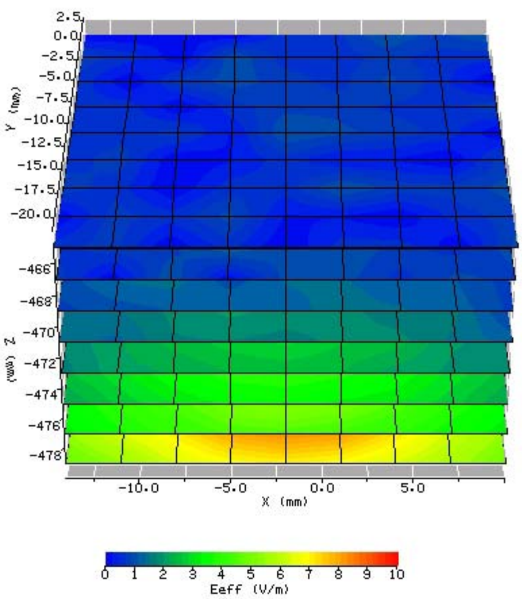
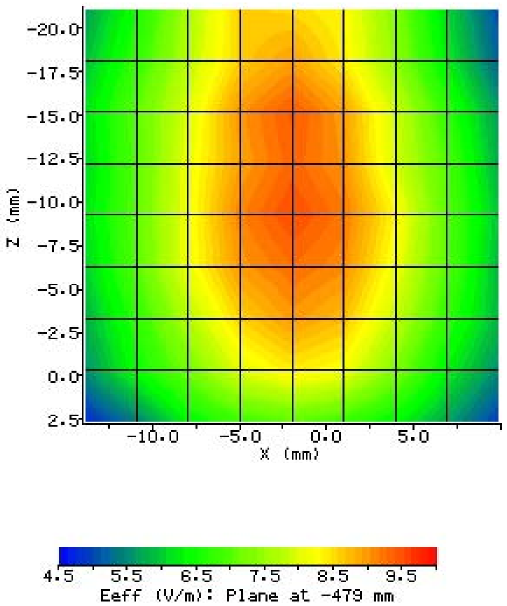
8.2.11 Host ACER, Perpendicular + 10 mm, channel 165.

Device Under Test:		**Agere CB 1106 2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**ACER**	
Position / Channel		**perpendicular / channel 165**	
DATE [dd/mm/yyyy]		**15-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	8
Test Frequency [MHz]	5825	Stepsize x and y [mm]	3
Antenna Configuration:	Integral	No. of steps z	7
Power / (setting(s) [dBm]	17.2	Stepsize z [mm]	2
Type of Modulation / bitrate [Mbit/s]	OFDM 6	Dist probe tip – phantom shell [mm]	1
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.750
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	14-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	9.35
Permittivity / Conductivity [S/m]	48.2 / 6.0	Location of max. X= [mm]	-2.0
Liquid Temperature [C]	22.5	Location of max Y= [mm]	-8.9
Ambient Temperature [C]	22.0	Location of max Z= [mm]	-479.0
Relative Humidity [%]	57.0	SAR Drift: [dB]	0.67
Results:			
SAR 1g [W/kg]:	0.406		
SAR 10g [W/kg]:	0.175		

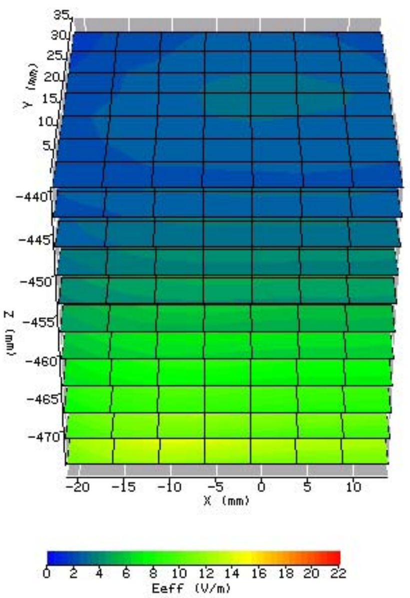


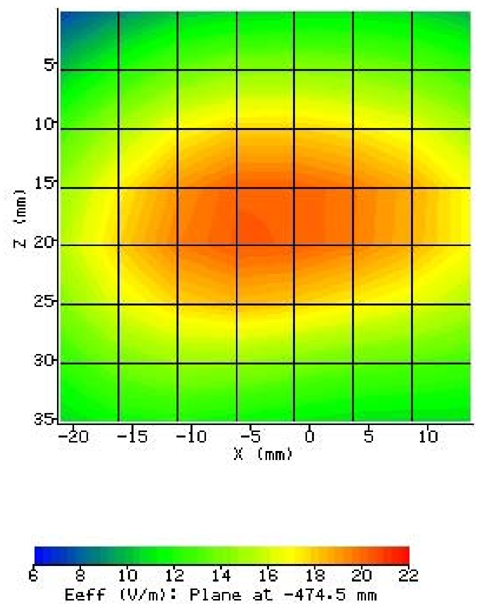


8.3 Host: IBM.

8.3.1 Host IBM, Lapheld, channel 1.

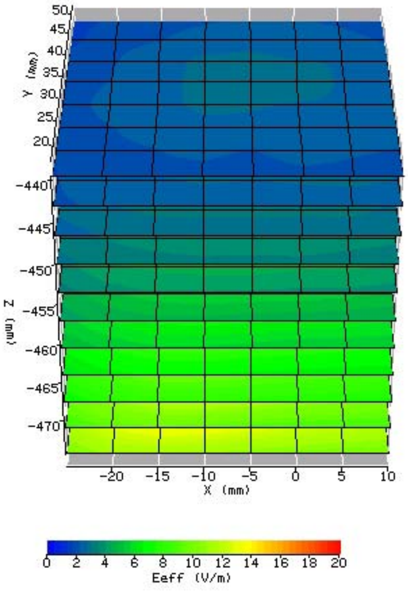
Device Under Test:		**Agere CB 1106 2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**IBM**	
Position / Channel		**lapheld / 1**	
DATE [dd/mm/yyyy]		**17-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	7
Test Frequency [MHz]	2412	Stepsize x and y [mm]	5
Antenna Configuration:	Integral	No. of steps z	10
Power / (setting(s) [dBm]	21.4	Stepsize z [mm]	3.5
Type of Modulation / bitrate: [Mbit/s]	DSSS 11	Dist probe tip – phantom shell [mm]	5
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.540
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	17-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	14.3
Permittivity / Conductivity [S/m]	52.8 / 1.91	Location of max. X= [mm]	-3.25
Liquid Temperature [C]	21.9	Location of max Y= [mm]	18.0
Ambient Temperature [C]	23.0	Location of max Z= [mm]	-474.5
Relative Humidity [%]	51.0	SAR Drift: [dB]	0
Results:			
SAR 1g [W/kg]:	0.455		
SAR 10g [W/kg]:	0.254		

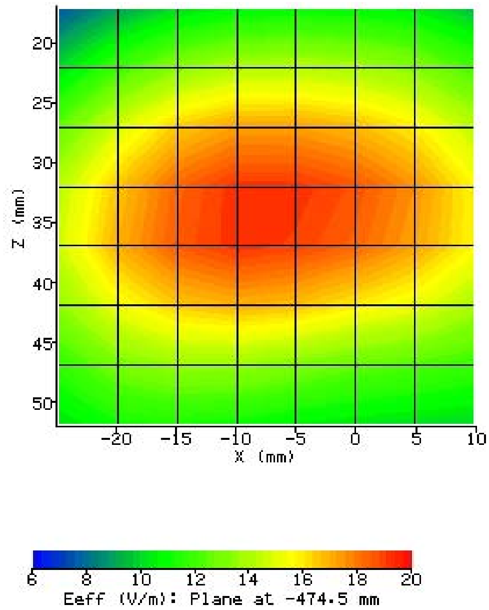




8.3.2 Host IBM, Lapheld, channel 6.

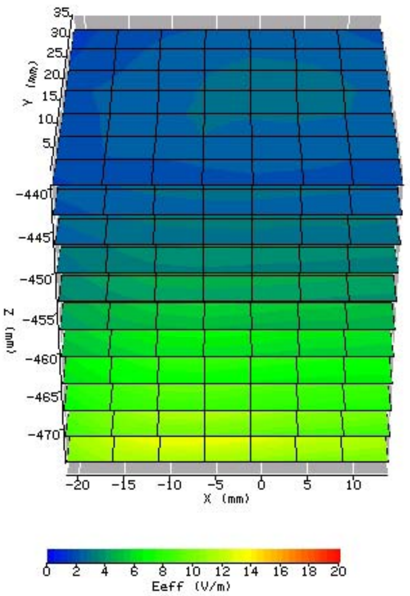
Device Under Test:		**Agere CB 1106** **2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**IBM**	
Position / Channel		**lapheld / 6**	
DATE [dd/mm/yyyy]		**17-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	7
Test Frequency [MHz]	2437	Stepsize x and y [mm]	5
Antenna Configuration:	Integral	No. of steps z	10
Power / (setting(s) [dBm]	21.4	Stepsize z [mm]	3.5
Type of Modulation / bitrate: [Mbit/s]	OFDM 6	Dist probe tip – phantom shell [mm]	5
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.540
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	17-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	19.11
Permittivity / Conductivity [S/m]	52.7 / 1.94	Location of max. X= [mm]	-7.97
Liquid Temperature [C]	21.9	Location of max Y= [mm]	35.0
Ambient Temperature [C]	23.0	Location of max Z= [mm]	-474.5
Relative Humidity [%]	51.0	SAR Drift: [dB]	0
Results:			
SAR 1g [W/kg]:	0.934		
SAR 10g [W/kg]:	0.512		

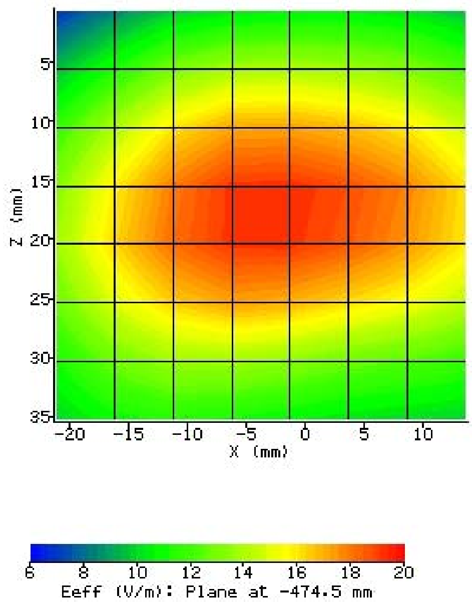




8.3.3 Host IBM, Lapheld, channel 11.

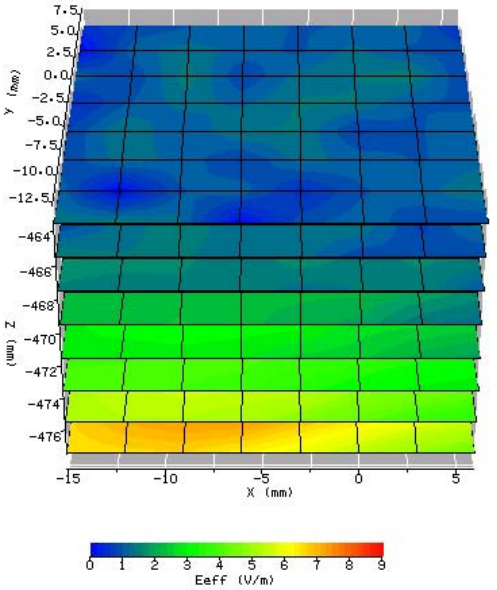
Device Under Test:		**Agere CB 1106** **2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**IBM**	
Position / Channel		**lapheld / 11**	
DATE [dd/mm/yyyy]		**17-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	7
Test Frequency [MHz]	2462	Stepsize x and y [mm]	5
Antenna Configuration:	Integral	No. of steps z	10
Power / (setting(s) [dBm]	21.4	Stepsize z [mm]	3.5
Type of Modulation / bitrate: [Mbit/s]	DSSS 5.5	Dist probe tip – phantom shell [mm]	5
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.540
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	17-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	19.61
Permittivity / Conductivity [S/m]	52.7 / 1.97	Location of max. X= [mm]	-3.25
Liquid Temperature [C]	21.9	Location of max Y= [mm]	18.0
Ambient Temperature [C]	23.0	Location of max Z= [mm]	-474.5
Relative Humidity [%]	51.0	SAR Drift: [dB]	0.03
Results:			
SAR 1g [W/kg]:	0.884		
SAR 10g [W/kg]:	0.508		

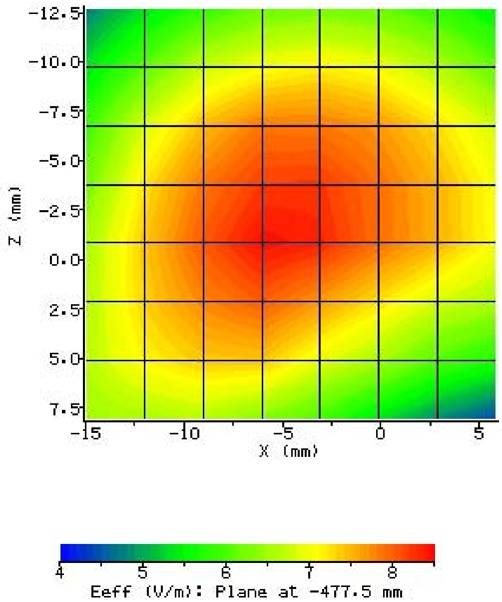




8.3.4 Host IBM, Lapheld, channel 52.

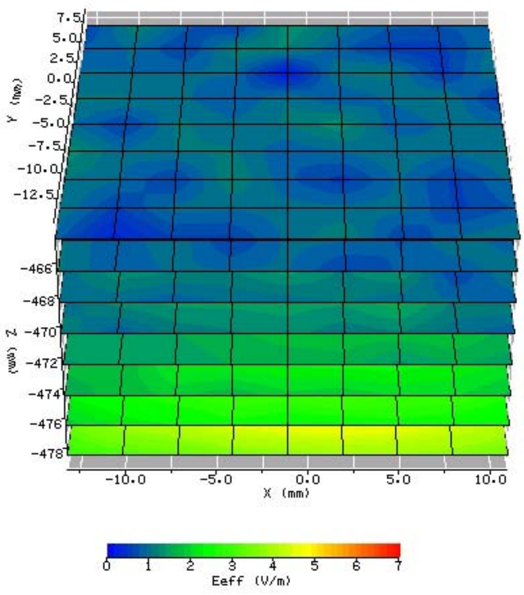
Device Under Test:		**Agere CB 1106** **2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**IBM**	
Position / Channel		**lapheld / 52**	
DATE [dd/mm/yyyy]		**16-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	7
Test Frequency [MHz]	5260	Stepsize x and y [mm]	3
Antenna Configuration:	Integral	No. of steps z	7
Power / (setting(s) [dBm]	20.4	Stepsize z [mm]	2
Type of Modulation / bitrate Mbit/s]	OFDM 6	Dist probe tip – phantom shell [mm]	2
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.870
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	16-6
Liquid Simulant:	Body	Max E-field [V/m in liquid]	8.3
Permittivity / Conductivity [S/m]	48.9 / 5.4	Location of max. X= [mm]	-4.9
Liquid Temperature [C]	21.5	Location of max Y= [mm]	-2.9
Ambient Temperature [C]	22.0	Location of max Z= [mm]	477.5
Relative Humidity [%]	50.0	SAR Drift: [dB]	0.0
Results:			
SAR 1g [W/kg]:	0.363		
SAR 10g [W/kg]:	0.164		

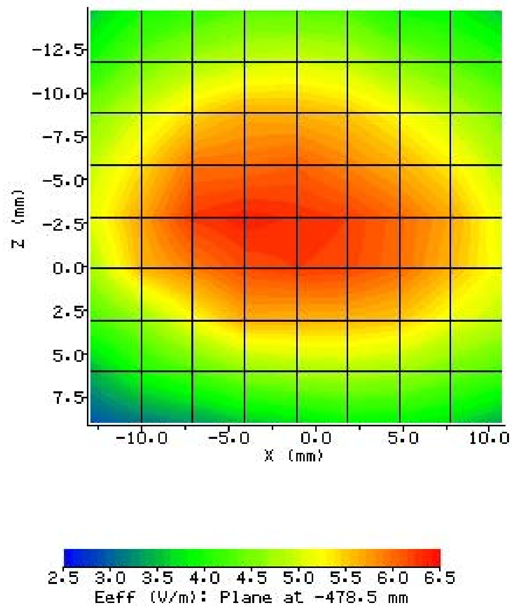




8.3.5 Host IBM, Lapheld, channel 165.

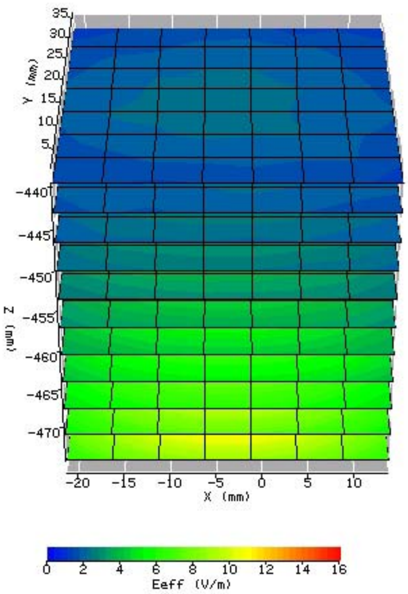
Device Under Test:		**Agere CB 1106 2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**IBM**	
Position / Channel		**lapheld / 165**	
DATE [dd/mm/yyyy]		**16-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	8
Test Frequency [MHz]	5825	Stepsize x and y [mm]	3
Antenna Configuration:	Integral	No. of steps z	7
Power / (setting(s) [dBm]	17.2	Stepsize z [mm]	2
Type of Modulation / bitrate Mbit/s]	OFDM 6	Dist probe tip – phantom shell [mm]	1
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.750
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	16-6
Liquid Simulant:	Body	Max E-field [V/m in liquid]	6.27
Permittivity / Conductivity [S/m]	48.2 / 6.0	Location of max. X= [mm]	-2.94
Liquid Temperature [C]	21.5	Location of max Y= [mm]	6.46
Ambient Temperature [C]	22.0	Location of max Z= [mm]	-478.5
Relative Humidity [%]	50.0	SAR Drift: [dB]	0
Results:			
SAR 1g [W/kg]:	0.204		
SAR 10g [W/kg]:	0.093		

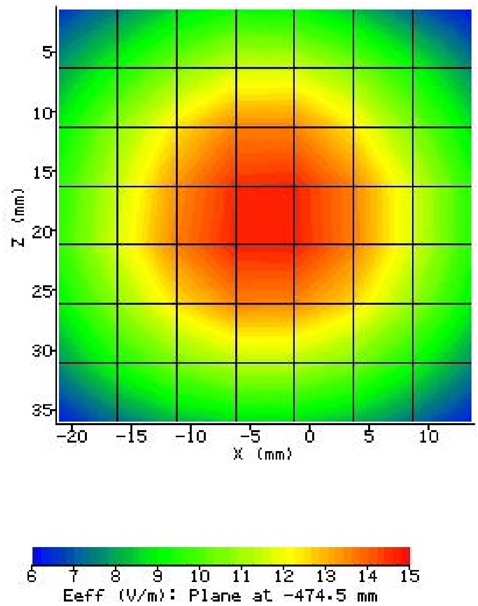




8.3.6 Host IBM, Perpendicular + 10 mm, channel 6.

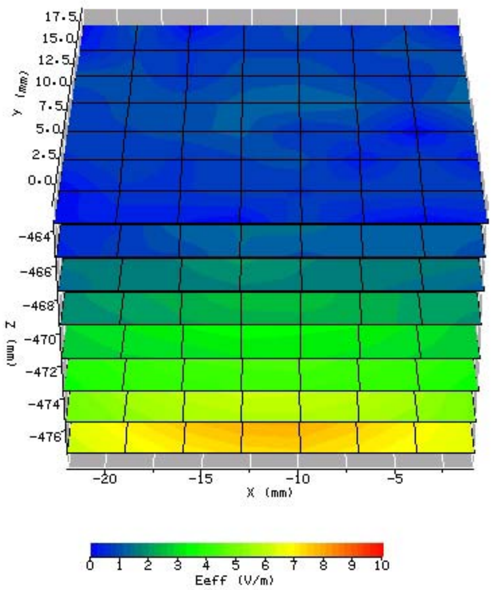
Device Under Test:		**Agere CB 1106 2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**IBM**	
Position / Channel		**perpendicular / 6**	
DATE [dd/mm/yyyy]		**17-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	7
Test Frequency [MHz]	2437	Stepsize x and y [mm]	5
Antenna Configuration:	Integral	No. of steps z	10
Power / (setting(s) [dBm]	21.4	Stepsize z [mm]	3.5
Type of Modulation / bitrate: [Mbit/s]	OFDM 6	Dist probe tip – phantom shell [mm]	5
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.540
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	16-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	14.61
Permittivity / Conductivity [S/m]	52.7 / 1.94	Location of max. X= [mm]	-3.25
Liquid Temperature [C]	21.9	Location of max Y= [mm]	18.75
Ambient Temperature [C]	23.0	Location of max Z= [mm]	-474.5
Relative Humidity [%]	51.0	SAR Drift: [dB]	0
Results:			
SAR 1g [W/kg]:	0.505		
SAR 10g [W/kg]:	0.290		

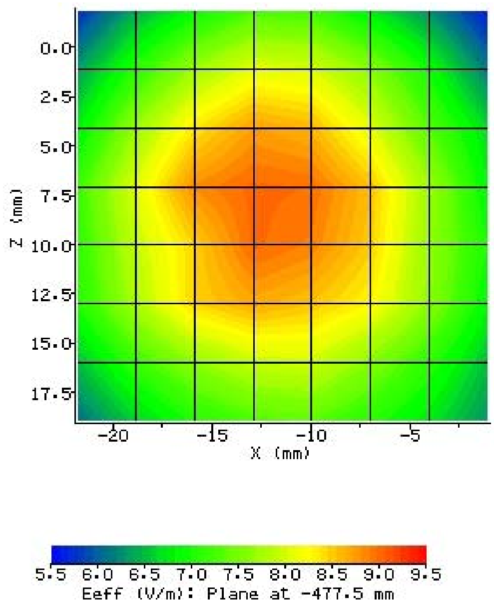




8.3.7 Host IBM, Perpendicular + 10 mm, channel 52.

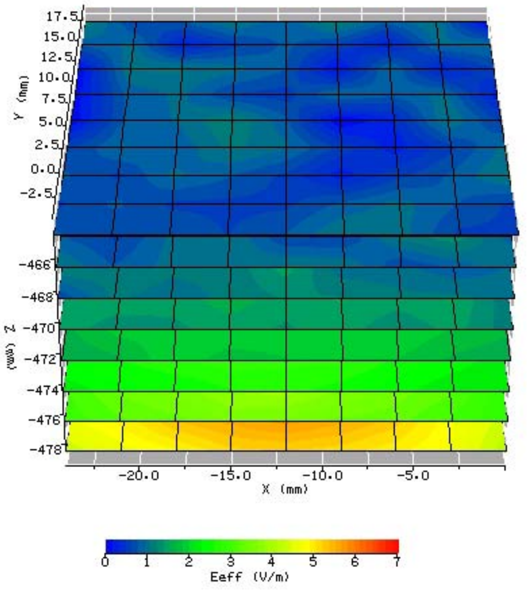
Device Under Test:		**Agere CB 1106 2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**IBM**	
Position / Channel		**perpendicular / 52**	
DATE [dd/mm/yyyy]		**16-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	7
Test Frequency [MHz]	5260	Stepsize x and y [mm]	3
Antenna Configuration:	Integral	No. of steps z	7
Power / (setting(s) [dBm]	20.4	Stepsize z [mm]	2
Type of Modulation / bitrate [Mbit/s]	OFDM 6	Dist probe tip – phantom shell [mm]	2
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.870
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	16-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	8.94
Permittivity / Conductivity [S/m]	48.9 / 5.4	Location of max. X= [mm]	-11.7
Liquid Temperature [C]	22.0	Location of max Y= [mm]	8.9
Ambient Temperature [C]	23.0	Location of max Z= [mm]	-477.5
Relative Humidity [%]	48.0	SAR Drift: [dB]	0
Results:			
SAR 1g [W/kg]:	0.501		
SAR 10g [W/kg]:	0.222		

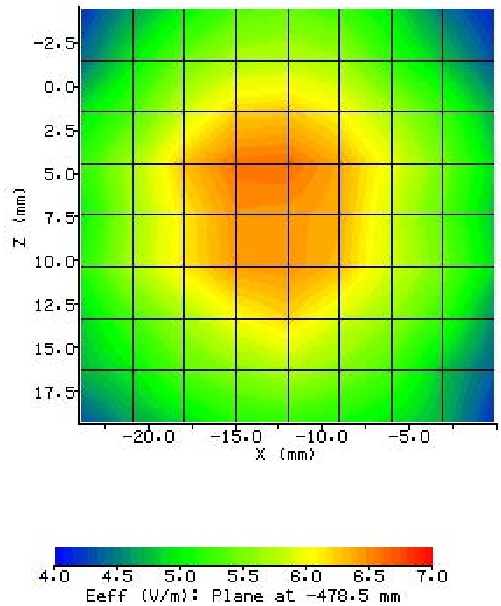




8.3.8 Host IBM, Perpendicular + 10 mm, channel 165.

Device Under Test:		**Agere CB 1106** **2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**IBM**	
Position / Channel		**perpendicular / 165**	
DATE [dd/mm/yyyy]		**16-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	8
Test Frequency [MHz]	5825	Stepsize x and y [mm]	3
Antenna Configuration:	Integral	No. of steps z	7
Power / (setting(s) [dBm]	17.2	Stepsize z [mm]	2
Type of Modulation / bitrate [Mbit/s]	OFDM 6	Dist probe tip – phantom shell [mm]	1
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.750
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	16-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	6.95
Permittivity / Conductivity [S/m]	48.2 / 6.0	Location of max. X= [mm]	6.52
Liquid Temperature [C]	21.0	Location of max Y= [mm]	-13.0
Ambient Temperature [C]	23.0	Location of max Z= [mm]	-478.5
Relative Humidity [%]	48.0	SAR Drift: [dB]	0
Results:			
SAR 1g [W/kg]:	0.259		
SAR 10g [W/kg]:	0.113		

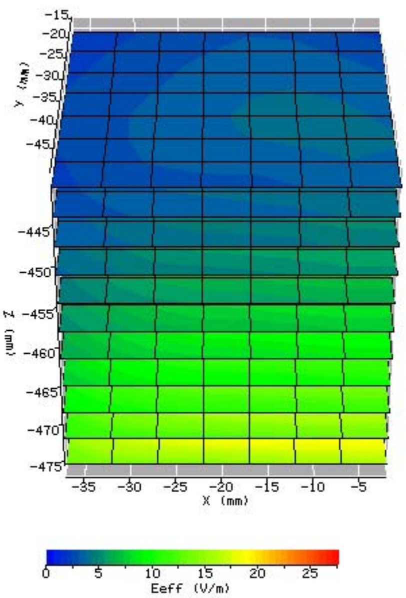


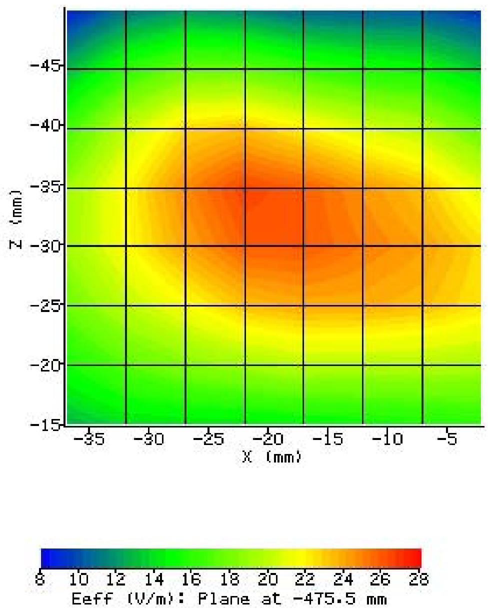


8.4 Host: COMPAQ.

8.4.1 Host COMPAQ, Lapheld, channel 1.

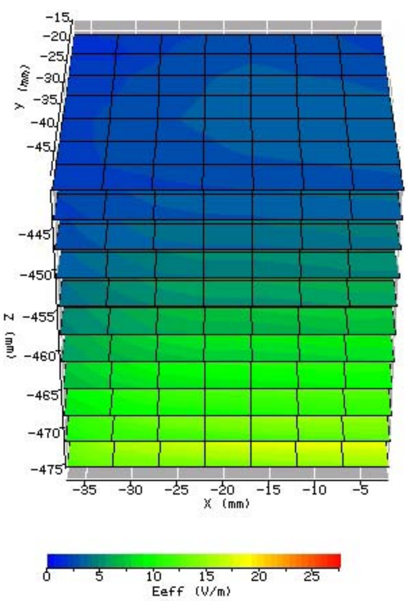
Device Under Test:		**Agere CB 1106 2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**COMPAQ**	
Position / Channel		**Lapheld / 1**	
DATE [dd/mm/yyyy]		**23-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	7
Test Frequency [MHz]	2412	Stepsize x and y [mm]	5
Antenna Configuration:	Integral	No. of steps z	10
Power / (setting(s) [dBm]	21.4	Stepsize z [mm]	3.5
Type of Modulation / bitrate [Mbit/s]	DSSS 11	Dist probe tip – phantom shell [mm]	5
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.540
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	22-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	18.37
Permittivity / Conductivity [S/m]	52.7 / 1.9	Location of max. X= [mm]	-20
Liquid Temperature [C]	21.0	Location of max Y= [mm]	-31
Ambient Temperature [C]	21.0	Location of max Z= [mm]	-475.5
Relative Humidity [%]	57.0	SAR Drift: [dB]	0.01
Results:			
SAR 1g [W/kg]:	0.793		
SAR 10g [W/kg]:	0.441		

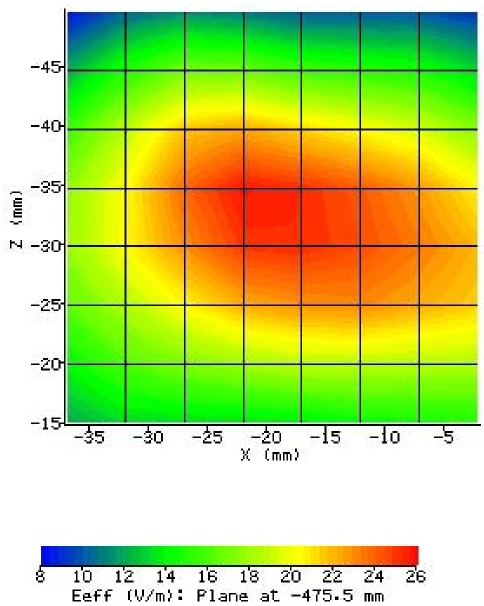




8.4.2 Host COMPAQ, Lapheld, channel 6.

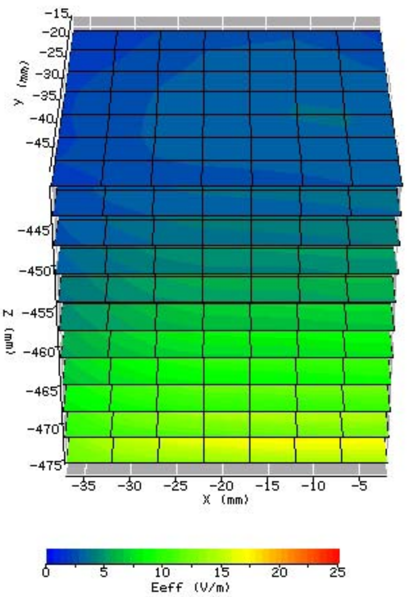
Device Under Test:		**Agere CB 1106 2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**COMPAQ**	
Position / Channel		**Lapheld / 6**	
DATE [dd/mm/yyyy]		**23-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	7
Test Frequency [MHz]	2437	Stepsize x and y [mm]	5
Antenna Configuration:	Integral	No. of steps z	10
Power / (setting(s) [dBm]	21.4	Stepsize z [mm]	3.5
Type of Modulation / bitrate [Mbit/s]	OFDM 6	Dist probe tip – phantom shell [mm]	5
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.540
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	22-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	24.31
Permittivity / Conductivity [S/m]	52.7 / 1.9	Location of max. X= [mm]	-20
Liquid Temperature [C]	21.0	Location of max Y= [mm]	-31
Ambient Temperature [C]	21.0	Location of max Z= [mm]	-475.5
Relative Humidity [%]	57.0	SAR Drift: [dB]	0.04
Results:			
SAR 1g [W/kg]:	1.502		
SAR 10g [W/kg]:	0.829		

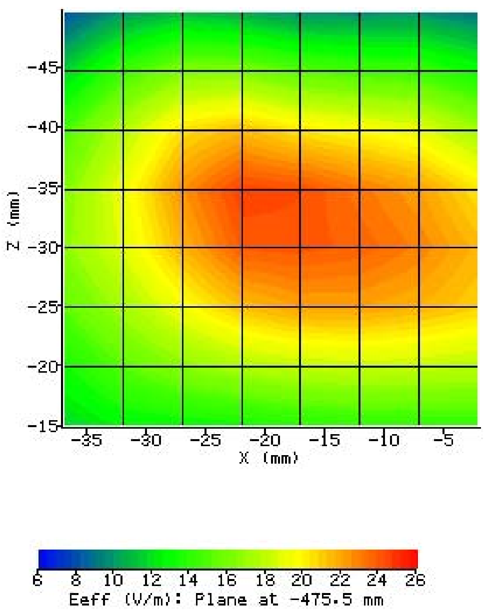




8.4.3 Host COMPAQ, Lapheld, channel 11.

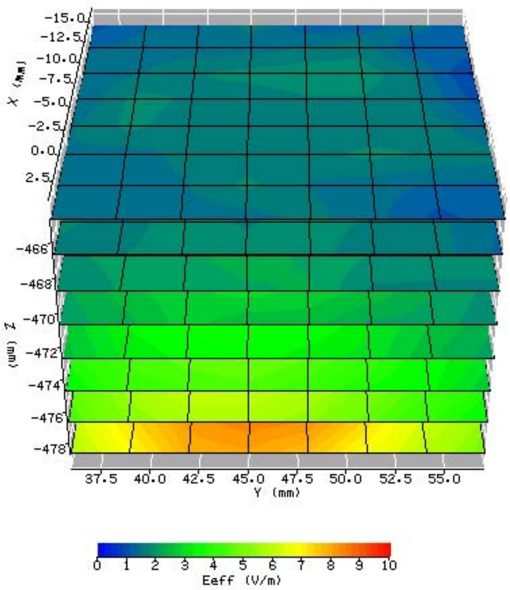
Device Under Test:		**Agere CB 1106** **2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**COMPAQ**	
Position / Channel		**Lapheld / 11**	
DATE [dd/mm/yyyy]		**23-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	7
Test Frequency [MHz]	2462	Stepsize x and y [mm]	5
Antenna Configuration:	Integral	No. of steps z	10
Power / (setting(s) [dBm]	21.4	Stepsize z [mm]	3.5
Type of Modulation / bitrate [Mbit/s]	DSSS 5.5	Dist probe tip – phantom shell [mm]	5
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.540
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	22-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	24.03
Permittivity / Conductivity [S/m]	52.7 / 2.0	Location of max. X= [mm]	-19.0
Liquid Temperature [C]	21.0	Location of max Y= [mm]	-31.0
Ambient Temperature [C]	21.0	Location of max Z= [mm]	-475.5
Relative Humidity [%]	57.0	SAR Drift: [dB]	0.01
Results:			
SAR 1g [W/kg]:	1.414		
SAR 10g [W/kg]:	0.778		

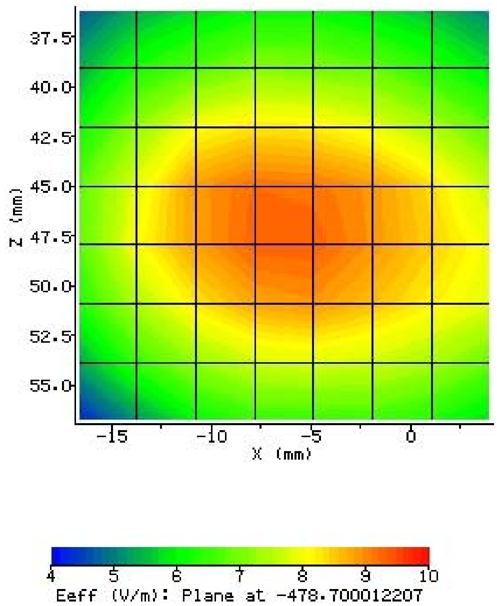




8.4.4 Host COMPAQ, Lapheld, channel 36.

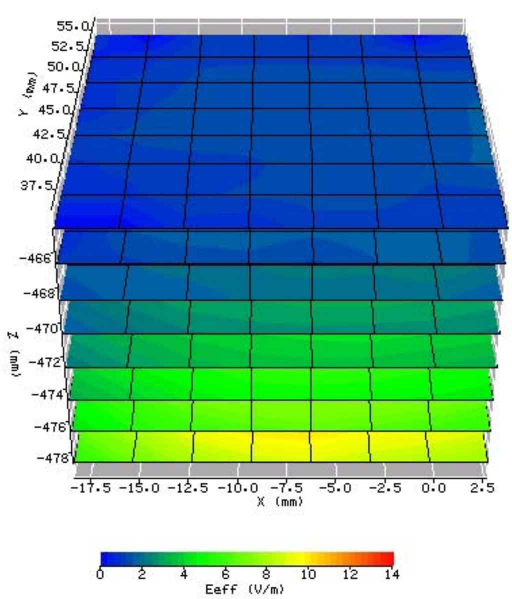
Device Under Test:		**Agere CB 1106 2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**COMPAQ**	
Position / Channel		**lapheld/ 36**	
DATE [dd/mm/yyyy]		**24-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	7
Test Frequency [MHz]	5180	Stepsize x and y [mm]	3
Antenna Configuration:	Integral	No. of steps z	7
Power / (setting(s) [dBm]	17.4	Stepsize z [mm]	2
Type of Modulation / bitrate [Mbit/s]:	OFDM 6	Dist probe tip – phantom shell [mm]	2
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.870
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	24-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	9.22
Permittivity / Conductivity [S/m]	49.0 / 5.3	Location of max. X= [mm]	-6.0
Liquid Temperature [C]	22.0	Location of max Y= [mm]	45.9
Ambient Temperature [C]	22.0	Location of max Z= [mm]	-478.7
Relative Humidity [%]	51.0	SAR Drift: [dB]	-0.15
Results:			
SAR 1g [W/kg]:	0.507		
SAR 10g [W/kg]:	0.219		

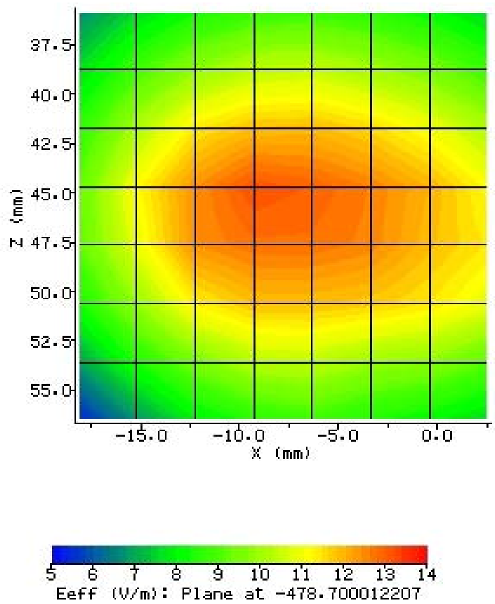




8.4.5 Host COMPAQ, Lapheld, channel 48.

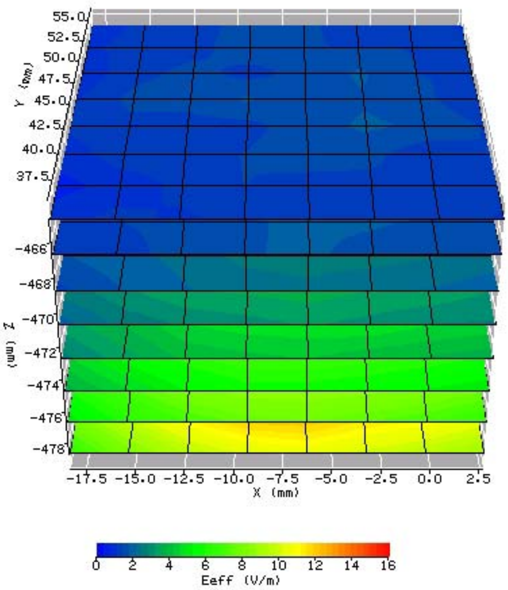
Device Under Test:		**Agere CB 1106 2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**COMPAQ**	
Position / Channel		**Lapheld / 48**	
DATE [dd/mm/yyyy]		**24-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	7
Test Frequency [MHz]	5240	Stepsize x and y [mm]	3
Antenna Configuration:	Integral	No. of steps z	7
Power / (setting(s) [dBm]	19.0	Stepsize z [mm]	2
Type of Modulation / bitrate [Mbit/s]:	OFDM 6	Dist probe tip – phantom shell [mm]	2
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.870
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	24-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	12.89
Permittivity / Conductivity [S/m]	49.0 / 5.3	Location of max. X= [mm]	-8.1
Liquid Temperature [C]	22.0	Location of max Y= [mm]	46.8
Ambient Temperature [C]	22.0	Location of max Z= [mm]	-478.7
Relative Humidity [%]	53.0	SAR Drift: [dB]	0.09
Results:			
SAR 1g [W/kg]:	1.02		
SAR 10g [W/kg]:	0.431		

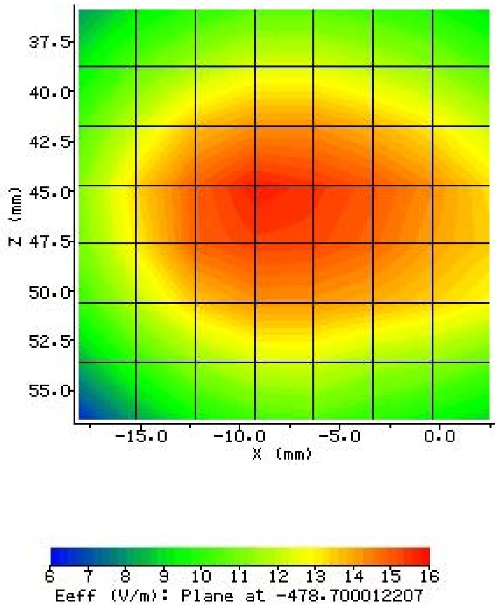




8.4.6 Host COMPAQ, Lapheld, channel 52.

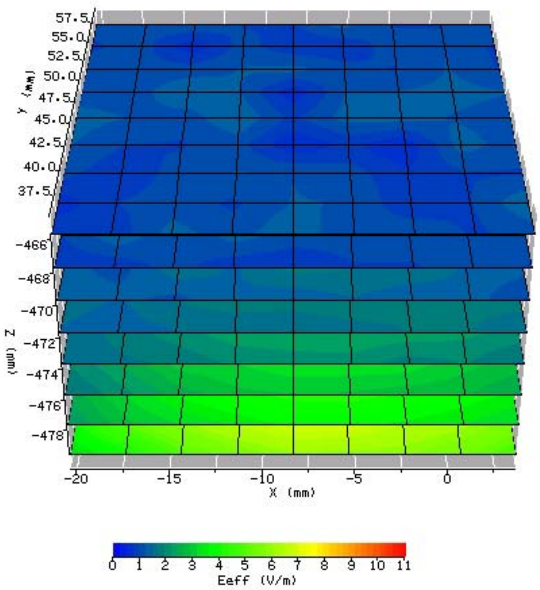
Device Under Test:		**Agere CB 1106 2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**COMPAQ**	
Position / Channel		**Lapheld / 52**	
DATE [dd/mm/yyyy]		**24-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	7
Test Frequency [MHz]	5260	Stepsize x and y [mm]	3
Antenna Configuration:	Integral	No. of steps z	7
Power / (setting(s) [dBm]	20.4	Stepsize z [mm]	2
Type of Modulation / bitrate [Mbit/s]:	OFDM 6	Dist probe tip – phantom shell [mm]	2
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.870
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	24-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	15.38
Permittivity / Conductivity [S/m]	48.9 / 5.37	Location of max. X= [mm]	-8.0
Liquid Temperature [C]	21.5	Location of max Y= [mm]	46.8
Ambient Temperature [C]	22.0	Location of max Z= [mm]	-478.7
Relative Humidity [%]	53.0	SAR Drift: [dB]	-0.17
Results:			
SAR 1g [W/kg]:	1.456		
SAR 10g [W/kg]:	0.609		

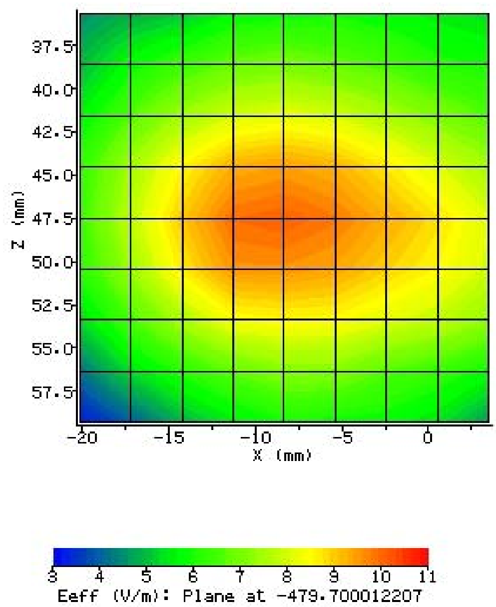




8.4.7 Host COMPAQ, Lapheld, channel 64.

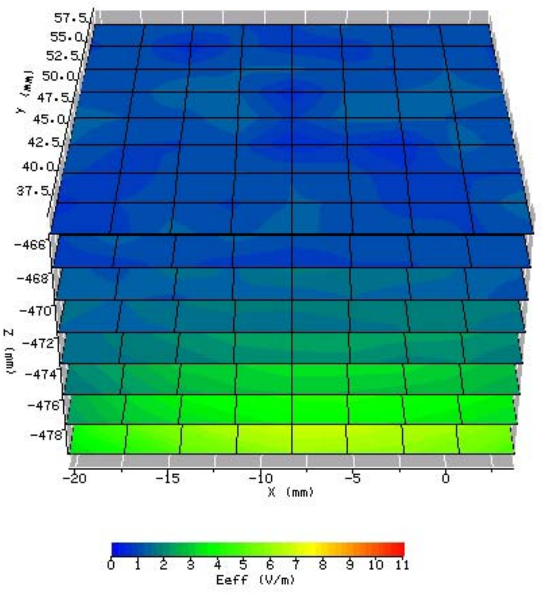
Device Under Test:		**Agere CB 1106** **2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**COMPAQ**	
Position / Channel		**Lapheld / 64**	
DATE [dd/mm/yyyy]		**24-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	7
Test Frequency [MHz]	5320	Stepsize x and y [mm]	3
Antenna Configuration:	Integral	No. of steps z	7
Power / (setting(s) [dBm]	17.9	Stepsize z [mm]	2
Type of Modulation / bitrate [Mbit/s]:	OFDM 6	Dist probe tip – phantom shell [mm]	2
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.870
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	24-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	8.88
Permittivity / Conductivity [S/m]	48.9 / 5.4	Location of max. X= [mm]	-8.7
Liquid Temperature [C]	22.0	Location of max Y= [mm]	46.2
Ambient Temperature [C]	22.0	Location of max Z= [mm]	-478.7
Relative Humidity [%]	52.0	SAR Drift: [dB]	0.1
Results:			
SAR 1g [W/kg]:	0.487		
SAR 10g [W/kg]:	0.203		

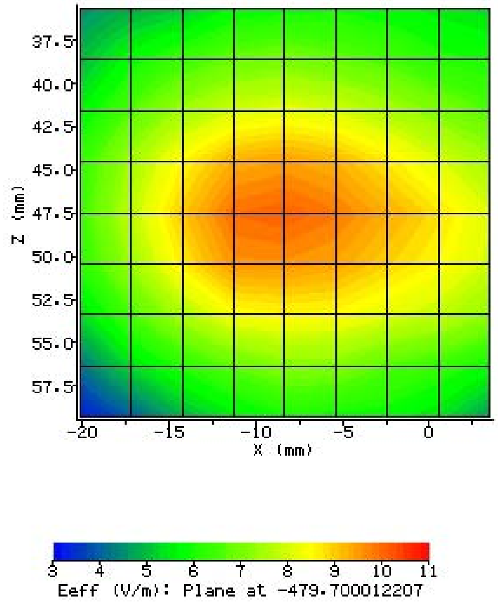




8.4.8 Host COMPAQ, Lapheld, channel 165.

Device Under Test:		**Agere CB 1106** **2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**COMPAQ**	
Position / Channel		**Lapheld / 165**	
DATE [dd/mm/yyyy]		**24-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	8
Test Frequency [MHz]	5825	Stepsize x and y [mm]	3
Antenna Configuration:	Integral	No. of steps z	7
Power / (setting(s) [dBm]	17.2	Stepsize z [mm]	2
Type of Modulation / bitrate [Mbit/s]:	OFDM 6	Dist probe tip – phantom shell [mm]	1
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.750
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	24-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	9.02
Permittivity / Conductivity [S/m]	48.2 / 6.0	Location of max. X= [mm]	-8.3
Liquid Temperature [C]	22.0	Location of max Y= [mm]	46.97
Ambient Temperature [C]	22.0	Location of max Z= [mm]	-479.7
Relative Humidity [%]	52.0	SAR Drift: [dB]	3[5]
Results:			
SAR 1g [W/kg]:	0.422		
SAR 10g [W/kg]:	0.182		

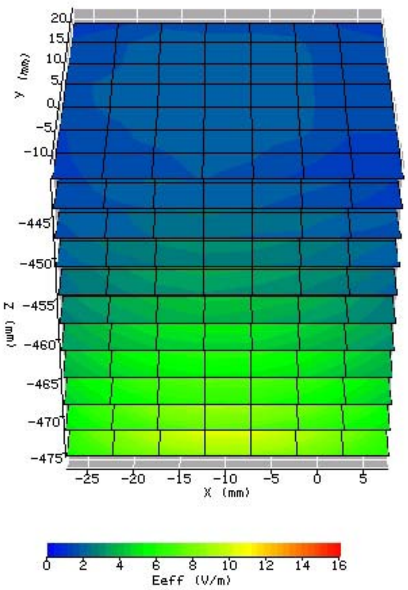


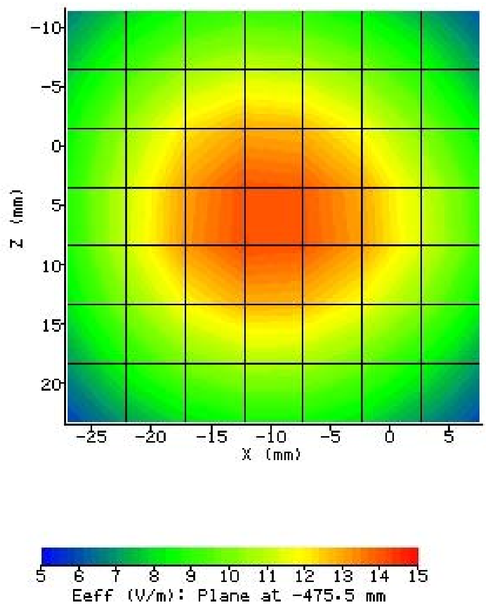


[5] The SAR drift is recorded in the middle of the scan cube as per the guidelines. In this situation the low field strength is noisy, hence the 3 dB drift. Power measurements show that the device transmits with stable power levels.

8.4.9 Host COMPAQ, Perpendicular + 10 mm, channel 6.

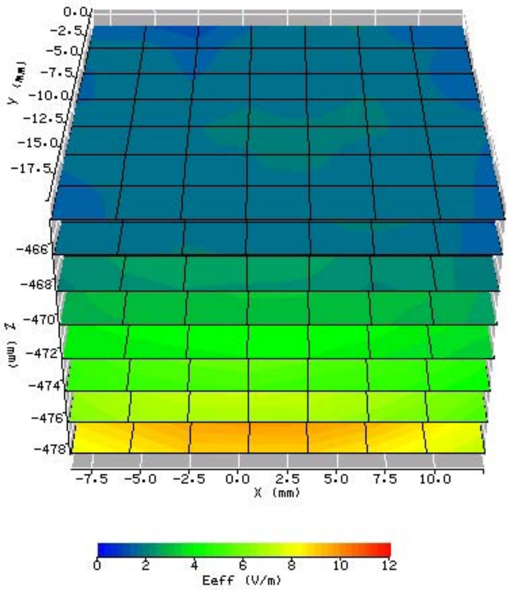
Device Under Test:		**Agere CB 1106 2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**COMPAQ**	
Position / Channel		**Perpendicular / 6**	
DATE [dd/mm/yyyy]		**23-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	7
Test Frequency [MHz]	2437	Stepsize x and y [mm]	5
Antenna Configuration:	Integral	No. of steps z	10
Power / (setting(s) [dBm]	21.4	Stepsize z [mm]	3.5
Type of Modulation / bitrate [Mbit/s]	OFDM 6	Dist probe tip – phantom shell [mm]	5
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.540
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	23-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	13.97
Permittivity / Conductivity [S/m]	52.7 / 1.94	Location of max. X= [mm]	-10.25
Liquid Temperature [C]	22.0	Location of max Y= [mm]	6.00
Ambient Temperature [C]	22.5	Location of max Z= [mm]	-475.5
Relative Humidity [%]	57.0	SAR Drift: [dB]	0.0
Results:			
SAR 1g [W/kg]:	0.468		
SAR 10g [W/kg]:	0.263		

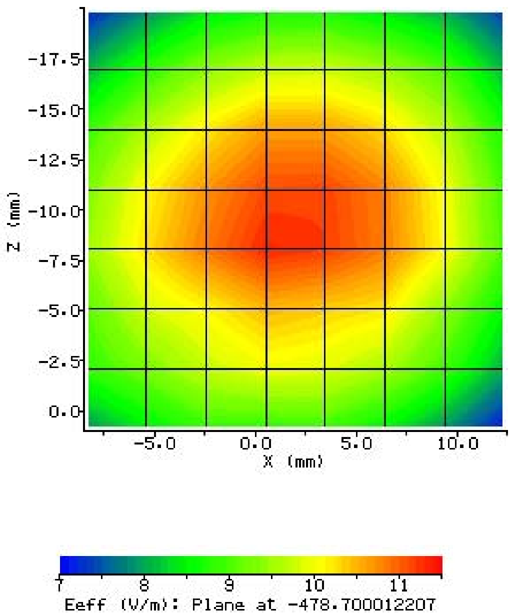




8.4.10 Host COMPAQ, Perpendicular + 10 mm, channel 52.

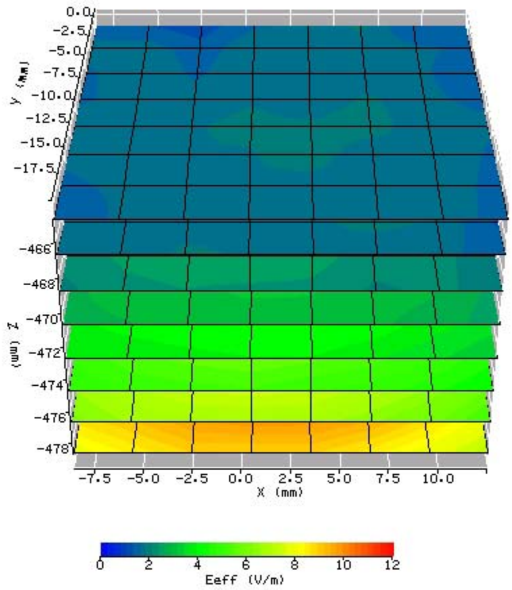
Device Under Test:		**Agere CB 1106 2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**COMPAQ**	
Position / Channel		**perpendicular / 52**	
DATE [dd/mm/yyyy]		**24-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	7
Test Frequency [MHz]	5260	Stepsize x and y [mm]	3
Antenna Configuration:	Integral	No. of steps z	7
Power / (setting(s) [dBm]	20.4	Stepsize z [mm]	2
Type of Modulation / bitrate [Mbit/s]	OFDM 6	Dist probe tip – phantom shell [mm]	2
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.870
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	24-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	11.17
Permittivity / Conductivity [S/m]	48.9 / 5.4	Location of max. X= [mm]	1.7
Liquid Temperature [C]	22.0	Location of max Y= [mm]	-9.8
Ambient Temperature [C]	22.0	Location of max Z= [mm]	478.8
Relative Humidity [%]	52.0	SAR Drift: [dB]	0.16
Results:			
SAR 1g [W/kg]:	0.703		
SAR 10g [W/kg]:	0.316		

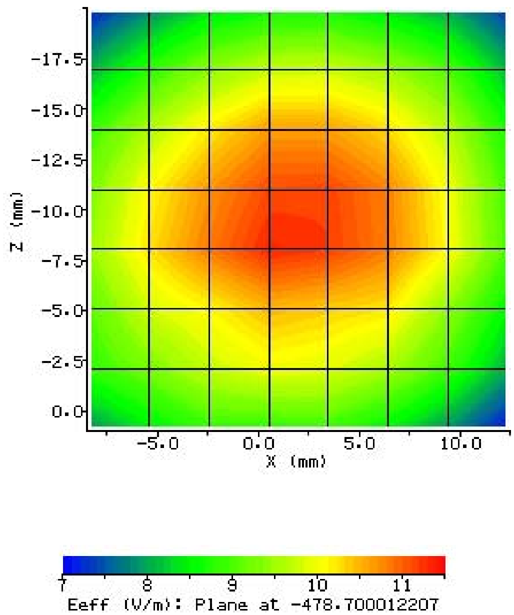




8.4.11 Host COMPAQ, Perpendicular + 10 mm, channel 165.

Device Under Test:		**Agere CB 1106 2.4/5 GHz IEEE 802.11g/a WLAN Cardbus card**	
HOST		**COMPAQ**	
Position / Channel		**perpendicular / 165**	
DATE [dd/mm/yyyy]		**24-6-2004**	
System / software:		SARA v2.3	
Phantom S/No:	Box phantom.	No. of steps x and y	8
Test Frequency [MHz]	5825	Stepsize x and y [mm]	3
Antenna Configuration:	Integral	No. of steps z	7
Power / (setting(s) [dBm]	17.4	Stepsize z [mm]	2
Type of Modulation / bitrate [Mbit/s]	OFDM 6	Dist probe tip – phantom shell [mm]	1
Modn. Duty Cycle [%]	100	Prove conversion factor …..	0.750
Probe Serial Number:	131	Probe battery check [dd/mm/yyyy]:	24-6-2004
Liquid Simulant:	Body	Max E-field [V/m in liquid]	7.71
Permittivity / Conductivity [S/m]	48.2 / 6.0	Location of max. X= [mm]	2.2
Liquid Temperature [C]	22.0	Location of max Y= [mm]	-8.9
Ambient Temperature [C]	22.0	Location of max Z= [mm]	479.7
Relative Humidity [%]	49.0	SAR Drift: [dB]	0.0
Results:			
SAR 1g [W/kg]:	0.288		
SAR 10g [W/kg]:	0.137		





8.5 Hotspot identification[6].

The location and orientation of the hotspot is given by means of an overlay of the 2d scan with an EUT photograph.

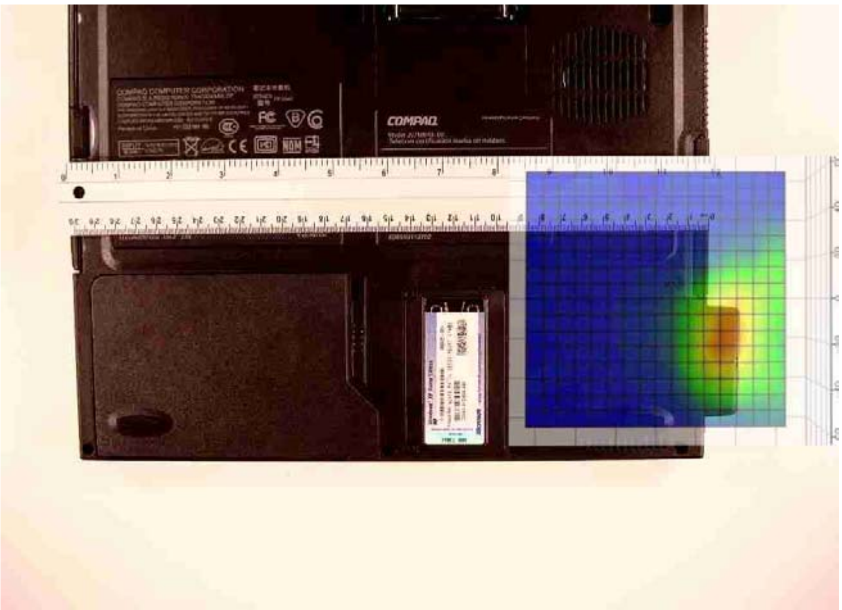


Photo 6: A 2d scan overlay giving the field strength in the first scanned plane, overlaid on a bottom side view photo of the laptop. 2d scan is that of the worst case lapheld value in channel 6, in the compaq host

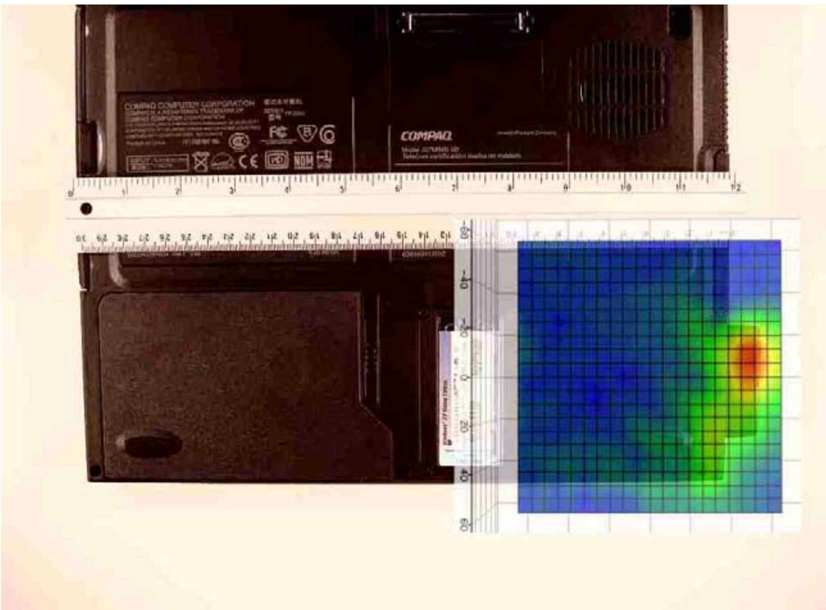


Photo 6: A 2d scan overlay giving the field strength in the first scanned plane, overlaid on a bottom view photo of the laptop (compaq). 2d scan is that of the worst case lapheld value in channel 52

[6] The hotspot is indicated with approximate values.

9 Description of test configuration.

9.1 SAR measurement system.

9.1.1 Robot system description.

The SAR measurement system, as used by TNO Electronic Products & Services (EPS) B.V., is the IndexSAR SARA2 system which consists of a Mitsubishi RV-2A six-axis robot-arm and controller, IndexSAR probe and amplifier and an appropriate phantom as required and considered appropriate for the test. The robot is used to move and manipulate the probe to programmed positions inside the phantom to obtain the SAR readings from the EUT.

The system is remote controlled by a PC, which contains the software to control the robot and data acquisition equipment. The software also displays the data obtained from test scans by calculating the measured values into corresponding SAR values based on the currently acceptable calculation methods.

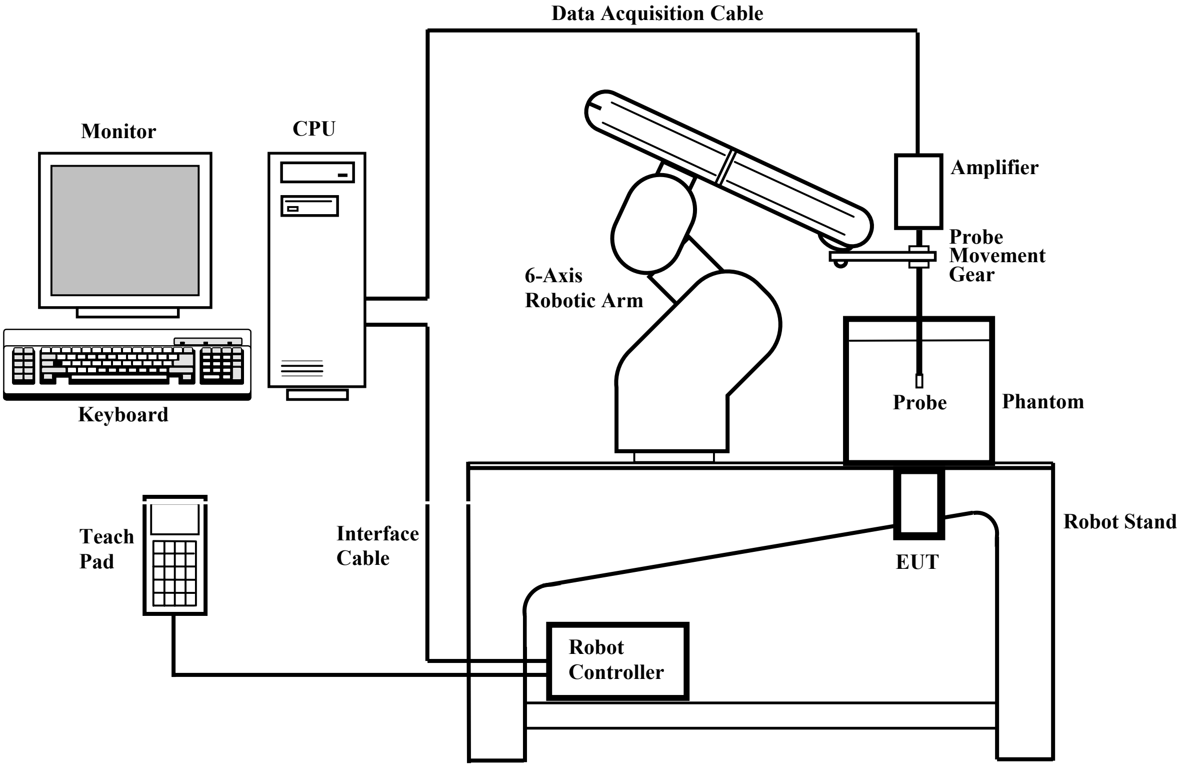


Figure 1: Overview of the SARA2 measurement system

The position and digitized shape of the phantom are made available to the software for accurate positioning of the probe and reduction of set-up time.

The SAM phantom heads are individually digitized using a Mitutoyo CMM machine to a precision of 0.001 mm. The data is then converted into a shape format for the software, providing an accurate description of the phantom shell.

When in operation, the system first performs 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.

9.1.2 Probe description.

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 section 10.1 of this test report.

9.1.3 Amplifier description.

The amplifier unit has a multi-pole connector to connect to the probe and a multiplexer selects between the 3-channel single-ended inputs. A 16-bit AtoD converter with programmable gain is used along with an on-board micro-controller with non-volatile firmware. Battery life is around 150 hours and data are transferred to the PC via 3 meters of duplex optical fibre and a self-powered RS232 to optical converter.

9.1.4 Phantom description.

Body-worn operating configurations are tested using a flat phantom. The body phantom shell is made of a low-loss dielectric material with dielectric constant and loss tangent less than 5.0 and 0.05 respectively. The shell thickness for all regions coupled to the test device and its antenna are within 2.0 ± 0.2 mm. The phantom was filled with the required head or body equivalent tissue medium to a depth of 15.0 ± 0.5 cm.

For body mounted and frontal held push-to-talk devices, a flat phantom of dimensions 20x20x20 cm with a base plate thickness of 2 mm is used.

For head mounted devices placed next to the ear, the phantom used in the evaluation of the RF exposure of the user of the wireless device is a IEEE P1528/CENELEC EN 50361 compliant phantom, shaped like a human head and filled with a mixture simulating the dielectric characteristics of the brain.

The Specific Anthropomorphic Mannequin (SAM) Upright Phantom which is used in combination with the SARA2 measurement system is fabricated using moulds generated from the CAD files as specified by the CENELEC EN 50361 standard. It is mounted via a rotation base to a supporting table, which also holds the robotic positioner. The phantom and robot alignment is assured by both mechanical and laser registration systems.

9.2 Measurement procedure.

During the SAR measurement, the positioning of the probe is performed with sufficient accuracy to obtain repeatable measurements in the presence of rapid spatial attenuation phenomena. The accurate positioning of the E-field probe is accomplished by using the high precision robot. The robot can be “trained” to position the probe sensor following a specific pattern of points.

After an area scan has been done at a fixed distance of 8 mm from the side of the phantom on the source side, a 3D scan is set up around the location of the maximum spot SAR. First, a point within the scan area is visited by the probe and a SAR reading taken at the start of testing. At the end of testing, the probe is returned to the same point and a second reading is taken. Comparison between these start and end readings enables the power (SAR) drift during measurement to be assessed.

9.2.1 SARA2 interpolation and extrapolation schemes.

SARA2 software contains support for both 2D cubic B-spline interpolation as well as 3D cubic B-spline interpolation. In addition, for extrapolation purposes, a general n^{-th} order polynomial fitting routine is implemented following a singular value decomposition algorithm presented in [4].

A 4^{th} order polynomial fit is used by default for data extrapolation, but a linear-logarithmic fitting function can be selected as an option. The polynomial fitting procedures have been tested by comparing the fitting coefficients generated by the SARA2 procedures with those obtained using the polynomial fit functions of Microsoft Excel when applied to the same test input data.

9.2.2 Interpolation of 2D area scan.

The 2D cubic B-spline interpolation is used after the initial area scan at fixed distance from the phantom shell wall. The initial scan data are collected with approx. 10 mm spatial resolution and spline interpolation is used to find the location of the local maximum to within a 1 mm resolution for positioning the subsequent 3D scanning.

9.2.3 Extrapolation of 3D scan.

For the 3D scan, data are collected on a spatially regular 3D grid having (by default) 6.4 mm steps in the lateral dimensions and 3.5 mm steps in the depth direction (away from the source). SARA2 enables full control over the selection of alternative step sizes in all directions.

The digitized shape of the Flat Phantom is available to the SARA2 software, which decides which points in the 3D array are sufficiently well within the shell wall to be 'visited' by the SAR probe. After the data collection, the data are extrapolated in the depth direction to assign values to points in the 3D array closer to the shell wall.

A notional extrapolation value is also assigned to the first point outside the shell wall so that subsequent interpolation schemes will be applicable right up to the shell wall boundary.

9.2.4 Interpolation of 3D scan and volume averaging.

The procedure used for defining the shape of the volumes used for SAR averaging in the SARA2 software follow the method of adapting the surface of the 'cube' to conform with the surface of the phantom (see Appendix C.2.2.1 in EN 50361). This is called, here, the conformal scheme.

For each row of data in the depth direction, the data are extrapolated and interpolated to less than 1 mm spacing and average values are calculated from the phantom surface for the row of data over distances corresponding to the requisite depth for 10g and 1g cubes.

This results in two 2D arrays of data, which are then cubic B-spline interpolated to sub mm lateral resolution. A search routine then moves an averaging square around through the 2D array and records the maximum value of the corresponding 1g and 10g volume averages.

For the definition of the surface in this procedure, the digitized position of the headshell surface is used for measurement in head-shaped phantoms. For measurements in rectangular, box phantoms, the distance between the phantom wall and the closest set of gridded data points is entered into the software.

For measurements in box-shaped phantoms, this distance is under the control of the user. The effective distance must be greater than 2.5 mm as this is the tip-sensor distance and to avoid interface proximity effects, it should be at least 5 mm. A value of 6 or 8 mm is recommended. This distance is called **dbe** in EN 50361.

For automated measurements inside the head, the distance cannot be less than 2.5 mm, which is the radius of the probe tip and to avoid interface proximity effects, a minimum clearance distance of x mm is retained. The actual value of dbe will vary from point to point depending upon how the spatially-regular 3D grid points fit within the shell. The greatest separation is when a grid point is just not visited due to the probe tip dimensions. In this case the distance could be as large as the step-size plus the minimum clearance distance (i.e with x = 5 and a step size of 3.5, **dbe** will be between 3.5 and 8.5 mm).

The default step size (**dstep** in EN 50361) used is 3.5 mm, but this is under user-control. The compromise is with time of scan, so it is not practical to make it much smaller or scan times become long and power-drop influences become larger.

The robot positioning system specification for the repeatability of the positioning (**dss** in EN 50361) is +/- 0.04 mm.

The Specific Anthropomorphic Mannequin (SAM) Upright Phantom shell is made by an industrial moulding process from the CAD files of the SAM shape, with both internal and external moulds. For the upright phantoms, the external shape is subsequently digitized on a Mitutoyo CMM machine (Euro C574) to a precision of 0.001 mm. Wall thickness measurements made non-destructively with an ultrasonic sensor indicate that the shell thickness (**dph**) away from the ear is 2.0 +/- 0.1 mm. The ultrasonic measurements were calibrated using additional mechanical measurements on available cut surfaces of the phantom shells.

The flat phantom is made from Polymethylmethacrylate (PMMA), a low-loss dielectric material with dielectric constant and loss tangent less than 5.0 and 0.05 respectively. The shell thickness for all regions coupled to the test device and its antenna are within 2.0 ± 0.2 mm.

For the upright phantom, the alignment is based upon registration of the rotation axis of the phantom on its 253 mm-diameter baseplate bearing and the position of the probe axis when commanded to go to the axial position. A laser alignment tool is provided (procedure detailed elsewhere). This enables the registration of the phantom tip (**dmis**) to be assured to within approx. 0.2 mm. This alignment is done with reference to the actual probe tip after installation and probe alignment. The rotational positioning of the phantom is variable – offering advantages for special studies, but locating pins ensure accurate repositioning at the principal positions (LH and RH ears).

10 Additional information supplementary to the test report.

10.1 Probe information.

To this report the probe test report and calibration document of the probe used are added. In the electronic version of this report, the pages are inserted after the last page of this test report.

10.2 SAR system check.

The purpose of the SAR system check is to verify that the system operates within its specifications at the device test frequency. The SAR system check is a simple check of repeatability to make sure that the system works correctly at the time of the compliance test. It is not a verification of the system with respect to external standards. The SAR system check should detect possible short term drift and errors in the system.

The SAR system check is a complete 1g or 10g averaged SAR measurement in a simplified test system with a standard source. The instrumentation and procedures are the same as those used for the compliance tests. The SAR system check has been performed using the specified tissue-equivalent liquid and at a chosen fixed frequency that is within ± 10 % of the compliance test mid-band frequency.

The SAR system check is performed prior to compliance tests and the result have been checked against the requirements (IEEE1528 and CENELEC standards) and must always be within ± 10 % of the target value corresponding to the test frequency, liquid and the source used mentioned in these standards.

The following measurement setup has been used for performing SAR system checks using a box phantoms is based on the procedures fully described in IEEE1528. This SAR system check is performed at the start of each measurement at a specific frequency range , with appropriate simulant liquids.

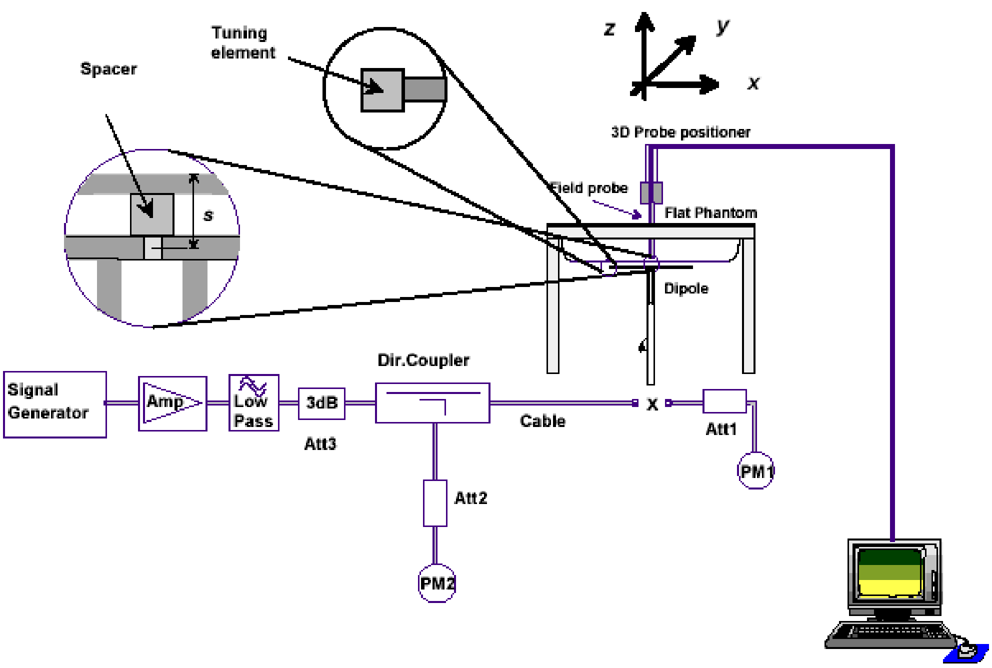


Fig. 10.2.1

With the signal generator, amplifier and directional coupler in place, the source signal has been set up at the relevant frequency and a power meter has been used to measure the power at the end of the SMA cable which is going to be connected to the balanced dipole. The low noise and distortion signal generator is adjusted so, that including all cable losses and other losses, the power at the connector X (to be connected to the balanced dipole) is 0.25 W (24 dBm) (Reading on PM1 in figure 10.2.1). A calibrated attenuator (Att. 1.20 dB) is used to protect overloading of the power meter.

No tuning of the balanced dipole was required because fixed tuned and calibrated balanced dipoles for the appropriate test frequencies were used.

10.3 5.8 GHz system check.

For 5.8 GHz validation, a waveguide method as proposed by Li, Ghandi and Kang, ‘An open ended waveguide system validation and/or probe calibration for frequencies above 3 GHz, submitted to the IEEE transactions on Microwave Theory and Techniques, June 2003.

The description of this method is taken from ‘SARA2 system validation at 5.2 and 5.8 GHz, MI Manning, Indexsar Ltd., 17 October 2003.

SARA2 SYSTEM VALIDATION AT 5.2 AND 5.8GHz

MI Manning, Indexsar Ltd.
17th October 2003.

10.3.1 Introduction.

Whilst international standards recommend techniques for performing system validations of SAR test systems for frequencies between 300 MHz and 3 GHz, proposals for validation testing at higher frequencies are only at an early-draft stage of discussion.

However, 5 GHz devices are on the market and need to be tested now. IEC 62209 has circulated two drafts of proposed procedures for 5 - 6 GHz SAR testing (Annex X), but the procedures are, as yet, ill-defined. The Annex X validation defines a small dipole as a source. Dimensions were incompletely specified in the first draft and are only more fully-defined in the second draft. No recommended separation distance for the dipole beneath the phantom is given in either draft to correspond with the computed reference values suggested.

Indexsar built some dipoles based on the first draft dimensions, but has found that use of these dipoles at the expected 10 mm spacing from the liquid do not give results that match the reference values. The 5.8 GHz validation results for max. 1g SAR with our prototype dipoles were 30 % low at a spacing of 10mm and 50 % high at a spacing of 7.5mm.

Since then, two useful contributions on 5 GHz validation testing have been circulated. A paper by Li, Gandhi and Kang [1] observes that “It is very difficult to develop half-wave dipole antennas for use in the 5.1 to 5.8 GHz band . . . .”. They propose an alternative procedure using an open-ended waveguide placed close to the bottom of the phantom. They propose that the open end of a WR187 waveguide is placed 10mm from the phantom liquid and they present FDTD computation results for use as reference values.

This particular waveguide has different internal dimensions to one recommended for probe calibration purposes in Annex X (WG13), which is unfortunate as otherwise the same waveguide could be recommended for both purposes.

The Utah paper [1] used liquids with the following properties for validations at 5250 and 5800 MHz:

Frequency (MHz)	Relative permittivity	Conductivity (S/m)
5250	48.8	6.82
5800	46.9	7.83

These property values are not very close to those recommended for compliance evaluations in Annex X, which are:

Frequency (MHz)	Relative permittivity	Conductivity (S/m)
5250	36.0	4.7
5800	35.3	5.3

In a separate paper [2], Utah authors argue that results of 1g SAR measurements are not very sensitive to liquid properties at 5 - 6 GHz and use this contention to justify the use of liquids with different properties.

Another paper recently circulated from Motorola personnel makes recommendations for SAR zoom scan measurement grids at 5 - 6 GHz [3]. The authors conclude that noise due to low measured values will compromise 10g volume average calculations and they recommend a restricted size zoom volume for 1g SAR determinations. They also conclude that 4th order polynomial extrapolations are not the best for these frequencies and suggest 3rd order polynomials or fitting to the logarithm of the SAR data.

10.3.2 Validation results using WR187 waveguide.

It would seem that an open-ended waveguide has some advantages in use as a source and we have performed validations based on the recommendations in [1]. The scanning parameters were set as per the recommendations in [3] and 3rd-order polynomial extrapolations were used instead of 4th order. The liquids have rather different property values to those employed in [1], but [2] suggests that this may not affect the max. 1g SAR results by much.

Using these conditions and with use of a WR187 waveguide, validation testing with the following liquid properties resulted in 1g SAR measurements close to the reference values given in [1]. The results are summarized below:

Frequency (MHz)	Relative permittivity	Conductivity (S/m)
5200	37.12	5.01
5800	35.41	5.79

Frequency (MHz)	Reference 1g SAR value (W/kg) from [1] normalized to 1W	Measured 1g SAR value (W/kg) / error (%)
5250	35.80	34.82 (-3%)
5800	39.46	43.08 (+9%)

Based on the testing performed, it is recommended that SARA2 systems are validated using the open-ended WR187 waveguide technique until improved procedures become available or specific methods become adopted in the relevant standards.

10.3.3 An alternative open-ended waveguide geometry.

It is not clear why [1] recommends a spacing of 10 mm from the liquid from a waveguide, when contact with the phantom would seem to be more appropriate and offer more accurate positioning. Also, a matching window with permittivity similar to that of the phantom wall material could minimize reflective losses. Lastly, a waveguide of the same dimensions as that recommended for probe calibration would be a useful reduction in the required equipment budget.

For these reasons, we are commissioning FDTD computations of reference values expected with a WG13 waveguide with a matching window as per Annex X in contact with a 2mm wall phantom filled with a liquid with the properties proposed in Annex X. In this way, we hope to have an optimized validation solution for 5 - 6 GHz testing.

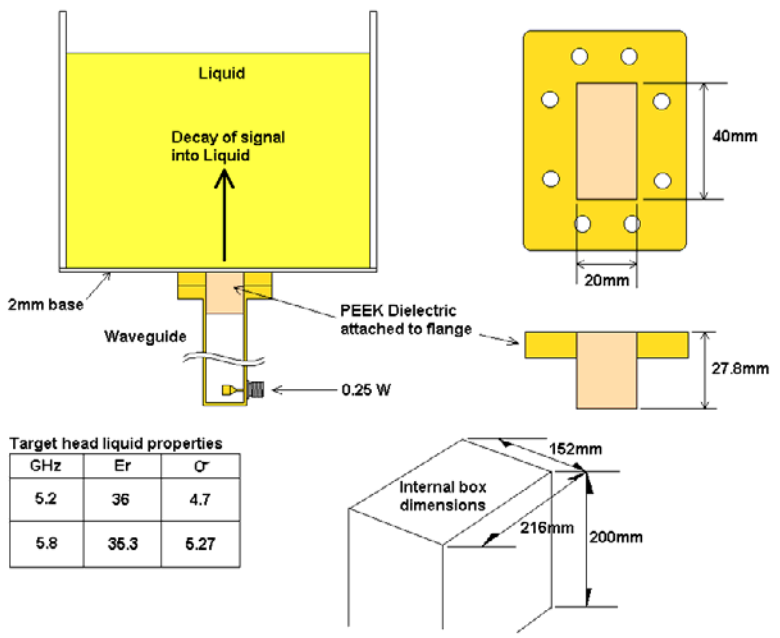


Figure 1: Proposed validation configuration with waveguide in contact with phantom for which reference values will be calculated

References:

[1] Q Li, OP Gandhi, G Kang, 'An open-ended waveguide system validation and/or probe calibration for frequencies above 3 GHz', submitted to IEEE Transactions on Microwave Theory and Techniques, June 2003.

[2] G Kang & OP Gandhi, 'Effect of dielectric properties on the peak 1g and 10g SAR for 802.11 a/b/g frequencies of 2.45 and 5.15 to 5.85 GHz', to be published in IEEE Transactions on Electromagnetic Compatibility.

[3] Recommendations for SAR zoom scan measurement grids at 5 - 6 GHz.

10.4 Dielectric property measurement of tissue-simulant liquids for SAR testing.

10.4.1 Introduction.

This section describes the measurement of the dielectric properties of tissue-equivalent material as part of the SAR characterization procedure and the method used.

The measurement method is based on a published technique *(Toropainen et al , 'Method for accurate measurement of complex permittivity of tissue equivalent liquids', Electronics Letters 36 (1) 2000 pp32-34)* and uses a fixture with 2 parallel planes with a conductor in between. Liquid filling the space between the planes immerses the inner conductor wholly. Measurements of S_{21} with an empty fixture and that of a filled fixture are conducted so that the complex dielectric properties of the fluid can be deduced. The fixture is also referred to as *TEM line.*

10.4.2 TEM-cell construction.

The TEM cell construction is shown in Figure 10.3.1 and consists of a central cylindrical transmission line sandwiched between two ground planes

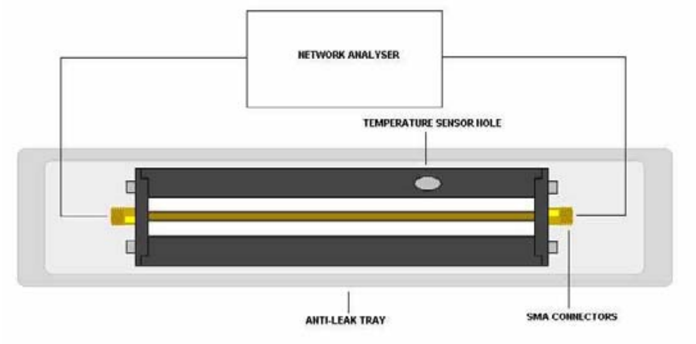


Figure 10.3.1. TEM Cell Construction.

Four different sensors can be used with transmission line lengths of 30 mm, 60 mm, 80 mm and 160 mm. The transmission line is terminated with SMA connectors at either end using short 50 Ohm launcher sections. The assembly is held firmly against a plastic base with a clamping arrangement providing a seal to retain the liquid. The liquid under test is introduced with a pipette to fill the space between the ground planes. Care has been taken to prevent air bubbles and this is particularly important with viscous liquids. A hole is provided in one of the ground planes so that a thermometer probe has been be inserted to monitor the temperature. The cell is washed out and thoroughly dried before further use.

A vector network analyser (VNA) is used to measure the performance of the cell. A good impedance match will be found when air filled indicating that the transmission line impedance is close to 50 Ohm. The transmission loss and phase are measured with and without the liquid to enable the electrical properties to be deduced.

10.4.3 Calculation of dielectric properties from VNA measurements.

The complex permittivity of the simulant liquids were measured using a TEM line sensor as recommended in the EN 50361standard and draft IEEE1528 standard. The method [1] is based on the measurement of complex transmission coefficient of a TEM-line filled with the liquid. Transmission measurement is done using a VNA, recording the magnitude and phase of scattering coefficient S_{21}. The complex permittivity of the liquid is calculated from the magnitude and phase of S_{21} by numerical solution of the equation of transmission coefficient derived by signal flow graph technique

$$S_{21} = \frac{\left(1-\Gamma^2\right)\exp\left(-\,\mathrm{j}(k-k_0)d\right)}{1\text{-}\Gamma^2\exp\left(-\,\mathrm{j}2kd\right)},$$

$$\Gamma = \frac{1-\sqrt{\varepsilon_r}}{1+\sqrt{\varepsilon_r}},$$

$$k = \frac{2\pi f}{c_0}\sqrt{\varepsilon_r},$$

where Γ is the reflection coefficient at liquid surfaces, k the propagation factor in the liquid, k_0 the vacuum propagation factor, d the length of the sample, f the frequency and $\varepsilon_r = \varepsilon_r' - \mathrm{j}\varepsilon_r''$ the relative complex permittivity of the sample.

10.5 Measurement uncertainty.

10.5.1 Introduction.

A measurement uncertainty assessment has been undertaken following guidance as given in EN 50361 and IEEE1528.

IndexSAR Ltd has supplied a generic uncertainty analysis for the SARA2 system in the form of a spreadsheet and the supporting assessments are documented in an IndexSAR document IXS-2028. Additionally, uncertainties resulting from the probe positioning system and the upright phantom geometry are discussed in additional documents.

Some of the uncertainty contributions are site-specific and, for these, TNO Electronic Products & Services (EPS) B.V. has assessed the uncertainty contributions arising from local environmental and procedural factors.

The resultant uncertainty budget is shown on the next pages.

10.5.2 Uncertainty calculated for IEEE1528: standard measurements (2450 MHz).

a	*b*	*c*	*d*	*e= f(d,k)*	*f*	*g*	*h= cxg/e*	*i= cxg/e*	*k*
Uncertainty Component	Section	Tol. (± %)	Prob. Dist.	Div.	ci (1-g)	ci (10-g)	1-g ui (±%)	10-g ui (±%)	vt
Measurement System									
Probe Calibration	E2.1	10.0	N	1or k	1	1	5.0	5.0	∞
Axial Isotropy	E2.2	5.93	R	√3	0.7	0.7	2.4	2.4	∞
Hemispherical Isotropy	E2.2	10.92	R	√3	1	1	6.3	6.3	∞
Boundary Effect	E2.3	4.0	R	√3	1	1	2.3	2.3	∞
Linearity	E2.4	0.93	R	√3	1	1	0.5	0.5	∞
System Detection Limits	E2.5	1.0	R	√3	1	1	0.6	0.6	∞
Readout Electronics	E2.6	1.0	N	1or k	1	1	1.0	1.0	∞
Response Time	E2.7	0.0	R	√3	1	1	0.0	0.0	∞
Integration Time	E2.8	1.8	R	√3	1	1	1.0	1.0	∞
RF Ambient Conditions	E6.1	3.0	R	√3	1	1	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E6.2	0.6	R	√3	1	1	0.3	0.3	∞
Probe Positioning wrt Phantom Shell	E6.3	5.0	R	√3	1	1	2.9	2.9	∞
SAR Evaluation Algoritms	E5.2	8.0	R	√3	1	1	4.6	4.6	∞
Test sample Related									∞
Test Sample Positioning	E4.2	5.0	R	√3	1	1	2.9	2.9	∞
Device Holder Uncertainty	E4.1	3	R	√3	1	1	1.7	1.7	∞
Output Power Variation	6.6.2	5.0	R	√3	1	1	2.9	2.9	∞
Phantom and Tissue Parameters									∞
Phantom Uncertainty (shape and thickness)	E3.1	4.0	R	√3	1	1	2.3	2.3	∞
Liquid Conductivity Target - tolerance	E3.2	1.0	R	√3	0.7	0.5	0.4	0.3	∞
Liquid Conductivity - measurement uncert.	E3.3	4.7	R	√3	0.7	0.5	1.9	1.4	∞
Liquid Permittivity Target tolerance	E3.2	4.4	R	√3	0.6	0.5	1.5	1.3	∞
Liquid Permittivity - measurement uncert.	E3.3	3.3	R	√3	0.6	0.5	1.1	1.0	∞
Combined Standard Uncertainty		$u_c = \sqrt{\sum_{i=1}^{m} c_i^2 \cdot u_i^2}$					11.7	11.6	
Expanded Uncertainty (95% confidence interval)	Normal k=1.96 **ue=k* u_c**						**22.9%**	**22.7%**	

10.5.3 Uncertainty calculated for IEEE1528: standard measurements (5800 MHz).

a	*b*	*c*	*d*	*e= f(d,k)*	*f*	*g*	*h= cxg/e*	*i= cxg/e*	*k*
Uncertainty Component	Section	Tol. (± %)	Prob. Dist.	Div.	ci (1-g)	ci (10-g)	1-g ui (±%)	10-g ui (±%)	vt
Measurement System									
Probe Calibration	E2.1	12.0	N	1or k	1	1	6.0	6.0	∞
Axial Isotropy	E2.2	5.93	R	√3	0.7	0.7	2.4	2.4	∞
Hemispherical Isotropy	E2.2	10.92	R	√3	1	1	6.3	6.3	∞
Boundary Effect	E2.3	4.0	R	√3	1	1	2.3	2.3	∞
Linearity	E2.4	0.93	R	√3	1	1	0.5	0.5	∞
System Detection Limits	E2.5	1.0	R	√3	1	1	0.6	0.6	∞
Readout Electronics	E2.6	1.0	N	1or k	1	1	1.0	1.0	∞
Response Time	E2.7	0.0	R	√3	1	1	0.0	0.0	∞
Integration Time	E2.8	1.8	R	√3	1	1	1.0	1.0	∞
RF Ambient Conditions	E6.1	3.0	R	√3	1	1	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E6.2	0.6	R	√3	1	1	0.3	0.3	∞
Probe Positioning wrt Phantom Shell	E6.3	5.0	R	√3	1	1	2.9	2.9	∞
SAR Evaluation Algoritms	E5.2	8.0	R	√3	1	1	4.6	4.6	∞
Test sample Related									∞
Test Sample Positioning	E4.2	10.0	R	√3	1	1	5.8	5.8	∞
Device Holder Uncertainty	E4.1	5.0	R	√3	1	1	2.9	2.9	∞
Output Power Variation	6.6.2	5.0	R	√3	1	1	2.9	2.9	∞
Phantom and Tissue Parameters									∞
Phantom Uncertainty (shape and thickness)	E3.1	4.0	R	√3	1	1	2.3	2. 3	∞
Liquid Conductivity Target - tolerance	E3.2	7.5	R	√3	0.7	0.5	3.0	2.2	∞
Liquid Conductivity - measurement uncert.	E3.3	5.0	R	√3	0.7	0.5	2.0	1.4	∞
Liquid Permittivity Target tolerance	E3.2	1.0	R	√3	0.7	0.5	0.4	0.3	∞
Liquid Permittivity - measurement uncert.	E3.3	3.3	R	√3	0.7	0.5	1.3	1.0	∞
Combined Standard Uncertainty		$u_c = \sqrt{\sum_{i=1}^{m} c_i^2 \cdot u_i^2}$					13.5	13.3	
Expanded Uncertainty (95% confidence interval)	Normal k=1.96 **ue=k* u_c**						**26.5%**	**26.1%**	

10.5.4 Uncertainty calculated for IEEE1528: system performance check (2450 MHz).

a	*b*	*c*	*d*	*e= f(d,k)*	*f*	*g*	*h= cxg/e*	*i= cxg/e*	*k*
Uncertainty Component	Section	Tol. (± %)	Prob. Dist.	Div.	ci (1-g)	ci (10-g)	1-g ui (±%)	10-g ui (±%)	vt
Measurement System									
Probe Calibration	E2.1	10.0	N	1or k	1	1	5.0	5.0	∞
Axial Isotropy	E2.2	5.93	R	√3	0.7	0.7	2.4	2.4	∞
Hemispherical Isotropy	E2.2	10.92	R	√3	1	1	6.3	6.3	∞
Boundary Effect	E2.3	4.0	R	√3	1	1	2.3	2.3	∞
Linearity	E2.4	0.93	R	√3	1	1	0.5	0.5	∞
System Detection Limits	E2.5	1.0	R	√3	1	1	0.6	0.6	∞
Readout Electronics	E2.6	1.0	N	1or k	1	1	1.0	1.0	∞
Response Time	E2.7	0.0	R	√3	1	1	0.0	0.0	∞
Integration Time	E2.8	1.8	R	√3	1	1	1.0	1.0	∞
RF Ambient Conditions	E6.1	3.0	R	√3	1	1	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E6.2	0.6	R	√3	1	1	0.3	0.3	∞
Probe Positioning wrt Phantom Shell	E6.3	5.0	R	√3	1	1	2.9	2.9	∞
SAR Evaluation Algoritms	E5.2	8.0	R	√3	1	1	4.6	4.6	∞
Dipole Related									∞
Dipole axis to liquid distance	8, E4.2	1.0	R	√3	1	1	0.6	0.6	∞
Input Power & SAR Drift measurments	8, 6.6.2	1.5	R	√3	1	1	0.9	0.9	∞
Phantom and Tissue Parameters									∞
Phantom Uncertainty (shape and thickness)	E3.1	4.0	R	√3	1	1	2.7	2. 7	∞
Liquid Conductivity Target - tolerance	E3.2	1.0	R	√3	0.7	0.5	0.4	0.3	∞
Liquid Conductivity - measurement uncert.	E3.3	4.7	R	√3	0.7	0.5	1.9	1.4	∞
Liquid Permittivity Target tolerance	E3.2	4.4	R	√3	0.6	0.5	1.5	1.3	∞
Liquid Permittivity - measurement uncert.	E3.3	3.3	R	√3	0.6	0.5	1.1	1.0	∞
Combined Standard Uncertainty		$u_c = \sqrt{\sum_{i=1}^{m} c_i^2 \cdot u_i^2}$					10.9	10.8	
Expanded Uncertainty (95% confidence interval)		Normal k=1.96 **ue=k* u_c**					**21.3%**	**21.1%**	

10.5.5 Uncertainty calculated for IEEE1528: system performance check (5800 MHz).

a	*b*	*c*	*d*	*e= f(d,k)*	*f*	*g*	*h= cxg/e*	*i= cxg/e*	*k*
Uncertainty Component	Section	Tol. (± %)	Prob. Dist.	Div.	ci (1-g)	ci (10-g)	1-g ui (±%)	10-g ui (±%)	vt
Measurement System									
Probe Calibration	E2.1	12.0	N	1or k	1	6.0	6.0	6.0	∞
Axial Isotropy	E2.2	5.93	R	√3	0.7	2.4	2.4	2.4	∞
Hemispherical Isotropy	E2.2	10.92	R	√3	1	6.3	6.3	6.3	∞
Boundary Effect	E2.3	4.0	R	√3	1	2.3	2.3	2.3	∞
Linearity	E2.4	0.93	R	√3	1	0.5	0.5	0.5	∞
System Detection Limits	E2.5	1.0	R	√3	1	0.6	0.6	0.6	∞
Readout Electronics	E2.6	1.0	N	1or k	1	1.0	1.0	1.0	∞
Response Time	E2.7	0.0	R	√3	1	0.0	0.0	0.0	∞
Integration Time	E2.8	1.8	R	√3	1	1.0	1.0	1.0	∞
RF Ambient Conditions	E6.1	3.0	R	√3	1	1.7	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E6.2	0.6	R	√3	1	0.3	0.3	0.3	∞
Probe Positioning wrt Phantom Shell	E6.3	5.0	R	√3	1	2.9	2.9	2.9	∞
SAR Evaluation Algorithms	E5.2	8.0	R	√3	1	4.6	4.6	4.6	∞
Dipole Related									∞
Dipole axis to liquid distance	8, E4.2	1.0	R	√3	1	1	7.5	7.5	∞
Input Power & SAR Drift measurements	8, 6.6.2	2.0	R	√3	1	1	2.89	2.89	∞
Phantom and Tissue Parameters									∞
Phantom Uncertainty (shape and thickness)	E2.1	4.0	R	√3	1	1	2.3	2. 3	∞
Liquid Conductivity Target - tolerance	E2.2	7.5	R	√3	0.7	0.5	3.0	2.2	∞
Liquid Conductivity - measurement uncert.	E2.2	5.0	R	√3	0.7	0.5	2.0	1.4	∞
Liquid Permittivity Target tolerance	E2.2	1.0	R	√3	0.7	0.5	0.4	0.3	5
Liquid Permittivity - measurement uncert.	E2.2	3.3	R	√3	0.7	0.5	1.3	1.0	∞
Combined Standard Uncertainty		$u_c = \sqrt{\sum_{i=1}^{m} c_i^2 \cdot u_i^2}$					11.0	10.9	
Expanded Uncertainty (95% confidence interval)		Normal k=1.96 **ue=k* u_c**					**21.5%**	**21.3%**	

11 List of utilized test equipment.

Inventory number	Description	Brand	Model
03012	Network Analyzer (VNA)	Rohde & Schwarz	ZVC
03013	VNA Calibration Kit	Rohde & Schwarz	
12483	Guidehorn	EMCO	3115
12484	Guidehorn	EMCO	3115
12488	Guidehorn 18 - 26.5 GHz	EMCO	RA42-K-F-4B-C
12533	Signalgenerator	MARCONI	2032
12559	Digital storage oscilloscope	Le Croy	9310M
12561	DC Power Supply 20A/70V	DELTA	SM7020D
12605	calibrated dipole 28MHz-1GHz	Emco	3121c
12608	HF milliwattmeter	Hewlett Packard	HP435a
12609	Power sensor 10MHz-18GHz	Hewlett Packard	HP8481A
3664	Spectrum analyzer	HP	HP8593E
13078	Preamplifier 0.1 GHz - 12 GHz	Miteq	AMF-3D-001120-35-4p
13526	Signalgenerator 20 GHz	Hewlett & Packard	83620A
13594	Preamplifier 10 GHz - 25 GHz	Miteq	AMF-6D-100250-10p
14450	2.4 GHz bandrejectfilter	BSC	XN-1783
99068	Detector N-F/BNC-F	Radiall	R451576000
99076	Bandpassfilter 4 - 10 GHz	Reactel	7AS-7G-6G-511
99112	Tripod	Chase	--
99136	Bandpassfilter 10 - 26.5 GHz	Reactel	9HS-10G/26.5G-S11
03011	RF Amplifier (1 Watt)	IndexSAR	
03010	Bench-top Robot	Mitsubishi	RV-E2
03009	Calibration dipole 2450	IndexSAR	IXD 0022
03008	Calibration dipole 5800	IndexSAR	
03007	Directional Coupler	Hewlett & Packard	779D
03006	Attenuator (3 dB)	Hewlett & Packard	
03005	Hygrometer/room temperature meter		
03004	SAR Probe	IndexSAR	S/N 0131
03003	Phantom box	IndexSAR	N.A.
03002	TEM line liquid measurement	IndexSAR	N.A.
03012	Waveguide W-137	IndexSAR	N.A.
03013	Calibrated mercury thermometers	NMI	15-30 C

12 Test software.

During the tests as indicated in this test report the TNO EPS SARA2 system was operated with:

SARA2 system v.0.281
Mitsubishi robot controller firmware revision RV-E2 Version C9a
IXA-10 Probe amplifier Version 2.4
DiLine Dielectric Kit Software v 0.109 (12/6/2003)