Certificate Number: 1449-01

ACCREDITED

CGISS EME Test Laboratory
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Fort Lauderdale, FL. 33322

S.A.R. EME Compliance Test Report
Part 5 of 5

Date of Report:	April 15, 2004
Report Revision:	Rev. A
Manufacturer:	Motorola
Product Description:	CN620; Quad band GSM and Tri band WLAN (802.11a, b, and g)
FCC ID:	**AZ489FT5829**
Device Model:	H77UBH6JA5AA

Test Period:	2/19/04-3/24/04
EME Tech:	Ed Church
Responsible Eng:	Deanna Zakharia (Elect. Principle Staff Eng.)
Author:	Michael Sailsman (Global EME Regulatory Affairs Liaison)

Note: Based on the information and the testing results provided herein, the undersigned certifies that when used as stated in the operating instructions supplied, said product complies with the national and international reference standards and guidelines listed in section 2.0 of this report.

Deanna Zakharia Signature on file for Ken Enger　　　4/15/04

Ken Enger
Senior Resource Manager, Laboratory Director, CGISS EME Lab

Date Approved

APPENDIX G

Explanation of 5GHz assessment and description of test methodology

Rainier simultaneous transmission

The highest SAR test configuration found was cheek position on the left side of the phantom for the stubby antenna. The two modes evaluated, and their 1-gram average SAR values (including drift) are:

- GSM 900 MHz, voice mode (1:8 duty cycle), SAR1g = 1.49 W/kg
- WLAN 5200 MHz, voice mode (1:7 duty cycle) SAR1g = 0.08 W/kg

These two modes are capable of simultaneous transmission. Using the most recent IEC 62209 proposal for simultaneous transmission (enclosed), the 1-gram average SAR was determined. Steps 6.4.1.1 to 6.4.1.5 of that document are described and followed as shown below.

6.4.1.1 Measure area and zoom scans at each frequency

Figure 1 shows the SAR distribution from the area scan for the GSM 900 mode. The solid and dashed blue boxes represent the location of the peak 1-gram average SAR and the location of the zoom scan, respectively.

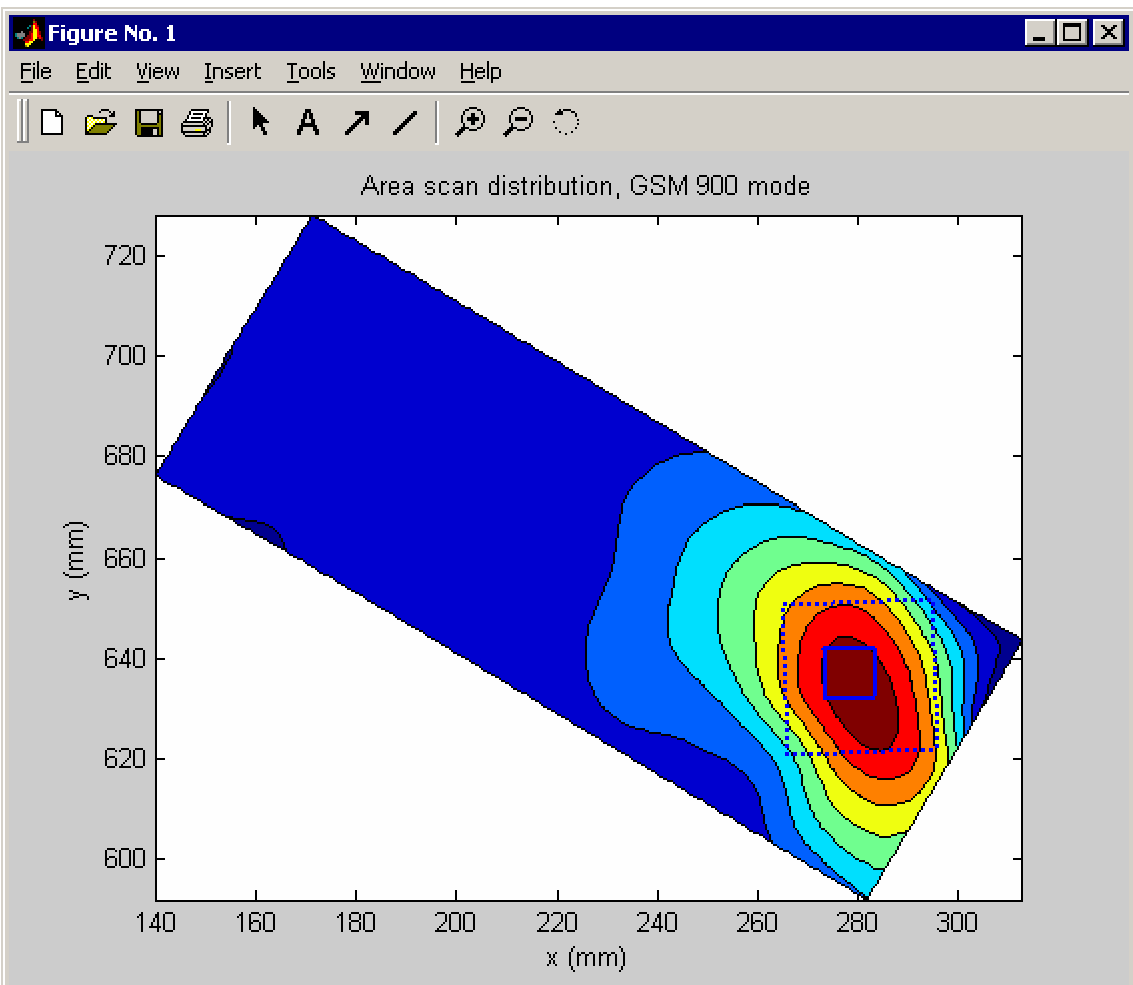
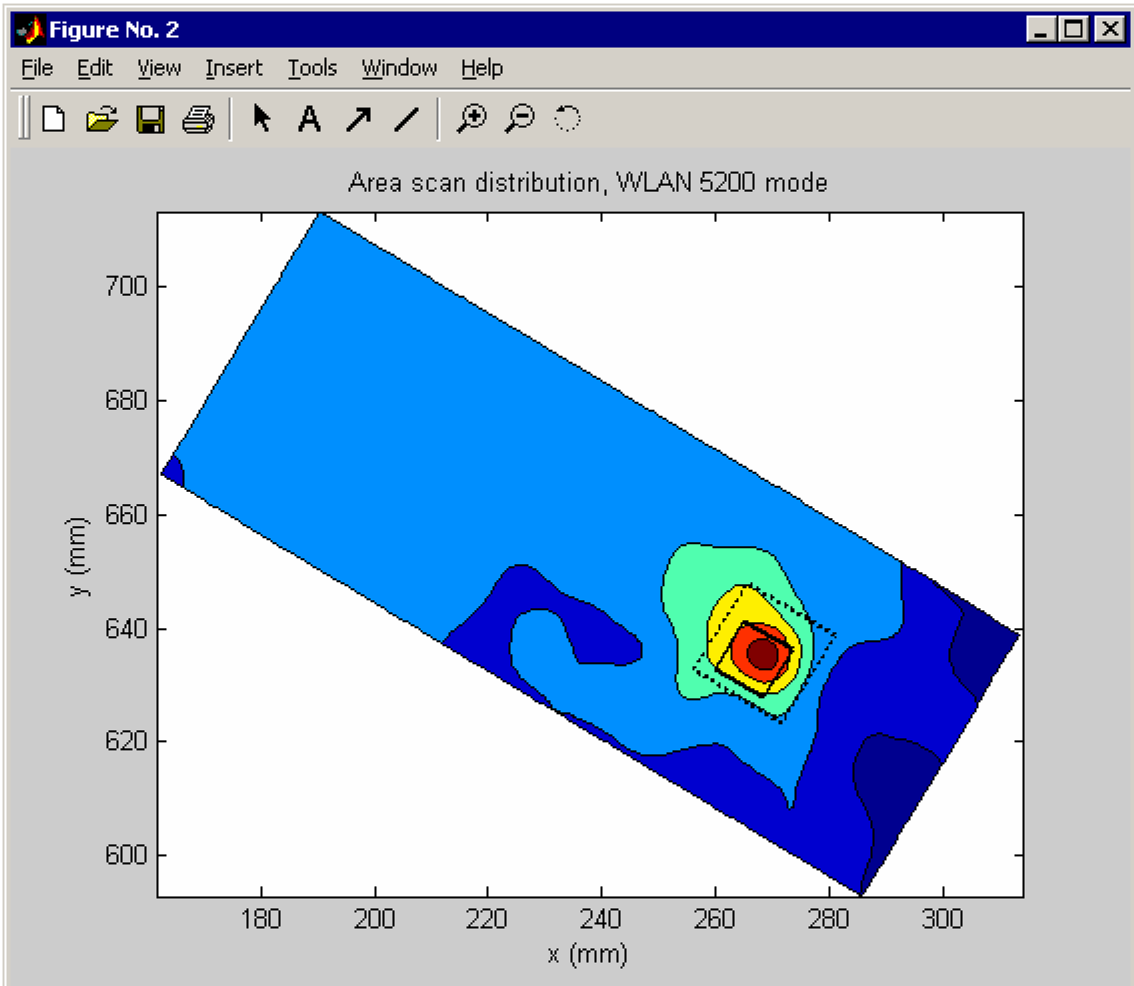


Figure 2 shows the SAR distribution from the area scan for the WLAN 5200 mode. The solid and dashed black boxes represent the location of the peak 1-gram average SAR and the location of the zoom scan, respectively.

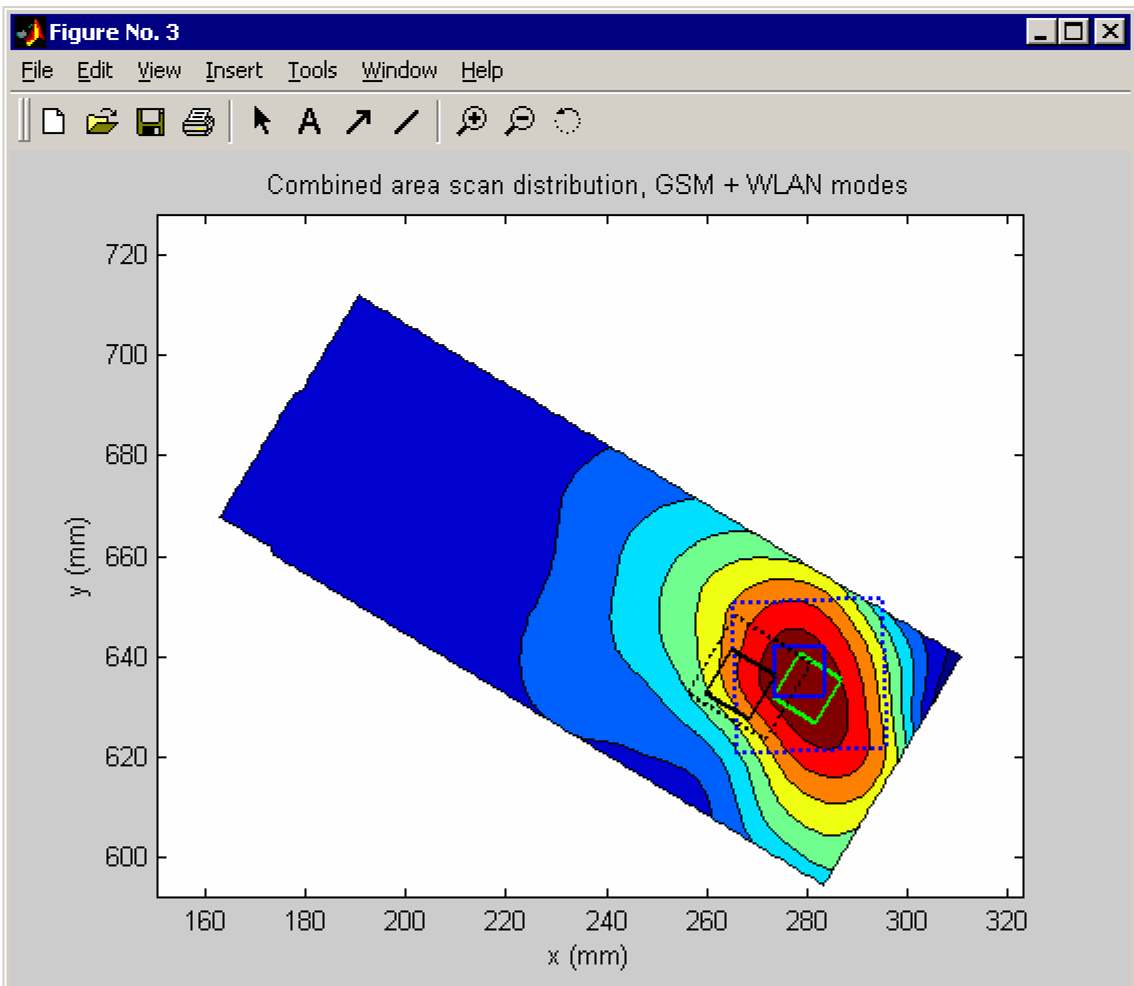


6.4.1.2. Add the peak spatial-average SAR values together

Adding these values (including drift) gives a conservative SAR value of 1.57 W/kg.

6.4.1.3. Determine whether it is possible to spatially add the zoom scans together

Figure 3 shows the combined area scan from the GSM and WLAN modes, taken by summing the individual GSM and WLAN distributions together. As expected, the combined area scan resembles that of the GSM mode. The blue and black lines represent the zoom scan distributions as in Figs. 1 and 2. It can be seen that the two zoom scans do not overlap enough to be able to spatially add the zoom scan distributions.



6.4.1.4. Spatially add the zoom scans if possible

This is not possible (see 6.4.1.3).

6.4.1.5.a) Create virtual SAR data from the area scans.

An estimate of the 1-gram average SAR was determined from the area scans. The location of this 1-gram volume is shown by the solid green lines in Fig. 3.

The 1-gram average SAR from this algorithm is 1.51 W/kg. As expected, this value is slightly higher than the 1-gram average SAR for the GSM mode alone, and less than the sum of the 1-gram average SAR values for the GSM and WLAN modes.

6.4.1 Multi-frequency simultaneous transmission

Wireless devices exist that can transmit at multiple frequencies at the same time. An example of this is a cellular telephone that can simultaneously transmit a cellular telephone signal (e.g., at 900 MHz) and a wireless LAN signal (e.g., at 2450 MHz). It is possible that such a device may be compliant with the regulatory SAR limit at each frequency while the composite SAR from simultaneous transmission is above the limit. Therefore, the accurate determination of the SAR in this situation is important. Given that the tissue simulating liquid and the probe calibration are frequency dependent, it is recommended that separate SAR measurements (area and zoom scans) are performed at each frequency as per IEC 62209 part 1 [1], then the SAR distributions are added. This will give the most accurate estimate of the SAR. However, in some circumstances a conservative estimate of the SAR can be determined by performing a single measurement in one tissue equivalent liquid with all transmitters turned on simultaneously. The following procedure is designed to estimate the SAR from simultaneous transmitters while saving measurement time (see also the flow chart of Fig. 6.4.2).

6.4.1.1. Measure the area and zoom scans at each frequency, as per IEC 62209 part 1 [1].

6.4.1.2. Add the peak spatial-average SAR values together. This will give a conservative value for the SAR of simultaneous transmission. If desired, record this value and stop. Otherwise, continue to step 6.4.1.3.

6.4.1.3. Determine whether it is possible to spatially add the zoom scan distributions together. This is true if:

a) The zoom scans overlap enough to contain the averaging volume (1g or 10g) plus additional volume to ensure that the peak spatial-average SAR is not adjacent to a boundary of the combined zoom scan (see Fig. 6.4.1), and

b) The combined zoom scan is located over the estimate of the peak location. The estimate the peak location of the summed SAR distributions is determined by adding the area scans together spatially. If the area scans are not aligned in x and/or y, interpolation is necessary. If the area scans were not measured in the same z plane, they must be first aligned before adding the distributions. While aligning the distributions, scaling must be done to account for the decay of the field in the z direction.

If it is possible to spatially add the zoom scans together, go to step 6.4.1.4, otherwise go to step 6.4.1.5.

6.4.1.4. Add the zoom scan distributions together spatially. If the measurement grids are not aligned, interpolation is necessary. Calculate the peak mass-averaged SAR from the combined zoom scan of step 6.4.1.3 as per IEC 62209 part 1 [1]. Record this value and stop.

6.4.1.5 At each frequency, generate volumetric SAR data in one of the following ways:

a) Create virtual zoom scan data from each area scan using the decay data in the corresponding zoom scan (e.g., as described in [2]). The same decay is applied across the area scan to create a volume of SAR data covering the entire area scan as if a large zoom scan was measured there. This method takes less time than the method in step 6.2. The uncertainty of this method is described in [2]. Add the virtual zoom scans spatially, using interpolation if necessary, and find the peak mass-averaged SAR as per IEC 62209 part 1 [1]. If the estimated SAR from this method is greater than the applicable SAR limit minus the uncertainty of the method ($k = 2$), go to step 6.4.1.5 b), otherwise, record this value and stop.

b) Re-measure the zoom scans at each frequency centered at the peak location determined in step 6.4.1.3. This method has a lower measurement uncertainty than the method of step 6.4.1.5 a), but it takes at least twice as long. Larger zoom scan volumes may be necessary to ensure that the combined peak mass-averaged SAR is captured. Note that the longer the measurement time, the larger the potential power drift of the DUT, due to the finite battery capacity. Also, some devices may not be able to maintain transmission at the peak power level for a long time. Add the zoom scans of step 6 spatially, using interpolation if necessary, and find the peak mass-averaged SAR as per IEC 62209 part 1 [1].

c) Measure one zoom scan with all transmitters transmitting simultaneously. For this method, the following conditions must be met:

- The calibration coefficient of the electric field probe is chosen to be the one associated with the lowest transmit frequency (and the corresponding tissue equivalent liquid)

- The tissue equivalent liquid must have a conductivity that is not less than the target conductivity range at each frequency transmitted.
- When calculating the SAR from the measured electric field, the value of conductivity used must be at least the highest target value for the frequencies transmitted.
- The device under test must be capable of transmitting simultaneously at the maximum power setting at each frequency (with a total drift within

The advantage of this method over the method of 6.4.1.5 b) is that it consumes less measurement time. However, this is an uncalibrated measurement in which the measurement uncertainty is unknown (the uncertainty depends on the relative SAR values at each frequency, which varies from point to point). Nevertheless, this method will produce a conservative estimate of SAR that outweighs the uncertainty issue.

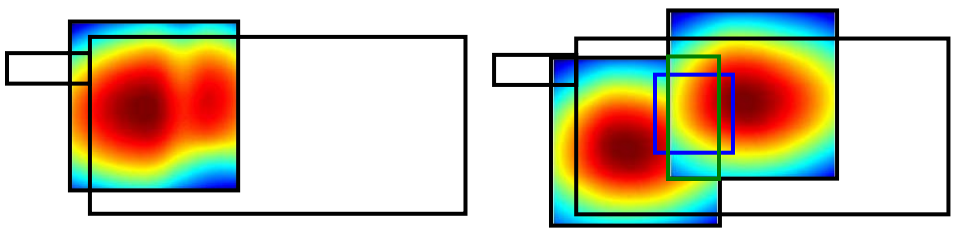


Fig. 6.4.1: Two examples showing the zoom scans of a handset at two different frequencies, where the zoom scans overlap completely (left) or overlap slightly (right, overlap area shown in green) but not enough to contain the entire averaging volume (shown in blue).

References:

[1] IEC 62209, Procedure to measure the Specific Absorption Rate (SAR) in the frequency range of 300 MHz to 3 GHz – Part 1: hand-held mobile wireless communication devices, Draft standard, 2004

[2] M.Y. Kanda, M.G. Douglas, E. Mendivil, M. Ballen, A.V. Gessner, C.K. Chou, “Faster Determination of Mass-Averaged SAR from 2-D Area Scans” accepted for publication in *IEEE Transactions on Microwave Theory and Techniques*, September 2004.

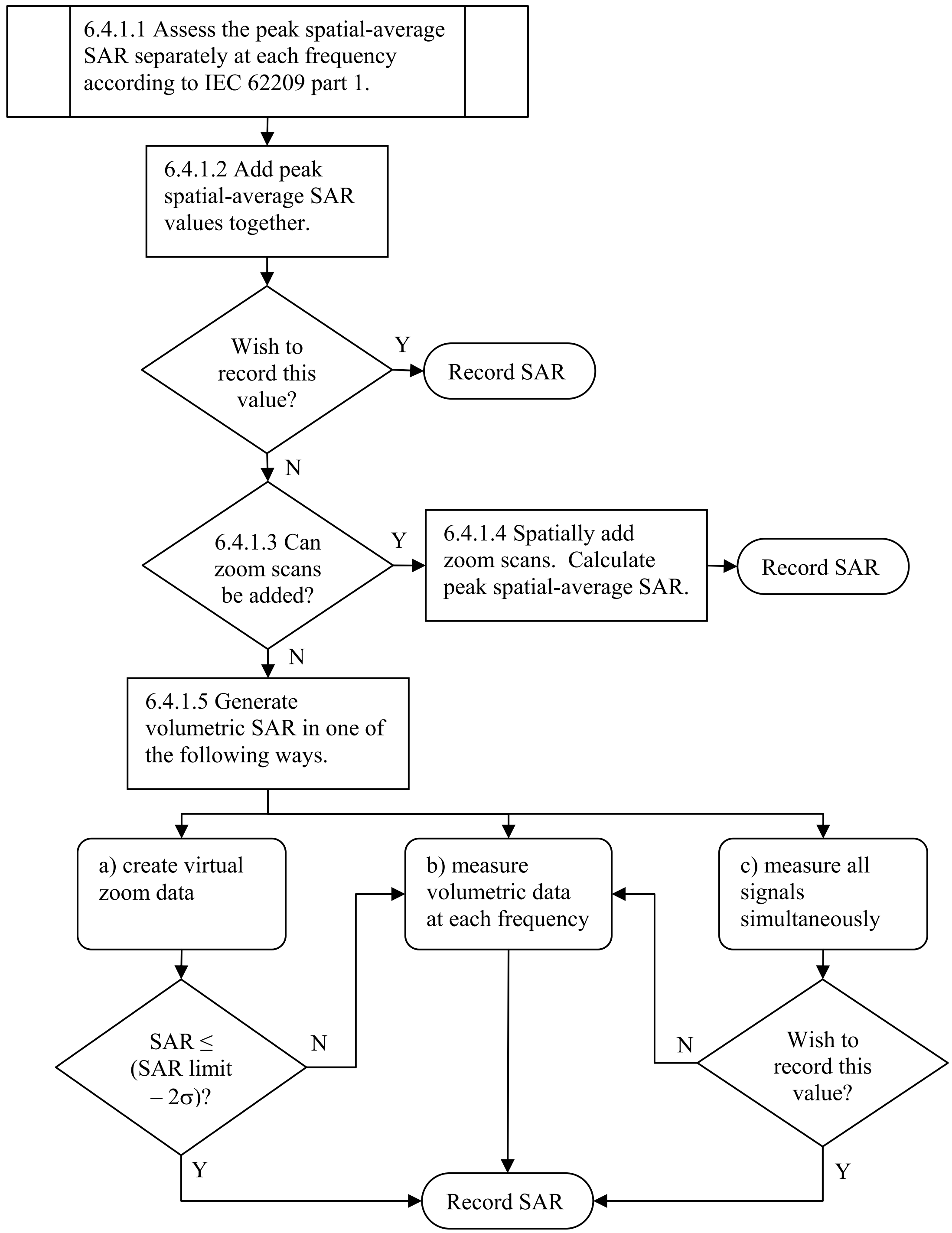


Fig. 6.4.2. Flow chart of the process of section 6.4.

Procedure for Assessing 1-gram Average SAR at 5 GHz

Mark Douglas

Introduction

This report gives procedures to be used when performing peak 1-gram averaged SAR measurements on the DASY3 system at frequencies in the range 5 – 6 GHz. These internally-developed procedures follow the latest guidance available from IEC 62209 Part 2 [1].

Background

Although standardized methods of measuring SAR exist for frequencies in the range 300 – 3000 MHz, standard methods have not yet been defined for the 3 – 6 GHz range. Recommendations are currently being accepted for IEC 62209 part 2 [1] on protocols for SAR measurements at these frequencies. Some proposals have been made (e.g., [2]), but this is still a work in progress.

As explained in [3], changes to the zoom scan volume and post-processing are needed at this frequency range. Reference [3] draws the following conclusions:

- A 7 x 7 x 7 point volume for the zoom scan has been defined that gives accurate results within a reasonable measurement time. It is also necessary to account for weak, noisy data during post-processing.
- The recommended resolution of this zoom scan volume is $\Delta x \leq 3.5$ mm, $\Delta y \leq 3.5$ mm and $\Delta z \leq 2$ mm.
- Due to the steep gradients at this frequency, the extrapolation was performed using a polynomial fit to the logarithm of the SAR data. This has been found to give much more accurate results than using a 4th-order polynomial fit to the raw SAR data (error of 0.8% vs 14%, see [3]).
- The post-processing uncertainty using the zoom scan volume and extrapolation method described above has been determined to be 2.1%.
- The zoom scan volume is not large enough to cover a 10-gram averaging volume. A method of estimating the SAR in the region surrounding the zoom scan volume has been proposed.

Procedure

A peak 1-gram averaged SAR measurement at 5 - 6 GHz should be performed according to the following steps:

1. The phantom shall be filled with a tissue simulating liquid having dielectric properties within 10% of the values specified below (from [2]). If the proprietary liquid from SPEAG is used, SPEAG recommends that the liquid is stirred before every measurement.

Frequency (MHz)	Relative Permittivity (ε_r')	Conductivity (σ) (S/m)
5000	36.2	4.4
5200	36.0	4.7
5400	35.8	4.9
5800	35.3	5.3

2. A 3-D dosimetric E-field should be used having a probe tip diameter no greater than 4 mm (e.g., ES3DVx and EX3DVx probes from SPEAG can be used, but not ET3DVx probes; x is the version number of the probe: 1, 2, 3, etc.).
3. The minimum distance between the probe tip and the phantom inner surface shall be set to 1.3 mm for ES3DVx probes. Consult the manufacturer for other probe types.
4. During measurements, Reference, Drift and Surface Check jobs should be performed as per standard procedures at lower frequencies.
5. The Coarse scan shall have measurement resolution no greater than 9 mm in the *x* and *y* directions.
6. The zoom scan shall have a measurement resolution no greater than 3.5 mm in the *x* and *y* directions, and no greater than 2 mm in the *z* direction. The minimum size of the zoom scan shall be 7 x 7 x 7 points. For the DASY3 system, it is not possible to modify the Cube scan resolution. Therefore, a multi-layered Coarse scan should be performed. Modify the standard Coarse scan job to measure a zoom scan using the parameters described above.
7. Export the multi-layered Coarse scan from DASY3 to a text file. The header information and coordinates must be included in the exported file. Use at least 4 significant digits. The units must be displayed in mW/g.
8. Calculate the peak 1-gram averaged SAR from the exported text file, using the algorithm described in [3].

References

[1] IEC Project Team 62209, "Evaluation of Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices in the Frequency Range of 30 MHz to 6 GHz: Human models, Instrumentation, and Procedures," IEC 62209 Part 2: "Procedure to measure the Specific Absorption Rate (SAR) for two-way radios, palmtops, laptops, desktop computers, and body-mounted devices including accessories and multiple transmitters," Draft version 0.7, September 2003.

[2] N. Kuster, "SECOND DRAFT: Frequency extension to 5 – 6 GHz," input document to IEC 62209 Part 2, July 2003.

[3] M.G. Douglas, "Recommendations for SAR Zoom Scan Measurement Grid at 5 - 6 GHz," Motorola internal document, October 8, 2003 (attached). This document was submitted to IEC PT 62209 in October, 2003.

Recommendations for SAR Zoom Scan Measurement Grid at 5 - 6 GHz

Mark Douglas
October 8, 2003

Introduction
The purpose of this report is to define a fixed-resolution zoom scan measurement grid for SAR measurements at 5 - 6 GHz, as input to IEC 62209 part 2 [1]. It will be shown that a 7 x 7 x 7 point zoom scan volume with a resolution of 2 mm in the *z* direction and 3.5 mm in the *x* and *y* directions gives good results. Modifications to the extrapolation routine were needed in order to accurately extrapolate the high field gradients. The post-processing uncertainty using this algorithm is 2.1%.

Due to the higher field gradients at these frequencies, it is necessary to reduce the distance between measured points if one is to maintain the same measurement uncertainty for the peak spatial-average SAR. In a recent proposal [2], it was recommended that for zoom scan measurements a resolution of 2 mm in all directions should be used. No new recommendations were made in [2] for the size of the zoom scan volume, implying that the same 30 x 30 x 30 mm volume required in [3] applies. If a fixed 2 mm resolution is used throughout the zoom scan volume, a total of 16 points in each direction are needed. The measurement time required to scan a 16 x 16 x 16 point zoom scan volume is over 2 hours using a commercial SAR measurement system. This represents a large test time burden. It is also a problem in that many commercial products will not be able to maintain transmission at full power for that long. In our experience, zoom scan measurement times significantly greater than 30 minutes will not be practical.

It is actually recommended in [2] that the zoom scan uses a graded resolution rather than a fixed resolution. This would save considerable time. However, graded resolutions are not currently implemented in many commercially-available SAR measurement systems. With 5 GHz products currently being launched in the market, a fixed-resolution option is also needed.

Method
Using a DASY3 system from SPEAG, SAR measurements were made of a 5.2 GHz dipole antenna placed under a flat phantom. The liquid dielectric parameters were within 10% of the values given in [2]. Two three-dimensional grids were used: a 16 x 16 x 16 point grid (2 mm resolution in x, y and z) and a 11 x 11 x 11 point grid (3 mm resolution). The probe tip diameter was 3.9 mm and the closest spacing of the probe tip to phantom inner surface was 1.3 mm (sensor to phantom surface distance was 4 mm). During post-processing, data was interpolated onto a grid with a 1 mm resolution in each direction.

Results: Extrapolation
Figure 1 shows the measured SAR distribution in the z direction at the (x, y) center of the volume (the peak location in x and y). The measured points (blue crosses) are shown

together with two curve fits. The red line shows the result of 4th order extrapolation to z = 0 and spline interpolation. The green line shows an exponential fit.

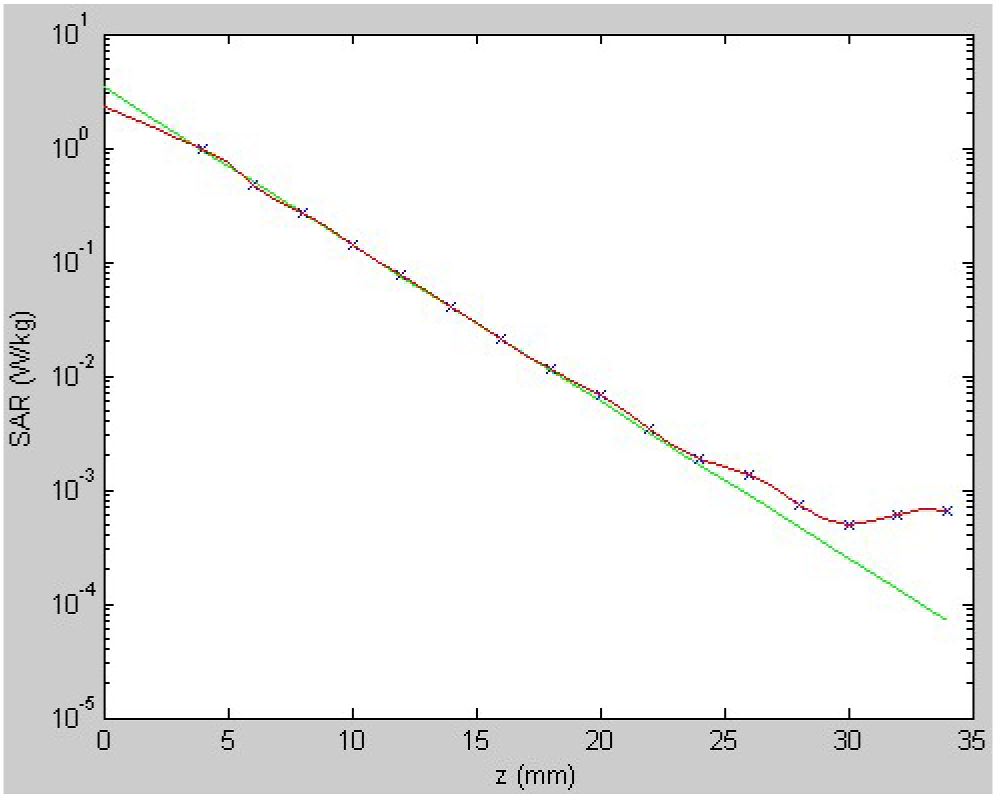


Fig. 1: SAR distribution in the z direction (16 points). Blue crosses represent measured data. Red line represents data after 4th order polynomial extrapolation and spline interpolation. Green line represents exponential fit.

From the data, the following can be observed:

- For z < 16 mm, the SAR decay has a distribution that is close to exponential, as expected. The exponential fit of this data is very good.
- For z > 16 mm, the signal becomes very weak, with local SAR values on the order of 10^{-2} or lower. These weak SAR values deviate from the exponential curve due to noise.

Using a 4th order extrapolation to all of the points results in an underestimation of the SAR at z = 0. This results in a 14% underestimation of the 1-gram average SAR (6.22 W/kg vs 7.20 W/kg using the exponential fit). Using other polynomial fits also results in underestimation. This is due to two effects:

1. Fitting to all of the points, including the noisy SAR data, causes ripple in the 4th order fit. Polynomial fitting algorithms are somewhat sensitive to noise.
2. Even without the noisy data, polynomials are not well-suited to fitting such steep exponential functions.

It is evident from Fig. 1 that there is more than a sufficient number of points to accurately represent the decay SAR(z) for the purpose of extrapolation and accurate determination of the mass-average SAR. Removing data points far from the phantom surface would also remove noisy data and reduce measurement time. Based on these results, it was decided to use 7 points rather than 16 points in the z direction. Further, SAR values of 10^{-2} or lower were removed from the data before extrapolation.

Removing noisy data is necessary but not sufficient to correct for the underestimation of the extrapolation to z = 0. In Fig. 2, a pure (noiseless) exponential function 4*exp(-z/2a), with a = 5 mm (as recommended in [2]) is shown. The measured data, represented by blue crosses, is extrapolated using a 4^{th} order polynomial. Some underestimation is still evident. Since we know that this data has an exponential decay, an exponential fit would be more appropriate (equivalent to a linear fit to the logarithm of the data). However, in the general case the decay may not be purely exponential. Therefore, it was decided to use a 3^{rd} order polynomial fit to the logarithm of the data. This result (shown in red) is directly on top of the exponential curve (in black), indicating a very good fit.

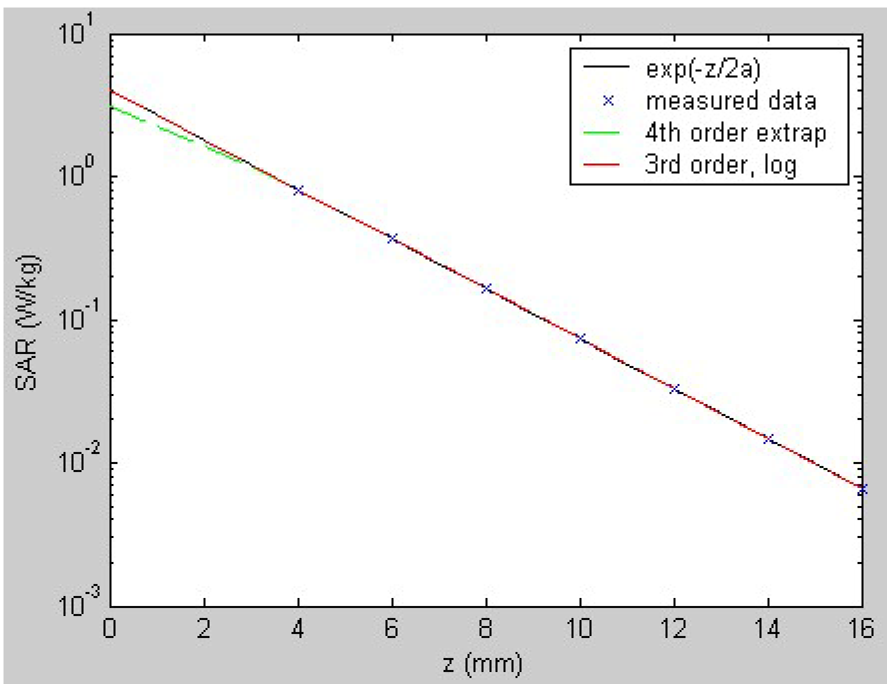


Fig. 2: Curve fitting of 4*exp(-z/2a) using two methods: 4^{th} order polynomial fit to SAR and 3^{rd} order polynomial fit to log10(SAR).

The same algorithms were tested on function f_3 in [1] with the decay constant changed to a = 5 mm, as recommended in [2]. This function is steeper than exponential. Therefore, it is particularly challenging and should result in a conservative estimate of the post-processing uncertainty compared with most SAR distributions at this frequency. Note that the dipole data of Fig. 1 is approximately equivalent to using f_3 with a = 6.5 mm. Therefore, f_3 with a = 5 mm is conservative for this case. It can be seen in Fig. 3 that the 3^{rd}-order logarithmic fit is better than the 4^{th}-order fit. The underestimations of the peak 1-gram averaged SAR using both algorithms are 0.8% and 14%, respectively (measurement resolutions are $\Delta x = \Delta y = 3$ mm and $\Delta z = 2$ mm).

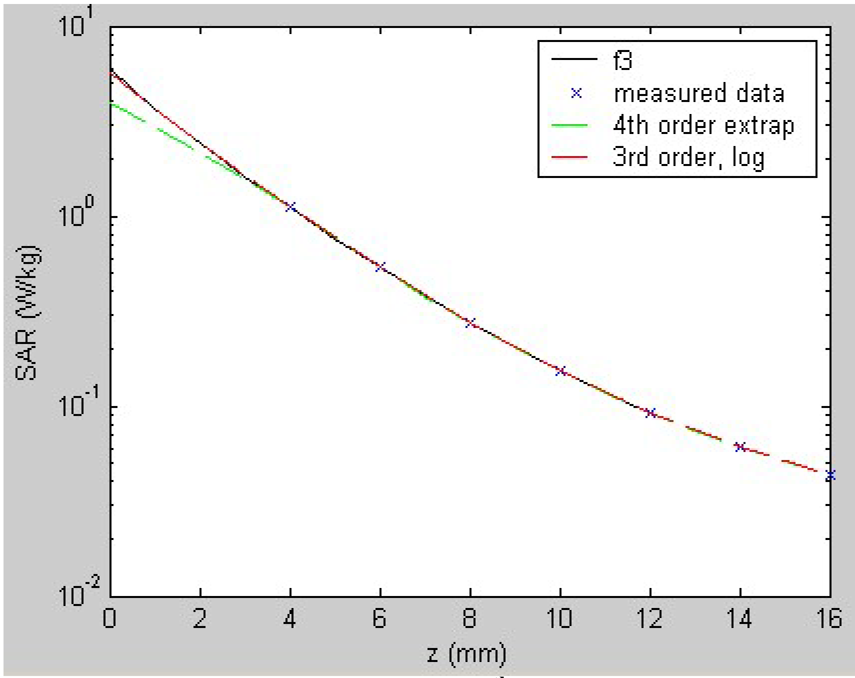


Fig. 3: Curve fitting of f_3 using two methods: 4th order polynomial fit to SAR and 3rd order polynomial fit to log10(SAR).

Figure 4 shows the effect of using the 3rd-order logarithmic fit on f_1, f_{x2} and f_3 in [2]. These functions are meant to represent the wide range of SAR distributions that may be observed for SAR compliance measurements. Black curves represent the pure functions, and the red curves represent the effect of taking measurements as described above and extrapolating using the 3rd-order logarithmic fit. For f_1, which has a decay of exp(-z/a), the fit is near perfect, as expected. For f_{x2}, where the peak SAR is not at the surface, the extrapolation results in a slight SAR overestimation.

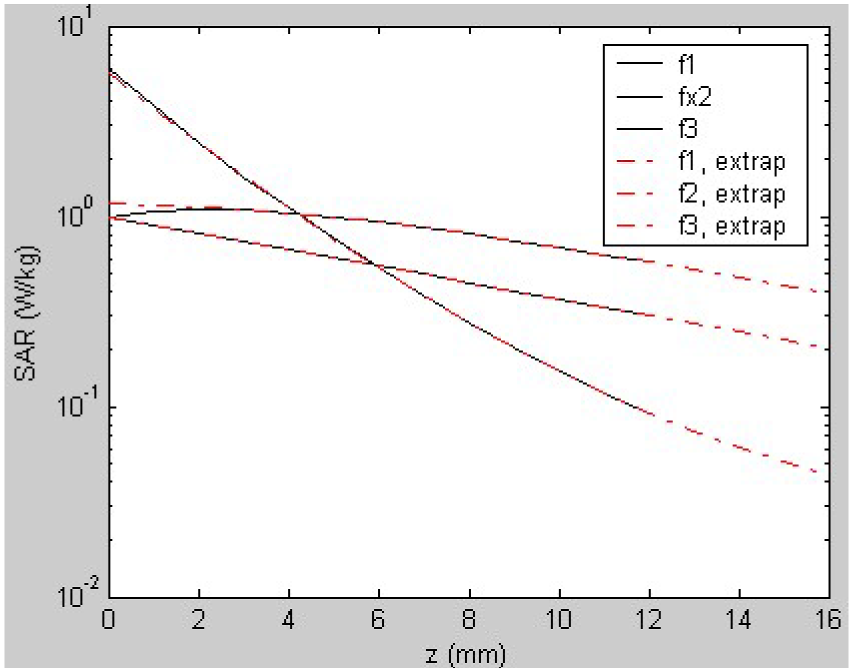


Fig. 4: Curve fitting of f_1, f_{x2} and f_3 using a 3rd order polynomial fit to log10(SAR).

Results: Zoom scan volume for 1-gram average SAR

The RMS uncertainty of post-processing using the 3rd-order logarithmic extrapolation, spline interpolation and trapezoidal integration was calculated according to the algorithm in [4] for the three reference functions f_1, f_{x2} and f_3 in [2], using a measurement resolution of $\Delta z = 2$ mm and a scan volume of 7 x 7 x 7 points. The resulting uncertainty values are shown in Table 1 for the 1-gram average SAR.

It can be seen in Table 1 that using $\Delta x = \Delta y = 2$ mm rather than 3 mm does not have a significant effect on the post-processing uncertainty. This is true for both 4th-order and 3rd-order logarithmic extrapolation algorithms. Even with $\Delta x = \Delta y = 3.5$ mm the post-processing uncertainty is relatively low when the 3rd-order logarithmic fit is used. The use of a larger resolution is preferred, as it covers more area (21 x 21 mm for a 3.5 mm resolution, as compared to 12 x 12 mm for a 2 mm resolution) and significantly reduces the risk that the peak SAR will not be captured. Note that the slight non-monotonic behavior of the data is due to round off errors and the finite resolution of the displacement *d* of the peak from [4].

Extrapolation	Δx, Δy (mm)	Uncertainty		
		f_1	f_{x2}	f_3
4th order	2	0.2%	0.6%	14%
“	3	0.2%	0.8%	14%
3rd order log	2	0.1%	1.5%	0.2%
“	3	0.1%	1.6%	0.8%
“	3.5	0.2%	1.5%	2.1%
“	4	0.1%	1.9%	4.1%

Table 1: Effect of measurement resolution in x and y on the post-processing uncertainty using the three reference functions (1-gram averaged SAR).

Table 2 shows the effect of increasing the number of points in x and y on the post-processing uncertainty (using 3rd-order logarithmic fit and $\Delta x = \Delta y = 3.5$ mm). The effect is very small. Therefore, using a 7 x 7 x 7 point grid is reasonable.

Cube size	Uncertainty		
	f_1	f_{x2}	f_3
7 x 7 x 7	0.2%	1.5%	2.1%
8 x 8 x 7	0.2%	1.5%	2.0%
10 x 10 x 7	0.2%	1.6%	1.8%

Table 2: Effect of the number of measurement points in x and y on the post-processing uncertainty for the three reference functions.

It is not recommended to increase Δz from 2 mm. Using $\Delta z = 3$ mm with $\Delta x = \Delta y = 3.5$ mm, the post-processing uncertainty of f_3 increases to 9.1%.

Results: Zoom scan volume for 10-gram average SAR

Note that the 7 x 7 x 7 point zoom scan with $\Delta x = \Delta y = 3.5$ mm and $\Delta z = 2$ mm covers a volume of 21 x 21 x 16 mm after extrapolation. This volume is sufficient for computing the 1-gram average SAR, but not for the 10-gram average SAR. For the 10-gram average SAR, more points in x, y and z are needed. The most accurate way to acquire the missing data in the z direction is to extrapolate the existing data. This is more accurate than measuring these points, as the measured data is likely to be noisy. To acquire the missing data in the x and y directions, there are three possibilities:

1. Measure a larger zoom scan volume. For example, use a 10 x 10 x 7 grid. This is not preferred, as it significantly increases the measurement time.
2. Extrapolate the measured data in the x and y dimensions. This may not be a good approach, especially if there are secondary peaks. In general, the SAR distribution in the x and y directions is complex and does not follow a simple rule, as it does in the z direction.
3. Use the SAR data from the area scan to determine the SAR distribution in x and y directions for the area surrounding the cube. Since this data exists for one plane only, no information about the decay in the z direction exists. However, it can be assumed that the decay in the z direction for the area scan data has the same characteristics as the decay for the zoom scan. A similar approach has been investigated and found to be very accurate [5, 6].

The third option is the recommended approach. The uncertainty of applying this approach must be documented and added to the uncertainty budget.

Conclusions:

For SAR measurements at 5 - 6 GHz, recommendations have been made for the resolution and size of the zoom scan volume, and methods for accurately extrapolating the measured data have been defined. The following conclusions have been drawn:

- A 7 x 7 x 7 point volume for the zoom scan has been defined that gives accurate results within a reasonable measurement time. It is also necessary to ignore weak, noisy data during post-processing.
- The recommended resolution of this zoom scan volume is $\Delta x = \Delta y = 3.5$ mm and $\Delta z = 2$ mm.
- Due to the steep gradients at this frequency, the extrapolation was performed using a polynomial fit to the logarithm of the SAR data. This has been found to give much more accurate results than using a 4^{th}-order polynomial fit to the raw SAR data (error of 0.8% vs 14%).
- The post-processing uncertainty using the zoom scan volume and extrapolation method described above has been determined to be 2.1%.
- The zoom scan volume is not large enough to cover a 10-gram averaging volume. A method of estimating the SAR in the region surrounding the zoom scan volume has been proposed.

References:

[1] IEC Project Team 62209, "Evaluation of Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices in the Frequency Range of 30 MHz to 6 GHz: Human models, Instrumentation, and Procedures," IEC 62209 Part 2: "Procedure to measure the Specific Absorption Rate (SAR) for two-way radios, palmtops, laptops, desktop computers, and body-mounted devices including accessories and multiple transmitters," Draft version 0.7, September 2003.

[2] N. Kuster, "SECOND DRAFT: Frequency extension to 5 – 6 GHz," input document to IEC 62209 Part 2, July 2003.

[3] IEC Project Team 62209, "Procedure to measure the Specific Absorption Rate (SAR) in the frequency range of 300 MHz to 3 GHz – Part 1: hand-held mobile wireless communication devices," Committee voting draft, August 2003.

[4] IEEE Standards Coordinating Committee 34, "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques," IEEE 1528, October 2003.

[5] M.Y. Kanda, M. Ballen, M.G. Douglas, A.V. Gessner and C.K. Chou, "Fast SAR determination of gram-averaged SAR from 2-D coarse scans," *Abstract Book of the Bioelectromagnetics Society 25th Annual Meeting*, June 22-27, 2003.

[6] M.G. Douglas, M.Y. Kanda and C.K. Chou, "Post-processing errors in peak spatial average SAR measurements of wireless handsets," *Abstract Book of the Bioelectromagnetics Society 25th Annual Meeting*, June 22-27, 2003.