Report on the Radio Testing

For

Accesso Technology Group PLC

on

Bluetooth Head Unit

Report no. TRA-033907-07-45-00A

21st March 2017

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-033907-07-45-00A
Issue: A

REPORT ON THE RADIO TESTING OF A
Accesso Technology Group PLC
Bluetooth Head Unit
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247 & IC RSS-247 Intermodulation Products Only

TEST DATE: 2nd -17th February 2017

Written by: Alan Wong

Alan Wong
Radio Test Engineer

Digitally signed by John Charters
DN: cn=John Charters, o=Element Materials Technology, ou, email=john.charters@element.com, c=GB
Date: 2017.04.06 14:05:53 +01'00'

Approved by:

John Charters
Department Manager - Radio

Date: 21st March 2017

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	21st March 2017	Original

2 Summary

TEST REPORT NUMBER:	TRA-033907-07-45-00A
WORKS ORDER NUMBER	TRA-033907-07
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. Canada: Testing of radio apparatus for TAC (technical acceptance certificate) per subsections 4(2) of the Radiocommunication Act and 21(1) of the Radiocommunication Regulations.
TEST SPECIFICATION(S):	47CFR15.247 & RSS-247 Intermodulation Products Only
EQUIPMENT UNDER TEST (EUT):	Bluetooth Head Unit
FCC IDENTIFIER:	2AKCM-P2400-485
INDUSTRY CANADA:	21963-P2400485
EUT SERIAL NUMBER:	Sample 45
MANUFACTURER:	Accesso Technology Group PLC
ADDRESS:	Unit 2 The Pavilions Ruscombe Park Twyford Berkshire RG10 9NN United Kingdom
CLIENT CONTACT:	Tony Underwood ☎ 0044 1189 347446 ✉ tony.underwood@accesso.com
ORDER NUMBER:	1451
TEST DATE:	2nd -17th February 2017
TESTED BY:	Alan Wong Element

2.1 Test Summary

Test Method and Description		*Requirement Clause*		*Applicable to this equipment*	*Result / Note*
		RSS	*47CFR15*		
Radiated spurious emissions (including any intermodulation products in restricted bands of operation and cabinet radiation)		Gen, 8.10	15.205	☒	*PASS*
AC power line conducted emissions		Gen, 8.8	15.207	☐	*NOTE 1*
Occupied bandwidth		247, 5.2 (1)	15.247(a)(2)	☐	*NOTE 1*
Conducted carrier power	Peak	247, 5.4 (4)	15.247(b)(3)	☐	*NOTE 1*
	Max.			☐	
Conducted / radiated RF power out-of-band		247, 5.5	15.247(d)	☐	*NOTE 1*
Power spectral density, conducted		247, 5.2 (2)	15.247(e)	☐	*NOTE 1*
Calculation of duty correction		-	15.35(c)	☐	*NOTE 1*

NOTE 1: Only intermodulation products and radiated spurious emissions was tested, under specific order from Accesso Technology Group PLC, hence other tests were not carried out.

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).

3 Contents

4 Introduction

This report TRA-033907-07-45-00A presents the results of the Radio testing on an Accesso Technology Group PLC, Bluetooth Head Unit to specification 47CFR15 Radio Frequency Devices and RSS-247 Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment.

The testing was carried out for Accesso Technology Group PLC by Element, at the address(es) detailed below.

☒ Element Hull
Unit E
South Orbital Trading Park
Hedon Road
Hull
HU9 1NJ
UK

☐ Element Skelmersdale
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.

IC Registration Number(s):

Element Hull	3483A
Element North West	3930B

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

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.
- Industry Canada RSS-247, Issue 1, May 2015 – Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- Industry Canada RSS-Gen, Issue 4, November 2014 – General Requirements for Compliance of Radio Apparatus

5.2 Deviations from Test Standards

There were no deviations from the test standard.

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: Bluetooth Head Unit
- Serial Number: Not applicable
- Model Number: model No-ACC
- 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.

Laptop Computer and feeder unit.

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for Tx tests was as follows…
Using the computer installed with test software, different batch files was used to set the feeder unit, which in turn to control the EUT for transmitting modulated signals on top, middle and low channels, with centre frequencies at 2480 MHz, 2426 MHz and 2402 MHz, respectively. Power level was fixed at +4 dBm on the sample.

7.3.2 Reception

Receiver test was not required.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	2.40 – 2.50 GHz
Modulation type(s):	GFSK
Occupied channel bandwidth(s):	2 MHz
Channel spacing:	2000 kHz
ITU emission designator(s):	2M00F1D
Declared output power(s):	+4dBm
Warning against use of alternative antennas in user manual (yes/no):	Yes
Nominal Supply Voltage:	24 V DC
Frequency stability:	20 ppm
Location of notice for license exempt use:	User manual
Method of prevention of use on non-US / non-Canadian frequencies:	Not user selectable
Duty cycle:	10 to 90 % (default 50%)

7.4.2 Antennas

Type:	TL-ANT2409A Directional Antenna
Frequency range:	2.4 – 2.5 GHz
Impedance:	50 Ω
SWR:	1.92:1 Max
Gain:	9dBi
Polarisation:	Linear Vertical
Beam width:	Horizontal 60º. Vertical 76º.
Connector type:	SMA
Length:	100cm
Weight:	500g
Environmental limits:	-10 ºC ~ 60 ºC, 10 % ~ 90 % non-condensing
Mounting:	Pole mount or wall mount

7.4.3 Product specific declarations

Multiple antenna configuration(s), e.g. MIMO:	Yes, 1 – 3 antennas working on different frequency channels
Fixed pt-pt operations (yes/no):	No
Installation manual advice on pt-pt operational restrictions (yes/no):	No
Fixed pt-mpt operations (yes/no):	Yes
Simultaneous tx (yes/no):	Yes

7.5 EUT Description

The EUT is part of the Accesso 100% Virtual Queuing System (VQS) allowing guests to make registrations for rides without the need to wait physically at the ride itself.
The BLE Base Station is a fixed mains powered device that is connected to a wired Ethernet network. It transmits and receives Bluetooth Low Energy data packets to and from the Qband+ wristbands which are worn by guests in public attractions such as theme parks and water parks. It also contains a GPS receiver to enable very accurate time synchronisation. The BLE Base Stations track the movement of guests around the park, and provide the facility to locate Qbands+ at the park exit for the purposes deactivating the band, and for application of simple detection of theft prevention.

The unit offers the following.

- 2.4GHz RF sub-system
- Supports Bluetooth Low Energy standard
- Supports GPS receiver for very accurate timing
- Supports RS422/RS485 for extended distances up to 1Km
- Simple 10 – 30V DC power requirement (nominal 24V DC)
- Weatherproof IP66 enclosure

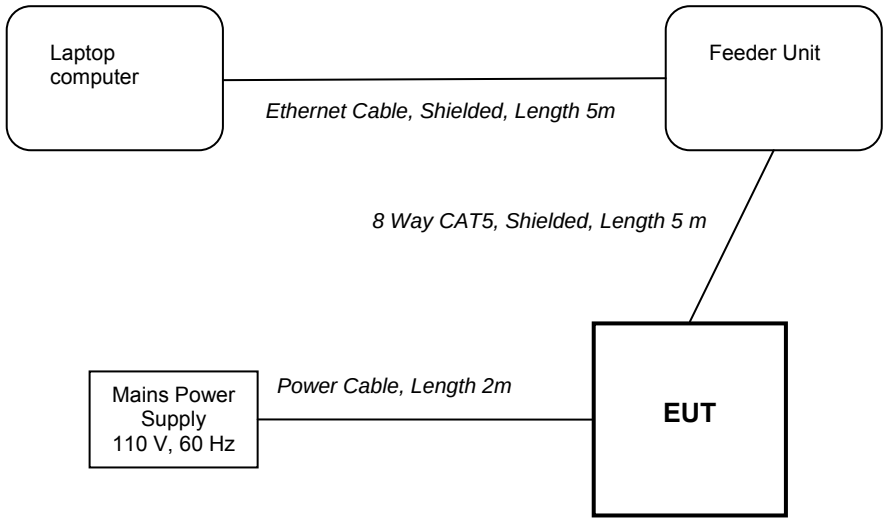
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

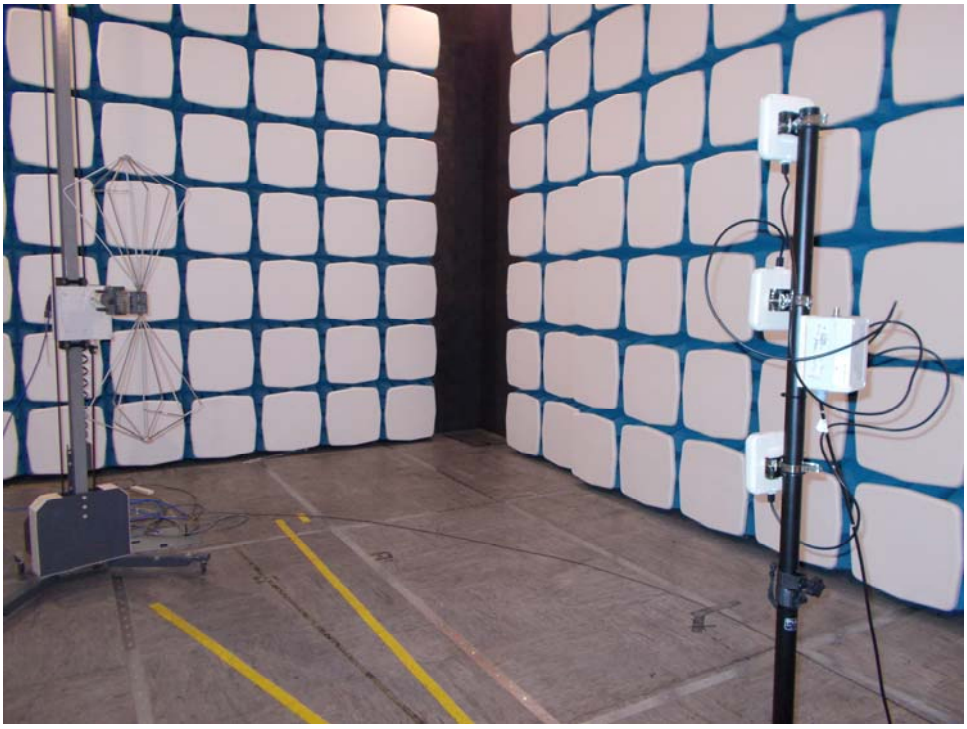
9.1 Block Diagram

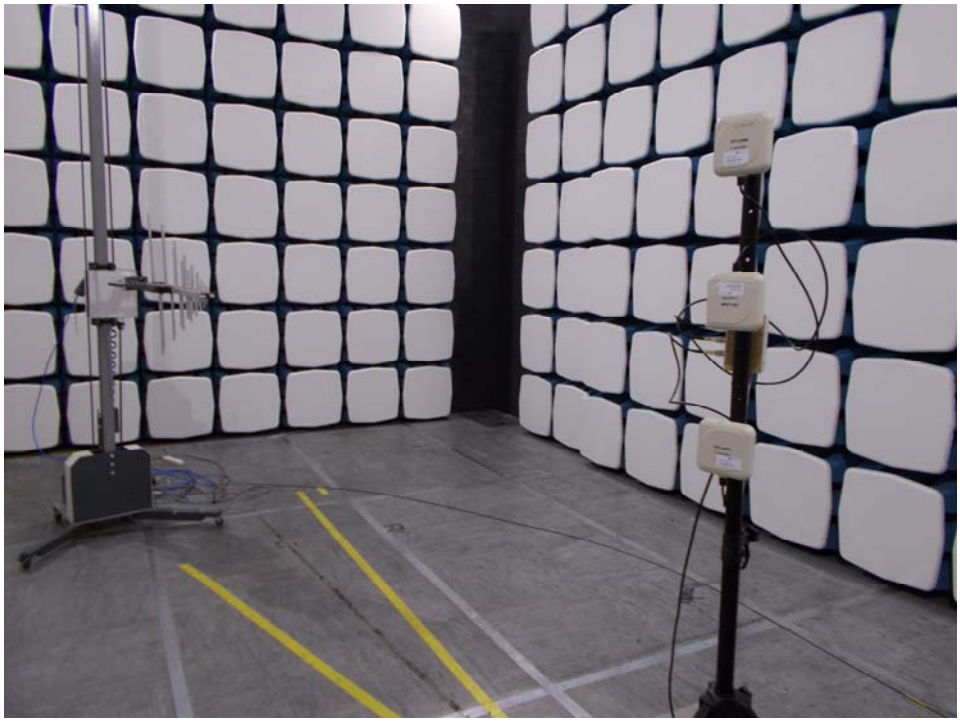
The following diagram shows basic EUT interconnections with cable type and cable lengths identified:

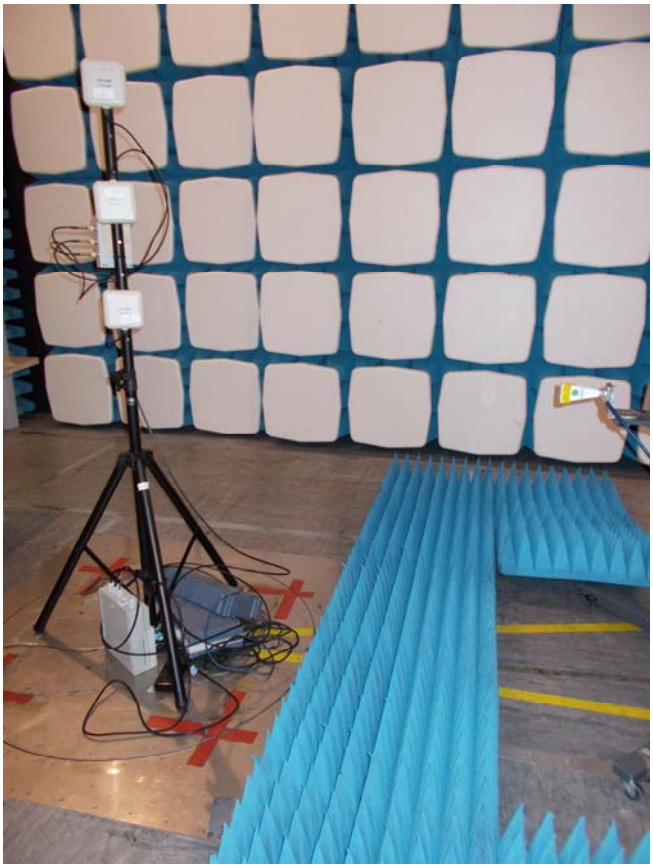


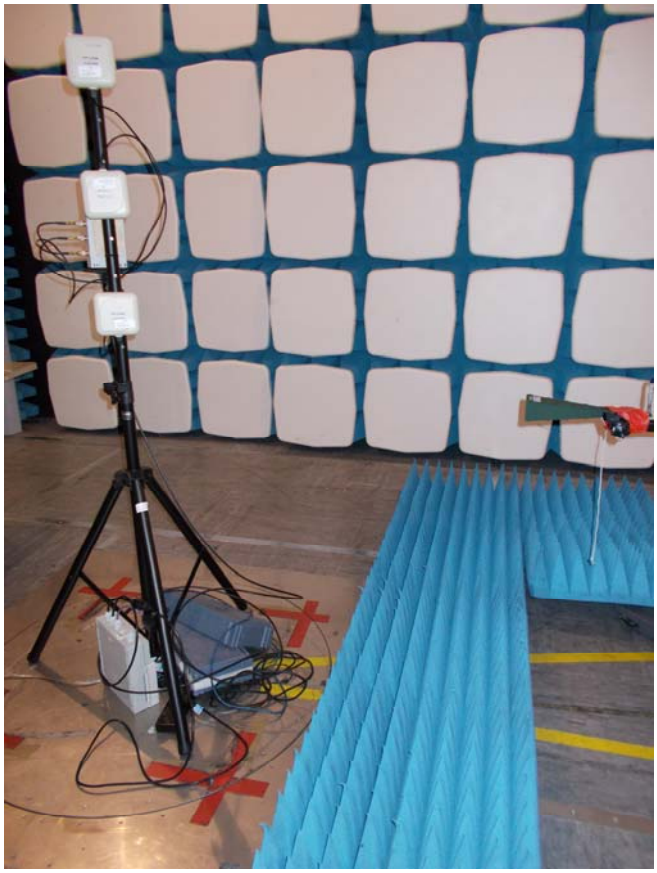
9.2 General Set-up Photograph

The following photograph shows basic EUT set-up:









10 General Technical Parameters

10.1 Normal Conditions

The E U T was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was approx. 110 V ac, 60 Hz, from the mains.

10.2 Varying Test Conditions

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

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

	Category	***Nominal***	***Variation***
☒	Mains	110Vac	85 % and 115 %
☐	Battery	New battery	N/A

11 Radiated emissions

11.1 Definitions

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. Note that intermodulation products that may be caused by simultaneous transmission of different antennae, are also included.

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 Laboratory 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequencies Measured:	2402, 2426 and 2480 MHz
EUT Channel Bandwidths:	2 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: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 110 V ac	110 V ac ±10 % (as declared)

11.3 Test Limit

Unwanted emissions that fall within the restricted frequency bands shall comply with the limits specified:

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

Frequency (MHz)	*Field Strength (µV/m at 3 m)*
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

11.4 Test Method

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

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

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

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

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

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

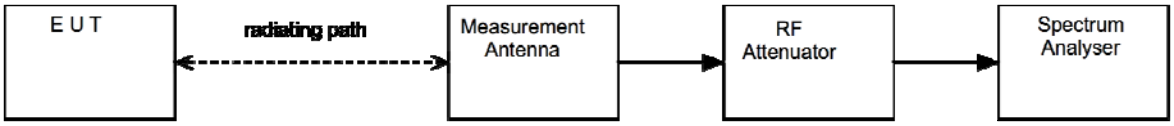
$$FS = PR + CL + AF – PA + DC – CF$$

Where,

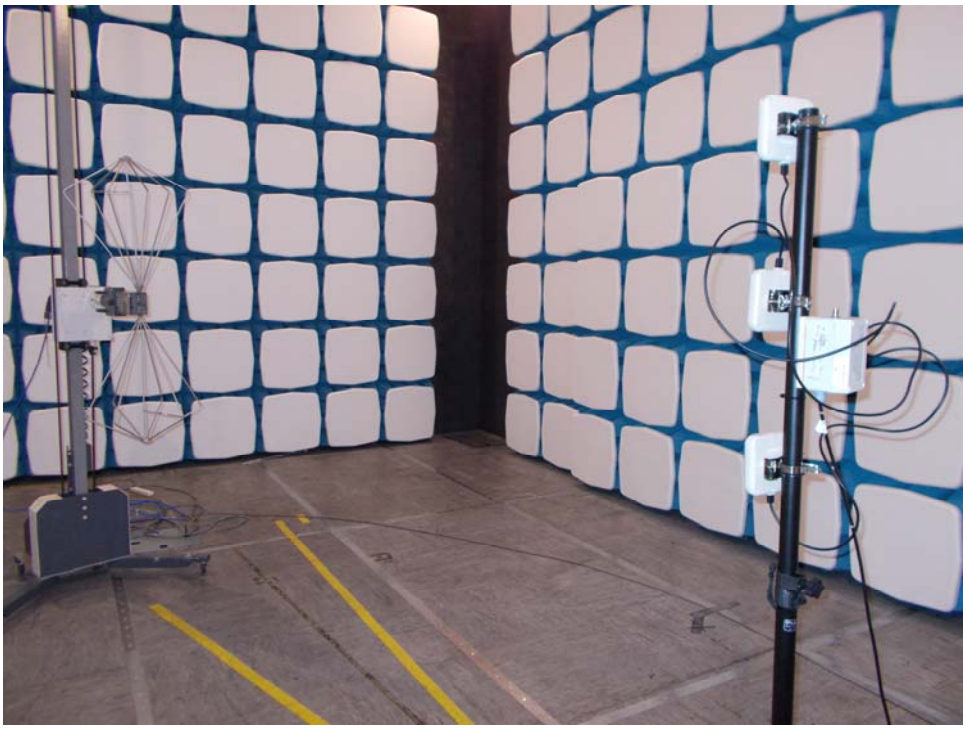
PR is the power recorded on the receiver / spectrum analyzer in dBµV;
CL is the cable loss in dB;
AF is the test antenna factor in dB/m;
PA is the pre-amplifier gain in dB (where used);
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
CF is the distance factor in dB (where measurement distance different to limit distance);

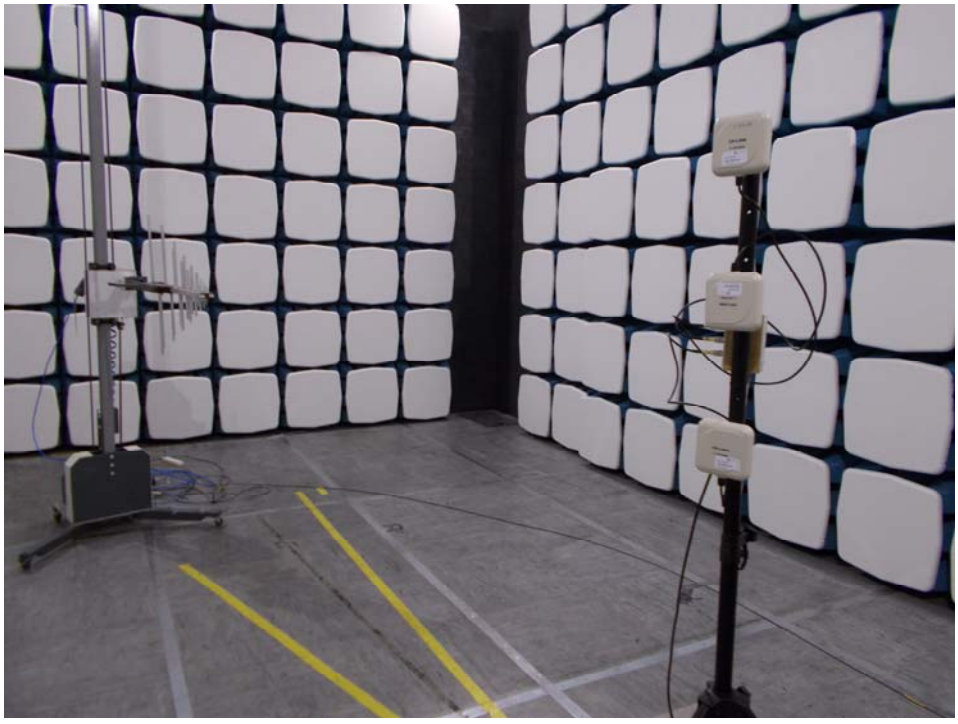
This field strength value is then compared with the regulatory limit.

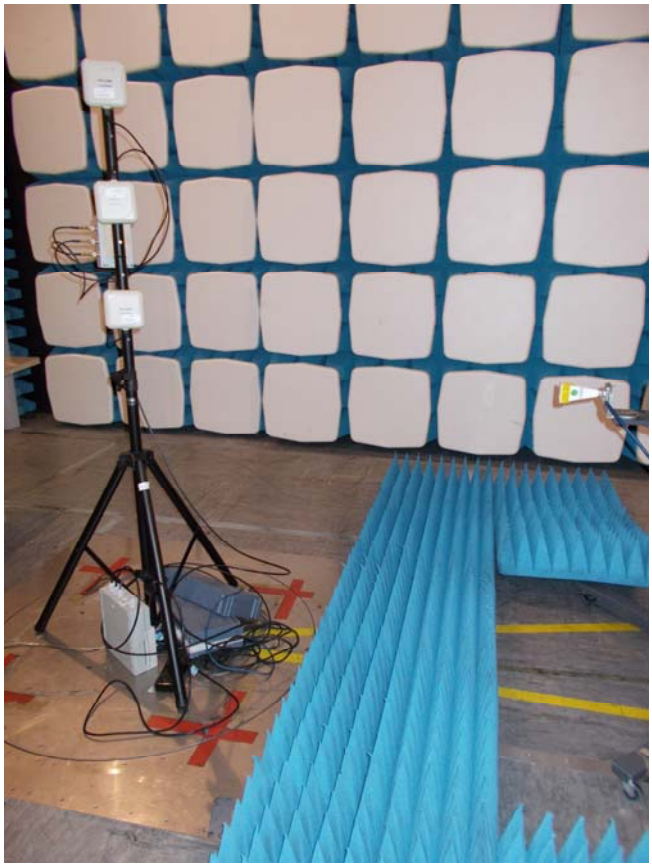
Figure i Test Setup

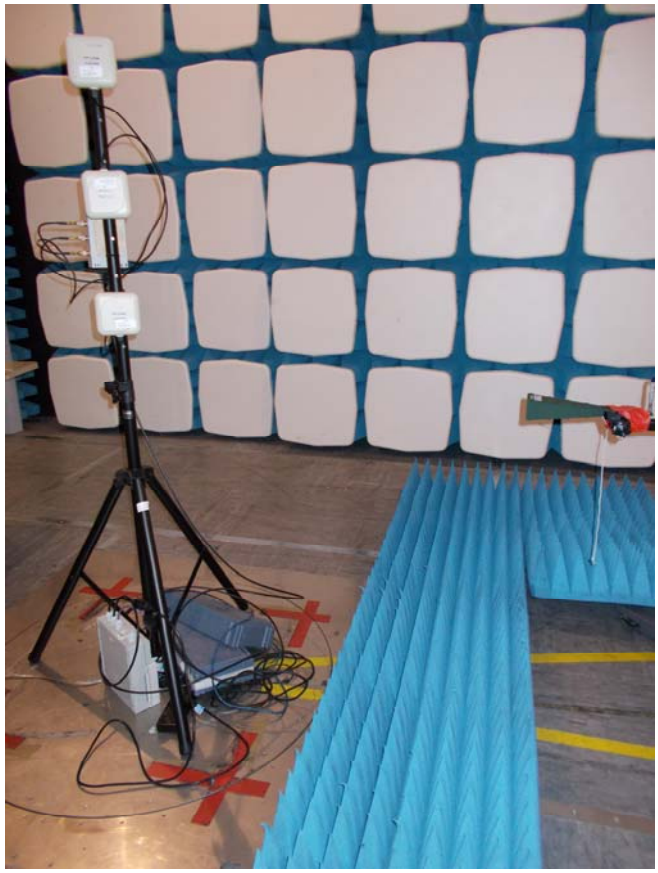


11.5 Test Set-up Photographs





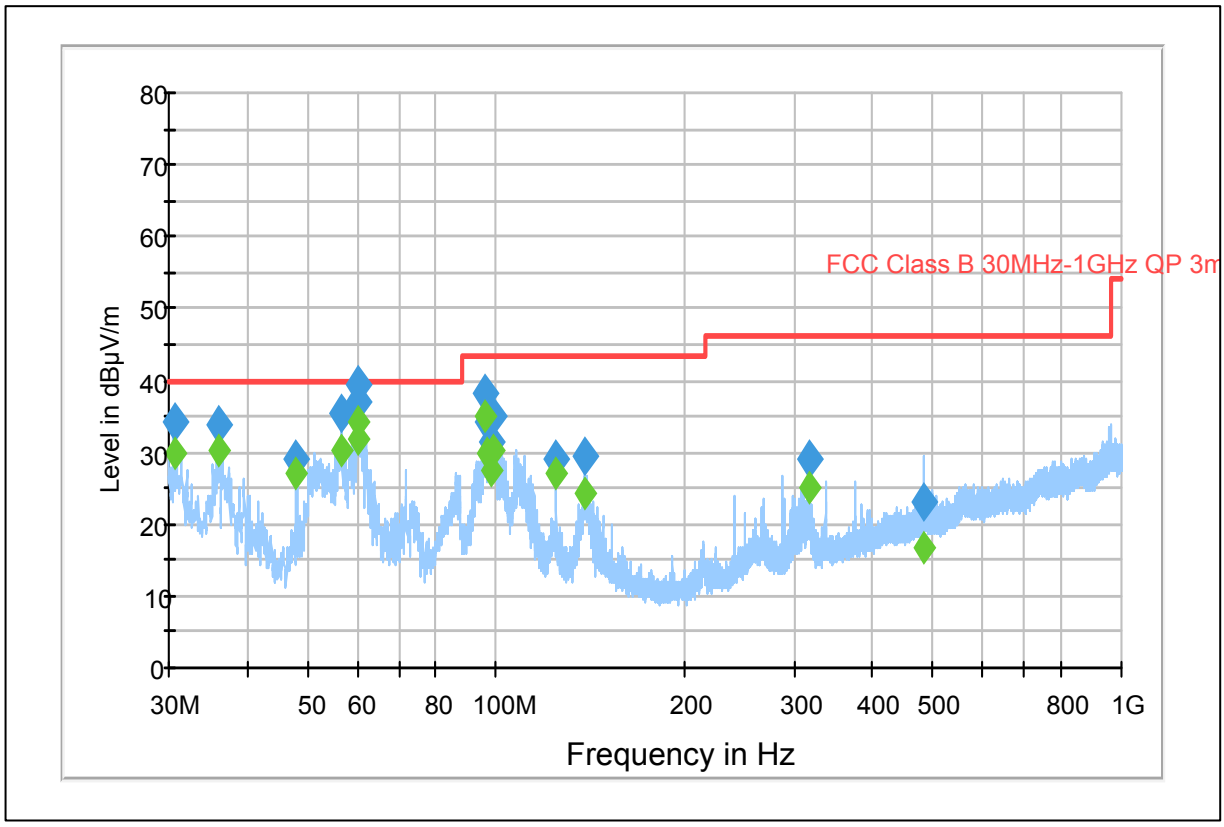


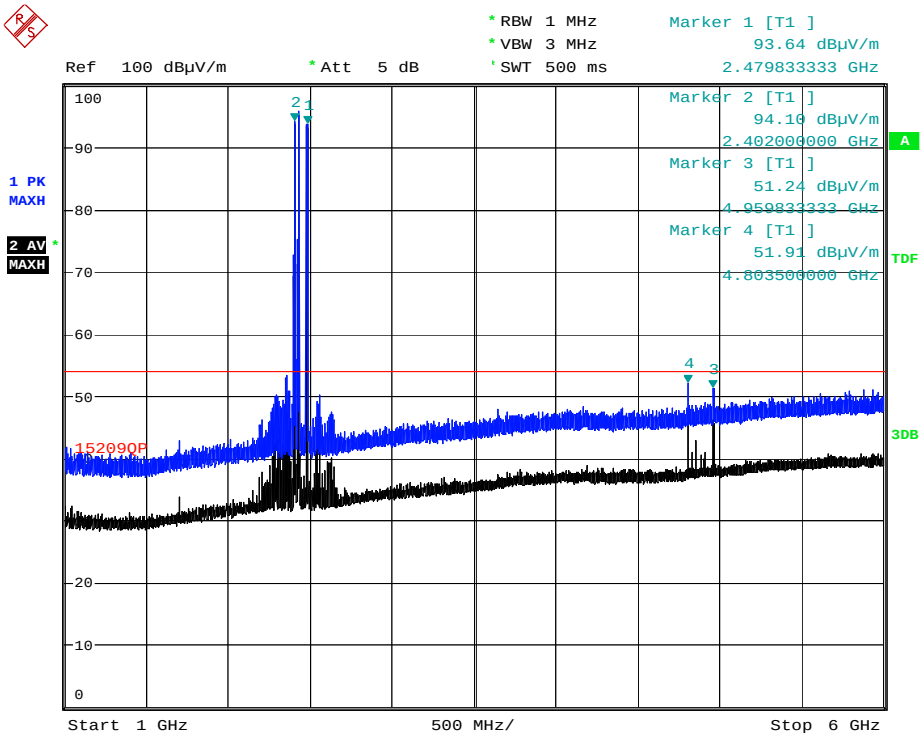


11.6 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Biconical Antenna	EMCO	3109	RFG095	17/05/2019
Log Periodic Antenna	EMCO	3146	RFG191	17/05/2019
Horn Antenna	EMCO	3115	RFG129	09/02/2018
Spectrum Analyser	R&S	FSU46	REF910	05/07/2017
N-Type RF coaxial cable	Unknown	Cable	REF884	04/12/2017
Pre-Amp (9kHz – 1GHz)	Sonoma	310	REF927	30/06/2018
Short SMA RF Cable	AtlanTec	Cable	REF2165	09/12/2017
Cable	Teledyne	5m 2.92mm	REF919	5/10/2017
Pre-Amp (1 – 26.5GHz)	Agilent	8449B	REF913	02/02/2018

11.7 Test Results





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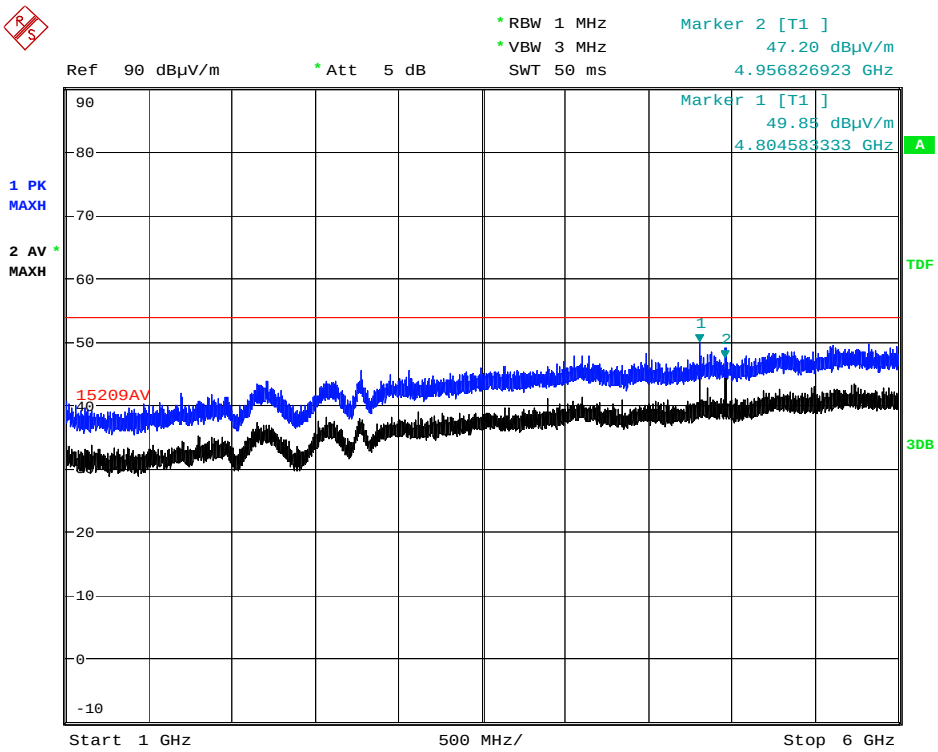
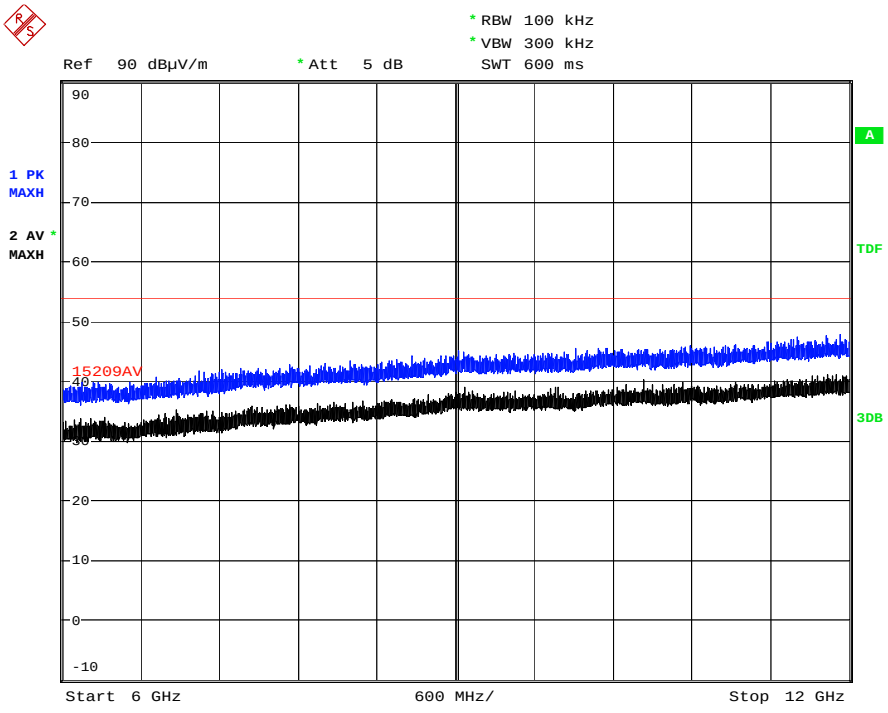


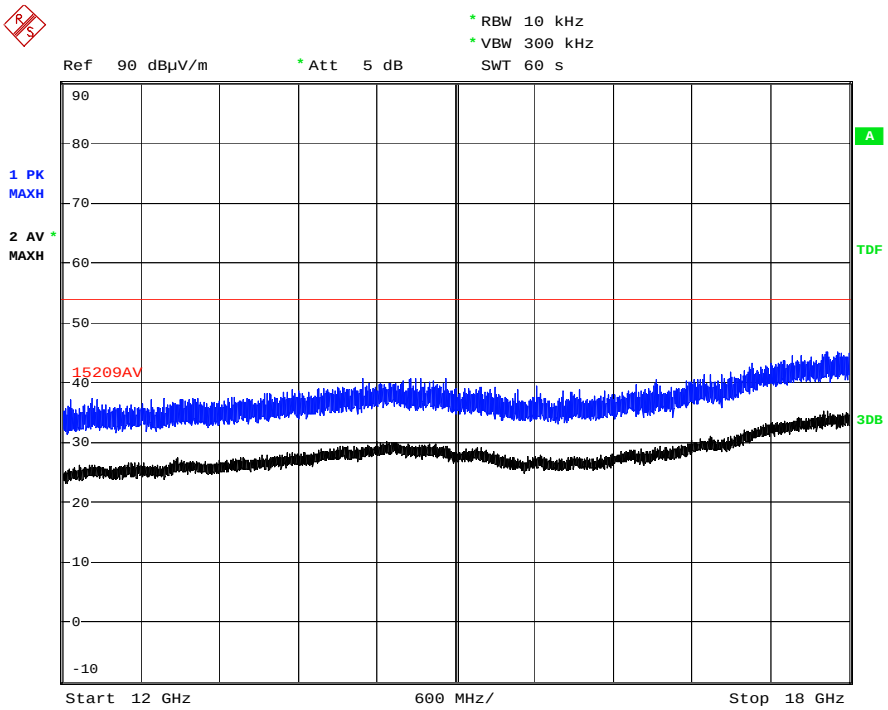
Date: 10.FEB.2017 07:51:02

Plot obtained when a 2.4 GHz bandstop filter was connected to the pre-amplifier.



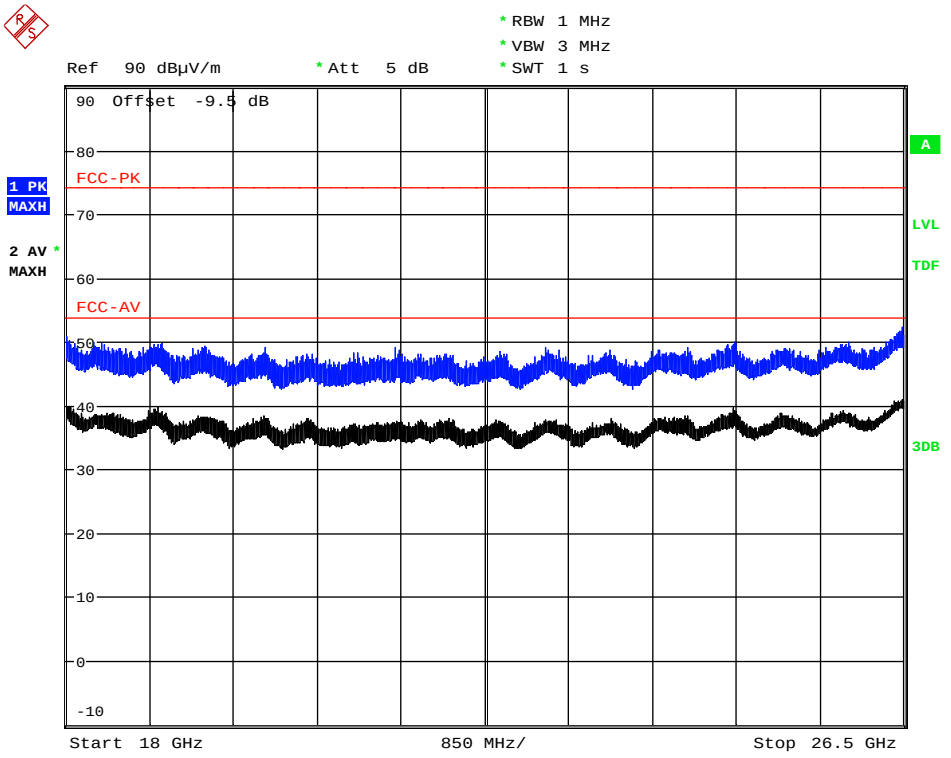
Date: 10.FEB.2017 07:42:07

Plot obtained when a 2.4 GHz bandstop filter was connected to the pre-amplifier.



Date: 10.FEB.2017 07:45:55

Plot obtained when a 2.4 GHz bandstop filter was connected to the pre-amplifier.



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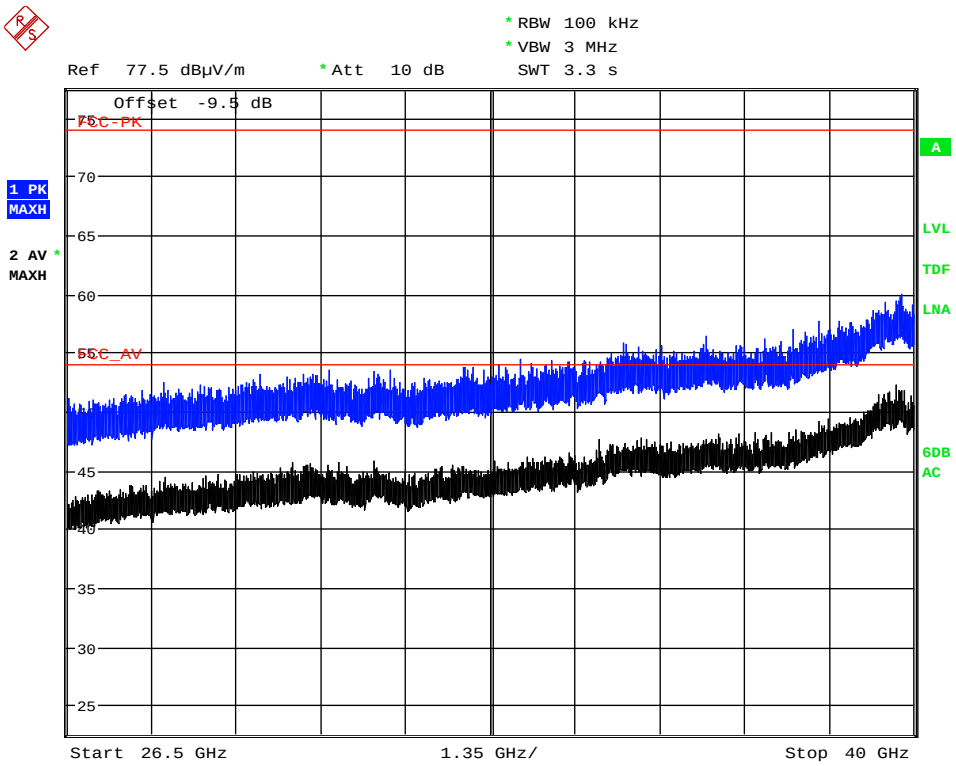

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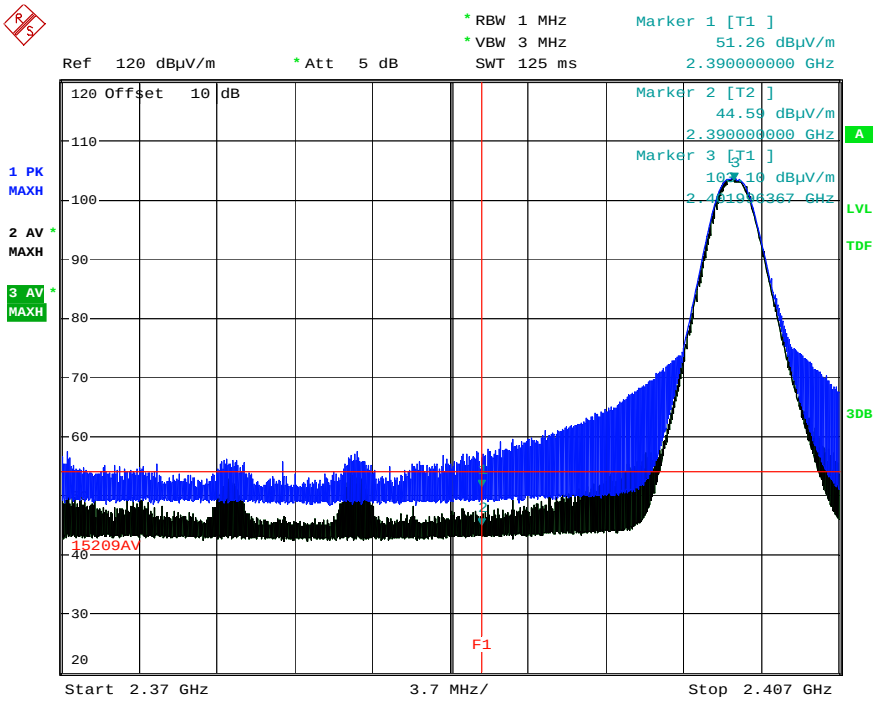
Power Setting: +4 dBm; Channels co-transmitting: 2402, 2426 and 2480 MHz				
Detector	***Frequency (MHz)***	***Field Strength (dBµV/m)***	***Field Strength (µV/m)***	***Limit (µV/m)***
Quasi Peak	30.641	30.0	31.6	100
Quasi Peak	36.158	30.2	32.4	100
Quasi Peak	48.002	26.9	22.1	100
Quasi Peak	56.789	30.1	32.0	100
Quasi Peak	60.190	34.1	50.7	100
Quasi Peak	60.240	31.8	38.9	100
Quasi Peak	95.990	35.2	57.5	150
Quasi Peak	96.958	30.0	31.6	150
Quasi Peak	98.385	27.4	23.4	150
Quasi Peak	98.965	30.4	33.1	150
Quasi Peak	125.012	26.9	22.1	150
Quasi Peak	139.186	24.1	16.0	200
Quasi Peak	316.782	25.1	18.0	200
Quasi Peak	483.082	16.8	6.9	200
Average	2352.016	39.61	95.6	500
Average	4803.983	48.27	259.1	500



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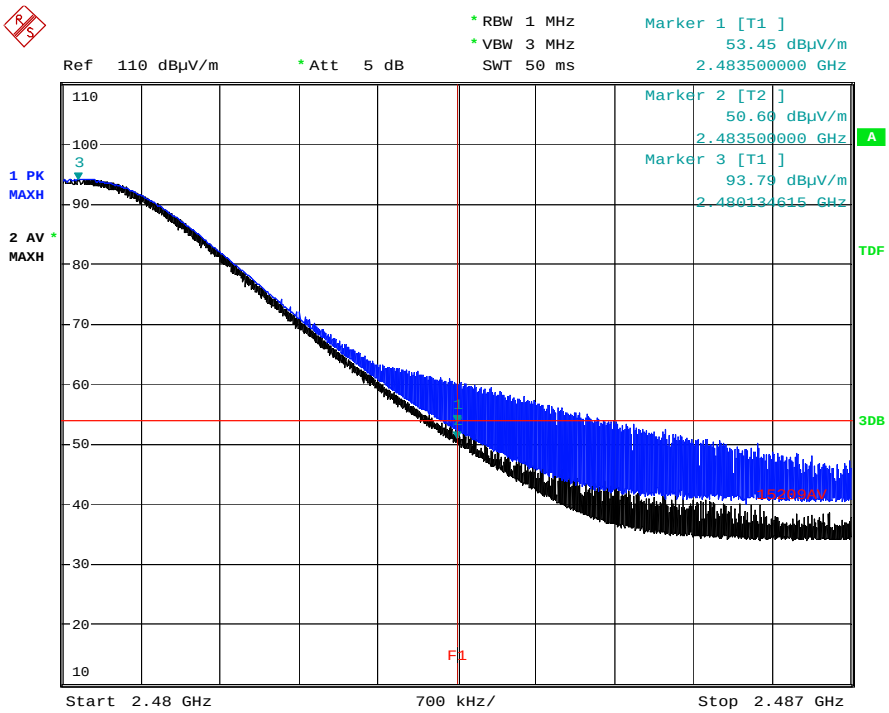

Date: 10.FEB.2017 07:28:56

Note: For peak detector limit, as per CFR47 15.35(b), 20 dB above permitted average emission limit of 54 dBµV/m applies, that is 74 dBµV/m, hence the limit for peak detector traces in the above plots, implying passing results.

12 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] Radiated 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**

[2] AC power line conducted emissions

Uncertainty in test result = **3.4 dB**

[3] Occupied bandwidth

Uncertainty in test result = **15.5 %**

[4] Conducted carrier power

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

[5] Conducted / radiated RF power out-of-band

Uncertainty in test result – up to 8.1 GHz = **3.31 dB**
Uncertainty in test result – 8.1 GHz to 15.3 GHz = **4.43 dB**
Uncertainty in test result (30 MHz to 1 GHz) = **4.6 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.7 dB**

[6] Power spectral density

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

13 RF Exposure

Maximum Permissible Exposure (MPE) Calculation according to KDB 447498

Prediction of MPE limit at a given distance

Equation from IEEE C95.1

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

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

Note:

The EIRP was calculated by addition of the maximum conducted carrier power plus the antenna gain, to compare the EIRP to the 4 watts limit. MPE power density limit is 1.0 mW / cm^2 and the averaging time is 30 minutes, for frequencies in the range of 1.5-100 GHz, according to clause CFR 47 1.1310(e).

Results

Prediction Frequency (MHz)	Maximum Conducted Power (dBm)	Antenna Gain (dBi)	Maximum EIRP (mW)	Minimum Distance (cm)	Fixed Power density at distance (mW/cm^2)	Power density limit (S) (mW/cm^2)
2402	-8.8	9	1.05	100	0.00836	1
2426	-8.8	9	1.05	100	0.00836	1
2480	-9.2	9	0.96	100	0.00764	1

At a distance of approximately 100 cm, the usual separation distance for general public, the highest power density is roughly 0.00836 mW/cm^2, which is well below the limit of 1.0 mW / cm^2.

RSS-102 Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)

2.5.2 Exemption Limits for Routine Evaluation — RF Exposure Evaluation

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows

> at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz;

Results

Prediction Frequency (MHz)	Maximum Conducted Power (dBm)	Antenna Gain (dBi)	Maximum EIRP (mW)	Exemption Limit: Maximum EIRP $1.31 \times 10^{-2} f^{0.6834}$ (mW)
2402	-8.8	9	1.05	2.676
2426	-8.8	9	1.05	2.695
2480	-9.2	9	0.96	2.736

The maximum e.i.r.p. of the device at the top, middle and low channels are well below the limits as shown in the table above. So it meets the exemption limits to operate without RF exposure evaluation is required