15 SAR Measurement Variability

SAR measurement variability must be assessed for each frequency band, which is determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media are required for SAR measurements in a frequency band, the variability measurement procedures should be applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium.

The following procedures are applied to determine if repeated measurements are required.

1) Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg; steps 2) through 4) do not apply.

2) When the original highest measured SAR is ≥ 0.80 W/kg, repeat that measurement once.

3) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 W/kg (~ 10% from the 1-g SAR limit).

4) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

Table 15.1: SAR Measurement Variability for Body GSM 850 (1g)

Frequency		Test Position	Spacing (mm)	Original SAR (W/kg)	First Repeated SAR (W/kg)	The Ratio	Second Repeated SAR (W/kg)
MHz	Ch.						
848.8	251	Rear	10	1.00	0.989	1.01	/

Table 15.2: SAR Measurement Variability for Body GSM 1900 (1g)

Frequency		Test Position	Spacing (mm)	Original SAR (W/kg)	First Repeated SAR (W/kg)	The Ratio	Second Repeated SAR (W/kg)
MHz	Ch.						
1880	661	Rear	10	0.832	0.817	1.02	/

Table 15.2: SAR Measurement Variability for Body WCDMA 1900 (1g)

Frequency		Test Position	Spacing (mm)	Original SAR (W/kg)	First Repeated SAR (W/kg)	The Ratio	Second Repeated SAR (W/kg)
MHz	Ch.						
1880	9400	Rear	10	0.951	0.926	1.03	/

16 Measurement Uncertainty

16.1 Measurement Uncertainty for Normal SAR Tests (300MHz~3GHz)

No.	Error Description	Type	Uncertainty value	Probably Distribution	Div.	(Ci) 1g	(Ci) 10g	Std. Unc. (1g)	Std. Unc. (10g)	Degree of freedom
Measurement system										
1	Probe calibration	B	5.5	N	1	1	1	5.5	5.5	∞
2	Isotropy	B	4.7	R	$\sqrt{3}$	0.7	0.7	1.9	1.9	∞
3	Boundary effect	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
4	Linearity	B	4.7	R	$\sqrt{3}$	1	1	2.7	2.7	∞
5	Detection limit	B	1.0	N	1	1	1	0.6	0.6	∞
6	Readout electronics	B	0.3	R	$\sqrt{3}$	1	1	0.3	0.3	∞
7	Response time	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
8	Integration time	B	2.6	R	$\sqrt{3}$	1	1	1.5	1.5	∞
9	RF ambient conditions-noise	B	0	R	$\sqrt{3}$	1	1	0	0	∞
10	RF ambient conditions-reflection	B	0	R	$\sqrt{3}$	1	1	0	0	∞
11	Probe positioned mech. restrictions	B	0.4	R	$\sqrt{3}$	1	1	0.2	0.2	∞
12	Probe positioning with respect to phantom shell	B	2.9	R	$\sqrt{3}$	1	1	1.7	1.7	∞
13	Post-processing	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
Test sample related										
14	Test sample positioning	A	3.3	N	1	1	1	3.3	3.3	71
15	Device holder uncertainty	A	3.4	N	1	1	1	3.4	3.4	5
16	Drift of output power	B	5.0	R	$\sqrt{3}$	1	1	2.9	2.9	∞
Phantom and set-up										
17	Phantom uncertainty	B	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
18	Liquid conductivity (target)	B	5.0	R	$\sqrt{3}$	0.64	0.43	1.8	1.2	∞
19	Liquid conductivity (meas.)	A	2.06	N	1	0.64	0.43	1.32	0.89	43
20	Liquid permittivity (target)	B	5.0	R	$\sqrt{3}$	0.6	0.49	1.7	1.4	∞
21	Liquid permittivity (meas.)	A	1.6	N	1	0.6	0.49	1.0	0.8	521
Combined standard uncertainty		$u_c^{'} = \sqrt{\sum_{i=1}^{21} c_i^2 u_i^2}$						9.25	9.12	257
Expanded uncertainty (confidence interval of 95 %)		$u_e = 2u_c$						18.5	18.2	

16.3 Measurement Uncertainty for Fast SAR Tests (300MHz~3GHz)

No.	Error Description	Type	Uncertainty value	Probably Distribution	Div.	(Ci) 1g	(Ci) 10g	Std. Unc. (1g)	Std. Unc. (10g)	Degree of freedom
Measurement system										
1	Probe calibration	B	5.5	N	1	1	1	5.5	5.5	∞
2	Isotropy	B	4.7	R	$\sqrt{3}$	0.7	0.7	1.9	1.9	∞
3	Boundary effect	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
4	Linearity	B	4.7	R	$\sqrt{3}$	1	1	2.7	2.7	∞
5	Detection limit	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
6	Readout electronics	B	0.3	R	$\sqrt{3}$	1	1	0.3	0.3	∞
7	Response time	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
8	Integration time	B	2.6	R	$\sqrt{3}$	1	1	1.5	1.5	∞
9	RF ambient conditions-noise	B	0	R	$\sqrt{3}$	1	1	0	0	∞
10	RF ambient conditions-reflection	B	0	R	$\sqrt{3}$	1	1	0	0	∞
11	Probe positioned mech. Restrictions	B	0.4	R	$\sqrt{3}$	1	1	0.2	0.2	∞
12	Probe positioning with respect to phantom shell	B	2.9	R	$\sqrt{3}$	1	1	1.7	1.7	∞
13	Post-processing	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
14	Fast SAR z-Approximation	B	7.0	R	$\sqrt{3}$	1	1	4.0	4.0	∞
Test sample related										
15	Test sample positioning	A	3.3	N	1	1	1	3.3	3.3	71
16	Device holder uncertainty	A	3.4	N	1	1	1	3.4	3.4	5
17	Drift of output power	B	5.0	R	$\sqrt{3}$	1	1	2.9	2.9	∞
Phantom and set-up										
18	Phantom uncertainty	B	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
19	Liquid conductivity (target)	B	5.0	R	$\sqrt{3}$	0.64	0.43	1.8	1.2	∞
20	Liquid conductivity (meas.)	A	2.06	N	1	0.64	0.43	1.32	0.89	43
21	Liquid permittivity (target)	B	5.0	R	$\sqrt{3}$	0.6	0.49	1.7	1.4	∞
22	Liquid permittivity (meas.)	A	1.6	N	1	0.6	0.49	1.0	0.8	521
Combined standard uncertainty		$u_c' = \sqrt{\sum_{i=1}^{22} c_i^2 u_i^2}$						10.1	9.95	257
Expanded uncertainty (confidence interval of 95 %)		$u_e = 2u_c$						20.2	19.9	

17 MAIN TEST INSTRUMENTS

Table 17.1: List of Main Instruments

No.	Name	Type	Serial Number	Calibration Date	Valid Period
01	Network analyzer	Agilent E5071C	MY46103759	December 27,2013	One year
02	Power meter	NRVD	101253	March 6, 2014	One year
03	Power sensor	NRV-Z5	100333		
04	Signal Generator	E4438C	MY45095825	January 14, 2014	One year
05	Amplifier	VTL5400	0404	No Calibration Requested	
06	BTS	E5515C	GB47460133	September 4, 2014	One year
07	E-field Probe	SPEAG ES3DV3	3151	September 01, 2014	One year
08	DAE	SPEAG DAE4	786	November 25, 2013	One year
09	Dipole Validation Kit	SPEAG D835V2	4d069	August 28, 2014	One year
10	Dipole Validation Kit	SPEAG D1900V2	5d101	July 23, 2014	One year
11	Dipole Validation Kit	SPEAG D2450V2	853	July 24, 2014	One year

END OF REPORT BODY

ANNEX A Graph Results

850 Left Cheek Low

Date/Time: 2014-10-18

Electronics: DAE4 Sn786

Medium: 900 Head

Medium parameters used (interpolated): f = 824.2 MHz; σ = 0.873 S/m; ε_r = 42.308; ρ = 1000 kg/m^3

Ambient Temperature:21.7^{o}C Liquid Temperature:21.2^{o}C

Communication System: GSM Frequency: 824.2 MHz Duty Cycle: 1:8.3

Probe: ES3DV3 - SN3151 ConvF(6.04, 6.04, 6.04);

Left Cheek Low/Area Scan (61x101x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 0.407 W/kg

Left Cheek Low/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 9.257 V/m; Power Drift = -0.12 dB

Peak SAR (extrapolated) = 0.478 W/kg

SAR(1 g) = 0.383 W/kg; SAR(10 g) = 0.286 W/kg

Maximum value of SAR (measured) = 0.398 W/kg

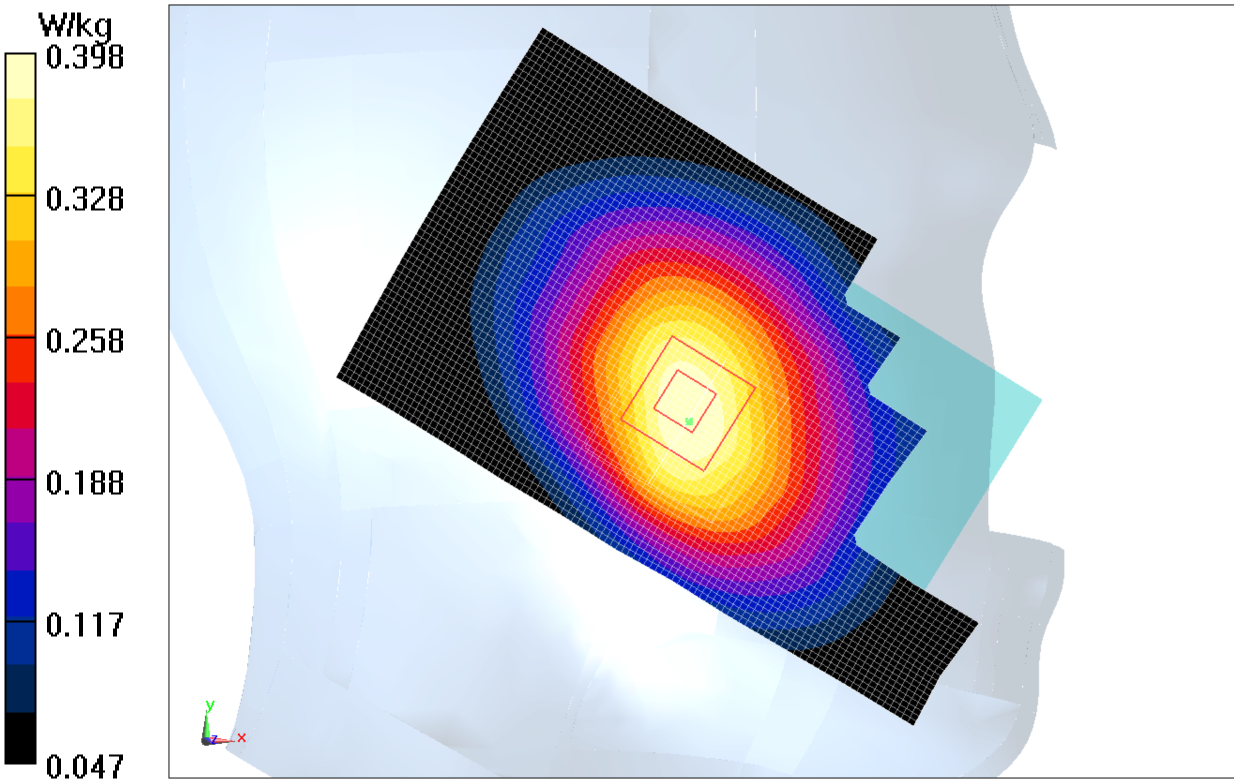


Fig.1 850MHz CH128

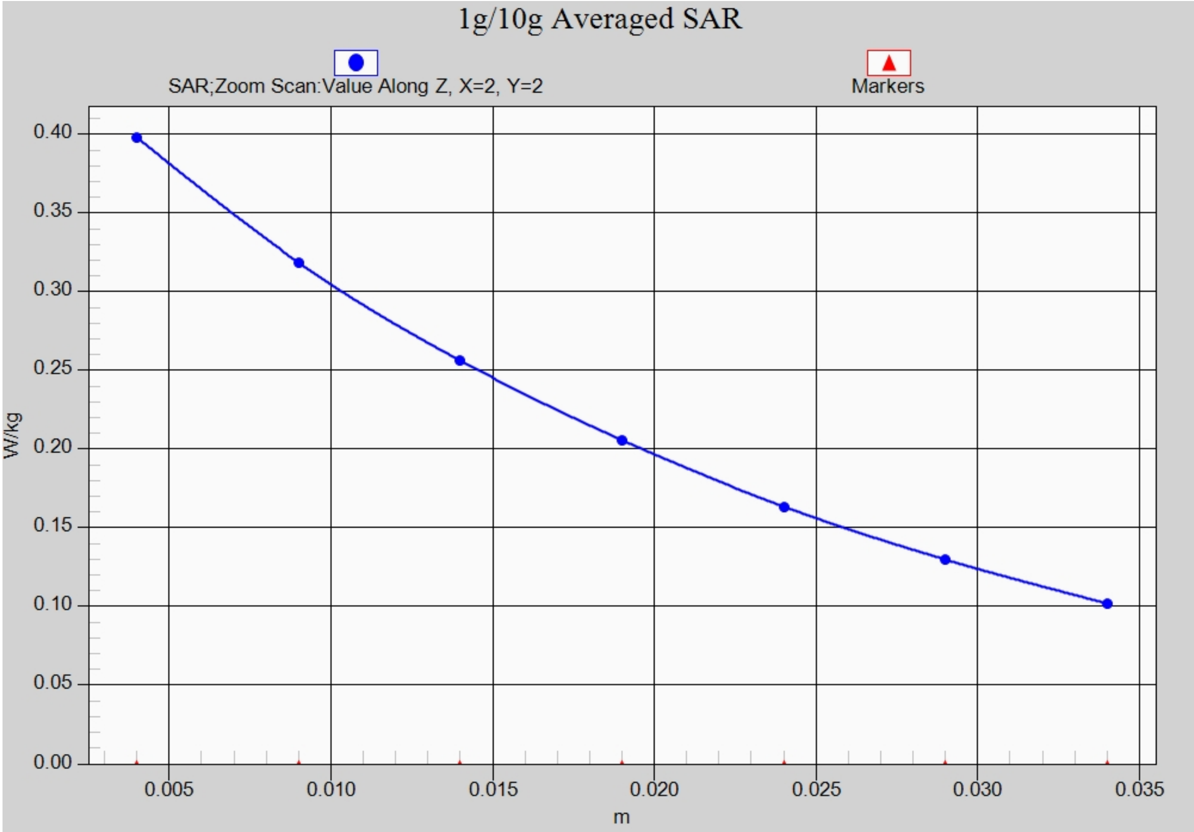


Fig. 1-1 Z-Scan at power reference point (850 MHz CH128)

850 Body Left High

Date/Time: 2014-10-19

Electronics: DAE4 Sn786

Medium: Body 900

Medium parameters used (interpolated): f = 848.8 MHz; σ = 0.987 S/m; ε_r = 52.501; ρ = 1000 kg/m^3

Ambient Temperature:21.7^{o}C   Liquid Temperature:21.2^{o}C

Communication System: 4 slot GPRS Frequency: 848.8 MHz Duty Cycle: 1:2.08018

Probe: ES3DV3 - SN3151 ConvF(6.14, 6.14, 6.14);

Left side High/Area Scan (61x101x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 1.07 W/kg

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

Reference Value = 24.857 V/m; Power Drift = 0.13 dB

Peak SAR (extrapolated) = 1.37 W/kg

SAR(1 g) = 1 W/kg; SAR(10 g) = 0.694 W/kg

Maximum value of SAR (measured) = 1.08 W/kg

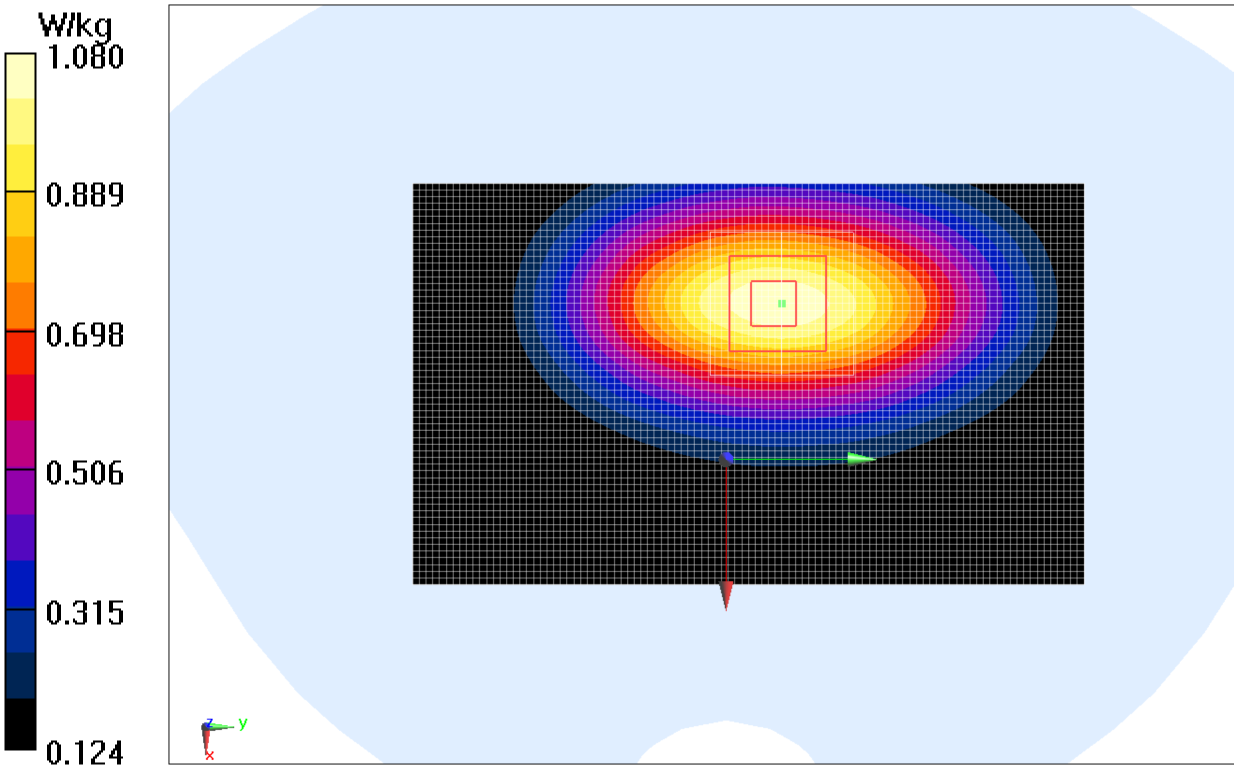


Fig.2 850 MHz CH251

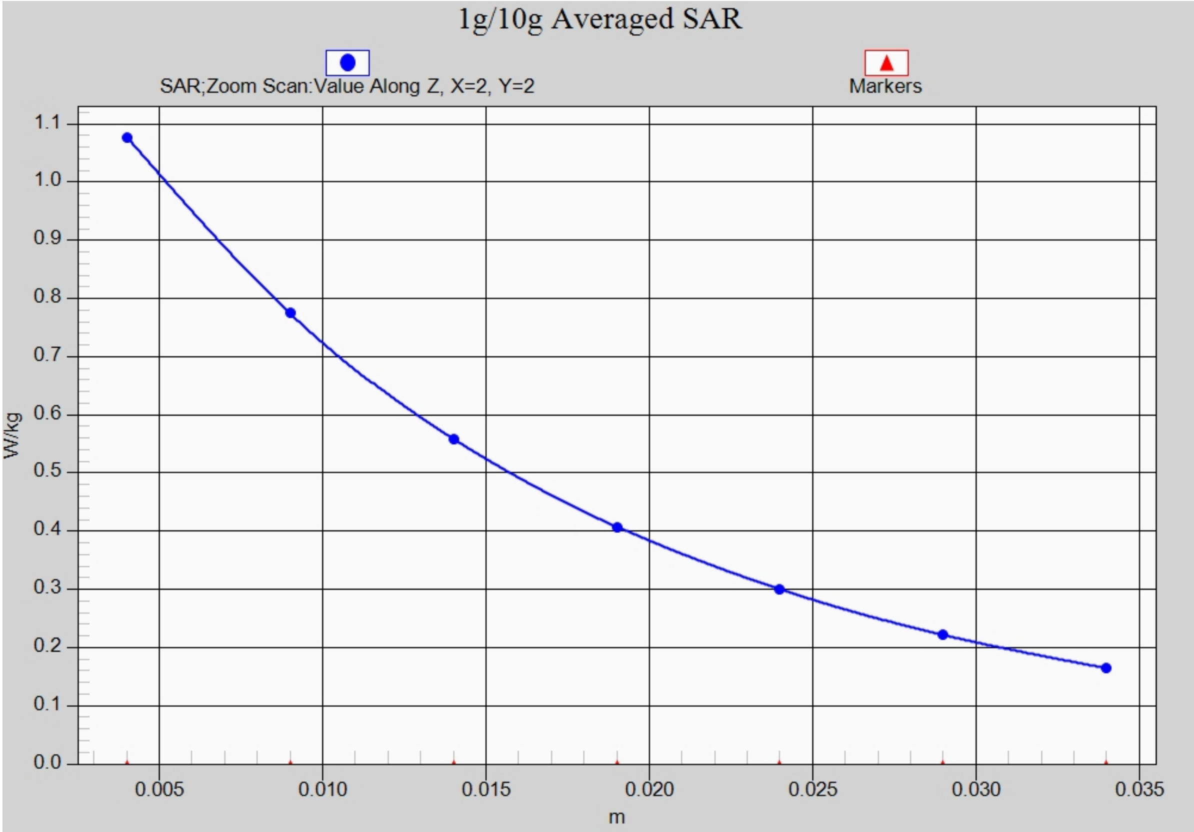


Fig. 2-1 Z-Scan at power reference point (850 MHz CH251)

GSM1900 Left Cheek Middle

Date/Time: 2014-10-17

Electronics: DAE4 Sn786

Medium: Head 1800 MHz

Medium parameters used: f = 1880 MHz; σ = 1.454 S/m; ε_r = 39.355; ρ = 1000 kg/m^3

Ambient Temperature:21.7^{o}C Liquid Temperature:21.2^{o}C

Communication System: GSM Frequency: 1880 MHz Duty Cycle: 1:8.30042

Probe: ES3DV3 - SN3151 ConvF(5.16, 5.16, 5.16);

Left Cheek Middle/Area Scan (61x111x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 0.501 W/kg

Left Cheek Middle/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 5.881 V/m; Power Drift = 0.14 dB

Peak SAR (extrapolated) = 0.703 W/kg

SAR(1 g) = 0.447 W/kg; SAR(10 g) = 0.268 W/kg

Maximum value of SAR (measured) = 0.489 W/kg

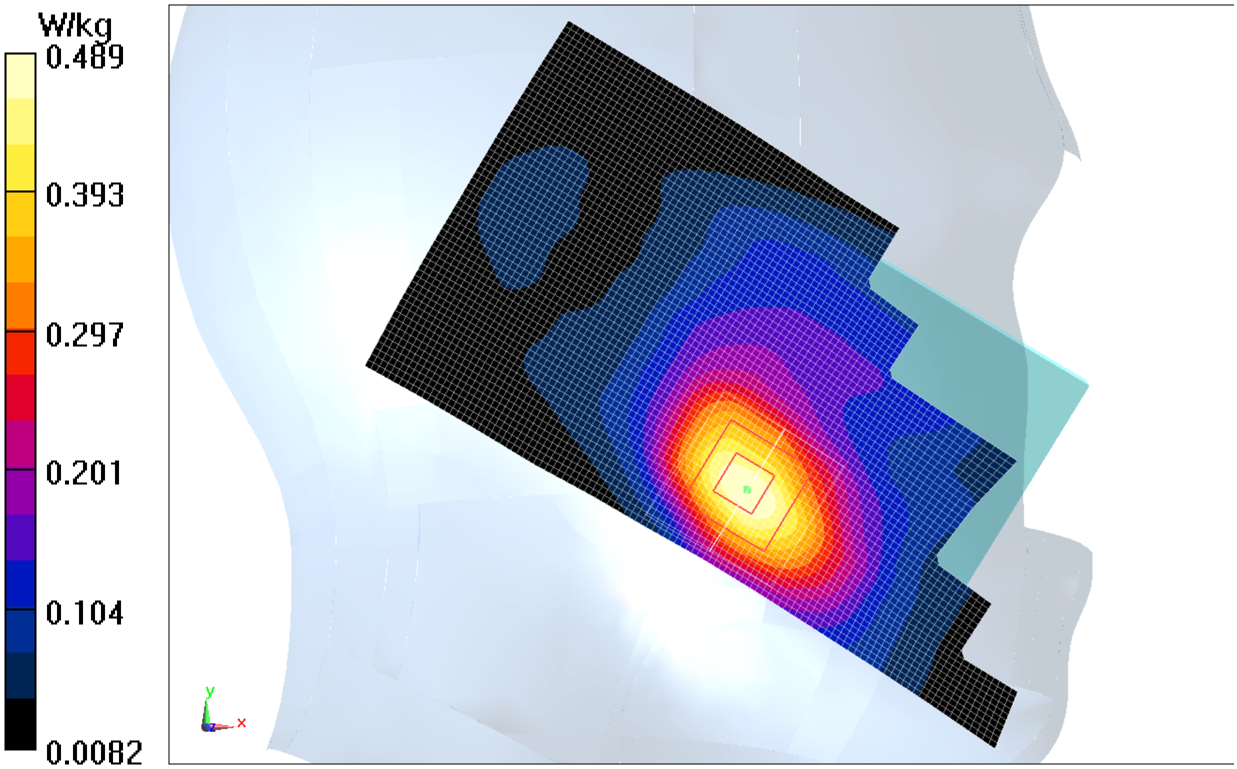


Fig.3 1900 MHz CH661

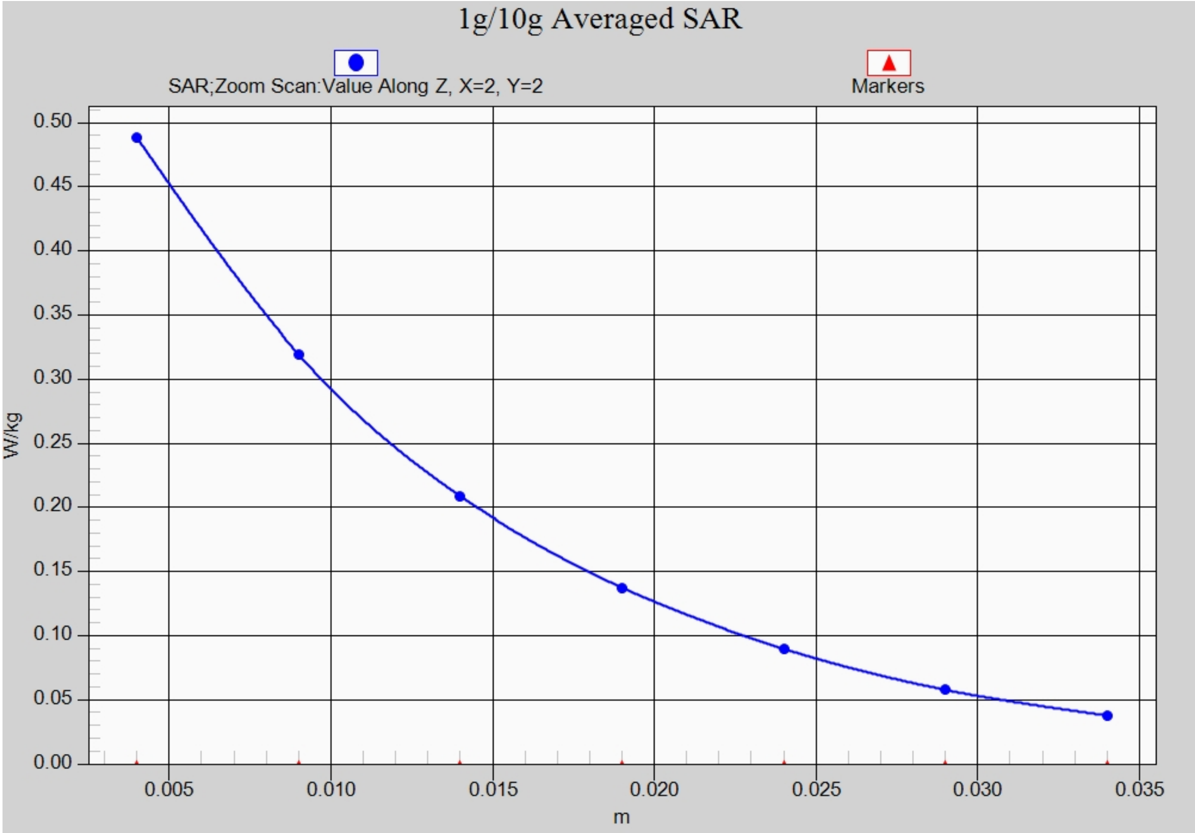


Fig. 3-1 Z-Scan at power reference point (1900 MHz CH661)

GSM1900 Body Rear Middle

Date/Time: 2014-10-19

Electronics: DAE4 Sn786

Medium: Body 1900MHz

Medium parameters used: f = 1880 MHz; σ = 1.494 S/m; ε_r = 52.663; ρ = 1000 kg/m^3

Ambient Temperature:21.7°C Liquid Temperature:21.2°C

Communication System: 4 slot GPRS Frequency: 1880 MHz Duty Cycle: 1:2

Probe: ES3DV3 - SN3151 ConvF(4.77, 4.77, 4.77);

Rear side Middle/Area Scan (61x101x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 0.938 W/kg

Rear side Middle/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 7.670 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 1.49 W/kg

SAR(1 g) = 0.832 W/kg; SAR(10 g) = 0.452 W/kg

Maximum value of SAR (measured) = 0.943 W/kg

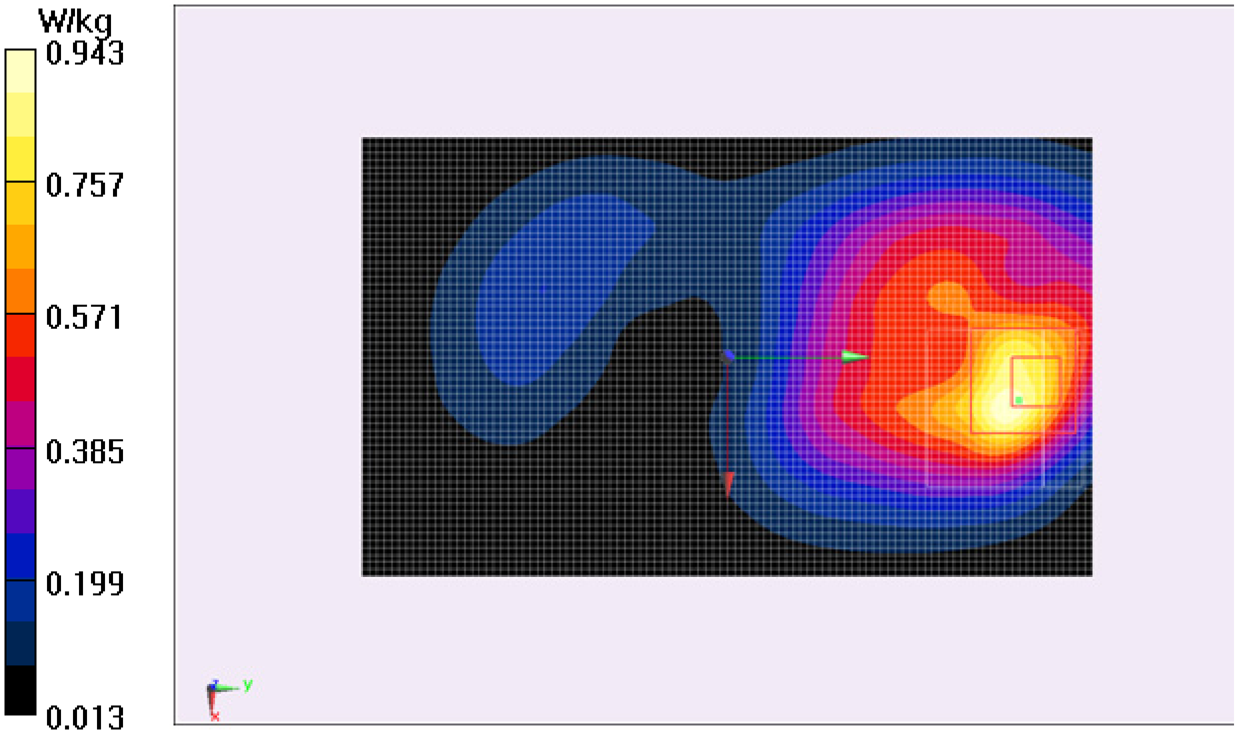


Fig.4 1900 MHz CH661

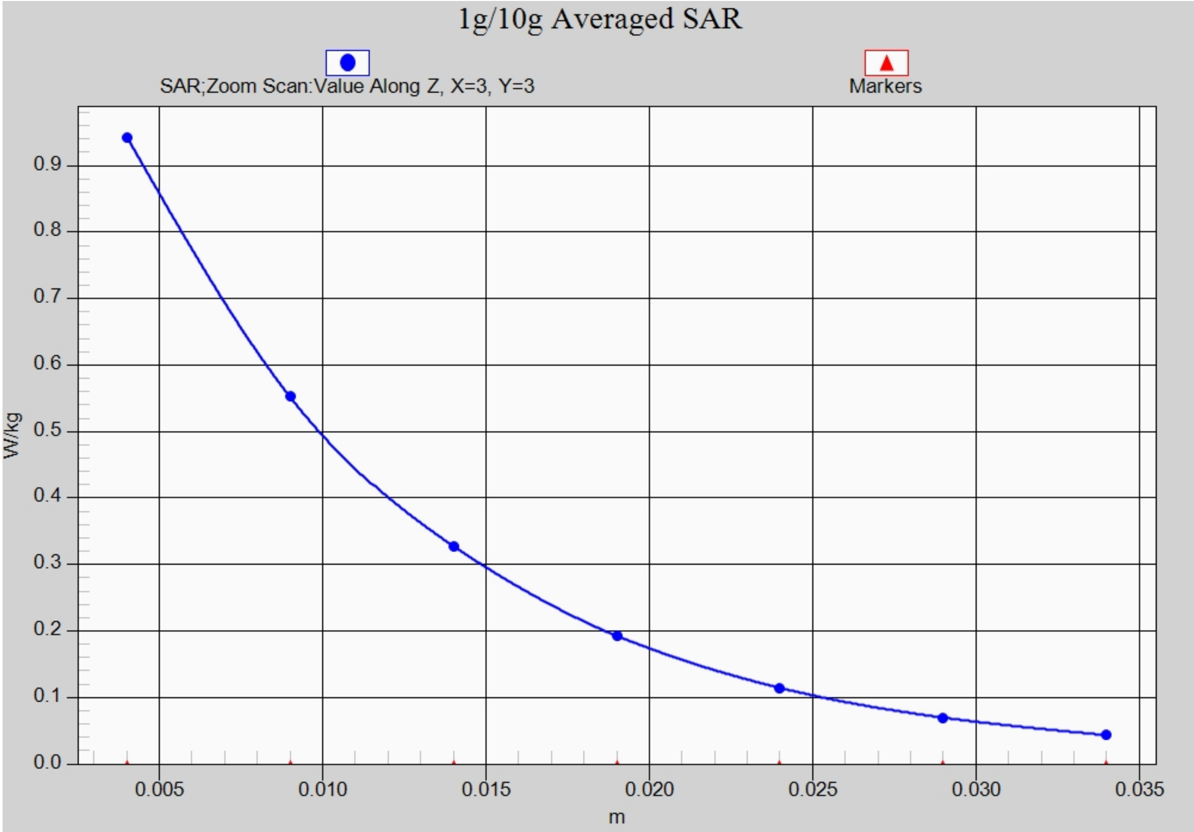


Fig.4-1 Z-Scan at power reference point (1900 MHz CH661)

WCDMA 850 Left Cheek High

Date/Time: 2014-10-18

Electronics: DAE4 Sn786

Medium: 900 Head

Medium parameters used (interpolated): f = 846.6 MHz; σ = 0.893 S/m; ε_r = 41.99; ρ = 1000 kg/m^3

Ambient Temperature:21.7^{o}C   Liquid Temperature:21.2^{o}C

Communication System: WCDMA Frequency: 846.6 MHz Duty Cycle: 1:1

Probe: ES3DV3 - SN3151 ConvF(6.04, 6.04, 6.04);

Left Cheek High/Area Scan (61x101x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 0.433 W/kg

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

Reference Value = 9.211 V/m; Power Drift = 0.13 dB

Peak SAR (extrapolated) = 0.525 W/kg

SAR(1 g) = 0.410 W/kg; SAR(10 g) = 0.307 W/kg

Maximum value of SAR (measured) = 0.438 W/kg

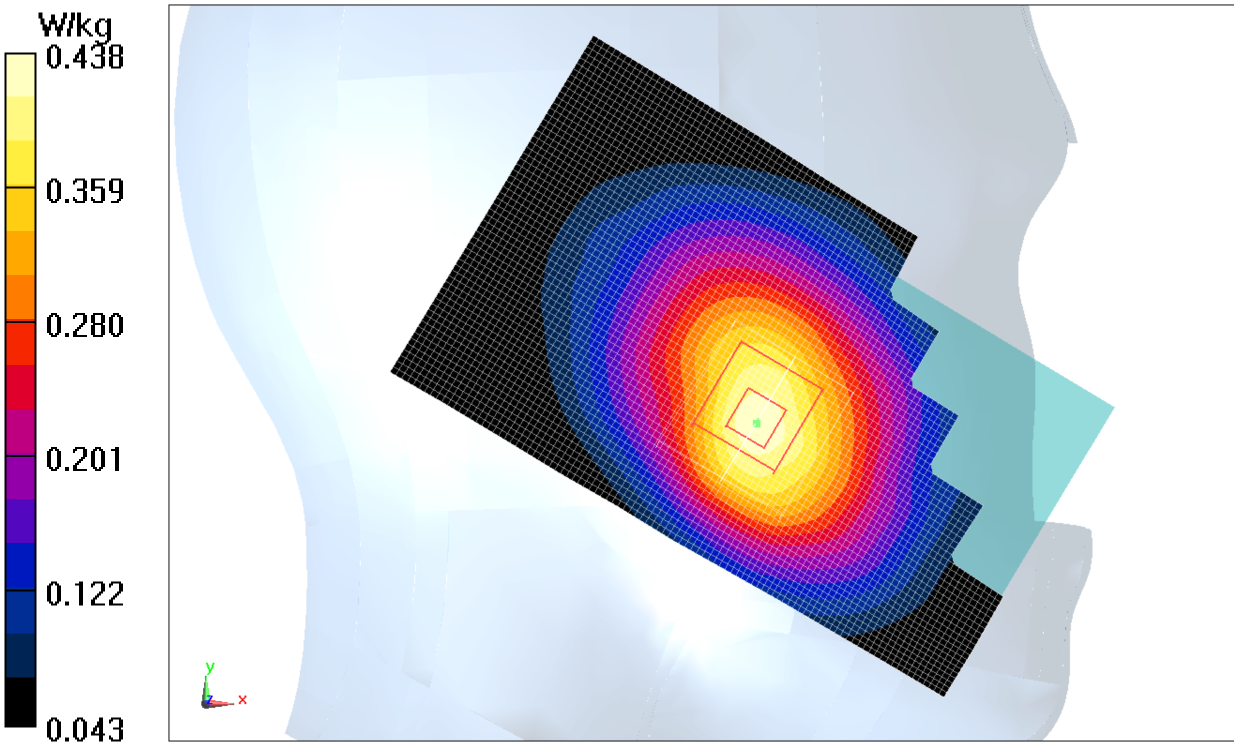


Fig.5 WCDMA 850 CH4233

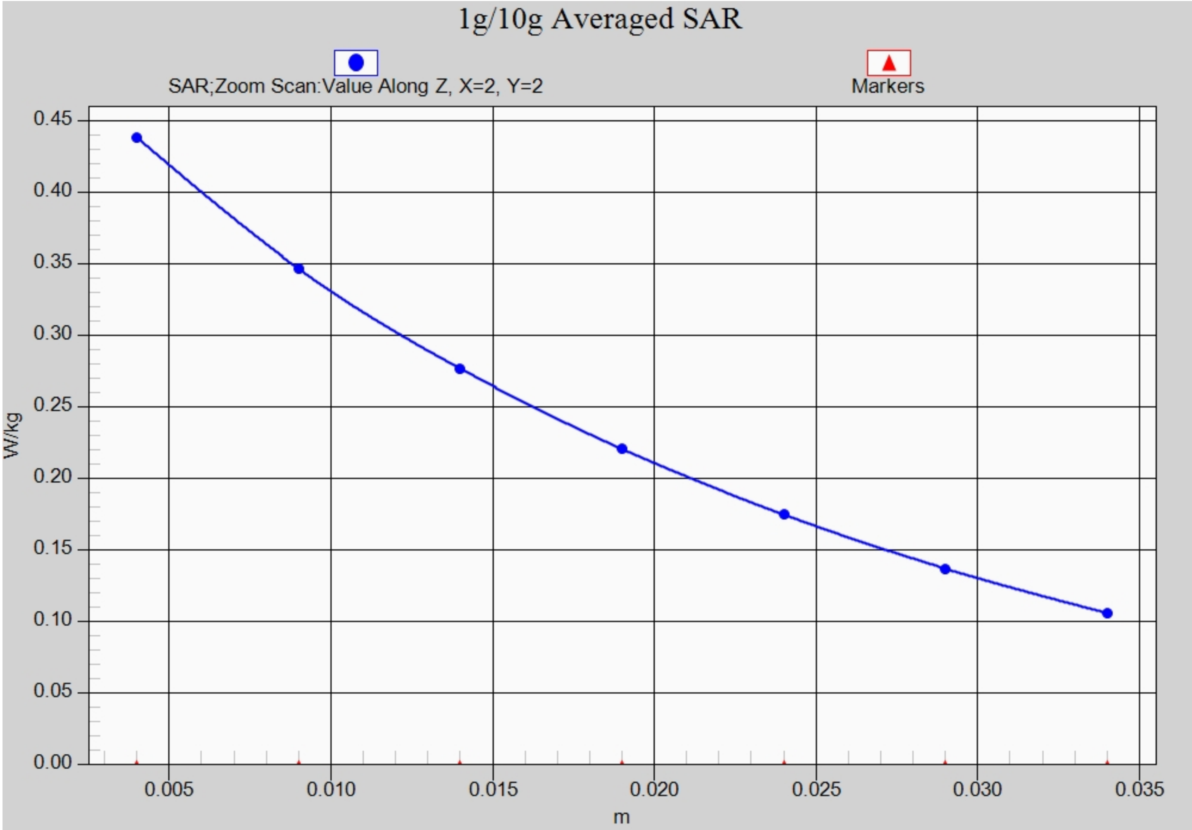


Fig. 5-1 Z-Scan at power reference point (WCDMA 850 CH4233)

WCDMA 850 Body Rear High

Date/Time: 2014-10-19

Electronics: DAE4 Sn786

Medium: Body 900

Medium parameters used (interpolated): f = 846.6 MHz; σ = 0.984 S/m; ε_r = 52.52; ρ = 1000 kg/m^3

Ambient Temperature:21.7^{o}C Liquid Temperature:21.2^{o}C

Communication System: WCDMA Frequency: 846.6 MHz Duty Cycle: 1:1

Probe: ES3DV3 - SN3151 ConvF(6.14, 6.14, 6.14);

Rear side High/Area Scan (61x101x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 0.792 W/kg

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

Reference Value = 27.214 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 0.925 W/kg

SAR(1 g) = 0.757 W/kg; SAR(10 g) = 0.576 W/kg

Maximum value of SAR (measured) = 0.794 W/kg

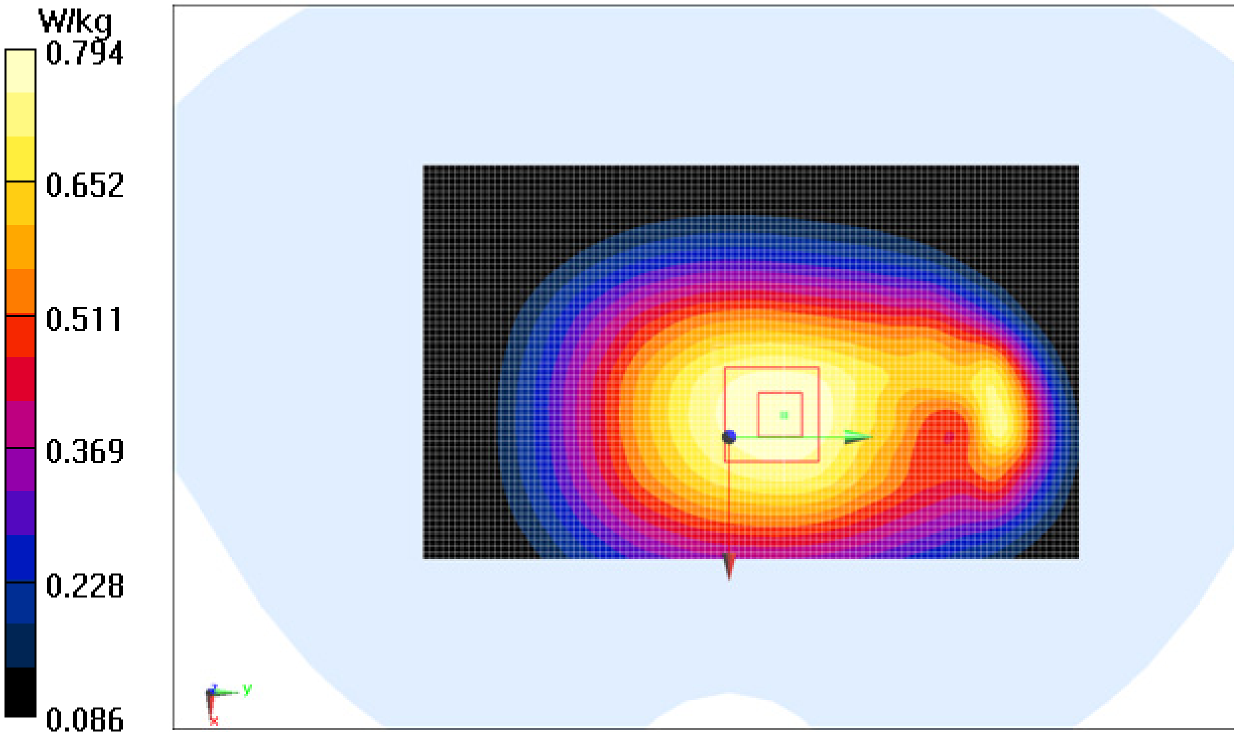


Fig.6 WCDMA 850 CH4233

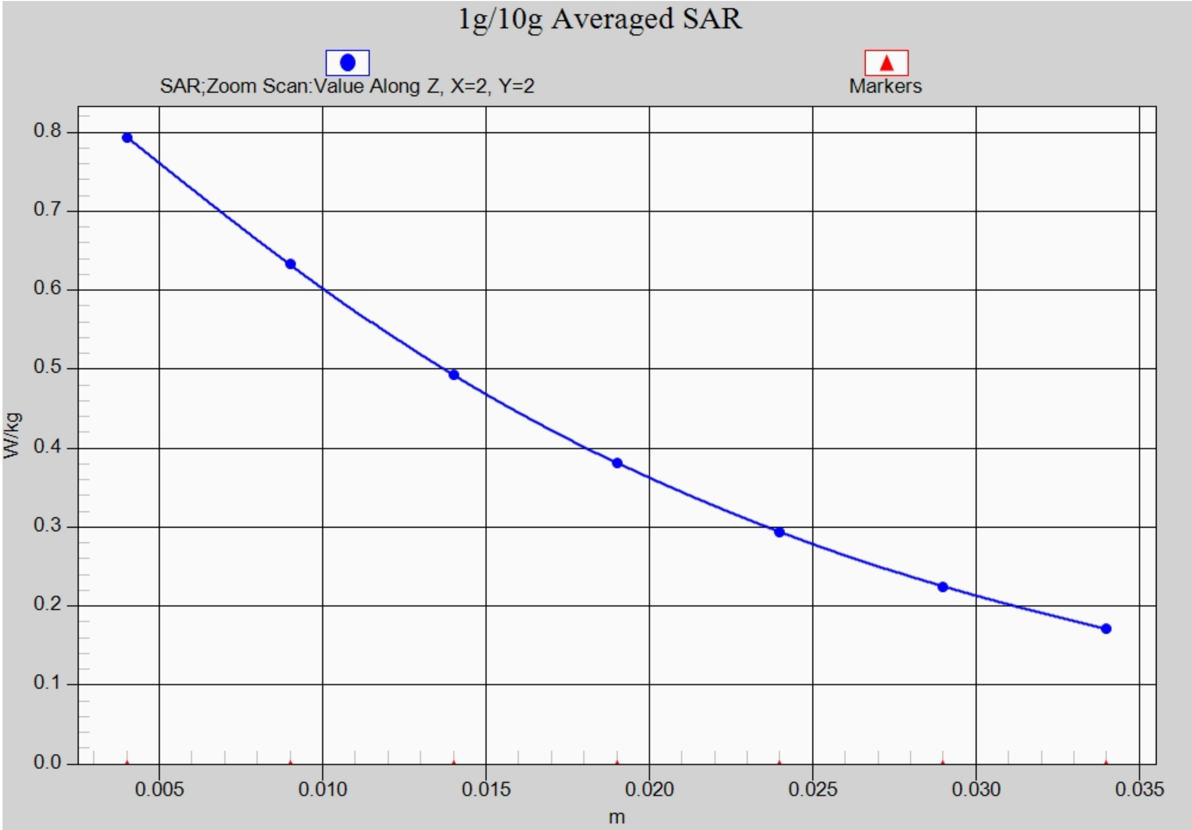


Fig. 6-1 Z-Scan at power reference point (WCDMA850 CH4233)

WCDMA 1900 Left Cheek High

Date: 2014-10-17
Electronics: DAE4 Sn786
Medium: Head 1900 MHz
Medium parameters used: f = 1908 MHz; σ = 1.443 S/m; ε_r = 41.465; ρ = 1000 kg/m^3
Ambient Temperature:22.2°C   Liquid Temperature:21.7°C
Communication System: WCDMA Frequency: 1908 MHz Duty Cycle: 1:1
Probe: ES3DV3 - SN3151 ConvF(5.16, 5.16, 5.16);

Cheek High/Area Scan (61x101x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.548 W/kg

Cheek High/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 8.917 V/m; Power Drift = -0.09 dB
Peak SAR (extrapolated) = 0.657 W/kg
SAR(1 g) = 0.439 W/kg; SAR(10 g) = 0.271 W/kg
Maximum value of SAR (measured) = 0.517 W/kg

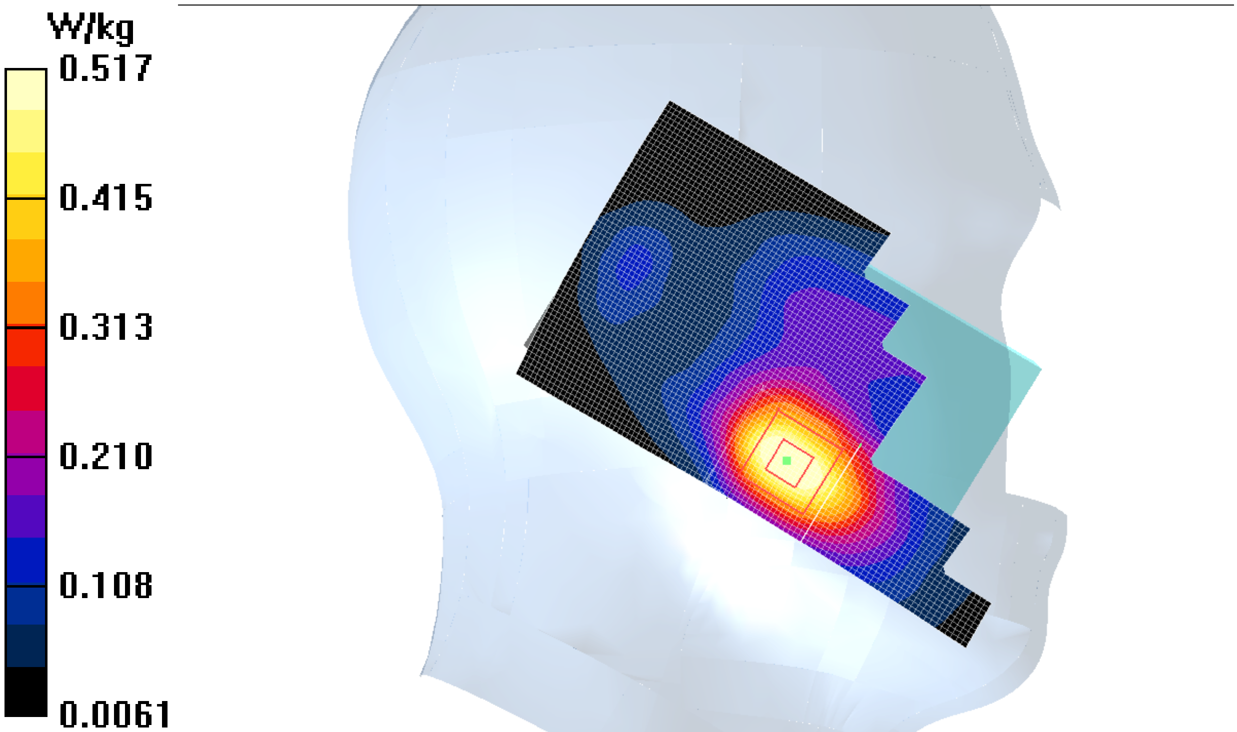


Fig.7 WCDMA1900 CH9538

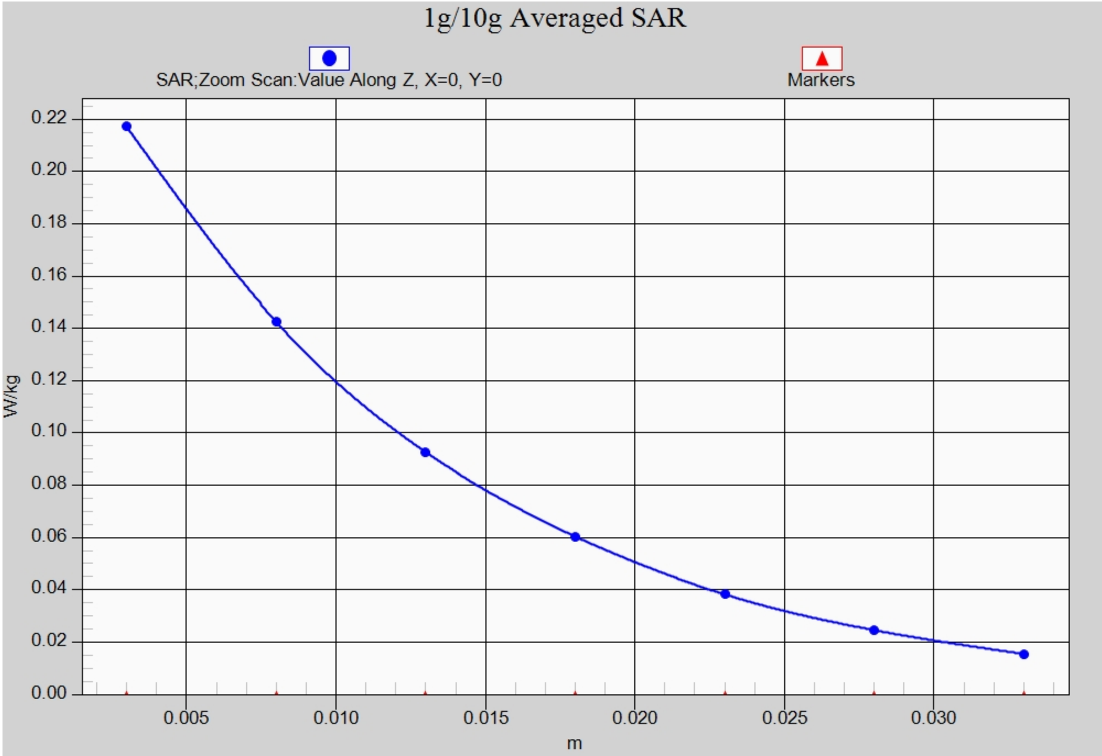


Fig. 7-1 Z-Scan at power reference point (WCDMA1900 CH9538)

WCDMA 1900 Body Rear Middle

Date: 2014-10-19

Electronics: DAE4 Sn786

Medium: Body 1900MHz

Medium parameters used: f = 1880 MHz; σ = 1.494 S/m; ε_r = 52.663; ρ = 1000 kg/m^3

Ambient Temperature:22.2^{o}C Liquid Temperature:21.7^{o}C

Communication System: WCDMA Frequency: 1880 MHz Duty Cycle: 1:1

Probe: ES3DV3 - SN3151 ConvF(4.77, 4.77, 4.77);

Rear Middle/Area Scan (111x61x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 1.08 W/kg

Rear Middle/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 8.678 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 1.59 W/kg
SAR(1 g) = 0.951 W/kg; SAR(10 g) = 0.568 W/kg
Maximum value of SAR (measured) = 1.04 W/kg

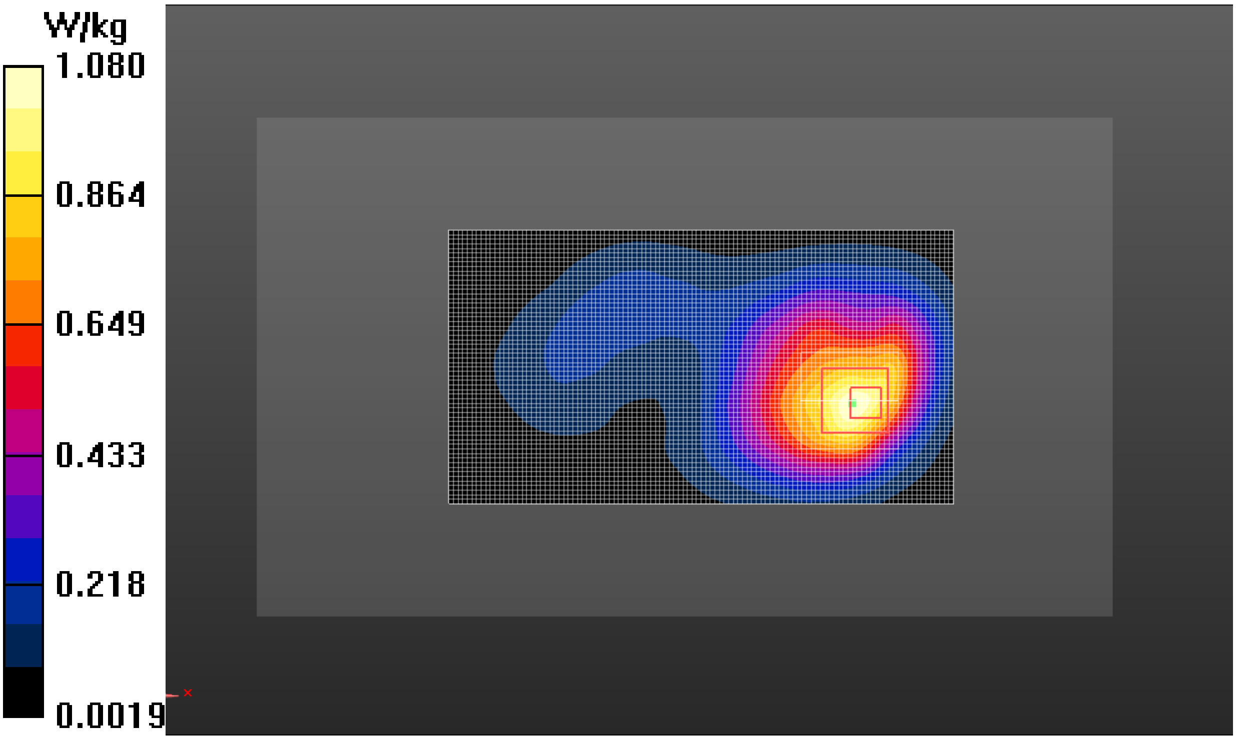


Fig.8 WCDMA1900 CH9400

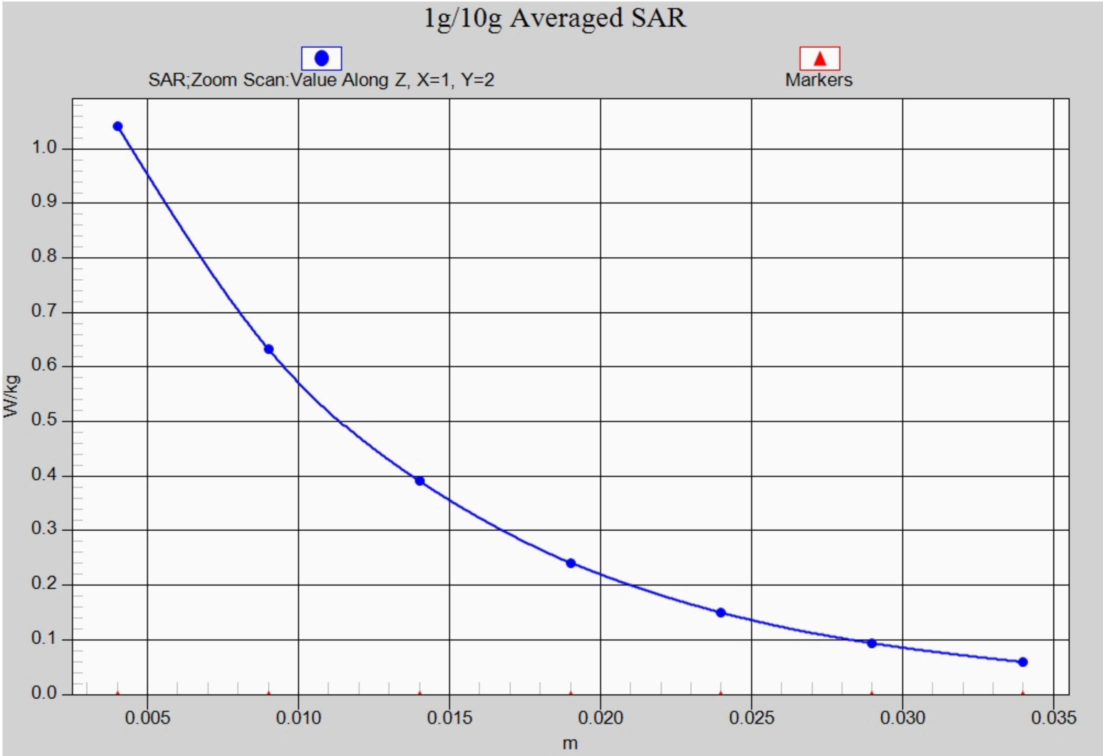


Fig. 8-1 Z-Scan at power reference point (WCDMA1900 CH9400)

Wifi 802.11b right Cheek Channel 6

Date/Time: 2014-11-19
Electronics: DAE4 Sn679
Medium: Head 2450
Medium parameters used (interpolated): f = 2437 MHz; σ = 1.836 S/m; ε_r = 38.651; ρ = 1000 kg/m^3
Ambient Temperature:21.7°C Liquid Temperature:21.2°C
Communication System: WiFi Frequency: 2437 MHz Duty Cycle: 1:1
Probe: ES3DV3 - SN3151 ConvF(4.71, 4.71, 4.71);

Cheek Middle/Area Scan (61x101x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.225 W/kg

Cheek Middle/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 6.573 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 0.469 W/kg
SAR(1 g) = 0.213 W/kg; SAR(10 g) = 0.103 W/kg
Maximum value of SAR (measured) = 0.239 W/kg

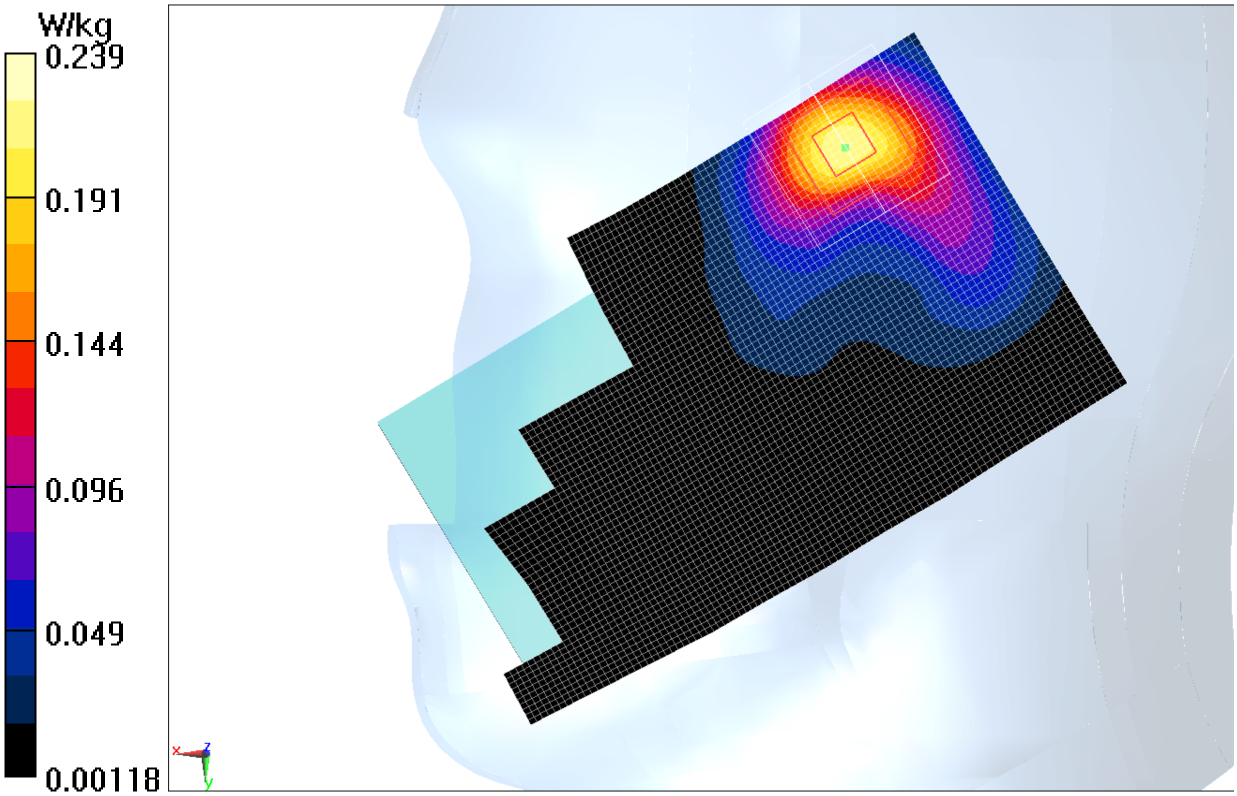


Fig.9 2450 MHz CH6

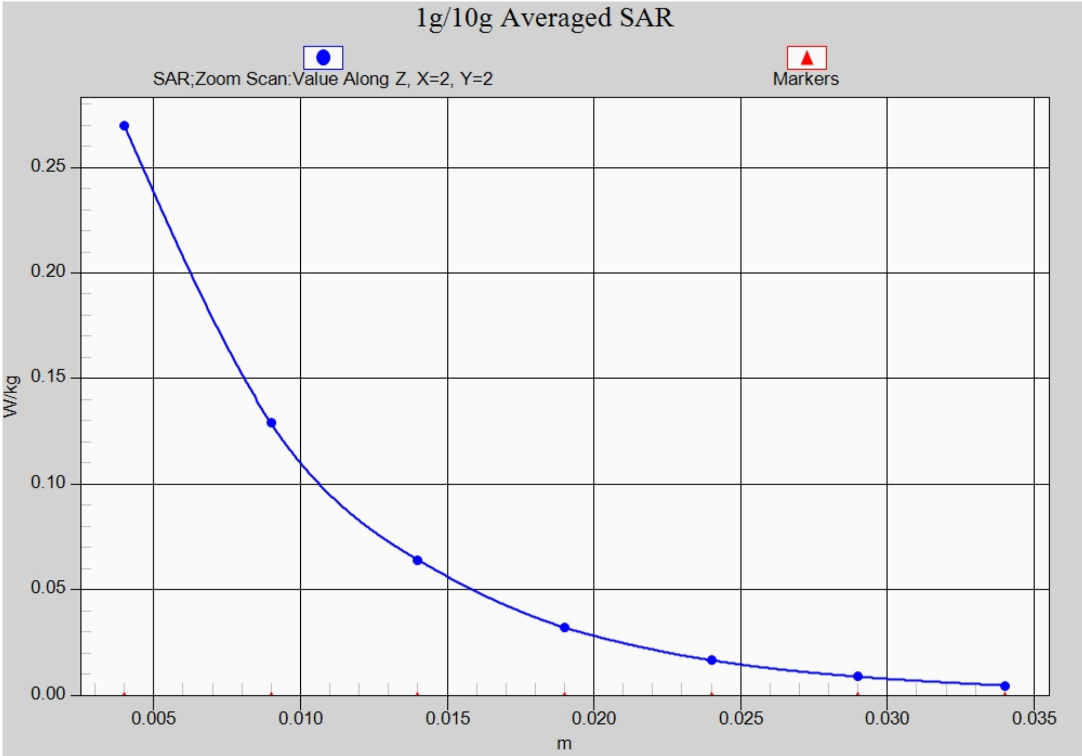


Fig. 9-1 Z-Scan at power reference point (2450 MHz CH6)

Wifi 802.11b Body Rear Channel 6

Date/Time: 2014-11-20
Electronics: DAE4 Sn786
Medium: Body 2450 MHz
Medium parameters used (interpolated): f = 2437 MHz; σ = 1.922 S/m; ε_r = 52.622; ρ = 1000 kg/m^3
Ambient Temperature:21.7°C Liquid Temperature:21.2°C
Communication System: WiFi Frequency: 2437 MHz Duty Cycle: 1:1
Probe: ES3DV3 - SN3151 ConvF(4.42, 4.42, 4.42);

Rear side Middle/Area Scan (61x101x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.157 W/kg

Rear side Middle/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 4.529 V/m; Power Drift = 0.19 dB
Peak SAR (extrapolated) = 0.257 W/kg
SAR(1 g) = 0.134 W/kg; SAR(10 g) = 0.068 W/kg
Maximum value of SAR (measured) = 0.153 W/kg

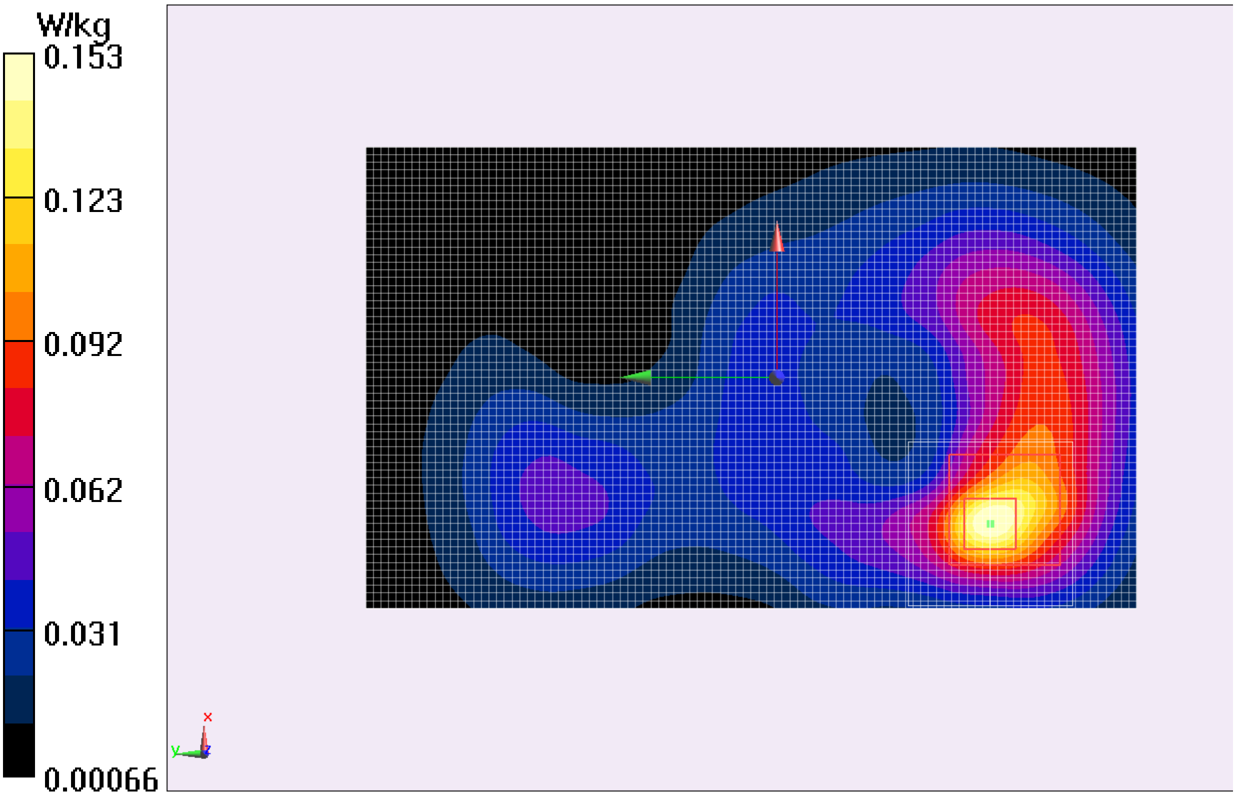


Fig.10 2450 MHz CH6

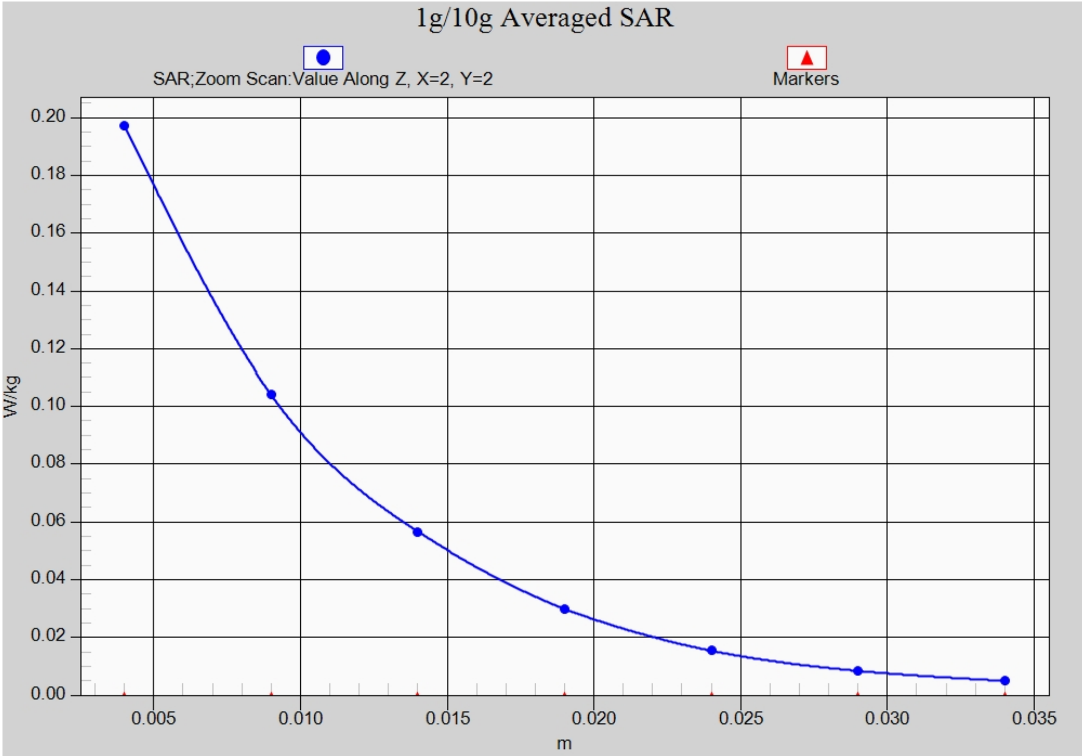


Fig. 10-1 Z-Scan at power reference point (2450 MHz CH6)

ANNEX B System Verification Results

835MHz

Date: 2014-10-18

Electronics: DAE4 Sn786

Medium: Head 900 MHz

Medium parameters used: f = 835 MHz; σ = 0.882 S/m; ε_r = 42.15; ρ = 1000 kg/m^3

Ambient Temperature: 22.5^{o}C Liquid Temperature: 22.0^{o}C

Communication System: CW Frequency: 835 MHz Duty Cycle: 1:1

Probe: ES3DV3 - SN3151 ConvF(6.04, 6.04, 6.04);

System Validation /Area Scan (81x161x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Reference Value = 54.722 V/m; Power Drift = 0.02 dB

Fast SAR: SAR(1 g) = 2.43 W/kg; SAR(10 g) = 1.59 W/kg

Maximum value of SAR (interpolated) = 2.62 W/kg

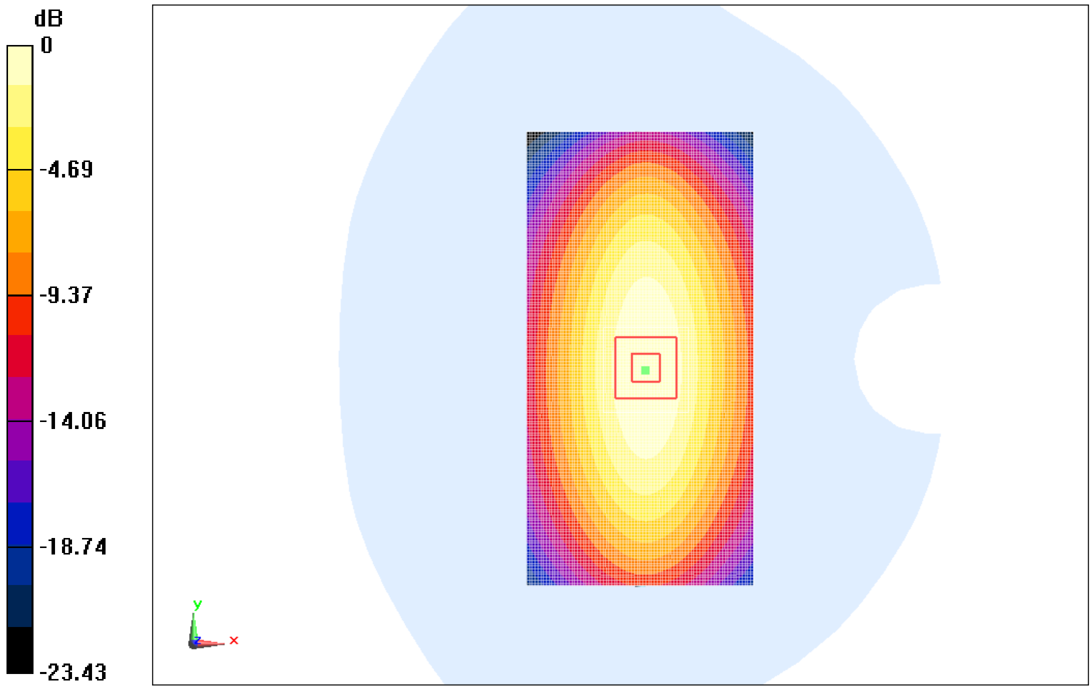
System Validation /Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 54.722 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 3.69 W/kg

SAR(1 g) = 2.44 W/kg; SAR(10 g) = 1.61 W/kg

Maximum value of SAR (measured) = 2.64 W/kg



0 dB = 2.64 W/kg = 1.84 dBW/kg

Fig.B.1 validation 835MHz 250mW

835MHz

Date: 2014-10-19

Electronics: DAE4 Sn786

Medium: Body 900 MHz

Medium parameters used: f = 835 MHz; σ = 0.972 S/m; ε_r = 52.62; ρ = 1000 kg/m^3

Ambient Temperature: 22.5°C Liquid Temperature: 22.0°C

Communication System: CW Frequency: 835 MHz Duty Cycle: 1:1

Probe: ES3DV3 - SN3151 ConvF(6.14, 6.14, 6.14);

System Validation /Area Scan (81x171x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Reference Value = 53.566 V/m; Power Drift = -0.02 dB

Fast SAR: SAR(1 g) = 2.40 W/kg; SAR(10 g) = 1.56 W/kg

Maximum value of SAR (interpolated) = 2.61 W/kg

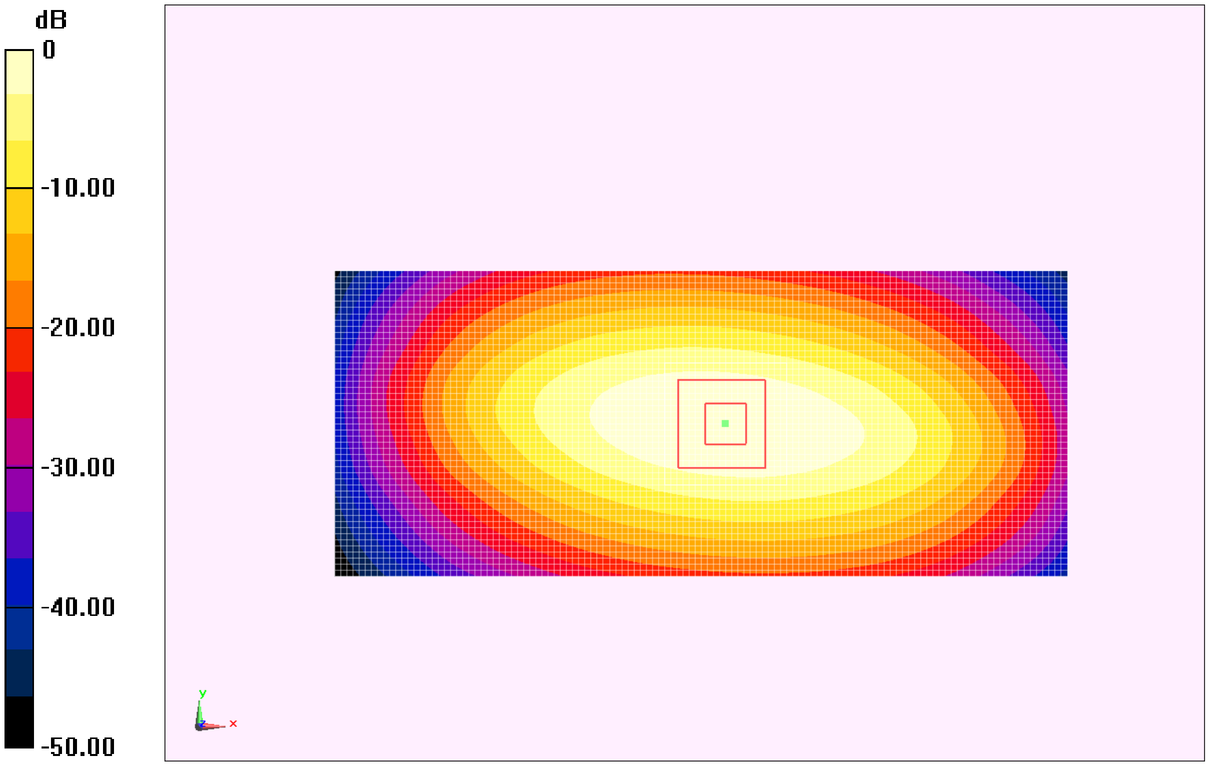
System Validation /Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 53.566 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 3.58 W/kg

SAR(1 g) = 2.42 W/kg; SAR(10 g) = 1.59 W/kg

Maximum value of SAR (measured) = 2.62 W/kg



0 dB = 2.62 W/kg = 1.83 dBW/kg

Fig.B.2 validation 835MHz 250mW

1900MHz

Date: 2014-10-17

Electronics: DAE4 Sn786

Medium: Head 1900 MHz

Medium parameters used: f = 1900 MHz; σ = 1.465 S/m; ε_r = 39.18; ρ = 1000 kg/m^3

Ambient Temperature: 22.5°C Liquid Temperature: 22.0°C

Communication System: CW Frequency: 1900 MHz Duty Cycle: 1:1

Probe: ES3DV3 - SN3151 ConvF(5.16, 5.16, 5.16);

System Validation /Area Scan (81x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Reference Value = 86.259 V/m; Power Drift = -0.09 dB

Fast SAR: SAR(1 g) = 9.88 W/kg; SAR(10 g) = 5.08 W/kg

Maximum value of SAR (interpolated) = 13.5 W/kg

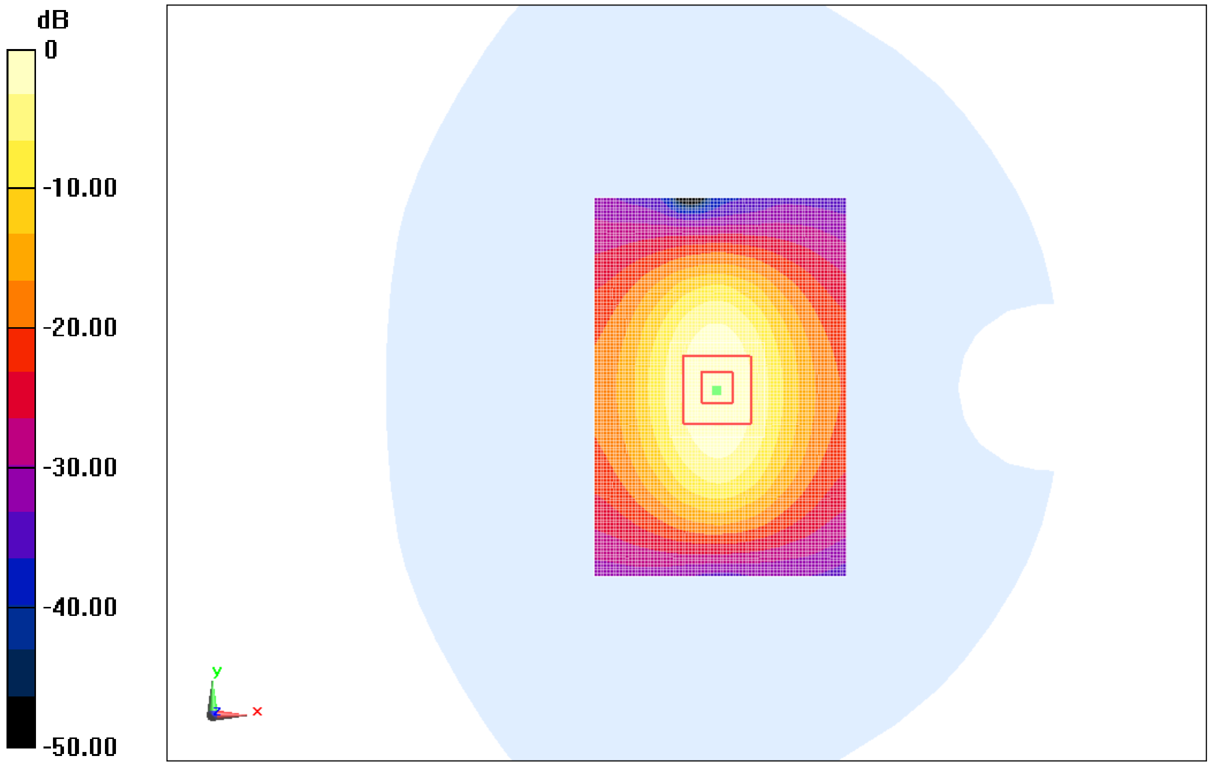
System Validation /Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 86.259 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 18.4 W/kg

SAR(1 g) = 10.1 W/kg; SAR(10 g) = 5.20 W/kg

Maximum value of SAR (measured) = 11.6 W/kg



0 dB = 11.6 W/kg = 10.64 dBW/kg

Fig.B.3 validation 1900MHz 250mW

1900MHz

Date: 2014-10-19

Electronics: DAE4 Sn786

Medium: Body 1900 MHz

Medium parameters used: f = 1900 MHz; σ = 1.512 S/m; ε_r = 52.61; ρ = 1000 kg/m^3

Ambient Temperature: 22.5^{o}C   Liquid Temperature: 22.0^{o}C

Communication System: CW Frequency: 1900 MHz Duty Cycle: 1:1

Probe: ES3DV3 - SN3151 ConvF(4.77, 4.77, 4.77);

System validation /Area Scan (81x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Reference Value = 60.339 V/m; Power Drift = 0.08 dB

Fast SAR: SAR(1 g) = 10.2 W/kg; SAR(10 g) = 5.39 W/kg

Maximum value of SAR (interpolated) = 13.5 W/kg

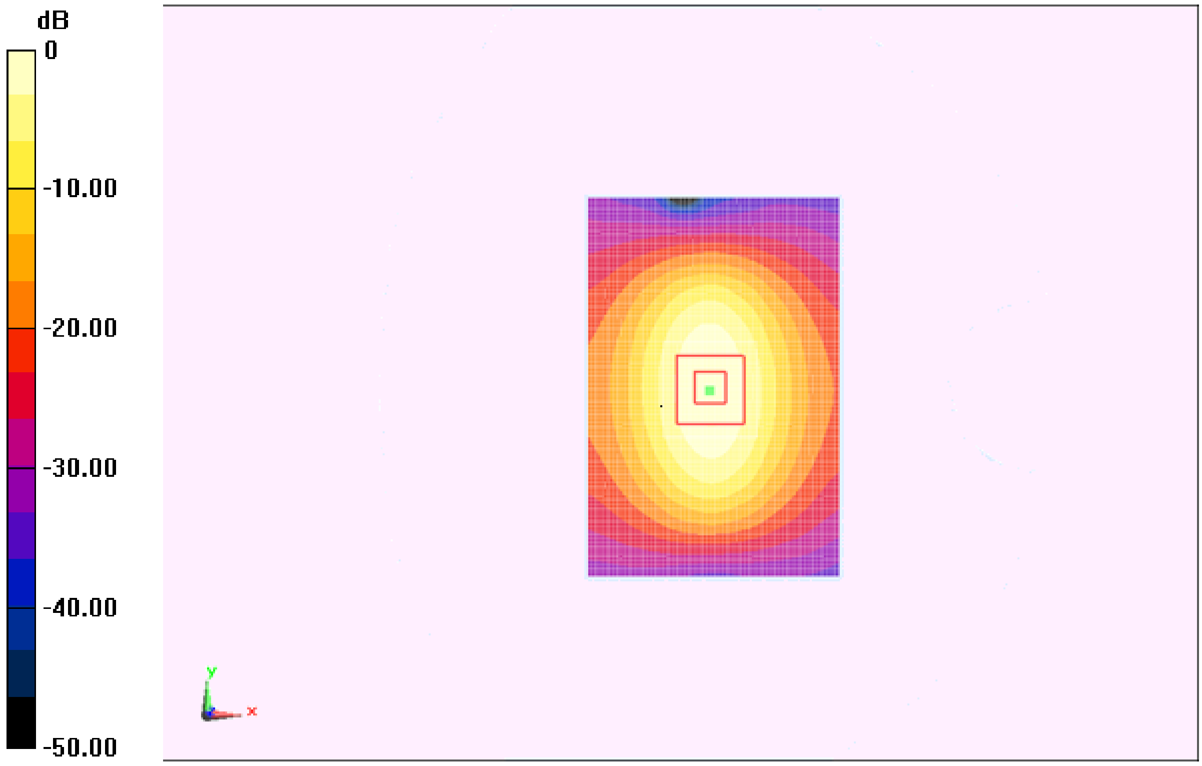
System validation /Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 60.339 V/m; Power Drift = 0.08 dB

Peak SAR (extrapolated) = 19.3 W/kg

SAR(1 g) = 10.3 W/kg; SAR(10 g) = 5.41 W/kg

Maximum value of SAR (measured) = 12.4 W/kg



0 dB = 12.4 W/kg = 10.93 dBW/kg

Fig.B.4 validation 1900MHz 250mW

2450MHz

Date: 2014-11-19

Electronics: DAE4 Sn786

Medium: Head 2450 MHz

Medium parameters used: f = 2450 MHz; σ = 1.855 S/m; ε_r = 38.61; ρ = 1000 kg/m^3

Ambient Temperature: 22.5°C Liquid Temperature: 22.0°C

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

Probe: ES3DV3 - SN3151 ConvF(4.71, 4.71, 4.71);

System Validation/Area Scan (81x101x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Reference Value = 84.926 V/m; Power Drift = 0.04 dB

Fast SAR: SAR(1 g) = 12.57 W/kg; SAR(10 g) = 6.24 W/kg

Maximum value of SAR (interpolated) = 11.5 W/kg

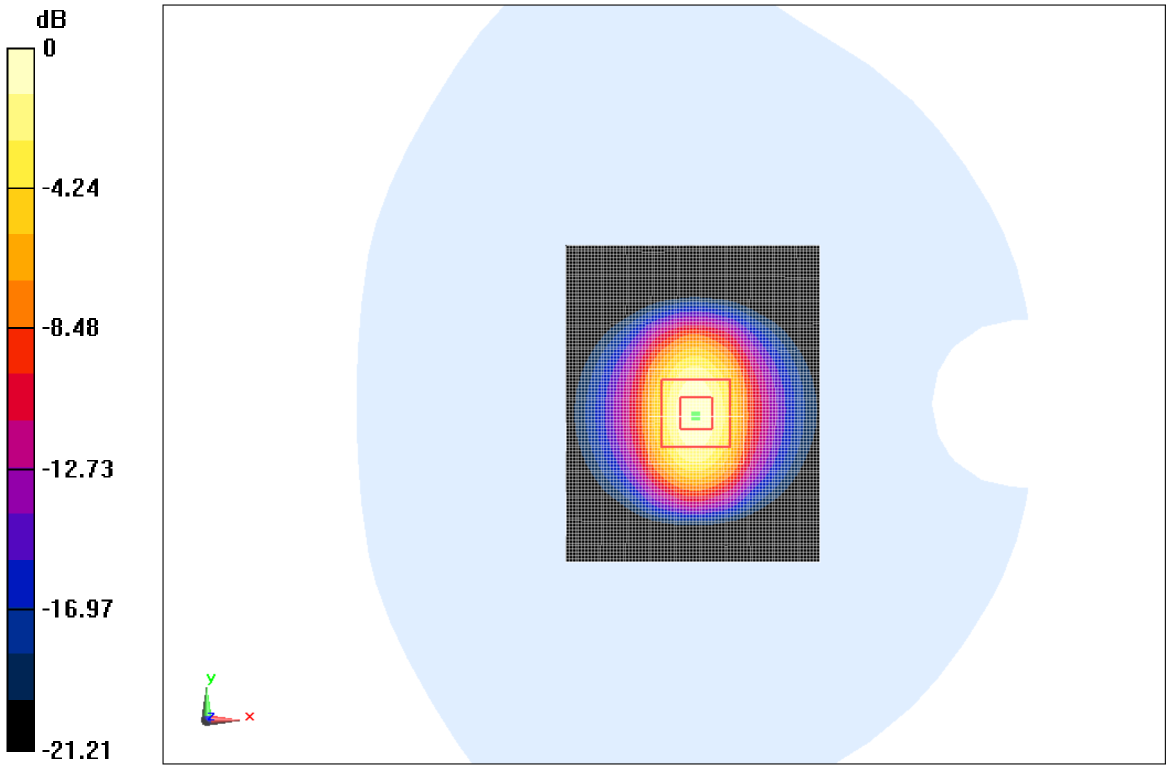
system check 2450M /Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 84.926 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 22.1 W/kg

SAR(1 g) = 12.8 W/kg; SAR(10 g) = 6.35 W/kg

Maximum value of SAR (measured) = 14.8 W/kg



0 dB = 14.8 W/kg = 23.41 dBW/kg

Fig.B.5 validation 2450MHz 250mW

2450MHz

Date: 2014-11-20

Electronics: DAE4 Sn786

Medium: Body 2450 MHz

Medium parameters used: f = 2450 MHz; σ = 1.938 S/m; ε_r = 52.59; ρ = 1000 kg/m^3

Ambient Temperature: 22.5°C Liquid Temperature: 22.0°C

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

Probe: ES3DV3 - SN3151 ConvF(4.42, 4.42, 4.42);

System Validation/Area Scan (81x101x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Reference Value = 84.926 V/m; Power Drift = 0.05 dB

Fast SAR: SAR(1 g) = 12.86 W/kg; SAR(10 g) = 6.14 W/kg

Maximum value of SAR (interpolated) = 12.2 W/kg

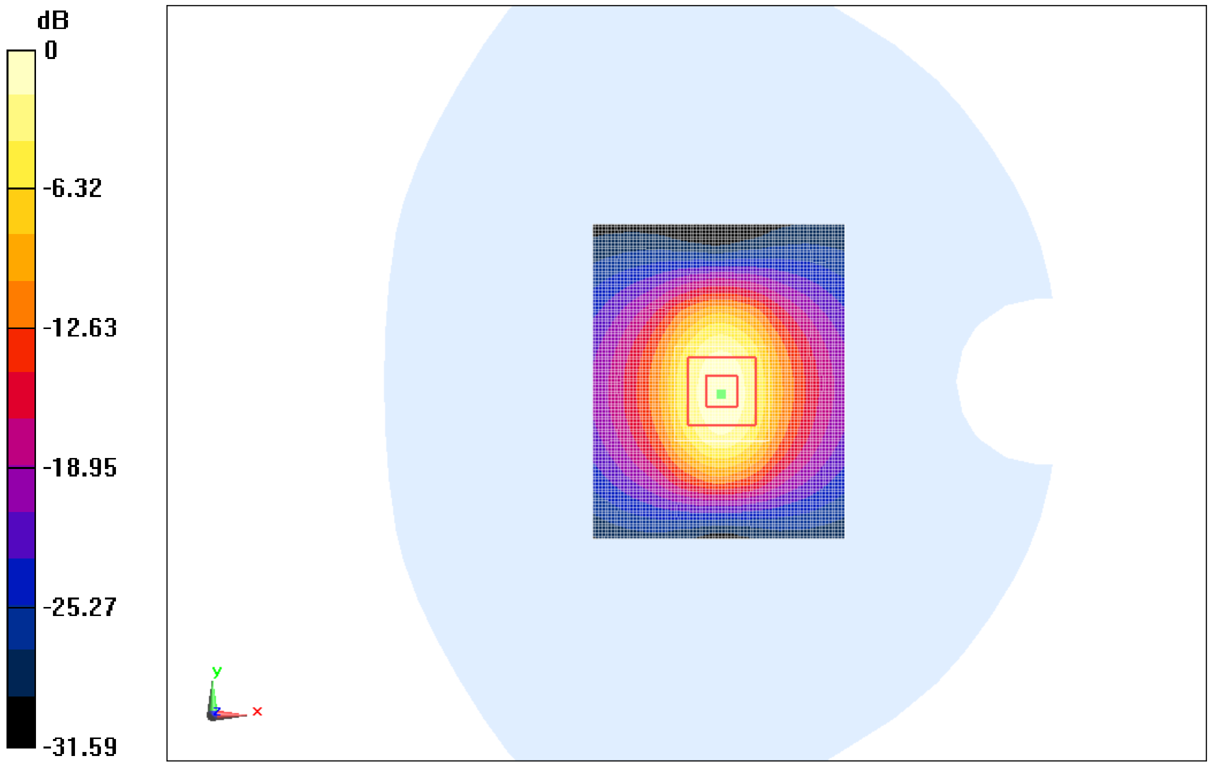
system check 2450M /Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 84.926 V/m; Power Drift = 0.05 dB

Peak SAR (extrapolated) = 26.2 W/kg

SAR(1 g) = 12.95 W/kg; SAR(10 g) = 6.22 W/kg

Maximum value of SAR (measured) = 14.4 W/kg



0 dB = 14.4 W/kg = 27.54 dBW/kg

Fig.B.6 validation 2450MHz 250mW

The SAR system verification must be required that the area scan estimated 1-g SAR is within 3% of the zoom scan 1-g SAR.

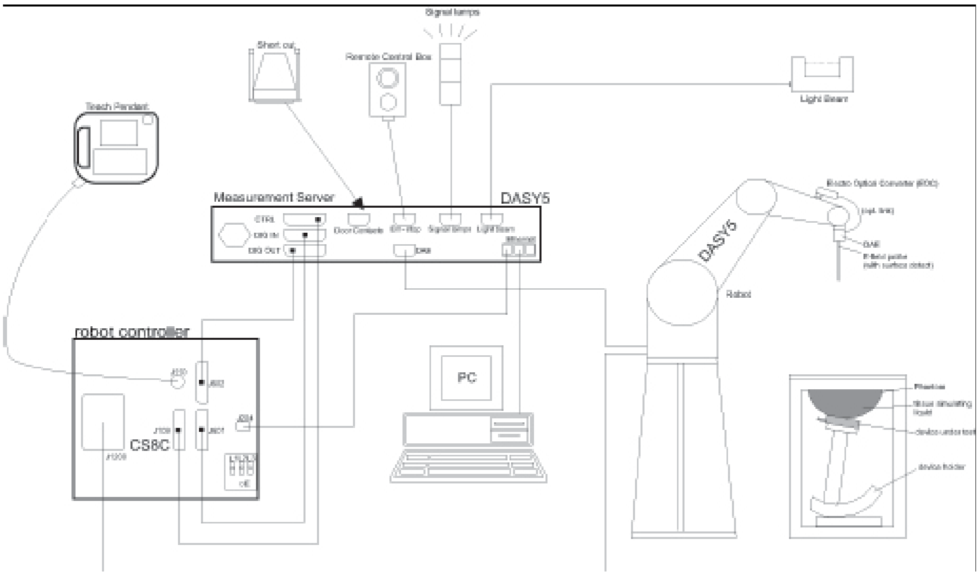
Table B.1 Comparison between area scan and zoom scan for system verification

Band	Position	Area scan (1g)	Zoom scan (1g)	Drift (%)
835	Head	2.43	2.44	0.4
835	Body	2.41	2.42	0.4
1900	Head	9.87	10.1	2.3
1900	Body	10.2	10.3	1.0
2450	Head	12.57	12.8	1.8
2450	Body	12.86	12.95	0.7

ANNEX C SAR Measurement Setup

C.1 Measurement Set-up

The Dasy4 or DASY5 system for performing compliance tests is illustrated above graphically. This system consists of the following items:



Picture C.1 SAR Lab Test Measurement Set-up

- A standard high precision 6-axis robot (Stäubli TX=RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running WinXP and the DASY4 or DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as
- warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.

C.2 Dasy4 or DASY5 E-field Probe System

The SAR measurements were conducted with the dosimetric probe designed in the classical triangular configuration 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 multifiber 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 DASY4 or DASY5 software reads the reflection durning a software approach and looks for the maximum using 2^{nd} ord curve fitting. The approach is stopped at reaching the maximum.

Probe Specifications:

Model: ES3DV3, EX3DV4

Frequency Range: 10MHz — 6.0GHz(EX3DV4)
10MHz — 4GHz(ES3DV3)

Calibration: In head and body simulating tissue at Frequencies from 835 up to 5800MHz

Linearity: ± 0.2 dB(30 MHz to 6 GHz) for EX3DV4
± 0.2 dB(30 MHz to 4 GHz) for ES3DV3

Dynamic Range: 10 mW/kg — 100W/kg

Probe Length: 330 mm

Probe Tip Length: 20 mm

Body Diameter: 12 mm

Tip Diameter: 2.5 mm (3.9 mm for ES3DV3)

Tip-Center: 1 mm (2.0mm for ES3DV3)

Application: SAR Dosimetry Testing
Compliance tests of mobile phones
Dosimetry in strong gradient fields

Picture C.2 Near-field Probe

Picture C.3 E-field Probe

C.3 E-field Probe Calibration

Each E-Probe/Probe Amplifier combination has unique calibration parameters. A TEM cell calibration procedure is conducted to determine the proper amplifier settings to enter in the probe parameters. The amplifier settings are determined for a given frequency by subjecting the probe to a known E-field density (1 mW/cm^2) using an RF Signal generator, TEM cell, and RF Power Meter.

The free space E-field from amplified probe outputs is determined in a test chamber. This calibration can be performed in a TEM cell if the frequency is below 1 GHz and inn a waveguide or other methodologies above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is then rotated 360 degrees until the three channels show the maximum reading. The power density readings equates to 1 mW/ cm^2.

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

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

Where:

Δt = Exposure time (30 seconds),

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

ΔT = Temperature increase due to RF exposure.

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

Where:

σ = Simulated tissue conductivity,

ρ = Tissue density (kg/m^3).

C.4 Other Test Equipment

C.4.1 Data Acquisition Electronics(DAE)

The data acquisition electronics consist 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 with a control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information, as well as an optical uplink for commands and the clock.

The mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection.

The input impedance of the DAE is 200 MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.

PictureC.4: DAE

C.4.2 Robot

The SPEAG DASY system uses the high precision robots (DASY4: RX90XL; DASY5: RX160L) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version from Stäubli is used. The Stäubli robot series have many features that are important for our application:

- High precision (repeatability 0.02mm)
- High reliability (industrial design)
- Low maintenance costs (virtually maintenance free due to direct drive gears; no belt drives)
- Jerk-free straight movements (brushless synchron motors; no stepper motors)
- Low ELF interference (motor control fields shielded via the closed metallic construction shields)

Picture C.6 DASY 5

C.4.3 Measurement Server

The Measurement server is based on a PC/104 CPU broad with CPU (dasy4: 166 MHz, Intel Pentium; DASY5: 400 MHz, Intel Celeron), chipdisk (DASY4: 32 MB; DASY5: 128MB), RAM (DASY4: 64 MB, DASY5: 128MB). The necessary circuits for communication with the DAE electronic box, as well as the 16 bit AD converter system for optical detection and digital I/O interface are contained on the DASY I/O broad, which is directly connected to the PC/104 bus of the CPU broad.

The measurement server performs all real-time data evaluation of field measurements and surface detection, controls robot movements and handles safety operation. The PC operating system cannot interfere with these time critical processes. All connections are supervised by a watchdog, and disconnection of any of the cables to the measurement server will automatically disarm the robot and disable all program-controlled robot movements. Furthermore, the measurement server is equipped with an expansion port which is reserved for future applications. Please note that this expansion port does not have a standardized pinout, and therefore only devices provided by SPEAG can be connected. Devices from any other supplier could seriously damage the measurement server.

Picture C.7 Server for DASY 4

Picture C.8 Server for DASY 5

C.4.4 Device Holder for Phantom

The SAR in the phantom is approximately inversely proportional to the square of the distance between the source and the liquid surface. For a source at 5mm distance, a positioning uncertainty of ±0.5mm would produce a SAR uncertainty of ±20%. Accurate device positioning is therefore crucial for accurate and repeatable measurements. The positions in which the devices must be measured are defined by the standards.

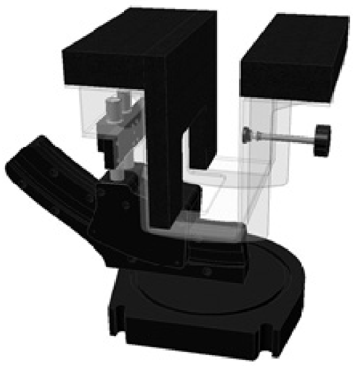
The DASY device holder is designed to cope with the different positions given in the standard. It has two scales for device rotation (with respect to the body axis) and device inclination (with respect to the line between the ear reference points). The rotation centers for both scales is the ear reference point (ERP). Thus the device needs no repositioning when changing the angles.

The DASY device holder is constructed of low-loss POM material having the following dielectric parameters: relative permittivity ε =3 and loss tangent δ =0.02. The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.

<Laptop Extension Kit>

The extension is lightweight and made of POM, acrylic glass and foam. It fits easily on the upper part of the Mounting Device in place of the phone positioner. The extension is fully compatible with the Twin-SAM and ELI phantoms.

Picture C.9-1: Device Holder



Picture C.9-2: Laptop Extension Kit

C.4.5 Phantom

The SAM Twin Phantom V4.0 is constructed of a fiberglass shell integrated in a table. The shape of the shell is based on data from an anatomical study designed to

Represent the 90th percentile of the population. The phantom enables the dissymmetric evaluation of SAR for both left and right handed handset usage, as well as body-worn usage using the flat phantom region. 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. The shell phantom has a 2mm shell thickness (except the ear region where shell thickness increases to 6 mm).

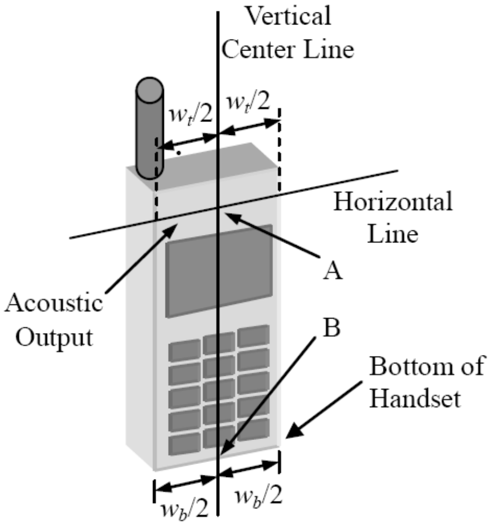
Shell Thickness: 2 ± 0. 2 mm
Filling Volume: Approx. 25 liters
Dimensions: 810 x l000 x 500 mm (H x L x W)
Available: Special

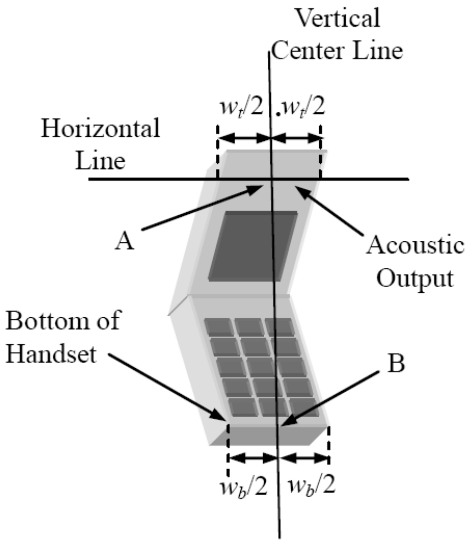
Picture C.10: SAM Twin Phantom

ANNEX D Position of the wireless device in relation to the phantom

D.1 General considerations

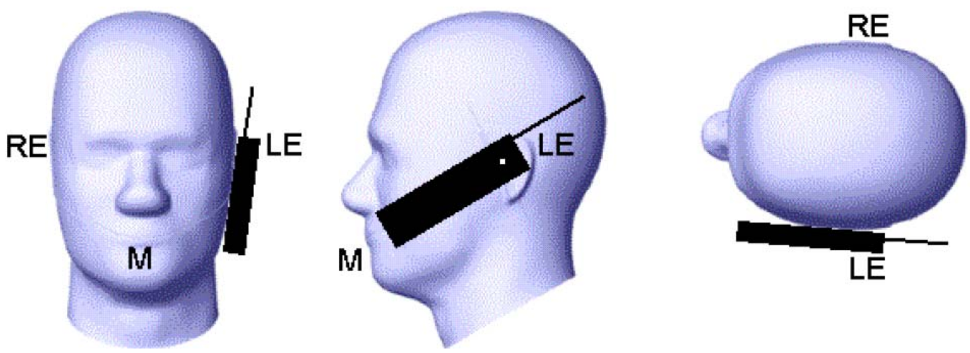
This standard specifies two handset test positions against the head phantom – the “cheek” position and the “tilt” position.





w_t	Width of the handset at the level of the acoustic
w_b	Width of the bottom of the handset
A	Midpoint of the width w_t of the handset at the level of the acoustic output
B	Midpoint of the width w_b of the bottom of the handset

Picture D.1-a Typical “fixed” case handset **Picture D.1-b Typical “clam-shell” case handset**



Picture D.2 Cheek position of the wireless device on the left side of SAM