2.4 GHz WLAN (DTS Systems)

FCC Test Report

FOR:

Inhand Electronics

Model Name: CTC-IS IPU

Product Description: Tracking device (Government/Military)

FCC ID: 24C4A-CTCISIPU

47 CFR Part 2, 15.247

TEST REPORT #: EMC_CONNE_034_14001_15.247_DTS_WLAN_rev1
DATE: 2015-1-20

FCC listed
A2LA Accredited

IC recognized #
3462E

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1 Assessment

The following device was evaluated against the applicable criteria specified in FCC rules Parts 15.247 of Title 47 of the Code of Federal Regulations. No deviations were ascertained.

Company	Description	Model #
In Hand Electronics	Tracking device(Government/Military)	CTC-IS IPU

Responsible for Testing Laboratory:

Date	Section	Name	Signature
2015-1-20	Compliance	Milton Ponce Deleon (Manager Compliance)	Milton Ponce de Leon Digitally signed by Milton Ponce de Leon DN: cn=Milton Ponce de Leon, c=US, o=Cetecom Inc., ou=OTA, email=milton.deleon@cetecom.com Date: 2015.01.22 11:08:11 -08'00'

Responsible for the Report:

Date	Section	Name	Signature
2015-1-20	Compliance	Muhammad Umair Anees (EMC Test Engineer)	Muhammad Umair Anees Digitally signed by Muhammad Umair Anees DN: cn=Muhammad Umair Anees, c=US, o=EMC, ou=Compliance, email=Muhammad.Anees@cetecom.com Date: 2015.01.22 10:22:59 -08'00'

The test results of this test report relate exclusively to the test item specified in Section3.
CETECOM Inc. USA does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item. The test report may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written approval of CETECOM Inc. USA.

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the Test Report

Company Name:	CETECOM Inc.
Department:	Compliance
Address:	6370 Nancy Ridge Drive #101 San Diego, CA 92121 U.S.A.
Telephone:	+1 (858) 362-2400
Fax:	+1 (858) 587-4809
Compliance Manager:	Milton Deleon
Responsible Project Leader:	Muhammad Anees

2.2 Identification of the Client

Applicant's Name:	InHand Electronics, Inc.
Street Address:	30 West Gude Drive Suite 550
City/Zip Code	Rockville, MD 20850
Country	United States
Contact Person:	Mark Price
Phone No.	(240) 558-2014
e-mail:	mprice@inhandelectronics.com

2.3 Identification of the Manufacturer

Manufacturer's Name:	Same as client
Manufacturers Address:	
City/Zip Code	
Country	

3 Equipment under Test (EUT)

3.1 Specification of the Equipment under Test

Marketing Name:	CTC-IS IPU
FCC-ID :	24C4A-CTCISIPU
Product Description:	Tracking device(Government/Military)
Technology / Type(s) of Modulation:	Microchip's Zigbee module MRF24J40MA with FCC ID OA3MRF24J40MA IEEE 802.15.4, using DSSS with O-QPSK
Operating Frequency Ranges (MHz) / Channels	Nominal band: 2400-2483.5 Center to center: 2405 (Ch11) – 2475 (Ch 25), 16 channels
Antenna Information as declared:	PCB dipole antenna with 2dBi maximum gain
Power Supply/ Rated Operating Voltage Range:	External Battery pack with a 15VDC output
Rated Operating Temperature Range:	-18°C ~ +49°C
Test Sample Status:	Prototype
Other Radios included in the device:	Sierra Wireless Integrated Radio Module MC 7354 features: LTE,HSPA+,GSM/GPRS/EDGE, EV-DO Rev A, 1xRTT

3.2 Identification of the Equipment under Test (EUT)

EUT #	Serial Number	Sample	HW/SW Version
1	DEF0000104	Radiated/Conducted	001/002

3.3 Environmental conditions during Test

The following environmental conditions were maintained during the course of testing:

Ambient Temperature: 20-25^{o}C
Relative Humidity: 40-60%

3.4 Dates of Testing

09/09/2014 – 10/01/2014

3.5 Other Testing Notes:

The device was configured for Zigbee operation by a set of commands provided by the manufacturer, capable of setting the unit in different channels of operation.

The Device was set to continuous framed Tx (burst) mode per test SW and could thus be operated with > 98% duty cycle during testing.

The EUT was tested on low, mid and high channels (2.4GHz) in 802.15.4 standard.

4 Subject Of Investigation

The objective of the evalulation documented in this report was to assess if the performance of the EUT meets the relevant requirements listed in FCC rules Part 15.247 of Title 47 of the Code of Federal Regulations.

This test report is to support a request for new equipment authorization under the FCC ID **24C4A-CTCISIPU.**

All testing was performed on the product referred to in Section 3 as EUT.

This product integrates the pre-certified Zigbee module: Microchip's **MRF24J40MA**

Taking into account, guidance from FCC KDB 996369 (modular approval) and where relevant test procedures did not change, conducted test results are leveraged from the test report # 3147916BOX-004 issued by Intertek - ETL SEMKO on May 13, 2008 for FCC/IC certification of the integrated Zigbee module Microchip's MRF24J40MA with FCC ID 24C4A-CTCISIPU.

5 Summary of Measurement Results

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	Fail	NA	NP	Result
§15.247(e)	Power Spectral Density	Nominal	IEEE 802.15.4	☐	☐	☐	■	Note 1
§15.247(a)(1)	Emission Bandwidth	Nominal	IEEE 802.15.4	☐	☐	☐	■	Note 1
§15.247(b)(3)	Maximum Peak Conducted Output Power	Nominal	IEEE 802.15.4	■	☐	☐	☐	Complies
§15.247(d)	Band edge compliance	Nominal	IEEE 802.15.4	☐	☐	☐	■	Note 1
§15.247(d)	TX Spurious emissions-Conducted	Nominal	IEEE 802.15.4	☐	☐	☐	■	Note 1
§15.247(d) §15.209(a)	TX Spurious emissions-Radiated	Nominal	IEEE 802.15.4	■	☐	☐	☐	Complies
§15.207(a)	AC Conducted Emissions <30MHz	Nominal	IEEE 802.15.4	☐	☐	■	☐	-

NA= Not Applicable; NP= Not Performed.
Note 1: Results leveraged from Microchip MRF24J40MA Zigbee module's original FCC filing.

6 Measurements

6.1 Radiated Measurement Procedure

The radiated measurement is performed according to:
ANSI C63.4 (2009)
ANSI C63.10 (2009)

- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 4 positions of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to cover the 3 orthogonal axis of the EUT. A max peak detector is utilized during the exploratory measurement. The Test-SW creates an overall maximum trace for all 16 sweeps and saves the settings for each point of this trace. The maximum trace is part of the test report.
- The 10 highest emissions are selected with an automatic algorithm of EMC32 searching for peaks in the noise floor and ensuring that broadband signals are not selected multiple times.
- The maxima are then put through the final measurement and again maximized in a 90deg range of the turntable, fine search in frequency domain and height scan between 1m and 4m.
- The above procedure is repeated for all possible ways of power supply to EUT and for all supported modulations.
- In case there are no emissions above noise floor level only the maximum trace is reported as described above.
- The results are split up into up to 4 frequency ranges due to antenna bandwidth restrictions. A magnetic loop is used from 9kHz to 30MHz, a Biconilog antenna is used from 30MHz to 1GHz, two different horn antennas are used to cover frequencies up to 40GHz.

Radiated Measurement Uncertainty: ±3dB

6.1.1 Sample Calculations for Radiated Measurements

Measurements from the Spectrum Analyzer/ Receiver are used to calculate the Field Strength, taking into account the following parameters:

1. Measured reading in dBµV
2. Cable Loss between the receiving antenna and SA in dB and
3. Antenna Factor in dB/m

FS (dBµV/m) = Measured Value on SA (dBµV)+ Cable Loss (dB)+ Antenna Factor (dB/m)
Eg:

Frequency (MHz)	Measured SA (dBµV)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dBµV/m)
1000	80.5	3.5	14	98.0

All radiated measurement plots in this report are taken from a test SW that calculates the Field Strength based on the above equation.

6.2 Maximum Conducted Output Power

6.2.1 Limits:
FCC §15.247 (b)(3): 1W (30dBm)

6.2.2 Test Conditions:
Tnom: 21°C; Vnom: 15V

6.2.3 Test Procedure
Measurements are according to FCC KDB 558074 D01 DTS v03r02 section 9.2.1. §15.247 permits the maximum (average) conducted output power to be measured as an alternative to the maximum peak conducted output power. When this option is exercised, the measured power is to be referenced to the OBW rather than the DTS bandwidth.
Note: Maximum conducted output power is calculated from radiated EIRP measurement and the rated antenna gain, due to unavailability of a conducted EUT sample.

Spectrum Analyzer settings:
Maximum Average Output Power (KDB section 9.2.2.2)
Span = 1.5 times the OBW.
RBW = 1-5% of the OBW, not to exceed 1 MHz
VBW ≥ 3xRBW
Sweep = auto
Detector function = RMS
Trace = Average of 100 traces
Use integrated band power method. Set channel bandwidth ≥ OBW bandwidth of the emission being measured.

OBW = 2.96 MHz (referenced from the modules original FCC filing report. See section 4.)

The EUT was measured in a radiated fashion. The Effective Isotropic Radiated Power (EIRP) is measured since the device has integral antenna for the Zigbee radio. The field strength measurements are converted to power reading taking into account the transducer factor (TF) of the antenna. These calculations are done by the EMC 32 software. Since the referenced KDB ask for power integration across the OBW of the signal, this calculation was done manually in excel by adding EIRP values in the OBW data range. Thus plots in section 6.2.7 show the maximum EIRP at any given point, and not the integrated power value.

6.2.4 Test Result: 2.4 GHz Band

Measured Maximum EIRP (dBm)			
Mode	Frequency (MHz)		
	2405 Channel 11	2440 Channel 18	2480 Channel 26
IEEE 802.15.4	-1.48	-1.76	-3.06

6.2.5 Maximum Power Verification

Channel No.	Frequency (MHz)	Pre-certified module EIRP (dBm)	Measured EIRP (dBm)
11	**2405**	-3.5	-1.48
18	**2440**	-2.9	-1.76
26	**2480**	-5.6	-3.06

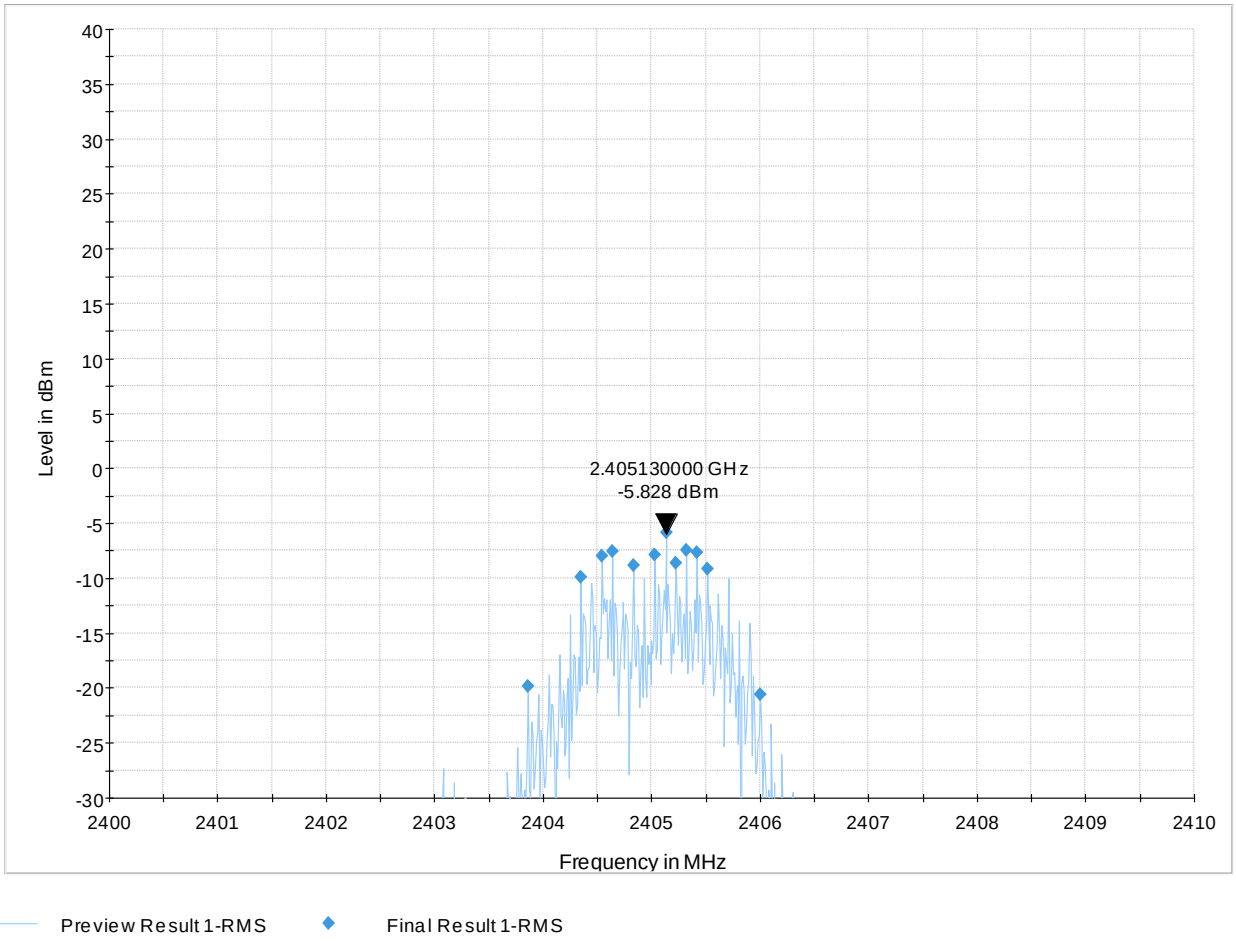
There is a delta of about 2 dBs between the pre-certified module data and measured data. The difference could arise due to radiated measurement tolerance and uncertainty.

6.2.6 Test Verdict:

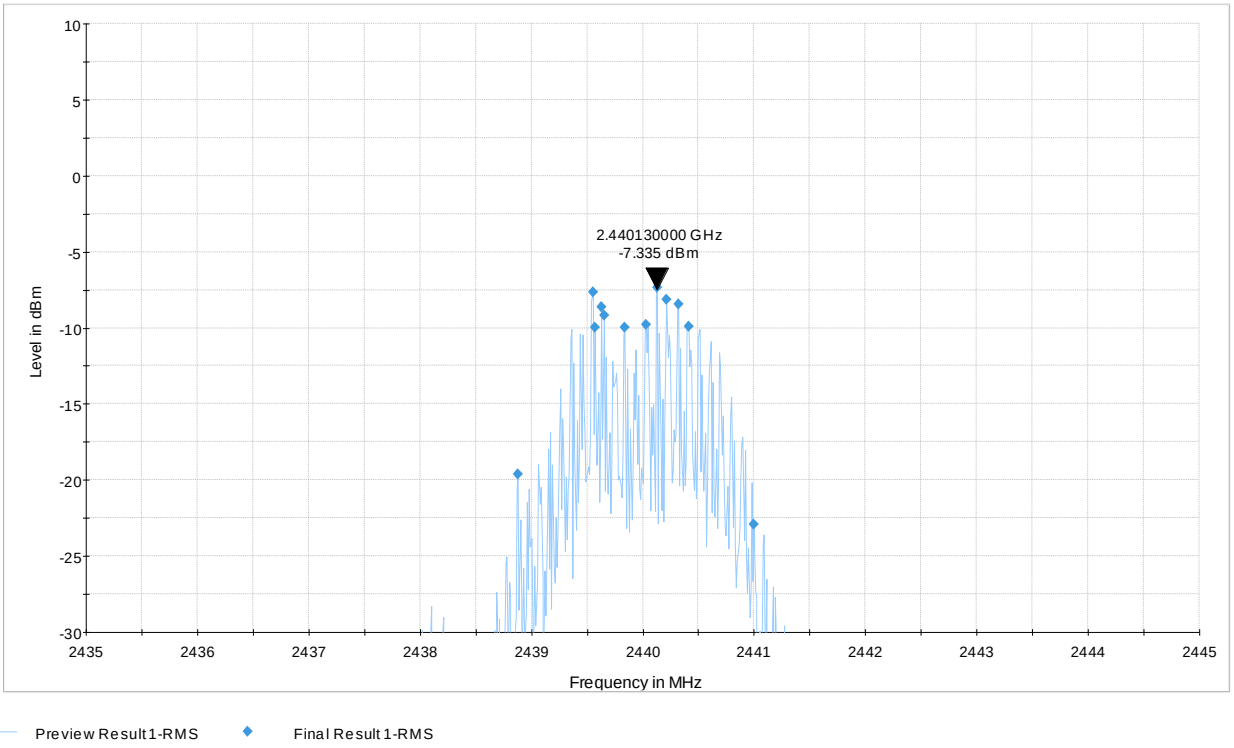
Passed

6.2.7 Test Data/plots: 2.4 GHz Band

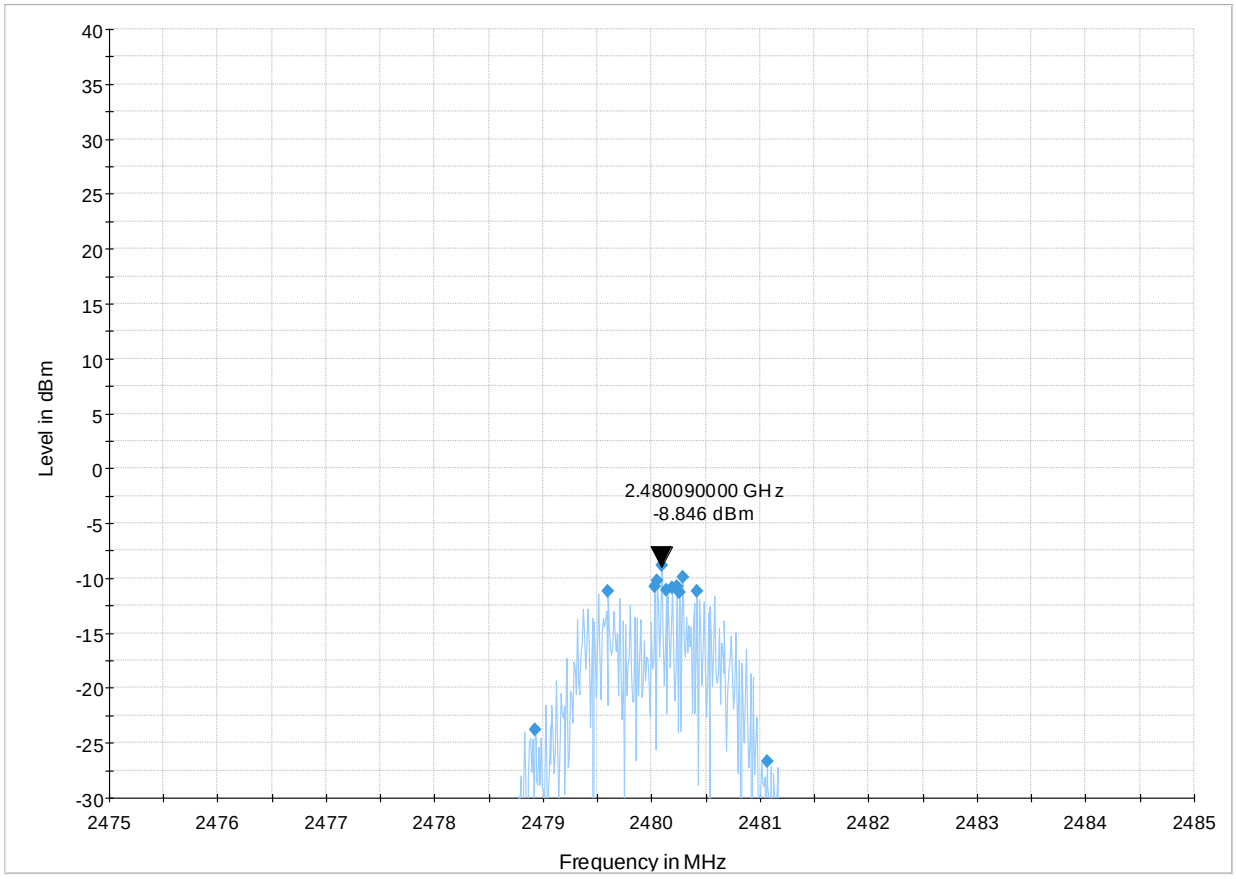
EIRP Low Channel



EIRP Mid Channel



EIRP High Channel



6.3 Radiated Transmitter Spurious Emissions:

6.3.1 Limits:

§15.247/15.205/15.209

Only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
[1]0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	([2])
13.36 - 13.41			

Frequency of emission (MHz)	Field strength (µV/m)
30–88	100 (40dBµV/m)
88–216	150 (43.5 dBµV/m)
216–960	200 (46 dBµV/m)
Above 960	500 (54 dBµV/m, average) (Peak limit: 54 dBµV/m,)

Frequency of emission (MHz)	Field strength (µV/m)	Measurement Distance (m)
0.009–0.490	2400/F(kHz)	300
0.490–1.705	24000/F(kHz)	30
1.705–30.0	30	30

6.3.2 Test Conditions:
Tnom: 23 °C; Vnom: 15V

6.3.3 Measurement procedure:
Measurement according to ANSI C63.10:2009 (also refer to section 6.1 in this test report)

6.3.4 Test Result:

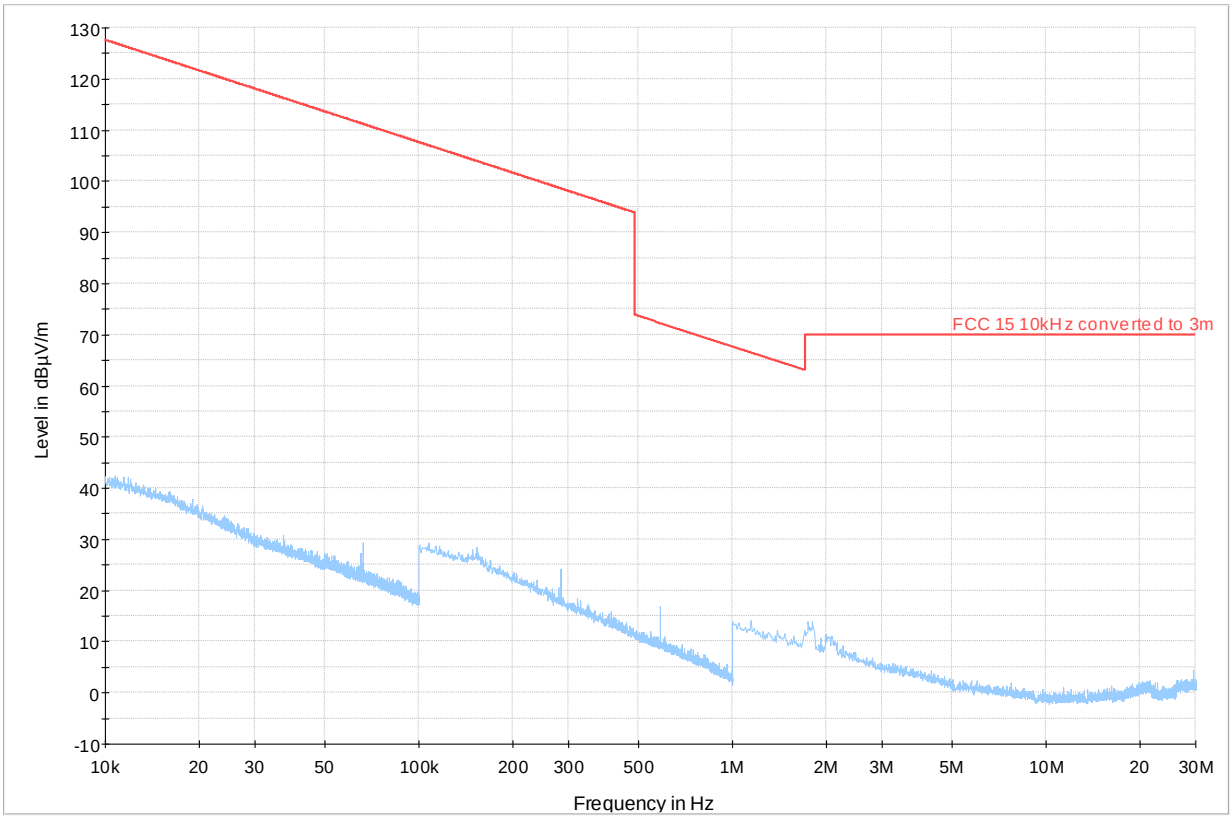
Unless mentioned otherwise, the emissions outside the limit lines in the plots are from the transmit signal.

Plots reported here represent the worst case emissions for horizontal and vertical antenna polarizations and for three orientations of the EUT.

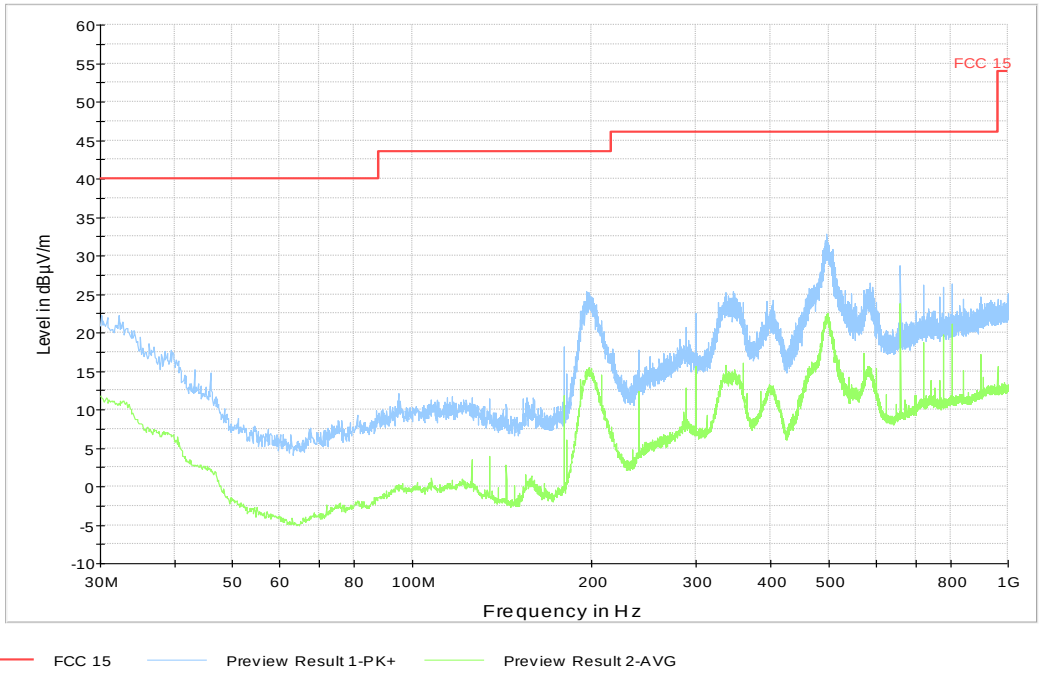
6.3.5 Measurement Result
Pass.

6.3.6 Test data/ plots: 2.4 GHz Band

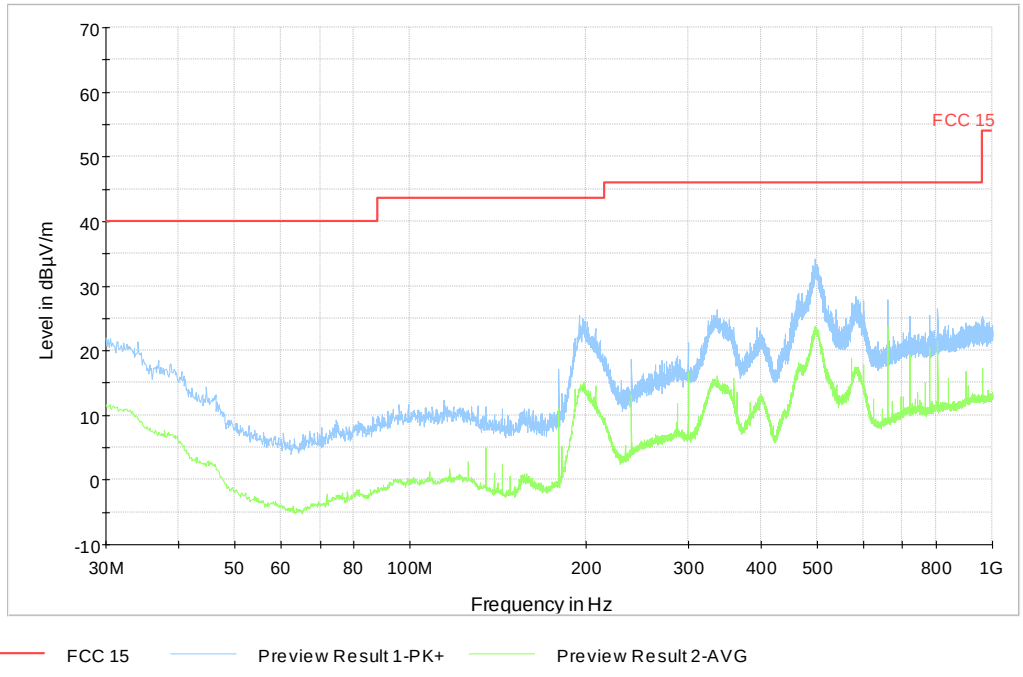
Transmitter Radiated Spurious Emission: Ch Mid- 10kHz – 30MHz



Transmitter Radiated Spurious Emission: Ch Low- 30 MHz – 1GHz

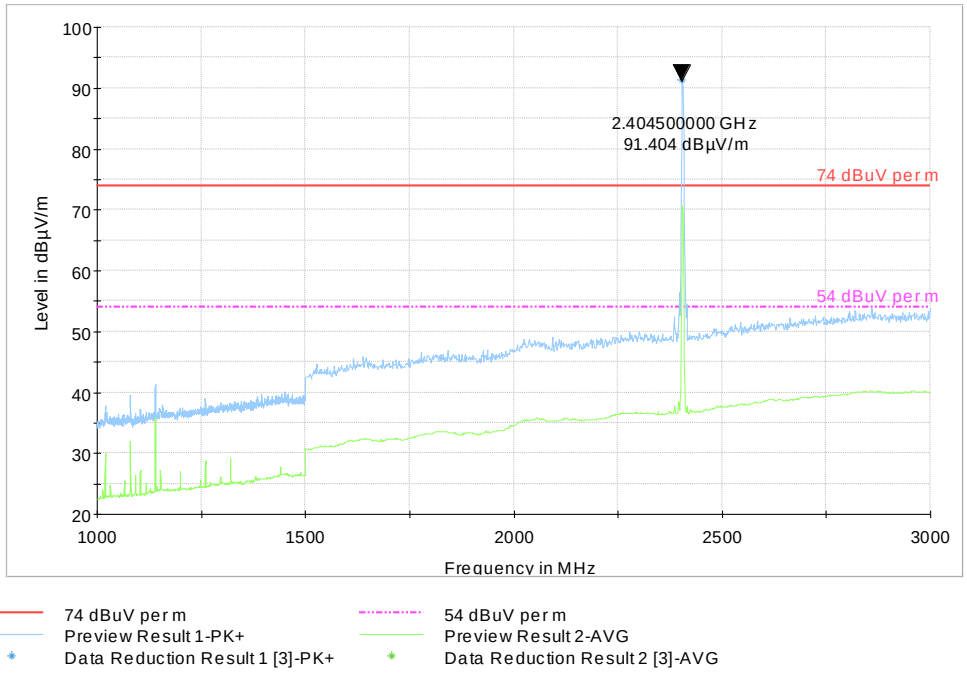


Transmitter Radiated Spurious Emission: Ch Mid- 30 MHz – 1GHz

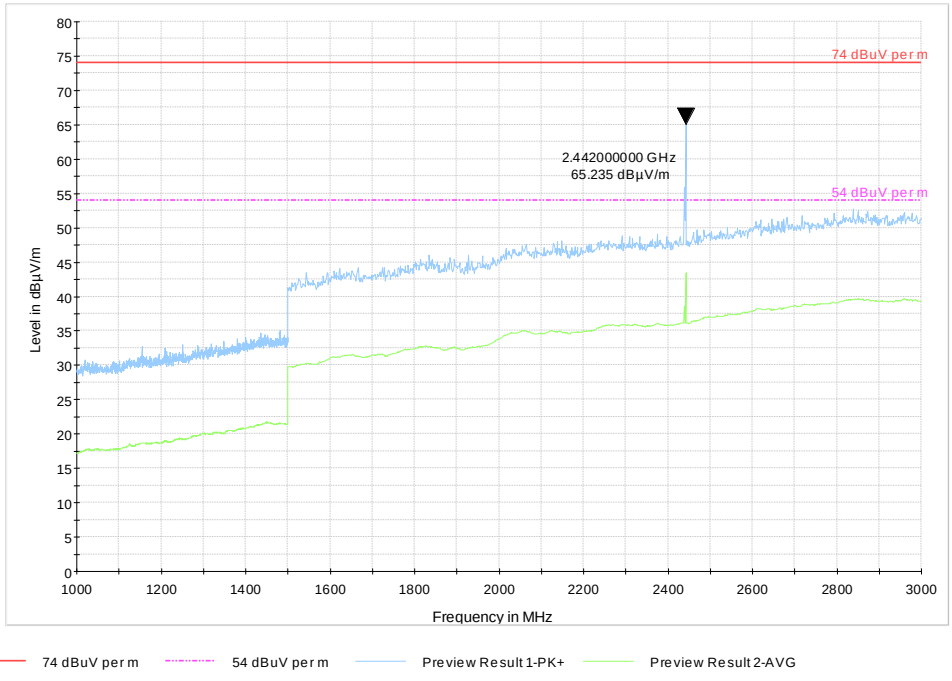


Transmitter Radiated Spurious Emission: Ch High- 30 MHz – 1GHz

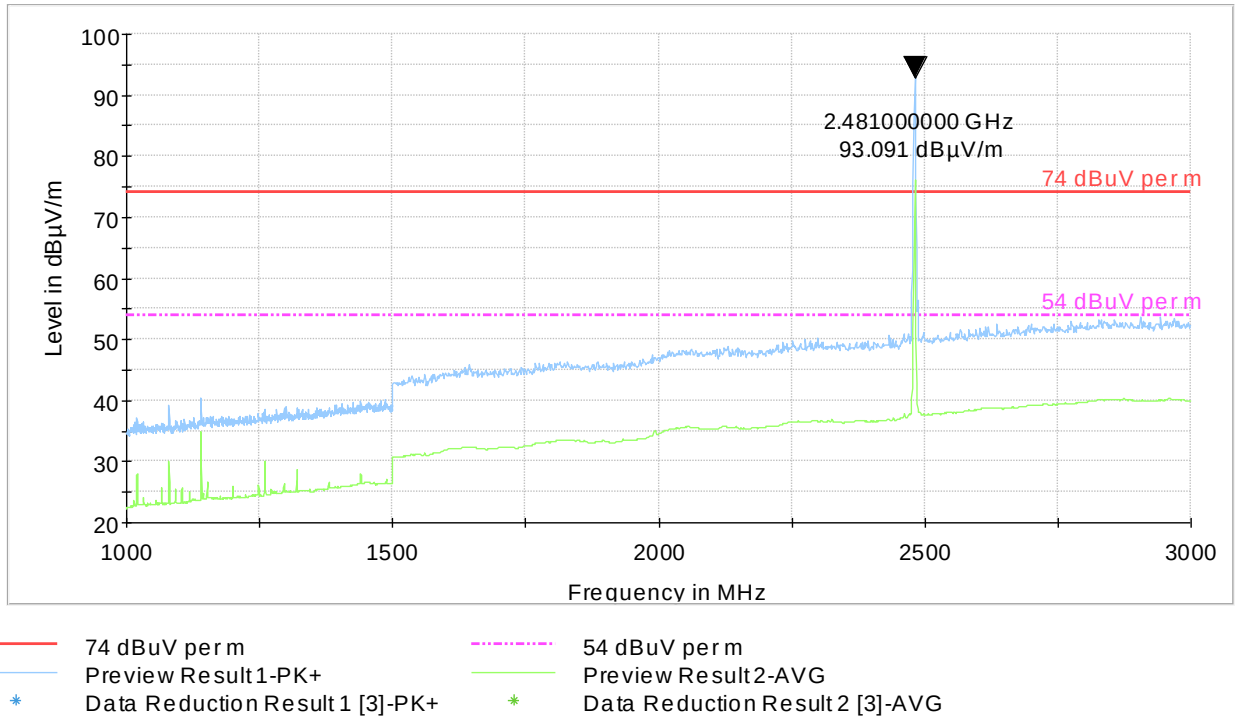
Transmitter Radiated Spurious Emission: Ch Low- 1 GHz – 3GHz



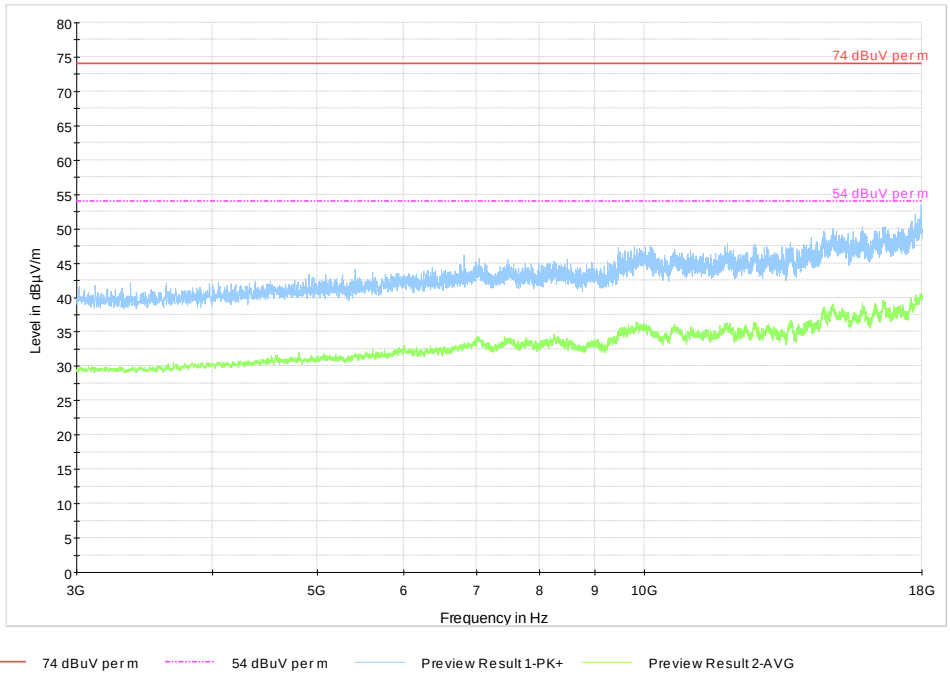
Transmitter Radiated Spurious Emission: Ch Mid- 1 GHz – 3GHz



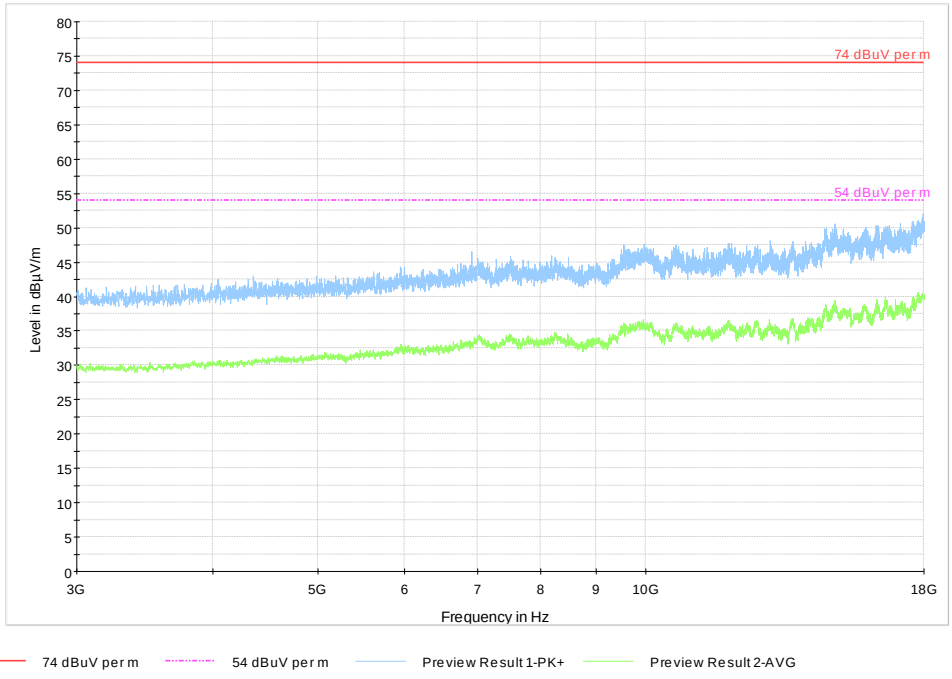
Transmitter Radiated Spurious Emission: Ch High- 1 GHz – 3GHz



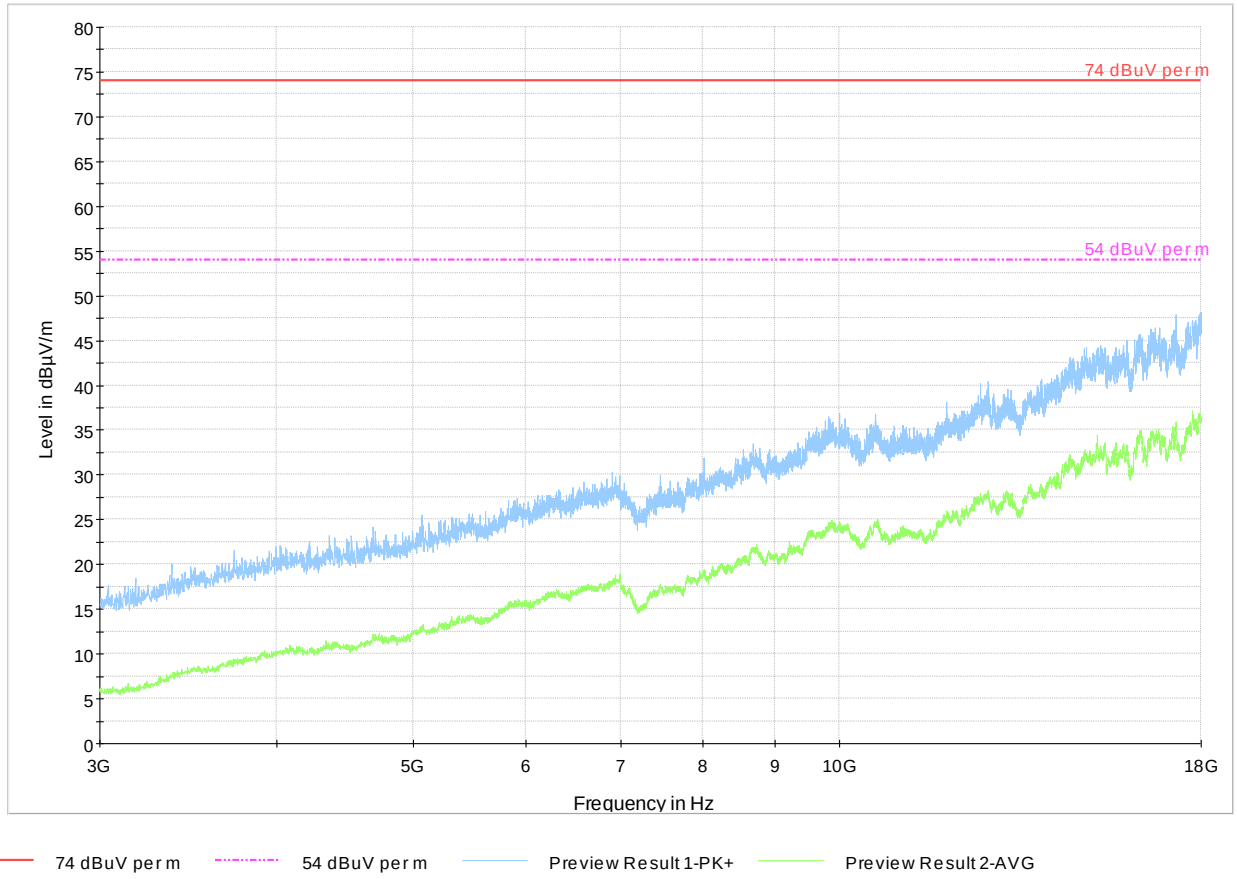
Transmitter Radiated Spurious Emission: Ch Low- 3 GHz – 18GHz



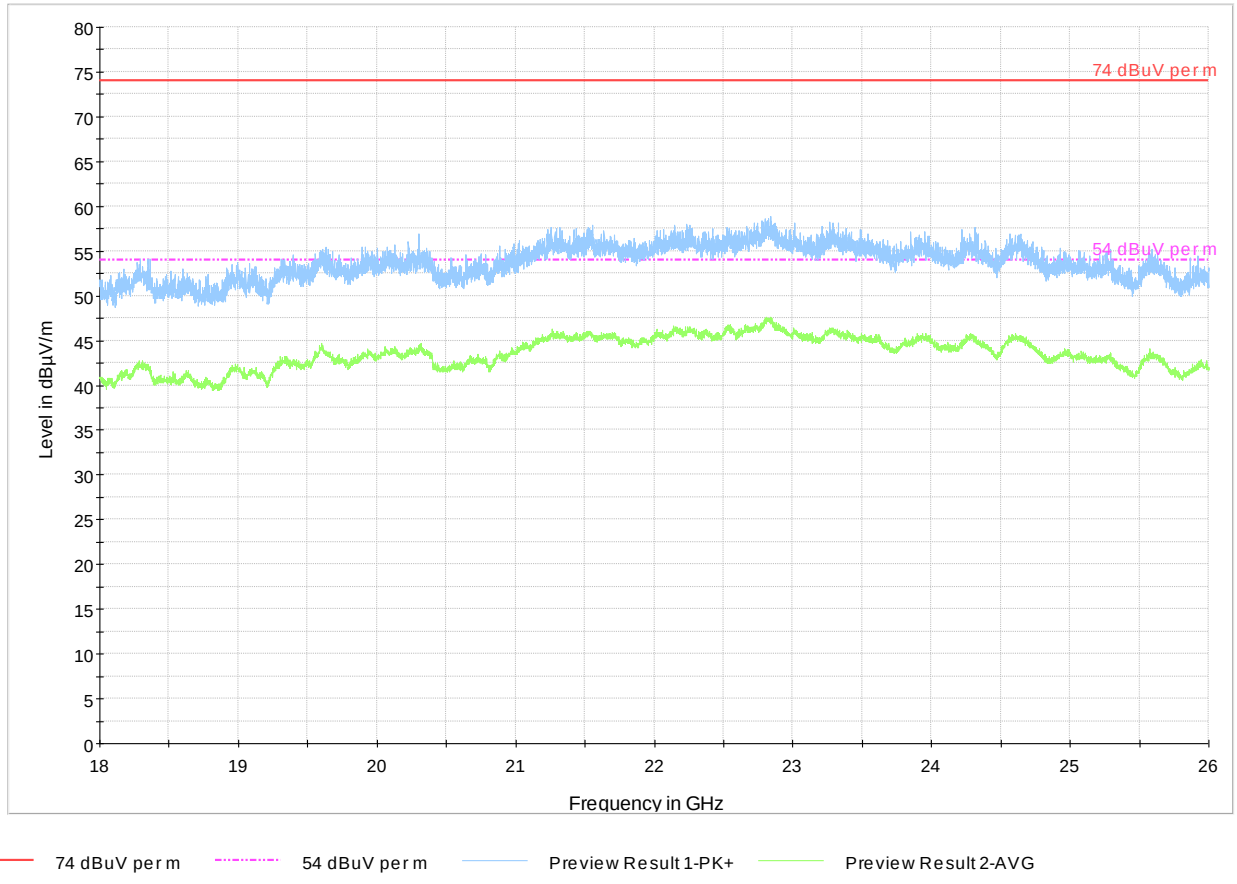
Transmitter Radiated Spurious Emission: Ch Mid- 3 GHz – 18GHz



Transmitter Radiated Spurious Emission: Ch High- 3 GHz – 18GHz



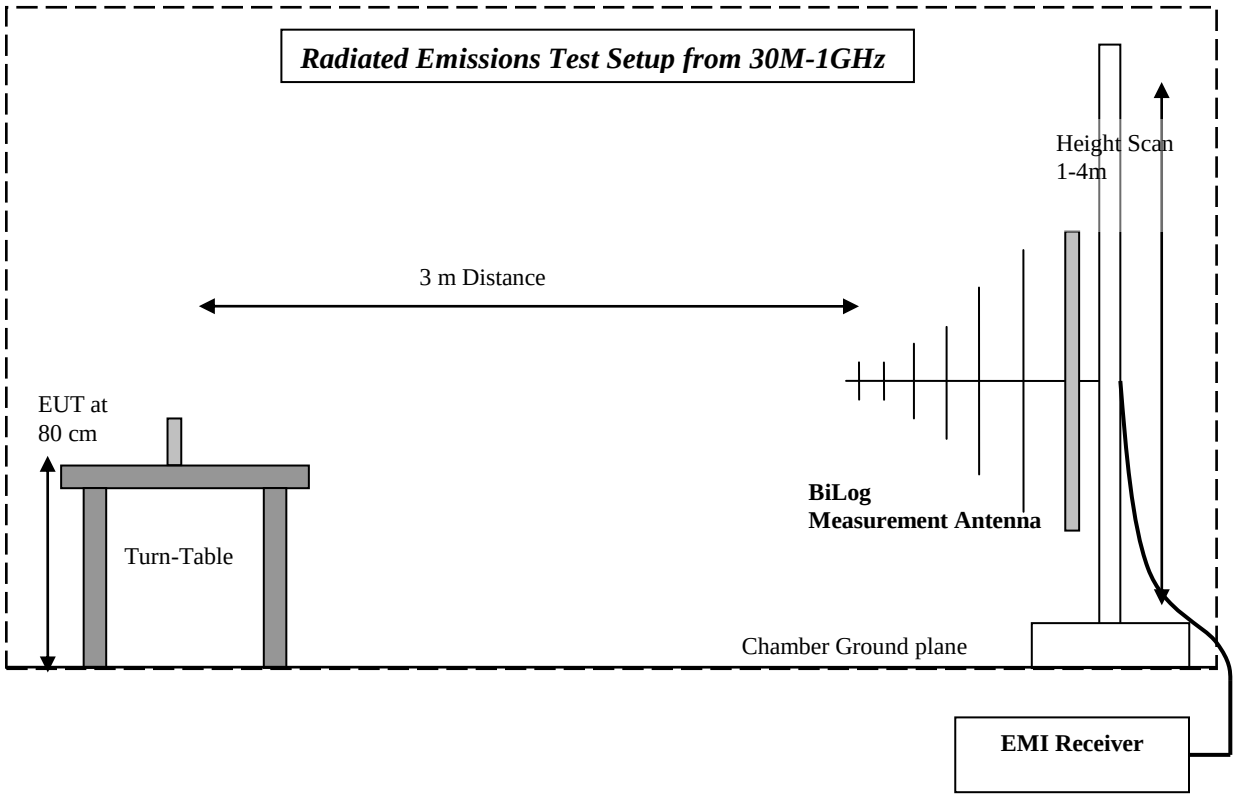
Transmitter Radiated Spurious Emission: Ch Mid- 18 GHz – 26 GHz

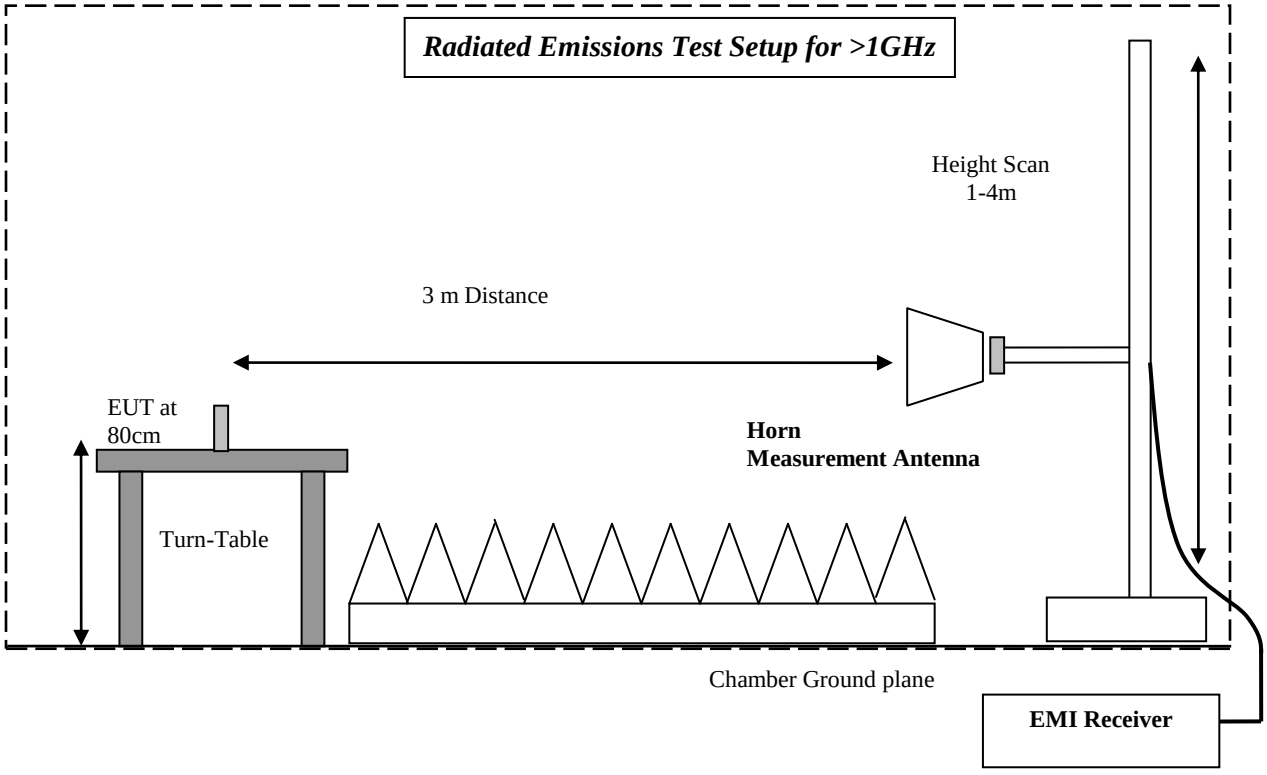


7 Test Equipment and Ancillaries used for tests

Equipment Name	Manufacturer	Type/Model	Serial No.	Cal Date	Cal Interval	Next cal date
3m Semi- Anechoic Chamber:						
Spectrum Analyzer	Rohde und Schwarz	FSU 26	200302	6/2013	2 years	6/2015
Spectrum Analyzer	Rohde und Schwarz	FSV 40	0547	7/2014	2 years	7/2016
Receiver	Rohde und Schwarz	ESR3	101663	2/2013	2 years	2/2015
LISN	Rohde und Schwarz	ESV 216	101129	1/2013	2 years	1/2015
Radio Communications Tester	Rohde and Schwarz	CMU 200	121672	7/2013	2 years	7/2015
Log Periodic Antenna	Rohde and Schwarz	HL 050	100515	4/2013	3 year	4/2016
Ultralog Antenna	Rohde and Schwarz	HL 562	100495	2/2012	3 year	2/2015
Double-ridge Horn Antenna (1G-18G)	ETS-Lindgren	3117-PA	00167061	7/2014	3 year	7/2017
Double-ridge Horn Antenna (18G-40G)	ETS-Lindgren	3116C-PA	00166821	7/2014	3 year	7/2017
Loop Antenna	ETS-Lindgren	6512	00164698	7/2014	3 year	7/2017
Open Switch Control Unit	Rohde and Schwarz	OPS 130	10085	n/a		
Extention Unit Open Switch Control Unit	Rohde and Schwarz	OSP 150	10086	n/a		
Turn Table TT	Maturo	1.5 SI	TT 1.5SI/204/6070910	n/a		
Compact antenna Mast	Maturo	CAM 4.0-P	CAM4.0-P/067/6000910	n/a		
Multiple Control Unit	Maturo	MCU	2140910	n/a		
Pre-Amplifier	Rohde and Schwarz	TS-PR 18	100072	Part of the system calibration		
High Pass Filter	Mini-Circuits	SHP-1200+	RUU11201224			
High Pass Filter	Wainwright Instr.	WHKX 3.0/18	109			

8 Test Setup Diagram:





9 Revision History

Date	Report Name	Changes to report	Report prepared by
2014-11-04	EMC_CONNE_034_14001_15.247_DTS_WLAN	First official version	M. Umair Anees
2015-1-20	EMC_CONNE_034_14001_15.247_DTS_WLAN_rev 1	Formatting, revised section 6.2	M. Umair Anees