



TEST REPORT

KCTL Inc. 65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea TEL: 82-31-285-0894 FAX: 82-505-299-8311 www.kctl.co.kr	Report No.: KR20-SRF0027-A Page (1) of (22)			
1. Client ◦ Name : POWEROS.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 : POWEROS.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	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px;"> Tested by Name : Euijung Kim (Signature) </td> <td style="width: 50%; padding: 5px;"> Technical Manager Name : Bobae Lee (Signature) </td> </tr> </table>	Tested by Name : Euijung Kim (Signature)	Technical Manager Name : Bobae Lee (Signature)	2020-02-11 KCTL Inc. As a test result of the sample which was submitted from the client, this report does not guarantee the whole product quality. This test report should not be used and copied without a written agreement by KCTL Inc.
Tested by Name : Euijung Kim (Signature)	Technical Manager Name : Bobae Lee (Signature)			

Report revision history

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

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 The report No. KR20-SRF0027 is superseded by the report No. KR20-SRF0027-A.



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1. General information

Client : POWEROS.CO.,LTD
 Address : Bizdong-B117, SKN TECHNOPARK, 124, Sagimakgol-ro, Jungwon-gu, Seongnam-si, Gyeonggi-do, Republic of Korea
 Manufacturer : POWEROS.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 MHz ~ 925 MHz
 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 °C

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

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 [MHz]	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)

- 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)
- This test is not applicable because the EUT uses battery and it's not to be connected to the public utility(AC) power line.
- 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.
- 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
- 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 indicate a 95 % level of confidence. The measurement data shown herein meets or 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 kHz ~ 30 MHz:	2.28 dB
	30 MHz ~ 300 MHz	4.98 dB
	300 MHz ~ 1 000 MHz	5.14 dB
	1 GHz ~ 6 GHz	6.70 dB
	Above 6 GHz	6.60 dB

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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 (MHz)	Factor(dB)	Frequency (MHz)	Factor(dB)
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

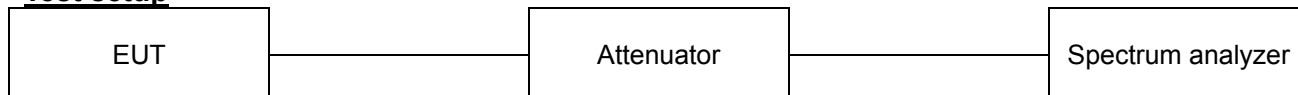
Note.

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

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 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 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

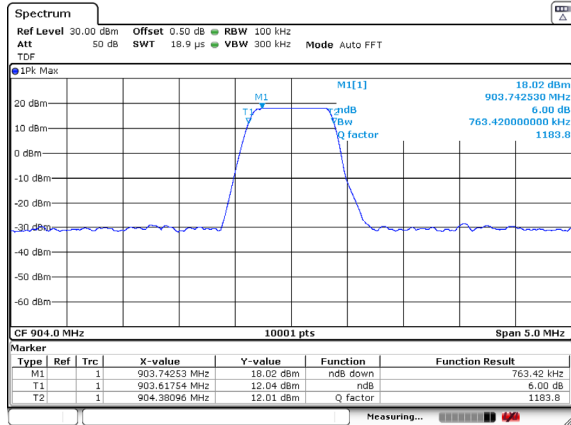
- 1) Set RBW = 100 kHz.
- 2) Set the video bandwidth (VBW) $\geq 3 \times$ RBW.
- 3) Detector = Peak.
- 4) Trace mode = max hold.
- 5) Sweep = auto couple.
- 6) Allow the trace to stabilize.
- 7) Measure the maximum width of the emission that is constrained by the frequencies associated with the two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

Test results

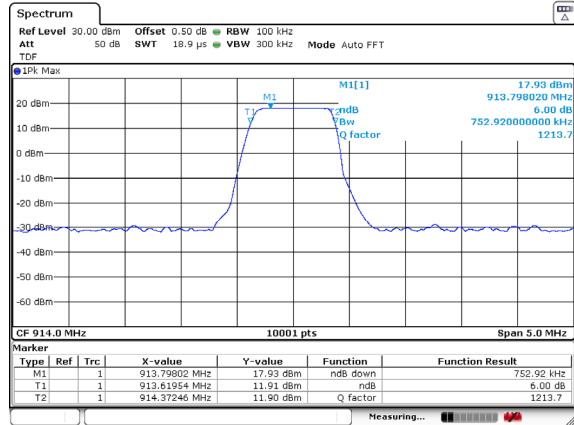
Test mode	Frequency(MHz)	6 dB bandwidth(MHz)
SF 9	904	0.76
	914	0.75
	925	0.75

6 dB bandwidth(MHz)

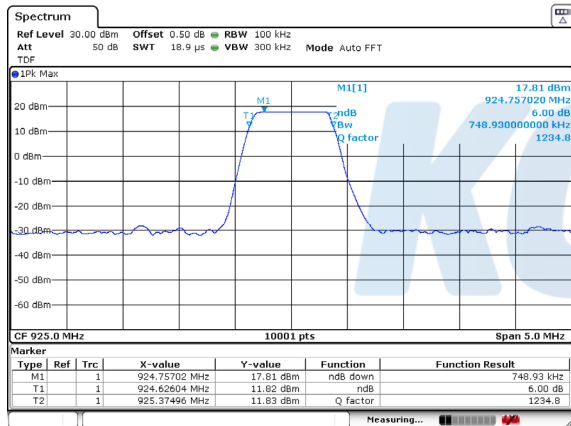
904 MHz



914 MHz



925 MHz

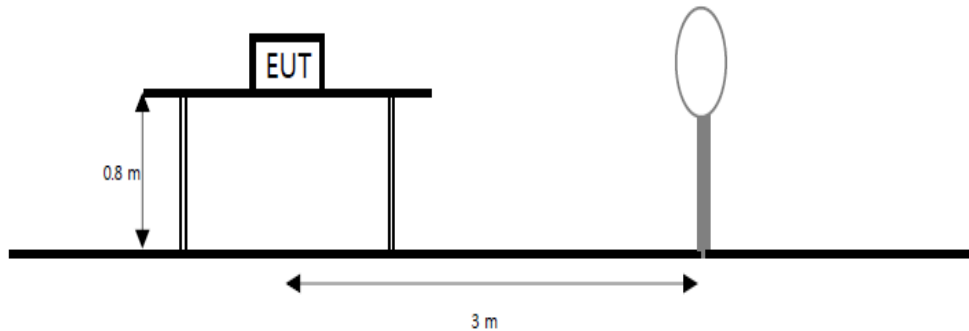


Blank

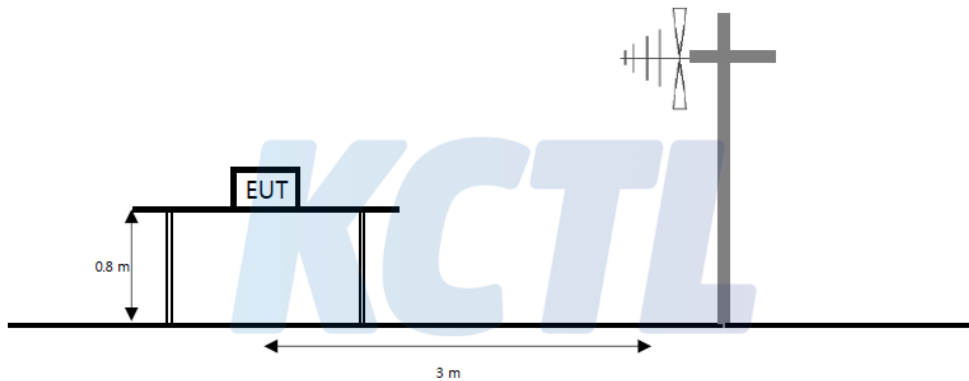
7.2. Radiated spurious emissions & band edge

Test setup

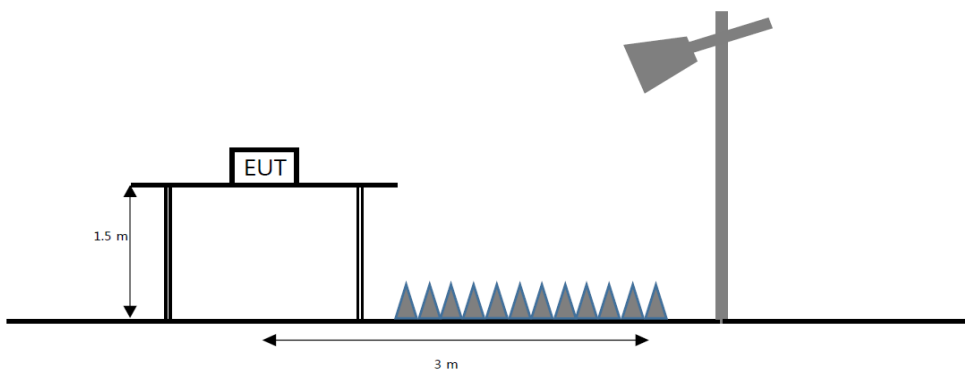
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 kHz to 30 MHz Emissions



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.



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 (MHz)	Field strength ($\mu\text{V/m}$)	Measurement distance (m)
0.009 - 0.490	2 400/F(kHz)	300
0.490 - 1.705	24 000/F(kHz)	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 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., Section 15.231 and 15.241.

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

MHz	MHz	MHz	GHz
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	2 483.5 - 2 500	17.7 - 21.4
8.376 25 - 8.386 75	25	2 690 - 2 900	22.01 - 23.12
8.414 25 - 8.414 75	156.7 - 156.9	3 260 - 3 267	23.6 - 24.0
12.29 - 12.293	162.012 5 - 167.17	3 332 - 3 339	31.2 - 31.8
12.519 75 - 12.520 25	167.72 - 173.2	3 345.8 - 3 358	36.43 - 36.5
12.576 75 - 12.577 25	240 - 285	3 600 - 4 400	Above 38.6
13.36 - 13.41	322 - 335.4		

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 MHz, compliance with the limits in section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1 000 MHz, 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 $\geq (3 \times \text{RBW})$
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 kHz to 150 kHz	200 Hz to 300 Hz
0.15 MHz to 30 MHz	9 kHz to 10 kHz
30 MHz to 1 000 MHz	100 kHz to 120 kHz
> 1 000 MHz	1 MHz

Average field strength measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1 MHz
3. VBW = $1/T \geq 1$ Hz
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 MHz for Peak detection and frequency above 1 GHz. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 1 kHz ($\geq 1/T$) for Average detection (AV) at frequency above 1 GHz. (where T = pulse width)
2. $f < 30$ 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. $F_d = 20 \log(D_m/D_s)$

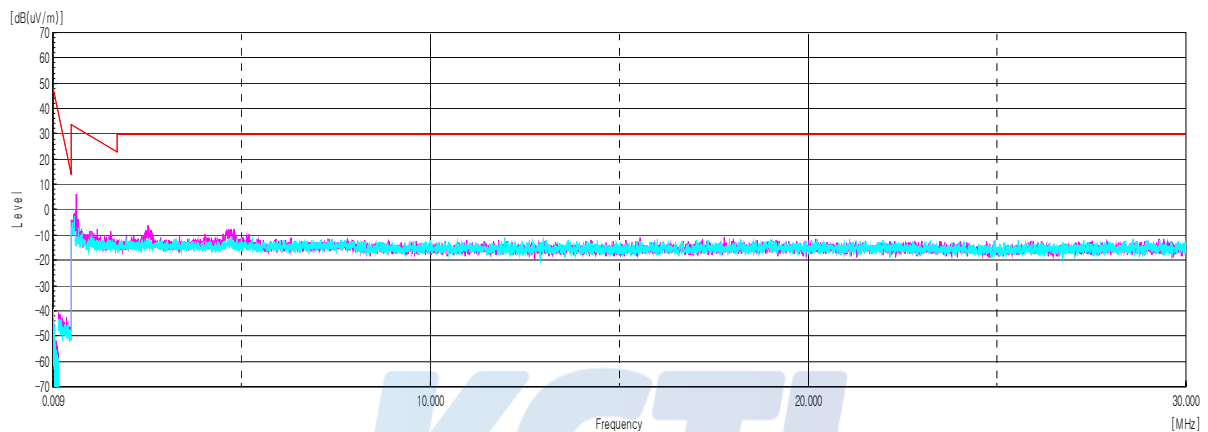
Where:

 F_d = Distance factor in dB D_m = Measurement distance in meters D_s = Specification distance in meters

3. Factors(dB) = Antenna factor(dB/m) + Cable loss(dB) + or Amp. gain(dB) + or F_d (dB)
4. The worst-case emissions are reported however emissions whose levels were not within 20 dB 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.

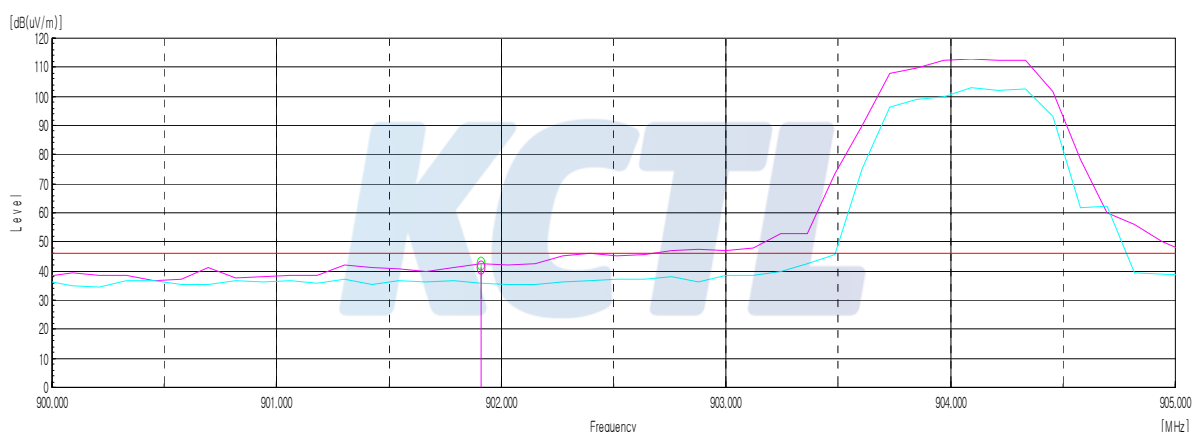
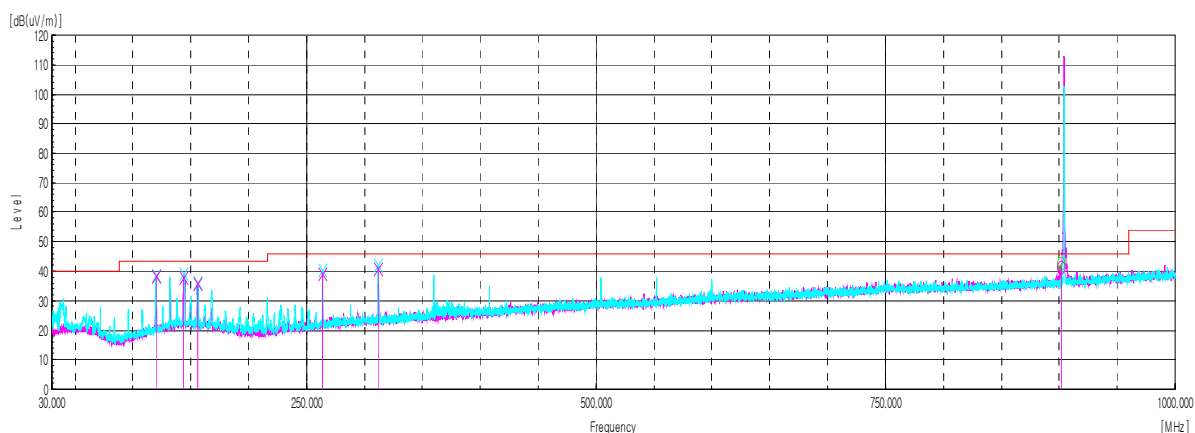
Test results (Below 30 MHz) – Worst case: SF9 lowest Channel

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

Horizontal/Vertical

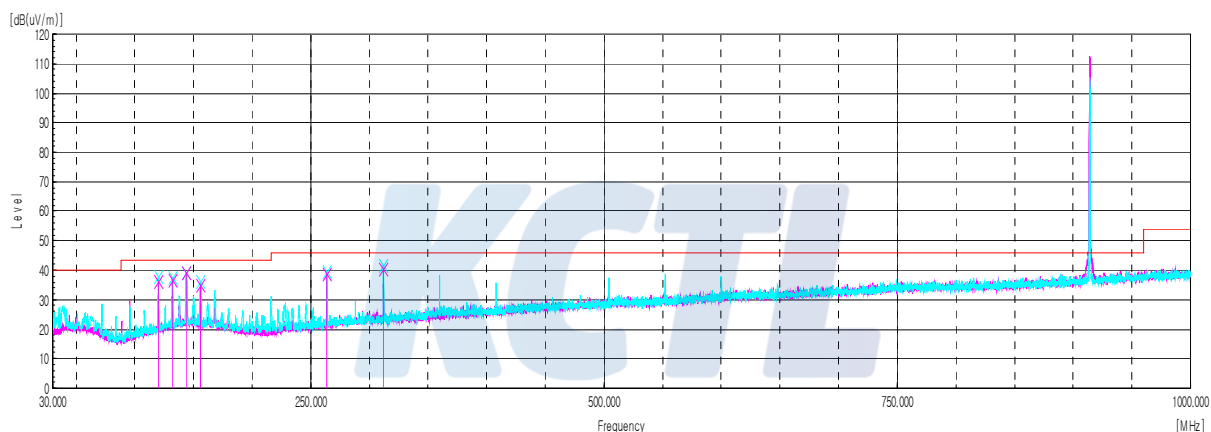
Test results (Below 1 000 MHz)**Low frequency**

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(MHz)	(V/H)	(dB(μV))	(dB)	(dB)	(dB)	(dB(μV/m))	(dB(μV/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**

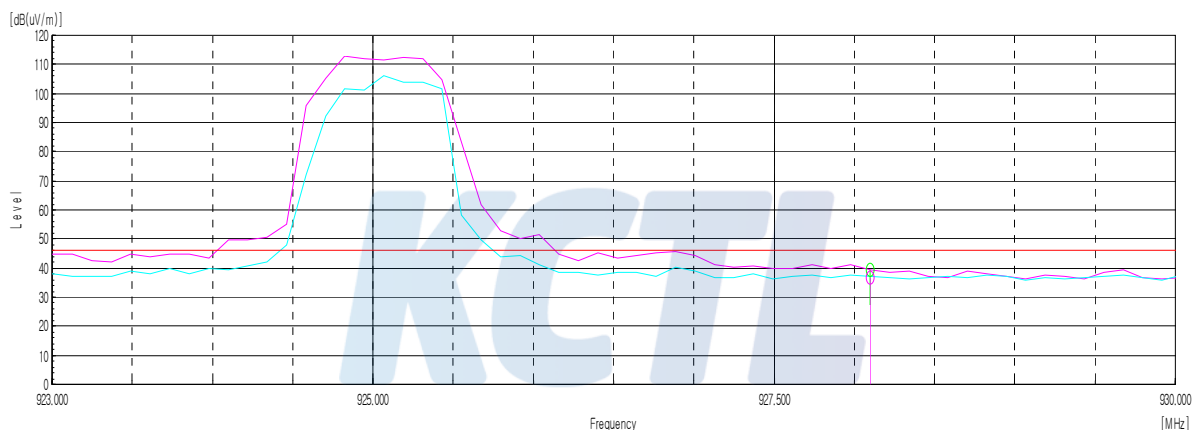
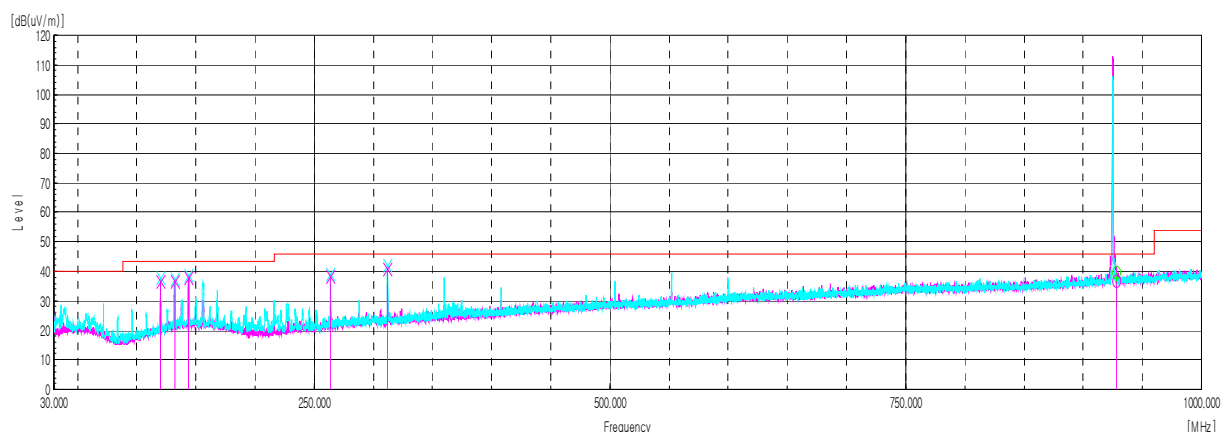
Middle frequency

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(MHz)	(V/H)	(dB(μ V))	(dB)	(dB)	(dB)	(dB(μ V/m))	(dB(μ V/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

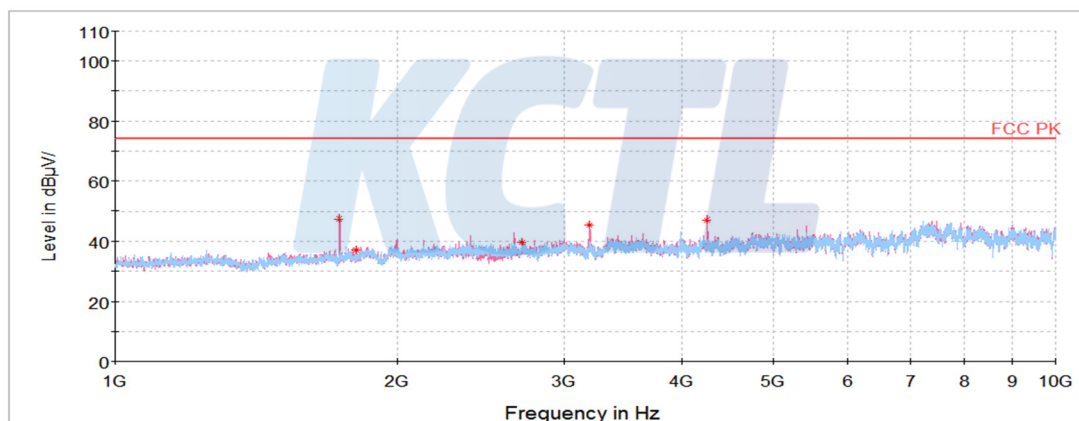
High frequency

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(MHz)	(V/H)	(dB(μ V))	(dB)	(dB)	(dB)	(dB(μ V/m))	(dB(μ V/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**

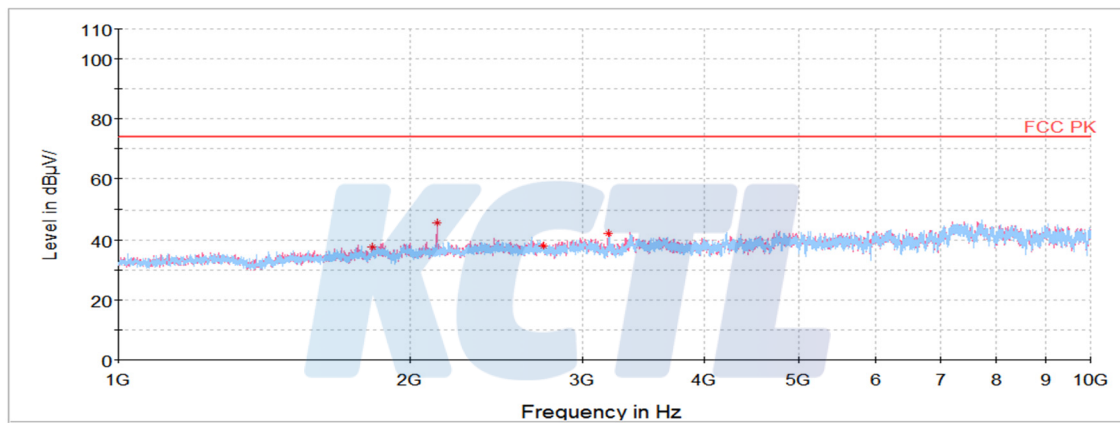
Test results (Above 1 000 MHz)**Low frequency**

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(MHz)	(V/H)	(dB(μ V))	(dB)	(dB)	(dB)	(dB(μ V/m))	(dB(μ V/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 dB of the limit.								

Horizontal/Vertical for 1 GHz ~ 10 GHz

Middle frequency

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(MHz)	(V/H)	(dB(μ V))	(dB)	(dB)	(dB)	(dB(μ V/m))	(dB(μ V/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 dB of the limit.								

Horizontal/Vertical for 1 GHz ~ 10 GHz

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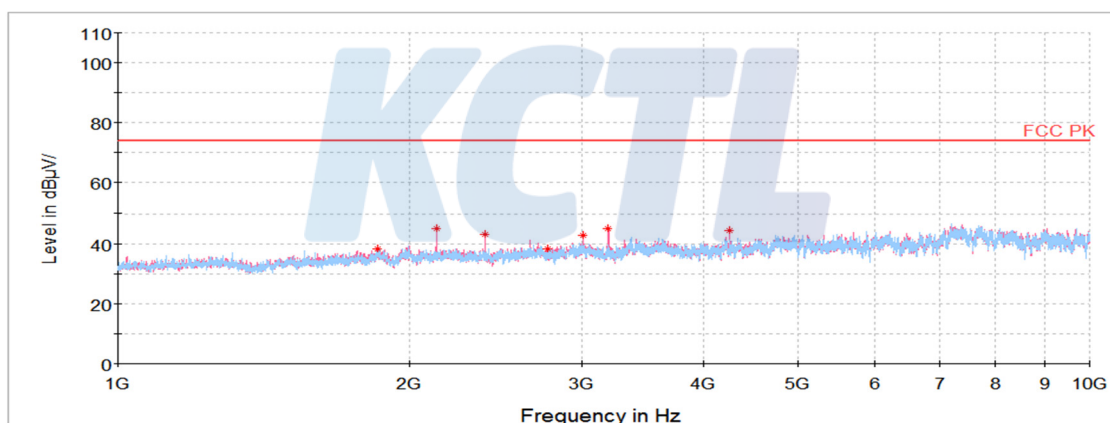
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Suwon-si, Gyeonggi-do, 16677, Korea
TEL: 82-31-285-0894 FAX: 82-505-299-8311
www.kctl.co.kr

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KCTL**High frequency**

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(MHz)	(V/H)	(dB(μ V))	(dB)	(dB)	(dB)	(dB(μ V/m))	(dB(μ V/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 dB of the limit.								

Horizontal/Vertical for 1 GHz ~ 10 GHz

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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