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Test report No.:
KES-RF-17T0055
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TEST REPORT

Part 15 Subpart C 15.247

Equipment under test REMOVU Motor Stabilizer

Model name REMOVU S1MN

FCC ID 2AC73-S1MN

Applicant ESSEL-T CO., LTD.

Manufacturer ESSEL-T CO., LTD.

Date of test(s) 2017.05.12 ~ 2017.05.23

Date of issue 2017.06.05

Issued to

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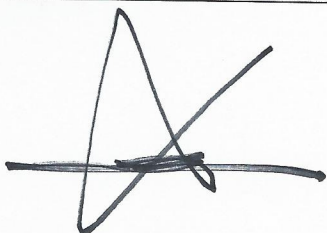

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KES Co., Ltd.

C-3701, 40, Simin-daero 365beon-gil, Dongan-gu, Anyang-si,
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Test and report completed by :	Report approval by :
	
Kwon-se Kim Test engineer	Jeff Do Technical manager

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Revision history

Revision	Date of issue	Test report No.	Description
-	2017.06.05	KES-RF-17T0055	Initial

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1. General information

Applicant: ESSEL-T CO., LTD.
Applicant address: 1211 kranztechno, dunchon-daero jungwon-gu
seongnam-si, gyeonggi-do, South Korea
Test site: KES Co., Ltd.
Test site address: C-3701, 40, Simin-daero 365beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do, Korea
473-21, Gayeo-ro, Yeosu-si, Gyeonggi-do, Korea
FCC rule part(s): 15.247
FCC ID: 2AC73-S1MN
Test device serial No.: ☐ Production ☒ Pre-production ☐ Engineering

1.1. EUT description

Equipment under test REMOVU Motor Stabilizer
Frequency range 2402 MHz ~ 2480 MHz
Model: REMOVU S1MN
Modulation technique GFSK
Number of channels 40
Antenna type Metal antenna
Antenna gain 1.85 dBi
Power source DC 7.4 V (Rechargeable Li-Polymer Battery)

1.2. Test configuration

The **ESSEL-T CO., LTD. REMOVU Motor Stabilizer FCC ID: 2AC73-S1MN** was tested per the guidance of KDB 558074 D01 v04. ANSI C63.10-2013 was used to reference the appropriate EUT setup for radiated spurious emissions testing.

1.3. Device modifications

N/A

1.4. Information about derivative model

N/A



1.5. Frequency/channel operations

Ch.	Frequency (MHz)	Rate(Mbps)
01	2 402	1
.	.	.
20	2 442	1
.	.	.
39	2 480	1

1.6. Accessory information

Equipment	Manufacturer	Model	Serial No.	Power source
Battery charger	CHINA	REMOVU S1CG	-	5V DC 2000 mA - MIN



2. Summary of tests

Reference	Parameter	Test results
15.247(a)(2)	6 dB bandwidth	Pass
15.247(b)(3)	Peak 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

3. Test results

3.1. 6 dB bandwidth

Test procedure

KDB 558074 D01 v04 – Section 8.1 or 8.2

Used test method is section 8.1.

Section 8.1

1. RBW = 100 kHz.
2. VBW $\geq 3 \times$ RBW.
3. Detector = peak.
4. Trace mode = max hold.
5. Sweep = auto couple.
6. Allow the trace to stabilize
7. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

Section 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 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 ≥ 6 dB.

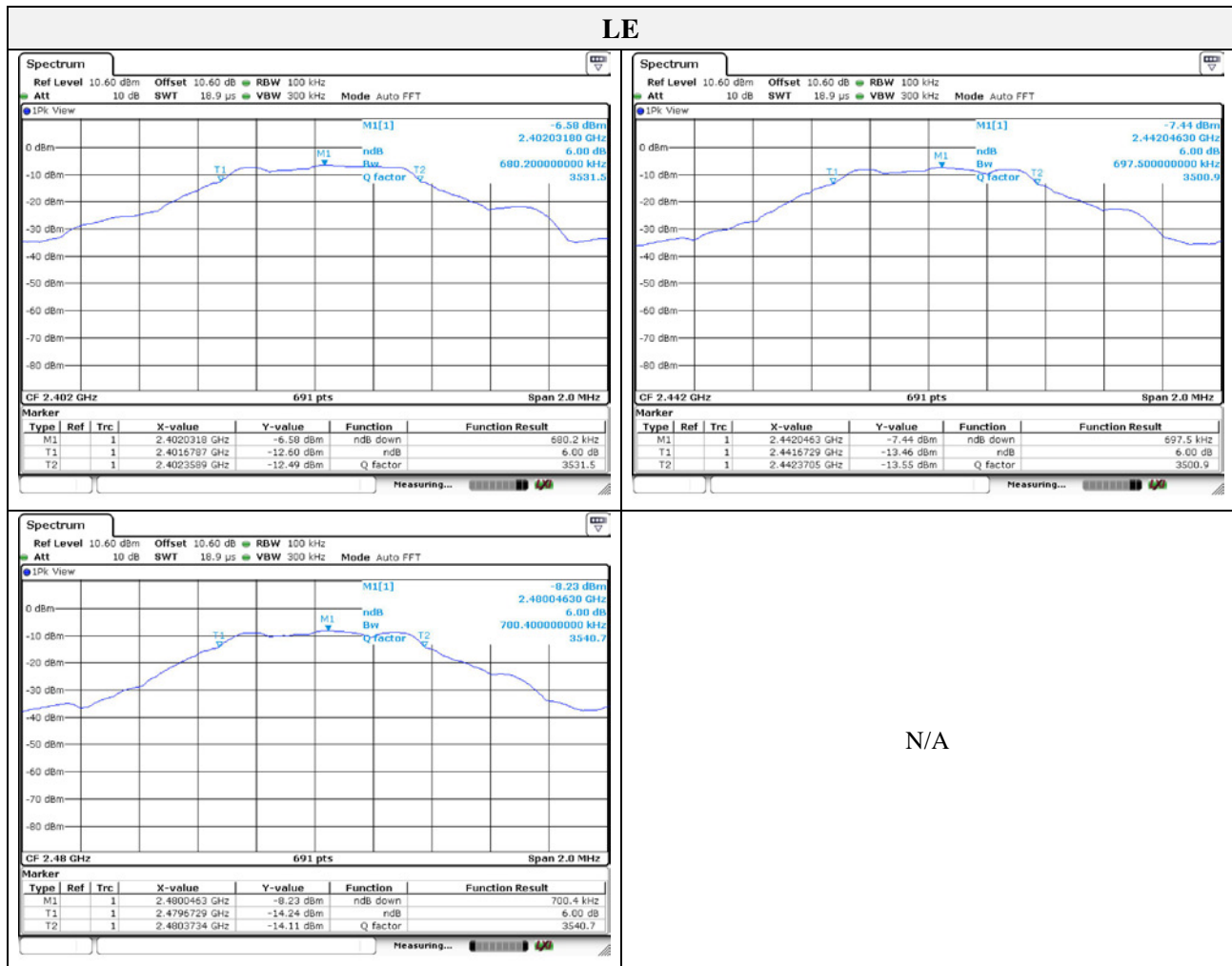
Limit

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

Frequency(MHz)	6 dB bandwidth(MHz)	Limit(MHz)
2 402	0.680	0.5
2 442	0.698	
2 480	0.700	



3.2. Output power

Test procedure

KDB 558074 D01 v04 – section 9.1.1 or 9.1.3

Used test method is section 9.1.1

Section 9.1.1

This procedure shall be used when the measurement instrument has available a resolution bandwidth that is greater than the DTS bandwidth.

1. Set the $RBW \geq DTS$ bandwidth.
2. Set $VBW \geq 3 \times RBW$.
3. Set $span \geq 3 \times RBW$
4. Sweep time = auto couple
5. Detector = peak
6. Trace mode = max hold
7. Allow trace to fully stabilize
8. Use peak marker function to determine the peak amplitude level

Section 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 utilize a fast-responding diode detector.

Limit

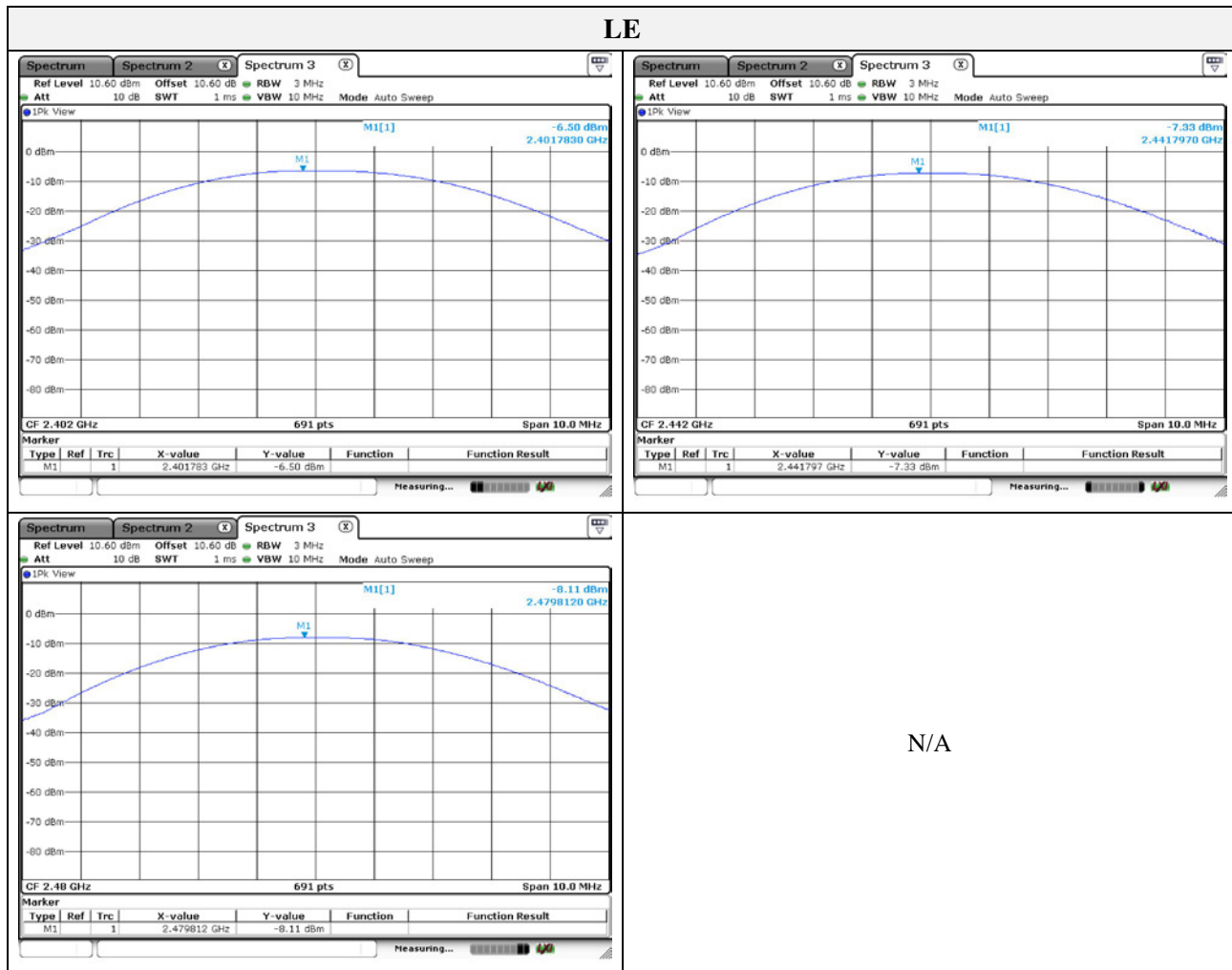
According to §15.247(b)(3), For systems using digital modulation in the 902~928 MHz, 2 400~2 483.5 MHz, and 5 725~5 850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted out-put power. Maximum Conducted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

According to §15.247(b)(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.



Test results

Frequency(MHz)	Peak output power(dBm)	Limit(dBm)
2 402	-6.50	30
2 442	-7.33	
2 480	-8.11	



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3.3. Power spectral density

Test procedure

KDB 558074 D01 v04- section 10.2

1. Set analyzer center frequency to DTS channel center frequency.
2. Set the span to 1.5 times the DTS channel bandwidth.
3. Set the RBW : $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$
4. Set the VBW $\geq 3 \times \text{RBW}$.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level.
10. If measured value exceeds limit, reduce RBW(no less than 3 kHz) and repeat.

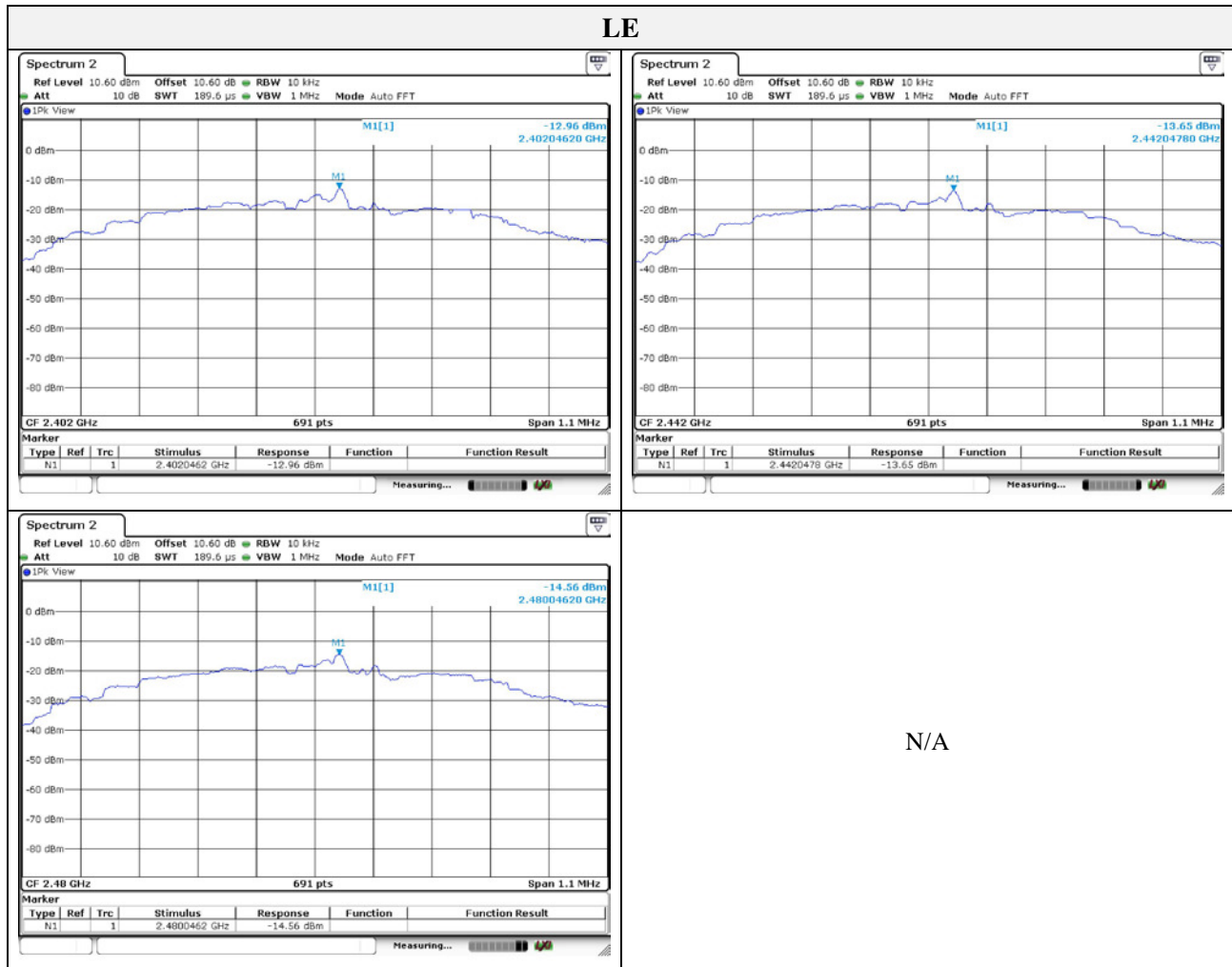
Limit

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.



Test results

Frequency(MHz)	PSD (dBm)	Limit(dBm)
2 402	-12.96	8
2 442	-13.65	
2 480	-14.56	

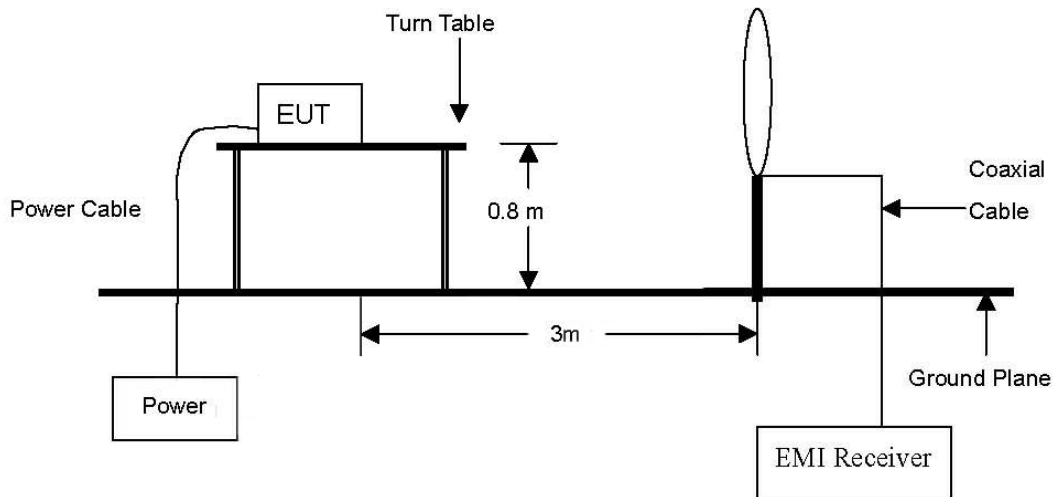


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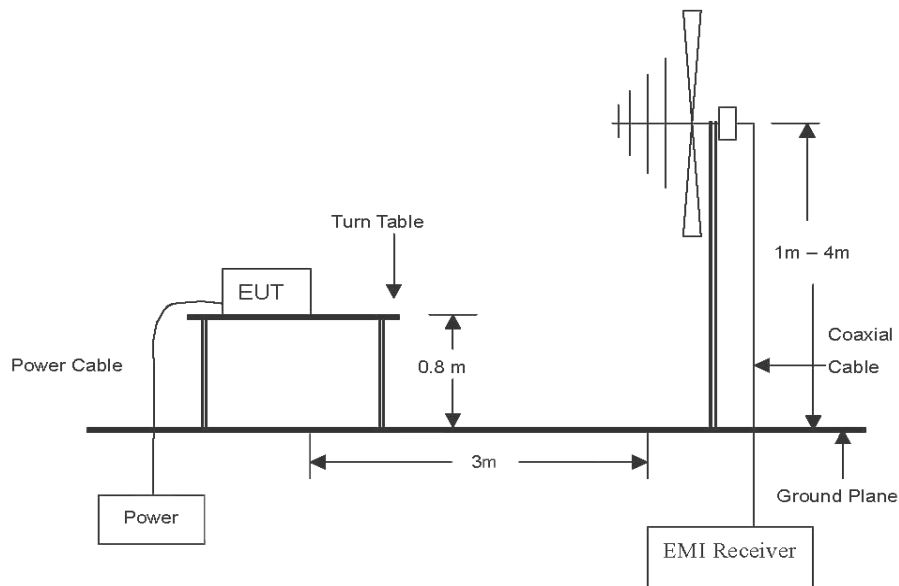
3.4. Radiated restricted band and emissions

Test setup

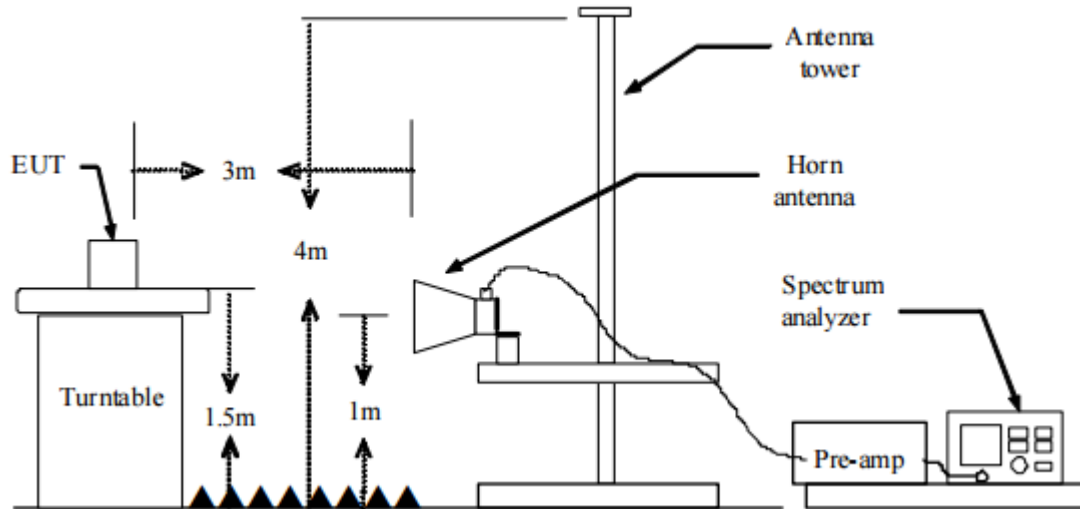
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 kHz to 30 MHz Emissions.



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 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 and perpendicular 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 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. Spectrum analyzer settings for $f < 1$ GHz:
 - 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
2. 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

3. 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 span/(# of points in sweep) \leq (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
3. CF(Correction factors(dB)) = Antenna factor(dB/m) + Cable loss(dB) + or Amp. gain(dB) + or F_d (dB)
4. Field strength(dBμV/m) = Level(dBμV) + CF (dB) + or DCF(dB)
5. Margin(dB) = Limit(dBμV/m) - Field strength(dBμV/m)
6. 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.
7. The fundamental of the EUT was investigated in three orthogonal orientations X, Y and Z, it was determined that **Y orientation** was worst-case orientation; therefore, all final radiated testing was performed with the EUT in **Y orientation**.
8. The worst-case emissions are reported however emissions whose levels were not within 20 dB of respective limits were not reported.
9. According to exploratory test no any obvious emission were detected from 9kHz to 30MHz. Although these tests were performed other than open area test site, adequate comparison measurements were confirmed against 30 m open are test 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 ($\mu\text{V/m}$)
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_v04, 6.0, the maximum duty cycles of all modes were investigated and set the spectrum analyzer as below.

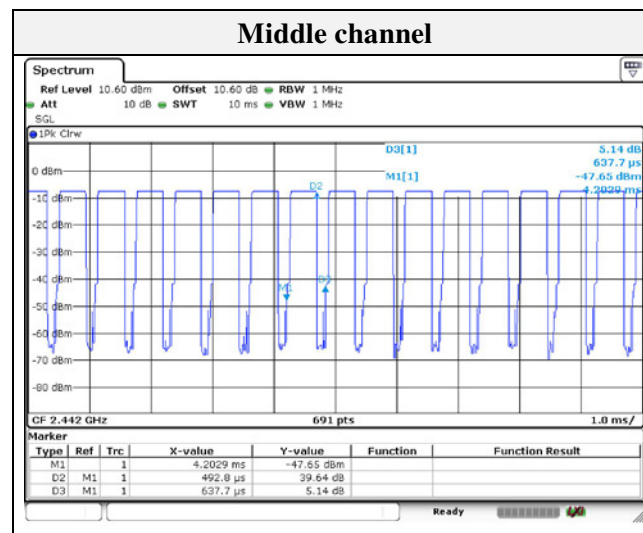
Set $RBW \geq OBW$ if possible; otherwise, set RBW to the largest available value. Set detector = peak or average. The zero-span measurement method shall not be used unless both RBW and VBW are $> 50/T$ and the number of sweep points across duration T exceeds 100.

T _{on} time (ms)	Period (ms)	Duty cycle (Linear)	Duty cycle (%)	Minimum VBW (kHz)	Duty cycle correction factor (dB)
0.492 8	0.637 7	0.773	77.28	2.03	1.12

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

Minimum VBW(kHz) = 1/T_{on}, where T is on time in second

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

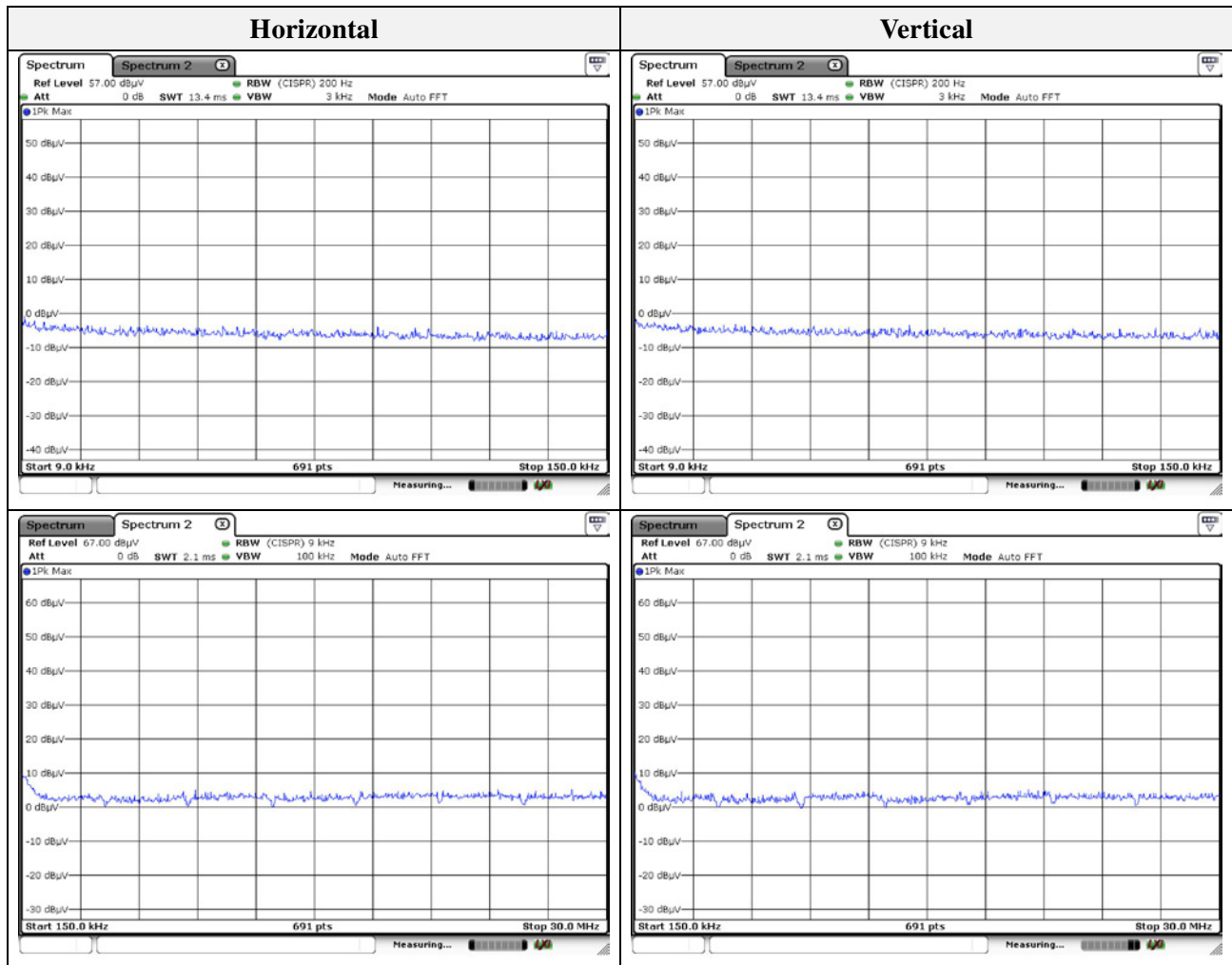




Test results (Below 30 MHz)

Mode: BLE
Distance of measurement: 3 meter
Channel: 00 (Worst case)

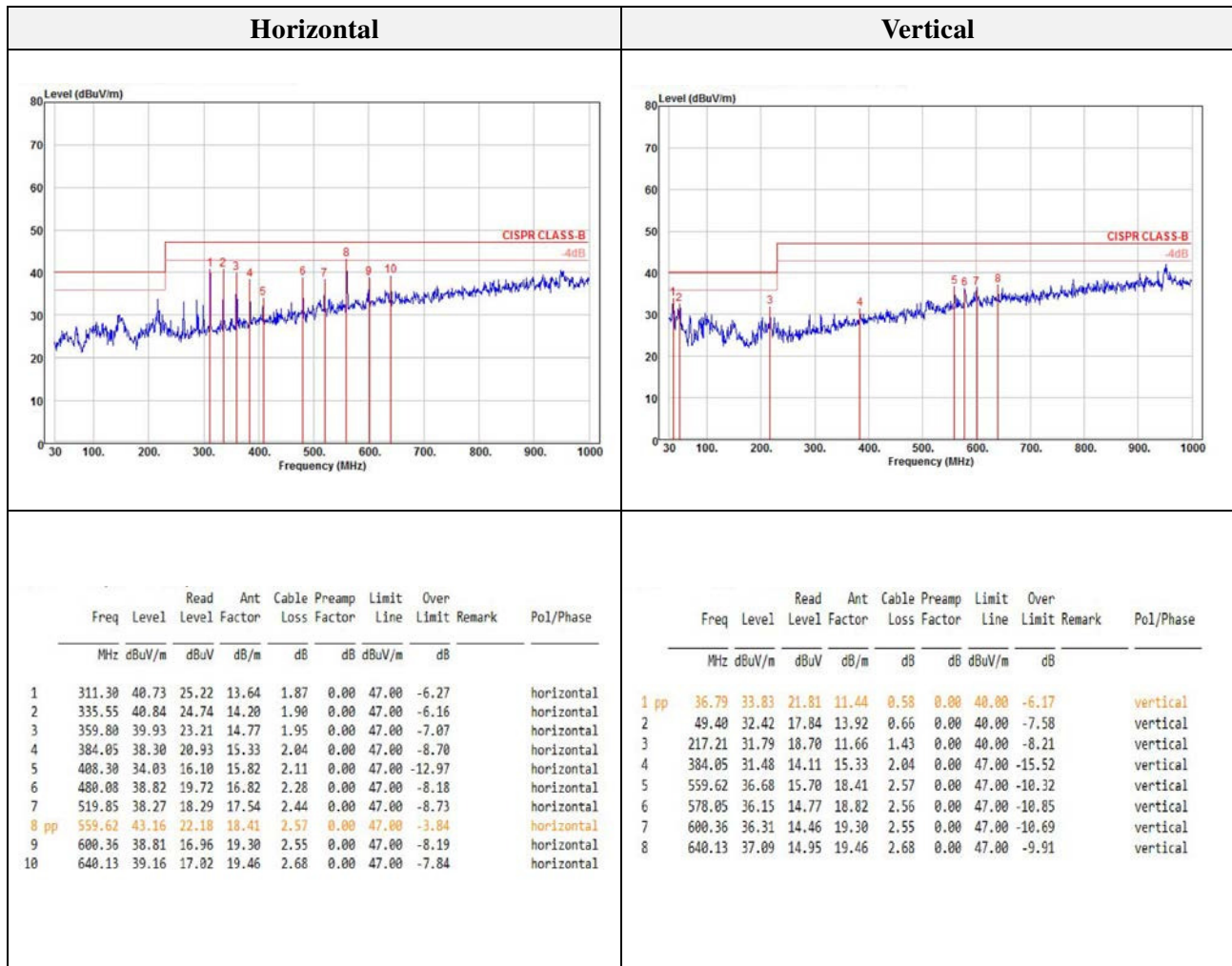
Frequency (MHz)	Level (dBμV)	Ant. Pol. (H/V)	CF (dB)	F _d (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
No spurious emissions were detected within 20 dB of the limit							





Test results (Below 1 000 MHz) – Worst case

Mode: BLE
Distance of measurement: 3 meter
Channel: 00 (Worst case)





Test results (Above 1 000 MHz)

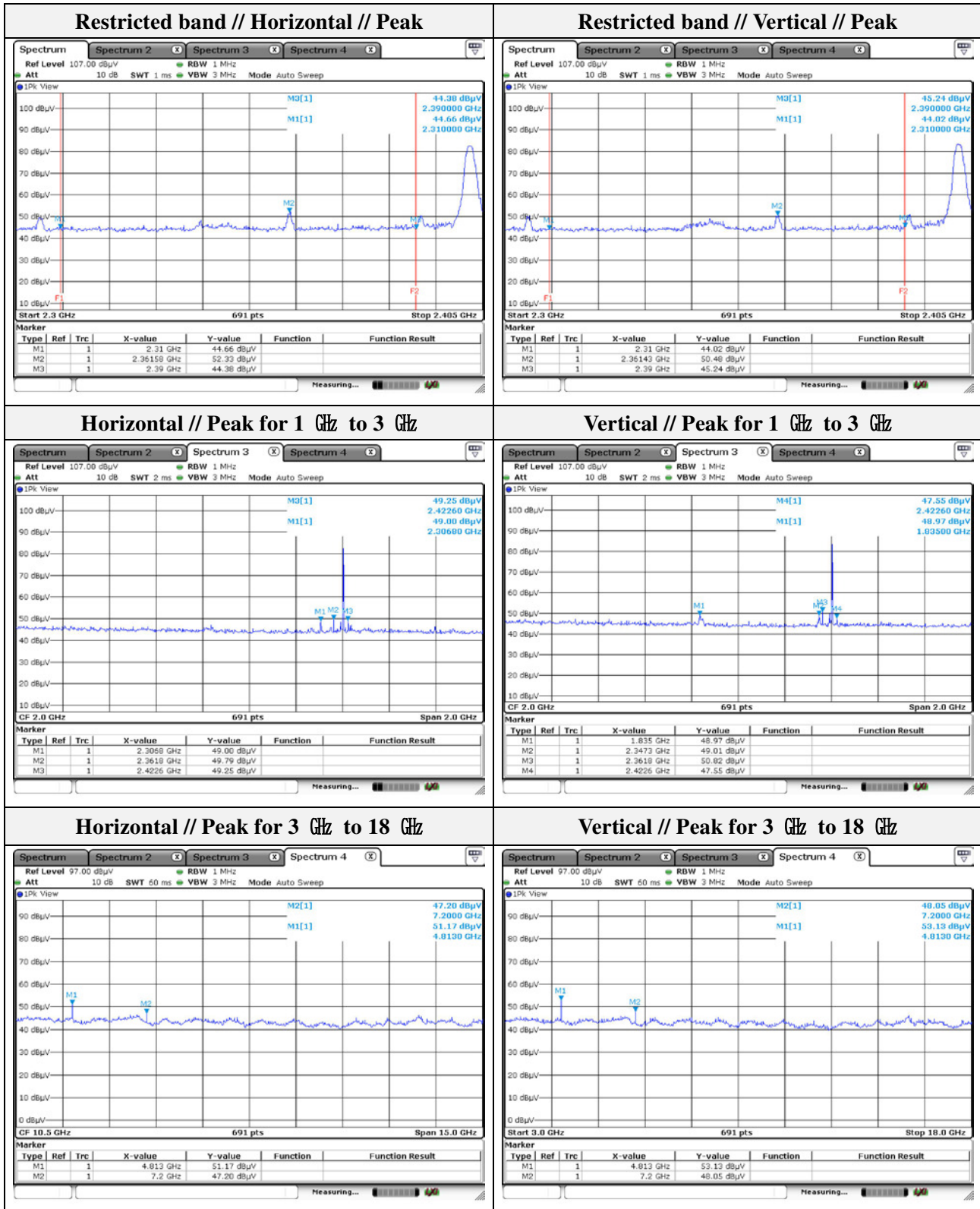
Mode: BLE
Distance of measurement: 3 meter
Channel: 00

- Spurious

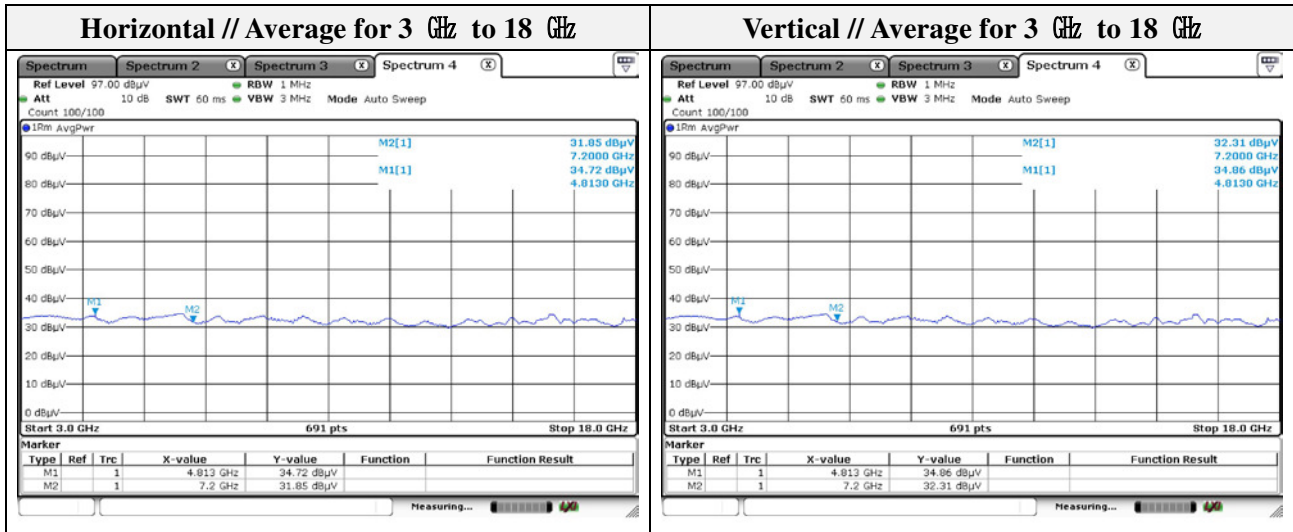
Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2306.80	49.00	Peak	H	-0.38	-	48.62	74.00	25.38
2361.80	49.79	Peak	H	-0.27	-	49.52	74.00	24.48
2422.60	49.25	Peak	H	-0.16	-	49.09	74.00	24.91
4813.00	51.17	Peak	H	7.66	-	58.83	74.00	15.17
4813.00	34.72	Avg	H	7.66	1.12	43.50	54.00	10.50
7200.00	47.20	Peak	H	11.26	-	58.46	74.00	15.54
7200.00	31.85	Avg	H	11.26	1.12	44.23	54.00	9.77
1835.00	48.97	Peak	V	-2.71	-	46.26	74.00	27.74
2347.30	49.01	Peak	V	-0.30	-	48.71	74.00	25.29
2361.80	50.82	Peak	V	-0.27	-	50.55	74.00	23.45
2422.60	47.55	Peak	V	-0.16	-	47.39	74.00	26.61
4813.00	53.13	Peak	V	7.66	-	60.79	74.00	13.21
4813.00	34.86	Avg	V	7.66	1.12	43.64	54.00	10.36
7200.00	48.05	Peak	V	11.26	-	59.31	74.00	14.69
7200.00	32.31	Avg	V	11.26	1.12	44.69	54.00	9.31

- Band edge

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2361.58	52.33	Peak	H	-0.27	-	52.06	74.00	21.94
2361.43	50.48	Peak	V	-0.27	-	50.21	74.00	23.79



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Note.

1. Average test would be performed if the peak result were greater than the average limit.

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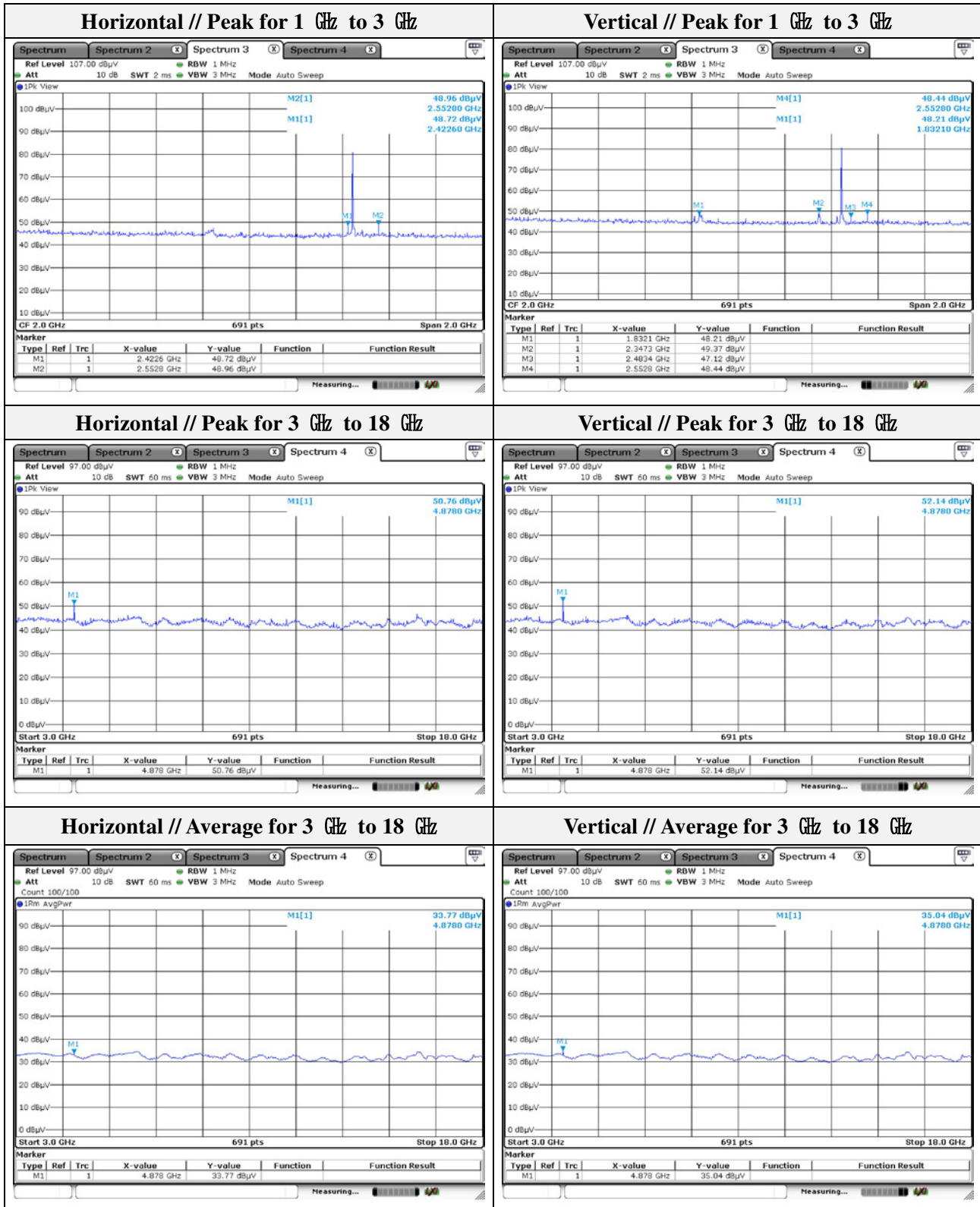
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Mode: BLE
Distance of measurement: 3 meter
Channel: 20

- Spurious

Frequency (MHz)	Level (dB μ V)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
2422.60	48.72	Peak	H	-0.16	-	48.56	74.00	25.44
2552.80	48.96	Peak	H	0.18	-	49.14	74.00	24.86
4878.00	50.76	Peak	H	8.17	-	58.93	74.00	15.07
4878.00	33.77	Avg	H	8.17	1.12	43.06	54.00	10.94
1832.10	48.21	Peak	V	-2.74	-	45.47	74.00	28.53
2347.30	49.37	Peak	V	-0.30	-	49.07	74.00	24.93
2483.40	47.12	Peak	V	-0.05	-	47.07	74.00	26.93
2552.80	48.44	Peak	V	0.18	-	48.62	74.00	25.38
4878.00	52.14	Peak	V	8.17	-	60.31	74.00	13.69
4878.00	35.04	Avg	V	8.17	1.12	44.33	54.00	9.67

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Note.

1. Average test would be performed if the peak result were greater than the average limit.

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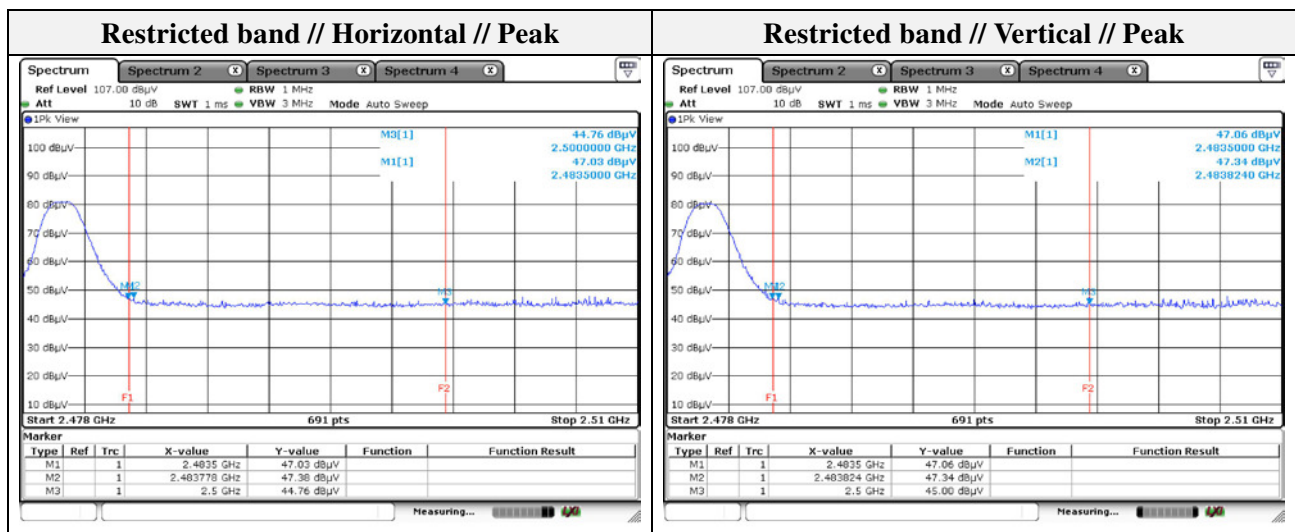
Mode: BLE
Distance of measurement: 3 meter
Channel: 39

- Spurious

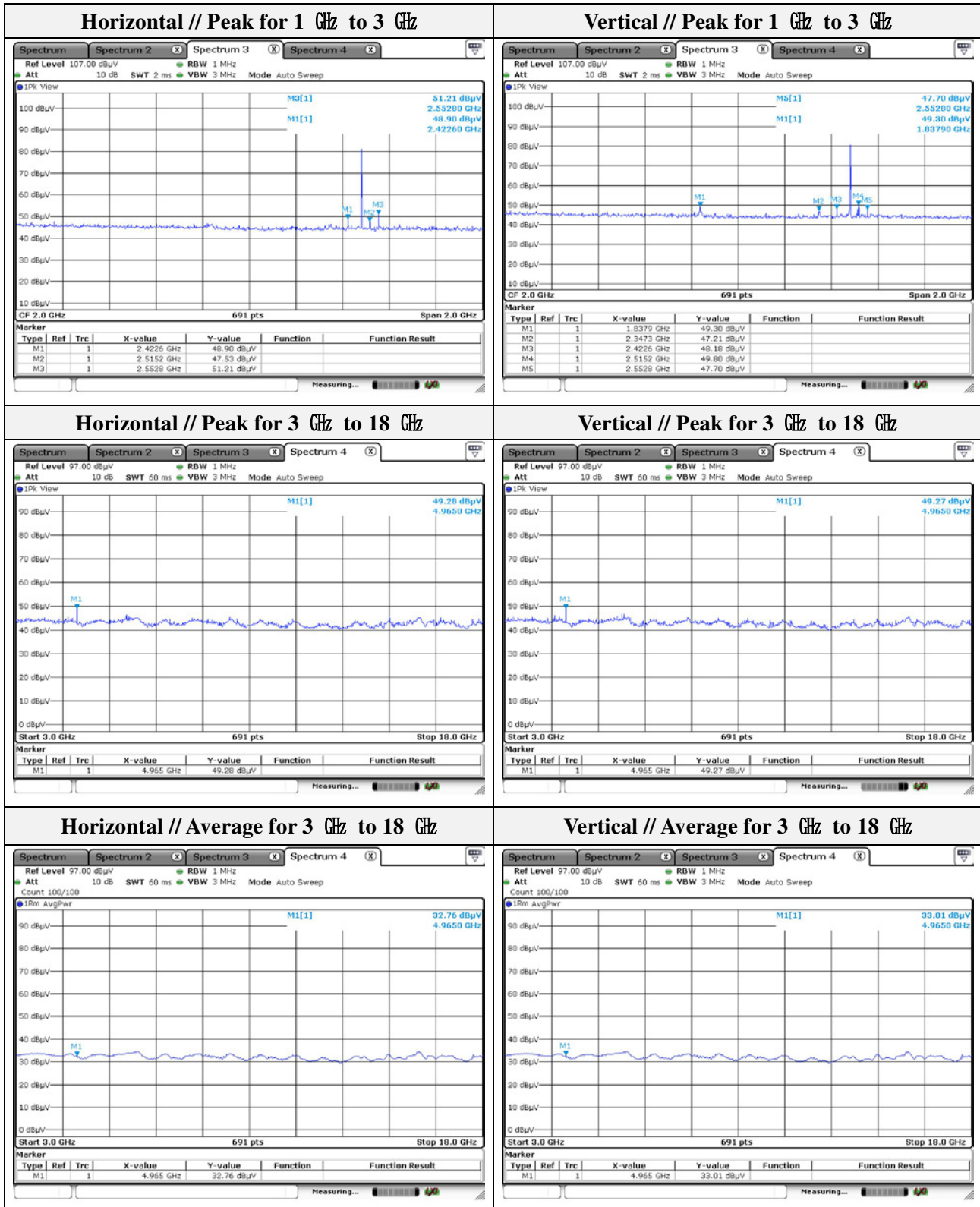
Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2422.60	48.90	Peak	H	-0.16	-	48.74	74.00	25.26
2515.20	47.53	Peak	H	0.04	-	47.57	74.00	26.43
2552.80	51.21	Peak	H	0.18	-	51.39	74.00	22.61
4965.00	49.28	Peak	H	8.85	-	58.13	74.00	15.87
4965.00	32.76	Avg	H	8.85	1.12	42.73	54.00	11.27
1837.90	49.30	Peak	V	-2.68	-	46.62	74.00	27.38
2347.30	47.21	Peak	V	-0.30	-	46.91	74.00	27.09
2422.60	48.18	Peak	V	-0.16	-	48.02	74.00	25.98
2515.20	49.80	Peak	V	0.04	-	49.84	74.00	24.16
2552.80	47.70	Peak	V	0.18	-	47.88	74.00	26.12
4965.00	49.27	Peak	V	8.85	-	58.12	74.00	15.88
4965.00	33.01	Avg	V	8.85	1.12	42.98	54.00	11.02

- Band edge

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2483.78	47.38	Peak	H	-0.05	-	47.33	74.00	26.67
2483.82	47.34	Peak	V	-0.05	-	47.29	74.00	26.71



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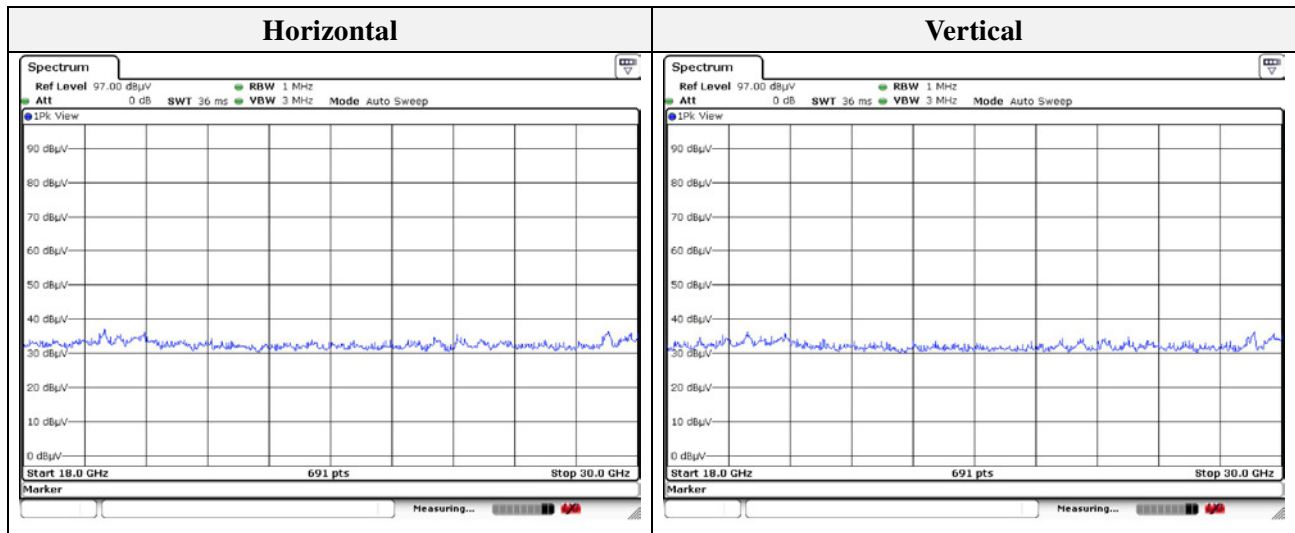
Note.

1. Average test would be performed if the peak result were greater than the average limit.



Test results (18 GHz to 30 GHz) – Worst case

Mode: BLE
Distance of measurement: 3 meter
Channel: 00 (Worst case)



Note.

1. No spurious emission were detected above 18 GHz.

3.5 Conducted spurious emissions & band edge

Test procedure

Band edge

KDB 558074 D01 v04 – Section 11.3

1. Start and stop frequency were set such that the band edge would be placed in the center of the plot
2. Span was set large enough so as to capture all out of band emissions near the band edge
3. RBW = 100 kHz
4. VBW = 300 kHz
5. Detector = Peak
6. Trace mode = max hold
7. Sweep time = auto
8. The trace was allowed to stabilize

Out of band emissions

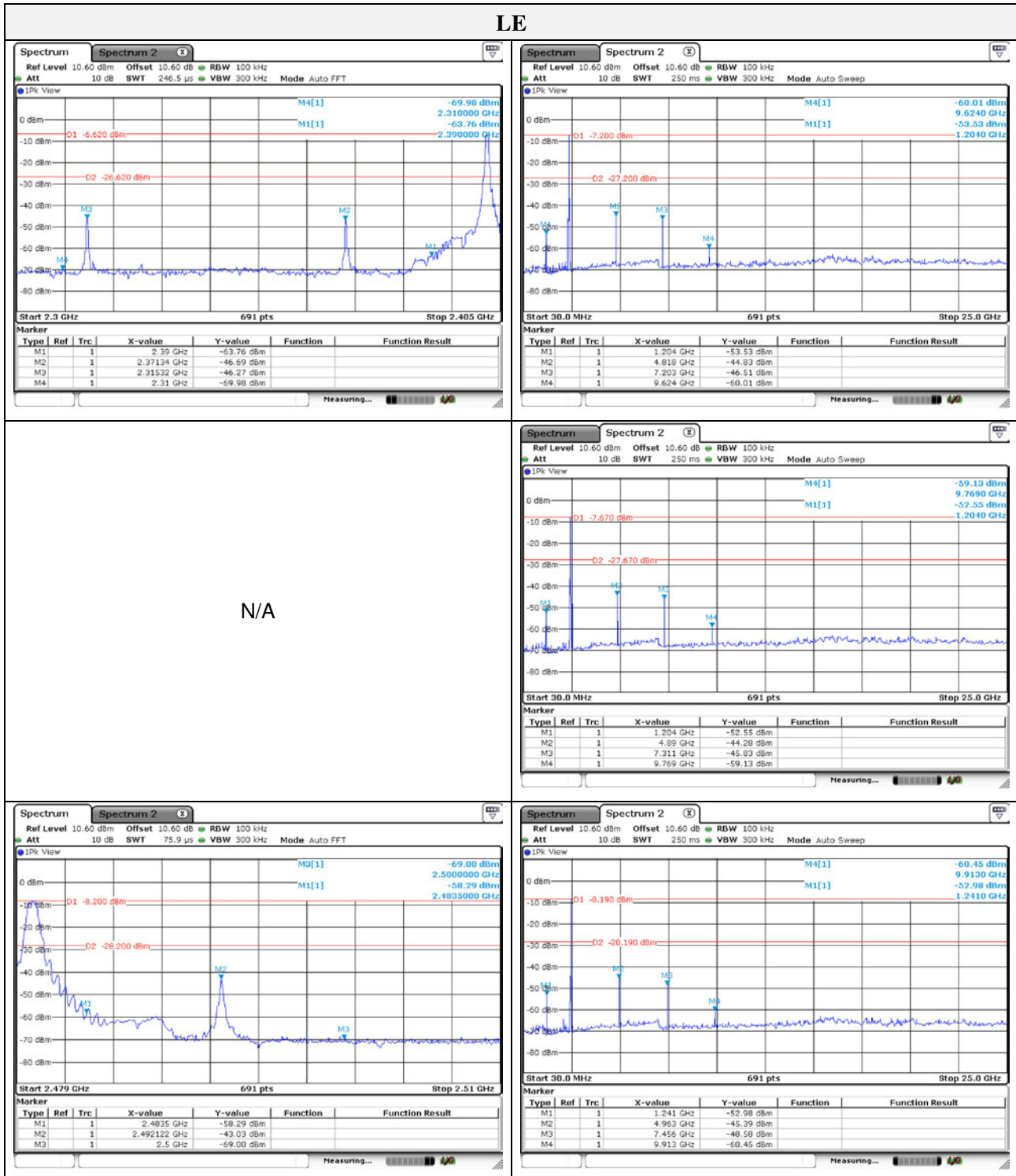
KDB 558074 D01 v04 – Section 11.3

1. Start frequency was set to 30 MHz and stop frequency was set to 25 GHz for 2.4 GHz frequencies and 40 GHz for 5 GHz frequencies
2. RBW = 100 kHz
3. VBW = 300 kHz
4. Detector = Peak
5. Trace mode = max hold
6. Sweep time = auto couple
7. The trace was allowed to stabilize

Limit

According to 15.247(d), 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 section 15.209(a) is not required. In addition, radiated emission which in the restricted band, as define in section 15.205(a), must also comply the radiated emission limits specified in section 15.209(a) (see section 15.205(c))

Test results



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Appendix A. Measurement equipment

Equipment	Manufacturer	Model	Serial No.	Calibration interval	Calibration due.
Spectrum Analyzer	R&S	FSV30	100736	1 year	2017.07.06
Spectrum Analyzer	R&S	FSV40	101002	1 year	2017.07.06
8360B Series Swept Signal Generator	HP	83630B	3844A00786	1 year	2018.01.23
Attenuator	Agilent	8493C	51401	1 year	2017.07.05
Loop Antenna	SCHWARZBECK	FMZB1513	225	2 years	2019.05.10
Trilog-broadband antenna	SCHWARZBECK	VULB 9163	9168-714	2 years	2018.11.28
Horn Antenna	A.H	SAS-571	414	2 years	2019.02.15
Horn Antenna	SCHWARZBECK	BBHA9170	BBHA9170550	2 years	2019.02.15
High Pass Filter	WAINWRIGHT INSTRUMENT	WHJS3000-10TT	1	1 year	2017.07.04
Low Pass Filter	WEINSCHL	WLK1.0/18G-10TT	1	1 year	2017.07.04
Preamplifier	HP	8449B	3008A00538	1 year	2017.07.05
Preamplifier	SCHWARZBECK	BBV-9718	9718-246	1 year	2017.10.14
EMI Test Receiver	R&S	ESR3	101781	1 year	2018.04.27
EMI Test Receiver	R&S	ESU26	100552	1 year	2018.04.19

Peripheral devices

Device	Manufacturer	Model No.	Serial No.
Notebook Computer	Samsung Electronics Co., Ltd.	NT-RV518-AD6S	HTK99NC600207R
Test Board	N/A	N/A	N/A