
	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>1(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

## APPENDIX D: PROBE & DIPOLE CALIBRATION DATA

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>2(49)</b>
	Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>

**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  
 Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)  
 The Swiss Accreditation Service is one of the signatories to the EA  
 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **RTS (RIM Testing Services)**

Certificate No: **ES3-3225\_Jan12**

## CALIBRATION CERTIFICATE

Object: **ES3DV3 + SN:3225**

Calibration procedure(s): **QA CAL-01.v8, QA CAL-23.v4, QA CAL-25.v4**  
**Calibration procedure for dosimetric E-field probes**



Calibration date: **January 11, 2012**

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 E4419B	GB41293874	31-Mar-11 (No. 217-01372)	Apr-12
Power sensor E4412A	MY41498087	31-Mar-11 (No. 217-01372)	Apr-12
Reference 3 dB Attenuator	SN: S5054 (3c)	29-Mar-11 (No. 217-01369)	Apr-12
Reference 20 dB Attenuator	SN: S5086 (20b)	29-Mar-11 (No. 217-01367)	Apr-12
Reference 30 dB Attenuator	SN: S5129 (30b)	29-Mar-11 (No. 217-01370)	Apr-12
Reference Probe ES3DV2	SN: 3013	29-Dec-11 (No. ES3-3013_Dec11)	Dec-12
DAE4	SN: 654	3-May-11 (No. DAE4-654_May11)	May-12
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-11)	In house check: Apr-13
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-11)	In house check: Oct-12

Calibrated by:	Name <b>Jeton Kastrati</b>	Function <b>Laboratory Technician</b>	Signature 
Approved by:	Name <b>Katja Pokovic</b>	Function <b>Technical Manager</b>	Signature 
Issued: January 12, 2012			
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			

Certificate No: ES3-3225\_Jan12

Page 1 of 11

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>				Page <b>3(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	

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#### Glossary:


TSL	tissue simulating liquid
NORM <sub>x,y,z</sub>	sensitivity in free space
ConvF	sensitivity in TSL / NORM <sub>x,y,z</sub>
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C	modulation dependent linearization parameters
Polarization $\varphi$	$\varphi$ rotation around probe axis
Polarization $\vartheta$	$\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\vartheta = 0$ is normal to probe axis

#### Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

#### Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>**: Assessed for E-field polarization  $\vartheta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not affect the E<sup>2</sup>-field uncertainty inside TSL (see below ConvF).
- NORM(f)<sub>x,y,z</sub>** = NORM<sub>x,y,z</sub> \* frequency\_response (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- DCP<sub>x,y,z</sub>**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- A<sub>x,y,z</sub>; B<sub>x,y,z</sub>; C<sub>x,y,z</sub>; VR<sub>x,y,z</sub>**: A, B, C are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters**: Assessed in flat phantom using E-field (or Temperature Transfer Standard for  $f \leq 800$  MHz) and inside waveguide using analytical field distributions based on power measurements for  $f > 800$  MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM<sub>x,y,z</sub> \* ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from  $\pm 50$  MHz to  $\pm 100$  MHz.
- Spherical isotropy (3D deviation from isotropy)**: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>				Page <b>4(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	

ES3DV3 – SN:3225


January 11, 2012

# Probe ES3DV3

## SN:3225

Manufactured: September 1, 2009  
Calibrated: January 11, 2012

Calibrated for DASY/EASY Systems  
(Note: non-compatible with DASY2 system!)

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>5(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

ES3DV3– SN:3225

January 11, 2012

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3225

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu\text{V}/(\text{V/m})^2$ ) <sup>A</sup>	1.26	1.20	1.30	± 10.1 %
DCP (mV) <sup>B</sup>	101.2	100.8	101.2	

### Modulation Calibration Parameters


UID	Communication System Name	PAR		A dB	B dB	C dB	VR mV	Unc <sup>E</sup> (k=2)
10000	CW	0.00	X	0.00	0.00	1.00	107.7	±1.7 %
			Y	0.00	0.00	1.00	113.4	
			Z	0.00	0.00	1.00	110.4	

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%.

<sup>A</sup> The uncertainties of NormX,Y,Z do not affect the E<sup>2</sup>-field uncertainty inside TSL (see Pages 5 and 6).

<sup>B</sup> Numerical linearization parameter: uncertainty not required.

<sup>E</sup> Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

	Document			Page	
	Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report			6(49)	
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	

ES3DV3– SN:3225

January 11, 2012

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3225


### Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (mm)	Unct. (k=2)
750	41.9	0.89	6.42	6.42	6.42	0.27	2.04	± 12.0 %
900	41.5	0.97	6.06	6.06	6.06	0.35	1.74	± 12.0 %
1810	40.0	1.40	5.23	5.23	5.23	0.73	1.21	± 12.0 %
1950	40.0	1.40	4.98	4.98	4.98	0.58	1.41	± 12.0 %
2450	39.2	1.80	4.50	4.50	4.50	0.79	1.26	± 12.0 %
2600	39.0	1.96	4.32	4.32	4.32	0.77	1.32	± 12.0 %

<sup>C</sup> Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

<sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.



	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>7(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

ES3DV3– SN:3225

January 11, 2012


## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3225

### Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) <sup>c</sup>	Relative Permittivity <sup>f</sup>	Conductivity (S/m) <sup>f</sup>	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (mm)	Unct. (k=2)
750	55.5	0.96	6.27	6.27	6.27	0.36	1.74	± 12.0 %
900	55.0	1.05	6.07	6.07	6.07	0.29	2.02	± 12.0 %
1810	53.3	1.52	4.92	4.92	4.92	0.50	1.57	± 12.0 %
1950	53.3	1.52	4.87	4.87	4.87	0.59	1.49	± 12.0 %
2450	52.7	1.95	4.30	4.30	4.30	0.68	1.16	± 12.0 %
2600	52.5	2.16	4.12	4.12	4.12	0.80	0.99	± 12.0 %

<sup>c</sup> Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

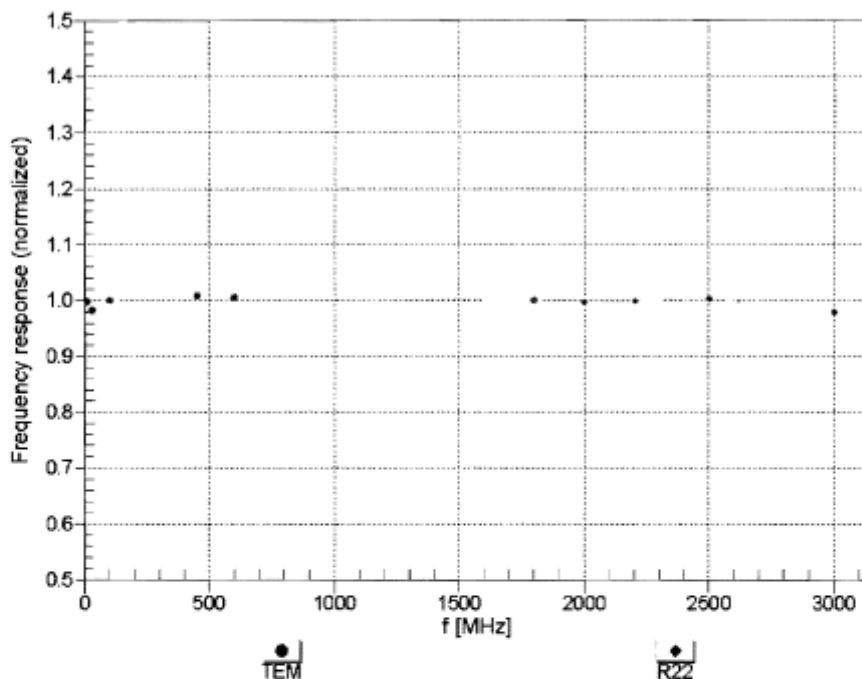
<sup>f</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>8(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

ES3DV3–SN:3225


January 11, 2012

## Frequency Response of E-Field (TEM-Cell: ifi110 EXX, Waveguide: R22)



Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)



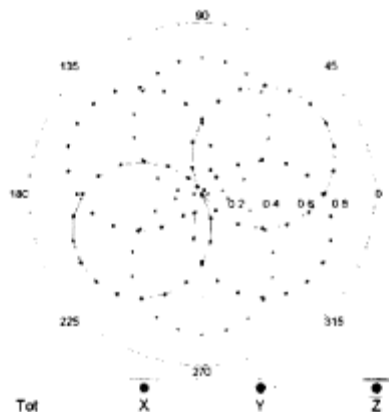
	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>9(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

ES3DV3– SN:3225

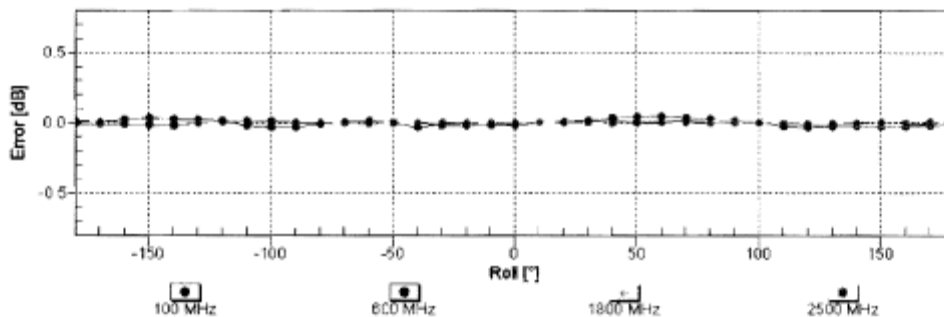
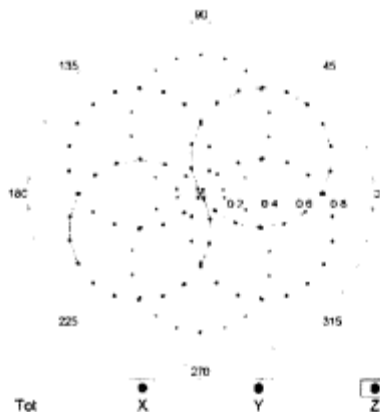
January 11, 2012


## Receiving Pattern ( $\phi$ ), $\theta = 0^\circ$

f=600 MHz,TEM



f=1800 MHz,R22

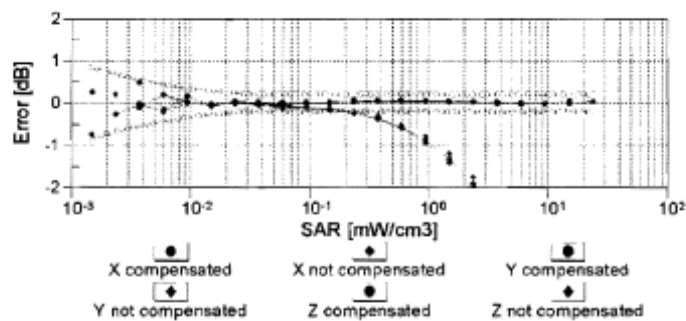
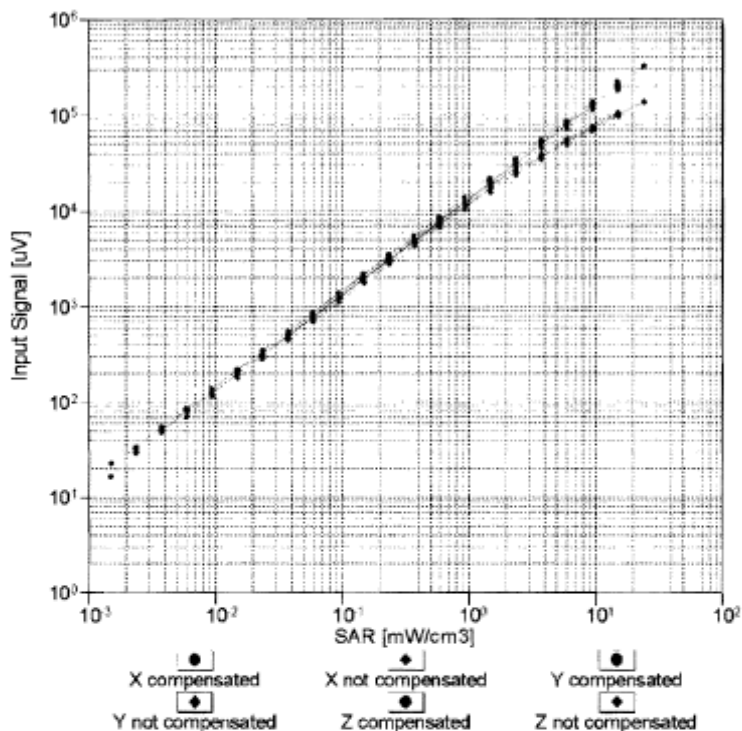

Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  (k=2)

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>10(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>


ES3DV3- SN:3225

January 11, 2012

## Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell , $f = 900 \text{ MHz}$ )



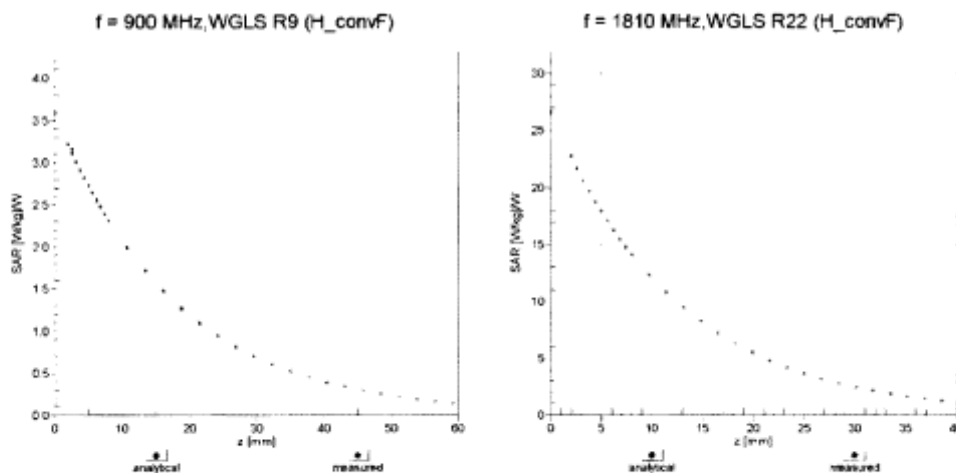
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>11(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

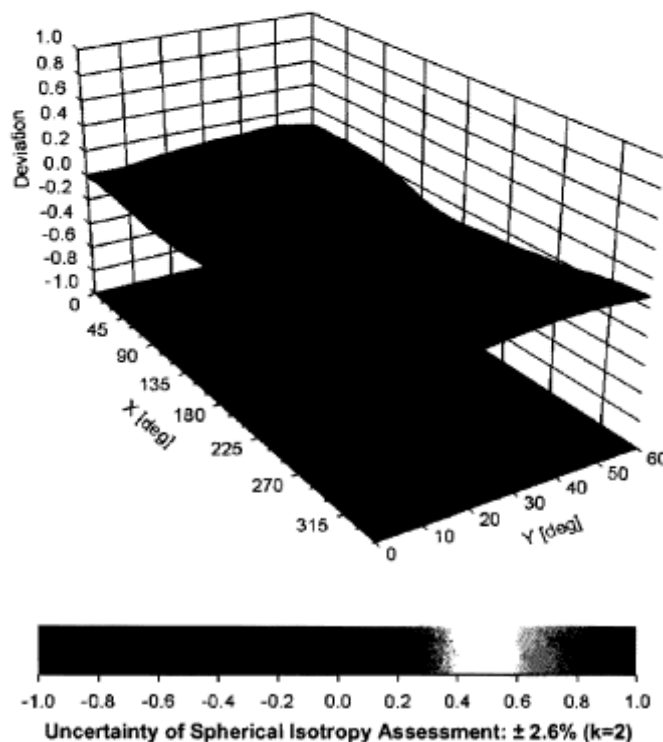
ES3DV3– SN:3225


January 11, 2012

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid Error ( $\phi$ , $\theta$ ), f = 900 MHz



	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>				Page <b>12(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	


ES3DV3– SN:3225

January 11, 2012

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3225

### Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	Not applicable
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	10 mm
Tip Diameter	4 mm
Probe Tip to Sensor X Calibration Point	2 mm
Probe Tip to Sensor Y Calibration Point	2 mm
Probe Tip to Sensor Z Calibration Point	2 mm
Recommended Measurement Distance from Surface	3 mm

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>13(49)</b>
	Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>

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Accreditation No.: **SCS 108**

Client **RTS (RIM Testing Services)**

Certificate No: **EX3-3592\_Nov11**

## CALIBRATION CERTIFICATE



Object **EX3DV4 - SN:3592**  
  
Calibration procedure(s) **QA CAL-01.v8, QA CAL-14.v3, QA CAL-23.v4, QA CAL-25.v4**  
**Calibration procedure for dosimetric E-field probes**  
  
Calibration date: **November 16, 2011**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
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Calibrated by:	Name <b>Jeton Kastrati</b>	Function <b>Laboratory Technician</b>	Signature 
Approved by:	Name <b>Katja Pokovic</b>	Technical Manager	


Issued: November 16, 2011

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Certificate No: EX3-3592\_Nov11

Page 1 of 11



	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>				Page <b>14(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	

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	Document			Page
	Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report			15(49)
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

EX3DV4 – SN:3592

November 16, 2011


# Probe EX3DV4

## SN:3592

Manufactured: September 18, 2006  
Calibrated: November 16, 2011

Calibrated for DASY/EASY Systems  
(Note: non-compatible with DASY2 system!)



	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>16(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

EX3DV4– SN:3592

November 16, 2011

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3592

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu V/(V/m)^2$ ) <sup>A</sup>	0.48	0.48	0.41	± 10.1 %
DCP (mV) <sup>B</sup>	95.2	95.3	98.7	

### Modulation Calibration Parameters


UID	Communication System Name	PAR		A dB	B dB	C dB	VR mV	Unc <sup>C</sup> (k=2)
10000	CW	0.00	X	0.00	0.00	1.00	117.9	±2.7 %
			Y	0.00	0.00	1.00	101.0	
			Z	0.00	0.00	1.00	104.3	

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%.

<sup>A</sup> The uncertainties of NormX,Y,Z do not affect the E<sup>2</sup>-field uncertainty inside TSL (see Pages 5 and 6).

<sup>B</sup> Numerical linearization parameter: uncertainty not required.

<sup>C</sup> Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

	Document			Page	
	Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report			17(49)	
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	

EX3DV4– SN:3592

November 16, 2011


## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3592

### Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) <sup>c</sup>	Relative Permittivity <sup>f</sup>	Conductivity (S/m) <sup>f</sup>	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (mm)	Unct. (k=2)
5200	36.0	4.66	4.89	4.89	4.89	0.33	1.80	± 13.1 %
5500	35.6	4.96	4.38	4.38	4.38	0.38	1.80	± 13.1 %
5800	35.3	5.27	4.17	4.17	4.17	0.40	1.80	± 13.1 %

<sup>c</sup> Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

<sup>f</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>18(49)</b>	
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	

EX3DV4– SN:3592

November 16, 2011


## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3592

### Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) <sup>c</sup>	Relative Permittivity <sup>f</sup>	Conductivity (S/m) <sup>f</sup>	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (mm)	Unct. (k=2)
5200	49.0	5.30	4.05	4.05	4.05	0.50	1.90	± 13.1 %
5500	48.6	5.65	3.62	3.62	3.62	0.55	1.90	± 13.1 %
5800	48.2	6.00	3.54	3.54	3.54	0.60	1.90	± 13.1 %

<sup>c</sup> Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

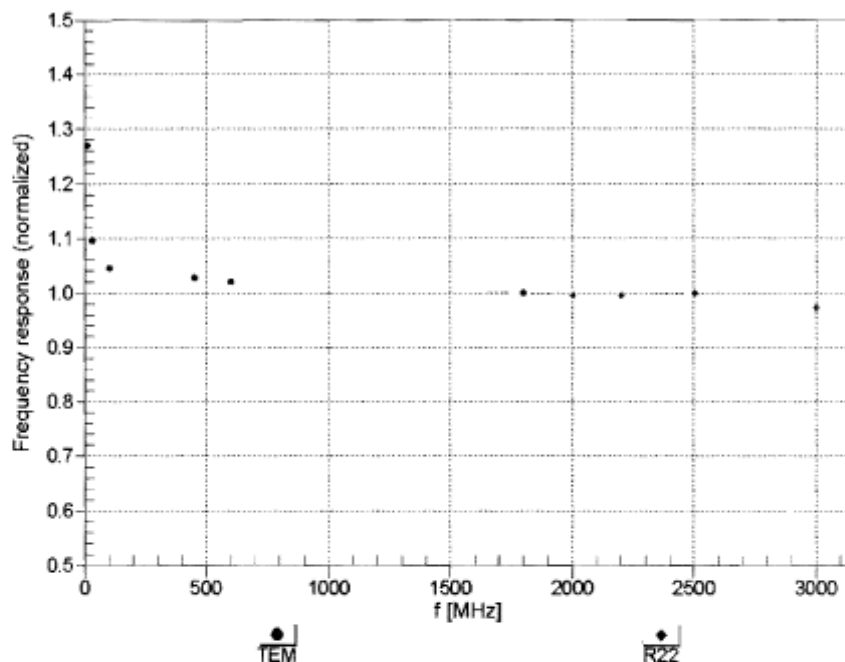
<sup>f</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>19(49)</b>	
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	


EX3DV4– SN:3592

November 16, 2011

## Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)



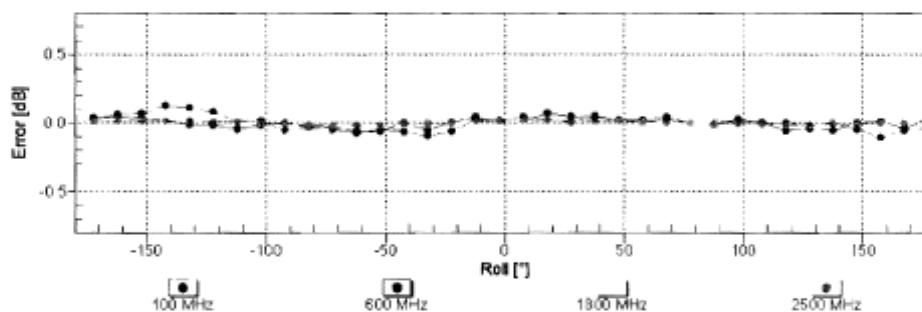
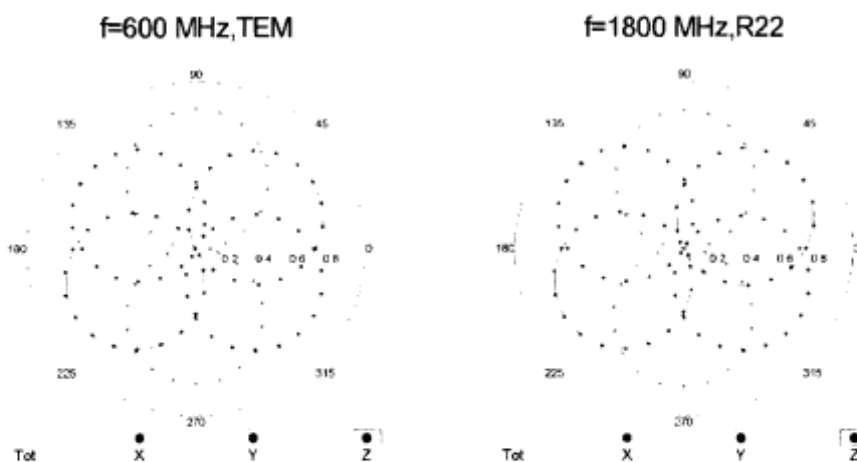
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>20(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>


EX3DV4– SN:3592

November 16, 2011

## Receiving Pattern ( $\phi$ ), $\theta = 0^\circ$



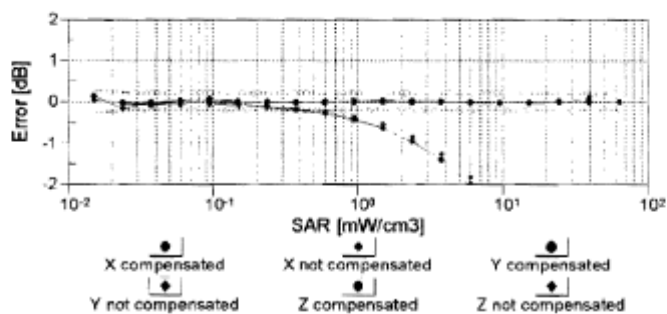
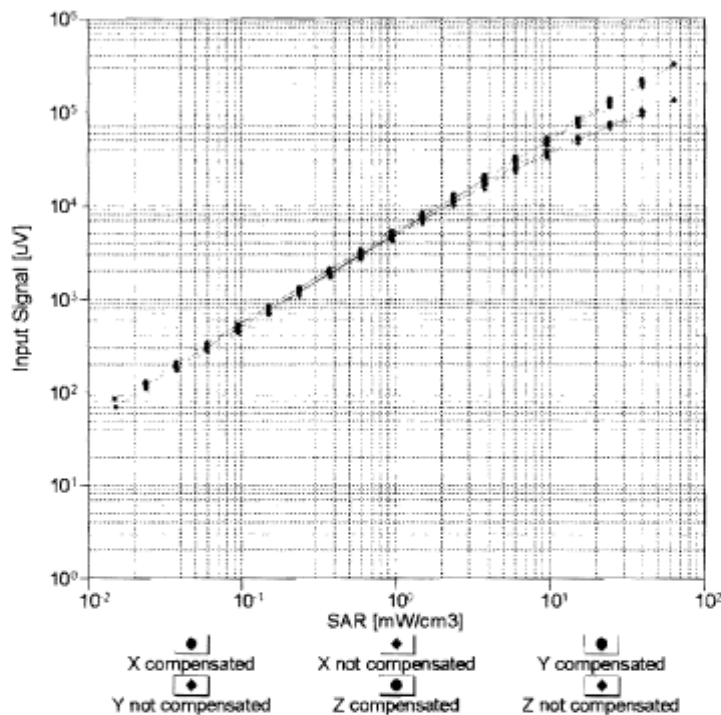
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>21(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>


EX3DV4– SN:3592

November 16, 2011

### Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell , $f = 900 \text{ MHz}$ )



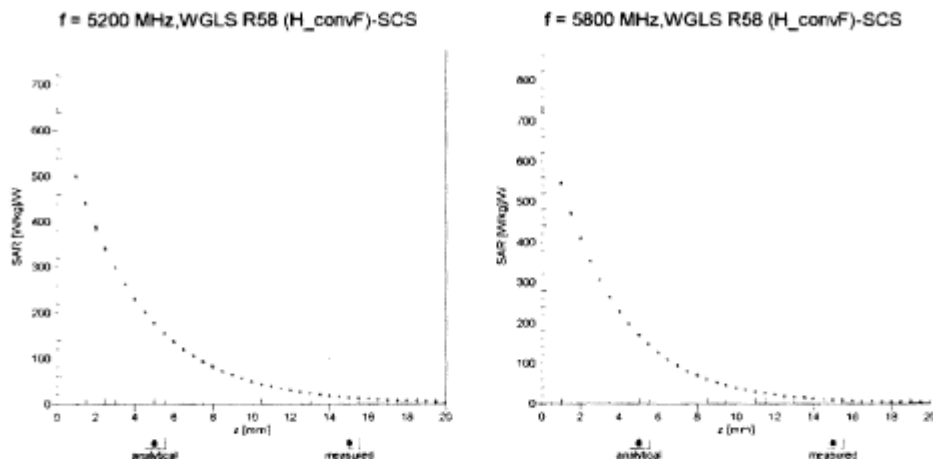
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>22(49)</b>	
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	

EX3DV4– SN:3592

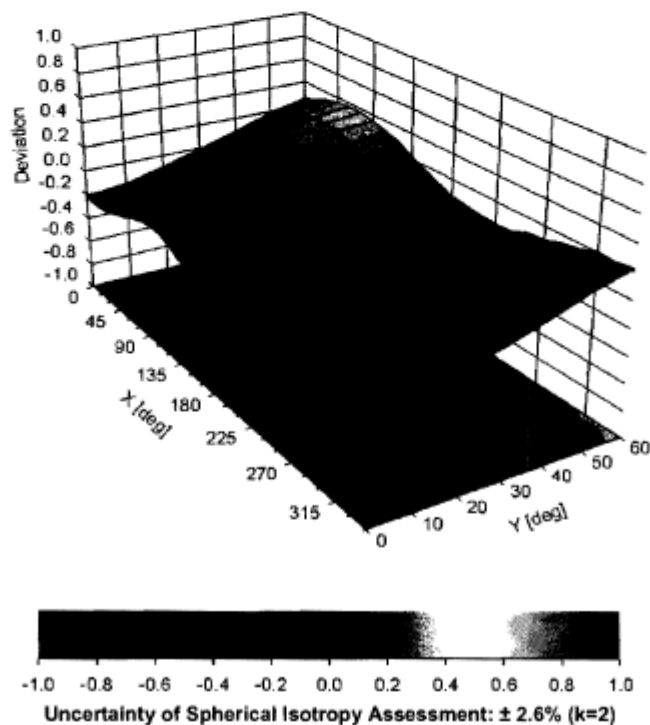
November 16, 2011

## Conversion Factor Assessment




## Deviation from Isotropy in Liquid

Error ( $\phi$ ,  $\theta$ ),  $f = 900 \text{ MHz}$





	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>				Page <b>23(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	


EX3DV4– SN:3592

November 16, 2011

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3592

### Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	Not applicable
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	2 mm

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>24(49)</b>
	Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>

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**S** Schweizerischer Kalibrierdienst  
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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **RTS (RIM Testing Services)**

Certificate No: **D835V2-446\_Jan11**

## CALIBRATION CERTIFICATE

Object **D835V2 - SN: 446**  
  
 Calibration procedure(s) **QA CAL-05.v8**  
**Calibration procedure for dipole validation kits**  
  
 Calibration date: **January 21, 2011**

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.

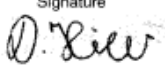
All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	06-Oct-10 (No. 217-01266)	Oct-11
Power sensor HP 8481A	US37292783	06-Oct-10 (No. 217-01266)	Oct-11
Reference 20 dB Attenuator	SN: 5086 (20g)	30-Mar-10 (No. 217-01158)	Mar-11
Type-N mismatch combination	SN: 5047.2 / 06327	30-Mar-10 (No. 217-01162)	Mar-11
Reference Probe ES3DV3	SN: 3205	30-Apr-10 (No. ES3-3205_Apr10)	Apr-11
DAE4	SN: 601	10-Jun-10 (No. DAE4-601_Jun10)	Jun-11
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power sensor HP 8481A	MY41092317	18-Oct-02 (in house check Oct-09)	In house check: Oct-11
RF generator R&S SMT-06	100005	4-Aug-99 (in house check Oct-09)	In house check: Oct-11
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-10)	In house check: Oct-11

Calibrated by: **Dimce Iliev** Function **Laboratory Technician**

Approved by: **Katja Pokovic** Technical Manager


Signature  
  


Issued: January 21, 2011

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Certificate No: D835V2-446\_Jan11

Page 1 of 6

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>				Page <b>25(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

#### 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 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

#### 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.

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>26(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

### Measurement Conditions

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

<b>DASY Version</b>	DASY5	V52.6
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom V4.9	
<b>Distance Dipole Center - TSL</b>	15 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5 mm	
<b>Frequency</b>	835 MHz ± 1 MHz	

### Head TSL parameters


The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	41.5	0.90 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	41.3 ± 6 %	0.89 mho/m ± 6 %
<b>Head TSL temperature during test</b>	(21.8 ± 0.2) °C	----	----

### SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	2.39 mW / g
SAR normalized	normalized to 1W	9.56 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	<b>9.63 mW /g ± 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	1.56 mW / g
SAR normalized	normalized to 1W	6.24 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	<b>6.27 mW /g ± 16.5 % (k=2)</b>

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>27(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

## Appendix

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.6 $\Omega$ - 7.7 j $\Omega$
Return Loss	- 22.2 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.386 ns
----------------------------------	----------


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.

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
Manufactured on	October 24, 2001

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>28(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

## DASY5 Validation Report for Head TSL

Date/Time: 21.01.2011 10:18:05

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:446**

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

Medium: HSL900

Medium parameters used:  $f = 835 \text{ MHz}$ ;  $\sigma = 0.89 \text{ mho/m}$ ;  $\epsilon_r = 41.2$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.03, 6.03, 6.03); Calibrated: 30.04.2010
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 10.06.2010
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- Measurement SW: DASY52, V52.6.1 Build (408)
- Postprocessing SW: SEMCAD X, V14.4.2 Build (2595)

**Pin=250 mW /d=15mm, dist=3.0mm (ES-Probe)/Zoom Scan (7x7x7) /Cube 0: Measurement**

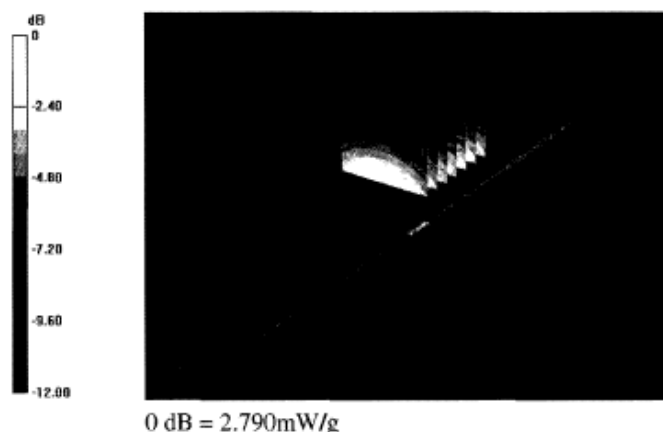
grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 57.426 V/m; Power Drift = 0.04 dB


Peak SAR (extrapolated) = 3.600 W/kg

**SAR(1 g) = 2.39 mW/g; SAR(10 g) = 1.56 mW/g**

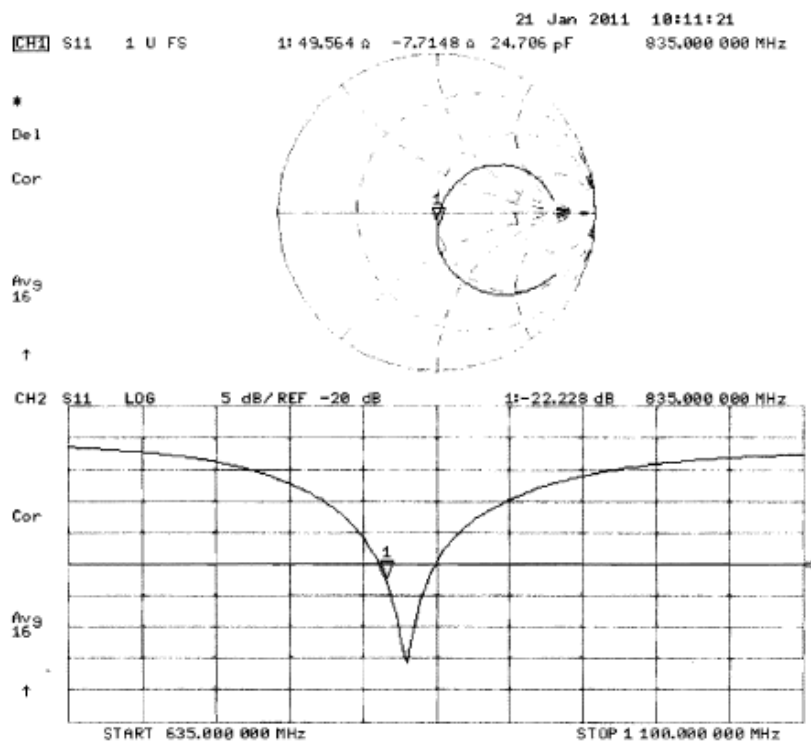
Maximum value of SAR (measured) = 2.790 mW/g






	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>29(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

### Impedance Measurement Plot for Head TSL





	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>30(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **RTS (RIM Testing Services)**

Certificate No: **D1900V2-545\_Jan11**

## CALIBRATION CERTIFICATE

Object **D1900V2 - SN: 545**

Calibration procedure(s) **QA CAL-05.v8**  
**Calibration procedure for dipole validation kits**



Calibration date: **January 13, 2011**

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 EPM-442A	GB37480704	06-Oct-10 (No. 217-01266)	Oct-11
Power sensor HP 8481A	US37292783	06-Oct-10 (No. 217-01266)	Oct-11
Reference 20 dB Attenuator	SN: 5086 (20g)	30-Mar-10 (No. 217-01158)	Mar-11
Type-N mismatch combination	SN: 5047.2 / 06327	30-Mar-10 (No. 217-01162)	Mar-11
Reference Probe ES3DV3	SN: 3205	30-Apr-10 (No. ES3-3205_Apr10)	Apr-11
DAE4	SN: 601	10-Jun-10 (No. DAE4-601_Jun10)	Jun-11
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power sensor HP 8481A	MY41092317	18-Oct-02 (in house check Oct-09)	In house check: Oct-11
RF generator R&S SMT-06	100005	4-Aug-99 (in house check Oct-09)	In house check: Oct-11
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-10)	In house check: Oct-11

Calibrated by:	Name <b>Dimitar Iliev</b>	Function <b>Laboratory Technician</b>	Signature 
Approved by:	Name <b>Katja Pokovic</b>	Function <b>Technical Manager</b>	Signature 

Issued: January 14, 2011  
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Certificate No: D1900V2-545\_Jan11

Page 1 of 6

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>				Page <b>31(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	

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Accredited by the Swiss Accreditation Service (SAS)  
The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

#### 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 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

#### 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.

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>32(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

### Measurement Conditions

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

<b>DASY Version</b>	DASY5	V52.6
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom V5.0	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5 mm	
<b>Frequency</b>	1900 MHz ± 1 MHz	

### Head TSL parameters


The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	40.0	1.40 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	38.5 ± 6 %	1.43 mho/m ± 6 %
<b>Head TSL temperature during test</b>	(21.2 ± 0.2) °C	----	----

### SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	10.2 mW / g
SAR normalized	normalized to 1W	40.8 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	<b>40.0 mW /g ± 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	5.26 mW / g
SAR normalized	normalized to 1W	21.0 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	<b>20.8 mW /g ± 16.5 % (k=2)</b>

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>				Page <b>33(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	

## Appendix

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	50.8 $\Omega$ + 1.8 j $\Omega$
Return Loss	- 34.4 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.199 ns
----------------------------------	----------


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.

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
Manufactured on	November 15, 2001

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>34(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

## DASY5 Validation Report for Head TSL

Date/Time: 13.01.2011 14:52:49

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:545**

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

Medium: HSL U12 BB

Medium parameters used:  $f = 1900$  MHz;  $\sigma = 1.43$  mho/m;  $\epsilon_r = 38.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(5.09, 5.09, 5.09); Calibrated: 30.04.2010
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 10.06.2010
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- Measurement SW: DASY52, V52.6.1 Build (408)
- Postprocessing SW: SEMCAD X, V14.4.2 Build (2595)

**Pin=250 mW /d=10mm, dist=3.0mm (ES-Probe)/Zoom Scan (7x7x7) /Cube 0: Measurement**

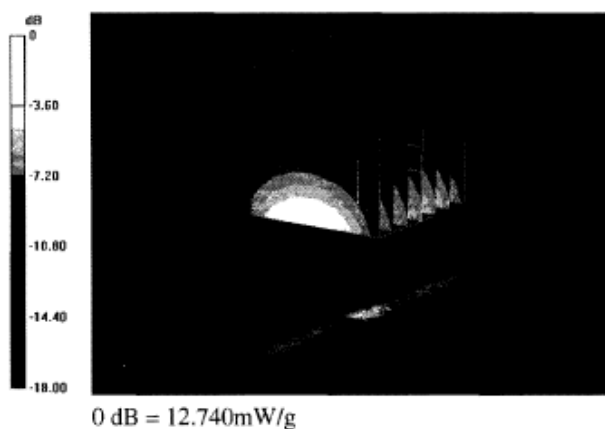
grid: dx=5mm, dy=5mm, dz=5mm


Reference Value = 98.053 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 18.648 W/kg

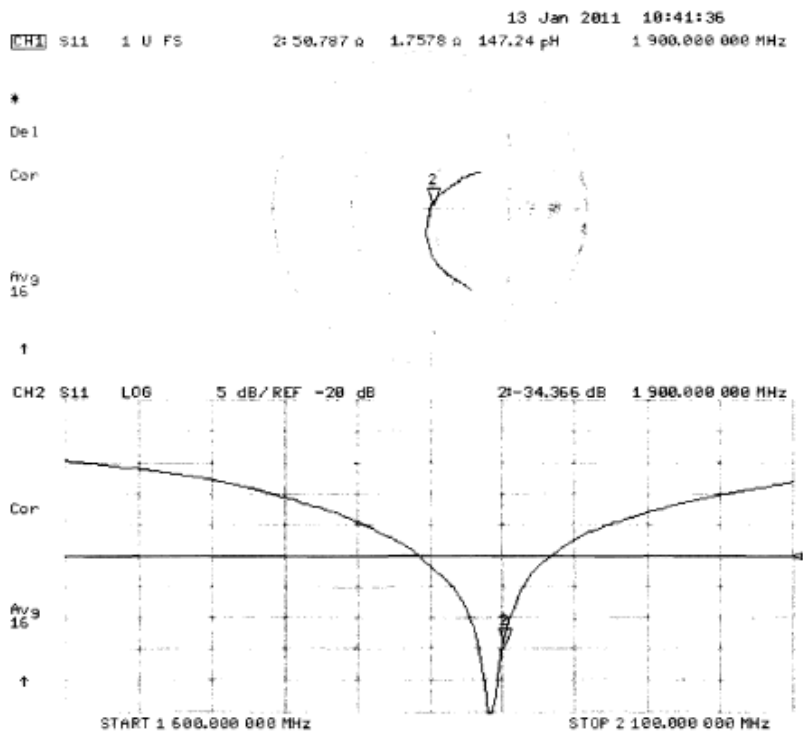
**SAR(1 g) = 10.2 mW/g; SAR(10 g) = 5.26 mW/g**

Maximum value of SAR (measured) = 12.743 mW/g




	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>35(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

### Impedance Measurement Plot for Head TSL





	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>36(49)</b>
	Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>

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**Engineering AG**  
 Zeughausstrasse 43, 8004 Zurich, Switzerland



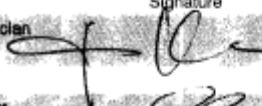
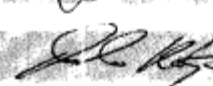
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 The Swiss Accreditation Service is one of the signatories to the EA  
 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **RTS (RIM Testing Services)**


Certificate No: **D2450V2-747\_Nov11**

CALIBRATION CERTIFICATE																																															
Object	<b>D2450V2 - SN: 747</b>																																														
Calibration procedure(s)	<b>QA CAL-05.v8</b> <b>Calibration procedure for dipole validation kits above 700 MHz</b>																																														
Calibration date:	<b>November 09, 2011</b>																																														
<p>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.</p> <p>All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity &lt; 70%.</p> <p>Calibration Equipment used (M&amp;TE critical for calibration)</p> <table border="1"> <thead> <tr> <th>Primary Standards</th> <th>ID #</th> <th>Cal Date (Certificate No.)</th> <th>Scheduled Calibration</th> </tr> </thead> <tbody> <tr> <td>Power meter EPM-442A</td> <td>GB37480704</td> <td>05-Oct-11 (No. 217-01451)</td> <td>Oct-12</td> </tr> <tr> <td>Power sensor HP 8481A</td> <td>US37292783</td> <td>05-Oct-11 (No. 217-01451)</td> <td>Oct-12</td> </tr> <tr> <td>Reference 20 dB Attenuator</td> <td>SN: 5086 (20g)</td> <td>29-Mar-11 (No. 217-01368)</td> <td>Apr-12</td> </tr> <tr> <td>Type-N mismatch combination</td> <td>SN: 5047.2 / 06327</td> <td>29-Mar-11 (No. 217-01371)</td> <td>Apr-12</td> </tr> <tr> <td>Reference Probe ES3DV3</td> <td>SN: 3205</td> <td>29-Apr-11 (No. ES3-3205_Apr11)</td> <td>Apr-12</td> </tr> <tr> <td>DAE4</td> <td>SN: 601</td> <td>04-Jul-11 (No. DAE4-601_Jul11)</td> <td>Jul-12</td> </tr> </tbody> </table> <table border="1"> <thead> <tr> <th>Secondary Standards</th> <th>ID #</th> <th>Check Date (in house)</th> <th>Scheduled Check</th> </tr> </thead> <tbody> <tr> <td>Power sensor HP 8481A</td> <td>MY41092317</td> <td>18-Oct-02 (in house check Oct-11)</td> <td>In house check: Oct-13</td> </tr> <tr> <td>RF generator R&amp;S SMT-06</td> <td>100005</td> <td>04-Aug-99 (in house check Oct-11)</td> <td>In house check: Oct-13</td> </tr> <tr> <td>Network Analyzer HP 8753E</td> <td>US37390585 S4206</td> <td>18-Oct-01 (in house check Oct-11)</td> <td>In house check: Oct-12</td> </tr> </tbody> </table>				Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration	Power meter EPM-442A	GB37480704	05-Oct-11 (No. 217-01451)	Oct-12	Power sensor HP 8481A	US37292783	05-Oct-11 (No. 217-01451)	Oct-12	Reference 20 dB Attenuator	SN: 5086 (20g)	29-Mar-11 (No. 217-01368)	Apr-12	Type-N mismatch combination	SN: 5047.2 / 06327	29-Mar-11 (No. 217-01371)	Apr-12	Reference Probe ES3DV3	SN: 3205	29-Apr-11 (No. ES3-3205_Apr11)	Apr-12	DAE4	SN: 601	04-Jul-11 (No. DAE4-601_Jul11)	Jul-12	Secondary Standards	ID #	Check Date (in house)	Scheduled Check	Power sensor HP 8481A	MY41092317	18-Oct-02 (in house check Oct-11)	In house check: Oct-13	RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-11)	In house check: Oct-13	Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-11)	In house check: Oct-12
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Calibrated by:	Name <b>Jeton Kastrati</b>	Function <b>Laboratory Technician</b>	Signature 																																												
Approved by:	Name <b>Katja Pokovic</b>	Technical Manager 																																													
<p>Issued: November 9, 2011</p> <p>This calibration certificate shall not be reproduced except in full without written approval of the laboratory.</p>																																															

Certificate No: D2450V2-747\_Nov11

Page 1 of 6



	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>				Page <b>37(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	

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Accreditation No.: **SCS 108**

#### 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 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

#### 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.

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>38(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

### Measurement Conditions

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

<b>DASY Version</b>	DASY5	V52.6.2
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5 mm	
<b>Frequency</b>	2450 MHz ± 1 MHz	

### Head TSL parameters


The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	39.2	1.80 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	37.7 ± 6 %	1.84 mho/m ± 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

### SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	13.8 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	<b>54.1 mW /g ± 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	6.39 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	<b>25.3 mW /g ± 16.5 % (k=2)</b>

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>				Page <b>39(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	

## Appendix

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.5 $\Omega$ + 1.3 j $\Omega$
Return Loss	- 31.2 dB

### General Antenna Parameters and Design


Electrical Delay (one direction)	1.161 ns
----------------------------------	----------

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.  
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
Manufactured on	December 01, 2003

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>40(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

## DASY5 Validation Report for Head TSL

Date: 09.11.2011

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 747**

Communication System: CW; Frequency: 2450 MHz

Medium parameters used:  $f = 2450 \text{ MHz}$ ;  $\sigma = 1.84 \text{ mho/m}$ ;  $\epsilon_r = 37.7$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.45, 4.45, 4.45); Calibrated: 29.04.2011
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.07.2011
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.6.2(482); SEMCAD X 14.4.5(3634)

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

Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 102.1 V/m; Power Drift = 0.04 dB


Peak SAR (extrapolated) = 28.853 W/kg

**SAR(1 g) = 13.8 mW/g; SAR(10 g) = 6.39 mW/g**

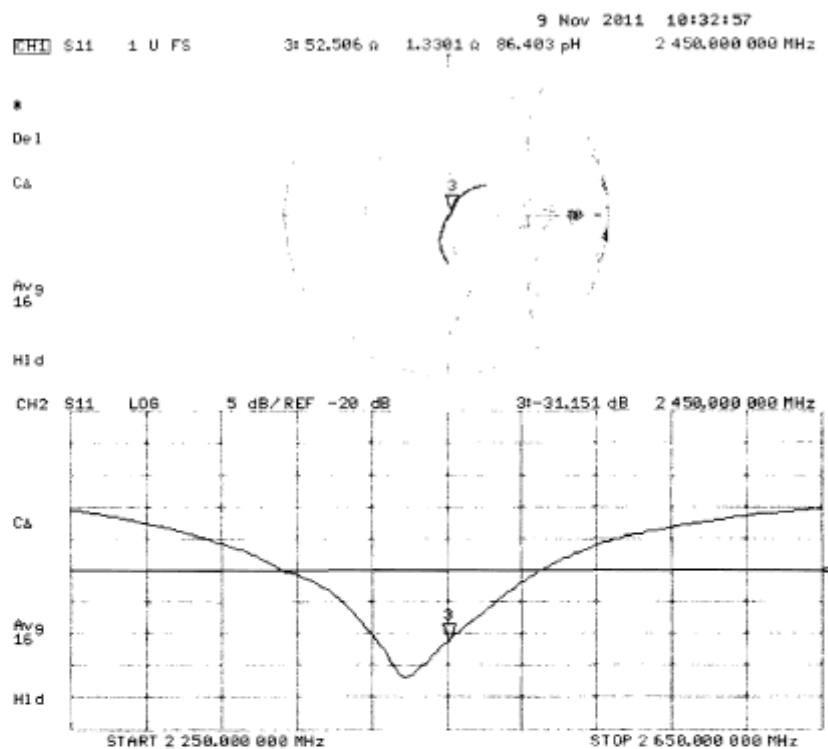
Maximum value of SAR (measured) = 17.782 mW/g




0 dB = 17.780mW/g

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>41(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

### Impedance Measurement Plot for Head TSL



	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>42(49)</b>
	Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>

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Accredited by the Swiss Accreditation Service (SAS)  
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Accreditation No.: **SCS 108**

Client **RTS (RIM Testing Services)**

Certificate No: **D5GHzV2-1033\_Nov11**

## CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN: 1033**

Calibration procedure(s) **QA CAL-22.v1**  
**Calibration procedure for dipole validation kits between 3-6 GHz**

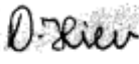

Calibration date: **November 15, 2011**

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 EPM-442A	GB37480704	05-Oct-11 (No. 217-01451)	Oct-12
Power sensor HP B481A	US37292783	05-Oct-11 (No. 217-01451)	Oct-12
Reference 20 dB Attenuator	SN: 5086 (20g)	29-Mar-11 (No. 217-01368)	Apr-12
Type-N mismatch combination	SN: 5047.2 / 06327	29-Mar-11 (No. 217-01371)	Apr-12
Reference Probe EX3DV4	SN: 3503	04-Mar-11 (No. EX3-3503_Mar11)	Mar-12
DAE4	SN: 601	04-Jul-11 (No. DAE4-601_Jul11)	Jul-12
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power sensor HP B481A	MY41092317	18-Oct-02 (in house check Oct-11)	in house check: Oct-13
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-11)	in house check: Oct-13
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-11)	in house check: Oct-12

Calibrated by:	Name <b>Dimce Iliev</b>	Function <b>Laboratory Technician</b>	Signature 
Approved by:	Name <b>Katja Pokovic</b>	Function <b>Technical Manager</b>	


Issued: November 16, 2011

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Certificate No: D5GHzV2-1033\_Nov11

Page 1 of 8



	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>				Page <b>43(49)</b>
	Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

**Calibration Laboratory of**  
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Zeughausstrasse 43, 8004 Zurich, Switzerland



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

Accredited by the Swiss Accreditation Service (SAS)  
The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

#### 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 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65


#### 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.



	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>				Page <b>44(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	

### Measurement Conditions

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

<b>DASY Version</b>	DASY5	V52.6.2
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom V5.0	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
<b>Frequency</b>	5200 MHz ± 1 MHz 5500 MHz ± 1 MHz 5800 MHz ± 1 MHz	

### Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	36.0	4.66 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	34.6 ± 6 %	4.46 mho/m ± 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

### SAR result with Head TSL at 5200 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	100 mW input power	8.16 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	<b>80.8 mW / g ± 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	100 mW input power	2.33 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	<b>23.0 mW / g ± 16.5 % (k=2)</b>

### Head TSL parameters at 5500 MHz


The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	35.6	4.96 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	34.2 ± 6 %	4.75 mho/m ± 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

### SAR result with Head TSL at 5500 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	100 mW input power	8.82 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	<b>87.3 mW / g ± 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	100 mW input power	2.50 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	<b>24.7 mW / g ± 16.5 % (k=2)</b>

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>45(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

### 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	33.7 ± 6 %	5.03 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	****	****

### SAR result with Head TSL at 5800 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	100 mW input power	8.03 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	<b>79.4 mW / g ± 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	100 mW input power	2.28 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	<b>22.5 mW / g ± 16.5 % (k=2)</b>

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>46(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

## Appendix

### Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	51.1 $\Omega$ - 8.7 $\mu\Omega$
Return Loss	- 21.2 dB

### Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	52.3 $\Omega$ - 2.7 $\mu\Omega$
Return Loss	- 29.2 dB

### Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	56.7 $\Omega$ - 4.3 $\mu\Omega$
Return Loss	- 22.6 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.202 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.

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
Manufactured on	July 09, 2004

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>47(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>

## DASY5 Validation Report for Head TSL

Date: 15.11.201

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1033**

Communication System: CW; Frequency: 5200 MHz, Frequency: 5500 MHz, Frequency: 5800 MHz  
Medium parameters used:  $f = 5200$  MHz;  $\sigma = 4.46$  mho/m;  $\epsilon_r = 34.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5500$  MHz;  $\sigma = 4.75$  mho/m;  $\epsilon_r = 34.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5800$  MHz;  $\sigma = 5.03$  mho/m;  $\epsilon_r = 33.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.41, 5.41, 5.41), ConvF(4.91, 4.91, 4.91), ConvF(4.81, 4.81, 4.81); Calibrated: 04.03.2011
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.07.2011
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.6.2(482); SEMCAD X 14.4.5(3634)

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 65.595 V/m; Power Drift = 0.07 dB

Peak SAR (extrapolated) = 30.134 W/kg

**SAR(1 g) = 8.16 mW/g; SAR(10 g) = 2.33 mW/g**

Maximum value of SAR (measured) = 18.725 mW/g

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 66.819 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 35.056 W/kg

**SAR(1 g) = 8.82 mW/g; SAR(10 g) = 2.5 mW/g**

Maximum value of SAR (measured) = 21.019 mW/g


**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

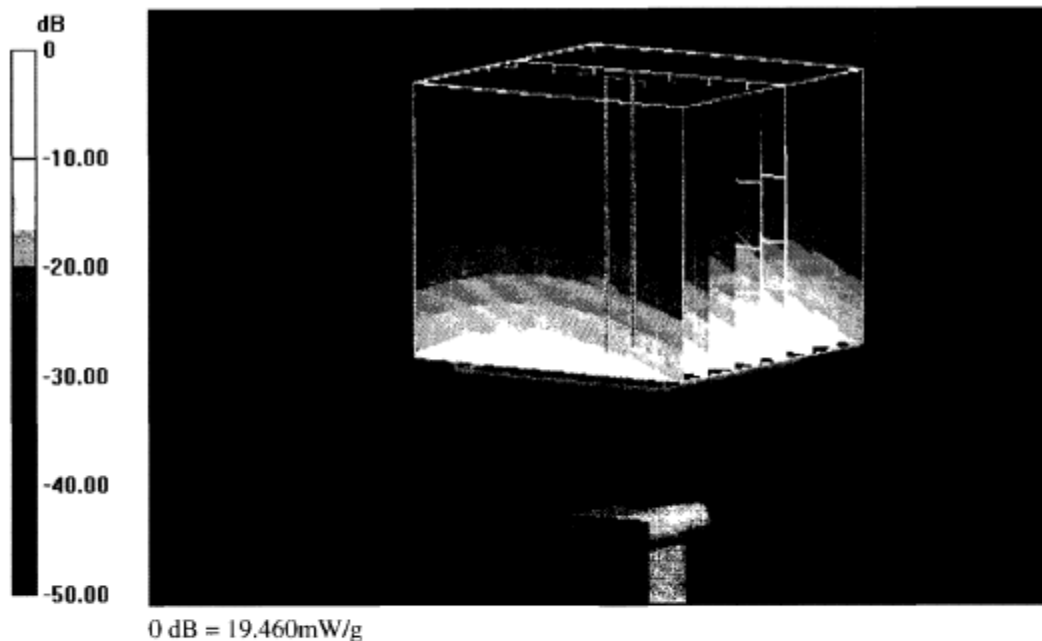
Reference Value = 62.220 V/m; Power Drift = 0.04 dB


Peak SAR (extrapolated) = 33.743 W/kg

**SAR(1 g) = 8.03 mW/g; SAR(10 g) = 2.28 mW/g**

Maximum value of SAR (measured) = 19.463 mW/g

	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>48(49)</b>
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>



	Document <b>Appendix D for the BlackBerry® Smartphone Model RFG81UW SAR Report</b>			Page <b>49(49)</b>	
Author Data <b>Andrew Becker</b>	Dates of Test <b>May 29 – August 16, 2012</b>	Test Report No <b>RTS-6011-1208-28</b>	FCC ID: <b>L6ARFG80UW</b>	IC ID <b>2503A-RFG80UW</b>	

# Impedance Measurement Plot for Head TSL

