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Hearing Aid Compatibility (HAC) RF Emissions TEST REPORT

Report No: STS1606188H01

Issued for

CLC HONG KONG LIMITED

1011A, 10/F., Harbour Centre Tower 1, No.1 Hok Cheung St.,
Hung Hom, Kowloon, Hong Kong

Product Name:	Axe Plus 2
Brand Name:	plum
Model No.:	Z404
Series Model:	N/A
FCC ID:	2AG4WZ404
Test Standard:	ANSI C63.19:2011
Test Result:	Pass

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Test Report Certification

Applicant's name : CLC HONG KONG LIMITED
Address : 1011A, 10/F., Harbour Centre Tower 1, No.1 Hok Cheung St., Hung Hom, Kowloon, Hong Kong
Manufacture's Name : CLC Technology Co. Ltd
Address : Room 6H, Block C, NEO Building, Chegongmiao, Futian District, Shenzhen, P.R. China

Product description

Product name : Axe Plus 2
Trademark : plum
Model and/or type reference : Z404
Serial Model : N/A

Standards : ANSI C63.19:2011

The device was tested by Shenzhen STS Test Services Co., Ltd. in accordance with the measurement methods and procedures specified in KDB 865664 The test results in this report apply only to the tested sample of the stated device/equipment. Other similar device/equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

Date of Test :
Date (s) of performance of tests : 08 Aug. 2016
Date of Issue : 09 Aug. 2016
Test Result : **Pass**

Testing Engineer : *Allen Chen*

 (Allen Chen)

Technical Manager : *John Zou*

 (John Zou)

Authorized Signatory : *Bovey Yang*

 (Bovey Yang)





TABLE OF CONTENTS

1. General Information	4
1.1 EUT Description	4
1.2 Test Environment	5
1.3 Test Facility	5
2. System components	6
2.1 SATIMO System Description	6
2.2 E-Field Probe Specification	6
2.3 H-Field Probe Specification	6
2.4 Axis Articulated Robot	7
2.5 Universal Device Positioner	7
2.6 Test Equipment List	8
2.7 Measurement Uncertainty	9
3. HAC RF Emission Measurement Evaluation	10
3.1 System Check	10
3.2 Dipole validation	10
3.3 System Validation Results	10
4. Device Under Test	11
5. Modulation interference Factor (MIF)	12
6. HAC TEST PROCEDURES	13
7. Test flowchart Per ANSI-PC63.19 2011	14
8. RF EMISSIONS	15
9 HAC RF Emission Test Results	15
9.1 Test Result	15
9.2 E-Field Emission for GSM:	16
10. HAC Test Photographs	22
11. System VALIDATION RESULTS	23
12. Probe Calibration And Dipole Calibration Report	24



1. General Information

1.1 EUT Description

Equipment	Axe Plus 2
Brand Name	plum
Model No.	Z404
Serial Model	N/A
FCC ID	2AG4WZ404
Model Difference	N/A
Hardware Version	V1.0
Software Version	N/A
Frequency Range	GSM 850: 824.2 ~ 848.8 MHz PCS1900: 1850.2 ~ 1909.8 MHz WCDMA II: 1852.4~1907.6 MHz WCDMA V: 826.4~846.6 MHz WLAN 802.11 b/g/n(HT20):2412 ~ 2462 MHz WLAN 802.11 n(HT40):2422 ~ 2452 MHz Bluetooth: 2402 ~ 2480MHz
Transmit Power(Average):	GSM 850: 32.83dBm GSM 1900: 30.11dBm WCDMA II: 22.76dBm WCDMA V: 22.72dBm
M category	M3
Test Result	Pass
Operating Mode:	GSM: GSM Voice, GPRS,EDGE Class 12; WCDMA: RMC, HSDPA, HSUPA Release 6; WLAN: 802.11 b/g/n; Bluetooth: V4.0+EDR (GFSK+ π /4DQPSK+8DPSK)
Antenna Specification:	GSM/WCDMA: PIFA Antenna BT/WIFI: PIFA Antenna
Hotspot Mode:	Not Support
DTM Mode:	Not Support



1.2 Test Environment

Ambient conditions in the SAR laboratory:

Items	Required	Actual
Temperature (°C)	15-30	21~23
Humidity (%RH)	30-70	55~65

1.3 Test Facility

Shenzhen STS Test Services Co., Ltd.

Add. : 1/F., Building B, Zhuoke Science Park, No.190, Chongqing Road,
Fuyong Street, Bao'an District, Shenzhen, Guangdong, China

CNAS Registration No.: L7649

FCC Registration No.: 842334; IC Registration No.: 12108A-1



2. System components

2.1 SATIMO System Description

SATIMO is fully compliant with the technical and scientific requirements of IEEE 1528, IEC 62209, CENELEC, ARIB, ACA, and the Federal Communications Commission. The system comprises of a six axes articulated robot which utilizes a dedicated controller. SATIMO uses the latest methodologies and FDTD order to provide a platform which is repeatable with minimum uncertainty.



2.2 E-Field Probe Specification

Device Under Test	
Device Type	COMOHAC E FIELD PROBE
Manufacturer	Satimo
Model	SCE
Serial Number	SN 06/14 EPH42
Product Condition (new / used)	new
Frequency Range of Probe	0.7GHz-2.5GHz
Resistance of Three Dipoles at Connector	Dipole 1: R1=0.214 MΩ Dipole 2: R2=0.213 MΩ Dipole 3: R3=0.204 MΩ



2.3 H-Field Probe Specification

Device Under Test	
Device Type	COMOHAC H FIELD PROBE
Manufacturer	Satimo
Model	SCH
Serial Number	SN 06/14 HPH51
Product Condition (new / used)	New
Frequency Range of Probe	0.7GHz-2.5GHz
Resistance of Three Loops at Connector	Loop 1: R1=0.280 MΩ Loop 2: R2=0.309 MΩ Loop 3: R3=0.297 MΩ



2.4 Axis Articulated Robot



SATIMO utilizes a six articulated robot, which is controlled using a Pentium based real-time movement controller. The movement kinematics engine utilizes proprietary (Thermo CRS) interpolation and extrapolation algorithms, which allow full freedom of movement for each of the six joints within the working envelop. Utilization of joint 6 allows for full probe rotation with a tolerance better than 0.05mm around the central axis.

Robot /Controller Manufacturer	KUKA
Number of Axis	Six independently controlled axis
Positioning Repeatability	< $\pm 0.03\text{mm}$
Controller Type	KR C4 compact
Robot Reach	901mm
Communication	RS232 and LAN compatible

2.5 Universal Device Positioner

The universal device positioner allows complete freedom of movement of the EUT. Developed to hold a EUT in a free-space scenario any additional loading attributable to the material used in the construction of the positioner has been eliminated. Repeatability has been enhanced through the linear scales which form the design used to indicate positioning for any given test scenario in all major axes.



2.6 Test Equipment List

NO.	Instrument	Manufacturer	Model	S/N	Cal. Date	Cal. Due Date
1	E-Field Probe	SATIMO	SCE	SN 06/14 EPH42	2015.09.01	2016.08.31
2	Reference Validation Dipole 850MHz	SATIMO	SID835	SN 13/14 DHA55	2014.09.01	2017.08.31
3	Reference Validation Dipole 1900MHz	SATIMO	SIDB1900	SN 13/14 DHB59	2014.09.01	2017.08.31
4	Dielectric Probe Kit	SATIMO	SCLMP	SN 32/14 OCPG52	2015.09.01	2016.08.31
5	Device Holder	SATIMO	SCLMP	SN 32/14 TABH37	Validated. No cal required	Validated. No cal required
6	Antenna	SATIMO	ANTA3	SN 07/13 ZNTA52	2014.09.01	2017.08.31
7	COMHAC Test Bench	SATIMO	Version 2	NA	Validated. No cal required	Validated. No cal required
8	HAC positioning ruler	SATIMO	TABH12 SN 42/09	NA	Validated. No cal required	Validated. No cal required
9	Temperature/Humidity sensor	Mieo	HH660	STS-H025	2015.10.28	2016.10.27
10	Multi Meter	Keithley	Multi Meter 2000	4050073	2015.11.20	2016.11.19
11	Amplifier	Mini-Circuit	ZHL-42	22374	2015.11.20	2016.11.19
12	Signal Generator	R&S	SMF100A	104260	2015.11.18	2016.11.17
13	Power Meter	R&S	NRP	100510	2015.10.24	2016.10.23
14	Power Sensor	R&S	NRP-Z11	101919	2015.10.10	2016.10.09
15	KUKA Robot	KUKA	10012265	501821	2015.09.01	2016.08.31
16	Wireless Communication Test Set	Agilent	8960-5071C	EMY46103472	2015.12.12	2016.12.11

Note: All equipment upon which need to be calibrated are with calibration period of 1 year.

2.7 Measurement Uncertainty

UNCERTAINTY EVALUATION FOR RF HAC MEASUREMENT

Uncertainty Component	Tol. (± dB)	Prob. Dist.	Div.	Uncertainty (dB)	Uncertainty (%)
Measurement System					
RF reflections	0.1	R	√3	0.06	
Field probe conv. Factor	0.4	R	√3	0.23	
Field probe anisotropy	0.25	R	√3	0.14	
Positioning accuracy	0.2	R	√3	0.12	
Probe cable placement	0.1	R	√3	0.06	
System repeatability	0.2	R	√3	0.12	
EUT repeatability	0.4	N	1	0.40	
Combined Standard Uncertainty		N	1	0.52	
Expanded Uncertainty (95% CONFIDENCE INTERVAL)		N	k=2	1.03	12.65
REPORTED Expanded uncertainty (confidence level of 95%, k = 2)		N	k=2	1.00	13.00

UNCERTAINTY EVALUATION FOR AUDIO HAC MEASUREMENT

Uncertainty Component	Tol. (± dB)	Prob. Dist.	Div.	Uncertainty (dB)	Uncertainty (%)
Measurement System					
RF reflections	0.1	R	√3	0.06	
Acoustic noise	0.1	R	√3	0.06	
Probe coil sensitivity	0.49	R	√3	0.28	
Reference signal level	0.25	R	√3	0.14	
Positioning accuracy	0.4	R	√3	0.23	
Cable loss	0.1	N	2	0.05	
Frequency analyzer	0.15	R	√3	0.09	
System repeatability	0.2	N	1	0.20	
Repeatability of the WD	0.4	N	1	0.40	
Combined Standard Uncertainty		N	1	0.61	
Expanded uncertainty (confidence level of 95%, k = 2)		N	k=2	1.22	15.05
REPORTED Expanded uncertainty (confidence level of 95%, k = 2)		N	k=2	1.20	15.00

3. HAC RF Emission Measurement Evaluation

3.1 System Check

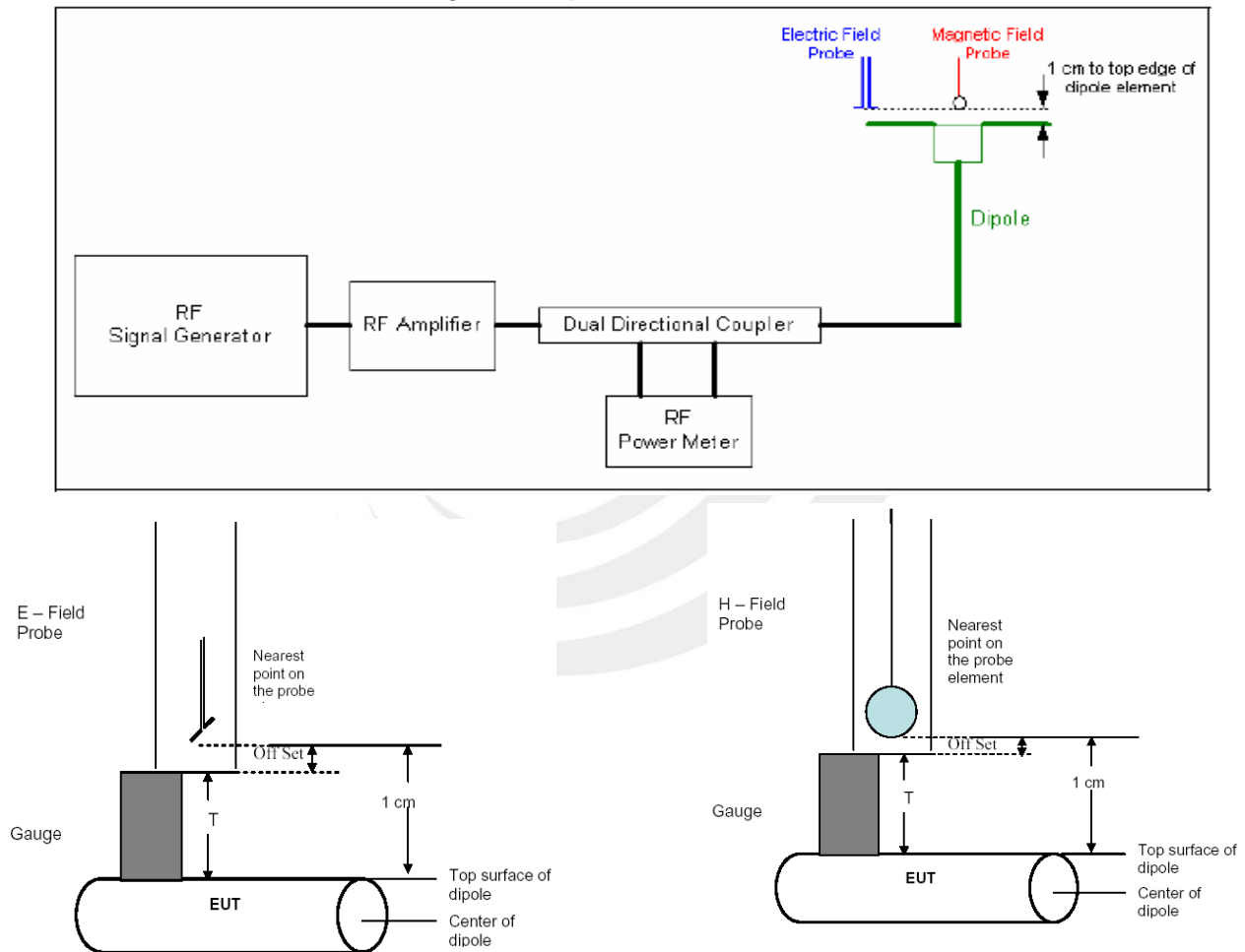
The test setup should be validated when first configured and verified periodically thereafter to ensure proper function. The procedure consists of two parts: dipole validation and determination of probe modulation factor

3.2 Dipole validation

The HAC validation dipole antenna serves as a known source for an electrical and magnetic RF output. Figure 2 shows the setup used for the dipole validation.

1. The dipole antenna was placed in the position normally occupied by the WD.
2. The dipole was energized with a 20 dBm un-modulated continuous-wave signal.
3. The length of the dipole was scanned with both E-field and H-field probes and the maximum value for each scan was recorded.
4. The readings were compared with the values provided by the probe manufacturer and were found to agree within the allowed tolerance of 10%.

Figure 2: Dipole Validation Procedure



The probe is positioned over the illuminated dipole at 10 mm distance from the nearest point on the probe sensor element to the top surface (edge) of the dipole element.

3.3 System Validation Results

Lab Temperature: 21 °C, Lab Humidity: 45%.

Date	Calibration Dipole	Frequency (MHz)	Input Power (dBm)	Target Value(V/m)	Measured (V/m)	Deviation(%)
2016/8/08	SN 06/14	850	20	220.4	218.15	-0.01
2016/8/08	EPH42 E-field	1900	20	153.4	156.32	0.02

Note: Deviation=((Measured Result)-(Target Value))/(Target Value)*100%



4. Device Under Test

Mobile model:	Z404
Normal operation:	Held to head
Accessory:	Standard cover

List of air interfaces/bands & operating modes for model Z404

air interfaces	Bands (MHz)	Type	C63.19/ Tested	Simultaneous Transmissions Note:Not to be tested	OTT	Reduced power 20.19(c)(1)
GSM	850	VO	Yes	Bluetooth, WLAN	N/A	N/A
	1900		Yes			
	GPRS/ EDGE	DT	N/A	Bluetooth, WLAN	N/A	No
WCDMA	850	VO	No	Bluetooth, WLAN	N/A	N/A
	1900					
	HSPA	DT	N/A	Bluetooth, WLAN	N/A	N/A
WLAN	2412	DT	N/A	GSM, WCDMA	N/A	N/A
	2437			GSM, WCDMA	N/A	N/A
	2462			GSM, WCDMA	N/A	N/A
Bluetooth	2450	DT	N/A	GSM, WCDMA	N/A	N/A

VO: Voice CMRS/PTSN Service Only
V/D: Voice CMRS/PTSN and Data Service
DT: Digital Transport

5. Modulation interference Factor (MIF)

For any specific fixed and repeatable modulated signal, a modulation interference factor (MIF, expressed in dB) may be developed that relates its interference potential to its steady-state rms signal level or average power level. This factor is a function only of the audio-frequency amplitude modulation characteristics of the signal and is the same for field-strength and conducted power measurements. It is important to emphasize that the MIF is valid only for a specific repeatable audio-frequency amplitude modulation characteristic. Any change in modulation characteristic requires determination and application of a new MIF.

The MIF may be determined using a radiated RF field, a conducted RF signal, or in a preliminary stage, a mathematical analysis of a modeled RF signal:

- a) Verify the slope accuracy and dynamic range capability over the desired operating frequency band of a fast probe or sensor, square-law detector, as specified in D.3, and weighting system as specified in D.4 and D.5. For the probe and instrumentation included in the measurement of MIF, additional calibration and application of calibration factors are not required.
- b) Using RF illumination or conducted coupling, apply the specific modulated signal in question to the measurement system at a level within its confirmed operating dynamic range.
- c) Measure the steady-state rms level at the output of the fast probe or sensor.
- d) Measure the steady-state average level at the weighting output.
- e) Without changing the square-law detector or weighting system, and using RF illumination or conducted coupling, substitute for the specific modulated signal a 1 kHz, 80% amplitude-modulated carrier at the same frequency and adjust its strength until the level at the weighting output equals the step d) measurement.
- f) Without changing the carrier level from step e), remove the 1 kHz modulation and again measure the steady-state rms level indicated at the output of the fast probe or sensor.
- g) The MIF for the specific modulation characteristic is provided by the ratio of the step f) measurement to the step c) measurement, expressed in dB ($20 \times \log(\text{step f}) / \text{step c}$).

In practice, step e) and step f) need not be repeated for each MIF determination if the relationship between the two measurements has been preestablished for the measurement system over the operating frequency and dynamic ranges.

As a check on the procedure, the MIF for the specific modulation consisting of a 1 kHz, 80% AM signal is -1.2 dB, which is the ratio in dB of the average power of the unmodulated carrier to the average power of the modulated carrier ($10 \times \log(P_{unmod}/P_{mod})$), or equivalently the ratio in dB of the rms level of the unmodulated carrier to the rms level of the modulated carrier ($20 \times \log(L_{unmod}/L_{mod})$). The MIF for a 1/8 duty cycle, 217 Hz pulse-modulated signal (similar to basic GSM) is $+3.3$ dB. (Actual GSM WD measurements could vary due to differences in implementation or network protocol.)

MIF results for a given amplitude modulation characteristic should remain consistent at any signal level within the operating dynamic range of the test system. Caution should be used when measuring modulations that have large-magnitude MIF measurements as these place greater requirements on the test system dynamic range

Typical MIF levels are presented in Table D.1. The results shown may be considered representative for the specified protocols, but they are not intended to substitute for measurements of actual devices under test and their respective operating modes.

Transmission protocol	Modulation interference factor
GSM; full-rate version 2; speech codec/handset low	+3.63 dB
WCDMA; speech; speech codec low; AMR 12.2 kb/s	-27.23 dB
CDMA; speech; SO3; RC3; full frame rate: 8kEVRC	-19.75 dB
CDMA; speech; SO3; RC1; 1/8th frame rate; 8kEVRC	+3.10 dB

Table D.1—Sample MIF values for sine-wave modulations

6. HAC TEST PROCEDURES

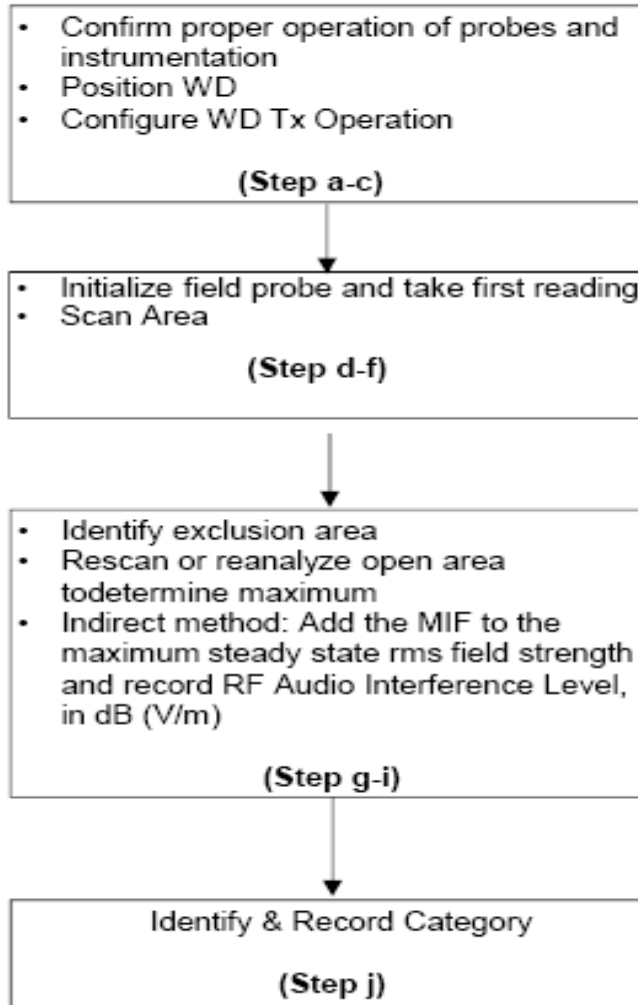
The following illustrate a typical RF emissions test scan over a wireless communications device:

1. Proper operation of the field probe, probe measurement system, other instrumentation, and the positioning system was confirmed.
2. DUT is positioned in its intended test position, acoustic output point of the device perpendicular to the field probe.
3. The DUT operation for maximum rated RF output power was configured and confirmed with the base station simulator, at the test channel and other normal operating parameters as intended for the test. The battery was ensured to be fully charged before each test.
4. The center sub-grid was centered over the center of the acoustic output (also audio band magnetic output, if applicable). The DUT audio output was positioned tangent (as physically possible) to the measurement plane.
5. A surface calibration was performed before each setup change to ensure repeatable spacing and proper maintenance of the measurement plane using the test Arch.
6. The measurement system measured the field strength at the reference location.
7. Measurements at 5 mm increments in the 5 × 5 cm region were performed and recorded. A 360° rotation about the azimuth axis at the maximum interpolated position was measured. For the worst-case condition, the peak reading from this rotation was used in re-evaluating the HAC category.
8. The system performed a drift evaluation by measuring the field at the reference location.
9. Steps 1 ~ 8 were done for both the E and H-Field measurements.



7. Test flowchart Per ANSI-PC63.19 2011

Test Instructions





8. RF EMISSIONS

The ANSI Standard presents performance requirements for acceptable interoperability of hearing aids with wireless communications devices. When these parameters are met, a hearing aid operates acceptably in close proximity to a wireless communications device.

Emission Categories	E-field emissions	
	< 960 MHz	> 960 MHz
Category M1	50 to 55 dB (V/m)	40 to 45 dB (V/m)
Category M2	45 to 50 dB (V/m)	35 to 40 dB (V/m)
Category M3	40 to 45 dB (V/m)	30 to 35 dB (V/m)
Category M4	<40 dB (V/m)	<30 dB (V/m)

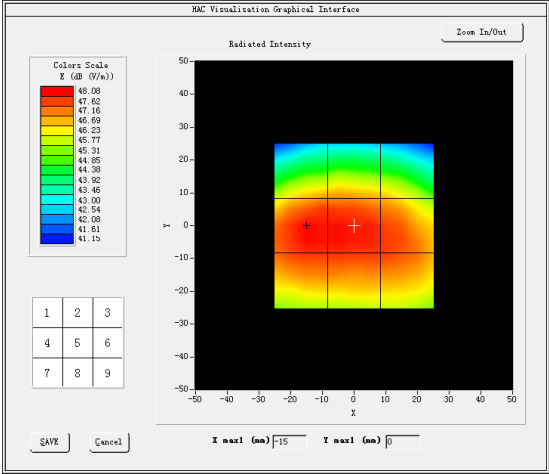
9 HAC RF Emission Test Results

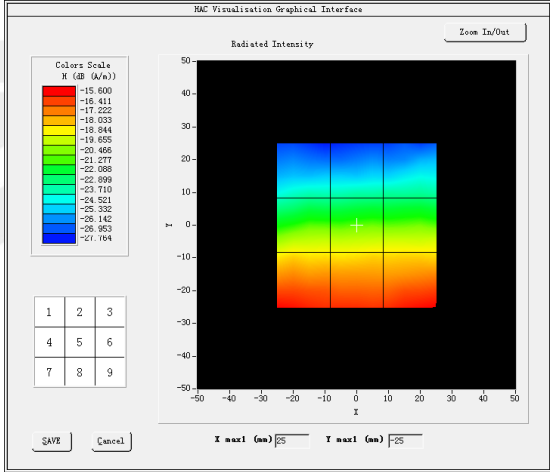
9.1 Test Result

Band	GSM 850			GSM 1900		
Channel	128	190	251	512	661	810
Frequency(MHz)	824.2	836.6	848.8	1850.2	1880.0	1909.8
RF Output power(dBm)	32.83	32.82	32.47	29.92	30.11	29.97
Result(dB V/m)	39.05	6.01	39.54	29.84	29.33	28.75
M-Rating	M4	M4	M4	M4	M4	M4

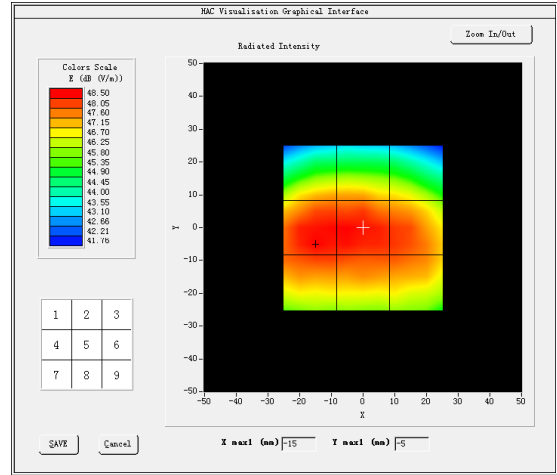
Band	WCDMA 850			WCDMA 1900		
Channel	4133	4175	4232	9263	9400	9537
Frequency(MHz)	826.6	8.35	846.4	1852.6	1880.0	1907.4
RF Output power(dBm)	22.66	22.72	22.58	22.76	22.59	22.39
Result(dB V/m)	38.31	36.91	39.15	30.04	30.27	30.16
M-Rating	M4	M4	M4	M3	M3	M3

9.2 E-Field Emission for GSM:

Grid 1: 37.72	Grid 2: 37.81	Grid 3: 37.44			
Grid 4: 39.14	Grid 5: 39.05	Grid 6: 38.69			
Grid 7: 38.81	Grid 8: 38.80	Grid 9: 38.66			
Operation mode	MIF(dB)	Channel	f(MHz)	Maximum value of total field (dB V/m)	M-Rating
GSM 850	3.63	128	824.2	39.05	M4

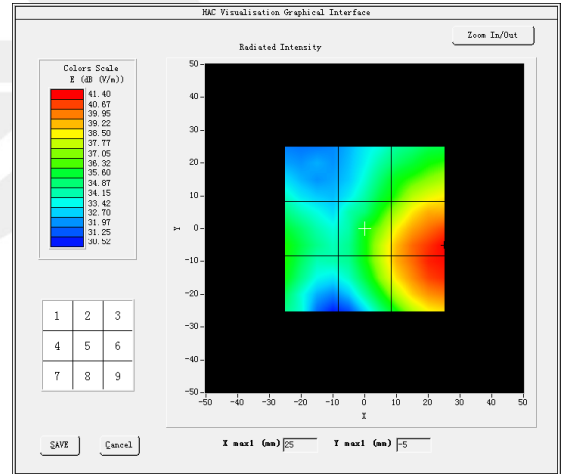
Grid 1: 4.34	Grid 2: 4.15	Grid 3: 2.74			
Grid 4: 12.71	Grid 5: 5.21	Grid 6: 4.85			
Grid 7: 5.88	Grid 8: 5.97	Grid 9: 6.01			
Operation mode	MIF(dB)	Channel	f(MHz)	Maximum value of total field (dB V/m)	M-Rating
GSM 850	3.63	189	836.4	6.01	M4

Grid 1: 38.31	Grid 2: 38.34	Grid 3: 37.86
Grid 4: 39.54	Grid 5: 39.54	Grid 6: 39.18
Grid 7: 39.27	Grid 8: 39.18	Grid 9: 39.01



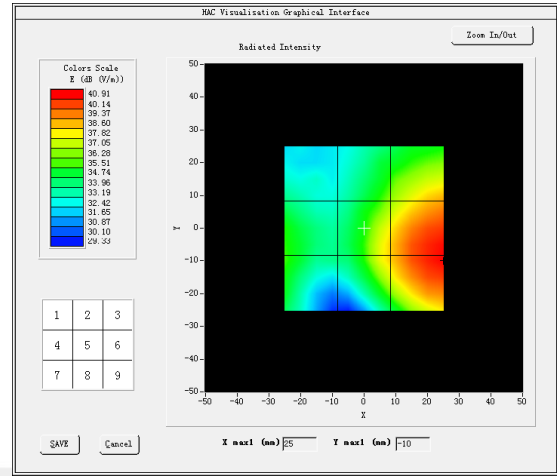
Operation mode	MIF(dB)	Channel	f(MHz)	Maximum value of total field (dB V/m)	M-Rating
GSM 850	3.63	250	848.6	39.54	M4

Grid 1: 24.62	Grid 2: 27.11	Grid 3: 29.32
Grid 4: 27.22	Grid 5: 29.84	Grid 6: 32.23
Grid 7: 27.21	Grid 8: 29.88	Grid 9: 32.19



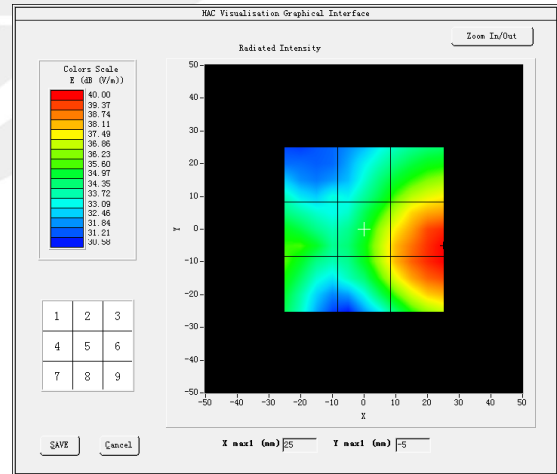
Operation mode	MIF(dB)	Channel	f(MHz)	Maximum value of total field (dB V/m)	M-Rating
GSM 1900	3.63	512	1850.4	29.84	M4

Grid 1: 24.33	Grid 2: 27.19	Grid 3: 29.36
Grid 4: 26.53	Grid 5: 29.33	Grid 6: 31.73
Grid 7: 26.61	Grid 8: 29.32	Grid 9: 31.76

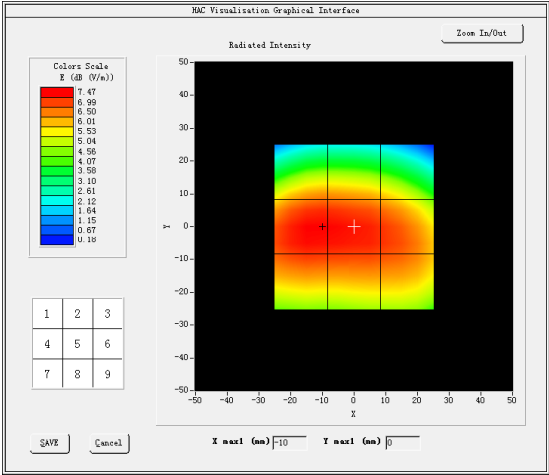


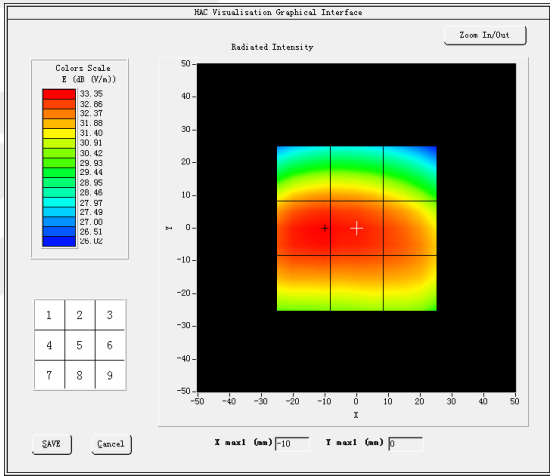
Operation mode	MIF(dB)	Channel	f(MHz)	Maximum value of total field (dB V/m)	M-Rating
GSM 1900	3.63	661	1880.0	29.33	M4

Grid 1: 24.33	Grid 2: 26.53	Grid 3: 28.29
Grid 4: 26.72	Grid 5: 28.75	Grid 6: 30.85
Grid 7: 26.78	Grid 8: 28.76	Grid 9: 30.85

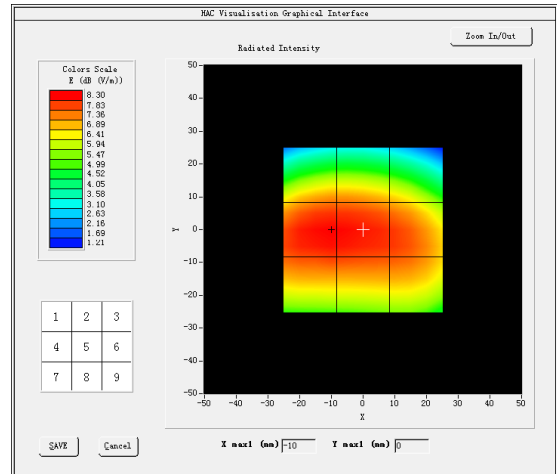


Operation mode	MIF(dB)	Channel	f(MHz)	Maximum value of total field (dB V/m)	M-Rating
GSM 1900	3.63	810	1909.8	28.75	M4

Grid 1: 37.17	Grid 2: 37.15	Grid 3: 36.60			
Grid 4: 38.36	Grid 5: 38.31	Grid 6: 37.94			
Grid 7: 38.03	Grid 8: 37.96	Grid 9: 37.77			
Operation mode	MIF(dB)	Channel	f(MHz)	Maximum value of total field (dB V/m)	M-Rating
WCDMA 850	-27.23	4133	826.6	38.31	M4

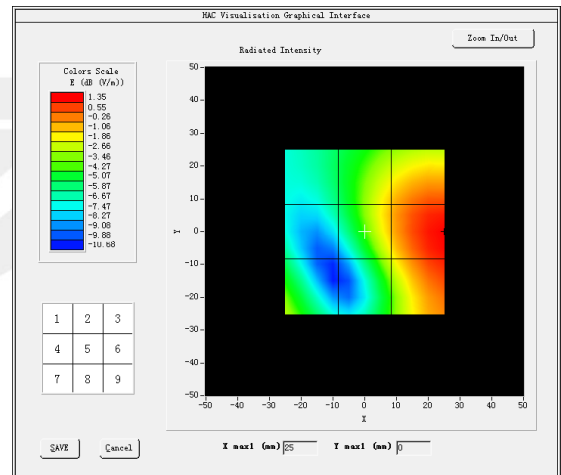
Grid 1: 35.80	Grid 2: 35.76	Grid 3: 35.17			
Grid 4: 37.00	Grid 5: 36.91	Grid 6: 36.51			
Grid 7: 36.64	Grid 8: 36.57	Grid 9: 36.34			
Operation mode	MIF(dB)	Channel	f(MHz)	Maximum value of total field (dB V/m)	M-Rating
WCDMA 850	-27.23	4175	835.0	36.91	M4

Grid 1: 38.05	Grid 2: 38.05	Grid 3: 37.48
Grid 4: 39.18	Grid 5: 39.15	Grid 6: 38.78
Grid 7: 38.80	Grid 8: 38.78	Grid 9: 38.57



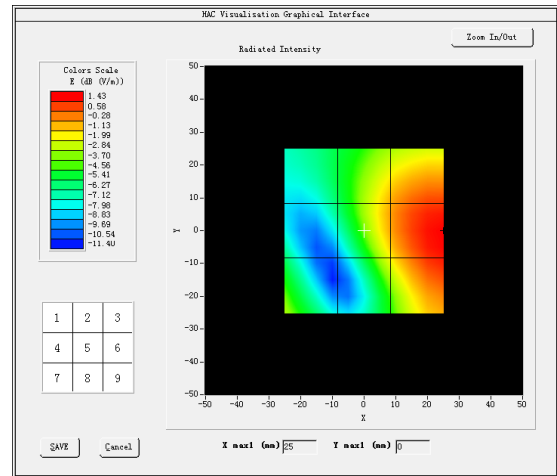
Operation mode	MIF(dB)	Channel	f(MHz)	Maximum value of total field (dB V/m)	M-Rating
WCDMA 850	-27.23	4232	846.4	39.15	M4

Grid 1: 25.50	Grid 2: 29.72	Grid 3: 31.13
Grid 4: 25.09	Grid 5: 30.04	Grid 6: 32.22
Grid 7: 27.97	Grid 8: 28.94	Grid 9: 31.92



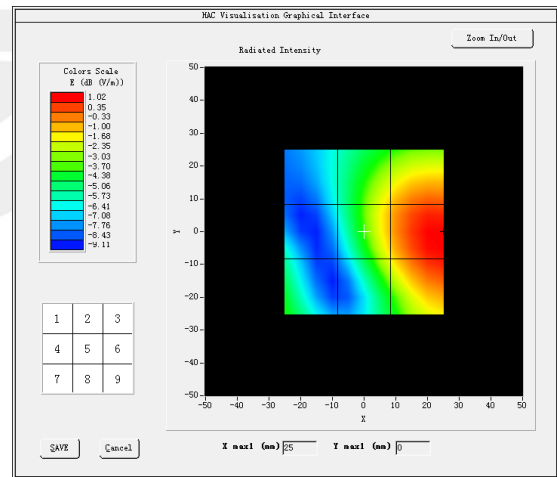
Operation mode	MIF(dB)	Channel	f(MHz)	Maximum value of total field (dB V/m)	M-Rating
WCDMA 1900	-27.23	9263	1852.6	31.04	M3

Grid 1: 25.39	Grid 2: 29.91	Grid 3: 31.28
Grid 4: 24.93	Grid 5: 30.27	Grid 6: 32.31
Grid 7: 27.63	Grid 8: 29.17	Grid 9: 32.04



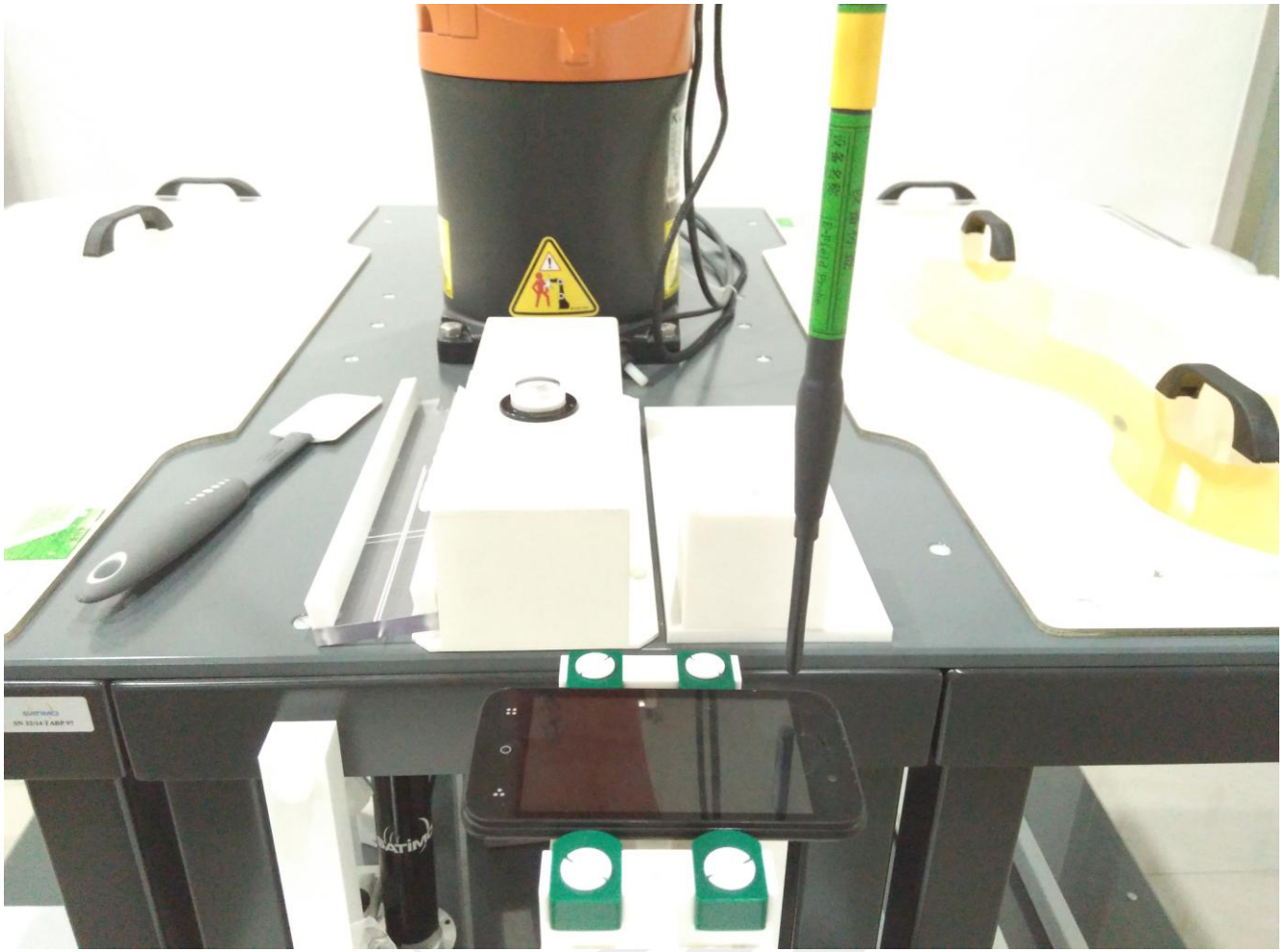
Operation mode	MIF(dB)	Channel	f(MHz)	Maximum value of total field (dB V/m)	M-Rating
WCDMA 1900	-27.23	9400	1880.0	30.27	M3

Grid 1: 25.02	Grid 2: 29.64	Grid 3: 30.84
Grid 4: 25.00	Grid 5: 30.16	Grid 6: 31.96
Grid 7: 27.11	Grid 8: 29.42	Grid 9: 31.73



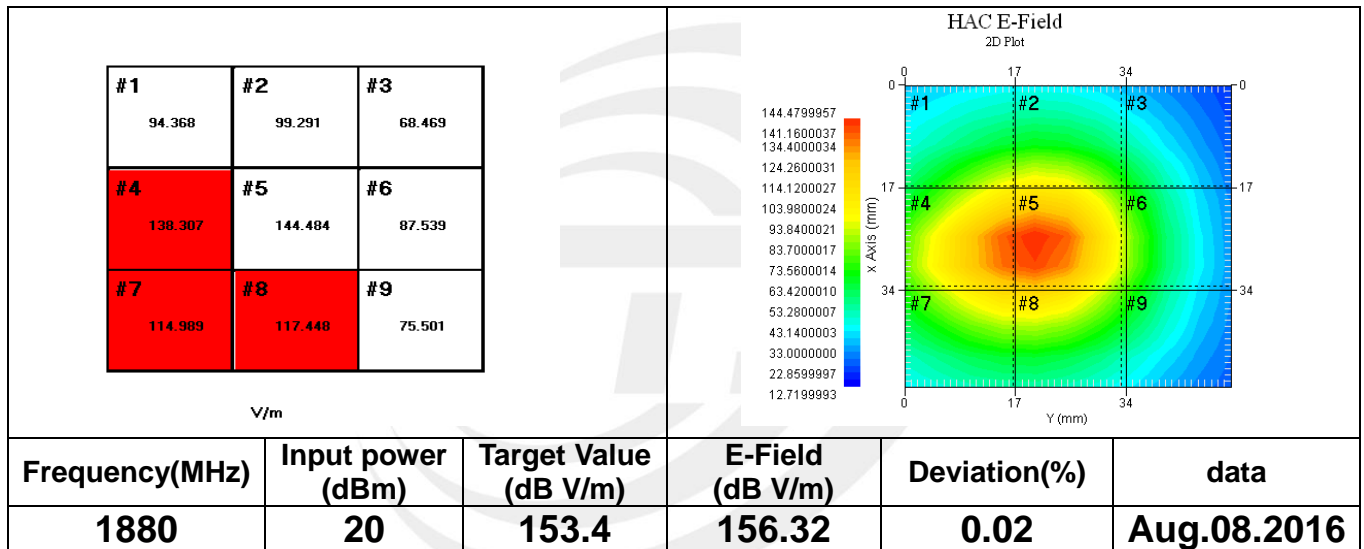
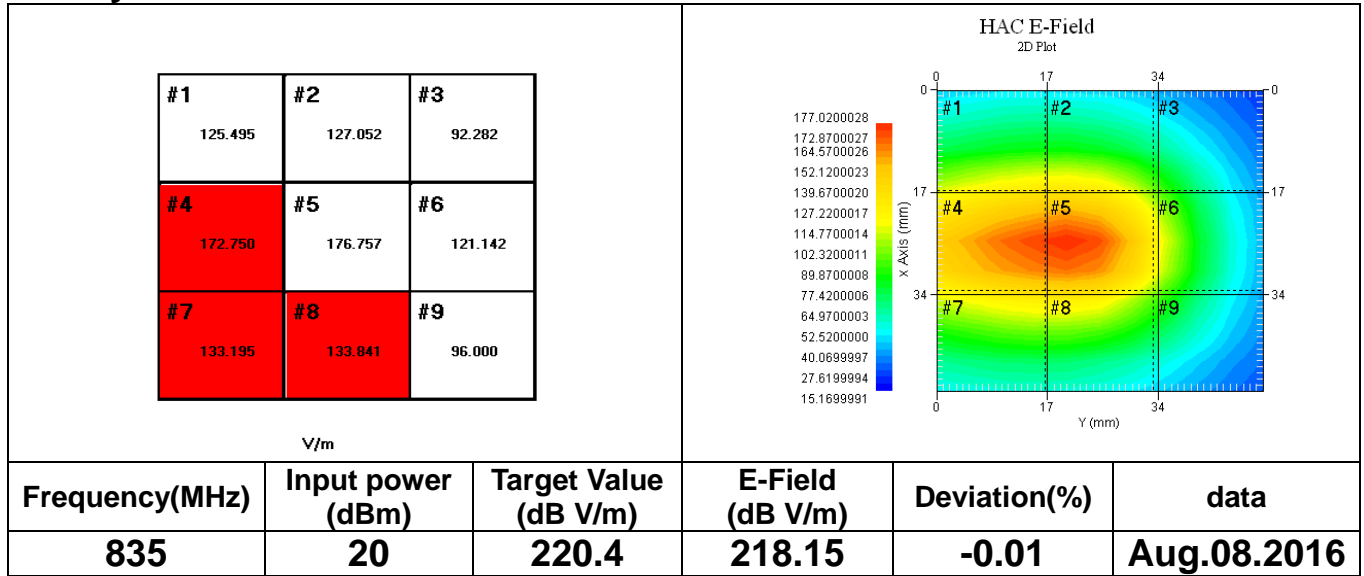
Operation mode	MIF(dB)	Channel	f(MHz)	Maximum value of total field (dB V/m)	M-Rating
WCDMA 1900	-27.23	9537	1907.4	30.16	M3

10. HAC Test Photographs



E-field

11. System VALIDATION RESULTS





12. Probe Calibration And Dipole Calibration Report

The following pages include the probe calibration used to evaluate HAC for the DUT.

