

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



**S** Schweizerischer Kalibrierdienst  
**C** Service suisse d'étalonnage  
**S** Servizio svizzero di taratura  
**S** Swiss Calibration Service

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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

 Client **DT&C (Dymstec)**

 Certificate No: **D2600V2-1103\_Feb20**

## CALIBRATION CERTIFICATE

Object: **D2600V2 - SN:1103**

Calibration procedure(s): **QA CAL-05.v11**  
**Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

Calibration date: **February 20, 2020**

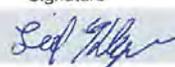
This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
 The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature ( $22 \pm 3$ )°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	03-Apr-19 (No. 217-02892/02893)	Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-19 (No. 217-02894)	Apr-20
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20
Reference Probe EX3DV4	SN: 7349	31-Dec-19 (No. EX3-7349_Dec19)	Dec-20
DAE4	SN: 601	27-Dec-19 (No. DAE4-601_Dec19)	Dec-20

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Feb-19)	In house check: Oct-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-19)	In house check: Oct-20

	Name	Function	Signature
Calibrated by:	Lelf Klysner	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: February 21, 2020

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Accreditation No.: **SCS 0108**

#### Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

#### 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"

#### Additional Documentation:

- DASY4/5 System Handbook

#### Methods Applied and Interpretation of Parameters:

- Measurement Conditions:** Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL:** The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss:** These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay:** One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- SAR measured:** SAR measured at the stated antenna input power.
- SAR normalized:** SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters:** The measured TSL parameters are used to calculate the nominal SAR result.

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%.

### Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2600 MHz $\pm$ 1 MHz	

### Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	37.8 $\pm$ 6 %	2.03 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	14.8 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	57.8 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.52 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.7 W/kg $\pm$ 16.5 % (k=2)

### Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.5	2.16 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	50.9 $\pm$ 6 %	2.21 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	14.2 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	55.8 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.30 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.9 W/kg $\pm$ 16.5 % (k=2)

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.5 $\Omega$ - 5.9 j $\Omega$
Return Loss	- 24.5 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.3 $\Omega$ - 4.8 j $\Omega$
Return Loss	- 24.1 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.147 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

### Additional EUT Data

Manufactured by	SPEAG
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**DASY5 Validation Report for Head TSL**

Date: 20.02.2020

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1103**

Communication System: UID 0 - CW; Frequency: 2600 MHz

Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2.03$  S/m;  $\epsilon_r = 37.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.69, 7.69, 7.69) @ 2600 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

**Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:**

Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 121.3 V/m; Power Drift = -0.06 dB

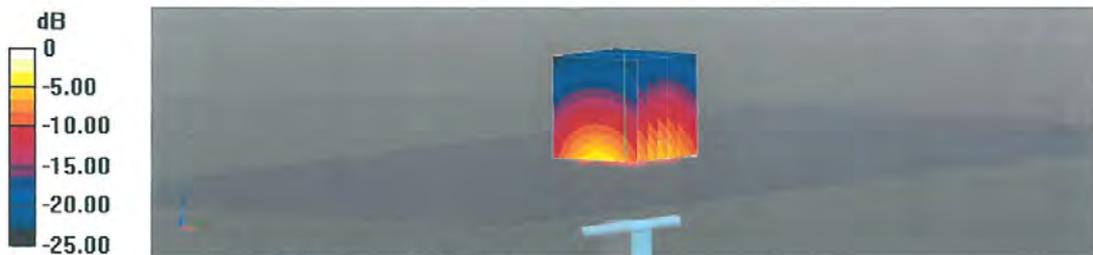
Peak SAR (extrapolated) = 30.1 W/kg

**SAR(1 g) = 14.8 W/kg; SAR(10 g) = 6.52 W/kg**

Smallest distance from peaks to all points 3 dB below = 9 mm

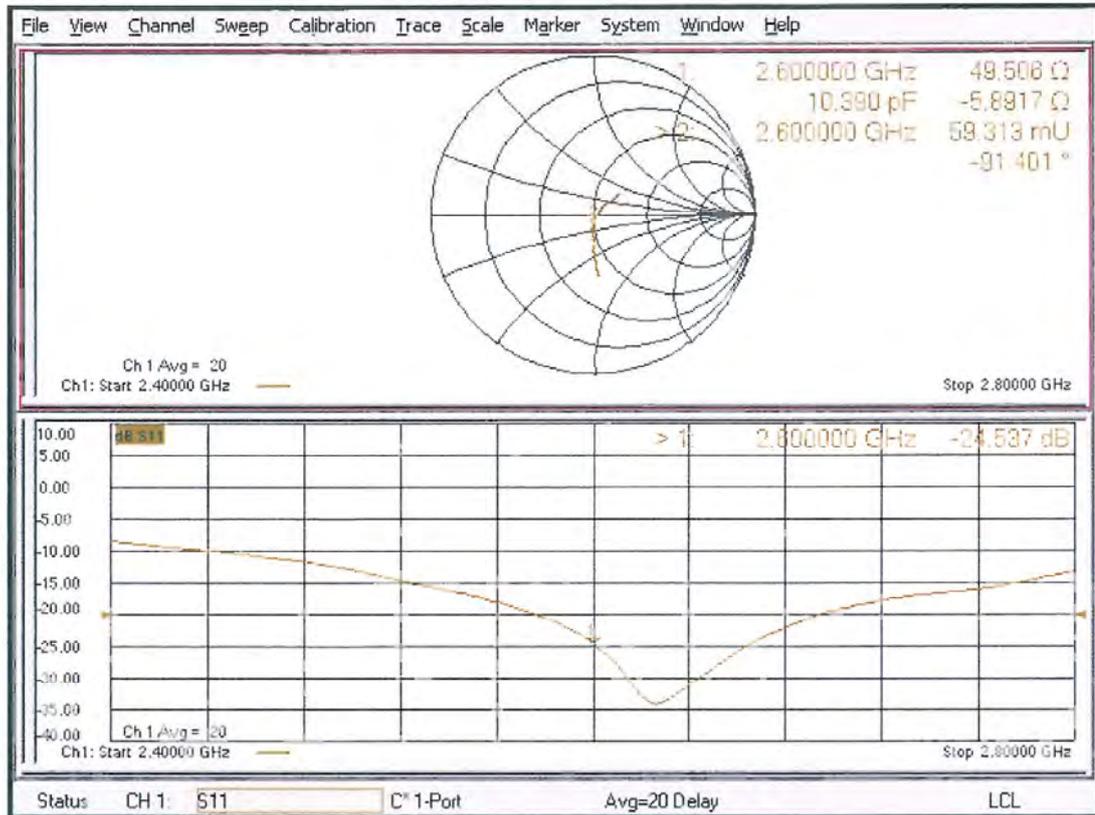
Ratio of SAR at M2 to SAR at M1 = 49%

Maximum value of SAR (measured) = 24.8 W/kg



0 dB = 24.8 W/kg = 13.94 dBW/kg

Impedance Measurement Plot for Head TSL



**DASY5 Validation Report for Body TSL**

Date: 20.02.2020

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1103**

Communication System: UID 0 - CW; Frequency: 2600 MHz

Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2.21$  S/m;  $\epsilon_r = 50.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.92, 7.92, 7.92) @ 2600 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

**Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:**

Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 111.9 V/m; Power Drift = -0.06 dB

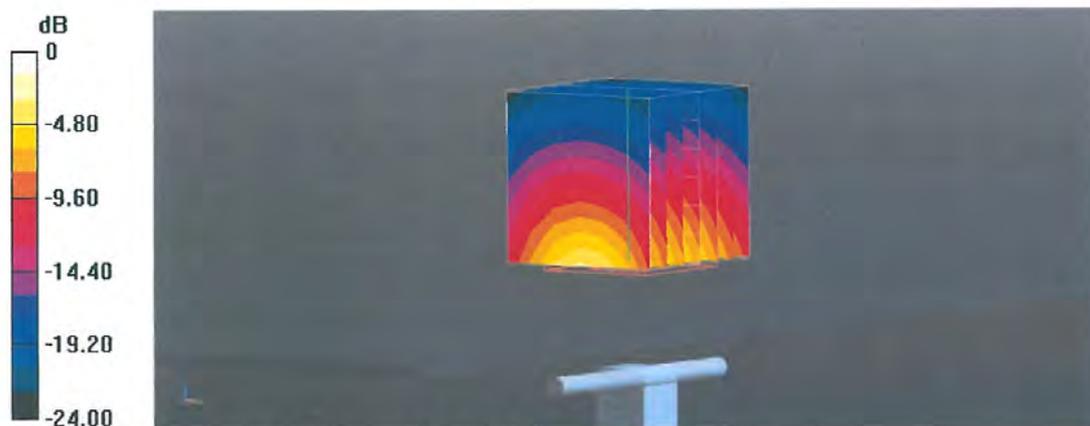
Peak SAR (extrapolated) = 28.6 W/kg

**SAR(1 g) = 14.2 W/kg; SAR(10 g) = 6.3 W/kg**

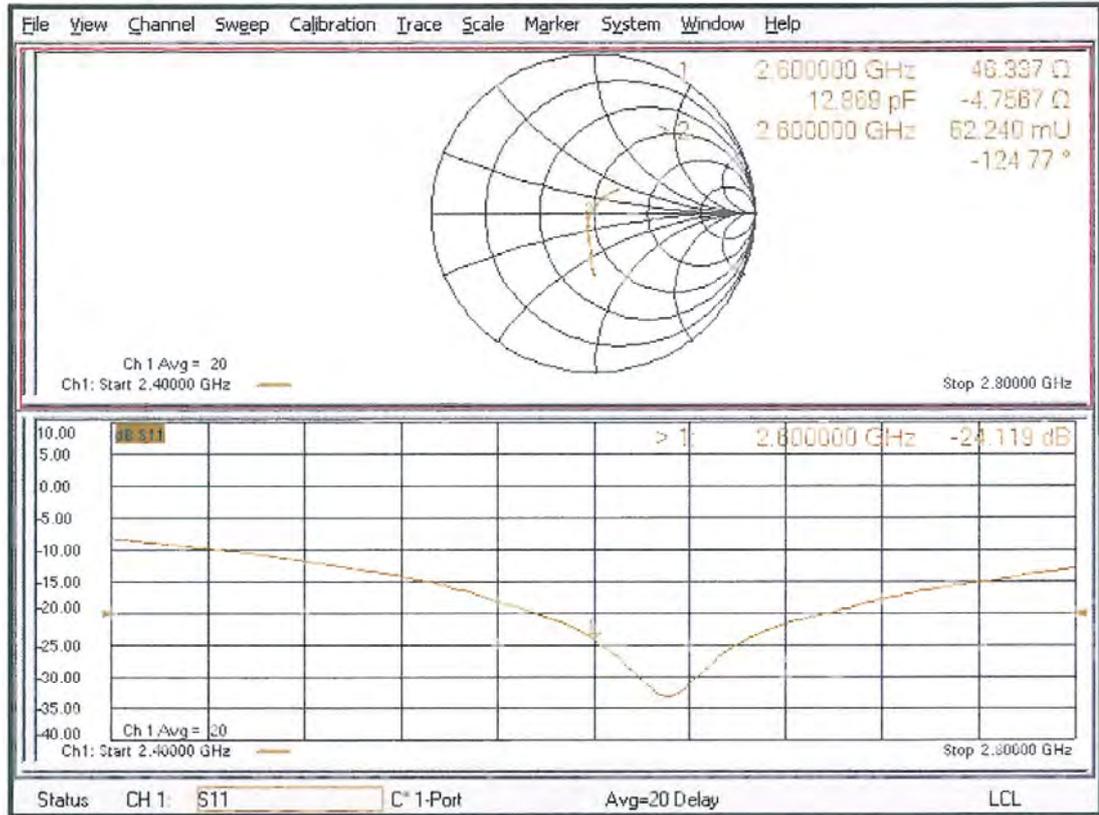
Smallest distance from peaks to all points 3 dB below = 8.5 mm

Ratio of SAR at M2 to SAR at M1 = 50.5%

Maximum value of SAR (measured) = 23.6 W/kg



Impedance Measurement Plot for Body TSL



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Accreditation No.: SCS 0108

Client **DT&C (Dymstec)**

Certificate No: D5GHzV2-1212\_Feb20

## CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN:1212**

Calibration procedure(s) **QA CAL-22.v4  
 Calibration Procedure for SAR Validation Sources between 3-6 GHz**

Calibration date: **February 27, 2020**

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)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	03-Apr-19 (No. 217-02892/02893)	Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-19 (No. 217-02894)	Apr-20
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20
Reference Probe EX3DV4	SN: 3503	31-Dec-19 (No. EX3-3503_Dec19)	Dec-20
DAE4	SN: 601	27-Dec-19 (No. DAE4-601_Dec19)	Dec-20

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Feb-19)	In house check: Oct-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-19)	In house check: Oct-20

Calibrated by: **Name** Michael Weber **Function** Laboratory Technician

Signature

Approved by: **Name** Katja Pokovic **Function** Technical Manager

Issued: February 27, 2020

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#### Glossary:

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ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

#### 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"

#### Additional Documentation:

- DASY4/5 System Handbook

#### Methods Applied and Interpretation of Parameters:

- Measurement Conditions:** Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL:** The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss:** These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay:** One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- SAR measured:** SAR measured at the stated antenna input power.
- SAR normalized:** SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters:** The measured TSL parameters are used to calculate the nominal SAR result.

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%.

### Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5200 MHz ± 1 MHz 5300 MHz ± 1 MHz 5500 MHz ± 1 MHz 5600 MHz ± 1 MHz 5800 MHz ± 1 MHz	

### Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.1 ± 6 %	4.48 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.07 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>80.2 W/kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.31 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>22.9 W/kg ± 19.5 % (k=2)</b>

### Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.9 ± 6 %	4.57 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.19 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>81.3 W/kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.32 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>23.0 W/kg ± 19.5 % (k=2)</b>

### Head TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.6	4.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.6 ± 6 %	4.78 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5500 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.69 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>86.3 W/kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.44 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>24.2 W/kg ± 19.5 % (k=2)</b>

### Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.5 ± 6 %	4.88 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.39 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	83.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.38 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.6 W/kg ± 19.5 % (k=2)

### Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.2 ± 6 %	5.08 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.21 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.5 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.7 W/kg ± 19.5 % (k=2)

**Body TSL parameters at 5200 MHz**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.4 ± 6 %	5.45 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

**SAR result with Body TSL at 5200 MHz**

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.32 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	72.8 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.05 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.4 W/kg ± 19.5 % (k=2)

**Body TSL parameters at 5300 MHz**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.42 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.2 ± 6 %	5.59 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

**SAR result with Body TSL at 5300 MHz**

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.33 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	72.8 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.04 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.2 W/kg ± 19.5 % (k=2)

### Body TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.6	5.65 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.9 ± 6 %	5.86 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5500 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.91 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>78.6 W/kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.18 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>21.6 W/kg ± 19.5 % (k=2)</b>

### Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.7 ± 6 %	5.99 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.81 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>77.6 W/kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.16 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>21.4 W/kg ± 19.5 % (k=2)</b>

**Body TSL parameters at 5800 MHz**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.3 ± 6 %	6.27 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

**SAR result with Body TSL at 5800 MHz**

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.42 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>73.7 W/kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.04 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>20.2 W/kg ± 19.5 % (k=2)</b>

**Appendix (Additional assessments outside the scope of SCS 0108)**
**Antenna Parameters with Head TSL at 5200 MHz**

Impedance, transformed to feed point	49.6 $\Omega$ - 4.5 j $\Omega$
Return Loss	- 26.9 dB

**Antenna Parameters with Head TSL at 5300 MHz**

Impedance, transformed to feed point	48.5 $\Omega$ - 0.5 j $\Omega$
Return Loss	- 36.2 dB

**Antenna Parameters with Head TSL at 5500 MHz**

Impedance, transformed to feed point	47.3 $\Omega$ + 1.7 j $\Omega$
Return Loss	- 29.7 dB

**Antenna Parameters with Head TSL at 5600 MHz**

Impedance, transformed to feed point	50.5 $\Omega$ + 2.0 j $\Omega$
Return Loss	- 33.7 dB

**Antenna Parameters with Head TSL at 5800 MHz**

Impedance, transformed to feed point	53.3 $\Omega$ + 2.9 j $\Omega$
Return Loss	- 27.4 dB

**Antenna Parameters with Body TSL at 5200 MHz**

Impedance, transformed to feed point	48.6 $\Omega$ - 2.2 j $\Omega$
Return Loss	- 31.6 dB

**Antenna Parameters with Body TSL at 5300 MHz**

Impedance, transformed to feed point	47.9 $\Omega$ + 0.2 j $\Omega$
Return Loss	- 33.2 dB

**Antenna Parameters with Body TSL at 5500 MHz**

Impedance, transformed to feed point	47.5 $\Omega$ + 3.0 j $\Omega$
Return Loss	- 27.9 dB

**Antenna Parameters with Body TSL at 5600 MHz**

Impedance, transformed to feed point	50.3 $\Omega$ + 2.7 j $\Omega$
Return Loss	- 31.3 dB

**Antenna Parameters with Body TSL at 5800 MHz**

Impedance, transformed to feed point	52.4 $\Omega$ + 3.4 j $\Omega$
Return Loss	- 27.9 dB

**General Antenna Parameters and Design**

Electrical Delay (one direction)	1.189 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

**Additional EUT Data**

Manufactured by	SPEAG
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**DASY5 Validation Report for Head TSL**

Date: 26.02.2020

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1212**

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used:  $f = 5200$  MHz;  $\sigma = 4.48$  S/m;  $\epsilon_r = 35.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>,Medium parameters used:  $f = 5300$  MHz;  $\sigma = 4.57$  S/m;  $\epsilon_r = 34.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>,Medium parameters used:  $f = 5500$  MHz;  $\sigma = 4.78$  S/m;  $\epsilon_r = 34.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>,Medium parameters used:  $f = 5600$  MHz;  $\sigma = 4.88$  S/m;  $\epsilon_r = 34.5$ ;  $\rho = 1000$  kg/m<sup>3</sup>,Medium parameters used:  $f = 5800$  MHz;  $\sigma = 5.08$  S/m;  $\epsilon_r = 34.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

**DASY52 Configuration:**

- Probe: EX3DV4 - SN3503; ConvF(5.8, 5.8, 5.8) @ 5200 MHz, ConvF(5.49, 5.49, 5.49) @ 5300 MHz, ConvF(5.25, 5.25, 5.25) @ 5500 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.01, 5.01, 5.01) @ 5800 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan,****dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 79.74 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 29.0 W/kg

**SAR(1 g) = 8.07 W/kg; SAR(10 g) = 2.31 W/kg**

Smallest distance from peaks to all points 3 dB below = 6.9 mm

Ratio of SAR at M2 to SAR at M1 = 69%

Maximum value of SAR (measured) = 18.2 W/kg

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan,****dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 78.26 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 29.6 W/kg

**SAR(1 g) = 8.19 W/kg; SAR(10 g) = 2.32 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.2 mm

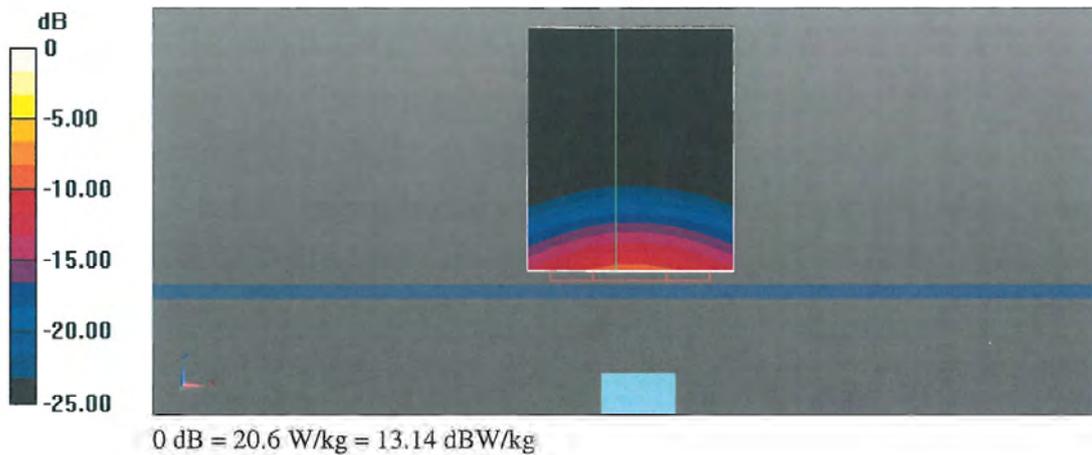
Ratio of SAR at M2 to SAR at M1 = 68.8%

Maximum value of SAR (measured) = 18.9 W/kg

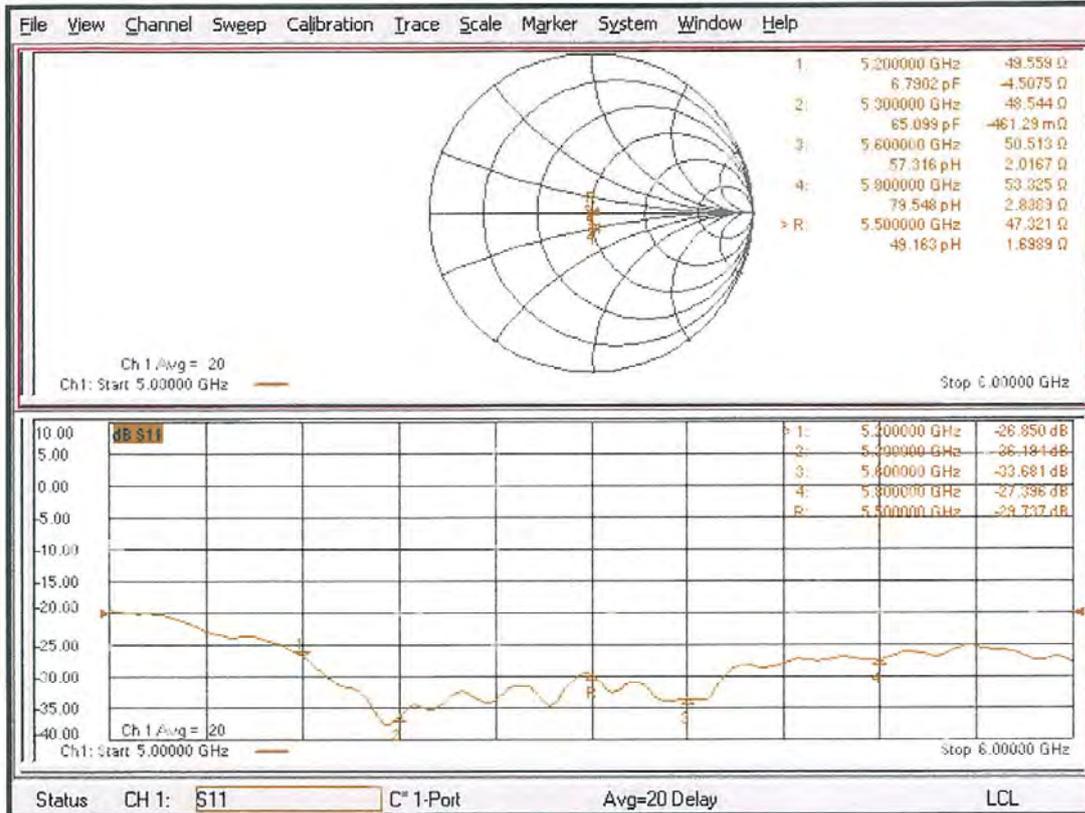
**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
 Reference Value = 77.35 V/m; Power Drift = 0.03 dB  
 Peak SAR (extrapolated) = 34.0 W/kg  
**SAR(1 g) = 8.69 W/kg; SAR(10 g) = 2.44 W/kg**  
 Smallest distance from peaks to all points 3 dB below = 7.2 mm  
 Ratio of SAR at M2 to SAR at M1 = 66%  
 Maximum value of SAR (measured) = 20.6 W/kg

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
 Reference Value = 77.32 V/m; Power Drift = -0.01 dB  
 Peak SAR (extrapolated) = 31.6 W/kg  
**SAR(1 g) = 8.39 W/kg; SAR(10 g) = 2.38 W/kg**  
 Smallest distance from peaks to all points 3 dB below = 7.4 mm  
 Ratio of SAR at M2 to SAR at M1 = 67.2%  
 Maximum value of SAR (measured) = 19.7 W/kg

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
 Reference Value = 75.65 V/m; Power Drift = -0.01 dB  
 Peak SAR (extrapolated) = 33.2 W/kg  
**SAR(1 g) = 8.21 W/kg; SAR(10 g) = 2.29 W/kg**  
 Smallest distance from peaks to all points 3 dB below = 7.2 mm  
 Ratio of SAR at M2 to SAR at M1 = 65%  
 Maximum value of SAR (measured) = 19.7 W/kg



Impedance Measurement Plot for Head TSL



**DASY5 Validation Report for Body TSL**

Date: 27.02.2020

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1212**

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used:  $f = 5200$  MHz;  $\sigma = 5.45$  S/m;  $\epsilon_r = 47.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>,Medium parameters used:  $f = 5300$  MHz;  $\sigma = 5.59$  S/m;  $\epsilon_r = 47.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>,Medium parameters used:  $f = 5500$  MHz;  $\sigma = 5.86$  S/m;  $\epsilon_r = 46.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>,Medium parameters used:  $f = 5600$  MHz;  $\sigma = 5.99$  S/m;  $\epsilon_r = 46.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>,Medium parameters used:  $f = 5800$  MHz;  $\sigma = 6.27$  S/m;  $\epsilon_r = 46.3$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.29, 5.29, 5.29) @ 5200 MHz, ConvF(5.23, 5.23, 5.23) @ 5300 MHz, ConvF(4.84, 4.84, 4.84) @ 5500 MHz, ConvF(4.79, 4.79, 4.79) @ 5600 MHz, ConvF(4.62, 4.62, 4.62) @ 5800 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan,****dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 67.25 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 27.3 W/kg

**SAR(1 g) = 7.32 W/kg; SAR(10 g) = 2.05 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 67.7%

Maximum value of SAR (measured) = 16.7 W/kg

**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan,****dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 66.70 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 28.7 W/kg

**SAR(1 g) = 7.33 W/kg; SAR(10 g) = 2.04 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.2 mm

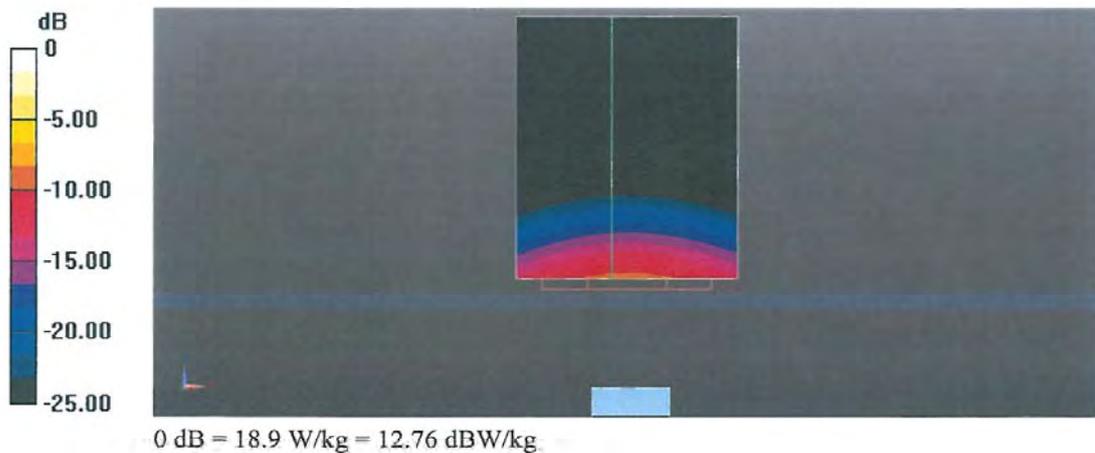
Ratio of SAR at M2 to SAR at M1 = 66.2%

Maximum value of SAR (measured) = 17.1 W/kg

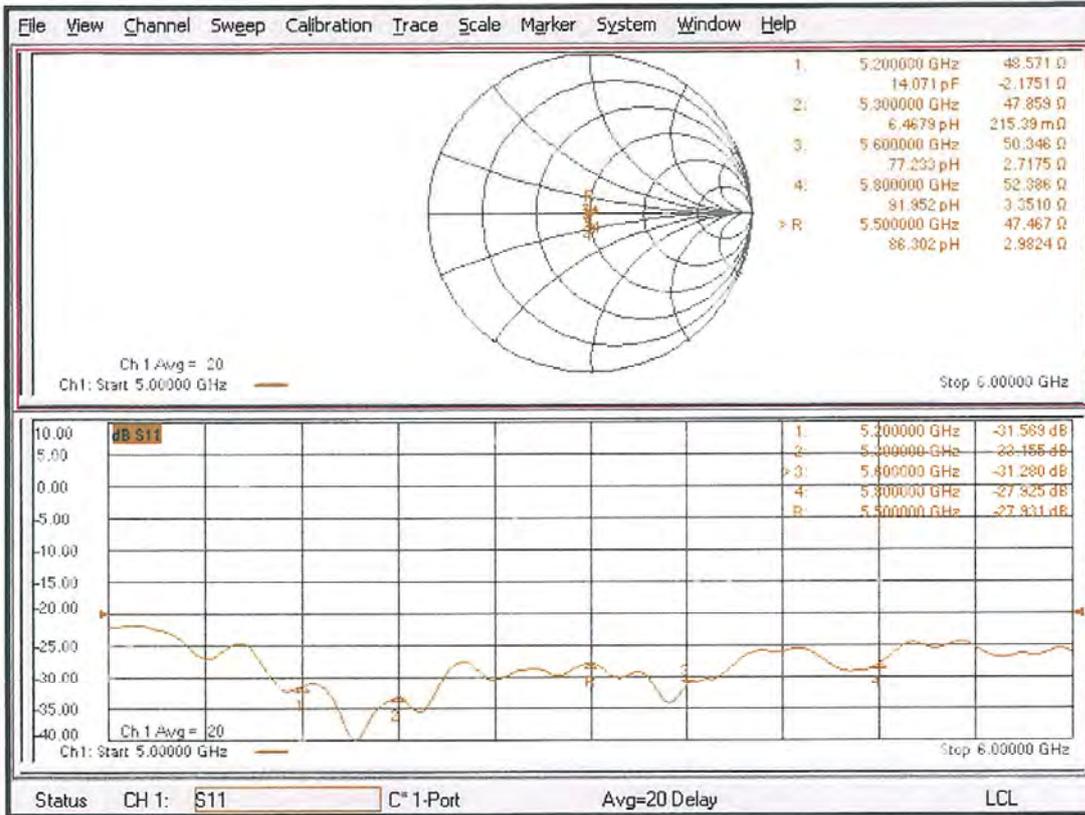
**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
 Reference Value = 68.06 V/m; Power Drift = -0.09 dB  
 Peak SAR (extrapolated) = 32.8 W/kg  
**SAR(1 g) = 7.91 W/kg; SAR(10 g) = 2.18 W/kg**  
 Smallest distance from peaks to all points 3 dB below = 7.2 mm  
 Ratio of SAR at M2 to SAR at M1 = 64.6%  
 Maximum value of SAR (measured) = 18.9 W/kg

**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
 Reference Value = 67.13 V/m; Power Drift = -0.08 dB  
 Peak SAR (extrapolated) = 33.4 W/kg  
**SAR(1 g) = 7.81 W/kg; SAR(10 g) = 2.16 W/kg**  
 Smallest distance from peaks to all points 3 dB below = 7.2 mm  
 Ratio of SAR at M2 to SAR at M1 = 63.4%  
 Maximum value of SAR (measured) = 18.8 W/kg

**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
 Reference Value = 65.12 V/m; Power Drift = -0.07 dB  
 Peak SAR (extrapolated) = 32.4 W/kg  
**SAR(1 g) = 7.42 W/kg; SAR(10 g) = 2.04 W/kg**  
 Smallest distance from peaks to all points 3 dB below = 7.2 mm  
 Ratio of SAR at M2 to SAR at M1 = 62.7%  
 Maximum value of SAR (measured) = 18.2 W/kg



Impedance Measurement Plot for Body TSL



## APPENDIX C. – SAR Tissue Specifications

The brain and muscle mixtures consist of a viscous gel using hydrox-ethylcellulose (HEC) gelling agent and saline solution (see Table 3.1). Preservation with a bactericide is added and visual inspection is made to make sure air bubbles are not trapped during the mixing process. The mixture is calibrated to obtain proper dielectric constant (permittivity) and conductivity of the desired tissue. The mixture characterizations used for the brain and muscle tissue simulating liquids are according to the data by C. Gabriel and G. Harts grove.



**Figure 3.9 Simulated Tissue**

**Table C.1 Composition of the Tissue Equivalent Matter**

Ingredients (% by weight)	Frequency (MHz)							
	835		1 900		2 450		5 200 ~ 5 800	
Tissue Type	Head	Body	Head	Body	Head	Body	Head	Body
Water	40.19	50.75	55.24	70.23	71.88	73.40	65.52	80.00
Salt (NaCl)	1.480	0.940	0.310	0.290	0.160	0.060	-	-
Sugar	57.90	48.21	-	-	-	-	-	-
HEC	0.250	-	-	-	-	-	-	-
Bactericide	0.180	0.100	-	-	-	-	-	-
Triton X-100	-	-	-	-	19.97	-	17.24	-
DGBE	-	-	44.45	29.48	7.990	26.54	-	-
Diethylene glycol hexyl ether	-	-	-	-	-	-	17.24	-
Polysorbate (Tween) 80	-	-	-	-	-	-	-	20.00
Target for Dielectric Constant	41.5	55.2	40.0	53.3	39.2	52.7	-	-
Target for Conductivity (S/m)	0.90	0.97	1.40	1.52	1.80	1.95	-	-

- Salt: 99 % Pure Sodium Chloride                      Sugar: 98 % Pure Sucrose
- Water: De-ionized, 16M resistivity                      HEC: Hydroxyethyl Cellulose
- DGBE: 99 % Di(ethylene glycol) butyl ether,[2-(2-butoxyethoxy) ethanol]
- Triton X-100(ultra pure): Polyethylene glycol mono[4-(1,1,3,3-tetramethylbutyl)phenyl] ether

**Table C.2 HSL/MSL750 (Head and Body liquids for 700 – 800 MHz)**

Item	Head Tissue Simulation Liquids HSL750
	Muscle (body) Tissue Simulation Liquids MSL750
Type No	SL AAH 075, SL AAM 075
Manufacturer	SPEAG
The item is composed of the following ingredients:	
H <sup>2</sup> O	Water, (35 – 58) %
Sucrose	Sucrose, (40 – 60) %
NaCl	Sodium Chloride, (0 – 6) %
Hydroxyethyl-cellulose	Medium Viscosity (CAS# 9004-62-0), < 0.3%
Preventol-D7	Preservative: aqueous preparation, (CAS# 55965-84-9), containing 5-chloro-2-methyl-3(2H)-isothiazolone and 2-methyl-3(2H)-isothiazolone, 0.1 – 0.6%

**Table C.3 HSL/MSL1 750 (Head and Body liquids for 1 700 – 1 800 MHz)**

Item	Head Tissue Simulation Liquids HSL1 750
	Muscle (body) Tissue Simulation Liquids MSL1 750
Type No	SL AAH 175, SL AAM 175
Manufacturer	SPEAG
The item is composed of the following ingredients:	
H <sup>2</sup> O	Water, (52 – 75) %
C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>	Diethylene glycol monobutyl ether (DGBE), (25 – 48) %
NaCl	Sodium Chloride, < 1.0%

## APPENDIX D. – SAR SYSTEM VALIDATION

## SAR System Validation

Per FCC KDB 865664 D02v01r02, SAR system validation status should be documented 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 were used with the required tissue- equivalent media for system validation, according to the procedures outlined in FCC KDB 865664 D01v01r04 and IEEE 1528-2013. Since SAR probe calibrations are frequency dependent, each probe calibration point was 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 including the validation date(s), measurement frequencies, SAR probes and tissue dielectric parameters has been included.

**Table D.1 SAR System Validation Summary**

SAR System	Freq. [MHz]	Date	Probe SN	Probe Type	Probe CAL. Point		PERM.	COND.	CW Validation			MOD. Validation		
							( $\epsilon_r$ )	( $\sigma$ )	Sensitivity	Probe Linearity	Probe Isortopy	MOD. Type	Duty Factor	PAR
F	750	2020.02.05	7368	EX3DV4	750	Head	41.898	0.884	PASS	PASS	PASS	N/A	N/A	N/A
E	835	2019.12.16	7337	EX3DV4	835	Head	41.699	0.912	PASS	PASS	PASS	GMSK	PASS	N/A
B	1 800	2019.09.04	3327	ES3DV3	1 800	Head	40.133	1.448	PASS	PASS	PASS	N/A	N/A	N/A
B	1 900	2019.09.05	3327	ES3DV3	1 900	Head	40.233	1.411	PASS	PASS	PASS	GMSK	PASS	N/A
A	2 450	2019.11.29	3930	EX3DV4	2 450	Head	38.859	1.798	PASS	PASS	PASS	OFDM/TDD	PASS	PASS
B	2 600	2019.09.01	3327	ES3DV3	2 600	Head	38.355	1.918	PASS	PASS	PASS	TDD	PASS	N/A
A	5 200	2019.12.05	3930	EX3DV4	5 200	Head	36.058	4.630	PASS	PASS	PASS	OFDM	N/A	PASS
A	5 300	2019.12.05	3930	EX3DV4	5 300	Head	34.664	4.674	PASS	PASS	PASS	OFDM	N/A	PASS
A	5 500	2019.12.06	3930	EX3DV4	5 500	Head	36.097	5.111	PASS	PASS	PASS	OFDM	N/A	PASS
A	5 600	2019.12.06	3930	EX3DV4	5 600	Head	36.368	5.252	PASS	PASS	PASS	OFDM	N/A	PASS
A	5 800	2019.12.07	3930	EX3DV4	5 800	Head	36.492	5.472	PASS	PASS	PASS	OFDM	N/A	PASS
F	750	2020.06.10	3866	EX3DV4	750	Body	56.582	0.976	PASS	PASS	PASS	N/A	N/A	N/A
E	835	2019.12.16	7337	EX3DV4	835	Body	55.192	0.990	PASS	PASS	PASS	GMSK	PASS	N/A
B	1 800	2019.09.04	3327	ES3DV3	1 800	Body	54.161	1.558	PASS	PASS	PASS	N/A	N/A	N/A
B	1 900	2019.09.05	3327	ES3DV3	1 900	Body	53.514	1.534	PASS	PASS	PASS	GMSK	PASS	N/A
A	2 450	2019.11.29	3930	EX3DV4	2 450	Body	53.574	2.022	PASS	PASS	PASS	OFDM/TDD	PASS	PASS
B	2 600	2019.09.01	3327	ES3DV3	2 600	Body	51.871	2.099	PASS	PASS	PASS	TDD	PASS	N/A
A	5 200	2019.12.05	3930	EX3DV4	5 200	Body	51.422	5.550	PASS	PASS	PASS	OFDM	N/A	PASS
A	5 300	2019.12.05	3930	EX3DV4	5 300	Body	47.749	5.449	PASS	PASS	PASS	OFDM	N/A	PASS
A	5 500	2019.12.06	3930	EX3DV4	5 500	Body	49.468	5.712	PASS	PASS	PASS	OFDM	N/A	PASS
A	5 600	2019.12.06	3930	EX3DV4	5 600	Body	50.416	5.913	PASS	PASS	PASS	OFDM	N/A	PASS
A	5 800	2019.12.07	3930	EX3DV4	5 800	Body	48.620	6.122	PASS	PASS	PASS	OFDM	N/A	PASS

NOTE: While the probes have been calibrated for both a 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 865664 D01v01r04 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 (>5 dB), such as OFDM according to KDB 865664.

## APPENDIX E. – Downlink LTE CA RF Conducted Powers

### E.1 LTE Downlink Only Carrier Aggregation Test Reduction Methodology

SAR test exclusion for LTE downlink Carrier Aggregation is determined by power measurements according to the number of component carriers (CCs) supported by the product implementation. Per April 2018 TCBC Workshop Notes, the following test reduction methodology was applied to determine the combinations required for conducted power measurements.

#### LTE DL CA Test Reduction Methodology:

- (1) Test supported combinations were arranged by the number of component carriers in columns.
- (2) Any limitations on the PCC or SCC for each combination were identified alongside the combination (e.g. CA\_2A-2A-4A-12A, but B12 can only be configured as a SCC).
- (3) Power measurements were performed for “supersets” (LTE CA combinations with multiple components carriers) and any “subsets” (LTE CA combinations with fewer component carriers) that were not completely covered by the supersets.
- (4) Only subsets that have the exact same components as a superset were excluded for measurement.
- (5) When there were certain restrictions on component carriers that existed in the superset that were not applied for the subset, the subset configuration was additionally evaluated.
- (6) Both inter-band and intra-band downlink carrier aggregation scenarios were considered.

Index	2CC	Restriction	Completely Covered by Measurement Superset	Index	3CC	Restriction	Completely Covered by Measurement Superset	Index	4CC	Restriction	Completely Covered by Measurement Superset	Index	5CC	Restriction	Completely Covered by Measurement Superset
RCC #1	CA 2C		3CC #7	RCC #1	CA 2A-2A-4A		4CC #1	HCC #1	CA 2A-2A-4A-4A		No	SCC #1	CA 2A-2A-4A-6D	B46 SCC Only	No
RCC #2	CA 2A-2A		4CC #1	RCC #2	CA 2A-2A-5A		4CC #2	RCC #2	CA 2A-2A-4A-5A		No	SCC #2	CA 2A-5B-30A-66A		No
RCC #3	CA 2A-4A(2)		4CC #1	RCC #3	CA 2A-2A-12A		No	HCC #3	CA 2A-2A-4A-12A	B12 SCC Only	No	SCC #3	CA 2A-5B-66A-66A		No
RCC #4	CA 2A-5A		4CC #2	RCC #4	CA 2A-2A-13A		4CC #8	HCC #4	CA 2A-2A-5A-30A		No	SCC #4	CA 2A-46D-66A	B46 SCC Only	No
RCC #5	CA 2A-7A		4CC #16	RCC #5	CA 2A-2A-29A	B29 SCC Only	4CC #9	RCC #5	CA 2A-2A-5A-66A		No	SCC #5	CA 2A-46A-46C-66A	B46 SCC Only	No
RCC #6	CA 2A-12A (1)		3CC #3	RCC #6	CA 2A-2A-30A		4CC #9	HCC #6	CA 2A-2A-12A-30A	B12 SCC Only	No	SCC #6	CA 41C-41D		No
RCC #7	CA 2A-13A		4CC #31	RCC #7	CA 2C-66A		No	HCC #7	CA 2A-2A-12A-66A	B12 SCC Only	No	SCC #7	CA 46D-66A-66A	B46 SCC Only	No
RCC #8	CA 2A-14A		3CC #27	RCC #8	CA 2A-2A-66A		4CC #7	HCC #8	CA 2A-2A-13A-66A		No	SCC #8			
RCC #9	CA 2A-17A		No	RCC #9	CA 2A-2A-71A	B71 SCC Only	No	HCC #9	CA 2A-2A-29A-30A	B29 SCC Only	No	SCA 9			
RCC #10	CA 2A-29A (2)	B29 SCC Only	4CC #9	RCC #10	CA 2A-4A-4A		4CC #1	HCC #10	CA 2A-2A-66A-66A		No	SCA 10			
RCC #11	CA 2A-30A		4CC #9	RCC #11	CA 2A-4A-5A		4CC #2	HCC #11	CA 2A-4A-4A-5A		No	SCA 11			
RCC #12	CA 2A-46A	B46 SCC Only	5CC #5	RCC #12	CA 2A-4A-7A		4CC #16	HCC #12	CA 2A-4A-4A-12A	B12 SCC Only	No	SCA 12			
RCC #13	CA 2A-66A		5CC #2	RCC #13	CA 2A-4A-12A		No	HCC #13	CA 2A-4A-5B		No	SCA 13			
RCC #14	CA 2A-71A	B71 SCC Only	3CC #17	RCC #14	CA 2A-4A-13A		No	HCC #14	CA 2A-4A-5A-30A		No	SCA 14			
RCC #15	CA 4A-4A		4CC #1	RCC #15	CA 2A-4A-29A	B29 SCC Only	4CC #20	HCC #15	CA 2A-4A-7C		No	SCA 15			
RCC #16	CA 4A-5A (1)		4CC #2	RCC #16	CA 2A-4A-30A		4CC #19	HCC #16	CA 2A-4A-7A-7A		No	SCA 16			
RCC #17	CA 4A-7A (1)		4CC #16	RCC #17	CA 2A-4A-71A	B71 SCC Only	No	HCC #17	CA 2A-4A-7A-12A	B12 SCC Only	No	SCA 17			
RCC #18	CA 4A-12A (2)		4CC #3	RCC #18	CA 2A-5B		4CC #13	HCC #18	CA 2A-4A-12B	B12 SCC Only	No	SCA 18			
RCC #19	CA 4A-13A		3CC #14	RCC #19	CA 2A-5A-30A		4CC #23	HCC #19	CA 2A-4A-12A-30A	B12 SCC Only	No	SCA 19			
RCC #20	CA 4A-17A	B17 SCC Only	No	RCC #20	CA 2A-5A-66A		4CC #23	HCC #20	CA 2A-4A-29A-30A	B29 SCC Only	No	SCA 20			
RCC #21	CA 4A-29A (2)	B29 SCC Only	4CC #20	RCC #21	CA 2A-7A-7A		4CC #16	HCC #21	CA 2A-5B-30A		5CC #2	SCA 21			
RCC #22	CA 4A-30A		4CC #19	RCC #22	CA 2A-7A-12A		No	HCC #22	CA 2A-5B-66A		5CC #3	SCA 22			
RCC #23	CA 4A-46A	B46 SCC Only	4CC #42	RCC #23	CA 2A-12B		No	HCC #23	CA 2A-5A-30A-66A		No	SCA 23			
RCC #24	CA 4A-71A	B71 SCC Only	3CC #43	RCC #24	CA 2A-12A-30A		No	HCC #24	CA 2A-5A-66B		No	SCA 24			
RCC #25	CA 5B		5CC #2	RCC #25	CA 2A-12A-66A		No	HCC #25	CA 2A-5A-66C		No	SCA 25			
RCC #26	CA 5A-25A		No	RCC #26	CA 2A-13A-66A		4CC #31	HCC #26	CA 2A-5A-66A-66A		No	SCA 26			
RCC #27	CA 5A-30A		4CC #23	RCC #27	CA 2A-14A-30A		No	HCC #27	CA 2A-12A-30A-66A	B12 SCC Only	No	SCA 27			
RCC #28	CA 5A-66A		4CC #23	RCC #28	CA 2A-29A-30A	B29 SCC Only	4CC #9	HCC #28	CA 2A-12A-66A-66A	B12 SCC Only	No	SCA 28			
RCC #29	CA 7A-7A (1)		4CC #16	RCC #29	CA 2A-30A-66A		4CC #23	HCC #29	CA 2A-13A-66B		No	SCA 29			
RCC #30	CA 7A-12A		3CC #22	RCC #30	CA 2A-46C	B46 SCC Only	5CC #5	HCC #30	CA 2A-13A-66C		No	SCA 30			
RCC #31	CA 7A-46A (1)	B46 SCC Only	No	RCC #31	CA 2A-46A-46A	B46 SCC Only	4CC #34	HCC #31	CA 2A-13A-66A-66A		No	SCA 31			
RCC #32	CA 12B		3CC #23	RCC #32	CA 2A-46A-66A	B46 SCC Only	4CC #34	HCC #32	CA 2A-46D	B46 SCC Only	5CC #1	SCA 32			
RCC #33	CA 12A-25A		No	RCC #33	CA 2A-66B		4CC #24	HCC #33	CA 2A-46A-46C	B46 SCC Only	5CC #5	SCA 33			
RCC #34	CA 12A-30A		4CC #4	RCC #34	CA 2A-66C		4CC #25	HCC #34	CA 2A-46A-46A-66A	B46 SCC Only	No	SCA 34			
RCC #35	CA 12A-66A (1)		3CC #25	RCC #35	CA 2A-66A-66A		4CC #26	HCC #35	CA 2A-46C-66A	B46 SCC Only	5CC #5	SCA 35			
RCC #36	CA 13A-46A	B46 SCC Only	No	RCC #36	CA 2A-66A-71A	B71 SCC Only	No	HCC #36	CA 4A-4A-5B		No	SCA 36			
RCC #37	CA 13A-66A		4CC #8	RCC #37	CA 4A-4A-5A		4CC #37	HCC #37	CA 4A-4A-5A-30A		No	SCA 37			
RCC #38	CA 14A-30A		3CC #27	RCC #38	CA 4A-4A-7A (1)		No	HCC #38	CA 4A-4A-12A-30A	B12 SCC Only	No	SCA 38			
RCC #39	CA 14A-66A		3CC #66	RCC #39	CA 4A-4A-12A		4CC #38	HCC #39	CA 4A-4A-29A-30A	B29 SCC Only	No	SCA 39			
RCC #40	CA 25A-25A (1)		4CC #49	RCC #40	CA 4A-4A-13A		No	HCC #40	CA 4A-5B-30A		No	SCA 40			

Table E.1.1 Example of Exclusion Table for LTE DL CA

## E.2 LTE Downlink Only Carrier Aggregation Test Selection and Setup

SAR test exclusion for LTE downlink Carrier Aggregation is determined by power measurements according to the number of component carriers (CCs) supported by the product implementation. For those configurations required by April 2018 TCBC Workshop Notes, conducted power measurements with LTE Carrier Aggregation (CA) (downlink only) active are made in accordance to KDB Publication 941225 D05Av01r02. The RRC connection is only handled by one cell, the primary component carrier (PCC) for downlink and uplink communications. After making a data connection to the PCC, the UE device adds secondary component carrier(s) (SCC) on the downlink only. All uplink communications and acknowledgements remain identical to specifications when downlink carrier aggregation is inactive on the PCC. Additional conducted output powers are measured with the downlink carrier aggregation active for the configuration with highest measured maximum conducted power with downlink carrier aggregation inactive measured among the channel bandwidth, modulation and RB combinations in each frequency band.

Per FCC KDB Publication 941225 D05Av01r02, no SAR measurements are required for carrier aggregation configurations when the average output power with downlink only carrier aggregation active is not more than 0.25 dB higher than the average output power with downlink only carrier aggregation inactive.

General PCC and SCC configuration selection procedure

PCC uplink channel, channel bandwidth, modulation and RB configurations were selected based on section C)3)b)ii) of KDB 941225 D05v01r02. The downlink PCC channel was paired with the selected PCC uplink channel according to normal configurations without carrier aggregation.

To maximize aggregation bandwidth, highest channel bandwidth available for that CA combination was selected for SCC. For inter-band CA, the SCC downlink channels were selected near the middle of their transmission bands. For contiguous intra-band CA, the downlink channel spacing between the component carriers was set to multiple of 300 kHz less than the nominal channel spacing defined in section 5.4.1A of 3GPP TS 36.521. For non-contiguous intra-band CA, the downlink channel spacing between the component carriers was set to be larger than the nominal channel spacing and provided maximum separation between the component carriers.

All selected PCC and SCC(s) remained fully within the uplink/downlink transmission band of the respective component carrier.

When a device supports LTE capabilities with overlapping transmission frequency ranges, the standalone powers from the band with a larger transmission frequency range can be used to select measurement configurations for the band with the fully covered transmission frequency range.

### E.3 LTE DL Carrier Aggregation Conducted Powers

- Below downlink CA configurations were determined based on Manufacturer's information.

Table E.3.1 CA BW Class

Class	ATBC		Maximum number of CC
	NRB.agg	MHz	
A	$N \leq 100$	20	1
B	$25 < N \leq 100$	20	2
C	$100 < N \leq 200$	40	2
D	$200 < N \leq 300$	60	3
E	$300 < N \leq 400$	80	4
F	$400 < N \leq 500$	100	5
I	$700 < N \leq 800$	160	8

Table E.3.2 Exclusion Table for LTE DL CA (2CC)

Index	2CC	Supported Channel Bandwidth [MHz]		Restriction	Completely Covered by Measurement Superset
		CC1	CC2		
2CC #1	CA 2A-4A (0)	1.4, 3, 5, 10, 15, 20	5, 10, 15, 20		No
2CC #2	CA 2A-4A (1)	5, 10	5, 10		No
2CC #3	CA 2A-4A (2)	5, 10, 15, 20	5, 10, 15, 20		No
2CC #4	CA 2A-5A (0)	5, 10, 15, 20	5, 10		No
2CC #5	CA 2A-5A (1)	5, 10	5, 10		No
2CC #6	CA 2A-7A (0)	5, 10, 15, 20	5, 10, 15, 20		No
2CC #7	CA 2C (0)	5, 10, 15, 20	5, 10, 15, 20		No
2CC #8	CA 4A-4A (0)	5, 10, 15, 20	5, 10, 15, 20		No
2CC #9	CA 4A-4A (1)	5, 10	5, 10		No
2CC #10	CA 4A-5A (0)	5, 10	5, 10		No
2CC #11	CA 4A-5A (1)	5, 10, 15, 20	5, 10		No
2CC #12	CA 4A-7A (0)	5, 10	5, 10, 15, 20		No
2CC #13	CA 4A-7A (1)	5, 10, 15, 20	5, 10, 15, 20		No
2CC #14	CA 4A-12A (0)	1.4, 3, 5, 10	5, 10		No
2CC #15	CA 4A-12A (1)	1.4, 3, 5, 10, 15, 20	5, 10		No
2CC #16	CA 4A-12A (2)	5, 10, 15, 20	3, 5, 10		No
2CC #17	CA 4A-12A (3)	5, 10	5, 10		No
2CC #18	CA 4A-12A (4)	5, 10, 15, 20	5, 10		No
2CC #19	CA 4A-12A (5)	5, 10, 15	5		No
2CC #20	CA 5A-7A (0)	1.4, 3, 5, 10	10, 15, 20		No
2CC #21	CA 5A-7A (1)	5, 10	10, 15, 20		No
2CC #22	CA 5A-66A (0)	5, 10	5, 10, 15, 20		No
2CC #23	CA 7A-7A (0)	5, 10, 15, 20	10, 15, 20		No
2CC #24	CA 7A-7A (1)	5, 10, 15, 20	5, 10, 15, 20		No
2CC #25	CA 7A-7A (2)	5, 10, 15, 20	5, 10		No
2CC #26	CA 7A-7A (3)	10, 15, 20	10, 15, 20		No
2CC #27	CA 7C (0)	15, 20	15, 20		No
2CC #28	CA 7C (1)	10, 15, 20	10, 15, 20		No
2CC #29	CA 7C (2)	15, 20	10, 15, 20		No
2CC #30	CA 12A-66A (0)	5, 10	1.4, 3, 5, 10		No
2CC #31	CA 12A-66A (1)	5, 10	1.4, 3, 5, 10, 15, 20		No
2CC #32	CA 12A-66A (2)	3, 5, 10	5, 10, 15, 20		No
2CC #33	CA 12A-66A (3)	5, 10	5, 10		No
2CC #34	CA 12A-66A (4)	5, 10	5, 10, 15, 20		No
2CC #35	CA 12A-66A (5)	5	5, 10, 15		No
2CC #36	CA 66A-66A (0)	5, 10, 15, 20	5, 10, 15, 20		No
2CC #37	CA 66B (0)	5, 10, 15	5, 10, 15		No
2CC #38	CA 66C (0)	5, 10, 15, 20	5, 10, 15, 20		No

Note: Only yellow highlighted cells need power measurement.

Table E.3.3 LTE Band 2 as PCC

PCC										SCC			Power		
Combination	PCC Band	PCC BW (MHz)	PCC (UL) CH.	PCC (UL) Freq. (MHz)	Mod.	PCC UL# RB	PCC UL RB Offset	PCC (DL) CH.	PCC (DL) Freq. (MHz)	SCC Band	SCC BW (MHz)	SCC (DL) CH.	SCC (DL) Freq. (MHz)	LTE Tx. Power with DL CA Enabled (dBm)	LTE Single Carrier Tx. Power (dBm)
CA 2A-4A (0)	LTE B2	20	19100	1 900.0	QPSK	1	50	1100	1 980.0	LTE B4	20	2175	2 132.5	24.46	24.54
CA 2A-4A (1)	LTE B2	10	19150	1 905.0	QPSK	1	25	1150	1 985.0	LTE B4	10	2175	2 132.5	24.38	24.49
CA 2A-4A (2)	LTE B2	20	19100	1 900.0	QPSK	1	50	1100	1 980.0	LTE B4	20	2175	2 132.5	24.44	24.54
CA 2A-5A (0)	LTE B2	20	19100	1 900.0	QPSK	1	50	1100	1 980.0	LTE B5	10	2525	881.5	24.45	24.54
CA 2A-5A (1)	LTE B2	10	19150	1 905.0	QPSK	1	25	1150	1 985.0	LTE B5	10	2525	881.5	24.43	24.49
CA 2A-7A (0)	LTE B2	20	19100	1 900.0	QPSK	1	0	1100	1 980.0	LTE B7	20	3100	2 655.0	24.41	24.54
CA 2C (0)	LTE B2	20	19100	1 900.0	QPSK	1	0	1100	1 980.0	LTE B2	20	902	1 960.2	24.39	24.54

Table E.3.4 LTE Band 4 as PCC

PCC										SCC			Power		
Combination	PCC Band	PCC BW (MHz)	PCC (UL) CH.	PCC (UL) Freq. (MHz)	Mod.	PCC UL# RB	PCC UL RB Offset	PCC (DL) CH.	PCC (DL) Freq. (MHz)	SCC Band	SCC BW (MHz)	SCC (DL) CH.	SCC (DL) Freq. (MHz)	LTE Tx. Power with DL CA Enabled (dBm)	LTE Single Carrier Tx. Power (dBm)
CA 2A-4A (0)	LTE B4	20	20175	1 732.5	QPSK	1	50	2175	2 132.5	LTE B2	20	900	1 960.0	24.54	24.63
CA 2A-4A (1)	LTE B4	10	20000	1 715.0	QPSK	1	25	2000	2 115.0	LTE B2	20	900	1 960.0	24.52	24.65
CA 2A-4A (2)	LTE B4	20	20175	1 732.5	QPSK	1	50	2175	2 132.5	LTE B2	20	900	1 960.0	24.51	24.63
CA 4A-4A (0)	LTE B4	20	20050	1 720.0	QPSK	1	50	2050	2 120.0	LTE B4	20	2300	2 145.0	24.55	24.67
CA 4A-4A (1)	LTE B4	10	20000	1 715.0	QPSK	1	25	2000	2 115.0	LTE B4	10	2350	2 150.0	24.53	24.65
CA 4A-5A (0)	LTE B4	10	20000	1 715.0	QPSK	1	25	2000	2 115.0	LTE B5	10	2525	881.5	24.51	24.65
CA 4A-5A (1)	LTE B4	20	20175	1 732.5	QPSK	1	50	2175	2 132.5	LTE B5	10	2525	881.5	24.50	24.63
CA 4A-7A (0)	LTE B4	10	20000	1 715.0	QPSK	1	25	2000	2 115.0	LTE B7	20	3100	2 655.0	24.48	24.65
CA 4A-7A (1)	LTE B4	20	20175	1 732.5	QPSK	1	50	2175	2 132.5	LTE B7	20	3100	2 655.0	24.48	24.63
CA 4A-12A (0)	LTE B4	10	20000	1 715.0	QPSK	1	25	2000	2 115.0	LTE B12	10	5095	737.5	24.53	24.65
CA 4A-12A (1)	LTE B4	20	20175	1 732.5	QPSK	1	50	2175	2 132.5	LTE B12	10	5095	737.5	24.51	24.63
CA 4A-12A (2)	LTE B4	20	20175	1 732.5	QPSK	1	50	2175	2 132.5	LTE B12	10	5095	737.5	24.50	24.63
CA 4A-12A (3)	LTE B4	10	20000	1 715.0	QPSK	1	25	2000	2 115.0	LTE B12	10	5095	737.5	24.47	24.65
CA 4A-12A (4)	LTE B4	20	20175	1 732.5	QPSK	1	50	2175	2 132.5	LTE B12	10	5095	737.5	24.46	24.63
CA 4A-12A (5)	LTE B4	15	20025	1 717.5	QPSK	1	36	2025	2 117.5	LTE B12	10	5095	737.5	24.44	24.61

**Table E.3.5 LTE Band 5 as PCC**

PCC										SCC				Power	
Combination	PCC Band	PCC BW (MHz)	PCC (UL) CH.	PCC (UL) Freq. (MHz)	Mod.	PCC UL# RB	PCC UL RB Offset	PCC (DL) CH.	PCC (DL) Freq. (MHz)	SCC Band	SCC BW (MHz)	SCC (DL) CH.	SCC (DL) Freq. (MHz)	LTE Tx. Power with DL CA Enabled (dBm)	LTE Single Carrier Tx. Power (dBm)
CA_2A-5A (0)	LTE B5	10	20525	836.5	QPSK	1	25	2525	881.5	LTE B2	20	900	1 960.0	24.87	24.98
CA_2A-5A (1)	LTE B5	10	20525	836.5	QPSK	1	25	2525	881.5	LTE B2	10	900	1 960.0	24.85	24.98
CA_4A-5A (0)	LTE B5	10	20525	836.5	QPSK	1	25	2525	881.5	LTE B4	10	2175	2 132.5	24.84	24.98
CA_4A-5A (1)	LTE B5	10	20525	836.5	QPSK	1	25	2525	881.5	LTE B4	20	2175	2 132.5	24.81	24.98
CA_5A-7A (0)	LTE B5	10	20525	836.5	QPSK	1	25	2525	881.5	LTE B7	20	3100	2 655.0	24.79	24.98
CA_5A-7A (1)	LTE B5	10	20525	836.5	QPSK	1	25	2525	881.5	LTE B7	20	3100	2 655.0	24.77	24.98
CA_5A-66A (0)	LTE B5	10	20525	836.5	QPSK	1	25	2525	881.5	LTE B66	20	66786	2 145.0	24.75	24.98

**Table E.3.6 LTE Band 7 as PCC**

PCC										SCC				Power	
Combination	PCC Band	PCC BW (MHz)	PCC (UL) CH.	PCC (UL) Freq. (MHz)	Mod.	PCC UL# RB	PCC UL RB Offset	PCC (DL) CH.	PCC (DL) Freq. (MHz)	SCC Band	SCC BW (MHz)	SCC (DL) CH.	SCC (DL) Freq. (MHz)	LTE Tx. Power with DL CA Enabled (dBm)	LTE Single Carrier Tx. Power (dBm)
CA_2A-7A (0)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B2	20	900	1 960.0	23.59	23.67
CA_4A-7A (0)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B4	20	2175	2 132.5	23.58	23.67
CA_4A-7A (1)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B4	20	2175	2 132.5	23.56	23.67
CA_5A-7A (0)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B5	10	2525	881.5	23.55	23.67
CA_5A-7A (1)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B5	10	2525	881.5	23.53	23.67
CA_7A-7A (0)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B7	20	3350	2 680.0	23.51	23.67
CA_7A-7A (1)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B7	20	3350	2 680.0	23.50	23.67
CA_7A-7A (2)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B7	10	3400	2 685.0	23.48	23.67
CA_7A-7A (3)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B7	20	3350	2 680.0	23.47	23.67
CA_7C (0)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B7	20	3298	2 674.8	23.45	23.67
CA_7C (1)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B7	20	3298	2 674.8	23.43	23.67
CA_7C (2)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B7	20	3298	2 674.8	23.41	23.67

**Table E.3.7 LTE Band 12 as PCC**

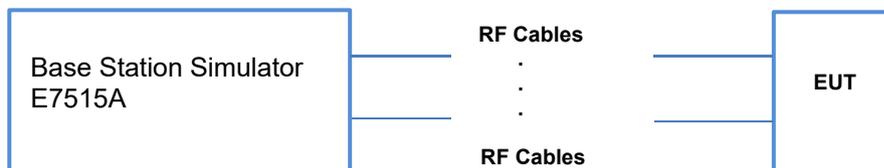
PCC										SCC				Power	
Combination	PCC Band	PCC BW (MHz)	PCC (UL) CH.	PCC (UL) Freq. (MHz)	Mod.	PCC UL# RB	PCC UL RB Offset	PCC (DL) CH.	PCC (DL) Freq. (MHz)	SCC Band	SCC BW (MHz)	SCC (DL) CH.	SCC (DL) Freq. (MHz)	LTE Tx. Power with DL CA Enabled (dBm)	LTE Single Carrier Tx. Power (dBm)
CA_4A-12A (0)	LTE 12	10	23095	707.5	QPSK	1	25	5095	737.5	LTE B4	10	2175	2 132.5	24.92	25.01
CA_4A-12A (1)	LTE 12	10	23095	707.5	QPSK	1	25	5095	737.5	LTE B4	20	2175	2 132.5	24.90	25.01
CA_4A-12A (2)	LTE 12	10	23095	707.5	QPSK	1	25	5095	737.5	LTE B4	20	2175	2 132.5	24.88	25.01
CA_4A-12A (3)	LTE 12	10	23095	707.5	QPSK	1	25	5095	737.5	LTE B4	10	2175	2 132.5	24.86	25.01
CA_4A-12A (4)	LTE 12	10	23095	707.5	QPSK	1	25	5095	737.5	LTE B4	20	2175	2 132.5	24.85	25.01
CA_4A-12A (5)	LTE 12	5	23155	713.5	QPSK	1	12	5155	743.5	LTE B4	15	2175	2 132.5	24.81	24.94
CA_12A-66A (0)	LTE 12	10	23095	707.5	QPSK	1	25	5095	737.5	LTE B66	10	66786	2 145.0	24.91	25.01
CA_12A-66A (1)	LTE 12	10	23095	707.5	QPSK	1	25	5095	737.5	LTE B66	20	66786	2 145.0	24.88	25.01
CA_12A-66A (2)	LTE 12	10	23095	707.5	QPSK	1	25	5095	737.5	LTE B66	20	66786	2 145.0	24.87	25.01
CA_12A-66A (3)	LTE 12	10	23095	707.5	QPSK	1	25	5095	737.5	LTE B66	10	66786	2 145.0	24.84	25.01
CA_12A-66A (4)	LTE 12	10	23095	707.5	QPSK	1	25	5095	737.5	LTE B66	20	66786	2 145.0	24.83	25.01
CA_12A-66A (5)	LTE 12	5	23155	713.5	QPSK	1	12	5155	743.5	LTE B66	15	66786	2 145.0	24.82	24.94

**Table E.3.8 LTE Band 66 as PCC**

PCC										SCC				Power	
Combination	PCC Band	PCC BW (MHz)	PCC (UL) CH.	PCC (UL) Freq. (MHz)	Mod.	PCC UL# RB	PCC UL RB Offset	PCC (DL) CH.	PCC (DL) Freq. (MHz)	SCC Band	SCC BW (MHz)	SCC (DL) CH.	SCC (DL) Freq. (MHz)	LTE Tx. Power with DL CA Enabled (dBm)	LTE Single Carrier Tx. Power (dBm)
CA_5A-66A (0)	LTE B66	20	132572	1 770.0	QPSK	1	50	67036	2 170.0	LTE B5	10	2525	881.5	24.57	24.68
CA_12A-66A (0)	LTE B66	10	132622	1 775.0	QPSK	1	25	67086	2 175.0	LTE B12	10	5095	737.5	24.50	24.61
CA_12A-66A (1)	LTE B66	20	132572	1 770.0	QPSK	1	50	67036	2 170.0	LTE B12	10	5095	737.5	24.52	24.68
CA_12A-66A (2)	LTE B66	20	132572	1 770.0	QPSK	1	50	67036	2 170.0	LTE B12	10	5095	737.5	24.51	24.68
CA_12A-66A (3)	LTE B66	10	132622	1 775.0	QPSK	1	25	67086	2 175.0	LTE B12	10	5095	737.5	24.49	24.61
CA_12A-66A (4)	LTE B66	20	132572	1 770.0	QPSK	1	50	67036	2 170.0	LTE B12	10	5095	737.5	24.53	24.68
CA_12A-66A (5)	LTE B66	15	132597	1 772.5	QPSK	1	36	67061	2 172.5	LTE B12	5	5095	737.5	24.44	24.56
CA_66A-66A (0)	LTE B66	20	132572	1 770.0	QPSK	1	50	67036	2 170.0	LTE B66	20	66536	2 120.0	24.50	24.68
CA_66B (0)	LTE B66	15	132597	1 772.5	QPSK	1	36	67061	2 172.5	LTE B66	5	66968	2 163.2	24.42	24.56
CA_66C (0)	LTE B66	20	132572	1 770.0	QPSK	1	50	67036	2 170.0	LTE B66	20	66838	2 150.2	24.53	24.68

Note(s):

- The device only supports downlink Carrier Aggregation. Uplink Carrier Aggregation is not supported. The DL carrier aggregation powers were measured according to the April 2018 TCB Workshop Notes (LTE Carrier Aggregation). Per Fall 2017 TCB Workshop Notes (LTE Carrier Aggregation) and FCC KDB Publication 941225 D05A01r02, no further power measurements and SAR measurements are required for DL carrier aggregation configurations when the average output power with downlink only carrier aggregation active is not more than 0.25 dB higher than the average output power with downlink only carrier aggregation inactive.
- For downlink carrier aggregation combinations, PCC uplink channel was selected based on section C.3)b)ii) of KDB 941225 D05A01r02.



**Figure E.3.1 DL 2CA Power Measurement Setup**

### E.5 Reduced DL Carrier Aggregation Conducted Powers

- Below downlink CA configurations were determined based on Manufacturer's information.

Table E.5.1 CA BW Class

Class	ATBC		Maximum number of CC
	NRB.agg	MHz	
A	$N \leq 100$	20	1
B	$25 < N \leq 100$	20	2
C	$100 < N \leq 200$	40	2
D	$200 < N \leq 300$	60	3
E	$300 < N \leq 400$	80	4
F	$400 < N \leq 500$	100	5
I	$700 < N \leq 800$	160	8

Table E.5.2 Exclusion Table for LTE DL CA (2CC)

Index	2CC	Supported Channel Bandwidth [MHz]		Restriction	Completely Covered by Measurement Superset
		CC1	CC2		
2CC #1	CA 2A-4A (0)	1.4, 3, 5, 10, 15, 20	5, 10, 15, 20		No
2CC #2	CA 2A-4A (1)	5, 10	5, 10		No
2CC #3	CA 2A-4A (2)	5, 10, 15, 20	5, 10, 15, 20		No
2CC #4	CA 2A-5A (0)	5, 10, 15, 20	5, 10		No
2CC #5	CA 2A-5A (1)	5, 10	5, 10		No
2CC #6	CA 2A-7A (0)	5, 10, 15, 20	5, 10, 15, 20		No
2CC #7	CA 2C (0)	5, 10, 15, 20	5, 10, 15, 20		No
2CC #8	CA 4A-4A (0)	5, 10, 15, 20	5, 10, 15, 20		No
2CC #9	CA 4A-4A (1)	5, 10	5, 10		No
2CC #10	CA 4A-5A (0)	5, 10	5, 10		No
2CC #11	CA 4A-5A (1)	5, 10, 15, 20	5, 10		No
2CC #12	CA 4A-7A (0)	5, 10	5, 10, 15, 20		No
2CC #13	CA 4A-7A (1)	5, 10, 15, 20	5, 10, 15, 20		No
2CC #14	CA 4A-12A (0)	1.4, 3, 5, 10	5, 10		No
2CC #15	CA 4A-12A (1)	1.4, 3, 5, 10, 15, 20	5, 10		No
2CC #16	CA 4A-12A (2)	5, 10, 15, 20	3, 5, 10		No
2CC #17	CA 4A-12A (3)	5, 10	5, 10		No
2CC #18	CA 4A-12A (4)	5, 10, 15, 20	5, 10		No
2CC #19	CA 4A-12A (5)	5, 10, 15	5		No
2CC #20	CA 5A-7A (0)	1.4, 3, 5, 10	10, 15, 20		No
2CC #21	CA 5A-7A (1)	5, 10	10, 15, 20		No
2CC #22	CA 5A-66A (0)	5, 10	5, 10, 15, 20		No
2CC #23	CA 7A-7A (0)	5, 10, 15, 20	10, 15, 20		No
2CC #24	CA 7A-7A (1)	5, 10, 15, 20	5, 10, 15, 20		No
2CC #25	CA 7A-7A (2)	5, 10, 15, 20	5, 10		No
2CC #26	CA 7A-7A (3)	10, 15, 20	10, 15, 20		No
2CC #27	CA 7C (0)	15, 20	15, 20		No
2CC #28	CA 7C (1)	10, 15, 20	10, 15, 20		No
2CC #29	CA 7C (2)	15, 20	10, 15, 20		No
2CC #30	CA 12A-66A (0)	5, 10	1.4, 3, 5, 10		No
2CC #31	CA 12A-66A (1)	5, 10	1.4, 3, 5, 10, 15, 20		No
2CC #32	CA 12A-66A (2)	3, 5, 10	5, 10, 15, 20		No
2CC #33	CA 12A-66A (3)	5, 10	5, 10		No
2CC #34	CA 12A-66A (4)	5, 10	5, 10, 15, 20		No
2CC #35	CA 12A-66A (5)	5	5, 10, 15		No
2CC #36	CA 66A-66A (0)	5, 10, 15, 20	5, 10, 15, 20		No
2CC #37	CA 66B (0)	5, 10, 15	5, 10, 15		No
2CC #38	CA 66C (0)	5, 10, 15, 20	5, 10, 15, 20		No

Note: Only yellow highlighted cells need power measurement.

Table E.5.3 LTE Band 2 as PCC

PCC										SCC				Power	
Combination	PCC Band	PCC BW (MHz)	PCC (UL) CH.	PCC (UL) Freq. (MHz)	Mod.	PCC UL# RB	PCC UL RB Offset	PCC (DL) CH.	PCC (DL) Freq. (MHz)	SCC Band	SCC BW (MHz)	SCC (DL) CH.	SCC (DL) Freq. (MHz)	LTE Tx. Power with DL CA Enabled (dBm)	LTE Single Carrier Tx. Power (dBm)
CA 2A-4A (0)	LTE B2	20	19100	1900.0	QPSK	1	50	1100	1980.0	LTE B4	20	2175	2132.5	23.51	23.63
CA 2A-4A (1)	LTE B2	10	19150	1905.0	QPSK	1	25	1150	1985.0	LTE B4	10	2175	2132.5	23.40	23.51
CA 2A-4A (2)	LTE B2	20	19100	1900.0	QPSK	1	50	1100	1980.0	LTE B4	20	2175	2132.5	23.50	23.63
CA 2A-5A (0)	LTE B2	20	19100	1900.0	QPSK	1	50	1100	1980.0	LTE B5	10	2525	881.5	23.48	23.63
CA 2A-5A (1)	LTE B2	10	19150	1905.0	QPSK	1	25	1150	1985.0	LTE B5	10	2525	881.5	23.38	23.51
CA 2A-7A (0)	LTE B2	20	19100	1900.0	QPSK	1	0	1100	1980.0	LTE B7	20	3100	2655.0	23.47	23.63
CA 2C (0)	LTE B2	20	19100	1900.0	QPSK	1	0	1100	1980.0	LTE B2	20	902	1960.2	23.45	23.63

Table E.5.4 LTE Band 4 as PCC

PCC										SCC				Power	
Combination	PCC Band	PCC BW (MHz)	PCC (UL) CH.	PCC (UL) Freq. (MHz)	Mod.	PCC UL# RB	PCC UL RB Offset	PCC (DL) CH.	PCC (DL) Freq. (MHz)	SCC Band	SCC BW (MHz)	SCC (DL) CH.	SCC (DL) Freq. (MHz)	LTE Tx. Power with DL CA Enabled (dBm)	LTE Single Carrier Tx. Power (dBm)
CA 2A-4A (0)	LTE B4	20	20175	1732.5	QPSK	1	50	2175	2132.5	LTE B2	20	900	1960.0	23.20	23.31
CA 2A-4A (1)	LTE B4	10	20000	1715.0	QPSK	1	25	2000	2115.0	LTE B2	20	900	1960.0	23.21	23.36
CA 2A-4A (2)	LTE B4	20	20175	1732.5	QPSK	1	50	2175	2132.5	LTE B2	20	900	1960.0	23.19	23.31
CA 4A-4A (0)	LTE B4	20	20050	1720.0	QPSK	1	50	2050	2120.0	LTE B4	20	2300	2145.0	23.18	23.31
CA 4A-4A (1)	LTE B4	10	20000	1715.0	QPSK	1	25	2000	2115.0	LTE B4	10	2350	2150.0	23.22	23.36
CA 4A-5A (0)	LTE B4	10	20000	1715.0	QPSK	1	25	2000	2115.0	LTE B5	10	2525	881.5	23.18	23.36
CA 4A-5A (1)	LTE B4	20	20175	1732.5	QPSK	1	50	2175	2132.5	LTE B5	10	2525	881.5	23.17	23.31
CA 4A-7A (0)	LTE B4	10	20000	1715.0	QPSK	1	25	2000	2115.0	LTE B7	20	3100	2655.0	23.15	23.36
CA 4A-7A (1)	LTE B4	20	20175	1732.5	QPSK	1	50	2175	2132.5	LTE B7	20	3100	2655.0	23.12	23.31
CA 4A-12A (0)	LTE B4	10	20000	1715.0	QPSK	1	25	2000	2115.0	LTE B12	10	5095	737.5	23.10	23.36
CA 4A-12A (1)	LTE B4	20	20175	1732.5	QPSK	1	50	2175	2132.5	LTE B12	10	5095	737.5	23.08	23.31
CA 4A-12A (2)	LTE B4	20	20175	1732.5	QPSK	1	50	2175	2132.5	LTE B12	10	5095	737.5	23.06	23.31
CA 4A-12A (3)	LTE B4	10	20000	1715.0	QPSK	1	25	2000	2115.0	LTE B12	10	5095	737.5	23.05	23.36
CA 4A-12A (4)	LTE B4	20	20175	1732.5	QPSK	1	50	2175	2132.5	LTE B12	10	5095	737.5	23.02	23.31
CA 4A-12A (5)	LTE B4	15	20025	1717.5	QPSK	1	36	2025	2117.5	LTE B12	10	5095	737.5	23.01	23.33

Table E.5.5 LTE Band 7 as PCC

PCC										SCC			Power		
Combination	PCC Band	PCC BW (MHz)	PCC (UL) CH.	PCC (UL) Freq. (MHz)	Mod.	PCC UL# RB	PCC UL RB Offset	PCC (DL) CH.	PCC (DL) Freq. (MHz)	SCC Band	SCC BW (MHz)	SCC (DL) CH.	SCC (DL) Freq. (MHz)	LTE Tx Power with DL CA Enabled (dBm)	LTE Single Carrier Tx Power (dBm)
CA_2A-7A (0)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B2	20	900	1 960.0	22.65	22.74
CA_4A-7A (0)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B4	10	2175	2 132.5	22.63	22.74
CA_4A-7A (1)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B4	20	2175	2 132.5	22.61	22.74
CA_5A-7A (0)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B5	10	2525	881.5	22.60	22.74
CA_5A-7A (1)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B5	10	2525	881.5	22.58	22.74
CA_7A-7A (0)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B7	20	3350	2 680.0	22.57	22.74
CA_7A-7A (1)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B7	20	3350	2 680.0	22.55	22.74
CA_7A-7A (2)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B7	10	3400	2 685.0	22.54	22.74
CA_7A-7A (3)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B7	20	3350	2 680.0	22.51	22.74
CA_7C (0)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B7	20	3298	2 674.8	22.50	22.74
CA_7C (1)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B7	20	3298	2 674.8	22.48	22.74
CA_7C (2)	LTE B7	20	21100	2 535.0	QPSK	1	50	3100	2 655.0	LTE B7	20	3298	2 674.8	22.47	22.74

Table E.5.6 LTE Band 66 as PCC

PCC										SCC			Power		
Combination	PCC Band	PCC BW (MHz)	PCC (UL) CH.	PCC (UL) Freq. (MHz)	Mod.	PCC UL# RB	PCC UL RB Offset	PCC (DL) CH.	PCC (DL) Freq. (MHz)	SCC Band	SCC BW (MHz)	SCC (DL) CH.	SCC (DL) Freq. (MHz)	LTE Tx Power with DL CA Enabled (dBm)	LTE Single Carrier Tx Power (dBm)
CA_5A-66A (0)	LTE B66	20	132572	1 770.0	QPSK	1	50	67036	2 170.0	LTE B5	10	2525	881.5	23.33	23.41
CA_12A-66A (0)	LTE B66	10	132622	1 775.0	QPSK	1	25	67086	2 175.0	LTE B12	10	5095	737.5	23.31	23.34
CA_12A-66A (1)	LTE B66	20	132572	1 770.0	QPSK	1	50	67036	2 170.0	LTE B12	10	5095	737.5	23.30	23.41
CA_12A-66A (2)	LTE B66	20	132572	1 770.0	QPSK	1	50	67036	2 170.0	LTE B12	10	5095	737.5	23.28	23.41
CA_12A-66A (3)	LTE B66	10	132622	1 775.0	QPSK	1	25	67086	2 175.0	LTE B12	10	5095	737.5	23.26	23.34
CA_12A-66A (4)	LTE B66	20	132572	1 770.0	QPSK	1	50	67036	2 170.0	LTE B12	10	5095	737.5	23.25	23.41
CA_12A-66A (5)	LTE B66	15	132597	1 772.5	QPSK	1	36	67061	2 172.5	LTE B12	5	5095	737.5	23.23	23.34
CA_66A-66A (0)	LTE B66	20	132572	1 770.0	QPSK	1	50	67036	2 170.0	LTE B66	20	66536	2 120.0	23.21	23.41
CA_66B (0)	LTE B66	15	132597	1 772.5	QPSK	1	36	67061	2 172.5	LTE B66	5	66968	2 163.2	23.20	23.34
CA_66C (0)	LTE B66	20	132572	1 770.0	QPSK	1	50	67036	2 170.0	LTE B66	20	66838	2 150.2	23.18	23.41

## Note(s):

- The device only supports downlink Carrier Aggregation. Uplink Carrier Aggregation is not supported. The DL carrier aggregation powers were measured according to the April 2018 TCB Workshop Notes (LTE Carrier Aggregation). Per Fall 2017 TCB Workshop Notes (LTE Carrier Aggregation) and FCC KDB Publication 941225 D05Av01r02, no further power measurements and SAR measurements are required for DL carrier aggregation configurations when the average output power with downlink only carrier aggregation active is not more than 0.25 dB higher than the average output power with downlink only carrier aggregation inactive.
- For downlink carrier aggregation combinations, PCC uplink channel was selected based on section C.3)b)ii) of KDB 941225 D05Av01r02.



Figure E.5.1 DL 2CA Power Measurement Setup

## APPENDIX F. – Description of Test Equipment

## F.1 SAR Measurement Setup

Measurements are performed using the DASY5 automated dosimetric assessment system. The DASY5 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland and consists of high precision robotics system (Staubli), robot controller, desktop computer, near-field probe, probe alignment sensor, and the generic twin phantom containing the brain equivalent material. The robot is a six-axis industrial robot performing precise movements to position the probe to the location (points) of maximum electromagnetic field (EMF) (see Fig. G.1.1).

A cell controller system contains the power supply, robot controller each pendant (Joystick), and a remote control used to drive the robot motors. The PC consists of the Intel Core i7-2 600 / i7-4 770 / i7-8 700K 3.40 GHz desktop computer with Windows 7 system and SAR Measurement Software DASY5, A/D interface card, monitor, mouse, and keyboard. The Staubli Robot is connected to the cell controller to allow software manipulation of the robot. A data acquisition electronic (DAE) circuit that performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. is connected to the Electro-optical coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC plug-in card.

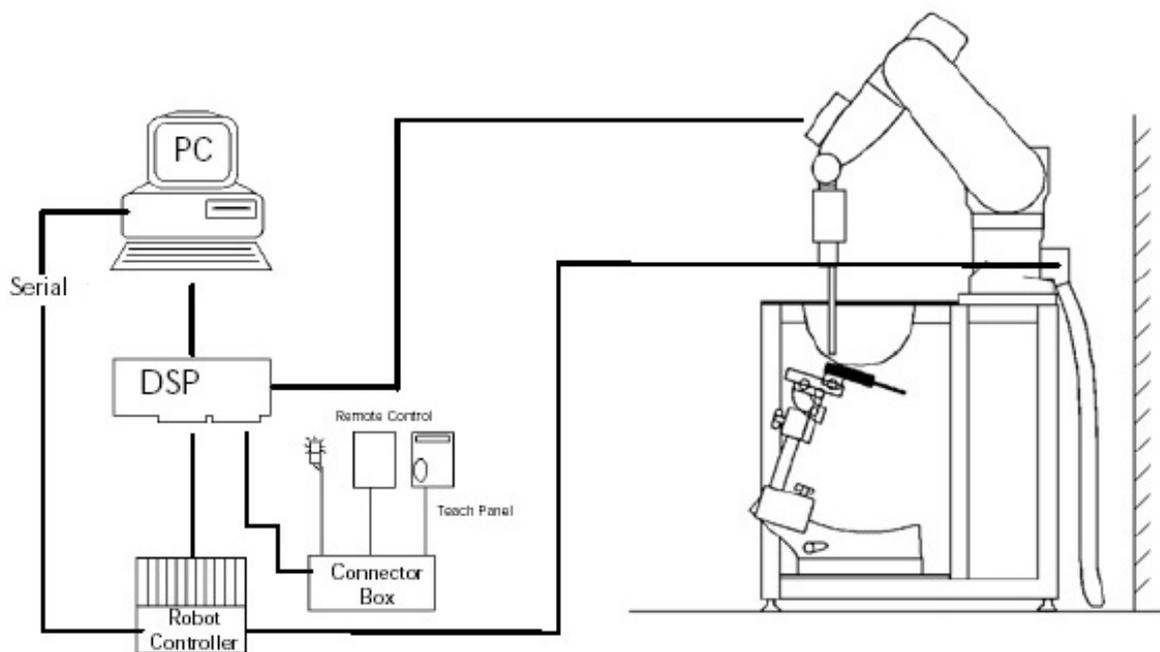
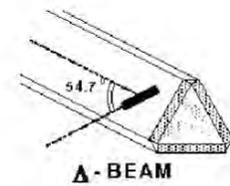


Figure F.1.1 SAR Measurement System Setup

The DAE4 consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the PC-card is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer. The system is described in detail.

**F.2 Probe Specification**

<b>Frequency</b>	10 MHz to 4 GHz/10 MHz to 6 GHz
<b>Linearity</b>	± 0.2 dB(30 MHz to 4 GHz/30 MHz to 6 GHz)
<b>Dynamic</b>	10 μW/g to > 100 mW/g
<b>Range</b>	Linearity : ±0.2 dB
<b>Dimensions</b>	Overall length : 337 mm
<b>Tip length</b>	20 mm
<b>Body diameter</b>	12 mm
<b>Tip diameter</b>	3.9 mm/2.5 mm
<b>Distance from probe tip to sensor center</b>	2.0 mm/1.0 mm
<b>Application</b>	SAR Dosimetry Testing Compliance tests of mobile phones



**Figure F.2.1 Triangular Probe Configurations**



**Figure F.2.2 Probe Thick-Film Technique**



**DAE System**

The SAR measurements were conducted with the dosimetric probe ES3DV3 and EX3DV4 designed in the classical triangular configuration(see F.2.1) and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multitier line ending at the front of the probe tip. It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface. Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY5 software reads the reflection during a software approach and looks for the maximum using a 2nd order fitting. The approach is stopped at reaching the maximum.

### F.3 E-Probe Calibration Process

#### Dosimetric Assessment Procedure

Each probe is calibrated according to a dosimetric assessment procedure with accuracy better than +/- 10%. The spherical isotropy was evaluated with the procedure and found to be better than +/-0.25dB. The sensitivity parameters (Norm X, Norm Y, Norm Z), the diode compression parameter (DCP) and the conversion factor (Conv F) of the probe is tested.

#### Free Space Assessment

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 waveguide above 1GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity at the proper orientation with the field. The probe is then rotated 360 degrees.

#### Temperature Assessment \*

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 the remits or based temperature probe is used in conjunction with the E-field probe.

$$SAR = C \frac{\Delta T}{\Delta t}$$

$$SAR = \frac{|E|^2 \cdot \sigma}{\rho}$$

where:

where:

$\Delta t$  = exposure time (30 seconds),

$\sigma$  = simulated tissue conductivity,

C = heat capacity of tissue (brain or muscle),

$\rho$  = Tissue density (1.25 g/cm<sup>3</sup> for brain tissue)

$\Delta T$  = temperature increase due to RF exposure.

SAR is proportional to  $\Delta T / \Delta t$ , the initial rate of tissue heating, before thermal diffusion takes place. Now it's possible to quantify the electric field in the simulated tissue by equating the thermally derived SAR to the E- field;

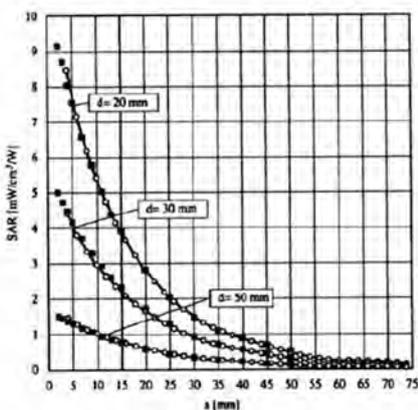


Figure F.3.1 E-Field and Temperature Measurements at 900MHz

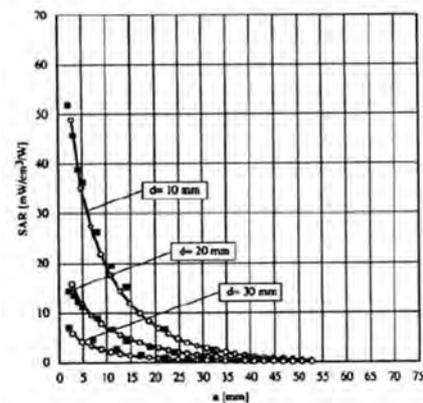


Figure F.3.2 E-Field and Temperature Measurements at 1800MHz

## F.4 Data Extrapolation

The DASY5 software automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given like below;

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

with  $V_i$  = compensated signal of channel i (i=x,y,z)  
 $U_i$  = input signal of channel i (i=x,y,z)  
 cf = crest factor of exciting field (DASY parameter)  
 dcp<sub>i</sub> = diode compression point (DASY parameter)

From the compensated input signals the primary field data for each channel can be evaluated:

E-field probes:

$$E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

with  $V_i$  = compensated signal of channel i (i = x,y,z)  
 Norm<sub>i</sub> = sensor sensitivity of channel i (i = x,y,z)  
 $\mu\text{V}/(\text{V/m})^2$  for E-field probes  
 ConvF = sensitivity of enhancement in solution  
 $E_i$  = electric field strength of channel i in V/m

The RSS value of the field components gives the total field strength (Hermetian magnitude):

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

The primary field data are used to calculate the derived field units.

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1000}$$

with SAR = local specific absorption rate in W/g  
 $E_{tot}$  = total field strength in V/m  
 $\sigma$  = conductivity in [mho/m] or [Siemens/m]  
 $\rho$  = equivalent tissue density in g/cm<sup>3</sup>

The power flow density is calculated assuming the excitation field to be a free space field.

$$P_{pwe} = \frac{E_{tot}^2}{3770}$$

with  $P_{pwe}$  = equivalent power density of a plane wave in W/cm<sup>2</sup>  
 $E_{tot}$  = total electric field strength in V/m

## F.5 SAM Twin Phantom

The SAM Twin Phantom V5.0 is constructed of a fiberglass shell integrated in a wooden table. The shape of the shell is based on data from an anatomical study designed to determine the maximum exposure in at least 90% of all users. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents the evaporation of the liquid.

Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot. (see Fig. F.5.1)



**Figure F.5.1 SAM Twin Phantom**

### SAM Twin Phantom Specification:

<b>Construction</b>	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209-1. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot. Twin SAM V5.0 has the same shell geometry and is manufactured from the same material as Twin SAM V4.0, but has reinforced top structure.
<b>Shell Thickness</b>	(2 ± 0.2) mm
<b>Filling Volume</b>	Approx. 25 liters
<b>Dimensions</b>	Length: 1000 mm Width: 500 mm Height: adjustable feet

### Specific Anthropomorphic Mannequin (SAM) Specifications:

The phantom for handset SAR assessment testing is a low-loss dielectric shell, with shape and dimensions derived from the anthropometric data of the 90th percentile adult male head dimensions as tabulated by the US Army. The SAM Twin Phantom shell is bisected along the mid-sagittal plane into right and left halves (see Fig. F.5.2). The perimeter sidewalls of each phantom halves are extended to allow filling with liquid to a depth that is sufficient to minimized reflections from the upper surface. The liquid depth is maintained at a minimum depth of 15cm to minimize reflections from the upper surface.



**Figure F.5.2 Sam Twin Phantom shell**

## F.6 Device Holder for Transmitters

In combination with the Twin SAM Phantom V4.0/V4.0c, V5.0 or ELI4, the Mounting Device enables the rotation of the mounted transmitter device in spherical coordinates. Rotation point is the ear opening point. Transmitter devices can be easily and accurately positioned according to IEC, IEEE, FCC or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat).

Note: A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produce infinite number of configurations. To produce the worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.



**Figure F.6.1 Mounting Device**

## F.7 Automated Test System Specifications

### Positioner

<b>Robot</b>	Stäubli Unimation Corp. Robot Model: TX90XL/ TX60L
<b>Repeatability</b>	0.02 mm
<b>No. of axis</b>	6

### Data Acquisition Electronic (DAE) System

#### Cell Controller

<b>Processor</b>	Intel Core i7-2 600 / i7-4 770 / i7-8 700K
<b>Clock Speed</b>	3.40 GHz
<b>Operating System</b>	Windows 7 Professional
<b>Data Card</b>	DASY5 PC-Board

#### Data Converter

<b>Features</b>	Signal, multiplexer, A/D converter. & control logic
<b>Software</b>	DASY5
<b>Connecting Lines</b>	Optical downlink for data and status info Optical uplink for commands and clock

#### PC Interface Card

<b>Function</b>	24 bit (64 MHz) DSP for real time processing Link to DAE 4 16 bit A/D converter for surface detection system serial link to robot direct emergency stop output for robot
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#### E-Field Probes

<b>Model</b>	ES3DV3 S/N: 3327 / EX3DV4 S/N: 3866, 3930. 7337, 7368
<b>Construction</b>	Triangular core fiber optic detection system
<b>Frequency</b>	10 MHz to 4 GHz/10 MHz to 6 GHz
<b>Linearity</b>	$\pm 0.2$ dB (30 MHz to 4 GHz/30 MHz to 6 GHz)

#### Phantom

<b>Phantom</b>	SAM Twin Phantom (V5.0)
<b>Shell Material</b>	Composite
<b>Thickness</b>	$(2.0 \pm 0.2)$ mm



**Figure F.7.1 DASY5 Test System**

## **APPENDIX G. – Power reduction verification with proximity sensor enabled**

**G.1 Cap Sensor (proximity sensor) Power Measurement, Triggering Distance**

**- Power reduction and Proximity Sensor information of ZNFQ730BAW**

(1) Power reduction by proximity (capacitance) sensing:

**WCDMA 1700, WCDMA 1900, LTE B66, LTE B4, LTE B2, LTE B7,**

a) A proximity sensor for power reduction is implemented in this device to address RF exposure compliance about SAR requirement for protection of the human body.

(2) Proximity sensor detection area:

a) All proximity sensor pads are combined with the primary antenna pattern, therefore, they occupy the same area as the primary antenna.

b) The primary antenna and the proximity sensor pads are collocated and the peak SAR location is overlapping with the sensors, therefore do not need to measure proximity sensor coverage according to the KDB 616217 D04v01r02, section 6.3.

c) Power reduction mechanism is implemented in this device

i) Bottom surface, Front surface, Rear surface

d) The proximity sensor is triggered at the following distances when:

i) The bottom surface of the device is 6 mm for the trigger from the phantom.

ii) The front surface of the device is 3 mm for the trigger from the phantom.

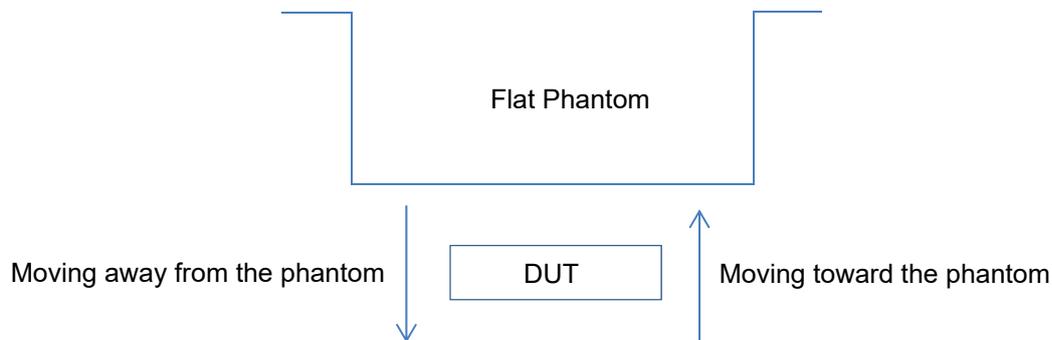
iii) The rear surface of the device is 2 mm for the trigger from the phantom.

iv) Other surfaces (Right/Left edges) will be tested with the maximum powers.

e) When a certain object or human body approaches the DUT, if the measured capacitance is higher than certain capacitance, proximity sensor is triggered and power is reduced as follows.

**Table G.1.1 Proximity Sensor power information**

Band	Proximity sensor state	Maximum	Power (dBm)	Normal	Power (dBm)
WCDMA 1700, WCDMA 1900, LTE B66, LTE B4, LTE B2	Inactive (Far)	Maximum	24.7	Normal	24.2
	Active (Near)	Maximum	23.7	Normal	23.2
LTE B7	Inactive (Far)	Maximum	24.2	Normal	23.7
	Active (Near)	Maximum	23.2	Normal	22.7



**Figure G.1.1 Proximity Sensor Triggering Distance Assessment**

### - Cap Sensor Power Measurement and Triggering Distance

As per the KDB616217 D04v01r02, section 6.2 and two parts power verification procedure is used to determine the triggering distances.

Using this procedure the most conservative sensor triggering distance was measured and SAR measurement distance is determined (The most conservative sensor triggering distance – 1 mm for each applicable sides and edges).

(1) Proximity sensor status table when DUT is moving towards/ moving away the phantom (Bottom)

Moving toward the phantom						Moving away from the phantom						Final SAR Measurement Distance (mm)
Dist. to the DUT (mm)	Capacitive Sensor Status (Bottom surface)	WCDMA B4/B2, LTE B66/B4/B2 Cond. Power (dBm)	LTE B7 Cond. Power (dBm)	Trigg. dist. (mm)	SAR meas. Dist. (mm)	Dist. to the DUT (mm)	Capacitive Sensor Status (Bottom surface)	WCDMA B4/B2, LTE B66/B4/B2 Cond. Power (dBm)	LTE B7 Cond. Power (dBm)	Trigg. dist. (mm)	SAR meas. Dist. (mm)	
26	Inactive (Far)	24.7	24.2	6	5	16	Inactive (Far)	24.7	24.2	6	5	5
23	Inactive (Far)											
20	Inactive (Far)											
17	Inactive (Far)											
14	Inactive (Far)											
11	Inactive (Far)											
10	Inactive (Far)											
9	Inactive (Far)											
8	Inactive (Far)											
7	Inactive (Far)											
6	Active (Near)	23.7	23.2	6	5	6	Active (Near)	23.7	23.2	6	5	5
5	Active (Near)											
4	Active (Near)											
3	Active (Near)											
2	Active (Near)											
1	Active (Near)											
0	Active (Near)											
15	Inactive (Far)											
14	Inactive (Far)											
13	Inactive (Far)											
12	Inactive (Far)											
11	Inactive (Far)											
10	Inactive (Far)											
9	Inactive (Far)											
8	Inactive (Far)											
7	Inactive (Far)											
6	Active (Near)											
5	Active (Near)											
4	Active (Near)											
3	Active (Near)											
2	Active (Near)											
1	Active (Near)											
0	Active (Near)											

(2) Proximity sensor status table when DUT is moving towards/ moving away the phantom (Front)

Moving toward the phantom						Moving away from the phantom						Final SAR Measurement Distance (mm)
Dist. to the DUT (mm)	Capacitive Sensor Status (Front surface)	WCDMA B4/B2, LTE B66/B4/B2 Cond. Power (dBm)	LTE B7 Cond. Power (dBm)	Trigg. dist. (mm)	SAR meas. Dist. (mm)	Dist. to the DUT (mm)	Capacitive Sensor Status (Front surface)	WCDMA B4/B2, LTE B66/B4/B2 Cond. Power (dBm)	LTE B7 Cond. Power (dBm)	Trigg. dist. (mm)	SAR meas. Dist. (mm)	
23	Inactive (Far)	24.7	24.2	3	2	13	Inactive (Far)	24.7	24.2	3	2	2
20	Inactive (Far)											
17	Inactive (Far)											
14	Inactive (Far)											
11	Inactive (Far)											
8	Inactive (Far)											
7	Inactive (Far)											
6	Inactive (Far)											
5	Inactive (Far)											
4	Inactive (Far)											
3	Active (Near)	23.7	23.2	3	2	3	Active (Near)	23.7	23.2	3	2	
2	Active (Near)											
1	Active (Near)											
0	Active (Near)											
12	Inactive (Far)											
11	Inactive (Far)											
10	Inactive (Far)											
9	Inactive (Far)											
8	Inactive (Far)											
7	Inactive (Far)											
6	Inactive (Far)											
5	Inactive (Far)											
4	Inactive (Far)											
3	Active (Near)											
2	Active (Near)											
1	Active (Near)											
0	Active (Near)											

(3) Proximity sensor status table when DUT is moving towards/ moving away the phantom (Rear)

Moving toward the phantom						Moving away from the phantom						Final SAR Measurement Distance (mm)
Dist. to the DUT (mm)	Capacitive Sensor Status (Rear surface)	WCDMA B4/B2, LTE B66/B4/B2 Cond. Power (dBm)	LTE B7 Cond. Power (dBm)	Trigg. dist. (mm)	SAR meas. Dist. (mm)	Dist. to the DUT (mm)	Capacitive Sensor Status (Rear surface)	WCDMA B4/B2, LTE B66/B4/B2 Cond. Power (dBm)	LTE B7 Cond. Power (dBm)	Trigg. dist. (mm)	SAR meas. Dist. (mm)	
22	Inactive (Far)	24.7	24.2	2	1	12	Inactive (Far)	24.7	24.2	2	1	1
19	Inactive (Far)											
16	Inactive (Far)											
13	Inactive (Far)											
10	Inactive (Far)											
7	Inactive (Far)											
6	Inactive (Far)											
5	Inactive (Far)											
4	Inactive (Far)											
3	Inactive (Far)											
2	Active (Near)	23.7	23.2	2	1	2	Active (Near)	23.7	23.2	2	1	
1	Active (Near)											
0	Active (Near)											
11	Inactive (Far)											
10	Inactive (Far)											
9	Inactive (Far)											
8	Inactive (Far)											
7	Inactive (Far)											
6	Inactive (Far)											
5	Inactive (Far)											
4	Inactive (Far)											
3	Inactive (Far)											
2	Active (Near)											
1	Active (Near)											
0	Active (Near)											

#### - Cap Sensor SAR Test Plan for ZNFQ730HMW

The smallest separation distance determined by the sensor triggering and sensor coverage for normal and/or tilt positions in KDB 616217 D04v01r02 section 6.2, 6.3 and 6.4 for front, back surface and edge triggering conditions, minus 1 mm, must be used as the test separation distance for SAR testing.

(1) The proximity sensor SAR will be tested at the following distances when:

- a) The **bottom surface** will be tested with the **maximum powers** of the device is **5 mm** from the phantom.
- b) The **front surface** will be tested with the **maximum powers** of the device is **2 mm** from the phantom.
- c) The **rear surface** will be tested with the **maximum powers** of the device is **1 mm** from the phantom.
- d) **Other surfaces** (Left/Right edges) will be tested with the **maximum powers** of the device is **0 mm** from the phantom.
- e) The **bottom surface** will be tested with the **reduction powers** of the device is **0 mm** from the phantom.
- f) The **front surface** will be tested with the **reduction powers** of the device is **0 mm** from the phantom.
- g) The **rear surface** will be tested with the **reduction powers** of the device is **0 mm** from the phantom.

Per FCC KDB Publication 616217 D04v01r02, this device was tested by test lab(DT&C) to determine the proximity sensor triggering distances for all applicable sides and edges of the device. The measured output power at distances within  $\pm 5$  mm of the triggering points (or until touching the phantom) is included for rear and front sides and each applicable edge per Step i) in Section 6.2 of the KDB. The technical descriptions in the filing contain the complete set of triggering data required by Section 6 of FCC Publication 616217 D04v01r02.

To ensure all production units are compliant, it is necessary to test SAR at a distance 1 mm less than the smallest distance between the device and SAR phantom (determined from the sensor triggering tests according to FCC KDB 616217 D04v01r02) with the device at the maximum output power (without power reduction). These SAR tests are included in addition to the SAR tests for the device touching the SAR phantom (at the reduced output power level).

The operational description contains information explaining how this device remains compliant in the event of a sensor malfunction.

### G.2 Cap Sensor (proximity sensor) Tilt Angle Assessment

The DUT was positioned perpendicular to the flat phantom, at the minimum sensor triggering test distance.

The DUT was rotated about bottom for angles  $\pm 45^\circ$ .

If sensor triggering is released and normal maximum output power is restored within the  $\pm 45^\circ$ , the DUT was moved 1mm toward the phantom and the rotation repeated.

This procedures should be repeated by until the proximity sensor no longer releases triggering, and maximum output power remains in the reduced mode.

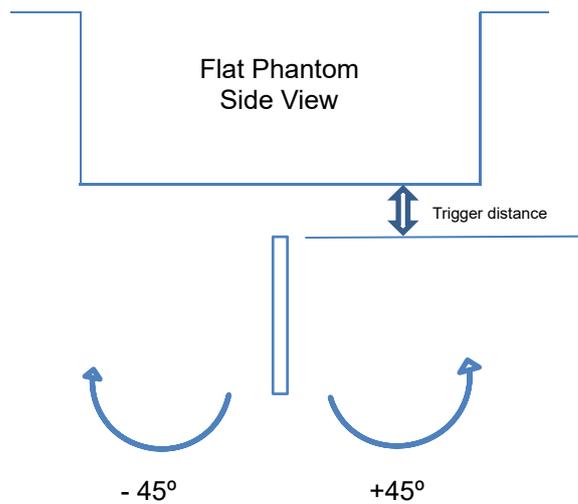


Table G.2.1 Tilt Angle Influence to Proximity Sensor Triggering (Bottom)

Band	Minimum triggering Distance	Minimum distance at which power reduction was maintained over $\pm 45^\circ$	Power reduction status											
			$-45^\circ$	$-40^\circ$	$-30^\circ$	$-20^\circ$	$-10^\circ$	$0^\circ$	$10^\circ$	$20^\circ$	$30^\circ$	$40^\circ$	$45^\circ$	
WCDMA B4/B2, LTE B66/B4/ B2/B7	6 mm	6 mm	On	On	On	On	On	On	On	On	On	On	On	On