

## 4 MEASUREMENT METHOD

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards provide requirements for reference dipoles used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

### 4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. A direct method is used with a network analyser and its calibration kit, both with a valid ISO17025 calibration.

### 4.2 MECHANICAL REQUIREMENTS

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards specify the mechanical components and dimensions of the validation dipoles, with the dimension's frequency and phantom shell thickness dependent. The COMOSAR test bench employs a 2 mm phantom shell thickness therefore the dipoles sold for use with the COMOSAR test bench comply with the requirements set forth for a 2 mm phantom shell thickness. A direct method is used with a ISO17025 calibrated caliper.

## 5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

### 5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

| Frequency band | Expanded Uncertainty on Return Loss |
|----------------|-------------------------------------|
| 400-6000MHz    | 0.08 LIN                            |

### 5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

| Length (mm) | Expanded Uncertainty on Length |
|-------------|--------------------------------|
| 0 - 300     | 0.20 mm                        |

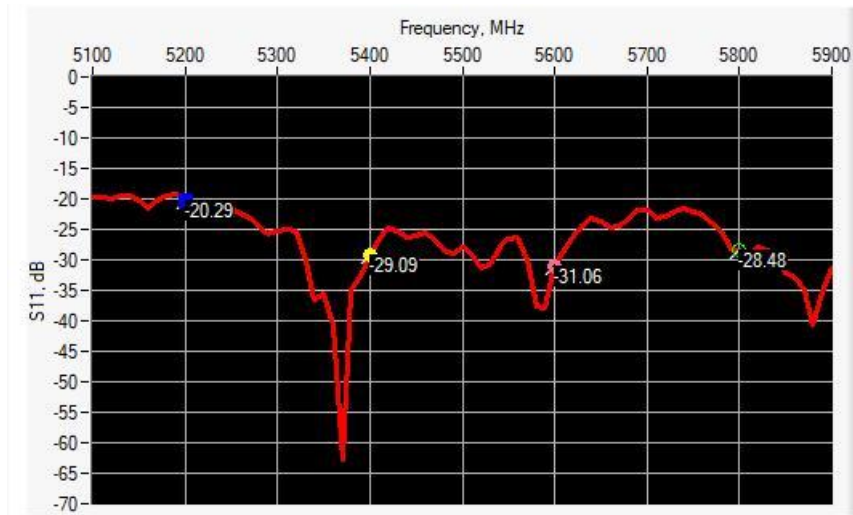
### 5.3 VALIDATION MEASUREMENT

The guidelines outlined in the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards were followed to generate the measurement uncertainty for validation measurements.

| Scan Volume | Expanded Uncertainty |
|-------------|----------------------|
| 1 g         | 19 % (SAR)           |
| 10 g        | 19 % (SAR)           |

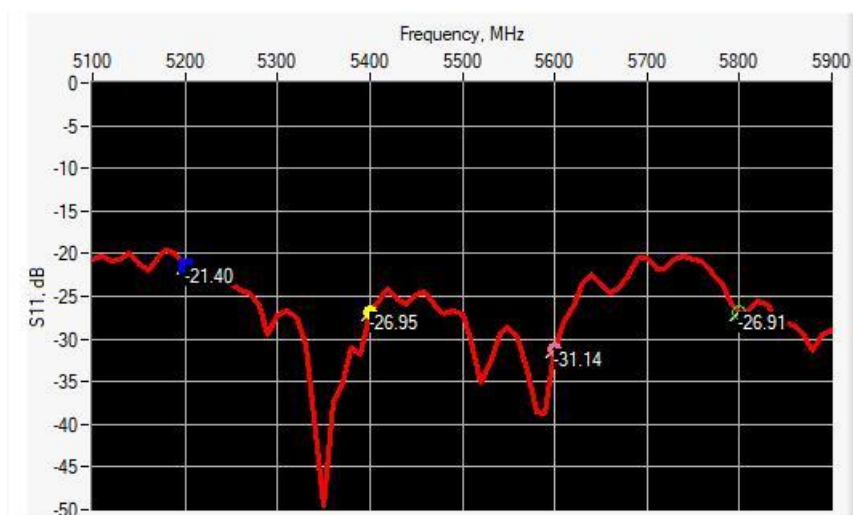
## 6 CALIBRATION MEASUREMENT RESULTS

### 6.1 RETURN LOSS IN HEAD LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                     |
|-----------------|------------------|------------------|-------------------------------|
| 5200            | -20.29           | -20              | $58.76 \Omega - 4.43 j\Omega$ |
| 5400            | -29.09           | -20              | $53.46 \Omega + 0.61 j\Omega$ |
| 5600            | -31.06           | -20              | $52.76 \Omega - 0.45 j\Omega$ |
| 5800            | -28.48           | -20              | $50.12 \Omega - 3.76 j\Omega$ |

### 6.2 RETURN LOSS IN BODY LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                        |
|-----------------|------------------|------------------|----------------------------------|
| 5200            | -21.40           | -20              | 57.13 $\Omega$ - 4.54 j $\Omega$ |
| 5400            | -26.95           | -20              | 54.47 $\Omega$ - 0.31 j $\Omega$ |
| 5600            | -31.14           | -20              | 52.65 $\Omega$ + 0.81 j $\Omega$ |
| 5800            | -26.91           | -20              | 49.92 $\Omega$ - 4.51 j $\Omega$ |

### 6.3 MECHANICAL DIMENSIONS

| Frequency MHz | L mm            |          | h mm            |          | d mm           |          |
|---------------|-----------------|----------|-----------------|----------|----------------|----------|
|               | required        | measured | required        | measured | required       | measured |
| 5000 to 6000  | 20.6 $\pm$ 1 %. | 20.78    | 40.3 $\pm$ 1 %. | 40.59    | 3.6 $\pm$ 1 %. | 3.59     |

## 7 VALIDATION MEASUREMENT

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. Per the standards, the dipole shall be positioned below the bottom of the phantom, with the dipole length centered and parallel to the longest dimension of the flat phantom, with the top surface of the dipole at the described distance from the bottom surface of the phantom.

### 7.1 HEAD LIQUID MEASUREMENT

| Frequency MHz | Relative permittivity ( $\epsilon_r'$ ) |          | Conductivity ( $\sigma$ ) S/m |          |
|---------------|-----------------------------------------|----------|-------------------------------|----------|
|               | required                                | measured | required                      | measured |
| 5000          | 36.2 $\pm$ 10 %                         |          | 4.45 $\pm$ 10 %               |          |
| 5100          | 36.1 $\pm$ 10 %                         |          | 4.56 $\pm$ 10 %               |          |
| 5200          | 36.0 $\pm$ 10 %                         | 34.44    | 4.66 $\pm$ 10 %               | 4.64     |
| 5300          | 35.9 $\pm$ 10 %                         |          | 4.76 $\pm$ 10 %               |          |
| 5400          | 35.8 $\pm$ 10 %                         | 33.63    | 4.86 $\pm$ 10 %               | 4.88     |
| 5500          | 35.6 $\pm$ 10 %                         |          | 4.97 $\pm$ 10 %               |          |
| 5600          | 35.5 $\pm$ 10 %                         | 32.80    | 5.07 $\pm$ 10 %               | 5.12     |
| 5700          | 35.4 $\pm$ 10 %                         |          | 5.17 $\pm$ 10 %               |          |
| 5800          | 35.3 $\pm$ 10 %                         | 32.63    | 5.27 $\pm$ 10 %               | 5.31     |
| 5900          | 35.2 $\pm$ 10 %                         |          | 5.38 $\pm$ 10 %               |          |
| 6000          | 35.1 $\pm$ 10 %                         |          | 5.48 $\pm$ 10 %               |          |

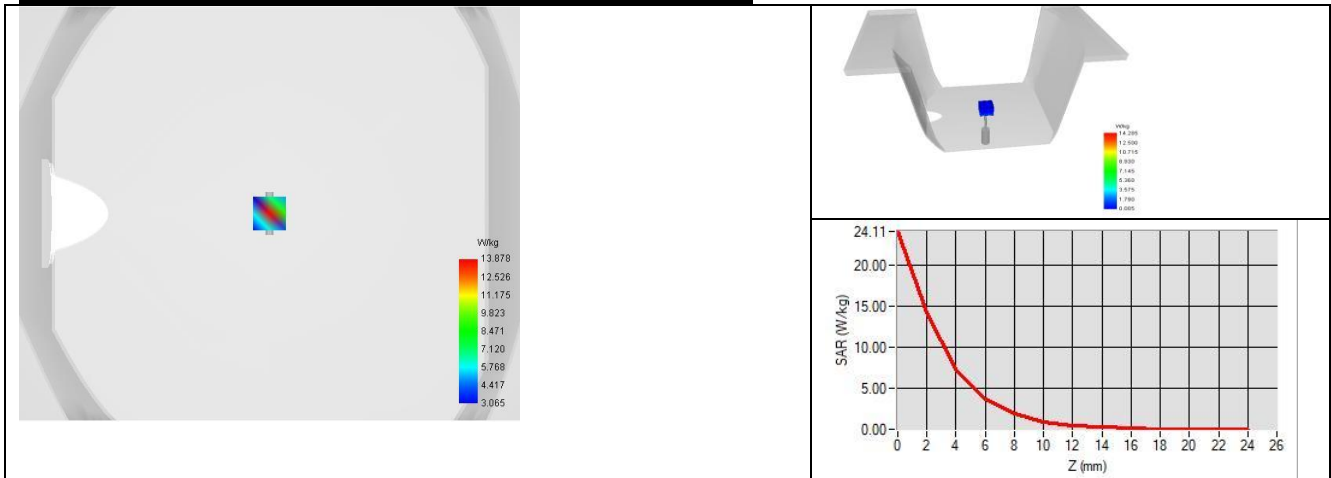
## 7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

At those frequencies, the target SAR value can not be generic. Hereunder is the target SAR value defined by MVG, within the uncertainty for the system validation. All SAR values are normalized to 1 W net power. In bracket, the measured SAR is given with the used input power.

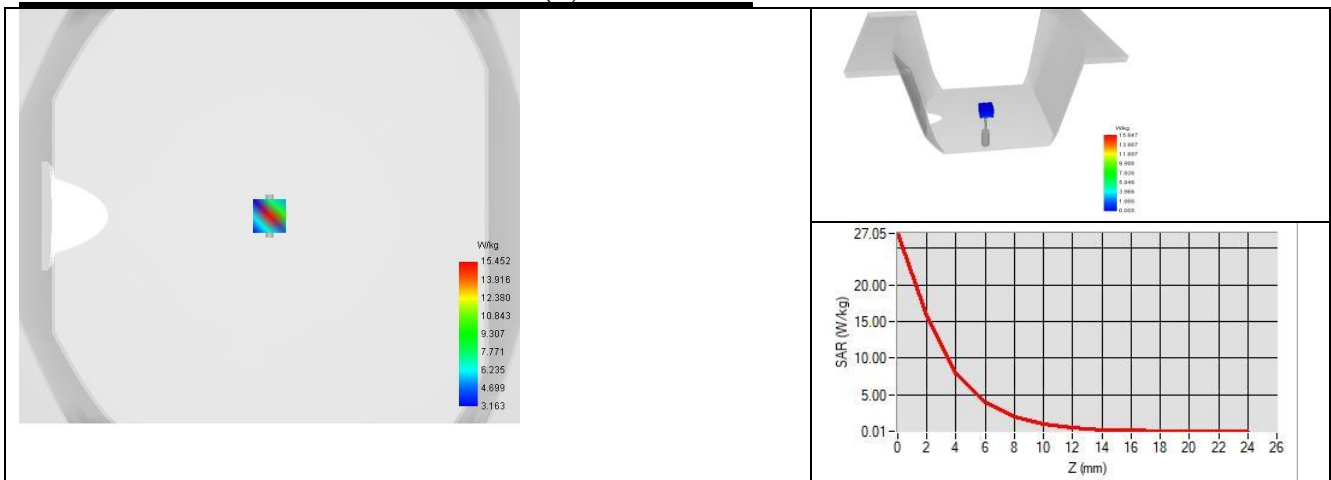
|                                    |                                                                                                                                                                                                                                  |
|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Software                           | OPENSAR V5                                                                                                                                                                                                                       |
| Phantom                            | SN 13/09 SAM68                                                                                                                                                                                                                   |
| Probe                              | SN 41/18 EPGO333                                                                                                                                                                                                                 |
| Liquid                             | Head Liquid Values 5200 MHz: eps' :34.44 sigma : 4.64<br>Head Liquid Values 5400 MHz: eps' :33.63 sigma : 4.88<br>Head Liquid Values 5600 MHz: eps' :32.80 sigma : 5.12<br>Head Liquid Values 5800 MHz: eps' :32.63 sigma : 5.31 |
| Distance between dipole and liquid | 10 mm                                                                                                                                                                                                                            |
| Area scan resolution               | dx=8mm/dy=8mm                                                                                                                                                                                                                    |
| Zoon Scan Resolution               | dx=4mm/dy=4m/dz=2mm                                                                                                                                                                                                              |
| Frequency                          | 5200 MHz<br>5400 MHz<br>5600 MHz<br>5800 MHz                                                                                                                                                                                     |
| Input power                        | 20 dBm                                                                                                                                                                                                                           |
| Liquid Temperature                 | 20 +/- 1 °C                                                                                                                                                                                                                      |
| Lab Temperature                    | 20 +/- 1 °C                                                                                                                                                                                                                      |
| Lab Humidity                       | 30-70 %                                                                                                                                                                                                                          |

| Frequency (MHz) | 1 g SAR (W/kg) |              | 10 g SAR (W/kg) |              |
|-----------------|----------------|--------------|-----------------|--------------|
|                 | required       | measured     | required        | measured     |
| 5200            | 76.50          | 73.88 (7.39) | 21.60           | 21.29 (2.13) |
| 5400            | -              | 81.47 (8.15) | -               | 23.23 (2.32) |
| 5600            | -              | 78.71 (7.87) | -               | 22.64 (2.26) |
| 5800            | 78.00          | 74.21 (7.42) | 21.90           | 21.50 (2.15) |

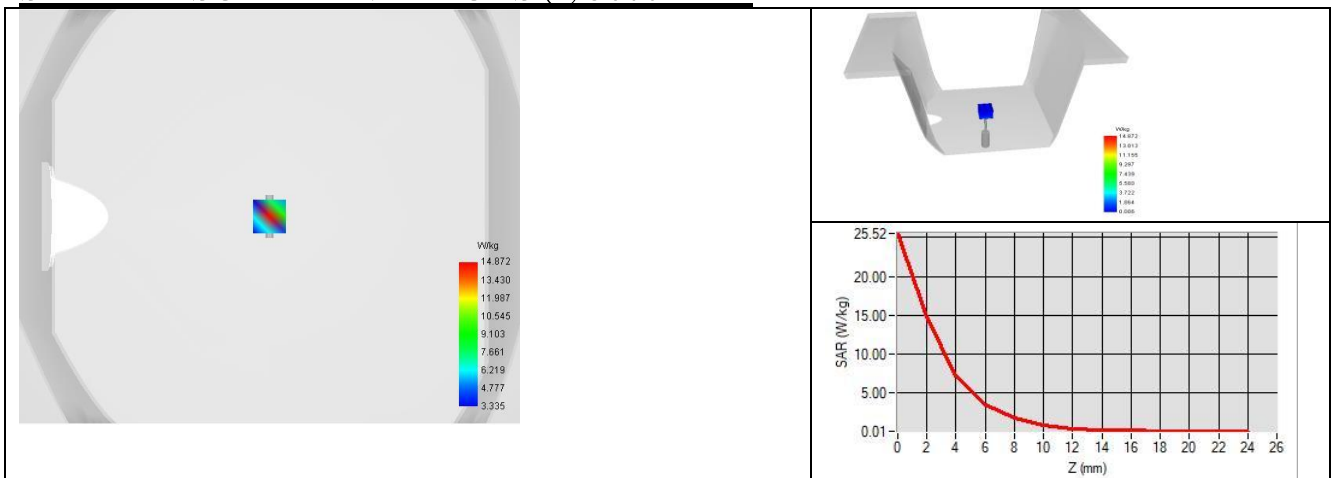
## SAR MEASUREMENT PLOTS @ 5200 MHz



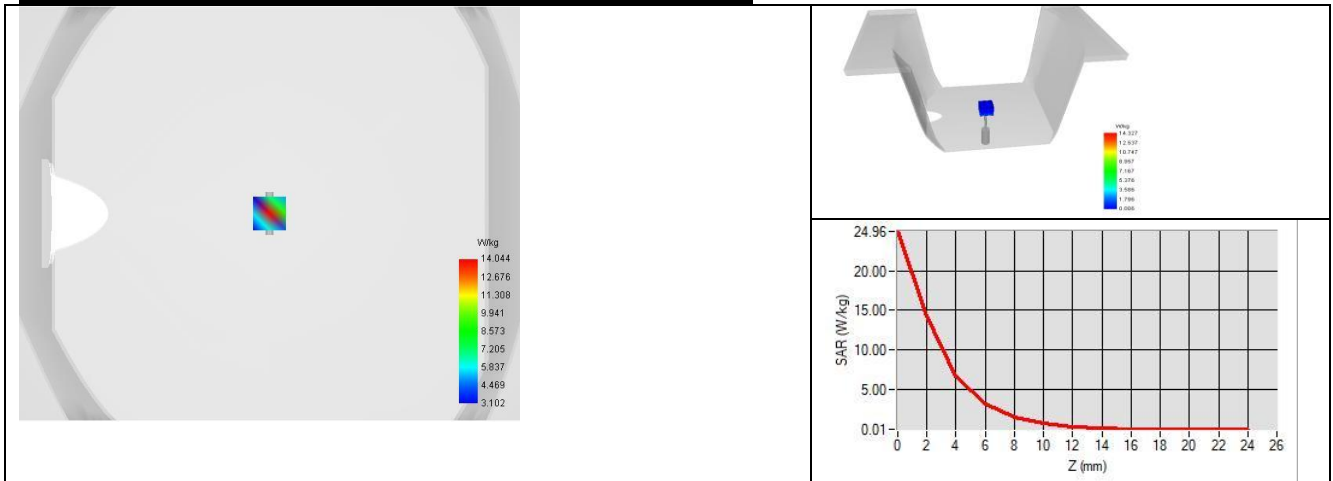
## SAR MEASUREMENT PLOTS @ 5400 MHz



## SAR MEASUREMENT PLOTS @ 5600 MHz



## SAR MEASUREMENT PLOTS @ 5800 MHz



### 7.3 BODY LIQUID MEASUREMENT

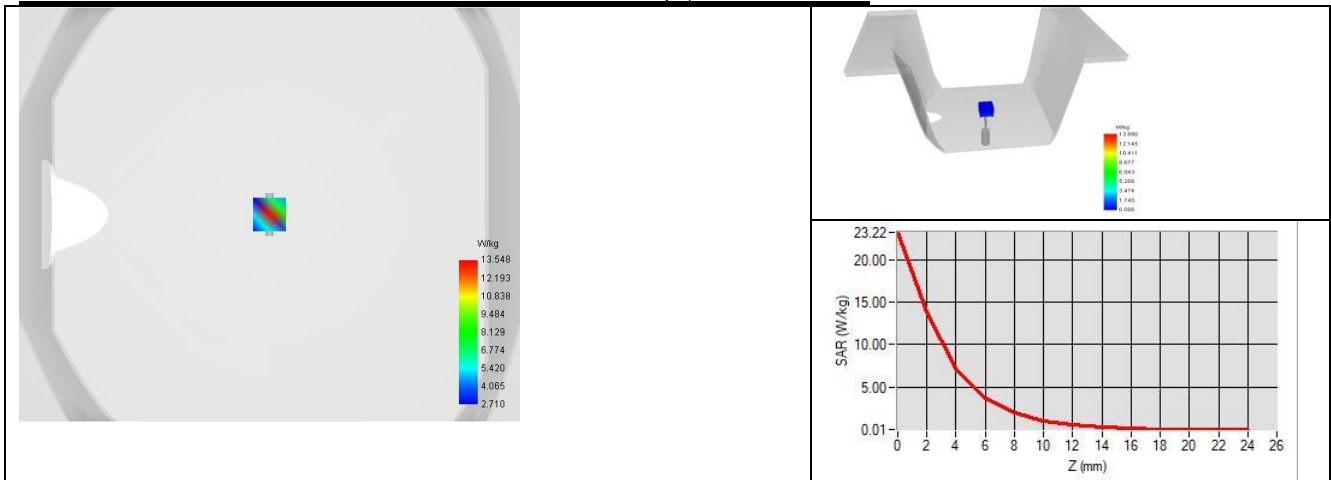
| Frequency<br>MHz | Relative permittivity ( $\epsilon_r'$ ) |          | Conductivity ( $\sigma$ ) S/m |          |
|------------------|-----------------------------------------|----------|-------------------------------|----------|
|                  | required                                | measured | required                      | measured |
| 5200             | 49.0 $\pm$ 10 %                         | 45.50    | 5.30 $\pm$ 10 %               | 5.63     |
| 5300             | 48.9 $\pm$ 10 %                         |          | 5.42 $\pm$ 10 %               |          |
| 5400             | 48.7 $\pm$ 10 %                         | 44.78    | 5.53 $\pm$ 10 %               | 5.95     |
| 5500             | 48.6 $\pm$ 10 %                         |          | 5.65 $\pm$ 10 %               |          |
| 5600             | 48.5 $\pm$ 10 %                         | 44.85    | 5.77 $\pm$ 10 %               | 6.26     |
| 5800             | 48.2 $\pm$ 10 %                         | 44.45    | 6.00 $\pm$ 10 %               | 6.58     |

### 7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

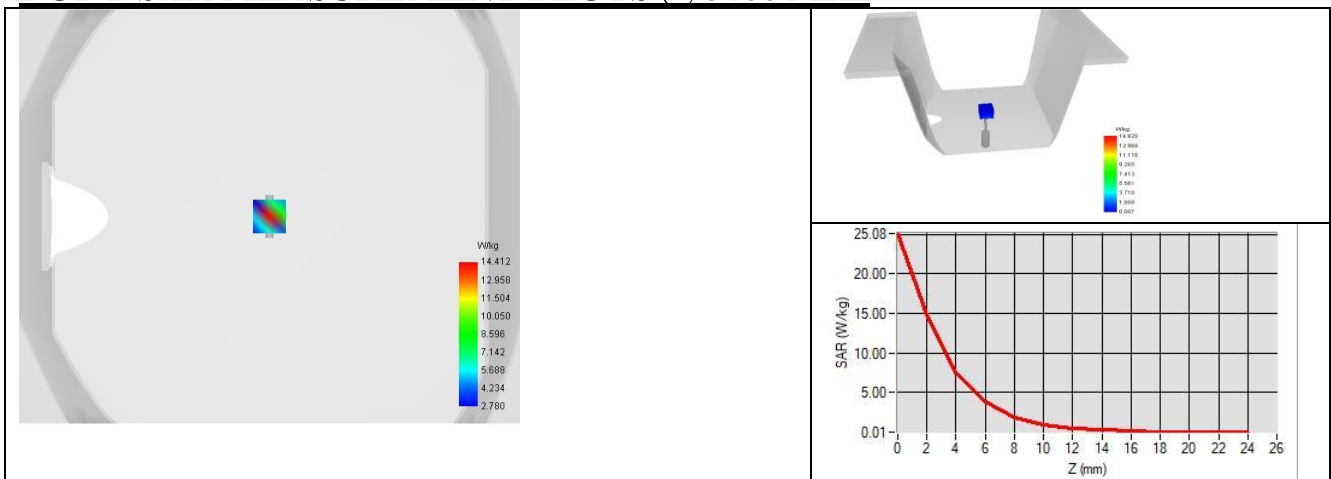
|                                    |                                                                                                                                                                                                                                                                      |
|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Software                           | OPENSAR V5                                                                                                                                                                                                                                                           |
| Phantom                            | SN 13/09 SAM68                                                                                                                                                                                                                                                       |
| Probe                              | SN 41/18 EPG0333                                                                                                                                                                                                                                                     |
| Liquid                             | Body Liquid Values 5200 MHz: $\epsilon_r'$ :45.50 sigma : 5.63<br>Body Liquid Values 5400 MHz: $\epsilon_r'$ :44.78 sigma : 5.95<br>Body Liquid Values 5600 MHz: $\epsilon_r'$ :44.85 sigma : 6.26<br>Body Liquid Values 5800 MHz: $\epsilon_r'$ :44.45 sigma : 6.58 |
| Distance between dipole and liquid | 10 mm                                                                                                                                                                                                                                                                |
| Area scan resolution               | dx=8mm/dy=8mm                                                                                                                                                                                                                                                        |
| Zoon Scan Resolution               | dx=4mm/dy=4m/dz=2mm                                                                                                                                                                                                                                                  |
| Frequency                          | 5200 MHz<br>5400 MHz<br>5600 MHz<br>5800 MHz                                                                                                                                                                                                                         |
| Input power                        | 20 dBm                                                                                                                                                                                                                                                               |
| Liquid Temperature                 | 20 +/- 1 °C                                                                                                                                                                                                                                                          |
| Lab Temperature                    | 20 +/- 1 °C                                                                                                                                                                                                                                                          |
| Lab Humidity                       | 30-70 %                                                                                                                                                                                                                                                              |

| Frequency (MHz) | 1 g SAR (W/kg) | 10 g SAR (W/kg) |
|-----------------|----------------|-----------------|
|                 | measured       | measured        |
| 5200            | 71.75 (7.18)   | 20.38 (2.04)    |
| 5400            | 75.93 (7.59)   | 21.44 (2.14)    |
| 5600            | 77.44 (7.74)   | 22.16 (2.22)    |
| 5800            | 69.01 (6.90)   | 19.75 (1.97)    |

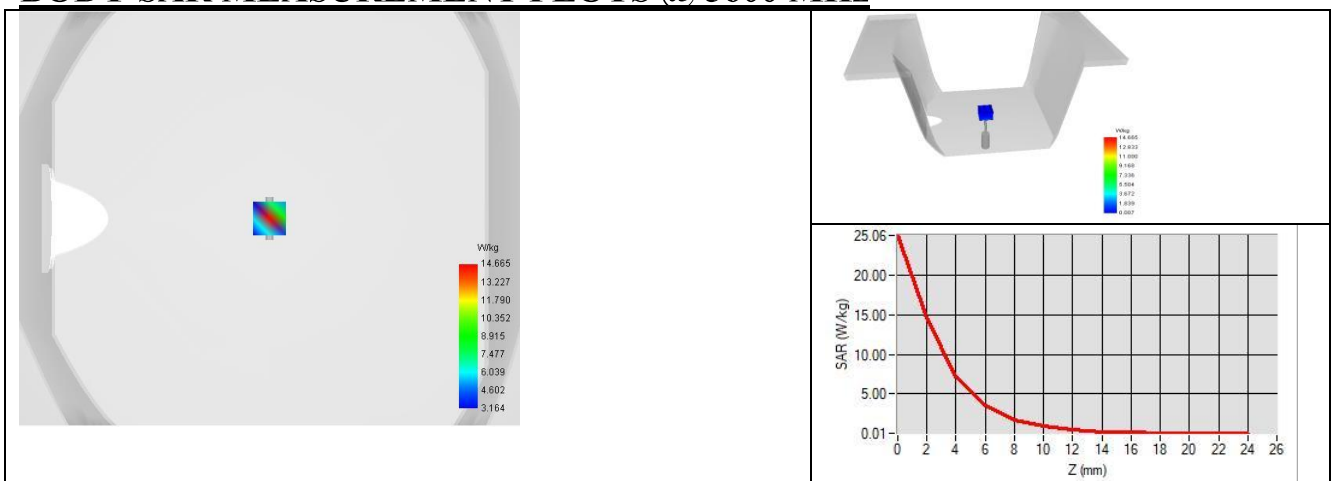
## BODY SAR MEASUREMENT PLOTS @ 5200 MHz



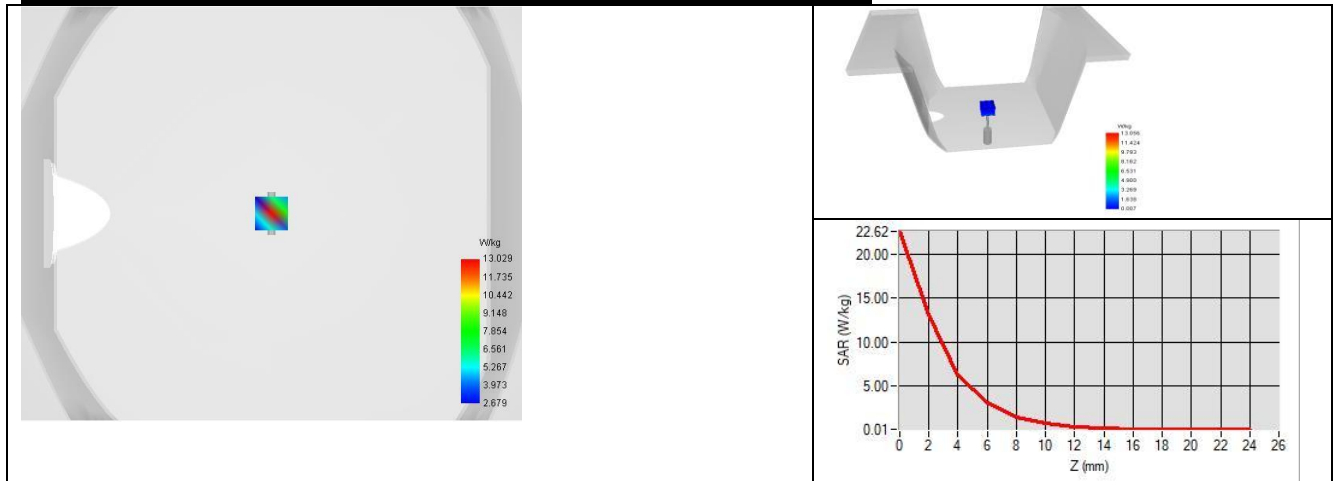
## BODY SAR MEASUREMENT PLOTS @ 5400 MHz



## BODY SAR MEASUREMENT PLOTS @ 5600 MHz



## BODY SAR MEASUREMENT PLOTS @ 5800 MHz





## 8 LIST OF EQUIPMENT

| Equipment Summary Sheet            |                         |                    |                                               |                                               |
|------------------------------------|-------------------------|--------------------|-----------------------------------------------|-----------------------------------------------|
| Equipment Description              | Manufacturer / Model    | Identification No. | Current Calibration Date                      | Next Calibration Date                         |
| SAM Phantom                        | MVG                     | SN 13/09 SAM68     | Validated. No cal required.                   | Validated. No cal required.                   |
| COMOSAR Test Bench                 | Version 3               | NA                 | Validated. No cal required.                   | Validated. No cal required.                   |
| Network Analyzer                   | Rohde & Schwarz ZVM     | 100203             | 08/2021                                       | 08/2024                                       |
| Network Analyzer                   | Agilent 8753ES          | MY40003210         | 10/2021                                       | 10/2024                                       |
| Network Analyzer – Calibration kit | Rohde & Schwarz ZV-Z235 | 101223             | 05/2021                                       | 05/2024                                       |
| Network Analyzer – Calibration kit | HP 85033D               | 3423A08186         | 06/2021                                       | 06/2027                                       |
| Calipers                           | Mitutoyo                | SN 0009732         | 10/2021                                       | 10/2024                                       |
| Reference Probe                    | MVG                     | SN 41/18 EPGO333   | 10/2021                                       | 10/2024                                       |
| Multimeter                         | Keithley 2000           | 1160271            | 02/2021                                       | 02/2024                                       |
| Signal Generator                   | Rohde & Schwarz SMB     | 106589             | 04/2021                                       | 04/2024                                       |
| Amplifier                          | MVG                     | MODU-023-C-0002    | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter                        | NI-USB 5680             | 170100013          | 06/2021                                       | 06/2024                                       |
| Power Meter                        | Rohde & Schwarz NRVD    | 832839-056         | 11/2021                                       | 11/2024                                       |
| Directional Coupler                | Krytar 158020           | 131467             | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Temperature / Humidity Sensor      | Testo 184 H1            | 44225320           | 06/2021                                       | 06/2024                                       |