TEST REPORT

Part 15 Subpart C 15.249

Equipment under test	SMART NECK
Model name	TF100
FCC ID	2ASZB-TF100
Applicant	Twofive Co.,Ltd.
Manufacturer	Twofive Co.,Ltd.
Date of test(s)	2019.06.20 ~ 2019.07.11
Date of issue	2019.07.12

Issued to
Twofive Co.,Ltd.
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Test and report completed by :	**Report approval by :**
Won-Jun Sim Test engineer	Hyeon-Su, Jang Technical manager

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Revision history

Revision	Date of issue	Test report No.	Description
-	2019.07.12	KES-RF-19T0094	Initial

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1. General information

Applicant:	Twofive Co.,Ltd.
Applicant address:	102, 34, Simin-daero, Manan-gu Manan-gu, Anyang-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 473-21, Gayeo-ro, Yeoju-si, Gyeonggi-do, Korea
Test Facility	FCC Accreditation Designation No.: KR0100, Registration No.: 444148
FCC rule part(s):	15.249
FCC ID:	2ASZB-TF100
Test device serial No.:	☒ Production ☐ Pre-production ☐ Engineering

1.1. EUT description

Equipment under test	SMART NECK
Frequency range	2 402 ㎒ ~ 2 480 ㎒ (BLE)
Model:	TF100
Modulation technique	GFSK
Number of channels	2 402 ㎒ ~ 2 480 ㎒ (BLE) : 40ch
Antenna specification	Antenna type : PCB Antenna // Peak gain: 2.813 ㏈i
Power source	AC 220 V
H/W version	1.0
S/W version	1.0

1.2. Test configuration

The **Twofive Co.,Ltd. // SMART NECK // FCC ID: 2ASZB-TF100** was tested according to the specification of EUT, the EUT must comply with following standards and KDB documents.

FCC Part 15.249
KDB 558074 D01 v05 r02
ANSI C63.10-2013

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1.3. Device modifications

N/A

1.4. Accessory information

N/A

1.5. Measurement results explanation example

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.

Offset(dB) = RF cable loss(dB) + attenuator factor(dB).
= 0.83 + 10 = 10.83 (dB)

1.6. Measurement Uncertainty

Test Item		Uncertainty
Uncertainty for Conduction emission test		2.62 dB
Uncertainty for Radiation emission test (include Fundamental emission)	9kHz - 30MHz	4.54 dB
	30MHz - 1GHz	4.36 dB
	Above 1GHz	5.00 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)	Rate(Mbps)
00	2 402	1 Mbps
. .	. .	. .
20	2 442	1 Mbps
. .	. .	. .
39	2 480	1 Mbps

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2. Summary of tests

Section in FCC Part 15	Test description	Test results
15.249(a), 15.249(d), 15.209	Radiated restricted band and emission	Pass

Note:
1) Certified module is mounted in the EUT as following
Applicant : Shenzhen Sheng Run Technology Co., Ltd.
Contains FCC ID : 2ADXE-HY-40R201PC
Model : HY-40R201PC
RF Test Report No. : AGC01629170901FE03

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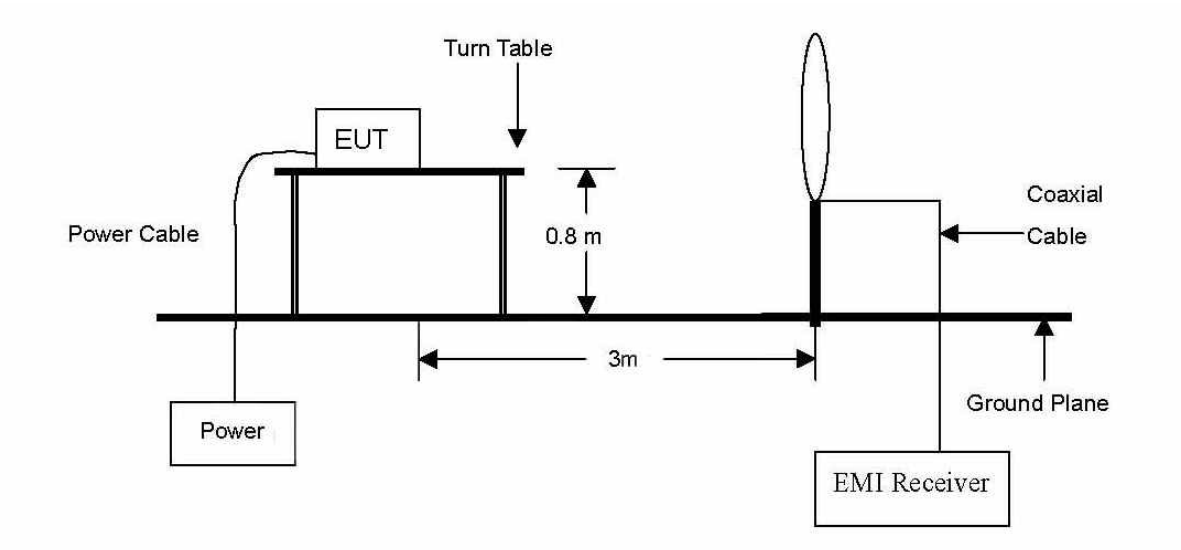
3. Test results

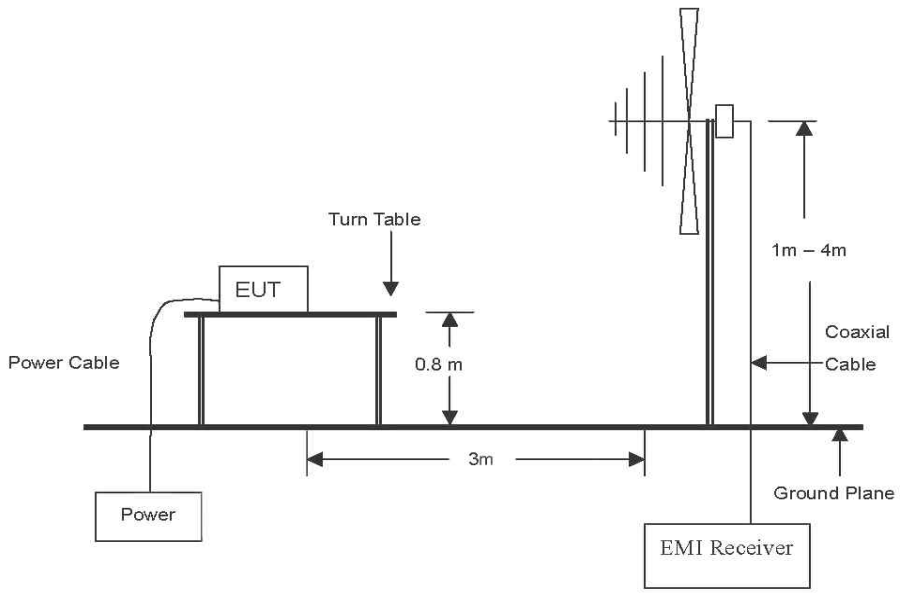
3.1. Radiated restricted band and emissions

Test setup

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



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



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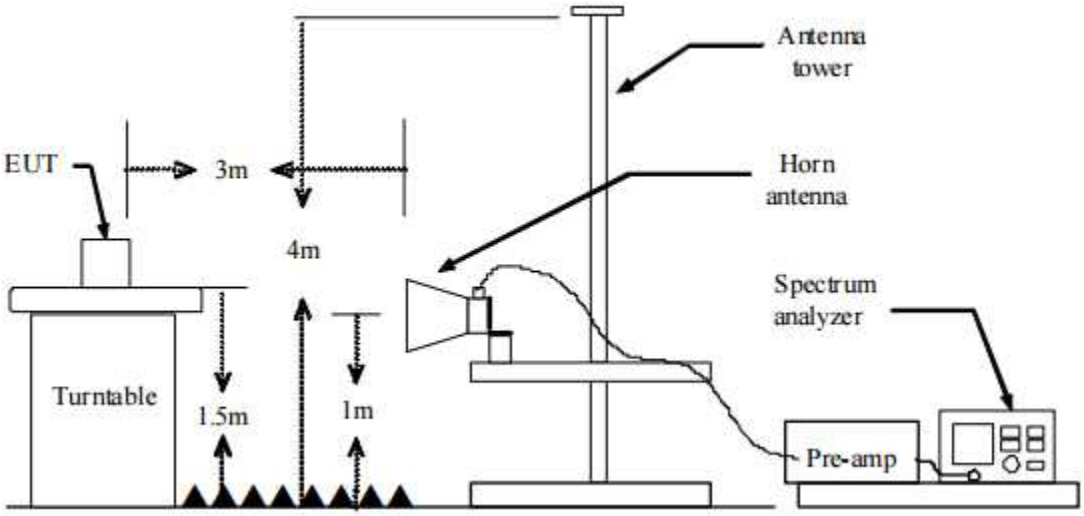
The diagram below shows the test setup that is utilized to make the measurements for emission from 1 ㎓ to the tenth harmonic of the highest fundamental frequency or to 40 ㎓ emissions, whichever is lower.



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 ㎒

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 ㎒

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. it was determined that **Horizontal** was worst-case polarizations
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.

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5. Spectrum analyzer settings for f < 1 ㎓:
   ① Span = wide enough to fully capture the emission being measured
   ② RBW = 100 ㎑
   ③ VBW ≥ RBW
   ④ Detector = quasi peak
   ⑤ Sweep time = auto
   ⑥ Trace = max hold
2. Spectrum analyzer settings for f ≥1 ㎓: Peak
   ① Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
   ② RBW = 1 ㎒
   ③ VBW ≥ 3 ㎒
   ④ Detector = peak
   ⑤ Sweep time = auto
   ⑥ Trace = max hold
   ⑦ Trace was allowed to stabilize

3. Spectrum analyzer settings for f ≥1 ㎓: Average
   ① Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
   ② RBW = 1 ㎒
   ③ VBW ≥ 3 × RBW
   ④ Detector = RMS, if span/(# of points in sweep) ≤ (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 ㏈ 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.

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Note.

1. f<30 ㎒, extrapolation factor of 40 ㏈/decade of distance. $F_d = 40\log(D_m/Ds)$
   f ≥30 ㎒, extrapolation factor of 20 ㏈/decade of distance. $F_d = 20\log(D_m/Ds)$
   Where:
   F_d = Distance factor in ㏈
   D_m = Measurement distance in meters
   D_s = Specification distance in meters
2. Field strength(㏈㎶/m) = Level(㏈㎶) + CF (㏈) + or DCF(㏈)
3. Margin(㏈) = Limit(㏈㎶/m) - Field strength(㏈㎶/m)
4. Emissions below 18 ㎓ were measured at a 3 meter test distance while emissions above 18 ㎓ 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 ㏈ of respective limits were not reported.
7. According to exploratory test no any obvious emission were detected from 9 ㎑ to 30 ㎒. 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 15.249(a) Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental Frequency	Field Strength of Fundamental	Field Strength of Harmonics
900 MHz ~ 928 MHz	50	500
2 400 MHz ~ 2 483.5 MHz	50	500
5 725 MHz ~ 5 875 MHz	50	500
24.0 GHz ~ 24.25 GHz	250	2500

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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 (㎒)	Distance (Meters)	Radiated (㎶/m)
0.009 ~ 0.490	300	2400/F(㎑)
0.490 ~ 1.705	30	24000/F(㎑)
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 ㎒, 76 ~ 88 ㎒, 174 ~ 216 ㎒ or 470 ~ 806 ㎒. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

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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) 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.

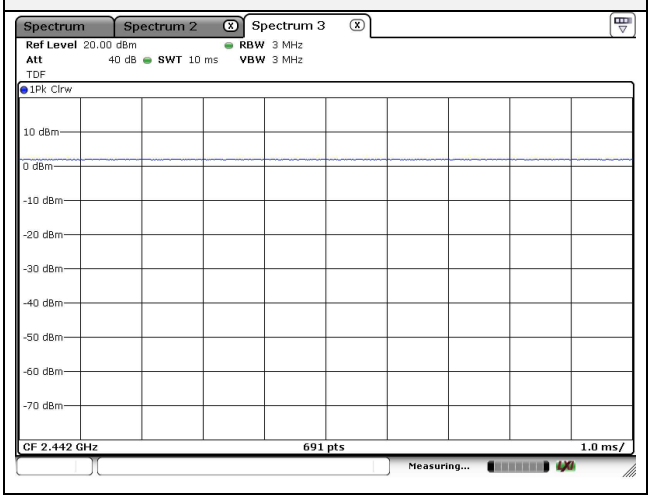
b) The zero-span mode on a spectrum analyzer or EMI receiver if the response time and spacing between bins on the sweep are sufficient to permit accurate measurements of the on- and off-times of the transmitted signal.

T_{on} time (ms)	Period (ms)	Duty cycle (Linear)	Duty cycle (%)	Duty cycle correction factor (dB)
10.0	10.0	1	100	0

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

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

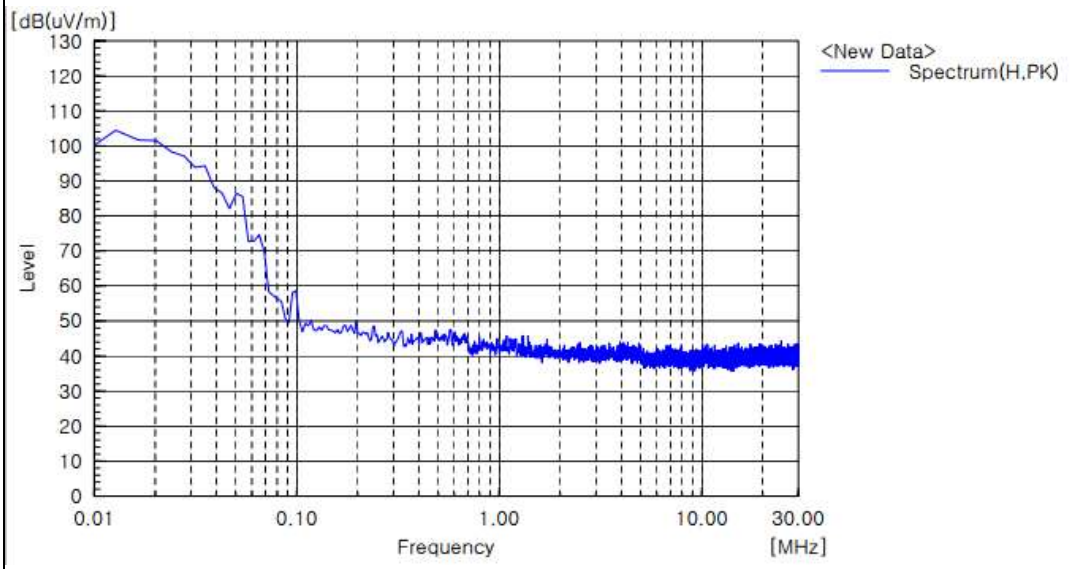
Middle channel



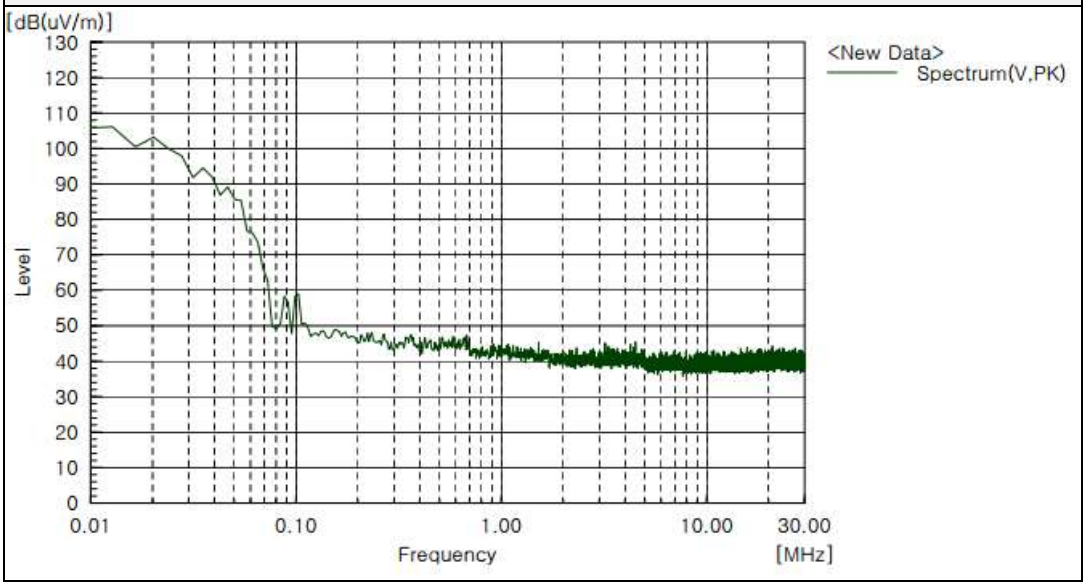
Test results (Below 30 ㎒)

Mode:	LE 5.0 1 Mbps
Distance of measurement:	3 meter
Channel:	39 (Worst case)

Horizontal



Vertical



No Spurious emission were detected below 30 ㎒

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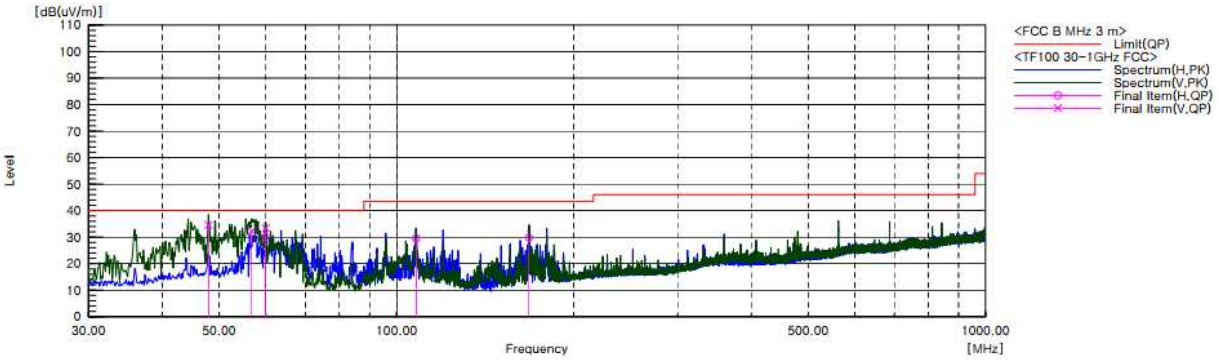
Test results (Below 1 000 ㎒)

Mode:	LE 5.0 1Mbps
Distance of measurement:	3 meter
Channel:	39 (Worst case)

Horizontal // Vertical



Final Result

No.	Frequency [MHz]	(P)	Reading QP [dB(uV)]	c.f [dB(1/m)]	Result QP [dB(uV/m)]	Limit QP [dB(uV/m)]	Margin QP [dB]	Height [cm]	Angle [deg]	Remark
1	47.945	V	56.7	-22.1	34.6	40.0	5.4	134.0	289.0	
2	56.796	V	54.9	-22.6	32.3	40.0	7.7	211.0	16.0	
3	59.949	H	53.2	-23.1	30.1	40.0	9.9	344.0	298.0	
4	59.995	V	56.4	-23.1	33.3	40.0	6.7	101.0	49.0	
5	107.964	H	52.9	-23.3	29.6	43.5	13.9	400.0	119.0	
6	167.861	H	55.2	-25.4	29.8	43.5	13.7	251.0	207.0	

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Test results (Above 1 000 ㎒)

Mode: LE 5.0 1 Mbps

Distance of measurement: 3 meter

Channel: 0

- **Fundamental**

Frequency (㎒)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	AF (dB)	AMP+CL (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 402.15	94.43	Peak	V	28.91	-29.52	93.82	114.00	20.18
2 402.15	88.06	Average	V	28.91	-29.52	87.45	94.00	6.55

- **Spurious**

Frequency (㎒)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	AF (dB)	AMP+CL (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1 113.09	45.73	Peak	V	24.10	-31.74	38.09	74.00	35.91
1 113.09	35.04	Average	V	24.10	-31.74	27.40	54.00	26.60
6 916.90	42.99	Peak	V	36.57	-20.96	58.60	74.00	15.40
6 916.90	31.88	Average	V	36.57	-20.96	47.49	54.00	6.51

- **Band edge**

Frequency (㎒)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	AF (dB)	AMP+CL (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 310.00	40.74	Peak	V	28.54	-30.39	38.89	74.00	35.11
2 310.00	30.74	Average	V	28.54	-30.39	28.89	54.00	25.11
2 357.70	43.02	Peak	V	28.73	-29.94	41.81	74.00	32.19
2 357.70	30.45	Average	V	28.73	-29.94	29.24	54.00	24.76
2 390.00	41.99	Peak	V	28.86	-29.63	41.22	74.00	32.78
2 390.00	31.43	Average	V	28.86	-29.63	30.66	54.00	23.34

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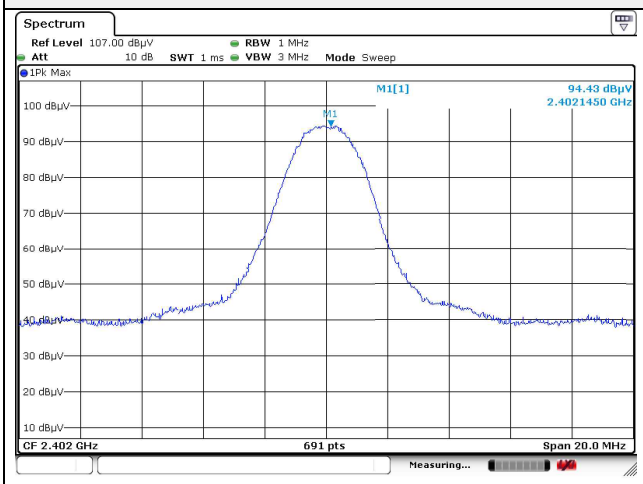
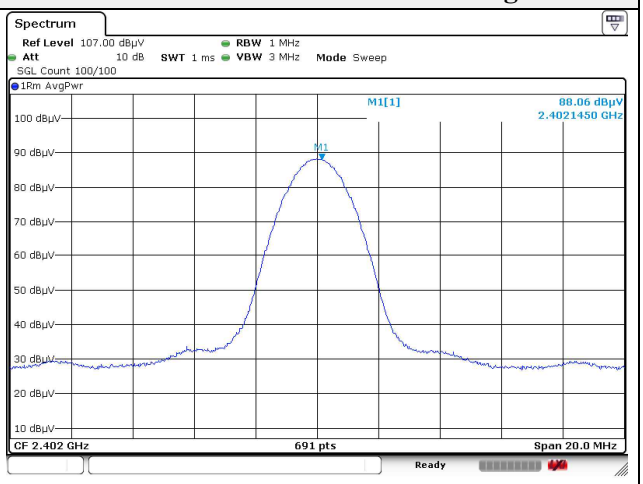
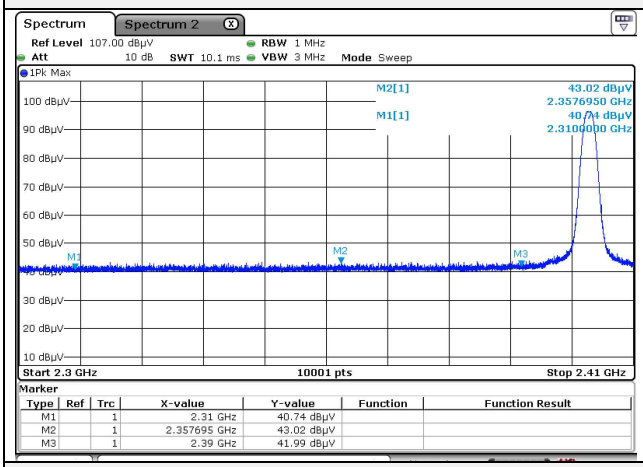
Fundamental // Vertical // Peak



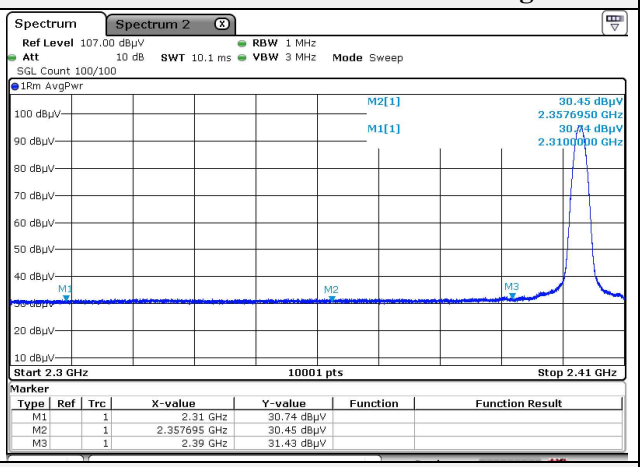
Fundamental // Vertical // Average



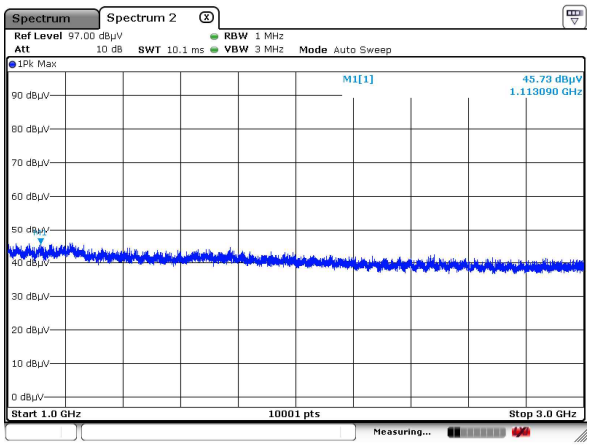
Restricted band // Vertical // Peak



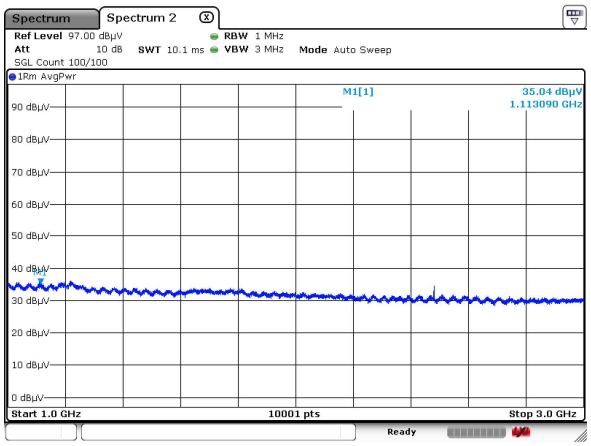
Restricted band // Vertical // Average



Vertical // Peak for 1 GHz to 3 GHz



Vertical // Average for 1 GHz to 3 GHz



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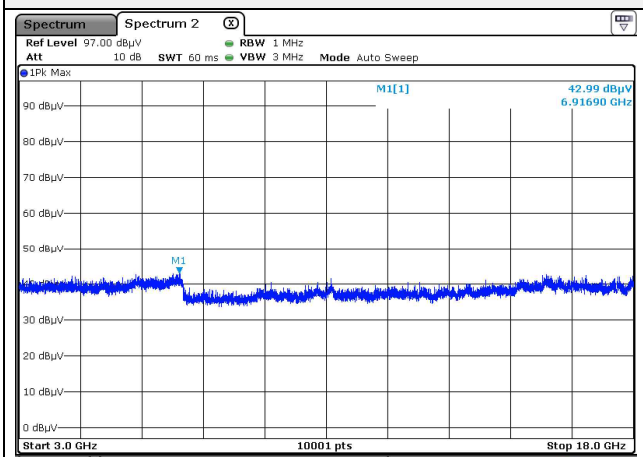
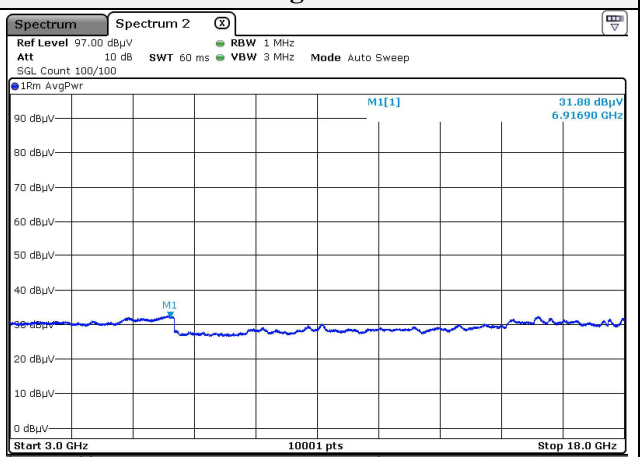
Vertical // Peak for 3 ㎓ to 18 ㎓	Vertical // Average for 3 ㎓ to 18 ㎓
	

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Mode: LE 5.0 1 Mbps

Distance of measurement: 3 meter

Channel: 20

- **Fundamental**

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	AF (dB)	AMP+CL (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 441.71	91.41	Peak	V	29.07	-29.13	91.35	114.00	22.65
2 441.71	89.59	Average	V	29.07	-29.13	89.53	94.00	4.47

- **Spurious**

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	AF (dB)	AMP+CL (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1 329.87	46.01	Peak	V	24.48	-30.74	39.75	74.00	34.25
1 329.87	34.45	Average	V	24.48	-30.74	28.19	54.00	25.81
6 804.40	43.84	Peak	V	36.12	-21.16	58.80	74.00	15.20
6 804.40	32.19	Average	V	36.12	-21.16	47.15	54.00	6.85

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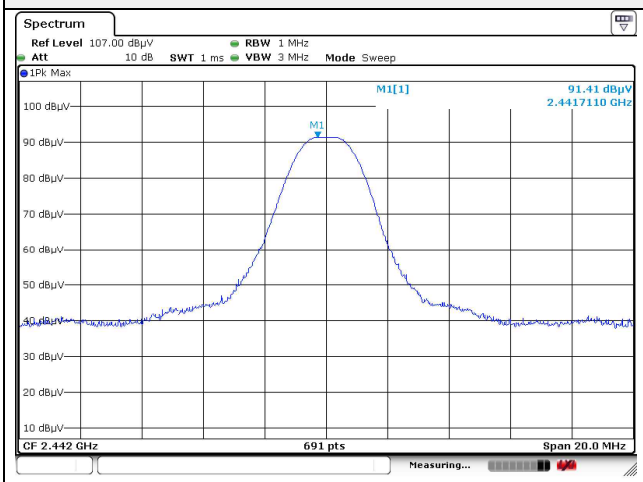
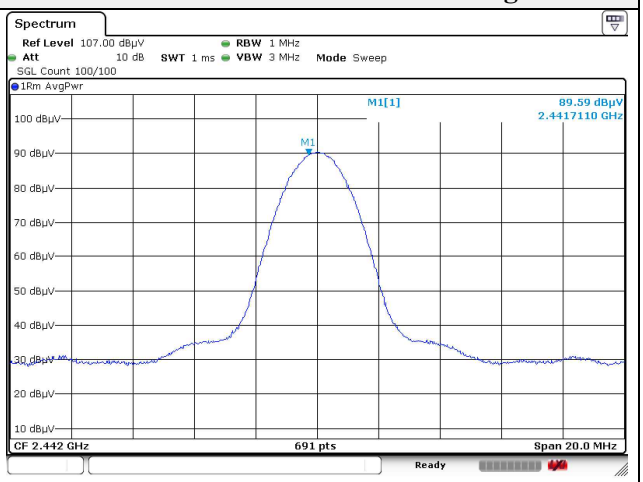
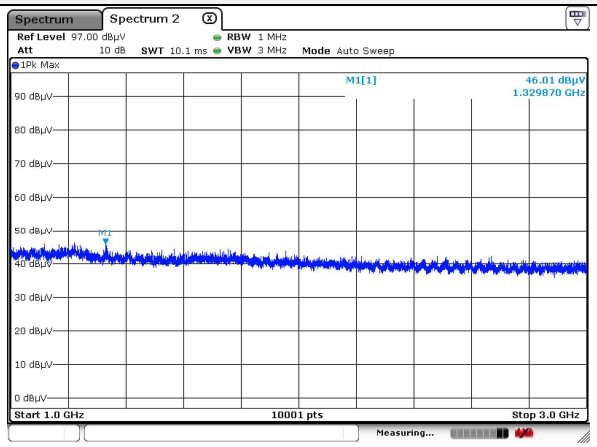
Fundamental // Vertical // Peak



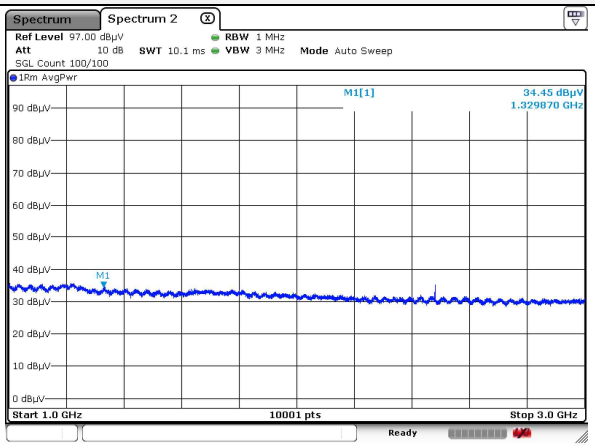
Fundamental // Vertical // Average



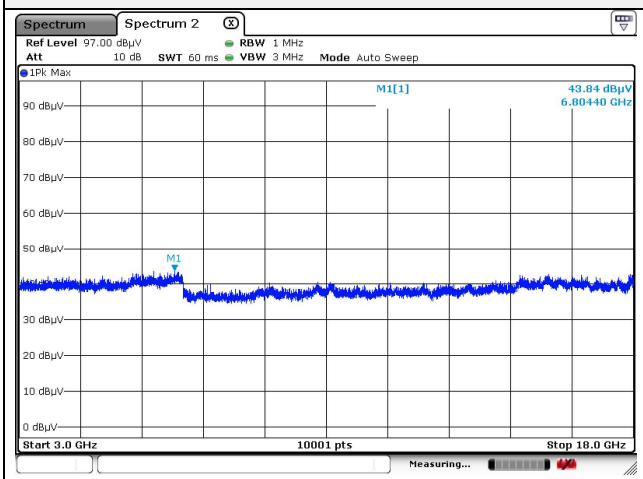
Vertical // Peak for 1 GHz to 3 GHz



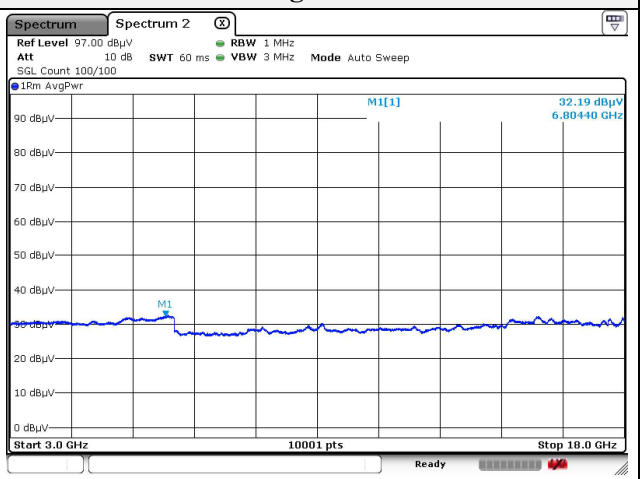
Vertical // Average for 1 GHz to 3 GHz



Vertical // Peak for 3 GHz to 18 GHz



Vertical // Average for 3 GHz to 18 GHz



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Mode: LE 5.0 1 Mbps

Distance of measurement: 3 meter

Channel: 39

- **Fundamental**

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	AF (dB)	AMP+CL (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 479.80	92.57	Peak	V	29.28	-28.75	93.10	114.00	20.90
2 479.80	88.67	Average	V	29.28	-28.75	89.20	94.00	4.80

- **Spurious**

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	AF (dB)	AMP+CL (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
1 073.29	45.58	Peak	V	23.99	-31.90	37.67	74.00	36.33
1 073.29	35.18	Average	V	23.99	-31.90	27.27	54.00	26.73
6 846.40	43.01	Peak	V	36.29	-21.09	58.21	74.00	15.79
6 846.40	32.20	Average	V	36.29	-21.09	47.40	54.00	6.60

- **Band edge**

Frequency (MHz)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	AF (dB)	AMP+CL (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 483.50	44.02	Peak	V	29.30	-28.72	44.60	74.00	29.40
2 483.50	35.59	Average	V	29.30	-28.72	36.17	54.00	17.83
2 484.16	46.07	Peak	V	29.30	-28.72	46.65	74.00	27.35
2 484.16	33.49	Average	V	29.30	-28.72	34.07	54.00	19.93
2 500.00	39.54	Peak	V	29.40	-28.56	40.38	74.00	33.62
2 500.00	30.34	Average	V	29.40	-28.56	31.18	54.00	22.82

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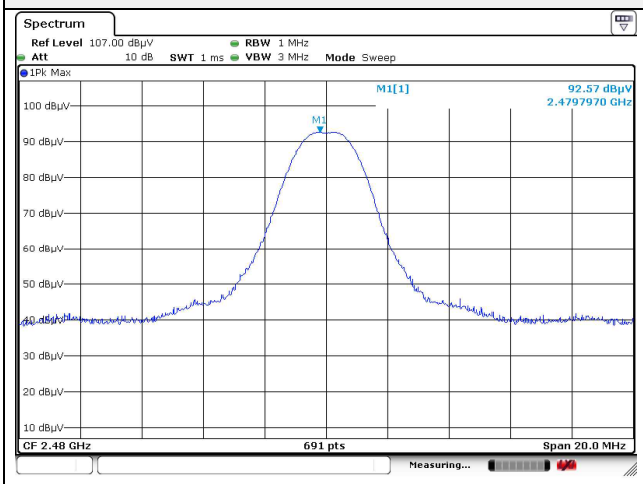
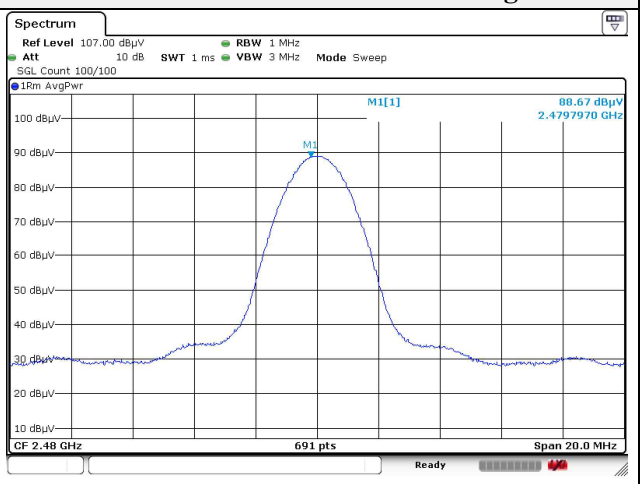
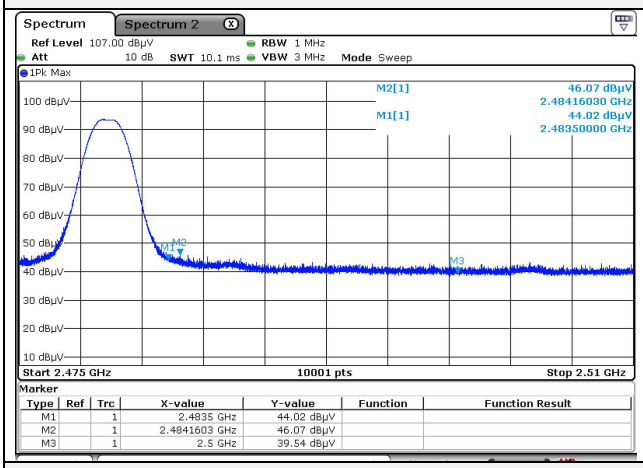
Fundamental // Vertical // Peak



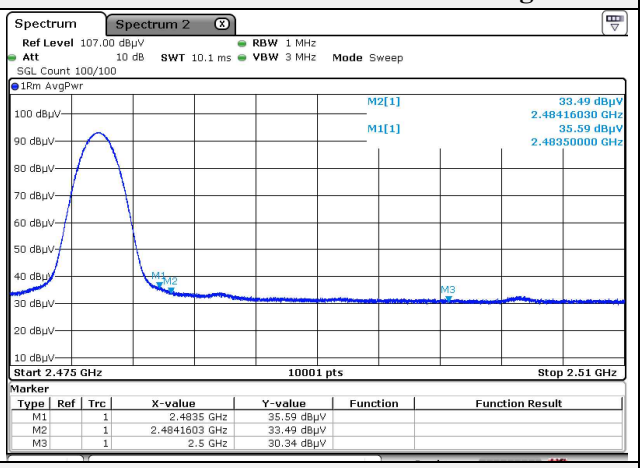
Fundamental // Vertical // Average



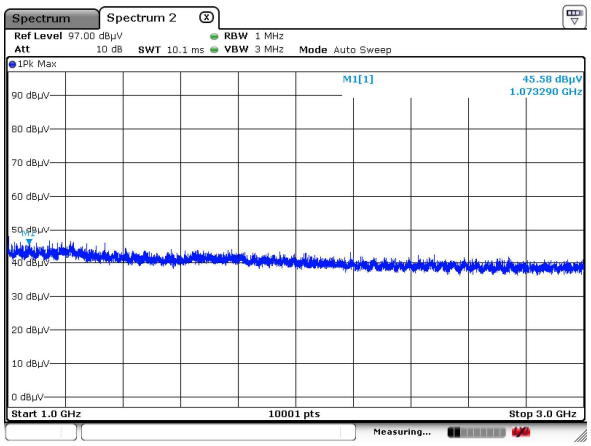
Restricted band // Vertical // Peak



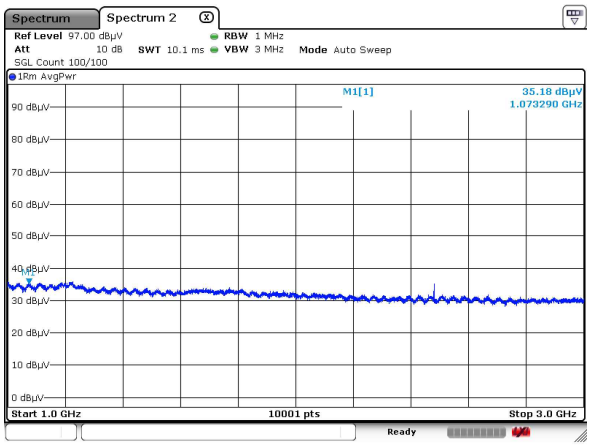
Restricted band // Vertical // Average



Vertical // Peak for 1 GHz to 3 GHz



Vertical // Average for 1 GHz to 3 GHz



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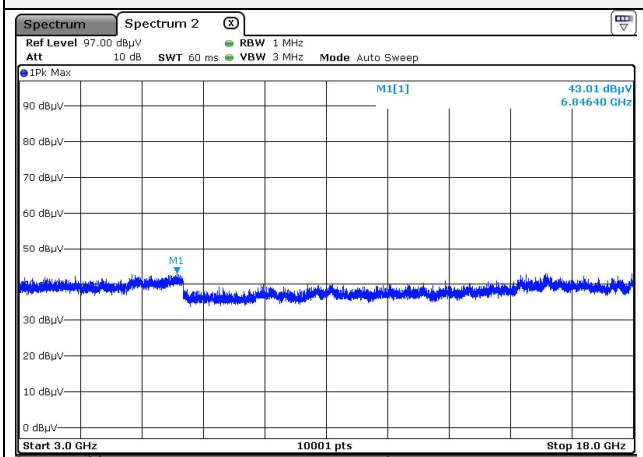
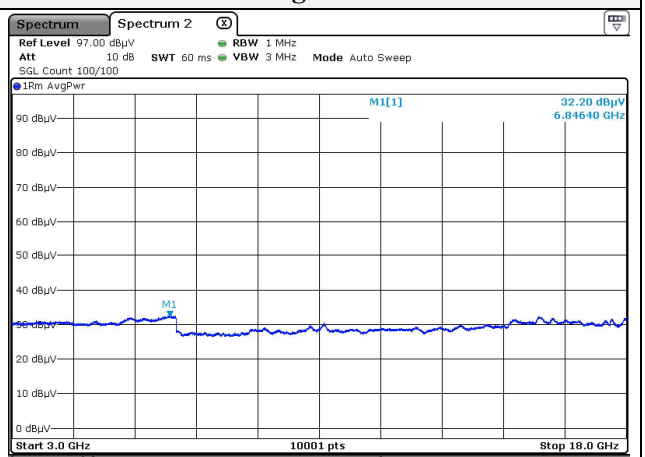
Vertical // Peak for 3 GHz to 18 GHz	Vertical // Average for 3 GHz to 18 GHz
	

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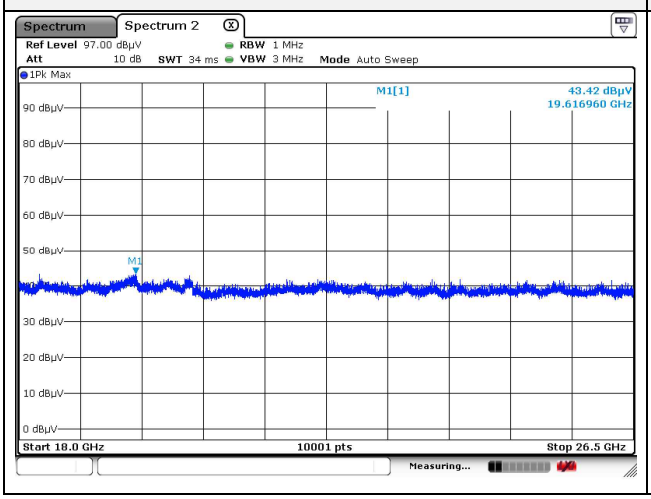
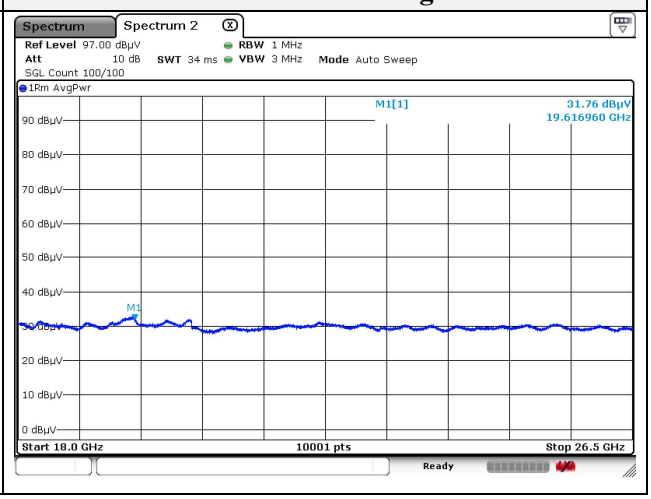
Test results (18 ㎓ to 30 ㎓) – Worst case

Mode:	LE 5.0 1 Mbps
Distance of measurement:	3 meter
Channel:	39 (Worst case)

Horizontal Peak	Horizontal Average
	

Note.
No spurious emission were detected above 18 ㎓.

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Appendix A. Measurement equipment

Equipment	Manufacturer	Model	Serial No.	Calibration interval	Calibration due.
Spectrum Analyzer	R&S	FSV30	101389	1 year	2020.01.09
Spectrum Analyzer	R&S	FSV40	101002	1 year	2020.06.24
8360B Series Swept Signal Generator	HP	83630B	3844A00786	1 year	2020.01.15
Power Meter	Anritsu	ML2495A	1438001	1 year	2020.01.15
Pulse Power Sensor	Anritsu	MA2411B	1339205	1 year	2020.01.15
Attenuator	HP	8494B	2630A12857	1 year	2020.01.15
Loop Antenna	Schwarzbeck	FMZB1513	225	2 years	2021.02.15
Trilog-broadband antenna	SCHWARZBECK	VULB 9163	714	2 years	2020.11.26
Horn Antenna	A.H	SAS-571	414	2 years	2021.02.11
Horn Antenna	SCHWARZBECK	BBHA9170	BBHA 9170550	2 years	2021.02.19
High Pass Filter	Wainwright Instrument Gmbh	WHJS3000-10TT	1	1 year	2020.06.25
Band Reject Filter	MICRO-TRONICS	BRM50702	G272	1 year	2020.01.16
Low Pass Filter	Wainwright Instrument Gmbh	WLK1.0/18G-10TT	1	1 year	2020.06.24
Broadband Amplifier	Schwarzbeck	BBV9721	PS9721-003	1 year	2020.01.16
Preamplifier	AGILENT	8449B	3008A01742	1 year	2020.01.08
Amplifier	R&S	SCU 01	100603	1 year	2019.11.26
EMI Test Receiver	R&S	ESU26	100551	1 year	2020.04.09
EMI Test Receiver	R&S	ESR3	101781	1 year	2020.04.22
DC Power supply	Agilent	6632B	MY43004090	1 year	2020.06.25
Pulse Limiter	R&S	ESH3-Z2	101915	1 year	2019.11.26
LISN	R&S	ENV216	101787	1 year	2020.01.04

Peripheral devices

Device	Manufacturer	Model No.	Serial No.
Notebook computer	LG Electronics Inc.,	LGS53	306QCZP560949

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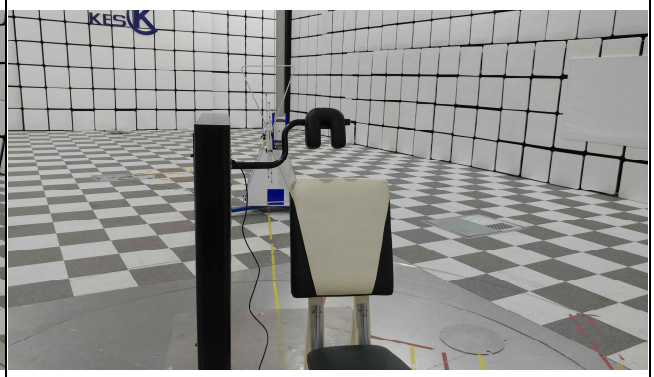
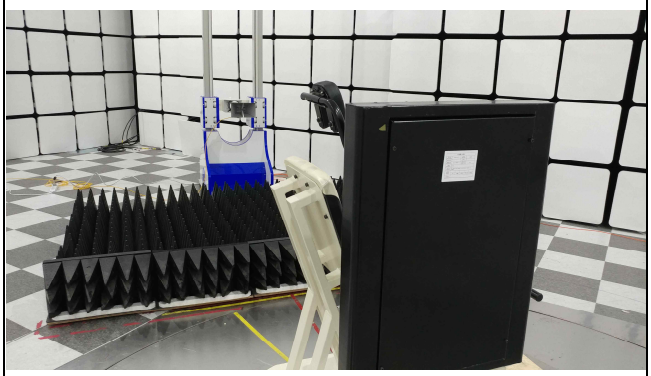
Appendix B. Test setup photos

Radiated	
	
	Blank

The end of test report.

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