

**Technical note – System
verification according
IEEE1528 with COMOSAR
system**



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System verification according IEEE1528 with COMOSAR system

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1 System verification according IEEE1528

The system validation procedure evaluates the system against reference SAR values and the performance of the probe, readout electronics, and software. The test setup utilizes a flat phantom and a reference dipole.

Thus, the system validation process does not include data scatter due to the use of anthropomorphic phantoms or uncertainty due to handset positioning variability.

System validation should be performed annually, or when a new system is put into operation, or whenever modifications have been made to the system, such as a new software release, different readout electronics or different types of probes. The probe used in the test system to be validated should be properly calibrated.

The objective of this subclause is to provide a methodology for SAR system validation. Since SAR measurement equipment and calibration techniques can vary widely between various laboratories, a validation methodology is needed to verify the system accuracy against its specifications. Numerically calculated reference SAR values for use in system validation are listed in the following table:

| Frequency (MHz) | 1 g SAR | 10 g SAR | Local SAR at surface (above feed-point) | Local SAR at surface (y = 2 cm offset from feed-point) ^a |
|-----------------|---------|----------|---|---|
| 300 | 3.0 | 2.0 | 4.4 | 2.1 |
| 450 | 4.9 | 3.3 | 7.2 | 3.2 |
| 835 | 9.5 | 6.2 | 4.1 | 4.9 |
| 900 | 10.8 | 6.9 | 16.4 | 5.4 |
| 1450 | 29.0 | 16.0 | 50.2 | 6.5 |
| 1800 | 38.1 | 19.8 | 69.5 | 6.8 |
| 1900 | 39.7 | 20.5 | 72.1 | 6.6 |
| 2000 | 41.1 | 21.1 | 74.6 | 6.5 |
| 2450 | 52.4 | 24.0 | 104.2 | 7.7 |
| 3000 | 63.8 | 25.7 | 140.2 | 9.5 |

System validation is used for verifying the accuracy of the probe and readout electronics, and performance of the software. Device positioning and head phantom shape errors are not considered. The system validation procedure consists of six steps. Step a) is the most important part of the system validation procedure and shall be done every time. Steps b) through f) (recommended) offer a means for quick and simple validation of performance of the probe, readout electronics, and software. The additional tests of steps b) through f) should be done whenever system components have been modified (e.g., new software release, new readout electronics, new probe type, etc.). The system validation procedures are as follows:

a) **SAR evaluation:** A complete 1 g or 10 g averaged SAR measurement is performed. The reference dipole input power is adjusted to produce a 1 g averaged SAR value falling in the range of 0.4–10 W/kg. The 1 g or 10 g averaged SAR is measured at frequencies within the

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range to be used in compliance tests. The results are normalized to 1 W forward input power and compared with the reference SAR values. The differences from the reference values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer.

b) **Extrapolation routine:** Local SAR values are measured along a vertical axis directly above the reference dipole feed-point using the same test grid-point spacing as used for handset SAR evaluations. This measurement is repeated along another vertical axis with a 2 cm transverse offset from the reference dipole feed-point. SAR values at the phantom surface are extrapolated and compared with the reference values. The difference from the reference values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer.

c) **Probe linearity:** The measurement in step a) is repeated using different reference dipole input power levels. The power levels are selected for each frequency to produce 1 g averaged SAR values of approximately 10 W/kg, 2 W/kg, and 0.4 W/kg. The measured SAR values are normalized to 1 W forward input power and compared with the 1 W normalized value from step a). The difference between these values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer.

d) **Modulation response:** The measurements in step a) are repeated with pulse-modulated signals having a duty factor of 0.1 and pulse repetition rate of 10 Hz. The power is adjusted to produce a 1 g-averaged SAR of approximately 8 W/kg with the pulse modulated signal (corresponding to a peak spatial-average SAR of approximately 80 W/kg). The measured SAR values are normalized to 1 W forward input power and duty factor of 1, and compared with the 1 W normalized values from step a). The difference between these values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer.

e) **System offset:** The measurements in step a) are repeated with a reference dipole input forward power that produces a 1 g or 10 g averaged SAR of approximately 0.05 W/kg. The measured SAR values are normalized to 1 W forward input power and compared with the 1 W normalized values from step a). The difference between these values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer.

f) **Probe axial isotropy:** The center point of the probe's sensors is placed directly above the reference dipole center at a measurement distance of approximately 5–10 mm from the phantom inner surface. The probe (or reference dipole, if precise rotations are supported by the dipole fixture) is rotated around its axis $\pm 180^\circ$ in steps no larger than 15° . The maximum and minimum SAR readings are recorded. The difference between these values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer.

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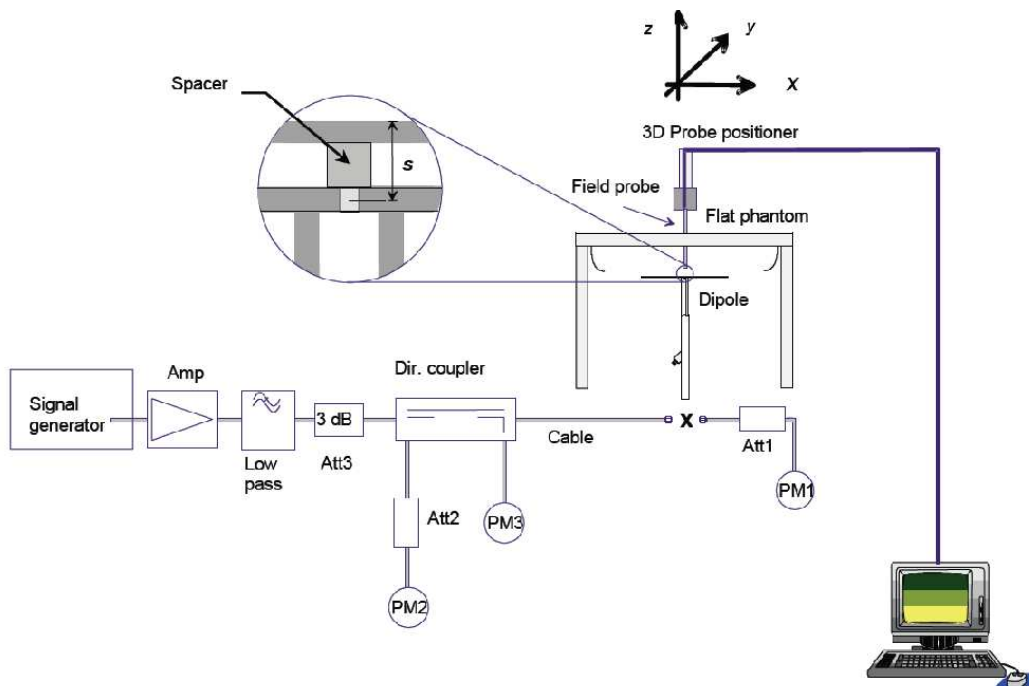
2 Step by step

The purpose of this technical note is to explain how to perform a system validation according the IEEE1528 with the COMOSAR system.

2.1. Preparation of the system – Liquid, dipole and probe installation

Step 1: Put the used liquid inside the phantom according the frequency of the validation (update the liquid value in the software – see OpenSAR user manual).

Step 2: Put the dipole in the correct configuration according the IEEE1528 standard.



Calibration was performed according to IEEE Std P1528-2003 and OET bulletin 65 Supplement C (Ed. 01-01)

The distance between the center of the dipole and the phantom is as follow (use the correct spacer according the frequency):

$s=15 \text{ mm for } 300 \text{ MHz} \leq f \leq 1000\text{MHz}$

$s=10 \text{ mm for } 1000 \text{ MHz} < f \leq 3000\text{MHz}$

Step 3: Connect the probe to the robot and perform an automatic reference with the robot (check that the serial number of the phantom and the probe define on OpenSAR software is the correct one according your setup – see OpenSAR user manual).

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2.2. Measurement parameters

Select the measurement parameters as follow:

| Measurement Parameters | |
|------------------------|-------------|
| Measurement Type | Validation |
| Phantom | Flat |
| Device position | Dipole |
| Tested band | GSM900 |
| Channel | Middle |
| Signal | CW |
| Liquid | Head Liquid |

| Area scan | |
|--------------|-----------------|
| Flat phantom | Flat adaptative |
| X0 | 0 |
| Y0 | 0 |

| Zoom scan | |
|------------------|--|
| Full measurement | |

For the tested band, you must set according the frequency you want to test:

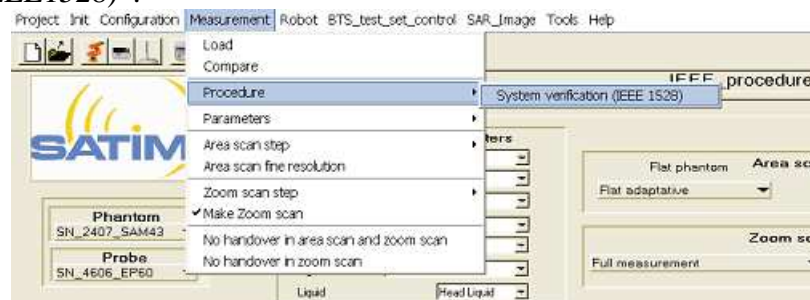
- 450 MHz: select the band GSM450
- 835 MHz: select the band GSM850
- 900 MHz: select the band GSM900
- 1800 MHz: select the band GSM1800
- 1900 MHz: select the band GSM1900
- 2000 MHz: select the band WCDMA
- 2450 MHz: select the band Bluetooth

For the zoom scan, if you want to perform faster the system verification, you can select the very fast zoom scan with 11 points (see OpenSAR user manual).

2.3. Launch the system verification

Prepare the software as for a SAR measurement: check robot, multimeter status (see OpenSAR user manual).

Launch the system verification panel in the menu “Measurement/Procedure/System verification (IEEE1528)”:



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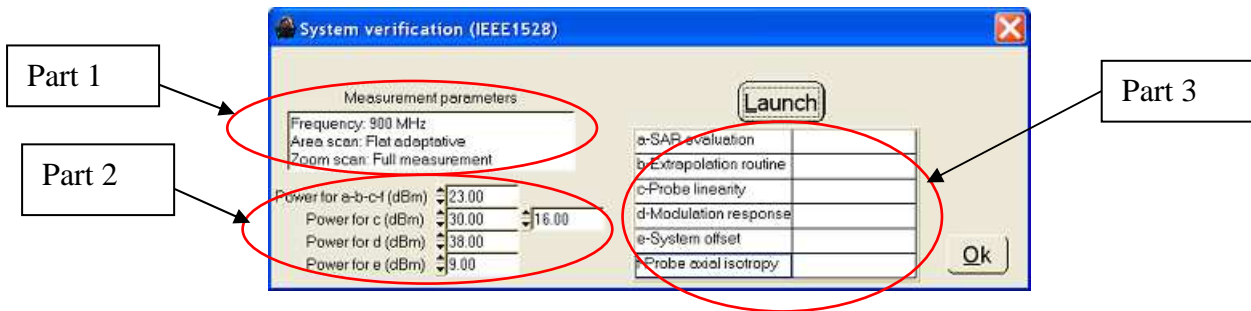
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The following panel will appear:



Part 1: The main measurement parameters will appear in this text box:

- The frequency according the tested band
- The area scan
- The zoom scan

Part 2: This part will set automatically the different input power in the dipole according the IEEE1528 recommendation. It is not recommended to change those values to be sure to be compliant with the IEEE1528 system verification procedure.

Part 3: This part will indicate the result deviation in % from the target value. For example, after the system verification:

| | |
|-------------------------|--------------|
| a-SAR evaluation | 4.4 % |
| b-Extrapolation routine | 3.2 %; 5.9 % |
| c-Probe linearity | 2.2 %; 3.1 % |
| d-Modulation response | 5.4 % |
| e-System offset | 5.1 % |
| f-Probe axial isotropy | 3.1 % |

The "Launch" button will serve to start the system verification. All the step will be perform automatically. You must set the power according the message popup when it will appear. For example, in the following example, you have to set the input power in the dipole to 23 dBm.

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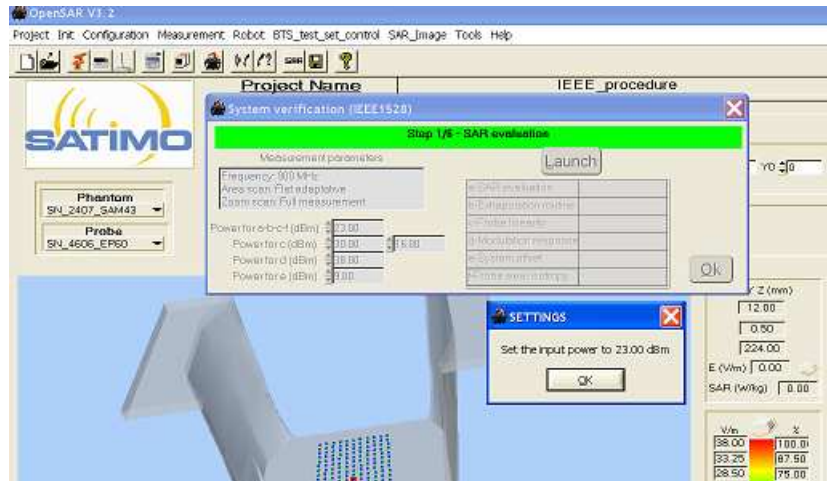


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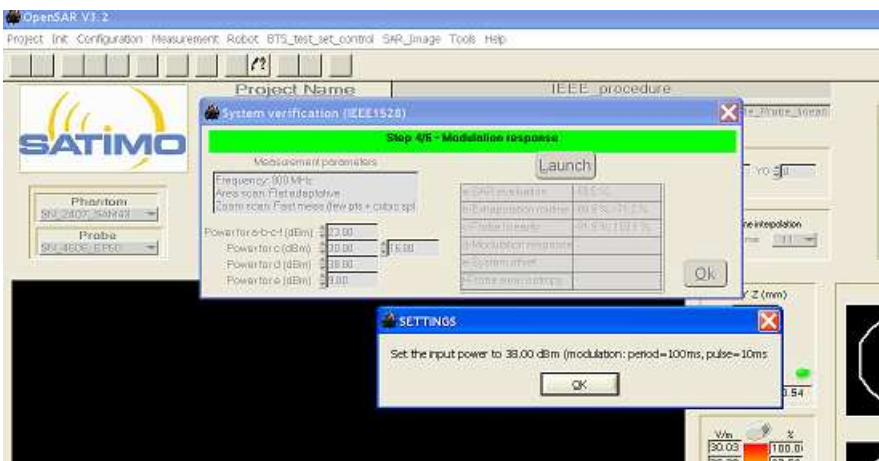
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For the d- Modulation response procedure, the signal is not a CW signal but a pulse signal with a period of 100 ms and a pulse width equal to 10 ms. In this case, the input power must be set as for the other stem with a CW signal. After setting the input power with the CW signal, the modulation must be applied without modifying the power. The following popup will appear:



You must set the 38 dBm with a CW signal then you must modulate the signal according the period and the pulse width defines to be compliant with the IEEE1528 procedure.

The “OK” button will discard this panel.

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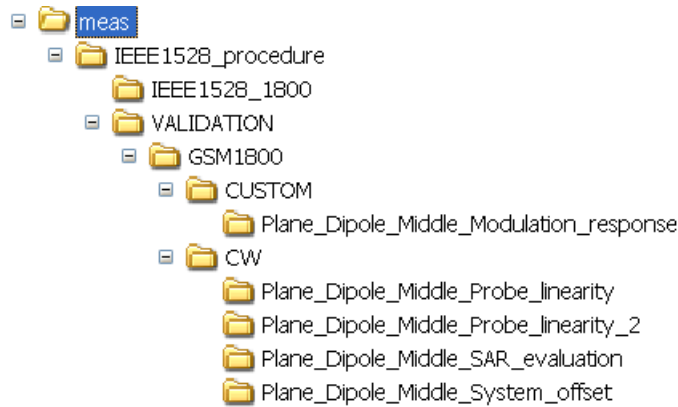
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2.4. Results

All the results will be saving automatically. For example, for a system verification at 1800 MHz, you will find the following folder under the meas/"project name" directory (here, the project name is "IEEE1528_procedure"):



In the IEEE1528_”tested frequency” folder (here, the tested frequency is 1800 MHz), you will find two files:

- IEEE1528.txt: resume the test results
- IEEE1528.png: image to show the results of the system verification. An example of this image is:

SYSTEM VALIDATION IEEE1528

a- SAR evaluation

| | Input power (dBm) | Measured value | Normalized measured value | Target value | Deviation (%) |
|----------------|-------------------|----------------|---------------------------|--------------|---------------|
| SAR 1g (W/kg) | 18.00 | 2.35 | 37.17 | 38.10 | -2.44 |
| SAR 10g (W/kg) | 18.00 | 1.26 | 19.96 | 19.80 | 0.90 |

b- Extrapolation routine

| | Input power (dBm) | Measured value | Normalized measured value | Target value | Deviation (%) |
|------------------------|-------------------|----------------|---------------------------|--------------|---------------|
| Local SAR y=0cm (W/kg) | 18.00 | 4.06 | 64.17 | 63.50 | 1.06 |
| Local SAR y=2cm (W/kg) | 18.00 | 0.41 | 6.49 | 6.80 | -4.60 |

c- Probe linearity

| | Input power (dBm) | Measured value | Normalized measured value | Target value | Deviation (%) |
|----------------|-------------------|----------------|---------------------------|--------------|---------------|
| SAR 1g (W/kg) | 24.00 | 9.43 | 37.54 | 38.10 | -1.48 |
| SAR 10g (W/kg) | 24.00 | 5.06 | 20.13 | 19.80 | 1.55 |
| SAR 1g (W/kg) | 18.00 | 2.35 | 37.17 | 38.10 | -2.44 |
| SAR 10g (W/kg) | 18.00 | 1.26 | 19.96 | 19.80 | 0.90 |
| SAR 1g (W/kg) | 11.00 | 0.47 | 37.50 | 38.10 | -1.57 |
| SAR 10g (W/kg) | 11.00 | 0.25 | 20.19 | 19.80 | 1.98 |

d- Modulation response (Period: 100ms; Pulse: 10ms)

| | Input power (dBm) | Measured value | Normalized measured value | Target value | Deviation (%) |
|----------------|-------------------|----------------|---------------------------|--------------|---------------|
| SAR 1g (W/kg) | 23.00 | 7.58 | 37.97 | 38.10 | -0.35 |
| SAR 10g (W/kg) | 23.00 | 4.06 | 20.34 | 19.80 | 2.74 |

e- System offset


| | Input power (dBm) | Measured value | Normalized measured value | Target value | Deviation (%) |
|----------------|-------------------|----------------|---------------------------|--------------|---------------|
| SAR 1g (W/kg) | 4.00 | 0.057 | 38.55 | 38.10 | 1.19 |
| SAR 10g (W/kg) | 4.00 | 0.053 | 21.11 | 19.80 | 6.64 |

f- Probe axial isotropy

| Axial angle (°) | 180 | 165 | 150 | 135 | 120 | 105 | 90 | 75 | 60 | 45 | 30 | 15 | 0 |
|------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| SAR local (W/kg) | 1.53 | 1.56 | 1.55 | 1.53 | 1.51 | 1.50 | 1.51 | 1.52 | 1.53 | 1.52 | 1.51 | 1.49 | 1.47 |

| Axial angle (°) | 15 | 30 | 45 | 60 | 75 | 90 | 105 | 120 | 135 | 150 | 165 | 180 |
|------------------|------|------|------|------|------|------|------|------|------|------|------|------|
| SAR local (W/kg) | 1.47 | 1.50 | 1.53 | 1.54 | 1.54 | 1.51 | 1.47 | 1.44 | 1.42 | 1.46 | 1.50 | 1.53 |

| Deviation (%) |
|---------------|
| 0.35 |

| | | | |
|--|---|----------|------------------|
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In the VALIDATION folder, you will find the root data from the different validation measurement:

- CUSTOM folder:
 - o Plane_Dipole_Middle_Modulation_response: root data from the modulation response measurement.
- CW folder:
 - o Plane_Dipole_Middle_SAR_evaluation: root data from the SAR evaluation measurement. This data is also used for the probe linearity step.
 - o Plane_Dipole_Middle_Probe_linearity and Plane_Dipole_Middle_Probe_linearity_2: root data from the probe linearity measurement.
 - o Plane_Dipole_Middle_System_offset: root data from the system offset measurement.

It is possible to create a word report with those measurements as a normal measurement.