

Test Report

Part 15 Subpart C 15.247

Equipment under test Ultra-low power & Long-range Wireless LAN Module
Model name NRM7292D A1SE
FCC ID 2A32R-NRM7292D
Applicant SRF Co.,Ltd
Manufacturer SRF Co.,Ltd
Date of test(s) 2022.08.03~2022.08.31
Date of issue 2022.09.16

Issued to
SRF Co.,Ltd

#303,311, business Incubation Center 155 Ansan Danhak-ro, Sangnok-gu,Ansan-si,
Gyeonggi-do, South Korea
Tel: +82-70-7918-2131, Fax: +82-50-4379-2131

Issued by
KES Co., Ltd.

3701, 40, Simin-daero 365beon-gil, Dongan-gu, Anyang-si,
Gyeonggi-do, 14057, Korea
473-21, Gayeo-ro, Yeosu-si, Gyeonggi-do, Korea
Tel: +82-31-425-6200 / Fax: +82-31-424-0450

Test and report completed by :	Report approval by :
	
Gu-Bong, Kang Test engineer	Yeong-Jun Cho Technical manager

This test report is not related to KS Q ISO/IEC 17025 and KOLAS

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Revision history

Revision	Date of issue	Test report No.	Description
-	2022.09.16	KES-RF1-22T0120	Initial

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1. General information

Applicant: SRF Co.,Ltd
Applicant address: #303,311, business Incubation Center 155 Ansan Danhak-ro, Sangnok-gu,Ansan-si, Gyeonggi-do, South Korea
Test site: KES Co., Ltd.
Test site address: ☐ 3701, 40, Simin-daero 365beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do, 14057, Korea
☒ 473-29, Gayeo-ro, Yeosu-si, Gyeonggi-do, Korea
Test Facility FCC Accreditation Designation No.: KR0100, Registration No.: 444148
FCC rule part(s): 15.247
FCC ID: 2A32R-NRM7292D
Test device serial No.: ☒ Production ☐ Pre-production ☐ Engineering

1.1. EUT description

Equipment under test Ultra-low power & Long-range Wireless LAN Module
Frequency range 802.11ah_1 Mhz : 903.5 Mhz ~ 926.5 Mhz
802.11ah_2 Mhz : 905 Mhz ~ 925 Mhz
802.11ah_4 Mhz : 906 Mhz ~ 922 Mhz
Model: NRM7292D A1SE
Modulation technique OFDM
Number of channels 802.11ah_1 Mhz : 903.5 Mhz ~ 926.5 Mhz // 24 ch
802.11ah_2 Mhz : 905 Mhz ~ 925 Mhz // 11 ch
802.11ah_4 Mhz : 906 Mhz ~ 922 Mhz // 5 ch
Antenna specification Antenna type : Dipole Antenna (Female type), Peak gain : 1.68 dBi
Power source DC 3.3 V
H/W Version NRM7292D_A1SE v0.1
S/W Version 05.01.09

1.2. Test configuration

The SRF Co.,Ltd // Ultra-low power & Long-range Wireless LAN Module // NRM7292D A1SE //
FCC ID: 2A32R-NRM7292D was tested according to the specification of EUT, the EUT must comply with following standards and KDB documents.

FCC Part 15.247
KDB 558074 D01 v05 r02
ANSI C63.10-2013

1.3. Derivative Model Information

N/A

1.4. Accessory information

Equipment	Manufacturer	Model	Serial No.	Power source
-	-	-	-	-

1.5. Sample calculation

Where relevant, the following sample calculation is provided

For all conducted test items :

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuator factor between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

$$\begin{aligned}\text{Offset(dB)} &= \text{RF cable loss(dB)} + \text{attenuator factor(dB)} \\ &= 0.76 + 10 = 10.76 \text{ (dB)}\end{aligned}$$

For Radiation test :

Field strength level (dB μ V/m) = Measured level (dB μ V) + Antenna factor (dB) + Cable loss (dB) – Amplifier gain (dB)

1.6. Measurement Uncertainty

Test Item		Uncertainty
Uncertainty for Conduction emission test		2.38 dB
Uncertainty for Radiation emission test (include Fundamental emission)	Below 1 GHz	4.50 dB
	Above 1 GHz	4.90 dB
Note. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.		

1.7. Frequency/channel operations

Ch.	Frequency (MHz)	Mode
01	903.5	802.11ah_1 MHz
.	.	.
13	915.5	802.11ah_1 MHz
.	.	.
24	926.5	802.11ah_1 MHz

Ch.	Frequency (MHz)	Mode
01	905.0	802.11ah_2 MHz
.	.	.
06	915.0	802.11ah_2 MHz
.	.	.
11	925.0	802.11ah_2 MHz

Ch.	Frequency (MHz)	Mode
01	906.0	802.11ah_4 MHz
.	.	.
03	914.0	802.11ah_4 MHz
.	.	.
05	922.0	802.11ah_4 MHz

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2. Summary of tests

Section in FCC Part 15	Test description	Test results
15.247(a)(2)	6 dB bandwidth	Pass
15.247(b)(3)	Output power	Pass
15.247(e)	Power spectral density	Pass
15.205, 15.209	Radiated restricted band and emission	Pass
15.247(d)	Conducted spurious emission and band edge	Pass
15.207(a)	AC Conducted emissions	Pass
15.203	Antenna Requirement	Pass ⁽¹⁾

Note.

1. The device uses a unique coupling to the intentional radiator, so it shall be considered sufficient to comply with the provisions of 15.203.
2. This test has been performed with power setting below:
802.11ah_1 MHz : 19
802.11ah_2 MHz : 25
802.11ah_4 MHz : 25

3. Test results

3.1. 6 dB bandwidth

Test procedure

ANSI C63.10-2013 - Section 11.8.2

Test setup



ANSI C63.10-2013 - Section 11.8.2

The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., $RBW = 100 \text{ kHz}$, $VBW \geq 3 \times RBW$, peak detector with maximum hold) is implemented by the instrumentation function. When using this capability, care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be $\geq 6 \text{ dB}$.

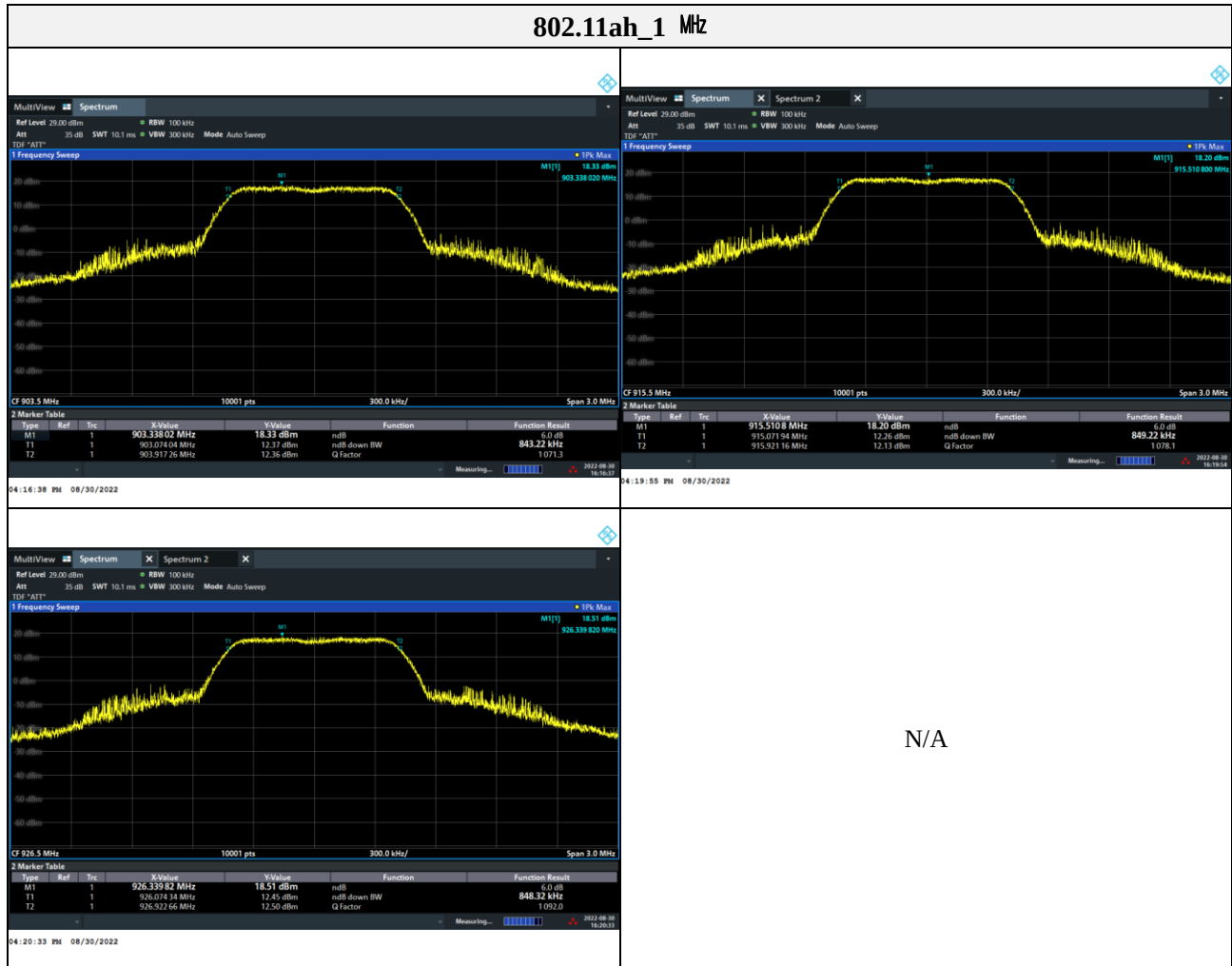
Limit

According to §15.247(a)(2), systems using digital modulation techniques may operate 902 ~ 928 MHz, 2 400 ~ 2 483.5 MHz, and 5 725 ~ 5 850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

Test results

Mode : 802.11ah_1 Mhz

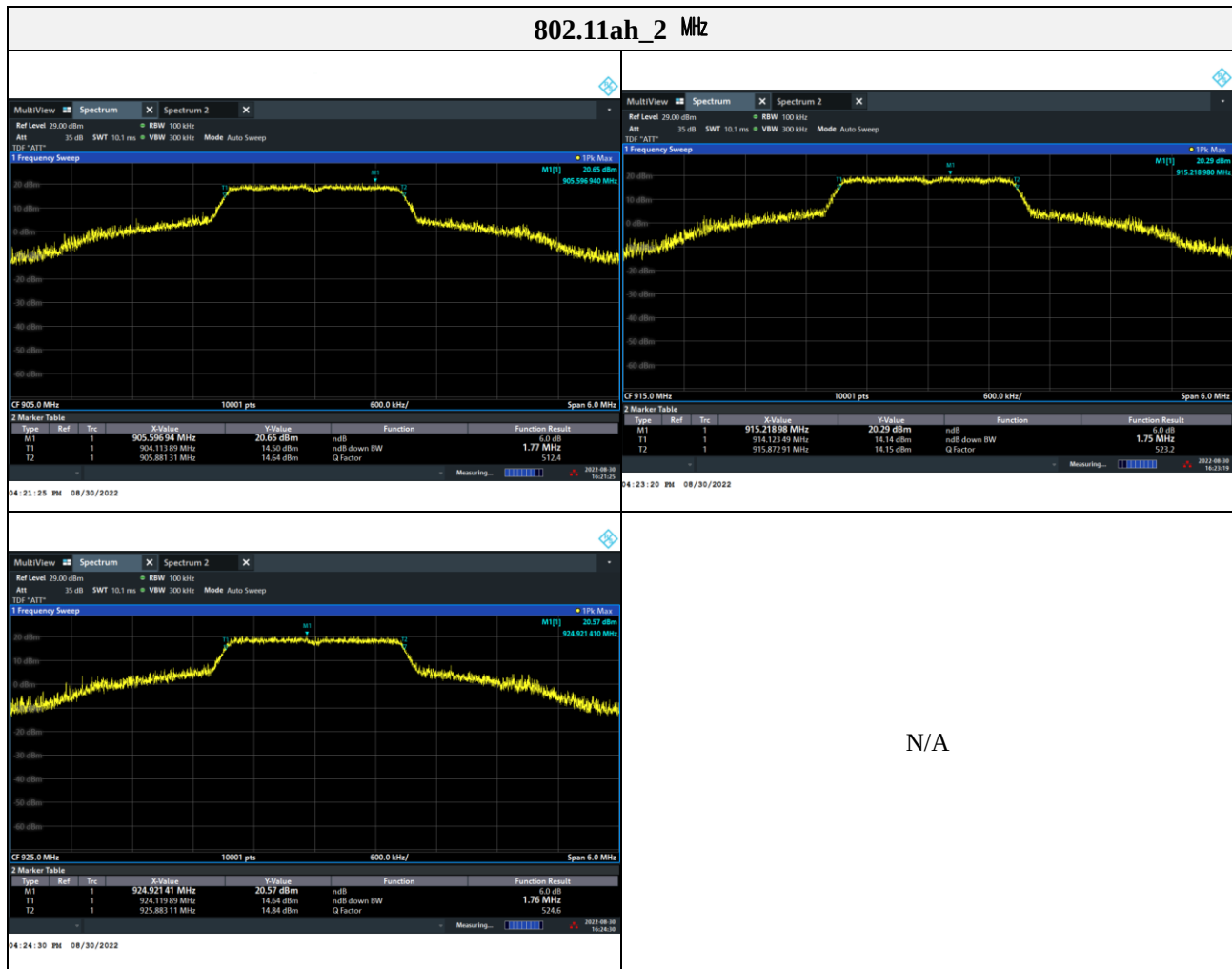
Frequency(MHz)	6 dB bandwidth(MHz)	Limit(MHz)
903.5	0.843 22	≥ 0.500
915.5	0.849 22	
926.5	0.848 32	



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Mode : 802.11ah_2 Mhz

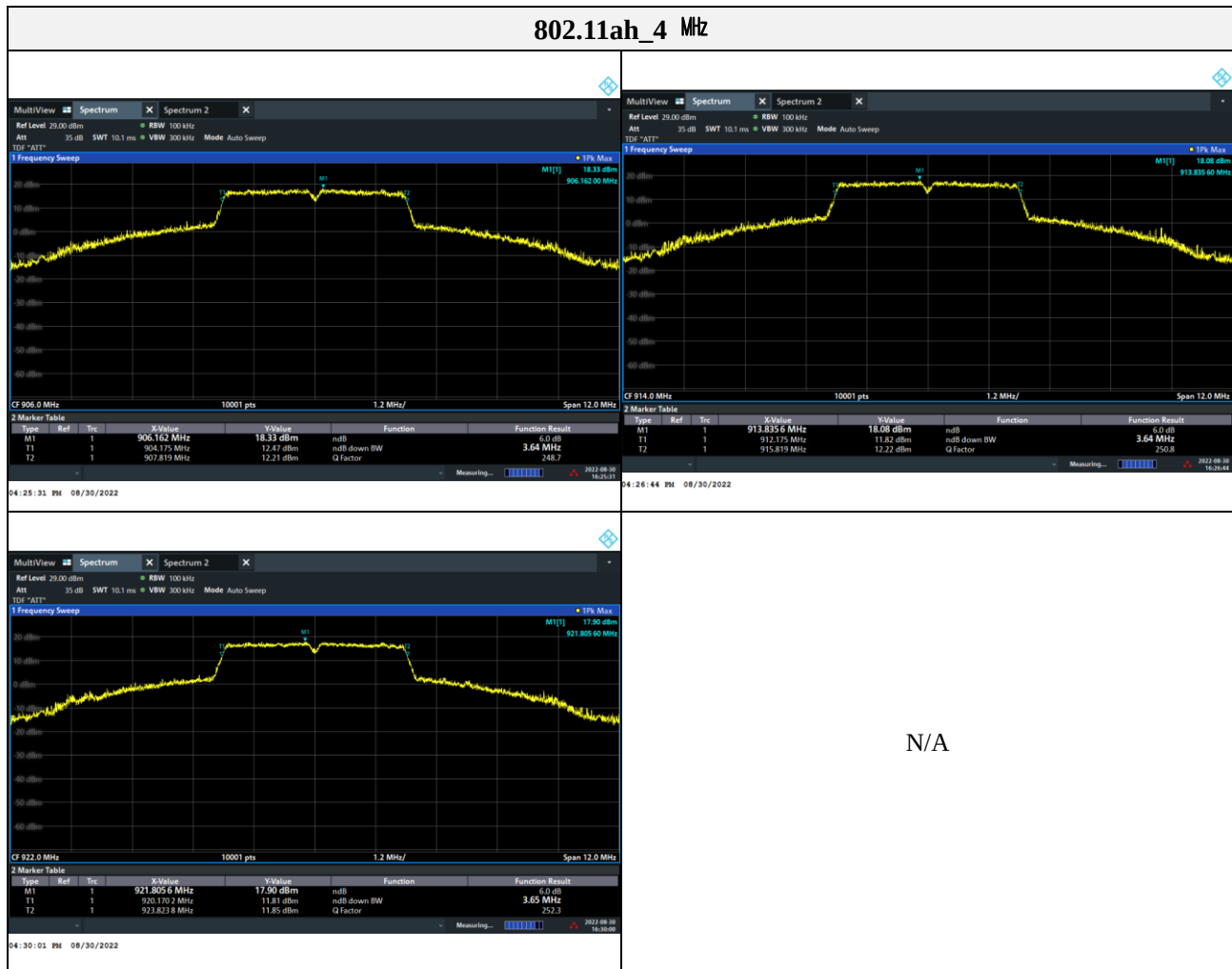
Frequency(MHz)	6 dB bandwidth(MHz)	Limit(MHz)
905.0	1.77	≥ 0.500
915.0	1.75	
925.0	1.76	



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Mode : 802.11ah_4 Mhz

Frequency(MHz)	6 dB bandwidth(MHz)	Limit(MHz)
906.0	3.64	≥ 0.500
914.0	3.64	
922.0	3.65	



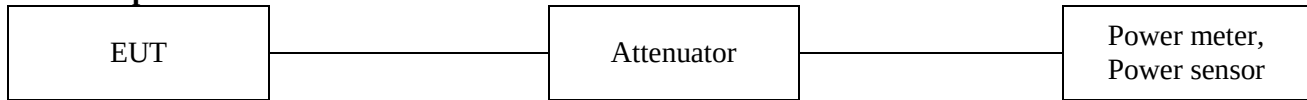
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3.2. Output power

Test procedure

ANSI C63.10-2013 - Section 11.9.1.3 and 11.9.2.3.2

Test setup



ANSI C63.10-2013 - Section 11.9.1.3

The maximum peak conducted output power may be measured using a broadband peak RF power meter. The power meter shall have a video bandwidth that is greater than or equal to the DTS bandwidth and shall use a fast-responding diode detector.

ANSI C63.10-2013 - Section 11.9.2.3.2

Alternatively, measurements may be performed using a wideband gated RF power meter provided that the gate parameters are adjusted such that the power is measured only when the EUT is transmitting at its maximum power control level. Because the measurement is made only during the ON time of the transmitter, no duty cycle correction is required.

Limit

According to §15.247(b)(3), For systems using digital modulation in the 902~928 MHz, 2 400~2 483.5 MHz, and 5 725~5 850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted out-put power. Maximum Conducted Out-put 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.

Test results

Mode : 802.11ah

Mode	903.5 MHz		915.5 MHz		926.5 MHz		Limit (dBm)
	Average (dBm)	Peak (dBm)	Average (dBm)	Peak (dBm)	Average (dBm)	Peak (dBm)	
1 MHz	19.53	26.15	19.54	26.12	19.76	26.14	30.00

Mode	905.0 MHz		915.0 MHz		925.0 MHz		Limit (dBm)
	Average (dBm)	Peak (dBm)	Average (dBm)	Peak (dBm)	Average (dBm)	Peak (dBm)	
2 MHz	24.56	27.35	24.46	27.19	24.70	27.14	30.00

Mode	906.0 MHz		914.0 MHz		922.0 MHz		Limit (dBm)
	Average (dBm)	Peak (dBm)	Average (dBm)	Peak (dBm)	Average (dBm)	Peak (dBm)	
4 MHz	24.62	27.26	24.46	27.14	24.38	27.07	30.00

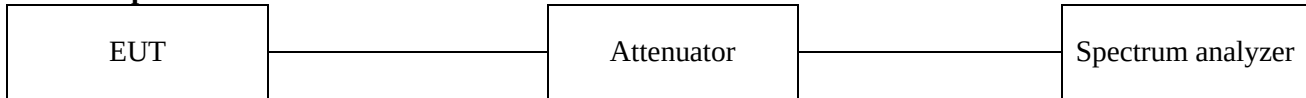
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3.3. Power spectral density

Test procedure

ANSI C63.10-2013 - Section 11.10.2

Test setup



Section 10.2 & ANSI C63.10-2013 - Section 11.10.2

- Set analyzer center frequency to DTS channel center frequency.
- Set the span to 1.5 times the DTS bandwidth.
- Set the RBW to $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$
- Set the VBW $\geq [3 \times \text{RBW}]$.
- Detector = peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum amplitude level within the RBW.
- If measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat.

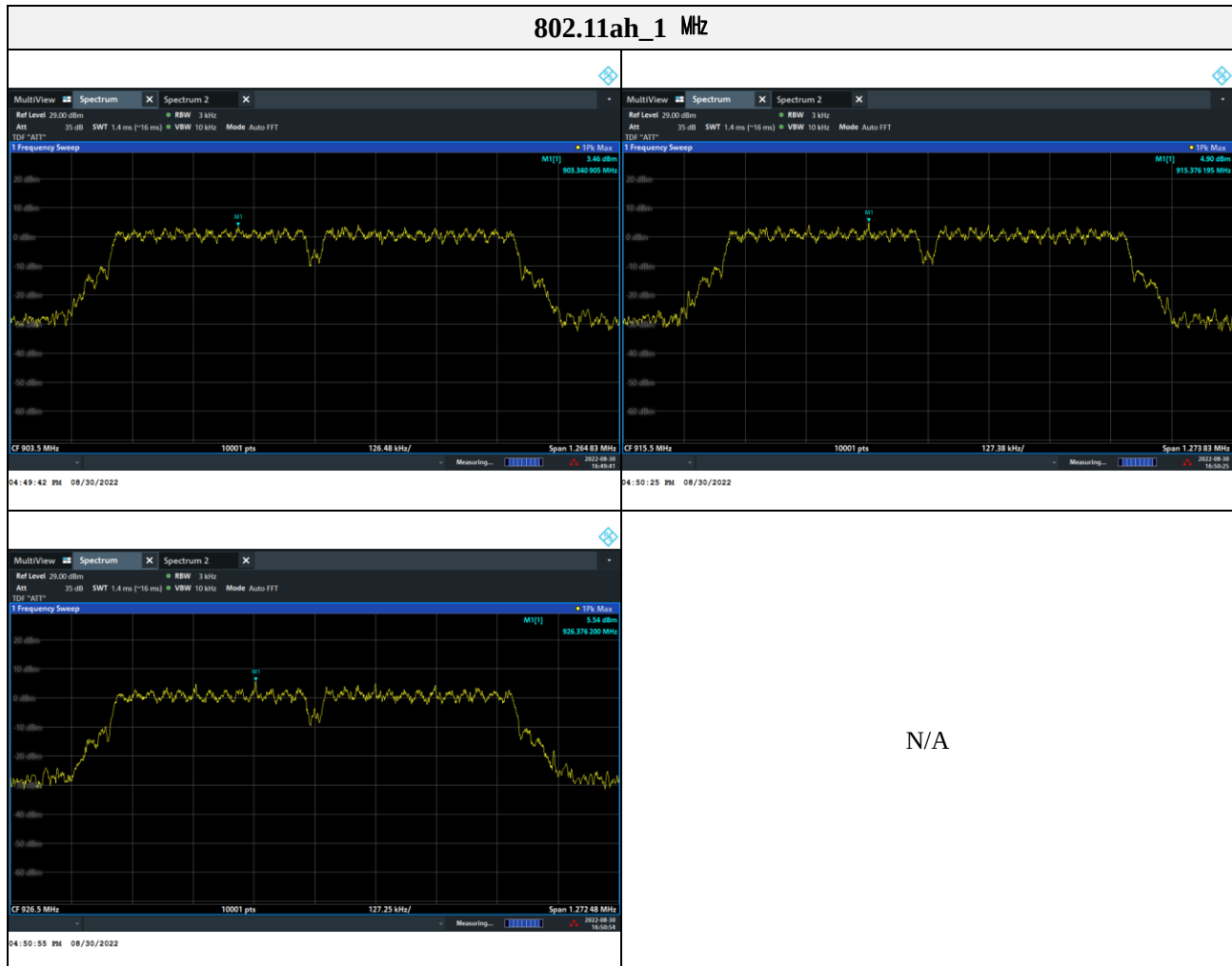
Limit

According to §15.247(e), 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.

Results

Mode : 802.11ah_1 Mhz

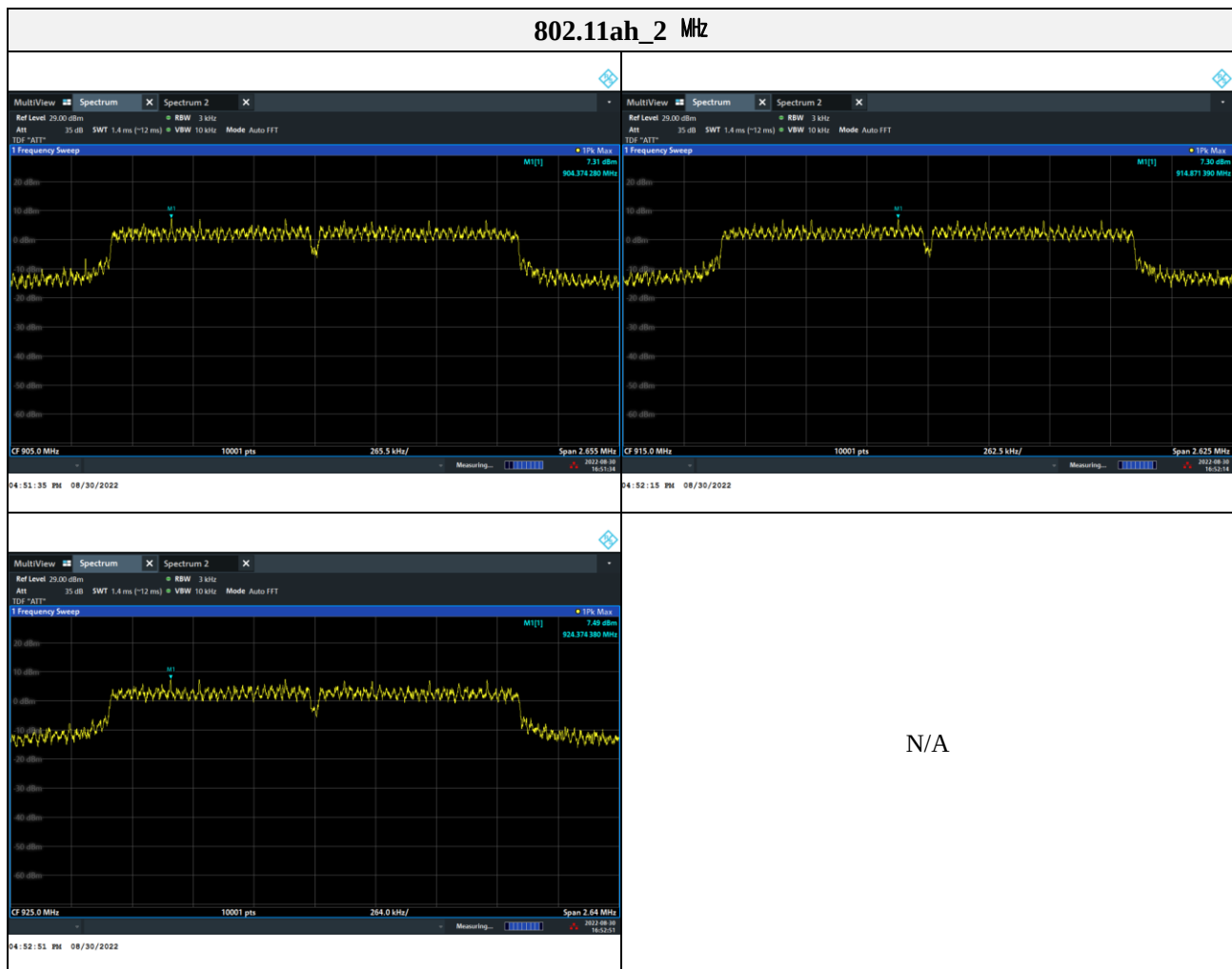
Frequency(MHz)	PSD (dBm)	Limit(dBm)
903.5	3.46	8
915.5	4.90	
926.5	5.54	



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Mode : 802.11ah_2 Mhz

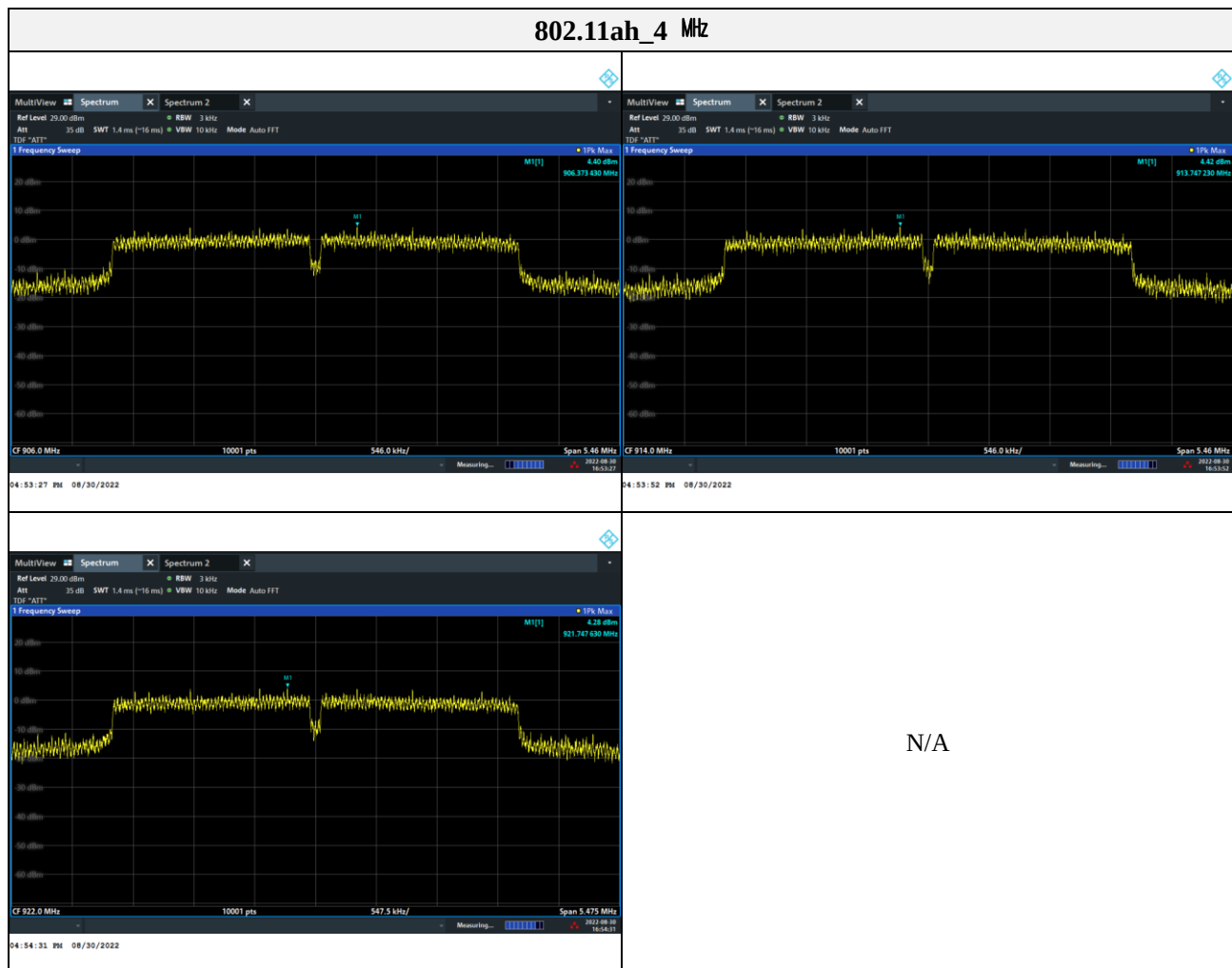
Frequency(MHz)	PSD (dBm)	Limit(dBm)
905.0	7.31	8
915.0	7.30	
925.0	7.49	



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Mode : 802.11ah_4 Mhz

Frequency(MHz)	PSD (dBm)	Limit(dBm)
906.0	4.40	8
914.0	4.42	
922.0	4.28	

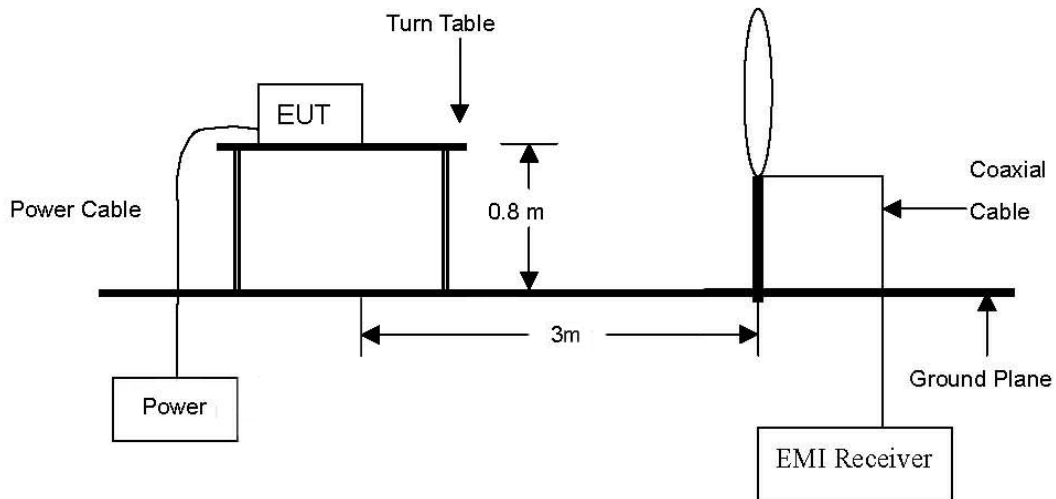


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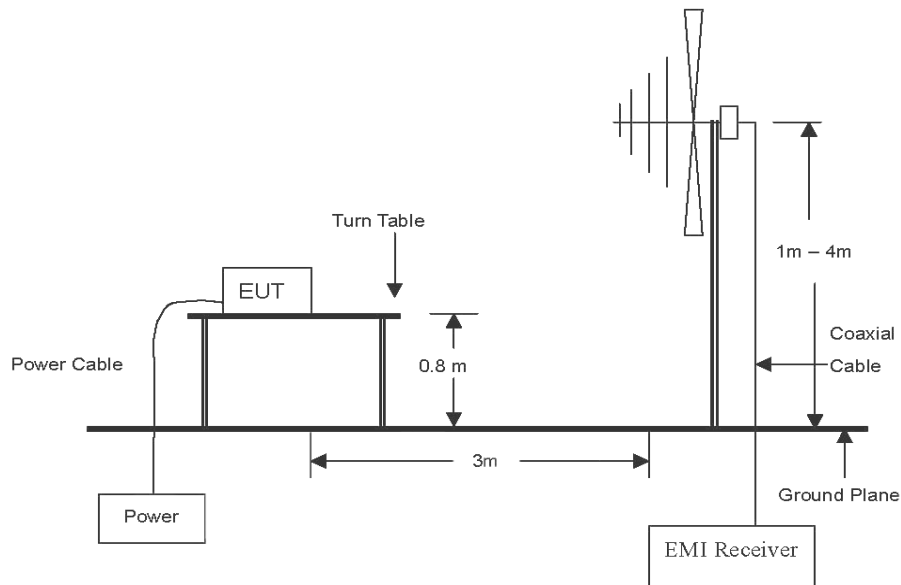
3.4. Radiated restricted band and emissions

Test setup

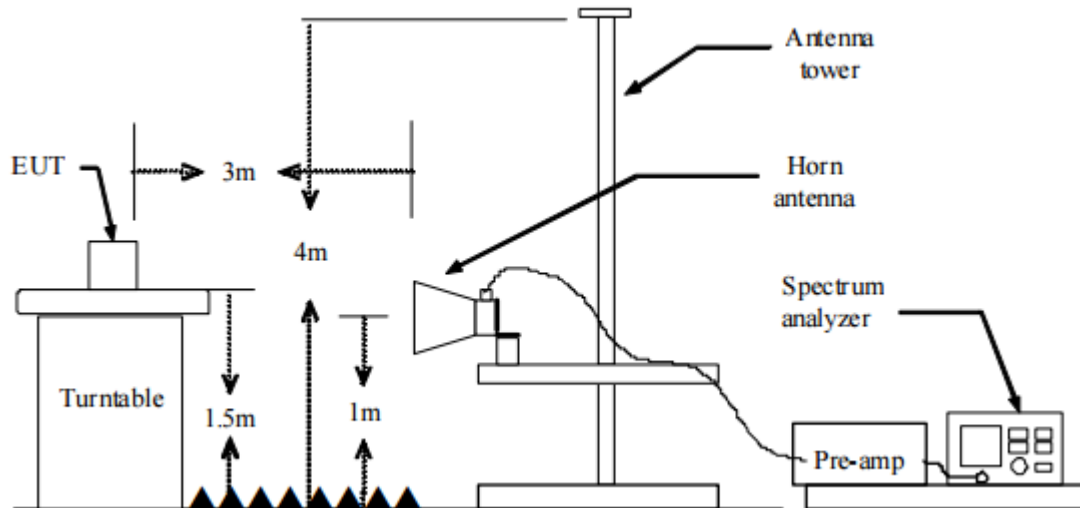
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 kHz to 30 MHz Emissions.



The diagram below shows the test setup that is utilized to make the measurements for emission from 30 MHz to 1 GHz emissions.



The diagram below shows the test setup that is utilized to make the measurements for emission from 1 GHz to the tenth harmonic of the highest fundamental frequency or to 40 GHz emissions, whichever is lower.



Test procedure

Radiated emissions from the EUT were measured according to the dictates in section 11.11 & 11.12 of ANSI C63.10-2013.

Test procedure below 30 MHz

1. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter anechoic chamber test site. The table was rotated 360 degrees to determine the position of the highest radiation.
2. Then antenna is a loop antenna is fixed at one meter above the ground to determine the maximum value of the field strength. Both parallel, ground parallel and perpendicular of the antenna are set to make the measurement. It was determined that parallel was worst-case orientation; therefore, all final radiated testing was performed with the EUT in parallel.
3. For each suspected emission, the EUT was arranged to its worst case and then the table was turned from 0 degrees to 360 degrees to find the maximum reading.
4. The test-receiver system was set to average or quasi peak detect function and Specified Bandwidth with Maximum hold mode.

Test procedure above 30 MHz

1. The EUT was placed on the top of a rotating table 1.5 meters above the ground at a 3 meter anechoic chamber test site. The table was rotated 360 degrees to determine the position of the highest radiation.
2. The antenna is a bi-log antenna, a horn antenna, and its height are varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
3. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the table was turned from 0 degrees to 360 degrees to find the maximum reading.
4. The test receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.
5. Spectrum analyzer settings for $f < 1 \text{ GHz}$:

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- ① Span = wide enough to fully capture the emission being measured
 - ② RBW = 100 kHz
 - ③ VBW $\geq$ RBW
 - ④ Detector = quasi peak
 - ⑤ Sweep time = auto
 - ⑥ Trace = max hold
6. Spectrum analyzer settings for $f \geq 1$ GHz: Peak
- ① Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
 - ② RBW = 1 MHz
 - ③ VBW $\geq$ 3 MHz
 - ④ Detector = peak
 - ⑤ Sweep time = auto
 - ⑥ Trace = max hold
 - ⑦ Trace was allowed to stabilize
7. Spectrum analyzer settings for $f \geq 1$ GHz: Average
- ① Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
 - ② RBW = 1 MHz
 - ③ VBW $\geq 3 \times$ RBW
 - ④ Detector = RMS, if $\text{span}/(\# \text{ of points in sweep}) \leq (\text{RBW}/2)$. Satisfying this condition may require increasing the number of points in the sweep or reducing the span. If this condition cannot be satisfied, then the detector mode shall be set to peak.
 - ⑤ Averaging type = power(i.e., RMS)
 - 1) As an alternative, the detector and averaging type may be set for linear voltage averaging.
 - 2) Some instruments require linear display mode in order to use linear voltage averaging. Log or dB averaging shall not be used.
 - ⑥ Sweep = auto
 - ⑦ Trace = max hold
 - ⑧ Perform a trace average of at least 100 traces.
 - ⑨ A correction factor shall be added to the measurement results prior to comparing to the emission limit in order to compute the emission level that would have been measured had the test been performed at 100 percent duty cycle. The correction factor is computed as follows:
 - 1) If power averaging (RMS) mode was used in step ⑤, then the applicable correction factor is $10 \log(1/x)$, where x is the duty cycle.
 - 2) If linear voltage averaging mode was used in step ⑤, then the applicable correction factor is $20 \log(1/x)$, where x is the duty cycle.
 - 3) If a specific emission is demonstrated to be continuous (≥ 98 percent duty cycle) rather than turning on and off with the transmit cycle, then no duty cycle correction is required for that emission.

Note.

1. $f < 30$ MHz, extrapolation factor of 40 dB/decade of distance. $F_d = 40\log(D_m/D_s)$
 $f \geq 30$ MHz, extrapolation factor of 20 dB/decade of distance. $F_d = 20\log(D_m/D_s)$
 Where:
 F_d = Distance factor in dB
 D_m = Measurement distance in meters
 D_s = Specification distance in meters
2. Field strength(dB μ V/m) = Level(dB μ V) + CF (dB) + or DCF(dB)
3. Margin(dB) = Limit(dB μ V/m) - Field strength(dB μ V/m)
4. Emissions below 18 GHz were measured at a 3 meter test distance while emissions above 18 GHz were measured at a 1 meter test distance with the application of a distance correction factor.
5. The fundamental of the EUT was investigated in three orthogonal orientations X, Y and Z, it was determined that X orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in X orientation.
6. The worst-case emissions are reported however emissions whose levels were not within 20 dB of respective limits were not reported.
7. According to exploratory test no any obvious emission were detected from 9 kHz to 30 MHz. Although these tests were performed other than open field site, adequate comparison measurements were confirmed against 30 m open field site. Therefore sufficient tests were made to demonstrate that the alternative site produces results that correlate with the ones of tests made in an open field based on KDB 414788.

Limit

According to 15.209(a), for an intentional radiator devices, the general required of field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values :

Frequency (MHz)	Distance (Meters)	Radiated (μ V/m)
0.009 ~ 0.490	300	2400/F(kHz)
0.490 ~ 1.705	30	24000/F(kHz)
1.705 ~ 30.0	30	30
30 ~ 88	3	100**
88 ~ 216	3	150**
216 ~ 960	3	200**
Above 960	3	500

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54 ~ 72 MHz, 76 ~ 88 MHz, 174 ~ 216 MHz or 470 ~ 806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

Duty cycle

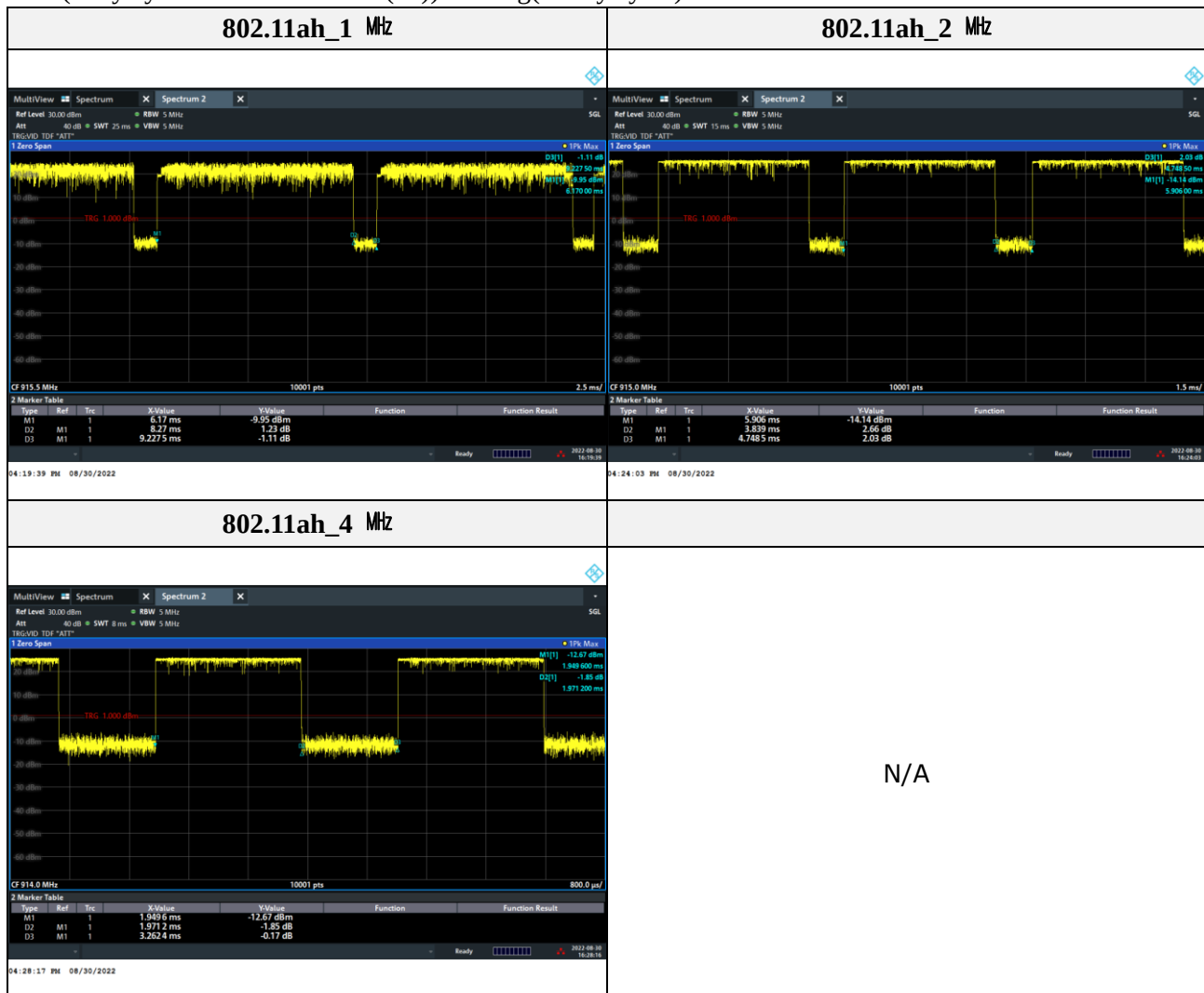
Regarding to KDB 558074 D01_v05 r02, 6. Measurements of duty cycle and transmission duration shall be performed using one of the following techniques:

- A diode detector and an oscilloscope that together have sufficiently short response time to permit accurate measurements of the on- and off-times of the transmitted signal.
- The zero-span mode on a spectrum analyzer or EMI receiver if the response time and spacing between bins on the sweep are sufficient to permit accurate measurements of the on- and off-times of the transmitted signal.

Mode	T _{on} time (ms)	Period (ms)	Duty cycle (Linear)	Duty cycle (%)	Duty cycle correction factor (dB)
802.11ah_1 MHz	8.270 0	9.227 5	0.891	89.140	0.50
802.11ah_2 MHz	3.839 0	4.748 5	0.808	80.847	0.92
802.11ah_4 MHz	1.971 2	3.262 4	0.604	60.422	2.19

Duty cycle (Linear) = T_{on} time/Period

DCF(Duty cycle correction factor (dB)) = 10log(1/duty cycle)



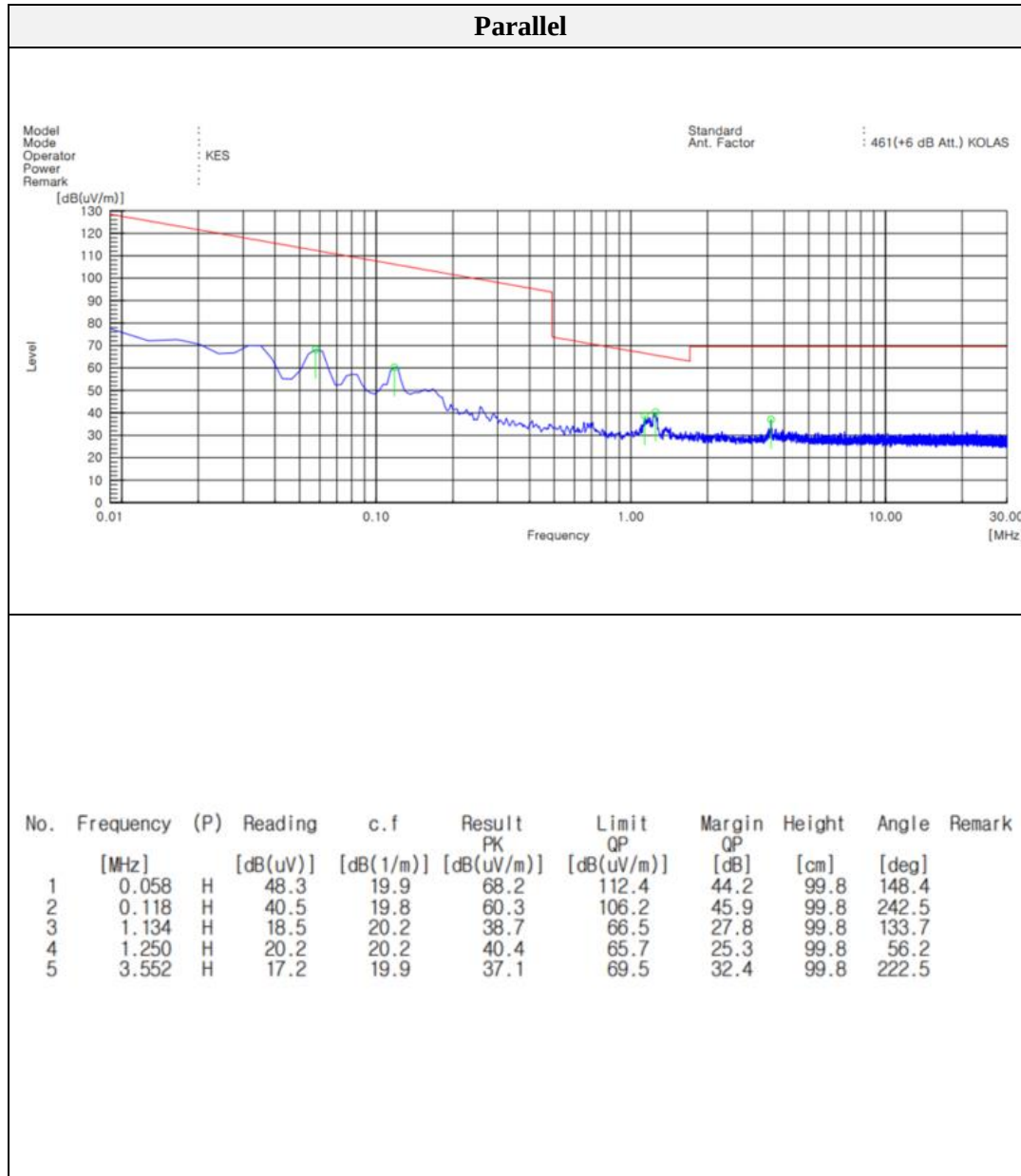
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Test results (Below 30 MHz)

Distance of measurement: 3 meter

Mode: 802.11ah_2 MHz (Worst case)

Channel: 01



Note.

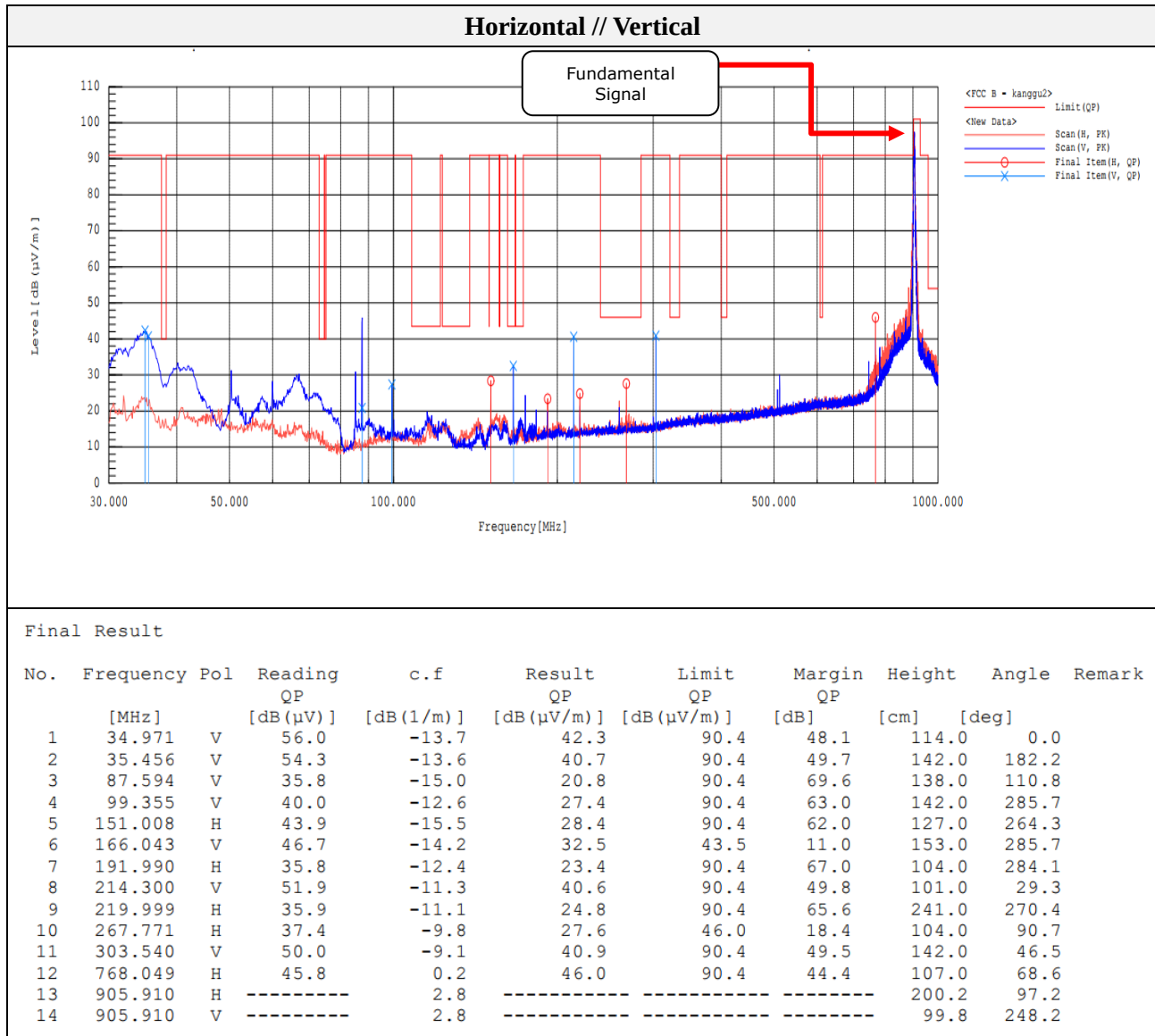
1. No spurious emission were detected under 30 MHz, the above test result is the peak result.

Test results (Below 1 000 MHz)

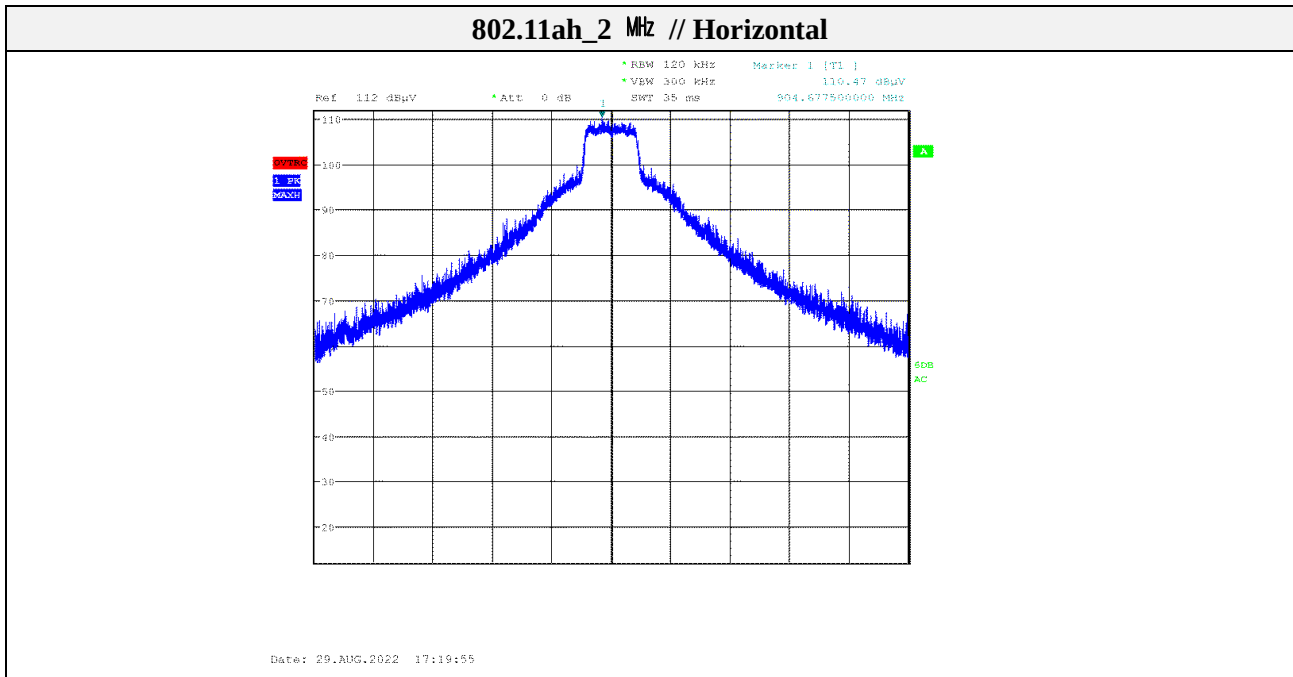
Distance of measurement: 3 meter

Mode: 802.11ah_2 MHz (Worst case)

Channel: 01



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Note.

In the Worst case **802.11ah_2 Mhz**, Fundamental signal level was **110.47 dBμV**. So except for Restricted band(Part 15.205), limit of spurious emission is applied as **90.47 dBμV**.

Test results (Above 1 000 MHz)

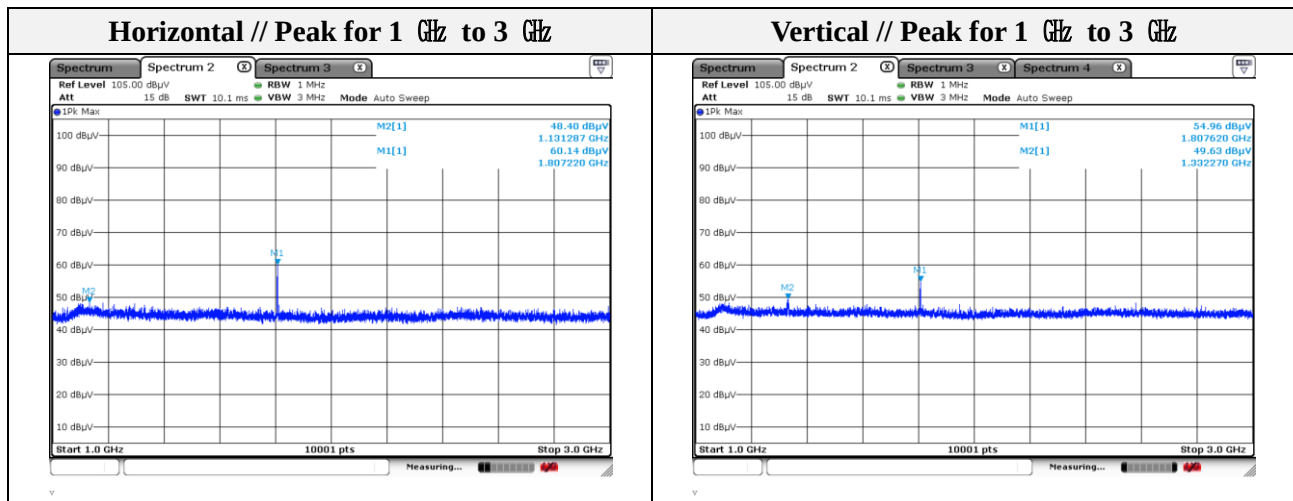
Distance of measurement: 3 meter

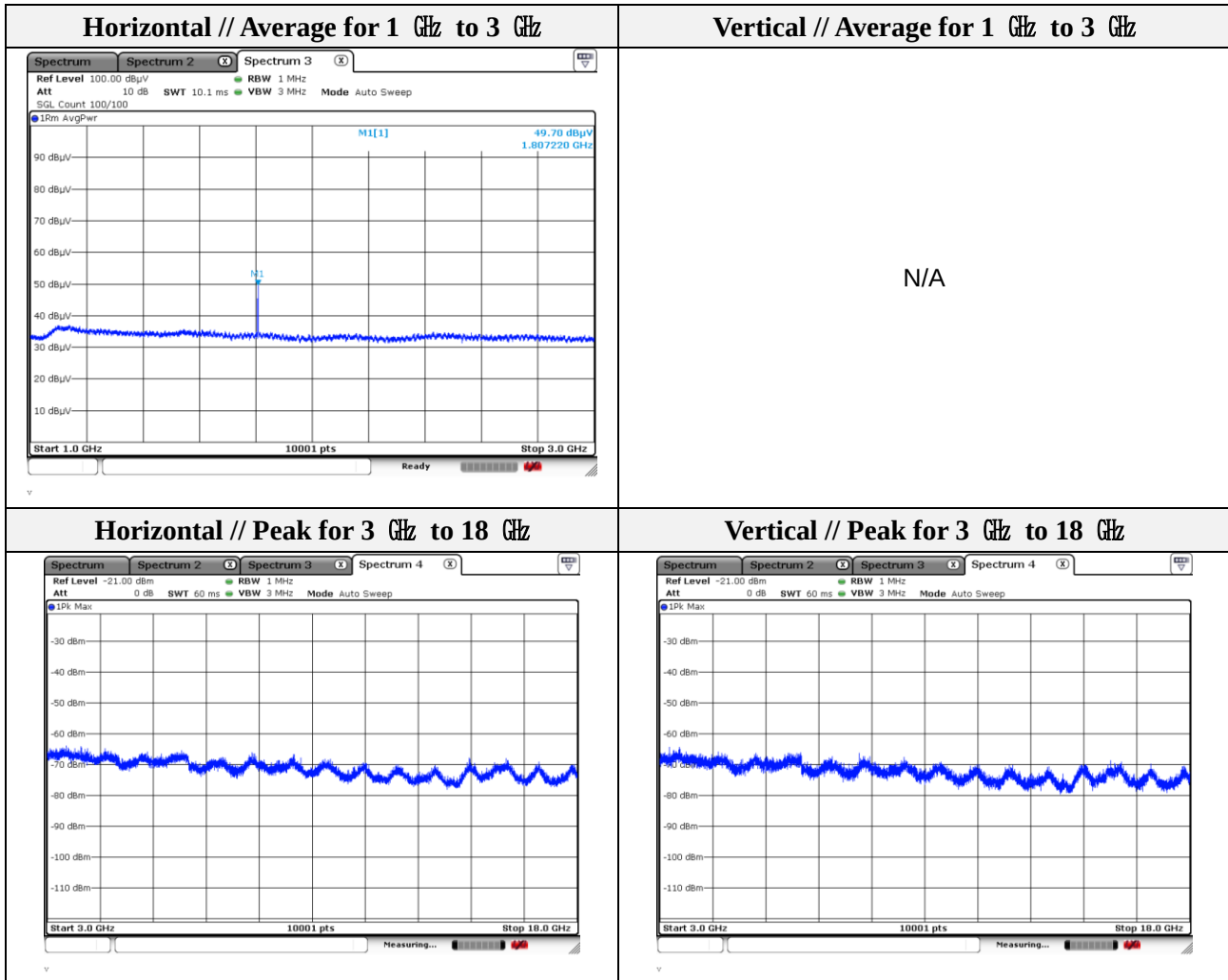
Mode: 802.11ah_1 MHz

Channel: 01

- Spurious

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1 131.29	48.40	Peak	H	-9.62	-	38.78	74.00	35.22
1 332.27	49.63	Peak	V	-8.38	-	41.25	74.00	32.75
1 807.22	60.14	Peak	H	-4.03	-	56.11	74.00	17.89
1 807.22	49.70	Average	H	-4.03	0.50	46.17	54.00	7.83
1 807.62	54.96	Peak	V	-4.02	-	50.94	74.00	23.06





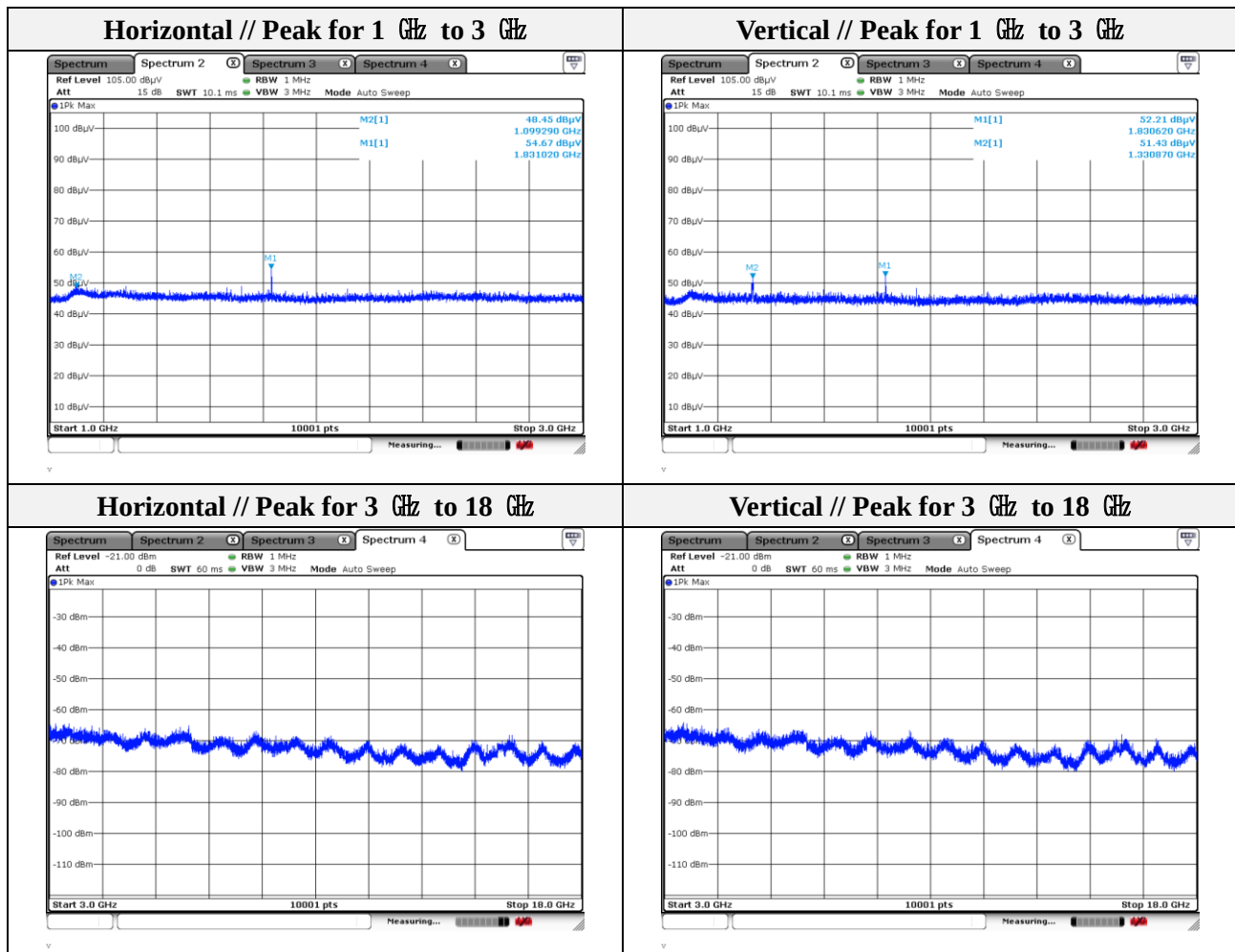
Note.

1. No spurious emission were detected at horizontal above 3 GHz.

Distance of measurement: 3 meter
Mode: 802.11ah_1 Mhz
Channel: 13

- Spurious

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1 099.29	48.45	Peak	H	-9.81	-	38.64	74.00	35.36
1 330.87	51.43	Peak	V	-8.39	-	43.04	74.00	30.96
1 830.62	52.21	Peak	V	-3.79	-	48.42	74.00	25.58
1 831.02	54.67	Peak	H	-3.78	-	50.89	74.00	23.11



Note.

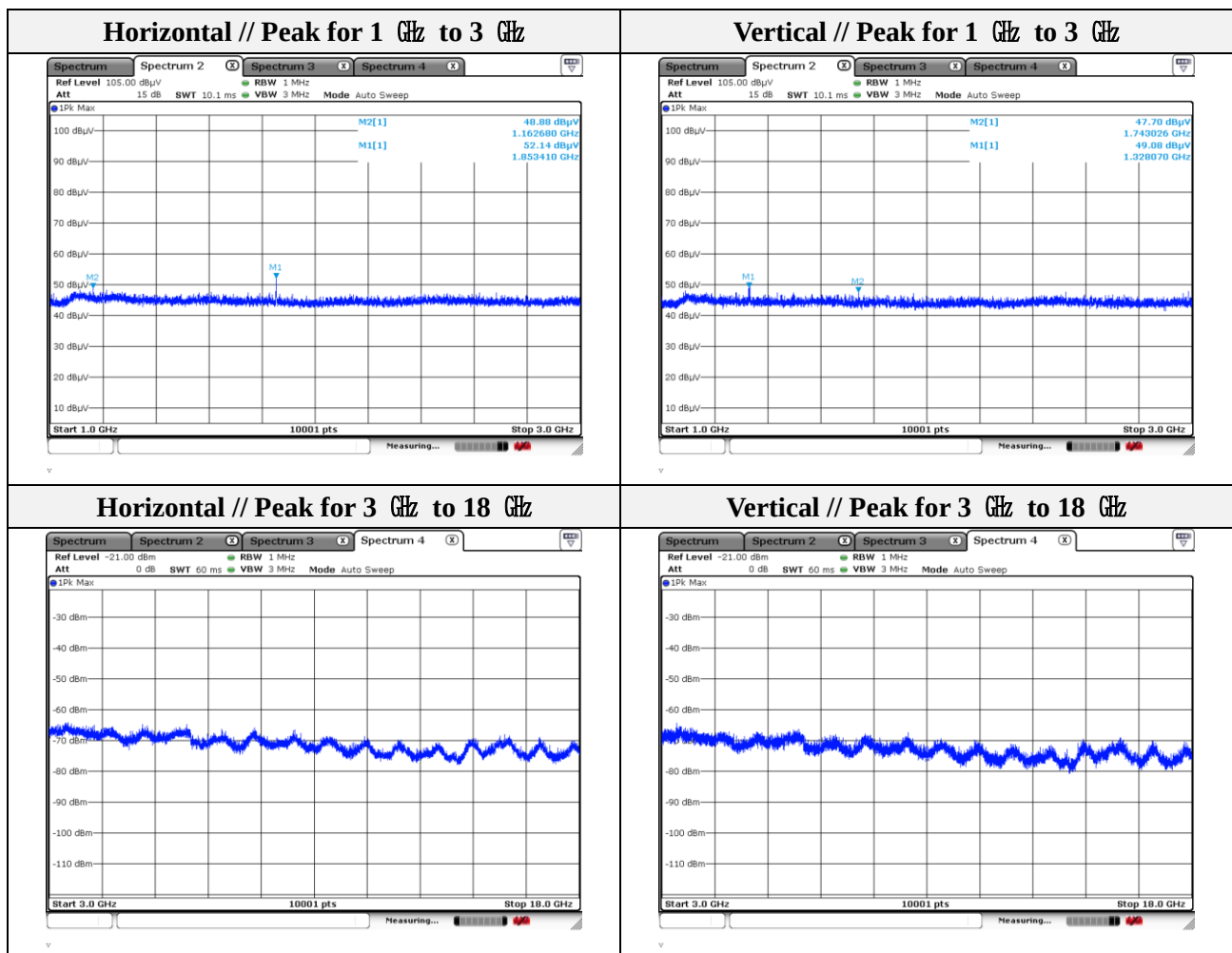
1. No spurious emission were detected at horizontal above 3 GHz.

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Distance of measurement: 3 meter
 Mode: 802.11ah_1 Mhz
 Channel: 24

- Spurious

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1 162.68	48.88	Peak	H	-9.43	-	39.45	74.00	34.55
1 328.07	49.08	Peak	V	-8.41	-	40.67	74.00	33.33
1 743.03	47.70	Peak	V	-4.76	-	42.94	74.00	31.06
1 853.41	52.14	Peak	H	-3.55	-	48.59	74.00	25.41



Note.

1. No spurious emission were detected at horizontal above 3 GHz.

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