



TEST REPORT

No.I21N00742-SAR

For

TCL Communication Ltd.

Tablet PC

Model Name: 9081X

With

Hardware Version: PIO

Software Version: 6A62

FCC ID: 2ACCJB153

Issued Date: 2021-04-06

Designation Number: CN1210

Note:

The test results in this test report relate only to the devices specified in this report. This report shall not be reproduced except in full without the written approval of SAICT.

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No. I21N00742-SAR

REPORT HISTORY

Report Number	Revision	Description	Issue Date
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1. Summary of Test Report

1.1. Test Items

Description:	Tablet PC
Model Name:	9081X
Applicant's name:	TCL Communication Ltd.
Manufacturer's Name:	TCL Communication Ltd.

1.2. Test Standards

ANSI C95.1-1992, IEEE 1528-2013

1.3. Test Result

Pass. Please refer to "12. Summary of Test Results"

1.4. Testing Location

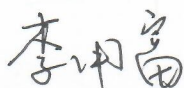
Address: Building G, Shenzhen International Innovation Center, No.1006 Shennan Road, Futian District, Shenzhen, Guangdong, P. R. China

1.5. Project Data

Testing Start Date: 2021-03-27

Testing End Date: 2021-03-28

1.6. Signature



Li Yongfu

(Prepared this test report)



Zhang Yunzhuan

(Reviewed this test report)



Cao Junfei

(Approved this test report)

2. Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing for TCL Communication Ltd. Tablet PC 9081X are as follows:

Table 2.1: Highest Reported SAR for Body (1g)

Exposure Configuration	Technology Band	Highest Reported SAR 1g(W/Kg)	Equipment Class
Body	Bluetooth	0.18	DSS
	WLAN 2.4GHz	1.28	DTS
	WLAN 5GHz	1.15	NII

The SAR values found for the Mobile Phone are below the maximum recommended levels of 1.6 W/Kg as averaged over any 1g tissue according to the ANSI C95.1-1992.

The EUT battery must be fully charged and checked periodically during the test to ascertain uniform power output.

The measurement together with the test system set-up is described in annex C of this test report. A detailed description of the equipment under test can be found in chapter 4 of this test report.

The highest reported SAR value is obtained at the case of (Table 2.1), and the value is: **1.28 W/kg (1g)**.



3. Client Information

3.1. Applicant Information

Company Name:	TCL Communication Ltd.
Address:	5/F, Building 22E, 22 Science Park East Avenue, Hong Kong Science Park, Shatin, NT, Hong Kong
City:	/
Country:	/
Telephone:	0086-755-36611722

3.2. Manufacturer Information

Company Name:	TCL Communication Ltd.
Address:	5/F, Building 22E, 22 Science Park East Avenue, Hong Kong Science Park, Shatin, NT, Hong Kong
City:	/
Country:	/
Telephone:	0086-755-36611722

4. Equipment under Test (EUT) and Ancillary Equipment (AE)

4.1. About EUT

Description:	Tablet PC
Model Name:	9081X
Operating mode(s):	Bluetooth, WLAN 2.4G/5G
Condition of EUT as received:	No obvious damage in appearance
Tested Tx Frequency:	2402 – 2480MHz (Bluetooth)
	2412 – 2462MHz (WLAN 2.4G)
	5180 – 5320MHz, 5745 – 5825MHz (WLAN 5G)
Test device Production information:	Production unit
Device type:	Portable device
Antenna type:	Integrated antenna
Product Dimensions:	Long 240.98mm; Wide 158.66mm; Overall Diagonal 281mm

4.2. Internal Identification of EUT used during the test

EUT ID*	UDID	HW Version	SW Version	Receipt Date
UT05aa	6409ACCE7B78298	PIO	6A62	2021-03-11
UT07aa	6409ACCE7B78295	PIO	6A62	2021-03-11
UT10aa	6409ACCE7B78111	PIO	6A62	2021-03-11

*EUT ID: is used to identify the test sample in the lab internally.

Note: It is performed to test SAR with the UT07aa & UT10aa, and conducted power with the UT05aa.

4.3. Internal Identification of AE used during the test

AE ID*	Description	Type	Manufacturer
AE1	Battery	TLp078A1	BYD
AE2	Battery	TLp078AA	TMB

*AE ID: is used to identify the test sample in the lab internally.

Note: The device has two types of batteries. AE1 battery was used for the initial test, AE2 battery was used for verification tests with the worst configuration.

5. Test Methodology

5.1. Applicable Limit Regulations

ANSI C95.1–1992 IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

It specifies the maximum exposure limit of **1.60 W/kg** as averaged over any 1 gram of tissue for portable devices being used within 20 cm of the user in the uncontrolled environment.

5.2. Applicable Measurement Standards

IEEE 1528–2013 Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Experimental Techniques.

KDB 447498 D01 General RF Exposure Guidance v06 Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies.

KDB 616217 D04 SAR for laptop and tablets v01r02 SAR Evaluation Considerations for Laptop, Notebook, Notebook and Tablet Computers.

KDB 248227 D01 802.11 Wi-Fi SAR v02r02 SAR Guidance for IEEE 802.11 (Wi-Fi) Transmitters.

KDB 865664 D01 SAR measurement 100 MHz to 6 GHz v01r04 SAR Measurement Requirements for 100 MHz to 6 GHz.

KDB 865664 D02 RF Exposure Reporting v01r02 RF Exposure Compliance Reporting and Documentation Considerations

TCB workshop April 2019; RF Exposure Procedures (Tissue Simulating Liquids)

6. Specific Absorption Rate (SAR)

6.1. Introduction

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

6.2. SAR Definition

The SAR definition is the time derivative (rate) of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dv) of a given density (ρ). The equation description is as below:

$$SAR = \frac{d}{dt} \left(\frac{dW}{dm} \right) = \frac{d}{dt} \left(\frac{dW}{\rho dv} \right)$$

SAR is expressed in units of Watts per kilogram (W/kg)

SAR measurement can be either related to the temperature elevation in tissue by

$$SAR = c \left(\frac{\delta T}{\delta t} \right)$$

Where: C is the specific heat capacity, δT is the temperature rise and δt is the exposure duration, or related to the electrical field in the tissue by

$$SAR = \frac{\sigma |E|^2}{\rho}$$

Where: σ is the conductivity of the tissue, ρ is the mass density of tissue and E is the RMS electrical field strength.

However for evaluating SAR of low power transmitter, electrical field measurement is typically applied.

7. Tissue Simulating Liquids

7.1. Targets for tissue simulating liquid

Table 7.1: Targets for tissue simulating liquid

Frequency (MHz)	Liquid Type	Conductivity (σ)	$\pm 5\%$ Range	Permittivity (ϵ)	$\pm 5\%$ Range
2450	Head	1.80	1.71~1.89	39.2	37.2~41.2
5250	Head	4.71	4.47~4.95	35.9	34.1~37.7
5750	Head	5.22	4.96~5.48	35.4	33.6~37.1

7.2. Dielectric Performance

Table 7.2: Dielectric Performance of Tissue Simulating Liquid

Measurement Date (yyyy-mm-dd)	Type	Frequency	Conductivity σ (S/m)	Drift (%)	Permittivity ϵ	Drift (%)
2021-03-28	Head	2450	1.838	2.11	38.46	-1.89
2021-03-27	Head	5250	4.642	-1.44	36.55	1.73
2021-03-27	Head	5750	5.307	1.67	34.42	-2.66

Note: The liquid temperature is 22.0°C.



Picture 7-1: Liquid depth in the Flat Phantom(2450MHz)

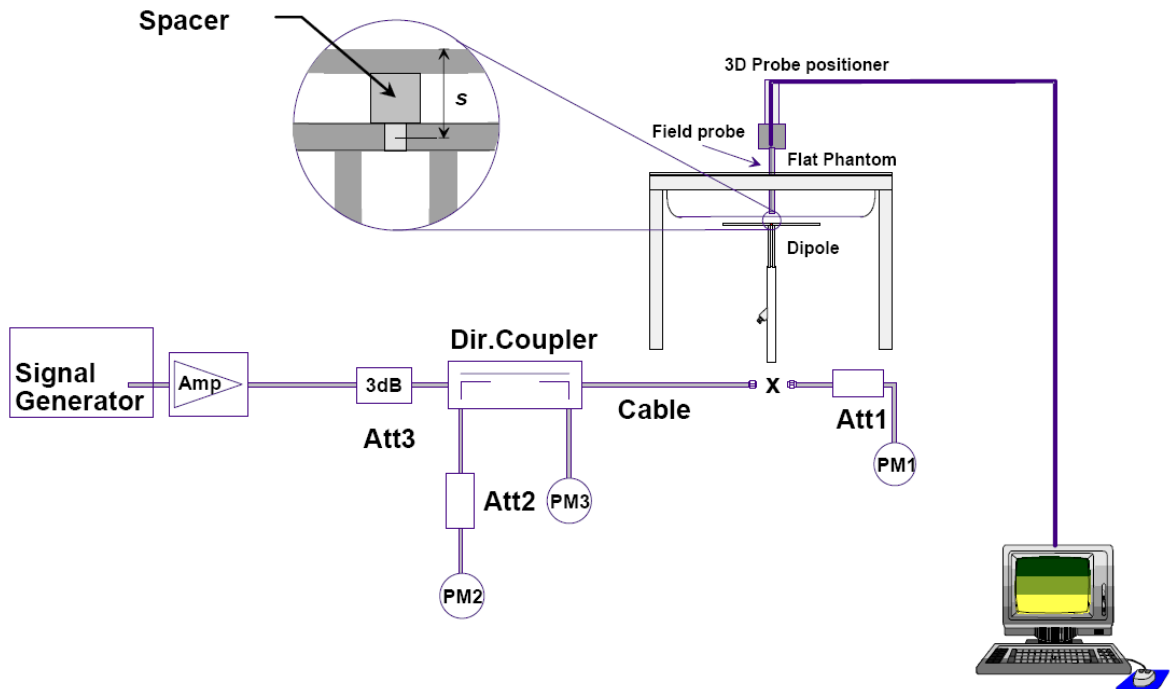


Picture 7-2: Liquid depth in the Flat Phantom(5GHz)

8. System verification

8.1. System Setup

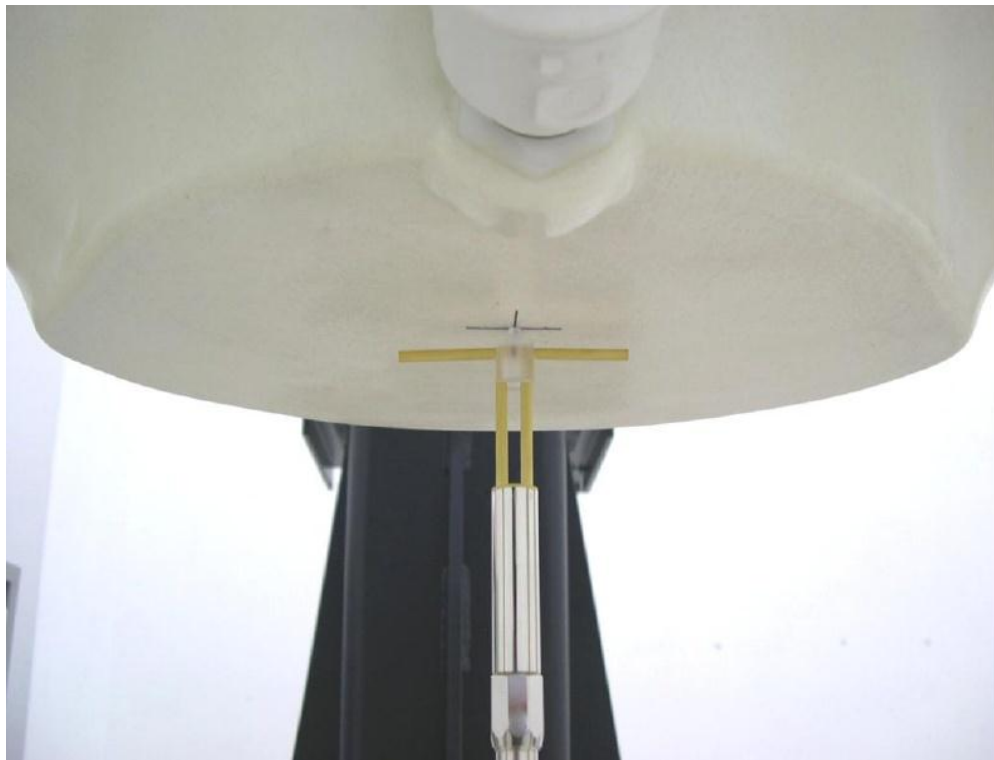
In the simplified setup for system evaluation, the DUT is replaced by a calibrated dipole and the power source is replaced by a continuous wave that comes from a signal generator. The calibrated dipole must be placed beneath the flat phantom section of the SAM twin phantom with the correct distance holder. The distance holder should touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the long side of the phantom. The equipment setup is shown below:



Picture 8.1 System Setup for System Evaluation

For the dipole below 3GHz, the output power on dipole port must be calibrated to 24 dBm (250mW) before dipole is connected.

For the dipole above 3GHz, the output power on dipole port must be calibrated to 20 dBm (100mW) before dipole is connected.



Picture 8.2 Photo of Dipole Setup

8.2. System Verification

SAR system verification is required to confirm measurement accuracy, according to the tissue dielectric media, probe calibration points and other system operating parameters required for measuring the SAR of a test device. The system verification must be performed for each frequency band and within the valid range of each probe calibration point required for testing the device.

Table 8.1: System Verification of Head

Measurement Date	Frequency (MHz)	Target value (W/kg)		Measured value (W/kg)				Deviation (%)	
				/		Normalize to 1W			
		10 g	1 g	10 g	1 g	10 g	1 g	10 g	1 g
2021-03-28	2450	24.10	52.00	6.22	13.6	24.88	54.40	3.24	4.62
2021-03-27	5250	22.30	78.00	2.16	7.42	21.60	74.20	-3.14	-4.87
2021-03-27	5750	22.20	78.40	2.25	8.03	22.50	80.30	1.35	2.42

9. Measurement Procedures

9.1. Tests to be performed

In order to determine the highest value of the peak spatial-average SAR of a handset, all device positions, configurations and operational modes shall be tested for each frequency band according to steps 1 to 3 below. A flowchart of the test process is shown in picture 9.1.

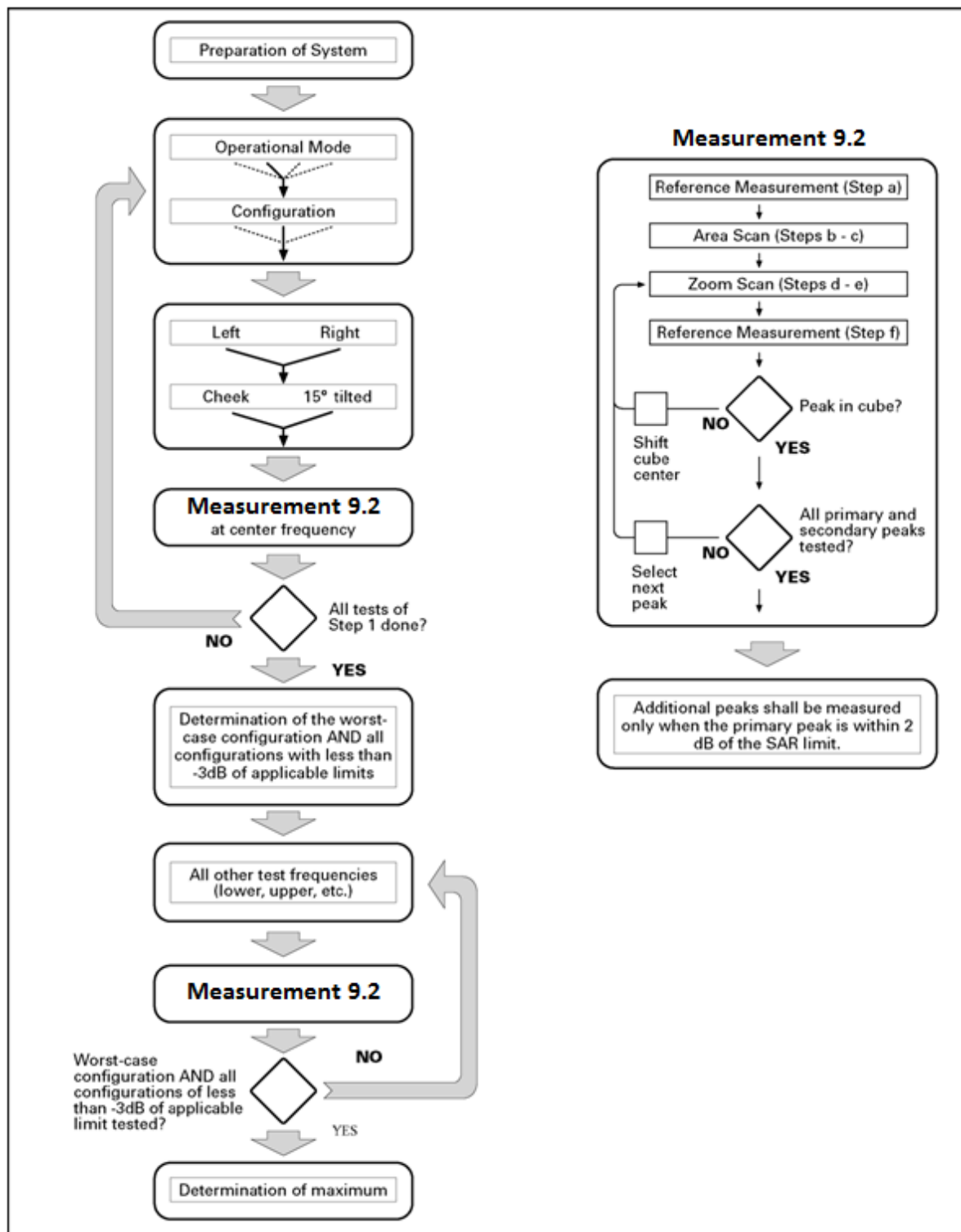
Step 1: The tests described in 9.2 shall be performed at the channel that is closest to the center of the transmit frequency band (f_c) for:

- a) all device positions (cheek and tilt, for both left and right sides of the SAM phantom, as described in annex D),
- b) all configurations for each device position in a), e.g., antenna extended and retracted, and
- c) all operational modes, e.g., analogue and digital, for each device position in a) and configuration in b) in each frequency band.

If more than three frequencies need to be tested according to 11.1 (i.e., $N_c > 3$), then all frequencies, configurations and modes shall be tested for all of the above test conditions.

Step 2: For the condition providing highest peak spatial-average SAR determined in Step 1, perform all tests described in 9.2 at all other test frequencies, i.e., 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 shall be tested as well.

Step 3: Examine all data to determine the highest value of the peak spatial-average SAR found in Steps 1 to 2.



Picture 9.1 Block diagram of the tests to be performed

9.2. General Measurement Procedure

The area and zoom scan resolutions specified in the table below must be applied to the SAR measurements and fully documented in SAR reports to qualify for TCB approval. Probe boundary effect error compensation is required for measurements with the probe tip closer than half a probe tip diameter to the phantom surface. Both the probe tip diameter and sensor offset distance must satisfy measurement protocols; to ensure probe boundary effect errors are minimized and the higher fields closest to the phantom surface can be correctly measured and extrapolated to the phantom surface for computing 1-g SAR. Tolerances of the post-processing algorithms must be verified by the test laboratory for the scan resolutions used in the SAR measurements, according to the reference distribution functions specified in IEEE Std 1528-2013. The results should be documented as part of the system validation records and may be requested to support test results when all the measurement parameters in the following table are not satisfied.

			≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface			5 ± 1 mm	$\frac{1}{2} \delta \ln(2) \pm 0.5$ mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location			$30^\circ \pm 1^\circ$	$20^\circ \pm 1^\circ$
Maximum area scan spatial resolution: Δx_{Area} , Δy_{Area}			≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 mm
			When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be $\leq$ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	
Maximum zoom scan spatial resolution: Δx_{Zoom} , Δy_{Zoom}			≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm*	3 – 4 GHz: ≤ 5 mm* 4 – 6 GHz: ≤ 4 mm*
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{Zoom}(n)$		≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm
	graded grid	$\Delta z_{Zoom}(1)$: between 1 st two points closest to phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 2 mm
		$\Delta z_{Zoom}(n>1)$: between subsequent points	$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$	
Minimum zoom scan volume	x, y, z		≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm
Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.				
* When zoom scan is required and the <u>reported</u> SAR from the area scan based 1-g SAR estimation procedures of KDB 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.				

9.3. Bluetooth & WLAN Measurement Procedures for SAR

Normal network operating configurations are not suitable for measuring the SAR of 802.11 transmitters in general. Unpredictable fluctuations in network traffic and antenna diversity conditions can introduce undesirable variations in SAR results. The SAR for these devices should be measured using chipset based test mode software to ensure that the results are consistent and reliable.

Chipset based test mode software is hardware dependent and generally varies among manufacturers. The device operating parameters established in a test mode for SAR measurements must be identical to those programmed in production units, including output power levels, amplifier gain settings and other RF performance tuning parameters. The test frequencies should correspond to actual channel frequencies defined for domestic use. SAR for devices with switched diversity should be measured with only one antenna transmitting at a time during each SAR measurement, according to a fixed modulation and data rate. The same data pattern should be used for all measurements.

9.4. Power Drift

To control the output power stability during the SAR test, DASY5 system calculates the power drift by measuring the E-field at the same location at the beginning and at the end of the measurement for each test position. These drift values can be found in Section 14 labeled as: (Power Drift [dB]). This ensures that the power drift during one measurement is within 5%.

10. Conducted Output Power

Table 10.5: The conducted Power measurement results for Bluetooth

Bluetooth	Tune up	Averaged Power (dBm)		
Mode		Ch.0 (2402MHz)	Ch.39 (2441MHz)	Ch.78 (2480MHz)
GFSK	10.5	9.44	9.13	9.70
EDR2M-4_DQPSK	10.0	8.64	8.51	8.80
EDR3M-8DPSK	10.0	8.64	8.65	8.96
/	/	Ch.0 (2402MHz)	Ch.19 (2440MHz)	Ch.39 (2480MHz)
BLE	-2.0	-3.93	-2.73	-3.36

Table 10.6: The conducted Power measurement results for WLAN 2.4G

WLAN 2.4GHz	Tune up	Averaged Power (dBm) Duty Cycle: 100%		
Mode		Ch.1 (2412MHz)	Ch.6 (2437MHz)	Ch.11 (2462MHz)
802.11b	16.5	15.40	15.75	15.56
802.11g	15.5	14.43	14.61	14.53
802.11n(20MHz)	15.5	14.25	14.68	14.41
/	/	Ch.3 (2422MHz)	Ch.6 (2437MHz)	Ch.9 (2452MHz)
802.11n(40MHz)	15.5	14.63	14.79	14.59

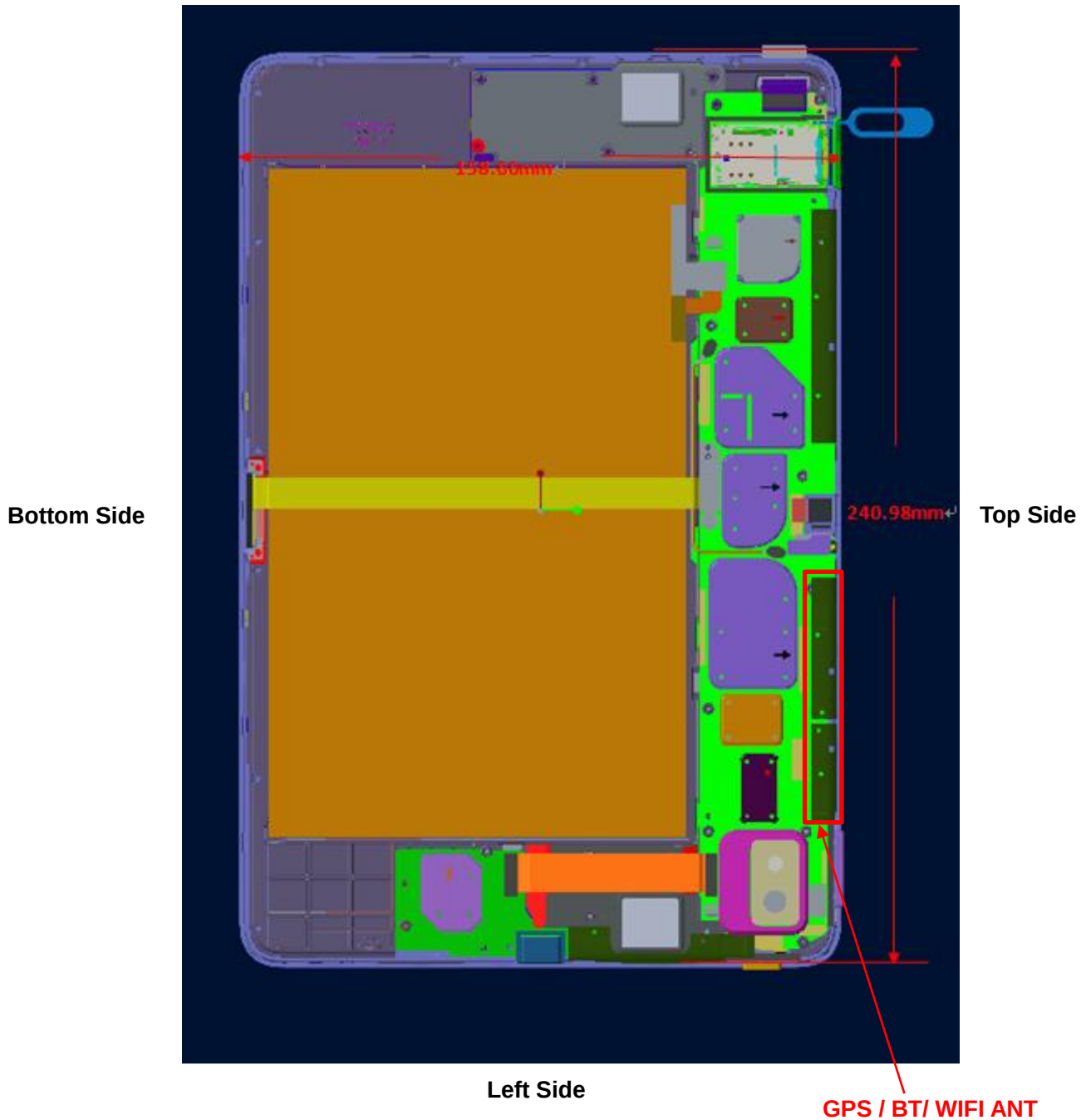
Table 10.7: The conducted Power measurement results for WLAN 5G

Averaged Power (dBm) Duty Cycle: 100%								
Mode	802.11a	802.11n -20MHz	802.11ac -20MHz	Mode	802.11n -40MHz	802.11ac -40MHz	Mode	802.11ac -80MHz
Channel	6Mbps	MCS0	MCS0	Channel	MCS0	MCS0	Channel	MCS0
<U-NII-1>								
Tune up	10.0	10.0	10.0	/	9.0	9.0	/	9.0
36(5180MHz)	9.67	9.56	9.54	38(5190MHz)	8.42	8.33	42(5210MHz)	8.30
40(5200MHz)	9.60	9.50	9.53	46(5230MHz)	8.18	8.12	/	/
44(5220MHz)	9.41	9.36	9.29	/	/	/	/	/
48(5240MHz)	9.39	9.35	9.26	/	/	/	/	/
<U-NII-2A>								
Tune up	10.0	10.0	10.0	/	9.0	9.0	/	9.0
52(5260MHz)	9.48	9.41	9.37	54(5270MHz)	8.25	8.18	58(5290MHz)	8.25
56(5280MHz)	9.43	9.41	9.26	62(5310MHz)	8.32	8.26	/	/
60(5300MHz)	9.45	9.39	9.37	/	/	/	/	/
64(5320MHz)	9.54	9.51	9.45	/	/	/	/	/
<U-NII-3>								
Tune up	10.5	10.5	10.5	/	9.5	9.5	/	9.5
149(5745MHz)	9.94	9.91	9.86	151(5755MHz)	8.66	8.55	155(5775MHz)	8.73
157(5785MHz)	9.97	9.95	9.88	159(5795MHz)	8.70	8.65	/	/
165(5825MHz)	9.94	9.89	9.87	/	/	/	/	/

11. Transmit Antenna

11.1. Transmit Antenna Separation Distances

Right Side



Picture 11.1 Antenna Locations (Back View)

11.2. SAR Measurement Positions

SAR measurement positions					
Antenna	Rear	Left edge	Right edge	Top edge	Bottom edge
WLAN / Bluetooth	Yes	Yes	No	Yes	No

Note:

1. Per KDB 447498 D01v06, the 1-g SAR test exclusion thresholds for 100 MHz to 6 GHz at *test separation distances* ≤ 50 mm are determined by:

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

$f(\text{GHz})$ is the RF channel transmit frequency in GHz

Power and distance are rounded to the nearest mW and mm before calculation

2. Per KDB 447498 D01v06, 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

1) $\{[\text{Power allowed at numeric threshold for 50 mm in step a)}] + [(\text{test separation distance} - 50 \text{ mm}) \cdot (f(\text{MHz})/150)]\}$ mW, for 100 MHz to 1500 MHz

2) $\{[\text{Power allowed at numeric threshold for 50 mm in step a)}] + [(\text{test separation distance} - 50 \text{ mm}) \cdot 10]\}$ mW, for > 1500 MHz and ≤ 6 GHz

11.3. Standalone SAR Test Exclusion Considerations

Standalone 1-g head or body SAR evaluation by measurement or numerical simulation is not required when the corresponding SAR Exclusion Threshold condition, listed below, is satisfied.

The 1-g SAR test exclusion threshold for 100 MHz to 6 GHz at *test separation distances* ≤ 50 mm are determined by:

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

- $f(\text{GHz})$ 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

Table 11.1: Standalone SAR test exclusion considerations

Band/Mode	f(GHz)	Position	SAR test exclusion threshold (mW)	RF output power		SAR test exclusion
				dBm	mW	
Bluetooth	2.4	Body	10.0	10.5	11.22	No
WLAN 2.4GHz	2.4	Body	10.0	16.5	44.67	No
WLAN 5GHz	5.2	Body	7.0	10.0	10.00	No
	5.3	Body	7.0	10.0	10.00	No
	5.8	Body	6.0	10.5	11.22	No

12. Summary of Test Results

According to the client's decision rule in the test registration form, which is "based on the measurement results as the basis of the conformity statement", the test conclusion of this report meets the limit requirements.

The calculated SAR is obtained by the following formula:

$$\text{Reported SAR} = \text{Measured SAR} \times 10^{(P_{\text{Target}} - P_{\text{Measured}})/10}$$

Where P_{Target} is the power of manufacturing upper limit;

P_{Measured} is the measured power in chapter 10.

Note:

B2 (Battery): TLp078AA (TMB)

Duty Cycle

Mode	Duty Cycle
Bluetooth 2.4G	1:1

12.1. Testing Environment

Temperature:	18°C~25°C
Relative humidity:	30%~70%
Ground system resistance:	<4Ω
Ambient noise & Reflection:	< 0.012 W/kg

12.2. Bluetooth Test results

Table 13.1: SAR Values (Bluetooth - Body)

Frequency		Ambient Temperature: 22.5°C		Liquid Temperature: 22.0°C					
Ch.	MHz	Test Mode	Test Position	Figure No. / Note	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift(dB)
0mm Test Data									
78	2480	GFSK	Rear	1	9.70	10.5	0.152	0.18	0.09
78	2480	GFSK	Left	/	9.70	10.5	0.015	0.02	0.10
78	2480	GFSK	Top	/	9.70	10.5	0.049	0.06	-0.15
78	2480	GFSK	Rear	B2	9.70	10.5	0.144	0.17	0.06

13.3. WLAN Evaluation for 2.4G

According to the KDB248227 D01, SAR is measured for 2.4GHz 802.11b DSSS using the initial test position procedure.

Table 13.2: SAR Values (WLAN 2.4G - Body)

Ambient Temperature: 22.5°C					Liquid Temperature: 22.0°C				
Frequency		Test Mode	Test Position	Figure No. / Note	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift(dB)
Ch.	MHz								
0mm Test Data									
6	2437	802.11b	Rear	2	15.75	16.5	1.080	1.28	0.07
6	2437	802.11b	Left	/	15.75	16.5	0.108	0.13	0.06
6	2437	802.11b	Top	/	15.75	16.5	0.349	0.41	-0.01
11	2462	802.11b	Rear	/	15.56	16.5	0.877	1.09	0.01
6	2437	802.11b	Rear	B2	15.75	16.5	0.922	1.10	-0.13

Note: For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is > 0.8 W/kg, SAR is measured for these test positions/configurations on the subsequent next highest measured output power channel until the reported SAR is ≤ 1.2 W/kg or all required channels are tested.

According to the KDB248227 D01, The reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit.

Table 13.3: SAR Values (WLAN - Body) – 802.11b (Scaled Reported SAR)

Frequency		Test Position	Actual duty factor	maximum duty factor	Reported SAR (1g)(W/kg)	Scaled reported SAR (1g)(W/kg)
Ch.	MHz					
6	2437	Rear	100%	100%	1.28	1.28

SAR is not required for OFDM because the 802.11b adjusted SAR ≤ 1.2 W/kg.

13.4. WLAN Evaluation for 5G

Table 13.4: SAR Values (WLAN 5G - Body)

Ambient Temperature: 22.8°C					Liquid Temperature: 22.3°C				
Frequency		Test Mode	Test Position	Figure No.	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift(dB)
Ch.	MHz								
U-NII-2A - 0mm Test Data									
64	5320	802.11a	Rear	/	9.54	10.0	0.397	0.44	0.06
64	5320	802.11a	Left	/	9.54	10.0	0.022	0.02	0.09
64	5320	802.11a	Top	/	9.54	10.0	0.857	0.95	0.09
52	5260	802.11a	Top	3	9.48	10.0	1.020	1.15	0.09
52	5260	802.11a	Top	B2	9.48	10.0	0.902	1.02	0.06
U-NII-3 - 0mm Test Data									
157	5785	802.11a	Rear	/	9.97	10.5	0.273	0.31	0.15
157	5785	802.11a	Left	/	9.97	10.5	0.045	0.05	0.14
157	5785	802.11a	Top	/	9.97	10.5	0.811	0.92	0.09
165	5825	802.11a	Top	/	9.94	10.5	0.755	0.86	0.04
149	5745	802.11a	Top	/	9.94	10.5	0.762	0.87	0.19
157	5785	802.11a	Top	B2	9.97	10.5	0.802	0.91	0.01

Note1: U-NII-1 and U-NII-2A bands have the same specified maximum output and tolerance; SAR is measured for U-NII-2A band first. Adjusted SAR of U-NII-2A band is ≤ 1.2 W/kg, SAR is not required for U-NII-1 band.

Note2: For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is > 0.8 W/kg, SAR is measured for these test positions/configurations on the subsequent next highest measured output power channel until the reported SAR is ≤ 1.2 W/kg or all required channels are tested.

According to the KDB248227 D01, The reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit.

Table 13.5: SAR Values (WLAN - Body) – 802.11a (Scaled Reported SAR)

Frequency		Test Position	Actual duty factor	maximum duty factor	Reported SAR (1g)(W/kg)	Scaled reported SAR (1g)(W/kg)
Ch.	MHz					
52	5260	Top	100%	100%	1.15	1.15

13. 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 .

Table 3.1: SAR Measurement Variability for Body – WLAN 2.4G

Frequency		Test Position	Original	1 st Repeated	Ratio	2 nd Repeated
Ch.	MHz		SAR (W/kg)	SAR (W/kg)		SAR (W/kg)
6	2437	Rear	1.08	1.03	1.05	/

Table 13.2: SAR Measurement Variability for Body – WLAN U-NII-2A

Frequency		Test Position	Original	1 st Repeated	Ratio	2 nd Repeated
Ch.	MHz		SAR (W/kg)	SAR (W/kg)		SAR (W/kg)
52	5260	Rear	1.02	0.994	1.03	/

Table 13.3: SAR Measurement Variability for Body – WLAN U-NII-3

Frequency		Test Position	Original	1 st Repeated	Ratio	2 nd Repeated
Ch.	MHz		SAR (W/kg)	SAR (W/kg)		SAR (W/kg)
157	5785	Rear	0.811	0.804	1.01	/

14. Measurement Uncertainty

14.1. Measurement Uncertainty for Normal SAR Tests (300MHz~3GHz)

No.	Error Description	Type	Uncertainty value	Probably Distribution	Div.	(Ci) 1g	(Ci) 10g	Std. Unc. (1g)	Std. Unc. (10g)	Degree of freedom
Measurement system										
1	Probe calibration	B	12	N	2	1	1	6.0	6.0	∞
2	Axial isotropy	B	4.7	R	$\sqrt{3}$	$\sqrt{0.5}$	$\sqrt{0.5}$	4.3	4.3	∞
3	Hemispherical isotropy	B	9.6	R	$\sqrt{3}$	1	1	4.8	4.8	∞
4	Boundary effect	B	1.1	R	$\sqrt{3}$	1	1	0.6	0.6	∞
5	Linearity	B	4.7	R	$\sqrt{3}$	1	1	2.7	2.7	∞
6	Detection limit	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
7	Modulation response	B	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
8	Readout electronics	B	1.0	N	1	1	1	1.0	1.0	∞
9	Response time	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
10	Integration time	B	1.7	R	$\sqrt{3}$	1	1	1.0	1.0	∞
11	RF ambient conditions-noise	B	3.0	R	$\sqrt{3}$	1	1	1.7	1.7	∞
12	RF ambient conditions-reflection	B	3.0	R	$\sqrt{3}$	1	1	1.7	1.7	∞
13	Probe positioned mech. restrictions	B	0.35	R	$\sqrt{3}$	1	1	0.2	0.2	∞
14	Probe positioning with respect to phantom shell	B	2.9	R	$\sqrt{3}$	1	1	1.7	1.7	∞
15	Post-processing	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
Test sample related										
16	Test sample positioning	A	3.3	N	1	1	1	3.3	3.3	5
17	Device holder uncertainty	A	3.4	N	1	1	1	3.4	3.4	5
18	Drift of output power	B	5.0	R	$\sqrt{3}$	1	1	2.9	2.9	∞
Phantom and set-up										
19	Phantom uncertainty	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
20	Liquid conductivity (target)	B	5.0	R	$\sqrt{3}$	0.64	0.43	1.8	1.2	∞
21	Liquid conductivity (meas.)	A	1.3	N	1	0.64	0.43	0.83	0.56	9
22	Liquid permittivity (target)	B	5.0	R	$\sqrt{3}$	0.6	0.49	1.7	1.4	∞
23	Liquid permittivity (meas.)	A	1.6	N	1	0.6	0.49	0.96	0.78	9
Combined standard uncertainty		$u_c = \sqrt{\sum_{i=1}^{23} c_i^2 u_i^2}$						11.3	11.2	95.5
Expanded uncertainty (Confidence interval of 95 %)		$u_e = 2u_c$						22.6	22.4	

14.2. Measurement Uncertainty for Normal SAR Tests (3GHz~6GHz)

No.	Error Description	Type	Uncertainty value	Probably Distribution	Div.	(Ci) 1g	(Ci) 10g	Std. Unc. (1g)	Std. Unc. (10g)	Degree of freedom
Measurement system										
1	Probe calibration	B	13	N	2	1	1	6.5	6.5	∞
2	Axial isotropy	B	4.7	R	$\sqrt{3}$	$\sqrt{0.5}$	$\sqrt{0.5}$	4.3	4.3	∞
3	Hemispherical isotropy	B	9.6	R	$\sqrt{3}$	1	1	4.8	4.8	∞
4	Boundary effect	B	2.3	R	$\sqrt{3}$	1	1	1.3	1.3	∞
5	Linearity	B	4.7	R	$\sqrt{3}$	1	1	2.7	2.7	∞
6	Detection limit	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
7	Modulation response	B	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
8	Readout electronics	B	1.0	N	1	1	1	1.0	1.0	∞
9	Response time	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
10	Integration time	B	1.7	R	$\sqrt{3}$	1	1	1.0	1.0	∞
11	RF ambient conditions-noise	B	3.0	R	$\sqrt{3}$	1	1	1.7	1.7	∞
12	RF ambient conditions-reflection	B	3.0	R	$\sqrt{3}$	1	1	1.7	1.7	∞
13	Probe positioned mech. restrictions	B	0.71	R	$\sqrt{3}$	1	1	0.4	0.4	∞
14	Probe positioning with respect to phantom shell	B	5.7	R	$\sqrt{3}$	1	1	3.3	3.3	∞
15	Post-processing	B	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
Test sample related										
16	Test sample positioning	A	3.3	N	1	1	1	3.3	3.3	5
17	Device holder uncertainty	A	3.4	N	1	1	1	3.4	3.4	5
18	Drift of output power	B	5.0	R	$\sqrt{3}$	1	1	2.9	2.9	∞
Phantom and set-up										
19	Phantom uncertainty	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
20	Liquid conductivity (target)	B	5.0	R	$\sqrt{3}$	0.64	0.43	1.8	1.2	∞
21	Liquid conductivity (meas.)	A	1.3	N	1	0.64	0.43	0.83	0.56	9
22	Liquid permittivity (target)	B	5.0	R	$\sqrt{3}$	0.6	0.49	1.7	1.4	∞
23	Liquid permittivity (meas.)	A	1.6	N	1	0.6	0.49	0.96	0.78	9
Combined standard uncertainty		$u_c' = \sqrt{\sum_{i=1}^{23} c_i^2 u_i^2}$						12.2	12.1	95.5
Expanded uncertainty (Confidence interval of 95 %)		$u_e = 2u_c$						24.4	24.2	

15. Main Test Instruments

Table 15.1: List of Main Instruments

No.	Name	Type	Serial Number	Calibration Date	Valid Period
01	Network analyzer	E5071C	MY46103759	2020-11-15	One year
02	Dielectric probe	85070E	MY44300317	/	/
03	Power meter	E4418B	MY50000366	2020-12-13	One year
04	Power sensor	E9304A	MY50000188		
05	Power meter	NRP	101460	2021-01-15	One year
06	Power sensor	NRP-Z91	100553		
07	Signal Generator	E8257D	MY47461211	2021-01-15	One year
08	Amplifier	VTL5400	0404	/	/
09	E-field Probe	EX3DV4	3633	2020-04-01	One year
10	DAE	DAE4	1527	2020-11-06	One year
11	Dipole Validation Kit	D2450V2	873	2018-10-26	Three year
12	Dipole Validation Kit	D5GHzV2	1238	2019-08-29	Three year
13	Software	DASY5	52.8.8.1222	/	/

ANNEX A: Graph Results

Bluetooth Body

Date: 2021-3-28

Electronics: DAE4 Sn1527

Medium: Head 2450MHz

Medium parameters used: $f = 2480$ MHz; $\sigma = 1.873$ S/m; $\epsilon_r = 38.364$; $\rho = 1000$ kg/m³

Communication System: UID 0, BT (0) Frequency: 2480 MHz Duty Cycle: 1:1

Probe: EX3DV4 - SN3633 ConvF (7.43, 7.43, 7.43)

Rear Side High/Area Scan (91x91x1): Interpolated grid: $dx=1.000$ mm, $dy=1.000$ mm

Maximum value of SAR (interpolated) = 0.304 W/kg

Rear Side High/Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 0.108 V/m; Power Drift = 0.09 dB

Peak SAR (extrapolated) = 0.374 W/kg

SAR(1 g) = 0.152 W/kg; SAR(10 g) = 0.061 W/kg

Maximum value of SAR (measured) = 0.250 W/kg

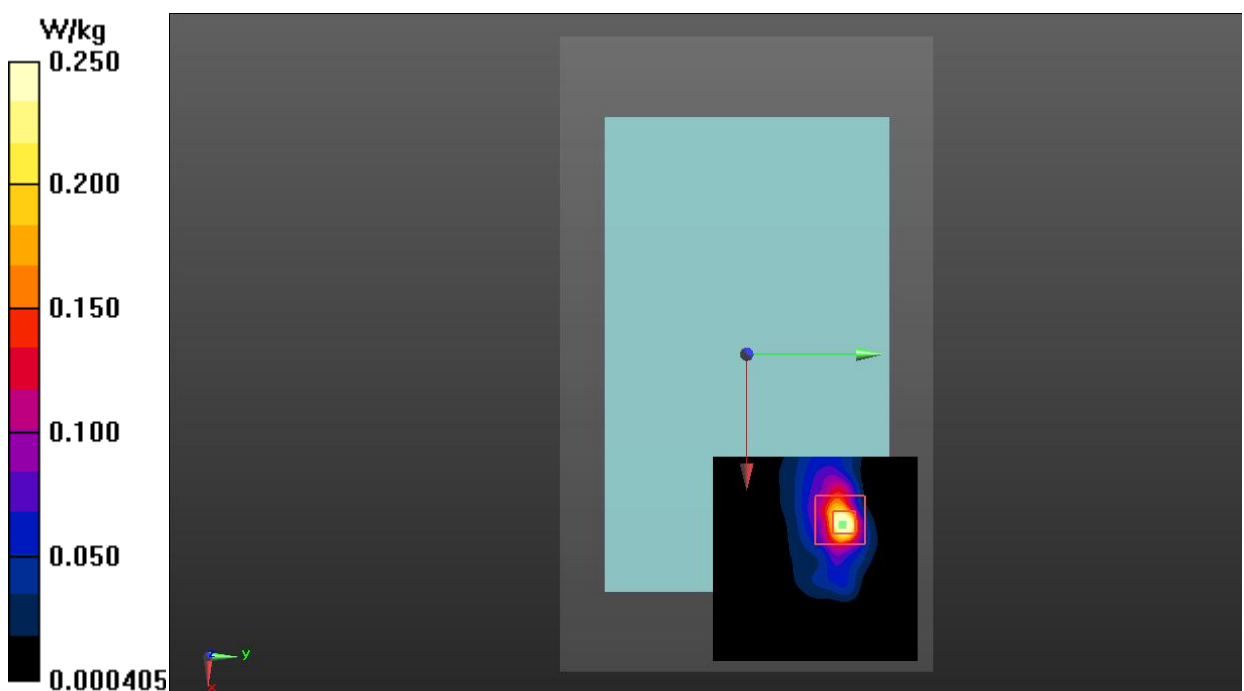


Fig.1 Bluetooth Body

WLAN 2.4G Body

Date: 2021-3-28

Electronics: DAE4 Sn1527

Medium: Head 2450MHz

Medium parameters used (interpolated): $f = 2437$ MHz; $\sigma = 1.823$ S/m; $\epsilon_r = 38.506$; $\rho = 1000$ kg/m³

Communication System: UID 0, WiFi (0) Frequency: 2437 MHz Duty Cycle: 1:1

Probe: EX3DV4 - SN3633 ConvF (7.43, 7.43, 7.43)

Rear Side Middle/Area Scan (91x91x1): Interpolated grid: $dx=1.000$ mm, $dy=1.000$ mm

Maximum value of SAR (interpolated) = 1.40 W/kg

Rear Side Middle/Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 2.332 V/m; Power Drift = 0.07 dB

Peak SAR (extrapolated) = 3.21 W/kg

SAR(1 g) = 1.08 W/kg; SAR(10 g) = 0.443 W/kg

Maximum value of SAR (measured) = 1.92 W/kg

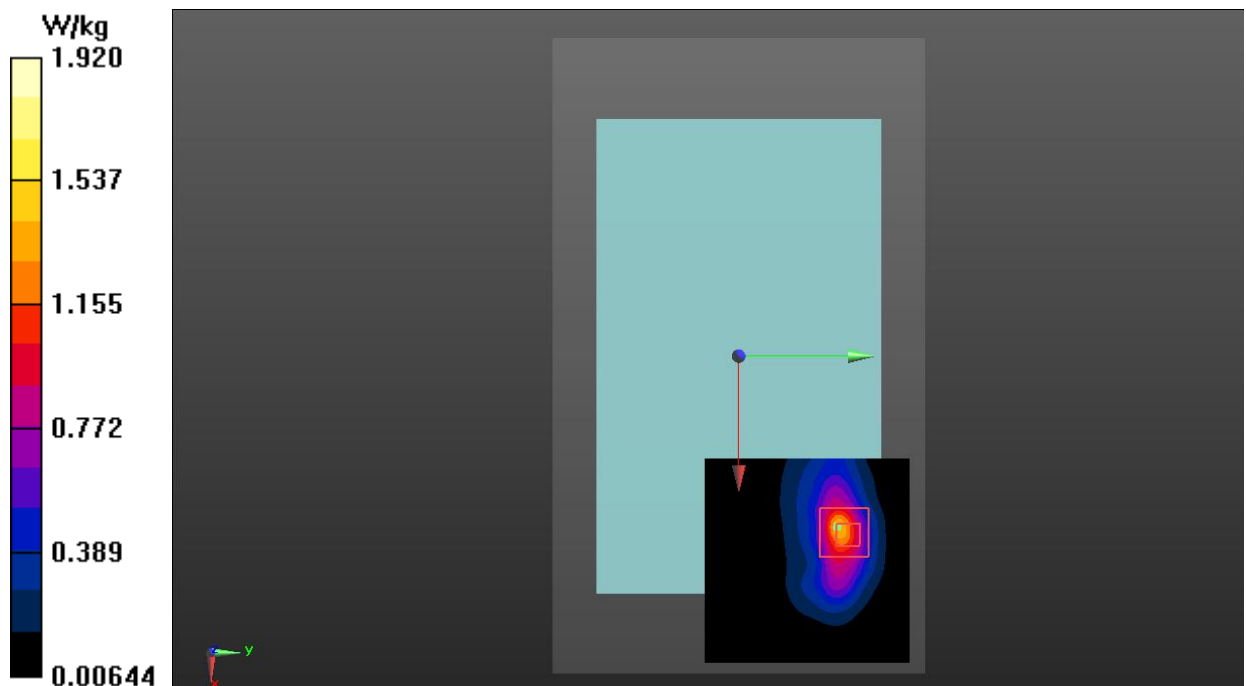


Fig.2 WLAN 2.4G Body

WLAN 5G Body

Date: 2021-3-27

Electronics: DAE4 Sn1527

Medium: Head 5250MHz

Medium parameters used: $f = 5260$ MHz; $\sigma = 4.656$ S/m; $\epsilon_r = 36.526$; $\rho = 1000$ kg/m³

Communication System: UID 0, WiFi (0) Frequency: 5260 MHz Duty Cycle: 1:1

Probe: EX3DV4 – SN3633 ConvF (5.47, 5.47, 5.47);

Top Side CH52/Area Scan (81x61x1): Interpolated grid: $dx=1.000$ mm, $dy=1.000$ mm

Maximum value of SAR (interpolated) = 1.32 W/kg

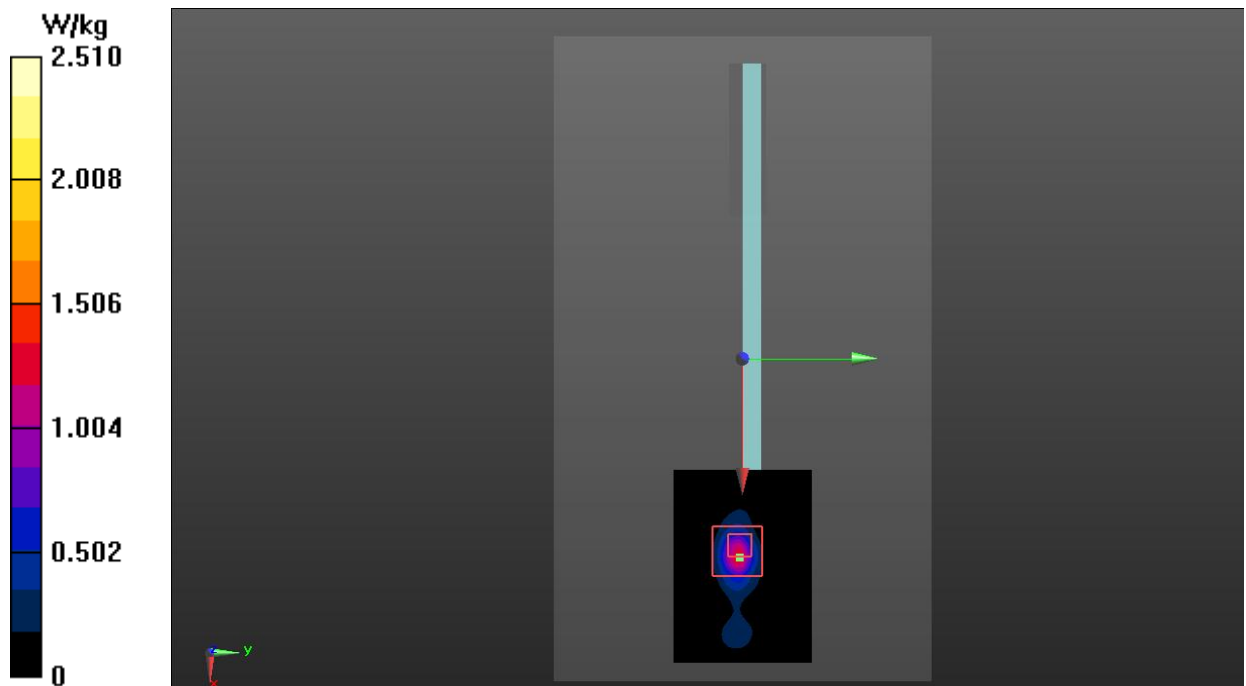
Top Side CH52/Zoom Scan (8x8x21)/Cube 0: Measurement grid: $dx=4$ mm, $dy=4$ mm, $dz=1.4$ mm

Reference Value = 1.580 V/m; Power Drift = 0.09 dB

Peak SAR (extrapolated) = 5.79 W/kg

SAR(1 g) = 1.02 W/kg; SAR(10 g) = 0.214 W/kg

Maximum value of SAR (measured) = 2.51 W/kg

**Fig.3 WLAN 5G Body**

ANNEX B: SystemVerification Results

2450MHz

Date: 2021-3-28

Electronics: DAE4 Sn1527

Medium: Head 2450MHz

Medium parameters used: $f = 2450 \text{ MHz}$; $\sigma = 1.838 \text{ S/m}$; $\epsilon_r = 38.464$; $\rho = 1000 \text{ kg/m}^3$

Communication System: CW_TMC Frequency: 2450 MHz Duty Cycle: 1:1

Probe: EX3DV4 – SN3633 ConvF (7.43, 7.43, 7.43);

System Validation/Area Scan (81x121x1): Interpolated grid: $dx=1.000 \text{ mm}$, $dy=1.000 \text{ mm}$

Reference Value = 86.062 V/m; Power Drift = 0.12 dB

SAR(1 g) = 13.5 W/kg; SAR(10 g) = 6.14 W/kg

Maximum value of SAR (interpolated) = 15.4 W/kg

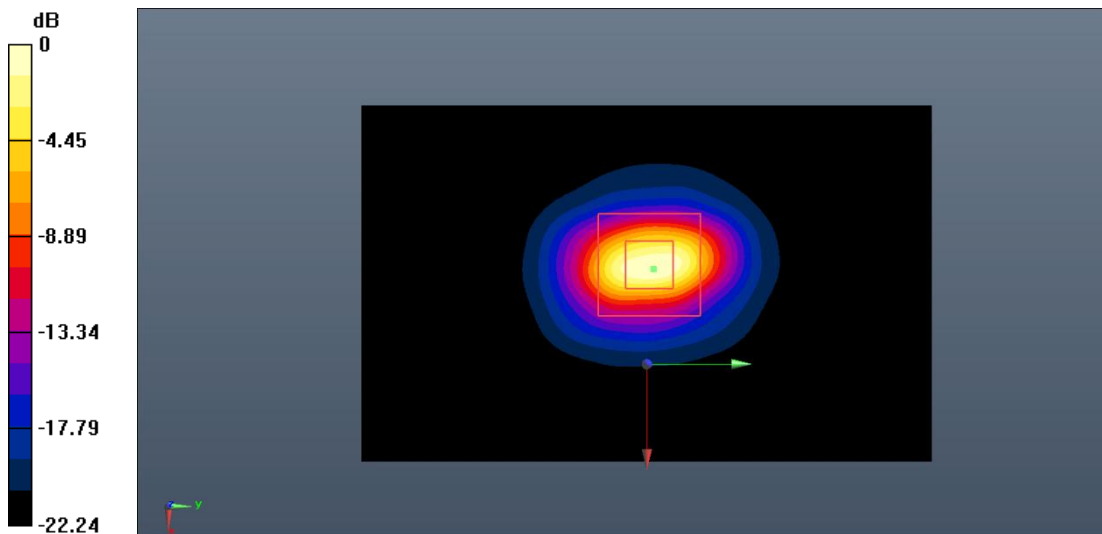
System Validation/Zoom Scan (7x7x7)/Cube0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 86.062 V/m; Power Drift = 0.12 dB

Peak SAR (extrapolated) = 27.3 W/kg

SAR(1 g) = 13.6 W/kg; SAR(10 g) = 6.22 W/kg

Maximum value of SAR (measured) = 15.7 W/kg



0 dB = 15.7 W/kg = 11.96 dB W/kg

Fig.B.1. Validation 2450MHz 250mW

5250MHz

Date: 2021-3-27

Electronics: DAE4 Sn1527

Medium: Head 5250MHz

Medium parameters used: $f = 5250 \text{ MHz}$; $\sigma = 4.642 \text{ S/m}$; $\epsilon_r = 36.55$; $\rho = 1000 \text{ kg/m}^3$

Communication System: CW Frequency: 5250 MHz Duty Cycle: 1:1

Probe: EX3DV4 – SN3633 ConvF (5.47, 5.47, 5.47);

System Validation/Area Scan (61x91x1): Interpolated grid: $dx=1.000 \text{ mm}$, $dy=1.000 \text{ mm}$

Reference Value = 62.925 V/m; Power Drift = -0.08 dB

SAR(1 g) = 7.61 W/kg; SAR(10 g) = 2.19 W/kg

Maximum value of SAR (interpolated) = 9.84 W/kg

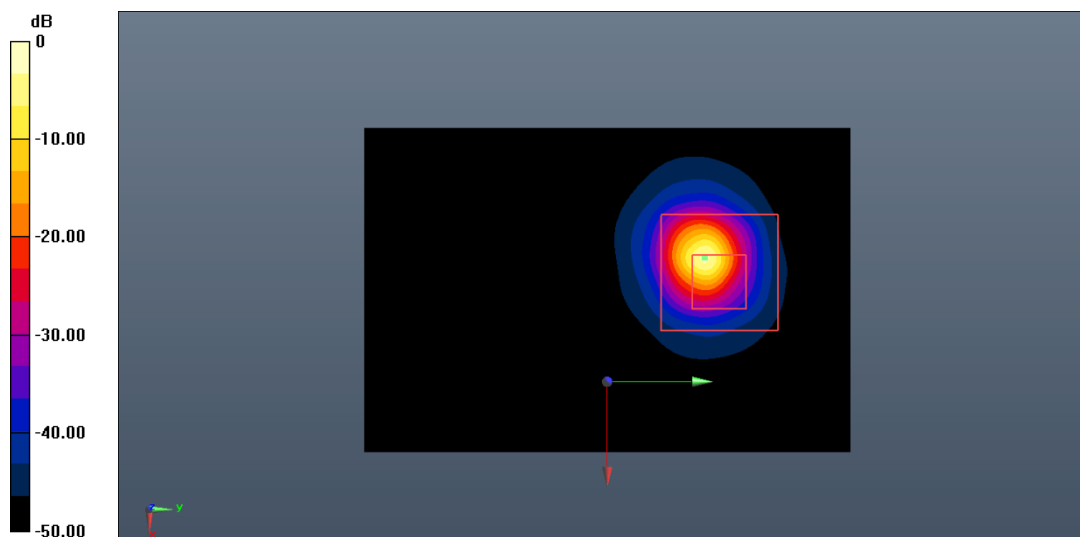
System Validation/Zoom Scan (8x8x21)/Cube0: Measurement grid: $dx=4\text{mm}$, $dy=4\text{mm}$, $dz=1.4\text{mm}$

Reference Value = 62.925 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 23.7 W/kg

SAR(1 g) = 7.42 W/kg; SAR(10 g) = 2.16 W/kg

Maximum value of SAR (measured) = 9.76 W/kg



0 dB = 9.76 W/kg = 9.89 dB W/kg

Fig.B.2. Validation 5250MHz 100mW

5750MHz

Date: 2021-3-27

Electronics: DAE4 Sn1527

Medium: Head 5750 MHz

Medium parameters used: $f = 5750$ MHz; $\sigma = 5.307$ S/m; $\epsilon_r = 34.422$; $\rho = 1000$ kg/m³

Communication System: CW Frequency: 5750 MHz Duty Cycle: 1:1

Probe: EX3DV4 – SN3633 ConvF (4.73, 4.73, 4.73);

System Validation/Area Scan (61x91x1): Interpolated grid: $dx=1.000$ mm, $dy=1.000$ mm

Reference Value = 66.765 V/m; Power Drift = 0.06 dB

SAR(1 g) = 7.86 W/kg; SAR(10 g) = 2.22 W/kg

Maximum value of SAR (interpolated) = 9.94 W/kg

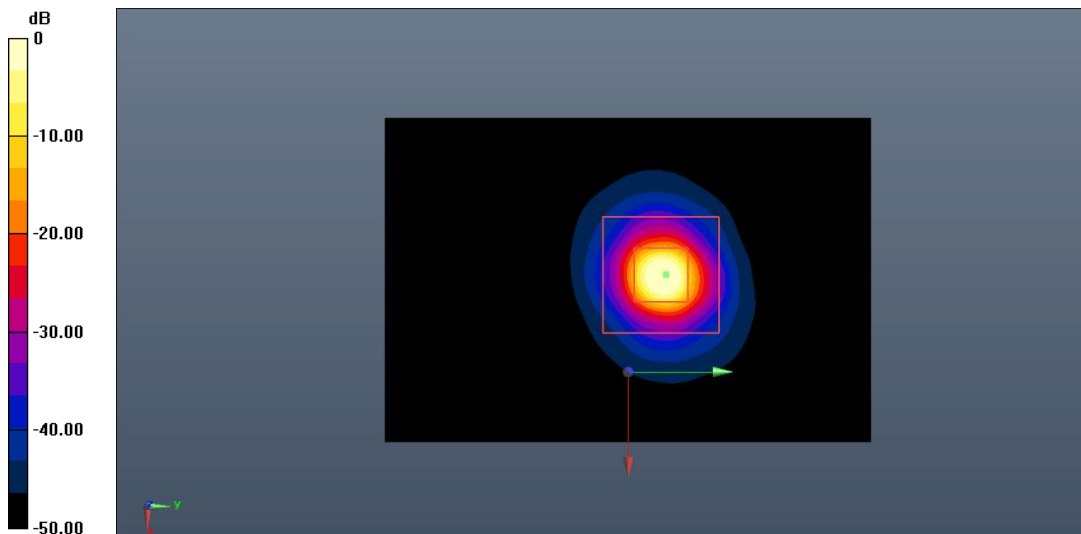
System Validation/Zoom Scan (8x8x21)/Cube0: Measurement grid: $dx=4$ mm, $dy=4$ mm, $dz=1.4$ mm

Reference Value = 66.765 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 27.1 W/kg

SAR(1 g) = 8.03 W/kg; SAR(10 g) = 2.25 W/kg

Maximum value of SAR (measured) = 10.2 W/kg



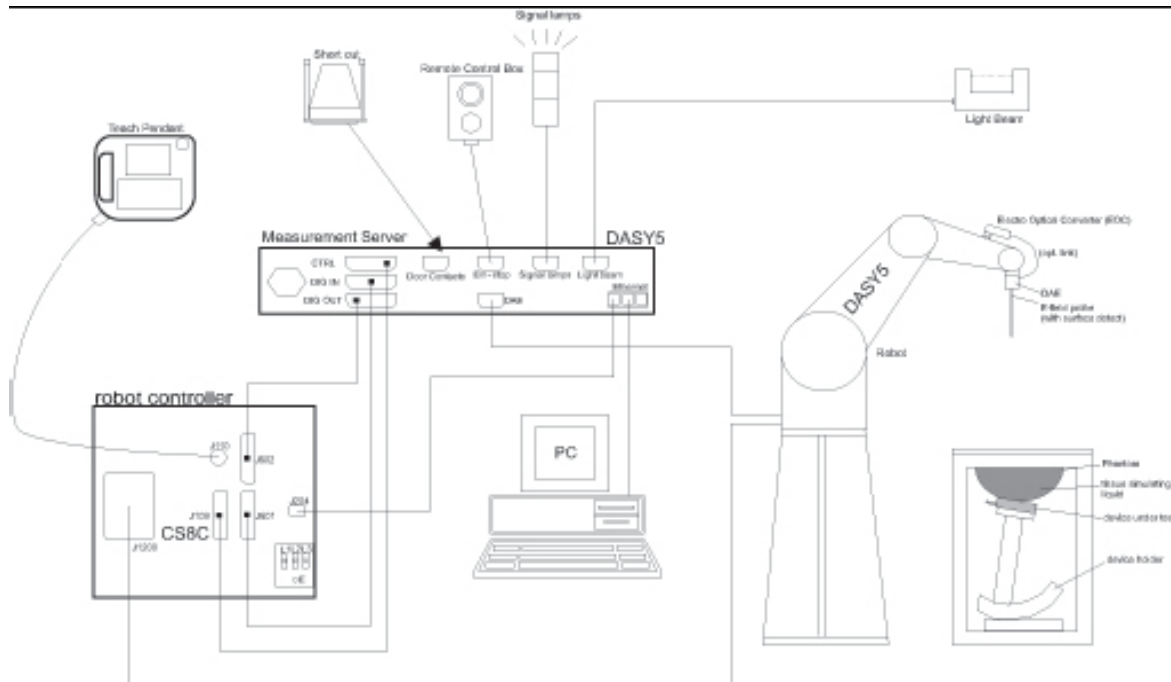
0 dB = 10.2 W/kg = 10.09 dB W/kg

Fig.B.3. Validation 5750MHz 100mW

ANNEX C: SAR Measurement Setup

C.1. Measurement Set-up

DASY5 system for performing compliance tests is illustrated above graphically. This system consists of the following items:



Picture C.1 SAR Lab Test Measurement Set-up

- A standard high precision 6-axis robot (Stäubli TX=RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running WinXP and the DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as
- warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.

C.2. DASY5 E-field Probe System

The SAR measurements were conducted with the dosimetric probe designed in the classical triangular configuration and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multifiber line ending at the front of the probe tip. It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface. Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY5 software reads the reflection during a software approach and looks for the maximum using 2nd order curve fitting. The approach is stopped at reaching the maximum.

Probe Specifications:

Model:	ES3DV3, EX3DV4
Frequency	10MHz — 6.0GHz(EX3DV4)
Range:	10MHz — 4GHz(ES3DV3)
Calibration:	In head and body simulating tissue at Frequencies from 835 up to 5800MHz
Linearity:	± 0.2 dB(30 MHz to 6 GHz) for EX3DV4 ± 0.2 dB(30 MHz to 4 GHz) for ES3DV3
Dynamic Range:	10 mW/kg — 100W/kg
Probe Length:	330 mm
Probe Tip	
Length:	20 mm
Body Diameter:	12 mm
Tip Diameter:	2.5 mm (3.9 mm for ES3DV3)
Tip-Center:	1 mm (2.0mm for ES3DV3)
Application:	SAR Dosimetry Testing Compliance tests of mobile phones Dosimetry in strong gradient fields



Picture C.2 Near-field Probe



Picture C.3 E-field Probe

C.3. E-field Probe Calibration

Each E-Probe/Probe Amplifier combination has unique calibration parameters. A TEM cell calibration procedure is conducted to determine the proper amplifier settings to enter in the probe parameters. The amplifier settings are determined for a given frequency by subjecting the probe to a known E-field density (1 mW/cm²) using an RF Signal generator, TEM cell, and RF Power Meter.

The free space E-field from amplified probe outputs is determined in a test chamber. This calibration can be performed in a TEM cell if the frequency is below 1 GHz and in a waveguide or other methodologies above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is then rotated 360 degrees until the three channels show the maximum reading. The power density readings equate to 1 mW/cm².

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue. The E-field in the medium correlates with the temperature rise in the dielectric medium. For temperature correlation calibration a RF transparent thermistor-based temperature probe is used in conjunction with the E-field probe.

$$SAR = C \frac{\Delta T}{\Delta t}$$

Where:

Δt = Exposure time (30 seconds),

C = Heat capacity of tissue (brain or muscle),

ΔT = Temperature increase due to RF exposure.

$$SAR = \frac{|E|^2 \cdot \sigma}{\rho}$$

Where:

σ = Simulated tissue conductivity,

ρ = Tissue density (kg/m³).

C.4. Other Test Equipment

C.4.1. Data Acquisition Electronics (DAE)

The data acquisition electronics consist 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 with a control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information, as well as an optical uplink for commands and the clock.

The mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection.

The input impedance of the DAE is 200 MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.



PictureC.4: DAE

C.4.2. Robot

The SPEAG DASY system uses the high precision robots (DASY5: RX160L) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version from Stäubli is used. The Stäubli robot series have many features that are important for our application:

- High precision (repeatability 0.02mm)
- High reliability (industrial design)
- Low maintenance costs (virtually maintenance free due to direct drive gears; no belt drives)
- Jerk-free straight movements (brushless synchron motors; no stepper motors)
- Low ELF interference (motor control fields shielded via the closed metallic construction shields)



Picture C.5 DASY 5

C.4.3. Measurement Server

The Measurement server is based on a PC/104 CPU board with CPU (DASY5: 400 MHz, Intel Celeron), chipdisk (DASY5:128MB), RAM (DASY5:128MB). The necessary circuits for communication with the DAE electronic box, as well as the 16 bit AD converter system for optical detection and digital I/O interface are contained on the DASY I/O board, which is directly connected to the PC/104 bus of the CPU board.

The measurement server performs all real-time data evaluation of field measurements and surface detection, controls robot movements and handles safety operation. The PC operating system cannot interfere with these time critical processes. All connections are supervised by a watchdog, and disconnection of any of the cables to the measurement server will automatically disarm the robot and disable all program-controlled robot movements. Furthermore, the measurement server is equipped with an expansion port which is reserved for future applications. Please note that this expansion port does not have a standardized pinout, and therefore only devices provided by SPEAG can be connected. Devices from any other supplier could seriously damage the measurement server.



Picture C.6 Server for DASY 5

C.4.4. Device Holder for Phantom

The SAR in the phantom is approximately inversely proportional to the square of the distance between the source and the liquid surface. For a source at 5mm distance, a positioning uncertainty of $\pm 0.5\text{mm}$ would produce a SAR uncertainty of $\pm 20\%$. Accurate device positioning is therefore crucial for accurate and repeatable measurements. The positions in which the devices must be measured are defined by the standards.

The DASY device holder is designed to cope with the different positions given in the standard. It has two scales for device rotation (with respect to the body axis) and device inclination (with respect to the line between the ear reference points). The rotation centers for both scales is the ear reference point (ERP). Thus the device needs no repositioning when changing the angles.

The DASY device holder is constructed of low-loss POM material having the following dielectric

parameters: relative permittivity $\epsilon = 3$ and loss tangent $\delta = 0.02$. The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.

<Laptop Extension Kit>

The extension is lightweight and made of POM, acrylic glass and foam. It fits easily on the upper part of the Mounting Device in place of the phone positioner. The extension is fully compatible with the Twin-SAM and ELI phantoms.



Picture C.7-1: Device Holder



Picture C.7-2: Laptop Extension Kit

C.4.5. Phantom

The SAM Twin Phantom V4.0 is constructed of a fiberglass shell integrated in a table. The shape of the shell is based on data from an anatomical study designed to represent the 90th percentile of the population. The phantom enables the dissymmetric evaluation of SAR for both left and right handed handset usage, as well as body-worn usage using the flat phantom region. Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot. The shell phantom has a 2mm shell thickness (except the ear region where shell thickness increases to 6 mm).

Shell Thickness: 2 ± 0.2 mm
 Filling Volume: Approx. 25 liters
 Dimensions: 810 x 1000 x 500 mm (H x L x W)
 Available: Special

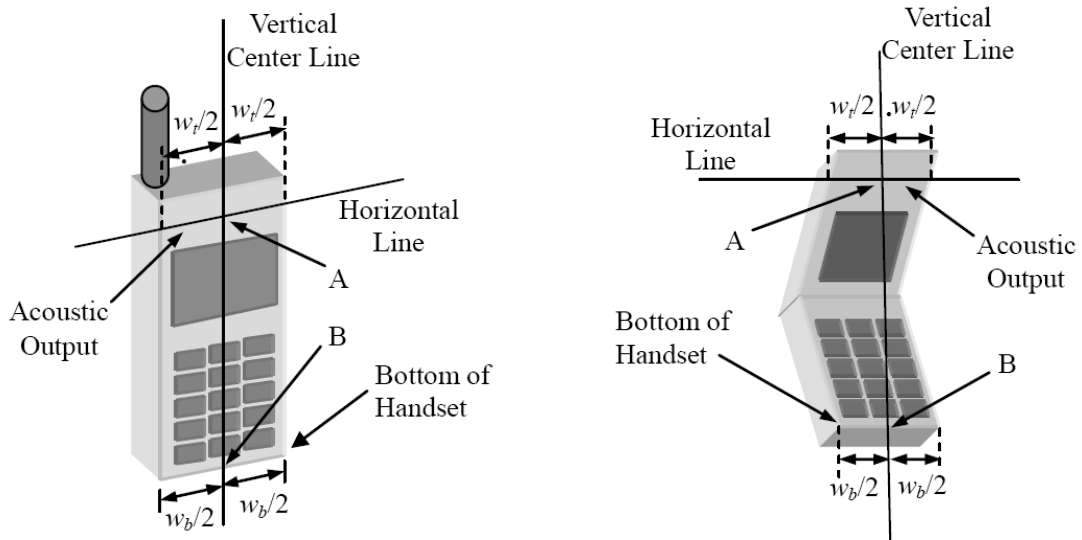


Picture C.8: SAM Twin Phantom

ANNEX D: Position of the wireless device in relation to the phantom

D.1. General considerations

This standard specifies two handset test positions against the head phantom – the “cheek” position and the “tilt” position.



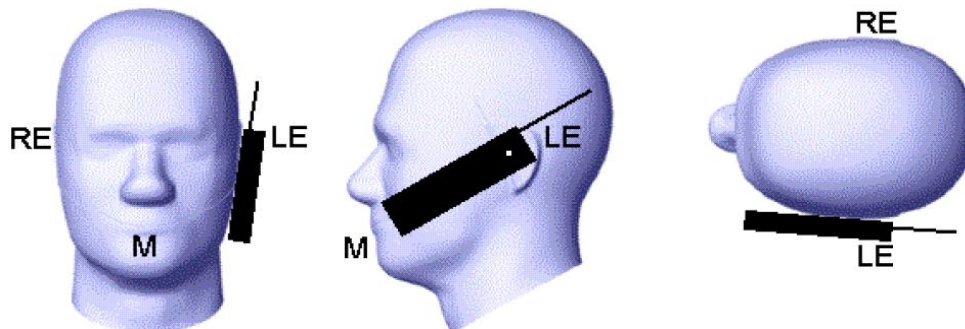
w_t Width of the handset at the level of the acoustic

w_b Width of the bottom of the handset

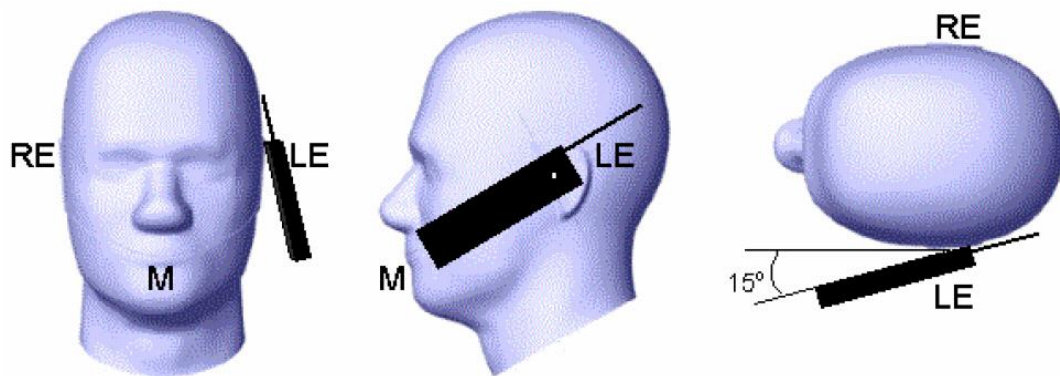
A Midpoint of the width w_t of the handset at the level of the acoustic output

B Midpoint of the width w_b of the bottom of the handset

Picture D.1-a Typical “fixed” case handset Picture D.1-b Typical “clam-shell” case handset



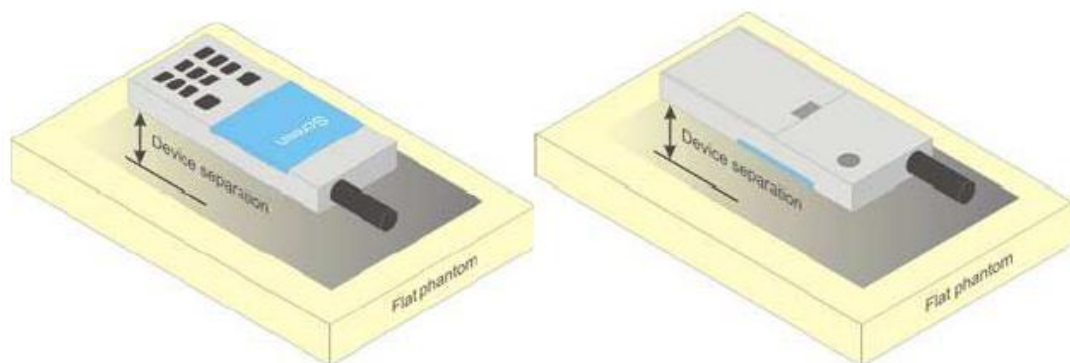
Picture D.2 Cheek position of the wireless device on the left side of SAM



Picture D.3 Tilt position of the wireless device on the left side of SAM

D.2. Body-worn device

A typical example of a body-worn device is a mobile phone, wireless enabled PDA or other battery operated wireless device with the ability to transmit while mounted on a person's body using a carry accessory approved by the wireless device manufacturer.

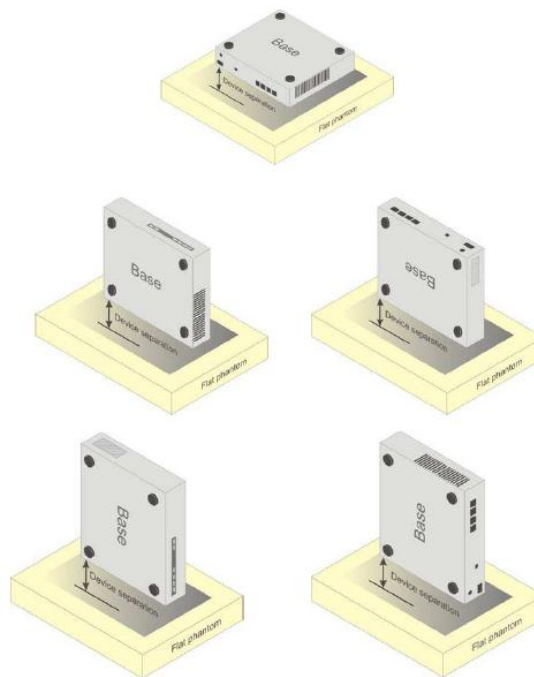


Picture D.4 Test positions for body-worn devices

D.3. Desktop device

A typical example of a desktop device is a wireless enabled desktop computer placed on a table or desk when used.

The DUT shall be positioned at the distance and in the orientation to the phantom that corresponds to the intended use as specified by the manufacturer in the user instructions. For devices that employ an external antenna with variable positions, tests shall be performed for all antenna positions specified. Picture 8.5 show positions for desktop device SAR tests. If the intended use is not specified, the device shall be tested directly against the flat phantom.



Picture D.5 Test positions for desktop devices

D.4. DUT Setup Photos



Picture D.6

ANNEX E: Equivalent Media Recipes

The liquid used for the frequency range of 700-6000 MHz consisted of water, sugar, salt, preventol, glycol monobutyl and Cellulose. The liquid has been previously proven to be suited for worst-case. The Table E.1 shows the detail solution. It's satisfying the latest tissue dielectric parameters requirements proposed by the IEEE 1528 and IEC 62209.

Table E.1: Composition of the Tissue Equivalent Matter

Frequency (MHz)	835 Head	835 Body	1900 Head	1900 Body	2450 Head	2450 Body	5800 Head	5800 Body
Ingredients (% by weight)								
Water	41.45	52.5	55.242	69.91	58.79	72.60	65.53	65.53
Sugar	56.0	45.0	\	\	\	\	\	\
Salt	1.45	1.4	0.306	0.13	0.06	0.18	\	\
Preventol	0.1	0.1	\	\	\	\	\	\
Cellulose	1.0	1.0	\	\	\	\	\	\
Glycol Monobutyl	\	\	44.452	29.96	41.15	27.22	\	\
Diethylenglycol monohexylether	\	\	\	\	\	\	17.24	17.24
Triton X-100	\	\	\	\	\	\	17.24	17.24
Dielectric Parameters Target Value	$\epsilon=41.5$ $\sigma=0.90$	$\epsilon=55.2$ $\sigma=0.97$	$\epsilon=40.0$ $\sigma=1.40$	$\epsilon=53.3$ $\sigma=1.52$	$\epsilon=39.2$ $\sigma=1.80$	$\epsilon=52.7$ $\sigma=1.95$	$\epsilon=35.3$ $\sigma=5.27$	$\epsilon=48.2$ $\sigma=6.00$

Note: There is a little adjustment respectively for 750, 1800, 2600, 5200, 5300, and 5600, based on the recipe of closest frequency in table E.1

ANNEX F: System Validation

The SAR system must be validated against its performance specifications before it is deployed. When SAR probes, system components or software are changed, upgraded or recalibrated, these must be validated with the SAR system(s) that operates with such components.

Table F.1: System Validation

Probe SN.	Liquid name	Validation date	Frequency point	Status (OK or Not)
3633	Head 750MHz	2020-04-03	750 MHz	OK
3633	Head 900MHz	2020-04-03	900 MHz	OK
3633	Head 1750MHz	2020-04-03	1750 MHz	OK
3633	Head 1900MHz	2020-04-03	1900 MHz	OK
3633	Head 2300MHz	2020-04-04	2300 MHz	OK
3633	Head 2450MHz	2020-04-04	2450 MHz	OK
3633	Head 2550MHz	2020-04-04	2550 MHz	OK
3633	Head 5200MHz	2020-04-05	5250 MHz	OK
3633	Head 5600MHz	2020-04-05	5600 MHz	OK
3633	Head 5750MHz	2020-04-05	5750 MHz	OK



No. I21N00742-SAR

ANNEX G: DAE Calibration Certificate

DAE4 SN: 1527 Calibration Certificate



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校准
CALIBRATION
CNAS L0570

Client : **CTTL(South Branch)**

Certificate No: **Z20-60433**

CALIBRATION CERTIFICATE

Object **DAE4 - SN: 1527**

Calibration Procedure(s) **FF-Z11-002-01**
Calibration Procedure for the Data Acquisition Electronics (DAEx)

Calibration date: **November 06, 2020**

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	16-Jun-20 (CTTL, No.J20X04342)	Jun-21
------------------------	---------	--------------------------------	--------

	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 08, 2020

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

Certificate No: Z20-60433

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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.



No. I21N00742-SAR



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DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = $6.1\mu\text{V}$, full range = $-100\dots+300\text{ mV}$

Low Range: 1LSB = 61nV , full range = $-1\dots+3\text{mV}$

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Calibration Factors	X	Y	Z
High Range	$403.863 \pm 0.15\% (k=2)$	$403.582 \pm 0.15\% (k=2)$	$403.801 \pm 0.15\% (k=2)$
Low Range	$3.95875 \pm 0.7\% (k=2)$	$3.98892 \pm 0.7\% (k=2)$	$3.96720 \pm 0.7\% (k=2)$

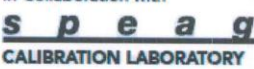
Connector Angle

Connector Angle to be used in DASY system	$223.5^\circ \pm 1^\circ$
---	---------------------------



No. I21N00742-SAR

ANNEX H: Probe Calibration Certificate**Probe EX3DV4-SN: 3633 Calibration Certificate**

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Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China Tel: +86-10-62304633-2512 Fax: +86-10-62304633-2504 E-mail: cttl@chinattl.com Http://www.chinattl.cn		
Client	CTTL(South Branch)	Certificate No: Z20-60108
CALIBRATION CERTIFICATE		
Object	EX3DV4 - SN : 3633	
Calibration Procedure(s)	FF-Z11-004-01 Calibration Procedures for Dosimetric E-field Probes	
Calibration date:	April 01, 2020	
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.)
Power Meter NRP2	101919	18-Jun-19(CTTL, No.J19X05125)
Power sensor NRP-Z91	101547	18-Jun-19(CTTL, No.J19X05125)
Power sensor NRP-Z91	101548	18-Jun-19(CTTL, No.J19X05125)
Reference 10dBAttenuator	18N50W-10dB	10-Feb-20(CTTL, No.J20X00525)
Reference 20dBAttenuator	18N50W-20dB	10-Feb-20(CTTL, No.J20X00526)
Reference Probe EX3DV4	SN 7307	24-May-19(SPEAG, No.EX3-7307_May19/2)
DAE4	SN 1525	26-Aug-19(SPEAG, No.DAE4-1525_Aug19)
Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)
SignalGenerator MG3700A	6201052605	18-Jun-19(CTTL, No.J19X05127)
Network Analyzer E5071C	MY46110673	10-Feb-20(CTTL, No.J20X00515)
Calibrated by:	Name	Function
	Yu Zongying	SAR Test Engineer
Reviewed by:	Lin Hao	SAR Test Engineer
Approved by:	Qi Dianyuan	SAR Project Leader
Issued: April 03, 2020 This calibration certificate shall not be reproduced except in full without written approval of the laboratory.		

Certificate No: Z20-60108

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Glossary:

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,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 $\theta=0$ 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:

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

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}: Assessed for E-field polarization $\theta=0$ ($f \leq 900\text{MHz}$ in TEM-cell; $f > 1800\text{MHz}$: waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not effect the E^2 -field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z} = NORM_{x,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.
- DCP_{x,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.
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; VR_{x,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 $f \leq 800\text{MHz}$) and inside waveguide using analytical field distributions based on power measurements for $f > 800\text{MHz}$. 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 NORM_{x,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 $\pm 50\text{MHz}$ to $\pm 100\text{MHz}$.
- 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 NORM_x (no uncertainty required).

Certificate No:Z20-60108

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DASY/EASY – Parameters of Probe: EX3DV4 – SN:3633

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.37	0.37	0.39	$\pm 10.0\%$
DCP(mV) ^B	98.2	98.8	98.0	

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	141.5	$\pm 2.3\%$
		Y	0.0	0.0	1.0		141.5	
		Z	0.0	0.0	1.0		141.9	

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 E²-field uncertainty inside TSL (see Page 4 and Page 5).

^B Numerical linearization parameter: uncertainty not required.

^E Uncertainty 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: EX3DV4 – SN: 3633

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	9.59	9.59	9.59	0.40	0.75	± 12.1%
900	41.5	0.97	9.33	9.33	9.33	0.21	1.14	± 12.1%
1640	40.3	1.29	8.17	8.17	8.17	0.16	1.22	± 12.1%
1750	40.1	1.37	8.09	8.09	8.09	0.15	1.42	± 12.1%
1900	40.0	1.40	7.76	7.76	7.76	0.19	1.14	± 12.1%
2100	39.8	1.49	7.73	7.73	7.73	0.18	1.26	± 12.1%
2300	39.5	1.67	7.69	7.69	7.69	0.48	0.78	± 12.1%
2450	39.2	1.80	7.43	7.43	7.43	0.50	0.77	± 12.1%
2600	39.0	1.96	7.20	7.20	7.20	0.58	0.72	± 12.1%
3500	37.9	2.91	6.88	6.88	6.88	0.35	1.23	± 13.3%
3700	37.7	3.12	6.57	6.57	6.57	0.44	0.98	± 13.3%
3900	37.5	3.32	6.51	6.51	6.51	0.35	1.40	± 13.3%
4100	37.2	3.53	6.44	6.44	6.44	0.40	1.20	± 13.3%
4400	36.9	3.84	6.30	6.30	6.30	0.35	1.35	± 13.3%
4600	36.7	4.04	6.10	6.10	6.10	0.45	1.40	± 13.3%
4800	36.4	4.25	5.98	5.98	5.98	0.45	1.60	± 13.3%
4950	36.3	4.40	5.80	5.80	5.80	0.45	1.45	± 13.3%
5250	35.9	4.71	5.47	5.47	5.47	0.45	1.25	± 13.3%
5600	35.5	5.07	4.72	4.72	4.72	0.45	1.50	± 13.3%
5750	35.4	5.22	4.73	4.73	4.73	0.45	1.50	± 13.3%

^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: EX3DV4 – SN: 3633

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	9.57	9.57	9.57	0.40	0.80	±12.1%
900	55.0	1.05	9.34	9.34	9.34	0.25	1.11	±12.1%
1640	53.8	1.40	8.05	8.05	8.05	0.22	1.19	±12.1%
1750	53.4	1.49	7.85	7.85	7.85	0.16	1.35	±12.1%
1900	53.3	1.52	7.66	7.66	7.66	0.17	1.32	±12.1%
2100	53.2	1.62	7.69	7.69	7.69	0.21	1.30	±12.1%
2300	52.9	1.81	7.61	7.61	7.61	0.50	0.86	±12.1%
2450	52.7	1.95	7.56	7.56	7.56	0.50	0.83	±12.1%
2600	52.5	2.16	7.33	7.33	7.33	0.59	0.74	±12.1%
3500	52.3	3.31	6.28	6.28	6.28	0.40	1.30	±13.3%
3700	52.1	3.55	6.14	6.14	6.14	0.40	1.35	±13.3%
3900	50.8	3.78	6.13	6.13	6.13	0.40	1.45	±13.3%
4100	50.5	4.01	6.12	6.12	6.12	0.35	1.40	±13.3%
4400	50.1	4.37	5.93	5.93	5.93	0.35	1.70	±13.3%
4600	49.8	4.60	5.60	5.60	5.60	0.45	1.50	±13.3%
4800	49.6	4.83	5.42	5.42	5.42	0.45	1.60	±13.3%
4950	49.4	5.01	5.22	5.22	5.22	0.45	1.70	±13.3%
5250	48.9	5.36	5.04	5.04	5.04	0.50	1.45	±13.3%
5600	48.5	5.77	4.16	4.16	4.16	0.55	1.50	±13.3%
5750	48.3	5.94	4.26	4.26	4.26	0.55	1.60	±13.3%

^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.

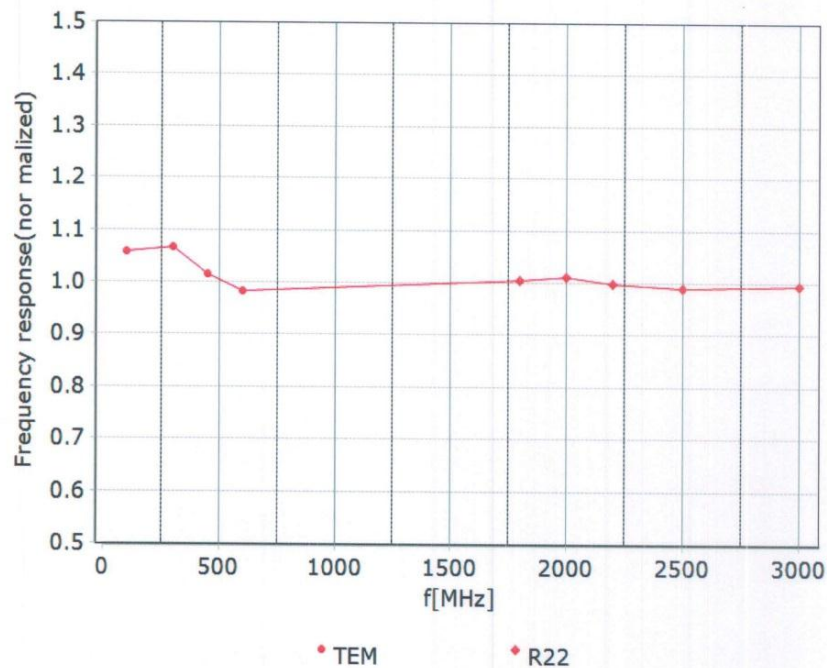
^F At frequency below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ±10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ±5%. The uncertainty is the RSS of the ConvF uncertainty 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: $\pm 7.4\%$ (k=2)