TEST REPORT

Part 15 Subpart C 15.231

Equipment under test Vehicle Security Gateway

Model name ST-900-CF

FCC ID KL7ST-900-CF

Applicant Savi Technology Inc.

Manufacturer Dae Kyung Philippines, Inc.

Date of test(s) 2016.10.04 ~ 2016.11.10

Date of issue 2016.11.10

Issued to
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Test and report completed by :	Report approval by :
	
Hyeon-su Jang Test engineer	Jeff Do Technical manager

Revision history

Revision	Date of issue	Test report No.	Description
-	2016.10.17	KES-RF-16T0094	Initial
R1	2016.11.10	KES-RF-16T0094-R1	Retest a Transmission time and added a test plot of duty cycle

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1. General information

Applicant:	Savi Technology Inc.
Applicant address:	3601 Eisenhower Avenue, STE 280, Alexandria VA 22304
Test site:	KES Co., Ltd.
Test site address:	C-3701, 40, Simin-daero 365beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do, Korea 473-21, Gayeo-ro, Yeoju-si, Gyeonggi-do, Korea
FCC rule part(s):	15.231
FCC ID:	KL7ST-900-CF
Test device serial No.:	☒ Production ☐ Pre-production ☐ Engineering

1.1. EUT description

Equipment under test	Vehicle Security Gateway
Frequency range	Tx :433.92 ㎒ Rx :433.92 ㎒ GSM 850 : 824.2 ㎒ ~ 848.8 ㎒ PCS 1900 : 1850.2 ㎒ ~ 1909.8 ㎒
Modulation technique	433.92 ㎒ : FSK GSM : GMSK
Number of channels	433.92 ㎒ : 1ch GSM 850 : 125ch, GSM 1900 : 300ch
Antenna specification	433.92 UHF Antenna type: PCB, Peak gain: -0.97 dBi GSM 850 Antenna type: PCB, Peak gain: -0.30 dBi GSM 1900 Antenna type: PCB, Peak gain: -1.70 dBi
Power source	External Power : DC 24.0 V / 2A Backup Battery : DC 3.7 V / 1400 mAh Li-polymer battery

Note:
1. Certificated GSM/GPRS module is mounted in the EUT as following
   - Applicant: Shanghai Simcom Ltd.
   - FCC Identifier : UDV-20160416
   - Model: SIM808
2. The installed module is completed identical as original.

1.2. Test configuration

The **Savi Technology, Inc. Vehicle Security Gateway FCC ID: KL7ST-900-CF** was tested per the guidance of ANSI C63.10-2013 was used to reference the appropriate EUT setup for radiated spurious emissions testing and AC line conducted testing.

1.3. Device modifications

N/A

1.4. Derivation model information

N/A

1.5. Frequency/channel operations

Ch.	Frequency (㎒)
01	433.92

1.6. Worst case configuration

The EUT was investigated in each of its External power mode and Battery mode. All radiated test and power line conducted test was performed with the EUT set to transmit mode. The test results shown in the following sections represent the worst case emissions for External power mode.

2. Summary of tests

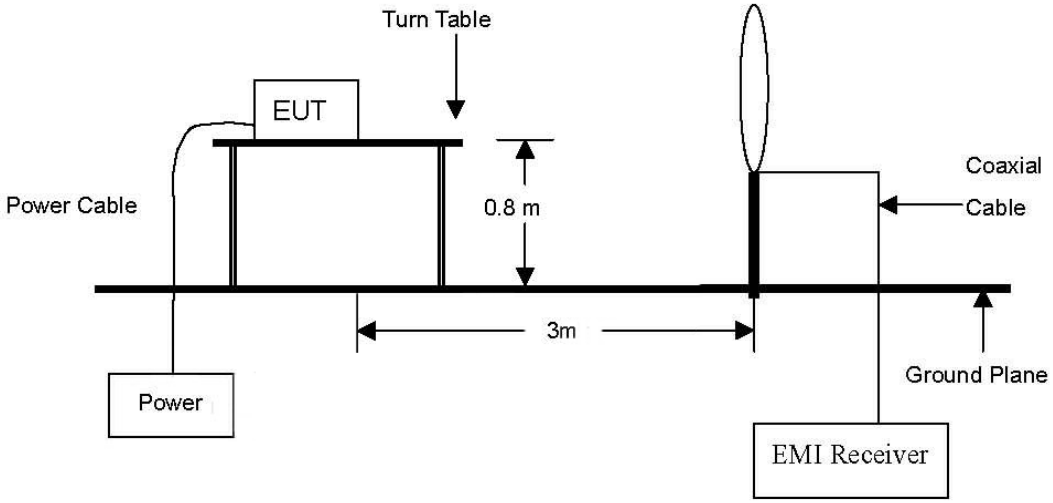
Reference	Parameter	Test results
15.209(a) 15.231(b)	Radiated emission, Spurious emission and Field Strength of Fundamental	Pass
15.231(c)	Bandwidth of operation frequency	Pass
15.231(a)	Transmission time	Pass
15.207(a)	AC conducted emissions	Pass

3. Test results

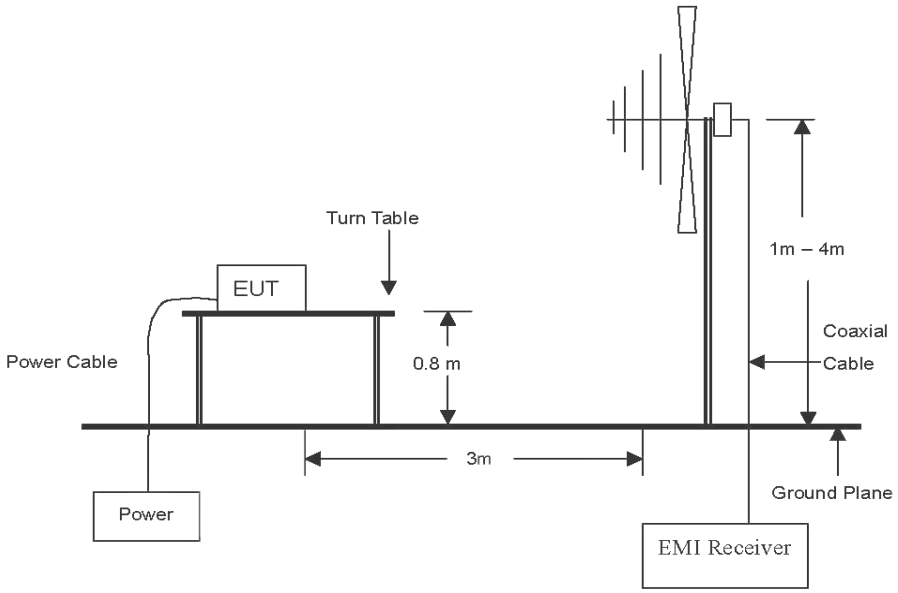
3.1. Field strength of fundamental and the field strength of spurious emission

Test setup

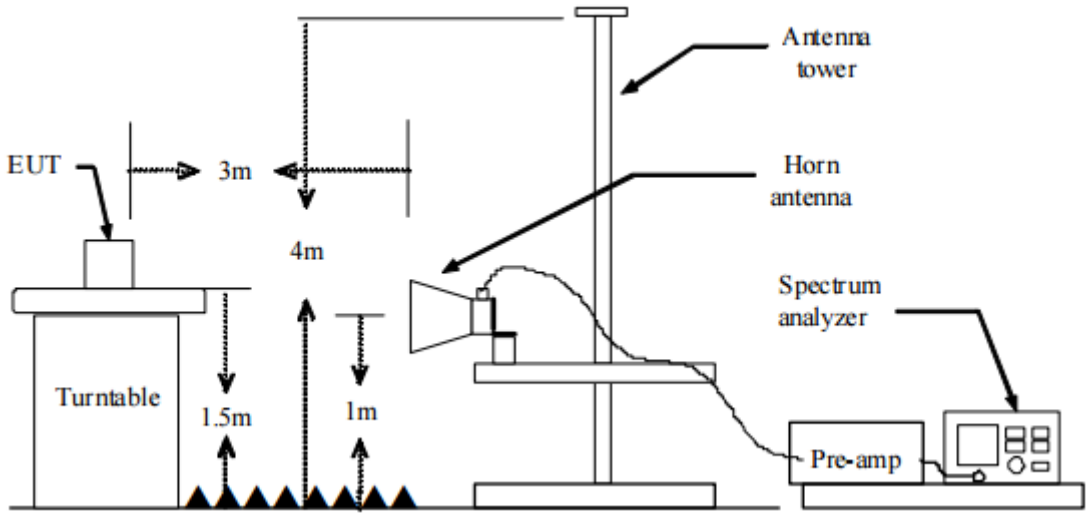
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 ㎑ to 30 ㎒ Emissions.



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.



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. 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 = Peak detection (PK) or Quasi-peak detection (QP)
   ⑤ Sweep time = auto
   ⑥ Trace = max hold
2. Spectrum analyzer settings for $f \geq 1$ ㎓: 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

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. CF(Correction factors(㏈)) = Antenna factor(㏈/m) + Cable loss(㏈) + or Amp. gain(㏈) + or F_d(㏈)
3. Field strength(㏈㎶/m) = Level(㏈㎶) + CF (㏈) + or DCF(㏈)
4. Margin(㏈) = Limit(㏈㎶/m) - Field strength(㏈㎶/m)
5. The fundamental of the EUT was investigated in three orthogonal orientations X, Y and Z, it was determined that **Y orientation** was worst-case orientation; therefore, all final radiated testing was performed with the EUT in **Y orientation**.
6. The emissions are reported however whose levels were not within 20 ㏈ of respective limits were not reported.

Limit

According to 15.209(a), for an intentional radiator devices, the general required of field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values：

Frequency (㎒)	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.

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 emission (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

**Where F is the frequency in ㎒, the formulas for calculating the maximum permitted fundamental field strengths are as follows: for the band 130 ~ 174 ㎒, ㎶/m at 3 meters = 56.81818(F) – 6136.3636; for the band 260 ~ 470 ㎒, ㎶/m at 3 meters = 41.6667(F) – 7083.333. The maximum permitted unwanted emission level is 20 ㏈ below the maximum permitted fundamental level.

Field strength

Test results

Mode: FSK

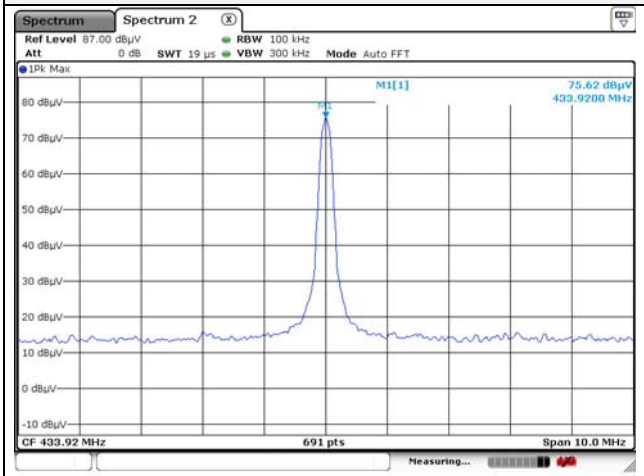
Distance of measurement: 3 meter

Channel: 1

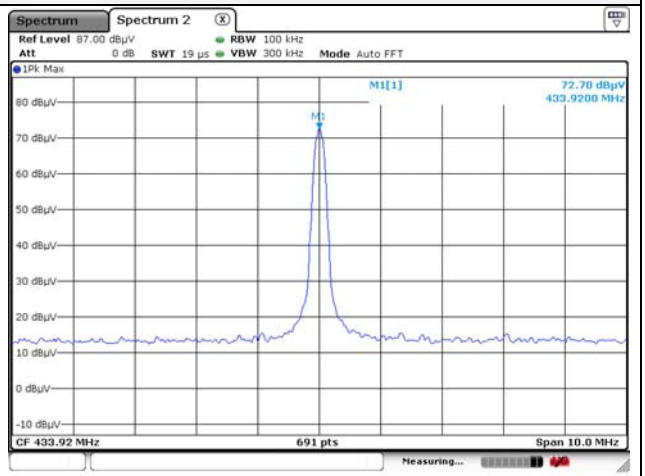
Frequency (㎒)	Level (dBμV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
433.92	75.62	Peak	H	17.43	-	93.05	100.83	7.78
		Average	H	17.43	-20.93	72.12	80.83	8.71
433.92	72.70	Peak	V	17.43	-	90.13	100.83	10.70
		Average	V	17.43	-20.93	69.20	80.83	11.63

Test plots

Horizontal // Peak



Vertical // Peak



Note.

1. 3m Average Limit(dBμV/m) = 20log[41.6667($F_{(㎒)}$-7083.3333) = 80.83
   3m Peak Limit(dBμV/m) = Average limit + 20 = 100.83
   Average Field strength = Peak Field strength + Duty Cycle Correction Factor
2. Duty Cycle Correction Factor : 20log(Ton / 100 ms) = 20log(8.986 / 100) = -20.93
   $Tx_{\text{on time}}$ = 8.986 ms
   $Tx_{\text{on+off}} \geq$ 100 ms (pulse train is 100 ms)

Spurious emission

Test results (Below 30 ㎒)

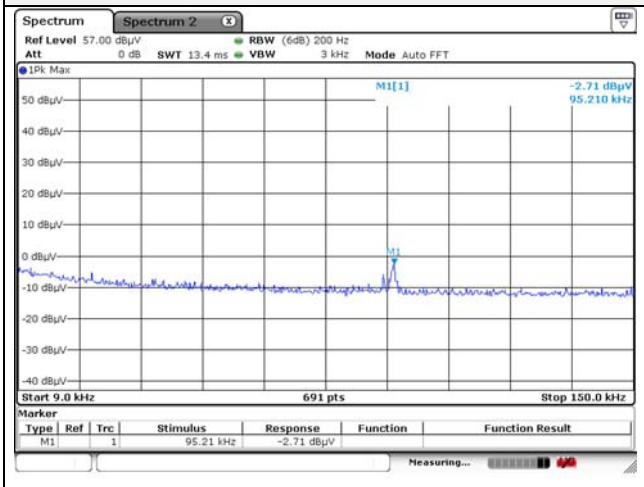
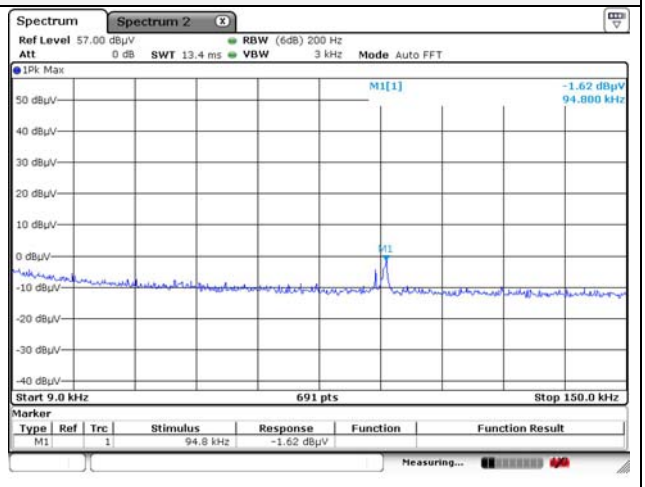
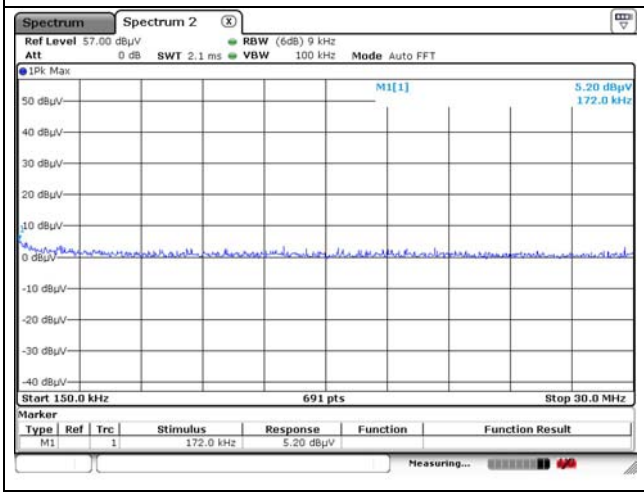
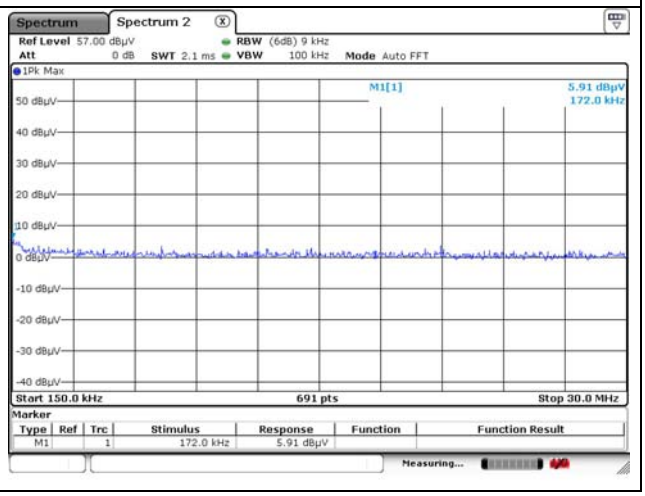
Mode: FSK

Distance of measurement: 3 meter

Channel: 1

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

Test plots (Below 30 ㎒)

Horizontal	Vertical
	
	

Test results (Below 1 000 ㎒)

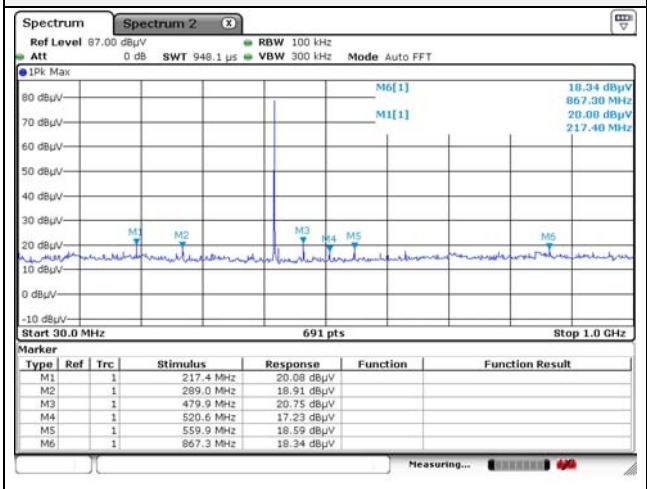
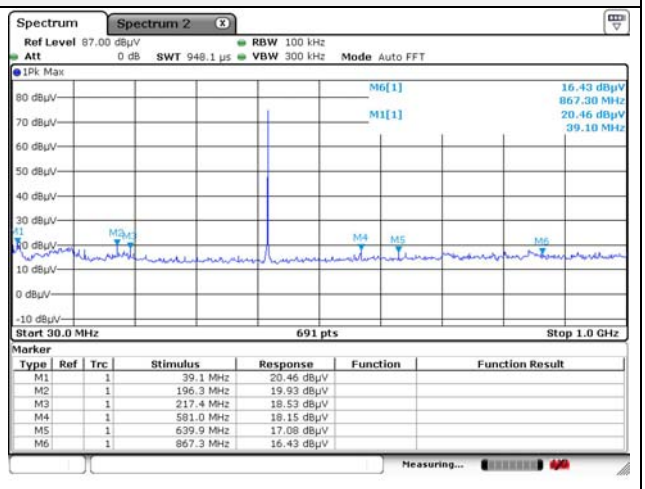
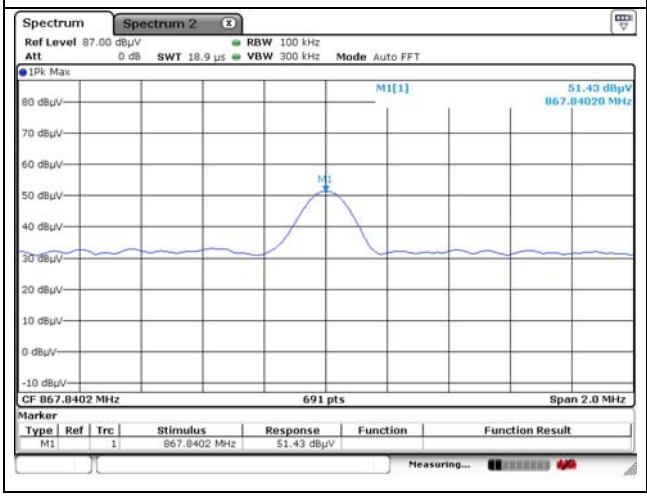
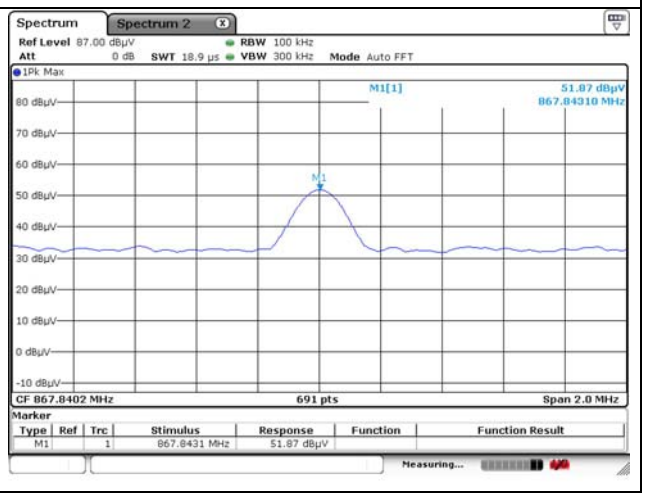
Mode: FSK

Distance of measurement: 3 meter

Channel: 1

Frequency (㎒)	Level (dB㎶)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
39.10	20.46	Peak	V	12.64	-	33.10	40.00	6.90
217.40	20.08	Peak	H	12.53	-	32.61	46.00	13.39
479.90	20.75	Peak	H	18.15	-	38.90	46.00	7.10
599.90	18.50	Peak	H	20.81	-	39.31	46.00	6.69
867.84	51.43	Peak	H	-7.88	-	45.35	80.83	35.48
867.84	51.87	Peak	V	-7.88	-	45.79	80.83	35.04

Test plots (Below 1 000 ㎒)

Horizontal	Vertical
	
	

Test results (Above 1 000 ㎒)

Mode: FSK

Distance of measurement: 3 meter

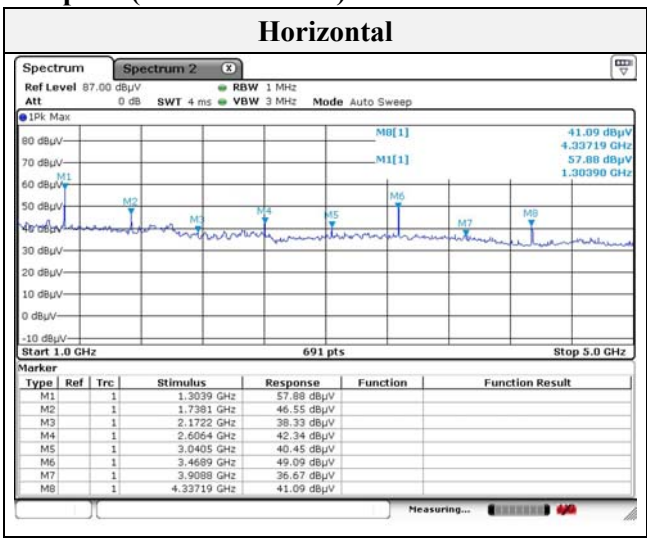
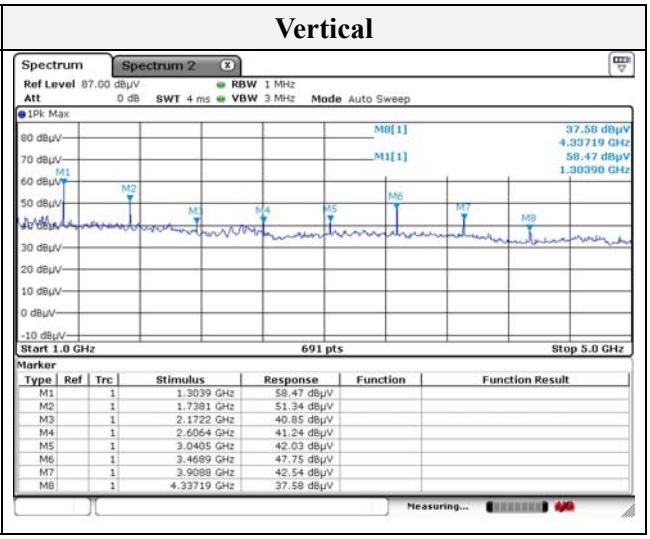
Channel: 1

Frequency (㎒)	Level (dB㎶)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
*1 303.90	57.88	Peak	H	-7.91	-	49.97	74.00	24.03
*1 303.90	58.47	Peak	V	-7.91	-	50.56	74.00	23.44
1 738.10	46.55	Peak	H	-4.79	-	41.76	80.83	39.07
1 738.10	51.34	Peak	V	-4.79	-	46.55	80.83	34.28
2 172.20	38.33	Peak	H	-1.49	-	36.84	80.83	43.99
2 172.20	40.85	Peak	V	-1.49	-	39.36	80.83	41.47
2 606.40	42.34	Peak	H	0.74	-	43.08	80.83	37.75
2 606.40	41.24	Peak	V	0.74	-	41.98	80.83	38.85
3 040.50	40.45	Peak	H	2.39	-	42.84	80.83	37.99
3 040.50	42.03	Peak	V	2.39	-	44.42	80.83	36.41
3 468.90	49.09	Peak	H	2.17	-	51.26	80.83	29.57
3 468.90	47.75	Peak	V	2.17	-	49.92	80.83	30.91
*3 908.80	36.67	Peak	H	4.17	-	40.84	74.00	33.16
*3 908.80	42.54	Peak	V	4.17	-	46.71	74.00	27.29
4 337.19	41.09	Peak	H	5.46	-	46.55	80.83	34.28
4 337.19	37.58	Peak	V	5.46	-	43.04	80.83	37.79

Note.

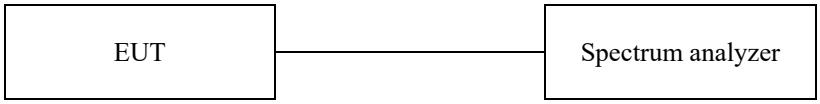
1. 3m PeakLimit(dB㎶/m) = 20log[41.6667($F_{(㎒)}$-7083.3333) = 80.83
   3m Average Limit(dB㎶/m) = Peak limit - 20 = 60.83
   Average Field strength = Peak Field strength + Duty Cycle Correction Factor
2. Correction Factors = Antenna Factor + Cable Loss + Amp.Gain
3. "*"means the restricted band.
4. Average test would not be applied if the peak results were lower than the average limit.
5. Duty Cycle Correction Factor : 20log(Ton / 100 ms) = 20log(8.986 / 100) = -20.93
   $Tx_{on\ time}$ = 8.986 ms
   $Tx_{on+off} \geq$ 100 ms (pulse train is 100 ms)

Test plots (Above 1 000 ㎒)

Horizontal	Vertical
	

3.2. Bandwidth of operation frequency

Test setup



Test procedure

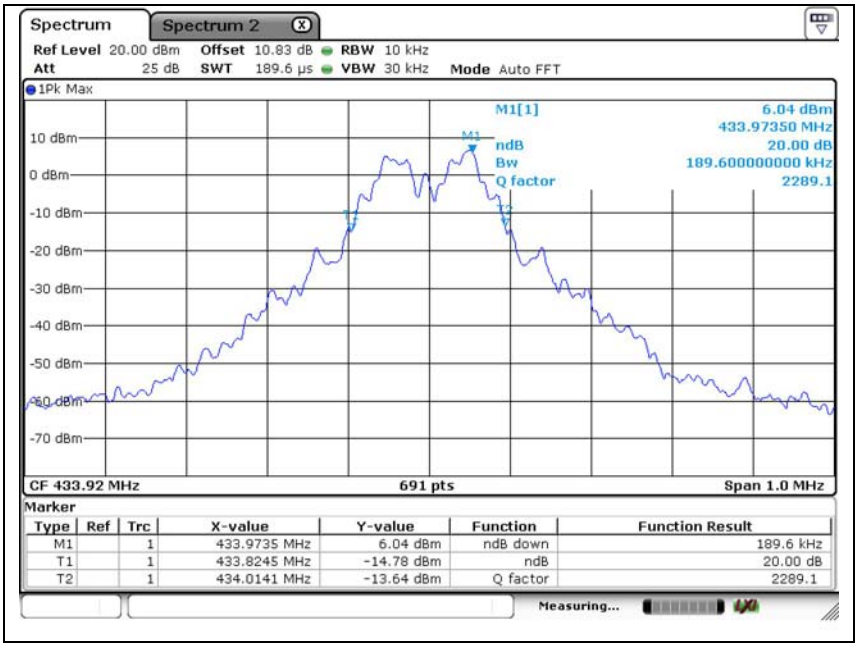
1. Use the following spectrum analyzer setting
2. RBW = 10 ㎑
3. VBW = 30 ㎑ (≥ RBW)
4. Span = 1 ㎒
5. Detector function = peak
6. Trace = max hold

Limit

The bandwidth of the emissions shall be no wider than 0.25 % of the center frequency for devices operating above 70 ㎒ and below 900 ㎒. Bandwidth is determined at the points 20 ㏈ down from the modulated carrier.

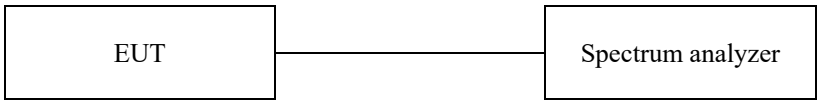
Test results

Frequency(㎒)	Bandwidth(㎑)	Limit (㎑)
433.92	189.6	1 084.80



3.3. Transmission time

Test setup



Test procedure

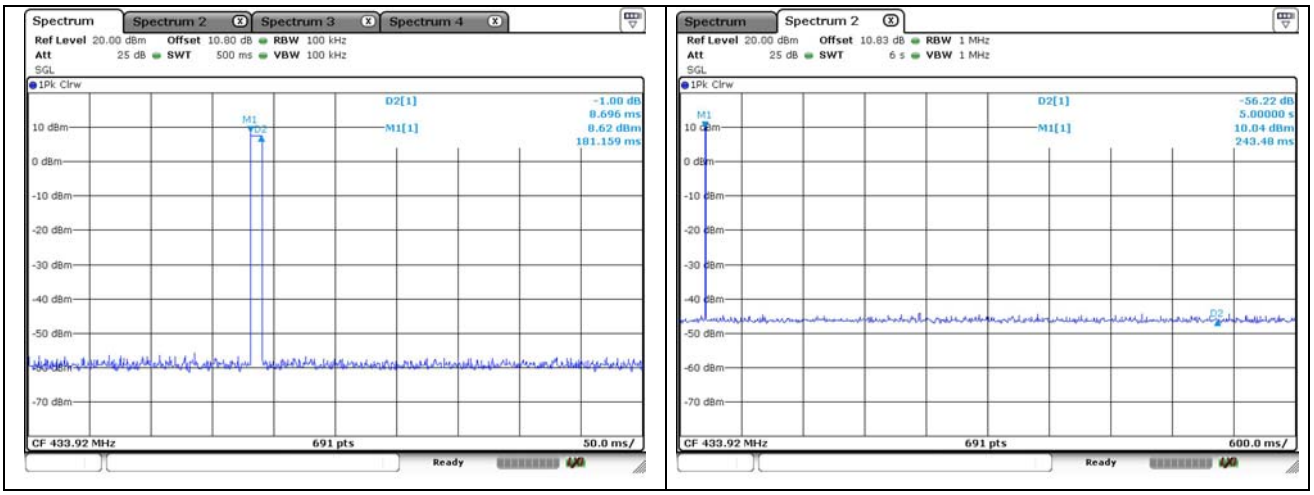
1. Place the EUT on the table and set it in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
3. Set center frequency of spectrum analyzer = operating frequency.
4. Set the spectrum analyzer as RBW=100 ㎑, VBW=100 ㎑, Span=0 ㎐.

Limit

A transmitter activated automatically shall cease transmission within 5 seconds after activation.

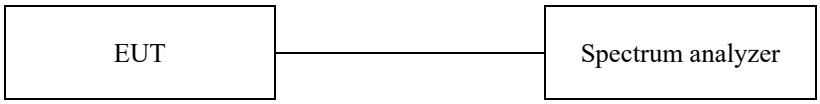
Test results

Frequency(㎒)	Transmission time (ms)	Limit (s)
433.92	8.696	Same or less than 5



3.4. Duty cycle correction factor

Test setup



Test procedure

1. The transmitter output is connected to the spectrum analyzer.
2. Set center frequency of spectrum analyzer = operating frequency.
3. Set the spectrum analyzer as RBW=100 ㎑, VBW=100 ㎑, Span=0 ㎐ and Sweep time =100 ㎳.

Limit

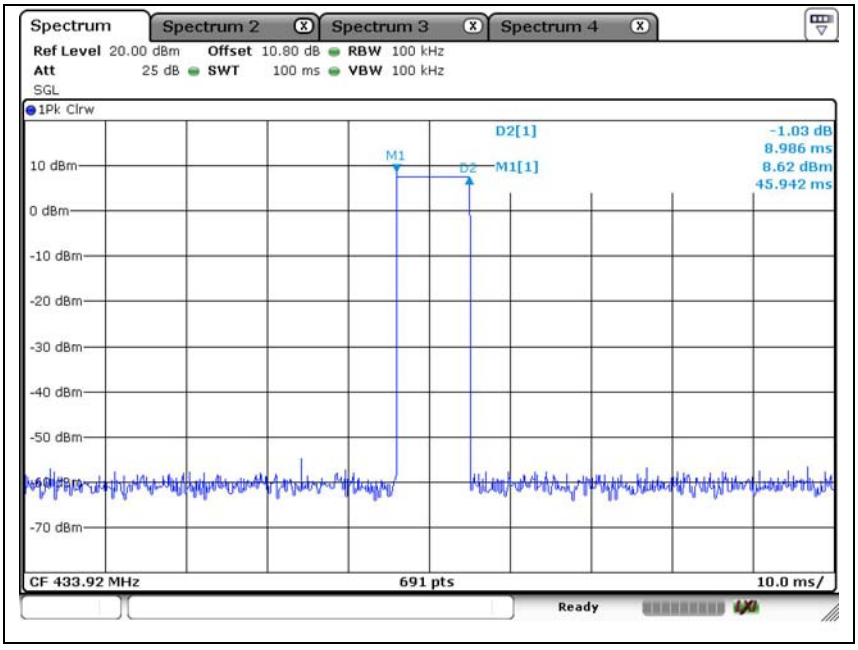
None (No dedicated Limit specified in the Rules)

Test results

Duty Cycle Correction Factor : 20log(Ton / 100 ms) = 20log(8.986 / 100) = -20.93

$Tx_{on\ time}$ = 8.986 ms

Tx_{on+off} ≥ 100 ms (pulse train is 100 ms)



3.5. AC conducted emissions

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.

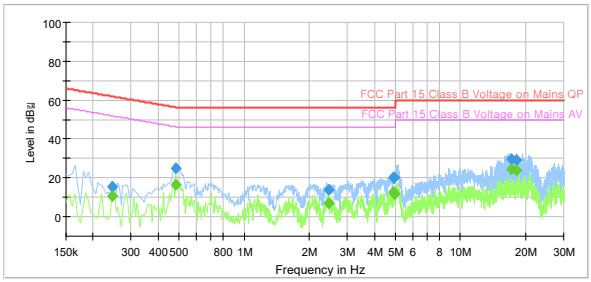
Frequency of Emission (㎒)	Conducted limit (dB㎶/m)	
	Quasi-peak	Average
0.15 – 0.50	66 - 56*	56 - 46*
0.50 – 5.00	56	46
5.00 – 30.0	60	50

Note.

1. All AC line conducted spurious emission are measured with a receiver connected to a grounded LISN while the EUT is operating at its maximum duty cycle, at maximum power, and the appropriate frequencies. All data rates and modes were investigated for conducted spurious emission. Only the conducted emissions of the configuration that produced the worst case emissions are reported in this section.
3. Both Cable loss and LISN factor are included in measurement level.(QP Level or AV Level).

Test results

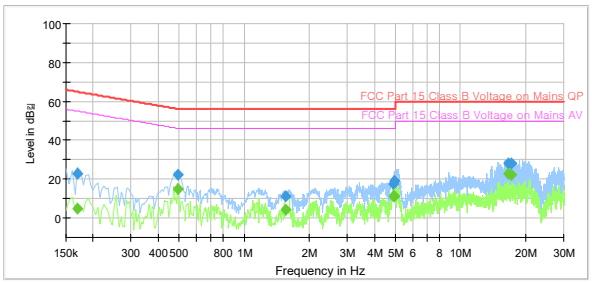
Hot Line



Final_Result

Frequency (MHz)	QuasiPeak (dBµ)	CAverage (dBµ)	Limit (dBµ)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.245000	---	10.83	51.92	41.09	1000.0	9.000	L1	9.7
0.245000	15.32	---	61.92	46.60	1000.0	9.000	L1	9.7
0.485000	---	16.26	46.25	29.99	1000.0	9.000	L1	9.8
0.485000	24.83	---	56.25	31.42	1000.0	9.000	L1	9.8
2.460000	13.56	---	56.00	42.44	1000.0	9.000	L1	10.0
2.460000	---	7.03	46.00	38.97	1000.0	9.000	L1	10.0
4.905000	---	12.93	46.00	33.07	1000.0	9.000	L1	10.0
4.905000	19.99	---	56.00	36.01	1000.0	9.000	L1	10.0
4.950000	---	11.85	46.00	34.15	1000.0	9.000	L1	10.0
4.950000	20.05	---	56.00	35.95	1000.0	9.000	L1	10.0
17.270000	29.50	---	60.00	30.50	1000.0	9.000	L1	10.1
17.270000	---	24.24	50.00	25.76	1000.0	9.000	L1	10.1
18.180000	28.88	---	60.00	31.12	1000.0	9.000	L1	10.1
18.180000	---	23.63	50.00	26.37	1000.0	9.000	L1	10.1

Neutral Line



Final_Result

Frequency (MHz)	QuasiPeak (dBµ)	CAverage (dBµ)	Limit (dBµ)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.170000	---	4.71	54.96	50.25	1000.0	9.000	N	9.7
0.170000	22.77	---	64.96	42.19	1000.0	9.000	N	9.7
0.495000	---	14.94	46.08	31.14	1000.0	9.000	N	9.8
0.495000	22.50	---	56.08	33.58	1000.0	9.000	N	9.8
1.555000	11.14	---	56.00	44.86	1000.0	9.000	N	10.0
1.555000	---	4.41	46.00	41.59	1000.0	9.000	N	10.0
4.870000	---	11.11	46.00	34.89	1000.0	9.000	N	10.0
4.870000	17.58	---	56.00	38.42	1000.0	9.000	N	10.0
4.965000	---	10.89	46.00	35.11	1000.0	9.000	N	10.0
4.965000	18.96	---	56.00	37.04	1000.0	9.000	N	10.0
16.620000	27.88	---	60.00	32.12	1000.0	9.000	N	10.0
16.620000	---	22.59	50.00	27.41	1000.0	9.000	N	10.0
17.275000	27.85	---	60.00	32.15	1000.0	9.000	N	10.0
17.275000	---	22.41	50.00	27.59	1000.0	9.000	N	10.0

Appendix A. Measurement equipment

Equipment	Manufacturer	Model	Serial No.	Calibration interval	Calibration due
Spectrum Analyzer	R&S	FSV30	10076	1 year	2017.07.06
8360B Series Swept Signal Generator	HP	83630B	3844A00786	1 year	2017.01.25
PSG Analog Signal Generator	AGILENT	E8257C	US42340237	1 year	2017.07.05
DC Power Supply	HP	6674A	US36370369	1 year	2017.07.04
Attenuator	Agilent	8493C	51401	1 year	2017.07.05
Loop Antenna	R&S	HFH2-Z2.335.4711.52	826532	2 years	2017.03.03
Trilog-broadband antenna	SCHWARZBECK	VULB 9163	9168-713	2 years	2017.05.15
Horn Antenna	A.H.	SAS-571	781	2 years	2017.05.07
High Pass Filter	WAINWRIGHT INSTRUMENT	WHJS3000-10TT	1	1 year	2017.07.04
Low Pass Filter	WEINSCHEL	WLK1.0/18G-10TT	1	1 year	2017.07.04
Preamplifier	SCHWARZBECK	BBV-9718	9718-246	1 year	2016.10.23
EMI Test Receiver	R&S	ESR3	101781	1 year	2017.05.03
EMI Test Receiver	R&S	ESU26	100552	1 year	2017.04.24
EMI Test Receiver	R&S	ESR3	101783	1 year	2017.05.03
LISN	R&S	ENV216	101137	1 year	2017.02.04

Peripheral devices

Device	Manufacturer	Model No.	Serial No.
Notebook	SAMSUNG	NT-R519-BA24J	ZKPA93ES900086Z