

C-3701, 40, Simin-daero 365beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do, Korea Tel: +82-31-425-6200 / Fax: +82-31-424-0450 www.kes.co.kr Test report No.: KES-RF-16T0094-R1 Page (1) of (22)

# 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 Savi Technology Inc.

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473-21, Gayeo-ro, Yeoju-si, Gyeonggi-do, Korea Tel: +82-31-425-6200 / Fax: +82-31-424-0450

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



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# **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 Mbz

Rx:433.92 Mbz

GSM 850 : 824.2 Mbz ~ 848.8 Mbz PCS 1900 : 1850.2 Mbz ~ 1909.8 Mbz

Modulation technique 433.92 Mz : FSK

GSM: GMSK

Number of channels 433.92 Mb : 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 <u>Savi Technology</u>, <u>Inc. Vehicle Security Gateway FCC ID: KL7ST-900-CF</u> 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



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# 1.5. Frequency/channel operations

Ch.	Frequency (Mb)
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.



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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

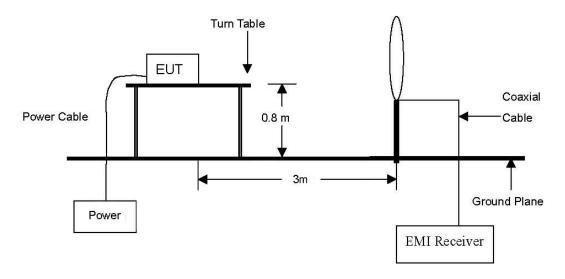


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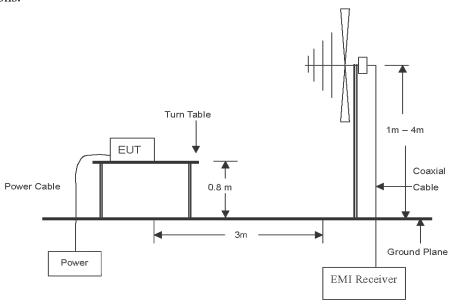
#### 3. Test results

# 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 kHz to 30 MHz Emissions.



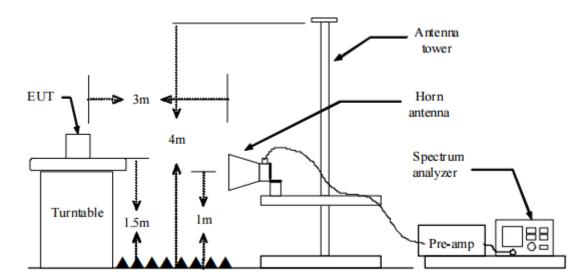
The diagram below shows the test setup that is utilized to make the measurements for emission from 30 Mz to 1 Gz emissions.





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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.



# Test procedure below 30 MHz

- 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 MHz

- 1. Spectrum analyzer settings for f < 1 GHz:
  - ① Span = wide enough to fully capture the emission being measured
  - (2) RBW = 100 kHz
  - $3 \text{ VBW} \geq \text{RBW}$
  - ① Detector = Peak detection (PK) or Quasi-peak detection (QP)
  - ⑤ Sweep time = auto
  - $\bigcirc$  Trace = max hold
- 2. Spectrum analyzer settings for  $f \ge 1$  GHz: Peak
  - ① Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
  - ② RBW = 1 Mbz
  - $\bigcirc$  VBW  $\geq$  3 MHz
  - 4 Detector = peak
  - ⑤ Sweep time = auto
  - 6 Trace = max hold
  - 7 Trace was allowed to stabilize



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#### Note.

1. f < 30 Mb, extrapolation factor of 40 dB/decade of distance.  $F_d = 40 log(D_m/Ds)$   $f \ge 30$  Mb, extrapolation factor of 20 dB/decade of distance.  $F_d = 20 log(D_m/Ds)$  Where:

 $F_d$  = Distance factor in dB

 $D_m$  = Measurement distance in meters

 $D_s$  = Specification distance in meters

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



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#### 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 (Mb)	Distance (Meters)	Radiated (µN/m)
0.009 ~ 0.490	300	2400/F(kllz)
0.490 ~ 1.705	30	24000/F(kHz)
1.705 ~ 30.0	30	30
30 ~ 88	3	100**
88 ~ 216	3	150**
216 ~ 960	3	200**
Above 960	3	500

<sup>\*\*</sup>Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands  $54 \sim 72~\text{MHz}$ ,  $76 \sim 88~\text{MHz}$ ,  $174 \sim 216~\text{MHz}$  or  $470 \sim 806~\text{MHz}$ . 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 (Mz)  Field strength of fundaments (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

<sup>\*\*</sup>Where F is the frequency in Mz, the formulas for calculating the maximum permitted fundamental field strengths are as follows: for the band  $130 \sim 174$  Mz,  $\mu$ V/m at 3 meters = 56.81818(F) - 6136.3636; for the band  $260 \sim 470$  Mz,  $\mu$ V/m at 3 meters = 41.6667(F) - 7083.333. The maximum permitted unwanted emission level is 20 dB below the maximum permitted fundamental level.



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#### Field strength

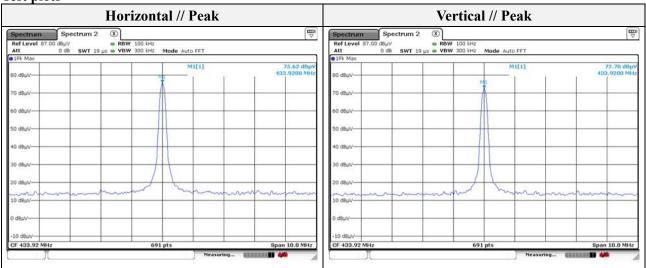
Test	results

Mode: FSK
Distance of measurement: 3 meter

Channel: 1

Frequency (MHz)	Level (dBµV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBµN/m)	Limit (dBµV/m)	Margin (dB)
433.92	75.60	Peak	Н	17.43	-	93.05	100.83	7.78
433.92	75.62	Average	Н	17.43	-20.93	72.12	80.83	8.71
422.02	72.70	Peak	V	17.43	-	90.13	100.83	10.70
433.92	433.92 72.70	Average	V	17.43	-20.93	69.20	80.83	11.63

**Test plots** 



#### Note.

- 3m Average Limit(dBμV/m) = 20log[41.6667(F(Mhz)-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 on time = 8.986 ms

 $Tx_{on+off} \ge 100 \text{ ms}$  (pulse train is 100 ms)



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#### **Spurious emission**

Test results (Below 30 Mb)

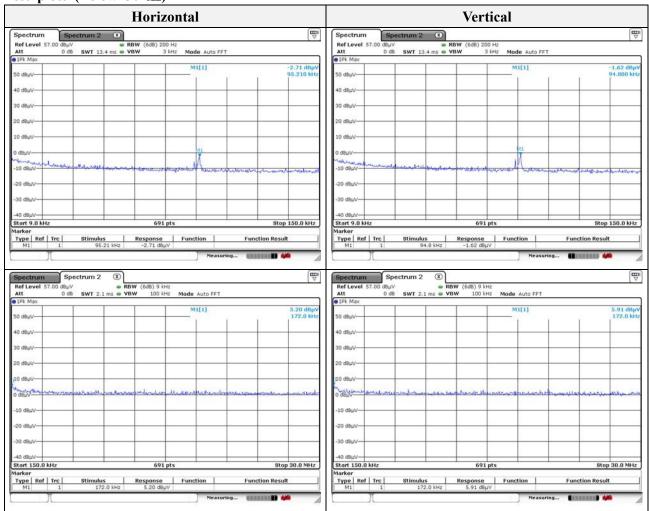
Mode: FSK

Distance of measurement: 3 meter

Channel: 1

Frequency (MHz)	Level (dBµV)	Ant. Pol. (H/V)	CF (dB)	F <sub>d</sub> (dB)	Field strength (dBµV/m)	Limit (dBµV/m)	Margin (dB)
No spurious emissions were detected within 20 dB of the limit							

#### Test plots (Below 30 Mb)





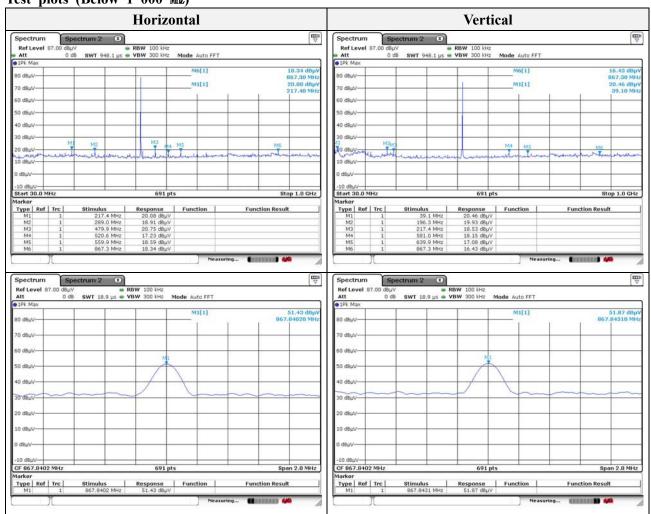
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# Test results (Below 1 000 Mb)

Mode: FSK
Distance of measurement: 3 meter
Channel: 1

Frequency (Mb)	Level (dBµV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBµN/m)	Limit (dBµV/m)	Margin (dB)
39.10	20.46	Peak	V	12.64	-	33.10	40.00	6.90
217.40	20.08	Peak	Н	12.53	-	32.61	46.00	13.39
479.90	20.75	Peak	Н	18.15	-	38.90	46.00	7.10
599.90	18.50	Peak	Н	20.81	-	39.31	46.00	6.69
867.84	51.43	Peak	Н	-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 Mb)





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#### Test results (Above 1 000 Mb)

Mode:	FSK
Distance of measurement:	3 meter
Channel:	1

Frequency (MHz)	Level (dBµV)	Detect mode	Ant. Pol. (H/V)	CF (dB)	DCF (dB)	Field strength (dBµV/m)	Limit (dBµV/m)	Margin (dB)
*1 303.90	57.88	Peak	Н	-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	Н	-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	Н	-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	Н	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	Н	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	Н	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	Н	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	Н	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.  $3m \ Peak Limit(dB\mu V/m) = 20log[41.6667(F_{(Mb)}-7083.3333) = 80.83$   $3m \ Average \ Limit(dB\mu V/m) = Peak \ limit - 20 = 60.83$  $Average \ Field \ strength = Peak \ Field \ strength + Duty \ Cycle \ Correction \ Factor$
- 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 :  $20\log(\text{Ton} / 100 \text{ ms}) = 20\log(8.986 / 100) = -20.93$

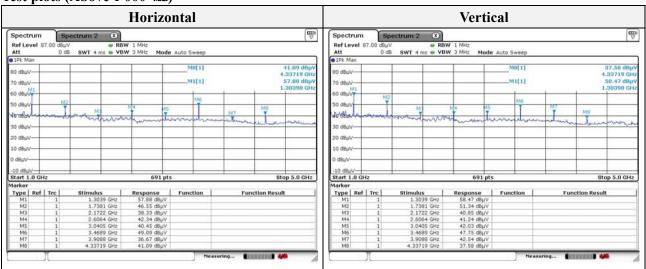
 $Tx_{on time} = 8.986 ms$ 

 $Tx_{on+off} \ge 100 \text{ ms}$  (pulse train is 100 ms)



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# Test plots (Above 1 000 Mb)





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# **3.2.** Bandwidth of operation frequency Test setup



#### **Test procedure**

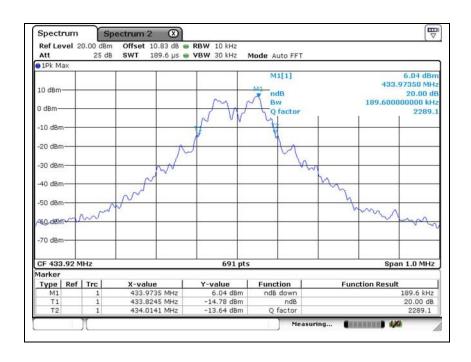
- 1. Use the following spectrum analyzer setting
- 2. RBW = 10 kHz
- 3. VBW = 30 kHz ( $\geq$  RBW)
- 4. Span = 1 MHz
- 5. Detector function = peak
- 6. Trace = max hold

#### Limit

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

#### **Test results**

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





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# **3.3.** Transmission time Test setup



#### **Test procedure**

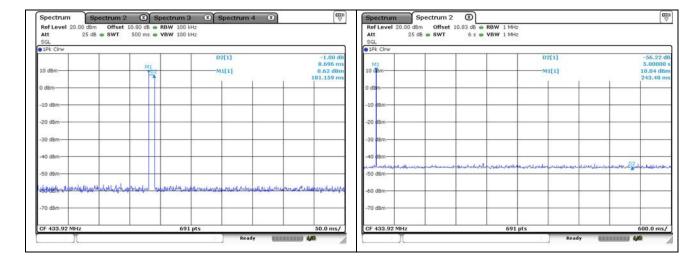
- 1. Place the EUT on the table and set it in transmitting mode.
- 2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
- 3. Set center frequency of spectrum analyzer = operating frequency.
- 4. Set the spectrum analyzer as RBW=100 kHz,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

#### Limit

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

#### **Test results**

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





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# 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 kHz, VBW=100 kHz, Span=0 Hz and Sweep time =100 ms.

#### Limit

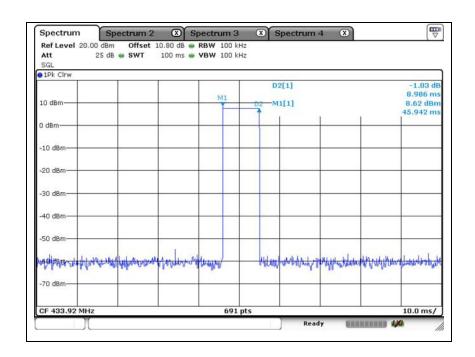
None (No dedicated Limit specified in the Rules)

#### **Test results**

Duty Cycle Correction Factor :  $20\log(\text{Ton} / 100 \text{ ms}) = 20\log(8.986 / 100) = -20.93$ 

 $Tx_{on time} = 8.986 \text{ ms}$ 

 $Tx_{on+off} \ge 100 \text{ ms}$  (pulse train is 100 ms)





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#### 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 kHz to 30 MHz, 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.

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

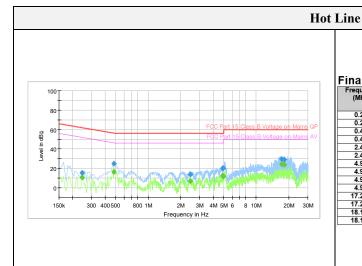
#### Note.

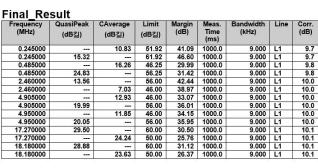
- 1. All AC line conducted spurious emission are measured with a receiver connected to a grounded LISN while the EUT is operating at its maximum duty cycle, at maximum power, and the appropriate frequencies. All data rates and modes were investigated for conducted spurious emission. Only the conducted 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).



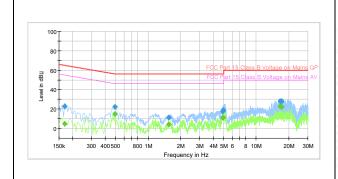
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#### Test results





#### **Neutral Line**



Final Re	sult							
Frequency (MHz)	QuasiPeak (dB킯)	CAverage (dB킮)	Limit (dB킯)	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



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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	НР	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