FCC OET BULLETIN 65 SUPPLEMENT C 01-01
IEEE Std 1528-2003 and IEEE Std 1528a-2005

SAR EVALUATION REPORT

For
GSM Phone with BT

Model: GT-C3592 and GT-C3590
FCC ID: A3LGTC3592

Report Number: 13I15211-5B
Issue Date: 7/11/2013

Prepared for
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NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
--	6/20/2013	Initial Issue	--
A	6/28/2013	Made the following modifications: 1. Updated RF output powers for GPRS mode & output power tolerance tables 2. Additional testing for Body-worn Accessory for GPRS mode	Kenneth Mak
B	7/11/2013	Made the following modification: 1. Sec. 9.3.& 12.3.: updated Bluetooth maximum tune-up tolerance limit 2. Sec. 14.1.: updated Sum of the SAR tables 3. Updated setup photos of Body-worn accessory exposure conditions.	Kenneth Mak

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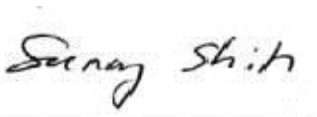
1. Attestation of Test Results

Applicant	Samsung Electronics Co., Ltd.			
DUT description	GSM Phone with BT			
Model	GT-C3592 and GT-C3590			
Test device is	An identical prototype			
Device category	Portable			
Exposure category	General Population/Uncontrolled Exposure			
Date tested	6/8/2013 – 6/9/2013 6/27/2013 (additional testing for body-worn accessory for GPRS mode)			
The highest reported SAR values	RF exposure conditions	Licensed	DTS	UNII
	Head	0.437 W/kg	N/A	N/A
	Body-worn Accessory	0.785 W/kg	N/A	N/A
	Wireless Router (Hotspot)	N/A	N/A	N/A
	Simultaneous Transmission	N/A	N/A	N/A
Applicable Standards	OET Bulletin 65 Supplement C IEEE Std 1528-2003 and IEEE Std 1528a-2005 FCC Published RF exposure KDB procedures, and TCB workshop updates			
Test Results	Pass			

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

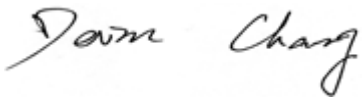
Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government (NIST Handbook 150, Annex A). This report is written to support regulatory compliance of the applicable standards stated above.

Approved & Released By:



Sunny Shih
WiSE Operations Manager
UL Verification Services Inc.

Prepared By:



Devin Chang
WiSE Engineer
UL Verification Services Inc.

2. Test Methodology

The tests documented in this report were performed in accordance with FCC OET Bulletin 65 Supplement C Edition 01-01, IEEE STD 1528-2003, IEEE Std 1528a-2005, the following FCC Published RF exposure KDB procedures and TCB workshop updates:

- 447498 D01 General RF Exposure Guidance v05r01
- 648474 D04 Handsets v01r01
- 941225 D03 SAR Test Reduction GSM GPRS EDGE v01
- 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r01
- 865664 D02 SAR Reporting v01r01
- 690783 D01 SAR Listings on Grants v01r02

3. Facilities and Accreditation

The test sites and measurement facilities used to collect data are located at 47173 Benicia Street, Fremont, California, USA.

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at http://www.ccsemc.com.

4. Calibration and Uncertainty

4.1. Measuring Instrument Calibration

The measuring equipment used to perform the tests documented in this report has been calibrated in accordance with the manufacturers' recommendations, and is traceable to recognized national standards.

Tissue Dielectric Properties

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due date
Network Analyzer	Agilent	8753ES	MY40001647	6/27/2013
Dielectronic Probe kit	SPEAG	DAK-3.5	1087	10/16/2013
Thermometer	TRACEABLE	4242	122529162	9/19/2014
Network Analyzer	Agilent	8753ES	MY40000980	2/20/2014
Dielectronic Probe kit	SPEAG	DAK-3.5	1082	9/18/2013
Thermometer	Control Company	4242	122529163	9/19/2013

System Performance Check

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due date
Synthesized Signal Generator	HP	8665B	3744A01084	3/26/2014
Power Meter	HP	438A	3513U04320	9/24/2013
Power Sensor	HP	8481A	2237A31744	9/24/2013
Power Sensor	HP	8481A	3318A95392	9/24/2013
Amplifier	MITEQ	AMF-4D-00400600-50-30P	1620606	N/A
Directional coupler	Werlatone	C8060-102	2141	N/A
DC Power Supply	HP	6296A	2410A-05117	N/A
Synthesized Signal Generator	HP	8665B	3744A01155	3/6/2014
Power Meter	HP	438A	2822A05684	10/7/2013
Power Sensor	HP	8481A	2702A66876	9/24/2013
Power Sensor	HP	8482A	2349A08568	9/26/2013
Amplifier	MITEQ	AMF-4D-00400600-50-30P	1622052	N/A
Directional coupler	Werlatone	C8060-102	2149	N/A
DC Power Supply	EKNWOOD	PA36-3A	7060074	N/A
System Validation Dipole	SPEAG	D835V2	4d142	10/4/2013
System Validation Dipole	SPEAG	D835V2	4d002	10/24/2013
System Validation Dipole	SPEAG	D1900V2	5d163	10/4/2013
Thermometer	TRACEABLE	4242	122529162	9/19/2013
Thermometer	TRACEABLE	4242	122529163	9/19/2013
E-Field Probe (SAR B)	SPEAG	EX3DV4	3751	11/15/2013
E-Field Probe (SAR D)	SPEAG	EX3DV4	3686	3/11/2014
E-Field Probe (SAR 2)	SPEAG	EX3DV4	3773	4/26/2014
Data Acquisition Electronics (SAR B)	SPEAG	DAE3	427	1/9/2014
Data Acquisition Electronics (SAR D)	SPEAG	DAE4	1257	8/28/2013

Others

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due date
Base Station Simulator	Agilent	8960	GB46160222	11/10/2013
Base Station Simulator	R & S	CMU200	106291	8/8/2013

4.2. Measurement Uncertainty

Measurement uncertainty for 30 MHz to 3 GHz averaged over 1 gram (Head)

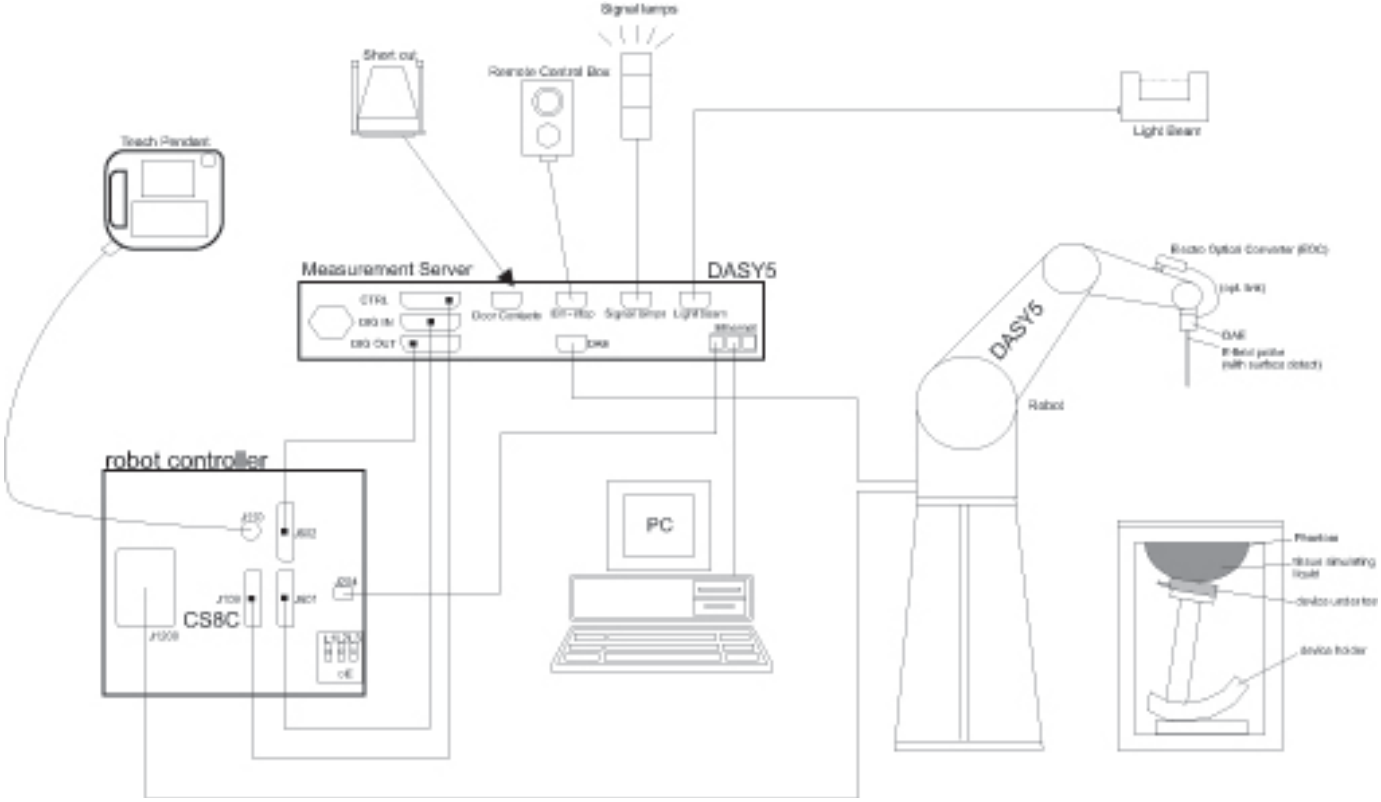
Component	Error, ±%	Prob Dist	Divisor	Sensitivity	U (Xi), %
Measurement System					
Probe Calibration (k=1)	**6.00**	Normal	1	1	6.00
Axial Isotropy	1.15	Rectangular	1.732	0.7	0.46
Hemispherical Isotropy	2.30	Rectangular	1.732	0.7	0.93
Boundary Effect	0.90	Rectangular	1.732	1	0.52
Probe Linearity	3.45	Rectangular	1.732	1	1.99
Modulation Response	2.40	Rectangular	1.732	1	1.39
System Detection Limits	1.00	Rectangular	1.732	1	0.58
Readout Electronics	0.30	Normal	1	1	0.30
Response Time	0.80	Rectangular	1.732	1	0.46
Integration Time	2.60	Rectangular	1.732	1	1.50
RF Ambient Noise	3.00	Rectangular	1.732	1	1.73
RF Ambient Reflections	3.00	Rectangular	1.732	1	1.73
Probe Positioner	0.40	Rectangular	1.732	1	0.23
Probe Positioning	2.90	Rectangular	1.732	1	1.67
Max.SAR Eval.	2.00	Rectangular	1.732	1	1.15
Test Sample Related					
Test Sample Positioning	2.90	Normal	1	1	2.90
Device Holder	3.60	Normal	1	1	3.60
Power Drift	5.00	Rectangular	1.732	1	2.89
Power Scaling	0.00	Rectangular	1.732	1	0.00
Phantom and Setup					
Phantom Uncertainty	6.10	Rectangular	1.732	1	3.52
SAR Correction	1.90	Rectangular	1.732	1	1.10
Liquid Permittivity - measurement	**-2.33**	Rectangular	1.732	0.26	-0.35
Liquid Conductivity - measurement	**3.47**	Rectangular	1.732	0.78	1.56
Liquid Permittivity - temperature uncertainty	0.40	Rectangular	1.732	0.23	0.05
Liquid Conductivity - temperature uncertainty	3.40	Rectangular	1.732	0.78	1.53
				Combined Standard Uncertainty Uc(y) =	10.05
				Expanded Uncertainty U, Coverage Factor = 2, > 95 % Confidence = 20.10	%
				Expanded Uncertainty U, Coverage Factor = 2, > 95 % Confidence = 1.59	dB

Measurement uncertainty for 30 MHz to 6 GHz averaged over 1 gram (Body)

Component	Error, ±%	Prob Dist	Divisor	Sensitivity	U (Xi), %
Measurement System					
Probe Calibration (k=1)	**6.55**	Normal	1	1	6.55
Axial Isotropy	1.15	Rectangular	1.732	0.7	0.46
Hemispherical Isotropy	2.30	Rectangular	1.732	0.7	0.93
Boundary Effect	0.90	Rectangular	1.732	1	0.52
Probe Linearity	3.45	Rectangular	1.732	1	1.99
Modulation Response	2.40	Rectangular	1.732	1	1.39
System Detection Limits	1.00	Rectangular	1.732	1	0.58
Readout Electronics	0.30	Normal	1	1	0.30
Response Time	0.80	Rectangular	1.732	1	0.46
Integration Time	2.60	Rectangular	1.732	1	1.50
RF Ambient Noise	3.00	Rectangular	1.732	1	1.73
RF Ambient Reflections	3.00	Rectangular	1.732	1	1.73
Probe Positioner	0.80	Rectangular	1.732	1	0.46
Probe Positioning	6.70	Rectangular	1.732	1	3.87
Max.SAR Eval.	4.00	Rectangular	1.732	1	2.31
Test Sample Related					
Test Sample Positioning	2.90	Normal	1	1	2.90
Device Holder	3.60	Normal	1	1	3.60
Power Drift	5.00	Rectangular	1.732	1	2.89
Power Scaling	0.00	Rectangular	1.732	1	0.00
Phantom and Setup					
Phantom Uncertainty	7.90	Rectangular	1.732	1	4.56
SAR Correction	1.90	Rectangular	1.732	1	1.10
Liquid Permittivity - measurement	**-3.81**	Rectangular	1.732	0.26	-0.57
Liquid Conductivity - measurement	**4.58**	Rectangular	1.732	0.78	2.06
Liquid Permittivity - temperature uncertainty	0.40	Rectangular	1.732	0.23	0.05
Liquid Conductivity - temperature uncertainty	3.40	Rectangular	1.732	0.78	1.53
				Combined Standard Uncertainty Uc(y) =	11.60
				Expanded Uncertainty U, Coverage Factor = 2, > 95 % Confidence = 23.21	%
				Expanded Uncertainty U, Coverage Factor = 2, > 95 % Confidence = 1.81	dB

5. Measurement System Description and Setup

The DASY5 system used for performing compliance tests consists of the following items:



- A standard high precision 6-axis robot 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 or Win7 and the 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.

6. SAR Measurement Procedure

6.1. Normal SAR Measurement Procedure

Step 1: Power Reference Measurement

The Power Reference Measurement and Power Drift Measurements are for monitoring the power drift of the device under test in the batch process. The minimum distance of probe sensors to surface determines the closest measurement point to phantom surface. The minimum distance of probe sensors to surface is 2.1 mm. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

Step 2: Area Scan

The Area Scan is used as a fast scan in two dimensions to find the area of high field values, before doing a fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASY software can find the maximum locations even in relatively coarse grids. When an Area Scan has measured all reachable points, it computes the field maximal found in the scanned area, within a range of the global maximum. The range (in dB) is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE Standard 1528 and IEC 62209 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan). If only one Zoom Scan follows the Area Scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of Zoom Scans has to be increased accordingly.

Area Scan Parameters extracted from KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r01

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	½·δ·ln(2) ± 0.5 mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location	30° ± 1°	20° ± 1°
Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}	≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 mm
	When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	

Step 3: Zoom Scan

Zoom Scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 g and 10 g of simulated tissue. The Zoom Scan measures points (refer to table below) within a cube whose base faces are centered on the maxima found in a preceding area scan job within the same procedure. When the measurement is done, the Zoom Scan evaluates the averaged SAR for 1 g and 10 g and displays these values next to the job's label.

Zoom Scan Parameters extracted from KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r01

			≤ 3 GHz	> 3 GHz
Maximum zoom scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}			≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm*	3 – 4 GHz: ≤ 5 mm* 4 – 6 GHz: ≤ 4 mm*
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{Zoom}(n)$		≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm
	graded grid	$\Delta z_{Zoom}(1)$: between 1st two points closest to phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 2 mm
		$\Delta z_{Zoom}(n>1)$: between subsequent points	≤ 1.5·$\Delta z_{Zoom}(n-1)$	
Minimum zoom scan volume	x, y, z		≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm

Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.

* When zoom scan is required and the *reported* SAR from the area scan based *1-g SAR estimation* procedures of KDB 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.

Step 4: Power drift measurement

The Power Drift Measurement measures the field at the same location as the most recent power reference measurement within the same procedure, and with the same settings. The Power Drift Measurement gives the field difference in dB from the reading conducted within the last Power Reference Measurement. This allows a user to monitor the power drift of the device under test within a batch process. The measurement procedure is the same as Step 1.

Step 5: Z-Scan (FCC only)

The Z Scan measures points along a vertical straight line. The line runs along the Z-axis of a one-dimensional grid. In order to get a reasonable extrapolation the extrapolated distance should not be larger than the step size in Z-direction.

6.2. Volume Scan Procedures

Step 1: Repeat Step 1-4 in Section 6.1

Step 2: Volume Scan
Volume Scans are used to assess peak SAR and averaged SAR measurements in largely extended 3-dimensional volumes within any phantom. This measurement does not need any previous area scan. The grid can be anchored to a user specific point or to the current probe location.

Step 3: Power drift measurement
The Power Drift Measurement measures the field at the same location as the most recent power reference measurement within the same procedure, and with the same settings. The Power Drift Measurement gives the field difference in dB from the reading conducted within the last Power Reference Measurement. This allows a user to monitor the power drift of the device under test within a batch process. The measurement procedure is the same as Step 1.

7. Device Under Test

7.1. General Information

GSM Phone with BT Model: GT-C3592 and GT-C3590	
Operating Configuration(s)	Held to head, Body-worn (Voice call)
Mobile Hotspot	WiFi Hotspot mode permits the device to share its cellular data connection with other WiFi-enabled devices. ☐ Mobile Hotspot (WiFi 2.4 GHz) ☐ Mobile Hotspot (WiFi 5 GHz)
WiFi Direct	Wi-Fi Direct enabled devices transfer data directly between each other ☐ WiFi Direct (WiFi 2.4 GHz) ☐ WiFi Direct (WiFi 5 GHz)
RF Exposure Condition(s)	☒ Head, ☒ Body-worn Accessory, ☐ Hotspot (Wireless router)
Device Dimensions	Overall (Length x Width): Flip open: 187 mm x 50.83 mm Flip close: 100.57 mm x 50.83 mm Overall Diagonal: 110 mm (Flip close); 190 mm (Flip open); Display Diagonal: 61 mm
Accessory	Headset
Battery Options	☒ Standard – Li-ion battery, 3.7 V, 3.33 Wh ☐ Extended (large capacity)

7.2. Wireless Technologies

Wireless Mode and Frequency Bands	GSM850/GSM1900, Bluetooth 2.4 GHz
Modulation	GSM (GMSK) / GPRS (GMSK) / EGPRS (8PSK), Bluetooth Ver. 3.0
Duty Cycle	GSM Voice: 12.5%; GPRS 1 Slot: 12.5%; 2 Slots: 25%; 3 Slots: 37.5%; 4 Slots: 50%
GPRS Multi-Slot Class	☐ Class 8 - One Up; ☐ Class 10 - Two Up; ☒ Class 12 - Four Up
VoIP (GPRS)	☐ Supported
Mobile Phone Capability	☐ Class A - Mobile phones can be connected to both GPRS and GSM services simultaneously. ☒ Class B - Mobile phones can be attached to both GPRS and GSM services, using one service at a time. ☐ Class C - Mobile phones are attached to either GPRS or GSM voice service. You need to switch manually between services

7.3. Simultaneous Transmission Condition

RF Exposure Condition	Capable Transmit Configurations
Head	N/A
Body-worn Accessory	GSM850/1900 MHz Voice + BT
Wireless Router (Hotspot)	N/A

8. RF Exposure Conditions

Refer to Section 17 “Antenna Locations and Separation Distances” for the specific details of the antenna-to-antenna, antenna-to-edge(s) distances, and device orientation description.

8.1. Head Exposure Conditions

Test Configurations	SAR Required	Note
Left Touch	Yes	
Left Tilt (15°)	Yes	
Right Touch	Yes	
Right Tilt (15°)	Yes	

8.2. Body-worn Accessory Exposure Conditions

Test Configurations	Antenna-to-edge/surface	SAR Required	Note
Rear	1.9 mm	Yes	
Front	2.95 mm	Yes	

9. RF Output Power Measurement

9.1. GSM850

	Min	Max
Tune-up Tolerance (dB):	-1.5	0.5

Output Power Tolerance (dBm)	Voice	GPRS 1 slot	GPRS 2 slots	GPRS 3 slots	GPRS 4 slots
Max	33.0	33.0	31.0	30.0	29.0
Target	32.5	32.5	30.5	29.5	28.5
Min	31.0	31.0	29.0	28.0	27.0

Test Results

GSM (GMSK) - Voice Mode

Band	Ch No.	Freq. (MHz)	Avg burst Pwr (dBm)
850	128	824.2	32.5
	190	836.6	32.6
	251	848.8	32.7

GPRS (GMSK) - Coding Scheme: CS1

Band	Ch No.	Freq. (MHz)	Avg Power (dBm)							
			1 time slot		2 time slots		3 time slots		4 time slots	
			Burst	Frame	Burst	Frame	Burst	Frame	Burst	Frame
850	128	824.2	32.6	23.6	30.4	24.4	29.3	25.0	28.3	25.3
	190	836.6	32.6	23.6	30.6	24.6	29.6	25.3	28.6	25.6
	251	848.8	32.6	23.6	30.8	24.8	29.8	25.5	28.9	25.9

EGPRS (8PSK) - Coding Scheme: MCS5

This mode is Rx only

Notes:

The worst-case configuration and mode for SAR testing is determined to be as follows:

- Head & Body-worn Accessory: GMSK Voice Mode

9.2. GSM1900

	Min	Max
Tune-up Tolerance (dB):	-1.5	0.5

Output Power Tolerance (dBm)	Voice	GPRS 1 slot	GPRS 2 slots	GPRS 3 slots	GPRS 4 slots
Max	30.0	30.0	28.0	27.0	26.0
Target	29.5	29.5	27.5	26.5	25.5
Min	28.0	28.0	26.0	25.0	24.0

Test Results

GSM (GMSK) - Voice Mode

Band	Ch No.	Freq. (MHz)	Avg burst Pwr (dBm)
1900	512	1850.2	30.0
	661	1880.0	29.8
	810	1909.8	29.8

Band	Ch No.	Freq. (MHz)	Avg Power (dBm)							
			1 time slot		2 time slots		3 time slots		4 time slots	
			Burst	Frame	Burst	Frame	Burst	Frame	Burst	Frame
1900	512	1850.2	29.9	20.9	27.7	21.7	26.7	22.4	25.6	22.6
	661	1880.0	29.6	20.6	27.5	21.5	26.4	22.1	25.3	22.3
	810	1909.8	29.8	20.8	27.6	21.6	26.5	22.2	25.4	22.4

EGPRS (8PSK) - Coding Scheme: MCS5

This mode is Rx only

Notes:

The worst-case configuration and mode for SAR testing is determined to be as follows:

- Head & Body-worn Accessory: GMSK Voice Mode

9.3. Bluetooth

Maximum tune-up tolerance limit is 8.0 dBm from the rated nominal maximum output power. This power level qualifies for exclusion of SAR testing.

Refer to Section 12.3.1. Standalone SAR Test Exclusion Considerations

10. Tissue Dielectric Properties

IEEE Std 1528-2003 Table 2

Target Frequency (MHz)	Head	
	ε_r	σ (S/m)
300	45.3	0.87
450	43.5	0.87
835	41.5	0.90
900	41.5	0.97
1450	40.5	1.20
1800 – 2000	40.0	1.40
2450	39.2	1.80
2600	39.0	1.96
3000	38.5	2.40

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Target Frequency (MHz)	Head		Body	
	ε_r	σ (S/m)	ε_r	σ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
835	41.5	0.90	55.2	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800 – 2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5000	36.2	4.45	49.3	5.07
5100	36.1	4.55	49.1	5.18
5200	36.0	4.66	49.0	5.30
5300	35.9	4.76	48.9	5.42
5400	35.8	4.86	48.7	5.53
5500	35.6	4.96	48.6	5.65
5600	35.5	5.07	48.5	5.77
5700	35.4	5.17	48.3	5.88
5800	35.3	5.27	48.2	6.00

10.1. Composition of Ingredients for the Tissue Material Used in the SAR Tests

The following tissue formulations are provided for reference only as some of the parameters have not been thoroughly verified. The composition of ingredients may be modified accordingly to achieve the desired target tissue parameters required for routine SAR evaluation.

Ingredients (% by weight)	Frequency (MHz)									
	450		835		915		1900		2450	
Tissue Type	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body
Water	38.56	51.16	41.45	52.4	41.05	56.0	54.9	40.4	62.7	73.2
Salt (NaCl)	3.95	1.49	1.45	1.4	1.35	0.76	0.18	0.5	0.5	0.04
Sugar	56.32	46.78	56.0	45.0	56.5	41.76	0.0	58.0	0.0	0.0
HEC	0.98	0.52	1.0	1.0	1.0	1.21	0.0	1.0	0.0	0.0
Bactericide	0.19	0.05	0.1	0.1	0.1	0.27	0.0	0.1	0.0	0.0
Triton X-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.8	0.0
DGBE	0.0	0.0	0.0	0.0	0.0	0.0	44.92	0.0	0.0	26.7
Dielectric Constant	43.42	58.0	42.54	56.1	42.0	56.8	39.9	54.0	39.8	52.5
Conductivity (S/m)	0.85	0.83	0.91	0.95	1.0	1.07	1.42	1.45	1.88	1.78

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

10.2. Tissue Dielectric Parameter Check Results

The temperature of the tissue-equivalent medium used during measurement must also be within 18°C to 25°C and within ± 2°C of the temperature when the tissue parameters are characterized.

The dielectric parameters must be measured before the tissue-equivalent medium is used in a series of SAR measurements. The parameters should be re-measured after each 3 – 4 days of use; or earlier if the dielectric parameters can become out of tolerance; for example, when the parameters are marginal at the beginning of the measurement series.

Tissue dielectric parameters were measured at the low, middle and high frequency of each operating frequency range of the test device.

SAR Room B

	Freq. (MHz)	Liquid Parameters			Measured	Target	Delta (%)	Limit ±(%)
6/6/2013	Head 1900	e'	39.1800	Relative Permittivity (ϵ_r):	39.18	40.00	-2.05	5
		e"	13.6300	Conductivity (σ):	1.44	1.40	2.85	5
	Head 1850	e'	39.4900	Relative Permittivity (ϵ_r):	39.49	40.00	-1.28	5
		e"	13.6400	Conductivity (σ):	1.40	1.40	0.22	5
	Head 1910	e'	39.0700	Relative Permittivity (ϵ_r):	39.07	40.00	-2.33	5
		e"	13.6400	Conductivity (σ):	1.45	1.40	3.47	5
6/6/2013	Body 1900	e'	51.4600	Relative Permittivity (ϵ_r):	51.46	53.30	-3.45	5
		e"	14.5400	Conductivity (σ):	1.54	1.52	1.06	5
	Body 1850	e'	51.6000	Relative Permittivity (ϵ_r):	51.60	53.30	-3.19	5
		e"	14.4500	Conductivity (σ):	1.49	1.52	-2.21	5
	Body 1910	e'	51.4100	Relative Permittivity (ϵ_r):	51.41	53.30	-3.55	5
		e"	14.5600	Conductivity (σ):	1.55	1.52	1.73	5

SAR Room D

	Freq. (MHz)	Liquid Parameters			Measured	Target	Delta (%)	Limit ±(%)
6/6/2013	Head 835	e'	41.9300	Relative Permittivity (ϵ_r):	41.93	41.50	1.04	5
		e"	20.0200	Conductivity (σ):	0.93	0.90	3.28	5
	Head 820	e'	42.1100	Relative Permittivity (ϵ_r):	42.11	41.60	1.22	5
		e"	20.0470	Conductivity (σ):	0.91	0.90	1.73	5
	Head 850	e'	41.7300	Relative Permittivity (ϵ_r):	41.73	41.50	0.55	5
		e"	19.9800	Conductivity (σ):	0.94	0.92	3.20	5
6/6/2013	Body 835	e'	54.0600	Relative Permittivity (ϵ_r):	54.06	55.20	-2.07	5
		e"	21.8500	Conductivity (σ):	1.01	0.97	4.58	5
	Body 820	e'	54.1900	Relative Permittivity (ϵ_r):	54.19	55.28	-1.97	5
		e"	21.9100	Conductivity (σ):	1.00	0.97	3.15	5
	Body 850	e'	53.9000	Relative Permittivity (ϵ_r):	53.90	55.16	-2.28	5
		e"	21.7600	Conductivity (σ):	1.03	0.99	4.18	5

SAR Room 2

	Freq. (MHz)	Liquid Parameters			Measured	Target	Delta (%)	Limit ±(%)
6/27/2013	Body 835	e'	53.2700	Relative Permittivity (ϵ_r):	53.27	55.20	-3.50	5
		e"	21.8500	Conductivity (σ):	1.01	0.97	4.58	5
	Body 820	e'	53.4000	Relative Permittivity (ϵ_r):	53.40	55.28	-3.40	5
		e"	21.9400	Conductivity (σ):	1.00	0.97	3.29	5
	Body 850	e'	53.1200	Relative Permittivity (ϵ_r):	53.12	55.16	-3.69	5
		e"	21.7800	Conductivity (σ):	1.03	0.99	4.28	5
6/27/2013	Body 1900	e'	51.3900	Relative Permittivity (ϵ_r):	51.39	53.30	-3.58	5
		e"	14.3700	Conductivity (σ):	1.52	1.52	-0.12	5
	Body 1850	e'	51.6700	Relative Permittivity (ϵ_r):	51.67	53.30	-3.06	5
		e"	14.2600	Conductivity (σ):	1.47	1.52	-3.50	5
	Body 1910	e'	51.2700	Relative Permittivity (ϵ_r):	51.27	53.30	-3.81	5
		e"	14.3600	Conductivity (σ):	1.53	1.52	0.33	5

11. System Performance Check

SAR system verification is required to confirm measurement accuracy, according to the tissue dielectric media, probe calibration points and other system operating parameters required for measuring the SAR of a test device. The system verification must be performed for each frequency band and within the valid range of each probe calibration point required for testing the device. The same SAR probe(s) and tissue-equivalent media combinations used with each specific SAR system for system verification must be used for device testing. When multiple probe calibration points are required to cover substantially large transmission bands, independent system verifications are required for each probe calibration point. A system verification must be performed before each series of SAR measurements using the same probe calibration point and tissue-equivalent medium. Additional system verification should be considered according to the conditions of the tissue-equivalent medium and measured tissue dielectric parameters, typically every three to four days when the liquid parameters are remeasured or sooner when marginal liquid parameters are used at the beginning of a series of measurements.

11.1. System Performance Check Measurement Conditions

- The measurements were performed in the flat section of the TWIN SAM or ELI phantom, shell thickness: 2.0 ±0.2 mm (bottom plate) filled with Body or Head simulating liquid of the following parameters.
- The depth of tissue-equivalent liquid in a phantom must be ≥ 15.0 cm ± 0.5 cm for SAR measurements ≤ 3 GHz and ≥ 10.0 cm ± 0.5 cm for measurements > 3 GHz.
- The DASY system with an E-Field Probe was used for the measurements.
- The dipole was mounted on the small tripod so that the dipole feed point was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10 mm (above 1 GHz) and 15 mm (below 1 GHz) from dipole center to the simulating liquid surface.
- The coarse grid with a grid spacing of 15 mm was aligned with the dipole.
  For 5 GHz band - The coarse grid with a grid spacing of 10 mm was aligned with the dipole.
- Special 7x7x7 (below 3 GHz) and/or 8x8x7 (above 3 GHz) fine cube was chosen for the cube.
- Distance between probe sensors and phantom surface was set to 3 mm.
  For 5 GHz band - Distance between probe sensors and phantom surface was set to 2.5 mm
- The dipole input power (forward power) was 100 mW.
- The results are normalized to 1 W input power.

11.2. Reference SAR Values for System Performance Check

The reference SAR values can be obtained from the calibration certificate of system validation dipoles

System Dipole	Serial No.	Cal. Date	Freq. (MHz)	Target SAR Values (mW/g)		
				1g/10g	Head	Body
D835V2	4d142	10/04/2012	835	1g	9.45	9.5
				10g	6.23	6.29
D1900V2	5d163	10/04/2012	1900	1g	39.4	39.6
				10g	20.7	21.1
D835V2	4d002	10/24/2012	835	1g	9.58	9.48
				10g	6.28	6.26

11.3. System Performance Check Results

The 1-g and 10-g SAR measured with a reference dipole, using the required tissue-equivalent medium at the test frequency, must be within 10% of the manufacturer calibrated dipole SAR target.

SAR Room B

Date Tested	System Dipole		T.S. Liquid		Measured Results			Target (Ref. Value)	Delta ±10 %	Est./Zoom Ratio ±3 %	Plot No.
	Type	Serial #			Area Scan	Zoom Scan	Normalize to 1 W				
6/6/2013	D1900V2	5d163	Head	1g	4.09	3.98	39.80	39.4	1.02	2.69	
				10g	2.11	2.07	20.70	20.7	0.00		
6/6/2013	D1900V2	5d163	Body	1g	4.09	4.06	40.60	39.6	2.53	0.73	1,2
				10g	2.06	2.11	21.10	21.1	0.00		

SAR Room D

Date Tested	System Dipole		T.S. Liquid		Measured Results			Target (Ref. Value)	Delta ±10 %	Est./Zoom Ratio ±3 %	Plot No.
	Type	Serial #			Area Scan	Zoom Scan	Normalize to 1 W				
6/6/2013	D835V2	4d142	Head	1g	0.96	0.98	9.80	9.45	3.70	-1.98	
				10g	0.65	0.64	6.42	6.23	3.05		
6/6/2013	D835V2	4d142	Body	1g	1.03	1.02	10.20	9.50	7.37	0.97	3, 4
				10g	0.70	0.67	6.71	6.29	6.68		

SAR Room 2

Date Tested	System Dipole		T.S. Liquid		Measured Results			Target (Ref. Value)	Delta ±10 %	Est./Zoom Ratio ±3 %	Plot No.
	Type	Serial #			Area Scan	Zoom Scan	Normalize to 1 W				
6/27/2013	D1900V2	5d163	Body	1g	3.99	4.00	40.00	39.6	1.01	-0.25	5,6
				10g	2.00	2.11	21.10	21.1	0.00		
6/27/2013	D835V2	4d002	Body	1g	0.99	0.97	9.72	9.48	2.53	1.82	7,8
				10g	0.66	0.64	6.44	6.26	2.88		

12. SAR Test Results

12.1. Head Exposure Conditions (Measured using Flat Phantom)

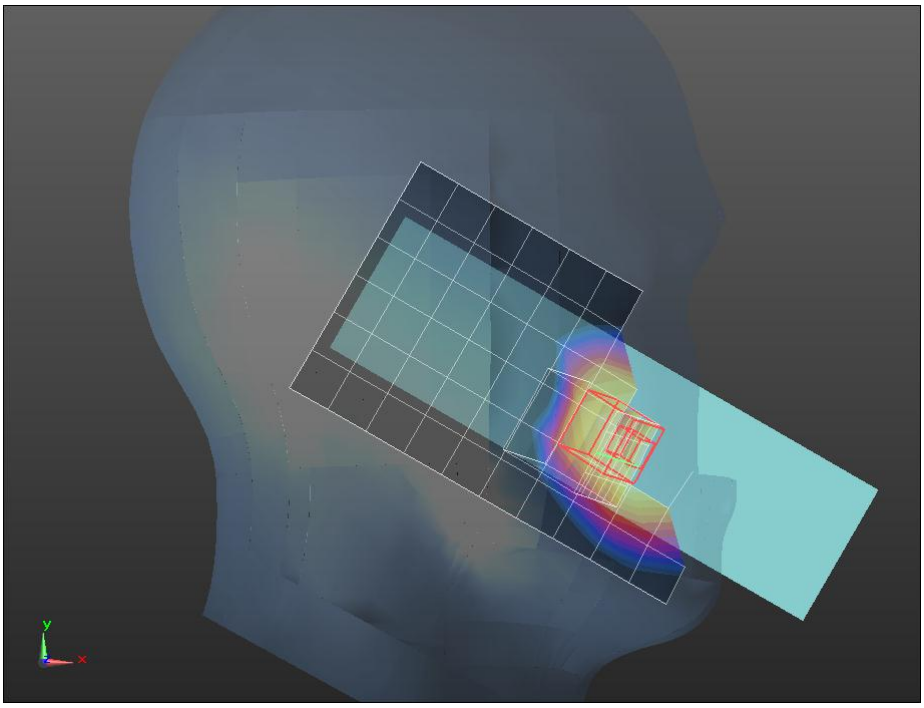
Test Position	Mode	Ch #.	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		Plot No.	Note
				Tune-up limit	Meas.	Meas.	Scaled		
Under Flat Phantom	GSM850 Voice	128	824.2	33.0	32.5				1
		190	836.6	33.0	32.6	0.170	0.186	1	
		251	848.8	33.0	32.7				1
	GSM1900 Voice	512	1850.2	30.0	30.0				1
		661	1880.0	30.0	29.8	0.417	**0.437**	3	
		810	1909.8	30.0	29.8				1

Note(s):

1. Testing of other required channels within the operating mode of a frequency band is not required when the reported 1-g or 10-g SAR for the mid-band or highest output power channel is:
   - ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz
   - ≤ 0.6 W/kg or 1.5 W/kg, for 1-g or 10-g respectively, when the transmission band is between 100 MHz and 200 MHz
   - ≤ 0.4 W/kg or 1.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≥ 200 MHz

12.1.1. Justification for using Flat Phantom Measuring Head SAR

Due to the EUT with antenna located near the bottom and lower side edges near the mouth and jaw regions. The following head SAR plot is provided to show the measurements with truncated SAR distributions in the head measured with the SAM Phantom.



The following procedure was applied (KDB 648474 D04 Handset SAR v01r01):

- The phone was positioned with a separation distance of <4 mm between the ear reference point (ERP) and the outer surface of the flat phantom shell.
- While maintaining this distance at the ERP location of the phone, the low (bottom) edge of the phone is lowered from the phantom to establish the same separation distance at the peak SAR location identified by the truncated partial SAR distribution measured with the SAM phantom.
- The distance from the peak SAR location to the phone should be determined by the straight line passing perpendicularly through the phantom surface.

12.2. Body-worn Accessory Exposure Conditions

GSMK mode

Test Position	Mode	Dist. (mm)	Ch #.	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		Plot No.	Note
					Tune-up limit	Meas.	Meas.	Scaled		
Rear	GSM850 Voice	15	128	824.2	33.0	32.5				1
			190	836.6	33.0	32.6	0.332	**0.364**	2	
			251	848.8	33.0	32.7				1
Front	GSM850 Voice	15	128	824.2	33.0	32.5				1
			190	836.6	33.0	32.6	0.090	0.099		
			251	848.8	33.0	32.7				1
Rear	GSM1900 Voice	15	512	1850.2	30.0	30.0				1
			661	1880.0	30.0	29.8	0.410	**0.429**	4	
			810	1909.8	30.0	29.8				1
Front	GSM1900 Voice	15	512	1850.2	30.0	30.0				1
			661	1880.0	30.0	29.8	0.196	0.205		
			810	1909.8	30.0	29.8				1

GPRS mode

Test Position	Mode	Dist. (mm)	Ch #.	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		Plot No.	Note
					Tune-up limit	Meas.	Meas.	Scaled		
Rear	GSM850 GPRS 4 slots	15	128	824.2	29.0	28.3				1
			190	836.6	29.0	28.6	0.716	**0.785**	5	
			251	848.8	29.0	28.9				1
Front	GSM850 GPRS 4 slots	15	128	824.2	29.0	28.3				1
			190	836.6	29.0	28.6	0.268	0.294		
			251	848.8	29.0	28.9				1
Rear	GSM1900 GPRS 4 slots	15	512	1850.2	26.0	25.6				1
			661	1880.0	26.0	25.3	0.581	**0.683**	6	
			810	1909.8	26.0	25.4				1
Front	GSM1900 GPRS 4 slots	15	512	1850.2	26.0	25.6				1
			661	1880.0	26.0	25.3	0.293	0.344		
			810	1909.8	26.0	25.4				1

Note(s):

1. Testing of other required channels within the operating mode of a frequency band is not required when the reported 1-g or 10-g SAR for the mid-band or highest output power channel is:
   - ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz
   - ≤ 0.6 W/kg or 1.5 W/kg, for 1-g or 10-g respectively, when the transmission band is between 100 MHz and 200 MHz
   - ≤ 0.4 W/kg or 1.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≥ 200 MHz

12.3. Bluetooth

12.3.1. Standalone SAR Test Exclusion Considerations

The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

[(max. power of channel, including tune-up tolerance, mW) / (min. test separation distance, mm)]·[√f(GHz)] ≤ 3.0, for 1-g SAR and ≤ 7.5 for 10-g extremity SAR, where

- $f_{(GHz)}$ is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

Body-worn Accessory Exposure Conditions

Max. tune-up tolerance limit		Min. test separation distance (mm)	Frequency (GHz)	Result
(dBm)	(mW)			
8.0	6	10	2.480	1.0

Conclusion:

The computed value is < 3; therefore, Bluetooth qualifies for Standalone SAR test exclusion.

12.3.2. Estimated SAR

When the standalone SAR test exclusion is applied to an antenna that transmits simultaneously with other antennas, the standalone SAR must be estimated according to following to determine simultaneous transmission SAR test exclusion:

- *(max. power of channel, including tune-up tolerance, mW) / (min. test separation distance, mm)]·[√$f_{(GHz)}$/x]* W/kg for test separation distances ≤ 50 mm;
  where x = 7.5 for 1-g SAR, and x = 18.75 for 10-g SAR.
- 0.4 W/kg for 1-g SAR and 1.0 W/kg for 10-g SAR, when the test separation distances is > 50 mm.

Estimated SAR Result for Body-worn Accessory Conditions:

Test Configuration	Max. tune-up tolerance limit (mW)	Min. test separation distance (mm)	Frequency (GHz)	Estimated 1-g SAR (W/kg)
Rear/Front	6	10	2.480	0.126

13. SAR Measurement Variability

In accordance with published RF Exposure KDB procedure 865664 D01 SAR measurement 100 MHz to 6 GHz v01. These additional measurements are repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device should be returned to ambient conditions (normal room temperature) with the battery fully charged before it is re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

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.

13.1. The Highest Measured SAR Configuration in Each Frequency Band

Head Exposure Condition

Not Applicable. Highest measured SAR is < 0.80 W/kg.

Body-worn Accessory Exposure Condition

Not Applicable. Highest measured SAR is < 0.80 W/kg.

13.2. Repeated Measurement Results

Head Exposure Condition

Not Applicable. Highest measured SAR is < 0.80 W/kg.

Body-worn Accessory Exposure Condition

Not Applicable. Highest measured SAR is < 0.80 W/kg.

Note(s):

1. Second Repeated Measurement is not required since the ratio of the largest to smallest SAR for the original and first repeated measurement is not > 1.20.

14. Simultaneous Transmission SAR Analysis

KDB 447498 D01 General RF Exposure Guidance v05, introduces a new formula for calculating the SAR to Peak Location Ratio (SPLSR) between pairs of simultaneously transmitting antennas:

$$SPLSR = (SAR_1 + SAR_2)^{1.5} / Ri$$

Where:

SAR_1 is the highest measured or estimated SAR for the first of a pair of simultaneous transmitting antennas, in a specific test operating mode and exposure condition

SAR_2 is the highest measured or estimated SAR for the second of a pair of simultaneous transmitting antennas, in the same test operating mode and exposure condition as the first

Ri is the separation distance between the pair of simultaneous transmitting antennas. When the SAR is measured, for both antennas in the pair, it is determined by the actual x, y and z coordinates in the 1-g SAR for each SAR peak location, based on the extrapolated and interpolated result in the zoom scan measurement, using the formula of $[(x_1-x_2)^2 + (y_1-y_2)^2 + (z_1-z_2)^2]$

A new threshold of 0.04 is also introduced in the draft KDB. Thus, in order for a pair of simultaneous transmitting antennas with the sum of 1-g SAR > 1.6 W/kg to qualify for exemption from Simultaneous Transmission SAR measurements, it has to satisfy the condition of:

$$(SAR_1 + SAR_2)^{1.5} / Ri < 0.04$$

14.1. Body-worn Accessory Exposure Conditions

Sum of the SAR for GMSK and Bluetooth

Test Position	Voice		Data	∑ 1-g SAR (mW/g)
	GSM 850	GSM 1900	Bluetooth 2.4 GHz	
Rear	0.364		0.126	0.490
		0.429	0.126	0.555
Front	0.099		0.126	0.225
		0.205	0.126	0.331

Sum of the SAR for GPRS and Bluetooth

Test Position	GPRS		Data	∑ 1-g SAR (mW/g)
	GSM 850	GSM 1900	Bluetooth 2.4 GHz	
Rear	0.785		0.126	0.911
		0.683	0.126	0.809
Front	0.294		0.126	0.420
		0.344	0.126	0.470

SAR to Peak Location Separation Ratio (SPLSR)
As the Sum of the SAR is not greater than 1.6 W/kg SPLSR assessment is not required.

Conclusion:
Simultaneous transmission SAR measurement (Volume Scan) is not required because the either sum of the 1-g SAR is < 1.6 W/kg or the SPLSR is < 0.04 for all circumstances that require SPLSR calculation.

15. Appendixes

Refer to separated files for the following appendixes.

15.1. System Performance Check Plots

15.2. Highest SAR Test Plots

SAR plot is required for the highest measured SAR in each exposure configuration, wireless mode and frequency band combination; for example, WCDMA head SAR at 1900 MHz. Plots are also required when the measured SAR is > 1.5 W/kg for occupational exposure.

15.3. Calibration Certificate for E-Field Probe EX3DV4 - SN 3751

15.4. Calibration Certificate for E-Field Probe EX3DV4 - SN 3686

15.5. Calibration Certificate for E-Field Probe EX3DV4 - SN 3773

15.6. Calibration Certificate for D835V2 - SN 4d142

15.7. Calibration Certificate for D1900V2 - SN 5d163

15.8. Calibration Certificate for D835V2 - SN 4d002