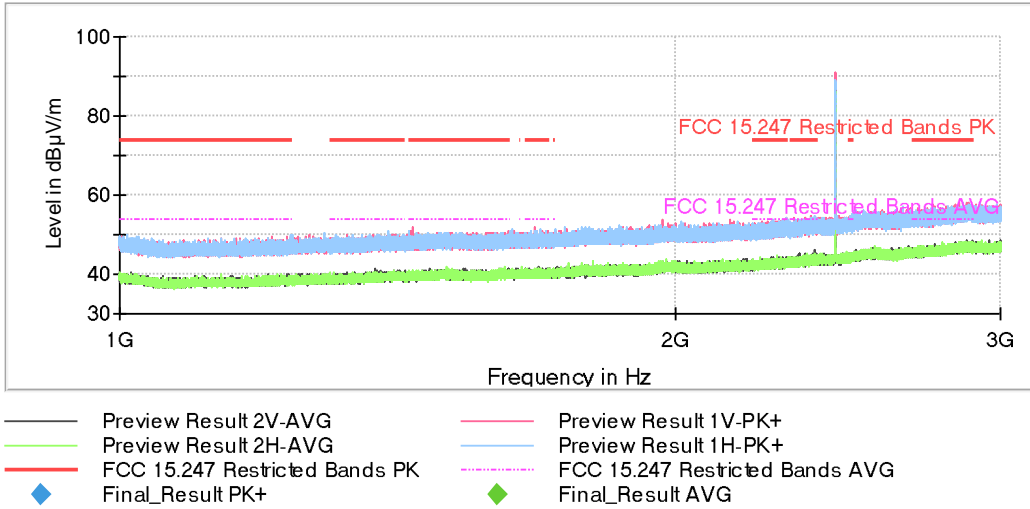
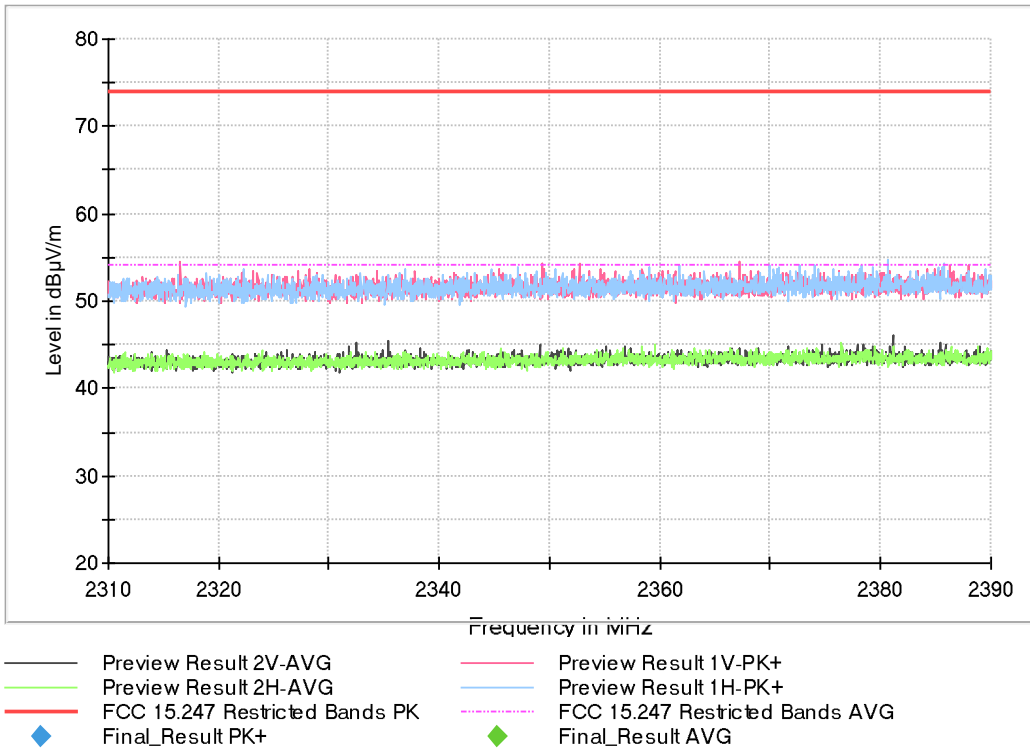


Frequency (MHz) = 2441.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS),  
 Modulation: BT (8DPSK 3-DH5), Frequency Range (GHz) = [1, 3], Number of Transmission Chains = 1

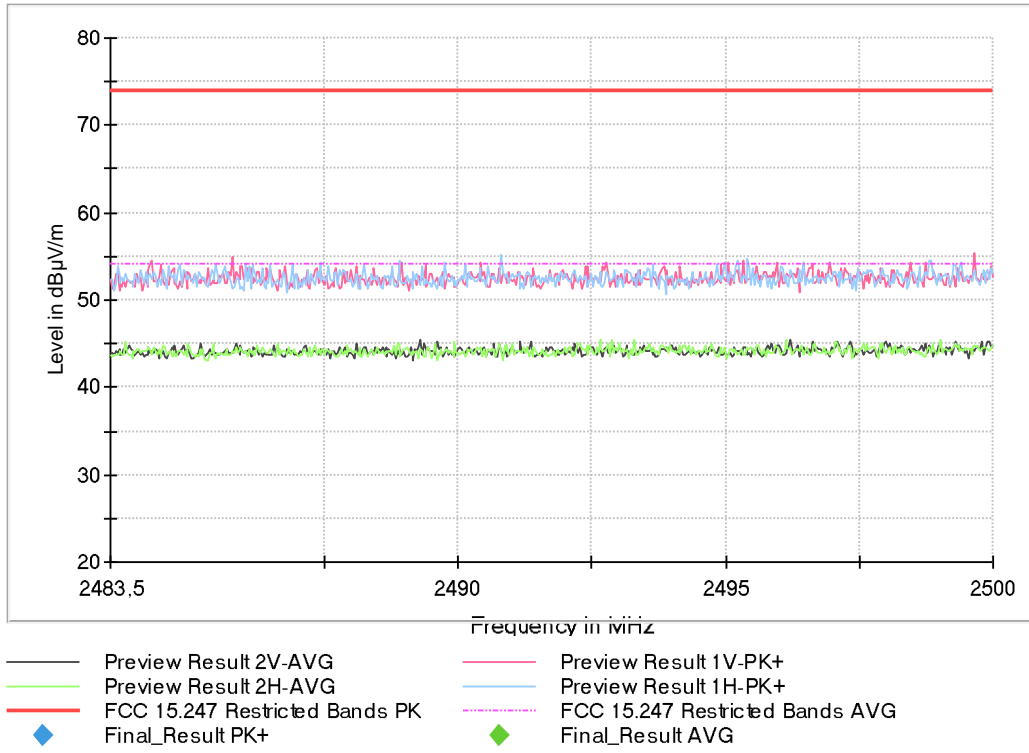
Plots:



Full Spectrum

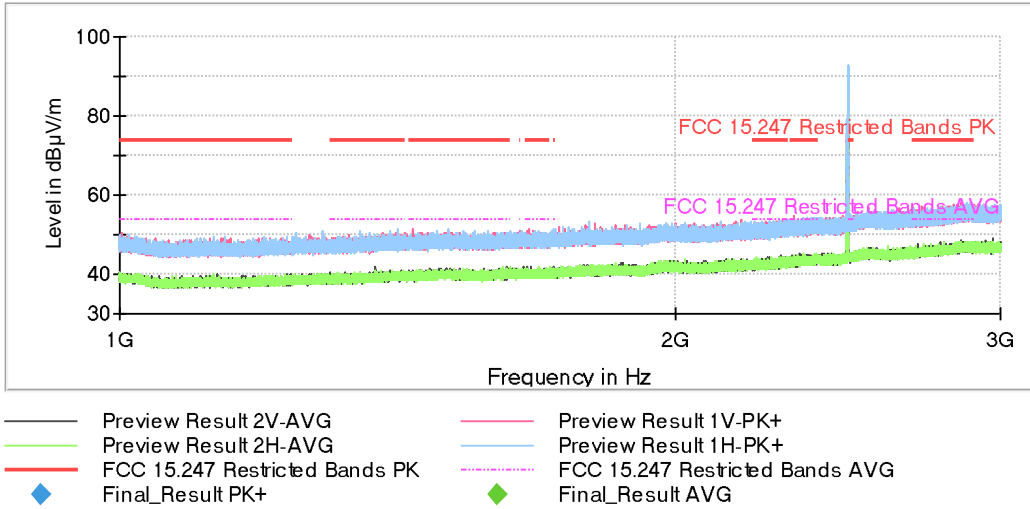


Full Spectrum

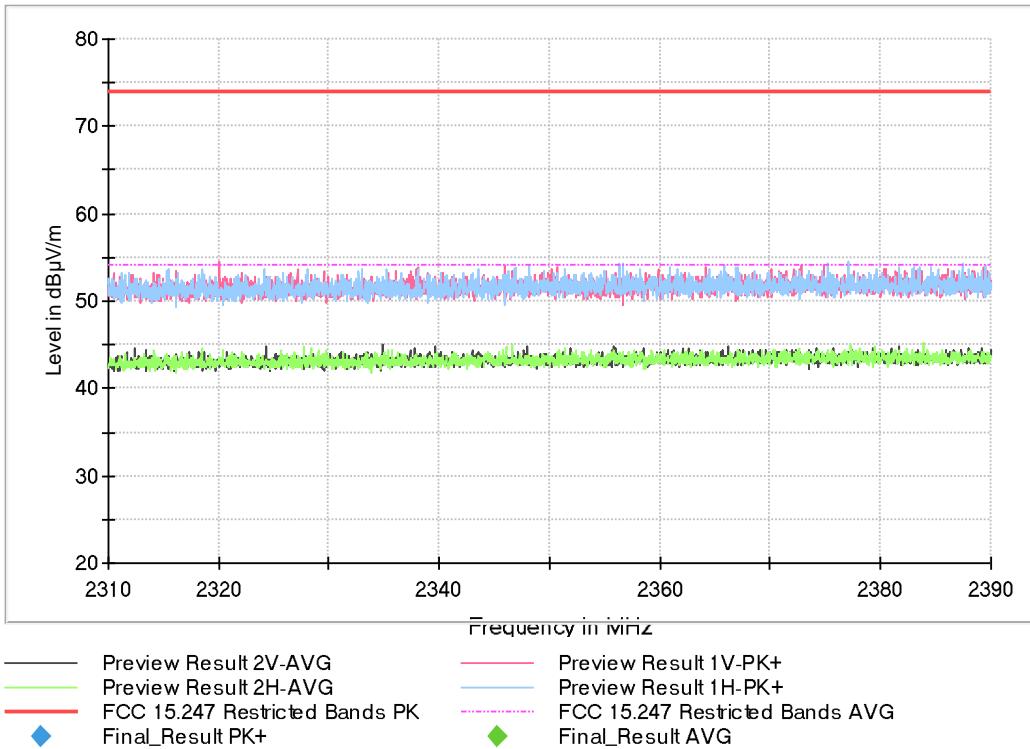


**Frequency (MHz) = 2480.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (8DPSK 3-DH5), Frequency Range (GHz) = [1, 3], Number of Transmission Chains = 1**

**Plots:**



Full Spectrum

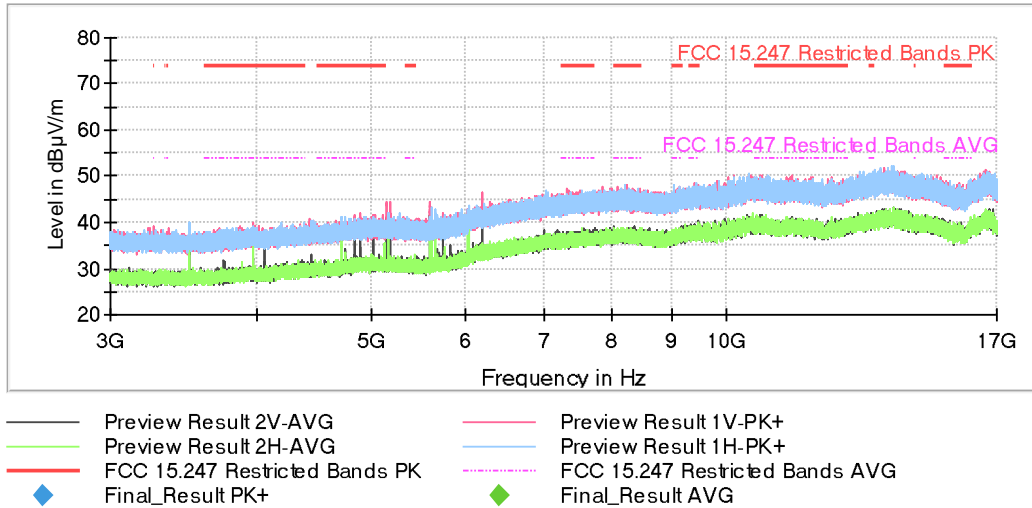


Full Spectrum



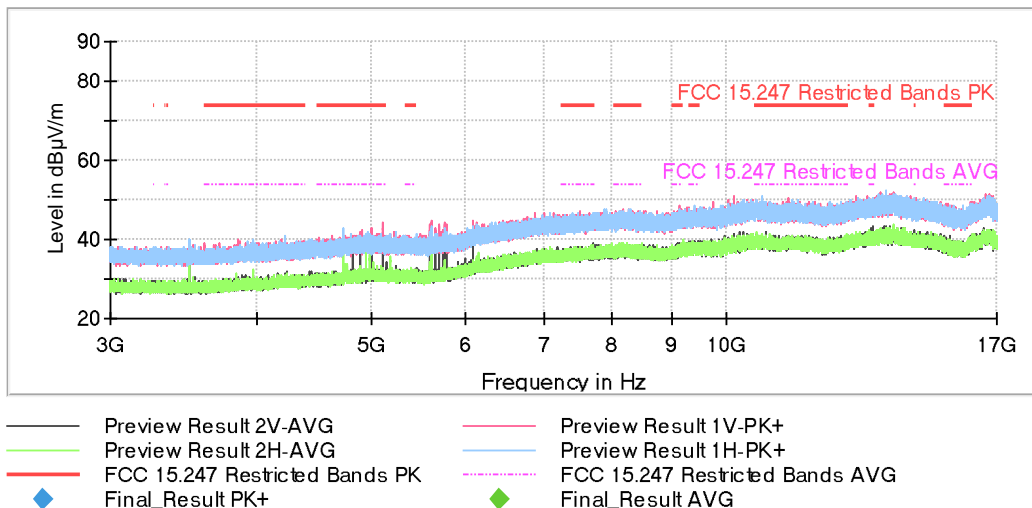
Frequency (MHz) = 2402.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS),  
 Modulation: BT (8DPSK 3-DH5), Frequency Range (GHz) = [3, 17], Number of Transmission Chains = 1

Plots:



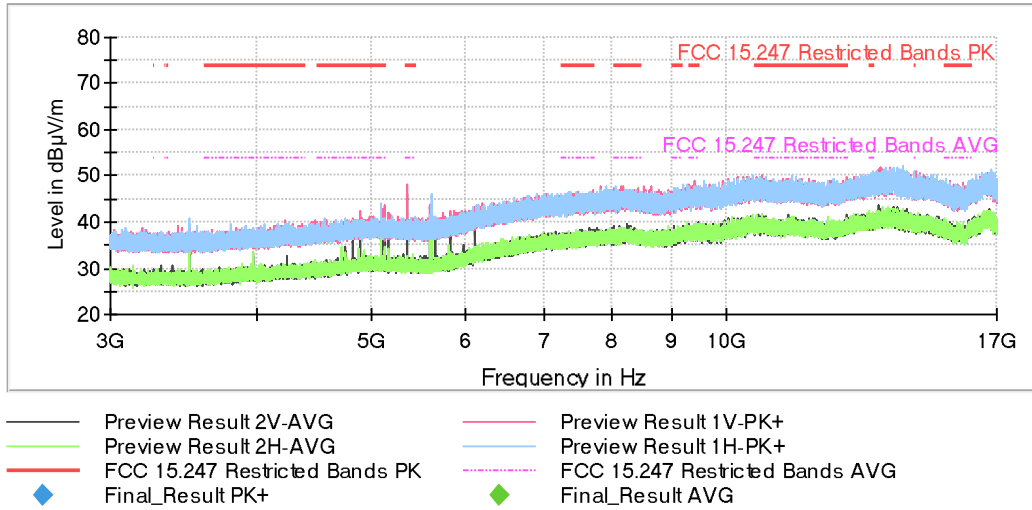
Frequency (MHz) = 2441.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS),  
 Modulation: BT (8DPSK 3-DH5), Frequency Range (GHz) = [3, 17], Number of Transmission Chains = 1

Plots:



**Frequency (MHz) = 2480.00000, Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Modulation: BT (8DPSK 3-DH5), Frequency Range (GHz) = [3, 17], Number of Transmission Chains = 1**

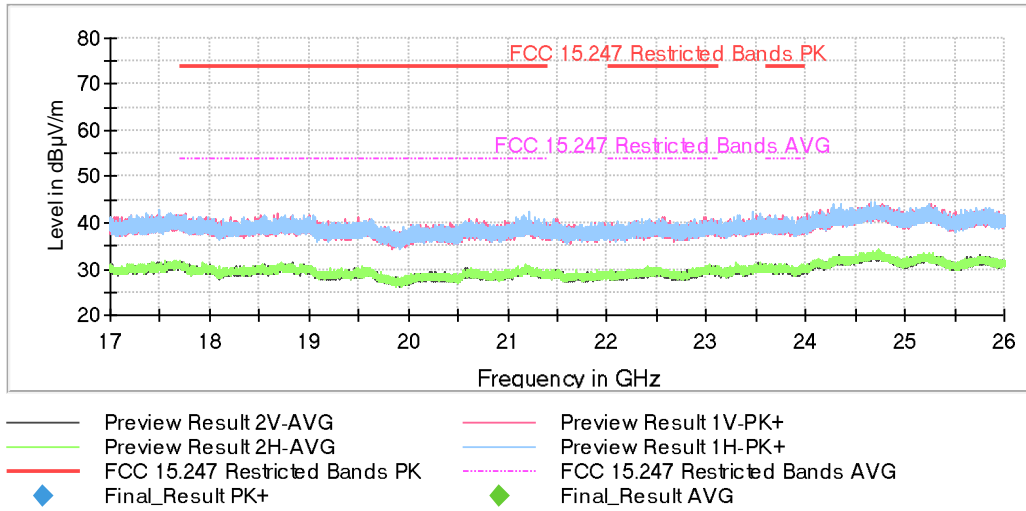
**Plots:**



**Modulations: BT (GFSK 1-DH5), BT (Pi/4 DQPSK 2-DH5), BT (8DPSK 3-DH5)**

**Equipment Type: Frequency Hopping Spread Spectrum systems (DSS), Frequency Range (GHz) = [17, 26],  
 Number of Transmission Chains = 1**

**Plots:**



This plot is valid for Low, Middle and High Channels and all modulations

## Appendix C: Test results. Bluetooth Low Energy 5.1 (1M, 2M). Chipset 1



## INDEX

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<i>FCC 15.247 (d) Emission limitations radiated (Transmitter)</i> .....	85

## TEST CONDITIONS

---

(\*): Data provided by the client.

### POWER SUPPLY (\*):

Vnominal:	12Vdc
Type of Power Supply:	External

### ANTENNA (\*):

Type of Antenna:	External antenna
Maximum Declared Antenna Gain:	2 dBi
RF Output Port:	3

### TEST FREQUENCIES (\*):

Low Channel:	2402 MHz
Middle Channel:	2440 MHz
High Channel:	2480 MHz

During transmitter test the EUT was controlled by a SW tool provided by the client to operate in a continuous transmit mode on the modulation schemes and test channels as required.

### RADIATED MEASUREMENTS:

All radiated tests were performed in a semi-anechoic chamber. The measurement antenna (bilog antenna for the range from 30 MHz to 1000 MHz and 1 – 17 GHz Double ridge horn antenna) is situated at a distance of 3 m and at a distance of 1.5 m for the frequency range 17 GHz – 26 GHz (17 GHz – 40 GHz horn antenna).

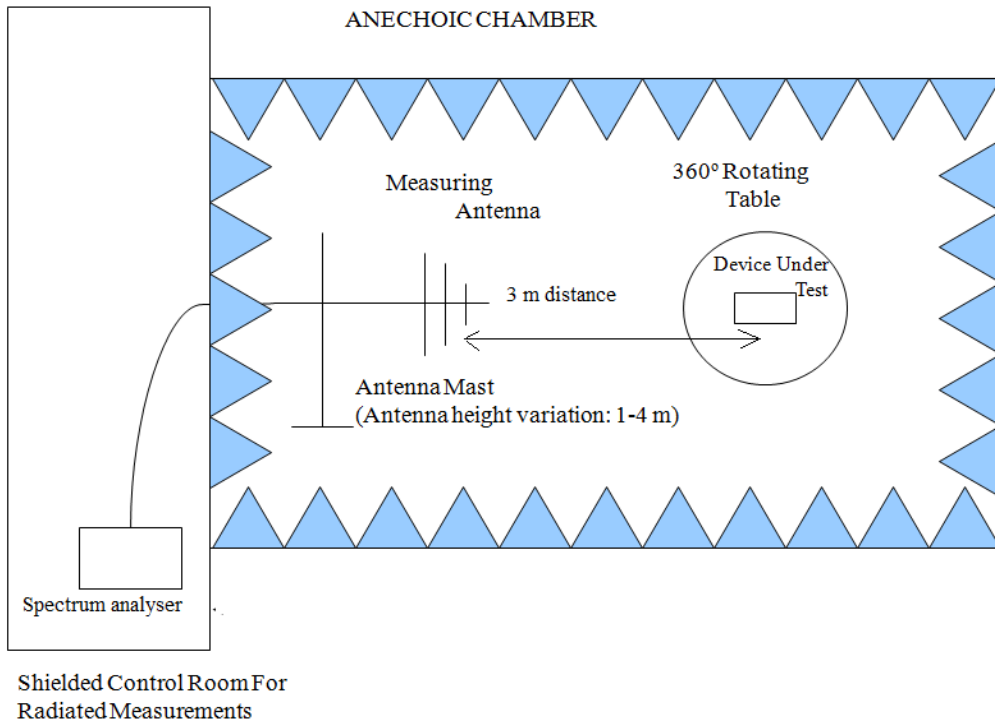
For radiated emissions in the range 17 GHz – 26 GHz performed at a distance closer than the distance specified in standard, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

The equipment under test was set up on a non-conductive platform above the ground plane and its situation and orientation were varied to find the maximum radiated emission. It was also rotated 360° and the antenna height was varied from 1 to 4 meters (up to 17GHz) to find the maximum radiated emission.

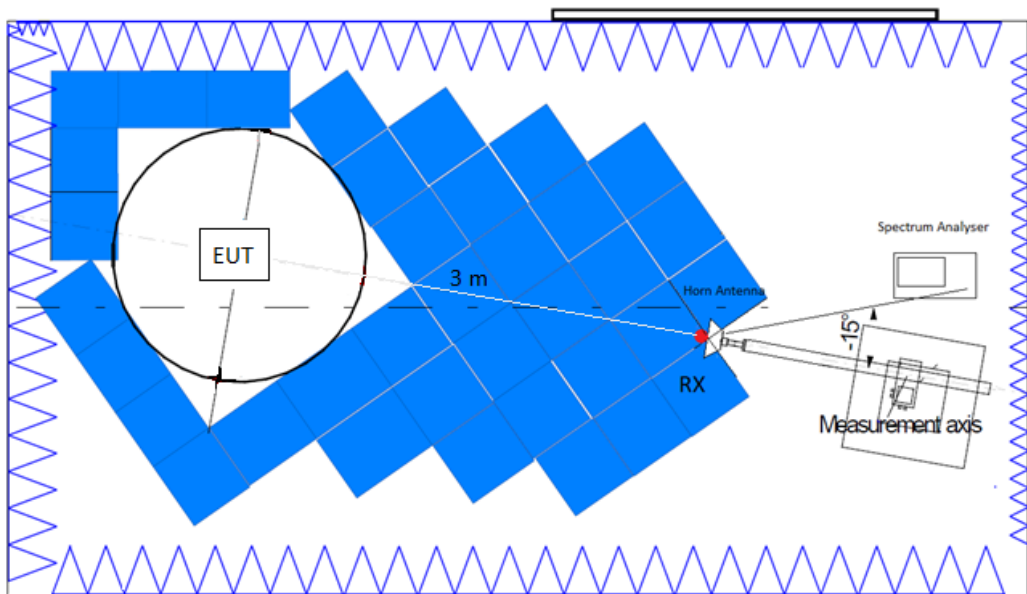
Measurements were made in both horizontal and vertical planes of polarization.

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

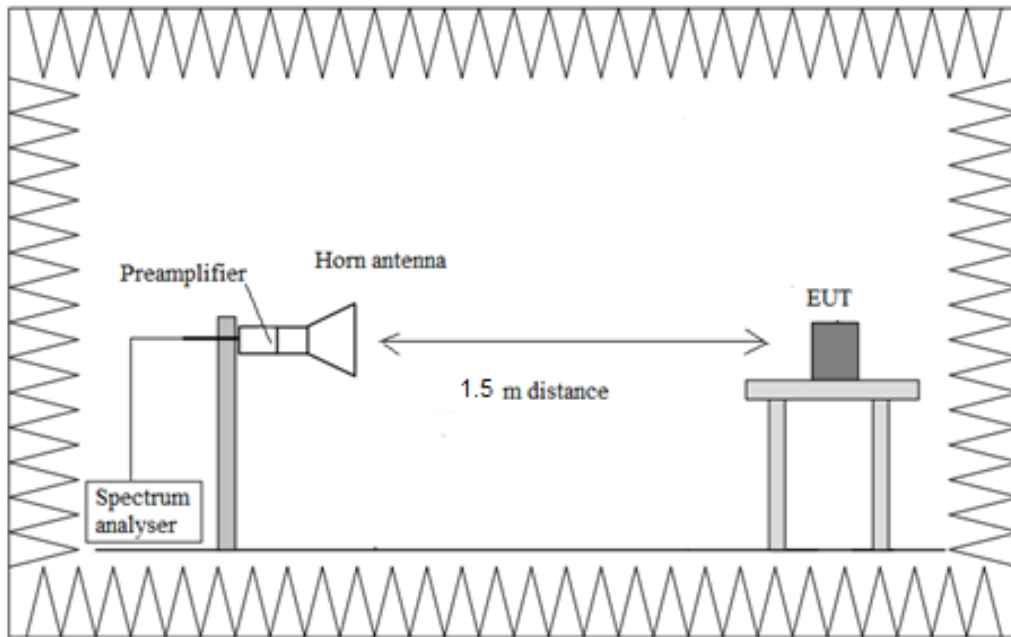
Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup from 1 GHz to 17 GHz:



Radiated measurements setup  $f > 17$  GHz:



## TEST CASES DETAILS

### FCC 15.247 (d) Emission limitations radiated (Transmitter)

#### Limits

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

Frequency Range (MHz)	Field strength ( $\mu\text{V/m}$ )	Field strength ( $\text{dB}\mu\text{V/m}$ )	Measurement distance (m)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	30
1.705 - 30.0	30	-	30
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 corresponding to 20 dB above the indicated values in the table specified when measuring with peak detector function.

#### Results

##### Frequency range 30 MHz – 1 GHz:

The spurious frequencies detected do not depend on either the modulation or the operating channel.

Spurious frequencies detected at less than 20 dB below the limit:

Freq Rng (GHz)	Unwanted Freq (MHz)	Unwanted Lvl ( $\text{dB}\mu\text{V/m}$ )	Pol	Detector
[0.03, 1]	600.027	29.02	V	QP
	874.991	33.91	V	QP

**Frequency range 1 GHz – 26 GHz:**

Modulation: BTLE 5.1 (GFSK 1 Mbit/s)

Spurious frequencies detected at less than 20 dB below the limit:

Freq Rng (GHz)	Freq (MHz)	Unwanted Freq (MHz)	Unwanted Lvl (dBµV/m)	Pol	Detector
[3, 17]	2402.0000	4757.700	43.40	V	Peak
		4910.580	43.54	H	Peak
		5002.000	44.29	V	Peak
		5136.540	43.28	H	Peak
	2440.0000	4734.740	41.56	V	Peak
		4824.060	44.37	H	Peak
		4985.846	43.83	V	Peak
		5016.560	42.24	H	Peak
	2480.0000	4092.560	40.40	H	Peak
		4747.760	42.22	V	Peak
		4961.260	42.17	V	Peak
		5117.360	41.63	H	Peak

Modulation: BTLE 5.1 (GFSK 2 Mbit/s)

Spurious frequencies detected at less than 20 dB below the limit:

Freq Rng (GHz)	Freq (MHz)	Unwanted Freq (MHz)	Unwanted Lvl (dBµV/m)	Pol	Detector
[3, 17]	2402.0000	4757.280	46.44	V	Peak
		4837.640	43.68	H	Peak
		5453.780	42.16	V	Peak
	2440.0000	4712.300	42.50	V	Peak
		5132.500	43.40	V	Peak
	2480.0000	4823.220	42.60	V	Peak
		4975.540	41.59	V	Peak
		5122.400	42.02	H	Peak

**Verdict**

Pass

**Attachments**

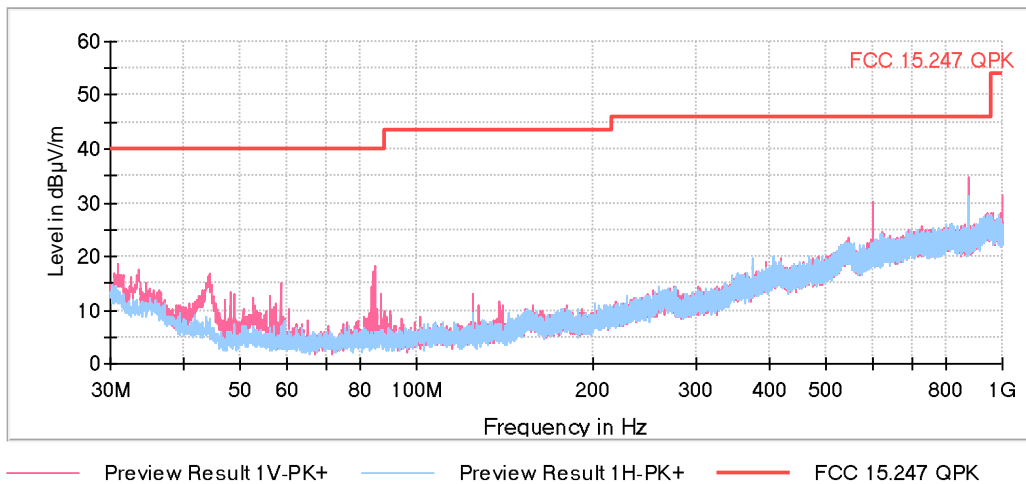
The setting for each range of frequency is indicated in the tables below:

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [ESW 44] 30 MHz - 1 GHz	30,312 kHz	PK+	100 kHz	1 s	0 dB
Receiver: [ESW 44] 1 GHz - 3 GHz	30,769 kHz	PK+ ; AVG	1 MHz	1 s	0 dB
Receiver: [ESW 44] 3 GHz - 17 GHz	140 kHz	PK+ ; AVG	1 MHz	1 s	30 dB
Receiver: [ESW 44] 17 GHz - 26 GHz	300 kHz	PK+ ; AVG	1 MHz	1 s	0 dB

**Modulations: BTLE 5.1 (GFSK 1 Mbit/s), BTLE 5.1 (GFSK 2 Mbit/s)**

**Equipment Type: Digital Transmission System (DTS), Frequency Range (GHz) = [0.03, 1], Number of Transmission Chains = 1**

**Plots:**

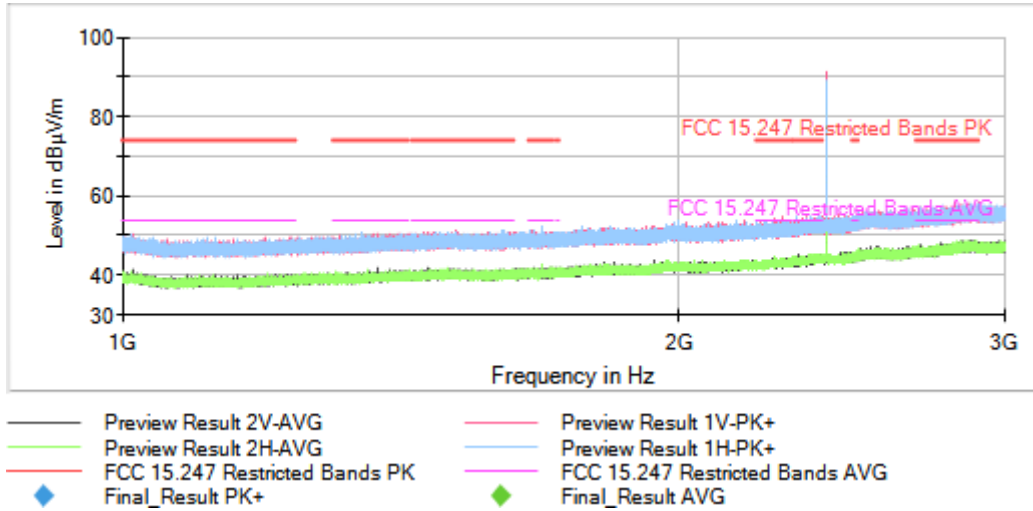


This plot is valid for Low, Middle and High Channels and all modulations

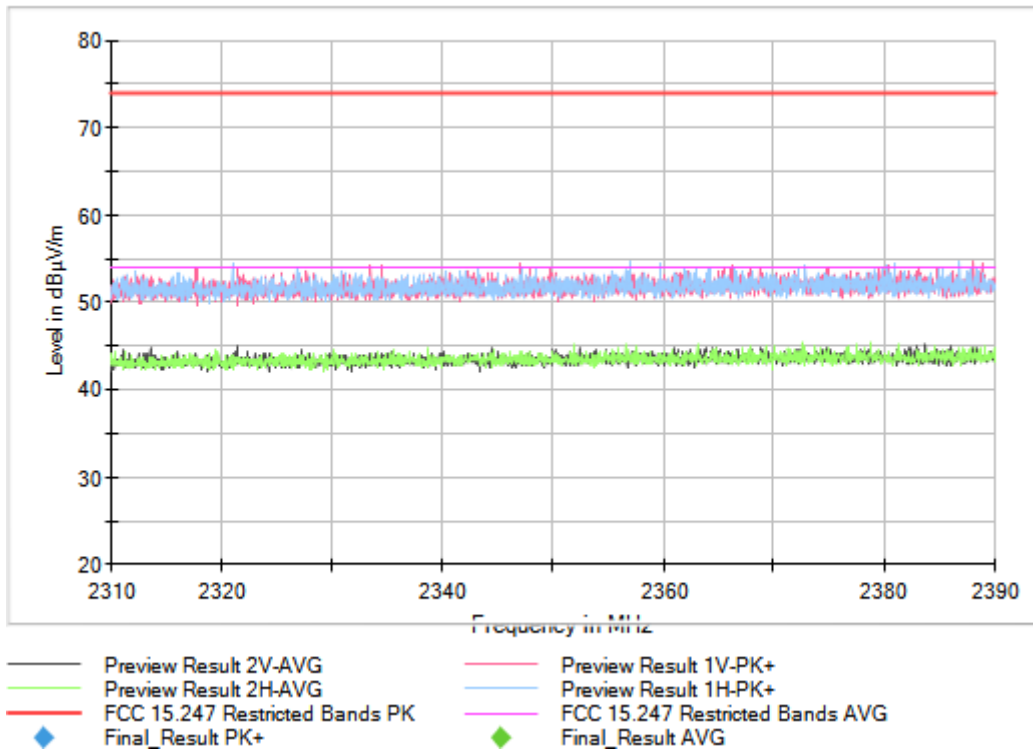
**Modulation: BTLE 5.1 (GFSK 1 Mbit/s)**

**Frequency (MHz) = 2402.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range (GHz) = [1, 3], Number of Transmission Chains = 1**

**Plots:**

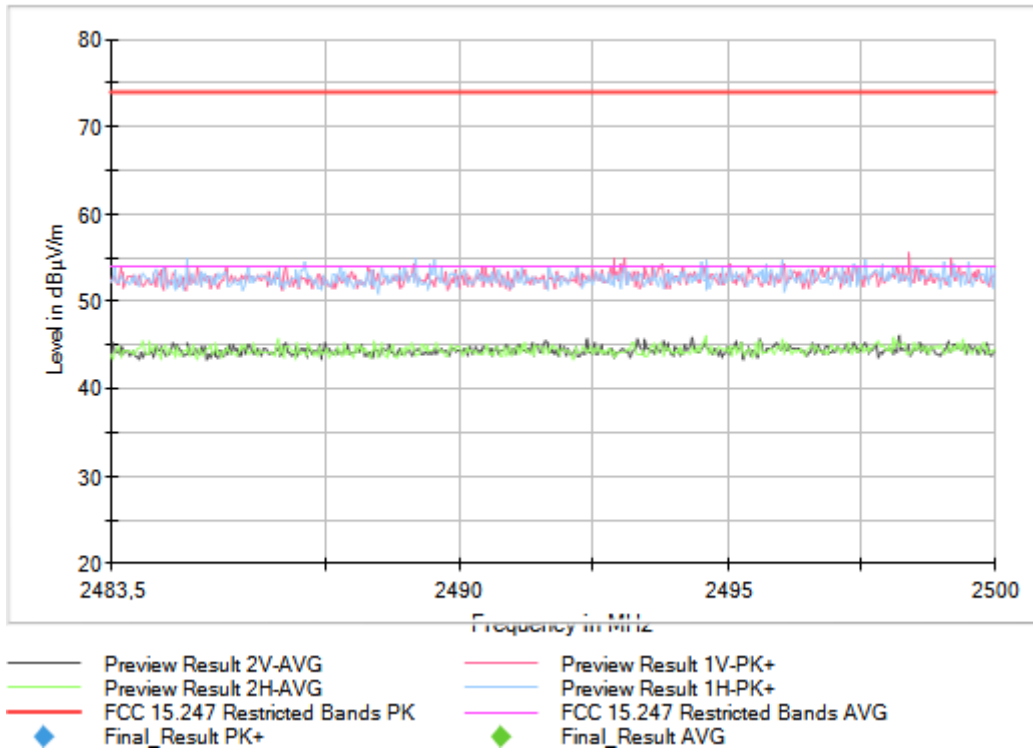


Full Spectrum



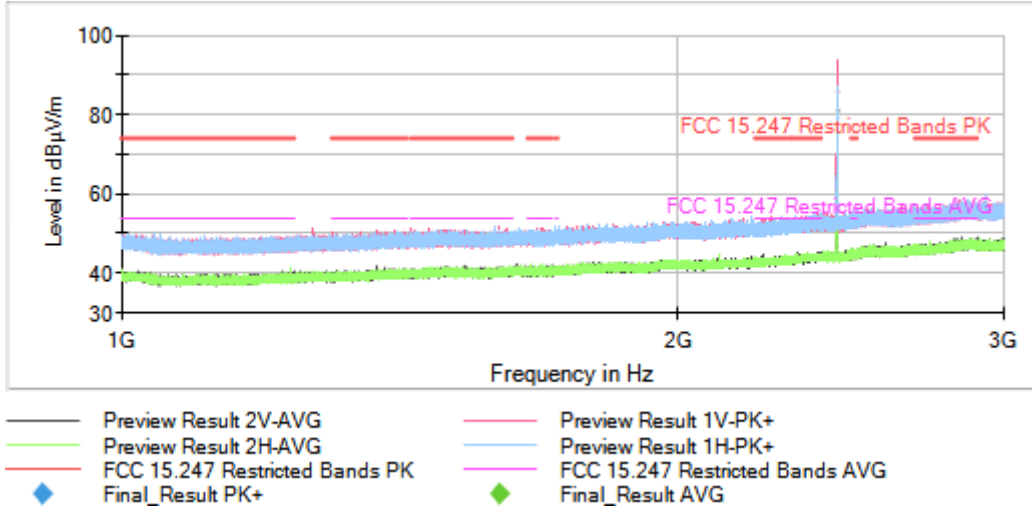


Full Spectrum

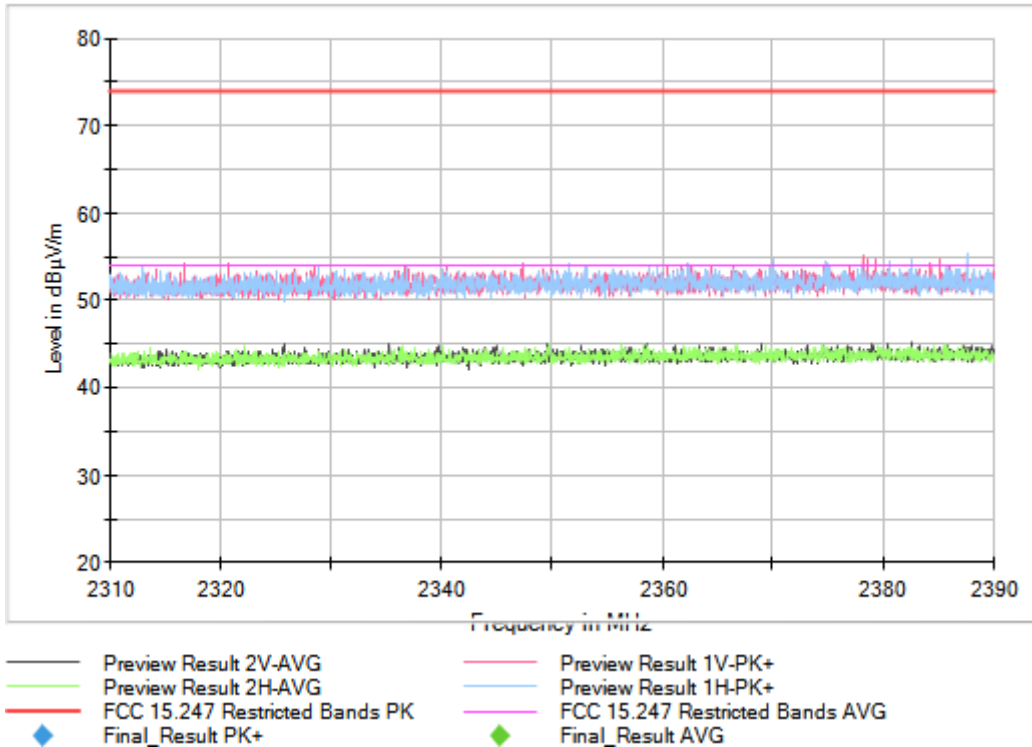


Frequency (MHz) = 2440.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range (GHz) = [1, 3], Number of Transmission Chains = 1

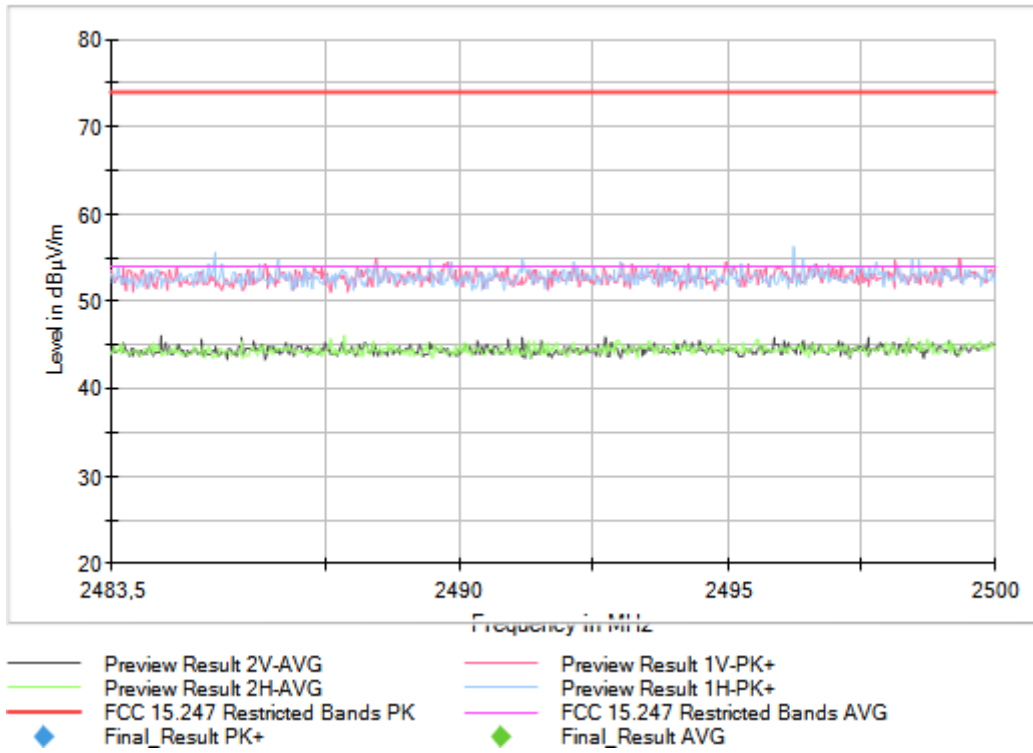
Plots:



Full Spectrum

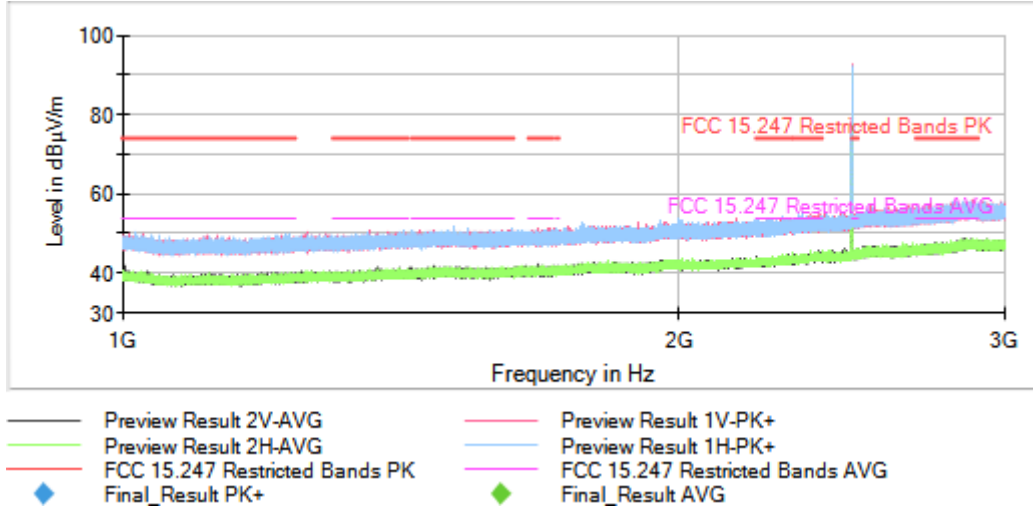


Full Spectrum

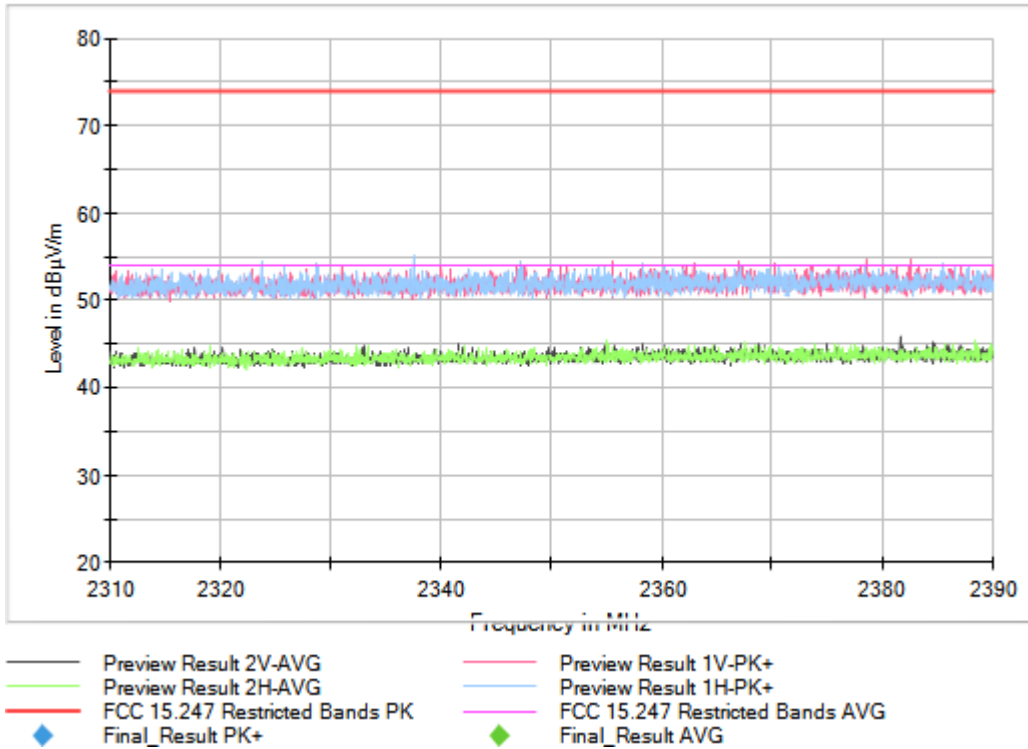


Frequency (MHz) = 2480.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range (GHz) = [1, 3], Number of Transmission Chains = 1

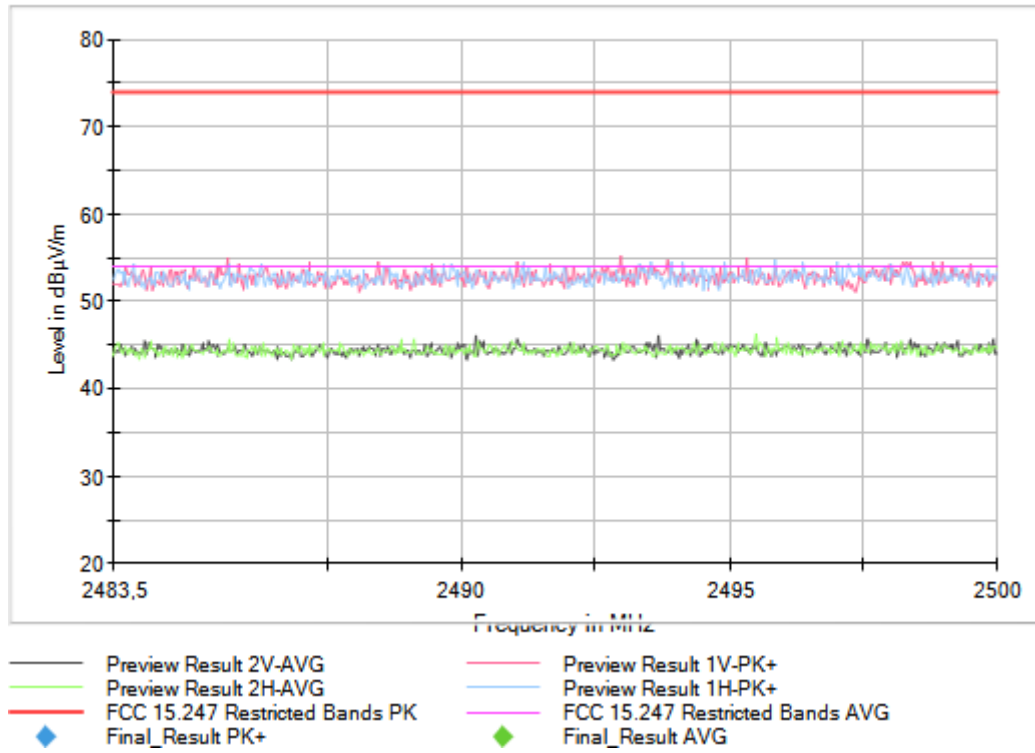
Plots:



Full Spectrum

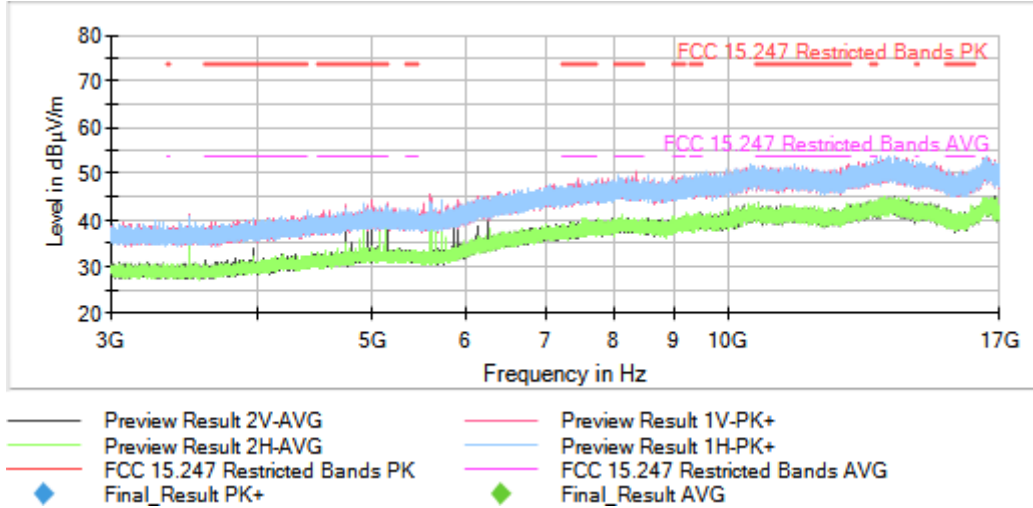


Full Spectrum



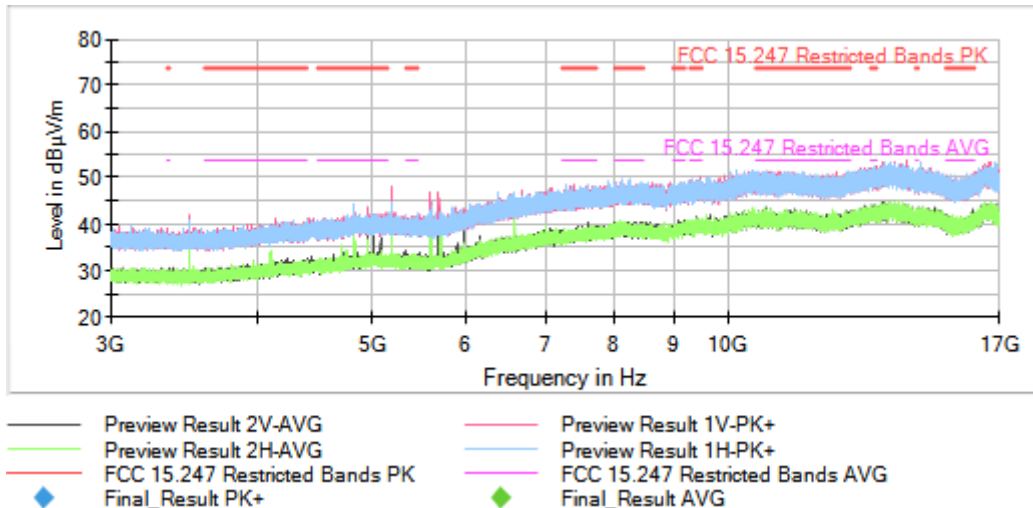
Frequency (MHz) = 2402.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range (GHz) = [3, 17], Number of Transmission Chains = 1

Plots:



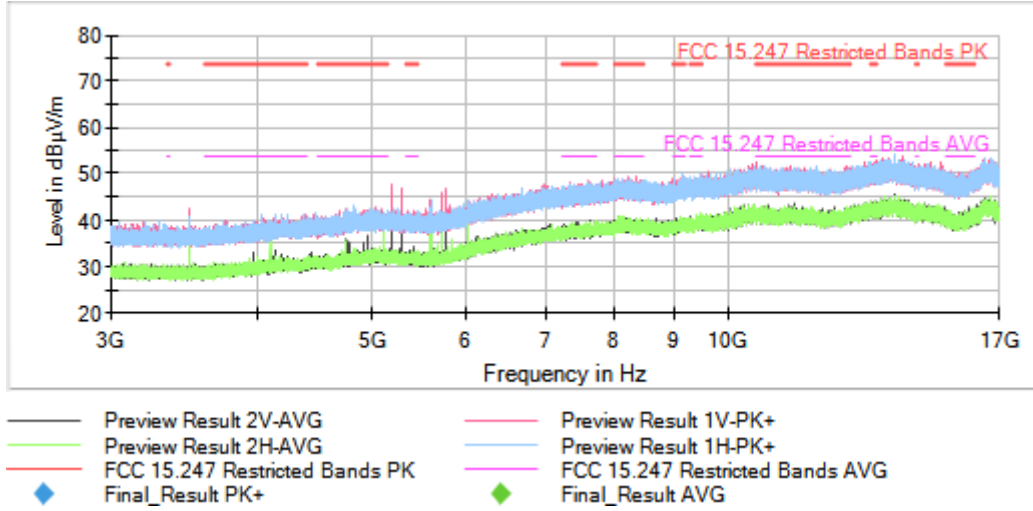
Frequency (MHz) = 2440.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range (GHz) = [3, 17], Number of Transmission Chains = 1

Plots:



Frequency (MHz) = 2480.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range (GHz) = [3, 17], Number of Transmission Chains = 1

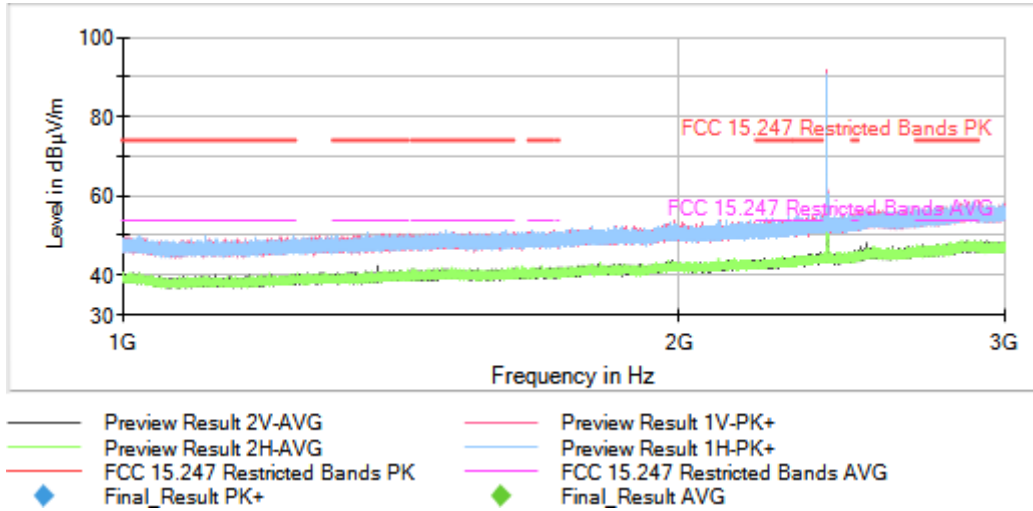
Plots:



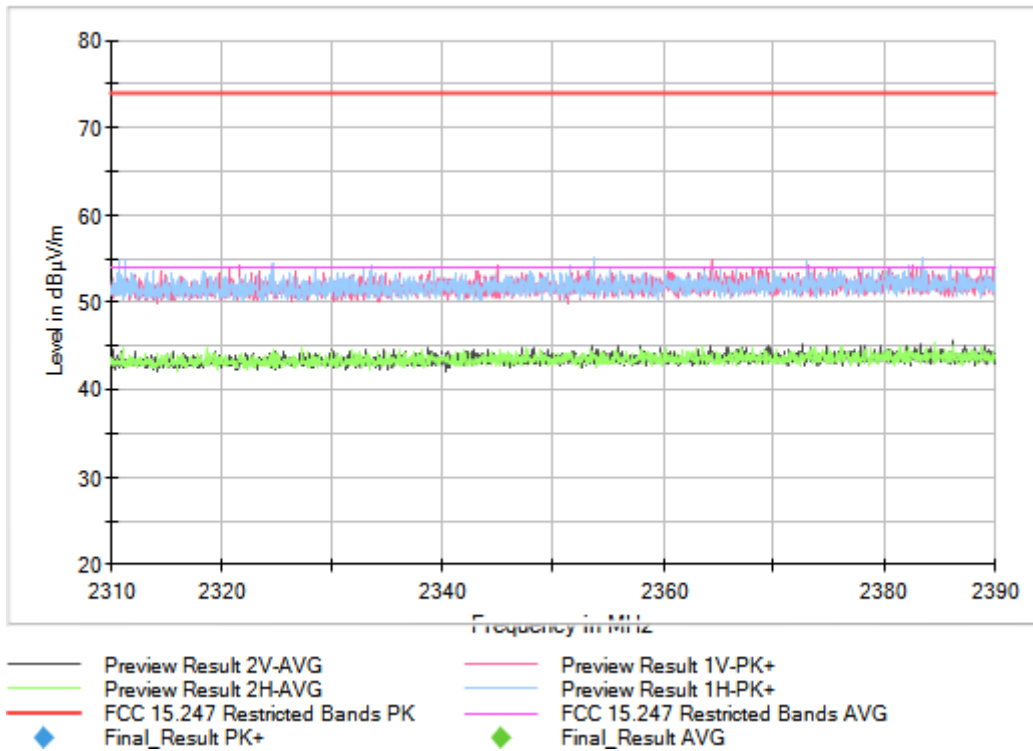
**Modulation: BTLE 5.1 (GFSK 2 Mbit/s)**

**Frequency (MHz) = 2402.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 2 Mbit/s), Frequency Range (GHz) = [1, 3], Number of Transmission Chains = 1**

**Plots:**

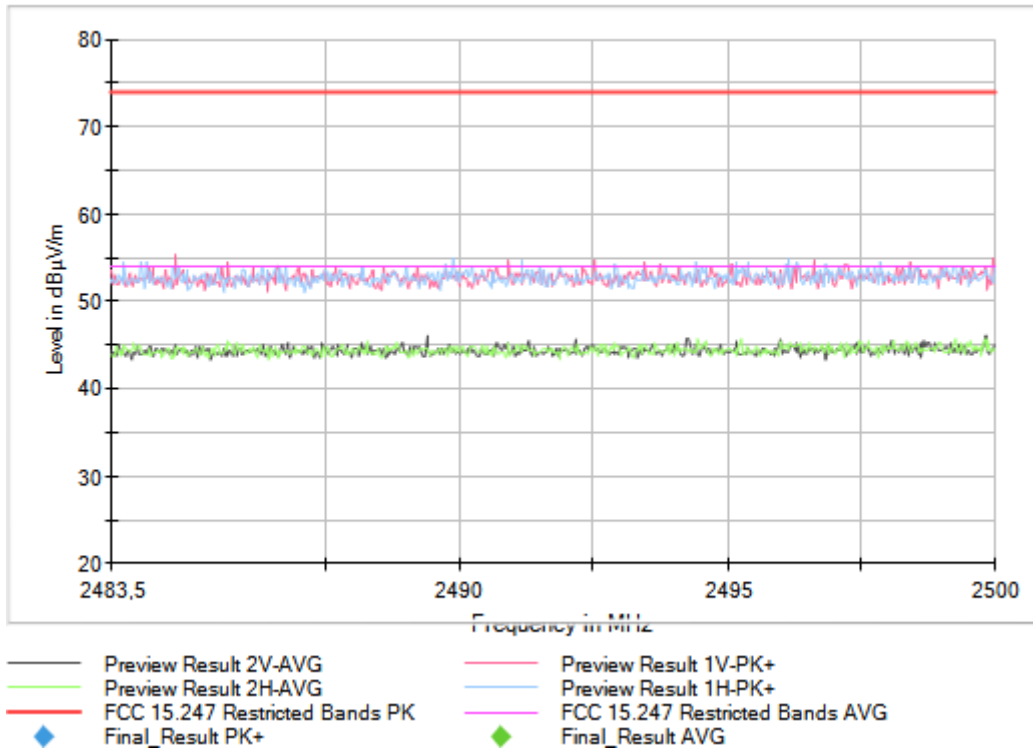


Full Spectrum



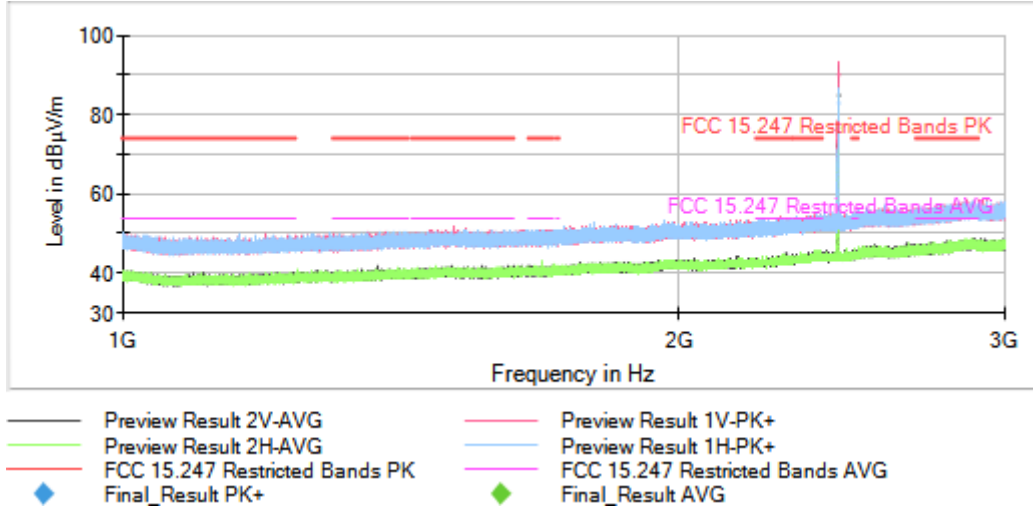


### Full Spectrum

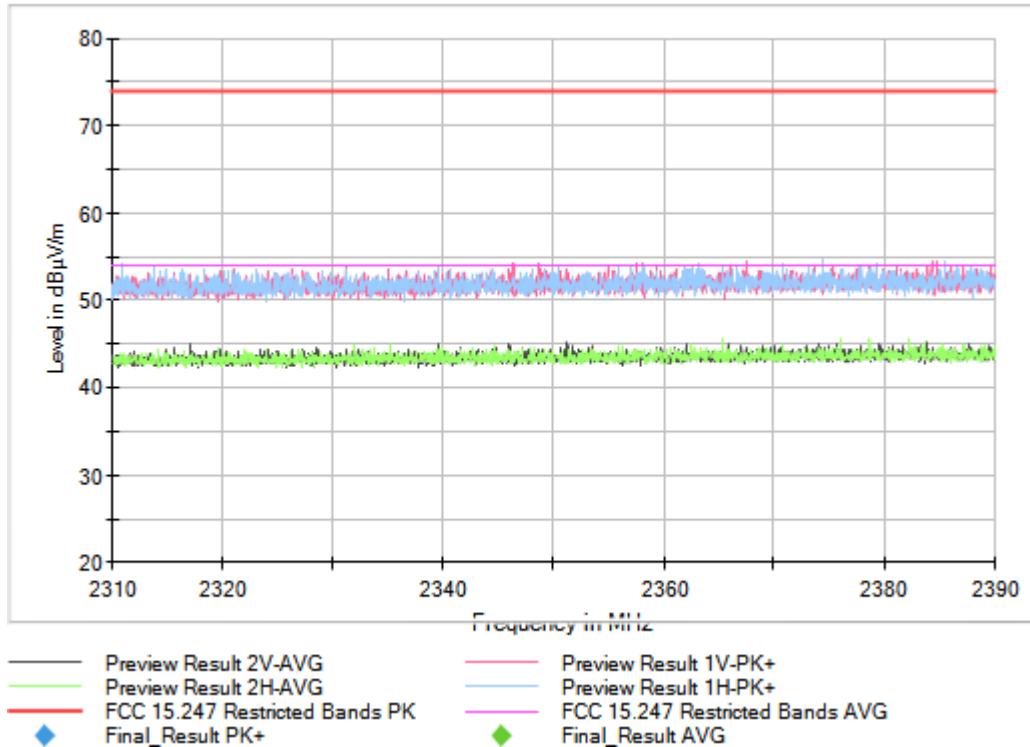


Frequency (MHz) = 2440.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 2 Mbit/s), Frequency Range (GHz) = [1, 3], Number of Transmission Chains = 1

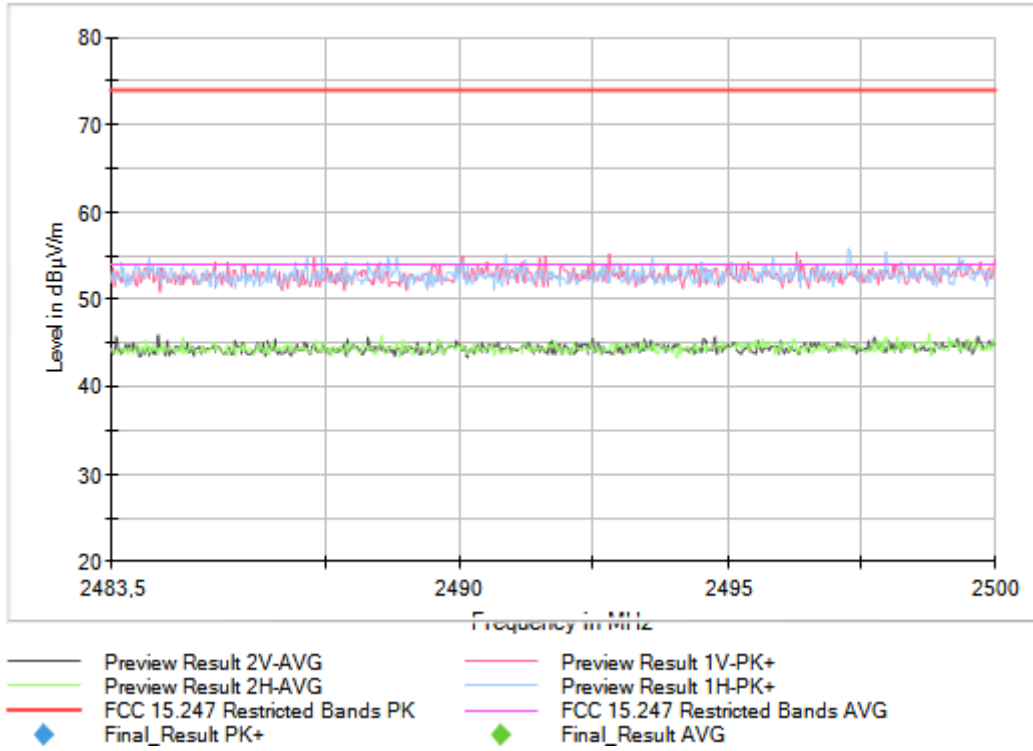
Plots:



Full Spectrum

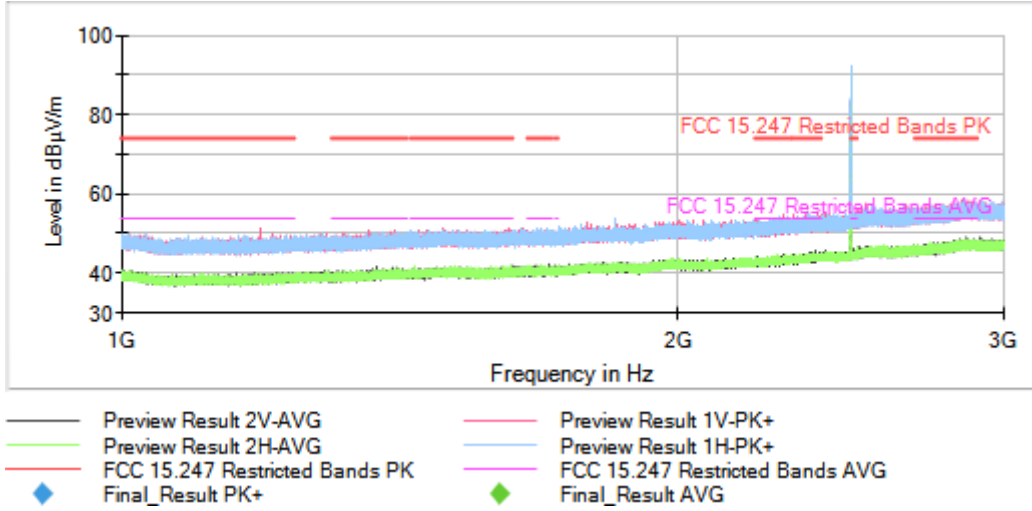


Full Spectrum

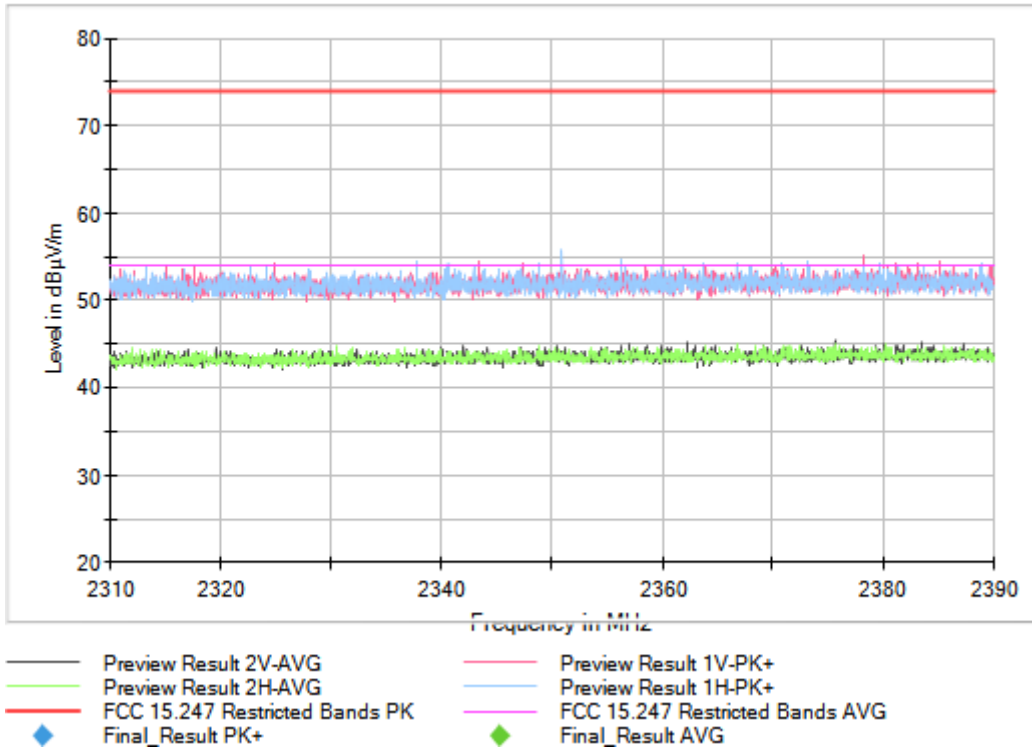


Frequency (MHz) = 2480.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 2 Mbit/s), Frequency Range (GHz) = [1, 3], Number of Transmission Chains = 1

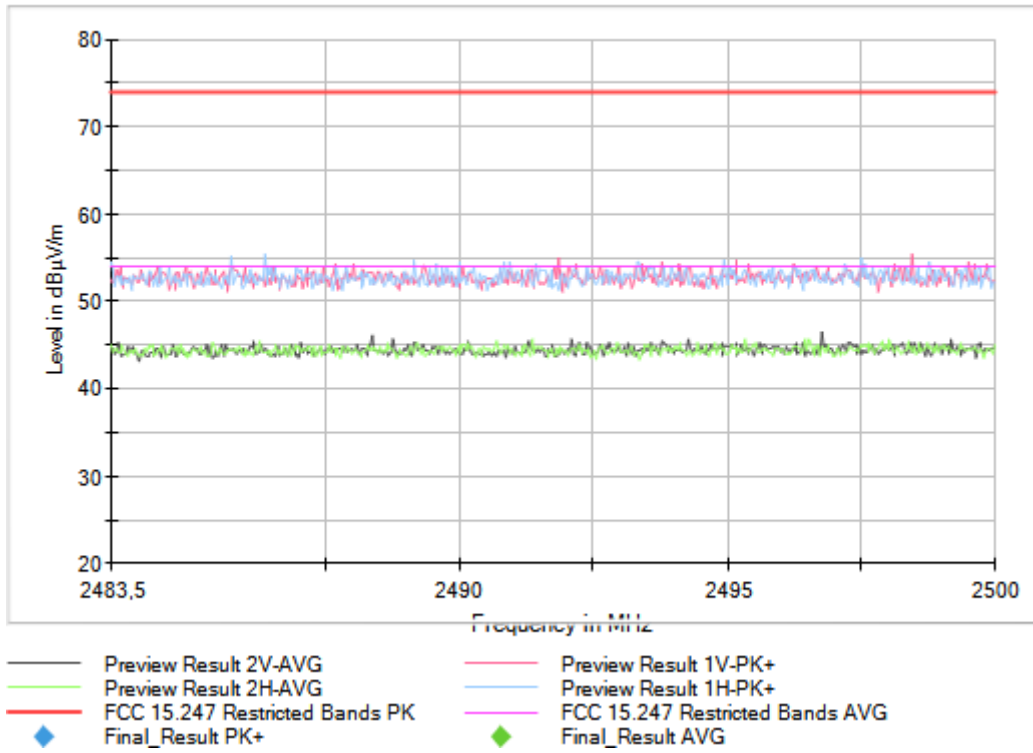
Plots:



Full Spectrum

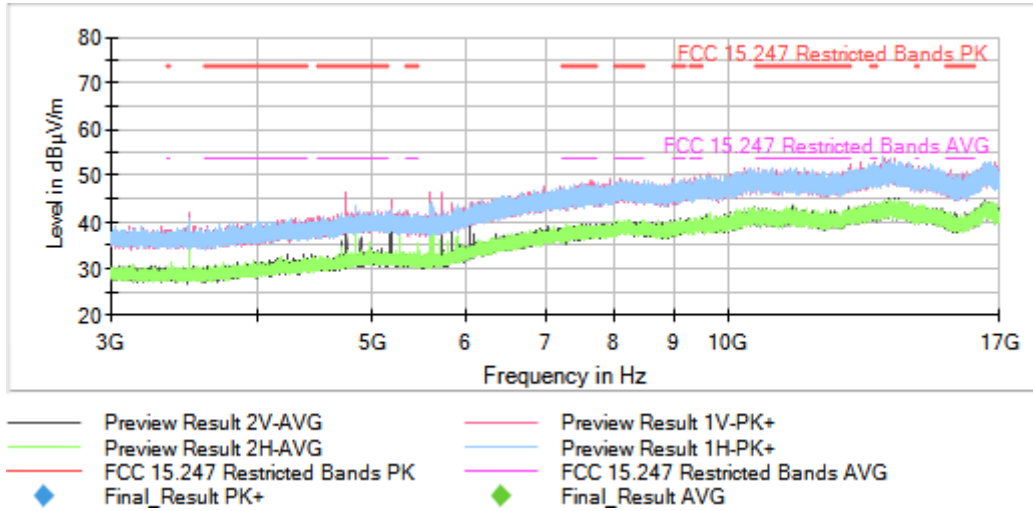


Full Spectrum



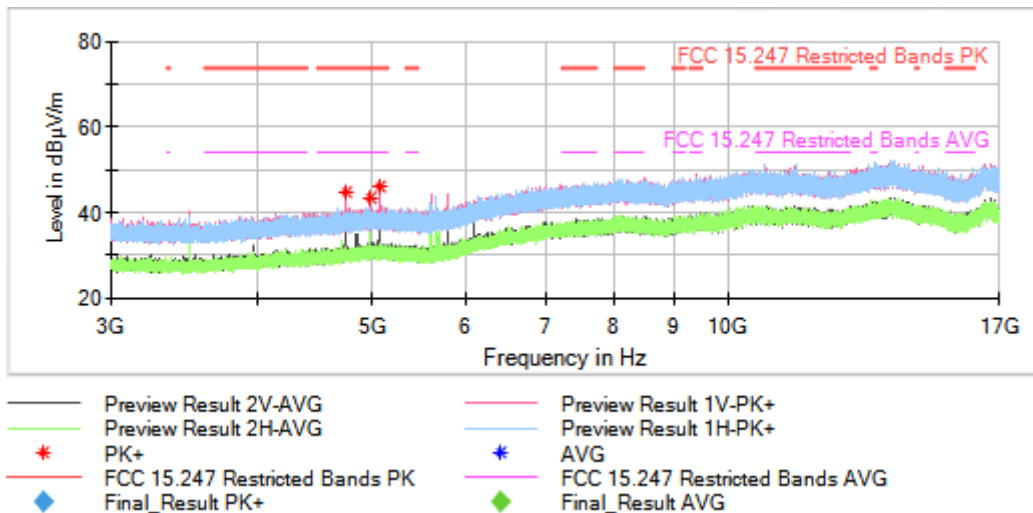
Frequency (MHz) = 2402.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 2 Mbit/s), Frequency Range (GHz) = [3, 17], Number of Transmission Chains = 1

Plots:



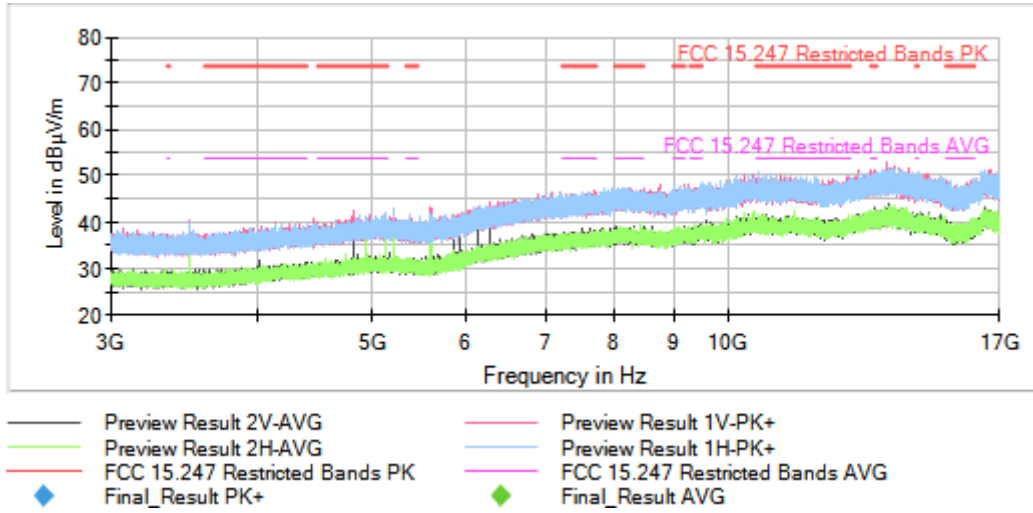
Frequency (MHz) = 2440.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 2 Mbit/s), Frequency Range (GHz) = [3, 17], Number of Transmission Chains = 1

Plots:



Frequency (MHz) = 2480.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 2 Mbit/s), Frequency Range (GHz) = [3, 17], Number of Transmission Chains = 1

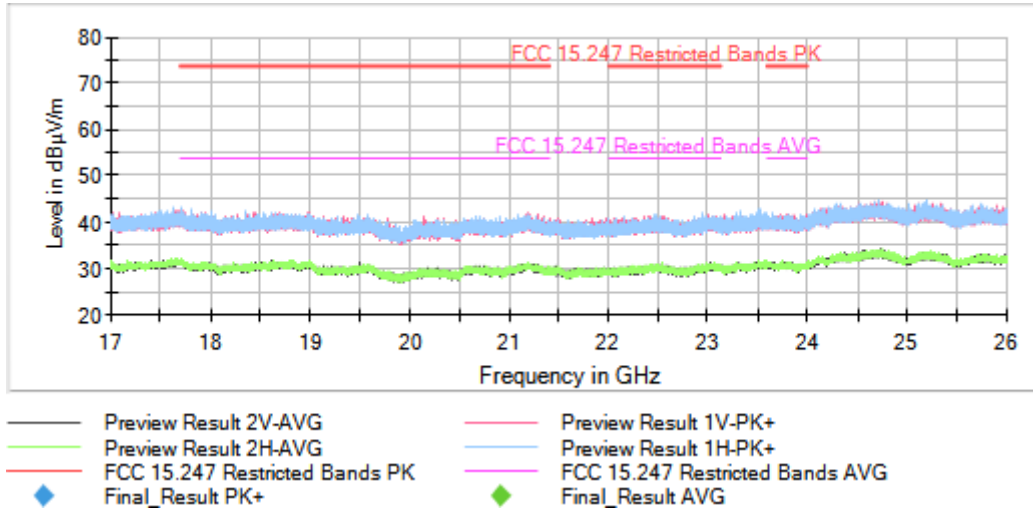
Plots:



**Modulations: BTLE 5.1 (GFSK 1 Mbit/s), BTLE 5.1 (GFSK 2 Mbit/s)**

**Equipment Type: Digital Transmission System (DTS), Frequency Range (GHz) = [17, 26], Number of Transmission Chains = 1**

**Plots:**



This plot is valid for Low, Middle and High Channels and all modulations



## Appendix D: Test results. Bluetooth Low Energy 5.1 (1M, 2M). Chipset 2

## INDEX

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<i>FCC 15.247 (d) Emission limitations radiated (Transmitter)</i> .....	110

## TEST CONDITIONS

---

(\*): Data provided by the client.

### POWER SUPPLY (\*):

Vnominal:	12Vdc
Type of Power Supply:	External

### ANTENNA (\*):

Type of Antenna:	External antenna
Maximum Declared Antenna Gain:	2 dBi
RF Output Port:	1

### TEST FREQUENCIES (\*):

Low Channel:	2402 MHz
Middle Channel:	2440 MHz
High Channel:	2480 MHz

During transmitter test the EUT was controlled by a SW tool provided by the client to operate in a continuous transmit mode on the modulation schemes and test channels as required.

### RADIATED MEASUREMENTS:

All radiated tests were performed in a semi-anechoic chamber. The measurement antenna (bilog antenna for the range from 30 MHz to 1000 MHz and 1 – 17 GHz Double ridge horn antenna) is situated at a distance of 3 m and at a distance of 1.5 m for the frequency range 17 GHz – 26 GHz (17 GHz – 40 GHz horn antenna).

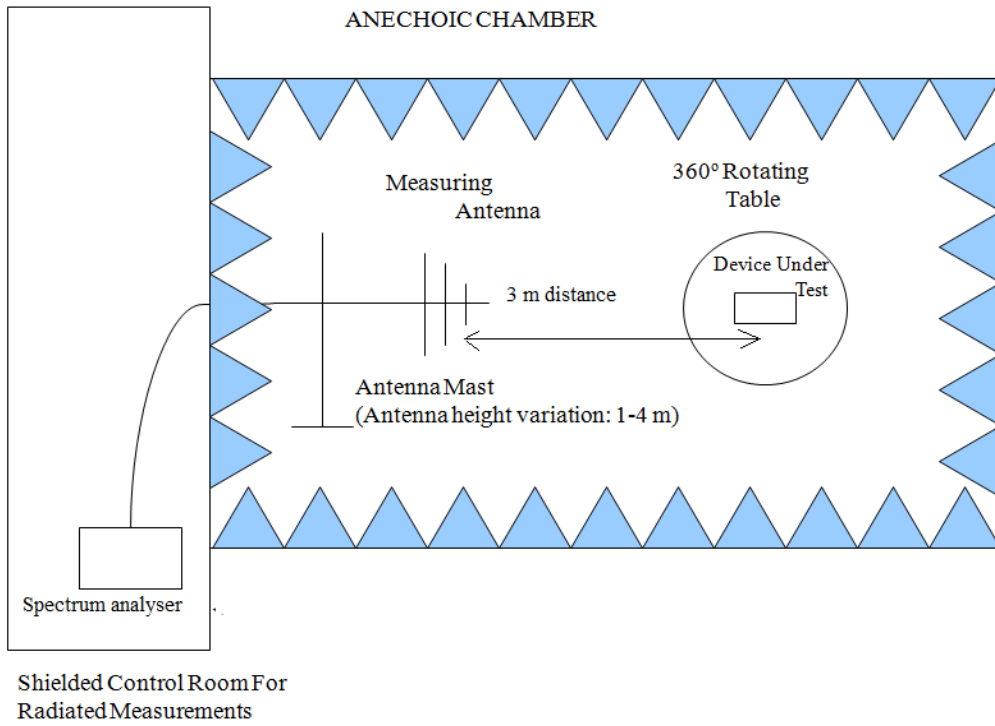
For radiated emissions in the range 17 GHz – 26 GHz performed at a distance closer than the distance specified in standard, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

The equipment under test was set up on a non-conductive platform above the ground plane and its situation and orientation were varied to find the maximum radiated emission. It was also rotated 360° and the antenna height was varied from 1 to 4 meters (up to 17GHz) to find the maximum radiated emission.

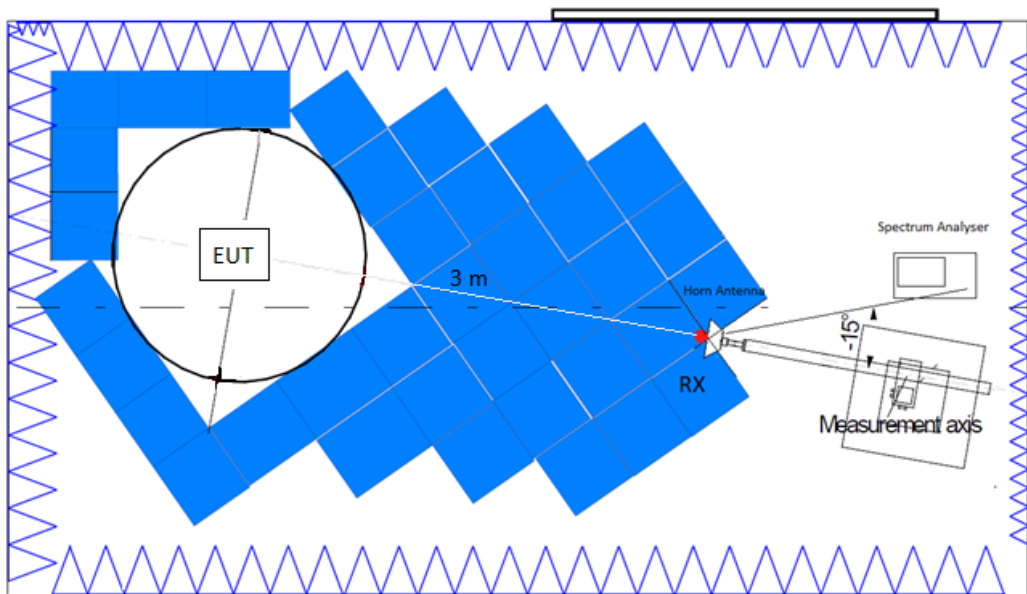
Measurements were made in both horizontal and vertical planes of polarization.

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

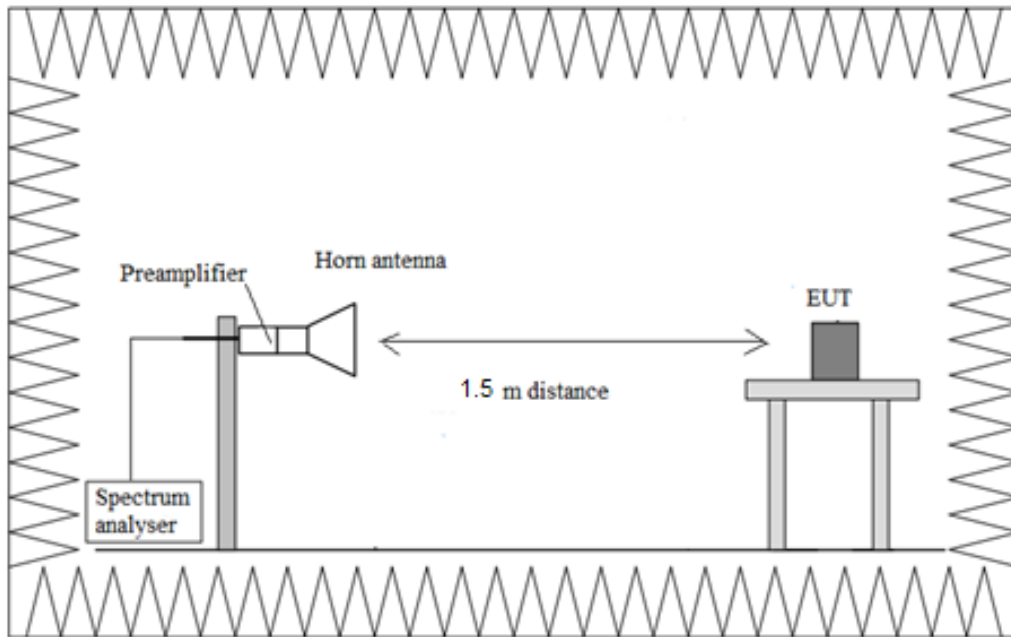
Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup from 1 GHz to 17 GHz:



Radiated measurements setup  $f > 17$  GHz:



## TEST CASES DETAILS

### FCC 15.247 (d) Emission limitations radiated (Transmitter)

#### Limits

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

Frequency Range (MHz)	Field strength ( $\mu\text{V}/\text{m}$ )	Field strength ( $\text{dB}\mu\text{V}/\text{m}$ )	Measurement distance (m)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	30
1.705 - 30.0	30	-	30
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 corresponding to 20 dB above the indicated values in the table specified when measuring with peak detector function.

#### Results

##### Frequency range 30 MHz – 1 GHz:

The spurious frequencies detected do not depend on either the modulation or the operating channel.

Spurious frequencies detected at less than 20 dB below the limit:

Freq Rng (GHz)	Unwanted Freq (MHz)	Unwanted Lvl ( $\text{dB}\mu\text{V}/\text{m}$ )	Pol	Detector
[0.03, 1]	37.457	23.48	V	QP
	250.008	28.46	V	QP
	599.996	31.01	V	QP
	874.991	30.43	V	QP

**Frequency range 1 GHz – 26 GHz:**

Modulation: BTLE 5.1 (GFSK 1 Mbit/s)

Spurious frequencies detected at less than 20 dB below the limit:

Freq Rng (GHz)	Freq (MHz)	Unwanted Freq (MHz)	Unwanted Lvl (dB $\mu$ V/m)	Pol	Detector
[3, 17]	2402.0000	4805.440	43.99	V	Peak
	2440.0000	5073.960	43.17	V	Peak
		5136.540	43.40	V	Peak
	2480.0000	4839.040	43.76	V	Peak
		5029.860	43.39	V	Peak

Modulation: BTLE 5.1 (GFSK 2 Mbit/s)

Spurious frequencies detected at less than 20 dB below the limit:

Freq Rng (GHz)	Freq (MHz)	Unwanted Freq (MHz)	Unwanted Lvl (dB $\mu$ V/m)	Pol	Detector
[3, 17]	2480.0000	4671.040	42.40	V	Peak
		4785.840	42.82	V	Peak
		4992.480	44.21	V	Peak

**Verdict**

Pass

**Attachments**

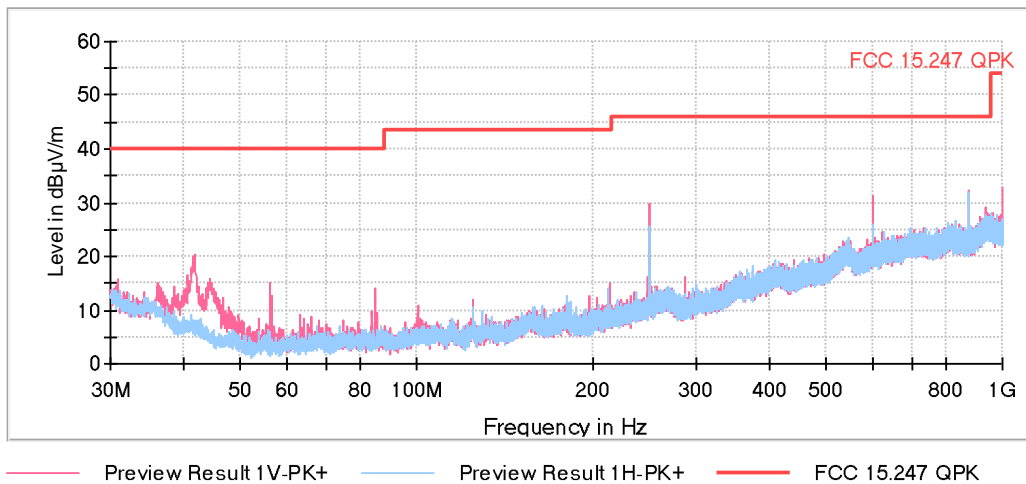
The setting for each range of frequency is indicated in the tables below:

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [ESW 44] 30 MHz - 1 GHz	30,312 kHz	PK+	100 kHz	1 s	0 dB
Receiver: [ESW 44] 1 GHz - 3 GHz	30,769 kHz	PK+ ; AVG	1 MHz	1 s	0 dB
Receiver: [ESW 44] 3 GHz - 17 GHz	140 kHz	PK+ ; AVG	1 MHz	1 s	30 dB
Receiver: [ESW 44] 17 GHz - 26 GHz	300 kHz	PK+ ; AVG	1 MHz	1 s	0 dB

**Modulations: BTLE 5.1 (GFSK 1 Mbit/s), BTLE 5.1 (GFSK 2 Mbit/s)**

**Equipment Type: Digital Transmission System (DTS), Frequency Range (GHz) = [0.03, 1], Number of Transmission Chains = 1**

**Plots:**



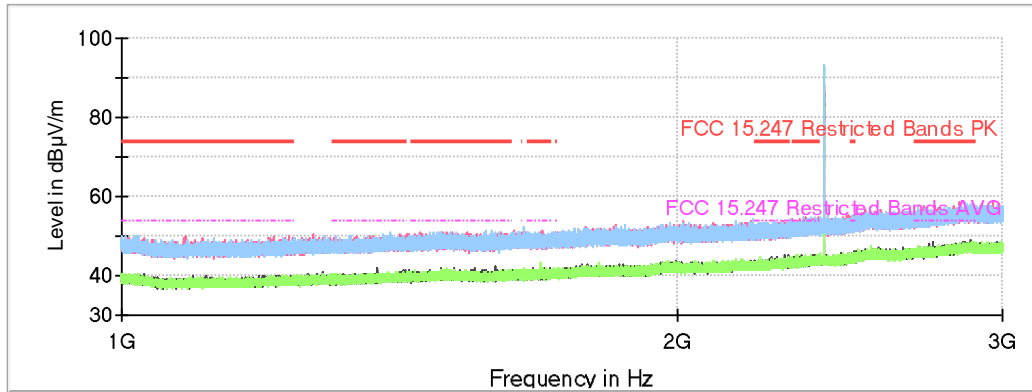
This plot is valid for Low, Middle and High Channels and all modulations



**Modulation: BTLE 5.1 (GFSK 1 Mbit/s)**

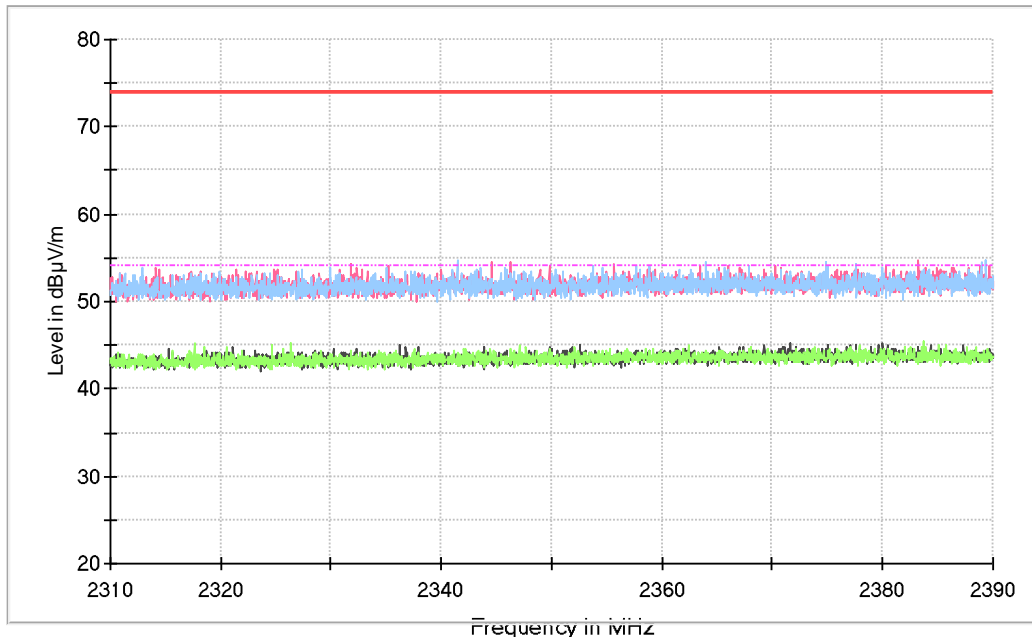
**Frequency (MHz) = 2402.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range (GHz) = [1, 3], Number of Transmission Chains = 1**

**Plots:**



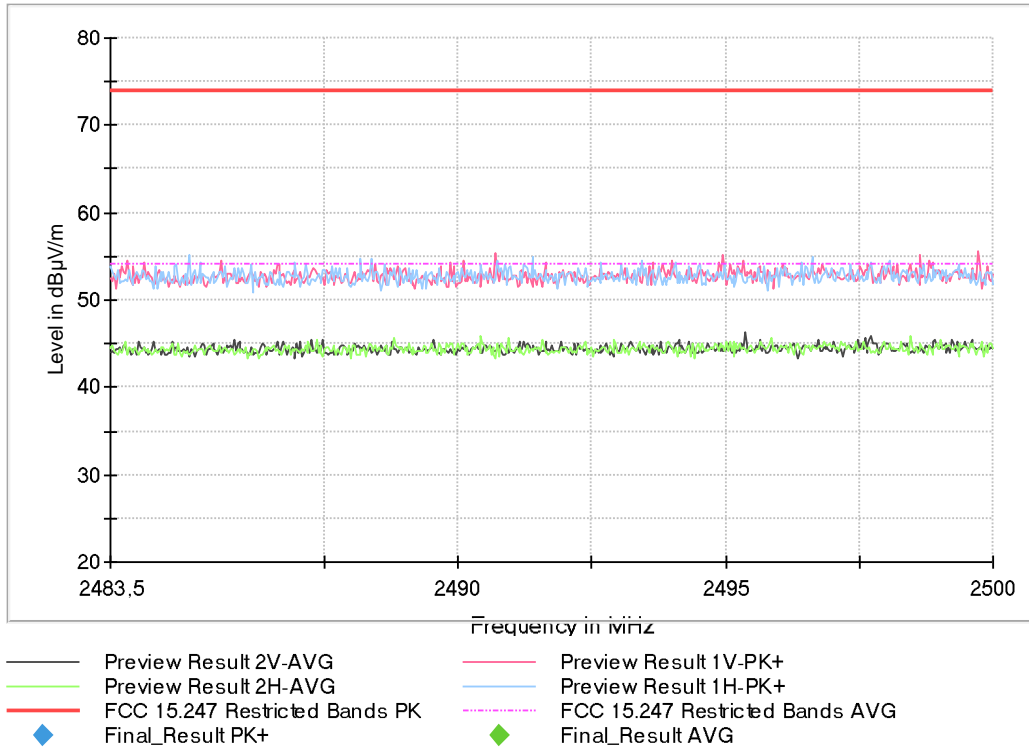
- Preview Result 2V-AVG
- Preview Result 2H-AVG
- FCC 15.247 Restricted Bands PK
- ◆ Final\_Result PK+
- Preview Result 1V-PK+
- Preview Result 1H-PK+
- FCC 15.247 Restricted Bands AVG
- ◆ Final\_Result AVG

Full Spectrum



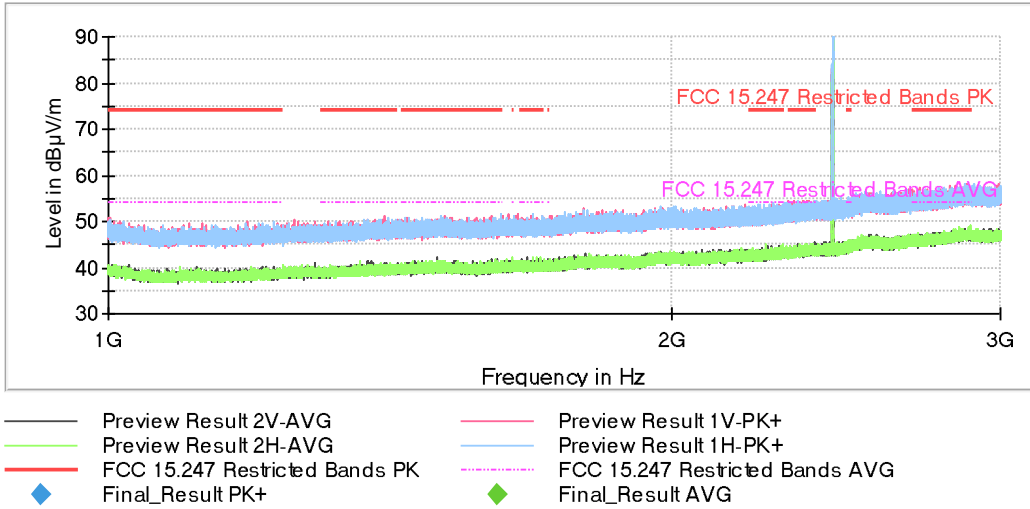
- Preview Result 2V-AVG
- Preview Result 2H-AVG
- FCC 15.247 Restricted Bands PK
- ◆ Final\_Result PK+
- Preview Result 1V-PK+
- Preview Result 1H-PK+
- FCC 15.247 Restricted Bands AVG
- ◆ Final\_Result AVG

Full Spectrum

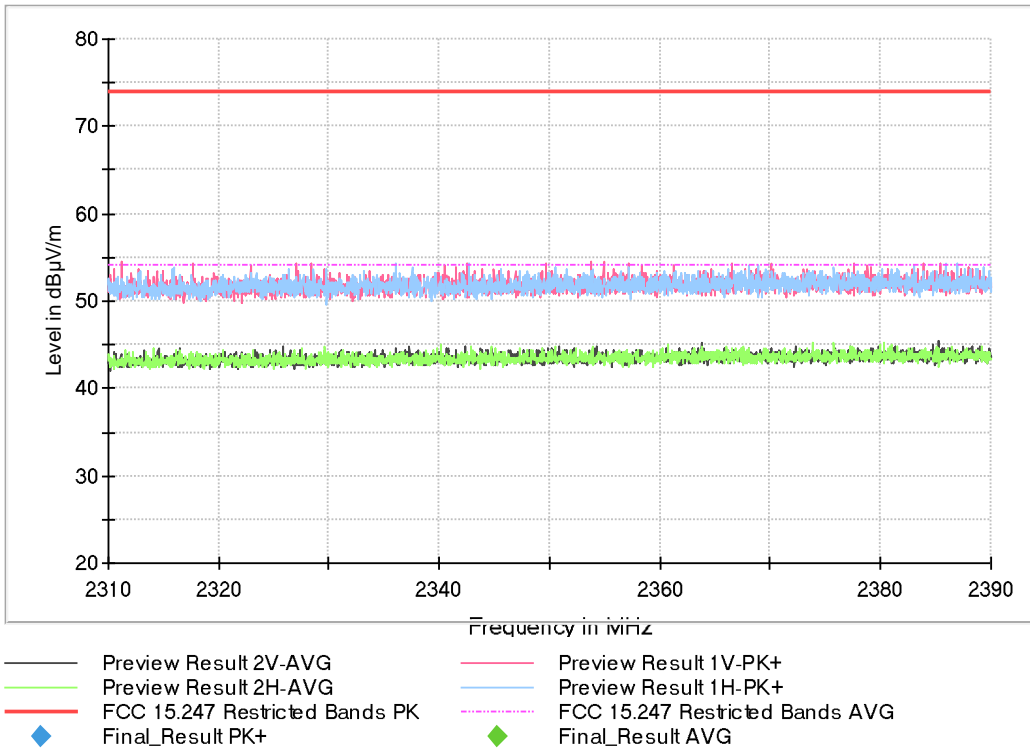


Frequency (MHz) = 2440.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range (GHz) = [1, 3], Number of Transmission Chains = 1

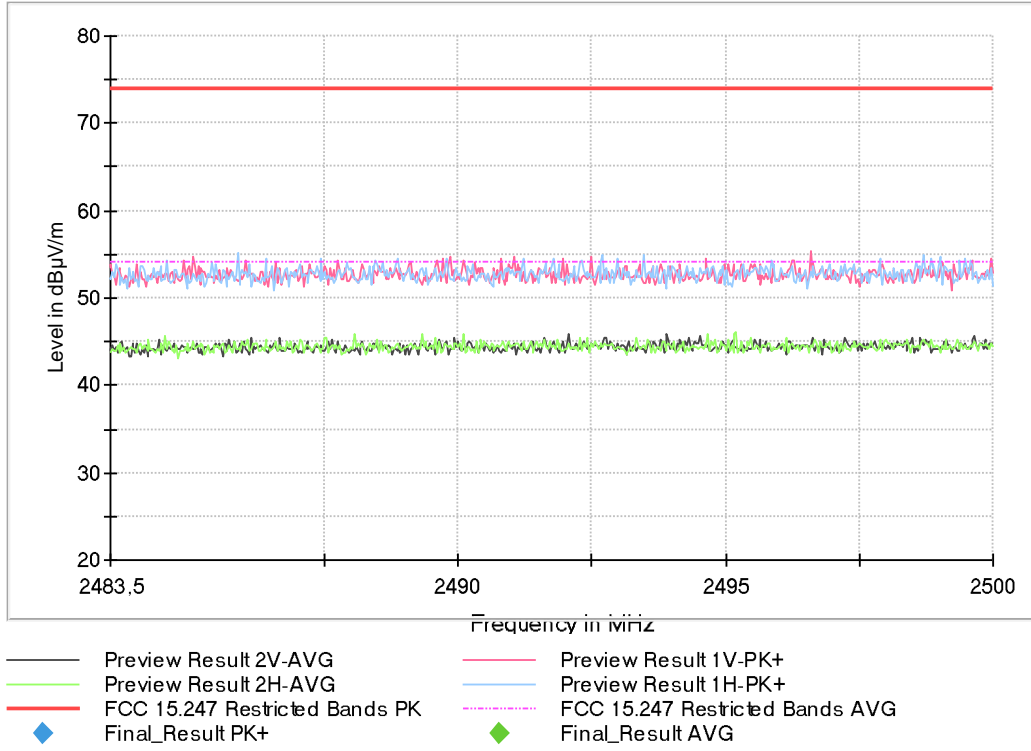
Plots:



Full Spectrum

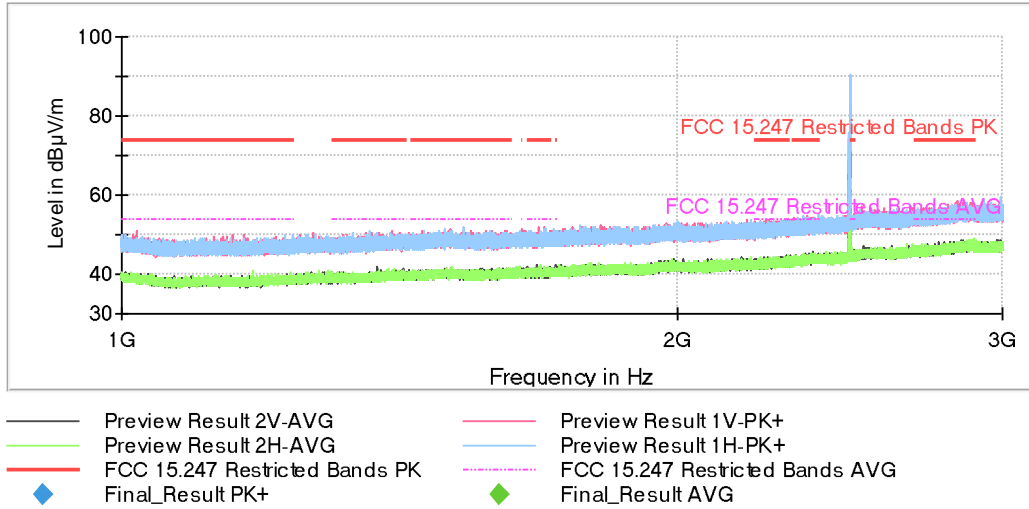


Full Spectrum

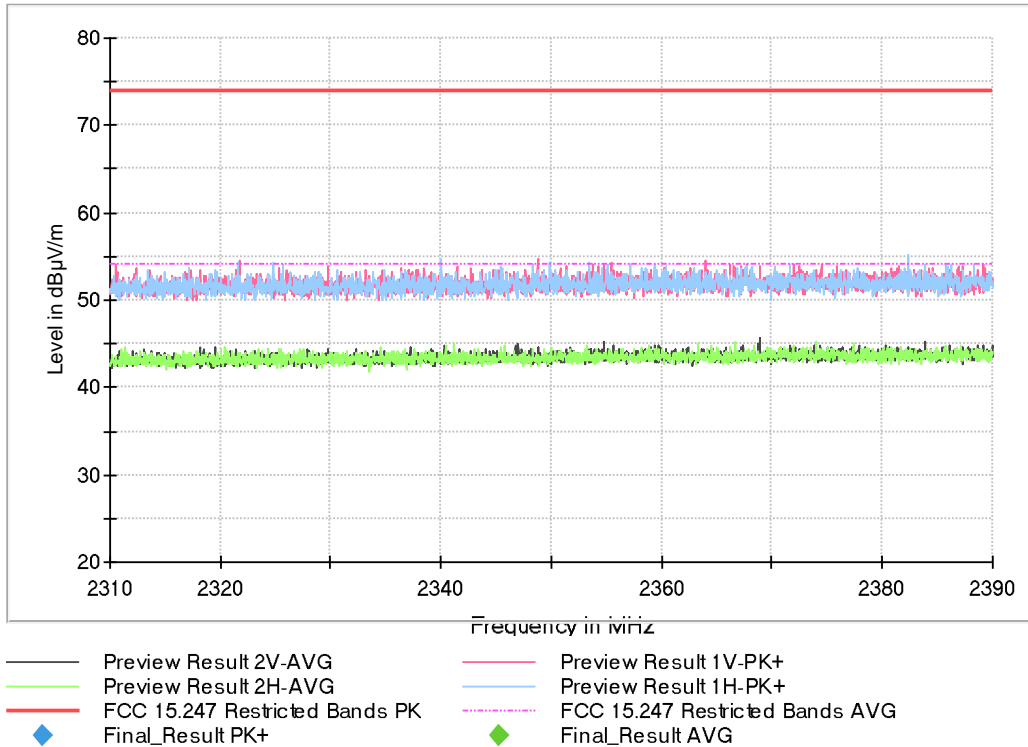


Frequency (MHz) = 2480.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range (GHz) = [1, 3], Number of Transmission Chains = 1

Plots:



Full Spectrum

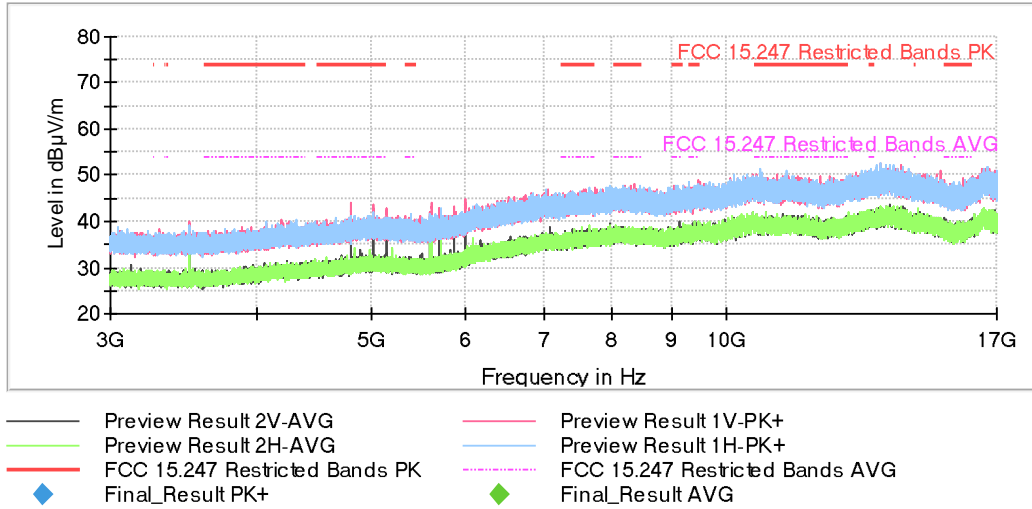


Full Spectrum



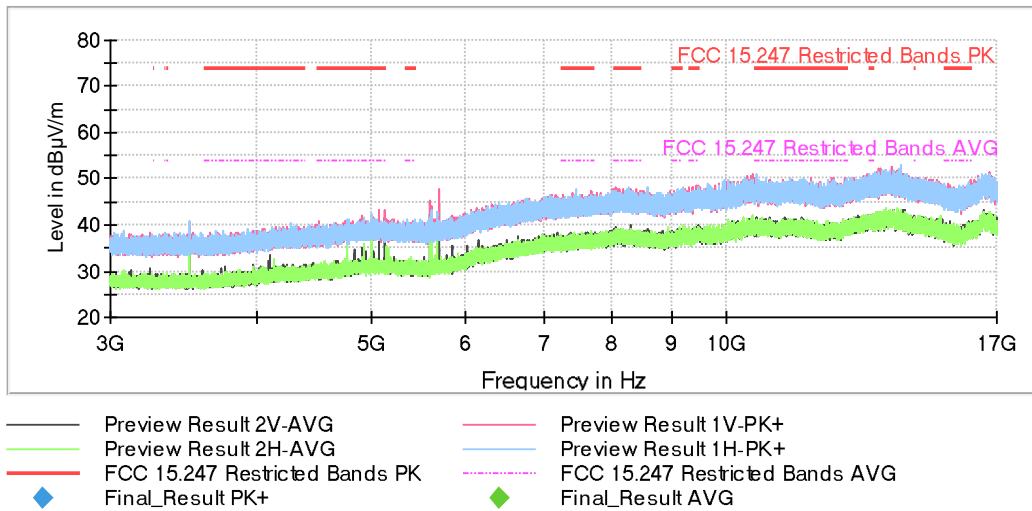
Frequency (MHz) = 2402.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range (GHz) = [3, 17], Number of Transmission Chains = 1

Plots:



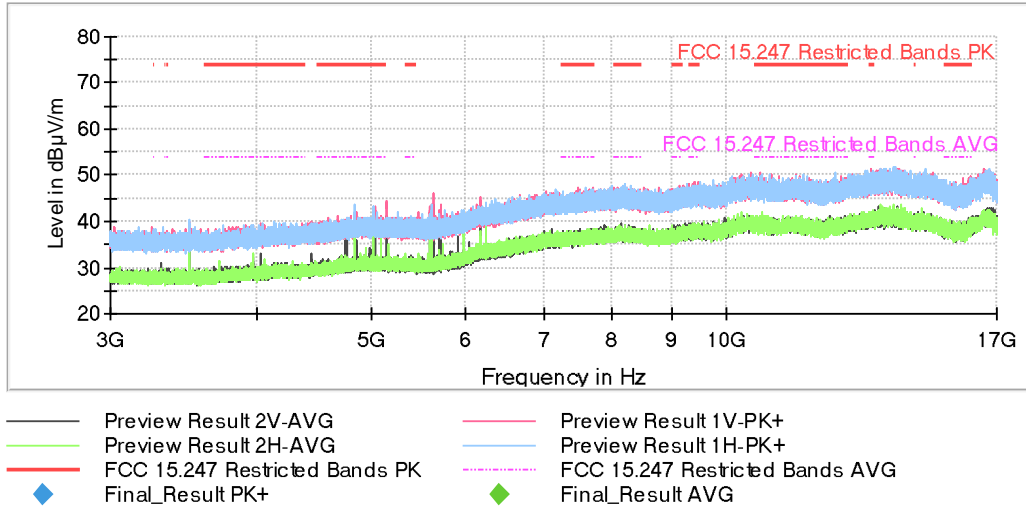
Frequency (MHz) = 2440.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range (GHz) = [3, 17], Number of Transmission Chains = 1

Plots:



Frequency (MHz) = 2480.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range (GHz) = [3, 17], Number of Transmission Chains = 1

Plots:

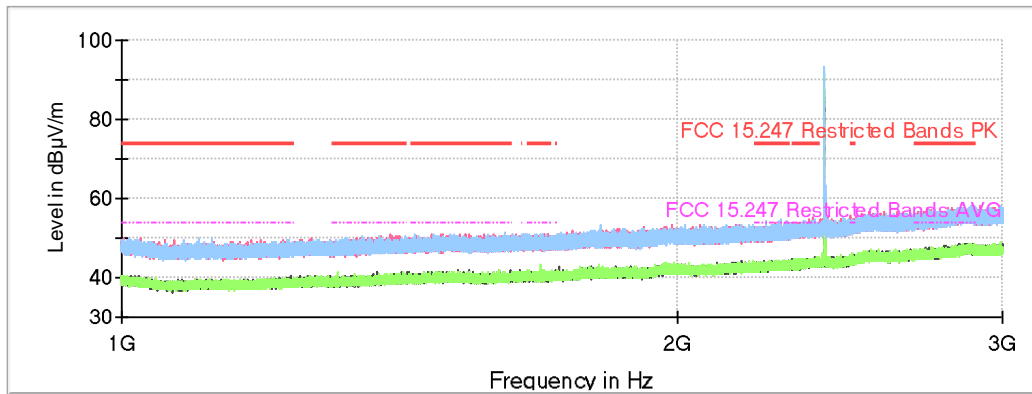




**Modulation: BTLE 5.1 (GFSK 2 Mbit/s)**

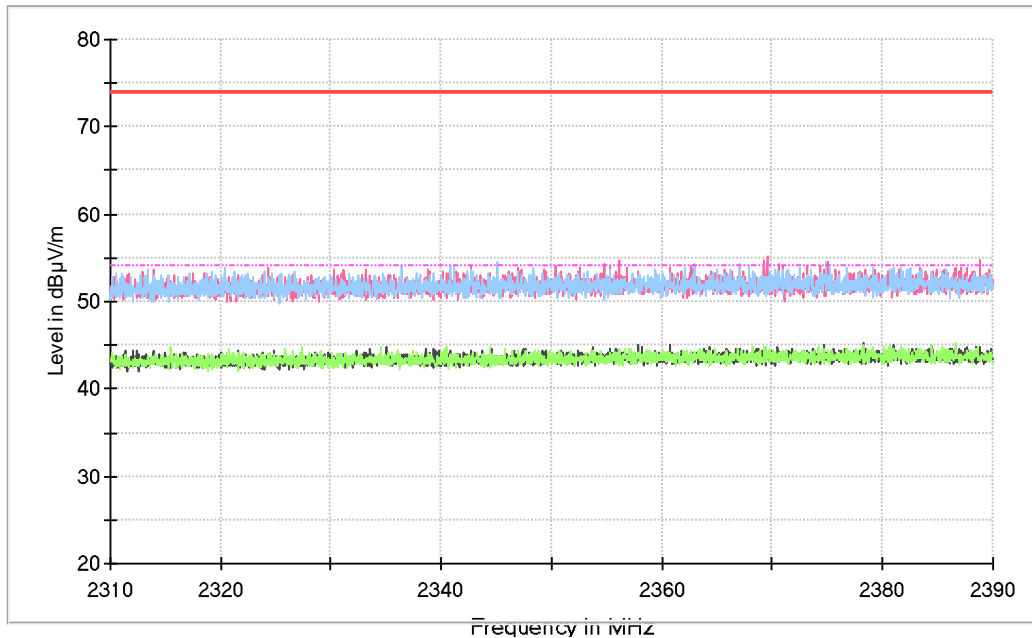
**Frequency (MHz) = 2402.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 2 Mbit/s), Frequency Range (GHz) = [1, 3], Number of Transmission Chains = 1**

**Plots:**



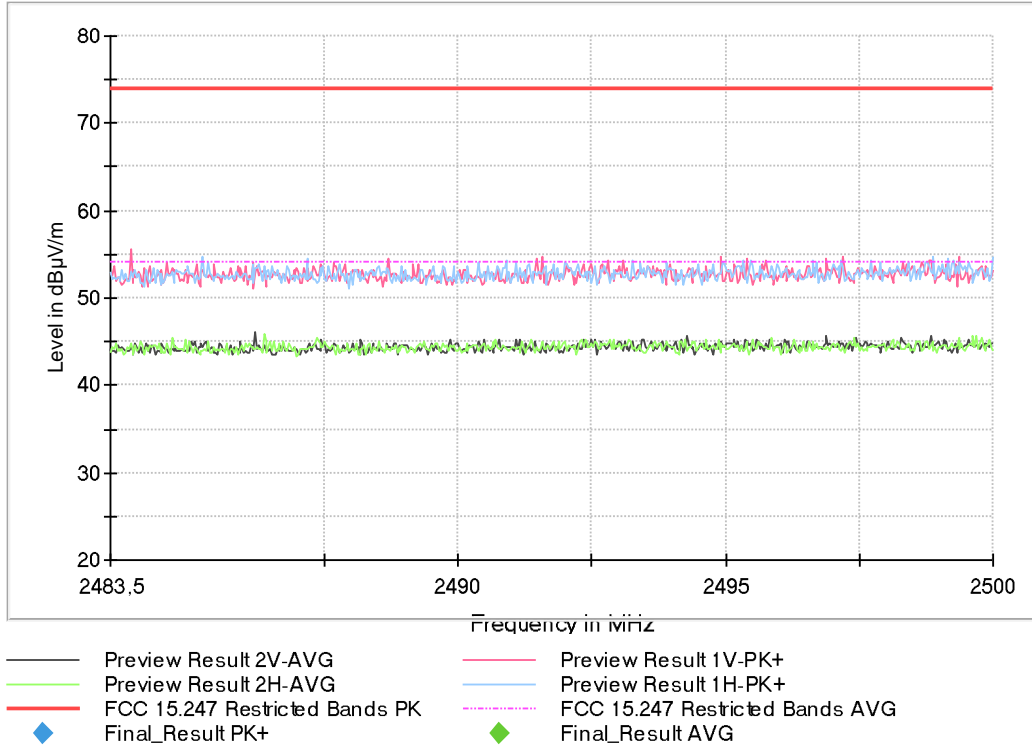
- Preview Result 2V-AVG
- Preview Result 2H-AVG
- FCC 15.247 Restricted Bands PK
- ◆ Final\_Result PK+
- Preview Result 1V-PK+
- Preview Result 1H-PK+
- FCC 15.247 Restricted Bands AVG
- ◆ Final\_Result AVG

**Full Spectrum**



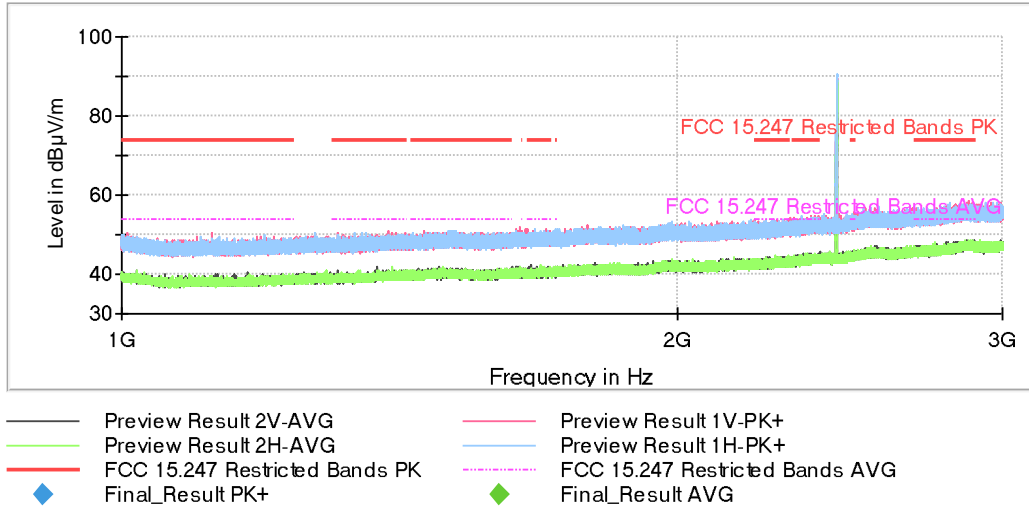
- Preview Result 2V-AVG
- Preview Result 2H-AVG
- FCC 15.247 Restricted Bands PK
- ◆ Final\_Result PK+
- Preview Result 1V-PK+
- Preview Result 1H-PK+
- FCC 15.247 Restricted Bands AVG
- ◆ Final\_Result AVG

Full Spectrum

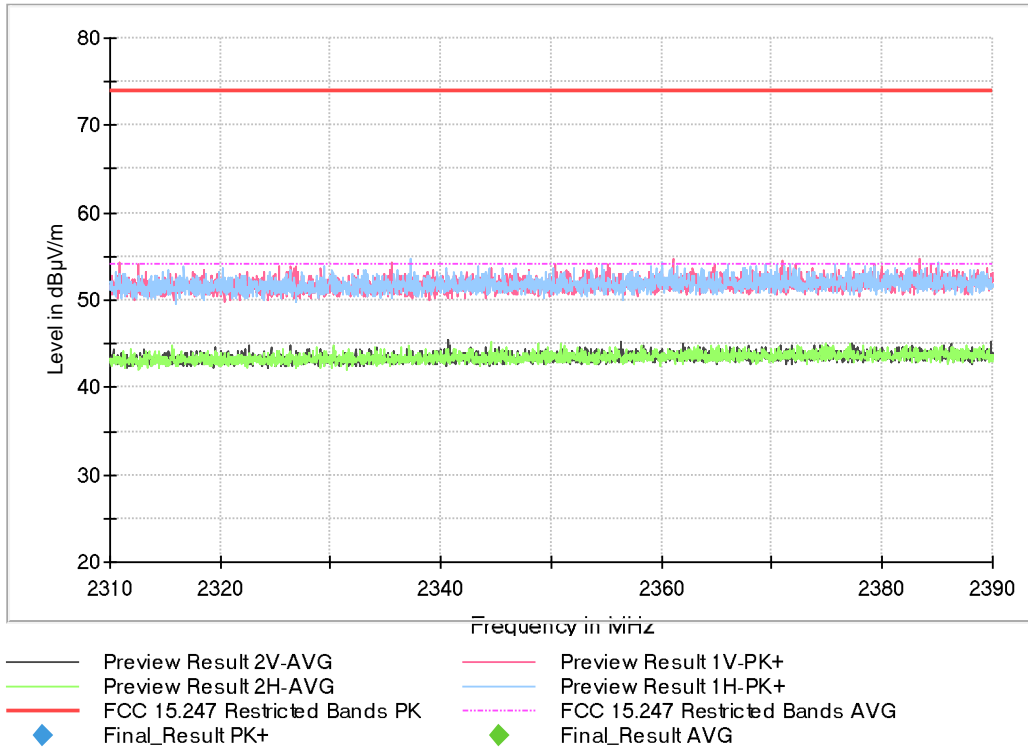


Frequency (MHz) = 2440.00000, Equipment Type: Digital Transmission System (DTS), Modulation: BTLE 5.1 (GFSK 2 Mbit/s), Frequency Range (GHz) = [1, 3], Number of Transmission Chains = 1

Plots:



Full Spectrum



Full Spectrum

