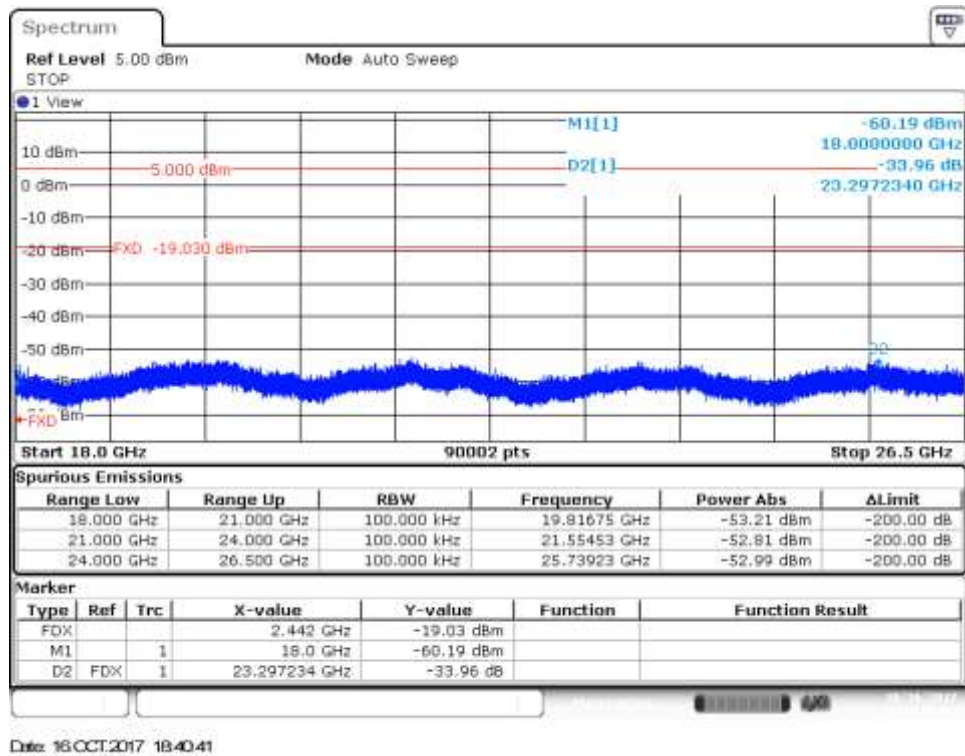


Channel 7F - Spurious 3 Delta Marker Measurement



# Annex C. Test Results BLE

## C.1 Test Results BLE

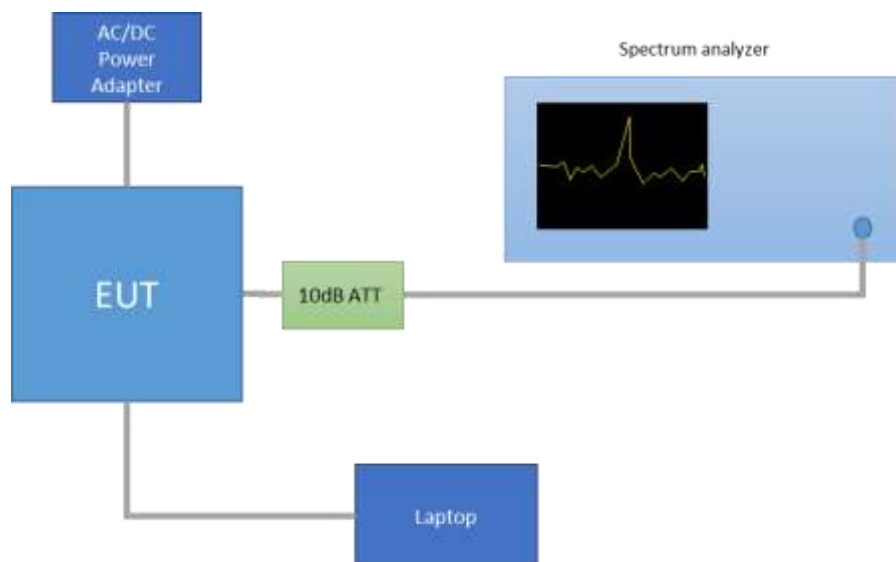
### C.1.1 6dB & 99% Bandwidth

#### Test limits

FCC part	RSS part	Limits
15.247 (a) (2)	RSS-247 Clause 5.2 (a)	Systems using digital modulation techniques may operate in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

#### Test procedure

The setup below was used to measure the 6dB & 99% Bandwidth. 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.



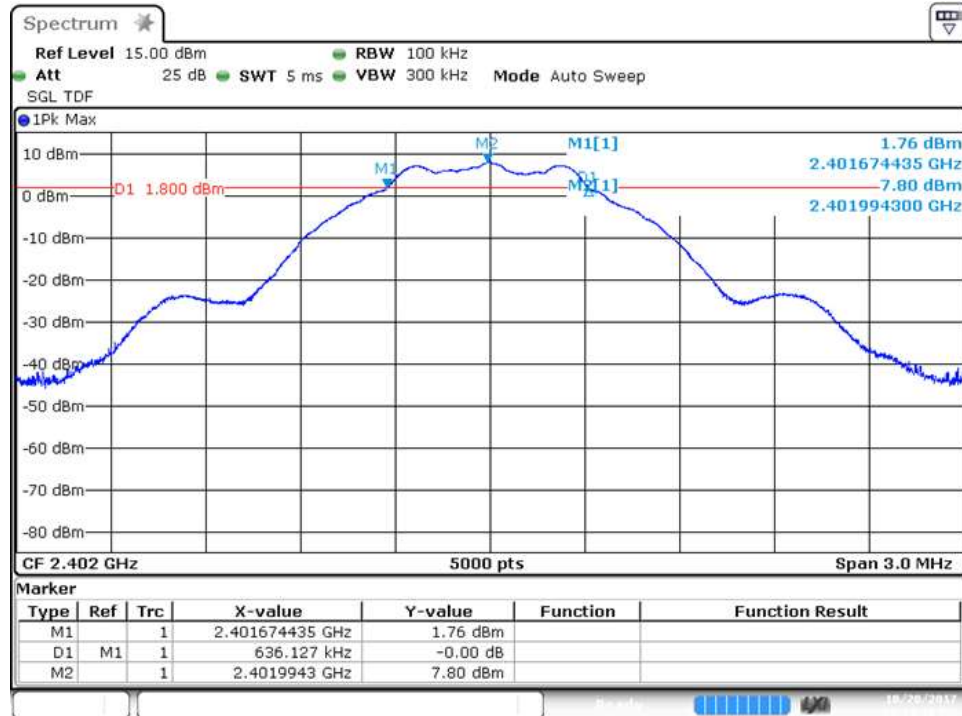
#### Results tables

Mode	Antenna	Channel	Frequency [MHz]	6dB BW [MHz]	99% BW [MHz]
BLE	Chain A Div1	0	2402	0.64	1.15
		19	2440	0.65	1.15
		39	2480	0.65	1.15
BLE	Chain A Div2	0	2402	0.64	1.15
		19	2440	0.64	1.15
		39	2480	0.65	1.14

## Results screenshot

### BLE

#### CHAIN A DIV1\_6dB BW – CH0



#### CHAIN A DIV1\_99% BW – CH0



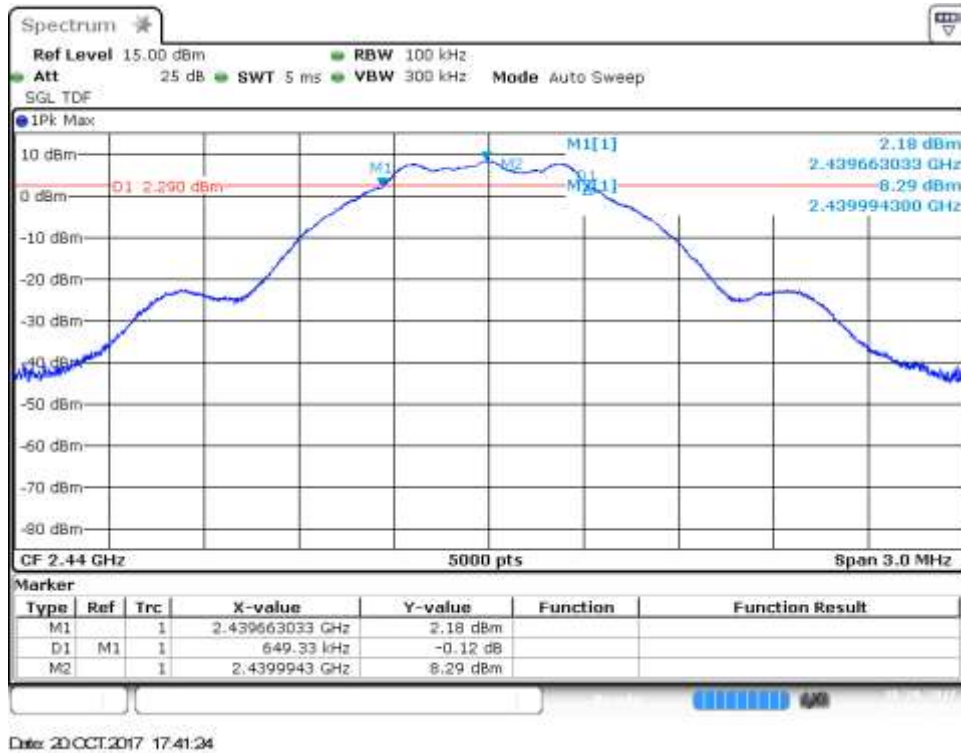
## CHAIN A DIV2\_6dB BW – CH0



## CHAIN A DIV2\_99% BW – CH0



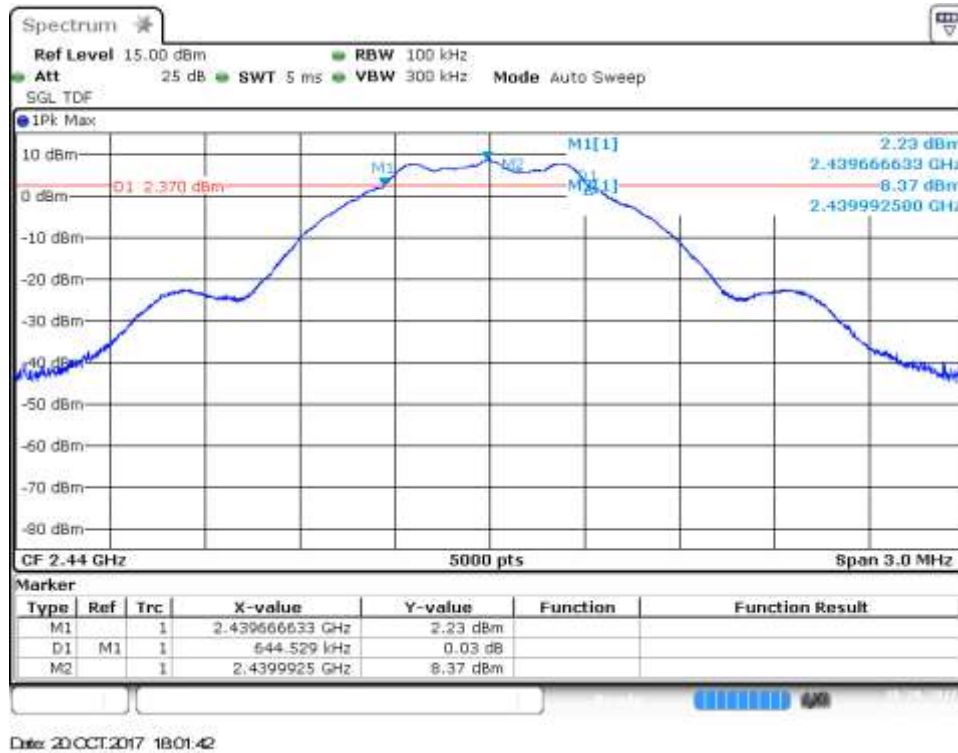
## CHAIN A DIV1\_6dB BW – CH19



## CHAIN A DIV1\_99% BW – CH19



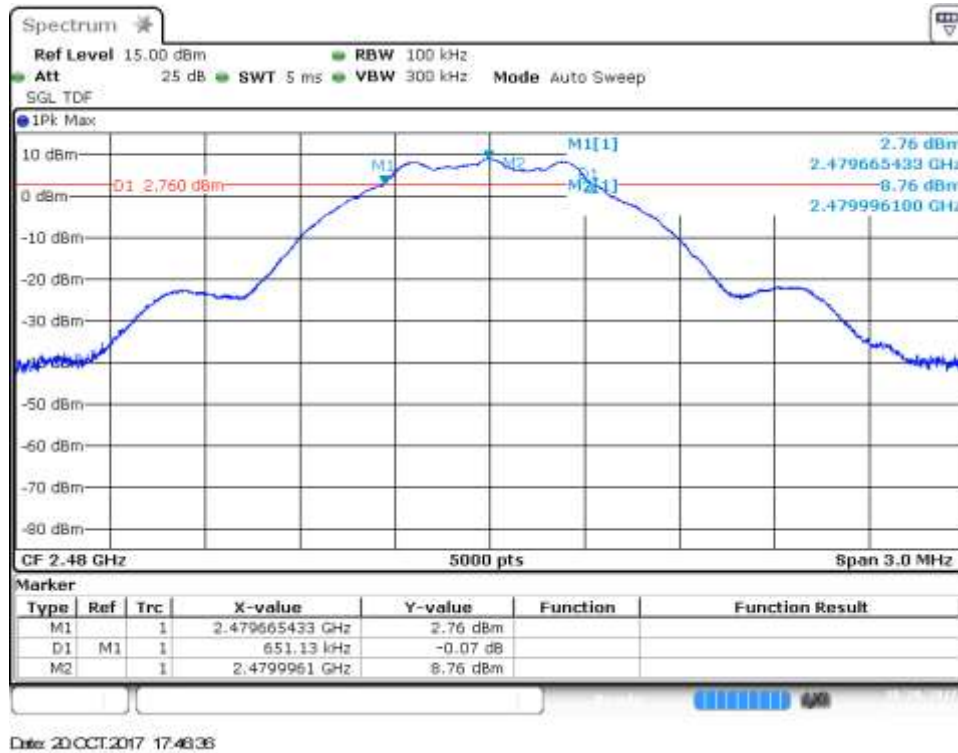
## CHAIN A DIV2\_6dB BW – CH19



## CHAIN A DIV2\_99% BW – CH19



## CHAIN A DIV1\_6dB BW – CH39

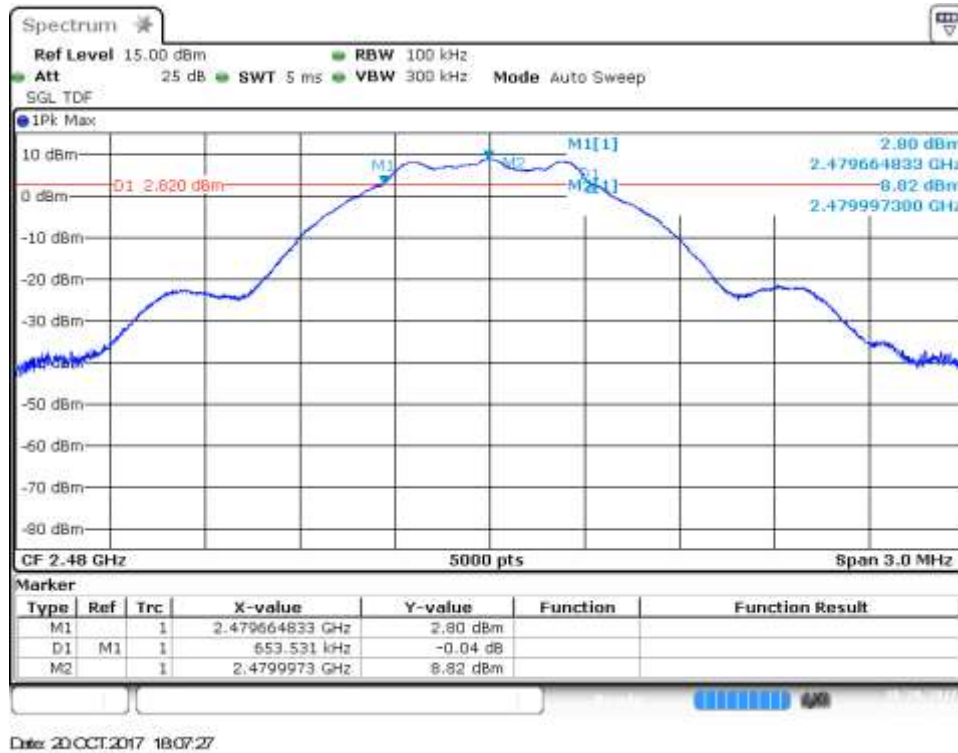


## CHAIN A DIV1\_99% BW – CH39





## CHAIN A DIV2\_6dB BW – CH39



## CHAIN A DIV2\_99% BW – CH39





## C.1.2 Maximum Output Power and antenna gain

### Test limits

	Limits
FCC Part 15.247 (b) (3)	<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>
RSS-247 Clause 5.4 (d)	<p>For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).</p> <p>As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power. The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements, averaged across all symbols in the signalling 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 transmitting at a reduced power level. If multiple modes of operation are implemented, the maximum conducted output power is the highest total transmit power occurring in any mode</p>

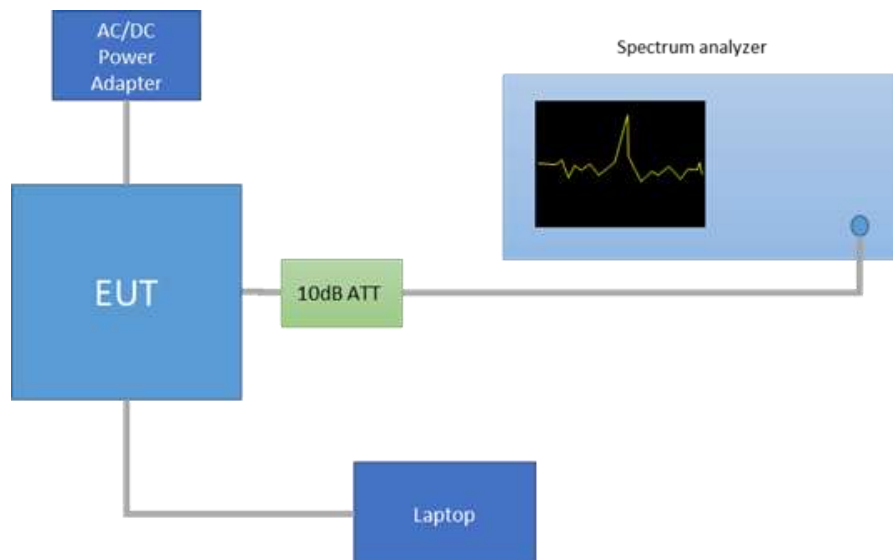
### Test procedure:

The Maximum peak conducted output power was measured using the *RBW  $\geq$  DTS 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 3.24dBi.

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	Antenna	Meas. Duty Cycle [%]	CH	Frequency [MHz]	Peak Power [dBm]		Peak Output Power [mW]
					Measured Conducted Output Power	EIRP	
BLE	Chain A Div1	62.05%	0	2402	8.01	11.25	6.32
			19	2440	8.55	11.79	7.16
			39	2480	9.00	12.24	7.94
	Chain A Div2	62.05%	0	2402	8.04	11.28	6.37
			19	2440	8.59	11.83	7.23
			39	2480	9.04	12.28	8.02

Max Value

Min Value

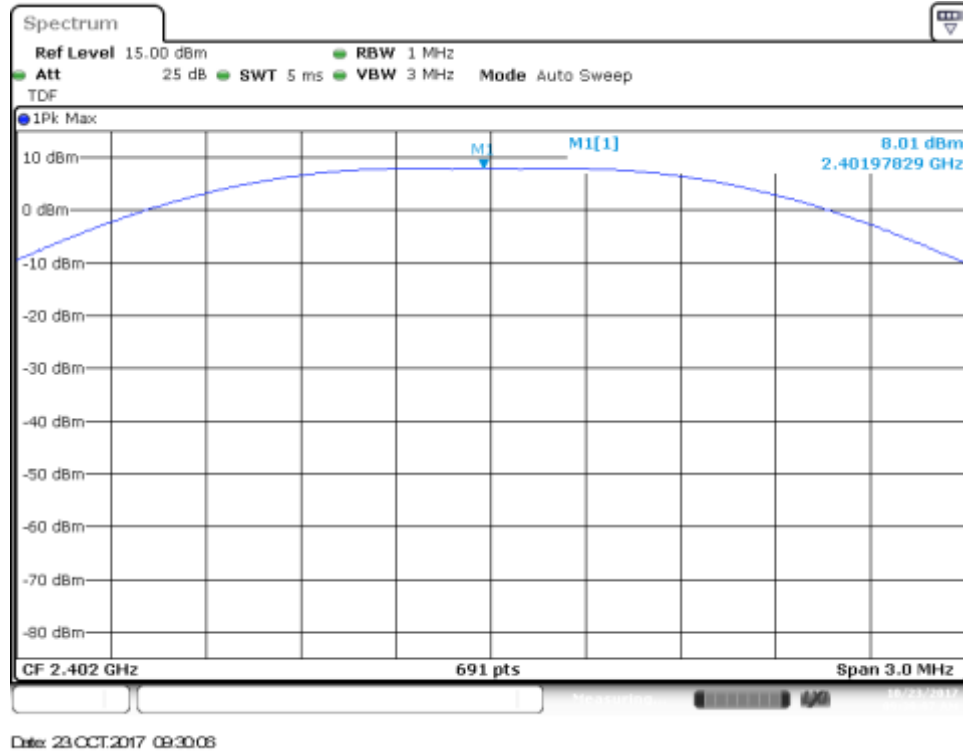
Mode	Antenna	Meas. Duty Cycle [%]	CH	Frequency [MHz]	Average Output Power* [dBm]		EIRP	Average Output Power [mW]
					Maximum Conducted Output Power	Maximum Conducted Output Power Duty cycle Compensated		
BLE	Chain A Div1	62.05%	0	2402	6.23	8.30	11.54	6.77
			19	2440	6.70	8.77	12.01	7.54
			39	2480	6.52	8.59	11.83	7.23
	Chain A Div2	62.05%	0	2402	5.79	7.86	11.10	6.11
			19	2440	6.38	8.45	11.69	7.00
			39	2480	6.14	8.21	11.45	6.63

\* Output Power RMS values are shown for indicative purpose only

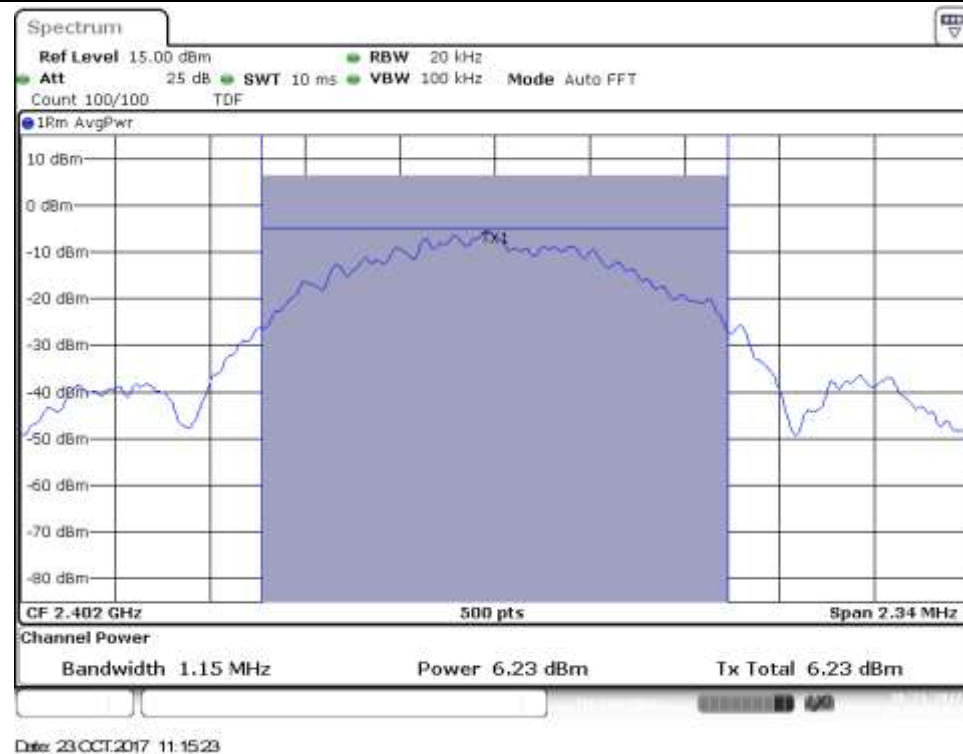
Results screenshot

## BLE

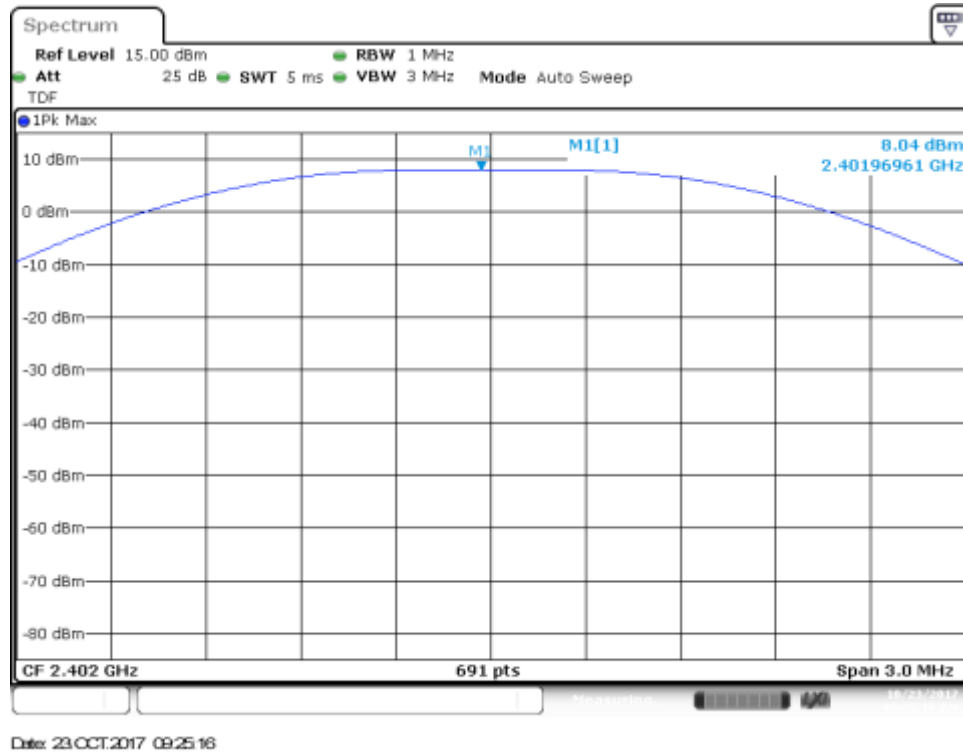
### CHAIN A DIV1\_Max Power Peak – CH0



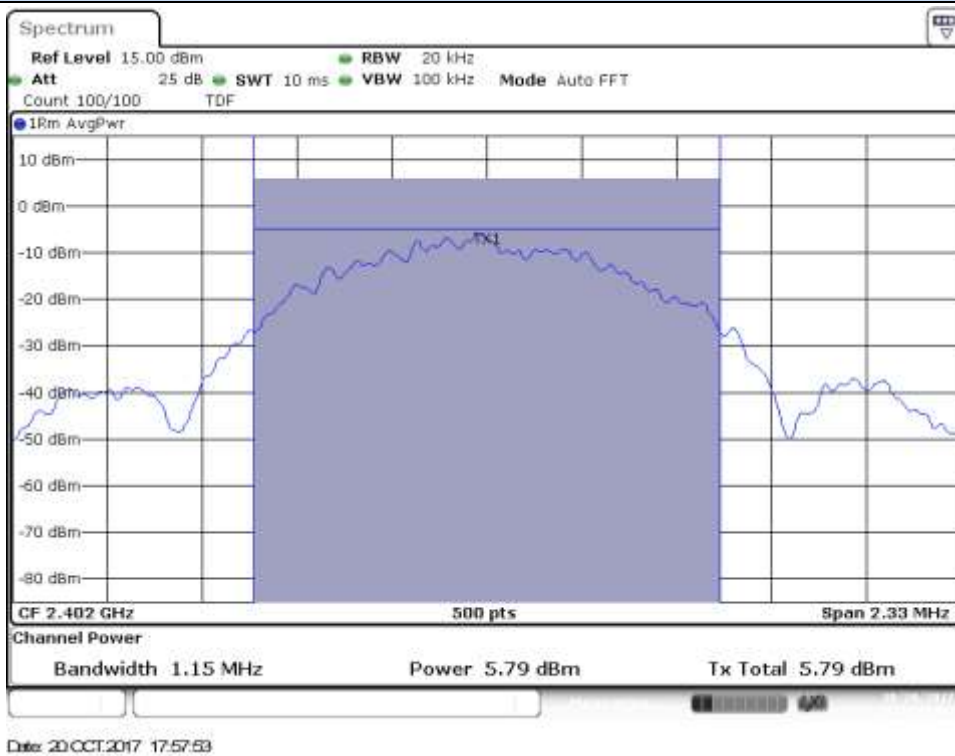
### CHAIN A DIV1\_Max Power RMS – CH0



### CHAIN A DIV2\_Max Power Peak – CH0

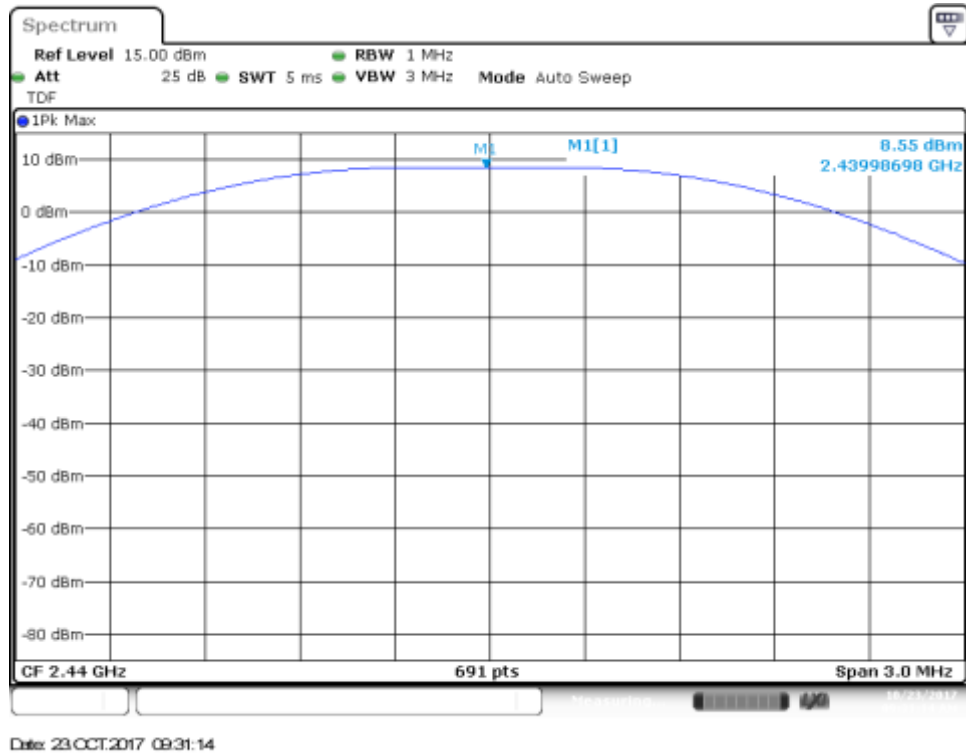


### CHAIN A DIV2\_Max Power RMS – CH0

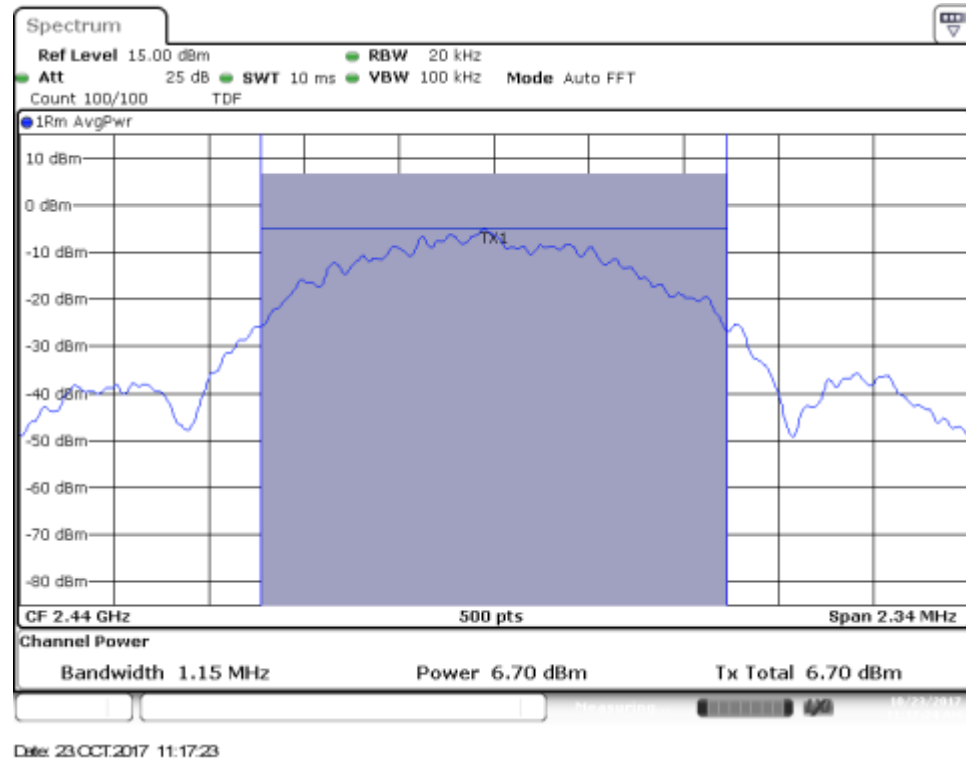


## BLE

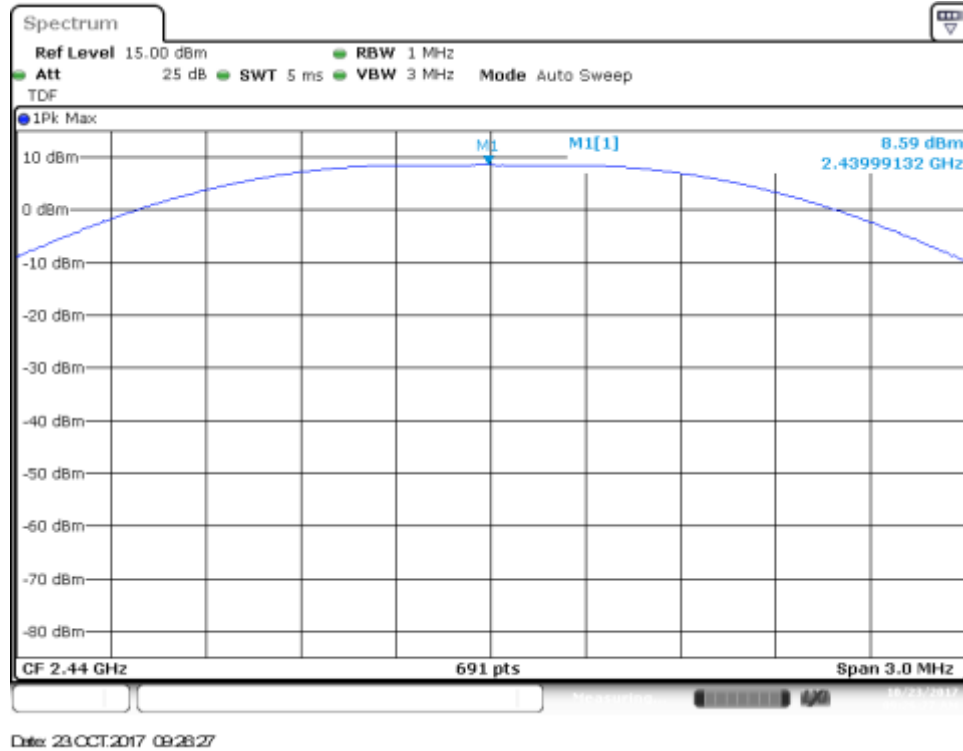
### CHAIN A DIV1\_Max Power Peak – CH19



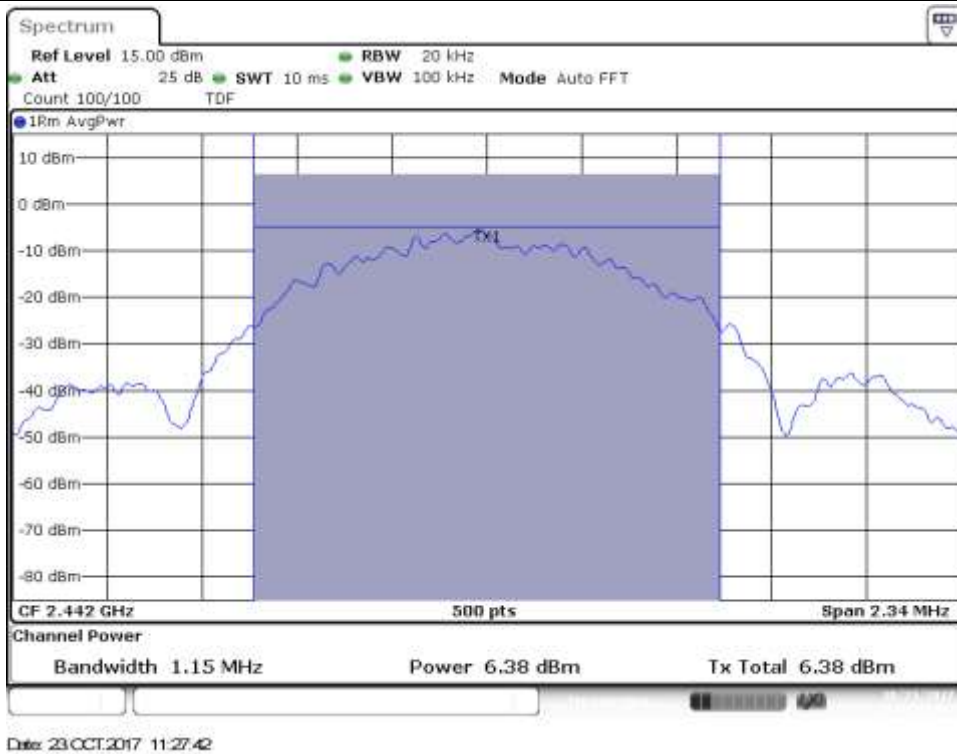
### CHAIN A DIV1\_Max Power RMS – CH19



### CHAIN A DIV2\_Max Power Peak – CH19



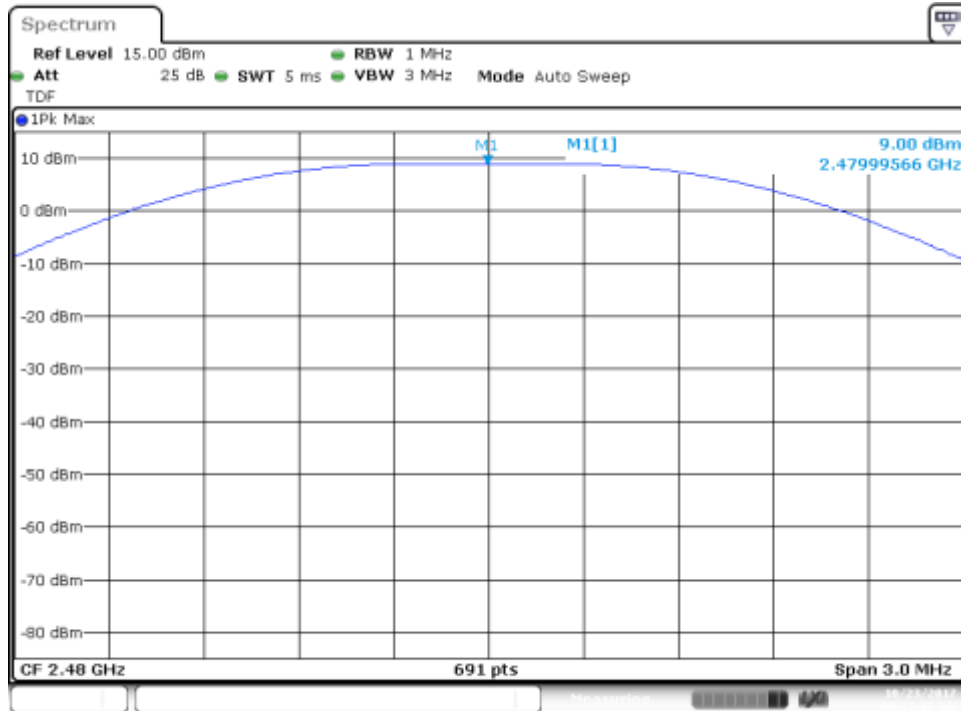
### CHAIN A DIV2\_Max Power RMS – CH19





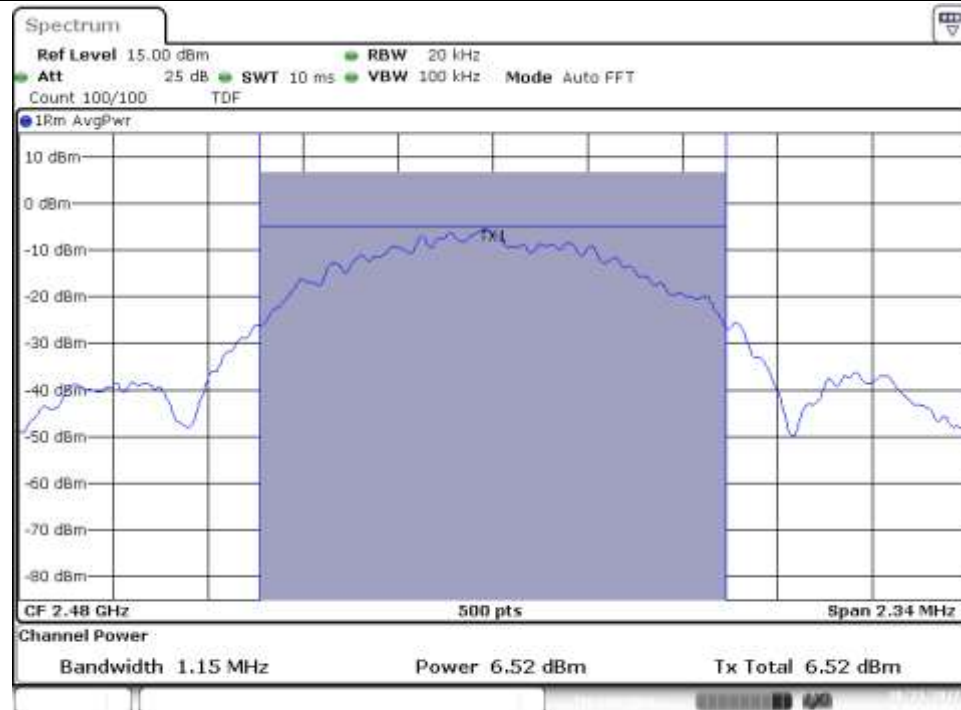
## BLE

### CHAIN A DIV1\_Max Power Peak – CH39



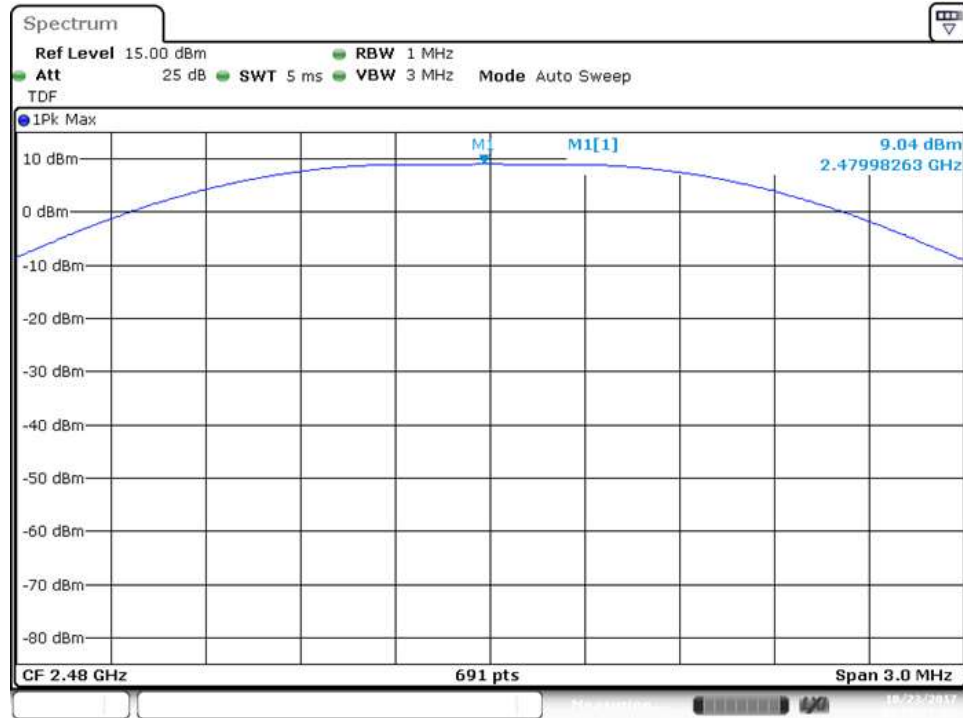
Date: 23 OCT.2017 09:31:48

### CHAIN A DIV1\_Max Power RMS – CH39

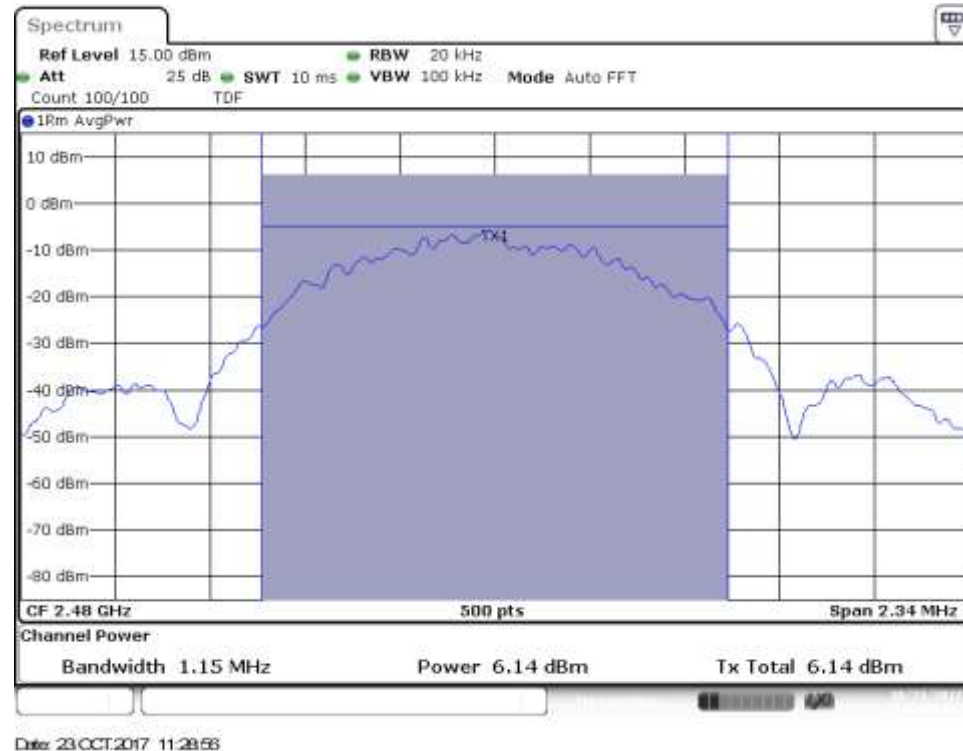


Date: 23 OCT.2017 10:03:49

## CHAIN A DIV2\_Max Power Peak – CH39



## CHAIN A DIV2\_Max Power RMS – CH39



### C.1.3 Power Spectral Density

#### Test limits

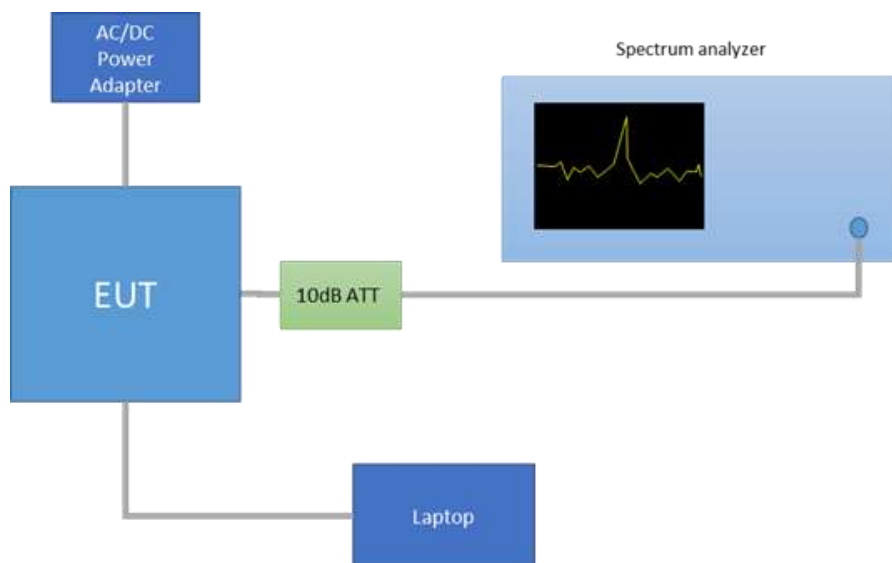
FCC part	RSS part	Limits
15.247 (e)	RSS-247 Clause 5.2 (b)	For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density 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 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 3.24dBi.

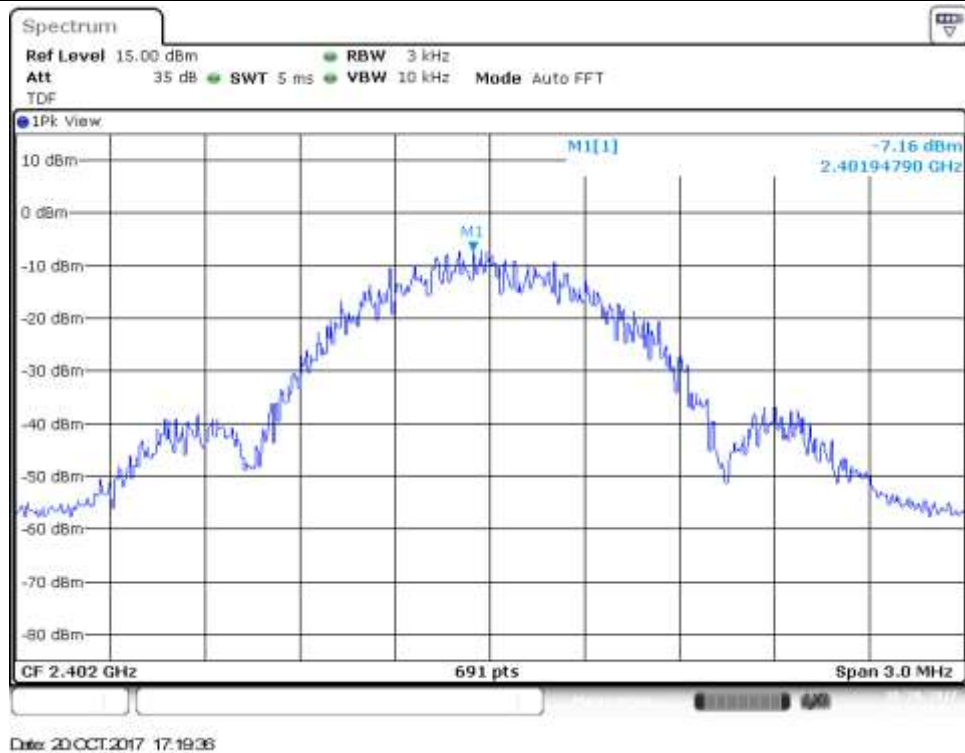


#### Results tables

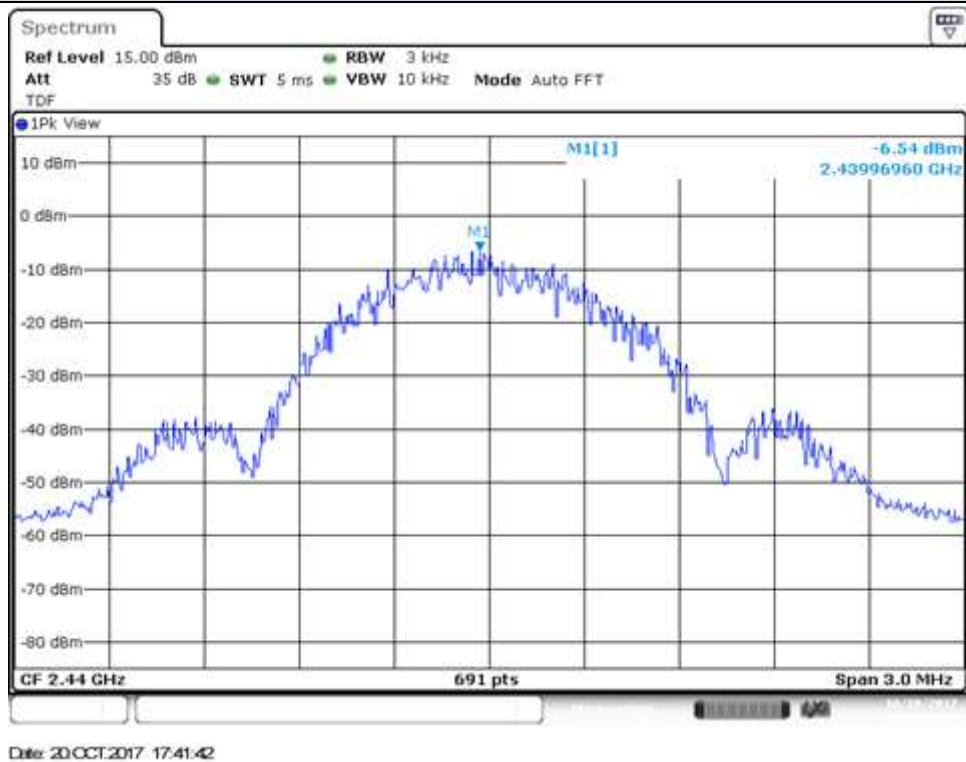
Mode	Antenna	CH	Frequency [MHz]	PSD Peak [dBm]
BLE	A	0	2402	-7.16
		19	2440	-6.54
		39	2480	-6.16
	B	0	2402	-7.10
		19	2440	-6.44
		39	2480	-6.01

## BLE

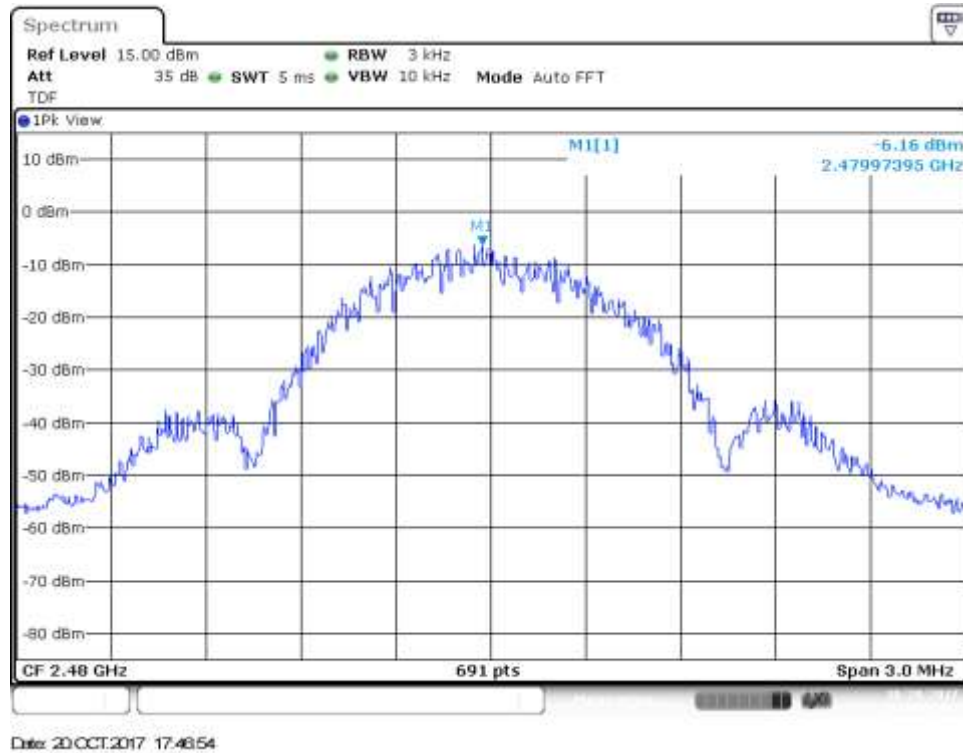
### CHAIN A DIV1\_PSD Peak – CH0



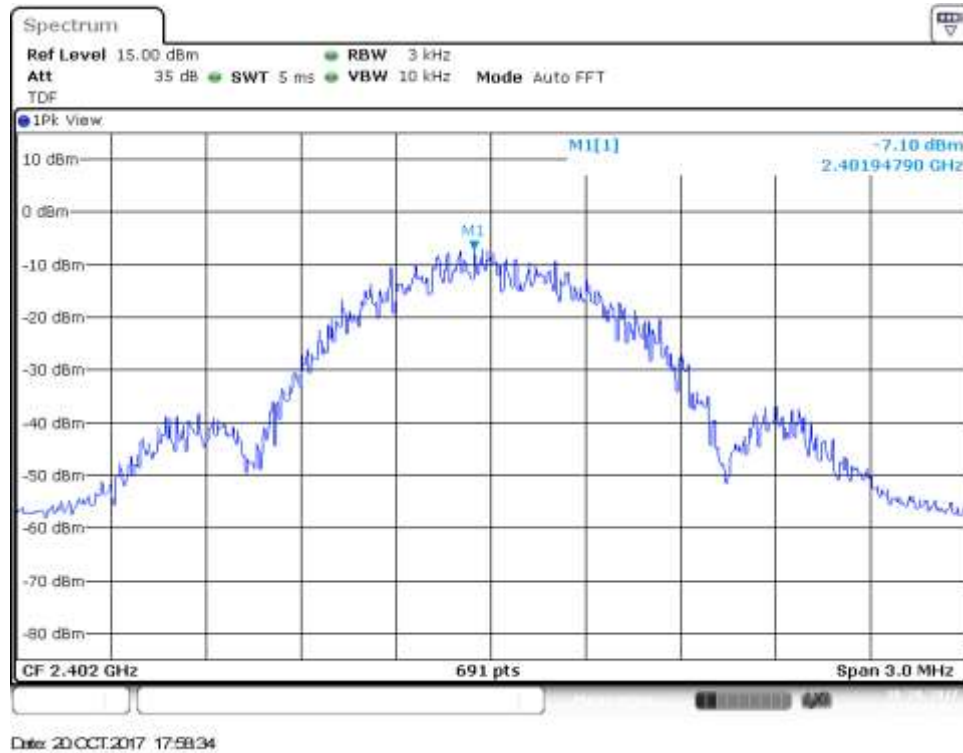
### CHAIN A DIV1\_PSD Peak – CH19



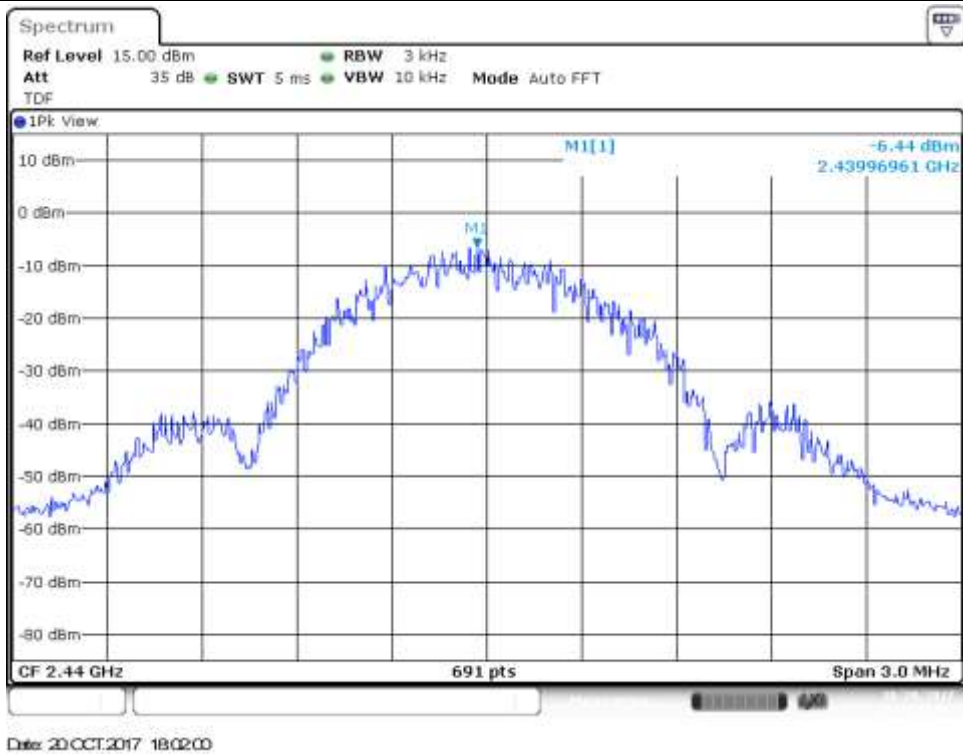
CHAIN A DIV1\_PSD Peak – CH39



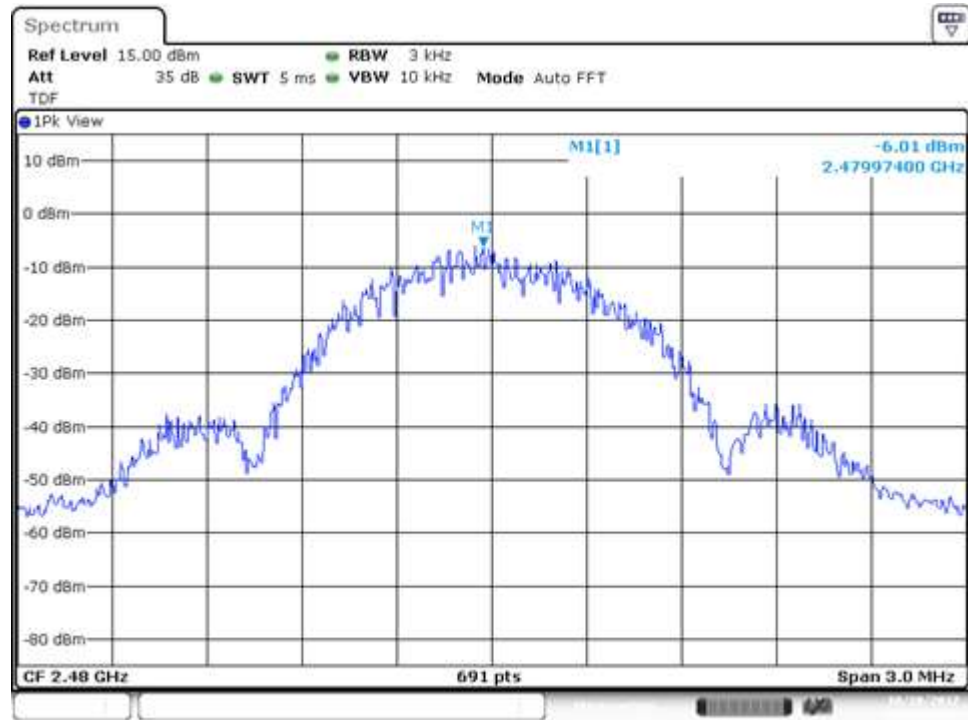
## CHAIN A DIV2\_PSD Peak – CH0



## CHAIN A DIV2\_PSD Peak – CH19



CHAIN A DIV2\_PSD Peak – CH39



Date: 20.OCT.2017 18:07:44



## C.1.4 Out-of-band emission (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-Gen Clause 8.9	<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><tr><th>Freq Range (MHz)</th><th>Field Streghth (μV/m)</th><th>Field Streghth (dBμV/m)</th><th>Meas. Distance (m)</th></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>Above 960</td><td>500</td><td>54</td><td>3</td></tr></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 Streghth (μV/m)	Field Streghth (dBμV/m)	Meas. Distance (m)	30-88	100	40	3	88-216	150	43.5	3	216-960	200	46	3	Above 960	500	54	3
Freq Range (MHz)	Field Streghth (μV/m)	Field Streghth (dBμV/m)	Meas. Distance (m)																			
30-88	100	40	3																			
88-216	150	43.5	3																			
216-960	200	46	3																			
Above 960	500	54	3																			

### Test procedure

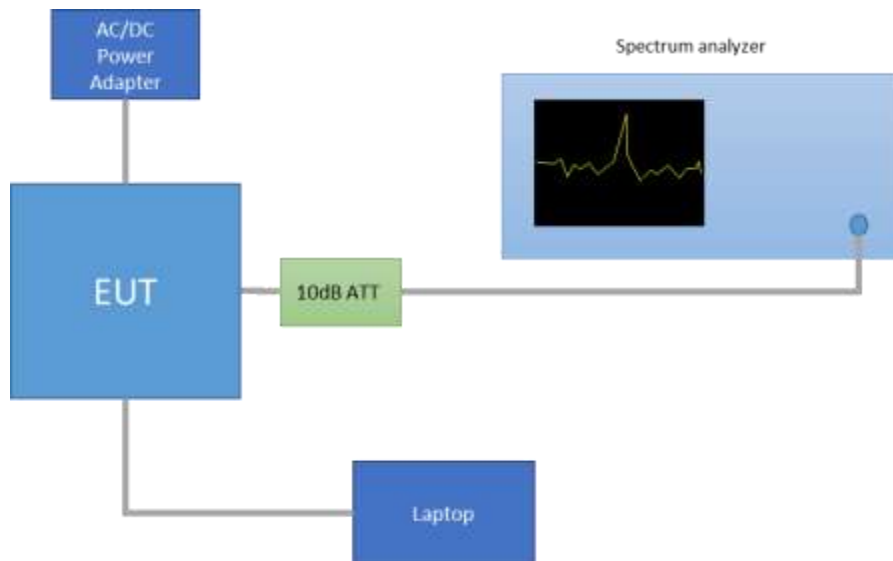
The setup below was used to measure the out-of-band emissions. The antenna terminal of the EUT is connected to the spectrum through an attenuator, and the spectrum analyzer reading is compensated to include the RF path loss.

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 3.24dBi.

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 dBμV/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)
Above 960	3	500	54.0	-41.2

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.

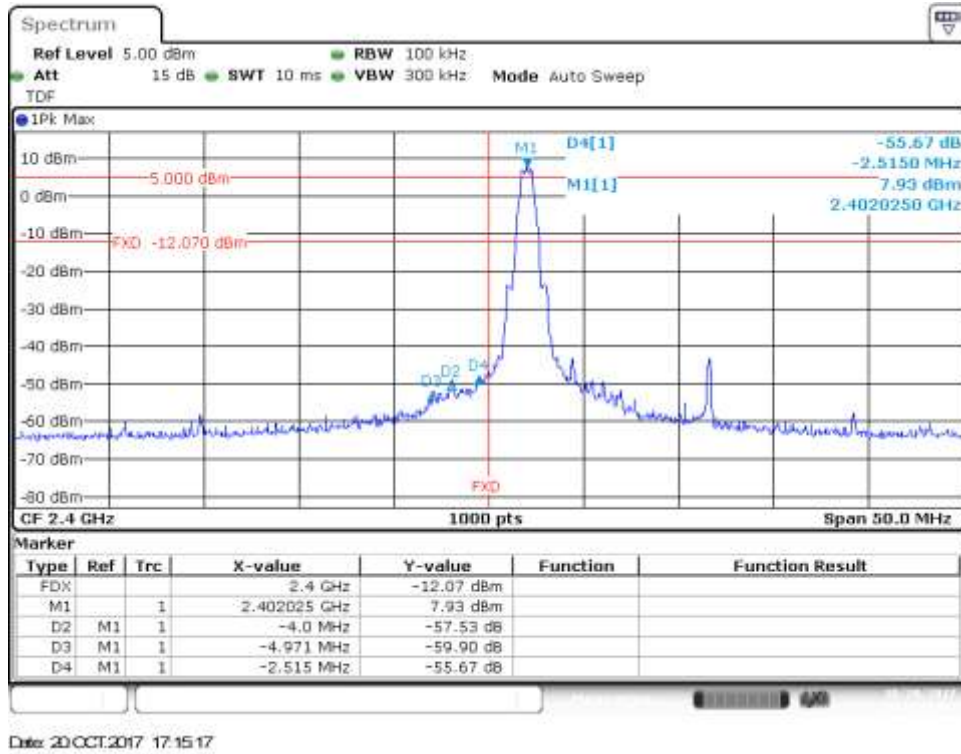


Note: these PSD<sub>Peak</sub> values are shown just as a reference for the compliance of the Out-of-band Measurements. Thus the RBW used for these measurements was 100kHz.

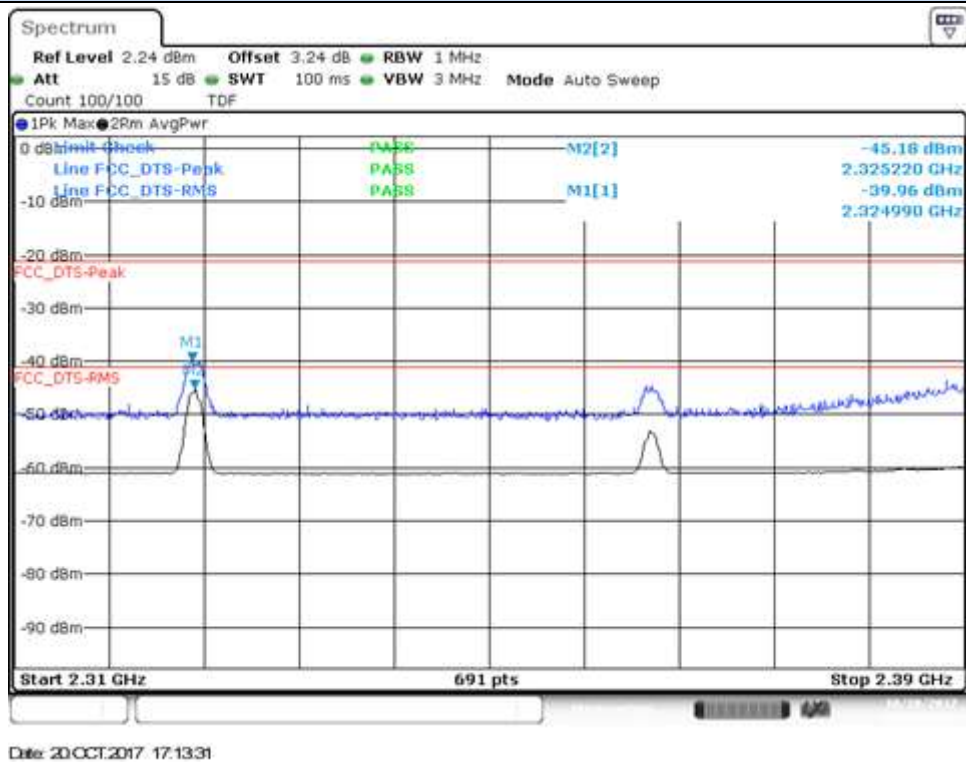
Mode	Antenna	CH	Frequency [MHz]	PSD Peak [dBm]
BLE	Chain A Div1	0	2402	7.93
		19	2440	8.34
		39	2480	8.77
	Chain A Div2	0	2402	7.91
		19	2440	8.41
		39	2480	8.84

## BLE

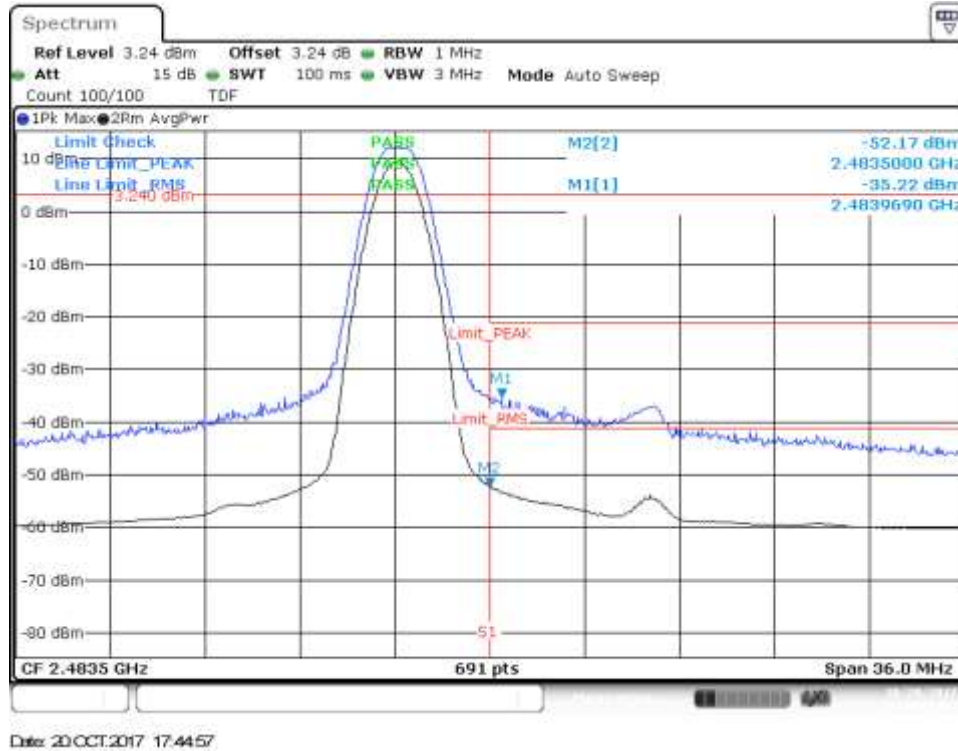
### CHAIN A DIV1\_BE Low Freq Section – CH0



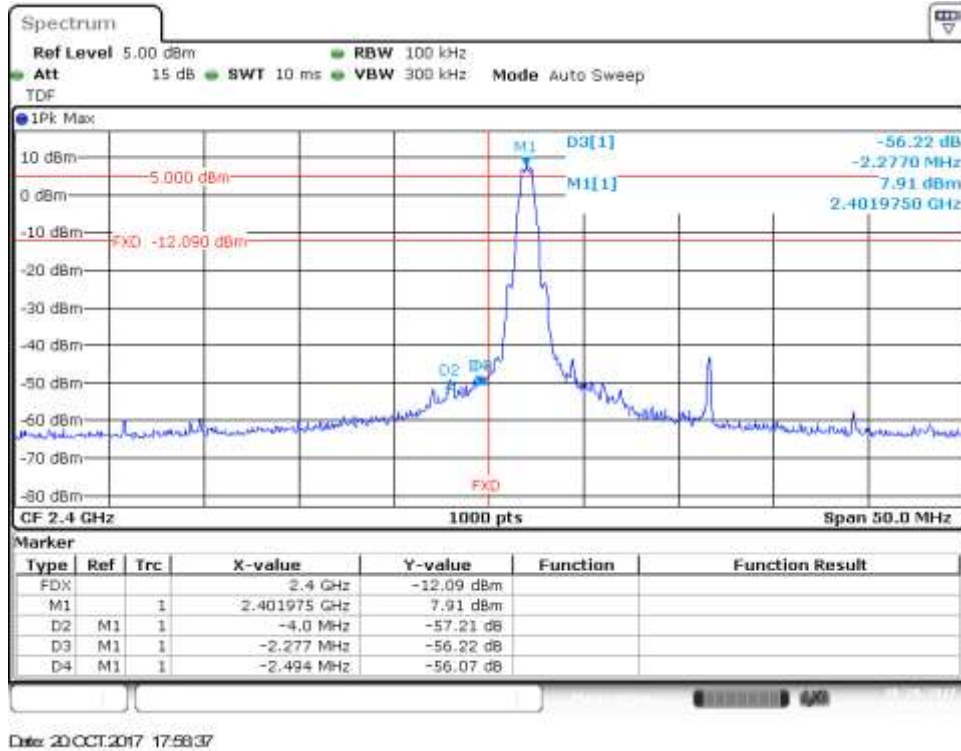
### CHAIN A DIV1\_BE Low (Non Restricted) – CH0



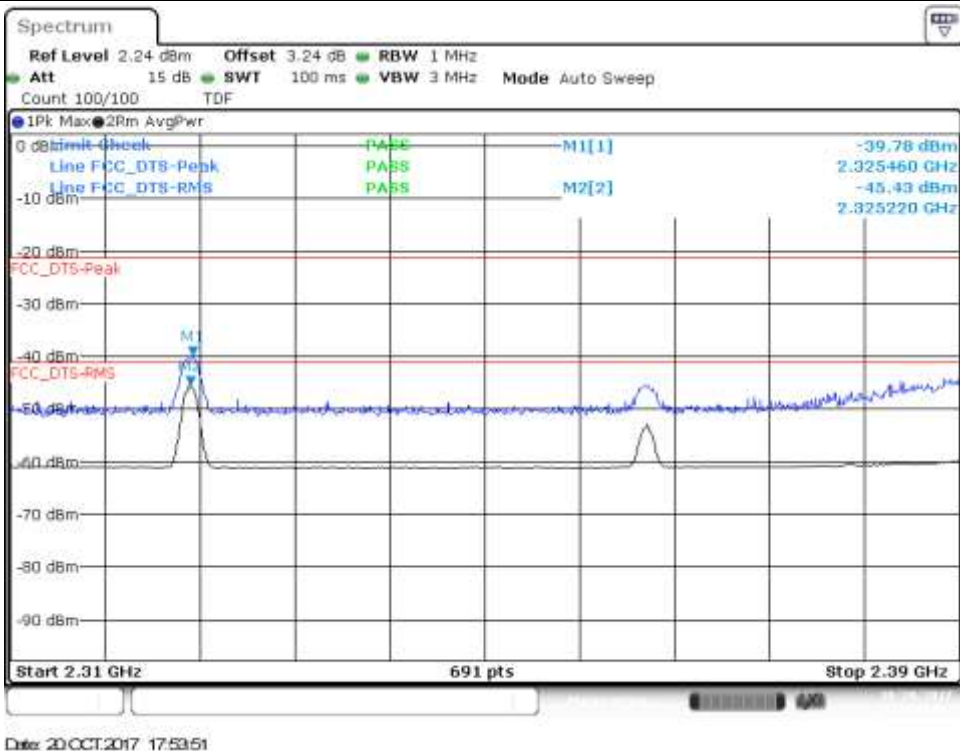
CHAIN A DIV1\_BE High Freq Section (Restricted) – CH39



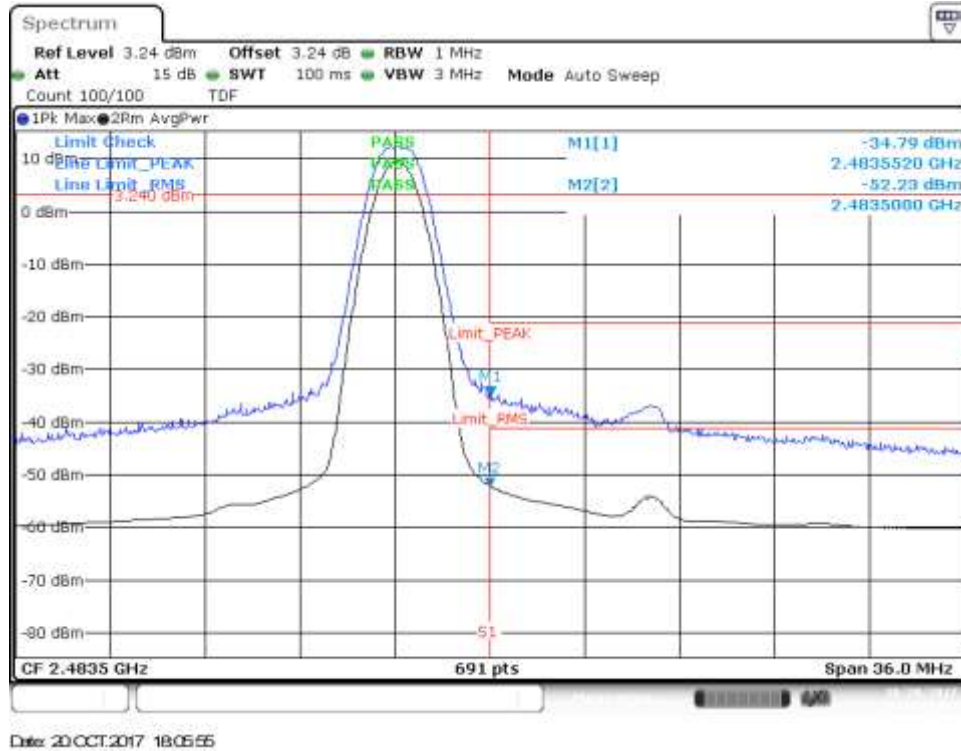
## CHAIN A DIV2\_BE Low Freq Section – CH0



## CHAIN A DIV2\_BE Low (Non Restricted) – CH0

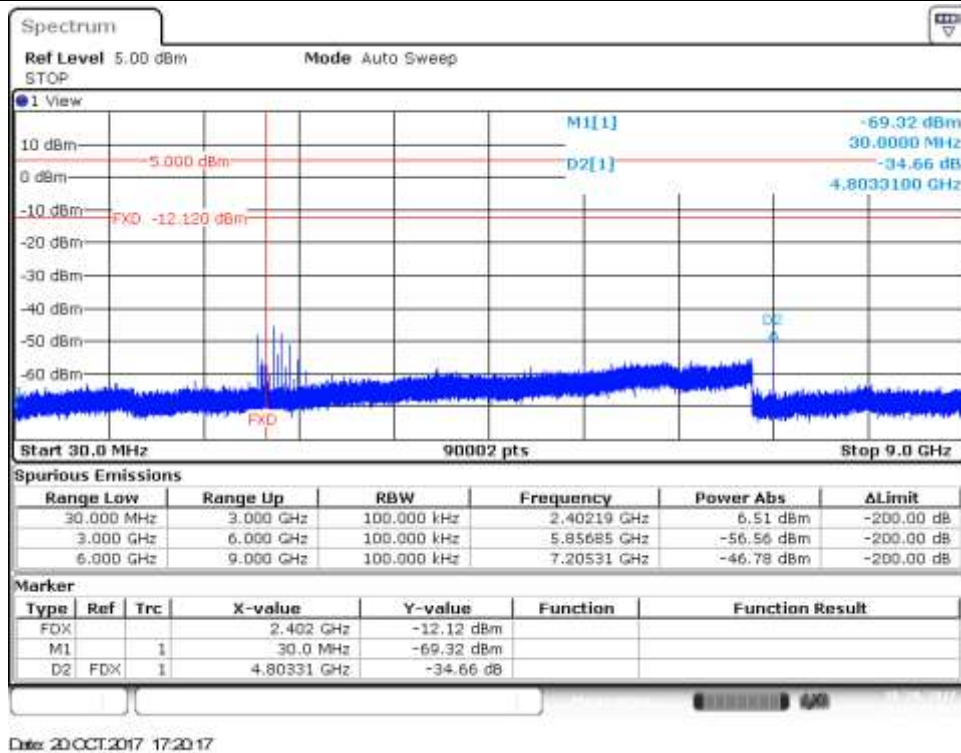


CHAIN A DIV2\_BE High Freq Section (Restricted) – CH39

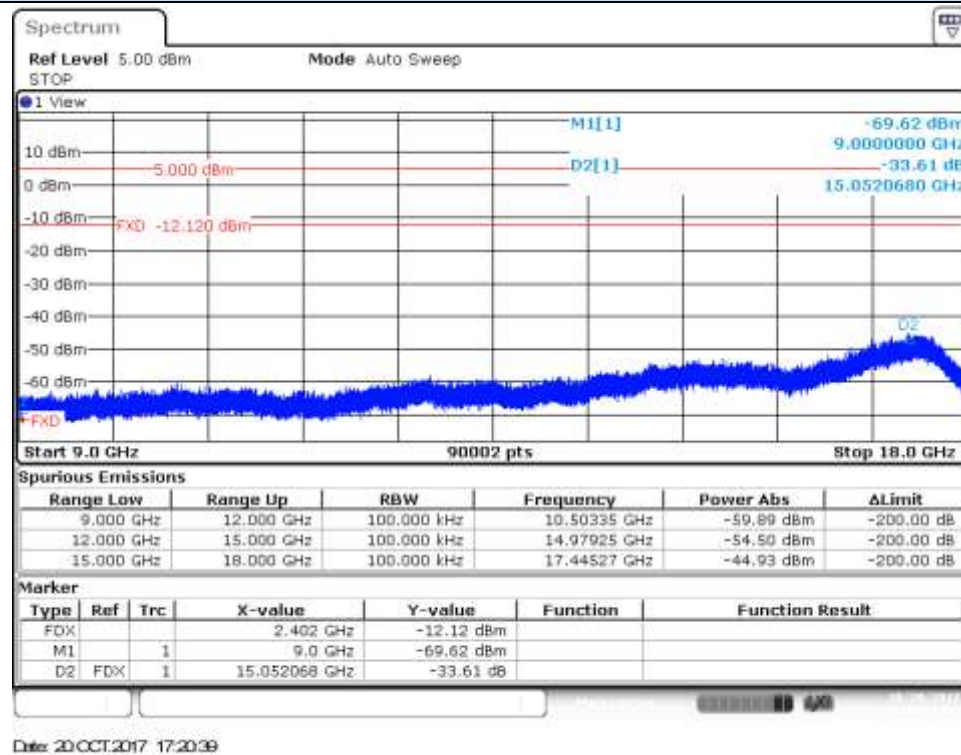


## BLE, CH0

### CHAIN A DIV1\_Cond Spur, 30MHz – 9GHz

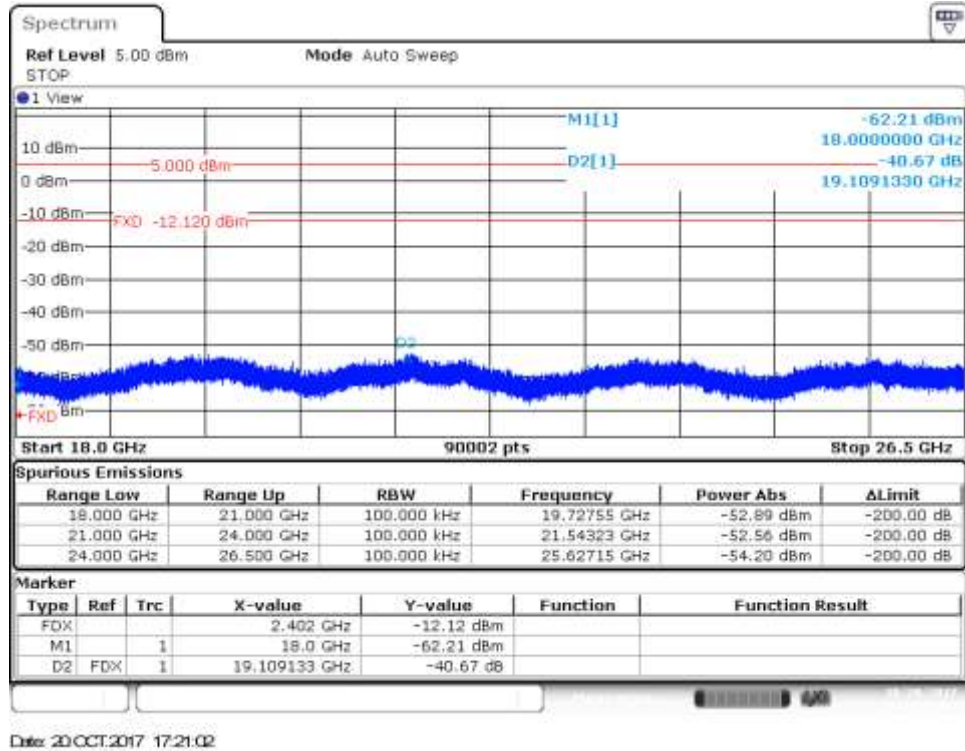


### CHAIN A DIV1\_Cond Spur, 9GHz – 18GHz

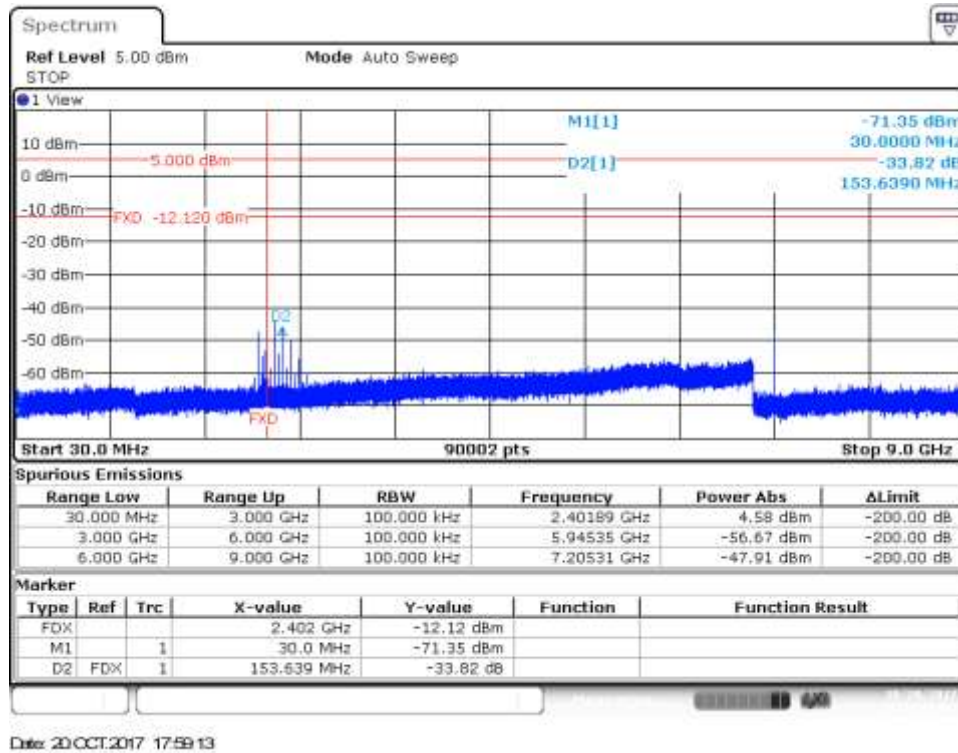




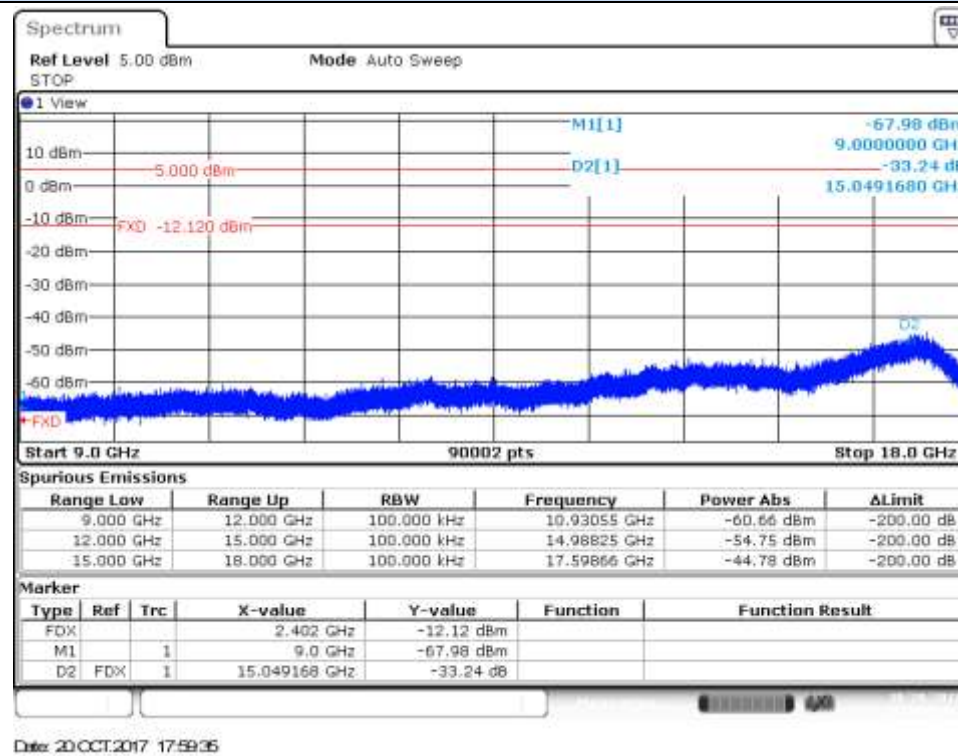
CHAIN A DIV1\_Cond Spur,18GHz – 26.5GHz



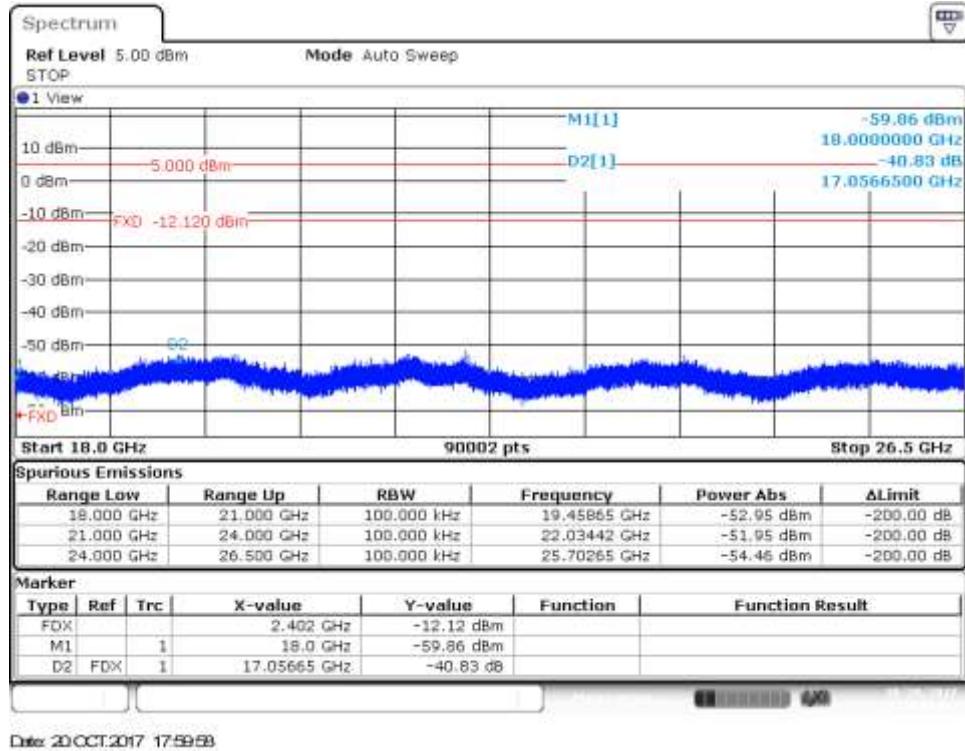
## CHAIN A DIV2\_Cond Spur, 30MHz – 9GHz



## CHAIN A DIV2\_Cond Spur, 9GHz – 18GHz

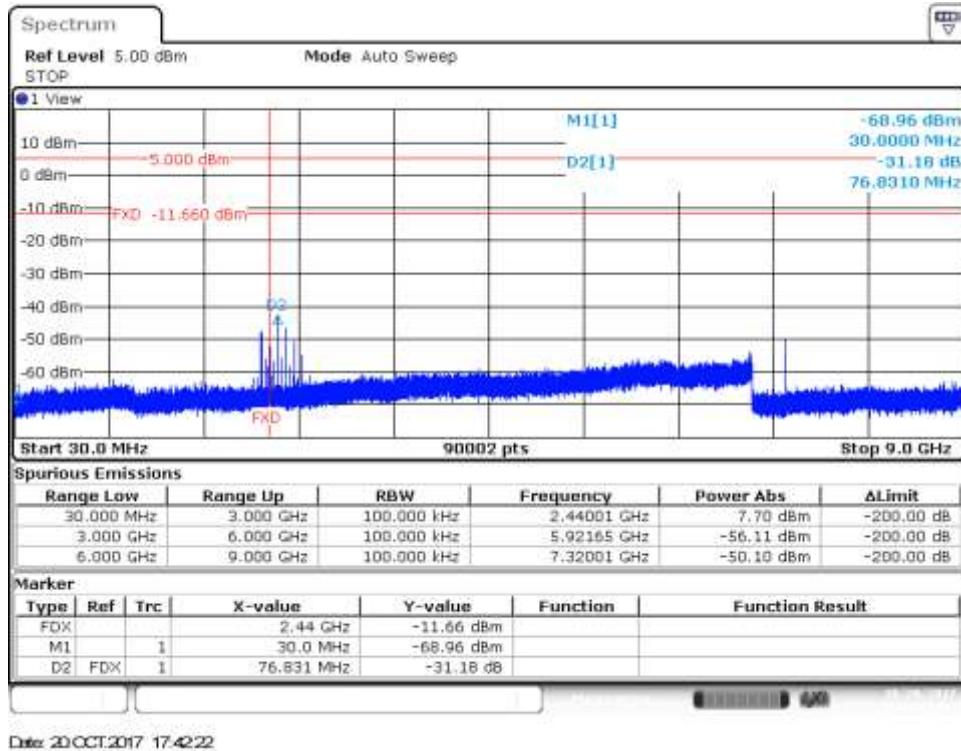


CHAIN A DIV2\_Cond Spur,18GHz – 26.5GHz

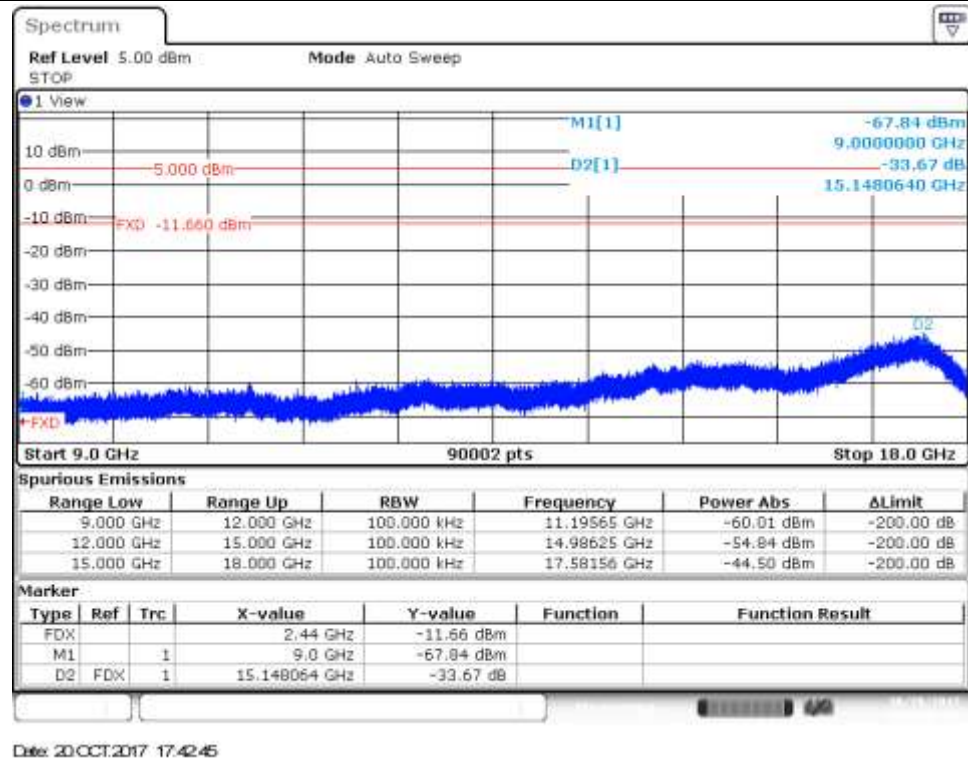


## BLE, CH19

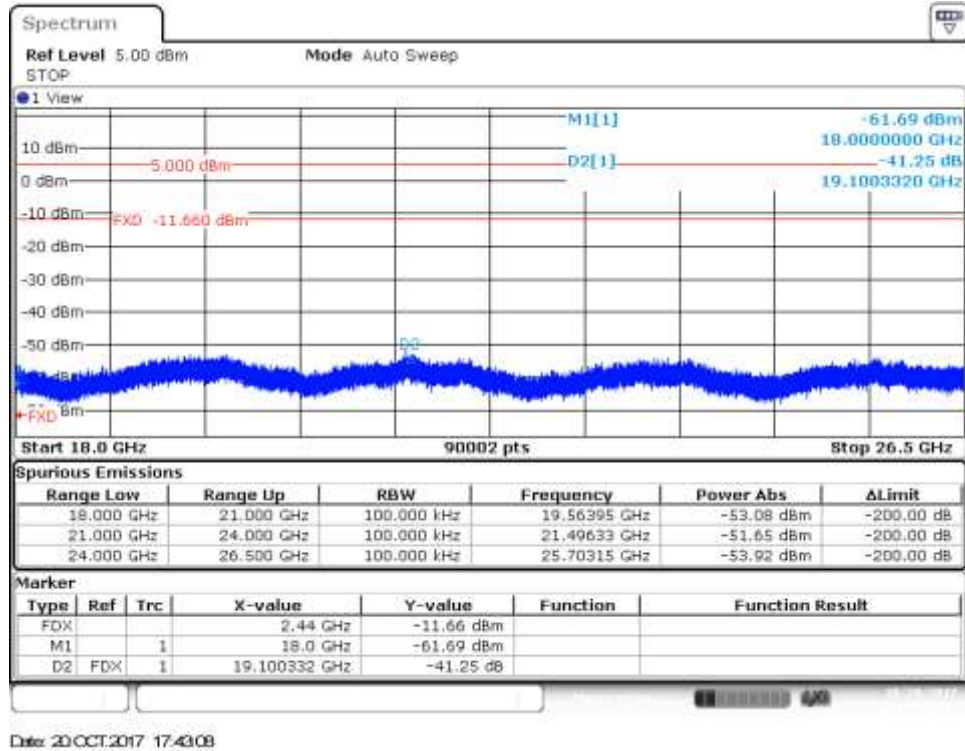
### CHAIN A DIV1\_Cond Spur, 30MHz – 9GHz



### CHAIN A DIV1\_Cond Spur, 9GHz – 18GHz

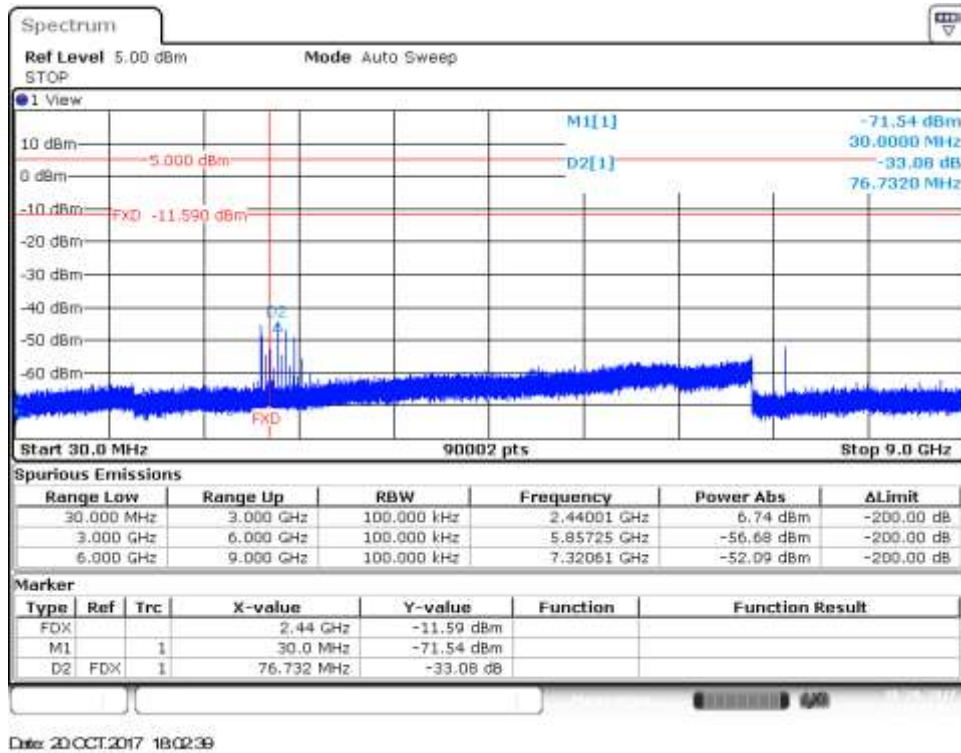


CHAIN A DIV1\_Cond Spur,18GHz – 26.5GHz

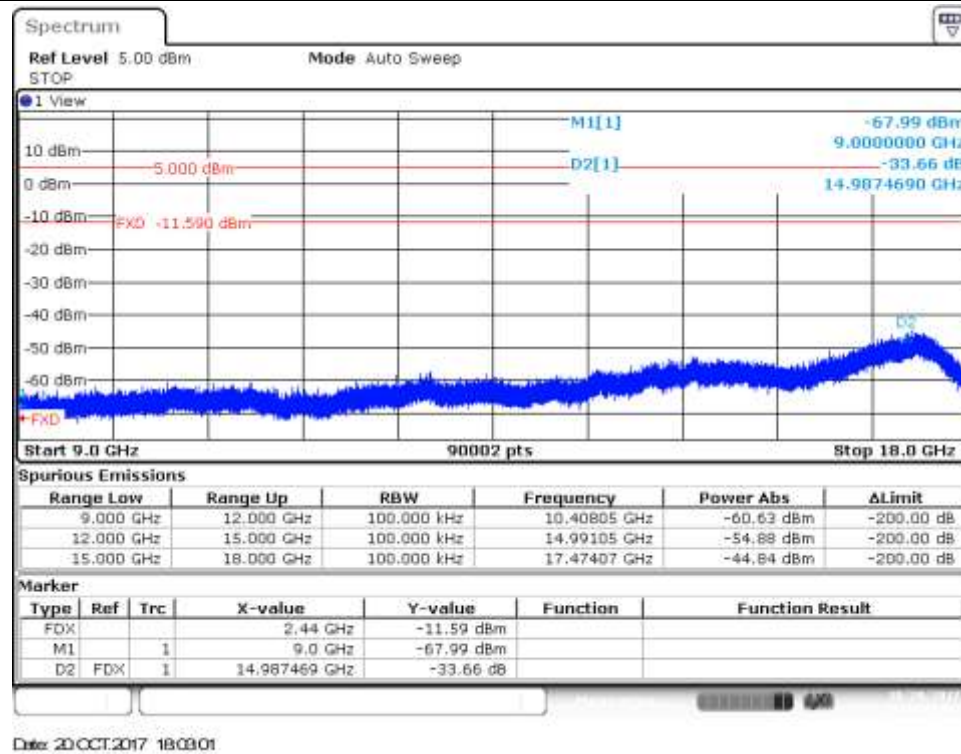




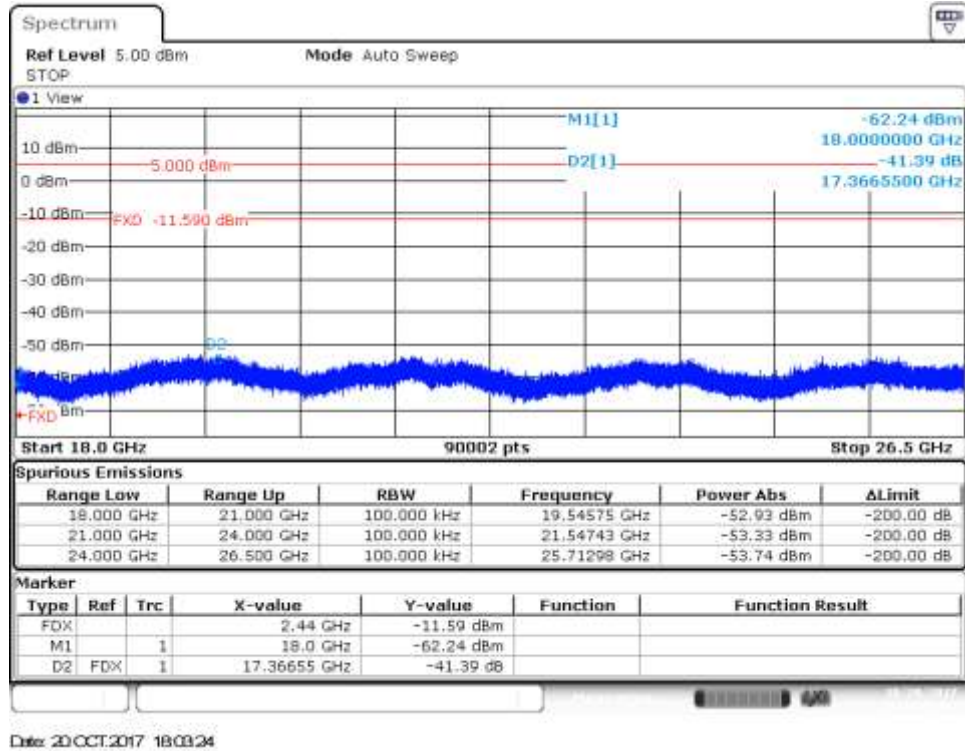
## CHAIN A DIV2\_Cond Spur, 30MHz – 9GHz



## CHAIN A DIV2\_Cond Spur, 9GHz – 18GHz

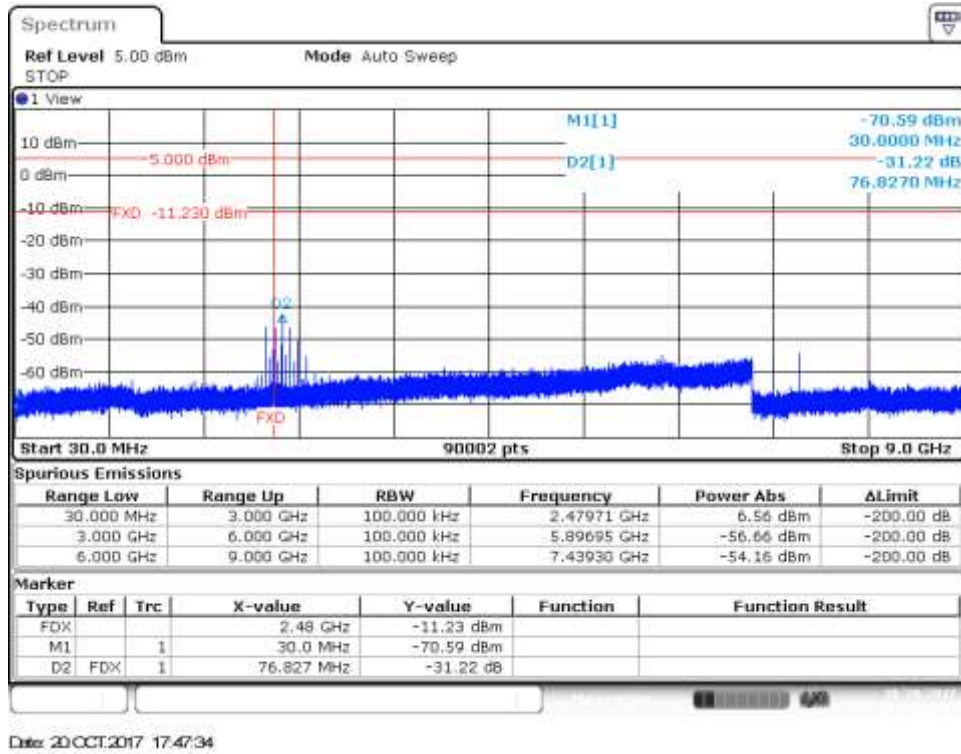


CHAIN A DIV2\_Cond Spur,18GHz – 26.5GHz

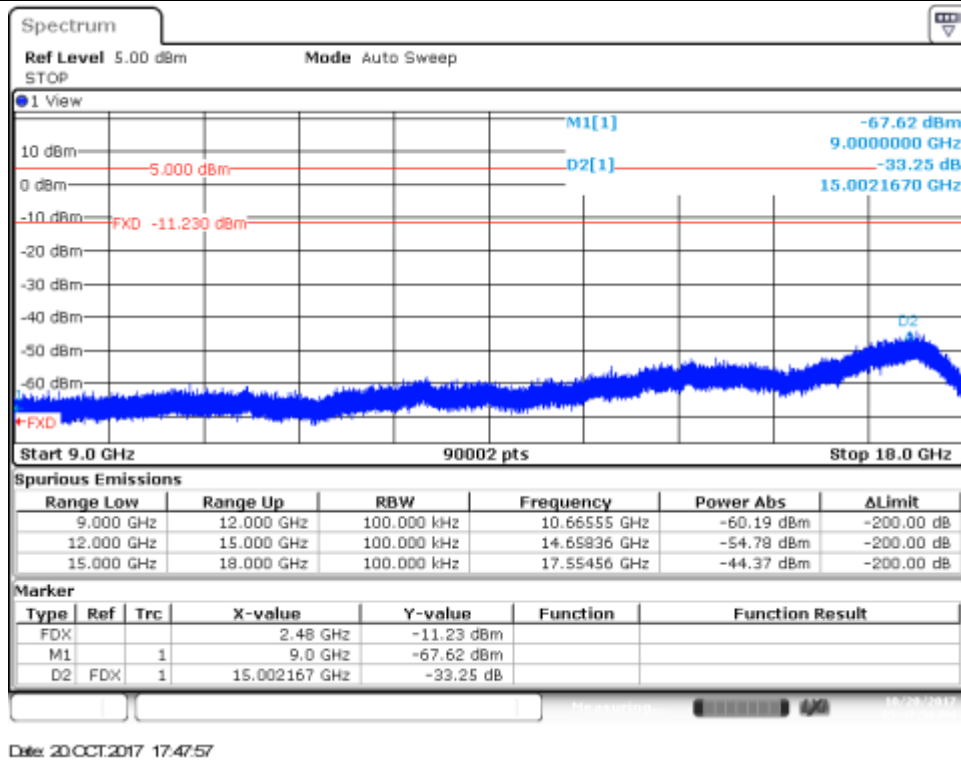


## BLE, CH39

### CHAIN A DIV1\_Cond Spur, 30MHz – 9GHz

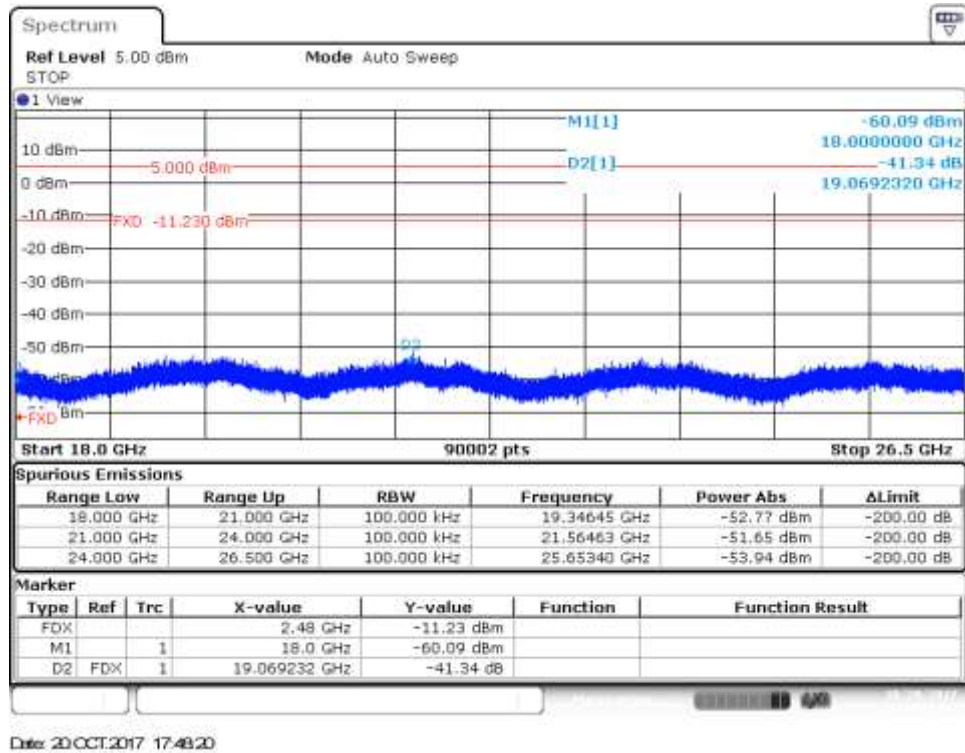


### CHAIN A DIV1\_Cond Spur, 9GHz – 18GHz

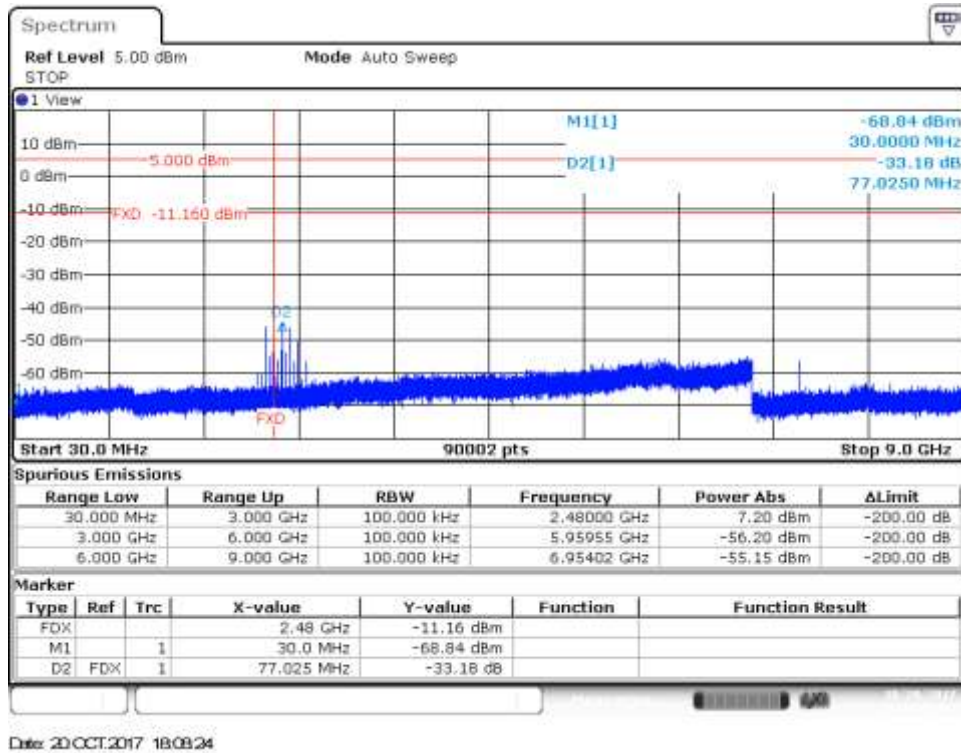




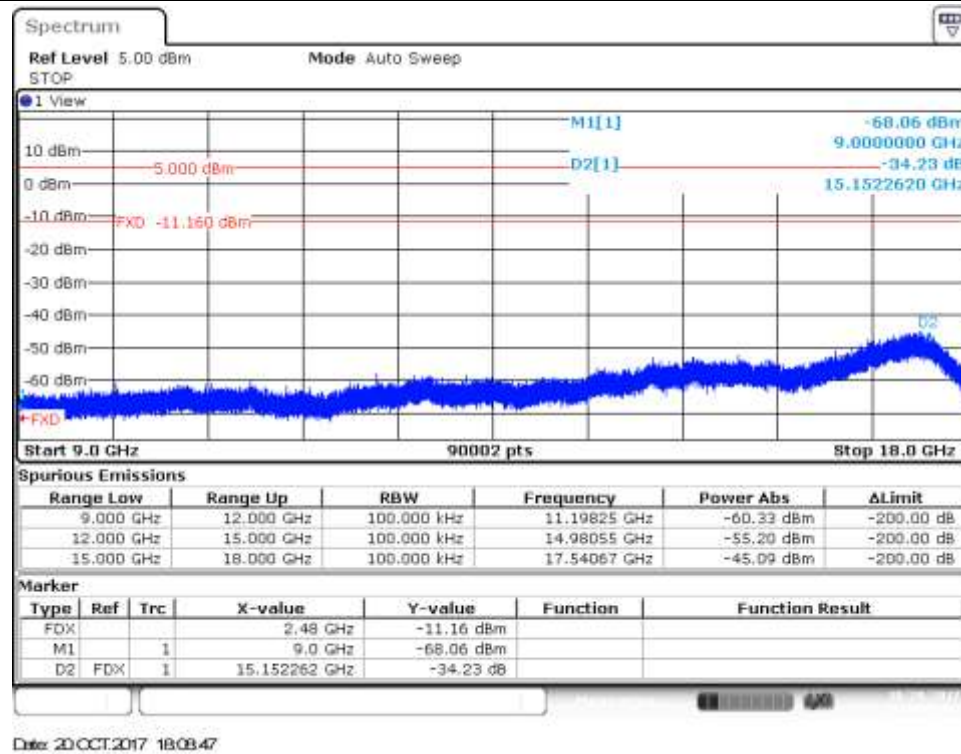
## CHAIN A DIV1\_Cond Spur,18GHz – 26.5GHz



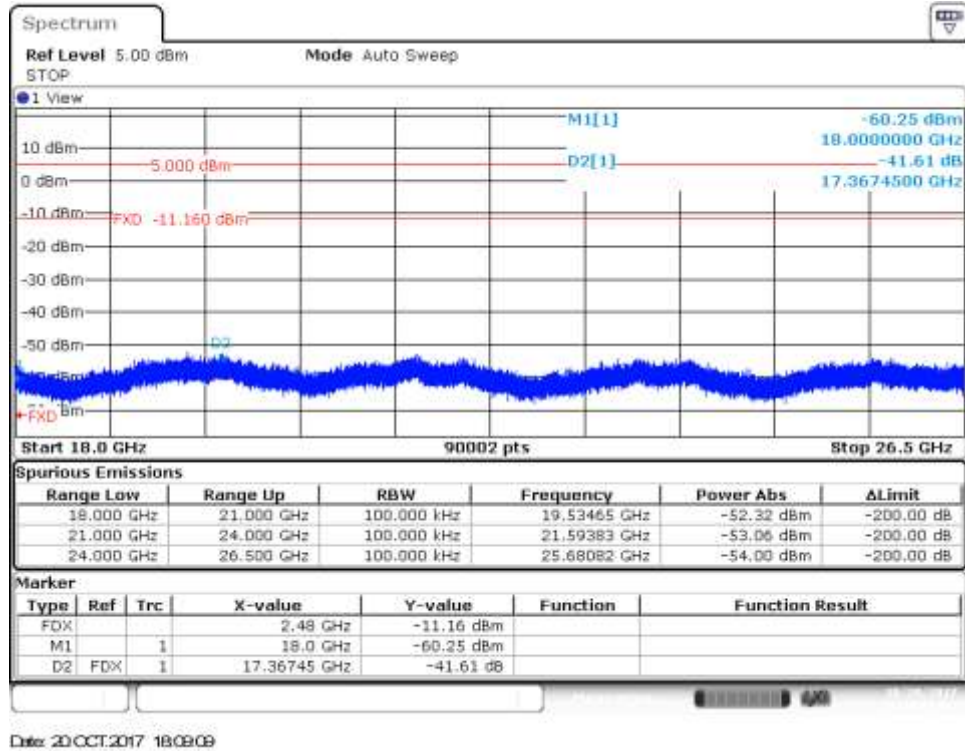
## CHAIN A DIV2\_Cond Spur, 30MHz – 9GHz



## CHAIN A DIV2\_Cond Spur, 9GHz – 18GHz



CHAIN A DIV2\_Cond Spur,18GHz – 26.5GHz



## C.1.5 Radiated spurious emission

### Standards references

FCC part	RSS part	Limits																				
15.247 (d) 15.209	RSS-247 Clause 5.5 RSS-Gen Clause 8.9	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):																				
		<table><tr><th>Freq Range (MHz)</th><th>Field Streghth (μV/m)</th><th>Field Streghth (dBμV/m)</th><th>Meas. Distance (m)</th></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>Above 960</td><td>500</td><td>54</td><td>3</td></tr></table>	Freq Range (MHz)	Field Streghth (μV/m)	Field Streghth (dBμV/m)	Meas. Distance (m)	30-88	100	40	3	88-216	150	43.5	3	216-960	200	46	3	Above 960	500	54	3
		Freq Range (MHz)	Field Streghth (μV/m)	Field Streghth (dBμV/m)	Meas. Distance (m)																	
		30-88	100	40	3																	
		88-216	150	43.5	3																	
		216-960	200	46	3																	
		Above 960	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 specified when measuring with peak detector function, corresponding to 20 dB above the indicated values in the table.																						

### Test procedure

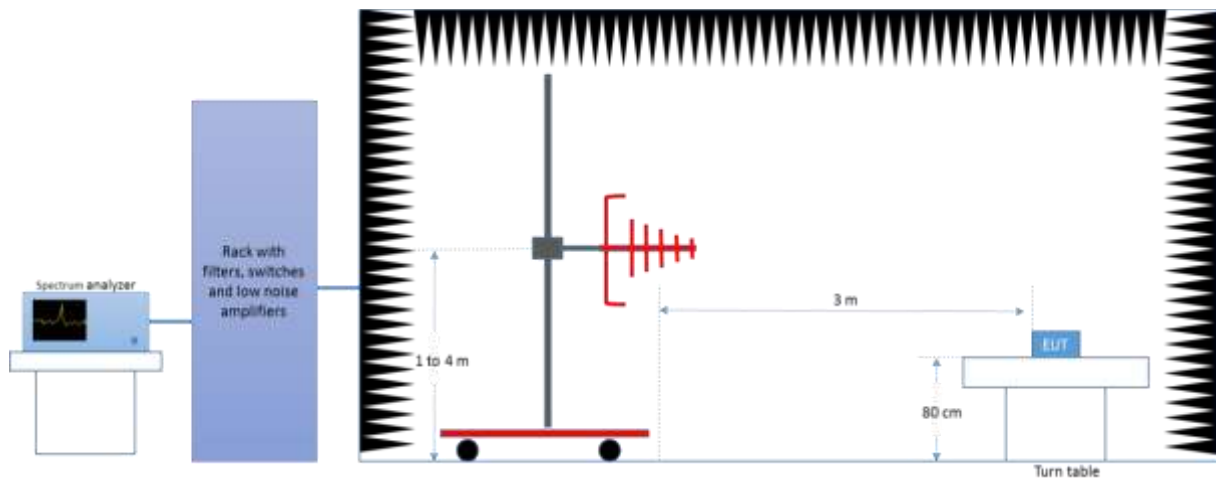
The setups below were used to measure the radiated spurious emissions.

Depending of the frequency range and bands being tested, different antennas and filters were used.

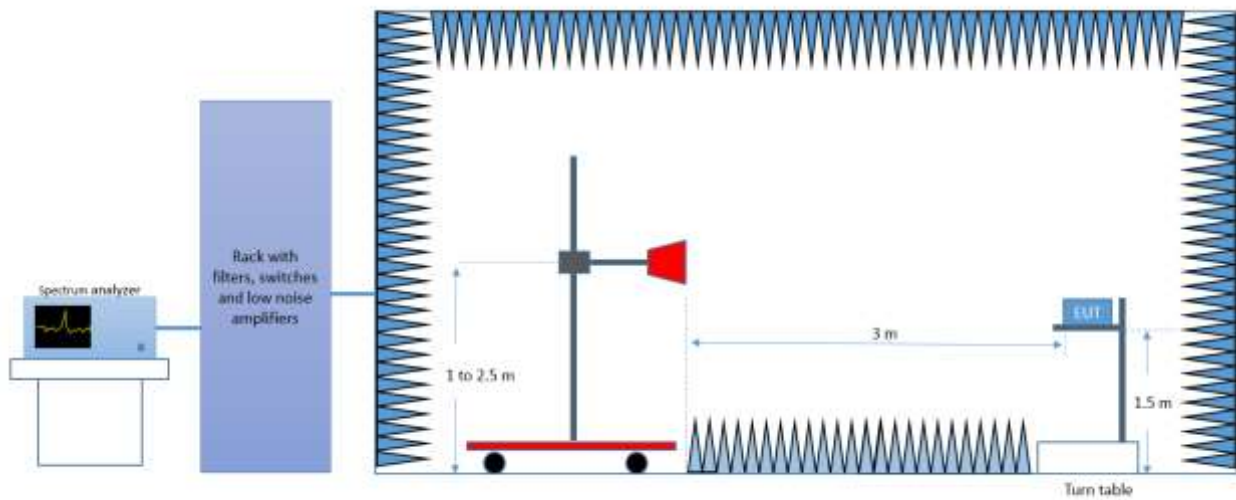
The final measurement is done by varying the antenna height from 1 to 4 meters, the EUT azimuth over 360° and for both Vertical and Horizontal polarizations.

The radiated spurious emissions were measured on the lowest, middle and highest channels.

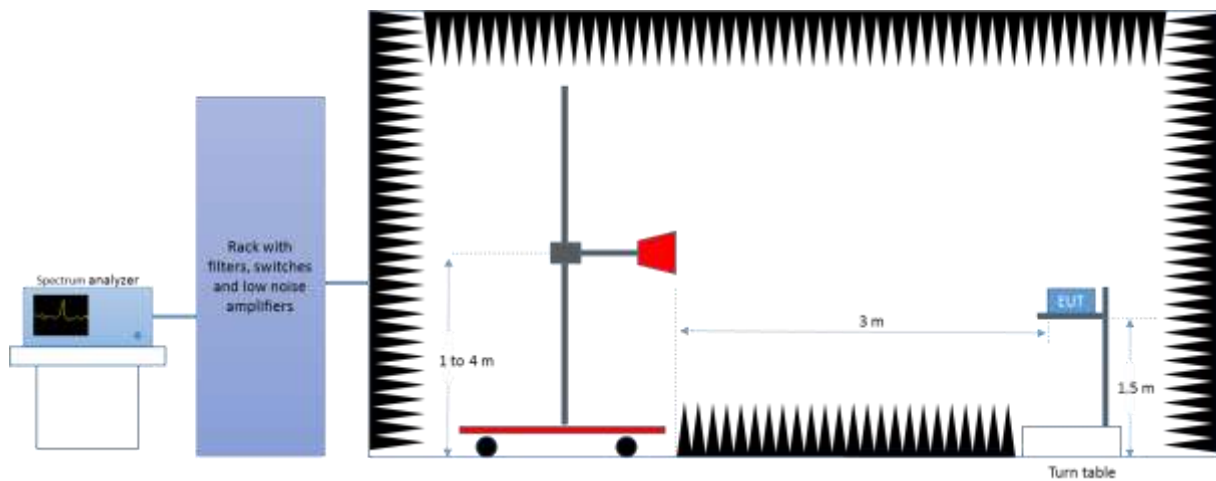
### Radiated Setup < 1GHz



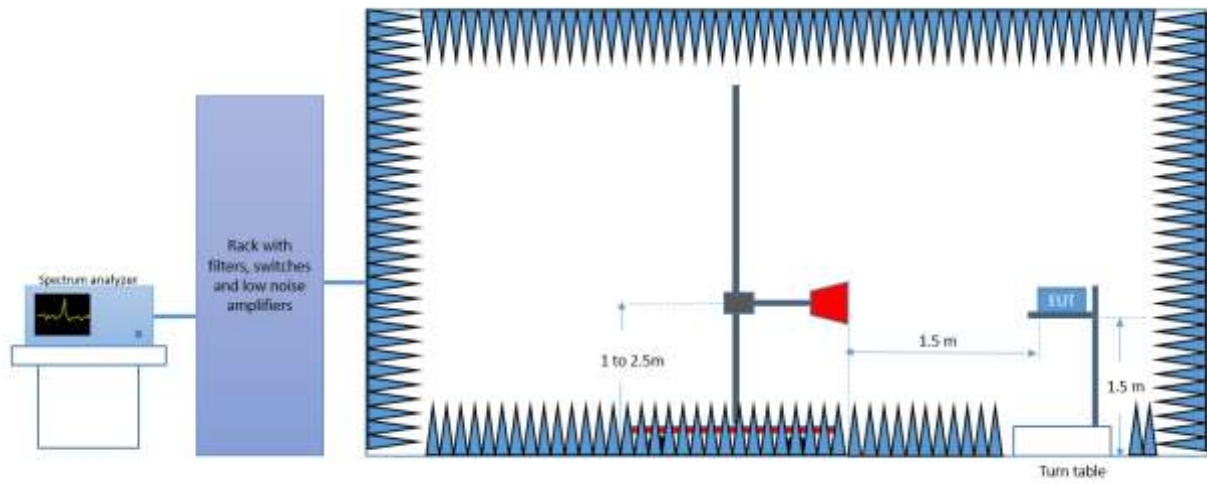
### Radiated Setup 1 GHz – 6.4 GHz



### Radiated Setup 6.4 GHz - 18 GHz



*Radiated Setup > 18 GHz*



Sample Calculation

The field strength is deduced from the radiated measurement using the following equation:

$$E = 126.8 - 20\log(\lambda) + P - G$$

where

*E* is the field strength of the emission at the measurement distance, in dBμV/m

*P* is the power measured at the output of the test antenna, in dBm

*λ* is the wavelength of the emission under investigation  $[300/f_{MHz}]$ , in m

*G* is the gain of the test antenna, in dBi

NOTE – The measured power P includes all applicable instrument correction factors up to the connection to the test Antenna e.g. cable losses, amplifier gains.

For field strength measurements made at other than the distance at which the applicable limit is specified, the field strength of the emission at the distance specified by the limit is deduced as follows:

$$E_{SpecLimit} = E_{Meas} + 20\log(D_{Meas}/D_{SpecLimit})$$

where

*E<sub>SpecLimit</sub>* is the field strength of the emission at the distance specified by the limit, in dBμV/m

*E<sub>Meas</sub>* is the field strength of the emission at the measurement distance, in dBμV/m

*D<sub>Meas</sub>* is the measurement distance, in m

*D<sub>SpecLimit</sub>* is the distance specified by the limit, in m

# Test Results

## 30 MHz – 26.5 GHz, BLE, CHAIN A Div1

### Radiated Spurious – CH0

Frequency	MaxPeak	Avg	Limit	Margin
MHz	dBuV/m	dBuV/m	dBuV/m	dB
96.0	21.7	---	43.5	21.8
192.0	27.8	---	43.5	15.7
216.1	28.2	---	46.0	17.9
288.0	30.1	---	46.0	15.9
312.0	33.0	---	46.0	13.0
598.5	35.4	---	46.0	10.6
7206.2	---	44.3	54.0	9.7
7206.2	51.1	---	74.0	22.9
9606.9	50.8	---	74.0	23.2
9607.9	---	42.3	54.0	11.7

### Radiated Spurious – CH19

Frequency	MaxPeak	Avg	Limit	Margin
MHz	dBuV/m	dBuV/m	dBuV/m	dB
62.5	25.9	---	40.0	14.1
96.0	22.4	---	43.5	21.1
191.9	29.4	---	43.5	14.1
216.0	27.9	---	43.5	15.6
312.0	32.0	---	46.0	14.0
821.0	41.1	---	46.0	4.9
7035.6	51.0	---	74.0	23.0
7037.0	---	40.0	54.0	14.0
9759.2	---	41.9	54.0	12.1
9759.2	49.4	---	74.0	24.6



### Radiated Spurious – CH39

Frequency	MaxPeak	Avg	Limit	Margin
MHz	dBuV/m	dBuV/m	dBuV/m	dB
62.5	24.9	---	40.0	15.1
192.0	28.5	---	43.5	15.0
204.0	27.5	---	43.5	16.0
216.0	28.1	---	43.5	15.4
312.0	32.0	---	46.0	14.0
832.8	40.3	---	46.0	5.7
7011.9	50.2	---	74.0	23.8
7013.8	---	39.8	54.0	14.2
9918.7	49.1	---	74.0	24.9
9919.2	---	39.2	54.0	14.8

## 30 MHz – 26.5 GHz, BLE, CHAIN A Div2

### Radiated Spurious – CH0

Frequency	MaxPeak	Avg	Limit	Margin
MHz	dBuV/m	dBuV/m	dBuV/m	dB
96.0	22.8	---	43.6	20.7
199.9	28.9	---	43.5	14.6
221.8	28.4	---	46.0	17.6
264.0	31.3	---	46.0	14.7
288.0	31.6	---	46.0	14.4
599.8	37.7	---	46.0	8.3
7205.2	---	40.3	54.0	13.7
7205.7	48.3	---	74.0	25.7
9606.9	---	41.2	54.0	12.8
9606.9	49.9	---	74.0	24.1

### Radiated Spurious – CH19

Frequency	MaxPeak	Avg	Limit	Margin
MHz	dBuV/m	dBuV/m	dBuV/m	dB
191.9	27.2	---	43.6	16.3
204.0	26.8	---	43.5	16.7
216.0	27.7	---	43.5	15.8
288.0	31.7	---	46.0	14.3
312.0	31.9	---	46.0	14.1
828.5	40.3	---	46.0	5.7
7313.5	48.5	---	74.0	25.5
7319.3	---	39.7	54.0	14.3
9760.6	---	41.5	54.0	12.5
9761.1	50.1	---	74.0	23.9

### Radiated Spurious – CH39

Frequency	MaxPeak	Avg	Limit	Margin
MHz	dBuV/m	dBuV/m	dBuV/m	dB
62.5	28.0	---	40.0	12.0
96.0	22.8	---	43.5	20.7
192.0	29.0	---	43.5	14.5
216.0	28.0	---	43.5	15.5
288.0	31.8	---	46.0	14.2
828.8	40.3	---	46.0	5.7
7018.7	---	40.0	54.0	14.0
7020.6	50.8	---	74.0	23.2
9918.7	49.8	---	74.0	24.2
9919.6	---	40.6	54.0	13.4