

3 SAR Test Equipment List

To simplify the identification of the test equipment and/or ancillaries which were used, the reporting of the relevant test cases only refer to the test item number as specified in the table below.

	Manufacturer	Device Type	Type(Model)	Serial number	Date of last calibration	Valid period
☐	SPEAG	E-Field Probe	EX3DV4	7328	2026-05-18	One year
☒	SPEAG	E-Field Probe	EX3DV4	7769	2026-04-08	One year
☐	SPEAG	835 MHz Dipole	D835V2	4d193	2024-01-17	Three years
☐	SPEAG	1750 MHz Dipole	D1750V2	1134	2024-01-17	Three years
☐	SPEAG	1900 MHz Dipole	D1900V2	5d198	2024-01-18	Three years
☐	SPEAG	2000 MHz Dipole	D2000V2	1078	2024-01-22	Three years
☐	SPEAG	2300 MHz Dipole	D2300V2	1082	2026-01-04	Three years
☒	SPEAG	2450 MHz Dipole	D2450V2	959	2024-01-17	Three years
☐	SPEAG	2600 MHz Dipole	D2600V2	1101	2024-01-22	Three years
☐	SPEAG	5 GHz Dipole	D5GHzV2	1208	2024-01-16	Three years
☒	SPEAG	DAKS Probe	DAKS-3.5	1052	2024-04-22	Three years
☒	SPEAG	Planar R140 Vector Reflectometer	DAKS-VNA R140	0200514	2024-04-22	Three years
☒	SPEAG	Data acquisition electronics	DAE4	1458	2026-01-12	One year
☒	SPEAG	Software	DASY 5	NA	NCR	NCR
☒	SPEAG	Twin Phantom	SAM V5.0	1875	NCR	NCR
☐	SPEAG	Flat Phantom	ELI V6.0	2024	NCR	NCR
☒	Liquid	Head Liquid	2450 Head	2450	/	/
☐	Liquid	Head Liquid	5200 Head	5250	/	/
☐	Liquid	Head Liquid	5600 Head	5600	/	/
☒	Liquid	Head Liquid	5800 Head	5750	/	/
☐	R & S	Universal Radio Communication Tester	CMW500	102898	2025-11-25	One year
☒	Agilent	Signal Generator	N5181A	MY50142334	2025-11-13	One year
☒	BONN	Power Amplifier and directional coupler	SU319W	BL-SZ1550140	2025-11-25	One year
☒	KEITHLEY	RF Power Meter	3500	1128079	2026-05-29	One year
☒	KEITHLEY	RF Power Meter	3500	1128081	2026-05-29	One year
☒	JINGCHUAN G	Temperature/ Humidity Indicator	GSP-8	EMK197F0009 5	2026-05-22	One year

Note:

- 1) Per KDB865664D01 requirements for dipole calibration, the test laboratory has adopted three-year extended calibration interval. Each measured dipole is expected to evaluate with the following criteria at least on annual interval in Appendix C.
 - a) There is no physical damage on the dipole;
 - b) System check with specific dipole is within 10% of calibrated value;
 - c) The most recent return-loss result, measured at least annually, deviates by no more than 20% from the previous measurement.

- d) The most recent measurement of the real or imaginary parts of the impedance, measured at least annually is within 5Ω from the previous measurement.

4 SAR Measurement Procedures

4.1 Spatial Peak SAR Evaluation

The DASY5 software includes all numerical Procedures necessary to evaluate the spatial peak SAR values. The base for the evaluation is a "cube" measurement in a volume of 30mm^3 ($7 \times 7 \times 7$ points). The measured volume must include the 1 g and 10 g cubes with the highest averaged SAR values. For that purpose, the center of the measured volume is aligned to the interpolated peak SAR value of a previously performed area scan. If the 10g cube or both cubes are not entirely inside the measured volumes, the system issues a warning regarding the evaluated spatial peak values within the PostProcessing engine (SEMCAD X). This means that if the measured volume is shifted, higher values might be possible. To get the correct values you can use a finer measurement grid for the area scan. In complicated field distributions, a large grid spacing for the area scan might miss some details and give an incorrectly interpolated peak location. The entire evaluation of the spatial peak values is performed within the PostProcessing engine (SEMCAD X). The system always gives the maximum values for the 1 g and 10 g cubes.

The algorithm to find the cube with highest averaged SAR is divided into the following stages:

1. extraction of the measured data (grid and values) from the Zoom Scan
2. calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
3. generation of a high-resolution mesh within the measured volume
4. interpolation of all measured values from the measurement grid to the high-resolution grid
5. extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
6. calculation of the averaged SAR within masses of 1 g and 10 g

4.2 Data Storage and Evaluation

Data Storage

The DASY5 software stores the measured voltage acquired by the Data Acquisition Electronics (DAE) as raw data together with all the necessary software parameters for the data evaluation (Probe calibration data, liquid parameters and communication system parameters) in measurement files with the extension .da5x. The postProcessing software evaluates the data every time the data is visualized or exported. This allows the verification and modification of the setup after completion of the measurement. For example, if a measurement has been performed with an incorrect crest factor, the parameter can be corrected afterwards and the data can be reevaluated.

To avoid unintentional parameter changes or data manipulations, the parameters in measured files are locked. In the administrator access mode of the software, the parameters can be unlocked. After changing the parameters, the measured scans can be reevaluated in the postProcessing engine.

The measured data can be visualized or exported in different units or formats, depending on the selected Probe type (e.g., E-field, H-field, SAR). Some of these units are not available in certain situations or give meaningless results, e.g., a SAR-output in a lossless media will always be zero. Raw data can also be exported to perform the evaluation with other software packages.

Data Evaluation

The fields and SAR are calculated from the measured voltage (Probe voltage acquired by the DAE) and the following parameters:

Probe parameters:	- Sensitivity	$\text{norm}_i, a_{i0}, a_{i1}, a_{i2}$
	- Conversion Factor	convF_i
	- Diode Compression Point	dcp_i
	- Probe Modulation Response Factors	a_i, b_i, c_i, d
Device parameters:	- Frequency	f
	- Crest factor	cf
Media parameters:	- Conductivity	σ
	- Relative Permittivity	ρ

This parameters are stored in the DASY5 V52 measurement file.

These parameters must be correctly set in the DASY5 V52 software setup. They are available as configuration file and can be imported into the measurement file. The values displayed in the multimeter window are assessed using the parameters of the actual system setup. In the scan visualization and export modes, the parameters stored in the measurement file are used.

The measured voltage is not Proportional to the exciting. It must be first linearized.

ApProximated Probe Response Linearization using Crest Factor.

This linearization method is enabled when a custom defined communication system is measured. The compensation applied is a function of the measured voltage, the detector diode compression point and the crest factor of the measured signal.

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

with	V_i	=	linearized voltage of channel i (uV)	(i = x,y,z)
	U_i	=	measured voltage of channel i (uV)	(i = x,y,z)
	cf	=	crest factor of exciting field	(DASY parameter)
	dcp _i	=	diode compression point of channel i (uV)	(Probe parameter, i = x,y,z)

Field and SAR Calculation

The primary field data for each channel are calculated using the linearized voltage:

$$E - \text{fieldProbes : } E_i = \sqrt{\frac{V_i}{\text{Norm}_i \cdot \text{ConvF}}}$$

$$H - \text{fieldProbes : } H_i = \sqrt{V_i} \cdot \frac{a_{i0} + a_{i1}f + a_{i2}f^2}{f}$$

with V_i = linearized voltage of channel i (i = x,y,z)
 Norm_i = sensor sensitivity of channel i (i = x,y,z)

$\mu\text{V}/(\text{V/m})^2$ for E-field Probes

ConvF = sensitivity enhancement in solution
 a_{ij} = sensor sensitivity factors for H-field Probes
 f = carrier frequency [GHz]
 E_i = electric field strength of channel i in V/m
 H_i = magnetic field strength of channel i in A/m

The RMS value of the field components gives the total field strength (Hermitian 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.

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1'000}$$

with SAR = local specific absorption rate in mW/g
 E_{tot} = total field strength in V/m
 σ = conductivity in [mho/m] or [Siemens/m]
 ρ = equivalent tissue density in g/cm³

Note that the density is set to 1, to account for actual head tissue density rather than the density of the tissue simulating liquid.

Spatial Peak SAR for 1 g and 10 g

The DASY5 software includes all numerical Procedures necessary to evaluate the spatial peak SAR values. The base for the evaluation is a "cube" measurement at the points of the fine cube grid consisting of 5 x 5 x 7 points (with 8mm horizontal resolution) or 7 x 7 x 7 points (with 5mm horizontal resolution) or 8 x 8 x 7 points (with 4mm horizontal resolution). The entire evaluation of the spatial peak values is performed within the PostProcessing engine (SEMCAD X). The system always gives the maximum values for the 1 g and 10 g cubes.

The algorithm to find the cube with highest averaged SAR is divided into the following stages:

1. extraction of the measured data (grid and values) from the Zoom Scan.
2. calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters).
3. generation of a high-resolution mesh within the measured volume.
4. interpolation of all measured values from the measurement grid to the high-resolution grid
5. extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface.
6. calculation of the averaged SAR within masses of 1 g and 10 g.

4.3 Data Storage and Evaluation

The DASY5 installation includes predefined files with recommended Procedures for measurements and validation. All test positions (head or body-worn) are tested with the same configuration of test steps differing only in the grid definition for the different test positions.

Step 1: Power reference measurement

The Power Reference Measurement and Power Drift Measurement are for monitoring the power drift of the device under test in the batch Process. The Minimum distance of Probe sensors to surface determines the closest measurement point to phantom surface. By default, the Minimum distance of Probe sensors to surface is 4 mm. This distance can be modified by the user, but cannot be smaller than the Distance of sensor calibration points to Probe tip as defined in the Probe Properties. The SAR measurement was taken at a selected spatial reference point to monitor power variations during testing. This fixed location point was measured and used as a reference value.

Step 2: Area Scan

The Area Scan is used as a fast scan in two dimensions to find the area of high field values, before doing a finer measurement around the hotspot. The sophisticated interpolation routines implemented in DASY5 software can find the maximum locations even in relatively coarse grids. When an Area Scan has measured all reachable points, it computes the field maxima found in the scanned area, within a range of the global maximum. The range (in dB) is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE 1528-2003 and IEC 62209 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan). If only one Zoom Scan follows the Area Scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of Zoom Scans has to be increased accordingly.

Step 3: Zoom Scan

The Zoom Scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 gram and 10 gram of simulated tissue. The default Zoom Scan is defined in the following table. DASY5 is also able to perform repeated zoom scans if more than 1 peak is found during area scan. When the measurement is done, the Zoom Scan evaluates the averaged SAR for 1 gram and 10 gram and displays these values next to the job's label.

Area scan and Zoom scan resolutions per FCC KDB Publication 865664 D01:

Frequency	Maximun Area Scan resolution ($\Delta x_{Area}, \Delta y_{Area}$)	Maximun Zoom Scan spatial resolution ($\Delta x_{Zoom}, \Delta y_{Zoom}$)	Maximun Zoom Scan spatial resolution			Minimum zoom scan volume (x,y,z)
			Uniform Grid	Graded Grad		
			$\Delta z_{Zoom}(n)$	$\Delta z_{Zoom}(1)^*$	$\Delta z_{Zoom}(n>1)^*$	
$\leq 2\text{GHz}$	$\leq 15\text{mm}$	$\leq 8\text{mm}$	$\leq 5\text{mm}$	$\leq 4\text{mm}$	$\leq 1.5^* \Delta z_{Zoom}(n-1)$	$\geq 30\text{mm}$
2-3GHz	$\leq 12\text{mm}$	$\leq 5\text{mm}$	$\leq 5\text{mm}$	$\leq 4\text{mm}$	$\leq 1.5^* \Delta z_{Zoom}(n-1)$	$\geq 30\text{mm}$
3-4GHz	$\leq 12\text{mm}$	$\leq 5\text{mm}$	$\leq 4\text{mm}$	$\leq 3\text{mm}$	$\leq 1.5^* \Delta z_{Zoom}(n-1)$	$\geq 28\text{mm}$
4-5GHz	$\leq 10\text{mm}$	$\leq 4\text{mm}$	$\leq 3\text{mm}$	$\leq 2.5\text{mm}$	$\leq 1.5^* \Delta z_{Zoom}(n-1)$	$\geq 25\text{mm}$
5-6GHz	$\leq 10\text{mm}$	$\leq 4\text{mm}$	$\leq 2\text{mm}$	$\leq 2\text{mm}$	$\leq 1.5^* \Delta z_{Zoom}(n-1)$	$\geq 22\text{mm}$

Step 4: Power Drift Monitoring

The Power Drift Measurement measures the field at the same location as the most recent power reference measurement job within the same Procedure, and with the same settings. The Power Drift Measurement gives the field difference in dB from the reading conducted within the last Power Reference Measurement. If the value changed by more than 5%, the evaluation should be retested.

5 SAR Verification Procedure

5.1 Tissue Simulating Liquids

For the measurement of the field distribution inside the SAM phantom with DASY, the phantom must be filled with around 25 liters of homogeneous body tissue simulating liquid. For head SAR testing, the liquid height from the ear reference point (ERP) of the phantom to the liquid top surface is larger than 15 cm, which is shown in Fig. 5.1. For body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15 cm, which is shown as followed:

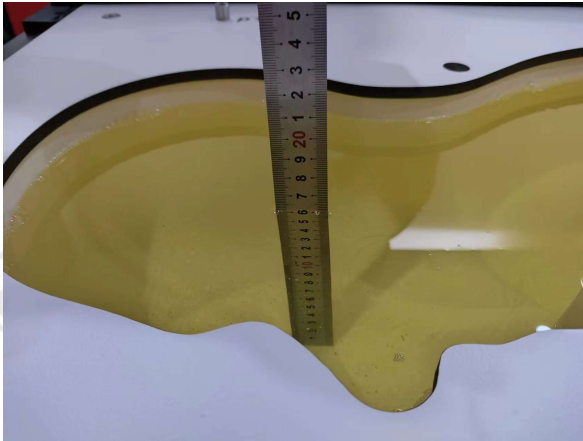


Photo of Liquid Height for Head SAR

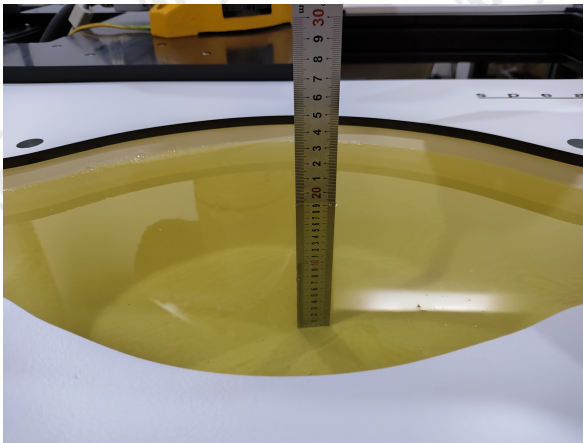


Photo of Liquid Height for Body SAR

5.2 Tissue Verification

The following materials are used for Producing the tissue-equivalent materials.

(Liquids used for tests are marked with ☒):

Ingredients (% of weight)	Frequency (MHz)						
	Head Tissue						
Tissue Type							
frequency band	☐ 835	☐ 1800	☐ 2000	☐ 2300	☒ 2450	☐ 2600	☐ 5200-5800
Water	41.45	52.64	54.9	62.82	62.7	55.242	65.52
Salt (NaCl)	1.45	0.36	0.18	0.51	0.5	0.306	0.0
Sugar	56.0	0.0	0.0	0.0	0.0	0.0	0.0
HEC	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Bactericide	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Triton X-100	0.0	0.0	0.0	0.0	36.8	0.0	17.24
DGBE	0.0	47.0	44.92	36.67	0.0	44.452	0.0
Diethylenglycol monohexylether	0.0	0.0	0.0	0.0	0.0	0.0	17.24

Salt: 99+% Pure Sodium Chloride

Sugar: 98+% Pure Sucrose

Water: De-ionized, 16MΩ+ 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

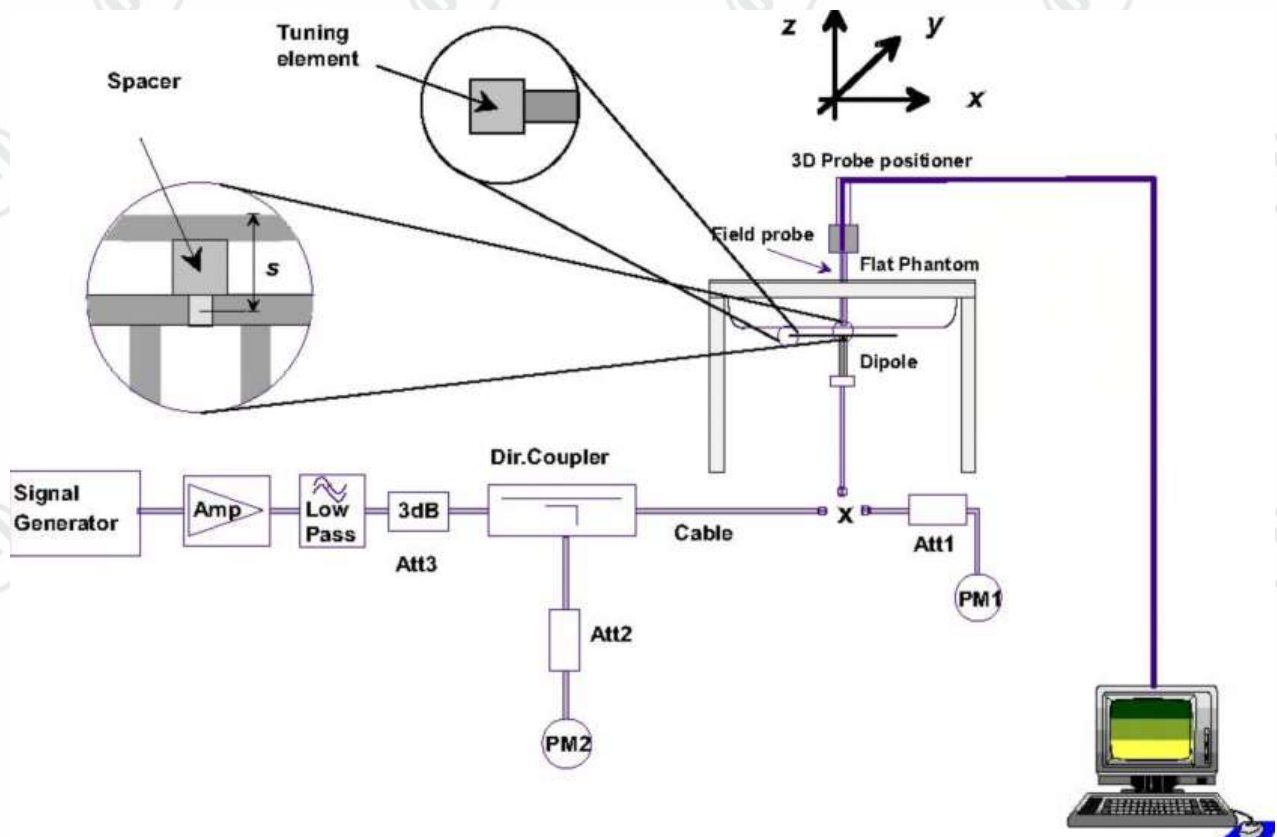
Tissue simulating liquids: parameters:

Tissue Type	Measured Frequency (MHz)	Target Tissue		Measured Tissue		Deviation (Within ±5%)		Liquid Temp.	Test Date
		ϵ_r (+/-5%)	σ (S/m) (+/-5%)	ϵ_r	σ (S/m)	$\Delta\epsilon_r$ %	$\Delta\sigma$ %		
2450H	2450	39.20 (37.24~41.16)	1.80 (1.71~1.89)	39.52	1.794	0.82	-0.33	21.30°C	7/14/2026
ϵ_r = Relative permittivity, σ = Conductivity									

5.3 System check Procedure

The System check is performed by using a System check dipole which is positioned parallel to the planar part of the SAM phantom at the reference point. The distance of the dipole to the SAM phantom is determined by a spacer. The dipole is connected to the signal source consisting of signal generator and amplifier via a directional coupler, N-connector cable and adaption to SMA. It is fed with a power of 250mW. To adjust this power a power meter is used. The power sensor is connected to the cable before the System check to measure the power at this point and do adjustments at the signal generator. At the outputs of the directional coupler both return loss as well as forward power are controlled during the validation to make sure that emitted power at the dipole is kept constant. This can also be checked by the power drift measurement after the test (result on plot).

System check results have to be equal or near the values determined during dipole calibration (target SAR in table above) with the relevant liquids and test system.



5.4 Liquid Check

The dielectric parameters check is done prior to the use of the tissue simulating liquid. The verification is made by comparing the relative permittivity and conductivity to the values recommended by the applicable standards.

The liquid verification was performed using the following test setup:

- ✓ VNA (Vector Network Analyzer)
- ✓ Open-Short-Load calibration kit
- ✓ RF Cable
- ✓ Open-Ended Coaxial probe
- ✓ DAK software tool
- ✓ SAR Liquid
- ✓ De-ionized water
- ✓ Thermometer

These are the target dielectric properties of the tissue-equivalent liquid material according to the manufacturer's datasheet:

Frequency	Head Tissue Simulating Media	
(MHz)	ϵ_r	σ (S/m)
2450	39.20	1.80

(ϵ_r = relative permittivity, σ = conductivity and $\rho = 1000 \text{ kg/m}^3$)

The measurement system implement a SAR error compensation algorithm as documented in IEEE Std 1528-2013 (equivalent to draft standard IEEE P1528-2011) to automatically compensate the measured SAR results for deviations between the measured and required tissue dielectric parameters (applied to only scale up the measured SAR, and not downward) so, according to FCC OET KDB 865664 D01, the tolerance for ϵ_r and σ may be relaxed to $\pm 10\%$.

5.5 System check results

The system Check is performed for verifying the accuracy of the complete measurement system and performance of the software. The following table shows System check results for all frequency bands and tissue liquids used during the tests (plot(s) see annex A).

System Check (MHz)	Target SAR (1W) (+/-10%)		Measured SAR 100mW		Measured SAR (Normalized to 1W)		Measured SAR (Tolerances)		Liquid Temp.	Test Date
	1-g (mW/g)	10-g (mW/g)	1-g (mW/g)	10-g (mW/g)	1-g (mW/g)	10-g (mW/g)	1-g(%)	10-g(%)		
D2450 Head	53.60 (48.24~58.96)	24.70 (22.23~27.17)	5.20	2.44	52.00	24.40	-2.99	-1.22	21.30°C	7/14/2026
Note: All SAR values are normalized to 1W forward power.										