



**KES Co., Ltd.**  
C-3701 Dongil Techno Town, 889-1, Gwanyang 2-dong,  
Dongan-gu, Anyang-si, Gyeonggi-do, 431-716, Korea  
Tel: +82-31-425-6200 / Fax: +82-31-424-0450  
www.kes.co.kr

# TEST REPORT

## Part 15 Subpart C 15.231

**Equipment under test** Tire pressure monitoring system

**Model name** TBO

**FCC ID** F2OTBO

**Applicant** Nae Woi Korea.,ltd

**Manufacturer** Nae Woi Korea.,ltd

**Date of test(s)** 2012.02.17 ~ 2012.03.19

**Date of issue** 2012.03.22

**Issued to**

**Nae Woi Korea.,ltd**

501 Junil B/D, 513-22 Sangdaewon dong Jungwon gu, Seongnam si,  
Gyunggido, South Korea

**Issued by**

**KES Co., Ltd.**

C3701 Dongil Techno Town, 889-1, Gwanyang 2-dong, Dongan-gu, Anyang-si,  
Gyeonggi-do, 431-716, Korea

477-6, Hageo-ri, Yeoju-eup, Yeoju-gun, Gyeonggi-do, 469-803, Korea  
Tel: +82-31-425-6200 / Fax: +82-31-424-0450

Test and report completed by :	Report approval by :
	
Jeff Do Test engineer	Gyu-cheol Shin Technical manager



## KES Co., Ltd.

C-3701 Dongil Techno Town, 889-1, Gwanyang 2-dong,  
Dongan-gu, Anyang-si, Gyeonggi-do, 431-716, Korea  
Tel: +82-31-425-6200 / Fax: +82-31-424-0450  
[www.kes.co.kr](http://www.kes.co.kr)

---

### Revision history

Revision	Date of issue	Test report No.	Description
-	2012.03.22	KES-RF-120014	Initial



## KES Co., Ltd.

C-3701 Dongil Techno Town, 889-1, Gwanyang 2-dong,  
Dongan-gu, Anyang-si, Gyeonggi-do, 431-716, Korea  
Tel: +82-31-425-6200 / Fax: +82-31-424-0450  
www.kes.co.kr

---

## TABLE OF CONTENTS

1.0	General product description .....	4
1.1	Test frequency .....	4
1.2	Model differences.....	4
1.3	Device modifications .....	4
1.4	Test facility.....	5
1.5	Laboratory accreditations and listings.....	5
2.0	Summary of tests.....	6
2.1	Test data .....	7
2.1.1	Fundamental, spurious emission .....	7
2.1.2	20 dB bandwidth .....	12
2.1.3	Frequency tolerance .....	13
	Appendix A. Test equipment used for test.....	15
	Appendix B. Test setup photos .....	16



## 1.0 General product description

<b>Equipment under test</b>	Tire pressure monitoring system
<b>Model name</b>	TBO
<b>Serial number</b>	N/A
<b>Frequency Range</b>	433.92 MHz
<b>Modulation technique</b>	ASK
<b>Number of channels</b>	1
<b>Antenna type</b>	STUB antenna
<b>Power source</b>	DC 3 V

### 1.1 Test frequency

	<b>Low channel</b>	<b>Middle channel</b>	<b>High channel</b>
<b>Frequency (MHz)</b>	433.92	N/A	N/A

### 1.2 Model differences

N/A

### 1.3 Device modifications

N/A



## 1.4 Test facility

C3701 Dongil Techno Town, 889-1, Gwanyang 2-dong, Dongan-gu, Anyang-si, Gyeonggi-do, 431-716, Korea  
477-6, Hageo-ri, Yeoju-eup, Yeoju-gun, Gyeonggi-do, 469-803, Korea

The sites are constructed in conformance with the requirements of ANSI C63.7, ANSI C63.4 and CISPR Publication 22.

## 1.5 Laboratory accreditations and listings

Country	Agency	Scope of accreditation	Logo
USA	FCC	3 & 10 meter Open Area Test Sites and one conducted site to perform FCC Part 15/18 measurements.	 343818
KOREA	KC	EMI (10 meter Open Area Test Site and two conducted sites) Radio (3 & 10 meter Open Area Test Sites and one conducted site)	 KR0100
Canada	IC	3 & 10 meter Open Area Test Sites and one conducted site	 4769B-1



## 2.0 Summary of tests

Section in FCC Part 15	Parameter	Status
15.231(e) 15.209(a)	The field strength of fundamental and the field strength of spurious emission	C
15.231(c)	20 dB bandwidth	C
15.231(e)	Transmission plot	C

Note 1: C=Complies NC=Not complies NT=Not tested NA=Not applicable

## 2.1 Test data

### 2.1.1 Fundamental, spurious emission

#### Test location

Testing was performed at a test distance of 3 meter Open Area Test Site

#### Test procedures

[9 kHz to 30 MHz]

The EUT was placed on the top of a rotating table 0.8 meter above the ground at a 3 meter open area test site. The table was rotated 360 degrees to determine the position of the highest radiation. 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. 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. The test-receiver system was set to Quasi-peak function and specified bandwidth with maximum hold mode.

The spectrum analyzer is set to:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer 200 Hz for Quasi-peak detection (QP) at frequency below 9 kHz~ 150 kHz.
2. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer 9 kHz for Quasi-peak detection (QP) at frequency below 150 kHz~ 30 MHz.

[30 MHz to 1 GHz and above 1 GHz]

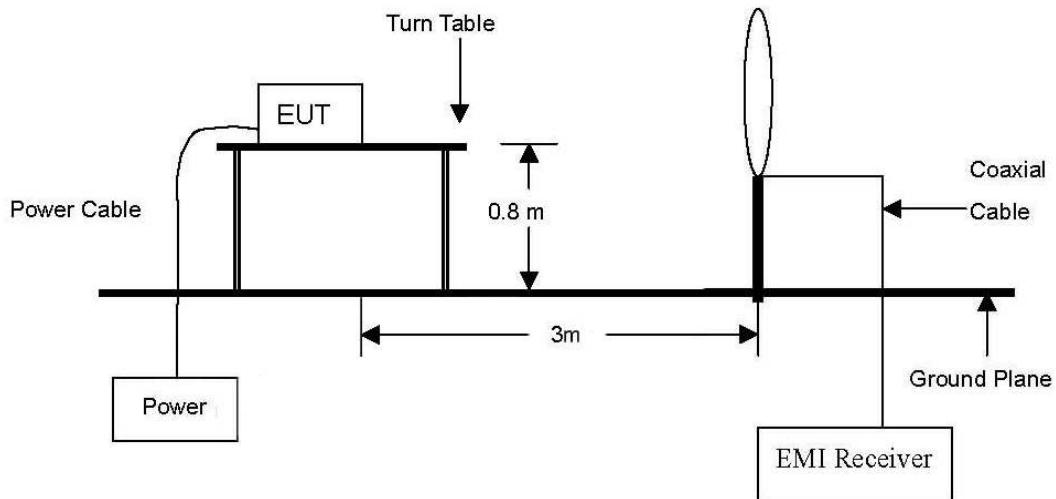
The height of the measuring antenna was varied between 1 to 4 m and the table was rotated a full revolution in order to obtain maximum values of the electric field intensity.

The measurement was made in both the vertical and horizontal polarization, and the maximum value is presented in the report.

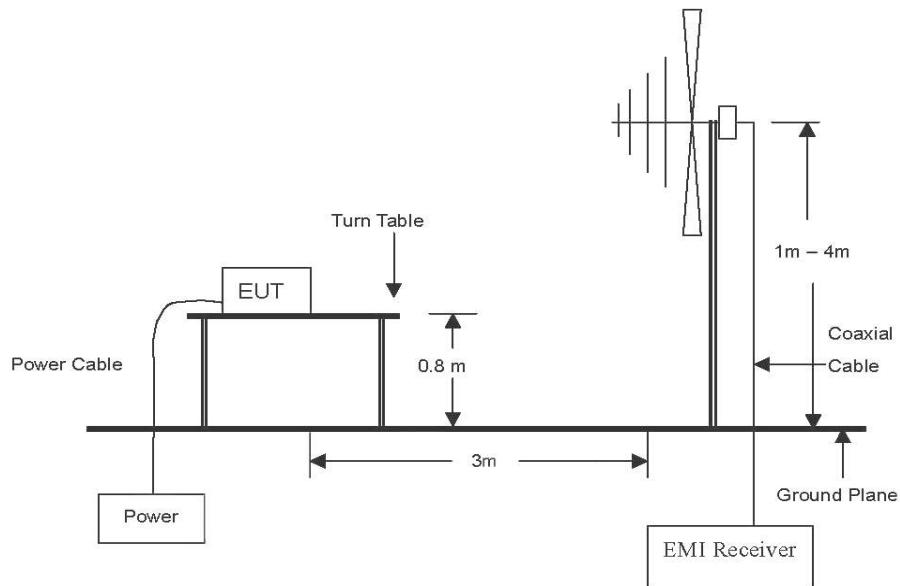
The spectrum analyzer is set to:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Peak detection (PK) or Quasi-peak detection (QP) at frequency below 1 GHz.
2. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 1 MHz for Peak detection at frequency above 1 GHz.

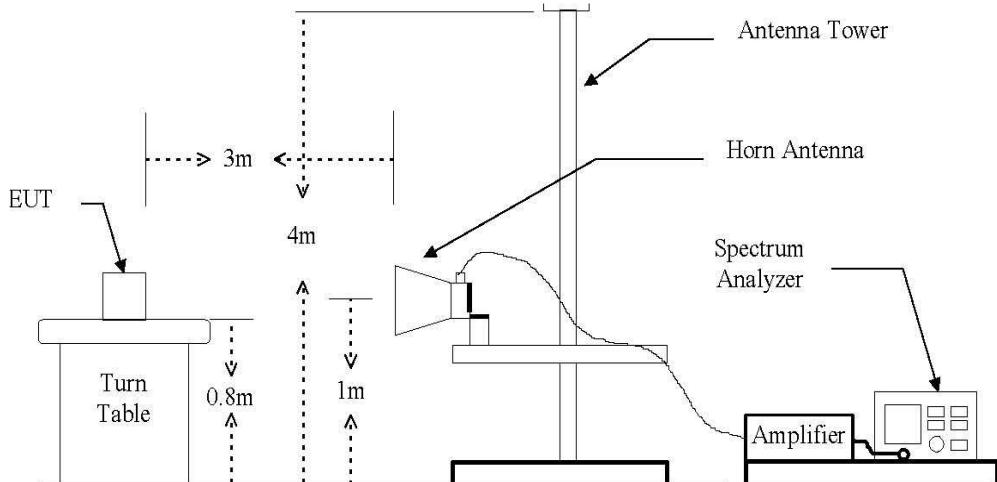
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 kHz to 30 MHz Emissions.



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 5 GHz emissions.



### Limit

In the section 15.209:

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)	Distance (Meters)	Radiated ( $\mu$ V/m)
0.009 ~ 0.490	300	2400 / F(kHz)
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

\*\*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., Sections 15.231 and 15.241.



In the section 15.231(e):

Intentional radiators may operate at a periodic rate exceeding that specified in paragraph (a) and may be employed for any type of operation, including operation prohibited in paragraph (a), provided the intentional radiator complies with the provisions of paragraphs (b) through (d) of this Section, except the field strength table in paragraph (b) is replaced by the following:

Fundamental frequency (MHz)	Field strength of fundamental (microvolts / meter)	Field strength of spurious emission (microvolts / meter)
40.66 ~ 40.70	1,000	100
70 ~ 130	500	50
130 ~ 174	500 to 1,500**	50 to 150**
174 ~ 260	1,500	150
260 ~ 470	1,500 to 5,000**	150 to 500**
Above 470	5,000	500

Where F is the frequency in MHz, the formulas for calculating the maximum permitted fundamental field strengths are as follows: for the band 130 ~ 174 MHz,  $\mu\text{V}/\text{m}$  at 3 meters =  $22.72727(F) - 2454.545$ ; for the band 260 ~ 470 MHz,  $\mu\text{V}/\text{m}$  at 3 meters =  $16.6667(F) - 2833.3333$ . The maximum permitted unwanted emission level is 20 dB below the maximum permitted fundamental level.

### Test results (Below 30 MHz)

The frequency spectrum from 9 kHz to 30 MHz was investigated. Emission levels are not reported much lower than the limits by over 20 dB.

Radiated emissions		Ant.	Correction factors			Total	Limit	
Frequency (MHz)	Reading (dB $\mu\text{V}$ )	Pol.	Ant. factor (dB/m)	Cable loss (dB)	F <sub>d</sub> (dB)	Actual (dB $\mu\text{V}/\text{m}$ )	Limit (dB $\mu\text{V}/\text{m}$ )	Margin (dB)
No emissions were detected at a level greater than 20 dB below limit.								

#### ※ Remark

1. All spurious emission at channels are almost the same below 30 MHz, so that high channel was chosen at representative in final test.
2. Actual = Reading + Ant. factor + Cable loss + F<sub>d</sub>
3. F<sub>d</sub> =  $40\log(D_m / D_s)$

Where:

F<sub>d</sub> = Distance factor in dB

D<sub>m</sub> = Measurement distance in meters

D<sub>s</sub> = Specification distance in meters



## KES Co., Ltd.

C-3701 Dongil Techno Town, 889-1, Gwanyang 2-dong,  
 Dongan-gu, Anyang-si, Gyeonggi-do, 431-716, Korea  
 Tel: +82-31-425-6200 / Fax: +82-31-424-0450  
 www.kes.co.kr

### Test results for fundamental

Radiated emissions		Ant.	Correction factors		Total	Limit		Detector mode
Frequency (MHz)	Reading (dB $\mu$ V)	Pol.	Ant. factor (dB/m)	Cable loss (dB)	Result (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	
433.92	36.79	H	16.33	4.43	57.55	72.87	15.32	Quasi-peak
433.92	31.83	V	16.33	4.43	52.59	72.87	20.28	Quasi-peak

#### \* Remark

- Actual = Reading + Ant. factor + Cable loss (or Amp. gain + cable loss)
- To get a maximum emission level from the EUT, the EUT was moved throughout the XY, XZ and YZ planes

### Test results for spurious

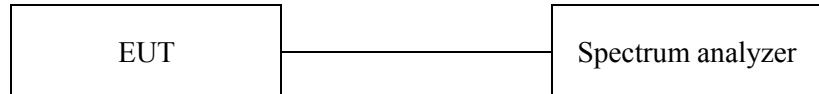
Radiated emissions		Ant.	Correction factors		Total	Limit		Detector mode
Frequency (MHz)	Reading (dB $\mu$ V)	Pol.	Ant. factor (dB/m)	Cable loss (dB)	Result (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	
56.70	10.87	V	13.29	1.40	25.56	40.00	14.44	Quasi-peak
301.60	8.69	H	13.40	3.62	25.71	46.00	20.29	Quasi-peak
301.60	10.38	V	13.40	3.62	27.40	46.00	18.60	Quasi-peak
867.84	14.50	H	22.97	6.64	44.11	52.87	8.76	Quasi-peak
867.84	15.17	V	22.97	6.64	44.78	52.87	8.09	Quasi-peak
Radiated emissions		Ant.	Correction factors		Total	Limit		Detector mode
Frequency (MHz)	Reading (dB $\mu$ V)	Pol.	Ant. factor (dB/m)	Amp. gain + cable loss (dB)	Result (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	
1301.76	62.80	H	24.62	-41.16	46.26	72.87	26.61	Peak
1301.76	-	H	24.62	-41.16	40.36	52.87	12.51	Average
1307.76	59.16	V	24.62	-41.16	42.62	72.87	30.25	Peak
1301.76	-	V	24.62	-41.16	36.72	52.87	16.15	Average
1735.68	64.75	H	26.42	-40.24	50.93	72.87	21.94	Peak
1735.68	-	H	26.42	-40.24	45.03	52.87	7.84	Average
1735.68	59.91	V	26.42	-40.24	46.09	72.87	26.78	Peak
1735.68	-	V	26.42	-40.24	40.19	52.87	12.68	Average

#### \* Remark

- Actual = Reading + Ant. factor + Cable loss (or Amp. gain + cable loss)
- To get a maximum emission level from the EUT, the EUT was moved throughout the XY, XZ and YZ planes
- Average result = result (peak) - duty factor.
- Duty factor =  $20\log(T_{on} / T_p) = 20\log(50.72 / 100) = -5.90 \text{ dB}$

## 2.1.2 20 dB bandwidth

### Test setup



### Test procedure

1. Use the following spectrum analyzer setting

RBW = 10 kHz

VBW = 30 kHz ( $\geq$  RBW)

Span = 1 MHz

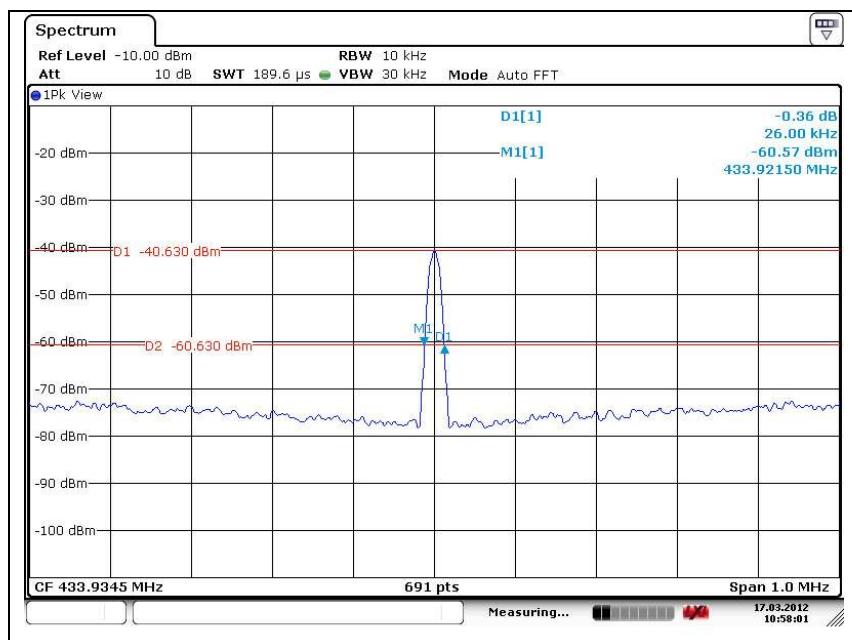
Detector function = peak

Trace = max hold

### Limit

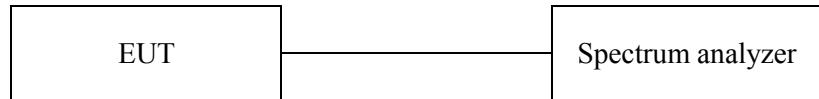
The bandwidth of the emissions shall be no wider than 0.25 % of the center frequency for devices operating above 70 MHz and below 900 MHz. Bandwidth is determined at the points 20 dB down from the modulated carrier.

### Test results



### 2.1.3 Transmission plot

#### 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.

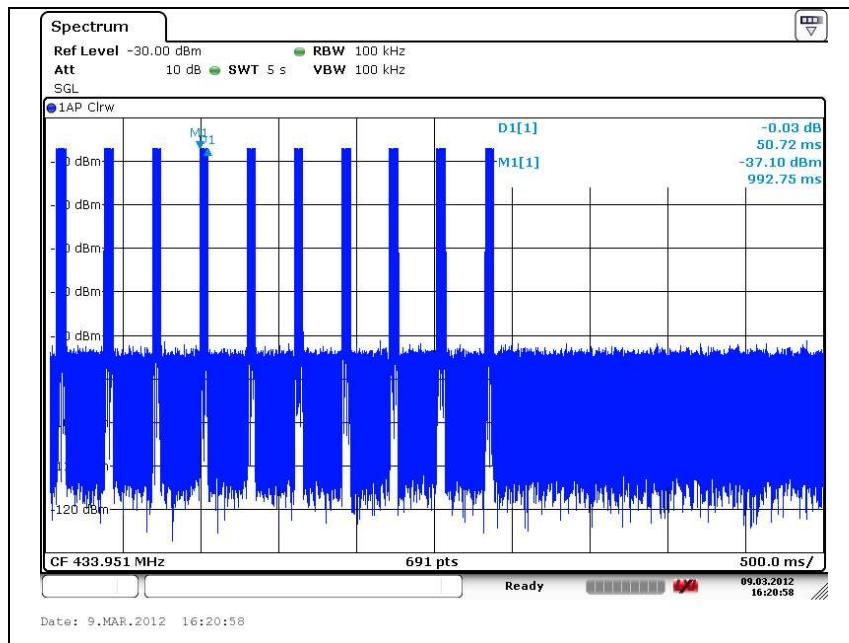
#### Limit

In addition, devices operated under the provisions of this paragraph shall be provided with a means for automatically limiting operation so that the duration of each transmission shall not be greater than one second and the silent period between transmissions shall be at least 30 times the duration of the transmission but in no case less than 10 seconds.

## Test results

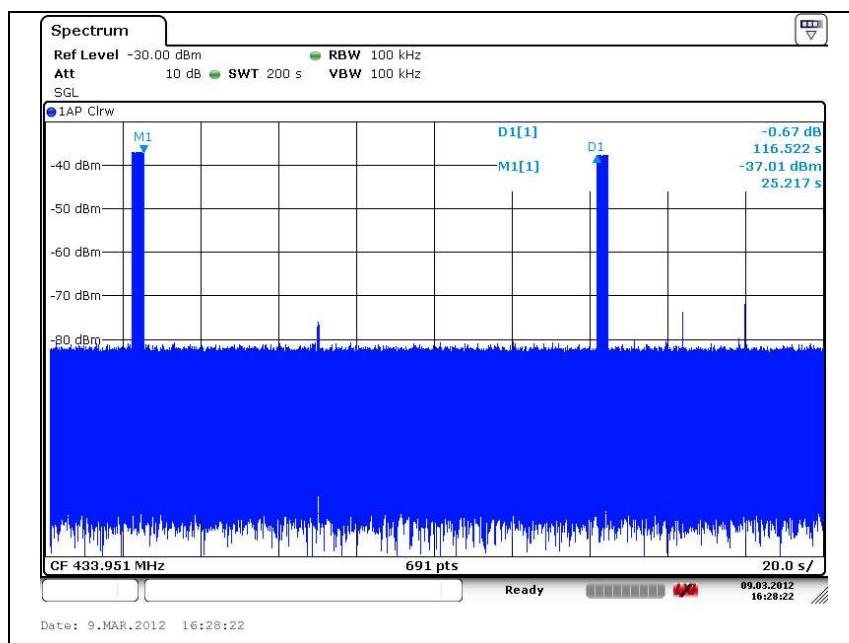
### Transmission time

Frequency(MHz)	Transmission time (ms)	Frame no.	Result(s)	Limit (s)
433.92	50.72	10	0.5072	<1



### Silent time

Frequency(MHz)	Silent time(s)	Limit (s)
433.92	116.522	≥15.216





## KES Co., Ltd.

C-3701 Dongil Techno Town, 889-1, Gwanyang 2-dong,  
Dongan-gu, Anyang-si, Gyeonggi-do, 431-716, Korea  
Tel: +82-31-425-6200 / Fax: +82-31-424-0450  
www.kes.co.kr

### Appendix A. Test equipment used for test

Equipment	Manufacturer	Model	Calibration due.
Spectrum Analyzer	R&S	FSV30	2013.01.10
Vector Signal Generator	R&S	SMBV2100A	2013.01.10
DC Power Supply	Agilent	6632B	2012.12.05
High Pass Filter	Mini-Circuits	NHP-800+	2012.08.05
Preamplifier	A.H.	PAM-0118	2012.05.04
Loop Antenna	R&S	HFH2-Z2.335.4711.52	2013.03.18
Trilog-Broadband Antenna	SCHWARZBECK	VULB 9168	2013.04.28
Horn Antenna	A.H.	SAS-571	2013.03.22
EMC Analyzer	Agilent	E7405A	2012.08.22

### Peripheral device

Device	Manufacturer	Model No.	Serial No.
N/A			

## Appendix B. Test setup photos

### Radiated field emissions

