

**FCC SAR Test Report**  
**Test report no.: 17-1-0180901T09a-C3**



**Testing Laboratory**

**CETECOM GmbH**  
 Im Teelbruch 116  
 45219 Essen / Germany

Phone: +49 (0) 20 54 / 95 19-0  
 Fax: +49 (0) 20 54 / 95 19-997  
 Internet: <http://www.cetecom.com>  
 e-mail: [info@cetecom.com](mailto:info@cetecom.com)

**Accredited Test Laboratory:**  
 The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 by the Deutsche Akkreditierungsstelle GmbH (DAkkS). The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate with the registration number: D-PL-12047-01-01

**Applicant**

**Datalogic S.r.l.**  
 Via S. Vitalino, 13  
 40012, Lippo di Calderara di Reno (BO)  
 ITALY  
 Phone: +39 05 13 14 70 11  
 Fax: ---  
 e-mail: [francesco.rossi@datalogic.com](mailto:francesco.rossi@datalogic.com)  
 Contact: Francesco Rossi

**Manufacturer**

**Datalogic S.r.l.**  
 Via S. Vitalino, 13  
 40012, Lippo di Calderara di Reno (BO)  
 ITALY

**Test Standard/s**

FCC 47CFR §2.1093: Radiofrequency radiation exposure evaluation: portable devices.  
 For further applied test standards please refer to the test standards/ procedures references of this test report.

<b>Test Item</b>	
Kind of test item:	Mobile Computer
<b>Model name:</b>	FALCON X4
FCC ID:	U4GFX4WB
S/N serial number:	Z17P02013
Hardware status:	BETA
Software status:	Android 4. 4.4
Firmware version:	2.01.46.20180109
Frequency:	see technical details
Antenna:	integrated antenna
Battery option:	integrated battery
Device type:	portable device
Test sample status:	identical prototype
Exposure category:	general population / uncontrolled environment

This test report is electronically signed and valid without handwriting signature. For verification of the electronic signatures, the public keys can be requested at the testing laboratory.

The current version of the Test Report CETECOM\_TR17-1-0180901T09a-C3 replaces the test report CETECOM\_17-1-0180901T09a-C2 dated 2018-02-28. The replaced test report is herewith invalid.

**Test Report authorized:**

  
 Testing Manager

**Test performed:**

  
 Test Expert

### Revision History

Version	Date	Comments	Revised By
V1	5/1/2018	Initial Issue	Marc Schäfers
C1	27/2/2018	Additional comments for worst case selection added	Marc Schäfers
C2	28/2/2018	Removal of MIMO calculations and correction of the Test measurement overview	Marc Schäfers
C3	5/3/2018	Removal of EUT picture	Marc Schäfers

## Table of Contents

<b>1</b>	<b>Summary of Measurement Results</b>	<b>5</b>
<b>2</b>	<b>General information</b>	<b>6</b>
2.1	Test Lab information	6
2.2	Application details	6
2.3	Test Environment	7
2.4	Notes and disclaimer	7
2.5	Statement of compliance	7
2.6	DUT Technical details	8
2.6.1	DUT Antenna(s) Location	9
<b>3</b>	<b>Test standards/ procedures references</b>	<b>10</b>
3.1	Test standards	10
3.2	RF exposure limits	11
<b>4</b>	<b>SAR measurement variability and uncertainty</b>	<b>12</b>
4.1	SAR measurement variability	12
4.2	SAR measurement uncertainty	13
<b>5</b>	<b>Test Set-up</b>	<b>14</b>
5.1	Measurement system	14
5.1.1	System Description	14
5.1.2	Probe description	15
5.1.3	Data Acquisition Electronics (DAE) description	16
5.1.4	Phantom description	16
5.1.5	Device holder description	17
5.1.6	Scanning procedure	18
5.1.7	Spatial Peak SAR Evaluation	19
5.1.8	Data Storage and Evaluation	20
5.2	Description of Test Position	22
5.2.1	EUT constructions	22
5.2.2	Body Exposure Condition	22
5.3	System Verification	23
5.3.1	Tissue simulating liquids: dielectric properties	23
5.3.2	Tissue simulating liquids: parameters	24
5.3.3	System check	25
5.3.4	System validation	26
5.3.5	Justification for Extended SAR Dipole Calibrations	27
<b>6</b>	<b>Technology Test Configuration</b>	<b>28</b>
6.1	Operation Configurations	28
6.1.1	Wi-Fi Test Configuration	28

<b>7</b>	<b>Detailed Test Results</b>	<b>35</b>
7.1	Conducted power measurements	35
7.1.1	Conducted Power of Wi-Fi	35
7.1.2	Conducted Power of BT	39
7.2	SAR test results	40
7.2.1	Stand-alone SAR test evaluation	40
7.2.2	Results overview of 2.4 GHz Wi-Fi	41
7.2.3	Results overview of 5 GHz Wi-Fi	42
7.2.4	Simultaneous Transmission SAR Analysis	44
<b>8</b>	<b>Test equipment and ancillaries used for tests</b>	<b>45</b>
<b>9</b>	<b>Observations</b>	<b>45</b>
<b>10</b>	<b>Calibration parameters</b>	<b>45</b>
<b>11</b>	<b>Photo documentation</b>	<b>45</b>
	<b>Annex A: System performance check</b>	<b>46</b>
	<b>Annex B: DASY5 measurement results</b>	<b>46</b>
	<b>Annex C: Calibration parameters</b>	<b>46</b>
	<b>Annex D: Photo documentation</b>	<b>46</b>
	<b>Glossary</b>	<b>47</b>







## 1 Summary of Measurement Results

<input checked="" type="checkbox"/>	<b>No deviations from the technical specifications ascertained</b>	
<input type="checkbox"/>	Deviations from the technical specifications ascertained	
<b>Maximum SAR value reported (W/kg)</b>		
<b>Frequency</b>	<b>Body</b>	<b>Limbs</b>
Wi-Fi (2.4GHz)	0.334	0.161
Wi-Fi (5GHz)	<b>0.935</b>	<b>0.242</b>

## 2 General information

### 2.1 Test Lab information

The test facility is recognized, certified, or accredited by the following organizations:

1	<p><b>VCCI:</b> CETECOM GmbH has been registered in accordance with the Regulations for Voluntary Control Measures with Registration No.: R-2666 C-2914, C2914, T-1967, and G-301 respectively.</p>	 Voluntary Controls for Electromagnetic Emissions Reg. No.: R-2666 C-2914, T-1967, G-301
2	<p><b>FCC:</b> CETECOM GmbH has been recognized as an accredited testing laboratory. Reg. Number: MRA US-EU0003</p>	 MRA US-EU 0003
3	<p><b>IC:</b> CETECOM GmbH has been recognized as an accredited testing laboratory. Reg. Number: 3462D-2, 3462D-3</p>	 Industry Canada Reg. No.: 3462D-2 Reg. No.: 3462D-3
4	<p><b>DAkKS:</b> CETECOM GmbH has been recognized as an accredited testing laboratory. Reg. Number: D-PL-12047-01-01</p>	 Deutsche Akkreditierungsstelle D-PL-12047-01-01
5	<p><b>Wi-Fi:</b> CETECOM GmbH has been recognized as an accredited testing laboratory.</p>	 <b>AUTHORIZED RF LABORATORY</b>
6	<p><b>CTIA:</b> CETECOM GmbH has been recognized as an accredited testing laboratory. Lab Code: 20011130-00</p>	 ctia Authorized™ Test Lab Lab Code: 20011130-00

### 2.2 Application details

Date of receipt of test item: 2017-03-20  
 Start of test: 2017-12-08  
 End of test: 2017-12-29  
 Date of report: 2018-1-5  
 Person(s) present during the test: Marc Schäfers

### 2.3 Test Environment

The DASY measurement system is placed in a laboratory room within an environment which avoids influence on SAR measurements by ambient electromagnetic fields and any reflection from the environment. The pictures at the beginning of the photo documentation show a complete view of the test environment. The system allows the measurement of SAR values larger than 0.005 mW/g.

Ambient temperature:	20 – 24 °C
Tissue Simulating liquid:	20 – 24 °C
Relative humidity content:	30 – 70 %
Air pressure:	not relevant for this kind of testing

Exact temperature values for each test are shown in the table(s) under 7.2 and/or on the measurement plots.

### 2.4 Notes and disclaimer

This test report is electronically signed and valid without handwriting signature. For verification of the electronic signatures, the public keys can be requested at the testing laboratory. The testing service provided by CETECOM GmbH has been rendered under the current "General Terms and Conditions for CETECOM GmbH". CETECOM GmbH will not be liable for any loss or damage resulting from false, inaccurate, inappropriate or incomplete product information provided by the customer. Under no circumstances does the CETECOM GmbH test report include any endorsement or warranty regarding the functionality, quality or performance of any other product or service provided. Under no circumstances does the CETECOM GmbH test report include or imply any product or service warranties from CETECOM GmbH, including, without limitation, any implied warranties of merchantability, fitness for purpose, or non-infringement, all of which are expressly disclaimed by CETECOM GmbH. All rights and remedies regarding vendor's products and services for which CETECOM GmbH has prepared this test report shall be provided by the party offering such products or services and not by CETECOM GmbH. In no case this test report can be considered as a Letter of Approval.

### 2.5 Statement of compliance

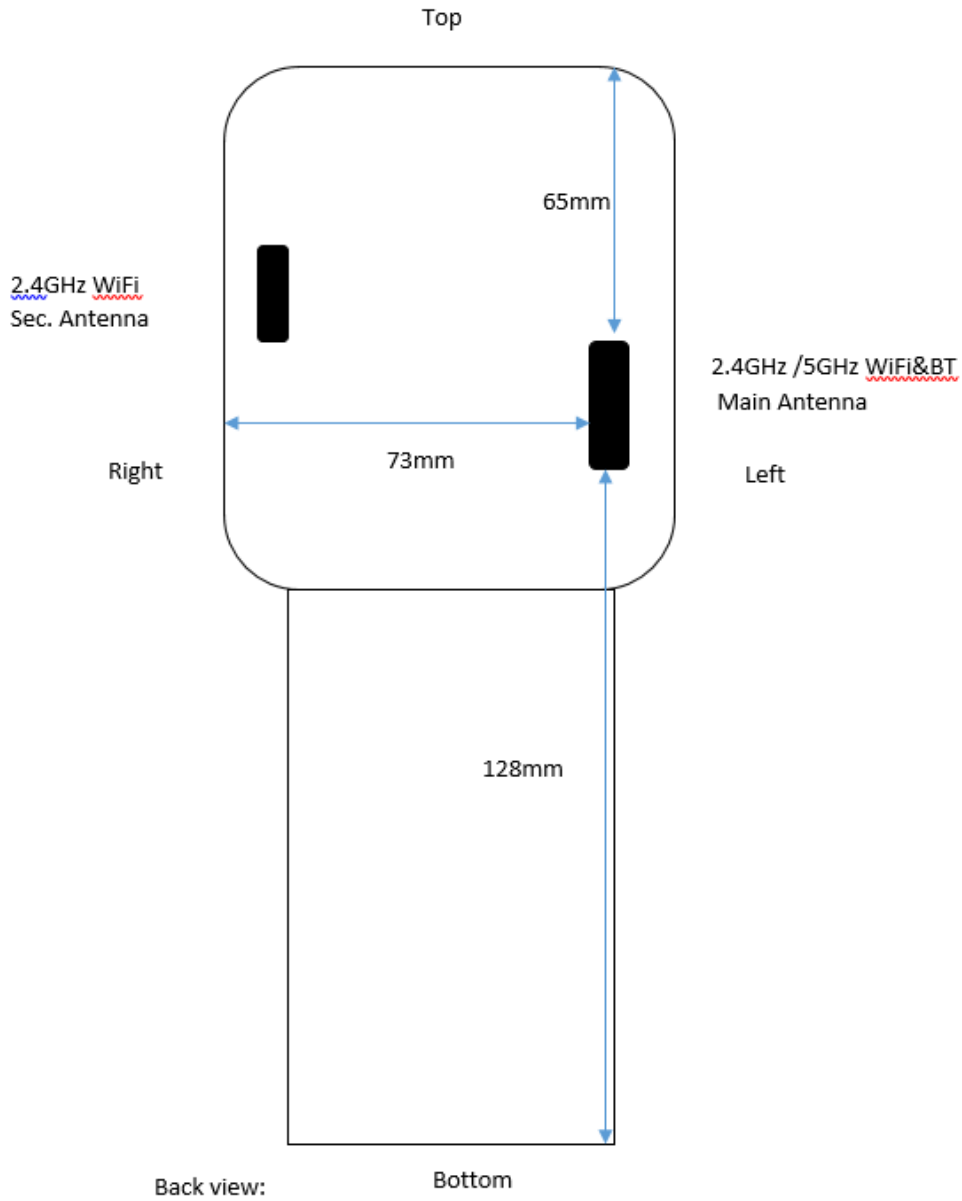
The SAR values found for the DUT are below the maximum recommended levels of 1.6 W/Kg as averaged over any 1 g tissue according to the FCC rule §2.1093, the ANSI/IEEE C 95.1:1992, the NCRP Report Number 86 for uncontrolled environment for General Population/Uncontrolled exposure.

## 2.6 DUT Technical details

Device Type :	portable device		
Exposure Category:	uncontrolled environment / general population		
Product Name:	Portable Mobile Computer		
Model No.(EUT):	<b>FALCON X4</b>		
FCC ID:	U4GFX4WB		
Product Phase:	production unit		
SN:	Z17P02013		
Hardware Version:	BETA		
Software Version:	Android 4.4.4		
Firmware Version:	2.01.46.20180109		
Antenna Details :	Integrated (ANT1 & ANT2)		
ANT1 Gain (Peak)	3.04 dBi (2400 MHz – 2500 MHz); 3.66 dBi (4900 MHz -5900 MHz) (According to Applicants Declaration)		
ANT2 Gain (Peak)	2.80 dBi (2400 MHz – 2500 MHz); (According to Applicants Declaration)		
Device Operating Configurations :			
Modulation Mode:	WIFI: DSSS,OFDM; BT: GFSK, $\pi/4$ DQPSK,8DPSK		
Frequency Bands:	Band	Tx (MHz)	Rx (MHz)
	Bluetooth	2400-2483.5	2400-2483.5
	Wi-Fi 2.4G	2400-2483.5	2400-2483.5
	Wi-Fi 5G	5150-5350 5470-5850	5150-5350 5470-5850
Battery Information:	Model: BT-26		
	Rated capacity :5200mAh		
	Battery Type :Rechargeable Li-ion Battery		
	Manufacturer: Datalogic S.r.l.		



**2.6.1 DUT Antenna(s) Location**



EUT Sides for SAR Testing(Main Antenna)						
Mode	Front	Back	Left	Right	Top	Bottom
Wi-Fi(2.4GHz)	Yes	Yes	Yes	Yes	Yes	No
Wi-Fi(5GHz)	Yes	Yes	Yes	Yes	Yes	No

Table 1: EUT Sides for SAR Testing

Note: The Sec. Antenna just for Wi-Fi 2.4GHz 802.11n HT20 MIMO transmit.

### 3 Test standards/ procedures references

#### 3.1 Test standards

Test Standard	Test Standard Description
FCC 47CFR §2.1093	Radiofrequency Radiation Exposure Evaluation: Portable Devices
IEEE Std C95.1 – 1991	IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz – 300 GHz.
IEEE 1528-2013	Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
KDB 248227 D01 802.11 Wi-Fi SAR v02r02	SAR GUIDANCE FOR IEEE 802.11 (Wi-Fi) TRANSMITTERS
KDB447498 D01 General RF Exposure Guidance v06	Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies
KDB447498 D03 Supplement C Cross-Reference v01	OET Bulletin 65, Supplement C Cross-Reference
KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04	SAR Measurement Requirements for 100 MHz to 6 GHz
KDB 865664 D02 RF Exposure Reporting v01r02	RF Exposure Compliance Reporting and Documentation Considerations

### 3.2 RF exposure limits

Human Exposure	Uncontrolled Environment General Population	Controlled Environment Occupational
<b>Spatial Peak SAR*</b> (Brain*Trunk)	1.60 mW/g	8.00 mW/g
<b>Spatial Average SAR**</b> (Whole Body)	0.08 mW/g	0.40 mW/g
<b>Spatial Peak SAR***</b> (Hands/Feet/Ankle/Wrist)	4.00 mW/g	20.00 mW/g

Table 2: RF exposure limits

**Notes:**

\* The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time

\*\* The Spatial Average value of the SAR averaged over the whole body.

\*\*\* The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

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

**Controlled Environments** are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation.)

#### 4 SAR measurement variability and uncertainty

##### 4.1 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  $\geq 0.80$  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  $\geq 1.45$  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  $\geq 1.5$  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.

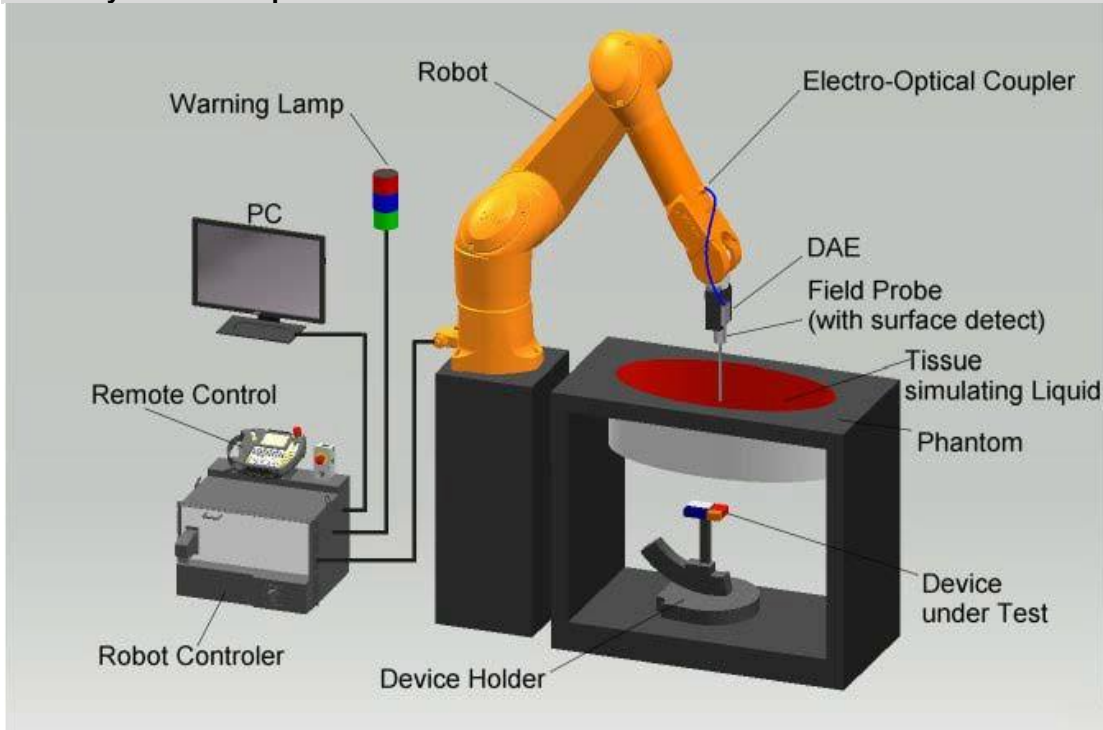
#### 4.2 SAR measurement uncertainty

Per KDB865664 D01 SAR Measurement 100 MHz to 6 GHz, when the highest measured 1-g SAR within a frequency band is < 1.5 W/kg, the extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval. The equivalent ratio (1.5/1.6) is applied to extremity and occupational exposure conditions.

## 5 Test Set-up

### 5.1 Measurement system

#### 5.1.1 System Description




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


- A standard high precision 6-axis robot (Stäubli RX/TX family) with controller and software. An arm extension for accommodating the data acquisition electronics (DAE).
- A dosimetric probe, i.e. an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid.
- 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.
- 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 DASy measurement server.
- The DASy 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.
- DASy software and SEMCAD data evaluation software.
- Remote control with teach panel and additional circuitry for robot safety such as warning lamps, etc.
- The generic twin phantom enabling the testing of left-hand and right-hand usage.
- The triple flat and eli phantom for the testing of handheld and body-mounted wireless devices.
- The device holder for handheld mobile phones and mounting device adaptor for laptops
- Tissue simulating liquid mixed according to the given recipes.
- System check dipoles allowing to validate the proper functioning of the system.

### 5.1.2 Probe description

#### Isotropic E-Field Probe EX3DV4 for Dosimetric Measurements

	<p>Symmetrical design with triangular core                  Built-in shielding against static charges                  PEEK enclosure material (resistant to organic solvents, e.g., DGBE)</p>
<p><b>Calibration</b></p>	<p>ISO/IEC 17025 <a href="#">calibration service</a> available.</p>
<p><b>Frequency</b></p>	<p>10 MHz to &gt; 6 GHz                  Linearity: <math>\pm 0.2</math> dB (30 MHz to 6 GHz)</p>
<p><b>Directivity</b></p>	<p><math>\pm 0.3</math> dB in TSL (rotation around probe axis)  <math>\pm 0.5</math> dB in TSL (rotation normal to probe axis)</p>
<p><b>Dynamic Range</b></p>	<p>10 <math>\mu</math>W/g to &gt; 100 mW/g                  Linearity: <math>\pm 0.2</math> dB (noise: typically &lt; 1 <math>\mu</math>W/g)</p>
<p><b>Dimensions</b></p>	<p>Overall length: 337 mm (Tip: 20 mm)                  Tip diameter: 2.5 mm (Body: 12 mm)                  Typical distance from probe tip to dipole centers: 1 mm</p>
<p><b>Application</b></p>	<p>High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields); the only probe that enables compliance testing for frequencies up to 6 GHz with precision of better 30%.</p>
<p><b>Compatibility</b></p>	<p>DASY3, DASY4, DASY52 SAR and higher, EASY4/MRI</p>


### 5.1.3 Data Acquisition Electronics (DAE) description

<b>Model</b>	DAE4	
<b>Construction</b>	Signal amplifier, multiplexer, A/D converter and control logic. Serial optical link for communication with DASY4/5 embedded system (fully remote controlled). Two step probe touch detector for mechanical surface detection and emergency robot stop.	
<b>Measurement Range</b>	-100 to +300 mV (16 bit resolution and two range settings: 4mV,400mV)	
<b>Input Offset Voltage</b>	< 5µV (with auto zero)	
<b>Input Bias Current</b>	< 50 f A	
<b>Dimensions</b>	60 x 60 x 68 mm	

### 5.1.4 Phantom description


The phantom consists of a fibreglass shell integrated in a wooden table. It allows left-hand and right-hand head as well as body-worn measurements with a maximum liquid depth of 18 cm in head position and 22 cm in planar position (body measurements). The thickness of the Phantom shell is 2 mm +/- 0.1 mm.

#### 5.1.4.1 SAM Twin Phantom

<b>Material</b>	Vinylester, glass fiber reinforced (VE-GF)	
<b>Liquid Compatibility</b>	Compatible with all SPEAG tissue simulating liquids (incl. DGBE type)	
<b>Shell Thickness</b>	2 ± 0.2 mm (6 ± 0.2 mm at ear point)	
<b>Dimensions (incl. Wooden Support)</b>	Length: 1000 mm Width: 500 mm Height: adjustable feet	
<b>Filling Volume</b>	approx. 25 liters	
<b>Wooden Support</b>	SPEAG standard phantom table	
<p>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.</p> <p>Twin SAM V5.0 has the same shell geometry and is manufactured from the same material as Twin SAM V4.0, but has reinforced top structure.</p>		



#### 5.1.4.2 ELI Phantom

<b>Material</b>	Vinylester, glass fiber reinforced (VE-GF)	
<b>Liquid Compatibility</b>	Compatible with all SPEAG tissue simulating liquids (incl. DGBE type)	
<b>Shell Thickness</b>	2.0 ± 0.2 mm (bottom plate)	
<b>Dimensions</b>	Major axis: 600 mm Minor axis: 400 mm	
<b>Filling Volume</b>	approx. 30 liters	
<b>Wooden Support</b>	SPEAG standard phantom table	

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.  
 ELI V5.0 has the same shell geometry and is manufactured from the same material as ELI4, but has reinforced top structure.

#### 5.1.5 Device holder description

The DASY device holder has two scales for device rotation (with respect to the body axis) and the device inclination (with respect to the line between the ear openings). The plane between the ear openings and the mouth tip has a rotation angle of 65°. The bottom plate contains three pair of bolts for locking the device holder. The device holder positions are adjusted to the standard measurement positions in the three sections. This device holder is used for standard mobile phones or PDA's only. If necessary an additional support of polystyrene material is used.



Larger DUT's (e.g. notebooks) cannot be tested using this device holder. Instead a support of bigger polystyrene cubes and thin polystyrene plates is used to position the DUT in all relevant positions to find and measure spots with maximum SAR values. Therefore those devices are normally only tested at the flat part of the SAM.

### 5.1.6 Scanning procedure

- The DASY installation includes predefined files with recommended procedures for measurements and system check. They are read-only document files and destined as fully defined but unmeasured masks. All test positions (head or body-worn) are tested with the same configuration of test steps differing only in the grid definition for the different test positions.
- The „reference“ and „drift“ measurements are located at the beginning and end of the batch process. They measure the field drift at one single point in the liquid over the complete procedure. The indicated drift is mainly the variation of the DUT's output power and should vary max. +/- 5 %.
- The highest integrated SAR value is the main concern in compliance test applications. These values can mostly be found at the inner surface of the phantom and cannot be measured directly due to the sensor offset in the probe. To extrapolate the surface values, the measurement distances to the surface must be known accurately. A distance error of 0.5mm could produce SAR errors of 6% at 1800 MHz. Using predefined locations for measurements is not accurate enough. Any shift of the phantom (e.g., slight deformations after filling it with liquid) would produce high uncertainties. For an automatic and accurate detection of the phantom surface, the DASY5 system uses the mechanical surface detection. The detection is always at touch, but the probe will move backward from the surface the indicated distance before starting the measurement.
- The “area scan” measures the SAR above the DUT or verification dipole on a parallel plane to the surface. It is used to locate the approximate location of the peak SAR with 2D spline interpolation. The robot performs a stepped movement along one grid axis while the local electrical field strength is measured by the probe. The probe is touching the surface of the SAM during acquisition of measurement values. The scan uses different grid spacings for different frequency measurements. Standard grid spacing for head measurements in frequency ranges  $\leq 2$ GHz is 15 mm in x- and y- dimension. For higher frequencies a finer resolution is needed, thus for the grid spacing is reduced according the following table:

Area scan grid spacing for different frequency ranges	
Frequency range	Grid spacing
$\leq 2$ GHz	$\leq 15$ mm
2 – 4 GHz	$\leq 12$ mm
4 – 6 GHz	$\leq 10$ mm

Grid spacing and orientation have no influence on the SAR result. For special applications where the standard scan method does not find the peak SAR within the grid, e.g. mobile phones with flip cover, the grid can be adapted in orientation. Results of this coarse scan are shown in annex B.

- A “zoom scan” measures the field in a volume around the 2D peak SAR value acquired in the previous “coarse” scan. It uses a fine meshed grid where the robot moves the probe in steps along all the 3 axis (x,y and z-axis) starting at the bottom of the Phantom. The grid spacing for the cube measurement is varied according to the measured frequency range, the dimensions are given in the following table:

Zoom scan grid spacing and volume for different frequency ranges			
Frequency range	Grid spacing for x, y axis	Grid spacing for z axis	Minimum zoom scan volume
$\leq 2$ GHz	$\leq 8$ mm	$\leq 5$ mm	$\geq 30$ mm
2 – 3 GHz	$\leq 5$ mm	$\leq 5$ mm	$\geq 28$ mm
3 – 4 GHz	$\leq 5$ mm	$\leq 4$ mm	$\geq 28$ mm
4 – 5 GHz	$\leq 4$ mm	$\leq 3$ mm	$\geq 25$ mm
5 – 6 GHz	$\leq 4$ mm	$\leq 2$ mm	$\geq 22$ mm

DASY is also able to perform repeated zoom scans if more than 1 peak is found during area scan. In this document, the evaluated peak 1g and 10g averaged SAR values are shown in the 2D-graphics in annex B. Test results relevant for the specified standard are shown in table form.

### 5.1.7 Spatial Peak SAR Evaluation

The spatial peak SAR - value for 1 and 10 g is evaluated after the Cube measurements have been done. The basis of the evaluation are the SAR values measured at the points of the fine cube grid consisting of all points in the three directions x, y and z. The algorithm that finds the maximal averaged volume is separated into three different stages.

- The data between the dipole center of the probe and the surface of the phantom are extrapolated. This data cannot be measured since the center of the dipole is 1 to 2.7 mm away from the tip of the probe and the distance between the surface and the lowest measuring point is about 1 mm (see probe calibration sheet). The extrapolated data from a cube measurement can be visualized by selecting 'Graph Evaluated'.
- The maximum interpolated value is searched with a straight-forward algorithm. Around this maximum the SAR - values averaged over the spatial volumes (1g or 10 g) are computed using the 3d-spline interpolation algorithm. If the volume cannot be evaluated (i.e., if a part of the grid was cut off by the boundary of the measurement area) the evaluation will be started on the corners of the bottom plane of the cube.
- All neighbouring volumes are evaluated until no neighbouring volume with a higher average value is found.

#### Extrapolation

The extrapolation is based on a least square algorithm [W. Gander, Computermathematik, p.168-180]. Through the points in the first 3 cm along the z-axis, polynomials of order four are calculated. These polynomials are then used to evaluate the points between the surface and the probe tip. The points, calculated from the surface, have a distance of 1 mm from each other.

#### Interpolation

The interpolation of the points is done with a 3d-Spline. The 3d-Spline is composed of three one-dimensional splines with the "Not a knot"-condition [W. Gander, Computermathematik, p.141-150] (x, y and z -direction) [Numerical Recipes in C, Second Edition, p.123ff].

#### Volume Averaging

At First the size of the cube is calculated. Then the volume is integrated with the trapezoidal algorithm. 8000 points (20x20x20) are interpolated to calculate the average.

#### Advanced Extrapolation

DASY uses the advanced extrapolation option which is able to compensate boundary effects on E-field probes.

### 5.1.8 Data Storage and Evaluation

#### Data Storage

The DASY 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 ".DA4", ".DA5x". 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/cm<sup>2</sup>], [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.

#### 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	Normi, ai0, ai1, ai2
	- Conversion factor	ConvFi
	- Diode compression point	Dcpi
Device parameters:	- Frequency	f
	• Crest factor	cf
Media parameters:	- Conductivity	$\sigma$
	- Density	$\rho$

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 DASY 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:

$$V_i = U_i + U^2 \cdot cf/dcpi$$

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)  
dcpi= diode compression point (DASY parameter)

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

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

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

[mV/(V/m)<sup>2</sup>] 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):

$$E_{tot} = (E_1^2 + E_2^2 + E_3^2)^{1/2}$$

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

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

With SAR = local specific absorption rate in mW/g  
 $E_{tot}$  = total field strength in V/m  
 $\sigma$  = conductivity in [mho/m] or [Siemens/m]  
 $\rho$  = equivalent tissue density in g/cm<sup>3</sup>

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.

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

With  $P_{pwe}$  = equivalent power density of a plane wave in mW/cm<sup>2</sup>  
 $E_{tot}$  = total electric field strength in V/m  
 $H_{tot}$  = total magnetic field strength in A/m

## 5.2 Description of Test Position

### 5.2.1 EUT constructions

### 5.2.2 Body Exposure Condition

#### 5.2.2.1 Body exposure conditions

The back surface and edges of the tablet should be tested for SAR compliance with the DUT touching the phantom. The SAR Exclusion Threshold in KDB 447498 D01 can be applied to determine SAR test exclusion for adjacent edge configurations. The closest distance from the antenna to an adjacent DUT edge is used to determine if SAR testing is required for the adjacent edges, with the adjacent edge positioned against the phantom and the edge containing the antenna positioned perpendicular to the phantom.

#### 5.2.2.2 Extremity exposure conditions

Devices that are designed or intended for use on extremities or mainly operated in extremity only exposure conditions; i.e., hands, wrists, feet and ankles, may require extremity SAR evaluation. When the device also operates in close proximity to the user's body, SAR compliance for the body is also required. The 1-g body and 10-g extremity SAR Exclusion Thresholds found in KDB Publication 447498 D01 should be applied to determine SAR test requirements.

### 5.3 System Verification

#### 5.3.1 Tissue simulating liquids: dielectric properties

(Liquids used for tests are marked with ☒)

HSL600-6000MHz is composed of the following ingredients and provided by SPEAG:

Water: 50-65%

Mineral oil: 10-30%

Emulsifiers: 8-25%

Sodium salt: 0-1.5%

MSL600-6000MHz is composed of the following ingredients and provided by SPEAG:

Water: 64-78%

Mineral oil: 11-18%

Emulsifiers: 9-15%

Sodium salt: 2-3%

Table 3: Body tissue dielectric properties

### 5.3.2 Tissue simulating liquids: parameters

The dielectric properties for this Tissue Simulate Liquids were measured by using the DAK. The Conductivity ( $\sigma$ ) and Permittivity ( $\rho$ ) are listed in bellow Table .For the SAR measurement given in this report. The temperature variation of the Tissue Simulate Liquids was  $22\pm 2^{\circ}\text{C}$ .

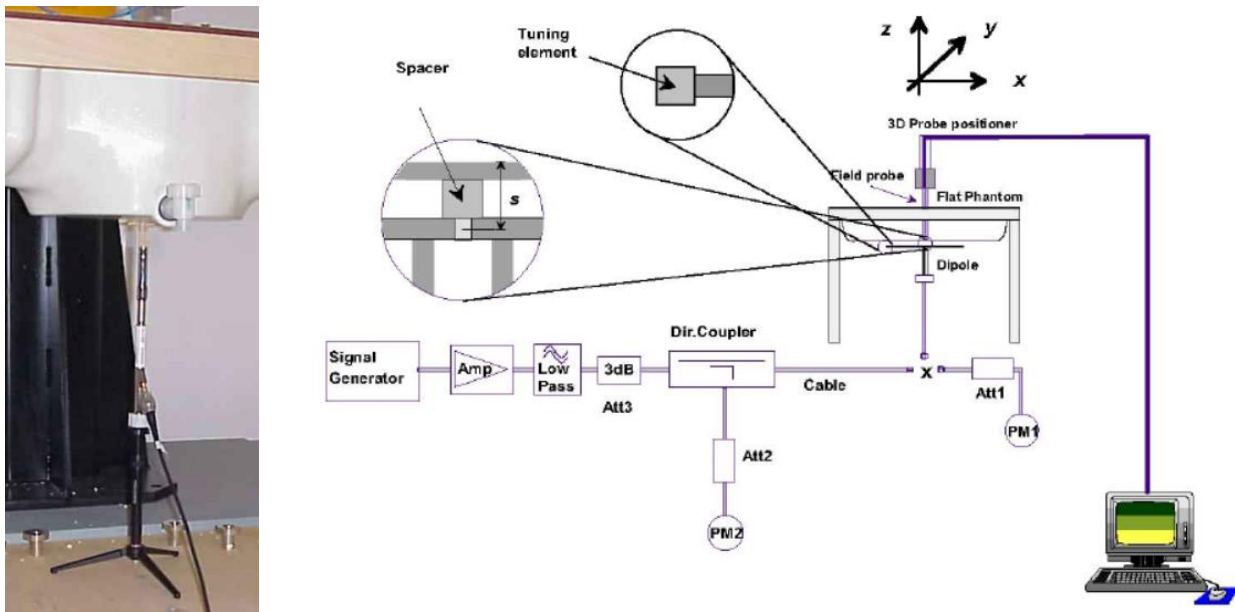
Tissue Type	Measured Frequency (MHz)	Target Tissue ( $\pm 5\%$ )		Measured Tissue		Liquid Temp. ( $^{\circ}\text{C}$ )	Measured Date
		$\epsilon_r$	$\sigma(\text{S/m})$	$\epsilon_r$	$\sigma(\text{S/m})$		
600-6000 Body	2450	52.70 (50.07~55.34)	1.95 (1.85~2.05)	52.29	2.02	22.2	13/12/2017
	5200	49.01 (46.56~51.47)	5.30 (5.03~5.56)	47.33	5.391	22.2	14/12/2017
	5600	48.47 (46.05~50.90)	5.77 (5.48~6.05)	46.41	5.965	22.2	15/12/2017
	5800	48.2 (45.79~50.61)	6.00 (5.70~6.30)	46.05	6.268	22.2	27/12/2017



### 5.3.3 System check

#### 5.3.3.1 System check procedure

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



F-1. the microwave circuit arrangement used for SAR system check

### 5.3.3.2 System check result(s)

Validation Kit		Measured SAR 250mW 1g (W/kg)	Measured SAR 250mW 10g (W/kg)	Measured SAR (normalized to 1w) 1g (W/kg)	Measured SAR ormalized to 1w) 10g (W/kg)	Target SAR (normalized to 1w) (±10%) 1-g(W/kg)	Target SAR (normalized to 1w) (±10%) 10-g(W/kg)	Liquid Temp. (°C)	Measured Date
D2450V2	Body	13.12	6.25	52.48	25	51.1 (45.99~56.21)	24.1 (21.69~26.51)	22.2	13/12/2017

Validation Kit		Measured SAR 100mW 1g (W/kg)	Measured SAR 100mW 10g (W/kg)	Measured SAR (normalized to 1w) 1g (W/kg)	Measured SAR ormalized to 1w) 10g (W/kg)	Target SAR (normalized to 1w) (±10%) 1-g(W/kg)	Target SAR (normalized to 1w) (±10%) 10-g(W/kg)	Liquid Temp. (°C)	Measured Date
D5GHzV2	5.2G Body	7.22	2.03	72.2	8.12	73.3 (65.97~80.63)	20.5 (18.45~22.55)	22.2	14/12/2017
	5.6G Body	7.82	2.15	78.2	8.6	79.4 (71.46~87.34)	22.3 (20.07~24.53)	22.2	15/12/2017
	5.8G Body	7.75	2.33	77.5	9.32	76.2 (68.58~83.82)	21.1 (18.99~23.21)	22.2	27/12/2017

Table 4: SAR System Check Result.

Note: Detailed System Check Results please see Annex A

### 5.3.4 System validation

The system validation is performed in a similar way as a system check. It needs to be performed once a SAR measurement system has been established and allows an evaluation of the system accuracy with all components used together with the specified system. It has to be repeated at least once a year or when new system components are used (DAE, probe, phantom, dipole, liquid type). In addition to the procedure used during system check a system validation also includes checks of probe isotropy, probe modulation factor and RF signal.

### 5.3.5 Justification for Extended SAR Dipole Calibrations

1) Referring to KDB865664 D01 requirements for dipole calibration, instead of the typical annual calibration recommended by measurement standards, longer calibration intervals of up to three years may be considered when it is demonstrated that the SAR target, impedance and return loss of a dipole have remain stable according to the following requirements. Each measured dipole is expected to evaluate with the following criteria at least on annual interval in Appendix C.

- a) There is no physical damage on the dipole;
- b) System check with specific dipole is within 10% of calibrated value;
- c) Return-loss is within 10% of calibrated measurement;
- d) Impedance is within  $5\Omega$  from the previous measurement.

2) DAK's probe calibration against air, distilled water and a shorting block performed before measuring liquid parameters.

## 6 Technology Test Configuration

### 6.1 Operation Configurations

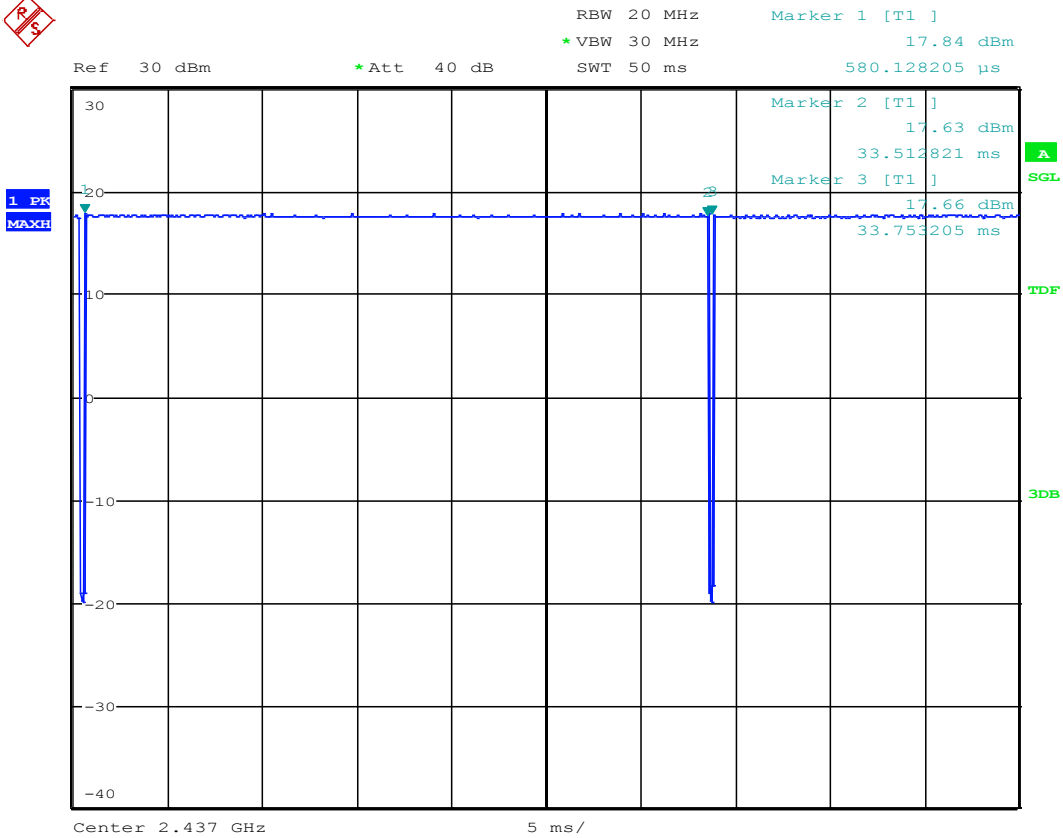
#### 6.1.1 Wi-Fi Test Configuration

A Wi-Fi device must be configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor supported by the test mode tools for SAR measurement.

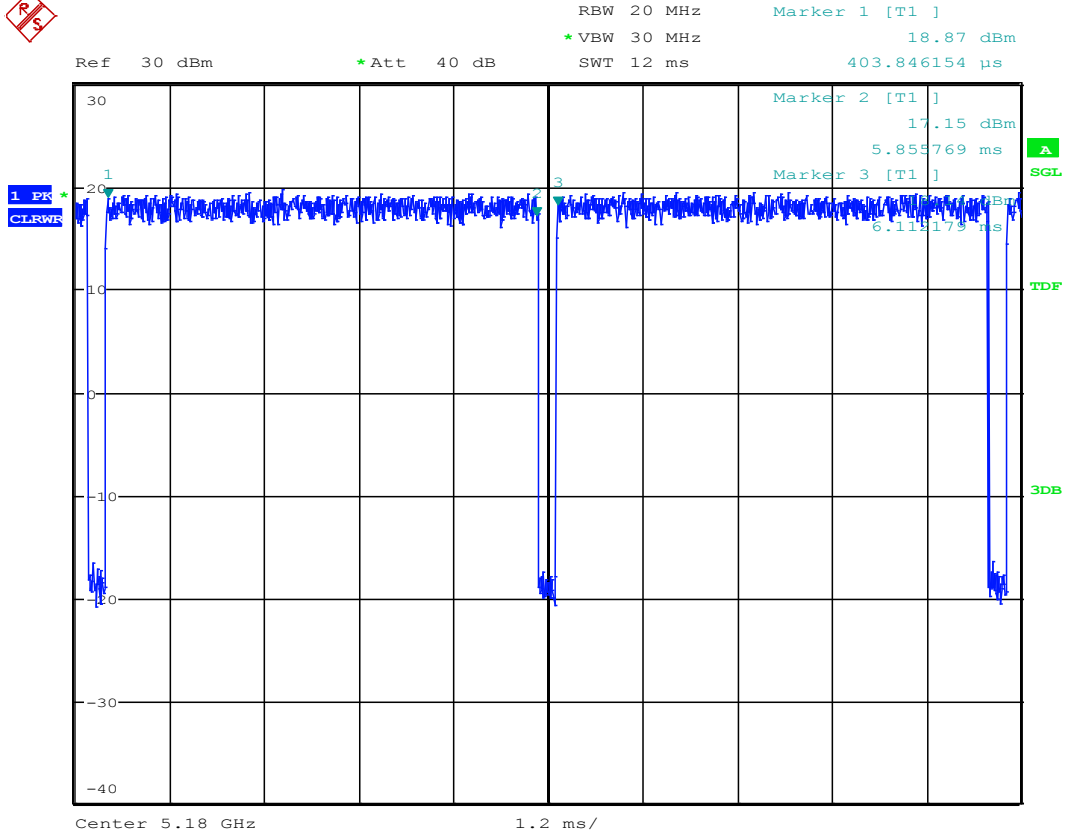
##### 6.1.1.1 Duty cycle:

1) 2.4GHz Wi-Fi 802.11b:

$$\text{Duty cycle} = \frac{32.93269}{32.93269 + 0.24038} = 99.28\%$$



- 2) 5GHz Wi-Fi 802.11a:  
Duty cycle= $5.45192 / (5.45192 + 0.25641) = 95.51\%$



### 6.1.1.2 Initial Test Position SAR Test Reduction Procedure

To determine the test setup pretests were performed with the following settings

- Handheld setup
- Handheld setup with soft case
- Pistol setup
- Pistol setup with soft case

Worst case setup was determined as handheld only.

- Soft case increases the distance to body and limbs which results into a lower SAR and consists of non-metallic materials
- Pistol setup increases distance to body on one side which results into a lower SAR

DSSS and OFDM configurations are considered separately according to the required SAR procedures. SAR is measured in the initial test position using the 802.11 transmission mode configuration required by the DSSS procedure or initial test configuration and subsequent test configuration(s) according to the OFDM procedures.

The initial test position procedure is described in the following:

- 1) . When the reported SAR of the initial test position is  $\leq 0.4$  W/kg, further SAR measurement is not required for the other (remaining) test positions in that exposure configuration and 802.11 transmission mode combinations within the frequency band or aggregated band. SAR is also not required for that exposure configuration in the subsequent test configuration(s).
- 2) . When the reported SAR of the initial test position is  $> 0.4$  W/kg, SAR is repeated for the 802.11 transmission mode configuration tested in the initial test position using subsequent highest extrapolated or estimated 1-g SAR conditions determined by area scans or next closest/smallest test separation distance and maximum RF coupling test positions based on manufacturer justification, on the highest maximum output power channel, until the reported SAR is  $\leq 0.8$  W/kg or all required test positions (left, right, touch, tilt or subsequent surfaces and edges) are tested.

For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is  $> 0.8$  W/kg, SAR is measured for these test positions/configurations on the subsequent next highest measured output power channel(s) until the reported SAR is  $\leq 1.2$  W/kg or all required channels are tested. a) Additional power measurements may be required for this step, which should be limited to those necessary for identifying the subsequent highest output power channels.

### 6.1.1.3 Initial Test Configuration Procedures

An initial test configuration is determined for OFDM transmission modes according to the channel bandwidth, modulation and data rate combination(s) with the highest maximum output power specified for production units in each standalone and aggregated frequency band. SAR is measured using the highest measured maximum output power channel. For configurations with the same specified or measured maximum output power, additional transmission mode and test channel selection procedures are required. SAR test reduction for subsequent highest output test channels is determined according to *reported* SAR of the initial test configuration.

For next to the ear, hotspot mode and UMC mini-tablet exposure configurations where multiple test positions are required, the initial test position procedure is applied to minimize the number of test positions required for SAR measurement using the initial test configuration transmission mode. For fixed exposure conditions that do not have multiple SAR test positions, SAR is measured in the transmission mode determined by the initial test configuration.

When the *reported* SAR of the initial test configuration is  $> 0.8$  W/kg, SAR measurement is required for subsequent next highest measured output power channel(s) in the initial test configuration until *reported* SAR is  $\leq 1.2$  W/kg or all required channels are tested.

#### 6.1.1.4 Subsequent Test Configuration Procedures

SAR measurement requirements for the remaining 802.11 transmission mode configurations that have not been tested in the initial test configuration are determined separately for each standalone and aggregated frequency band, in each exposure condition, according to the maximum output power specified for production units. The initial test position procedure is applied to next to the ear, UMPC mini-tablet and hotspot mode configurations. When the same maximum output power is specified for multiple transmission modes, additional power measurements may be required to determine if SAR measurements are required for subsequent highest output power channels in a subsequent test configuration. The subsequent test configuration and SAR measurement procedures are described in the following.

- 1) . When SAR test exclusion provisions of KDB Publication 447498 are applicable and SAR measurement is not required for the initial test configuration, SAR is also not required for the next highest maximum output power transmission mode subsequent test configuration(s) in that frequency band or aggregated band and exposure configuration.
- 2) . When the highest *reported* SAR for the initial test configuration (when applicable, include subsequent highest output channels), according to the initial test position or fixed exposure position requirements, is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is  $\leq 1.2$  W/kg, SAR is not required for that subsequent test configuration.
- 3) . The number of channels in the initial test configuration and subsequent test configuration can be different due to differences in channel bandwidth. When SAR measurement is required for a subsequent test configuration and the channel bandwidth is smaller than that in the initial test configuration, all channels in the subsequent test configuration that overlap with the larger bandwidth channel tested in the initial test configuration should be used to determine the highest maximum output power channel. This step requires additional power measurement to identify the highest maximum output power channel in the subsequent test configuration to determine SAR test reduction.
  - a) SAR should first be measured for the channel with highest measured output power in the subsequent test configuration.
  - b) SAR for subsequent highest measured maximum output power channels in the subsequent test configuration is required only when the *reported* SAR of the preceding higher maximum output power channel(s) in the subsequent test configuration is  $> 1.2$  W/kg or until all required channels are tested. i) For channels with the same measured maximum output power, SAR should be measured using the channel closest to the center frequency of the larger channel bandwidth channel in the initial test configuration.
- 4) . SAR measurements for the remaining highest specified maximum output power OFDM transmission mode configurations that have not been tested in the initial test configuration (highest maximum output) or subsequent test configuration(s) (subsequent next highest maximum output power) is determined by recursively applying the subsequent test configuration procedures in this section to the remaining configurations according to the following:
  - a) replace “subsequent test configuration” with “next subsequent test configuration” (i.e., subsequent next highest specified maximum output power configuration)
  - b) replace “initial test configuration” with “all tested higher output power configurations”

#### 6.1.1.5 2.4 GHz Wi-Fi SAR Procedures

Separate SAR procedures are applied to DSSS and OFDM configurations in the 2.4 GHz band to simplify DSSS test requirements. For 802.11b DSSS SAR measurements, DSSS SAR procedure applies to fixed exposure test position and initial test position procedure applies to multiple exposure test positions. When SAR measurement is required for an OFDM configuration, the initial test configuration, subsequent test configuration and initial test position procedures are applied. The SAR test exclusion requirements for 802.11g/n OFDM configurations are described in following.

- **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  $\leq 0.8$  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 (section 5.3, including sub-sections). 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  $\leq 1.2$  W/kg.

- **SAR Test Requirements for OFDM configurations**

When SAR measurement is required for 802.11 g/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.



#### 6.1.1.6 5 GHz Wi-Fi SAR Procedures

- **U-NII-1 and U-NII-2A Bands**

For devices that operate in only one of the U-NII-1 and U-NII-2A bands, the normally required SAR procedures for OFDM configurations are applied. For devices that operate in both U-NII bands using the same transmitter and antenna(s), SAR test reduction is determined according to the following:

- 1) When the same maximum output power is specified for both bands, begin SAR measurement in U-NII-2A band by applying the OFDM SAR requirements. If the highest reported SAR for a test configuration is  $\leq 1.2$  W/kg, SAR is not required for U-NII-1 band for that configuration (802.11 mode and exposure condition); otherwise, both bands are tested independently for SAR.
- 2) When different maximum output power is specified for the bands, begin SAR measurement in the band with higher specified maximum output power. The highest reported SAR for the tested configuration is adjusted by the ratio of lower to higher specified maximum output power for the two bands. When the adjusted SAR is  $\leq 1.2$  W/kg, SAR is not required for the band with lower maximum output power in that test configuration; otherwise, both bands are tested independently for SAR.
- 3) The two U-NII bands may be aggregated to support a 160 MHz channel on channel number 50. Without additional testing, the maximum output power for this is limited to the lower of the maximum output power certified for the two bands. When SAR measurement is required for at least one of the bands and the highest reported SAR adjusted by the ratio of specified maximum output power of aggregated to standalone band is  $> 1.2$  W/kg, SAR is required for the 160 MHz channel. This procedure does not apply to an aggregated band with maximum output higher than the standalone band(s); the aggregated band must be tested independently for SAR. SAR is not required when the 160 MHz channel is operating at a reduced maximum power and also qualifies for SAR test exclusion.

- **U-NII-2C and U-NII-3 Bands**

The frequency range covered by these bands is 380 MHz (5.47 – 5.85 GHz), which requires a minimum of at least two SAR probe calibration frequency points to support SAR measurements. When Terminal Doppler Weather Radar (TDWR) restriction applies, all channels that operate at 5.60 – 5.65 GHz must be included to apply the SAR test reduction and measurement procedures.

When the same transmitter and antenna(s) are used for U-NII-2C band and U-NII-3 band or 5.8 GHz band of §15.247, the bands may be aggregated to enable additional channels with 20, 40 or 80 MHz bandwidth to span across the band gap, as illustrated in Appendix B. The maximum output power for the additional band gap channels is limited to the lower of those certified for the bands. Unless band gap channels are permanently disabled, they must be considered for SAR testing. The frequency range covered by these bands is 380 MHz (5.47 – 5.85 GHz), which requires a minimum of at least two SAR probe calibration frequency points to support SAR measurements. To maintain SAR measurement accuracy and to facilitate test reduction, the channels in U-NII-2C band above 5.65 GHz may be grouped with the 5.8 GHz channels in U-NII-3 or §15.247 band to enable two SAR probe calibration frequency points to cover the bands, including the band gap channels. When band gap channels are supported and the bands are not aggregated for SAR testing, band gap channels must be considered independently in each band according to the normally required OFDM SAR measurement and probe calibration frequency points requirements.

- **OFDM Transmission Mode SAR Test Configuration and Channel Selection Requirements**

The initial test configuration for 5 GHz OFDM 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 (802.11 a/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. After an initial test configuration is determined, if multiple test channels have the same measured maximum output power, the channel chosen for SAR measurement is determined according to the following. These channel selection procedures apply to both the initial test configuration and subsequent test configuration(s), with respect to the default power measurement procedures or additional power measurements required for further SAR test reduction. The same procedures also apply to subsequent highest output power channel(s) selection.
  - a) The channel closest to mid-band frequency is selected for SAR measurement.
  - b) For channels with equal separation from mid-band frequency; for example, high and low channels or two mid-band channels, the higher frequency (number) channel is selected for SAR measurement.

- **SAR Test Requirements for OFDM configurations**

When SAR measurement is required for 802.11 a/n/ac OFDM configurations, each standalone and frequency aggregated band is considered separately for SAR test reduction. When the same transmitter and antenna(s) are used for U-NII-1 and U-NII-2A bands, additional SAR test reduction applies. When band gap channels between U-NII-2C band and 5.8 GHz U-NII-3 or §15.247 band are supported, the highest maximum output power transmission mode configuration and maximum output power channel across the bands must be used to determine SAR test reduction, according to the initial test configuration and subsequent test configuration requirements. 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.

#### **6.1.1.7 Wi-Fi MIMO SAR Considerations**

Per KDB 248227D01v02r01, simultaneous transmission provisions in KDB Publication 447498 should be used to determine simultaneous transmission SAR test exclusion for Wi-Fi MIMO. If the sum of 1-g SAR single transmission SAR measurement is  $<1.6\text{W/kg}$ , no additional SAR measurements for MIMO are required. Alternatively, SAR for MIMO can be measured with all antennas transmitting simultaneously at the specified maximum output power of MIMO operation.

## 7 Detailed Test Results

### 7.1 Conducted power measurements

#### 7.1.1 Conducted Power of Wi-Fi

Mode	Antenna Port	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune up	Average Power (dBm)	SAR Test
802.11b	Main Antenna Port	1	2412	1	16	15.14	Yes
		6	2437		16	15.05	Yes
		11	2462		16	14.88	Yes
802.11g	Main Antenna Port	1	2412	6	16.5	10.95	NO
		6	2437		16.5	15.43	NO
		11	2462		16.5	10.68	NO
802.11n HT20 SISO	Main Antenna Port	1	2412	6.5	15.5	11.06	NO
		6	2437		15.5	14.72	NO
		11	2462		15.5	10.84	NO
802.11n HT20 MIMO	Main Antenna Port	1	2412	6.5	13	10.24	NO
		6	2437		13	11.84	NO
		11	2462		13	10.02	NO
	Sec. Antenna Port	1	2412	6.5	12	11.12	NO
		6	2437		12	11.28	NO
		11	2462		12	11.38	NO

5GHz Main Antenna Port	mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune up	Average Power (dBm)	SAR Test
802.11a	U-NII-1	36	5180	6	14	11.78	No
		40	5200		14	12.08	No
		44	5220		14	<b>12.21</b>	Yes
		48	5240		14	12.08	No
	U-NII-2A	52	5260		12	9.89	No
		56	5280		12	10.17	No
		60	5300		12	10.28	No
		64	5320		12	10.38	No
	U-NII-2C	100	5500		14	11.88	No
		104	5520		14	<b>12.83</b>	Yes
		108	5540		14	12.46	No
		112	5560		14	12.17	No
		116	5580		14	12.10	No
		120	5600		14	12.81	No
		124	5620		14	12.76	No
		128	5640		14	12.46	No
	U-NII-3	132	5660		14	11.91	No
		136	5680		14	11.55	No
		140	5700		14	8.12	No
		149	5745		12	<b>8.09</b>	Yes
153		5765	12	<b>10.76</b>	Yes		
157		5785	12	<b>10.62</b>	Yes		
161		5805	12	<b>10.64</b>	Yes		
165		5825	12	<b>9.33</b>	Yes		

5GHz Main Antenna Port	mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune up	Average Power (dBm)	SAR Test
802.11n- HT20	U-NII-1	36	5180	MCS0	14	12.17	No
		40	5200		14	12.05	No
		44	5220		14	12.18	No
		48	5240		14	12.30	No
	U-NII-2A	52	5260		12	9.88	No
		56	5280		12	10.17	No
		60	5300		12	10.30	No
		64	5320		12	10.55	No
	U-NII-2C	100	5500		14	11.89	No
		104	5520		14	12.78	No
		108	5540		14	12.72	No
		112	5560		14	12.41	No
		116	5580		14	12.27	No
		120	5600		14	13.07	No
		124	5620		14	12.78	No
		128	5640		14	12.62	No
	U-NII-3	132	5660		14	12.09	No
		136	5680		14	11.82	No
		140	5700		14	8.27	No
		149	5745		12	7.68	No
153		5765	12	9.57	No		
157		5785	12	9.38	No		
161		5805	12	9.35	No		
165		5825	12	8.57	No		

5GHz Main Antenna Port	mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune up	Average Power (dBm)	SAR Test
802.11n-HT40	U-NII-1	38	5190	MCS0	13	7.34	No
		46	5230		13	11.39	No
	U-NII-2A	54	5270		13	11.33	No
		62	5310		13	8.81	No
	U-NII-2C	102	5510		13	9.88	No
		110	5550		13	11.62	No
		118	5590		13	11.21	No
		126	5630		13	11.97	No
		134	5670		13	10.44	No
		142	5710		13	12.31	No
	U-NII-3	151	5755		11	6.02	No
		159	5795		11	9.71	No

Table 5: Conducted Power Of WIFI

Note:

- a) Power must be measured at each transmit antenna port according to the DSSS and OFDM transmission configurations in each standalone and aggregated frequency band.
- b) Power measurement is required for the transmission mode configuration with the highest maximum output power specified for production units.
  - 1) When the same highest maximum output power specification applies to multiple transmission modes, the largest channel bandwidth configuration with the lowest order modulation and lowest data rate is measured.
  - 2) When the same highest maximum output power is specified for multiple largest channel bandwidth configurations with the same lowest order modulation or lowest order modulation and lowest data rate, power measurement is required for all equivalent 802.11 configurations with the same maximum output power.
- c) For each transmission mode configuration, power must be measured for the highest and lowest channels; and at the mid-band channel(s) when there are at least 3 channels. For configurations with multiple mid-band channels, due to an even number of channels, both channels should be measured.

**7.1.2 Conducted Power of BT**

BT		Tune-up (dBm)	Average Conducted Power(dBm)
Modulation	Channel		GFSK
GFSK	0	7	5.31
	39	7	5.61
	78	7	5.52
$\pi/4$ DQPSK	0	7	5.43
	39	7	5.69
	78	7	5.57
8DPSK	0	7	5.43
	39	7	5.68
	78	7	5.57
BLE		Tune-up (dBm)	Average Conducted Power(dBm)
Modulation	Channel		GFSK
GFSK	0	1	-1.22
	19	1	-0.55
	39	1	-0.53

Table 6: Conducted Power Of BT

## 7.2 SAR test results

### 7.2.1 Stand-alone SAR test evaluation

Unless specifically required by the published RF exposure KDB procedures, standalone 1-g head or body and 10-g extremity SAR evaluation for general population exposure conditions, by measurement or numerical simulation, is not required when the corresponding SAR Test Exclusion Threshold condition is satisfied. These test exclusion conditions are based on source-based time-averaged maximum conducted output power of the RF channel requiring evaluation, adjusted for tune-up tolerance, and the minimum test separation distance required for the exposure conditions.

Freq. Band	Frequency (GHz)	Position	Tune Up		Test Separation (mm)	Calculate Value	Exclusion Threshold	Exclusion (Y/N)
			dBm	mW				
Wi-Fi	2.450	Body	16.5	44.7	0	14.0	3.0	N
		Limbs	16.5	44.7	0	14.0	7.5	N
	5.8	Body	14	25.1	0	12.1	3.0	N
		Limbs	14	25.1	0	12.1	7.5	N
Bluetooth	2.450	Body	7	5.0	0	1.6	3.0	Y
		Limbs	7	5.0	0	1.6	7.5	Y

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

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

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

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



## 7.2.2 Results overview of 2.4 GHz Wi-Fi

Test position	Test mode	Test Ch./Freq.	Duty Cycle	Duty Cycle Scaled factor	SAR (W/kg) 1-g	Power drift (dB)	Conducted power (dBm)	Tune up Limit (dBm)	Scaled factor	Scaled SAR (W/kg)	Liquid Temp.
Main Antenna Body Test data (Separate 0mm)											
Front side	802.11b	1/2412	99.28%	1.007	0.0116	0.12	15.14	16	1.219	0.014	22
Back side	802.11b	1/2412	99.28%	1.007	0.091	-0.15	15.14	16	1.219	0.112	22
Left side	802.11b	1/2412	99.28%	1.007	0.272	-0.14	15.14	16	1.219	<b>0.334</b>	22
Right side	802.11b	1/2412	99.28%	1.007	0.0347	-0.15	15.14	16	1.219	0.043	22
Top side	802.11b	1/2412	99.28%	1.007	0.00104	-0.08	15.14	16	1.219	0.001	22

Test position	Test mode	Test Ch./Freq.	Duty Cycle	Duty Cycle Scaled factor	SAR (W/kg) 10-g	Power drift (dB)	Conducted power (dBm)	Tune up Limit (dBm)	Scaled factor	Scaled SAR (W/kg)	Liquid Temp.
Main Antenna Limbs Test data (Separate 0mm)											
Front side	802.11b	1/2412	99.28%	1.007	0.00161	0.12	15.14	16	1.219	0.002	22
Back side	802.11b	1/2412	99.28%	1.007	0.0523	-0.15	15.14	16	1.219	0.064	22
Left side	802.11b	1/2412	99.28%	1.007	0.131	-0.14	15.14	16	1.219	<b>0.161</b>	22
Right side	802.11b	1/2412	99.28%	1.007	0.0116	-0.15	15.14	16	1.219	0.014	22
Top side	802.11b	1/2412	99.28%	1.007	0.000104	-0.08	15.14	16	1.219	0.000	22

Table 7: SAR of 2.4GHz for Body and Limbs.

Note:

- 1) The maximum Scaled SAR value is marked in bold. Graph results refer to Appendix B
- 2) Per FCC KDB Publication 447498 D01, if the reported (scaled) SAR measured at the middle channel or highest output power channel for each test configuration is  $\leq 0.8$  W/kg then testing at the other channels is not required for such test configuration(s).

### 7.2.3 Results overview of 5 GHz Wi-Fi

Test position	Test mode	Test Ch./Freq.	Duty Cycle	Duty Cycle Scaled factor	SAR (W/kg) 1-g	Power drift (dB)	Conducted power (dBm)	Tune up Limit (dBm)	Scaled factor	Scaled SAR (W/kg)	Liquid Temp.
Main Antenna Body Test data U-NII-1(Separate 0mm)											
Front side	802.11a	44/5220	95.51%	1.047	0.00133	0.16	12.21	14	1.510	0.002	22.2
Back side	802.11a	44/5220	95.51%	1.047	0.132	-0.1	12.21	14	1.510	0.209	22.2
Left side	802.11a	44/5220	95.51%	1.047	0.502	0.08	12.21	14	1.510	0.794	22.2
Right side	802.11a	44/5220	95.51%	1.047	0.000966	-0.06	12.21	14	1.510	0.002	22.2
Top side	802.11a	44/5220	95.51%	1.047	0.0026	0.15	12.21	14	1.510	0.004	22.2
Main Antenna Body Test data U-NII-2C(Separate 0mm)											
Front side	802.11a	104/5520	95.51%	1.047	0.0274	-0.09	12.83	14	1.309	0.038	22.2
Back side	802.11a	104/5520	95.51%	1.047	0.106	0.09	12.83	14	1.309	0.145	22.2
Left side	802.11a	104/5520	95.51%	1.047	0.558	0.14	12.83	14	1.309	0.765	22.2
Right side	802.11a	104/5520	95.51%	1.047	0.00138	0	12.83	14	1.309	0.002	22.2
Top side	802.11a	104/5520	95.51%	1.047	0.0649	0.07	12.83	14	1.309	0.089	22.2
Main Antenna Body Test data U-NII-3(Separate 0mm)											
Front side	802.11a	153/5765	95.51%	1.047	0.0035	-0.17	10.76	12	1.330	0.005	22.2
Back side	802.11a	153/5765	95.51%	1.047	0.25	0	10.76	12	1.330	0.348	22.2
Left side	802.11a	149/5745	95.51%	1.047	0.256	0.19	8.32	12	2.333	0.625	21.2
Left side	802.11a	153/5765	95.51%	1.047	0.467	0.09	10.76	12	1.330	0.651	22.2
Left side	802.11a	157/5785	95.51%	1.047	0.499	0.11	10.62	12	1.374	0.718	22.2
Left side	802.11a	161/5805	95.51%	1.047	0.509	-0.16	10.64	12	1.368	0.729	22.2
Left side	802.11a	165/5825	95.51%	1.047	0.483	0.02	9.33	12	1.849	<b>0.935</b>	22.2
Right side	802.11a	153/5765	95.51%	1.047	0.0241	0	10.76	12	1.330	0.034	22.2
Top side	802.11a	153/5765	95.51%	1.047	0.173	0.19	10.76	12	1.330	0.241	22.2

Test position	Test mode	Test Ch./Freq.	Duty Cycle	Duty Cycle Scaled factor	SAR (W/kg) 10-g	Power drift (dB)	Conducted power (dBm)	Tune up Limit (dBm)	Scaled factor	Scaled SAR (W/kg)	Liquid Temp.
Main Antenna Limbs Test data U-NII-1(Separate 0mm)											
Front side	802.11a	44/5220	95.51%	1.047	0.000131	0.16	12.21	14	1.510	0.000	22.2
Back side	802.11a	44/5220	95.51%	1.047	0.0227	-0.1	12.21	14	1.510	0.036	22.2
Left side	802.11a	44/5220	95.51%	1.047	0.13	0.08	12.21	14	1.510	0.206	22.2
Right side	802.11a	44/5220	95.51%	1.047	0.000137	-0.06	12.21	14	1.510	0.000	22.2
Top side	802.11a	44/5220	95.51%	1.047	0.00074	0.15	12.21	14	1.510	0.001	22.2
Main Antenna Limbs Test data U-NII-2C(Separate 0mm)											
Front side	802.11a	104/5520	95.51%	1.047	0.00951	-0.09	12.83	14	1.309	0.013	22.2
Back side	802.11a	104/5520	95.51%	1.047	0.036	0.09	12.83	14	1.309	0.049	22.2
Left side	802.11a	104/5520	95.51%	1.047	0.141	0.14	12.83	14	1.309	0.193	22.2
Right side	802.11a	104/5520	95.51%	1.047	0.0000259	0	12.83	14	1.309	0.000	22.2
Top side	802.11a	104/5520	95.51%	1.047	0.0184	0.07	12.83	14	1.309	0.025	22.2
Main Antenna Limbs Test data U-NII-3(Separate 0mm)											
Front side	802.11a	153/5765	95.51%	1.047	0.000359	-0.17	10.76	12	1.330	0.001	22.2
Back side	802.11a	153/5765	95.51%	1.047	0.0826	0	10.76	12	1.330	0.115	22.2
Left side	802.11a	149/5745	95.51%	1.047	0.0562	0.19	8.32	12	2.333	0.137	21.2
Left side	802.11a	153/5765	95.51%	1.047	0.109	0.09	10.76	12	1.330	0.152	22.2
Left side	802.11a	157/5785	95.51%	1.047	0.107	0.11	10.62	12	1.374	0.154	22.2
Left side	802.11a	161/5805	95.51%	1.047	0.107	-0.16	10.64	12	1.368	0.153	22.2
Left side	802.11a	165/5825	95.51%	1.047	0.125	0.02	9.33	12	1.849	<b>0.242</b>	22.2
Right side	802.11a	153/5765	95.51%	1.047	0.00322	0	10.76	12	1.330	0.004	22.2
Top side	802.11a	153/5765	95.51%	1.047	0.0598	0.19	10.76	12	1.330	0.083	22.2

Table 8: SAR of 5 GHz Wi-Fi for Body and Limbs.

Note:

- 1) The maximum Scaled SAR value is marked in bold. Graph results refer to Appendix B
- 2) Per FCC KDB Publication 447498 D01, if the reported (scaled) SAR measured at the middle channel or highest output power channel for each test configuration is  $\leq 0.8$  W/kg then testing at the other channels is not required for such test configuration(s).

## 7.2.4 Simultaneous Transmission SAR Analysis

When the sum of SAR is larger than the limit, SAR test exclusion is determined by the SAR to peak location separation ratio (SPLSR). The simultaneously transmitting antennas in each operating mode and exposure condition combination must be considered one pair at a time to determine the SAR to peak location separation ratio to qualify for test exclusion. The ratio is determined by  $(SAR_1 + SAR_2)^{1.5}/R_i$ , rounded to two decimal digits, and must be  $\leq 0.04$  for all antenna pairs in the configuration to qualify for 1-g SAR test exclusion. When 10-g SAR applies, the ratio must be  $\leq 0.10$ .  $SAR_1$  and  $SAR_2$  are the highest *reported* or estimated SAR values for each antenna in the pair, and  $R_i$  is the separation distance in mm between the peak SAR locations for the antenna pair. 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.

### 7.2.4.1 Simultaneous Transmission condition

NO.	Simultaneous Transmission Configuration	Body	Limbs
1	BT+ 2.4GHz Wi-Fi SISO	No	No
2	BT+ 2.4GHz Wi-Fi MIMO	No	No
3	2.4GHz Wi-Fi SISO + 5GHz Wi-Fi	No	No
4	2.4GHz Wi-Fi MIMO + 5GHz Wi-Fi	No	No

Note:

- 1) Wi-Fi 2.4G and Bluetooth share the same TX antenna and can't transmit simultaneously.

## 8 Test equipment and ancillaries used for tests

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

Equipment	Type	Manufacturer	Serial No.	Last Calibration	Frequency (months)
Dosimetric E-Field Probe	EX3DV4	Schmid & Partner Engineering AG	3860	2017.9.25	12
2450 MHz System Validation Dipole	D2450V2	Schmid & Partner Engineering AG	993	2017.3.23	36
5 GHz System Validation Dipole	D5GHzV2	Schmid & Partner Engineering AG	1193	2017.3.23	36
Data acquisition electronics	DAE4	Schmid & Partner Engineering AG	1233	2017.2.16	12
Software	DASY52 52.8.8	Schmid & Partner Engineering AG	---	N/A	--
Flat Phantom	QD OVA 002 Ax	Schmid & Partner Engineering AG	1125	N/A	--
SAM Twin Phantom V5.0	QD 000 P40 CD	Schmid & Partner Engineering AG	1639	N/A	--
Vector Reflectometer	DAKS_VNA R40	Schmid & Partner Engineering AG	0150616	2017.4.25	12
Dielectric Probe Kit	DAKS-3.5	Schmid & Partner Engineering AG	1081	2017.4.25	12
Signal Generator	SMR 20	Rohde & Schwarz	832033/011	2017.5.18	12
Amplifier	TLV204400 61-2	Telemeter Electronic	14061801A	N/A	--
Power Meter	NRVD	Rohde & Schwarz	101700	2017.5.15	12
Power Meter Sensor	NRV-Z4	Rohde & Schwarz	100399	2017.5.15	12
Power Meter Sensor	NRV-Z5	Rohde & Schwarz	8435323	2017.5.15	12
Directional Coupler	1851	KRYTAR	109891	N/A	--

)\*: DAK's probe calibration against air, distilled water and a shorting block performed before measuring liquid parameters.

## 9 Observations

No observations exceeding those reported with the single test cases have been made.

## 10 Calibration parameters

Please see Annex C

## 11 Photo documentation

Please see Annex D

**Annex A: System performance check**

**Annex B: DASY5 measurement results**

**Annex C: Calibration parameters**

**Annex D: Photo documentation**

## Glossary

DTS	-	Distributed Transmission System
DUT	-	Device under Test
EUT	-	Equipment under Test
FCC	-	Federal Communication Commission
FCC ID	-	Company Identifier at FCC
HW	-	Hardware
IC	-	Industry Canada
Inv. No.	-	Inventory number
N/A	-	not applicable
SAR	-	Specific Absorption Rate
S/N	-	Serial Number
SW	-	Software
UNII	-	Unlicensed National Information Infrastructure

**End of the report**

---