TEST REPORT

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1. Report No : DRRFCC2404-0017(1)

2. Customer

   • Name : KC industrial Co.,Ltd.

   • Address : 19F, 534, Teheran-ro, Gangnam-gu, Seoul South Korea

3. Use of Report : FCC Certification

4. Product Name / Model Name : UHF RFID READER / R-5710

   FCC ID: 2ARHHR5710

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 : 2024.03.26

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 : DongHyeok Gwak	Reviewed by Name : HakMin Kim

2024 . 04 . 25 .

Dt&C Co., Ltd.

Test Report Version

Test Report No.	Date	Description	Tested by	Reviewed by
DRRFCC2404-0017	Apr. 1, 2024	Initial issue	DongHyeok Gwak	HakMin Kim
DRRFCC2404-0017(1)	Apr. 25, 2024	Revise section 1.1	DongHyeok Gwak	HakMin Kim

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1. DESCRIPTION OF DEVICE

1.1 General Information

EUT type	UHF RFID READER
FCC ID	2ARHHR5710
Equipment model name	R-5710
Equipment add model name	N/A
Equipment serial no.	Identical prototype
FCC & ISED MRA Designation No.	KR0034
ISED#	5740A
Mode(s) of Operation	RFID(900 MHz), Bluetooth LE

	Band	Mode	Operating Modes	Bandwidth	Frequency
TX Frequency Range	RFID(900 MHz)	-	Data	-	902.75 ~ 927.25 MHz
	Bluetooth LE	-	Data	-	2402 ~ 2480 MHz
RX Frequency Range	RFID(900 MHz)	-	Data	-	902.75 ~ 927.25 MHz
	Bluetooth LE	-	Data	-	2402 ~ 2480 MHz

Equipment Class	Band	Reported SAR	
		1g SAR (W/kg)	10g SAR (W/kg)
		Body	Extremity
DSS	RFID(900 MHz),	**1.32**	**0.77**
Simultaneous SAR per KDB 690783 D01v01r03		**1.47**	**0.83**

FCC Equipment Class	Part 15 Spread Spectrum Transmitter (DSS)
Date(s) of Tests	2024.03.26
Antenna Type	Internal Antenna
Functions	● Simultaneous transmission between [RFID & BT].
Note	● The device integrates certified Bluetooth LE modules. (FCC ID: SH6MDBT50)

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 SAR Test Exclusions

Per FCC KDB 447498 D01v06, the 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 1.1 SAR exclusion threshold for distances < 50 mm

Mode	Equation	Result	SAR exclusion threshold	Required SAR
Bluetooth LE	[(4.0/5.0) * √2.480]	1.1	3.0	X

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

1.5 Simultaneous Transmission Capabilities

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

1.6 Guidance Applied

- IEEE 1528-2013
- IEC/IEEE 62209-1528
- FCC KDB Publication 447498 D01v06 (General RF Exposure Guidance)
- 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)

1.7 Device Serial Numbers

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

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.

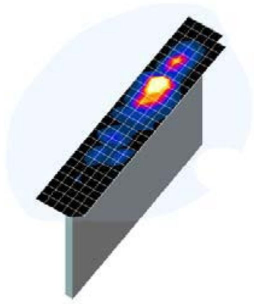

Figure 3.1
Sample SAR Area Scan

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.

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 (1g or 10g) 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.

			≤ 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}			≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 mm
			When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	
Maximum zoom scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}			≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm*	3 – 4 GHz: ≤ 5 mm* 4 – 6 GHz: ≤ 4 mm*
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{Zoom}(n)$		≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm
	graded grid	$\Delta z_{Zoom}(1)$: between 1st two points closest to phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 2 mm
		$\Delta z_{Zoom}(n>1)$: between subsequent points	≤ $1.5\cdot\Delta z_{Zoom}(n-1)$ mm	
Minimum zoom scan volume	x, y, z		≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm

Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see 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 ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.

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. SAR MEASUREMENT PROCEDURES

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 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.

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

- Duty Cycle = On time / (On time + OFF time)
  = 42.788 ms / 152.404 ms
  = 28.08 %

Channel	Frequency(MHz)	Duty Cycle [%]	Crest Factor
1	902.75	28.08	3.561
26	915.25	28.08	3.561
50	927.25	28.08	3.561

5.3 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.

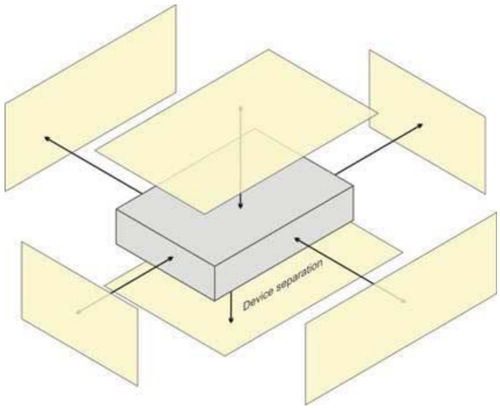

Figure 7.1 Test positions for a generic device

5.4 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 447498D01v06 should be applied to determine SAR test requirements.

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 RFID Nominal and Maximum Output Power Spec and Conducted Powers

Band	Frequency [MHz]	Frame Modulated Average [dBm]	
		Maximum	Nominal
RFID	902.75 ~ 927.25 MHz	23.50	22.50

Table 6.1.1 RFID Nominal and Maximum Output Power Spec (Frame)

Band	Freq. (MHz)	Channel	RFID Frame AVG Conducted Power (dBm)
RFID	902.75	1	23.14
	915.25	26	23.09
	927.25	50	23.42

Table 6.1.2 RFID Frame Average RF Power

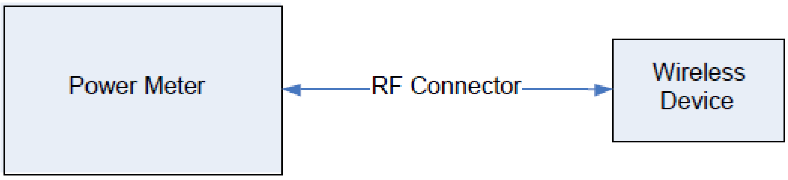

Figure 6.1.1 Power Measurement Setup

6.2 Bluetooth LE Conducted Powers

Burst Modulated Average[dBm]		
Bluetooth LE	Maximum	7.50
	Nominal	6.50

Table 6.2.1 Nominal and Maximum Output Power Spec (Burst)

Frame Modulated Average[dBm]		
Bluetooth (LE) 1 Mbps	Maximum	5.50
	Nominal	4.50
Bluetooth (LE) 2 Mbps	Maximum	2.50
	Nominal	1.50

Table 6.2.2 Nominal and Maximum Output Power Spec (Frame)

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	7.29	5.26	7.19	2.33
Mid	2 440	7.24	5.21	7.13	2.27
High	2 480	7.04	5.01	7.04	2.18

Table 6.2.3 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.
   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.
   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.

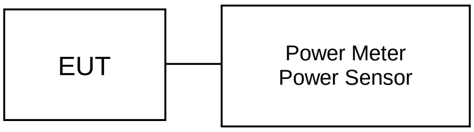

Figure 6.2.1 Average Power Measurement Setup

- **Bluetooth Transmission Plot**

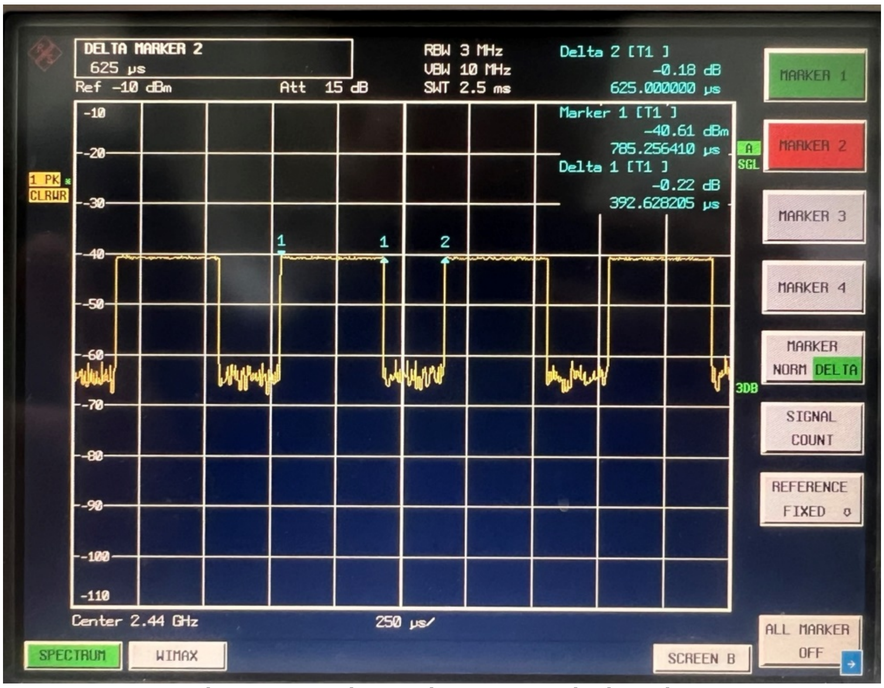

Figure 6.2.2 Bluetooth LE Transmission Plot

- **Bluetooth LE Duty Cycle Calculation**

Duty Cycle = Pulse/Period * 100% = (393/625) * 100 = 62.9 %

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. 26. 2024	900 Head	21.3	21.2	900.00	41.500	0.970	42.076	0.982	1.39	1.24
				902.75	41.496	0.971	41.928	0.983	1.04	1.25
				915.25	41.473	0.976	41.199	0.984	-0.66	0.79
				927.25	41.451	0.981	40.687	0.987	-1.84	0.58

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 (1g)

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_{1g} (W/kg)	Measured SAR_{1g} (W/kg)	1 W Normalized SAR_{1g} (W/kg)	Deviation [%]
A	900	D900V2, SN: 1d146	Mar. 26. 2024	Head	21.3	21.2	3327	250	11.00	2.73	10.92	-0.73

Table 7.2.2 System Verification Results (10g)

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_{10g} (W/kg)	Measured SAR_{10g} (W/kg)	1 W Normalized SAR_{10g} (W/kg)	Deviation [%]
A	900	D900V2, SN: 1d146	Mar. 26. 2024	Head	21.3	21.2	3327	250	7.06	1.82	7.28	3.12

Note(s) :
1. System Verification was measured with input 250 mW and normalized to 1W.
2. Full system validation status and results can be found in Attachment D.

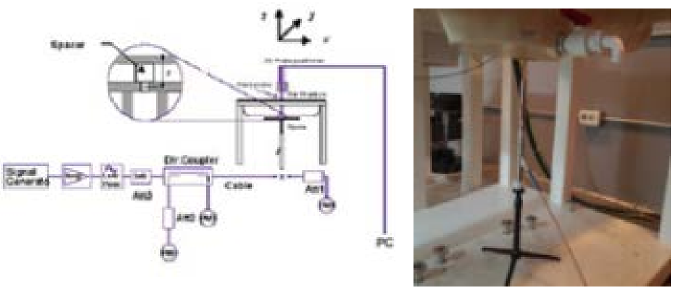

Figure 7.1 Dipole Verification Test Setup Diagram & Photo

8. SAR TEST RESULTS

8.1 SAR Results

Table 8.1.1 RFID Body SAR

MEASUREMENT RESULTS										
FREQUENCY		Mode	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	Phantom Position	Device Serial Number	1g SAR (W/kg)	Scaling Factor	1g Scaled SAR (W/kg)	Plots #
MHz	Ch										
915.25	26	RFID	23.50	23.09	0.060	0 mm [Top]	FCC #1	0.491	1.099	0.540	
915.25	26	RFID	23.50	23.09	-0.020	0 mm [Bottom]	FCC #1	0.454	1.099	0.499	
915.25	26	RFID	23.50	23.09	0.050	0 mm [Front]	FCC #1	0.151	1.099	0.166	
902.75	1	RFID	23.50	23.14	-0.180	0 mm [Rear #1]	FCC #1	0.972	1.086	1.056	
915.25	26	RFID	23.50	23.09	0.130	0 mm [Rear #1]	FCC #1	1.030	1.099	1.132	
927.25	50	RFID	23.50	23.42	-0.010	0 mm [Rear #1]	FCC #1	1.070	1.019	1.090	
902.75	1	RFID	23.50	23.14	-0.170	0 mm [Rear #2]	FCC #1	1.100	1.086	1.195	
915.25	26	RFID	23.50	23.09	-0.190	0 mm [Rear #2]	FCC #1	1.200	1.099	**1.319**	A1
927.25	50	RFID	23.50	23.42	0.190	0 mm [Rear #2]	FCC #1	1.240	1.019	1.264	
915.25	26	RFID	23.50	23.09	0.180	0 mm [Right]	FCC #1	0.565	1.099	0.621	
902.75	1	RFID	23.50	23.14	0.160	0 mm [Left]	FCC #1	0.839	1.086	0.911	
915.25	26	RFID	23.50	23.09	0.100	0 mm [Left]	FCC #1	0.985	1.099	1.083	
927.25	50	RFID	23.50	23.42	0.160	0 mm [Left]	FCC #1	1.020	1.019	1.039	
927.25	50	RFID	23.50	23.42	0.160	0 mm [Rear #2]	FCC #1	1.180	1.019	1.202	
ANSI / IEEE C95.1-1992– SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure							**Body 1.6 W/kg (mW/g) averaged over 1 gram**				

Note: Blue entries represent variability measurements.

Table 8.1.2 RFID Extremity SAR

MEASUREMENT RESULTS											
FREQUENCY		Mode	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	Phantom Position	Device Serial Number	10g SAR (W/kg)	Scaling Factor	10g Scaled SAR (W/kg)	Plots #
MHz	Ch										
915.25	26	RFID	23.50	23.09	0.060	0 mm [Top]	FCC #1	0.315	1.099	0.346	
915.25	26	RFID	23.50	23.09	-0.020	0 mm [Bottom]	FCC #1	0.217	1.099	0.238	
915.25	26	RFID	23.50	23.09	0.050	0 mm [Front]	FCC #1	0.103	1.099	0.113	
915.25	26	RFID	23.50	23.09	0.130	0 mm [Rear #1]	FCC #1	0.615	1.099	0.676	
915.25	26	RFID	23.50	23.09	-0.190	0 mm [Rear #2]	FCC #1	0.698	1.099	**0.767**	A1
915.25	26	RFID	23.50	23.09	0.180	0 mm [Right]	FCC #1	0.365	1.099	0.401	
915.25	26	RFID	23.50	23.09	0.100	0 mm [Left]	FCC #1	0.581	1.099	0.639	
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.

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 physical test configuration is $\leq$ 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 9.2.1 Estimated SAR (Body)

Mode	Frequency	Maximum Allowed Power		Separation Distance	Estimated SAR (Body)
	[MHz]	[dBm]	[mW]	[mm]	[W/kg]
Bluetooth LE	2 480	5.5	4.0	5	0.149

Table 9.2.2 Estimated SAR (Extremity)

Mode	Frequency	Maximum Allowed Power		Separation Distance	Estimated SAR (Extermity)
	[MHz]	[dBm]	[mW]	[mm]	[W/kg]
Bluetooth LE	2480	5.5	4.0	5	0.060

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 9.3.2 Simultaneous SAR Cases

No.	Capable Transmit Configuration	Body SAR	Note
1	RFID + Bluetooth LE	Yes	

9.4 Body & Extremity SAR Simultaneous Transmission Analysis

Table 9.4.1 Simultaneous Transmission Scenario : RFID + Bluetooth LE (Body)

Exposure Condition	Mode	Configuration	RFID SAR (W/kg)	Bluetooth LE SAR (W/kg)	ΣSAR (W/kg)
			1	2	1+2
Body SAR	RFID	Top	0.540	0.149	0.689
		Bottom	0.499	0.149	0.648
		Front	0.166	0.149	0.315
		Rear #1	1.132	0.149	1.281
		Rear #2	1.319	0.149	**1.468**
		Right	0.621	0.149	0.770
		Left	1.083	0.149	1.232

Table 9.4.1Simultaneous Transmission Scenario : RFID +Bluetooth LE(Extremity)

Exposure Condition	Mode	Configuration	RFID SAR (W/kg)	BluetoothLE SAR (W/kg)	ΣSAR(W/kg)
			1	2	1+2
Extremity SAR	RFID	Top	0.346	0.060	0.406
		Bottom	0.238	0.060	0.298
		Front	0.113	0.060	0.173
		Rear #1	0.676	0.060	0.736
		Rear #2	0.767	0.060	**0.827**
		Right	0.401	0.060	0.461
		Left	0.639	0.060	0.699

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.

Table 10.2 Body SAR Measurement Variability Results

Frequency		Mode	Service	# of Time Slots	Phantom Position	Measured SAR (1 g)	1st Repeated SAR (1 g)	Ratio	2nd Repeated SAR(1g)	Ratio	3rd Repeated SAR(1g)	Ratio
MHz	Ch.					(W/kg)	(W/kg)		(W/kg)		(W/kg)	
927.25	50	RFID	-	-	Rear #2	1.240	1.180	1.05	-	-	-	-
ANSI / IEEE C95.1-1992– SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure							Body 1.6 W/kg (mW/g) averaged over 1 gram					

10.2 Measurement Uncertainty

The measured SAR was < 1.5 W/kg for 1g and < 3.75 W/kg for 10g 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
☒	Robot	SPEAG	TX60L	N/A	N/A	F12/5LP5A1/A/01
☒	Robot Controller	SPEAG	CS8C	N/A	N/A	F12/5LP5A1/C/01
☒	Joystick	SPEAG	N/A	N/A	N/A	S-12030401
☒	Intel Xeon W-2 255 3.70 GHz Windows 10 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
☒	Device Holder	SPEAG	SD000H01KA	N/A	N/A	N/A
☒	Twin SAM Phantom	SPEAG	QD000P40CD	N/A	N/A	1679
☒	Data Acquisition Electronics	SPEAG	DAE3V1	2023-11-17	2024-11-17	520
☒	Dosimetric E-Field Probe	SPEAG	ES3DV3	2024-01-22	2025-01-22	3327
☒	900 MHz SAR Dipole	SPEAG	D900V2	2023-04-26	2025-04-26	1d146
☒	Signal Generator	Agilent	E4438C	2023-06-23	2024-06-23	US41461520
☒	High Power RF Amplifier	EMPOWER	BBS3Q8CCJ	2023-06-23	2024-06-23	1005
☒	Power Meter	H/P	EPM-442A	2023-12-15	2024-12-15	GB37170267
☒	Power Meter	Anritsu	ML2495A	2023-12-15	2024-12-15	1435003
☒	Power Sensor	Anritsu	MA2472A	2023-12-15	2024-12-15	003861
☒	Power Sensor	H/P	8481A	2023-12-15	2024-12-15	2702A65976
☒	Power Sensor	H/P	8481A	2023-12-15	2024-12-15	2702A61707
☒	Dual Directional Coupler	Agilent	778D-012	2023-12-15	2024-12-15	50228
☒	Low Pass Filter 1.5 GHz	MICROLAB	LA-15N	2023-06-23	2024-06-23	2
☒	Attenuators	Saluki	3.5TS2-3dB-26.5G	2023-06-23	2024-06-23	21090703
☒	Attenuators (10 dB)	WEINSCHEL	23-10-34	2023-12-15	2024-12-15	BP4387
☒	Attenuators (30 dB)	Mini Circuits	BW-N10W20+	2023-12-15	2024-12-15	2211
☒	Dielectric Probe kit	SPEAG	DAK-3.5	2023-07-17	2024-07-17	1046
		SPEAG	R140	2023-07-31	2024-07-31	0101213

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 MHz Head

Error Description	Uncertainty value ±%	Probability Distribution	Divisor	(Ci) 1 g	(Ci) 10 g	Standard 1 g (± %)	Standard 10 g (± %)	vi 2 or Veff
Measurement System								
Probe calibration	6.0	Normal	1	1	1	6.0	6.0	∞
Axial isotropy	4.7	Rectangular	√3	1	1	2.7	2.7	∞
Hemispherical isotropy	9.6	Rectangular	√3	1	1	5.5	5.5	∞
Boundary Effects	0.8	Rectangular	√3	1	1	0.46	0.46	∞
Probe Linearity	4.7	Rectangular	√3	1	1	2.7	2.7	∞
Probe modulation response	2.4	Rectangular	√3	1	1	1.4	1.4	∞
Detection limits	0.3	Rectangular	√3	1	1	0.14	0.14	∞
Readout Electronics	1.0	Normal	1	1	1	1.0	1.0	∞
Response time	0.8	Rectangular	√3	1	1	0.46	0.46	∞
Integration time	2.6	Rectangular	√3	1	1	1.5	1.5	∞
RF Ambient Conditions – Noise	3.0	Rectangular	√3	1	1	1.7	1.7	∞
RF Ambient Conditions – Reflections	3.0	Rectangular	√3	1	1	1.7	1.7	∞
Probe Positioner	0.4	Rectangular	√3	1	1	0.23	0.23	∞
Probe Positioning	2.9	Rectangular	√3	1	1	1.7	1.7	∞
Spatial x-y-Resolution	10.0	Rectangular	√3	1	1	5.8	5.8	∞
Fast SAR z-Approximation	7.0	Rectangular	√3	1	1	4.0	4.0	∞
Test Sample Related								
Device Positioning	3.3	Normal	1	1	1	3.3	3.3	∞
Device Holder	2.4	Normal	1	1	1	2.4	2.4	∞
Power Drift	5.0	Rectangular	√3	1	1	2.9	2.9	∞
SAR Scaling	2.0	Rectangular	√3	1	1	1.2	1.2	∞
Physical Parameters								
Phantom Shell	7.6	Rectangular	√3	1	1	4.4	4.4	∞
Liquid conductivity (Target)	5.0	Rectangular	√3	0.64	0.43	1.8	1.2	∞
Liquid conductivity (Meas.)	3.3	Normal	1	0.78	0.71	2.6	2.3	∞
Liquid permittivity (Target)	5.0	Rectangular	√3	0.60	0.49	1.7	1.4	∞
Liquid permittivity (Meas.)	3.2	Normal	1	0.23	0.26	0.74	0.8	∞
Temp. unc. - Conductivity	2.0	Rectangular	√3	0.78	0.71	0.90	0.82	∞
Temp. unc. - Permittivity	2.0	Rectangular	√3	0.23	0.26	0.27	0.30	∞
Combined Standard Uncertainty						**14**	**14**	
Expanded Uncertainty (k=2)						**28**	**28**	

$U(1\ g) = k \cdot u_c$
= 2 · 14 %
= 28 % (The confidence level is about 95 % $k = 2$)
$U(10\ g) = k \cdot u_c$
= 2 · 14 %
= 28 % (The confidence level is about 95 % $k = 2$)

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

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

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

Accreditation No.: **SCS 0108**

Client	**Dt&C** **Gyeonggi-do, Republic of Korea**	**Certificate No.**	**ES-3327_Jan24**

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, 2024

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP2	SN: 104778	30-Mar-23 (No. 217-03804/03805)	Mar-24
Power sensor NRP-Z91	SN: 103244	30-Mar-23 (No. 217-03804)	Mar-24
OCP DAK-3.5 (weighted)	SN: 1249	05-Oct-23 (OCP-DAK3.5-1249_Oct23)	Oct-24
OCP DAK-12	SN: 1016	05-Oct-23 (OCP-DAK12-1016_Oct23)	Oct-24
Reference 20 dB Attenuator	SN: CC2552 (20x)	30-Mar-23 (No. 217-03809)	Mar-24
DAE4	SN: 660	16-Mar-23 (No. DAE4-660_Mar23)	Mar-24
Reference Probe EX3DV4	SN: 7349	03-Nov-23 (No. EX3-7349_Nov23)	Nov-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 22, 2024

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).

ES3DV3 - SN:3327 January 22, 2024

Parameters of Probe: ES3DV3 - SN:3327

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm (μV/(V/m)^2) A	1.12	1.14	1.08	±10.1%
DCP (mV) B	105.0	104.8	106.1	±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	146.5	±0.7%	±4.7%
		Y	0.00	0.00	1.00		129.3		
		Z	0.00	0.00	1.00		146.1		
10352	Pulse Waveform (200Hz, 10%)	X	20.00	93.91	25.00	10.00	60.0	±1.2%	±9.6%
		Y	20.00	93.87	25.04		60.0		
		Z	20.00	94.07	24.01		60.0		
10353	Pulse Waveform (200Hz, 20%)	X	20.00	93.80	23.47	6.99	80.0	±1.0%	±9.6%
		Y	20.00	93.79	23.49		80.0		
		Z	20.00	94.21	22.83		80.0		
10354	Pulse Waveform (200Hz, 40%)	X	20.00	95.60	22.63	3.98	95.0	±1.4%	±9.6%
		Y	20.00	95.20	22.42		95.0		
		Z	20.00	96.60	22.47		95.0		
10355	Pulse Waveform (200Hz, 60%)	X	20.00	99.33	22.93	2.22	120.0	±1.6%	±9.6%
		Y	20.00	97.94	22.20		120.0		
		Z	20.00	100.62	22.99		120.0		
10387	QPSK Waveform, 1 MHz	X	1.75	66.61	15.25	1.00	150.0	±2.2%	±9.6%
		Y	1.60	65.03	14.21		150.0		
		Z	1.62	65.91	14.64		150.0		
10388	QPSK Waveform, 10 MHz	X	2.33	68.67	15.98	0.00	150.0	±1.2%	±9.6%
		Y	2.10	66.86	14.90		150.0		
		Z	2.14	67.50	15.35		150.0		
10396	64-QAM Waveform, 100 kHz	X	3.25	72.08	19.55	3.01	150.0	±0.7%	±9.6%
		Y	3.12	71.24	19.00		150.0		
		Z	3.16	72.81	19.87		150.0		
10399	64-QAM Waveform, 40 MHz	X	3.45	66.91	15.62	0.00	150.0	±1.4%	±9.6%
		Y	3.46	66.80	15.41		150.0		
		Z	3.47	67.05	15.61		150.0		
10414	WLAN CCDF, 64-QAM, 40 MHz	X	4.80	65.44	15.36	0.00	150.0	±2.9%	±9.6%
		Y	4.67	64.92	15.00		150.0		
		Z	4.64	65.09	15.12		150.0		

Note: For details on UID parameters see Appendix

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

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

Sensor Model Parameters

	C1 fF	C2 fF	α V^{-1}	T1 $ms V^{-2}$	T2 $ms V^{-1}$	T3 ms	T4 V^{-2}	T5 V^{-1}	T6
x	48.5	341.24	34.11	27.80	1.82	5.10	1.05	0.29	1.01
y	48.0	338.33	34.09	27.67	1.88	5.10	1.36	0.24	1.01
z	43.3	302.70	33.69	23.96	0.98	5.10	1.94	0.04	1.01

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-38.6°
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	6.22	5.92	5.82	0.33	2.18	±12.0%
835	41.5	0.90	6.23	5.83	5.77	0.32	2.18	±12.0%
900	41.5	0.97	6.09	5.85	5.74	0.32	2.18	±12.0%
1750	40.1	1.37	5.65	5.42	5.24	0.21	2.38	±12.0%
1900	40.0	1.40	5.47	5.25	5.09	0.38	1.91	±12.0%
2450	39.2	1.80	4.96	4.76	4.64	0.27	2.19	±12.0%
2600	39.0	1.96	4.89	4.68	4.58	0.35	1.82	±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.