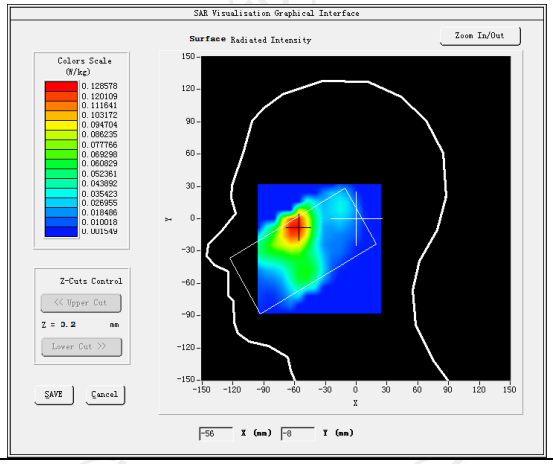
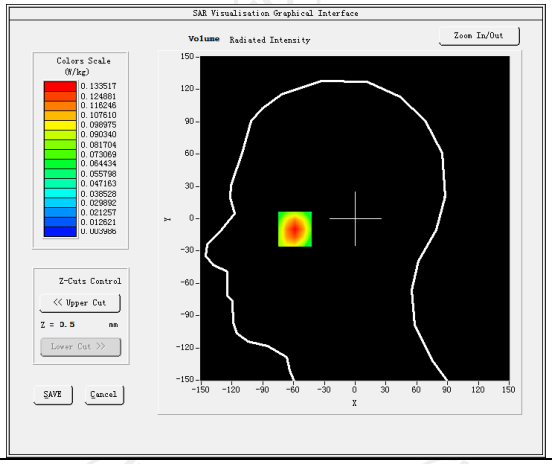
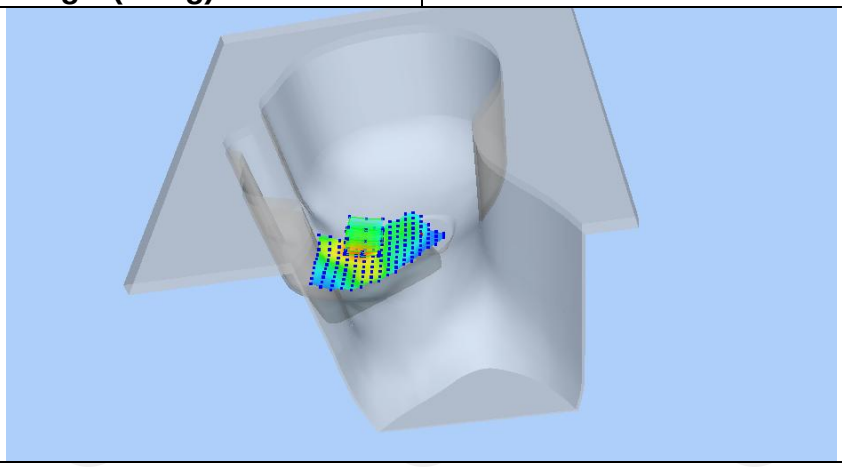
LTE Band 66

MEASUREMENT 1	
Higher Band SAR (Channel 132647):	Date: 08/03/2020
Frequency (MHz)	1777.500000
Relative permittivity (real part)	39.071278
Relative permittivity (imaginary part)	12.468729
Conductivity (S/m)	1.376212
Variation (%)	-1.690000
Crest Factor	1.0
Probe Conversion factor	2.08
E-Field Probe:	SSE2 (SN 41/18 EPGO331)
Area Scan	dx=8mm dy=8mm, h= 5.00 mm
ZoomScan	5x5x7,dx=8mm dy=8mm dz=5mm,Complete/ndx=8mm dy=8mm, h= 5.00 mm
Phantom	Right head
Device Position	Cheek
Band	LTE band 66(1 RB#0)
SURFACE SAR	**VOLUME SAR**
	
Maximum location: X=-59.00, Y=-8.00 SAR Peak: 0.19 W/kg	
SAR 10g (W/Kg)	0.074855
SAR 1g (W/Kg)	0.125465
	

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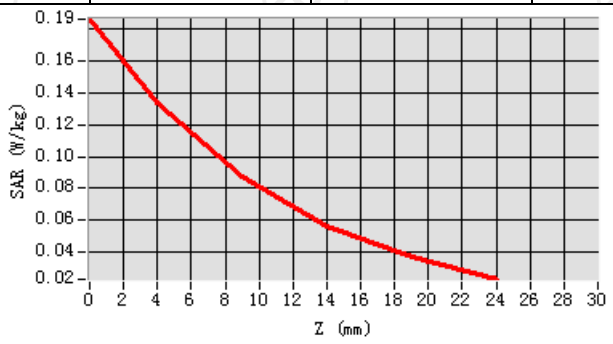
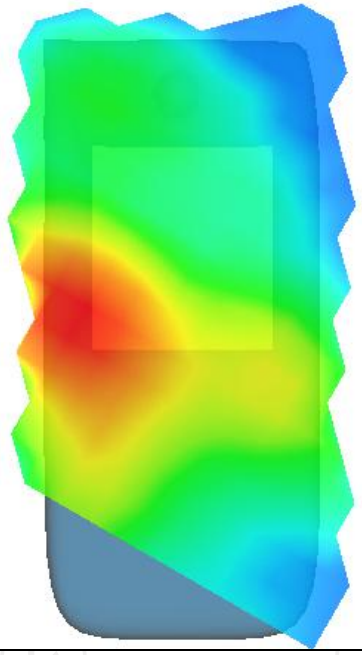
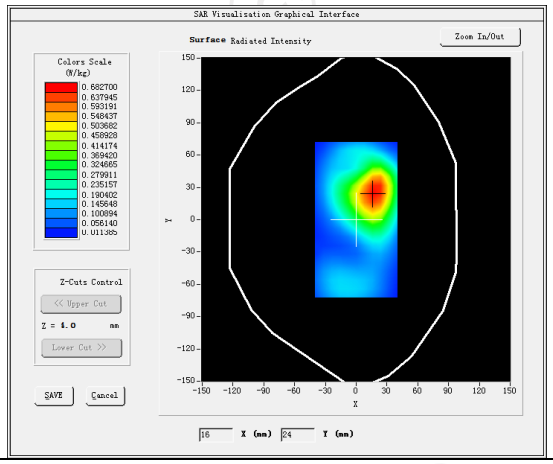
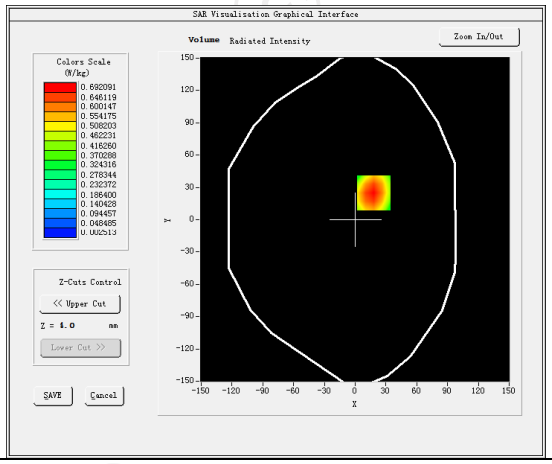
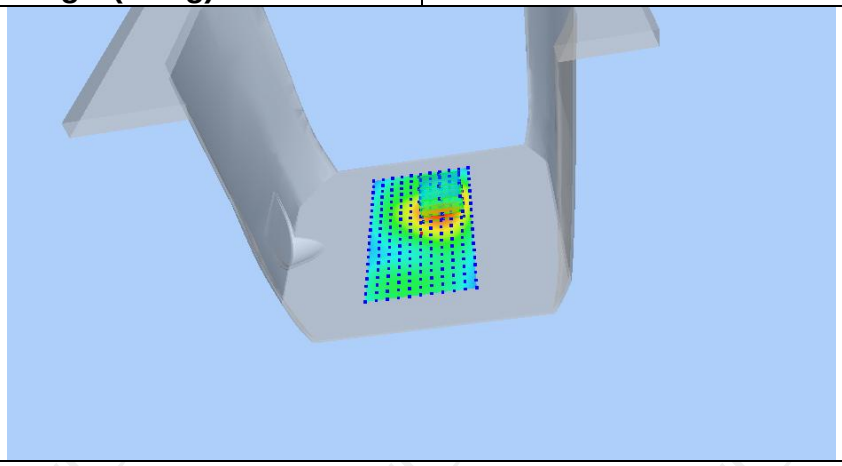
Z (mm)	0.00	4.00	9.00	14.00	19.00
SAR (W/Kg)	0.1860	0.1335	0.0871	0.0566	0.0370

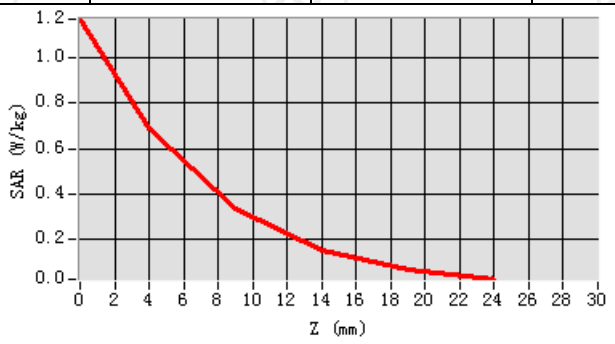


Hot spot position

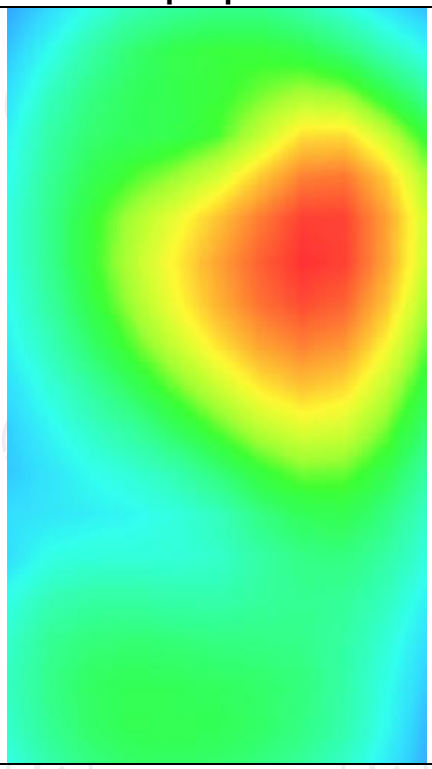


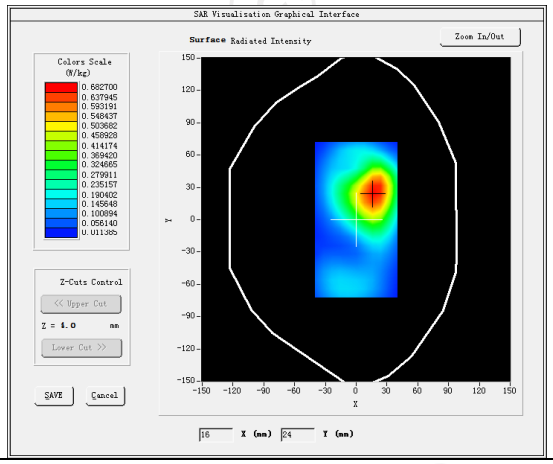
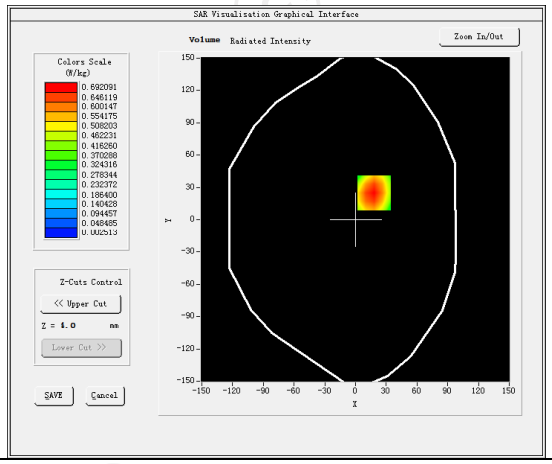
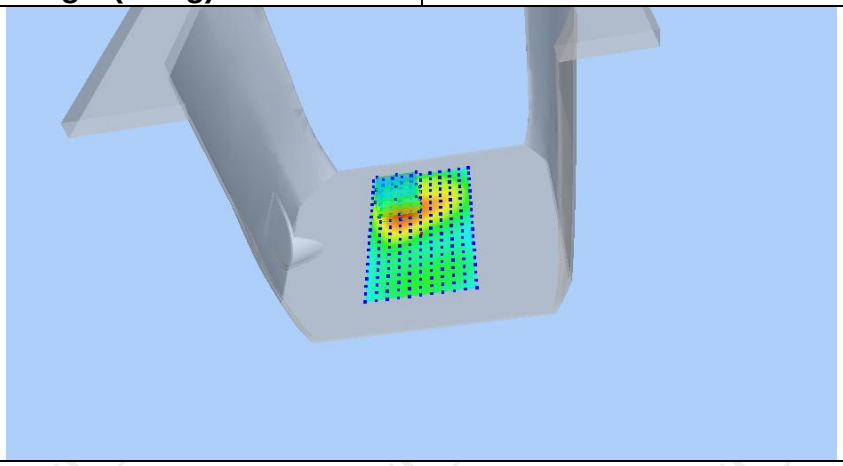
MEASUREMENT 2	
Higher Band SAR (Channel 132647):	Date: 08/03/2020
Frequency (MHz)	1777.500000
Relative permittivity (real part)	53.293758
Relative permittivity (imaginary part)	12.468142
Conductivity (S/m)	1.532887
Variation (%)	0.420000
Crest Factor	1.0
Probe Conversion factor	2.16
E-Field Probe:	SSE2 (SN 41/18 EPGO331)
Area Scan	dx=8mm dy=8mm, h= 5.00 mm
ZoomScan	5x5x7,dx=8mm dy=8mm dz=5mm,Complete/ndx=8mm dy=8mm, h= 5.00 mm
Phantom	Validation plane
Device Position	Body back(10mm)
Band	LTE band 66(1 RB#0)
SURFACE SAR	**VOLUME SAR**
	
Maximum location: X=18.00, Y=25.00 SAR Peak: 1.17 W/kg	
SAR 10g (W/Kg)	0.341959
SAR 1g (W/Kg)	0.658034
	

Z (mm)	0.00	4.00	9.00	14.00	19.00
SAR (W/Kg)	1.1714	0.6921	0.3347	0.1518	0.0654



Hot spot position



MEASUREMENT 3	
Higher Band SAR (Channel 132647):	Date: 08/03/2020
Frequency (MHz)	1777.500000
Relative permittivity (real part)	53.293758
Relative permittivity (imaginary part)	12.468142
Conductivity (S/m)	1.532887
Variation (%)	0.290000
Crest Factor	1.0
Probe Conversion factor	2.16
E-Field Probe:	SSE2 (SN 41/18 EPGO331)
Area Scan	dx=8mm dy=8mm, h= 5.00 mm
ZoomScan	5x5x7,dx=8mm dy=8mm dz=5mm,Complete/ndx=8mm dy=8mm, h= 5.00 mm
Phantom	Validation plane
Device Position	Body back(hotspot 10mm)
Band	LTE band 66(1 RB#0)
SURFACE SAR	**VOLUME SAR**
	
Maximum location: X=18.00, Y=25.00 SAR Peak: 1.17 W/kg	
SAR 10g (W/Kg)	0.351273
SAR 1g (W/Kg)	0.666371
	

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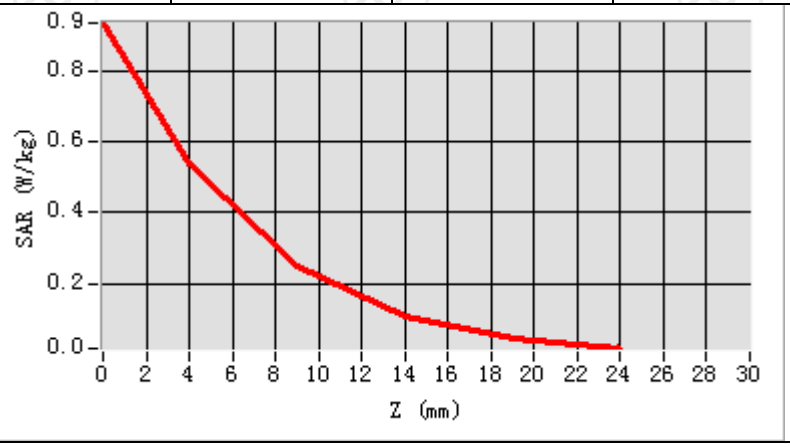
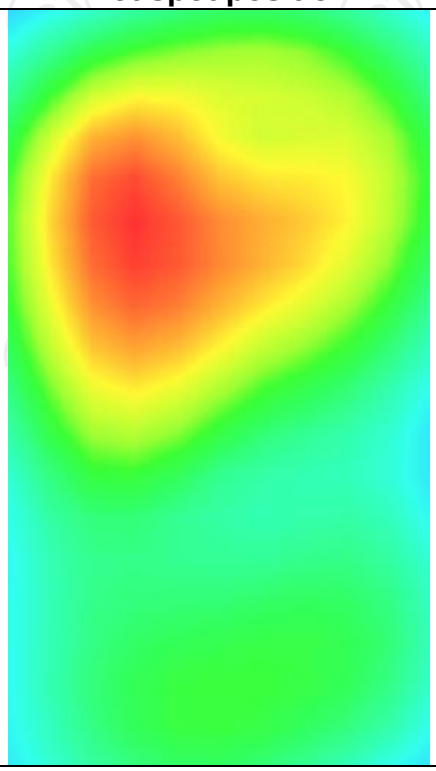
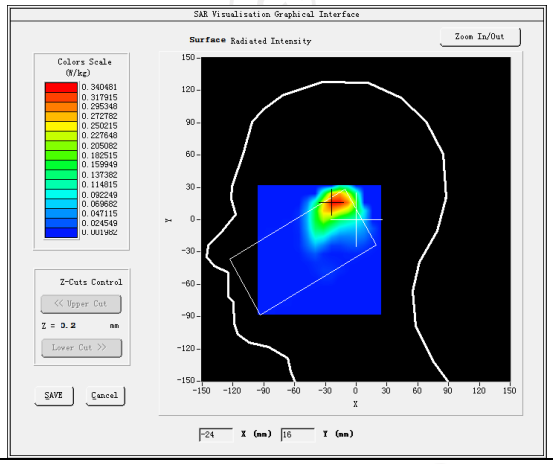
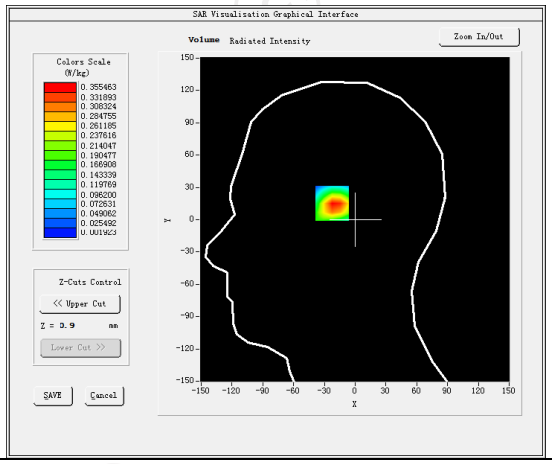
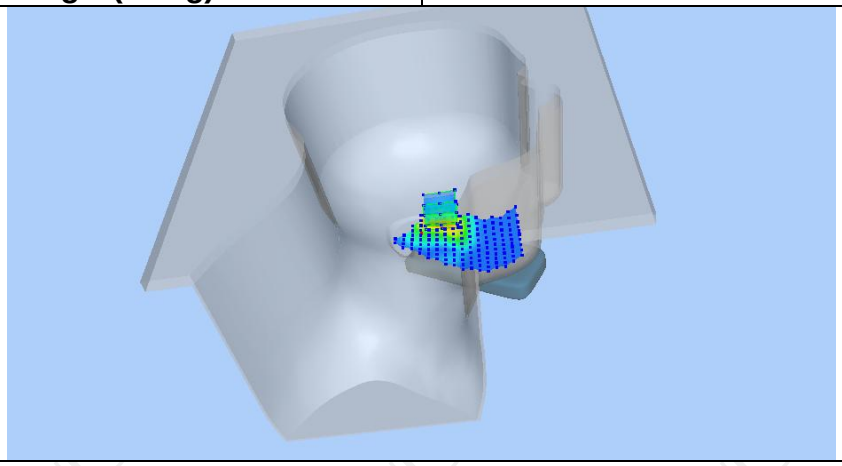
Z (mm)	0.00	4.00	9.00	14.00	19.00
SAR (W/Kg)	0.9371	0.5352	0.2513	0.1105	0.0488



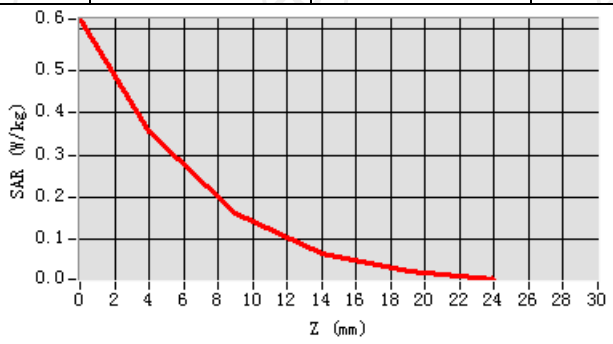
Hot spot position



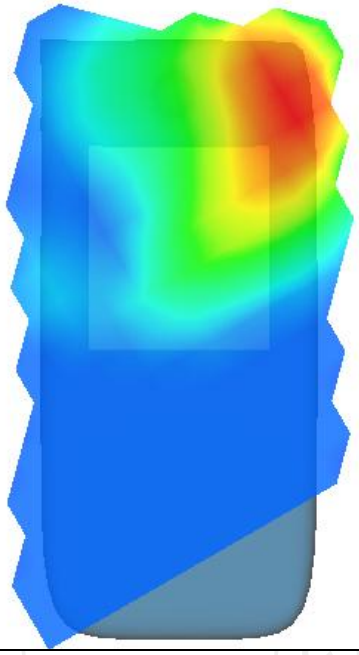
WIFI 2.4G

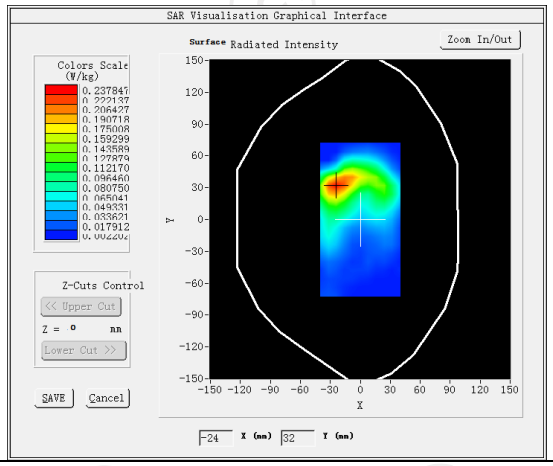
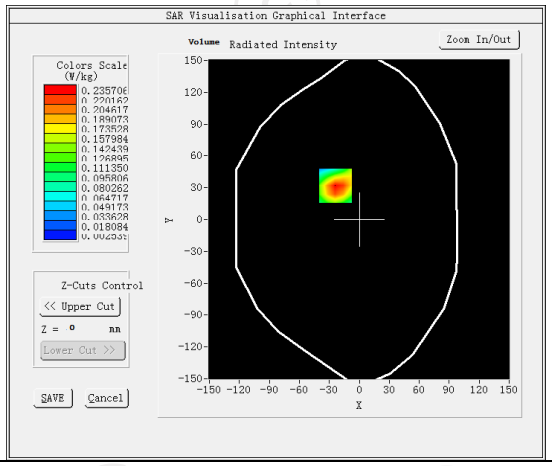
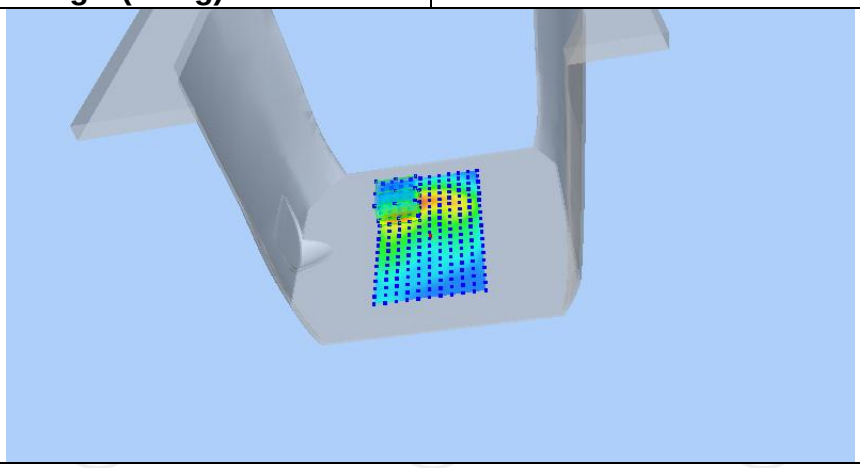
MEASUREMENT 1	
Higher Band SAR (Channel 11):	Date: 08/13/2020
Frequency (MHz)	2462.000000
Relative permittivity (real part)	37.802831
Relative permittivity (imaginary part)	13.546209
Conductivity (S/m)	1.842611
Variation (%)	-3.740000
Crest Factor	1.0
Probe Conversion factor	2.31
E-Field Probe:	SSE2 (SN 41/18 EPGO331)
Area Scan	dx=8mm dy=8mm, h= 5.00 mm
ZoomScan	5x5x7,dx=8mm dy=8mm dz=5mm,Complete/ndx=8mm dy=8mm, h= 5.00 mm
Phantom	Left head
Device Position	Cheek
Band	IEEE 802.11b ISM
SURFACE SAR	**VOLUME SAR**
	
Maximum location: X=-21.00, Y=17.00 SAR Peak: 0.65 W/kg	
SAR 10g (W/Kg)	0.153877
SAR 1g (W/Kg)	0.337537
	

Z (mm)	0.00	4.00	9.00	14.00	19.00
SAR (W/Kg)	0.6233	0.3555	0.1601	0.0638	0.0215

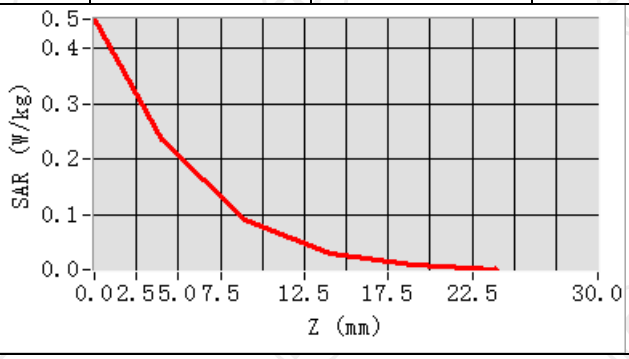


Hot spot position

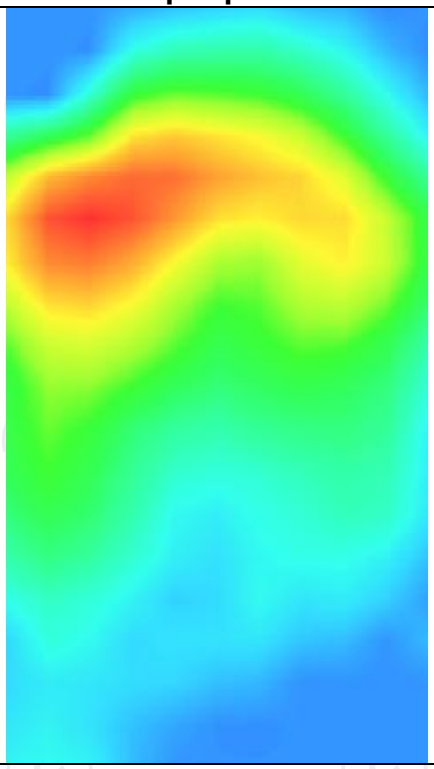


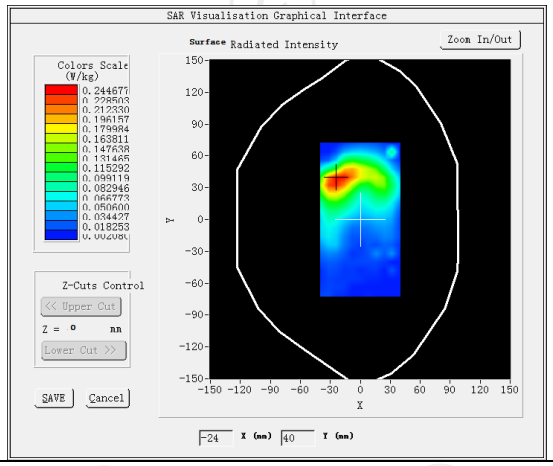
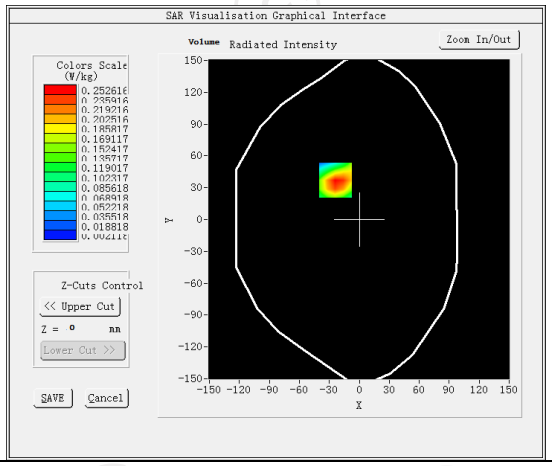
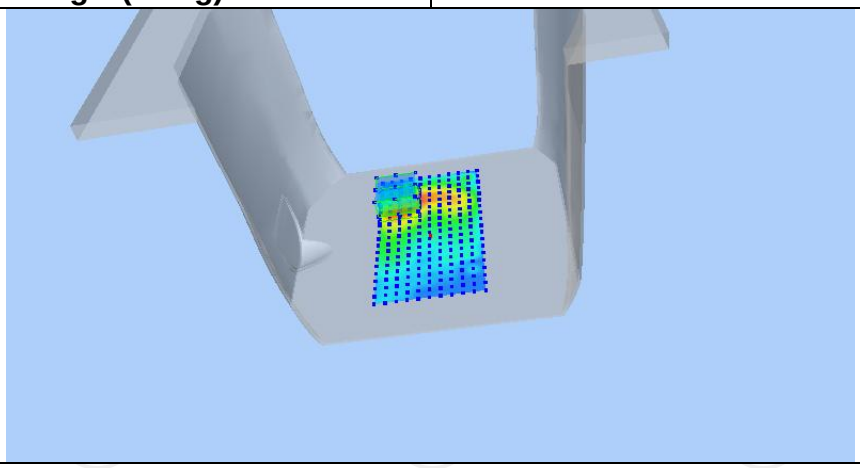
MEASUREMENT 2	
Higher Band SAR (Channel 11):	Date: 08/13/2020
Frequency (MHz)	2462.000000
Relative permittivity (real part)	54.590667
Relative permittivity (imaginary part)	14.318428
Conductivity (S/m)	2.032536
Variation (%)	-3.590000
Crest Factor	1.0
Probe Conversion factor	2.37
E-Field Probe:	SSE2 (SN 41/18 EPGO331)
Area Scan	dx=8mm dy=8mm, h= 5.00 mm
ZoomScan	5x5x7,dx=8mm dy=8mm dz=5mm,Complete/ndx=8mm dy=8mm, h= 5.00 mm
Phantom	Validation plane
Device Position	Body back(10mm)
Band	IEEE 802.11b ISM
SURFACE SAR	**VOLUME SAR**
	
Maximum location: X=-24.00, Y=32.00 SAR Peak: 0.46 W/kg	
SAR 10g (W/Kg)	0.103710
SAR 1g (W/Kg)	0.225808
	

Z (mm)	0.00	4.00	9.00	14.00	19.00
SAR (W/Kg)	0.4514	0.2357	0.0925	0.0321	0.0106

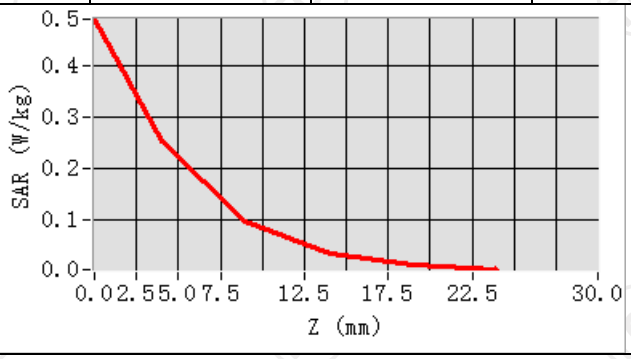


Hot spot position

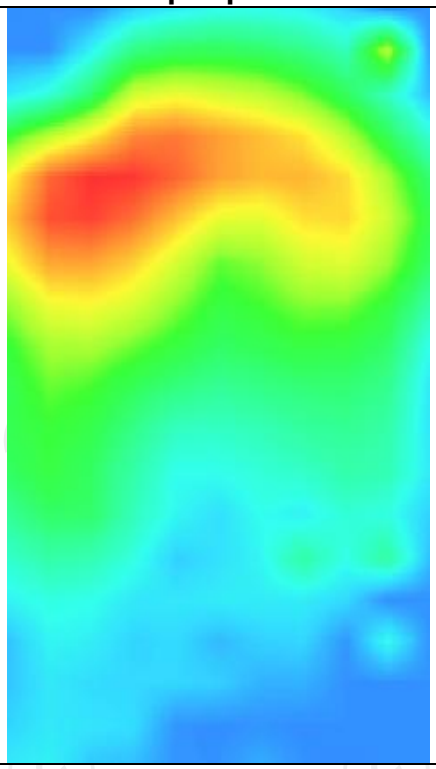


MEASUREMENT 3	
Higher Band SAR (Channel 11):	Date: 08/13/2020
Frequency (MHz)	2462.000000
Relative permittivity (real part)	54.590667
Relative permittivity (imaginary part)	14.318428
Conductivity (S/m)	2.032536
Variation (%)	-4.690000
Crest Factor	1.0
Probe Conversion factor	2.37
E-Field Probe:	SSE2 (SN 41/18 EPGO331)
Area Scan	dx=8mm dy=8mm, h= 5.00 mm
ZoomScan	5x5x7,dx=8mm dy=8mm dz=5mm,Complete/ndx=8mm dy=8mm, h= 5.00 mm
Phantom	Validation plane
Device Position	Body back(10mm)
Band	IEEE 802.11b ISM(hotspot)
SURFACE SAR	**VOLUME SAR**
	
Maximum location: X=-24.00, Y=37.00 SAR Peak: 0.50 W/kg	
SAR 10g (W/Kg)	0.109967
SAR 1g (W/Kg)	0.243410
	

Z (mm)	0.00	4.00	9.00	14.00	19.00
SAR (W/Kg)	0.4909	0.2526	0.0965	0.0323	0.0102



Hot spot position



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Appendix A: EUT Photos

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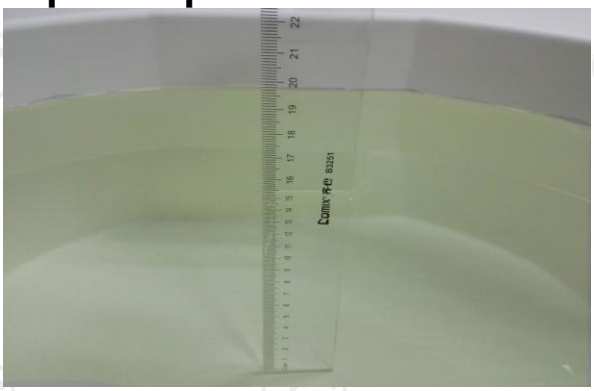
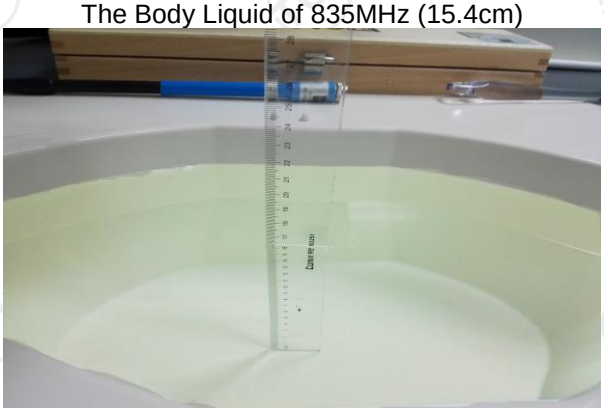
Liquid depth

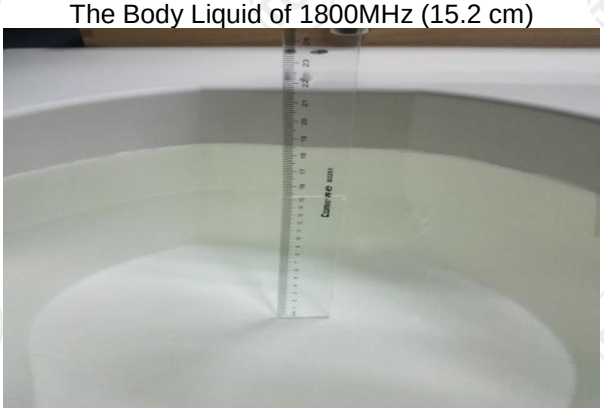


The Body Liquid of 835MHz (15.4cm)

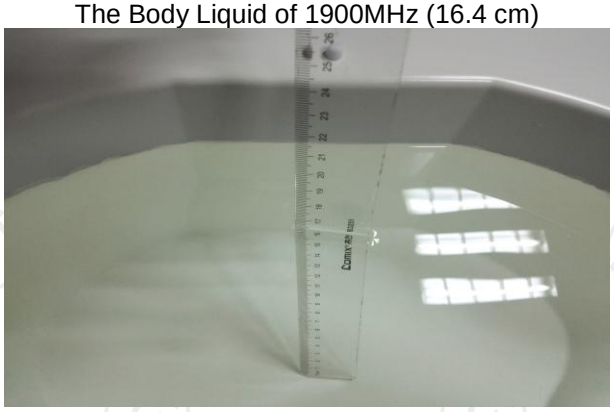
The Body Liquid of 1800MHz (15.2 cm)



The Body Liquid of 1900MHz (16.4 cm)



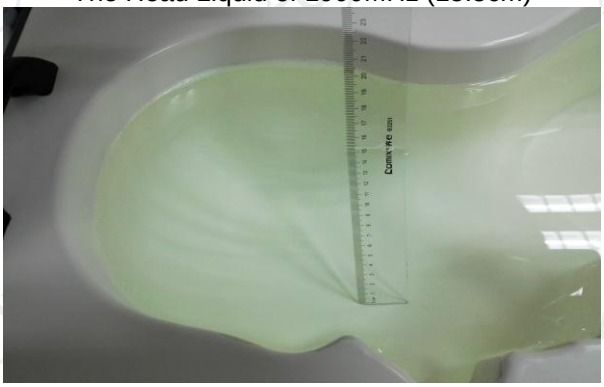
The Body Liquid of 2450MHz (15.3cm)



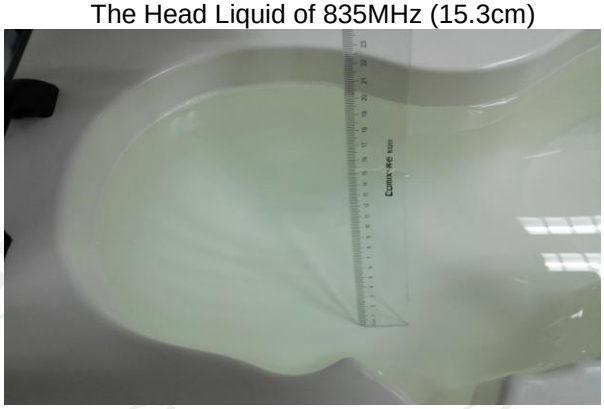
The Body Liquid of 2600MHz (16.5cm)


The Head Liquid of 1900MHz (15.5cm)

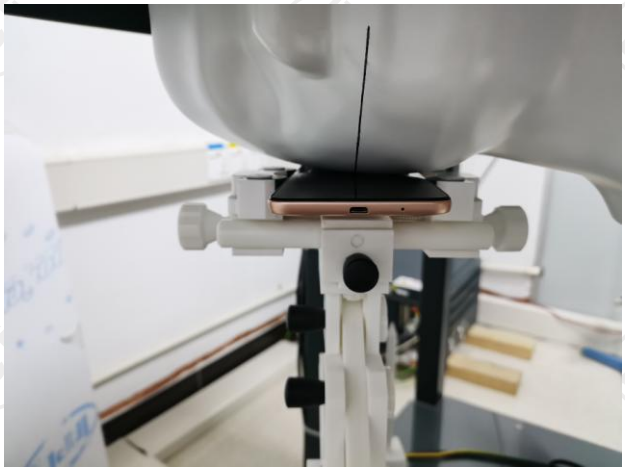

The Head Liquid of 2450MHz (15.6cm)


The Head Liquid of 835MHz (15.3cm)

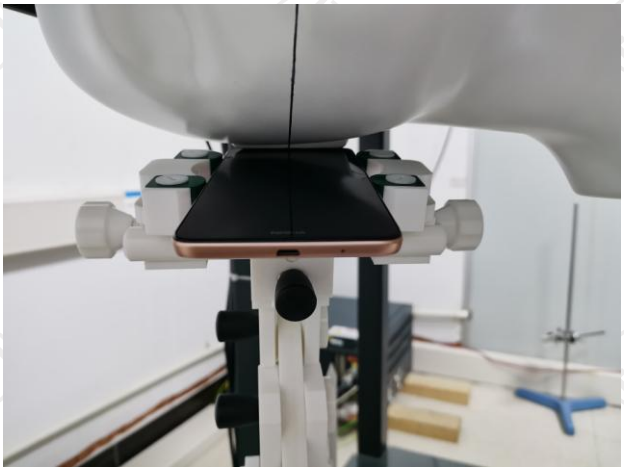

The Head Liquid of 2600MHz (15.1cm)


The Head Liquid of 1800MHz (15.2cm)

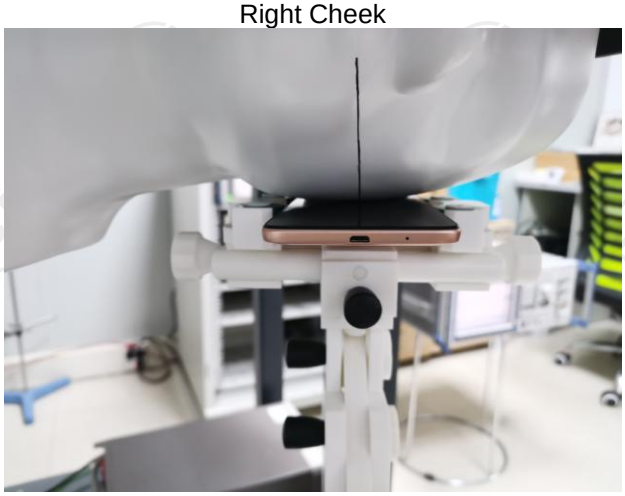
Appendix B: Test Setup Photos



Right Cheek

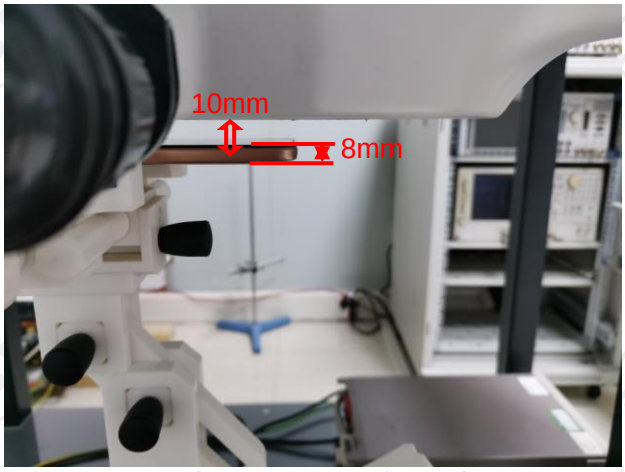


Right Tilted

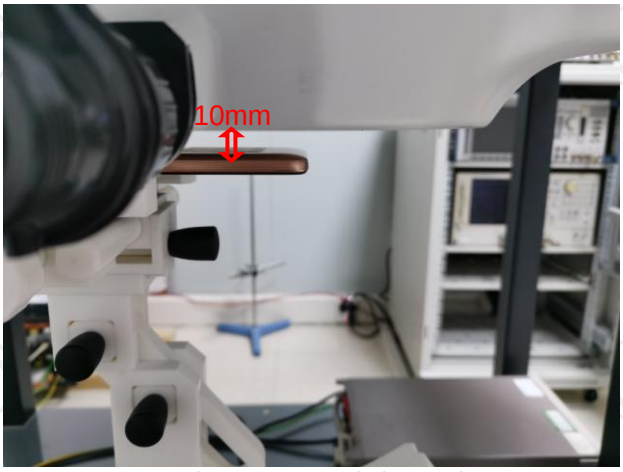


Left Cheek

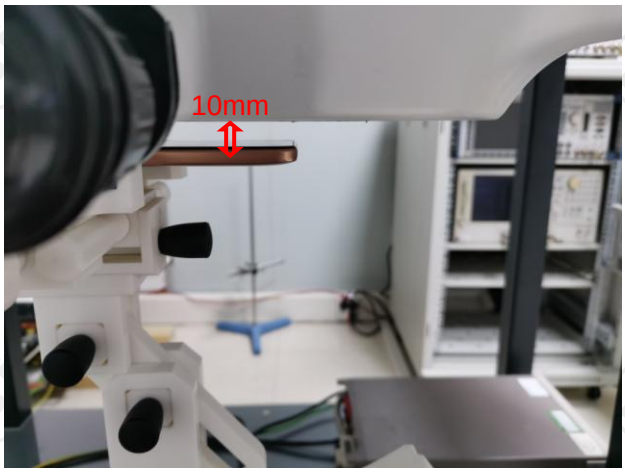
Left Tilted



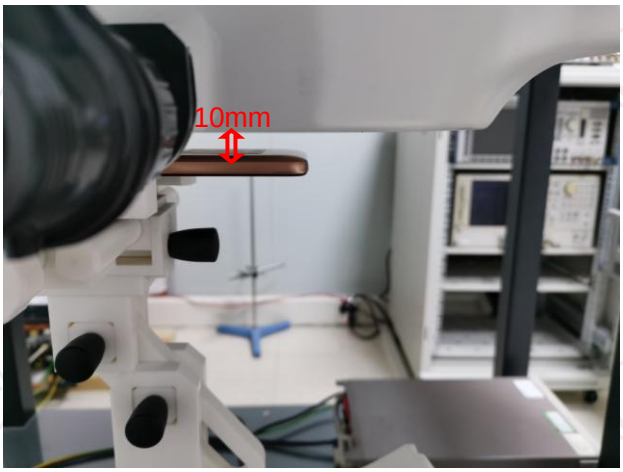
Body worn – Front (10mm)



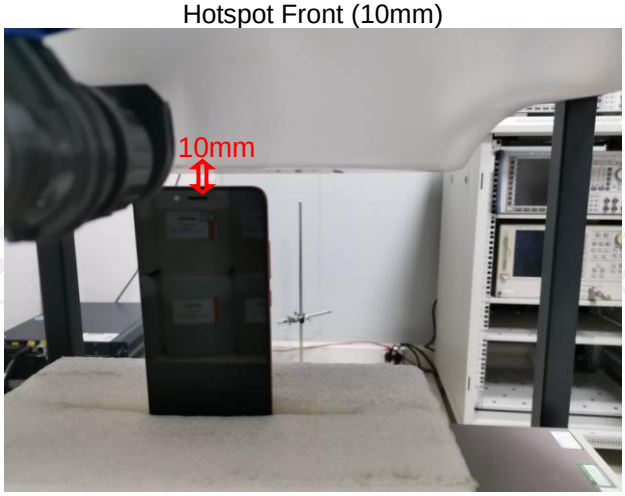
Body worn – Back (10mm)



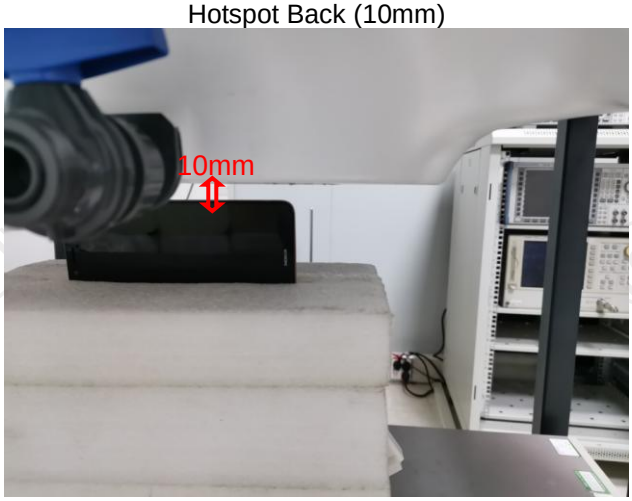
Hotspot Front (10mm)



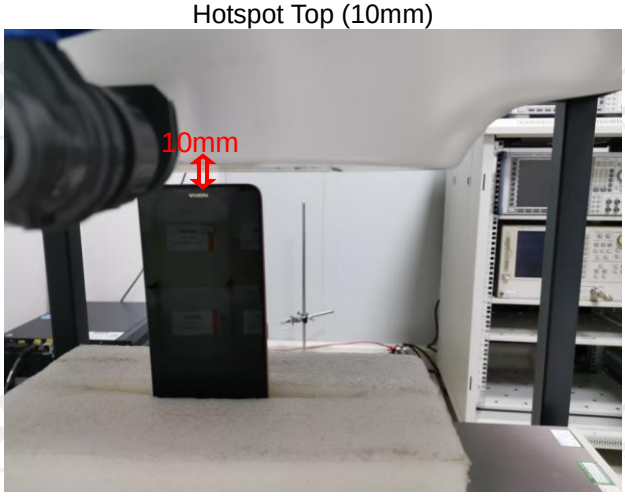
Hotspot Back (10mm)



Hotspot Top (10mm)



Hotspot Right (10mm)



Hotspot Bottom (10mm)

Hotspot Left (10mm)

Appendix C: Probe Calibration Certificate

COMOSAR E-FIELD Probe

COMOSAR E-Field Probe Calibration Report

Ref : ACR.241.1.19.SATU.A

SHENZHEN TCT TESTING TECHNOLOGY CO.,LTD
1F, NO.1 BUILDING, YIBAOLAI INDUSTRIAL PARK,NO.1 CHONGQING ROAD,QIAOTOU VILLAGE, FUYONG TOWN, BAOAN DISTRICT
MVG COMOSAR DOSIMETRIC E-FIELD PROBE
SERIAL NO.: SN 41/18 EPGO331

Calibrated at MVG US
2105 Barrett Park Dr. - Kennesaw, GA 30144

Calibration Date: 08/29/2019

Summary:

This document presents the method and results from an accredited COMOSAR Dosimetric E-Field Probe calibration performed in MVG USA using the CALISAR / CALIBAIR test bench, for use with a COMOSAR system only. All calibration results are traceable to national metrology institutions.

COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.241.1.19.SATU.A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	8/29/2019	
Checked by :	Jérôme LUC	Product Manager	8/29/2019	
Approved by :	Kim RUTKOWSKI	Quality Manager	8/29/2019	

	Customer Name
Distribution :	Shenzhen TCT Testing Technology Co.,Ltd

Issue	Date	Modifications
A	8/29/2019	Initial release

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1 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR DOSIMETRIC E FIELD PROBE
Manufacturer	MVG
Model	SSE2
Serial Number	SN 41/18 EPGO331
Product Condition (new / used)	New
Frequency Range of Probe	0.4 GHz-6GHz
Resistance of Three Dipoles at Connector	Dipole 1: R1=0.184 MΩ Dipole 2: R2=0.191 MΩ Dipole 3: R3=0.192 MΩ

A yearly calibration interval is recommended.

2 PRODUCT DESCRIPTION

2.1 GENERAL INFORMATION

MVG's COMOSAR E field Probes are built in accordance to the IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards.

Figure 1 – *MVG COMOSAR Dosimetric E field Dipole*

Probe Length	330 mm
Length of Individual Dipoles	2 mm
Maximum external diameter	8 mm
Probe Tip External Diameter	2.5 mm
Distance between dipoles / probe extremity	1 mm

3 MEASUREMENT METHOD

The IEEE 1528, OET 65 Bulletin C, CENELEC EN50361 and CEI/IEC 62209 standards provide recommended practices for the probe calibrations, including the performance characteristics of interest and methods by which to assess their affect. All calibrations / measurements performed meet the fore mentioned standards.

3.1 LINEARITY

The evaluation of the linearity was done in free space using the waveguide, performing a power sweep to cover the SAR range 0.01W/kg to 100W/kg.

3.2 SENSITIVITY

The sensitivity factors of the three dipoles were determined using a two step calibration method (air and tissue simulating liquid) using waveguides as outlined in the standards.

3.3 LOWER DETECTION LIMIT

The lower detection limit was assessed using the same measurement set up as used for the linearity measurement. The required lower detection limit is 10 mW/kg.

3.4 ISOTROPY

The axial isotropy was evaluated by exposing the probe to a reference wave from a standard dipole with the dipole mounted under the flat phantom in the test configuration suggested for system validations and checks. The probe was rotated along its main axis from 0 - 360 degrees in 15 degree steps. The hemispherical isotropy is determined by inserting the probe in a thin plastic box filled with tissue-equivalent liquid, with the plastic box illuminated with the fields from a half wave dipole. The dipole is rotated about its axis (0°–180°) in 15° increments. At each step the probe is rotated about its axis (0°–360°).

3.5 BOUNDARY EFFECT

The boundary effect is defined as the deviation between the SAR measured data and the expected exponential decay in the liquid when the probe is oriented normal to the interface. To evaluate this effect, the liquid filled flat phantom is exposed to fields from either a reference dipole or waveguide. With the probe normal to the phantom surface, the peak spatial average SAR is measured and compared to the analytical value at the surface.

4 MEASUREMENT UNCERTAINTY

The guidelines outlined in the IEEE 1528, OET 65 Bulletin C, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty associated with an E-field probe calibration using the waveguide technique. All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

Uncertainty analysis of the probe calibration in waveguide					
ERROR SOURCES	Uncertainty value (%)	Probability Distribution	Divisor	ci	Standard Uncertainty (%)
Incident or forward power	3.00%	Rectangular	$\sqrt{3}$	1	1.732%
Reflected power	3.00%	Rectangular	$\sqrt{3}$	1	1.732%
Liquid conductivity	5.00%	Rectangular	$\sqrt{3}$	1	2.887%
Liquid permittivity	4.00%	Rectangular	$\sqrt{3}$	1	2.309%
Field homogeneity	3.00%	Rectangular	$\sqrt{3}$	1	1.732%
Field probe positioning	5.00%	Rectangular	$\sqrt{3}$	1	2.887%

Field probe linearity	3.00%	Rectangular	$\sqrt{3}$	1	1.732%
Combined standard uncertainty					5.831%
Expanded uncertainty 95 % confidence level k = 2					12.0%

5 CALIBRATION MEASUREMENT RESULTS

Calibration Parameters	
Liquid Temperature	21 °C
Lab Temperature	21 °C
Lab Humidity	45 %

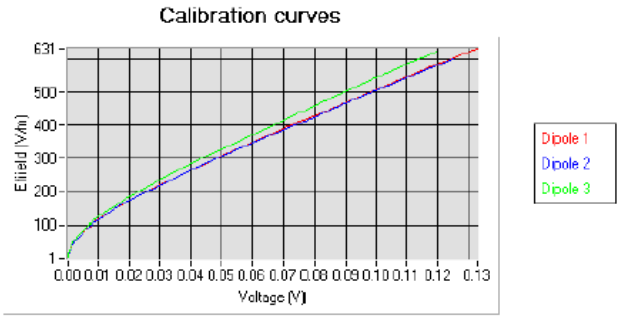
5.1 SENSITIVITY IN AIR

Normx dipole 1 (μV/(V/m)^2)	Normy dipole 2 (μV/(V/m)^2)	Normz dipole 3 (μV/(V/m)^2)
0.86	0.78	0.74

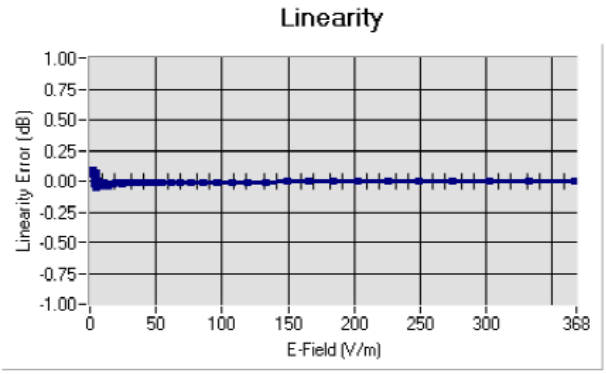
DCP dipole 1 (mV)	DCP dipole 2 (mV)	DCP dipole 3 (mV)
95	93	91

Calibration curves ei=f(V) (i=1,2,3) allow to obtain H-field value using the formula:

$$E = \sqrt{E_1^{\,2} + E_2^{\,2} + E_3^{\,2}}$$



5.2 LINEARITY



Linearity: +/-1.92% (+/-0.08dB)

5.3 SENSITIVITY IN LIQUID

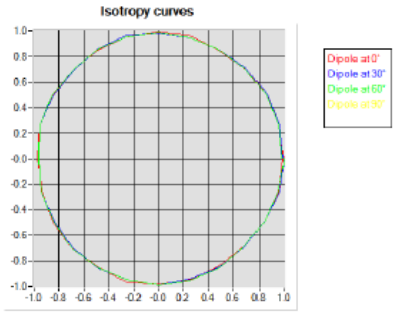
Liquid	Frequency (MHz +/- 100MHz)	Permittivity	Epsilon (S/m)	ConvF
HL450	450	45.43	0.86	1.85
BL450	450	58.80	0.90	1.92
HL750	750	40.76	0.93	1.71
BL750	750	56.70	0.98	1.78
HL850	835	40.86	0.92	1.80
BL850	835	56.35	0.99	1.86
HL900	900	41.94	0.93	1.91
BL900	900	54.62	0.98	1.96
HL1800	1800	40.86	1.29	2.08
BL1800	1800	52.27	1.47	2.16
HL1900	1900	39.67	1.38	2.23
BL1900	1900	52.84	1.59	2.32
HL2000	2000	38.71	1.42	2.03
BL2000	2000	52.03	1.52	2.10
HL2450	2450	38.72	1.80	2.31
BL2450	2450	54.91	1.97	2.37
HL2600	2600	39.98	1.89	2.16
BL2600	2600	54.42	2.18	2.23
HL3500	3500	37.96	2.87	2.21
BL3500	3500	53.40	3.28	2.28
HL5200	5200	36.68	4.45	2.01
BL5200	5200	49.02	5.46	2.08
HL5400	5400	36.08	4.69	1.94
BL5400	5400	49.55	5.53	1.99
HL5600	5600	35.34	4.95	2.07
BL5600	5600	47.60	5.77	2.12
HL5800	5800	34.81	5.08	2.06
BL5800	5800	47.81	6.12	2.13

LOWER DETECTION LIMIT: 9mW/kg

5.4 ISOTROPY

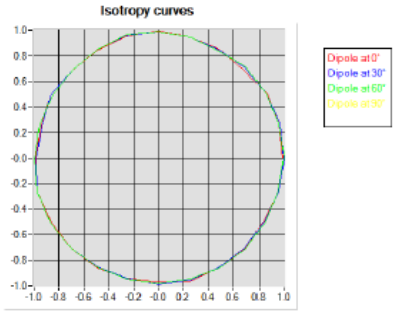
HL850 MHz

- Axial isotropy: 0.04 dB
- Hemispherical isotropy: 0.07 dB



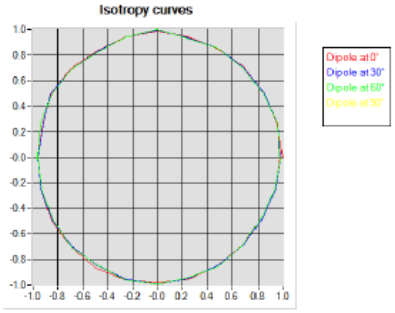
HL1900 MHz

- Axial isotropy: 0.04 dB
- Hemispherical isotropy: 0.08 dB



HL5600 MHz

- Axial isotropy: 0.06 dB
- Hemispherical isotropy: 0.10 dB



6 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	**Manufacturer / Model**	**Identification No.**	**Current Calibration Date**	**Next Calibration Date**
Flat Phantom	MVG	SN-20/09-SAM71	Validated. No cal required.	Validated. No cal required.
COMOSAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rhode & Schwarz ZVA	SN100132	02/2019	02/2022
Reference Probe	MVG	EP 94 SN 37/08	10/2017	10/2019
Multimeter	Keithley 2000	1188656	01/2017	01/2020
Signal Generator	Agilent E4438C	MY49070581	01/2017	01/2020
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	HP E4418A	US38261498	01/2017	01/2020
Power Sensor	HP ECP-E26A	US37181460	01/2017	01/2020
Directional Coupler	Narda 4216-20	01386	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Waveguide	Mega Industries	069Y7-158-13-712	Validated. No cal required.	Validated. No cal required.
Waveguide Transition	Mega Industries	069Y7-158-13-701	Validated. No cal required.	Validated. No cal required.
Waveguide Termination	Mega Industries	069Y7-158-13-701	Validated. No cal required.	Validated. No cal required.
Temperature / Humidity Sensor	Control Company	150798832	11/2017	11/2020

Dielectric Probe Calibration Report

Ref : ACR.138.4.33.SATU.A

Shenzhen Tongce Testing Lab.

1B/F., Building 1, Yibaolai Industrial Park,

Qiaotou, Fuyong, Baoan District, Shenzhen, Guangdong, China

MVG COMOSAR DOSIMETRIC E-FIELD PROBE

FREQUENCY: 0.3-6 GHZ

SERIAL NO.: SN 19/15 OCPG 71

Calibrated at MVG US

2105 Barrett Park Dr. - Kennesaw, GA 30144

ACCREDITED Calibration CERT #2246-02

Calibration Date: 06/05/2018

Summary:

This document presents the method and results from an accredited Dielectric Probe calibration performed in MVG USA using the LIMESAR test bench. All calibration results are traceable to national metrology institutions.

SAR DIELECTRIC PROBE CALIBRATION REPORT

Ref: ACR.138.4.33..SATU.A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	06/05/2018	
Checked by :	Jérôme LUC	Product Manager	06/05/2018	
Approved by :	Kim RUTKOWSKI	Quality Manager	06/05/2018	

	Customer Name
Distribution :	Shenzhen Tongce Testing Lab

Issue	Date	Modifications
A	06/05/2018	Initial release

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1 INTRODUCTION

This document contains a summary of the suggested methods and requirements set forth by the IEEE 1528 and CEI/IEC 62209 standards for liquid permittivity measurements and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

Device Under Test	
Device Type	LIMESAR DIELECTRIC PROBE
Manufacturer	MVG
Model	SCLMP
Serial Number	SN 19/15 OCPG 71
Product Condition (new / used)	Used

A yearly calibration interval is recommended.

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

MVG's Dielectric Probes are built in accordance to the IEEE 1528 and CEI/IEC 62209 standards. The product is designed for use with the LIMESAR test bench only.

Figure 1 – *MVG LIMESAR Dielectric Probe*

4 MEASUREMENT METHOD

The IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209-1 & 2 standards outline techniques for dielectric property measurements. The LIMESAR test bench employs one of the methods outlined in the standards, using a contact probe or open-ended coaxial transmission-line probe and vector network analyzer. The standards recommend the measurement of two reference materials that have well established and stable dielectric properties to validate the system, one for the calibration and one for checking the calibration. The LIMESAR test bench uses De-ionized water as the reference for the calibration and either DMS or Methanol as the reference for checking the calibration. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 LIQUID PERMITTIVITY MEASUREMENTS

The permittivity of a liquid with well established dielectric properties was measured and the measurement results compared to the values provided in the fore mentioned standards.

5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 DIELECTRIC PERMITTIVITY MEASUREMENT

The following uncertainties apply to the Dielectric Permittivity measurement:

Uncertainty analysis of Permittivity Measurement					
ERROR SOURCES	**Uncertainty value (+/-%)**	**Probability Distribution**	**Divisor**	**ci**	**Standard Uncertainty (+/-%)**
Repeatability (n repeats, mid-band)	4.00%	N	1	1	4.000%
Deviation from reference liquid	5.00%	R	√3	1	2.887%
Network analyser-drift, linearity	2.00%	R	√3	1	1.155%
Test-port cable variations	0.00%	U	√2	1	0.000%
Combined standard uncertainty					5.066%
Expanded uncertainty (confidence level of 95%, k = 2)					10.0%

Uncertainty analysis of Conductivity Measurement					
ERROR SOURCES	**Uncertainty value (+/-%)**	**Probability Distribution**	**Divisor**	**ci**	**Standard Uncertainty (+/-%)**
Repeatability (n repeats, mid-band)	3.50%	N	1	1	3.500%
Deviation from reference liquid	3.00%	R	√3	1	1.732%
Network analyser-drift, linearity	2.00%	R	√3	1	1.155%
Test-port cable variations	0.00%	U	√2	1	0.000%
Combined standard uncertainty					4.072%
Expanded uncertainty (confidence level of 95%, k = 2)					8.1%

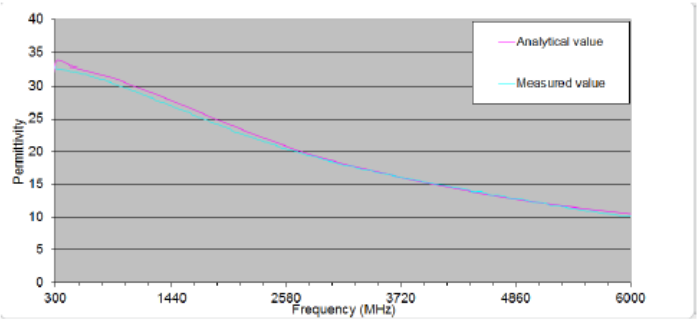
6 CALIBRATION MEASUREMENT RESULTS

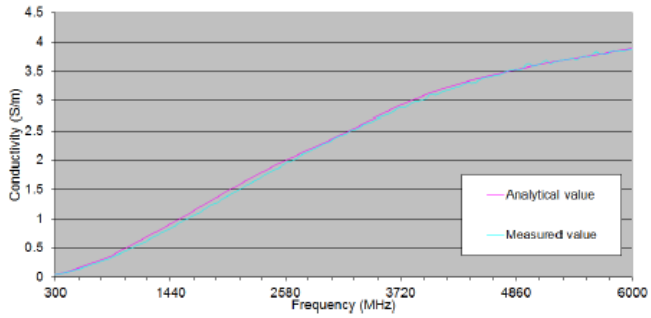
Measurement Condition

Software	LIMESAR
Liquid Temperature	21°C
Lab Temperature	21°C
Lab Humidity	44%

6.1 LIQUID PERMITTIVITY MEASUREMENT

A liquid of known characteristics (methanol at 20°C) is measured with the probe and the results (complex permittivity ε'+jε") are compared with the well-known theoretical values for this liquid.





7 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	**Manufacturer / Model**	**Identification No.**	**Current Calibration Date**	**Next Calibration Date**
LIMESAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rhode & Schwarz ZVA	SN100132	02/2018	02/2021
Methanol CAS 67-56-1	Alpha Aesar	Lot D13W011	Validated. No cal required.	Validated. No cal required.
Temperature and Humidity Sensor	Control Company	11-661-9	09/2018	09/2019

Appendix D: Dipole Calibration Report

SID 835

SAR Reference Dipole Calibration Report

Ref : ACR.156.4.15.SATU.A

SHENZHEN TONGCE TESTING Lab.

1B/F., Building 1, Yibaolai Industrial Park,

Qiaotou, Fuyong, Baoan District, Shenzhen, Guangdong, China

MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 835 MHZ

SERIAL NO.: SN 16/15 DIP 0G835-369

Calibrated at MVG US

2105 Barrett Park Dr. - Kennesaw, GA 30144

ACCREDITED

Calibration CERT #2246-02

Calibration Date: 06/05/2018

Summary:

This document presents the method and results from an accredited SAR reference dipole calibration performed in MVG USA using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.

SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.4.15.SATU.A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	06/05/2018	
Checked by :	Jérôme LUC	Product Manager	06/05/2018	
Approved by :	Kim RUTKOWSKI	Quality Manager	06/05/2018	

	Customer Name
Distribution :	Shenzhen Tongce Testing Lab

Issue	Date 6	Modifications
A	06/05/2018	Initial release

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1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEEE 1528, FCC KDBs and CEI/IEC 62209 standards for reference dipoles used for SAR measurement system validations and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR 835 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID835
Serial Number	SN 16/15 DIP 0G835-369
Product Condition (new / used)	Used

A yearly calibration interval is recommended.

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

MVG's COMOSAR Validation Dipoles are built in accordance to the IEEE 1528, FCC KDBs and CEI/IEC 62209 standards. The product is designed for use with the COMOSAR test bench only.

Figure 1 – *MVG COMOSAR Validation Dipole*

4 MEASUREMENT METHOD

The IEEE 1528, FCC KDBs and CEI/IEC 62209 standards provide requirements for reference dipoles used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constucted as outlined in the fore mentioned standards.

4.2 MECHANICAL REQUIREMENTS

The IEEE Std. 1528 and CEI/IEC 62209 standards specify the mechanical components and dimensions of the validation dipoles, with the dimensions frequency and phantom shell thickness dependent. The COMOSAR test bench employs a 2 mm phantom shell thickness therefore the dipoles sold for use with the COMOSAR test bench comply with the requirements set forth for a 2 mm phantom shell thickness.

5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

Frequency band	Expanded Uncertainty on Return Loss
400-6000MHz	0.1 dB

5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

Length (mm)	Expanded Uncertainty on Length
3 - 300	0.05 mm

5.3 VALIDATION MEASUREMENT

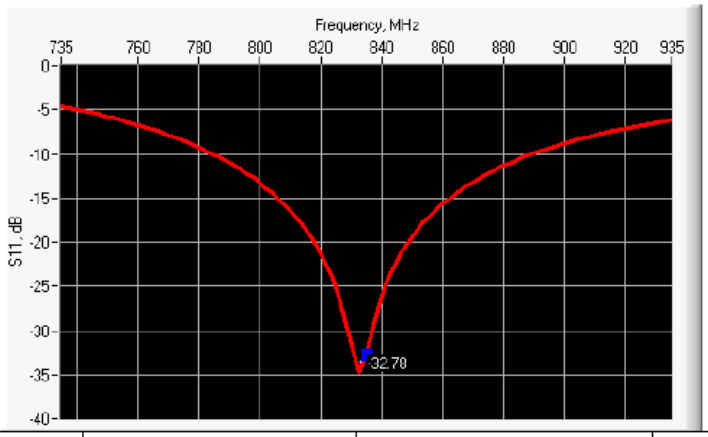
The guidelines outlined in the IEEE 1528, FCC KDBs, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty for validation measurements.

Scan Volume	Expanded Uncertainty
1 g	20.3 %

10 g	20.1 %

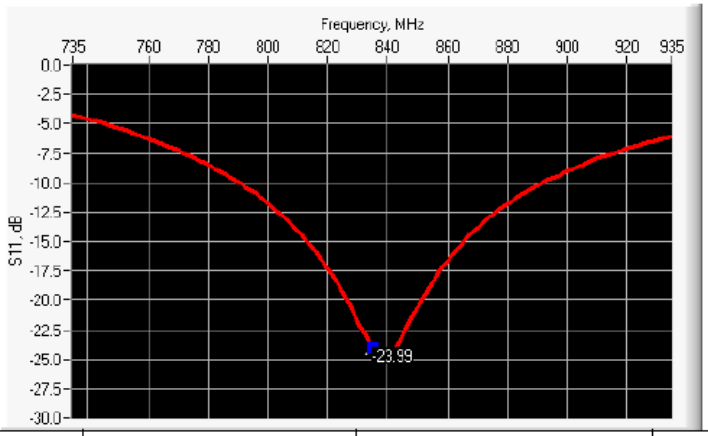
6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
835	-32.78	-20	51.5 Ω + 1.7 jΩ

6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
835	-23.99	-20	47.3 Ω + 5.6 jΩ

6.3 MECHANICAL DIMENSIONS

Frequency MHz	L mm		h mm		d mm	
	required	measured	required	measured	required	measured
300	420.0 ±1 %.		250.0 ±1 %.		6.35 ±1 %.	

450	290.0 ±1 %.		166.7 ±1 %.		6.35 ±1 %.	
750	176.0 ±1 %.		100.0 ±1 %.		6.35 ±1 %.	
835	161.0 ±1 %.	PASS	89.8 ±1 %.	PASS	3.6 ±1 %.	PASS
900	149.0 ±1 %.		83.3 ±1 %.		3.6 ±1 %.	
1450	89.1 ±1 %.		51.7 ±1 %.		3.6 ±1 %.	
1500	80.5 ±1 %.		50.0 ±1 %.		3.6 ±1 %.	
1640	79.0 ±1 %.		45.7 ±1 %.		3.6 ±1 %.	
1750	75.2 ±1 %.		42.9 ±1 %.		3.6 ±1 %.	
1800	72.0 ±1 %.		41.7 ±1 %.		3.6 ±1 %.	
1900	68.0 ±1 %.		39.5 ±1 %.		3.6 ±1 %.	
1950	66.3 ±1 %.		38.5 ±1 %.		3.6 ±1 %.	
2000	64.5 ±1 %.		37.5 ±1 %.		3.6 ±1 %.	
2100	61.0 ±1 %.		35.7 ±1 %.		3.6 ±1 %.	
2300	55.5 ±1 %.		32.6 ±1 %.		3.6 ±1 %.	
2450	51.5 ±1 %.		30.4 ±1 %.		3.6 ±1 %.	
2600	48.5 ±1 %.		28.8 ±1 %.		3.6 ±1 %.	
3000	41.5 ±1 %.		25.0 ±1 %.		3.6 ±1 %.	
3500	37.0±1 %.		26.4 ±1 %.		3.6 ±1 %.	
3700	34.7±1 %.		26.4 ±1 %.		3.6 ±1 %.	

7 VALIDATION MEASUREMENT

The IEEE Std. 1528, FCC KDBs and CEI/IEC 62209 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. Per the standards, the dipole shall be positioned below the bottom of the phantom, with the dipole length centered and parallel to the longest dimension of the flat phantom, with the top surface of the dipole at the described distance from the bottom surface of the phantom.

7.1 HEAD LIQUID MEASUREMENT

Frequency MHz	Relative permittivity (ε,')		Conductivity (σ) S/m	
	required	measured	required	measured
300	45.3 ±5 %		0.87 ±5 %	
450	43.5 ±5 %		0.87 ±5 %	
750	41.9 ±5 %		0.89 ±5 %	
835	41.5 ±5 %	PASS	0.90 ±5 %	PASS
900	41.5 ±5 %		0.97 ±5 %	
1450	40.5 ±5 %		1.20 ±5 %	
1500	40.4 ±5 %		1.23 ±5 %	
1640	40.2 ±5 %		1.31 ±5 %	
1750	40.1 ±5 %		1.37 ±5 %	

1800	40.0 ±5 %		1.40 ±5 %	
1900	40.0 ±5 %		1.40 ±5 %	
1950	40.0 ±5 %		1.40 ±5 %	
2000	40.0 ±5 %		1.40 ±5 %	
2100	39.8 ±5 %		1.49 ±5 %	
2300	39.5 ±5 %		1.67 ±5 %	
2450	39.2 ±5 %		1.80 ±5 %	
2600	39.0 ±5 %		1.96 ±5 %	
3000	38.5 ±5 %		2.40 ±5 %	
3500	37.9 ±5 %		2.91 ±5 %	

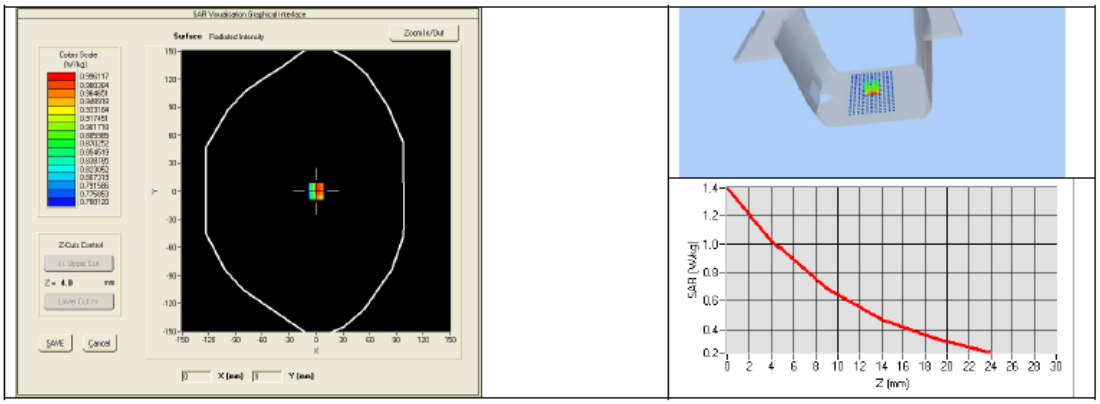
7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

The IEEE Std. 1528 and CEI/IEC 62209 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is given with the used input power.

Software	OPENSAR V4
Phantom	SN 20/09 SAM71
Probe	SN 18/11 EPG122
Liquid	Head Liquid Values: eps' : 42.3 sigma : 0.92
Distance between dipole center and liquid	15.0 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=8mm/dy=8mm/dz=5mm
Frequency	835 MHz
Input power	20 dBm
Liquid Temperature	21 °C
Lab Temperature	21 °C
Lab Humidity	45 %

Frequency MHz	1 g SAR (W/kg/W)		10 g SAR (W/kg/W)	
	required	measured	required	measured
300	2.85		1.94	
450	4.58		3.06	
750	8.49		5.55	
835	9.56	9.53 (0.82)	6.22	6.12 (0.58)
900	10.9		6.99	
1450	29		16	
1500	30.5		16.8	
1640	34.2		18.4	
1750	36.4		19.3	
1800	38.4		20.1	

1900	39.7		20.5	
1950	40.5		20.9	
2000	41.1		21.1	
2100	43.6		21.9	
2300	48.7		23.3	
2450	52.4		24	
2600	55.3		24.6	
3000	63.8		25.7	
3500	67.1		25	



7.3 BODY LIQUID MEASUREMENT

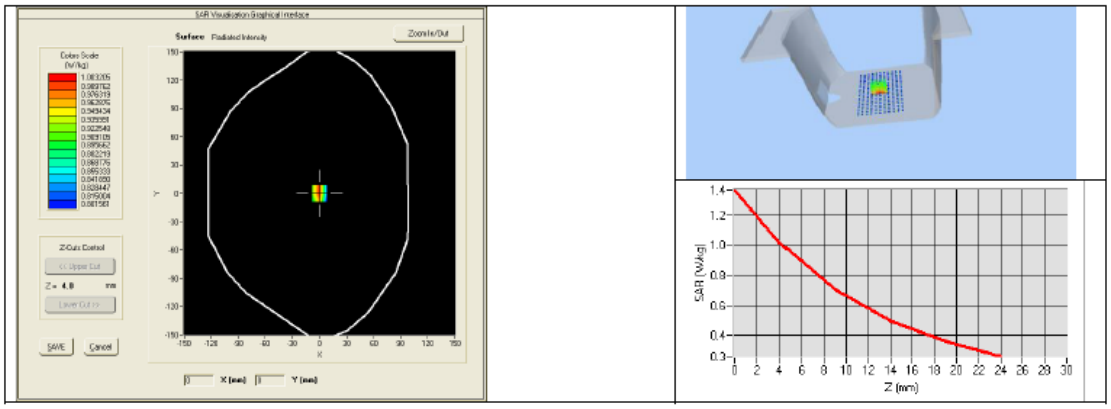
Frequency MHz	Relative permittivity (εr')		Conductivity (σ) S/m	
	required	measured	required	measured
150	61.9 ±5 %		0.80 ±5 %	
300	58.2 ±5 %		0.92 ±5 %	
450	56.7 ±5 %		0.94 ±5 %	
750	55.5 ±5 %		0.96 ±5 %	
835	55.2 ±5 %	PASS	0.97 ±5 %	PASS
900	55.0 ±5 %		1.05 ±5 %	
915	55.0 ±5 %		1.06 ±5 %	
1450	54.0 ±5 %		1.30 ±5 %	
1610	53.8 ±5 %		1.40 ±5 %	
1800	53.3 ±5 %		1.52 ±5 %	
1900	53.3 ±5 %		1.52 ±5 %	
2000	53.3 ±5 %		1.52 ±5 %	
2100	53.2 ±5 %		1.62 ±5 %	
2450	52.7 ±5 %		1.95 ±5 %	

2600	52.5 ±5 %		2.16 ±5 %	
3000	52.0 ±5 %		2.73 ±5 %	
3500	51.3 ±5 %		3.31 ±5 %	
5200	49.0 ±10 %		5.30 ±10 %	
5300	48.9 ±10 %		5.42 ±10 %	
5400	48.7 ±10 %		5.53 ±10 %	
5500	48.6 ±10 %		5.65 ±10 %	
5600	48.5 ±10 %		5.77 ±10 %	
5800	48.2 ±10 %		6.00 ±10 %	

7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

Software	OPENSAR V4
Phantom	SN 20/09 SAM71
Probe	SN 18/11 EPG122
Liquid	Body Liquid Values: eps' : 53.3 sigma : 0.97
Distance between dipole center and liquid	15.0 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=8mm/dy=8mm/dz=5mm
Frequency	835 MHz
Input power	20 dBm
Liquid Temperature	21 °C
Lab Temperature	21 °C
Lab Humidity	45 %

Frequency MHz	1 g SAR (W/kg/W)	10 g SAR (W/kg/W)
	measured	measured
835	9.62 (0.91)	6.44 (0.59)



8 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	**Manufacturer / Model**	**Identification No.**	**Current Calibration Date**	**Next Calibration Date**
SAM Phantom	MVG	SN-20/09-SAM71	Validated. No cal required.	Validated. No cal required.
COMOSAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rhode & Schwarz ZVA	SN100132	02/2018	02/2021
Calipers	Carrera	CALIPER-01	02/2018	02/2021
Reference Probe	MVG	EPG122 SN 18/11	02/2018	02/2019
Multimeter	Keithley 2000	1188656	02/2018	02/2021
Signal Generator	Agilent E4438C	MY49070581	02/2018	02/2021
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	HP E4418A	US38261498	02/2018	02/2021
Power Sensor	HP ECP-E26A	US37181460	02/2018	02/2021
Directional Coupler	Narda 4216-20	01386	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Temperature and Humidity Sensor	Control Company	11-661-9	02/2018	02/2021

SAR Reference Dipole Calibration Report

Ref : ACR.156.6.15.SATU.A

SHENZHEN TONGCE TESTING Lab.

1B/F., Building 1, Yibaolai Industrial Park,

Qiaotou, Fuyong, Baoan District, Shenzhen, Guangdong, China

MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 1800 MHZ

SERIAL NO.: SN 16/15 DIP 1G800-371

Calibrated at MVG US

2105 Barrett Park Dr. - Kennesaw, GA 30144

ACCREDITED Calibration CERT #2246-02

Calibration Date: 06/05/2018

Summary:

This document presents the method and results from an accredited SAR reference dipole calibration performed in MVG USA using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.

Hotline: 400-6611-140 Tel: 86-755-27673339 Fax: 86-755-27673332 http://www.tct-lab.com

SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.6.15.SATU.A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	06/05/2018	
Checked by :	Jérôme LUC	Product Manager	06/05/2018	
Approved by :	Kim RUTKOWSKI	Quality Manager	06/05/2018	

	Customer Name
Distribution :	Shenzhen Tongce Testing Lab

Issue	Date	Modifications
A	06/05/2018	Initial release

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1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEEE 1528, FCC KDBs and CEI/IEC 62209 standards for reference dipoles used for SAR measurement system validations and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR 1800 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID1800
Serial Number	SN 16/15 DIP 1G800-371
Product Condition (new / used)	Used

A yearly calibration interval is recommended.

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

MVG's COMOSAR Validation Dipoles are built in accordance to the IEEE 1528, FCC KDBs and CEI/IEC 62209 standards. The product is designed for use with the COMOSAR test bench only.

Figure 1 – *MVG COMOSAR Validation Dipole*

4 MEASUREMENT METHOD

The IEEE 1528, FCC KDBs and CEI/IEC 62209 standards provide requirements for reference dipoles used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constucted as outlined in the fore mentioned standards.

4.2 MECHANICAL REQUIREMENTS

The IEEE Std. 1528 and CEI/IEC 62209 standards specify the mechanical components and dimensions of the validation dipoles, with the dimensions frequency and phantom shell thickness dependent. The COMOSAR test bench employs a 2 mm phantom shell thickness therefore the dipoles sold for use with the COMOSAR test bench comply with the requirements set forth for a 2 mm phantom shell thickness.

5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

Frequency band	Expanded Uncertainty on Return Loss
400-6000MHz	0.1 dB

5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

Length (mm)	Expanded Uncertainty on Length
3 - 300	0.05 mm

5.3 VALIDATION MEASUREMENT

The guidelines outlined in the IEEE 1528, FCC KDBs, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty for validation measurements.

Scan Volume	Expanded Uncertainty
1 g	20.3 %