SAR TEST REPORT

Test Report No.: 14498715H-I-R1

Customer	**Keyence Corporation**
Description of EUT	**Communication module**
Model Number of EUT	**LBEE5HY1MW**
FCC ID	**RF41675A**
Test Regulation	**FCC47CFR 2.1093**
Test Result	**Complied (Refer to SECTION 4)**
Issue Date	**February 8, 2023**
Remarks	**The highest reported SAR (1 g)** Body : 0.67 W/kg

Representative Test Engineer	**Approved By**
Hisayoshi Sato Engineer	Satofumi Matsuyama Engineer

CERTIFICATE 5107.02

☐ The testing in which "Non-accreditation" is displayed is outside the accreditation scopes in UL Japan, Inc.
☒ There is no testing item of "Non-accreditation".

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- The information provided from the customer for this report is identified in Section 1.
- For test report(s) referred in this report, the latest version (including any revisions) is always referred.

REVISION HISTORY

Original Test Report No.: 14498715H-I

This report is a revised version of 14498715H-I. 14498715H-I is replaced with this report.

Revision	Test report No.	Date	Page Revised Contents
- (Original)	14498715H-I	November 28, 2022	-
1	14498715H-I-R1	February 8, 2023	Correction of the Antenna Gain in Radio Specification of SECTION 2.2; - WLAN (IEEE802.11b/11g/11n-20): from 1.8 dBi to 2.1 dBi - WLAN (IEEE802.11a/11n-20): from 0.5 dBi to 3.5 dBi - Bluetooth (BR / EDR): from 1.8 dBi to 2.1 dBi
1	14498715H-I-R1	February 8, 2023	Addition of the following sentence in SECTION 5; Power setting values adjusted to be within -2 dB of the Maximum Tune-up tolerance limit, and are not the power setting values of the final product.

Reference: Abbreviations (Including words undescribed in this report)

AAN	Asymmetric Artificial Network	GPS	Global Positioning System
AC	Alternating Current	Hori.	Horizontal
AM	Amplitude Modulation	ICES	Interference-Causing Equipment Standard
AMN	Artificial Mains Network	I/O	Input/Output
Amp, AMP	Amplifier	IEC	International Electrotechnical Commission
ANSI	American National Standards Institute	IEEE	Institute of Electrical and Electronics Engineers
Ant, ANT	Antenna	IF	Intermediate Frequency
AP	Access Point	ILAC	International Laboratory Accreditation Conference
ASK	Amplitude Shift Keying	ISED	Innovation, Science and Economic Development Canada
Atten., ATT	Attenuator	ISN	Impedance Stabilization Network
AV	Average	ISO	International Organization for Standardization
BPSK	Binary Phase-Shift Keying	JAB	Japan Accreditation Board
BR	Bluetooth Basic Rate	LAN	Local Area Network
BT	Bluetooth	LCL	Longitudinal Conversion Loss
BT LE	Bluetooth Low Energy	LIMS	Laboratory Information Management System
BW	BandWidth	LISN	Line Impedance Stabilization Network
C.F	Correction Factor	MRA	Mutual Recognition Arrangement
Cal Int	Calibration Interval	N/A	Not Applicable
CAV	CISPR AV	NIST	National Institute of Standards and Technology
CCK	Complementary Code Keying	NS	No signal detect.
CDN	Coupling Decoupling Network	NSA	Normalized Site Attenuation
Ch., CH	Channel	OBW	Occupied BandWidth
CISPR	Comite International Special des Perturbations Radioelectriques	OFDM	Orthogonal Frequency Division Multiplexing
Corr.	Correction	PER	Packet Error Rate
CPE	Customer premise equipment	PK	Peak
CW	Continuous Wave	P_{LT}	long-term flicker severity
DBPSK	Differential BPSK	POHC(A)	Partial Odd Harmonic Current
DC	Direct Current	Pol., Pola.	Polarization
DET	Detector	PR-ASK	Phase Reversal ASK
D-factor	Distance factor	P_{ST}	short-term flicker severity
Dmax	maximum absolute voltage change during an observation period	QAM	Quadrature Amplitude Modulation
DQPSK	Differential QPSK	QP	Quasi-Peak
DSSS	Direct Sequence Spread Spectrum	QPSK	Quadrature Phase Shift Keying
DUT	Device Under Test	r.m.s., RMS	Root Mean Square
EDR	Enhanced Data Rate	RBW	Resolution BandWidth
e.i.r.p., EIRP	Equivalent Isotropically Radiated Power	RE	Radio Equipment
EM clamp	Electromagnetic clamp	REV	Reverse
EMC	ElectroMagnetic Compatibility	RF	Radio Frequency
EMI	ElectroMagnetic Interference	RFID	Radio Frequency Identifier
EMS	ElectroMagnetic Susceptibility	RNSS	Radio Navigation Satellite Service
EN	European Norm	RSS	Radio Standards Specifications
e.r.p., ERP	Effective Radiated Power	Rx	Receiving
ETSI	European Telecommunications Standards Institute	SINAD	Ratio of (Signal + Noise + Distortion) to (Noise + Distortion)
EU	European Union	S/N	Signal to Noise ratio
EUT	Equipment Under Test	SA, S/A	Spectrum Analyzer
Fac.	Factor	SG	Signal Generator
FCC	Federal Communications Commission	SVSWR	Site-Voltage Standing Wave Ratio
FHSS	Frequency Hopping Spread Spectrum	THC(A)	Total Harmonic Current
FM	Frequency Modulation	THD(%)	Total Harmonic Distortion
Freq.	Frequency	TR, T/R	Test Receiver
FSK	Frequency Shift Keying	Tx	Transmitting
Fund	Fundamental	VBW	Video BandWidth
FWD	Forward	Vert.	Vertical
GFSK	Gaussian Frequency-Shift Keying	WLAN	Wireless LAN
GNSS	Global Navigation Satellite System	xDSL	Generic term for all types of DSL technology (DSL: Digital Subscriber Line)

CONTENTS PAGE

SECTION 1: Customer information

Company Name	Keyence Corporation
Address	1-3-14, Higashinakajima, Higashiyodogawa-ku, Osaka-shi, Osaka, Japan
Telephone Number	+81-6-6379-1352
Contact Person	Kazuya Fujimori

The information provided from the customer is as follows;
- Customer, Description of EUT, Model Number of EUT, FCC ID on the cover and other relevant pages
- Operating/Test Mode(s) (Mode(s)) on all the relevant pages
- SECTION 1: Customer Information
- SECTION 2: Equipment Under Test (EUT) other than the Receipt Date and Test Date
- SECTION 5: Tune-up tolerance information and software information

* The laboratory is exempted from liability of any test results affected from the above information in SECTION 2 and 5.

SECTION 2: Equipment under test (EUT)

2.1 Identification of EUT

Description	Communication module
Model Number	LBEE5HY1MW
Serial Number	SS2530005-AW
Condition	Production model
Modification	No Modification by the test lab
Receipt Date	September 20, 2022
Test Date	September 29 to November 17, 2022

2.2 Product Description

General Specification

Rating	DC 3.3 V
Option battery	N/A
Body-worn accessory	N/A

Radio Specification

WLAN (IEEE802.11b/11g/11n-20)

Equipment Type	Transceiver
Frequency of Operation	2412 MHz to 2462 MHz
Type of Modulation	DSSS, OFDM
Antenna Gain	2.1 dBi

WLAN (IEEE802.11a/11n-20)

Equipment Type	Transceiver
Frequency of Operation	5180 MHz to 5240 MHz 5260 MHz to 5320 MHz
Type of Modulation	OFDM
Antenna Gain	3.5 dBi

Bluetooth (BR / EDR)

Equipment Type	Transceiver
Frequency of Operation	2402 MHz to 2480 MHz
Type of Modulation	FHSS (GFSK, π/4 DQPSK, 8 DPSK)
Antenna Gain	2.1 dBi

Wireless powering system

Equipment Type	Receiver
Operating Frequency	100 kHz to 110 kHz
Rated Output Power	5 W
Coil system	Single Coil
Charging distance	Contact

* WLAN and Bluetooth do not transmit simultaneously.

SECTION 3: Test standard information

3.1 Test Specification

Title : **FCC47CFR 2.1093**
Radiofrequency radiation exposure evaluation: portable devices.

Published RF exposure KDB procedures

☑ **KDB 447498 D01(v06)**	RF Exposure Procedures and Equipment Authorization Policies for Mobile and Portable Devices
☐ **KDB 447498 D02(v02r01)**	SAR Measurement Procedures for USB Dongle Transmitters
☐ **KDB 648474 D04(v01r03)**	SAR Evaluation Considerations for Wireless Handsets
☐ **KDB 941225 D01(v03r01)**	3G SAR Measurement Procedures
☐ **KDB 941225 D05(v02r05)**	SAR Evaluation Considerations for LTE Devices
☐ **KDB 941225 D06(v02r01)**	SAR Evaluation Procedures for Portable Devices with Wireless Router Capabilities (Hot Spot SAR)
☐ **KDB 941225 D07(v01r02)**	SAR Evaluation Procedures for UMPC Mini-Tablet Devices
☐ **KDB 616217 D04(v01r02)**	SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers
☑ **KDB 865664 D01(v01r04)**	SAR Measurement Requirements for 100 MHz to 6 GHz
☑ **KDB 248227 D01(v02r02)**	SAR Guidance for 802.11(Wi-Fi) Transmitters

Reference
[1] SPEAG uncertainty document
[2] IEEE Std 1528-2013
[3] IEC 62209-2:2010 + AMD1:2019 CS

3.2 Procedure

Transmitter	WLAN and Bluetooth
Test Procedure	Published RF exposure KDB procedures
Category	SAR
Note: UL Japan, Inc. 's SAR Work Procedures: Work Instructions-ULID-003598 and Work Instructions-ULID-003599	

This EUT operates only with the specified Handheld code reader.
Therefore the test was performed with the Handheld code reader (Host) in which the distance to the exterior surface is shortest.

3.3 Additions or deviations to standard

Other than above, no addition, exclusion nor deviation has been made from the standard.

3.4 Exposure limit

(A) Limits for Occupational/Controlled Exposure (W/kg)

Spatial Average (averaged over the whole body)	Spatial Peak (averaged over any 1 g of tissue)	Spatial Peak (hands/wrists/feet/ankles averaged over 10 g)
0.4	8.0	20.0

(B) Limits for General population/Uncontrolled Exposure (W/kg)

Spatial Average (averaged over the whole body	Spatial Peak (averaged over any 1 g of tissue)	Spatial Peak (hands/wrists/feet/ankles averaged over 10 g)
0.08	1.6	4.0

Occupational/Controlled Environments: are defined as locations where there is exposure that may be incurred by people who are aware of the potential for exposure, (i.e. as a result of employment or occupation).

General Population/Uncontrolled Environments: are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure.

NOTE:GENERAL POPULATION/UNCONTROLLED EXPOSURE
SPATIAL PEAK(averaged over any 1 g of tissue) LIMIT
1.6 W/kg

3.5 SAR

Specific Absorption Rate (SAR): 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), as shown in the following equation:

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

SAR is expressed in units of watts per kilogram (W/kg) or equivalently milliwatts per gram (mW/g).

SAR is related to the E-field at a point by the following equation:

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

where
σ = conductivity of the tissue (S/m)
ρ = mass density of the tissue (kg/m3)
E = rms E-field strength (V/m)

3.6 Test Location

UL Japan, Inc. Ise EMC Lab.
Shielded room for SAR testing
*A2LA Certificate Number: 5107.02 / FCC Test Firm Registration Number: 884919
ISED Lab Company Number: 2973C / CAB identifier: JP0002
4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 JAPAN
Telephone: +81 596 24 8999

SECTION 4: Test result

4.1 Result

Complied
Highest values at each band are listed next section.

4.2 Stand-alone SAR result

RF Exposure Conditions		Equipment Class - Highest Reported SAR (W/kg)		
		DTS(WLAN 2.4 GHz band)	NII(WLAN 5 GHz band)	DSS (Bluetooth BDR/EDR)
Standalone Tx (1-g SAR)	Body-worn	0.260	0.672	0.054

*Details are shown at section 12.

4.3 Simultaneous transmission SAR result

Wireless LAN and Bluetooth do not transmit simultaneously.

SECTION 5: Tune-up tolerance information and software information

Maximum tune-up tolerance limit

Mode	Frequency in each band	Maximum tune-up tolerance limit [dBm]	Maximum tune-up tolerance limit [mW]
WLAN 11b	2.4 GHz band	16.50	44.67
WLAN 11g/ 11n20	2412 MHz, 2417 MHz, 2457 MHz and 2462 MHz	12.50	17.78
WLAN 11g/ 11n20	2422 MHz to 2452 MHz	15.50	35.48
WLAN 11a/ 11n20	5180 MHz and 5200 MHz	12.00	15.85
WLAN 11a/ 11n20	5220 MHz and 5240 MHz	13.00	19.95
WLAN 11a/ 11n20	5260 MHz and 5280 MHz	13.00	19.95
WLAN 11a/ 11n20	5300 MHz and 5320 MHz	12.00	15.85
BT BDR	2.4 GHz band	10.00	10.00
BT EDR	2.4 GHz band	6.00	3.98

For WLAN/ BT Maximum tune-up tolerance limit is defined by a customer as duty100 %.

Software setting
*The power value of the EUT was set for testing as follows (setting value might be different from product specification value); Power settings: Refer to below table. Software: WLAN test: Firmware Ver: 0.10 BT test: Firmware Ver: 0.22bt *This setting of software is the worst case. The test was performed with condition that obtained the maximum average power in pre-check. Any conditions under the normal use do not exceed the condition of setting. In addition, end users cannot change the settings of the output power of the product.

[Power setting]

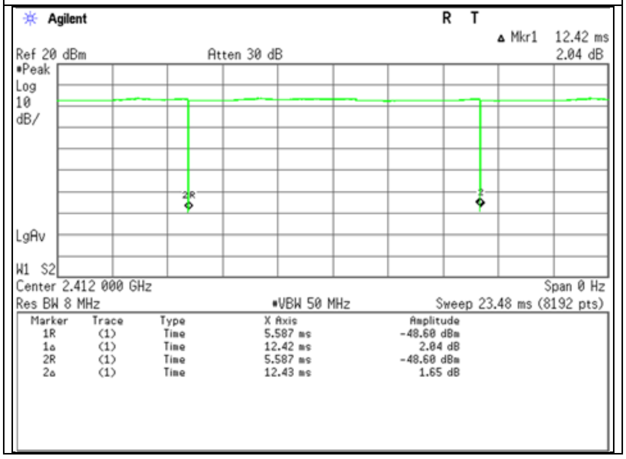
Mode	Frequency	Power Setting
11b	2412 MHz, 2437 MHz 2462 MHz	16
11a	5260 MHz, 5280 MHz	11
11a	5320 MHz	10
BT BDR	2441 MHz	0 (Max power)

Power setting values adjusted to be within -2 dB of the Maximum Tune-up tolerance limit, and are not the power setting values of the final product.

Duty conformation

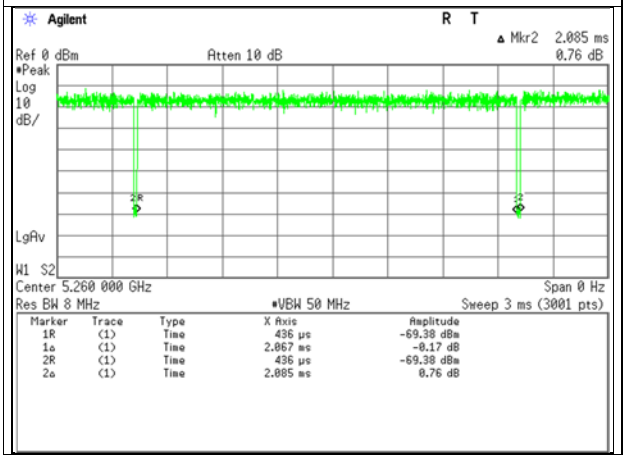
11b 1 Mbps

Tx on / (Tx on + Tx off) =	0.999
Tx on / (Tx on + Tx off) * 100 =	99.9 %



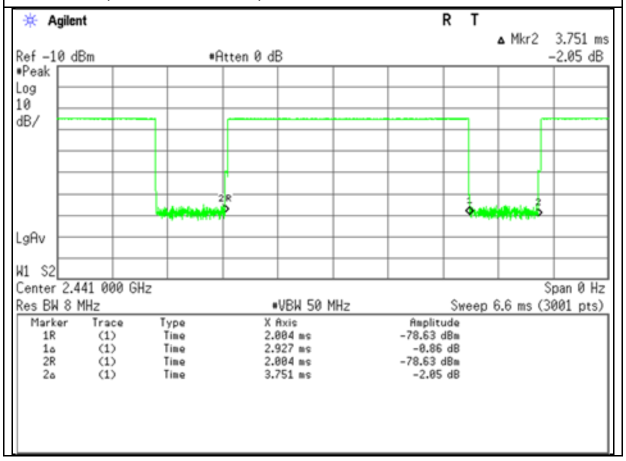
11a 6 Mbps

Tx on / (Tx on + Tx off) =	0.991
Tx on / (Tx on + Tx off) * 100 =	99.1 %



BDR DH5

Tx on / (Tx on + Tx off) =	0.780
Tx on / (Tx on + Tx off) * 100 =	78.0 %



SECTION 6: RF Exposure Conditions (Test Configurations)

6.1 Summary of the distance between antenna and surface of EUT

Test position	Distance
Front	67.6 mm
Rear	16.9 mm
Right	8.1 mm
Left	53.5 mm
Top	17 mm
Bottom	140.4 mm
Right tilt	7.5 mm

*Details are shown in appendix 4

6.2 SAR test exclusion considerations according to KDB 447498 D01

The following is based on KDB 447498 D01.
1) The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:
[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] ·[√f(GHz)] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR

1. The upper frequency of the frequency band was used in order to calculate standalone SAR test exclusion considerations.
2. Power and distance are rounded to the nearest mW and mm before calculation
3. The result is rounded to one decimal place for comparison
4. 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. When the separation of antenna to EUT's surfaces and edges are ≤ 50 mm, the separation distance used for the SAR exclusion calculations is 5 mm.
5. "N/A" displayed on below exclusion calculation means not applicable this formula since distance between antenna and surface is > 50 mm.

When the calculated threshold value by a numerical formula above-mentioned in the following table is 3.0 or less, SAR test is excluded.
The following table lists only the highest tune up limit and the highest channel in each frequency band.

SAR exclusion calculations for antenna <50mm from the user

Antenna	Tx Interface	Frequency (MHz)	Output Power		Calculated Threshold Value						
			dBm	mW	Front	Rear	Right	Left	Top	Bottom	Right tilt
Main	11b	2462	16.50	45	N/A	14 -MEASURE-	14 -MEASURE-	N/A	14 -MEASURE-	N/A	14 -MEASURE-
Main	11g	2462	15.50	35	N/A	11.1 -MEASURE-	11.1 -MEASURE-	N/A	11.1 -MEASURE-	N/A	11.1 -MEASURE-
Main	11n20	2462	15.50	35	N/A	11.1 -MEASURE-	11.1 -MEASURE-	N/A	11.1 -MEASURE-	N/A	11.1 -MEASURE-
Main	11a	5240	13.00	20	N/A	9.1 -MEASURE-	9.1 -MEASURE-	N/A	9.1 -MEASURE-	N/A	9.1 -MEASURE-
Main	11n20	5240	13.00	20	N/A	9.1 -MEASURE-	9.1 -MEASURE-	N/A	9.1 -MEASURE-	N/A	9.1 -MEASURE-
Main	11a	5320	13.00	20	N/A	9.2 -MEASURE-	9.2 -MEASURE-	N/A	9.2 -MEASURE-	N/A	9.2 -MEASURE-
Main	11n20	5320	13.00	20	N/A	9.2 -MEASURE-	9.2 -MEASURE-	N/A	9.2 -MEASURE-	N/A	9.2 -MEASURE-

SAR exclusion calculations for antenna <50mm from the user

Antenna	Tx Interface	Frequency (MHz)	Output Power		Calculated Threshold Value						
			dBm	mW	Front	Rear	Right	Left	Top	Bottom	Right tilt
Main	BDR	2480	10.00	10	N/A	3.1 -MEASURE-	3.1 -MEASURE-	N/A	3.1 -MEASURE-	N/A	3.1 -MEASURE-
Main	EDR	2480	6.00	4	N/A	1.3 -EXEMPT-	1.3 -EXEMPT-	N/A	1.3 -EXEMPT-	N/A	1.3 -EXEMPT-

2) At 100 MHz to 6 GHz and for test separation distances > 50 mm, the SAR test exclusion threshold is determined according to the following.
a) [(3·50)/(√f(GHz))) + (test separation distance - 50 mm)·(f(MHz)/150)] mW at > 100 MHz and ≤ 1500 MHz
b) [(3·50)/(√f(GHz))) + (test separation distance - 50 mm)·10] mW at > 1500 MHz and ≤ 6 GHz

1. The upper frequency of the frequency band was used in order to calculate standalone SAR test exclusion considerations.
2. Power and distance are rounded to the nearest mW and mm before calculation
3. “N/A” displayed on below exclusion calculation means not applicable this formula since distance between antenna and surface is < 50 mm.

When output power is less than the calculated threshold value by a numerical formula above-mentioned in the following table, SAR test is excluded.
The following table lists only the highest tune up limit and the highest channel in each frequency band.

SAR exclusion calculations for antenna >50mm from the user

Antenna	Tx Interface	Frequency (MHz)	Output Power		Calculated Threshold Value						
			dBm	mW	Front	Rear	Right	Left	Top	Bottom	Right tilt
Main	11b	2462	16.50	45	271.6 mW -EXEMPT-	N/A	N/A	130.6 mW -EXEMPT-	N/A	999.6 mW -EXEMPT-	N/A
Main	11g	2462	15.50	35	271.6 mW -EXEMPT-	N/A	N/A	130.6 mW -EXEMPT-	N/A	999.6 mW -EXEMPT-	N/A
Main	11n20	2462	15.50	35	271.6 mW -EXEMPT-	N/A	N/A	130.6 mW -EXEMPT-	N/A	999.6 mW -EXEMPT-	N/A
Main	11a	5240	13.00	20	241.5 mW -EXEMPT-	N/A	N/A	100.5 mW -EXEMPT-	N/A	969.5 mW -EXEMPT-	N/A
Main	11n20	5240	13.00	20	241.5 mW -EXEMPT-	N/A	N/A	100.5 mW -EXEMPT-	N/A	969.5 mW -EXEMPT-	N/A
Main	11a	5320	13.00	20	241 mW -EXEMPT-	N/A	N/A	100 mW -EXEMPT-	N/A	969 mW -EXEMPT-	N/A
Main	11n20	5320	13.00	20	241 mW -EXEMPT-	N/A	N/A	100 mW -EXEMPT-	N/A	969 mW -EXEMPT-	N/A

SAR exclusion calculations for antenna >50mm from the user

Antenna	Tx Interface	Frequency (MHz)	Output Power		Calculated Threshold Value						
			dBm	mW	Front	Rear	Right	Left	Top	Bottom	Right tilt
Main	BDR	2480	10.00	10	271.3 mW -EXEMPT-	N/A	N/A	130.3 mW -EXEMPT-	N/A	999.3 mW -EXEMPT-	N/A
Main	EDR	2480	6.00	4	271.3 mW -EXEMPT-	N/A	N/A	130.3 mW -EXEMPT-	N/A	999.3 mW -EXEMPT-	N/A

SECTION 7: Description of the Body setup

7.1 Procedure for SAR test position determination

-The tested procedure was performed according to the KDB 447498 D01 (Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies).

7.2 Test position for Body setup

No.	Position	Test distance	WLAN	BT
			Tested	Tested
1	Front	0 mm	☐	☐
2	Rear	0 mm	☑	☑
3	Right	0 mm	☑	☑
4	Left	0 mm	☐	☐
5	Top	0 mm	☑	☑
7	Bottom	0 mm	☐	☐
8	Right tilt	0 mm	☑	☑

*The test was conservatively performed with test distance 0 mm.

SECTION 8: Description of the operating mode

8.1 Output Power and SAR test required

According to KDB 248227 D01, The initial test configuration for 2.4 GHz and 5 GHz OFDM transmission modes is determined by the 802.11 configuration with the highest maximum output power specified for production units, including tune-up tolerance, in each standalone and aggregated frequency band. SAR for the initial test configuration is measured using the highest maximum output power channel determined by the default power measurement procedures. When multiple configurations in a frequency band have the same specified maximum output power, the initial test configuration is determined according to the following steps applied sequentially.

1. The largest channel bandwidth configuration is selected among the multiple configurations with the same specified maximum output power.
2. If multiple configurations have the same specified maximum output power and largest channel bandwidth, the lowest order modulation among the largest channel bandwidth configurations is selected.
3. If multiple configurations have the same specified maximum output power, largest channel bandwidth and lowest order modulation, the lowest data rate configuration among these configurations is selected.
4. When multiple transmission modes (802.11a/g/n/ac) have the same specified maximum output power, largest channel bandwidth, lowest order modulation and lowest data rate, the lowest order 802.11 mode is selected; i.e., 802.11a is chosen over 802.11n then 802.11ac or 802.11g is chosen over 802.11n.

WLAN 2.4 GHz (DTS Band)

Band (GHz)	Mode	Data Rate	Ch #	Freq. (MHz)	Tune-up upper Power (dBm)	Measured average Power (dBm)	Initial test configuration	Note(s)
2.4	11b	1 Mbps	1	2412	16.50	15.61		
			6	2437	16.50	16.40	Yes	
			11	2462	16.50	15.66		
	11g	6 Mbps	1	2412	12.50	-		1
			3	2422	15.50	-		
			6	2437	15.50	-		
			9	2452	15.50	-		
			11	2462	12.50	-		
	11n-20	MCS0	1	2412	12.50	-		1
			3	2422	15.50	-		
			6	2437	15.50	-		
			9	2452	15.50	-		
			11	2462	12.50	-		

Note(s):

1. According to KDB 248227 D01, SAR is not required for 802.11g/n-20 channels when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg.
2. SAR test channel was chosen. (shaded blue frame)

WLAN 5 GHz (U-NII-1 Bands)

SISO

Band	Mode	Data Rate	Ch #	Freq. (MHz)	Tune-up upper Power (dBm) (Burst)	Measured average Power (dBm) (Burst)	Initial test configuration	Note(s)
U-NII-1	11a	6 Mbps	36	5180	12.00	-		2
			44	5220	13.00	-		
			48	5240	13.00	-		
U-NII-1	11n-20	MCS0	36	5180	12.00	-		2
			44	5220	13.00	-		
			48	5240	13.00	-		
U-NII-2	11a	6 Mbps	52	5260	13.00	11.93	Yes	
			56	5280	13.00	11.84		
			64	5320	12.00	11.10		
U-NII-2	11n-20	MCS0	52	5260	13.00	-		1
			56	5280	13.00	-		
			64	5320	12.00	-		

Note(s):

1. Excerpt from KDB 248227 D01 clause 5.3.4 b), when the highest reported SAR for the initial test configuration (when applicable, include subsequent highest output channels), according to the initial test position or fixed exposure position requirements, is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for that subsequent test configuration.
2. When the specified maximum output power is the same for both UNII band I and UNII band 2A, begin SAR measurement in UNII band 2A; and if the highest *reported* SAR for UNII band 2A is
   - ≤ 1.2 W/kg, SAR is not required for UNII band I
   - > 1.2 W/kg, both bands should be tested independently for SAR.
3. SAR test channel was chosen. (shaded blue frame)

BT

Band (GHz)	Mode	Data Rate	Freq. (MHz)	Tune-up upper Power (dBm) (Burst)	Measured average Power (dBm) (Burst)	Initial test configuration	Note(s)
2.4	Bluetooth	BDR(DH5)	2402	10.00	-		
			2441	10.00	8.06	Yes	
			2480	10.00	-		
		EDR(3DH5)	2402	6.00	-		1
			2441	6.00	-		
			2480	6.00	-		

Note(s):

1. According to KDB 865664, SAR measurement is not required for EDR when the specified tune-up tolerances for EDR are lower than BDR.
2. SAR test channel was chosen. (shaded blue frame) Since the Tune-up upper Power is lower than WLAN, only the Mid ch will be measured as a representative.

SECTION 9: Test surrounding

9.1 Measurement uncertainty

This measurement uncertainty budget is suggested by IEEE Std 1528(2013) and IEC62209-2:2010+AMD1:2019 CSV, and determined by Schmid & Partner Engineering AG (DASY5/6 Uncertainty Budget). Per KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz Section 2.8.1., when the highest measured SAR(1 g) within a frequency band is < 1.5 W/kg, the extensive SAR measurement uncertainty analysis described in IEEE Std.1528 (2013) is not required in SAR reports submitted for equipment approval.

<Body>

Error Description	Uncert. value	Prob. Dist.	Div.	(ci) 1 g	(ci) 10 g	Std. Unc. (1 g)	Std.Unc. (10 g)
Measurement System							
Probe Calibration	± 6.55 %	N	1	1	1	± 6.55 %	± 6.55 %
Axial Isotropy	± 4.7 %	R	√3	0.7	0.7	± 1.9 %	± 1.9 %
Hemispherical Isotropy	± 9.6 %	R	√3	0.7	0.7	± 3.9 %	± 3.9 %
Linearity	± 4.7 %	R	√3	1	1	± 2.7 %	± 2.7 %
Modulation Response	± 2.4 %	R	√3	1	1	± 1.4 %	± 1.4 %
System Detection Limits	± 1.0 %	R	√3	1	1	± 0.6 %	± 0.6 %
Boundary Effects	± 2.0 %	R	√3	1	1	± 1.2 %	± 1.2 %
Readout Electronics	± 0.3 %	N	1	1	1	± 0.3 %	± 0.3 %
Response Time	± 0.8 %	R	√3	1	1	± 0.5 %	± 0.5 %
Integration Time	± 2.6 %	R	√3	1	1	± 1.5 %	± 1.5 %
RF Ambient Noise	± 3.0 %	R	√3	1	1	± 1.7 %	± 1.7 %
RF Ambient Reflections	± 3.0 %	R	√3	1	1	± 1.7 %	± 1.7 %
Probe Positioner	± 0.04 %	R	√3	1	1	± 0.0 %	± 0.0 %
Probe Positioning	± 0.8 %	R	√3	1	1	± 0.5 %	± 0.5 %
Post-processing	± 4.0 %	R	√3	1	1	± 2.3 %	± 2.3 %
Test Sample Related							
Device Holder	± 3.6 %	N	1	1	1	± 3.6 %	± 3.6 %
Test sample Positioning	± 2.9 %	N	1	1	1	± 2.9 %	± 2.9 %
Power Scaling	± 0.0 %	R	√3	1	1	± 0.0 %	± 0.0 %
Power Drift	± 5.0 %	R	√3	1	1	± 2.9 %	± 2.9 %
Phantom and Setup							
Phantom Uncertainty	± 7.6 %	R	√3	1	1	± 4.4 %	± 4.4 %
SAR correction	± 1.9 %	N	1	1	0.84	± 1.9 %	± 1.6 %
Liquid Conductivity (mea.)	- 2.4 %	N	1	0.78	0.71	± 1.9 %	± 1.7 %
Liquid Permittivity (mea.)	- 4.6 %	N	1	0.23	0.26	± 1.1 %	± 1.2 %
Temp. unc. - Conductivity	± 3.4 %	R	√3	0.78	0.71	± 1.5 %	± 1.4 %
Temp. unc. - Permittivity	± 0.4 %	R	√3	0.23	0.26	± 0.1 %	± 0.1 %
Combined Std. Uncertainty						± 12.1 %	± 12.0 %
Expanded STD Uncertainty (κ =2)						± 24.2 %	± 24.1 %

Note: This uncertainty budget for validation is worst-case.
Table of uncertainties are listed for ISO/IEC 17025.

SECTION 10: Parameter Check

The dielectric parameters were checked prior to assessment using the DAK dielectric probe kit.
The dielectric parameters measurement is reported in each correspondent section.

According to KDB 865664 D01, +/- 5 % tolerances are required for εr and σ and then below table which is the target value of the simulated tissue liquid is quoted from KDB 865664 D01.

Target Frequency	Head		Body	
(MHz)	ε_r	σ (S/m)	ε_r	σ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
835	41.5	0.90	55.2	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800 – 2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5800	35.3	5.27	48.2	6.00

(ε_r = relative permittivity, σ = conductivity and ρ = 1000 kg/m^3)

The dielectric parameters are linearly interpolated between the closest pair of target frequencies to determine the applicable dielectric parameters corresponding to the device test frequency.

10.1 For SAR system check

DIELECTRIC PARAMETERS MEASUREMENT RESULTS													
Date	Ambient Temp. [deg.c]	Relative Humidity [%]	Liquid type	Liquid Temp. [deg.c]	Measured Frequency [MHz]	Target [σ]	Target [εr]	Measure [σ]	Measure [εr]	Deviation σ [%]	Deviation εr [%]	Limit [%]	Remark
2022/10/11	22.0	40	HBBL600-10000	21.5	2450.0	1.80	39.2	1.76	37.6	***-2.39***	-4.00	+/- 5	
2022/9/29	22.0	40	HBBL600-10000	21.5	5250.0	4.71	35.9	4.62	34.3	-1.85	***-4.46***	+/- 5	
2022/11/17	22.0	40	HBBL600-10000	21.5	2450.0	1.80	39.2	1.76	38.5	-2.11	-1.77	+/- 5	

10.2 For SAR measurement

DIELECTRIC PARAMETERS MEASUREMENT RESULTS													
Date	Ambient Temp. [deg.c]	Relative Humidity [%]	Liquid type	Liquid Temp. [deg.c]	Measured Frequency [MHz]	Target [σ]	Target [εr]	Measure [σ]	Measure [εr]	Deviation σ [%]	Deviation εr [%]	Limit [%]	Remark
2022/10/11	22.0	40	HBBL600-10000	21.5	2412.0	1.77	39.3	1.73	37.6	-2.22	-4.17	+/- 5	
2022/10/11	22.0	40	HBBL600-10000	21.5	2437.0	1.79	39.2	1.75	37.6	-2.37	-4.07	+/- 5	
2022/10/11	22.0	40	HBBL600-10000	21.5	2462.0	1.81	39.2	1.77	37.6	***-2.49***	-3.95	+/- 5	
2022/9/29	22.0	40	HBBL600-10000	21.5	5260.0	4.72	35.9	4.64	34.3	-1.64	-4.51	+/- 5	
2022/9/29	22.0	40	HBBL600-10000	21.5	5280.0	4.74	35.9	4.68	34.3	-1.31	***-4.57***	+/- 5	
2022/9/29	22.0	40	HBBL600-10000	21.5	5320.0	4.78	35.8	4.77	34.3	-0.27	-4.44	+/- 5	
2022/11/17	22.0	40	HBBL600-10000	21.5	2441.0	1.79	39.2	1.76	38.5	-2.07	-1.82	+/- 5	

SECTION 11: System Check confirmation

The measurements were performed in the flat section of the TWIN SAM or ELI phantom, shell thickness: 2.0 ±0.2 mm (bottom plate) filled with Body or Head simulating liquid of the following parameters.
The depth of tissue-equivalent liquid in a phantom must be ≥ 15.0 cm ± 0.5 cm for SAR measurements ≤ 3 GHz and ≥ 10.0 cm ± 0.5 cm for measurements > 3 GHz.
The DASY system with an E-Field Probe was used for the measurements.
The dipole was mounted on the small tripod so that the dipole feed point was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom).
The standard measuring distance was 10 mm (above 1 GHz to 6 GHz) and 15 mm (below 1 GHz) from dipole center to the simulating liquid surface.
The coarse grid with a grid spacing of 15 mm (below 2 GHz), 12 mm (2 GHz to 4 GHz) and 10 mm (4 GHz to 6 GHz) was aligned with the dipole.
Distance between probe sensors and phantom surface was set to 1.4 mm.
The dipole input power (forward power) was 100 mW or 250 mW.
The results are normalized to 1 W input power.

Target Value

Freq [MHz]	Model,S/N	Head	
		(SPEAG) 1 g [W/kg]	(SPEAG) 10 g [W/kg]
2450	D2450V2,713	53.20	24.76
5250	D5GHV2,1020	77.90	22.30

The target(reference) SAR values can be obtained from the calibration certificate of system validation dipoles(Refer to Appendix 3). The target SAR values are SAR measured value in the calibration certificate scaled to 1 W.

Date Tested	Test Freq	Model,S/N	T.S. Liquid		Measured Results		Target (Ref. Value)	Delta ± 10 %
					Zoom Scan	Normalize to 1 W		
2022/10/11	2450	D2450V2,713	Head	1 g	13.60	54.40	53.20	2.3
				10 g	6.34	25.36	24.76	2.4
2022/9/29	5250	D5GHV2,1020	Head	1 g	8.28	82.80	77.90	6.3
				10 g	2.37	23.70	22.30	6.3
2022/11/17	2450	D2450V2,713	Head	1 g	13.80	55.20	53.20	3.8
				10 g	6.41	25.64	24.76	3.6

SECTION 12: Measured and Reported (Scaled) SAR Results

WLAN SAR Test Reduction criteria are as follows

- **KDB 248227 D01 (SAR Guidance for 802.11(Wi-Fi) Transmitters):**

SAR test reduction for 802.11 WLAN transmission mode configurations are considered separately for DSSS and OFDM. An initial test position is determined to reduce the number of tests required for certain exposure configurations with multiple test positions. An initial test configuration is determined for each frequency band and aggregated band according to maximum output power, channel bandwidth, wireless mode configurations and other operating parameters to streamline the measurement requirements. For 2.4 GHz DSSS, either the initial test position or DSSS procedure is applied to reduce the number of SAR tests; these are mutually exclusive. For OFDM, an initial test position is only applicable to next to the ear, UMPC mini-tablet and hotspot mode configurations, which is tested using the initial test configuration to facilitate test reduction. For other exposure conditions with a fixed test position, SAR test reduction is determined using only the initial test configuration.
The multiple test positions require SAR measurements in head, hotspot mode or UMPC mini-tablet configurations may be reduced according to the highest reported SAR determined using the *initial test position(s)* by applying the DSSS or OFDM SAR measurement procedures in the required wireless mode test configuration(s). The *initial test position(s)* is measured using the highest measured maximum output power channel in the required wireless mode test configuration(s). When the *reported* SAR for the *initial test position* is:

- ✧ ≤ 0.4 W/kg, further SAR measurement is not required for the other test positions in that exposure configuration and wireless mode combination within the frequency band or aggregated band. DSSS and OFDM configurations are considered separately according to the required SAR procedures.
- ✧ > 0.4 W/kg, SAR is repeated using the same wireless mode test configuration tested in the *initial test position* to measure the subsequent next closet/smallest test separation distance and maximum coupling test position, on the highest maximum output power channel, until the *reported* SAR is ≤ 0.8 W/kg or all required test positions are tested.
    - o For subsequent test positions with equivalent test separation distance or when exposure is dominated by coupling conditions, the position for maximum coupling condition should be tested.
    - o When it is unclear, all equivalent conditions must be tested.
- ✧ For all positions/configurations tested using the *initial test position* and subsequent test positions, when the *reported* SAR is > 0.8 W/kg, measure the SAR for these positions/configurations on the subsequent next highest measured output power channel(s) until the *reported* SAR is ≤ 1.2 W/kg or all required test channels are considered.
    - o The additional power measurements required for this step should be limited to those necessary for identifying subsequent highest output power channels to apply the test reduction.
- ✧ When the specified maximum output power is the same for both UNII 1 and UNII 2A, begin SAR measurements in UNII 2A with the channel with the highest measured output power. If the reported SAR for UNII 2A is ≤ 1.2 W/kg, SAR is not required for UNII 1; otherwise treat the remaining bands separately and test them independently for SAR.
- ✧ When the specified maximum output power is different between UNII 1 and UNII 2A, begin SAR with the band that has the higher specified maximum output. If the highest reported SAR for the band with the highest specified power is ≤ 1.2 W/kg, testing for the band with the lower specified output power is not required; otherwise test the remaining bands independently for SAR.

To determine the *initial test position*, Area Scans were performed to determine the position with the *Maximum Value of SAR (measured)*. The position that produced the highest *Maximum Value of SAR* is considered the worst case position; thus used as the *initial test position*.

SAR Test Reduction criteria(excluding WLAN) are as follows
KDB 447498 D01 (General RF Exposure Guidance):
Testing of other required channels within the operating mode of a frequency band is not required when the reported 1-g or 10-g SAR for the mid-band or highest output power channel is:
- ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz
- ≤ 0.6 W/kg or 1.5 W/kg, for 1-g or 10-g respectively, when the transmission band is between 100 MHz and 200 MHz
- ≤ 0.4 W/kg or 1.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≥ 200 MHz

- According to Notice 2016-DRS001 based on the IEEE1528 and IEC 62209 requirements, the low, mid and high frequency channels for the configuration with the highest SAR value must be tested regardless of the SAR value measured.
- When reported SAR value is exceed 1.2 W/kg(if any), device holder perturbation verification is required; however, since distance between device holder and antenna of EUT is enough, it was not conducted.
- Reported SAR= Measured SAR [W/kg] * Power Scaled factor * Duty Scaled factor
  Maximum tune-up tolerance limit is by the specification from a customer.
  * Power Scaled factor = Maximum tune-up tolerance limit [mW] / Measured power [mW]
  * Duty Scaled factor = 1 / Duty (%) / 100
- Maximum tune-up tolerance limit is by the specification from a customer.

Note: Measured value is rounded round off to three decimal places

12.1 Result of Body SAR of WLAN 2.4 GHz

Test Position	Dist. (mm)	Mode	Freq. (MHz)	Power (dBm)		Power Scaled factor	Duty (%)	Duty Scaled factor	1-g SAR (W/kg)		Note	Plot No.
				Tune-up upper Power	Measured average Power				Meas.	Reported		
Rear	0	11b	2412	16.50	15.61	1.23	99.9	1.00				
			2437	16.50	16.40	1.02	99.9	1.00	0.194	0.199		
			2462	16.50	15.66	1.21	99.9	1.00				
Right	0	11b	2412	16.50	15.61	1.23	99.9	1.00				
			2437	16.50	16.40	1.02	99.9	1.00	0.191	0.196		
			2462	16.50	15.66	1.21	99.9	1.00				
Top	0	11b	2412	16.50	15.61	1.23	99.9	1.00				
			2437	16.50	16.40	1.02	99.9	1.00	0.140	0.143		
			2462	16.50	15.66	1.21	99.9	1.00				
Right tilt	0	11b	2412	16.50	15.61	1.23	99.9	1.00	0.175	0.215	2	
			2437	16.50	16.40	1.02	99.9	1.00	0.247	0.253	1	
			2462	16.50	15.66	1.21	99.9	1.00	0.214	0.260	2	1

*1: Worst position
*2: Frequency change

OFDM was excluded from the following table according to KDB 248227 D01.
SAR is not required for the following 2.4 GHz OFDM conditions according to KDB 248227 D01.
1) When KDB 447498 D01 SAR test exclusion applies to the OFDM configuration.
2) When the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg.

Maximum tune-up tolerance limit		Maximum tune-up tolerance limit		OFDM scaled factor	Position	DSSS Reported SAR value [W/kg]	OFDM Estimated SAR value [W/kg]	Exclusion limit [W/kg]	**Standalone SAR request**
DSSS		OFDM							
[dBm]	[mW]	[dBm]	[mW]						
16.50	44.67	15.50	35.48	0.794	Right tilt	0.260	0.207	< 1.2	**No**

Note(s):
1. OFDM scaled factor = Maximum tune-up tolerance limit of OFDM [mW] / Maximum tune-up tolerance limit of DSSS [mW]
2. Estimated SAR of OFDM= Reported SAR of DSSS[W/kg] · OFDM scaled factor

12.2 Result of Body SAR of WLAN 5.3 GHz

Test Position	Dist. (mm)	Mode	Freq. (MHz)	Power (dBm)		Power Scaled factor	Duty (%)	Duty Scaled factor	1-g SAR (W/kg)		Note	Plot No.
				Tune-up upper Power	Measured average Power				Meas.	Reported		
Rear	0	11a	5260	13.00	11.93	1.28	99.1	1.01	0.063	0.081		
			5280	13.00	11.84	1.31	99.1	1.01				
			5320	12.00	11.10	1.23	99.1	1.01				
Right	0	11a	5260	13.00	11.93	1.28	99.1	1.01	0.300	0.387		
			5280	13.00	11.84	1.31	99.1	1.01				
			5320	12.00	11.10	1.23	99.1	1.01				
Top	0	11a	5260	13.00	11.93	1.28	99.1	1.01	0.096	0.124		
			5280	13.00	11.84	1.31	99.1	1.01				
			5320	12.00	11.10	1.23	99.1	1.01				
Right tilt	0	11a	5260	13.00	11.93	1.28	99.1	1.01	0.466	0.602	1	
			5280	13.00	11.84	1.31	99.1	1.01	0.510	0.672	2	2
			5320	12.00	11.10	1.23	99.1	1.01	0.395	0.490	2	

*1: Worst position
*2: Frequency change

Subsequent test configuration was excluded from the following table according to KDB 248227 D01.
SAR is not required for the following exclusion conditions according to KDB 248227 D01.
When the highest reported SAR for initial test configuration is adjusted by the ratio of Subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg.

Maximum tune-up tolerance limit		Maximum tune-up tolerance limit		Scaled factor	Position	11a Reported SAR value [W/kg]	11n20 Estimated SAR value [W/kg]	Exclusion limit [W/kg]	**Standalone SAR request**
11a		11n20							
[dBm]	[mW]	[dBm]	[mW]						
13.00	19.95	13.00	19.95	1.000	Right tilt	0.672	0.672	< 1.2	**No**

Notes:
- Scaled factor = Maximum tune-up tolerance limit of subsequent test configuration [mW] / Maximum tune-up tolerance limit of initial test configuration [mW]
- Estimated SAR of subsequent test configuration = Reported SAR of initial test configuration [W/kg] ·scaled factor.

12.3 Result of Body SAR of BT

Test Position	Dist. (mm)	Mode	Freq. (MHz)	Power (dBm)		Power Scaled factor	Duty (%)	Duty Scaled factor	1-g SAR (W/kg)		Note	Plot No.
				Tune-up upper Power	Measured average Power				Meas.	Reported		
Rear	0	DH5	2402	10.00	-	-	78.0	1.28				
			2441	10.00	8.06	1.56	78.0	1.28	0.025	0.050		
			2480	10.00	-	-	78.0	1.28				
Right	0	DH5	2402	10.00	-	-	78.0	1.28				
			2441	10.00	8.06	1.56	78.0	1.28	0.021	0.042		
			2480	10.00	-	-	78.0	1.28				
Top	0	DH5	2402	10.00	-	-	78.0	1.28				
			2441	10.00	8.06	1.56	78.0	1.28	0.017	0.034		
			2480	10.00	-	-	78.0	1.28				
Right tilt	0	DH5	2402	10.00	-	-	78.0	1.28				
			2441	10.00	8.06	1.56	78.0	1.28	0.027	0.054	1	3
			2480	10.00	-	-	78.0	1.28				

*1: Worst position

12.4 Repeated measurement

According to KDB 865664 D1.
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.

Wireless Technologies	Test Configuration			Mode	Freq. (MHz)	Meas. SAR (W/kg)		Largest to Smallest SAR Ratio	Plot No.
	Exposure	Position	Dist. (mm)			Original	Repeated		
WLAN	Body	Right tilt	0	11b	2437	0.247	N/A	N/A	-
WLAN	Body	Right tilt	0	11a	5280	0.510	N/A	N/A	-
BT	Body	Right tilt	0	DH5	2441	0.027	N/A	N/A	-

Note(s):
N/A: Repeated Measurement is not required since the original highest measured SAR for all band is < 0.80 W/kg.

SECTION 13: Test instruments

Local Id	LIMS ID	Description	Manufacturer	Model	Serial	Last Cal Date	Interval
MDAE-03	141484	Data Acquisition Electronics	Schmid & Partner Engineering AG	DAE4	1372	2022/04/11	12
MPB-09	141589	Dosimetric E-Field Probe	Schmid & Partner Engineering AG	EX3DV4	3922	2022/08/19	12
MDA-07	141457	Dipole Antenna	Schmid & Partner Engineering AG	D2450V2	713	2022/09/12	12
MDA-08	141467	Dipole Antenna	Schmid&Partner Engineering AG	D5GHzV2	1020	2021/11/18	12
MDH-01	142484	Device holder	Schmid&Partner Engineering AG	Mounting device for transmitter	-	2021/11/01	12
MOS-33	88581	Thermo-Hygrometer	CUSTOM. Inc	CTH-201	-	2022/07/03	12
MRBT-02	142247	SAR robot	Schmid & Partner Engineering AG	TX60 Lspeag	F10/5E3LA1/A/01	2022/04/25	12
MPF-02	142056	2mm Oval Flat Phantom	Schmid & Partner Engineering AG	QDOVA001BB	1045	2022/05/23	12
COTS-MSAR-04	141182	Dielectric assessment software	Schmid&Partner Engineering AG	DAK	-	-	-
COTS-MPSE-02	173900	Software for MA24106A	Anritsu Corporation	Anritsu PowerXpert	-	-	-
MDPK-03	141471	Dielectric assessment kit	Schmid & Partner Engineering AG	DAKS-3.5	0008	2022/04/19	12
MAT-78	142313	Attenuator	Telegrartner	J01156A0011	42294119	-	-
MPM-15	141811	Power Meter	Keysight Technologies Inc	N1914A	MY53060017	2022/06/16	12
MNA-03	141551	Vector Reflectometer	COPPER MOUNTAIN TECHNOLOGIES	PLANAR R140	0030913	2022/04/18	12
MOS-37	141574	Digital thermometer	LKM electronic	DTM3000	-	2022/07/03	12
MPSE-20	141833	Power sensor	Keysight Technologies Inc	N8482H	MY53050001	2022/06/16	12
MPSE-24	141843	Power sensor	Anritsu Corporation	MA24106A	1026164	2022/03/17	12
MPSE-25	141844	Power sensor	Anritsu Corporation	MA24106A	1031504	2022/03/17	12
MRFA-24	141875	Pre Amplifier	R&K	R&K CGA020M602-2633R	B30550	2022/06/27	12
MHBBL600-10000	176484	Head Simulating Liquid	Schmid & Partner Engineering AG	HBBL600-10000V6	SL AAH U16 BC	-	-
COTS-MSAR-03	141181	Dasy5	Schmid & Partner Engineering AG	DASY5	-	-	-
MSG-10	141890	Signal Generator	Keysight Technologies Inc	N5181A	MY47421098	2021/11/18	12
MHDC-12	142559	Dual Directional Coupler	Hewlett Packard	772D	2839A0016	-	-
MAT-81	141311	Attenuator	Weinschel Associates	WA1-20-33	100131	2022/04/06	12

The expiration date of the calibration is the end of the expired month.
All equipment is calibrated with valid calibrations. Each measurement data is traceable to the national or international standards.

As for some calibrations performed after the tested dates, those test equipment have been controlled by means of an unbroken chains of calibrations.

SAR room is checked before every testing and ambient noise is <0.012 W/kg

APPENDIX 1: System Check

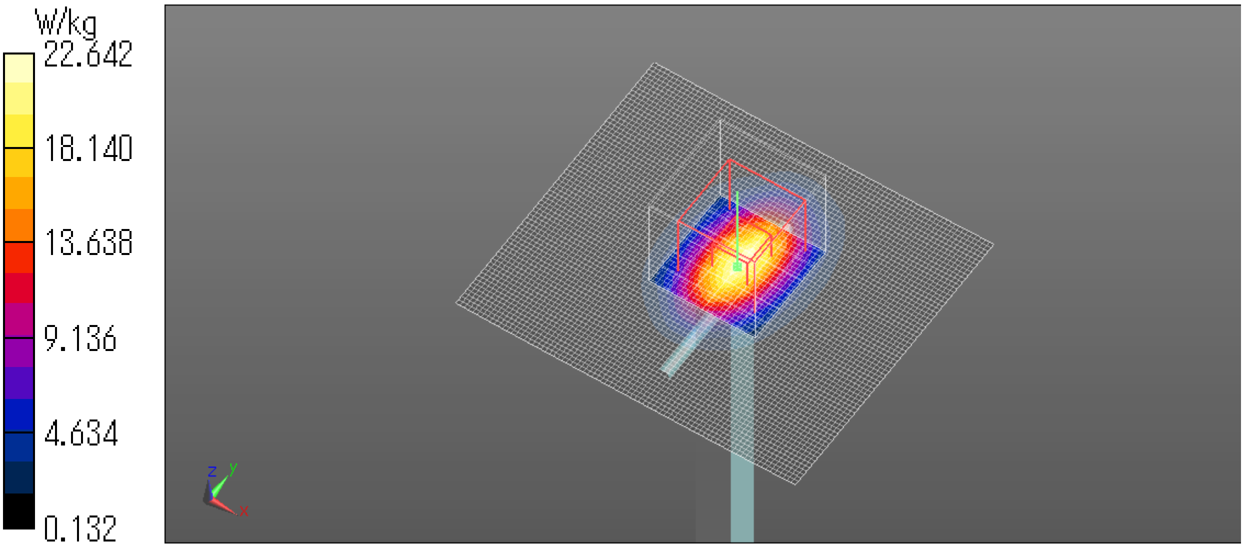
2450 MHz System check
Communication System: UID 0, CW (0); Communication System Band: D2450 (2450.0 MHz); ; Duty Cycle: 1:1
Medium parameters used: f = 2450 MHz; σ = 1.757 S/m; ε_r = 37.632; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY5 Configuration
Probe: EX3DV4 - SN3922; ConvF(7.85, 7.85, 7.85) @ 2450 MHz;
Sensor-Surface: 1.4 mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1372;
Phantom: ELI v4.0 (20deg probe tilt); Type: QDOVA001BB;Serial: TP:1045
Measurement SW: DASY52, Version 52.10 (4);SEMCAD X Version 14.6.14 (7501)

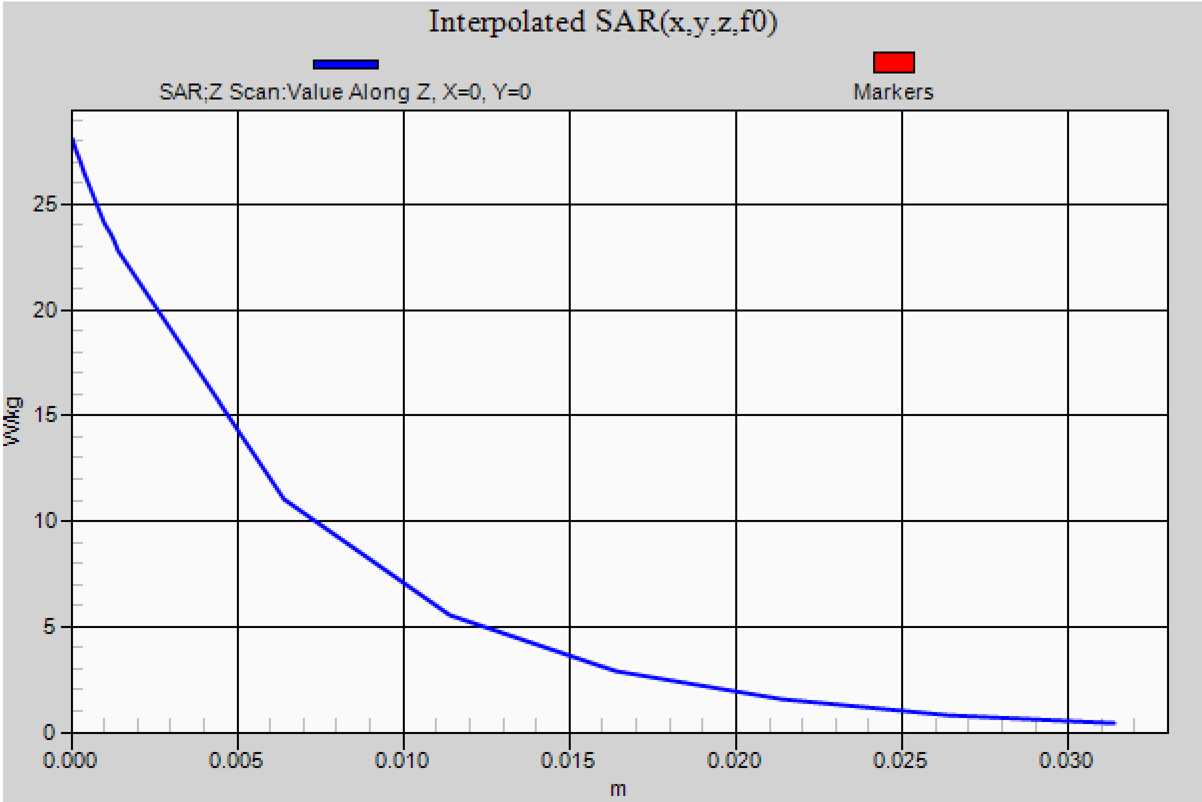
Area Scan (81x71x1): Interpolated grid: dx = 1.200 mm, dy = 1.200 mm
Maximum value of SAR (interpolated) = 23.1 W/kg

Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx = 5 mm, dy = 5 mm, dz = 5 mm
Reference Value = 118.6 V/m; Power Drift = - 0.00 dB
Peak SAR (extrapolated) = 28.1 W/kg
SAR(1 g) = 13.6 W/kg; SAR(10 g) = 6.34 W/kg
Smallest distance from peaks to all points 3 dB below = 9 mm
Ratio of SAR at M2 to SAR at M1 = 48.8 %
Maximum value of SAR (measured) = 22.6 W/kg

Z Scan (1x1x18): Measurement grid: dx = 20 mm, dy = 20 mm, dz = 5 mm
Penetration depth = 7.258 (6.906, 7.492) [mm]
Maximum value of SAR (interpolated) = 28.1 W/kg

Ambient Temp. : 22.0 degree.C. Liquid Temp.; 21.5 degree.C.
Liquid temp. is kept within the 2 degree.C. during the test.
Date: 2022/10/11




Interpolated SAR(x,y,z,f0)
SAR;Z Scan:Value Along Z, X=0, Y=0
Markers
W/kg
0
5
10
15
20
25
0.000
0.005
0.010
0.015
0.020
0.025
0.030
m

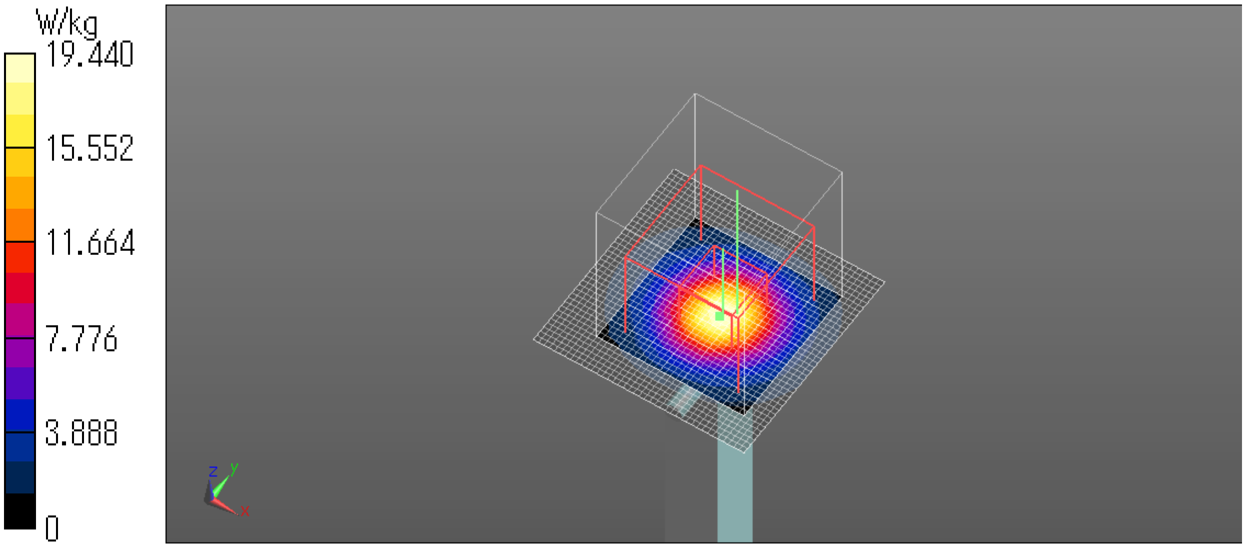
5250 MHz System check
Communication System: UID 0, #CW (0); Communication System Band: D5GHz (5000.0 - 6000.0 MHz); ; Duty Cycle: 1:1
Medium parameters used: f = 5250 MHz; σ = 4.619 S/m; ε_r = 34.325; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY5 Configuration
Probe: EX3DV4 - SN3922; ConvF(5.54, 5.54, 5.54) @ 5250 MHz;
Sensor-Surface: 1.4 mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1372;
Phantom: ELI v4.0 (20deg probe tilt); Type: QDOVA001BB;Serial: TP:1045
Measurement SW: DASY52, Version 52.10 (4);SEMCAD X Version 14.6.14 (7501)

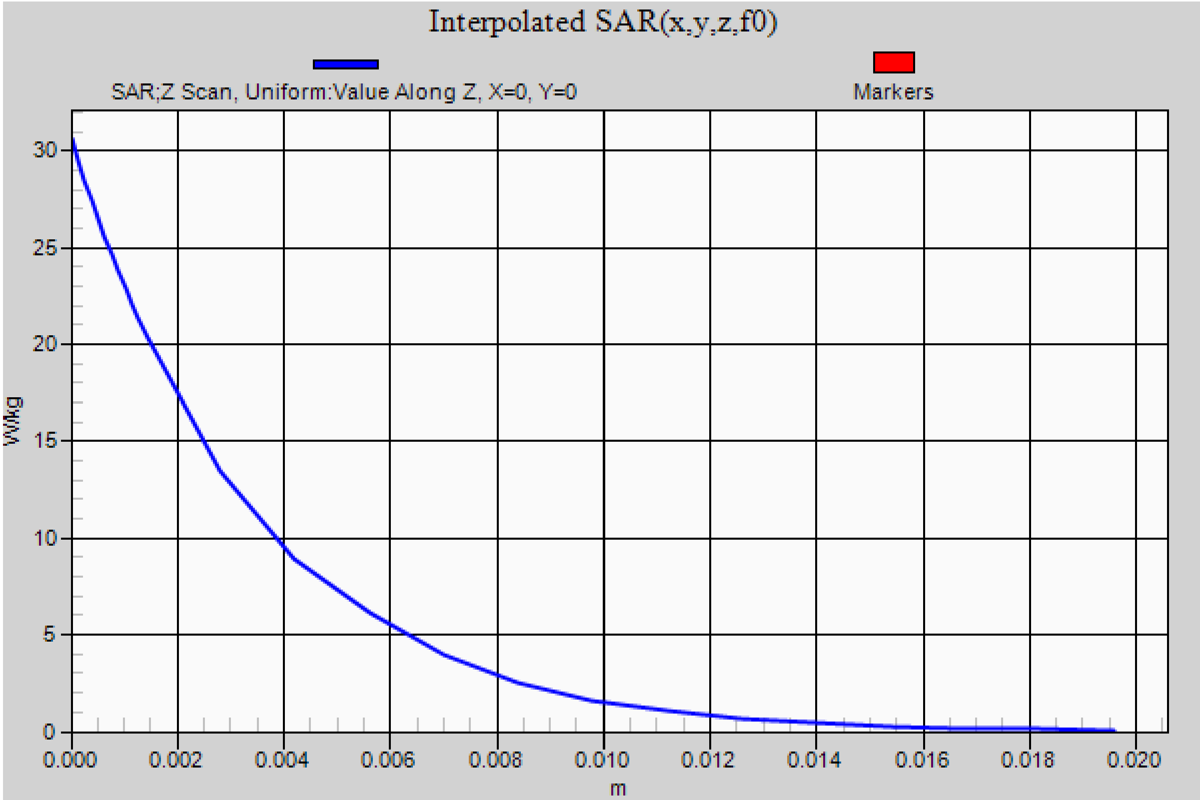
Area Scan (41x41x1): Interpolated grid: dx = 1.000 mm, dy = 1.000 mm
Maximum value of SAR (interpolated) = 20.0 W/kg

Zoom Scan, dist=1.4 mm (8x8x8)/Cube 0: Measurement grid: dx = 4 mm, dy = 4 mm, dz = 1.4 mm
Reference Value = 74.12 V/m; Power Drift = - 0.13 dB
Peak SAR (extrapolated) = 32.4 W/kg
SAR(1 g) = 8.28 W/kg; SAR(10 g) = 2.37 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 66.1 %
Maximum value of SAR (measured) = 19.4 W/kg

Z Scan, Uniform (1x1x25): Measurement grid: dx = 20 mm, dy = 20 mm, dz = 1.4 mm
Penetration depth = 3.211 (3.640, 3.273) [mm]
Maximum value of SAR (interpolated) = 30.6 W/kg

Ambient Temp. : 22.0 degree.C. Liquid Temp.; 21.5 degree.C.
Liquid temp. is kept within the 2 degree.C. during the test.
Date: 2022/09/29




Interpolated SAR(x,y,z,f0)
SAR;Z Scan, Uniform:Value Along Z, X=0, Y=0
Markers
W/kg
30
25
20
15
10
5
0
0.000
0.002
0.004
0.006
0.008
0.010
0.012
0.014
0.016
0.018
0.020
m

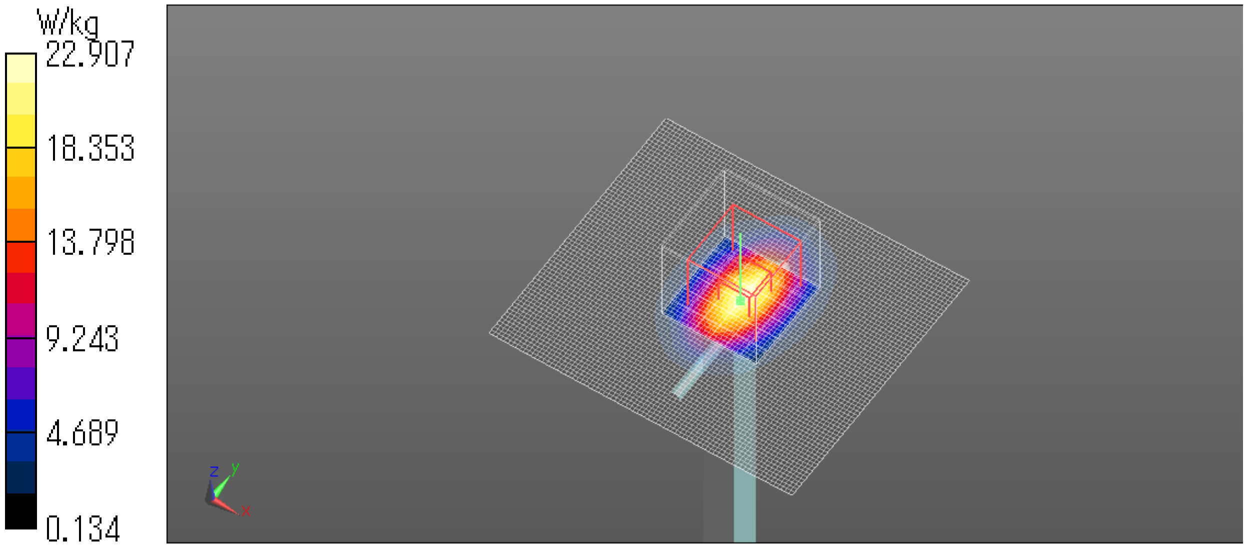
2450MHz System Check
Communication System: UID 0, CW (0); Communication System Band: D2450 (2450.0 MHz); ; Duty Cycle: 1:1
Medium parameters used: f = 2450 MHz; σ = 1.762 S/m; ε_r = 38.506; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY5 Configuration
Probe: EX3DV4 - SN3922; ConvF(7.85, 7.85, 7.85) @ 2450 MHz;
Sensor-Surface: 1.4 mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1372;
Phantom: ELI v4.0 (20deg probe tilt); Type: QDOVA001BB;Serial: TP:1045
Measurement SW: DASY52, Version 52.10 (4);SEMCAD X Version 14.6.14 (7501)

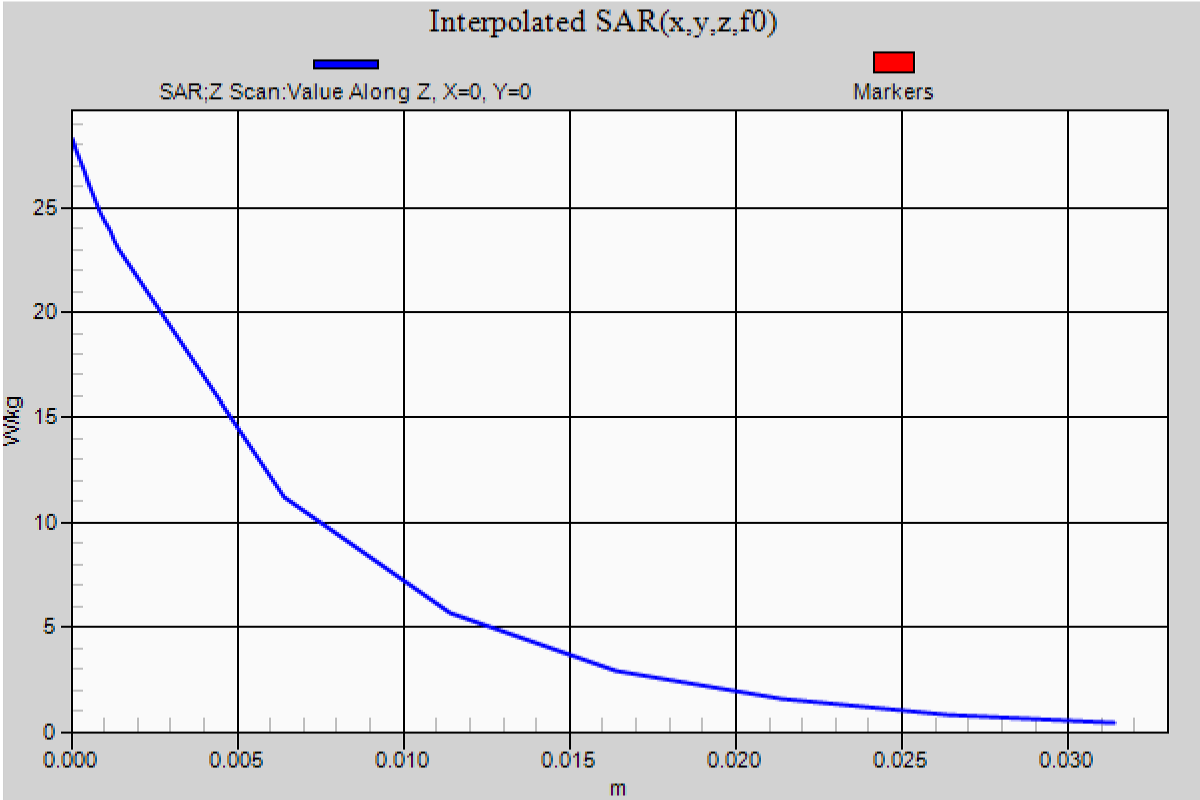
Area Scan (81x71x1): Interpolated grid: dx = 1.200 mm, dy = 1.200 mm
Maximum value of SAR (interpolated) = 23.1 W/kg

Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx = 5 mm, dy = 5 mm, dz = 5 mm
Reference Value = 119.5 V/m; Power Drift = - 0.04 dB
Peak SAR (extrapolated) = 28.4 W/kg
SAR(1 g) = 13.8 W/kg; SAR(10 g) = 6.41 W/kg
Smallest distance from peaks to all points 3 dB below = 9 mm
Ratio of SAR at M2 to SAR at M1 = 48.8 %
Maximum value of SAR (measured) = 22.9 W/kg

Z Scan (1x1x18): Measurement grid: dx = 20 mm, dy = 20 mm, dz = 5 mm
Penetration depth = 7.286 (6.989, 7.564) [mm]
Maximum value of SAR (interpolated) = 28.3 W/kg

Ambient Temp. : 22.0 degree.C. Liquid Temp.; 21.5 degree.C.
Liquid temp. is kept within the 2 degree.C. during the test.
Date: 2022/11/17




Interpolated SAR(x,y,z,f0)
SAR;Z Scan:Value Along Z, X=0, Y=0
Markers
W/kg
25
20
15
10
5
0
0.000
0.005
0.010
0.015
0.020
0.025
0.030
m

APPENDIX 2: SAR Measurement data

Evaluation procedure

The evaluation was performed with the following procedure:

Step 1: Measurement of the E-field at a fixed location above the ear point or central position of flat phantom was used as a reference value for assessing the power drop.

Step 2: The SAR distribution at the exposed side of head or body position was measured at a distance of each device from the inner surface of the shell. The area covered the entire dimension of the antenna of EUT and the horizontal grid spacing was 15 mm x 15 mm, 12 mm x 12 mm or 10 mm x 10 mm. Based on these data, the area of the maximum absorption was determined by spline interpolation.

Step 3: Around this point found in the Step 2 (area scan), a volume of 30 mm x 30 mm x 30 mm or more was assessed by measuring 7 x 7 x 7 points at least for below 3 GHz and a volume of 28 mm x 28 mm x 22.5 mm or more was assessed by measuring 8 x 8 x 6(ratio step method (*1)) points at least for above 3 GHz band.

And for any secondary peaks found in the Step2 which are within 2 dB of maximum peak and not with this Step3 (Zoom scan) is repeated. On the basis of this data set, the spatial peak SAR value was evaluated under the following procedure:

(1). The data at the surface were extrapolated, since the center of the dipoles is 1 mm(EX3DV4) away from the tip of the probe and the distance between the surface and the lowest measuring point is 1.3 mm. The extrapolation was based on a least square algorithm [4]. A polynomial of the fourth order was calculated through the points in z-axes.
This polynomial was then used to evaluate the points between the surface and the probe tip.

(2). The maximum interpolated value was searched with a straightforward algorithm. Around this maximum the SAR values averaged over the spatial volumes (1 g or 10 g) were computed by the 3D-Spline interpolation algorithm. The 3D-Spline is composed of three one-dimensional splines with the "Not a knot"-condition (in x, y and z-directions). The volume was integrated with the trapezoidal-algorithm. One thousand points (10 x 10 x 10) were interpolated to calculate the average.

(3). All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.

***1. Ratio step method parameters used;**
The first measurement point: 1.4 mm from the phantom surface, the initial grid separation: 1.4 mm, subsequent graded grid ratio: 1.4
These parameters comply with the requirement of the KDB 865664 D01.

Step 4: Re-measurement of the E-field at the same location as in Step 1.
Confirmation after SAR testing
It was checked that the power drift [W] is within +/-5 %.The verification of power drift during the SAR test is that DASY5 system calculates the power drift by measuring the e-filed at the same location at beginning and the end of the scan measurement for each test position.

DASY5 system calculation Power drift value[dB] =20log(Ea)/(Eb)
Before SAR testing : Eb [V/m]
After SAR testing : Ea [V/m]

Limit of power drift[W] = +/- 5 %
X[dB] = 10log[P] = 10log(1.05/1) = 10log(1.05) -10log(1) = 0.212 dB

from E-filed relations with power.
$p=E^2/\eta$
Therefore, The correlation of power and the E-filed
X dB = 10log(P) = 10log(E)^2 = 20log(E)

Therefore,
The calculated power drift of DASY5 System must be the less than +/- 0.212 dB.

Measurement data

Plot No. 1

WLAN 2.4 GHz
Communication System: UID 0, _WLAN (0); Communication System Band: 11b/g/n; ; Duty Cycle: 1:1
Medium parameters used (interpolated): f = 2462 MHz; σ = 1.768 S/m; ε_r = 37.636; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY5 Configuration
Probe: EX3DV4 - SN3922; ConvF(7.85, 7.85, 7.85) @ 2462 MHz;
Sensor-Surface: 1.4 mm (Mechanical Surface Detection (Locations From Previous Scan Used)), Sensor-Surface: 1.4 mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1372;
Phantom: ELI v4.0 (20deg probe tilt); Type: QDOVA001BB;Serial: TP:1045
Measurement SW: DASY52, Version 52.10 (4);SEMCAD X Version 14.6.14 (7501)

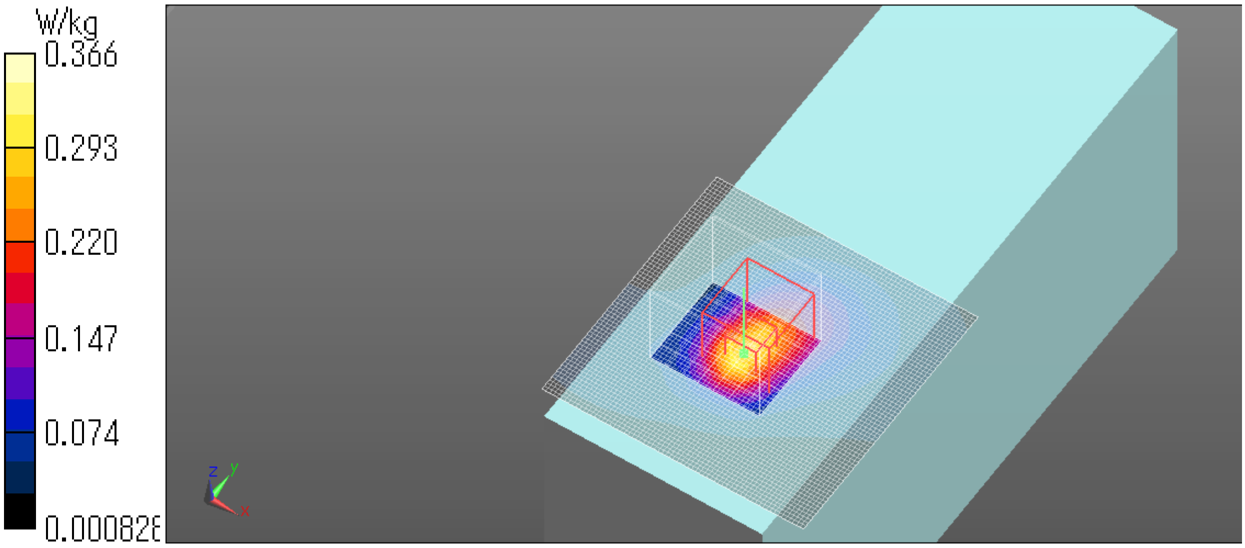
Configuration/Right tilt High ch/Area Scan (71x71x1): Interpolated grid: dx = 1.200 mm, dy = 1.200 mm

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (interpolated) = 0.287 W/kg

Configuration/Right tilt High ch/Zoom Scan (8x7x7)/Cube 0: Measurement grid: dx = 5 mm, dy = 5 mm, dz = 5 mm
Reference Value = 14.94 V/m; Power Drift = - 0.01 dB
Peak SAR (extrapolated) = 0.466 W/kg
SAR(1 g) = 0.214 W/kg; SAR(10 g) = 0.102 W/kg
Smallest distance from peaks to all points 3 dB below = 9 mm
Ratio of SAR at M2 to SAR at M1 = 46.2 %

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.366 W/kg

Ambient Temp. : 22.0 degree.C. Liquid Temp.; 21.5 degree.C.
Liquid temp. is kept within the 2 degree.C. during the test.
Date: 2022/10/11



Plot. No: 2

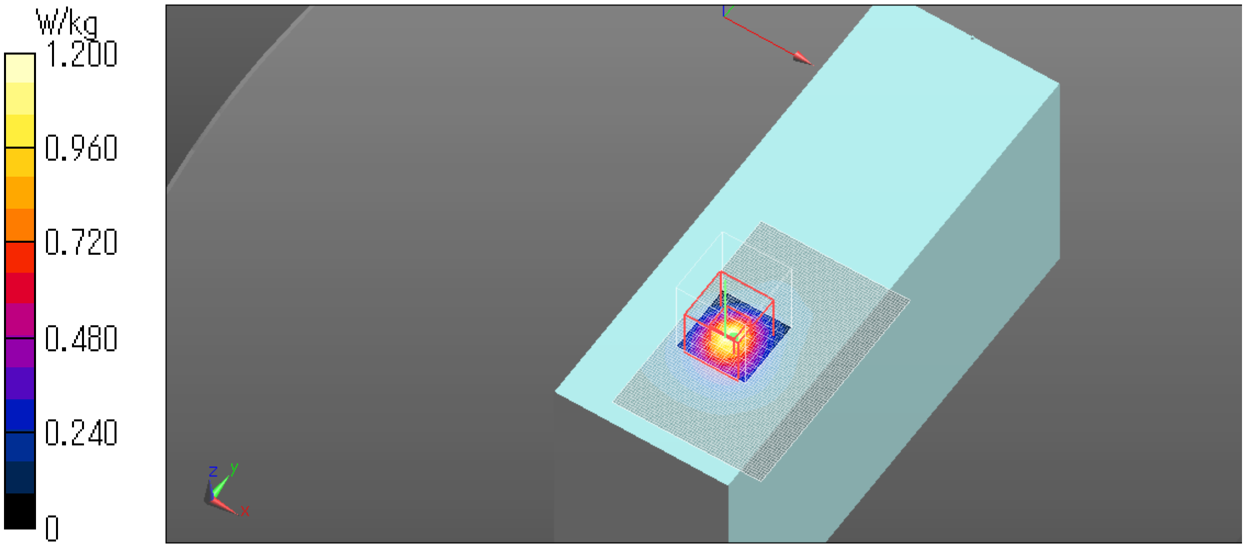
WLAN 5.3 GHz
Communication System: UID 0, _WLAN (0); Communication System Band: 11a/n/ac; ; Duty Cycle: 1:1
Medium parameters used: f = 5280 MHz; σ = 4.675 S/m; ε_r = 34.255; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY5 Configuration
Probe: EX3DV4 - SN3922; ConvF(5.54, 5.54, 5.54) @ 5280 MHz;
Sensor-Surface: 1.4 mm (Mechanical Surface Detection (Locations From Previous Scan Used)), Sensor-Surface: 1.4 mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1372;
Phantom: ELI v4.0 (20deg probe tilt); Type: QDOVA001BB;Serial: TP:1045
Measurement SW: DASY52, Version 52.10 (4);SEMCAD X Version 14.6.14 (7501)

Configuration/Right tilt Mid ch/Area Scan (61x91x1): Interpolated grid: dx = 1.000 mm, dy = 1.000 mm
Maximum value of SAR (interpolated) = 1.32 W/kg

Configuration/Right tilt Mid ch/Zoom Scan (8x8x8)/Cube 0: Measurement grid: dx = 4 mm, dy = 4 mm, dz = 1.4 mm
Reference Value = 17.67 V/m; Power Drift = - 0.11 dB
Peak SAR (extrapolated) = 1.95 W/kg
SAR(1 g) = 0.510 W/kg; SAR(10 g) = 0.161 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 65.5 %

Maximum value of SAR (measured) = 1.20 W/kg

Ambient Temp. : 22.0 degree.C. Liquid Temp.; 21.5 degree.C.
Liquid temp. is kept within the 2 degree.C. during the test.
Date: 2022/09/29



Plot No. 3

BT
Communication System: UID 0, #Bluetooth (0); Communication System Band: Bluetooth; ; Duty Cycle: 1:1
Medium parameters used (interpolated): f = 2441 MHz; σ = 1.755 S/m; ε_r = 38.502; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY5 Configuration
Probe: EX3DV4 - SN3922; ConvF(7.85, 7.85, 7.85) @ 2441 MHz;
Sensor-Surface: 1.4 mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1372;
Phantom: ELI v4.0 (20deg probe tilt); Type: QDOVA001BB;Serial: TP:1045
Measurement SW: DASY52, Version 52.10 (4);SEMCAD X Version 14.6.14 (7501)

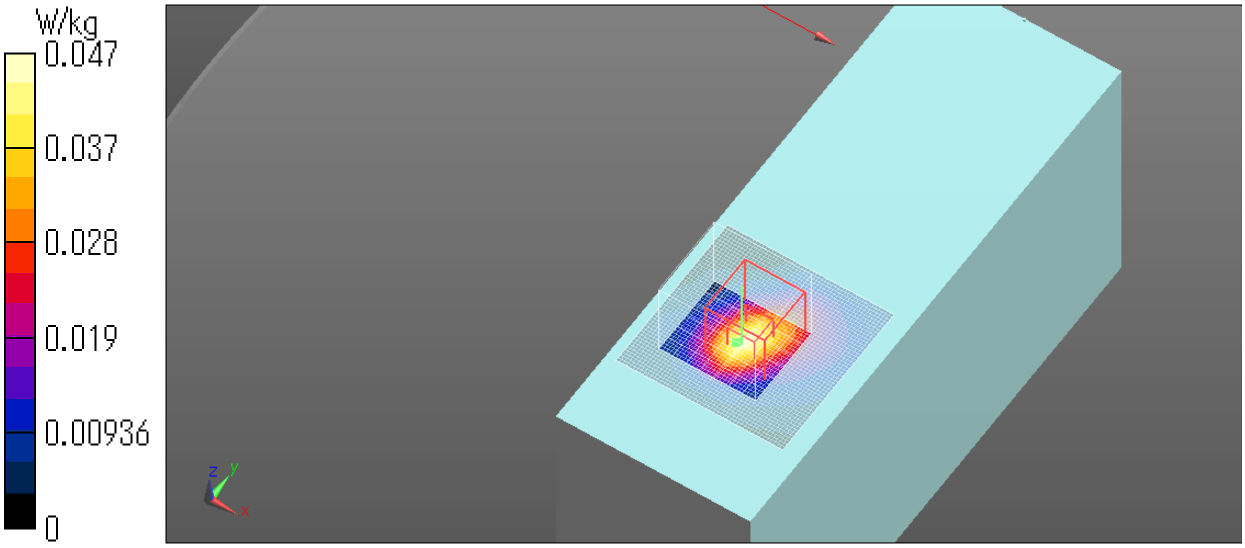
Configuration/Right tilt/Area Scan 3 (51x51x1): Interpolated grid: dx = 1.200 mm, dy = 1.200 mm

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (interpolated) = 0.0441 W/kg

Configuration/Right tilt/Zoom Scan (8x7x7)/Cube 0: Measurement grid: dx = 5 mm, dy = 5 mm, dz = 5 mm
Reference Value = 5.406 V/m; Power Drift = - 0.13 dB
Peak SAR (extrapolated) = 0.0610 W/kg
SAR(1 g) = 0.027 W/kg; SAR(10 g) = 0.012 W/kg
Smallest distance from peaks to all points 3 dB below: Larger than measurement grid (> 15 mm)
Ratio of SAR at M2 to SAR at M1 = 42.2 %

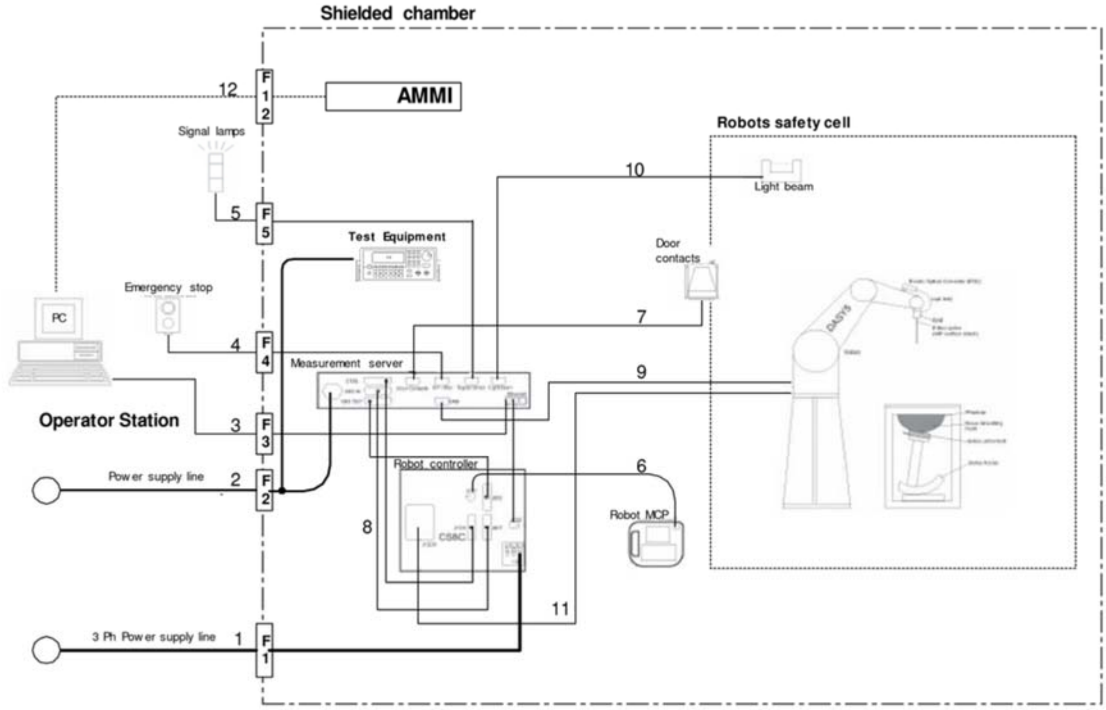
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.0468 W/kg

Ambient Temp. : 22.0 degree.C.   Liquid Temp.; 21.5 degree.C.
Liquid temp. is kept within the 2 degree.C. during the test.
Date: 2022/11/17



APPENDIX 3: System specifications

Configuration and peripherals



The DASY5 system for performing compliance tests consist of the following items:
Our system is DASY6; however, it behaves as DASY5.

a) A standard high precision 6-axis robot (Stäubli RX family) with controller and software.
An arm extension for accommodating the data acquisition electronics (DAE).

b) An isotropic field probe optimized and calibrated for the targeted measurement.

c) A data acquisition electronic (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.

d) The Electro-optical converter (EOC) performs the conversion between optical and electrical of the signals for the digital communication to the DAE and for the analog signal from the optical surface detection.
The EOC is connected to the measurement server.

e) 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.

f) The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.

g) A computer running Windows 10 or 7 and the DASY5/6 software.

h) Remote control with teaches pendant and additional circuitry for robot safety such as warning lamps, etc.

i) The phantom, the device holder and other accessories according to the targeted measurement.

Specifications

a) Robot TX60L

Number of Axes	:	6
Nominal Load	:	2 kg
Maximum Load	:	5 kg
Reach	:	920 mm
Repeatability	:	+/-0.03 mm
Control Unit	:	CS8c
Programming Language	:	VAL3
Weight	:	52.2 kg
Manufacture	:	Stäubli Robotics

b) E-Field Probe

Model	:	EX3DV4
Construction	:	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., glycol ether)
Frequency	:	10 MHz to > 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz)
Directivity	:	+/-0.3 dB in HSL (rotation around probe axis) +/-0.5 dB in tissue material (rotation normal probe axis)
Dynamic Range	:	10uW/g to > 100 mW/g;Linearity +/-0.2 dB(noise: typically < 1uW/g)
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
Application	:	Highprecision dosimetric measurement in any exposure scenario (e.g., very strong gradient fields).Only probe which enables compliance testing for frequencies up to 6 GHz with precision of better 30 %.
Manufacture	:	Schmid & Partner Engineering AG

EX3DV4 E-field Probe

c) Data Acquisition Electronic (DAE4)

Features	:	Signal amplifier, multiplexer, A/D converter and control logic Serial optical link for communication with DASY5 embedded system (fully remote controlled) Two step probe touch detector for mechanical surface detection and emergency robot stop
Measurement Range	:	-100 to +300 mV (16 bit resolution and two range settings: 4 mV, 400 mV)
Input Offset voltage	:	< 5 µV (with auto zero)
Input Resistance	:	200 MΩ
Input Bias Current	:	< 50 fA
Battery Power	:	> 10 h of operation (with two 9.6 V NiMH accus)
Dimension	:	60 x 60 x 68 mm
Manufacture	:	Schmid & Partner Engineering AG

d) Electro-Optic Converter (EOC)

Version	:	EOC 61
Description	:	for TX60 robot arm, including proximity sensor
Manufacture	:	Schmid & Partner Engineering AG

e) DASY5 Measurement server

Features	:	Intel ULV Celeron 400 MHz 128 MB chip disk and 128 MB RAM 16 Bit A/D converter for surface detection system Vacuum Fluorescent Display Robot Interface Serial link to DAE (with watchdog supervision) Door contact port (Possibility to connect a light curtain) Emergency stop port (to connect the remote control) Signal lamps port Light beam port Three Ethernet connection ports Two USB 2.0 Ports Two serial links Expansion port for future applications
Dimensions (L x W x H)	:	440 x 241 x 89 mm
Manufacture	:	Schmid & Partner Engineering AG

f) Light Beam Switches

Version	:	LB5
Dimensions (L x H)	:	110 x 80 mm
Thickness	:	12 mm
Beam-length	:	80 mm
Manufacture	:	Schmid & Partner Engineering AG

g) Software

Item	:	Dosimetric Assessment System DASY5
Type No.	:	SD 000 401A, SD 000 402A
Software version No.	:	DASY52, Version 52.6 (1)
Manufacture / Origin	:	Schmid & Partner Engineering AG

h) Robot Control Unit

Weight	:	70 Kg
AC Input Voltage	:	selectable
Manufacturer	:	Stäubli Robotics

i) Phantom and Device Holder

Phantom

Type	:	SAM Twin Phantom V4.0
Description	:	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209-1. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot.
Material	:	Vinylester, glass fiber reinforced (VE-GF)
Shell Material	:	Fiberglass
Thickness	:	2.0 +/- 0.2 mm
Dimensions	:	Length: 1000 mm Width: 500 mm Height: adjustable feet
Volume	:	Approx. 25 liters
Manufacture	:	Schmid & Partner Engineering AG

Type	:	2 mm Flat phantom ELI4.0 or 5
Description	:	Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI4 is fully compatible with the latest draft of the standard IEC 62209 Part II and all known tissue simulating liquids. ELI4 has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is supported by software version DASY4.5 and higher and is compatible with all SPEAG dosimetric probes and dipoles.
Material	:	Vinylester, glass fiber reinforced (VE-GF)
Shell Thickness	:	2.0 ± 0.2 mm (sagging: < 1 %)
Filling Volume	:	Approx. 30 liters
Dimensions	:	Major ellipse axis: 600 mm Minor axis: 400 mm
Manufacture	:	Schmid & Partner Engineering AG

Device Holder

In combination with the Twin SAM Phantom V4.0/V4.0c or ELI4, the Mounting Device enables the rotation of the mounted transmitter device in spherical coordinates. Rotation point is the ear opening point. Transmitter devices can be easily and accurately positioned according to IEC, IEEE, FCC or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat).

Material : POM

Laptio Extensions kit

Simple but effective and easy-to-use extension for Mounting Device that facilitates the testing of larger devices according to IEC 62209-2 (e.g., laptops, cameras, etc.). It is lightweight and 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, ELI4 Phantoms.

Material : POM, Acrylic glass, Foam

Urethane

For this measurement, the urethane foam was used as device holder.

j)Simulated Tissues (Liquid)

The following tissue formulations are provided for reference only as some of the parameters have not been thoroughly verified. The composition of ingredients may be modified accordingly to achieve the desired target tissue parameters required for routine SAR evaluation.

Product identifier

Trade name	Broad Band Tissue Simulation Liquid HBBL600-10000V6, MBBL600-6000V6, HU16B, MU16B
Manufacturer/Supplier	Schmid & Partner Engineering AG

Declarable components:

CAS: 107-21-1 EINECS: 203-473-3 Reg.nr.: 01-2119456816-28-0000	**Ethanediol** STOT RE 2, H373; Acute Tox. 4, H302	< 5.2%
CAS: 68608-26-4 EINECS: 271-781-5 Reg.nr.: 01-2119527859-22-0000	**Sodium petroleum sulfonate** Eye Irrit. 2, H319	< 2.9%
CAS: 107-41-5 EINECS: 203-489-0 Reg.nr.: 01-2119539582-35-0000	**Hexylene Glycol / 2-Methyl-pentane-2,4-diol** Skin Irrit. 2, H315; Eye Irrit. 2, H319	< 2.9%
CAS: 68920-66-1 NLP: 500-236-9 Reg.nr.: 01-2119489407-26-0000	**Alkoxylated alcohol, > C_{16}** Aquatic Chronic 2, H411; Skin Irrit. 2, H315; Eye Irrit. 2, H319	< 2.0%

System Check Dipole SAR Calibration Certificate -DipoleD5GHz (D5GHzV2 S/N: 1020)

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **UL Japan (RCC)**

Certificate No: **D5GHzV2-1020_Nov21**

CALIBRATION CERTIFICATE

Object	D5GHzV2 - SN:1020
Calibration procedure(s)	QA CAL-22.v6 Calibration Procedure for SAR Validation Sources between 3-10 GHz
Calibration date:	November 18, 2021

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 (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	09-Apr-21 (No. 217-03291/03292)	Apr-22
Power sensor NRP-Z91	SN: 103244	09-Apr-21 (No. 217-03291)	Apr-22
Power sensor NRP-Z91	SN: 103245	09-Apr-21 (No. 217-03292)	Apr-22
Reference 20 dB Attenuator	SN: BH9394 (20k)	09-Apr-21 (No. 217-03343)	Apr-22
Type-N mismatch combination	SN: 310982 / 06327	09-Apr-21 (No. 217-03344)	Apr-22
Reference Probe EX3DV4	SN: 3503	30-Dec-20 (No. EX3-3503_Dec20)	Dec-21
DAE4	SN: 601	01-Nov-21 (No. DAE4-601_Nov21)	Nov-22

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-22

	Name	Function	Signature
Calibrated by:	Jeffrey Katzman	Laboratory Technician	
Approved by:	Niels Kuster	Quality Manager	

Issued: November 18, 2021

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

Certificate No: D5GHzV2-1020_Nov21 Page 1 of 14

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

a) IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices - Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

c) DASY 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 source is mounted in a touch configuration below the center marking of the flat phantom.
- *Return Loss:* This parameter is measured with the source positioned under the liquid filled phantom (as described in the measurement condition clause). The Return Loss ensures low reflected power. 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%.

Measurement Conditions

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

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5250 MHz ± 1 MHz 5600 MHz ± 1 MHz 5800 MHz ± 1 MHz 5850 MHz ± 1 MHz	

Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	35.9	4.71 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.9 ± 6 %	4.58 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5250 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.79 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**77.8 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.23 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.3 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.4 ± 6 %	4.94 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.18 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**81.7 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.2 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.1 ± 6 %	5.15 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.80 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**77.8 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.21 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.1 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5850 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.2	5.32 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.0 ± 6 %	5.20 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5850 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.08 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**80.7 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.28 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.8 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.36 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.7 ± 6 %	5.43 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5250 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.38 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**73.8 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.05 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.5 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.1 ± 6 %	5.91 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.69 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**76.9 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.12 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**21.2 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.8 ± 6 %	6.19 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.29 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**72.9 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	1.99 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**19.9 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5850 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.1	6.06 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.7 ± 6 %	6.26 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5850 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.50 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**75.0 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.05 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.5 W/kg ± 19.5 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	52.3 Ω - 6.9 jΩ
Return Loss	- 23.0 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	54.7 Ω - 2.4 jΩ
Return Loss	- 25.9 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	56.0 Ω + 0.5 jΩ
Return Loss	- 24.9 dB

Antenna Parameters with Head TSL at 5850 MHz

Impedance, transformed to feed point	55.5 Ω + 0.6 jΩ
Return Loss	- 25.6 dB

Antenna Parameters with Body TSL at 5250 MHz

Impedance, transformed to feed point	52.2 Ω - 4.7 jΩ
Return Loss	- 25.9 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	55.9 Ω - 0.2 jΩ
Return Loss	- 25.1 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	56.7 Ω + 2.9 jΩ
Return Loss	- 23.3 dB

Antenna Parameters with Body TSL at 5850 MHz

Impedance, transformed to feed point	56.6 Ω + 2.0 jΩ
Return Loss	- 23.8 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.200 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

DASY5 Validation Report for Head TSL

Date: 18.11.2021

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1020

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz, Frequency: 5850 MHz
Medium parameters used: f = 5250 MHz; σ = 4.58 S/m; ε_r = 35.9; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5600 MHz; σ = 4.94 S/m; ε_r = 35.4; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5800 MHz; σ = 5.15 S/m; ε_r = 35.1; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5850 MHz; σ = 5.20 S/m; ε_r = 35.0; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

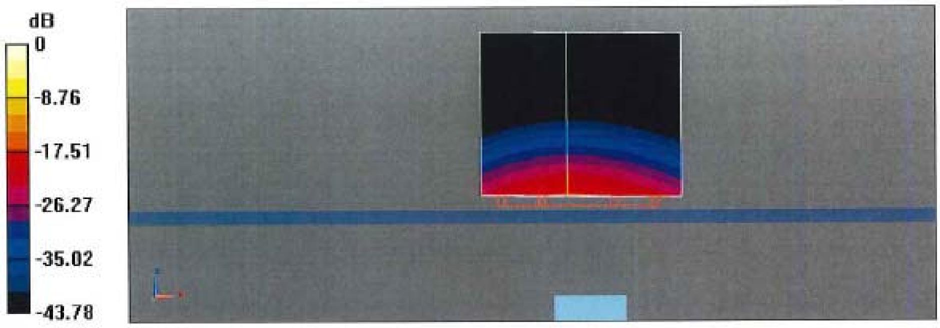
- Probe: EX3DV4 - SN3503; ConvF(5.5, 5.5, 5.5) @ 5250 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.01, 5.01, 5.01) @ 5800 MHz, ConvF(4.99, 4.99, 4.99) @ 5850 MHz; Calibrated: 30.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 01.11.2021
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 77.24 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 26.0 W/kg
SAR(1 g) = 7.79 W/kg; SAR(10 g) = 2.23 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 71.2%
Maximum value of SAR (measured) = 17.4 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 77.85 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 29.5 W/kg
SAR(1 g) = 8.18 W/kg; SAR(10 g) = 2.33 W/kg
Smallest distance from peaks to all points 3 dB below = 7.4 mm
Ratio of SAR at M2 to SAR at M1 = 68.5%
Maximum value of SAR (measured) = 18.9 W/kg

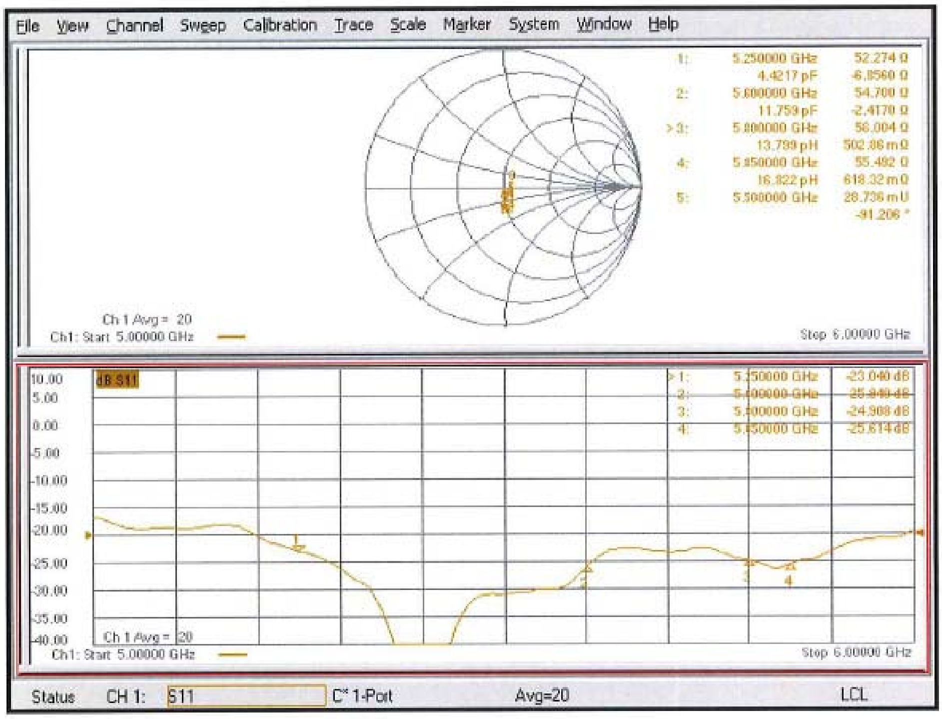
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 74.63 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 30.0 W/kg
SAR(1 g) = 7.80 W/kg; SAR(10 g) = 2.21 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 66.7%
Maximum value of SAR (measured) = 18.4 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5850 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 75.98 V/m; Power Drift = -0.00 dB
Peak SAR (extrapolated) = 31.5 W/kg
SAR(1 g) = 8.08 W/kg; SAR(10 g) = 2.28 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 66.2%
Maximum value of SAR (measured) = 19.4 W/kg



0 dB = 19.4 W/kg = 12.87 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 15.11.2021

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1020

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz, Frequency: 5850 MHz
Medium parameters used: f = 5250 MHz; σ = 5.43 S/m; ε_r = 48.7; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5600 MHz; σ = 5.91 S/m; ε_r = 48.1; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5800 MHz; σ = 6.19 S/m; ε_r = 47.8; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5850 MHz; σ = 6.26 S/m; ε_r = 47.7; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

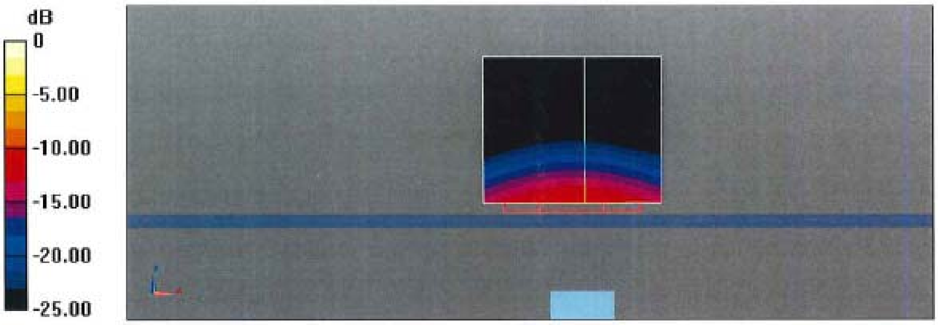
- Probe: EX3DV4 - SN3503; ConvF(5.26, 5.26, 5.26) @ 5250 MHz, ConvF(4.79, 4.79, 4.79) @ 5600 MHz, ConvF(4.62, 4.62, 4.62) @ 5800 MHz, ConvF(4.61, 4.61, 4.61) @ 5850 MHz; Calibrated: 30.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 01.11.2021
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 67.20 V/m; Power Drift = -0.07 dB
Peak SAR (extrapolated) = 27.4 W/kg
SAR(1 g) = 7.38 W/kg; SAR(10 g) = 2.05 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 68.2%
Maximum value of SAR (measured) = 16.9 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 67.24 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 31.8 W/kg
SAR(1 g) = 7.69 W/kg; SAR(10 g) = 2.12 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 64.6%
Maximum value of SAR (measured) = 18.4 W/kg

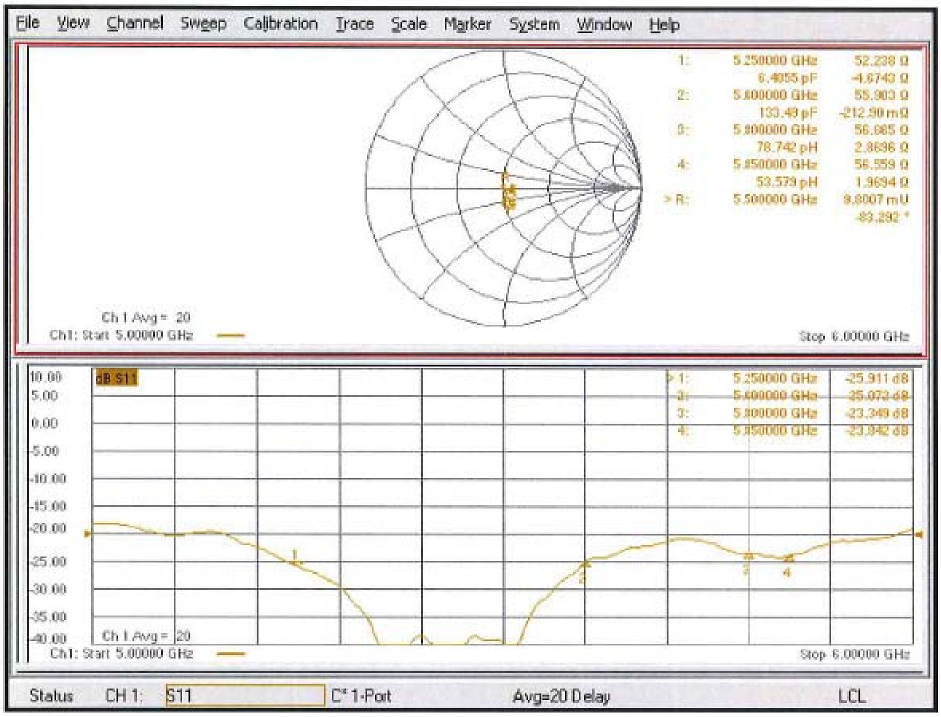
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.49 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 30.8 W/kg
SAR(1 g) = 7.29 W/kg; SAR(10 g) = 1.99 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 64%
Maximum value of SAR (measured) = 17.7 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5850 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.50 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 32.6 W/kg
SAR(1 g) = 7.50 W/kg; SAR(10 g) = 2.05 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 63.2%
Maximum value of SAR (measured) = 18.3 W/kg



0 dB = 18.4 W/kg = 12.65 dBW/kg

Impedance Measurement Plot for Body TSL



Certificate No: D5GHzV2-1020_Nov21 Page 14 of 14

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System Check Dipole SAR Calibration Certificate -Dipole 2450 MHz (D2450V2 S/N: 713)

Calibration Laboratory of
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Accreditation No.: SCS 0108

Client **UL Japan Head Office (RCC)**

Certificate No: **D2450V2-713_Sep22**

CALIBRATION CERTIFICATE

Object	D2450V2 - SN:713
Calibration procedure(s)	QA CAL-05.v11 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz
Calibration date:	September 12, 2022

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 (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-22 (No. 217-03525/03524)	Apr-23
Power sensor NRP-Z91	SN: 103244	04-Apr-22 (No. 217-03524)	Apr-23
Power sensor NRP-Z91	SN: 103245	04-Apr-22 (No. 217-03525)	Apr-23
Reference 20 dB Attenuator	SN: BH9394 (20k)	04-Apr-22 (No. 217-03527)	Apr-23
Type-N mismatch combination	SN: 310982 / 06327	04-Apr-22 (No. 217-03528)	Apr-23
Reference Probe EX3DV4	SN: 7349	31-Dec-21 (No. EX3-7349_Dec21)	Dec-22
DAE4	SN: 601	31-Aug-22 (No. DAE4-601_Aug22)	Aug-23

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41093315	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-22

	Name	Function	Signature
Calibrated by:	Michael Weber	Laboratory Technician	M.Weber
Approved by:	Sven Kühn	Technical Manager	S.

Issued: September 13, 2022

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

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S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
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Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

a) IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices - Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

c) DASY 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 source is mounted in a touch configuration below the center marking of the flat phantom.
- *Return Loss:* This parameter is measured with the source positioned under the liquid filled phantom (as described in the measurement condition clause). The Return Loss ensures low reflected power. 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%.

Measurement Conditions

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

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.8 ± 6 %	1.84 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.3 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**52.3 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.19 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**24.5 W/kg ± 16.5 % (k=2)**

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	51.0 ± 6 %	2.03 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.0 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**50.6 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.15 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**24.2 W/kg ± 16.5 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.0 Ω + 1.9 jΩ
Return Loss	- 29.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.7 Ω + 4.7 jΩ
Return Loss	- 26.5 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.160 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

DASY5 Validation Report for Head TSL

Date: 12.09.2022

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 713

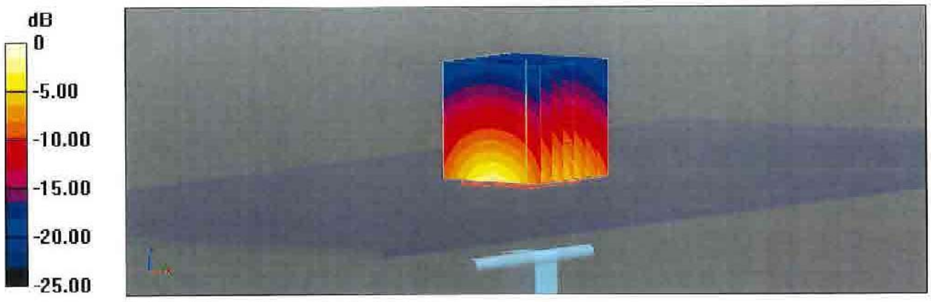
Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 1.84 S/m; ε_r = 37.8; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.96, 7.96, 7.96) @ 2450 MHz; Calibrated: 31.12.2021
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 31.08.2022
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

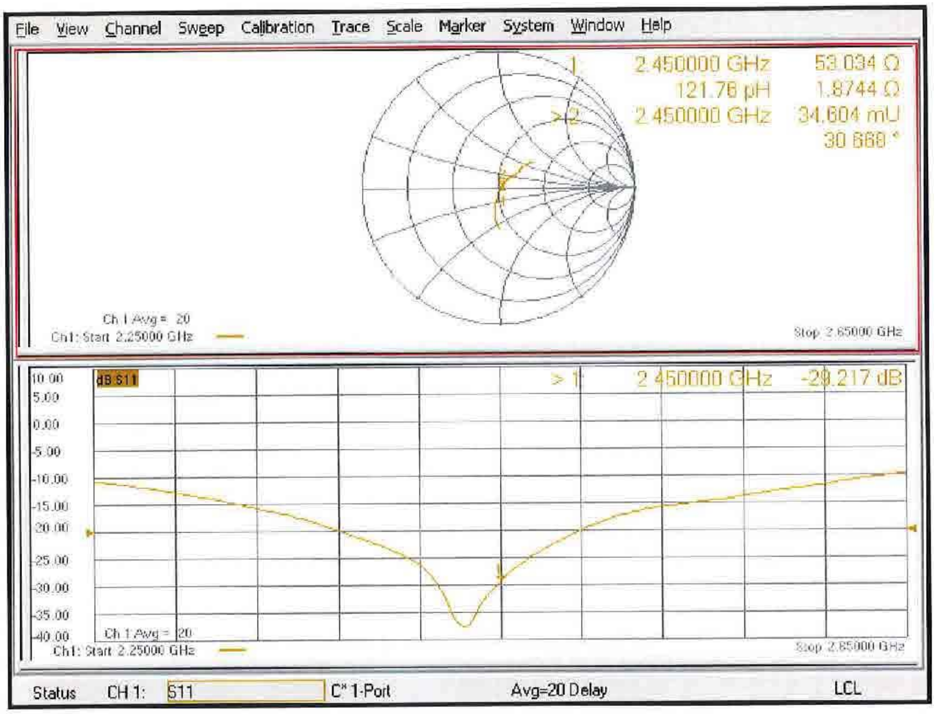
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 114.4 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 26.0 W/kg
SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.19 W/kg
Smallest distance from peaks to all points 3 dB below = 9 mm
Ratio of SAR at M2 to SAR at M1 = 51.3%
Maximum value of SAR (measured) = 21.6 W/kg



0 dB = 21.6 W/kg = 13.34 dBW/kg

Certificate No: D2450V2-713_Sep22 Page 5 of 8

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 12.09.2022

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 713

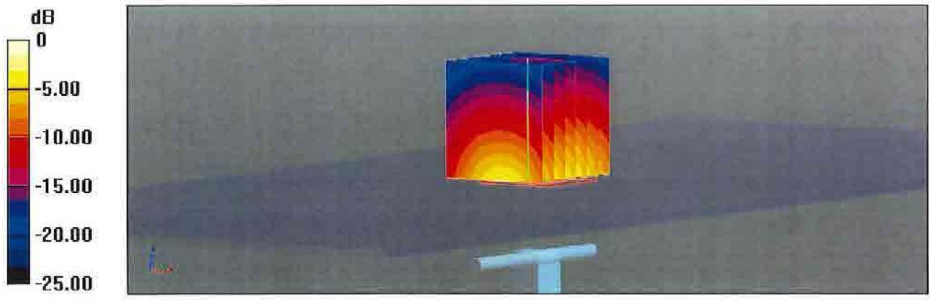
Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 2.03 S/m; ε_r = 51; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.12, 8.12, 8.12) @ 2450 MHz; Calibrated: 31.12.2021
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 31.08.2022
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

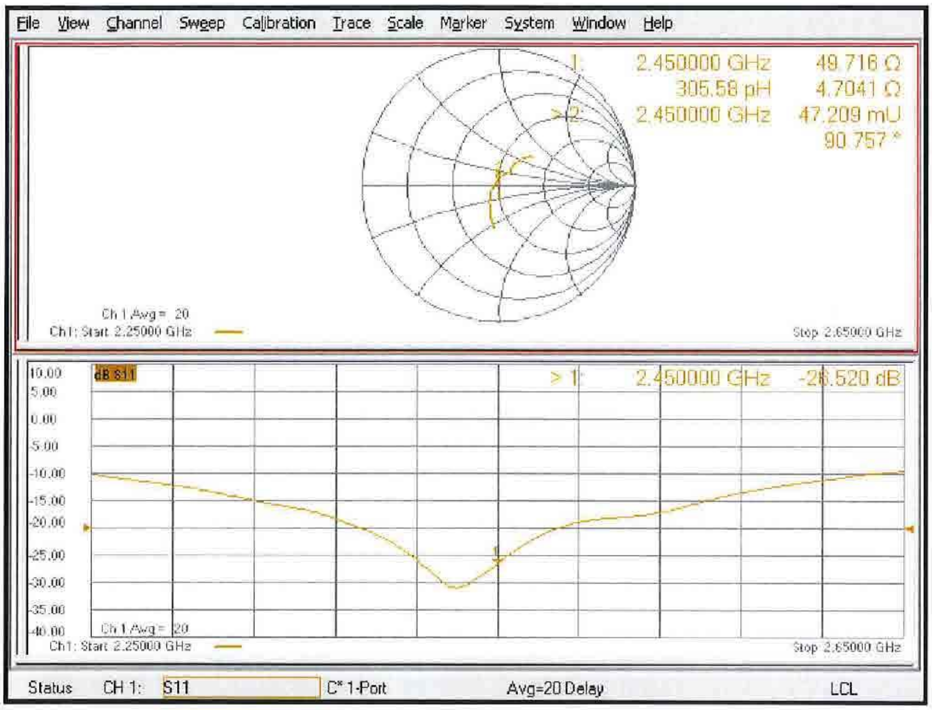
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 108.3 V/m; Power Drift = -0.07 dB
Peak SAR (extrapolated) = 24.2 W/kg
SAR(1 g) = 13.0 W/kg; SAR(10 g) = 6.15 W/kg
Smallest distance from peaks to all points 3 dB below = 9 mm
Ratio of SAR at M2 to SAR at M1 = 55.3%
Maximum value of SAR (measured) = 19.7 W/kg



0 dB = 19.7 W/kg = 12.93 dBW/kg

Certificate No: D2450V2-713_Sep22 Page 7 of 8

Impedance Measurement Plot for Body TSL



Certificate No: D2450V2-713_Sep22 Page 8 of 8

Dosimetric E-Field Probe Calibration Certificate (EX3DV4, S/N: 3922)

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
Servizio svizzero di taratura
S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client: UL Japan Head Office (RCC)

Certificate No: EX-3922_Aug22

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3922
Calibration procedure(s)	QA CAL-01.v9, QA CAL-12.v9, QA CAL-14.v6, QA CAL-23.v5, QA CAL-25.v7 Calibration procedure for dosimetric E-field probes
Calibration date	August 19, 2022

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 (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-22 (No. 217-03525/03524)	Apr-23
Power sensor NRP-Z91	SN: 103244	04-Apr-22 (No. 217-03524)	Apr-23
OCP DAK-3.5 (weighted)	SN: 1249	20-Oct-21 (OCP-DAK3.5-1249_Oct21)	Oct-22
OCP DAK-12	SN: 1016	20-Oct-21 (OCP-DAK12-1016_Oct21)	Oct-22
Reference 20 dB Attenuator	SN: CC2552 (20x)	04-Apr-22 (No. 217-03527)	Apr-23
DAE4	SN: 660	13-Oct-21 (No. DAE4-660_Oct21)	Oct-22
Reference Probe ES3DV2	SN: 3013	27-Dec-21 (No. ES3-3013_Dec21)	Dec-22

Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-22)	In house check: Jun-24
Network Analyzer E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-22

	Name	Function	Signature
Calibrated by	Michael Weber	Laboratory Technician	M.Weber
Approved by	Sven Kühn	Technical Manager	S.K.

Issued: August 23, 2022

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

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.e., $\vartheta = 0$ 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) IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices – Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
b) 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 $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect 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 with CW signal. 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; Dx,y,z; VRx,y,z: A, B, C, D* 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 $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values 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 ±50 MHz to ±100 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 *NORMx* (no uncertainty required).

EX3DV4 - SN:3922 August 19, 2022

Parameters of Probe: EX3DV4 - SN:3922

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k = 2)
Norm ($\mu V/(V/m)^2$) [A]	0.64	0.56	0.59	±10.1%
DCP (mV) [B]	102.4	103.0	103.0	±4.7%

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB$\sqrt{\mu V}$	C	D dB	VR mV	Max dev.	Max Unc[E] k = 2
0	CW	X	0.00	0.00	1.00	0.00	162.8	±3.0%	±4.7%
		Y	0.00	0.00	1.00		152.0		
		Z	0.00	0.00	1.00		164.5		
10352	Pulse Waveform (200Hz, 10%)	X	20.00	91.57	21.64	10.00	60.0	±3.8%	±9.6%
		Y	20.00	90.85	20.66		60.0		
		Z	20.00	91.33	21.58		60.0		
10353	Pulse Waveform (200Hz, 20%)	X	20.00	91.52	20.65	6.99	80.0	±2.2%	±9.6%
		Y	20.00	91.86	20.06		80.0		
		Z	20.00	91.16	20.55		80.0		
10354	Pulse Waveform (200Hz, 40%)	X	20.00	93.72	20.45	3.98	95.0	±1.4%	±9.6%
		Y	20.00	91.87	18.61		95.0		
		Z	20.00	92.80	20.10		95.0		
10355	Pulse Waveform (200Hz, 60%)	X	20.00	97.56	21.00	2.22	120.0	±1.3%	±9.6%
		Y	20.00	91.17	16.93		120.0		
		Z	20.00	95.35	20.07		120.0		
10387	QPSK Waveform, 1 MHz	X	1.73	66.35	15.27	1.00	150.0	±2.9%	±9.6%
		Y	1.46	65.18	13.82		150.0		
		Z	1.62	64.68	14.21		150.0		
10388	QPSK Waveform, 10 MHz	X	2.33	68.61	16.02	0.00	150.0	±1.0%	±9.6%
		Y	1.98	66.65	14.76		150.0		
		Z	2.12	66.69	14.86		150.0		
10396	64-QAM Waveform, 100 kHz	X	3.33	72.28	19.75	3.01	150.0	±0.8%	±9.6%
		Y	2.63	68.97	18.02		150.0		
		Z	3.31	71.62	19.28		150.0		
10399	64-QAM Waveform, 40 MHz	X	3.56	67.34	15.91	0.00	150.0	±2.2%	±9.6%
		Y	3.34	66.56	15.32		150.0		
		Z	3.45	66.54	15.35		150.0		
10414	WLAN CCDF, 64-QAM, 40 MHz	X	4.95	65.78	15.64	0.00	150.0	±4.2%	±9.6%
		Y	4.71	65.46	15.33		150.0		
		Z	4.87	65.35	15.29		150.0		

Note: For details on UID parameters see Appendix

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 Pages 5 and 6).
[B] Linearization parameter uncertainty for maximum specified field strength.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.