

## FCC - TEST REPORT

Report Number : **60.790.22.020.01R02** Date of Issue : June 2, 2022

Model : HUS

Product Type : Head Unit

Applicant : MAHLE SmartBike Systems SLU

Address : Orfebres 10, Palencia, 34004, Spain.

Production Facility : KENDY ELECRTONICS (DONGGUAN) CO., LTD.

Address : XIN SI HUANG TANG VILLAGE HENG LI TOWN,  
DONGGUAN CITY, GUANGDONG, CHINA.

Test Result : ☒ Positive ☐ Negative

Total pages  
including  
Appendices : 21

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## 2 Description of Equipment Under Test

### Description of the Equipment Under Test

Product: Head Unit

Model no.: HUS

FCC ID: 2APUWHUS

Rating: 6.0 VDC

Frequency: ANT+  
2457MHz

Antenna gain: 0 dBi

Number of operated channel: 1

Modulation: GFSK

### Auxiliary Equipment and Software Used during Test:

DESCRIPTION	MANUFACTURER	MODEL NO.	S/N
Computer	Lenovo	X220	0A72168
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### Auxiliary Software Used during Test:

DESCRIPTION	SOFTWARE NAME	VERSION	REMARK
RF Test Mode Software	nRFgo	1.16	Provided by applicant

### 3 Summary of Test Standards

Test Standards
FCC Part 15 Subpart C 10-1-20 Edition Federal Communications Commission, PART 15 — Radio Frequency Devices, Subpart C — Intentional Radiators

All the tests were performed using the procedures from ANSI C63.4(2014) and ANSI C63.10 (2013).

## 4 Details about the Test Laboratory

### Site 1

Company name: TÜV SÜD Certification and Testing (China) Co., Ltd. Shenzhen Branch  
Building 12&13 Zhiheng Wisdomland Business Park,  
Nantou Checkpoint Road 2, Nanshan District,  
Shenzhen 518052, P.R.China  
FCC Registration Number: 514049  
ISED test site number: 10320A

Emission Tests	
Test Item	Test Site
<b>FCC Part 15 Subpart C</b>	
FCC Title 47 Part 15.205, 15.209 & 15.249 & Radiated Emission	Site 1
FCC Title 47 Part 15.207 Conduct Emission	Site 1
FCC Title 47 Part 15.215 20dB & 99% Bandwidth	Site 1
FCC Title 47 Part 15.203 Antenna Requirement	Site 1

## 4.1 Test Equipment Site List

### Radiated emission Test – Site 1

DESCRIPTION	MANUFACTURER	MODEL NO.	SERIAL NO.	CAL. DUE DATE
EMI Test Receiver	Rohde & Schwarz	ESR 26	101269	2022-6-29
Signal Analyzer	Rohde & Schwarz	FSV40	101031	2022-6-22
Loop Antenna	Rohde & Schwarz	HFH2-Z2	100398	2022-7-7
Trilog Super Broadband Test Antenna	Schwarzbeck	VULB 9163	707	2022-8-4
Horn Antenna	Rohde & Schwarz	HF907	102294	2022-7-5
Wideband Horn Antenna	Q-PAR	QWH-SL-18-40-K-SG	12827	2022-6-21
Pre-amplifier	Rohde & Schwarz	SCU 18	102230	2022-6-21
Pre-amplifier	Rohde & Schwarz	SCU 40A	100432	2022-7-30
Attenuator	Agilent	8491A	MY39264334	2022-6-21
3m Semi-anechoic chamber	TDK	9X6X6	----	2022-10-28
Test software	Rohde & Schwarz	EMC32	Version 9.15.00	N/A

### Conducted Emission Test – Site 1

DESCRIPTION	MANUFACTURER	MODEL NO.	SERIAL NO.	CAL. DUE DATE
EMI Test Receiver	Rohde & Schwarz	ESR 3	101782	2022-6-29
LISN	Rohde & Schwarz	ENV4200	100249	2022-6-12
LISN	Rohde & Schwarz	ENV432	101318	2022-6-12
LISN	Rohde & Schwarz	ENV216	100326	2022-6-12
LISN	Rohde & Schwarz	ENV216	102472	2022-6-12
ISN	Rohde & Schwarz	ENY81	100177	2022-6-12
ISN	Rohde & Schwarz	ENY81-CA6	101664	2022-6-12
High Voltage Probe	Schwarzbeck	TK9420(VT9420)	9420-584	2022-6-23
RF Current Probe	Rohde & Schwarz	EZ-17	100816	2022-6-28
Attenuator	Shanghai Huaxiang	TS2-26-3	080928189	2022-6-21
Test software	Rohde & Schwarz	EMC32	Version 9.15.00	N/A
Shielding Room	TDK	CSR #1	----	2022-11-07

### 20dB & 99% Bandwidth – Site 1

DESCRIPTION	MANUFACTURER	MODEL NO.	SERIAL NO.	CAL. DUE DATE
Signal Analyzer	Rohde & Schwarz	FSV40	101030	2022-6-21
RF Switch Module	Rohde & Schwarz	OSP120/OSP-B157	101226/100851	2022-6-21

## 4.2 Measurement System Uncertainty

### Measurement System Uncertainty Emissions

System Measurement Uncertainty	
Items	Extended Uncertainty
Uncertainty for Radiated Emission in 3m chamber 9kHz-30MHz	4.76dB
Uncertainty for Radiated Emission in 3m chamber 30MHz-1000MHz	Horizontal: 5.12dB; Vertical: 5.10dB;
Uncertainty for Radiated Emission in 3m chamber 1000MHz-25000MHz	Horizontal: 5.01dB; Vertical: 5.00dB;
Uncertainty for Conducted Emission at AC Power Line 150kHz-30MHz	3.21dB
Uncertainty for conducted power test	1.16dB
Uncertainty for frequency test	$0.6 \times 10^{-7}$

### Measurement Uncertainty Decision Rule

Determination of conformity with the specification limits is based on the decision rule according to IEC Guide 115: 2007, clause 4.4.3 and 4.5.1.

## 5 Summary of Test Results

Emission Tests				
FCC Part 15 Subpart C				
Test Condition	Pages	Test Result		
		Pass	Fail	N/A
FCC Title 47 Part 15.205, 15.209 & 15.249 Radiated Emission	12-13	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
FCC Title 47 Part 15.215 20dB & 99% Bandwidth	14	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
FCC Title 47 Part 15.207 Conduct Emission (1)	15	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
FCC Title 47 Part 15.203 Antenna Requirement	16	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

### Remarks:

- (1) Test not applicable for Battery Operated Product.



## 6 General Remarks

### Remarks

All tests were performed on model: **HUS**. All data packet type modes have been tested, only the worst case is shown on the report.

This submittal(s) (test report) is intended for **FCC ID: 2APUWHUS**, complies with Section 15.203, 15.205, 15.209, 15.249 of the FCC Part 15, Subpart C rules.

The TX and RX range is 2457MHz.

### SUMMARY:

- All tests according to the regulations cited on page 8 were

n - Performed

o - **Not** Performed

- The Equipment Under Test

n - **Fulfills** the general approval requirements.

o - **Does not** fulfill the general approval requirements.

Sample Received Date: May 6, 2022

Testing Start Date: May 10, 2022

Testing End Date: May 24, 2022

- TÜV SÜD Certification and Testing (China) Co., Ltd. Shenzhen Branch -

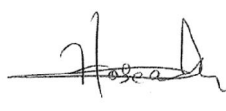
Reviewed by:

Prepared by:

Tested by:



Eric Li  
EMC Project Manager



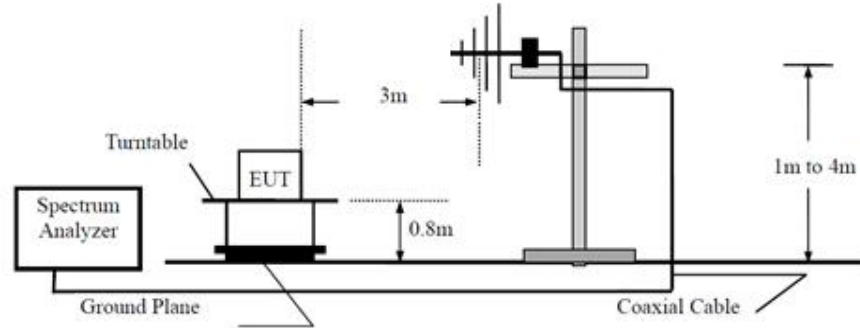
Hosea CHAN  
EMC Project Engineer



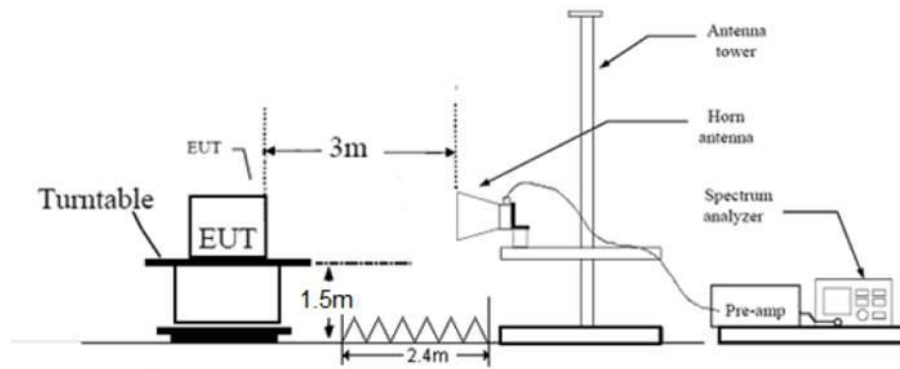
Louise Liu  
EMC Test Engineer

## 7 Test Setups

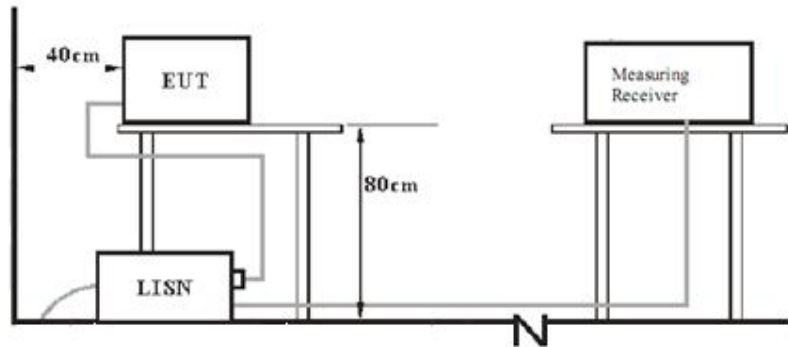
### 7.1 Radiated test setups Below 1GHz



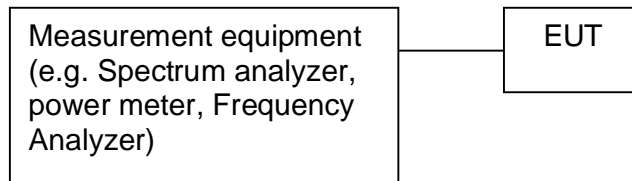
### 7.2 Radiated test setups Above 1GHz



### 7.3 AC Power Line Conducted Emission test setups



### 7.4 Conducted RF test setups



## 8 Emission Test Results

### 8.1 Radiated Emission

EUT: HUS  
 Op Condition: Operated, TX Mode (2457MHz)  
 Test Specification: FCC15.249 & 15.209, Antenna: Horizontal  
 Comment: 6.0 VDC  
 Remark: Measurement range up to 25GHz

Test Result	
<input checked="" type="checkbox"/>	Passed
<input type="checkbox"/>	Not Passed

Frequency MHz	Result dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Detector PK/QP/AV	Corr. (dB)	RSE. or Fund.
47.190556	21.89	40.00	18.11	Quasi Peak	21.08	Spurious emission
101.133333	20.75	43.50	22.75	Quasi Peak	18.55	Spurious emission
247.980556	29.33	46.00	16.68	Quasi Peak	19.89	Spurious emission
367.991111	32.62	46.00	13.38	Quasi Peak	22.39	Spurious emission
511.982222	33.15	46.00	12.85	Quasi Peak	25.50	Spurious emission
704.150000	32.96	46.00	13.04	Quasi Peak	28.78	Spurious emission
<b>2457.000000</b>	<b>96.15</b>	<b>114.00</b>	<b>17.85</b>	<b>Peak</b>	<b>-5.78</b>	<b>Fundamental</b>
<b>2457.000000</b>	<b>88.55</b>	<b>94.00</b>	<b>5.45</b>	<b>AV</b>	<b>-5.78</b>	<b>Fundamental</b>
2329.000000	45.78	74.00	28.22	Peak	-5.60	Spurious emission
2585.500000	48.89	74.00	25.11	Peak	-4.11	Spurious emission
3459.000000	44.51	74.00	29.49	Peak	-0.17	Spurious emission
4328.000000	47.82	74.00	26.18	Peak	3.34	Spurious emission

Remark:

1. According to C63.10, if the peak (or quasi-peak) measured value complies with the average limit, it is unnecessary to perform an average measurement, so AV emission value did not show in data table if the peak value complies with average limit.
2. Consequence Level=Reading Level + Correction Factor  
 Above 1GHz: Corrector factor = Antenna Factor + Cable Loss- Amplifier Gain  
 Below 1GHz: Corrector factor = Antenna Factor + Cable Loss  
 (The Reading Level is recorded by software which is not shown in the sheet)
3. No significant emissions were detected above 18GHz.

## Radiated Emission

EUT: HUS  
 Op Condition: Operated, TX Mode (2457MHz)  
 Test Specification: FCC15.249 & 15.209, Antenna: Vertical  
 Comment: 6.0 VDC  
 Remark: Measurement range up to 25GHz

Test Result	
<input checked="" type="checkbox"/>	Passed
<input type="checkbox"/>	Not Passed

Frequency MHz	Result dBμV/m	Limit dBμV/m	Margin dB	Detector PK/QP/AV	Corr. (dB)	RSE. or Fund.
47.621667	22.61	40.00	17.39	Quasi Peak	20.99	Spurious emission
101.564444	20.47	43.50	23.03	Quasi Peak	18.59	Spurious emission
241.837222	23.00	46.00	23.00	Quasi Peak	19.62	Spurious emission
421.233333	27.61	46.00	18.39	Quasi Peak	23.97	Spurious emission
594.162778	32.00	46.00	14.00	Quasi Peak	27.52	Spurious emission
906.179444	36.69	46.00	9.31	Quasi Peak	31.67	Spurious emission
<b>2457.000000</b>	<b>94.40</b>	<b>114.00</b>	<b>19.6</b>	<b>Peak</b>	<b>-5.78</b>	<b>Fundamental</b>
<b>2457.000000</b>	<b>88.30</b>	<b>94.00</b>	<b>5.7</b>	<b>AV</b>	<b>-5.78</b>	<b>Fundamental</b>
2665.000000	44.05	74.00	29.95	Peak	-3.75	Spurious emission
3472.000000	44.70	74.00	29.30	Peak	-0.20	Spurious emission
4117.500000	48.68	74.00	25.32	Peak	2.27	Spurious emission
8925.000000	44.90	74.00	29.10	Peak	13.00	Spurious emission

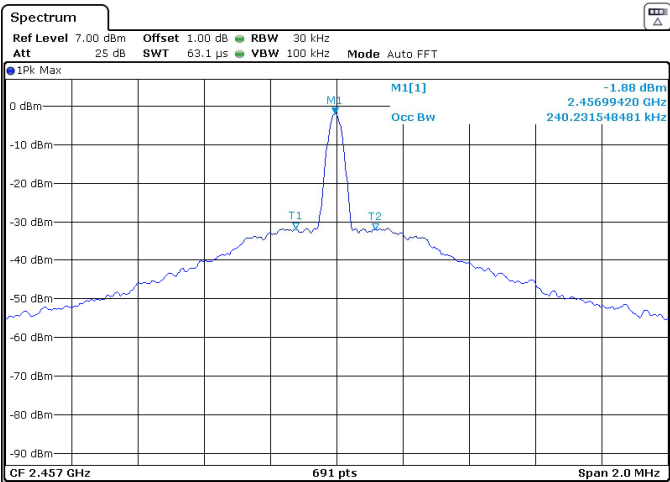
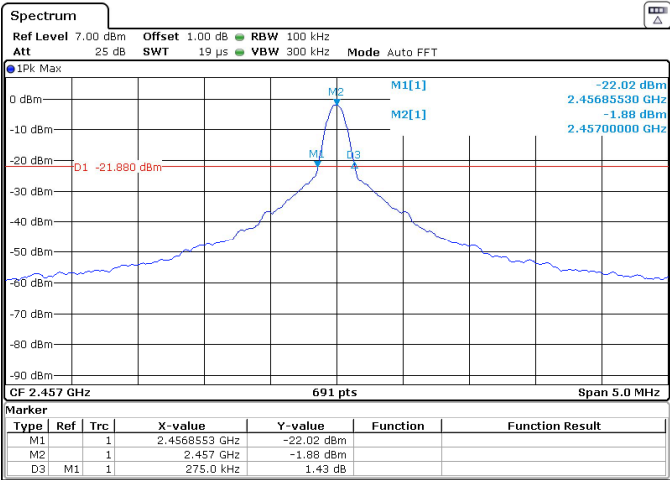
### Remark:

- According to C63.10, if the peak (or quasi-peak) measured value complies with the average limit, it is unnecessary to perform an average measurement, so AV emission value did not show in data table if the peak value complies with average limit.
- Consequence Level=Reading Level + Correction Factor  
 Above 1GHz: Corrector factor = Antenna Factor + Cable Loss- Amplifier Gain  
 Below 1GHz: Corrector factor = Antenna Factor + Cable Loss  
 (The Reading Level is recorded by software which is not shown in the sheet)
- No significant emissions were detected above 18GHz.

8.2 20dB & 99% Bandwidth

EUT: HUS  
Op Condition: Operated, TX Mode (2457MHz)  
Test Specification: FCC15.215  
Comment: 6.0 VDC

Test Result  
☒ Passed  
☐ Not Passed



Bandwidth	Measured Value
20dB bandwidth	0.275 MHz
99% OCB	0.240 MHz

### 8.3 Conducted Emission at AC Power line

Conducted Emission testing is not applicable for this product because it is powered by DC power, and do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines.

## 8.4 Antenna Requirement

EUT: HUS  
Op Condition: Operated, TX Mode  
Test Specification: FCC15.203 (b)  
Comment: 6.0 VDC

Test Result	
<input checked="checked" type="checkbox"/>	Passed
<input type="checkbox"/>	Not Passed

### Limit

For intentional device, according to FCC Title 47 Part 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.

### Antenna Connector Construction

The antenna used in this product is an integrated antenna on PCB, which in accordance to section 15.203, is considered sufficient to comply with the antenna requirement.



## 9 Test setup procedure

### 9.1 Field strength of emissions and Restricted bands

#### Test Method

- 1: The EUT was placed on a turn table which is 1.5m above ground plane for above 1GHz and 0.8m above ground for below 1GHz at 3-meter chamber room for test. The table was rotated 360 degrees to determine the position of the highest radiation.
- 2: The EUT was set 3 meters away from the interference – receiving antenna, which was mounted on the top of a variable – height antenna tower.
- 3: The height of antenna is varied from one meter to four 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.
- 4: 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 rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
- 5: Use the following spectrum analyzer settings According to C63.10:

#### For Above 1GHz

Span = wide enough to capture the peak level of the in-band emission and all spurious  
RBW = 1MHz, VBW $\geq$ 3RBW, Sweep = auto, Detector function = peak and average,  
Trace = max hold.

#### For Below 1GHz

Use the following spectrum analyzer settings:

Span = wide enough to capture the peak level of the in-band emission and all spurious  
RBW = 120KHz, VBW $\geq$ 3RBW, Sweep = auto, Detector function = QP,  
Trace = max hold.

## Field strength of emissions and Restricted bands

### Limits

According to §15.249 (a), the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental frequency	Field strength of fundamental (millivolts/meter)	Field strength of harmonics (microvolts/meter)
902–928 MHz	50	500
2400–2483.5 MHz	50	500
5725–5875 MHz	50	500
24.0–24.25 GHz	250	2500

According to §15.249 (c), Field strength limits are specified at a distance of 3 meters.

According to §15.249 (d), Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

According to §15.205 Unwanted emissions falling into restricted bands in §15.205 (a) shall comply with the limits specified in §15.209.

Frequency MHz	Field Strength uV/m	Field Strength dBμV/m	Detector
30-88	100	40	QP
88-216	150	43.5	QP
216-960	200	46	QP
960-1000	500	54	QP
Above 1000	500	54	AV
Above 1000	5000	74	PK

## 9.2 Conducted Emission at AC Power line

### Test Method

1. The EUT was placed on a table, which is 0.8m above ground plane
2. The power line of the EUT is connected to the AC mains through a Artificial Mains Network (A.M.N.).
3. Maximum procedure was performed to ensure EUT compliance
4. A EMI test receiver is used to test the emissions from both sides of AC line

### Limit

Frequency MHz	QP Limit dB $\mu$ V	AV Limit dB $\mu$ V
0.150-0.500	66-56*	56-46*
0.500-5	56	46
5-30	60	50

\*Decreasing linearly with logarithm of the frequency.

### 9.3 20dB & 99% Bandwidth

#### Test Method

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT without connection to spectrum analyser. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
3. Measure the frequency difference of two frequencies that were attenuated 20dB from the reference level. Record the frequency difference as the emission bandwidth.

#### Limits:

According to 15.215 (c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in Subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

## 10 Appendix A - General Product Information

### Radiofrequency radiation exposure evaluation

This exposure evaluation is intended for **FCC ID: 2APUWHUS**

According to KDB 447498 D01v06 section 4.3.1, For frequencies between 100 MHz to 6GHz and test separation distances  $\leq 50$  mm, the Numeric threshold is determined as:

Step a)

$[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})}] \leq 3.0$  for 1-g SAR

>> The fundamental frequency of the EUT is 2457MHz,  
the test separation distance is  $\leq 50$ mm.  
(Manufacturer specified the separation distance is: 5mm)  
(5mm is the worst case according to the KDB)

Step b)

>> Numeric threshold (2457MHz),  $\text{mW} / 5\text{mm} \cdot \sqrt{2.457\text{GHz}} \leq 3.0$   
Numeric threshold (2457MHz)  $\leq 9.569\text{mW}$

>> The power (calculated power + tune up tolerance) of EUT at 2457MHz is: 1.26mW  
Which is smaller than the Numeric threshold.  
Therefore, the device is exempt from stand-alone SAR test requirements.

Power calculation (According to C63.10 chapter 9.5)


	Value	Unit
Field Strength Measured (E)	96.15	dB $\mu$ V/m
Measurement Distance (D)	3	m
Equivalent Isotropically Radiated Power (E.I.R.P in dBm)	0.992	dBm
Equivalent Isotropically Radiated Power (E.I.R.P in mW)	1.26	mW

Remark:  $\text{EIRP} = E + 20\log(D) - 104.7$

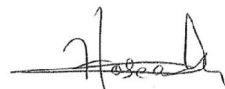
(EIRP is in dBm, E is in dB $\mu$ V/m, D is in metres)

Reviewed by:

Prepared by:



Eric LI  
EMC Project Manager

Hosea CHAN  
EMC Project Engineer