



# SAR TEST REPORT

**Applicant**      AXIS COMMUNICATIONS AB  
**FCC ID**          PNB-AXISW100  
**Product**        AXIS W100 BODY WORN CAMERA  
**Brand**            AXIS  
**Model**            AXIS W100 BODY WORN CAMERA  
**Report No.**      R1912A0744-S1  
**Issue Date**      May 12, 2020

TA Technology (Shanghai) Co., Ltd. tested the above equipment in accordance with the requirements in **IEEE 1528- 2013, ANSI C95.1: 1992, IEEE C95.1: 1991**. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

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## 1 Test Laboratory

### 1.1 Notes of the Test Report

This report shall not be reproduced in full or partial, without the written approval of **TA technology (shanghai) co., Ltd.** The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. Measurement Uncertainties were not taken into account and are published for informational purposes only. This report is written to support regulatory compliance of the applicable standards stated above.

### 1.2. Test facility

#### **FCC (Designation number: CN1179, Test Firm Registration Number: 446626)**

TA Technology (Shanghai) Co., Ltd. has been listed on the US Federal Communications Commission list of test facilities recognized to perform electromagnetic emissions measurements.

#### **A2LA (Certificate Number: 3857.01)**

TA Technology (Shanghai) Co., Ltd. has been listed by American Association for Laboratory Accreditation to perform electromagnetic emission measurement.

### 1.3 Testing Location

Company: TA Technology (Shanghai) Co., Ltd.  
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## 1.4 Laboratory Environment

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

## 2 Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing for the EUT are as follows:

Table 1: Highest Reported SAR

| Mode                                                                                                                                                                                                                                                                                  | Highest Reported SAR (W/kg)         |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|                                                                                                                                                                                                                                                                                       | 1g SAR Body SAR<br>(Separation 5mm) |
| Wi-Fi (2.4G)                                                                                                                                                                                                                                                                          | 0.262                               |
| BT                                                                                                                                                                                                                                                                                    | NA                                  |
| Date of Testing:                                                                                                                                                                                                                                                                      | February 29, 2020                   |
| Note: All indications of Pass/Fail in this report are opinions expressed by TA Technology (Shanghai) Co., Ltd. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. |                                     |

### 3 Description of Equipment under Test

#### Client Information

|                             |                                        |
|-----------------------------|----------------------------------------|
| <b>Applicant</b>            | AXIS COMMUNICATIONS AB                 |
| <b>Applicant address</b>    | Emdalavagen 14 ,SE-223 69 Lund, Sweden |
| <b>Manufacturer</b>         | AXIS COMMUNICATIONS AB                 |
| <b>Manufacturer address</b> | Emdalavagen 14 ,SE-223 69 Lund, Sweden |

#### General Technologies

|                                                                                                             |                                                                        |
|-------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| Application Purpose:                                                                                        | Original Grant                                                         |
| EUT Stage:                                                                                                  | Identical Prototype                                                    |
| Model:                                                                                                      | AXIS W100 BODY WORN CAMERA                                             |
| SN:                                                                                                         | 1#                                                                     |
| Hardware Version:                                                                                           | M10                                                                    |
| Software Version:                                                                                           | 9.65alpha1                                                             |
| Antenna Type:                                                                                               | Internal Antenna                                                       |
| Device Class:                                                                                               | C                                                                      |
| Wi-Fi Hotspot:                                                                                              | Wi-Fi 2.4G                                                             |
| EUT Accessory                                                                                               |                                                                        |
| Battery                                                                                                     | Manufacturer: Icon Energy System (Shenzhen) Co., Ltd.<br>Model: ID1058 |
| BODY WORN MINI BULLET SENSOR                                                                                | Manufacturer: AXIS<br>Model: AXIS TW1200                               |
| Note: The EUT is sent from the applicant to TA and the information of the EUT is declared by the applicant. |                                                                        |

**Wireless Technology and Frequency Range**

| Wireless Technology |                                                                                                   | Modulation     | Operating mode   | Tx (MHz)    |
|---------------------|---------------------------------------------------------------------------------------------------|----------------|------------------|-------------|
| BT                  | 2.4G                                                                                              | Version 4.1 LE |                  | 2402 ~2480  |
| Wi-Fi               | 2.4G                                                                                              | DSSS,OFDM      | 802.11b/g/n HT20 | 2412 ~ 2462 |
|                     | Does this device support MIMO <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No |                |                  |             |



## 4 Test Specification, Methods and Procedures

The tests documented in this report were performed in accordance with FCC 47 CFR § 2.1093, IEEE 1528- 2013, ANSI C95.1: 1992, IEEE C95.1: 1991, the following FCC Published RF exposure KDB procedures:

IEC 62209-1

KDB 248227 D01 802.11Wi-Fi SAR v02r02

KDB 447498 D01 General RF Exposure Guidance v06

KDB 648474 D04 Handset SAR v01r03

KDB 690783 D01 SAR Listings on Grants v01r03

KDB 865664 D01 SAR measurement 100 MHz to 6 GHz v01r04

KDB 865664 D02 RF Exposure Reporting v01r02

KDB 941225 D06 Hotspot Mode v02r01



## 5 Operational Conditions during Test

### 5.3 Test Positions

#### 5.3.1 Body Worn Configuration

Body-worn operating configurations should be tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in normal use configurations.

Per FCC KDB Publication 648474 D04, 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 D01 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  $> 1.2$  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.

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.

## 5.4 Measurement Variability

Per FCC KDB Publication 865664 D01, 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  $\geq 0.80$  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  $\geq 1.45$  W/kg ( $\sim 10\%$  from the 1-g SAR limit).
- 3) A third repeated measurement was performed only if the original, first or second repeated measurement was  $\geq 1.5$  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

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

## 5.5 Test Configuration

### 5.5.1 Wi-Fi Test Configuration

SAR test reduction for 802.11 Wi-Fi transmission mode configurations are considered separately for DSSS and OFDM. An initial test position is determined to reduce the number of tests required for certain exposure configurations with multiple test positions. An initial test configuration is determined for each frequency band and aggregated band according to maximum output power, channel bandwidth, wireless mode configurations and other operating parameters to streamline the measurement requirements. For 2.4 GHz DSSS, either the initial test position or DSSS procedure is applied to reduce the number of SAR tests; these are mutually exclusive. For OFDM, an initial test position is only applicable to next to the ear, UMPC mini-tablet and hotspot mode configurations, which is tested using the initial test configuration to facilitate test reduction. For other exposure conditions with a fixed test position, SAR test reduction is determined using only the initial test configuration.

The multiple test positions require SAR measurements in head, hotspot mode or UMPC mini-tablet configurations may be reduced according to the highest reported SAR determined using the *initial test position(s)* by applying the DSSS or OFDM SAR measurement procedures in the required wireless mode test configuration(s). The *initial test position(s)* is measured using the highest measured maximum output power channel in the required wireless mode test configuration(s). When the *reported SAR* for the *initial test position* is:

- $\leq 0.4$  W/kg, further SAR measurement is not required for the other test positions in that exposure configuration and wireless mode combination within the frequency band or aggregated band. DSSS and OFDM configurations are considered separately according to the required SAR procedures.
- 0.4 W/kg, SAR is repeated using the same wireless mode test configuration tested in the *initial test position* to measure the subsequent next closet/smallest test separation distance and maximum coupling test position, on the highest maximum output power channel, until the *reported SAR* is  $\leq 0.8$  W/kg or all required test positions are tested.
  - ✧ For subsequent test positions with equivalent test separation distance or when exposure is dominated by coupling conditions, the position for maximum coupling condition should be tested.
  - ✧ When it is unclear, all equivalent conditions must be tested.
- For all positions/configurations tested using the *initial test position* and subsequent test positions, when the *reported SAR* is  $> 0.8$  W/kg, measure the SAR for these positions/configurations on the subsequent next highest measured output power channel(s) until the *reported SAR* is  $\leq 1.2$  W/kg or all required test channels are considered.
  - ✧ The additional power measurements required for this step should be limited to those necessary for identifying subsequent highest output power channels to apply the test reduction.

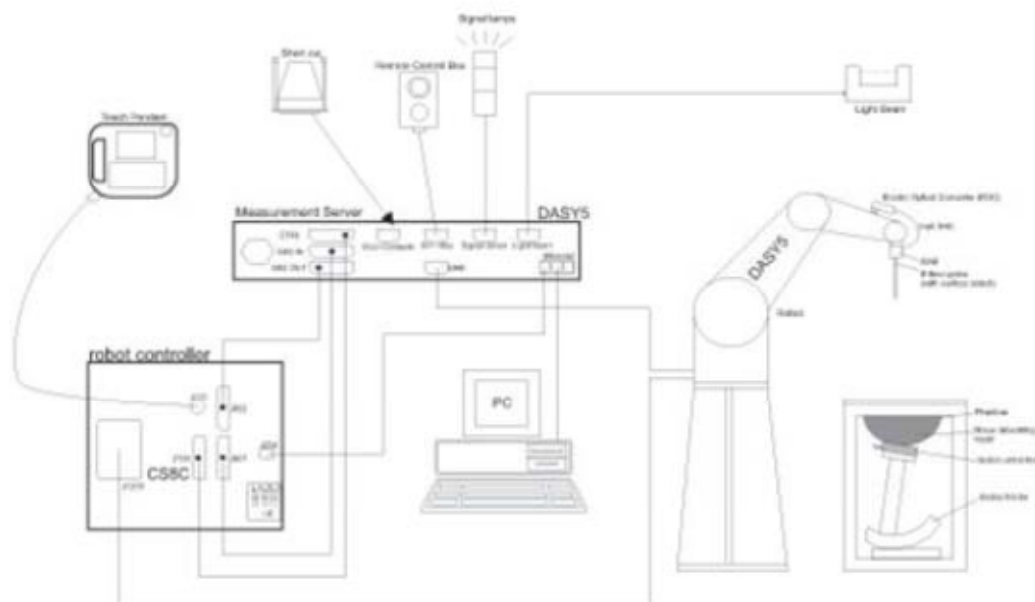
To determine the initial test position, Area Scans were performed to determine the position with the Maximum Value of SAR (measured). The position that produced the highest Maximum Value of SAR is considered the worst case position; thus used as the initial test position.

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

## 6 SAR Measurements System Configuration

### 6.1 SAR Measurement Set-up

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



- A standard high precision 6-axis robot with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic Field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running WinXP or Win7 and the DASY software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.

## 6.2 DASY5 E-field Probe System

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

### EX3DV4 Probe Specification

|               |                                                                                                                                                                                                            |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Construction  | Symmetrical design with triangular core<br>Built-in shielding against static charges<br>PEEK enclosure material (resistant to organic solvents, e.g., DGBE)                                                |
| Calibration   | ISO/IEC 17025 calibration<br>service available                                                                                                                                                             |
| Frequency     | 10 MHz to > 6 GHz<br>Linearity: $\pm 0.2$ dB<br>(30 MHz to 6 GHz)                                                                                                                                          |
| Directivity   | $\pm 0.3$ dB in HSL (rotation around probe axis) $\pm 0.5$ dB in tissue material (rotation normal to probe axis)                                                                                           |
| Dynamic Range | 10 $\mu$ W/g to > 100 mW/g Linearity: $\pm 0.2$ dB (noise: typically < 1 $\mu$ W/g)                                                                                                                        |
| Dimensions    | Overall length: 330 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm)<br>Typical distance from probe tip to dipole centers: 1 mm                                                                          |
| Application   | High precision dosimetric measurements in any exposure Scenario (e.g., very strong gradient fields). Only probe which enables compliance testing for frequencies up to 6 GHz with precision of better 30%. |



### E-field Probe Calibration

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

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies below 1 GHz, and in a wave guide above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is then rotated 360 degrees.

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

$$SAR = C \Delta T / \Delta t$$

Where:  $\Delta t$  = Exposure time (30 seconds),  
 $C$  = Heat capacity of tissue (brain or muscle),  
 $\Delta T$  = Temperature increase due to RF exposure.

Or

$$SAR = IEI^2 \sigma / \rho$$

Where:  $\sigma$  = Simulated tissue conductivity,  
 $\rho$  = Tissue density ( $\text{kg/m}^3$ ).

## 6.3 SAR Measurement Procedure

### Power Reference Measurement

The Power Reference Measurement and Power Drift Measurements are for monitoring the power drift of the device under test in the batch process. The minimum distance of probe sensors to surface determines the closest measurement point to phantom surface. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

### Area Scan

The area scan is used as a fast scan in two dimensions to find the area of high field values, before doing a fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASY software can find the maximum found in the scanned area, within a range of the global maximum. The range (in dB) is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE standard 1528 and IEC 62209 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan), if only one zoom scan follows the area scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of zoom scans has to be increased accordingly.

Area scan parameters extracted from FCC KDB 865664 D01 SAR measurement 100 MHz to 6 GHz.

|                                                                                                        | $\leq 3$ GHz                                                                                                                                                                                                                                                           | $> 3$ GHz                                              |
|--------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface | $5 \pm 1$ mm                                                                                                                                                                                                                                                           | $\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5$ 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:<br>$\Delta x_{\text{Area}}, \Delta y_{\text{Area}}$              | $\leq 2$ GHz: $\leq 15$ mm<br>$2 - 3$ GHz: $\leq 12$ mm                                                                                                                                                                                                                | $3 - 4$ GHz: $\leq 12$ mm<br>$4 - 6$ GHz: $\leq 10$ 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. |                                                        |

## Zoom Scan

Zoom scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 gram and 10 gram of simulated tissue. The zoom scan measures points (refer to table below) within a cube whose base faces are centered on the maxima found in a preceding area scan job within the same procedure. When the measurement is done, the zoom scan evaluates the averaged SAR for 1 gram and 10 gram and displays these values next to the job's label.

Zoom scan parameters extracted from FCC KDB 865664 D01 SAR measurement 100 MHz to 6 GHz.

|                                                                                                                                                                                                                                                                            |                                           |                                                                                             | ≤3GHz                               | > 3 GHz                                               |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|---------------------------------------------------------------------------------------------|-------------------------------------|-------------------------------------------------------|
| Maximum zoom scan spatial resolution: $\Delta x_{\text{zoom}} \Delta y_{\text{zoom}}$                                                                                                                                                                                      |                                           |                                                                                             | ≤2GHz: ≤8mm<br>2 – 3GHz: ≤5mm*      | 3 – 4GHz: ≤5mm*<br>4 – 6GHz: ≤4mm*                    |
| Maximum zoom scan spatial resolution, normal to phantom surface                                                                                                                                                                                                            | Uniform grid: $\Delta z_{\text{zoom}}(n)$ |                                                                                             | ≤5mm                                | 3 – 4GHz: ≤4mm<br>4 – 5GHz: ≤3mm<br>5 – 6GHz: ≤2mm    |
|                                                                                                                                                                                                                                                                            | Graded grid                               | $\Delta z_{\text{zoom}}(1)$ : between 1 <sup>st</sup> two points closest to phantom surface | ≤4mm                                | 3 – 4GHz: ≤3mm<br>4 – 5GHz: ≤2.5mm<br>5 – 6GHz: ≤2mm  |
|                                                                                                                                                                                                                                                                            |                                           | $\Delta z_{\text{zoom}}(n>1)$ : between subsequent points                                   | ≤1.5• $\Delta z_{\text{zoom}}(n-1)$ |                                                       |
| Minimum zoom scan volume                                                                                                                                                                                                                                                   | X, y, z                                   |                                                                                             | ≥30mm                               | 3 – 4GHz: ≥28mm<br>4 – 5GHz: ≥25mm<br>5 – 6GHz: ≥22mm |
| Note: $\delta$ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 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 447498 is ≤ 1.4W/kg, ≤8mm, ≤7mm and ≤5mm zoom scan resolution may be applied, respectively, for 2GHz to 3GHz, 3GHz to 4GHz and 4GHz to 6GHz. |                                           |                                                                                             |                                     |                                                       |

## Volume Scan Procedures

The volume scan is used to assess overlapping SAR distributions for antennas transmitting in different frequency bands. It is equivalent to an oversized zoom scan used in standalone measurements. The measurement volume will be used to enclose all the simultaneous transmitting antennas. For antennas transmitting simultaneously in different frequency bands, the volume scan is measured separately in each frequency band. In order to sum correctly to compute the 1g aggregate SAR, the EUT remain in the same test position for all measurements and all volume scan use the same spatial resolution and grid spacing. When all volume scan were completed, the software, SEMCAD postprocessor can combine and subsequently superpose these measurement data to calculating the multiband SAR.

## Power Drift Monitoring

All SAR testing is under the EUT install full charged battery and transmit maximum output power. In DASY measurement software, the power reference measurement and power drift measurement procedures are used for monitoring the power drift of EUT during SAR test. Both these procedures measure the field at a specified reference position before and after the SAR testing. The software will calculate the field difference in dB. If the power drifts more than 5%, the SAR will be retested.



## 7 Main Test Equipment

| Name of Equipment        | Manufacturer    | Type/Model | Serial Number | Last Cal.  | Cal. Due Date |
|--------------------------|-----------------|------------|---------------|------------|---------------|
| Network analyzer         | Agilent         | E5071B     | MY42404014    | 2019-05-19 | 2020-05-18    |
| Dielectric Probe Kit     | HP              | 85070E     | US44020115    | 2019-05-19 | 2020-05-18    |
| Power meter              | Agilent         | E4417A     | GB41291714    | 2019-05-19 | 2020-05-18    |
| Power sensor             | Agilent         | N8481H     | MY50350004    | 2019-05-19 | 2020-05-18    |
| Power sensor             | Agilent         | E9327A     | US40441622    | 2019-05-19 | 2020-05-18    |
| Dual directional coupler | Agilent         | 777D       | 50146         | 2019-05-19 | 2020-05-18    |
| Amplifier                | INDEXSAR        | IXA-020    | 0401          | 2019-05-19 | 2020-05-18    |
| Base Station Simulator   | R&S             | CMW270     | 100673        | 2019-05-19 | 2020-05-18    |
| E-field Probe            | SPEAG           | EX3DV4     | 3677          | 2019-06-19 | 2020-06-18    |
| DAE                      | SPEAG           | DAE4       | 1317          | 2019-10-23 | 2020-10-22    |
| Validation Kit 2450MHz   | SPEAG           | D2450V2    | 786           | 2017-08-29 | 2020-08-28    |
| Temperature Probe        | Tianjin jinming | JM222      | AA1009129     | 2019-05-19 | 2020-05-18    |
| Hygrothermograph         | Anymetr         | NT-311     | 20150731      | 2019-05-19 | 2020-05-18    |
| Software for Test        | Speag           | DASY5      | 52.10         | /          | /             |
| Softwarefor Tissue       | Agilent         | 85070      | E06.01.36     | /          | /             |



## 8 Tissue Dielectric Parameter Measurements & System Verification

### 8.1 Tissue Verification

The temperature of the tissue-equivalent medium used during measurement must also be within 18°C to 25°C and within  $\pm 2^\circ\text{C}$  of the temperature when the tissue parameters are characterized. The dielectric parameters must be measured before the tissue-equivalent medium is used in a series of SAR measurements. The parameters should be re-measured after each 3 – 4 days of use; or earlier if the dielectric parameters can become out of tolerance.

#### Target values

| Frequency<br>(MHz) | Water<br>(%) | Salt<br>(%) | Sugar<br>(%) | Glycol<br>(%) | Preventol<br>(%) | Cellulose<br>(%) | $\epsilon_r$ | $\sigma(\text{s/m})$ |
|--------------------|--------------|-------------|--------------|---------------|------------------|------------------|--------------|----------------------|
| 2450               | 62.7         | 0.5         | 0            | 36.8          | 0                | 0                | 39.2         | 1.80                 |

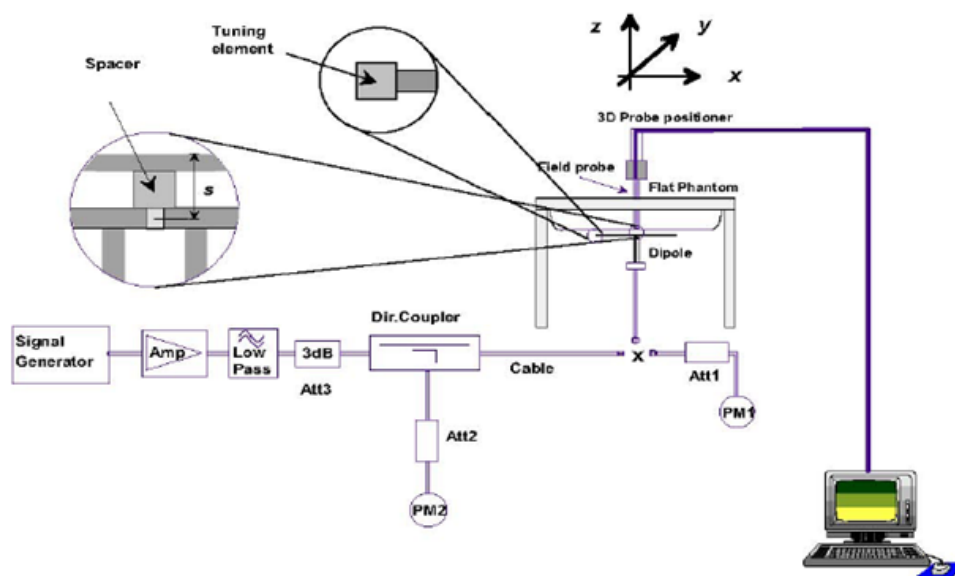
## Measurements results

| Frequency<br>(MHz)                                                                                                                                               | Test Date | Temp<br>℃ | Measured Dielectric<br>Parameters |                | Target Dielectric<br>Parameters |                | Limit<br>(Within ±5%)   |                     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------|-----------------------------------|----------------|---------------------------------|----------------|-------------------------|---------------------|
|                                                                                                                                                                  |           |           | $\epsilon_r$                      | $\sigma$ (s/m) | $\epsilon_r$                    | $\sigma$ (s/m) | Dev<br>$\epsilon_r$ (%) | Dev<br>$\sigma$ (%) |
| 2450                                                                                                                                                             | 2/29/2020 | 21.5      | 38.6                              | 1.81           | 39.2                            | 1.80           | -1.53                   | 0.56                |
| Note: The depth of tissue-equivalent liquid in a phantom must be $\geq 15.0$ cm for SAR measurements $\leq 3$ GHz and $\geq 10.0$ cm for measurements $> 3$ GHz. |           |           |                                   |                |                                 |                |                         |                     |

## 8.2 System Performance Check

The manufacturer calibrates the probes annually. Dielectric parameters of the tissue simulates were measured using the dielectric probe kit and the network analyzer. A system check measurement for every day was made following the determination of the dielectric parameters of the Tissue simulates, using the dipole validation kit. The dipole antenna was placed under the flat section of the twin SAM phantom.

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



Picture 1 System Performance Check setup



Picture 2 Setup Photo

### Justification for Extended SAR Dipole Calibrations

Usage of SAR dipoles calibrated less than 3 years ago but more than 1 year ago were confirmed in maintaining return loss ( $< -20$  dB, within 20% of prior calibration) and impedance (within 5 ohm from prior calibration) requirements per extended calibrations in KDB 865664 D01:

| Dipole                       |                | Date of Measurement | Return Loss(dB) | $\Delta$ % | Impedance ( $\Omega$ ) | $\Delta\Omega$ |
|------------------------------|----------------|---------------------|-----------------|------------|------------------------|----------------|
| Dipole<br>D2450V2<br>SN: 786 | Head<br>Liquid | 8/29/2017           | -25.5           | /          | 53.4                   | /              |
|                              |                | 8/28/2018           | -23.0           | 10.9       | 57.2                   | -3.8           |
|                              |                | 8/27/2019           | -22.2           | 3.6        | 56.4                   | 0.8            |

### System Check results

| Frequency<br>(MHz)                                                                            | Test Date | Temp<br>°C | 250mW<br>Measured<br>SAR <sub>1g</sub><br>(W/kg) | 1W<br>Normalized<br>SAR <sub>1g</sub><br>(W/kg) | 1W<br>Target<br>SAR <sub>1g</sub><br>(W/kg) | $\Delta$ %<br>(Limit<br>$\pm 10\%$ ) | Plot<br>No. |
|-----------------------------------------------------------------------------------------------|-----------|------------|--------------------------------------------------|-------------------------------------------------|---------------------------------------------|--------------------------------------|-------------|
| 2450                                                                                          | 2/29/2020 | 21.5       | 13.7                                             | 54.80                                           | 52.6                                        | 4.18                                 | 1           |
| Note: Target Values used derive from the calibration certificate Data Storage and Evaluation. |           |            |                                                  |                                                 |                                             |                                      |             |

### 8.3 SAR System Validation

Per FCC KDB 865664 D02v01, SAR system verification is required to confirm measurement accuracy. The SAR systems (including SAR probes, system components and software versions) used for this device were validated against its performance specifications prior to the SAR measurements. Reference dipoles are used with the required tissue-equivalent media for system validation, according to the procedures outlined in FCC KDB 865664 D01 and IEEE 1528-2013. Since SAR probe calibrations are frequency dependent, each probe calibration point must be validated at a frequency within the valid frequency range of the probe calibration point, using the system that normally operates with the probe for routine SAR measurements and according to the required tissue-equivalent media.

a tabulated summary of the system validation status, measurement frequencies, SAR probes, calibrated signal type(s) and tissue dielectric parameters has been included.

| Frequency [MHz] | Date      | Probe SN | Probe Type | Probe Cal Point |      | PERM (Er) | COND (Σ) | CW Validation |                 |                | Mod. Validation |             |      |
|-----------------|-----------|----------|------------|-----------------|------|-----------|----------|---------------|-----------------|----------------|-----------------|-------------|------|
|                 |           |          |            |                 |      |           |          | Sensitivity   | Probe Linearity | Probe Isotropy | Mod. Type       | Duty Factor | PAR  |
| 750             | 6/25/2019 | 3677     | EX3DV4     | 750             | Head | 42.81     | 0.85     | PASS          | PASS            | PASS           | FDD             | PASS        | N/A  |
| 835             | 6/25/2019 | 3677     | EX3DV4     | 835             | Head | 42.22     | 0.90     | PASS          | PASS            | PASS           | GMSK            | PASS        | N/A  |
| 1750            | 6/25/2019 | 3677     | EX3DV4     | 1750            | Head | 39.91     | 1.32     | PASS          | PASS            | PASS           | NA              | N/A         | N/A  |
| 1900            | 6/25/2019 | 3677     | EX3DV4     | 1900            | Head | 39.43     | 1.42     | PASS          | PASS            | PASS           | GMSK            | PASS        | N/A  |
| 2450            | 6/25/2019 | 3677     | EX3DV4     | 2450            | Head | 38.19     | 1.83     | PASS          | PASS            | PASS           | OFDM            | PASS        | PASS |
| 2600            | 6/25/2019 | 3677     | EX3DV4     | 2600            | Head | 37.60     | 1.99     | PASS          | PASS            | PASS           | TDD             | PASS        | N/A  |
| 5250            | 6/25/2019 | 3677     | EX3DV4     | 5250            | Head | 35.36     | 4.83     | PASS          | PASS            | PASS           | OFDM            | N/A         | PASS |
| 5600            | 6/25/2019 | 3677     | EX3DV4     | 5600            | Head | 34.43     | 5.29     | PASS          | PASS            | PASS           | OFDM            | N/A         | PASS |
| 5750            | 6/25/2019 | 3677     | EX3DV4     | 5750            | Head | 34.07     | 5.47     | PASS          | PASS            | PASS           | OFDM            | N/A         | PASS |
| 750             | 6/25/2019 | 3677     | EX3DV4     | 750             | Body | 55.35     | 0.99     | PASS          | PASS            | PASS           | FDD             | PASS        | N/A  |
| 835             | 6/25/2019 | 3677     | EX3DV4     | 835             | Body | 54.88     | 0.98     | PASS          | PASS            | PASS           | GMSK            | PASS        | N/A  |
| 1750            | 6/25/2019 | 3677     | EX3DV4     | 1750            | Body | 51.24     | 1.44     | PASS          | PASS            | PASS           | NA              | N/A         | N/A  |
| 1900            | 6/25/2019 | 3677     | EX3DV4     | 1900            | Body | 50.98     | 1.56     | PASS          | PASS            | PASS           | GMSK            | PASS        | N/A  |
| 2450            | 6/25/2019 | 3677     | EX3DV4     | 2450            | Body | 50.59     | 1.95     | PASS          | PASS            | PASS           | OFDM            | PASS        | PASS |
| 2600            | 6/25/2019 | 3677     | EX3DV4     | 2600            | Body | 50.14     | 2.13     | PASS          | PASS            | PASS           | TDD             | PASS        | N/A  |
| 5250            | 6/25/2019 | 3677     | EX3DV4     | 5250            | Body | 47.37     | 5.44     | PASS          | PASS            | PASS           | OFDM            | N/A         | PASS |
| 5600            | 6/25/2019 | 3677     | EX3DV4     | 5600            | Body | 46.42     | 5.99     | PASS          | PASS            | PASS           | OFDM            | N/A         | PASS |
| 5750            | 6/25/2019 | 3677     | EX3DV4     | 5750            | Body | 46.02     | 6.23     | PASS          | PASS            | PASS           | OFDM            | N/A         | PASS |

NOTE: While the probes have been calibrated for both CW and modulated signals, all measurements were performed using communication systems calibrated for CW signals only. Modulations in the table above represent test configurations for which the measurement system has been validated per FCC KDB Publication 865664D01v01 for scenarios when CW probe calibrations are used with other signal types. SAR systems were validated for modulated signals with a periodic duty cycle, such as GMSK, or with a high peak to average ratio (>5dB), such as OFDM according to KDB 865664.

## 9 Normal and Maximum Output Power

KDB 447498 D01 at the maximum rated output power and within the tune-up tolerance range specified for the product, but not more than 2 dB lower than the maximum tune-up tolerance limit.

### 9.1 WLAN Mode

| Wi-Fi 2.4G<br>Mode     | Channel<br>/Frequency(MHz) | Maximum Output Power (dBm) |       |              |
|------------------------|----------------------------|----------------------------|-------|--------------|
|                        |                            | Tune-up                    | Meas. | TP Set Level |
| 802.11b<br>(1M)        | 1/2412                     | 19.00                      | 17.83 | 17           |
|                        | 6/2437                     | 19.00                      | 17.77 | 17           |
|                        | 11/2462                    | 19.00                      | 17.93 | 17           |
| 802.11g<br>(6M)        | 1/2412                     | 15.00                      | 14.15 | 13           |
|                        | 6/2437                     | 15.00                      | 14.02 | 13           |
|                        | 11/2462                    | 15.00                      | 14.23 | 13           |
| 802.11n-HT20<br>(MCS0) | 1/2412                     | 14.00                      | 13.16 | 12           |
|                        | 6/2437                     | 14.00                      | 12.99 | 12           |
|                        | 11/2462                    | 14.00                      | 13.02 | 12           |

Note: Initial test configuration is 802.11b mode.

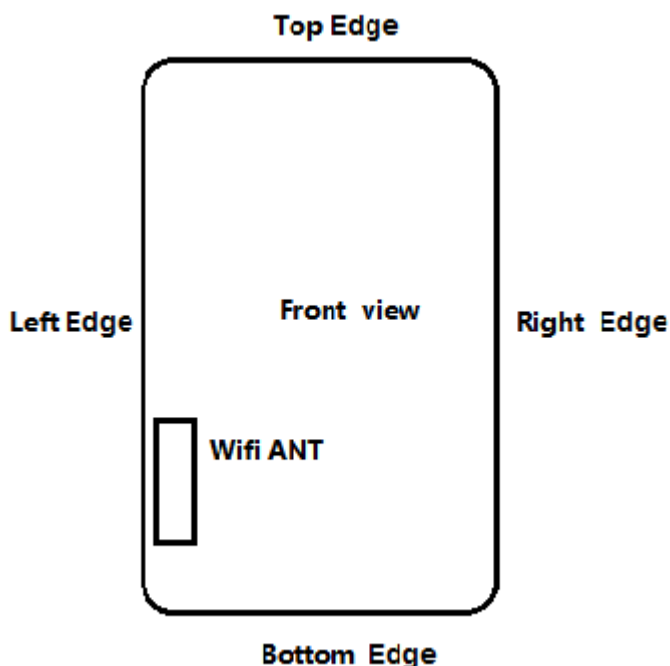


## 9.2 Bluetooth Mode

| BLE  | Conducted Power(dBm)   |                |                | Tune-up<br>Limit (dBm) |
|------|------------------------|----------------|----------------|------------------------|
|      | Channel/Frequency(MHz) |                |                |                        |
|      | Ch 0/2402 MHz          | Ch 19/2440 MHz | Ch 39/2480 MHz |                        |
| GFSK | 6.84                   | 7.46           | 6.70           | 9.00                   |

## 10 Measured and Reported (Scaled) SAR Results

### 10.1 EUT Antenna Locations



Overall (Length x Width): 93.7 mm x 68.7 mm

Overall Diagonal: 116.2 mm

Distance of the Antenna to the EUT surface/edge

| Antenna          | Back Side | Front side | Left Edge | Right Edge | Top Edge | Bottom Edge |
|------------------|-----------|------------|-----------|------------|----------|-------------|
| BT/Wi-Fi Antenna | <25mm     | <25mm      | <25mm     | >25mm      | >25mm    | <25mm       |

Hotspot mode, Positions for SAR tests

| Mode             | Back Side | Front side | Left Edge | Right Edge | Top Edge | Bottom Edge |
|------------------|-----------|------------|-----------|------------|----------|-------------|
| BT/Wi-Fi Antenna | Yes       | Yes        | Yes       | NA         | NA       | Yes         |

Note: 1. Per KDB 941225 D06, when the overall device length and width are  $\geq 9\text{cm} \times 5\text{cm}$ , the test distance is 10mm. SAR must be measured for all sides and surfaces with a transmitting antenna located within 25mm from that surface or edge.

2. Per FCC KDB 447498 D01,

for each exposure position, testing of other required channels within the operating mode of a frequency band is not required when the reported 1-g or 10-g SAR for the mid-band or highest output power channel is:

a)  $\leq 0.8 \text{ W/kg}$  or  $2.0 \text{ W/kg}$ , for 1-g or 10-g respectively, when the transmission band is  $\leq 100\text{MHz}$

b)  $\leq 0.6 \text{ W/kg}$  or  $1.5 \text{ W/kg}$ , for 1-g or 10-g respectively, when the transmission band is between 100 MHz and 200 MHz.

c)  $\leq 0.4 \text{ W/kg}$  or  $1.0 \text{ W/kg}$ , for 1-g or 10-g respectively, when the transmission band is  $\geq 200 \text{ MHz}$ .

3. When the original highest measured SAR is  $\geq 0.80 \text{ W/kg}$ , the measurement was repeated once.

4. Per FCC KDB Publication 648474 D04, SAR was evaluated without a headset connected to the device. Since the reported SAR was  $\leq 1.2 \text{ W/kg}$ , no additional SAR evaluations using a headset cable were required.



## 10.2 Standalone SAR test exclusion considerations

Per KDB 447498 D01, the 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances  $\leq 50$  mm are determined by:

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

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

Per KDB 447498 D01, when the minimum test separation distance is  $< 5$  mm, a distance of 5 mm is applied to determine SAR test exclusion.

| Bluetooth | Distance (mm) | MAXPower (dBm) | Frequency (MHz) | Ratio | Evaluation |
|-----------|---------------|----------------|-----------------|-------|------------|
| Body      | 5             | 9              | 2480            | 2.50  | No         |



### 10.3 Measured SAR Results

Table 2: Wi-Fi (2.4G)

| Test Position           | Cover Type | Mode 802.11b | Duty Cycle | Channel/ Frequency (MHz) | Tune-up dBm) | Measured power (dBm) | Limit of SAR 1.6 W/kg (mW/g) |                  |                  |                |               | Plot No. |
|-------------------------|------------|--------------|------------|--------------------------|--------------|----------------------|------------------------------|------------------|------------------|----------------|---------------|----------|
|                         |            |              |            |                          |              |                      | Area Scan SAR 1g             | Zoom Scan SAR 1g | Power Drift (dB) | Scaling Factor | Report SAR 1g |          |
| Body SAR (Distance 5mm) |            |              |            |                          |              |                      |                              |                  |                  |                |               |          |
| Back Side               | standard   | DSSS         | 1:1.01     | 11/2462                  | 19.00        | 17.93                | 0.106                        | 0.107            | 0.034            | 1.29           | 0.138         | /        |
| Front Side              | standard   | DSSS         | 1:1.01     | 11/2462                  | 19.00        | 17.93                | 0.180                        | 0.203            | 0.141            | 1.29           | 0.262         | 2        |
| Left Edge               | standard   | DSSS         | 1:1.01     | 11/2462                  | 19.00        | 17.93                | 0.141                        | 0.147            | -0.010           | 1.29           | 0.190         | /        |
| Right Edge              | standard   | DSSS         | 1:1.01     | 11/2462                  | 19.00        | 17.93                | 0.116                        | 0.110            | 0.098            | 1.29           | 0.142         | /        |
| Top Edge                | standard   | DSSS         | 1:1.01     | 11/2462                  | 19.00        | 17.93                | 0.041                        | 0.037            | 0.063            | 1.29           | 0.047         | /        |
| Bottom Edge             | standard   | DSSS         | 1:1.01     | 11/2462                  | 19.00        | 17.93                | 0.042                        | 0.024            | -0.082           | 1.29           | 0.030         | /        |

Note: 1. The value with blue color is the maximum SAR Value of each test band.

**Table 3: BT**

| Band                                                                                                                                                                                                                                                                                                                                                                                                                     | Configuration | Frequency (MHz) | Maximum Power (dBm) | Separation Distance (mm) | Estimated SAR (W/kg) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-----------------|---------------------|--------------------------|----------------------|
| Bluetooth                                                                                                                                                                                                                                                                                                                                                                                                                | Body          | 2480            | 9                   | 5                        | 0.334                |
| <p>For simultaneous transmission analysis, Bluetooth SAR is estimated per KDB 447498 D01 based on the formula below.</p> <p>(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm) · [<math>\sqrt{f(\text{GHz})/x}</math>] W/kg</p> <p>for test separation distances <math>\leq 50</math> mm; where <math>x = 7.5</math> for 1-g SAR, and <math>x = 18.75</math> for 10-g SAR.</p> |               |                 |                     |                          |                      |



## 11 Measurement Uncertainty

Per KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz, when the highest measured 1-g SAR within a frequency band is  $< 1.5$  W/kg, the extensive SAR measurement uncertainty analysis described in IEEE Std 1528- 2013 is not required in SAR reports submitted for equipment approval.

## ANNEX A: Test Layout



### Tissue Simulating Liquids

For the measurement of the field distribution inside the flat phantom with DASY, the phantom must be filled with around 25 liters of homogeneous body tissue simulating liquid. For Body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15 cm, which is shown in Picture 3.



Picture 3: Liquid depth in the flat Phantom

## ANNEX B: System Check Results

### Plot 1 System Performance Check at 2450 MHz TSL

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2

Date: 2/29/2020

Communication System: CW; Frequency: 2450 MHz; Duty Cycle: 1:1

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.81$  S/m;  $\epsilon_r = 38.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature: 22.3 °C      Liquid Temperature: 21.5 °C

Phantom section: Flat Section

DASY5 Configuration:

Sensor-Surface: 1.4mm (Mechanical Surface Detection)

Probe: EX3DV4 - SN3677; ConvF(7.50, 7.50, 7.50); Calibrated: 6/19/2019;

Electronics: DAE4 SN1317; Calibrated: 10/23/2019

Phantom: SAM1; Type: SAM; Serial: TP-1534

Measurement SW: DASY52, Version 52.10 (1); SEMCAD X Version 14.6.11 (7439)

**d=10mm, Pin=250mW/Area Scan (41x71x1):** Measurement grid: dx=12mm, dy=12mm

Maximum value of SAR (interpolated) = 18.2 mW/g

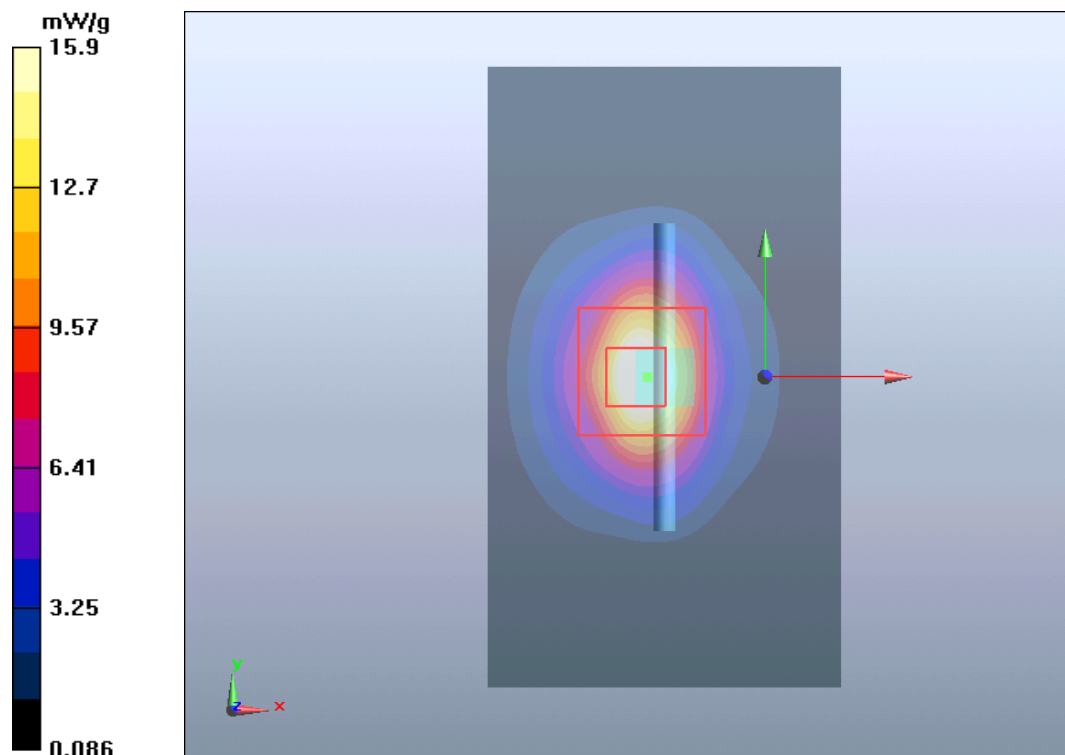
**d=10mm, Pin=250mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 88.8 V/m; Power Drift = 0.075 dB

Peak SAR (extrapolated) = 30 W/kg

**SAR(1 g) = 13.7 mW/g; SAR(10 g) = 6.22 mW/g**

Maximum value of SAR (measured) = 15.9 mW/g



## ANNEX C: Highest Graph Results

### Wi-Fi-Antenna

#### Plot 2 802.11b Front Side High(Distance 5mm)

Date: 2/29/2020

Communication System: UID 0, 802.11b (0); Frequency: 2462 MHz; Duty Cycle: 1:1.01

Medium parameters used:  $f = 2462$  MHz;  $\sigma = 1.886$  S/m;  $\epsilon_r = 40.724$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature: 22.3 °C      Liquid Temperature: 21.5 °C

Phantom section: Flat Section

DASY5 Configuration:

Sensor-Surface: 1.4mm (Mechanical Surface Detection)

Probe: EX3DV4 - SN3677; ConvF(7.50, 7.50, 7.50); Calibrated: 6/19/2019;

Electronics: DAE4 SN1317; Calibrated: 10/23/2019

Phantom: SAM1; Type: SAM; Serial: TP-1534

Measurement SW: DASY52, Version 52.10 (1); SEMCAD X Version 14.6.11 (7439)

**Front Side High/Area Scan (81x101x1):** Interpolated grid: dx=12 mm, dy=12 mm

Maximum value of SAR (interpolated) = 0.246 W/kg

**Front Side High/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

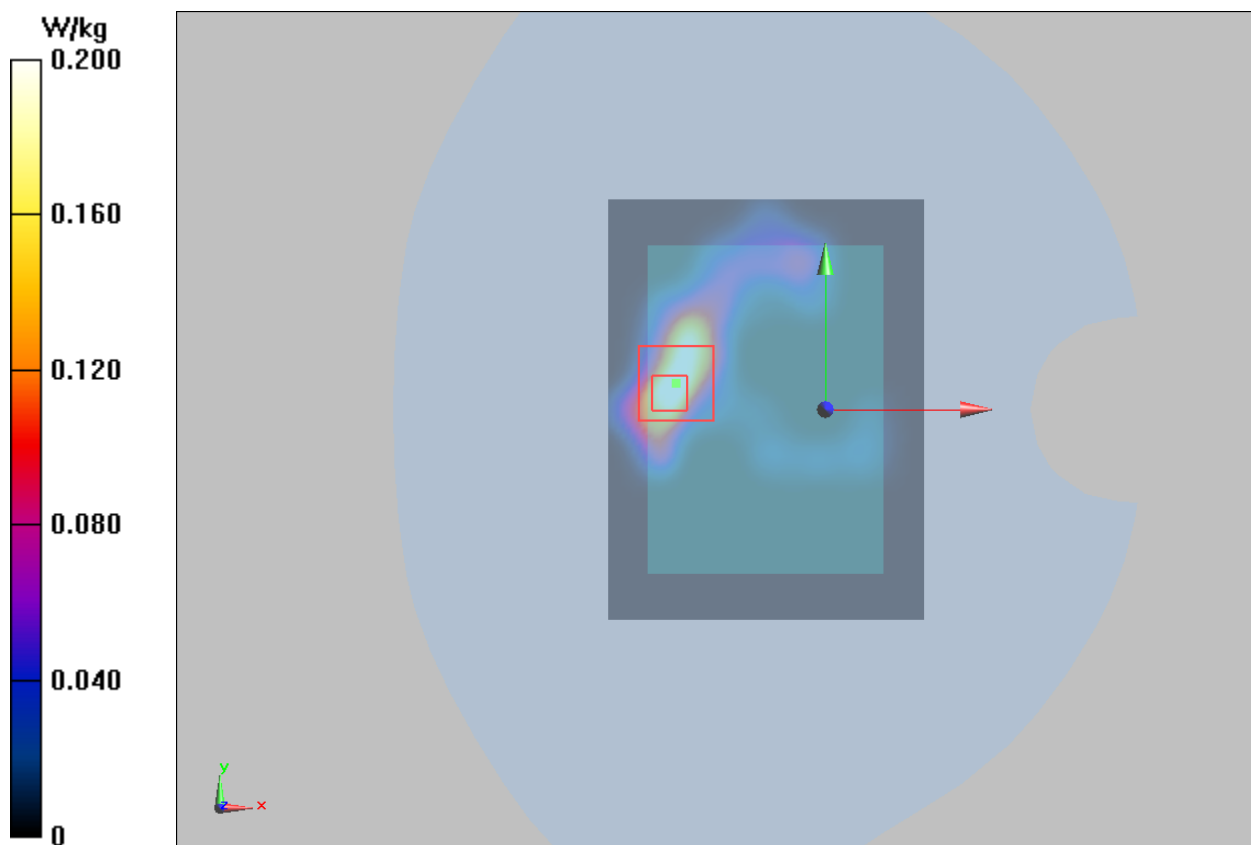
Reference Value = 2.831 V/m; Power Drift = 0.141 dB

Peak SAR (extrapolated) = 0.757 W/kg

**SAR(1 g) = 0.203 W/kg; SAR(10 g) = 0.077 W/kg**

Maximum value of SAR (measured) = 0.200 W/kg







## ANNEX D: Probe Calibration Certificate



In Collaboration with  
**s p e a g**  
CALIBRATION LABORATORY



中国认可  
国际互认  
校准  
CALIBRATION  
CNAS L0570

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E-mail: cttl@chinattl.com Http://www.chinattl.cn

Client

TA(Shanghai)

Certificate No: Z19-60169

## CALIBRATION CERTIFICATE

Object

EX3DV4 - SN:3677

Calibration Procedure(s)

FF-Z11-004-01

Calibration Procedures for Dosimetric E-field Probes

Calibration date:

June 19, 2019

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

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

Calibration Equipment used (M&amp;TE critical for calibration)

| Primary Standards       | ID #        | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
|-------------------------|-------------|------------------------------------------|-----------------------|
| Power Meter NRP2        | 101919      | 20-Jun-18 (CTTL, No.J18X05032)           | Jun-19                |
| Power sensor NRP-Z91    | 101547      | 20-Jun-18 (CTTL, No.J18X05032)           | Jun-19                |
| Power sensor NRP-Z91    | 101548      | 20-Jun-18 (CTTL, No.J18X05032)           | Jun-19                |
| Reference10dBAttenuator | 18N50W-10dB | 09-Feb-18(CTTL, No.J18X01133)            | Feb-20                |
| Reference20dBAttenuator | 18N50W-20dB | 09-Feb-18(CTTL, No.J18X01132)            | Feb-20                |
| Reference Probe EX3DV4  | SN 3617     | 31-Jan-19(SPEAG,No.EX3-3617_Jan19)       | Jan-20                |
| DAE4                    | SN 1331     | 06-Feb-19(SPEAG, No.DAE4-1331_Feb19)     | Feb -20               |
| Secondary Standards     | ID #        | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
| SignalGeneratorMG3700A  | 6201052605  | 21-Jun-18 (CTTL, No.J18X05033)           | Jun-19                |
| Network Analyzer E5071C | MY46110673  | 24-Jan-19 (CTTL, No.J19X00547)           | Jan -20               |

Calibrated by:

Name

Yu Zongying

Function

SAR Test Engineer

Reviewed by:

Lin Hao

SAR Test Engineer

Approved by:

Qi Dianyuan

SAR Project Leader

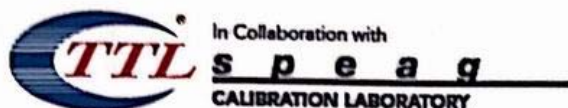


Issued: June 20, 2019

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

Certificate No: Z19-60169

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### Glossary:

|                       |                                                                                                                                        |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| TSL                   | tissue simulating liquid                                                                                                               |
| NORM <sub>x,y,z</sub> | sensitivity in free space                                                                                                              |
| ConvF                 | sensitivity in TSL / NORM <sub>x,y,z</sub>                                                                                             |
| DCP                   | diode compression point                                                                                                                |
| CF                    | crest factor (1/duty_cycle) of the RF signal                                                                                           |
| A,B,C,D               | modulation dependent linearization parameters                                                                                          |
| Polarization $\Phi$   | $\Phi$ rotation around probe axis                                                                                                      |
| Polarization $\theta$ | $\theta$ rotation around an axis that is in the plane normal to probe axis (at measurement center), $\theta=0$ 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<sub>x,y,z</sub>: Assessed for E-field polarization  $\theta=0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not effect the  $E^2$ -field uncertainty inside TSL (see below ConvF).
- NORM( $f$ )<sub>x,y,z</sub> = NORM<sub>x,y,z</sub> \* 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<sub>x,y,z</sub>: DCP are numerical linearization parameters assessed based on the data of power sweep (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<sub>x,y,z</sub>; B<sub>x,y,z</sub>; C<sub>x,y,z</sub>; VR<sub>x,y,z</sub>; A,B,C 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 valued are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM<sub>x,y,z</sub> \* 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  $\pm 50$  MHz to  $\pm 100$  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<sub>x</sub> (no uncertainty required).





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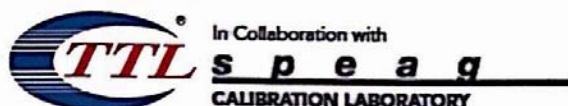
# Probe EX3DV4

## SN: 3677

Calibrated: June 19, 2019

Calibrated for DASY/EASY Systems

(Note: non-compatible with DASY2 system!)



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## DASY/EASY – Parameters of Probe: EX3DV4 – SN: 3677

### Basic Calibration Parameters

|                                                          | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|----------------------------------------------------------|----------|----------|----------|-----------|
| Norm( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup> | 0.41     | 0.46     | 0.40     | ±10.0%    |
| DCP(mV) <sup>B</sup>                                     | 101.1    | 102.9    | 101.9    |           |

### Modulation Calibration Parameters

| UID | Communication System Name |   | A dB | B dB $\mu\text{V}$ | C   | D dB | VR mV | Unc <sup>E</sup> (k=2) |
|-----|---------------------------|---|------|--------------------|-----|------|-------|------------------------|
| 0   | CW                        | X | 0.0  | 0.0                | 1.0 | 0.00 | 152.0 | ±2.6%                  |
|     |                           | Y | 0.0  | 0.0                | 1.0 |      | 170.1 |                        |
|     |                           | Z | 0.0  | 0.0                | 1.0 |      | 147.7 |                        |

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%.

<sup>A</sup> The uncertainties of Norm X, Y, Z do not affect the E<sup>2</sup>-field uncertainty inside TSL (see Page 5 and Page 6).

<sup>B</sup> Numerical linearization parameter: uncertainty not required.

<sup>E</sup> 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: 3677

### Calibration Parameter Determined in Head Tissue Simulating Media

| f [MHz] <sup>C</sup> | Relative Permittivity <sup>F</sup> | Conductivity (S/m) <sup>F</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>G</sup> | Depth <sup>G</sup> (mm) | Unct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 750                  | 41.9                               | 0.89                            | 9.54    | 9.54    | 9.54    | 0.11               | 1.56                    | ±12.1%      |
| 835                  | 41.5                               | 0.90                            | 9.20    | 9.20    | 9.20    | 0.11               | 1.61                    | ±12.1%      |
| 1750                 | 40.1                               | 1.37                            | 8.21    | 8.21    | 8.21    | 0.22               | 1.11                    | ±12.1%      |
| 1900                 | 40.0                               | 1.40                            | 7.79    | 7.79    | 7.79    | 0.22               | 1.04                    | ±12.1%      |
| 2300                 | 39.5                               | 1.67                            | 7.66    | 7.66    | 7.66    | 0.57               | 0.72                    | ±12.1%      |
| 2450                 | 39.2                               | 1.80                            | 7.50    | 7.50    | 7.50    | 0.59               | 0.71                    | ±12.1%      |
| 2600                 | 39.0                               | 1.96                            | 7.20    | 7.20    | 7.20    | 0.65               | 0.68                    | ±12.1%      |
| 5250                 | 35.9                               | 4.71                            | 5.56    | 5.56    | 5.56    | 0.40               | 1.40                    | ±13.3%      |
| 5600                 | 35.5                               | 5.07                            | 4.90    | 4.90    | 4.90    | 0.45               | 1.40                    | ±13.3%      |
| 5750                 | 35.4                               | 5.22                            | 4.99    | 4.99    | 4.99    | 0.50               | 1.35                    | ±13.3%      |

<sup>C</sup> Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of 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.

<sup>F</sup> At frequency below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) 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 ( $\epsilon$  and  $\sigma$ ) is restricted to ±5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

<sup>G</sup> 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 the 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: 3677

### Calibration Parameter Determined in Body Tissue Simulating Media

| f [MHz] <sup>C</sup> | Relative Permittivity <sup>F</sup> | Conductivity (S/m) <sup>F</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>G</sup> | Depth <sup>G</sup> (mm) | Unct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 750                  | 55.5                               | 0.96                            | 9.75    | 9.75    | 9.75    | 0.40               | 0.75                    | ±12.1%      |
| 835                  | 55.2                               | 0.97                            | 9.40    | 9.40    | 9.40    | 0.18               | 1.38                    | ±12.1%      |
| 1750                 | 53.4                               | 1.49                            | 7.86    | 7.86    | 7.86    | 0.23               | 1.09                    | ±12.1%      |
| 1900                 | 53.3                               | 1.52                            | 7.62    | 7.62    | 7.62    | 0.22               | 1.15                    | ±12.1%      |
| 2300                 | 52.9                               | 1.81                            | 7.67    | 7.67    | 7.67    | 0.55               | 0.81                    | ±12.1%      |
| 2450                 | 52.7                               | 1.95                            | 7.57    | 7.57    | 7.57    | 0.59               | 0.75                    | ±12.1%      |
| 2600                 | 52.5                               | 2.16                            | 7.33    | 7.33    | 7.33    | 0.74               | 0.65                    | ±12.1%      |
| 5250                 | 48.9                               | 5.36                            | 4.93    | 4.93    | 4.93    | 0.45               | 1.55                    | ±13.3%      |
| 5600                 | 48.5                               | 5.77                            | 4.24    | 4.24    | 4.24    | 0.50               | 1.45                    | ±13.3%      |
| 5750                 | 48.3                               | 5.94                            | 4.35    | 4.35    | 4.35    | 0.50               | 1.50                    | ±13.3%      |

<sup>C</sup> Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of 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.

<sup>F</sup> At frequency below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) 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 ( $\epsilon$  and  $\sigma$ ) is restricted to ±5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

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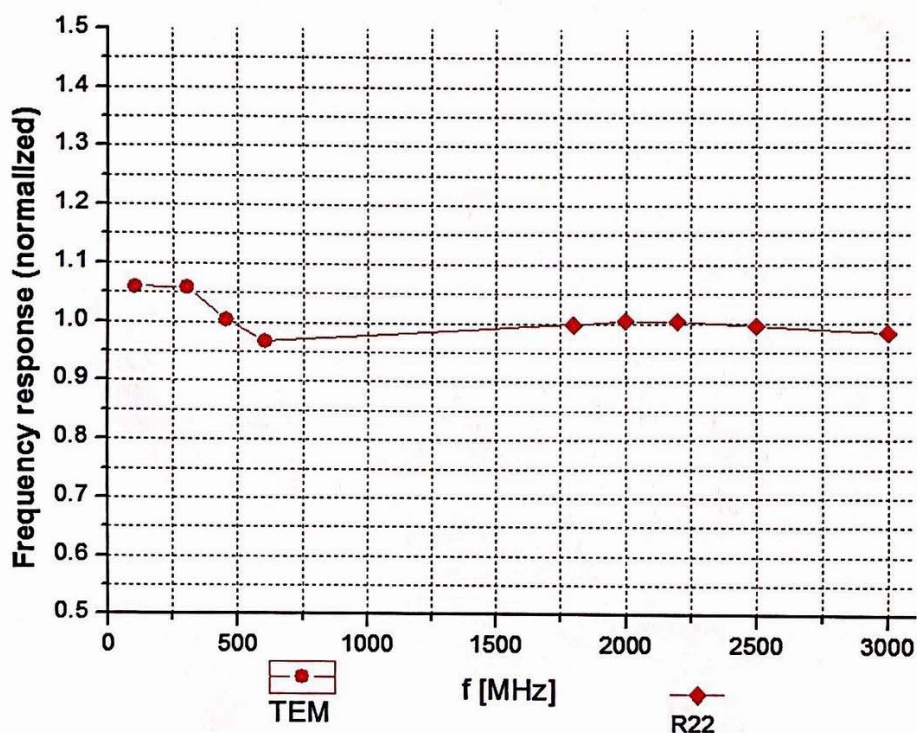




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## Frequency Response of E-Field (TEM-Cell: ifi110 EXX, Waveguide: R22)



Uncertainty of Frequency Response of E-field:  $\pm 7.4\%$  ( $k=2$ )





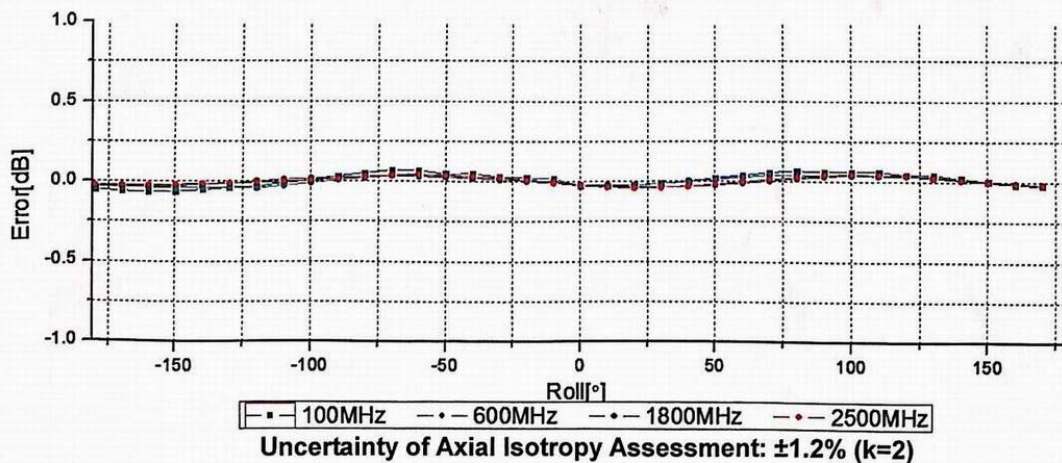
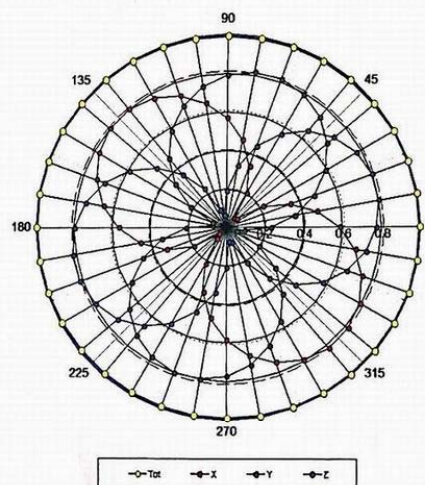
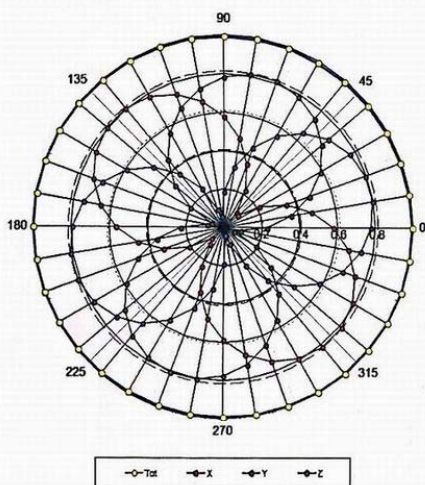
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## Receiving Pattern ( $\Phi$ ), $\theta=0^\circ$

**f=600 MHz, TEM**

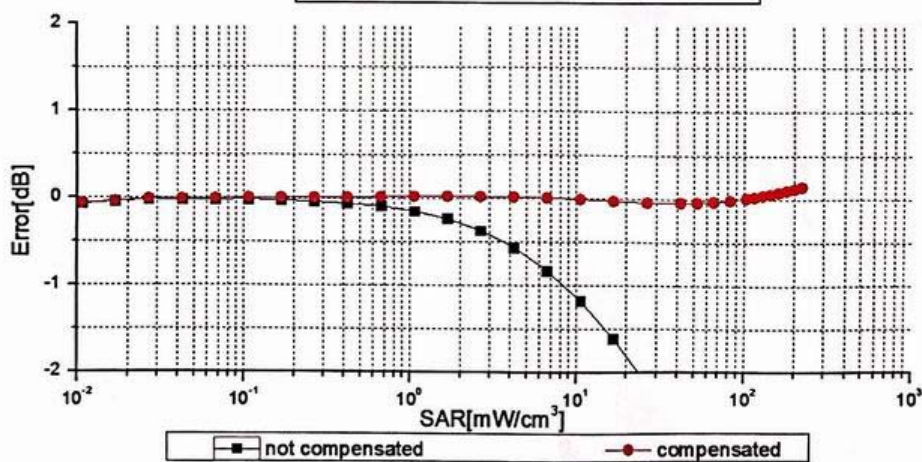
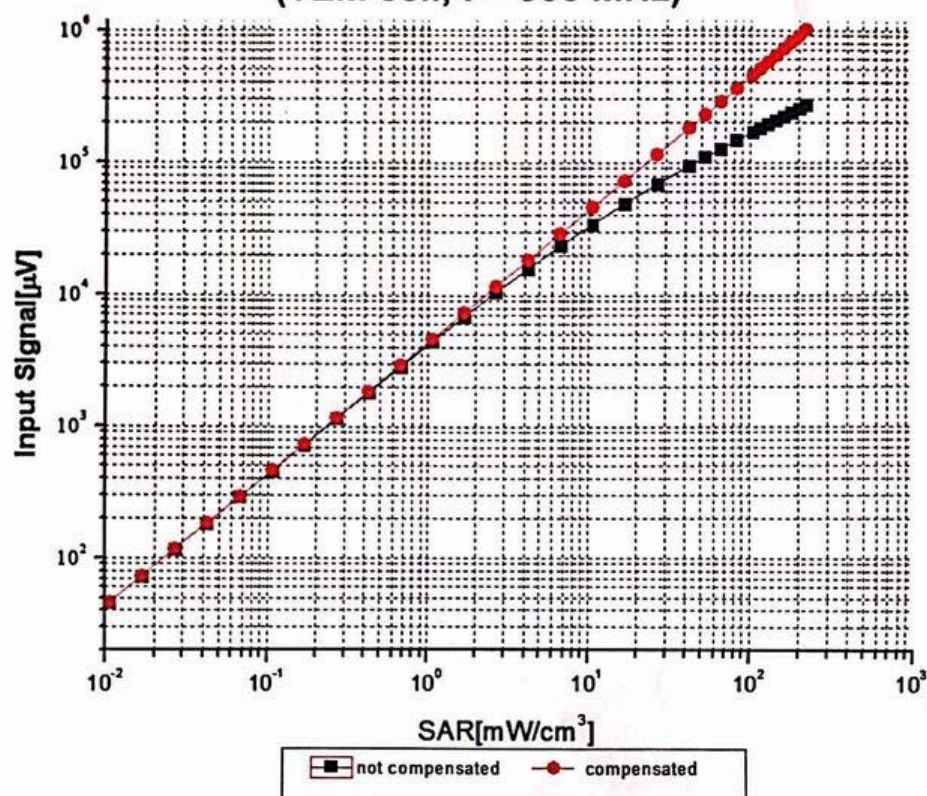
**f=1800 MHz, R22**





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### Dynamic Range f(SAR<sub>head</sub>) (TEM cell, f = 900 MHz)



Uncertainty of Linearity Assessment:  $\pm 0.9\%$  ( $k=2$ )

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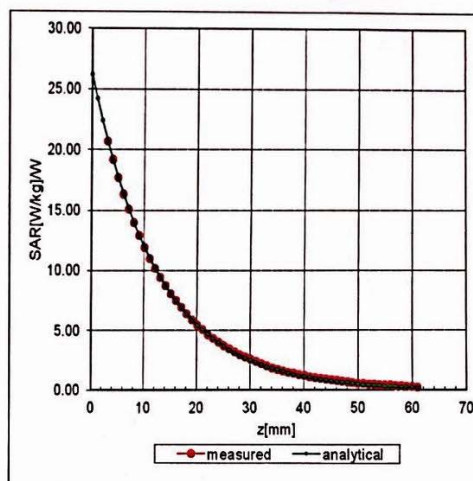
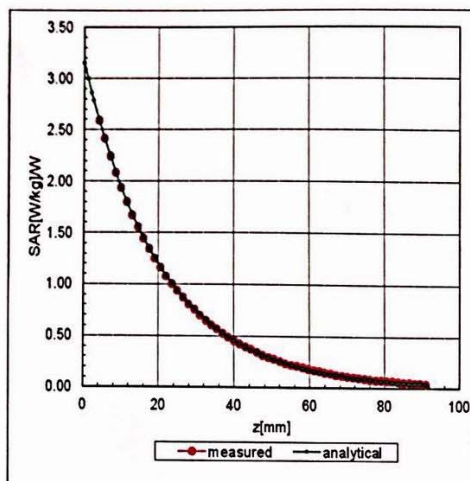


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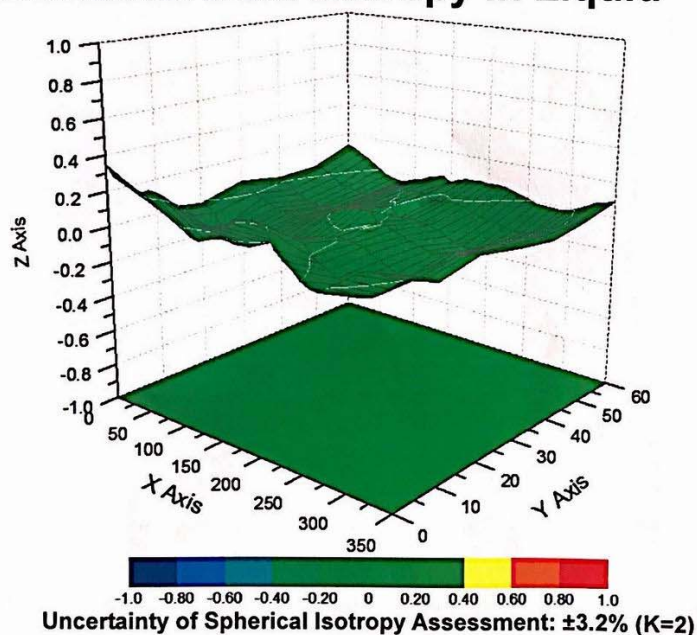
## Conversion Factor Assessment

f=750 MHz, WGLS R9(H\_convF)

f=1750 MHz, WGLS R22(H\_convF)



## Deviation from Isotropy in Liquid



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## DASY/EASY – Parameters of Probe: EX3DV4 – SN: 3677

### Other Probe Parameters

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 117.9      |
| Mechanical Surface Detection Mode             | enabled    |
| Optical Surface Detection Mode                | disable    |
| Probe Overall Length                          | 337mm      |
| Probe Body Diameter                           | 10mm       |
| Tip Length                                    | 9mm        |
| Tip Diameter                                  | 2.5mm      |
| Probe Tip to Sensor X Calibration Point       | 1mm        |
| Probe Tip to Sensor Y Calibration Point       | 1mm        |
| Probe Tip to Sensor Z Calibration Point       | 1mm        |
| Recommended Measurement Distance from Surface | 1.4mm      |