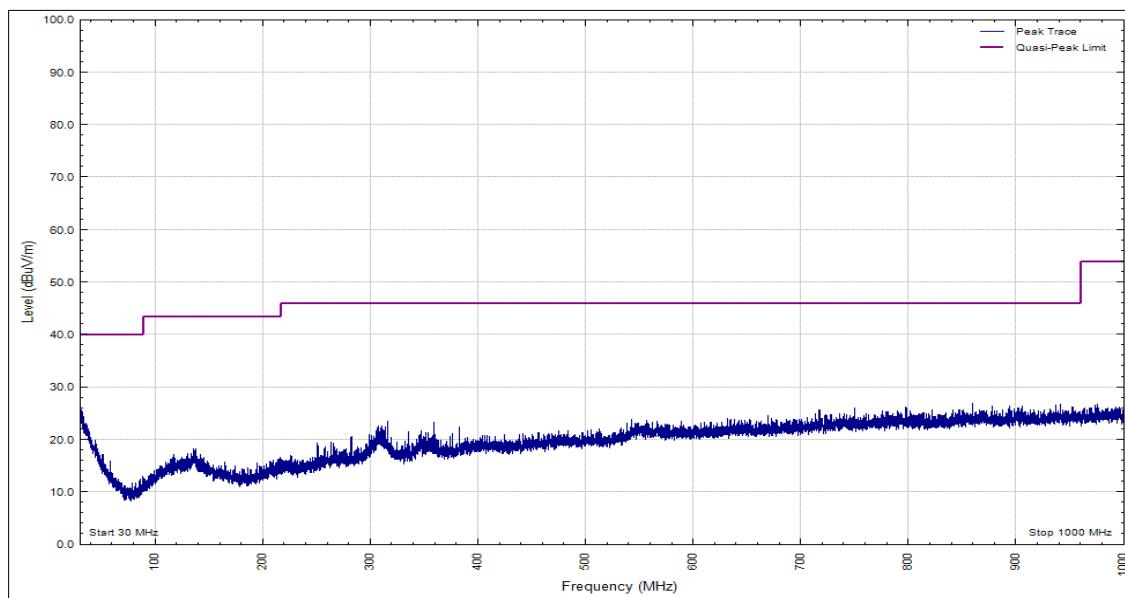


Figure 6 Graphical Results - 30 MHz to 1 GHz – Horizontal Polarity (Peak)

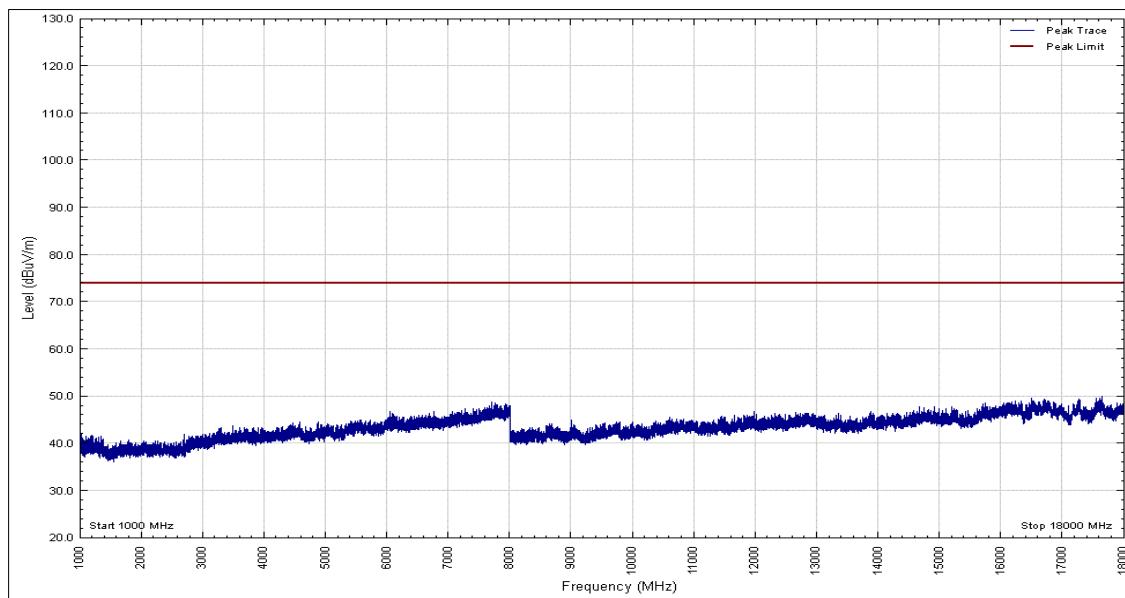


Figure 7 - Graphical Results - 1GHz to 18GHz, Horizontal Polarity (Peak)

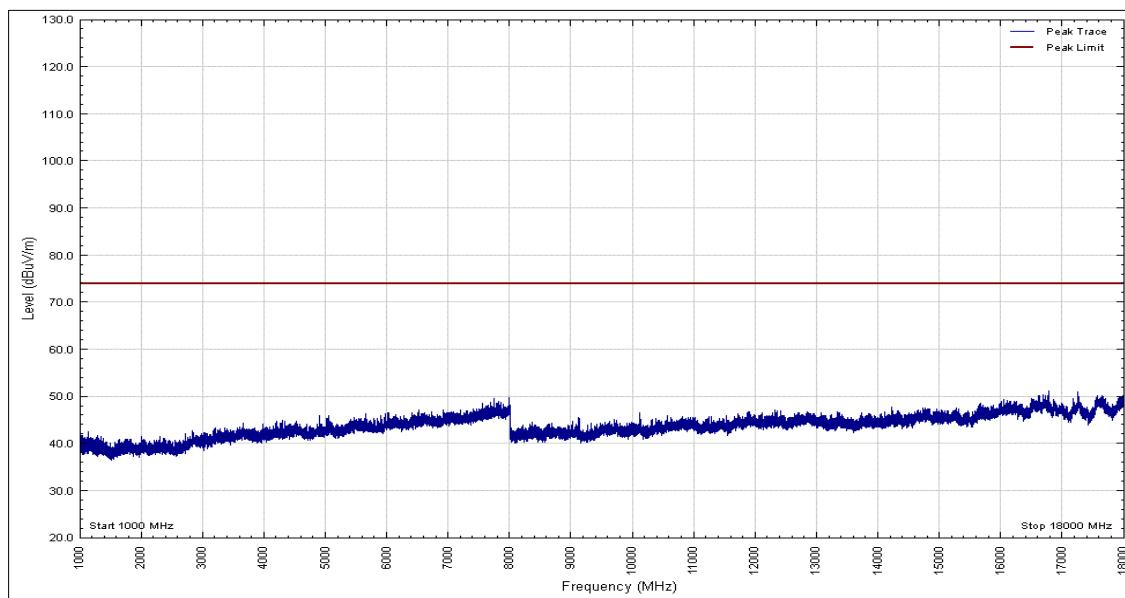


Figure 8 - Graphical Results - 1GHz to 18GHz, Vertical Polarity (Peak)

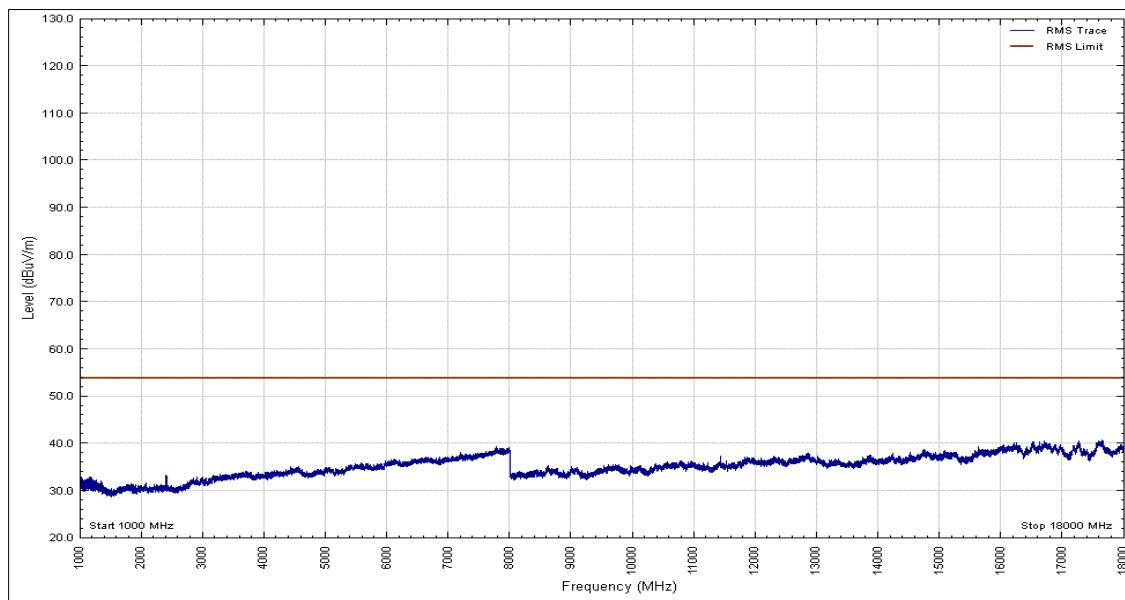


Figure 9 - Graphical Results - 1GHz to 18GHz, Horizontal Polarity (Average)

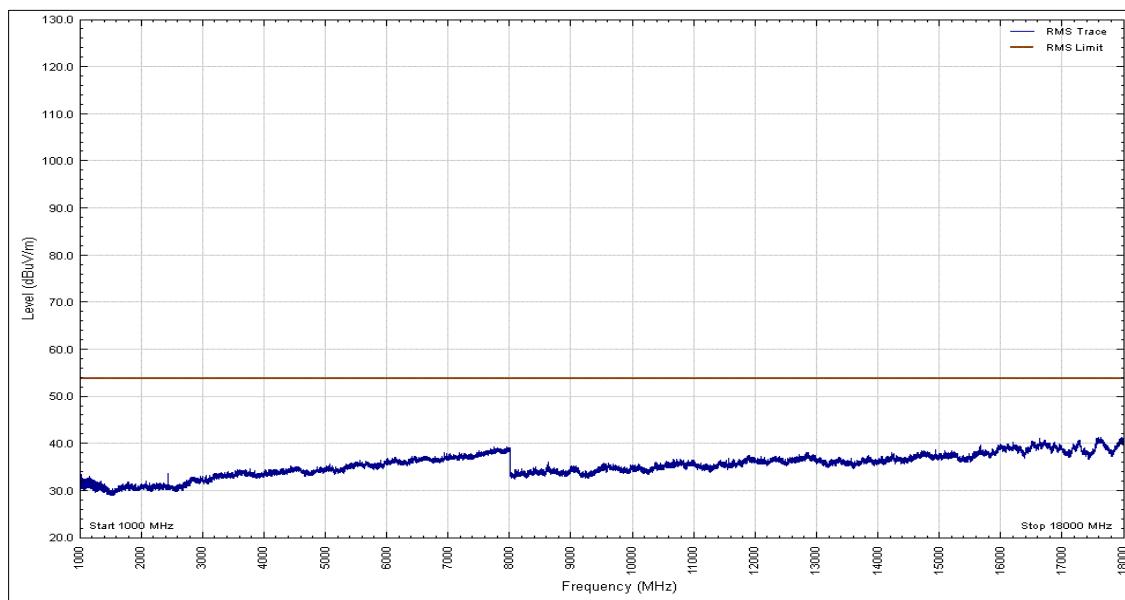


Figure 10 - Graphical Results - 1GHz to 18GHz, Vertical Polarity (Average)

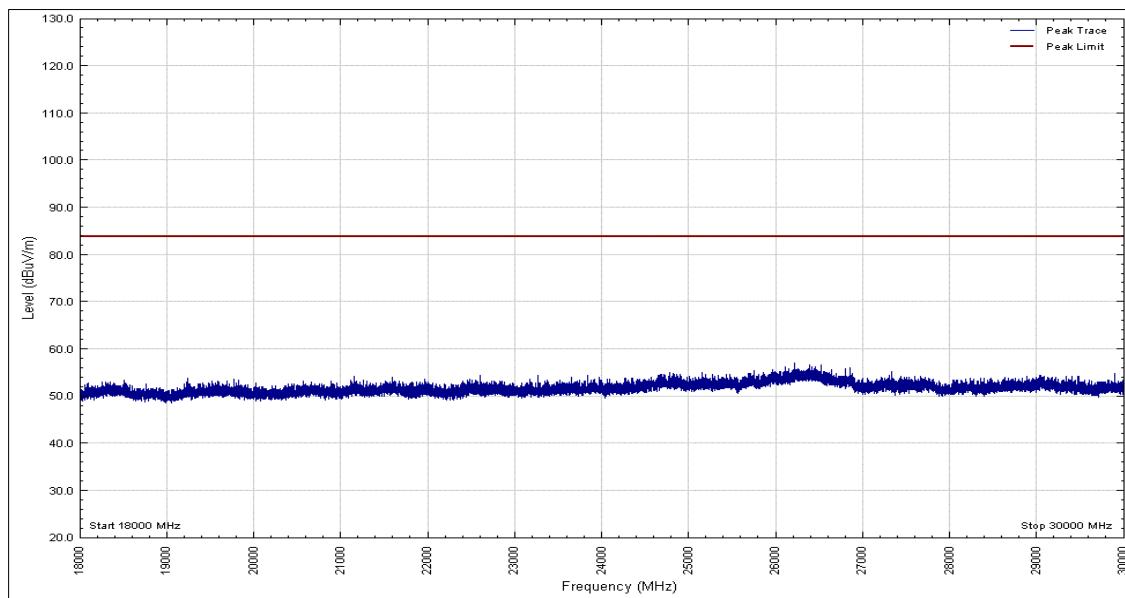


Figure 11 - Graphical Results - 18GHz to 30GHz, Horizontal Polarity (Peak)

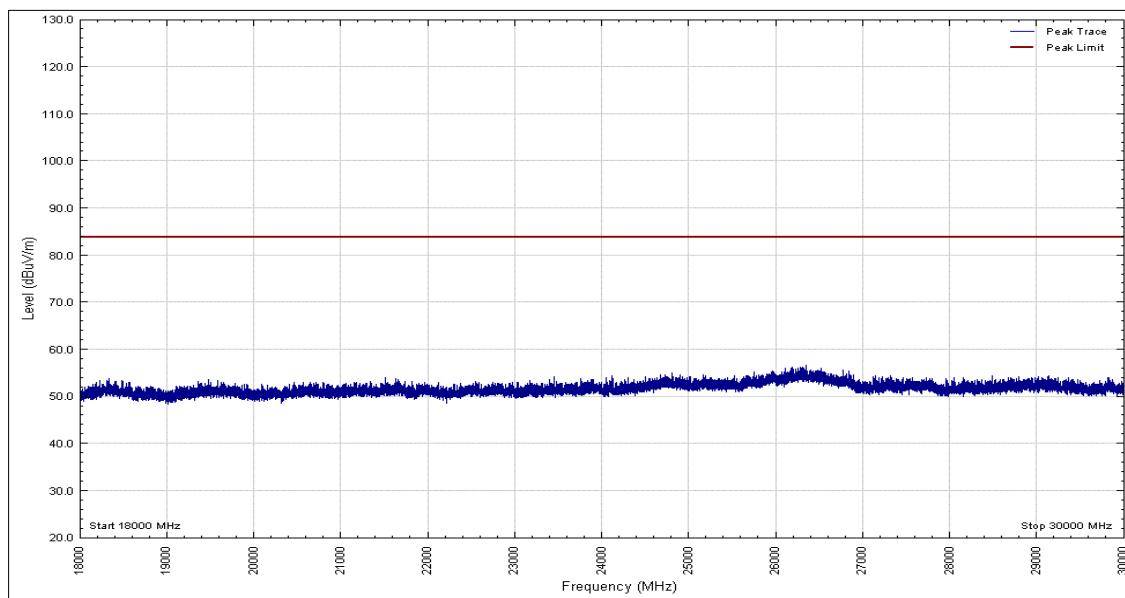


Figure 12 - Graphical Results - 18GHz to 30GHz, Vertical Polarity (Peak)

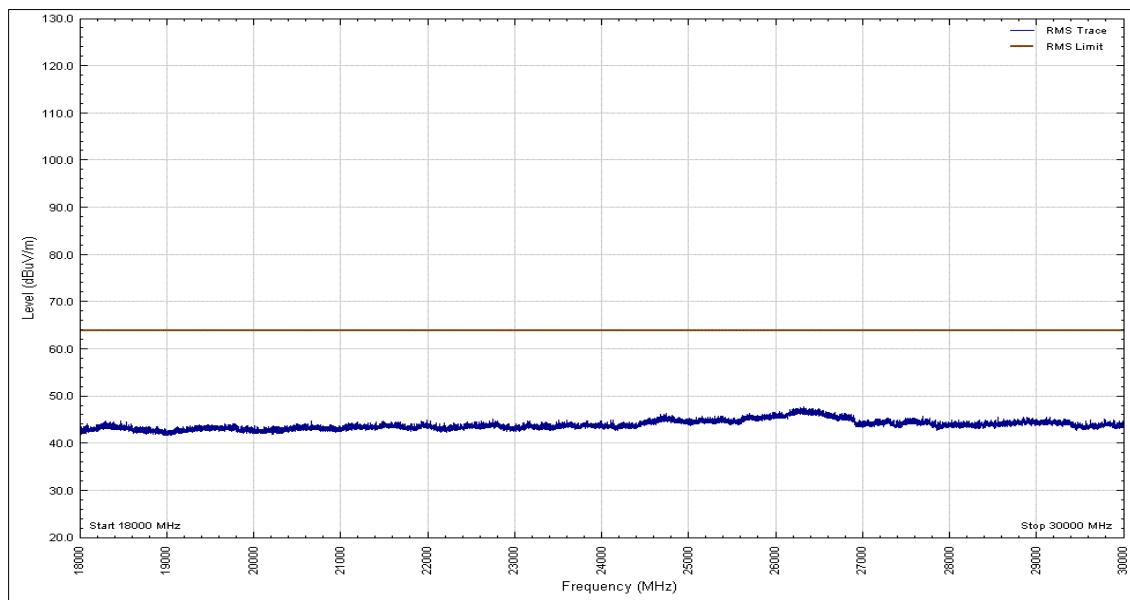


Figure 13 - Graphical Results - 18GHz to 30GHz, Horizontal Polarity (Average)

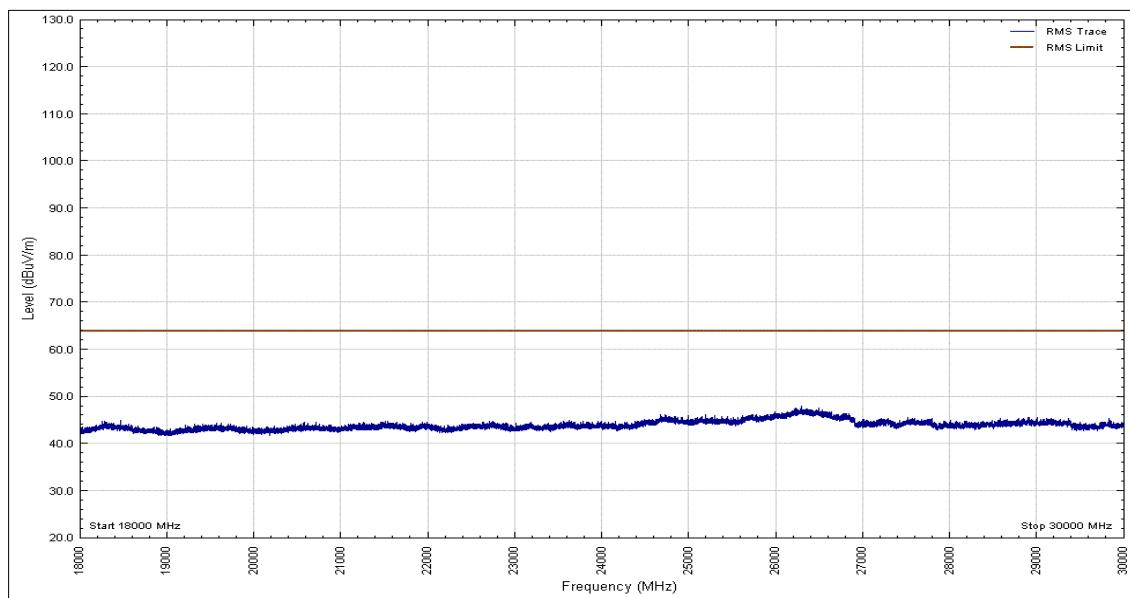


Figure 14 - G Graphical Results - 18GHz to 30GHz, Vertical Polarity (Average)



2.2.9 Test Location and Test Equipment Used

This test was carried out in RF Chamber 11.

| Instrument | Manufacturer | Type No | TE No | Calibration Period (months) | Calibration Due |
|-------------------------------------------|---------------------|--------------------|-------|-----------------------------|-----------------|
| Screened Room (11) | Rainford | Rainford | 5136 | 36 | 01-Nov-2021 |
| EMI Test Receiver | Rohde & Schwarz | ESW44 | 5084 | 12 | 12-Sep-2019 |
| EmX Test Software | TÜV SUD | V1.4.4 | 5125 | - | Software |
| Mast Controller | Maturo | Maturo NCD | 5159 | - | TU |
| Antenna with permanent attenuator (Bilog) | Schaffner | CBL6143 | 287 | 24 | 15-May-2020 |
| Double Ridged Waveguide Horn Antenna | ETS-Lindgren | 3117 | 4722 | 12 | 05-Mar-2020 |
| Antenna 18-40GHz (Double Ridge Guide) | Link Microtek Ltd | AM180HA-K-TU2 | 230 | 24 | 02-May-2020 |
| Pre-Amplifier, 1GHz to 8GHz | Wright Technologies | APS04-0085 | 4365 | 12 | 25-Oct-2019 |
| Pre-Amplifier, 8GHz to 18GHz | Phase One | PS04-0086 | 1533 | 12 | 08-Feb-2020 |
| Pre-Amplifier, 18GHz to 40GHz | Phase One | PS04-0087 | 1534 | 12 | 05-Feb-2020 |
| Hygrometer | Rotronic | Hygropalm | 2404 | 12 | 26-Apr-2019 |
| Cable 1503 2M 2.92(P)m 2.92(P)m | Rhophase | KPS-1503A-2000-KPS | 4293 | 12 | 26-Oct-2019 |
| Cable (Rx, Km-Km 2m) | Scott Cables | KPS-1501-2000-KPS | 4526 | 6 | 26-Apr-2019 |
| 4dB Attenuator | Pasternack | PE7047-4 | 4935 | 24 | 28-Nov-2019 |
| 8m N-Type RF Cable | Teledyne | PR90-088-8MTR | 5095 | 12 | 04-Oct-2019 |
| Cable (18GHz) | Rosenberger | LU7-071-1000 | 5101 | 12 | 04-Oct-2019 |
| Cable (18GHz) | Rosenberger | LU7-071-1000 | 5102 | 12 | 04-Oct-2019 |
| Cable (18GHz) | Rosenberger | LU7-071-1000 | 5104 | 12 | 05-Oct-2019 |
| Cable (18GHz) | Rosenberger | LU7-071-2000 | 5107 | 12 | 05-Oct-2019 |

Table 10

TU – Traceability Unscheduled



3 Measurement Uncertainty

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

| Test Name | Measurement Uncertainty |
|------------------------------------------|---------------------------------------------------------------------------------------------|
| Radiated Disturbance | 30 MHz to 1 GHz, Bilog Antenna, ± 5.2 dB 1 GHz to 40 GHz, Horn Antenna, ± 6.3 dB |
| Conducted Disturbance at Mains Terminals | 150 kHz to 30 MHz, LISN, ± 3.7 dB |

Table 11

Worst case error for both Time and Frequency measurement 12 parts in 106.
All measurement uncertainties have been calculated in accordance with CISPR guidelines.