

C.2 Maximum Output Power and antenna gain

Test limits:

FCC part	RSS part	Limits
15.247 (b) (3)	RSS-247 Clause 5.4 (4)	<p>(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:</p> <p>(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level.</p> <p>(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi.</p>

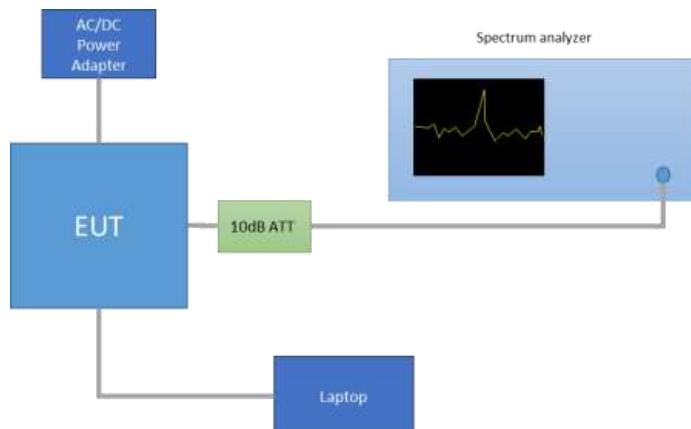
Test procedure:

The Maximum peak conducted output power was measured using the $RBW \geq DTS \text{ bandwidth}$ method defined in paragraph 9.1.1 of FCC KDB 558074 D01 - Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247.

The Maximum conducted average output power was measured using the channel integration method according to Method AVGSA-2, defined in paragraph 9.2.2.4 of FCC KDB 558074 D01 - Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247.

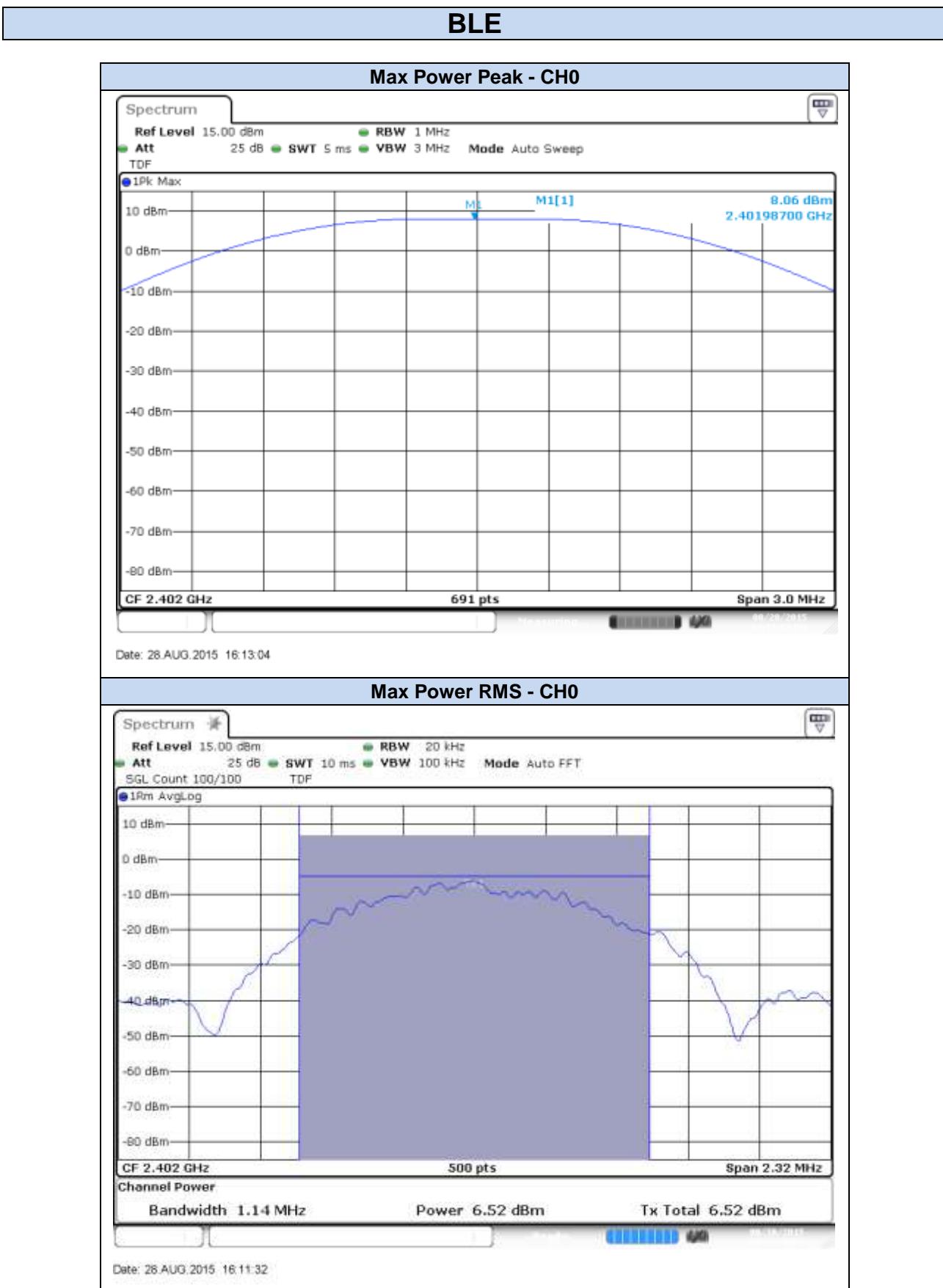
The EIRP power (dBm) is calculated by adding the declared maximum antenna gain to the measured conducted power. The declared maximum antenna gain is 3dBi.

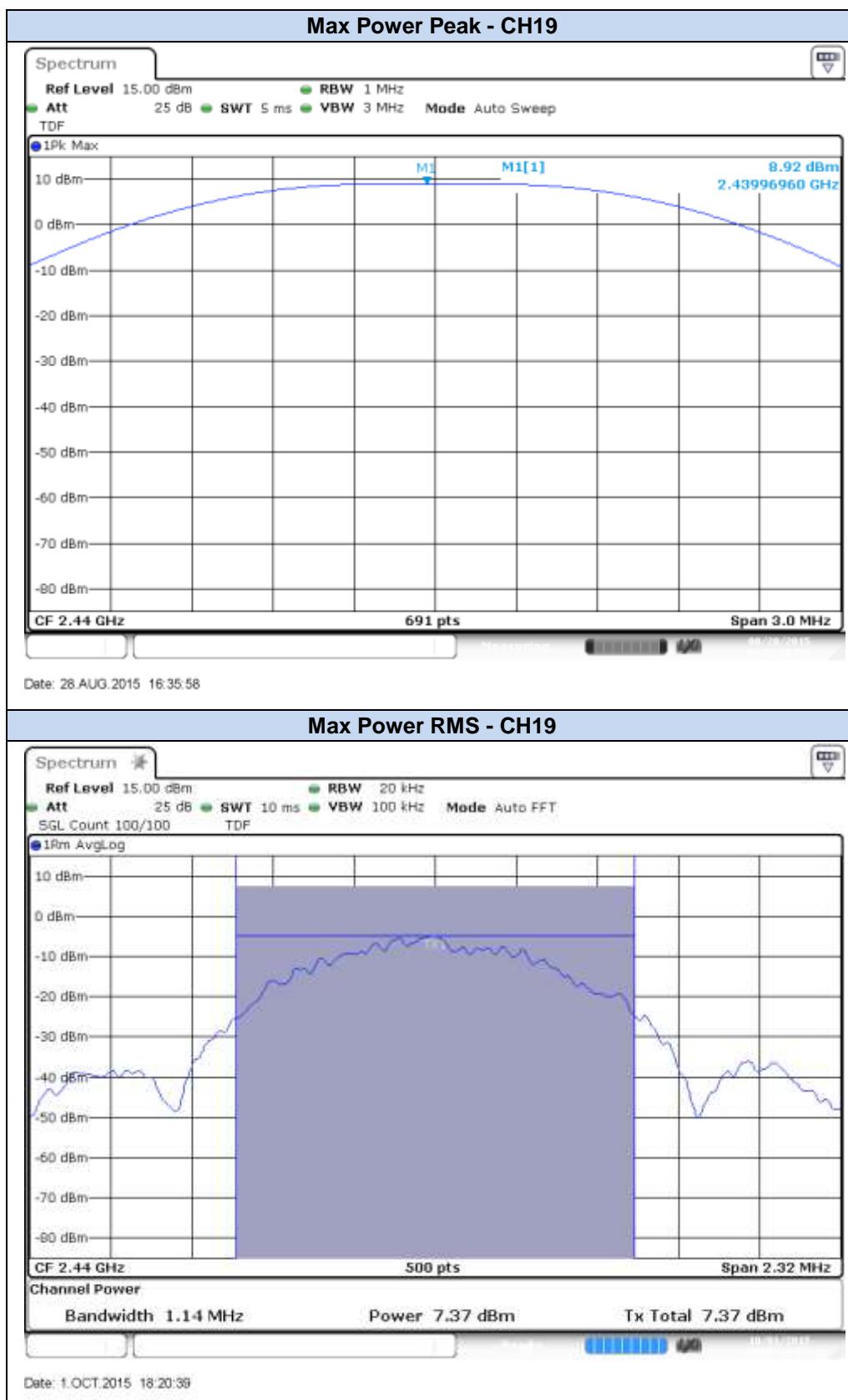
The setup below was used to measure the maximum conducted output power. The antenna terminal of the EUT is connected to the spectrum through an attenuator, and the spectrum analyzer reading is compensated to include the RF path loss.

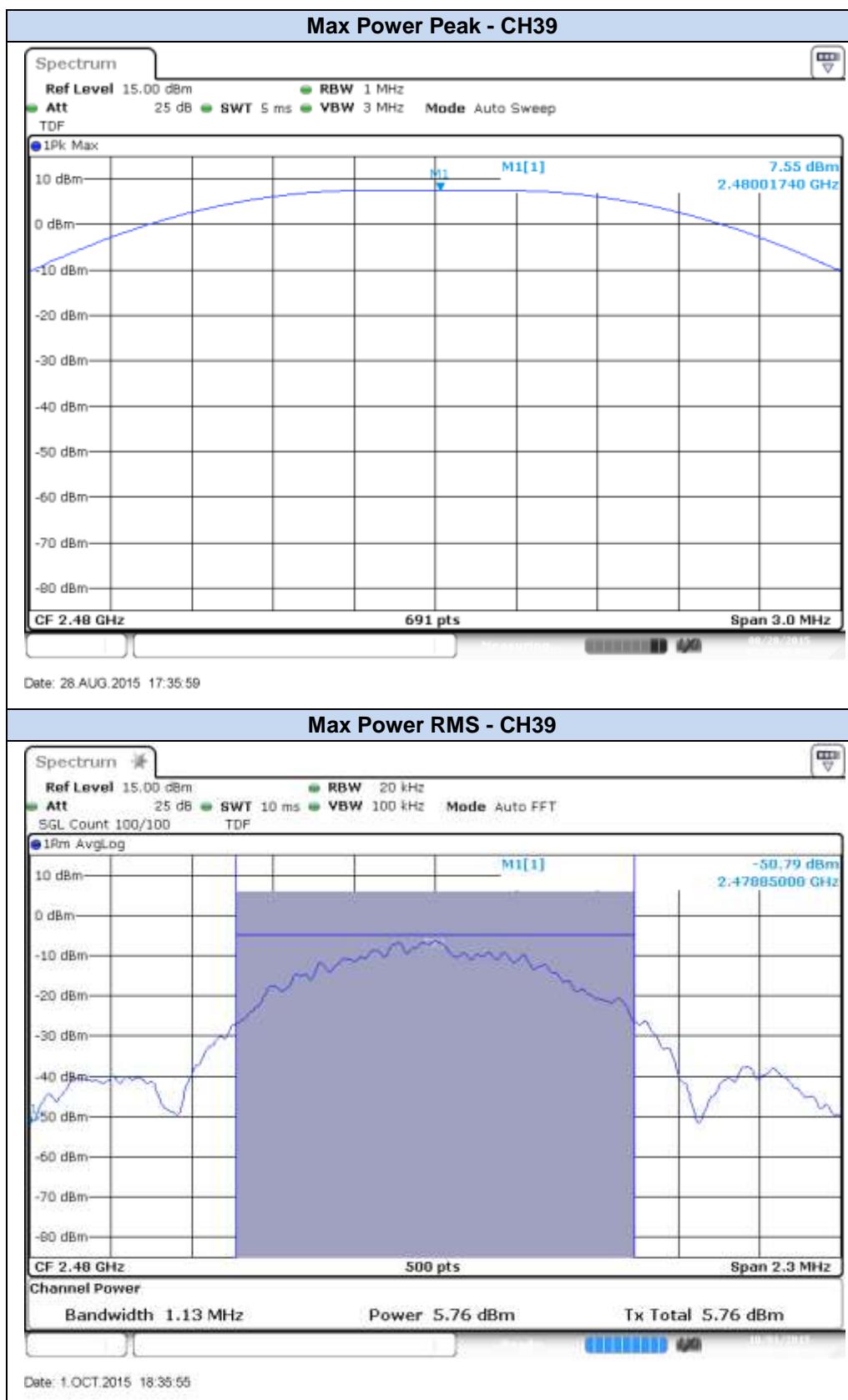


Results tables:

Mode	Meas. Duty Cycle [%]	CH	Frequency [MHz]	Power [dBm]			
				Measured Conducted RMS	Duty cycle Compensated	EIRP	Measured Conducted PEAK
BLE	62.6	0	2402	6.52	8.55	11.55	8.06
		19	2440	7.37	9.40	12.40	8.92
		39	2480	5.76	7.79	10.79	7.55

Results screenshot:






C.3 Out-of-band emissions (conducted)

Test limits:

FCC part	RSS part	Limits																																			
15.247 (d)	RSS-247 Clause 5.5	In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.																																			
15.209	RSS-247 Clause 6.2.2 (2)	<p>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):</p> <table border="1"> <thead> <tr> <th>Freq Range (MHz)</th> <th>Field Strength (μV/m)</th> <th>Field Strength ($\text{dB}\mu$V/m)</th> <th>Meas. Distance (m)</th> </tr> </thead> <tbody> <tr> <td>0.009-0.490</td> <td>2400/f(kHz)</td> <td>-</td> <td>300</td> </tr> <tr> <td>0.490-1.705</td> <td>24000/f(kHz)</td> <td>-</td> <td>300</td> </tr> <tr> <td>1.705-30.0</td> <td>30</td> <td>-</td> <td>30</td> </tr> <tr> <td>30-88</td> <td>100</td> <td>40</td> <td>3</td> </tr> <tr> <td>88-216</td> <td>150</td> <td>43.5</td> <td>3</td> </tr> <tr> <td>216-960</td> <td>200</td> <td>46</td> <td>3</td> </tr> <tr> <td>960-25000</td> <td>500</td> <td>54</td> <td>3</td> </tr> </tbody> </table> <p>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 specified when measuring with peak detector function, corresponding to 20 dB above the indicated values in the table.</p>				Freq Range (MHz)	Field Strength (μ V/m)	Field Strength ($\text{dB}\mu$ V/m)	Meas. 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	960-25000	500	54	3
Freq Range (MHz)	Field Strength (μ V/m)	Field Strength ($\text{dB}\mu$ V/m)	Meas. 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																																		
960-25000	500	54	3																																		

Test procedure:

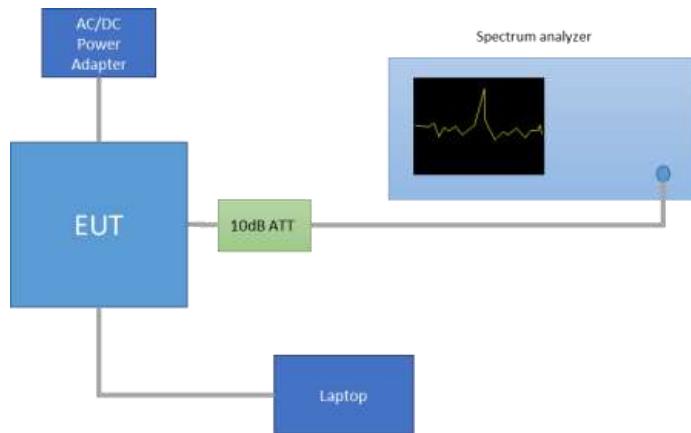
The PSD reference values to determine the -20dB compliance are taken from *C.4 Power Spectral Density*.

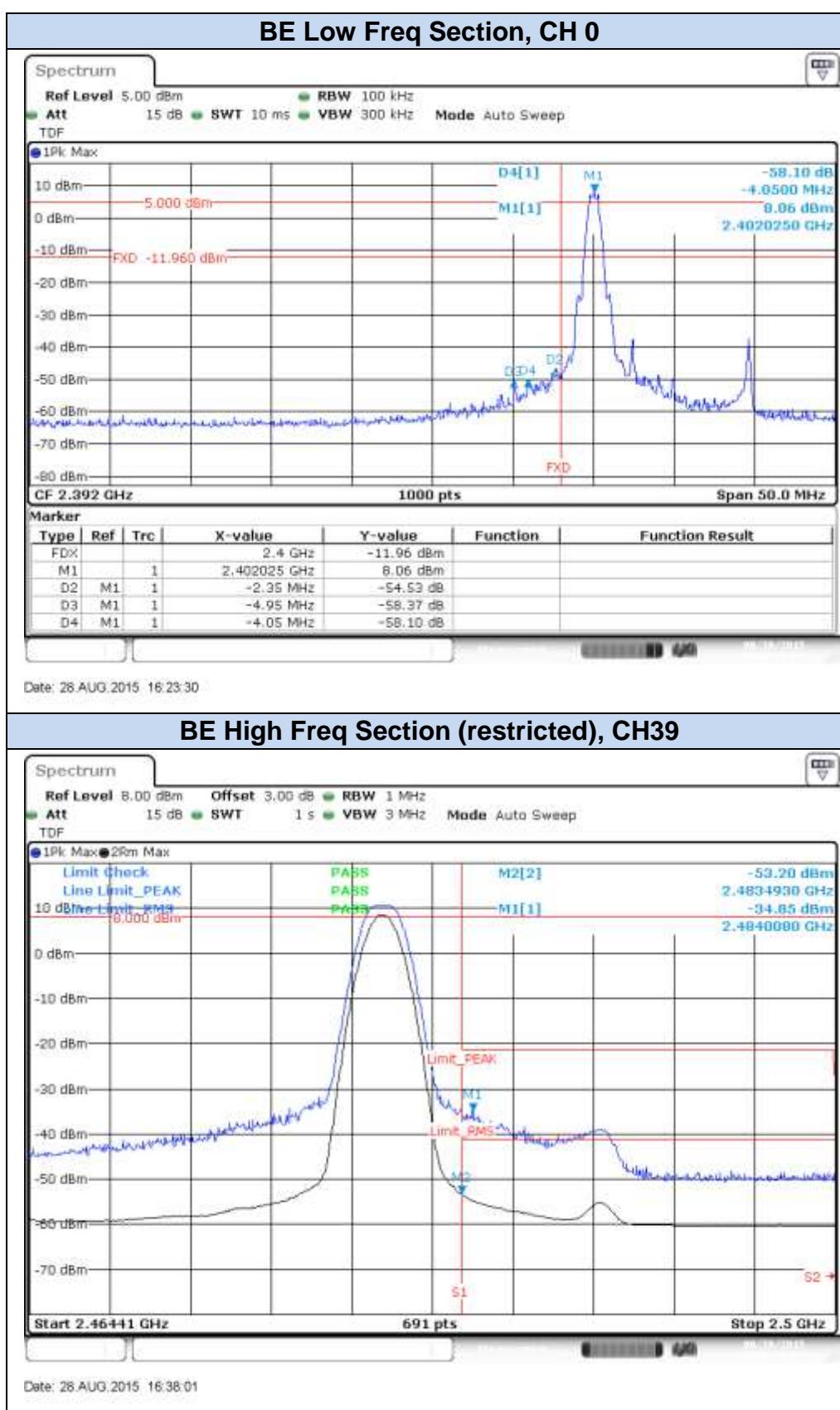
For Band Edge measurements falling in restricted bands, the following limits in dBm were applied for the average detector after the conversion from the limits detailed above in $\text{dB}\mu$ V/m, according to FCC 47 CFR part 15 - Subpart C – §15.209(a). The limits in dBm for peak detector are 20dB above the indicated values in the table.

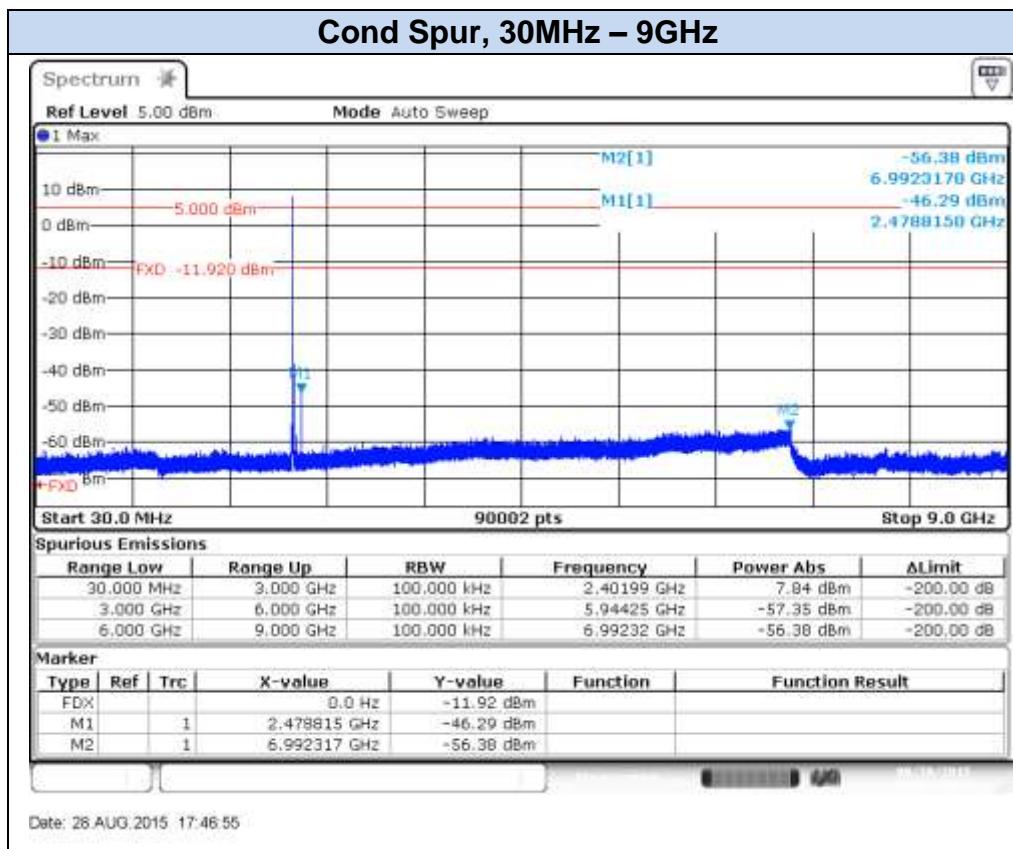
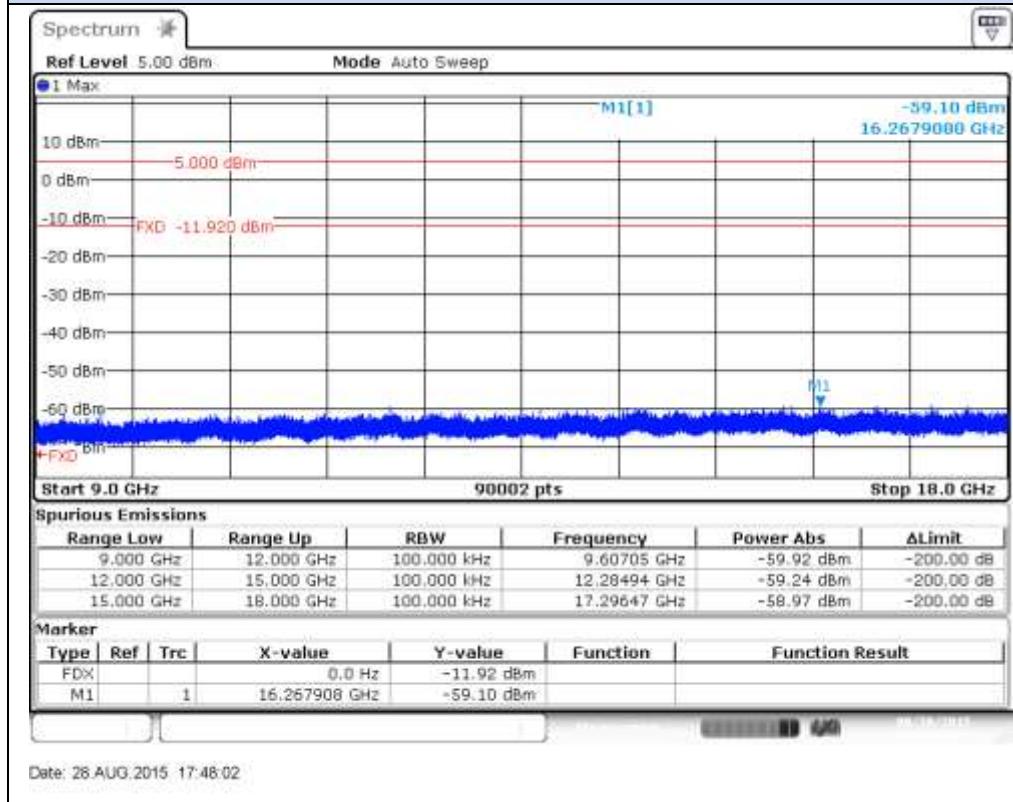
§15.209(a)			Converted values	
Freq. Range (MHz)	Distance (m)	Field strength (microvolts/meter)	Field strength (dB microvolts/meter)	Power (dBm)
960-25000	3	500	54.0	-41.2

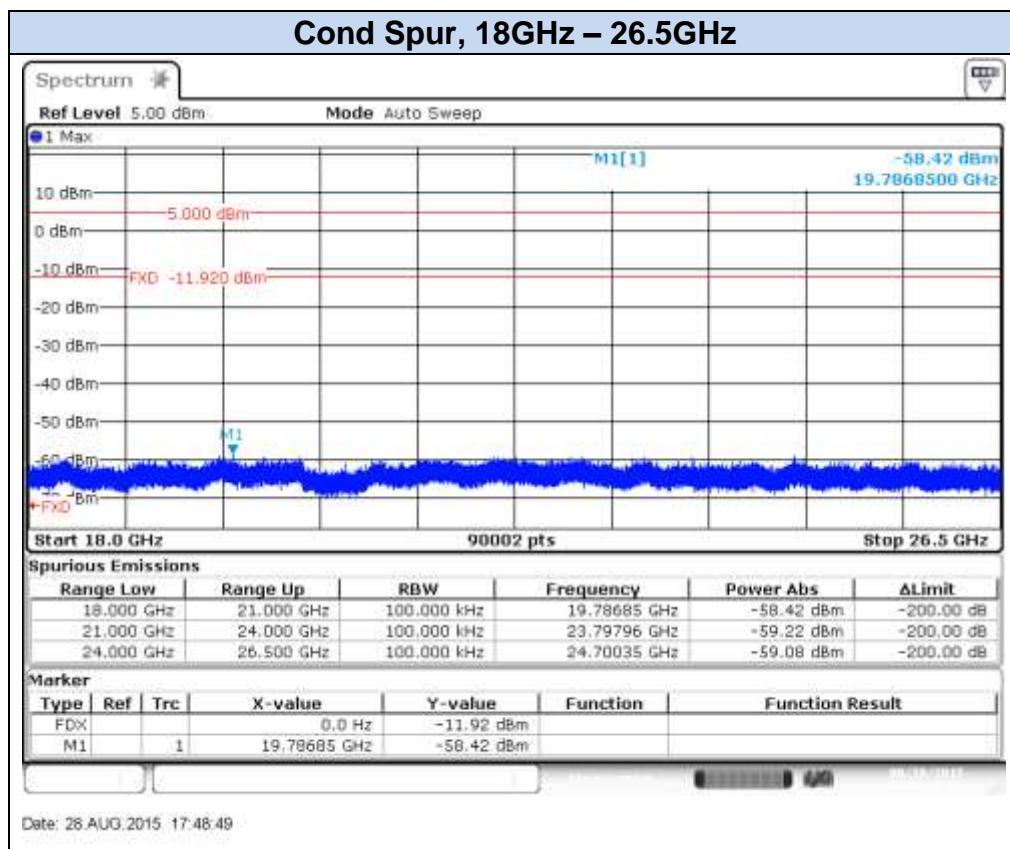
In case of Band Edge measurements falling in restricted bands, the declared Antenna Gain is also compensated in the graph. The declared maximum antenna gain is 3dBi.

The setup below was used to measure the out-of-band emissions. The antenna terminal of the EUT is connected to the spectrum through an attenuator, and the spectrum analyzer reading is compensated to include the RF path loss.

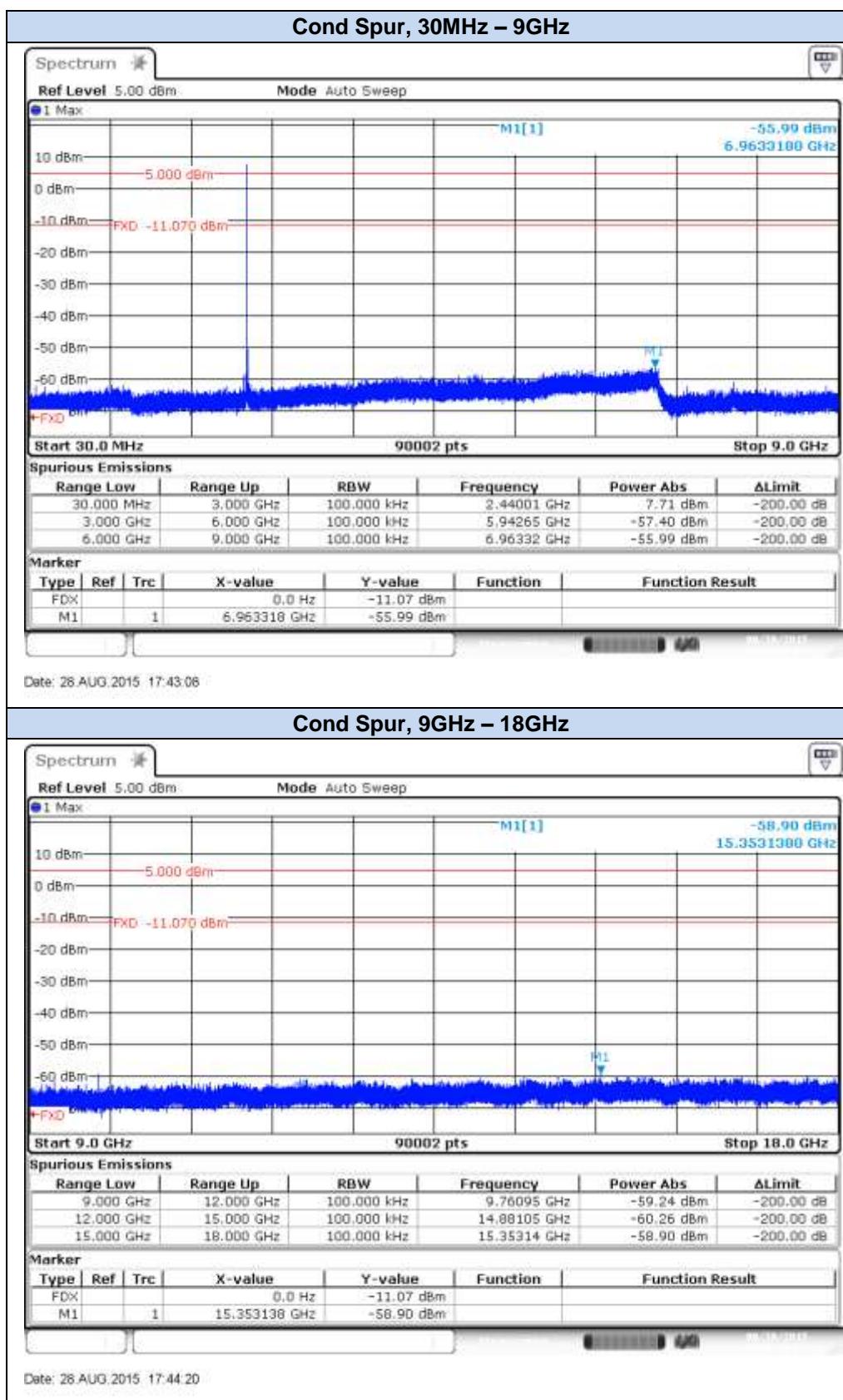


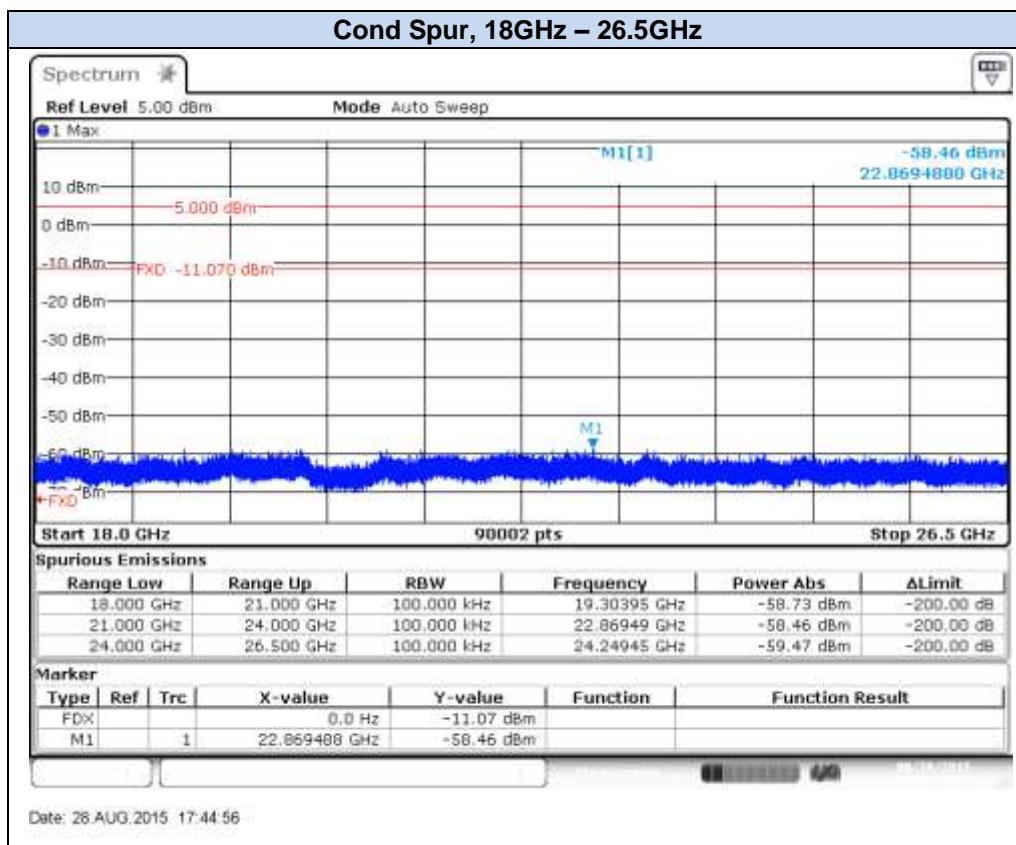
Band Edge results Screenshot:


Spurious results Screenshot:
BLE, CH0

Cond Spur, 9GHz – 18GHz


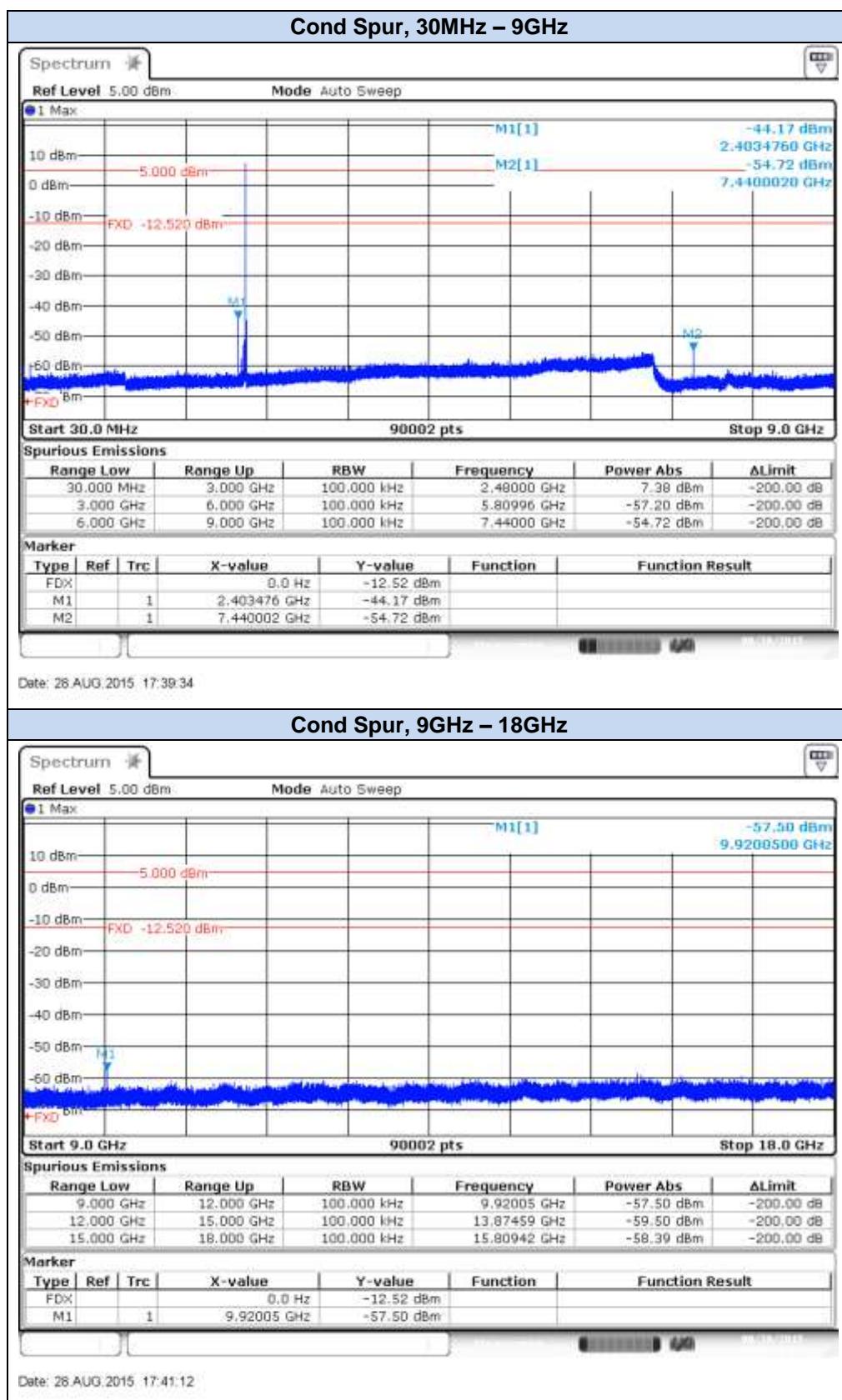


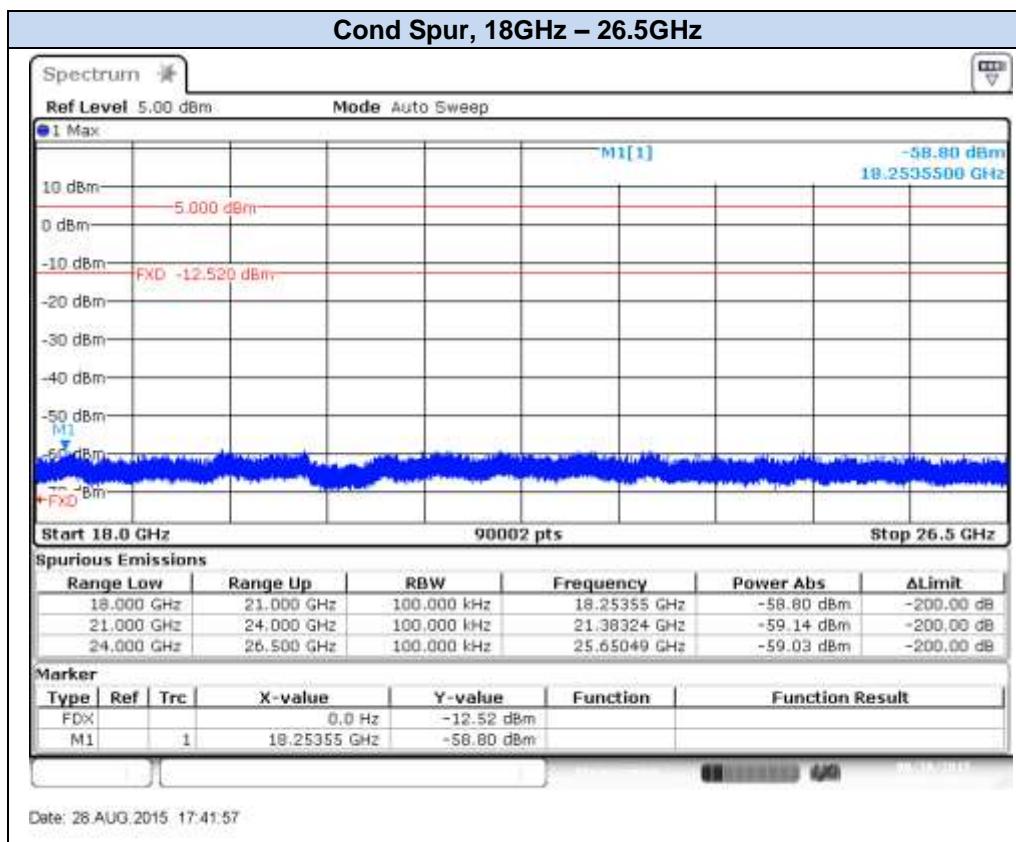
BLE, CH19





BLE, CH39





C.4 Power Spectral Density

Test limits:

FCC part	RSS part	Limits
15.247 (e)	RSS-247 Clause 5.2 (2)	For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

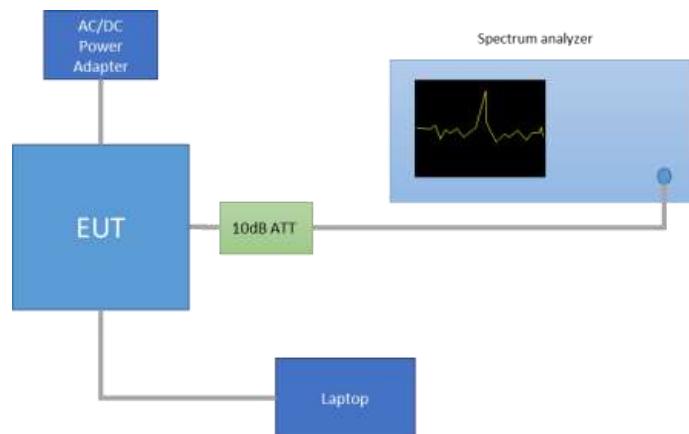
Test procedure:

The maximum peak power spectral density level of the fundamental emission was measured using the method PKPSD, defined in paragraph 10.2 of FCC KDB 558074 D01 - Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247.

The maximum average power spectral density level of the fundamental emission was measured using the method AVGPSD-2, defined in paragraph 10.5 FCC KDB 558074 D01 - Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247.

The setup below was used to measure the power spectral density. The antenna terminal of the EUT is connected to the spectrum through an attenuator, and the spectrum analyzer reading is compensated to include the RF path loss.

The declared maximum antenna gain is 3dBi.



Results tables:
PSD RMS

PSD RMS [dBm]					
Mode	Meas. Duty Cycle [%]	CH	Frequency [MHz]	Measured Conducted	Duty cycle Compensated
BLE	62.6	0	2402	-0.09	1.94
		19	2440	0.77	2.80
		39	2480	-0.7	1.33

PSD Peak

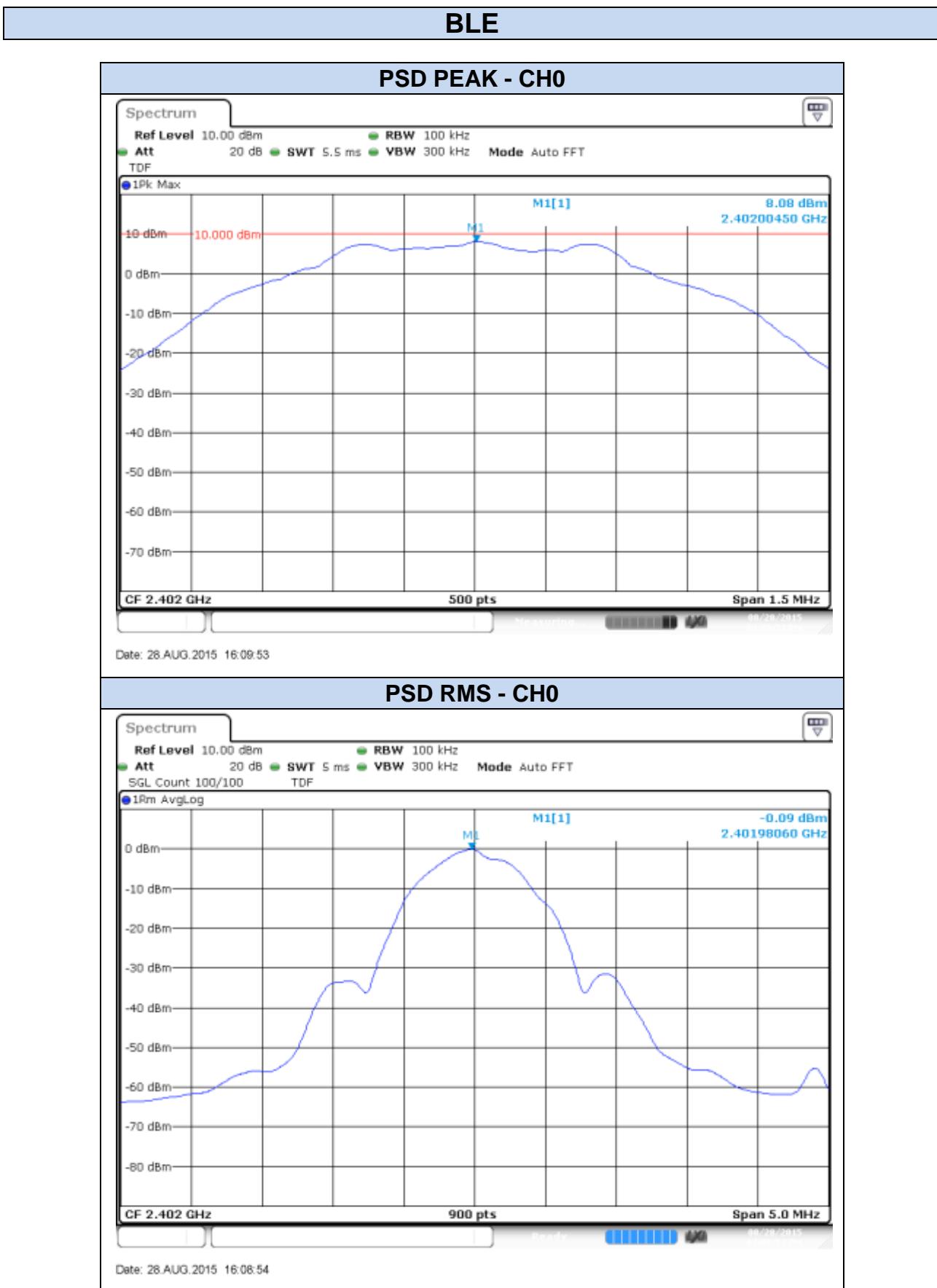
Note: these PSD_{Peak} values are shown just as a reference for the compliance of the Out-of-band Measurements, thus the RBW used for these measurements was 100kHz.

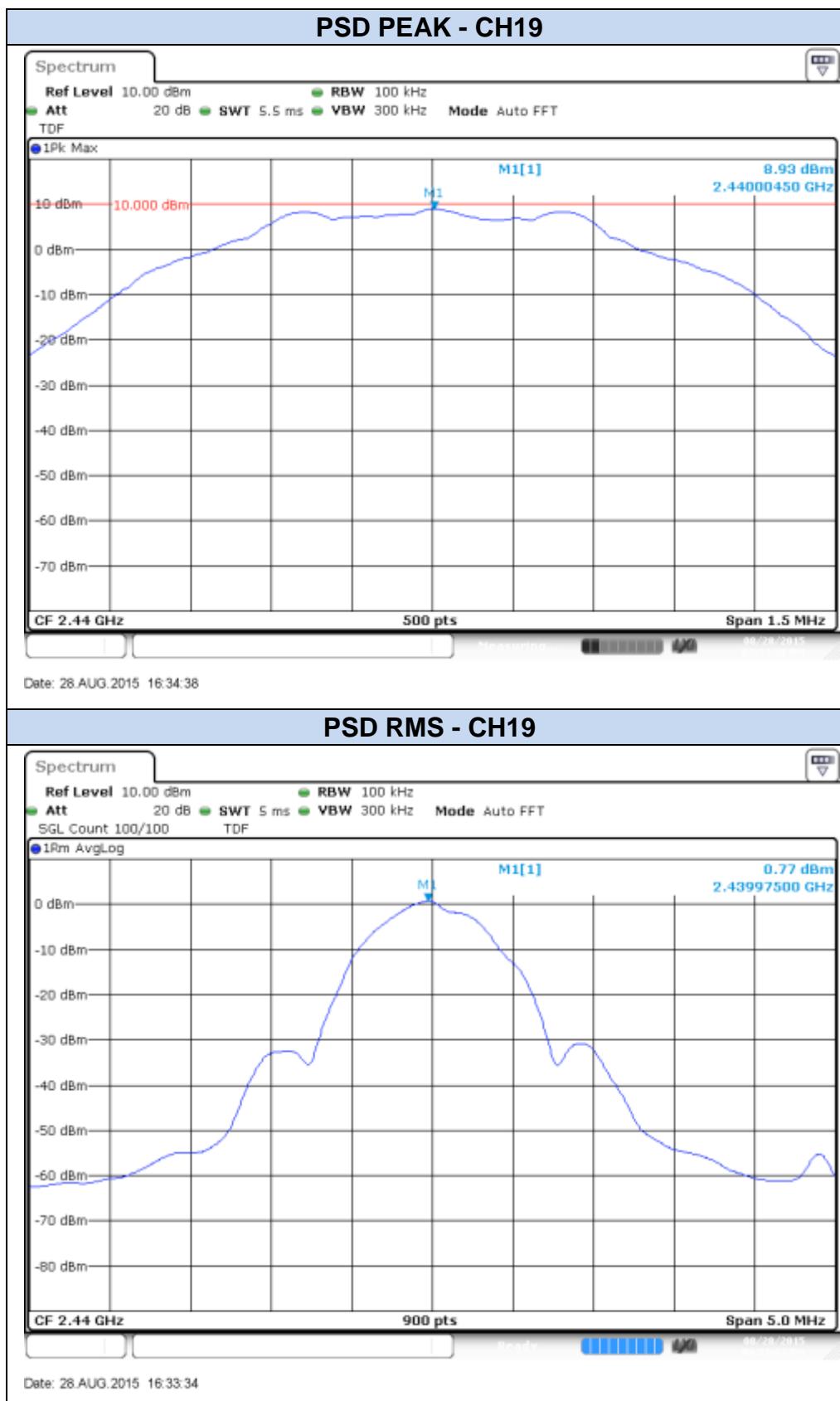
In any case, the corresponding PSD Peak value at 3kHz can be derived from these results by using the RBW correction:

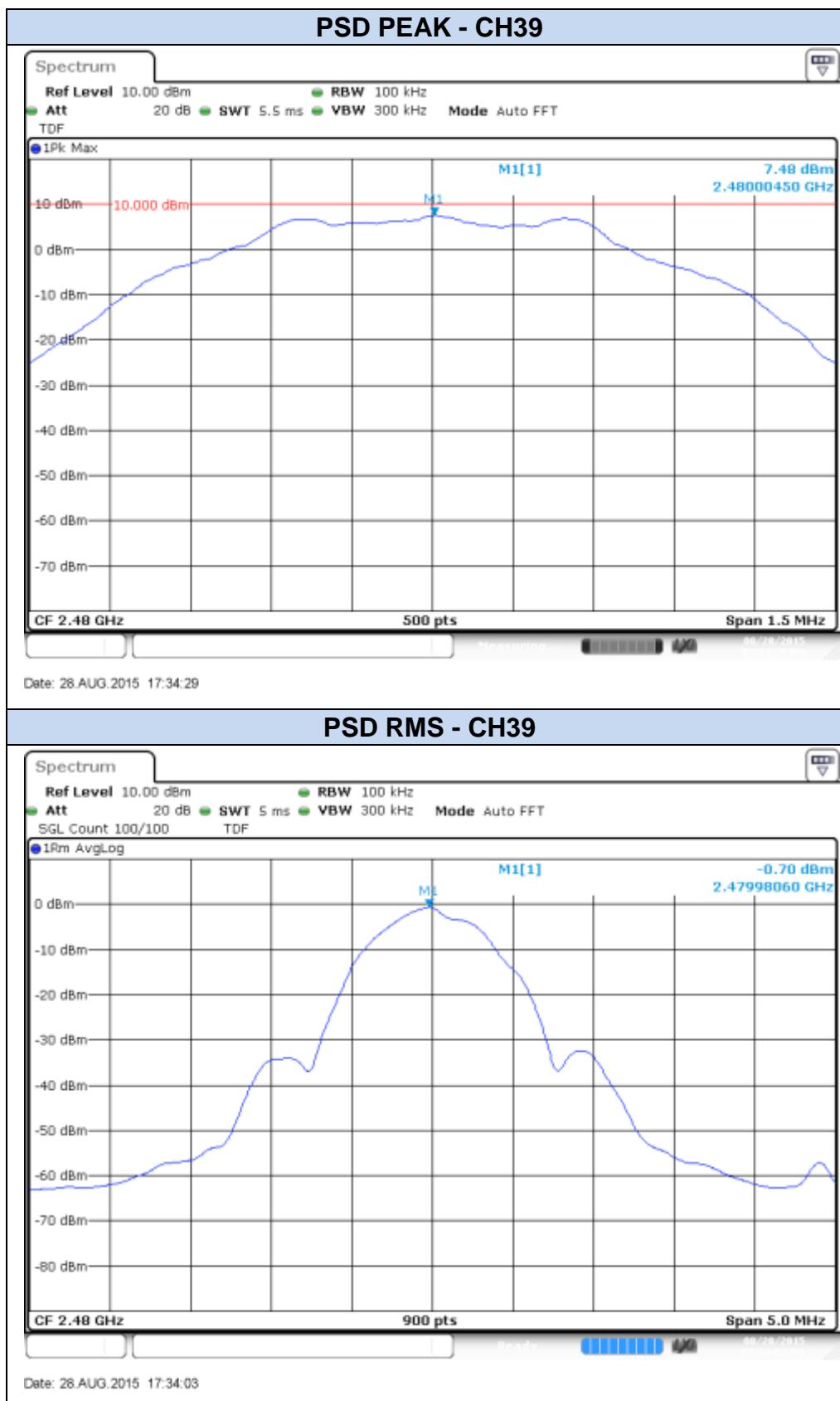
$$PSD_{Peak}@3kHz = PSD_{Peak}@100kHz - 10\log\left(\frac{100kHz}{3kHz}\right)$$

For the maximum PSD_{Peak} value found (8.93dBm), the corresponding PSD_{Peak} at 3kHz is -6.30dBm.

PSD PEAK [dBm]			
Mode	CH	Frequency [MHz]	Measured Conducted
BLE	0	2402	8.08
	19	2440	8.93
	39	2480	7.48

Results screenshot:






C.5 Radiated spurious emission

Standard references:

FCC part	RSS part	Limits																																
15.247 (d)	RSS-247 Clause 5.5	<p>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):</p> <table border="1"> <thead> <tr> <th>Freq Range (MHz)</th><th>Field Strength (μV/m)</th><th>Field Strength ($\text{dB}\mu$V/m)</th><th>Meas. Distance (m)</th></tr> </thead> <tbody> <tr> <td>0.009-0.490</td><td>2400/f(kHz)</td><td>-</td><td>300</td></tr> <tr> <td>0.490-1.705</td><td>24000/f(kHz)</td><td>-</td><td>300</td></tr> <tr> <td>1.705-30.0</td><td>30</td><td>-</td><td>30</td></tr> <tr> <td>30-88</td><td>100</td><td>40</td><td>3</td></tr> <tr> <td>88-216</td><td>150</td><td>43.5</td><td>3</td></tr> <tr> <td>216-960</td><td>200</td><td>46</td><td>3</td></tr> <tr> <td>960-25000</td><td>500</td><td>54</td><td>3</td></tr> </tbody> </table> <p>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 specified when measuring with peak detector function, corresponding to 20 dB above the indicated values in the table.</p>	Freq Range (MHz)	Field Strength (μ V/m)	Field Strength ($\text{dB}\mu$ V/m)	Meas. 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	960-25000	500	54	3
Freq Range (MHz)	Field Strength (μ V/m)	Field Strength ($\text{dB}\mu$ V/m)	Meas. Distance (m)																															
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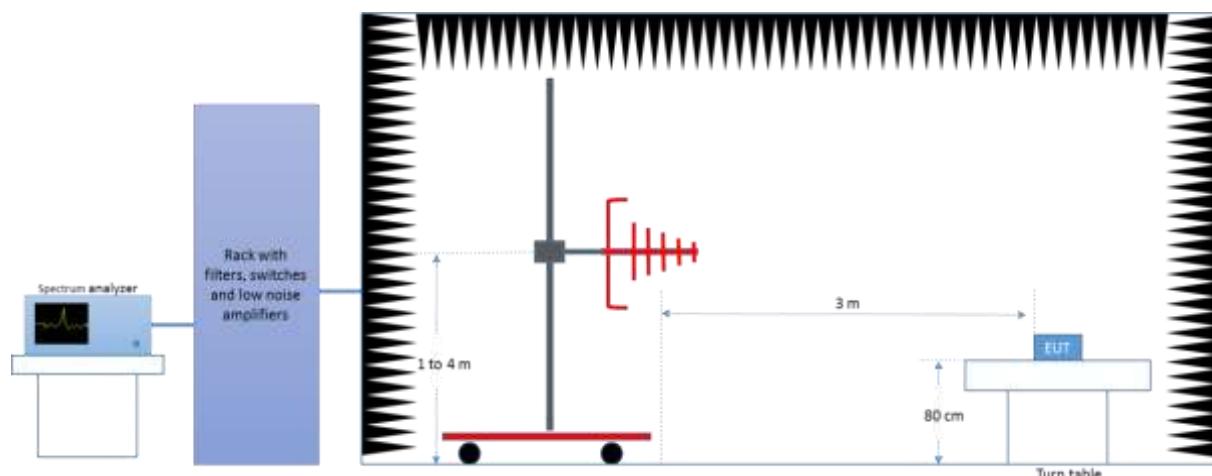
Test procedure:

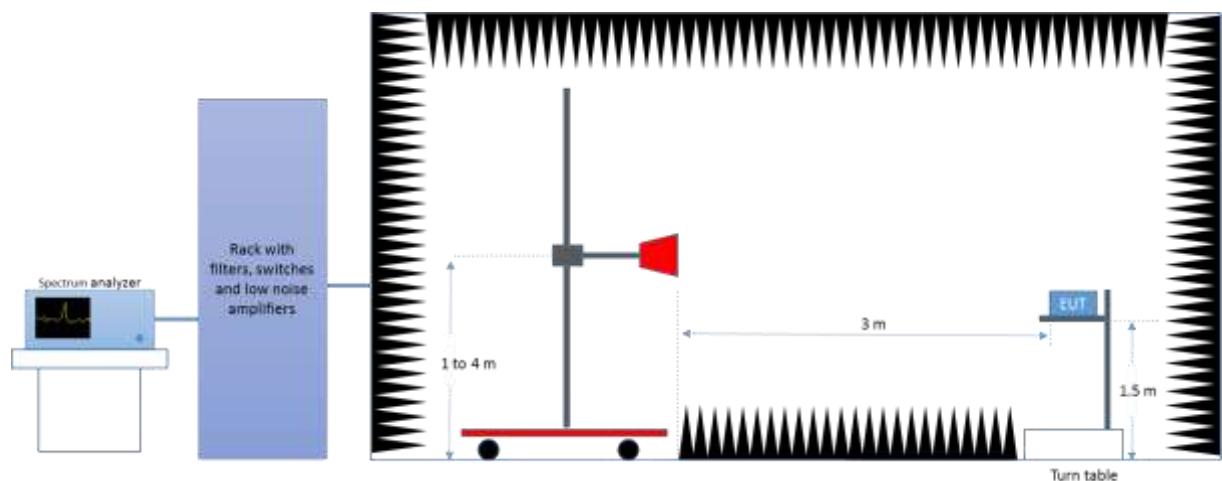
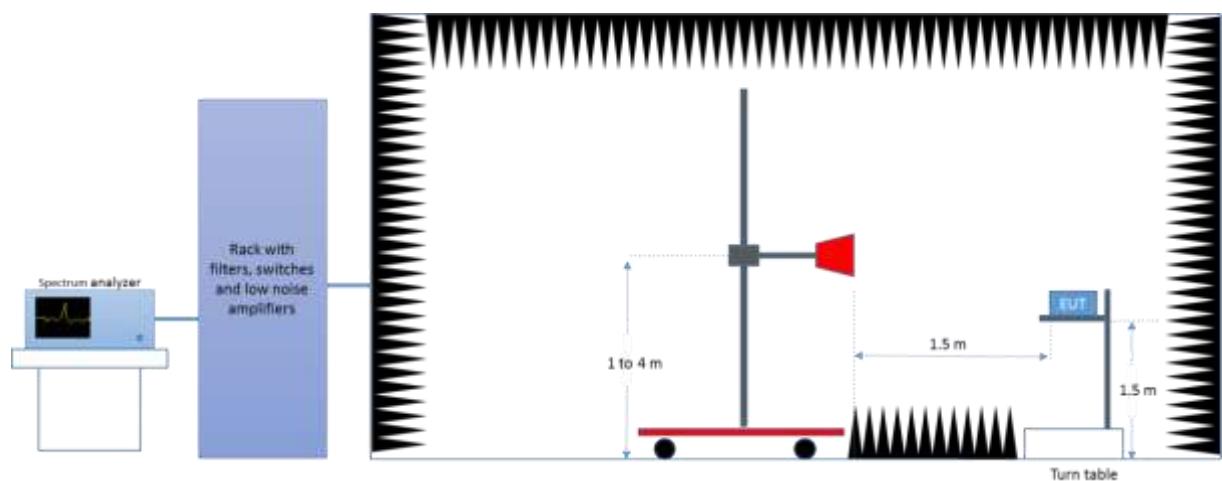
The setups below were used to measure the radiated spurious emissions.

Depending of the frequency range and bands being tested, different antennas and filters were used. The final measurement is done by varying the antenna height from 1 to 4 meters, the EUT azimuth over 360° and for both Vertical and Horizontal polarizations.

The radiated spurious emissions were measured on the worst case configuration selected from the chapter *C.2 Maximum Output Power and antenna gain* and using the lowest, middle and highest channels.

Radiated Setup < 1GHz



Radiated Setup 1GHz - 18GHz*Radiated Setup > 18GHz*

Test Results: