TEST REPORT

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1. Client

- Name : VESTA.DS,Inc.
- Address : 401 south. Dupont Ave. Ontario. CA 91761
- Date of Receipt : 2019-05-13

2. Use of Report : -

3. Name of Product and Model : SMART I/O / DR960I

4. Manufacturer and Country of Origin : DAESUNG CELTIC ENERSYS / Korea

5. FCC ID : 2ARQP-DR960I

6. Date of Test : 2019-05-27 to 2019-06-05

7. Test Standards : FCC Part 15 Subpart C, 15.209, 15.231

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

Affirmation	Tested by Name : Kwonse Kim (Signature)	Technical Manager Name : Jaehyong Lee (Signature)

2019-08-22

KCTL Inc.

Report revision history

Date	Revision	Page No
2019-07-23	Initial report	-
2019-08-22	Updated	6

CONTENTS

1. General information

Client	:	VESTA.DS,Inc.
Address	:	401 south. Dupont Ave. Ontario. CA 91761
Manufacturer	:	DAESUNG CELTIC ENERSYS
Address	:	55-72, SANGGOK-RO,SAMSUNG-MYUN,EUMSUNG-GUN,CHUNGBUK, KOREA,27658
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-3327, G-198, C-3706, T-1849
		Industry Canada Registration No. : 8035A
		KOLAS No.: KT231

2. Device information

Equipment under test	:	SMART I/O
Model	:	DR960I
Frequency range	:	433.125 ㎒ ~ 434.125 ㎒
Modulation technique	:	FSK
Number of channels	:	20 ch
Power source	:	DC 12 V
Antenna specification	:	Helical Antenna
Antenna gain	:	-2.35 dBi
Software version	:	1.0.1
Hardware version	:	DR960I_v1.1
Test device serial No.	:	N/A
Operation temperature	:	23 ℃

2.1. Accessory information

Equipment	Manufacturer	Model	Serial No.	Power source
Power cable	-	-	-	DC12V, 200mA

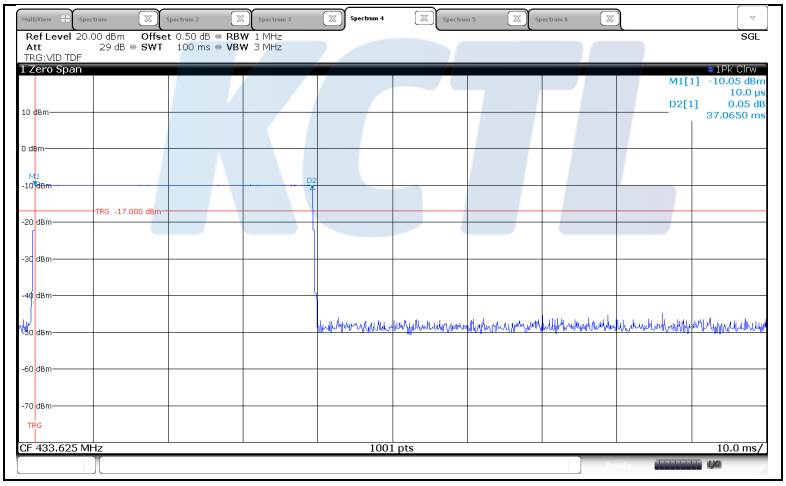
2.2. Frequency/channel operations

This device contains the following capabilities:
433 ㎒

Ch.	Frequency (㎒)
0	433.125
.	.
.	.
10	433.625
.	.
.	.
20	434.125

Table 2.2.1. 433 ㎒ mode

2.3. Duty Cycle Correction Factor



Note1) : Period : 100 ㎳, On time : 37.07 ㎳
Note2) : DCCF = 20log(1/x) = 20log(1/0.37) = 8.62 dB, x = 37.07/100 = 0.37

3. Antenna requirement

According to §15.203
"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can 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 a unique coupling(Reverse type SMA).

4. Summary of tests

FCC Part section(s)	Parameter	Test results
15.231(c)	20dB Bandwidth	Pass
15.231(a)	Transmission Time	Pass
15.205(a),(b) 15.209(a) 15.231(b)	Field Strength of Fundamental and Spurious Emission	Pass
15.207(a)	Conducted Emissions	Pass

Notes:

1. 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.
2. 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
3. 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(±)	
Conducted RF power	1.76 dB	
Conducted spurious emissions	4.03 dB	
Radiated spurious emissions	9 ㎑ ~ 30 ㎒	2.28 dB
	30 ㎒ ~ 300 ㎒	4.98 dB
	300 ㎒ ~ 1 000 ㎒	5.14 dB
	1 ㎓ ~ 6 ㎓	6.70 dB
	Above 6 ㎓	6.60 dB
Conducted emissions	9 ㎑ ~ 150 ㎑	3.66 dB
	150 ㎑ ~ 30 ㎒	3.26 dB

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.

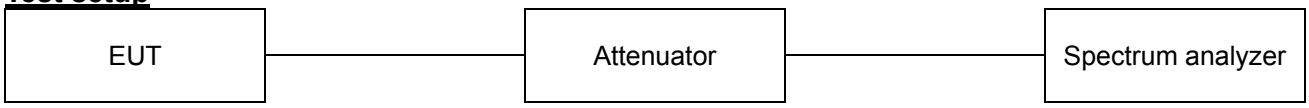
Frequency (㎒)	Factor(㏈)	Frequency (㎒)	Factor(㏈)
30	10.08	800	10.45
100	10.19	900	10.55
200	10.12	1 000	10.52
300	10.26	2 000	10.87
400	10.30	3 000	11.07
500	10.40	4 000	11.30
600	10.45	5 000	11.46
700	10.46	6 000	11.70

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

7. Test results

7.1. 20 dB Bandwidth

Test setup



Limit

According to §15.231(c), the bandwidth of the emission shall be no wider than 0.25 % of the center frequency for devices operating above 70 ㎒ and below 900 ㎒. For devices operating above 900 ㎒, the emission shall be no wider than 0.5 % of the Center Frequency. Bandwidth is determined at the point 20 dB down from the modulated carrier.

Test procedure

ANSI C63.10, Section 6.9.2

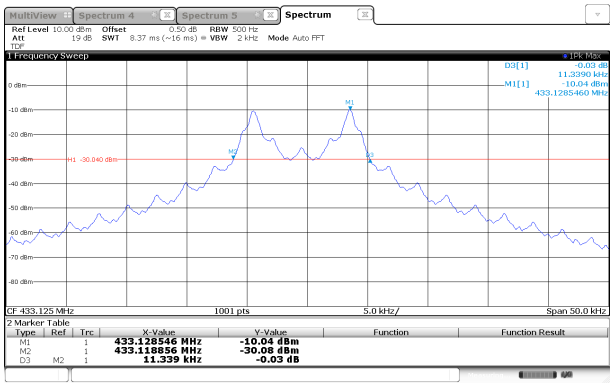
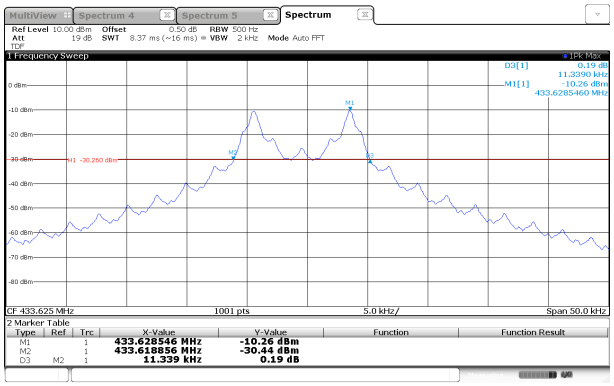
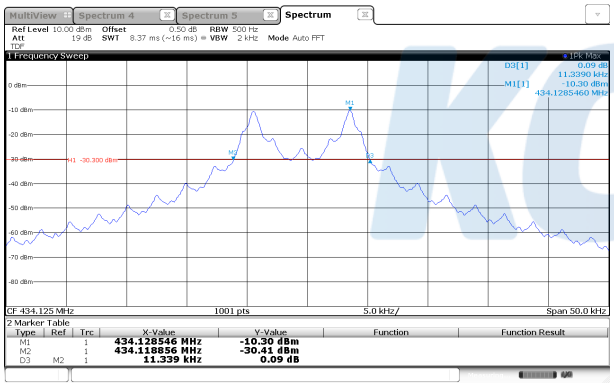
Test settings

1. Set RBW = 1% to 5% of the OBW
2. Set the VBW > RBW. X 3
3. Detector = Peak.
4. Trace mode = Max hold.

Test results

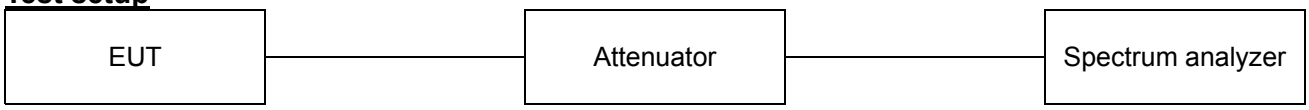
Frequency [㎒]	20 dB Bandwidth [㎒]	Limit [㎒]
433.125	0.011	1.083
433.625	0.011	1.084
434.125	0.011	1.085

Test plot

Low Channel	Mid Channel
	
High Channel	
	Blank

7.2. Transmission Time

Test setup



Limit

According to §15.231(a)(1), a manually operated transmitter shall employ a switch that will automatically deactivate the transmitter within not more than 5 seconds of being released.

Test procedure

ANSI C63.10-2013.

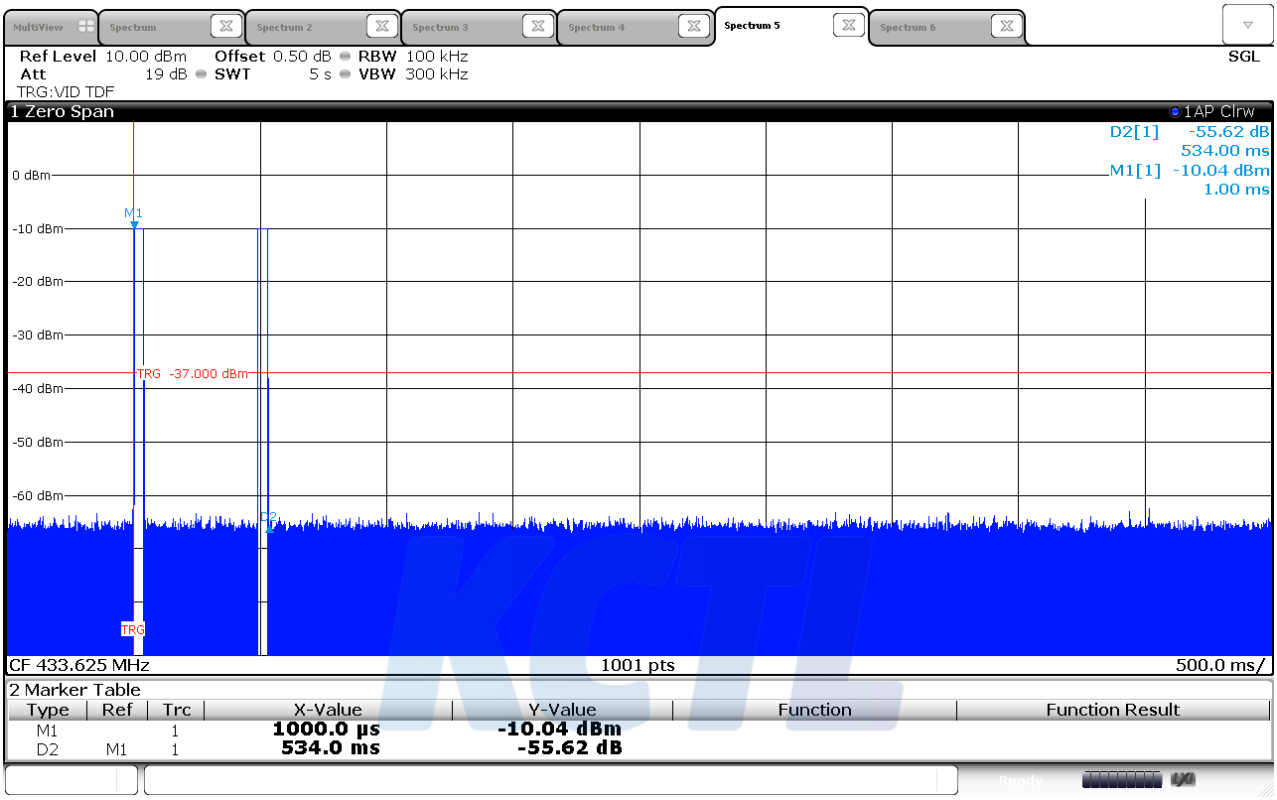
1. The transmitter output is connected to the spectrum analyzer.
2. RBW : 100 ㎑
3. VBW : 300 ㎑
4. Span : Zero span
5. The bandwidth of fundamental frequency was measured and recorded.

Test results

Frequency [㎒]	Transmission time [s]	Limit [s]
433.625	0.534	5.000

Test plot

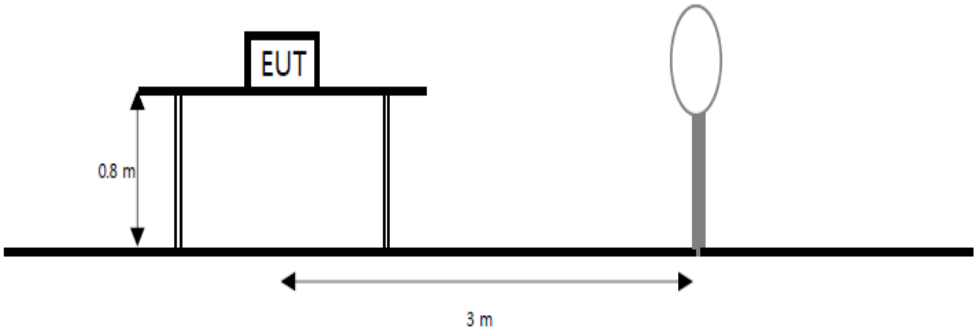
FSK



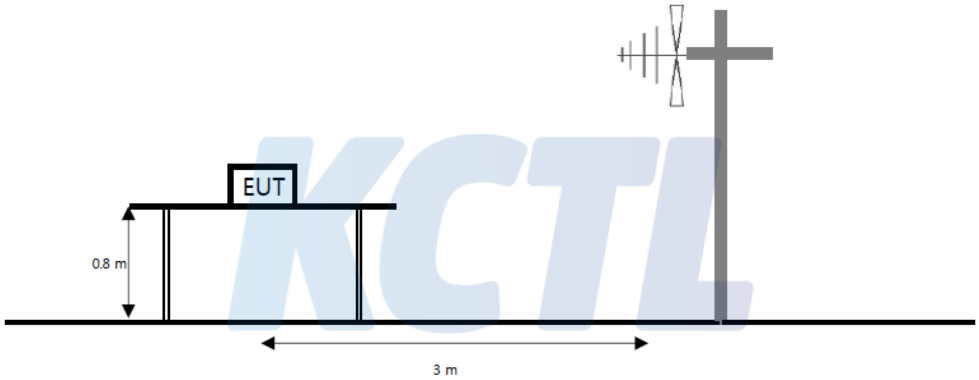
7.3. Field strength of Fundamental and Spurious emission

Test setup

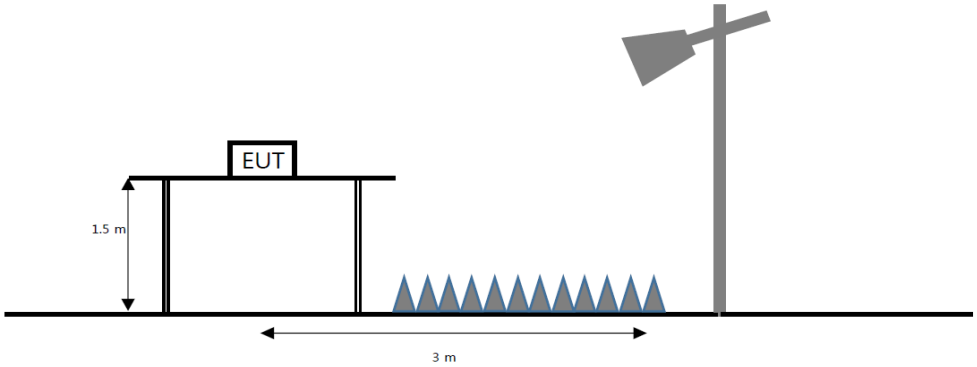
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 ㎑ to 30 ㎒ Emissions



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 §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: 83

Frequency (㎒)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 - 0.490	2 400/F(㎑)	300
0.490 - 1.705	24 000/F(㎑)	30
1.705 - 30.0	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., Sections 15.231 and 15.241..

According to §15.231(b), in addition to the provisions of Section 15.205, the field strength of emissions from intentional radiators operated under this Section shall not exceed the following:

Fundamental Frequency (㎒)	Field Strength of Fundamental (microvolts/meter)	Field Strength of Spurious Emissions (microvolts/meter)
40.66 - 40.70	2,250	225
70 - 130	1,250	125
130 - 174	1,250 to 3,750 **	125 to 375 **
174 - 260	3,750	375
260 - 470	3,750 to 12,500 **	375 to 1,250 **
Above 470	12,500	1,250

** linear interpolations

Test procedure

ANSI C63.10-2013

Test settings

a. 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.

b. During performing radiated emission below 1 ㎓, the EUT was set 3 meters away from the interference receiving antenna, which was mounted on the top of a variable-height antenna tower. During performing radiated emission above 1 ㎓, the EUT was set 3 meter away from the interference-receiving antenna.

c. The spectrum from 9 ㎑ to 6 ㎓ was investigated with the transmitter on. For 9 ㎑ to 30 ㎒, the transmitter was set to the worst-case channel. For 30 ㎒ to 6 ㎓, the transmitter was set to Low and High channels, as described in 15.31(m).

d. The antenna is a broadband antenna, and its height is varied from 1 meter to 4 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.

e. 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.

f. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.

g. If the emission level of the EUT in peak mode was 10 ㏈ lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 ㏈ margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

h. It tested x,y and z – 3 axis each, mentioned only worst case data at this report.

i. Normally, output is measured with average result. but in this case, average result is calculated by measuring peak result and applying DCCF.

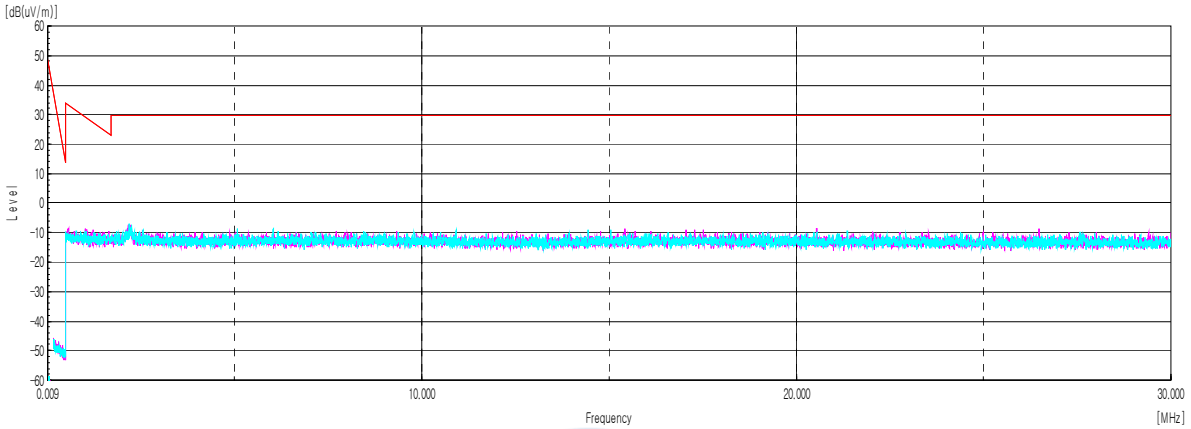
Notes:.

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 ㎑ for peak detection(PK) and Quasi-peak detection (QP) at frequency below 1 ㎓.
2. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 1 ㎒ for peak detection and frequency above 1 ㎓.
3. The radiated restricted band edge and spurious radiated emissions average measurements use a duty cycle correction factor (DCCF).
4. 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)
5. f <30 ㎒, extrapolation factor of 40 ㏈/decade of distance. Fd = 40log(Dm/Ds)
   f ≥30 ㎒, extrapolation factor of 20 ㏈/decade of distance. Fd = 20log(Dm/Ds)
   Where:
   Fd= Distance factor in ㏈
   Dm= Measurement distance in meters
   Ds= Specification distance in meters
6. Factors(㏈) = Antenna factor(㏈/m) + Cable loss(㏈) + or Amp. gain(㏈) + or Fd(㏈)
7. The worst-case emissions are reported however emissions whose levels were not within 20 ㏈ of respective limits were not reported.
8. Average test would be performed if the peak result were greater than the average limit.
9. 1) means restricted band.
10. 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: Middle frequency

Frequency	Pol.	Reading	Cable Loss	Amp Gain	Ant. 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

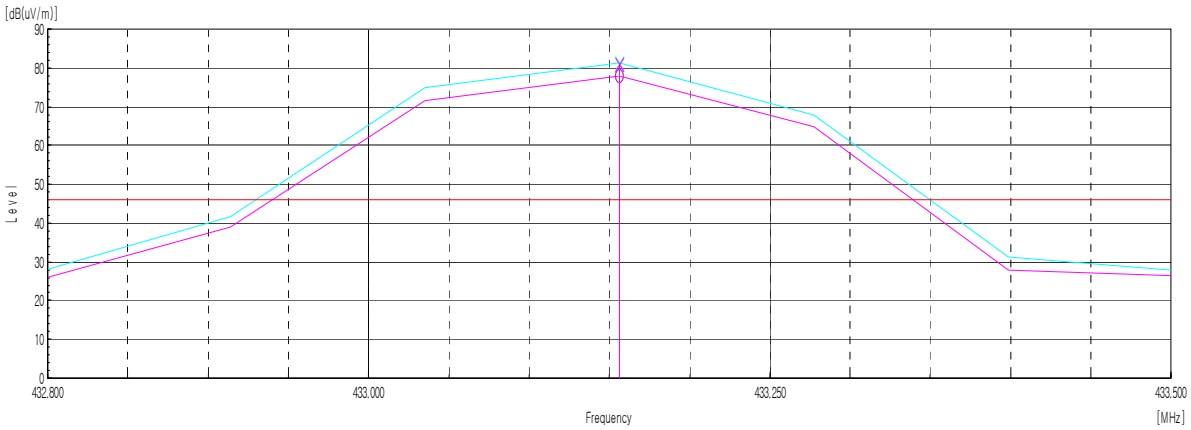


Test results (Below 1 000 ㎒) - Field strength of fundamental

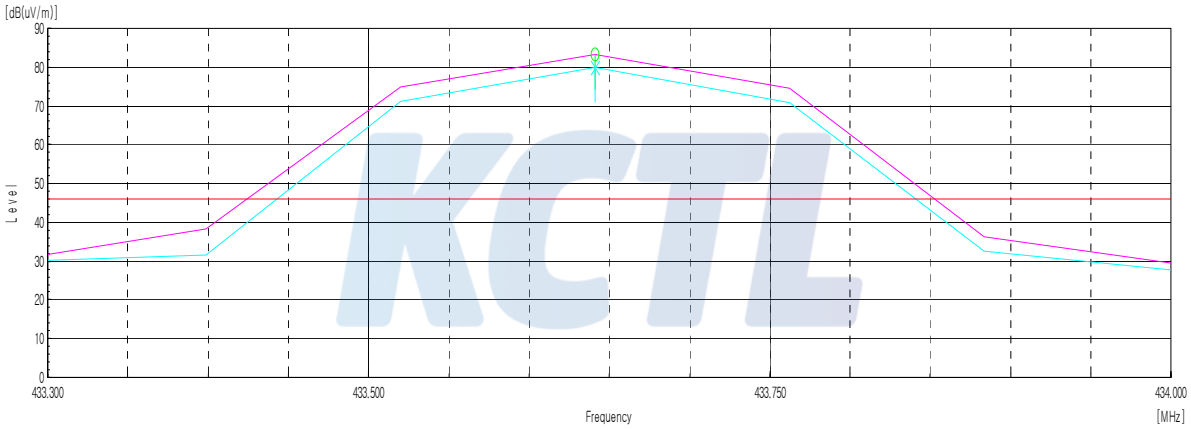
Frequency	Reading	Pol.	Ant. Factor	Amp + Cable	DCCF	Result	Limit	Margin
(㎒)	(dB(㎶))	(V/H)	(dB)	(dB)	(dB)	(dB(㎶/m))	(dB(㎶/m))	(dB)
Peak data								
433.125	85.8	H	22.66	-27.33	-	81.20	100.80	19.60
433.625	87.8	H	22.67	-27.33	-	83.20	100.82	17.62
434.125	85.7	H	22.68	-27.33	-	81.10	100.83	19.73
Average Data								
433.125	85.8	H	22.66	-27.33	-8.62	72.58	80.80	8.22
433.625	87.8	H	22.67	-27.33	-8.62	74.58	80.82	6.24
434.125	85.7	H	22.68	-27.33	-8.62	72.48	80.83	8.35

Note.
1. Average results : Peak reading + Duty cycle correction factor

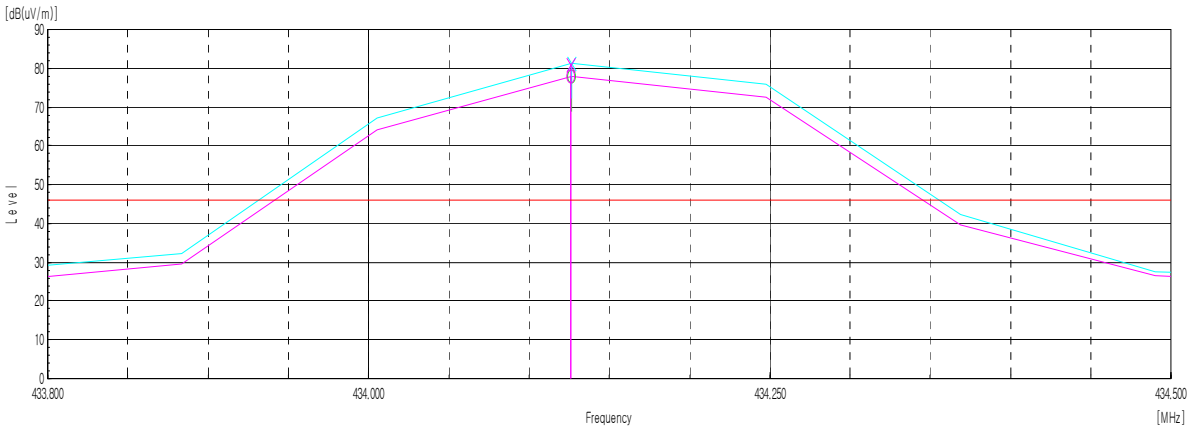
Horizontal/Vertical for Low channel



Horizontal/Vertical for Middle channel



Horizontal/Vertical for High channel

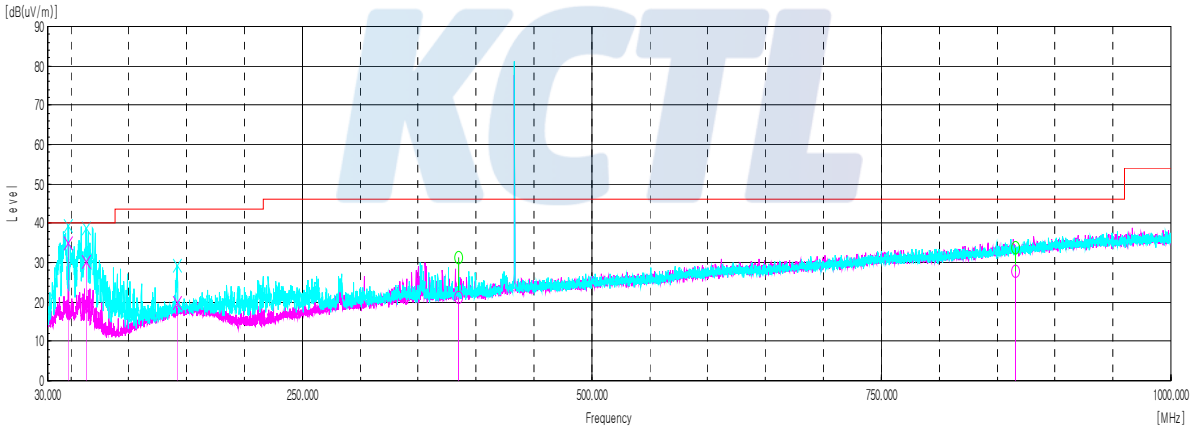


Test results (Below 1 000 ㎒) – Spurious emission

Low Channel

Frequency	Reading	Pol.	Ant. Factor	Amp + Cable	DCCF	Result	Limit	Margin
(㎒)	(dB(㎶))	(V/H)	(dB)	(dB)	(dB)	(dB(㎶/m))	(dB(㎶/m))	(dB)
Peak data								
866.14	29.80	H	28.90	-24.77	-	33.90	80.75	46.85
Average data								
No spurious emissions were detected within 20 ㏈ of the limit.								
Quasi peak Data								
47.95	47.40	V	18.40	-30.63	-	35.17	40.00	4.83
63.10	43.30	V	17.40	-30.36	-	30.34	40.00	9.66
141.91	30.50	V	18.91	-29.52	-	19.90	65.70	45.80
385.02	27.40	H	21.35	-27.63	-	21.10	46.00	24.90

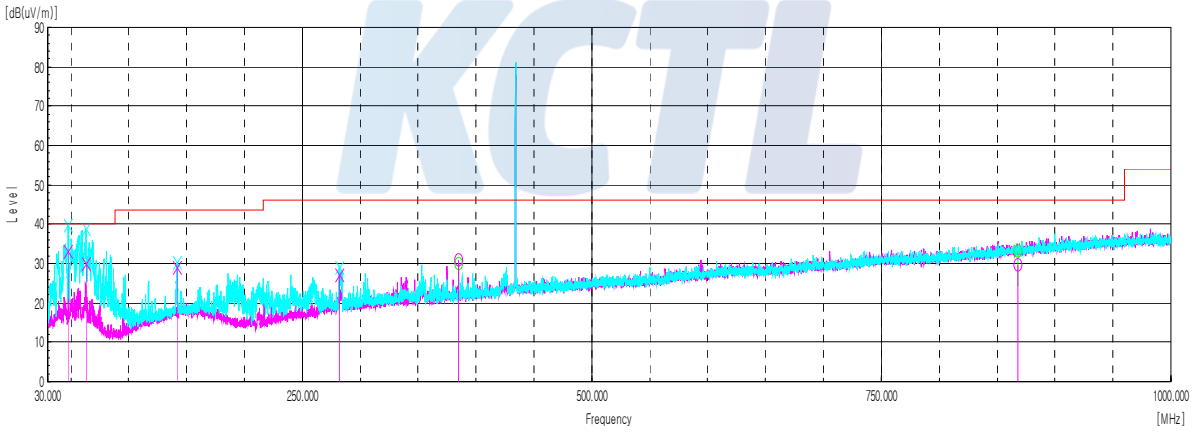
Horizontal/Vertical



High Channel

Frequency	Reading	Pol.	Ant. Factor	Amp + Cable	DCCF	Result	Limit	Margin
(㎒)	(dB(㎶))	(V/H)	(dB)	(dB)	(dB)	(dB(㎶/m))	(dB(㎶/m))	(dB)
Peak data								
868.20	31.00	H	28.90	-24.75	-	35.10	80.75	45.65
Average data								
No spurious emissions were detected within 20 ㏈ of the limit.								
Quasi peak Data								
47.95	42.40	V	18.40	-30.63	-	30.17	40.00	9.83
63.10	34.70	V	17.40	-30.36	-	21.74	40.00	18.26
141.79	26.80	V	18.91	-29.52	-	16.19	65.67	36.77
281.72	28.50	V	18.93	-28.33	-	19.10	46.00	18.90
385.02	31.00	H	21.35	-27.63	-	24.72	46.00	15.10

Horizontal/Vertical

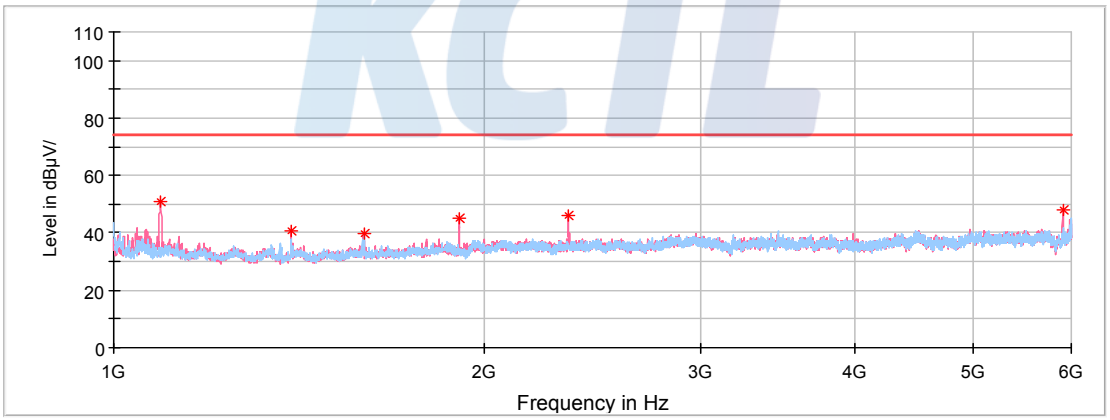


Test results (Above 1 000 ㎒)

Low Channel

Frequency	Reading	Pol.	Ant. Factor	Amp + Cable	DCCF	Result	Limit	Margin
(㎒)	(dB(㎶))	(V/H)	(dB)	(dB)	(dB)	(dB(㎶/m))	(dB(㎶/m))	(dB)
Peak data								
1 090.84	83.00	V	28.08	-60.17	-	50.91	74.00	23.09
1 394.19	71.74	V	28.02	-59.21	-	40.55	74.00	33.45
1 597.13	69.80	H	28.72	-58.59	-	39.93	74.00	34.07
1 909.50	72.03	V	31.03	-58.22	-	44.84	74.00	29.16
2 342.47	72.19	V	31.97	-57.94	-	46.22	74.00	27.78
5 905.56	67.76	V	34.99	-54.75	-	48.00	74.00	26.00
Average data								
No spurious emissions were detected within 20 dB of the limit.								

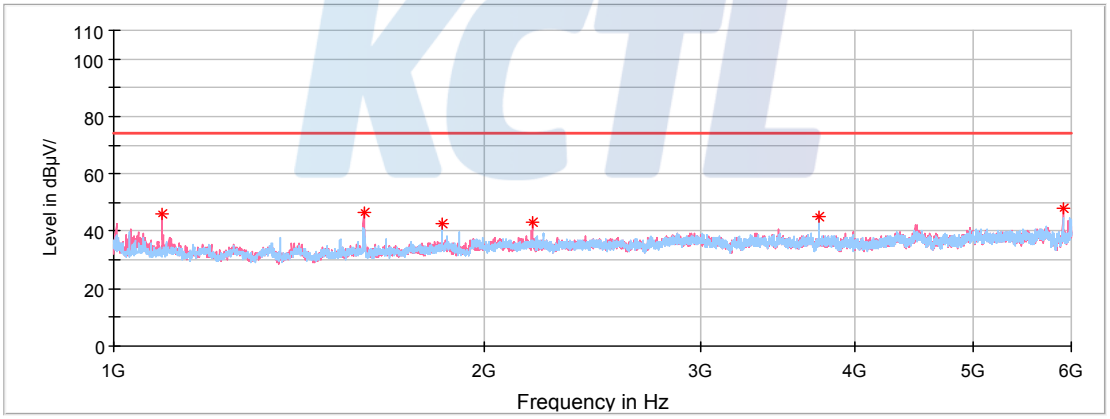
Horizontal/Vertical for 1 ㎓ ~ 6 ㎓



High Channel

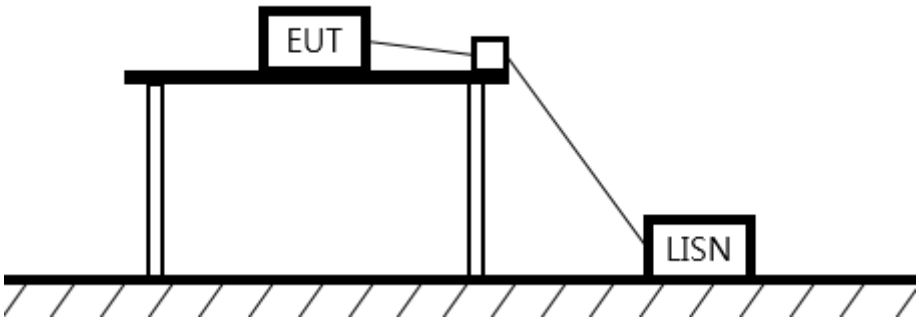
Frequency	Reading	Pol.	Ant. Factor	Amp + Cable	DCCF	Result	Limit	Margin
(㎒)	(dB(㎶))	(V/H)	(dB)	(dB)	(dB)	(dB(㎶/m))	(dB(㎶/m))	(dB)
Peak data								
1 094.03	78.03	V	28.08	-60.18	-	45.93	74.00	28.07
1 596.59	76.57	V	28.71	-58.59	-	46.69	74.00	27.31
1 848.94	70.39	H	30.58	-58.54	-	42.43	74.00	31.57
2 187.34	69.58	V	31.85	-58.16	-	43.27	74.00	30.73
3 743.91	69.20	H	32.65	-56.73	-	45.12	74.00	28.88
5 905.56	67.53	V	34.99	-54.75	-	47.77	74.00	26.23
Average data								
No spurious emissions were detected within 20 ㏈ of the limit.								

Horizontal/Vertical for 1 ㎓ ~ 6 ㎓



7.4. AC Conducted emission

Test setup



Limit

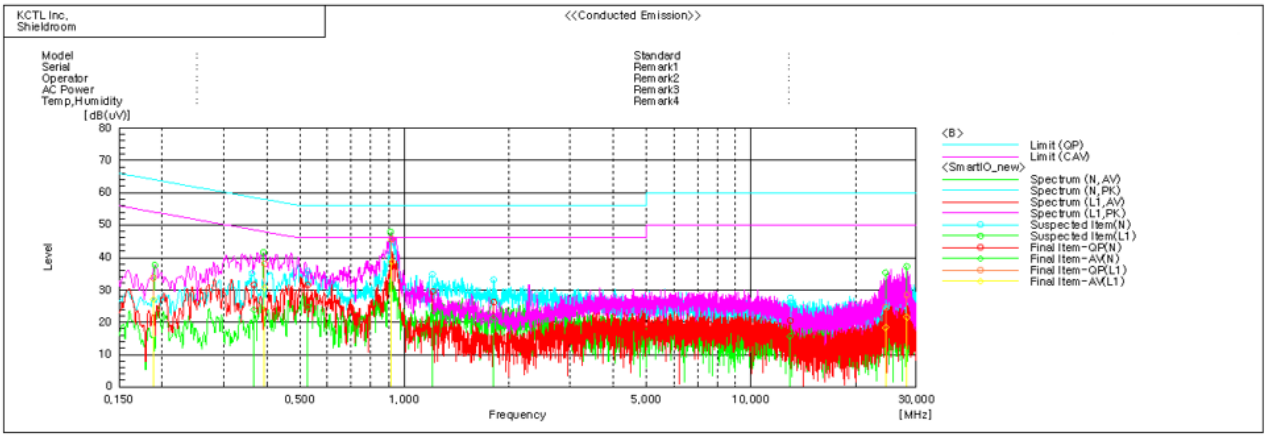
According to 15.207(a), for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 ㎑ to 30 ㎒, shall not exceed the limits in the following table, as measured using a 50uH/50 ohm line impedance stabilization network (LISN). Compliance with the provision of this paragraph shall on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower applies at the boundary between the frequencies ranges.

Frequency of Emission (㎒)	Conducted limit (dBμV/m)	
	Quasi-peak	Average
0.15 – 0.50	66 - 56*	56 - 46*
0.50 – 5.00	56	46
5.00 – 30.0	60	50

Measurement procedure

1. The EUT was placed on a wooden table of size, 1 m by 1.5 m, raised 80 ㎝ in which is located 40 ㎝ away from the vertical wall and 1.5m away from the side wall of the shielded room.
2. Each current-carrying conductor of the EUT power cord was individually connected through a 50Ω/50μH LISN, which is an input transducer to a spectrum analyzer or an EMI/Field Intensity meter, to the input power source.
3. Exploratory measurements were made to identify the frequency of the emission that had the highest amplitude relative to the limit by operating the EUT in a range of typical modes of operation, cable position, and with a typical system equipment configuration and arrangement. Based on the exploratory tests of the EUT, the one EUT cable configuration and arrangement and mode of operation that had produced the emission with the highest amplitude relative to the limit was selected for the final measurement.
4. The final test on all current-carrying conductors of all of the power cords to the equipment that comprises the EUT (but not the cords associated with other non-EUT equipment is the system) was then performed over the frequency range of 0.15 ㎒ to 30 ㎒.
5. The measurements were made with the detector set to peak amplitude within a bandwidth of 10 ㎑ or to quasi-peak and average within a bandwidth of 9 ㎑. The EUT was in transmitting mode during the measurements.

Test results



Final Result

--- N Phase ---

No.	Frequency [MHz]	Reading QP [dB(uV)]	Reading CAV [dB(uV)]	c.f [dB]	Result QP [dB(uV)]	Result CAV [dB(uV)]	Limit QP [dB(uV)]	Limit AV [dB(uV)]	Margin QP [dB]	Margin CAV [dB]
1	0.36777	21.9	14.1	9.7	31.6	23.8	58.6	48.6	27.0	24.8
2	0.52635	21.8	14.7	9.8	31.6	24.5	56.0	46.0	24.4	21.5
3	1.20593	19.9	13.2	9.6	29.5	22.8	56.0	46.0	26.5	23.2
4	1.80879	16.7	11.7	9.6	26.3	21.3	56.0	46.0	29.7	24.7
5	12.99054	10.6	5.8	9.9	20.5	15.7	60.0	50.0	39.5	34.3

--- L1 Phase ---

No.	Frequency [MHz]	Reading QP [dB(uV)]	Reading CAV [dB(uV)]	c.f [dB]	Result QP [dB(uV)]	Result CAV [dB(uV)]	Limit QP [dB(uV)]	Limit AV [dB(uV)]	Margin QP [dB]	Margin CAV [dB]
1	0.18839	23.9	17.2	9.9	33.8	27.1	64.1	54.1	30.3	27.0
2	0.39457	28.3	20.9	9.8	38.1	30.7	58.0	48.0	19.9	17.3
3	0.91719	36.0	29.0	9.7	45.7	38.7	56.0	46.0	10.3	7.3
4	24.43626	14.6	8.4	10.1	24.7	18.5	60.0	50.0	35.3	31.5
5	28.14739	18.2	11.4	10.1	28.3	21.5	60.0	50.0	31.7	28.5

8. Measurement equipment

Equipment Name	Manufacturer	Model No.	Serial No.	Next Cal. Date
Spectrum Analyzer	R&S	FSW50	101013	20.05.13
Spectrum Analyzer	R&S	FSV30	100914	19.09.10
ATTENUATOR	API Inmet	40AH2W-10	14	20.05.15
Vector Signal Generator	R&S	SMBV100A	257566	20.01.04
Signal Generator	R&S	SMR40	100007	20.05.13
EMI TEST RECEIVER	R&S	ESCI7	100732	19.08.23
EMI TEST RECEIVER	R&S	ESCI3	100001	19.08.23
TWO-LINE V - NETWORK	R&S	ENV216	101584	20.04.05
Bi-Log Antenna	SCHWARZBECK	VULB 9168	583	20.05.21
COAXIAL FIXED ATTENUATOR	Agilent	8491B-003	2708A18758	20.05.04
Horn antenna	ETS.lindgren	3117	161225	20.05.22
Amplifier	SONOMA INSTRUMENT	310N	284608	19.08.23
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	-	-
Antenna Mast	Innco Systems	MA4000-EP	303	-
Turn Table	Innco Systems	DT2000	79	-
Turn Table	Innco Systems	DT2000	79	-
Cable Assembly	RadiAll	2301761768000PJ	1724.659	-
Cable Assembly	gigalane	RG-400	-	-

End of test report