TEST REPORT

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1. Report No : DRRFCC2002-0010
2. Customer
   - Name : LINKFLOW Co., Ltd.
   - Address : 3,4F, 54, Nonhyeon-ro 2-gil, Gangnam-gu, Seoul, South Korea
3. Use of Report : FCC Original Grant
4. Product Name / Model Name : FITT360 / LF-F200U
   FCC ID : 2AVCKLFF200U
5. Test Method Used : IEEE 1528-2013, FCC SAR KDB Publications (Details in test report)
   Test Specification : CFR 47 Part 2 subpart 2.1093
6. Date of Test : 2019.12.10 ~ 2019.12.20
7. Testing Environment : Refer to appended test report.
8. Test Result : Refer to attached test report.

Affirmation	Tested by Name : BumJun Park (Signature)	Reviewed by Name : HakMin Kim (Signature)

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Test Report Version

Test Report No.	Date	Description	Revised By	Reviewed By
DRRFCC2002-0010	Feb. 21, 2020	Initial issue	BumJun Park	HakMin Kim

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1. DESCRIPTION OF DEVICE

1.1 General Information

EUT type	FITT360				
FCC ID	2AVCKLFF200U				
Equipment model name	LF-F200U				
Equipment add model name	N/A				
Equipment serial no.	Identical prototype				
Mode(s) of Operation	2.4 G W-LAN (802.11b/g/n-HT20/n-HT40/ac-VHT20/ac-VHT40), 5 G W-LAN (802.11a/n-HT20/n-HT40/ac-VHT20/ac-VHT40/ac-VHT80), Bluetooth				
	Band	**Mode**	**Operating Modes**	**Bandwidth**	**Frequency**
TX Frequency Range	2.4 GHz W-LAN	802.11b/g/n/ac	Voice/Data	HT20/VHT20	2412 ~ 2462 MHz
		802.11 n/ac	Voice/Data	HT40/VHT40	2422 ~ 2452 MHz
	5.2 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT20	5180 ~ 5240 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5190 ~ 5230 MHz
		802.11ac	Voice/Data	VHT80	5210 MHz
	5.3 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT20	5260 ~ 5320 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5270 ~ 5310 MHz
		802.11ac	Voice/Data	VHT80	5290 MHz
	5.6 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT20	5500 ~ 5720 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5510 ~ 5710 MHz
		802.11ac	Voice/Data	VHT80	5530 ~ 5690 MHz
	5.8 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT20	5745 ~ 5825 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5755 ~ 5795 MHz
		802.11ac	Voice/Data	VHT80	5775 MHz
	Bluetooth	-	Data	-	2402 ~ 2480 MHz
RX Frequency Range	2.4 GHz W-LAN	802.11b/g/n/ac	Voice/Data	HT20/VHT20	2412 ~ 2462 MHz
		802.11 n/ac	Voice/Data	HT40/VHT40	2422 ~ 2452 MHz
	5.2 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT20	5180 ~ 5240 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5190 ~ 5230 MHz
		802.11ac	Voice/Data	VHT80	5210 MHz
	5.3 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT200	5260 ~ 5320 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5270 ~ 5310 MHz
		802.11ac	Voice/Data	VHT80	5290 MHz
	5.6 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT20	5500 ~ 5720 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5510 ~ 5710 MHz
		802.11ac	Voice/Data	VHT80	5530 ~ 5690 MHz
	5.8 GHz W-LAN	802.11a/n/ac	Voice/Data	HT20/VHT20	5745 ~ 5825 MHz
		802.11n/ac	Voice/Data	HT40/VHT40	5755 ~ 5795 MHz
		802.11ac	Voice/Data	VHT80	5775 MHz
	Bluetooth	-	Data	-	2402 ~ 2480 MHz

Equipment Class	**Band**	**Reported SAR 1g SAR (W/kg) Neck-Worn**
DTS(SISO)	2.4 GHz W-LAN	1.09
DTS(MIMO)	2.4 GHz W-LAN	1.16
U-NII-1(SISO)	5.2 GHz W-LAN	-
U-NII-1(MIMO)	5.2 GHz W-LAN	-
U-NII-2A(SISO)	5.3 GHz W-LAN	0.76
U-NII-2A(MIMO)	5.3 GHz W-LAN	0.69
U-NII-2C(SISO)	5.6 GHz W-LAN	0.38
U-NII-2C(MIMO)	5.6 GHz W-LAN	0.34
U-NII-3(SISO)	5.8 GHz W-LAN	0.57
U-NII-3(MIMO)	5.8 GHz W-LAN	0.64
DSS	Bluetooth	0.63
Simultaneous SAR per KDB 690783 D01v01r03		1.39

FCC Equipment Class	Part 15 Spread Spectrum Transmitter(DSS) Digital Transmission System(DTS) Unlicensed National Information Infrastructure (UNII)
Date(s) of Tests	2019.12.10 ~ 2019.12.20
Antenna Type	Internal Antenna

1.2 Power Reduction for SAR

There is no power reduction used for any band/mode implemented in this device for SAR purposes.

1.3 Nominal and Maximum Output Power Specifications

The Nominal and Maximum Output Power Specifications are in section 7 of this test report.

1.4 DUT Antenna Locations

The SAR tests of the device were performed by reference to FCC KDB Inquiry (Tracking No. 463058) at the worst SAR for each position.

1.5 Simultaneous Transmission Capabilities

The Simultaneous Transmission Capabilities are in section 10 of this test report.

1.6 Guidance Applied

- IEEE 1528-2013
- FCC KDB Publication 248227 D01v02r02 (802.11 Wi-Fi SAR)
- FCC KDB Publication 447498 D01v06 (General RF Exposure Guidance)
- FCC KDB Publication 690783 D01v01r03 (SAR Listings on Grants)
- FCC KDB Publication 865664 D01v01r04 (SAR Measurement 100 MHz to 6 GHz)
- FCC KDB Publication 865664 D02v01r02 (RF Exposure Reporting)
- April 2015 TCB Workshop Notes (Simultaneous transmission summation clarified)
- October 2016 TCB Workshop Notes (Bluetooth Duty Factor)
- April 2019 TCB Workshop Notes (Tissue Simulating Liquids)

1.7 Device Serial Numbers

The serial numbers used for each test are indicated alongside the results in Section 9.

2. INTROCUCTION

The FCC and Industry Canada have adopted the guidelines for evaluating the environmental effects of radio frequency (RF) radiation in ET Docket 93-62 on Aug. 6, 1996 and Health Canada Safety Code 6 to protect the public and workers from the potential hazards of RF emissions due to FCC-regulated portable devices.

The FCC has adopted the guidelines for evaluating the environmental effects of radio frequency radiation in ET Docket 93-62 on Aug. 6, 1996 to protect the public and workers from the potential hazards of RF emissions due to FCC-regulated portable devices. The safety limits used for the environmental evaluation measurements are based on the criteria published by the American National Standards Institute (ANSI) for localized specific absorption rate (SAR) in IEEE/ANSI C95.1-1992 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz. The measurement procedure described in IEEE/ANSI C95.3-2002 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave is used for guidance in measuring SAR due to the RF radiation exposure from the Equipment Under Test (EUT). These criteria for SAR evaluation are similar to those recommended by the National Council on Radiation Protection and Measurements (NCRP) in Biological Effects and Exposure Criteria for Radio frequency Electromagnetic Fields," NCRP Report No. 86 NCRP, 1986, Bethesda, MD 20814. SAR is a measure of the rate of energy absorption due to exposure to an RF transmitting source. SAR values have been related to threshold levels for potential biological hazards.

SAR Definition

Specific Absorption Rate (SAR) is defined as the time derivative (rate) of the incremental energy (dU) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dV) of a given density (ρ) It is also defined as the rate of RF energy absorption per unit mass at a point in an absorbing body (see Fig. 2.1)

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

Fig. 2.1 SAR Mathematical Equation

SAR is expressed in units of Watts per Kilogram (W/kg).

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

where:

σ = conductivity of the tissue-simulating material (S/m)
ρ = mass density of the tissue-simulating material (kg/m^3)
E = Total RMS electric field strength (V/m)

NOTE: The primary factors that control rate of energy absorption were found to be the wavelength of the incident field in relations to the dimensions and geometry of the irradiated organism, the orientation of the organism in relation to the polarity of field vectors, the presence of reflecting surfaces, and whether conductive contact is made by the organism with a ground plane.

3. DOSIMETRIC ASSESSMENT

3.1 Measurement Procedure

The evaluation was performed using the following procedure compliant to FCC KDB Publication 865664 D01v01r04 and IEEE 1528-2013:

1. The SAR distribution at the exposed side of the head or body was measured at a distance no greater than 5.0 mm from the inner surface of the shell. The area covered the entire dimension of the device-head and body interface and the horizontal grid resolution was determined per FCC KDB Publication 865664 D01v01r04 (See Table 3.1) and IEEE1528-2013.

2. The point SAR measurement was taken at the maximum SAR region determined from Step 1 to enable the monitoring of SAR fluctuations/drifts during the 1g/10g cube evaluation. SAR at this fixed point was measured and used as a reference value.

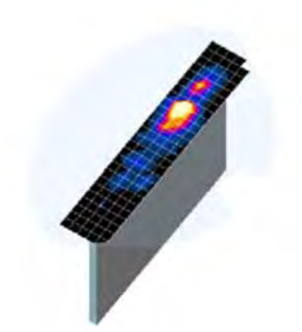

Figure 3.1
Sample SAR Area Scan

3. Based on the area scan data, the peak of the region with maximum SAR was determined by spline interpolation. Around this point, a volume was assessed according to the measurement resolution and volume size requirements of FCC KDB Publication 865664 D01v01r04 (See Table 3.1) and IEEE 1528-2013. On the basis of this data set, the spatial peak SAR value was evaluated with the following procedure (see references or the DASY manual online for more details):

   a. SAR values at the inner surface of the phantom are extrapolated from the measured values along the line away from the surface with spacing no greater than that in Table 3.1. The extrapolation was based on a least-squares algorithm. A polynomial of the fourth order was calculated through the points in the z-axis (normal to the phantom shell).

   b. After the maximum interpolated values were calculated between the points in the cube, the SAR was averaged over the spatial volume (1g or 10g) using a 3D-Spline interpolation algorithm. The 3D-spline is composed of three one-dimensional splines with the “Not a knot” condition (in x, y, and z directions). The volume was then integrated with the trapezoidal algorithm. One thousand points (10 x 10 x 10) were obtained through interpolation, in order to calculate the averaged SAR.

   c. All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.

4. The SAR reference value, at the same location as step 2, was re-measured after the zoom scan was complete to calculate the SAR drift. If the drift deviated by more than 5%, the SAR test and drift measurements were repeated.

<table>
<tr><td colspan="3"></td><td>$\leq$ 3 GHz</td><td>$>$ 3 GHz</td></tr>
<tr><td colspan="3">Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface</td><td>5 mm ± 1 mm</td><td>½·δ·ln(2) mm ± 0.5 mm</td></tr>
<tr><td colspan="3">Maximum probe angle from probe axis to phantom surface normal at the measurement location</td><td>30° ± 1°</td><td>20° ± 1°</td></tr>
<tr><td colspan="3" rowspan="2">Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}</td><td>$\leq$ 2 GHz: $\leq$ 15 mm
2 – 3 GHz: $\leq$ 12 mm</td><td>3 – 4 GHz: $\leq$ 12 mm
4 – 6 GHz: $\leq$ 10 mm</td></tr>
<tr><td colspan="2">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 $\leq$ the corresponding x or y dimension of the test device with at least one measurement point on the test device.</td></tr>
<tr><td colspan="3">Maximum zoom scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}</td><td>$\leq$ 2 GHz: $\leq$ 8 mm
2 – 3 GHz: $\leq$ 5 mm*</td><td>3 – 4 GHz: $\leq$ 5 mm*
4 – 6 GHz: $\leq$ 4 mm*</td></tr>
<tr><td rowspan="3">Maximum zoom scan spatial resolution, normal to phantom surface</td><td colspan="2">uniform grid: $\Delta z_{Zoom}(n)$</td><td>$\leq$ 5 mm</td><td>3 – 4 GHz: $\leq$ 4 mm
4 – 5 GHz: $\leq$ 3 mm
5 – 6 GHz: $\leq$ 2 mm</td></tr>
<tr><td rowspan="2">graded grid</td><td>$\Delta z_{Zoom}(1)$: between 1st two points closest to phantom surface</td><td>$\leq$ 4 mm</td><td>3 – 4 GHz: $\leq$ 3 mm
4 – 5 GHz: $\leq$ 2.5 mm
5 – 6 GHz: $\leq$ 2 mm</td></tr>
<tr><td>$\Delta z_{Zoom}(n>1)$: between subsequent points</td><td colspan="2">$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$ mm</td></tr>
<tr><td>Minimum zoom scan volume</td><td colspan="2">x, y, z</td><td>$\geq$ 30 mm</td><td>3 – 4 GHz: $\geq$ 28 mm
4 – 5 GHz: $\geq$ 25 mm
5 – 6 GHz: $\geq$ 22 mm</td></tr>
<tr><td colspan="5">Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see IEEE Std 1528-2013 for details.
* When zoom scan is required and the <u>reported</u> SAR from the area scan based 1-g SAR estimation procedures of KDB Publication 447498 is $\leq$ 1.4 W/kg, $\leq$ 8 mm, $\leq$ 7 mm and $\leq$ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.</td></tr>
</table>

Table 3.1 Area and Zoom Scan Resolutions per FCC KDB Publication 865664 D01v01r04*

4. TEST CONFIGURATION POSITIONS FOR HANDSETS

4.1 Device Holder

The device holder is made out of low-loss POM material having the following dielectric parameters: relative permittivity ε = 3 and loss tangent δ = 0.02.

4.2 Neck-worn Configurations

The SAR tests of the device were performed by reference to FCC KDB Inquiry (Tracking No. 463058) at the worst SAR for each position.

Neck-worn SAR was performed both cases, i.e. unmodified (without cutting / breaking) and modified (cutting / breaking).

The test case is as follows:
1. Unmodified (without cutting / breaking)
   (1) Upside of the right side
   (2) Downside of the right side

2. modified (cutting / breaking)
   (1) Upside of the right side
   (2) Downside of the right side
   (3) Inside of the right side

5. RF EXPOSURE LIMITS

Uncontrolled Environment:

UNCONTROLLED ENVIRONMENTS are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

Controlled Environment:

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). In general, occupational/controlled exposure limits are employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. This exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

Table 5.1.SAR Human Exposure Specified in ANSI/IEEE C95.1-1992

	HUMAN EXPOSURE LIMITS	
	General Public Exposure (W/kg) or (mW/g)	Occupational Exposure (W/kg) or (mW/g)
SPATIAL PEAK SAR * (Brain)	1.60	8.00
SPATIAL AVERAGE SAR ** (Whole Body)	0.08	0.40
SPATIAL PEAK SAR *** (Hands / Feet / Ankle / Wrist)	4.00	20.0

1. 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.
2. The Spatial Average value of the SAR averaged over the whole body.
3. 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).

6. FCC MEASUREMENT PROCEDURES

Power measurements were performed using a base station simulator under digital average power.

6.1 Measured and Reported SAR

Per FCC KDB Publication 447498 D01v06, When SAR is not measured at the maximum power level allowed for production units, the results must be scaled to the maximum tune-up tolerance limit according to the power applied to the individual channels tested to determine compliance. For simultaneous transmission, the measured aggregate SAR must be scaled according to the sum of the differences between the maximum tune-up tolerance and actual power used to test each transmitter. When SAR is measured at or scaled to the maximum tune-up tolerance limit, the results are referred to as reported SAR. The highest reported SAR results are identified on the grant of equipment authorization according to procedures in KDB 690783 D01v01r03.

6.2 SAR Testing with 802.11 Transmitters

The normal network operating configurations are not suitable for measuring the SAR of 802.11 b/g/n transmitters. Unpredictable fluctuations in network traffic and antenna diversity conditions can introduce undesirable variations in SAR results. The SAR for these devices should be measured using chipset based test mode software to ensure the results are consistent and reliable. See KDB Publication 248227D01v02r02 for more details.

6.2.1 General Device Setup

Chipset based test mode software is hardware dependent and generally varies among manufacturers. The device operating parameters established in test mode for SAR measurements must be identical to those programmed in production units, including output power levels, amplifier gain settings and other RF performance tuning parameters. The test frequencies should correspond to actual channel frequencies defined for domestic use. SAR for devices with switched diversity should be measured with only one antenna transmitting at a time during each SAR measurement, according to a fixed modulation and data rate. The same data pattern should be used for all measurements.

A periodic duty factor is required for current generation SAR systems to measure SAR. When 802.11 frame gaps are accounted for in the in the transmission, a maximum transmission duty factor of 92-96% is typically achievable in most test mode configurations. A minimum transmission duty factor of 85% is required to avoid certain hardware and device implementation issues related to wide range SAR scaling. The reported SAR is scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit.

6.2.2 U-NII and U-NII-2A

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, with respect to the highest reported SAR and maximum output power specified for production units. The procedures are applied independently to each exposure configuration; for example, head, body, hotspot mode etc.

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 ≤ 1.2 W/kg, SAR is not required for U-NII-1 band for that configuration (802.11 mode and exposure condition); otherwise, each band is 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 ≤ 1.2 W/kg, SAR is not required for the band with lower maximum output power in that test configuration; otherwise, each band is tested independently for SAR.

6.2.3 U-NII-2C and U-NII-3

The frequency range covered by U-NII-2C and U-NII-3 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 Rader (TDWR) restriction applies, the channels at 5.60 – 5.65 GHz in U-NII-2C band must be disabled with acceptable mechanisms and documented in the equipment certification.
Unless band gap channels are permanently disabled, SAR must be considered for these channels. When band gap channels are disabled, each band is tested independently according to the normally required OFDM SAR measurements and probe calibration frequency points requirements.

6.2.4 Initial Test Position Procedure

For exposure conditions with multiple test positions, such as handset operating next to the ear, devices with hotspot mode or UMPC mini-tablet, procedures for initial test position can be applied. Using the transmission mode determined by the DSSS procedure or initial test configuration, area scans are measured for all position in an exposure condition. The test position with the highest extrapolated (peak) SAR is used as the initial test position. When reported SAR for the initial test position is ≤ 0.4 W/kg, no additional testing for the remaining test positions is required. Otherwise, SAR is evaluated at the subsequent highest peak SAR position until the reported SAR result is ≤ 0.8 W/kg or all test position are measured.

6.2.5 2.4 GHz SAR Test Requirements

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

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

2.4 GHz 802.11 g/n OFDM are additionally evaluated for SAR if the highest reported SAR for 802.11b, adjusted by the ratio of the OFDM to DSSS specified maximum output power is > 1.2 W/kg. When SAR is required for OFDM modes in 2.4 GHz band, the Initial Test Configuration Procedures should be followed.

6.2.6 OFDM Transmission Mode and SAR Test Channel Selection

For the 2.4 GHz and 5 GHz bands, when the same maximum output power was specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration with the largest channel bandwidth, lowest order modulation and lowest data rate. When the maximum output power of a channel is the same for equivalent OFDM configurations; for example, 802.11a and 802.11n or 802.11g and 802.11n with the same channel bandwidth, modulation and data rate etc., the lower order 802.11 mode i.e., 802.11a, then 80211n or 802.11g then 802.11n is used for SAR measurement. When the maximum output power ware the same for multiple test channels, either according to the default or additional power measurement requirements, SAR is measured using the channel closest to the middle of the frequency band or aggregated band. When there are multiple channels with the same maximum output power, SAR is measured using the higher number channel.

6.2.7 Initial Test Configuration Procedure

For OFDM, in both 2.4 and 5 GHz bands, an initial test configuration is determined for each frequency band and aggregated band, according to the transmission mode with the highest maximum output power specified for SAR measurements. When the same maximum output is specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration(s) with the largest channel bandwidth, lowest order modulation, and lowest data rate. The channel of the transmission mode with the highest average RF output conducted power will be the initial test configuration.

When the reported SAR is ≤ 0.8 W/kg, no additional measurements on other test channels are required.
Otherwise, SAR is evaluated using the subsequent highest average RF output channel until the reported SAR result is ≤ 1.2 W/kg or all channels are measured.

6.2.8 Subsequent Test Configuration Procedures

For OFDM configurations, in each frequency band and aggregated band, SAR is evaluated for initial test configuration using the fixed test position or the initial test position procedure, when applicable. When the highest reported SAR for the initial test configuration, adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power is ≤ 1.2 W/kg, no additional SAR testing for the subsequent test configurations is required.

6.2.9 MIMO SAR Considerations

Per KDB Publication 248227 D01v02r02, the simultaneous SAR provisions in KDB Publication 447498 D01v06 should be applied to determine simultaneous transmission SAR test exclusion for WIFI MIMO. If the sum of 1g single transmission chain SAR measurements is < 1.6 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. RF CONDUCTED POWERS

This device operates using the following maximum and nominal output power specifications. SAR values were scaled to the maximum allowed power to determine compliance per KDB Publication 447498 D01v06

7.1 WLAN Nominal and Maximum Output Power Spec and Conducted Powers

Band (GHz)	Mode	Ch	Modulated Average[dBm]					
			Ant.1		Ant.2		MIMO(CDD/SDM)	
			Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
2.4	802.11b	1	14.5	13.5	14.5	13.5	17.5	16.5
		6	14.5	13.5	14.5	13.5	17.5	16.5
		11	14.5	13.5	14.5	13.5	17.5	16.5
	802.11g	1	13.5	12.5	13.5	12.5	16.5	15.5
		6	14.0	13.0	14.0	13.0	17.0	16.0
		11	14.0	13.0	14.0	13.0	17.0	16.0
	802.11n (HT-20)	1	13.0	12.0	13.0	12.0	16.0	15.0
		6	14.0	13.0	14.0	13.0	17.0	16.0
		11	14.0	13.0	14.0	13.0	17.0	16.0
	802.11n (HT-40)	3	14.0	13.0	14.0	13.0	17.0	16.0
		6	14.0	13.0	14.0	13.0	17.0	16.0
		9	14.0	13.0	14.0	13.0	17.0	16.0

Table 7.1.1 Nominal and Maximum Output Power Spec

Mode	Freq. (MHz)	Channel	IEEE 802.11 (2.4 GHz) Conducted Power[dBm]			
			Ant.1	Ant.2	MIMO(CDD)	MIMO(SDM)
802.11b	**2412**	**1**	13.30	13.72	16.53	-
	2437	**6**	13.45	13.34	16.41	-
	2472	**11**	13.29	13.64	16.48	-
802.11g	2412	1	13.19	13.12	16.17	-
	2437	6	13.81	13.85	16.84	-
	2472	11	13.79	13.89	16.85	-
802.11n (HT-20)	2412	1	11.73	12.28	15.02	14.96
	2437	6	13.87	13.76	16.83	16.86
	2472	11	13.88	13.90	16.90	16.92
802.11n (HT-40)	2422	3	13.80	13.91	16.87	16.67
	2437	6	13.79	13.80	16.81	16.89
	2452	9	13.74	13.82	16.79	16.84

Table 7.1.2 IEEE 802.11 Average RF Power

Band (GHz)	Mode	Ch	Modulated Average[dBm]							
			Ant.1		Ant.2		MIMO(CDD)		MIMO(SDM)	
			Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
5 (UNII)	802.11a	36-40	8.5	7.5	9.5	8.5	12.0	11.0	-	-
		44-48	9.0	8.0	10.0	9.0	12.5	11.5		
		52-56	9.5	8.5	10.0	9.0	12.8	11.8		
		60-64	10.5	9.5	10.5	9.5	13.5	12.5		
		100	10.0	9.0	10.5	9.5	13.3	12.3		
		120	8.5	7.5	9.0	8.0	11.8	10.8		
		132-144	8.0	7.0	9.0	8.0	11.5	10.5		
		149-157	7.5	6.5	9.5	8.5	11.6	10.6		
		165	8.0	7.0	9.5	8.5	11.8	10.8		
	802.11n/ac (20MHz)	36-40	8.0	7.0	9.0	8.0	11.5	10.5	11.5	10.5
		44-48	8.5	7.5	9.0	8.0	11.8	10.8	11.8	10.8
		52-56	9.0	8.0	9.5	8.5	12.3	11.3	12.3	11.3
		60-64	10.0	9.0	10.0	9.0	13.0	12.0	13.0	12.0
		100	9.5	8.5	10.0	9.0	12.8	11.8	12.8	11.8
		120	8.0	7.0	8.0	7.0	11.0	10.0	11.0	10.0
		132-144	7.5	6.5	8.0	7.0	10.8	9.8	10.8	9.8
		149-157	7.0	6.0	8.5	7.5	10.8	9.8	10.8	9.8
		165	7.0	6.0	9.0	8.0	11.1	10.1	11.1	10.1
	802.11n/ac (40MHz)	38	8.0	7.0	9.0	8.0	11.5	10.5	11.5	10.5
		46	8.5	7.5	9.0	8.0	11.8	10.8	11.8	10.8
		54	8.5	7.5	9.5	8.5	12.0	11.0	12.0	11.0
		62	10.0	9.0	10.0	9.0	13.0	12.0	13.0	12.0
		102	9.5	8.5	10.5	9.5	13.0	12.0	13.0	12.0
		118	8.0	7.0	9.5	8.5	11.8	10.8	11.8	10.8
		134	7.0	6.0	8.0	7.0	10.5	9.5	10.5	9.5
		142	7.0	6.0	8.0	7.0	10.5	9.5	10.5	9.5
		151	6.5	5.5	8.5	7.5	10.6	9.6	10.6	9.6
		159	7.0	6.0	9.0	8.0	11.1	10.1	11.1	10.1
	802.11ac (80MHz)	42	8.0	7.0	9.0	8.0	11.5	10.5	11.5	10.5
		58	9.0	8.0	9.5	8.5	12.3	11.3	12.3	11.3
		106	8.5	7.5	9.5	8.5	12.0	11.0	12.0	11.0
		122	7.5	6.5	8.0	7.0	10.8	9.8	10.8	9.8
		138	7.0	6.0	8.0	7.0	10.5	9.5	10.5	9.5
		155	7.0	6.0	8.5	7.5	10.8	9.8	10.8	9.8

Table 7.1.3 Nominal and Maximum Output Power Spec

Mode	Freq. (MHz)	Channel	IEEE 802.11a (5 GHz) Conducted Power[dBm]			
			Ant.1	Ant.2	MIMO(CDD)	MIMO(SDM)
802.11a	5180	36	8.15	9.31	11.78	-
	5200	40	8.31	9.14	11.76	-
	5220	44	8.58	9.28	11.95	-
	5240	48	8.78	9.57	12.20	-
	5260	52	9.03	9.55	12.31	-
	5280	56	9.33	9.80	12.58	-
	5300	**60**	10.26	10.15	13.22	-
	5320	**64**	10.25	10.19	13.23	-
	5500	**100**	9.75	10.40	13.10	-
	5600	120	8.33	8.64	11.50	-
	5660	132	7.73	8.34	11.06	-
	5720	144	7.32	8.53	10.98	-
	5745	149	7.16	8.83	11.09	-
	5785	157	7.30	9.01	11.25	-
	5825	**165**	7.65	9.35	11.59	-

Table 7.1.4 IEEE 802.11a Average RF Power

Mode	Freq. (MHz)	Channel	IEEE 802.11n HT20 (5 GHz) Conducted Power[dBm]			
			Ant.1	Ant.2	MIMO(CDD)	MIMO(SDM)
802.11n (HT-20)	5180	36	7.42	8.81	11.18	11.10
	5200	40	7.65	8.71	11.22	11.17
	5220	44	7.91	8.76	11.37	11.40
	5240	48	8.05	8.85	11.48	11.45
	5260	52	8.36	9.09	11.75	11.70
	5280	56	8.65	9.28	11.99	11.96
	5300	60	9.84	9.50	12.68	12.72
	5320	64	9.95	9.64	12.81	12.76
	5500	100	9.13	9.98	12.59	12.45
	5600	120	7.63	7.87	10.76	10.80
	5660	132	7.03	7.84	10.46	10.49
	5720	144	6.62	8.00	10.37	10.42
	5745	149	6.43	8.25	10.44	10.42
	5785	157	6.61	8.41	10.61	10.58
	5825	165	6.81	8.68	10.86	10.66

Table 7.1.5 IEEE 802.11n HT20 Average RF Power

Mode	Freq. (MHz)	Channel	IEEE 802.11ac VHT20 (5 GHz) Conducted Power[dBm]			
			Ant.1	Ant.2	MIMO(CDD)	MIMO(SDM)
802.11ac (VHT-20)	5180	36	7.41	8.85	11.20	11.34
	5200	40	7.67	8.76	11.26	11.20
	5220	44	7.89	8.78	11.37	11.42
	5240	48	8.03	8.85	11.47	11.53
	5260	52	8.35	9.08	11.74	11.80
	5280	56	8.54	9.38	11.99	11.97
	5300	60	9.82	9.49	12.67	12.74
	5320	64	9.95	9.53	12.76	12.75
	5500	100	9.21	9.99	12.63	12.66
	5600	120	7.62	7.86	10.75	10.85
	5660	132	7.03	7.85	10.47	10.47
	5720	144	6.62	7.91	10.32	10.48
	5745	149	6.45	8.25	10.45	10.46
	5785	157	6.61	8.38	10.59	10.64
	5825	165	6.73	8.44	10.68	10.65

Table 7.1.6 IEEE 802.11ac VHT20 Average RF Power

Mode	Freq. (MHz)	Channel	IEEE 802.11n HT40 (5 GHz) Conducted Power[dBm]			
			Ant.1	Ant.2	MIMO(CDD)	MIMO(SDM)
802.11n (HT-40)	5190	38	7.58	8.83	11.26	11.36
	5230	46	8.02	8.89	11.49	11.38
	5270	54	8.41	9.23	11.85	11.85
	5310	62	9.72	9.54	12.64	12.55
	5510	102	9.01	9.88	12.48	12.31
	5590	118	7.53	9.50	11.64	10.99
	5670	134	6.87	7.69	10.31	10.42
	5710	142	6.62	7.75	10.23	10.20
	5755	151	6.30	8.13	10.32	10.56
	5795	159	6.65	8.20	10.50	10.66

Table 7.1.7 IEEE 802.11n HT40 Average RF Power

Mode	Freq. (MHz)	Channel	IEEE 802.11ac VHT40 (5 GHz) Conducted Power[dBm]			
			Ant.1	Ant.2	MIMO(CDD)	MIMO(SDM)
802.11ac (VHT-40)	5190	38	7.47	8.81	11.20	11.17
	5230	46	7.89	8.74	11.35	11.34
	5270	54	8.30	9.08	11.72	11.75
	5310	62	9.75	9.46	12.62	12.54
	5510	102	8.91	10.07	12.54	12.31
	5590	118	7.51	8.64	11.12	10.91
	5670	134	6.89	7.85	10.41	10.29
	5710	142	6.61	7.81	10.26	10.15
	5755	151	6.38	8.40	10.52	10.34
	5795	159	6.53	8.54	10.66	10.57

Table 7.1.8 IEEE 802.11ac VHT40 Average RF Power

Mode	Freq. (MHz)	Channel	IEEE 802.11ac VHT80 (5 GHz) Conducted Power[dBm]			
			Ant.1	Ant.2	MIMO(CDD)	MIMO(SDM)
802.11ac (VHT-80)	5210	42	7.88	8.68	11.31	11.32
	5290	58	8.65	9.49	12.10	12.19
	5530	106	8.48	9.40	11.97	11.73
	5610	122	7.37	7.74	10.57	10.55
	5690	138	6.84	7.89	10.41	10.22
	5775	155	6.57	8.13	10.43	10.50

Table 7.1.9 IEEE 802.11ac VHT80 Average RF Power

Justification for reduced test configurations for WIFI channels per KDB Publication 248227 D01v02r02:

- Power measurements were performed for the transmission mode configuration with the highest maximum output power specified for production units.
- For transmission modes with the same maximum output power specification, powers were measured for the largest channel bandwidth, lowest order modulation and lowest data rate.
- For transmission modes with identical maximum specified output power, channel bandwidth, modulation and data rates, power measurements were required for all identical configurations.
- For each transmission mode configuration, powers were measured for the highest and lowest channels; and at the mid-band channel(s) when there were at least 3 channels supported. For configurations with multiple mid-band channels, duo to an even number of channels, both channels were measured.
- Output Power and SAR is not required for 802.11 g/n HT20/ac VHT20 channels when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjust SAR is ≤ 1.2 W/kg.
- The underlined data rate and channel above were tested for SAR.

The average output powers of this device were tested by below configuration.

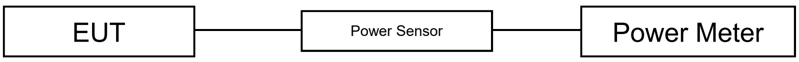

Figure 7.1 Power Measurement Setup

7.2 Bluetooth Conducted Powers

Frame Modulated Average[dBm]		
Bluetooth 1 Mbps	Maximum	10.35
	Nominal	9.35
Bluetooth 2 Mbps	Maximum	8.85
	Nominal	7.85
Bluetooth 3 Mbps	Maximum	8.85
	Nominal	7.85

Table 7.2.1 Nominal and Maximum Output Power Spec (Frame)

Burst Modulated Average[dBm]		
Bluetooth (LE / 1Mbps)	Maximum	2.0
	Nominal	1.0
Bluetooth (LE / 2Mbps)	Maximum	2.0
	Nominal	1.0

Table 7.2.2 Nominal and Maximum Output Power Spec (Burst)

Channel	Frequency (MHz)	Frame AVG Output Power (1Mbps) (dBm)	Frame AVG Output Power (2Mbps) (dBm)	Frame AVG Output Power (3Mbps) (dBm)
Low	2402	9.92	8.54	8.53
Mid	**2441**	10.14	7.87	7.86
High	2480	10.07	8.61	8.60

Table 7.2.3 Bluetooth Frame Average RF Power

Channel	Frequency (MHz)	Burst AVG Output Power(LE / 1Mbps) (dBm)	Burst AVG Output Power(LE / 2Mbps) (dBm)
Low	2402	1.37	1.40
Mid	2440	0.75	0.78
High	2480	1.74	1.79

Table 7.2.4 Bluetooth LE Burst RF Power

- **Bluetooth Conducted Powers procedures**

1. Bluetooth (BDR, EDR)
 1) Enter DUT mode in EUT and operate it.
 When it operating, The EUT is transmitting at maximum power level and duty cycle fixed.
 2) Instruments and EUT were connected like Figure 7.2.1(A).
 3) The maximum output powers of BDR(1 Mbps), EDR(2, 3 Mbps) and each frequency were set by a Bluetooth Tester.
 4) Power levels were measured by a Power Meter.

2. Bluetooth (LE)
 1) Enter LE mode in EUT and operate it.
 When it operating, The EUT is transmitting at maximum power level and duty cycle fixed.
 2) Instruments and EUT were connected like Figure 7.2.1(B).
 3) The average conducted output powers of LE and each frequency can measurement according to setting program in EUT.
 4) Power levels were measured by a Power Meter.

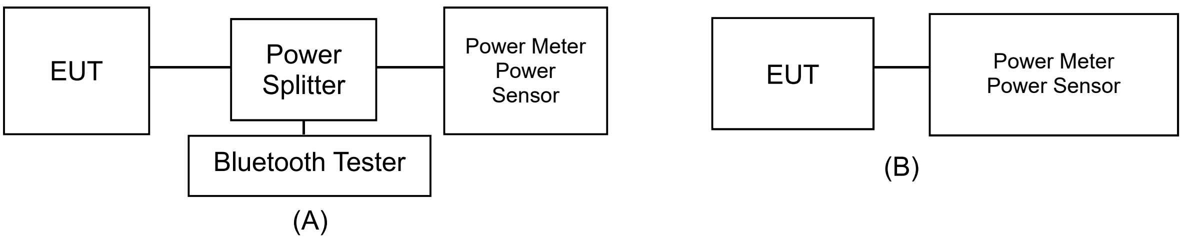

Figure 7.2.1 Average Power Measurement Setup

- **Bluetooth Transmission Plot**

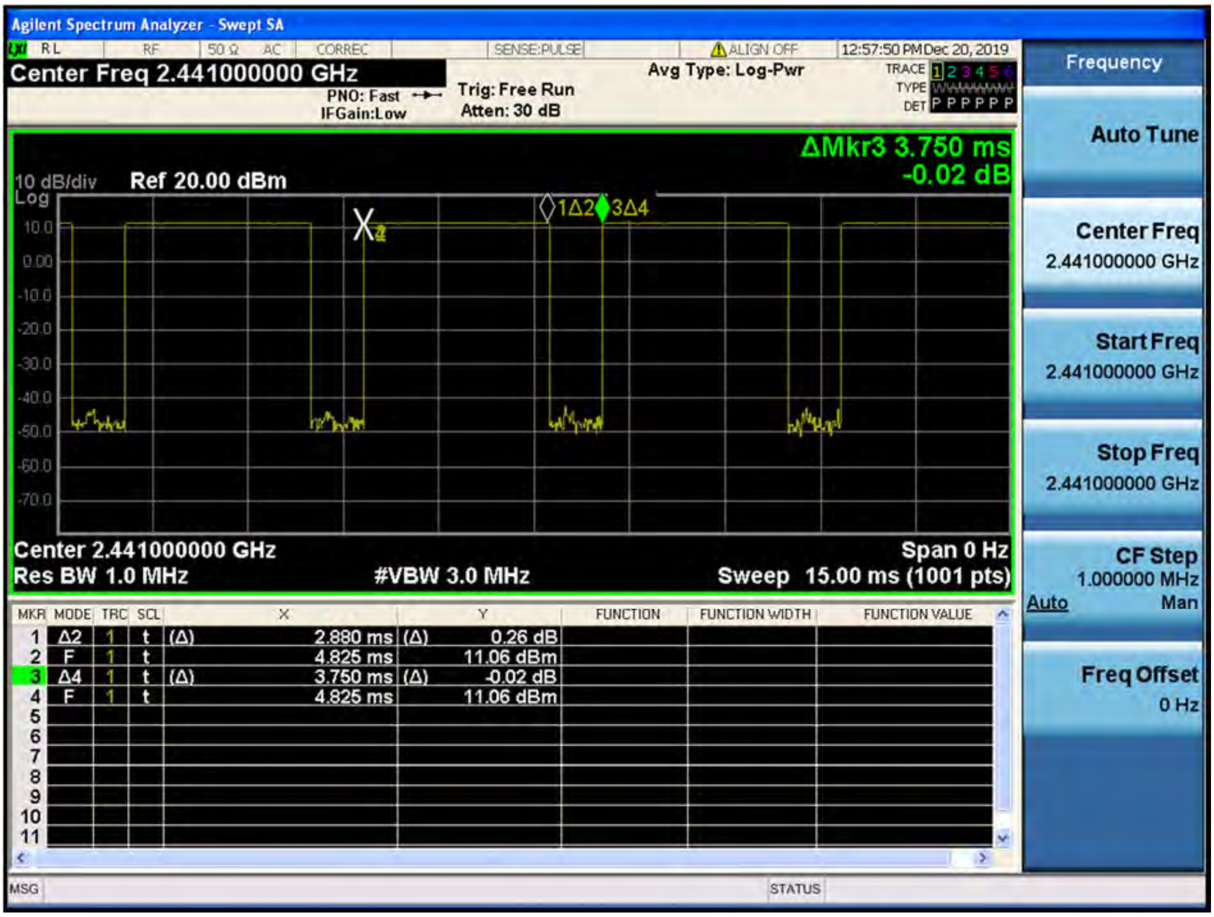

Figure 7.5.2 Bluetooth Transmission Plot

- **Bluetooth Duty Cycle Calculation**

Duty Cycle = Pulse/Period * 100% = (2.880/3.750) * 100 = 76.8%

8. SYSTEM VERIFICATION

8.1 Tissue Verification

MEASURED TISSUE PARAMETERS										
Date(s)	Tissue Type	Ambient Temp.[°C]	Liquid Temp.[°C]	Measured Frequency [MHz]	Target Dielectric Constant, εr	Target Conductivity, σ (S/m)	Measured Dielectric Constant, εr	Measured Conductivity, σ (S/m)	Er Deviation [%]	σ Deviation [%]
Dec. 10. 2019	2450 Head	21.3	21.0	2402.0	39.282	1.757	37.873	1.751	-3.59	-0.34
				2412.0	39.265	1.766	37.838	1.762	-3.63	-0.23
				2437.0	39.222	1.788	37.748	1.791	-3.76	0.17
				2441.0	39.215	1.792	37.734	1.795	-3.78	0.17
				2450.0	39.200	1.800	37.703	1.805	-3.82	0.28
				2462.0	39.184	1.813	37.670	1.818	-3.86	0.28
				2467.0	39.177	1.818	37.653	1.823	-3.89	0.28
				2472.0	39.171	1.823	37.633	1.828	-3.93	0.27
				2480.0	39.160	1.832	37.605	1.837	-3.97	0.27
Dec. 12. 2019	5300 Head	21.2	21.3	5260.0	35.940	4.720	34.750	4.584	-3.31	-2.88
				5270.0	35.930	4.730	34.740	4.595	-3.31	-2.85
				5280.0	35.920	4.740	34.743	4.603	-3.28	-2.89
				5290.0	35.910	4.750	34.744	4.612	-3.25	-2.91
				5300.0	35.900	4.760	34.728	4.622	-3.26	-2.90
				5310.0	35.890	4.770	34.711	4.636	-3.29	-2.81
				5320.0	35.880	4.780	34.699	4.649	-3.29	-2.74
Dec. 16. 2019	5600 Head	20.8	21.1	5500.0	35.650	4.965	35.129	5.043	-1.46	1.57
				5510.0	35.635	4.976	35.108	5.052	-1.48	1.53
				5530.0	35.605	4.997	35.064	5.077	-1.52	1.60
				5550.0	35.575	5.018	35.039	5.098	-1.51	1.59
				5580.0	35.530	5.049	34.975	5.138	-1.56	1.76
				5600.0	35.500	5.070	34.958	5.158	-1.53	1.74
				5660.0	35.440	5.130	34.853	5.220	-1.66	1.75
				5670.0	35.430	5.140	34.833	5.230	-1.69	1.75
				5690.0	35.410	5.160	34.792	5.257	-1.75	1.88
				5710.0	35.390	5.180	34.776	5.280	-1.73	1.93
				5720.0	35.380	5.190	34.766	5.287	-1.74	1.87
Dec. 17. 2019	5800 Head	21.0	21.5	5745.0	35.355	5.215	34.366	5.239	-2.80	0.46
				5755.0	35.345	5.225	34.358	5.251	-2.79	0.50
				5775.0	35.325	5.245	34.312	5.268	-2.87	0.44
				5785.0	35.315	5.255	34.289	5.281	-2.91	0.49
				5795.0	35.305	5.265	34.273	5.296	-2.92	0.59
				5800.0	35.300	5.270	34.264	5.304	-2.93	0.65
				5825.0	35.275	5.296	34.243	5.329	-2.93	0.62

The above measured tissue parameters were used in the DASY software. The DASY software was used to perform interpolation to determine the dielectric parameters at the SAR test device frequencies (per KDB 865664 and IEEE 1528-2013 6.6.1.2). The tissue parameters listed in the SAR test plots may slightly differ from the table above due to significant digit rounding in the software.

Measurement Procedure for Tissue verification:

1) The network analyzer and probe system was configured and calibrated.
2) The probe was immersed in the sample which was placed in a nonmetallic container. Trapped air bubbles beneath the flange were minimized by placing the probe at a slight angle.
3) The complex admittance with respect to the probe aperture was measured
4) The complex relative permittivity , for example from the below equation (Pournaropoulos and Misra):

$$Y = \frac{j2\omega\varepsilon_r\varepsilon_0}{[\ln(b/a)]^2}\int_a^b\int_a^b\int_0^\pi \cos\phi' \frac{\exp\left[-j\omega r(\mu_0\varepsilon_r'\varepsilon_0)^{1/2}\right]}{r} d\phi' d\rho' d\rho$$

where Y is the admittance of the probe in contact with the sample, the primed and unprimed coordinates refer to source and observation points, respectively, $r^2 = \rho^2 + \rho'^2 - 2\rho\rho'\cos\phi'$, ω is the angular frequency, and $j = \sqrt{-1}$.

8.2 Test System Verification

Prior to assessment, the system is verified to the ± 10 % of the specifications at using the SAR Dipole kit(s). (Graphic Plots Attached)

Table 8.2.1 System Verification Results (1g)

SYSTEM DIPOLE VERIFICATION TARGET & MEASURED												
SAR System #	Freq. [MHz]	SAR Dipole kits	Date(s)	Tissue Type	Ambient Temp. [°C]	Liquid Temp. [°C]	Probe S/N	Input Power (mW)	1 W Target SAR_{1g} (W/kg)	Measured SAR_{1g} (W/kg)	1 W Normalized SAR_{1g} (W/kg)	Deviation [%]
F	2450	D2450V2, SN: 726	Dec. 10. 2019	Head	21.3	21.0	3916	100	51.2	5.22	52.20	1.95
F	5300	D5GHzV2, SN:1103	Dec. 12. 2019	Head	21.2	21.3	3916	100	82.4	8.48	84.80	2.91
F	5600	D5GHzV2, SN:1103	Dec. 16. 2019	Head	20.8	21.1	3916	100	84.0	8.25	82.50	-1.79
F	5800	D5GHzV2, SN:1103	Dec. 17. 2019	Head	21.0	21.5	3916	100	81.4	8.12	81.20	-0.25

Note(s):
1. System Verification was measured with input 100 mW and normalized to 1W.
2. Full system validation status and results can be found in Appendix D.
3. Effective February 19, 2019, FCC has permitted the use of single head-tissue simulating liquid specified in IEC 62209-1 for all SAR tests.

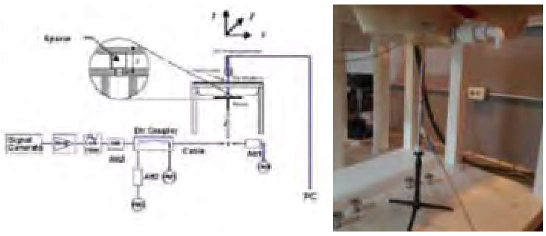

Figure 9.1 Dipole Verification Test Setup Diagram & Photo

9. SAR TEST RESULTS

9.1 Standalone Neck-Worn SAR Results

Table 9.1.1 DTS Neck-Worn SAR

MEASUREMENT RESULTS

FREQUENCY MHz	Ch	Mode	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	Device Condition	Phantom Position	Device Serial Number	Peak SAR of Area Scan	Data Rate [Mbps]	Duty Cycle	1g SAR (W/kg)	Scaling Factor	Scaling Factor (Duty Cycle)	SAR (W/kg)	Plots #
2437.0	6	802.11b (Ant.1)	14.50	13.45	0.130	Unmodified	0 mm [Right upside]	FCC #1	0.112	1	96.0	0.098	1.135	1.042	0.130	
2437.0	6	802.11b (Ant.1)	14.50	13.45	-0.170	Unmodified	0 mm [Right downside]	FCC #1	0.283	1	96.0	0.249	1.135	1.042	0.330	
2437.0	6	802.11b (Ant.1)	14.50	13.45	-0.170	Modified	0 mm [Right upside]	FCC #1	0.406	1	96.0	0.379	1.135	1.042	0.503	
2437.0	6	802.11b (Ant.1)	14.50	13.45	0.110	Modified	0 mm [Right downside]	FCC #1	0.567	1	96.0	0.533	1.274	1.042	0.707	
2412.0	1	802.11b (Ant.1)	14.50	13.30	-0.060	Modified	0 mm [Right inside]	FCC #1	0.403	1	96.0	0.361	1.318	1.042	0.496	
2437.0	6	802.11b (Ant.1)	14.50	13.45	-0.130	Modified	0 mm [Right inside]	FCC #1	0.877	1	96.0	0.819	1.274	1.042	**1.087**	A1
2412.0	1	802.11b (Ant.2)	14.50	13.72	0.010	Unmodified	0 mm [Right upside]	FCC #1	0.014	1	96.0	0.010	1.067	1.042	0.012	
2412.0	1	802.11b (Ant.2)	14.50	13.72	0.170	Unmodified	0 mm [Right downside]	FCC #1	0.031	1	96.0	0.023	1.067	1.042	0.029	
2412.0	1	802.11b (Ant.2)	14.50	13.72	0.000	Modified	0 mm [Right upside]	FCC #1	0.071	1	96.0	0.066	1.067	1.042	0.082	
2412.0	1	802.11b (Ant.2)	14.50	13.72	-0.070	Modified	0 mm [Right downside]	FCC #1	0.127	1	96.0	0.134	1.197	1.042	0.167	
2412.0	1	802.11b (Ant.2)	14.50	13.72	0.110	Modified	0 mm [Right inside]	FCC #1	0.218	1	96.0	0.192	1.197	1.042	**0.239**	A2
2412.0	1	802.11g (MIMO)	17.50	16.53	0.110	Unmodified	0 mm [Right upside]	FCC #1	0.111	1	96.0	0.100	1.175	1.042	0.137	
2412.0	1	802.11g (MIMO)	17.50	16.53	-0.020	Unmodified	0 mm [Right downside]	FCC #1	0.271	1	96.0	0.233	1.175	1.042	0.320	
2412.0	1	802.11g (MIMO)	17.50	16.53	0.070	Modified	0 mm [Right upside]	FCC #1	0.369	1	96.0	0.344	1.175	1.042	0.472	
2412.0	1	802.11g (MIMO)	17.50	16.53	-0.190	Modified	0 mm [Right downside]	FCC #1	0.502	1	96.0	0.523	1.318	1.042	0.718	
2412.0	1	802.11g (MIMO)	17.50	16.53	0.130	Modified	0 mm [Right inside]	FCC #1	0.910	1	96.0	0.841	1.318	1.042	**1.155**	A3
2462.0	11	802.11b (MIMO)	17.50	16.48	0.110	Modified	0 mm [Right inside]	FCC #1	0.582	1	96.0	0.521	1.318	1.042	0.715	
ANSI / IEEE C95.1-1992– SAFETY LIMIT **Spatial Peak** **Uncontrolled Exposure/General Population Exposure**									**Body** **1.6 W/kg (mW/g)** averaged over 1 gram							

Note(s):
1. Neck-worn SAR was performed both cases, i.e. unmodified (without cutting / breaking) and modified (cutting / breaking).

Adjusted SAR results for OFDM SAR

FREQUENCY MHz	Ch	Mode/ Antenna	Service	Maximum Allowed Power [dBm]	1g Scaled SAR (W/kg)	FREQUENCY [MHz]	Mode	Service	Maximum Allowed Power [dBm	Ratio of OFDM to DSSS	1g Adjusted SAR (W/kg)	Determine OFDM SAR
2437.0	6	802.11b (Ant.1)	DSSS	14.5	1.087	2437	802.11g	OFDM	14.0	0.891	**0.969**	X
2437.0	6	802.11b (Ant.1)	DSSS	14.5	1.087	2437	802.11n	OFDM	14.0	0.891	**0.969**	X
2437.0	6	802.11b (Ant.1)	DSSS	14.5	1.087	2437	802.11ac	OFDM	14.0	0.891	**0.969**	X
2412.0	1	802.11b (Ant.2)	DSSS	14.5	0.239	2437	802.11g	OFDM	14.0	0.891	**0.213**	X
2412.0	1	802.11b (Ant.2)	DSSS	14.5	0.239	2437	802.11n	OFDM	14.0	0.891	**0.213**	X
2412.0	1	802.11b (Ant.2)	DSSS	14.5	0.239	2437	802.11ac	OFDM	14.0	0.891	**0.213**	X
2412.0	1	802.11b (MIMO)	DSSS	17.5	1.155	2437	802.11g	OFDM	17.0	0.891	**1.029**	X
2412.0	1	802.11b (MIMO)	DSSS	17.5	1.155	2437	802.11n	OFDM	17.0	0.891	**1.029**	X
2412.0	1	802.11b (MIMO)	DSSS	17.5	1.155	2437	802.11ac	OFDM	17.0	0.891	**1.029**	X
ANSI / IEEE C95.1-1992– SAFETY LIMIT **Spatial Peak** **Uncontrolled Exposure/General Population Exposure**						**Body** **1.6 W/kg (mW/g)** averaged over 1 gram						

Note: SAR is not required for the following 2.4 GHz OFDM conditions. When the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg.

Table 9.1.2 UNII Neck-Worn SAR

MEASUREMENT RESULTS

FREQUENCY MHz	Ch	Mode	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	Device Condition	Phantom Position	Device Serial Number	Peak SAR of Area Scan	Data Rate [Mbps]	Duty Cycle	1g SAR (W/kg)	Scaling Factor	Scaling Factor (Duty Cycle)	1g Scaled SAR (W/kg)	Plots #
5300.0	60	802.11a (Ant.1)	10.5	10.26	0.090	Unmodified	0 mm [Right upside]	FCC #1	0.248	6	97.6	0.231	1.057	1.025	0.250	
5300.0	60	802.11a (Ant.1)	10.5	10.26	0.010	Unmodified	0 mm [Right downside]	FCC #1	0.221	6	97.6	0.239	1.057	1.025	0.259	
5300.0	60	802.11a (Ant.1)	10.5	10.26	-0.150	Modified	0 mm [Right upside]	FCC #1	0.432	6	97.6	0.432	1.057	1.025	0.468	
5300.0	60	802.11a (Ant.1)	10.5	10.26	-0.030	Modified	0 mm [Right downside]	FCC #1	0.363	6	97.6	0.354	1.057	1.025	0.383	
5300.0	60	802.11a (Ant.1)	10.5	10.26	0.120	Modified	0 mm [Right inside]	FCC #1	0.708	6	97.6	0.701	1.057	1.025	**0.759**	A4
5320.0	64	802.11a (Ant.2)	10.5	10.19	0.120	Unmodified	0 mm [Right upside]	FCC #1	0.032	6	97.6	0.012	1.074	1.025	0.013	
5320.0	64	802.11a (Ant.2)	10.5	10.19	0.130	Unmodified	0 mm [Right downside]	FCC #1	0.088	6	97.6	0.053	1.074	1.025	0.058	
5320.0	64	802.11a (Ant.2)	10.5	10.19	0.090	Modified	0 mm [Right upside]	FCC #1	0.100	6	97.6	0.088	1.074	1.025	0.097	
5320.0	64	802.11a (Ant.2)	10.5	10.19	0.180	Modified	0 mm [Right downside]	FCC #1	0.205	6	97.6	0.192	1.074	1.025	**0.211**	A5
5320.0	64	802.11a (Ant.2)	10.5	10.19	0.130	Modified	0 mm [Right inside]	FCC #1	0.092	6	97.6	0.076	1.074	1.025	0.084	
5320.0	64	802.11a (MIMO)	13.5	13.23	0.110	Unmodified	0 mm [Right upside]	FCC #1	0.261	6	97.6	0.251	1.074	1.025	0.276	
5320.0	64	802.11a (MIMO)	13.5	13.23	-0.070	Unmodified	0 mm [Right downside]	FCC #1	0.263	6	97.6	0.256	1.074	1.025	0.282	
5320.0	64	802.11a (MIMO)	13.5	13.23	0.030	Modified	0 mm [Right upside]	FCC #1	0.390	6	97.6	0.416	1.074	1.025	0.458	
5320.0	64	802.11a (MIMO)	13.5	13.23	-0.050	Modified	0 mm [Right downside]	FCC #1	0.308	6	97.6	0.281	1.074	1.025	0.309	
5320.0	64	802.11a (MIMO)	13.5	13.23	0.120	Modified	0 mm [Right inside]	FCC #1	0.574	6	97.6	0.628	1.074	1.025	**0.691**	A6
ANSI / IEEE C95.1-2005– SAFETY LIMIT **Spatial Peak** **Uncontrolled Exposure/General Population Exposure**									**Body** **1.6 W/kg (mW/g)** averaged over 1 gram							

Note(s):
1. Neck-worn SAR was performed both cases, i.e. unmodified (without cutting / breaking) and modified (cutting / breaking).

Adjusted SAR results for UNII-1 and UNII-2A SAR

FREQUENCY MHz	Ch	Mode/ Antenna	Service	Maximum Allowed Power [dBm]	1g Scaled SAR (W/kg)	FREQUENCY [MHz]	Mode	Service	Maximum Allowed Power [dBm	Adjusted Factor	1g Adjusted SAR (W/kg)	SAR for the band with lower maximum output power
5300.0	60	802.11a (Ant.1)	OFDM	10.5	0.759	5240	802.11a	OFDM	9.5	0.794	**0.603**	X
5320.0	64	802.11a (Ant.2)	OFDM	10.5	0.211	5240	802.11a	OFDM	10.0	0.891	**0.188**	X
5320.0	64	802.11a (MIMO)	OFDM	13.5	0.691	5240	802.11a	OFDM	12.8	0.851	**0.588**	X
ANSI / IEEE C95.1-1992– SAFETY LIMIT **Spatial Peak** **Uncontrolled Exposure/General Population Exposure**						**Body** **1.6 W/kg (mW/g)** averaged over 1 gram						

Note(s):
1. U-NII-1 and U-NII-2A Bands: 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 ≤ 1.2 W/kg, SAR is not required for the band with lower maximum output power in that test configuration.

Table 9.1.3 UNII Neck-Worn SAR

MEASUREMENT RESULTS																
FREQUENCY		Mode	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	Device Condition	Phantom Position	Device Serial Number	Peak SAR of Area Scan	Data Rate [Mbps]	Duty Cycle	1g SAR (W/kg)	Scaling Factor	Scaling Factor (Duty Cycle)	1g Scaled SAR (W/kg)	Plots #
MHz	Ch															
5500.0	100	802.11a (Ant.1)	10.0	9.75	0.010	Unmodified	0 mm [Right upside]	FCC #1	0.238	6	97.2	0.237	1.059	1.029	0.258	
5500.0	100	802.11a (Ant.1)	10.0	9.75	-0.010	Unmodified	0 mm [Right downside]	FCC #1	0.156	6	97.2	0.137	1.059	1.029	0.149	
5500.0	100	802.11a (Ant.1)	10.0	9.75	0.130	Modified	0 mm [Right upside]	FCC #1	0.269	6	97.2	0.266	1.059	1.029	0.290	
5500.0	100	802.11a (Ant.1)	10.0	9.75	-0.010	Modified	0 mm [Right downside]	FCC #1	0.285	6	97.2	0.300	1.059	1.029	0.327	
5500.0	100	802.11a (Ant.1)	10.0	9.75	-0.040	Modified	0 mm [Right inside]	FCC #1	0.322	6	97.2	0.344	1.059	1.029	**0.375**	A7
5500.0	100	802.11a (Ant.2)	10.5	10.40	0.030	Unmodified	0 mm [Right upside]	FCC #1	0.029	6	97.2	0.011	1.023	1.029	0.012	
5500.0	100	802.11a (Ant.2)	10.5	10.40	0.160	Unmodified	0 mm [Right downside]	FCC #1	0.072	6	97.2	0.040	1.023	1.029	0.042	
5500.0	100	802.11a (Ant.2)	10.5	10.40	0.040	Modified	0 mm [Right upside]	FCC #1	0.073	6	97.2	0.045	1.023	1.029	0.047	
5500.0	100	802.11a (Ant.2)	10.5	10.40	0.070	Modified	0 mm [Right downside]	FCC #1	0.090	6	97.2	0.068	1.023	1.029	**0.072**	A8
5500.0	100	802.11a (Ant.2)	10.5	10.40	0.110	Modified	0 mm [Right inside]	FCC #1	0.059	6	97.2	0.051	1.023	1.029	0.054	
5500.0	100	802.11a (MIMO)	13.3	13.10	-0.070	Unmodified	0 mm [Right upside]	FCC #1	0.278	6	97.2	0.264	1.059	1.029	0.288	
5500.0	100	802.11a (MIMO)	13.3	13.10	0.060	Unmodified	0 mm [Right downside]	FCC #1	0.213	6	97.2	0.171	1.059	1.029	0.186	
5500.0	100	802.11a (MIMO)	13.3	13.10	-0.110	Modified	0 mm [Right upside]	FCC #1	0.273	6	97.2	0.276	1.059	1.029	0.301	
5500.0	100	802.11a (MIMO)	13.3	13.10	0.160	Modified	0 mm [Right downside]	FCC #1	0.273	6	97.2	0.311	1.059	1.029	0.339	
5500.0	100	802.11a (MIMO)	13.3	13.10	-0.060	Modified	0 mm [Right inside]	FCC #1	0.280	6	97.2	0.316	1.059	1.029	**0.344**	A9
5825.0	165	802.11a (Ant.1)	8.0	7.65	-0.110	Unmodified	0 mm [Right upside]	FCC #1	0.370	6	96.9	0.321	1.084	1.032	0.359	
5825.0	165	802.11a (Ant.1)	8.0	7.65	0.110	Unmodified	0 mm [Right downside]	FCC #1	0.299	6	96.9	0.336	1.084	1.032	0.376	
5825.0	165	802.11a (Ant.1)	8.0	7.65	0.110	Modified	0 mm [Right upside]	FCC #1	0.316	6	96.9	0.375	1.084	1.032	0.420	
5825.0	165	802.11a (Ant.1)	8.0	7.65	0.010	Modified	0 mm [Right downside]	FCC #1	0.534	6	96.9	0.492	1.084	1.032	0.550	
5825.0	165	802.11a (Ant.1)	8.0	7.65	-0.100	Modified	0 mm [Right inside]	FCC #1	0.508	6	96.9	0.510	1.084	1.032	**0.571**	A10
5825.0	165	802.11a (Ant.2)	9.5	9.35	0.110	Unmodified	0 mm [Right upside]	FCC #1	0.042	6	96.9	0.021	1.035	1.032	0.022	
5825.0	165	802.11a (Ant.2)	9.5	9.35	-0.110	Unmodified	0 mm [Right downside]	FCC #1	0.028	6	96.9	0.021	1.035	1.032	0.022	
5825.0	165	802.11a (Ant.2)	9.5	9.35	0.040	Modified	0 mm [Right upside]	FCC #1	0.151	6	96.9	0.157	1.035	1.032	**0.168**	A11
5825.0	165	802.11a (Ant.2)	9.5	9.35	-0.170	Modified	0 mm [Right downside]	FCC #1	0.146	6	96.9	0.145	1.035	1.032	0.155	
5825.0	165	802.11a (Ant.2)	9.5	9.35	-0.130	Modified	0 mm [Right inside]	FCC #1	0.076	6	96.9	0.066	1.035	1.032	0.070	
5825.0	165	802.11a (MIMO)	11.8	11.59	-0.050	Unmodified	0 mm [Right upside]	FCC #1	0.398	6	96.9	0.352	1.084	1.032	0.394	
5825.0	165	802.11a (MIMO)	11.8	11.59	-0.180	Unmodified	0 mm [Right downside]	FCC #1	0.315	6	96.9	0.345	1.084	1.032	0.386	
5825.0	165	802.11a (MIMO)	11.8	11.59	-0.190	Modified	0 mm [Right upside]	FCC #1	0.439	6	96.9	0.453	1.084	1.032	0.507	
5825.0	165	802.11a (MIMO)	11.8	11.59	0.130	Modified	0 mm [Right downside]	FCC #1	0.504	6	96.9	0.573	1.084	1.032	0.641	
5825.0	165	802.11a (MIMO)	11.8	11.59	-0.050	Modified	0 mm [Right inside]	FCC #1	0.566	6	96.9	0.575	1.084	1.032	**0.643**	A12
ANSI / IEEE C95.1-1992– SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure									**Body 1.6 W/kg (mW/g)** averaged over 1 gram							

Note(s):
1. Neck-worn SAR was performed both cases, i.e. unmodified (without cutting / breaking) and modified (cutting / breaking).

Table 9.1.4 Bluetooth Neck-Worn SAR

MEASUREMENT RESULTS															
FREQUENCY		Mode	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	Device Condition	Phantom Position	Device Serial Number	Rate [Mbps]	Duty Cycle (%)	1g SAR (W/kg)	Scaling Factor	Scaling Factor (Duty Cycle)	1g Scaled SAR (W/kg)	Plots #
MHz	Ch														
2441.0	39	Bluetooth	10.35	10.14	0.160	Unmodified	0 mm [Right upside]	FCC #1	1	76.8	0.010	1.050	1.302	0.014	
2441.0	39	Bluetooth	10.35	10.14	0.090	Unmodified	0 mm [Right downside]	FCC #1	1	76.8	0.017	1.050	1.302	0.023	
2441.0	39	Bluetooth	10.35	10.14	-0.160	Modified	0 mm [Right upside]	FCC #1	1	76.8	0.081	1.050	1.302	0.111	
2441.0	39	Bluetooth	10.35	10.14	-0.170	Modified	0 mm [Right downside]	FCC #1	1	76.8	0.045	1.050	1.302	0.062	
2441.0	39	Bluetooth	10.35	10.14	-0.190	Modified	0 mm [Right inside]	FCC #1	1	76.8	0.458	1.050	1.302	**0.626**	A13
ANSI / IEEE C95.1-1992– SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure									**Body 1.6 W/kg (mW/g)** averaged over 1 gram						

Note(s):
1. Neck-worn SAR was performed both cases, i.e. unmodified (without cutting / breaking) and modified (cutting / breaking).

9.2 SAR Test Notes

General Notes:

1. The test data reported are the worst-case SAR values according to test procedures specified in IEEE 1528-2013, and FCC KDB Publication 447498 D01v06.
2. Batteries are fully charged at the beginning of the SAR measurements. A standard battery was used for all SAR measurements.
3. Liquid tissue depth was at least 15.0 cm for all frequencies.
4. The manufacturer has confirmed that the device(s) tested have the same physical, mechanical and thermal characteristics and are within operational tolerances expected for production units
5. SAR results were scaled to the maximum allowed power to demonstrate compliance per FCC KDB Publication 447498 D01v06.
6. SAR measurements were performed using the DASY5 automated system. The procedure for spatial peak SAR evaluation has been implemented according to the IEEE 1528 standard. During a maximum search, global and local maxima searches are automatically performed in 2-D after each area scan measurement. The algorithm will find the global maximum and all local maxima within 2 dB of the global maxima for all SAR distributions. All local maxima within 2 dB of the global maximum were searched and passed for the Zoom Scan measurement.

WLAN Notes:

1. The initial test position procedures were applied. The test position with the highest extrapolated peak SAR will be used as the initial test position. When reported SAR for the initial test position is ≤ 0.4 W/kg, no additional testing for the remaining test positions was required. Otherwise, SAR is evaluated at the subsequent highest peak SAR positions until the reported SAR result is ≤ 0.8 W/kg or all test positions are measured.
2. Justification for test configurations for WLAN per KDB Publication 248227 D01v02r02 for 2.4 GHz WIFI single transmission chain operations, the highest measured maximum output power channel for DSSS was selected for SAR measurement. SAR for OFDM modes (2.4 GHz 802.11g/n) was not required duo to the maximum allowed powers and the highest reported DSSS SAR when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output and the adjust SAR is ≤ 1.2 W/kg.
3. Justification for test configurations for WLAN per KDB Publication 248227 D01v02r02 for 5 GHz WIFI single transmission chain operations, the initial test configuration was selected according to the transmission mode with the highest maximum allowed powers. Other transmission modes were not investigated since the highest reported SAR for initial test configuration adjusted by the ratio of maximum output powers is less than 1.2 W/kg.
4. When the maximum reported 1g averaged SAR ≤ 0.8 W/kg, SAR testing on additional channels was not required. Otherwise, SAR for the next highest output power channel was required until the reported SAR result was ≤ 1.20 W/kg or all test channels were measured.
5. The device was configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor to determine compliance.
6. Per KDB Publication 248227 D01v02r02, SAR for MIMO was evaluated by following the simultaneous SAR provisions from KDB Publication 447498 D01v06 by making a SAR measurement with both antennas transmitting simultaneously.

Bluetooth Notes:

1. Bluetooth SAR was measured with the device connected to a call with hopping disabled with DH5 operation and Tx test mode type. Per October 2016 TCB Workshop Notes, the reported SAR was scaled to the 100% transmission duty factor to determine compliance. Refer to section 7.2 for the time-domain plot and calculation for the duty factor of the device.

10. FCC MULTI-TX AND ANTENNA SAR CONSIDERATIONS

10.1 Introduction

The following procedures adopted from FCC KDB Publication 447498 D01v06 are applicable to handsets with built-in unlicensed transmitters such as 802.11b/g/n and Bluetooth devices which may simultaneously transmit with the licensed transmitter.

10.2 Simultaneous Transmission Procedures

This device contains transmitters that may operate simultaneously. Therefore simultaneous transmission analysis is required. Per FCC KDB 447498 D01v06 4.3.2 and IEEE 1528-2013 Section 6.3.4.1.2,simultaneous transmission SAR test exclusion may be applied when the sum of the sum 1-g SAR for all the simultaneous transmitting antennas in a specific a physical test configuration is ≤ 1.6 W/kg. The different test positon in an exposure condition may be considered collectively to determine SAR test exclusion according to the sum of 1-g or 10-g SAR.

10.3 Simultaneous Transmission Capabilities

According to FCC KDB Publication 447498 D01v06, transmitters are considered to be transmitting simultaneously when there is overlapping transmission, with the exception of transmissions during network hand-offs with maximum hand-off duration less than 30 seconds.

This device contains multiple transmitters that may operate simultaneously, and therefore requires a simultaneous transmission analysis according to FCC KDB Publication 447498 D01v06.

Table 10.3.1 Simultaneous Transmission Scenarios

No.	Capable TX Configuration	WIFI 2.4GHz 802.11b/g/n/ac	WIFI 5GHz 802.11a/n/ac	Bluetooth 2.4GHz
1	WIFI 2.4GHz 802.11b/g/n/ac		No	No
2	WIFI 5GHz 802.11a/n/ac	No		Yes
3	Bluetooth 2.4GHz	No	Yes	

Table 10.3.2 Simultaneous SAR Cases

No.	Capable Transmit Configuration	Neck-Worn SAR	Note
1	Bluetooth 2.4 GHz + Wi-Fi 5GHz	Yes	

Notes:

1. Bluetooth and WiFi can not transmit simultaneously at 2.4G band.

10.4 Neck-Worn Simultaneous Transmission Analysis

Table 10.4.1 Simultaneous Transmission Scenario : Bluetooth + 5 GHz W-LAN Ant.1 (Neck-Worn at 15 mm)

Exposure Condition	Mode	Configuration	Bluetooth SAR (W/kg)	5G W-LAN SAR (W/kg)	ΣSAR (W/kg)
			1	2	1+2
Neck-Worn SAR	5.3G W-LAN Ant.1	Right upside	0.111	0.468	0.579
		Right downside	0.062	0.383	0.445
		Right inside	**0.626**	**0.759**	1.385
	5.6G W-LAN Ant.1	Right upside	0.111	0.290	0.401
		Right downside	0.062	0.327	0.389
		Right inside	0.626	0.375	**1.001**
	5.8G W-LAN Ant.1	Right upside	0.111	0.420	0.531
		Right downside	0.062	0.550	0.612
		Right inside	0.626	0.571	**1.197**

Table 10.4.2 Simultaneous Transmission Scenario : Bluetooth + 5 GHz W-LAN Ant.2 (Neck-Worn at 15 mm)

Exposure Condition	Mode	Configuration	Bluetooth SAR (W/kg)	5G W-LAN SAR (W/kg)	ΣSAR (W/kg)
			1	2	1+2
Neck-Worn SAR	5.3G W-LAN Ant.2	Right upside	0.111	0.097	0.208
		Right downside	0.062	0.211	0.273
		Right inside	0.626	0.084	**0.710**
	5.6G W-LAN Ant.2	Right upside	0.111	0.047	0.158
		Right downside	0.062	0.072	0.134
		Right inside	0.626	0.054	**0.680**
	5.8G W-LAN Ant.2	Right upside	0.111	0.168	0.279
		Right downside	0.062	0.155	0.217
		Right inside	0.626	0.070	**0.696**

Table 10.4.3 Simultaneous Transmission Scenario : Bluetooth + 5 GHz W-LAN MIMO (Neck-Worn at 15 mm)

Exposure Condition	Mode	Configuration	Bluetooth SAR (W/kg)	5G W-LAN SAR (W/kg)	ΣSAR (W/kg)
			1	2	1+2
Neck-Worn SAR	5.3G W-LAN MIMO	Right upside	0.111	0.458	0.569
		Right downside	0.062	0.309	0.371
		Right inside	0.626	0.691	**1.317**
	5.6G W-LAN MIMO	Right upside	0.111	0.301	0.412
		Right downside	0.062	0.339	0.401
		Right inside	0.626	0.344	**0.970**
	5.8G W-LAN MIMO	Right upside	0.111	0.507	0.618
		Right downside	0.062	0.641	0.703
		Right inside	0.626	0.643	**1.269**

10.5 Simultaneous Transmission Conclusion

The above numerical summed SAR results for all the worst-case simultaneous transmission conditions were below the SAR limit. Therefore, the above analysis is sufficient to determine that simultaneous transmission cases will not exceed the SAR limit and therefore no measured volumetric simultaneous SAR summation is required per FCC KDB Publication 447498 D01v06 and IEEE 1528-2013 Section 6.3.4.1.2.

11. SAR MEASUREMENT VARIABILITY

11.1 Measurement Variability

Per FCC KDB Publication 865664 D01v01r04, SAR measurement variability was assessed for each frequency band, which was determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media were required for SAR measurements in a frequency band, the variability measurement procedures were applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium. These additional measurements were repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device was returned to ambient conditions (normal room temperature) with the battery fully charged before it was re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

SAR Measurement Variability was assessed using the following procedures for each frequency band:

1. When the original highest measured SAR is ≥ 0.80 W/kg, the measurement was repeated once.
2. A second repeated measurement was performed only if the ratio of largest to smallest SAR for the original and first repeated measurements was > 1.20 or when the original or repeated measurement was ≥ 1.45 W/kg (~ 10% from the 1-g SAR limit).
3. A third repeated measurement was performed only if the original, first or second repeated measurement was ≥ 1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.
4. Repeated measurements are not required when the original highest measured SAR is < 0.80 W/kg
5. The same procedures should be adapted for measurements according to extremity exposure limits by applying a factor of 2.5 for extremity exposure to the corresponding SAR thresholds.

11.2 Measurement Uncertainty

The measured SAR was < 1.5 W/kg for 1g and < 3.75 W/kg for 10g for all frequency bands. Therefore, per KDB Publication 865664 D01v01r04, the extended measurement uncertainty analysis per IEEE 1528-2013 was not required.

12. EQUIPMENT LIST

Table 12.1.1 Test Equipment Calibration

	Type	Manufacturer	Model	Cal.Date	Next.Cal.Date	S/N
☒	SEMITEC Engineering	SEMITEC	N/A	N/A	N/A	Shield Room
☒	Robot	SPEAG	TX90XL	N/A	N/A	F13/5RR2A1/A/01
☒	Robot Controller	SPEAG	CS8C	N/A	N/A	F13/5RR2A1/C/01
☒	Joystick	SPEAG	N/A	N/A	N/A	S-13200990
☒	Intel Core i7-3770 3.40 GHz Windows 7 Professional	N/A	N/A	N/A	N/A	N/A
☒	Probe Alignment Unit LB	N/A	N/A	N/A	N/A	SE UKS 030 AA
☒	Device Holder	SPEAG	SD000H01HA	N/A	N/A	N/A
☒	Twin SAM Phantom	SPEAG	QD000P40CD	N/A	N/A	1785
☒	Data Acquisition Electronics	SPEAG	DAE4V1	2019-09-20	2020-09-20	1453
☒	Dosimetric E-Field Probe	SPEAG	EX3DV4	2019-04-25	2020-04-25	3916
☒	2450MHz SAR Dipole	SPEAG	D2450V2	2019-09-19	2021-09-19	726
☒	5GHz SAR Dipole	SPEAG	D5GHzV2	2019-02-28	2021-02-28	1103
☒	Network Analyzer	Agilent	E5071C	2019-06-24	2020-06-24	MY46106970
☒	Signal Generator	Agilent	E4438C	2019-06-24	2020-06-24	US41461520
☒	Amplifier	EMPOWER	BBS3Q7ELU	2019-06-24	2020-06-24	1020
☒	High Power RF Amplifier	EMPOWER	BBS3Q8CCJ	2019-06-24	2020-06-24	1005
☒	Power Meter	HP	EPM-442A	2019-12-18	2020-12-18	GB37170267
☒	Power Meter	HP	EPM-442A	2019-12-16	2020-12-16	GB37170413
☒	Power Sensor	HP	8481A	2019-12-16	2020-12-16	US37294267
☒	Power Sensor	HP	8481A	2019-12-18	2020-12-18	3318A96566
☒	Power Sensor	HP	8481A	2019-12-18	2020-12-18	2702A65976
☒	Directional Coupler	HP	772D	2019-06-24	2020-06-24	2889A01064
☒	Low Pass Filter 3.0GHz	Micro LAB	LA-30N	2019-06-24	2020-06-24	2
☒	Low Pass Filter 6.0GHz	Micro LAB	LA-60N	2019-12-17	2020-12-17	03942
☒	Attenuators(10 dB)	WEINSCHEL	23-10-34	2019-12-17	2020-12-17	BP4387
☒	Attenuators	Cernexwave	CFADC2603U5	2019-06-27	2020-06-27	C11740
☒	Dielectric Probe kit	SPEAG	DAK-3.5	2019-11-19	2020-11-19	1092
☒	Power Splitter	Anritsu	K241B	2019-12-16	2020-12-16	1301183
☒	Bluetooth Tester	TESCOM	TC-3000C	2019-06-24	2020-06-24	3000C000563

NOTE(S):
1. The E-field probe was calibrated by SPEAG, by temperature measurement procedure. Dipole Verification measurement is performed by DT&C before each test. The brain and muscle simulating material are calibrated by DT&C using the dielectric probe system and network analyzer to determine the conductivity and permittivity (dielectric constant) of the brain and muscle-equivalent material. Each equipment item was used solely within its respective calibration period.
2. CBT(Calibrated Before Testing). Prior to testing, the measurement paths containing a cable, amplifier, attenuator, coupler or filter were connected to a calibrated source (i.e. signal generator) to determine the losses of the measurement path. The power meter offset was then adjusted to compensate for the measurement system losses. This level offset is stored within the power meter before measurements are made. This calibration verification procedure applies to the system verification and output power measurements. The calibrated reading is then taken directly from the power meter after compensation of the losses for all final power measurements.

13. MEASUREMENT UNCERTAINTIES

2450 MHz Head

Error Description	Uncertainty value ±%	Probability Distribution	Divisor	(Ci) 1g	(Ci) 10g	Standard (1g)	Standard (10g)	vi 2 or Veff
Measurement System								
Probe calibration	± 6.0	Normal	1	1	1	± 6.0 %	± 6.0 %	∞
Isotropy	± 1.3	Normal	1	1	1	± 1.3 %	± 1.3 %	∞
Boundary Effects	± 2.0	Rectangular	√3	1	1	± 1.2 %	± 1.2 %	∞
Probe Linearity	± 0.3	Normal	1	1	1	± 0.3 %	± 0.3 %	∞
Probe modulation response	± 0.0	Rectangular	√3	1	1	± 0.0 %	± 0.0 %	∞
Detection limits	± 0.25	Rectangular	√3	1	1	± 0.14 %	± 0.14 %	∞
Readout Electronics	± 0.3	Normal	1	1	1	± 0.3 %	± 0.3 %	∞
Response time	± 0.8	Rectangular	√3	1	1	± 0.46 %	± 0.46 %	∞
Integration time	± 2.6	Rectangular	√3	1	1	± 1.5 %	± 1.5 %	∞
RF Ambient Conditions – Noise	± 3.0	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
RF Ambient Conditions – Reflections	± 3.0	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
Probe Positioner	± 0.8	Rectangular	√3	1	1	± 0.46 %	± 0.46 %	∞
Probe Positioning	± 6.7	Rectangular	√3	1	1	± 3.9 %	± 3.9 %	∞
Algorithms for Max. SAR Eval.	± 4.0	Rectangular	√3	1	1	± 2.3 %	± 2.3 %	∞
Test Sample Related								
Device Positioning	± 2.9	Normal	1	1	1	± 2.9 %	± 2.9 %	145
Device Holder	± 3.6	Normal	1	1	1	± 3.6 %	± 3.6 %	5
Power Drift	± 5.0	Rectangular	√3	1	1	± 2.9 %	± 2.9 %	∞
SAR Scaling	± 0.0	Rectangular	√3	1	1	± 0.0 %	± 0.0 %	∞
Physical Parameters								
Phantom Shell	± 7.6	Rectangular	√3	1	1	± 4.4 %	± 4.4 %	∞
SAR correction	± 0.0	Normal	1	1	0.84	± 0.0 %	± 0.0 %	∞
Liquid conductivity (Target)	± 5.0	Rectangular	√3	0.64	0.43	± 1.8 %	± 1.2 %	∞
Liquid conductivity (Meas.)	± 4.1	Normal	1	0.78	0.71	± 3.2 %	± 2.9 %	10
Liquid permittivity (Target)	± 5.0	Rectangular	√3	0.60	0.49	± 1.7 %	± 1.4 %	∞
Liquid permittivity (Meas.)	± 3.8	Normal	1	0.23	0.26	± 0.9 %	± 1.0 %	10
Temp. unc. - Conductivity	± 1.9	Rectangular	√3	0.78	0.71	± 0.9 %	± 0.8 %	∞
Temp. unc. - Permittivity	± 1.9	Rectangular	√3	0.23	0.26	± 0.3 %	± 0.3 %	∞
Combined Standard Uncertainty						**± 11.6 %**	**± 11.4 %**	330
Expanded Uncertainty (k=2)						**± 23.2 %**	**± 22.8 %**	

The above measurement uncertainties are according to IEEE Std 1528

5300 MHz Head

Error Description	Uncertainty value ±%	Probability Distribution	Divisor	(Ci) 1g	(Ci) 10g	Standard (1g)	Standard (10g)	vi 2 or Veff
Measurement System								
Probe calibration	± 6.55	Normal	1	1	1	± 6.6 %	± 6.6 %	∞
Isotropy	± 1.3	Normal	1	1	1	± 1.3 %	± 1.3 %	∞
Boundary Effects	± 2.0	Rectangular	√3	1	1	± 1.2 %	± 1.2 %	∞
Probe Linearity	± 0.3	Normal	1	1	1	± 0.3 %	± 0.3 %	∞
Probe modulation response	± 0.0	Rectangular	√3	1	1	± 0.0 %	± 0.0 %	∞
Detection limits	± 0.25	Rectangular	√3	1	1	± 0.14 %	± 0.14 %	∞
Readout Electronics	± 0.3	Normal	1	1	1	± 0.3 %	± 0.3 %	∞
Response time	± 0.8	Rectangular	√3	1	1	± 0.46 %	± 0.46 %	∞
Integration time	± 2.6	Rectangular	√3	1	1	± 1.5 %	± 1.5 %	∞
RF Ambient Conditions – Noise	± 3.0	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
RF Ambient Conditions – Reflections	± 3.0	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
Probe Positioner	± 0.8	Rectangular	√3	1	1	± 0.46 %	± 0.46 %	∞
Probe Positioning	± 6.7	Rectangular	√3	1	1	± 3.9 %	± 3.9 %	∞
Algorithms for Max. SAR Eval.	± 4.0	Rectangular	√3	1	1	± 2.3 %	± 2.3 %	∞
Test Sample Related								
Device Positioning	± 2.9	Normal	1	1	1	± 2.9 %	± 2.9 %	145
Device Holder	± 3.6	Normal	1	1	1	± 3.6 %	± 3.6 %	5
Power Drift	± 5.0	Rectangular	√3	1	1	± 2.9 %	± 2.9 %	∞
SAR Scaling	± 0.0	Rectangular	√3	1	1	± 0.0 %	± 0.0 %	∞
Physical Parameters								
Phantom Shell	± 7.6	Rectangular	√3	1	1	± 4.4 %	± 4.4 %	∞
SAR correction	± 0.0	Normal	1	1	0.84	± 0.0 %	± 0.0 %	∞
Liquid conductivity (Target)	± 5.0	Rectangular	√3	0.64	0.43	± 1.8 %	± 1.2 %	∞
Liquid conductivity (Meas.)	± 3.8	Normal	1	0.78	0.71	± 3.0 %	± 2.7 %	10
Liquid permittivity (Target)	± 5.0	Rectangular	√3	0.60	0.49	± 1.7 %	± 1.4 %	∞
Liquid permittivity (Meas.)	± 4.1	Normal	1	0.23	0.26	± 0.9 %	± 1.1 %	10
Temp. unc. - Conductivity	± 1.8	Rectangular	√3	0.78	0.71	± 0.8 %	± 0.7 %	∞
Temp. unc. - Permittivity	± 1.8	Rectangular	√3	0.23	0.26	± 0.2 %	± 0.3 %	∞
Combined Standard Uncertainty						**± 11.9 %**	**± 11.7 %**	330
Expanded Uncertainty (k=2)						**± 23.8 %**	**± 23.4 %**	

The above measurement uncertainties are according to IEEE Std 1528

5500 MHz Head

Error Description	Uncertainty value ±%	Probability Distribution	Divisor	(Ci) 1g	(Ci) 10g	Standard (1g)	Standard (10g)	vi 2 or Veff
Measurement System								
Probe calibration	± 6.55	Normal	1	1	1	± 6.6 %	± 6.6 %	∞
Isotropy	± 1.3	Normal	1	1	1	± 1.3 %	± 1.3 %	∞
Boundary Effects	± 2.0	Rectangular	√3	1	1	± 1.2 %	± 1.2 %	∞
Probe Linearity	± 0.3	Normal	1	1	1	± 0.3 %	± 0.3 %	∞
Probe modulation response	± 0.0	Rectangular	√3	1	1	± 0.0 %	± 0.0 %	∞
Detection limits	± 0.25	Rectangular	√3	1	1	± 0.14 %	± 0.14 %	∞
Readout Electronics	± 0.3	Normal	1	1	1	± 0.3 %	± 0.3 %	∞
Response time	± 0.8	Rectangular	√3	1	1	± 0.46 %	± 0.46 %	∞
Integration time	± 2.6	Rectangular	√3	1	1	± 1.5 %	± 1.5 %	∞
RF Ambient Conditions – Noise	± 3.0	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
RF Ambient Conditions – Reflections	± 3.0	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
Probe Positioner	± 0.8	Rectangular	√3	1	1	± 0.46 %	± 0.46 %	∞
Probe Positioning	± 6.7	Rectangular	√3	1	1	± 3.9 %	± 3.9 %	∞
Algorithms for Max. SAR Eval.	± 4.0	Rectangular	√3	1	1	± 2.3 %	± 2.3 %	∞
Test Sample Related								
Device Positioning	± 2.9	Normal	1	1	1	± 2.9 %	± 2.9 %	145
Device Holder	± 3.6	Normal	1	1	1	± 3.6 %	± 3.6 %	5
Power Drift	± 5.0	Rectangular	√3	1	1	± 2.9 %	± 2.9 %	∞
SAR Scaling	± 0.0	Rectangular	√3	1	1	± 0.0 %	± 0.0 %	∞
Physical Parameters								
Phantom Shell	± 7.6	Rectangular	√3	1	1	± 4.4 %	± 4.4 %	∞
SAR correction	± 0.0	Normal	1	1	0.84	± 0.0 %	± 0.0 %	∞
Liquid conductivity (Target)	± 5.0	Rectangular	√3	0.64	0.43	± 1.8 %	± 1.2 %	∞
Liquid conductivity (Meas.)	± 4.2	Normal	1	0.78	0.71	± 3.3 %	± 3.0 %	10
Liquid permittivity (Target)	± 5.0	Rectangular	√3	0.60	0.49	± 1.7 %	± 1.4 %	∞
Liquid permittivity (Meas.)	± 4.0	Normal	1	0.23	0.26	± 0.9 %	± 1.0 %	10
Temp. unc. - Conductivity	± 1.7	Rectangular	√3	0.78	0.71	± 0.8 %	± 0.7 %	∞
Temp. unc. - Permittivity	± 1.9	Rectangular	√3	0.23	0.26	± 0.3 %	± 0.3 %	∞
Combined Standard Uncertainty						**± 11.9 %**	**± 11.8 %**	330
Expanded Uncertainty (k=2)						**± 23.8 %**	**± 23.6 %**	

The above measurement uncertainties are according to IEEE Std 1528

5800 MHz Head

Error Description	Uncertainty value ±%	Probability Distribution	Divisor	(Ci) 1g	(Ci) 10g	Standard (1g)	Standard (10g)	vi 2 or Veff
Measurement System								
Probe calibration	± 6.55	Normal	1	1	1	± 6.6 %	± 6.6 %	∞
Isotropy	± 1.3	Normal	1	1	1	± 1.3 %	± 1.3 %	∞
Boundary Effects	± 2.0	Rectangular	√3	1	1	± 1.2 %	± 1.2 %	∞
Probe Linearity	± 0.3	Normal	1	1	1	± 0.3 %	± 0.3 %	∞
Probe modulation response	± 0.0	Rectangular	√3	1	1	± 0.0 %	± 0.0 %	∞
Detection limits	± 0.25	Rectangular	√3	1	1	± 0.14 %	± 0.14 %	∞
Readout Electronics	± 0.3	Normal	1	1	1	± 0.3 %	± 0.3 %	∞
Response time	± 0.8	Rectangular	√3	1	1	± 0.46 %	± 0.46 %	∞
Integration time	± 2.6	Rectangular	√3	1	1	± 1.5 %	± 1.5 %	∞
RF Ambient Conditions – Noise	± 3.0	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
RF Ambient Conditions – Reflections	± 3.0	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
Probe Positioner	± 0.8	Rectangular	√3	1	1	± 0.46 %	± 0.46 %	∞
Probe Positioning	± 6.7	Rectangular	√3	1	1	± 3.9 %	± 3.9 %	∞
Algorithms for Max. SAR Eval.	± 4.0	Rectangular	√3	1	1	± 2.3 %	± 2.3 %	∞
Test Sample Related								
Device Positioning	± 2.9	Normal	1	1	1	± 2.9 %	± 2.9 %	145
Device Holder	± 3.6	Normal	1	1	1	± 3.6 %	± 3.6 %	5
Power Drift	± 5.0	Rectangular	√3	1	1	± 2.9 %	± 2.9 %	∞
SAR Scaling	± 0.0	Rectangular	√3	1	1	± 0.0 %	± 0.0 %	∞
Physical Parameters								
Phantom Shell	± 7.6	Rectangular	√3	1	1	± 4.4 %	± 4.4 %	∞
SAR correction	± 0.0	Normal	1	1	0.84	± 0.0 %	± 0.0 %	∞
Liquid conductivity (Target)	± 5.0	Rectangular	√3	0.64	0.43	± 1.8 %	± 1.2 %	∞
Liquid conductivity (Meas.)	± 3.7	Normal	1	0.78	0.71	± 2.9 %	± 2.6 %	10
Liquid permittivity (Target)	± 5.0	Rectangular	√3	0.60	0.49	± 1.7 %	± 1.4 %	∞
Liquid permittivity (Meas.)	± 4.1	Normal	1	0.23	0.26	± 0.9 %	± 1.1 %	10
Temp. unc. - Conductivity	± 1.9	Rectangular	√3	0.78	0.71	± 0.9 %	± 0.8 %	∞
Temp. unc. - Permittivity	± 2.0	Rectangular	√3	0.23	0.26	± 0.3 %	± 0.3 %	∞
Combined Standard Uncertainty						**± 11.9 %**	**± 11.7 %**	330
Expanded Uncertainty (k=2)						**± 23.8 %**	**± 23.4 %**	

The above measurement uncertainties are according to IEEE Std 1528

14. CONCLUSION

Measurement Conclusion

The SAR measurement indicates that the EUT complies with the RF radiation exposure limits of the FCC. These measurements are taken to simulate the RF effects exposure under the worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The tested device complies with the requirements in respect to all parameters subject to the test. The test results and statements relate only to the item(s) tested.

Please note that the absorption and distribution of electromagnetic energy in the body are every complex phenomena that depend on the mass, shape, and size of the body, the orientation of the body with respect to the field vectors, and the electrical properties of both the body and the environment. Other variables that may play a substantial role impossible biological effect are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease).

Because innumerable factors may interact to determine the specific biological outcome of an exposure to electromagnetic fields, any protection guide shall consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables.

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APPENDIX A. – Probe Calibration Data

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
Servizio svizzero di taratura
S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **DT&C (Dymstec)**

Certificate No: **EX3-3916_Apr19**

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3916
Calibration procedure(s)	QA CAL-01.v9, QA CAL-14.v5, QA CAL-23.v5, QA CAL-25.v7 Calibration procedure for dosimetric E-field probes
Calibration date:	April 25, 2019

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	03-Apr-19 (No. 217-02892/02893)	Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: S5277 (20x)	04-Apr-19 (No. 217-02894)	Apr-20
DAE4	SN: 660	19-Dec-18 (No. DAE4-660_Dec18)	Dec-19
Reference Probe ES3DV2	SN: 3013	31-Dec-18 (No. ES3-3013_Dec18)	Dec-19
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-18)	In house check: Jun-20
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-18)	In house check: Jun-20
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-18)	In house check: Jun-20
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-18)	In house check: Jun-20
Network Analyzer E8358A	SN: US41080477	31-Mar-14 (in house check Oct-18)	In house check: Oct-19

	Name	Function	Signature
Calibrated by:	Leif Klysner	Laboratory Technician	Leif Klysner
Approved by:	Katja Pokovic	Technical Manager	Katja Pokovic

Issued: April 27, 2019

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Calibration Laboratory of
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Accreditation No.: **SCS 0108**

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization ϑ	ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, ", "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z*: *A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3916

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	0.56	0.48	0.52	± 10.1 %
DCP (mV)[B]	101.7	96.9	104.5	

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Max dev.	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	146.1	±3.8 %	± 4.7 %
		Y	0.0	0.0	1.0		139.8		
		Y	0.0	0.0	1.0		143.5		

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of Norm X,Y,Z do not affect the E^2-field uncertainty inside TSL (see Pages 5 and 6).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3916

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	90.9
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3916

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha [G]	Depth [G] (mm)	Unc (k=2)
2450	39.2	1.80	7.66	7.66	7.66	0.39	0.85	± 12.0 %
2600	39.0	1.96	7.46	7.46	7.46	0.36	0.86	± 12.0 %
5200	36.0	4.66	5.14	5.14	5.14	0.40	1.80	± 13.1 %
5300	35.9	4.76	4.94	4.94	4.94	0.40	1.80	± 13.1 %
5500	35.6	4.96	4.89	4.89	4.89	0.40	1.80	± 13.1 %
5600	35.5	5.07	4.75	4.75	4.75	0.40	1.80	± 13.1 %
5800	35.3	5.27	4.82	4.82	4.82	0.40	1.80	± 13.1 %

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4-9 MHz, and ConvF assessed at 13 MHz is 9-19 MHz. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3916

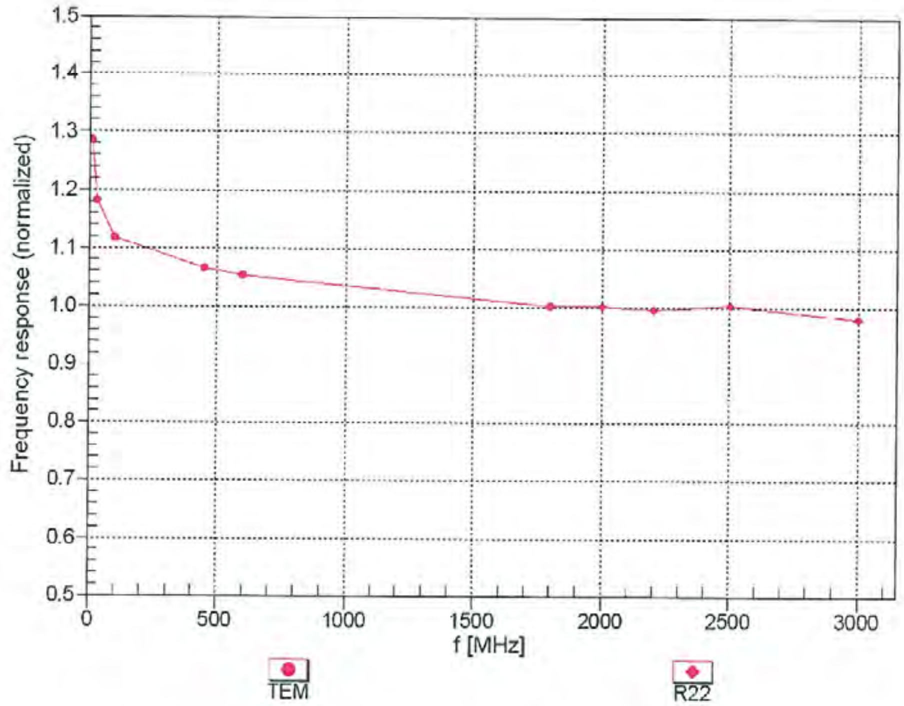
Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha [G]	Depth [G] (mm)	Unc (k=2)
2450	52.7	1.95	7.62	7.62	7.62	0.34	0.85	± 12.0 %
2600	52.5	2.16	7.42	7.42	7.42	0.22	1.03	± 12.0 %
5200	49.0	5.30	4.56	4.56	4.56	0.50	1.90	± 13.1 %
5300	48.9	5.42	4.37	4.37	4.37	0.50	1.90	± 13.1 %
5500	48.6	5.65	4.14	4.14	4.14	0.50	1.90	± 13.1 %
5600	48.5	5.77	4.00	4.00	4.00	0.50	1.90	± 13.1 %
5800	48.2	6.00	4.23	4.23	4.23	0.50	1.90	± 13.1 %

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4-9 MHz, and ConvF assessed at 13 MHz is 9-19 MHz. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

Frequency Response of E-Field

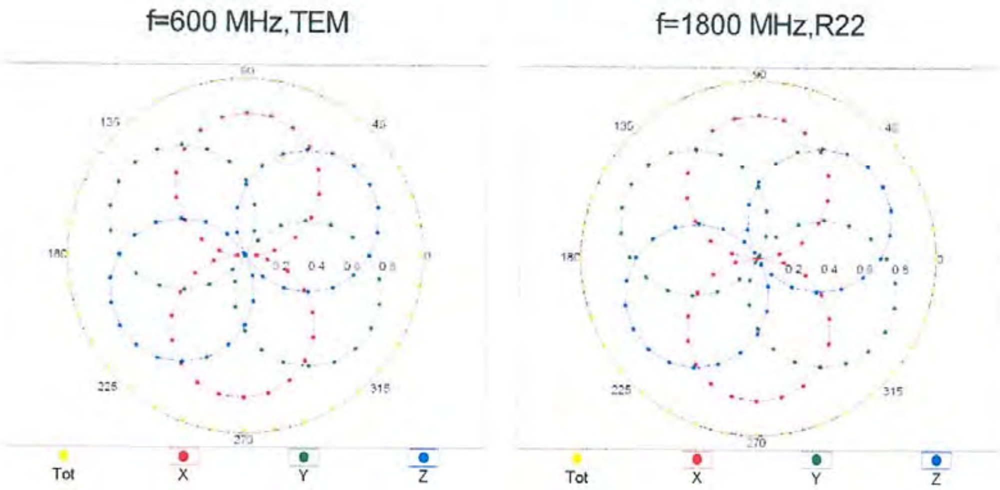
(TEM-Cell:ifi110 EXX, Waveguide: R22)

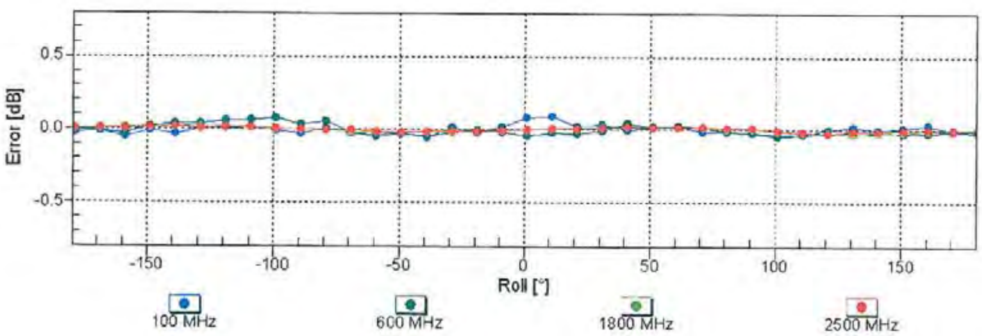


Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

EX3DV4– SN:3916 April 25, 2019

Receiving Pattern (ϕ), ϑ = 0°





Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

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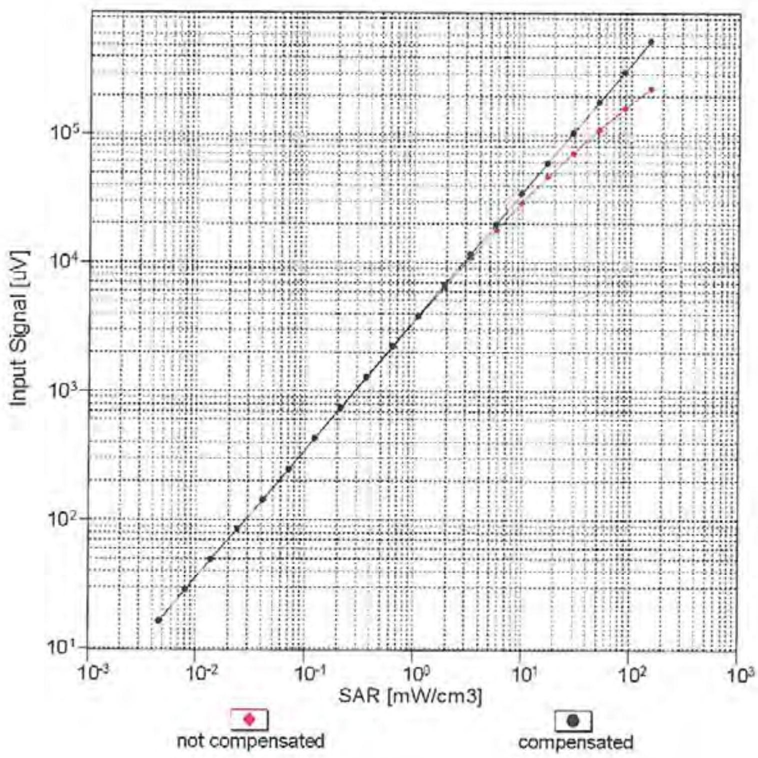
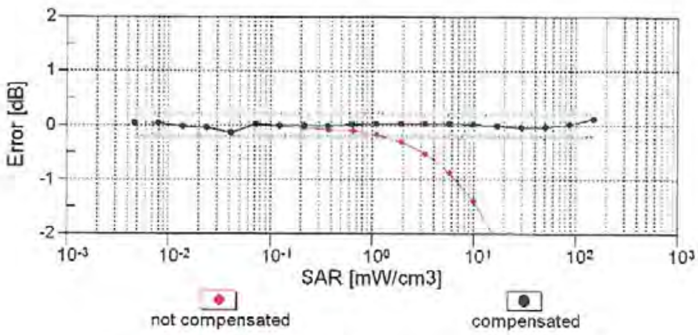
Dynamic Range f(SAR_{head})
(TEM cell , f_{eval}= 1900 MHz)



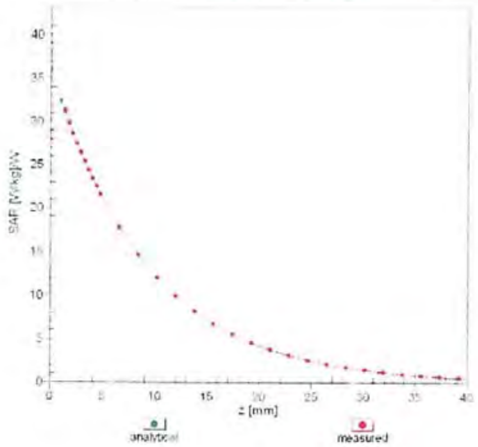


Uncertainty of Linearity Assessment: ± 0.6% (k=2)

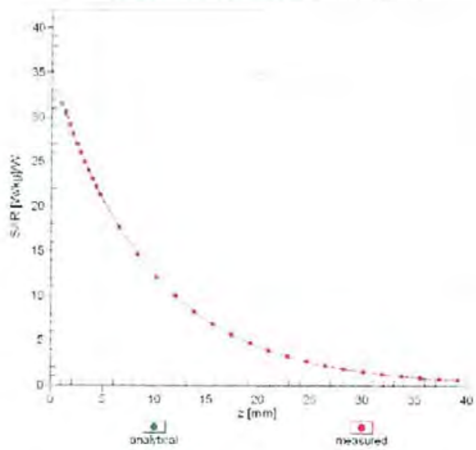
EX3DV4– SN:3916 April 25, 2019

Conversion Factor Assessment

f = 2450 MHz,WGLS R22 (H_convF)

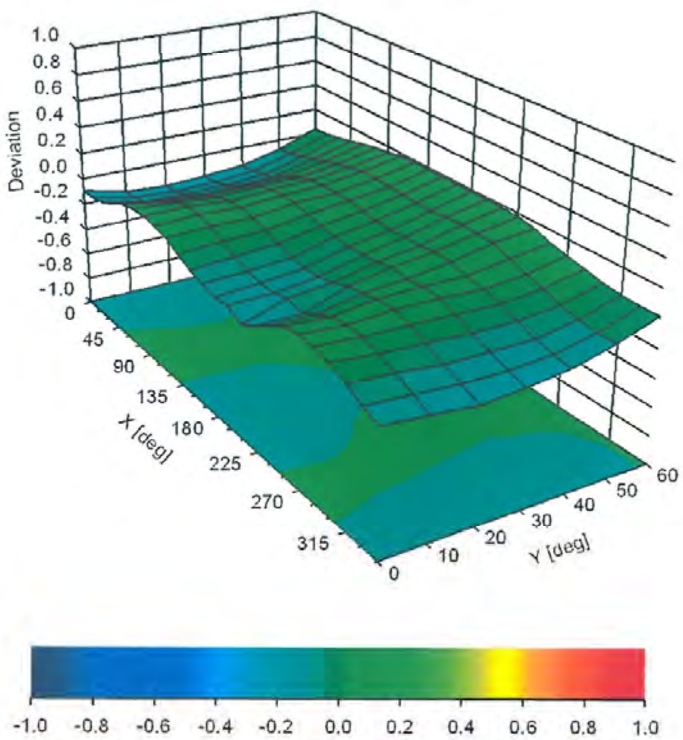


f = 2450 MHz,WGLS R22 (M_convF)



Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)

APPENDIX B. – Dipole Calibration Data

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Accreditation No.: SCS 0108

Client DT&C (Dymstec)

Certificate No: D2450V2-726_Sep19

CALIBRATION CERTIFICATE

Object	D2450V2 - SN:726
Calibration procedure(s)	QA CAL-05.v11 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz
Calibration date:	September 19, 2019

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	03-Apr-19 (No. 217-02892/02893)	Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-19 (No. 217-02894)	Apr-20
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20
Reference Probe EX3DV4	SN: 7349	29-May-19 (No. EX3-7349_May19)	May-20
DAE4	SN: 601	30-Apr-19 (No. DAE4-601_Apr19)	Apr-20

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Feb-19)	In house check: Oct-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-18)	In house check: Oct-19

	Name	Function	Signature
Calibrated by:	Manu Seitz	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: September 19, 2019

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Accreditation No.: **SCS 0108**

Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.10.2
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.9 ± 6 %	1.86 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**51.2 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.09 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**24.0 W/kg ± 16.5 % (k=2)**

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	50.7 ± 6 %	2.04 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.4 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**52.0 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.25 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**24.6 W/kg ± 16.5 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.7 Ω + 4.2 jΩ
Return Loss	- 25.4 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.3 Ω + 6.9 jΩ
Return Loss	- 23.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.161 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG

DASY5 Validation Report for Head TSL

Date: 19.09.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:726

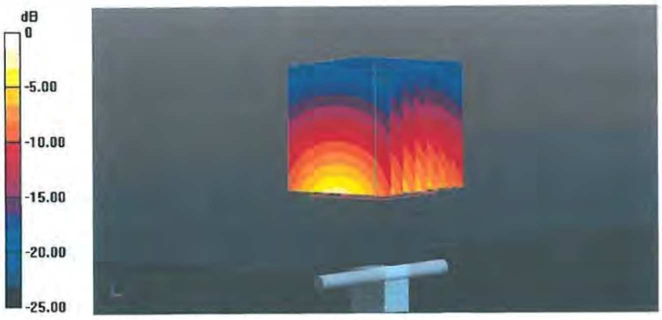
Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 1.86 S/m; ε_r = 37.9; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.9, 7.9, 7.9) @ 2450 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

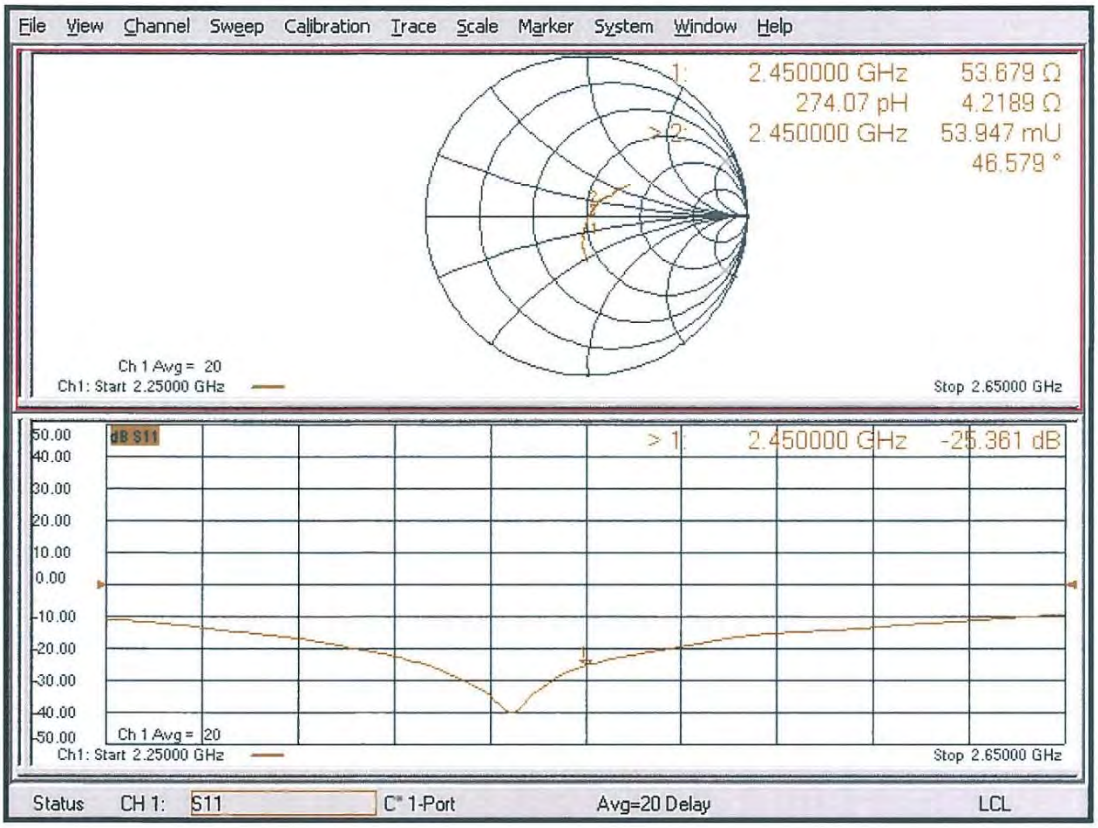
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 115.4 V/m; Power Drift = 0.04 dB
Peak SAR (extrapolated) = 26.1 W/kg
SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.09 W/kg
Maximum value of SAR (measured) = 21.7 W/kg



0 dB = 21.7 W/kg = 13.36 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 19.09.2019

Test Laboratory: SPEAG, Zurich, Switzerland

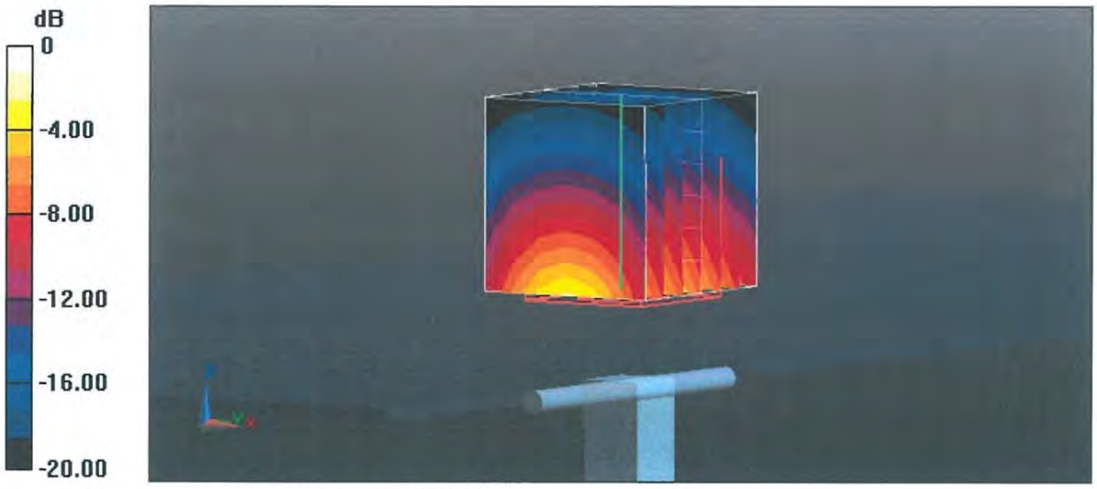
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:726

Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 2.04 S/m; ε_r = 50.7; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

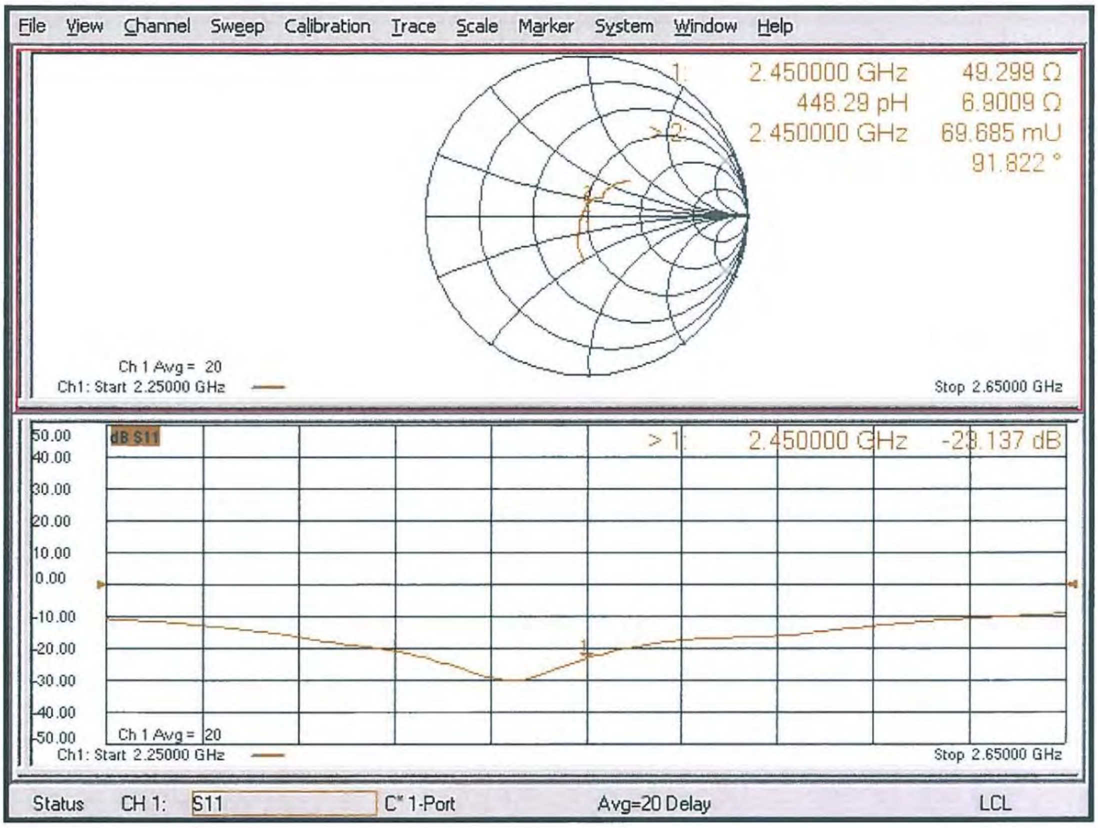
- Probe: EX3DV4 - SN7349; ConvF(7.94, 7.94, 7.94) @ 2450 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 110.1 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 26.5 W/kg
SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.25 W/kg
Maximum value of SAR (measured) = 22.0 W/kg



0 dB = 22.0 W/kg = 13.42 dBW/kg

Impedance Measurement Plot for Body TSL



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