



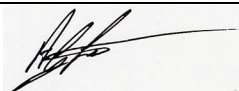
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**Test Report for Quantum Express Marine Radar PSU PCB  
Wi-Fi Module (Texas Instruments 3100)**

**To FCC CFR 47 Part 15 Subpart C and Industry Canada RSS-247**

Model Number	E70210		
Product Description	Maritime Radar		
Report Number	EMC2015/002		
Report Version	V1.04		
Report Author David Jamieson EMC Engineer		Date	4 <sup>th</sup> November 2015
Technical Check Mike Thompson Senior EMC Engineer		Date	21/12/2015
Approval Andrew Little Compliance Manager		Date	12 <sup>th</sup> January 2016

Test Date Range	23 <sup>rd</sup> July 2015 to 10 <sup>th</sup> September 2015
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Product Status	PASS
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The test data and results contained within this report relate only to the items tested.

## 1 Report History

Version	Date	Reason for change
1.00	As cover sheet	Initial Issue
1.01	05/11/2015	RE Test equipment updated. Item description updated. Antenna gain value updated.
1.02	23/11/2015	Unit information updated.
1.03	26/11/2015	Wired Extender Wi-Fi module Carambola information added.
1.04	27/11/2015	Antenna gain data and plots added.

## 2 FCC 47 CFR Part 15 and IC RSS-247 Test Summary


Test Name	FCC CFR 47 Part 15	RSS-247	Section	Result
Peak Output Power	15.247(b)	A5.4(2)	6.3	Pass
Carrier Frequency Separation	15.247(a)	A5.1(2)	N/A	N/A
Frequency Band Edges	15.247(d)	N/A	6.6	Pass
20dB Bandwidth	15.247(a)(1)	A5.1(1)	6.5	Pass
Radiated Emissions	15.209(a)	RSS-GEN 7.5.2	6.9	Pass
Spurious Emissions	15.247(d)	A5.5	6.10	Pass
Number of Channels	15,247(a)(1)	A5.1(4)	N/A	N/A
Directional antenna with >6dBi	15.247(c)	N/A	6.2	N/A
Dwell Time	15.247(a)	A5.1(4)	N/A	N/A
6dB Bandwidth	N/A	A5.2(1)	6.7	Pass
Power Spectral Density	N/A	A5.2(2)	6.8	Pass

### 3 Attestations

This equipment has been tested in accordance with the standards identified in this report. To the best of my knowledge and belief, these tests were performed using the measurement procedures described in these reports.

All measuring instruments used to determine the status of the product's compliance to the identified standards are calibrated regularly in accordance with UKAS requirements.

A comprehensive system of traceable calibration in accordance with ISO9001 is maintained.

Name/Position	Signature	Date
David Jamieson EMC Engineer		4 <sup>th</sup> November 2015

I attest that the necessary measurements were made, under my supervision at:

Raymarine UK Ltd, Marine House, Cartwright Drive, Fareham, PO15 5RJ.



Andy Little  
Compliance Manager

**Date: 12<sup>th</sup> January 2016**

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## 4 Test Information

### 4.1 Test Facilities

Site 1	9m x 6m x 5.5m Semi Anechoic Chamber	FCC ID IC Certification	Reg 371673 Reg 4069B-2
Site 5	2m x 3m x 2.5m Screened Room		

### 4.2 Overall Test Conditions

Date	Ambient Temperature (°C)	Relative Humidity (%)	Air Pressure (mbar)
23/07/15	20.2	56	954
24/07/15	20.6	57	946
28/07/15	20.0	52	941
08/09/15	18.7	51	962
09/09/15	18.9	52	955
10/09/15	19.7	53	955

### 4.3 Test Methods

The objective of the report is to perform testing according to 47 CFR Part 15 Subpart C (Bluetooth and WIFI, 2.4GHz ISM band radiators) for the EUT FCC ID Certification and RSS-247 for the Industry Canada certification:

Number	Standard Number	Document Title
1	47 CFR Part 15 (April 9, 2012)	Radio Frequency Devices
2	RSS-247 Issue 1 May 2015	Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment

#### 4.3.1 Deviations from Test Methods

None

## 5 EUT Information

### 5.1 Test Rationale

Full compliance for PSU PCB Wi-Fi module Texas Instruments 3100 only.  
Wired Extender PCB Wi-Fi module is unmodified from supplier, with FCC ID= Z9W-CM2.

5.2 Description of Equipment under Test (EUT)

Date of Receipt:	01/07/2015
Client:	Paul Thomas
Brand Name:	Raymarine
Product Range:	Quantum Express Radar
Country of Manufacture:	Hungary
Operational voltage range:	12V to 24V

**Unit 1**

Model Name or Number:	Quantum Express Radar
Unique Type Identification:	E70210
Serial Number:	0750122 (EMC2015/001)
CCT Diagram Number(s) & Issue:	Main Board: 1003643 Issue 3 PSU Board: 1003653 Issue 5 Wired Extender: 1003493 Issue 2
PCB Assembly Number(s) & Issue:	Main Board: 1003644 Issue 3 PSU Board: 1003654 Issue 7 Wired Extender: 1003494 Issue 2
Software Version:	IF App: 0.78 PSU App: 0.29 FPGA Version: V2.63 Wired Extender: v1.0
Modifications to Unit:	None.
Modulation Type	CCK, DQPSK, DBPSK for DSSS 64QAM, 16QAM, QPSK, BPSK for OFDM
Modulation Technology	DSSS, OFDM
Transfer Rate	IEEE 802.11b: 11/5.5/2/1Mbps IEEE 802.11g: 54/48/36/24/18/12/9/6Mbps
Frequency Range	2400MHz - 2483.5MHz
Number of Channels	802.11b: 11 802.11g: 11

**Unit 2**

Model Name or Number:	Quantum Express Radar
Unique Type Identification:	E70210
Serial Number:	Engineering unit
CCT Diagram Number(s) & Issue:	Main Board: 1003643 Issue 3 PSU Board: 1003653 Issue 5 Wired Extender: 1003493 Issue 1
PCB Assembly Number(s) & Issue:	Main Board: 1003644; Issue 3; S/N = 9492792 PSU Board: 1003654; Issue 7; S/N = 9715074 Wired Extender: 1003494; Issue 1; S/N = 9672373
Software Version:	IF App: 0.78 PSU App: 0.27-90 Ti Wi-Fi CC3100 Service pack = 1.0.0.10.0 FPGA Version: V2.63 Wired Extender: v1.0
Modifications to Unit:	Wired Extender mods (to bring in line with issue 2): 1 Over voltage protection change - R109=11k, R30=1k (change R109 to 9K76) 2 Inrush, R3=470R 3 Limiting current rush from boost to PSU board: C63=1uF 4 Reduce output voltage to 32V: R41=11k 5 Remove Boost voltage feedback to input protection: D20=NF 6 Kill circuit - reduce time to latch - change R27 to 150K 7 3V3 turn off at TX turn on: R33,R38,R46=NF 8 Remove boost external soft start circuit: D21, R108, C68, D22=NF 9 add extra 1500uF hold up capacitor, remove C66 to make space - R4 needs to be increased to 12K to compensate inrush 10 EMC mod 1 - CM choke L8 fitted 9600PULSE3 , R11 and R113 removed. 11 EMC mod 2 - Snubber added across boost diode - R82=560pF, R83-6.8R 12 EMC mod 3 - Capacitor fitted in position R112 - 1uF 93CKHBxxx1U. 13 EMC mod 4 - Change input CM choke in position L5/L6 - 744 801 450 1
Modulation Type	CCK, DQPSK, DBPSK for DSSS 64QAM, 16QAM, QPSK, BPSK for OFDM
Modulation Technology	DSSS, OFDM
Transfer Rate	IEEE 802.11b: 11/5.5/2/1Mbps IEEE 802.11g: 54/48/36/24/18/12/9/6Mbps
Frequency Range	2400MHz - 2483.5MHz
Number of Channels	802.11b: 11 802.11g: 11

**5.3 Additional information**

Unit 3 is an engineering unit used as Wi-Fi module section is unchanged from final version.

**5.4 Description of Auxiliary Equipment**

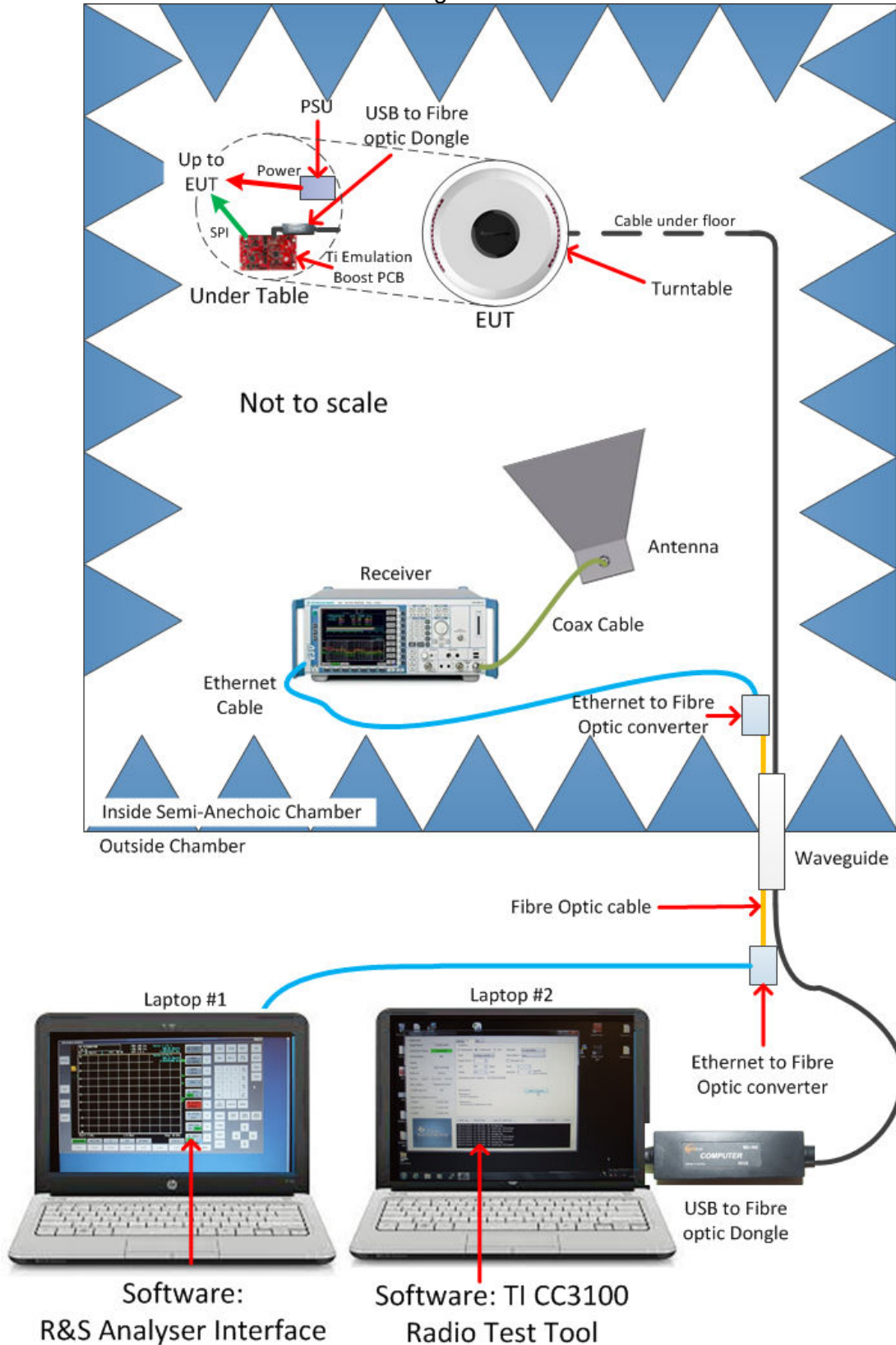
Product Type	Part Number	Serial Number
Laptop	Compaq 6910p	CND83026CQ



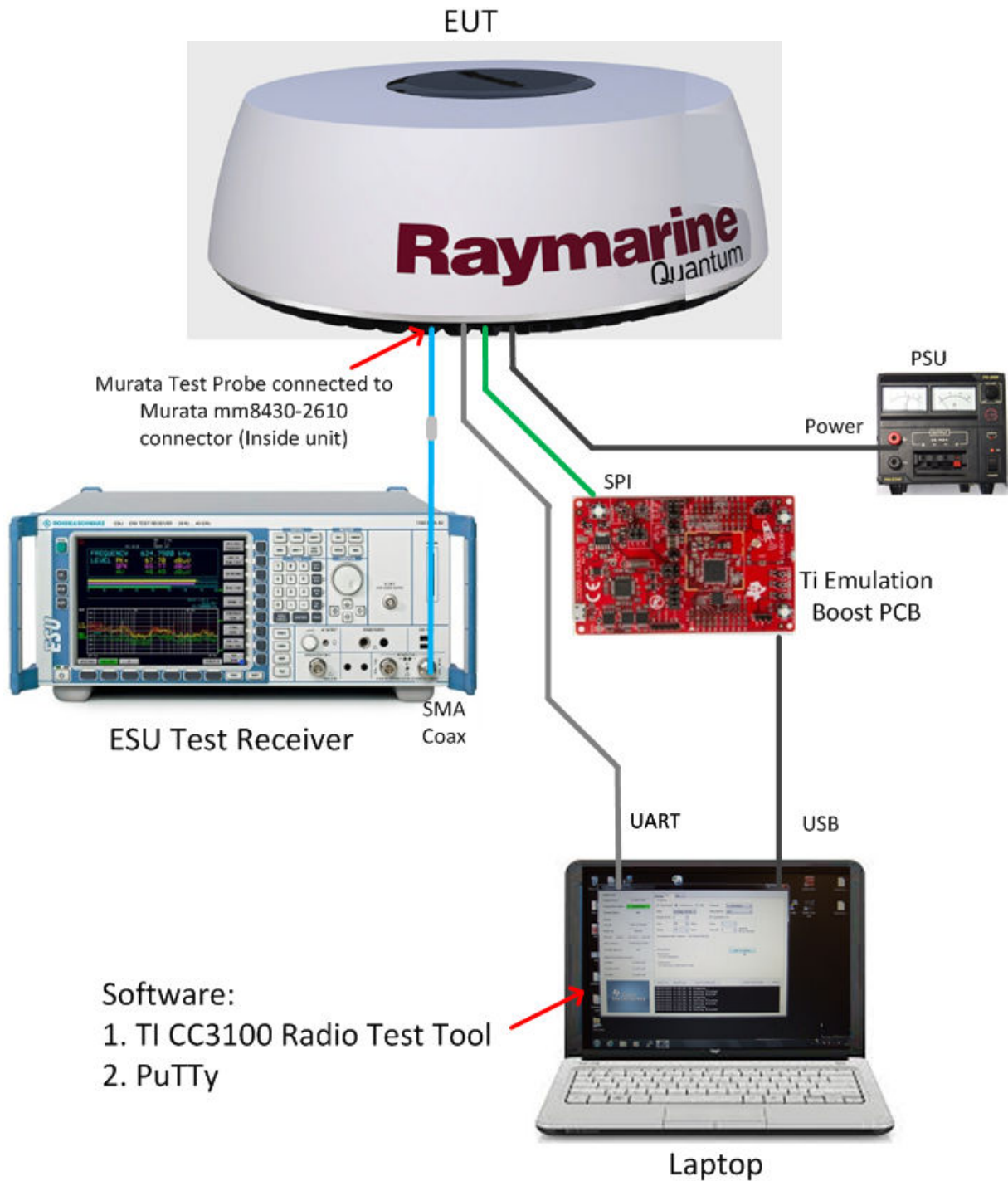
5.5 Test Configurations

5.5.1 Setup A (Radiated)

Note: LISN's were not used during this test.

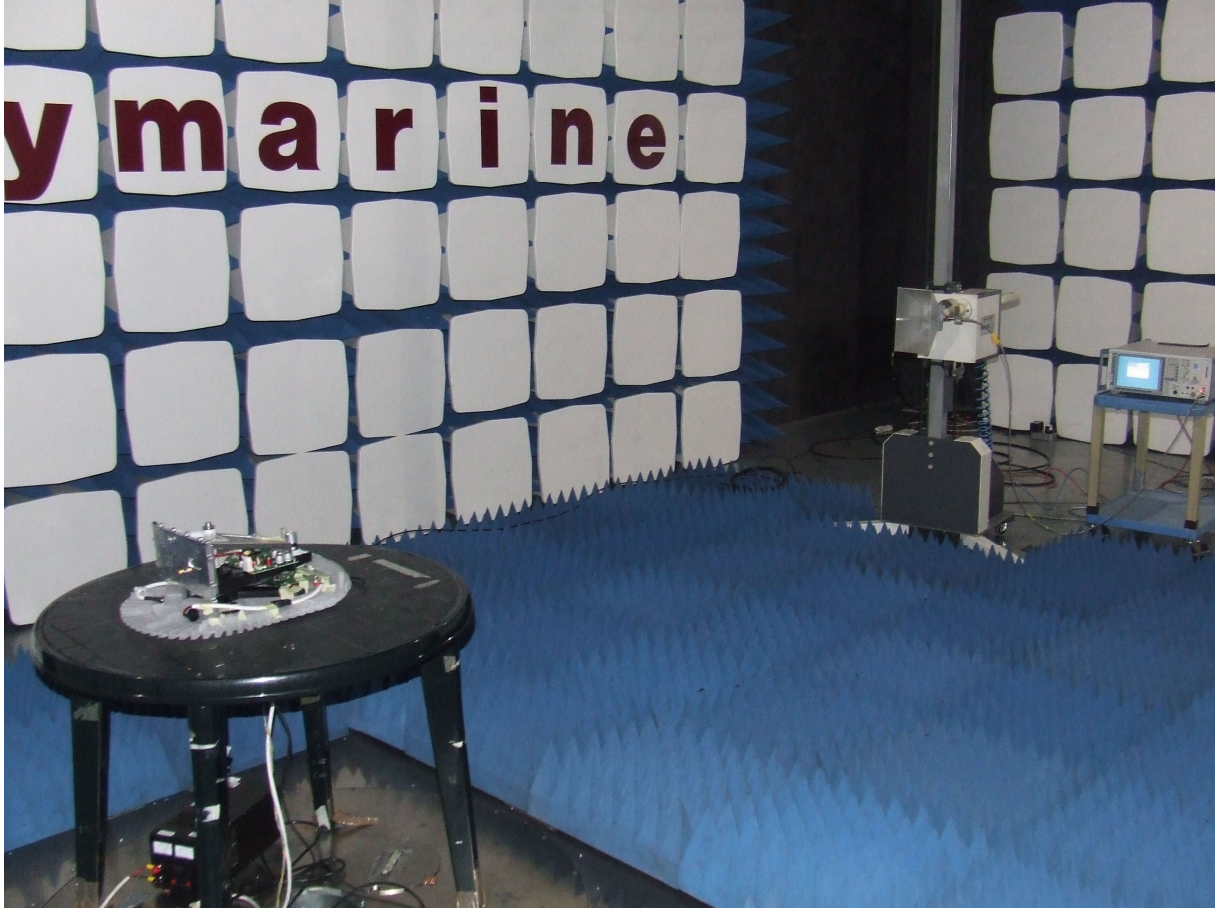


5.5.2 Setup B (Conducted)

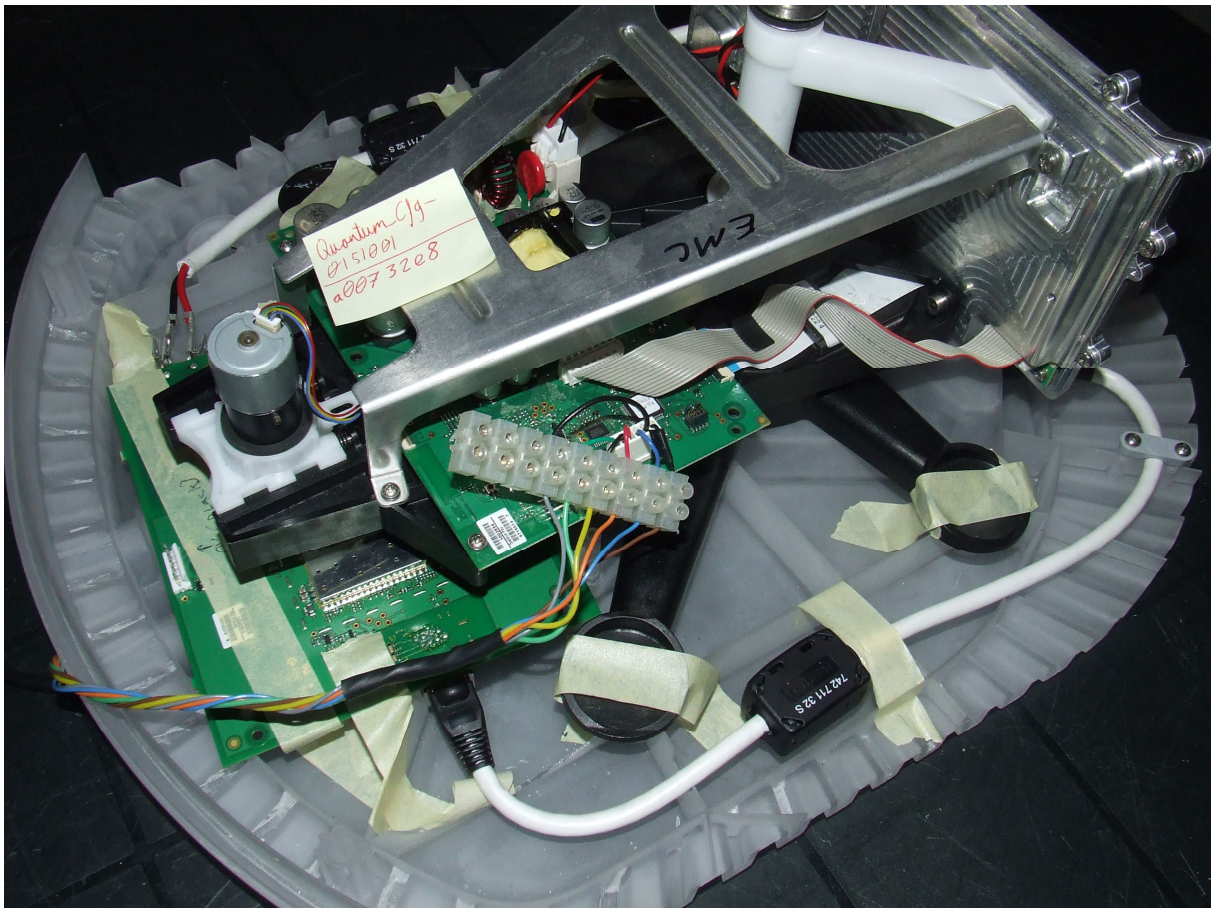


5.5.3 Photos

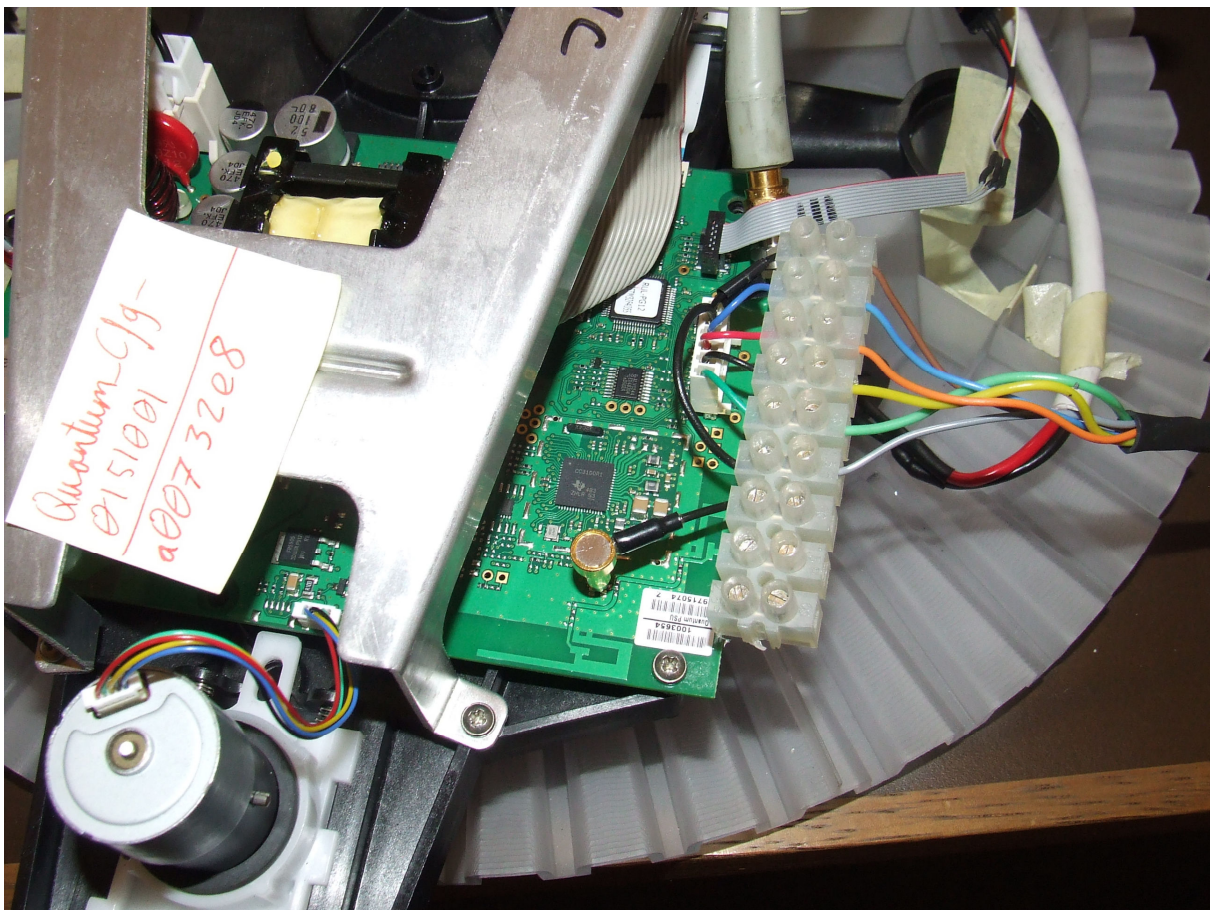
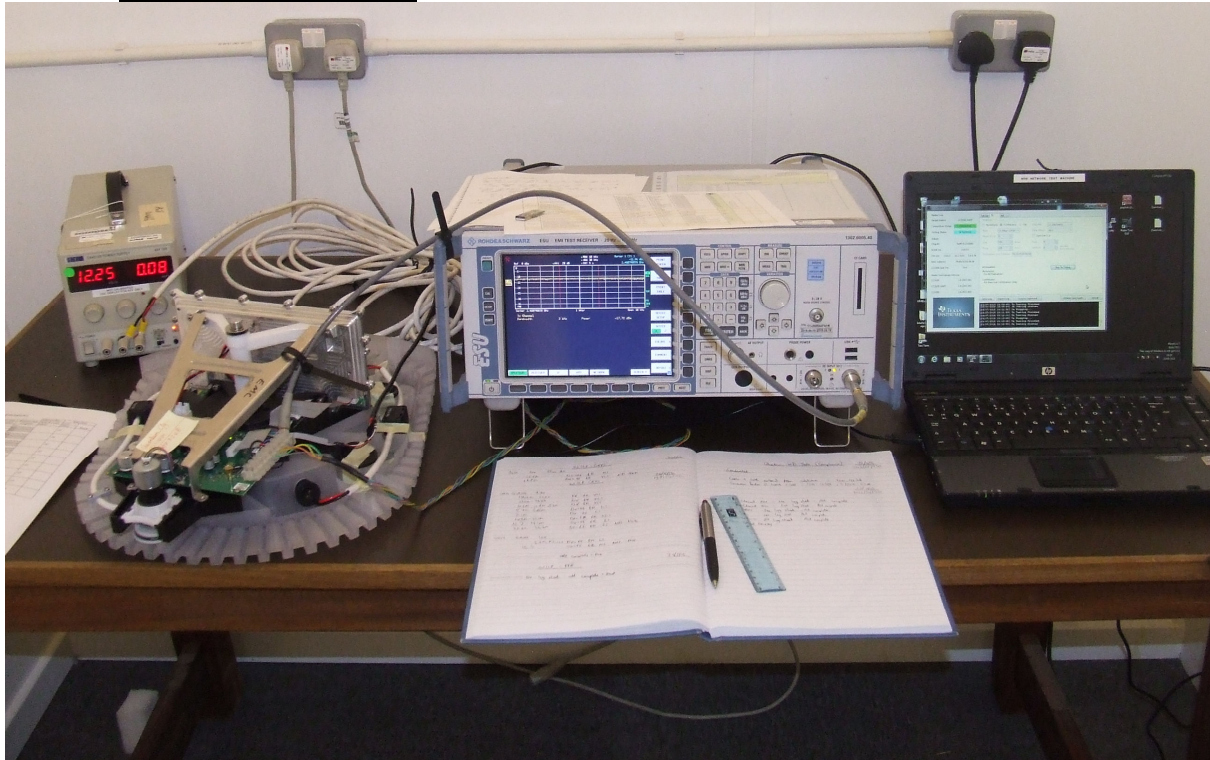
5.5.3.1 Setup A - Radiated







5.5.3.2 Setup B - Conducted



5.6 Operating Modes

5.6.1 Peak Output Power and Frequency Range

The tests performed with the UUT in each of two operating modes:

Mode	IEEE 802.11b	IEEE 802.11g
Modulation Technique	Direct Sequence Spread Spectrum (DSSS)	Orthogonal Frequency Division Multiplexing (OFDM)
Modulation Scheme	Complementary Code Keying (CCK)	64 point - Quadrature amplitude modulation (64-QAM)
Data Rate	11Mbps	54Mbps
Transmission	Continuous	Continuous
Peak Output Power	20dBm	14.5dBm
Channels	1 – 11	1 – 11
Frequency Low	2412MHz	2412MHz
Frequency High	2462MHz	2462MHz

## 6 Test Results

### 6.1 Transmit Duty Cycle, “x”

Transmit duty cycle (symbol “x”) is required for the calculations relating average power (measured) to EIRP for Maximum Transmit Power, Maximum EIRP Spectral Density and Frequency Range tests.

UUT Operating Mode	Transmit Duty Cycle, x
11Mbps 802.11b DSSS CCK 20dBm nominal	0.45
54Mbps 802.11g OFDM 14.5dBm nominal	0.085

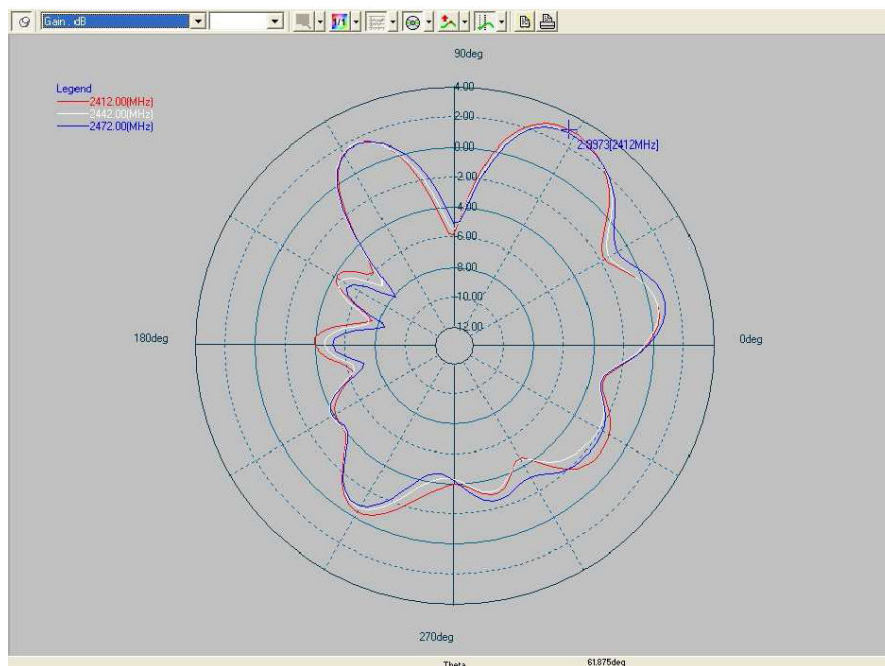
### 6.2 UUT Antenna Gain, “G”

Antenna gain (symbol “G”) is required for the calculations relating average power (measured) to EIRP for Maximum Transmit Power, Maximum EIRP Spectral Density and Frequency Range tests.

UUT Max Antenna Gain (dBi)
+3.65

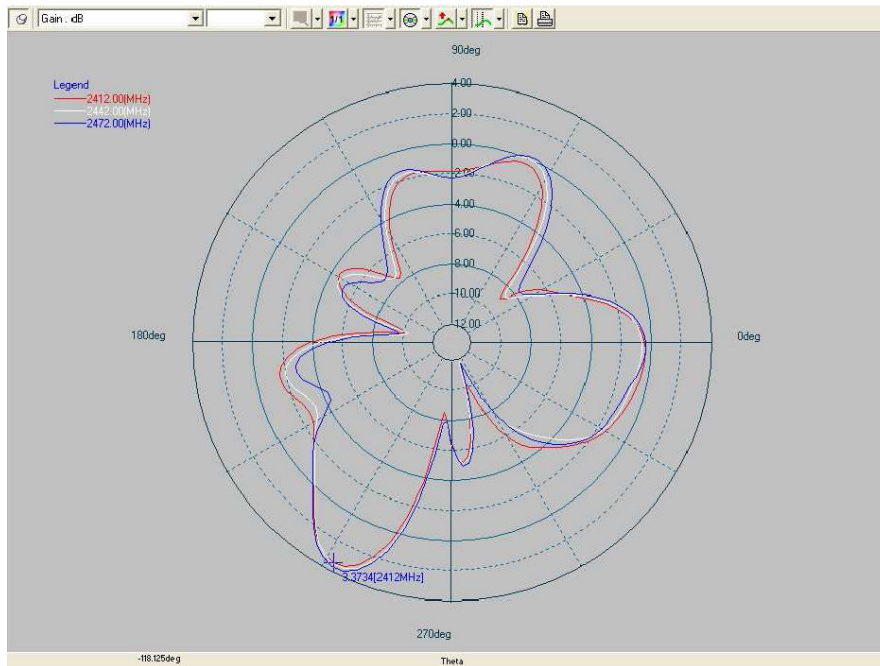
Since the antenna gain is <6dBi, the FCC requirement is not applicable.

**Antenna 1 – Radiation Pattern XZ**

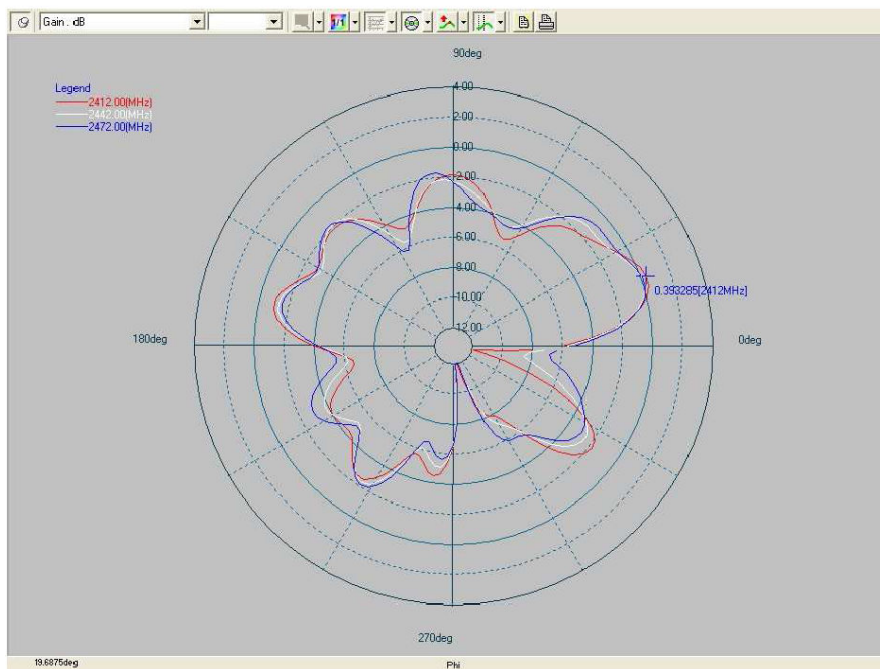




**Antenna 1 – Radiation Pattern YZ**



**Antenna 1 – Radiation Pattern XY**



For more information, see Test report UL\_NAO1\_RP10946592JD01A (11 November 2015).

6.3 Peak Output Power

Conducted measurements as specified in 15.247(b)(1).

6.3.1 Normal Test Conditions; 22°C, 12.0V

Operating Mode (Modulation)	Channel \ Frequency (No. \ MHz)	Power Measured A (dBm)	Tx Duty Cycle x	Peak Power (mW)	Limit max. (mW)	Pass/Fail
11Mbps 802.11b DSSS 20dBm nominal	1 \ 2412	9.055	0.45	17.88	1000	Pass
	7 \ 2442	10.195	0.45	23.24	1000	Pass
	11 \ 2462	8.75	0.45	16.66	1000	Pass
54Mbps 802.11g OFDM 14.5dBm nominal	1 \ 2412	-2.936	0.085	5.98	1000	Pass
	7 \ 2442	-1.831	0.085	7.72	1000	Pass
	11 \ 2462	-2.567	0.085	6.51	1000	Pass

**Comments:** None.

**Unit:** 2

**Tested by:** D. Jamieson

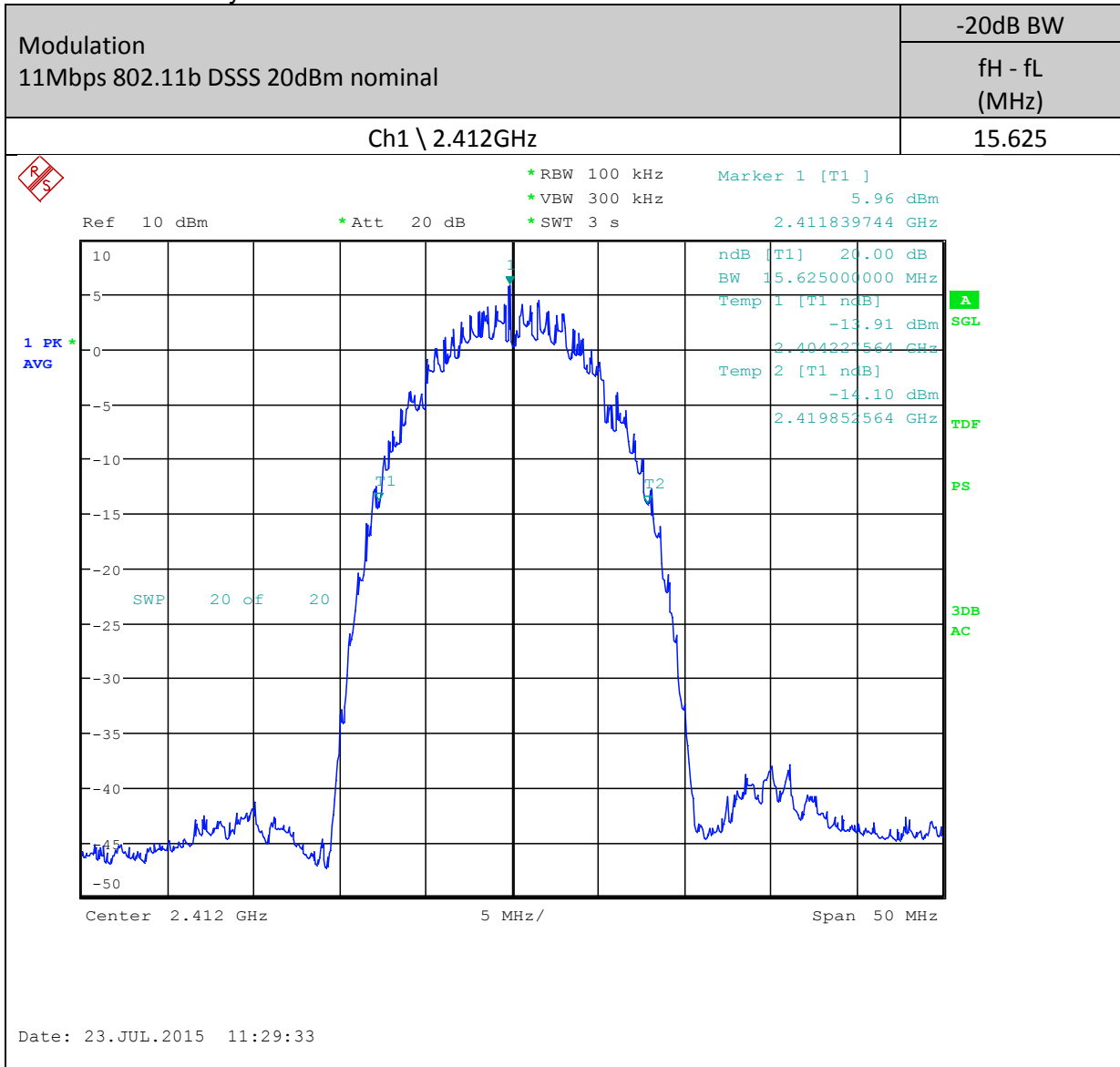
**Test Date/s:** 24<sup>th</sup> July 2015

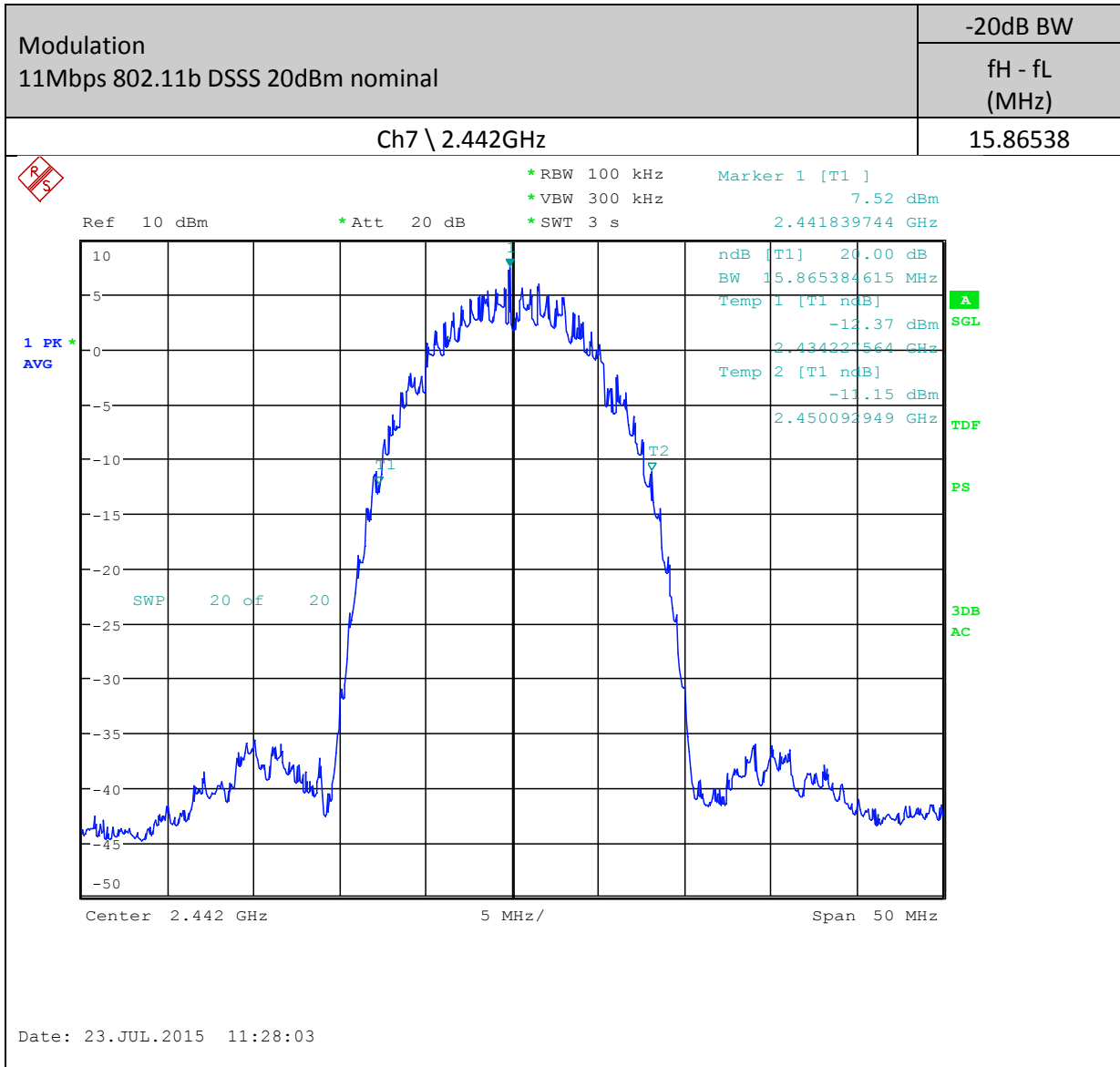
**Test Status:** **PASS**

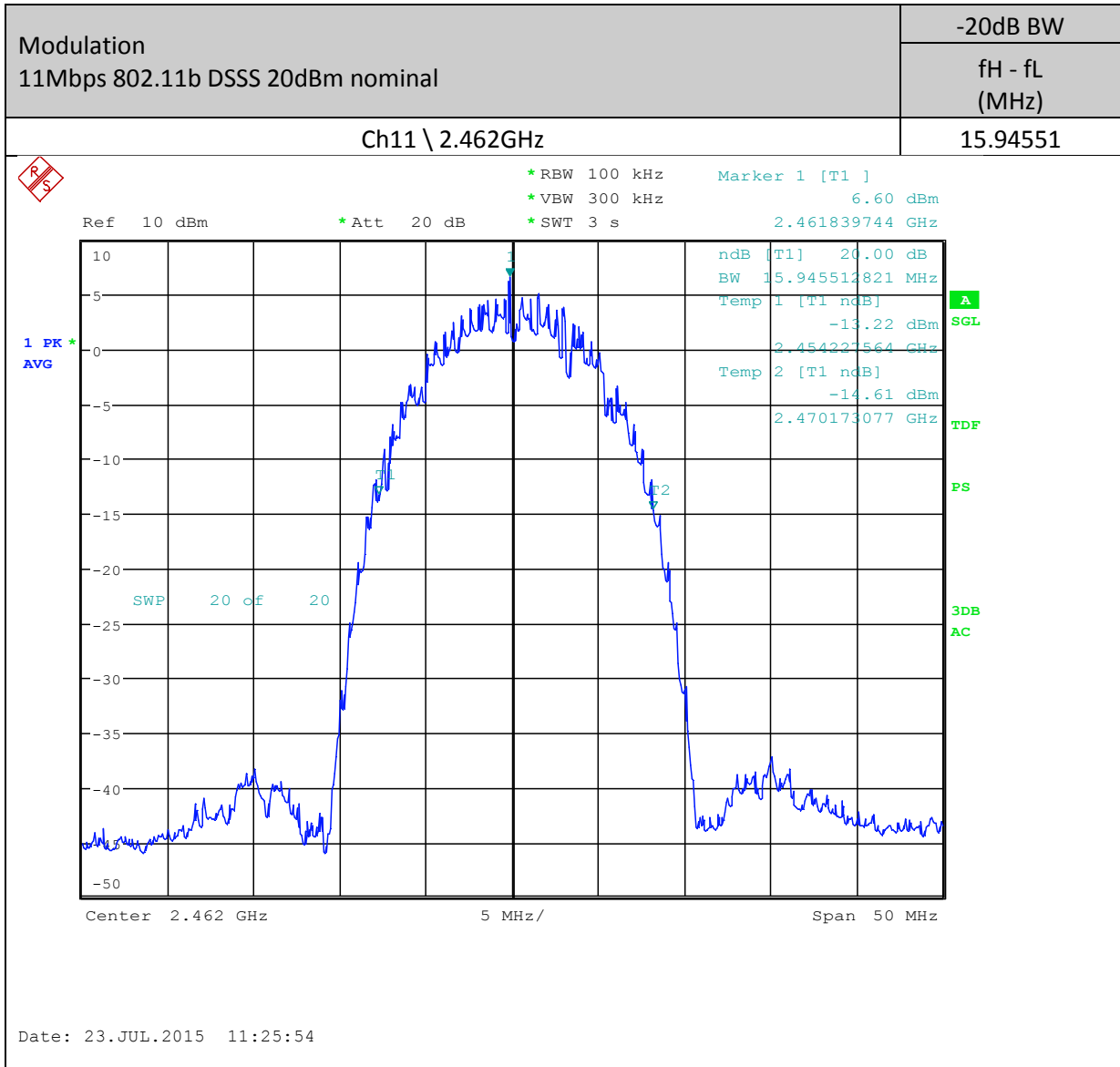
## 6.4 Medium Access Protocol

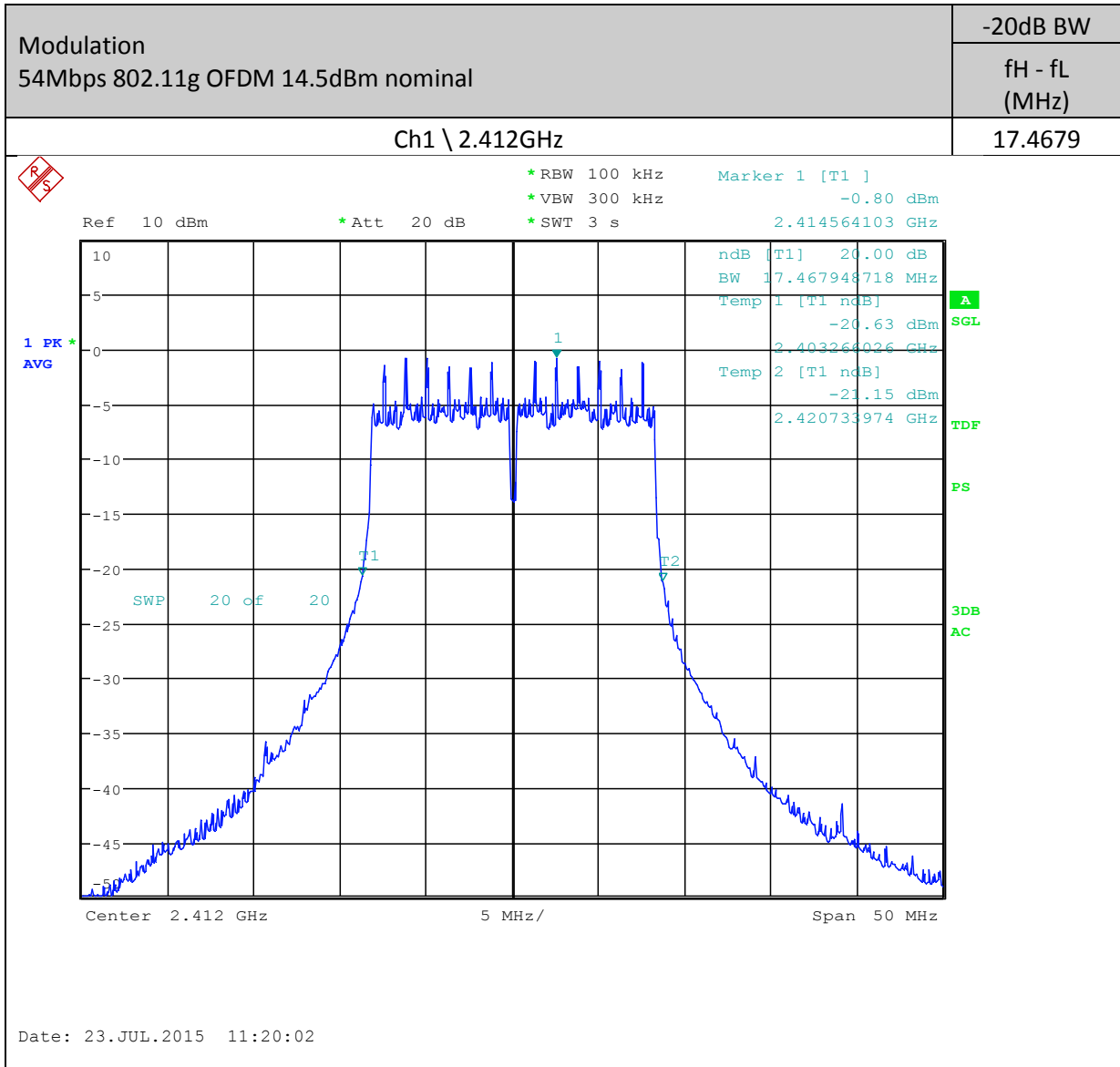
		UUT
Technical Specification	Requirement	
Medium Access Protocol	A medium access protocol shall be implemented by the equipment	The UUT implements medium access protocols defined by IEEE 802.11 b/g specifications

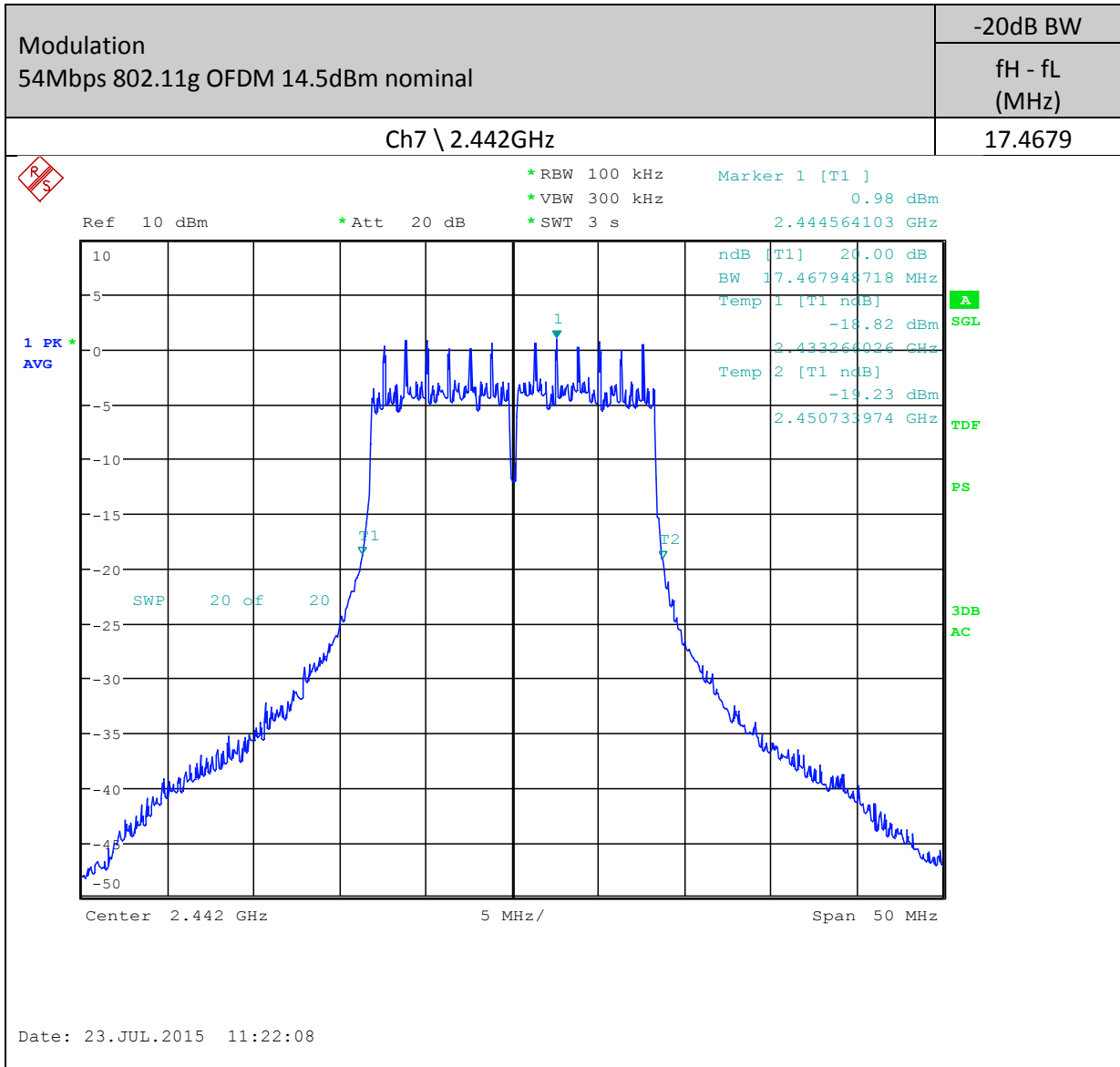
6.5 20dB Channel Bandwidth  
For information only.



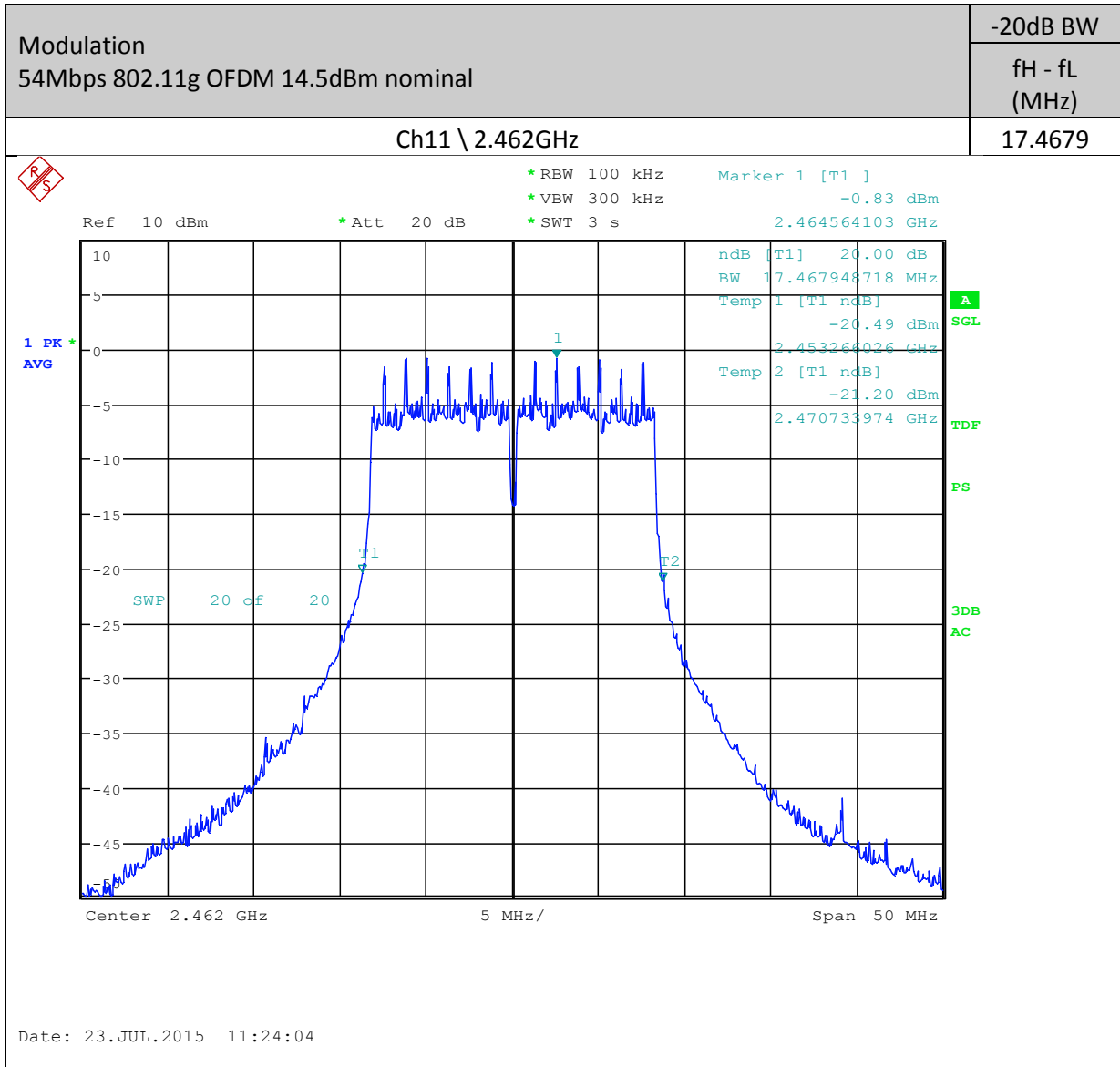












**Comments:** None.  
**Unit:** 2  
**Tested by:** D. Jamieson  
**Test Date/s:** 27<sup>th</sup> July 2015  
**Test Status:** For information only.

## 6.6 Frequency Band Edges

Type	Channel / Area	Frequency (GHz)	Limit (GHz)	Result
11b	1 / Lower	2.404227564	2.4	Pass
	11 / Upper	2.470173077	2.4835	Pass
11g	1 / Lower	2.403266026	2.4	Pass
	11 / Upper	2.470733974	2.4835	Pass

**Comments:** None.

**Unit:** 2

**Tested by:** D. Jamieson

**Test Date/s:** 23<sup>rd</sup> July 2015

**Test Status:** **PASS**

## 6.7 6dB Channel Bandwidth (RSS-210)

Type	Channel	6dB Channel Bandwidth (Hz)	6dB Channel Bandwidth (MHz)	Limit (MHz)	Result
11b	1	6330128.000	6.330	0.5	Pass
	7	6330128.000	6.330	0.5	Pass
	11	6330128.000	6.330	0.5	Pass
11g	1	16442300.000	16.442	0.5	Pass
	7	16442300.000	16.442	0.5	Pass
	11	16442300.000	16.442	0.5	Pass

**Comments:** None.

**Unit:** 2

**Tested by:** D. Jamieson

**Test Date/s:** 23<sup>rd</sup> July 2015

**Test Status:** **PASS**

## 6.8 Power Spectral Density (RSS-210)

Type	Channel	PSD (dBm/3kHz)	Limit (dBm)	Result
11b	1	-10.93	8	Pass
	7	-9.43	8	Pass
	11	-10.37	8	Pass
11g	1	-18.35	8	Pass
	7	-16.76	8	Pass
	11	-17.72	8	Pass

**Comments:** None.

**Unit:** 2

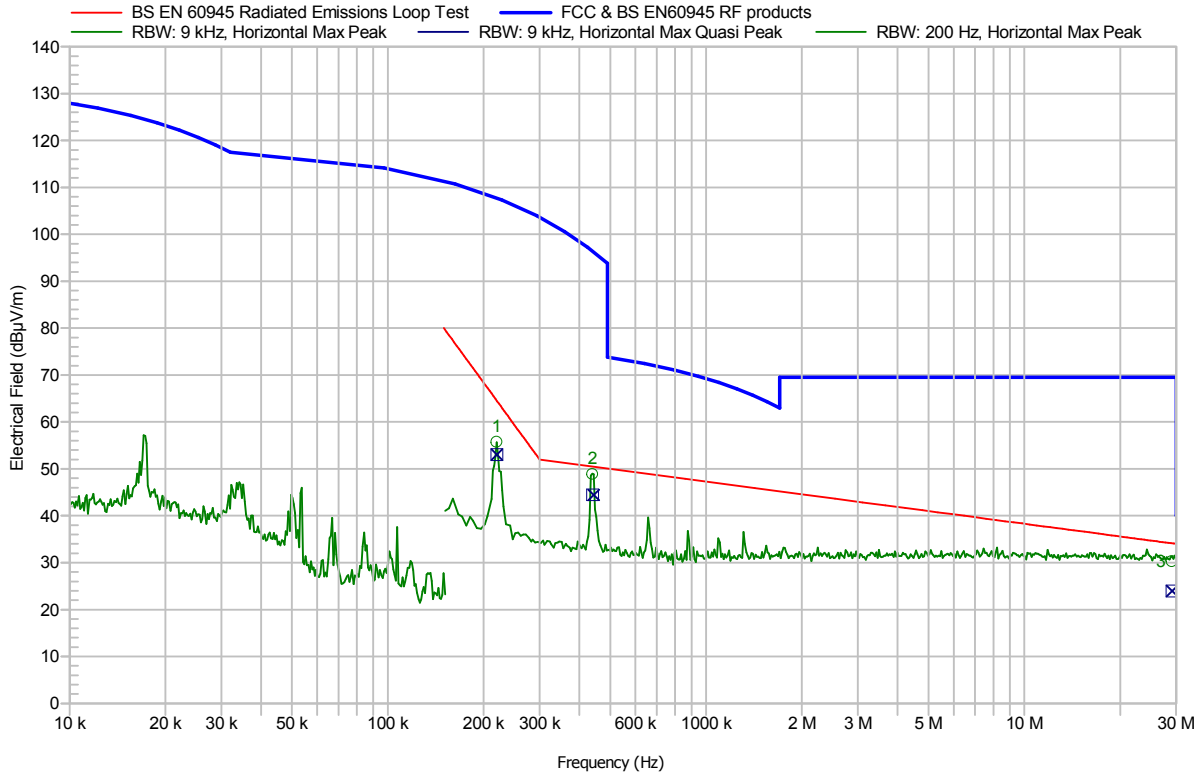
**Tested by:** D. Jamieson

**Test Date/s:** 23<sup>rd</sup> July 2015

**Test Status:** **PASS**

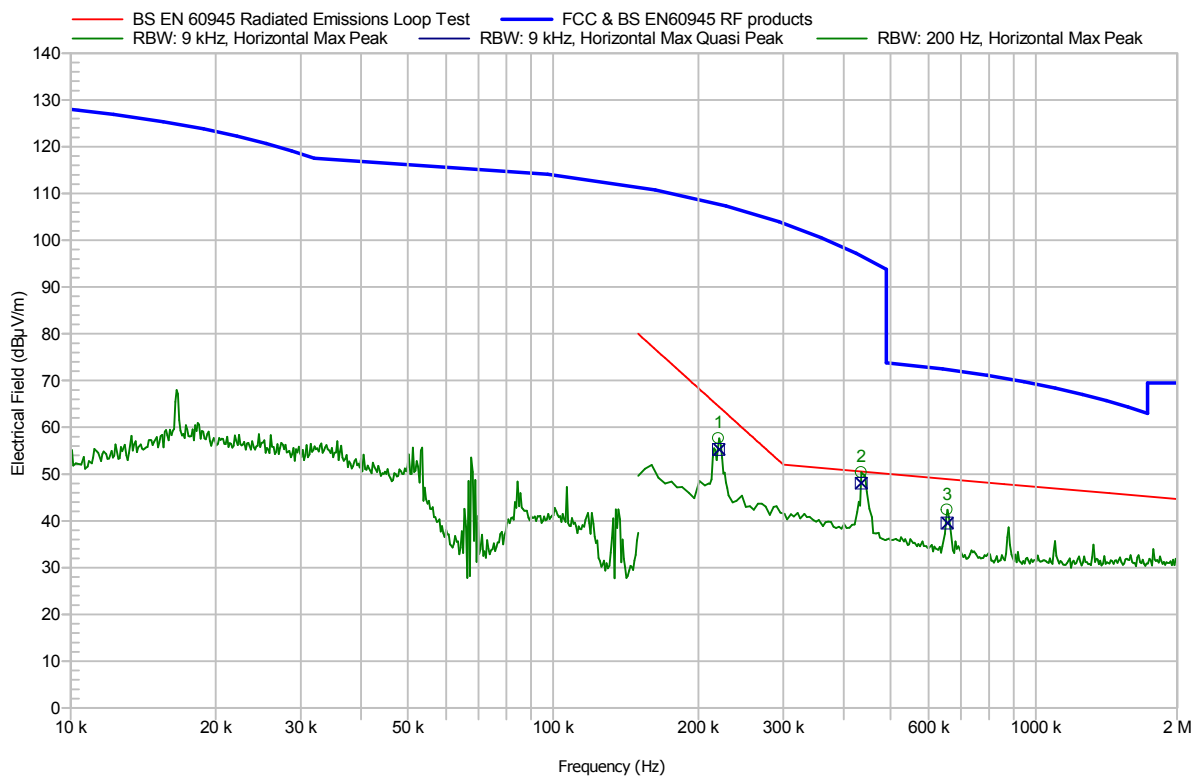
## 6.9 Transmitter Spurious Emissions

### 6.9.1.1 10kHz to 30MHz – 24V nom – X Polarity (Side on)



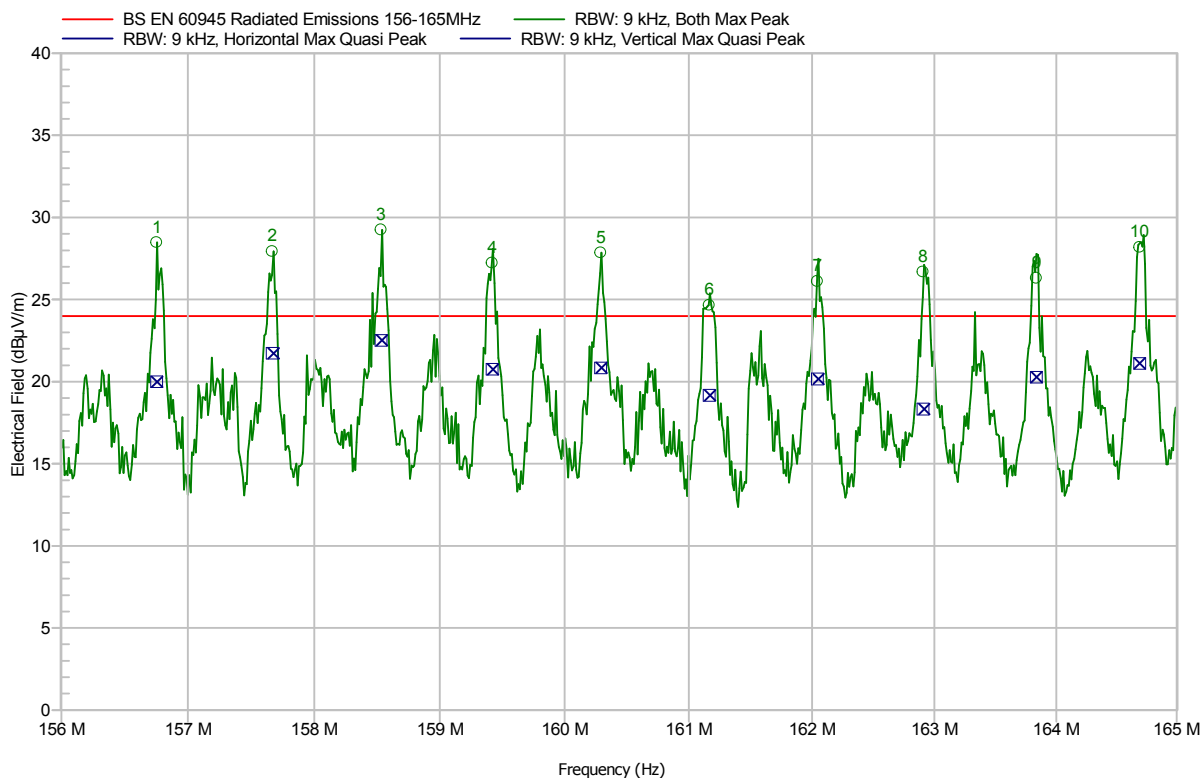
Nr	Frequency	Peak	Quasi-Peak	Quasi-Peak Difference	Status	Angle	Polarization
1	220 kHz	55.68 dBµV/m	53.05 dBµV/m	-11.48 dB	Pass	157 Degree	Horizontal
2	440 kHz	48.82 dBµV/m	44.46 dBµV/m	-6.04 dB	Pass	165 Degree	Horizontal
3	29.115 MHz	30.27 dBµV/m	23.97 dBµV/m	-10.14 dB	Pass	22 Degree	Horizontal

6.9.1.2 10kHz to 30MHz – 24V nom – Y Polarity (Face on)



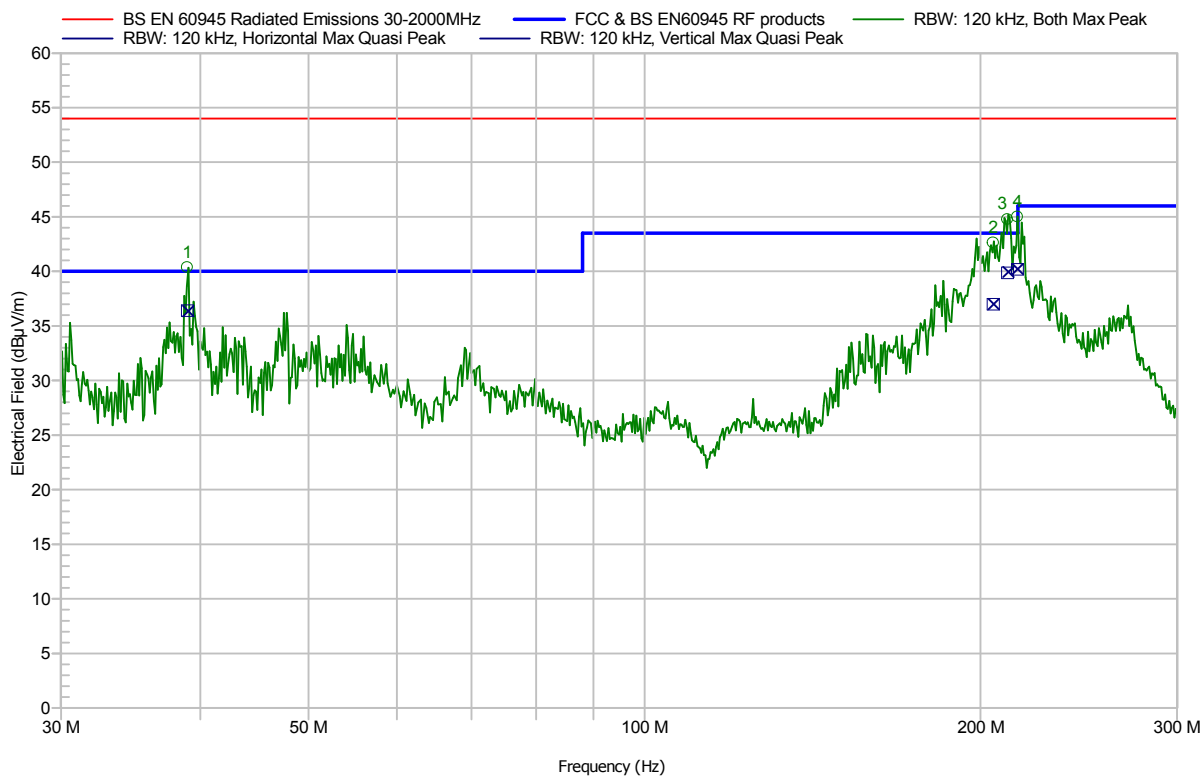
Nr	Frequency	Peak	Quasi-Peak	Quasi-Peak Difference	Status	Angle	Polarization
1	220 kHz	57.66 dBµV/m	55.27 dBµV/m	-9.26 dB	Pass	22 Degree	Horizontal
2	435 kHz	50.36 dBµV/m	48.08 dBµV/m	-2.47 dB	Pass	90 Degree	Horizontal
3	655 kHz	42.4 dBµV/m	39.54 dBµV/m	-9.41 dB	Pass	105 Degree	Horizontal

### 6.9.1.3 156MHz to 165MHz – 24V nom



Nr	Frequency	Peak	Quasi-Peak	Quasi-Peak Difference	Status	Angle	Polarization
1	156.753 MHz	28.47 dBµV/m	19.99 dBµV/m	-4.01 dB	Pass	202 Degree	Horizontal
2	157.667 MHz	27.93 dBµV/m	21.73 dBµV/m	-2.27 dB	Pass	225 Degree	Horizontal
3	158.53 MHz	29.25 dBµV/m	22.52 dBµV/m	-1.48 dB	Pass	202 Degree	Horizontal
4	159.419 MHz	27.23 dBµV/m	20.75 dBµV/m	-3.25 dB	Pass	202 Degree	Horizontal
5	160.29 MHz	27.85 dBµV/m	20.84 dBµV/m	-3.16 dB	Pass	202 Degree	Horizontal
6	161.165 MHz	24.66 dBµV/m	19.17 dBµV/m	-4.83 dB	Pass	22 Degree	Vertical
7	162.043 MHz	26.11 dBµV/m	20.17 dBµV/m	-3.83 dB	Pass	225 Degree	Horizontal
8	162.905 MHz	26.69 dBµV/m	18.33 dBµV/m	-5.67 dB	Pass	225 Degree	Horizontal
9	163.836 MHz	26.3 dBµV/m	20.27 dBµV/m	-3.73 dB	Pass	247 Degree	Horizontal
10	164.689 MHz	28.19 dBµV/m	21.11 dBµV/m	-2.89 dB	Pass	240 Degree	Horizontal

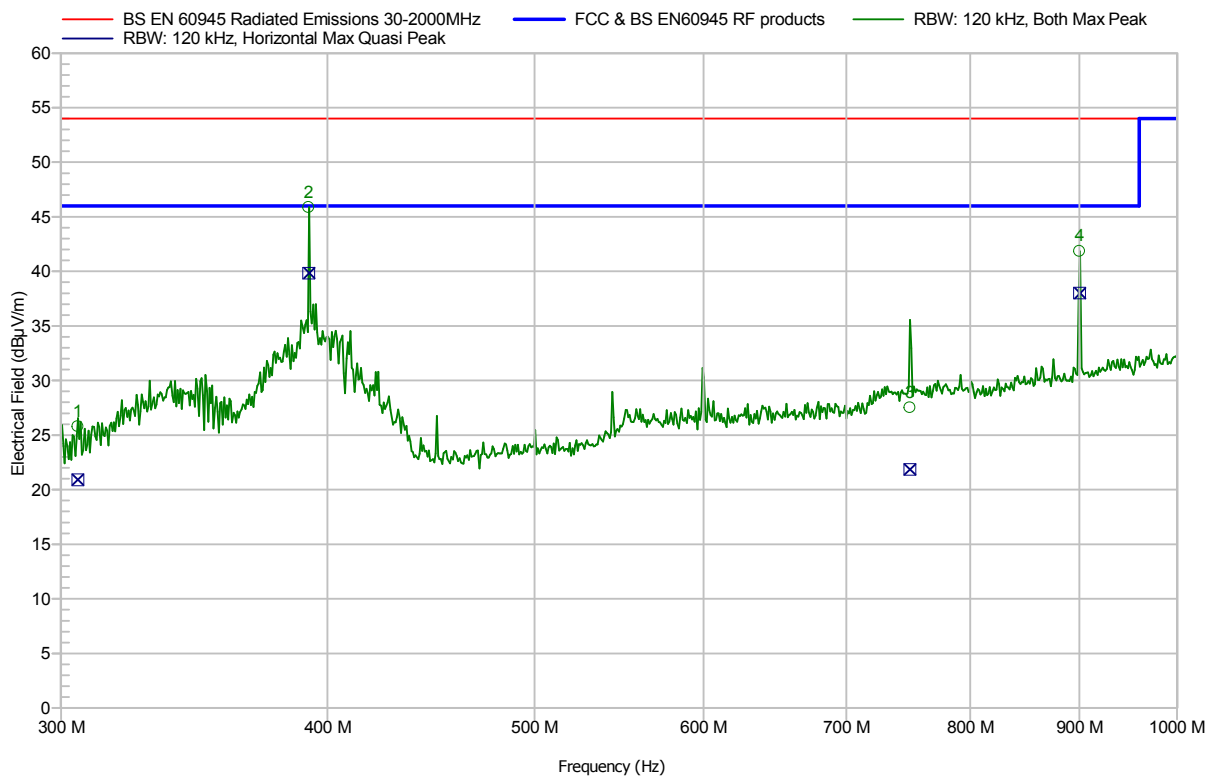
6.9.1.4 30MHz to 300MHz – 24V nom



Nr	Frequency	Peak	Quasi-Peak	Quasi-Peak Difference	Status	Angle	Polarization
1	38.951 MHz	40.37 dBµV/m	36.41 dBµV/m	-3.59 dB	Pass	285 Degree	Vertical
2	205.281 MHz	42.63 dBµV/m	37 dBµV/m	-6.5 dB	Pass	202 Degree	Horizontal
3	211.407 MHz	44.76 dBµV/m	39.87 dBµV/m	-3.63 dB	Pass	202 Degree	Horizontal
4	215.842 MHz	44.99 dBµV/m	40.19 dBµV/m	-3.31 dB	Pass	195 Degree	Horizontal

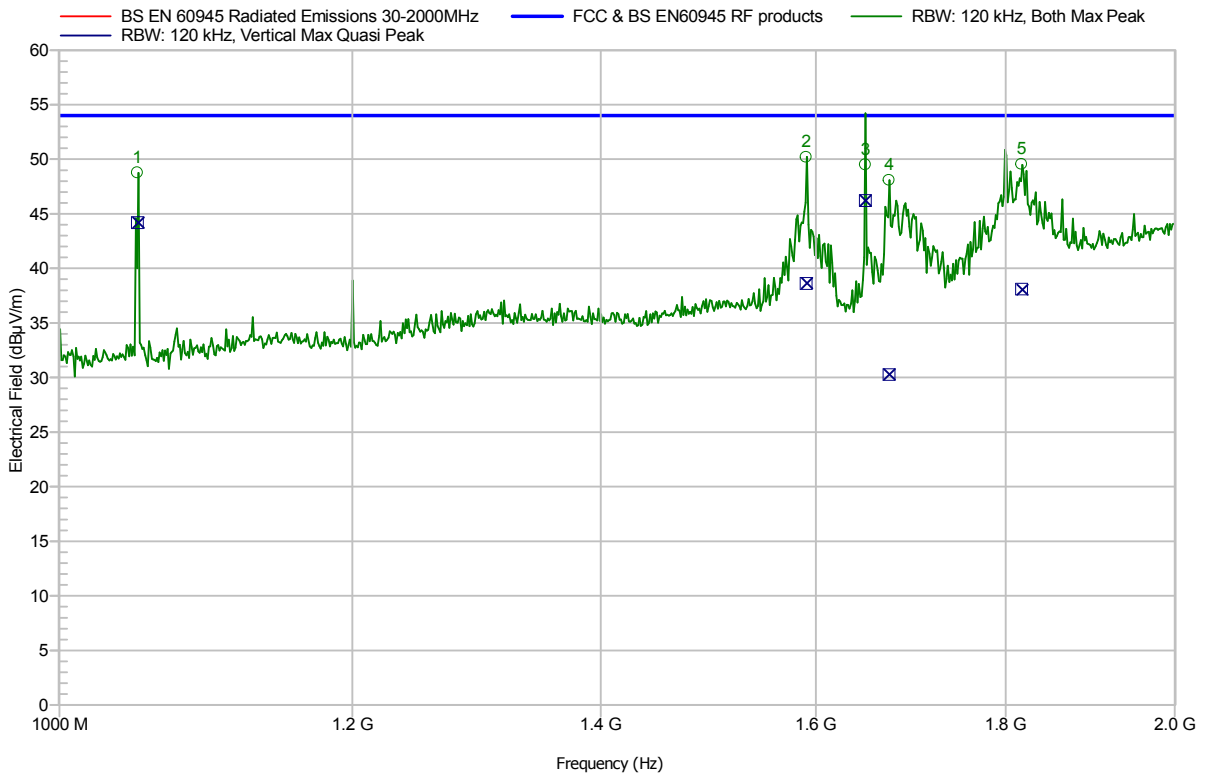


6.9.1.5 300MHz to 1GHz – 24V nom



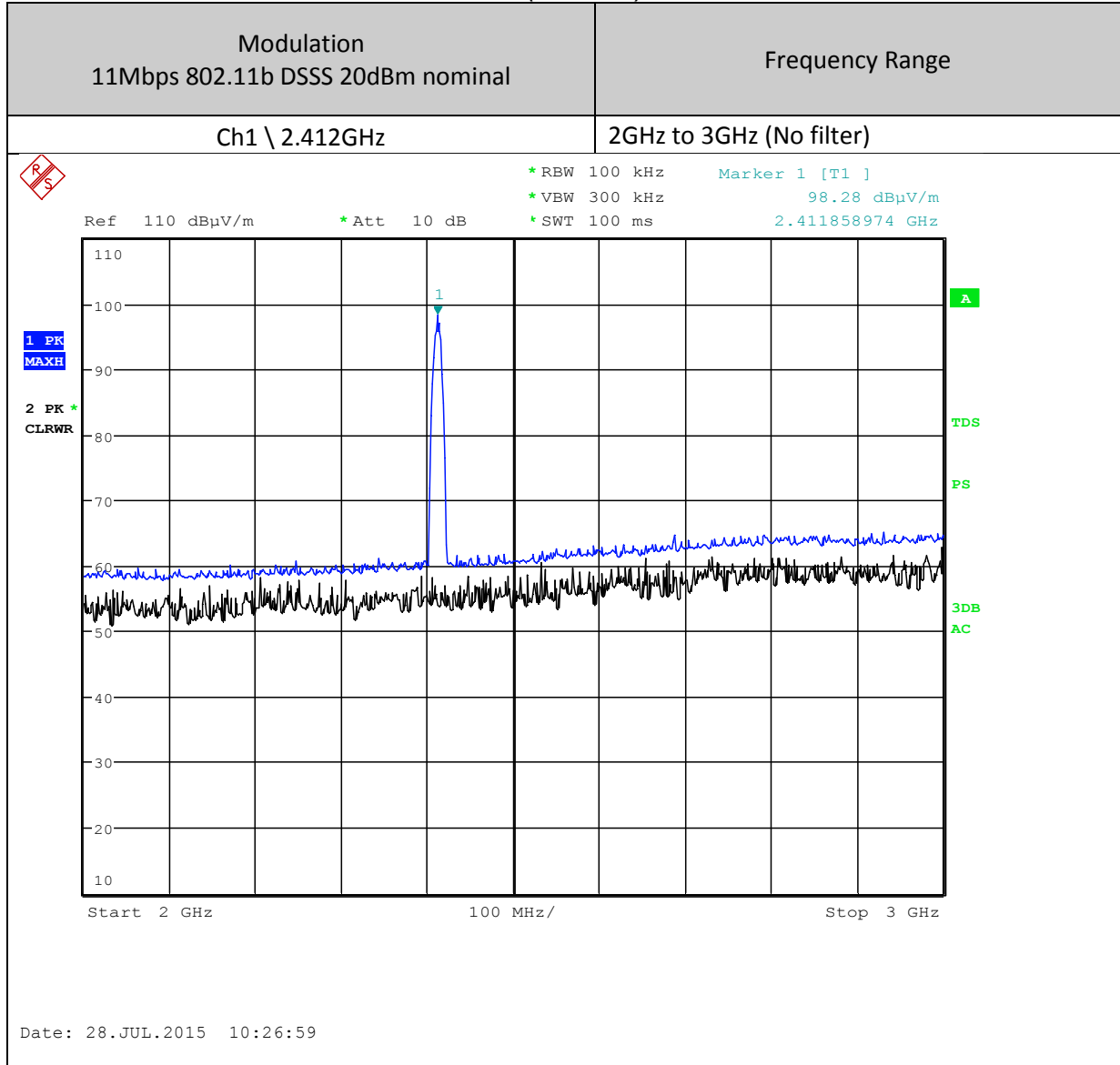
Nr	Frequency	Peak	Quasi-Peak	Quasi-Peak Difference	Status	Angle	Polarization
1	305.594 MHz	25.78 dBµV/m	20.91 dBµV/m	-25.09 dB	Pass	157 Degree	Horizontal
2	391.928 MHz	45.86 dBµV/m	39.84 dBµV/m	-6.16 dB	Pass	270 Degree	Horizontal
3	749.65 MHz	27.51 dBµV/m	21.86 dBµV/m	-24.14 dB	Pass	240 Degree	Horizontal
4	900.01 MHz	41.84 dBµV/m	38.01 dBµV/m	-7.99 dB	Pass	202 Degree	Horizontal

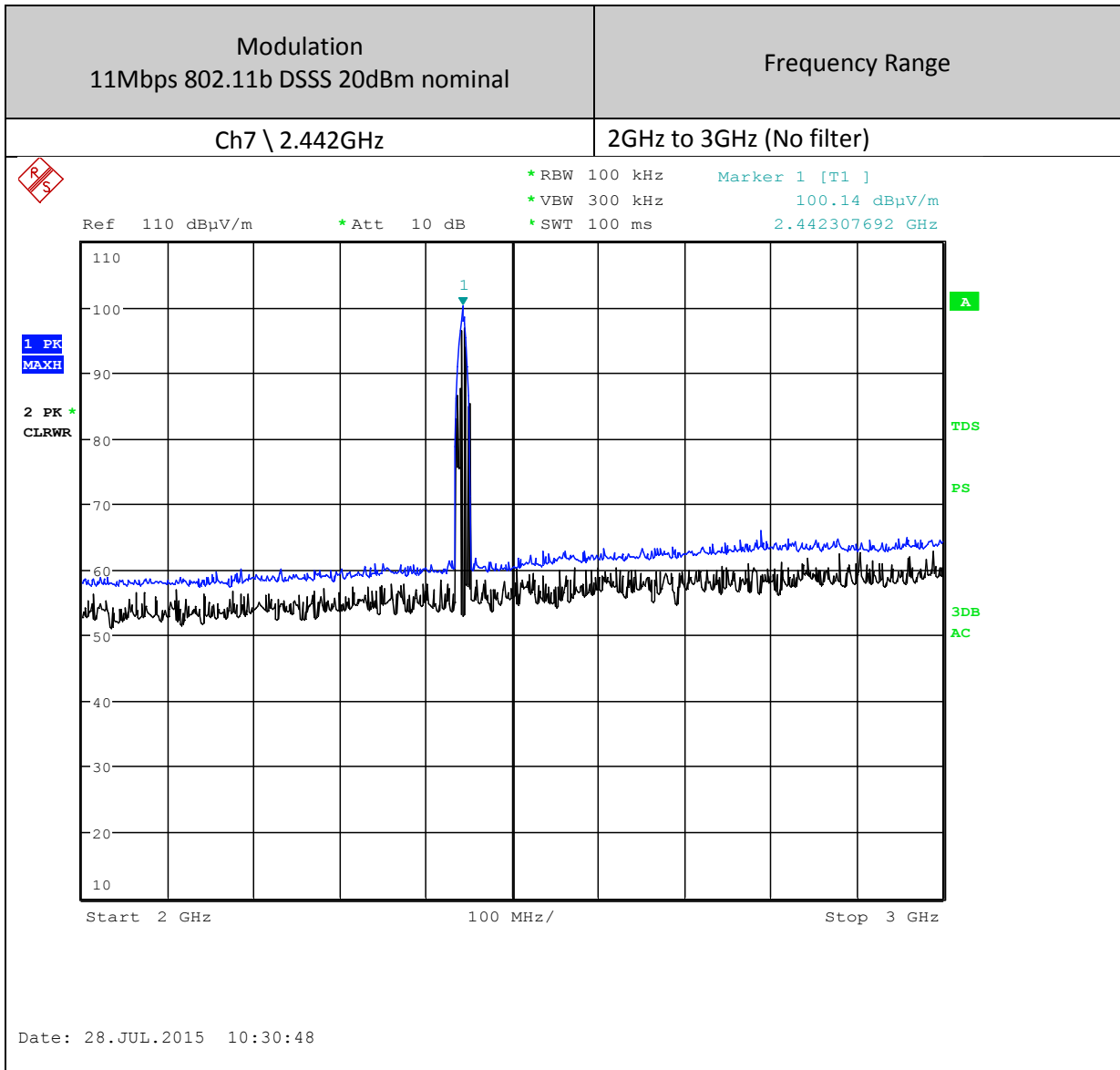
6.9.1.6 1GHz to 2GHz – 24V nom

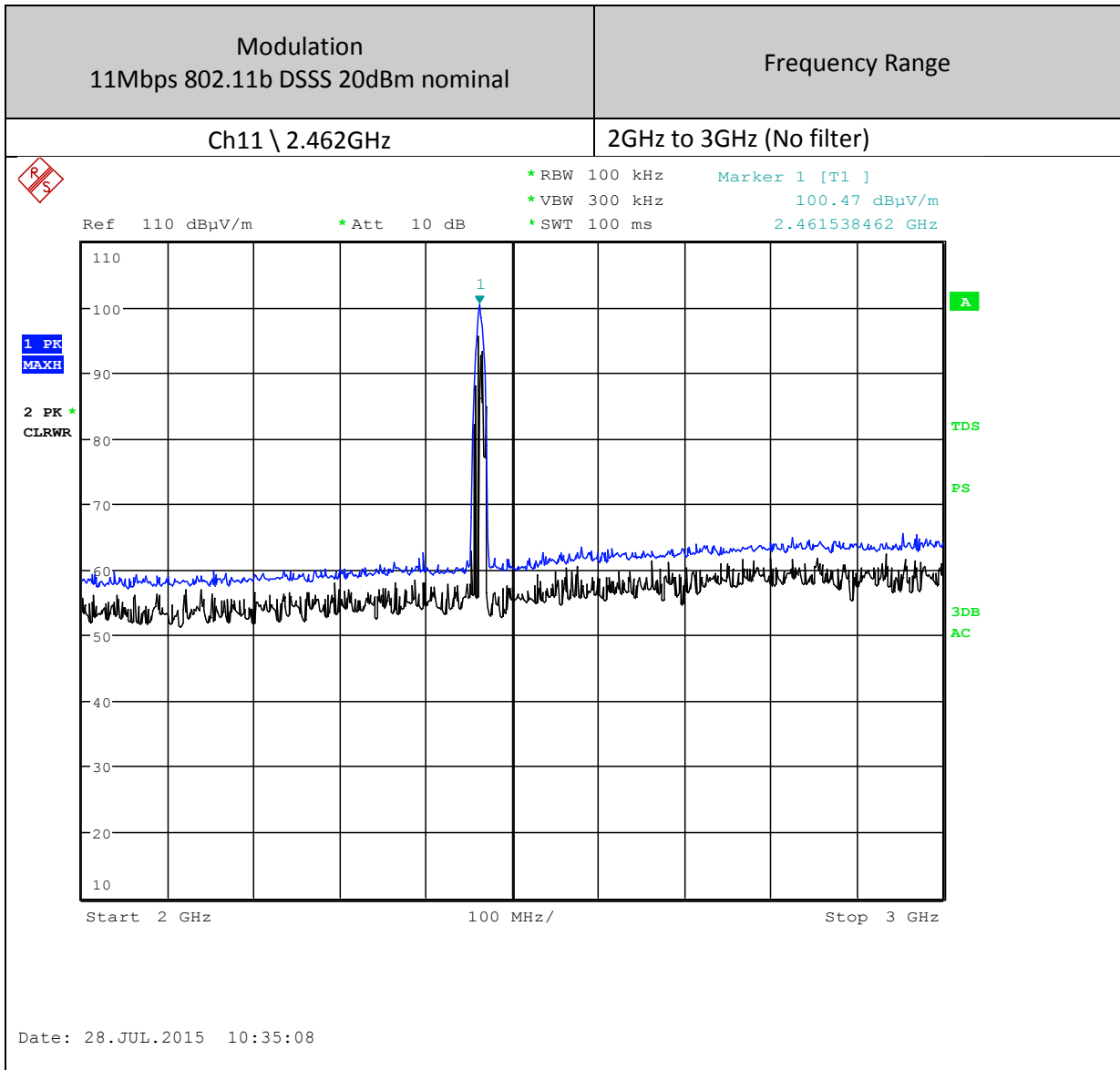


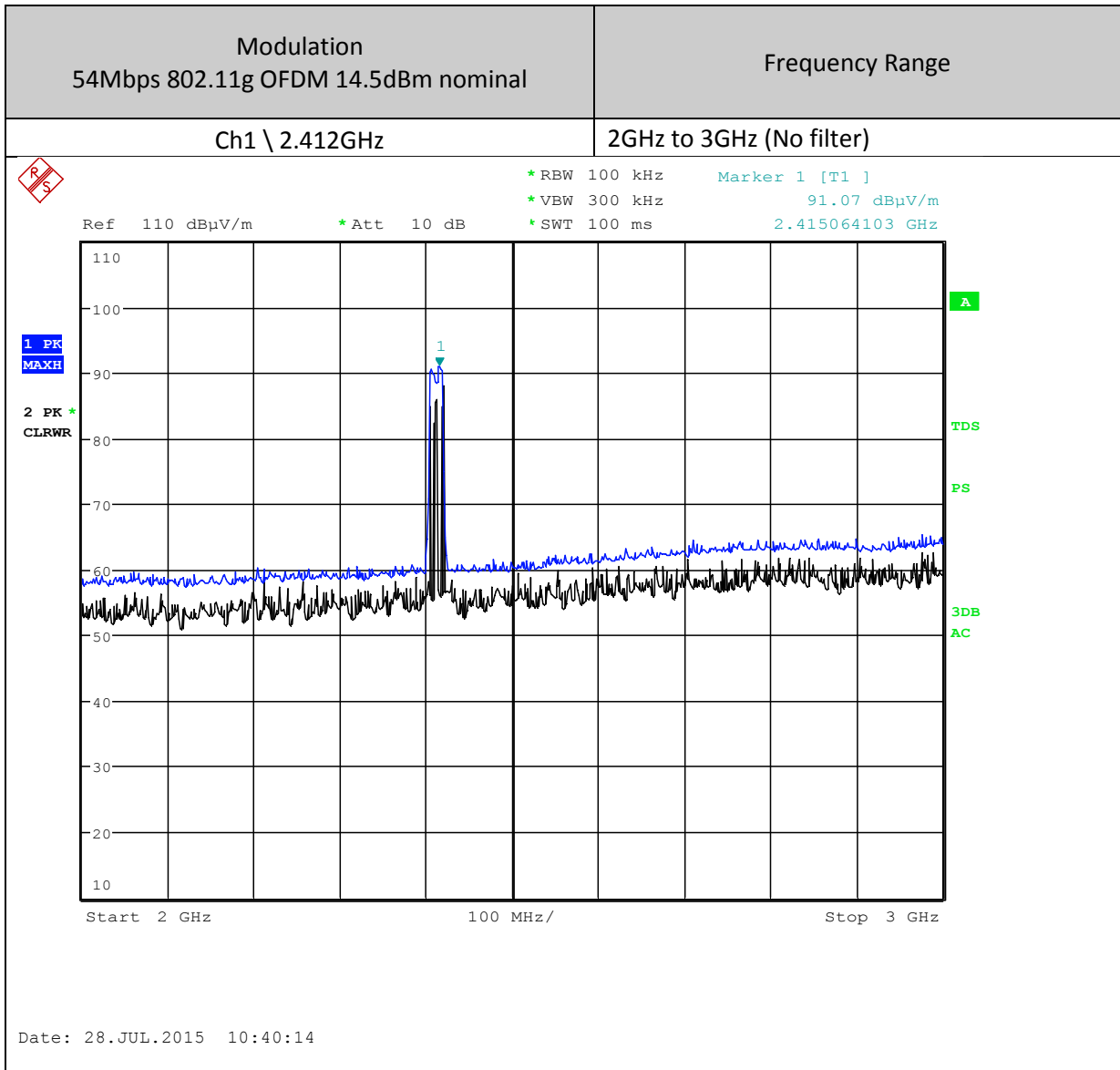
Nr	Frequency	Peak	Quasi-Peak	Quasi-Peak Difference	Status	Angle	Polarization
1	1.05 GHz	48.76 dBµV/m	44.19 dBµV/m	-9.81 dB	Pass	330 Degree	Vertical
2	1.59 GHz	50.19 dBµV/m	38.63 dBµV/m	-15.37 dB	Pass	285 Degree	Vertical
3	1.65 GHz	49.5 dBµV/m	46.22 dBµV/m	-7.78 dB	Pass	255 Degree	Vertical
4	1.675 GHz	48.08 dBµV/m	30.28 dBµV/m	-23.72 dB	Pass	202 Degree	Vertical
5	1.818 GHz	49.54 dBµV/m	38.1 dBµV/m	-15.9 dB	Pass	15 Degree	Vertical

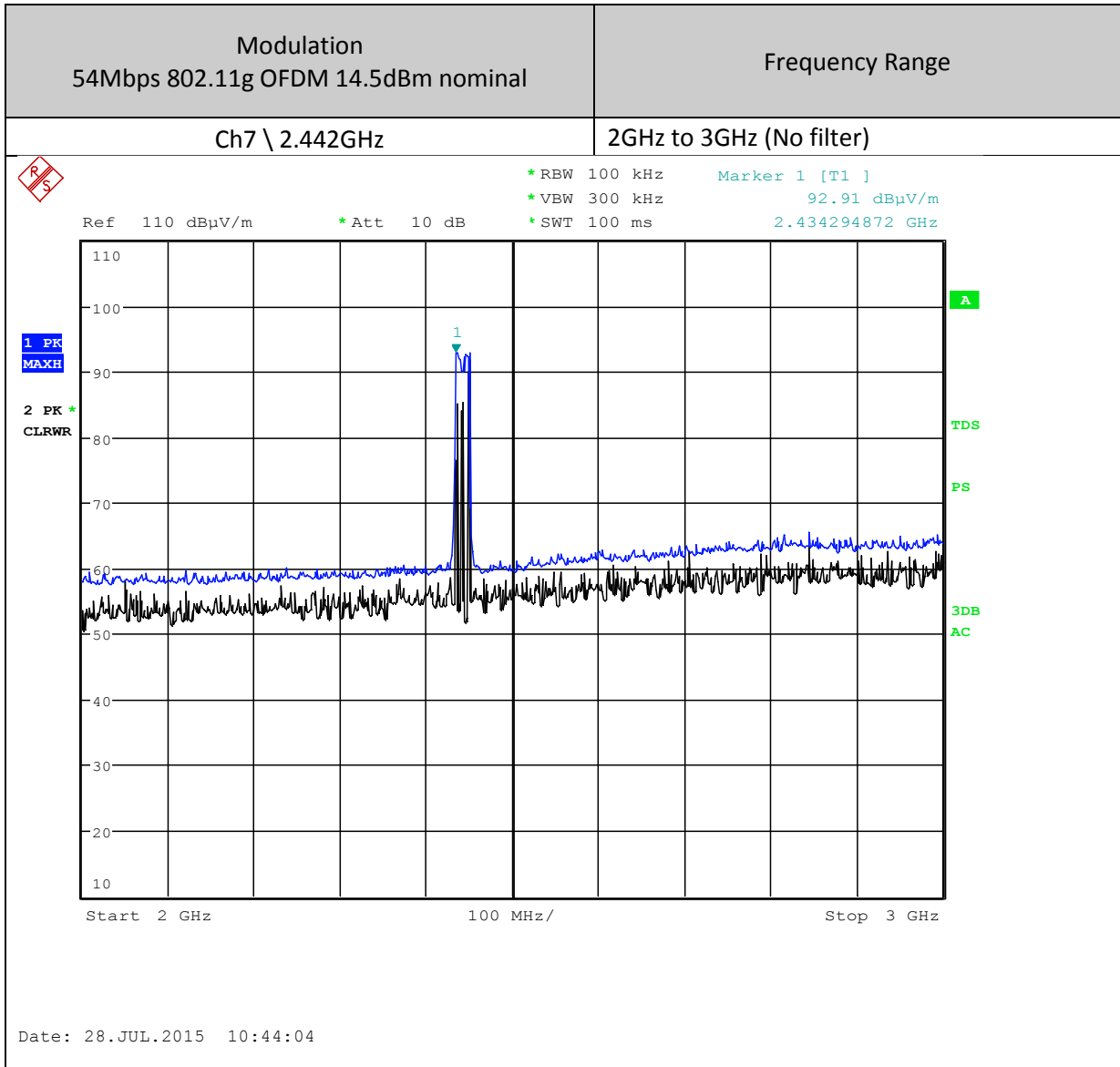
6.9.2 Radiated Emissions 2GHz-3GHz (No filter)

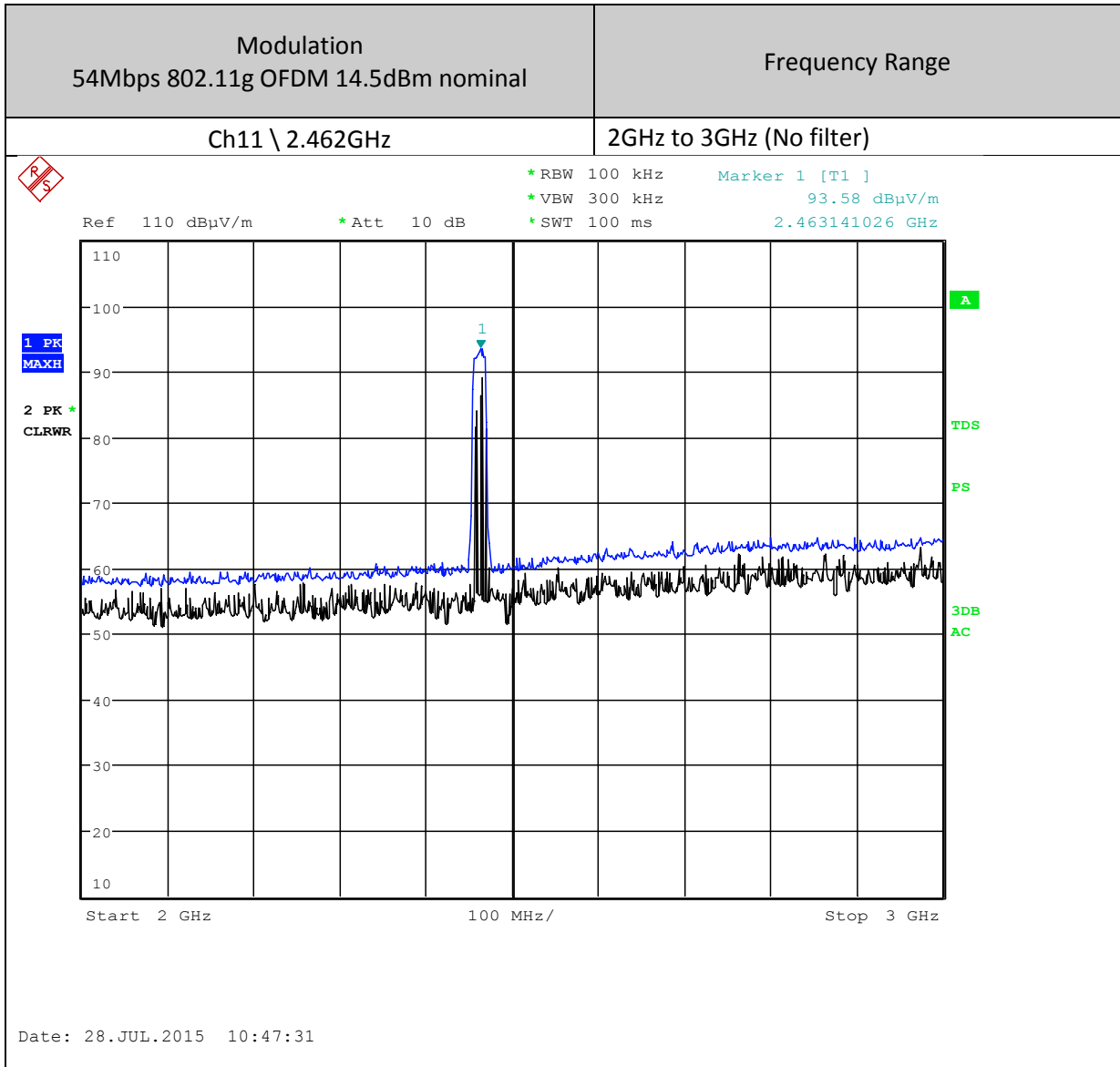






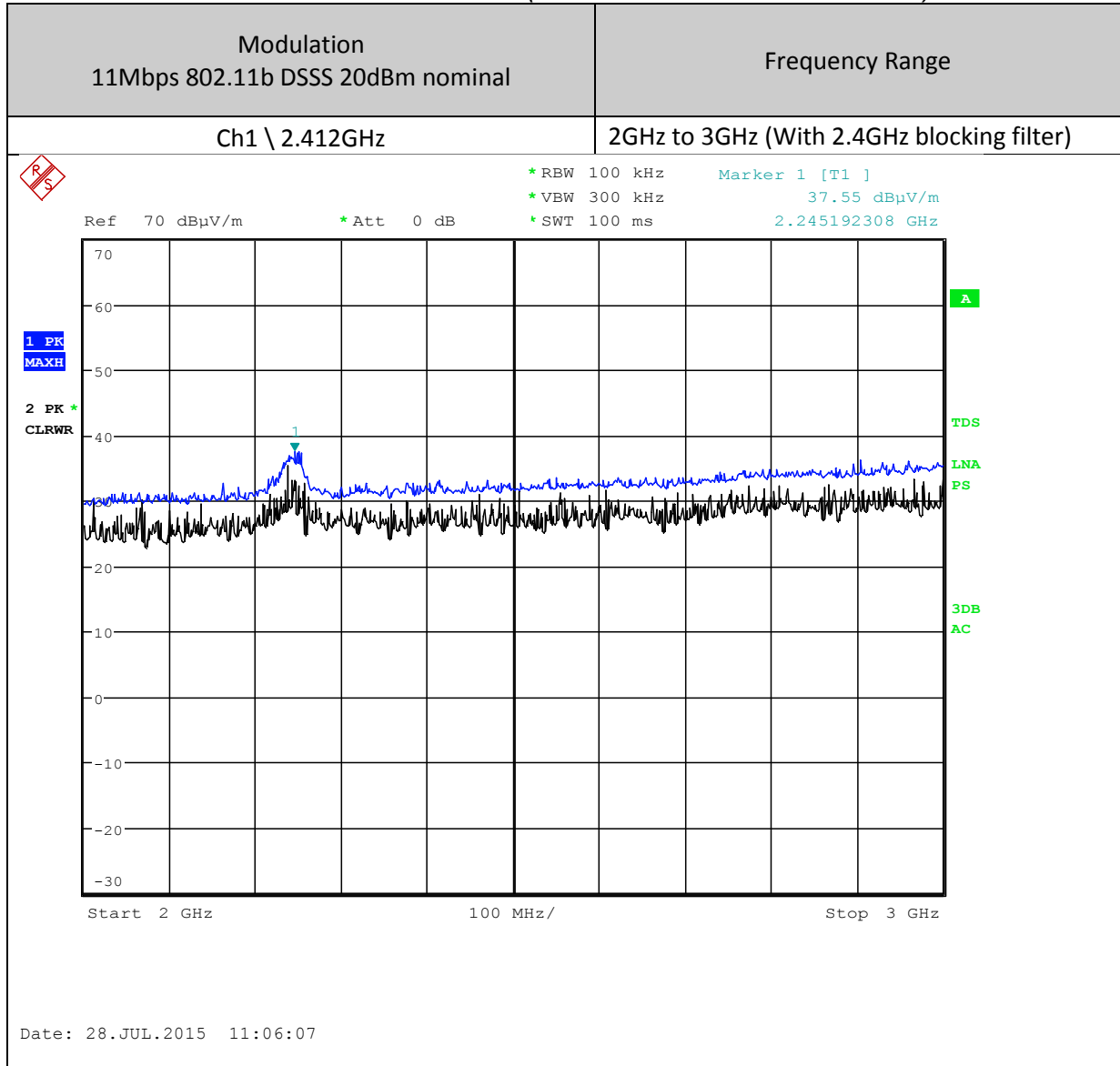


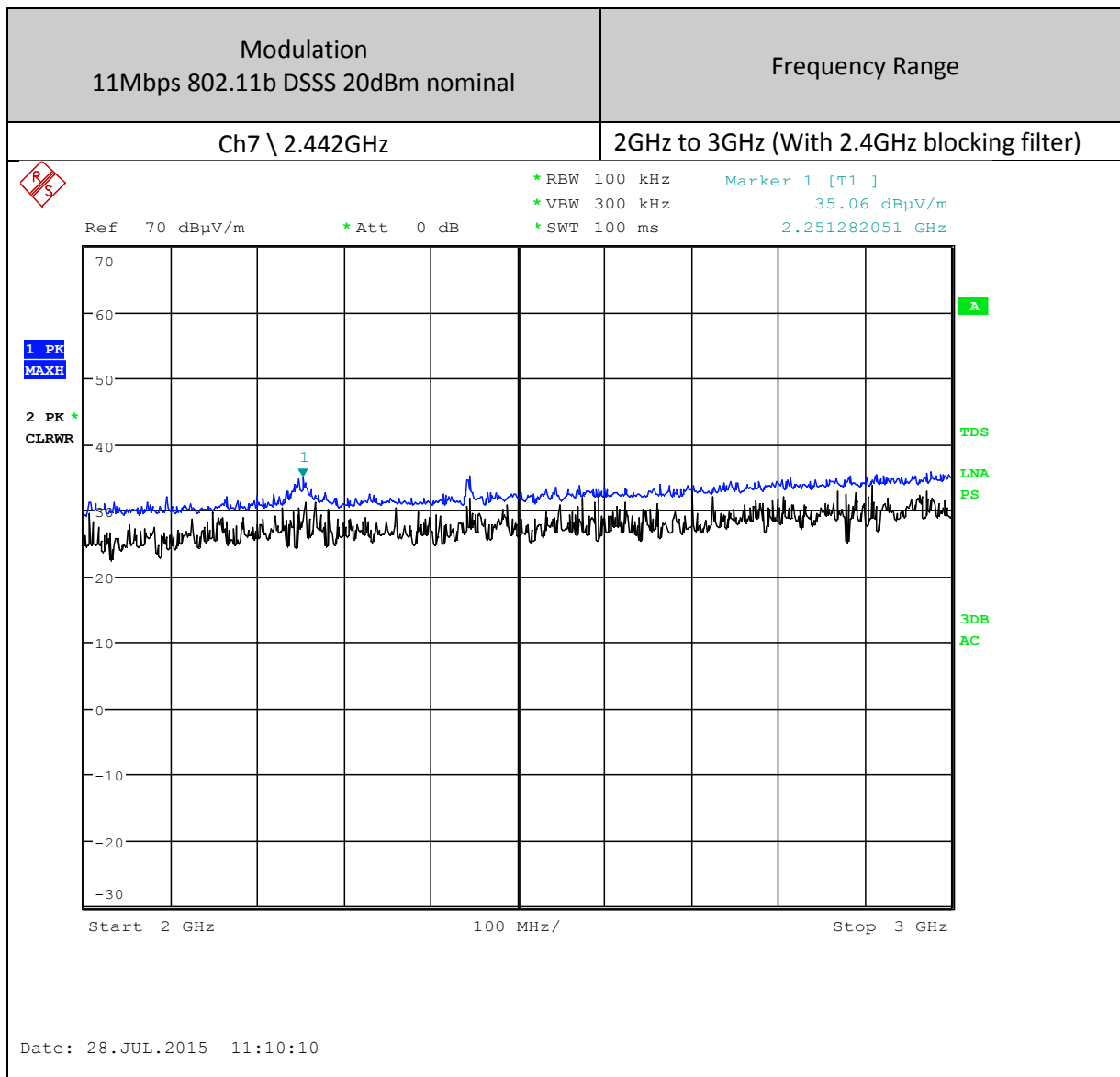


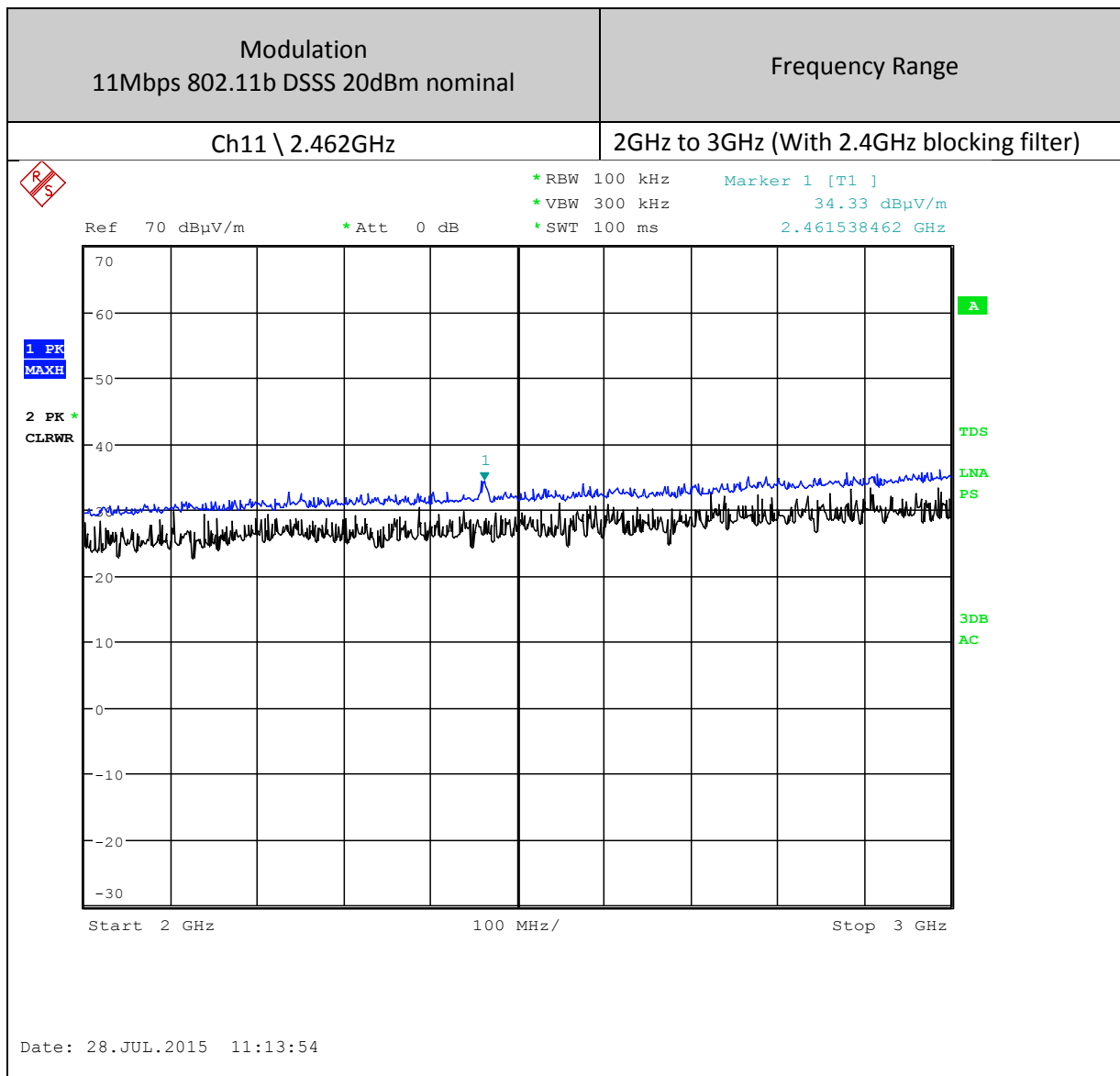


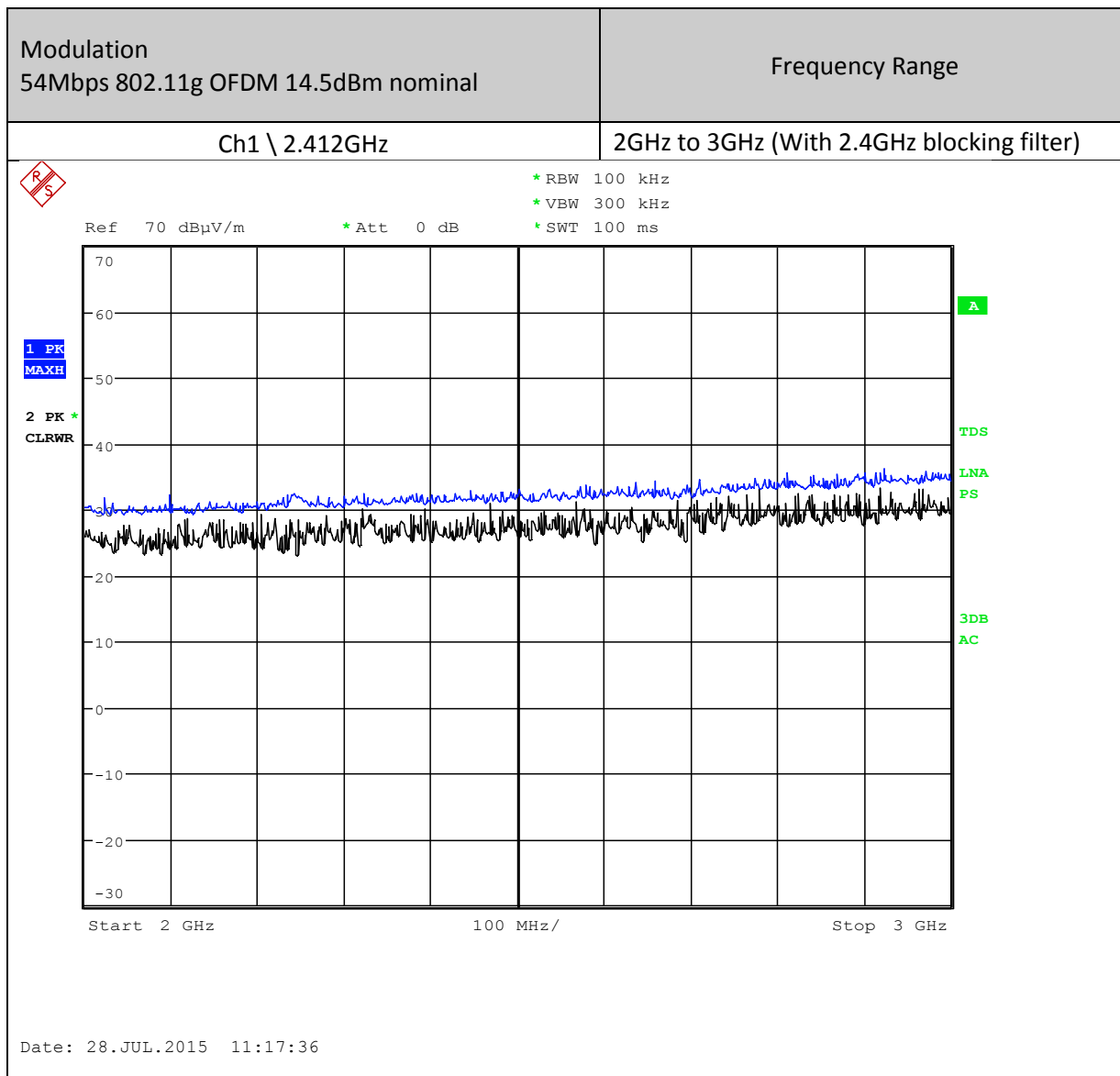


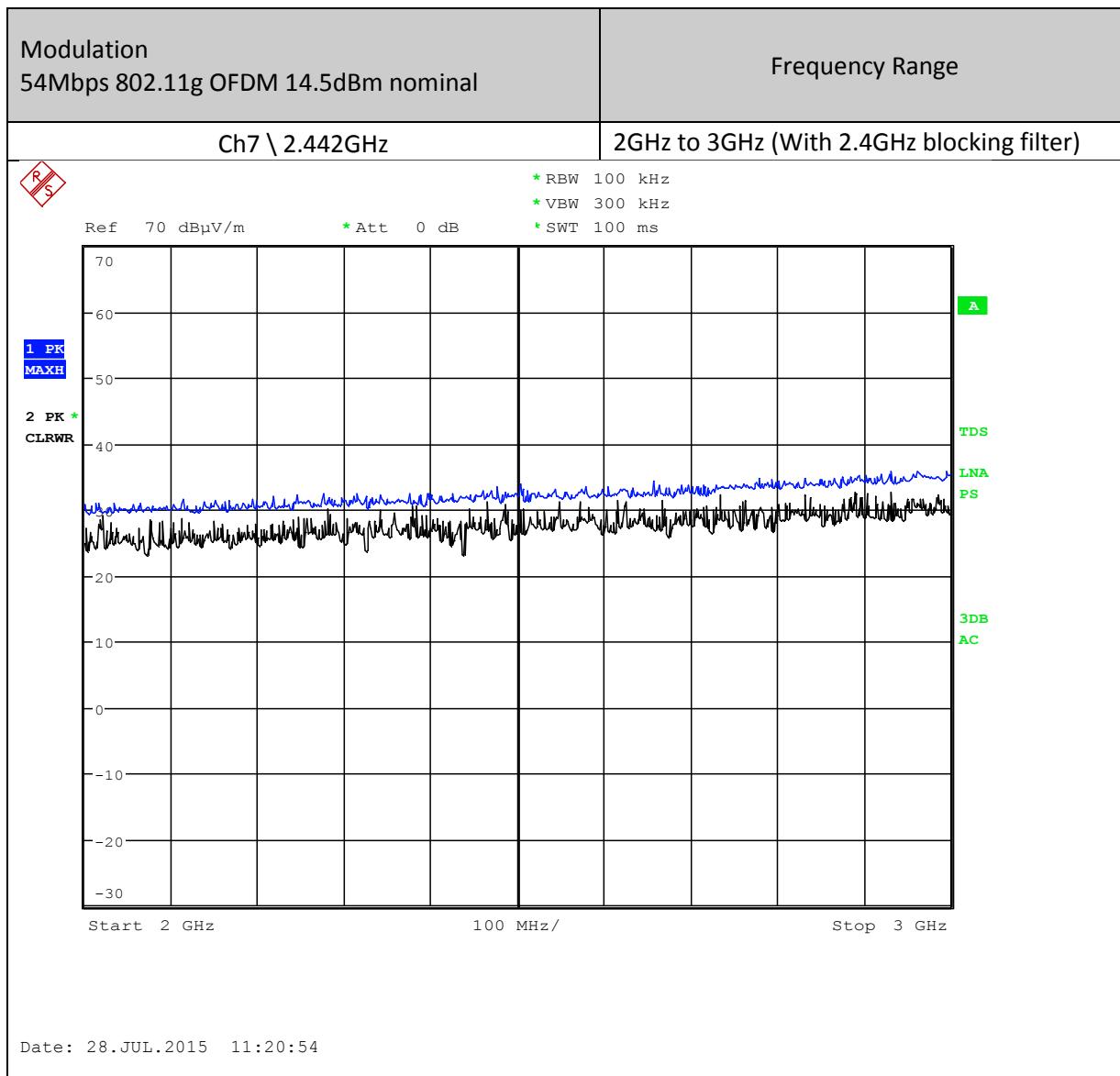
6.9.3 Radiated Emissions 2GHz-3GHz (2.4GHz block used on ESU40)

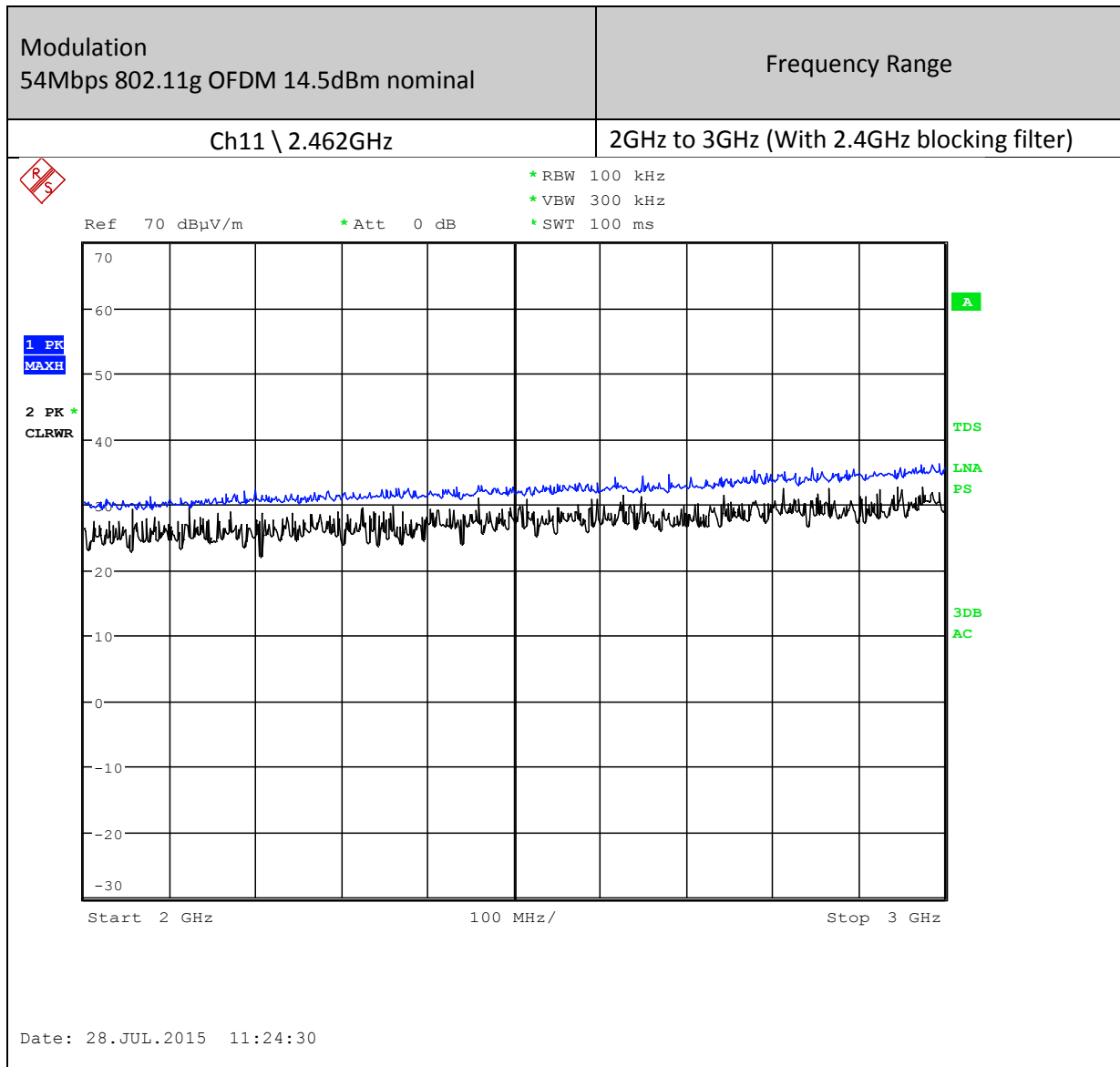




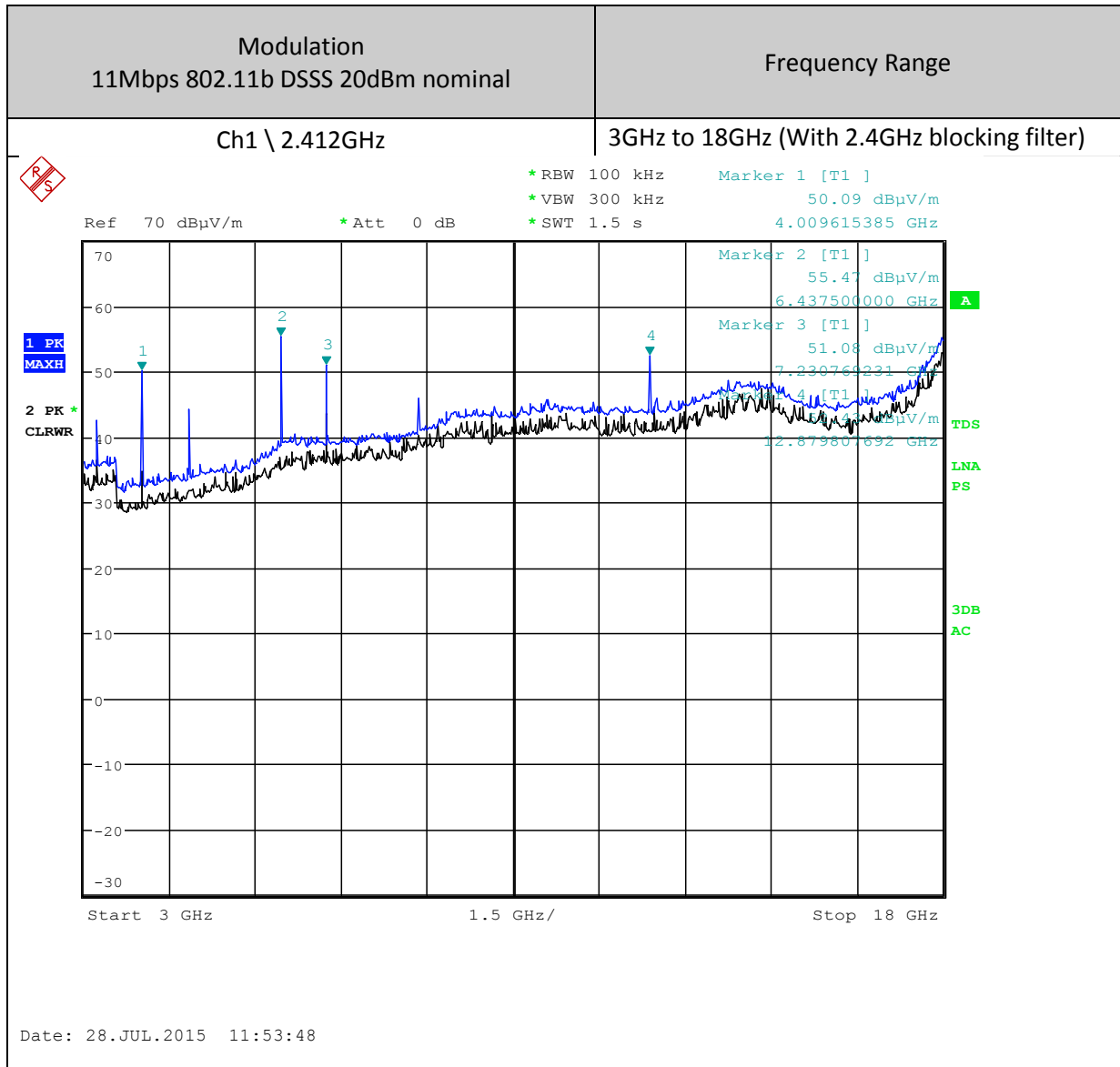


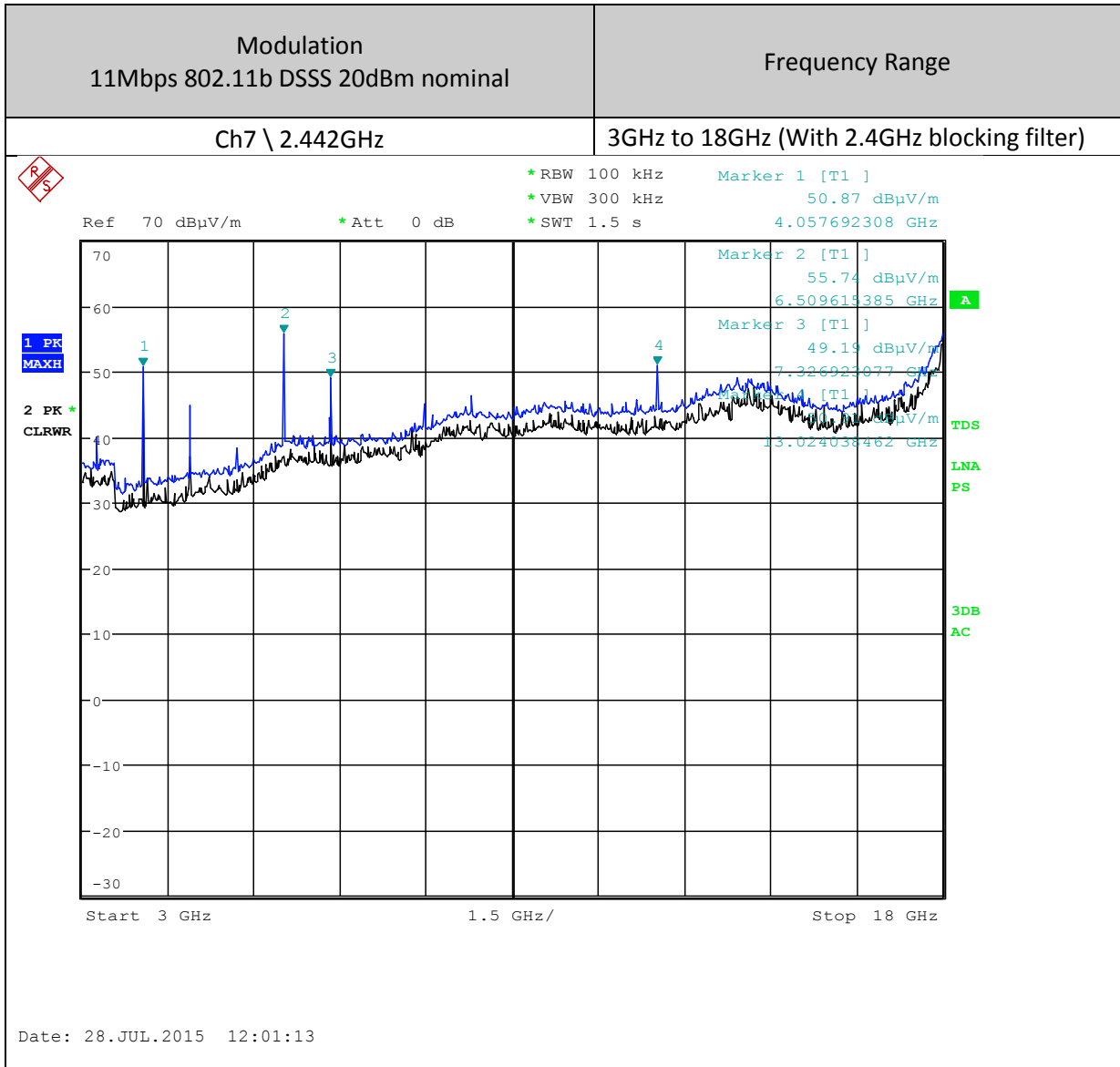




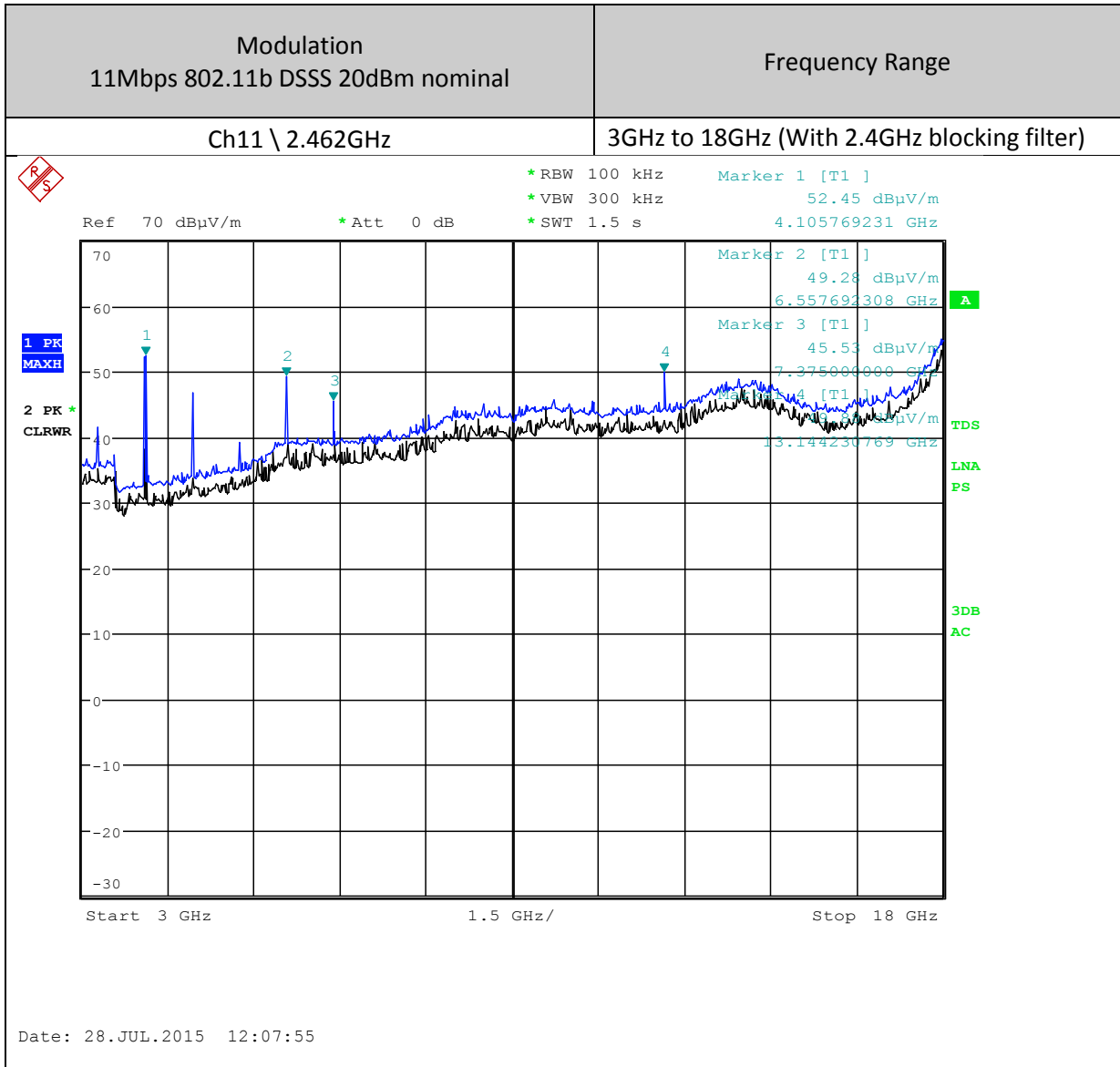


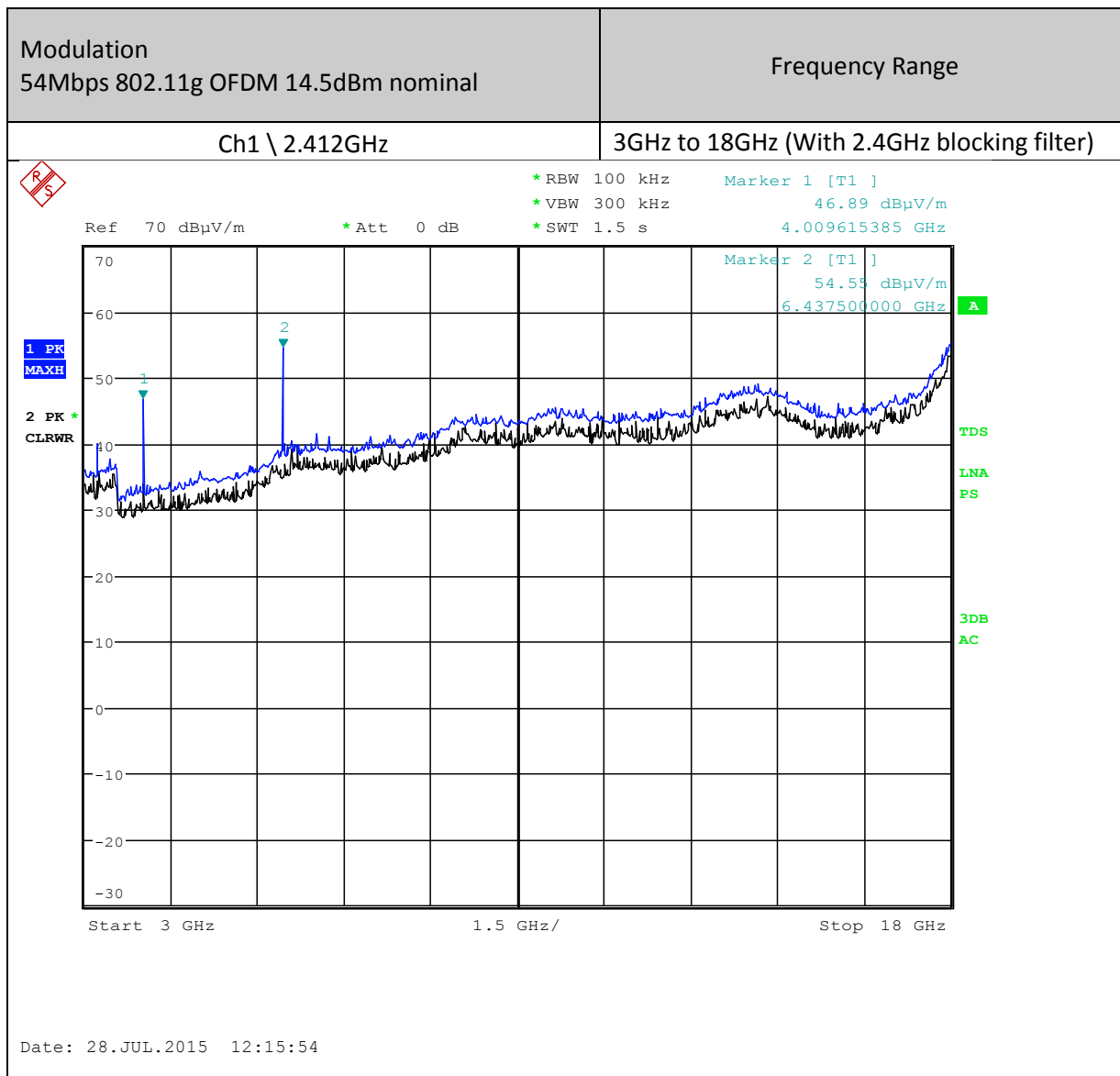
6.9.4 Radiated Emissions 3GHz-18GHz

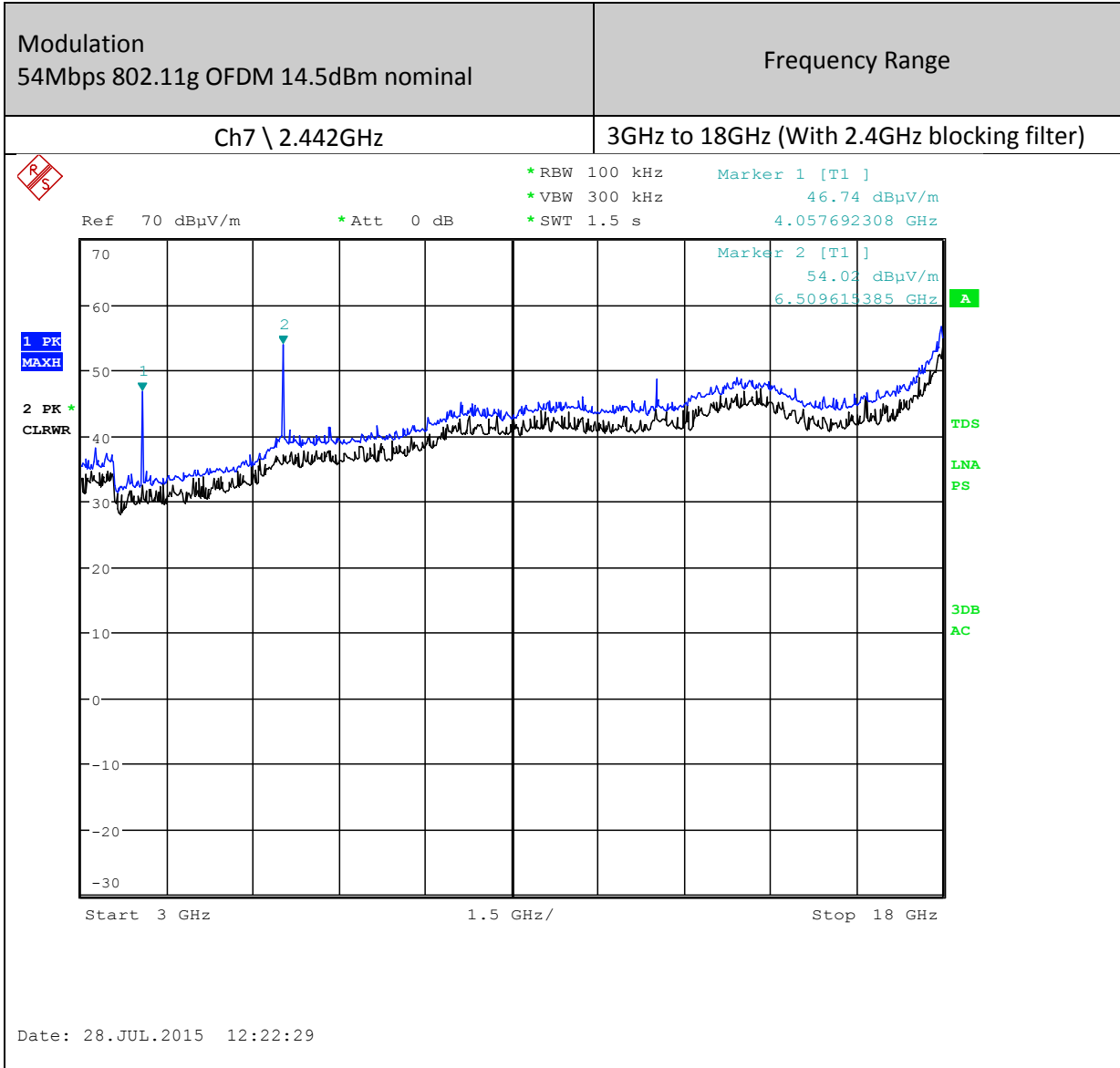


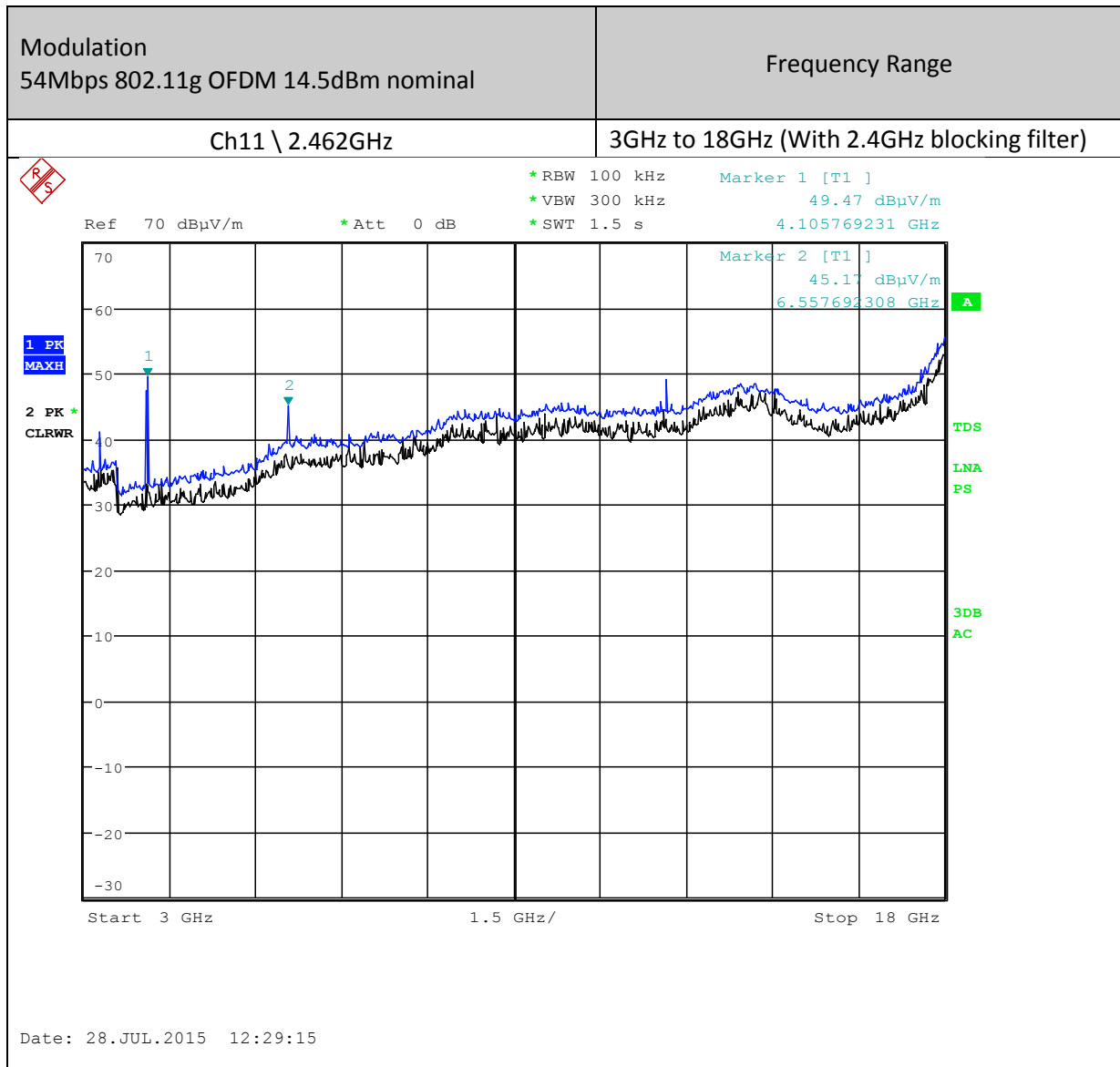




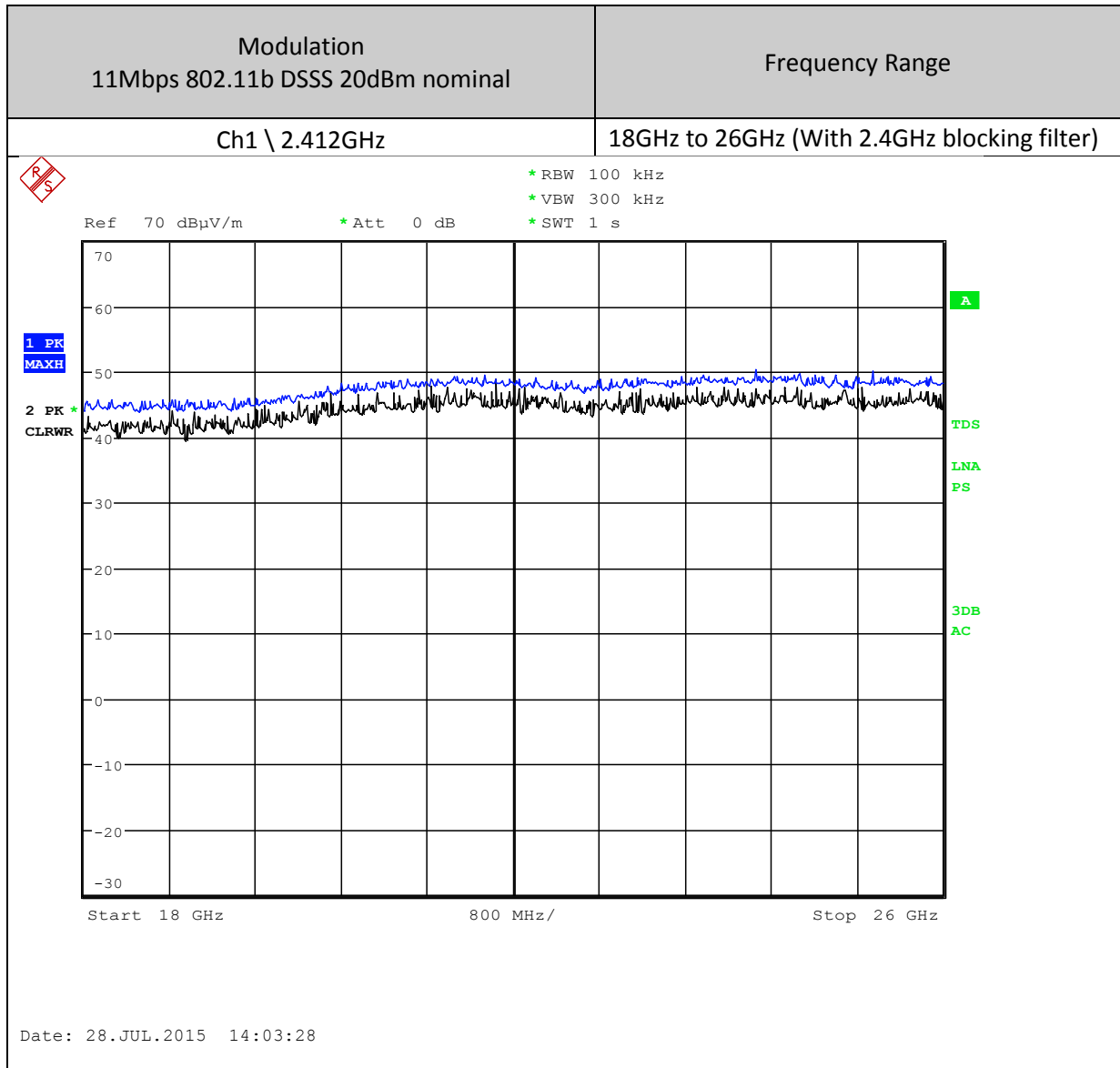


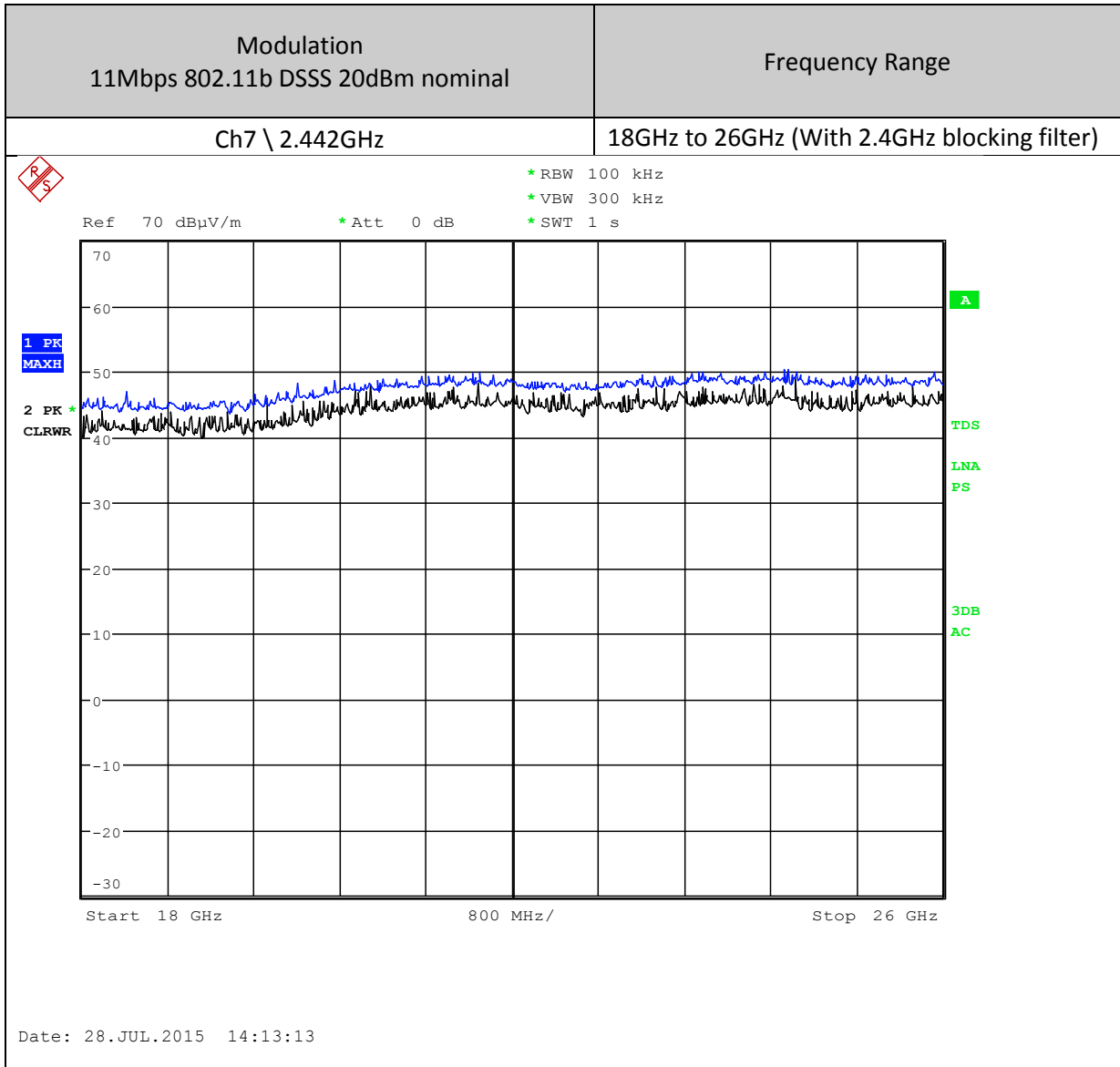


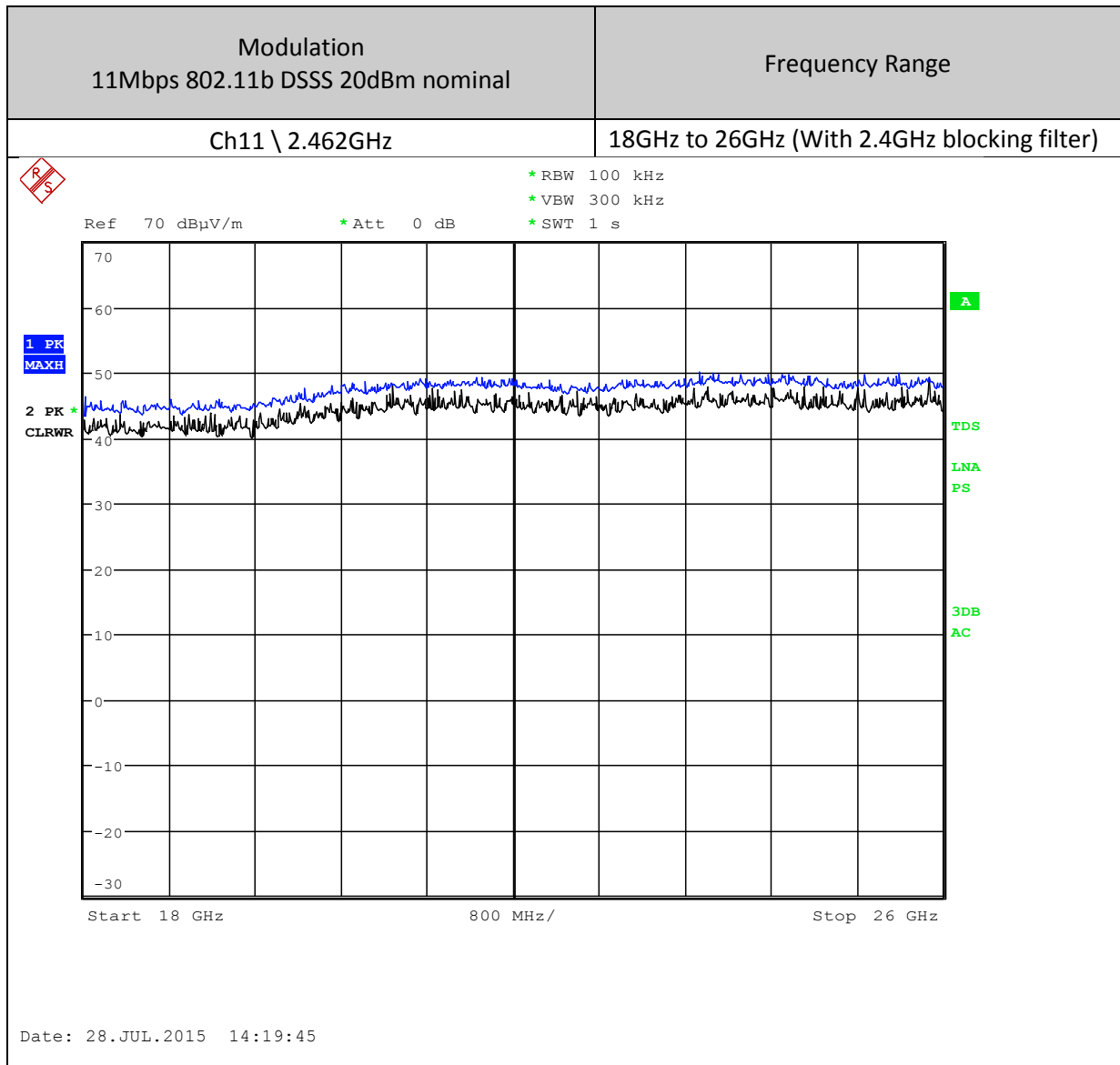


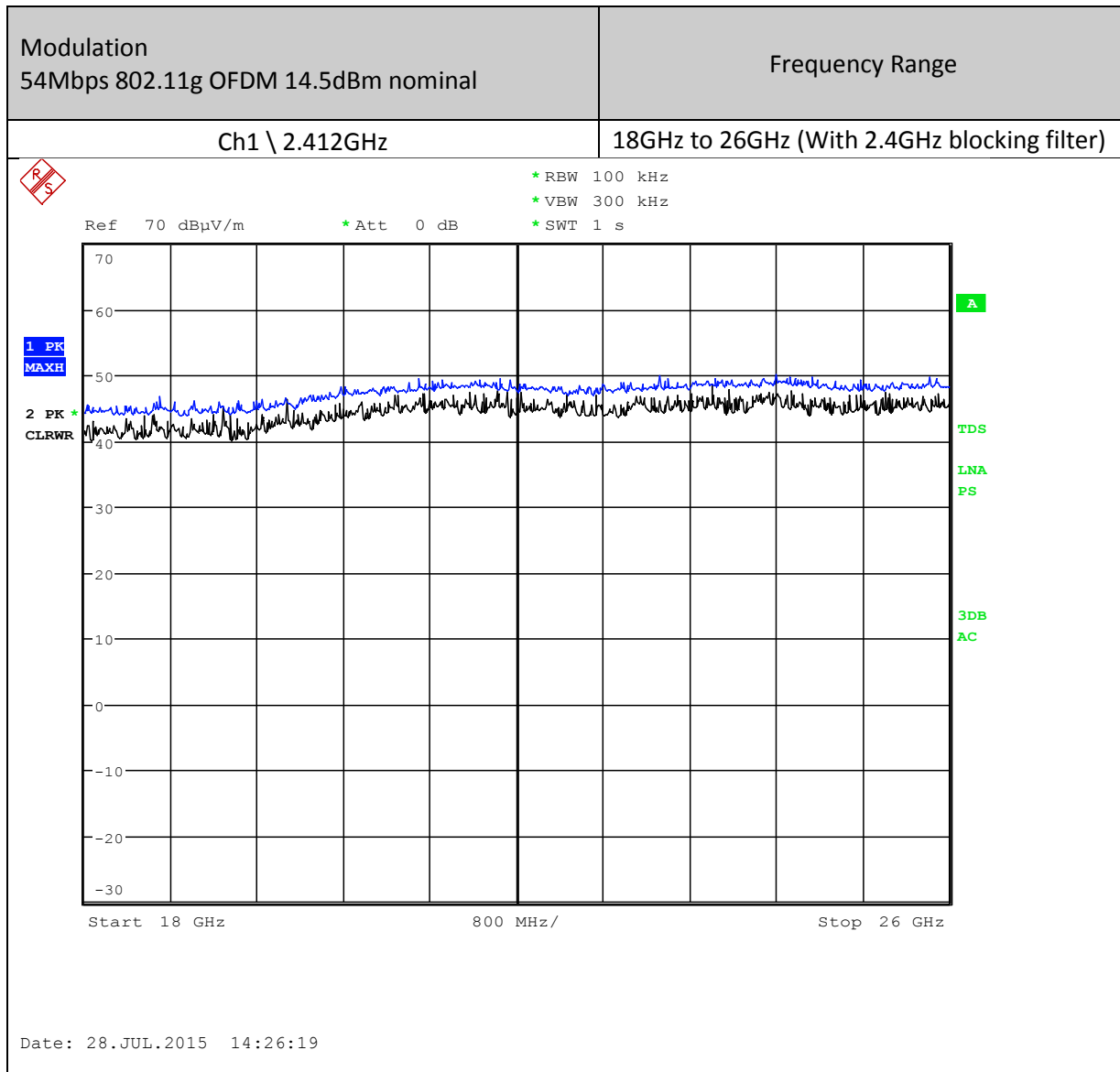


6.9.5 Radiated Emissions 18GHz to 26GHz

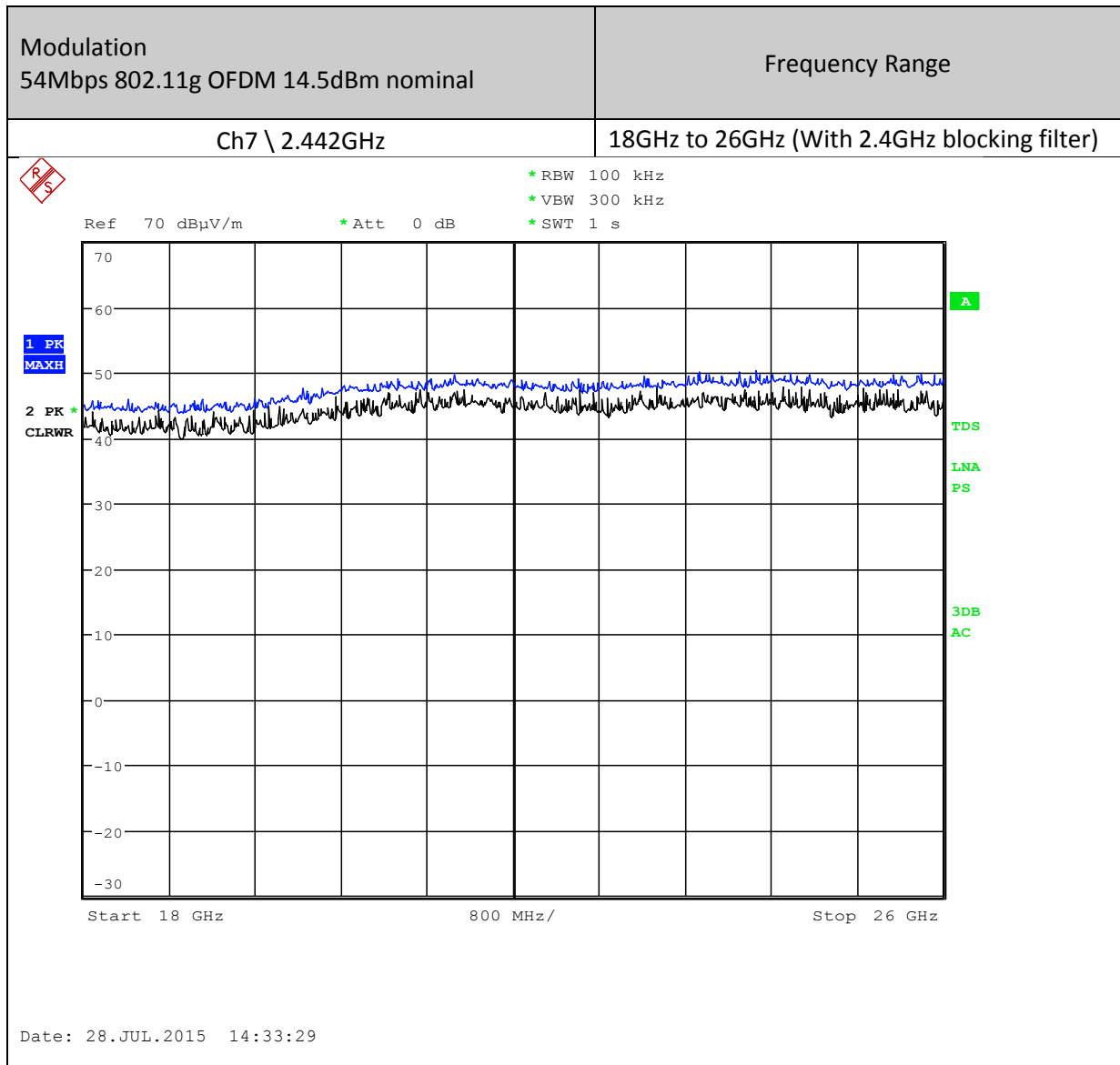


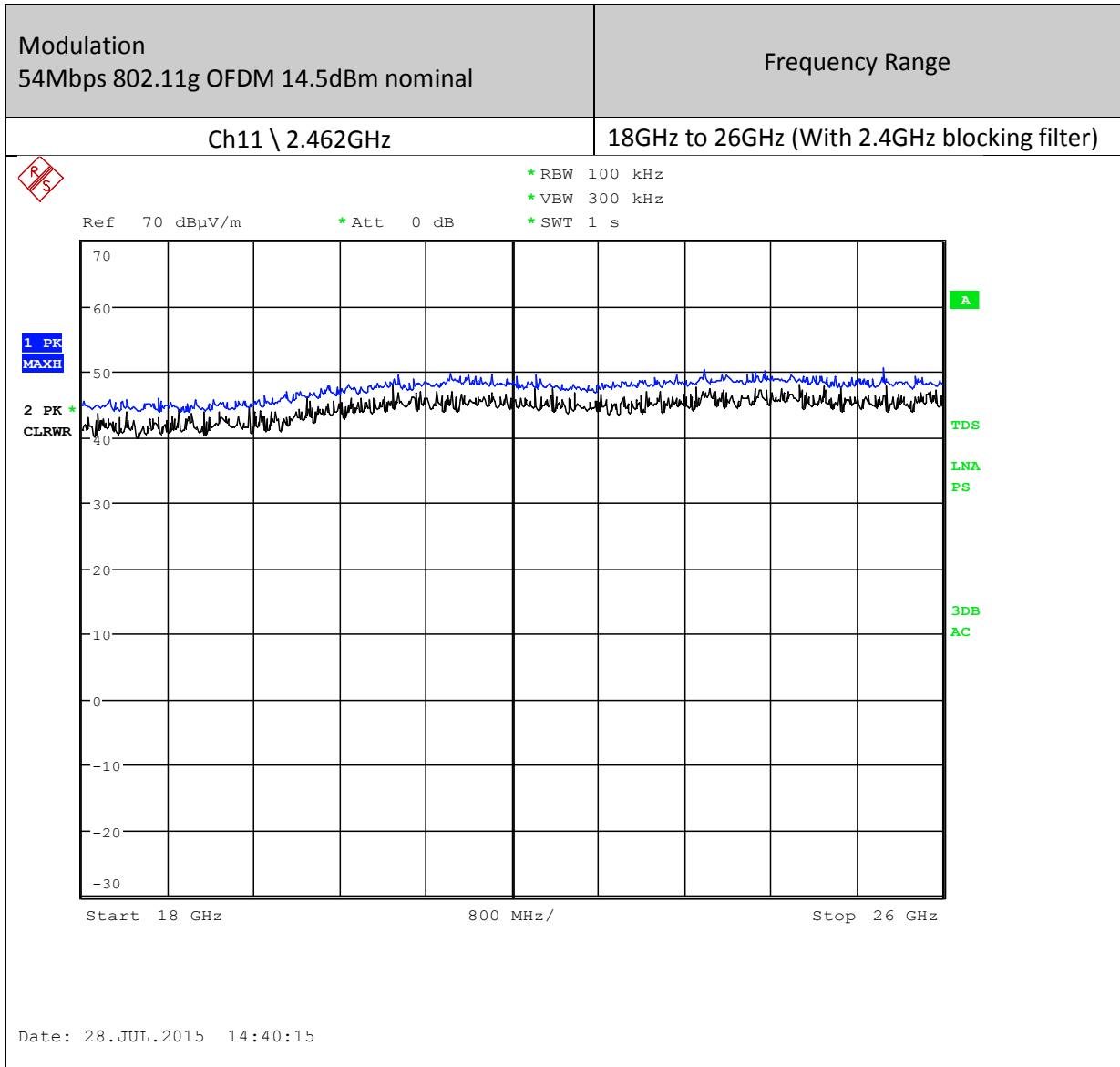






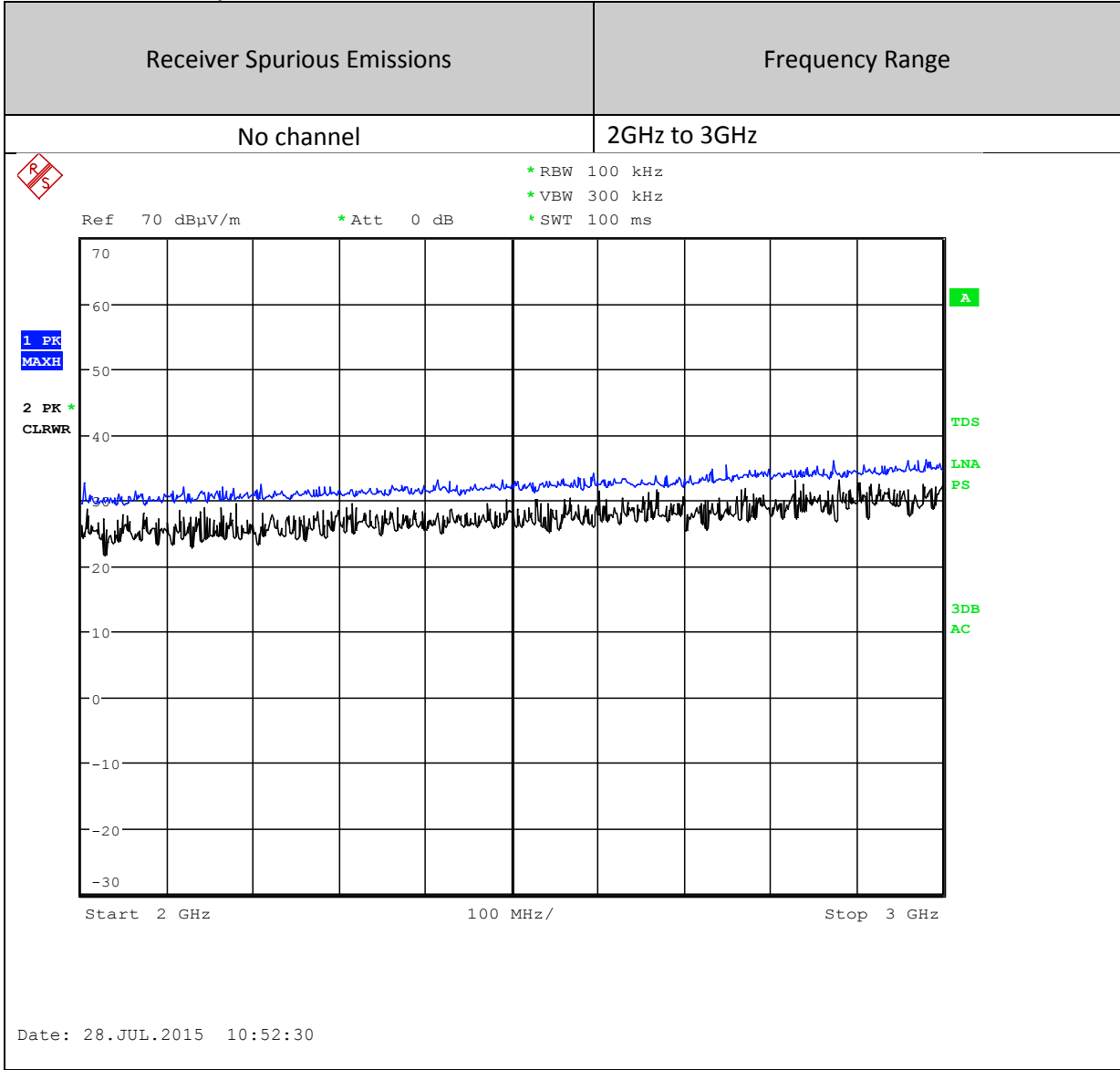




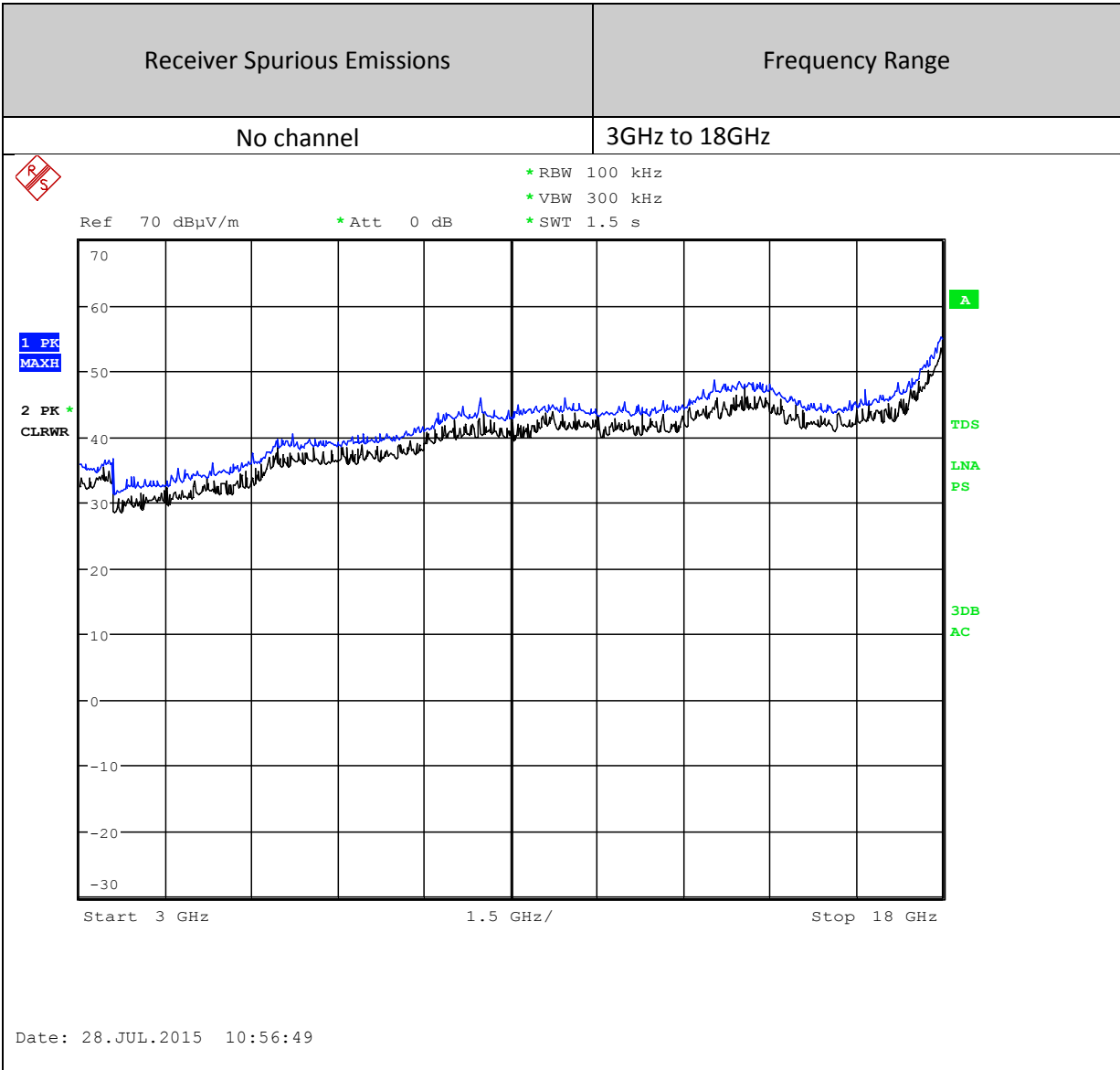


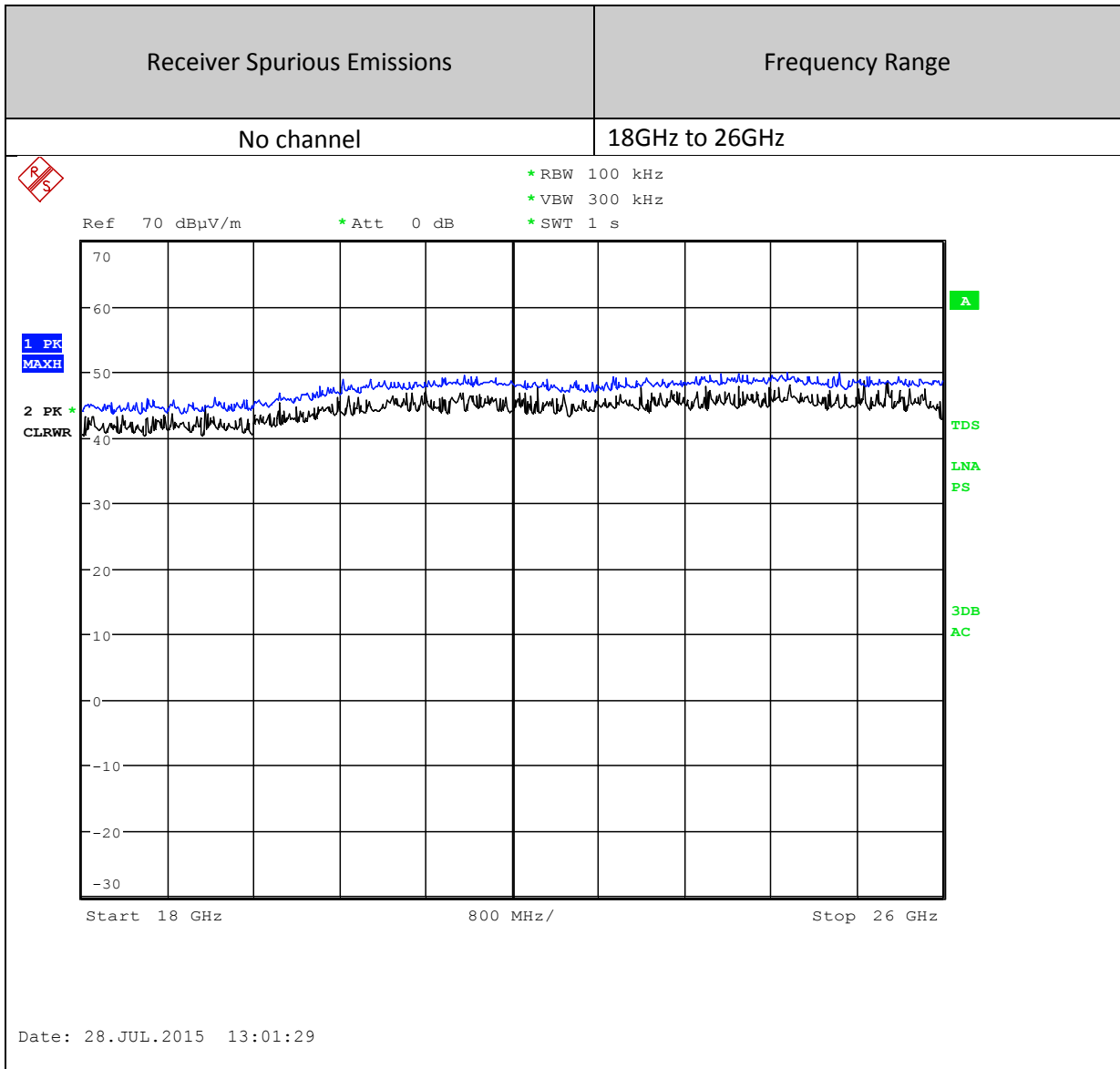
**Comments:** None.  
**Unit:** 1 & 2  
**Tested by:** D. Jamieson  
**Test Date/s:** Unit 2: 28<sup>th</sup> July 2015; Unit 1: 8<sup>th</sup> – 10<sup>th</sup> September 2015  
**Test Status:** PASS

6.10 Receiver Spurious Emissions









**Comments:** None.  
**Unit:** 2  
**Tested by:** D. Jamieson  
**Test Date/s:** 23<sup>rd</sup> July 2015  
**Test Status:** PASS

## 7 List of Test Equipment

Test Equipment Type	Manufacturer and Type Number	Serial Number	Cal No.	Cal Due
Digital Multimeter	Fluke 115	96520337	02249	15/01/2016
EMI Receiver 20Hz to 40GHz	Rohde & Schwarz ESU40	100017	01721	15 <sup>th</sup> Apr 2016
Test Site 1- S/A Chamber	Global EMC	Site 1 - GE004_AC3	02074	01/12/2017
Antenna Mast (4m)	Inn-co GmbH MM4000	MM4000/056/13750 806/L	02075	Cal not required
Turntable Site 4	Inn-co GmbH DS1200S	DS1200S/175/1375 0806/L	02076	Cal not required
Mast/Turntable Controller Site 4	Inn-co GmbH Co 2000	CO/2000/359/137/5 0806/L	02077	Cal not required
Computer (Site 1)	HP Compaq dc7800p CMT	CZC8170C7M	N/A	Cal not required
Emissions Software	DARE! RadiMation v5.3.18	N/A	N/A	Cal not required
EMI Receiver 9kHz-3GHz	ESCI	100416	01692	19/02/2016
Antenna 30-2000MHz	Chase CBL6141	22932	01802	24/07/2016
Loop Antenna 9khz - 30MHz	Chase HLA6120	1122	00442	20/03/2016
Loop Power Supply	Chase CBP9720	1076	00450	Not Calibrated
Power Supply Unit	Palstar PS30M	130348923	01218	Not Calibrated
Power Supply Unit	Palstar PS-06	130616126	01936	Not Calibrated

In accordance with UKAS requirements, all measuring equipment is on a calibration cycle.