SAR Test Report

Test Report No.: 14993588H-A

Customer	**Panasonic Corporation of North America**
Description of EUT	**Wireless Module** **(Tested inside of Panasonic Personal Computer FZ-40)**
Model Number of EUT	**WW21A**
FCC ID	**ACJ9TGWW21A**
Test Regulation	**FCC47CFR 2.1093**
Test Result	**Complied**
Issue Date	**March 26, 2024**
Remarks	***For Permissive Change** **The highest reported value** Body: 0.06 W/kg$_{1g}$ Limbs: 0.31 W/kg$_{10g}$ Simultaneous Transmission (Body): 1.52 W/kg$_{1g}$ Simultaneous Transmission (Limbs): 3.88 W/kg$_{10g}$

Representative test engineer	**Approved by**
Tomohisa Nakagawa Engineer	Takayuki Shimada Leader

CERTIFICATE 5107.02

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REVISION HISTORY

Original Test Report No. 14993588H-A

Revision	Test report No.	Date	Page Revised Contents
- (Original)	14993588H-A	March 26, 2024	-

Reference: Abbreviations (Including words undescribed in this report)

AAN	Asymmetric Artificial Network	GPS	Global Positioning System
AC	Alternating Current	Hori.	Horizontal
AM	Amplitude Modulation	ICES	Interference-Causing Equipment Standard
AMN	Artificial Mains Network	I/O	Input/Output
Amp, AMP	Amplifier	IEC	International Electrotechnical Commission
ANSI	American National Standards Institute	IEEE	Institute of Electrical and Electronics Engineers
Ant, ANT	Antenna	IF	Intermediate Frequency
AP	Access Point	ILAC	International Laboratory Accreditation Conference
ASK	Amplitude Shift Keying	ISED	Innovation, Science and Economic Development Canada
Atten., ATT	Attenuator	ISN	Impedance Stabilization Network
AV	Average	ISO	International Organization for Standardization
BPSK	Binary Phase-Shift Keying	JAB	Japan Accreditation Board
BR	Bluetooth Basic Rate	LAN	Local Area Network
BT	Bluetooth	LCL	Longitudinal Conversion Loss
BT LE	Bluetooth Low Energy	LIMS	Laboratory Information Management System
BW	BandWidth	LISN	Line Impedance Stabilization Network
C.F	Correction Factor	MRA	Mutual Recognition Arrangement
Cal Int	Calibration Interval	N/A	Not Applicable
CAV	CISPR AV	NIST	National Institute of Standards and Technology
CCK	Complementary Code Keying	NS	No signal detect.
CDN	Coupling Decoupling Network	NSA	Normalized Site Attenuation
Ch., CH	Channel	OBW	Occupied BandWidth
CISPR	Comite International Special des Perturbations Radioelectriques	OFDM	Orthogonal Frequency Division Multiplexing
Corr.	Correction	PER	Packet Error Rate
CPE	Customer premise equipment	PK	Peak
CW	Continuous Wave	P_{LT}	long-term flicker severity
DBPSK	Differential BPSK	POHC(A)	Partial Odd Harmonic Current
DC	Direct Current	Pol., Pola.	Polarization
DET	Detector	PR-ASK	Phase Reversal ASK
D-factor	Distance factor	P_{ST}	short-term flicker severity
Dmax	maximum absolute voltage change during an observation period	QAM	Quadrature Amplitude Modulation
DQPSK	Differential QPSK	QP	Quasi-Peak
DSSS	Direct Sequence Spread Spectrum	QPSK	Quadrature Phase Shift Keying
DUT	Device Under Test	r.m.s., RMS	Root Mean Square
EDR	Enhanced Data Rate	RBW	Resolution BandWidth
e.i.r.p., EIRP	Equivalent Isotropically Radiated Power	RE	Radio Equipment
EM clamp	Electromagnetic clamp	REV	Reverse
EMC	ElectroMagnetic Compatibility	RF	Radio Frequency
EMI	ElectroMagnetic Interference	RFID	Radio Frequency Identifier
EMS	ElectroMagnetic Susceptibility	RNSS	Radio Navigation Satellite Service
EN	European Norm	RSS	Radio Standards Specifications
e.r.p., ERP	Effective Radiated Power	Rx	Receiving
ETSI	European Telecommunications Standards Institute	SINAD	Ratio of (Signal + Noise + Distortion) to (Noise + Distortion)
EU	European Union	S/N	Signal to Noise ratio
EUT	Equipment Under Test	SA, S/A	Spectrum Analyzer
Fac.	Factor	SG	Signal Generator
FCC	Federal Communications Commission	SVSWR	Site-Voltage Standing Wave Ratio
FHSS	Frequency Hopping Spread Spectrum	THC(A)	Total Harmonic Current
FM	Frequency Modulation	THD(%)	Total Harmonic Distortion
Freq.	Frequency	TR, T/R	Test Receiver
FSK	Frequency Shift Keying	Tx	Transmitting
Fund	Fundamental	VBW	Video BandWidth
FWD	Forward	Vert.	Vertical
GFSK	Gaussian Frequency-Shift Keying	WLAN	Wireless LAN
GNSS	Global Navigation Satellite System	xDSL	Generic term for all types of DSL technology
			(DSL: Digital Subscriber Line)

Contents

SECTION 0: Introduction

Purpose of this report is for assessment which is only for replaced the simultaneously transmission WLAN module. This WWAN module has Time-averaging SAR functionality (TAS) described in test report issued by UL Japan, which is not affected to TAS assessment by the change in the WLAN module.

Table. 1 WWAN original certification number

FCC ID	ACJ9TGWW21A	Report number	14131461H-A, B, C 14809943H-A, B, C
ISED certification number	216H-CFWW21A	Report number	14131461H-D, E, F
			respectively part 0,1,2

SECTION 1: Customer information

Company Name	Panasonic Corporation of North America
Address	Two Riverfront Plaza, Newark, New Jersey, 07102-5490, USA
Telephone Number	+1-201-348-7760
Contact Person	Ben Botros

*Remarks:
Panasonic Connect Co., Ltd. is on behalf of the applicator: Panasonic Corporation of North America (Company incorporated abroad).

The information provided by the customer is as follows;
- Customer, Description of EUT, Model No., FCC ID on the cover and other relevant pages
- Operating/Test Mode(s) (Mode(s)) on all the relevant pages
- SECTION 1: Customer information
- SECTION 2: Equipment under test (EUT) other than the Receipt Date
- SECTION 6: WWAN exposure level
- SECTION 7: Tune-up tolerance information and software information

SECTION 2: Equipment under test (EUT)

2.1 Identification of EUT

Description	Wireless Module
Model Number	WW21A
Serial number	356952940170584
Condition	Engineering prototype (Not for Sale: This sample is equivalent to mass-produced items.)
Modification	No Modification by the test lab.
Receipt Date	December 8, 2023
Test Date	December 13, 2023 to March 1, 2024

<Information of Host device>

Type of Equipment	Personal Computer
Model No.	FZ-40
Serial No.	3KTSA00019
Remarks	Intel Core Ultra 5 processor 135H (up to 4.6 GHz), 14 core / 18 thread 14-inch LCD (1920 x 1080)

2.2 Product description

General Specification

Rating	DC 3.0 to 3.6 V
Body-worn accessory	N/A

Radio Specification

Model: WW21A is a Wireless Module. In this test report, referred to as the *5G module*.

Wireless technologies	Dup.	Band		Mode
WCDMA	FDD		2	UMTS Rel. 99 (Data) HSDPA (Rel. 5)
	FDD		4	HSUPA (Rel. 6), HSPA+ (Rel. 7), DC-HSDPA (Rel. 8)
	FDD		5	
LTE	FDD		2	QPSK, 16QAM, 64AQM, 256QAM
	FDD		4	
	FDD		5	Downlink MIMO Support: Yes(2x2, 4x4)
*B42: not used in US (FCC)	FDD		7	Supported band : B2, B4, B7, B25, B38, B41, B42, B48, B66
	FDD		12	
*B48: not used in	FDD		13	Uplink MIMO Support: No
Canada(ISED)	FDD		14	Uplink transmission is limited to a single output stream.
	FDD		17	
	FDD		25	
	FDD		26	
	FDD(Rx only)		29	
	TDD		38	
	TDD		41	
	TDD		42	
	TDD(Rx only)		46	
	TDD		48	
	FDD		66	
	FDD		71	
LTE CA	Downlink			Uplink *B42: not used in US (FCC) / B48: not used in Canada(ISED)
	Maximum 7 carriers			Maximum 2 carriers Supported combination: <Inrta-band contiguous> 7C, 41C, 42C, 48C <Inter-band>2A-5A, 2A-12A, 2A-13A, 4A-5A, 4A-12A, 4A-13A, 5A-7A,5A-66A, 12A-66A, 13A-66A
5G NR (FR1)	FDD	15 kHz	n2	Pi/2 BPSK (DFT-s-OFDM),
	FDD	15 kHz	n5	QPSK (CP-OFDM/DFT-s-OFDM),
*n78: not used in US (FCC)	TDD	15 kHz	n41	16QAM (CP-OFDM/DFT-s-OFDM),
	FDD	15 kHz	n66	64QAM (CP-OFDM/DFT-s-OFDM),
	FDD	15 kHz	n71	256QAM (CP-OFDM/DFT-s-OFDM)
	TDD	30 kHz	n77	Downlink MIMO Support: Yes(2x2, 4x4)
	TDD	30 kHz	n78	Supported band : n2, n41, n66, n77, n78
	-	-	-	Uplink MIMO Support: No
	-	-	-	Uplink transmission is limited to a single output stream.
EN-DC(LTE-FR1 Sub6)	Supported combination			*n78: not used in US (FCC)
(NSA mode only)	LTE Anchor Bands for NR band n2			LTE Band 5/12/13
	LTE Anchor Bands for NR band n5			LTE Band 2/7/66
	LTE Anchor Bands for NR band n41			LTE Band 2/25/26/66
	LTE Anchor Bands for NR band n66			LTE Band 5/12/13/14/71
	LTE Anchor Bands for NR band n71			LTE Band 2/7/66
	LTE Anchor Bands for NR band n77			LTE Band 41
	LTE Anchor Bands for NR band n78*			LTE Band 2/5/7/12/38/66

Wireless module (Tested inside of Panasonic Personal Computer FZ-40)
Model: WL23B (FCC ID ACJ9TGWL23B / ISED certification number 216H-CFWL23B)

Band & Mode	Operating Mode	Tx Frequency
WLAN 2.4 GHz	802.11b 802. 11g 802. 11n-20 802. 11ax-20 802. 11be-20	2412 MHz ~ 2472 MHz
WLAN 5 GHz	802. 11a 802. 11n-20 802. 11ac-20 802. 11ax-20 802. 11be-20	5180 MHz ~ 5240 MHz 5260 MHz ~ 5320 MHz 5500 MHz ~ 5720 MHz 5745 MHz ~ 5825 MHz 5825 MHz ~ 5895 MHz
WLAN 5 GHz	802. 11n-40 802. 11ac-40 802. 11ax-40 802. 11be-40	5190 MHz ~ 5230 MHz 5270 MHz ~ 5310 MHz 5510 MHz ~ 5710 MHz 5755 MHz ~ 5795 MHz 5835 MHz, 5875 MHz
WLAN 5 GHz	802. 11n-80 802. 11ac-80 802. 11ax-80 802. 11be-80	5210 MHz 5290 MHz 5530 MHz, 5690 MHz 5775 MHz 5855 MHz
WLAN 5 GHz	802. 11ac-160 802. 11ax-160 802. 11be-160	5250 MHz 5570 MHz
WLAN 6 GHz	802. 11ax-20 802. 11be-20	5950 MHz ~ 7125 MHz
WLAN 6 GHz	802. 11ax-40 802. 11be-40	5960 MHz ~ 7115 MHz
WLAN 6 GHz	802. 11ax-80 802. 11be-80	5985 MHz ~ 7025 MHz
WLAN 6 GHz	802. 11ax-160 802. 11be-160	6025 MHz ~ 6985 MHz

2.3 WWAN Antenna configuration

The 5G module antenna configuration consists below combination and supports Tx/Rx configurations.

WWAN Antennas	WWAN band	
	Tx	Rx
WWAN-Main	All bands except n41	All bands
WWAN-aux	-	All bands
WWAN-3rd	-	All bands
WWAN-4th	n41	All bands

The WWAN transmitter operates independently of the WLAN/BT wireless transmitter in the device, and it only supports data transmission.

WLAN/BT Antennas	WLAN	BT
WLAN-#1 (Main)	Y	N
WLAN-#2 (Aux)	Y	Y

SECTION 3: Test standard information

3.1 Test Specification

	Title	
☒	FCC47CFR 2.1093	RF Exposure Procedures and Equipment Authorization Policies for Portable Devices

3.2 Published RF exposure KDB procedures

	Name of documents	Title
☒	KDB 447498 D01(v06)	RF Exposure Procedures and Equipment Authorization Policies for Mobile and Portable Devices
☐	KDB 447498 D02(v02r01)	SAR Measurement Procedures for USB Dongle Transmitters
☐	KDB 648474 D04(v01r04)	SAR Evaluation Considerations for Wireless Handsets
☒	KDB 941225 D01(v03r01)	3G SAR Measurement Procedures
☒	KDB 941225 D05(v02r05)	SAR Evaluation Considerations for LTE Devices
☐	KDB 941225 D06(v02r01)	SAR Evaluation Procedures for Portable Devices with Wireless Router Capabilities
☐	KDB 941225 D07(v01r02)	SAR Evaluation Procedures for UMPC Mini-Tablet Devices
☒	KDB 616217 D04(v01r02)	SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers
☒	KDB 865664 D01(v01r04)	SAR Measurement Requirements for 100MHz to 6 GHz
☒	KDB 248227 D01(v02r02)	SAR Guidance for IEEE 802.11 (Wi-Fi) transmitters

3.3 Work Procedures

	Name of documents	Title or details
☒	C/N: Work Instructions-ULID-003598 Name:13-EM-W0429	UL Japan, Inc.'s SAR Work Procedures Procedure
☒	C/N: Work Instructions-ULID-003599 Name:13-EM-W0430	UL Japan, Inc.'s SAR Work Procedures Procedure
☒	C/N: Work Instructions-ULID-003619 Name: 13-EM-W0863	UL Japan, Inc.'s PD Work Procedures Procedure
☒	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.
☒	IEC/IEEE 63195-1:2021	Assessment of power density of human exposure to radio frequency fields from wireless devices in close proximity to the head and body (frequency range of 6 GHz to 300 GHz) - Part 1: Measurement procedure
☒	IEC/IEEE 63195-2:2021	Assessment of power density of human exposure to radio frequency fields from wireless devices in close proximity to the head and body (frequency range of 6 GHz to 300 GHz) - Part 2: Computational procedure

3.4 Additions or deviations to standard

No addition, exclusion nor deviation has been made from the standard.

3.5 References

[1] Schmid & Partner Engineering AG, DASY Manual
[2] IEC/IEEE 62209-1528 Edition 1.0 2020-10
[3] RF Exposure Policies and Procedures: TCB Workshop – October 2020

3.6 Additions or deviations to standard

Other than above, no addition, exclusion nor deviation has been made from the standard.

3.7 Limit

3.7.1 For SAR (FCC)

(A) Limits for Occupational/Controlled Exposure (W/kg)

Spatial Average (averaged over the whole body)	Spatial Peak (averaged over any 1g of tissue)	Spatial Peak (hands/wrists/feet/ankles averaged over 10g)
0.4	8.0	20.0

(B) Limits for General population/Uncontrolled Exposure (W/kg)

Spatial Average (averaged over the whole body	Spatial Peak (averaged over any 1g of tissue)	Spatial Peak (hands/wrists/feet/ankles averaged over 10g)
0.08	1.6	4.0

Occupational/Controlled Environments: are defined as locations where there is exposure that may be incurred by people who are aware of the potential for exposure, (i.e. because of employment or occupation).

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

1.6 W/kg limit is applied.

3.7.2 For PD (Above 6 GHz) (FCC)

Frequency Range [MHz]	Power Density [mW/cm^2]	Average Time [Minutes]
(A) Limits For Occupational / Controlled Environments		
1,500 – 100,000	5	6
(B) Limits For General Population / Uncontrolled Environments		
1,500 – 100,000	1	30

Note: 1.0 mW/cm^2 is 10 W/m^2

1.0 mW/cm^2 limit is applied.

SECTION 4: Location

UL Japan, Inc. Ise EMC Lab.
Shielded room for SAR testing
*A2LA Certificate Number: 5107.02 / FCC Test Firm Registration Number: 884919
ISED Lab Company Number: 2973C / CAB identifier: JP0002
4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 JAPAN
Telephone : +81-596-24-8999

SECTION 5: Definitions, symbols, and abbreviations

5.1 Definitions

power density (PD) or S_{av} : energy per unit time and unit area crossing a surface of area *A* characterized by the normal unit vector ˆ**n** and averaging time.

$$S_{av} = \frac{1}{AT}\int\int(\mathbf{E}\times\mathbf{H})\cdot\hat{\boldsymbol{n}}\,\mathrm{d}A\,\mathrm{d}T$$

Specific Absorption Rate (SAR) : 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), as shown in the following equation:

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

Absorbed power density (APD) : The APD (absorbed power density) shall be derived from the measured SAR values using the formulas in the Compliance Assessment of the Epithelial.

$$APD\ 1cm^2(W/m^2) = 10(kg/m^2) \times SAR\_{1g}(W/kg)$$
$$APD\ 4cm^2(W/m^2) = 20(kg/m^2) \times SAR\_{8g}(W/kg)$$

Reported SAR / IPD / APD : Measured SAR / IPD / APD is scaled to the maximum tune-up tolerance limit and the maximum duty by the following formulas.

$$Reported\ \mathrm{SAR\ /\ IPD\ /\ APD} = Measured\ \mathrm{SAR\ /\ IPD\ /\ APD} \times scale\ factor\ for\ power \times Scaled\ factor\ for\ duty(if\ needed)$$

Where

$$Scaled\ factor\ for\ power = \frac{Maximum\ tune\ up\ tolerance\ limit\ [mW]}{Measured\ power\ [mW]}$$

And

$$Scaled\ factor\ for\ duty = \frac{1}{Duty}$$

Maximum Tune-up tolerance limit : Tolerance power specified by customer.

Tune up limit or Tune-up limit : same as Maximum Tune-up tolerance limit.

5.2 Symbols

Symbol	Quantity	Unit	Dimensions
E	Electric field	volt per meter	V / m
f	Frequency	hertz	Hz
H	Magnetic field	ampere per meter	A / m
λ	Wavelength	meter	m
S	Local power density	watt per square meter	W / m^2
PD or S_{av}	Spatial-average power density	watt per square meter	W / m^2 (mW / cm^2)
SAR	Specific Absorption Rate	watt per square meter	W / kg

SECTION 6: Test result

6.1 verdict
Complied

6.2 Stand-alone SAR result
The 5G module result for this device is quoted from original report details in SECTION 0.
WWAN 0.4 W/kg and 1.0 W/kg respectively 1g and 10g for bottom side and keyboard excluding n41.
WWAN 0.06 W/kg and 0.31 W/kg respectively 1g and 10g for bottom side and keyboard for n41.

WLAN result

RF Exposure Conditions		Equipment Class - Highest Reported SAR (W/kg)			
		PCE	DTS (Include BT LE)	NII	DSS (Bluetooth BR/EDR)
Standalone Tx (1-g SAR)	Head	N/A	N/A	N/A	N/A
	Body-worn	N/A	0.02	0.32	N/A
	Hotspot	N/A	N/A	N/A	N/A
Standalone Tx (10-g SAR)	Limbs	N/A	0.20	0.88	N/A

RF Exposure Conditions	Equipment Class - Highest Reported IPD (W/m^2)			
	PCE	DTS (Include BT LE)	NII	DSS (Bluetooth BR/EDR)
Standalone Tx (IPD)	N/A	N/A	2.36	N/A

6.3 Simultaneous transmission SAR result

Simultaneous Transmission
Body: 1.52 W/kg_{1g}
Limbs: 3.88 W/kg_{10g}

See SECTION 13.

6.4 Measurement uncertainty

This measurement uncertainty budget is suggested by IEC/IEEE 62209-1528 and determined by Schmid & Partner Engineering AG (DASY5/6 Uncertainty Budget). Per KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz Section 2.8.1., when the highest measured SAR(1 g) within a frequency band is < 1.5 W/kg, the extensive SAR measurement uncertainty analysis described in IEC/IEEE 62209-1528 is not required in SAR reports submitted for equipment approval.

300 MHz to 6 GHz for SAR

Error Description		Uncert. value		Prob. Dist.	Div.	(ci) 1g	(ci) 10g	Std. Unc. (1g)	Std.Unc. (10g)
Measurement System Errors									
Probe Calibration	±	13.10	%	N	2	1	1	±6.6%	±6.55%
Probe Calibration Drift	±	1.7	%	R	√3	1	1	±1.0%	±1.0%
Probe Linearity	±	4.7	%	R	√3	1	1	±2.7%	±2.7%
Broadband Signal	±	2.6	%	R	√3	1	1	±1.5%	±1.5%
Probe Isotropy	±	7.6	%	R	√3	1	1	±4.4%	±4.4%
Other Probe + Electronic	±	1.2	%	N	1	1	1	±1.2%	±1.2%
RF Ambient	±	1.8	%	N	1	1	1	±1.8%	±1.8%
Probe Positioning	±	0.005	mm	N	1	0.29	0.29	±0.2%	±0.2%
Data Processing	±	2.3	%	N	1	1	1	±2.3%	±2.3%
Phantom and Device Errors									
Conductivity (meas.)[DAK]	±	5.0	%	N	1	0.78	0.71	±3.9%	±3.6%
Conductivity (temp.)[BB]	±	5.0	%	R	√3	0.78	0.71	±2.3%	±2.1%
Phantom Permittivity	±	14.0	%	R	√3	0.25	0.25	±2.0%	±2.0%
Distance DUT - TSL	±	2.0	%	N	1	2	2	±4.0%	±4.0%
Device Positioning (+/- 0.5mm)	±	1.0	%	N	1	1	1	±1.0%	±1.0%
Device Holder	±	3.6	%	N	1	1	1	±3.6%	±3.6%
DUT Modulation[m]	±	2.4	%	R	√3	1	1	±1.4%	±1.4%
Time-average SAR	±	1.7	%	R	√3	1	1	±1.0%	±1.0%
DUT drift	±	2.5	%	N	1	1	1	±2.5%	±2.5%
Val Antenna Unc.[val]	±	0.0	%	N	1	1	1	±0.0%	±0.0%
Unc. Input Power[val]	±	0.0	%	N	1	1	1	±0.0%	±0.0%
Correction to the SAR results									
Deviation to Target	±	1.9	%	N	1	1	0.84	±1.9%	±1.6%
SAR scaling[p]	±	0.0	%	R	√3	1	1	±0.0%	±0.0%
Combined Std. Uncertainty								±12.3%	±12.1%
Expanded STD Uncertainty (κ=2)								±24.5%	±24.1%

Note: This uncertainty budget for validation is worst-case.
Table of uncertainties are listed for ISO/IEC 17025.

This measurement uncertainty budget is suggested by IEC/IEEE 63195 and determined by Schmid & Partner Engineering AG (DASY6 Uncertainty Budget).
6 GHz to 10 GHz for PD

Error Description		Unc. Value (±dB)	Probab. Distri.	Div.	(*ci*)	Std. Unc. (±dB)	(*vi*) *v*eff
Uncertainty terms dependent on the measurement system							
CAL	Calibration	0.49	N	1	1	0.49	∞
COR	Probe correction	0	R	√3	1	0.00	∞
FRS	Frequency response (BW ≤ 1 GHz)	0.2	R	√3	1	0.12	∞
SCC	Sensor cross coupling	0	R	√3	1	0.00	∞
ISO	Isotropy	0.5	R	√3	1	0.29	∞
LIN	Linearity	0.2	R	√3	1	0.12	∞
PSC	Probe scattering	0	R	√3	1	0.00	∞
PPO	Probe positioning offset	0.3	R	√3	1	0.17	∞
PPR	Probe positioning repeatability	0.04	R	√3	1	0.02	∞
SMO	Sensor mechanical offset	0	R	√3	1	0.00	∞
PSR	Probe spatial resolution	0	R	√3	1	0.00	∞
FLD	Field impedance dependence	0	R	√3	1	0.00	∞
MED	Measurement drift	0.05	R	√3	1	0.03	∞
APN	Amplitude and phase noise	0.04	R	√3	1	0.02	∞
TR	Measurement area truncation	0	R	√3	1	0.00	∞
DAQ	Data acquisition	0.03	N	1	1	0.03	∞
SMP	Sampling	0	R	√3	1	0.00	∞
REC	Field reconstruction	0.6	R	√3	1	0.35	∞
SNR	Signal-to-Noise Ratio	0	R	√3	1	0.00	∞
TRA	FTE/MEO	0 (0)	R	√3	1	0.00	∞
SCA	Power density scaling	–	R	√3	1	–	∞
SAV	Spatial averaging	0.1	R	√3	1	0.06	∞
Uncertainty terms dependent on the DUT and environmental factors							
PC	Probe coupling with DUT	0	R	√3	1	0.00	∞
MOD	Modulation response	0.4	R	√3	1	0.23	∞
IT	Integration time	0	R	√3	1	0.00	∞
RT	Response time	0	R	√3	1	0.00	∞
DH	Device holder influence	0.1	R	√3	1	0.06	∞
DA	DUT alignment	0	R	√3	1	0.00	∞
AC	RF ambient conditions	0.04	R	√3	1	0.02	∞
TEM	Laboratory Temperature	0.05	R	√3	1	0.03	∞
REF	Laboratory Reflections	0.04	R	√3	1	0.02	∞
MSI	Immunity / secondary reception	0	R	√3	1	0.00	∞
DRI	Drift of the DUT	–	R	√3	1	–	∞
Combined Std Uncertainty (w/ FTE/MEO)						0.75	∞
Expanded Std Uncertainty (w/ FTE/MEO)						**1.51**	

Note: This uncertainty budget for validation is worst-case.
Table of uncertainties are listed for ISO/IEC 17025.

SECTION 7: Tune-up tolerance information and software information

7.1 Tune-up tolerance

Band	Technology	Central Channel	Maximum Target Power for Host Approval(dBm)			
			SISO		MIMO	
			Main Antenna(B)	Aux Antenna(A)	Main Antenna(B)	Aux Antenna(A)
2.4 GHz	20MHz DSSS (802.11b)	1	19.50	21.50	N/A	N/A
		2	20.00	21.50	N/A	N/A
		3	20.75	21.75	N/A	N/A
		4	21.50	22.50	N/A	N/A
		5-6	22.00	22.50	N/A	N/A
		7-8	22.50	22.50	N/A	N/A
		9	22.50	22.25	N/A	N/A
		10	22.50	22.00	N/A	N/A
		11	22.50	21.25	N/A	N/A
		12	19.50	18.25	N/A	N/A
		13	18.50	16.75	N/A	N/A
	20MHz OFDM (802.11g)	1	20.75	19.25	N/A	N/A
		2	21.75	20.25	N/A	N/A
		3	21.75	20.50	N/A	N/A
		4	21.75	20.75	N/A	N/A
		5	21.75	20.50	N/A	N/A
		6-7	21.75	21.00	N/A	N/A
		8	21.75	20.75	N/A	N/A
		9	21.75	20.50	N/A	N/A
		10	21.75	20.25	N/A	N/A
		11	21.25	20.00	N/A	N/A
		12	16.25	15.25	N/A	N/A
		13	14.25	13.50	N/A	N/A
	20MHz OFDM (802.11n) (802.11ax) (802.11be)	1	20.75	19.25	18.25	18.25
		2	21.75	20.25	20.00	20.00
		3	21.75	20.50	20.00	20.00
		4	21.75	20.75	20.00	20.00
		5	21.75	20.50	20.00	20.00
		6-7	21.75	21.00	20.00	20.00
		8	21.75	20.75	20.00	20.00
		9	21.75	20.50	20.00	20.00
		10	21.75	20.25	19.75	19.75
		11	21.25	20.00	19.25	19.25
		12	16.25	15.25	13.50	13.50
		13	14.25	13.50	12.00	12.00
	40MHz OFDM (802.11n) (802.11ax) (802.11be)	3	19.75	18.75	17.25	17.25
		4	20.50	19.25	18.00	18.00
		5-7	20.50	19.50	18.00	18.00
		8	19.75	19.50	17.75	17.75
		9	18.75	19.00	17.50	17.50
		10	14.25	13.75	11.25	11.25
		11	13.50	14.00	10.50	10.50

Band	Technology	Channel	Maximum Target Power for Host Approval(dBm)			
			SISO		MIMO	
			Main Antenna(B)	Aux Antenna(A)	Main Antenna(B)	Aux Antenna(A)
Wi-Fi 5GHz 5150 - 5350 MHz	20MHz OFDM (802.11a)	36-64	21.25	21.25	N/A	N/A
	20MHz OFDM (802.11n) (802.11ac) (802.11ax) (802.11be)	36-64	21.25	21.25	18.00	18.00
	40MHz OFDM (802.11n) (802.11ac) (802.11ax) (802.11be)	38	19.00	19.25	17.50	17.50
		46	21.00	21.00	20.25	20.25
		54	21.00	21.00	20.50	20.50
		62	19.50	19.50	17.50	17.50
	80MHz OFDM (802.11ac) (802.11ax) (802.11be)	42	19.50	20.25	17.75	17.75
		58	19.25	19.50	18.25	18.25
	160MHz OFDM (802.11ac) (802.11ax) (802.11be)	50	17.75	17.75	16.75	16.75

Band	Technology	Channel	Maximum Target Power for Host Approval(dBm)			
			SISO		MIMO	
			Main Antenna(B)	Aux Antenna(A)	Main Antenna(B)	Aux Antenna(A)
Wi-Fi 5 GHz 5470 - 5725 MHz	20MHz OFDM (802.11a)	100	21.25	21.25	N/A	N/A
		120	21.25	21.25	N/A	N/A
		140	21.25	21.25	N/A	N/A
		144	21.50	21.50	N/A	N/A
	20MHz OFDM (802.11n) (802.11ac) (802.11ax) (802.11be)	100	21.25	21.25	18.25	18.25
		120	21.25	21.25	18.25	18.25
		140	21.25	21.25	18.25	18.25
		144	21.50	21.50	19.00	19.00
	40MHz OFDM (802.11n) (802.11ac) (802.11ax) (802.11be)	102	20.75	20.75	18.50	18.50
		110	21.00	21.00	20.50	20.50
		118-126	22.50	22.50	20.50	20.50
		134	21.25	22.00	20.25	20.25
		142	23.50	23.50	21.00	21.00
	80MHz OFDM (802.11ac) (802.11ax) (802.11be)	106	20.00	20.00	18.25	18.25
		122	22.00	22.00	20.50	20.50
		138	23.50	23.50	21.00	21.00
	160MHz OFDM (802.11ac) (802.11ax) (802.11be)	114	18.00	18.00	17.00	17.00
Wi-Fi 5 GHz 5725 - 5925 MHz	20MHz OFDM (802.11a)	149-161	23.50	23.25	N/A	N/A
		165	23.00	22.75	N/A	N/A
		169-173	19.25	19.50	N/A	N/A
		177	19.50	19.50	N/A	N/A
	20MHz OFDM (802.11n) (802.11ac) (802.11ax) (802.11be)	149-161	23.50	23.25	23.00	23.00
		165	23.00	22.75	22.00	22.00
		169-173	19.25	19.50	16.75	16.75
		177	19.50	19.50	16.75	16.75
	40MHz OFDM (802.11n) (802.11ac) (802.11ax) (802.11be)	151	22.00	21.75	20.50	20.50
		159	23.50	23.00	20.50	20.50
		167	23.00	23.00	20.00	20.00
		175	22.50	22.50	20.00	20.00
	80MHz OFDM (802.11ac) (802.11ax) (802.11be)	155	21.25	21.00	19.75	19.75
		171	22.00	22.00	20.25	20.25
	160MHz OFDM (802.11ac) (802.11ax) (802.11be)	163	18.50	17.75	17.25	17.25

Band	Technology	Channel	Maximum Target Power for Host Approval(dBm)			
			SISO		MIMO	
			Main Antenna(B)	Aux Antenna(A)	Main Antenna(B)	Aux Antenna(A)
Wi-Fi 6 GHz 5925 - 7125 MHz	20MHz OFDM (802.11ax) (802.11be)	1-229	5.50	5.50	2.50	2.50
		233	-3.50	-2.50	-5.50	-5.50
	40MHz OFDM (802.11ax) (802.11be)	3-227	8.50	8.50	5.50	5.50
	80MHz OFDM (802.11ax) (802.11be)	7-215	11.50	11.50	8.50	8.50
	160MHz OFDM (802.11ax) (802.11be)	15-207	14.50	14.50	11.50	11.50
	320MHz OFDM (802.11be)	31	16.50	16.50	13.50	13.50
		63	15.00	16.50	13.50	13.50
		95-127	16.50	16.50	13.50	13.50
		159	15.75	15.75	13.50	13.50
		191	14.50	14.25	13.50	13.50

Bluetooth	Power
Basic rate	15.25 dBm
Enhanced Data Rate 2	13.00 dBm
Enhanced Data Rate 3	13.00 dBm
Low Energy	15.25 dBm

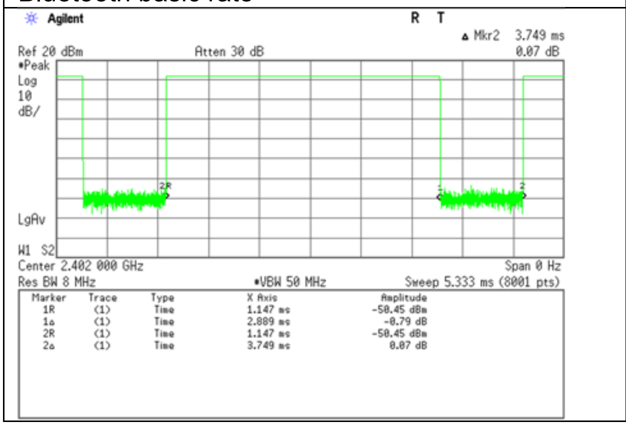
For WLAN Maximum tune-up tolerance limit is defined by a customer as duty100%.

7.2 Software setting

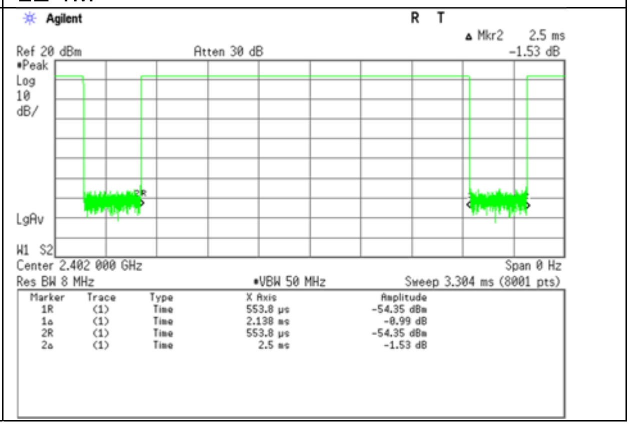
Software setting
*The power value of the EUT was set for testing as follows (setting value might be different from product specification value); Software: DRTU version 05158.23.10.0 Power settings: Shown in SECTION 12 *This setting of software is the worst case. The test was performed with condition that obtained the maximum average power (Burst) in pre-check. Any conditions under the normal use do not exceed the condition of setting. In addition, end users cannot change the settings of the output power of the product.

7.3 Duty

Bluetooth basic rate



LE 1M



SECTION 8: SAR Exposure Conditions (Test Configurations)

8.1 SAR test exclusion considerations according to KDB 447498 D01

8.1.1 Test Configurations for the WWAN-main

Test Configurations	Test distance	SAR Required	Note
Front	-	No	SAR is not required as this is not a typical use scenario and also the front side SAR test is not required because of overall diagonal dimension >20cm based on KDB 616217D04.
Rear	-	No	In normal use case this surface does not face to user.
Top	-	No	In normal use case this surface does not face to user
Left Side (Edge 2)	-	No	In normal use case this surface does not face to user.
Right Side (Edge 4)	-	No	Since distance from antenna to person is >20cm, so this surface is omitted from SAR testing.
Bottom	-	No	Since distance from antenna to person is >20cm, so this surface is omitted from SAR testing.
Keyboard	-	No	Since distance from antenna to person is >20cm, so this surface is omitted from SAR testing.

8.1.2 Test Configurations for the WWAN-4th

Test Configurations	Test distance	SAR Required	Note
Front	-	No	SAR is not required as this is not a typical use scenario and also the front side SAR test is not required because of overall diagonal dimension >20cm based on KDB 616217D04.
Rear	-	No	In normal use case this surface does not face to user.
Top	-	No	In normal use case this surface does not face to user
Left Side (Edge 2)	-	No	In normal use case this surface does not face to user.
Right Side (Edge 4)	-	No	Since distance from antenna to person is >20cm, so this surface is omitted from SAR testing.
Bottom	0 mm	Yes	Tested on 5G module test report.
Keyboard	0 mm	Yes	Tested on 5G module test report.

8.2 SAR test exclusion considerations for simultaneous transmission

8.2.1 Below 100 MHz

KDB 447498D01(v06) has the following exclusion for portable devices:
The SAR test exclusion thresholds for below 100 MHz at test separation distances ≤ 50 mm are determined by step c) 2):

c) For frequencies below 100 MHz, the following may be considered for SAR test exclusion:

1) For test separation distances > 50 mm and < 200 mm, the power threshold at the corresponding test separation distance at 100 MHz in step b) is multiplied by [1 + log(100 / f(MHz))]
2) For test separation distances ≤ 50 mm, the power threshold determined by the equation in c) 1) for 50 mm and 100 MHz is multiplied by ½

Numeric exemption threshold:

Pth $_{step\ c)}$ [mW]:	442.97

Radio specification and use-case for this deveice are below:

f [MHz]:	13.56
d [mm]:	0
Maximum average output power [mW]:	218

f [MHz]: Operating frequency
d [mm]: Minimum separation distance

This is less than Pth step c), so SAR test is exemption for this device.

8.2.2 Above 100 MHz

8.2.3 Test Configurations for the WLAN-main

Test Configurations	Test distance	SAR Required	Note
Front	-	No	SAR is not required as this is not a typical use scenario and also the front side SAR test is not required because of overall diagonal dimension >20cm based on KDB 616217D04.
Rear	-	No	In normal use case this surface does not face to user.
Top	-	No	In normal use case this surface does not face to user
Left Side (Edge 2)	-	No	Since distance from antenna to person is >20cm, so this surface is omitted from SAR testing.
Right Side (Edge 4)	-	No	In normal use case this surface does not face to user.
Bottom	0 mm	Yes	Since distance from antenna to person is < 20cm, so this surface is testing.
Keyboard	0 mm	Yes	Since distance from antenna to person is < 20cm, so this surface is testing.

8.2.4 Test Configurations for the WLAN-aux (BT)

Test Configurations	Test distance	SAR Required	Note
Front	-	No	SAR is not required as this is not a typical use scenario and also the front side SAR test is not required because of overall diagonal dimension >20cm based on KDB 616217D04.
Rear	-	No	In normal use case this surface does not face to user.
Top	-	No	In normal use case this surface does not face to user
Left Side (Edge 2)	-	No	In normal use case this surface does not face to user. Since distance from antenna to person is >20cm, so this surface is omitted from SAR testing.
Right Side (Edge 4)	-	No	In normal use case this surface does not face to user.
Bottom	-	No	Since distance from antenna to person is >20cm, so this surface is omitted from SAR testing.
Keyboard	-	No	Since distance from antenna to person is >20cm, so this surface is omitted from SAR testing.

SECTION 9: SAR System Check

All reference equipment and value which is calibrated by Speag are listed in appendix.

9.1 Dielectric Property

The dielectric parameters were checked prior to assessment using the DAK dielectric probe kit.

According to KDB 865664 D01 or IEC/IEEE 62209-1528, the dielectric constant (εr) and conductivity (σ) of typical tissue-equivalent media recipes are expected to be within 5% of the required target values for a range of approximately 50 MHz at frequencies below 300 MHz. At above 3 GHz, 5% tolerance can usually be maintained for ± 100 MHz or more.

For SAR measurement systems that have implemented the SAR error compensation algorithms documented in IEEE Std 1528-2013 or IEC/IEEE 62209-1528, to automatically compensate the measured SAR results for deviations between the measured and required tissue dielectric parameters, the tolerance for εr and σ may be relaxed to ± 10% (<= 3 GHz).

The dielectric parameters were linearly interpolated between the closest pair of target frequencies defined in KDB 865664D01 to determine the applicable dielectric parameters corresponding to the device test frequency for measurement.

Listed conductivity and relative permittivity values including the target are rounded one or two decimal places due to significant digit, so some differences might be observed, and actual SAR calculation is done four decimal places.

Table 9-1 standard parameters on the KDB 865664 D01

Target Frequency	Head		Body	
(MHz)	ε_r	σ (S/m)	ε_r	σ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
835	41.5	0.90	55.2	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800 – 2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5800	35.3	5.27	48.2	6.00

Table 9-2 Directric Property Measurements Result:

Date	Frequency	Permittivity			Conductivity			Remark
		Measured	Target	Delta	Measured	Target	Delta	
	[MHz]	ε'	ε'	+/- 5 [%]	σ [S/m]	σ [S/m]	+/- 5 [%]	
2023/12/15	2450	39.70	39.20	1.26	1.74	1.80	-3.27	SPC
2023/12/15	2442	39.71	39.21	1.25	1.73	1.79	-3.32	
2023/12/18	5250	37.23	35.95	3.57	4.75	4.71	0.92	SPC
2023/12/18	5260	37.20	35.94	3.50	4.78	4.72	1.18	
2023/12/19	5600	36.73	35.50	3.47	5.08	5.07	0.24	SPC
2023/12/19	5690	36.51	35.41	3.12	5.28	5.16	2.23	
2023/12/20	5800	36.38	35.30	3.07	5.40	5.27	2.47	SPC
2023/12/20	5795	36.39	35.31	3.06	5.40	5.27	2.59	
2023/12/20	5835	36.33	35.27	3.02	5.39	5.31	1.64	
2024/2/27	5600	36.70	35.50	3.38	4.90	5.07	-3.43	SPC
2024/2/27	5690	36.52	35.41	3.13	5.06	5.16	-1.85	
2024/2/27	5795	36.37	35.31	3.03	5.19	5.27	-1.38	
2024/2/27	5800	36.37	35.30	3.03	5.19	5.27	-1.49	SPC
2024/2/27	5835	36.35	35.27	3.08	5.18	5.31	-2.34	
2024/2/27	5875	36.26	35.23	2.94	5.19	5.35	-2.90	
2024/2/28	2442	39.50	39.21	0.73	1.73	1.79	-3.63	
2024/2/28	2450	39.49	39.20	0.73	1.73	1.80	-3.67	SPC
2024/3/1	5250	36.67	35.95	1.99	4.67	4.71	-0.89	SPC
2024/3/1	5260	36.64	35.94	1.95	4.69	4.72	-0.59	
2024/3/1	5280	36.60	35.92	1.89	4.74	4.74	-0.08	
2024/3/1	5320	36.61	35.88	2.02	4.80	4.78	0.52	

9.2 SAR System check

SAR system verification is required to confirm measurement accuracy, according to the tissue dielectric media,probe calibration points and other system operating parameters required for measuring the SAR of a test device.The system verification must be performed for each frequency band and within the valid range of each probe calibration point required for testing the device. The same SAR probe(s) and tissue-equivalent media combinations used with each specific SAR system for system verification must be used for device testing. When multiple probe calibration points are required to cover substantially large transmission bands, independent system verifications are required for each probe calibration point. A system verification must be performed before each series of SAR measurements using the same probe calibration point and tissue-equivalent medium. Additional system verification should be considered according to the conditions of the tissue-equivalent medium and measured tissue dielectric parameters, typically every three to four days when the liquid parameters are re-measured or sooner when marginal liquid parameters are used at the beginning of a series of measurements.

The measurements were performed in the flat section of the TWIN SAM or ELI phantom, shell thickness: 2.0 ±0.2 mm (bottom plate) filled with Body or Head simulating liquid of the following parameters.
The depth of tissue-equivalent liquid in a phantom must be ≥ 15.0 cm ± 0.5 cm for SAR measurements ≤ 3 GHz and ≥ 10.0 cm ± 0.5 cm for measurements > 3 GHz.
The DASY system with an E-Field Probe was used for the measurements.
The dipole was mounted on the small tripod so that the dipole feed point was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom).

The standard measuring distance was 10 mm (above 1 GHz to 6 GHz) and 15 mm (below 1 GHz) from dipole center to the simulating liquid surface.
The coarse grid with a grid spacing of 15 mm (below 2 GHz), 12 mm (2 GHz to 4 GHz) and 10 mm (4 GHz to 6 GHz) was aligned with the dipole.
Around this point found in the coarse grid, a volume of 30 mm x 30 mm x 30 mm or more was assessed by measuring 7 x 7 x 7 points at least for below 3 GHz, a volume of 28 mm x 28 mm x 34 mm or more was assessed by measuring 8 x 8 x 8(ratio step method) points at least for 3 GHz to 5 GHz and a volume of 28 mm x 28 mm x 24 mm or more was assessed by measuring 8 x 8 x 8(ratio step method) points at least for 5 GHz to 6 GHz.
Distance between probe sensors and phantom surface was set to 1.4 mm.
The dipole input power (forward power) was 100 mW or 250 mW.
The results are normalized to 1 W input power.
The target(reference) SAR values can be obtained from the calibration certificate of system validation dipoles(Refer to Appendix). The target SAR values are SAR measured value in the calibration certificate scaled to 1 W.

9.3 System Check Results

9.3.1 SAR

Conditions				Meas value 250mW (100mW for >=3GHz		Meas value Normalized to 1W		Deviation of SPEAG			
Date	Frequency [MHz]	Temp [deg. C]	Humid [% RH]	1g [W/kg]	10g [W/kg]	1g [W/kg]	10g [W/kg]	(SPEAG) 1g [W/kg]	(SPEAG) 10g[W/kg]	[%]	[%]
12/15	2450	24	36	12.5	5.87	50.00	23.48	53.2	24.8	-6.02	-5.17
12/18	5250	21	38	8.39	2.38	83.90	23.80	80.2	23.0	4.61	3.48
12/19	5600	21	38	8.44	2.40	84.40	24.00	81.5	23.3	3.56	3.00
12/20	5800	21	38	8.12	2.33	81.20	23.30	80.3	22.5	1.12	3.56
2/27	5600	21	43	8.61	2.48	86.10	24.80	81.5	23.3	5.64	6.44
2/27	5800	21	43	8.03	2.32	80.30	23.20	80.3	22.5	0.00	3.11
2/28	2450	22	43	12.9	6.10	51.60	24.40	53.2	24.8	-3.01	-1.45
3/1	5250	22	45	8.07	2.31	80.70	23.10	80.2	23.0	0.62	0.43

SECTION 10: IPD System Check

10.1 Dielectric Property

Media is air so Relative Permittivity (ϵr) and Conductivity (σ) are 1 and 0 respectively.

10.2 System Check

System validation is required before a system is deployed for measurement
Peak and spatially averaged power density at the peak location(s) must be compared to calibrated results according to the defined test conditions

- the same spatial resolution and measurement region used in the waveguide calibration should be applied to system validation and system check
- power density distribution should also be verified, both spatially (shape) and numerically (level) through visual inspection for noticeable differences
- the measured results should be within 0.66 dB* of the calibrated targets

* Within 0.66 dB is recommended by SPEAG(Schmid & Partner Engineering AG).

10.3 Setting

Then create a measurement file with a test distance of 10mm for 10 GHz and 5.55mm for 30 GHz and above (the later will account for the retracted location of the horn aperture towards the top surface of a verification source). Use the scan settings defined in below table.

Table 10-1 Grid setting

Frequency (GHz)	Grid Step (lambda)	Grid extent X/Y (mm)	Meas. points
10	0.125	60 / 60	18 X 18
30	0.25	60 / 60	26 X 26
45	0.25	42 / 42	28 X 28
60	0.25	32.5 / 32.5	28 X 28
90	0.25	30 / 30	38 X 38

10.4 Radiating source description and PD distribution for each frequency band.

System verification device consists of a 10 GHz, 30 GHz, 60 GHz, 90 GHz band horn antenna with corresponding Gunn oscillator packaged within a cube-shaped housing. Power supply provided.

ISO 17025 calibrated frequency: 10 GHz, 30 GHz, 60 GHz, 90 GHz at 10mm from the antenna (5.55 mm from the case surface)
Frequency accuracy: ±100 MHz
E-field polarization: linear
Total radiated power: 14 dBm (typ)
Power stability: 0.15 dB (after 30 min warmup)
Power consumption: 20 W (10 GHz) / 5 W (max) (30 GHz, 60 GHz, 90 GHz)
Size: 100 x 100 x 100 mm (30 GHz, 60 GHz, 90 GHz)
Weight: 700 g (10 GHz) / 1 kg (30 GHz, 60 GHz, 90 GHz)

10.5 System Check

System verification is required before a system is deployed for measurement.
Peak and spatially averaged power density at the peak location(s) must be compared to calibrated results according to the defined test conditions:

- the same spatial resolution and measurement region used in the waveguide calibration should be applied to system validation and system check.
- power density distribution should also be verified, both spatially (shape) and numerically (level) through visual inspection for noticeable differences.
- the measured results should be within 0.66B of the calibrated targets.

Criteria

$$\Delta psPD_{tgt} = \left| 10 \times log\left\{\frac{psPD_{meas}}{psPD_{tgt}}\right\}\right| < min(2 \times |u_c|, 2\ dB)$$

$$u_{relative} = \sqrt{u^{2antentena\_cal} + u^{2power} + u^{2meas}}$$

$$2 \times u_{relative} = \sqrt{0.64^2 + 0.635^2 + 0.21^2} = 1.85\ dB$$

Where

$u_{antenna\_cal}$	is the standard uncertainty (k = 1), of the psPD of the antenna model comprising both numerical and the physical modelling of the calibrated antenna 1.28 dB (k = 2)
u_{power}	is the standard uncertainty (*k* = 1), for the measured *TRP* 1.27 dB (k = 2)
u_{meas}	is the standard uncertainty (*k* = 1), of the *psPD* measurement (probe calibration, electronics, and positioning). 0.42 dB (k = 2)

But Speag declares that difference is expected to be below 0.66 dB.

10.6 System Check Results

Table 10-2 PD system check result

Conditions				Meas value (Circular)				Reference value of SPEAG (Circular)							
Date	Frequency [MHz]	Temp [deg. C]	Humid [% RH]	4cm² psPDn+	4cm² psPDtot+	4cm² psPDmod+	4cm² Avg(PsPDn+, PSPDtot+, pdPDmod+)	4cm² psPDn+	4cm² psPDtot+	4cm² psPDmod+	4cm² Avg(PsPDn+, PSPDtot+, pdPDmod+)	[dB]	[dB]	[dB]	[dB]
1/8	10000	23	45	56.8	57.7	58.0	57.5	57.2	58.4	58.8	58.1	-0.03	-0.05	-0.06	-0.05
1/9	10000	23	45	55.6	56.4	56.7	56.2	57.2	58.4	58.8	58.1	-0.12	-0.15	-0.16	-0.14
2/29	10000	23	35	57.9	58.2	58.5	58.2	57.2	58.4	58.8	58.1	0.05	-0.01	-0.02	0.01

SECTION 11: SAR / IPD Measurements

11.1 Measurement configuration for SAR

11.1.1 SAR evaluation procedure

The evaluation was performed with the following procedure:

Step 1: Measurement of the E-field at a fixed location above the ear point or central position of flat phantom was used as a reference value for assessing the power drop.

Step 2: The SAR distribution at the exposed side of head or body position was measured at a distance of each device from the inner surface of the shell. The area covered the entire dimension of the antenna of EUT and the horizontal grid spacing was 15 mm x 15 mm, 12 mm x 12 mm, 10 mm x 10 mm or 8.5 mm x 8.5 mm. Based on these data, the area of the maximum absorption was determined by spline interpolation.

Step 3: Around this point found in the Step 2 (area scan), a volume of 30 mm x 30 mm x 30 mm or more was assessed by measuring 7 x 7 x 7 points at least for below 3 GHz, a volume of 28 mm x 28 mm x 34 mm or more was assessed by measuring 8 x 8 x 8(ratio step method (*1)) points at least for 3 GHz to 5 GHz, a volume of 28 mm x 28 mm x 24 mm or more was assessed by measuring 8 x 8 x 8(ratio step method) points at least for 5 GHz to 6 GHz and a volume of 22 mm x 22 mm x 22 mm

And for any secondary peaks found in the Step2 which are within 2 dB of maximum peak and not with this Step3 (Zoom scan) is repeated. On the basis of this data set, the spatial peak SAR value was evaluated under the following procedure:
(1). The data at the surface were extrapolated, since the center of the dipoles is 1 mm(EX3DV4) away from the tip of the probe and the distance between the surface and the lowest measuring point is 1.3 mm. The extrapolation was based on a least square algorithm [4]. A polynomial of the fourth order was calculated through the points in z-axes.
This polynomial was then used to evaluate the points between the surface and the probe tip.
(2). The maximum interpolated value was searched with a straightforward algorithm. Around this maximum the SAR values averaged over the spatial volumes (1 g or 10 g) were computed by the 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 integrated with the trapezoidal-algorithm. One thousand points (10 x 10 x 10) were interpolated to calculate the average.
(3). All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.

***1. Ratio step method parameters used;**
The first measurement point: 1.4 mm from the phantom surface, the initial grid separation: 1.4 mm, subsequent graded grid ratio: 1.4
These parameters comply with the requirement of the KDB 865664 D01.

Step 4: Re-measurement of the E-field at the same location as in Step 1.
Confirmation after SAR testing
It was checked that the power drift [W] is within +/-5 %.The verification of power drift during the SAR test is that DASY system calculates the power drift by measuring the e-filed at the same location at beginning and the end of the scan measurement for each test position.

DASY system calculation Power drift value[dB] =20log(Ea)/(Eb)
Before SAR testing : Eb [V/m]
After SAR testing : Ea [V/m]

Limit of power drift[W] = +/- 5 %
X[dB] = 10log[P] = 10log(1.05/1) = 10log(1.05) -10log(1) = 0.212 dB

from E-filed relations with power.
p=E^2/η
Therefore, The correlation of power and the E-filed
X dB = 10log(P) = 10log(E)^2 = 20log(E)

Therefore,
The calculated power drift of DASY System must be the less than +/- 0.212 dB.

Step size.

			≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface			5 mm □ 1 mm	½·δ·ln(2) mm □ 0.5 mm
Maximum probe angle from probe axis to phantomsurface normal at the measurement location			30□ □ 1□	20□ □ 1□
Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}			≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 mm 6 – 7 GHz: ≤ 8.57 mm
			When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device withat least one measurement point on the test device.	
Maximum zoom scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}			≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm*	3 – 4 GHz: ≤ 5 mm 4 – 6 GHz: ≤ 4 mm 6 – 7 GHz: ≤ 3.4 mm
Maximum zoom scan spatial resolution, normal tophantom surface	uniform grid: $\Delta z_{Zoom}(n)$		≤ 5 mm	3– 4 GHz: ≤ 4 mm 4– 5 GHz: ≤ 3 mm 5– 6 GHz: ≤ 2 mm 6– 7 GHz: ≤ 1.6 mm
	graded grid	$\Delta z_{Zoom}(1)$: between 1st two points closestto phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 2 mm 6 – 7 GHz: ≤ 1.7 mm
		$\Delta z_{Zoom}(n>1)$: between subsequentpoints	≤ 1.5·$\Delta z_{Zoom}(n-1)$ mm	
Minimum zoomscan volume	x, y, z		≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 7 GHz: ≥ 22 mm
Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see IEEE Std1528-2013 for details.				

11.1.2 IPD evaluation procedure

11.1.2.1 Computation of the Electric Field Polarization Ellipse

For the numerical description of an arbitrarily oriented ellipse in three-dimensional space, five parameters are needed: the semi-major axis (a), the semi-minor axis (b), two angles describing the orientation of the normal vector of the ellipse (ϕ, θ), and one angle describing the tilt of the semi-major axis (ψ). For the two extreme cases, i.e., circular and linear polarizations, only three parameters (a, ϕ, and θ) are sufficient for the description of the incident field.
For the reconstruction of the ellipse parameters from measured data, the problem can be reformulated as a nonlinear search problem. The semi-major and semi-minor axes of an elliptical field can be expressed as functions of the three angles (ϕ, θ, and ψ). The parameters can be uniquely determined to minimize the error based on least-squares for the given set of angles and the measured data. In this way, the number of free parameters is reduced from five to three, which means that at least three sensor readings are necessary to gain sufficient information for the reconstruction of the ellipse parameters. However, to suppress the noise and increase the reconstruction accuracy, it is desirable to overdetermine the system of equations. The solution to use a probe consisting of two sensors angled by γ1 and γ2 toward the probe axis and to perform measurements at three angular positions of the probe, i.e., at β1, β2, and β3, results in overdeterminations by a factor of two. If more information or increased accuracy is required, more rotation angles can be added.
The reconstruction of the ellipse parameters can be separated into linear and non-linear parts that are best solved by the Givens algorithm combined with a downhill simplex algorithm. To minimize the mutual coupling, sensor angles are set with a shift of 90° (γ2 = γ1 + 90°), and, for simplification, the first rotation angle of the probe (β1) can be set to 0°. More details can be found in [1]

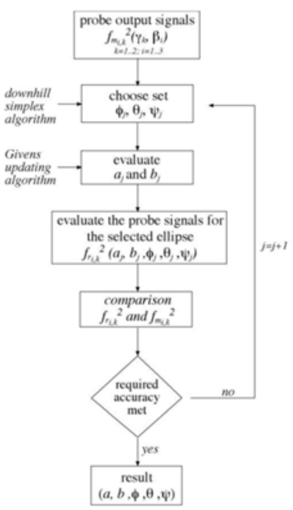


Figure 1 Numerical algorithm for reconstructing the ellipse parameters

11.1.3 Total Field and Power Flux Density Reconstruction

11.1.3.1 Plane-to-Plane Phase Reconstruction (PTP-PR)

Computation of the PD in general requires knowledge of the electric (E-) and magnetic (H-) field amplitudes and phases in the plane of incidence. Reconstruction of these quantities from pseudo-vector E-field measurements is feasible, as they are constrained by Maxwell's equations.
The Plane-to-Plane Phase Reconstruction (PTP-PR) reconstruction approach based on the Gerchberg-Saxton algorithm [2] [3], which benefits from the availability of the E-field polarization ellipse information obtained with the EUmmWVx probe. This reconstruction algorithm, together with the ability of the probe to measure extremely close to the source without perturbing the field, permits reconstruction of the E- and H-fields and the PD on measurement planes located as near as $\lambda/2\pi$ [3]. At closer distances, the uncertainty might be larger.

11.1.3.2 Equivalent Source Reconstruction (ESR)

In order to overcome the main limitations of PTP-PR at distances $d \leq \lambda/2\pi$ from the EUT, i.e., in the reactive near-field and beyond planar evaluation surfaces, SPEAG and the IT'IS Foundation (Zurich, Switzerland) have joined forces in a research collaboration to develop a novel equivalent source reconstruction (ESR) algorithm, that models an unknown and inaccessible transmitter not anymore in terms of plane waves but as a set of distributed known auxiliary sources below the surface of the device enclosure. The locations, amplitudes, and phases of these sources are then determined to reconstruct the measured near-fields optimally. As a result, the transmitters inside any enclosure can be replaced with these equivalent sources in any radiation problem, including exposure assessment scenarios. ESR even enables back transformation within a limited range.
This approach has three main advantages:

- lower reconstruction errors in the reactive near-field regions, which ease compliance testing of EUT operating in the 6 to 24 GHz frequency range
- evaluation of phones with non-planar surfaces, e.g., a flat surface with a protruding camera module
- possibility to perform phase reconstruction in any parts of the radiation region without any limitation to planar measurement domains. In other words, measurements can be done on a conformal surface or even on scattered points in the radiation domain and still obtain reliable data on the phase variations. This opens the way for evaluations on non-planar device surfaces (e.g., virtualreality goggles) and enables full-wave simulations using measurement results only, i.e., without requiring models for the transmitters.

11.1.3.3 Power Flux Density Averaging

The average of the reconstructed power density is evaluated on the measurement plane. Two averaging geometries are available: a circle and a rotating square. The averaging area is defined by the user; typical values are 1 cm^2 and 4 cm^2. The three variants of the spatial-average Power Density (sPD) defined in the IEC 63195 standard draft are computed by integration of the Poynting vector:

- *sPDn+:* surface normal propagating power flux density into the phantom
- *sPDtot+:* total propagating power flux density into the phantom
- *sPDmod+*: total power flux density into the phantom considering near-field exposure.

11.1.4 Scan method(s)

The system moves over and measures the area that encompasses the radiational source with specified scan set up. After acquiring the data, the system calculates the power density.

Scan setup: The details such as steps, sensor surface distance and grid extent are included in the plot data.

Algorithm: the ESR algorithm will be used for measurements ≤ 24 GHz and the PTP-PR algorithm above > 24 GHz

Step size: The default grid step is calculated from the measurement distance and test frequency. The grid extents should not be less than 2λ, or 16x16 points.

Scan dimension

	5G scan at a distance > λ/8	Forward Transform scan at a distance > λ/8	at a distance ≤ λ/8
Scan planes	two	three	four

11.1.5 Laboratory Requirements

Section of 63195	
6.2 a) ambient noise	< -20 dB conformed
6.2 b) reflection	< -17 dB conformed
6.2 c) ambient temperature	Including test data.
6.2 d) aging	> 30 min aging

a) b) values are conformed annually.

SECTION 12: WLAN additional testing for simultaneous measurement

12.1 Output Power and SAR test required

According to KDB 248227 D01, the initial test configuration for 2.4 GHz, 5 GHz, 6 GHz OFDM or OFDMA transmission modes is determined by the 802.11 configuration with the highest maximum output power specified for production units, including tune-up tolerance, in each standalone and aggregated frequency band. SAR for the initial test configuration is measured using the highest maximum output power channel determined by the default power measurement procedures. When multiple configurations in a frequency band have the same specified maximum output power, the initial test configuration is determined according to the following steps applied sequentially.

1. The largest channel bandwidth configuration is selected among the multiple configurations with the same specified maximum output power.
2. If multiple configurations have the same specified maximum output power and largest channel bandwidth, the lowest order modulation among the largest channel bandwidth configurations is selected.
3. If multiple configurations have the same specified maximum output power, largest channel bandwidth and lowest order modulation, the lowest data rate configuration among these configurations is selected.
4. When multiple transmission modes (802.11a/g/n/ac) have the same specified maximum output power, largest channel bandwidth, lowest order modulation and lowest data rate, the lowest order 802.11 mode is selected; i.e., 802.11a is chosen over 802.11n then 802.11ac or 802.11g is chosen over 802.11n.

12.1.1 WLAN power results

				SISO									
				Main						Aux			
(GHz)	Band	Mode	Data Rate	ch	Freq.(MHz)	Tune-up power [dBm]	Meas. Power[dBm]	Power Setting	ch	Freq.(MHz)	Tune-up power [dBm]	Meas. Power[dBm]	Power Setting
2.4	-	11b	1 Mbps	7	2442	22.50	22.46	22.750	4	2427	22.50	22.36	23.500
				9	2452	22.50	22.45	22.875	6	2437	22.50	22.40	23.500
				11	2462	22.50	22.43	22.750	8	2447	22.50	22.44	23.500
5.3	U-NII-2a	11a	6 Mbps	52	5260	21.25	21.18	21.375	52	5260	21.25	21.19	20.875
				56	5280	21.25	21.14	21.375	56	5280	21.25	21.20	20.875
				64	5320	21.25	21.07	21.375	64	5320	21.25	21.10	20.875
5.6	U-NII-2c	11ac-80	VHT0	106	5530	20.00	19.97	19.875	106	5530	20.00	19.84	19.750
				122	5610	22.00	21.83	21.875	122	5610	22.00	21.89	21.750
				138	5690	23.50	23.31	23.875	138	5690	23.50	23.42	23.500
5.8	U-NII-3	11n-40	HT0	151	5755	22.00	21.81	22.125					
				159	5795	23.50	23.32	24.000					
		11a	6 Mbps						149	5745	23.25	23.17	23.125
									157	5785	23.25	23.09	23.125
									161	5805	23.25	23.14	23.250
5.9	U-NII-4	11n-40	HT0	167	5835	23.00	22.93	23.500	167	5835	23.00	22.95	23.375
				175	5875	22.50	22.39	22.750	175	5875	22.50	22.43	22.750
6.2	U-NII-5	11be-320	EHT0	31	6105	16.50	16.36	16.750	31	6105	16.50	16.46	16.250
				63	6265	15.00	15.00	15.250	63	6265	16.50	16.40	16.375
				95	6425	16.50	16.43	16.875	95	6425	16.50	16.34	16.500
6.5	U-NII-6	11ax-160	HE0	111	6505	14.50	14.39	15.250	111	6505	14.50	14.46	15.000
6.7	U-NII-7	11be-320	EHT0	127	6585	16.50	16.50	16.875	127	6585	16.50	16.37	16.500
				159	6745	15.75	15.75	15.875	159	6745	15.75	15.67	15.500
7	U-NII-8	11be-320	EHT0	191	6905	14.50	14.46	14.750					
		11ax-160	HE0						207	6985	14.50	14.38	14.625

12.1.2 BT power results

BT					SISO		
					Main		
Band (GHz)	Mode	Packet	ch	Freq.(MHz)	Tune-up power [dBm]	Meas. Power[dBm]	Power Setting
2.4	BR	DH5	0	2402	14.25	14.01	13.75
			39	2441	14.25	14.25	13.875
			78	2480	14.25	14.21	13.875
2.4	LE(1M)	-	0	2402	14.25	13.99	13.75
			20	2440	14.25	14.22	13.875
			39	2480	14.25	14.16	13.875
2.4	LE(2M)	-	0	2402	14.25	13.99	13.75
			20	2440	14.25	14.24	13.875
			39	2480	14.25	14.18	13.875

12.2 KDB 248227 D01 (SAR Guidance for 802.11(Wi-Fi) Transmitters):

SAR test reduction for 802.11 WLAN transmission mode configurations are considered separately for DSSS and OFDM. An initial test position is determined to reduce the number of tests required for certain exposure configurations with multiple test positions. An initial test configuration is determined for each frequency band and aggregated band according to maximum output power, channel bandwidth, wireless mode configurations and other operating parameters to streamline the measurement requirements. For 2.4 GHz DSSS, either the initial test position or DSSS procedure is applied to reduce the number of SAR tests; these are mutually exclusive. For OFDM, an initial test position is only applicable to next to the ear, UMPC mini-tablet and hotspot mode configurations, which is tested using the initial test configuration to facilitate test reduction. For other exposure conditions with a fixed test position, SAR test reduction is determined using only the initial test configuration.
The multiple test positions require SAR measurements in head, hotspot mode or UMPC mini-tablet configurations may be reduced according to the highest reported SAR determined using the ***initial test position(s)*** by applying the DSSS or OFDM SAR measurement procedures in the required wireless mode test configuration(s). The ***initial test position(s)*** is measured using the highest measured maximum output power channel in the required wireless mode test configuration(s). When the ***reported*** SAR for the ***initial test position*** is:

- ≤ 0.4 W/kg, further SAR measurement is not required for the other test positions in that exposure configuration and wireless mode combination within the frequency band or aggregated band. DSSS and OFDM configurations are considered separately according to the required SAR procedures.
- > 0.4 W/kg, SAR is repeated using the same wireless mode test configuration tested in the ***initial test position*** to measure the subsequent next closet/smallest test separation distance and maximum coupling test position, on the highest maximum output power channel, until the ***reported*** SAR is ≤ 0.8 W/kg or all required test positions are tested.
    - For subsequent test positions with equivalent test separation distance or when exposure is dominated by coupling conditions, the position for maximum coupling condition should be tested.
    - When it is unclear, all equivalent conditions must be tested.
- For all positions/configurations tested using the ***initial test position*** and subsequent test positions, when the ***reported*** SAR is > 0.8 W/kg, measure the SAR for these positions/configurations on the subsequent next highest measured output power channel(s) until the ***reported*** SAR is ≤ 1.2 W/kg or all required test channels are considered.
    - The additional power measurements required for this step should be limited to those necessary for identifying subsequent highest output power channels to apply the test reduction.
- When the specified maximum output power is the same for both UNII 1 and UNII 2A, begin SAR measurements in UNII 2A with the channel with the highest measured output power. If the reported SAR for UNII 2A is ≤ 1.2 W/kg, SAR is not required for UNII 1; otherwise treat the remaining bands separately and test them independently for SAR.
- When the specified maximum output power is different between UNII 1 and UNII 2A, begin SAR with the band that has the higher specified maximum output. If the highest reported SAR for the band with the highest specified power is ≤ 1.2 W/kg, testing for the band with the lower specified output power is not required; otherwise test the remaining bands independently for SAR.

To determine the ***initial test position***, Area Scans were performed to determine the position with the *Maximum Value of SAR (measured)*. The position that produced the highest *Maximum Value of SAR* is considered the worst case position; thus used as the ***initial test position***.

12.3 Result of SAR

Below 6 GHz: SAR
Above 6 GHz: IPD

12.4 Result of bottom (FCC)

12.4.1 WLAN 2.4 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
Bottom	0	Main	11b	7	2442.0	22.50	***22.46***	0.023	**0.023**	1
				9	2452.0	22.50	22.45			
				11	2462.0	22.50	22.43			

12.4.2 WLAN 5.3 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
Bottom	0	Main	11a	52	5260.0	21.25	21.18	0.129	**0.131**	2
				56	5280.0	21.25	21.14			
				64	5320.0	21.25	21.07			

12.4.3 WLAN 5.6 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
Bottom	0	Main	11ac-80	106	5530.0	20.00	19.97			
				122	5610.0	22.00	21.83			
				138	5690.0	23.50	23.31	0.304	**0.318**	3

12.4.4 WLAN 5.8 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
Bottom	0	Main	11n-40	151	5755.0	22.00	21.81			
				159	5795.0	23.50	23.32	0.261	**0.272**	4

12.4.5 WLAN 5.9 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
Bottom	0	Main	11n-40	167	5835.0	23.00	22.93	0.288	**0.293**	5
				175	5875.0	22.50	22.39			

12.4.6 WLAN 6.2 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		4 cm^2 PD (W/m^2) n+		4 cm^2 PD (W/m^2) ntot+		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	Meas.	Scaled	
Bottom	0	Main	11be-320	31	6105.0	16.50	16.36					
				63	6265.0	15.00	15.00					
				95	6425.0	16.50	16.43	0.134	0.136	0.289	**0.294**	6

12.4.7 WLAN 6.5 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		4 cm^2 PD (W/m^2) n+		4 cm^2 PD (W/m^2) ntot+		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	Meas.	Scaled	
Bottom	0	Main	11ax-160	111	6505.0	14.50	14.39	0.056	0.057	0.136	**0.139**	7

12.4.8 WLAN 6.7 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		4 cm^2 PD (W/m^2) n+		4 cm^2 PD (W/m^2) ntot+		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	Meas.	Scaled	
Bottom	0	Main	11be-320	127	6585.0	16.50	16.50	0.118	0.118	0.262	**0.262**	8
				159	6745.0	15.75	15.75					

12.4.9 WLAN 7 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		4 cm^2 PD (W/m^2) n+		4 cm^2 PD (W/m^2) ntot+		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	Meas.	Scaled	
Bottom	0	Main	11be-320	191	6905.0	14.50	14.46	0.104	0.105	0.124	**0.125**	9

12.5 Keyboard

12.5.1 WLAN 2.4 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		10-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
Keyboard	0	Main	11b	7	2442.0	22.50	***22.46***	0.195	**0.197**	K1
				9	2452.0	22.50	22.45			
				11	2462.0	22.50	22.43			

12.5.2 WLAN 5.3 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		10-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
Keyboard	0	Main	11a	52	5260.0	21.25	21.18	0.867	**0.881**	K2
				56	5280.0	21.25	21.14	0.706	0.724	
				64	5320.0	21.25	21.07	0.746	0.778	

12.5.3 WLAN 5.6 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		10-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
Keyboard	0	Main	11ac-80	106	5530.0	20.00	19.97			
				122	5610.0	22.00	21.83			
				138	5690.0	23.50	23.31	0.352	**0.368**	K3

12.5.4 WLAN 5.8 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		10-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
Keyboard	0	Main	11n-40	151	5755.0	22.00	21.81			
				159	5795.0	23.50	23.32	0.401	**0.418**	K4

12.5.5 WLAN 5.9 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		10-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
Keyboard	0	Main	11n-40	167	5835.0	23.00	22.93	0.246	**0.250**	K5
				175	5875.0	22.50	22.39			

12.5.6 WLAN 6.2 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		4 cm² PD (W/m²) n+		4 cm² PD (W/m²) ntot+		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	Meas.	Scaled	
Keyboard	0	Main	11be-320	31	6105.0	16.50	16.36	0.528	0.545	0.956	0.987	
				63	6265.0	15.00	15.00	0.577	0.577	1.320	1.320	
				95	6425.0	16.50	16.43	1.100	1.118	2.090	**2.124**	K6

12.5.7 WLAN 6.5 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		4 cm² PD (W/m²) n+		4 cm² PD (W/m²) ntot+		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	Meas.	Scaled	
Keyboard	0	Main	11ax-160	111	6505.0	14.50	14.39	0.763	0.783	1.230	**1.262**	K7

12.5.8 WLAN 6.7 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		4 cm² PD (W/m²) n+		4 cm² PD (W/m²) ntot+		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	Meas.	Scaled	
Keyboard	0	Main	11be-320	127	6585.0	16.50	16.50	1.240	1.240	2.360	**2.360**	K8
				159	6745.0	15.75	15.75	0.621	0.621	1.180	1.180	

12.5.9 WLAN 7 GHz

Test Position	Dist. (mm)	Antenna	Mode	Ch #.	Freq. (MHz)	Power (dBm)		4 cm² PD (W/m²) n+		4 cm² PD (W/m²) ntot+		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	Meas.	Scaled	
Keyboard	0	Main	11be-320	191	6905.0	14.50	14.46	0.500	0.505	1.120	**1.130**	K9

SECTION 13: Simultaneous transmission SAR test exclusion considerations

NFC exposure information is quoted from ACJ9TGRI21A or ACJ9TGRI23A submission documents.

13.1 Sum and SPLSR

KDB 447498 D01 General RF Exposure Guidance provides two procedures for determining simultaneous transmission SAR test exclusion: Sum of SAR and SAR to Peak Location Ratio (SPLSR)

Sum of SAR

To qualify for simultaneous transmission SAR test exclusion based on sum of SAR, the sum of the reported standalone SARs for all simultaneously transmitting antennas shall be below the applicable standalone SAR limit. If the sum of the SARs is above the applicable limit, then simultaneous transmission SAR test exclusion may still apply if the requirements of the SAR to Peak Location Ratio (SPLSR) evaluation are met. When a pair of the summation is above 1.58 W/kg for 1g SAR, then SAR to Peak Location Ratio (SPLSR) is performed, as conservative even though applicable limit is 1.6 W/kg. finally sum of SAR value is convert to TER, see next section.
Simultaneous transmission for ENDC mode is treated on part2 test report.

SAR to Peak Location Ratio (SPLSR)

KDB 447498 D01 General RF Exposure Guidance explains how to calculate the SAR to Peak Location Ratio (SPLSR) between pairs of simultaneously transmitting antennas:

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

Where:
SAR_1 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

SAR_2 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

Ri 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

$$[(x_1-x_2)^2 + (y_1-y_2)^2 + (z_1-z_2)^2]$$

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:

$$(SAR_1 + SAR_2)^{1.5} / Ri \le 0.04$$

When an individual antenna transmits at on two bands simultaneously, the sum of the highest *reported* SAR for the frequency bands should be used to determine ***SAR_1***.or ***SAR_2***. When SPLSR is necessary, the smallest distance between the peak SAR locations for the antenna pair with respect to the peaks from each antenna should be used.

The antennas in all antenna pairs that do not qualify for simultaneous transmission SAR test exclusion must be tested for SAR compliance, according to the enlarged zoom scan and volume scan post-processing procedures in KDB Publication 865664 D01

13.1.1 Simultaneous transmission consideration.

To calculate, output power is quoted from highest tune up limit for each band.
Calculations are worst case of all combinations for compliance.

13.1.2 Below 6 GHz for bottom side

WWAN / NFC / WLAN-BT aux antenna (Below 6GHz) is estimated value, 0.4 W/kg.
WWAN + NFC + WLAN-BT aux antenna (Below 6GHz) + WLAN main antenna (Below 6GHz)
= (0.4 + 0.4 + 0.4 + 0.318) W/kg = 1.52 W/kg

13.1.3 Below 6 GHz for keyboard side

WWAN / NFC / WLAN-BT aux antenna (Below 6GHz) is estimated value, 1.0 W/kg.
WWAN + NFC + WLAN-BT aux antenna (Below 6GHz) + WLAN main antenna (Below 6GHz)
= (1.0 + 1.0 + 1.0 + 0.881) W/kg = 3.88 W/kg

13.1.4 Above 6 GHz

According to the FCC section § 1.1310, the following information provides the minimum separation distance for the highest gain antenna provided with the EUT calculated from (B) Limits for General Population / Uncontrolled Exposure of TABLE 1- LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE) of §1.1310 Radiofrequency radiation exposure limits.

$$Power\ Density = \frac{Power[mW]\ \times Gain[numeric]}{4\,\pi\ (Separation\ distance: 20cm)^2}$$

Power Density Result = 0.01537 mW / cm^2

For WLAN-BT Antenna, 0.02 for calculation.

13.1.5 Above 6 GHz for bottom side

WWAN + NFC + WLAN-BT aux antenna (Above 6GHz) + WLAN main antenna (Above 6GHz)
= (0.4 + 0.4) / 1.6 + 0.02 + 0.03 = 0.56 < 1

13.1.6 Above 6 GHz for keyboard side
WWAN + NFC + WLAN-BT aux antenna (Above 6GHz) + WLAN main antenna (Above 6GHz)
= (1.0 + 1.0) / 4.0 + 0.02 + 0.236 = 0.76 < 1

13.2 Conclusion

Complied.

SECTION 14: Test instrument

14.1 For power measurement

LIMS ID	Description	Manufacturer	Model	Serial	Last Cal Date	Interval
141901	Spectrum Analyzer	Keysight Technologies Inc	E4440A	MY48250080	2023/01/16	12
141366	Attenuator	Weinschel Associates	WA56-20	56200213	2023/05/18	12
208187	Pow er Sensor	Rohde & Schw arz	NRP50S	101419	2023/06/28	12

14.2 For SAR and PD

LIMS ID	Description	Manufacturer	Model	Serial	Last Cal Date	Interval
141484	Data Acquisition Electronics	Schmid & Partner Engineering AG	DAE4	1372	2023/03/16	12
141597	Dosimetric E-Field Probe	Schmid & Partner Engineering AG	EX3DV4	3825	2023/07/12	12
141457	Dipole Antenna	Schmid & Partner Engineering AG	D2450V2	713	2022/09/12	36
141467	Dipole Antenna	Schmid & Partner Engineering AG	D5GHzV2	1020	2023/11/15	12
168521	cDASY6 Module SAR	Schmid & Partner Engineering AG	cDASY6 Module SAR	-	-	-
141483	Data Acquisition Electronics	Schmid & Partner Engineering AG	DAE4	1369	2023/05/23	12
141598	Dosimetric E-Field Probe	Schmid & Partner Engineering AG	EX3DV4	3917	2023/05/23	12
142057	2mm Oval Flat Phantom	Schmid&Partner Engineering AG	QDOVA001BB	1203	2023/05/10	12
142488	Device holder	Schmid & Partner Engineering AG	Mounting device for transmitte	-	2023/11/17	12
142489	Device holder	Schmid & Partner Engineering AG	Mounting device for transmitte	-	2023/11/17	12
141573	Digital thermometer	HANNA INSTRUMENTS	Checktemp 4	-	2023/07/18	12
245238	Data Acquisition Electronics	Schmid & Partner Engineering AG	DAE4	518	2023/4/19	12

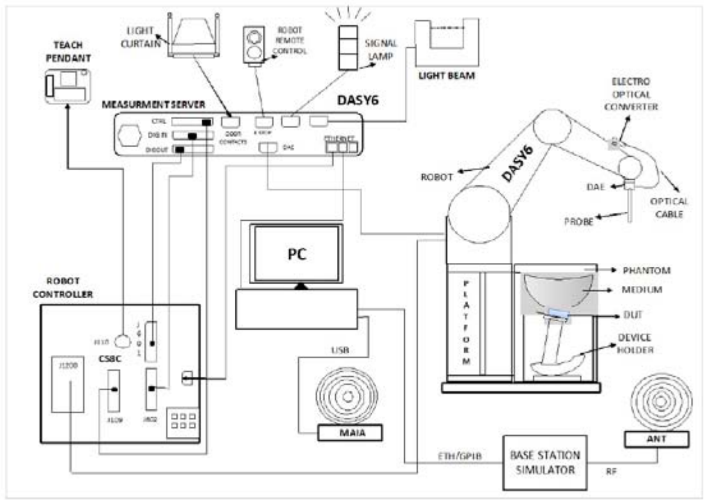
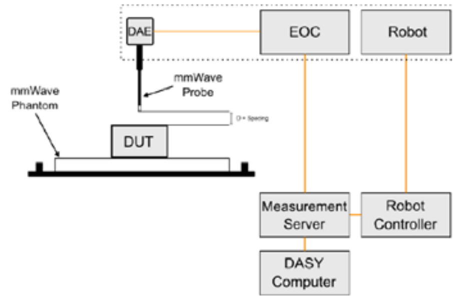
LIMS ID	Description	Manufacturer	Model	Serial	Last Cal Date	Interval
142248	SAR robot	Schmid & Partner Engineering AG	TX60 Lspeag	F13/5PP1D1/A/	2023/04/26	12
141570	Thermo-Hygrometer	CUSTOM. Inc	CTH-201	3101	2023/07/18	12
141182	Dielectric assessment softw are	Schmid & Partner Engineering AG	DAK	-	-	-
173900	Softw are for MA24106A	Anritsu Corporation	Anritsu Pow erXpert	-	-	-
141471	Dielectric assessment kit	Schmid & Partner Engineering AG	DAKS-3.5	0008	2023/04/17	12
142313	Attenuator	Telegrartner	J01156A0011	42294119	-	-
141551	Vector Reflectometer	Copper Mountain Technologies	PLANAR R140	0030913	2023/04/13	12
141574	Digital thermometer	LKM electronic	DTM3000	-	2023/07/18	12
142058	2mm Oval Flat Phantom	Schmid&Partner Engineering AG	QDOVA001BB	1207	2023/05/10	12
141875	Pre Amplifier	R&K	R&K CGA020M602-2633R	B30550	2023/06/27	12
176484	Head Simulating Liquid	Schmid & Partner Engineering AG	HBBL600-10000V6	SL AAH U16 BC	-	-
142249	SAR robot	Schmid & Partner Engineering AG	TX60 Lspeag	F13/5PP1A1/A/	2023/04/26	12
141890	Signal Generator	Keysight Technologies Inc	N5181A	MY47421098	2023/11/10	12
142559	Dual Directional Coupler	Hew lett Packard	772D	2839A0016	-	-
186095	mmWave Phantom	Schmid & Partner Engineering AG	QD 015 025 CA	1038	-	-
186090	mmWave probe	Schmid & Partner Engineering AG	EUmmWV4	9450	2023/11/07	12
186091	Dummy probe 5G	Schmid & Partner Engineering AG	SP DP2 002 AA	-	-	-
186096	cDASY6 Module mmWave	Schmid & Partner Engineering AG	cDASY6 Module mmWave	-	-	-
223861	Verification Source	Schmid & Partner Engineering AG	5G Verification Source 10 GHz	1051	2023/08/11	12
141311	Attenuator	Weinschel Associates	WA1-20-33	100131	2023/04/03	12
141223	Attenuator	Weinschel Associates	WA56-10	56100306	2023/05/18	12
222012	Pre Amplifier	R&K	AA350-RS	22055001	2023/08/03	12
222013	Pre Amplifier	R&K	AA360-RS	22055001	2023/08/03	12
213581	Signal Generator	Rohde & Schw arz	SMW200A	107688	2023/02/07	12
141808	Dual Pow er Meter	Keysight Technologies Inc	E4419B	MY45102060	2023/08/25	12
221492	Pow er sensor	Keysight Technologies Inc	E9300H	MY62080002	2023/08/25	12
221493	Pow er Sensor	Anritsu Corporation	MA24118A	2123074	2023/08/24	12
221497	Pow er Sensor	Anritsu Corporation	MA24118A	2123095	2023/08/24	12
141895	Signal Generator	Rohde & Schw arz	SMR40	100023	2023/8/8	12

Lims ID 213581 is used within due date.

*Hyphens for Last Calibration Date and Cal Int (month) are instruments that Calibration is not required (e.g. software), or instruments checked in advance before use.
The expiration date of the calibration is the end of the expired month.
As for some calibrations performed after the tested dates, those test equipment have been controlled by means of an unbroken chains of calibrations.
All equipment is calibrated with valid calibrations. Each measurement data is traceable to the national or international standards.

14.3 Test system

14.3.1 System components

<table>
<tr><th>SAR</th><th>mmW power density</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

14.3.2 Data Acquisition Electronics (DAE)

The data acquisition electronics (DAE4 or DAE3) 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.

14.3.3 Probes (SAR)

Dosimetric Probes: These probes are specially designed and calibrated for use in liquids with high permittivities. They should not be used in air, since the spherical isotropy in air is poor (+/- 2 dB). The dosimetric probes are specially calibrated in various liquids at different frequencies.

14.3.4 Probes (mmWave)

Dimensions and spatial resolutions:

- Overall length: 320 mm (tip: 20 mm)
- Tip diameter: encapsulation 8 mm (internal sensor <1mm)
- Distance from probe tip to dipole centers: <2 mm
- Sensor displacement to probe's calibration point: <0.3 mm
- linearity error and isotropy: included by calibration data
- dynamic range: <50 – 10'000 V/m with PRE-10 (min <50 – 3000 V/m)

14.3.5 EOC

The electrooptical converter (EOC), which is mounted on the robot arm. An internal data link is used from the EOC to the robot back panel. From there, a 10-meter cable connects to the measurement server DAE input.

14.3.6 Robot

The DASY6 system uses the high precision industrial robots TX60L from Stuaubli SA (France).

14.3.7 Simulated Tissues (Liquid)

series of tissue simulating liquids are available for various testing applications. The dielectric parameters of these liquids are matched to the target tissue parameters over a certain frequency range. A summary of available liquids is as follows:

HEAD TISSUE LIQUIDS	Dielectric parameters for simulating head-tissue parameters as defined in the SAR compliance standards (IEEE 1528, IEC 62209-1/2, etc.) Frequency range: 4 MHz – 10 GHz Tolerance to target: ±5% / ± 10% Detailed specifications: HSL
BODY TISSUE LIQUIDS	Dielectric parameters for simulating body-tissue parameters as defined in the SAR measurement guidance (FCC KDB 865664) Frequency range: 150 MHz – 6 GHz Tolerance to target: ±5% / ±10% Detailed specifications: MSL
SPECIAL LIQUIDS	CTIA Applications: brain tissue simulating liquid for radiation measurements according to CTIA 2.2 Appx C.3 MRI Solutions: tissue simulating Media for RF safety evaluation at MR Frequencies

14.3.8 Others

The SAR phantom, mmW phantom, the device holder and other accessories according to the targeted measurement.

SECTION 15: Appendixes

Refer to separated files for the following appendixes.

Appendix A: DUT and SAR Setup Photos

Appendix B: SAR Measurement data

Appendix C: System Check

Appendix D: Calibration data

Appendix E: Antenna location

End of Report