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Photogram Ltd

TEST REPORT

SCOPE OF WORK
FCC TESTING– Camera

REPORT NUMBER
240322036SZN-003

ISSUE DATE
07 August 2024

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[--------------------]

PAGES
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DOCUMENT CONTROL NUMBER
FCC SAR_b

SAR TEST REPORT

For

Photogram Ltd

Product Description: Digital Camera

FCC ID: 2BGK8AC1

Model No.: Camera

Report No.: 240322036SZN-003

Issue Date: 05 August 2024

Prepared and Checked by:	Approved by:
Draven Li Project Engineer	Peter Kang Senior Technical supervisor 05 August 2024

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1. GENERAL INFORMATION

Applicant:	Photogram Ltd 71 - 75 Shelton Street, London, WC2H 9JQ, UK
Manufacturer:	Photogram Ltd 71 - 75 Shelton Street, London, WC2H 9JQ, UK
Product Description:	Digital Camera
Model Number:	Camera
Sample Number:	Z240322036-001
File Number:	240322036SZN-003
Date of Test:	22 March 2024 to 27 June 2024

The above equipment was tested by Intertek Testing Services Shenzhen Ltd. Longhua Branch. The test data, data evaluation, test procedures, and equipment configurations shown in this report were made in accordance with the procedures given in IEEE 1528-2013 and KDB 865664. This device is in compliance with Specific Absorption Rate (SAR) for general population/uncontrolled exposure limits (4.0 W/kg) specified in ANSI/IEEE C95.1-1992.

The test results of this report relate only to the tested sample identified in this report.

2. STATEMENT OF COMPLIANCE

The Maximum reported SAR10g

Mode	Highest Limb SAR-10g (W/kg)
WLAN 2.4G	0.111
WLAN 5G	0.105

The SAR values found for the Digital Camera are below the maximum recommended levels of 4 W/kg as averaged over any 10g tissue according to the ANSI C95.1-1992.

The maximum reported SAR value is: 0.111 W/kg (10g).

3. Equipment Under Test (EUT) TECHNICAL DESCRIPTION

Characteristics	Description	
Product Name:	Digital Camera	
Device type:	Portable device	
Exposure Category:	Uncontrolled Environment/General Population	
Test Mode(s):	Wi-Fi 2.4G (DSSS/OFDM)	
	Wi-Fi 5G (OFDM)	
Device Class:	B	
Antenna Type:	PIFA antenna	
Antenna Gain:	2.0dBi	
Operating Frequency Range(s)	Band	Frequency Rang (MHz)
	Wi-Fi 2.4G	2400-2483.5
	Wi-Fi 5G	5150-5250
		5250-5350
		5470-5725
		5725-5850
Power supply:	DC 3.7V rechargeable battery	
Product Software Version:	N/A	
Product Hardware Version:	N/A	

Note:

1. N/A is Not Applicable.
2. For more details, please refer to the User's manual of the EUT.
3. The sample under test was selected by the Client.

4. Auxiliary Equipment Details

N/A

5. Test Facility

Site Description	
EMC Lab.	The Laboratory has been assessed and proved to be in compliance with CNAS/CL01: 2006(identical to ISO/IEC17025: 2005) The Certificate Registration Number is L0327
	FCC Registration Number:435976 FCC Designation Number:CN1188
Name of Firm	Intertek Testing Services Shenzhen Ltd. Longhua Branch
Site Location	101, 201, Building B, No. 308 Wuhe Avenue, Zhangkengjing Community, GuanHu Subdistrict, LongHua District, ShenZhen, P.R. China

6. Guidance Standard

The Specific Absorption Rate (SAR) testing specification, method, and procedure for this device is in accordance with the following standards:

☒FCC 47CFR §2.1093 Radiofrequency Radiation Exposure Evaluation: Portable Devices

☒ ANSI C95.1, 1992: Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz. (IEEE Std C95.1-1991)

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

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

☒KDB 865664 D02 SAR Reporting v01r02

☒KDB 690783 D01 SAR Listings on Grants v01r03

☒KDB 447498 D01 Mobile Portable RF Exposure v06: Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies

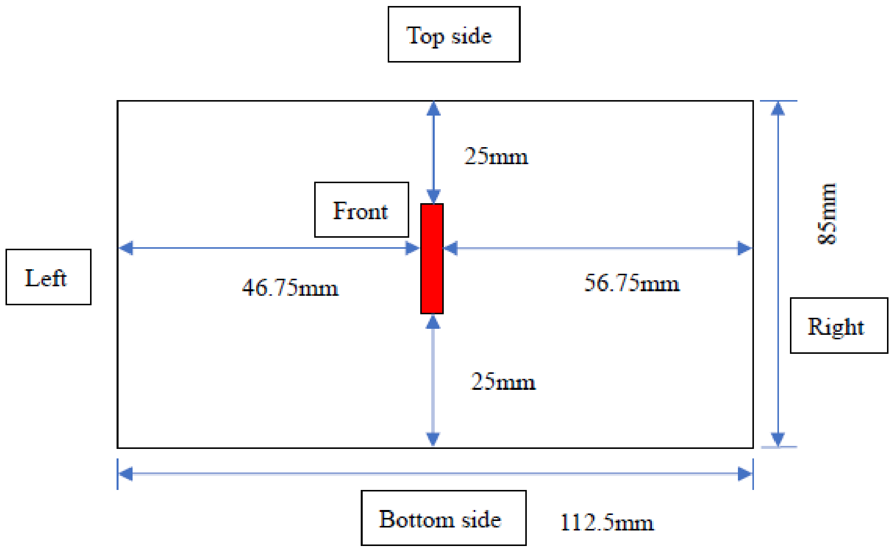
☒KDB 941225 D06 Hotspot Mode v02r01: SAR Evaluation Procedures for Portable Devices with Wireless Router Capabilities

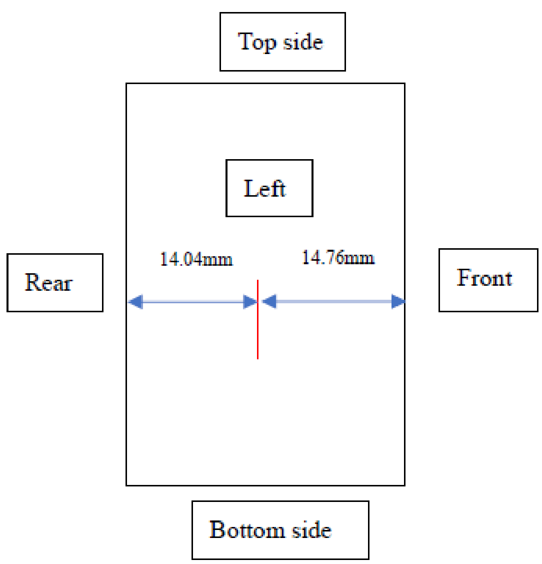
☒KDB 248227 D01 SAR Guidance for IEEE 802.11 (Wi-Fi) Transmitters

☒ KDB 616217 D04 SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers

Remark:
This portable wireless equipment has been measured in all cases requested by the relevant standards. Test results in Chapter 12 of this test report are below limits specified in the relevant standards for the tested bands only.

7. EUT Antenna Locations





Note: The red part is the antenna.

Test position consideration:

Distance of EUT antenna-to-edge/surface(mm), Test distance: 0mm					
Front	Rear	Left	Right	Top	Bottom
14.76	14.04	46.75	56.75	25	25

All Sides for SAR Testing Evaluation (Test distance: 0mm):

Mode	Location	Distance from ANT (mm)	Max. tune-up Power (mW)	Exemption with Max. Allowed Power (10g, mW)	SAR Test
2.4G Wi-Fi	Front Side	14.76	39.81	70.41	N/A (See note)
	Rear Side	14.04		66.97	
	Top Side	25		119.26	
	Bottom Side	25		119.26	
	Left Side	46.75		223.01	
	Right Side	56.75		306.01	
5G Wi-Fi	Front Side	14.76	31.62	45.87	
	Rear Side	14.04		43.63	
	Top Side	25		77.69	
	Bottom Side	25		77.69	
	Left Side	46.75		145.28	
	Right Side	56.75		222.88	

Note: SAR testing exemption according to KDB 447498 D01 Clause 4.3.1 with the following formula.

a) For 100 MHz to 6 GHz and test separation distances ≤ 50 mm, the 10-g SAR test exclusion thresholds are determined by the following:

[(max. power of channel, including tune-up tolerance, mW) / (min. test separation distance mm)] ·

[√f(GHz)] ≤ 7.5 for 10-g extremity SAR,

*where f(GHz) is the RF channel transmit frequency in GHz

*When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine

SAR test exclusion.

b) For 100 MHz to 6 GHz and test separation distances > 50 mm, the 10-g SAR test exclusion thresholds are determined by the following

{[Power allowed at numeric threshold for 50 mm in step a)] + [(test separation distance – 50 mm)·10]}

mW, for > 1500 MHz and ≤ 6 GHz

Since Max. tune-up is below the SAR low threshold level, so the EUT is considered to comply with SAR requirement without testing. However, we need to determine whether the SAR result is less than 25% of the limit value, so we continue the SAR test.

8. RF Exposure

8.1 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.

Limits for General Population/Uncontrolled Exposure (W/kg)

Whole-Body	Partial-Body	Hands, Wrists, Feet and ankles
0.08	1.6	4.0

Whole-Body SAR is averaged over the entire body, partial-body SAR is averaged over any 1gram of tissue defined as a tissue volume in the shape of a cube. SAR for hands, wrists, feet and ankles is averaged over any 10 grams of tissue defined as a tissue volume in the shape of a cube.

8.2 EVALUATION

According to FCC KDB447498 D01 and §1.1310, systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.

1) The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at *test separation distances* ≤ 50 mm are determined by:

   [(*max. power of channel, including tune-up tolerance, mW*)/(*min. test separation distance, mm*)] · [$\sqrt{f_{(GHz)}}$] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR,[16] where

   - $f_{(GHz)}$ is the RF channel transmit frequency in GHz
   - Power and distance are rounded to the nearest mW and mm before calculation[17]
   - The result is rounded to one decimal place for comparison

   The test exclusions are applicable only when the minimum *test separation distance* is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum *test separation distance* is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

Routine SAR evaluation refers to that specifically required by § 2.1093, using measurements or computer simulation. Portable transmitters with output power greater than the applicable low threshold require SAR testing to qualify for TCB approval.

Exclusion Thresholds = $P\sqrt{F}/D$
P= Maximum turn-up power in mW
F= Channel frequency in GHz
D= Minimum test separation distance in mm

Test Distance (5mm)

Band	Mode	Frequency (GHz)	MAX Power (dBm)	Tune Up Power (dBm)	Max Tune Up Power (dBm)	Max Tune Up Power (mW)	Exclusion Thresholds	Limit
WIFI 2.4GHz	802.11b	2.442	15.89	13.0±3	16.0	39.81	12.4	7.5
WIFI 5GHz	802.11a	5.580	14.92	6.0±9	15.0	31.62	14.9	7.5

Result: SAR measurement for WIFI is required.

9. Specific Absorption Rate (SAR)

9.1 INTRODUCTION

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical 12 odelling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

9.2 SAR DEFINITION

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

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

SAR is expressed in units of Watts per kilogram (W/kg)
SAR measurement can be either related to the temperature elevation in tissue by

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

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

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

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

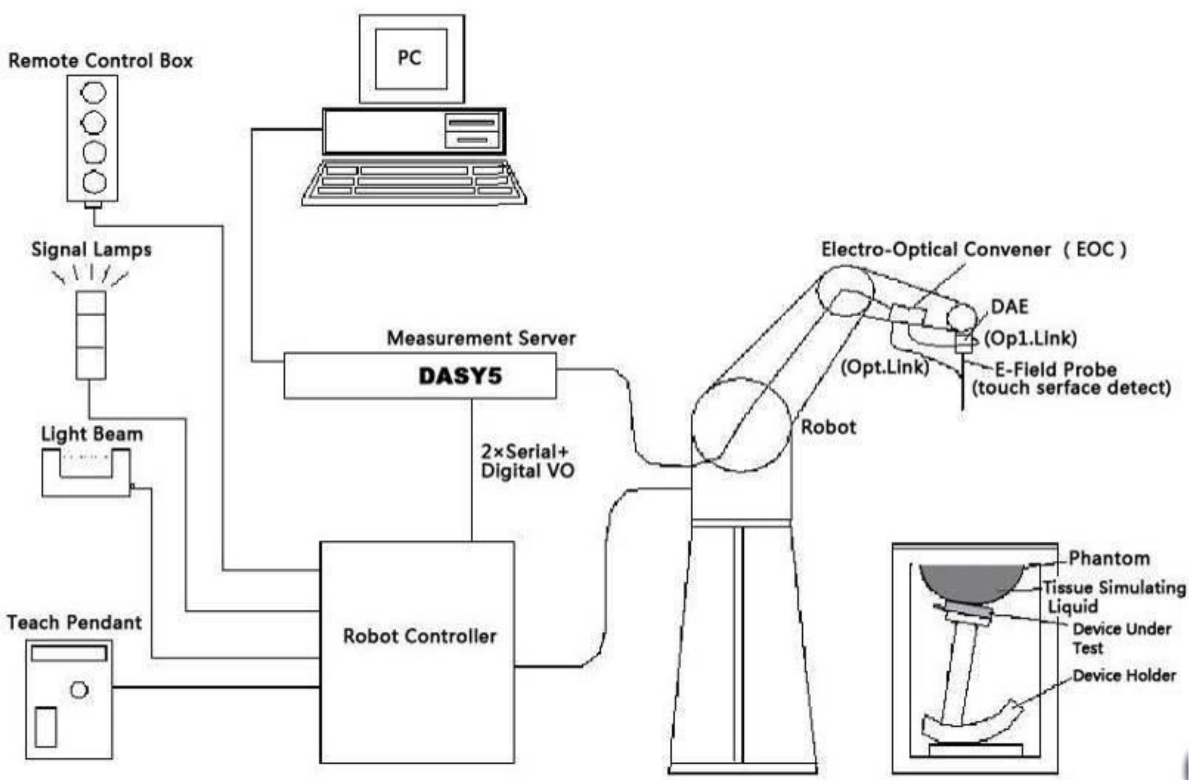
However for evaluating SAR of low power transmitter, electrical field measurement is typically applied.

10. SAR Measurements System Configuration

10.1 SAR MEASUREMENT SET-UP

The DASY5 system for performing compliance tests consists of the following items:

- A standard high precision 6-axis robot (Stäubli TX=RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running Win 7 profesional operating system and the DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.



Picture 1 SAR Lab Test Measurement Set-up

10.2 DASY5 E-FIELD PROBE SYSTEM

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

Probe Specifications:

Model:	EX3DV4
Calibration:	ISO/IEC 17025 calibration service available
Probe Length:	337 mm
Probe Tip Length:	9 mm
Body Diameter:	10 mm
Tip Diameter:	2.5 mm
Application:	High Precision dosimetric measurements in any exposure scenario (e.g., very strong Picture 2 E-field Probe gradient fields).

Picture 2 E-field Probe

10.3 E-FIELD PROBE CALIBRATION

Each E-Probe/Probe Amplifier combination has unique calibration parameters. A TEM cell calibration procedure is conducted to determine the proper amplifier settings to enter in the probe parameters. The amplifier settings are determined for a given frequency by subjecting the probe to a known E-field density (1 Mw/cm^2) using an RF Signal generator, TEM cell, and RF Power Meter.

The free space E-field from amplified probe outputs is determined in a test chamber. This calibration can be performed in a TEM cell if the frequency is below 1 GHz and inn a waveguide or other methodologies above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is then rotated 360 degrees until the three channels show the maximum reading. The power density readings equate to 1 mw/ cm^2.

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

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

Where:
Δt = Exposure time (30 seconds),
C = Heat capacity of tissue (brain or muscle),
ΔT = Temperature increase due to RF exposure.

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

Where:
σ = Simulated tissue conductivity,
ρ = Tissue density (kg/m^3).

10.4 OTHER TEST EQUIPMENT

10.4.1 Data Acquisition Electronics (DAE)

The data acquisition electronics consist of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder with a control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information, as well as an optical uplink for commands and the clock.

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

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

Picture 3 DAE

10.4.2 Robot

The SPEAG DASY system uses the high precision robots (DASY5: TX90XL) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version from Stäubli is used. The Stäubli robot series have many features that are important for our application:

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

Picture 4 DASY 5

10.4.3 Measurement Server

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

Picture 5 Server for DASY 5

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

10.4.4 Device Holder for Phantom

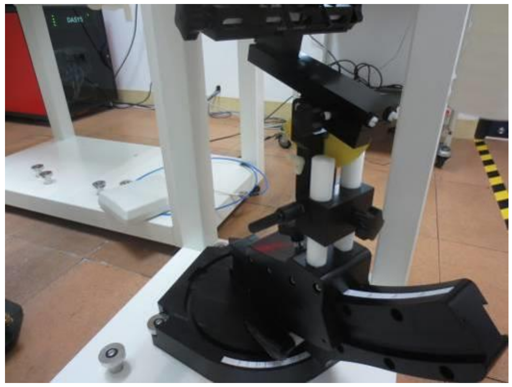
The SAR in the phantom is approximately inversely proportional to the square of the distance between the source and the liquid surface. For a source at 5mm distance, a positioning uncertainty of ±0.5mm would produce a SAR uncertainty of ±20%. Accurate device positioning is therefore crucial for accurate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

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

The DASY device holder is constructed of low-loss POM material having the following dielectric parameters: relative permittivity ε =3 and loss tangent δ =0.02. The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.

<Laptop Extension Kit>

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

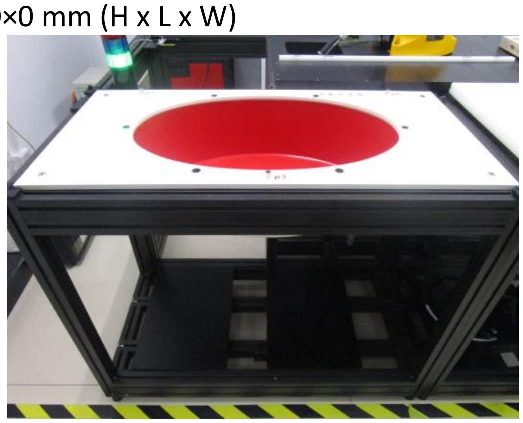


Picture 6 Device Holder

10.4.5 Phantom

Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is compatible with all SPEAG dosimetric probes and dipoles.

Shell Thickness: 2±0.2 mm
Filling Volume: Approx. 30 liters
Dimensions: 190×600×0 mm (H x L x W)



Picture 7 ELI Phantom

10.5 SCANNING PROCEDURE

The DASY5 installation includes predefined files with recommended procedures for measurements and validation. They are read-only document files and destined as fully defined but unmeasured masks. 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.

The “reference” and “drift” measurements are located at the beginning and end of the batch process. They measure the field drift at one single point in the liquid over the complete procedure. The indicated drift is mainly the variation of the DUT’s output power and should vary max. ± 5 %.

The “surface check” measurement tests the optical surface detection system of the DASY5 system by repeatedly detecting the surface with the optical and mechanical surface detector and comparing the results. The output gives the detecting heights of both systems, the difference between the two systems and the standard deviation of the detection repeatability. Air bubbles or refraction in the liquid due to separation of the sugar-water mixture gives poor repeatability (above ± 0.1mm). To prevent wrong results tests are only executed when the liquid is free of air bubbles. The difference between the optical surface detection and the actual surface depends on the probe and is specified with each probe. (It does not depend on the surface reflectivity or the probe angle to the surface within ± 30°.)

Area Scan

The Area Scan is used as a fast scan in two dimensions to find the area of high field values before running a detailed measurement around the hot spot. Before starting the area scan a grid spacing is set according to FCC KDB Publication 865664. During scan the distance of the probe to the phantom remains unchanged. After finishing area scan, the field maxima within a range of 2 Db will be ascertained.

Zoom Scan

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.

Spatial Peak Detection

The procedure for spatial peak SAR evaluation has been implemented and can determine values of masses of 1g and 10g, as well as for user-specific masses. The DASY5 system allows evaluations that combine measured data and robot positions, such as:

- maximum search
- extrapolation
- boundary correction
- peak search for averaged SAR

During a maximum search, global and local maxima searches are automatically performed in 2-D after each Area Scan measurement with at least 6 measurement points. It is based on the evaluation of the local SAR gradient calculated by the Quadratic Shepard's method. The algorithm will find the global maximum and all local maxima within -2 Db of the global maxima for all SAR distributions.

Extrapolation routines are used to obtain SAR values between the lowest measurement points and the inner phantom surface. The extrapolation distance is determined by the surface detection distance and the probe sensor offset. Several measurements at different distances are necessary for the extrapolation. Extrapolation routines require at least 10 measurement points in 3-D space.

They are used in the Zoom Scan to obtain SAR values between the lowest measurement points and the inner phantom surface. The routine uses the modified Quadratic Shepard's method for extrapolation.

A Z-axis scan measures the total SAR value at the x-and y-position of the maximum SAR value found during the cube scan. The probe is moved away in z-direction from the bottom of the SAM phantom in 5mm steps.

Table 1: Area and Zoom Scan Resolutions per FCC KDB Publication 865664 D01

Frequency	Maximum Area Scan Resolution (mm) (Δxarea, Δyarea)	Maximum Zoom Scan Resolution (mm) (Δxzoom, Δyzoom)	Maximum Zoom Scan Spatial Resolution (mm) Δzzoom(n)	Minimum Zoom Scan Volume (mm) (x,y,z)
≤2 GHz	≤15	≤8	≤5	≥ 30
2-3 GHz	≤12	≤5	≤5	≥30
3-4 GHz	≤12	≤5	≤4	≥28
4-5 GHz	≤10	≤4	≤3	≥25
5-6 GHz	≤10	≤4	≤2	≥22

10.6 DATA STORAGE AND EVALUATION

10.6.1 Data Storage

The DASY5 software stores the acquired data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all necessary software parameters for the data evaluation (probe calibration data, liquid parameters and device frequency and modulation data) in measurement files with the extension ".DAE4". The software evaluates the desired unit and format for output each time the data is visualized or exported. This allows verification of the complete software setup even after the measurement and allows correction of incorrect parameter settings. For example, if a measurement has been performed with a wrong crest factor parameter in the device set up, the parameter can be corrected afterwards and the data can be re-evaluated.

The measured data can be visualized or exported in different units or formats, depending on the selected probe type ([V/m], [A/m], [°C], [Mw/g], [Mw/cm²], [dBrel], etc.). Some of these units are not available in certain situations or show meaningless results, e.g., a SAR output in a loss less media will always be zero. Raw data can also be exported to perform the evaluation with other software packages.

10.6.2 Data Evaluation by SEMCAD

The SEMCAD software automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The parameters used in the evaluation are stored in the configuration modules of the software:

Probe parameters:
- Sensitivity $Norm_i$, a_{i0}, a_{i1}, a_{i2}
- Conversion factor $ConvF_i$
- Diode compression point Dcp_i

Device parameters:
- Frequency f
- Crest factor cf

Media parameters:
- Conductivity
- Density

These parameters must be set correctly in the software. They can be found in the component documents or they can be imported into the software from the configuration files issued for the DASY5 components. In the direct measuring mode of the multimeter option, the parameters of the actual system setup are used. In the scan visualization and export modes, the parameters stored in the corresponding document files are used.

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 as:

$$\mathbf{V_i = U_i + U_i^2 \cdot c\,f / dcp_i}$$

With $\mathbf{V_i}$ = compensated signal of channel I (I = x, y, z)
$\mathbf{U_i}$ = input signal of channel I (I = x, y, z)
cf = crest factor of exciting field (DASY parameter)
$\mathbf{dcp_i}$ = diode compression point (DASY parameter)

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

E-field probes: $\mathbf{E_i = (V_i / Norm_i \cdot ConvF)^{1/2}}$
H-field probes: $\mathbf{H_i = (V_i)^{1/2} \cdot (a_{i0} + a_{i1} f + a_{i2} f^2) / f}$

With $\mathbf{V_i}$ = compensated signal of channel I (I = x, y, z)
$\mathbf{Norm_i}$ = sensor sensitivity of channel I (I = x, y, z)
[Mv/(V/m)2] for E-field Probes
ConvF = sensitivity enhancement in solution
$\mathbf{a_{ij}}$ **=** sensor sensitivity factors for H-field probes
f = carrier frequency [GHz]
$\mathbf{E_i}$ = electric field strength of channel I in V/m
$\mathbf{H_i}$ = magnetic field strength of channel I in A/m

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

$$\mathbf{E_{tot} = (E_x^2 + E_Y^2 + E_z^2)^{1/2}}$$

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

$$\mathbf{SAR = (E_{tot})\ 2 \cdot \sigma / (\rho \cdot 1000)}$$

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

Note that the density is normally set to 1 (or 1.06), to account for actual brain density rather than the density of the simulation liquid. The power flow density is calculated assuming the excitation field to be a free space field.

$$\mathbf{P_{pwe} = E_{tot}^2 / 3770 \text{ or } P_{pwe} = H_{tot}^2 \cdot 37.7}$$

with $\mathbf{P_{pwe}}$ = equivalent power density of a plane wave in Mw/cm^2
$\mathbf{E_{tot}}$ = total electric field strength in V/m ; $\mathbf{H_{tot}}$ = total magnetic field strength in A/m

10.7 TISSUE-EQUIVALENT LIQUID

10.7.1 Tissue-equivalent Liquid Ingredients

The liquid is consisted of water, salt and Glycol. The liquid has previously been proven to be suited for worst-case. The Table 2 & 3 shows the detail solution. It's satisfying the latest tissue dielectric parameters requirements proposed by the KDB 865664 D01.

Table 2: The following recipe(s) were used for Body (B) Tissue-equivalent liquid(s)

Tissue Type	Bactericide	DGBE	HEC	NaCl	Sucrose	Triton X-100	Water	Diethylene Glycol Mono- hexylether
H2450	-	45.0	-	0.1	-	-	54.9	-
H5G	-	-	-	-	-	17.2	65.52	17.3
B2450	-	31.4	-	0.1	-	-	68.5	-
B5G	-	-	-	-	-	10.7	78.6	10.7

Targets of Tissue Simulating Liquid

Frequency (MHz)	Relative permittivity ε_r	Conductivity (σ) S/m
2450	39.2	1.80
5200	36.0	4.66
5300	35.9	4.76
5600	35.5	5.07
5800	35.3	5.27

10.7.2 Tissue-equivalent Liquid Properties

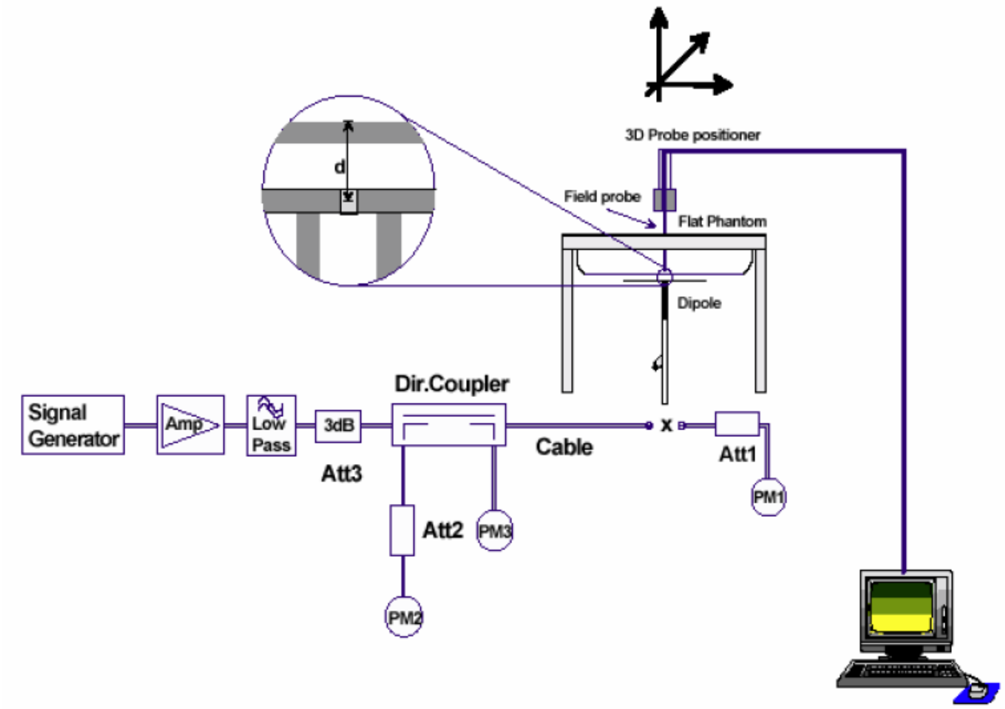
Table 3: Dielectric Performance of Head Tissue Simulating Liquid

Tissue Verification								
Tissue Type	Frequency (MHz)	Conductivity (σ)	Permittivity (εr)	Targeted Conductivity (σ)	Targeted Permittivity (εr)	Deviation Conductivity (σ)	Deviation Permittivity (εr)	Date
Head	2450	1.882	38.250	1.80	39.2	4.56	-2.42	2024-06-26
Head	5200	4.564	34.807	4.66	36.0	-2.06	-3.31	2024-06-26
Head	5300	4.649	34.738	4.76	35.9	-2.33	-3.24	2024-06-26
Head	5600	4.920	34.278	5.07	35.5	-2.96	-3.52	2024-06-26
Head	5800	5.124	33.938	5.27	35.3	-2.77	-3.86	2024-06-26

10.8 SYSTEM CHECK

10.8.1 Description of System Check

The manufacturer calibrates the probes annually. Dielectric parameters of the tissue simulants were measured every day using the dielectric probe kit and the network analyzer. A system check measurement was made following the determination of the dielectric parameters of the simulant, using the dipole validation kit. A power level of 250 Mw was supplied to the dipole antenna, which was placed under the flat section of the twin SAM phantom. The system check results (dielectric parameters and SAR values) are given in the table 5. System check results have to be equal or near the values determined during dipole calibration with the relevant liquids and test system (±10 %). System check is performed regularly on all frequency bands where tests are performed with the DASY5 system.



Picture 8 ystem Check Set-up

Justification for Extended SAR Dipole Calibrations

Usage of SAR dipoles calibrated less than 3 years ago but more than 1 year ago were confirmed in maintaining return loss (< - 20 dB, within 20% of prior calibration) and impedance (within 5 ohm from prior calibration) requirements per extended calibrations in KDB 865664 D01:

10.8.2 System Check Results

Table 5: System Check for Simulating Liquid

Measurement Date	Frequency (MHz)	1W Target SAR1g (W/kg)	Measured SAR1g (W/kg)	1W Normalized SAR1g (W/kg)	Limit (±10% Deviation)
2024-06-26	2450	52.40	13.30	53.20	1.53
2024-06-26	5200	76.40	7.29	72.90	4.58
2024-06-26	5300	77.90	7.66	76.60	-1.67
2024-06-26	5600	80.30	8.18	81.80	1.87
2024-06-26	5800	78.20	7.77	77.70	-0.64

Note: Plots of the system checking scans are given in Appendix B.

11. Measurement Procedures

11.1 GENERAL DESCRIPTION OF TEST PROCEDURES

For WLAN SAR testing, WLAN engineering testing software installed on the DUT can provide continuous transmitting RF signal. This RF signal utilized in SAR measurement has almost 100% duty cycle and its crest factor is 1.

For the 802.11b/g/n SAR tests, a communication link is set up with the test mode software for WIFI mode test. During the test, at the each test frequency channel, the EUT is operated at the RF continuous emission mode. Provided higher maximum output power is not specified for the other channels, channels 1, 6, 11, are used to configure 20 MHz DSSS and 20/40MHz OFDM channels for SAR measurements; otherwise, the closest adjacent channel with the highest maximum output power specified for production units should be tested instead of channels 1, 6, 11. In addition, SAR test reduction with respect to reported SAR and transmission band width according to 4.3.3 of KDB Publication 447498 D01 may also be applied.

802.11b/g/n operating modes are tested independently according to the service requirements in each frequency band. 802.11b/g/n modes are tested on the maximum average output channel.

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:

a) When the reported SAR of the highest measured maximum output power channel (see 3.1) for the exposure configuration is ≤ 0.8 W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.
b) 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.

When SAR measurement is required for 2.4 GHz 802.11g/n OFDM configurations, the measurement and test reduction procedures for OFDM are applied (see 11.1.2, including subclauses). SAR is not required for the following 2.4 GHz OFDM conditions.

a) When KDB Publication 447498 D01 SAR test exclusion applies to the OFDM configuration.
b) 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.

11.2 MEASUREMENT VARIABILITY

Per FCC KDB Publication 865664 D01, 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. Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg; steps 2) through 4) do not apply.
2. When the original highest measured SAR is ≥ 0.80 W/kg, repeat that measurement once.
3. Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 W/kg (~ 10% from the 1-g SAR limit).
4. Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

12. TEST RESULTS

12.1 Conducted Power Results

Test Condition:

1. Conducted Measurement
   EUT was set for low, mid, high channel with modulated mode and highest RF output power.
   The base station simulator was connected to the antenna terminal.

2 Conducted Emissions Measurement Uncertainty
All test measurements carried out are traceable to national standards. The uncertainty of the measurement at a confidence level of approximately 95% (in the case where distributions are normal), with a coverage factor of 2, in the range 30MHz – 40GHz is ±1.5dB.

3 Environmental Conditions

Environmental Conditions	Temperature	22°C
	Relative Humidity	54%
	Atmospheric Pressure	1009mbar

4 Test Date: 26 June 2024

Test Procedures:
The output power was measured using power meter at low, mid, and hi channels.

Wi-Fi 2.4G Measurement Result

Mode	Channel	Frequency (MHz)	Data Rate(Mbps)	Max. Tune-up	AveragePower (dBm)
802.11b	1	2412	1	16	15.83
	7	2442		16	15.89
	13	2462		16	15.26
802.11g	1	2412	6	13	12.62
	7	2442		13	12.57
	13	2462		13	12.51
802.11n HT20	1	2412	MCS0	12	10.45
	7	2442		12	11.42
	13	2462		12	10.73
802.11n HT40	3	2422	MCS0	11	10.94
	7	2442		11	10.34
	11	2452		11	10.06

Wi-Fi 5G Measurement Result

Mode	Frequency (MHz)	Data rate (Mbps)	Output Power(dBm)	Tune up limited(dBm)
11A	5180	MCS0	14.25	11.0±4
	5200	MCS0	14.20	11.0±4
	5240	MCS0	14.80	11.0±4
	5260	MCS0	14.87	11.0±4
	5280	MCS0	14.88	11.0±4
	5320	MCS0	14.70	11.0±4
	5500	MCS0	14.40	11.0±4
	5580	MCS0	14.92	11.0±4
	5700	MCS0	14.64	11.0±4
	5720_UNII-2C	MCS0	13.91	11.0±4
	5720_UNII-3	MCS0	7.03	11.0±4
	5745	MCS0	14.37	11.0±4
	5785	MCS0	14.68	11.0±4
	5825	MCS0	14.09	11.0±4
11N20	5180	MCS0	13.18	6.0±9
	5200	MCS0	13.19	6.0±9
	5240	MCS0	13.95	6.0±9
	5260	MCS0	13.02	6.0±9
	5280	MCS0	13.42	6.0±9
	5320	MCS0	13.74	6.0±9
	5500	MCS0	13.22	6.0±9
	5580	MCS0	13.88	6.0±9
	5700	MCS0	13.42	6.0±9
	5720_UNII-2C	MCS0	13.64	6.0±9
	5720_UNII-3	MCS0	-2.31	6.0±9
	5745	MCS0	13.01	6.0±9
	5785	MCS0	13.50	6.0±9
	5825	MCS0	13.79	6.0±9
11N40	5190	MCS0	12.97	8.0±6
	5230	MCS0	12.33	8.0±6
	5270	MCS0	12.69	8.0±6
	5310	MCS0	12.11	8.0±6
	5510	MCS0	12.64	8.0±6
	5550	MCS0	12.08	8.0±6
	5670	MCS0	12.56	8.0±6
	5710_UNII-2C	MCS0	12.13	8.0±6
	5710_UNII-3	MCS0	2.36	8.0±6

Mode	Frequency (MHz)	Data rate (Mbps)	Output Power(dBm)	Tune up limited(dBm)
	5755	MCS0	12.49	8.0±6
	5795	MCS0	12.09	8.0±6
11AC20	5180	MCS0	13.22	11.0±4
	5200	MCS0	13.31	11.0±4
	5240	MCS0	13.81	11.0±4
	5260	MCS0	13.94	11.0±4
	5280	MCS0	13.31	11.0±4
	5320	MCS0	13.68	11.0±4
	5500	MCS0	13.14	11.0±4
	5580	MCS0	13.96	11.0±4
	5700	MCS0	13.49	11.0±4
	5720_UNII-2C	MCS0	13.64	11.0±4
	5720_UNII-3	MCS0	7.32	11.0±4
	5745	MCS0	13.10	11.0±4
	5785	MCS0	13.53	11.0±4
	5825	MCS0	13.88	11.0±4
11AC40	5190	MCS0	12.87	7.0±6
	5230	MCS0	12.33	7.0±6
	5270	MCS0	12.70	7.0±6
	5310	MCS0	12.15	7.0±6
	5510	MCS0	12.62	7.0±6
	5550	MCS0	12.00	7.0±6
	5670	MCS0	12.54	7.0±6
	5710_UNII-2C	MCS0	11.21	7.0±6
	5710_UNII-3	MCS0	1.09	7.0±6
	5755	MCS0	12.62	7.0±6
	5795	MCS0	12.84	7.0±6
11AC80	5210	MCS0	11.25	5.0±8
	5290	MCS0	11.88	5.0±8
	5530	MCS0	11.29	5.0±8
	5610	MCS0	11.64	5.0±8
	5690_UNII-2C	MCS0	10.98	5.0±8
	5690_UNII-3	MCS0	-2.43	5.0±8
	5775	MCS0	11.11	5.0±8

12.2 SAR TEST RESULTS

Table 6: Limb SAR test results of Wi-Fi 2.4G

Band	Mode	Test Position	Channel	Maximum Tune-up (dBm)	Conducted Power (dBm)	SAR 10g	Scaling Factor	Scaled 10g SAR
802.11b	CCK	Front Face	7	16.0	15.89	0.010	1.03	0.025
802.11b	CCK	Rear Face	7	16.0	15.89	0.054	1.03	**0.111**
802.11b	CCK	Left Side	7	16.0	15.89	0.024	1.03	0.044
802.11b	CCK	Right Side	7	16.0	15.89	0.014	1.03	0.034
802.11b	CCK	Top Side	7	16.0	15.89	0.017	1.03	0.036
802.11b	CCK	Bottom Side	7	16.0	15.89	0.013	1.03	0.031
Note: SAR is not required for the 2.4 GHz OFDM conditions if 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 7: 2.4 GHz OFDM SAR Test Exclusion Requirements

Band	Mode	Test Position	Channel	Maximum Tune-up (dBm)	Conducted Power (dBm)	SAR 10g	Scaling Factor	Scaled 10g SAR
802.11a	OFDM	Front Face	48	15	14.80	0.078	1.05	0.014
802.11a	OFDM	Rear Face	48	15	14.80	0.027	1.05	**0.056**
802.11a	OFDM	Left Side	48	15	14.80	0.014	1.05	0.020
802.11a	OFDM	Right Side	48	15	14.80	0.013	1.05	0.019
802.11a	OFDM	Top Side	48	15	14.80	0.013	1.05	0.019
802.11a	OFDM	Bottom Side	48	15	14.80	0.011	1.05	0.018
802.11a	OFDM	Front Face	56	15	14.88	0.010	1.03	0.024
802.11a	OFDM	Rear Face	56	15	14.88	0.039	1.03	**0.105**
802.11a	OFDM	Left Side	56	15	14.88	0.014	1.03	0.036
802.11a	OFDM	Right Side	56	15	14.88	0.013	1.03	0.033
802.11a	OFDM	Top Side	56	15	14.88	0.014	1.03	0.034
802.11a	OFDM	Bottom Side	56	15	14.88	0.010	1.03	0.029
802.11a	OFDM	Front Face	116	15	14.92	0.007	1.02	0.012
802.11a	OFDM	Rear Face	116	15	14.92	0.010	1.02	**0.026**
802.11a	OFDM	Left Side	116	15	14.92	0.009	1.02	0.019
802.11a	OFDM	Right Side	116	15	14.92	0.009	1.02	0.018
802.11a	OFDM	Top Side	116	15	14.92	0.010	1.02	0.019
802.11a	OFDM	Bottom Side	116	15	14.92	0.005	1.02	0.010
802.11a	OFDM	Front Face	157	15	14.68	0.009	1.08	0.015
802.11a	OFDM	Rear Face	157	15	14.68	0.021	1.08	**0.060**
802.11a	OFDM	Left Side	157	15	14.68	0.011	1.08	0.021
802.11a	OFDM	Right Side	157	15	14.68	0.013	1.08	0.021
802.11a	OFDM	Top Side	157	15	14.68	0.011	1.08	0.020
802.11a	OFDM	Bottom Side	157	15	14.68	0.011	1.08	0.020

Note: Because the SAR test value is less than 25% of the Limbs-10g SAR limit, so it does not need to be tested together with phone.

12.3 Measurement variability consideration

According to KDB 865664 D01v01r04 section 2.8.1, repeated measurements are required following the procedures as below:

1. Repeated measurement is not required when the original highest measured SAR is < 0.80W/kg; steps 2) through 4) do not apply.
2. When the original highest measured SAR is ≥ 0.80 W/kg, repeat that measurement once.
3. Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 W/kg (~ 10% from the 1-g SAR limit).
4. Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

12.3.1 Repeated SAR

N/A

12.4 Simultaneous Transmission SAR Analysis.

The simultaneous transmission possibilities for this device are listed as below Table

Simultaneous TX Combination
WIFI 2.4GHz+ WIFI 5GHz

12.5 Simultaneous Transmission SAR Value

The Max Σ10-g SAR is calculated as below table:

Position / SAR10g(W/Kg)	Front Face	Rear Face	Left Side	Right Side	Top side	Bottom Side
Wi-Fi 2.4G	0.025	0.111	0.044	0.034	0.036	0.031
Wi-Fi 5G	0.024	0.105	0.036	0.033	0.034	0.029
MAX $\sum SAR_{10g}$	**0.049**	**0.216**	**0.080**	**0.067**	**0.070**	**0.060**

12.6 MAXIMUM GRAPH RESULTS

The graph results see ANNEX C.

13. Measurement Uncertainty

When the highest measured 1-g SAR within a frequency band is < 1.5 W/kg, the extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval.

14. Main Test Instrument

Equipment No.	Equipment	Manufacturer	Model No.	Serial No.	Last Cal.	Cal. Interval
SZ060-01	SAR Test System	SPEAG	DASY52 SAR TX90XL	F14/5YJ0B1/A/01	2024-03-18	1 year
SZ060-01-01	E-Field Probe	SPEAG	EX3DV4	7322	2024-03-26	1 year
SZ060-01-10	System Validation Dipole	SPEAG	D2450V2	966	2021-10-21	3 years
SZ060-01-12	System Validation Dipole	SPEAG	D5GHzV2	1218	2021-10-15	3 years
SZ060-01-13	Data Acquisition Unit	SPEAG	DAE4	1473	2024-03-18	1 year
SZ060-01-14	Dielectric Assessment Kit	SPEAG	DAKS 3.5	1056	N/A	N/A
SZ060-01-15	Vector Reflectometer	Copper Mountain Technologies	Planar R140	0090614	N/A	N/A
SZ060-01-16	Thermometer	LKM electronics GmbH	DTM3000	3477	2024-01-02	1 year
SZ060-01-17	Power Amplifier	Mini Circuits	ZHL-42W+	QA1449003	2024-05-10	1 year
SZ060-01-18	Power Amplifier	Mini Circuits	ZVE-8G+	111701437	2024-05-10	1 year
SZ060-01-19	SAM Twin Phantom	SPEAG	SAM Twin Phantom V5.0	1888	N/A	N/A
SZ060-01-20	SAM Twin Phantom	SPEAG	SAM Twin Phantom V5.0	1891	N/A	N/A
SZ060-01-21	ELI Phantom	SPEAG	ELI Phantom V6.0	2033	N/A	N/A
SZ180-13	MXG Vector Signal Generator	Keysight	N5182B	MY53051328	2023-09-25	1 year
SZ070-04	Directional Bridge	Agilent	86205A	MY31402141	2023-12-13	1 year
SZ182-02	RF Power Meter	Anritsu	ML2496A	1302005	2024-04-22	1 year
SZ182-03	Average power sensor	R&S	NRP-Z22	101689	2024-04-22	1 year
SZ065-06	Wideband Radio Communication Tester	R&S	CMU200	112012	2023-09-25	1 year
N/A	Device Holder	SPEAG	N/A	N/A	N/A	N/A

ANNEX A: Test Layout and Setup

The graph results see 240322036SZN-003_SAR Appendix-Appendix A.

ANNEX B: System Check Results

The graph results see 240322036SZN-003_SAR Appendix-Appendix B.

ANNEX C: MAXIMUM GRAPH RESULTS

The graph results see 240322036SZN-003_SAR Appendix-Appendix C.

ANNEX D: SYSTEM VALIDATION

The graph results see 240322036SZN-003_SAR Appendix-Appendix D.

ANNEX E: RELEVANT PAGES FROM PROBE CALIBRATION REPORT(S)

The graph results see 240322036SZN-003_SAR Appendix-Appendix E.

ANNEX F: RELEVANT PAGES FROM DIPOLE VALIDATION KIT REPORT(S)

The graph results see 240322036SZN-003_SAR Appendix-Appendix F.

ANNEX G: RELEVANT PAGES FROM DAE CALIBRATION REPORT(S)

The graph results see 240322036SZN-003_SAR Appendix-Appendix G.

ANNEX H: EUT PHOTO

The EUT photos are saved with filenames: external photos.pdf & internal photos.pdf.

*********************************End the Report**********************************