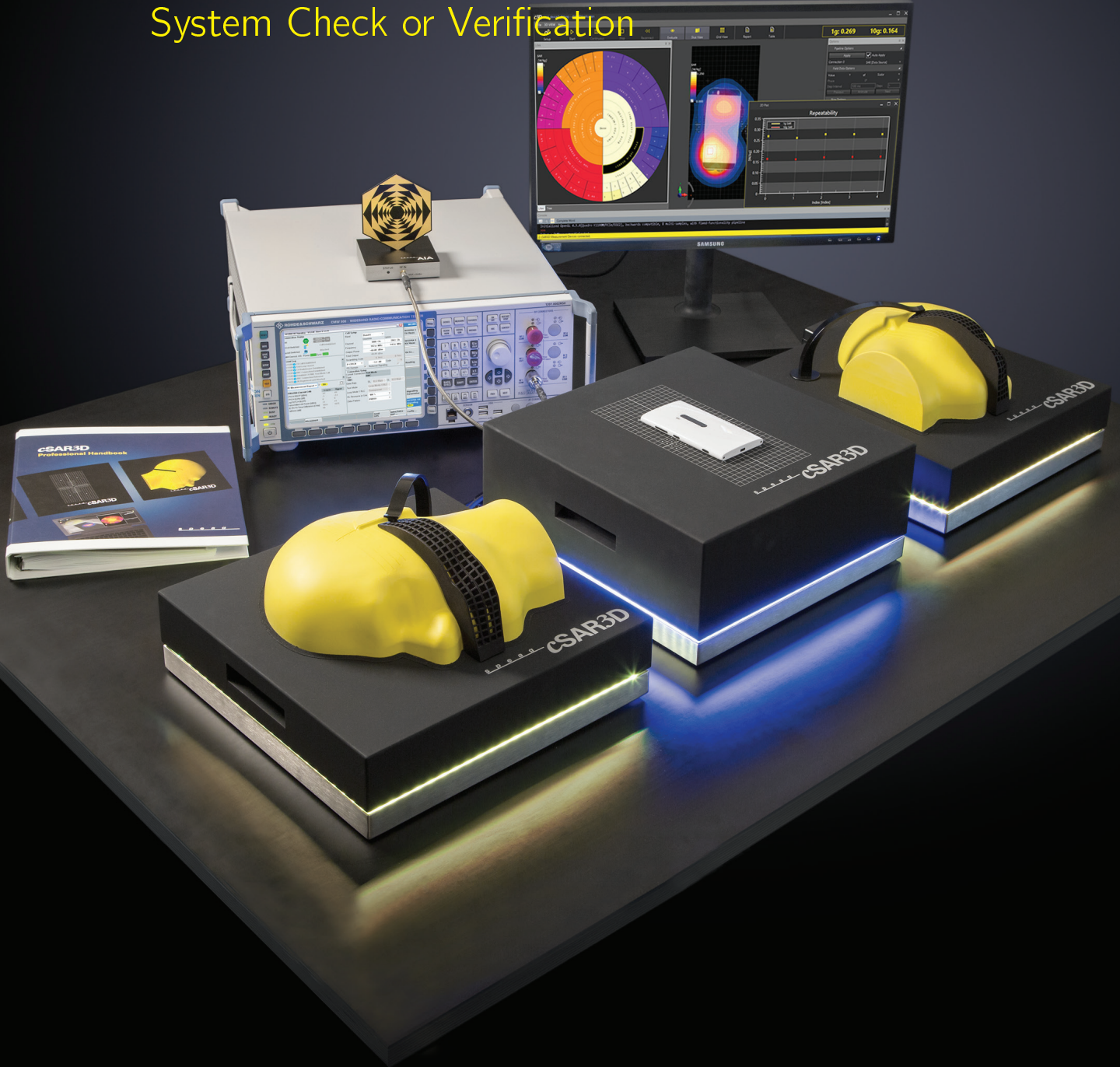


SAR Measurements with cSAR3D

APPLICATION NOTE

System Check or Verification



System Check or Verification

1 Introduction

These instructions describe the system verification (i.e., system check) procedure for cSAR3D. This procedure conforms to IEC 62209-3. System verification provides a fast and reliable method to verify that the SAR system is operational with no system component failure, drifts or deviation from target performance requirements. A system verification also verifies the measurement repeatability of the SAR measurement system against calibrated system check antenna(s) before compliance testing.

2 Objective

System verification should be performed on a regular basis, especially:

- upon receiving a new or recalibrated cSAR3D,
- after the cSAR3D has been moved to a new location,
- prior to starting a set of DUT measurements in conformance with IEC 62209-3 and within seven days of any measurement of the DUT,

The measured SAR values are compared against numerical targets. They are also compared against measured reference values available in the cSAR3D calibration certificate. To make the comparison easier, an Excel file is attached at the end of this Application Note. The system verification is successful if, for all tests:

- the differences between the measured peak 1-gram and 10-gram average SAR values ($SAR_{1g,meas}$, $SAR_{10g,meas}$) and the absolute targets ($SAR_{1g,cal}$, $SAR_{10g,cal}$) are less than the expanded measurement uncertainty for system check ($\Delta SAR_{1g,syscheck}$, $\Delta SAR_{10g,syscheck}$, and
- the differences between the measured SAR values and the reference values from the cSAR3D calibration certificate ($SAR_{1g,sys}$, $SAR_{10g,sys}$) are less than $\pm 10\%$.

The expanded measurement uncertainty for system check is the root-sum-squared of the reported measurement uncertainty of the cSAR3D software and three additional uncertainty terms for the validation antenna (DEX, PMU, OVS) described in IEC 62209-3. For example, if the cSAR3D software reports an uncertainty of 0.99 dB (25.6%), and the uncertainties of DEX, PMU and OVS are 0.5 dB (rectangular distribution), 0.1 dB (normal distribution), and 0.2 dB (rectangular distribution), the combined expanded uncertainty for system check is 1.1 dB. This calculation is performed automatically in the Excel sheet attached to this Application Note.

3 Equipment Required

The system verification test requires the use of cSAR3D devices, cSAR3D Verification Dipoles (and their accessories) and an accurate power reference. It is performed on each of the cSAR3D devices (Flat, Head, Quad).

3.1 System Verification Dipoles

System check is performed using a CW signal, at five frequencies (835 MHz, 1950 MHz, 2450 MHz, 5200 MHz and 5800 MHz) to cover measurements in the range of 650 MHz to 6 GHz. When a cSAR3D system has been calibrated for 6 GHz to 10 GHz range and system validation is performed by SPEAG including the 6 GHz to 10 GHz validation extension defined in the cSAR3D System Handbook, the same system check procedures also apply to measurements in the 650 MHz to 10 GHz range.

cSAR3D Verification Dipoles from SPEAG should have a valid calibration, including a calibration certificate. The dipole antennas are standardized dipole antennas whose electrical and mechanical specifications are described in the latest published standards (IEC 62209-1, IEC 62209-2, IEC 62209-3 and IEEE 1528) and shown in Figure 1.1. The separation distances of the dipole antennas to the flat phantom ($s = 15$ mm for $f < 1$ GHz, and $s = 10$ mm for $f > 1$ GHz) are also as defined in these standards.

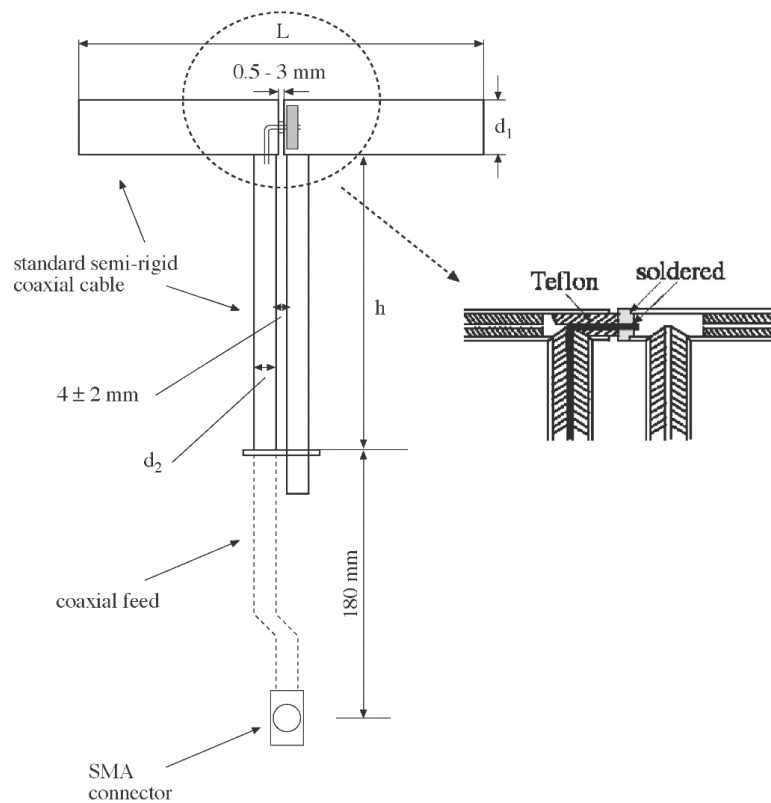


Figure 1.1: Mechanical details of the standard dipole. L = length of the dipole, d_1 = diameter of the dipole, d_2 = Diameter of the coaxial cable at the balun, h = length of the balun choke section.

The measured reference values in the cSAR3D calibration certificate will be used for the comparison. The Set of cSAR3D Verification Dipoles and the Set of Verification Accessories include the following components. Dipoles are also available at other frequencies.

Set of cSAR3D Verification Dipoles:

- 1 D835V2 - cSAR3D Verification Dipole, including calibration certificate
- 1 D1950V3 - cSAR3D Verification Dipole, including calibration certificate
- 1 D2450V2 - cSAR3D Verification Dipole, including calibration certificate
- 1 D5GHzV2 - cSAR3D Verification Dipole, including calibration certificate

Verification dipole accessories:

- 1 cSAR3D Verification Dipole Spacer, 15 mm (for frequencies below 1 GHz)
- 3 cSAR3D Verification Dipole Spacers, 10 mm (for frequencies above 1 GHz)
- 1 VAHV1 - Verification Antenna Holder for cSAR3D Heads V1
- 1 VDSV1 - Verification Dipole Stand for cSAR3D Flat/Quad V1



Figure 1.2: cSAR3D Verification Kit.

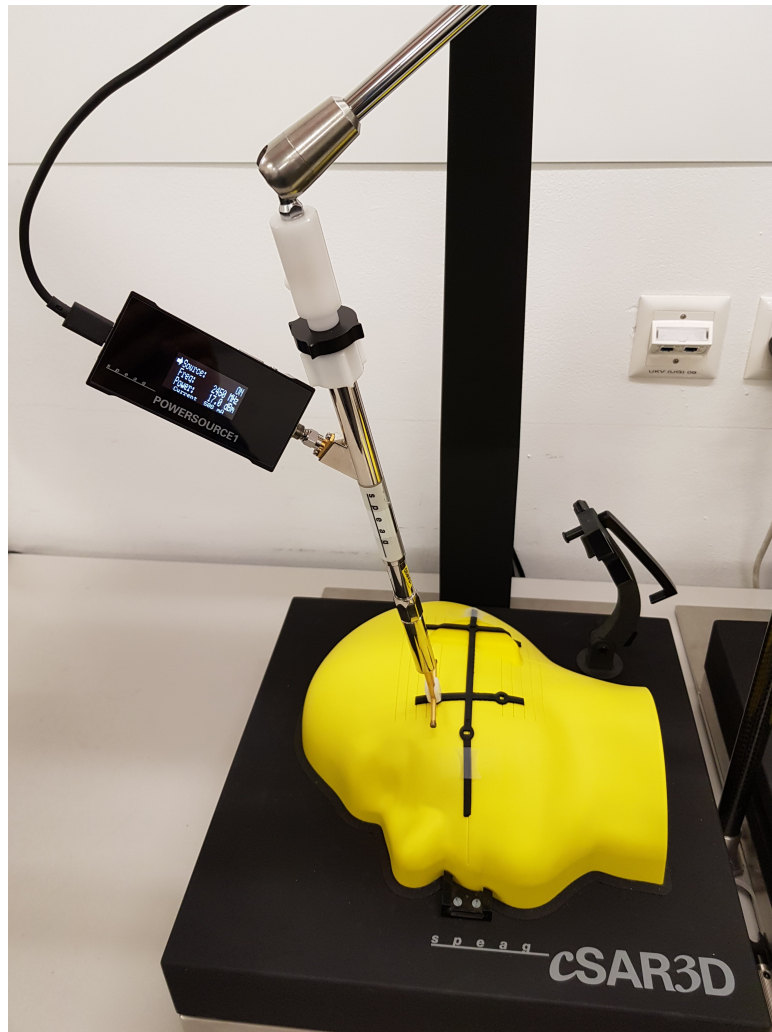


Figure 1.3: VAHV1 - Verification Antenna Holder for cSAR3D Heads V1.

3.2 Masks for Head Phantoms

Masks are used to keep reference antennas at fixed positions on the head phantoms during System Verification. The masks are fixed onto the head phantom and include features to maintain the dipole location and orientation. It is important that the antennas are at fixed locations because the head curvature and ear thickness affect the peak spatial-average SAR.

Set of Verification Masks:

- 1 VMLV1 - Verification Mask for cSAR3D Left Head
- 1 VMRV1 - Verification Mask for cSAR3D Right Head

Two versions of head masks have been developed by SPEAG for cSAR3D (see Figure 1.4).

Please use the same mask version as used in the cSAR3D calibration certificate when performing the System Verification. There are differences in the geometry between the two masks that influence the SAR.

The original head verification mask (V1) was delivered with the cSAR3D System Verification Kit prior to August 2018. These red masks have four defined dipole locations, called Ear, Top, Neck, and Mouth, corresponding to their locations on the face. These masks were designed during the early stages of the development of IEC 62209-3.

Starting August 2018, an updated version of the masks (V2) was delivered to cSAR3D customers. In the cSAR3D system verification kit, a set of black verification masks replaces the red masks. The black masks are designed to match the locations and layout of the validation masks defined in IEC 62209-3 (see Figure 2). The black verification mask has four of the nine locations on the validation mask. The locations of these four points are identical to the corresponding points on the validation mask. They also have the same names. Four points are defined instead of nine because this makes regular system check more manageable.

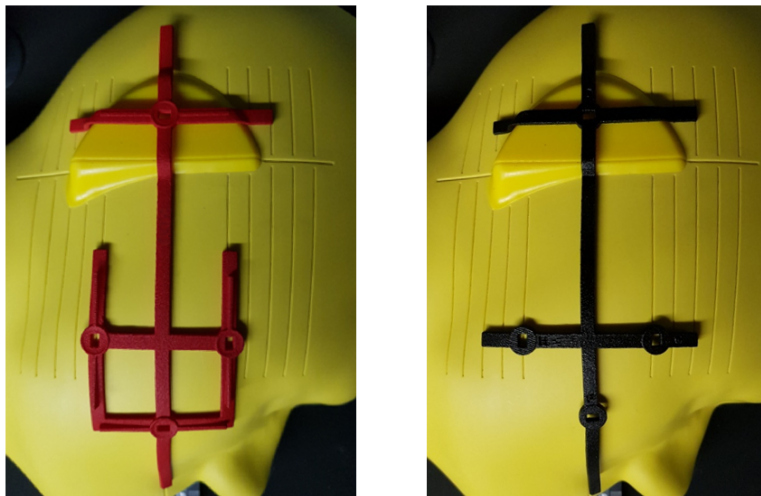


Figure 1.4: Original (red) masks and updated (black) masks for System Verification on Head phantoms.

3.3 Power Source

The tests require an accurate power source. The POWERSOURCE1 from SPEAG is suitable for this test. It is calibrated by SPEAG in accordance with the ISO/IEC 17025 standard, with a measurement uncertainty as reported in our scope of accreditation.

If POWERSOURCE1 is used, please review the POWERSOURCE1 Handbook for installation and setup instructions.

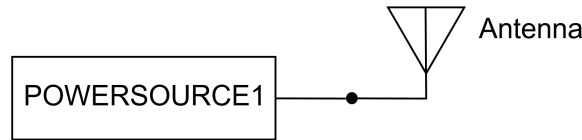


Figure 1.5: Equipment setup for system check and system validation using POWERSOURCE1. The amplifier, filter and directional coupler are not required when using the POWERSOURCE1. If traceability is required for submission and the unit is not ISO/IEC 17025 calibrated, measure the output power before and after the SAR measurement using a calibrated power meter in order to achieve the required traceability.

If POWERSOURCE1 is not available, Figure 1.6 shows the recommended setup. This setup consists of a generator, a bi-directional coupler, attenuators and power meters. The setup is also described in international SAR measurement standards such as IEEE 1528, IEC 62209-1, IEC 62209-2, IEC 62209-3, and various national SAR measurement regulations. The requirements for this setup are described in the section “Verification Setup” in the cSAR3D System Handbook.

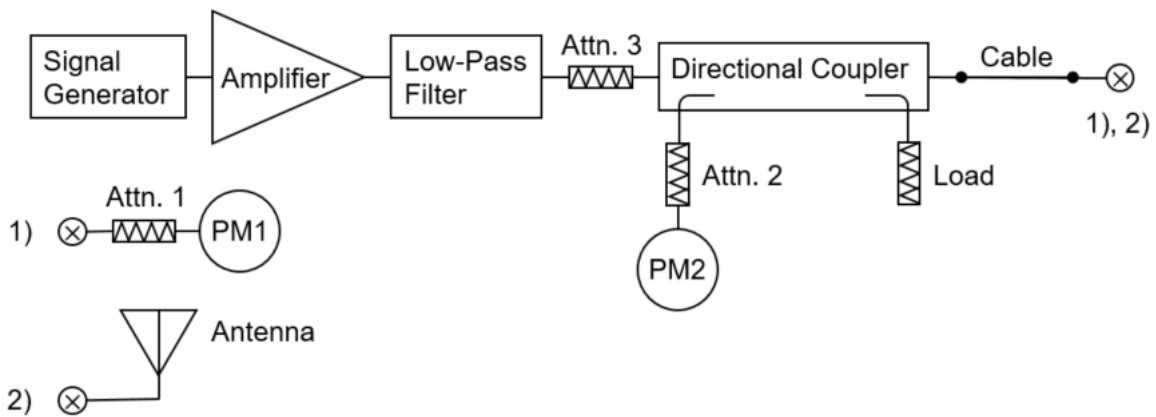


Figure 1.6: Equipment setup for system check and system validation according to IEC 62209-3 and other standards.

4 Verification Source Locations

For the head phantom, the four defined positions will be used: C(0°) (top), F(90°) (mouth), H(0°) (ear), and D(90°) (neck). Figure 1.7 shows the four locations on the Head phantoms, and Figure 1.8 shows the angle definitions.

For the flat phantom, use any four locations and orientations of the antenna. These may be chosen at random, for example. It is recommended to use position A0(0°) as the first position for consistency. For the other three locations, it is suggested to cover the locations of the measurement area of the phantom.

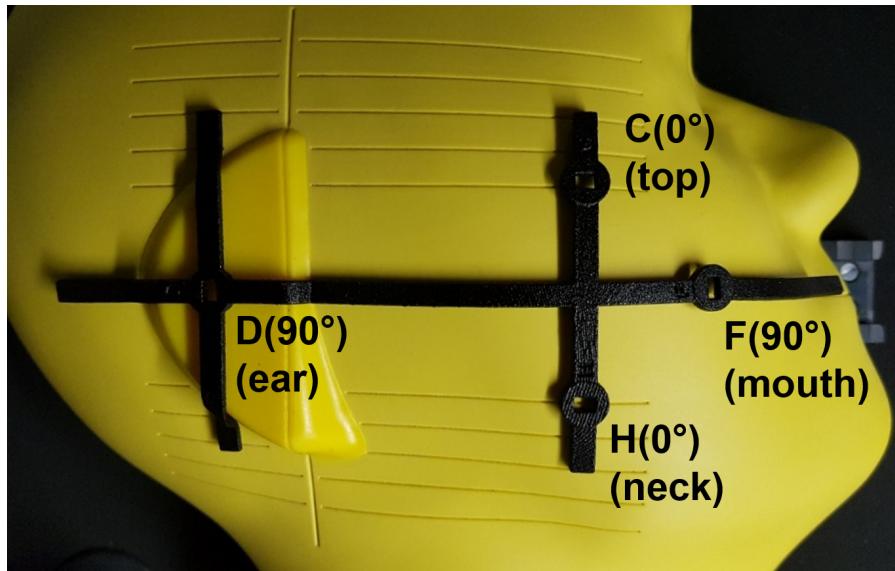


Figure 1.7: The verification mask indicates four locations: C(0°) (top), D(90°) (ear), F(90°) (mouth), H(0°) (neck).

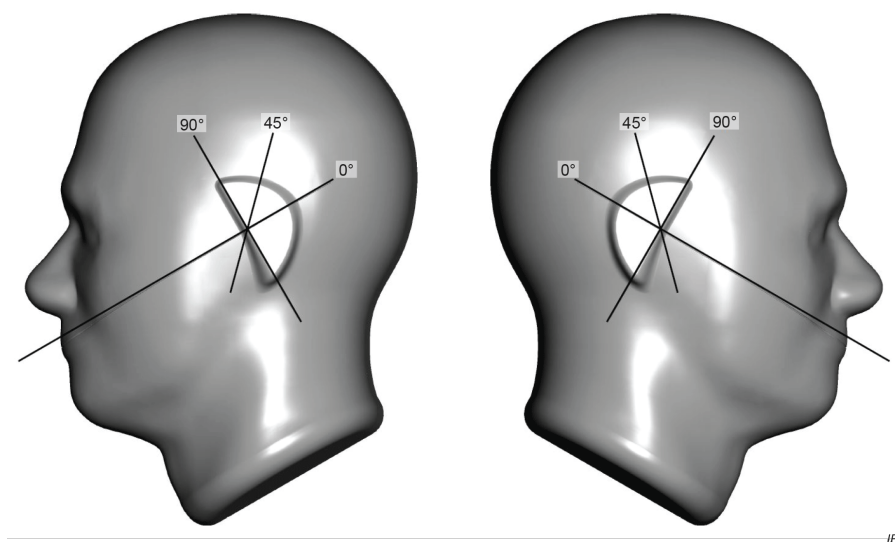


Figure 1.8: Dipole orientations. The 0° angle is parallel to the line from the mouth to the ear reference point. For the right head, the other angles are defined with clockwise rotation from 0°.

5 Procedure

The following procedure should be used for each cSAR3D device. Record all data in the attached Excel file.



https://speag.com/assets/downloads/products/csar3d/free_downloads/TNcSAR3DVerificationTestData.xlsx

5.1 Preparation

Fill in the data (yellow cells) in the Excel file as described in the following steps.

1. Go to the tab for the cSAR3D device type: Flat, Head or Quad
2. Ensure that the ambient temperature in the laboratory is within 18° to 25° and has stabilized before starting the tests.
3. Turn on the RF source (either POWERSOURCE1 or other signal generator) and allow it to warm up.
4. Fill in the top section with the date, software version, laboratory, operator and ambient temperature.
5. Fill in the serial number of the cSAR3D device.
6. Fill in the serial number of each cSAR3D Validation Dipole.
7. Fill in the reference SAR from the cSAR3D calibration certificate for each dipole frequency.

5.2 Verification Testing

This section describes the procedure for accurately measuring the SAR using the dipole antenna. If the POWERSOURCE1 is used as the RF source, follow Application Note “POWERSOURCE1”.

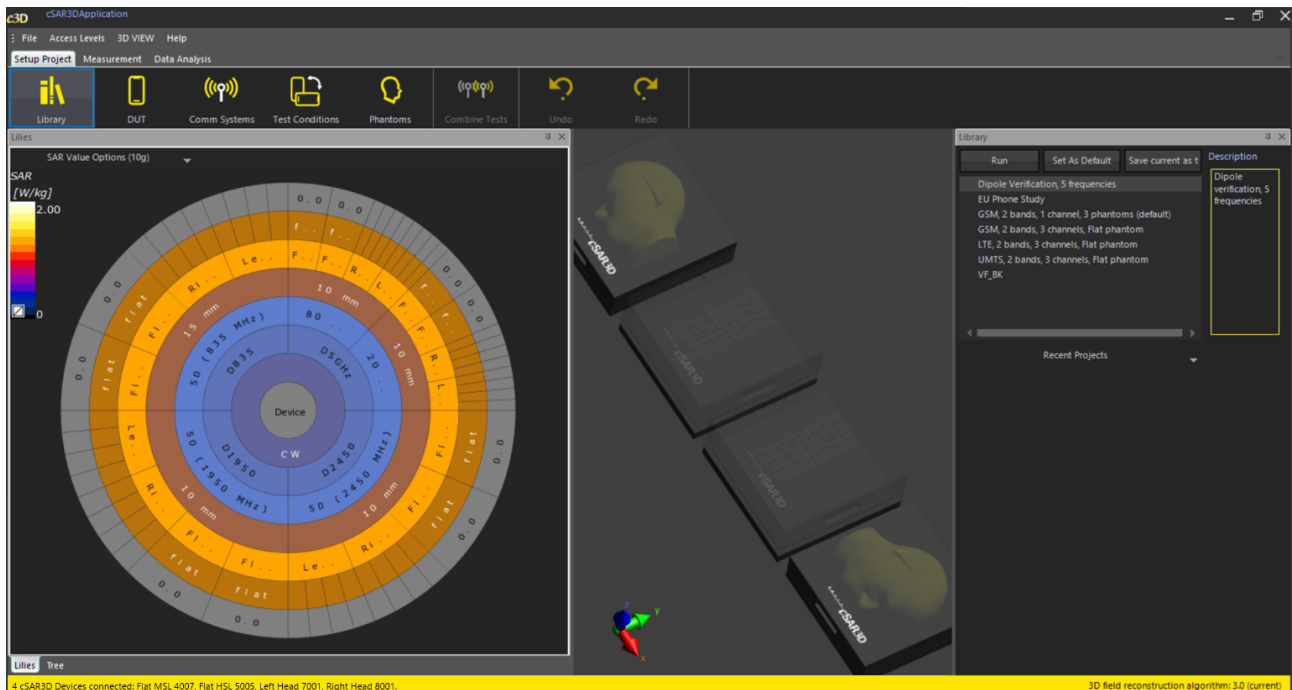


Figure 1.9: Predefined setup for verification measurements.

Select the predefined setup called "Dipole Verification, 5 frequencies" (see Figure 1.9). Add or remove phantoms and frequency bands to the Lilies wheel as desired.

For each dipole antenna, apply the following steps.

8. Set the frequency of the RF source to match the operating frequency of the dipole antenna. Using POWERSOURCE1, this is done via the cSAR3D software or the buttons on the device.
9. Set the power level at 15 dBm or more. Using POWERSOURCE1, this is done via the cSAR3D software or the buttons on the device.
10. Measure the output power using a calibrated power meter (connection 1 of either Figure 1.5 or 1.6, depending on the source type).
11. Enter the power level in the Excel worksheet.

For each dipole antenna and antenna position, apply the following steps.

12. Connect the dipole antenna at the end of the RF source (see Figure 1.5 or connection 2 of 1.6).
13. Connect the dipole antenna to the appropriate low-loss spacer (see Figure 1.10). The spacer maintains a fixed distance from the axis of the dipole antenna to the tissue simulating medium (including the 2 mm thick phantom shell). The total spacing is:
 - 15 mm for frequencies up to 1 GHz
 - 10 mm for frequencies above 1 GHz

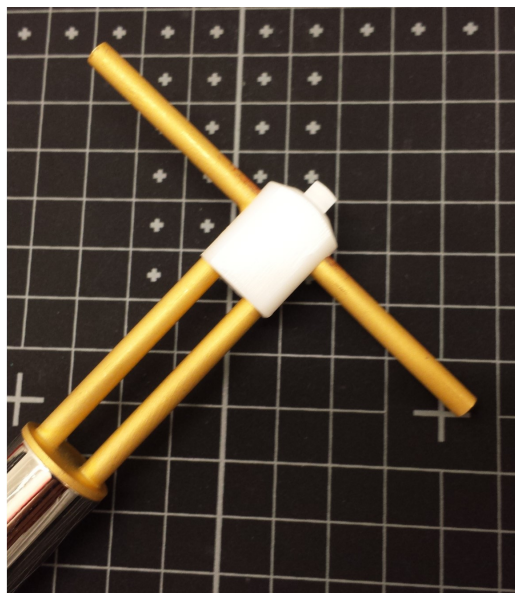


Figure 1.10: Low-loss spacer connected at the dipole feed point.

14. Place the dipole antenna at a location on the cSAR3D phantom. For Flat and Quad phantoms, use the VDSV1 Verification Dipole Stand for cSAR3D Flat/Quad V1 to hold the dipole antenna vertically on the phantom. For Head phantoms use VAHV1 Verification Antenna Holder for cSAR3D Heads V1. If not available, hold the dipole by hand at one of the four locations of the Head Verification mask.
15. Ensure that the dipole arms are parallel to the phantom surface and oriented at the correct angle (see Figure 1.12).
16. Wait for the auto-leveling period, which is typically 5 seconds and ends when the power level indicator has stopped flashing.

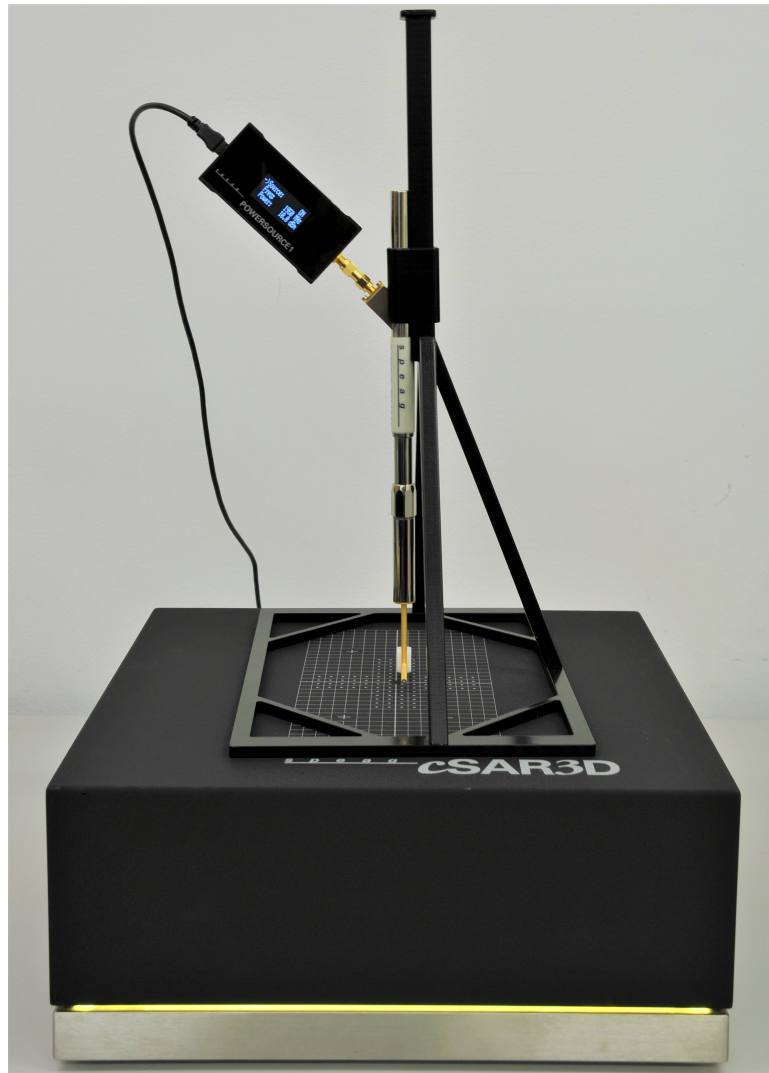


Figure 1.11: Verification dipole mounted on the dipole stand VDSV1 and connected to POWERSOURCE1.

17. Measure the peak spatial-average SAR values at the phantom: SAR_{1g} and SAR_{10g} .
18. Enter the measured SAR values and the reported uncertainty in the Excel worksheet.

If the above test is outside the tolerances for any of the tested configurations, check the setup thoroughly and repeat all above steps for this configuration. It is recommended to repeat at least 10 times in order to preclude measurement outliers. Record the average from the 10 or more values in the Excel worksheet.



Figure 1.12: At the measurement location, the dipole shall be oriented so that a) the dipole arms are parallel to the phantom, b) the coaxial feed line is normal to the phantom, and c) the dipole arms are oriented at the correct angle.