TEST REPORT

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1. Client

- Name : POWERTOS.CO.,LTD
- Address : Bizdong-B117, SKN TECHNOPARK, 124, Sagimakgol-ro, Jungwon-gu, Seongnam-si, Gyeonggi-do, Republic of Korea
- Date of Receipt : 2019-11-28

2. Use of Report : Certification

3. Name of Product and Model : Fault Detector / PIA-1010

4. Manufacturer and Country of Origin : POWERTOS.CO.,LTD / Korea

5. FCC ID : 2AVA6-PIA-1010

6. Date of Test : 2020-01-15 to 2020-01-17

7. Test Standards : FCC Part 15 Subpart C, 15.247

8. Test Results : Refer to the test result in the test report

Affirmation	Tested by Name : Euijung Kim (Signature)	Technical Manager Name : Bobae Lee (Signature)

2020-02-11

KCTL Inc.

Report revision history

Date	Revision	Page No
2020-01-31	Initial report	-
2020-02-11	Updated	4,6,7,9~11

Note. The report No. KR20-SRF0027 is superseded by the report No. KR20-SRF0027-A.

CONTENTS

1. General information

Client	:	POWERTOS.CO.,LTD
Address	:	Bizdong-B117, SKN TECHNOPARK, 124, Sagimakgol-ro, Jungwon-gu, Seongnam-si, Gyeonggi-do, Republic of Korea
Manufacturer	:	POWERTOS.CO.,LTD
Address	:	Bizdong-B117, SKN TECHNOPARK, 124, Sagimakgol-ro, Jungwon-gu, Seongnam-si, Gyeonggi-do, Republic of Korea
Laboratory	:	KCTL Inc.
Address	:	65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea
Accreditations	:	FCC Site Designation No: KR0040, FCC Site Registration No: 687132 VCCI Registration No. : R-20080, G-20078, C-20059, T-20056 Industry Canada Registration No. : 8035A KOLAS No.: KT231

2. Device information

Equipment under test	:	Fault Detector
Model	:	PIA-1010
Frequency range	:	904 ㎒ ~ 925 ㎒
Modulation technique	:	LoRa (DTS)
Number of channels	:	43 ch
Power source	:	DC 3.6 V
Antenna specification	:	Patch Antenna
Antenna gain	:	1.05 dBi
Software version	:	V1.0
Hardware version	:	V1.0
Test device serial No.	:	1903-0096
Operation temperature	:	23 ℃

2.1. Accessory information

Equipment	Manufacturer	Model	Serial No.	Power source
N/A	-	-	-	-

2.2. Frequency/channel operations

This device contains the following capabilities: LORA

Channel	Frequency(㎒)	Channel	Frequency(㎒)
1	904.0 ㎒	23	915.0 ㎒
2	904.5 ㎒	24	915.5 ㎒
3	905.0 ㎒	25	916.0 ㎒
4	905.5 ㎒	26	916.5 ㎒
5	906.0 ㎒	27	917.0 ㎒
6	906.5 ㎒	28	917.5 ㎒
7	907.0 ㎒	29	918.0 ㎒
8	907.5 ㎒	30	918.5 ㎒
9	908.0 ㎒	31	919.0 ㎒
10	908.5 ㎒	32	919.5 ㎒
11	909.0 ㎒	33	920.0 ㎒
12	909.5 ㎒	34	920.5 ㎒
13	910.0 ㎒	35	921.0 ㎒
14	910.5 ㎒	36	921.5 ㎒
15	911.0 ㎒	37	922.0 ㎒
16	911.5 ㎒	38	922.5 ㎒
17	912.0 ㎒	39	923.0 ㎒
18	912.5 ㎒	40	923.5 ㎒
19	913.0 ㎒	41	924.0 ㎒
20	913.5 ㎒	42	924.5 ㎒
21	914.0 ㎒	43	925.0 ㎒
22	914.5 ㎒		

2.3. Peak output power

PKPM1 Peak-reading power meter method

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.

-Peak output power

Mode	Channel	Frequency [㎒]	Peak output power [dBm]	Average output power [dBm]
SF 7	Lowest	904	18.82	18.80
	Middle	914	18.72	18.49
	Highest	925	18.62	18.54
SF 8	Lowest	904	18.82	18.75
	Middle	914	18.72	18.64
	Highest	925	18.62	18.58
SF 9	Lowest	904	18.82	**18.84**
	Middle	914	18.72	18.57
	Highest	925	18.62	18.58
SF 10	Lowest	904	18.82	18.74
	Middle	914	18.72	18.69
	Highest	925	18.62	18.53

Note1) : The above peak output power were retested results.
Note2) : SF = Expand Spreading Factor.

Spreading Factor (S.F)	Payload
7	158
8	85
9	40
10	14

3. Antenna requirement

Requirement of FCC part section 15.203:
An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

- The transmitter has permanently attached Patch Antenna.
- The Antenna port is composed of SMA male connector. The antenna inside the device is fixed by using “Loctite” adhesive so that the user cannot easily remove it.

4. Summary of tests

FCC Part section(s)	Parameter	Test results
15.247(b)(3)	Maximum peak output power	Pass
15.247(e)	Peak power spectral density	N/T(Note1)
15.247(a)(2)	6 dB channel bandwidth	Pass
-	Occupied bandwidth	N/T(Note1)
15.247(d), 15.205(a), 15.209(a)	Spurious emission	Pass
	Band-edge, restricted band	Pass
15.207(a)	Conducted emissions	N/T(Note2)

Notes: (N/T: Not Tested, N/A: Not Applicable)

1. These test item was performed. (Model Name: RN2903, FCC ID: T9JRN2903, Test Report No. EMC_15009_2 issued on May 28, 2015 by H.B. Compliance Solutions)
2. This test is not applicable because the EUT uses battery and it's not to be connected to the public utility(AC) power line.
3. 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.
4. 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
5. The test procedure(s) in this report were performed in accordance as following.
   - ANSI C63.10-2013

5. Measurement uncertainty

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013.

All measurement uncertainty values are shown with a coverage factor of k=2 to indicated a 95 % level of confidence. The measurement data shown herein meets of exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and thus, can be compared directly to specified limits to determine compliance.

Parameter	Expanded uncertainty(±)	
Radiated spurious emissions	9 ㎑ ~ 30 ㎒:	2.28 ㏈
	30 ㎒ ~ 300 ㎒	4.98 ㏈
	300 ㎒ ~ 1 000 ㎒	5.14 ㏈
	1 ㎓ ~ 6 ㎓	6.70 ㏈
	Above 6 ㎓	6.60 ㏈

6. Measurement results explanation example

The offset level is set in the spectrum analyzer to compensate the RF cable loss 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.

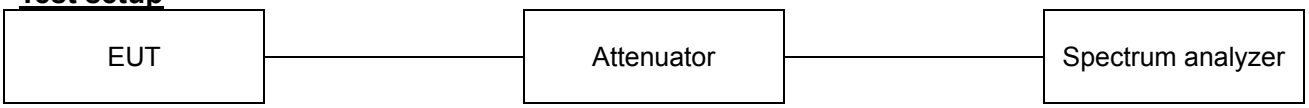
Frequency (㎒)	Factor(㏈)	Frequency (㎒)	Factor(㏈)
30	9.94	9 000	12.30
50	9.97	10 000	12.58
100	10.02	11 000	12.47
200	10.12	12 000	12.50
300	10.19	13 000	12.85
400	10.26	14 000	12.69
500	10.33	15 000	13.24
600	10.34	16 000	12.93
700	10.40	17 000	13.33
800	10.45	18 000	13.33
900	10.48	19 000	13.19
1 000	10.51	20 000	13.37
2 000	10.83	21 000	13.45
3 000	11.07	22 000	13.63
4 000	11.40	23 000	13.82
5 000	11.59	24 000	13.78
6 000	12.19	25 000	13.87
7 000	11.69	26 000	14.08
8 000	12.11	26 500	14.10

Note.
Offset(㏈) = RF cable loss(㏈) + Attenuator(㏈) + EUT cable loss(㏈)

7. Test results

7.1. 6 dB Bandwidth(DTS Channel Bandwidth)

Test setup



Limit

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

Test procedure

ANSI C63.10 - Section 11.8

Test settings

DTS bandwidth

One of the following procedures may be used to determine the modulated DTS bandwidth.

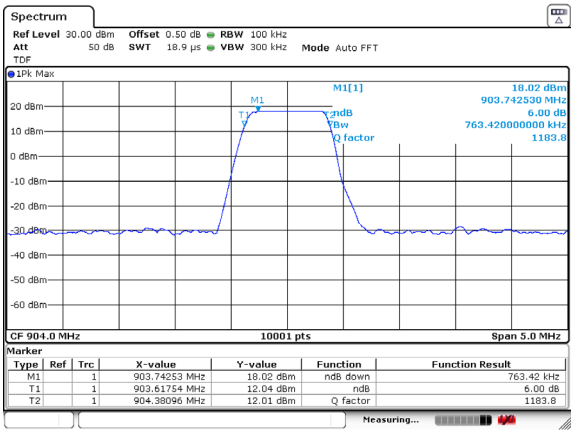
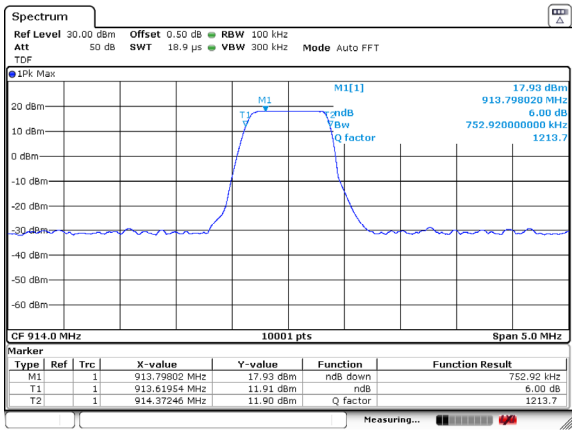
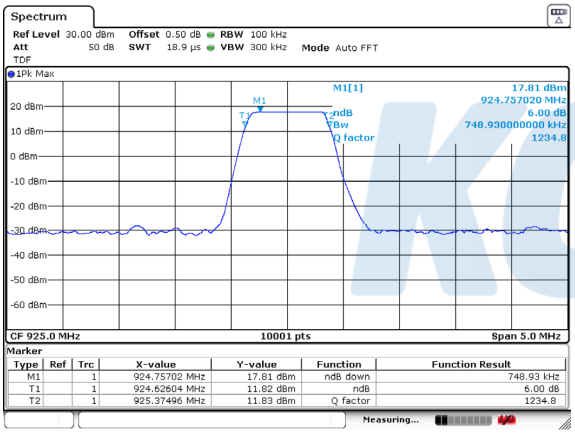
Option 1

1) Set RBW = 100 ㎑.
2) Set the video bandwidth (VBW) ≥ 3 x 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 ㏈ relative to the maximum level measured in the fundamental emission.

Test results

Test mode	Frequency(㎒)	6 ㏈ bandwidth(㎒)
SF 9	904	0.76
	914	0.75
	925	0.75

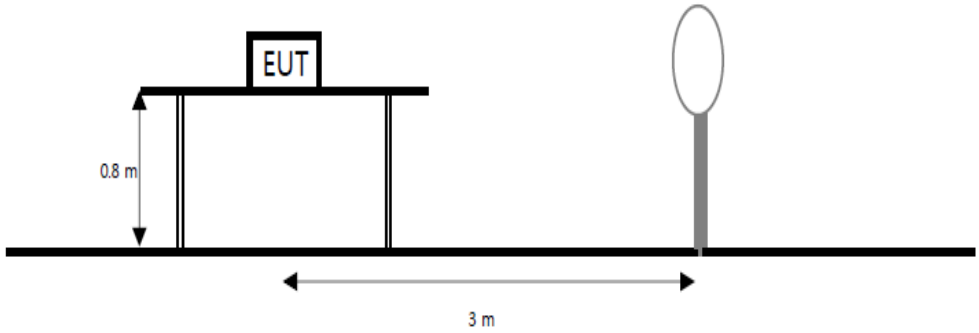
6 dB bandwidth(㎒)

904 ㎒	914 ㎒
	
925 ㎒	
	Blank

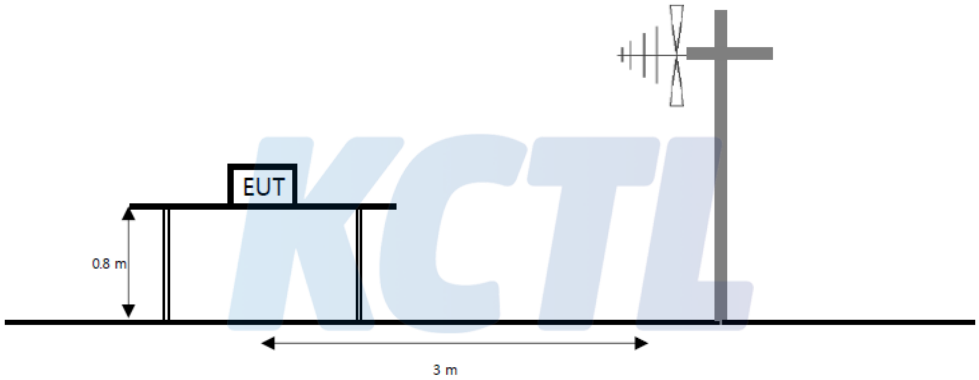
7.2. Radiated spurious emissions & band edge

Test setup

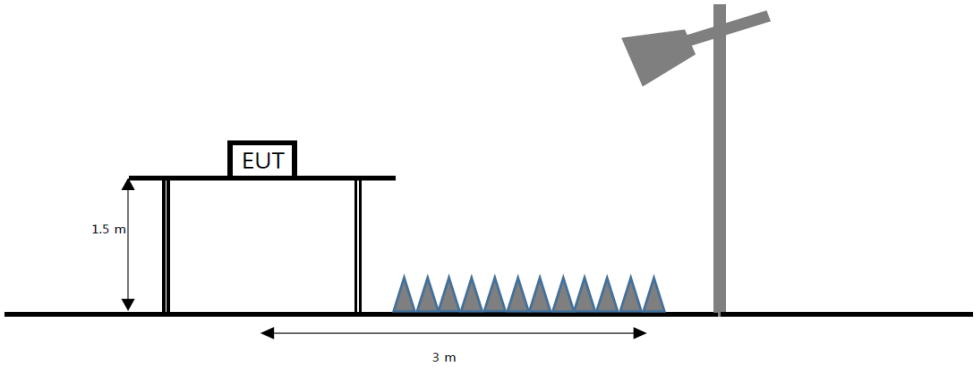
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 ㎑ to 30 ㎒ Emissions



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



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.



Limit

According to section 15.209(a), except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (㎒)	Field strength (㎶/m)	Measurement distance (m)
0.009 - 0.490	2 400/F(㎑)	300
0.490 - 1.705	24 000/F(㎑)	30
1.705 - 30	30	30
30 - 88	100**	3
88 - 216	150**	3
216 - 960	200**	3
Above 960	500	3

**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., Section15.231 and 15.241.

According to section 15.205(a) and (b), only spurious emissions are permitted in any of the frequency bands listed below:

㎒	㎒	㎒	㎓
0.009 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
0.495 - 0.505	16.694 75 - 16.695 25	608 - 614	5.35 - 5.46
2.173 5 - 2.190 5	16.804 25 - 16.804 75	960 – 1 240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1 300 – 1 427	8.025 - 8.5
4.177 25 - 4.177 75	37.5 - 38.25	1 435 – 1 626.5	9.0 - 9.2
4.207 25 - 4.207 75	73 - 74.6	1 645.5 – 1 646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1 660 – 1 710	10.6 - 12.7
6.267 75 - 6.268 25	108 - 121.94	1 718.8 – 1 722.2	13.25 - 13.4
6.311 75 - 6.312 25	123 - 138	2 200 – 2 300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2 310 – 2 390	15.35 - 16.2
8.362 - 8.366	156.524 75 - 156.525 25	2 483.5 – 2 500	17.7 - 21.4
8.376 25 - 8.386 75	156.7 - 156.9	2 690 – 2 900	22.01 - 23.12
8.414 25 - 8.414 75	162.012 5 - 167.17	3 260 – 3 267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3 332 – 3 339	31.2 - 31.8
12.519 75 - 12.520 25	240 - 285	3 345.8 – 3 358	36.43 - 36.5
12.576 75 - 12.577 25	322 - 335.4	3 600 – 4 400	Above 38.6
13.36 - 13.41			

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in section 15.209. At frequencies equal to or less than 1 000 ㎒, compliance with the limits in section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1 000 ㎒, compliance with the emission limits in section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in section 15.35 apply to these measurements.

Test procedure
ANSI C63.10-2013

Test settings
Peak field strength measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = as specified in table
3. VBW ≥ (3×RBW)
4. Detector = peak
5. Sweep time = auto
6. Trace mode = max hold
7. Allow sweeps to continue until the trace stabilizes

Table. RBW as a function of frequency

Frequency	RBW
9 ㎑ to 150 ㎑	200 ㎐ to 300 ㎐
0.15 ㎒ to 30 ㎒	9 ㎑ to 10 ㎑
30 ㎒ to 1 000 ㎒	100 ㎑ to 120 ㎑
> 1 000 ㎒	1 ㎒

Average field strength measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1 ㎒
3. VBW = 1/T ≥ 1 ㎐
4. Averaging type was set to RMS to ensure that video filtering was applied in the power domain
5. Detector = peak
6. Sweep time = auto
7. Trace mode = max hold
8. Trace was allowed to run for at least 50 times(1/duty cycle) traces

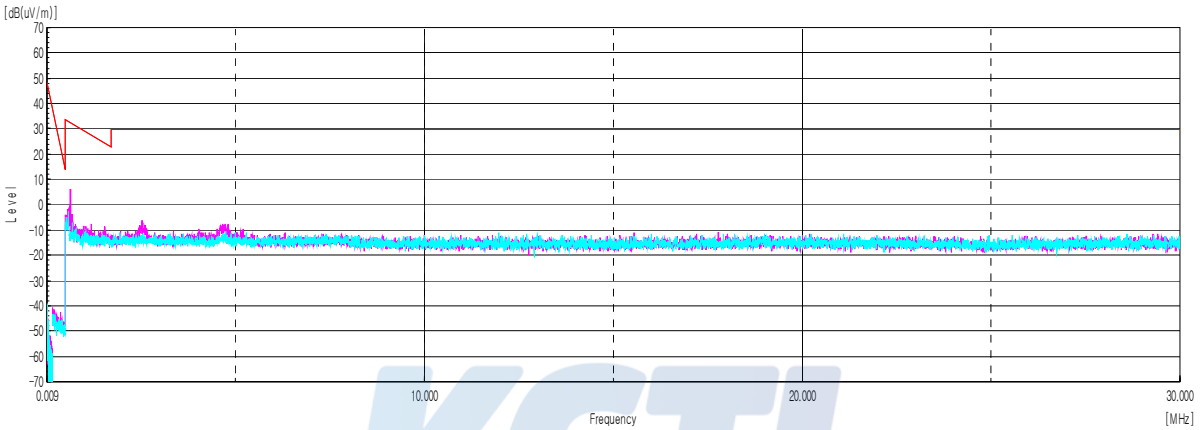
Notes:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 1 ㎒ for Peak detection and frequency above 1 ㎓. The resolution bandwidth of test receiver/spectrum analyzer is 1 ㎒ and the video bandwidth is 1 ㎑(≥1/T) for Average detection (AV) at frequency above 1 ㎓. (where T = pulse width)
2. *f* <30 ㎒, extrapolation factor of 40 ㏈/decade of distance. F_d = 40log(D_m/Ds)
   f ≥30 ㎒, extrapolation factor of 20 ㏈/decade of distance. F_d = 20log(D_m/Ds)
   Where:
   F_d= Distance factor in ㏈
   D_m= Measurement distance in meters
   D_s= Specification distance in meters
3. Factors(㏈) = Antenna factor(㏈/m) + Cable loss(㏈) + or Amp. gain(㏈) + or F_d(㏈)
4. The worst-case emissions are reported however emissions whose levels were not within 20 ㏈ of respective limits were not reported.
5. Average test would be performed if the peak result were greater than the average limit.
6. [1] mean is restricted band.
7. According to part 15.31(f)(2), an extrapolation factor of 40 dB/decade is applied because measured distance of radiated emission is 3 m.

Test results (Below 30 ㎒) – Worst case: SF9 lowest Channel

Frequency	Pol.	Reading	Cable Loss	Amp Gain	Antenna Factor	DCCF	Result	Limit	Margin
[㎒]	[V/H]	[dB(㎶)]	[dB]	[dB]	[dB]	[dB]	[dB(㎶/m)]	[dB(㎶/m)]	[dB]
No spurious emissions were detected within 20 ㏈ of the limit.									

Horizontal/Vertical

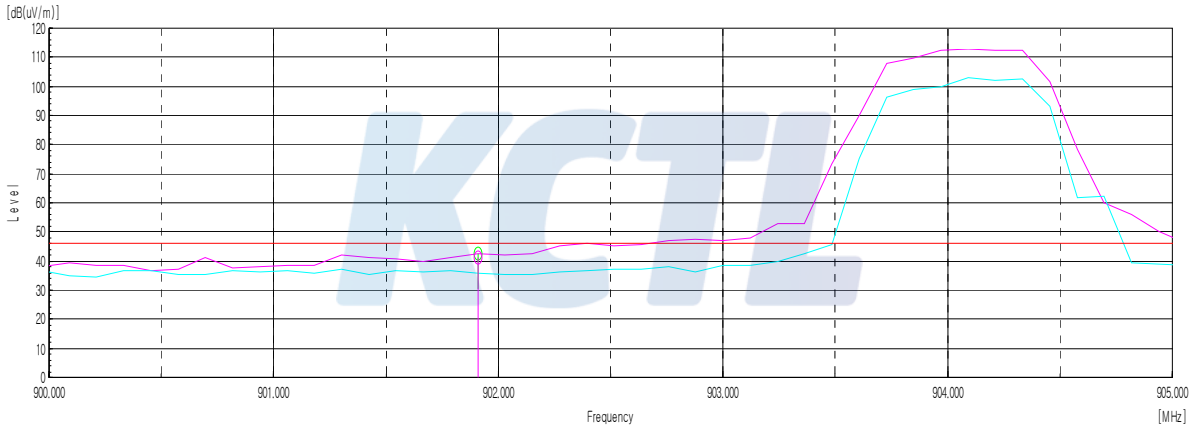


Test results (Below 1 000 ㎒)

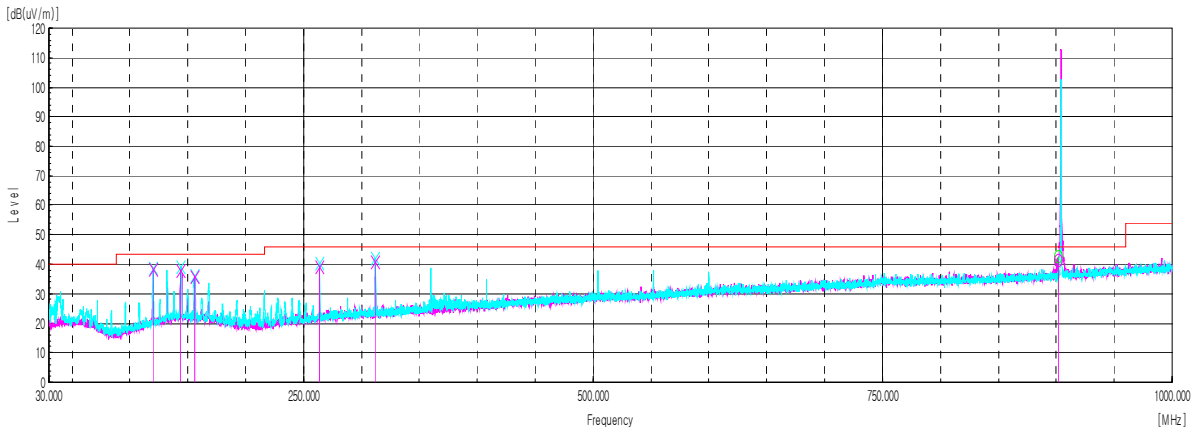
Low frequency

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(㎒)	(V/H)	(dB(㎶))	(dB)	(dB)	(dB)	(dB(㎶/m))	(dB(㎶/m))	(dB)
Quasi peak data								
119.97[1)]	V	50.10	17.20	-29.08	-	38.22	43.50	5.28
143.85	V	47.90	19.03	-28.83	-	38.10	43.50	5.40
156.10	V	45.70	18.98	-28.78	-	35.90	43.50	7.60
264.01[1)]	V	49.20	18.24	-28.13	-	39.31	46.00	6.69
312.03	V	49.00	19.62	-27.70	-	40.92	46.00	5.08
901.91	H	36.40	29.36	-24.33	-	41.43	46.00	4.57

Horizontal/Vertical for Band-edge



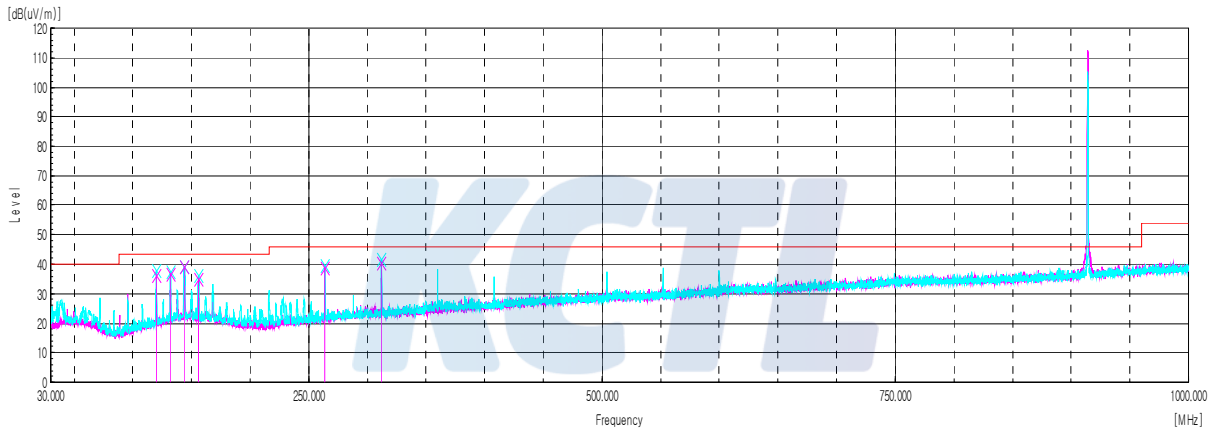
Horizontal/Vertical



Middle frequency

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(㎒)	(V/H)	(dB(㎶))	(dB)	(dB)	(dB)	(dB(㎶/m))	(dB(㎶/m))	(dB)
Quasi peak data								
119.97[1)]	V	48.10	17.20	-29.08	-	36.22	43.50	7.28
132.09[1)]	V	47.50	18.11	-28.94	-	36.67	43.50	6.83
143.73	V	48.90	19.02	-28.83	-	39.09	43.50	4.41
155.98	V	44.80	18.98	-28.78	-	35.00	43.50	8.50
264.01[1)]	V	48.80	18.24	-28.13	-	38.91	46.00	7.09
312.03	V	48.60	19.62	-27.70	-	40.52	46.00	5.48

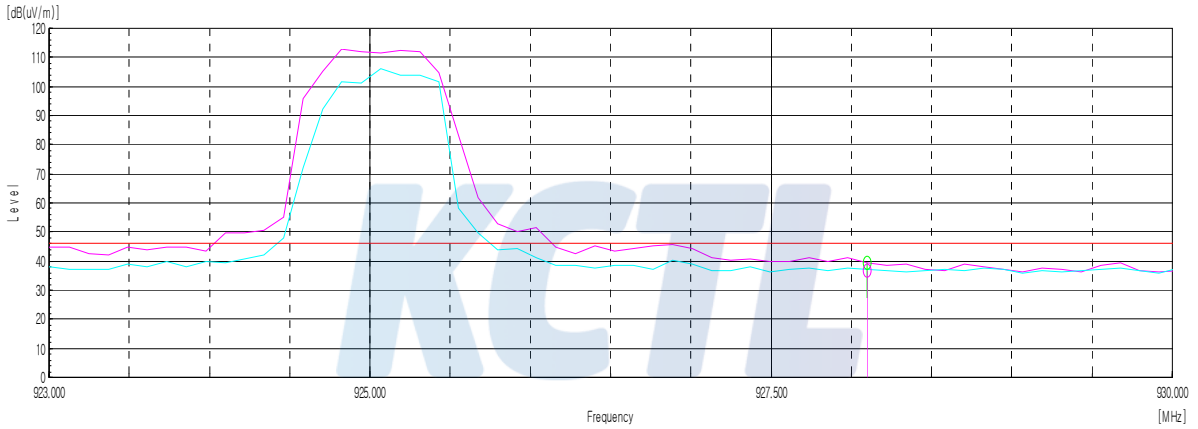
Horizontal/Vertical



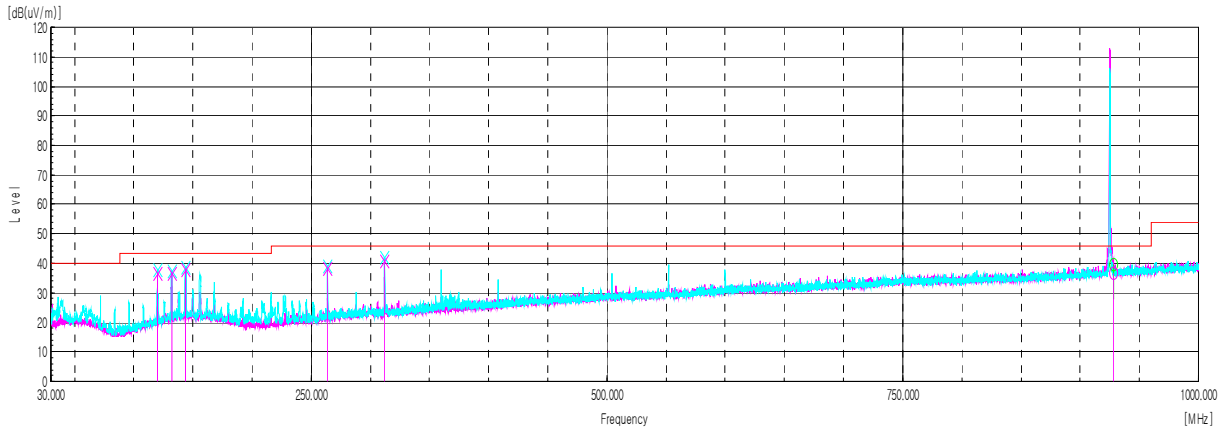
High frequency

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(㎒)	(V/H)	(dB(㎶))	(dB)	(dB)	(dB)	(dB(㎶/m))	(dB(㎶/m))	(dB)
Quasi peak data								
119.97[1)]	V	48.70	17.20	-29.08	-	36.82	43.50	6.68
132.09[1)]	V	47.60	18.11	-28.94	-	36.77	43.50	6.73
144.10	V	47.90	19.05	-28.83	-	38.12	43.50	5.38
264.01[1)]	V	48.30	18.24	-28.13	-	38.41	46.00	7.59
312.03	V	49.00	19.62	-27.70	-	40.92	46.00	5.08
928.10	H	31.10	29.66	-23.86	-	36.90	46.00	9.10

Horizontal/Vertical for Band-edge



Horizontal/Vertical

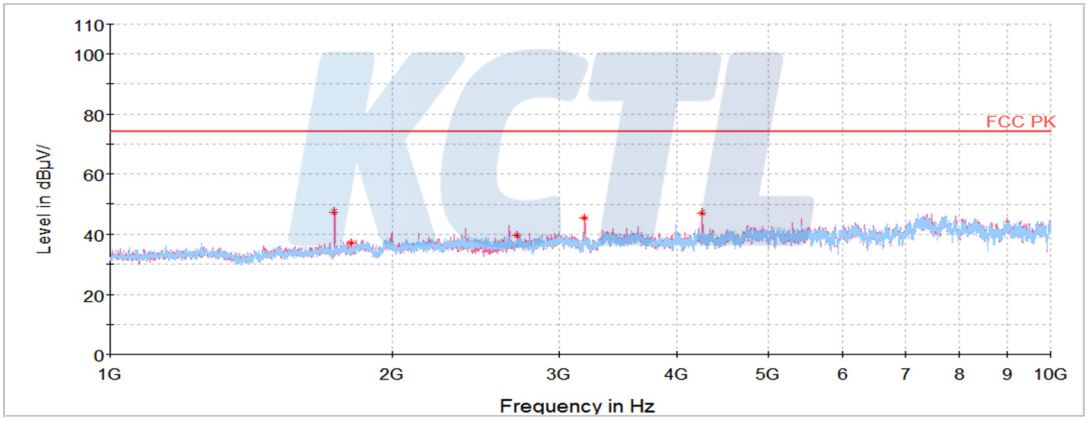


Test results (Above 1 000 ㎒)

Low frequency

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(㎒)	(V/H)	(dB(㎶))	(dB)	(dB)	(dB)	(dB(㎶/m))	(dB(㎶/m))	(dB)
Peak data								
1 733.13	V	76.78	29.45	-58.69	-	47.54	74.00	26.46
1 808.03	V	66.00	29.91	-58.86	-	37.05	74.00	36.95
2 712.22[1)]	V	65.32	32.27	-57.76	-	39.83	74.00	34.17
3 190.88	V	70.85	32.54	-57.83	-	45.56	74.00	28.44
4 251.78[1)]	V	69.20	33.40	-55.48	-	47.12	74.00	26.88
Average Data								
No spurious emissions were detected within 20 ㏈ of the limit.								

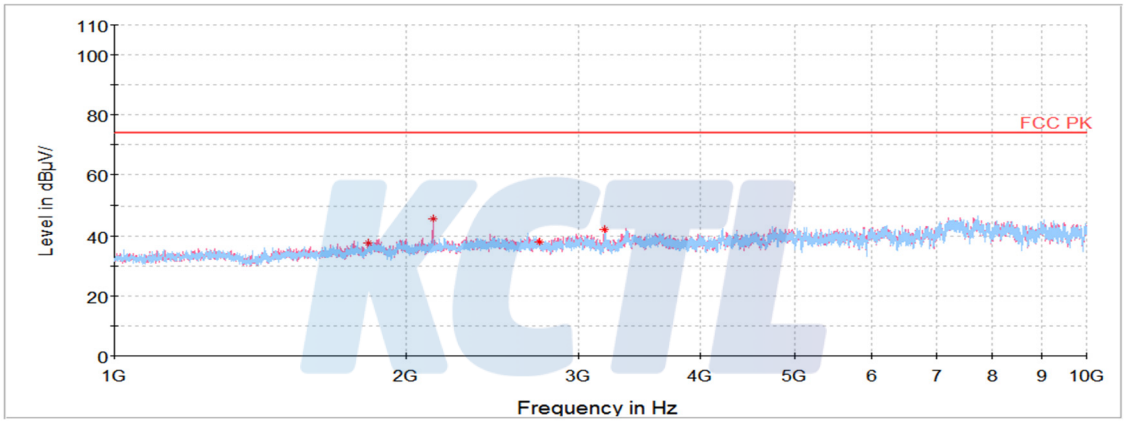
Horizontal/Vertical for 1 ㎓ ~ 10 ㎓



Middle frequency

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(㎒)	(V/H)	(dB(㎶))	(dB)	(dB)	(dB)	(dB(㎶/m))	(dB(㎶/m))	(dB)
Peak data								
1 828.75	V	66.35	30.04	-58.8	-	37.59	74.00	36.41
2 131.03	V	73.04	31.36	-58.71	-	45.69	74.00	28.31
2 741.97[1)]	V	63.75	32.29	-58.05	-	37.99	74.00	36.01
3 186.63	V	67.58	32.54	-57.85	-	42.27	74.00	31.73
Average Data								
No spurious emissions were detected within 20 ㏈ of the limit.								

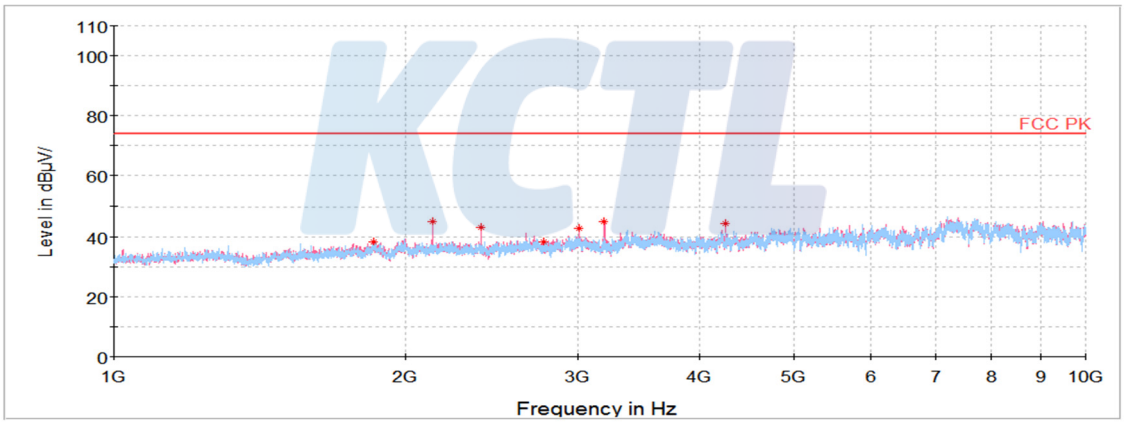
Horizontal/Vertical for 1 ㎓ ~ 10 ㎓



High frequency

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(㎒)	(V/H)	(dB(㎶))	(dB)	(dB)	(dB)	(dB(㎶/m))	(dB(㎶/m))	(dB)
Peak data								
1 850.00	V	67.00	30.17	-58.74	-	38.43	74.00	35.57
2 128.38	V	72.32	31.36	-58.71	-	44.97	74.00	29.03
2 390.81	V	69.47	31.88	-58.16	-	43.19	74.00	30.81
2 774.38[1)]	V	64.37	32.32	-58.37	-	38.32	74.00	35.68
3 006.00	V	67.30	32.50	-57.12	-	42.68	74.00	31.32
3 191.94	V	70.25	32.54	-57.82	-	44.97	74.00	29.03
4 260.28[1)]	V	66.45	33.42	-55.57	-	44.30	74.00	29.70
Average Data								
No spurious emissions were detected within 20 ㏈ of the limit.								

Horizontal/Vertical for 1 ㎓ ~ 10 ㎓



8. Measurement equipment

Equipment Name	Manufacturer	Model No.	Serial No.	Next Cal. Date
Spectrum Analyzer	R&S	FSV40	100988	21.01.03
Wideband Power Sensor	R&S	NRP-Z81	102398	21.01.21
ATTENUATOR	R&S	DNF Dämpfungsglied 10 dB in N-50 Ohm	31212	20.05.13
EMI TEST RECEIVER	R&S	ESCI7	100732	20.08.22
Bi-Log Antenna	SCHWARZBECK	VULB 9168	583	20.05.04
Amplifier	SONOMA INSTRUMENT	310N	284608	20.08.22
COAXIAL FIXED ATTENUATOR	Agilent	8491B-003	2708A18758	20.05.04
Horn antenna	ETS.lindgren	3117	155787	20.10.24
Attenuator	API Inmet	40AH2W-10	12	20.05.15
AMPLIFIER	L-3 Narda-MITEQ	AMF-7D-01001800 -22-10P	2031196	20.02.21
LOOP Antenna	R&S	HFH2-Z2	100355	20.08.24
Antenna Mast	Innco Systems	MA4640-XP-ET	-	-
Turn Table	Innco Systems	DT2000	79	-
Antenna Mast	Innco Systems	MA4000-EP	303	-
Turn Table	Innco Systems	DT2000	79	-
High Pass Filter	Wainwright Instruments GmbH	WHKX10-1290-1500-15000-60SS	6	20.05.02
Vector Signal Generator	R&S	SMBV100A	257566	20.07.16
Signal Generator	R&S	SMR40	100007	20.05.13
Cable Assembly	RadiAll	2301761768000PJ	1724.659	-
Cable Assembly	gigalane	RG-400	-	-
Cable Assembly	HUER+SUHNER	SUCOFLEX 104	MY4342/4	-

End of test report