TEST REPORT

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1. Report No : DRRFCC2306-0049
2. Customer
   - Name : BLUEBIRD INC.
   - Address : 3F, 115, Irwon-ro, Gangnam-gu, Seoul South Korea
3. Use of Report : FCC Original Grant
4. Product Name / Model Name : RFID Handheld Scanner / RFR901
   FCC ID: SS4RFR901
5. FCC Regulation(s) : CFR 47 Part 2 subpart 2.1093
   Test Method Used : IEEE 1528-2013, IEC/IEEE 62209-1528
   FCC SAR KDB Publications (Details in test report)
6. Date of Test : 2023.03.07 ~ 2023.03.10
7. Location of Test : ☒ Permanent Testing Lab ☐ On Site Testing
8. Testing Environment : Refer to appended test report.
9. Test Result : Refer to attached test report.

The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
This test report is not related to KOLAS accreditation.

Affirmation	Tested by Name : YeJin Seo (Signature)	Reviewed by Name : HakMin Kim (Signature)

2023 . 06 . 07 .

Dt&C Co., Ltd.

Test Report Version

Test Report No.	Date	Description	Tested by	Reviewed by
DRRFCC2306-0049	Jun. 07, 2023	Initial issue	YeJin Seo	HakMin Kim

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1. DESCRIPTION OF DEVICE

1.1 General Information

EUT type	RFID Handheld Scanner				
FCC ID	SS4RFR901				
Equipment model name	RFR901				
Equipment add model name	N/A				
Equipment serial no.	Identical prototype				
Firmware Version Identification Number	1.0				
FCC & ISED MRA Designation No.	KR0034				
ISED#	5740A				
Mode(s) of Operation (Mobile Computer)	2.4 GHz W-LAN (802.11b/g/n-HT20), 5 GHz W-LAN (802.11a/n-HT20/n-HT40/ac-VHT20/ac-VHT40/ac-VHT80), Bluetooth				
Mode(s) of Operation (RFID/USN Wireless Device)	RFID (900 MHz)				
	Band	**Mode**	**Operating Modes**	**Bandwidth**	**Frequency**
TX Frequency Range (Mobile Computer)	2.4 GHz W-LAN	802.11b/g/n	Voice/Data	HT20	2 412 MHz ~ 2 462 MHz
	5.2 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT20	5 180 MHz ~ 5 240 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5 190 MHz ~ 5 230 MHz
		802.11ac	Voice/Data	VHT80	5 210 MHz
	5.3 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT20	5 260 MHz ~ 5 320 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5 270 MHz ~ 5 310 MHz
		802.11ac	Voice/Data	VHT80	5 290 MHz
	5.6 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT20	5 500 MHz ~ 5 720 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5 510 MHz ~ 5 710 MHz
		802.11ac	Voice/Data	VHT80	5 530 MHz ~ 5 690 MHz
	5.8 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT20	5 745 MHz ~ 5 825 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5 755 MHz ~ 5 795 MHz
		802.11ac	Voice/Data	VHT80	5 775 MHz
	Bluetooth	-	Data	-	2 402 MHz ~ 2 480 MHz
TX Frequency Range (RFID/USN Wireless Device)	RFID (900 MHz)	-	Data	-	902.75 MHz~ 927.25 MHz
RX Frequency Range	2.4 GHz W-LAN	802.11b/g/n	Voice/Data	HT20	2 412 MHz ~ 2 462 MHz
	5.2 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT20	5 180 MHz ~ 5 240 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5 190 MHz ~ 5 230 MHz
		802.11ac	Voice/Data	VHT80	5 210 MHz
	5.3 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT20	5 260 MHz ~ 5 320 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5 270 MHz ~ 5 310 MHz
		802.11ac	Voice/Data	VHT80	5 290 MHz
	5.6 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT20	5 500 MHz ~ 5 720 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5 510 MHz ~ 5 710 MHz
		802.11ac	Voice/Data	VHT80	5 530 MHz ~ 5 690 MHz
	5.8 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT20	5 745 MHz ~ 5 825 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5 755 MHz ~ 5 795 MHz
		802.11ac	Voice/Data	VHT80	5 775 MHz
	Bluetooth	-	Data	-	2 402 MHz ~ 2 480 MHz
RX Frequency Range (RFID/USN Wireless Device)	RFID (900 MHz)	-	Data	-	902.75 MHz~ 927.25 MHz

Equipment Class	Band	Reported SAR 10 g SAR (W/kg) Extremity
DTS(SISO)	2.4 GHz W-LAN	< 0.10
DTS(MIMO)	2.4 GHz W-LAN	< 0.10
U-NII-1(SISO)	5.2 GHz W-LAN	< 0.10
U-NII-1(MIMO)	5.2 GHz W-LAN	< 0.10
U-NII-2A(SISO)	5.3 GHz W-LAN	< 0.10
U-NII-2A(MIMO)	5.3 GHz W-LAN	-
U-NII-2C(SISO)	5.6 GHz W-LAN	< 0.10
U-NII-2C(MIMO)	5.6 GHz W-LAN	< 0.10
U-NII-3(SISO)	5.8 GHz W-LAN	< 0.10
U-NII-3(MIMO)	5.8 GHz W-LAN	< 0.10
DSS	Bluetooth	< 0.10 Note
DTS	Bluetooth LE	< 0.10 Note

DUT Type	Equipment Class	Band	Reported SAR 10 g SAR (W/kg) Extremity
Mount 1 type	DSS	RFID (900 MHz)	**0.72**
Mount 2 type	DSS	RFID (900 MHz)	0.71
Simultaneous SAR per KDB 690783 D01v01r03			**0.06**

FCC Equipment Class	Part 15 Spread Spectrum Transmitter(DSS) Digital Transmission System(DTS) Unlicensed National Information Infrastructure (UNII)
Date(s) of Tests	2023.03.07 ~ 2023.03.10
Note	Bluetooth / Bluetooth LE SAR was estimated
Antenna Type	Internal Antenna
Functions	● VoIP is supported.
Information	● The Body SAR is not applicable because the RFID reader only transmits when user presses the scanning button and big separation distance from the human body in normal usage condition. ● When evaluating SAR only for RFID readers, test was performed 6 sides (Top, Bottom, Front, Rear, Right and Left) for conservative evaluation. ● Since the RFID antenna has high directionality, the test was performed by applying TCB Workshop Notes. ● Top, Front, Rear, Right and Left sides are not typically touched by Extremity, so Extremity SAR for RFID readers with PDA wade not performed for these positions. ● Because distance between PDA and user's hand is 25 mm, Extremity SAR for RFID readers with PDA of Bottom and Pistol grip sides tested the rear of PDA with separation distance 25 mm without deformation of device. Please refer to '(SS4RFR901)_Test photo(SAR)' and 'TCB inquiry_(Mar 3, 2023)' ● This model has two types (Mount 1 type, Mount 2 type). ● This report was tested with EF550_only W-LAN at the request of the applicant. ● The operational description contains additional information.

1.2 Power Reduction for SAR

There is no power reduction used for any band/mode implemented in this device for SAR purposes.

1.3 Nominal and Maximum Output Power Specifications

The Nominal and Maximum Output Power Specifications are in section 6 of this test report.

1.4 Simultaneous Transmission Capabilities

The Simultaneous Transmission Capabilities are in section 9 of this test report.

1.5 SAR Test Configurations and Exclusions

(A) WIFI & BT for Extremity SAR configuration

Per FCC KDB 447498 D01v06, **the 10 g SAR exclusion threshold for distances < 50 mm** is defined by the following equation:

$$\frac{Max\ Power\ of\ Channel\ (mW)}{Test\ Separation\ Dist\ (mm)} * \sqrt{Frequency(GHz)} \leq 3.0$$

Table 1.1SAR exclusion threshold for distances < 50 mm

Mode	Equation	Result	SAR exclusion threshold	Required SAR
Bluetooth (Mobile Computer)	[(3.85/25)* √2.480]	0.2	7.5	X
Bluetooth LE (Mobile Computer)	[(5.04/25)* √2.480]	0.3	7.5	X

Per KDB Publication 447498 D01v06, the maximum power of the channel was rounded to the nearest mW before calculation.

1.6 Guidance Applied

- IEEE 1528-2013
- IEC/IEEE 62209-1528
- FCC KDB Publication 248227 D01v02r02 (802.11 Wi-Fi SAR)
- FCC KDB Publication 447498 D01v06 (General RF Exposure Guidance)
- FCC KDB Publication 648474 D04v01r03 (Handset SAR)
- FCC KDB Publication 690783 D01v01r03 (SAR Listings on Grants)
- FCC KDB Publication 865664 D01v01r04 (SAR Measurement 100 MHz to 6 GHz)
- FCC KDB Publication 865664 D02v01r02 (RF Exposure Reporting)
- April 2015 TCB Workshop Notes (Simultaneous transmission summation clarified)
- October 2016 TCB Workshop Notes (Bluetooth Duty Factor)
- April 2019 TCB Workshop Notes (Tissue Simulating Liquids)
- October 2020 TCB Workshop Notes (Handheld RFID/Barcode Scanners)

1.7 Device Serial Numbers

The serial numbers used for each test are indicated alongside the results in Section 8.

DUT Type	Serial Number
RFID/USN Wireless Device (Mount 1 Type)	FCC #1
RFID/USN Wireless Device (Mount 2 Type)	FCC #2
Mobile Computer (EF550)	FCC #3

1.8 FCC & ISED MRA test lab designation no. : KR0034

2. INTROCUCTION

The FCC and Industry Canada have adopted the guidelines for evaluating the environmental effects of radio frequency (RF) radiation in ET Docket 93-62 on Aug. 6, 1996 and Health Canada Safety Code 6 to protect the public and workers from the potential hazards of RF emissions due to FCC-regulated portable devices.

The FCC has adopted the guidelines for evaluating the environmental effects of radio frequency radiation in ET Docket 93-62 on Aug. 6, 1996 to protect the public and workers from the potential hazards of RF emissions due to FCC-regulated portable devices. The safety limits used for the environmental evaluation measurements are based on the criteria published by the American National Standards Institute (ANSI) for localized specific absorption rate (SAR) in IEEE/ANSI C95.1-1992 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz. The measurement procedure described in IEEE/ANSI C95.3-2002 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave is used for guidance in measuring SAR due to the RF radiation exposure from the Equipment Under Test (EUT). These criteria for SAR evaluation are similar to those recommended by the National Council on Radiation Protection and Measurements (NCRP) in Biological Effects and Exposure Criteria for Radio frequency Electromagnetic Fields," NCRP Report No. 86 NCRP, 1986, Bethesda, MD 20814. SAR is a measure of the rate of energy absorption due to exposure to an RF transmitting source. SAR values have been related to threshold levels for potential biological hazards.

SAR Definition

Specific Absorption Rate (SAR) is defined as the time derivative (rate) of the incremental energy (dU) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dV) of a given density (ρ) It is also defined as the rate of RF energy absorption per unit mass at a point in an absorbing body (see Fig. 2.1)

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

Fig. 2.1 SAR Mathematical Equation

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

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

where:

σ = conductivity of the tissue-simulating material (S/m)

ρ = mass density of the tissue-simulating material (kg/m^3)

E = Total RMS electric field strength (V/m)

NOTE: The primary factors that control rate of energy absorption were found to be the wavelength of the incident field in relations to the dimensions and geometry of the irradiated organism, the orientation of the organism in relation to the polarity of field vectors, the presence of reflecting surfaces, and whether conductive contact is made by the organism with a ground plane.

3. DOSIMETRIC ASSESSMENT

3.1 Measurement Procedure

The evaluation was performed using the following procedure compliant to FCC KDB Publication 865664 D01v01r04 and IEEE 1528-2013:

1. The SAR distribution at the exposed side of the head or body was measured at a distance no greater than 5.0 mm from the inner surface of the shell. The area covered the entire dimension of the device-head and body interface and the horizontal grid resolution was determined per FCC KDB Publication 865664 D01v01r04 (See Table 3.1) and IEEE1528-2013.

2. The point SAR measurement was taken at the maximum SAR region determined from Step 1 to enable the monitoring of SAR fluctuations/drifts during the 1g/10g cube evaluation. SAR at this fixed point was measured and used as a reference value.

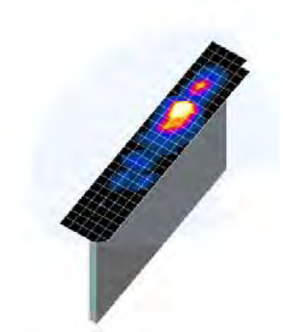

Figure 3.1
Sample SAR Area Scan

3. Based on the area scan data, the peak of the region with maximum SAR was determined by spline interpolation. Around this point, a volume was assessed according to the measurement resolution and volume size requirements of FCC KDB Publication 865664 D01v01r04 (See Table 3.1) and IEEE 1528-2013. On the basis of this data set, the spatial peak SAR value was evaluated with the following procedure (see references or the DASY manual online for more details):

   a. SAR values at the inner surface of the phantom are extrapolated from the measured values along the line away from the surface with spacing no greater than that in Table 3.1. The extrapolation was based on a least-squares algorithm. A polynomial of the fourth order was calculated through the points in the z-axis (normal to the phantom shell).

   b. After the maximum interpolated values were calculated between the points in the cube, the SAR was averaged over the spatial volume (1 g or 10 g) using a 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 then integrated with the trapezoidal algorithm. One thousand points (10 x 10 x 10) were obtained through interpolation, in order to calculate the averaged SAR.

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

4. The SAR reference value, at the same location as step 2, was re-measured after the zoom scan was complete to calculate the SAR drift. If the drift deviated by more than 5 %, the SAR test and drift measurements were repeated.

			$\leq$ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface			5 mm ± 1 mm	$\frac{1}{2}\cdot\delta\cdot\ln(2)$ mm ± 0.5 mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location			30° ± 1°	20° ± 1°
Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}			$\leq$ 2 GHz: $\leq$ 15 mm 2 – 3 GHz: $\leq$ 12 mm	3 – 4 GHz: $\leq$ 12 mm 4 – 6 GHz: $\leq$ 10 mm
			When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be $\leq$ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	
Maximum zoom scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}			$\leq$ 2 GHz: $\leq$ 8 mm 2 – 3 GHz: $\leq$ 5 mm*	3 – 4 GHz: $\leq$ 5 mm* 4 – 6 GHz: $\leq$ 4 mm*
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{Zoom}(n)$		$\leq$ 5 mm	3 – 4 GHz: $\leq$ 4 mm 4 – 5 GHz: $\leq$ 3 mm 5 – 6 GHz: $\leq$ 2 mm
	graded grid	$\Delta z_{Zoom}(1)$: between 1st two points closest to phantom surface	$\leq$ 4 mm	3 – 4 GHz: $\leq$ 3 mm 4 – 5 GHz: $\leq$ 2.5 mm 5 – 6 GHz: $\leq$ 2 mm
		$\Delta z_{Zoom}(n>1)$: between subsequent points	$\leq 1.5\cdot\Delta z_{Zoom}(n-1)$ mm	
Minimum zoom scan volume	x, y, z		$\geq$ 30 mm	3 – 4 GHz: $\geq$ 28 mm 4 – 5 GHz: $\geq$ 25 mm 5 – 6 GHz: $\geq$ 22 mm

Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see IEEE Std 1528-2013 for details.

* When zoom scan is required and the _reported_ SAR from the *area scan based 1-g SAR estimation* procedures of KDB Publication 447498 is $\leq$ 1.4 W/kg, $\leq$ 8 mm, $\leq$ 7 mm and $\leq$ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.

Table 3.1 Area and Zoom Scan Resolutions per FCC KDB Publication 865664 D01v01r04*

4. RF EXPOSURE LIMITS

Uncontrolled Environment:

UNCONTROLLED ENVIRONMENTS are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

Controlled Environment:

CONTROLLED ENVIRONMENTS are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. This exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

Table 4.1.SAR Human Exposure Specified in ANSI/IEEE C95.1-1992

	HUMAN EXPOSURE LIMITS	
	General Public Exposure (W/kg) or (mW/g)	Occupational Exposure (W/kg) or (mW/g)
SPATIAL PEAK SAR * (Brain)	1.60	8.00
SPATIAL AVERAGE SAR ** (Whole Body)	0.08	0.40
SPATIAL PEAK SAR *** (Hands / Feet / Ankle / Wrist)	4.00	20.0

1. The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.
2. The Spatial Average value of the SAR averaged over the whole body.
3. The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

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

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

5. FCC MEASUREMENT PROCEDURES

Power measurements were performed using a base station simulator under digital average power.

5.1 Measured and Reported SAR

Per FCC KDB Publication 447498 D01v06, When SAR is not measured at the maximum power level allowed for production units, the results must be scaled to the maximum tune-up tolerance limit according to the power applied to the individual channels tested to determine compliance. For simultaneous transmission, the measured aggregate SAR must be scaled according to the sum of the differences between the maximum tune-up tolerance and actual power used to test each transmitter. When SAR is measured at or scaled to the maximum tune-up tolerance limit, the results are referred to as reported SAR. The highest reported SAR results are identified on the grant of equipment authorization according to procedures in KDB 690783 D01v01r03.

5.2 Procedures Used to Establish RF Signal for SAR

The following procedures are according to FCC KDB Publication 941225 D01v03r01.

The device was placed into a simulated call using a base station simulator in a RF shielded chamber. Establishing connections in this manner ensure a consistent means for testing SAR and are recommended for evaluating SAR [4]. Devices under test were evaluated prior to testing, with a fully charged battery and were configured to operate at maximum output power. In order to verify that the device was tested throughout the SAR test at maximum output power, the SAR measurement system measures a “point SAR” at an arbitrary reference point at the start and end of the 1 gram SAR evaluation, to assess for any power drifts during the evaluation. If the power drift deviated by more than 5 %, the SAR test and drift measurements were repeated.

5.3 SAR Testing with 802.11 Transmitters

The normal network operating configurations are not suitable for measuring the SAR of 802.11 b/g/n transmitters. Unpredictable fluctuations in network traffic and antenna diversity conditions can introduce undesirable variations in SAR results. The SAR for these devices should be measured using chipset based test mode software to ensure the results are consistent and reliable. See KDB Publication 248227D01v02r02 for more details.

5.3.1 General Device Setup

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

A periodic duty factor is required for current generation SAR systems to measure SAR. When 802.11 frame gaps are accounted for in the in the transmission, a maximum transmission duty factor of 92-96 % is typically achievable in most test mode configurations. A minimum transmission duty factor of 85 % is required to avoid certain hardware and device implementation issues related to wide range SAR scaling. The reported SAR is scaled to 100 % transmission duty factor to determine compliance at the maximum tune-up tolerance limit.

5.3.2 U-NII and U-NII-2A

For devices that operate in only one of the U-NII-1 and U-NII-2A bands, the normally required SAR procedures for OFDM configurations are applied. For devices that operate in both U-NII bands using the same transmitter and antenna(s), SAR test reduction is determined according to the following, with respect to the highest reported SAR and maximum output power specified for production units. The procedures are applied independently to each exposure configuration; for example, head, body, hotspot mode etc.

1) When the same maximum output power is specified for both bands, begin SAR measurement in U-NII-2A band by applying the OFDM SAR requirements. If the highest reported SAR for a test configuration is ≤ 1.2 W/kg, SAR is not required for U-NII-1 band for that configuration (802.11 mode and exposure condition); otherwise, each band is tested independently for SAR.
2) When different maximum output power is specified for the bands, begin SAR measurement in the band with higher specified maximum output power. The highest reported SAR for the tested configuration is adjusted by the ratio of lower to higher specified maximum output power for the two bands. When the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for the band with lower maximum output power in that test configuration; otherwise, each band is tested independently for SAR.

5.3.3 U-NII-2C and U-NII-3

The frequency range covered by U-NII-2C and U-NII-3 is 380 MHz (5.47 – 5.85 GHz), which requires a minimum of at least two SAR probe calibration frequency points to support SAR measurements.
When Terminal Doppler Weather Rader (TDWR) restriction applies, the channels at 5.60 – 5.65 GHz in U-NII-2C band must be disabled with acceptable mechanisms and documented in the equipment certification.
Unless band gap channels are permanently disabled, SAR must be considered for these channels. When band gap channels are disabled, each band is tested independently according to the normally required OFDM SAR measurements and probe calibration frequency points requirements.

5.3.4 Initial Test Position Procedure

For exposure conditions with multiple test positions, such as handset operating next to the ear, devices with hotspot mode or UMPC mini-tablet, procedures for initial test position can be applied. Using the transmission mode determined by the DSSS procedure or initial test configuration, area scans are measured for all position in an exposure condition. The test position with the highest extrapolated (peak) SAR is used as the initial test position. When reported SAR for the initial test position is ≤ 0.4 W/kg, no additional testing for the remaining test positions is required. Otherwise, SAR is evaluated at the subsequent highest peak SAR position until the reported SAR result is ≤ 0.8 W/kg or all test position are measured.

5.3.5 2.4 GHz SAR Test Requirements

SAR is measured for 2.4 GHz 802.11b DSSS using either a fixed test position or, when applicable, the initial test position procedure. SAR test reduction is determined according to the following:

1) When the reported SAR of the highest measured maximum output power channel for the exposure configuration is ≤ 0.8 W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.
2) When the reported SAR is > 0.8 W/kg, SAR is required for that exposure configuration using the next highest measured output power channel. When any reported SAR is > 1.2 W/kg, SAR is required for the third channel; i.e., all channels require testing.

2.4 GHz 802.11 g/n OFDM are additionally evaluated for SAR if the highest reported SAR for 802.11b, adjusted by the ratio of the OFDM to DSSS specified maximum output power is > 1.2 W/kg. When SAR is required for OFDM modes in 2.4 GHz band, the Initial Test Configuration Procedures should be followed.

5.3.6 OFDM Transmission Mode and SAR Test Channel Selection

For the 2.4 GHz and 5 GHz bands, when the same maximum output power was specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration with the largest channel bandwidth, lowest order modulation and lowest data rate. When the maximum output power of a channel is the same for equivalent OFDM configurations; for example, 802.11a and 802.11n or 802.11g and 802.11n with the same channel bandwidth, modulation and data rate etc., the lower order 802.11 mode i.e., 802.11a, then 80211n or 802.11g then 802.11n is used for SAR measurement. When the maximum output power ware the same for multiple test channels, either according to the default or additional power measurement requirements, SAR is measured using the channel closest to the middle of the frequency band or aggregated band. When there are multiple channels with the same maximum output power, SAR is measured using the higher number channel.

5.3.7 Initial Test Configuration Procedure

For OFDM, in both 2.4 and 5 GHz bands, an initial test configuration is determined for each frequency band and aggregated band, according to the transmission mode with the highest maximum output power specified for SAR measurements. When the same maximum output is specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration(s) with the largest channel bandwidth, lowest order modulation, and lowest data rate. The channel of the transmission mode with the highest average RF output conducted power will be the initial test configuration.

When the reported SAR is ≤ 0.8 W/kg, no additional measurements on other test channels are required.
Otherwise, SAR is evaluated using the subsequent highest average RF output channel until the reported SAR result is ≤ 1.2 W/kg or all channels are measured.

5.3.8 Subsequent Test Configuration Procedures

For OFDM configurations, in each frequency band and aggregated band, SAR is evaluated for initial test configuration using the fixed test position or the initial test position procedure, when applicable. When the highest reported SAR for the initial test configuration, adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power is ≤ 1.2 W/kg, no additional SAR testing for the subsequent test configurations is required.

5.3.9 MIMO SAR Considerations

Per KDB Publication 248227 D01v02r02, the simultaneous SAR provisions in KDB Publication 447498 D01v06 should be applied to determine simultaneous transmission SAR test exclusion for WIFI MIMO. If the sum of 1g single transmission chain SAR measurements is < 1.6 W/kg, no additional SAR measurements for MIMO are required. Alternatively, SAR for MIMO can be measured with all antennas transmitting simultaneously at the specified maximum output power of MIMO operation.

5.4 Generic device

The SAR evaluation shall be performed for all surfaces of the DUT that are accessible during intended use, as indicated in Figure 7.1. The separation distance in testing shall correspond to the intended use distance as specified in the user instructions provided by the manufacturer. If the intended use is not specified, all surfaces of the DUT shall be tested directly against the flat phantom.

The surface of the generic device (or the surface of the carry accessory holding the DUT) pointing towards the flat phantom shall be parallel to the surface of the phantom.

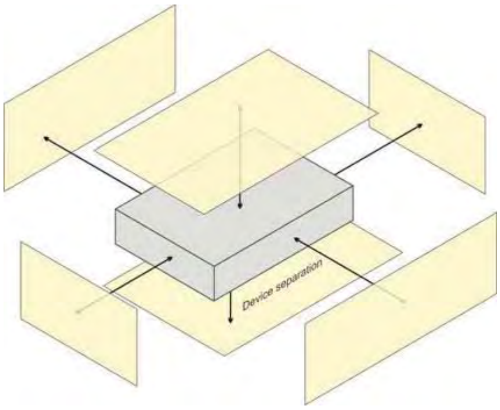

Figure 7.1 Test positions for a generic device

This device was tested with continuous modulated transmission and below duty cycle.

- Duty Cycle = On time / (On time + OFF time)
  = 192.3 ms / 291.7 ms
  = 65.9 %

Channel	Frequency(MHz)	Duty Cycle [%]	Crest Factor
1	902.75	65.9	1.517
26	915.75	65.9	1.517
50	927.25	65.9	1.517

5.5 Extremity Exposure Configurations

Devices that are designed or intended for use on extremities or mainly operated in extremity only exposure conditions; i.e., hands, wrists, feet and ankles, may require extremity SAR evaluation. When the device also operates in close proximity to the user's body, SAR compliance for the body is also required. The 1-g body and 10-g extremity SAR Exclusion Thresholds found in KDB Publication 447498 D01v06 should be applied to determine SAR test requirements.

5.6 Handheld RFID/Barcode Scanners (Oct 2020 TCB Workshop Notes)

Guidance update: If the RFID antenna is highly directional you may apply the following testing guidance.

- Provide a directivity of the antenna.
- Provide a conservative minimum distance between the back of the RFID antenna and the fingers during normal operation.
- Measure the 10 g Extremity SAR from the front of the RFID antenna at that antenna-to-finger distance and use that SAR value in place of the back side SAR data.

  * Example: Back side of RFID antenna is 25 mm away from user's finger during normal operation.

    Test front surface at 25 mm away from flat phantom and use that SAR data in place of back side SAR data
- In the test setup section of the SAR report clearly explain the test setup and the fact the front side SAR was used in place of the back side SAR data.

6. RF CONDUCTED POWERS

This device operates using the following maximum and nominal output power specifications. SAR values were scaled to the maximum allowed power to determine compliance per KDB Publication 447498 D01v06

6.1 WLAN Nominal and Maximum Output Power Spec and Conducted Powers

Band (GHz)	Mode	Ch	Modulated Average[dBm]					
			Ant.1		Ant.2		MIMO(CDD/SDM)	
			Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
2.4	802.11b	1	12.00	11.50	14.00	13.50	-	
		6	13.00	12.50	13.00	12.50	-	
		11	12.00	11.50	13.50	13.00	-	
	802.11g	1-11	10.00	9.50	12.00	11.50	14.12	13.62
	802.11n	1-11	9.00	8.50	10.00	9.50	12.54	12.04

Table 6.1.1 Nominal and Maximum Output Power Spec

Mode	Freq. (MHz)	Channel	IEEE 802.11 (2.4 GHz) Conducted Power[dBm]			
			Ant.1	Ant.2	MIMO(CDD)	MIMO(SDM)
802.11b	2 412	1	11.92	13.58	-	-
	2 437	6	12.41	12.90	-	-
	2 462	11	11.81	12.95	-	-
802.11g	2 412	1	9.85	11.50	13.76	-
	2 437	6	9.73	11.10	13.48	-
	2 462	11	9.71	11.45	13.68	-
802.11n (HT-20)	2 412	1	8.42	9.44	11.97	12.12
	2 437	6	8.82	9.74	12.31	12.06
	2 462	11	8.85	9.77	12.34	12.15

Table 6.1.2 IEEE 802.11 Average RF Power

Mode	Freq. (MHz)	Channel	Modulated Average[dBm]						
			Ant.1		Ant.2		MIMO(CDD)		MIMO(SDM)
			Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	-
802.11a (6 Mbps)	5 180	36	12.00	11.50	10.00	9.50	14.12	13.62	-
	5 200	40	12.00	11.50	9.00	8.50	13.76	13.26	-
	5 220	44	12.00	11.50	9.00	8.50	13.76	13.26	-
	5 240	48	12.00	11.50	9.00	8.50	13.76	13.26	-
	5 260	52	12.00	11.50	8.00	7.50	13.46	12.96	-
	5 280	56	12.00	11.50	8.00	7.50	13.46	12.96	-
	5 300	60	12.00	11.50	7.00	6.50	13.19	12.69	-
	5 320	64	12.00	11.50	7.00	6.50	13.19	12.69	-
	5 500	100	12.60	12.10	8.50	8.00	14.03	13.53	-
	5 580	116	12.60	12.10	7.00	6.50	13.66	13.16	-
	5 660	132	12.60	12.10	6.50	6.00	13.55	13.05	-
	5 720	144	12.60	12.10	6.00	5.50	13.46	12.96	-
	5 745	149	12.60	12.10	5.00	4.50	13.30	12.80	-
	5 785	157	12.60	12.10	5.00	4.50	13.30	12.80	-
	5 825	165	12.60	12.10	6.50	6.00	13.55	13.05	-

Table 6.1.3 Nominal and Maximum Output Power Spec

Mode	Freq. (MHz)	Channel	IEEE 802.11a (5 GHz) Conducted Power[dBm]			
			Ant.1	Ant.2	MIMO(CDD)	MIMO(SDM)
802.11a (6 Mbps)	5 180	36	11.72	9.49	13.76	-
	5 200	40	11.15	8.58	13.06	-
	5 220	44	11.28	8.37	13.07	-
	5 240	48	11.09	8.11	12.86	-
	5 260	52	11.13	7.24	12.62	-
	5 280	56	11.12	7.35	12.64	-
	5 300	60	11.23	6.87	12.59	-
	5 320	64	11.81	6.92	13.03	-
	5 500	100	11.41	7.61	12.92	-
	5 580	116	12.36	6.62	13.39	-
	5 660	132	11.70	5.41	12.14	-
	5 720	144	11.73	5.17	12.60	-
	5 745	149	11.18	3.54	11.87	-
	5 785	157	10.68	3.59	12.11	-
	5 825	165	12.28	5.60	13.12	-

Table 6.1.4 IEEE 802.11a Average RF Power

Mode	Freq. (MHz)	Channel	Modulated Average[dBm]							
			Ant.1		Ant.2		MIMO(CDD)		MIMO(SDM)	
			Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
802.11n (HT-20) (MCS0)	5 180	36	12.00	11.50	8.00	7.50	13.46	12.96	13.46	12.96
	5 200	40	12.00	11.50	8.00	7.50	13.46	12.96	13.46	12.96
	5 220	44	12.00	11.50	8.00	7.50	13.46	12.96	13.46	12.96
	5 240	48	12.00	11.50	8.00	7.50	13.46	12.96	13.46	12.96
	5 260	52	12.00	11.50	8.00	7.50	13.46	12.96	13.46	12.96
	5 280	56	12.00	11.50	7.00	6.50	13.19	12.69	13.19	12.69
	5 300	60	12.00	11.50	7.00	6.50	13.19	12.69	13.19	12.69
	5 320	64	12.00	11.50	7.00	6.50	13.19	12.69	13.19	12.69
	5 500	100	12.00	11.50	8.00	7.50	13.46	12.96	13.46	12.96
	5 580	116	12.00	11.50	7.00	6.50	13.19	12.69	13.19	12.69
	5 660	132	12.00	11.50	6.50	6.00	13.08	12.58	13.08	12.58
	5 720	144	12.00	11.50	5.50	5.00	12.88	12.38	12.88	12.38
	5 745	149	12.00	11.50	4.00	3.50	12.64	12.14	12.64	12.14
	5 785	157	12.00	11.50	4.00	3.50	12.64	12.14	12.64	12.14
	5 825	165	12.00	11.50	6.00	5.50	12.97	12.47	12.97	12.47

Table 6.1.5 Nominal and Maximum Output Power Spec

Mode	Freq. (MHz)	Channel	IEEE 802.11n HT20 (5 GHz) Conducted Power[dBm]			
			Ant.1	Ant.2	MIMO(CDD)	MIMO(SDM)
802.11n (HT-20) (MCS0)	5 180	36	11.51	7.92	13.09	12.98
	5 200	40	11.45	7.79	13.00	12.87
	5 220	44	11.43	7.55	12.92	12.82
	5 240	48	11.19	7.10	12.62	12.82
	5 260	52	10.71	7.10	12.28	12.24
	5 280	56	11.31	6.73	12.61	12.44
	5 300	60	11.27	6.45	12.51	12.37
	5 320	64	11.19	6.67	12.50	12.38
	5 500	100	10.92	6.33	12.22	12.25
	5 580	116	11.09	6.61	12.41	12.34
	5 660	132	11.44	6.06	12.55	12.50
	5 720	144	11.95	5.28	12.80	12.78
	5 745	149	10.68	3.24	11.40	11.50
	5 785	157	10.60	3.64	11.40	12.01
	5 825	165	10.94	5.05	11.94	12.33

Table 6.1.6 IEEE 802.11n HT20 Average RF Power

Mode	Freq. (MHz)	Channel	Modulated Average[dBm]							
			Ant.1		Ant.2		MIMO(CDD)		MIMO(SDM)	
			Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
802.11ac (VHT-20) (MCS0)	5 180	36	12.00	11.50	8.00	7.50	13.46	12.96	13.46	12.96
	5 200	40	12.00	11.50	8.00	7.50	13.46	12.96	13.46	12.96
	5 220	44	12.00	11.50	8.00	7.50	13.46	12.96	13.46	12.96
	5 240	48	12.00	11.50	8.00	7.50	13.46	12.96	13.46	12.96
	5 260	52	12.00	11.50	7.50	7.00	13.32	12.82	13.32	12.82
	5 280	56	12.00	11.50	7.00	6.50	13.19	12.69	13.19	12.69
	5 300	60	12.00	11.50	7.00	6.50	13.19	12.69	13.19	12.69
	5 320	64	12.00	11.50	7.00	6.50	13.19	12.69	13.19	12.69
	5 500	100	12.00	11.50	8.00	7.50	13.46	12.96	13.46	12.96
	5 580	116	12.00	11.50	7.00	6.50	13.19	12.69	13.19	12.69
	5 660	132	12.00	11.50	6.50	6.00	13.08	12.58	13.08	12.58
	5 720	144	12.00	11.50	5.50	5.00	12.88	12.38	12.88	12.38
	5 745	149	12.00	11.50	4.00	3.50	12.64	12.14	12.64	12.14
	5 785	157	12.00	11.50	4.00	3.50	12.64	12.14	12.64	12.14
	5 825	165	12.00	11.50	6.00	5.50	12.97	12.47	12.97	12.47

Table 6.1.7 Nominal and Maximum Output Power Spec

Mode	Freq.	Channel	IEEE 802.11ac VHT20 (5 GHz) Conducted Power[dBm]			
	(MHz)		Ant.1	Ant.2	MIMO(CDD)	MIMO(SDM)
802.11ac (VHT-20) (MCS0)	5 180	36	11.26	7.85	12.89	12.89
	5 200	40	11.30	7.77	12.89	12.71
	5 220	44	11.25	7.44	12.76	12.81
	5 240	48	11.35	6.92	12.69	12.55
	5 260	52	11.05	7.17	12.54	12.48
	5 280	56	10.95	6.60	12.31	12.33
	5 300	60	11.01	6.45	12.31	12.28
	5 320	64	11.01	6.55	12.34	12.42
	5 500	100	11.35	7.66	12.90	12.84
	5 580	116	11.63	6.44	12.78	12.86
	5 660	132	11.57	5.66	12.56	12.42
	5 720	144	11.88	5.27	12.74	12.63
	5 745	149	11.02	3.44	11.72	11.71
	5 785	157	11.21	3.46	11.88	11.84
	5 825	165	11.31	4.99	12.22	12.14

Table 6.1.8 IEEE 802.11ac VHT20 Average RF Power

Mode	Freq. (MHz)	Channel	Modulated Average[dBm]							
			Ant.1		Ant.2		MIMO(CDD)		MIMO(SDM)	
			Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
802.11n (HT-40) (MCS0)	5 190	38	12.00	11.50	8.50	8.00	13.60	13.10	13.60	13.10
	5 230	46	12.00	11.50	8.00	7.50	13.46	12.96	13.46	12.96
	5 270	54	12.00	11.50	7.50	7.00	13.32	12.82	13.32	12.82
	5 310	62	12.00	11.50	7.00	6.50	13.19	12.69	13.19	12.69
	5 510	102	12.50	12.00	8.00	7.50	13.82	13.32	13.82	13.32
	5 550	110	12.50	12.00	7.00	6.50	13.58	13.08	13.58	13.08
	5 670	134	12.50	12.00	6.00	5.50	13.38	12.88	13.38	12.88
	5 710	142	12.50	12.00	5.50	5.00	13.29	12.79	13.29	12.79
	5 755	151	12.50	12.00	5.00	4.50	13.21	12.71	13.21	12.71
	5 795	159	12.50	12.00	6.00	5.50	13.38	12.88	13.38	12.88

Table 6.1.9 Nominal and Maximum Output Power Spec

Mode	Freq.	Channel	IEEE 802.11n HT40 (5 GHz) Conducted Power[dBm]			
	(MHz)		Ant.1	Ant.2	MIMO(CDD)	MIMO(SDM)
802.11n (HT-40) (MCS0)	5 190	38	11.50	8.32	13.21	13.12
	5 230	46	11.27	7.78	12.88	12.84
	5 270	54	11.21	7.47	12.74	12.73
	5 310	62	11.69	6.94	12.94	12.90
	5 510	102	11.89	7.18	13.15	13.09
	5 550	110	12.25	6.73	13.32	13.30
	5 670	134	11.51	5.79	12.54	12.41
	5 710	142	11.95	5.42	12.82	12.75
	5 755	151	11.28	4.69	12.14	12.07
	5 795	159	11.51	5.50	12.48	12.35

Table 6.1.10 IEEE 802.11n HT40 Average RF Power

Mode	Freq. (MHz)	Channel	Modulated Average[dBm]							
			Ant.1		Ant.2		MIMO(CDD)		MIMO(SDM)	
			Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
802.11ac (VHT-40) (MCS0)	5 190	38	12.00	11.50	8.50	8.00	13.60	13.10	13.60	13.10
	5 230	46	12.00	11.50	8.00	7.50	13.46	12.96	13.46	12.96
	5 270	54	12.00	11.50	7.50	7.00	13.32	12.82	13.32	12.82
	5 310	62	12.00	11.50	7.00	6.50	13.19	12.69	13.19	12.69
	5 510	102	12.50	12.00	8.00	7.50	13.82	13.32	13.82	13.32
	5 550	110	12.50	12.00	7.00	6.50	13.58	13.08	13.58	13.08
	5 670	134	12.50	12.00	6.00	5.50	13.38	12.88	13.38	12.88
	5 710	142	12.50	12.00	5.50	5.00	13.29	12.79	13.29	12.79
	5 755	151	12.50	12.00	5.00	4.50	13.21	12.71	13.21	12.71
	5 795	159	12.50	12.00	6.00	5.50	13.38	12.88	13.38	12.88

Table 6.1.11 Nominal and Maximum Output Power Spec

Mode	Freq.	Channel	IEEE 802.11ac VHT40 (5 GHz) Conducted Power[dBm]			
	(MHz)		Ant.1	Ant.2	MIMO(CDD)	MIMO(SDM)
802.11ac (VHT-40) (MCS0)	5 190	38	11.07	8.17	12.87	12.88
	5 230	46	11.24	7.70	12.83	12.84
	5 270	54	11.29	7.40	12.78	12.72
	5 310	62	11.47	6.78	12.74	12.57
	5 510	102	12.06	7.56	13.38	13.31
	5 550	110	12.34	6.70	13.39	13.40
	5 670	134	11.67	5.71	12.65	12.63
	5 710	142	12.26	5.34	13.06	13.04
	5 755	151	11.34	4.77	12.20	12.83
	5 795	159	11.84	5.54	12.75	12.60

Table 6.1.12 IEEE 802.11ac VHT40 Average RF Power

Mode	Freq. (MHz)	Channel	Modulated Average[dBm]							
			Ant.1		Ant.2		MIMO(CDD)		MIMO(SDM)	
			Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
802.11ac (VHT-80) (MCS0)	5 210	42	12.00	11.50	8.00	7.50	13.46	12.96	13.46	12.96
	5 290	58	12.00	11.50	7.00	6.50	13.19	12.69	13.19	12.69
	5 530	106	12.50	12.00	7.00	6.50	13.58	13.08	13.58	13.08
	5 690	138	12.50	12.00	6.00	5.50	13.38	12.88	13.38	12.88
	5 775	155	12.50	12.00	5.50	5.00	13.29	12.79	13.29	12.79

Table 6.1.13 Nominal and Maximum Output Power Spec

Mode	Freq.	Channel	IEEE 802.11ac VHT80 (5 GHz) Conducted Power[dBm]			
	(MHz)		Ant.1	Ant.2	MIMO(CDD)	MIMO(SDM)
802.11ac (VHT-80) (MCS0)	5 210	42	11.77	7.54	13.16	13.08
	5 290	58	11.71	6.64	12.89	13.01
	5 530	106	12.27	6.78	13.35	13.27
	5 690	138	12.32	5.51	13.14	12.86
	5 775	155	12.28	4.94	13.02	13.13

Table 6.1.14 IEEE 802.11ac VHT80 Average RF Power

Justification for reduced test configurations for WIFI channels per KDB Publication 248227 D01v02r02:

- Power measurements were performed for the transmission mode configuration with the highest maximum output power specified for production units.
- For transmission modes with the same maximum output power specification, powers were measured for the largest channel bandwidth, lowest order modulation and lowest data rate.
- For transmission modes with identical maximum specified output power, channel bandwidth, modulation and data rates, power measurements were required for all identical configurations.
- For each transmission mode configuration, powers were measured for the highest and lowest channels; and at the mid-band channel(s) when there were at least 3 channels supported. For configurations with multiple mid-band channels, duo to an even number of channels, both channels were measured.
- Output Power and SAR is not required for 802.11 a, g, n HT20/HT40, ac VHT20/VHT40/VHT80 channels when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjust SAR is ≤ 1.2 W/kg.
- The underlined data rate and channel above were tested for SAR.

The average output powers of this device were tested by below configuration.

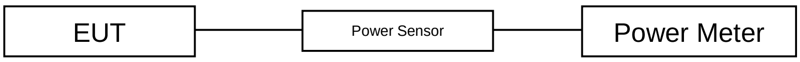

Figure 6.1 Power Measurement Setup

6.2 Bluetooth Conducted Powers

- Mobile Computer (EF550)

Burst Modulated Average[dBm]		
Bluetooth 1 Mbps	Maximum	7.00
	Nominal	6.50
Bluetooth 2 Mbps	Maximum	4.00
	Nominal	3.50
Bluetooth 3 Mbps	Maximum	4.00
	Nominal	3.50
Bluetooth LE	Maximum	7.70
	Nominal	7.20

Table 6.2.1 Nominal and Maximum Output Power Spec (Burst)

Frame Modulated Average[dBm]		
Bluetooth 1 Mbps	Maximum	5.85
	Nominal	5.35
Bluetooth 2 Mbps	Maximum	2.85
	Nominal	2.35
Bluetooth 3 Mbps	Maximum	2.85
	Nominal	2.35
Bluetooth (LE / 1 Mbps)	Maximum	7.02
	Nominal	6.52
Bluetooth (LE / 2 Mbps)	Maximum	5.31
	Nominal	4.81

Table 6.2.2 Nominal and Maximum Output Power Spec (Frame)

Channel	Frequency	Burst AVG Output Power (1 Mbps)	Frame AVG Output Power (1 Mbps)	Burst AVG Output Power (2 Mbps)	Frame AVG Output Power (2 Mbps)	Burst AVG Output Power (3 Mbps)	Frame AVG Output Power (3 Mbps)
	(MHz)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)
Low	2 402	6.25	5.10	3.14	1.99	3.13	1.98
Mid	2 441	5.85	4.70	2.61	1.46	2.60	1.45
High	2 480	6.16	5.01	3.11	1.96	3.10	1.95

Table 6.2.3 Bluetooth Burst and Frame Average RF Power

Channel	Frequency	Burst AVG Output Power (LE / 1 Mbps)	Frame AVG Output Power (LE / 1 Mbps)	Burst AVG Output Power (LE / 2 Mbps)	Frame AVG Output Power (LE / 2 Mbps)
	(MHz)	(dBm)	(dBm)	(dBm)	(dBm)
Low	2 402	7.69	7.01	7.62	5.23
Mid	2 440	6.90	6.22	6.83	4.44
High	2 480	7.71	7.03	6.15	3.76

Table 6.2.4 Bluetooth LE Burst and Frame Average RF Power

- **Bluetooth Conducted Powers procedures**

1. Bluetooth (BDR, EDR)
   1) Enter DUT mode in EUT and operate it.
      When it operating, The EUT is transmitting at maximum power level and duty cycle fixed.
   2) Instruments and EUT were connected like Figure 6.2.1(A).
   3) The maximum output powers of BDR(1 Mbps), EDR(2, 3 Mbps) and each frequency were set by a Bluetooth Tester.
   4) Power levels were measured by a Power Meter.

2. Bluetooth (LE)
   1) Enter LE mode in EUT and operate it.
      When it operating, The EUT is transmitting at maximum power level and duty cycle fixed.
   2) Instruments and EUT were connected like Figure 6.2.1(B).
   3) The average conducted output powers of LE and each frequency can measurement according to setting program in EUT.
   4) Power levels were measured by a Power Meter.

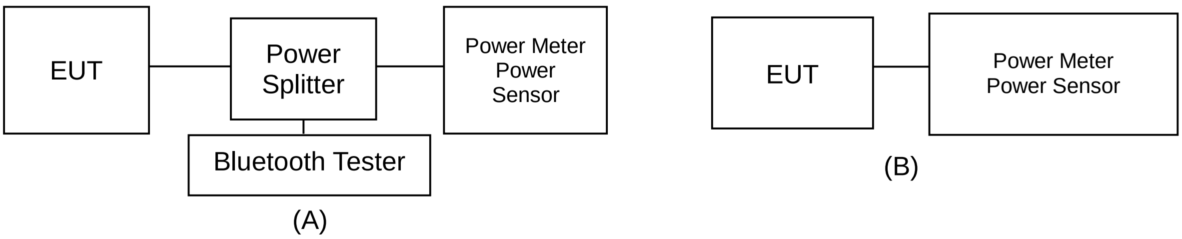

Figure 6.2.1 Average Power Measurement Setup

6.3 RFID Nominal and Maximum Output Power Spec and Conducted Powers

- RFID/USN Wireless Device (Mount 1 type)

Band	Frequency [MHz]	Frame Modulated Average[dBm]	
		Maximum	Nominal
RFID	902.75 ~ 927.25 MHz	25.50	25.00

Table 6.3.1 RFID Nominal and Maximum Output Power Spec (Frame)

Band	Freq. (MHz)	Channel	RFID Frame AVG Conducted Power (dBm)
RFID	902.75	1	25.40
	915.75	26	25.28
	927.25	50	25.38

Table 6.3.2 RFID Frame Average RF Power

- RFID/USN Wireless Device (Mount 2 type)

Band	Frequency [MHz]	Frame Modulated Average[dBm]	
		Maximum	Nominal
RFID	902.75 ~ 927.25 MHz	25.50	25.00

Table 6.3.3 RFID Nominal and Maximum Output Power Spec (Frame)

Band	Freq. (MHz)	Channel	RFID Frame AVG Conducted Power (dBm)
RFID	902.75	1	25.46
	915.75	26	25.42
	927.25	50	25.32

Table 6.3.4 RFID Frame Average RF Power

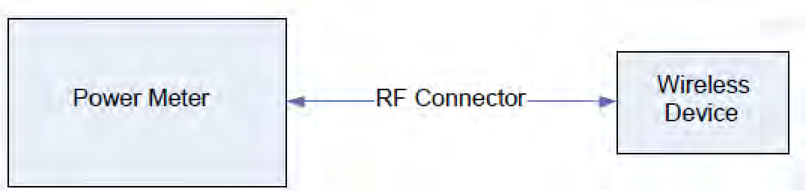

Figure 6.3.1 Power Measurement Setup

7. SYSTEM VERIFICATION

7.1 Tissue Verification

MEASURED TISSUE PARAMETERS

Date(s)	Tissue Type	Ambient Temp.[°C]	Liquid Temp.[°C]	Measured Frequency [MHz]	Target Dielectric Constant, εr	Target Conductivity, σ (S/m)	Measured Dielectric Constant, εr	Measured Conductivity, σ (S/m)	Er Deviation [%]	σ Deviation [%]
Mar. 10. 2023	2 450 Head	22.0	22.1	2 412.0	39.265	1.766	38.130	1.805	-2.89	2.21
				2 437.0	39.222	1.788	38.034	1.836	-3.03	2.68
				2 450.0	39.200	1.800	38.002	1.851	-3.06	2.83
				2 462.0	39.184	1.813	37.971	1.863	-3.10	2.76
Mar. 08. 2023	5 200 Head	20.5	20.3	5 180.0	36.020	4.639	36.147	4.698	0.35	1.27
				5 200.0	36.000	4.660	36.121	4.728	0.34	1.46
				5 220.0	35.980	4.680	36.078	4.742	0.27	1.32
				5 240.0	35.960	4.700	36.010	4.751	0.14	1.09
Mar. 08. 2023	5 300 Head	20.5	20.3	5 260.0	35.940	4.720	35.949	4.776	0.03	1.19
				5 280.0	35.920	4.740	35.917	4.813	-0.01	1.54
				5 300.0	35.900	4.760	35.892	4.851	-0.02	1.91
				5 320.0	35.880	4.780	35.868	4.878	-0.03	2.05
Mar. 09. 2023	5 600 Head	20.7	21.0	5 500.0	35.650	4.965	34.567	4.980	-3.04	0.30
				5 580.0	35.530	5.049	34.387	5.078	-3.22	0.57
				5 600.0	35.500	5.070	34.354	5.105	-3.23	0.69
				5 660.0	35.440	5.130	34.239	5.177	-3.39	0.92
				5 720.0	35.380	5.190	34.111	5.252	-3.59	1.19
Mar. 10. 2023	5 800 Head	20.8	20.5	5 745.0	35.355	5.215	34.717	5.314	-1.80	1.90
				5 785.0	35.315	5.255	34.632	5.365	-1.93	2.09
				5 800.0	35.300	5.270	34.607	5.387	-1.96	2.22
				5 825.0	35.275	5.296	34.568	5.416	-2.00	2.27

MEASURED TISSUE PARAMETERS

Date(s)	Tissue Type	Ambient Temp.[°C]	Liquid Temp.[°C]	Measured Frequency [MHz]	Target Dielectric Constant, εr	Target Conductivity, σ (S/m)	Measured Dielectric Constant, εr	Measured Conductivity, σ (S/m)	Er Deviation [%]	σ Deviation [%]
Mar. 07. 2023	900 Head	21.5	21.3	900.00	41.500	0.970	42.703	0.988	2.90	1.86
				902.75	41.496	0.971	42.671	0.991	2.83	2.06
				915.75	41.473	0.976	42.507	1.002	2.49	2.66
				927.25	41.451	0.981	42.353	1.012	2.18	3.16

The above measured tissue parameters were used in the DASY software. The DASY software was used to perform interpolation to determine the dielectric parameters at the SAR test device frequencies (per KDB 865664 and IEEE 1528-2013 6.6.1.2). The tissue parameters listed in the SAR test plots may slightly differ from the table above due to significant digit rounding in the software.

Measurement Procedure for Tissue verification:

1) The network analyzer and probe system was configured and calibrated.
2) The probe was immersed in the sample which was placed in a nonmetallic container. Trapped air bubbles beneath the flange were minimized by placing the probe at a slight angle.
3) The complex admittance with respect to the probe aperture was measured
4) The complex relative permittivity , for example from the below equation (Pournaropoulos and Misra):

$$Y = \frac{j2\omega\varepsilon_r\varepsilon_0}{[\ln(b/a)]^2}\int_a^b\int_a^b\int_0^\pi \cos\phi' \frac{\exp\left[-j\omega r(\mu_0\varepsilon_r\varepsilon_0)^{1/2}\right]}{r} d\phi' d\rho' d\rho$$

where Y is the admittance of the probe in contact with the sample, the primed and unprimed coordinates refer to source and observation points, respectively, $r^2 = \rho^2 + \rho'^2 - 2\rho\rho'\cos\phi'$, ω is the angular frequency, and $j = \sqrt{-1}$.

7.2 Test System Verification

Prior to assessment, the system is verified to the ±10 % of the specifications at using the SAR Dipole kit(s). (Graphic Plots Attached)

Table 7.2.1 System Verification Results (10 g)

SYSTEM DIPOLE VERIFICATION TARGET & MEASURED												
SAR System #	Freq. [MHz]	SAR Dipole kits	Date(s)	Tissue Type	Ambient Temp. [°C]	Liquid Temp. [°C]	Probe S/N	Input Power (mW)	1 W Target $SAR_{10\,g}$ (W/kg)	Measured $SAR_{10\,g}$ (W/kg)	1 W Normalized $SAR_{10\,g}$ (W/kg)	Deviation [%]
E	900	D900V2, SN: 1d175	Mar. 07. 2023	Head	21.5	21.3	3327	250	6.98	1.69	6.76	-3.15
E	2 450	D2450V2, SN: 920	Mar. 10. 2023	Head	22.0	22.1	3327	100	24.7	2.49	24.90	0.81
C	5 200	D5GHzV2, SN:1103	Mar. 08. 2023	Head	20.5	20.3	3930	100	22.8	2.14	21.40	-6.14
C	5 300	D5GHzV2, SN:1103	Mar. 08. 2023	Head	20.5	20.3	3930	100	23.8	2.35	23.50	-1.26
C	5 500	D5GHzV2, SN:1103	Mar. 09. 2023	Head	20.7	21.0	3930	100	24.5	2.42	24.20	-1.22
C	5 600	D5GHzV2, SN:1103	Mar. 09. 2023	Head	20.7	21.0	3930	100	23.9	2.51	25.10	5.02
C	5 800	D5GHzV2, SN:1103	Mar. 10. 2023	Head	20.8	20.5	3930	100	22.9	2.42	24.20	5.68

Note1 : System Verification was measured with input 250 mW, 100 mW and normalized to 1 W.
Note2 : Full system validation status and results can be found in Appendix D.

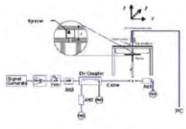

Figure 7.1 Dipole Verification Test Setup Diagram & Photo

8. SAR TEST RESULTS

8.1 Standalone Extremity SAR Results

Table 8.1.1 DTS Extremity SAR

MEASUREMENT RESULTS

FREQUENCY MHz	Ch	Mode	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	Phantom Position	Device Serial Number	Peak SAR of Area Scan	Data Rate [Mbps]	Duty Cycle	10 g SAR (W/kg)	Scaling Factor	Scaling Factor (Duty Cycle)	10 g Scaled SAR (W/kg)	Plots #
2 437.0	6	802.11b (Ant.1)	13.00	12.41	-0.190	25 mm [Rear]	FCC #3	0.012	1	99.3	0.010	1.146	1.007	**0.012**	A1
2 412.0	1	802.11b (Ant.2)	14.00	13.58	-0.110	25 mm [Rear]	FCC #3	0.006	1	99.3	0.005	1.102	1.007	**0.006**	A2
2 412.0	1	802.11g (MIMO)	14.12	13.76	0.000	25 mm [Rear]	FCC #3	0.008	6	98.1	0.005	1.086	1.019	**0.006**	A3

ANSI / IEEE C95.1-1992– SAFETY LIMIT
Spatial Peak
Uncontrolled Exposure/General Population Exposure

Extremity
4.0 W/kg (mW/g)
averaged over 10 gram

Adjusted SAR results for OFDM SAR

FREQUENCY MHz	Ch	Mode/ Antenna	Service	Maximum Allowed Power [dBm]	10 g Scaled SAR (W/kg)	FREQUENCY [MHz]	Mode	Service	Maximum Allowed Power [dBm	Ratio of OFDM to DSSS	10 g Adjusted SAR (W/kg)	Determine OFDM SAR
2 437.0	6	802.11b (Ant.1)	DSSS	13.00	0.012	2 462.0	802.11g	OFDM	10.00	0.501	**0.006**	X
2 437.0	6	802.11b (Ant.1)	DSSS	13.00	0.012	2 462.0	802.11n	OFDM	9.00	0.398	**0.005**	X
2 412.0	1	802.11b (Ant.2)	DSSS	14.00	0.006	2 462.0	802.11g	OFDM	12.00	0.631	**0.004**	X
2 412.0	1	802.11b (Ant.2)	DSSS	14.00	0.006	2 462.0	802.11n	OFDM	10.00	0.398	**0.002**	X
2 412.0	1	802.11g (MIMO)	OFDM	14.12	0.006	2 462.0	802.11n	OFDM	12.54	0.695	**0.004**	X

ANSI / IEEE C95.1-1992– SAFETY LIMIT
Spatial Peak
Uncontrolled Exposure/General Population Exposure

Extremity
4.0 W/kg (mW/g)
averaged over 10 gram

Note: SAR is not required for the following 2.4 GHz OFDM conditions. 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.

Table 8.1.2 UNII Extremity SAR

MEASUREMENT RESULTS

FREQUENCY MHz	Ch	Mode	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	Phantom Position	Device Serial Number	Peak SAR of Area Scan	Data Rate [Mbps]	Duty Cycle	10 g SAR (W/kg)	Scaling Factor	Scaling Factor (Duty Cycle)	10 g Scaled SAR (W/kg)	Plots #
5 320.0	64	802.11a (Ant.1)	12.00	11.81	-0.040	25 mm [Rear]	FCC #3	0.004	6	98.2	0.003	1.045	1.018	**0.003**	A4
5 180.0	36	802.11a (Ant.2)	10.00	9.49	-0.100	25 mm [Rear]	FCC #3	0.017	6	98.2	0.013	1.125	1.018	**0.015**	A5
5 180.0	36	802.11a (MIMO)	14.12	13.76	-0.140	25 mm [Rear]	FCC #3	0.021	6	98.2	0.015	1.086	1.018	**0.017**	A6
5 580.0	116	802.11a (Ant.1)	12.60	12.36	0.190	25 mm [Rear]	FCC #3	0.006	6	98.2	0.003	1.057	1.018	**0.003**	A7
5 500.0	100	802.11a (Ant.2)	8.50	7.61	-0.180	25 mm [Rear]	FCC #3	0.013	6	98.2	0.010	1.227	1.018	**0.012**	A8
5 500.0	100	802.11a (MIMO)	14.03	12.92	-0.120	25 mm [Rear]	FCC #3	0.020	6	98.2	0.028	1.291	1.018	**0.037**	A9
5 825.0	165	802.11a (Ant.1)	12.60	12.28	0.140	25 mm [Rear]	FCC #3	0.005	6	98.2	0.017	1.076	1.018	**0.019**	A10
5 825.0	165	802.11a (Ant.2)	6.50	5.60	0.190	25 mm [Rear]	FCC #3	0.011	6	98.2	0.020	1.230	1.018	**0.025**	A11
5 825.0	165	802.11a (MIMO)	13.55	13.12	-0.050	25 mm [Rear]	FCC #3	0.012	6	98.2	0.021	1.104	1.018	**0.024**	A12

ANSI / IEEE C95.1-1992– SAFETY LIMIT
Spatial Peak
Uncontrolled Exposure/General Population Exposure

Extremity
4.0 W/kg (mW/g)
averaged over 10 gram

Adjusted SAR results for UNII-1 and UNII-2A SAR

FREQUENCY MHz	Ch	Mode/ Antenna	Service	Maximum Allowed Power [dBm]	10 g Scaled SAR (W/kg)	FREQUENCY [MHz]	Mode	Service	Maximum Allowed Power [dBm]	Adjusted Factor	10 g Adjusted SAR (W/kg)	SAR for the band with lower maximum output power
5 320.0	64	802.11a (Ant.1)	OFDM	12.00	0.003	5 240.0	802.11a	OFDM	12.00	1.000	**0.003**	X
5 180.0	36	802.11a (Ant.2)	OFDM	10.00	0.015	5 280.0	802.11a	OFDM	8.00	0.631	**0.009**	X
5 180.0	36	802.11a (MIMO)	OFDM	14.12	0.017	5 280.0	802.11a	OFDM	13.46	0.859	**0.015**	X

ANSI / IEEE C95.1-1992– SAFETY LIMIT
Spatial Peak
Uncontrolled Exposure/General Population Exposure

Extremity
4.0 W/kg (mW/g)
averaged over 10 gram

Note: U-NII-1 and U-NII-2A Bands: When different maximum output power is specified for the bands, begin SAR measurement in the band with higher specified maximum output power. The highest reported SAR for the tested configuration is adjusted by the ratio of lower to higher specified maximum output power for the two bands. When the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for the band with lower maximum output power in that test configuration.

Table 10.3 RFID Extremity SAR

MEASUREMENT RESULTS

FREQUENCY MHz	Ch	Mode	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	Phantom Position	Device Serial Number	10 g SAR (W/kg)	Scaling Factor	10 g Scaled SAR (W/kg)	Plots #
915.75	26	RFID	25.50	25.28	0.050	0 mm [Top]	FCC #1	0.084	1.052	0.088	
915.75	26	RFID	25.50	25.28	0.090	0 mm [Bottom]	FCC #1	0.036	1.052	0.038	
915.75	26	RFID	25.50	25.28	0.150	10 mm [Front]	FCC #1	0.453	1.052	0.477	
915.75	26	RFID	25.50	25.28	0.000	0 mm [Rear]	FCC #1	0.026	1.052	0.027	
915.75	26	RFID	25.50	25.28	-0.060	0 mm [Right]	FCC #1	0.683	1.052	**0.719**	A13
915.75	26	RFID	25.50	25.28	-0.030	0 mm [Left]	FCC #1	0.613	1.052	0.645	
915.75	26	RFID	25.50	25.42	-0.110	0 mm [Top]	FCC #2	0.087	1.019	0.089	
915.75	26	RFID	25.50	25.42	0.080	0 mm [Bottom]	FCC #2	0.017	1.019	0.017	
915.75	26	RFID	25.50	25.42	-0.010	10 mm [Front]	FCC #2	0.447	1.019	0.455	
915.75	26	RFID	25.50	25.42	0.050	0 mm [Rear]	FCC #2	0.025	1.019	0.025	
915.75	26	RFID	25.50	25.42	0.120	0 mm [Right]	FCC #2	0.699	1.019	**0.712**	A14
915.75	26	RFID	25.50	25.42	-0.050	0 mm [Left]	FCC #2	0.606	1.019	0.618	

ANSI / IEEE C95.1-1992– SAFETY LIMIT
Spatial Peak
Uncontrolled Exposure/General Population Exposure

Extremity
4.0 W/kg (mW/g)
averaged over 10 gram

8.2 SAR Test Notes

General Notes:

1. The test data reported are the worst-case SAR values according to test procedures specified in IEEE 1528-2013 and FCC KDB Publication 447498 D01v06.
2. Batteries are fully charged at the beginning of the SAR measurements. A standard battery was used for all SAR measurements.
3. Liquid tissue depth was at least 15.0 cm for all frequencies.
4. The manufacturer has confirmed that the device(s) tested have the same physical, mechanical and thermal characteristics and are within operational tolerances expected for production units
5. SAR results were scaled to the maximum allowed power to demonstrate compliance per FCC KDB Publication 447498 D01v06.
6. SAR measurements were performed using the DASY5 automated system. The procedure for spatial peak SAR evaluation has been implemented according to the IEEE 1528 standard. During a maximum search, global and local maxima searches are automatically performed in 2-D after each area scan measurement. The algorithm will find the global maximum and all local maxima within 2 dB of the global maxima for all SAR distributions. All local maxima within 2 dB of the global maximum were searched and passed for the Zoom Scan measurement.

WLAN Notes:

1. The initial test position procedures were applied. The test position with the highest extrapolated peak SAR will be used as the initial test position. When reported SAR for the initial test position is ≤ 0.4 W/kg, no additional testing for the remaining test positions was required. Otherwise, SAR is evaluated at the subsequent highest peak SAR positions until the reported SAR result is ≤ 0.8 W/kg or all test positions are measured.
2. Justification for test configurations for WLAN per KDB Publication 248227 D01v02r02 for 2.4 GHz WIFI single transmission chain operations, the highest measured maximum output power channel for DSSS was selected for SAR measurement. SAR for OFDM modes (2.4 GHz 802.11g/n) was not required duo to the maximum allowed powers and the highest reported DSSS SAR when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output and the adjust SAR is ≤ 1.2 W/kg.
3. Justification for test configurations for WLAN per KDB Publication 248227 D01v02r02 for 5 GHz WIFI single transmission chain operations, the initial test configuration was selected according to the transmission mode with the highest maximum allowed powers. Other transmission modes were not investigated since the highest reported SAR for initial test configuration adjusted by the ratio of maximum output powers is less than 1.2 W/kg.
4. When the maximum reported 1g averaged SAR ≤ 0.8 W/kg, SAR testing on additional channels was not required. Otherwise, SAR for the next highest output power channel was required until the reported SAR result was ≤ 1.20 W/kg or all test channels were measured**.**
5. The device was configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor to determine compliance.
6. Per KDB Publication 248227 D01v02r02, SAR for MIMO was evaluated by following the simultaneous SAR provisions from KDB Publication 447498 D01v06 by making a SAR measurement with both antennas transmitting simultaneously.

Bluetooth Notes:

1. Bluetooth SAR was measured with the device connected to a call with hopping disabled with DH5 operation and Tx test mode type. Per October 2016 TCB Workshop Notes, the reported SAR was scaled to the 100 % transmission duty factor to determine compliance. Refer to section 9.5 for the time-domain plot and calculation for the duty factor of the device.
2. Head and hotspot Bluetooth SAR were evaluated for BT tethering applications.

9. FCC MULTI-TX AND ANTENNA SAR CONSIDERATIONS

9.1 Introduction

The following procedures adopted from FCC KDB Publication 447498 D01v06 are applicable to handsets with built-in unlicensed transmitters such as 802.11b/g/n and Bluetooth devices which may simultaneously transmit with the licensed transmitter.

9.2 Simultaneous Transmission Procedures

This device contains transmitters that may operate simultaneously. Therefore, simultaneous transmission analysis is required. Per FCC KDB 447498 D01v06 4.3.2 and IEEE 1528-2013 Section 6.3.4.1.2,simultaneous transmission SAR test exclusion may be applied when the sum of the sum 1-g SAR for all the simultaneous transmitting antennas in a specific a physical test configuration is ≤ 1.6 W/kg. The different test positon in an exposure condition may be considered collectively to determine SAR test exclusion according to the sum of 1-g or 10-g SAR.

Table 10.2.1 Estimated SAR (Extremity)

Mode	Frequency	Maximum Allowed Power		Separation Distance (Extremity)	Estimated SAR (Extremity)
	[MHz]	[dBm]	[mW]	[mm]	[W/kg]
Bluetooth (Mobile Computer)	2 441	5.85	3.85	25	0.013
Bluetooth LE (Mobile Computer)	2 440	7.02	5.04	25	0.017

9.3 Simultaneous Transmission Capabilities

According to FCC KDB Publication 447498 D01v06, transmitters are considered to be transmitting simultaneously when there is overlapping transmission, with the exception of transmissions during network hand-offs with maximum hand-off duration less than 30 seconds.

This device contains multiple transmitters that may operate simultaneously, and therefore requires a simultaneous transmission analysis according to FCC KDB Publication 447498 D01v06.

Table 9.3.1 Simultaneous SAR Cases

No.	Capable Transmit Configuration (EF550 + RFR901)	Extremity SAR	Note
1	Wi-Fi 2.4 GHz + RFID	Yes	
2	Wi-Fi 5 GHz + RFID	Yes	
3	Bluetooth 2.4 GHz + RFID	Yes	

EF550 Note(s):

1. Wi-Fi 2.4 GHz and Wi-Fi 5 GHz are not transmitted simultaneously.
2. Bluetooth 2.4 GHz and Wi-Fi (2.4 GHz/5 GHz) are not transmitted simultaneously.

9.4 Extremity SAR Simultaneous Transmission Analysis

Table 9.4.1 Simultaneous Transmission Scenario : 2.4 GHz W-LAN + RFID (Extremity)

Exposure Condition	Mode		Configuration	2.4 GHz W-LAN SAR (W/kg)	RFID SAR (W/kg)	ΣSAR (W/kg)
				1	3	1+2+3
Extremity SAR	Mount 1 type	2.4 GHz W-LAN Ant.1	Bottom and Rear	0.012	0.027	0.039
		2.4 GHz W-LAN Ant.2	Bottom and Rear	0.006	0.027	0.033
		2.4 GHz W-LAN Ant.MIMO	Bottom and Rear	0.006	0.027	0.033
	Mount 2 type	2.4 GHz W-LAN Ant.1	Bottom and Rear	0.012	0.025	0.037
		2.4 GHz W-LAN Ant.2	Bottom and Rear	0.006	0.025	0.031
		2.4 GHz W-LAN Ant.MIMO	Bottom and Rear	0.006	0.025	0.031

Table 9.4.2 Simultaneous Transmission Scenario : 5.2 GHz W-LAN + RFID (Extremit)

Exposure Condition	Mode		Configuration	5.2 GHz W-LAN SAR (W/kg)	RFID SAR (W/kg)	ΣSAR (W/kg)
				1	3	1+2+3
Extremity SAR	Mount 1 type	5.2 GHz W-LAN Ant.2	Bottom and Rear	0.015	0.027	0.042
		5.2 GHz W-LAN Ant.MIMO	Bottom and Rear	0.017	0.027	0.044
	Mount 2 type	5.2 GHz W-LAN Ant.2	Bottom and Rear	0.015	0.025	0.040
		5.2 GHz W-LAN Ant.MIMO	Bottom and Rear	0.017	0.025	0.042

Table 9.4.3 Simultaneous Transmission Scenario : 5.3 GHz W-LAN + RFID (Extremity)

Exposure Condition	Mode		Configuration	5.3 GHz W-LAN SAR (W/kg)	RFID SAR (W/kg)	ΣSAR (W/kg)
				1	3	1+2+3
Extremity SAR	Mount 1 type	5.3 GHz W-LAN Ant.1	Bottom and Rear	0.003	0.027	0.030
	Mount 2 type	5.3 GHz W-LAN Ant.1	Bottom and Rear	0.003	0.025	0.028

Table 9.4.4 Simultaneous Transmission Scenario : 5.6 GHz W-LAN + RFID (Extremit)

Exposure Condition	Mode		Configuration	5.6 GHz W-LAN SAR (W/kg)	RFID SAR (W/kg)	ΣSAR (W/kg)
				1	3	1+2+3
Extremity SAR	Mount 1 type	5.6 GHz W-LAN Ant.1	Bottom and Rear	0.003	0.027	0.030
		5.6 GHz W-LAN Ant.2	Bottom and Rear	0.012	0.027	0.039
		5.6 GHz W-LAN Ant.MIMO	Bottom and Rear	0.037	0.027	0.064
	Mount 2 type	5.6 GHz W-LAN Ant.1	Bottom and Rear	0.003	0.025	0.028
		5.6 GHz W-LAN Ant.2	Bottom and Rear	0.012	0.025	0.037
		5.6 GHz W-LAN Ant.MIMO	Bottom and Rear	0.037	0.025	0.062

Table 9.4.5 Simultaneous Transmission Scenario : 5.8 GHz W-LAN + RFID (Extremit)

Exposure Condition	Mode		Configuration	5.8 GHz W-LAN SAR (W/kg)	RFID SAR (W/kg)	ΣSAR (W/kg)
				1	3	1+2+3
Extremity SAR	Mount 1 type	5.8 GHz W-LAN Ant.1	Bottom and Rear	0.019	0.027	0.046
		5.8 GHz W-LAN Ant.2	Bottom and Rear	0.025	0.027	0.052
		5.8 GHz W-LAN Ant.MIMO	Bottom and Rear	0.024	0.027	0.051
	Mount 2 type	5.8 GHz W-LAN Ant.1	Bottom and Rear	0.019	0.025	0.044
		5.8 GHz W-LAN Ant.2	Bottom and Rear	0.025	0.025	0.050
		5.8 GHz W-LAN Ant.MIMO	Bottom and Rear	0.024	0.025	0.049

Table 9.4.6 Simultaneous Transmission Scenario : Bluetooth + RFID (Extremity)

Exposure Condition	Mode		Configuration	Bluetooth SAR (W/kg)	RFID SAR (W/kg)	ΣSAR (W/kg)
				1	3	1+2+3
Extremity SAR	Mount 1 type	Bluetooth	Bottom and Rear	0.013	0.027	0.040
	Mount 2 type	Bluetooth	Bottom and Rear	0.013	0.025	0.038

Table 9.4.7 Simultaneous Transmission Scenario : Bluetooth LE + RFID (Extremity)

Exposure Condition	Mode	Configuration	Bluetooth LE SAR (W/kg)	RFID SAR (W/kg)	ΣSAR (W/kg)
			1	3	1+2+3
Extremity SAR	Bluetooth LE	Bottom and Rear	0.017	0.027	0.044
	Bluetooth LE	Bottom and Rear	0.017	0.025	0.042

9.5 Simultaneous Transmission Conclusion

The above numerical summed SAR results for all the worst-case simultaneous transmission conditions were below the SAR limit. Therefore, the above analysis is sufficient to determine that simultaneous transmission cases will not exceed the SAR limit and therefore no measured volumetric simultaneous SAR summation is required per FCC KDB Publication 447498 D01v06 and IEEE 1528-2013 Section 6.3.4.1.2.

10. SAR MEASUREMENT VARIABILITY

10.1 Measurement Variability

Per FCC KDB Publication 865664 D01v01r04, SAR measurement variability was assessed for each frequency band, which was determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media were required for SAR measurements in a frequency band, the variability measurement procedures were applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium. These additional measurements were repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device was returned to ambient conditions (normal room temperature) with the battery fully charged before it was re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

SAR Measurement Variability was assessed using the following procedures for each frequency band:

1. When the original highest measured SAR is ≥ 0.80 W/kg, the measurement was repeated once.
2. A second repeated measurement was performed only if the ratio of largest to smallest SAR for the original and first repeated measurements was > 1.20 or when the original or repeated measurement was ≥ 1.45 W/kg (~ 10 % from the 1-g SAR limit).
3. A third repeated measurement was performed only if the original, first or second repeated measurement was ≥ 1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.
4. Repeated measurements are not required when the original highest measured SAR is < 0.80 W/kg
5. The same procedures should be adapted for measurements according to extremity exposure limits by applying a factor of 2.5 for extremity exposure to the corresponding SAR thresholds.

10.2 Measurement Uncertainty

The measured SAR was < 1.5 W/kg for 1g and < 3.75 W/kg for 10 g for all frequency bands. Therefore, per KDB Publication 865664 D01v01r04, the extended measurement uncertainty analysis per IEEE 1528-2013 was not required.

11. EQUIPMENT LIST

Table 11.1.1 Test Equipment Calibration

	Type	Manufacturer	Model	Cal.Date	Next.Cal.Date	S/N
☒	SEMITEC Engineering	SEMITEC	N/A	N/A	N/A	Shield Room
☒	SEMITEC Engineering	SEMITEC	N/A	N/A	N/A	Shield Room
☒	Robot	SPEAG	TX60L	N/A	N/A	F15/50NHA1/A/01
☒	Robot	SPEAG	TX90XL	N/A	N/A	F13/5P9GA1/A/01
☒	Robot Controller	SPEAG	CS8C	N/A	N/A	F12/5LP5A1/C/01
☒	Robot Controller	SPEAG	CS8C	N/A	N/A	F13/5P9GA1/C/01
☒	Joystick	SPEAG	N/A	N/A	N/A	D21142605A
☒	Joystick	SPEAG	N/A	N/A	N/A	S-12450905
☒	Intel Core i7-8 700K 3.70 GHz Window 10 Pro	N/A	N/A	N/A	N/A	N/A
☒	Intel Core i7-3 770 3.40 GHz Window 7 Professional	N/A	N/A	N/A	N/A	N/A
☒	Probe Alignment Unit LB	N/A	N/A	N/A	N/A	SE UKS 030 AA
☒	Probe Alignment Unit LB	N/A	N/A	N/A	N/A	SE UKS 030 AA
☒	Device Holder	SPEAG	SD000H01KA	N/A	N/A	N/A
☒	Device Holder	SPEAG	SD000H01HA	N/A	N/A	N/A
☒	Twin SAM Phantom	SPEAG	QD000P40CD	N/A	N/A	1895
☒	Twin SAM Phantom	SPEAG	QD000P40CD	N/A	N/A	1786
☒	Data Acquisition Electronics	SPEAG	DAE4V1	2022-09-21	2023-09-21	1453
☒	Data Acquisition Electronics	SPEAG	DAE4V1	2022-03-24	2023-03-24	1394
☒	Dosimetric E-Field Probe	SPEAG	ES3DV3	2023-01-22	2024-01-22	3327
☒	Dosimetric E-Field Probe	SPEAG	EX3DV4	2022-07-25	2023-07-25	3930
☒	900 MHz System Validation Dipole	SPEAG	D900V2	2022-05-30	2024-05-30	1d175
☒	2 450 MHz SAR Validation Dipole	SPEAG	D2450V2	2022-08-18	2024-08-18	920
☒	5 GHz SAR Validation Dipole	SPEAG	D5GHzV2	2023-01-25	2025-01-25	1103
☒	Network Analyzer	Agilent	E5071C	2022-06-24	2023-06-24	MY46106970
☒	Signal Generator	Agilent	E4438C	2022-06-24	2023-06-24	US41461520
☒	High Power RF Amplifier	EMPOWER	BBS3Q8CCJ	2022-06-24	2023-06-24	1005
☒	Power Meter	HP	EPM-442A	2022-12-16	2023-12-16	GB37170267
☒	Power Meter	Anritsu	ML2488B	2022-12-16	2023-12-16	0846003
☒	Power Sensor	Anritsu	MA2472D	2022-12-16	2023-12-16	0845419
☒	Power Sensor	HP	8481A	2022-12-16	2023-12-16	2702A65976
☒	Power Sensor	HP	8481A	2022-12-16	2023-12-16	2702A61707
☒	Dual Directional Coupler	Agilent	778D-012	2022-12-16	2023-12-16	50228
☒	Directional Coupler	HP	772D	2022-06-24	2023-06-24	2889A01064
☒	Low Pass Filter 1.5 GHz	MICROLAB	LA-15N	2022-06-24	2023-06-24	2
☒	Low Pass Filter 3.0 GHz	MICROLAB	LA-30N	2022-06-24	2023-06-24	2
☒	Low Pass Filter 6.0 GHz	MICROLAB	LA-60N	2022-12-16	2023-12-16	03942
☒	Attenuators(10 dB)	WEINSCHEL	23-10-34	2022-12-16	2023-12-16	BP4387
☒	Attenuators	Saluki	3.5TS2-3dB-26.5G	2022-06-24	2023-06-24	21090703
☒	Dielectric Probe kit	SPEAG	DAKS-3.5	2022-07-25	2023-07-25	1046
☒			R140	2022-07-26	2023-07-26	0101213
☒	Power Splitter	Anritsu	K241B	2022-12-16	2023-12-16	1301183
☒	Bluetooth Tester	TESCOM	TC-3000C	2022-12-16	2023-12-16	3000C000678

NOTE(S):

1. The E-field probe was calibrated by SPEAG, by temperature measurement procedure. Dipole Verification measurement is performed by Dt&C before each test. The brain and muscle simulating material are calibrated by Dt&C using the dielectric probe system and network analyzer to determine the conductivity and permittivity (dielectric constant) of the brain and muscle-equivalent material. Each equipment item was used solely within its respective calibration period.
2. CBT (Calibrated Before Testing). Prior to testing, the measurement paths containing a cable, amplifier, attenuator, coupler or filter were connected to a calibrated source (i.e. signal generator) to determine the losses of the measurement path. The power meter offset was then adjusted to compensate for the measurement system losses. This level offset is stored within the power meter before measurements are made. This calibration verification procedure applies to the system verification and output power measurements. The calibrated reading is then taken directly from the power meter after compensation of the losses for all final power measurements.

12. MEASUREMENT UNCERTAINTIES

900 ~ 2 450 MHz Head (S/N: 3327)

Error Description	Uncertainty value %	Probability Distribution	Divisor	(Ci) 1 g	(Ci) 10 g	Standard 1 g (%)	Standard 10 g (%)	Ci x U_i 1 g	Ci x U_i 10 g	vi 2 or Veff
Measurement System										
Probe calibration	6.0	Normal	1	1	1	6.0	6.0	6.0	6.0	∞
Axial isotropy	4.7	Rectangular	√3	1	1	2.7	2.7	2.7	2.7	∞
Hemispherical isotropy	9.6	Rectangular	√3	1	1	5.5	5.5	5.5	5.5	∞
Boundary Effects	0.8	Rectangular	√3	1	1	0.46	0.46	0.46	0.46	∞
Probe Linearity	4.7	Rectangular	√3	1	1	2.7	2.7	2.7	2.7	∞
Probe modulation response	2.4	Rectangular	√3	1	1	1.4	1.4	1.4	1.4	∞
Detection limits	0.25	Rectangular	√3	1	1	0.14	0.14	0.14	0.14	∞
Readout Electronics	1.0	Normal	1	1	1	1.0	1.0	1.0	1.0	∞
Response time	0.8	Rectangular	√3	1	1	0.46	0.46	0.46	0.46	∞
Integration time	2.6	Rectangular	√3	1	1	1.5	1.5	1.5	1.5	∞
RF Ambient Conditions – Noise	3.0	Rectangular	√3	1	1	1.8	1.8	1.8	1.8	∞
RF Ambient Conditions – Reflections	3.0	Rectangular	√3	1	1	1.8	1.8	1.8	1.8	∞
Probe Positioner	0.4	Rectangular	√3	1	1	0.23	0.23	0.23	0.23	∞
Probe Positioning	2.9	Rectangular	√3	1	1	1.7	1.7	1.7	1.7	∞
Spatial x-y-Resolution	3.0	Rectangular	√3	1	1	5.8	5.8	5.8	5.8	∞
Fast SAR z-Approximation	3.0	Rectangular	√3	1	1	4.0	4.0	4.0	4.0	
Test Sample Related										
Device Positioning	2.9	Normal	1	1	1	2.9	2.9	2.9	2.9	145
Device Holder	3.6	Normal	1	1	1	3.6	3.6	3.6	3.6	5
Power Drift	5.0	Rectangular	√3	1	1	2.9	2.9	2.9	2.9	∞
SAR Scaling	2.0	Rectangular	√3	1	1	1.2	1.2	1.2	1.2	∞
Physical Parameters										
Phantom Shell	7.6	Rectangular	√3	1	1	4.4	4.4	4.4	4.4	∞
Liquid conductivity (Target)	5.0	Rectangular	√3	0.64	0.43	1.8	1.2	1.2	0.5	∞
Liquid conductivity (Meas.)	3.8	Normal	1	0.78	0.71	3.0	2.7	2.3	1.9	10
Liquid permittivity (Target)	5.0	Rectangular	√3	0.60	0.49	1.7	1.4	1.0	0.7	∞
Liquid permittivity (Meas.)	3.7	Normal	1	0.23	0.26	0.85	1.0	0.20	0.25	10
Temp. unc. - Conductivity	1.8	Rectangular	√3	0.78	0.71	0.81	0.74	0.63	0.52	∞
Temp. unc. - Permittivity	1.9	Rectangular	√3	0.23	0.26	0.25	0.29	0.06	0.07	∞
Combined Standard Uncertainty						**13**	**13**			330
Expanded Uncertainty (k=2)						**26**	**26**			

$U(1\ g) = k \times u_c$
= 2 x 13 %
= 26 % (The confidence level is about 95 % $k = 2$)
$U(10\ g) = k \times u_c$
= 2 x 13 %
= 26 % (The confidence level is about 95 % $k = 2$)

Note. Refer to "DTNC-UP-TS06-2023"

5 200 ~ 5 800 MHz Head (S/N: 3930)

Error Description	Uncertainty value %	Probability Distribution	Divisor	(Ci) 1 g	(Ci) 10 g	Standard 1 g (%)	Standard 10 g (%)	Ci x U_i 1 g	Ci x U_i 10 g	vi 2 or Veff
Measurement System										
Probe calibration	6.0	Normal	1	1	1	6.6	6.6	6.6	6.6	∞
Axial isotropy	4.7	Rectangular	√3	1	1	2.7	2.7	2.7	2.7	∞
Hemispherical isotropy	9.6	Rectangular	√3	1	1	5.5	5.5	5.5	5.5	∞
Boundary Effects	0.8	Rectangular	√3	1	1	0.46	0.46	0.46	0.46	∞
Probe Linearity	4.7	Rectangular	√3	1	1	2.7	2.7	2.7	2.7	∞
Probe modulation response	2.4	Rectangular	√3	1	1	1.4	1.4	1.4	1.4	∞
Detection limits	0.25	Rectangular	√3	1	1	0.14	0.14	0.14	0.14	∞
Readout Electronics	1.0	Normal	1	1	1	1.0	1.0	1.0	1.0	∞
Response time	0.8	Rectangular	√3	1	1	0.46	0.46	0.46	0.46	∞
Integration time	2.6	Rectangular	√3	1	1	1.5	1.5	1.5	1.5	∞
RF Ambient Conditions – Noise	3.0	Rectangular	√3	1	1	1.8	1.8	1.8	1.8	∞
RF Ambient Conditions – Reflections	3.0	Rectangular	√3	1	1	1.8	1.8	1.8	1.8	∞
Probe Positioner	0.4	Rectangular	√3	1	1	0.23	0.23	0.23	0.23	∞
Probe Positioning	2.9	Rectangular	√3	1	1	1.7	1.7	1.7	1.7	∞
Spatial x-y-Resolution	3.0	Rectangular	√3	1	1	5.8	5.8	5.8	5.8	∞
Fast SAR z-Approximation	3.0	Rectangular	√3	1	1	4.0	4.0	4.0	4.0	
Test Sample Related										
Device Positioning	2.9	Normal	1	1	1	2.9	2.9	2.9	2.9	145
Device Holder	3.6	Normal	1	1	1	3.6	3.6	3.6	3.6	5
Power Drift	5.0	Rectangular	√3	1	1	2.9	2.9	2.9	2.9	∞
SAR Scaling	2.0	Rectangular	√3	1	1	1.2	1.2	1.2	1.2	∞
Physical Parameters										
Phantom Shell	7.6	Rectangular	√3	1	1	4.4	4.4	4.4	4.4	∞
Liquid conductivity (Target)	5.0	Rectangular	√3	0.64	0.43	1.8	1.2	1.2	0.5	∞
Liquid conductivity (Meas.)	4.2	Normal	1	0.78	0.71	3.1	2.8	2.4	2.0	10
Liquid permittivity (Target)	5.0	Rectangular	√3	0.60	0.49	1.7	1.4	1.0	0.7	∞
Liquid permittivity (Meas.)	4.0	Normal	1	0.23	0.26	0.94	1.1	0.22	0.28	10
Temp. unc. - Conductivity	2.1	Rectangular	√3	0.78	0.71	0.95	0.86	0.74	0.61	∞
Temp. unc. - Permittivity	2.1	Rectangular	√3	0.23	0.26	0.28	0.32	0.07	0.08	∞
Combined Standard Uncertainty						**14**	**13**			330
Expanded Uncertainty (k=2)						**28**	**26**			

$U(1\ g) = k \times u_c$
= 2 x 14 %
= 28 % (The confidence level is about 95 % $k = 2$)
$U(10\ g) = k \times u_c$
= 2 x 13 %
= 26 % (The confidence level is about 95 % $k = 2$)

Note. Refer to “DTNC-UP-TS05-2022”

13. CONCLUSION

Measurement Conclusion

The SAR measurement indicates that the EUT complies with the RF radiation exposure limits of the FCC. These measurements are taken to simulate the RF effects exposure under the worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The tested device complies with the requirements in respect to all parameters subject to the test. The test results and statements relate only to the item(s) tested.

Please note that the absorption and distribution of electromagnetic energy in the body are every complex phenomena that depend on the mass, shape, and size of the body, the orientation of the body with respect to the field vectors, and the electrical properties of both the body and the environment. Other variables that may play a substantial role impossible biological effect are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease).

Because innumerable factors may interact to determine the specific biological outcome of an exposure to electromagnetic fields, any protection guide shall consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables.

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APPENDIX A. – Probe Calibration Data

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 **DT&C (Dymstec)**

Certificate No **ES-3327_Jan23**

CALIBRATION CERTIFICATE

Object	ES3DV3 - SN:3327
Calibration procedure(s)	QA CAL-01.v10, QA CAL-12.v10, QA CAL-23.v6, QA CAL-25.v8 Calibration procedure for dosimetric E-field probes
Calibration date	January 22, 2023

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-22 (OCP-DAK3.5-1249_Oct22)	Oct-23
OCP DAK-12	SN: 1016	20-Oct-22 (OCP-DAK12-1016_Oct22)	Oct-23
Reference 20 dB Attenuator	SN: CC2552 (20x)	04-Apr-22 (No. 217-03527)	Apr-23
DAE4	SN: 660	10-Oct-22 (No. DAE4-660_Oct22)	Oct-23
Reference Probe ES3DV2	SN: 3013	06-Jan-23 (No. ES3-3013_Jan23)	Jan-24

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-22)	In house check: Oct-24

	Name	Function	Signature
Calibrated by	Joanna Lleshaj	Laboratory Technician	
Approved by	Sven Kühn	Technical Manager	

Issued: January 23, 2023

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

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**

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).

Parameters of Probe: ES3DV3 - SN:3327

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu V/(V/m)^2$) A	1.05	1.13	1.03	±10.1%
DCP (mV) B	105.0	102.0	104.0	±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	183.1	±2.5%	±4.7%
		Y	0.00	0.00	1.00		196.0		
		Z	0.00	0.00	1.00		182.9		

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

A The uncertainties of Norm X,Y,Z do not affect the E^2-field uncertainty inside TSL (see Page 5).
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.

Parameters of Probe: ES3DV3 - SN:3327

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-35.8°
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	10 mm
Tip Diameter	4 mm
Probe Tip to Sensor X Calibration Point	2 mm
Probe Tip to Sensor Y Calibration Point	2 mm
Probe Tip to Sensor Z Calibration Point	2 mm
Recommended Measurement Distance from Surface	3 mm

Parameters of Probe: ES3DV3 - SN:3327

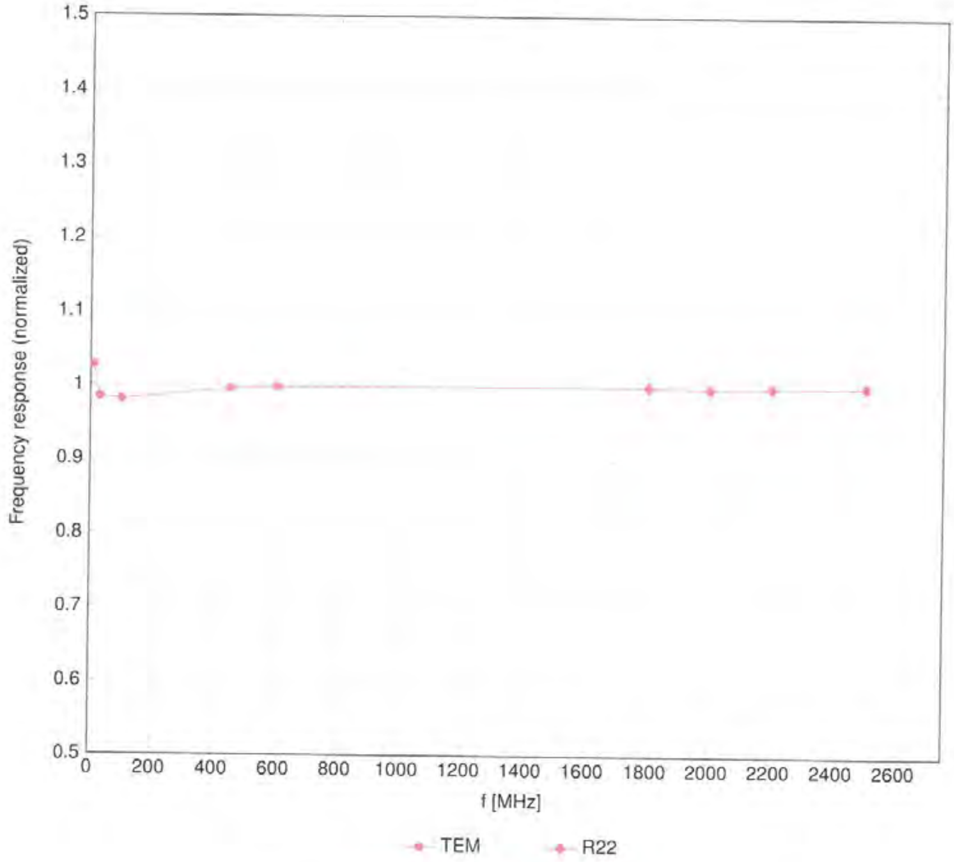
Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz)[C]	Relative Permittivity[F]	Conductivity[F] (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha[G]	Depth[G] (mm)	Unc ($k = 2$)
750	41.9	0.89	6.90	6.36	6.41	0.40	1.27	±12.0%
835	41.5	0.90	6.90	6.20	6.26	0.40	1.27	±12.0%
900	41.5	0.97	6.73	6.29	6.19	0.40	1.27	±12.0%
1750	40.1	1.37	6.17	5.66	5.64	0.40	1.27	±12.0%
1900	40.0	1.40	5.91	5.42	5.43	0.40	1.27	±12.0%
2450	39.2	1.80	5.43	4.96	5.03	0.40	1.27	±12.0%
2600	39.0	1.96	5.10	4.67	4.73	0.40	1.27	±12.0%

[C] Frequency validity above 300 MHz of ±100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ±50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ±10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4–9 MHz, and ConvF assessed at 13 MHz is 9–19 MHz. Above 5 GHz frequency validity can be extended to ±110 MHz.
[F] The probes are calibrated using tissue simulating liquids (TSL) that deviate for ε and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10%. If TSL with deviations from the target of less than ±5% are used, the calibration uncertainties are 11.1% for 0.7 - 3 GHz and 13.1% for 3 - 6 GHz.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz and below ±2% for frequencies between 3–6 GHz at any distance larger than half the probe tip diameter from the boundary.

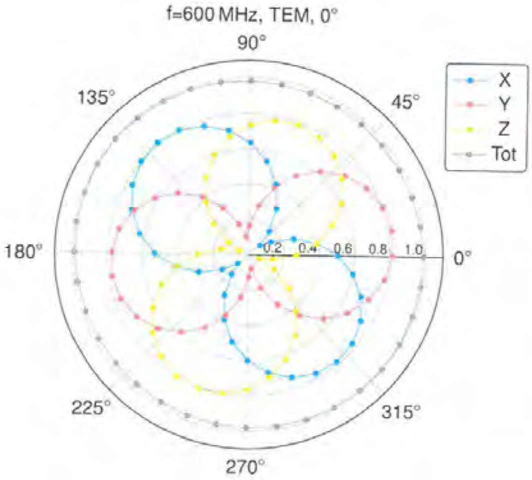
Frequency Response of E-Field

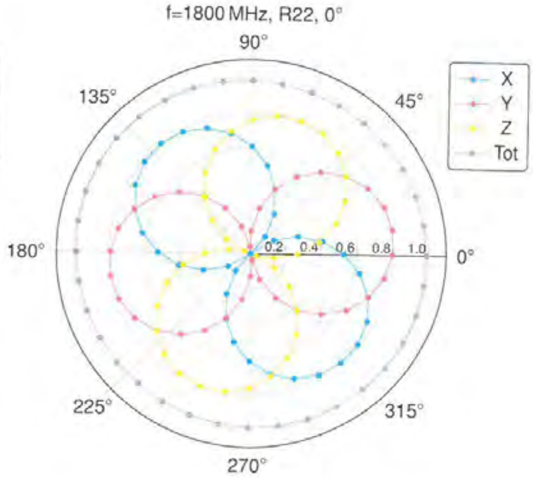
(TEM-Cell:ifi110 EXX, Waveguide:R22)

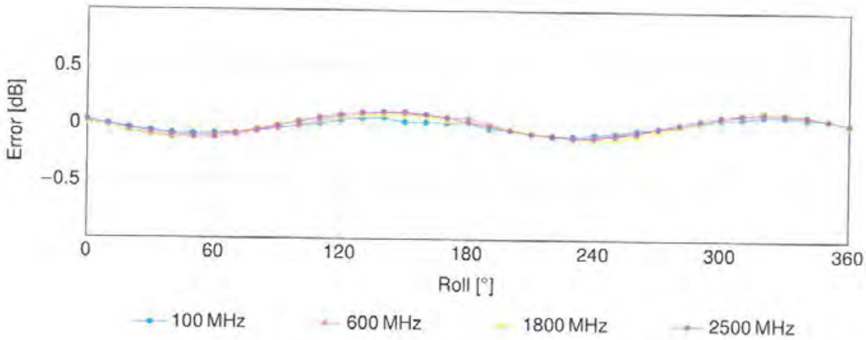


Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

Receiving Pattern (ϕ), $\vartheta = 0°$



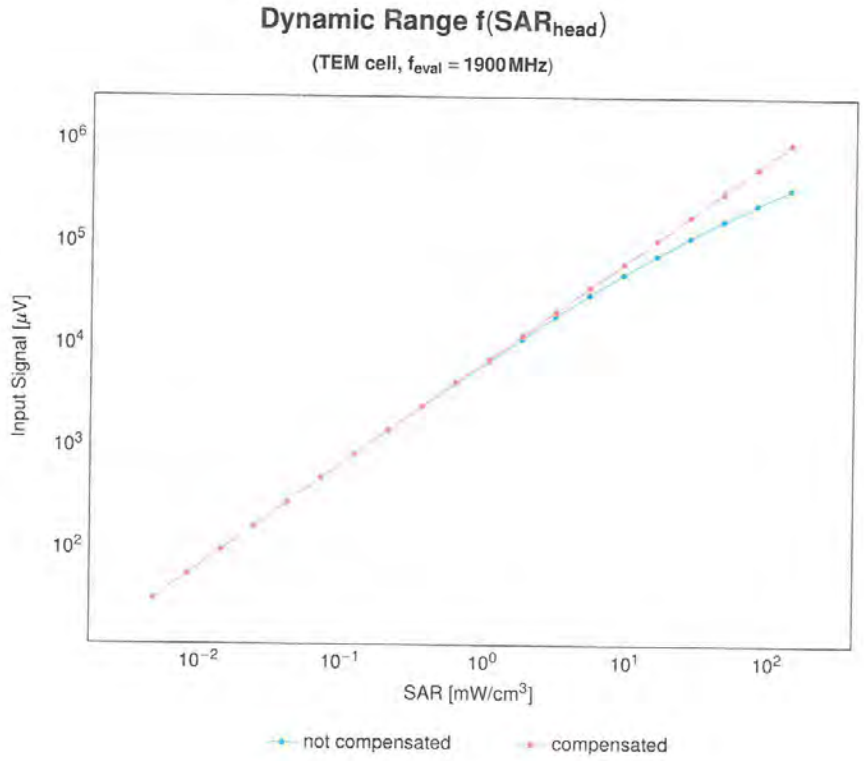


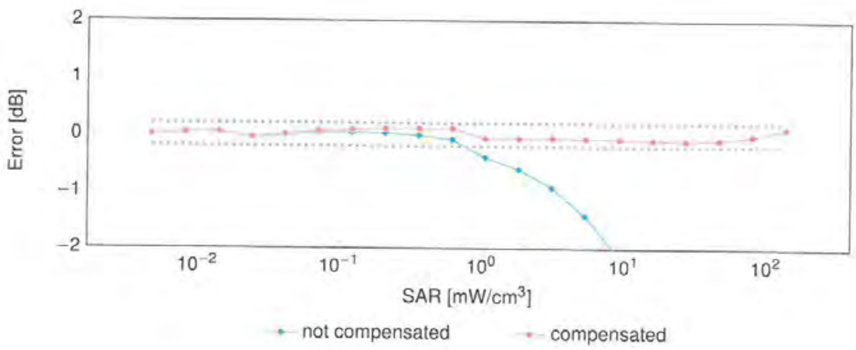


Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

ES3DV3 - SN:3327

January 22, 2023



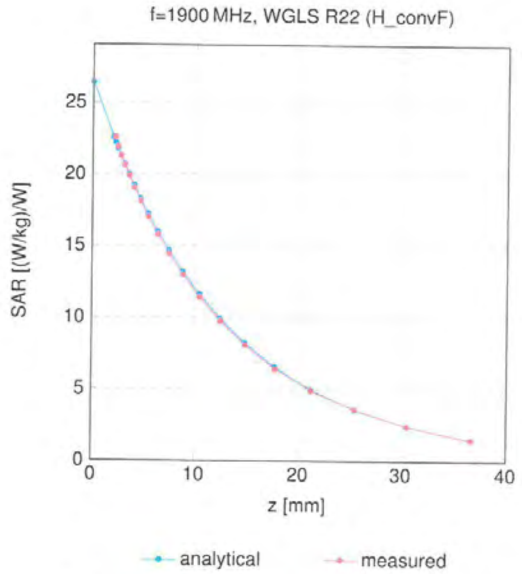


Uncertainty of Linearity Assessment: ±0.6% (k=2)

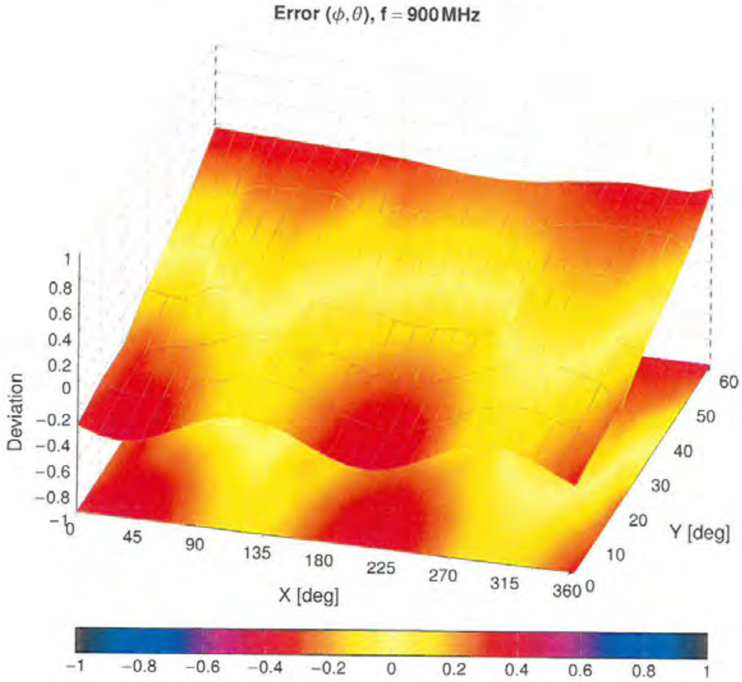
Certificate No: ES-3327_Jan23 Page 8 of 9

ES3DV3 - SN:3327 January 22, 2023

Conversion Factor Assessment



Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment: ±2.6% (k=2)

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Accreditation No.: **SCS 0108**

Client **DT&C (Dymstec)** Certificate No **EX-3930_Jul22**

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3930
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	July 25, 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	Aidonia Georgiadou	Laboratory Technician	
Approved by	Sven Kühn	Technical Manager	

Issued: July 25, 2022

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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).

Parameters of Probe: EX3DV4 - SN:3930

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k = 2)
Norm ($\mu V/(V/m)^2$) [A]	0.38	0.35	0.44	±10.1%
DCP (mV) [B]	106.6	105.2	104.1	±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	165.8	±2.7%	±4.7%
		Y	0.00	0.00	1.00		162.5		
		Z	0.00	0.00	1.00		150.1		

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

[A] The uncertainties of Norm X,Y,Z do not affect the E^2-field uncertainty inside TSL (see Page 5).
[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.

Parameters of Probe: EX3DV4 - SN:3930

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-82.9°
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

Note: Measurement distance from surface can be increased to 3–4 mm for an *Area Scan* job.

Parameters of Probe: EX3DV4 - SN:3930

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz)[C]	Relative Permittivity[F]	Conductivity[F] (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha[G]	Depth[G] (mm)	Unc ($k = 2$)
1450	40.5	1.20	8.82	8.82	8.82	0.30	0.86	±12.0%
2450	39.2	1.80	7.78	7.78	7.78	0.34	0.90	±12.0%
2600	39.0	1.96	7.66	7.66	7.66	0.43	0.90	±12.0%
3500	37.9	2.91	6.95	6.95	6.95	0.30	1.30	±13.1%
3700	37.7	3.12	6.80	6.80	6.80	0.30	1.30	±13.1%
5200	36.0	4.66	5.64	5.64	5.64	0.40	1.80	±13.1%
5300	35.9	4.76	5.41	5.41	5.41	0.40	1.80	±13.1%
5500	35.6	4.96	5.05	5.05	5.05	0.40	1.80	±13.1%
5600	35.5	5.07	4.95	4.95	4.95	0.40	1.80	±13.1%
5800	35.3	5.27	4.89	4.89	4.89	0.40	1.80	±13.1%

[C] Frequency validity above 300 MHz of ±100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ±50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ±10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4–9 MHz, and ConvF assessed at 13 MHz is 9–19 MHz. Above 5 GHz frequency validity can be extended to ±110 MHz.

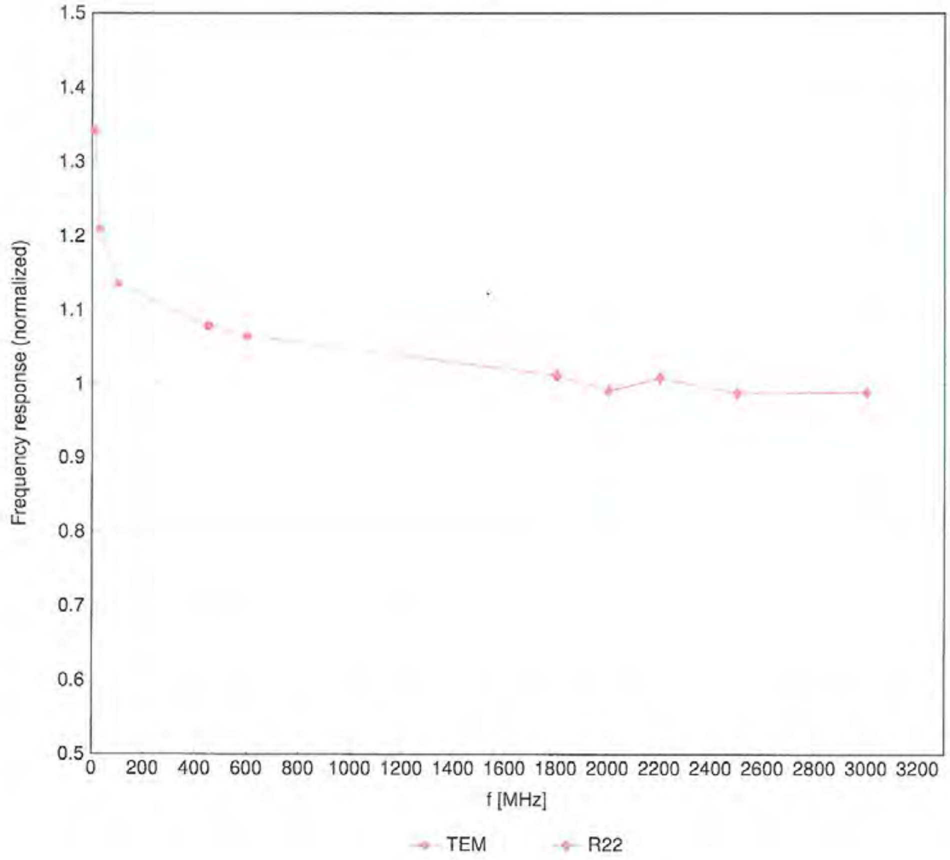
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ±10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ±5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz and below ±2% for frequencies between 3–6 GHz at any distance larger than half the probe tip diameter from the boundary.

EX3DV4 - SN:3930 July 25, 2022

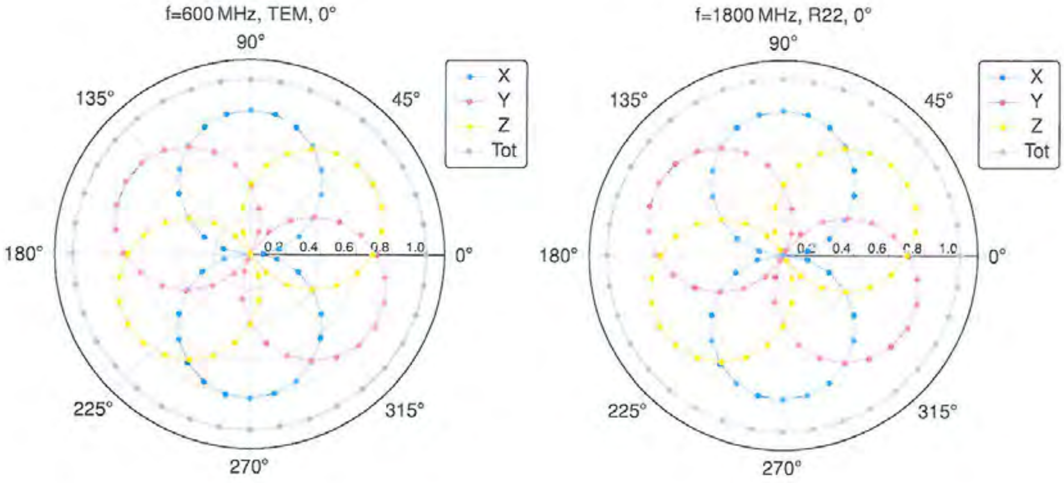
Frequency Response of E-Field

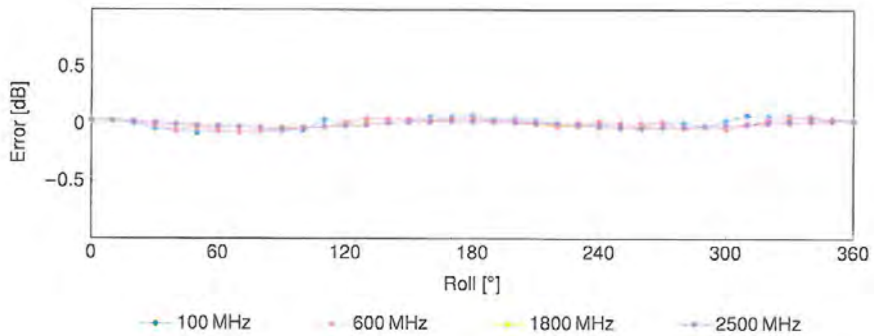
(TEM-Cell:ifi110 EXX, Waveguide:R22)



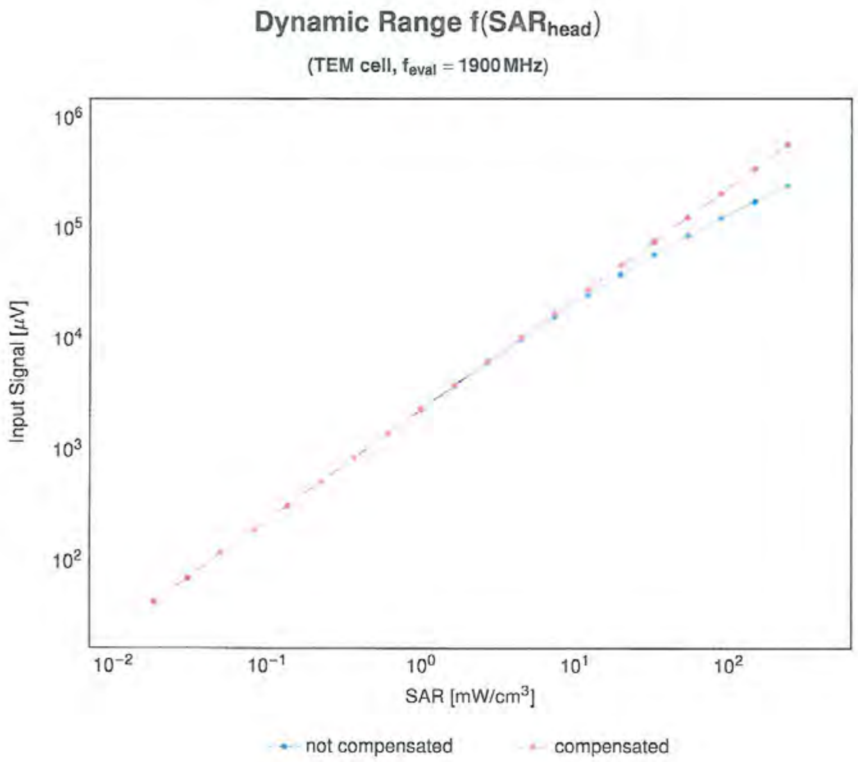
Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

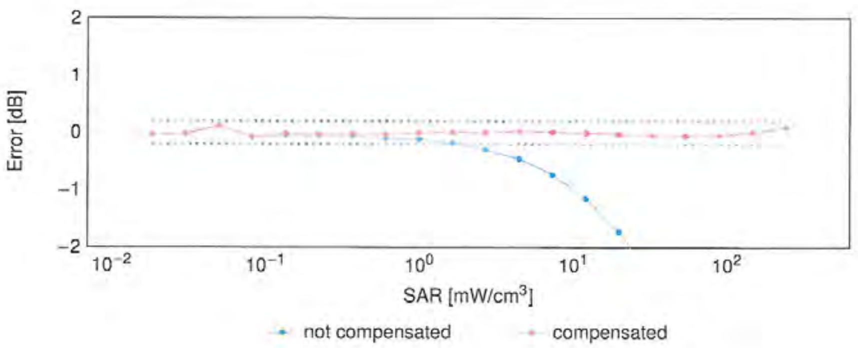
Receiving Pattern (ϕ), $\vartheta = 0°$





Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

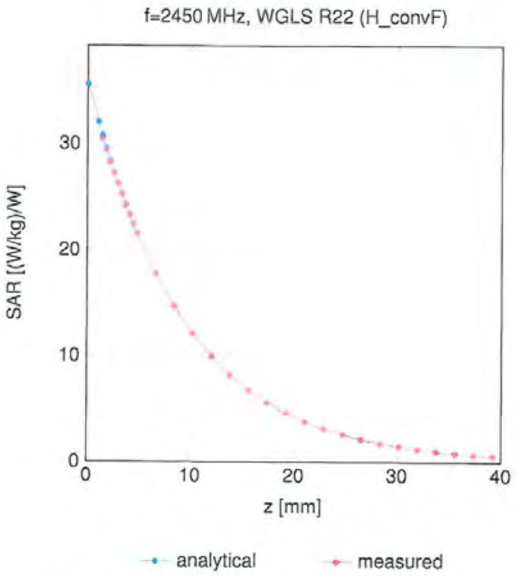




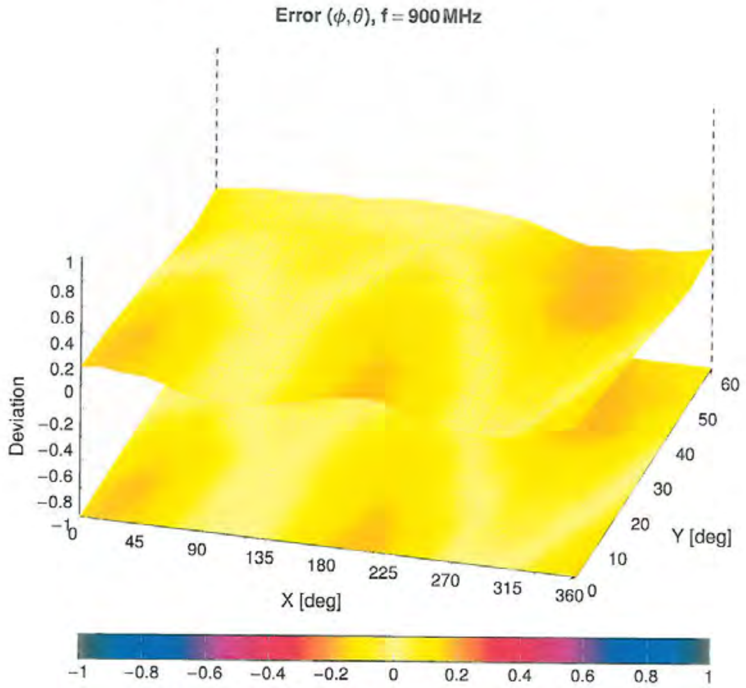
Uncertainty of Linearity Assessment: ±0.6% (k=2)

EX3DV4 - SN:3930 July 25, 2022

Conversion Factor Assessment



Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment: ±2.6% (k=2)

APPENDIX B. – Dipole Calibration Data

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Accreditation No.: **SCS 0108**

Client **DT&C (Dymstec)**

Certificate No: **D900V2-1d175_May22**

CALIBRATION CERTIFICATE

Object	D900V2 - SN:1d175
Calibration procedure(s)	QA CAL-05.v11 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz
Calibration date:	May 30, 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	02-May-22 (No. DAE4-601_May22)	May-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:	Joanna Lleshaj	Laboratory Technician	
Approved by:	Sven Kühn	Technical Manager	

Issued: June 2, 2022

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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	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	900 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.5	0.97 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.5 ± 6 %	0.94 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.70 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**11.0 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.72 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**6.98 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	55.0	1.05 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	53.8 ± 6 %	1.00 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.72 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**11.2 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.78 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**7.30 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	52.8 Ω + 0.2 jΩ
Return Loss	- 31.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.5 Ω - 3.4 jΩ
Return Loss	- 27.3 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.414 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: 27.05.2022

Test Laboratory: SPEAG, Zurich, Switzerland

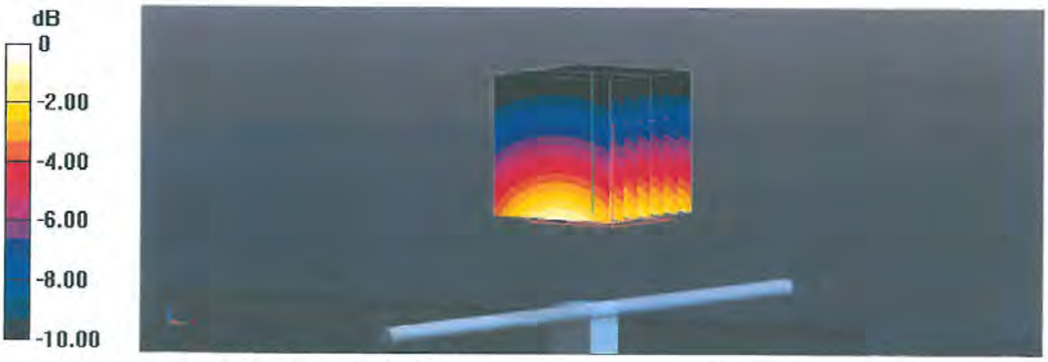
DUT: Dipole 900 MHz; Type: D900V2; Serial: D900V2 - SN:1d175

Communication System: UID 0 - CW; Frequency: 900 MHz
Medium parameters used: f = 900 MHz; $\sigma = 0.94$ S/m; $\varepsilon_r = 40.5$; $\rho = 1000$ kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

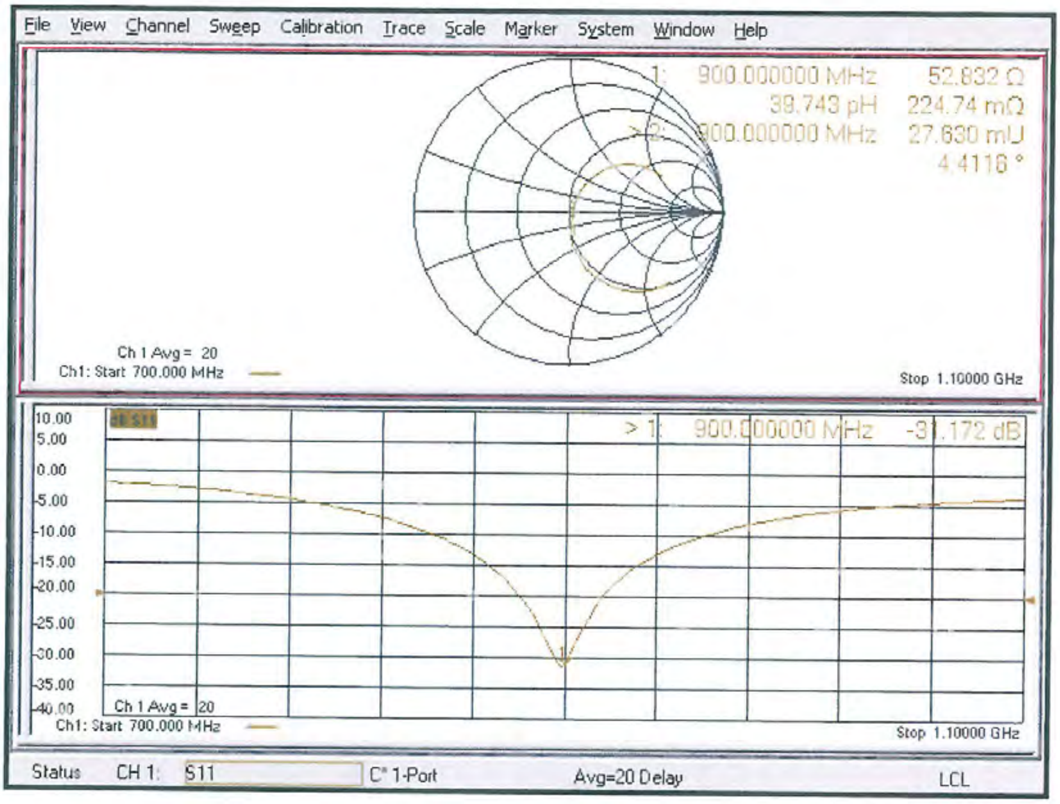
- Probe: EX3DV4 - SN7349; ConvF(9.62, 9.62, 9.62) @ 900 MHz; Calibrated: 31.12.2021
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.05.2022
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 65.40 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 4.19 W/kg
SAR(1 g) = 2.7 W/kg; SAR(10 g) = 1.72 W/kg
Smallest distance from peaks to all points 3 dB below = 16 mm
Ratio of SAR at M2 to SAR at M1 = 64.7%
Maximum value of SAR (measured) = 3.64 W/kg



0 dB = 3.64 W/kg = 5.61 dBW/kg

Impedance Measurement Plot for Head TSL



Certificate No: D900V2-1d175_May22 Page 6 of 8

DASY5 Validation Report for Body TSL

Date: 30.05.2022

Test Laboratory: SPEAG, Zurich, Switzerland

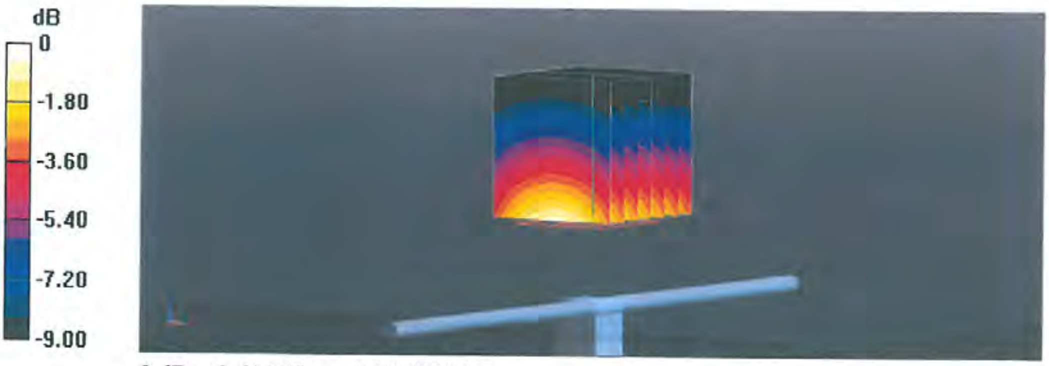
DUT: Dipole 900 MHz; Type: D900V2; Serial: D900V2 - SN:1d052

Communication System: UID 0 - CW; Frequency: 900 MHz
Medium parameters used: f = 900 MHz; σ = 1 S/m; ε_r = 53.8; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.81, 9.81, 9.81) @ 900 MHz; Calibrated: 31.12.2021
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.05.2022
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

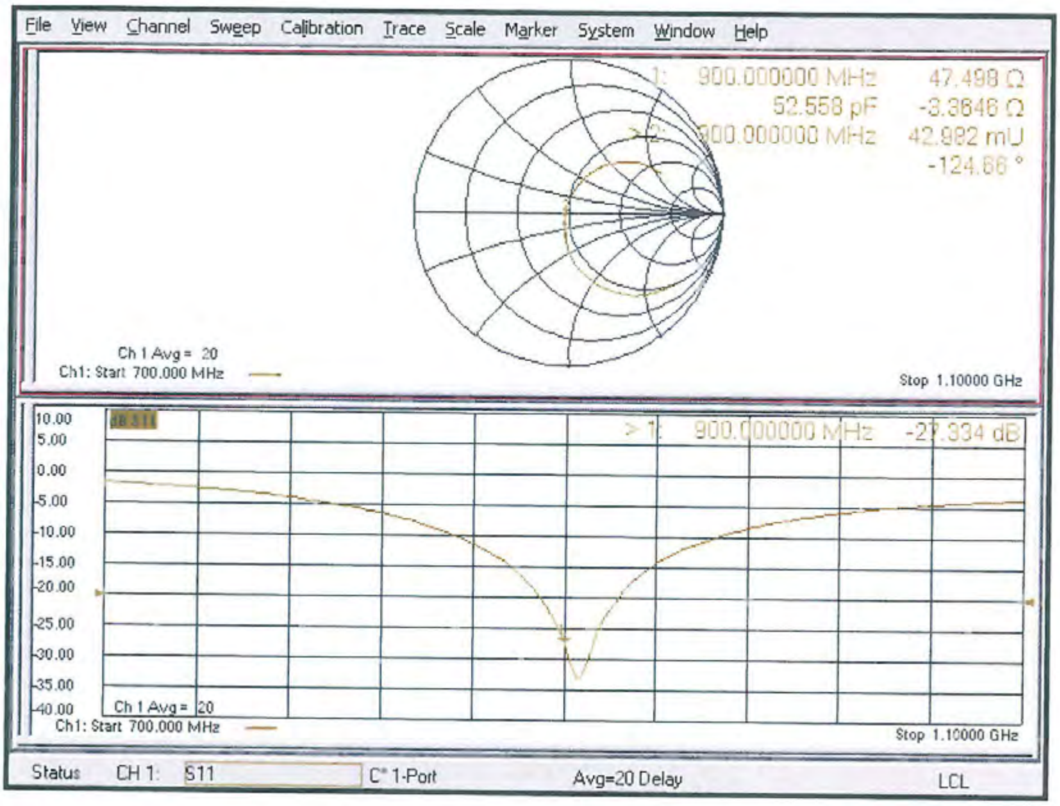
Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 61.75 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 4.04 W/kg
SAR(1 g) = 2.72 W/kg; SAR(10 g) = 1.78 W/kg
Smallest distance from peaks to all points 3 dB below = 16 mm
Ratio of SAR at M2 to SAR at M1 = 67.4%
Maximum value of SAR (measured) = 3.61 W/kg



0 dB = 3.61 W/kg = 5.58 dBW/kg

Certificate No: D900V2-1d175_May22 Page 7 of 8

Impedance Measurement Plot for Body TSL



Certificate No: D900V2-1d175_May22 Page 8 of 8

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Accreditation No.: **SCS 0108**

Client **DT&C (Dymstec)**

Certificate No: **D2450V2-920_Aug22**

CALIBRATION CERTIFICATE

Object	D2450V2 - SN:920
Calibration procedure(s)	QA CAL-05.v11 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz
Calibration date:	August 18, 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	02-May-22 (No. DAE4-601_May22)	May-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:	Jeffrey Katzman	Laboratory Technician	
Approved by:	Sven Kühn	Technical Manager	

Issued: August 22, 2022

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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	38.0 ± 6 %	1.85 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.5 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**52.9 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.26 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**24.7 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	51.2 ± 6 %	2.04 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	12.9 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**50.2 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.04 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**23.8 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	55.4 Ω + 2.2 jΩ
Return Loss	- 25.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	51.3 Ω + 4.9 jΩ
Return Loss	- 25.9 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.154 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: 18.08.2022

Test Laboratory: SPEAG, Zurich, Switzerland

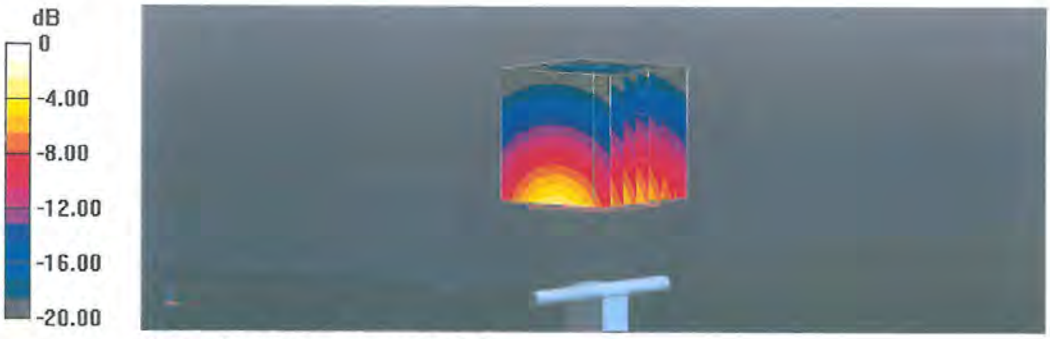
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:920

Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 1.85 S/m; ε_r = 38; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

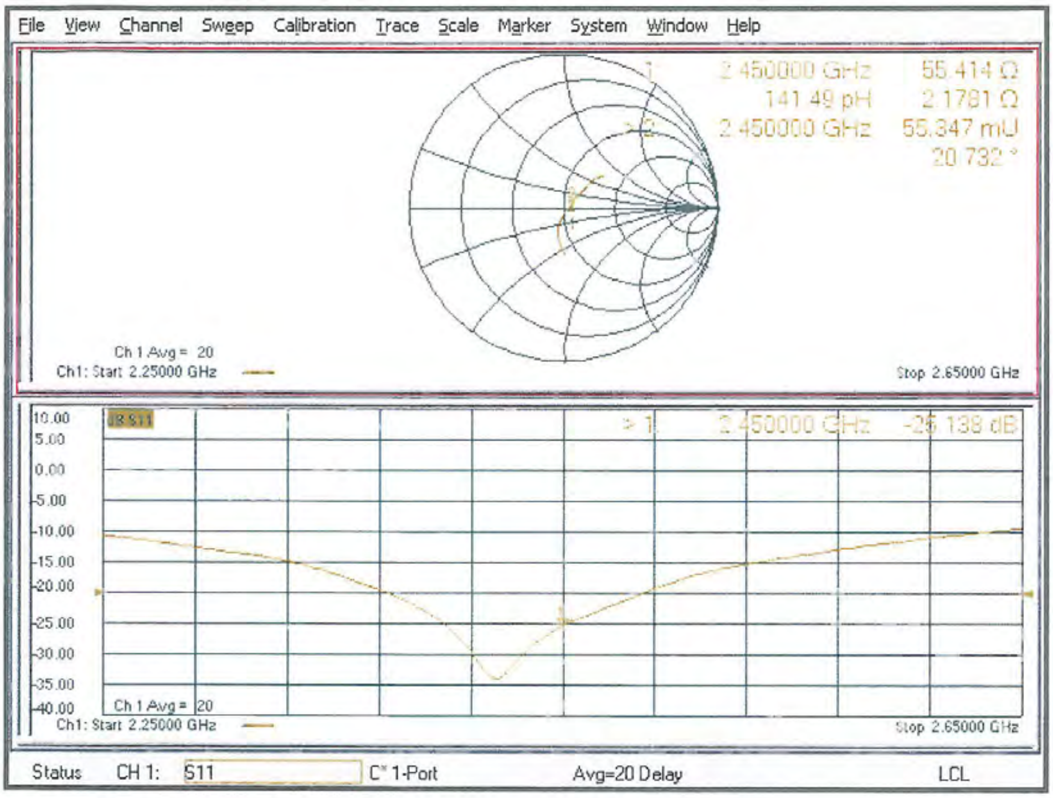
- Probe: EX3DV4 - SN7349; ConvF(7.96, 7.96, 7.96) @ 2450 MHz; Calibrated: 31.12.2021
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.05.2022
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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 = 117.1 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 26.8 W/kg
SAR(1 g) = 13.5 W/kg; SAR(10 g) = 6.26 W/kg
Smallest distance from peaks to all points 3 dB below = 9 mm
Ratio of SAR at M2 to SAR at M1 = 50.4%
Maximum value of SAR (measured) = 22.3 W/kg



0 dB = 22.3 W/kg = 13.48 dBW/kg

Impedance Measurement Plot for Head TSL



Certificate No: D2450V2-920_Aug22 Page 6 of 8

DASY5 Validation Report for Body TSL

Date: 18.08.2022

Test Laboratory: SPEAG, Zurich, Switzerland

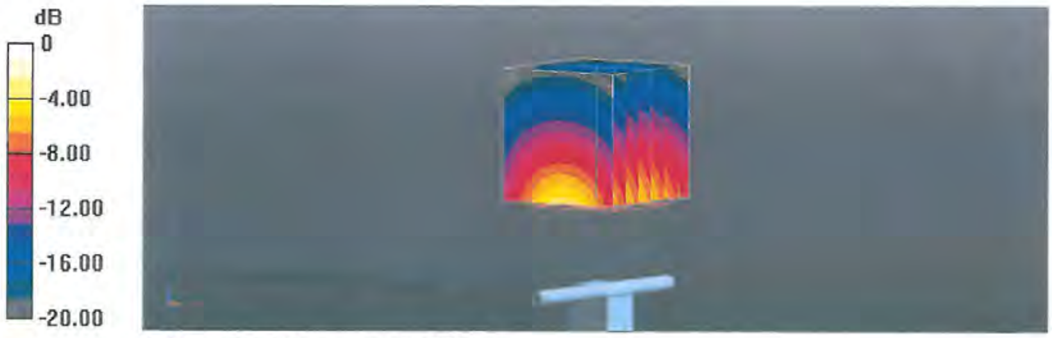
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:920

Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 2.04 S/m; ε_r = 51.2; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

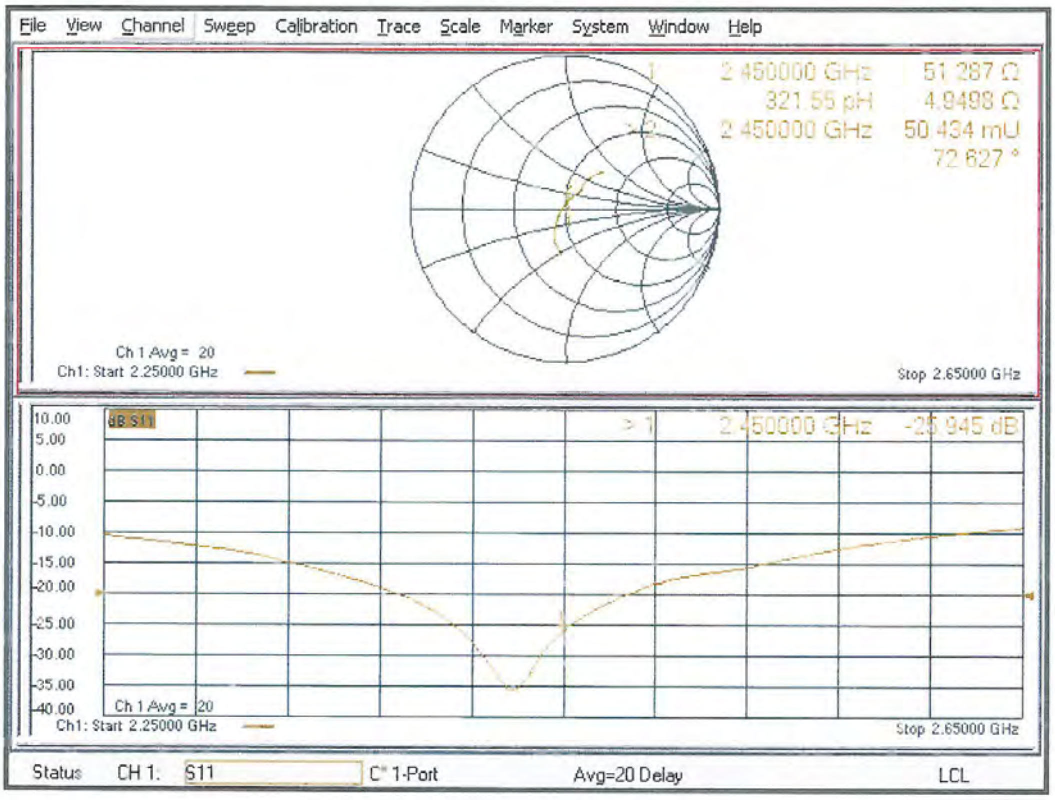
- Probe: EX3DV4 - SN7349; ConvF(8.12, 8.12, 8.12) @ 2450 MHz; Calibrated: 31.12.2021
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.05.2022
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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 = 108.1 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 24.3 W/kg
SAR(1 g) = 12.9 W/kg; SAR(10 g) = 6.04 W/kg
Smallest distance from peaks to all points 3 dB below = 8.9 mm
Ratio of SAR at M2 to SAR at M1 = 54%
Maximum value of SAR (measured) = 20.5 W/kg



0 dB = 20.5 W/kg = 13.12 dBW/kg

Impedance Measurement Plot for Body TSL



Certificate No: D2450V2-920_Aug22 Page 8 of 8

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Accreditation No.: SCS 0108

Client **DT&C (Dymstec)**

Certificate No: D5GHzV2-1103_Jan23

CALIBRATION CERTIFICATE

Object	D5GHzV2 - SN:1103
Calibration procedure(s)	QA CAL-22.v7 Calibration Procedure for SAR Validation Sources between 3-10 GHz
Calibration date:	January 25, 2023

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: 3503	08-Mar-22 (No. EX3-3503_Mar22)	Mar-23
DAE4	SN: 601	19-Dec-22 (No. DAE4-601_Dec22)	Dec-23

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-22)	In house check: Oct-24
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-22)	In house check: Oct-24
Power sensor HP 8481A	SN: MY41093315	07-Oct-15 (in house check Oct-22)	In house check: Oct-24
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-22)	In house check: Oct-24
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-22)	In house check: Oct-24

	Name	Function	Signature
Calibrated by:	Paulo Pina	Laboratory Technician	
Approved by:	Sven Kühn	Technical Manager	

Issued: January 26, 2023

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

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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 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	5200 MHz ± 1 MHz 5300 MHz ± 1 MHz 5500 MHz ± 1 MHz 5600 MHz ± 1 MHz 5800 MHz ± 1 MHz	

Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.7 ± 6 %	4.58 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5200 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	**80.6 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.8 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.6 ± 6 %	4.72 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.39 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**83.8 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.39 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.8 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.6	4.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.5 ± 6 %	4.95 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5500 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.68 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**86.8 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.45 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**24.5 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 %	5.03 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	8.48 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**84.8 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.39 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.9 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 %	5.18 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	8.17 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**81.6 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.30 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.9 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.0 ± 6 %	5.42 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.39 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**74.0 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.06 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.6 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.42 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.9 ± 6 %	5.59 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5300 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.57 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**75.8 W/kg ± 19.9 % (k=2)**

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

Body TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.6	5.65 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.7 ± 6 %	5.88 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5500 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.87 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**78.9 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.18 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**21.9 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	48.6 ± 6 %	6.00 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	8.00 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**80.2 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.22 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**22.2 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	48.2 ± 6 %	6.24 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	7.42 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**74.3 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)**

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	51.2 Ω - 6.4 jΩ
Return Loss	- 23.9 dB

Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	48.4 Ω - 0.2 jΩ
Return Loss	- 36.0 dB

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	49.7 Ω - 2.0 jΩ
Return Loss	- 34.0 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	55.5 Ω + 0.8 jΩ
Return Loss	- 25.5 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	51.9 Ω + 1.5 jΩ
Return Loss	- 32.4 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	51.4 Ω - 4.5 jΩ
Return Loss	- 26.8 dB

Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	48.5 Ω + 2.1 jΩ
Return Loss	- 31.6 dB

Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	50.4 Ω + 0.1 jΩ
Return Loss	- 46.6 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	56.4 Ω + 4.2 jΩ
Return Loss	- 22.9 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	53.8 Ω + 2.5 jΩ
Return Loss	- 27.2 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.207 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: 25.01.2023

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1103

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 4.58 S/m; ε_r = 35.7; ρ = 1000 kg/m^3
Medium parameters used: f = 5300 MHz; σ = 4.72 S/m; ε_r = 35.6; ρ = 1000 kg/m^3
Medium parameters used: f = 5500 MHz; σ = 4.95 S/m; ε_r = 35.5; ρ = 1000 kg/m^3
Medium parameters used: f = 5600 MHz; σ = 5.03 S/m; ε_r = 35.4; ρ = 1000 kg/m^3
Medium parameters used: f = 5800 MHz; σ = 5.18 S/m; ε_r = 35.1; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.8, 5.8, 5.8) @ 5200 MHz, ConvF(5.49, 5.49, 5.49) @ 5300 MHz, ConvF(5.25, 5.25, 5.25) @ 5500 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.01, 5.01, 5.01) @ 5800 MHz; Calibrated: 08.03.2022
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 19.12.2022
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

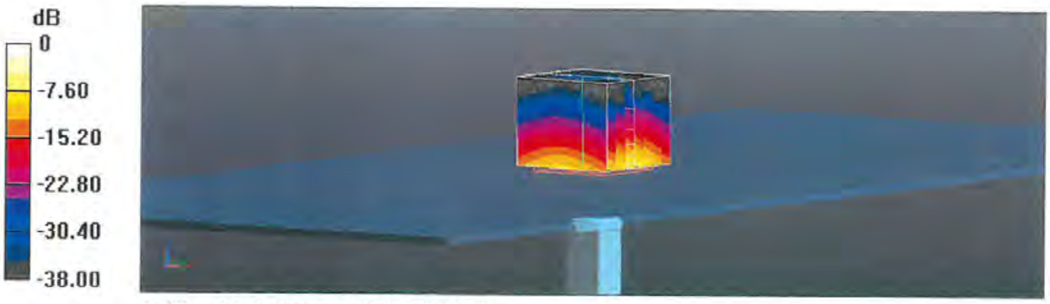
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 74.46 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 28.6 W/kg
SAR(1 g) = 8.08 W/kg; SAR(10 g) = 2.29 W/kg
Smallest distance from peaks to all points 3 dB below = 6.9 mm
Ratio of SAR at M2 to SAR at M1 = 69.2%
Maximum value of SAR (measured) = 18.3 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 75.84 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 29.6 W/kg
SAR(1 g) = 8.39 W/kg; SAR(10 g) = 2.39 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 69.4%
Maximum value of SAR (measured) = 19.1 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 74.72 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 33.3 W/kg
SAR(1 g) = 8.68 W/kg; SAR(10 g) = 2.45 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 66.6%
Maximum value of SAR (measured) = 20.3 W/kg

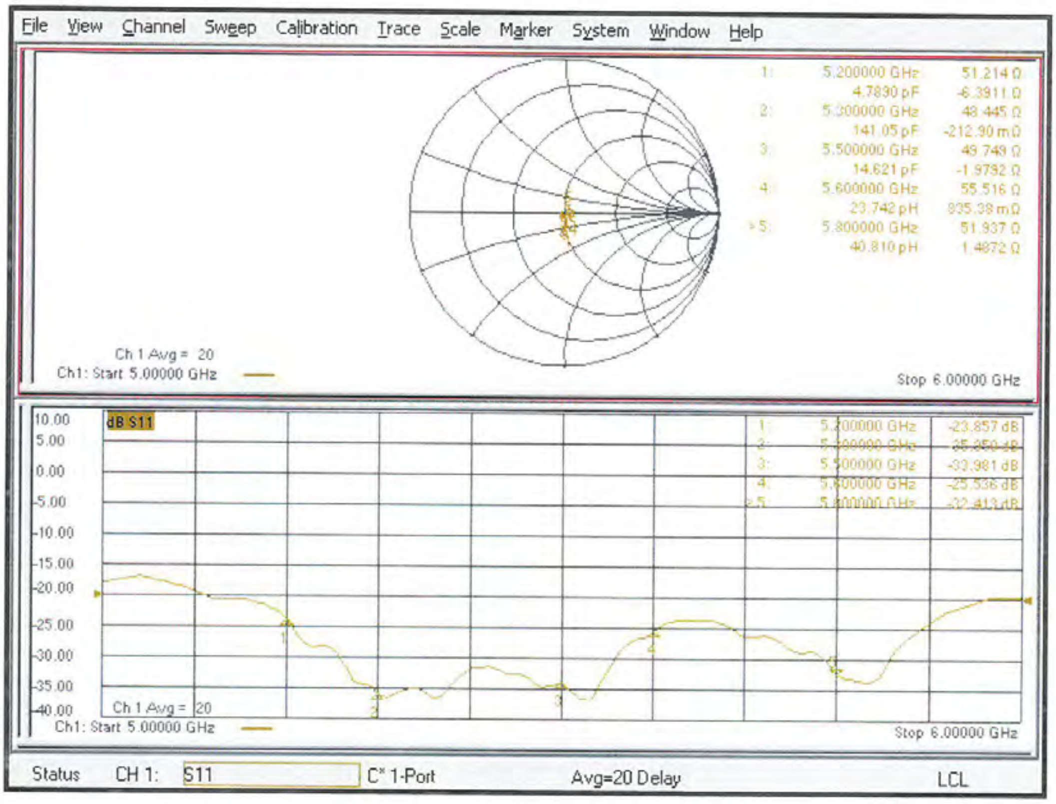
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 76.00 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 31.4 W/kg
SAR(1 g) = 8.48 W/kg; SAR(10 g) = 2.39 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 67.7%
Maximum value of SAR (measured) = 19.7 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 = 72.84 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 32.2 W/kg
SAR(1 g) = 8.17 W/kg; SAR(10 g) = 2.30 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 65.6%
Maximum value of SAR (measured) = 19.3 W/kg



0 dB = 20.3 W/kg = 13.07 dBW/kg

Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL

Date: 18.01.2023

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1103

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 5.42 S/m; ε_r = 49; ρ = 1000 kg/m^3
Medium parameters used: f = 5300 MHz; σ = 5.59 S/m; ε_r = 48.9; ρ = 1000 kg/m^3
Medium parameters used: f = 5500 MHz; σ = 5.88 S/m; ε_r = 48.7; ρ = 1000 kg/m^3
Medium parameters used: f = 5600 MHz; σ = 6 S/m; ε_r = 48.6; ρ = 1000 kg/m^3
Medium parameters used: f = 5800 MHz; σ = 6.24 S/m; ε_r = 48.2; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.29, 5.29, 5.29) @ 5200 MHz, ConvF(5.23, 5.23, 5.23) @ 5300 MHz, ConvF(4.84, 4.84, 4.84) @ 5500 MHz, ConvF(4.79, 4.79, 4.79) @ 5600 MHz, ConvF(4.62, 4.62, 4.62) @ 5800 MHz; Calibrated: 08.03.2022
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 19.12.2022
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

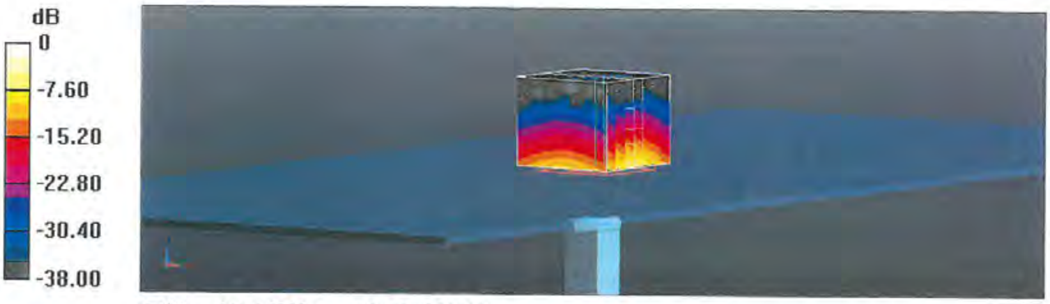
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.29 V/m; Power Drift = -0.08 dB
Peak SAR (extrapolated) = 27.2 W/kg
SAR(1 g) = 7.39 W/kg; SAR(10 g) = 2.06 W/kg
Smallest distance from peaks to all points 3 dB below = 6.8 mm
Ratio of SAR at M2 to SAR at M1 = 68.1%
Maximum value of SAR (measured) = 17.3 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.11 V/m; Power Drift = -0.07 dB
Peak SAR (extrapolated) = 28.8 W/kg
SAR(1 g) = 7.57 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 = 66.9%
Maximum value of SAR (measured) = 17.9 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.78 V/m; Power Drift = -0.08 dB
Peak SAR (extrapolated) = 31.9 W/kg
SAR(1 g) = 7.87 W/kg; SAR(10 g) = 2.18 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%
Maximum value of SAR (measured) = 19.1 W/kg

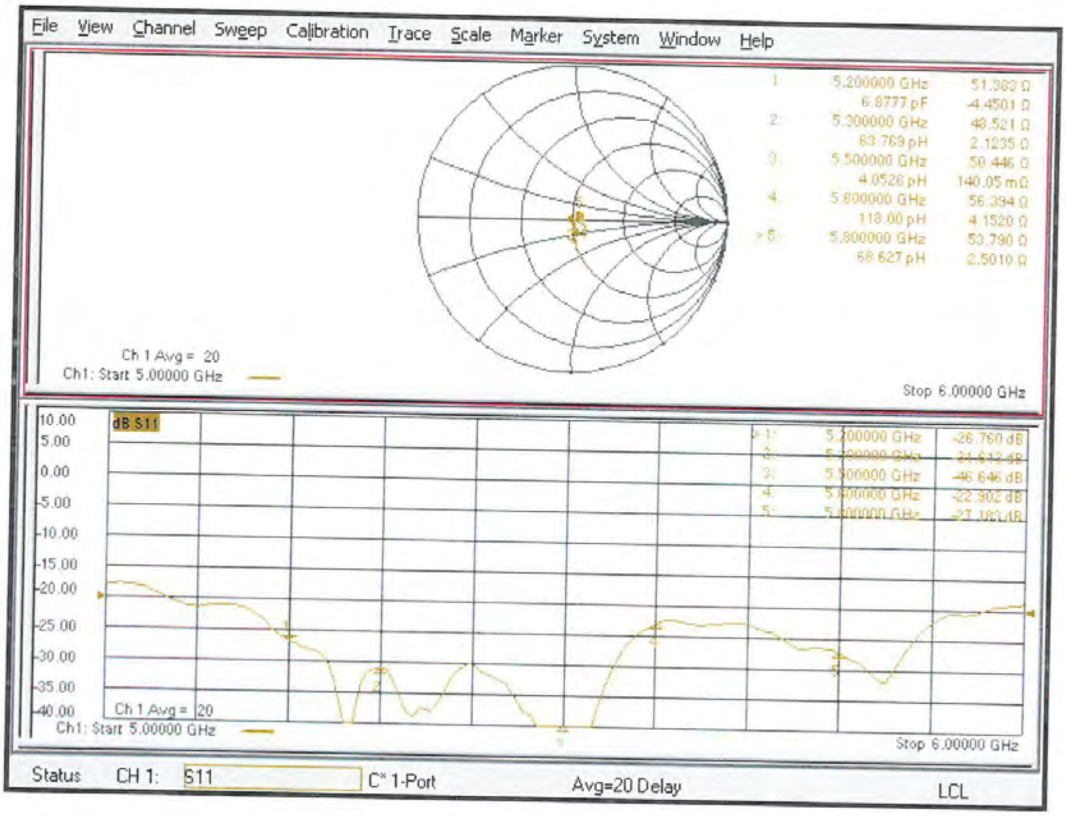
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.97 V/m; Power Drift = -0.09 dB
Peak SAR (extrapolated) = 33.3 W/kg
SAR(1 g) = 8 W/kg; SAR(10 g) = 2.22 W/kg
Smallest distance from 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) = 19.6 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 = 63.41 V/m; Power Drift = -0.08 dB
Peak SAR (extrapolated) = 31.4 W/kg
SAR(1 g) = 7.42 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 = 63.4%
Maximum value of SAR (measured) = 18.4 W/kg



0 dB = 19.6 W/kg = 12.92 dBW/kg

Impedance Measurement Plot for Body TSL



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APPENDIX C. – SAR Tissue Specifications

The brain and muscle mixtures consist of a viscous gel using hydrox-ethylcellulose (HEC) gelling agent and saline solution (see Table 3.1). Preservation with a bactericide is added and visual inspection is made to make sure air bubbles are not trapped during the mixing process. The mixture is calibrated to obtain proper dielectric constant (permittivity) and conductivity of the desired tissue. The mixture characterizations used for the brain and muscle tissue simulating liquids are according to the data by C. Gabriel and G. Harts grove.

Figure 3.9 Simulated Tissue

Table C.1 Composition of the Tissue Equivalent Matter

Ingredients (% by weight)	Frequency (MHz)			
	900	1 900	2 450	5 200 ~ 5 800
Tissue Type	**Head**	**Head**	**Head**	**Head**
Water	41.45	55.24	71.88	65.52
Salt (NaCl)	1.45	0.310	0.160	-
Sugar	56.00	-	-	-
HEC	1.00	-	-	-
Bactericide	0.10	-	-	-
Triton X-100	-	-	19.97	17.24
DGBE	-	44.45	7.990	-
Diethylene glycol hexyl ether	-	-	-	17.24
Polysorbate (Tween) 80	-	-	-	
Target for Dielectric Constant	41.50	40.0	39.2	-
Target for Conductivity (S/m)	0.97	1.40	1.80	-

Salt:	99 % Pure Sodium Chloride	Sugar:	98 % Pure Sucrose
Water:	De-ionized, 16M resistivity	HEC:	Hydroxyethyl Cellulose
DGBE:	99 % Di(ethylene glycol) butyl ether,[2-(2-butoxyethoxy) ethanol]		
Triton X-100(ultra pure):	Polyethylene glycol mono[4-(1,1,3,3-tetramethylbutyl)phenyl] ether		

APPENDIX D. – SAR SYSTEM VALIDATION

SAR System Validation

Per FCC KDB 865664 D02v01r02, SAR system validation status should be documented to confirm measurement accuracy. The SAR systems (including SAR probes, system components and software versions) used for this device were validated against its performance specifications prior to the SAR measurements. Reference dipoles were used with the required tissue- equivalent media for system validation, according to the procedures outlined in FCC KDB 865664 D01v01r04 and IEEE 1528-2013.Since SAR probe calibrations are frequency dependent, each probe calibration point was validated at a frequency within the valid frequency range of the probe calibration point, using the system that normally operates with the probe for routine SAR measurements and according to the required tissue-equivalent media.

A tabulated summary of the system validation status including the validation date(s), measurement frequencies, SAR probes and tissue dielectric parameters has been included.

Table D.1 SAR System Validation Summary

SAR System	Freq. [MHz]	Date	Probe SN	Probe Type	Probe CAL. Point		PERM.	COND.	CW Validation			MOD. Validation		
							(εr)	(σ)	Sensi-tivity	Probe Linearity	Probe Isortopy	MOD. Type	Duty Factor	PAR
E	900	2023.02.14	3327	ES3DV3	900	Head	41.997	1.003	PASS	PASS	PASS	N/A	N/A	N/A
E	2 450	2023.02.16	3327	ES3DV3	2 450	Head	39.867	1.828	PASS	PASS	PASS	OFDM/TDD	PASS	PASS
C	5 200	2022.08.19	3930	EX3DV4	5 200	Head	36.444	4.802	PASS	PASS	PASS	OFDM	N/A	PASS
C	5 300	2022.08.20	3930	EX3DV4	5 300	Head	36.417	4.896	PASS	PASS	PASS	OFDM	N/A	PASS
C	5 500	2022.08.23	3930	EX3DV4	5 500	Head	35.477	5.017	PASS	PASS	PASS	OFDM	N/A	PASS
C	5 600	2022.08.24	3930	EX3DV4	5 600	Head	35.323	5.096	PASS	PASS	PASS	OFDM	N/A	PASS
C	5 800	2022.08.25	3930	EX3DV4	5 800	Head	34.997	5.275	PASS	PASS	PASS	OFDM	N/A	PASS

NOTE: While the probes have been calibrated for both a CW and modulated signals, all measurements were performed using communication systems calibrated for CW signals only. Modulations in the table above represent test configurations for which the measurement system has been validated per FCC KDB Publication 865664 D01v01r04 for scenarios when CW probe calibrations are used with other signal types. SAR systems were validated for modulated signals with a periodic duty cycle, such as GMSK, or with a high peak to average ratio (>5 dB), such as OFDM according to KDB 865664.

APPENDIX E. – Description of Test Equipment

E.1 SAR Measurement Setup

Measurements are performed using the DASY5 automated dosimetric assessment system. The DASY5 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland and consists of high precision robotics system (Staubli), robot controller, desktop computer, near-field probe, probe alignment sensor, and the generic twin phantom containing the brain equivalent material. The robot is a six-axis industrial robot performing precise movements to position the probe to the location (points) of maximum electromagnetic field (EMF) (see Fig. E.1.1).

A cell controller system contains the power supply, robot controller each pendant (Joystick), and a remote control used to drive the robot motors. The PC consists of the Intel Core i7-8 700K 3.70 GHz / i7-3 770 3.40 GHz desktop computer with Windows 7 system and SAR Measurement Software DASY5, A/D interface card, monitor, mouse, and keyboard. The Staubli Robotis connected to the cell controller to allow software manipulation of the robot. A data acquisition electronic (DAE) circuit that performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. is connected to the Electro-optical coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC plug-in card.

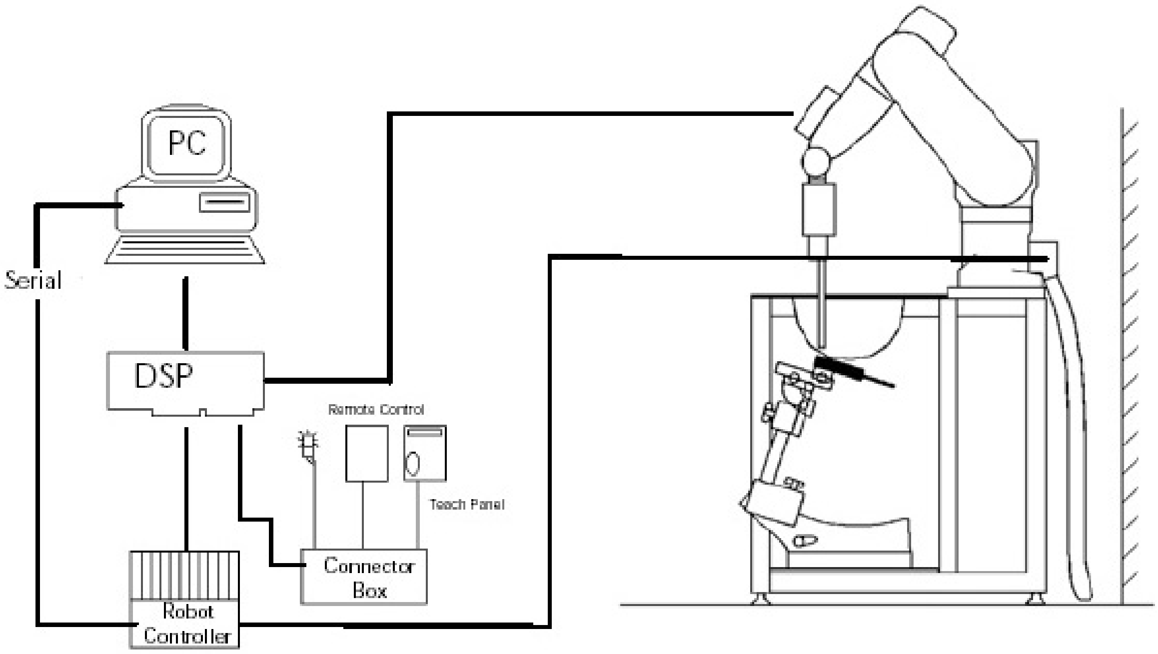


Figure E.1.1 SAR Measurement System Setup

The DAE4 consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the PC-card is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer. The system is described in detail.

E.2 Probe Specification

Frequency	4 MHz to 4 GHz/4 MHz to 10 GHz	
Linearity	±0.2 dB (30 MHz to 4 GHz/30 MHz to 10 GHz)	
Dynamic	10 µW/g to > 100 mW/g	
Range	Linearity :	±0.2 dB
Dimensions	Overall length :	337 mm
Tip length	20 mm	
Body diameter	12 mm	
Tip diameter	3.9 mm/2.5 mm	
Distance from probe tip to sensor center	2.0 mm/1.0 mm	
Application	SAR Dosimetry Testing Compliance tests of mobile phones	

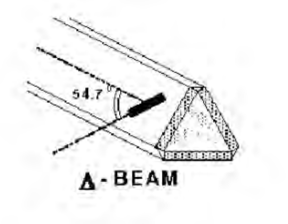
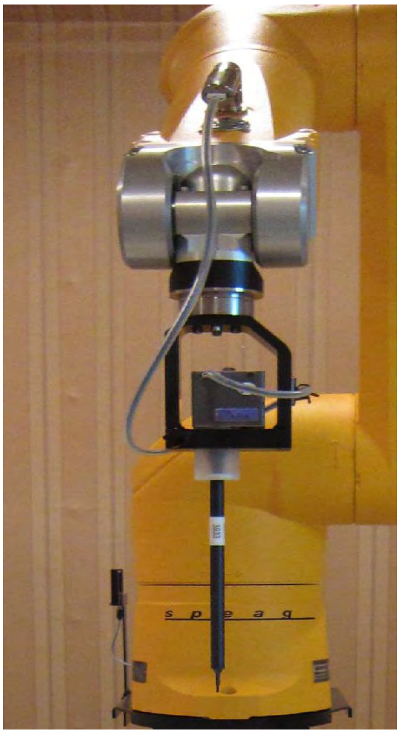


Figure E.2.1 Triangular Probe Configurations

Figure E.2.2 Probe Thick-Film Technique



DAE System

The SAR measurements were conducted with the dosimetric probe ES3DV3 and EX3DV4 designed in the classical triangular configuration(see E.2.1) and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multitier line ending at the front of the probe tip. It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface. Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY5 software reads the reflection during a software approach and looks for the maximum using a 2nd order fitting. The approach is stopped at reaching the maximum.

E.3 E-Probe Calibration Process

Dosimetric Assessment Procedure

Each probe is calibrated according to a dosimetric assessment procedure with accuracy better than ±10 %. The spherical isotropy was evaluated with the procedure and found to be better than ±0.25 dB. The sensitivity parameters (Norm X, Norm Y, Norm Z), the diode compression parameter (DCP) and the conversion factor (Conv F) of the probe is tested.

Free Space Assessment

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies below 1 GHz, and in a waveguide above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity at the proper orientation with the field. The probe is then rotated 360 degrees.

Temperature Assessment *

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

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

where:

Δt = exposure time (30 seconds),

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

ΔT = temperature increase due to RF exposure.

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

where:

σ = simulated tissue conductivity,

ρ = Tissue density (1.25 g/cm^3 for brain tissue)

SAR is proportional to ΔT / Δt , the initial rate of tissue heating, before thermal diffusion takes place. Now it's possible to quantify the electric field in the simulated tissue by equating the thermally derived SAR to the E- field;

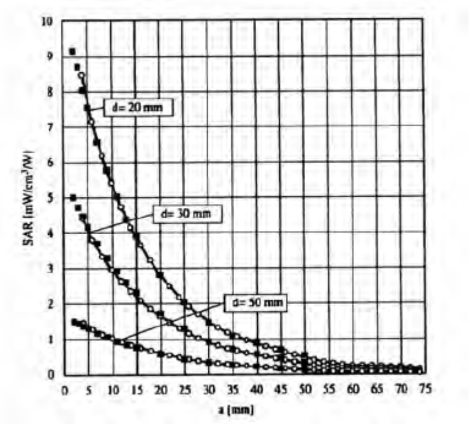


Figure E.3.1 E-Field and Temperature Measurements at 900 MHz

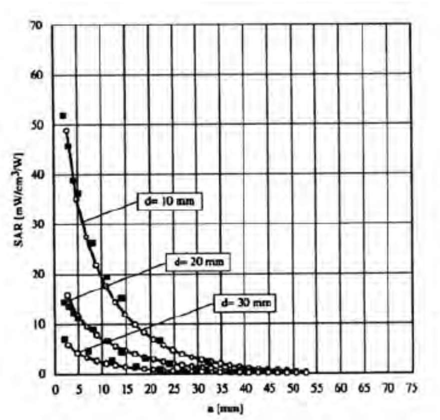


Figure E.3.2 E-Field and Temperature Measurements at 1 800 MHz

E.4 Data Extrapolation

The DASY5 software automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given like below;

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

with V_i = compensated signal of channel i (i=x,y,z)
U_i = input signal of channel i (i=x,y,z)
cf = crest factor of exciting field (DASY parameter)
dcp_i = diode compression point (DASY parameter)

From the compensated input signals the primary field data for each channel can be evaluated:

E-field probes:

$$E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

with V_i = compensated signal of channel i (i = x,y,z)
$Norm_i$ = sensor sensitivity of channel i (i = x,y,z) $\mu V/(V/m)^2$ for E-field probes
ConvF = sensitivity of enhancement in solution
E_i = electric field strength of channel i in V/m

The RSS value of the field components gives the total field strength (Hermetian magnitude):

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

The primary field data are used to calculate the derived field units.

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1000}$$

with SAR = local specific absorption rate in W/g
E_{tot} = total field strength in V/m
σ = conductivity in [mho/m] or [Siemens/m]
ρ = equivalent tissue density in g/cm^3

The power flow density is calculated assuming the excitation field to be a free space field.

$$P_{pwe} = \frac{E_{tot}^2}{3770}$$

with P_{pwe} = equivalent power density of a plane wave in W/cm^2
E_{tot} = total electric field strength in V/m

E.5 SAM Twin Phantom

The SAM Twin Phantom V5.0 is constructed of a fiberglass shell integrated in a wooden table. The shape of the shell is based on data from an anatomical study designed to determine the maximum exposure in at least 90% of all users. 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 the evaporation of the liquid.

Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot. (see Fig. E.5.1)

Figure E.5.1 SAM Twin Phantom

SAM Twin Phantom Specification:

Construction	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. Twin SAM V5.0 has the same shell geometry and is manufactured from the same material as Twin SAM V4.0, but has reinforced top structure.
Shell Thickness	(2.0 ± 0.2) mm
Filling Volume	Approx. 25 liters
Dimensions	Length: 1000 mm Width: 500 mm Height: adjustable feet

Specific Anthropomorphic Mannequin (SAM) Specifications:

The phantom for handset SAR assessment testing is a low-loss dielectric shell, with shape and dimensions derived from the anthropometric data of the 90th percentile adult male head dimensions as tabulated by the US Army. The SAM Twin Phantom shell is bisected along the mid-sagittal plane into right and left halves (see Fig. E.5.2). The perimeter sidewalls of each phantom halves are extended to allow filling with liquid to a depth that is sufficient to minimized reflections from the upper surface. The liquid depth is maintained at a minimum depth of 15cm to minimize reflections from the upper surface.

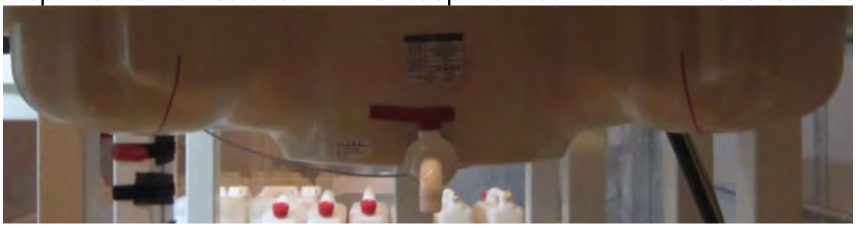


Figure E.5.2 Sam Twin Phantom shell

E.6 Device Holder for Transmitters


Figure E.6.1 Mounting Device

In combination with the Twin SAM Phantom V4.0/V4.0c, V5.0 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).
Note: A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produce infinite number of configurations. To produce the worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.

E.7 Automated Test System Specifications

Positioner

Robot	Stäubli Unimation Corp. Robot Model: TX60L/TX90XL
Repeatability	0.02 mm
No. of axis	6

Data Acquisition Electronic (DAE) System

Cell Controller

Processor	Intel Core i7-8 700K / i7-3 770
Clock Speed	3.70 GHz / 3.40 GHz
Operating System	Window 10 Pro / Windows 7 Professional
Data Card	DASY5 PC-Board

Data Converter

Features	Signal, multiplexer, A/D converter. & control logic
Software	DASY5
Connecting Lines	Optical downlink for data and status info Optical uplink for commands and clock

PC Interface Card

Function	24 bit (64 MHz) DSP for real time processing Link to DAE 4 16 bit A/D converter for surface detection system serial link to robot direct emergency stop output for robot

E-Field Probes

Model	ES3DV3 S/N: 3327 / EX3DV4 S/N: 3930
Construction	Triangular core fiber optic detection system
Frequency	4 MHz to 4 GHz/4 MHz to 10 GHz
Linearity	±0.2 dB (30 MHz to 4 GHz/30 MHz to 10 GHz)

Phantom

Phantom	SAM Twin Phantom (V5.0)
Shell Material	Composite
Thickness	(2.0 ± 0.2) mm

Figure E.7.1 DASY5 Test System