

CERTIFICATION REPORT

Subject: **Specific Absorption Rate (SAR) Experimental Analysis for the Bystander**

Product: Wireless Point of Sale Terminal with a Novatel NRM-6832 Expedite Wireless IP Modem

Model: Nurit 3010, CDPD

Client: Lipman USA Inc.

Address: 50 Gordon Dr.
Syosset, NY 11791 USA

Project #: LPMB-Nurit 3010 CDPD-3507B

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FCC ID: O2SNURIT3010C
 Applicant: Lipman USA Inc.
 Equipment: Wireless Point of Sale Terminal with a Novatel NRM-6832 Expedite Wireless IP Modem
 Model: Nurit 3010, CDPD
 Standard: FCC 96 –326, Guidelines for Evaluating the Environmental Effects of Radio-Frequency Radiation

ENGINEERING SUMMARY

This report contains the results of the engineering evaluation performed on a Lipman Nurit 3010 wireless point of sale terminal (POS) which incorporates a Novatel NRM-6832 Expedite Wireless IP Modem. This report is supplementary to the engineering evaluation for user's hand exposure, report LPMB-Nurit 3010 CDPD-3507U. The measurements were carried out in accordance with FCC 96-326. The POS was evaluated at its nominal maximum power level (power level 2) with 100% duty factor.

For the SAR Analysis for the Bystander, the Lipman Nurit 3010 wireless point of sale terminal (POS) was tested at low, middle and high channels with the antenna oriented in two positions (at the antenna side of the terminal, 0°, and pointing straight out, 180°) as well as the keyboard, battery, antenna, right and top sides. The maximum SAR (6.18 W/kg) was found to coincide with the peak performance RF output power of channel 400 (middle, 837 MHz), with the antenna side of the DUI facing up against the bottom of the phantom and the antenna pointing straight out. Test data and graphs are presented in this report.

Based on the test results and on how the device will be used, with the duty factor of the POS intrinsically limited to less than 7% (see Appendix F), it is certified that the product meets the requirements as set forth in the above specifications, for an uncontrolled RF partial body exposure environment.

(The results presented in this report relate only to the sample tested.)



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1. INTRODUCTION

Tests were conducted to determine the Specific Absorption Rate (SAR) of a sample of a Lipman Nurit 3010 wireless point of sale terminal (POS), which incorporates a Novatel NRM-6832 Expedite Wireless IP Modem. These tests were conducted at APREL Laboratories' facility located at 51 Spectrum Way, Nepean, Ontario, Canada. A view of the SAR measurement setup can be seen in Appendix A Figure 1. This report describes the results obtained.

2. APPLICABLE DOCUMENTS

The following documents are applicable to the work performed:

- 1) FCC 96-326, Guidelines for Evaluating the Environmental Effects of Radio-Frequency Radiation
- 2) ANSI/IEEE C95.1-1992, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.
- 3) ANSI/IEEE C95.3-1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave.
- 4) OET Bulletin 65 (Edition 97-01) Supplement C (Edition 97-01), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields".

3. EQUIPMENT UNDER INVESTIGATION

- Lipman Nurit 3010 wireless point of sale terminal (POS), s/n 86U04 5907107, received on 24 July 2000.

The POS will be called DUI (Device Under Investigation) in the following.

The DUI is intended to be used in the hand and may be carried in a case that hooks onto a belt. The antenna is a 5in centre-fed half-wavelength dipole with a gain of 1 dB.



A photograph of the DUI can be found in Appendix B. See the manufacturer's submission documentation for drawings and more design details.

4. TEST EQUIPMENT

- APREL Triangular Dosimetric Probe Model E-009, s/n 115, Asset # 301420
- CRS Robotics A255 articulated robot arm, s/n RA2750, Asset # 301335
- CRS Robotics C500 robotic system controller, s/n RC584, Asset # 301334
- APREL F-1, flat manikin, s/n 001
- Tissue Recipe and Calibration Requirements, APREL procedure SSI/DRB-TP-D01-033
- HP 438A power meter, s/n 2502A01684, Asset # 301417
- HP 8482A power sensor, s/n 2652A1512B, Asset # 301418
- Toshiba Laptop computer Satellite ProTM 400S (to setup device via RS232 port)

5. TEST METHODOLOGY

1. The test methodology utilised in the certification of the DUI complies with the requirements of FCC 96-326 and ANSI/IEEE C95.3-1992.
2. The E-field is measured with a small isotropic probe (output voltage proportional to E^2).
3. The probe is moved precisely from one point to the next using the robot (10 mm increments for wide area scanning, 5 mm increments for zoom scanning, and 2.5 mm increments for the final depth profile measurement).
4. The probe travels in the homogeneous liquid simulating human tissue. Appendix D contains information about the recipe and properties of the simulated tissue used for these measurements.
5. The liquid is contained in a manikin simulating a portion of the human body.



6. The DUI is positioned with the surface under investigation against the phantom.
7. All tests were performed with the highest power available from the sample DUI under transmit conditions.

More detailed descriptions of the test method is given in Section 6 when appropriate.

6. TEST RESULTS

6.1. TRANSMITTER CHARACTERISTICS

The battery-powered DUI will consume energy from its batteries, which may affect the DUI's transmission characteristics. In order to gage this effect the output of the transmitter is sampled before and after each SAR run. In the case of this DUI, which does not have an externally accessible feedpoint, the radiated power was sampled. A power meter was connected to an antenna adjacent to a fixture to hold the transmitter in a reproducible position. The following table shows the radiated RF power sampled before and after each of the six sets of data used for the worst case SAR in this report.

Table 1. Sampled Radiated RF Power

Scan		Relative Power Reading (dB)	Battery #
Type	Height (mm)		
Area	2.5	-0.3	10
Area	12.5	-0.2	-
Zoom	2.5	-	-
Zoom	7.5	-	-
Zoom	12.5	-0.5	-
Depth	2.5 – 12.5	-0.5	-



6.2. SAR MEASUREMENTS

- 1) RF exposure is expressed as a Specific Absorption Rate (SAR). SAR is calculated from the E-field, measured in a grid of test points as shown in Appendix A Figure 2. SAR is expressed as RF power per kilogram of mass, averaged in 10 grams of tissue for the extremities and 1 gram of tissue elsewhere.
- 2) The DUI was put into test mode for the SAR measurements via communications software supplied by the radio manufacturer running on a PC to control the channel and operating power (nominally power level 2).
- 3) Figure 3 in Appendix A shows a contour plot of the SAR measurements for the DUI (channel 400, middle, 837 MHz, antenna side, antenna pointing straight out, power level 2). The presented values were taken 2.5mm into the simulated tissue from the flat phantom's solid inner surface. Figures 1 and 2 show the flat phantom used in the measurements. A grid is shown inside the phantom indicating the orientation of the x-y grid used, with the co-ordinates (0,0) on the top left (orange dot). The x-axis is positive towards the bottom and the y-axis is positive towards the right. For this side of the DUI, the bottom was aligned with y = 1, and the antenna, with x = 2.

A different presentation of the same data is shown in Appendix A Figure 4. This is a surface plot, where the measured SAR values provide the vertical dimension, which is useful as a visualisation aid.

Similar data was obtained 12.5 mm into the simulated tissue. These measurements are presented as a contour plot in Appendix A Figure 5 and surface plot in Figure 6.

Figure 10 in Appendix A shows an overlay of the DUI's outlines, superimposed onto the contour plot previously shown as Figure 3.

Figures 3 through 6 in Appendix A show that there is a dominant peak, in the contour plots, that diminishes in magnitude with depth into the tissue simulation.

- 4) For the SAR Analysis for the Bystander (Table 2), wide area scans were performed for the low (991, 824 MHz), middle (400, 837 MHz) and high (799, 849 MHz) channels. The antenna was also oriented in two positions: stowed (0°) and pointing straight out (180°), with the keyboard, battery, antenna, right and



top sides of the DUI facing up against the bottom of the phantom. The DUI was operating at maximum output power (power level 2) and 100% duty factor. The peak single point SAR for the scans were:

Table 2. SAR Measurements for the Bystander

DUI side	Antenna position	Channel			Peak SAR (W/kg)
		L/M/H	#	Freq (MHz)	
keyboard	extended (180°)	low	991	824	0.31
battery side	extended (180°)	low	991	824	0.28
antenna side	extended (180°)	low	991	824	5.09
right side	extended (180°)	low	991	824	0.63
antenna	extended (180°)	middle	400	837	5.89
antenna side	extended (180°)	high	799	849	5.83
antenna side	stowed (0°)	low	991	824	5.47
antenna	stowed (0°)	middle	400	837	6.70
antenna side	stowed (0°)	high	799	849	5.43
top side	stowed (0°)	middle	400	837	0.12
battery side with carrier	stowed (0°)	middle	400	837	0.26

All subsequent testing for bystander exposure (or parts of the user other than extremities) was performed on channel 400 (middle, 837 MHz), with the antenna pointing straight out (180°) and the antenna side of the DUI against the phantom.

- 5) Wide area scans were then performed on channel 400 (middle, 837 MHz) versus separation at 100% duty factor. The peak single point SAR for the scans were:

Table 3. SAR versus DUI Separation

Channel			DUI to phantom's inner surface separation (mm)	Peak SAR (W/kg)
L/M/H	#	Freq (MHz)		
middle	400	837	13	2.33
			23	0.95
			33	0.45



- 6) Channel 400 (middle, 837 MHz) was then explored on a refined 5 mm grid in three dimensions. Figures 7, 8 and 9 show the measurements made at 2.5, 7.5 and 12.5 mm, respectively. The SAR value averaged over 1 gram was determined from these measurements by averaging the 27 points (3x3x3) comprising a 1 cm cube. The maximum SAR value measured averaged over 1 gram was determined from these measurements to be 4.54 W/kg.
- 7) To extrapolate the maximum SAR value averaged over 1 gram to the inner surface of the phantom a series of measurements were made at a few (x,y) co-ordinates within the refined grid as a function of depth, with 2.5 mm spacing. Figure 11 in Appendix A shows the data gathered and the exponential curves fit to them. The average exponential coefficient was determined to be $(-0.064 \pm 0.007) / \text{mm}$.
- 8) The distance from the probe tip to the inner surface of the phantom for the lowest point is 2.5 mm. The distance from the probe tip to the tip of the measuring dipole within the APREL Triangular Dosimetric Probe Model E-009 is 2.3 mm. The total extrapolation distance is 4.8 mm, the sum of these two.

Applying the exponential coefficient over the 4.8 mm to the maximum SAR value averaged over 1 gram that was determined previously, we obtain **the maximum SAR value at the surface averaged over 1 gram, 6.18 W/kg**.

7. SEPARATION AT 100% DF

The measurements of highest local SAR versus separation of the DUI from the bottom of the phantom (Section 6.2.5) will enable the maximum 1g SAR measured for a separation of 3 mm (previous section) to be interpolated for other separations.

If the data for Figure 11 is fitted to an exponential equation we get:

$$\text{Peak Local SAR} = 7.874 e^{-0.0888 * (\text{separation})}$$

A similar equation will exist for the maximum 1g SAR versus separation:

$$\text{Maximum 1g SAR} = k e^{-0.0888 * (\text{separation})}$$



Using this equation with the previous section's data:

Maximum 1g SAR at the surface = 6.18 W/kg
Tissue to DUI separation = 3 mm,

results in a $k = 8.064$ W/kg, which corresponds to the maximum 1g SAR when the separation is 0 mm. A conservative maximum 1g SAR of 1.18 W/kg (1.6 W/kg reduced by our measurement uncertainty) would occur for a separation of 21.6 mm.

At a standard separation distance of 4 cm the maximum 1g SAR would be 0.23 W/kg.

8. DUTY FACTORS

The manufacturer's software limits the operation further to 6.9% (see Appendix F).

The test software supplied by Novatel Wireless permitted the SAR testing to be performed with a duty factor of 100%. However, testing with a duty factor of 6.9% was not possible.

Consequently, the maximum 1g SAR for the end product, with a maximum 6.9% duty factor, has to be estimated using proportional scaling with respect to the duty factor. The **maximum 1g SAR value at the surface averaged over 1 gram is 0.43 W/kg.**

9. CONCLUSIONS

The maximum Specific Absorption Rate (SAR) averaged over 1 gram, determined at 837 MHz (channel 400, middle, antenna side, antenna pointing straight out, power level 2) of the Lipman Nurit 3010 wireless point of sale terminal (POS), which incorporates a Novatel NRM-6832 Expedite Wireless IP Modem operating with a 100% duty factor, is 6.18 W/kg. The overall margin of uncertainty for this measurement is $\pm 26.1\%$ (Appendix C). The SAR limit given in the FCC 96-326 safety guideline for uncontrolled RF partial body exposure (1.6 W/kg reduced by the measurement uncertainty) is 1.18 W/kg.

Since the POS duty factor is limited to 6.9% by the manufacture's (Lipman, see Appendix F) software, the maximum SAR averaged over 1 gram at this duty factor would be 0.43 W/kg.

Considering the above, this unit as tested, and as it will be marketed, with a duty factor of less than 7%, is found to be compliant with this requirement.



APPENDIX A. Measurement Setup and SAR Graphs

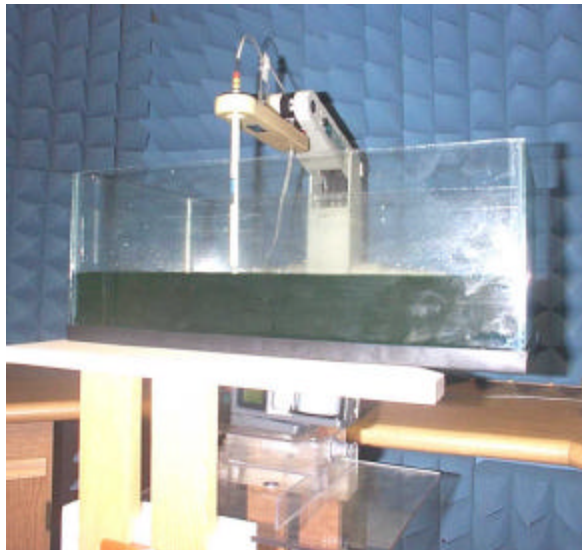


Figure 1. Setup and Close up of the Setup



Figure 2. Grid inside the Phantom

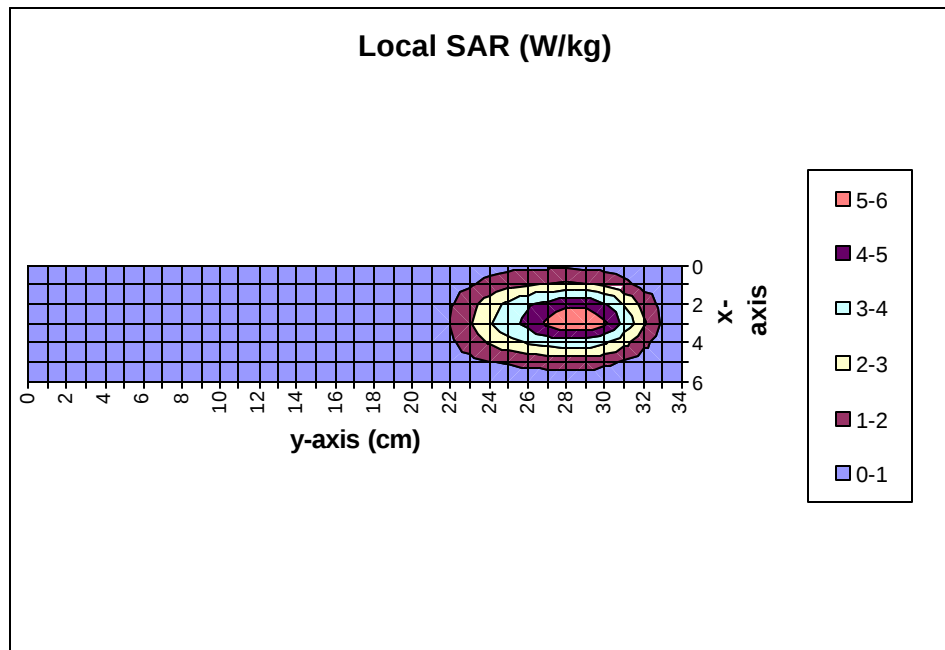


Figure 3. Contour Plot of the Area Scan 2.5mm Above Phantom Surface

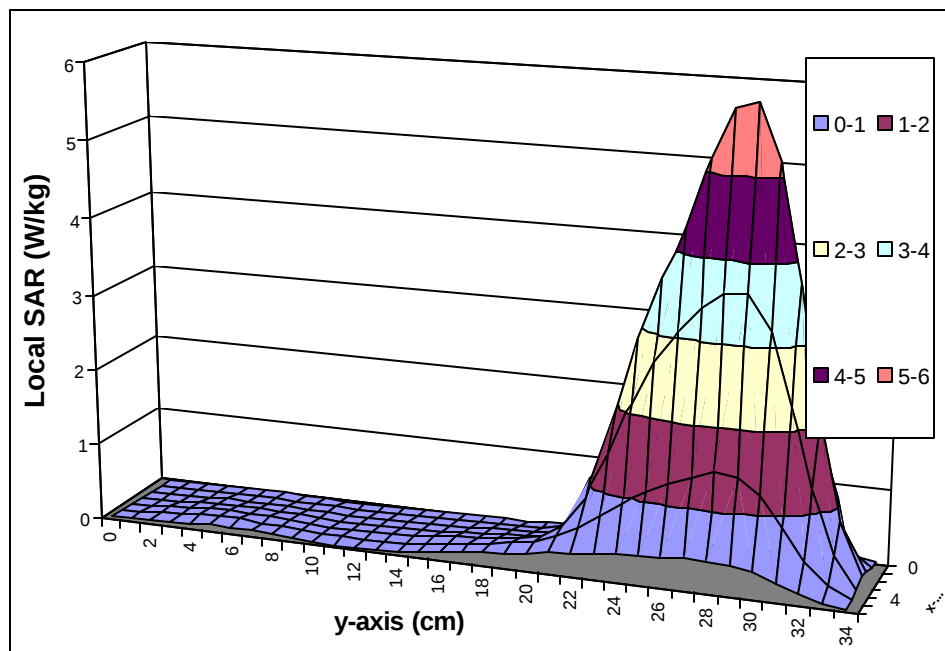


Figure 4. Surface Plot of the Area Scan 2.5mm Above Phantom Surface



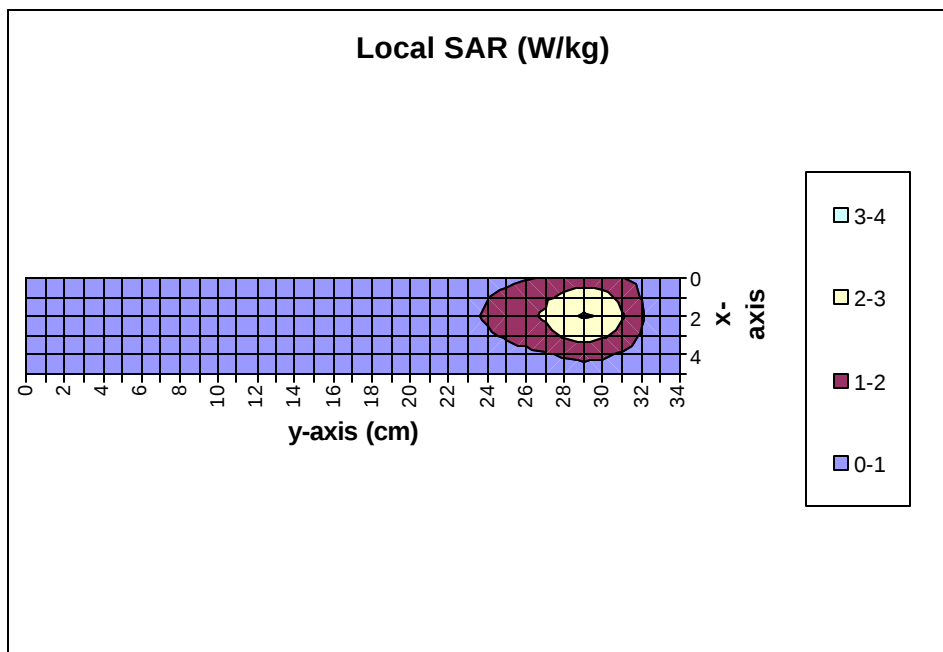


Figure 5. Contour Plot of the Area Scan 12.5mm Above Phantom Surface

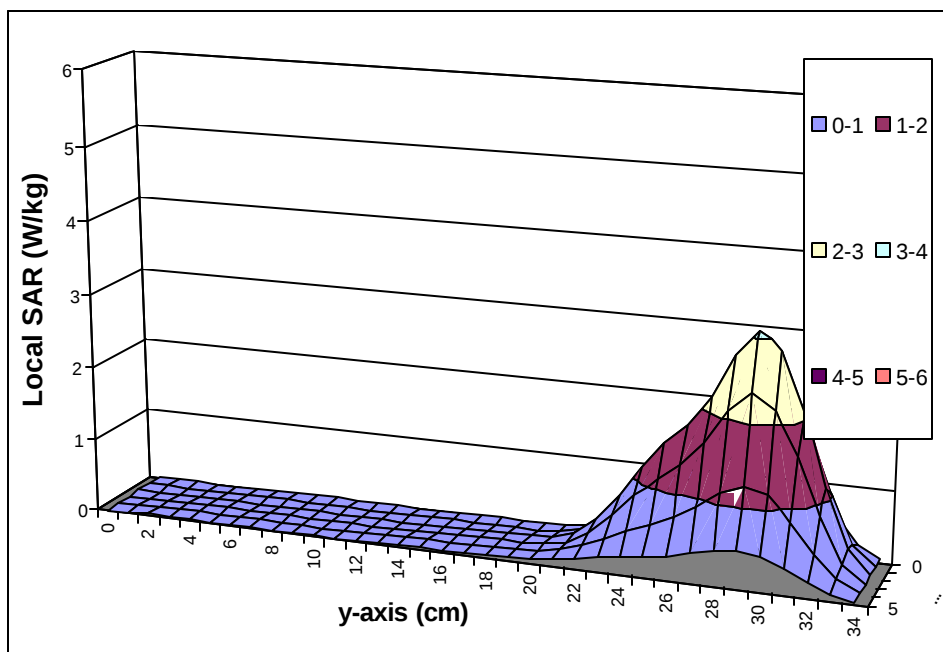


Figure 6. Surface Plot of the Area Scan 12.5mm Above Phantom Surface



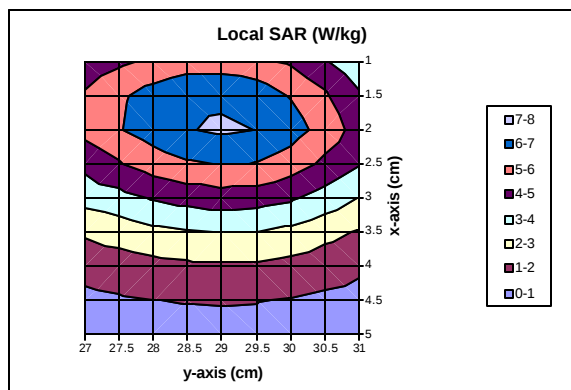


Figure 7. Zoom Scan 2.5mm Above Phantom Surface

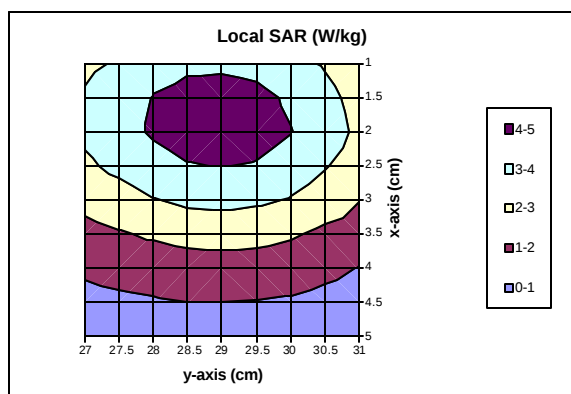


Figure 8. Zoom Scan 7.5mm Above Phantom Surface

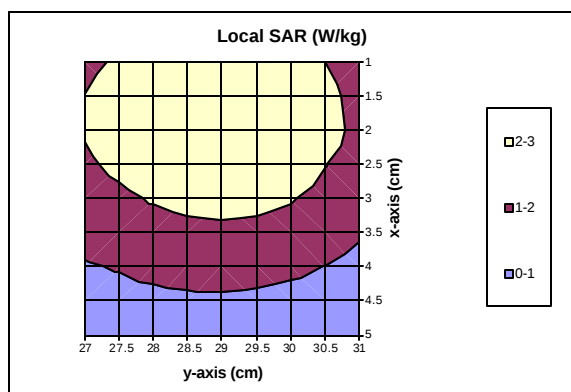


Figure 9. Zoom Scan 12.5mm Above Phantom Surface



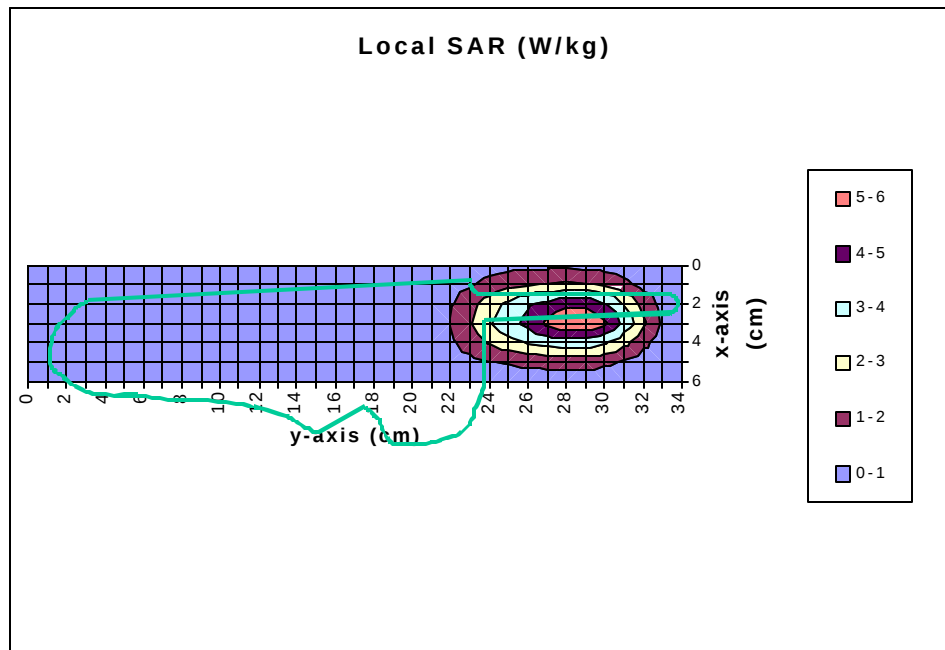


Figure 10. Overlay of the DUI's Outlines Superimposed onto the Area Scan

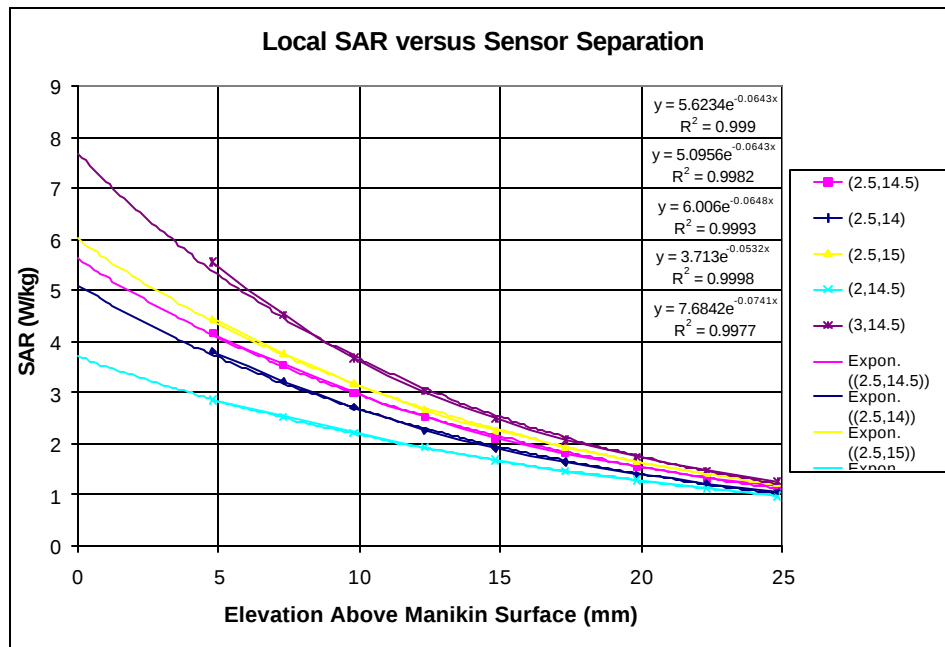


Figure 11. Local SAR versus Sensor Separation

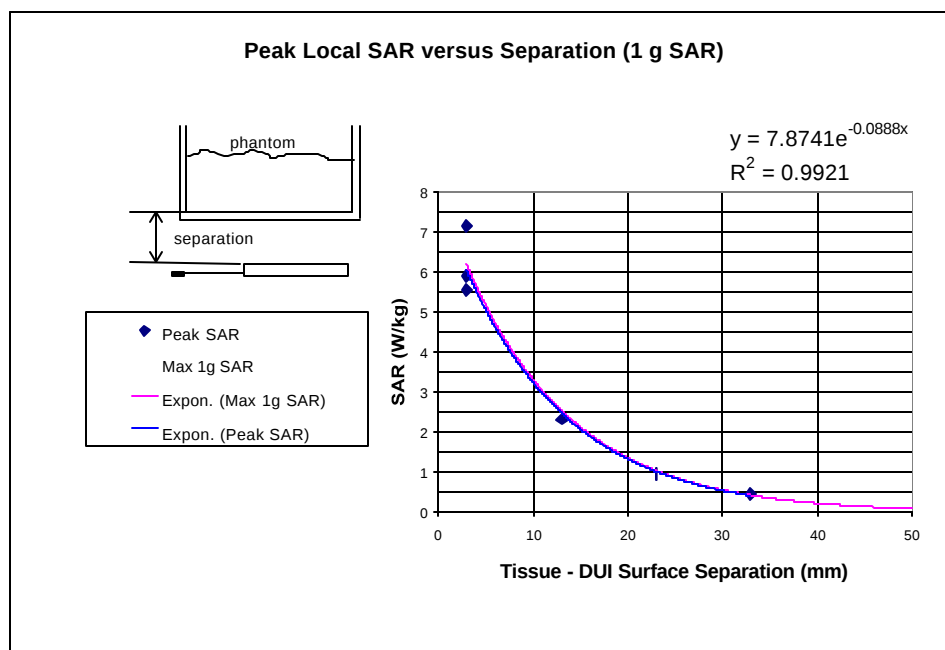


Figure 12. Peak Local SAR versus Separation (1g SAR)



APPENDIX B. Manufacturer's Specifications



Antenna stowed (0° position)



Antenna extended (180° position)

The antenna is a 5in centre-fed half-wavelength dipole with a gain of 1 dB

(See manufacturer's submission documentation for drawings and more design details)



APPENDIX C. Uncertainty Budget

Uncertainties Contributing to the Overall Uncertainty		
Type of Uncertainty	Specific to	Uncertainty
Power variation due to battery condition	phone	5.9%
Extrapolation due to curve fit of SAR vs depth	phone	23.0%
Extrapolation due to depth measurement	setup	3.2%
Conductivity	setup	6.0%
Density	setup	2.6%
Tissue enhancement factor	setup	7.0%
Voltage measurement	setup	1.5%
Probe sensitivity factor	setup	3.5%
		26.1% RSS



APPENDIX D. Simulated Muscle Tissue Material and Calibration Technique

The mixture used was based on that presented SSI/DRB-TP-D01-033, “Tissue Recipe and Calibration Requirements”.

De-ionised water	52.8%
Sugar	45.3%
Salt	1.5%
HEC	0.3 %
Bactericide	0.1 %

Mass density, ρ 1.30 g/ml
(The density used to determine SAR from the measurements was the recommended 1040 kg/m³ found in Appendix C of Supplement C to OET Bulletin 65, Edition 97-01).

Dielectric parameters of the simulated tissue material were determined using a Hewlett Packard 8510 Network Analyser, a Hewlett Packard 809B Slotted Line Carriage, and an APREL SLP-001 Slotted Line Probe.

The dielectric properties at 835 MHz are:

	APREL	OET 65 Supplement	Δ (%) (OET)
Dielectric constant, ϵ_r	58.6	56.11	4.4%
Conductivity, σ [S/m]	1.09	0.946	15.3%
Tissue Conversion Factor, γ	7.8	-	-



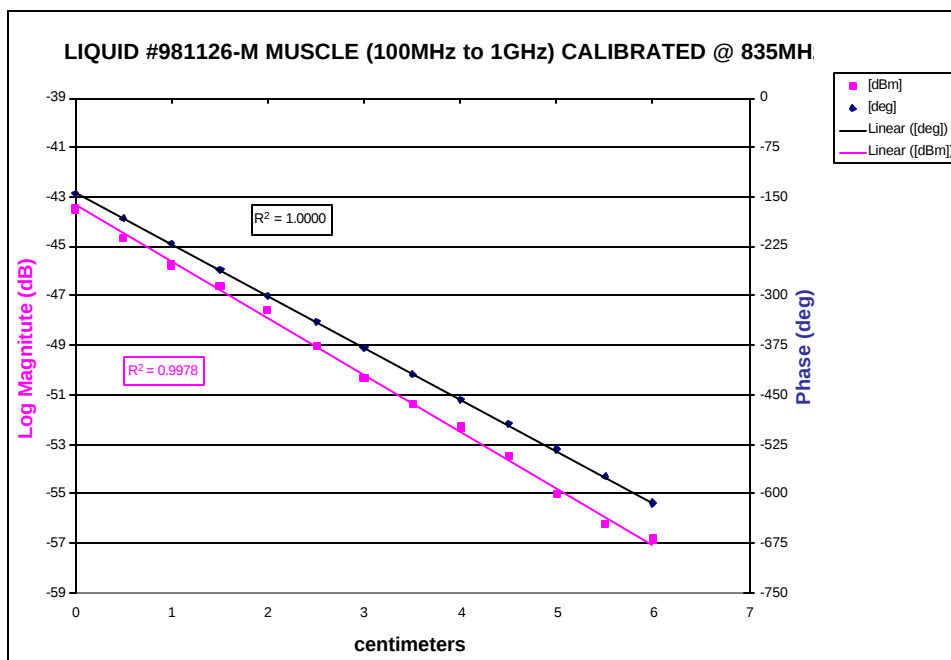
SIMULATION FLUID # 981126-M
 CALIBRATION DATE 31-Jul-00
 CALIBRATED BY Ken O'Donnell
 Frequency Range 100MHz-1GHz
 Frequency Calibrated 835 MHz
 Tissue Type Muscle

Position [cm]	Amplitude [dBm]	Phase [deg]	Phase [deg]
0	-43.48	-143.7	-143.7
0.5	-44.66	177.8	-182.2
1	-45.77	138.3	-221.7
1.5	-46.58	99.6	-260.4
2	-47.61	61.03	-298.97
2.5	-48.99	21.06	-338.94
3	-50.3	-18.14	-378.14
3.5	-51.34	-58.06	-418.06
4	-52.27	-96.03	-456.03
4.5	-53.47	-134.13	-494.13
5	-55.04	-171.99	-531.99
5.5	-56.22	145.77	-574.23
6	-56.8	105.82	-614.18

ΔdB _{avg}	-6.82	Δdeg _{avg}	-234.44
ΔdB _{avg}	-6.68	Δdeg _{avg}	-235.86
ΔdB _{avg}	-6.5	Δdeg _{avg}	-234.33
ΔdB _{avg}	-6.89	Δdeg _{avg}	-233.73
ΔdB _{avg}	-7.43	Δdeg _{avg}	-233.02
ΔdB _{avg}	-7.23	Δdeg _{avg}	-235.29
ΔdB _{avg}	-6.5	Δdeg _{avg}	-236.04
ΔdB _{avg} [dB]	-6.86	Δdeg _{avg} [deg]	-234.6728571
dB _{avg} (°avg) [dB/cm]	-2.29	deg _{avg} (°avg) [deg/cm]	-78.22428571
(α _{avg}) [NP/cm]	-0.263426699	(β _{avg}) [rad/cm]	-1.365271341

f [Hz]	8.35E+08
μ [H/cm]	1.25664E-08
ε ₀ [F/cm]	8.854E-14

ε_r 58.6
 % effective 1.09



835 MHz Data (Heike & Tony) Muscle with E-115

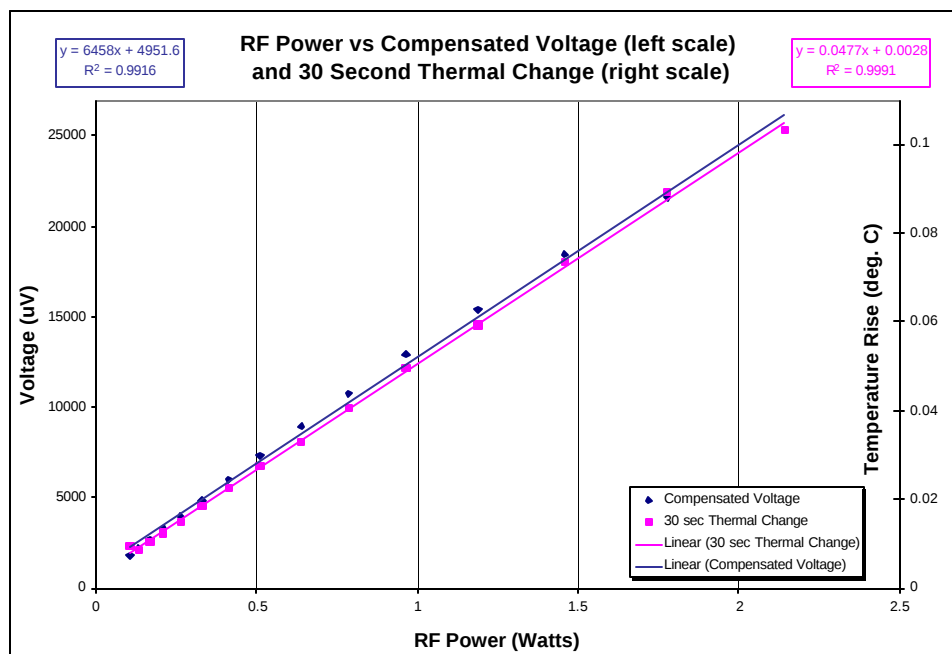
RF Power			Ch0	Ch1	Ch2	delta T	Sum	Thermal
W	dBm	R&S	uV	uV	uV	(30 sec)	V/I/EI	SAR
						deg. C		W/kg
0.10660	20.28	-25.61	391	1196	2954	0.0093	1792.736	0.86
0.13335	21.25	-24.64	439	1440	3638	0.0086	2177.984	0.80
0.16904	22.28	-23.61	513	1782	4517	0.0102	2689.029	0.94
0.21086	23.24	-22.65	586	2173	5542	0.0125	3276.59	1.16
0.26307	24.2	-21.69	684	2661	6787	0.0147	3999.08	1.36
0.32809	25.16	-20.73	830	3247	8276	0.0185	4875.658	1.71
0.41209	26.15	-19.74	1001	4028	10205	0.0227	6012.429	2.10
0.50933	27.07	-18.82	1196	4932	12402	0.0273	7312.846	2.53
0.63973	28.06	-17.83	1440	6079	15137	0.0331	8940.589	3.06
0.78704	28.96	-16.93	1733	7397	18188	0.0405	10779.67	3.75
0.96605	29.85	-16.04	2100	8960	21680	0.0495	12918.42	4.58
1.18850	30.75	-15.14	2515	10815	25806	0.0592	15441.16	5.48
1.45881	31.64	-14.25	3052	13086	30640	0.0736	18455.06	6.81
1.77827	32.5	-13.38	3662	15603	35718	0.0893	21651.69	8.26
2.14289	33.31	-12.58	4395	18335	41528	0.1031	25349.01	9.54

Directional Coupler factor 25.89 dB (Asset 100251 cal file data)
Additional inline attenuation 20 dB

Sensitivity (e) 1.658 1.721 1.68 - Sensor Sensitivity in mV/ (mW/cm²) 835 MHz cal
η = 1.50 e 2.487 2.5815 2.52

Density 1.3 g/cm³ 1300 kg/m³
Conductivity 10.8 mS/cm 1.08 S/m
Heat Capacity (c) 2.775 J/C/g 2775 J/C/kg
Exposure Time 30 seconds 30 seconds
Slope of Measure Voltage (m_v) 11722.36 uV/W 0.011722 V/W
- standard error or m_v 182.1283 uV/W 0.000182 V/W 1.6%
Slope of Measure Temp Change (m_t) 0.047724 CW 0.047724 CW
- standard error or m_t 0.000398 CW 0.000398 CW 0.8%

Tissue Conversion Factor (α) 7.8



APPENDIX E. Validation Scans on a Flat Phantom

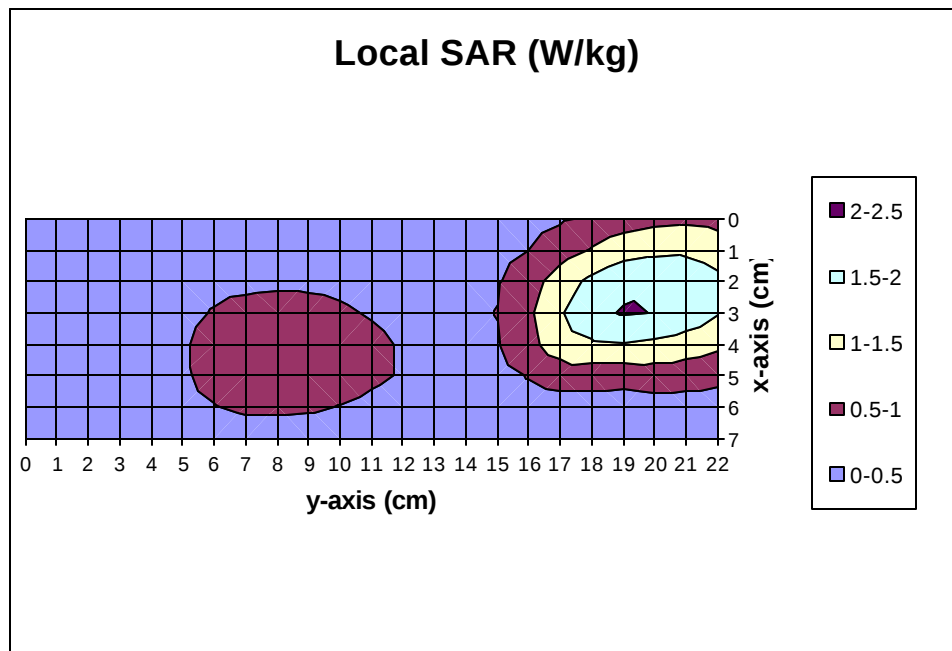


Figure 13. Contour Plot of the Reference Area Scan 2.5mm Above Phantom

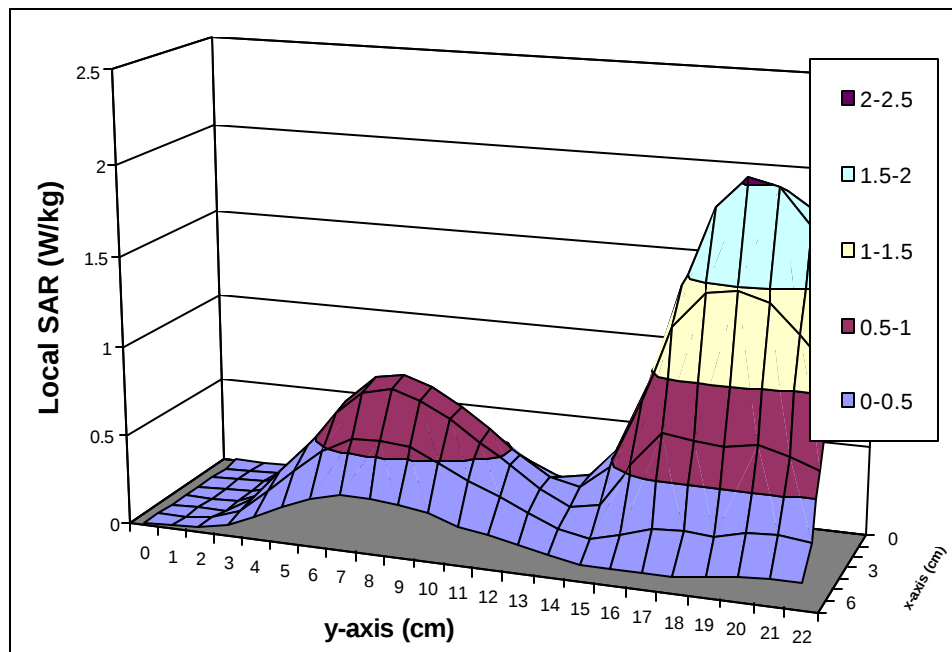


Figure 14. Surface Plot of the Reference Area Scan 2.5mm Above Phantom



APPENDIX F. Duty Factor Limitation of Lipman Nurit 3010 POS



LIPMAN U.S.A. Inc. *The Ideal Solution®*

50 Gordon Drive
Syosset, New York 11791

September 14, 2000

Federal Communications Commission
Equipment Authorization Branch
7435 Oakland Mills Road
Columbia, MD 21406

To Whom It May Concern:

A typical authorization financial transaction in the POS industry consists of approximately 100 bytes of request that is transmitted by the POS device and 50 bytes of response received by the POS device. The fastest transaction time that has been achieved on the CDPD network was 3 seconds. A regular transaction time is about 6 seconds and it takes another 10 seconds before the next transaction can be run after swiping the next card and entering the amount.

To be conservative, we will still assume that we can transmit one transaction per 3 sec continuously. According to Novatel Wireless, CDPD transmits at a maximum of 19200 bits per second, which would be 57600 bits in 3 seconds. The maximum duty factor is therefore $100 \text{ bytes} * 8 \text{ bits/byte} / 57600 = 0.0139$ or 1.4%.

Some of the financial institutions may require the terminal to submit all transactions as a batch at the end of each day. During this batch upload terminal uploads all necessary transactions to the host computer.

The current maximum byte stream transmitted for a transaction in a batch upload is 250.

Assuming the worst condition situation, the terminal will submit one transaction (500-byte stream, double the size of current numbers) per 3 seconds. According to Novatel Wireless, CDPD transmits at a maximum of 19200 bits per second, which would be 57600 bits in 3 seconds. The maximum duty factor is therefore $500 \text{ (bytes per transaction)} * 8 \text{ bits/byte} / 57600 \text{ bits (per 3 seconds shortest transaction interval)} = 0.0694$ or 6.9%.

Sincerely,
Bulent Ozayaz
Chief Engineer

