Appendix E: Test result for 5.725GHz – 5.850GHz.

INDEX

TEST CONDITIONS

Power supply (V):

Vnominal = 120 Vac

Type of power supply = AC voltage main supply.

Type of antenna = External antenna.

Declared Gain for antenna (maximum):

$G_{ANTENNA\ SISO1}$ = 6 dBi

$G_{ANTENNA\ SISO2}$ = 6 dBi

Technology Tested:	MulteFire 1.0	
Modes:	QPSK, 16QAM, 64QAM	
Antena ports:	1, 2	
Beamforming:	No	
Frequency Range:	5725 MHz to 5850 MHz	
Channel Spacing:	20 MHz	
Transmit Channels	Channel	Channel Frequency (MHz)
	Lowest: 149	5745
	Middle: 157	5785
	Highest: 165	5825

The test set-up was made in accordance to the general provisions of FCC Unlicensed National Information Infrastructure (U-NII) Devices 789033 D02 General U-NII Test Procedures New Rules v02r01 dated Dec 14, 2017.

The EUT was tested in the following operating mode:

- Continuously transmitting with a modulated carrier at maximum power in all required channels using the supported data rates/modulations types.

The field strength at the band edges was evaluated for each mode for the channel under test.

During transmitter test the EUT was being controlled by the SW tool to operate in a continuous transmit mode on the test channel as required and in each of the different modulation modes. FCC and Canada power setting used during the test were different to be in compliance with both limits.

SISO Port 1:

Channel	Channel Frequency (MHz)	FCC & CANADA Attenuation value
Lowest: 149	5745	0
Middle: 157	5785	0
Highest: 165	5825	0

SISO Port 2:

Channel	Channel Frequency (MHz)	FCC & CANADA Attenuation value
Lowest: 149	5745	0
Middle: 157	5785	0
Highest: 165	5825	0

CONDUCTED MEASUREMENTS:

The equipment under test was set up in a shielded room and it is connected to the TS8997 using a low loss RF cable. The reading of the spectrum analyser is corrected taking into account the cable loss.

The AC supply voltage is applied using an external power supply.

RADIATED MEASUREMENTS

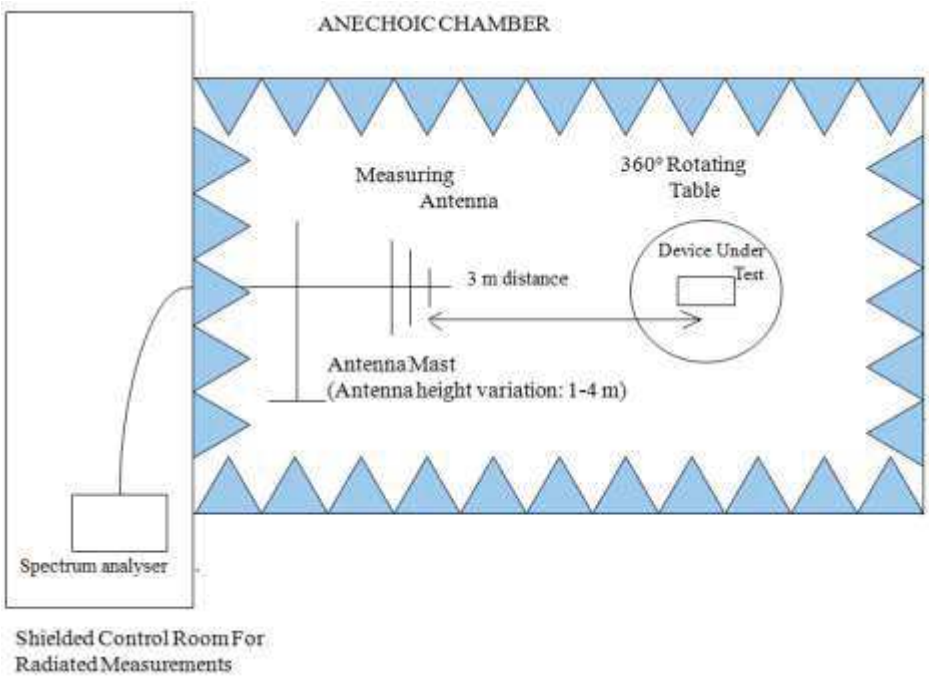
All radiated tests were performed in a semi-anechoic chamber. The measurement antenna is situated at a distance of 3 m. The EUT was placed at a height of 80 cm above the reference ground plane in the center of the chamber turntable to perform the measurements below 1GHz and The EUT was placed at a height of 1.5 meters above the test chamber floor in the center of the chamber turntable to perform the measurements above 1GHz. It was also rotated 360º and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission.

Measurements were made in both horizontal and vertical planes of polarization.

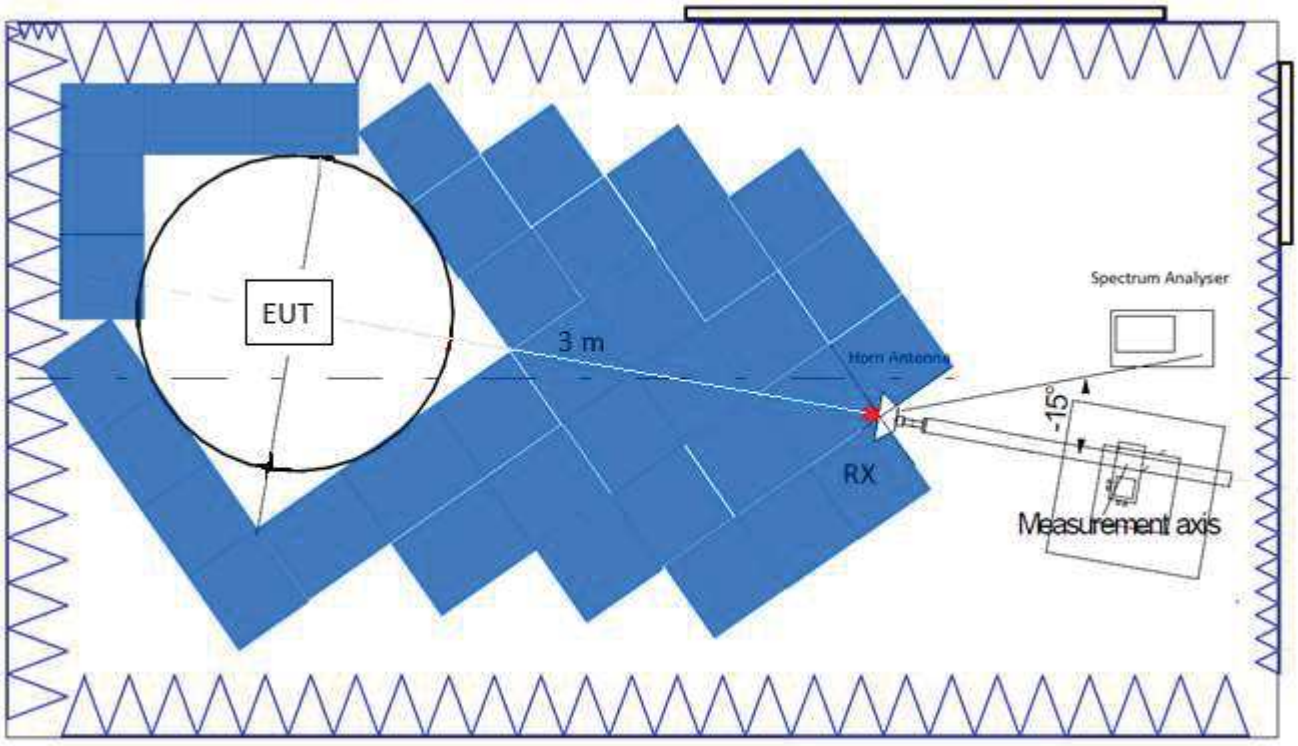
The final measured value, for the given emission, in the tables below incorporates the calibrated antenna factor and cable loss.

A resolution bandwidth/video bandwidth of 100 kHz/300 kHz was used for frequencies below 1 GHz and 1MHz/3MHz for frequencies above 1 GHz.

Radiated measurements setup f < 1 GHz



Radiated measurements setup f > 1 GHz



FCC Section 15.247 Subclause (e) / RSS-247 6.2.4.1. 6 dB Bandwidth

SPECIFICATION

The minimum 6 dB bandwidth shall be at least 500 kHz.

RESULTS:

6 dB Bandwidth (see next plots).

The following modes and data rates were selected based on preliminary testing that identified those corresponding to the worst cases:

SISO Port 1:

Mode : QPSK – 20MHz

(5725-5850 Channels)

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
6 dB bandwidth (MHz)	18.100	18.100	18.100
Measurement uncertainty (kHz)	<± 25.02		

Mode : 16QAM – 20MHz

(5725-5850 Channels)

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
6 dB bandwidth (MHz)	18.150	18.100	18.100
Measurement uncertainty (kHz)	<± 25.02		

Mode : 64QAM – 20MHz

(5725-5850 Channels)

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
6 dB bandwidth (MHz)	18.150	18.100	18.050
Measurement uncertainty (kHz)	<± 25.02		

Verdict: PASS

SISO Port 2:

Mode : QPSK – 20MHz

(5725-5850 Channels)

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
6 dB bandwidth (MHz)	18.150	18.100	18.100
Measurement uncertainty (kHz)	<± 25.02		

Mode : 16QAM – 20MHz

(5725-5850 Channels)

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
6 dB bandwidth (MHz)	18.100	18.100	18.100
Measurement uncertainty (kHz)	<± 25.02		

Mode : 64QAM – 20MHz

(5725-5850 Channels)

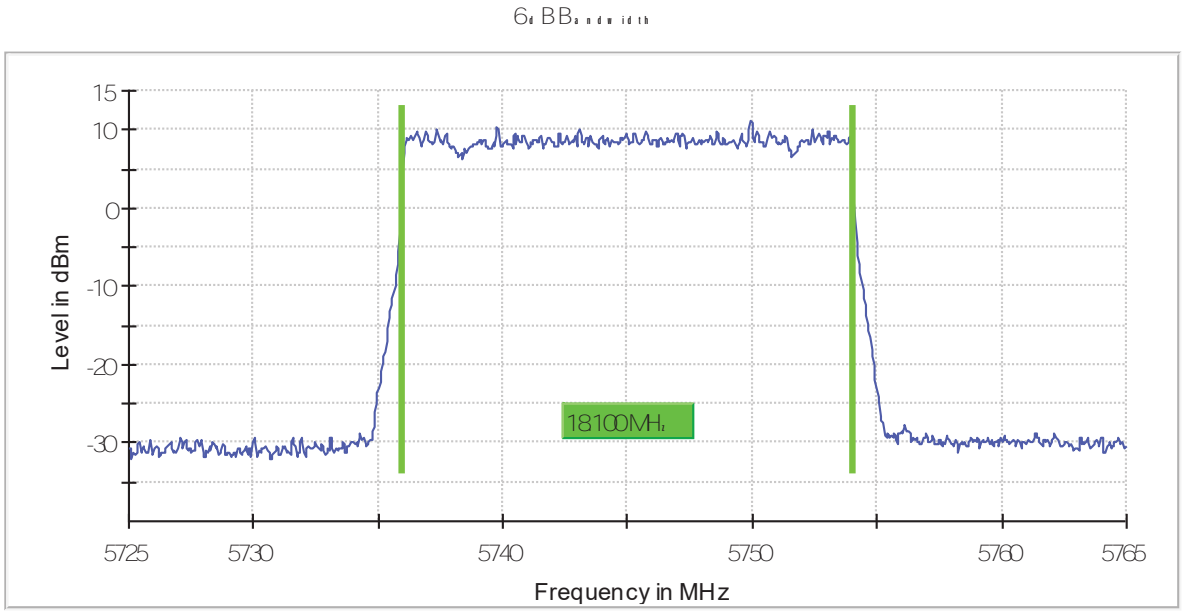
	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
6 dB bandwidth (MHz)	18.100	18.100	18.100
Measurement uncertainty (kHz)	<± 25.02		

Verdict: PASS

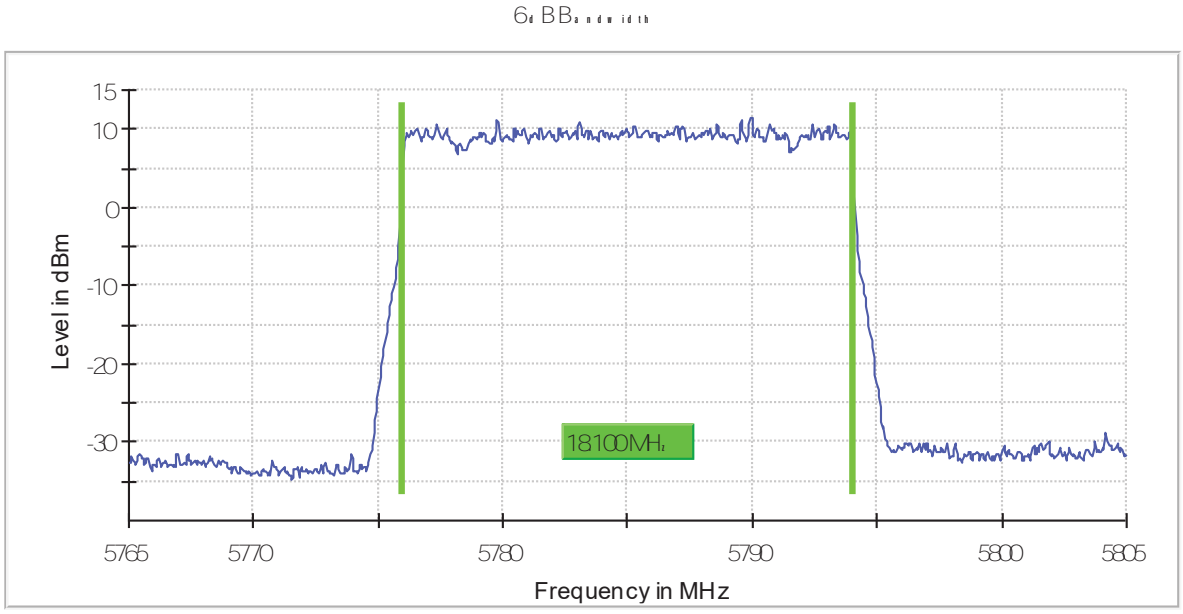
SISO Port 1:

Mode: QPSK – 20 MHz

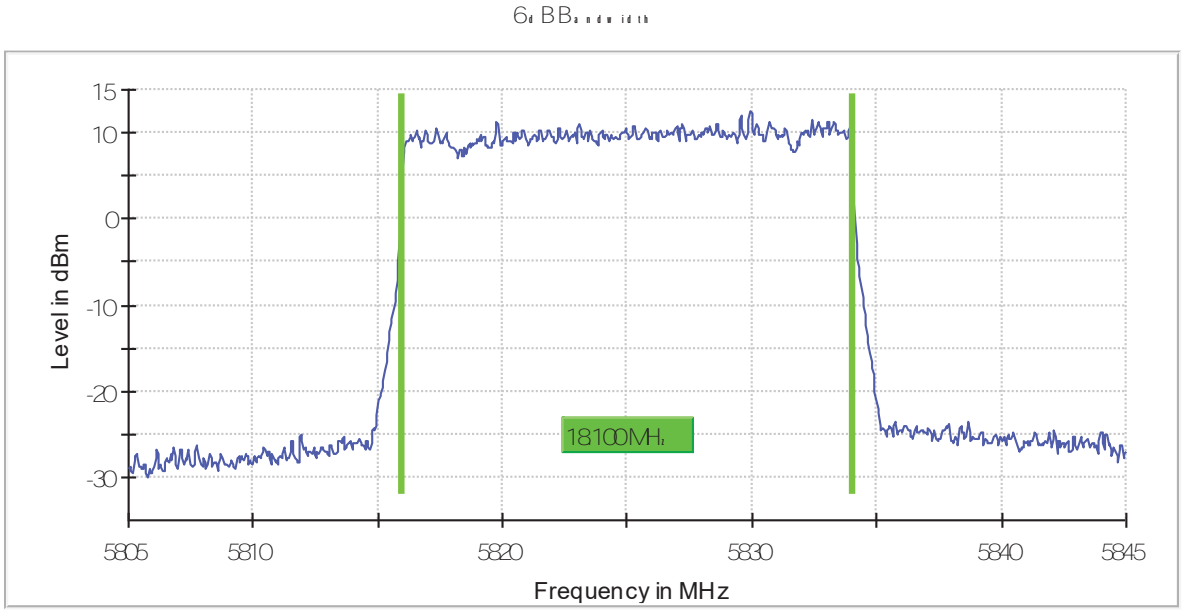
Channel 149



Channel 157

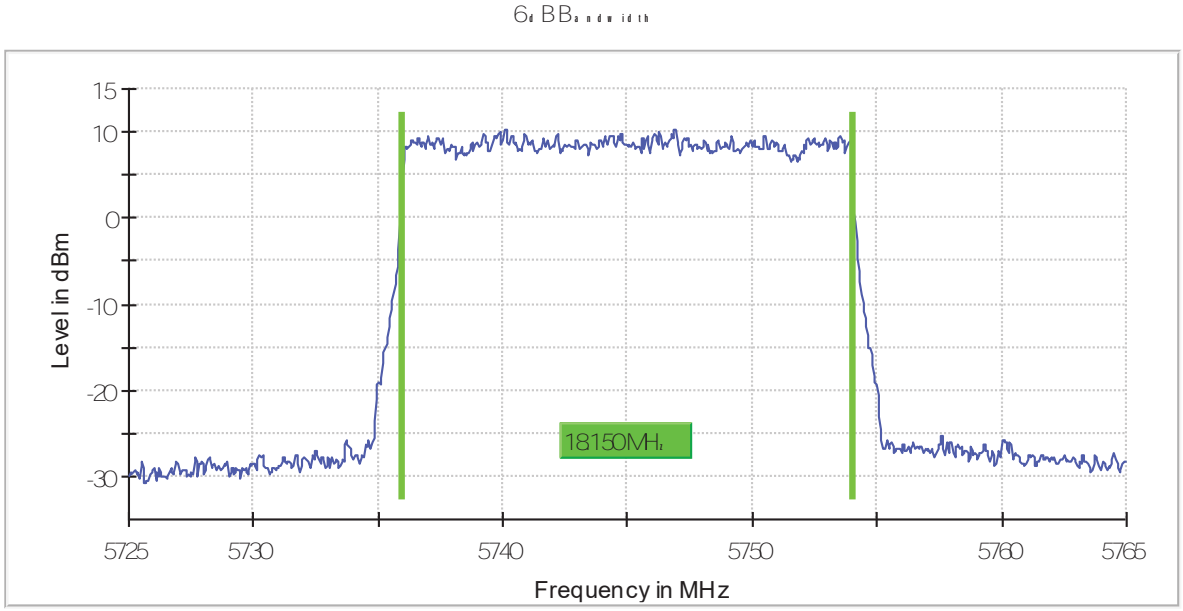


Channel 165

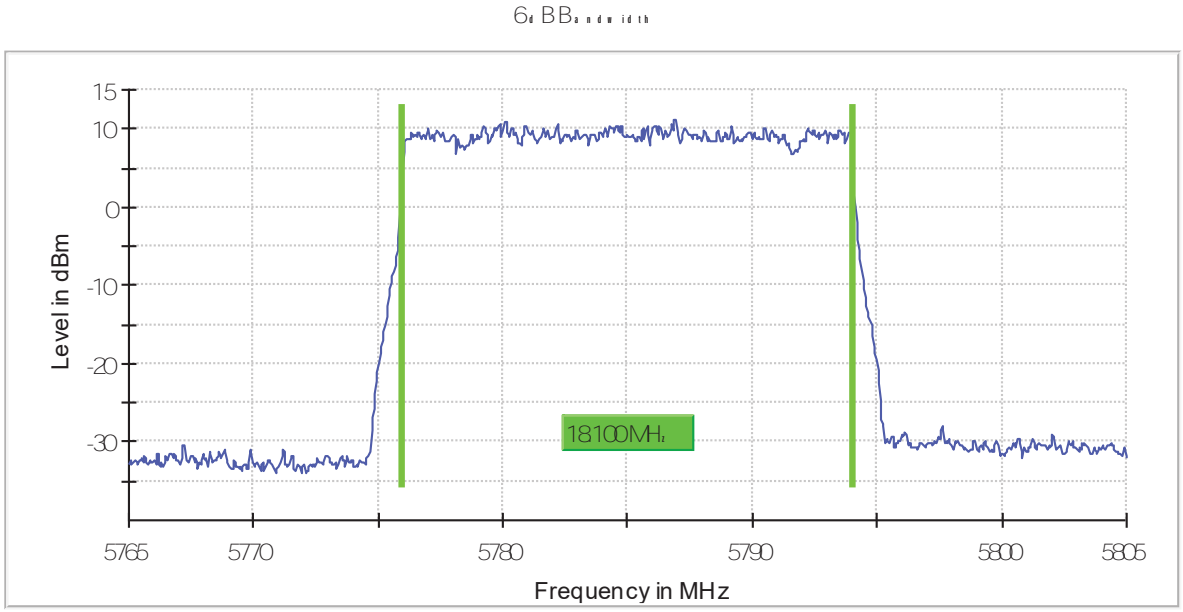


Mode: 16QAM – 20MHz

Channel 149



Channel 157



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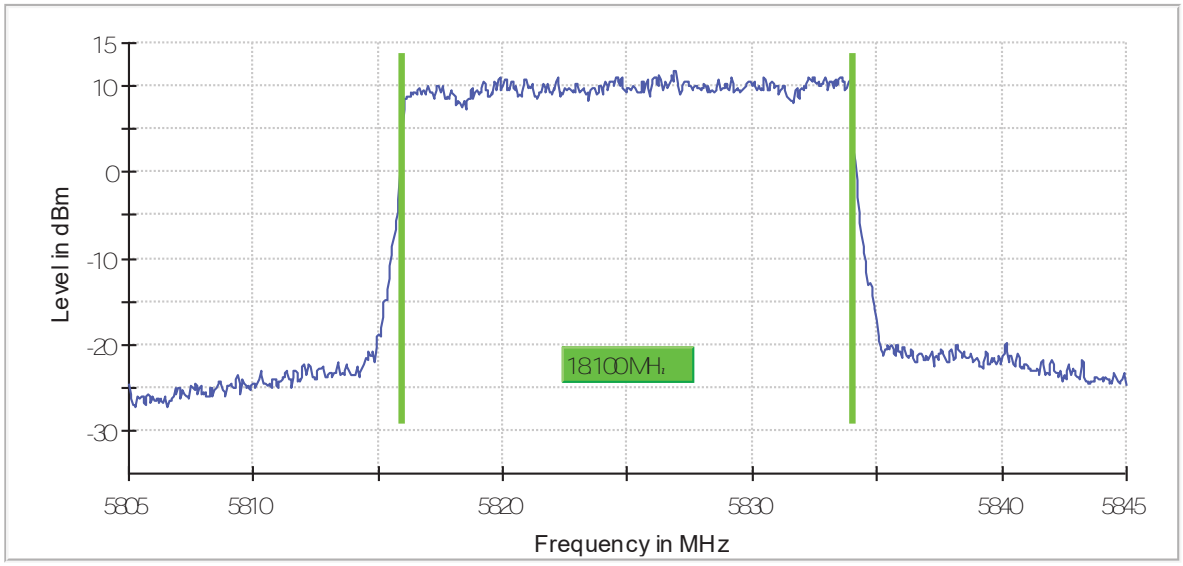
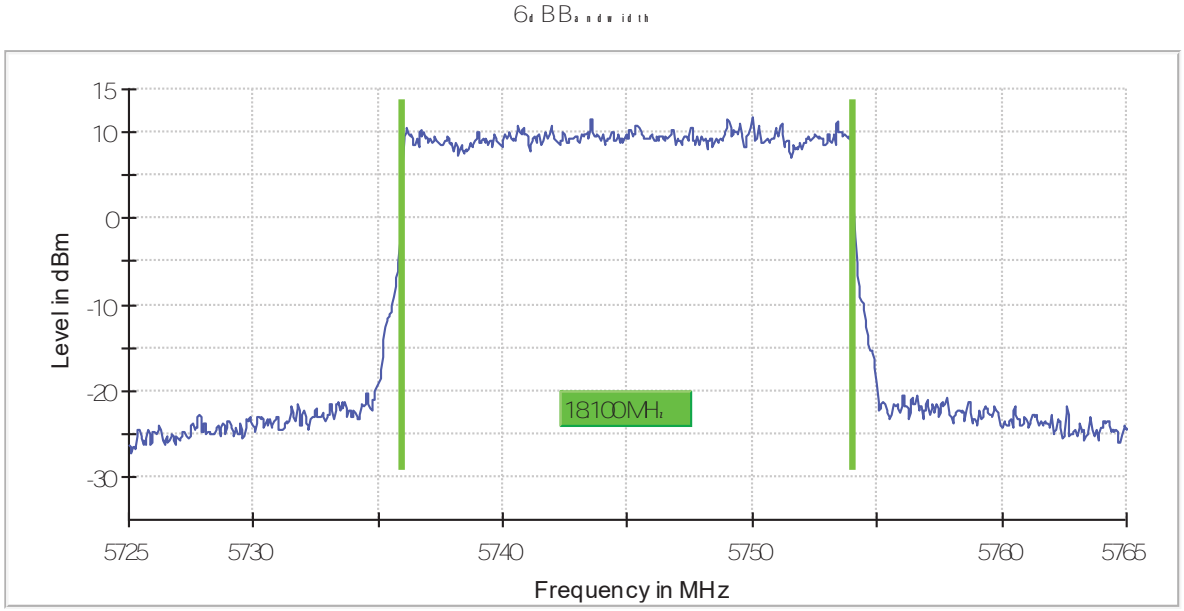
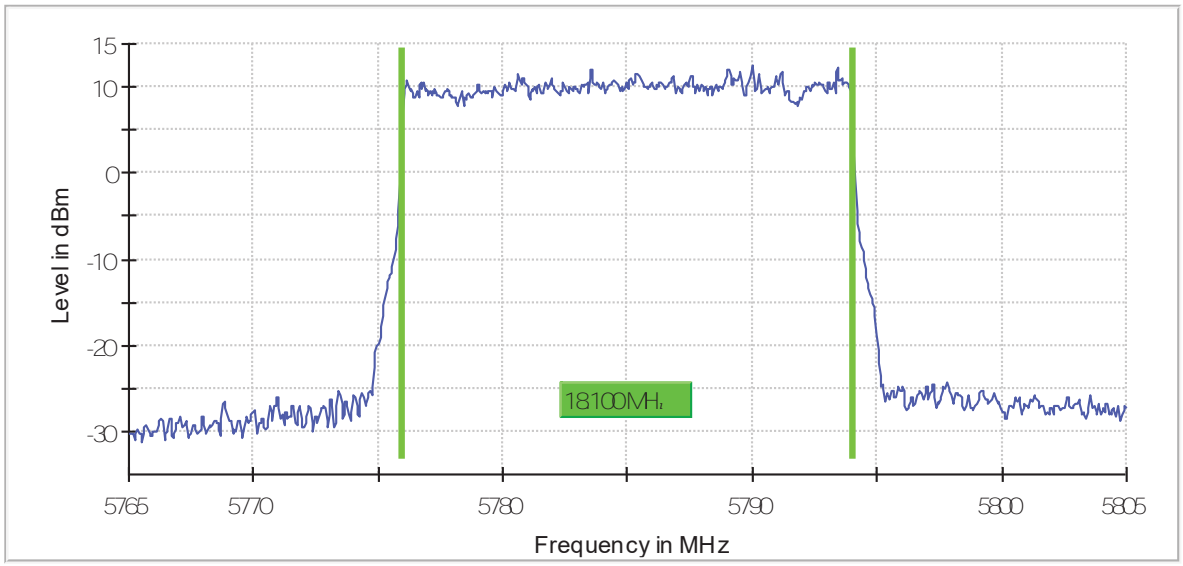


Mode: 64QAM – 20MHz

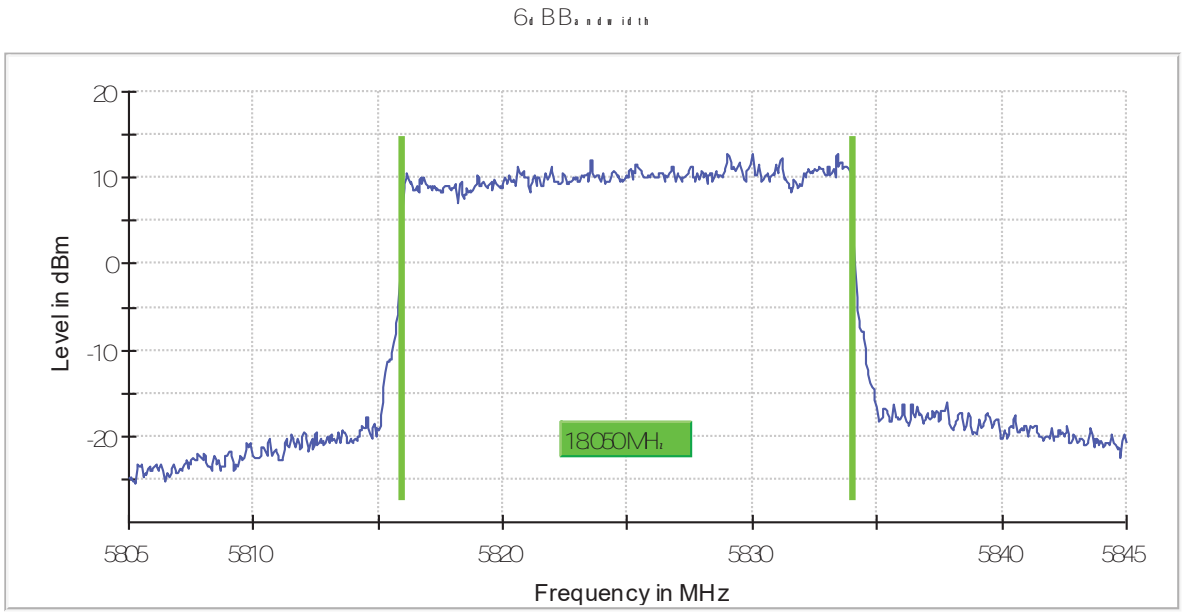
Channel 149



Channel 157



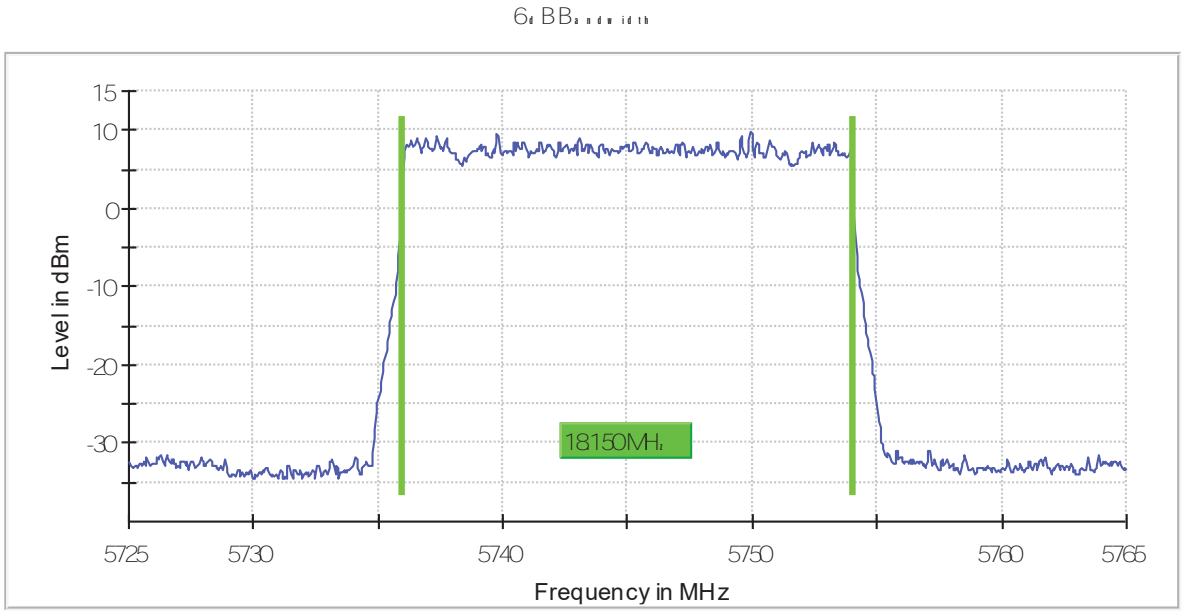
Channel 165



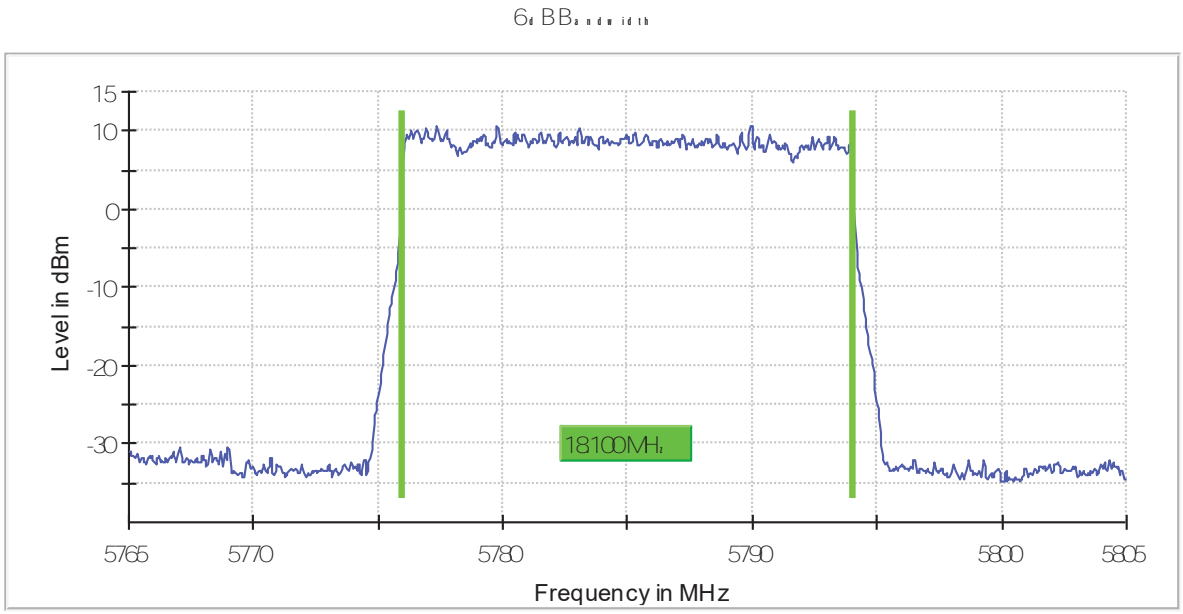
SISO Port 2:

Mode: QPSK – 20 MHz

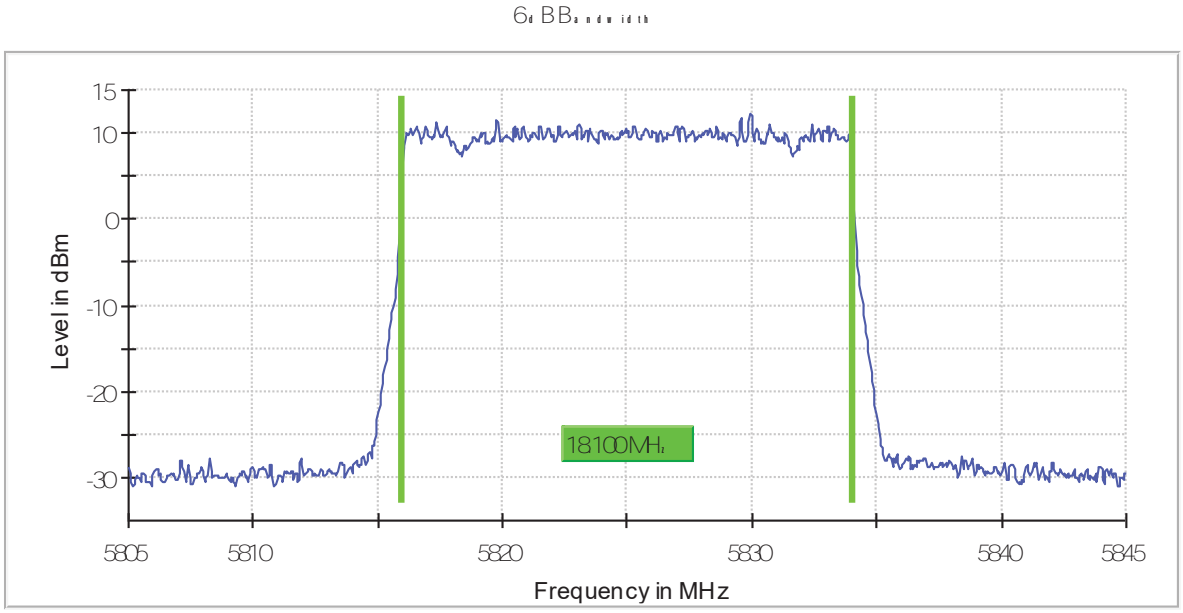
Channel 149



Channel 157

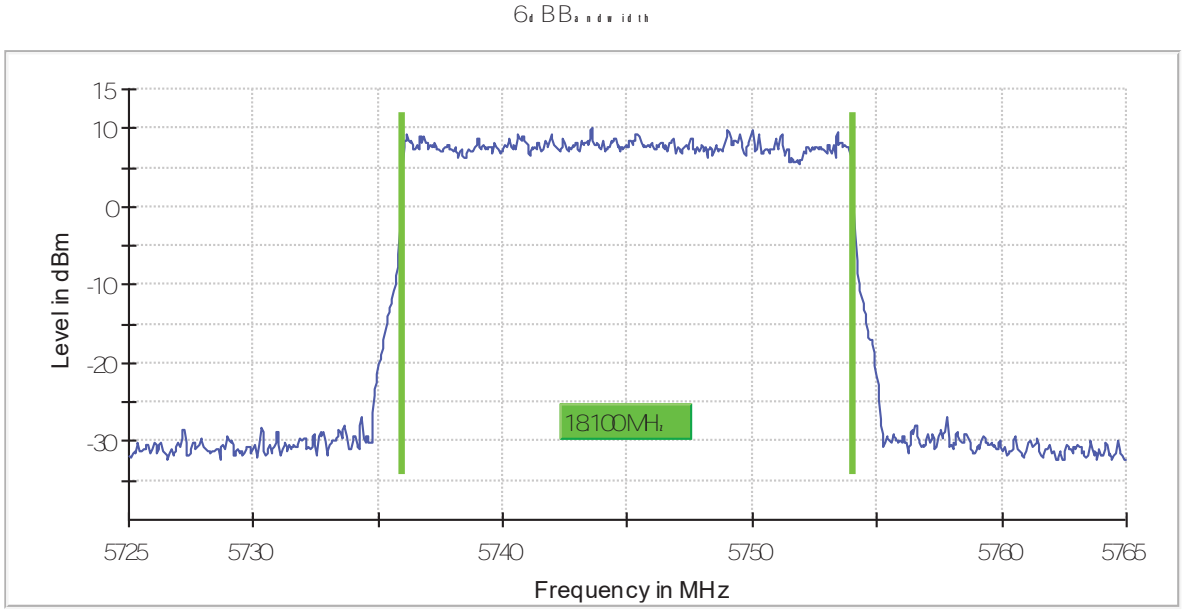


Channel 165

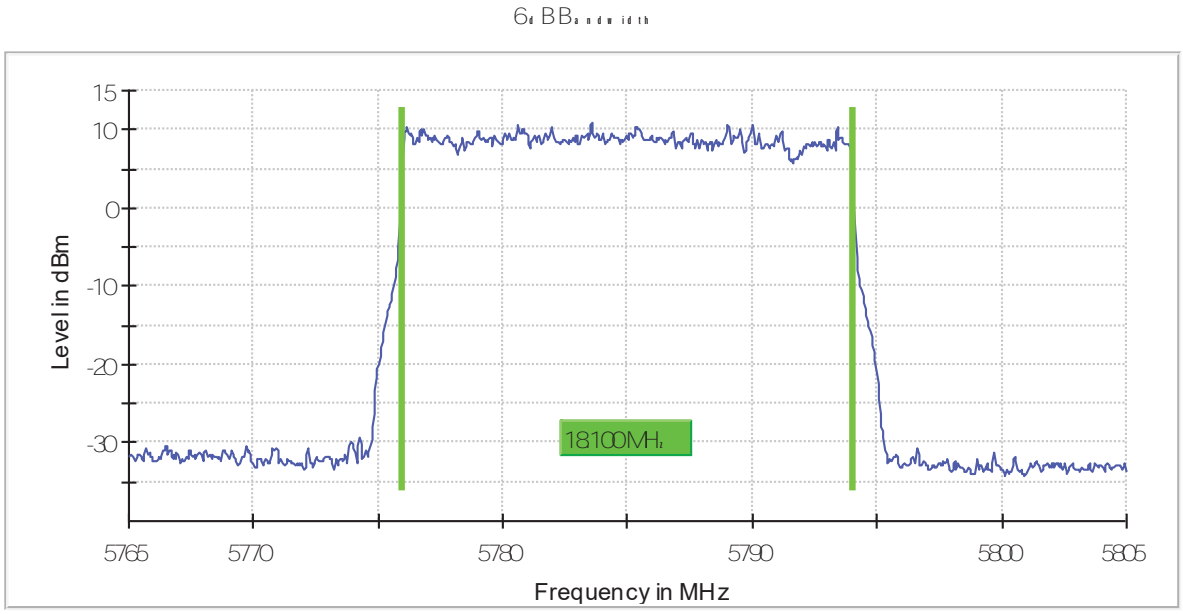


Mode: 16QAM – 20MHz

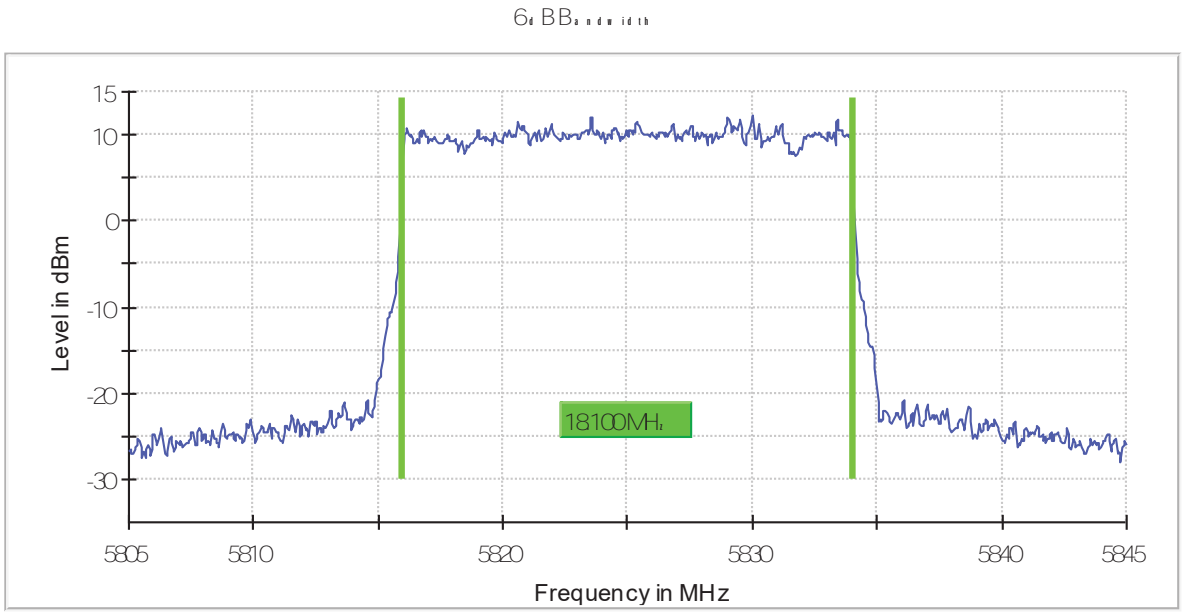
Channel 149



Channel 157

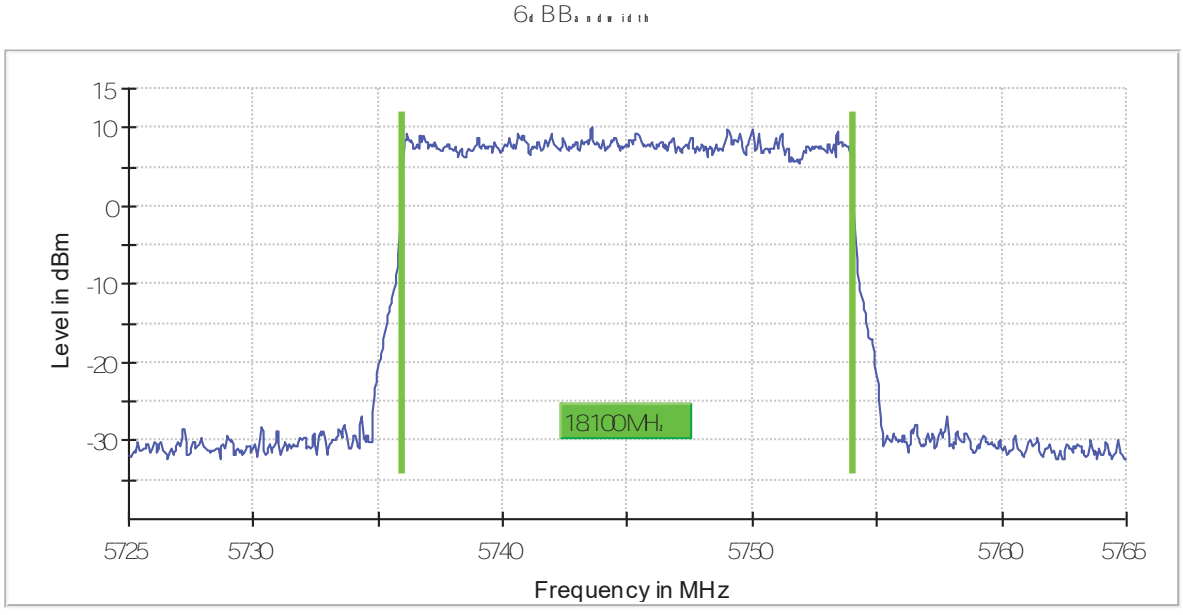


Channel 165

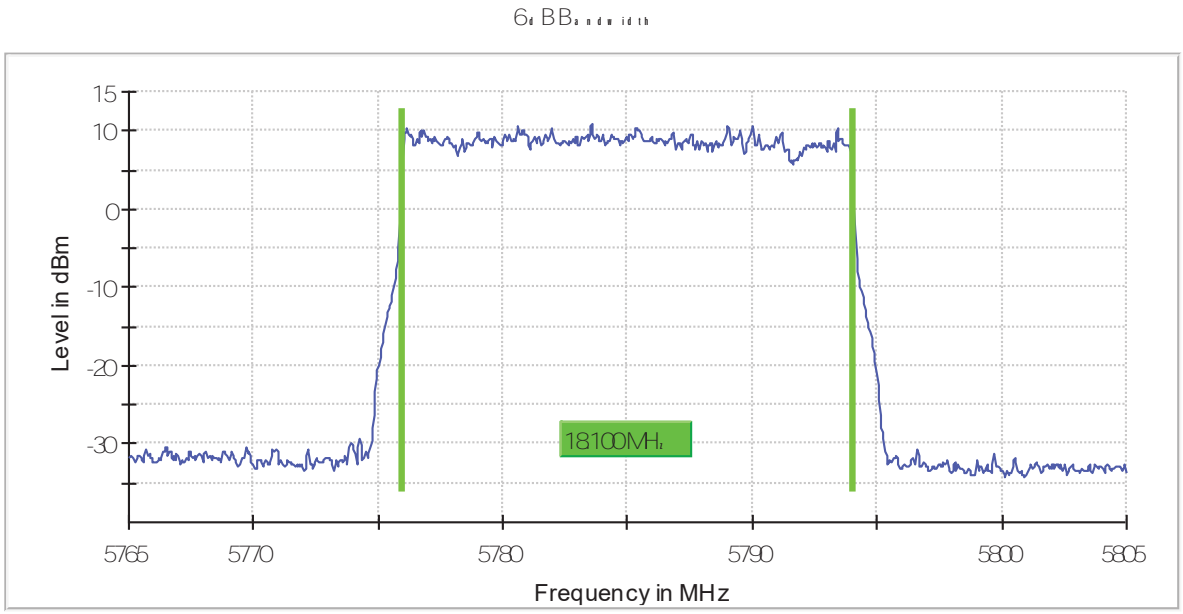


Mode: 64QAM – 20MHz

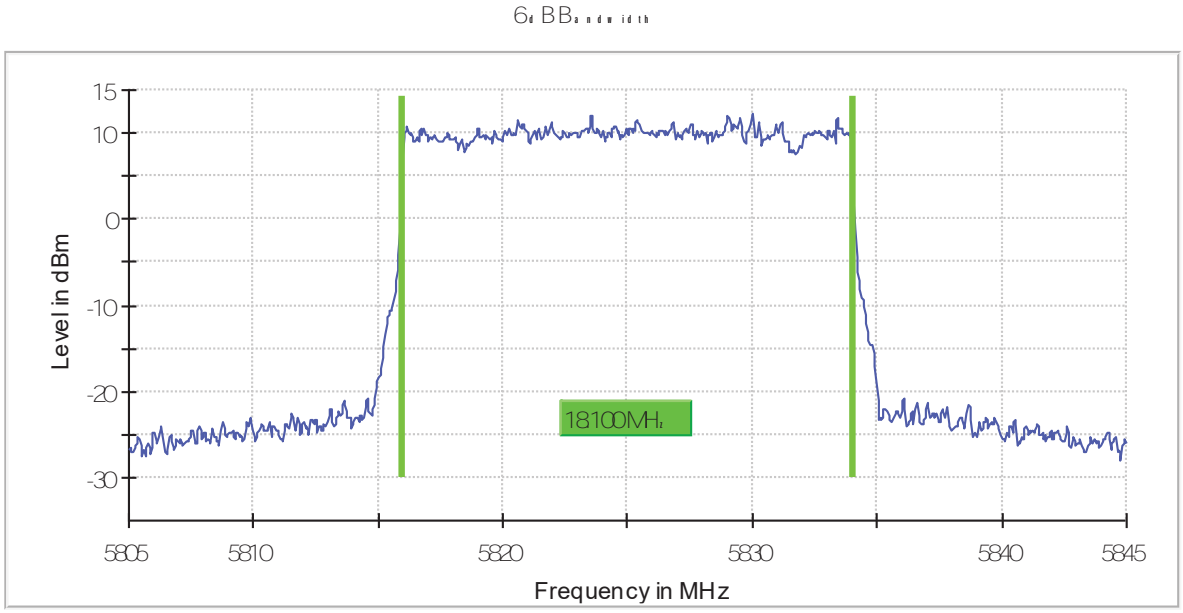
Channel 149



Channel 157



Channel 165



FCC Section 15.407 Subclause (a)(3). / RSS-247 Clause 6.2.4.1. Transmitter Maximum Conducted Output Power

SPECIFICATION

FCC 15.407/RSS-247: For the band 5.725-5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1W (30 dBm). If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

RESULTS:

The maximum conducted output power was measured using the channel power integration method according to point E) 2) b) (Method SA-1) of 789033 D02 General UNII Test Procedures New Rules v02r01 when the duty cycle is >98% and the channel power integration method according to point E) 2) d) (Method SA-2) of 789033 D02 General UNII Test Procedures New Rules v02r01 when the duty cycle is <98%.

The e.i.r.p. levels are calculated by adding the corresponding antenna gain (dBi).

FCC and Canada power setting

SISO Port 1:

Mode: QPSK – 20 MHz

Declared antenna gain: 3 dBi

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
Max. conducted power (dBm)	23.09	22.89	23.25
Conducted Power Limit (dBm)	30		
Margin (dB)	6.91	7.11	6.75
Maximum EIRP power (dBm)	26.09	25.89	26.25
EIRP power Limit (dBm)	36		
Margin (dB)	9.91	10.11	9.75
Measurement uncertainty (dB)	<±1.20		

Mode: 16QAM – 20MHz

Declared antenna gain: 3 dBi

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
Max. conducted power (dBm)	23.01	22.80	23.35
Conducted Power Limit (dBm)	30		
Margin (dB)	6.99	7.20	6.65
Maximum EIRP power (dBm)	26.01	25.80	26.25
EIRP power Limit (dBm)	36		
Margin (dB)	9.99	10.20	9.65
Measurement uncertainty (dB)	<±1.20		

Mode: 64QAM – 20 MHz

Declared antenna gain: 3 dBi

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
Max. conducted power (dBm)	23.88	23.56	23.95
Conducted Power Limit (dBm)	30		
Margin (dB)	6.12	6.44	6.05
Maximum EIRP power (dBm)	26.88	26.56	26.95
EIRP power Limit (dBm)	36		
Margin (dB)	9.12	9.44	9.05
Measurement uncertainty (dB)	<±1.20		

SISO Port 2:

Mode: QPSK – 20 MHz

Declared antenna gain: 3 dBi

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
Max. conducted power (dBm)	21.73	22.26	23.36
Conducted Power Limit (dBm)	30		
Margin (dB)	8.27	7.44	6.64
Maximum EIRP power (dBm)	24.73	25.26	26.36
EIRP power Limit (dBm)	36		
Margin (dB)	11.27	10.44	9.64
Measurement uncertainty (dB)	<±1.20		

Mode: 16QAM – 20MHz

Declared antenna gain: 3 dBi

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
Max. conducted power (dBm)	22.05	22.12	23.50
Conducted Power Limit (dBm)	30		
Margin (dB)	7.95	7.88	6.50
Maximum EIRP power (dBm)	25.05	25.12	26.50
EIRP power Limit (dBm)	36		
Margin (dB)	10.95	10.88	9.50
Measurement uncertainty (dB)	<±1.20		

Mode: 64QAM – 20 MHz

Declared antenna gain: 3 dBi

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
Max. conducted power (dBm)	22.05	22.12	23.50
Conducted Power Limit (dBm)	30		
Margin (dB)	7.95	7.88	6.50
Maximum EIRP power (dBm)	25.05	25.12	26.50
EIRP power Limit (dBm)	36		
Margin (dB)	10.95	10.88	9.50
Measurement uncertainty (dB)	<±1.20		

Verdict: PASS

FCC Section 15.407 Subclause (a) (3) / RSS-247 Clause 6.2.4.1. Transmitter Maximum Power Spectral Density

FCC 15.407/RSS-247: The maximum power spectral density shall not exceed 30 dBm in any 500-kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

RESULTS

The maximum power spectral density (PSD) was measured using the method according to point F) referencing E.2.b) (Method SA-1) of Guidance 789033 D02 General UNII Test Procedures New Rules v02r01.

In accordance with ANSI C63.10 Section 4.1.4.1, use of bandwidths greater than those specified can produce higher readings. Compliance against the applicable limits is showns using a 1 MHz resolution bandwidth. This was deemed worst case.

FCC and Canada power setting

SISO Port 1:

Mode: QPSK – 20MHz

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
PSD (dBm/MHz)	6.59	7.18	8.09
PSD Limit (dBm/500KHz)	30		
Margin (dB)	23.41	22.82	21.91
Measurement uncertainty (dB)	<±1.20		

Mode: 16QAM – 20MHz

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
PSD (dBm/MHz)	6.44	7.06	8.14
PSD Limit (dBm/500KHz)	30		
Margin (dB)	23.56	22.94	21.86
Measurement uncertainty (dB)	<±1.20		

Mode: 64QAM – 20MHz

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
PSD (dBm/MHz)	7.29	8.00	8.94
PSD Limit (dBm/500KHz)	30		
Margin (dB)	22.71	22.00	21.06
Measurement uncertainty (dB)	<±1.20		

SISO Port 2:

Mode: QPSK – 20MHz

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
PSD (dBm/MHz)	5.58	6.89	7.71
PSD Limit (dBm/500KHz)	30		
Margin (dB)	24.42	23.11	22.29
Measurement uncertainty (dB)	<±1.20		

Mode: 16QAM – 20MHz

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
PSD (dBm/MHz)	5.82	6.95	7.89
PSD Limit (dBm/500KHz)	30		
Margin (dB)	24.18	23.05	22.11
Measurement uncertainty (dB)	<±1.20		

Mode: 64QAM – 20MHz

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
PSD (dBm/MHz)	5.82	6.95	7.89
PSD Limit (dBm/500KHz)	30		
Margin (dB)	24.18	23.05	22.11
Measurement uncertainty (dB)	<±1.20		

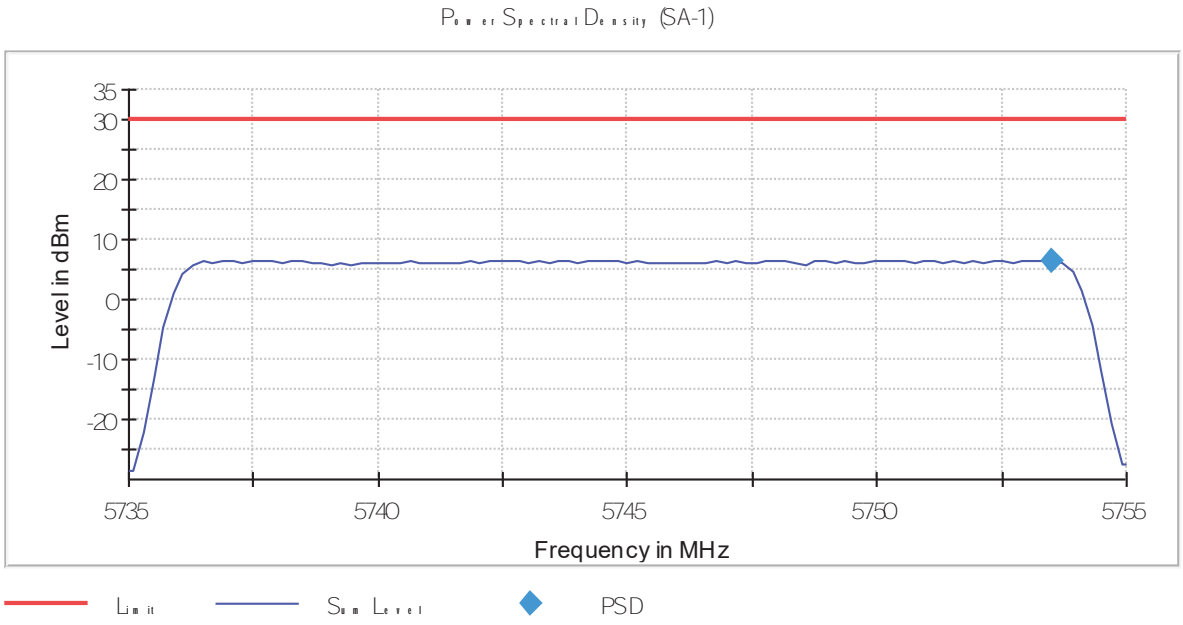
Verdict: PASS

FCC & Canada power setting

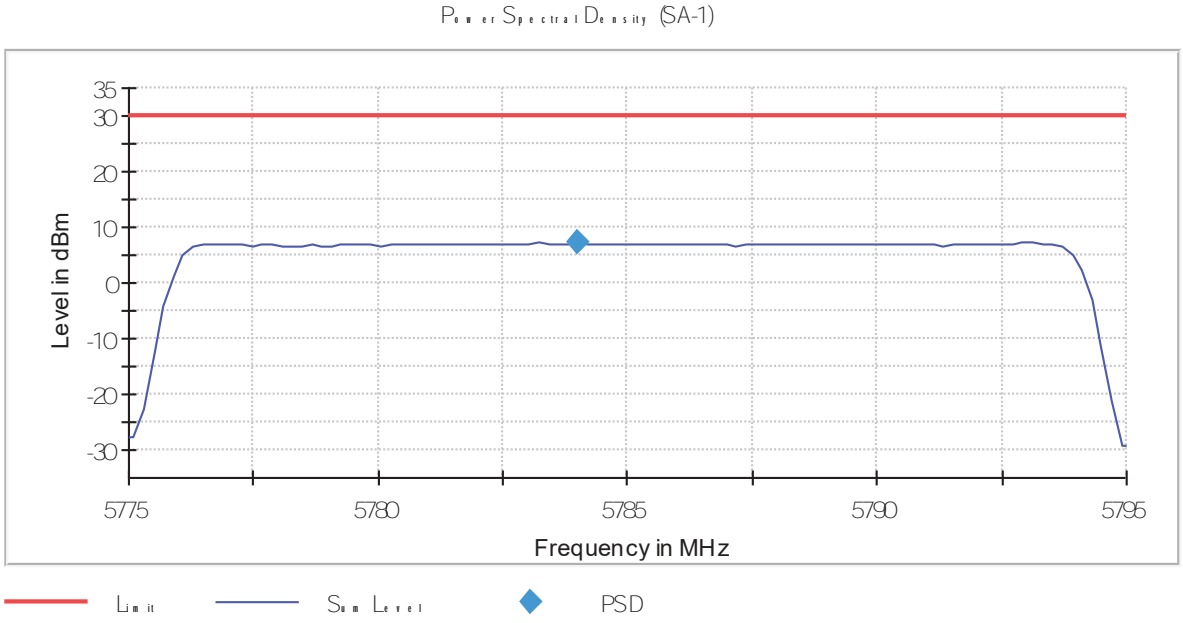
SISO Port 1:

Mode: QPSK – 20MHz

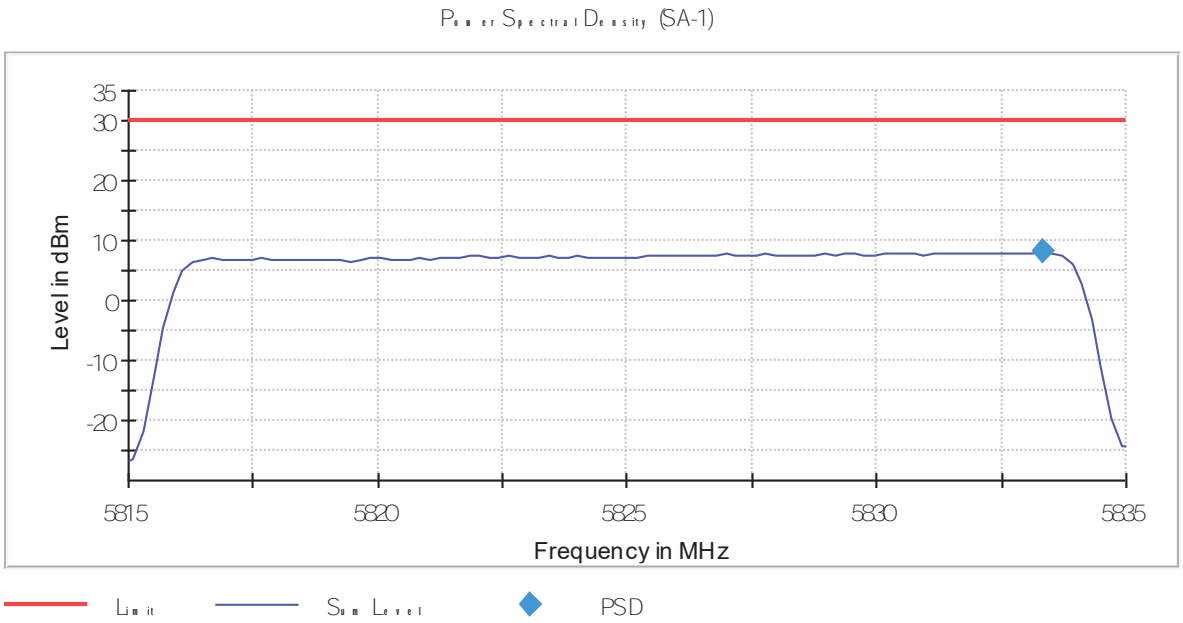
Channel 149



Channel 157

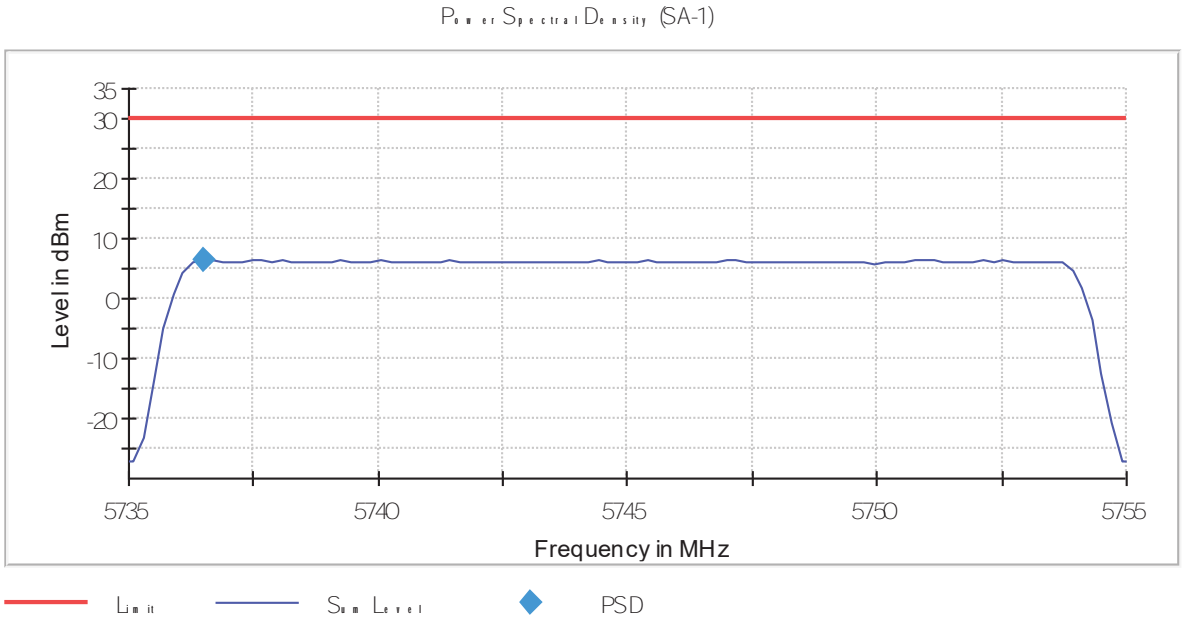


Channel 165

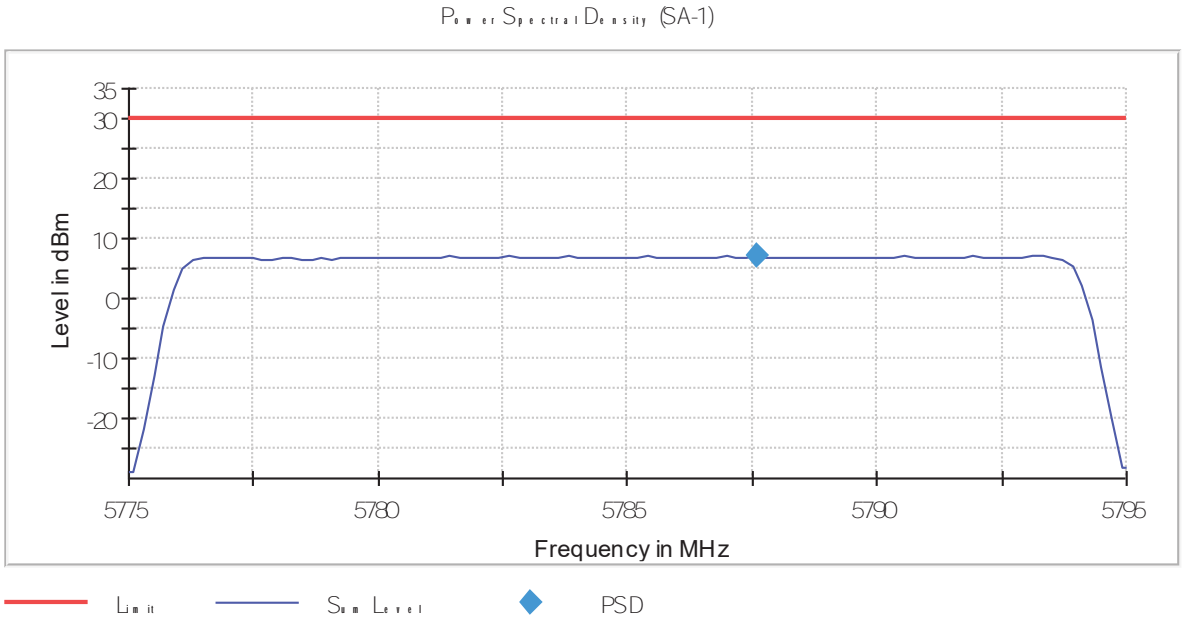


Mode: 16QAM – 20MHz

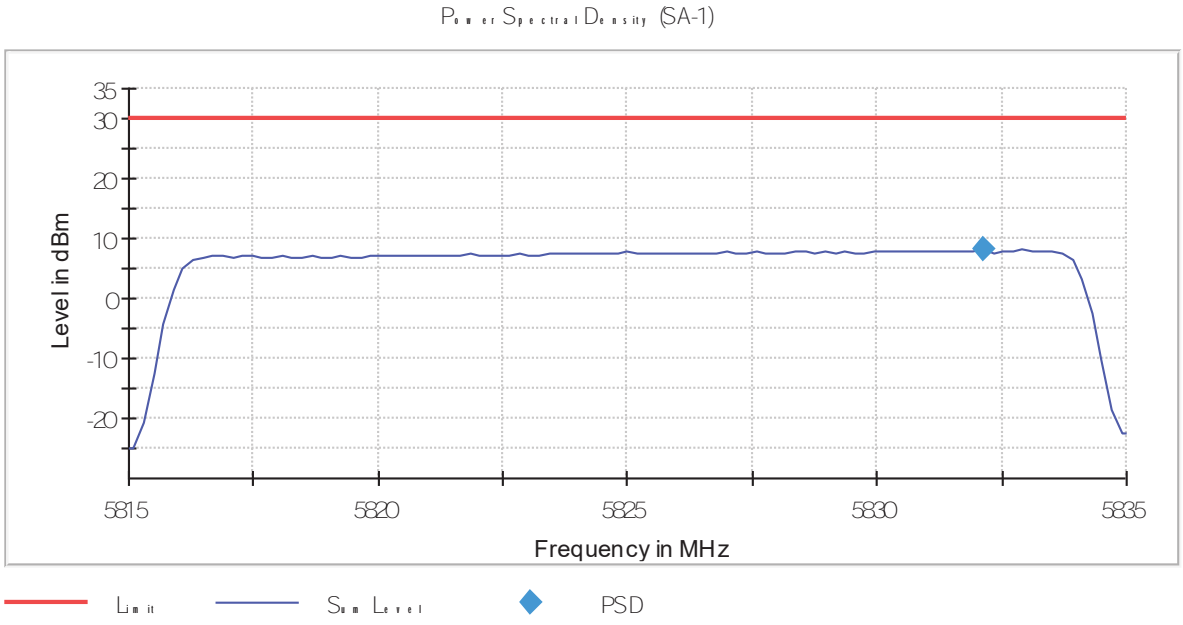
Channel 149



Channel 157

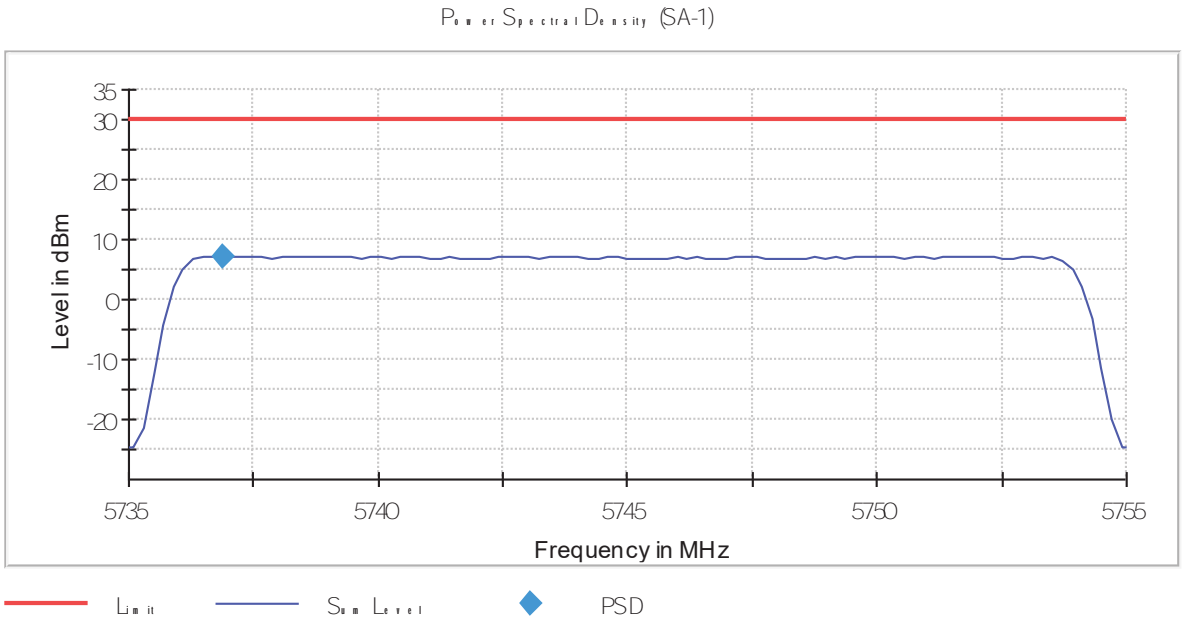


Channel 165

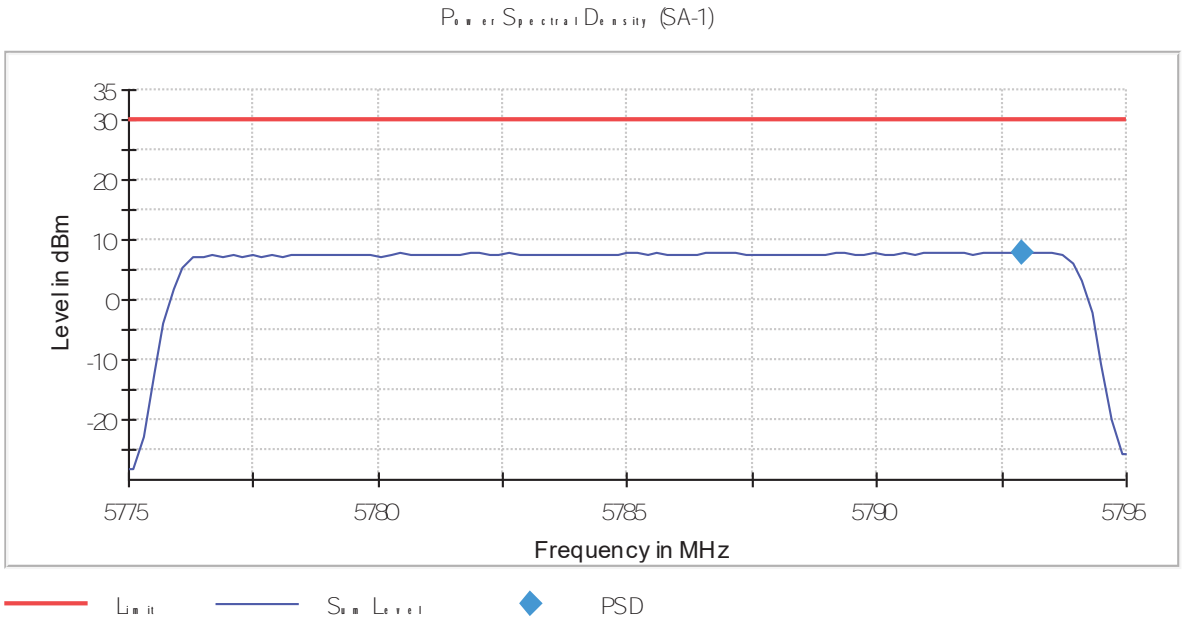


Mode: 64QAM – 20MHz

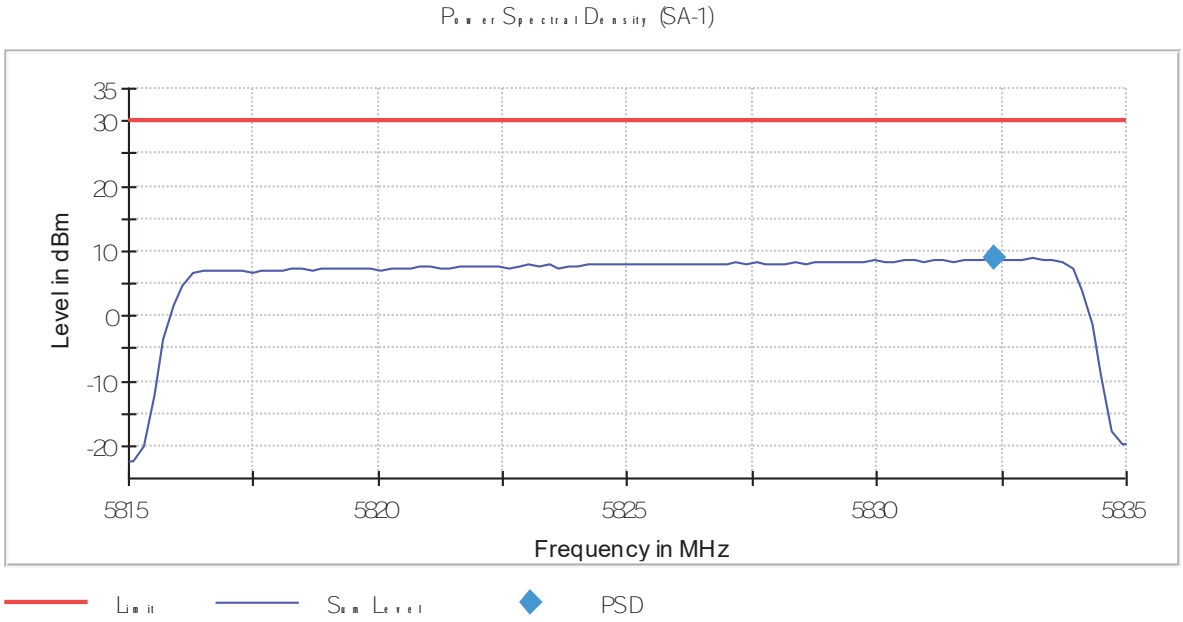
Channel 149



Channel 157



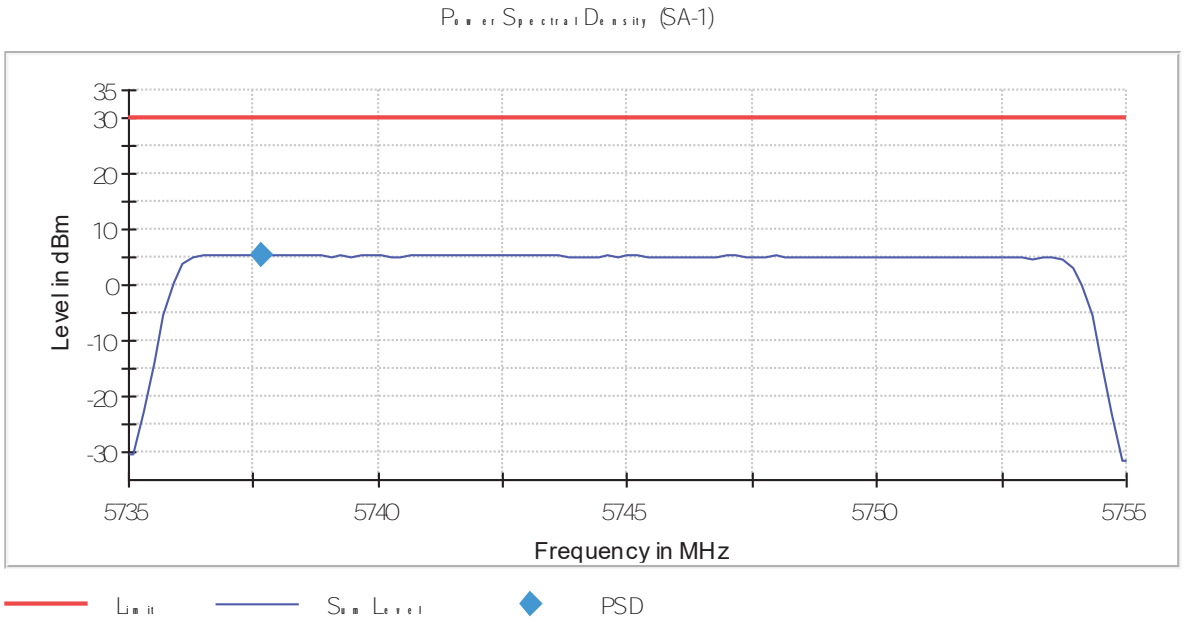
Channel 165



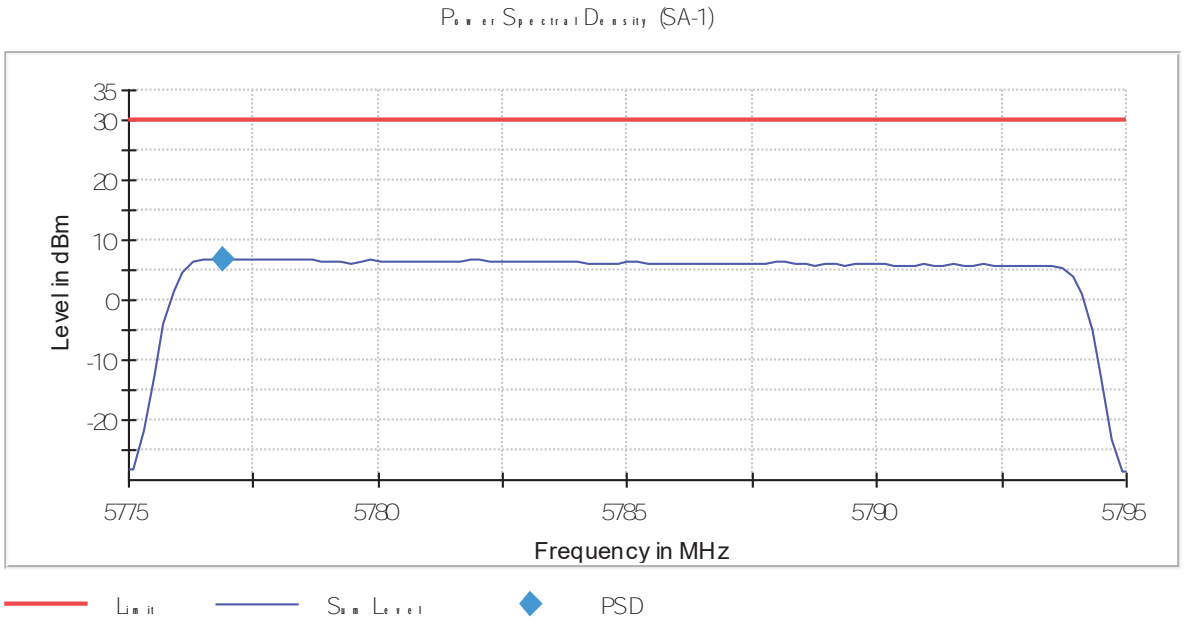
SISO Port 2:

Mode: QPSK – 20MHz

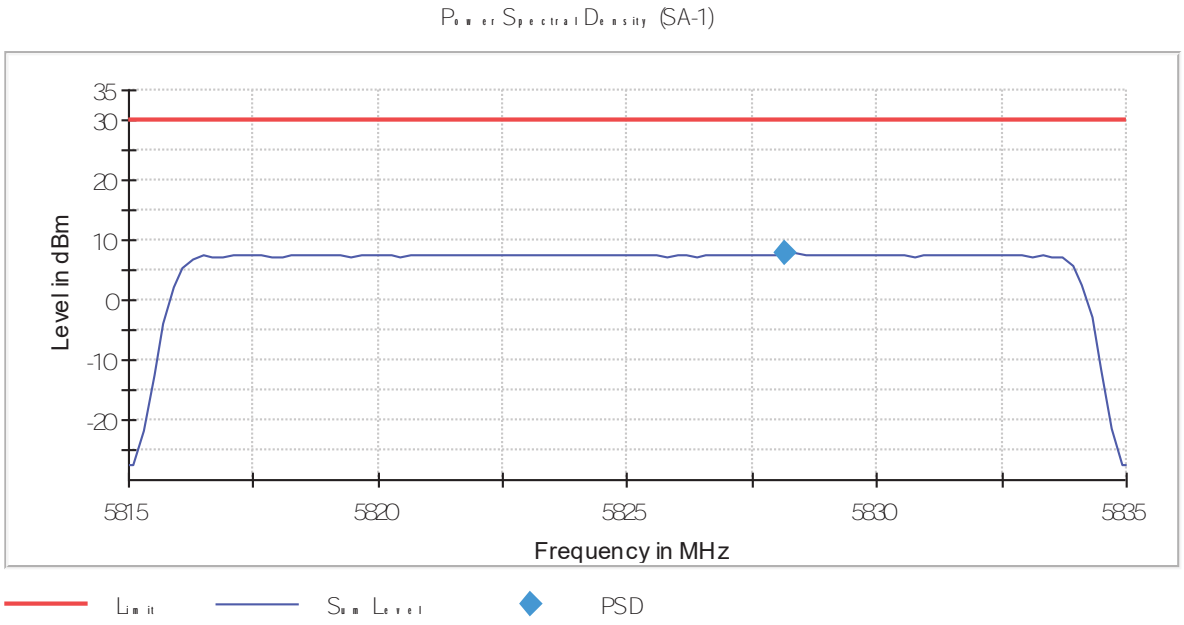
Channel 149



Channel 157

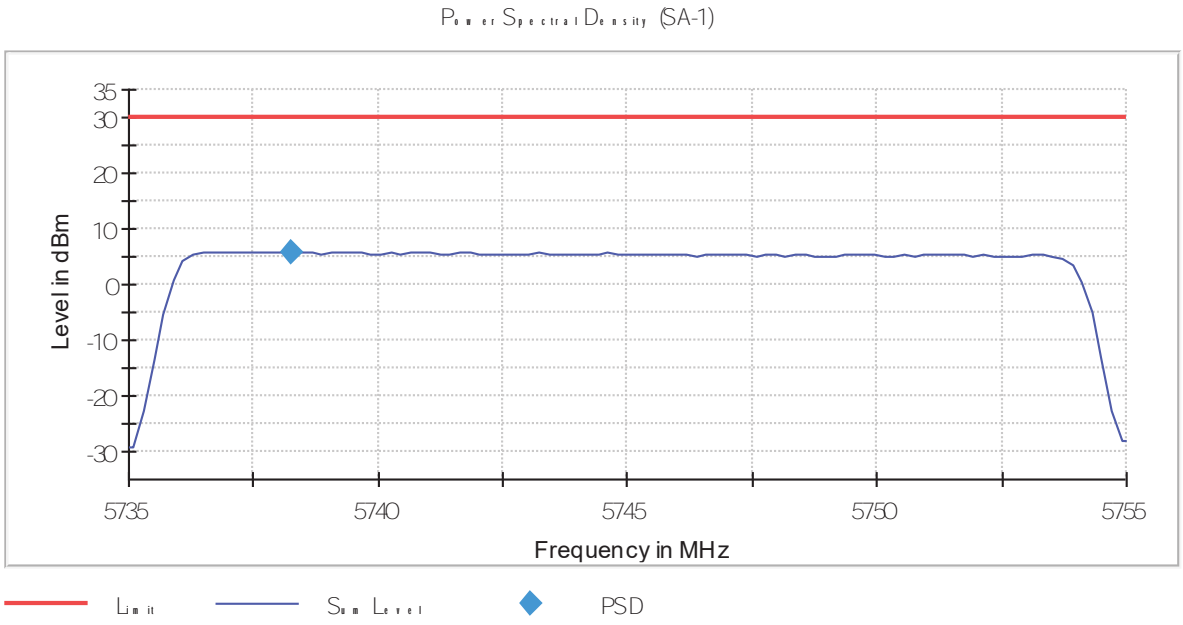


Channel 165

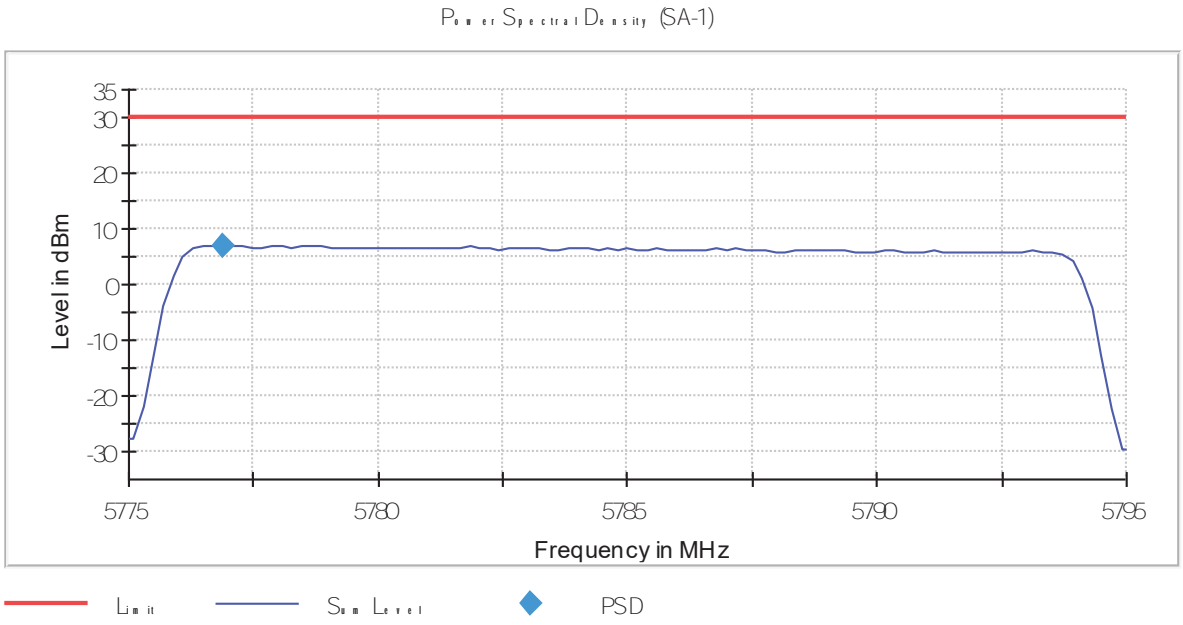


Mode: 16QAM – 20MHz

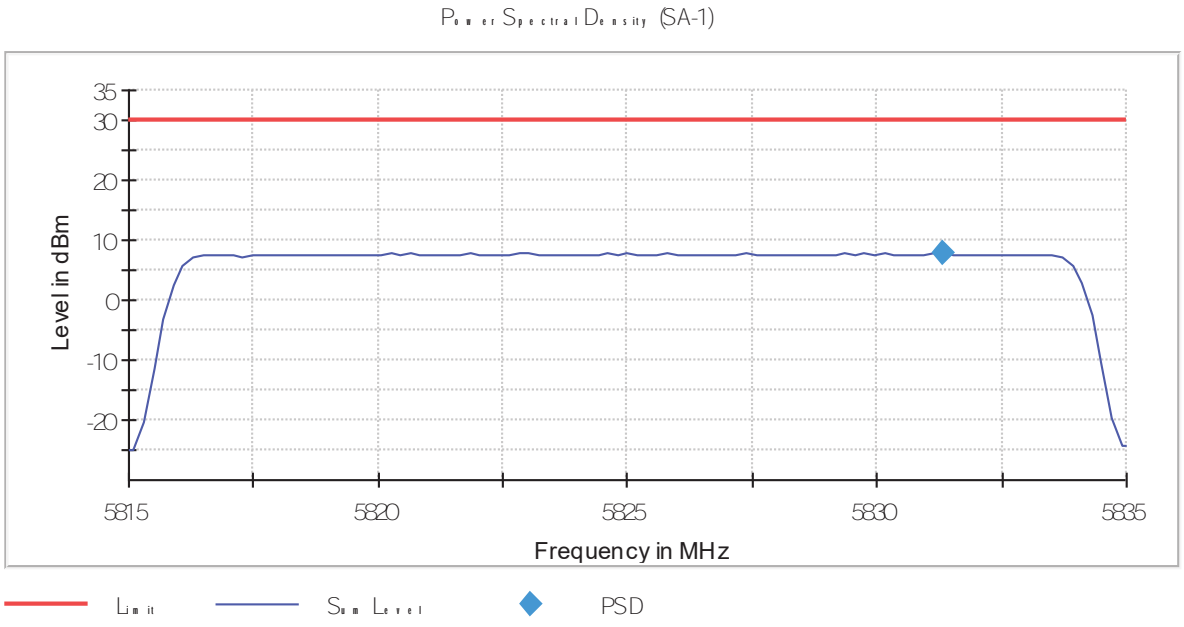
Channel 149



Channel 157

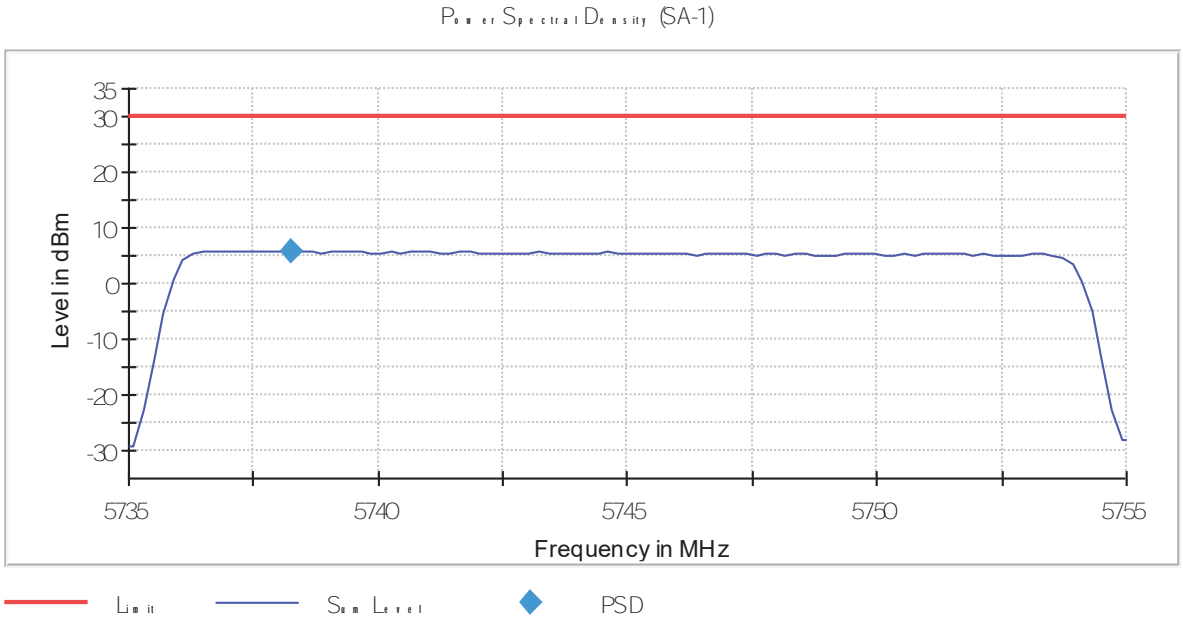


Channel 165

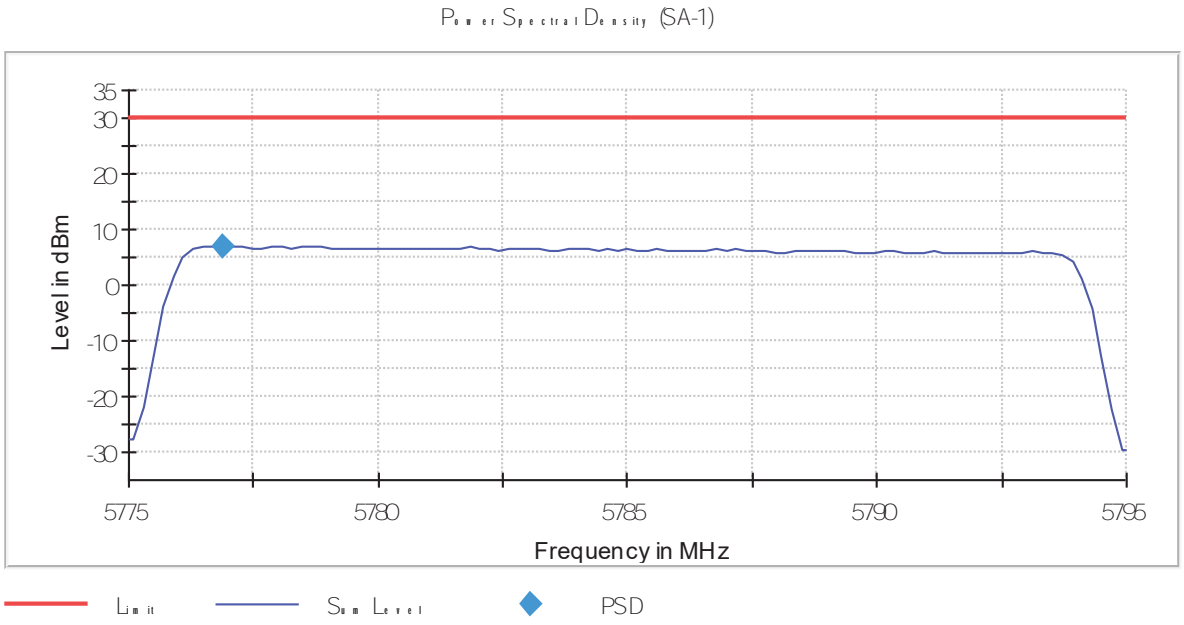


Mode: 64QAM – 20MHz

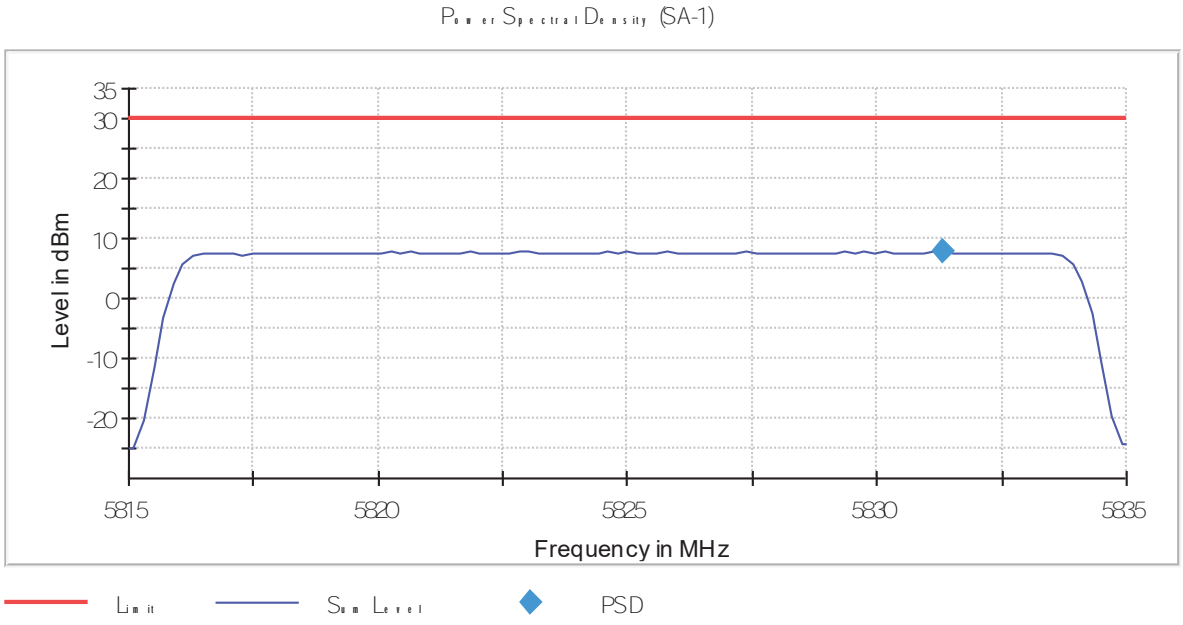
Channel 149



Channel 157



Channel 165



FCC Section 15.407(b)(4)(6) /RSS-247 6.2.4.2. Transmitter Out of Band Radiated Emissions

SPECIFICATION

For transmitters operating in the 5.725–5.85 GHz band:
All emissions shall be limited to a level of −27 dBm/MHz at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)):

Frequency Range (MHz)	Field strength (µV/m)	Field strength (dBµV/m)	Measurement distance (m)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	300
1.705 - 30.0	30	-	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
960 - 40000	500	54	3

The emission limits shown in the above table are based on measurements employing CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

For average radiated emission measurements above 1000 MHz, there is also a limit corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

RESULTS:

The situation and orientation was varied to find the maximum radiated emission. It was also rotated 360º and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission.

Measurements were made in both horizontal and vertical planes of polarization.

All tests were performed in a semi-anechoic chamber at a distance of 3 m for the frequency range 30 MHz-25 GHz.

The field strength is calculated by adding correction factor to the measured level from the spectrum analyzer. This correction factor includes antenna factor, cable loss and pre-amplifiers gain.

A preliminary scan determined the antenna port 2 and the 64QAM modulation as the worst case. The following tables and plots show the results for the worst case modulation.

SISO Antenna Port 2:

Frequency range 30 MHz-1000 MHz.

Note: The spurious emissions below 1 GHz do not depend on either the operating channel or the modulation mode selected in the EUT.

Spurious levels operating (radiated) closest to limit.

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Measurement Uncertainty (dB)
47.1690	Vertical	Quasi-Peak	30.36	40	6.64	± 4.99
57.2085	Vertical	Quasi-Peak	26.89	40	13.11	± 4.99
70.6915	Vertical	Quasi-Peak	33.40	40	6.60	± 4.99
94.6020	Vertical	Quasi-Peak	29.24	43.5	14.26	± 4.99
875.0155	Horizontal	Quasi-Peak	45.09	46	0.91	± 4.99

Frequency range 1 GHz-40 GHz

The results in the next tables show the maximum measured levels in the 1-40 GHz frequency range.

Mode 64QAM:

Channel 149

- No radiated spurious signals were detected at less than 20 dB respect to the limit.

Channel 157

- Radiated spurious signals were detected at less than 20 dB respect to the limit.

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Measurement Uncertainty (dB)
1640.0000	Vertical	Peak	48.59	68.23	19.64	± 4.98
5998.4000	Vertical	Peak	48.41	68.23	19.82	± 4.98
6031.0000	Vertical	Peak	48.77	68.23	19.46	± 4.98

Channel 165

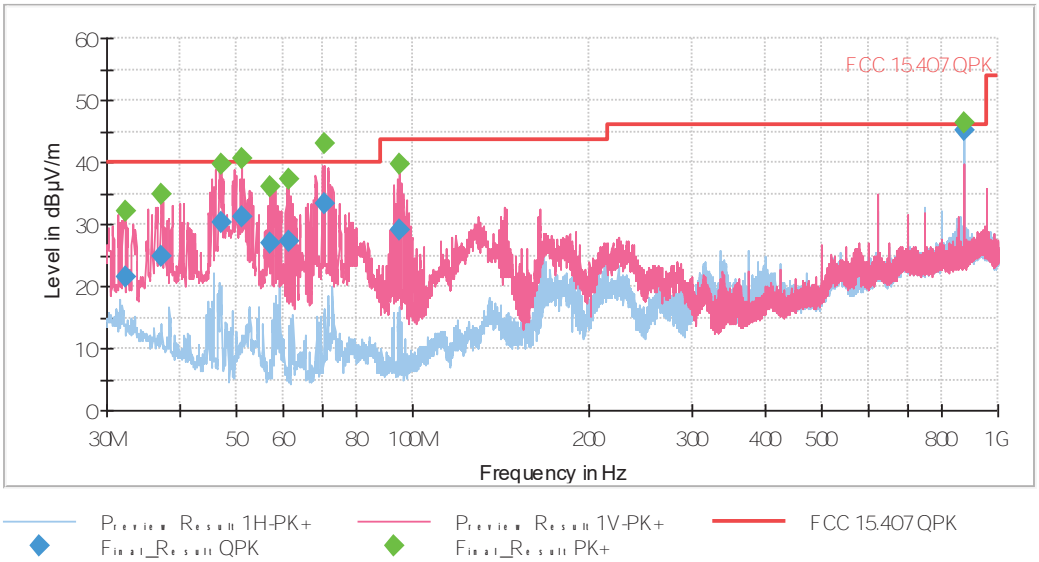
- Radiated spurious signals were detected at less than 20 dB respect to the limit.

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Measurement Uncertainty (dB)
1639.8000	Vertical	Peak	49.19	68.23	19.04	± 4.98
6000.6000	Vertical	Peak	50.27	68.23	17.96	± 4.98
11647.000	Vertical	Peak	55.16	68.23	13.07	± 4.98
		AVG	42.25	54	11.75	± 4.98

Measurement Uncertainty (dB): 1GHz to 17GHz <± 4.98
17GHz to 26.5GHz <± 5.08
26.5GHz to 40GHz <± 5.33

Verdict: PASS

FREQUENCY RANGE 30 MHz-1000 MHz.

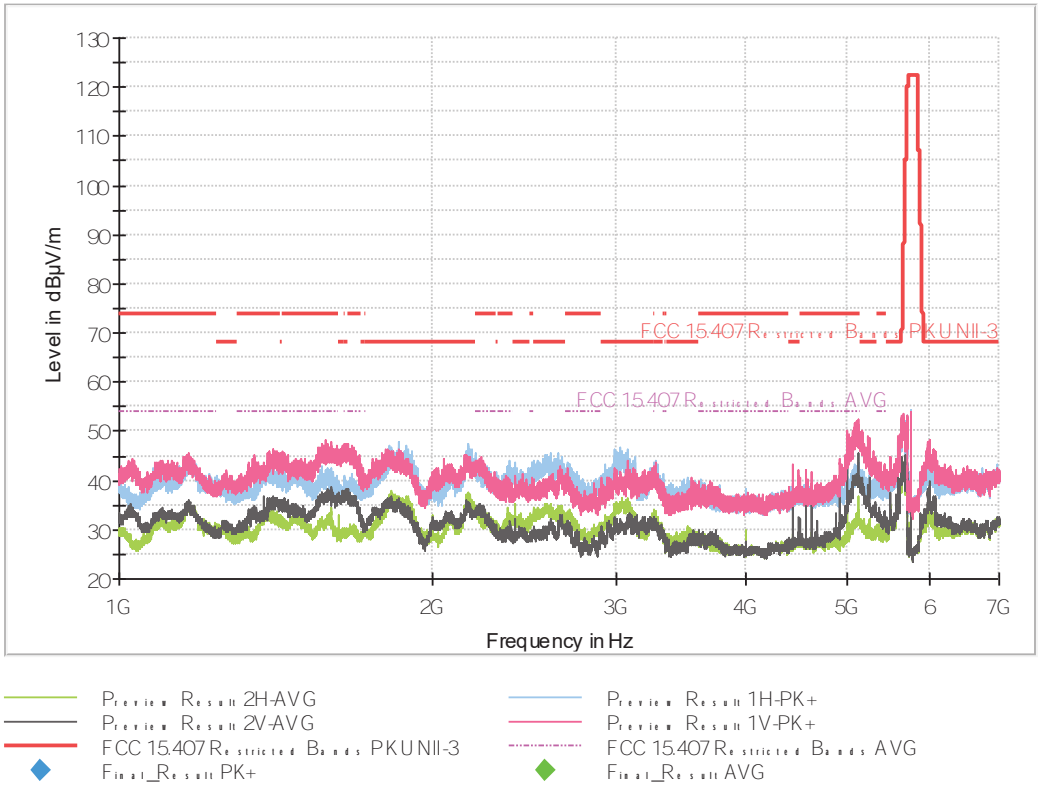


This plot is valid for all channels.

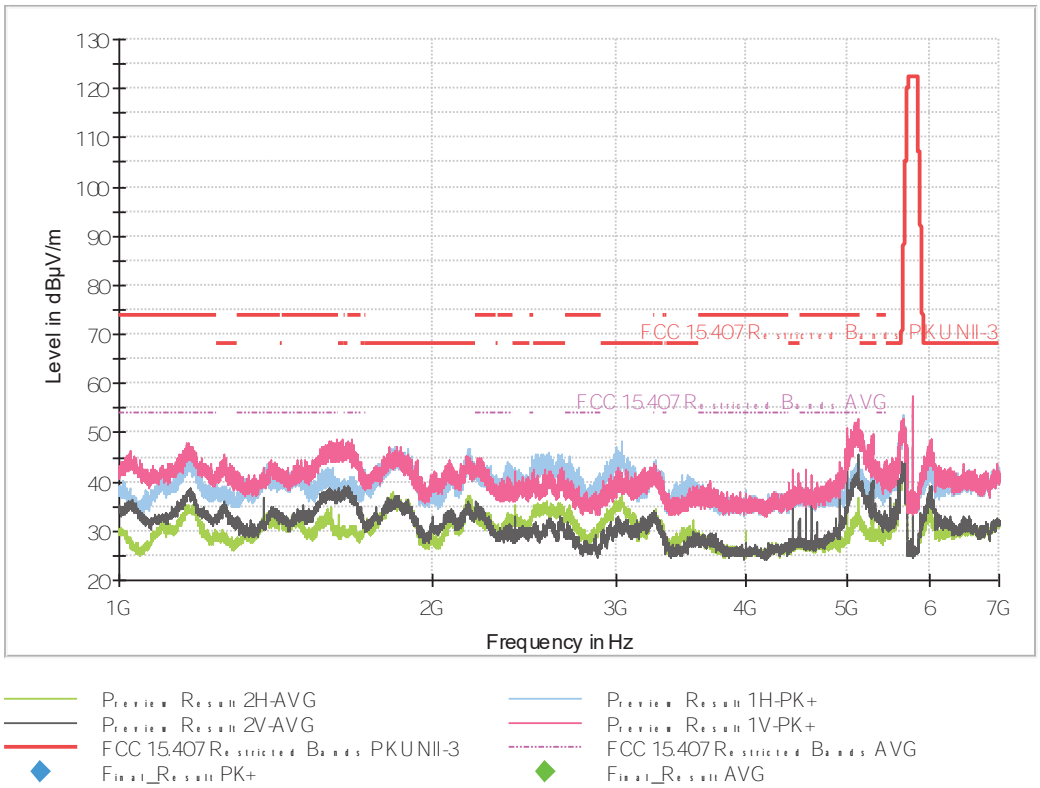
FREQUENCY RANGE 1 GHz to 7 GHz.

Mode 64QAM:

Channel 149:

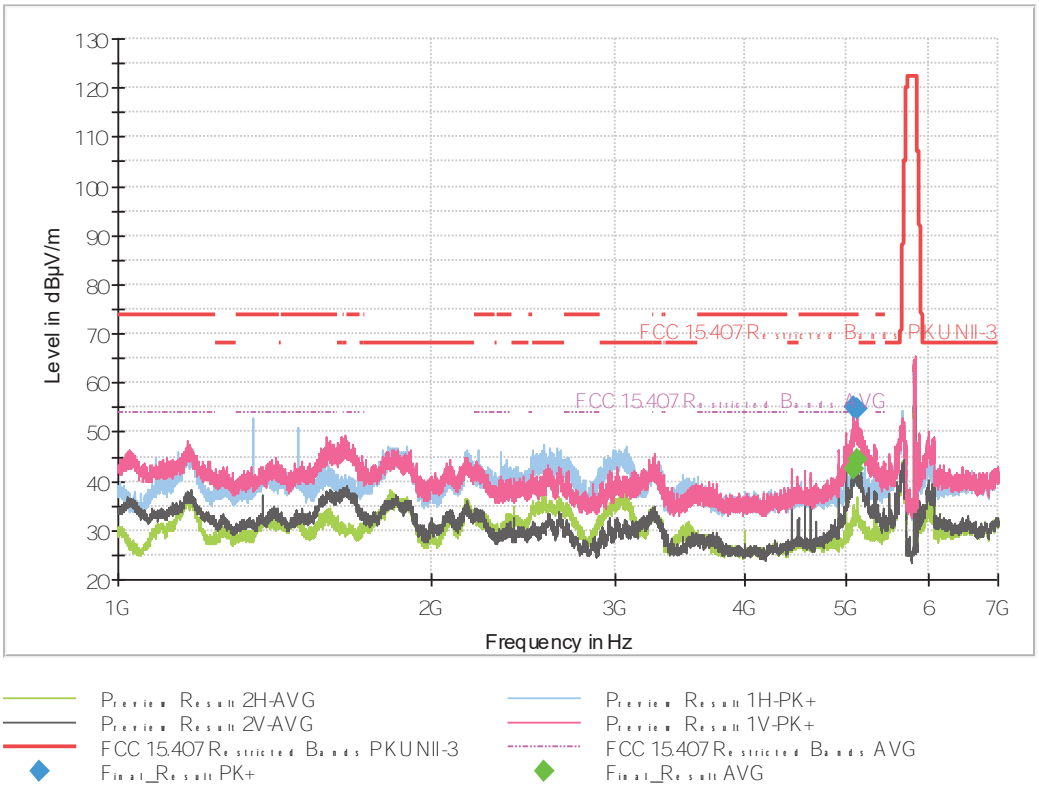


Channel 157:



Note: The peak shown in the plot above the limit is the carrier frequency.

Channel 165:

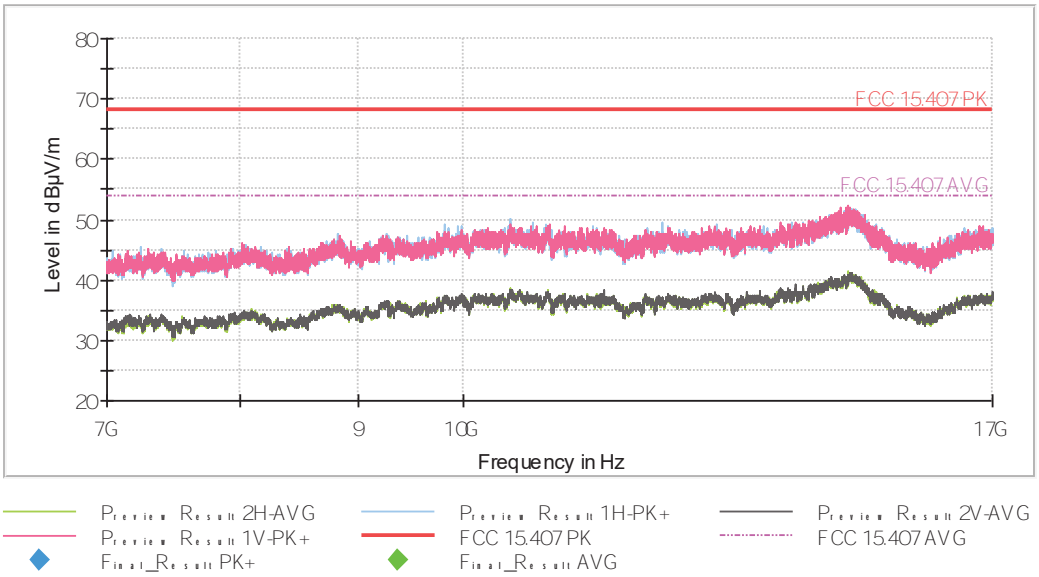


Note: The peak shown in the plot above the limit is the carrier frequency.

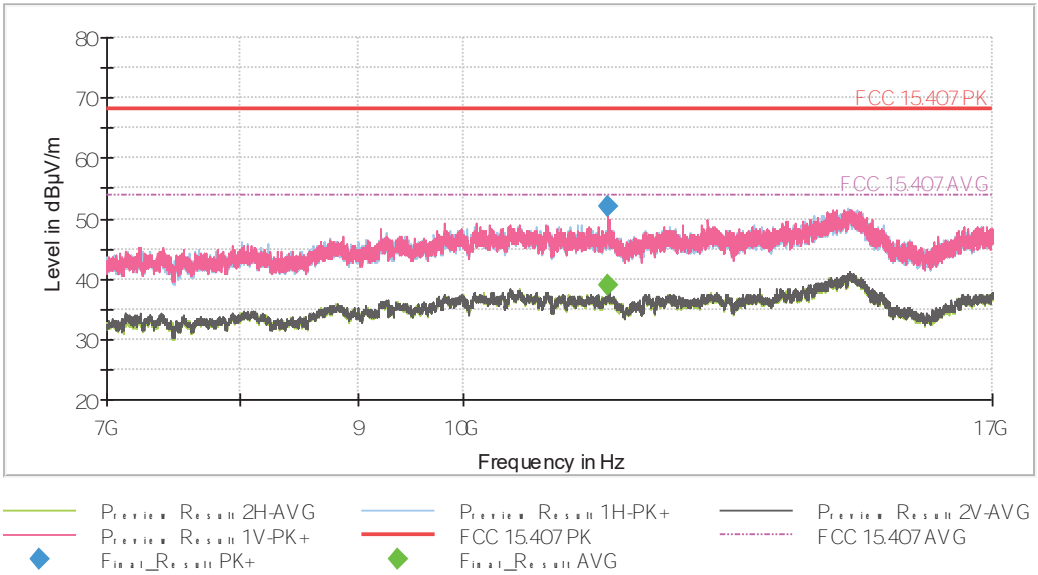
FREQUENCY RANGE 7 GHz to 17 GHz.

Mode 64QAM:

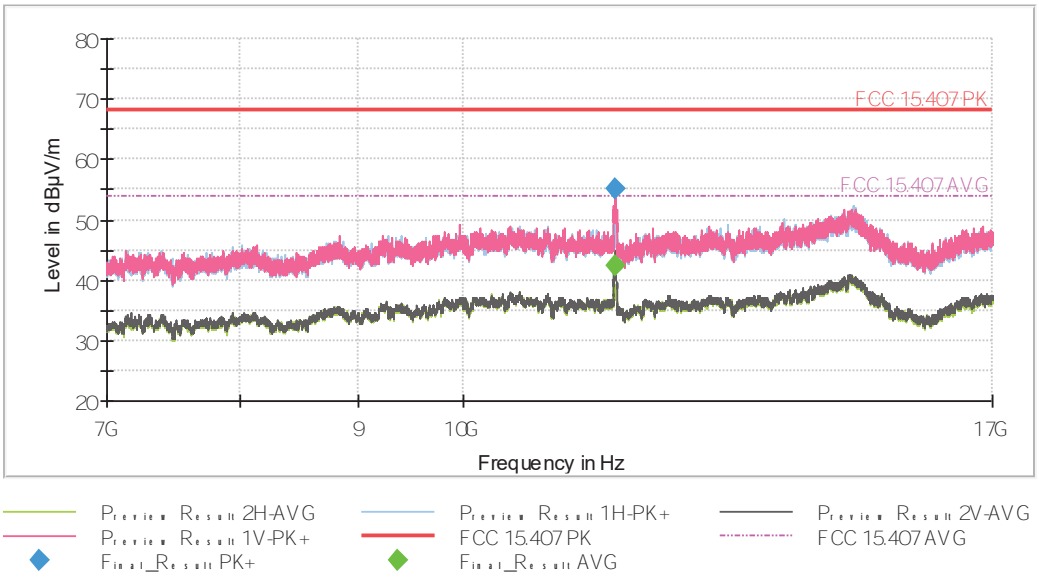
Channel 149:



Channel 157:

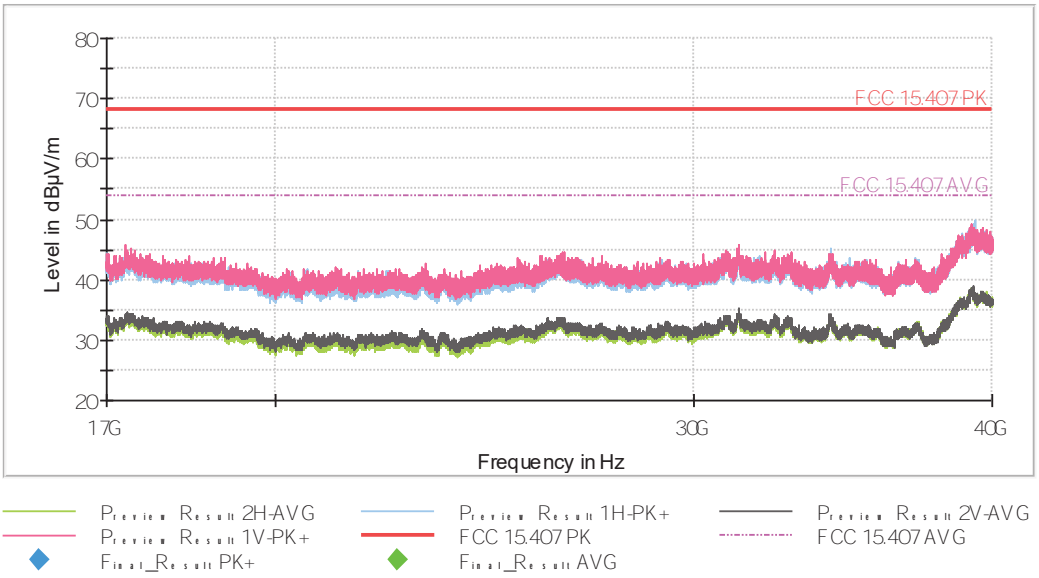


Channel 165:



FREQUENCY RANGE 17 GHz to 40 GHz.

Mode 64QAM:



This plot is valid for all channels.

FCC Section 15.407 Subclause (b) (4) / RSS-247 6.2.4.2. Transmitter Band Edge Radiated Emissions.

SPECIFICATION

For transmitters operating in the 5.725–5.85 GHz band:
All emissions shall be limited to a level of −27 dBm/MHz at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.

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1.705 - 30.0	30	-	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
960 - 40000	500	54	3

The emission limits shown in the above table are based on measurements employing CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

For average radiated emission measurements above 1000 MHz, there is also a limit corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

RESULTS:

The field strength is calculated by adding correction factor to the measured level from the spectrum analyzer. This correction factor includes antenna factor, cable loss and pre-amplifiers gain.

A preliminary scan determined the antenna port 2 as the worst case.

Test performed on the following worst cases modes in all relevant tests channels:

SISO Antenna Port 2:

Results for Mode: QPSK – 20 MHz

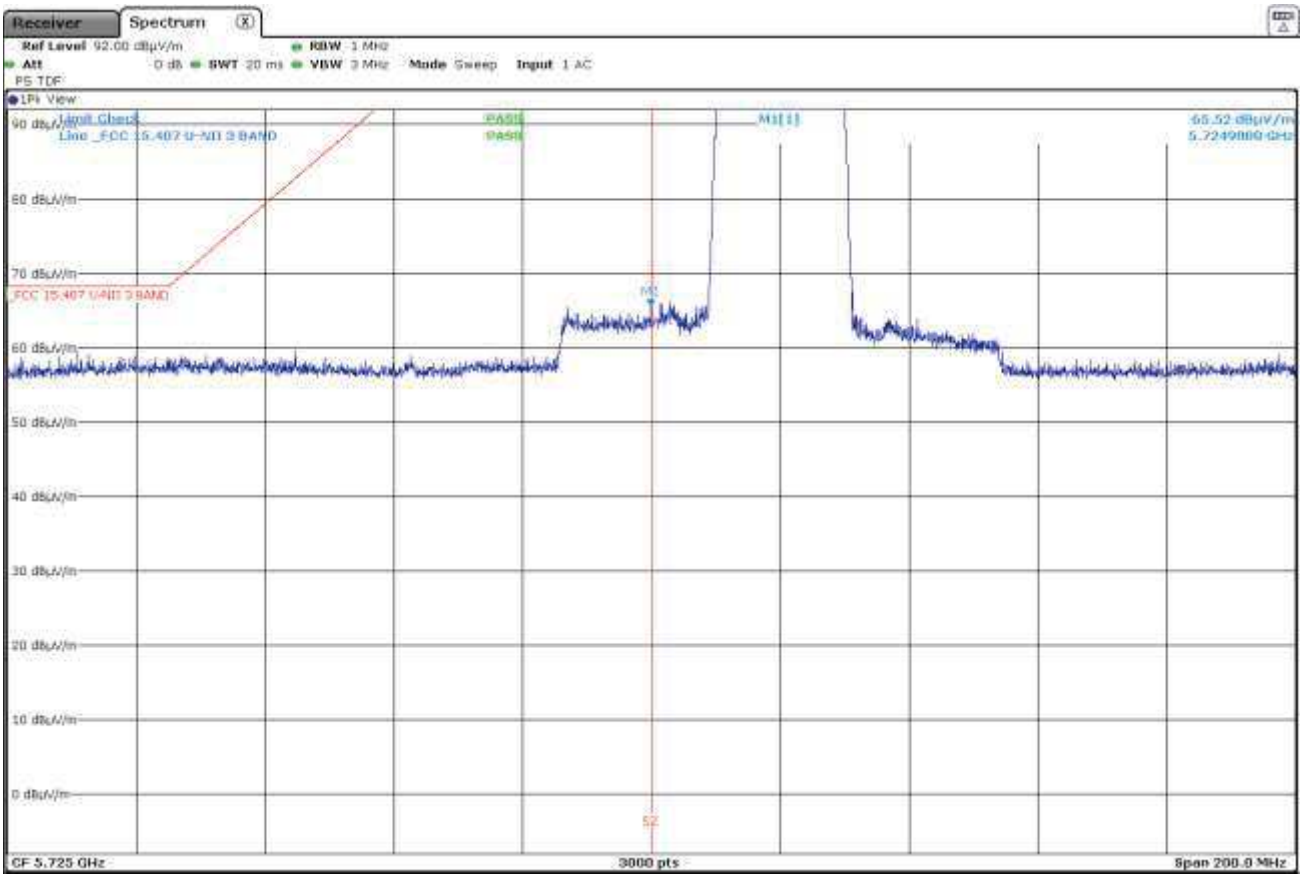
Results: Peak / Channel 149

Frequency (MHz)	Antenna Polarity	Peak Level (dBuV/m)	Measurement uncertainty (dB)	Verdict
5724.9000	Vertical	65.52	<± 3.98	PASS

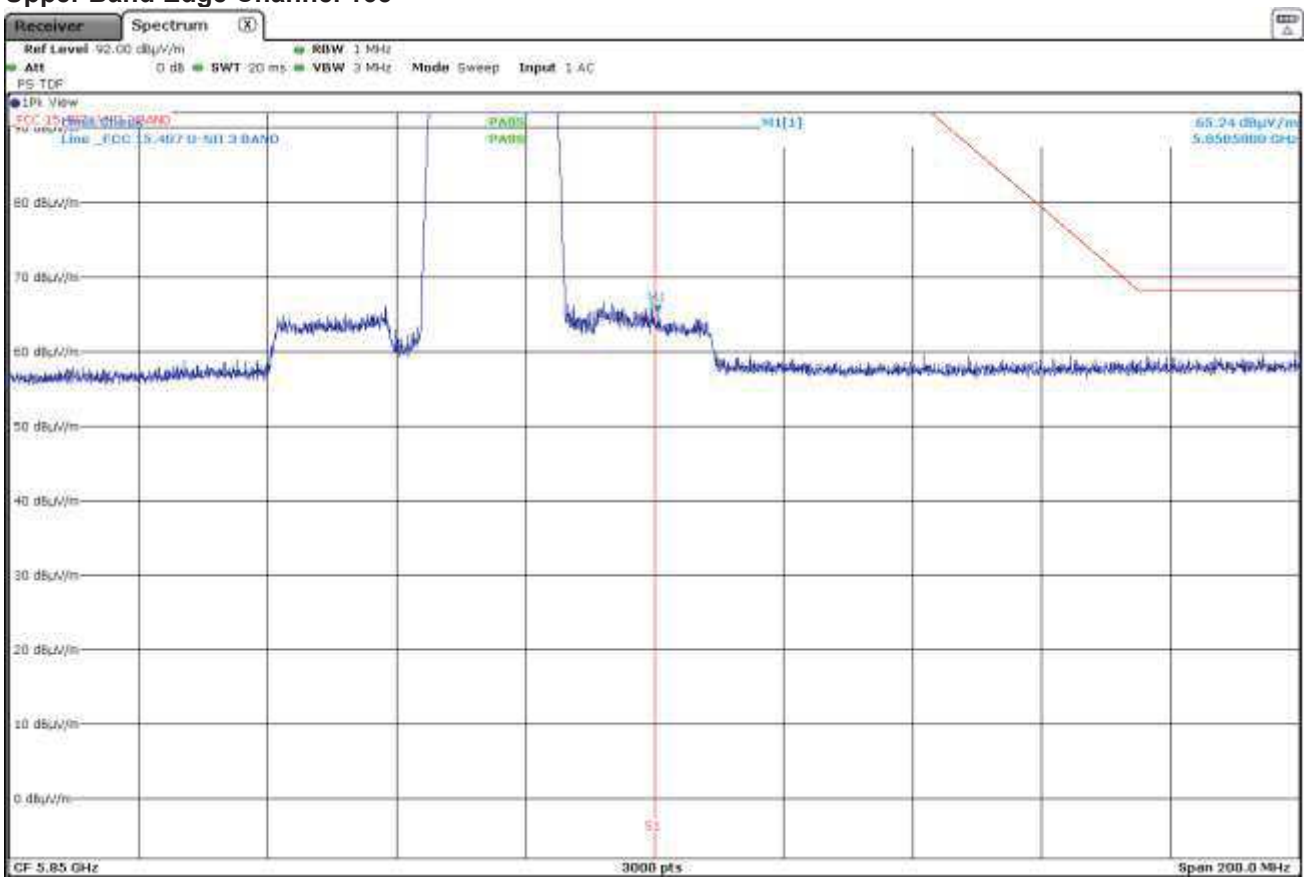
Results: Peak / Channel 165

Frequency (MHz)	Antenna Polarity	Peak Level (dBuV/m)	Measurement uncertainty (dB)	Verdict
5850.5000	Vertical	65.24	<± 3.98	PASS

Lower Band Edge Channel 149



Upper Band Edge Channel 165



Results for Mode: 16QAM – 20 MHz

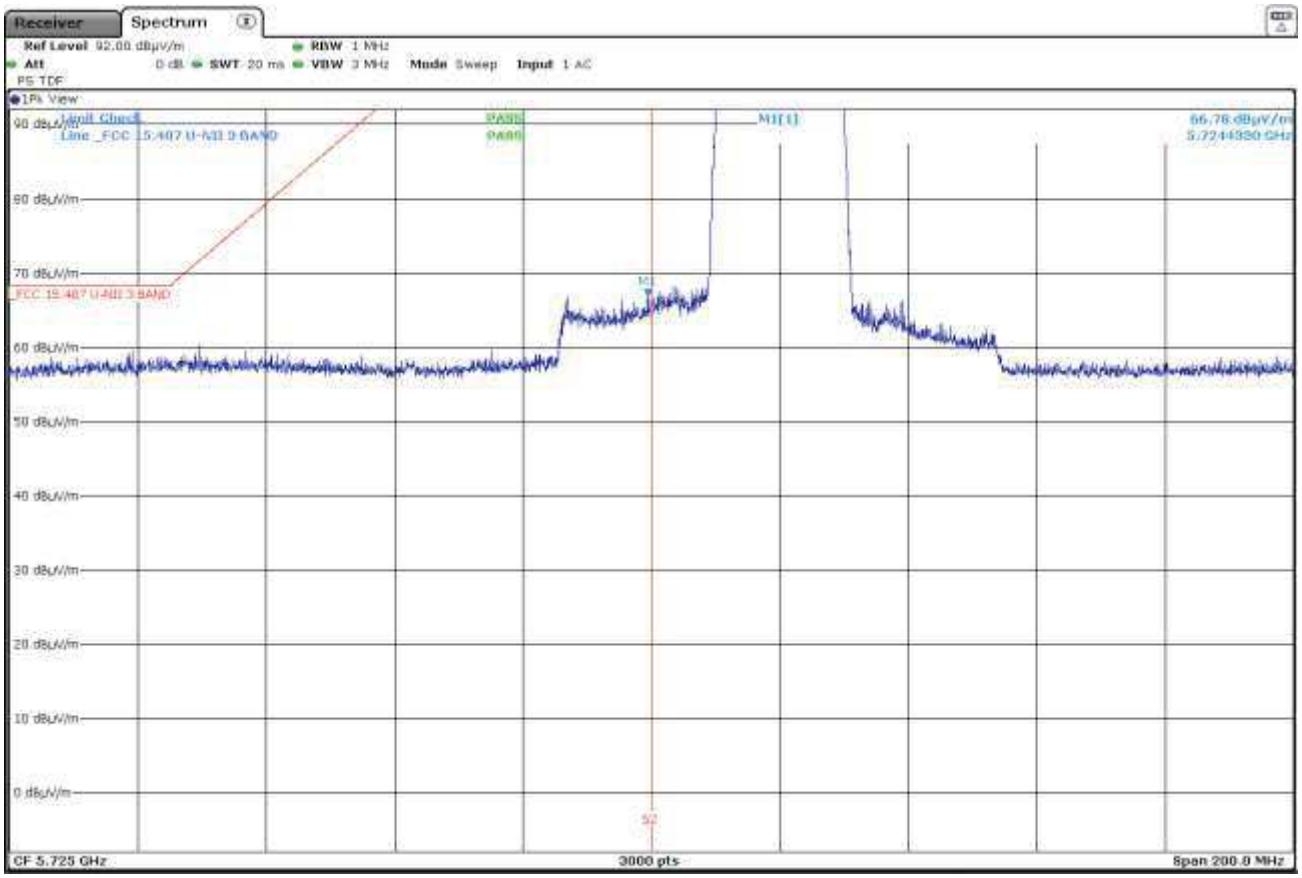
Results: Peak / Channel 149

Frequency (MHz)	Antenna Polarity	Peak Level (dBuV/m)	Measurement uncertainty (dB)	Verdict
5724.4330	Vertical	66.78	<± 3.98	PASS

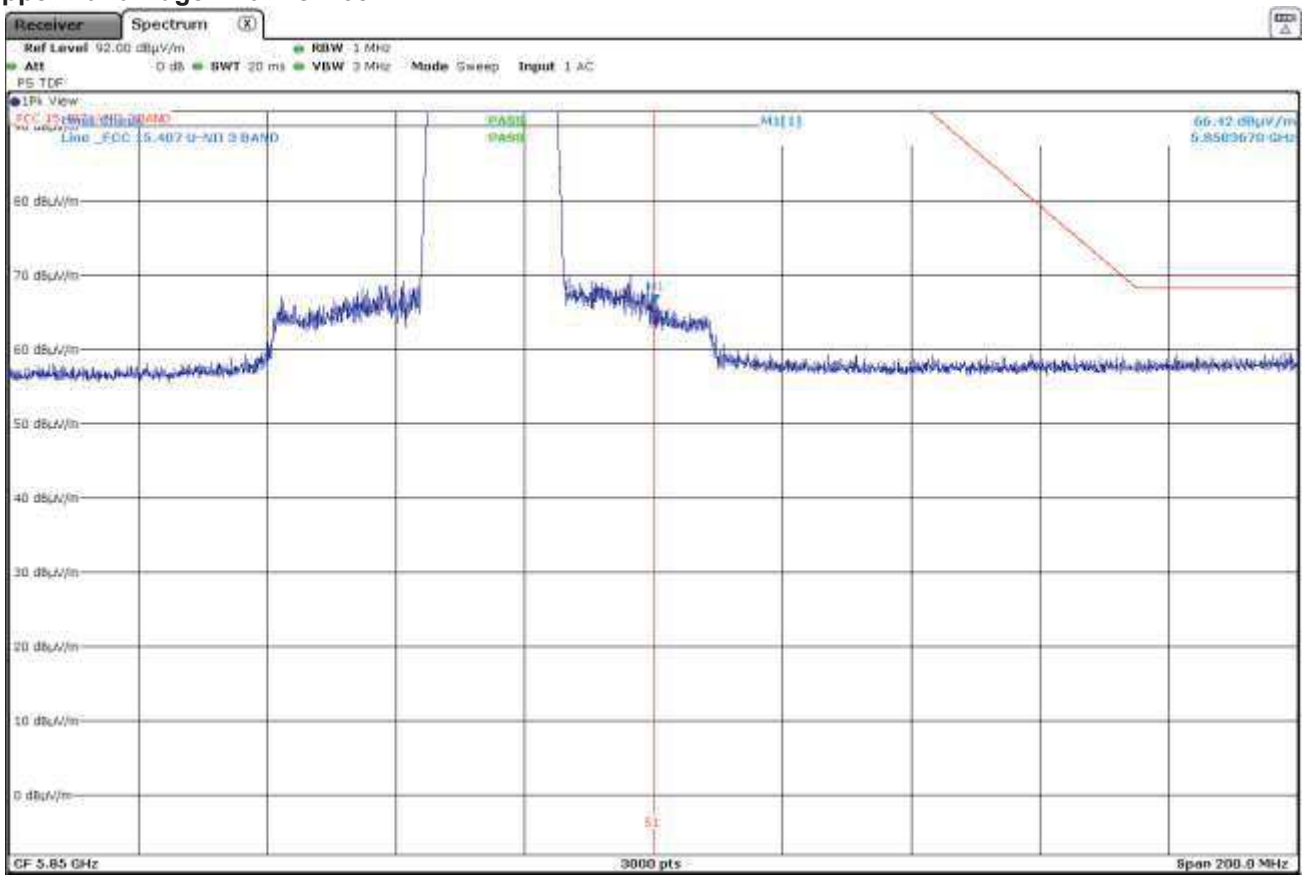
Results: Peak / Channel 165

Frequency (MHz)	Antenna Polarity	Peak Level (dBuV/m)	Measurement uncertainty (dB)	Verdict
5850.3670	Vertical	66.42	<± 3.98	PASS

Lower Band Edge Channel 149



Upper Band Edge Channel 165



Results for Mode: 64QAM – 20 MHz

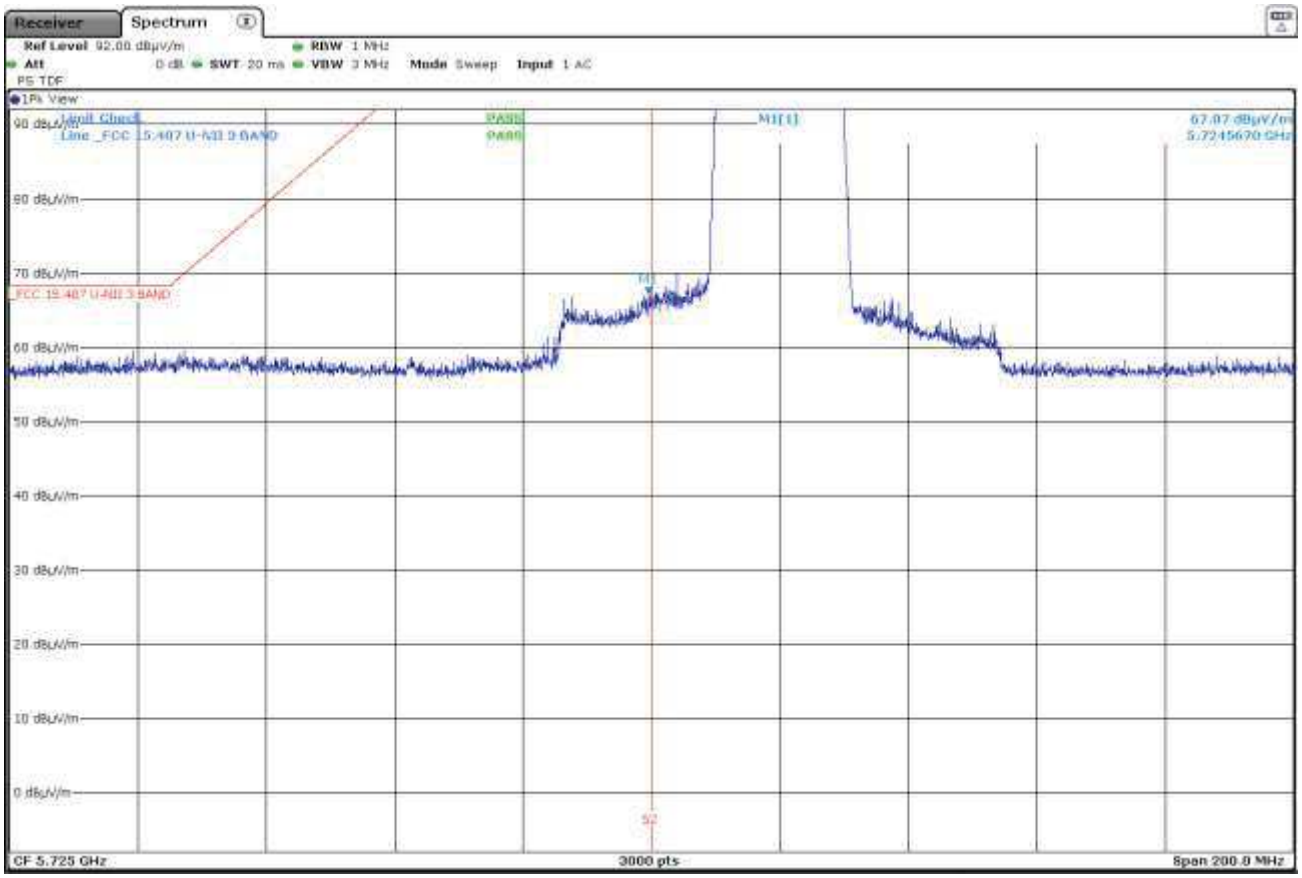
Results: Peak / Channel 149

Frequency (MHz)	Antenna Polarity	Peak Level (dBuV/m)	Measurement uncertainty (dB)	Verdict
5724.5670	Vertical	67.07	<± 3.98	PASS

Results: Peak / Channel 165

Frequency (MHz)	Antenna Polarity	Peak Level (dBuV/m)	Measurement uncertainty (dB)	Verdict
5850.9000	Vertical	69.67	<± 3.98	PASS

Lower Band Edge Channel 149



Upper Band Edge Channel 165