SAR Test Report

FOR:

Manufacturer: Garmin International
Model Name: Nuvi 2598FL
FCC ID: IPH-A2AVGC00
IC ID: 1792A-A2AVGC00

Test Report #: SAR_GARMI_041_12001_FCC

Date of Report: 2012-07-02

LAB CODE 20020328-00

TESTING LABORATORY
Certificate #2135.01

FCC Listed #:
A2LA Accredited

IC Recognized #
3462B-1

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1. Assessment

The following device was tested against the limits for general population uncontrolled exposure specified in FCC 2.1093. The device was tested according to measurement standards and procedures specified in FCC OET Bulletin 65, Supplement C (Edition 01-01) and IEEE 1528:2003, December 19, 2003 and no deviations were ascertained during the course of the tests performed.

Company	Description	Model #
Garmin International	Personal Navigation Device	A2AVGC00

Responsible for Testing Laboratory:

Date	Section	Name	Signature
2012-07-02	Compliance	Sajay Jose (Test Lab Manager)	[signature]

Responsible for the Report:

Date	Section	Name	Signature
2012-07-02	Compliance	Zack Gray (Test Engineer)	Zack Gray I am the author of this document 2012.07.02 17:57:30 -07'00'

The test results of this test report relate exclusively to the test item specified in Section3.
CETECOM Inc. USA does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item. The test report may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written approval of CETECOM Inc. USA.

2. Administrative Data

2.1. Identification of the Testing Laboratory Issuing the SAR Test Report

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Telephone:	+1 (408) 586 6200
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Test Lab Manager:	Sajay Jose
Test Engineer:	Zack Gray

2.2. Identification of the Client

Applicant's Name:	Garmin International
Street Address:	100 Regency Forest Drive, Suite #350
City/Zip Code	Cary, NC 27518
Country	USA
Contact Person:	Jay Everett
Phone No.	(919) 337-0163
Fax:	(919) 337-0199
e-mail:	Jay.everett@garmin.com

2.3. Identification of the Manufacturer

Manufacturer's Name:	Garmin International
Manufacturers Address:	No. 68, Jangshu 2nd Road
City/Zip Code	Shijr, Taipei County
Country	Taiwan

3. Equipment under Test (EUT)

3.1. Specification of the Equipment under Test

Product Type:	Portable
Prototype/Production:	Production
RF Exposure Environment:	General / Uncontrolled
Exposure Conditions:	Near the body, Handheld
Marketing Name:	Nuvi 2598FL
Model No:	A2AVGC00
Supported Radios:	GPRS/EGPRS, MS Class 12, Power Class 4/1 WCDMA/HSPA+, Power Class 3, Cat 6 (5.7 Mbps uplink and QPSK) Bluetooth GPS receiver
FCC-ID:	IPH-A2AVGC00
IC-ID :	1792A-A2AVGC00
Frequency Range:	GSM 850: 824.2 – 848.8 MHz PCS 1900: 1850.2 – 1909.8 MHz WCDMA FDD II: 1852.4 – 1907.6 MHz WCDMA FDDIV:1712.4 – 1752.6 MHz WCDMA FDD V: 826.4 – 846.6 MHz Bluetooth: 2400 – 2483.5 MHz GPS: 1.575 GHz
Type(s) of Modulation:	GSM/GPRS: GMSK EGPRS: GMSK, 8PSK WCDMA/HSPA+: QPSK, 16 QAM Bluetooth: GFSK
Antenna Information:	**Cellular Antenna:** Monopole Antenna *Max Gain (as declared by manufacturer):* 850 band: 1 dBi 1900 band: 2.5 dBi 1700 band: -1.2 dBi **Bluetooth Antenna:** Linear Chip Antenna Manufacturer stated, Max (peak) gain= 2.2 dBi
Maximum Conducted Output Power:	GSM850: 32.6 dBm PCS1900: 29.5 dBm WCDMA FDDII: 21.87 dBm WCDMA FDDIV: 23.46 dBm WCDMA FDDV: 23.4 dBm
Power Supply (VDC):	Dedicated Lithium battery pack Rated operating voltage: 4.75 (Low)/5.0 (Nom)/ 5.25 (High)
Rated Operating Temperature Range:	-20ºC to 55ºC

3.2. Identification of the Equipment Under Test (EUT)

EUT #	Serial Number	HW Version	SW Version	Comments
1	2KM000244	1 ; HE910-D: 0	1.04; HE910-D: 12.00.022	Radiated Unit
2	2KM000250	1 ; HE910-D: 0	1.04; HE910-D: 12.00.022	Radiated Unit
3	2KM000253	1 ; HE910-D: 0	1.04; HE910-D: 12.00.022	Radiated Unit
4	2KM000259	1 ; HE910-D: 0	1.04; HE910-D: 12.00.022	Radiated Unit
5	2KM000231	1 ; HE910-D: 0	1.04; HE910-D: 12.00.022	Conducted Power Verification Unit
6	2KM000233	1 ; HE910-D: 0	1.04; HE910-D: 12.00.022	Conducted Power Verification Unit

3.1. Identification of Accessory equipment

No accessory equipment.

4. Subject of Investigation

The objective of the measurements done by Cetecom Inc. was the dosimetric assessment of one device. The tests were performed in configurations for devices operated next to a person's body. The examinations were carried out with the dosimetric assessment system DASY52 described in Section 6.

4.1. The IEEE Standard C95.1 and the FCC Exposure Criteria

In the USA the recent FCC exposure criteria [FCC 2001] are based upon the IEEE Standard C95.1 [IEEE 1999]. The IEEE standard C95.1 sets limits for human exposure to radio frequency electromagnetic fields in the frequency range 3 kHz to 300 GHz.

4.2. Distinction Between Exposed Population, Duration of Exposure and Frequencies

The American Standard [IEEE 1999] distinguishes between controlled and uncontrolled environment. Controlled environments are locations where there is exposure that may be incurred by persons who are aware of the potential for exposure as a concomitant of employment or by other cognizant persons. Uncontrolled environments are locations where there is the exposure of individuals who have no knowledge or control of their exposure. The exposures may occur in living quarters or workplaces. For exposure in controlled environments higher field strengths are admissible. In addition the duration of exposure is considered. Due to the influence of frequency on important parameters, as the penetration depth of the electromagnetic fields into the human body and the absorption capability of different tissues, the limits in general vary with frequency.

4.3. Distinction between Maximum Permissible Exposure and SAR Limits

The biological relevant parameter describing the effects of electromagnetic fields in the frequency range of interest is the specific absorption rate SAR (dimension: power/mass). It is a measure of the power absorbed per unit mass. The SAR may be spatially averaged over the total mass of an exposed body or its parts. The SAR is calculated from the r.m.s. electric field strength *E* inside the human body, the conductivity σ and the mass density ρ of the biological tissue:

$$SAR = \sigma \frac{E2}{\rho} = c \frac{\partial T}{\partial t}\bigg|_{t \to 0+}$$

The specific absorption rate describes the initial rate of temperature rise $\partial T / \partial t$ as a function of the specific heat capacity *c* of the tissue. A limitation of the specific absorption rate prevents an excessive heating of the human body by electromagnetic energy.

As it is sometimes difficult to determine the SAR directly by measurement (e.g. whole body averaged SAR), the standard specifies more readily measurable maximum permissible exposures in terms of external electric *E* and magnetic field strength *H* and power density S, derived from the SAR limits. The limits for E, *H* and *S* have been fixed so that even under worst case conditions, the limits for the specific absorption rate SAR are not exceeded.

For the relevant frequency range the maximum permissible exposure may be exceeded if the exposure can be shown by appropriate techniques to produce SAR values below the corresponding limits.

4.4. SAR Limit

In this report the comparison between the American exposure limits and the measured data is made using the spatial peak SAR; the power level of the device under test guarantees that the whole body averaged SAR is not exceeded.

Having in mind a worst case consideration, the SAR limit is valid for uncontrolled environment and mobile respectively portable transmitters. According to Table 1 the SAR values have to be averaged over a mass of 1 g (SAR_{1g}) with the shape of a cube.

Standard	Status	Exposure Condition	Averaged SAR Mass	SAR limit (W/kg)
IEEE C95.1	In force	Body	1g	1.6
		Handheld	10g	4.0

Table 1: Relevant spatial peak SAR limit

5. The FCC Measurement Procedure and IC Measurement Procedure

The Federal Communications Commission (FCC) has published a report and order on the 1st of August 1996 [FCC 1996], which requires routine dosimetric assessment of mobile telecom-communications devices, either by laboratory measurement techniques or by computational modeling, prior to equipment authorization or use. In 2001 the Commission's Office of Engineering and Technology has released Edition 01-01 of Supplement C to OET Bulletin 65. This revised edition, which replaces Edition 97-01, provides additional guidance and information for evaluating compliance of mobile and portable devices with FCC limits for human exposure to radiofrequency emissions [FCC 2001]. The following KDB Publications have also been applied:

447498 D01 V04 – Mobile and portable device RF Exposure Procedures
648474 D01 V01R05 – SAR Evaluation Considerations for Handsets with Multiple Transmitters
941225 D01 V02 – SAR Measurement Procedures for 3G Devices
941225 D07 V01 – UMPC Mini Tablet Devices

Body exposure conditions were tested with a 10 mm separation distance. Hand exposure conditions were tested with a 0 mm separation distance. A KDB inquiry to the FCC was submitted to approve the use of these separation distances. Option 2 of this KDB inquiry reflects these procedures.

The Industry Canada (IC) measurement procedure follows RSS-102, Issue 4, March 2010. IC follows many of the same procedures as the FCC regarding EUT specific technologies and form factors. The above FCC KDBs are applied to the IC SAR measurements.

5.1. General Requirements

SAR evaluation was performed in a laboratory with an environment which avoids influence on SAR measurements by ambient EM sources and any reflection from the environment itself. The ambient temperature was in the range of 20°C to 26°C and 30-70% humidity. Simulating liquid temperature did not deviate more than +/- 2°C throughout SAR evaluation.

5.2. Body-worn and Other Configurations

Phantom Requirements
For body-worn and other configurations a flat phantom shall be used which is comprised of material with electrical properties similar to the corresponding tissues.

Test Position
The body-worn configurations shall be tested with the supplied accessories (belt-clips, holsters, etc.) attached to the device in normal use configuration. Devices with a headset output shall be tested with a connected headset.

Test to be Performed

For purpose of determining test requirements, accessories may be divided into two categories: those that do not contain metallic components and those that do. For multiple accessories that do not contain metallic components, the device may be tested only with that accessory which provides the closest spacing to the body. For multiple accessories that contain metallic components, the device must be tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component, only the accessory that provides the closest spacing to the body must be tested. If the manufacturer provides no body-worn accessories a separation distance of 1.5 cm between the back of the device and the flat phantom is recommended. Other separation distances may be used, but they shall not exceed 2.5 cm. In these cases, the device may use body-worn accessories that provide a separation distance greater than that tested for the device provided however that the accessory contains no metallic components.

For devices with retractable antenna the SAR test shall be performed with the antenna fully extended and fully retracted. Other factors that may affect the exposure shall also be tested. For example, optional antennas or optional battery packs which may significantly change the volume, lengths, flip open/closed, etc. of the device, or any other accessories which might have the potential to considerably increase the peak spatial-average SAR value.

5.3. Procedure for assessing the peak spatial-average SAR

Step 1: Power reference measurement:

Prior to the SAR test, a local SAR measurement should be taken at a user-selected spatial reference point to monitor power variations during testing. For example, this power reference point can be spaced 10 mm or less in the normal direction from the liquid-shell interface and within ± 10 mm transverse to the normal line at the ear reference point.

Step 2: Area scan

The measurement procedures for evaluating SAR associated with wireless handsets typically start with a coarse measurement grid in order to determine the approximate location of the local peak SAR values. This is referred to as the "area scan" procedure. The SAR distribution is scanned along the inside surface of typically half of the head of the phantom but at least larger than the areas projected (normal to the phantom's surface) by the handset and antenna. An example grid is given in Figure 4. The distance between the measured points and phantom surface should be less than 8 mm, and should remain constant (variation less than ± 1 mm) during the entire scan in order to determine the locations of the local peak SAR with sufficient precision. The distance between the measurement points should enable the detection of the location of local maximum with an accuracy of better than half the linear dimension of the tissue cube after interpolation. The resolution can also be tested using the functions in Annex E (see E.5.2). The approximate locations of the peak SARs should be determined from area scan. Since a given amplitude local peak with steep gradients may produce lower spatial-average SAR than slightly lower amplitude peaks with less steep gradients, it is necessary to evaluate the other peaks as well. However, since the spatial gradients of local SAR peaks are a function of wavelength inside the tissue simulating liquid and incident magnetic field strength, it is not necessary to evaluate peaks that are less than – 2dB of the local maximum. Two-dimensional spline algorithms [Press, et al, 1996], [Brishoual, 2001] are typically used to determine the peaks and gradients within the scanned area. If the peak is closer than one-half of the linear dimension of the 1 g or 10 g tissue cube to the scan border, the measurement area should be enlarged if possible, e.g., by tilting the probe or the phantom (see Figure 5).

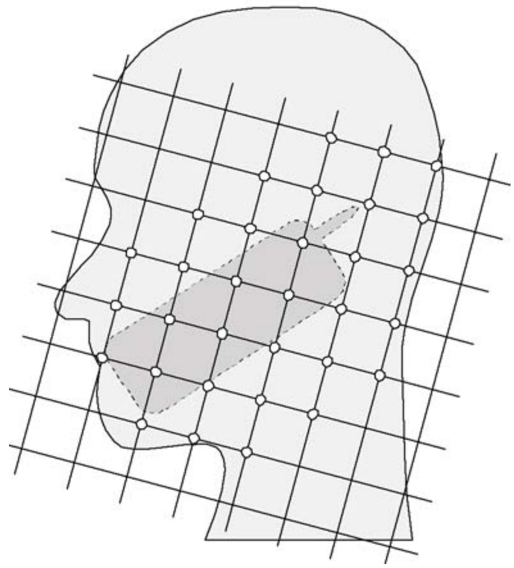

Figure 4 – Example of an area scan including the position of the handset. The scanned area (white dots) should be larger than the area projected by the handset and antenna.

Step 3: Zoom scan

In order to assess the peak spatial SAR values averaged over a 1 g and 10 g cube, fine resolution volume scans, called "zoom scans", are performed at the peak SAR locations determined during the “area scan.” The zoom scan volume should have at least 1.5 times the linear dimension of either a 1 g or a 10 g tissue cube for whichever peak spatial-average SAR is being evaluated. The peak local SAR locations that were determined in the area scan (interpolated value) should be on the centerline of the zoom scans. The centerline is the line that is normal to the surface and in the center of the volume scan. If this is not possible, the zoom scan can be shifted but not by more than half the dimension of the 1 g or a 10 g tissue cube.

The maximum spatial-average SAR is determined by a numerical analysis of the SAR values obtained in the volume of the zoom scan, whereby interpolation (between measured points) and extrapolation (between surface and closest measured points) routines should be applied. A 3-D-spline algorithm [Press, et al, 1996], [Kreyszig, 1983], [Brishoual, 2001] can be used for interpolation and a trapezoidal algorithm for the integration (averaging). Scan resolutions of larger than 2 mm can be used provided the uncertainty is evaluated according to E (see E.5).

In some areas of the phantom, such as the jaw and upper head region, the angle of the probe with respect to the line normal to the surface might become large, e.g., at angles larger than ± 30º (see Figure 5), which may increase the boundary effect to an unacceptable level. In these cases, a change in the orientation of the probe and/or the phantom is recommended during the zoom scan so that the angle between the probe housing tube and the line normal to the surface is significantly reduced (<30º).

Step 4: Power reference measurement

The local SAR should be measured at exactly the same location as in Step 1. The absolute value of the measurement drift (the difference between the SAR measured in Step 4 and Step 1) should be recorded in the uncertainty budget. It is recommended that the drift be kept within ± 5%. If this is not possible, even with repeat testing, additional information may be used to demonstrate the power stability during the test. Power reference measurements can be taken after each zoom scan, if more than one zoom scan is needed. However, the drift should always be referred to the initial state with fully charged battery.

5.4. Determination of the largest peak spatial-average SAR

In order to determine the largest value of the peak spatial-average SAR of a handset, all device positions, configurations and operational modes should be tested for each frequency band according to steps 1 to 3 below.

Step 1: The tests of 6.4 should be conducted at the channel that is closest to the center of the transmit frequency band (*fc*) for:

a) all device positions (cheek and tilt, for both left and right sides of the SAM phantom,

b) all configurations for each device position in (a), e.g. antenna extended and retracted, and

c) all operational modes for each device position in (a) and configuration in (b) in each frequency band, e.g. analog and digital.

If more than three frequencies need to be tested, (i.e., Nc > 3), then all frequencies, configurations and modes must be tested for all of the above positions.

Step 2: For the condition providing highest spatial peak SAR determined in Step 1 conduct all tests of 6.4 at all other test frequencies, e.g. lowest and highest frequencies. In addition, for all other conditions (device position, configuration and operational mode) where the spatial peak SAR value determined in Step 1 is within 3dB of the applicable SAR limit, it is recommended that all other test frequencies should be tested as well[1].

Step 3: Examine all data to determine the largest value of the peak spatial-average SAR found in Steps 1 to 2.

6. The Measurement System

6.1. Robot system specification

The SAR measurement system being used is the SPEAG DASY52 system, which consists of a Stäubli TX90XL 6-axis robot arm and CS8c controller, SPEAG SAR Probe, Data Acquisition Electronics, and SAM Twin Phantom. The robot is used to articulate the probe to programmed positions inside the phantom to obtain the SAR readings from the EUT.

The system is controlled remotely from a PC, which contains the software to control the robot and data acquisition equipment. The software also displays the data obtained from test scans.

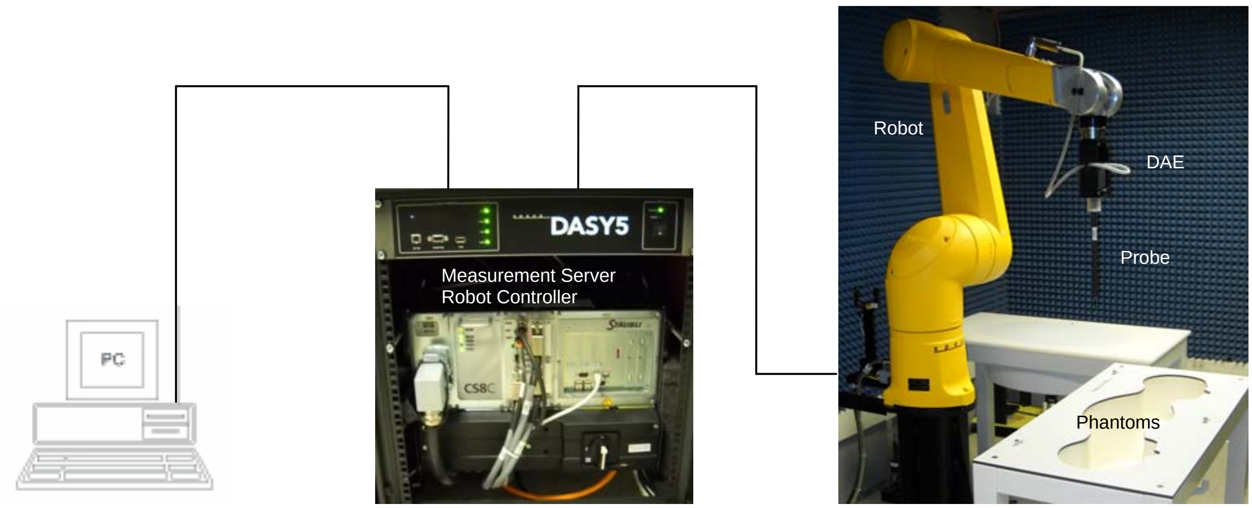

Figure 5: Schematic diagram of the SAR measurement system

In operation, the system first does an area (2D) scan at a fixed depth within the liquid from the inside wall of the phantom. When the maximum SAR point has been found, the system will then carry out a 3D scan centered at that point to determine volume averaged SAR level.

6.2. Isotropic E-Field Probe for Dosimetric Measurements

The probes are constructed using three orthogonal dipole sensors arranged on an interlocking, triangular prism core. The probes have built-in shielding against static charges and are contained within a PEEK cylindrical enclosure material at the tip. Probe calibration is described in the probe's calibration certificate (see appendix C).

6.3. Data Acquisition Electronics

The DAE contains a signal amplifier, multiplexer, 16bit A/D converter and control logic. It uses an optical link for communication with the DASY5 system. The DAE has a dynamic range of -100 to 300 mV. It also contains a two step probe touch detector for mechanical surface detection and emergency robot stop.

6.4. Phantoms

The Twin SAM V4.0 Phantom is designed to specifications defined in IEEE 1528 and IEC 62209-1. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region.

Additionally, the Oval Flat ELI V4.0 Phantom is designed to specification defined in IEEE 1528 and IEC 62209-2. It enables the dosimetric evaluation of body mounted usage.

6.5. Interpolation and Extrapolation schemes

The interpolation, extrapolation and maximum search routines are all based on the modifed Quadratic Shepard's method. The interpolation scheme combines a least-square fitted function method and a weighted average method which are the two basic types of computational interpolation and approximation. The routines construct a once-continuously differentiable function that interpolates the measurement values.

7. Uncertainty Assessment

Measurement uncertainty values were evaluated for SAR measurements performed by Cetecom Inc. The uncertainty values for components specified in *FCC Supplement C (01-01) to OET Bulletin 65 (97-01)* were evaluated according to the procedures of *IEEE 1528-200X December 29, 2002, NIST 1297 1994 edition and ISO Guide to the Expression of Uncertainty in Measurements (GUM)*.

7.1. Measurement Uncertainty Budget

a	*b*	*c*	*d*	*e = f(d,k)*	*f*	*g = c x f / e*	*k*
Uncertainty Component	**Sec.**	**Tol. (± %)**	**Prob. Dist.**	**Div.**	**c_i (1-g)**	**1-g u_i (±%)**	**v_i**
Measurement System							
Probe Calibration	E2.1	5.5	N	1	1	5.5	∞
Axial Isotropy	E2.2	4.7	R	√3	0.7	1.9	∞
Hemispherical Isotropy	E2.2	9.6	R	√3	0.7	3.9	∞
Boundary Effect	E2.3	1.0	R	√3	1	0.6	∞
Linearity	E2.4	4.7	R	√3	1	2.7	∞
System Detection Limits	E2.5	1.0	R	√3	1	0.6	∞
Readout Electronics	E2.6	0.3	N	1	1	0.3	∞
Response Time	E2.7	0.8	R	√3	1	0.5	∞
Integration Time	E2.8	2.6	R	√3	1	1.5	∞
RF Ambient Noise	E6.1	3.0	R	√3	1	1.7	∞
RF Ambient Reflections	E6.1	3.0	R	√3	1	1.7	∞
Probe Positioner Mechanical Tolerance	E6.2	0.4	R	√3	1	0.2	∞
Probe Positioning with respect to Phantom Shell	E6.3	2.9	R	√3	1	1.7	∞
Extrapolation, interpolation and Integration Algorithms for Max. SAR Evaluation	E5.2	1.0	R	√3	1	0.6	∞
Test sample Related							
Test Sample Positioning	E4.2	2.9	N	1	1	2.9	*145*
Device Holder Uncertainty	E4.1	3.6	N	1	1	3.6	*5*
Output Power Variation - SAR drift measurement	6.6.2	5.0	R	√3	1	2.9	∞
Phantom and Tissue Parameters							
Phantom Uncertainty (shape and thickness tolerances)	E3.1	4.0	R	√3	1	2.3	∞
Liquid Conductivity Target - tolerance	E3.2	5.0	R	√3	0.7	1.8	∞
Liquid Conductivity - measurement uncertainty	E3.3	2.5	N	1	0.7	1.6	∞
Liquid Permittivity Target tolerance	E3.2	5.0	R	√3	0.6	1.7	∞
Liquid Permittivity - measurement uncertainty	E3.3	2.5	N	1	0.6	1.5	∞
Combined Standard Uncertainty			RSS			**± 10.7%**	
Expanded Uncertainty (95% CONFIDENCE INTERVAL)			*k*= 2.00705			**± 21.4%**	

8. Test results summary

8.1. Conducted Average Output Power

Measurement uncertainty for conducted measurements is ±0.5dB

Bluetooth

Average power measured using an average power meter.

Channel	Frequency [MHz]	Average Power [dBm]
0	**2402**	3.97
39	**2441**	4.04
78	**2480**	3.95

GSM 850 Band – (E)GPRS

Average power measured using a Rhode and Schwarz CMU 200.

Mode of Operation	Modulation	Channel	Frequency [MHz]	Measured Burst Average Power [dBm]	Calculated Time Average Power [dBm]
GPRS 1 uplink timeslot	GMSK	128	824.2	32.4	23.4
		190	836.6	32.6	23.2
		251	848.8	32.6	23.2
GPRS 2 uplink timeslots	GMSK	128	824.2	32.3	26.3
		190	836.6	32.5	26.5
		251	848.8	32.6	26.6
GPRS 3 uplink timeslots	GMSK	128	824.2	31.6	27.35
		190	836.6	31.8	27.55
		251	848.8	31.8	27.55
GPRS 4 uplink timeslots	GMSK	128	824.2	**30.5**	**27.5**
		190	836.6	**30.6**	**27.6**
		251	848.8	**30.6**	**27.6**
EGPRS 1 uplink timeslot	GMSK	128	824.2	32.4	23.4
		190	836.6	32.5	23.5
		251	848.8	32.6	23.6
EGPRS 2 uplink timeslots	GMSK	128	824.2	32.3	26.3
		190	836.6	32.5	26.5
		251	848.8	32.5	26.5
EGPRS 3 uplink timeslots	GMSK	128	824.2	31.6	27.35
		190	836.6	31.8	27.55
		251	848.8	31.8	27.55
EGPRS 4 uplink timeslots	GMSK	128	824.2	30.5	27.5
		190	836.6	30.6	27.6
		251	848.8	30.6	27.6
EGPRS 1 uplink timeslot	8PSK	128	824.2	26.8	17.8
		190	836.6	27	18
		251	848.8	27.1	18.1
EGPRS 2 uplink timeslots	8PSK	128	824.2	26.8	20.8
		190	836.6	27	21
		251	848.8	27.1	21.1
EGPRS 3 uplink timeslots	8PSK	128	824.2	26	21.75
		190	836.6	26.2	21.95
		251	848.8	26.2	21.95
EGPRS 4 uplink timeslots	8PSK	128	824.2	24.8	21.8
		190	836.6	25	22
		251	848.8	25.1	22.1

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PCS 1900 Band - (E)GPRS

Average power measured using a Rhode and Schwarz CMU 200.

Mode of Operation	Modulation	Channel	Frequency [MHz]	Measured Burst Average Power [dBm]	Calculated Time Average Power [dBm]
GPRS 1 uplink timeslot	GMSK	512	1850.2	29.5	20.5
		661	1880	29.4	20.4
		810	1909.8	29.5	20.5
GPRS 2 uplink timeslots	GMSK	512	1850.2	29.5	23.5
		661	1880	29.4	23.4
		810	1909.8	29.4	23.4
GPRS 3 uplink timeslots	GMSK	512	1850.2	**28.7**	**24.45**
		661	1880	**28.6**	**24.35**
		810	1909.8	**28.6**	**24.35**
GPRS 4 uplink timeslots	GMSK	512	1850.2	27.4	24.4
		661	1880	27.3	24.3
		810	1909.8	27.5	24.5
EGPRS 1 uplink timeslot	GMSK	512	1850.2	29.5	20.5
		661	1880	29.4	20.4
		810	1909.8	29.5	20.5
EGPRS 2 uplink timeslots	GMSK	512	1850.2	29.5	23.5
		661	1880	29.4	23.4
		810	1909.8	29.4	23.4
EGPRS 3 uplink timeslots	GMSK	512	1850.2	28.7	24.45
		661	1880	28.6	24.35
		810	1909.8	28.6	24.35
EGPRS 4 uplink timeslots	GMSK	512	1850.2	27.4	24.4
		661	1880	27.3	24.3
		810	1909.8	27.5	24.5
EGPRS 1 uplink timeslot	8PSK	512	1850.2	25.6	16.6
		661	1880	25.6	16.6
		810	1909.8	25.6	16.6
EGPRS 2 uplink timeslots	8PSK	512	1850.2	25.6	19.6
		661	1880	25.6	19.6
		810	1909.8	25.6	19.6
EGPRS 3 uplink timeslots	8PSK	512	1850.2	24.8	20.55
		661	1880	24.7	20.45
		810	1909.8	24.8	20.55
EGPRS 4 uplink timeslots	8PSK	512	1850.2	23.7	20.7
		661	1880	23.7	20.7
		810	1909.8	23.8	20.8

WCDMA

Average power measured using a Rhode and Schwarz CMU 200.

Band	Channel	Frequency [MHz]	Average Power [dBm]
			12.2kbps RMC
WCDMA FDD V	4132	826.4	23.4
	4175	835	23.34
	4233	846.6	23.22
WCDMA FDD IV	1312	1712.4	23.46
	1413	1732.6	23.44
	1513	1752.6	23.21
WCDMA FDD II	9262	1852.4	21.87
	9400	1880	21.85
	9538	1907.6	22.07

HSDPA

Settings are according to FCC KDB 941225 D01, "SAR Measurement Procedures for 3G Devices" section "Release 5 HSDPA Data Devices"

Average power measured using a Rhode and Schwarz CMU 200.

Band	Channel	Frequency [MHz]	Average Power [dBm]			
			Sub-test 1	Sub-test 2	Sub-test 3	Sub-test 4
WCDMA FDD V	4132	826.4	23.36	22.33	21.12	21.8
	4175	835	23.25	22.23	22	21.74
	4233	846.6	23.12	21.61	21.9	21.63
WCDMA FDD IV	1312	1712.4	23.22	22.21	21.7	21.68
	1413	1732.6	23.17	22.19	21.94	21.67
	1513	1752.6	22.93	21.94	21.68	21.46
WCDMA FDD II	9262	1852.4	21.6	20.62	20.39	20.1
	9400	1880	21.6	20.54	20.36	20.05
	9538	1907.6	21.87	20.84	20.65	20.36

HSPA

Settings are according to FCC KDB 941225 D01, "SAR Measurement Procedures for 3G Devices" section "Release 6 HSPA Data Devices"

Average power measured using a Rhode and Schwarz CMU 200.

Band	Channel	Frequency [MHz]	Average Power [dBm]				
			Sub-test 1	Sub-test 2	Sub-test 3	Sub-test 4	Sub-test 5
WCDMA FDD V	4132	826.4	22.25	20.47	21.00	20.40	21.96
	4175	835	22.16	20.09	20.95	20.27	21.83
	4233	846.6	22.00	19.96	20.80	20.08	22.04
WCDMA FDD IV	1312	1712.4	22.34	20.28	21.13	20.55	22.06
	1413	1732.6	22.28	20.24	21.08	20.47	22
	1513	1752.6	22.05	20.03	20.85	20.32	22.14
WCDMA FDD II	9262	1852.4	20.77	18.7	19.56	19	20.49
	9400	1880	20.75	18.7	19.45	18.83	20.88
	9538	1907.6	20.91	18.9	19.65	19.1	21.03

8.2. Stand-Alone SAR Evaluation Exclusion

Antenna	Operation Mode	SAR Evaluation Exclusion Reason
Bluetooth	GFSK	According to KDB 648474, Bluetooth is not required when the output power is ≤ 12 mW and the antenna is ≥ 2.5 cm from other antennas
Cellular	HSDPA	According to KDB 941225, SAR evaluation is not required when the maximum average output power is < ¼ dB higher than that measured on the corresponding channels without HSDPA using 12.2 kbps RMC
Cellular	HSPA	According to KDB 941225, SAR evaluation is not required when the maximum average output power is < ¼ dB higher than that measured on the corresponding channels without HSPA using 12.2 kbps RMC

8.3. Test Positions and Configurations

Exposure Condition	Position	Positioning Photo (Appendix B)
Hand SAR	Front 0mm	Photo 1
	Back 0mm	Photo 3
	Bottom Edge 0mm	Photo 5
	Top Edge 0mm	Photo 7
	Right Edge 0mm	Photo 9
Body SAR	Front 10mm	Photo 2
	Back 10mm	Photo 4
	Bottom Edge 10mm	Photo 6
	Top Edge 10mm	Photo 8
	Right Edge 10mm	Photo 10

If the SAR value on the middle channel was more than 3dB below the limit, high and low channels were not evaluated. Otherwise, high and low channels were evaluated for the position with the highest SAR value only.

For GMSK and 8PSK modulation, four timeslots were used to achieve maximum source-based time-averaged output power on the GSM850 band. Three timeslots were used to achieve maximum output power on the PCS1900 band since the time-averaged power was highest for a three timeslot configuration in this band. Spot check measurements at the highest measured SAR position were made on the remaining timeslot configurations in each respective band to ensure compliance.

KDB 941225 and IEEE 1528-2003 footnote 11 require SAR evaluation for low-power modes for devices that produce a peak SAR larger than one half of the compliance limit. SAR evaluation for EGPRS with 8PSK modulation was measured for the configuration with the highest SAR value only because the SAR value for 8PSK is lower than GMSK.

SAR evaluation procedures according to KDB 941225 D07 v01 are used. A KDB inquiry was submitted to use a 10 mm test separation distance for body exposure conditions. A test separation distance of 0 mm is used for hand exposure conditions. All sides and edges within 25 mm of the cellular antenna are tested. See appendix C for the antenna locations and distances.

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8.4. SAR Results for Body(1g) and Hand(10g) Exposure

SAR 1g for body exposure with 1.6 W/kg limit. SAR 10g for hand exposure with 4.0 W/kg limit.

8.4.1. GSM 850 Band

Operation Mode	Channel	Frequency (MHz)	Position	SAR 1g (W/kg)	SAR 10g (W/kg)	Results (Appendix A)
GPRS / GMSK / 4 Uplink Timeslots	190	836.6	EUT front at 0mm		0.798	Plot 1
			EUT front at 10mm	0.595		Plot 2
			EUT back at 0mm		1.5	Plot 3
			EUT back at 10mm	1.3		Plot 4
			EUT bottom edge at 0mm		1.5	Plot 5
			EUT bottom edge at 10mm	0.901		Plot 6
			EUT top edge at 0mm		0.949	Plot 7
			EUT top edge at 10mm	1.01		Plot 8
			EUT right edge at 0mm		1.03	Plot 9
			EUT right edge at 10mm	0.547		Plot 10
	128	824.2	EUT back at 10mm	1.33		Plot 11
	251	848.8	EUT back at 10mm	1.32		Plot 12
EGPRS / 8PSK / 4 Uplink Timeslots	251	848.8	EUT back at 10mm	0.407		Plot 13
GPRS / GMSK / 3 Uplink Timeslots	190	836.6	EUT back at 0mm		1.5	Plot 14
			EUT back at 10mm	1.28		Plot 15
GPRS / GMSK / 2 Uplink Timeslots	190	836.6	EUT back at 0mm		1.33	Plot 16
			EUT back at 10mm	1.07		Plot 17
GPRS / GMSK / 1 Uplink Timeslots	190	836.6	EUT back at 0mm		0.665	Plot 18
			EUT back at 10mm	0.599		Plot 19

8.4.2. PCS 1900 Band

Operation Mode	Channel	Frequency (MHz)	Position	SAR 1g (W/kg)	SAR 10g (W/kg)	Results (Appendix A)
GPRS / GMSK / 3 Uplink Timeslots	**661**	**1880**	EUT front at 0mm		1.3	Plot 20
			EUT front at 10mm	0.542		Plot 21
			EUT back at 0mm		2.13	Plot 22
			EUT back at 10mm	0.937		Plot 23
			EUT bottom edge at 0mm		0.131	Plot 24
			EUT bottom edge at 10mm	0.141		Plot 25
			EUT top edge at 0mm		1.73	Plot 26
			EUT top edge at 10mm	0.915		Plot 27
			EUT right edge at 0mm		1.67	Plot 28
			EUT right edge at 10mm	0.888		Plot 29
	512	**1850.2**	EUT back at 0mm		2.02	Plot 30
			EUT back at 10mm	0.801		Plot 31
	810	**1909.8**	EUT back at 0mm		2.09	Plot 32
			EUT back at 10mm	1.17		Plot 33
EGPRS / 8PSK / 3 Uplink Timeslots	**661**	**1880**	EUT back at 0mm		1.01	Plot 34
			EUT back at 10mm	0.439		Plot 35
GPRS / GMSK / 4 Uplink Timeslots	**661**	**1880**	EUT back at 0mm		2.01	Plot 36
			EUT back at 10mm	0.931		Plot 37
GPRS / GMSK / 2 Uplink Timeslots	**661**	**1880**	EUT back at 0mm		1.86	Plot 38
			EUT back at 10mm	0.754		Plot 39
GPRS / GMSK / 1 Uplink Timeslot	**661**	**1880**	EUT back at 0mm		0.914	Plot 40
			EUT back at 10mm	0.377		Plot 41

8.4.3. WCDMA FDD V

Operation Mode	Channel	Frequency (MHz)	Position	SAR 1g (W/kg)	SAR 10g (W/kg)	Results (Appendix A)
12.2 kbps RMC	4183	836.6	EUT front at 0mm		0.387	Plot 42
			EUT front at 10mm	0.392		Plot 43
			EUT back at 0mm		0.787	Plot 44
			EUT back at 10mm	0.508		Plot 45
			EUT bottom edge at 0mm		0.839	Plot 46
			EUT bottom edge at 10mm	0.408		Plot 47
			EUT top edge at 0mm		0.568	Plot 48
			EUT top edge at 10mm	0.289		Plot 49
			EUT right edge at 0mm		0.423	Plot 50
			EUT right edge at 10mm	0.198		Plot 51

8.4.4. WCDMA FDD IV

Operation Mode	Channel	Frequency (MHz)	Position	SAR 1g (W/kg)	SAR 10g (W/kg)	Results (Appendix A)
12.2 kbps RMC	1413	1732.6	EUT front at 0mm		0.457	Plot 52
			EUT front at 10mm	0.275		Plot 53
			EUT back at 0mm		1.7	Plot 54
			EUT back at 10mm	0.573		Plot 55
			EUT bottom edge at 0mm		0.115	Plot 56
			EUT bottom edge at 10mm	0.0604		Plot 57
			EUT top edge at 0mm		0.718	Plot 58
			EUT top edge at 10mm	0.281		Plot 59
			EUT right edge at 0mm		0.207	Plot 60
			EUT right edge at 10mm	0.362		Plot 61

8.4.5. WCDMA FDD II

Operaiton Mode	Channel	Frequency (MHz)	Position	SAR 1g (W/kg)	SAR 10g (W/kg)	Results (Appendix A)
12.2 kbps RMC	9400	1880	EUT front at 0mm		0.839	Plot 62
			EUT front at 10mm	0.332		Plot 63
			EUT back at 0mm		1.37	Plot 64
			EUT back at 10mm	0.691		Plot 65
			EUT bottom edge at 0mm		0.0852	Plot 66
			EUT bottom edge at 10mm	0.0972		Plot 67
			EUT top edge at 0mm		1.11	Plot 68
			EUT top edge at 10mm	0.588		Plot 69
			EUT right edge at 0mm		0.909	Plot 70
			EUT right edge at 10mm	0.46		Plot 71

8.5. SAR Results Extrapolated to Upper Tolerance Limit

TCB Workshop presentation "RF Exposure Procedure Review" April 2010, slide 43, states test results must demonstrate compliance when results are extrapolated to the upper tune-up tolerance limit, with respect to the maximum measured output power of the test sample, to ensure all production units are compliant. **The upper tune-up tolerance is taken from Telit "Power Tune up procedure for HE910 Products Family" Release 5.** The tables below extrapolate the measured SAR results to the upper tune-up tolerance limit of licensed bands. Only the highest SAR results of each band and each exposure condition are shown.

Body SAR at 10mm:

Band	Operating Mode	Channel	Frequency (MHz)	Measured Avg Output Power (dBm)	Upper Tolerance Limit (dBm)	Measured SAR 1g (W/kg)	Extrapolated SAR 1g (W/kg)
GSM 850	**GPRS / GMSK / 4 Uplink Timeslots**	**128**	**824.2**	30.5	31	1.33	1.49
PCS 1900	**GPRS / GMSK / 3 Uplink Timeslots**	**810**	**1909.8**	28.6	29	1.17	1.28
WCDMA FDD V	**12.2 kbps RMC**	**4183**	**836.6**	23.34	23.5	0.508	0.527
WCDMA FDD IV	**12.2 kbps RMC**	**1413**	**1732.6**	23.44	23.5	0.573	0.581
WCDMA FDD II	**12.2 kbps RMC**	**9400**	**1880**	21.85	23.5	0.691	1.01

Hand SAR at 0mm:

Band	Operating Mode	Channel	Frequency (MHz)	Measured Avg Output Power (dBm)	Upper Tolerance Limit (dBm)	Measured SAR 10g (W/kg)	Extrapolated SAR 10g (W/kg)
GSM 850	GPRS / GMSK / 4 Uplink Timeslots	251	848.8	30.6	31	1.5	1.64
PCS 1900	GPRS / GMSK / 3 Uplink Timeslots	661	1880	28.6	29	2.13	2.34
WCDMA FDD V	12.2 kbps RMC	4183	836.6	23.34	23.5	0.839	0.87
WCDMA FDD IV	12.2 kbps RMC	1413	1732.6	23.44	23.5	1.7	1.72
WCDMA FDD II	12.2 kbps RMC	9400	1880	21.85	23.5	1.37	2.00

8.6. Simultaneous Transmission SAR Evaluation Consideration

According to KDB 648474, SAR evaluation for simultaneous transmission can be excluded when specific requirements are satisfied.

Exposure Condition	Antenna	Highest measured SAR (W/kg)
Body SAR	Bluetooth[1]	0.00
	Cellular	1.33
Handheld SAR	Bluetooth[1]	0.00
	Cellular	2.13

1. When stand-alone SAR evaluation is not required, SAR value is assumed to be 0.0 W/kg.

Exposure Condition	Simultaneous Transmission Antenna Combinations	Antenna-to-Antenna Distance	Sum of SAR (W/kg)	SAR to Peak Location Separation Ratio[1]
Body SAR	Bluetooth and Cellular	60 mm	1.33	N/A
Handheld SAR	Bluetooth and Cellular	60 mm	2.13	N/A

1. SAR to Peak Location Separation Ratio is only calculated if the Sum of SAR (W/kg) is equal to or greater than the limit.

Exposure Condition	Simultaneous Transmission Antenna Combinations	Simultaneous Transmission SAR Evaluation Exclusion Reason
Body SAR	Bluetooth and Cellular	Sum of SAR 1g is less than 1.6 W/kg
Handheld SAR	Bluetooth and Cellular	Sum of SAR 1g is less than 4.0 W/kg

8.7. Dipole verification

Prior to formal testing at each frequency a system verification was performed in accordance with IEEE 1528. The 1 Watt reference SAR value is taken from the SPEAG dipole calibration report as required by FCC KDB 450824 D01. All of the testing described in this report was performed within 24 hours of the system verification. The following results were obtained:

1g SAR Verfication

Date	Liquid Type	Frequency (MHz)	CW input at dipole feed (Watts)	1g SAR (W/kg)	Reference SPEAG Report		Results (Appendix A)
					1 Watt reference SAR value (W/kg)	Difference reference SAR value to normalized SAR	
6/4/12	MSL	835	1	10	9.96	0.4%	Plot 72
6/5/12	MSL	835	1	10.1	9.96	1.4%	Plot 73
6/6/12	MSL	835	1	9.97	9.96	0.0%	Plot 74
6/7/12	MSL	835	1	10.8	9.96	8.4%	Plot 75
6/8/12	MSL	835	1	10.1	9.96	1.4%	Plot 76
6/11/12	MSL	835	1	10.4	9.96	4.4%	Plot 77
6/13/12	MSL	835	1	10.5	9.96	5.4%	Plot 78
6/29/12	MSL	835	1	10	9.96	0.4%	Plot 79
6/12/12	MSL	1750	1	34	37.4	-9.1%	Plot 80
6/13/12	MSL	1750	1	36.7	37.4	1.9%	Plot 81
6/13/12	MSL	1900	1	42.4	40.1	5.7%	Plot 82
6/15/12	MSL	1900	1	37.3	40.1	-7.0%	Plot 83
6/18/12	MSL	1900	1	38.6	40.1	-3.7%	Plot 84
6/29/12	MSL	1900	1	37	40.1	-7.5%	Plot 85

10g SAR Verification

Date	Liquid Type	Frequency (MHz)	CW input at dipole feed (Watts)	10g SAR (W/kg)	Reference SPEAG Report		Results (Appendix A)
					1 Watt reference SAR value (W/kg)	Difference reference SAR value to normalized SAR	
6/4/12	MSL	835	1	6.66	6.59	1.06%	Plot 72
6/5/12	MSL	835	1	6.72	6.59	1.97%	Plot 73
6/6/12	MSL	835	1	6.63	6.59	0.61%	Plot 74
6/7/12	MSL	835	1	7.16	6.59	8.65%	Plot 75
6/8/12	MSL	835	1	6.7	6.59	1.67%	Plot 76
6/11/12	MSL	835	1	6.92	6.59	5.01%	Plot 77
6/13/12	MSL	835	1	6.84	6.59	3.79%	Plot 78
6/29/12	MSL	835	1	6.69	6.59	1.52%	Plot 79
6/12/12	MSL	1750	1	18.4	19.9	-7.54%	Plot 80
6/13/12	MSL	1750	1	19.8	19.9	-0.50%	Plot 81
6/13/12	MSL	1900	1	22.3	21.3	4.69%	Plot 82
6/15/12	MSL	1900	1	19.7	21.3	-7.51%	Plot 83
6/18/12	MSL	1900	1	20.4	21.3	-4.23%	Plot 84
6/29/12	MSL	1900	1	19.6	21.3	-7.98%	Plot 85

9. References

1. [FCC 2001] Federal Communications Commission: Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01), FCC, June 2001.

2. [IEEE 1999] IEEE Std C95.1-2005: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, Inst. of Electrical and Electronics Engineers, Inc., October 2005.

3. [IEEE 2003] IEEE Std 1528-2003: IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head From Wireless Communications Devices: Measurement Techniques. Inst. of Electrical and Electronics Engineers, Inc., December 2003.

4. [NIST 1994] NIST: Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results, Technical Note 1297 (TN1297), United States Department of Commerce Technology Administration, National Institute of Standards and Technology, September 1994.

5. [IC 2010] RSS-102: Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands), Industry Canada, Issue 4, March 2010.

10. Report History

2012-07-02: Original Report.