

FCC SAR Test Report

FCC ID: 2ANR7-TPMS6

Report No. : BTL-FCC SAR-1-2502T052
Equipment : Tire-pressure monitoring system
Model Name : TPMS6
Brand Name : Snap-on
Applicant : ATEQ INSTRUMENTS (ASIA) PTE LTD.TAIWAN BRANCH (SINGAPORE)
Address : NO.3, LANE 223, SAN JIA DONG STREET, 40642, TAICHUNG, TAIWAN
Radio Function : Bluetooth, WLAN 2.4G, Short Range Devices
Standard(s) : KDB447498 D04 Interim General RF Exposure Guidance v01
KDB248227 D01 802.11 Wi-Fi SAR v02r02
KDB865664 D01 SAR measurement 100 MHz to 6 GHz v01r04
KDB865664 D02 SAR Reporting v01r02
KDB941225 D07 UMPC Mini Tablet v01r02
FCC§2.1093 Radiofrequency radiation exposure evaluation: portable devices
IEEE C95.1:2019 Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz – 300 GHz
IEEE Std 1528:2013 Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques

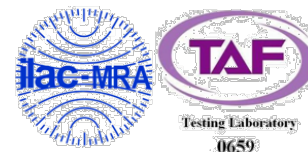
Date of Receipt : Feb. 13, 2025
Date of Test : Mar. 18, 2025
Issued Date : May. 26, 2025

The above equipment has been tested and found in compliance with the requirement of the above standards by BTL Inc.

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Declaration

BTL represents to the client that testing is done in accordance with standard procedures as applicable and that test instruments used has been calibrated with standards traceable to international standard(s) and/or national standard(s).

BTL's reports apply only to the specific samples tested under conditions. It is manufacture's responsibility to ensure that additional production units of this model are manufactured with the identical electrical and mechanical components. **BTL** shall have no liability for any declarations, inferences or generalizations drawn by the client or others from **BTL** issued reports.

This report is the confidential property of the client. As a mutual protection to the clients, the public and ourselves, the test report shall not be reproduced, except in full, without our written approval.

BTL's laboratory quality assurance procedures are in compliance with the **ISO/IEC 17025** requirements, and accredited by the conformity assessment authorities listed in this test report.

BTL is not responsible for the sampling stage, so the results only apply to the sample as received.

The information, data and test plan are provided by manufacturer which may affect the validity of results, so it is manufacturer's responsibility to ensure that the apparatus meets the essential requirements of applied standards and in all the possible configurations as representative of its intended use.

Limitation

For the use of the authority's logo is limited unless the Test Standard(s)/Scope(s)/Item(s) mentioned in this test report is (are) included in the conformity assessment authorities acceptance respective.

Please note that the measurement uncertainty is provided for informational purpose only and are not use in determining the Pass/Fail results.

Table of Contents	Page
1. GENERAL INFORMATION	6
1.1. GENERAL DESCRIPTION OF EUT	6
2. RF EMISSIONS MEASUREMENT	7
2.1. TEST FACILITY	7
2.2. MEASUREMENT UNCERTAINTY	8
2.3. WLAN ANTENNA INFORMATION	9
2.4. OOK ANTENNA INFORMATION	9
2.5. BLE ANTENNA INFORMATION	9
2.6. THE MAXIMUM SAR-1G & POWER DENSITY VALUES	10
2.7. LABORATORY ENVIRONMENT	10
2.8. MAIN TEST INSTRUMENTS	11
3. SAR MEASUREMENTS SYSTEM CONFIGURATION	12
3.1. SAR MEASUREMENT SETUP	12
3.1.1. TEST SETUP LAYOUT	12
3.2. DASY5 E-FIELD PROBE SYSTEM	13
3.2.1. EX3DV4 PROBE SPECIFICATION	13
3.2.2. E-FIELD PROBE CALIBRATION	14
3.2.3. OTHER TEST EQUIPMENT	15
3.2.4. SCANNING PROCEDURE	16
3.2.5. DATA STORAGE AND EVALUATION	17
3.2.6. DATA EVALUATION BY SEMCAD	18
4. TISSUE-EQUIVALENT LIQUID	20
4.1. TISSUE-EQUIVALENT LIQUID INGREDIENTS	20
4.2. TISSUE-EQUIVALENT LIQUID PROPERTIES	20
5. SYSTEM CHECK	21
5.1. DESCRIPTION OF SYSTEM CHECK	21
5.2. DESCRIPTION OF SYSTEM CHECK	22
6. OPERATIONAL CONDITIONS DURING TEST	23
6.1. GENERAL DESCRIPTION OF TEST PROCEDURES	23
6.2. TEST POSITION ANTENNA LOCATION	23
6.3. TEST POSITION OF PORTABLE DEVICES	24
7. SAR MEASUREMENT VARIABILITY AND UNCERTAINTY	25
7.1. SAR MEASUREMENT VARIABILITY	25
7.2. WIFI TEST CONFIGURATION	26
7.3. TEST CONFIGURATION	27
7.4. WLAN 2.4G SAR TEST REQUIREMENTS	29
7.5. OFDM TRANSMISSION MODE AND SAR TEST CHANNEL SELECTION	30
7.6. INITIAL TEST CONFIGURATION PROCEDURE	30
8. CONDUCTED POWER RESULTS	31
8.1. CONDUCTED POWER MEASUREMENTS OF BLUETOOTH	31
8.2. CONDUCTED POWER MEASUREMENTS OF 2.4G OOK	31

8.3. CONDUCTED POWER MEASUREMENTS OF WI-FI 2.4GHZ BAND	31
8.4. SAR TEST RESULTS	32
9. SAR TEST RESULTS	33
9.1. BODY SAR TEST RESULTS	33
10. SIMULTANEOUS TRANSMISSION CONDITIONS	34
10.1. STAND-ALONE SAR TEST EXCLUSION	34
10.2. SIMULTANEOUS TRANSMISSION CONDITIONS	35
10.3. ABOUT BT/WIFI	36
11. TEST LAYOUT	37

REPORT ISSUED HISTORY

Report Version	Description	Issued Date
R00	Original Issue.	2025/4/10
R01	Revised Wi-Fi 2.4GHz Conducted power table's channel. Revised Bluetooth SAR test result's Max tune-up power and results. Revised Maximum SAR-1g of Bluetooth. Revised Simultaneous transmission conditions about Bluetooth.	2025/5/13
R02	Revised WiFi 2.4G Operation Frequency. Revised Wi-Fi 2.4GHz Conducted power table's frequency and channel.	2025/5/15
R03	Revised OOK's Operation Frequency Revised Antenna Information	2025/5/26

1. GENERAL INFORMATION

1.1. General Description Of EUT

Equipment	Tire-pressure monitoring system		
Model Name	TPMS6,		
Brand Name	Snap-on		
Power Rating	Brand : DEE VAN Model : DSA-10PFP-05 050200 Input : 100-240V,50/60Hz,0.3A Max Output : 5.0V/2.0A 10W		
Battery Information	Brand : Nexcell Model : NLI-N7100 Rating : 3.8V 3050mAh 11.59Wh		
WIFI+BT Module	ESPRESSIF / ESP32-C3-WROOM-02		
2.4G OOK Module	TEXAS / CC2500		
Operation Frequency	Function	Band	Frequency (MHz)
	Bluetooth	Bluetooth Low Energy	TX : 2402 - 2480 MHz
	OOK	2.4G OOK	TX : 2450 MHz
	WiFi	2.4G	TX : 2412 - 2462 MHz
Sample Status	Engineering Sample		
EUT Modification(s)	N/A		

The above equipment has been tested and found compliance with the requirement of the relative standards by BTL Inc. The test data, data evaluation, and equipment configuration contained in our test report were obtained utilizing the test procedures, test instruments, test sites that has been accredited by the Authority of TAF according to the ISO/IEC 17025 quality assessment standard and technical standard(s).

2. RF EMISSIONS MEASUREMENT

2.1. Test Facility

The test locations stated below are under the TAF Accreditation Number 0659.

The test facilities used to collect the test data in this report is **SAR Test room** at the location of No. 68-1, Ln. 169, Sec.2, Datong Rd., Xizhi Dist., New Taipei City 221, Taiwan.
(FCC DN: TW0659)

☒ SAR 01

☐ SAR 02

☐ SAR 03

2.2. Measurement Uncertainty

Uncertainty Budget for Frequency range of 300 MHz to 3 GHz

Error Description	Uncertainty Value ($\pm$ %)	Probability Distribution	Divisor	Ci (1g)	Ci (10g)	Standard Uncertainty (1g)	Standard Uncertainty (10g)	V _i V _{eff}
Measurement System								
Probe Calibration	5.5	Normal	1	1	1	± 5.5 %	± 5.5 %	∞
Axial Isotropy	4.7	Rectangular	$\sqrt{3}$	0.7	0.7	± 1.9 %	± 1.9 %	∞
Hemispherical Isotropy	9.6	Rectangular	$\sqrt{3}$	0.7	0.7	± 3.9 %	± 3.9 %	∞
Boundary Effects	1	Rectangular	$\sqrt{3}$	1	1	± 0.6 %	± 0.6 %	∞
Linearity	4.7	Rectangular	$\sqrt{3}$	1	1	± 2.7 %	± 2.7 %	∞
Detection Limits	1	Rectangular	$\sqrt{3}$	1	1	± 0.6 %	± 0.6 %	∞
Modulation response	2.4	Rectangular	$\sqrt{3}$	1	1	± 1.4 %	± 1.4 %	∞
Readout Electronics	0.3	Normal	1	1	1	± 0.3 %	± 0.3 %	∞
Response Time	0.8	Rectangular	$\sqrt{3}$	1	1	± 0.5 %	± 0.5 %	∞
Integration Time	2.6	Rectangular	$\sqrt{3}$	1	1	± 1.5 %	± 1.5 %	∞
RF Ambient – Noise	3	Rectangular	$\sqrt{3}$	1	1	± 1.7 %	± 1.7 %	∞
RF Ambient– Reflections	3	Rectangular	$\sqrt{3}$	1	1	± 1.7 %	± 1.7 %	∞
Probe Positioner	0.02	Rectangular	$\sqrt{3}$	1	1	± 0.0 %	± 0.0 %	∞
Probe Positioning	0.4	Rectangular	$\sqrt{3}$	1	1	± 0.2 %	± 0.2 %	∞
Max.SAR Evaluation	2	Rectangular	$\sqrt{3}$	1	1	± 1.2 %	± 1.2 %	∞
Test Sample Related								
Device Positioning	2.9	Normal	1	1	1	± 2.9 %	± 2.9 %	145
Device Holder	3.6	Normal	1	1	1	± 3.6 %	± 3.6 %	5
Power Drift	5.0	Rectangular	$\sqrt{3}$	1	1	± 2.9 %	± 2.9 %	∞
Phantom and Setup								
Phantom Production Tolerances	6.1	Rectangular	$\sqrt{3}$	1	1	± 3.5 %	± 3.5 %	∞
SAR correction	1.9	Rectangular	$\sqrt{3}$	1	0.84	± 1.9 %	± 1.6 %	
Liquid Conductivity (mea.)	2.5	Rectangular	$\sqrt{3}$	0.78	0.71	± 1.1 %	± 1.1 %	∞
Liquid Permittivity (mea.)	2.6	Rectangular	$\sqrt{3}$	0.26	0.26	± 0.4 %	± 0.4 %	∞
Temp. unc. - Conductivity	3.4	Rectangular	$\sqrt{3}$	0.78	0.71	± 1.5 %	± 1.4 %	∞
Temp. unc. - Permittivity	0.4	Rectangular	$\sqrt{3}$	0.23	0.26	± 0.1 %	± 0.1 %	∞
Combined Standard Uncertainty (K = 1)						± 10.78 %	± 10.73 %	361
Expanded Uncertainty (K = 2)						± 21.55 %	± 21.46 %	

2.3. WLAN Antenna Information

Antenna	Manufacture	Model	Type	Frequency Range (MHz)	Gain (dBi)
Ant1	Espressif System (Shanghai) Co.,Ltd	ESP-ANT B	PCB	2402-2462	3.16

The above Antenna information are derived from the antenna data sheet provided by manufacturer and for more detailed features description, please refer to the manufacturer's specifications, the laboratory shall not be held responsible.

2.4. OOK Antenna Information

Antenna	Manufacture	P/N	Type	Frequency Range (MHz)	Gain (dBi)
Ant1	MOLEX ELECTRONIC TECHNOLOGIES, LLC	1461539150	Flex	2400-2500	2.8

The above Antenna information are derived from the antenna data sheet provided by manufacturer and for more detailed features description, please refer to the manufacturer's specifications, the laboratory shall not be held responsible.

2.5. BLE Antenna Information

Antenna	Manufacture	Model	Type	Frequency Range (MHz)	Gain (dBi)
Ant1	Espressif System (Shanghai) Co.,Ltd	ESP-ANT B	PCB	2402-2477	3.18

The above Antenna information are derived from the antenna data sheet provided by manufacturer and for more detailed features description, please refer to the manufacturer's specifications, the laboratory shall not be held responsible.

2.6. The Maximum SAR-1g & Power Density Values

Band	Mode	Highest Body Reported SAR-1g(W/kg)
GFSK	BLE 2M	0.256
2.4G OOK	2.4G OOK	0.386
DTS	Wi-Fi 2.4G	0.143

Note:

1. The device is in compliance with Specific Absorption Rate(SAR)for general population uncontrolled exposure limits according to the FCC rule §2.1093, the ANSI C95.1:2019/IEEE C95.1:2019, the NCRP Report Number 86 for uncontrolled environment and had been tested in accordance with the measurement methods and procedures specified in IEEE Std 1528:2013.

2.7. Laboratory Environment

Temperature	Min. = 18°C, Max. = 25°C
Relative humidity	Min. = 30%, Max. = 70%
Ground system resistance	< 0.5 Ω
Ambient noise is checked and found very low and in compliance with requirement of standards. Reflection of surrounding objects is minimized and in compliance with requirement of standards.	

2.8. Main Test Instruments

Item	Equipment	Manufacturer	Model	Serial No.	Cal. Date	Cal. Interval
1	DASY5	Speag	DASY 5 (Version 52.10.4.1535)	N/A	N/A	N/A
2	Data Acquisition Electronics	Speag	DAE4	1486	May. 16, 2024	1 Year
3	E-field Probe	Speag	EX3DV4	7369	Jun. 3, 2024	1 Year
4	System Validation Dipole	Speag	D2450V2	973	Feb. 19, 2024	3 Year
5	ELI4 Phantom	Speag	ELI4 Phantom V5.0	1240	N/A	N/A
6	Vector network analyzer	Keysight	P5007A	MY58100505	Feb. 25, 2025	1 Year
7	RF and Microwave Signal Generator	R&S	SMB100A	113244	Jun. 18, 2024	1 Year
8	Spectrum Analyzer	R&S	FSV7	103032	Aug. 7, 2024	1 Year
9	Power Meter	Anritsu	ML2495A	1128008	May. 11, 2024	1 Year
10	Power Sensor	Anritsu	MA2411B	1126001	May. 11, 2024	1 Year
11	Dielectric Probe Kit	Agilent	85070E	2593	N/A	N/A
12	Power Amplifier	EMCI	EMC053035	980869	N/A	N/A
13	Thermometer	Kolin	KGM-DLB03	01	Oct. 18, 2024	1 Year
14	Directional Coupler	Woken	50W Coupler	DOM5CIW3E2	N/A	N/A
15	Attenuator	Woken	WATT-518FS-10	N/A	N/A	N/A

Remark: "N/A" denotes no model name, serial No. or calibration specified.

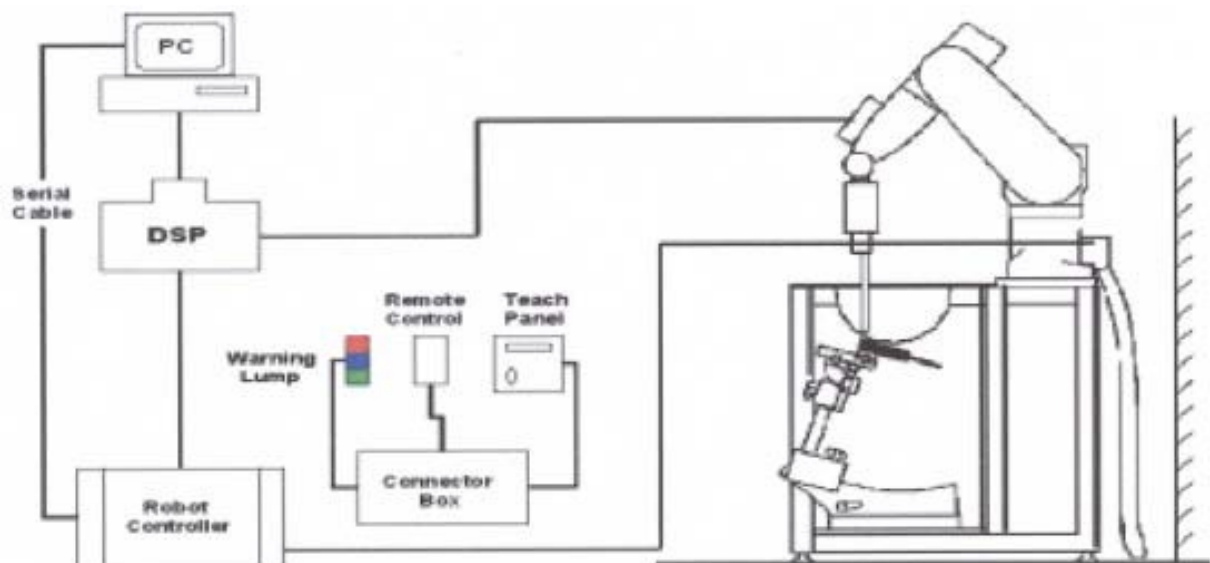
3. SAR MEASUREMENTS SYSTEM CONFIGURATION

3.1. SAR Measurement Setup

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

1. A standard high precision 6-axis robot (Stäubli RX family) with controller and software. An arm extension for accommodating the data acquisition electronics (DAE).
2. A dosimetric probe, i.e. an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.
3. A data acquisition electronic (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
4. A unit to operate the optical surface detector which is connected to the EOC.
5. The Electro-Optical Coupler (EOC) performs the conversion from the optical into a digital electric signal of the DAE. The EOC is connected to the DASY5 measurement server.
6. The DASY5 measurement server, which performs all real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operation. A computer operating Windows.
7. DASY5 software and SEMCAD data evaluation software.
8. Remote control with teach panel and additional circuitry for robot safety such as warning lamps, etc.
9. The generic twin phantom enabling the testing of left-hand and right-hand usage.
10. The device holder for handheld mobile phones.
11. Tissue simulating liquid mixed according to the given recipes.
12. System validation dipoles allowing to validate the proper functioning of the system.

3.1.1. TEST SETUP LAYOUT

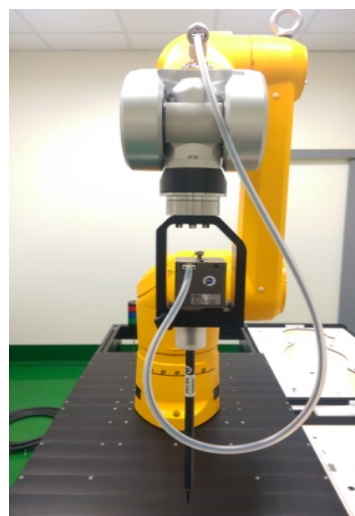


3.2. DASY5 E-field Probe System

The SAR measurements were conducted with the dosimetric probe EX3DV4 (manufactured by SPEAG), designed in the classical triangular configuration and optimized for dosimetric evaluation.

3.2.1. EX3DV4 PROBE SPECIFICATION

Construction	Symmetrical design with triangular core Interleaved sensors Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Calibration	ISO/IEC 17025 calibration service available
Frequency	10 MHz to 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz)
Directivity	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)
Dynamic Range	10 μ W/g to > 100 mW/g Linearity: ± 0.2 dB
Dimensions	Overall length: 330 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Distance from probe tip to dipole centers: 1.0 mm



EX3DV4 E-field Probe

3.2.2. E-FIELD PROBE CALIBRATION

Each probe is calibrated according to a dosimetric assessment procedure with accuracy better than $\pm 10\%$. The spherical isotropy was evaluated and found to be better than $\pm 0.25\text{dB}$. The sensitivity parameters (NormX, NormY, NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe are tested.

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies below 1 GHz, and in a wave guide 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.

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

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

Where: Δt = Exposure time (30 seconds),

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

ΔT = Temperature increase due to RF exposure.

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

Where: σ = Simulated tissue conductivity,

ρ = Tissue density (kg/m^3).

3.2.3. OTHER TEST EQUIPMENT

3.2.3.1. DEVICE HOLDER FOR TRANSMITTERS

Construction: Simple but effective and easy-to-use extension for Mounting Device that facilitates the testing of larger devices according to IEC 62209-2 (e.g., laptops, cameras, etc.) It is lightweight and fits easily on the upper part of the Mounting Device in place of the phone positioner. The extension is fully compatible with the Twin SAM, ELI4 and SAM v6.0 Phantoms.

Material: POM, Acrylic glass, Foam

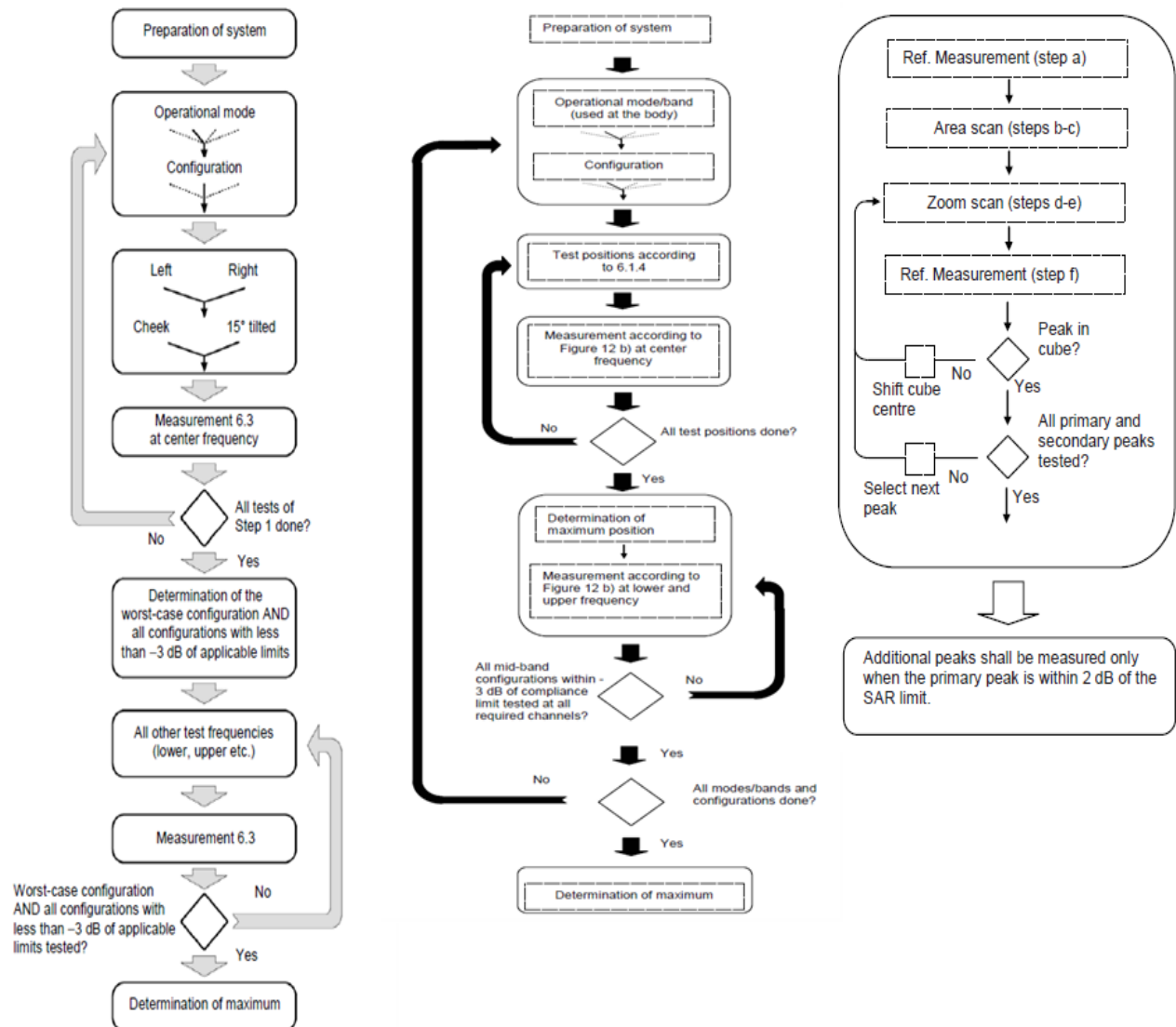
3.2.3.2. PHANTOM

Model	ELI4 Phantom	
Construction	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±0.1 mm	
Filling Volume	Approx. 30 liters	
Dimensions	Length: 600 mm ; Width: 190mm Height: adjustable feet	
Available	Special	

Model	Twin SAM	
Construction	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209-1. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot.	
Shell Thickness	2 ± 0.2 mm	
Filling Volume	Approx. 25 liters	
Dimensions	Length:1000mm; Width: 500mm Height: adjustable feet	
Available	Special	

3.2.4. SCANNING PROCEDURE

The SAR test against the head and body-worn phantom was carried out as follow:



After an area scan has been done at a fixed distance of 1.4mm from the surface of the phantom on the source side, a 3D scan is set up around the location of the maximum spot SAR. First, a point within the scan area is visited by the probe and a SAR reading taken at the start of testing. At the end of testing, the probe is returned to the same point and a second reading is taken. Comparison between these start and end readings enables the power drift during measurement to be assessed.

Above is the scanning procedure flow chart and table from the IEEE1528 standard.

This is the procedure for which all compliant testing should be carried out to ensure that all variations of the device position and transmission behavior are tested.

3.2.5. DATA STORAGE AND EVALUATION

3.2.5.1. 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 setup, 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 lossless media will always be zero. Raw data can also be exported to perform the evaluation with other software packages.

3.2.6. 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	$\text{Norm}_i, a_{i0}, a_{i1}, a_{i2}$
	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:

$$V_i = U_i + U_i^2 \cdot cf / dcp_i$$

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

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

$$\text{E-field probes: } E_i = (V_i / \text{Norm}_i \cdot \text{ConvF})^{1/2}$$

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

With V_i = compensated signal of channel i ($i = x, y, z$)

Norm_i = sensor sensitivity of channel i ($i = x, y, z$)
[mV/(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 RSS value of the field components gives the total field strength (Hermitian magnitude):

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

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

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

With SAR = local specific absorption rate in mW/g

E_{tot} = total field strength in V/m
= conductivity in [mho/m] or [Siemens/m]
= equivalent tissue density in g/cm³

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.

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

With P_{pwe} = equivalent power density of a plane wave in mW/cm²

E_{tot} = total field strength in V/m

H_{tot} = total magnetic field strength in A/m

4. TISSUE-EQUIVALENT LIQUID

4.1. Tissue-equivalent Liquid Ingredients

The liquid is consisted of water, salt and Glycol, Sugar, Preventol and Cellulose. The liquid has previously been proven to be suited for worst-case. The measured conductivity and relative permittivity should be within $\pm 5\%$ of the target values. The below table shows the detail solution. It's satisfying the latest tissue dielectric parameters requirements proposed by the IEC 62209.

Composition of the Tissue Equivalent Matter

Tissue Type	Bactericide	DGBE	HEC	NaCl	Sucrose	Triton X-100	Water	Diethylene Glycol Mono-hexylether	Oxidized Mineral Oil
Head 2450	-	45.0	-	0.1	-	-	54.9	-	-

4.2. Tissue-equivalent Liquid Properties

Dielectric Performance of Tissue Simulating Liquid

Tissue Verification									
Date	Tissue Type	Frequency (MHz)	Conductivity (σ)	Permittivity (ϵ_r)	Targeted Conductivity (σ)	Targeted Permittivity (ϵ_r)	Deviation Conductivity (σ) (%)	Deviation Permittivity (ϵ_r) (%)	Limit (%) ± 5
2025/3/18	Head	2450	1.79	38.05	1.80	39.20	-0.61	-2.94	± 5

Note:

1. The dielectric parameters of the tissue-equivalent liquid should be measured under similar ambient conditions and within 2 °C of the conditions expected during the SAR evaluation to satisfy protocol requirements.
2. KDB 865664 was ensured to be applied for probe calibration frequencies greater than or equal to 50MHz of the EUT frequencies.
3. The above measured tissue parameters were used in the DASY software to perform interpolation via the DASY software to determine actual dielectric parameters at the test frequencies. The SAR test plots may slightly differ from the table above since the DASY rounds to three significant digits.
4. According to FCC TCB workshop April, 2019 RF Exposure Procedures Update(Effective February 19,2019, FCC has permitted the use of single head-tissue simulating liquid specified in IEEE 62209-1- for all SAR tests.

5. SYSTEM CHECK

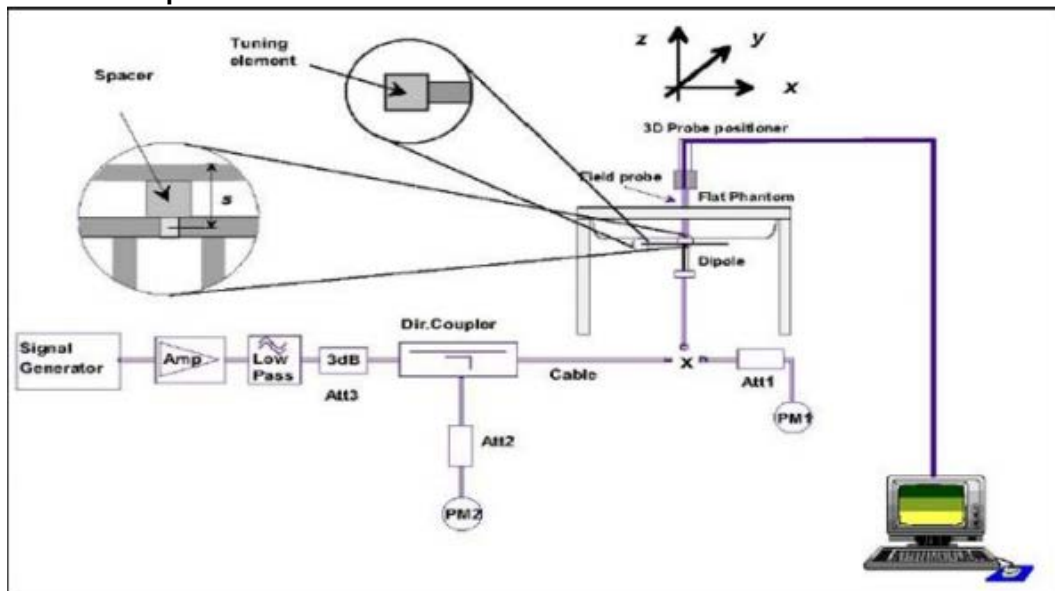
5.1. Description of System Check

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 (below 3GHz) or 100mW (3-6GHz), 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 6.2.

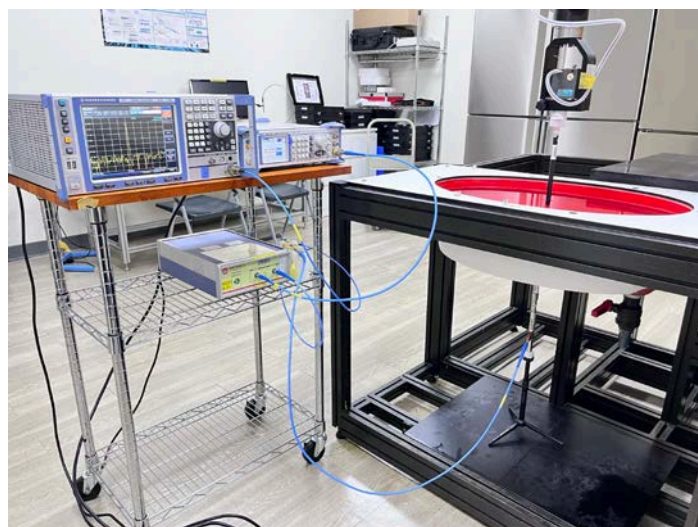
System check results have to be equal or near the values determined during dipole calibration with the relevant liquids and test system ($\pm 10\%$).

System check is performed regularly on all frequency bands where tests are performed with the DASY5 system.

System Check Set-up



System Check photo



5.2. Description of System Check

System Check in Tissue Simulating Liquid

The system check is performed for verifying the accuracy of the complete measurement system and performance of the software. The system check is performed with tissue equivalent material according to IEEE P1528 (described above). The following table shows system check results for all frequency bands and tissue liquids used during the tests.

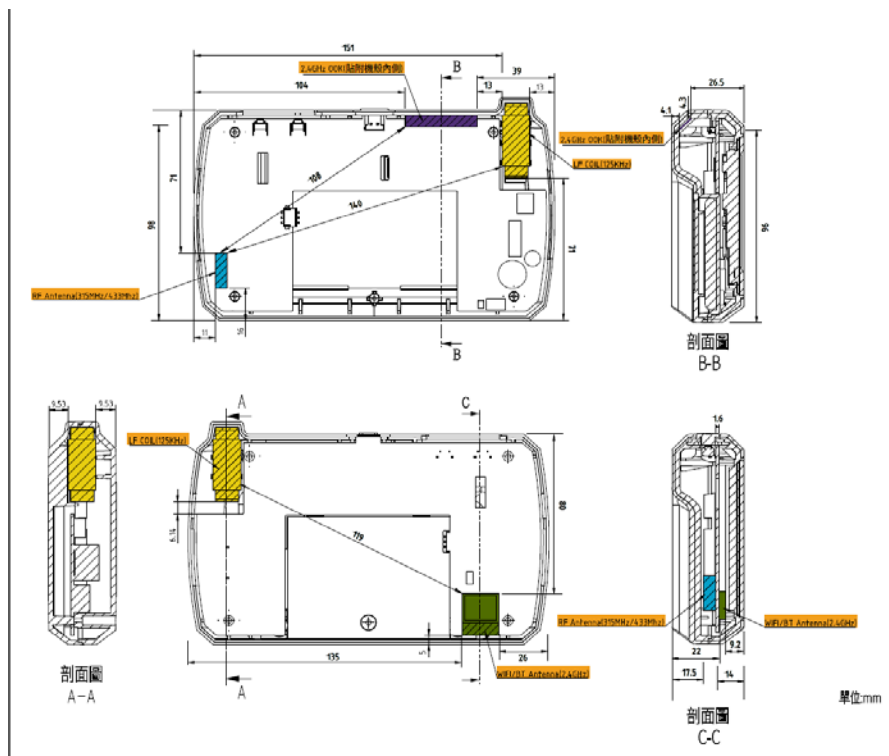
Date	System Dipole			Target 1g [W/kg]	Measured 1g [W/kg]	Normalized to 1W 10g[W/kg]	Deviation [%]	Limited [%]
	Type	Serial No.	Liquid					
2025/3/18	D2450V2	973	Head	52.90	13.20	52.80	-0.19	± 10

6. OPERATIONAL CONDITIONS DURING TEST

6.1. General Description of Test Procedures

Connection to the EUT is established via air interface with base station An, and the EUT is Set to maximum output power by base station. The EUT battery must be fully charged and checked periodically during the test to ascertain uniform power output. The antenna connected to the output of the base station simulator shall be placed at least 50cm away from the EUT. The signal transmitted by the simulator to the antenna feeding point shall be lower than the output power level of the EUT by at least 30dB.

6.2. Test position Antenna Location



6.3 Test Position of Portable Devices

Antenna	Position	Distance(mm)	Evaluation
BLE	Rear	22	Yes
	Edge1	80	No
	Edge2	135	No
	Edge3	5	Yes
	Edge4	26	No
2.4G OOK	Rear	4.1	Yes
	Edge1	4.3	Yes
	Edge2	104	No
	Edge3	98	No
	Edge4	39	No
WIFI 2.4G	Rear	22	Yes
	Edge1	80	No
	Edge2	135	No
	Edge3	5	Yes
	Edge4	26	No

Note :

1. The distance of the positions to edge which more than 25mm are not required to test.

7.SAR MEASUREMENT VARIABILITY AND UNCERTAINTY

7.1. SAR MEASUREMENT VARIABILITY

Per KDB865664 D01 SAR measurement 100 MHz to 6 GHz, SAR measurement variability must be assessed for each frequency band, which is determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. The additional measurements are repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device should be returned to ambient conditions (normal room temperature) with the battery fully charged before it is re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

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 .

The same procedures should be adapted for measurements according to extremity and occupational exposure limits by applying a factor of 2.5 for extremity exposure and a factor of 5 for occupational exposure to the corresponding SAR thresholds.

The detailed repeated measurement results are shown in Section 9.

7.2. WIFI Test Configuration

For WLAN SAR testing, WLAN engineering testing software installed on the DUT can provide continuous transmitting RF signal.

Wi-Fi 2.4GHz Band

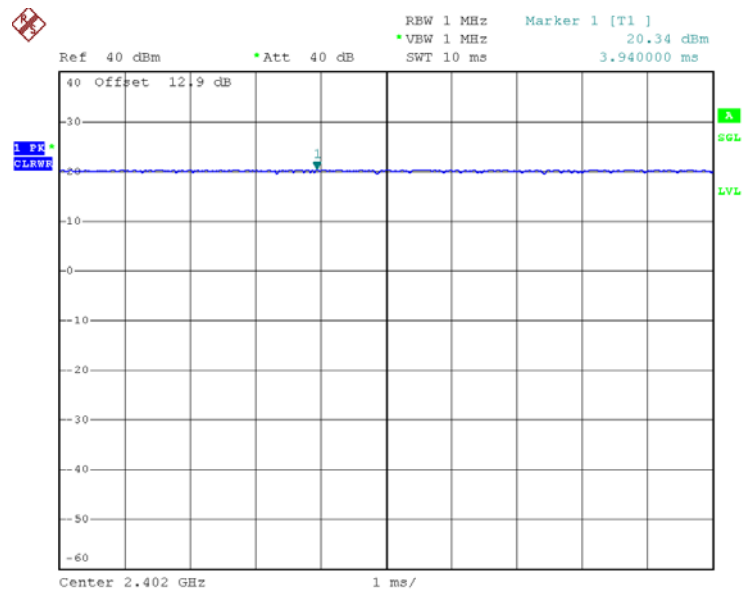
Mode	802.11b	802.11g	802.11n20	802.11n40
Duty cycle	100%			
Crest factor	1			

For WiFi SAR testing, 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. The RF signal utilized in SAR measurement has 100% duty cycle and its crest factor is 1. The test procedures in KDB 248227 D01 are applied.

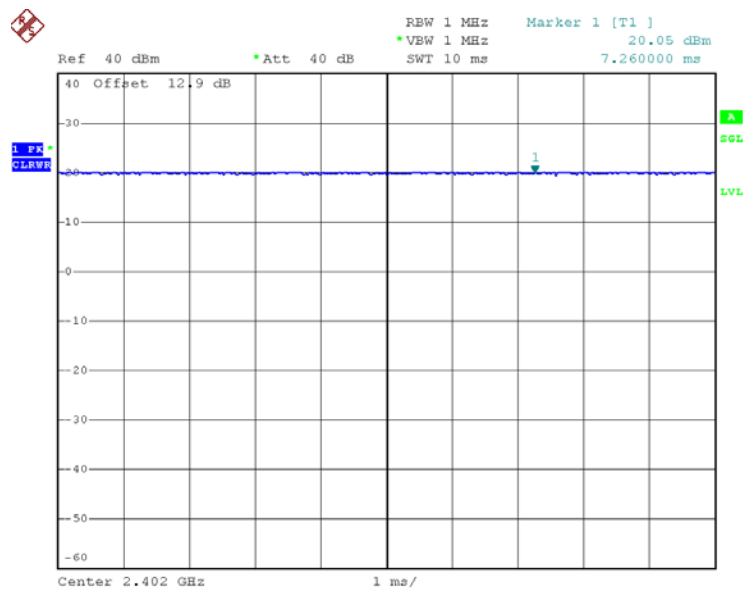
7.3. TEST CONFIGURATION

Mode	BLE 1M	BLE 2M	2.4G OOK
Duty cycle	100.00%	100.00%	51.13%
Duty factor	1.00	1.00	1.96

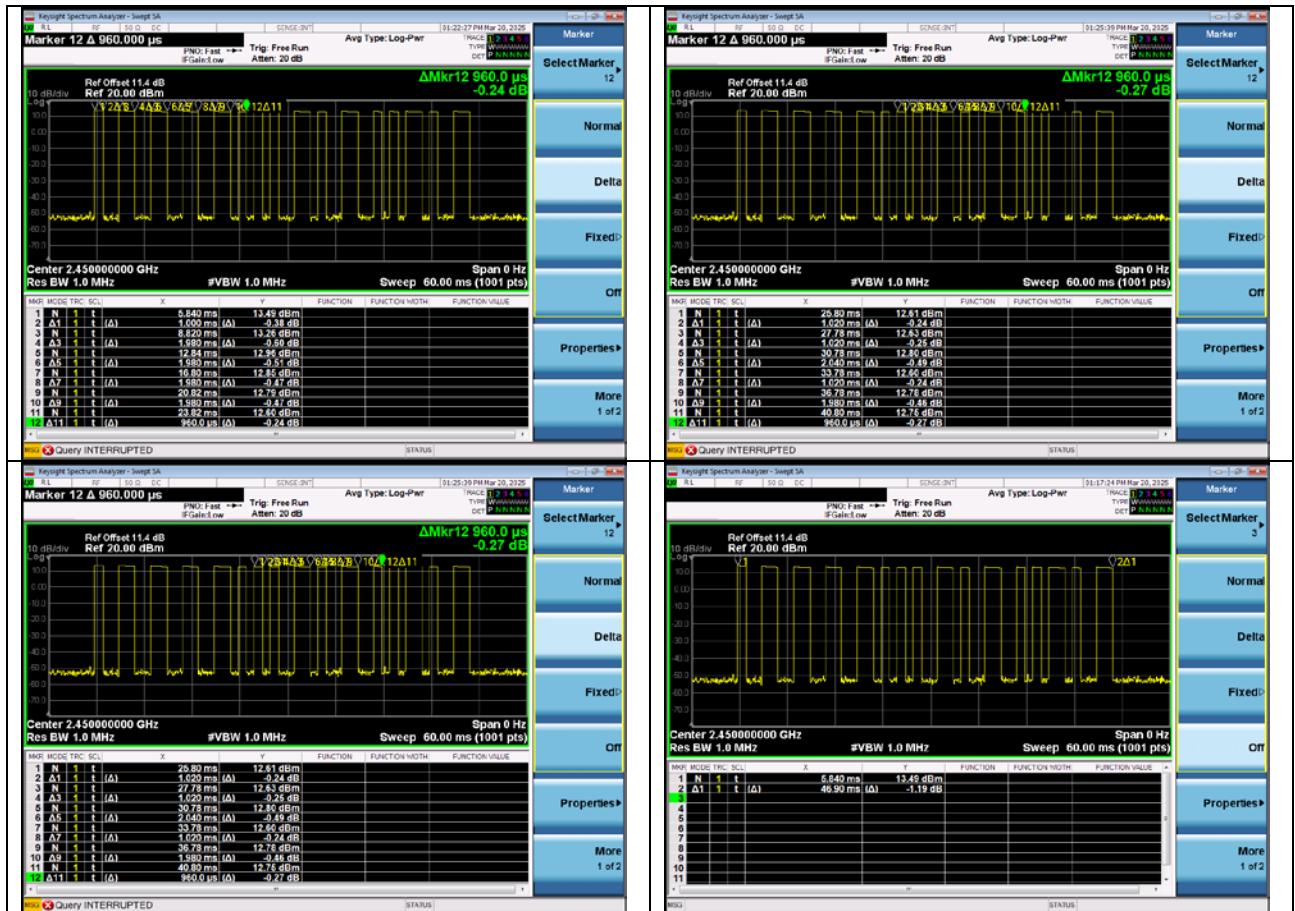
BLE_1M



BLE_2M



2.4G OOK



7.4. WLAN 2.4G SAR Test Requirements

802.11b DSSS SAR Test Requirements

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

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

2.4 GHz 802.11g/n OFDM SAR Test Exclusion Requirements

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

- 1) When KDB Publication 447498 SAR test exclusion applies to the OFDM configuration.
- 2) When the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg.

SAR Test Requirements for OFDM configurations

When SAR measurement is required for 2.4 GHz 802.11g/n OFDM configurations, each standalone and frequency aggregated band is considered separately for SAR test reduction. In applying the initial test configuration and subsequent test configuration procedures, the 802.11 transmission configuration with the highest specified maximum output power and the channel within a test configuration with the highest measured maximum output power should be clearly distinguished to apply the procedures.

7.5. OFDM TRANSMISSION MODE AND SAR TEST CHANNEL SELECTION

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

7.6. INITIAL TEST CONFIGURATION PROCEDURE

For OFDM, in both 2.4G and 5GHz bands, an initial test configuration is determined for each frequency band and aggregated band, according to the transmission mode with the highest maximum output power specified for SAR measurements. When the same maximum output power is specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration(s) with the largest channel bandwidth, lowest order modulation, and lowest data rate. If the average RF output powers of the highest identical transmission modes are within 0.25 dB of each other, mid channel of the transmission mode with highest average RF output powers is the initial test channel. Otherwise, the channel of the transmission mode with the highest average RF output power will be the initial test configuration. When the reported SAR is ≤ 0.8 W/kg, no additional measurements on other test channels are required. Otherwise, SAR is evaluated using the subsequent highest average RF output channel until the reported SAR result is ≤ 1.2 W/kg or all channels are measured. When there are multiple untested channels having the same subsequent highest average RF output power, the channel with higher frequency from the lowest 802.11 mode is considered for SAR measurement.

8. CONDUCTED POWER RESULTS

8.1. Conducted power measurementS of Bluetooth

Band	Mode	Channel	Frequency (MHz)	Max Power (dBm)	AVG Power (dBm)
BLE	1M	0	2402	18.50	18.48
		19	2440	19.00	18.77
		39	2480	19.00	18.86
BLE	2M	0	2402	18.50	18.32
		19	2440	19.00	18.86
		39	2480	19.00	18.92

8.2. Conducted power measurements of 2.4G OOK

Band	Mode	Channel	Frequency (MHz)	Max Power (dBm)	AVG Power (dBm)
2.4G	OOK	1	2450	-7.50	-7.95

8.3. Conducted power measurements of Wi-Fi 2.4GHz Band

Band	Mode	Channel	Frequency (MHz)	Data Rate	Max Tune-Up Power (dBm)	AVG Power (dBm)
2.4G	802.11b	1	2412	1	17.50	17.47
		6	2437		18.00	17.56
		11	2462		18.00	17.64
	802.11g	1	2412	6	16.50	16.50
		6	2437		17.00	16.67
		11	2462		17.00	16.70
	802.11 n20	1	2412	HT0	15.50	15.50
		6	2437		16.00	15.74
		11	2462		16.00	15.73
	802.11 n40	3	2422	HT0	15.50	15.37
		6	2437		15.50	15.31
		9	2452		15.50	15.51

Note:

1. As per FCC OET KDB 248227 D01, conducted output power and SAR testing are not required for 802.11g/n20 channels when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is $\leq 1.2\text{W/kg}$.

8.4. SAR TEST RESULTS

General Notes:

1. Per KDB447498 D04, all measurement SAR results are scaled to the maximum tune-up tolerance limit to demonstrate compliant.
2. Per KDB447498 D04, testing of other required channels within the operating mode of a frequency band is not required when the reported 1-g or 10-g SAR for the mid-band or highest output power channel is: ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz. When the maximum output power variation across the required test channels is $> \frac{1}{2}$ dB, instead of the middle channel, the highest output power channel must be used.
3. Per KDB865664 D01, for each frequency band, repeated SAR measurement is required only when the measured SAR is ≥ 0.8 W/kg; if the deviation among the repeated measurement is $\leq 20\%$, and the measured SAR < 1.45 W/kg, only one repeated measurement is required.

WLAN Notes:

1. For exposure conditions with multiple test positions, such as handset operating next to the ear, devices with hotspot mode, procedures for initial test position can be applied. Using the transmission mode determined by the DSSS procedure or initial test configuration, area scans are measured for all positions in an exposure condition. The test position with the highest extrapolated (peak) SAR is used as the initial test position. When the reported SAR of the initial test position is ≤ 0.4 W/kg, further SAR measurement is not required for the other (remaining) test positions. Otherwise, SAR is evaluated at the subsequent highest peak SAR position until the reported SAR result is ≤ 0.8 W/kg or all test positions are measured.
2. Justification for test configurations for WLAN per KDB Publication 248227 for 2.4GHz WIFI single transmission chain operations, the highest measured maximum output power Channel for DSSS was selected for SAR measurement. SAR for OFDM modes (2.4GHz 802.11g/n) was not required due to the maximum allowed powers and the highest reported DSSS SAR. See Section 7.1.4 for more information.
3. Justification for test configurations for WLAN per KDB Publication 248227 for 5GHz WIFI single transmission chain operations, the initial test configuration was selected according to the transmission mode with the highest maximum allowed power. Other transmission mode was not investigated since the highest reported SAR for initial test configuration adjusted by the ratio of maximum output powers is less than 1.2W/kg. See Section 7.1.4 for more information.

9. SAR TEST RESULTS

9.1. Body SAR test results

SAR test results of Bluetooth

Mode	Channel	Test Position	Distance (mm)	Max Tune-up (dBm)	AVG Power (dBm)	SAR 1g	Duty Cycle %	Duty Factor	Reported SAR 1g
BLE_2M	39	Rear	0	19.00	18.92	0.089	100.00%	1.00	0.091
	39	Edge3	0	19.00	18.92	0.150	100.00%	1.00	0.153
	0	Edge3	0	18.50	18.32	0.246	100.00%	1.00	0.256
	19	Edge3	0	19.00	18.86	0.231	100.00%	1.00	0.239

SAR test results of 2.4G OOK

Mode	Channel	Test Position	Distance (mm)	Max Tune-up (dBm)	AVG Power (dBm)	SAR 1g	Duty Cycle %	Duty Factor	Reported SAR 1g
2.4G OOK	1	Rear	0	-7.50	-7.95	0.158	51.13%	1.96	0.343
	1	Edge1	0	-7.50	-7.95	0.178	51.13%	1.96	0.386

SAR test results of 2.4G WiFi

Mode	Channel	Test Position	Distance (mm)	Max Tune-up (dBm)	AVG Power (dBm)	SAR 1g	Reported SAR 1g
802.11b	11	Rear	0	18.00	17.64	0.060	0.065
	11	Edge3	0	18.00	17.64	0.122	0.133
	1	Edge3	0	17.50	17.47	0.142	0.143
	6	Edge3	0	18.00	17.56	0.129	0.143

10. SIMULTANEOUS TRANSMISSION CONDITIONS

10.1. STAND-ALONE SAR TEST EXCLUSION

SAR compliance for simultaneous transmission must be considered when the maximum duration of overlapping transmissions, including network hand-offs, is greater than 30 seconds. This device contains multiple transmitters that may operate simultaneously, and therefore requires a simultaneous transmission analysis.

The Simultaneous Transmission Possibilities of this device are as below:

No.	Configuration	Body
1	WiFi 2.4G(Main) + 2.4G OOK(Main)	Yes
2	BT(Main) + 2.4G OOK(Main)	Yes

10.2. SIMULTANEOUS TRANSMISSION CONDITIONS

KDB 447498 D04 General RF Exposure Guidance v01, introduces a new formula for calculating the SAR to Peak Location Ratio (SPLSR) between pairs of simultaneously transmitting antennas:

$$SPLSR = (SAR_1 + SAR_2)^{1.5} / R_i$$

Where:

SAR₁ is the highest Reported or estimated SAR for the first of a pair of simultaneous transmitting antennas, in a specific test operating mode and exposure condition

SAR₂ is the highest Reported or estimated SAR for the second of a pair of simultaneous transmitting antennas, in the same test operating mode and exposure condition as the first

R_i is the separation distance between the pair of simultaneous transmitting antennas. When the SAR is measured, for both antennas in the pair, it is determined by the actual x, y and z coordinates in the 1-g SAR for each SAR peak location, based on the extrapolated and interpolated result in the zoom scan measurement, using the formula of $[(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2]$

A new threshold of 0.04 is also introduced in the KDB. Thus, in order for a pair of simultaneous transmitting antennas with the sum of 1-g SAR > 1.6 W/kg to qualify for exemption from Simultaneous Transmission SAR measurements, it has to satisfy the condition of:

$$(SAR_1 + SAR_2)^{1.5} / R_i \leq 0.04$$

10.3. About BT/WiFi

Test Position SAR _{1g} (W/kg)	Edge1	Edge3	Rear
2.4G WiFi_Main		0.143	0.065
2.4G OOK_Main	0.386		0.343
BT		0.256	0.091
WLAN_Main + 2.4G OOK_Main MAX Σ SAR _{1g}	0.386	0.143	0.408
BT_Main + 2.4G OOK_Main MAX Σ SAR _{1g}	0.386	0.256	0.434

Note:

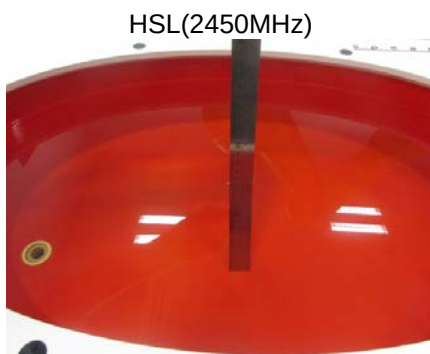
1. MAX. Σ SAR_{1g} = 0.434 W/Kg < 1.6 W/Kg, so Peak location SAR are not required.

11. TEST LAYOUT

Specific Absorption Rate Test Layout



Liquid depth in the flat Phantom ($\geq 15\text{cm}$ depth)



Appendix A. SAR Plots of System Verification

(Pls See BTL-FCC SAR-1-2502T052_Appendix A.)

Appendix B. SAR Plots of SAR Measurement

(Pls See BTL-FCC SAR-1-2502T052_Appendix B.)

Appendix C. Calibration Certificate

(Pls See BTL-FCC SAR-1-2502T052_Appendix C.)

Appendix D. Photographs of the Test Set-Up

(Pls See BTL-FCC SAR-1-2502T052_Appendix D.)

End of Test Report