

TEST REPORT



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1. Report No : DRRFCC1901-0009

2. Customer

• Name : LG Electronics USA, Inc.

• Address : 1000 Sylvan Ave. Englewood Cliffs, New Jersey, United States 07632

3. Use of Report : FCC Original Grant

4. Product Name / Model Name : Mobile Phone / LM-G820V

FCC ID : ZNFG820V

5. Test Method Used : IEEE 1528-2013, FCC SAR KDB Publications (Details in test report)

Test Specification : CFR §2.1093

6. Date of Test : 2019.01.21 ~ 2019.01.24

7. Testing Environment : Refer to appended test report.

8. Test Result : Refer to attached test report.

Affirmation	Tested by	Reviewed by
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Test Report Version

Test Report No.	Date	Description
DRRFCC1901-0009	Jan. 29, 2019	Initial issue

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1. DESCRIPTION OF DEVICE

1.1 General Information

EUT type	Mobile Phone				
FCC ID	ZNFG820V				
Equipment model name	LM-G820V				
Equipment add model name	LMG820V, G820V				
Equipment serial no.	Identical prototype				
Mode(s) of Operation	2.4 G W-LAN (802.11b/g/n-HT20/ac-VHT20), Bluetooth				
TX Frequency Range	Band	Mode	Operating Modes	Bandwidth	Frequency
	2.4 GHz W-LAN	802.11b/g/n/ac	Voice/Data	HT20/VHT20	2412 ~ 2462 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
	Bluetooth	-	Data	-	2402 ~ 2480 MHz
Equipment Class	Band	Reported SAR			
		1g SAR (W/kg)			10g SAR (W/kg)
		Head	Body-Worn	Phablet	
DTS	2.4 GHz W-LAN	0.40	0.17	0.83	
FCC Equipment Class	Part 15 Spread Spectrum Transmitter(DSS) Digital Transmission System(DTS)				
Date(s) of Tests	2019.01.21 ~ 2019.01.24				
Antenna Type	Internal Antenna				
Functions	● VoIP is supported.				

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 8 of this test report.

1.4 DUT Antenna Locations

The overall dimensions of this device are > 9 x 5 cm. A diagram showing the location of the device of the device antenna can be found in ZNFG820V_Antenna Location. Since the diagonal dimension of this device is > 160 mm and < 200 mm. it is considered a "phablet".

Mode	Device Sides for SAR Testing					
	Top	Bottom	Front	Rear	Right	Left
2.4G W-LAN	O	X	O	O	X	O

Note 1: Particular DUT edges were not required to be evaluated for Phablet SAR if the edges were greater than 2.5 cm from the transmitting antenna according to FCC KDB Publication 648474 D04v01r03. The antenna document shows the distances between the transmit antennas and the edges of the device.

Note 2: O - Test / X - Not test.

1.5 Miscellaneous SAR Test Considerations

BT

Per FCC KDB 447498 D01v06, the 1g SAR exclusion threshold for distances < 50 mm is defined by the following equation:

$$\frac{\text{Max Power of Channel (mW)}}{\text{Test Separation Dist (mm)}} * \sqrt{\text{Frequency(GHz)}} \leq 3.0$$

Based on the maximum conducted power of Bluetooth (rounded to the nearest mW) and the antenna to user separation distance, body-worn **Bluetooth SAR was not required; [(16/10)*√2.480] = 2.5 (< 3.0)**. Per KDB Publication 447498 D01v06, the maximum power of the channel was rounded to the nearest mW before calculation.

Per FCC KDB 447498 D01v06, the 10g SAR exclusion threshold for distance < 50 mm is defined by the following equation:

$$\frac{\text{Max Power of Channel (mW)}}{\text{Test Separation Dist (mm)}} * \sqrt{\text{Frequency(GHz)}} \leq 7.5$$

Based on the maximum conducted power of Bluetooth (rounded to the nearest mW) and the antenna to user separation distance, phablet **Bluetooth SAR was not required; [(16/5)*√2.480] = 5.0 (< 7.5)**. Per KDB Publication 447498 D01v06, the maximum power of the channel was rounded to the nearest mW before calculation.

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 648474 D04v01r03 (Handset SAR)
- 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)

1.7 Device Serial Numbers

The serial numbers used for each test are indicated alongside the results in Section 10.

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. 3.1)

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

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/m³)
- 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.
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.

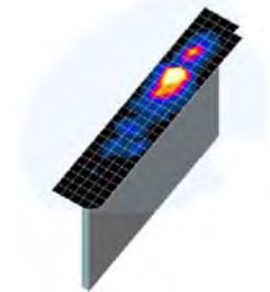


Figure 3.1
Sample SAR Area Scan

			≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface			$5 \text{ mm} \pm 1 \text{ mm}$	$\frac{1}{2} \cdot \delta \cdot \ln(2) \text{ mm} \pm 0.5 \text{ mm}$
Maximum probe angle from probe axis to phantom surface normal at the measurement location			$30^\circ \pm 1^\circ$	$20^\circ \pm 1^\circ$
Maximum area scan spatial resolution: Δx_{Area} , Δy_{Area}			$\leq 2 \text{ GHz}: \leq 15 \text{ mm}$ $2 - 3 \text{ GHz}: \leq 12 \text{ mm}$	$3 - 4 \text{ GHz}: \leq 12 \text{ mm}$ $4 - 6 \text{ GHz}: \leq 10 \text{ mm}$
			When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be $\leq$ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	
Maximum zoom scan spatial resolution: Δx_{Zoom} , Δy_{Zoom}			$\leq 2 \text{ GHz}: \leq 8 \text{ mm}$ $2 - 3 \text{ GHz}: \leq 5 \text{ mm}^*$	$3 - 4 \text{ GHz}: \leq 5 \text{ mm}^*$ $4 - 6 \text{ GHz}: \leq 4 \text{ mm}^*$
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{Zoom}(n)$		$\leq 5 \text{ mm}$	$3 - 4 \text{ GHz}: \leq 4 \text{ mm}$ $4 - 5 \text{ GHz}: \leq 3 \text{ mm}$ $5 - 6 \text{ GHz}: \leq 2 \text{ mm}$
	graded grid	$\Delta z_{Zoom}(1)$: between 1 st two points closest to phantom surface	$\leq 4 \text{ mm}$	$3 - 4 \text{ GHz}: \leq 3 \text{ mm}$ $4 - 5 \text{ GHz}: \leq 2.5 \text{ mm}$ $5 - 6 \text{ GHz}: \leq 2 \text{ mm}$
		$\Delta z_{Zoom}(n>1)$: between subsequent points	$\leq 1.5 \cdot \Delta z_{Zoom}(n-1) \text{ mm}$	
Minimum zoom scan volume	x, y, z		$\geq 30 \text{ mm}$	$3 - 4 \text{ GHz}: \geq 28 \text{ mm}$ $4 - 5 \text{ GHz}: \geq 25 \text{ mm}$ $5 - 6 \text{ GHz}: \geq 22 \text{ mm}$
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 <i>area scan based 1-g SAR estimation</i> procedures of KDB Publication 447498 is $\leq 1.4 \text{ W/kg}$, $\leq 8 \text{ mm}$, $\leq 7 \text{ mm}$ and $\leq 5 \text{ mm}$ zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.				

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

5.4 Body-Worn Accessory Configurations

Body-worn operating configurations are tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in a normal use configuration (see Figure 5.4). Per FCC KDB Publication 648474 D04v01r03, Body-worn accessory exposure is typically related to voice mode operations when handsets are carried in body-worn accessories. The body-worn accessory procedures in FCC KDB Publication 447498 D01v06 should be used to test for body-worn accessory SAR compliance, without a headset connected to it. This enables the test results for such configuration to be compatible with that required for hotspot mode when the body-worn accessory test separation distance is greater than or equal to that required for hotspot mode, when applicable. When the reported SAR for a body-worn accessory, measured without a headset connected to the handset, is $> 1.2 \text{ W/kg}$, the highest reported SAR configuration for that wireless mode and frequency band should be repeated for that body-worn accessory with a headset attached to the handset.

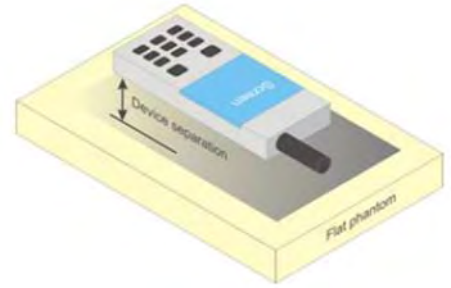


Figure 5.4 Sample Body-Worn Diagram

Accessories for Body-worn operation configurations are divided into two categories: those that do not contain metallic components and those that do contain metallic components. When multiple accessories that do not contain metallic components are supplied with the device, the device is tested with only the accessory that dictates the closest spacing to the body. Then multiple accessories that contain metallic components are tested with the device with each accessory. If multiple accessories share an identical metallic component (i.e. the same metallic belt-clip used with different holsters with no other metallic components) only the accessory that dictates the closest spacing to the body is tested.

Body-worn accessories may not always be supplied or available as options for some devices intended to be authorized for body-worn use. In this case, a test configuration with a separation distance between the back of the device and the flat phantom is used. Test position spacing was documented.

Transmitters that are designed to operate in front of a person's face, as in push-to-talk configurations, are tested for SAR compliance with the front of the device positioned to face the flat phantom in head fluid. For devices that are carried next to the body such as a shoulder, waist or chest-worn transmitters, SAR compliance is tested with the accessories, including headsets and microphones, attached to the device and positioned against a flat phantom in a normal use configuration.

5.5 Extremity Exposure Configurations

Devices that are designed or intended for use on extremities or mainly operated in extremity only exposure conditions; i.e., hands, wrists, feet and ankles, may require extremity SAR evaluation. When the device also operates in close proximity to the user's body, SAR compliance for the body is also required. The 1-g body and 10-g extremity SAR Exclusion Thresholds found in KDB Publication 447498 D01v06 should be applied to determine SAR test requirements.

Per KDB Publication 447498 D01v06, Cell phones (handsets) are not normally designed to be used on extremities or operated in extremity only exposure conditions. The maximum output power levels of handsets generally do not require extremity SAR testing to show compliance. Therefore, extremity SAR was not evaluated for this device.

6. 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 6.1.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).

7. FCC MEASUREMENT PROCEDURES

7.1 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.

7.2 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.

7.2.1 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 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.

7.2.2 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.

7.2.3 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.

7.2.4 OFDM Transmission Mode and SAR Test Channel Selection

For the 2.4 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, 802.11g and 802.11n with the same channel bandwidth, modulation and data rate etc., the lower order 802.11 mode i.e., 802.11g then 802.11n is used for SAR measurement. When the maximum output power were the same for multiple test channels, either according to the default or additional power measurement requirements, SAR is measured using the channel closest to the middle of the frequency band or aggregated band. When there are multiple channels with the same maximum output power, SAR is measured using the higher number channel.

7.2.5 Initial Test Configuration Procedure

For OFDM, in 2.4 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.

7.2.6 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.

8. 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

8.1 WLAN Nominal and Maximum Output Power Spec and Conducted Powers

Band (GHz)	Mode	Ch	Modulated Average[dBm]	
			Maximum	Nominal
2.4	802.11b	1-11	16.5	15.5
	802.11g	1-11	13.5	12.5
	802.11n	1-11	13.5	12.5
	802.11ac	1-11	13.5	12.5

Table 8.1.1 Nominal and Maximum Output Power Spec

Mode	Freq. (MHz)	Channel	IEEE 802.11 (2.4 GHz) Conducted Power[dBm]
802.11b	2412	1	15.98
	2437	6	16.35
	2462	11	16.37
802.11g	2412	1	13.08
	2437	6	13.25
	2462	11	13.30
802.11n (HT-20)	2412	1	12.79
	2437	6	13.04
	2462	11	12.98
802.11ac (VHT-20)	2412	1	12.85
	2437	6	13.02
	2462	11	12.92

Table 8.1.2 IEEE 802.11 Average RF Power

8.2 Bluetooth Conducted Powers

Burst Modulated Average[dBm]		
Bluetooth 1 Mbps	Maximum	12.0
	Nominal	11.0
Bluetooth 2 Mbps	Maximum	12.0
	Nominal	11.0
Bluetooth 3 Mbps	Maximum	12.0
	Nominal	11.0
Bluetooth LE	Maximum	5.0
	Nominal	4.0

Table 8.2.1 Nominal and Maximum Output Power Spec (Burst)

Frame Modulated Average[dBm]		
Bluetooth 1 Mbps	Maximum	10.85
	Nominal	9.85
Bluetooth 2 Mbps	Maximum	10.85
	Nominal	9.85
Bluetooth 3 Mbps	Maximum	10.85
	Nominal	9.85
Bluetooth (LE / 1Mbps)	Maximum	4.31
	Nominal	3.31
Bluetooth (LE / 2Mbps)	Maximum	2.59
	Nominal	1.59

Table 8.2.2 Nominal and Maximum Output Power Spec (Frame)

Channel	Frequency	Burst AVG Output Power (1Mbps)	Frame AVG Output Power (1Mbps)	Burst AVG Output Power (2Mbps)	Frame AVG Output Power (2Mbps)	Burst AVG Output Power (3Mbps)	Frame AVG Output Power (3Mbps)
	(MHz)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)
Low	2402	11.05	9.90	10.35	9.20	10.34	9.19
Mid	2441	10.72	9.57	10.66	9.51	10.66	9.51
High	2480	11.20	10.05	10.48	9.33	10.47	9.32

Table 8.2.3 Bluetooth Burst and Frame Average RF Power

Channel	Frequency	Burst AVG Output Power(LE / 1Mbps)	Frame AVG Output Power(LE / 1Mbps)	Burst AVG Output Power(LE / 2Mbps)	Frame AVG Output Power(LE / 2Mbps)
	(MHz)	(dBm)	(dBm)	(dBm)	(dBm)
Low	2402	4.92	4.23	4.89	2.48
Mid	2440	4.51	3.82	4.49	2.08
High	2480	4.98	4.29	4.93	2.52

Table 8.2.4 Bluetooth LE Burst and Frame Average 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 8.2.1(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 8.2.1(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.

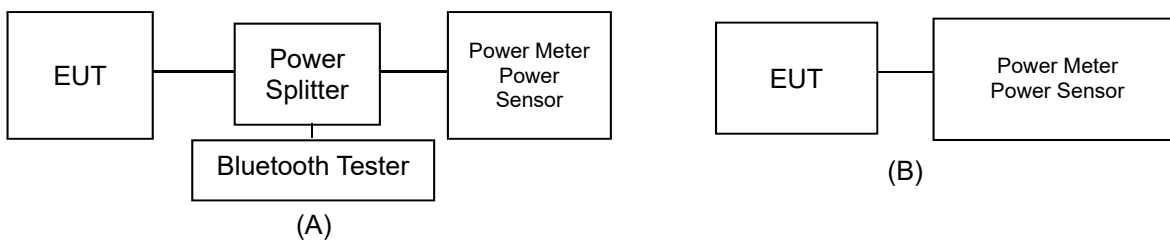


Figure 8.2.1 Average Power Measurement Setup

9 SYSTEM VERIFICATION

9.1 Tissue Verification

MEASURED TISSUE PARAMETERS										
Date(s)	Tissue Type	Ambient Temp.[°C]	Liquid Temp.[°C]	Measured Frequency [MHz]	Target Dielectric Constant, ϵ_r	Target Conductivity, σ (S/m)	Measured Dielectric Constant, ϵ_r	Measured Conductivity, σ (S/m)	Er Deviation [%]	σ Deviation [%]
Jan. 23. 2019	2450 Head	21.5	21.6	2402.0	39.282	1.757	38.400	1.744	-2.25	-0.74
				2412.0	39.265	1.766	38.375	1.755	-2.27	-0.62
				2437.0	39.222	1.788	38.297	1.781	-2.36	-0.39
				2441.0	39.215	1.792	38.282	1.785	-2.38	-0.39
				2450.0	39.200	1.800	38.248	1.795	-2.43	-0.28
				2462.0	39.184	1.813	38.220	1.808	-2.46	-0.28
				2480.0	39.160	1.832	38.173	1.827	-2.52	-0.27
Jan. 24. 2019	2450 Body	20.3	20.5	2402.0	52.764	1.904	52.563	1.849	-0.38	-2.89
				2412.0	52.751	1.914	52.538	1.860	-0.40	-2.82
				2437.0	52.717	1.938	52.473	1.889	-0.46	-2.53
				2441.0	52.712	1.941	52.461	1.893	-0.48	-2.47
				2450.0	52.700	1.950	52.434	1.904	-0.50	-2.36
				2462.0	52.685	1.967	52.416	1.918	-0.51	-2.49
				2480.0	52.662	1.993	52.382	1.938	-0.53	-2.76

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):

$$Y = \frac{j2\omega\epsilon_r\epsilon_0}{[\ln(b/a)]^2} \int_a^b \int_a^b \int_0^\pi \cos\phi' \frac{\exp[-j\omega r(\mu_0\epsilon_r\epsilon_0)^{1/2}]}{r} d\phi' d\rho' d\rho$$

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 $j = \sqrt{-1}$.

9.2 Test System Verification

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

Table 9.2.1 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 [%]
A	2450	D2450V2, SN: 920	Jan. 23. 2019	Head	21.5	21.6	3866	100	51.9	5.03	50.30	-3.08
A	2450	D2450V2, SN: 920	Jan. 24. 2019	Body	20.3	20.5	3327	100	52.1	4.96	49.60	-4.80

Table 10.2.2 System Verification Results (10g)

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 _{10g} (W/kg)	Measured SAR _{10g} (W/kg)	1 W Normalized SAR _{10g} (W/kg)	Deviation [%]
A	2450	D2450V2, SN: 920	Jan. 24. 2019	Body	20.3	20.5	3327	100	24.6	2.32	23.20	-5.69

Note1 : System Verification was measured with input 100 mW and normalized to 1W.

Note2 : Full system validation status and results can be found in Attachment 3.

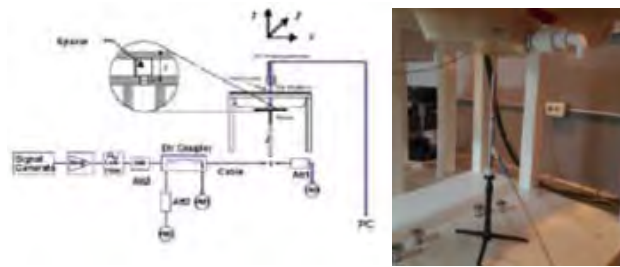


Figure 9.1 Dipole Verification Test Setup Diagram & Photo

10. SAR TEST RESULTS

10.1 Head SAR Results

Table 10.1.1 DTS Head SAR

MEASUREMENT RESULTS															
FREQUENCY		Mode (Antenna)	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	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)	Plot s #
MHz	Ch														
2462.0	11	802.11b	16.50	16.37	0.020	Left Touch	FCC #1	0.206	1	99.2	0.195	1.030	1.008	0.202	
2462.0	11	802.11b	16.50	16.37	-0.050	Right Touch	FCC #1	0.435	1	99.2	0.384	1.030	1.008	0.399	A1
2462.0	11	802.11b	16.50	16.37	-0.130	Left Tilt	FCC #1	0.065	1	99.2	0.067	1.030	1.008	0.070	
2462.0	11	802.11b	16.50	16.37	-0.190	Right Tilt	FCC #1	0.189	1	99.2	0.180	1.030	1.008	0.187	
ANSI / IEEE C95.1-1992– SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure								Head 1.6 W/kg (mW/g) averaged over 1 gram							

Adjusted SAR results for OFDM SAR												
FREQUENCY		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
MHz	Ch											
2462.0	11	802.11b	DSSS	16.5	0.399	2437	802.11g	OFDM	13.5	0.501	0.200	X
2462.0	11	802.11b	DSSS	16.5	0.399	2437	802.11n	OFDM	13.5	0.501	0.200	X
2462.0	11	802.11b	DSSS	16.5	0.399	2437	802.11ac	OFDM	13.5	0.501	0.200	X
ANSI / IEEE C95.1-1992- SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure							Head 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.

10.2 Standalone Body-Worn SAR Worn SAR Results

Table 10.2.1 DTS Body-Worn SAR

MEASUREMENT RESULTS															
FREQUENCY		Mode	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	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 #
MHz	Ch														
2462.0	11	802.11b	16.50	16.37	0.100	10 mm [Front]	FCC #1	0.071	1	99.2	0.074	1.030	1.008	0.077	
2462.0	11	802.11b	16.50	16.37	0.020	10 mm [Rear]	FCC #1	0.160	1	99.2	0.163	1.030	1.008	0.169	A2
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							

Adjusted SAR results for OFDM SAR												
FREQUENCY		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
MHz	Ch											
2462.0	11	802.11b	DSSS	16.5	0.169	2437	802.11g	OFDM	13.5	0.501	0.085	X
2462.0	11	802.11b	DSSS	16.5	0.169	2437	802.11n	OFDM	13.5	0.501	0.085	X
2462.0	11	802.11b	DSSS	16.5	0.169	2437	802.11ac	OFDM	13.5	0.501	0.085	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.

10.3 Standalone Phablet SAR Results

Table 10.3.1 DTS Phablet SAR
MEASUREMENT RESULTS

FREQUENCY		Mode	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	Phantom Position	Device Serial Number	Peak SAR of Area Scan	Data Rate [Mbps]	Duty Cycle	10g SAR (W/kg)	Scaling Factor	Scaling Factor (Duty Cycle)	10g Scaled SAR (W/kg)	Plots #
MHz	Ch														
2462.0	11	802.11b	16.50	16.37	0.050	0 mm [Top]	FCC #1	0.066	1	99.2	0.071	1.030	1.008	0.074	
2462.0	11	802.11b	16.50	16.37	0.120	0 mm [Front]	FCC #1	0.288	1	99.2	0.275	1.030	1.008	0.286	
2462.0	11	802.11b	16.50	16.37	-0.010	0 mm [Rear]	FCC #1	0.609	1	99.2	0.603	1.030	1.008	0.626	
2462.0	11	802.11b	16.50	16.37	0.150	0 mm [Left]	FCC #1	0.744	1	99.2	0.802	1.030	1.008	0.833	A3
ANSI / IEEE C95.1-1992- SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure								Phablet 4.0 W/kg (mW/g) averaged over 10 gram							

Adjusted SAR results for OFDM SAR

FREQUENCY		Mode/ Antenna	Service	Maximum Allowed Power [dBm]	10g Scaled SAR (W/kg)	FREQUENCY [MHz]	Mode	Service	Maximum Allowed Power [dBm]	Ratio of OFDM to DSSS	10g Adjusted SAR (W/kg)	Determine OFDM SAR
MHz	Ch											
2462.0	11	802.11b	DSSS	16.5	0.833	2437	802.11g	OFDM	13.5	0.501	0.417	X
2462.0	11	802.11b	DSSS	16.5	0.833	2437	802.11n	OFDM	13.5	0.501	0.417	X
2462.0	11	802.11b	DSSS	16.5	0.833	2437	802.11ac	OFDM	13.5	0.501	0.417	X
ANSI / IEEE C95.1-1992- SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure								Phablet 4.0 W/kg (mW/g) averaged over 10 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 ≤ 3.0 W/kg.

10.4 SAR Test Notes

General Notes:

- 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.
- Batteries are fully charged at the beginning of the SAR measurements. A standard battery was used for all SAR measurements.
- Liquid tissue depth was at least 15.0 cm for all frequencies.
- 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
- SAR results were scaled to the maximum allowed power to demonstrate compliance per FCC KDB Publication 447498 D01v06.
- Device was tested using a fixed spacing for body-worn accessory testing. A separation distance of 10 mm was considered because the manufacturer has determined that there will be body-worn accessories available in the marketplace for users to support this separation distance.
- Per FCC KDB Publication 648474 D04v01r03, body-worn SAR was evaluated without a headset connected to the device. Since the standalone reported boy-worn SAR was not > 1.2 W/kg, no additional body-worn SAR evaluations using a headset cable were performed.
- 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 due 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. 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.
4. 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.

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 14.1.1 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	TX60L	N/A	N/A	F12/5LP5A1/A/01
☒	Robot Controller	SPEAG	CS8C	N/A	N/A	F12/5LP5A1/C/01
☒	Joystick	SPEAG	N/A	N/A	N/A	S-12030401
☒	Intel Core i7-2600 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	Holder	N/A	N/A	SD000H01KA
☒	Twin SAM Phantom	SPEAG	QD000P40CD	N/A	N/A	1679
☒	Data Acquisition Electronics	SPEAG	DAE4V1	2018-04-24	2019-04-24	1391
☒	Data Acquisition Electronics	SPEAG	DAE4V1	2018-09-19	2019-09-19	1453
☒	Dosimetric E-Field Probe	SPEAG	EX3DV4	2018-05-31	2019-05-31	3866
☒	Dosimetric E-Field Probe	SPEAG	ES3DV3	2018-08-28	2019-08-28	3327
☒	2450MHz SAR Dipole	SPEAG	D2450V2	2018-08-24	2020-08-24	920
☒	Network Analyzer	Agilent	E5071C	2018-02-02	2019-02-02	MY46111534
☒	Signal Generator	Agilent	E4438C	2018-07-04	2019-07-04	US41461520
☒	Amplifier	EMPOWER	BBS3Q7ELU	2018-07-10	2019-07-10	1020
☒	High Power RF Amplifier	EMPOWER	BBS3Q8CCJ	2018-07-06	2019-07-06	1005
☒	Power Meter	HP	EPM-442A	2018-12-19	2019-12-19	GB37170267
☒	Power Meter	HP	EPM-442A	2018-12-18	2019-12-18	GB37170413
☒	Power Meter	Anritsu	ML2495A	2018-07-04	2019-07-04	1435003
☒	Power Sensor	Anritsu	MA2490A	2018-07-04	2019-07-04	1409034
☒	Power Sensor	HP	8481A	2018-12-18	2019-12-18	US37294267
☒	Power Sensor	HP	8481A	2018-12-19	2019-12-19	3318A96566
☒	Power Sensor	HP	8481A	2018-12-19	2019-12-19	2702A65976
☒	Directional Coupler	HP	772D	2018-07-03	2019-07-03	2889A01064
☒	Low Pass Filter 3.0GHz	Micro LAB	LA-30N	2018-07-05	2019-07-05	2
☒	Attenuators(3 dB)	Agilent	8491B	2018-12-19	2019-12-19	MY39260700
☒	Attenuators(10 dB)	WEINSCHEL	23-10-34	2018-12-19	2019-12-19	BP4387
☒	Dielectric Probe kit	SPEAG	DAK-3.5	2018-07-24	2019-07-24	1046
☒	Power Splitter	Anritsu	K241B	2018-12-18	2019-12-18	1301183
☒	Bluetooth Tester	TESCOM	TC-3000B	2018-12-18	2019-12-18	3000B770243

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 (SN: 3866)

Error Description	Uncertainty value $\pm\%$	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	$\pm 6.0 \%$	$\pm 6.0 \%$	∞
Isotropy	± 1.3	Normal	1	1	1	$\pm 1.3 \%$	$\pm 1.3 \%$	∞
Boundary Effects	± 2.0	Rectangular	$\sqrt{3}$	1	1	$\pm 1.2 \%$	$\pm 1.2 \%$	∞
Probe Linearity	± 0.3	Normal	1	1	1	$\pm 0.3 \%$	$\pm 0.3 \%$	∞
Probe modulation response	± 0.0	Rectangular	$\sqrt{3}$	1	1	$\pm 0.0 \%$	$\pm 0.0 \%$	∞
Detection limits	± 0.25	Rectangular	$\sqrt{3}$	1	1	$\pm 0.14 \%$	$\pm 0.14 \%$	∞
Readout Electronics	± 0.3	Normal	1	1	1	$\pm 0.3 \%$	$\pm 0.3 \%$	∞
Response time	± 0.8	Rectangular	$\sqrt{3}$	1	1	$\pm 0.46 \%$	$\pm 0.46 \%$	∞
Integration time	± 2.6	Rectangular	$\sqrt{3}$	1	1	$\pm 1.5 \%$	$\pm 1.5 \%$	∞
RF Ambient Conditions – Noise	± 3.0	Rectangular	$\sqrt{3}$	1	1	$\pm 1.7 \%$	$\pm 1.7 \%$	∞
RF Ambient Conditions – Reflections	± 3.0	Rectangular	$\sqrt{3}$	1	1	$\pm 1.7 \%$	$\pm 1.7 \%$	∞
Probe Positioner	± 0.8	Rectangular	$\sqrt{3}$	1	1	$\pm 0.46 \%$	$\pm 0.46 \%$	∞
Probe Positioning	± 6.7	Rectangular	$\sqrt{3}$	1	1	$\pm 3.9 \%$	$\pm 3.9 \%$	∞
Algorithms for Max. SAR Eval.	± 4.0	Rectangular	$\sqrt{3}$	1	1	$\pm 2.3 \%$	$\pm 2.3 \%$	∞
Test Sample Related								
Device Positioning	± 2.9	Normal	1	1	1	$\pm 2.9 \%$	$\pm 2.9 \%$	145
Device Holder	± 3.6	Normal	1	1	1	$\pm 3.6 \%$	$\pm 3.6 \%$	5
Power Drift	± 5.0	Rectangular	$\sqrt{3}$	1	1	$\pm 2.9 \%$	$\pm 2.9 \%$	∞
SAR Scaling	± 0.0	Rectangular	$\sqrt{3}$	1	1	$\pm 0.0 \%$	$\pm 0.0 \%$	∞
Physical Parameters								
Phantom Shell	± 7.6	Rectangular	$\sqrt{3}$	1	1	$\pm 4.4 \%$	$\pm 4.4 \%$	∞
SAR correction	± 0.0	Normal	1	1	0.84	$\pm 0.0 \%$	$\pm 0.0 \%$	∞
Liquid conductivity (Target)	± 5.0	Rectangular	$\sqrt{3}$	0.64	0.43	$\pm 1.8 \%$	$\pm 1.2 \%$	∞
Liquid conductivity (Meas.)	± 3.8	Normal	1	0.78	0.71	$\pm 3.0 \%$	$\pm 2.7 \%$	10
Liquid permittivity (Target)	± 5.0	Rectangular	$\sqrt{3}$	0.60	0.49	$\pm 1.7 \%$	$\pm 1.4 \%$	∞
Liquid permittivity (Meas.)	± 4.3	Normal	1	0.23	0.26	$\pm 1.0 \%$	$\pm 1.1 \%$	10
Temp. unc. - Conductivity	± 1.8	Rectangular	$\sqrt{3}$	0.78	0.71	$\pm 0.8 \%$	$\pm 0.7 \%$	∞
Temp. unc. - Permittivity	± 2.0	Rectangular	$\sqrt{3}$	0.23	0.26	$\pm 0.3 \%$	$\pm 0.3 \%$	∞
Combined Standard Uncertainty						$\pm 11.6 \%$	$\pm 11.4 \%$	330
Expanded Uncertainty (k=2)						$\pm 23.2 \%$	$\pm 22.8 \%$	

The above measurement uncertainties are according to IEEE Std 1528

2450 MHz Body (SN: 3327)

Error Description	Uncertainty value $\pm\%$	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	$\pm 6.0 \%$	$\pm 6.0 \%$	∞
Isotropy	± 1.3	Normal	1	1	1	$\pm 1.3 \%$	$\pm 1.3 \%$	∞
Boundary Effects	± 2.0	Rectangular	$\sqrt{3}$	1	1	$\pm 1.2 \%$	$\pm 1.2 \%$	∞
Probe Linearity	± 0.3	Normal	1	1	1	$\pm 0.3 \%$	$\pm 0.3 \%$	∞
Probe modulation response	± 0.0	Rectangular	$\sqrt{3}$	1	1	$\pm 0.0 \%$	$\pm 0.0 \%$	∞
Detection limits	± 0.25	Rectangular	$\sqrt{3}$	1	1	$\pm 0.14 \%$	$\pm 0.14 \%$	∞
Readout Electronics	± 0.3	Normal	1	1	1	$\pm 0.3 \%$	$\pm 0.3 \%$	∞
Response time	± 0.8	Rectangular	$\sqrt{3}$	1	1	$\pm 0.46 \%$	$\pm 0.46 \%$	∞
Integration time	± 2.6	Rectangular	$\sqrt{3}$	1	1	$\pm 1.5 \%$	$\pm 1.5 \%$	∞
RF Ambient Conditions – Noise	± 3.0	Rectangular	$\sqrt{3}$	1	1	$\pm 1.7 \%$	$\pm 1.7 \%$	∞
RF Ambient Conditions – Reflections	± 3.0	Rectangular	$\sqrt{3}$	1	1	$\pm 1.7 \%$	$\pm 1.7 \%$	∞
Probe Positioner	± 0.8	Rectangular	$\sqrt{3}$	1	1	$\pm 0.46 \%$	$\pm 0.46 \%$	∞
Probe Positioning	± 6.7	Rectangular	$\sqrt{3}$	1	1	$\pm 3.9 \%$	$\pm 3.9 \%$	∞
Algorithms for Max. SAR Eval.	± 4.0	Rectangular	$\sqrt{3}$	1	1	$\pm 2.3 \%$	$\pm 2.3 \%$	∞
Test Sample Related								
Device Positioning	± 2.9	Normal	1	1	1	$\pm 2.9 \%$	$\pm 2.9 \%$	145
Device Holder	± 3.6	Normal	1	1	1	$\pm 3.6 \%$	$\pm 3.6 \%$	5
Power Drift	± 5.0	Rectangular	$\sqrt{3}$	1	1	$\pm 2.9 \%$	$\pm 2.9 \%$	∞
SAR Scaling	± 0.0	Rectangular	$\sqrt{3}$	1	1	$\pm 0.0 \%$	$\pm 0.0 \%$	∞
Physical Parameters								
Phantom Shell	± 7.6	Rectangular	$\sqrt{3}$	1	1	$\pm 4.4 \%$	$\pm 4.4 \%$	∞
SAR correction	± 0.0	Normal	1	1	0.84	$\pm 0.0 \%$	$\pm 0.0 \%$	∞
Liquid conductivity (Target)	± 5.0	Rectangular	$\sqrt{3}$	0.64	0.43	$\pm 1.8 \%$	$\pm 1.2 \%$	∞
Liquid conductivity (Meas.)	± 4.2	Normal	1	0.78	0.71	$\pm 3.3 \%$	$\pm 3.0 \%$	10
Liquid permittivity (Target)	± 5.0	Rectangular	$\sqrt{3}$	0.60	0.49	$\pm 1.7 \%$	$\pm 1.4 \%$	∞
Liquid permittivity (Meas.)	± 3.9	Normal	1	0.23	0.26	$\pm 0.9 \%$	$\pm 1.0 \%$	10
Temp. unc. - Conductivity	± 2.0	Rectangular	$\sqrt{3}$	0.78	0.71	$\pm 0.9 \%$	$\pm 0.8 \%$	∞
Temp. unc. - Permittivity	± 1.8	Rectangular	$\sqrt{3}$	0.23	0.26	$\pm 0.2 \%$	$\pm 0.3 \%$	∞
Combined Standard Uncertainty						$\pm 11.7 \%$	$\pm 11.5 \%$	330
Expanded Uncertainty (k=2)						$\pm 23.4 \%$	$\pm 23.0 \%$	

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.

15. REFERENCES

- [1] Federal Communications Commission, ET Docket 93-62, Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation, Aug. 1996.
- [2] ANSI/IEEE C95.1-2005, American National Standard safety levels with respect to human exposure to radiofrequency electromagnetic fields, 3kHz to 300GHz, New York: IEEE, 2006.
- [3] ANSI/IEEE C95.1-1992, American National Standard safety levels with respect to human exposure to radiofrequency electromagnetic fields, 3kHz to 300GHz, New York: IEEE, Sept. 1992.
- [4] ANSI/IEEE C95.3-2002, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave, New York: IEEE, December 2002.
- [5] IEEE Standards Coordinating Committee 39 –Standards Coordinating Committee 34 – IEEE Std. 1528-2003, Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices.
- [6] NCRP, National Council on Radiation Protection and Measurements, Biological Effects and Exposure Criteria for Radio Frequency Electromagnetic Fields, NCRP Report No. 86, 1986. Reprinted Feb. 1995.
- [7] T. Schmid, O. Egger, N. Kuster, Automated E-field scanning system for dosimetric assessments, IEEE Transaction on Microwave Theory and Techniques, vol. 44, Jan. 1996, pp. 105-113.
- [8] K. Pokovic, T. Schmid, N. Kuster, Robust setup for precise calibration of E-field probes in tissue simulating liquids at mobile communications frequencies, ICECOM97, Oct. 1997, pp. -124.
- [9] K. Pokovic, T. Schmid, and N. Kuster, E-field Probe with improved isotropy in brain simulating liquids, Proceedings of the ELMAR, Zadar, Croatia, June 23-25, 1996, pp. 172-175.
- [10] Schmid& Partner Engineering AG, Application Note: Data Storage and Evaluation, June 1998, p2.
- [11] V. Hombach, K. Meier, M. Burkhardt, E. Kuhn, N. Kuster, The Dependence of EM Energy Absorption upon Human Modeling at 900 MHz, IEEE Transaction on Microwave Theory and Techniques, vol. 44 no. 10, Oct.1996, pp. 1865-1873.
- [12] N. Kuster and Q. Balzano, Energy absorption mechanism by biological bodies in the near field of dipole antennas above 300MHz, IEEE Transaction on Vehicular Technology, vol. 41, no. 1, Feb. 1992, pp. 17-23.
- [13] G. Hartsgrrove, A. Kraszewski, A. Surowiec, Simulated Biological Materials for Electromagnetic Radiation Absorption Studies, University of Ottawa, Bio electromagnetics, Canada: 1987, pp. 29-36.
- [14] Q. Balzano, O. Garay, T. Manning Jr., Electromagnetic Energy Exposure of Simulated Users of Portable Cellular Telephones, IEEE Transactions on Vehicular Technology, vol. 44, no.3, Aug. 1995.
- [15] W. Gander, Computer mathematick, Birkhaeuser, Basel, 1992.
- [16] W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery, Numerical Recipes in C, The Art of Scientific Computing, Second edition, Cambridge University Press, 1992.
- [17] N. Kuster, R. Kastle, T. Schmid, Dosimetric evaluation of mobile communications equipment with known precision, IEEE Transaction on Communications, vol. E80-B, no. 5, May 1997, pp. 645-652.
- [18] CENELEC CLC/SC111B, European Prestandard (prENV 50166-2), Human Exposure to Electromagnetic Fields High-frequency: 10kHz-300GHz, Jan. 1995.
- [19] Prof. Dr. Niels Kuster, ETH, Eidgenössische Technische Hochschule Zürich, Dosimetric Evaluation of the Cellular Phone.

- [20] IEC 62209-1, Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures - Part 1: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300MHz to 3 GHz), Feb. 2005.
- [21] Industry Canada RSS-102 Radio Frequency Exposure Compliance of Radio communication Apparatus (All Frequency Bands) Issue 5, March 2015.
- [22] Health Canada Safety Code 6 Limits of Human Exposure to Radio Frequency Electromagnetic Fields in the Frequency Range from 3 kHz – 300 GHz, 2009
- [23] FCC SAR Test Procedures for 2G-3G Devices, Mobile Hotspot and UMPC Devices KDB Publications 941225,D01-D07
- [24] SAR Measurement procedures for IEEE 802.11a/b/g KDB Publication 248227 D01v02
- [25] FCC SAR Considerations for Handsets with Multiple Transmitters and Antennas, KDB Publications 648474D02-D04
- [26] FCC SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers, FCC KDB Publication 616217 D04
- [27] FCC SAR Measurement and Reporting Requirements for 100MHz – 6 GHz, KDB Publications 865664 D01-D02
- [28] FCC General RF Exposure Guidance and SAR Procedures for Dongles, KDB Publication 447498, D01-D02
- [29] 615223 D01 802 16e Wi-Max SAR Guidance v01, Nov. 13, 2009
- [30] Anexo à Resolução No. 533, de 10 de September de 2009.
- [31] IEC 62209-2, Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures - Part 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), Mar. 2010.

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
S Servizio svizzero di taratura
Swiss Calibration Service

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **DT&C (Dymstec)**

Certificate No: **ES3-3327_Aug18**

CALIBRATION CERTIFICATE

Object **ES3DV3 - SN:3327**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes**

Calibration date: **August 28, 2018**

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 $(22 \pm 3)^{\circ}\text{C}$ 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	04-Apr-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Reference 20 dB Attenuator	SN: S5277 (20x)	04-Apr-18 (No. 217-02682)	Apr-19
Reference Probe ES3DV2	SN: 3013	30-Dec-17 (No. ES3-3013_Dec17)	Dec-18
DAE4	SN: 660	21-Dec-17 (No. DAE4-660_Dec17)	Dec-18
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-17)	In house check: Oct-18

	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			Issued: August 30, 2018

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



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Accreditation No.: **SCS 0108**

Glossary:

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,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., $\vartheta = 0$ 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:

- 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
- 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
- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}:** Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E²-field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z} = NORM_{x,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
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,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 $f \leq 800$ 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 NORM_{x,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 NORM_x (no uncertainty required).

ES3DV3 – SN:3327

August 28, 2018

Probe ES3DV3

SN:3327

Manufactured: January 10, 2012
Calibrated: August 28, 2018

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

ES3DV3- SN:3327

August 28, 2018

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3327

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	1.15	1.10	1.03	$\pm 10.1 \%$
DCP (mV) ^B	104.8	103.1	108.7	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc ^E (k=2)
0	CW	X	0.0	0.0	1.0	0.00	197.7	$\pm 3.0 \%$
		Y	0.0	0.0	1.0		199.9	
		Z	0.0	0.0	1.0		193.5	

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.

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August 28, 2018

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3327

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)
750	41.9	0.89	6.57	6.57	6.57	0.67	1.25	± 12.0 %
835	41.5	0.90	6.35	6.35	6.35	0.80	1.14	± 12.0 %
900	41.5	0.97	6.18	6.18	6.18	0.44	1.51	± 12.0 %
1750	40.1	1.37	5.50	5.50	5.50	0.80	1.30	± 12.0 %
1900	40.0	1.40	5.27	5.27	5.27	0.80	1.25	± 12.0 %
2450	39.2	1.80	4.56	4.56	4.56	0.76	1.33	± 12.0 %
2600	39.0	1.96	4.48	4.48	4.48	0.80	1.35	± 12.0 %

^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. 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.

ES3DV3- SN:3327

August 28, 2018

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3327

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)
750	55.5	0.96	6.38	6.38	6.38	0.80	1.16	± 12.0 %
835	55.2	0.97	6.24	6.24	6.24	0.80	1.15	± 12.0 %
900	55.0	1.05	6.21	6.21	6.21	0.63	1.29	± 12.0 %
1750	53.4	1.49	5.15	5.15	5.15	0.71	1.40	± 12.0 %
1900	53.3	1.52	4.91	4.91	4.91	0.55	1.65	± 12.0 %
2450	52.7	1.95	4.50	4.50	4.50	0.77	1.35	± 12.0 %
2600	52.5	2.16	4.30	4.30	4.30	0.80	1.25	± 12.0 %

^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. Above 5 GHz frequency validity can be extended to ± 110 MHz.

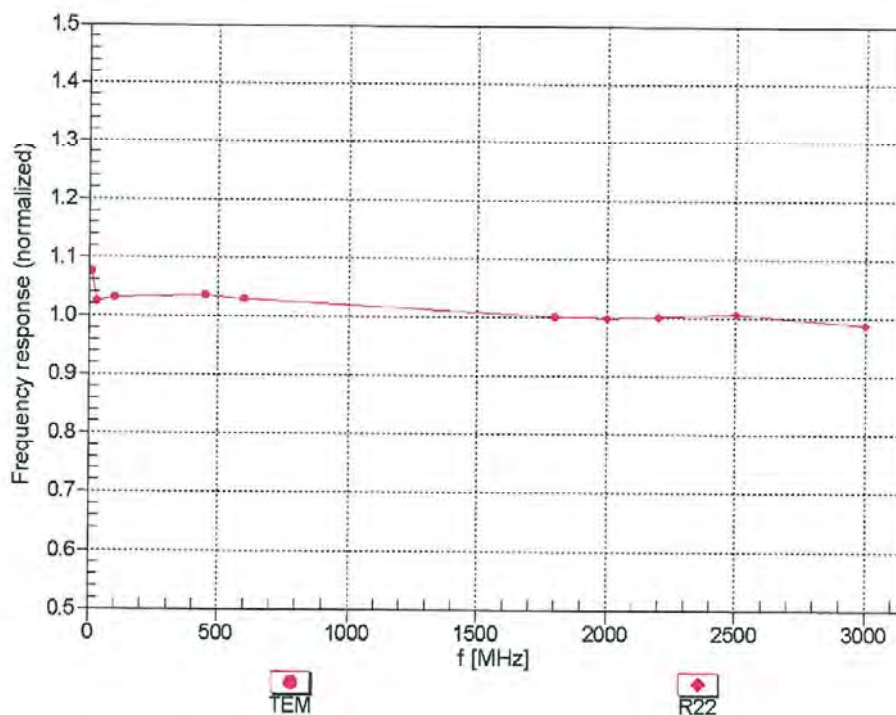
^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty 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.

ES3DV3--SN:3327

August 28, 2018

Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)

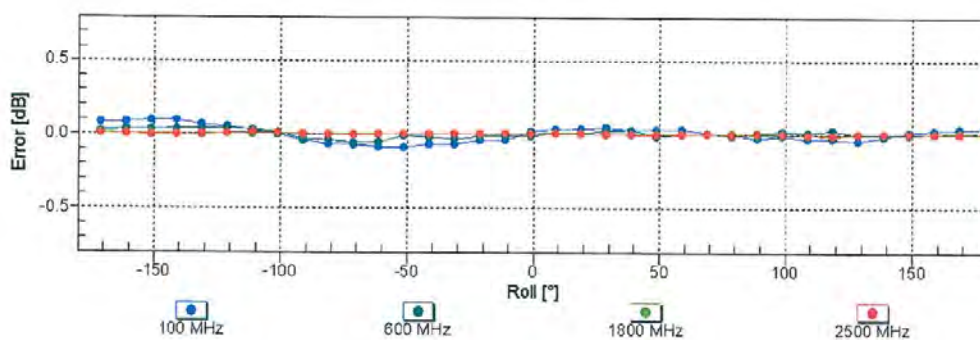
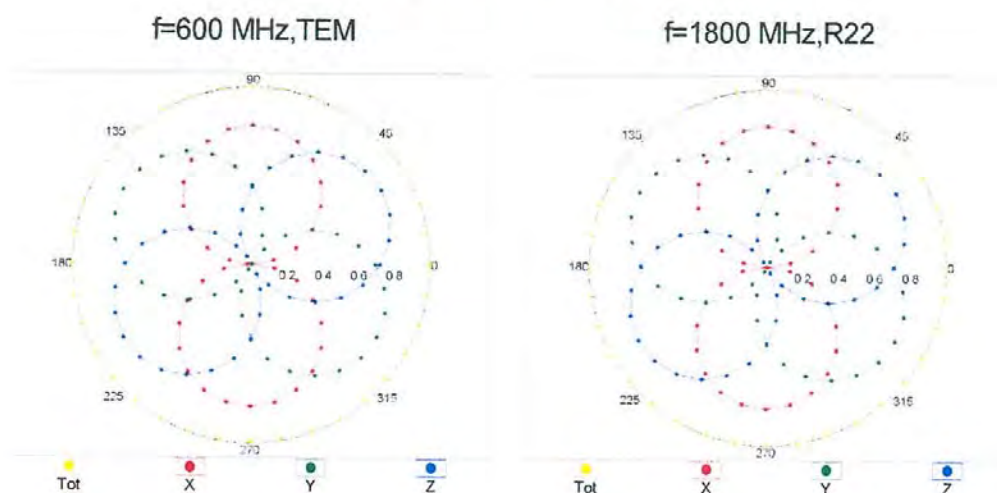


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

ES3DV3--SN:3327

August 28, 2018

Receiving Pattern (ϕ), $\theta = 0^\circ$

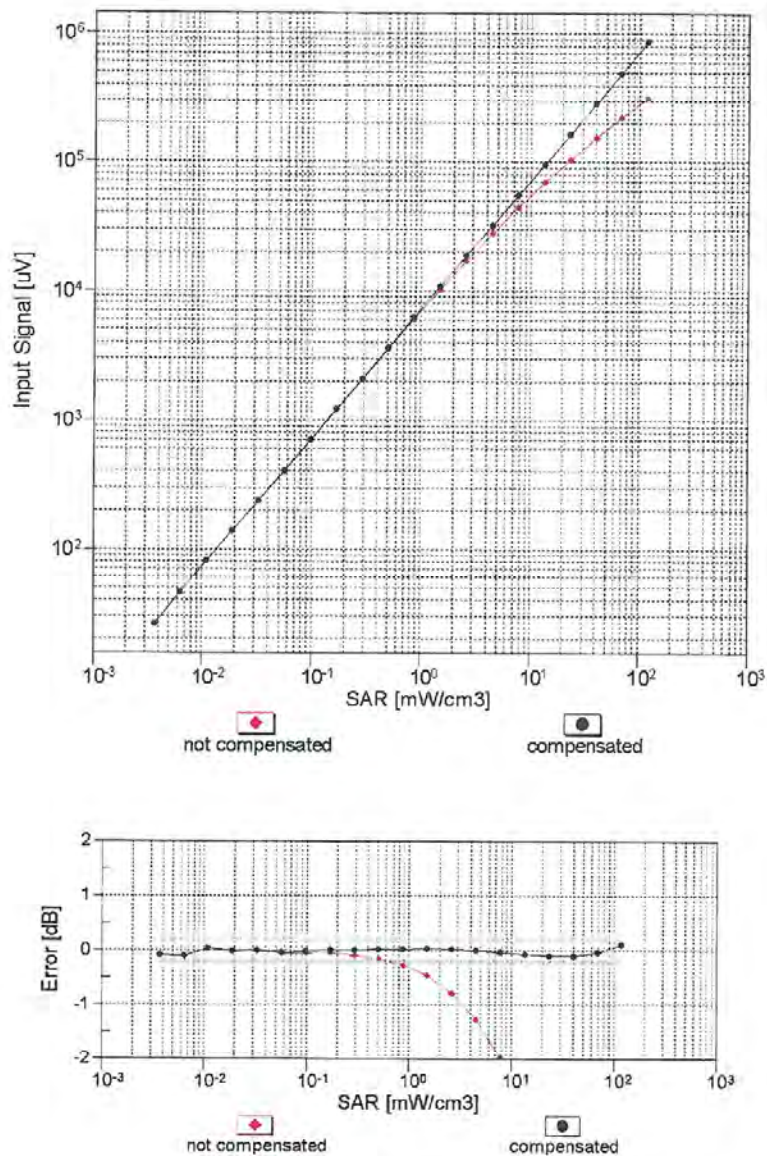


Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

ES3DV3- SN:3327

August 28, 2018

Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell, $f_{\text{eval}} = 1900 \text{ MHz}$)

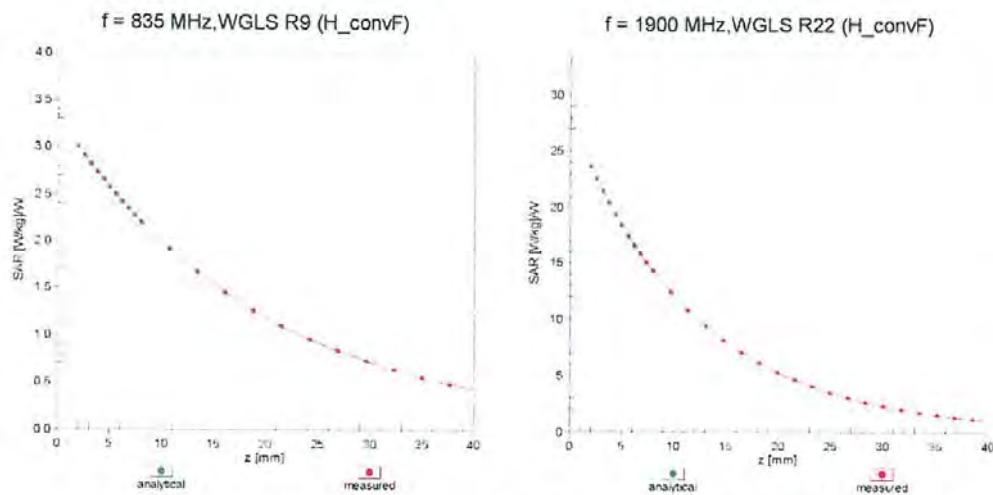


Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

ES3DV3-SN:3327

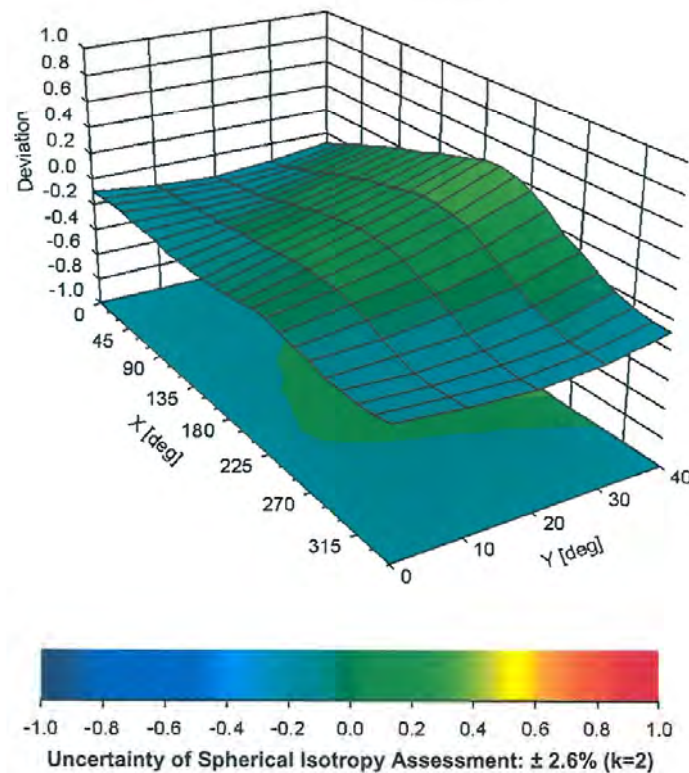
August 28, 2018

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ , θ), $f = 900$ MHz



ES3DV3- SN:3327

August 28, 2018

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3327

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	8.7
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	10 mm
Tip Diameter	4 mm
Probe Tip to Sensor X Calibration Point	2 mm
Probe Tip to Sensor Y Calibration Point	2 mm
Probe Tip to Sensor Z Calibration Point	2 mm
Recommended Measurement Distance from Surface	3 mm

**Calibration Laboratory of
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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **DT&C (Dymstec)**

Certificate No: **EX3-3866_May18**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3866**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6**
Calibration procedure for dosimetric E-field probes

Calibration date: **May 31, 2018**

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 $(22 \pm 3)^{\circ}\text{C}$ 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	04-Apr-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Reference 20 dB Attenuator	SN: S5277 (20x)	04-Apr-18 (No. 217-02682)	Apr-19
Reference Probe ES3DV2	SN: 3013	30-Dec-17 (No. ES3-3013_Dec17)	Dec-18
DAE4	SN: 660	21-Dec-17 (No. DAE4-660_Dec17)	Dec-18
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-16)	In house check: Jun-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

Calibrated by:	Name Jeton Kastrati	Function Laboratory Technician	Signature 
Approved by:	Katja Pokovic	Technical Manager	

Issued: May 31, 2018

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Calibration Laboratory of
Schmid & Partner
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Accreditation No.: **SCS 0108**

Glossary:

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,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., $\theta = 0$ 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:

- 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
- 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
- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\theta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E^2 -field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z}** = NORM_{x,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.
- DCP_{x,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
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,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 $f \leq 800$ 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 NORM_{x,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 NORM_x (no uncertainty required).

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Probe EX3DV4

SN:3866

Manufactured: February 2, 2012
Calibrated: May 31, 2018

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3866

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.43	0.32	0.35	$\pm 10.1 \%$
DCP (mV) ^B	98.7	101.4	105.4	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc ^E (k=2)
0	CW	X	0.0	0.0	1.0	0.00	129.5	$\pm 3.3 \%$
		Y	0.0	0.0	1.0		142.9	
		Z	0.0	0.0	1.0		132.3	

Note: For details on UID parameters see Appendix.

Sensor Model Parameters

	C1 fF	C2 fF	α V^{-1}	T1 $\text{ms}\cdot\text{V}^{-2}$	T2 $\text{ms}\cdot\text{V}^{-1}$	T3 ms	T4 V^{-2}	T5 V^{-1}	T6
X	61.34	450.3	34.79	20.71	0.897	5.071	0.953	0.532	1.007
Y	35.97	270.0	35.93	7.616	0.990	4.996	0.120	0.508	1.005
Z	34.59	248.7	33.42	8.463	0.617	4.987	2.000	0.071	1.005

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.

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3866

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)
750	41.9	0.89	10.16	10.16	10.16	0.49	0.80	± 12.0 %
835	41.5	0.90	9.62	9.62	9.62	0.39	0.93	± 12.0 %
900	41.5	0.97	9.40	9.40	9.40	0.40	0.92	± 12.0 %
1750	40.1	1.37	8.38	8.38	8.38	0.34	0.84	± 12.0 %
1900	40.0	1.40	8.03	8.03	8.03	0.27	0.87	± 12.0 %
2300	39.5	1.67	7.86	7.86	7.86	0.30	0.85	± 12.0 %
2450	39.2	1.80	7.45	7.45	7.45	0.34	0.82	± 12.0 %
2600	39.0	1.96	7.22	7.22	7.22	0.38	0.85	± 12.0 %
3500	37.9	2.91	6.89	6.89	6.89	0.20	1.25	± 13.1 %
5200	36.0	4.66	5.14	5.14	5.14	0.40	1.80	± 13.1 %
5300	35.9	4.76	4.95	4.95	4.95	0.40	1.80	± 13.1 %
5500	35.6	4.96	4.61	4.61	4.61	0.40	1.80	± 13.1 %
5600	35.5	5.07	4.52	4.52	4.52	0.40	1.80	± 13.1 %
5800	35.3	5.27	4.69	4.69	4.69	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. 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.

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3866

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)
750	55.5	0.96	9.69	9.69	9.69	0.33	0.97	± 12.0 %
835	55.2	0.97	9.43	9.43	9.43	0.42	0.80	± 12.0 %
900	55.0	1.05	9.57	9.57	9.57	0.48	0.80	± 12.0 %
1750	53.4	1.49	7.95	7.95	7.95	0.39	0.80	± 12.0 %
1900	53.3	1.52	7.68	7.68	7.68	0.30	0.85	± 12.0 %
2300	52.9	1.81	7.50	7.50	7.50	0.39	0.85	± 12.0 %
2450	52.7	1.95	7.40	7.40	7.40	0.43	0.90	± 12.0 %
2600	52.5	2.16	7.28	7.28	7.28	0.25	1.05	± 12.0 %
3500	51.3	3.31	6.43	6.43	6.43	0.28	1.20	± 13.1 %
5200	49.0	5.30	4.69	4.69	4.69	0.50	1.90	± 13.1 %
5300	48.9	5.42	4.50	4.50	4.50	0.50	1.90	± 13.1 %
5500	48.6	5.65	3.95	3.95	3.95	0.50	1.90	± 13.1 %
5600	48.5	5.77	3.87	3.87	3.87	0.50	1.90	± 13.1 %
5800	48.2	6.00	4.16	4.16	4.16	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. Above 5 GHz frequency validity can be extended to ± 110 MHz.

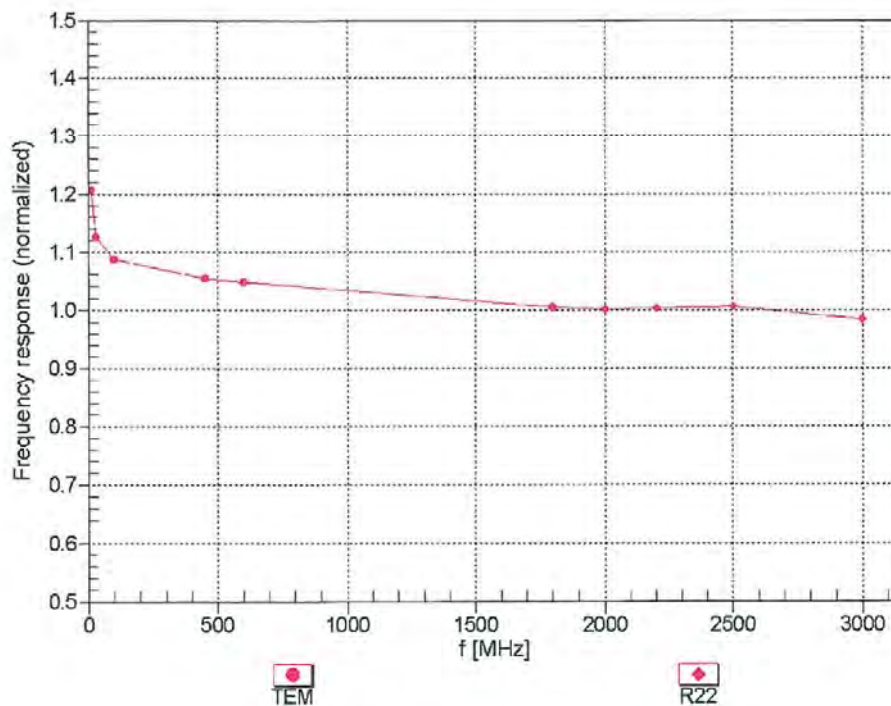
^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty 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.

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Frequency Response of E-Field (TEM-Cell: ifi110 EXX, Waveguide: R22)

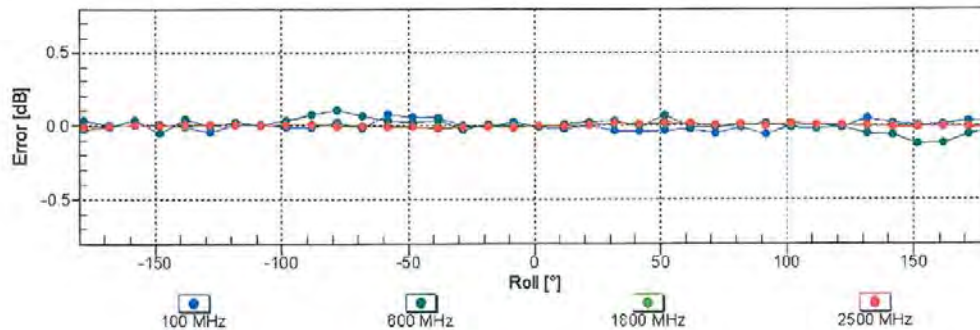
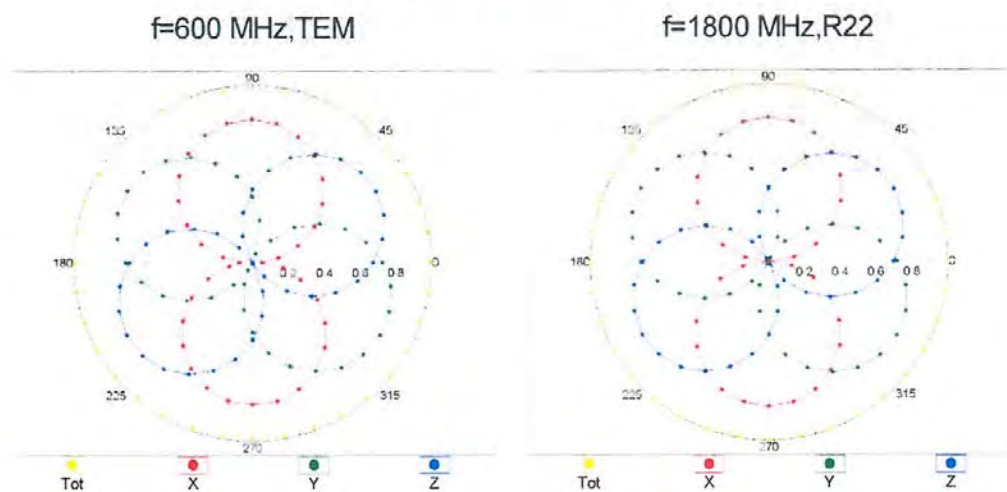


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

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Receiving Pattern (ϕ), $\theta = 0^\circ$

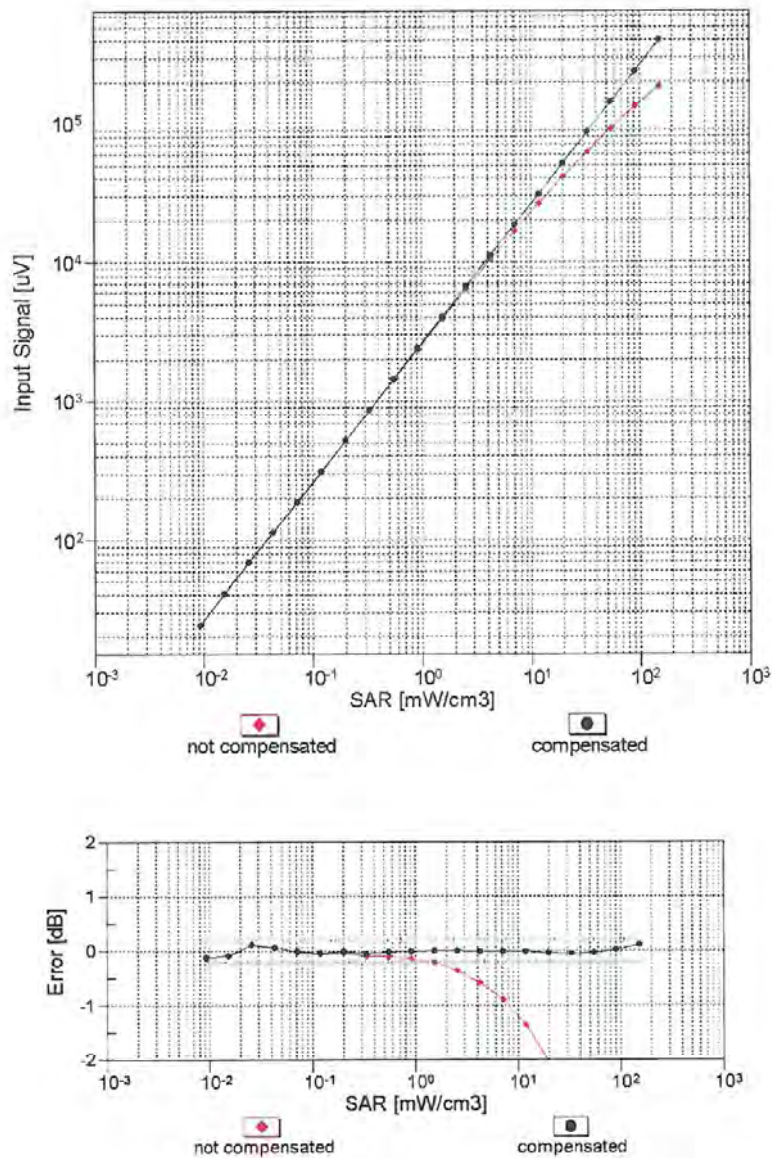


Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

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Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell , $f_{\text{eval}} = 1900 \text{ MHz}$)

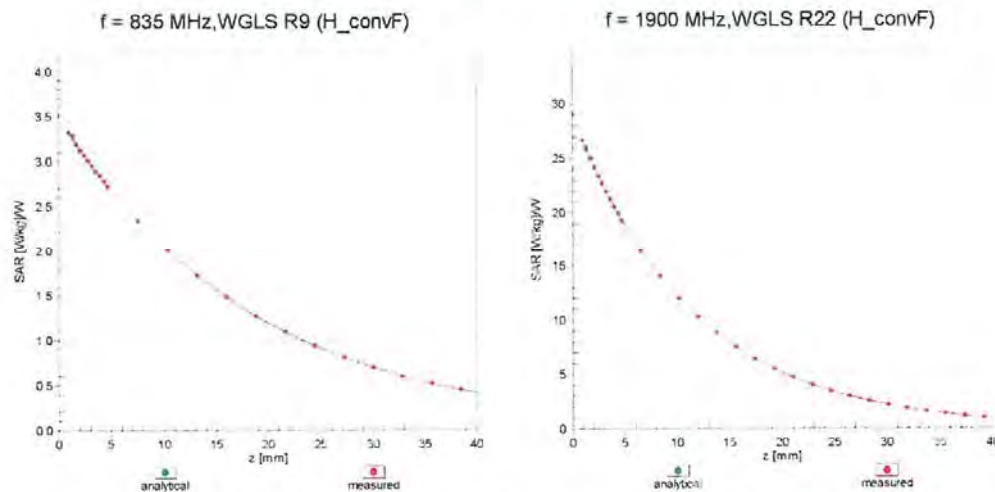


Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

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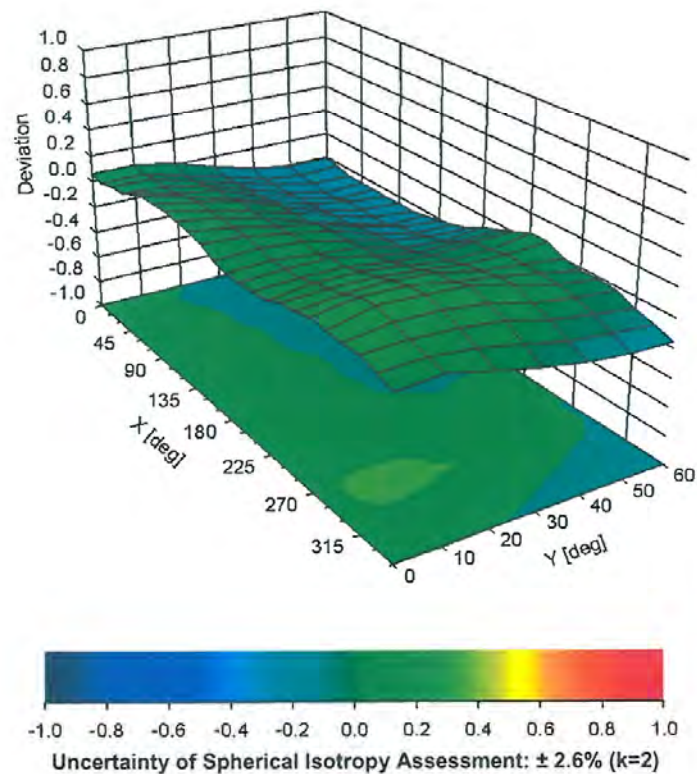
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Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ , θ), f = 900 MHz



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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3866**Other Probe Parameters**

Sensor Arrangement	Triangular
Connector Angle (°)	61.8
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

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Appendix: Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu V}$	C	D dB	VR mV	Max Unc ^E (k=2)
0	CW	X	0.00	0.00	1.00	0.00	129.5	$\pm 3.3 \%$
		Y	0.00	0.00	1.00		142.9	
		Z	0.00	0.00	1.00		132.3	
10010- CAA	SAR Validation (Square, 100ms, 10ms)	X	4.96	74.03	14.55	10.00	20.0	$\pm 9.6 \%$
		Y	1.96	62.67	8.25		20.0	
		Z	1.98	63.61	8.75		20.0	
10011- CAB	UMTS-FDD (WCDMA)	X	1.46	74.36	19.19	0.00	150.0	$\pm 9.6 \%$
		Y	0.84	66.93	14.18		150.0	
		Z	1.06	69.91	16.41		150.0	
10012- CAB	IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)	X	1.27	66.19	17.07	0.41	150.0	$\pm 9.6 \%$
		Y	1.01	63.39	14.61		150.0	
		Z	1.12	64.44	15.48		150.0	
10013- CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps)	X	5.02	66.95	17.37	1.46	150.0	$\pm 9.6 \%$
		Y	4.56	66.54	16.75		150.0	
		Z	4.61	66.83	16.87		150.0	
10021- DAC	GSM-FDD (TDMA, GMSK)	X	100.00	116.34	28.99	9.39	50.0	$\pm 9.6 \%$
		Y	4.35	71.51	13.58		50.0	
		Z	10.49	82.17	17.30		50.0	
10023- DAC	GPRS-FDD (TDMA, GMSK, TN 0)	X	100.00	116.24	28.99	9.57	50.0	$\pm 9.6 \%$
		Y	4.08	70.51	13.19		50.0	
		Z	7.34	77.92	15.91		50.0	
10024- DAC	GPRS-FDD (TDMA, GMSK, TN 0-1)	X	100.00	114.37	27.13	6.56	60.0	$\pm 9.6 \%$
		Y	2.47	68.27	11.00		60.0	
		Z	99.64	104.22	21.52		60.0	
10025- DAC	EDGE-FDD (TDMA, 8PSK, TN 0)	X	7.29	85.63	33.51	12.57	50.0	$\pm 9.6 \%$
		Y	3.34	62.89	20.63		50.0	
		Z	4.59	72.89	26.66		50.0	
10026- DAC	EDGE-FDD (TDMA, 8PSK, TN 0-1)	X	19.51	108.37	37.98	9.56	60.0	$\pm 9.6 \%$
		Y	6.99	84.48	28.68		60.0	
		Z	7.40	87.18	30.26		60.0	
10027- DAC	GPRS-FDD (TDMA, GMSK, TN 0-1-2)	X	100.00	114.69	26.54	4.80	80.0	$\pm 9.6 \%$
		Y	1.47	65.78	9.10		80.0	
		Z	100.00	103.55	20.47		80.0	
10028- DAC	GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)	X	100.00	116.57	26.68	3.55	100.0	$\pm 9.6 \%$
		Y	0.75	62.53	6.91		100.0	
		Z	100.00	103.86	19.98		100.0	
10029- DAC	EDGE-FDD (TDMA, 8PSK, TN 0-1-2)	X	10.84	94.12	31.96	7.80	80.0	$\pm 9.6 \%$
		Y	4.68	76.74	24.63		80.0	
		Z	4.76	77.76	25.40		80.0	
10030- CAA	IEEE 802.15.1 Bluetooth (GFSK, DH1)	X	100.00	113.28	26.21	5.30	70.0	$\pm 9.6 \%$
		Y	1.50	64.87	8.87		70.0	
		Z	14.61	85.51	16.17		70.0	
10031- CAA	IEEE 802.15.1 Bluetooth (GFSK, DH3)	X	100.00	120.46	26.88	1.88	100.0	$\pm 9.6 \%$
		Y	0.28	60.00	3.77		100.0	
		Z	100.00	97.01	16.04		100.0	

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10032-CAA	IEEE 802.15.1 Bluetooth (GFSK, DH5)	X	100.00	134.94	31.61	1.17	100.0	± 9.6 %
		Y	2.98	214.36	19.03		100.0	
		Z	100.00	96.12	15.00		100.0	
10033-CAA	IEEE 802.15.1 Bluetooth (PI/4-DQPSK, DH1)	X	100.00	129.71	35.52	5.30	70.0	± 9.6 %
		Y	3.37	73.07	15.63		70.0	
		Z	5.18	79.83	18.59		70.0	
10034-CAA	IEEE 802.15.1 Bluetooth (PI/4-DQPSK, DH3)	X	38.25	116.38	31.11	1.88	100.0	± 9.6 %
		Y	1.32	66.13	11.17		100.0	
		Z	2.19	72.52	14.56		100.0	
10035-CAA	IEEE 802.15.1 Bluetooth (PI/4-DQPSK, DH5)	X	10.07	97.58	26.00	1.17	100.0	± 9.6 %
		Y	1.02	64.74	10.26		100.0	
		Z	1.68	70.82	13.73		100.0	
10036-CAA	IEEE 802.15.1 Bluetooth (8-DPSK, DH1)	X	100.00	130.10	35.71	5.30	70.0	± 9.6 %
		Y	3.79	74.73	16.33		70.0	
		Z	6.44	82.95	19.72		70.0	
10037-CAA	IEEE 802.15.1 Bluetooth (8-DPSK, DH3)	X	33.36	114.28	30.54	1.88	100.0	± 9.6 %
		Y	1.25	65.67	10.94		100.0	
		Z	1.95	71.33	14.08		100.0	
10038-CAA	IEEE 802.15.1 Bluetooth (8-DPSK, DH5)	X	11.00	99.37	26.64	1.17	100.0	± 9.6 %
		Y	1.03	65.03	10.52		100.0	
		Z	1.72	71.30	14.06		100.0	
10039-CAB	CDMA2000 (1xRTT, RC1)	X	4.41	85.41	21.99	0.00	150.0	± 9.6 %
		Y	0.86	64.63	9.97		150.0	
		Z	1.99	74.44	15.11		150.0	
10042-CAB	IS-54 / IS-136 FDD (TDMA/FDM, PI/4-DQPSK, Halfrate)	X	100.00	112.07	26.26	7.78	50.0	± 9.6 %
		Y	2.24	65.83	9.99		50.0	
		Z	4.60	73.72	13.31		50.0	
10044-CAA	IS-91/EIA/TIA-553 FDD (FDMA, FM)	X	0.01	122.05	4.07	0.00	150.0	± 9.6 %
		Y	0.35	142.03	0.00		150.0	
		Z	0.02	123.73	10.80		150.0	
10048-CAA	DECT (TDD, TDMA/FDM, GFSK, Full Slot, 24)	X	100.00	117.95	31.07	13.80	25.0	± 9.6 %
		Y	4.50	67.37	13.41		25.0	
		Z	5.19	70.06	14.31		25.0	
10049-CAA	DECT (TDD, TDMA/FDM, GFSK, Double Slot, 12)	X	100.00	116.36	29.33	10.79	40.0	± 9.6 %
		Y	4.23	69.49	13.02		40.0	
		Z	5.27	72.87	14.27		40.0	
10056-CAA	UMTS-TDD (TD-SCDMA, 1.28 Mcps)	X	77.81	121.32	33.78	9.03	50.0	± 9.6 %
		Y	6.03	75.76	17.19		50.0	
		Z	9.07	82.59	19.86		50.0	
10058-DAC	EDGE-FDD (TDMA, 8PSK, TN 0-1-2-3)	X	7.57	86.51	28.41	6.55	100.0	± 9.6 %
		Y	3.72	73.02	22.40		100.0	
		Z	3.78	73.63	22.92		100.0	
10059-CAB	IEEE 802.11b WiFi 2.4 GHz (DSSS, 2 Mbps)	X	1.41	68.44	18.21	0.61	110.0	± 9.6 %
		Y	1.03	64.26	15.02		110.0	
		Z	1.14	65.37	15.93		110.0	
10060-CAB	IEEE 802.11b WiFi 2.4 GHz (DSSS, 5.5 Mbps)	X	100.00	140.28	36.98	1.30	110.0	± 9.6 %
		Y	5.52	92.10	22.15		110.0	
		Z	23.32	116.45	30.29		110.0	

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10061-CAB	IEEE 802.11b WiFi 2.4 GHz (DSSS, 11 Mbps)	X	32.15	121.96	35.02	2.04	110.0	± 9.6 %
		Y	2.04	75.39	19.12		110.0	
		Z	2.36	78.14	20.85		110.0	
10062-CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 6 Mbps)	X	4.83	66.99	16.83	0.49	100.0	± 9.6 %
		Y	4.37	66.55	16.24		100.0	
		Z	4.43	66.90	16.40		100.0	
10063-CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 9 Mbps)	X	4.85	67.11	16.95	0.72	100.0	± 9.6 %
		Y	4.38	66.62	16.31		100.0	
		Z	4.44	66.97	16.47		100.0	
10064-CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 12 Mbps)	X	5.19	67.41	17.17	0.86	100.0	± 9.6 %
		Y	4.62	66.81	16.50		100.0	
		Z	4.67	67.13	16.63		100.0	
10065-CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 18 Mbps)	X	5.05	67.34	17.29	1.21	100.0	± 9.6 %
		Y	4.49	66.66	16.55		100.0	
		Z	4.54	66.96	16.68		100.0	
10066-CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 24 Mbps)	X	5.08	67.39	17.47	1.46	100.0	± 9.6 %
		Y	4.50	66.65	16.68		100.0	
		Z	4.54	66.92	16.80		100.0	
10067-CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 36 Mbps)	X	5.35	67.39	17.83	2.04	100.0	± 9.6 %
		Y	4.79	66.90	17.13		100.0	
		Z	4.82	67.14	17.23		100.0	
10068-CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 48 Mbps)	X	5.44	67.63	18.14	2.55	100.0	± 9.6 %
		Y	4.82	66.81	17.26		100.0	
		Z	4.85	67.03	17.35		100.0	
10069-CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 54 Mbps)	X	5.51	67.49	18.27	2.67	100.0	± 9.6 %
		Y	4.89	66.85	17.46		100.0	
		Z	4.91	67.04	17.53		100.0	
10071-CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 9 Mbps)	X	5.12	67.05	17.68	1.99	100.0	± 9.6 %
		Y	4.66	66.59	17.01		100.0	
		Z	4.70	66.85	17.11		100.0	
10072-CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 12 Mbps)	X	5.14	67.52	17.95	2.30	100.0	± 9.6 %
		Y	4.62	66.83	17.17		100.0	
		Z	4.65	67.08	17.27		100.0	
10073-CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 18 Mbps)	X	5.21	67.69	18.29	2.83	100.0	± 9.6 %
		Y	4.68	67.01	17.47		100.0	
		Z	4.71	67.23	17.56		100.0	
10074-CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 24 Mbps)	X	5.18	67.59	18.46	3.30	100.0	± 9.6 %
		Y	4.69	66.95	17.60		100.0	
		Z	4.71	67.17	17.70		100.0	
10075-CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 36 Mbps)	X	5.26	67.87	18.86	3.82	90.0	± 9.6 %
		Y	4.73	66.99	17.83		90.0	
		Z	4.74	67.18	17.92		90.0	
10076-CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 48 Mbps)	X	5.23	67.53	18.89	4.15	90.0	± 9.6 %
		Y	4.77	66.89	18.00		90.0	
		Z	4.78	67.06	18.08		90.0	
10077-CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 54 Mbps)	X	5.25	67.58	18.98	4.30	90.0	± 9.6 %
		Y	4.81	66.98	18.11		90.0	
		Z	4.81	67.15	18.19		90.0	

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10081-CAB	CDMA2000 (1xRTT, RC3)	X	1.61	75.86	18.26	0.00	150.0	± 9.6 %
		Y	0.40	60.59	6.95		150.0	
		Z	0.70	65.91	10.99		150.0	
10082-CAB	IS-54 / IS-136 FDD (TDMA/FDM, PI/4-DQPSK, Fullrate)	X	0.97	60.00	5.20	4.77	80.0	± 9.6 %
		Y	6.26	66.77	5.69		80.0	
		Z	1.47	63.08	5.04		80.0	
10090-DAC	GPRS-FDD (TDMA, GMSK, TN 0-4)	X	100.00	114.42	27.18	6.56	60.0	± 9.6 %
		Y	2.51	68.39	11.07		60.0	
		Z	91.59	103.46	21.38		60.0	
10097-CAB	UMTS-FDD (HSDPA)	X	2.10	70.41	17.58	0.00	150.0	± 9.6 %
		Y	1.66	67.98	15.08		150.0	
		Z	1.92	70.17	16.49		150.0	
10098-CAB	UMTS-FDD (HSUPA, Subtest 2)	X	2.06	70.42	17.57	0.00	150.0	± 9.6 %
		Y	1.62	67.91	15.04		150.0	
		Z	1.88	70.12	16.47		150.0	
10099-DAC	EDGE-FDD (TDMA, 8PSK, TN 0-4)	X	19.63	108.47	38.01	9.56	60.0	± 9.6 %
		Y	7.02	84.55	28.70		60.0	
		Z	7.45	87.29	30.29		60.0	
10100-CAD	LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)	X	3.76	73.52	18.27	0.00	150.0	± 9.6 %
		Y	2.83	69.91	16.35		150.0	
		Z	3.08	71.35	17.24		150.0	
10101-CAD	LTE-FDD (SC-FDMA, 100% RB, 20 MHz, 16-QAM)	X	3.49	68.90	16.77	0.00	150.0	± 9.6 %
		Y	2.97	67.19	15.62		150.0	
		Z	3.10	67.97	16.12		150.0	
10102-CAD	LTE-FDD (SC-FDMA, 100% RB, 20 MHz, 64-QAM)	X	3.59	68.75	16.81	0.00	150.0	± 9.6 %
		Y	3.08	67.24	15.76		150.0	
		Z	3.21	67.97	16.22		150.0	
10103-CAD	LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK)	X	8.41	79.82	22.06	3.98	65.0	± 9.6 %
		Y	4.84	71.96	18.48		65.0	
		Z	5.42	74.19	19.53		65.0	
10104-CAD	LTE-TDD (SC-FDMA, 100% RB, 20 MHz, 16-QAM)	X	7.70	76.73	21.71	3.98	65.0	± 9.6 %
		Y	5.32	71.47	19.01		65.0	
		Z	5.48	72.25	19.42		65.0	
10105-CAD	LTE-TDD (SC-FDMA, 100% RB, 20 MHz, 64-QAM)	X	7.04	74.96	21.27	3.98	65.0	± 9.6 %
		Y	4.70	68.99	18.19		65.0	
		Z	5.14	70.85	19.09		65.0	
10108-CAE	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK)	X	3.28	72.58	18.09	0.00	150.0	± 9.6 %
		Y	2.43	69.27	16.18		150.0	
		Z	2.65	70.70	17.10		150.0	
10109-CAE	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, 16-QAM)	X	3.17	68.85	16.81	0.00	150.0	± 9.6 %
		Y	2.61	67.16	15.46		150.0	
		Z	2.76	68.08	16.06		150.0	
10110-CAE	LTE-FDD (SC-FDMA, 100% RB, 5 MHz, QPSK)	X	2.68	71.66	17.86	0.00	150.0	± 9.6 %
		Y	1.91	68.41	15.56		150.0	
		Z	2.13	70.09	16.68		150.0	
10111-CAE	LTE-FDD (SC-FDMA, 100% RB, 5 MHz, 16-QAM)	X	2.94	70.01	17.44	0.00	150.0	± 9.6 %
		Y	2.36	68.46	15.69		150.0	
		Z	2.60	69.97	16.63		150.0	

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10112-CAE	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, 64-QAM)	X	3.28	68.68	16.79	0.00	150.0	± 9.6 %
		Y	2.74	67.25	15.57		150.0	
		Z	2.89	68.13	16.13		150.0	
10113-CAE	LTE-FDD (SC-FDMA, 100% RB, 5 MHz, 64-QAM)	X	3.09	69.94	17.46	0.00	150.0	± 9.6 %
		Y	2.52	68.70	15.88		150.0	
		Z	2.75	70.13	16.75		150.0	
10114-CAC	IEEE 802.11n (HT Greenfield, 13.5 Mbps, BPSK)	X	5.23	67.48	16.65	0.00	150.0	± 9.6 %
		Y	4.84	67.00	16.28		150.0	
		Z	4.90	67.34	16.43		150.0	
10115-CAC	IEEE 802.11n (HT Greenfield, 81 Mbps, 16-QAM)	X	5.59	67.72	16.77	0.00	150.0	± 9.6 %
		Y	5.08	67.08	16.32		150.0	
		Z	5.13	67.37	16.44		150.0	
10116-CAC	IEEE 802.11n (HT Greenfield, 135 Mbps, 64-QAM)	X	5.36	67.74	16.70	0.00	150.0	± 9.6 %
		Y	4.92	67.20	16.31		150.0	
		Z	4.98	67.52	16.45		150.0	
10117-CAC	IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK)	X	5.24	67.49	16.68	0.00	150.0	± 9.6 %
		Y	4.83	66.95	16.28		150.0	
		Z	4.89	67.29	16.43		150.0	
10118-CAC	IEEE 802.11n (HT Mixed, 81 Mbps, 16-QAM)	X	5.66	67.87	16.85	0.00	150.0	± 9.6 %
		Y	5.16	67.27	16.43		150.0	
		Z	5.20	67.52	16.53		150.0	
10119-CAC	IEEE 802.11n (HT Mixed, 135 Mbps, 64-QAM)	X	5.33	67.68	16.69	0.00	150.0	± 9.6 %
		Y	4.92	67.19	16.31		150.0	
		Z	4.97	67.51	16.46		150.0	
10140-CAD	LTE-FDD (SC-FDMA, 100% RB, 15 MHz, 16-QAM)	X	3.64	68.73	16.72	0.00	150.0	± 9.6 %
		Y	3.10	67.23	15.65		150.0	
		Z	3.23	67.98	16.12		150.0	
10141-CAD	LTE-FDD (SC-FDMA, 100% RB, 15 MHz, 64-QAM)	X	3.75	68.73	16.84	0.00	150.0	± 9.6 %
		Y	3.23	67.43	15.88		150.0	
		Z	3.36	68.16	16.32		150.0	
10142-CAD	LTE-FDD (SC-FDMA, 100% RB, 3 MHz, QPSK)	X	2.50	72.12	17.94	0.00	150.0	± 9.6 %
		Y	1.65	68.10	14.67		150.0	
		Z	1.94	70.53	16.23		150.0	
10143-CAD	LTE-FDD (SC-FDMA, 100% RB, 3 MHz, 16-QAM)	X	2.95	71.49	17.71	0.00	150.0	± 9.6 %
		Y	2.12	68.46	14.53		150.0	
		Z	2.52	71.14	16.09		150.0	
10144-CAD	LTE-FDD (SC-FDMA, 100% RB, 3 MHz, 64-QAM)	X	2.62	68.66	15.91	0.00	150.0	± 9.6 %
		Y	1.78	65.25	12.38		150.0	
		Z	2.00	66.87	13.49		150.0	
10145-CAE	LTE-FDD (SC-FDMA, 100% RB, 1.4 MHz, QPSK)	X	2.08	72.58	16.71	0.00	150.0	± 9.6 %
		Y	0.62	60.00	6.54		150.0	
		Z	0.76	61.85	8.27		150.0	
10146-CAE	LTE-FDD (SC-FDMA, 100% RB, 1.4 MHz, 16-QAM)	X	4.74	77.79	17.95	0.00	150.0	± 9.6 %
		Y	0.91	59.91	6.14		150.0	
		Z	1.03	60.93	6.75		150.0	
10147-CAE	LTE-FDD (SC-FDMA, 100% RB, 1.4 MHz, 64-QAM)	X	8.02	85.30	20.79	0.00	150.0	± 9.6 %
		Y	0.95	60.19	6.39		150.0	
		Z	1.09	61.38	7.09		150.0	