TESTING (OR CALIBRATION)
NVLAP LAB CODE 600141-0

Registration No.788871

TEST REPORT
FOR SAR TESTING

Report No.: SRTC2019-9004(F)- 19080201(H)

Product Name: Fi Smart Collar

Product Model: FC1

Applicant: Barking Labs Corp.

Manufacturer: Barking Labs Corp.

Specification: Part 2.1093

IEEE Std 1528

KDB Procedures

FCC ID: 2ARXN-FC1

The State Radio_monitoring_center Testing Center (SRTC)

15th Building, No.30 Shixing Street, Shijingshan District, Beijing, P.R. China

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1 GENERAL INFORMATION

1.1 Notes of the test report

The test report may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written permission of The State Radio_monitoring_center Testing Center (SRTC).
The test results relate only to individual items of the samples which have been tested.
The certification and accreditation identifiers used in this report shall not be applicable to the tested or calibrated samples thereof. The manufacturer shall not mark the tested samples or items (or a separate part of the item) with the identifiers of certification and accreditation to mislead relevant parties about the tested samples or items.

1.2 Information about the testing laboratory

Company:	The State Radio_monitoring_center Testing Center (SRTC)
Address:	15th Building, No.30 Shixing Street, Shijingshan District, Beijing P.R. China
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1.3 Applicant's details

Company:	Barking Labs Corp.
Address:	53 Bridge St., Suite 103
City:	Brooklyn, NY
Country or Region:	USA
Contacted person:	Bob Blake
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Email:	bob@tryfi.com

1.4 Manufacturer's details

Company:	Barking Labs Corp.
Address:	53 Bridge St., Suite 103
City:	Brooklyn, NY
Country or Region:	USA
Contacted person:	Bob Blake
Tel:	+1-914-249-9347
Fax:	---
Email:	bob@tryfi.com

1.5 Test Environment

Date of Receipt of test sample at SRTC:	2019.08.02
Testing Start Date:	2019.08.10
Testing End Date:	2019.08.12

Environmental Data:	Temperature (°C)	Humidity (%)
Ambient	21~23	30~33

Normal Supply Voltage (V d.c.):	3.8

2.1 Final equipment build status

Wireless Technology and Frequency Bands	☐GSM Band: GSM900/DCS1800 ☐WCDMA Band: 1/8 ☒Cat.M: Band 2/4/12 ☐Bluetooth Band: 2.4GHz~2.4835GHz ☐Wi-Fi Band: 2.4GHz~2.4835GHz
Mode	GSM ☐Voice (GMSK) ☐GPRS (GMSK) ☐EGPRS (GMSK) WCDMA ☐UMTS Rel. 99 (Voice & Data) ☐HSDPA (Rel. 5) ☐HSUPA (Rel. 6) ☐HSPA+ (Rel.7) ☐DC-HSDPA (Rel.8) Wi-Fi (802.11a/b/g/n) ☐802.11a ☐802.11b ☐802.11g ☐802.11n (20MHz) ☐802.11n (40MHz) Bluetooth ☐BR(GFSK) ☐EDR (π/4 DQPSK, 8-DPSK) ☐BLE(GFSK) LTE ☐QPSK ☐16QAM ☐64QAM
Duty Cycle	GSM Voice: 12.5%; GPRS: 12.5% (1 Slot), 25% (2 Slots), 37.5% (3 Slots), 50% (4 Slots) WCDMA: 100% Wi-Fi 802.11b/g/n: 100% Bluetooth: 32.25% (DH1), 66.68% (DH3), 77.52% (DH5)
GPRS Multi-Slot Class	☐Class 8 - One Up ☐Class 10 - Two Up ☐Class 12 - Four Up
Mobile Phone Capability	☐Class A - Mobile phones can be connected to both GPRS and GSM services simultaneously. ☐Class B - Mobile phones can be attached to both GPRS and GSM services, using one service at a time. ☐Class C - Mobile phones are attached to either GPRS or GSM voice service. You need to switch manually between services
DTM (Dual Transfer Mode)	Not Supported

2.2 Support equipment

The following support equipment was used to exercise the EUT during testing:

Batteries	JKIT/Li-Lon
H/W Version	Rev.B
S/W Version	v1.0
IMEI	357812093107545
Notes	The relevant tests have been performed in order to verify in which combination case the EUT would have the worst features.

3 REFERENCE SPECIFICATION

Specification	Version	Title
Part 2.1093	2018	Radiofrequency radiation exposure evaluation: portable devices.
IEEE Std 1528	2013	IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
IEEE Std 1528a	2005	IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques Amendment 1: CAD File for Human Head Model (SAM Phantom)
KDB 447498 D01	v06	General RF Exposure Guidance
KDB 648474 D04	v01r03	Handset SAR
KDB 865664 D01	v01r04	SAR Measurement from 100 MHz to 6 GHz
KDB 865664 D02	v01r02	RF Exposure Reporting
KDB 941225 D05	v02r05	SAR for LTE Devices

4 TEST CONDITIONS

4.1 Picture to demonstrate the required liquid depth

The liquid depth in the used SAM phantoms

Liquid depth for SAR Measurement

4.2 Test signal, frequencies and output power

The device was put into operation by using a call tester. Communication between the device and the call tester was established by air link.
The device output power was set to maximum power level for all tests; a fully charged battery was used for every test sequence.
In all operating bands the measurements were performed on lowest, middle and highest channels.

4.3 SAR measurement set-up

The system is based on a high precision robot (working range greater than 0.9m), which positions the probes with a positional repeatability of better than ± 0.02mm. Special E- probe have been developed for measurements close to material discontinuity, the sensors of which are directly loaded with a Schottky diode and connected via highly resistive lines (length =300mm) to the data acquisition unit. A cell controller system contains the power supply, robot controller, teaches pendant (Joystick), and remote control, is used to drive the robot motors.
The PC consists of the Micron Pentium IV computer with Win7 system and SAR

Measurement Software DASY5 Professional, A/D interface card, monitor, mouse, and keyboard. The Stäubli Robot is connected to the cell controller to allow software manipulation of the robot.
A data acquisition electronic (DAE) circuit performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. is connected to the Electro-optical coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC plug-in card. The DAE consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16-bit AD-converter and a command decoder and control logic unit. Transmission to the PC-card is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines.
The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection
The robot uses its own controller with a built in VME-bus computer.

4.4 Phantoms

The phantom used for all tests i.e. for both system checks and device testing, was the twin headed "SAM Phantom", manufactured by SPEAG. The phantom conforms to the requirements of EN 62209-1 & 2.
System checking was performed using the flat section, whilst Head SAR tests used the left and right head profile sections. Body SAR testing also used the flat section between the head profiles.
The SPEAG device holder (see Section 4.6.1) was used to position the device in all tests whilst a tripod was used to position the validation dipoles against the flat section of phantom.

4.5 Tissue simulants

Recommended values for the dielectric parameters of the tissue simulants are given in EN 62209-1 & 2. All tests were carried out using simulants whose dielectric parameters were within ± 5% of the recommended values. All tests were carried out within 24 hours of measuring the dielectric parameters.
The depth of the tissue simulant was 15.0 ± 0.5 cm measured from the ear reference point during system checking and device measurements.
The following tissue stimulants were used for Head and Body test:

Name	Broadband tissue-equivalent liquid
Type	HBBL600-6000V6 Head Simulating Liquid

4.6 Description of the test procedure

4.6.1 Device Holder

The device was placed in the device holder (illustrated below) that is supplied by SPEAG as an integral part of the Dasy52 system.

Device holder supplied by SPEAG

4.6.2 Test positions

4.6.2.1 Against Phantom Head

Measurements were made in “cheek” and “tilt” positions on both the left hand and right hand sides of the phantom.
The positions used in the measurements were according to EN 62209-1 & 2.

4.6.2.2 Body Worn Configuration

The device was placed in the SPEAG holder below the flat section of the phantom. The distance between the device and the phantom was kept at the separation distance using a separate flat spacer that was removed before the start of the measurements. And the distances are 5mm for trunk. The device was oriented with its antenna facing the phantom since this orientation gives higher results.

4.6.3 Scan Procedure

First, area scans were used for determination of the field distribution and the approximate location of the local peak SAR values. The SAR distribution is scanned along the inside surface, at least for an area larger than the projection of the handset and antenna. The angle between the probe axis and the surface normal line is recommended but not required to be less than 30°. The SAR distribution is first measured on a 2-D coarse grid. The scan region should cover all areas that are exposed and encompassed by the projection of the handset. There are 15 mm × 15 mm (equal or less than 2GHz), 12 mm × 12 mm (from 2GHz~3GHz) and 10mm x 10mm (above 5GHz) measurement grid used when two staggered one-dimensional cubic splines are used to estimate the maximum SAR location. Next, a zoom scan, a minimum of 7 x 7x7 points covering a volume of at least 30x30x30mm, was performed around the highest E-field value to determine the averaged SAR value. Drift was determined by measuring the same point at the start of the area scan and again at the end of the zoom scan.

4.6.4 SAR Averaging Methods

The maximum SAR value was averaged over a cube of tissue using interpolation and extrapolation.
The interpolation, extrapolation and maximum search routines within Dasy5 are all based on the modified Quadratic Shepard’s method (Robert J. Renka, “Multivariate Interpolation Of Large Sets Of Scattered Data”, University of North Texas ACM Transactions on Mathematical Software, vol. 14, no. 2, June 1988, pp. 139-148).
The interpolation scheme combines a least-square fitted function method with a weighted average method. A trivariate 3-D / bivariate 2-D quadratic function is computed for each measurement point and fitted to neighboring points by a least-square method. For the zoom scan, inverse distance weighting is incorporated to fit distant points more accurately. The interpolating function is finally calculated as a weighted average of the quadratics.
In the zoom scan, the interpolation function is used to extrapolate the Peak SAR from the deepest measurement points to the inner surface of the phantom.

5 RESULT SUMMARY

The maximum measured SAR values for Head configuration and Body Worn configuration are given as follows. The device conforms to the requirements of the standard(s) when the maximum measured SAR value is less than or equal to the limit.

Exposure Position	Mode/Band	10g-SAR Reported Result (W/kg)	Highest 10g-SAR Reported Result (W/kg)	10g-Limit (W/kg)	Result
Limbs (0mm Gap)	Band 2	0.308	0.41	4.0	Pass
	Band 4	0.411			
	Band 12	0.121			

Simultaneous Transmission Summary

Exposure Position	Mode	Highest 10g-SAR Result(W/kg)	Limit (W/kg)/10g	Result
Limbs (0mm Gap)	Cat M & BLE	0.42	4.0	Pass

This Test Report Is Issued by:	Checked by:
Mr. Peng Zhen	Mr. Li Bin
Tested by: Miss. Wu Han	Issued date: 20190820

6 TEST RESULTS

6.1 Manufacturing Tolerance

Cat M

Band 2

20BW 1RB			
Channel	Channel 18700	Channel 18900	Channel 19100
Tolerance (dBm)	18.5~22.5	18.5~22.5	18.5~22.5
20BW 50%RB			
Channel	Channel 18700	Channel 18900	Channel 19100
Tolerance (dBm)	18.0~22.0	18.0~22.0	18.0~22.0

Band 4

20BW 1RB			
Channel	Channel 20050	Channel 20175	Channel 20300
Tolerance (dBm)	19.5~23.5	19.5~23.5	19.5~23.5
20BW 50%RB			
Channel	Channel 20050	Channel 20175	Channel 20300
Tolerance (dBm)	18.5~22.5	18.5~22.5	18.5~22.5

Band 12

10BW 1RB			
Channel	Channel 23060	Channel 23095	Channel 23130
Tolerance (dBm)	20.0~24.0	20.0~24.0	20.0~24.0
10BW 50%RB			
Channel	Channel 23060	Channel 23095	Channel 23130
Tolerance (dBm)	18.5~22.5	18.5~22.5	18.5~22.5

Bluetooth (BLE)

GFSK			
Channel	0	19	39
Tolerance (dBm)	-6.0~-3.0	-6.0~-3.0	-6.0~-3.0

6.2 Cat M Measurement result

LTE_CAT.M1_ Band 2

Modulation	Carrier frequency (MHz)	UL Channel	BW	RB Size	RB Offset	Conducted Power (dBm)
QPSK	1850.7	18607	1.4	1	0	22.37
				3	0	21.48
				6	0	20.26
	1880	18900		1	0	22.07
				3	0	21.58
				6	0	20.15
	1909.3	19193		1	0	22.03
				3	0	21.23
				6	0	20.16
16QAM	1850.7	18607	1.4	1	0	21.32
				1	5	21.21
				3	0	20.63
				5	0	20.06
				5	1	20.08
	1880	18900		1	0	21.26
				1	5	21.19
				3	0	20.47
				5	0	20.04
				5	1	20.06
	1909.3	19193		1	0	21.28
				1	5	21.19
				3	0	20.58
				5	0	20.01
				5	1	20.05
QPSK	1851.7	18615	3	1	0	22.34
				3	0	21.47
				6	0	20.24
	1880	18900		1	0	22.06
				3	0	21.59
				6	0	20.17
	1908.5	19185		1	0	22.02
				3	0	21.58
				6	0	20.21
16QAM	1851.7	18615	3	1	0	21.33
				1	5	21.22
				3	0	20.38
				5	0	20.07
				5	1	20.08
	1880	18900		1	0	21.27
				1	5	21.21
				3	0	20.61
				5	0	20.02
				5	1	20.06
	1908.5	19185		1	0	21.26
				1	5	21.20
				3	0	20.56
				5	0	20.03
				5	1	20.06

Modulation	Carrier frequency (MHz)	UL Channel	BW	RB Size	RB Offset	Conducted Power (dBm)
QPSK	1852.5	18625	5	1	0	22.34
				3	0	21.59
				6	0	20.27
	1880	18900		1	0	22.07
				3	0	21.28
				6	0	20.16
	1907.5	19175		1	0	22.03
				3	0	21.30
				6	0	20.18
16QAM	1852.5	18625	5	1	0	21.35
				1	5	21.25
				3	0	20.28
				5	0	20.06
				5	1	20.09
	1880	18900		1	0	21.28
				1	5	21.21
				3	0	20.48
				5	0	20.04
				5	1	20.06
	1907.5	19175		1	0	21.32
				1	5	21.19
				3	0	20.18
				5	0	20.03
				5	1	20.07
QPSK	1855	18650	10	1	0	22.38
				3	0	21.48
				6	0	20.25
	1880	18900		1	0	22.11
				3	0	21.45
				6	0	20.15
	1905	19150		1	0	22.08
				3	0	21.42
				6	0	20.21
16QAM	1855	18650	10	1	0	21.36
				1	5	21.22
				3	0	20.15
				5	0	20.12
				5	1	20.17
	1880	18900		1	0	21.31
				1	5	21.21
				3	0	20.45
				5	0	20.06
				5	1	20.08
	1905	19150		1	0	21.29
				1	5	21.12
				3	0	20.58
				5	0	20.03
				5	1	20.06

Modulation	Carrier frequency (MHz)	UL Channel	BW	RB Size	RB Offset	Conducted Power (dBm)
QPSK	1857.5	18675	15	1	0	22.39
				3	0	21.28
				6	0	20.24
	1880	18900		1	0	22.12
				3	0	21.67
				6	0	20.16
	1902.5	19125		1	0	22.11
				3	0	21.68
				6	0	20.21
16QAM	1857.5	18675	15	1	0	21.34
				1	5	21.26
				3	0	20.17
				5	0	20.12
				5	1	20.16
	1880	18900		1	0	21.34
				1	5	21.24
				3	0	20.19
				5	0	20.12
				5	1	20.23
	1902.5	19125		1	0	21.31
				1	5	21.25
				3	0	20.17
				5	0	20.12
				5	1	20.24
QPSK	1860	18700	20	1	0	**22.43**
				3	0	21.68
				6	0	20.25
	1880	18900		1	0	**22.13**
				3	0	21.53
				6	0	20.21
	1900	19100		1	0	**22.14**
				3	0	21.70
				6	0	20.12
16QAM	1860	18700	20	1	0	21.36
				1	5	21.24
				3	0	20.38
				5	0	20.13
				5	1	20.21
	1880	18900		1	0	21.32
				1	5	21.24
				3	0	20.47
				5	0	20.21
				5	1	20.06
	1900	19100		1	0	21.32
				1	5	21.25
				3	0	20.37
				5	0	20.15
				5	1	20.18

LTE_CAT.M1_ Band 4

Modulation	Carrier frequency (MHz)	UL Channel	BW	RB Size	RB Offset	Conducted Power (dBm)
QPSK	1710.5	19957	1.4	1	0	23.02
				3	0	21.37
				6	0	20.93
	1732.5	20175		1	0	22.86
				3	0	21.47
				6	0	20.84
	1754.3	20393		1	0	22.85
				3	0	21.27
				6	0	20.79
16QAM	1710.5	19957	1.4	1	0	21.78
				1	5	21.64
				3	0	21.26
				5	0	20.89
				5	1	20.93
	1732.5	20175		1	0	21.62
				1	5	21.57
				3	0	21.35
				5	0	20.83
				5	1	20.86
	1754.3	20393		1	0	21.60
				1	5	21.58
				3	0	21.45
				5	0	20.81
				5	1	20.84
QPSK	1711.5	19965	3	1	0	23.14
				3	0	22.10
				6	0	21.05
	1732.5	20175		1	0	22.98
				3	0	21.25
				6	0	20.96
	1753.5	20385		1	0	22.97
				3	0	21.34
				6	0	20.91
16QAM	1711.5	19965	3	1	0	21.87
				1	5	21.76
				3	0	21.28
				5	0	21.01
				5	1	21.08
	1732.5	20175		1	0	21.74
				1	5	21.69
				3	0	21.39
				5	0	20.95
				5	1	20.98
	1753.5	20385		1	0	21.72
				1	5	21.70
				3	0	21.45
				5	0	20.93
				5	1	20.96

Modulation	Carrier frequency (MHz)	UL Channel	BW	RB Size	RB Offset	Conducted Power (dBm)
QPSK	1712.5	19975	5	1	0	23.15
				3	0	22.16
				6	0	21.06
	1732.5	20175		1	0	22.99
				3	0	21.20
				6	0	20.97
	1752.5	20375		1	0	22.98
				3	0	21.24
				6	0	20.92
16QAM	1712.5	19975	5	1	0	21.91
				1	5	21.77
						21.15
				5	0	21.02
				5	1	21.06
	1732.5	20175		1	0	21.75
				1	5	21.72
				3	0	21.10
				5	0	20.96
				5	1	20.98
	1752.5	20375		1	0	21.73
				1	5	21.71
				3	0	21.30
				5	0	20.94
				5	1	20.97
QPSK	1715	20000	10	1	0	23.27
				3	0	22.10
				6	0	21.18
	1732.5	20175		1	0	23.11
				3	0	21.47
				6	0	21.09
	1750	20350		1	0	23.12
				3	0	21.43
				6	0	21.04
16QAM	1715	20000	10	1	0	22.21
				1	5	21.89
				3	0	21.65
				5	0	21.14
				5	1	21.16
	1732.5	20175		1	0	21.87
				1	5	21.82
				3	0	21.43
				5	0	21.08
				5	1	21.11
	1750	20350		1	0	21.85
				1	5	21.83
				3	0	21.52
				5	0	21.06
				5	1	21.07

Modulation	Carrier frequency (MHz)	UL Channel	BW	RB Size	RB Offset	Conducted Power (dBm)
QPSK	1717.5	20025	15	1	0	23.35
				3	0	22.19
				6	0	21.26
	1732.5	20175		1	0	23.19
				3	0	22.16
				6	0	21.17
	1747.5	20325		1	0	23.22
				3	0	22.14
				6	0	21.12
16QAM	1717.5	20025	15	1	0	22.29
				1	5	21.97
				3	0	21.56
				5	0	21.22
				5	1	21.24
	1732.5	20175		1	0	21.95
				1	5	21.97
				3	0	21.43
				5	0	21.16
				5	1	21.19
	1747.5	20325		1	0	21.93
				1	5	21.91
				3	0	21.42
				5	0	21.14
				5	1	21.15
QPSK	1720	20050	20	1	0	**23.44**
				3	0	22.31
				6	0	21.35
	1732.5	20175		1	0	**23.28**
				3	0	22.47
				6	0	21.26
	1745	20300		1	0	**23.29**
				3	0	22.38
				3	0	21.21
16QAM	1720	20050	20	1	0	22.38
				1	5	22.06
				3	0	21.59
				5	0	21.31
				5	1	21.33
	1732.5	20175		1	0	22.04
				1	5	21.99
				3	0	21.45
				5	0	21.25
				5	1	21.28
	1745	20300		1	0	22.02
				1	5	22.08
				3	0	21.68
				5	0	21.23
				5	1	21.24

LTE_CAT.M1_ Band 12

Modulation	Carrier frequency (MHz)	UL Channel	BW	RB Size	RB Offset	Conducted Power (dBm)
QPSK	699.7	23017	1.4	1	0	23.49
				3	0	22.10
				6	0	21.65
	707.5	23095		1	0	23.63
				3	0	22.37
				6	0	21.65
	715.3	23173		1	0	23.74
				3	0	22.48
				6	0	21.78
16QAM	699.7	23017	1.4	1	0	22.38
				1	5	22.34
				3	0	21.72
				5	0	21.58
				5	1	21.59
	707.5	23095		1	0	22.51
				1	5	22.48
				3	0	21.73
				5	0	21.67
				5	1	21.68
	715.3	23173		1	0	22.57
				1	5	22.54
				3	0	21.94
				5	0	21.70
				5	1	21.72
QPSK	700.5	23025	3	1	0	23.50
				3	0	22.29
				6	0	21.66
	707.5	23095		1	0	23.64
				3	0	22.36
				6	0	21.66
	714.5	23165		1	0	23.75
				3	0	22.39
				6	0	21.79
16QAM	700.5	23025	3	1	0	22.39
				1	5	22.35
				3	0	21.68
				5	0	21.59
				5	1	21.60
	707.5	23095		1	0	22.52
				1	5	22.49
				3	0	21.85
				5	0	21.68
				5	1	21.69
	714.5	23165		1	0	22.58
				1	5	22.55
				3	0	21.84
				5	0	21.71
				5	1	21.73

Modulation	Carrier frequency (MHz)	UL Channel	BW	RB Size	RB Offset	Conducted Power (dBm)
QPSK	701.5	23035	5	1	0	23.51
				3	0	22.10
				6	0	21.67
	707.5	23095		1	0	23.65
				3	0	22.39
				6	0	21.67
	713.5	23155		1	0	23.76
				3	0	22.13
				6	0	21.80
16QAM	701.5	23035	5	1	0	22.40
				1	5	22.36
				3	0	21.83
				5	0	21.60
				5	1	21.61
	707.5	23095		1	0	22.53
				1	5	22.50
				3	0	21.93
				5	0	21.69
				5	1	21.70
	713.5	23155		1	0	22.59
				1	5	22.56
				3	0	21.87
				5	0	21.72
				5	1	21.74
QPSK	704	23060	10	1	0	**23.57**
				3	0	22.46
				6	0	21.73
	707.5	23095		1	0	**23.71**
				3	0	22.41
				6	0	21.73
	711	23130		1	0	**23.82**
				3	0	22.37
				6	0	21.86
16QAM	704	23060	10	1	0	22.46
				1	5	22.42
				3	0	21.84
				5	0	21.66
				5	1	21.67
	707.5	23095		1	0	22.59
				1	5	22.56
				3	0	21.94
				5	0	21.75
				5	1	21.76
	711	23130		1	0	22.65
				1	5	22.62
				3	0	21.92
				5	0	21.78
				5	1	21.80

6.3 Bluetooth Measurement result

Modulation type	Test Result (dBm)		
	2402MHz (Ch0)	2440MHz (Ch19)	2480MHz (Ch39)
GFSK (LE 1Mbps))	-3.44	-3.27	-3.15

6.4 Standalone SAR Test Exclusion Considerations

Standalone 10-g limbs SAR evaluation by measurement or numerical simulation is not required when the corresponding SAR Exclusion Threshold condition, listed below, is satisfied.

SAR Test Exclusion Thresholds for 100 MHz – 6 GHz and ≤ 50 mm

According to the KDB447498 4.3.1 (1)

For 100 MHz to 6 GHz and test separation distances ≤ 50 mm, the 1-g and 10-g SAR test exclusion thresholds are determined by the following:

[(max. power of channel, including tune-up tolerance, mW) / (min. test separation distance, mm)] · [√f (GHz)] ≤ 3.0 for 1-g SAR, where

·f(GHz) is the RF channel transmit frequency in GHz
·Power and distance are rounded to the nearest mW and mm before calculation
·The result is rounded to one decimal place for comparison

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm, and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

This is equivalent to [(max. power of channel, including tune-up tolerance, mW)/(60/√f(GHz) mW)] ·[20 mm/(min.test separation distance, mm)] ≤ 1.0 for 1-g SAR; also see Appendix A for approximate exclusion threshold values at selected frequencies and distances.
According to the KDB447498 appendix A

Approximate SAR Test Exclusion Power Thresholds at Selected Frequencies and Test Separation Distances are illustrated in the following Table.

MHz	5	10	15	20	25	mm
150	39	77	116	155	194	*SAR Test Exclusion Threshold* (mW)
300	27	55	82	110	137	
450	22	45	67	89	112	
835	16	33	49	66	82	
900	16	32	47	63	79	
1500	12	24	37	49	61	
1900	11	22	33	44	54	
2450	10	19	29	38	48	
3600	8	16	24	32	40	
5200	7	13	20	26	33	
5400	6	13	19	26	32	
5800	6	12	19	25	31	

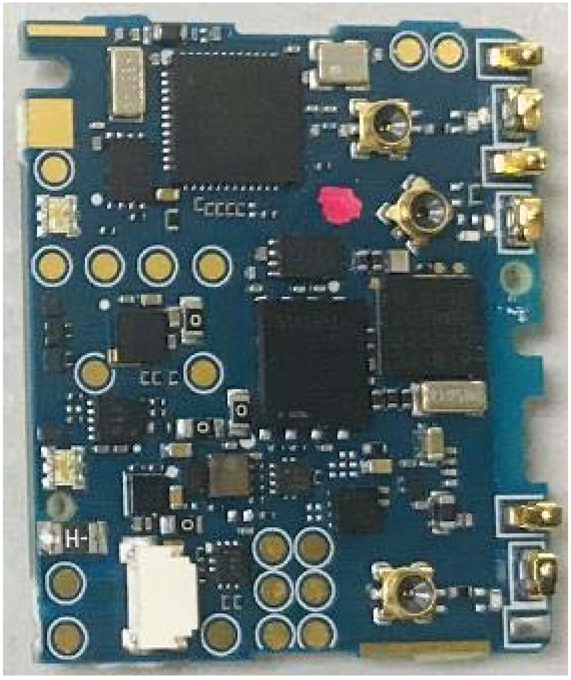
Note: 10-g Extremity SAR Test Exclusion Power Thresholds are 2.5 times higher than the 1-g SAR Test Exclusion Thresholds indicated above. These thresholds do not apply, by extrapolation or other means, to occupational exposure limits.

Summary of Transmitters

Band/Mode	Position	Max. RF output power (mW)	SAR test exclusion Threshold (mW)	SAR Required
(2.4~2.4835) GHz Bluetooth	Limbs	0.484	25	No

6.5 RF exposure conditions

Refer to the follow picture “Antenna Locations & Separation Distances” for the specific details of the antenna-to-antenna and antenna-to-edge(s) distances.



6.5.1 Limbs Exposure conditions

For WWAN

Test Configurations	SAR Required	Note
Back	yes	/
Front	yes	/
Top	yes	/
Bottom	yes	/
Left	yes	/
Right	yes	/

6.6 System Checking

The manufacturer calibrates the probes annually. Dielectric parameters of the tissue simulants were measured every day using the dielectric probe kit and the network analyzer. A system check measurement was made following the determination of the dielectric parameters of the simulant, using the dipole validation kit. A power level of 250mW was supplied to the dipole antenna, which was placed under the flat section of the twin SAM phantom. The system checking results (dielectric parameters and SAR values) are given in the table below.

Date Tested	System dipole	T.S. Liquid	SAR measured (normalized to 1W)		Target (Ref.Value)	Delta (%)	Tolerance (%)
2019.08.10	D750V3	Body	10g	5.62	5.73	-1.92	±10
2019.08.11	D1800V2	Body	10g	20.37	20.8	-2.07	±10
2019.08.12	D2000V2	Body	10g	19.62	20.4	-3.82	±10

Plots of the system checking scans are given in Appendix A.

Tissue Simulants used in the Measurements
For the measurement of the following parameters the SPEAG DAKS-3.5 dielectric parameter probe is used, representing the open-ended coaxial probe measurement procedure.

Date Tested	Freq. (MHz)	Liquid parameters	measured	Target	Delta (%)	Tolerance (%)
2019.08.10	Body 750	εr	53.07	55.50	-4.4	±5
		σ[S/m]	0.94	0.96	-2.1	±5
2019.08.11	Body 1800	εr	53.22	53.30	-0.2	±5
		σ[S/m]	1.48	1.52	-2.6	±5
2019.08.12	Body 2000	εr	52.60	53.30	-1.3	±5
		σ[S/m]	1.50	1.52	-1.3	±5

6.7 SAR Test result

In order to determine the largest value of the peak spatial-average SAR of a handset, all device positions, configurations, and operational modes should be tested for each frequency band according to Steps 1 to 3 below.

Step 1: The tests should be performed at the channel that is closest to the centre of the transmit frequency band.
a) all device positions (cheek and tilt, for both left and right sides of the SAM phantom),
b) all configurations for each device position in a), e.g., antenna extended and retracted, and
c) All operational modes for each device position in item a) and configuration in item b) in each frequency band, e.g., analog and digital, If more than three frequencies need to be tested (i.e., Nc > 3), then all frequencies, configurations and modes shall be tested for all of the above test conditions.
Step 2: For the condition providing the highest peak spatial-average SAR determined in Step 1 for each frequency, perform all tests at all other test frequency channels, e.g., lowest and highest frequencies. In addition, for all other conditions (device position, configuration, and operational mode) where the peak spatial-average SAR value determined in Step 1 is within 3 dB of the applicable SAR limit, it is recommended that all other test frequencies should be tested as well.
Step 3: Examine all data to determine the largest value of the peak.

Note: There is no KDB for Cat M, since Cat M belongs to LTE, KDB 941225 is referred.

The measured Limbs SAR values for the test device are tabulated below:
Mode: Cat.M Band 2
L:1860MHz M:1880 MHz H:1900MHz
SAR Values Limit of SAR (W/kg): 4.0W/kg (10g Average)

Test Case		Channel	Measure Conducted Power (dBm)	Tune-up limit (dBm)	Scaling Factor	Measure Results (W/kg)	Reported Results (W/kg)
position	Mode					10g Average	10g Average
Back	20BW 1RB (limbs)	L	22.43	22.50	1.02	---	---
		M	22.13	22.50	1.09	0.097	0.106
		H	22.14	22.50	1.09	---	---
Front		L	22.43	22.50	1.02	---	---
		M	22.13	22.50	1.09	0.170	0.185
		H	22.14	22.50	1.09	---	---
Top		L	22.43	22.50	1.02	---	---
		M	22.13	22.50	1.09	0.283	0.308
		H	22.14	22.50	1.09	---	---
Bottom		L	22.43	22.50	1.02	---	---
		M	22.13	22.50	1.09	0.093	0.102
		H	22.14	22.50	1.09	---	---
Left		L	22.43	22.50	1.02	---	---
		M	22.13	22.50	1.09	0.036	0.039
		H	22.14	22.50	1.09	---	---
Right		L	22.43	22.50	1.02	---	---
		M	22.13	22.50	1.09	0.024	0.026
		H	22.14	22.50	1.09	---	---

Test Case		Channel	Measure Conducted Power (dBm)	Tune-up limit (dBm)	Scaling Factor	Measure Results (W/kg)	Reported Results (W/kg)
position	Mode					10g Average	10g Average
Back	20BW 50%RB (limbs)	L	21.68	22.00	1.08	---	---
		M	21.53	22.00	1.11	0.093	0.103
		H	21.70	22.00	1.07	---	---
Front		L	21.68	22.00	1.08	---	---
		M	21.53	22.00	1.11	0.103	0.114
		H	21.70	22.00	1.07	---	---
Top		L	21.68	22.00	1.08	---	---
		M	21.53	22.00	1.11	**0.249**	**0.276**
		H	21.70	22.00	1.07	---	---
Bottom		L	21.68	22.00	1.08	---	---
		M	21.53	22.00	1.11	0.072	0.080
		H	21.70	22.00	1.07	---	---
Left		L	21.68	22.00	1.08	---	---
		M	21.53	22.00	1.11	0.017	0.019
		H	21.70	22.00	1.07	---	---
Right		L	21.68	22.00	1.08	---	---
		M	21.53	22.00	1.11	0.015	0.017
		H	21.70	22.00	1.07	---	---

Mode: Cat.M Band 4

L:1720MHz M:1732.5 MHz H:1745MHz

SAR Values Limit of SAR (W/kg): 4.0W/kg (10g Average)

Test Case		Channel	Measure Conducted Power (dBm)	Tune-up limit (dBm)	Scaling Factor	Measure Results (W/kg)	Reported Results (W/kg)
position	Mode					10g Average	10g Average
Back	20BW 1RB (limbs)	L	23.44	23.50	1.01	---	---
		M	23.28	23.50	1.05	0.118	0.124
		H	23.29	23.50	1.05	---	---
Front		L	23.44	23.50	1.01	---	---
		M	23.28	23.50	1.05	0.225	0.236
		H	23.29	23.50	1.05	---	---
Top		L	23.44	23.50	1.01	---	---
		M	23.28	23.50	1.05	0.185	0.194
		H	23.29	23.50	1.05	---	---
Bottom		L	23.44	23.50	1.01	---	---
		M	23.28	23.50	1.05	**0.391**	**0.411**
		H	23.29	23.50	1.05	---	---
Left		L	23.44	23.50	1.01	---	---
		M	23.28	23.50	1.05	0.024	0.025
		H	23.29	23.50	1.05	---	---
Right		L	23.44	23.50	1.01	---	---
		M	23.28	23.50	1.05	0.053	0.056
		H	23.29	23.50	1.05	---	---

Test Case		Channel	Measure Conducted Power (dBm)	Tune-up limit (dBm)	Scaling Factor	Measure Results (W/kg)	Reported Results (W/kg)
position	Mode					10g Average	10g Average
Back	20BW 50%RB (limbs)	L	22.31	22.50	1.04	---	---
		M	22.47	22.50	1.01	0.091	0.092
		H	22.38	22.50	1.03	---	---
Front		L	22.31	22.50	1.04	---	---
		M	22.47	22.50	1.01	0.172	0.174
		H	22.38	22.50	1.03	---	---
Top		L	22.31	22.50	1.04	---	---
		M	22.47	22.50	1.01	0.142	0.143
		H	22.38	22.50	1.03	---	---
Bottom		L	22.31	22.50	1.04	---	---
		M	22.47	22.50	1.01	0.322	0.325
		H	22.38	22.50	1.03	---	---
Left		L	22.31	22.50	1.04	---	---
		M	22.47	22.50	1.01	0.016	0.016
		H	22.38	22.50	1.03	---	---
Right		L	22.31	22.50	1.04	---	---
		M	22.47	22.50	1.01	0.018	0.018
		H	22.38	22.50	1.03	---	---

Mode: Cat.M Band 12

L:704MHz M:707.5 MHz H:711MHz

SAR Values Limit of SAR (W/kg): 4.0W/kg (10g Average)

Test Case		Channel	Measure Conducted Power (dBm)	Tune-up limit (dBm)	Scaling Factor	Measure Results (W/kg)	Reported Results (W/kg)
position	Mode					10g Average	10g Average
Back	10BW 1RB (limbs)	L	23.57	24.00	1.10	---	---
		M	23.71	24.00	1.07	0.102	0.109
		H	23.82	24.00	1.04	---	---
Front		L	23.57	24.00	1.10	---	---
		M	23.71	24.00	1.07	**0.113**	**0.121**
		H	23.82	24.00	1.04	---	---
Top		L	23.57	24.00	1.10	---	---
		M	23.71	24.00	1.07	0.054	0.058
		H	23.82	24.00	1.04	---	---
Bottom		L	23.57	24.00	1.10	---	---
		M	23.71	24.00	1.07	0.078	0.083
		H	23.82	24.00	1.04	---	---
Left		L	23.57	24.00	1.10	---	---
		M	23.71	24.00	1.07	0.056	0.060
		H	23.82	24.00	1.04	---	---
Right		L	23.57	24.00	1.10	---	---
		M	23.71	24.00	1.07	0.041	0.044
		H	23.82	24.00	1.04	---	---

Test Case		Channel	Measure Conducted Power (dBm)	Tune-up limit (dBm)	Scaling Factor	Measure Results (W/kg)	Reported Results (W/kg)
position	Mode					10g Average	10g Average
Back	10BW 50%RB (limbs)	L	22.46	22.50	1.01	---	---
		M	22.41	22.50	1.02	0.083	0.085
		H	22.37	22.50	1.03	---	---
Front		L	22.46	22.50	1.01	---	---
		M	22.41	22.50	1.02	0.072	0.073
		H	22.37	22.50	1.03	---	---
Top		L	22.46	22.50	1.01	---	---
		M	22.41	22.50	1.02	0.046	0.047
		H	22.37	22.50	1.03	---	---
Bottom		L	22.46	22.50	1.01	---	---
		M	22.41	22.50	1.02	0.026	0.027
		H	22.37	22.50	1.03	---	---
Left		L	22.46	22.50	1.01	---	---
		M	22.41	22.50	1.02	0.023	0.023
		H	22.37	22.50	1.03	---	---
Right		L	22.46	22.50	1.01	---	---
		M	22.41	22.50	1.02	0.015	0.016
		H	22.37	22.50	1.03	---	---

6.8 SAR Measurement Variability

SAR measurement variability must be assessed for each frequency band, which is determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media are required for SAR measurements in a frequency band, the variability measurement procedures should be applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium.

The following procedures are applied to determine if repeated measurements are required.

1) Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg; steps 2) through 4) do not apply.

2) When the original highest measured SAR is ≥ 0.80 W/kg, repeat that measurement once.

3) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 W/kg (~ 10% from the 1-g SAR limit).

4) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

The same procedures shouldbe adapted for measurements according to extremity and occupational exposure limits by applying a factor of 2.5 for extremity exposure and a factor of 5 for occupational exposure to the corresponding SAR thresholds.

The Highest Reported SAR configuration in Each Frequency Band

Frequency band	Air interface	Limbs(w/kg)
750 MHz	Cat M BAND12	<2.0
1800/1900 MHz	Cat M BAND2 Cat M BAND4	<2.0

6.9 Simultaneous Transmission SAR Analysis

According to the formula (KDB447498 4.3.2) the Bluetooth SAR as follow:
[(max. power of channel, including tune-up tolerance, mw)/ (min. test separation distance, mm)] [√f(GHz)/x] W/kg for test separation distances≤50mm.
Limbs:
min. test separation distance = 5mm
Where x=7.5 for 1-g SAR, and x=18.75 for 10-g SAR.

Estimated SAR BLE

Mode	Position	F(GHz)	Distance(mm)	Estimated
BLE	Limbs	2.480	5	0.008

The sum of SAR values for Cat M& BLE

	MAXIMUM SAR VALUE FOR LIMBS
Cat M	0.411
BLE	0.008
Sum	0.419
Note	Bottom: Cat M Band4+BLE

According to the above tables, the sum of SAR values for Cat M and BLE ＜4.0 W/kg. So simultaneous transmission SAR are not required for BLE transmitter.

7 MEASUREMENT UNCERTAINTY

DASY5 Uncertainty Budget								
Error description	Uncertainty value	Prob. Dist.	Div.	(c_i) 1g	(c_i) 10g	Std.Unc (1g).	Std.Unc. (10g)	(vi) Veff
Measurement system								
Probe calibration	±6.55%	N	1	1	1	±6.55%	±6.55%	∞
Axial isotropy	±4.7%	R	$\sqrt{3}$	0.7	0.7	±1.9%	±1.9%	∞
Hemispherical isotropy	±9.6%	R	$\sqrt{3}$	0.7	0.7	±3.9%	±3.9%	∞
Linearity	±4.7%	R	$\sqrt{3}$	1	1	±2.7%	±2.7%	∞
Modulation Response	±2.4%	R	$\sqrt{3}$	1	1	±1.4%	±1.4%	∞
System detection limits	±1.0%	R	$\sqrt{3}$	1	1	±0.6%	±0.6%	∞
Boundary effects	±2.0%	R	$\sqrt{3}$	1	1	±0.6%	±1.2%	∞
Readout electronics	±0.3%	N	1	1	1	±0.3%	±0.3%	∞
Response time	±0.8%	R	$\sqrt{3}$	1	1	±0.5%	±0.5%	∞
Integration time	±2.6%	R	$\sqrt{3}$	1	1	±1.5%	±1.5%	∞
RF ambient noise	±3.0%	R	$\sqrt{3}$	1	1	±1.7%	±1.7%	∞
RF ambient reflections	±3.0%	R	$\sqrt{3}$	1	1	±1.7%	±1.7%	∞
Probe positioner	±0.8%	R	$\sqrt{3}$	1	1	±0.5%	±0.5%	∞
Probe positioning	±6.7%	R	$\sqrt{3}$	1	1	±3.9%	±3.9%	∞
Post-processing	±4.0%	R	$\sqrt{3}$	1	1	±2.3%	±2.3%	∞
Test Sample Related								
Device holder	±3.6%	N	1	1	1	±3.6%	±3.6%	5
Device Positioning	±2.9%	N	1	1	1	±2.9%	±2.9%	145
Power Scaling	±0%	R	$\sqrt{3}$	1	1	±0%	±0%	∞
Power drift	±5.0%	R	$\sqrt{3}$	1	1	±2.9%	±2.9%	∞
Phantom and Setup								
Phantom uncertainty	±7.9%	R	$\sqrt{3}$	1	1	±4.6%	±4.6%	∞
SAR correction	±1.9%	R	$\sqrt{3}$	1	0.84	±1.1%	±0.9%	∞
Liquid conductivity(mea.)	±2.5%	N	$\sqrt{3}$	0.78	0.71	±1.1%	±1.0%	∞
Liquid Permittivity (mea.)	±2.5%	N	$\sqrt{3}$	0.26	0.26	±0.3%	±0.4%	∞
Temp. unc. - Conductivity	±3.4%	N	$\sqrt{3}$	0.78	0.71	±1.5%	±1.4%	∞
Temp. unc. - Permittivity	±0.4%	N	$\sqrt{3}$	0.23	0.26	±0.1%	±0.1%	∞
Combined std. Uncertainty						±12.5%	±12.5%	748
Expanded STD Uncertainty						±25.1%	±25.0%	

8 TEST EQUIPMENTS

The measurements were performed using an automated near-field scanning system, DASY5, manufactured by Schmid & Partner Engineering AG (SPEAG) in Switzerland. The SAR extrapolation algorithm used in all measurements was the 'advanced extrapolation' algorithm.
The following table lists calibration dates of SPEAG components which the initial certified product used:

Test Equipment	Model	Serial Number	Calibration date	Calibration Due data
DAE	DAE4	546	2018.10.15	2019.10.14
Dosimetric E-field Probe	ES3DV3	3127	2018.11.02	2019.11.01
Dipole Validation Kit	D750V3	1011	2017.09.13	2020.09.12
Dipole Validation Kit	D1800V2	2d084	2017.09.15	2020.09.14
Dipole Validation Kit	D2000V2	1009	2018.02.01	2021.01.31

According to KDB 865664 D01 section 3.2.2, instead of the typical annual calibration recommended by measurement standards, longer calibration intervals of up to three years may be considered when it is demonstrated that the SAR target, impedance and return loss of a dipole have remain stable according to the following requirements.

1) The test laboratory must ensure that the required supporting information and documentation are included in the SAR report to qualify for the three-year extended calibration interval; otherwise, the IEEE Std 1528-2013 recommended annual calibration applies.
2) Immediate re-calibration is required for the following conditions.
a) After a dipole is damaged and properly repaired to meet required specifications.
b) When the measured SAR deviates from the calibrated SAR value by more than 10% due to changes in physical, mechanical, electrical or other relevant dipole conditions; i.e., the error is not introduced by incorrect measurement procedures or other issues relating to the SAR measurement system.
c) When the most recent return-loss result, measured at least annually, deviates by more than 20% from the previous measurement (i.e. value in dB×0.2) or not meeting the required 20 dB minimum return-loss requirement.
d) When the most recent measurement of the real or imaginary parts of the impedance, measured at least annually, deviates by more than 5 Ω from the previous measurement.

Dipole 750

SAR target

Refers to system check, measured SAR (1g and 10g) deviates from the Target SAR value of calibration report within 10%.

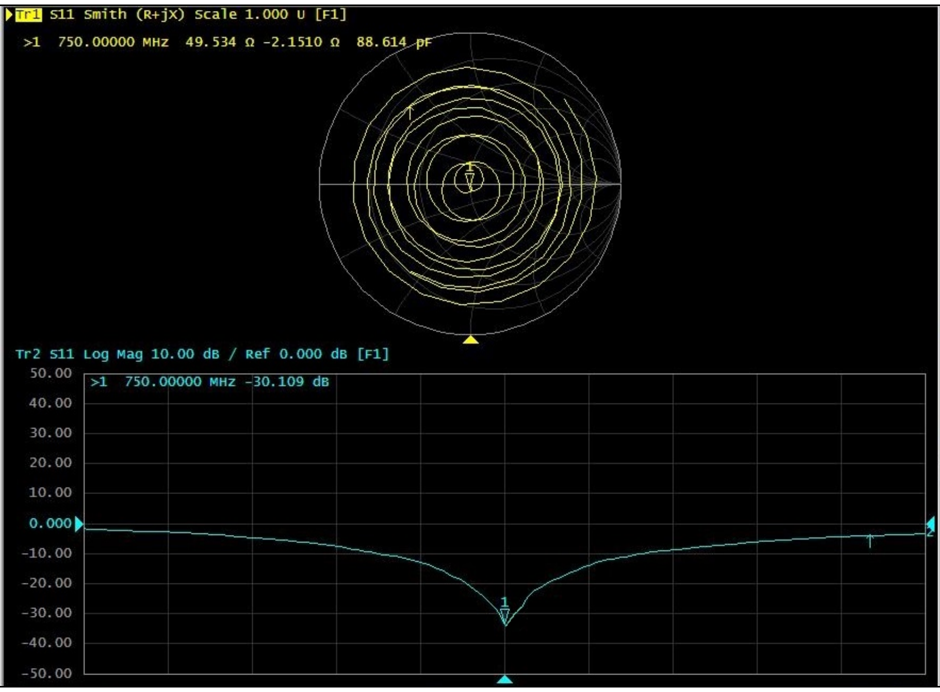
Impedance and Return loss measured by Network analyzer

The most recent measurement of the real or imaginary parts of the impedance (measured on 2018.8.20), deviates within 5 Ω from the previous measurement. (Data from the last calibration report)

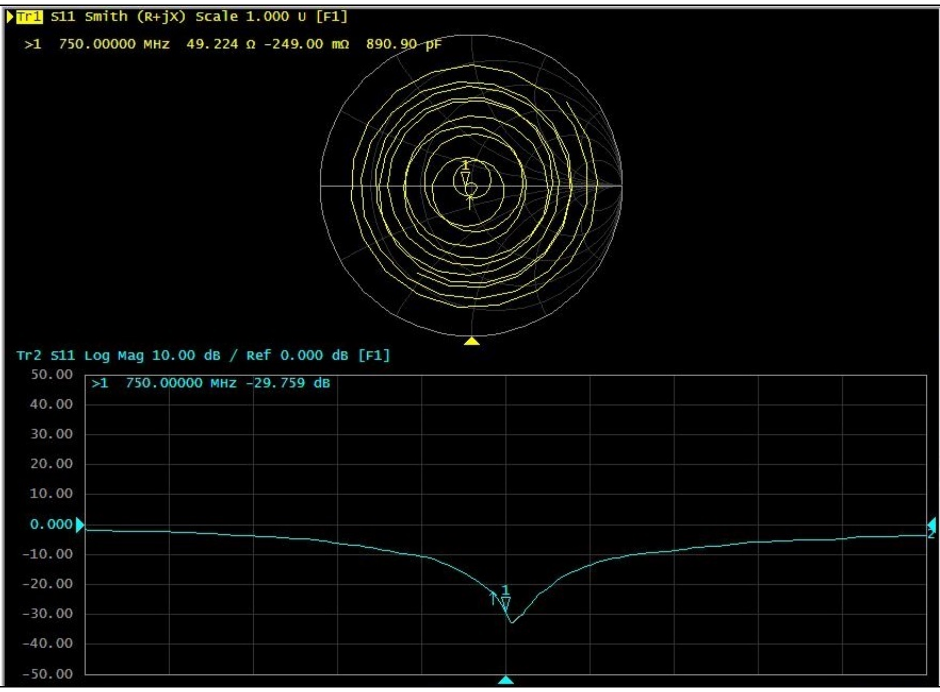
The most recent return-loss result (measured on 2018.8.20) deviates within 20% from the previous measurement. (Data from the last calibration report)

Head TSL Parameters			
Parameters	Target (Ref. Value)	Measured data	deviation
Impedance	51.0Ω-2.79jΩ	49.5Ω-2.15jΩ	<5Ω
Return loss	-30.7 db	-33.1 db	<20%

Body TSL Parameters			
Parameters	Target (Ref. Value)	Measured data	deviation
Impedance	46.6Ω-3.61jΩ	49.5Ω-0.22jΩ	<5Ω
Return loss	-25.8db	-28.8db	<20%



Head TSL Parameters



Body TSL Parameters

Dipole1800

SAR target

Refers to system check, measured SAR (1g and 10g) deviates from the Target SAR value of calibration report within 10%.

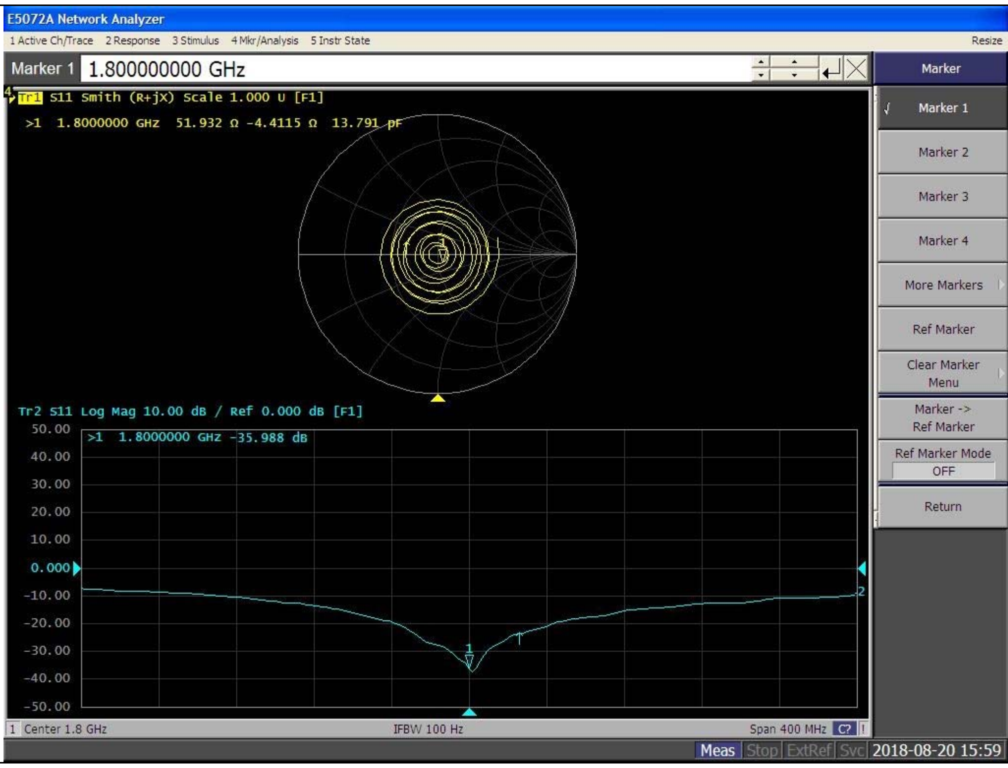
Impedance and Return loss measured by Network analyzer

The most recent measurement of the real or imaginary parts of the impedance (measured on 2018.8.20), deviates within 5 Ω from the previous measurement. (Data from the last calibration report)

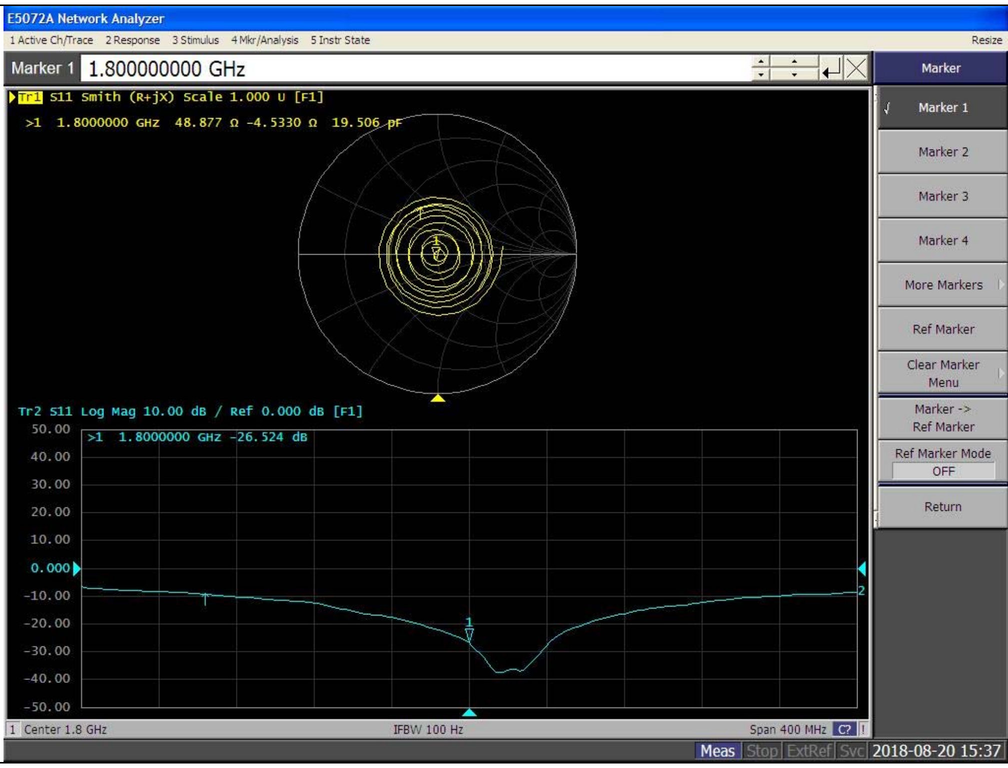
The most recent return-loss result (measured on 2018.8.20) deviates within 20% from the previous measurement. (Data from the last calibration report)

Head TSL Parameters			
Parameters	Target (Ref. Value)	Measured data	deviation
Impedance	49.3Ω-1.55jΩ	51.9Ω-4.41jΩ	<5Ω
Return loss	-35.4 db	-36.0db	<20%

Body TSL Parameters			
Parameters	Target (Ref. Value)	Measured data	deviation
Impedance	46.0Ω-1.32jΩ	48.9Ω-4.53jΩ	<5Ω
Return loss	-27.1db	-26.5db	<20%



Head TSL Parameters



Body TSL Parameters

Dipole2000

SAR target

Refers to system check, measured SAR (1g and 10g) deviates from the Target SAR value of calibration report within 10%.

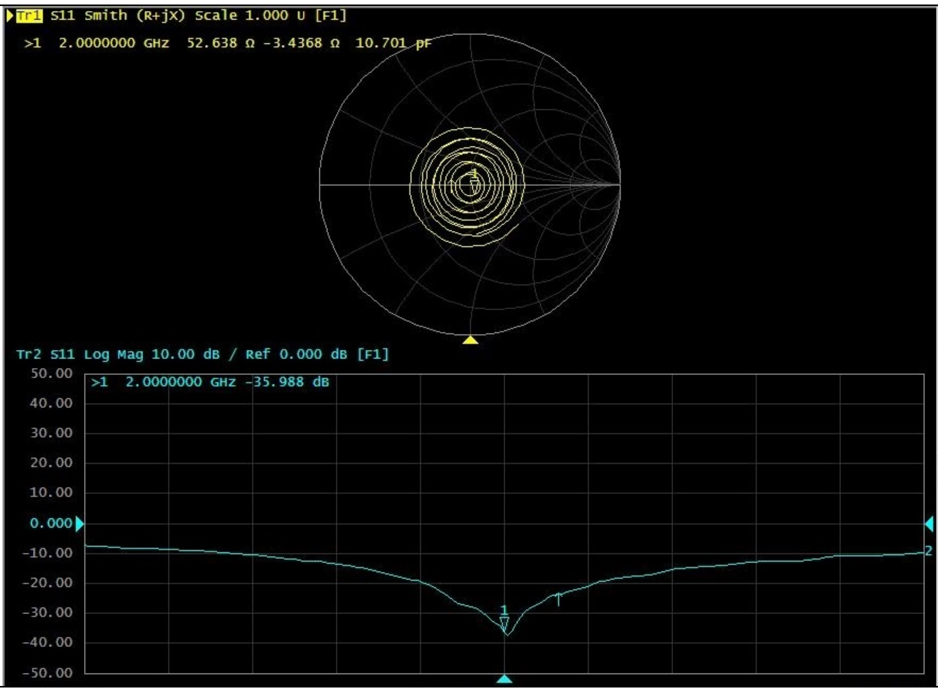
Impedance and Return loss measured by Network analyzer

The most recent measurement of the real or imaginary parts of the impedance (measured on 2018.8.20), deviates within 5 Ω from the previous measurement. (Data from the last calibration report)

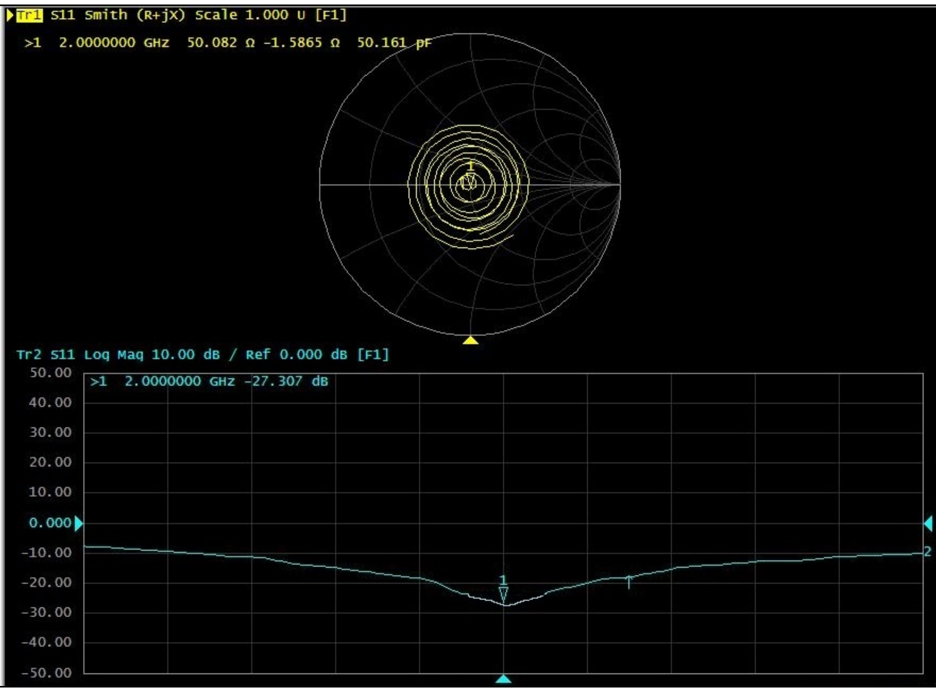
The most recent return-loss result (measured on 2018.8.20) deviates within 20% from the previous measurement. (Data from the last calibration report)

Head TSL Parameters			
Parameters	Target (Ref. Value)	Measured data	deviation
Impedance	49.8Ω-2.08jΩ	52.64Ω-3.44jΩ	<5Ω
Return loss	-33.6 db	-36.0db	<20%

Body TSL Parameters			
Parameters	Target (Ref. Value)	Measured data	deviation
Impedance	46.3Ω-1.63jΩ	50.08Ω-1.59jΩ	<5Ω
Return loss	-27.6db	-27.31db	<20%



Head TSL Parameters



Body TSL Parameters

Additional test equipment used in testing:

Test Equipment	Model	Serial Number	Calibration date	Calibration Due data
Signal Generator	E4428C	MY45280865	2018.08.20	2019.08.19
Signal Generator	SML 03	103514	2018.08.20	2019.08.19
Power meter	E4417A	MY45101182	2018.08.20	2019.08.19
Power Sensor	E4412A	MY41502214	2018.08.20	2019.08.19
Power Sensor	E4412A	MY41502130	2018.08.20	2019.08.19
Power meter	E4417A	MY45101004	2018.08.20	2019.08.19
Power Sensor	E9300B	MY41496001	2018.08.20	2019.08.19
Power Sensor	E9300B	MY41496003	2018.08.20	2019.08.19
Communication Tester	CMW500	134669	2018.08.20	2019.08.19
Vector Network Analyzer	VNA R140	0011213	2018.10.17	2019.10.16
Dielectric Parameter Probe	DAKS-3.5	1042	2018.10.17	2019.10.16
Network Analyzer	E5072A	MY51100334	2018.03.01	2019.02.28

Detailed information of Isotropic E-field Probe Type ES3DV3

Construction	Symmetrical design with triangular core Interleaved sensors Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Calibration	Calibration certificate in Appendix C
Frequency	10 MHz to 4 GHz; Linearity: ± 0.2 dB (30 MHz to 4 GHz)
Optical Surface Detection	± 0.2 mm repeatability in air and clear liquids over diffuse reflecting surfaces
Dimensions	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 3.9 mm (Body: 12 mm) Distance from probe tip to dipole centers: 2.0 mm
Dynamic Range	5 μW/g to > 100 W/kg; Linearity: ± 0.2 dB
Application	General dosimetry up to 4 GHz Dosimetry in strong gradient fields Compliance tests of mobile phones

Detailed information of Isotropic E-field Probe Type EX3DV4

Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Calibration	Calibration certificate in Appendix C
Frequency	10 MHz to > 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz)
Optical Surface Detection	± 0.3 mm repeatability in air and clear liquids over diffuse reflecting surfaces
Dimensions	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm
Dynamic Range	10 μW/g to > 100 W/kg Linearity: ± 0.2 dB (noise: typically < 1 μW/g)
Application	High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields); the only probe that enables compliance testing for frequencies up to 6 GHz with precision of better 30%.

ANNEX A – TEST PLOTS

Please refer to the attachment.

ANNEX B – RELEVANT PAGES FROM CALIBRATION REPORTS

Please refer to the attachment.

ANNEX A – TEST PLOTS

Body liquid

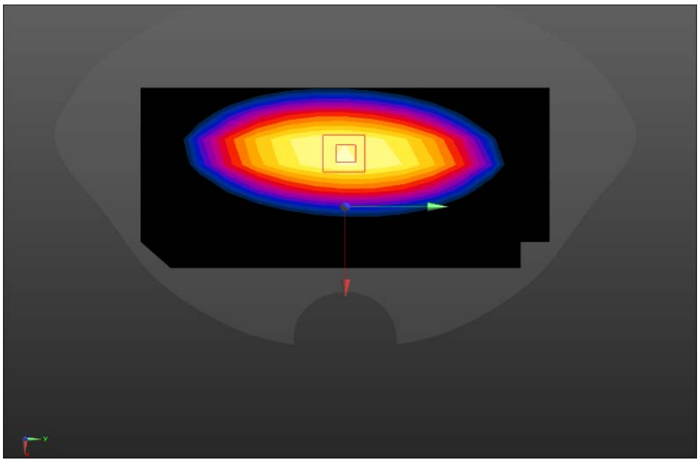
System check	750MHz

Communication System: UID 0, CW (0); Communication System Band: D750 (750.0 MHz); Frequency: 750 MHz; Communication System PAR: 0 dB
Medium parameters used: f = 750 MHz; σ = 0.936 S/m; ε_r = 53.074; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY Configuration:

- Probe: ES3DV3 - SN3127; ConvF(6.34, 6.34, 6.34); Calibrated: 2018/11/2;
- Sensor-Surface: 3mm (Mechanical Surface Detection), z = -3.0, 32.0
- Electronics: DAE4 Sn546; Calibrated: 2018/10/15
- Phantom: 1659; Type: QD 000 P40 CD; Serial: xxxx
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

System Performance Check at Frequencies 750MHz/d=15mm, Pin=250 mW, dist=3.0mm (ES-Probe)/Area Scan (8x15x1): Measurement grid: dx=15mm, dy=15mm
Maximum value of SAR (measured) = 2.31 W/kg
System Performance Check at Frequencies 750MHz/d=15mm, Pin=250 mW, dist=3.0mm (ES-Probe)/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 41.26 V/m; Power Drift = 0.13 dB
Peak SAR (extrapolated) = 3.45 W/kg
SAR(1 g) = 2.36 W/kg; SAR(10 g) = 1.405 W/kg
Maximum value of SAR (measured) = 2.66 W/kg



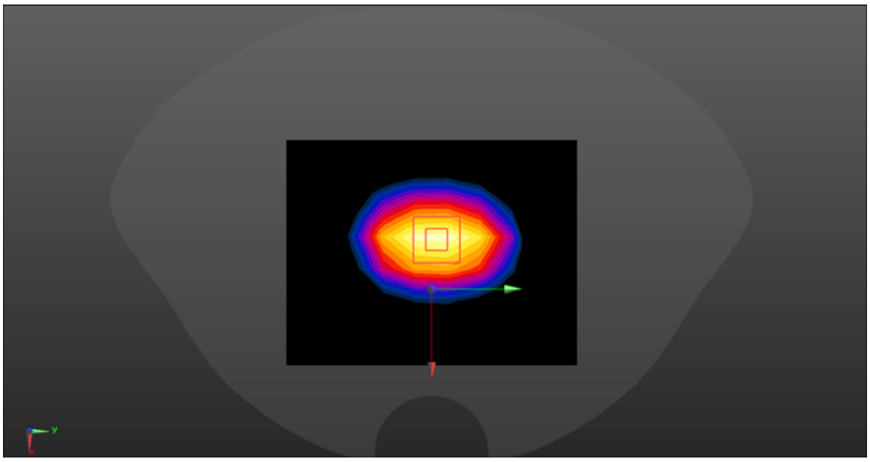
System check	1800MHz

Communication System: UID 0, CW (0); Frequency: 1800 MHz
Medium parameters used: f = 1800 MHz; σ = 1.482 S/m; ε_r = 53.217; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: ES3DV3 - SN3127; ConvF(4.76, 4.76, 4.76); Calibrated: 2018/11/2;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn546; Calibrated: 2018/10/15
- Phantom: 1659; Type: QD 000 P40 CD; Serial: xxxx

- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7373)
  Configuration 1800/1800/Area Scan (8x10x1): Measurement grid: dx=15mm, dy=15mm
  Maximum value of SAR (measured) = 11.5 W/kg
  Configuration 1800/1800/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
  Reference Value = 80.17 V/m; Power Drift = 0.05 dB
  Peak SAR (extrapolated) = 17.8 W/kg
  SAR(1 g) = 9.20 W/kg; SAR(10 g) = 5.09 W/kg
  Maximum value of SAR (measured) = 12.4 W/kg



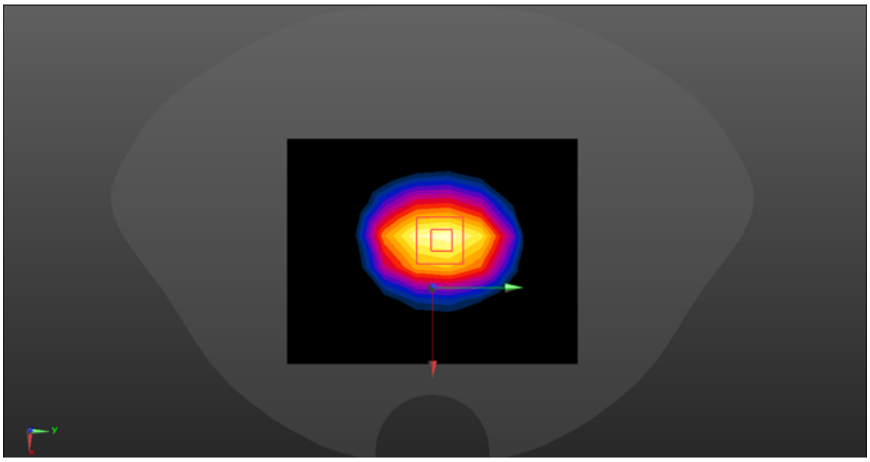
System check	2000MHz

Communication System: UID 0, CW (0); Frequency: 2000 MHz
Medium parameters used: f = 2000 MHz; σ = 1.496 S/m; ε_r = 52.601; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: ES3DV3 - SN3127; ConvF(4.80, 4.80, 4.80); Calibrated: 2018/11/2;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn546; Calibrated: 2018/10/15
- Phantom: 1659; Type: QD 000 P40 CD; Serial: xxxx
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7373)

Configuration 2000/2000/Area Scan (8x10x1): Measurement grid: dx=12mm, dy=12mm
Maximum value of SAR (measured) = 11.1 W/kg
Configuration 2000/2000/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 78.14 V/m; Power Drift = 0.05 dB
Peak SAR (extrapolated) = 17.8 W/kg
SAR(1 g) = 9.42 W/kg; SAR(10 g) = 4.90 W/kg
Maximum value of SAR (measured) = 12.1 W/kg



Cat M Band2

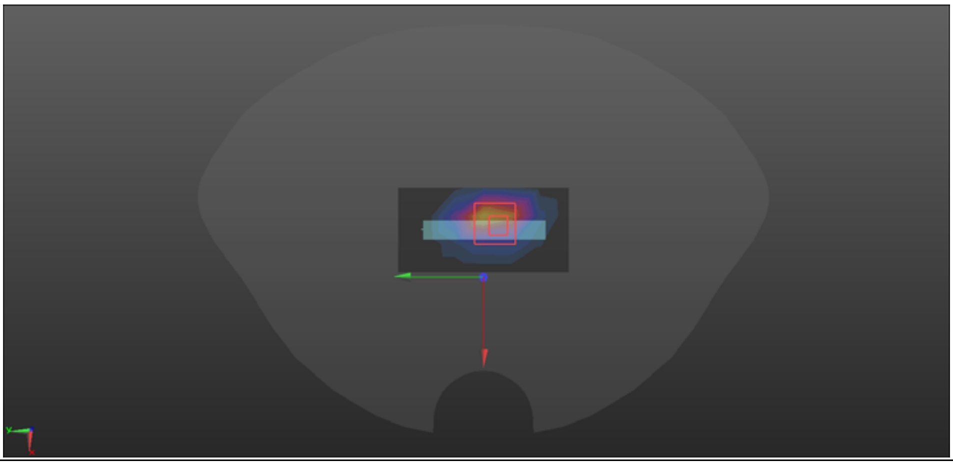
Limbs	Top

Communication System: UID 0, LTE band 02 (0); Frequency: 1880 MHz
Medium parameters used (interpolated): f = 1880 MHz; σ = 1.526 S/m; ε_r = 53.291; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5

DASY Configuration:

- Probe: ES3DV3 - SN3127; ConvF(4.76, 4.76, 4.76); Calibrated: 2018/11/2;
- Sensor-Surface: 3mm (Mechanical Surface Detection (Locations From Previous Scan Used)), Sensor-Surface: 3mm (Mechanical Surface Detection), z = -3.0, 32.0
- Electronics: DAE4 Sn546; Calibrated: 2018/10/15
- Phantom: 1659; Type: QD 000 P40 CD; Serial: xxxx
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

TOP/LTE2/Area Scan (4x8x1): Measurement grid: dx=15mm, dy=15mm
Maximum value of SAR (measured) = 0.641 W/kg
TOP/LTE2/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 21.44 V/m; Power Drift = 0.19 dB
Peak SAR (extrapolated) = 1.18 W/kg
SAR(1 g) = 0.596 W/kg; SAR(10 g) = 0.283 W/kg
Maximum value of SAR (measured) = 0.789 W/kg



Cat M Band4

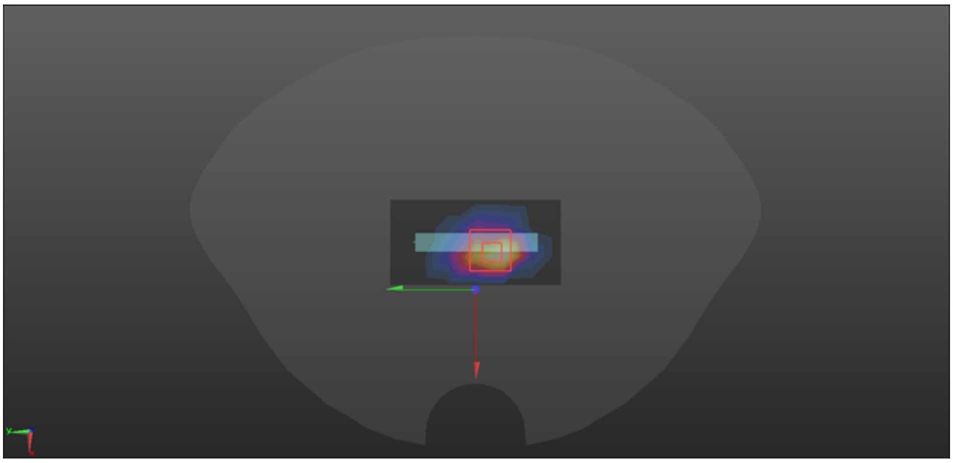
Limbs	Bottom

Communication System: UID 0, LTE band 4 (0); Frequency: 1732.5 MHz
Medium parameters used (interpolated): f = 1732.5 MHz; σ = 1.477 S/m; ε_r = 53.46; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5

DASY Configuration:

- Probe: ES3DV3 - SN3127; ConvF(4.76, 4.76, 4.76); Calibrated: 2018/11/2;
- Sensor-Surface: 3mm (Mechanical Surface Detection (Locations From Previous Scan Used)), Sensor-Surface: 3mm (Mechanical Surface Detection), z = -3.0, 32.0
- Electronics: DAE4 Sn546; Calibrated: 2018/10/15
- Phantom: 1659; Type: QD 000 P40 CD; Serial: xxxx
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

FRONT/LTE4/Area Scan (5x8x1): Measurement grid: dx=15mm, dy=15mm
Maximum value of SAR (measured) = 1.23 W/kg
FRONT/LTE4/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 26.58 V/m; Power Drift = -0.11 dB
Peak SAR (extrapolated) =1.44 W/kg
SAR(1 g) = 0.783 W/kg; SAR(10 g) = 0.391 W/kg
Maximum value of SAR (measured) = 1.13 W/kg



Cat M Band12

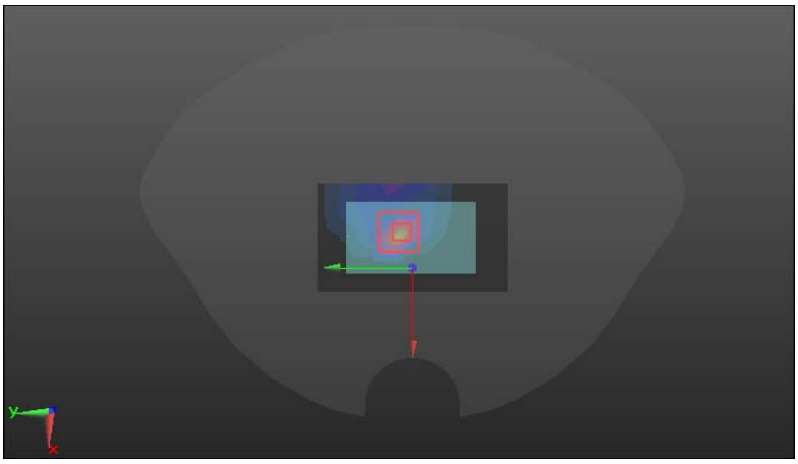
Limbs	Front

Communication System: UID 0, LTE Band 12 (0); Frequency: 707.5 MHz
Medium parameters used (interpolated): f = 707.5 MHz; σ = 0.955 S/m; ε_r = 55.657; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5

DASY Configuration:

- Probe: ES3DV3 - SN3127; ConvF(6.33, 6.33, 6.33); Calibrated: 2018/11/2;
- Sensor-Surface: 3mm (Mechanical Surface Detection (Locations From Previous Scan Used)), Sensor-Surface: 3mm (Mechanical Surface Detection), z = -3.0, 32.0
- Electronics: DAE4 Sn546; Calibrated: 2018/10/15
- Phantom: 1659; Type: QD 000 P40 CD; Serial: xxxx
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

FRONT/LTE12/Area Scan (5x8x1): Measurement grid: dx=15mm, dy=15mm
Maximum value of SAR (measured) = 0.497 W/kg
FRONT/LTE12/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 9.03 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 2.53 W/kg
SAR(1 g) = 0.362 W/kg; SAR(10 g) = 0.113 W/kg
Maximum value of SAR (measured) = 0.496 W/kg



ANNEX B - RELEVANT PAGES FROM CALIBRATION REPORTS

DAE4 Sn:546

In Collaboration with speag
CALIBRATION LABORATORY
Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
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E-mail: cttl@chinattl.com Http://www.chinattl.cn

中国认可 国际互认 校准 CALIBRATION CNAS L0570

Client : SRTC

Certificate No: Z18-60400

CALIBRATION CERTIFICATE

Object	DAE4 - SN: 546
Calibration Procedure(s)	FF-Z11-002-01 Calibration Procedure for the Data Acquisition Electronics (DAEx)
Calibration date:	October 15, 2018

This calibration Certificate documents the traceability to national standards, which realize the physical units of measurements(SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)°C and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Process Calibrator 753	1971018	20-Jun-18 (CTTL, No.J18X05034)	June-19

	Name	Function	Signature
Calibrated by:	Yu Zongying	SAR Test Engineer	
Reviewed by:	Lin Hao	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	

Issued: October 17, 2018

In Collaboration with speag
CALIBRATION LABORATORY
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E-mail: cttl@chinattl.com Http://www.chinattl.cn

Glossary:

DAE	data acquisition electronics
Connector angle	information used in DASY system to align probe sensor X to the robot coordinate system.

Methods Applied and Interpretation of Parameters:

- *DC Voltage Measurement*: Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle*: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The report provide only calibration results for DAE, it does not contain other performance test results.

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DC Voltage Measurement

A/D - Converter Resolution nominal
High Range: 1LSB = 6.1μV , full range = -100...+300 mV
Low Range: 1LSB = 61nV , full range = -1.......+3mV
DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Calibration Factors	X	Y	Z
High Range	405.306 ± 0.15% (k=2)	404.059 ± 0.15% (k=2)	404.180 ± 0.15% (k=2)
Low Range	3.98893 ± 0.7% (k=2)	3.95876 ± 0.7% (k=2)	3.98021 ± 0.7% (k=2)

Connector Angle

Connector Angle to be used in DASY system	238° ± 1 °

ES3DV3 Sn:3127

In Collaboration with s p e a g CALIBRATION LABORATORY
CNAS CALIBRATION CNAS L0570
Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
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E-mail: cttl@chinattl.com Http://www.chinattl.cn

Client SRTC Certificate No: Z18-60398

CALIBRATION CERTIFICATE

Object: ES3DV3 - SN:3127

Calibration Procedure(s): FF-Z11-004-01
Calibration Procedures for Dosimetric E-field Probes

Calibration date: November 02, 2018

This calibration Certificate documents the traceability to national standards, which realize the physical units of measurements(SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)℃ and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRP2	101919	20-Jun-18 (CTTL, No.J18X05032)	Jun-19
Power sensor NRP-Z91	101547	20-Jun-18 (CTTL, No.J18X05032)	Jun-19
Power sensor NRP-Z91	101548	20-Jun-18 (CTTL, No.J18X05032)	Jun-19
Reference10dBAttenuator	18N50W-10dB	09-Feb-18(CTTL, No.J18X01133)	Feb-20
Reference20dBAttenuator	18N50W-20dB	09-Feb-18(CTTL, No.J18X01132)	Feb-20
Reference Probe EX3DV4	SN 3846	25-Jan-18(SPEAG,No.EX3-3846_Jan18)	Jan-19
DAE4	SN 777	15-Dec-17(SPEAG, No.DAE4-777_Dec17)	Dec -18
Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
SignalGeneratorMG3700A	6201052605	21-Jun-18 (CTTL, No.J18X05033)	Jun-19
Network Analyzer E5071C	MY46110673	14-Jan-18 (CTTL, No.J18X00561)	Jan -19

	Name	Function	Signature
Calibrated by:	Yu Zongying	SAR Test Engineer	
Reviewed by:	Lin Hao	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	

Issued: November 04, 2018

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Certificate No: Z18-60398 Page 1 of 11

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E-mail: cttl@chinattl.com Http://www.chinattl.cn

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A,B,C,D	modulation dependent linearization parameters
Polarization Φ	Φ rotation around probe axis
Polarization θ	θ rotation around an axis that is in the plane normal to probe axis (at measurement center), i θ=0 is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013

b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016

c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010

d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization θ=0 (f≤900MHz in TEM-cell; f>1800MHz: waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not effect the E^2-field uncertainty inside TSL (see below ConvF).
- *NORM(f)x,y,z = NORMx,y,z* frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep (no uncertainty required). DCP does not depend on frequency nor media.
- PAR: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics.
- *Ax,y,z; Bx,y,z; Cx,y,z; VRx,y,z:A,B,C* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f≤800MHz) and inside waveguide using analytical field distributions based on power measurements for f >800MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty valued are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORMx,y,z* ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from±50MHz to±100MHz.
- *Spherical isotropy (3D deviation from isotropy):* in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset:* The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle:* The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

Certificate No: Z18-60398 Page 2 of 11

Probe ES3DV3

SN: 3127

Calibrated: November 02, 2018

Calibrated for DASY/EASY Systems

(Note: non-compatible with DASY2 system!)

Certificate No: Z18-60398 Page 3 of 11

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DASY/EASY – Parameters of Probe: ES3DV3 - SN: 3127

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm(μV/(V/m)²)[A]	1.27	1.26	1.21	±10.0%
DCP(mV)[B]	103.3	104.4	105.0	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	285.6	±2.2%
		Y	0.0	0.0	1.0		287.9	
		Z	0.0	0.0	1.0		282.9	

The reported uncertainty of measurement is stated as the standard uncertainty of Measurement multiplied by the coverage factor k=2, which for a normal distribution Corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of Norm X, Y, Z do not affect the E^2-field uncertainty inside TSL (see Page 5 and Page 6).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainly is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

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DASY/EASY – Parameters of Probe: ES3DV3 - SN: 3127

Calibration Parameter Determined in Head Tissue Simulating Media

f [MHz][C]	Relative Permittivity[F]	Conductivity (S/m)[F]	ConvF X	ConvF Y	ConvF Z	Alpha[G]	Depth[G] (mm)	Unct. (k=2)
750	41.9	0.89	6.34	6.34	6.34	0.40	1.35	±12.1%
835	41.5	0.90	6.18	6.18	6.18	0.35	1.58	±12.1%
1810	40.0	1.40	5.07	5.07	5.07	0.66	1.24	±12.1%
2000	40.0	1.40	4.96	4.96	4.96	0.70	1.20	±12.1%
2300	39.5	1.67	4.79	4.79	4.79	0.90	1.08	±12.1%
2450	39.2	1.80	4.66	4.66	4.66	0.90	1.08	±12.1%
2600	39.0	1.96	4.40	4.40	4.40	0.80	1.21	±12.1%

[C] Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequency below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ±10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ±5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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DASY/EASY – Parameters of Probe: ES3DV3 - SN: 3127

Calibration Parameter Determined in Body Tissue Simulating Media

f [MHz][C]	Relative Permittivity[F]	Conductivity (S/m)[F]	ConvF X	ConvF Y	ConvF Z	Alpha[G]	Depth[G] (mm)	Unct. (k=2)
750	55.5	0.96	6.33	6.33	6.33	0.40	1.40	±12.1%
835	55.2	0.97	6.13	6.13	6.13	0.37	1.62	±12.1%
1810	53.3	1.52	4.76	4.76	4.76	0.65	1.27	±12.1%
2000	53.3	1.52	4.80	4.80	4.80	0.67	1.27	±12.1%
2300	52.9	1.81	4.46	4.46	4.46	0.90	1.15	±12.1%
2450	52.7	1.95	4.31	4.31	4.31	0.78	1.28	±12.1%
2600	52.5	2.16	4.14	4.14	4.14	0.90	1.10	±12.1%

[C] Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequency below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ±10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ±5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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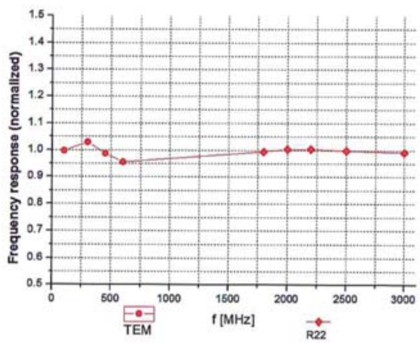
Frequency Response of E-Field
(TEM-Cell: ifi110 EXX, Waveguide: R22)



Uncertainty of Frequency Response of E-field: ±7.4% (k=2)

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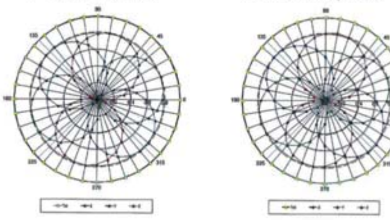
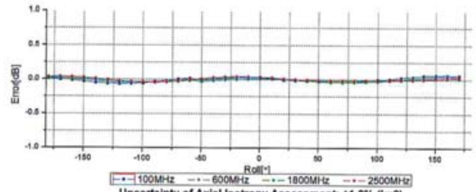
Receiving Pattern (Φ), θ=0°

f=600 MHz, TEM   f=1800 MHz, R22





Uncertainty of Axial Isotropy Assessment: ±1.2% (k=2)

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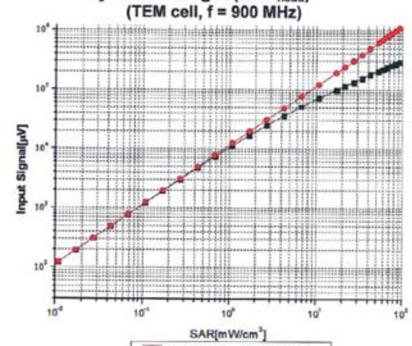
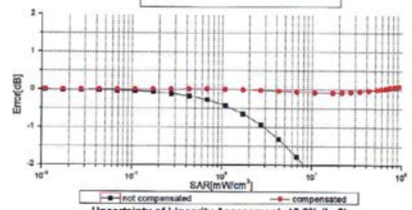
Dynamic Range f(SAR_{head})
(TEM cell, f = 900 MHz)





Uncertainty of Linearity Assessment: ±0.9% (k=2)

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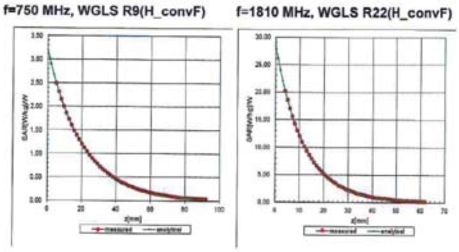
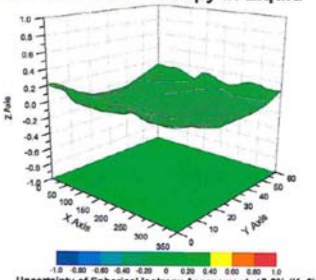
Conversion Factor Assessment

f=750 MHz, WGLS R9(H_convF)   f=1810 MHz, WGLS R22(H_convF)



Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment: ±3.2% (K=2)

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Appendix: Modulation Calibration Parameters

UID	Communication System Name	PAR		A dB	B dB√μV	C	VR mV	Unc[E] (k=2)
0	CW	0.00	X	0.0	0.0	1.0	282.3	±2.5%
			Y	0.0	0.0	1.0	280.9	
			Z	0.0	0.0	1.0	275.1	
10012	IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)	1.87	X	2.77	68.02	18.46	143.0	±1.8%
			Y	2.75	68.05	18.52	145.0	
			Z	2.71	67.79	18.25	142.3	
10100	LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)	5.67	X	6.13	66.4	18.97	141.9	±1.9%
			Y	6.15	66.49	19.06	144.2	
			Z	6.09	66.32	18.90	140.9	
10108	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK)	5.80	X	6.09	66.24	19.07	139.5	±1.9%
			Y	6.10	66.33	19.15	141.5	
			Z	6.05	66.19	19.05	138.0	
10154	LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)	5.75	X	5.81	65.85	18.93	136.1	±1.9%
			Y	5.82	65.92	19.01	137.8	
			Z	5.79	65.89	18.97	134.7	
10169	LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)	5.73	X	4.84	65.92	19.20	130.8	±1.9%
			Y	4.82	65.98	19.27	131.3	
			Z	4.80	66.00	19.29	129.1	
10175	LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)	5.72	X	4.88	66.14	19.40	131.6	±1.9%
			Y	4.83	66.08	19.33	130.9	
			Z	4.79	66.02	19.29	129.3	
10297	LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)	5.81	X	6.19	66.61	19.42	141.9	±1.9%
			Y	6.13	66.43	19.26	140.7	
			Z	6.14	66.52	19.33	139.6	

D750V3 Sn:1101

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中国认可 国际互认 校准 CALIBRATION CNAS L0570

Client SRTC Certificate No: Z17-97134

CALIBRATION CERTIFICATE

Object	D750V3 - SN: 1101
Calibration Procedure(s)	FF-Z11-003-01 Calibration Procedures for dipole validation kits
Calibration date:	September 13, 2017

This calibration Certificate documents the traceability to national standards, which realize the physical units of measurements(SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)℃ and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRVD	102196	02-Mar-17 (CTTL, No.J17X01254)	Mar-18
Power sensor NRV-Z5	100596	02-Mar-17 (CTTL, No.J17X01254)	Mar-18
Reference Probe EX3DV4	SN 7433	26-Sep-16(SPEAG,No.EX3-7433_Sep16)	Sep-17
DAE4	SN 1331	19-Jan-17(CTTL-SPEAG,No.Z17-97015)	Jan-18
Secondary Standards	**ID #**	**Cal Date(Calibrated by, Certificate No.)**	**Scheduled Calibration**
Signal Generator E4438C	MY49071430	13-Jan-17 (CTTL, No.J17X00286)	Jan-18
Network Analyzer E5071C	MY46111013	13-Jan-17 (CTTL, No.J17X00285)	Jan-18

	Name	Function	Signature
Calibrated by:	Zhao Jing	SAR Test Engineer	
Reviewed by:	Yu Zongying	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	

Issued: September 16, 2017

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Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORMx,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013

b) IEC 62209-1, "Measurement procedure for assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices- Part 1: Device used next to the ear (Frequency range of 300MHz to 6GHz)", July 2016

c) IEC 62209-2, "Procedure to measure the Specific Absorption Rate (SAR) For wireless communication devices used in close proximity to the human body (frequency range of 30MHz to 6GHz)", March 2010

d) KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of Measurement multiplied by the coverage factor k=2, which for a normal distribution Corresponds to a coverage probability of approximately 95%.

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Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY52	52.10.0.1446
Extrapolation	Advanced Extrapolation	
Phantom	Triple Flat Phantom 5.1C	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	750 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.9	0.89 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	41.5 ± 6 %	0.88 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.05 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	**8.26 mW /g ± 18.8 % (k=2)**
SAR averaged over 10 cm^3 (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	1.34 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	**5.39 mW /g ± 18.7 % (k=2)**

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.5	0.96 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	55.4 ± 6 %	0.95 mho/m ± 6 %
Body TSL temperature change during test	<1.0 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.15 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	**8.69 mW /g ± 18.8 % (k=2)**
SAR averaged over 10 cm^3 (10 g) of Body TSL	Condition	
SAR measured	250 mW input power	1.42 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	**5.73 mW /g ±18.7 % (k=2)**

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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.9Ω+ 0.24jΩ
Return Loss	- 28.4dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	52.0Ω- 2.22jΩ
Return Loss	- 30.6dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.136 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG

D750V3 Sn:1101

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DASY5 Validation Report for Head TSL Date: 09.13.2017

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN: 1101

Communication System: UID 0, CW; Frequency: 750 MHz; Duty Cycle: 1:1

Medium parameters used: f = 750 MHz; σ = 0.879 S/m; ε_r = 41.54; ρ = 1000 kg/m^3

Phantom section: Left Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: EX3DV4 - SN7433; ConvF(10.01, 10.01, 10.01); Calibrated: 9/26/2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1331; Calibrated: 1/19/2017
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/1
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

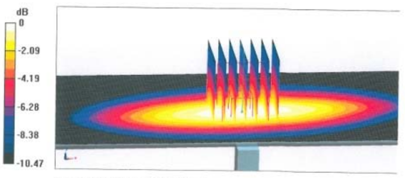
Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 53.10 V/m; Power Drift = -0.05 dB

Peak SAR (extrapolated) = 3.17 W/kg

SAR(1 g) = 2.05 W/kg; SAR(10 g) = 1.34 W/kg

Maximum value of SAR (measured) = 2.77 W/kg



0 dB = 2.77 W/kg = 4.42 dBW/kg

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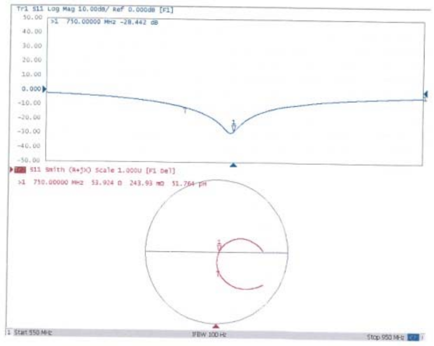
Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL Date: 09.13.2017

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN: 1101

Communication System: UID 0, CW; Frequency: 750 MHz; Duty Cycle: 1:1

Medium parameters used: f = 750 MHz; σ = 0.946 S/m; ε_r = 55.41; ρ = 1000 kg/m^3

Phantom section: Center Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: EX3DV4 - SN7433; ConvF(9.83, 9.83, 9.83); Calibrated: 9/26/2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1331; Calibrated: 1/19/2017
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/1
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

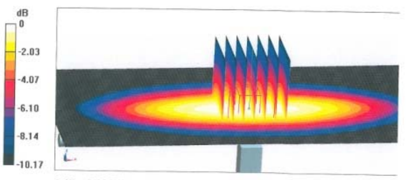
Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 53.35 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 3.27 W/kg

SAR(1 g) = 2.15 W/kg; SAR(10 g) = 1.42 W/kg

Maximum value of SAR (measured) = 2.88 W/kg



0 dB = 2.88 W/kg = 4.59 dBW/kg

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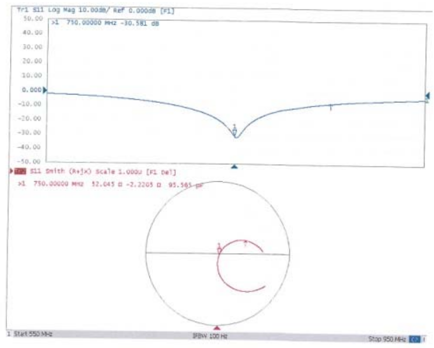
Impedance Measurement Plot for Body TSL



D1800V2 Sn:2d084

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Client SRTC Certificate No: Z17-97138

CALIBRATION CERTIFICATE

Object: D1800V2 - SN: 2d084

Calibration Procedure(s): FF-Z11-003-01
Calibration Procedures for dipole validation kits

Calibration date: September 15, 2017

This calibration Certificate documents the traceability to national standards, which realize the physical units of measurements(SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)℃ and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRP2	102196	02-Mar-17 (CTTL, No.J17X01254)	Mar-18
Power sensor NRP-Z91	100596	02-Mar-17 (CTTL, No.J17X01254)	Mar-18
Reference Probe EX3DV4	SN 7433	26-Sep-16(SPEAG,No.EX3-7433_Sep16)	Sep-17
DAE4	SN 1331	19-Jan-17(CTTL-SPEAG,No.Z17-97015)	Jan-18
Secondary Standards	**ID #**	**Cal Date(Calibrated by, Certificate No.)**	**Scheduled Calibration**
Signal Generator E4438C	MY49071430	13-Jan-17 (CTTL, No.J17X00286)	Jan-18
Network Analyzer E5071C	MY46110673	13-Jan-17 (CTTL, No.J17X00285)	Jan-18

	Name	Function	Signature
Calibrated by:	Zhao Jing	SAR Test Engineer	
Reviewed by:	Yu Zongying	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	

Issued: September 18, 2017

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Certificate No: Z17-97138 Page 1 of 8

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Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORMx,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) For hand-held devices used in close proximity to the ear (frequency range of 300MHz to 3GHz)", February 2005
c) IEC 62209-2, "Procedure to measure the Specific Absorption Rate (SAR) For wireless communication devices used in close proximity to the human body (frequency range of 30MHz to 6GHz)", March 2010
d) KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of Measurement multiplied by the coverage factor k=2, which for a normal distribution Corresponds to a coverage probability of approximately 95%.

Certificate No: Z17-97138 Page 2 of 8

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Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY52	52.10.0.1446
Extrapolation	Advanced Extrapolation	
Phantom	Triple Flat Phantom 5.1C	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1800 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.4 ± 6 %	1.42 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.79 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	**38.9 mW /g ± 18.8 % (k=2)**
SAR averaged over 10 cm^3 (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	5.12 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	**20.4 mW /g ± 18.7 % (k=2)**

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	53.8 ± 6 %	1.50 mho/m ± 6 %
Body TSL temperature change during test	<1.0 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	9.84 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	**39.7 mW /g ± 18.8 % (k=2)**
SAR averaged over 10 cm^3 (10 g) of Body TSL	Condition	
SAR measured	250 mW input power	5.18 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	**20.8 mW /g ± 18.7 % (k=2)**

Certificate No: Z17-97138 Page 3 of 8

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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.3Ω- 1.55jΩ
Return Loss	- 35.4dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.0Ω- 1.32jΩ
Return Loss	- 27.1dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.316 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG

Certificate No: Z17-97138 Page 4 of 8

D1800V2 Sn:2d084

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DASY5 Validation Report for Head TSL Date: 09.15.2017

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 1800 MHz; Type: D1800V2; Serial: D1800V2 - SN: 2d084

Communication System: UID 0, CW; Frequency: 1800 MHz; Duty Cycle: 1:1

Medium parameters used: f = 1800 MHz; σ = 1.423 S/m; εr = 40.37; ρ = 1000 kg/m3

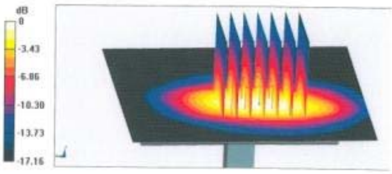
Phantom section: Left Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: EX3DV4 - SN7433; ConvF(7.97, 7.97, 7.97); Calibrated: 9/26/2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1331; Calibrated: 1/19/2017
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/1
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

System Performance Check/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 93.90 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 18.7 W/kg
SAR(1 g) = 9.79 W/kg; SAR(10 g) = 5.12 W/kg
Maximum value of SAR (measured) = 15.5 W/kg



0 dB = 15.5 W/kg = 11.90 dBW/kg

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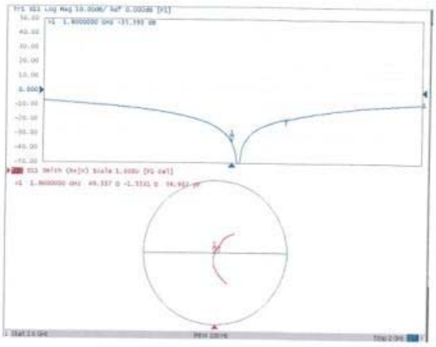
Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL Date: 09.14.2017

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 1800 MHz; Type: D1800V2; Serial: D1800V2 - SN: 2d084

Communication System: UID 0, CW; Frequency: 1800 MHz; Duty Cycle: 1:1

Medium parameters used: f = 1800 MHz; σ = 1.503 S/m; ϵ_r = 53.79; ρ = 1000 kg/m^3

Phantom section: Center Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: EX3DV4 - SN7433; ConvF(7.75, 7.75, 7.75); Calibrated: 9/26/2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1331; Calibrated: 1/19/2017
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/1
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7413)

System Performance Check/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 97.57 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 18.0 W/kg
SAR(1 g) = 9.84 W/kg; SAR(10 g) = 5.18 W/kg
Maximum value of SAR (measured) = 15.2 W/kg

0 dB = 15.2 W/kg = 11.82 dBW/kg

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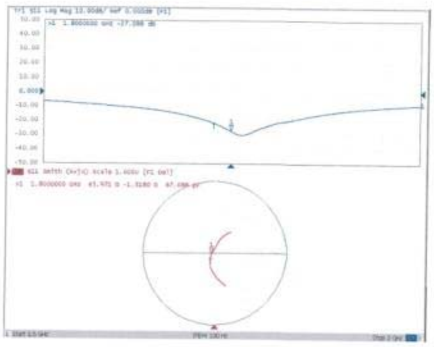
Impedance Measurement Plot for Body TSL



D2000V2 Sn:1009

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Client: SRTC Certificate No: Z18-97021

CALIBRATION CERTIFICATE

Object: D2000V2 - SN: 1009

Calibration Procedure(s): FF-Z11-003-01
Calibration Procedures for dipole validation kits

Calibration date: February 1, 2018

This calibration Certificate documents the traceability to national standards, which realize the physical units of measurements(SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)℃ and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRVD	102196	02-Mar-17 (CTTL, No.J17X01254)	Mar-18
Power sensor NRV-Z5	100596	02-Mar-17 (CTTL, No.J17X01254)	Mar-18
Reference Probe EX3DV4	SN 7464	12-Sep-17(SPEAG,No.EX3-7464_Sep17)	Sep-18
DAE4	SN 1525	02-Oct-17(SPEAG,No.DAE4-1525_Oct17)	Oct-18

Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Signal Generator E4438C	MY49071430	23-Jan-18 (CTTL, No.J18X00560)	Jan-19
Network Analyzer E5071C	MY46110673	24-Jan-18 (CTTL, No.J18X00561)	Jan-19

	Name	Function	Signature
Calibrated by:	Zhao Jing	SAR Test Engineer	
Reviewed by:	Lin Hao	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	

Issued: February 4, 2018

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Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORMx,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Measurement procedure for assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices- Part 1: Device used next to the ear (Frequency range of 300MHz to 6GHz)", July 2016
c) IEC 62209-2, "Procedure to measure the Specific Absorption Rate (SAR) For wireless communication devices used in close proximity to the human body (frequency range of 30MHz to 6GHz)", March 2010
d) KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of Measurement multiplied by the coverage factor k=2, which for a normal distribution Corresponds to a coverage probability of approximately 95%.

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Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY52	52.10.0.1446
Extrapolation	Advanced Extrapolation	
Phantom	Triple Flat Phantom 5.1C	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2000 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	38.9 ± 6 %	1.42 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	10.2 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	**40.3 mW /g ± 18.8 % (k=2)**
SAR averaged over 10 cm^3 (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	5.17 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	**20.6 mW /g ± 18.7 % (k=2)**

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	51.8 ± 6 %	1.56 mho/m ± 6 %
Body TSL temperature change during test	<1.0 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	10.3 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	**40.3 mW /g ± 18.8 % (k=2)**
SAR averaged over 10 cm^3 (10 g) of Body TSL	Condition	
SAR measured	250 mW input power	5.18 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	**20.4 mW /g ± 18.7 % (k=2)**

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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.8Ω- 2.08jΩ
Return Loss	- 33.6dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.3Ω- 1.63jΩ
Return Loss	- 27.6dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.047 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG

D2000V2 Sn:1009

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DASY5 Validation Report for Head TSL Date: 02.01.2018

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 2000 MHz; Type: D2000V2; Serial: D2000V2 - SN: 1009

Communication System: UID 0, CW; Frequency: 2000 MHz; Duty Cycle: 1:1

Medium parameters used: f = 2000 MHz; σ = 1.416 S/m; εr = 38.89; ρ = 1000 kg/m3

Phantom section: Left Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: EX3DV4 - SN7464; ConvF(8.39, 8.39, 8.39); Calibrated: 9/12/2017,
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1525; Calibrated: 10/2/2017
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/1
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

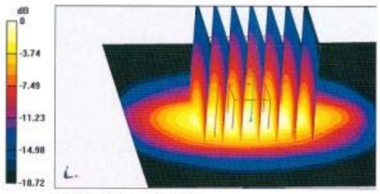
System Performance Check/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 95.98 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 19.7 W/kg

SAR(1 g) = 10.2 W/kg; SAR(10 g) = 5.17 W/kg

Maximum value of SAR (measured) = 16.2 W/kg



0 dB = 16.2 W/kg = 12.10 dBW/kg

Certificate No: Z18-97021 Page 5 of 8

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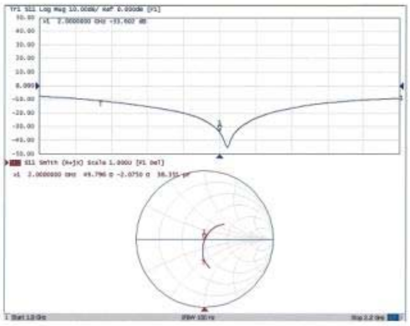
Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL Date: 02.01.2018

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 2000 MHz; Type: D2000V2; Serial: D2000V2 - SN: 1009

Communication System: UID 0, CW; Frequency: 2000 MHz; Duty Cycle: 1:1

Medium parameters used: f = 2000 MHz; σ = 1.564 S/m; ϵ_r = 51.83; ρ = 1000 kg/m^3

Phantom section: Center Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: EX3DV4 - SN7464; ConvF(8.24,8.24,8.24); Calibrated: 9/12/2017,
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1525; Calibrated: 10/2/2017
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/1
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

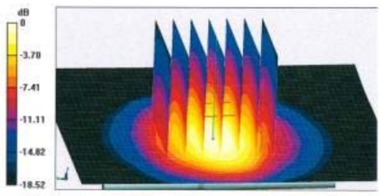
System Performance Check/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 93.84 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 19.7 W/kg

SAR(1 g) = 10.3 W/kg; SAR(10 g) = 5.18 W/kg

Maximum value of SAR (measured) = 16.3 W/kg



0 dB = 16.3 W/kg = 12.12 dBW/kg

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In Collaboration with s p e a g CALIBRATION LABORATORY

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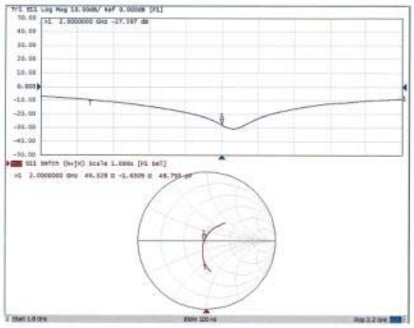
Impedance Measurement Plot for Body TSL



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--End of the test report--