

RF Test Report:

Zinwave ORU

FCC part 27 cellular

FCC ID: UPO302-1107

SC_TR_221_B

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1 Revision History

Revision	Originator	Date	Comment	Signature
A	C Blackham Director, Sulis Consultants Ltd	23 Oct 2016	1 st release	
B	C Blackham Director, Sulis Consultants Ltd	31 Oct 2016	Updated to correct typos	

2 Purpose

This document details the Zinwave Optical Remote Unit, ORU, model number 302-1107, whilst operating in the following bands under FCC Part 27:

2180 – 2200 MHz.

2345 – 2360 MHz.

2496 – 2690 MHz.

3 Reference Documents

- | | | |
|-----|--------------------------|---|
| [1] | 47CFR2 | Title 47 Code of Federal Regulations Part 2: frequency allocations and radio treaty matters; general rules and regulations |
| [2] | 47 CFR27 | Title 47 Code of Federal Regulations Part 27: Miscellaneous Communications Services |
| [3] | TIA-603-D | Land Mobile FM or PM – Communications Equipment – Measurement and Performance Standards |
| [4] | KDB 935210 D05
V01r01 | Federal Communications Commission Office of Engineering and Technology Laboratory Division; Measurement guidance for Industrial and Non-consumer signal booster, repeater and amplifier devices |
| [5] | KDB971168 DO1
v02r02 | Federal Communications Commission Office of Engineering and Technology Laboratory Division; Measurement guidance for certification of licensed digital transmitters. |

4 Test Information

4.1 Client and manufacturer

Zinwave Ltd
Harston Mill
Harston
Cambridge
CB22 7GG
UK

4.2 Test Locations

Antenna port testing was performed by Charlie Blackham of Sulis Consultants Ltd between 15th September and 23rd October 2016, at Sulis Consultants offices as detailed on cover page

Radiated Spurious Emissions testing was performed at Hursley EMC Service on 23rd September 2016 under job number 16R471

4.3 Test sample

The results herein only refer to sample detailed in section 5

5 Test Configuration

5.1 Test sample and Operating mode

The equipment under test (EUT) was:

Manufacturer	Name	Model Number	Serial Number
Zinwave	ORU	302-1107	#10

Table 1: Equipment under test

Modifications during test: None

Procedure:

- Set the system to maximum gain using the network management software
- Connect the signal generator to the RF service module of the Primary Hub
- Raise the signal level until the maximum output power is reached
- Perform the required test.

Test modulations:

- The system supports operation with a number of wideband services, so testing was performed with AWGN signal as per KDB 935210 D05.

5.2 Support equipment

The following equipment shall be used, configured as shown in Figure 1:

Name	Part Number	Serial Number
Chassis	302-1001	00-17-68-00-09-B7
RF Service module	Service Module	SM 15 1/6
Optical module	Optical module	OM 15 5/6
Chassis	302-1001	00-17-68-00-09-67
Input Optical module	Optical module	OM 15 1/6
Optical module	Optical module	OM 6/6

Table 2: Support Equipment

5.3 Equipment arrangement

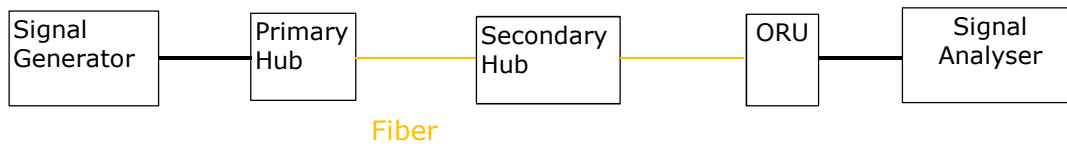


Figure 1: Test configuration – single channel

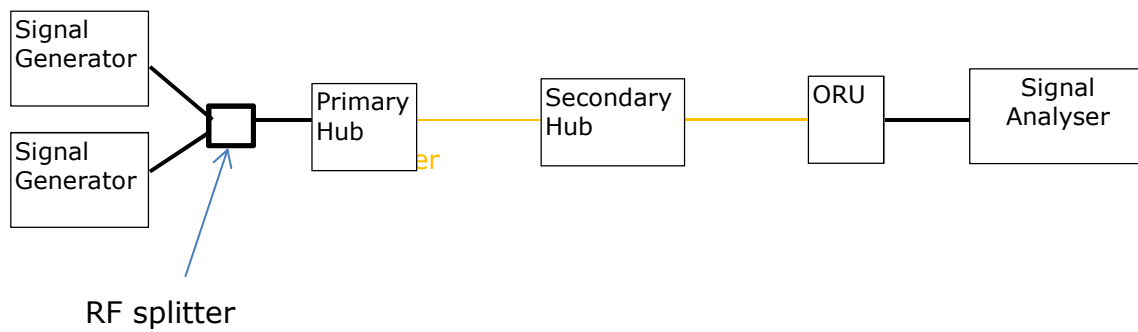


Figure 2: Test configuration – dual channel

6 Summary of Tests performed

Test	Band (MHz)	47 CFR Part	FCC limit	Section	Result
Determination of f_0	2180 - 2200	KDB 935210 D05 Section 3.3	None	7	N/A
	2345 - 2360			7	N/A
	2496 - 2690			7	N/A
Transmit Power	2180 - 2200	27.50(d)	1,640 W EIRP	8	Pass
	2345 - 2360	27.50(a)	2,000 W / 5 MHz EIRP	11	
	2496 - 2690	27.50(h)	2,000 W EIRP	14	Pass
Occupied Bandwidth	2180 - 2200	2.1049 KDB 935210 D05 Section 3.4	None	9	Pass
	2345 - 2360			12	
	2496 - 2690			15	Pass
Conducted Spurious Emissions inc. band edge	2180 - 2200	27.53(h)	-13dBm / MHz	10	Pass
	2345 - 2360	27.53(a)(1)	Various, see section 13.1	13	
	2496 - 2690	27.53(m)	-13dBm / MHz	16	Pass
Radiated Spurious Emissions	2180 - 2200	27.53(h)	-13dBm / MHz	17	Pass
	2345 - 2360	27.53(a)(1)	Various, see section 13.1	17	
	2496 - 2690	27.53(m)	-13dBm / MHz	17	Pass

Table 3: Summary of tests performed

6.1 Comments on requirements in KDB 935210 D05 V01:

Section	Comment
3.1 General	As the bands under investigation are for LTE operation only, one signal sources shall be used: • "wideband" 4.2 MHz AWGN
3.2 Measuring the EUT AGC threshold	Not applicable to ORU and 3000 DAS "Devices intended to be directly connected to an RF source only need to be evaluated for any over-the-air transmit paths." There are no such over-the-air paths so increased input level testing is not required
3.7 EUT frequency stability measurements	Not required as DAS does not contain oscillator and therefore has no ability to change frequency.

7 Determination of f_0

As per kDB 935210 D05 section 3.3, but measurement was performed over the service band frequency range only.

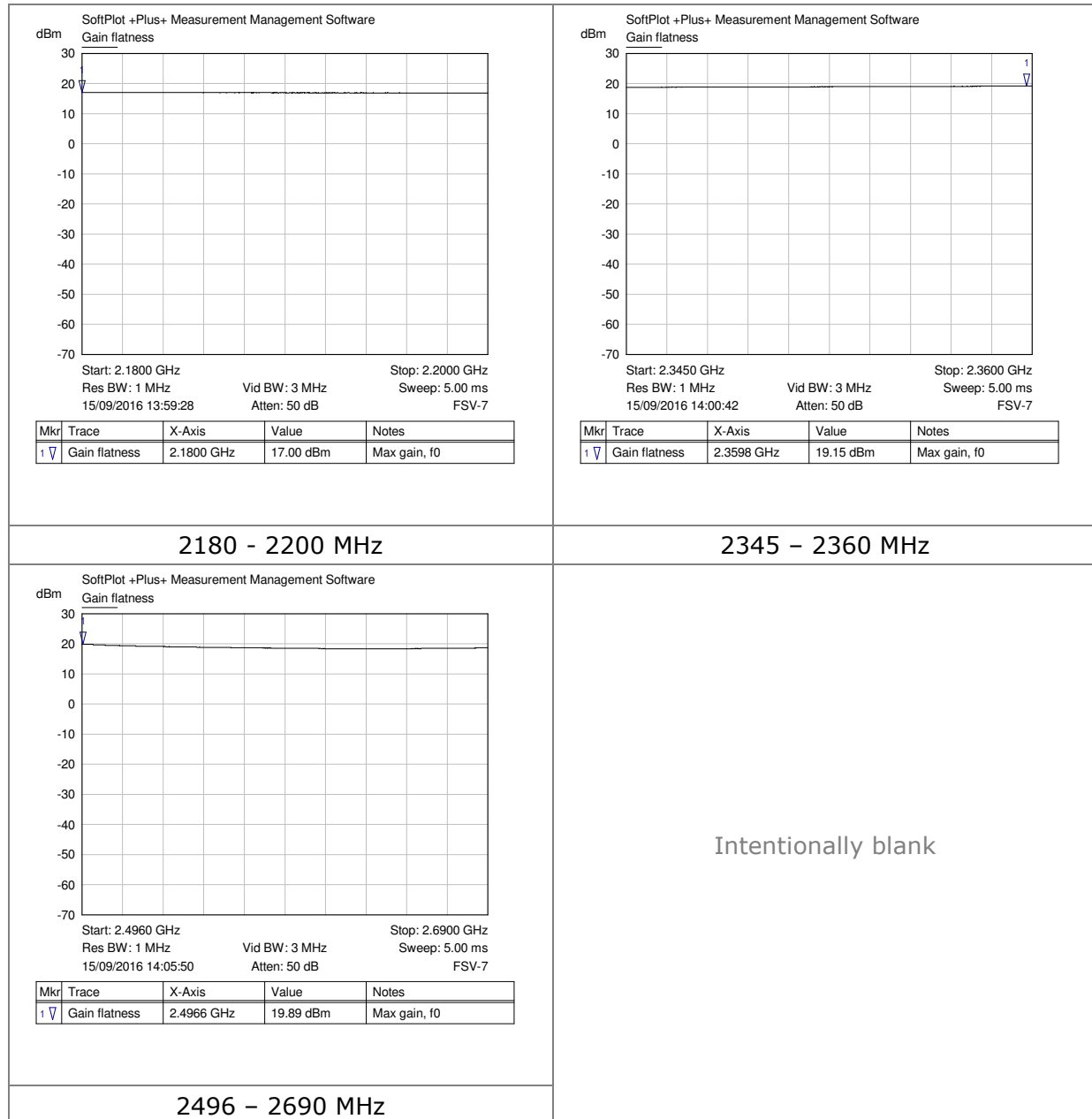


Figure 3: Determination of f_0 for the bands of operation

8 Transmit Power: 2180 - 2200 MHz

8.1 Test method

The equipment was configured with maximum gain of 25dB and connected as per figure 1.

The signal generator was set to provide -5dBm to the input of the hub and the frequency set to an appropriate channel to include f_0 as determined in section 7.

Measurements were made in accordance with KDB 971168 D01 using an RMS detector and the Peak to Average ratio was measured using the CCDF function of the analyser.

8.2 Test results

Frequency	TX power (dBm)	TX power EIRP (dBm)	TX power EIRP (W)	Limit EIRP (W)	0.1% PAR	Result
2182.5	18.69	26.69	0.47	3280.0	8.38 dB	Pass

Table 4: Transmit power and Peak-to-Average ratio

Peak to Average (PAR) ratio was measured using the analyser in-built CCDF function.

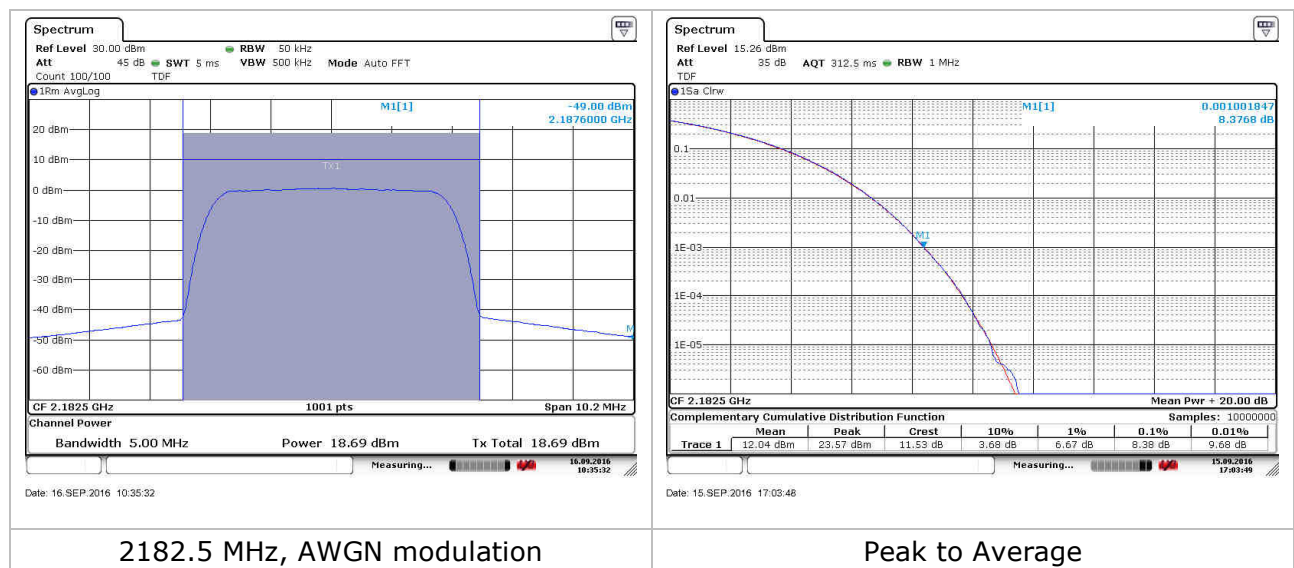


Figure 4: Power and Peak to Average (PAR) plots

9 Occupied bandwidth: 2180 - 2200 MHz

9.1 Test method

KDB 935210 D05 section 3.4.

The occupied bandwidth was measured using the inbuilt function on the Signal Analyser set to measure the 99% occupied bandwidth. Measurement was made using peak detector and max hold.

The two plots are overlaid on the same graph by using different vertical axes for input and output signals.

9.2 Test results

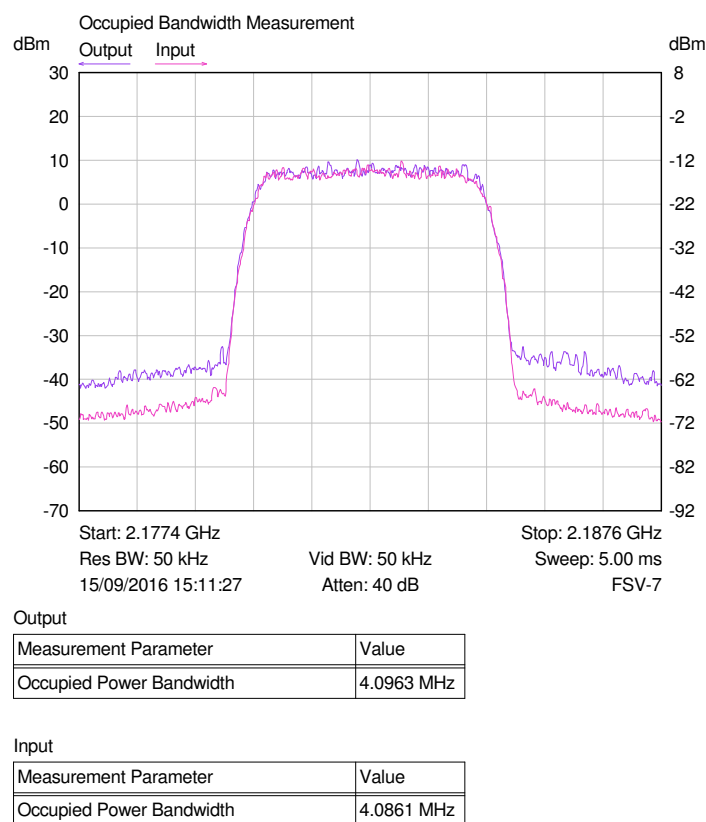


Figure 5: Input vs output plot for 2180 – 2200 MHz band

10 FCC CSE inc. Band Edge: 2180 - 2200 MHz

10.1 Requirement and test method

27.53

(h) AWS emission limits—(1) General protection levels. Except as otherwise specified below, for operations in the 1695-1710 MHz, 1710-1755 MHz, 1755-1780 MHz, 1915-1920 MHz, 1995-2000 MHz, 2000-2020 MHz, 2110-2155 MHz, 2155-2180 MHz, and 2180-2200 bands, the power of any emission outside a licensee's frequency block shall be attenuated below the transmitter power (P) in watts by at least $43 + 10 \log_{10} (P)$ dB.

(3) Measurement procedure.

(i) Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater. However, in the 1 megahertz bands immediately outside and adjacent to the licensee's frequency block, a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.

(ii) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the licensee's frequency block edges, both upper and lower, as the design permits.

(iii) The measurements of emission power can be expressed in peak or average values, provided they are expressed in the same parameters as the transmitter power.

The licensed band of operation was considered to be a single 5 MHz channel for the 5 MHz operation.

Some emissions > 1 MHz from bandedge were measured using the spectrum analyser adjacent channel power function that integrated power from a lower resolution bandwidth into the 1 MHz required by the rule part.

10.2 Test results

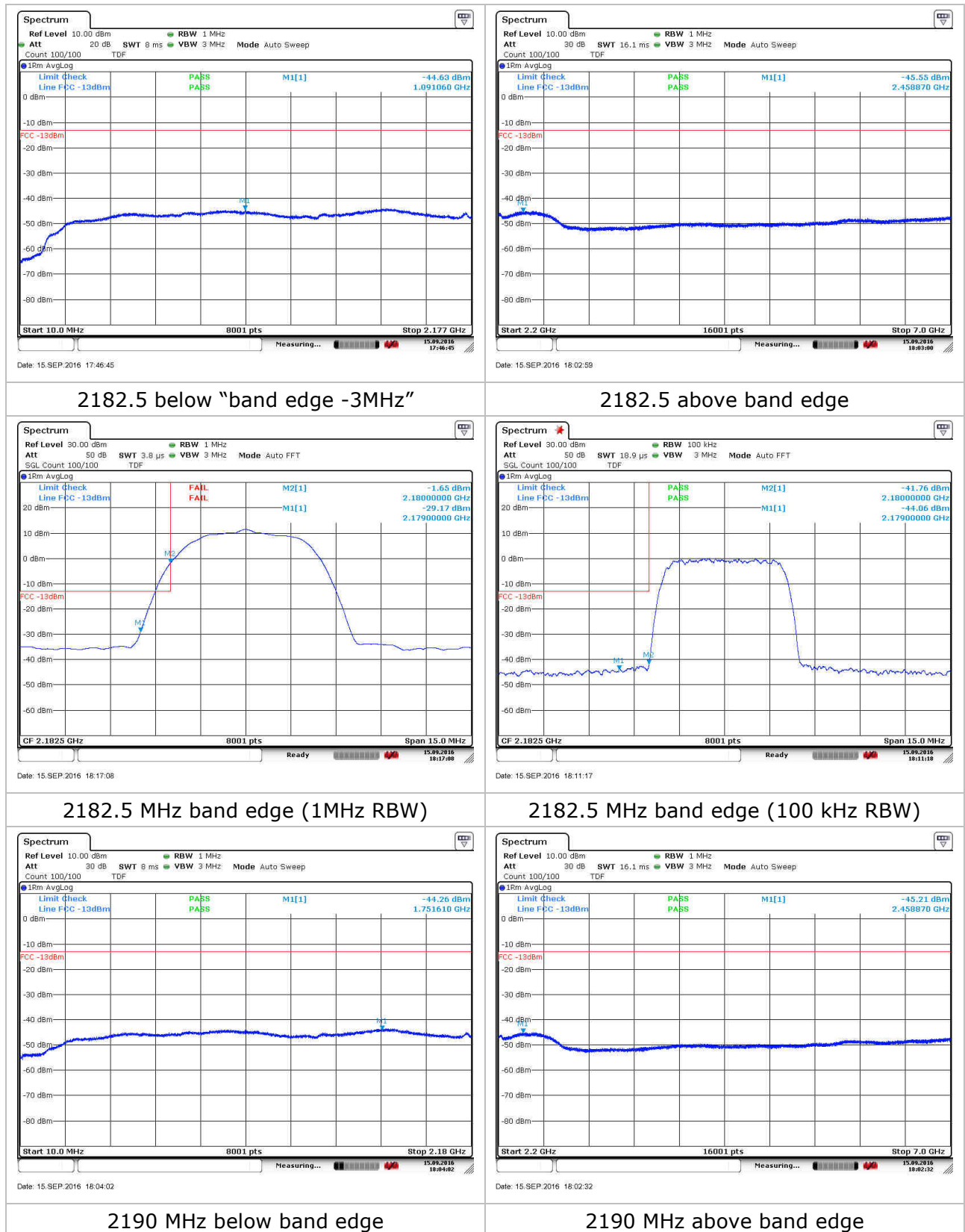
Plots are included for all modes up to 7GHz.

No emissions above noise floor above 7 GHz for any frequency of operation

Single channel measurements were > 25 dB below the limit

Dual channel measurements were > 9 dB below the limit

10.2.1 Single frequency, inc. band edge



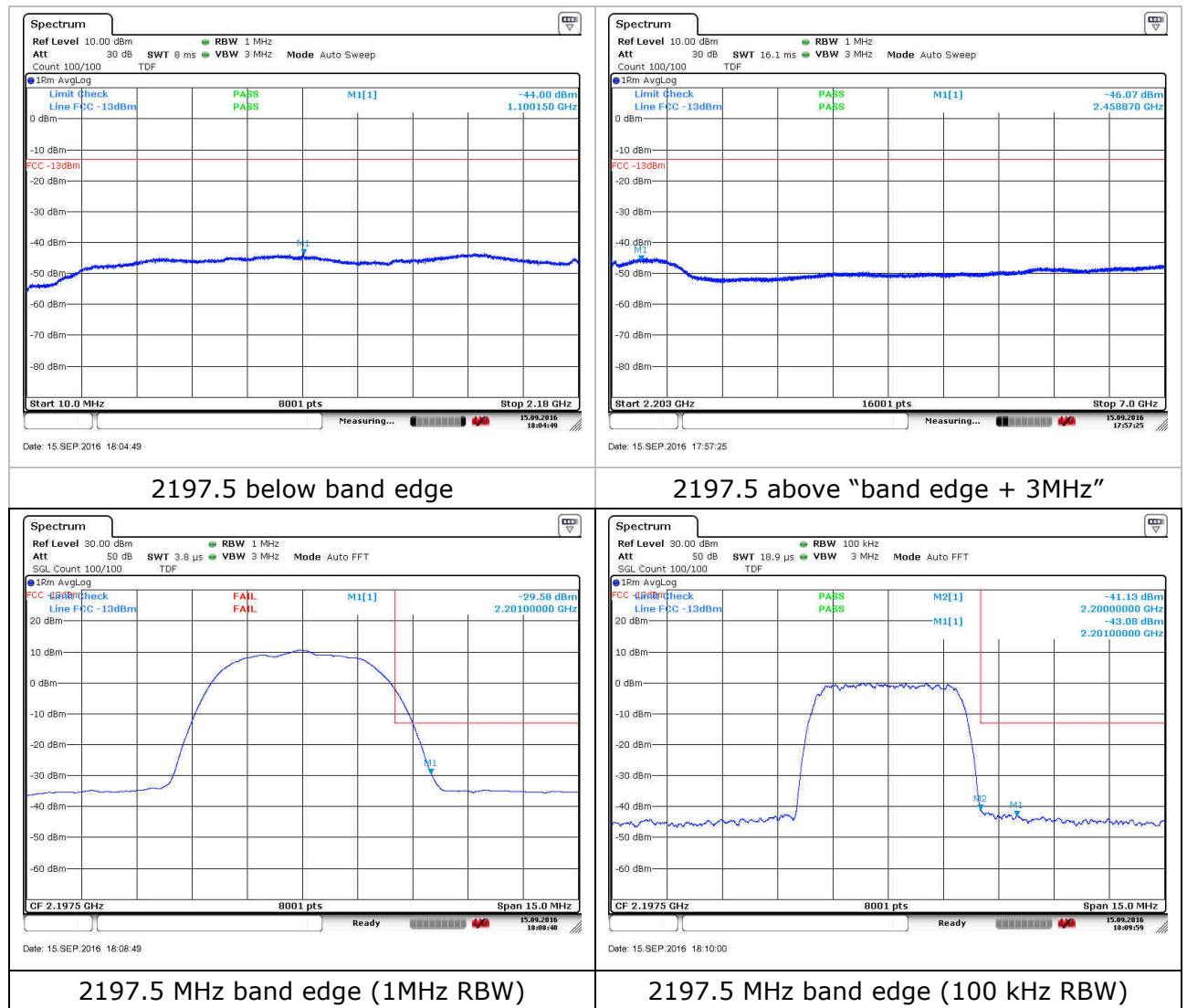


Figure 6: CSE including band edge for 2180 - 2200 MHz band

10.2.2 Dual Channel: AWGN

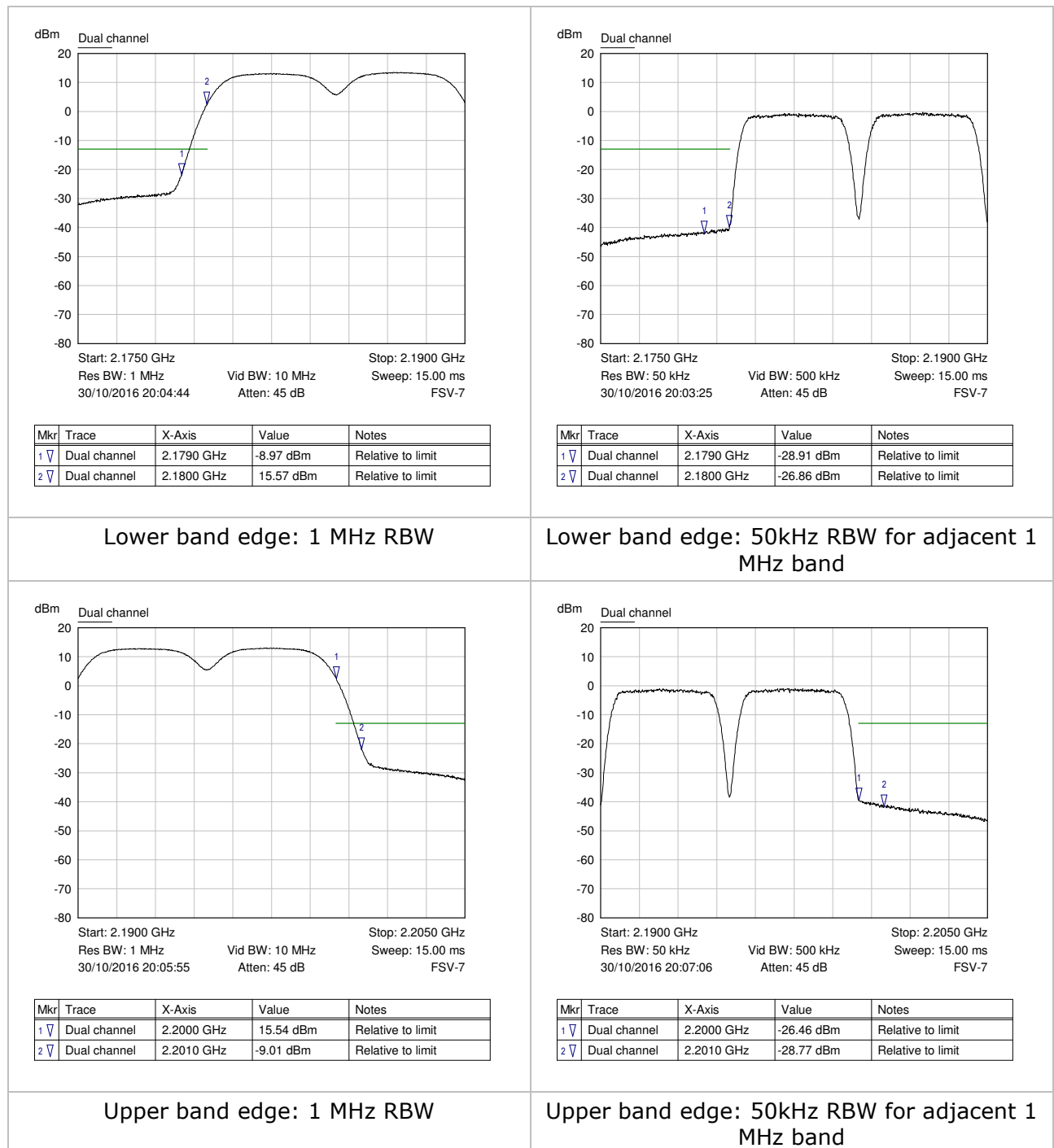


Figure 7: CSE band edge for 2180 - 2200 MHz band – dual channel

11 Transmit Power: 2345 - 2360 MHz

11.1 Test method

The equipment was configured with maximum gain of 25dB and connected as per figure 1.

The signal generator was set to provide -6 dBm to the input of the hub and the frequency set to an appropriate channel to include f_0 as determined in section 7.

Measurements were made in accordance with KDB 971168 D01 using an RMS detector and the Peak to Average ratio was measured using the CCDF function of the analyser.

11.2 Test results

Frequency	TX power (dBm)	TX power EIRP (dBm)	TX power EIRP (W)	Limit EIRP (W)	0.1% PAR	Result
2357.5	15.7	23.7	0.23	2000.0	8.29 dB	Pass

Table 5: Transmit power and Peak-to-Average ratio

Peak to Average (PAR) ratio was measured using the analyser in-built CCDF function.

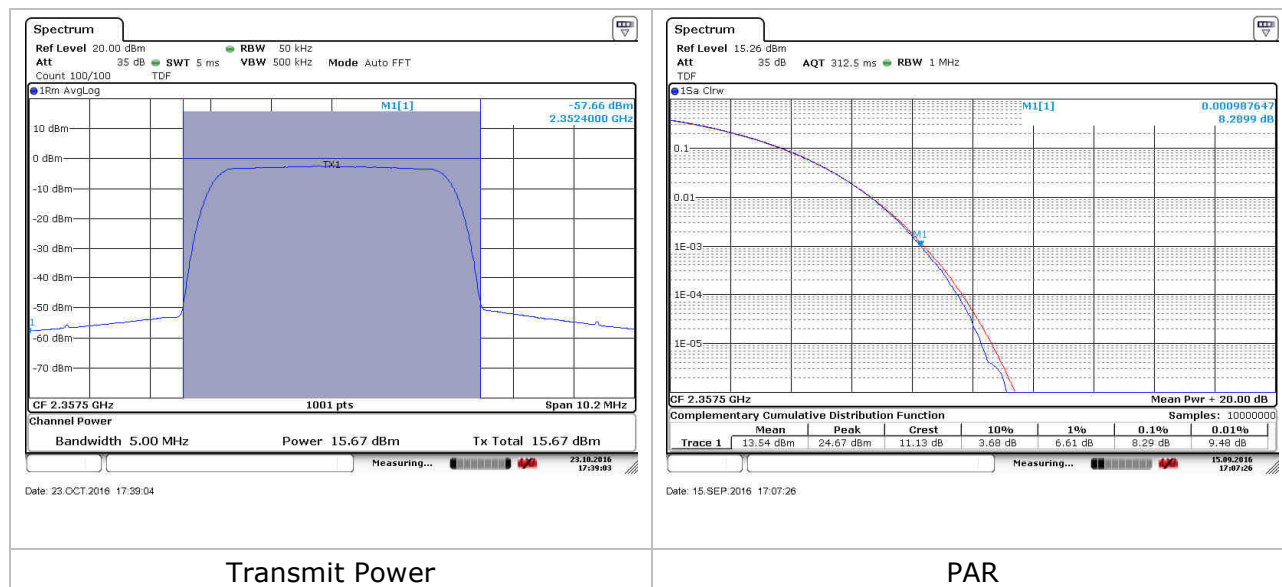


Figure 8: Peak to Average (PAR) plots

12 Occupied Bandwidth: 2345 - 2360 MHz

12.1 Test method

KDB 935210 D05 section 3.4.

The occupied bandwidth was measured using the inbuilt function on the Signal Analyser set to measure the 99% occupied bandwidth. Measurement was made using peak detector and max hold.

The two plots are overlaid on the same graph by using different vertical axes for input and output signals.

12.2 Test results

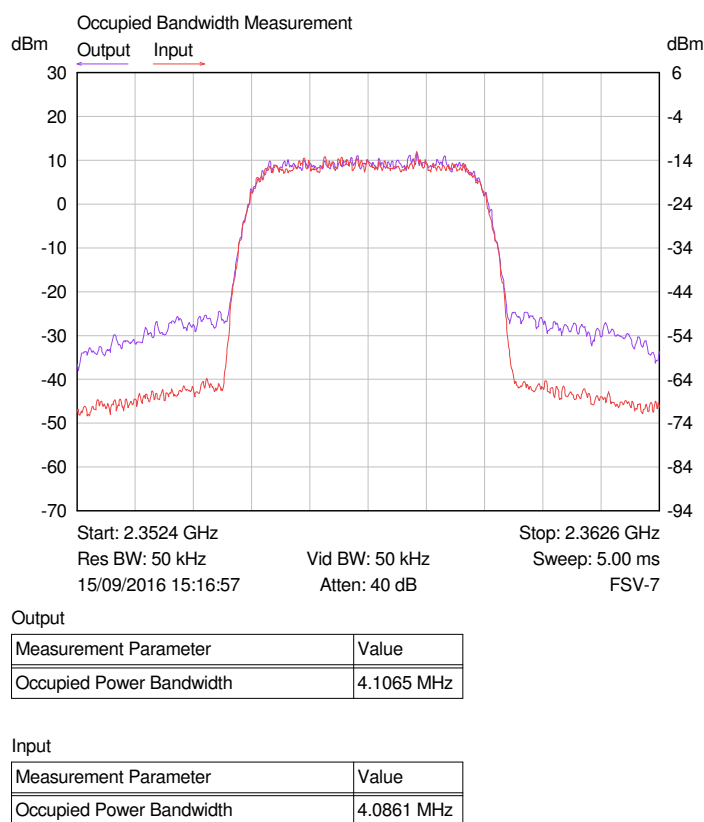


Figure 9: Input vs output plot for 2345 – 2360 MHz band

13 CSE inc. Band Edge: 2345 - 2360 MHz

13.1 Requirement and test method

27.53 (a) For operations in the 2305-2320 MHz band and the 2345-2360 MHz band, the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power P (with averaging performed only during periods of transmission) within the licensed band(s) of operation, in watts, by the following amounts:

(1) For base and fixed stations' operations in the 2305-2320 MHz band and the 2345-2360 MHz band:

(i) By a factor of not less than $43 + 10 \log (P)$ dB on all frequencies between 2305 and 2320 MHz and on all frequencies between 2345 and 2360 MHz that are outside the licensed band(s) of operation, and not less than $75 + 10 \log (P)$ dB on all frequencies between 2320 and 2345 MHz;

(ii) By a factor of not less than $43 + 10 \log (P)$ dB on all frequencies between 2300 and 2305 MHz, $70 + 10 \log (P)$ dB on all frequencies between 2287.5 and 2300 MHz, $72 + 10 \log (P)$ dB on all frequencies between 2285 and 2287.5 MHz, and $75 + 10 \log (P)$ dB below 2285 MHz;

(iii) By a factor of not less than $43 + 10 \log (P)$ dB on all frequencies between 2360 and 2362.5 MHz, $55 + 10 \log (P)$ dB on all frequencies between 2362.5 and 2365 MHz, $70 + 10 \log (P)$ dB on all frequencies between 2365 and 2367.5 MHz, $72 + 10 \log (P)$ dB on all frequencies between 2367.5 and 2370 MHz, and $75 + 10 \log (P)$ dB above 2370 MHz.

(5) Measurement procedure. Compliance with these rules is based on the use of measurement instrumentation employing a resolution bandwidth of 1 MHz or greater. However, in the 1 MHz bands immediately outside and adjacent to the channel blocks at 2305, 2310, 2315, 2320, 2345, 2350, 2355, and 2360 MHz, a resolution bandwidth of at least 1 percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. A narrower resolution bandwidth is permitted in all cases to improve measurement accuracy provided the measured power is integrated over the full required measurement bandwidth (i.e., 1 MHz). The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.

The licensed band of operation was considered to be a single 5 MHz channel for the 5 MHz operation.

Some emissions > 1 MHz from bandedge were measured using the spectrum analyser adjacent channel power function that integrated power from a lower resolution bandwidth into the 1 MHz required by the rule part.

13.2 Test results

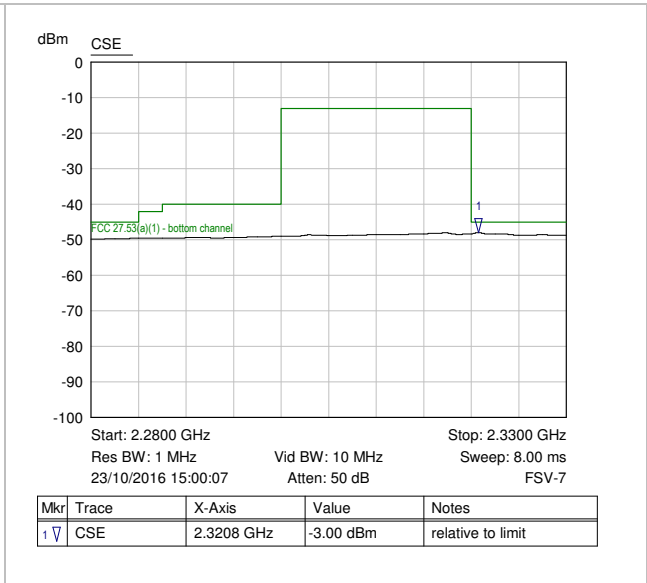
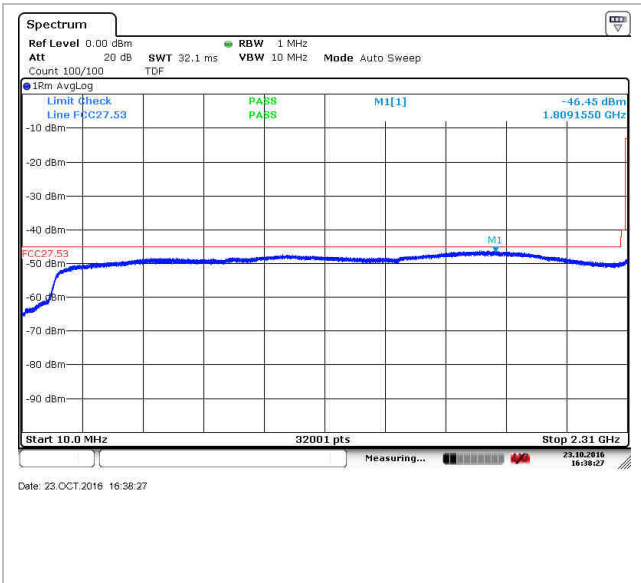
Measurements were performed on the following three channels, each representing a 5 MHz licensed band:

- Bottom channel: 2347.5 MHz
- Middle channel: 2352.5 MHz
- Top channel: 2357.5 MHz

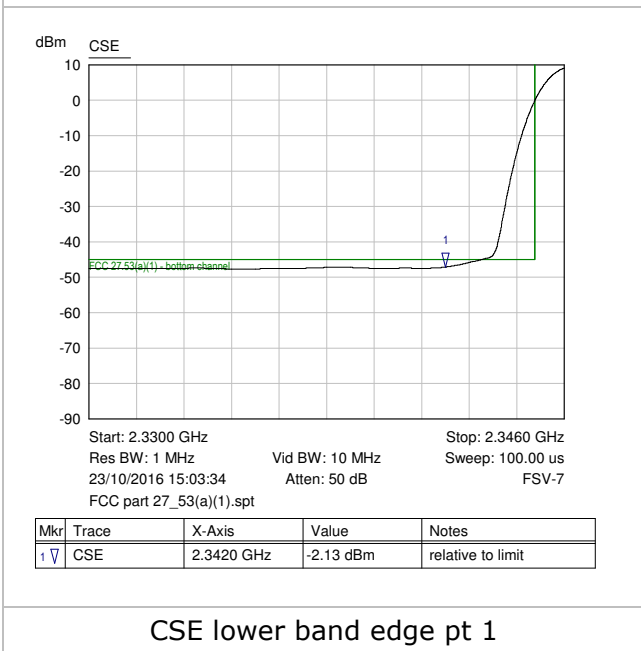
Plots are included for all modes up to 7GHz.

No emissions above noise floor above 7 GHz for any frequency of operation

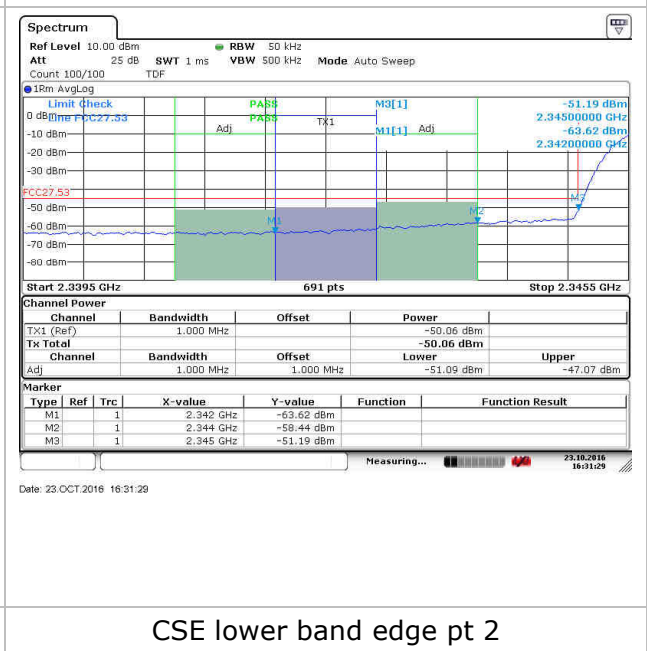
13.2.1 Bottom Channel



10 MHz to 2310 MHz



CSE lower band edge pt 1



CSE lower band edge pt 2

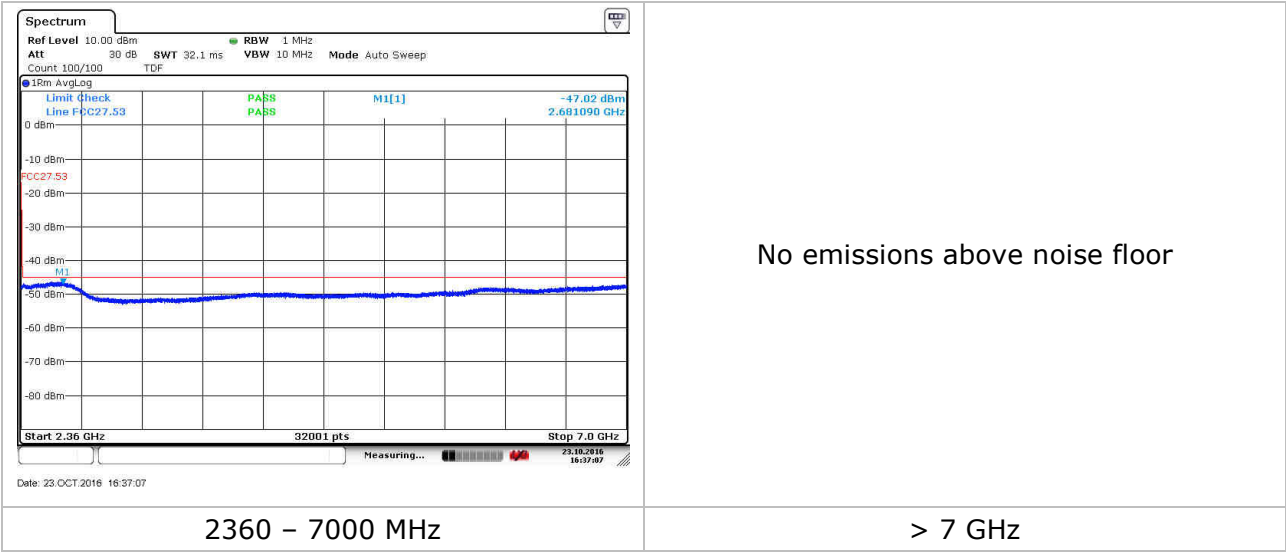
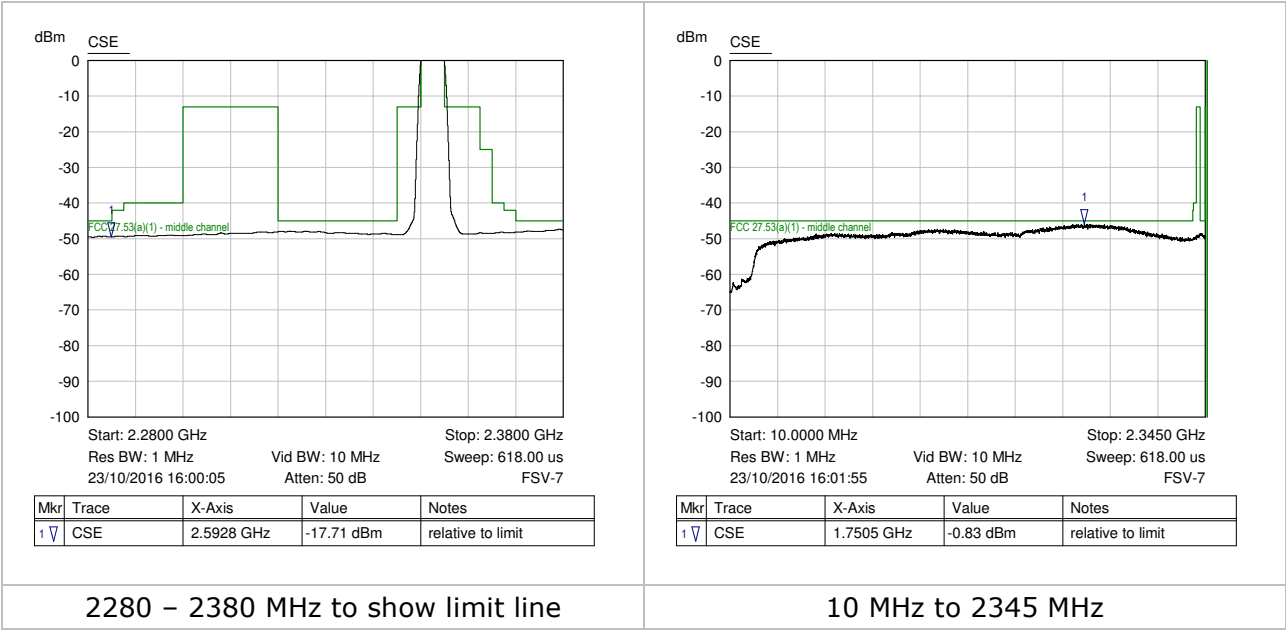


Figure 10: CSE bottom channel: 2347.5 MHz

13.2.2 Middle Channel



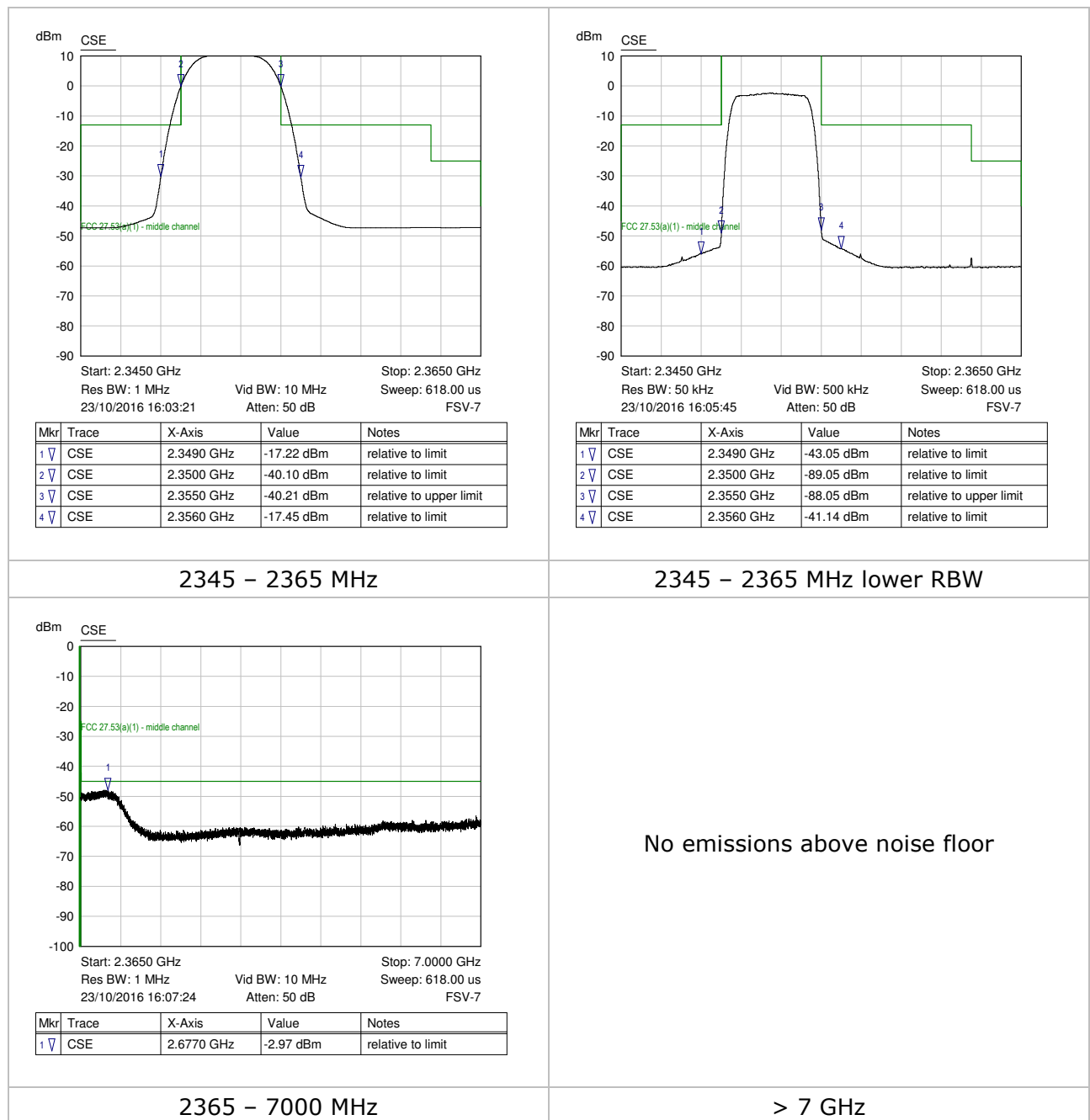
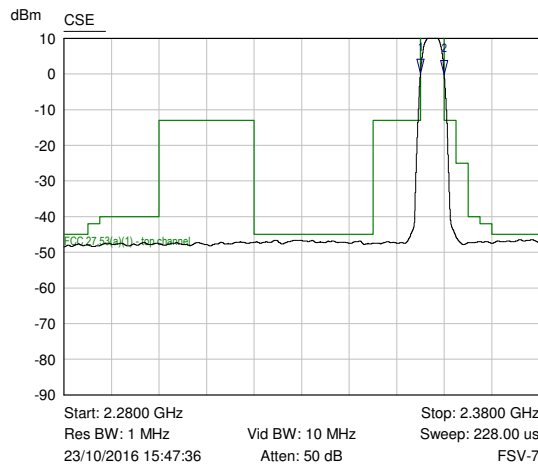
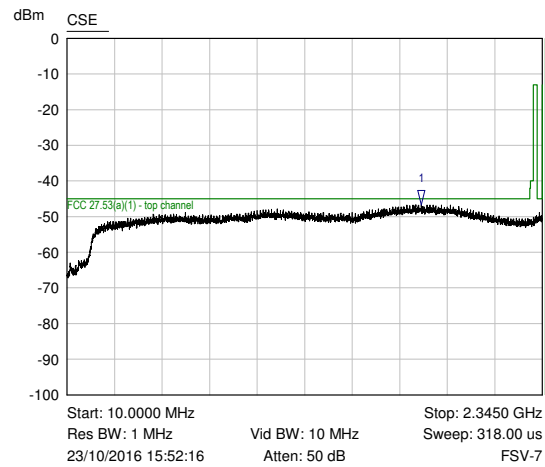


Figure 11: CSE middle channel: 2352.5 MHz

13.2.3 Top Channel

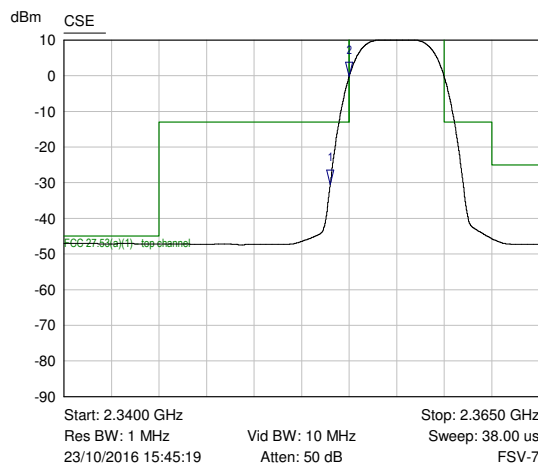


Mkr	Trace	X-Axis	Value	Notes
1	▼	CSE	2.3550 GHz	0.14 dBm
2	▼	CSE	2.3600 GHz	-0.20 dBm



Mkr	Trace	X-Axis	Value	Notes
1	▼	CSE	1.7506 GHz	-1.61 dBm relative to limit

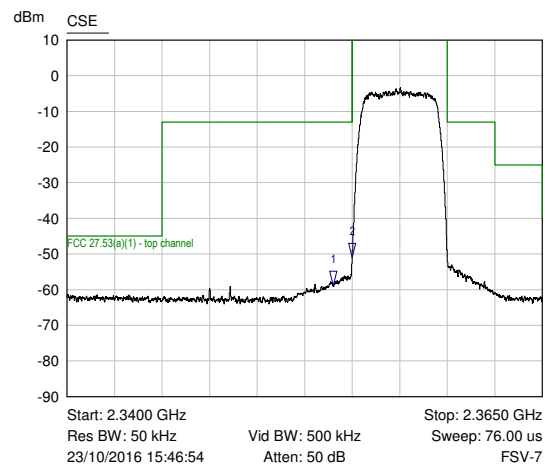
2280 – 2380 MHz to show limit line



Mkr	Trace	X-Axis	Value	Notes
1	▼	CSE	2.3540 GHz	-17.56 dBm relative to limit
2	▼	CSE	2.3550 GHz	-0.17 dBm relative to limit

2355MHz lower band edge pt1

10 MHz to 2345 MHz



Mkr	Trace	X-Axis	Value	Notes
1	▼	CSE	2.3540 GHz	-45.89 dBm relative to limit
2	▼	CSE	2.3550 GHz	-51.07 dBm relative to limit

2355MHz lower band edge pt2 (lower RBW)

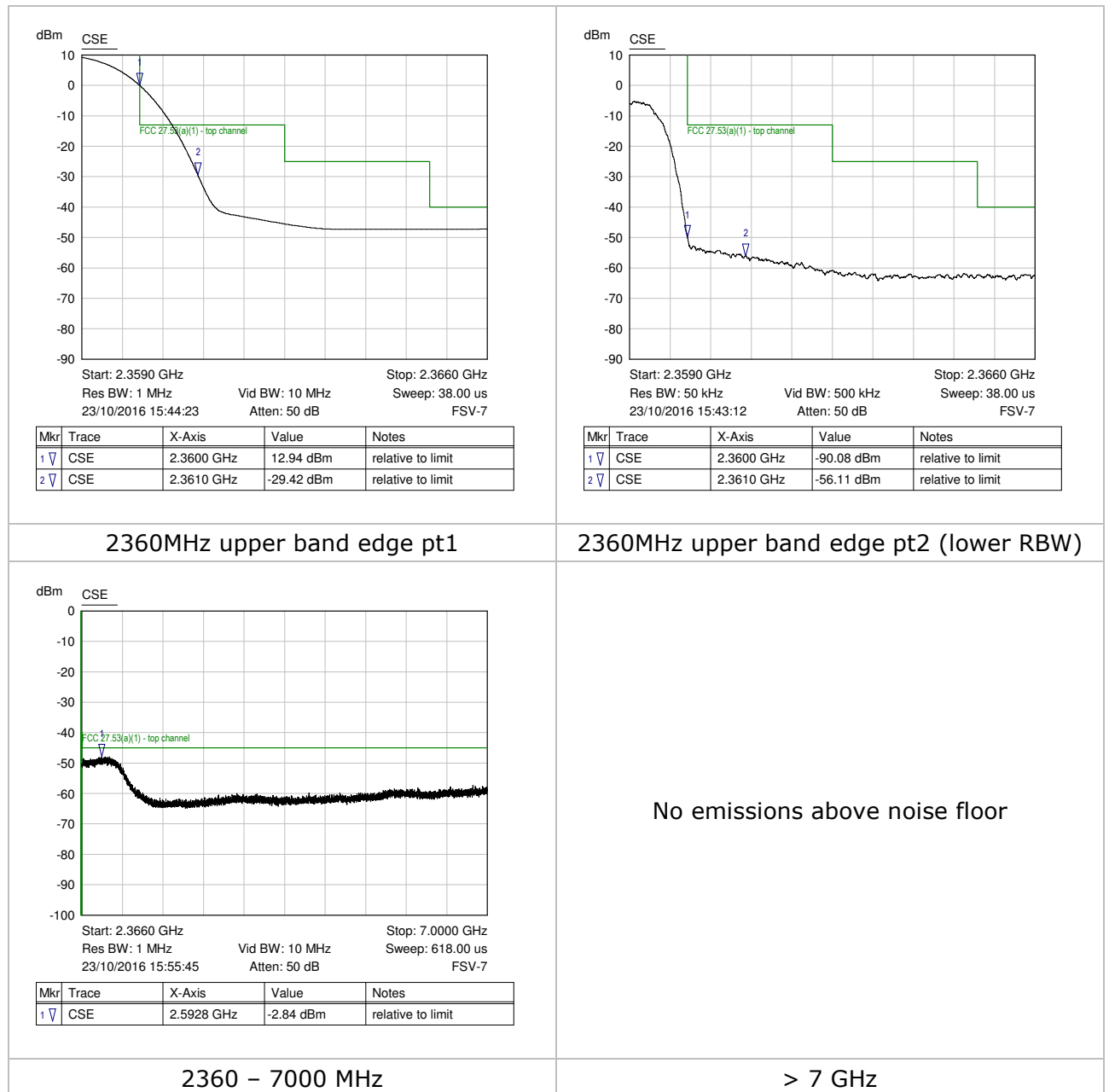
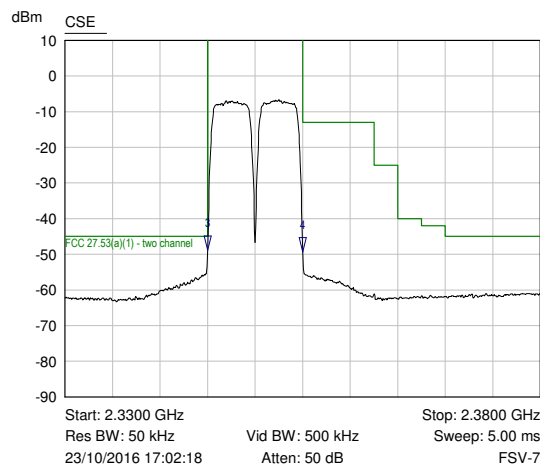
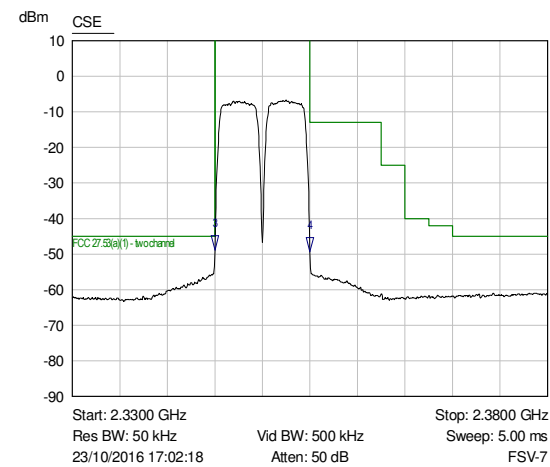


Figure 12: CSE top channel: 2357.5 MHz

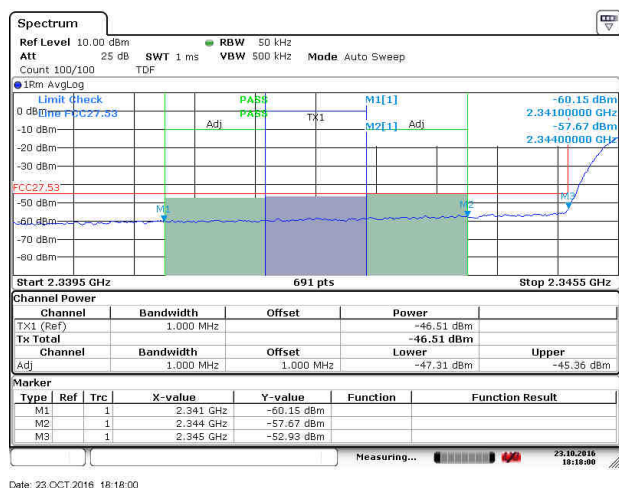
13.2.4 Dual Channel: AWGN



Mkr	Trace	X-Axis	Value	Notes
3	↓	CSE	2.3450 GHz	-3.82 dBm relative to limit
4	↓	CSE	2.3550 GHz	-36.25 dBm relative to limit



Mkr	Trace	X-Axis	Value	Notes
3	↓	CSE	2.3450 GHz	-3.82 dBm relative to limit
4	↓	CSE	2.3550 GHz	-36.25 dBm relative to limit



Band edge 2347.5 and 2352.5 MHz signals
(Channel power measurement for 2341 – 2344 MHz band)

Band edge 2347.5 and 2352.5 MHz signals
with lower RBW for 1 MHz adjacent to
bandedge

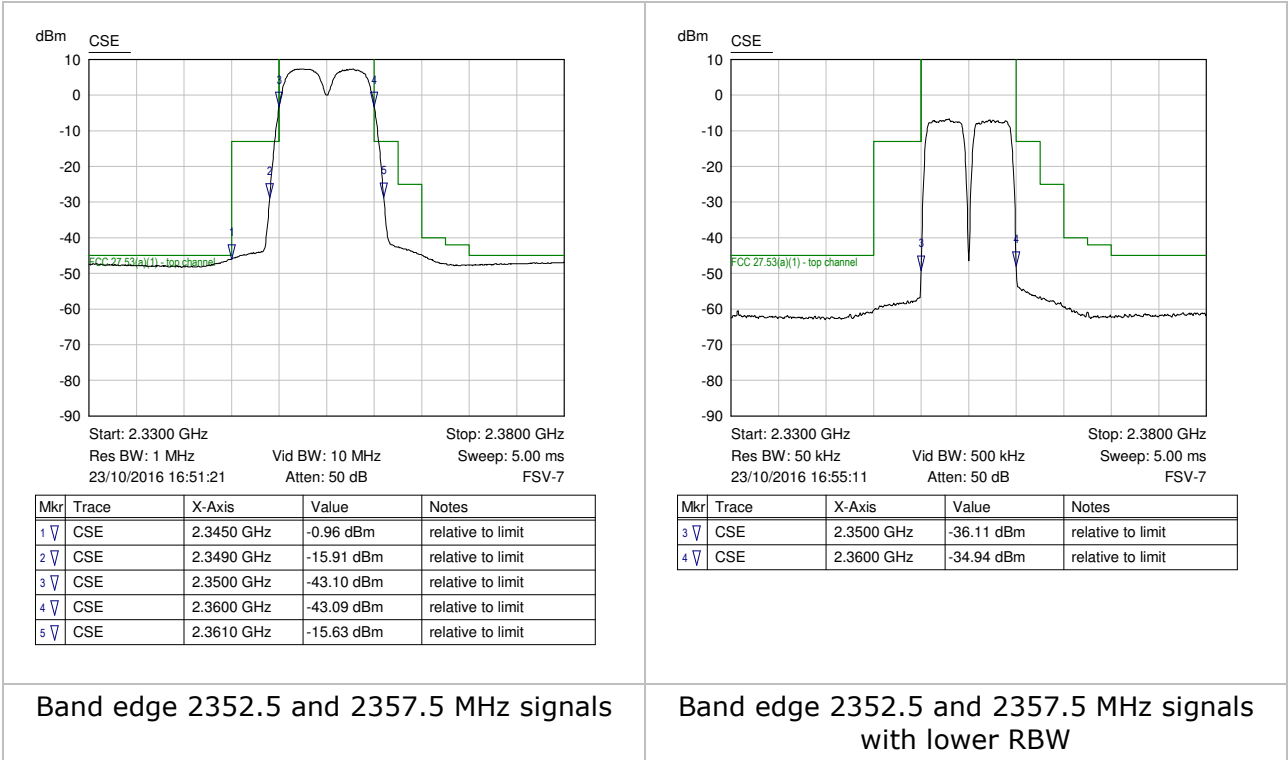


Figure 13: CSE and band edge 2345 - 2360 MHz Band dual channel

14 Transmit Power: 2496 - 2690 MHz

14.1 Test method

The equipment was configured with maximum gain of 25dB and connected as per figure 1.

The signal generator was set to provide -5 dBm to the input of the hub and the frequency set to an appropriate channel to include f_0 as determined in section 7.

Measurements were made in accordance with KDB 971168 D01 using an RMS detector and the Peak to Average ratio was measured using the CCDF function of the analyser.

14.2 Test results

Frequency	TX power (dBm)	TX power EIRP (dBm)	TX power EIRP (W)	Limit EIRP (W)	0.1% PAR	Result
2498.5	19.80	27.80	0.60	2000.0	7.94 dB	Pass

Table 6: Transmit power and Peak-to-Average ratio

Plots may be seen in figures 7 and 13.

Peak to Average (PAR) ratio was measured using the analyser in-built CCDF function.

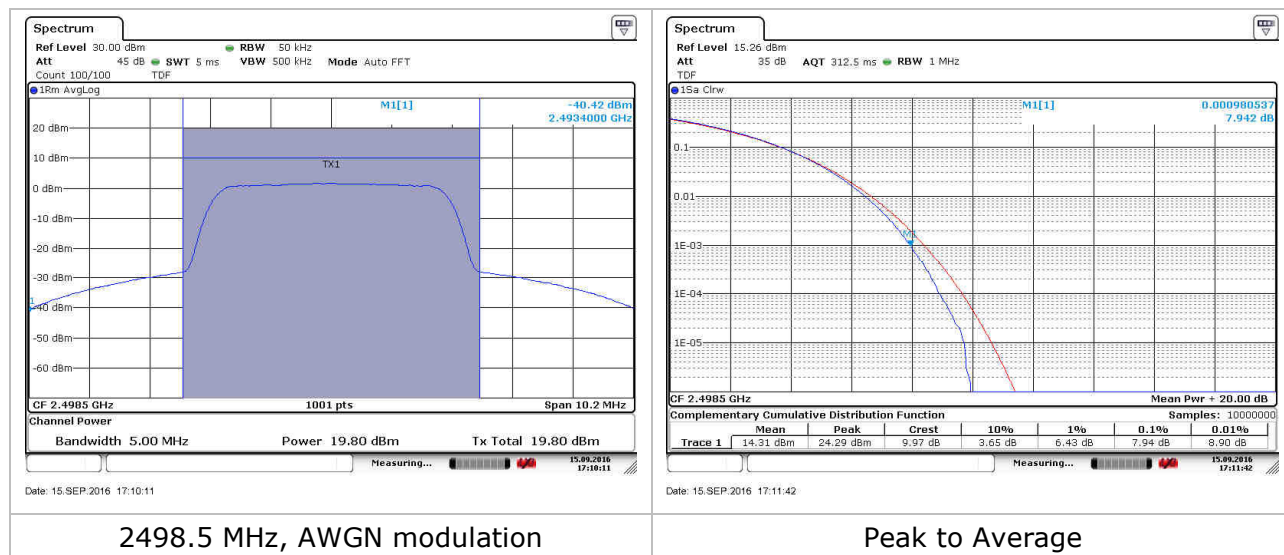


Figure 14: Power and Peak to Average (PAR) plots

15 Occupied Bandwidth: 2496 - 2690 MHz

15.1 Test method

KDB 935210 D05 section 3.4.

The occupied bandwidth was measured using the inbuilt function on the Signal Analyser set to measure the 99% occupied bandwidth. Measurement was made using peak detector and max hold.

The two plots are overlaid on the same graph by using different vertical axes for input and output signals.

15.2 Test results

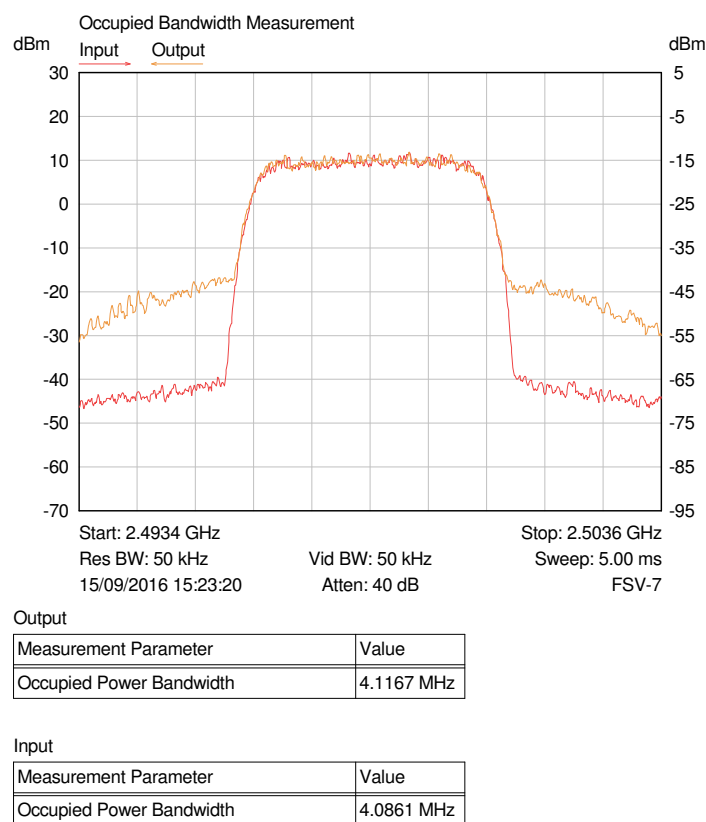


Figure 15: Input vs output plot for 2496 - 2690 MHz band

16 CSE inc. Band Edge: 2496 - 2690 MHz

16.1 Requirement and test method

27.53.

(m) For BRS and EBS stations, the power of any emissions outside the licensee's frequency bands of operation shall be attenuated below the transmitter power (P) measured in watts in accordance with the standards below. If a licensee has multiple contiguous channels, out-of-band emissions shall be measured from the upper and lower edges of the contiguous channels.

(2) For digital base stations, the attenuation shall be not less than $43 + 10 \log (P)$ dB, unless a documented interference complaint is received from an adjacent channel licensee with an overlapping Geographic Service Area. Mobile Satellite Service licensees operating on frequencies below 2495 MHz may also submit a documented interference complaint against BRS licensees operating on channel BRS No. 1 on the same terms and conditions as adjacent channel BRS or EBS licensees. Provided that a documented interference complaint cannot be mutually resolved between the parties prior to the applicable deadline, then the following additional attenuation requirements shall apply:

(6) Measurement procedure. Compliance with these rules is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater. However, in the 1 MHz bands immediately outside and adjacent to the frequency block a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed; for mobile digital stations, in the 1 megahertz bands immediately outside and adjacent to the frequency block a resolution bandwidth of at least two percent may be employed, except when the 1 megahertz band is 2495-2496 MHz, in which case a resolution bandwidth of at least one percent may be employed. A narrower resolution bandwidth is permitted in all cases to improve measurement accuracy provided the measured power is integrated over the full required measurement bandwidth (i.e. 1 megahertz or 1 percent of emission bandwidth, as specified; or 1 megahertz or 2 percent for mobile digital stations, except in the band 2495-2496 MHz). The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.

The licensed band of operation was considered to be a single 5 MHz channel for the 5 MHz operation.

Some emissions > 1 MHz from bandedge were measured using the spectrum analyser adjacent channel power function that integrated power from a lower resolution bandwidth into the 1 MHz required by the rule part.

16.2 Test results

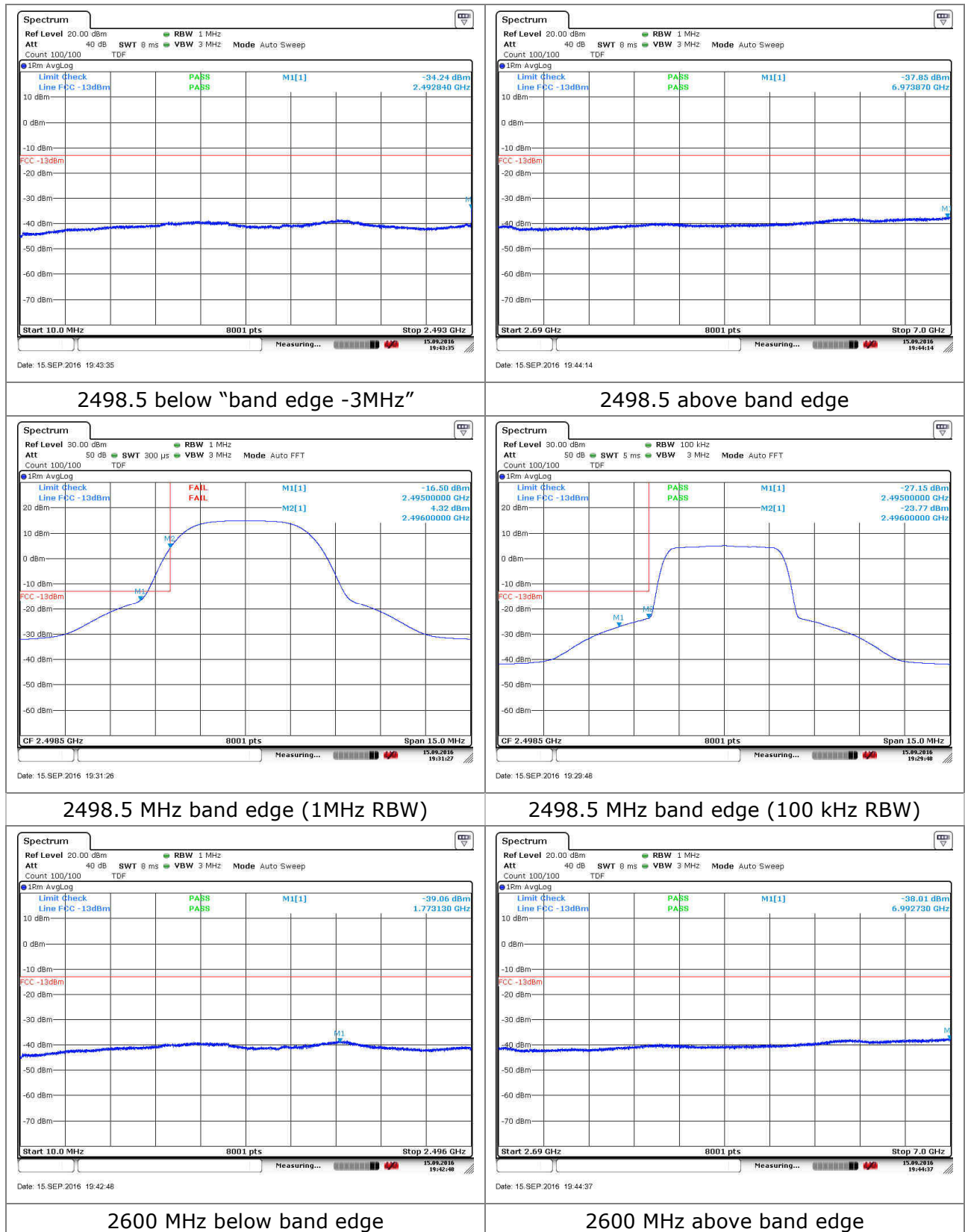
Single channel measurements were > 3.5 dB below the limit

Dual channel measurements were > 3 dB below the limit

Plots are included for all modes up to 7GHz.

No emissions above noise floor above 7 GHz for any frequency of operation

16.2.1 Wideband single frequency



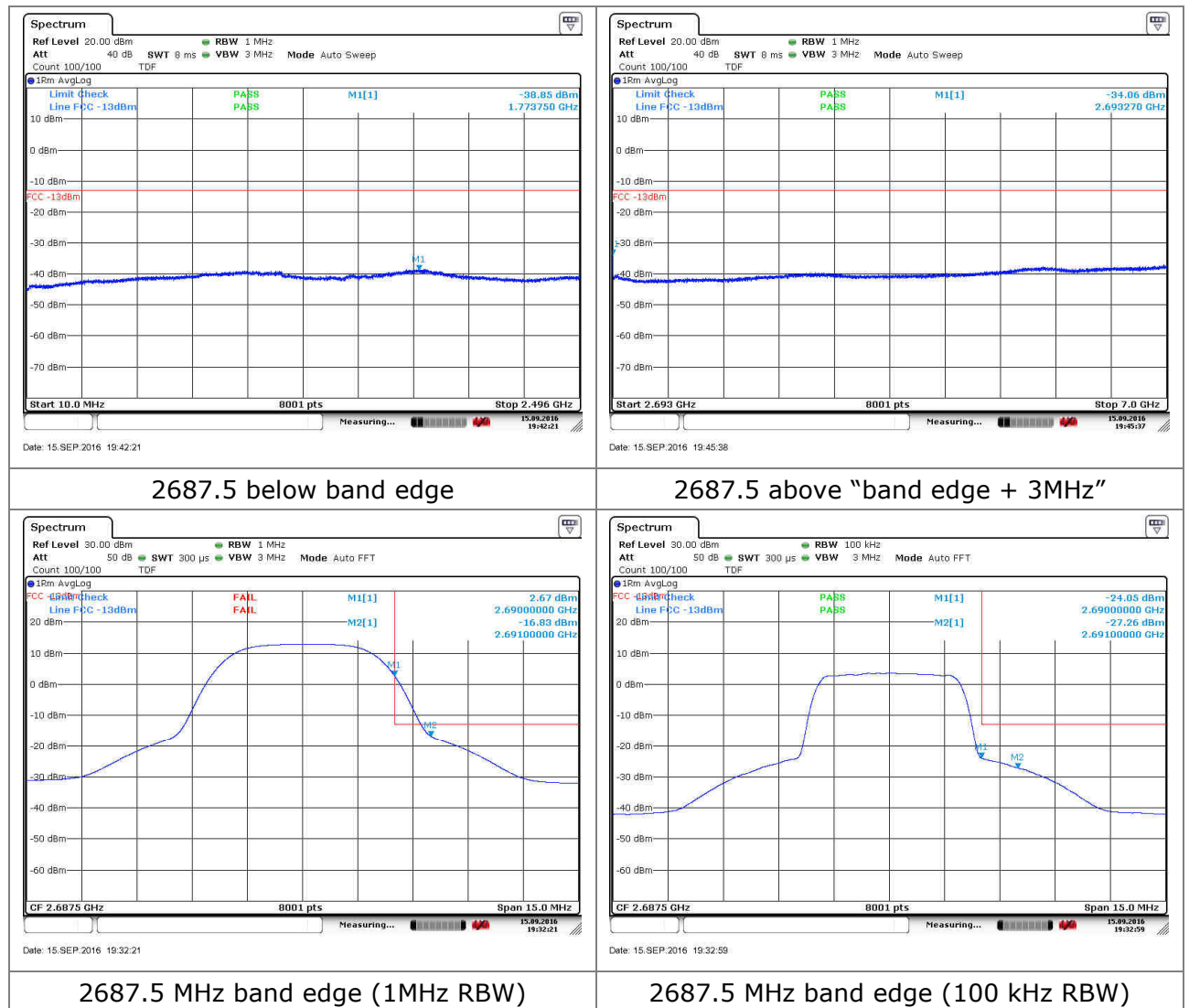


Figure 16: CSE and band edge 2496 - 2690 MHz Band

16.2.2 Dual Channel: AWGN

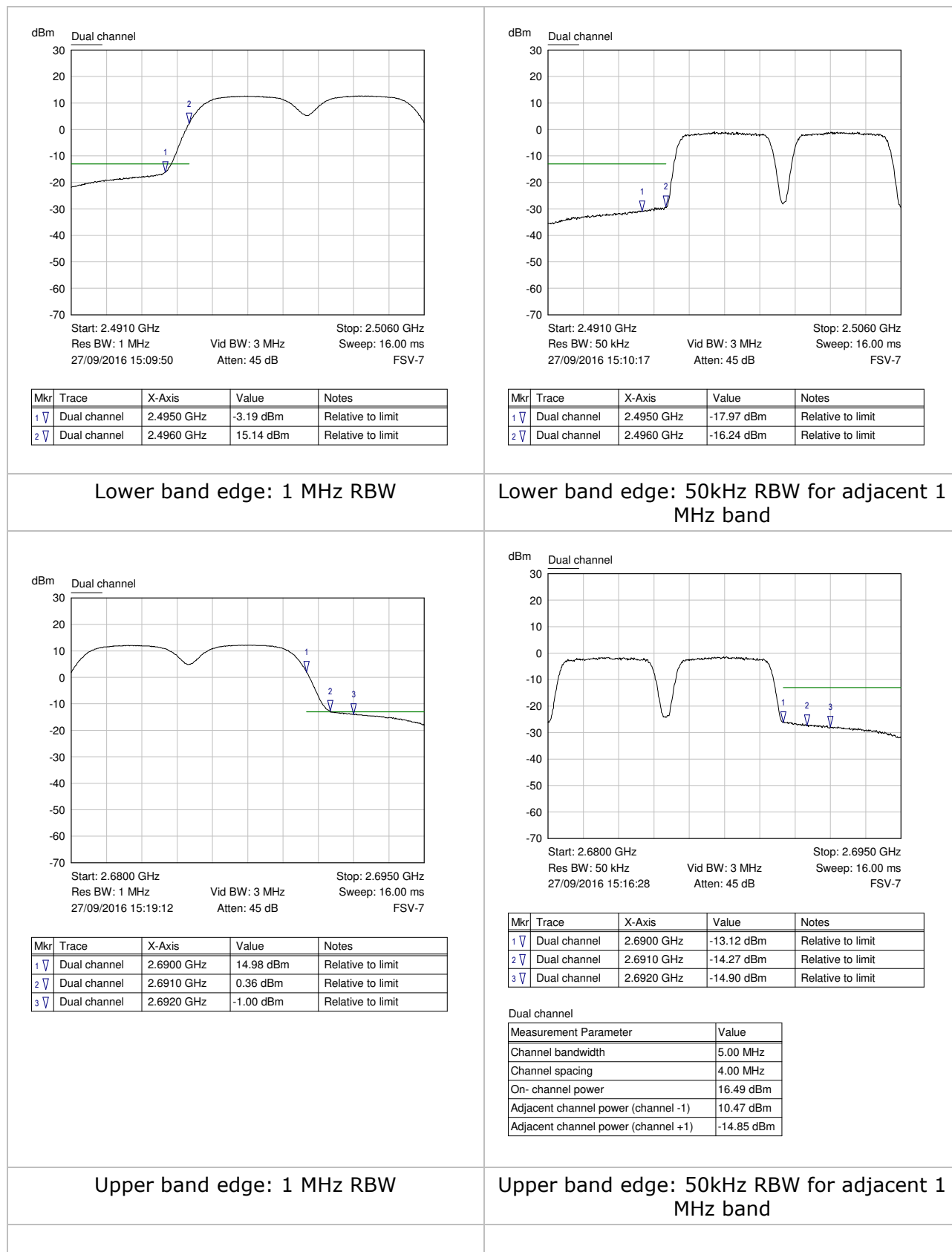


Figure 17: CSE and band edge 2496 - 2690 MHz Band dual channel

17 Radiated Spurious Emissions testing

17.1 Test method

Pre-scan measurements were performed with a spectrum analyser, using a peak detector and max hold.

Measurement bandwidths for pre-scan emissions were 100 kHz RBW for frequencies below 1 GHz and 1 MHz for frequencies above 1 GHz.

Measurement bandwidths for final emissions measurements by substitution were 1 MHz except for 1 MHz band immediately adjacent to band edge.

All measurements below 18 GHz were performed at 3m distance and emissions above 18 GHz were measured at 1m.

The cabinet radiation was performed while transmit antenna port was terminated with a 50Ω load.

Initial pre-scan measurements were performed against a field strength limit determined by

$$E = \text{EIRP} - 20\log D + 104.8$$

Where pre-scans showed any emissions of note, final measurement was made using substitution method, with results presented in sections 17.3 and 17.5.

17.2 Pre-scans for single channel operation

Emissions were investigated with device transmitting on bottom, middle and top channels.

Worst case pre-scans are shown below:

17.2.1 2180 – 2200 MHz RSE

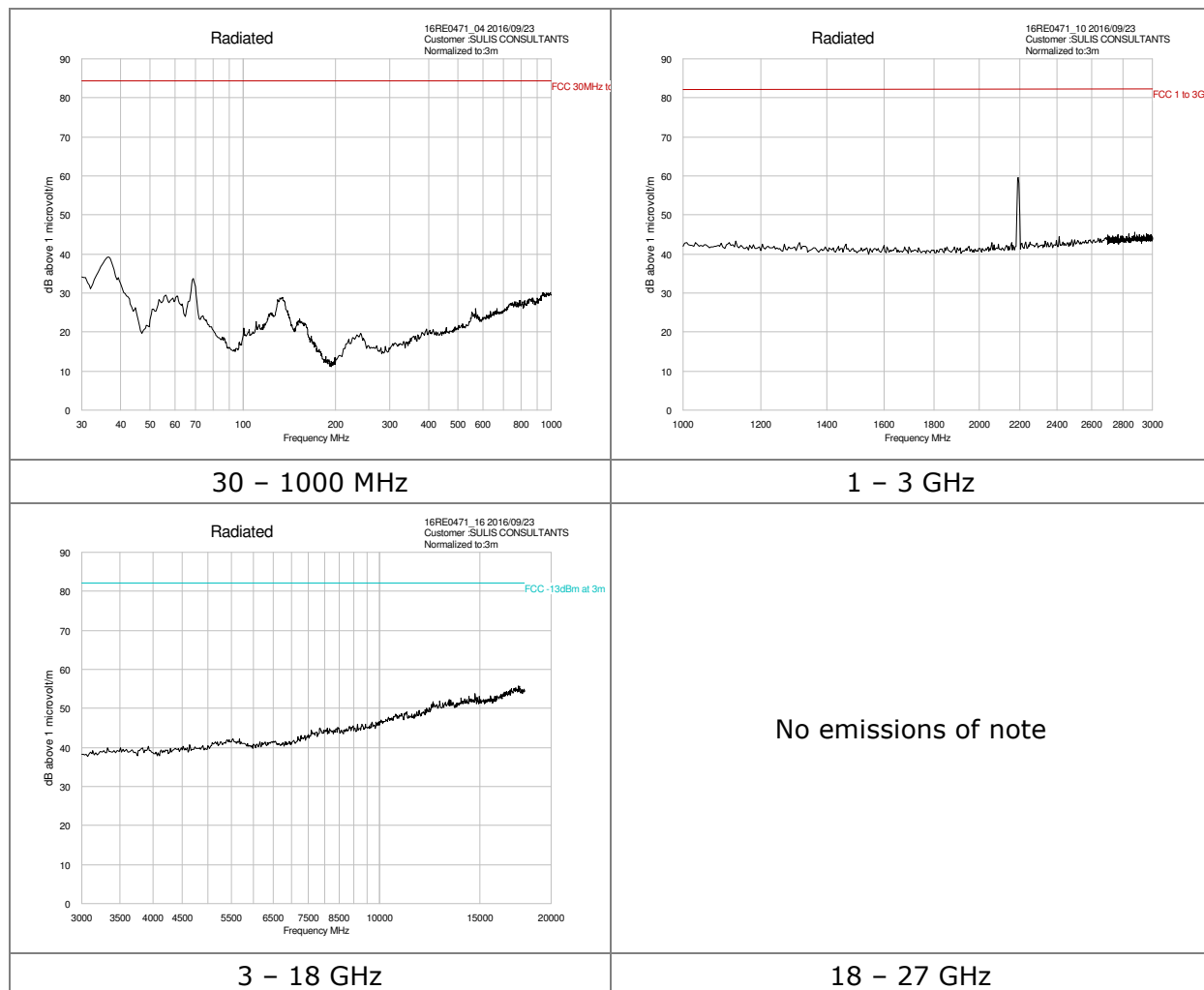


Figure 18: RSE pre-scans: 2180-2200 MHz band operation

17.2.2 2345 - 2360 MHz RSE

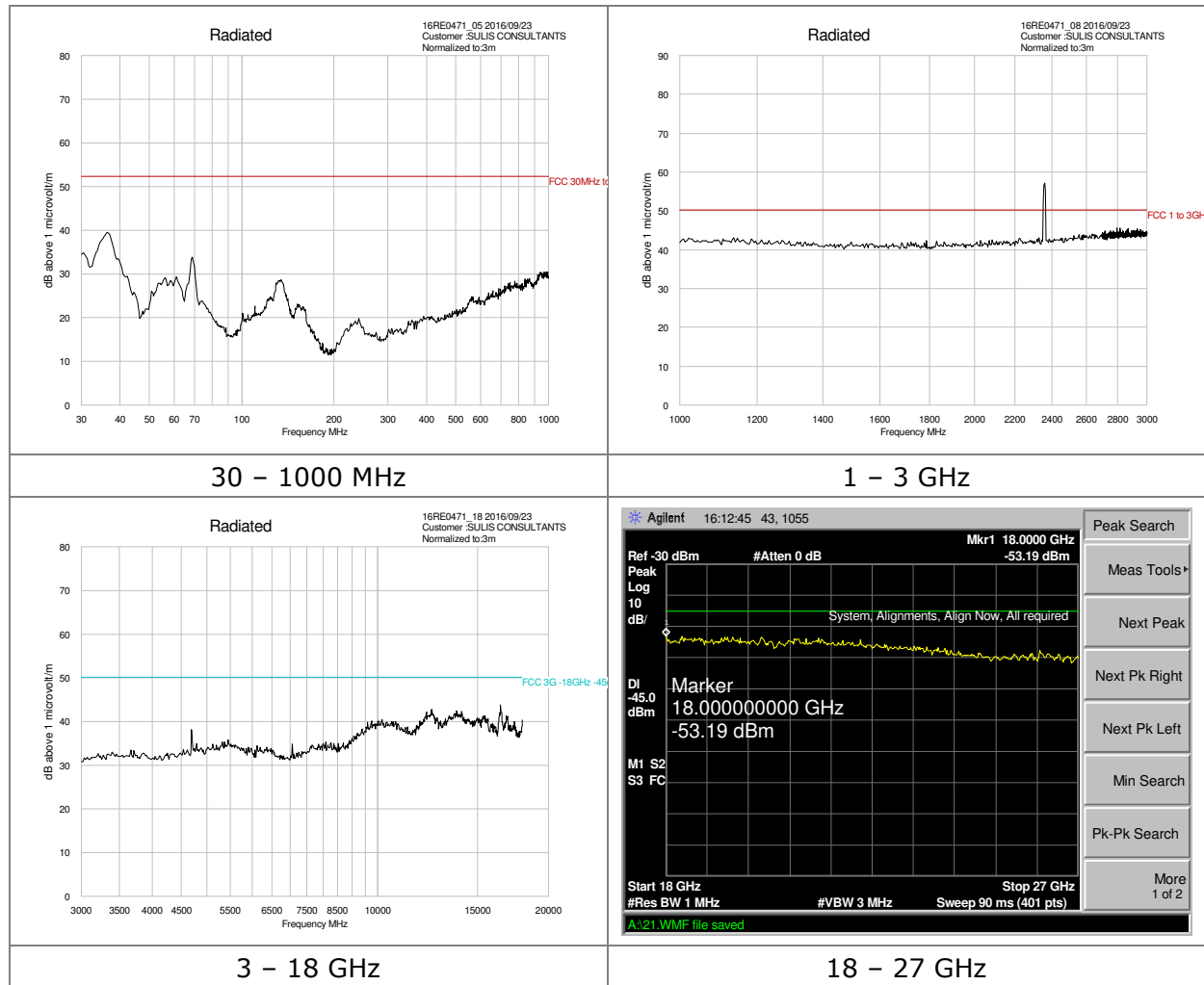


Figure 19: RSE pre-scans: 2345 - 2360 MHz band operation

17.2.3 2496 - 2690 MHz RSE

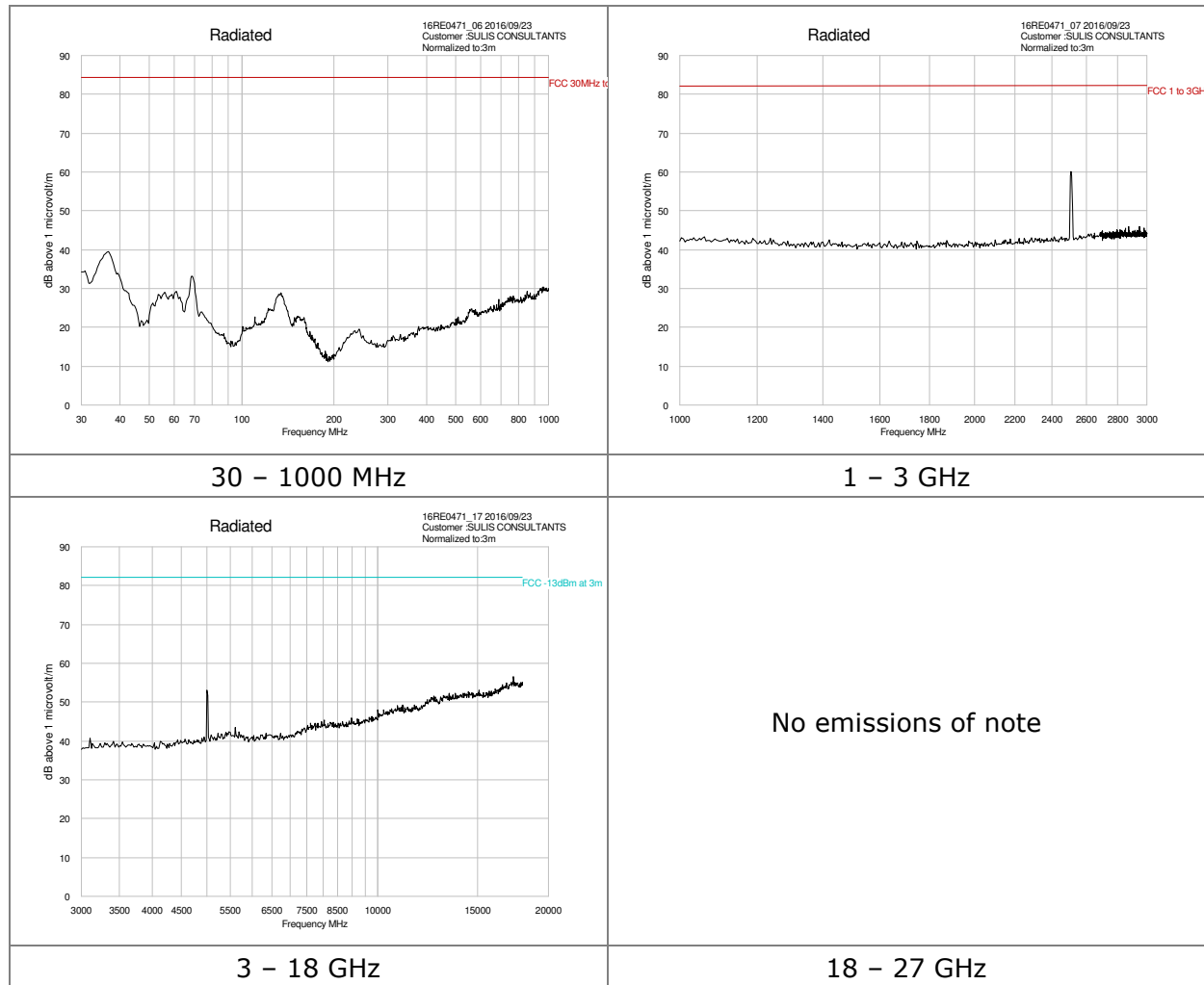


Figure 20: RSE pre-scans: 2496 - 2690 MHz band operation

17.3 Final measurements for single channel operation

The only emissions of note were in the 2345-2360 MHz band where the limit line is more stringent.

Measurements were made using RMS detector and trace averaging.

Band-edge Frequency (MHz)	Frequency being measured	Measurement bandwidth	Emission level (dBm)	Limit (dBm)	Result
2345.0	Band edge – 1MHz	1 MHz	-61.8	-45.0	Pass
2345.0	Band edge	100 kHz	-74.6	-45.0	Pass
2360.0	Band edge + 1MHz	1 MHz	-60.6	-45.0	Pass
2360.0	Band edge	100 kHz	-74.6	-45.0	Pass

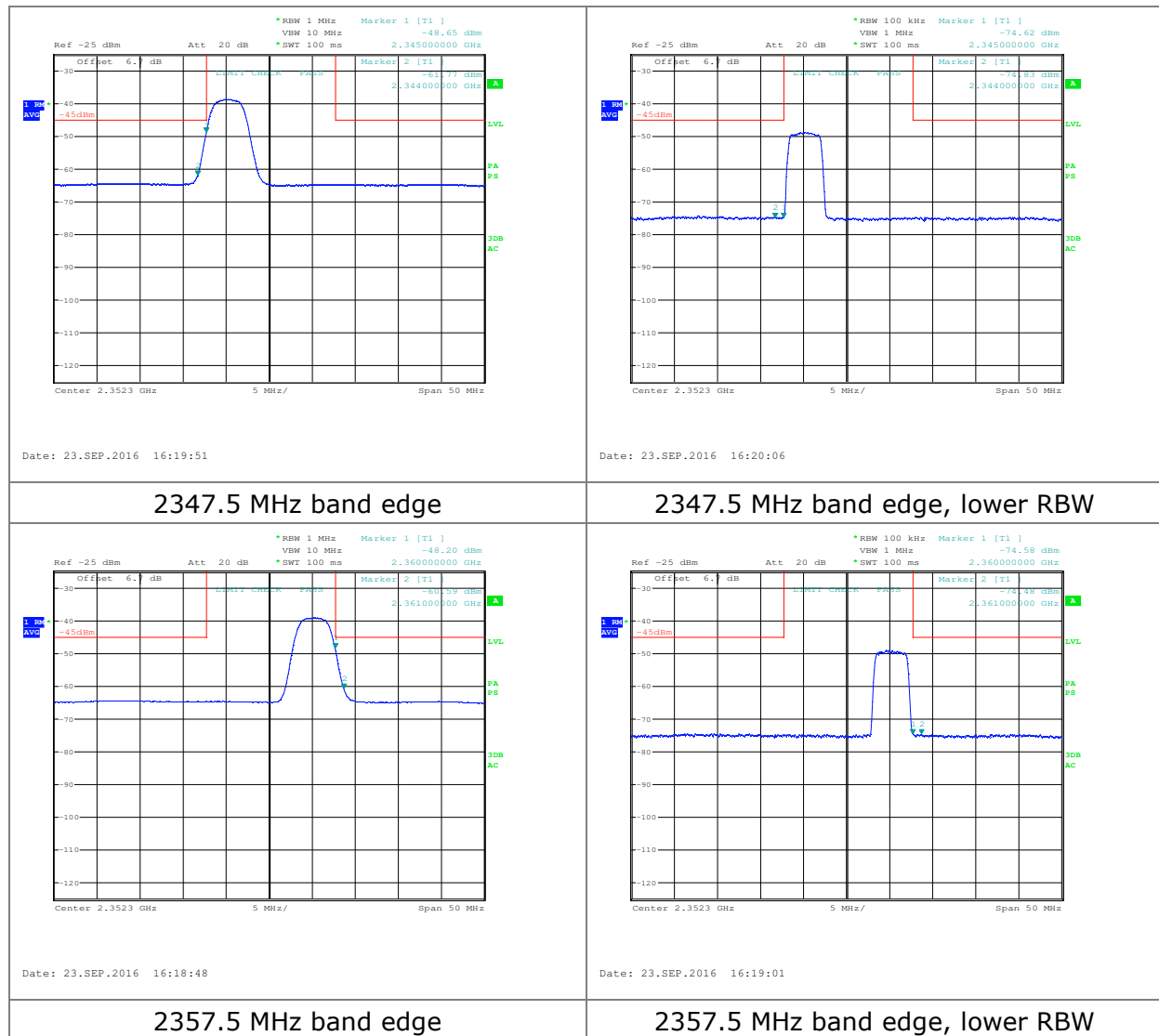


Figure 21: RSE final measurements

17.4 Pre-scans for dual channel operation

Emissions were investigated with device transmitting in two modes:

- Bottom and adjacent channels.
- Top and adjacent channels

Worst case pre-scans are shown below

17.4.1 2180 – 2200 MHz RSE – dual channel

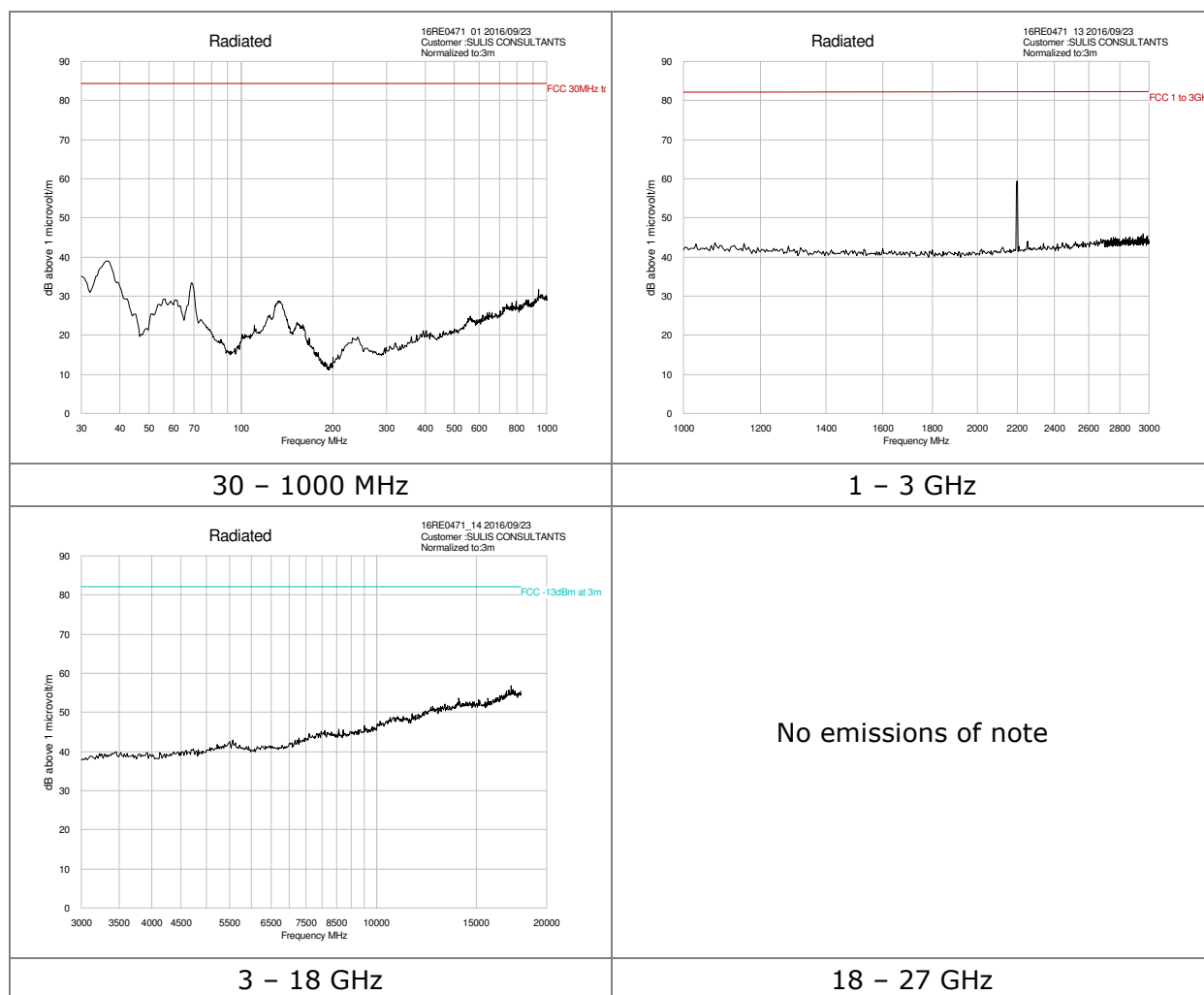


Figure 22: RSE pre-scans: 2180-2200 MHz band operation – dual channel

17.4.2 2345 - 2360 MHz RSE – dual channel

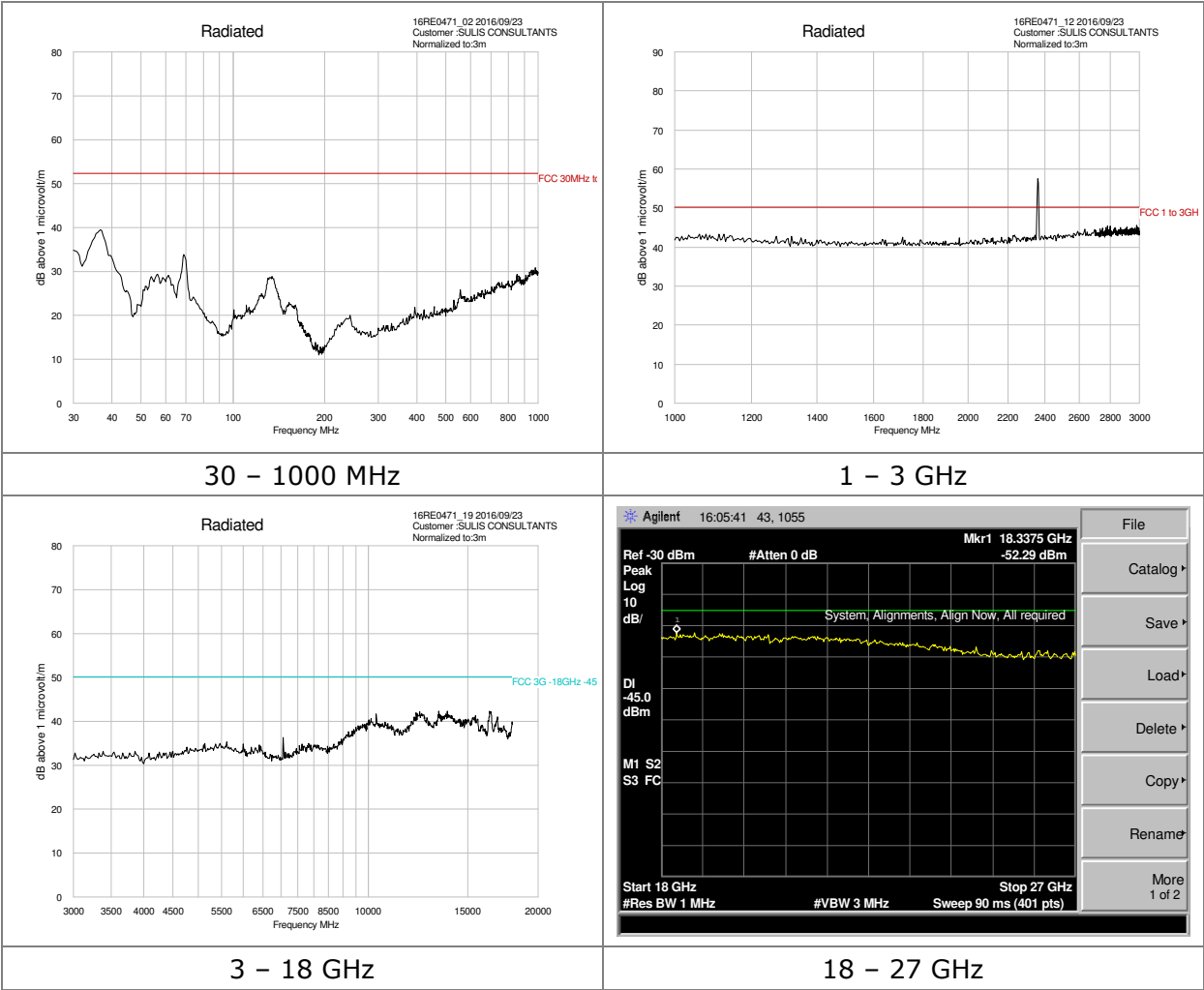


Figure 23: RSE pre-scans: 2345 - 2360 MHz band operation – dual channel

17.4.3 2496 - 2690 MHz RSE – dual channel

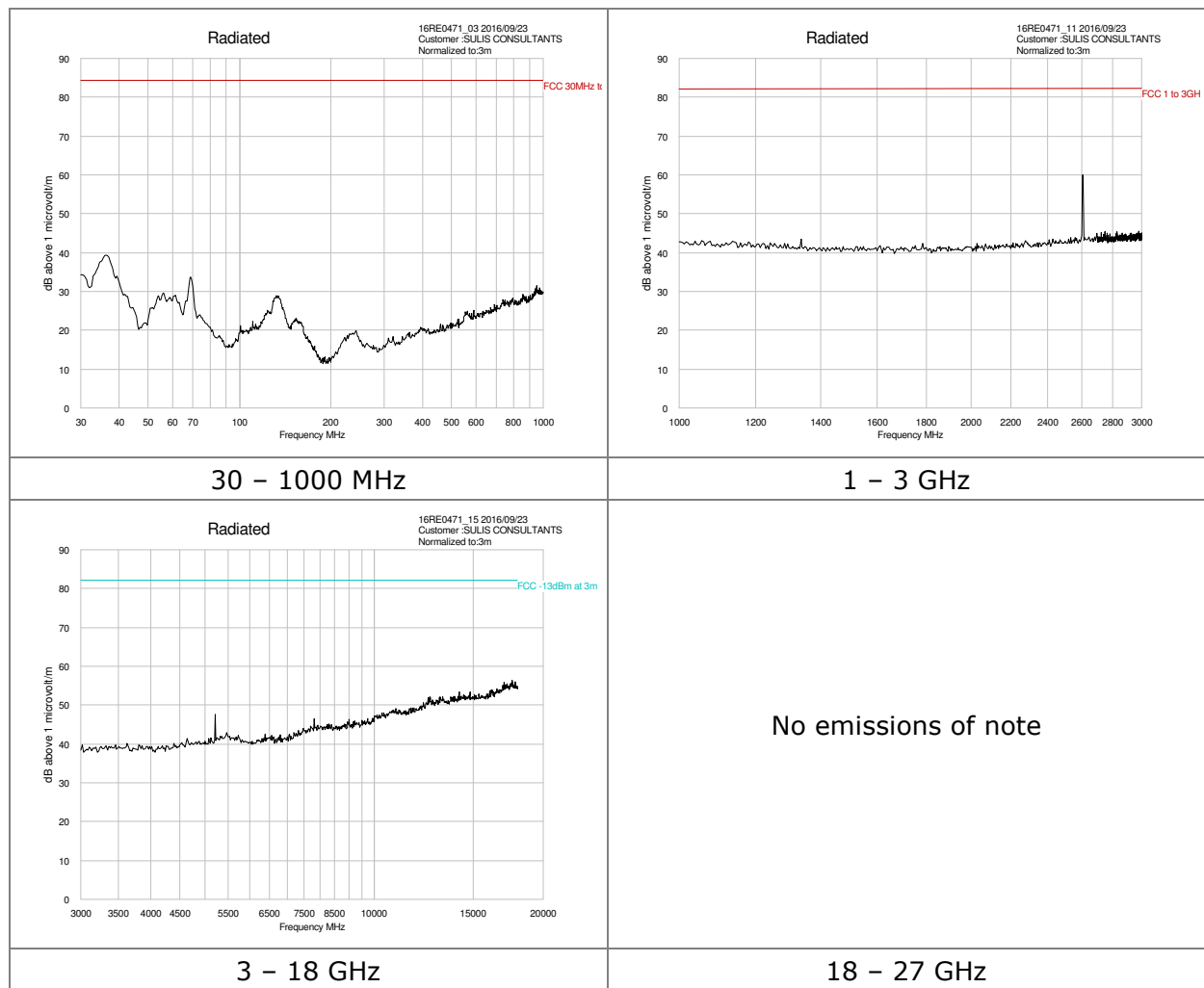


Figure 24: RSE pre-scans: 2496 - 2690 MHz band operation – dual channel

17.5 Final measurements for dual channel operation

The only emissions of note were in the 2345-2360 MHz band where the limit line is more stringent.

Measurements were made using RMS detector and trace averaging.

Band-edge Frequency (MHz)	Frequency being measured	Measurement bandwidth	Emission level (dBm)	Limit (dBm)	Result
2345.0	Band edge – 1MHz	1 MHz	-62.0	-45.0	Pass
2345.0	Band edge	100 kHz	-74.4	-45.0	Pass
2360.0	Band edge + 1MHz	1 MHz	-60.9	-45.0	Pass
2360.0	Band edge	100 kHz	-74.0	-45.0	Pass

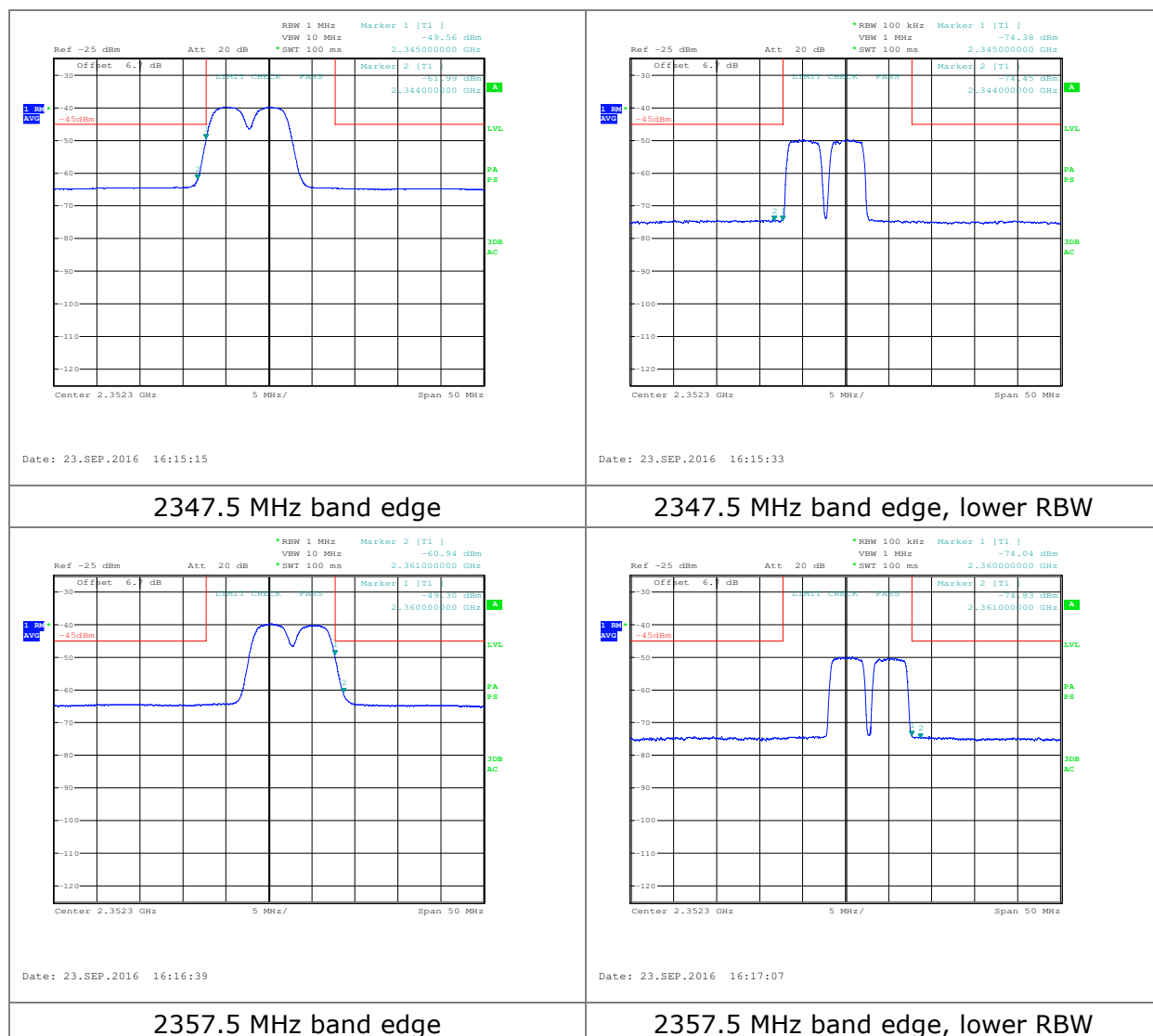


Figure 25: RSE final measurements – dual channel

18 Test equipment

Description	Manufacturer	Model	Serial Number	Calibration
Signal Analyser	Rohde & Schwarz	FSV 7	Zinwave 000073	R&S 20-516458 Due 14 Nov 16
Signal Generator	Rohde & Schwarz	SMBV100A	Microlease asset 45440	Ref: 45440 Due 19 Nov 15
Cable	Utiflex	BUA01G	FA210A0009M30309	ABEX UK. Ref: green bua01g Due 08 Oct 17
Spectrum analyser (9kHz-26.5GHz)	HP	8593EM	3536A00137	HEMC Cal due 17/12/2016
Signal Generator	Rohde & Schwarz	SMJ100A	100156	Verified as part of system test
Signal Generator	Agilent	E4432B	G83934071A	
Attenuator	Mini-circuits	VAT 10	3 0433	
Cable (input)	Mini-circuits	CBL-1M-SMNM+	120274	
Cable (input)	Mini-circuits	CBL-1M-SMNM+	120295	
2-way splitter (input)	Mini-circuits	ZN2PD2-63-S+	UU21401232	
RSE testing at Hursley EMC Services Ltd. All calibration maintained under UKAS ISO17025 accreditation no 1874				
Pre-amplifier (30-1000MHz)	HP	8447D	1937A02341	HEMC Cal due 14/09/2017
Pre-amplifier (1.0-26.5GHz)	HP	8449B	3008A01394	HEMC Cal due 25/08/2017
Pink 30M-2G Antenna	CHASE	CBL 6141	4013	HEMC Cal due 01/10/2018
1-10GHz Horn	Schwarzbeck	BBHA 9120 571	571	HEMC Cal due 24/02/2019
Horn antenna (2-18GHz)	Q-par Angus	WBH218HN	5367	HEMC Cal due 22/06/2019
18 to 40GHz Horn	Q-par Angus	WBH18-40k	10300	HEMC Cal due Internal
7GHz Receiver	Rohde & Schwarz	ESCI7	1.167E+09	HEMC Cal due 20/05/2017
Spectrum analyser (9kHz-26.5GHz)	HP	8593EM	3536A00137	HEMC Cal due 17/12/2016
Synthesized sweeper	HP	8341B	2819A1509	HEMC Cal due 14/10/2017
Spectrum Analyser	Agilent	E4407B	MY44220967	HEMC Cal due 30/11/20116

Table 7: Test Equipment