

8.5.5 Test data, 150 kbps

Table 8.5-7: 20 dB bandwidth results, 150 kbps

Frequency, MHz	20 dB bandwidth, kHz	Max 20 dB bandwidth limit, kHz	Margin, kHz
902.4	351.0	500	149.0
914.8	350.5	500	149.5
927.6	351.2	500	148.8



Figure 8.5-11: 20 dB bandwidth on low channel, 150 kbps



Figure 8.5-12: 20 dB bandwidth on mid channel, 150 kbps



Figure 8.5-13: 20 dB bandwidth on high channel, 150 kbps

Test data continued, 150 kbps

Table 8.5-8: 99% occupied bandwidth results, 150 kbps

Frequency, MHz	99% occupied bandwidth, kHz
902.4	320.2
914.8	316.8
927.6	319.4

Note: there is no 99% occupied bandwidth limit in the standard's requirements, the measurement results provided for information purposes only.



Figure 8.5-14: 99% OBW on low channel, 150 kbps



Figure 8.5-15: 99% OBW on mid channel, 150 kbps



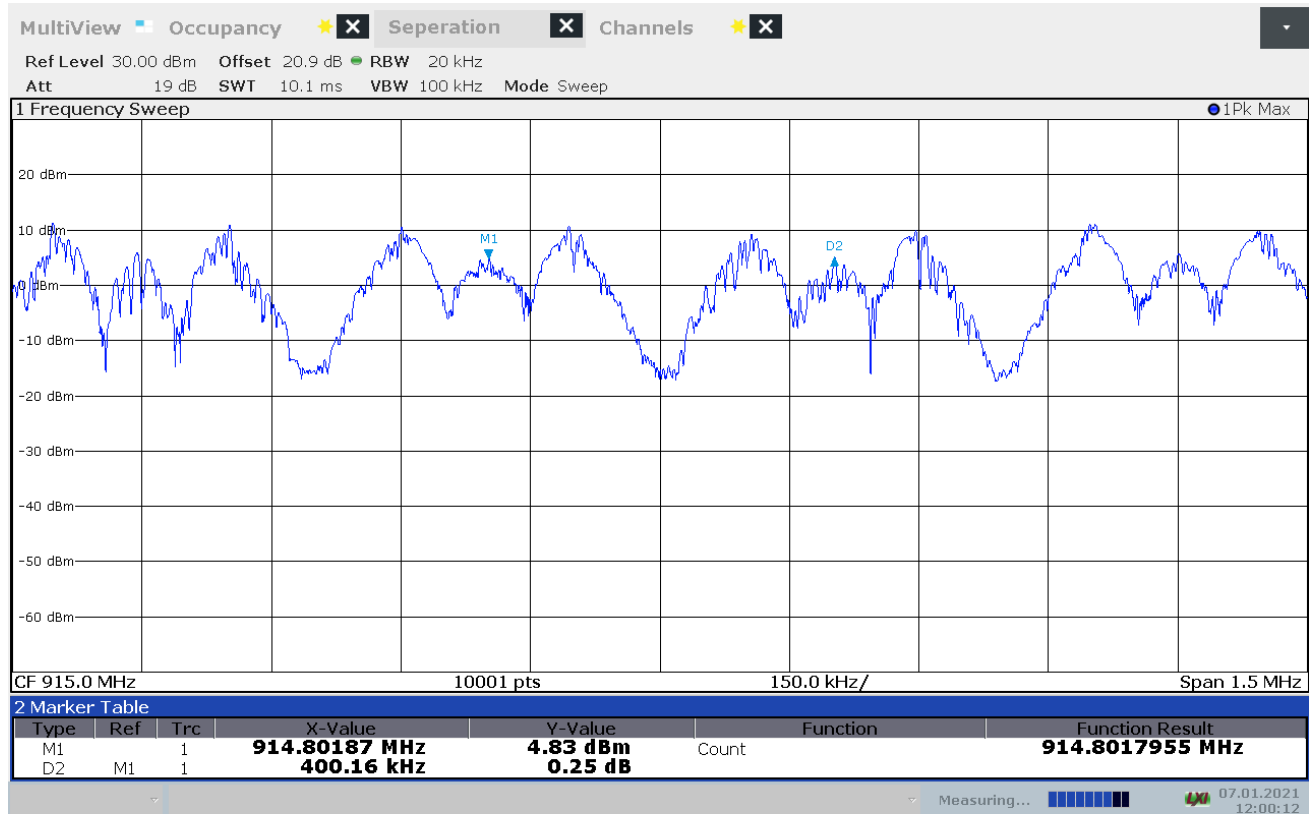
Figure 8.5-16: 99% OBW bandwidth on high channel, 150 kbps

Test data continued, 150 kbps

Table 8.5-9: Carrier frequency separation results, 150 kbps

Carrier frequency separation, kHz	Minimum limit, kHz	Margin, kHz
400.2	351.2	49.0

Note: Minimum limit = 25 kHz or the 20 dB BW whichever is greater



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Figure 8.5-17: Carrier frequency separation

Test data continued, 150 kbps

Table 8.5-10: Number of hopping frequencies results, 150 kbps

Number of hopping frequencies	Minimum limit	Margin
64	25	39

Note: 20 dB bandwidth > 250 kHz, Minimum limit = 25 hopping frequencies



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Figure 8.5-18: Number of hopping frequencies = 64

No	X-Value	Y-Value	No	X-Value	Y-Value
1	902.502000 MHz	11.817 dBm	33	915.300000 MHz	11.742 dBm
2	902.892000 MHz	11.807 dBm	34	915.689000 MHz	11.732 dBm
3	903.282000 MHz	11.799 dBm	35	916.079000 MHz	11.727 dBm
4	903.492000 MHz	11.782 dBm	36	916.289000 MHz	11.693 dBm
5	904.091000 MHz	11.802 dBm	37	916.888000 MHz	11.715 dBm
6	904.481000 MHz	11.803 dBm	38	917.278000 MHz	11.658 dBm
7	904.900000 MHz	11.796 dBm	39	917.697000 MHz	11.662 dBm
8	905.290000 MHz	11.817 dBm	40	918.087000 MHz	11.638 dBm
9	905.679000 MHz	11.811 dBm	41	918.506000 MHz	11.618 dBm
10	906.099000 MHz	11.802 dBm	42	918.896000 MHz	11.645 dBm
11	906.489000 MHz	11.826 dBm	43	919.286000 MHz	11.625 dBm
12	906.878000 MHz	11.822 dBm	44	919.705000 MHz	11.632 dBm
13	907.298000 MHz	11.827 dBm	45	920.095000 MHz	11.613 dBm
14	907.687000 MHz	11.833 dBm	46	920.485000 MHz	11.626 dBm
15	908.077000 MHz	11.827 dBm	47	920.904000 MHz	11.630 dBm
16	908.497000 MHz	11.807 dBm	48	921.294000 MHz	11.645 dBm
17	908.886000 MHz	11.812 dBm	49	921.683000 MHz	11.638 dBm
18	909.306000 MHz	11.806 dBm	50	922.103000 MHz	11.649 dBm
19	909.695000 MHz	11.799 dBm	51	922.493000 MHz	11.645 dBm
20	910.085000 MHz	11.782 dBm	52	922.882000 MHz	11.638 dBm
21	910.504000 MHz	11.776 dBm	53	923.302000 MHz	11.609 dBm
22	910.894000 MHz	11.772 dBm	54	923.691000 MHz	11.632 dBm
23	911.284000 MHz	11.753 dBm	55	924.081000 MHz	11.620 dBm
24	911.703000 MHz	11.757 dBm	56	924.500000 MHz	11.614 dBm
25	912.093000 MHz	11.746 dBm	57	924.890000 MHz	11.606 dBm
26	912.483000 MHz	11.752 dBm	58	925.280000 MHz	11.595 dBm
27	912.902000 MHz	11.744 dBm	59	925.699000 MHz	11.591 dBm
28	913.292000 MHz	11.748 dBm	60	926.089000 MHz	11.567 dBm
29	913.681000 MHz	11.749 dBm	61	926.479000 MHz	11.553 dBm
30	914.101000 MHz	11.739 dBm	62	926.898000 MHz	11.571 dBm
31	914.491000 MHz	11.745 dBm	63	927.288000 MHz	11.540 dBm
32	914.880000 MHz	11.741 dBm	64	927.677000 MHz	11.578 dBm

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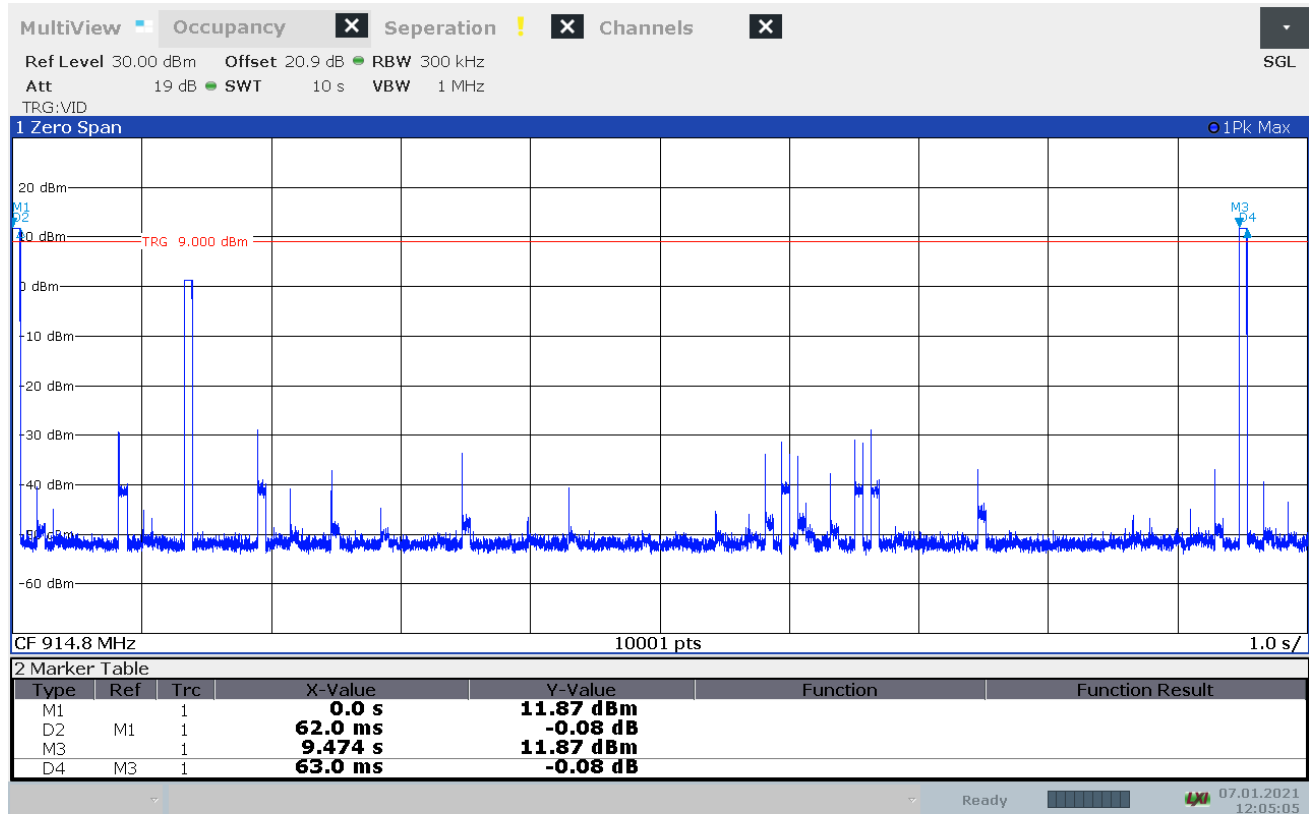
Figure 8.5-19: List of hopping frequencies

Test data continued, 150 kbps

Table 8.5-11: Average time of occupancy results, 150 kbps

Dwell time of each pulse, ms	Number of pulses within period	Total dwell time within period, ms	Limit, ms	Margin, ms
63	2	126	400	274

Note: 20 dB bandwidth > 250 kHz, therefore Measurement Period is 10 s



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Figure 8.5-20: Dwell time

8.5.1 Test data, 250 kbps

Table 8.5-12: 20 dB bandwidth results, 250 kbps

Frequency, MHz	20 dB bandwidth, kHz	Max 20 dB bandwidth limit, kHz	Margin, kHz
902.5	403.8	500	96.2
915.0	414.4	500	85.6
927.5	407.7	500	92.3

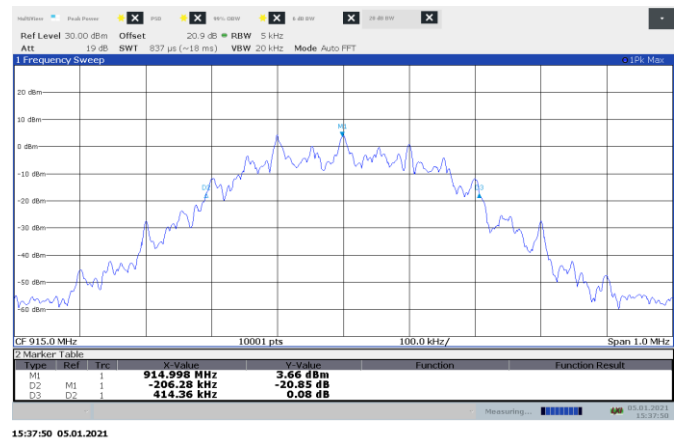

Figure 8.5-21: 20 dB bandwidth on low channel, 250 kbps

Figure 8.5-22: 20 dB bandwidth on mid channel, 250 kbps

Figure 8.5-23: 20 dB bandwidth on high channel, 250 kbps

Test data continued, 250 kbps

Table 8.5-13: 99% occupied bandwidth results, 250 kbps

Frequency, MHz	99% occupied bandwidth, kHz
902.5	386.8
915.0	385.1
927.5	369.3

Note: there is no 99% occupied bandwidth limit in the standard's requirements, the measurement results provided for information purposes only.

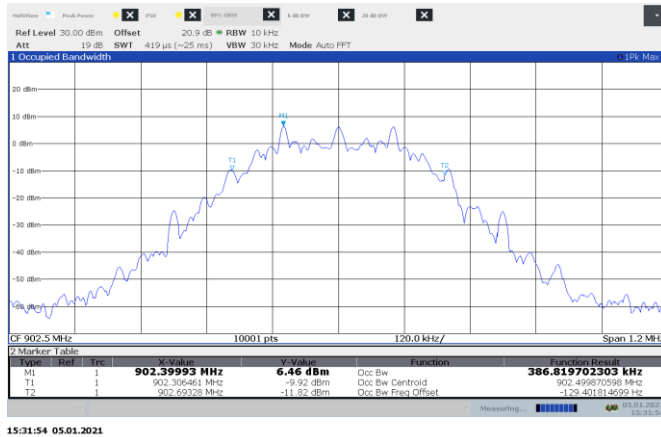


Figure 8.5-24: 99% OBW on low channel, 250 kbps

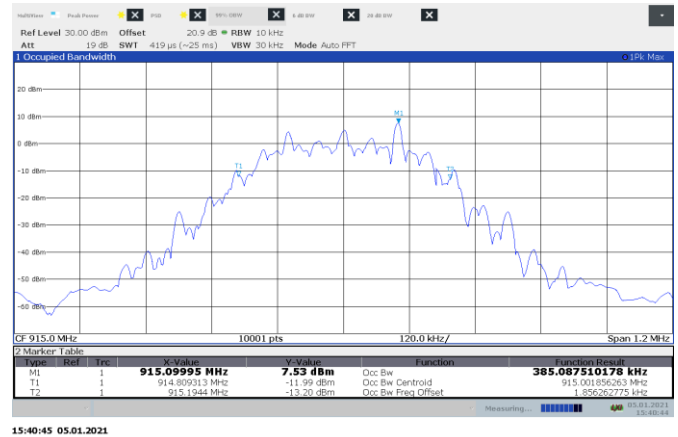


Figure 8.5-25: 99% OBW on mid channel, 250 kbps



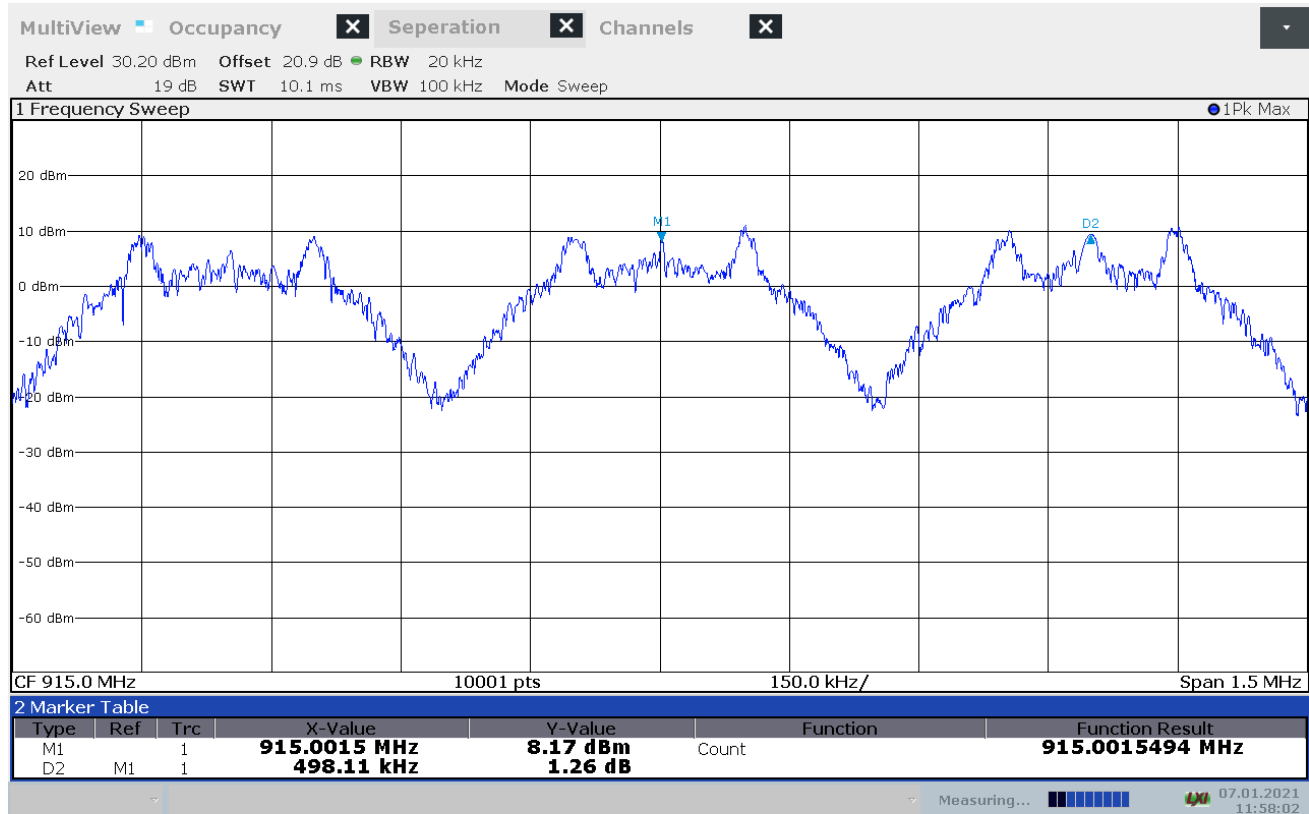
Figure 8.5-26: 99% OBW bandwidth on high channel, 250 kbps

Test data continued, 250 kbps

Table 8.5-14: Carrier frequency separation results, 250 kbps

Carrier frequency separation, kHz	Minimum limit, kHz	Margin, kHz
498.1	414.4	83.7

Note: Minimum limit = 25 kHz or the 20 dB BW whichever is greater



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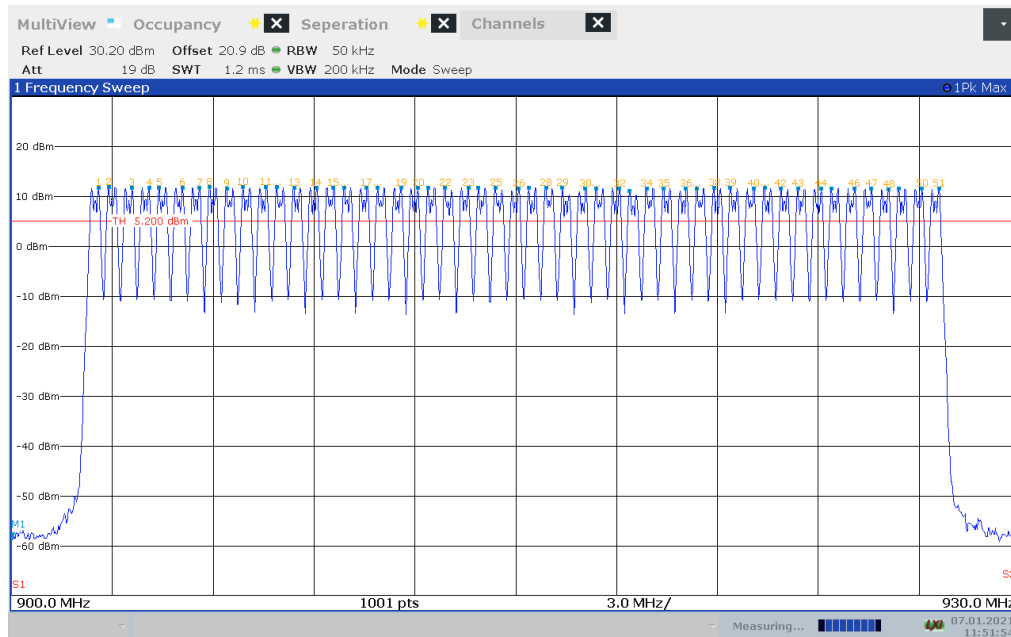
Figure 8.5-27: Carrier frequency separation

Test data continued, 250 kbps

Table 8.5-15: Number of hopping frequencies results, 250 kbps

Number of hopping frequencies	Minimum limit	Margin
51	25	26

Note: 20 dB bandwidth > 250 kHz, Minimum limit = 25 hopping frequencies



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Figure 8.5-28: Number of hopping frequencies = 51

No.	X-Value	Y-Value	No.	X-Value	Y-Value
1	902.383000 MHz	11.857 dBm	27	915.390000 MHz	11.800 dBm
2	902.892000 MHz	11.876 dBm	28	915.899000 MHz	11.785 dBm
3	903.581000 MHz	11.856 dBm	29	916.379000 MHz	11.788 dBm
4	904.091000 MHz	11.837 dBm	30	917.068000 MHz	11.652 dBm
5	904.391000 MHz	11.864 dBm	31	917.398000 MHz	11.721 dBm
6	905.080000 MHz	11.805 dBm	32	918.087000 MHz	11.573 dBm
7	905.589000 MHz	11.865 dBm	33	918.566000 MHz	11.638 dBm
8	905.889000 MHz	11.869 dBm	34	918.896000 MHz	11.689 dBm
9	906.399000 MHz	11.894 dBm	35	919.406000 MHz	11.703 dBm
10	906.878000 MHz	11.895 dBm	36	919.885000 MHz	11.677 dBm
11	907.567000 MHz	11.874 dBm	37	920.395000 MHz	11.696 dBm
12	907.897000 MHz	11.885 dBm	38	920.904000 MHz	11.708 dBm
13	908.586000 MHz	11.868 dBm	39	921.384000 MHz	11.714 dBm
14	909.086000 MHz	11.811 dBm	40	922.073000 MHz	11.691 dBm
15	909.396000 MHz	11.849 dBm	41	922.403000 MHz	11.714 dBm
16	909.905000 MHz	11.861 dBm	42	922.882000 MHz	11.708 dBm
17	910.564000 MHz	11.818 dBm	43	923.392000 MHz	11.663 dBm
18	910.894000 MHz	11.836 dBm	44	923.901000 MHz	11.667 dBm
19	911.583000 MHz	11.804 dBm	45	924.381000 MHz	11.652 dBm
20	911.883000 MHz	11.820 dBm	46	925.070000 MHz	11.634 dBm
21	912.393000 MHz	11.822 dBm	47	925.400000 MHz	11.659 dBm
22	912.902000 MHz	11.803 dBm	48	925.879000 MHz	11.616 dBm
23	913.591000 MHz	11.799 dBm	49	926.389000 MHz	11.639 dBm
24	913.891000 MHz	11.798 dBm	50	926.898000 MHz	11.644 dBm
25	914.580000 MHz	11.755 dBm	51	927.587000 MHz	11.617 dBm
26	914.880000 MHz	11.751 dBm			

Figure 8.5-29: List of hopping frequencies

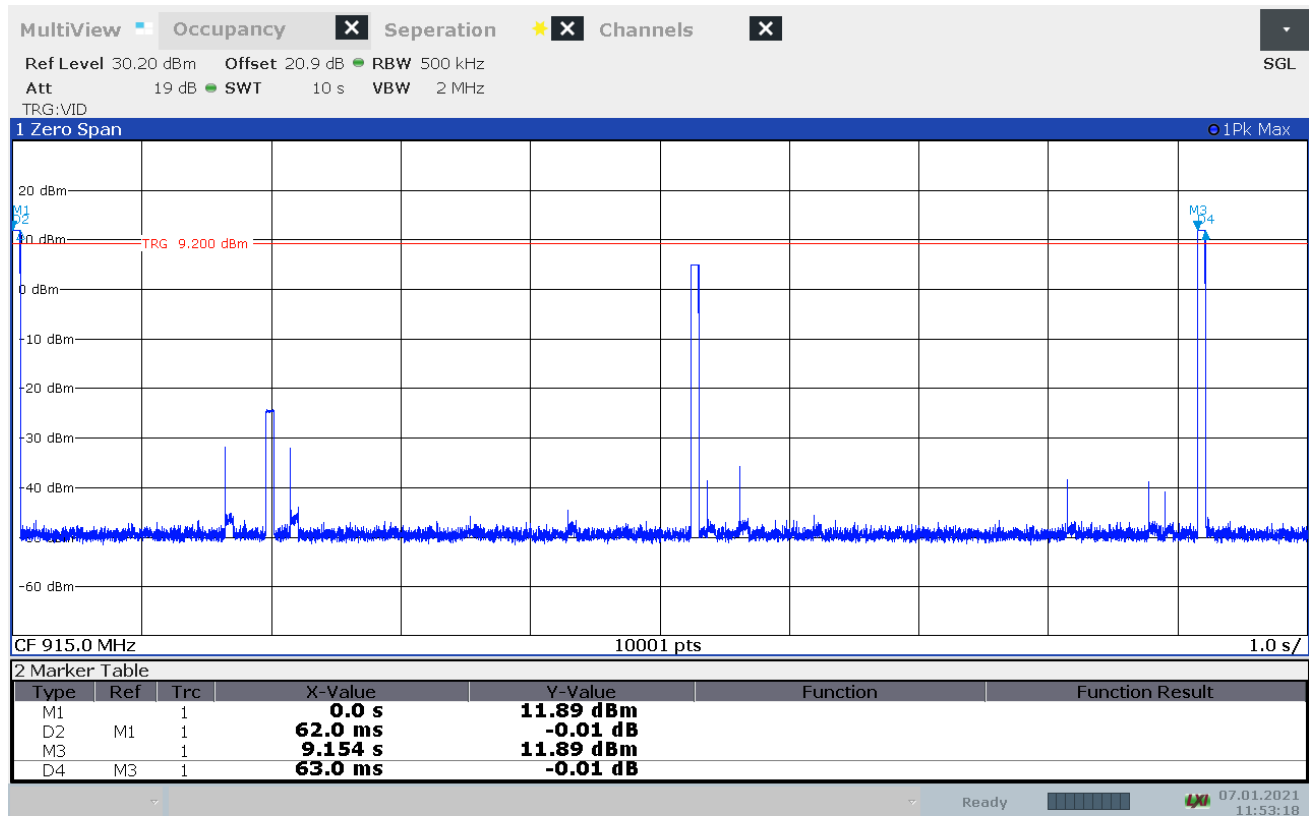


Test data continued, 250 kbps

Table 8.5-16: Average time of occupancy results, 250 kbps

Dwell time of each pulse, ms	Number of pulses within period	Total dwell time within period, ms	Limit, ms	Margin, ms
63	2	126	400	274

Note: 20 dB bandwidth > 250 kHz, therefore Measurement Period is 10 s



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Figure 8.5-30: Dwell time

8.6 FCC 15.247(b) and RSS-247 5.4(a) Transmitter output power and e.i.r.p. requirements for FHSS 900 MHz

8.6.1 References, definitions and limits

FCC:

- (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
- (2) For frequency hopping systems operating in the 902–928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.
 - (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. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

ISED:

For FHSs operating in the band 902–928 MHz, the maximum peak conducted output power shall not exceed 1.0 W, and the e.i.r.p. shall not exceed 4 W if the hopset uses 50 or more hopping channels; the maximum peak conducted output power shall not exceed 0.25 W and the e.i.r.p. shall not exceed 1 W if the hopset uses less than 50 hopping channels.

8.6.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	November 30, 2020

8.6.3 Observations, settings and special notes

Conducted output power was tested per ANSI C63.10 subclause 7.8.5. The hopping shall be disabled for this test. Spectrum analyser settings: EUT utilizes > 50 hopping frequencies for all modulations

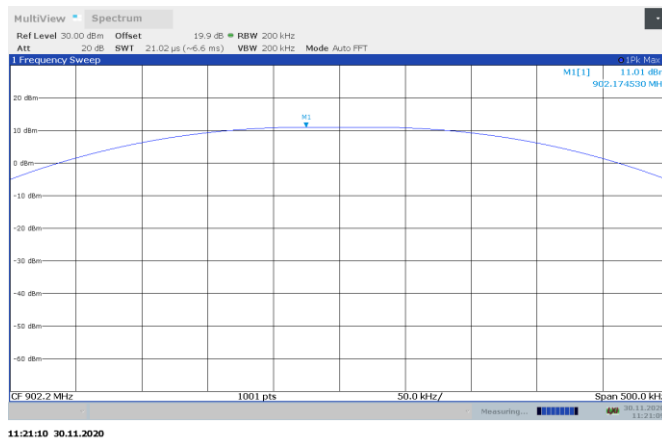
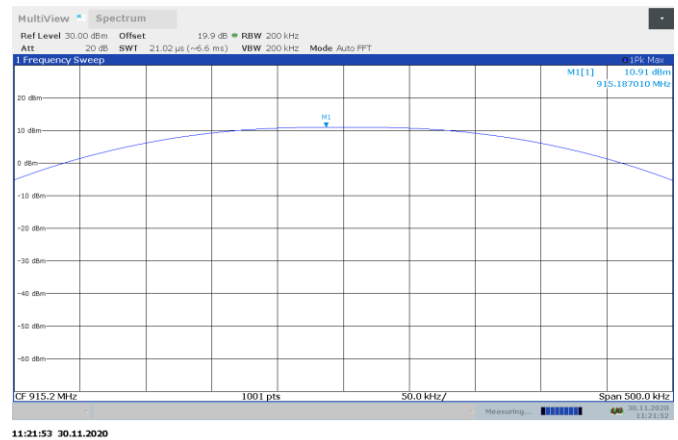
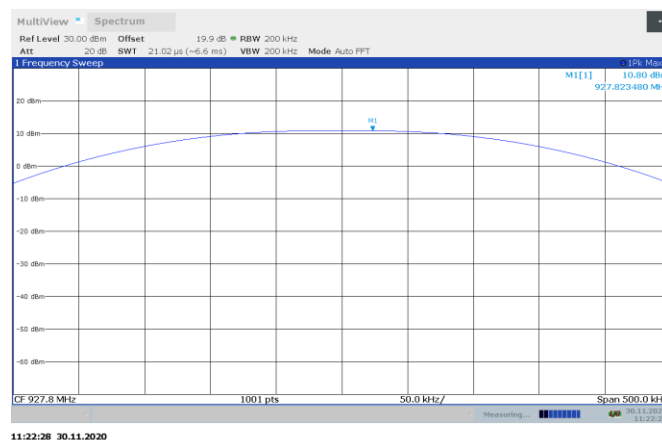
Resolution bandwidth	> 20 dB bandwidth of the emission being measured
Video bandwidth	≥ RBW
Frequency span	approximately 5 times the 20 dB bandwidth, centered on a hopping channel
Detector mode	Peak
Trace mode	Max Hold

8.6.4 Test data, 50 kbps

Table 8.6-1: Output power and EIRP results, 50 kbps

Frequency, MHz	Output power, dBm	Output power limit, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
902.2	11.0	30.00	19.0	0.8	11.8	36.0	24.2
915.2	10.9	30.00	19.1	0.8	11.7	36.0	24.3
927.8	10.8	30.00	19.2	0.8	11.6	36.0	24.4

EIRP = Output power + Antenna gain

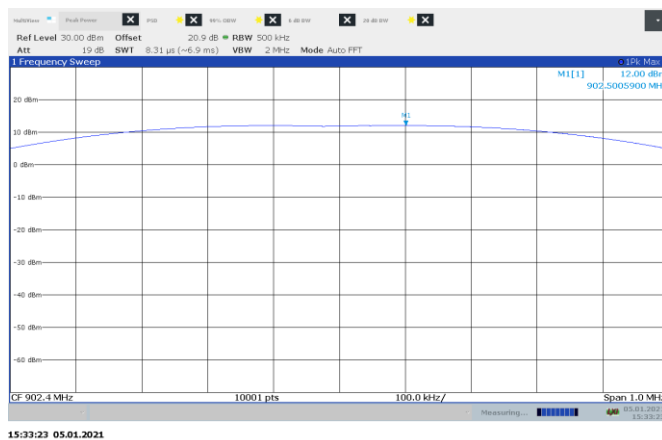
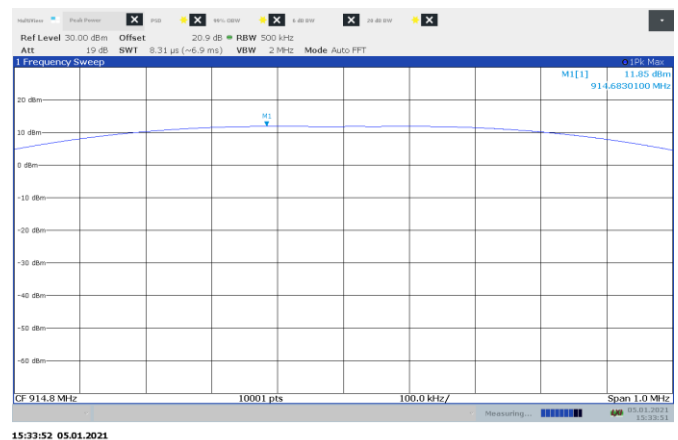
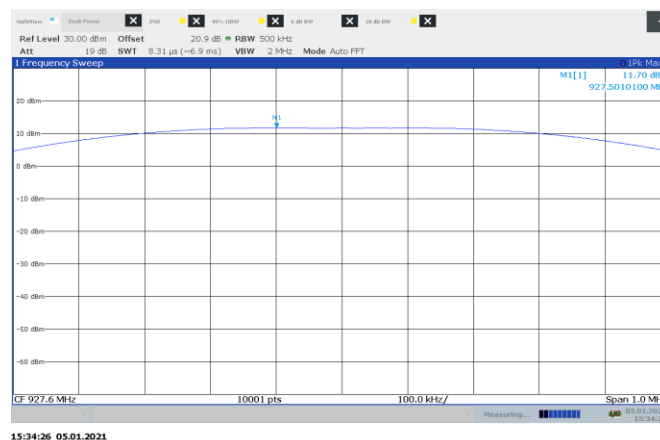

Figure 8.6-1: Output power on low channel, 50 kbps

Figure 8.6-2: Output power on mid channel, 50 kbps

Figure 8.6-3: Output power on high channel, 50 kbps

8.6.1 Test data, 150 kbps

Table 8.6-2: Output power and EIRP results, 150 kbps

Frequency, MHz	Output power, dBm	Output power limit, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
902.4	12.0	30.0	18.0	0.8	12.8	36.0	23.2
914.8	11.9	30.0	18.1	0.8	12.7	36.0	23.3
927.6	11.7	30.0	18.3	0.8	12.5	36.0	23.5

EIRP = Output power + Antenna gain


Figure 8.6-4: Output power on low channel, 150 kbps

Figure 8.6-5: Output power on mid channel, 150 kbps

Figure 8.6-6: Output power on high channel, 150 kbps

8.6.1 Test data, 250 kbps

Table 8.6-3: Output power and EIRP results, 250 kbps

Frequency, MHz	Output power, dBm	Output power limit, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
902.5	12.0	30.0	18.0	0.8	12.8	36.0	23.2
915.0	11.9	30.0	18.1	0.8	12.7	36.0	23.3
927.5	11.7	30.0	18.3	0.8	12.5	36.0	23.5

EIRP = Output power + Antenna gain

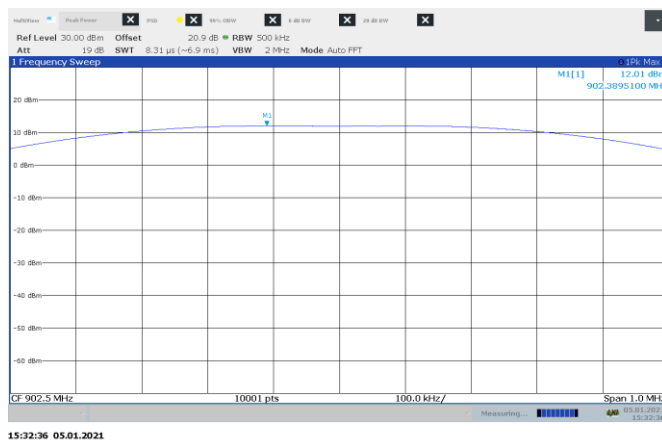


Figure 8.6-7: Output power on low channel, 250 kbps

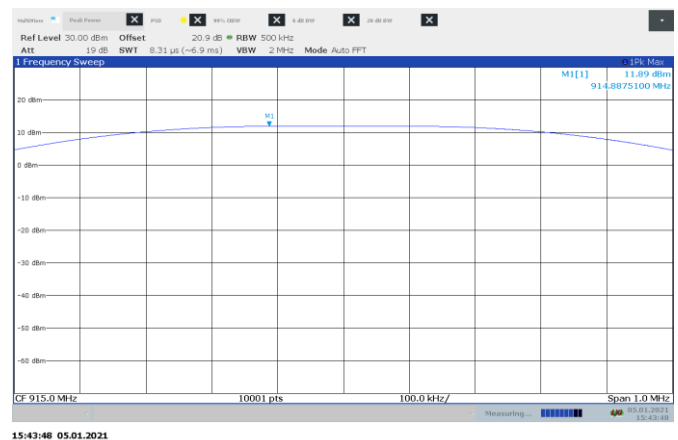


Figure 8.6-8: Output power on mid channel, 250 kbps

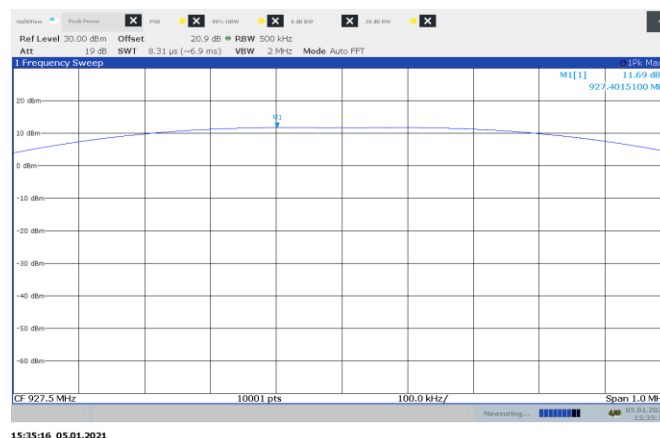


Figure 8.6-9: Output power on high channel, 250 kbps

8.7 FCC 15.247(a)(2) and RSS-247 5.2(a) Minimum 6 dB bandwidth for DTS systems

8.7.1 References, definitions and limits

FCC:

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.

ISED:

The minimum 6 dB bandwidth shall be 500 kHz.

RSS-GEN, Section 6.7:

6 dB bandwidth is defined as the frequency range between two points, one at the lowest frequency below and one at the highest frequency above the carrier frequency, at which the maximum power level of the transmitted emission is attenuated 6 dB below the maximum in-band power level of the modulated signal, where the two points are on the outskirts of the in-band emission.

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).

8.7.2 Test summary

Verdict	Pass		
Tested by	Alvin Liu	Test date	November 11, 2020

8.7.3 Observations, settings and special notes

The test was performed as per KDB 558074, section 8.2 with reference to ANSI C63.10 subclause 11.8.

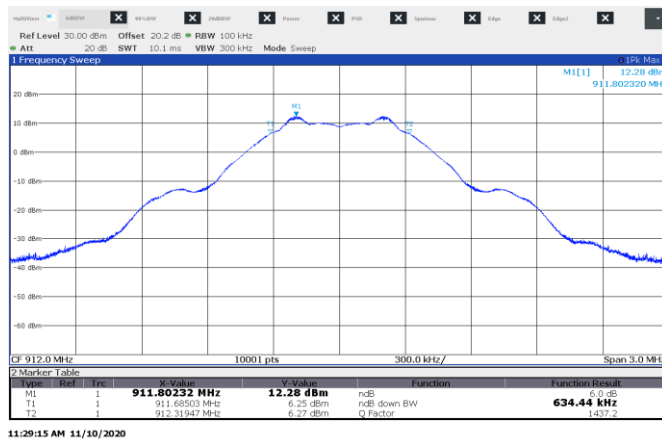
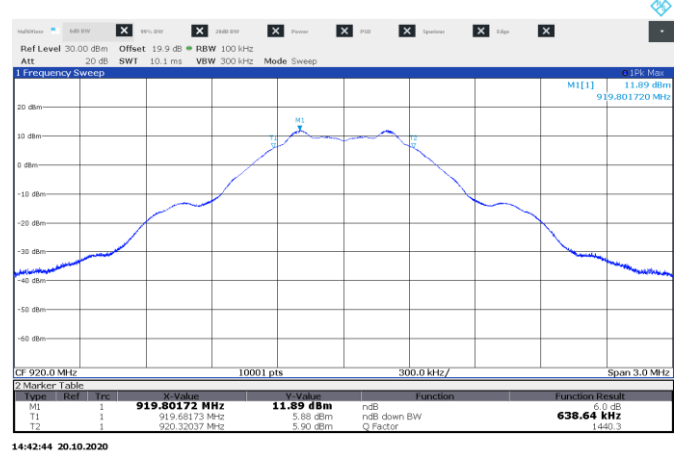
Spectrum analyser settings:

Resolution bandwidth	6 dB BW: 100 kHz; 99% OBW: 1–5% of OBW
Video bandwidth	$\geq 3 \times \text{RBW}$
Frequency span	$1 - 5 \times \text{OBW}$
Detector mode	Peak
Trace mode	Max Hold

8.7.4 Test data

Table 8.7-1: 6 dB bandwidth results, Z-Wave Long Range

Modulation	Frequency, MHz	6 dB bandwidth, kHz	Minimum limit, kHz	Margin, kHz
DSSS-OQPSK	912.0	634.4	500	134.4
DSSS-OQPSK	920.0	638.6	500	138.6


Figure 8.7-1: 6 dB bandwidth on 912 MHz channel, Z-Wave Long Range

Figure 8.7-2: 6 dB bandwidth on 920 MHz channel, Z-Wave Long Range
Table 8.7-2: 99% occupied bandwidth results, Z-Wave Long Range

Frequency, MHz	99% occupied bandwidth, kHz
912.0	931.4
920.0	932.1

Note: there is no 99% occupied bandwidth limit in the standard's requirements, the measurement results provided for information purposes only.

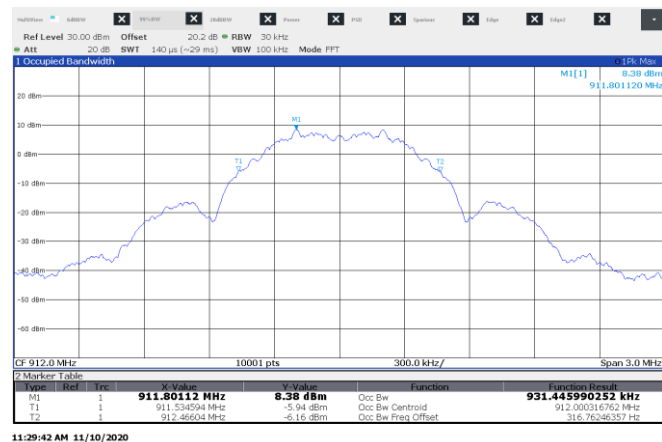

Figure 8.7-3: 99% OBW on 912 MHz channel, Z-Wave Long Range

Figure 8.7-4: 99% OBW on 920 MHz channel, Z-Wave Long Range

8.8 FCC 15.247(b) and RSS-247 5.4(d) Transmitter output power and e.i.r.p. requirements for DTS in 900 MHz

8.8.1 References, definitions and limits

FCC:

- (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
- (3) For systems using digital modulation in the 902–928 MHz band: 1 W (30 dBm). 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. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.
 - (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. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.
- (c) Operation with directional antenna gains greater than 6 dBi.
- (1) Fixed point-to-point operation:
- (iii) Fixed, point-to-point operation, as used in paragraphs (c)(1)(i) and (c)(1)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

ISED:

- d. For DTSs employing digital modulation techniques operating in the 902–928 MHz band, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

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.

8.8.2 Test summary

Verdict	Pass		
Tested by	Alvin Liu	Test date	November 11, 2020

8.8.3 Observations, settings and special notes

The test was performed as per KDB 558074, section 8.3 with reference to ANSI C63.10 subclause 11.9.1 (peak power) using method RBW $\geq$ DTS bandwidth (Maximum peak conducted output power).

Per ANSI 63.10 (2015) section 11.12.2.6 minimum allowable antenna gain = 2 dBi

Spectrum analyser settings:

Resolution bandwidth	$\geq$ OBW
Video bandwidth	$\geq 3 \times$ RBW
Frequency span	2 – 5 $\times$ OBW
Detector mode	Peak
Trace mode	Max Hold

8.8.4 Test data

Table 8.8-1: Output power and EIRP results (antenna port measurement)

Frequency, MHz	Conducted output power, dBm	Output power limit, dBm	Output power margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
912	12.6	30.0	17.4	0.8	13.4	36.0	22.6
920	12.2	30.0	17.8	0.8	13.0	36.0	23.0

Note: EIRP [dBm] = Conducted output power [dBm] + Antenna gain [dBi]

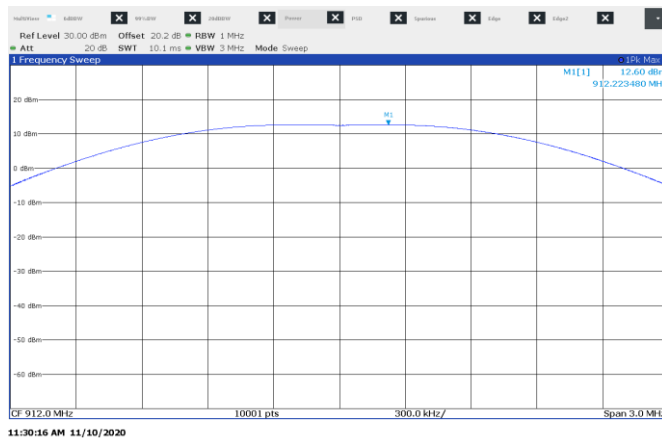


Figure 8.8-1: Output power on 912 MHz channel

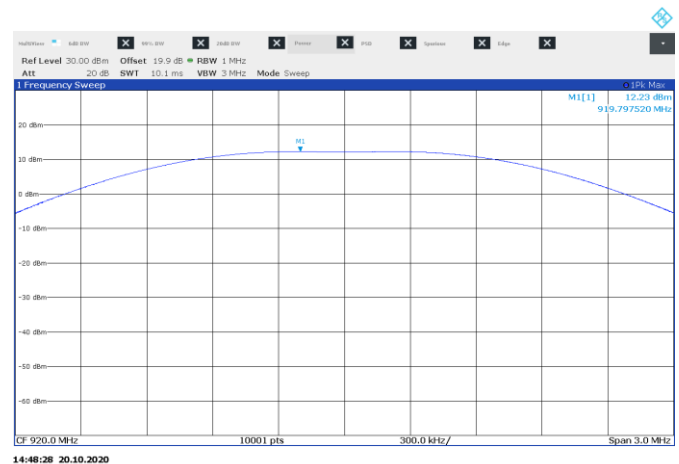


Figure 8.8-2: Output power on 920 MHz channel

8.9 FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) unwanted emissions

8.9.1 References, definitions and limits

FCC:

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. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

ISED:

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Table 8.9-1: FCC §15.209 and RSS-Gen – Radiated emission limits

Frequency, MHz	Field strength of emissions		Measurement distance, m
	μV/m	dBμV/m	
0.009–0.490	2400/F	$67.6 - 20 \times \log_{10}(F)$	300
0.490–1.705	24000/F	$87.6 - 20 \times \log_{10}(F)$	30
1.705–30.0	30	29.5	30
30–88	100	40.0	3
88–216	150	43.5	3
216–960	200	46.0	3
above 960	500	54.0	3

Notes: In the emission table above, the tighter limit applies at the band edges.

For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test

Table 8.9-2: ISED restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	12.57675–12.57725	399.9–410	7.25–7.75
0.495–0.505	13.36–13.41	608–614	8.025–8.5
2.1735–2.1905	16.42–16.423	960–1427	9.0–9.2
3.020–3.026	16.69475–16.69525	1435–1626.5	9.3–9.5
4.125–4.128	16.80425–16.80475	1645.5–1646.5	10.6–12.7
4.17725–4.17775	25.5–25.67	1660–1710	13.25–13.4
4.20725–4.20775	37.5–38.25	1718.8–1722.2	14.47–14.5
5.677–5.683	73–74.6	2200–2300	15.35–16.2
6.215–6.218	74.8–75.2	2310–2390	17.7–21.4
6.26775–6.26825	108–138	2483.5–2500	22.01–23.12
6.31175–6.31225	149.9–150.05	2655–2900	23.6–24.0
8.291–8.294	156.52475–156.52525	3260–3267	31.2–31.8
8.362–8.366	156.7–156.9	3332–3339	36.43–36.5
8.37625–8.38675	162.0125–167.17	3345.8–3358	Above 38.6
8.41425–8.41475	167.72–173.2	3500–4400	
12.29–12.293	240–285	4500–5150	
12.51975–12.52025	322–335.4	5350–5460	

Note: Certain frequency bands listed in Table 8.9-2 and above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to related devices are set out in the 200 and 300 series of RSSs.

Table 8.9-3: FCC restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	Above 38.6
13.36–13.41			

8.9.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	October 20, 2020

8.9.3 Observations, settings and special notes

As part of the current assessment, the test range of 9 kHz to 10th harmonic has been fully considered and compared to the actual frequencies utilized within the EUT. Since the EUT contains a transmitter in the GHz range, the EUT has been deemed compliant without formal testing in the 9 kHz to 30 MHz test range, therefore formal test results (tabular data and/or plots) are not provided within this test report.

EUT was set to transmit with 100 % duty cycle.

Radiated measurements were performed at a distance of 3 m.

DTS emissions in non-restricted frequency bands test was performed as per KDB 558074, section 8.5 with reference to ANSI C63.10 subclause 11.11.

Since fundamental power was tested using the maximum peak conducted output power procedure to demonstrate compliance, the spurious emissions limit is –20 dBc/100 kHz.

DTS emissions in restricted frequency bands test was performed as per KDB 558074, section 8.6 with reference to ANSI C63.10 subclause 11.12.

DTS band-edge emission measurements test was performed as per KDB 558074, section 8.7 with reference to ANSI C63.10 subclause 11.13.

Spectrum analyser settings for radiated measurements within restricted bands below 1 GHz:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for peak radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for conducted spurious emissions measurements:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

8.9.4 Test data

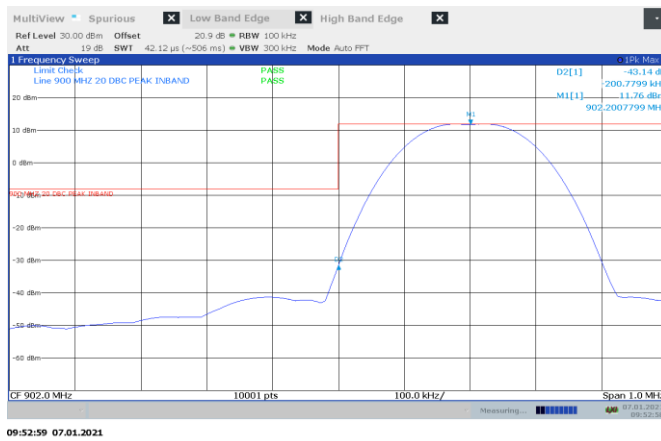


Figure 8.9-1: Conducted Band-edge on low channel, FSK 50kbps

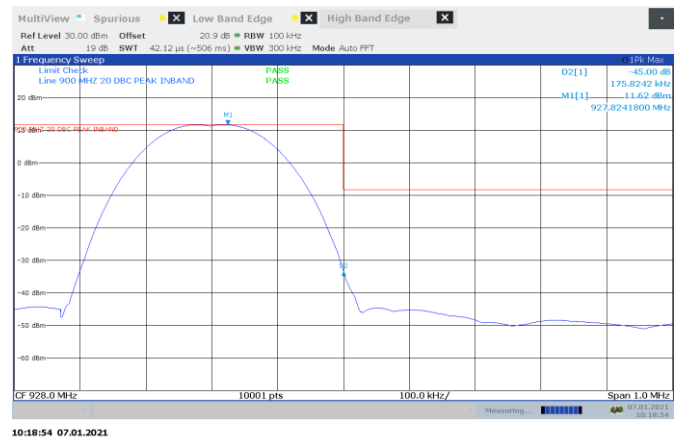


Figure 8.9-2: Conducted Band-edge on high channel, FSK 50kbps

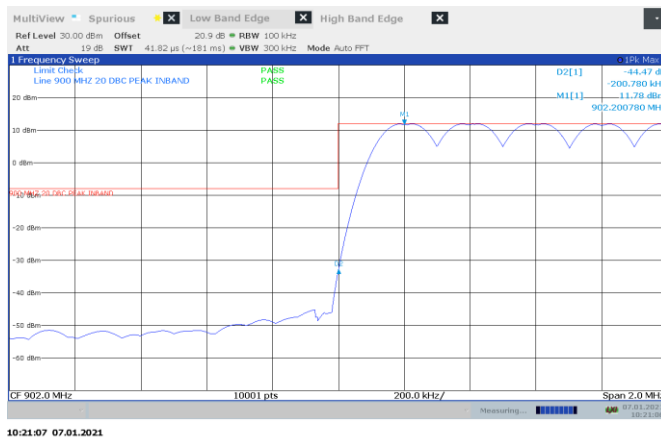


Figure 8.9-3: Conducted low Band-edge on Hopping, FSK 50kbps



Figure 8.9-4: Conducted high Band-edge on Hopping, FSK 50kbps

Test data, continued

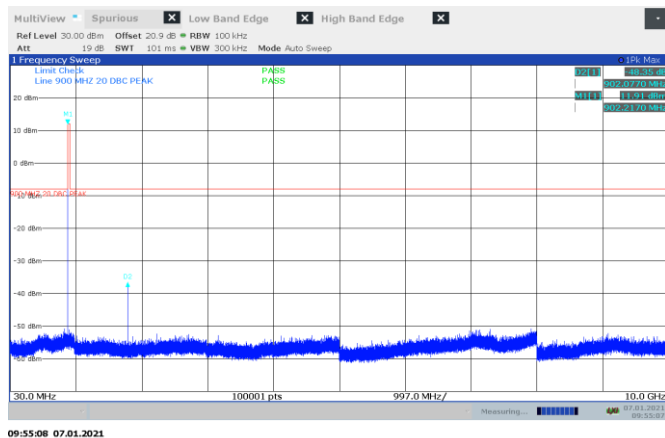


Figure 8.9-5: Conducted spurious emissions on low channel, FSK 50kbps

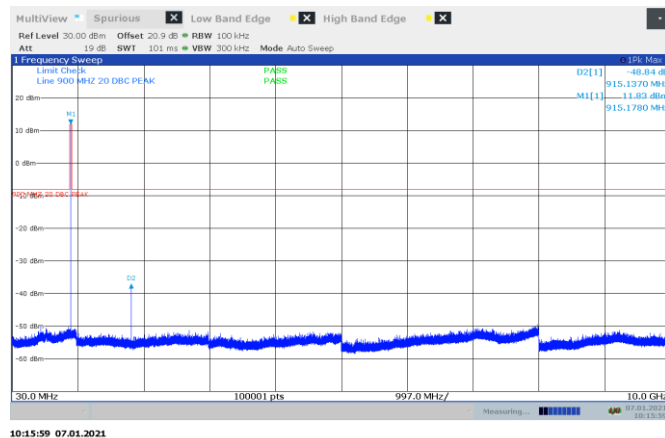


Figure 8.9-6: Conducted spurious emissions on mid channel, FSK 50kbps

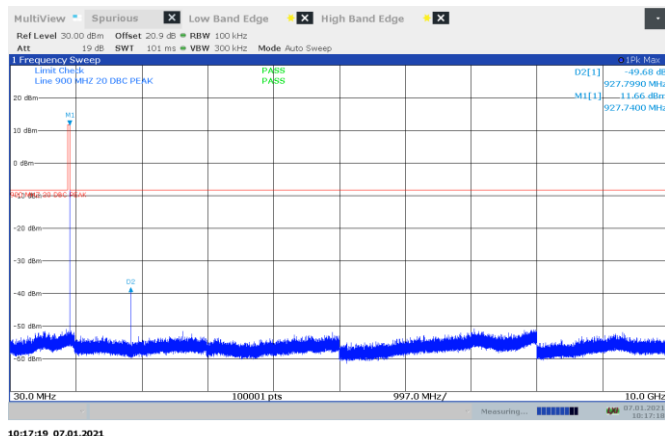


Figure 8.9-7: Conducted spurious emissions on high channel, FSK 50kbps

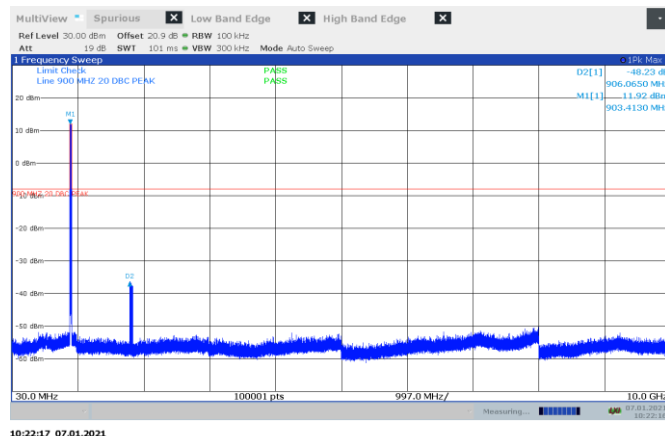


Figure 8.9-8: Conducted spurious emissions on Hopping, FSK 50kbps

Test data, continued

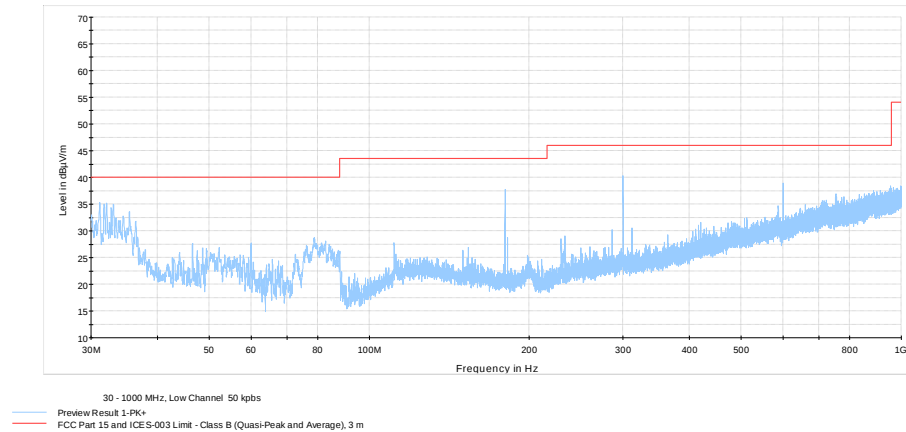


Figure 8.9-9: Radiated spurious emissions 30 MHz – 1 GHz on low channel, FSK 50kbps

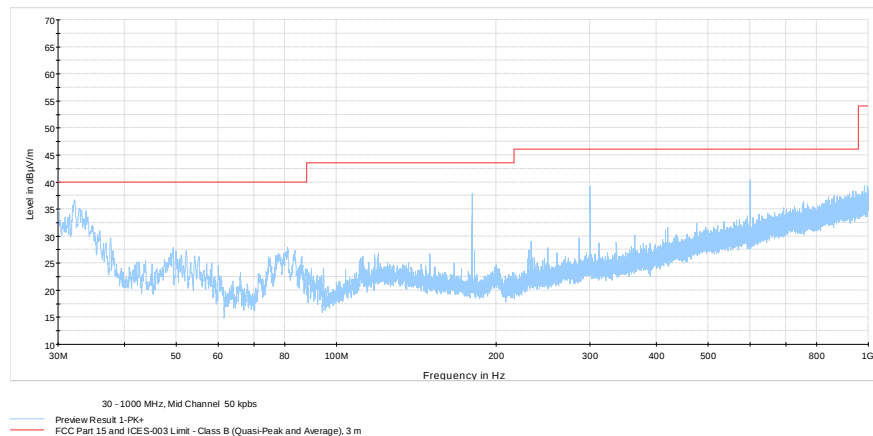


Figure 8.9-10: Radiated spurious emissions 30 MHz – 1 GHz on mid channel, FSK 50kbps

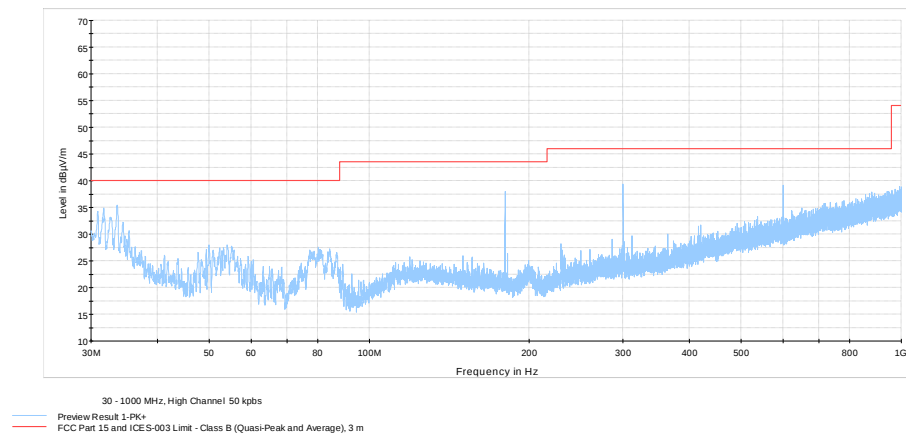


Figure 8.9-11: Radiated spurious emissions 30 MHz – 1 GHz on high channel, FSK 50kbps

Test data, continued

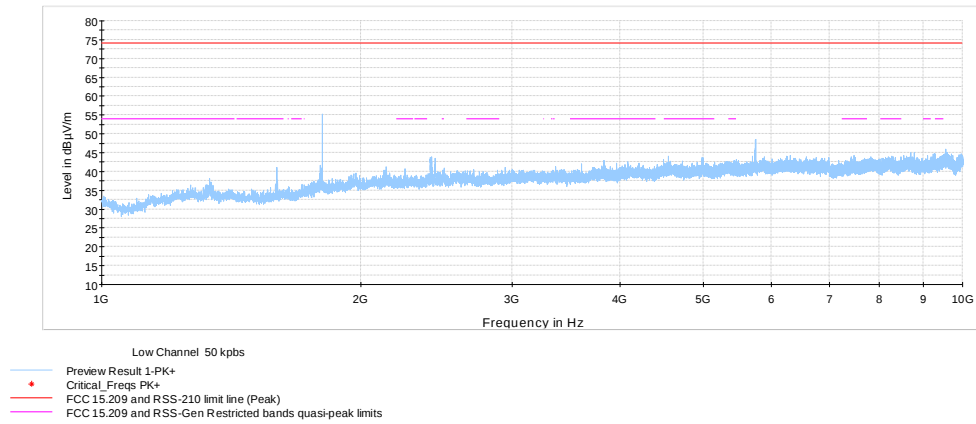


Figure 8.9-12: Radiated spurious emissions 1 – 10 GHz on low channel, FSK 50kbps

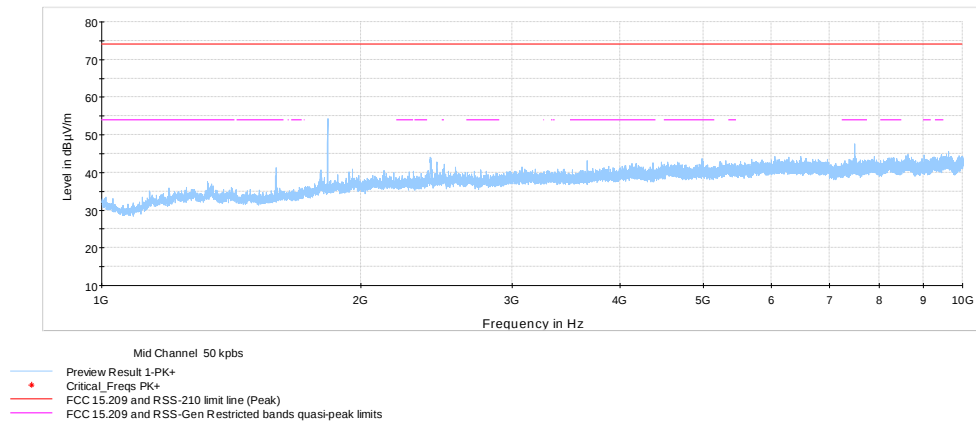


Figure 8.9-13: Radiated spurious emissions 1 – 10 GHz on mid channel, FSK 50kbps

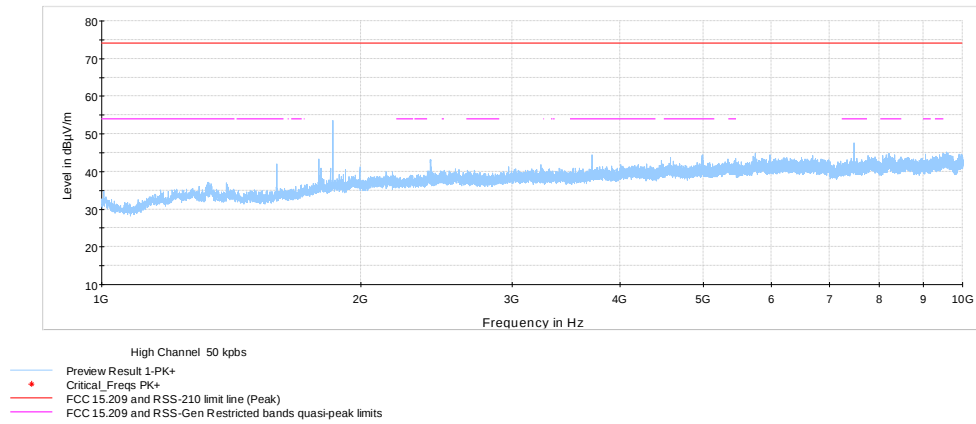


Figure 8.9-14: Radiated spurious emissions 1 – 10 GHz on high channel, FSK 50kbps

Test data, continued

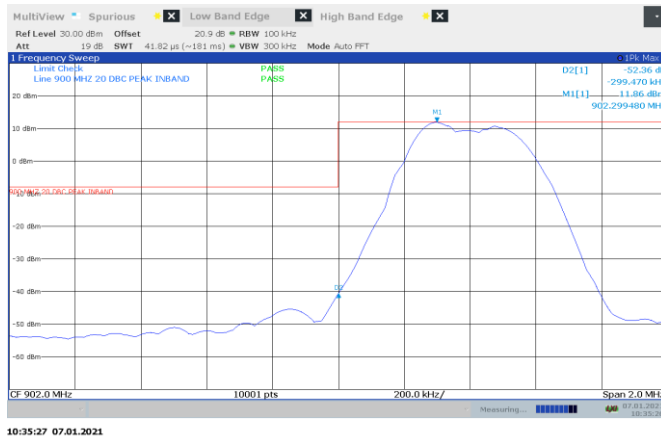


Figure 8.9-15: Conducted Band-edge on low channel, FSK 150kbps



Figure 8.9-16: Conducted Band-edge on high channel, FSK 150kbps

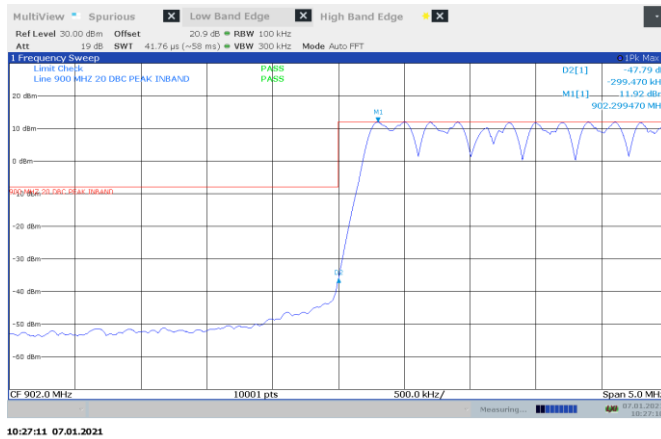


Figure 8.9-17: Conducted low Band-edge on Hopping, FSK 150kbps

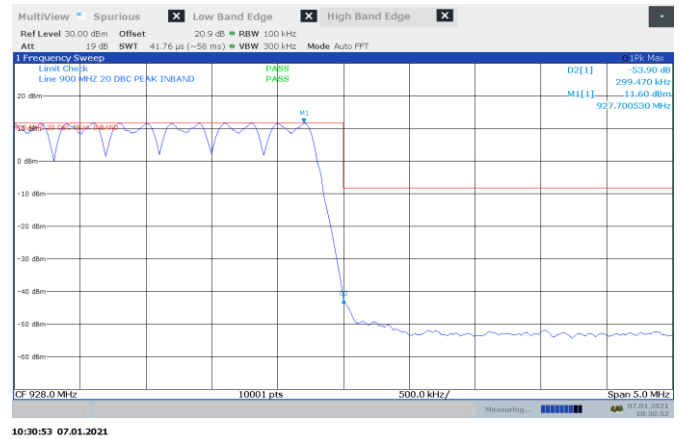


Figure 8.9-18: Conducted high Band-edge on Hopping, FSK 150kbps

Test data, continued

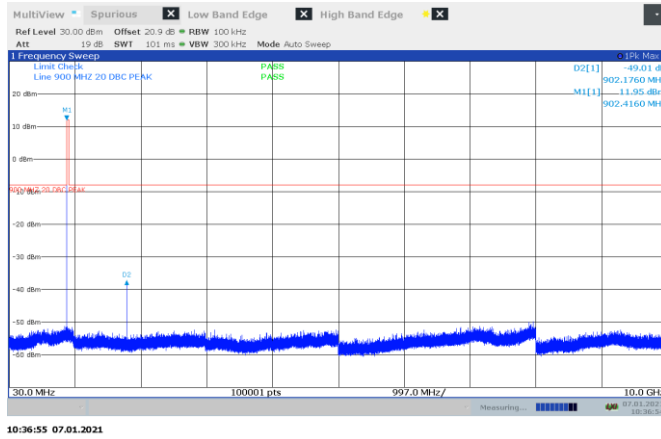


Figure 8.9-19: Conducted spurious emissions on low channel, FSK 150kbps

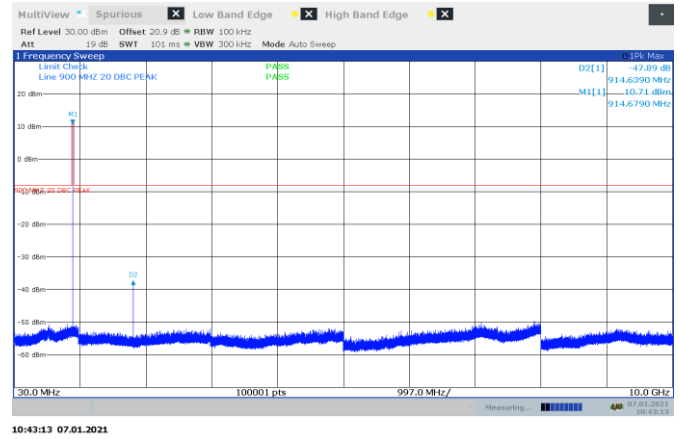


Figure 8.9-20: Conducted spurious emissions on mid channel, FSK 150kbps

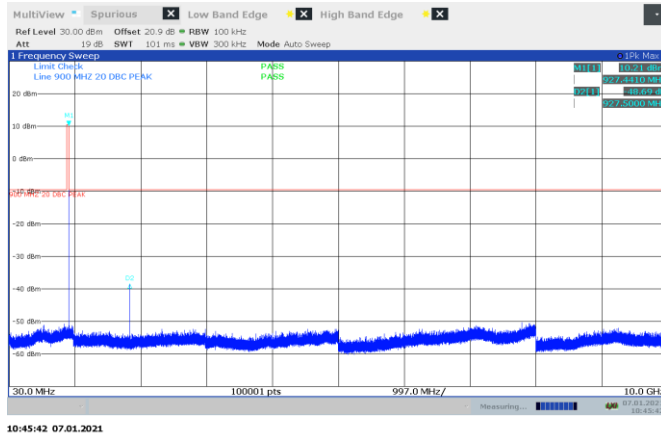


Figure 8.9-21: Conducted spurious emissions on high channel, FSK 150kbps

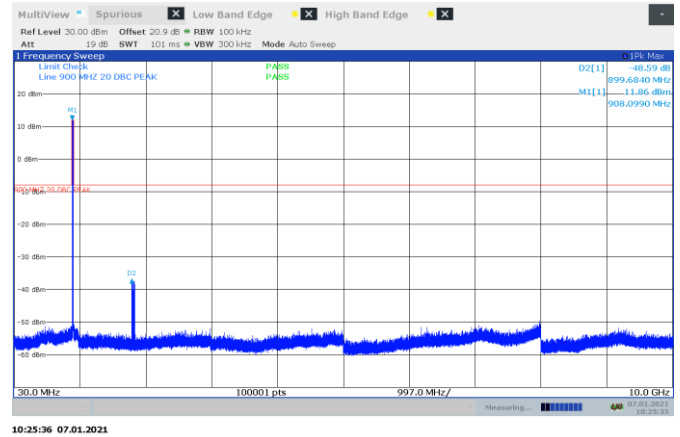


Figure 8.9-22: Conducted spurious emissions on hopping, FSK 150kbps

Test data, continued

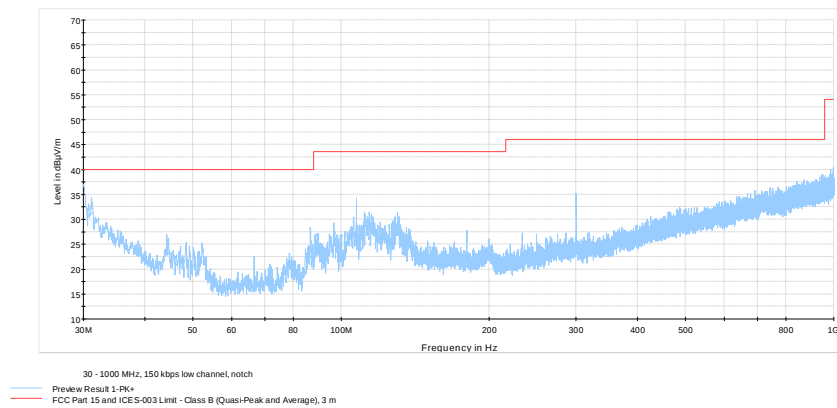


Figure 8.9-23: Radiated spurious emissions 30 MHz – 1 GHz on low channel, FSK 150kbps

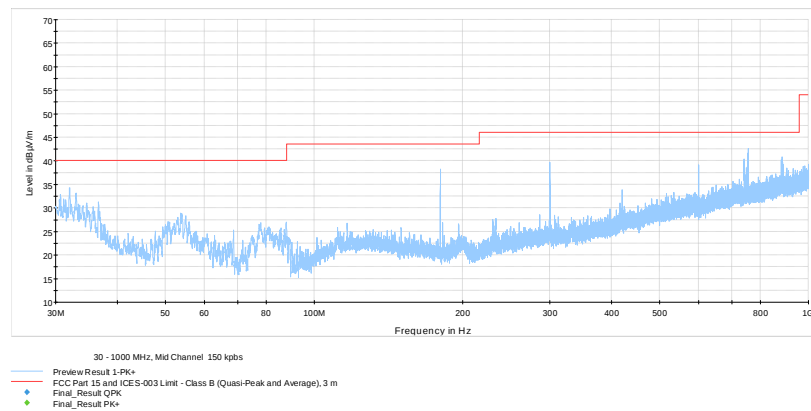


Figure 8.9-24: Radiated spurious emissions 30 MHz – 1 GHz on mid channel, FSK 150kbps

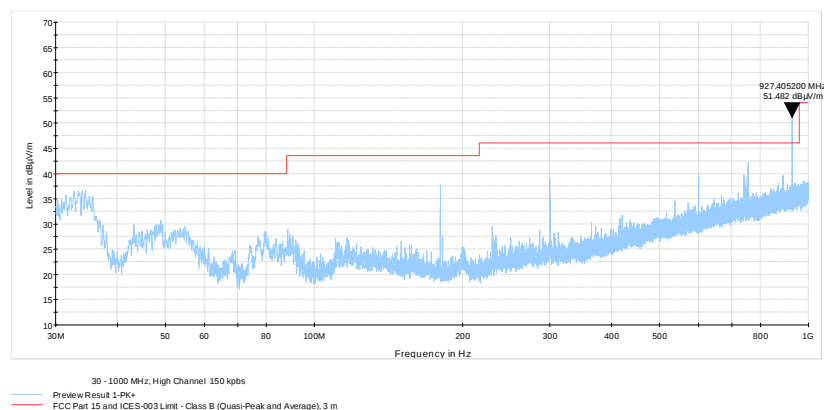


Figure 8.9-25: Radiated spurious emissions 30 MHz – 1 GHz on high channel, FSK 150kbps

Test data, continued

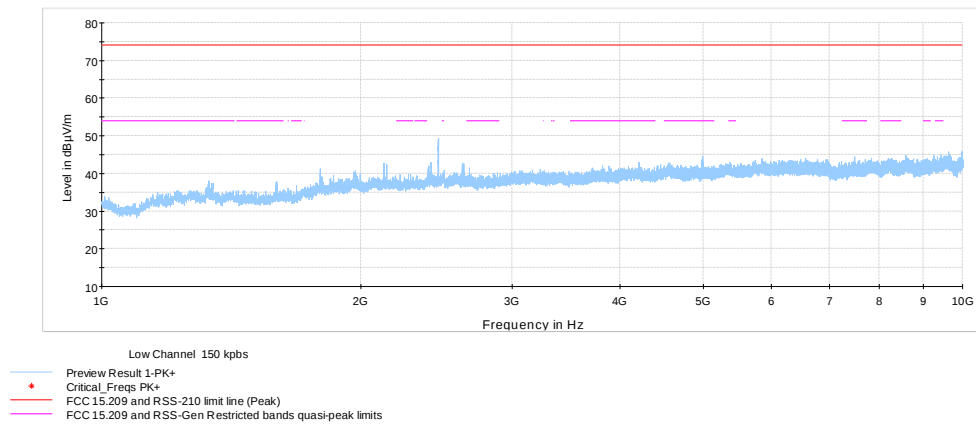


Figure 8.9-26: Radiated spurious emissions 1 – 10 GHz on low channel, FSK 150kbps

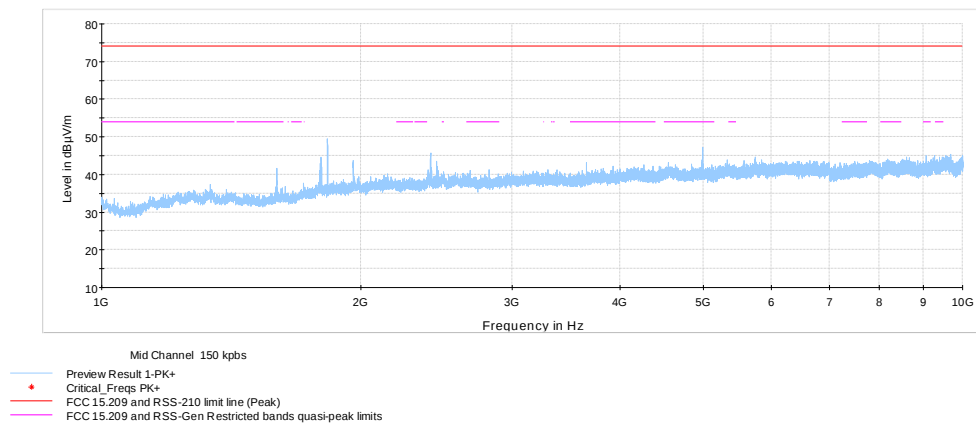


Figure 8.9-27: Radiated spurious emissions 1 – 10 GHz on mid channel, FSK 150kbps

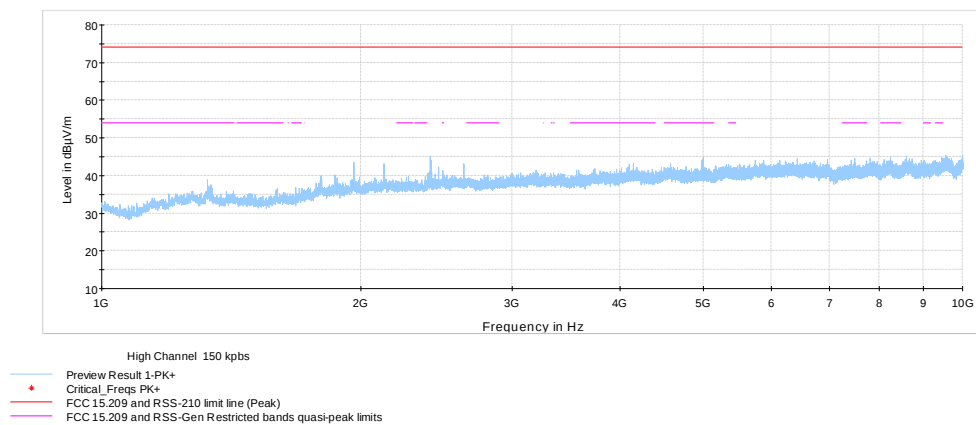


Figure 8.9-28: Radiated spurious emissions 1 – 10 GHz on high channel, FSK 150kbps

Test data, continued

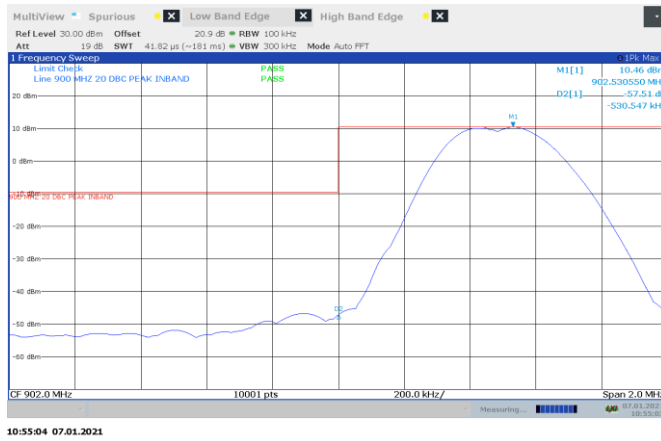


Figure 8.9-29: Conducted Band-edge on low channel, FSK 250kbps

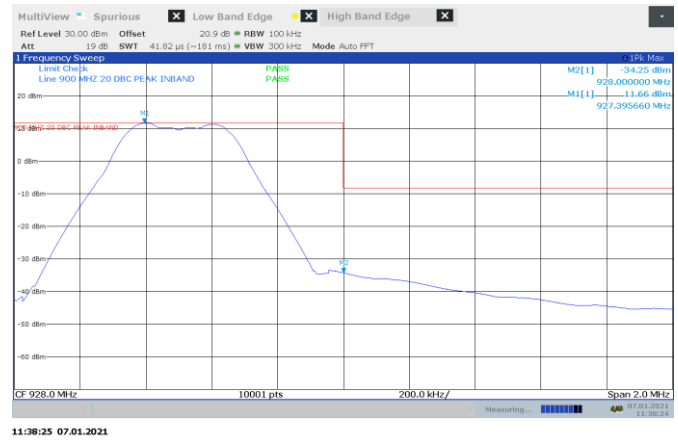


Figure 8.9-30: Conducted Band-edge on high channel, FSK 250kbps

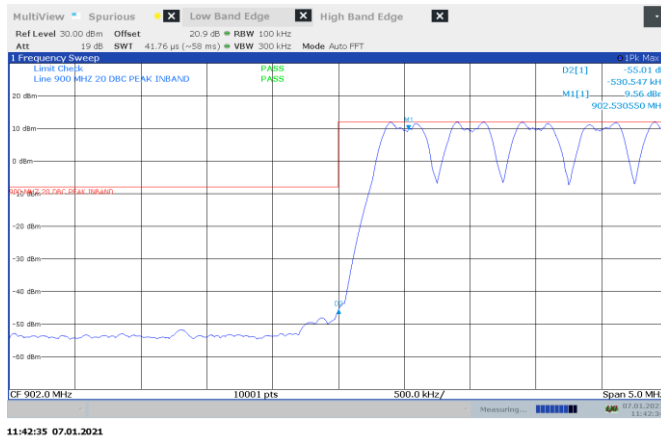


Figure 8.9-31: Conducted low Band-edge on Hopping, FSK 250kbps

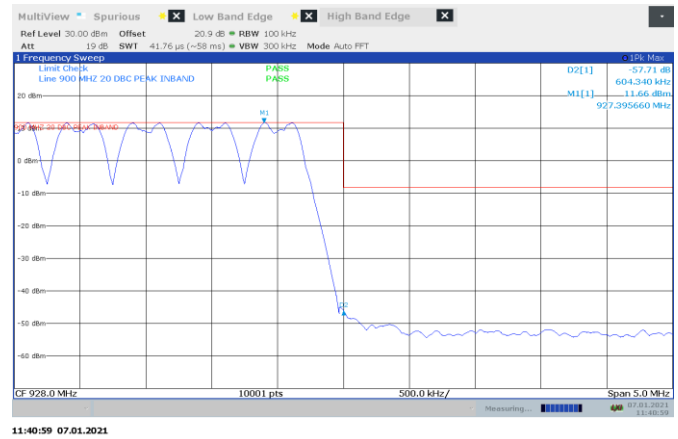


Figure 8.9-32: Conducted high Band-edge on Hopping, FSK 250kbps

Test data, continued

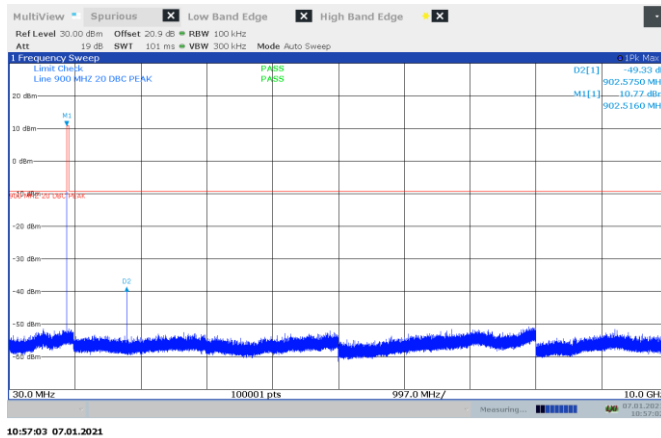


Figure 8.9-33: Conducted spurious emissions on low channel, FSK 250kbps

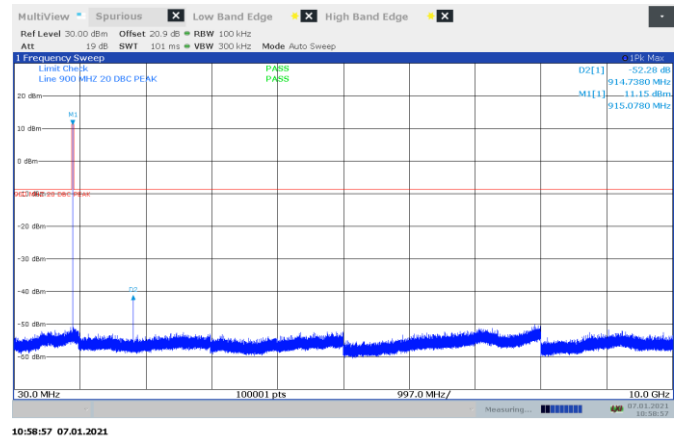


Figure 8.9-34: Conducted spurious emissions on mid channel, FSK 250kbps

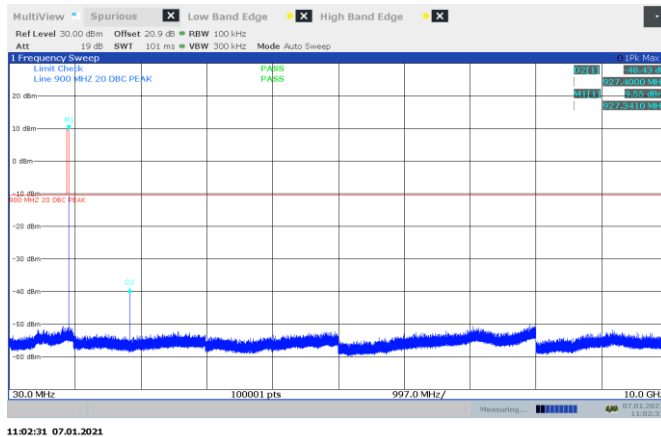


Figure 8.9-35: Conducted spurious emissions on high channel, FSK 250kbps

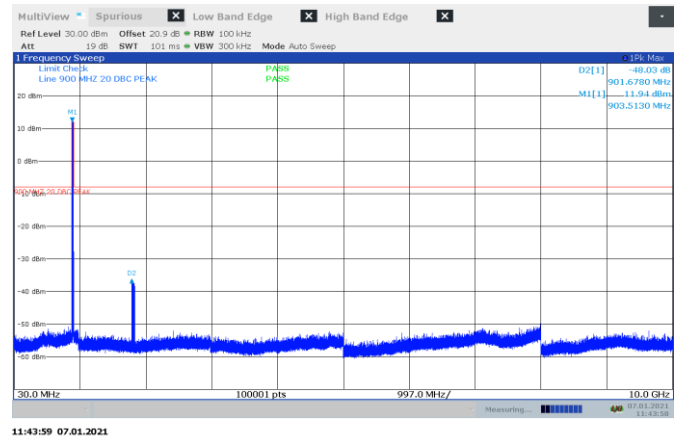


Figure 8.9-36: Conducted spurious emissions on hopping, FSK 250kbps

Test data, continued

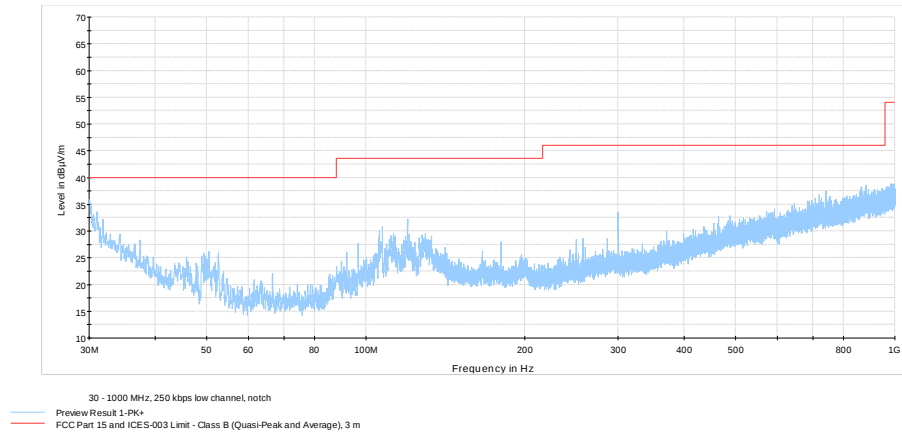


Figure 8.9-37: Radiated spurious emissions 30 MHz – 1 GHz on low channel, FSK 250kbps

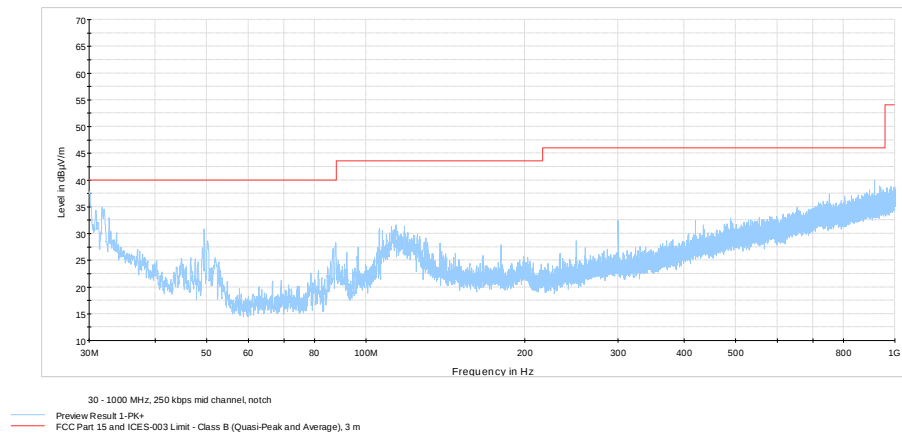


Figure 8.9-38: Radiated spurious emissions 30 MHz – 1 GHz on mid channel, FSK 250kbps

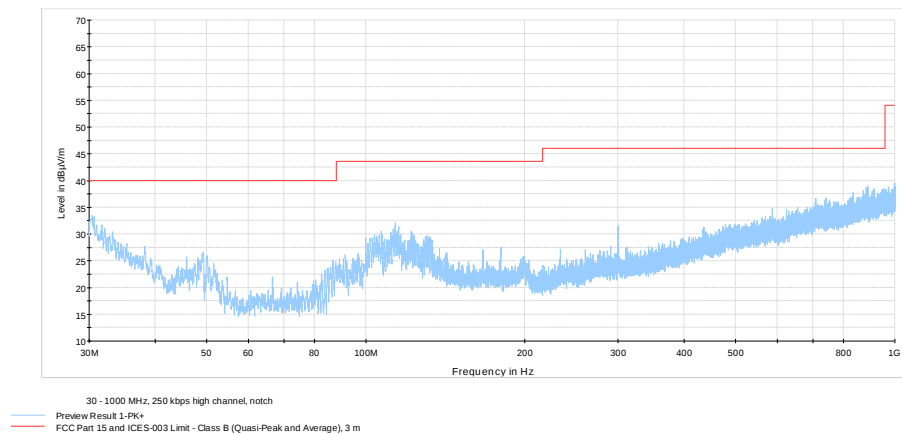


Figure 8.9-39: Radiated spurious emissions 30 MHz – 1 GHz on high channel, FSK 250kbps

Test data, continued

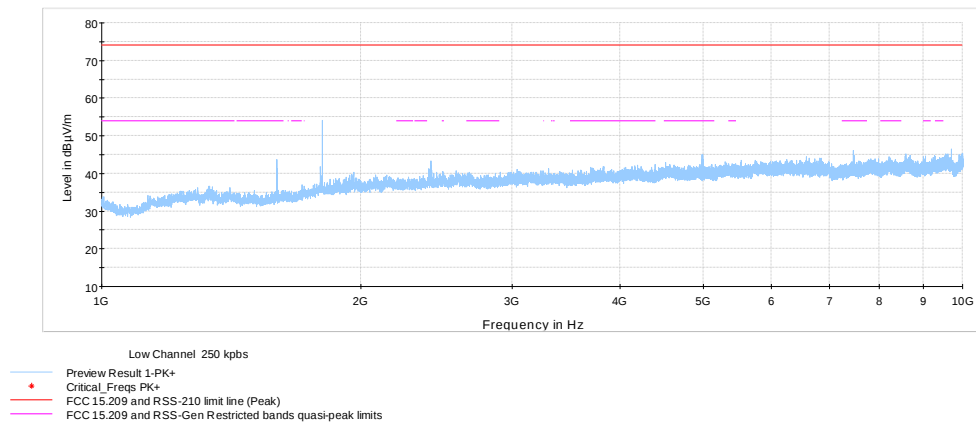


Figure 8.9-40: Radiated spurious emissions 1 – 10 GHz on low channel, FSK 250kbps

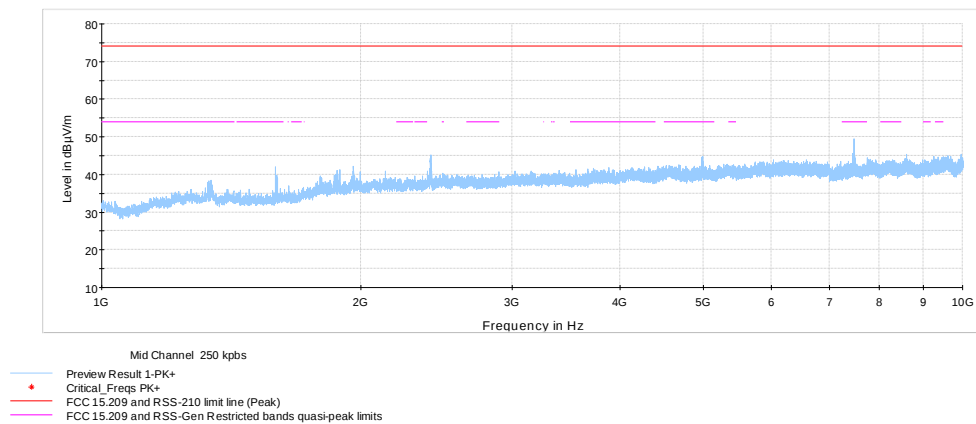


Figure 8.9-41: Radiated spurious emissions 1 – 10 GHz on mid channel, FSK 250kbps

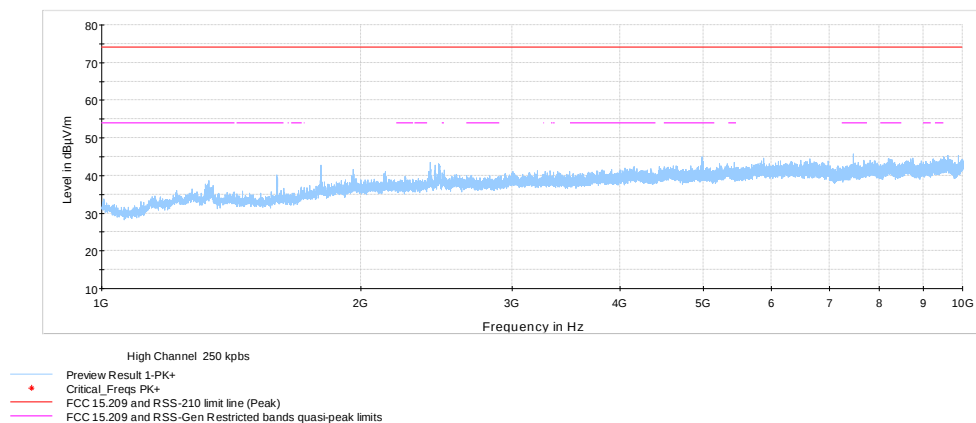


Figure 8.9-42: Radiated spurious emissions 1 – 10 GHz on high channel, FSK 250kbps

Test data, continued

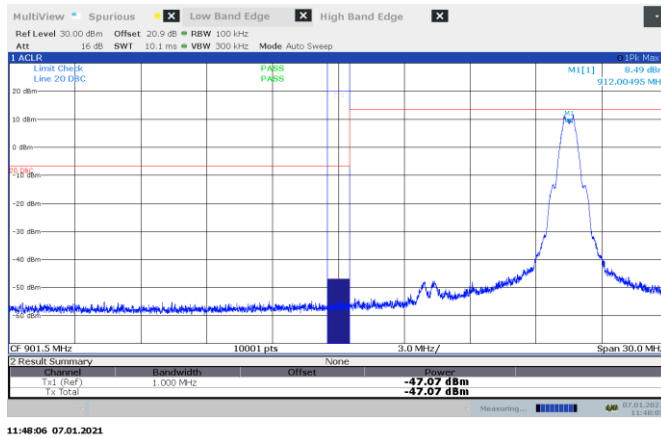


Figure 8.9-43: Conducted Band-edge on 912 MHz channel, Z-Wave Long Range

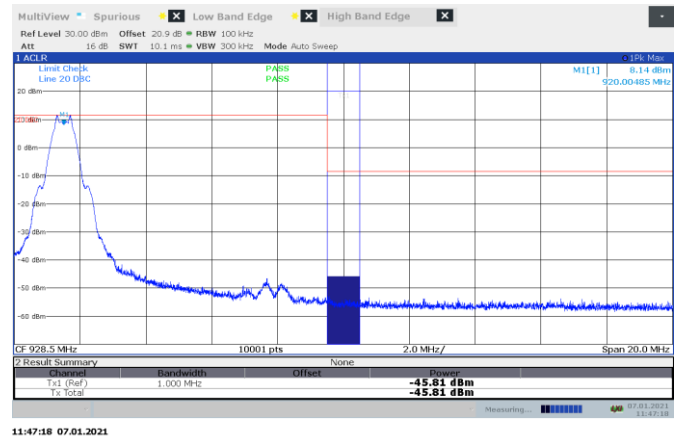


Figure 8.9-44: Conducted Band-edge on 920 MHz channel, Z-Wave Long Range

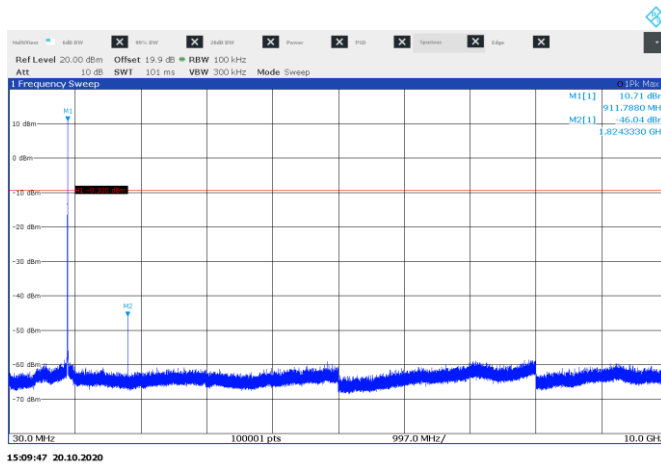


Figure 8.9-45: Conducted spurious emissions on 912 MHz channel, Z-Wave Long Range

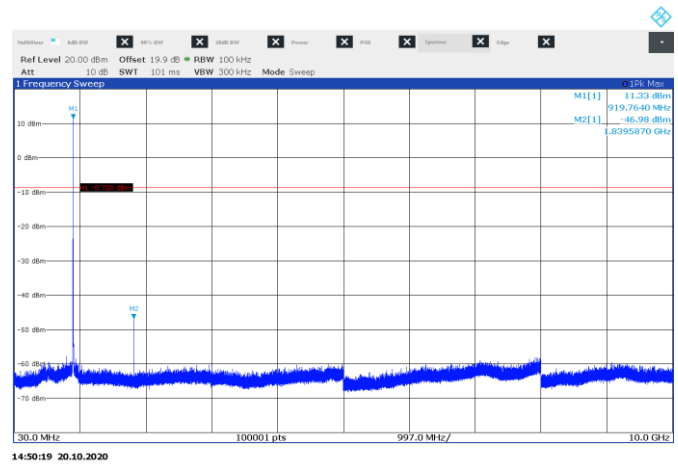


Figure 8.9-46: Conducted spurious emissions on 920 MHz channel, Z-Wave Long Range

Test data, continued

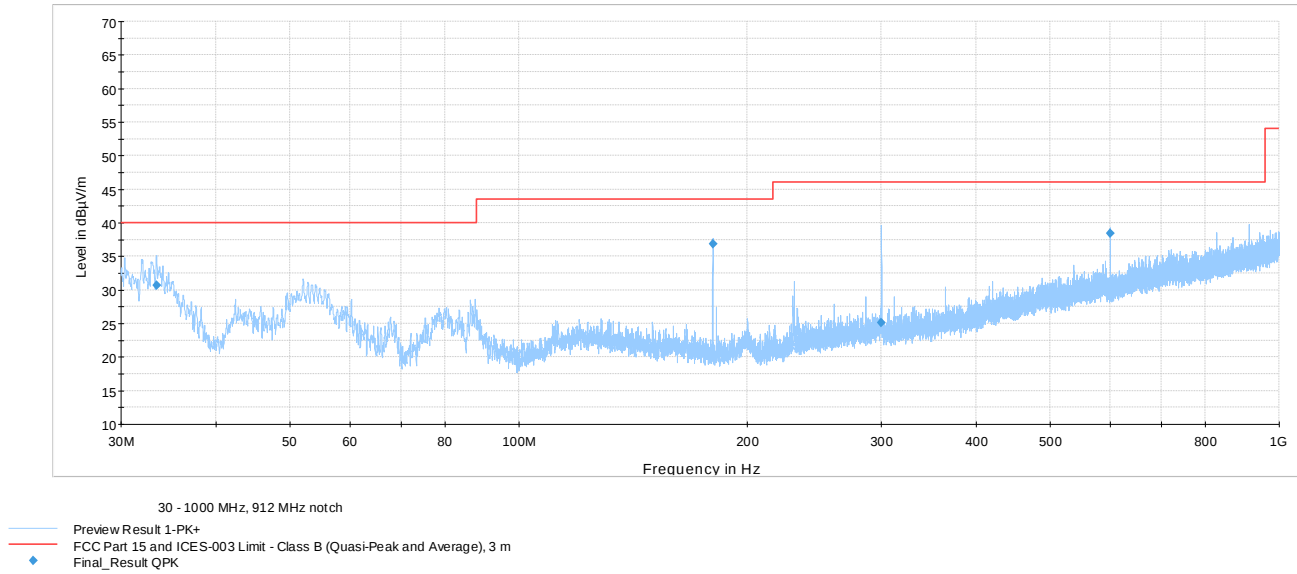


Figure 8.9-47: Radiated spurious emissions 30 MHz – 1 GHz on 912 MHz channel, Z-Wave Long Range

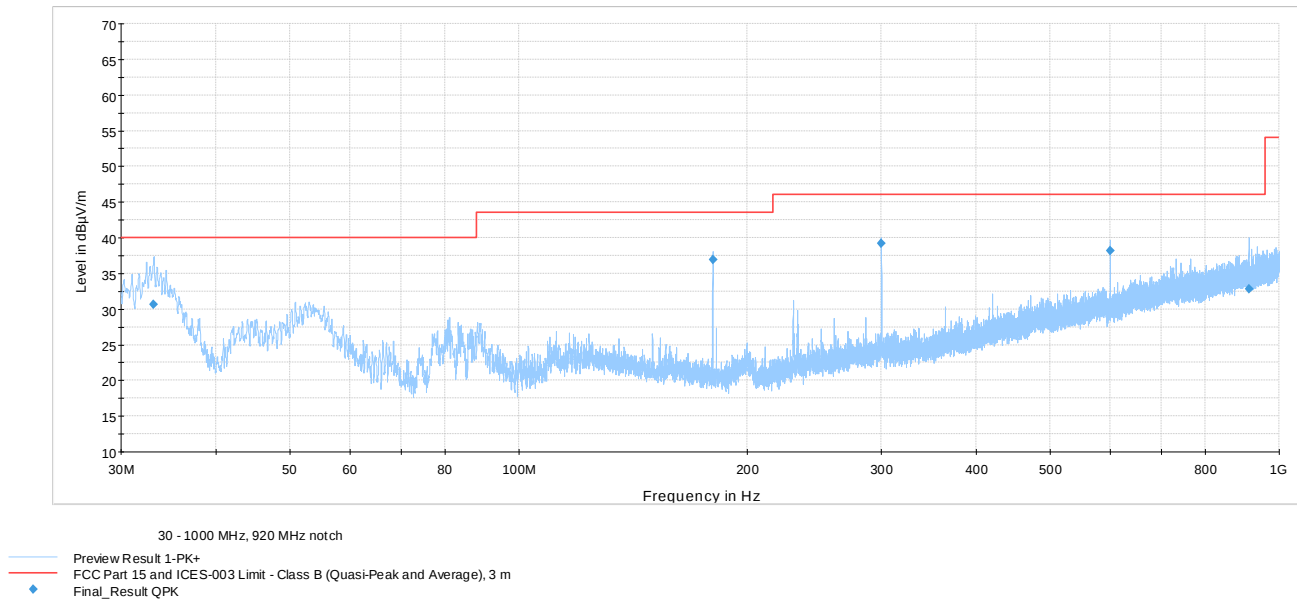
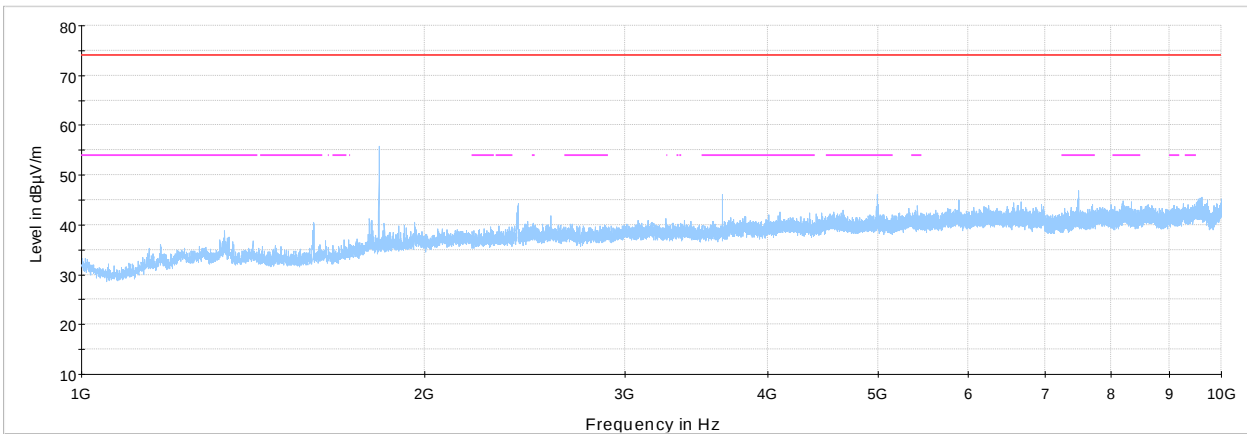


Figure 8.9-48: Radiated spurious emissions 30 MHz – 1 GHz on 920 MHz channel, Z-Wave Long Range

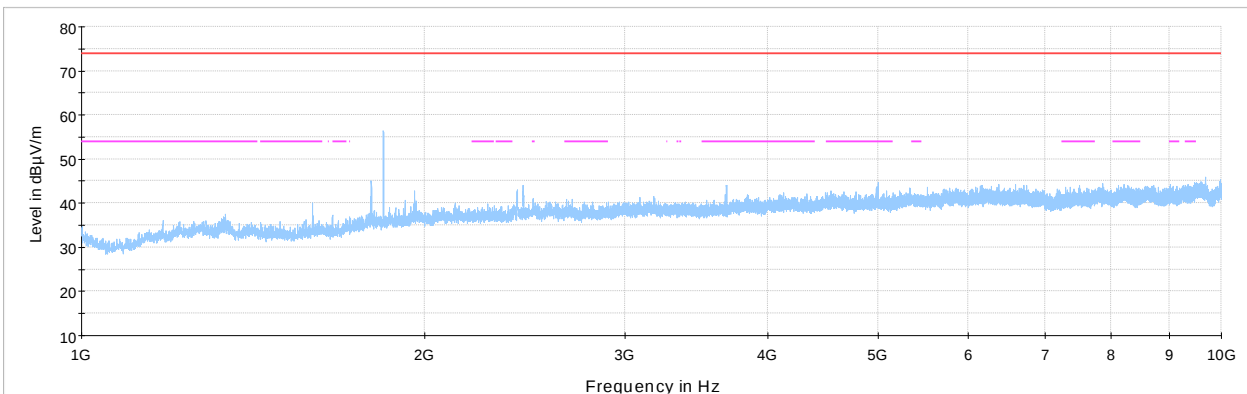
Test data, continued



912 MHz

- Preview Result 1-PK+
- Critical_Freqs PK+
- FCC 15.209 and RSS-210 limit line (Peak)
- FCC 15.209 and RSS-Gen Restricted bands quasi-peak limits

Figure 8.9-49: Radiated spurious emissions 1 - 10 GHz on 912 MHz channel, Z-Wave Long Range



920 MHz

- Preview Result 1-PK+
- Critical_Freqs PK+
- FCC 15.209 and RSS-210 limit line (Peak)
- FCC 15.209 and RSS-Gen Restricted bands quasi-peak limits

Figure 8.9-50: Radiated spurious emissions 1 - 10 GHz on 920 MHz channel, Z-Wave Long Range

8.10 FCC 15.247(e) and RSS-247 5.2(b) Power spectral density for digitally modulated devices

8.10.1 References, definitions and limits

FCC:

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.

(f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

ISED:

The transmitter power spectral density conducted from the transmitter 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 section 5.4(d), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

5.3 Hybrid systems

Hybrid systems employ a combination of both frequency hopping and digital transmission techniques and shall comply with the following:

With the frequency hopping turned off, the digital transmission operation shall comply with the power spectral density requirements for digital modulation systems set out in of section 5.2(b) or section 6.2.4 for hybrid devices operating in the band 5725–5850 MHz.

8.10.2 Test summary

Verdict	Pass		
Tested by	Alvin Liu	Test date	October 20, 2020

8.10.3 Observations, settings and special notes

Power spectral density test was performed as per KDB 558074, section 8.4 with reference to ANSI C63.10 subclause 11.10.

The test was performed using method PKPSD (peak PSD).

Spectrum analyser settings:

Resolution bandwidth:	3 kHz
Video bandwidth:	$\geq 3 \times \text{RBW}$
Frequency span:	1.5 times the DTS BW (Peak)
Detector mode:	Peak
Trace mode:	Max Hold

8.10.4 Test data

Table 8.10-1: PSD results (antenna port measurement)

Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
912	0.5	8.0	7.5
920	0.1	8.0	7.9

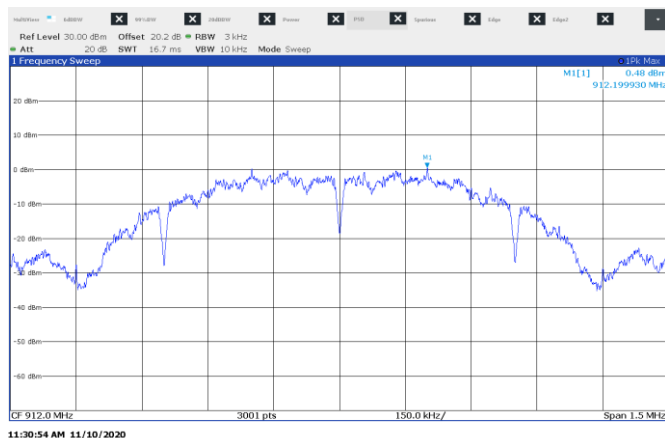


Figure 8.10-1: PSD on 912 MHz channel, Z-Wave Long Range

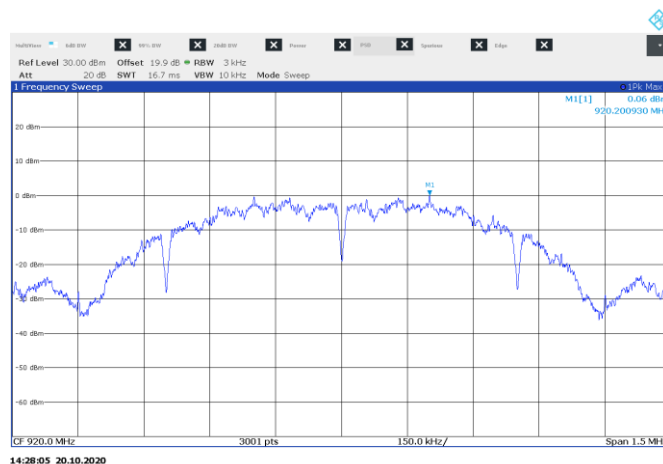


Figure 8.10-2: PSD on 920 MHz channel, Z-Wave Long Range

End of the test report