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TEST CONDITIONS

(*) Declared by the Applicant

POWER SUPPLY (*):

Vmin:	6.5Vdc
Vnom:	12Vdc
Vmax:	16Vdc
Type of Power Supply:	Battery

ANTENNA (*):

Type of Antenna:	Integrated PCB monopole antenna
Maximum Declared Antenna Gain:	Ch5 Peak Gain=3.6dBi, Ch9 Peak Gain= 3.8dBi

TEST FREQUENCY FOR FCC:

Channels:	Ch5 (6240 - 6740MHz) & Ch9 (7737- 8237MHz)
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TEST FREQUENCY FOR CANADA:

Channels:	Ch5 (6240 - 6740MHz) & Ch9 (7737- 8237MHz)
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RADIATED MEASUREMENTS:

All radiated tests were performed in a semi-anechoic chamber. The measurement antenna is situated at a distance of 3 m for the frequency range 30 MHz-1000 MHz (30 MHz-1000 MHz Bilog Antenna) and at a distance of 1 m for the frequency range 960 MHz-40 GHz (960 MHz-17 GHz Double Ridge Horn Antenna and 17 GHz-40 GHz Horn Antenna).

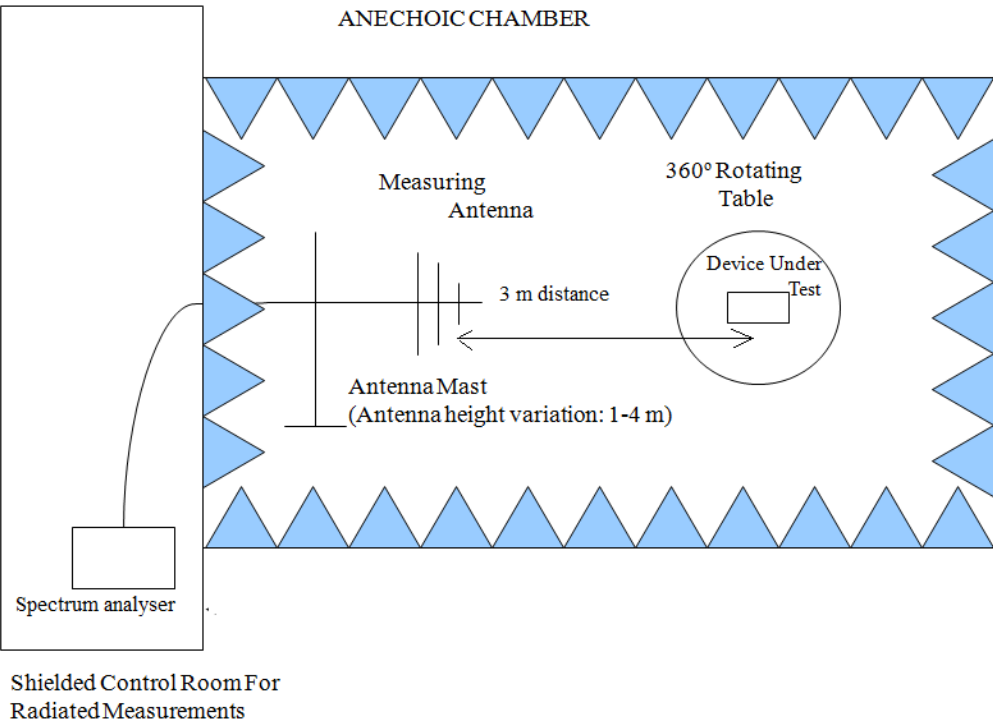
For radiated emissions in the range 960 MHz-40 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

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

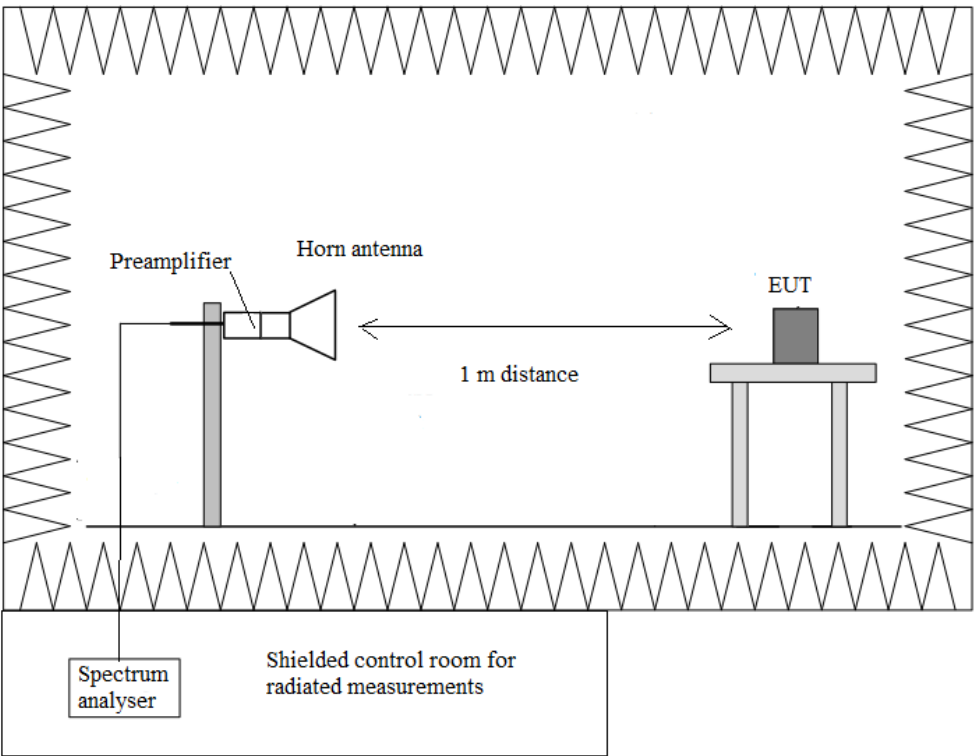
Measurements were made in both horizontal and vertical planes of polarization.

A resolution bandwidth/video bandwidth of 100 kHz / 300 kHz was used for frequencies below 960 MHz and 1 MHz / 3 MHz for frequencies above 960 MHz.

Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements above 960 MHz:



FCC 15.519 (a)(1) / RSS-220 5.3.1. (b). UWB Transmission Cessation

SPECIFICATION:

A UWB device operating under the provisions of this section shall transmit only when it is sending information to an associated receiver. The UWB intentional radiator shall cease transmission within 10 seconds unless it receives an acknowledgement from the associated receiver that its transmission is being received. An acknowledgment of reception must continue to be received by the UWB intentional radiator at least every 10 seconds or the UWB device must cease transmitting.

RESULTS:

Test Methodology:

- The EUT (Responder) was configured to establish an active UWB ranging session with an associated receiver (Initiator) using the provided test software.
- Active communication (acknowledgement) was verified via the Spectrum Analyzer (CF: 7.9872 GHz, Zero Span).
- The Initiator was then manually disabled (via software "Reset" button) to simulate a loss of acknowledgment.
- The time taken for the EUT to cease transmission was monitored and recorded.

Measurement Data:

UWB Channel: CH 5 (7.9872 GHz).

Parameter	Measured Value	Limit
Transmission Cessation Time	Instantaneous (< 1 second)	< 10 seconds

Figure 1: Active UWB ranging session. Both Initiator and DUT pulses are visible.

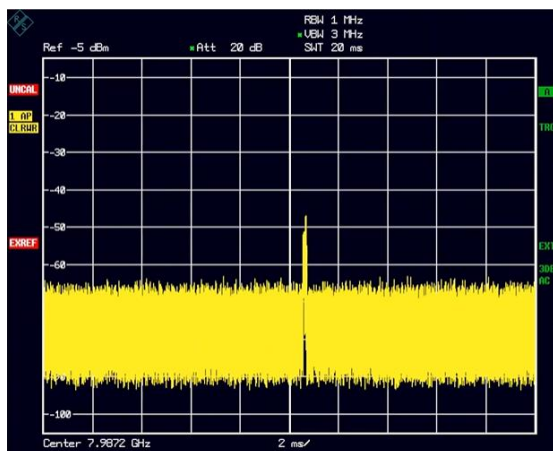
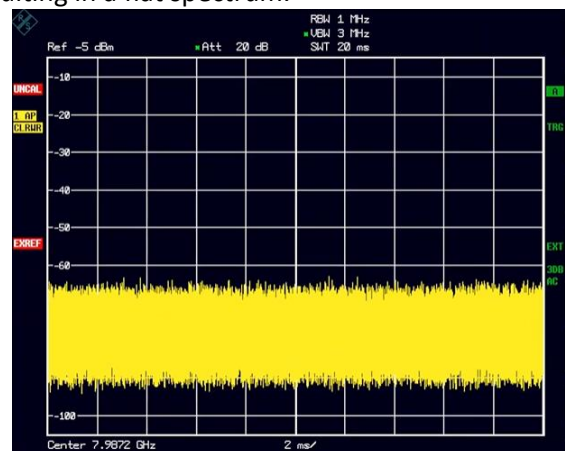


Figure 2: Immediately after the Initiator is disabled (loss of acknowledgment). The DUT stops transmitting, resulting in a flat spectrum.



Verdict: PASS

FCC 15.519 (b) / RSS-220 5.1. (a) UWB Bandwidth

SPECIFICATION:

* FCC §15.503 (a) UWB bandwidth: For the purpose of this subpart, the UWB bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated emission, as based on the complete transmission system including the antenna. The upper boundary is designated fH and the lower boundary is designated fL. The frequency at which the highest radiated emission occurs is designated fM.

* FCC §15.503 (b) Center frequency: The center frequency, fC, equals (fH + fL)/2.

* FCC §15.503 (c) Fractional bandwidth: The fractional bandwidth equals 2(fH-fL)/(fH + fL).

* FCC §15.503 (d) Ultra-wideband (UWB) transmitter: An intentional radiator that, at any point in time, has a fractional bandwidth equal to or greater than 0.20 or has a UWB bandwidth equal to or greater than 500 MHz, regardless of the fractional bandwidth.

* FCC §15.519 (b): The UWB bandwidth of a device operating under the provisions of this section must be contained between 3100 MHz and 10600 MHz.

* RSS-220 2: A UWB device is an intentional radiator that has either a -10 dB bandwidth of at least 500 MHz or a -10 dB fractional bandwidth greater than 0.2.

* RSS-220 5.1. (a): The -10 dB bandwidth of the device shall be totally contained in the band 3.1-10.6 GHz.

"-10 dB bandwidth B₋₁₀" and "-10 dB fractional bandwidth μ₋₁₀" are defined as follows:

$$B_{-10} = fH - fL$$

$$\mu_{-10} = B_{-10}/fC$$

where:

fM is the frequency of maximum UWB transmission;
fH is the highest frequency at which the power spectral density of the UWB transmission is -10 dB relative to fM;
fL is the lowest frequency at which the power spectral density of the UWB transmission is -10 dB relative to fM; and
fC = (fH + fL)/2 is the centre frequency of the -10 dB bandwidth.

RESULTS:

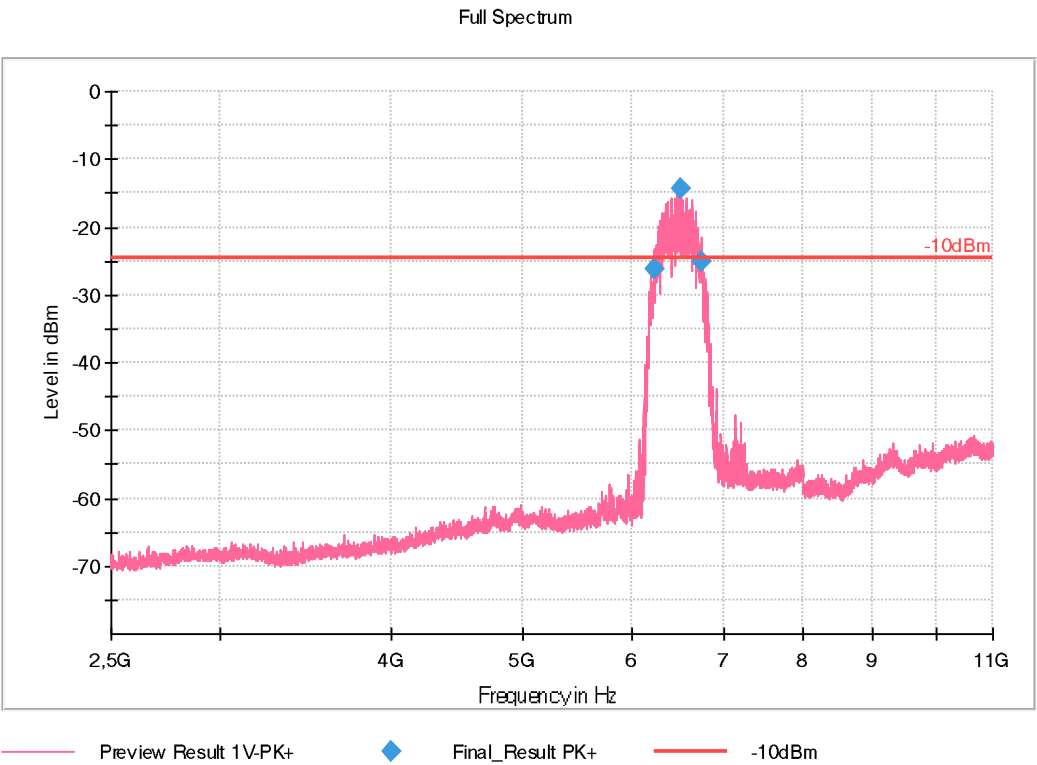
Channel	FM (MHz)	FL (MHz)	FH (MHz)	FC (MHz)	B ₋₁₀ (MHz)	Min B ₋₁₀ (MHz)
6489.6 MHz (Ch5)	6514.55	6229.80	6751.70	6490.75	521.9	500
7987.2 MHz (Ch9)	7837.15	7679.05	8222.20	7950.625	543.15	500
Measurement uncertainty (kHz)	<± 130					

Verdict: PASS

• CHANNEL 5 (6489.6 MHz):

Measurement settings:

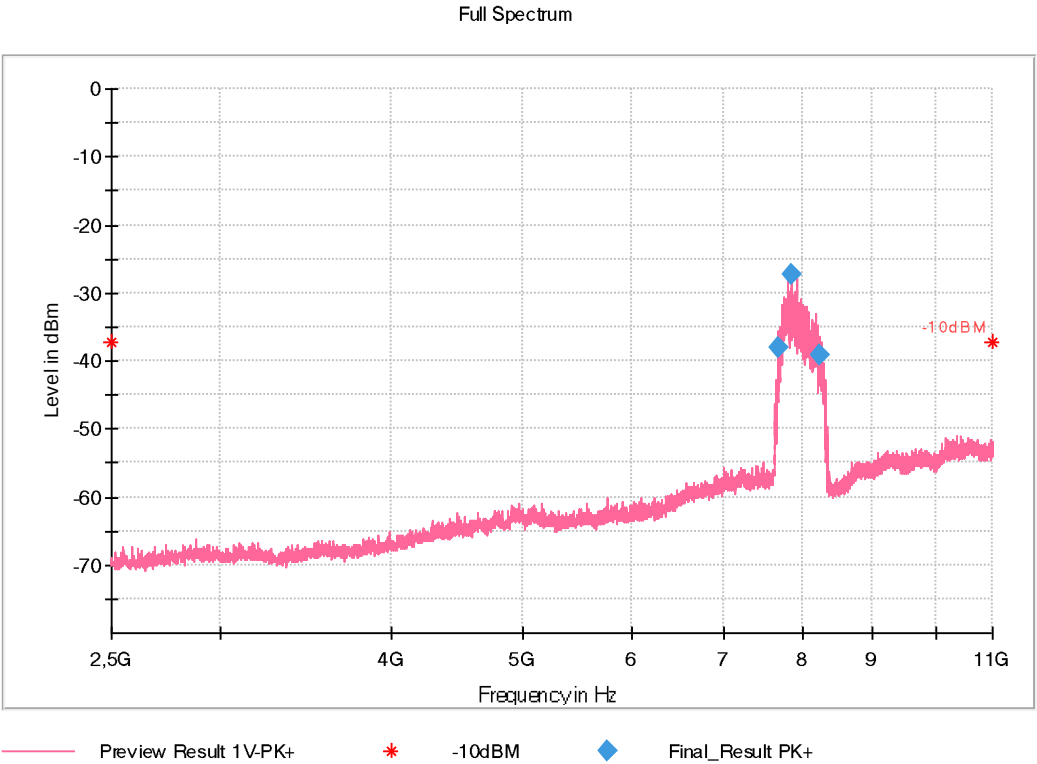
Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
2,5 GHz - 11 GHz	850 kHz	PK+	1 MHz	0,15 s	0 dB



• CHANNEL 9 (7987.2MHz):

Measurement settings:

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
2,5 GHz - 11 GHz	850 kHz	PK+	1 MHz	0,15 s	0 dB



FCC 15.519 (c),(d), 15.521 (c) / RSS-220 5.3.1. (c),(d),(e), Annex. Section 4 (m): Radiated Emissions

SPECIFICATION:

The radiated emissions at or below 960 MHz shall not exceed the emission levels in §15.209:

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)	-	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

* §15.519 (c): The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in §15.209. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency Range (MHz)	EIRP (dBm)
960-1610	-75.3
1610-1990	-63.3
1990-3100	-61.3
3100-10600	-41.3
Above 10600	-61.3

* §15.519 (d): In addition to the radiated emission limits specified in the table above, UWB transmitters shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency Range (MHz)	EIRP (dBm)
1164-1240	-85.3
1559-1610	-85.3

* §15.521 (c): Emissions from digital circuitry used to enable the operation of the UWB transmitter shall comply with the limits in §15.209, rather than the limits specified above for EIRP, provided it can be clearly demonstrated that those emissions from the UWB device are due solely to emissions from digital circuitry contained within the transmitter and that the emissions are not intended to be radiated from the transmitter's antenna.

* RSS-220 5.3.1. (c): Radiated emissions at or below 960 MHz from a device shall not exceed the limits. Measurements of radiated emissions at and below 960 MHz are to be made using a CISPR quasi-peak detector. CISPR measurement bandwidth specifications are to be used.

Frequency Range (MHz)	Field strength (µV/m)	Measurement distance (m)	E.i.r.p (dBmW)
0.009-0.490	2400/F(kHz)	300	10 log (17.28 / F ²) (F in KHz)
0.490-1.705	24000/F(kHz)	30	10 log (17.28 / F ²) (F in KHz)
1.705 - 30.0	30	30	-45.7
30 - 88	100	3	-55.2
88 - 216	150	3	-51.7
216 - 960	200	3	-49.2

Note: The emission limits for the bands 9-90 kHz and 110-490 kHz are based on measurements employing an average emissions detector.

* RSS-220 5.3.1. (d): Radiated emissions above 960 MHz from a device shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz.

Frequency Range (MHz)	EIRP (dBm) in a RBW of 1 MHz
960-1610	-75.3
1610-4750	-70.0
4750-10600	-41.3
Above 10600	-61.3

* RSS-220 5.3.1. (e): In addition to the radiated emission limits specified in the table above, radiated emissions shall not exceed the following average limits when measured using a resolution bandwidth greater than or equal to 1 kHz. The measurements shall demonstrate compliance with the stated limits at whatever resolution bandwidth is used.

Frequency Range (MHz)	EIRP (dBm)
1164-1240	-85.3
1559-1610	-85.3

* RSS-220 Annex. Section 4 (m): Emissions from digital circuitry (used only to enable the operation of the UWB transmitter and that does not control additional functions or capabilities) shall comply with the average and peak power limits applicable to the UWB transmitter. If it can be clearly demonstrated that an emission from a UWB transmitter is due solely to emissions from digital circuitry contained within the transmitter, and that the emission is not intended to be radiated from the transmitter's antenna, the limits for emissions from digital circuitry prescribed in RSS-Gen apply to that emission rather than the UWB limits.

RESULTS:

1. UWB TRANSMITTER ON. CHANNEL 5 (6489.6 MHz):

Frequency range 30 MHz - 960 MHz:

Unwanted Freq (MHz)	Emission Lvl (dBμV/m)	Polarization	Detector
30.000000	29.09	H	QPK
117.010800	31.31	H	QPK
166.049700	29.45	H	QPK
166.431000	29.39	H	QPK
184.621800	25.74	H	QPK
333.235800	28.38	H	QPK
399.991200	25.45	H	QPK

Frequency range 960 MHz - 10.6 GHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious Frequency (MHz)	Emission Level (dBm)	Polarization	Detector
998.945600	-74.79*	V	RMS
1162.729200	-74.41*	V	RMS
1165.139200	-75.13*	V	RMS

(*) Peaks exceeding the limit were due to the circuitry evaluated in 3 UWB TRANSMITTER OFF

Frequency range 10.6 - 40 GHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious Frequency (MHz)	Emission Level (dBm)	Polarization	Detector
10928.066000	-69.89	V	RMS
12980.612000	-64.53	H	RMS
13103.726000	-63.46	H	RMS
13229.152000	-64.95	H	RMS
14279.990000	-66.35	H	RMS
16605.950000	-67.23	V	RMS
16995.260000	-66.73	H	RMS

Frequency range 1164-1240 MHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious Frequency (MHz)	Emission Level (dBm)	Polarization	Detector
1177.592600	-112.69	V	RMS
1192.049320	-113.65	V	RMS
1199.999680	-92.18	V	RMS
1200.027800	-105.33	V	RMS
1216.985680	-115.06	H	RMS
1225.103240	-114.71	H	RMS

Frequency range 1559-1610 MHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious Frequency (MHz)	Emission Level (dBm)	Polarization	Detector
1561.015520	-115.43	V	RMS
1585.597520	-115.16	H	RMS
1600.000430	-94.56	V	RMS
1604.110520	-116.51	V	RMS
1606.556480	-113.81	H	RMS
1609.120250	-116.58	H	RMS

Measurement Uncertainty (dB):
1 GHz <± f < 17 GHz: <± 4.6
17 GHz <± f <± 26.5 GHz: <± 4.89
26.5 GHz <± f <± 40 GHz: <± 5.14

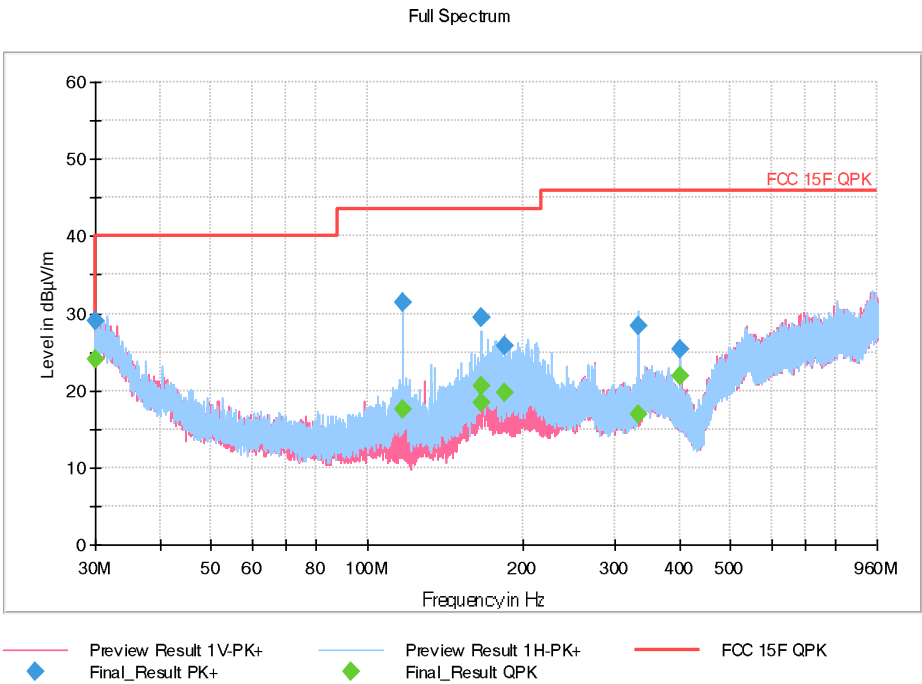
Verdict: PASS

• UWB TRANSMITTER ON. CHANNEL 5 (6489.6 MHz):

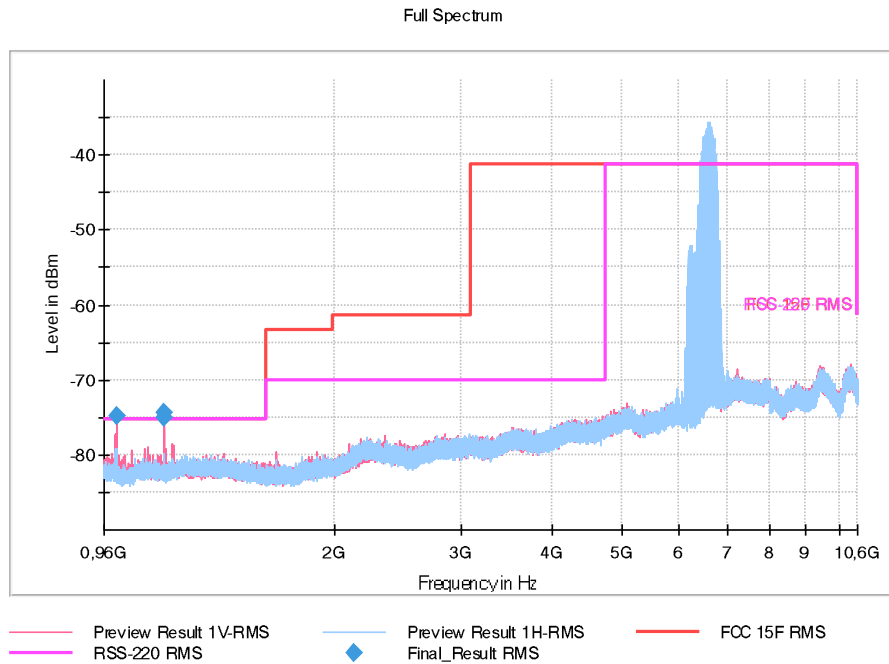
Measurement settings:

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
30 MHz – 960 MHz	9,3 kHz	PK+	100 kHz	1 s	0 dB
960 MHz - 10.6 GHz	96.4 kHz	RMS	1 MHz	1 s	0 dB
10.6 GHz - 14 GHz	34 kHz	RMS	1 MHz	1 s	0 dB
14 GHz - 17 GHz	30 kHz	RMS	1 MHz	1 s	0 dB
17 GHz - 26 GHz	90 kHz	RMS	1 MHz	1 s	0 dB
26 GHz - 40 GHz	140 kHz	RMS	1 MHz	1 s	0 dB
1,164 GHz - 1,24 GHz	760 Hz	RMS	3 kHz	Coupled	0 dB
1,559 GHz - 1,61 GHz	510 Hz	RMS	3 kHz	Coupled	0 dB

FREQUENCY RANGE 30 MHz - 1 GHz:

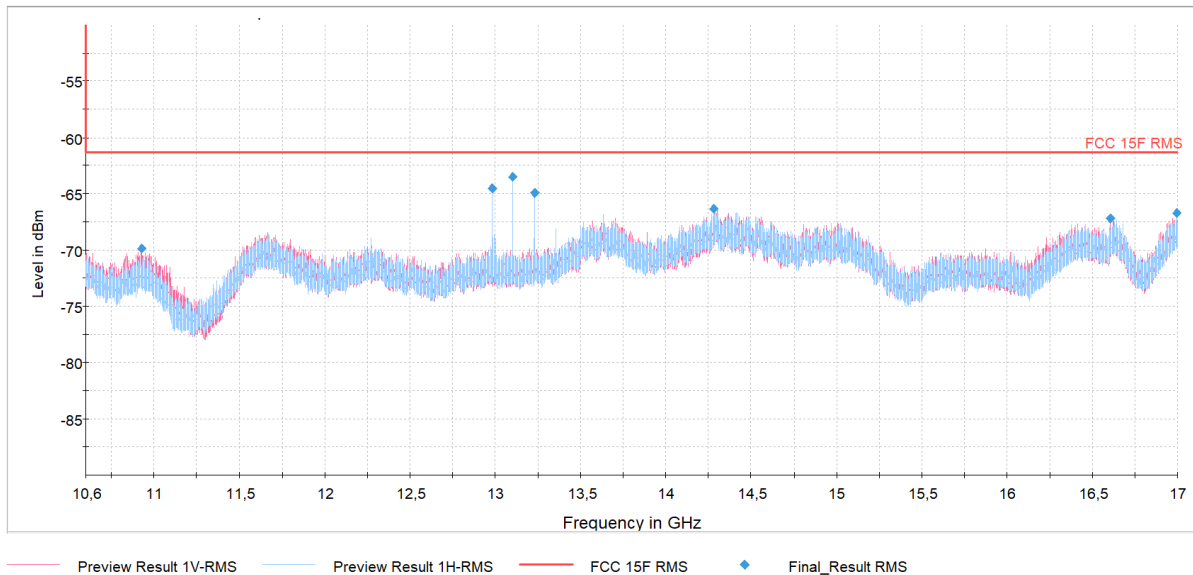


FREQUENCY RANGE 960 MHz - 10.6 GHz:

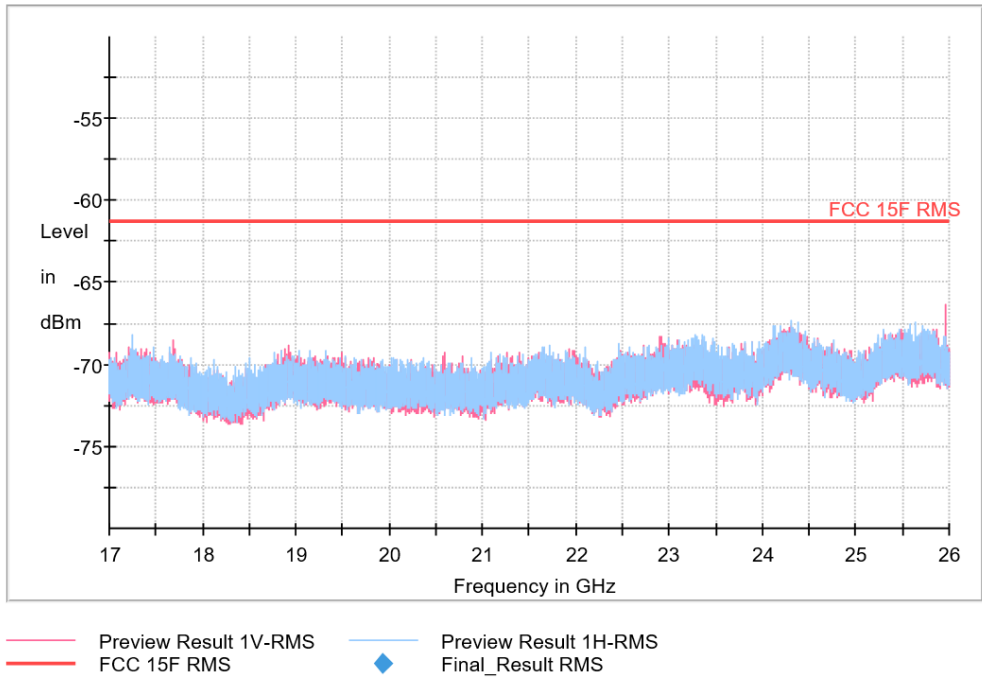


Note: The peaks near 1 GHz are due to internal circuitry and are independent of the UWB transmission. As verified with the transmitter OFF, they are not subject to the UWB limits of FCC15.519/FCC15.521/RSS-220 but instead are assessed under FCC15.209/RSS-Gen, as shown in section: "3. UWB TRANSMITTER OFF".

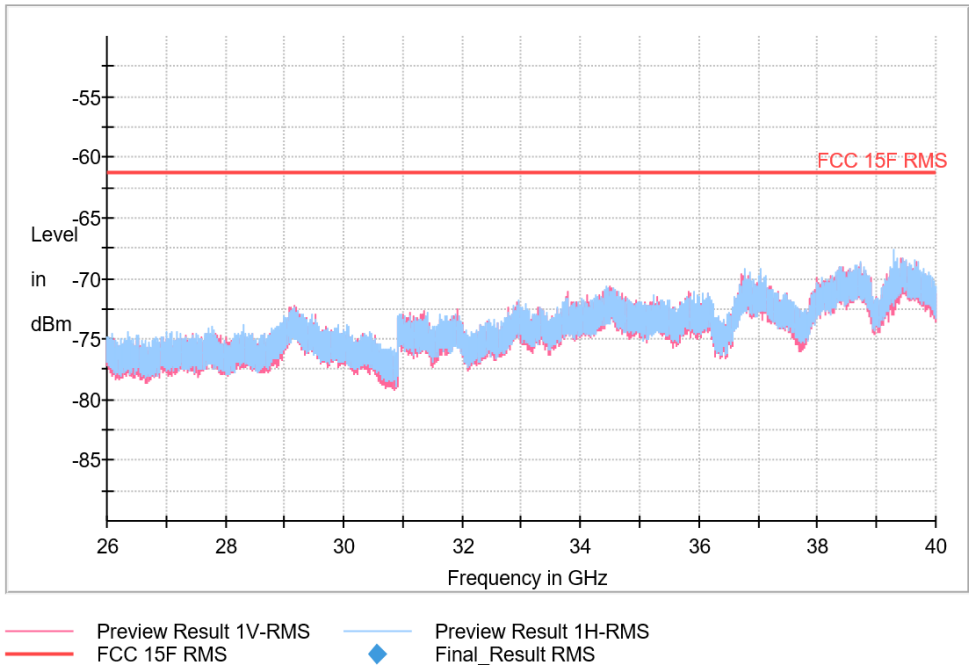
FREQUENCY RANGE 10.6 - 40 GHz:



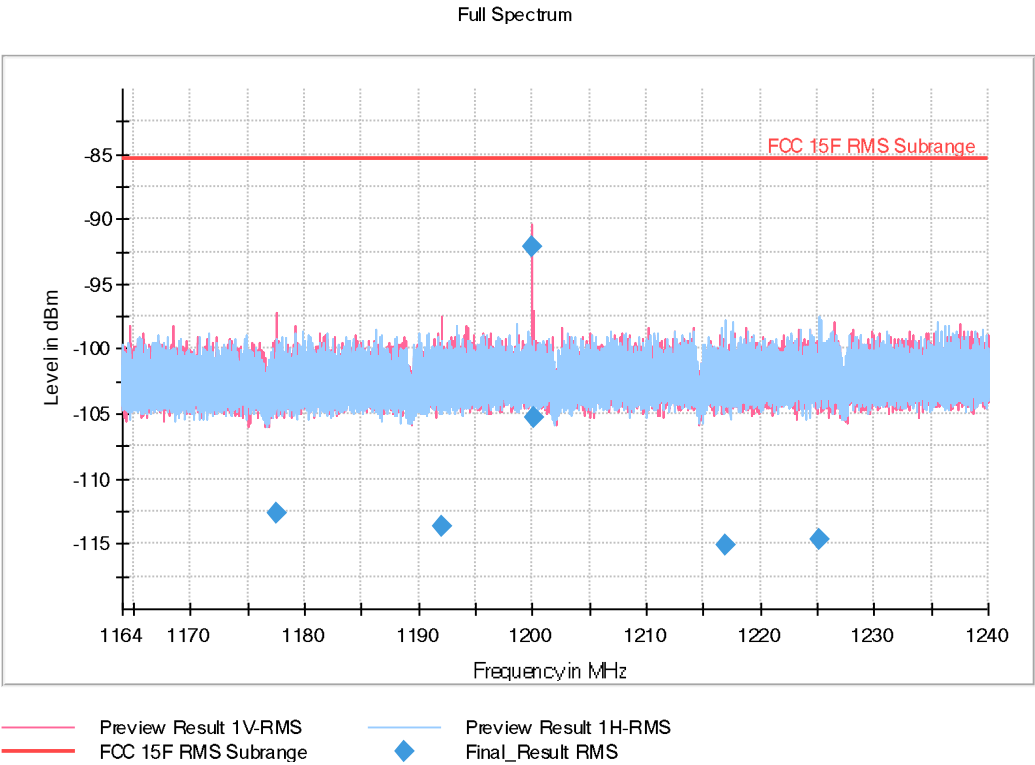
Full Spectrum



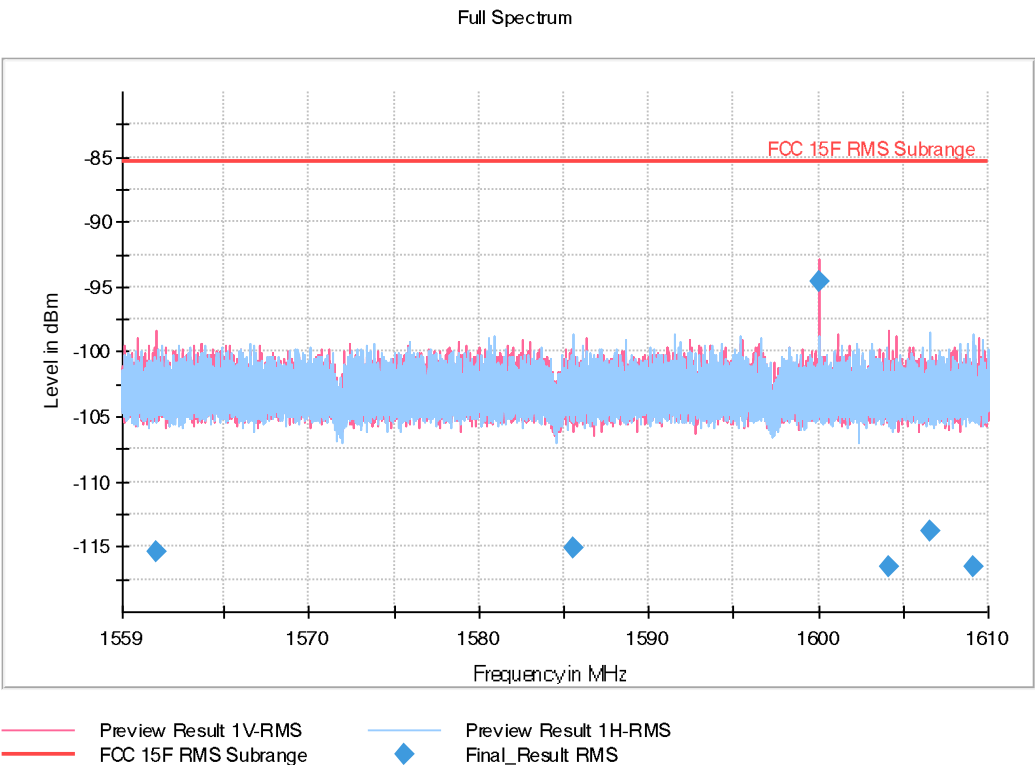
Full Spectrum



FREQUENCY RANGE 1.164 -1.240GHz:



FREQUENCY RANGE 1.559-1.610GHz:



2. UWB TRANSMITTER ON. CHANNEL 9 (7987.2MHz):

Frequency range 30 MHz - 960 MHz:

Unwanted Freq (MHz)	Emission Lvl (dBµV/m)	Polarization	Detector
30.000000	29.52	V	QPK
46.740000	18.68	H	QPK
117.020100	26.03	H	QPK
166.468200	29.18	H	QPK
196.804800	27.64	H	QPK
207.462600	28.60	H	QPK
331.292100	20.36	H	QPK
400.009800	27.33	H	QPK

Frequency range 960 MHz - 10.6 GHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious Frequency (MHz)	Emission Level (dBm)	Polarization	Detector
2554.648800	-71.99	H	RMS

Frequency range 10.6 - 40 GHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious Frequency (MHz)	Emission Level (dBm)	Polarization	Detector
10958.734000	-67.20	V	RMS
14292.620000	-66.21	H	RMS
15599.690000	-66.45	H	RMS
15724.490000	-65.34	H	RMS
15973.700000	-66.57	H	RMS
16098.920000	-66.34	V	RMS
16621.880000	-66.96	H	RMS
25452.440000	-68.28	V	RMS
29247.440000	-71.77	V	RMS
34499.820000	-70.15	H	RMS
38583.060000	-68.68	V	RMS

Frequency range 1164-1240 MHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious Frequency (MHz)	Emission Level (dBm)	Polarization	Detector
1167.436720	-113.11	V	RMS
1181.257320	-114.36	V	RMS
1184.045000	-111.98	V	RMS
1200.000440	-97.07	H	RMS
1200.028560	-99.86	V	RMS
1215.971080	-95.04	V	RMS

Frequency range 1559-1610 MHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious Frequency (MHz)	Emission Level (dBm)	Polarization	Detector
1562.756150	-109.77	V	RMS
1562.857130	-112.68	V	RMS
1565.546870	-110.86	V	RMS
1566.864200	-111.03	V	RMS
1566.928970	-112.07	V	RMS
1599.999920	-94.55	V	RMS

Measurement Uncertainty (dB):
 1 GHz $\leq f < 17$ GHz: $\leq \pm 4.6$
 17 GHz $\leq f < 26.5$ GHz: $\leq \pm 4.89$
 26.5 GHz $\leq f < 40$ GHz: $\leq \pm 5.14$

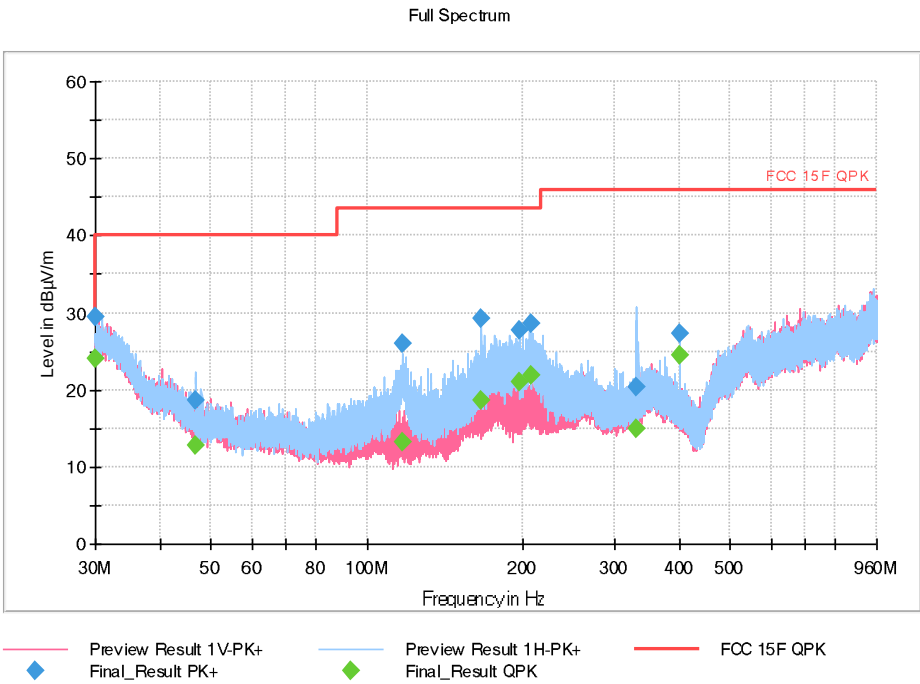
Verdict: PASS

• UWB TRANSMITTER ON. CHANNEL 9 (7987.2MHz):

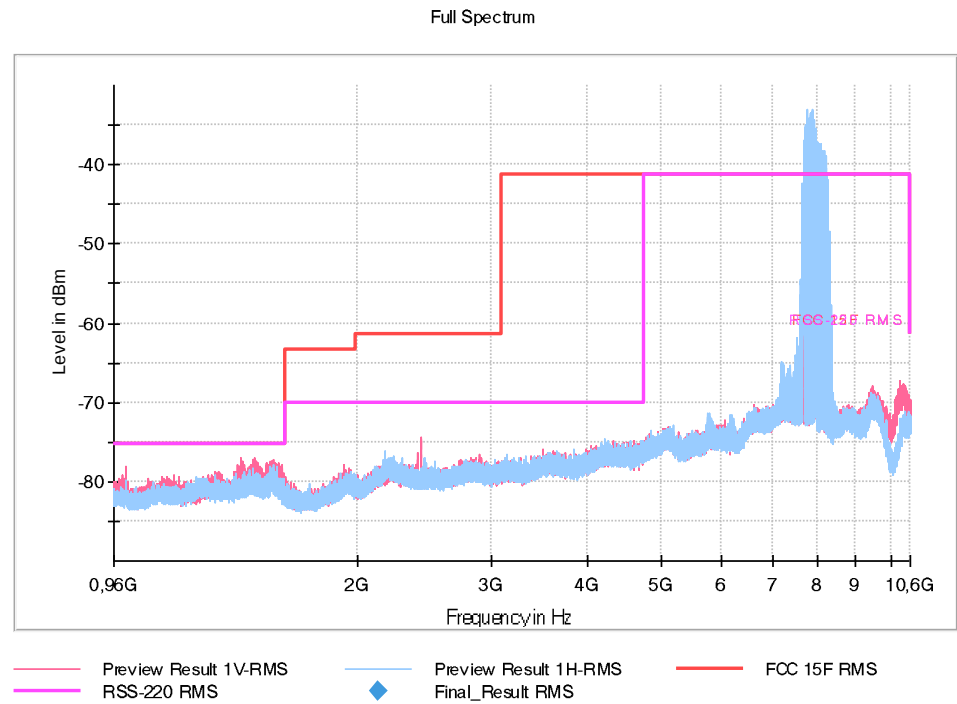
Measurement settings:

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
30 MHz – 960 MHz	9,3 kHz	PK+	100 kHz	1 s	0 dB
960 MHz - 10.6 GHz	96.4 kHz	RMS	1 MHz	1 s	0 dB
10.6 GHz - 14 GHz	34 kHz	RMS	1 MHz	1 s	0 dB
14 GHz - 17 GHz	30 kHz	RMS	1 MHz	1 s	0 dB
1,164 GHz - 1,24 GHz	760 Hz	RMS	3 kHz	Coupled	0 dB
1,559 GHz - 1,61 GHz	510 Hz	RMS	3 kHz	Coupled	0 dB

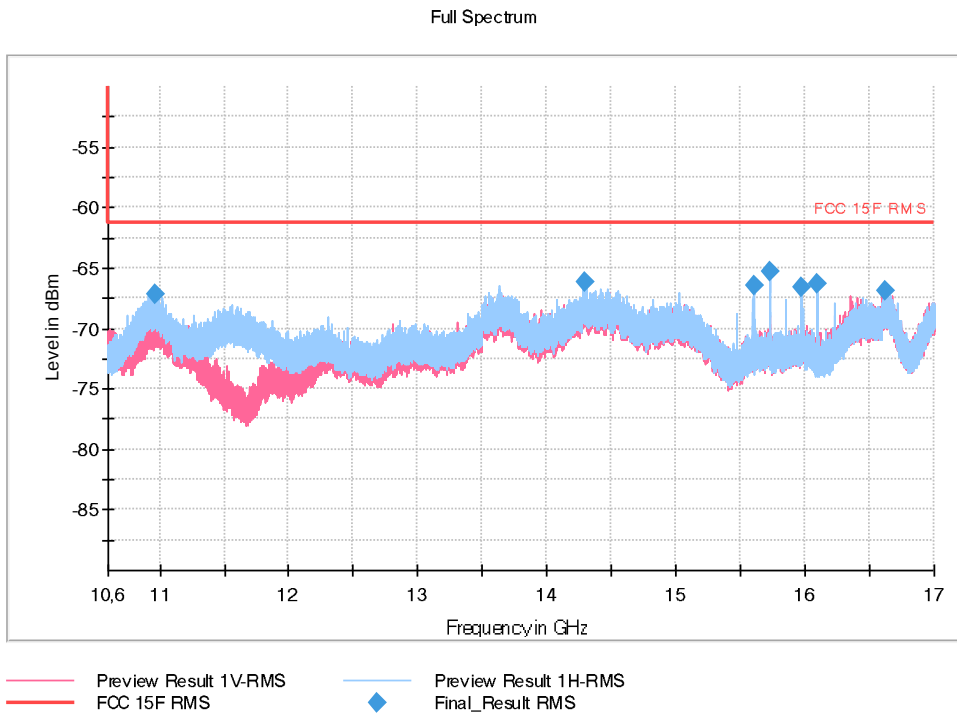
FREQUENCY RANGE 30 MHz - 1 GHz:



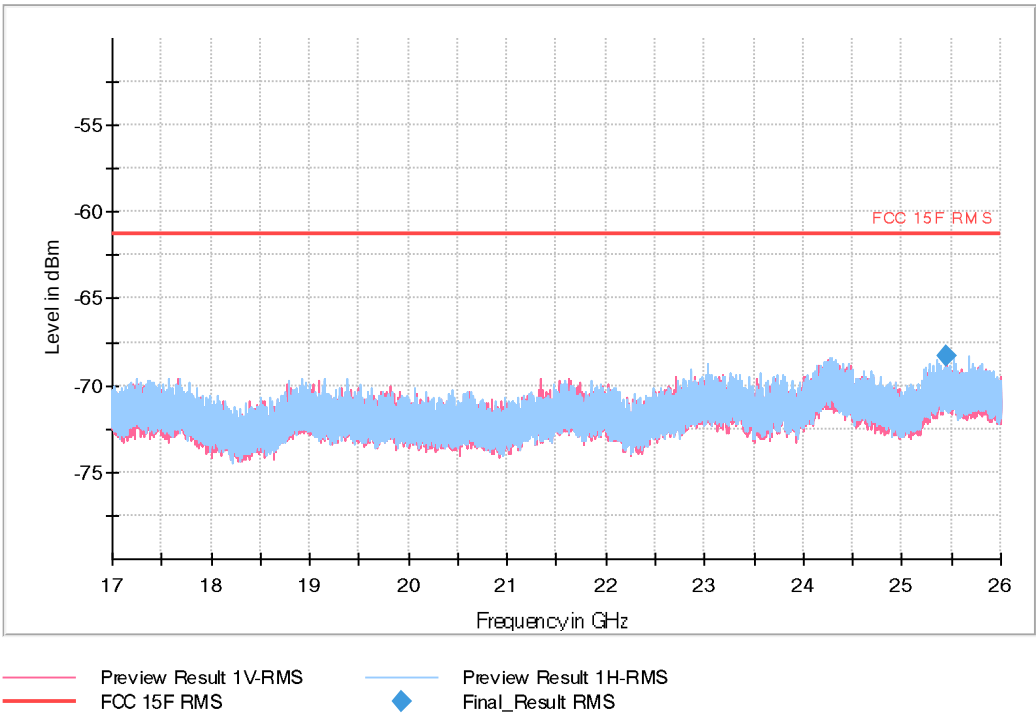
FREQUENCY RANGE 960 MHz - 10.6 GHz:



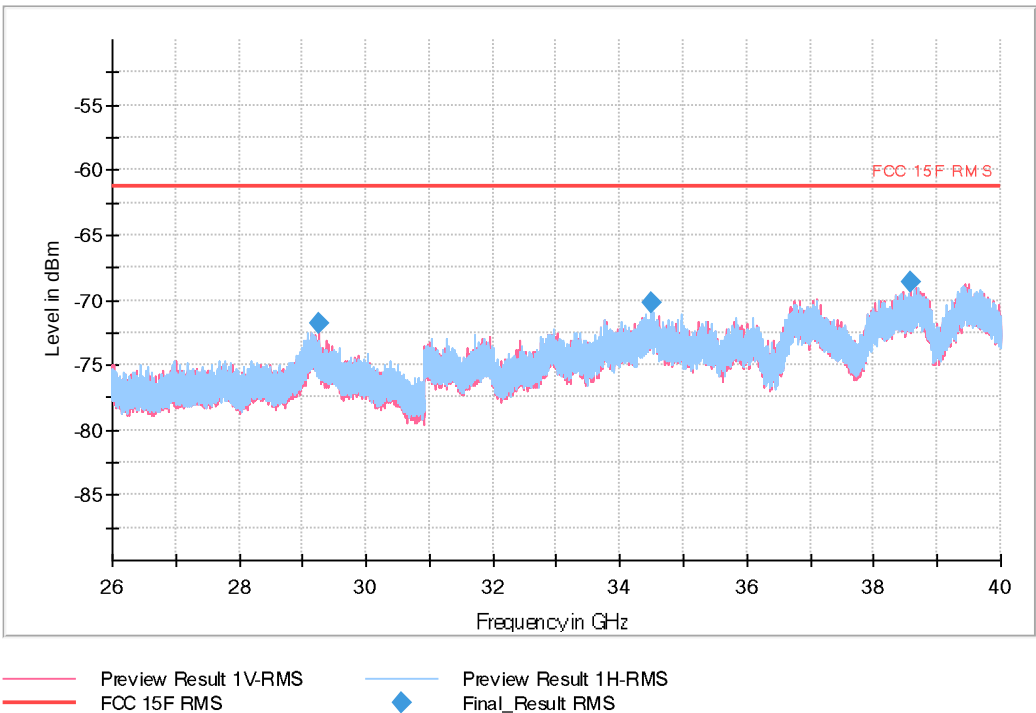
FREQUENCY RANGE 10.6 - 40 GHz:



Full Spectrum

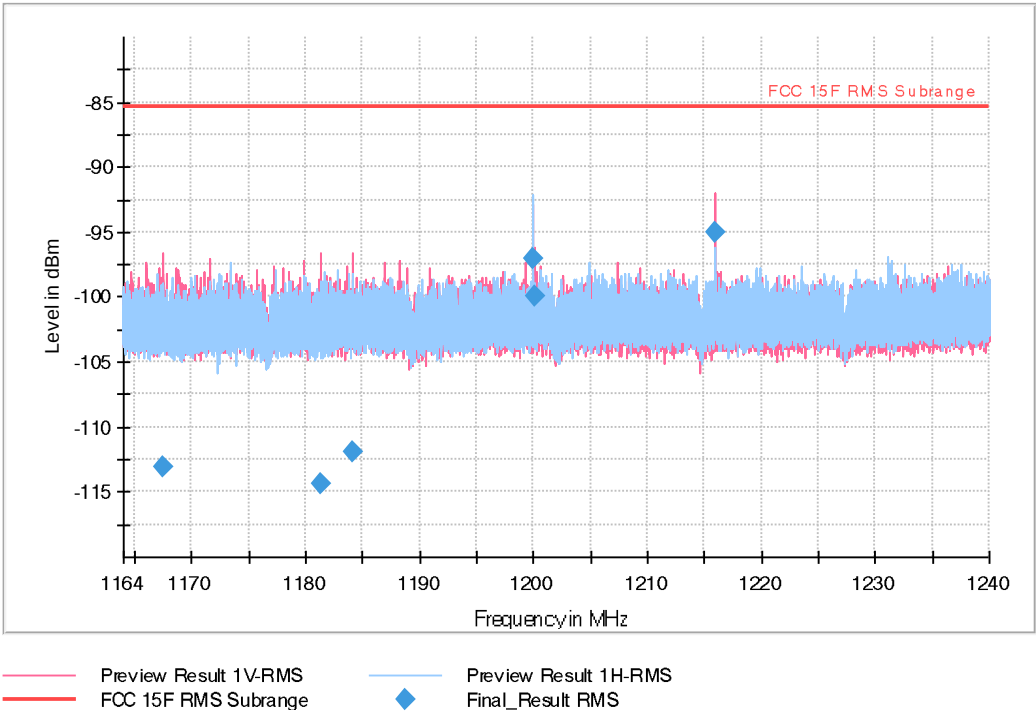


Full Spectrum



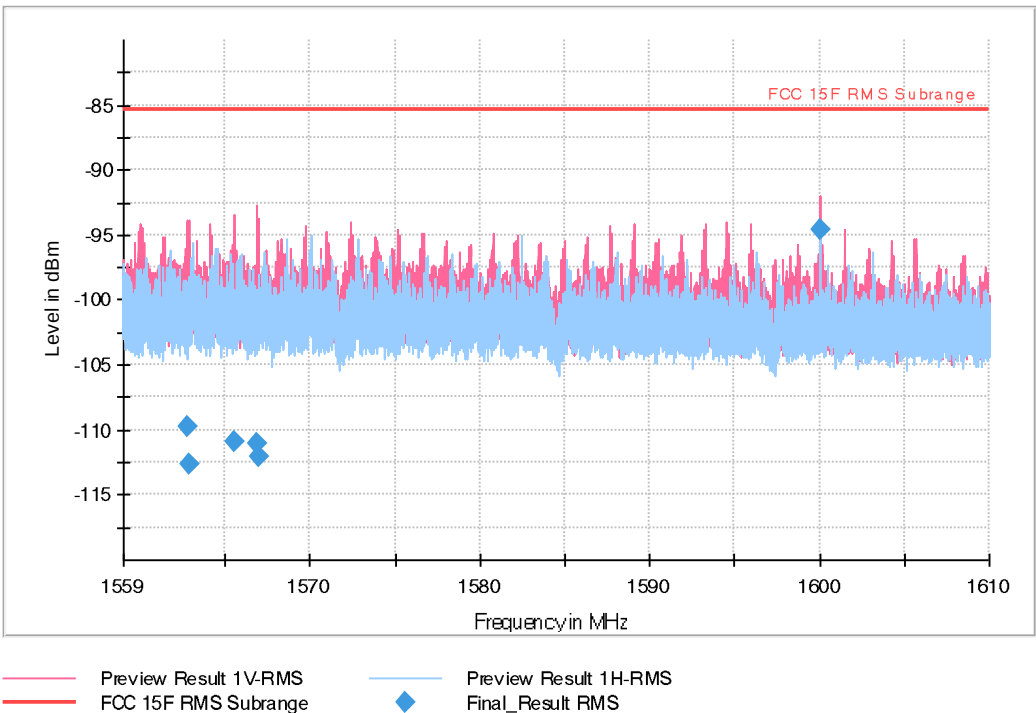
FREQUENCY RANGE 1.164 -1.240GHz:

Full Spectrum



FREQUENCY RANGE 1.559-1.610GHz:

Full Spectrum



3. UWB TRANSMITTER OFF:

• CHANNEL 5 (6489.6 MHz):

Frequency range 960 MHz - 10.6 GHz:

Spurious Frequency (MHz)	Emission Level (dBm)	Polarization	Detector
999.524000	-77.31	V	RMS
1163.500400	-78.36	V	RMS
1193.384400	-79.39	V	RMS

Measurement Uncertainty (dB): 1 GHz <± f < 17 GHz: <± 4.6
17 GHz <± f <± 26.5 GHz: <± 4.89
26.5 GHz <± f <± 40 GHz: <± 5.14

Verdict: PASS

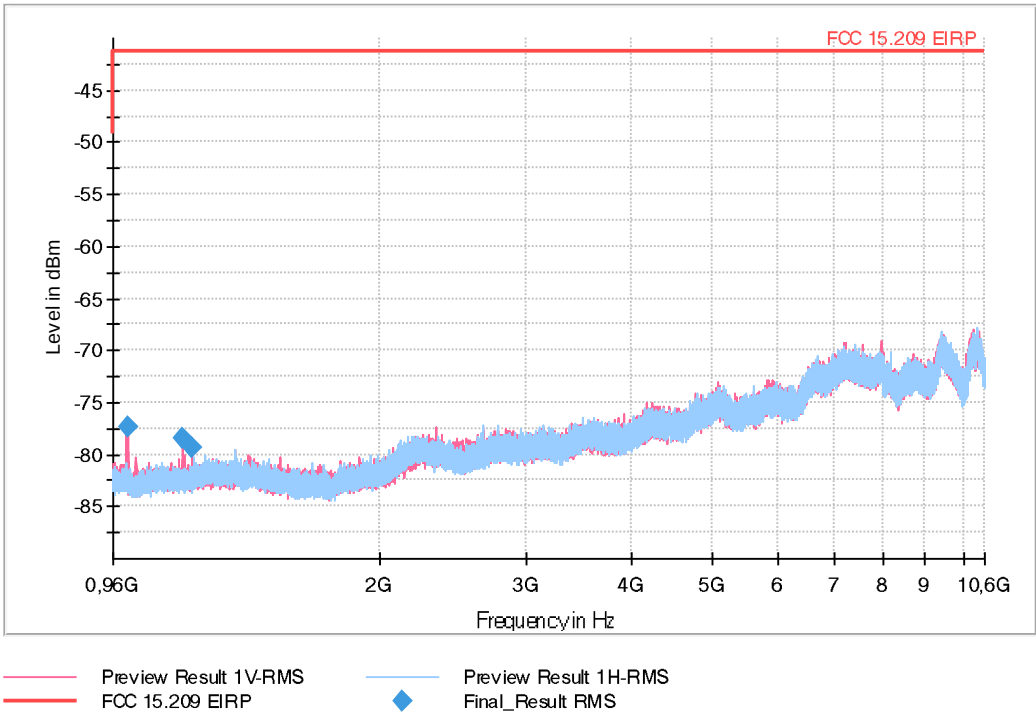
• UWB TRANSMITTER OFF. CHANNEL 5 (6489.6MHz):

Measurement settings:

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
960 MHz - 10.6 GHz	96.4 kHz	RMS	1 MHz	1 s	0 dB

FREQUENCY RANGE 960 MHz - 10.6 GHz:

Full Spectrum



Selected peaks are not related to UWB transmission.

FCC 15.519 (e) / RSS-220 5.3.1. (g) UWB Peak Level

SPECIFICATION:

* §15.519 (e): There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, fM. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in § 15.521.

* RSS-220 5.3.1. (g): The peak level of the transmissions shall not exceed the peak equivalent of the average limit contained within any 50 MHz bandwidth, as defined in section 4 of the Annex.

* Annex, Section 4 (c): Peak measurements shall be made in addition to average measurements. Transmissions shall not exceed 0 dBm e.i.r.p. in any 50 MHz bandwidth when the average limit is -41.3 dBm/MHz.

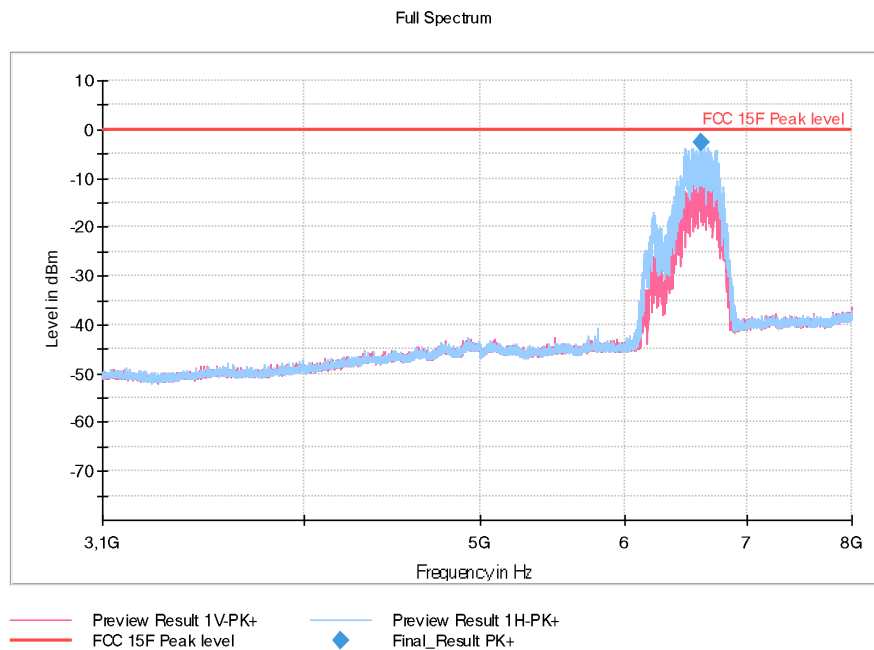
RESULTS:

Channel	Frequency at which the highest radiated emission occurs (MHz)	EIRP Peak Level (dBm)	Polarization
6489.6 MHz (Ch5)	6613.300000	-2.53	H
7987.2 MHz (Ch9)	7742.750000	-0.27	H

• CHANNEL 5 (6489.6 MHz):

Measurement settings:

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
3,1 GHz - 8 GHz	490 kHz	PK+	50 MHz	0,15 s	0 dB

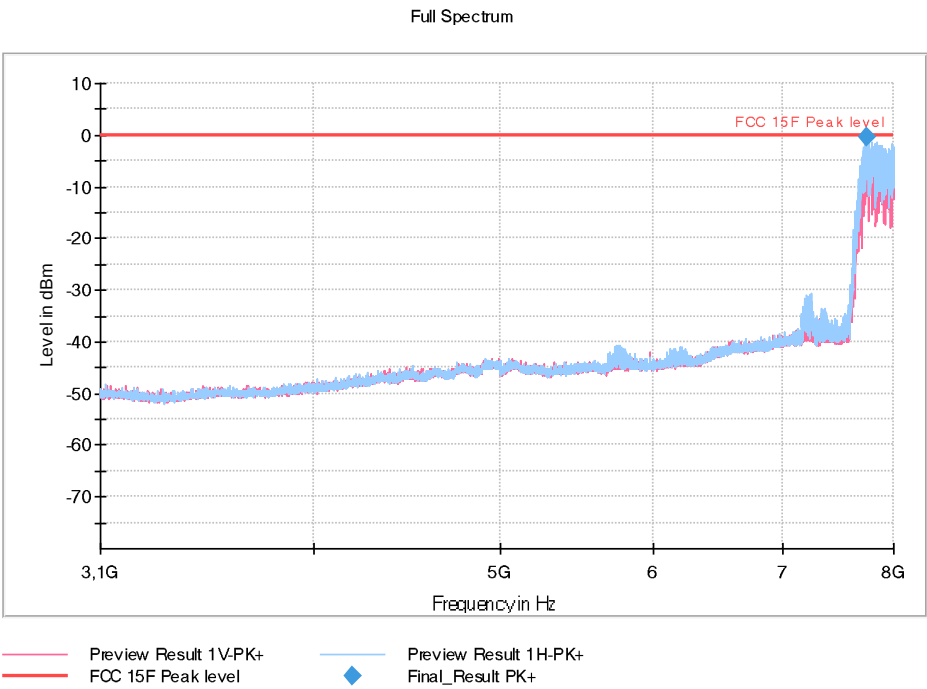


Verdict: PASS

• CHANNEL 9 (7987.2 MHz):

Measurement settings:

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
3,1 GHz - 8 GHz	490 kHz	PK+	50 MHz	0,15 s	0 dB



Verdict: PASS

RSS-Gen Section 6.7. 99% Occupied bandwidth

SPECIFICATION:

The occupied bandwidth or the “99% emission bandwidth” is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).

RESULTS:

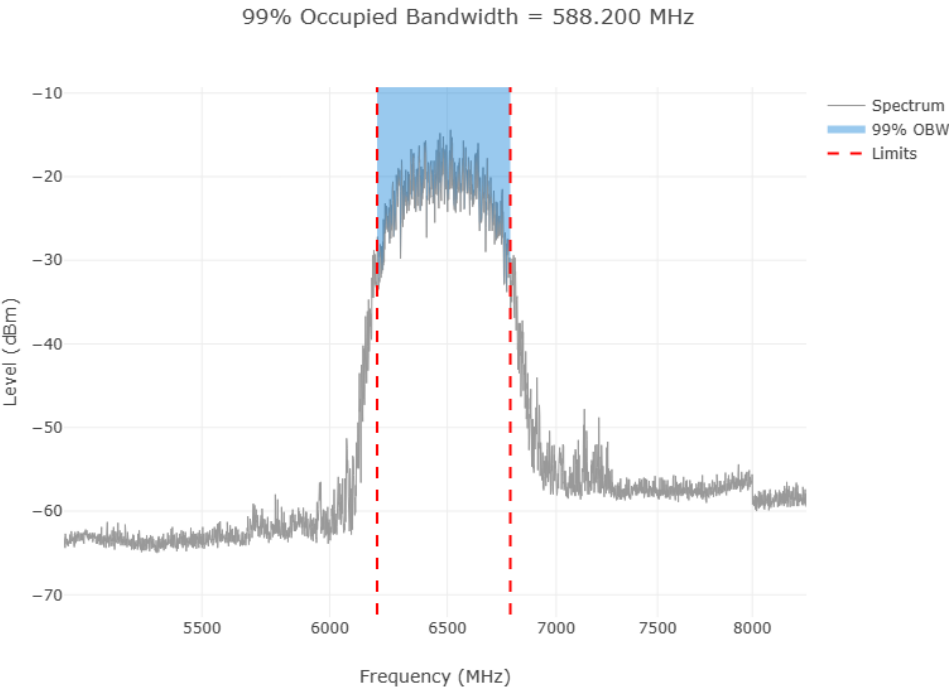
Parameter	Calculated Value (CHANNEL 5)	Calculated Value (CHANNEL 9)
99% Occupied Bandwidth	588.200 MHz	638.350 MHz
Lower Frequency (0.5% Power)	6196.650 MHz	7652.700 MHz
Upper Frequency (99.5% Power)	6784.850 MHz	8291.050 MHz
Total Integrated Power (Range)	5.80e+0 mW (7.64 dBm)	2.17e-1 mW (-6.64 dBm)
Measurement uncertainty (kHz)	<± 130	

Verdict: PASS

• CHANNEL 5 (6489.6 MHz):

Measurement settings:

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
2,5 GHz - 11 GHz	850 kHz	PK+	1 MHz	0,15 s	0 dB



• CHANNEL 9 (7987.2MHz):

Measurement settings:

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
2,5 GHz - 11 GHz	850 kHz	PK+	1 MHz	0,15 s	0 dB

