



Test Laboratory: Neutron Engineering Inc.

**WF2190 802.11AC mode HT80 ant A+B 5775MHz 5mm**

**DUT: WF2190-5mm; Type: Sample; Serial: 1307C140A**

Communication System: UID 0, IEEE 802.11AC HT80 WiFi 5G(OFDMA, 6 Mbps.); Frequency: 5775 MHz

Medium parameters used (interpolated):  $f = 5775$  MHz;  $\sigma = 6.185$  S/m;  $\epsilon_r = 48.35$ ;  $\rho = 996$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASYS (IEEE/TEC/ANSI C63.19-2007)

**DASY Configuration:**

- Probe: EX3DV4 - SN3932; ConvF(4.19, 4.19, 4.19); Calibrated: 09/16/2013;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection),  $z = 1.0, 31.0$
- Electronics: DAE4 Sn1390; Calibrated: 09/10/2013
- Phantom: SAM 1; Type: SAM; Serial: 1784
- DASYS2 52.8.7(1137); SEMCAD X 14.6.10(7164)

**802.11AC HT80 5mm/WF2190 802.11AC HT80 antA+B 5775MHz 5mm/Area Scan (81x81x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm**

Reference Value = 0.106 V/m; Power Drift = 0.014 dB

Fast SAR: SAR(1 g) = 0.00288 W/kg; SAR(10 g) = 0.000472 W/kg

Maximum value of SAR (interpolated) = 0.0182 W/kg

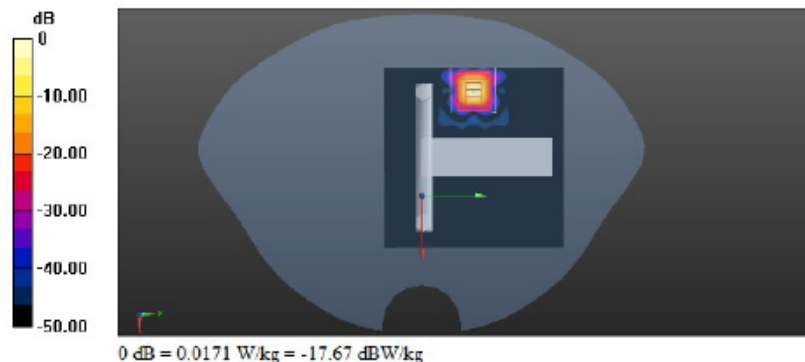
**802.11AC HT80 5mm/WF2190 802.11AC HT80 antA+B 5775MHz 5mm/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm**

Reference Value = 0.106 V/m; Power Drift = 0.014 dB

Peak SAR (extrapolated) = 0.0390 W/kg

SAR(1 g) = 0.00594 W/kg; SAR(10 g) = 0.00164 W/kg

Maximum value of SAR (measured) = 0.0171 W/kg





Test Laboratory: Neutron Engineering Inc.

**WF2190 802.11AC mode HT80 ant A+B 5775MHz 10mm**

DUT: WF2190-10mm; Type: Sample; Serial: 1307C140A

Communication System: UID 0, IEEE 802.11AC HT80 WiFi 5G(OFDM, 6 Mbps.) ; Frequency: 5775 MHz

Medium parameters used (interpolated):  $f = 5775$  MHz;  $\sigma = 6.185$  S/m;  $\epsilon_r = 48.35$ ;  $\rho = 996$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3932; ConvF(4.19, 4.19, 4.19); Calibrated: 09/16/2013;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection),  $z = 1.0, 31.0$
- Electronics: DAE4 Sn1390; Calibrated: 09/10/2013
- Phantom: SAM 1; Type: SAM; Serial: 1784
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

**802.11AC HT80 10mm/WF2190 802.11AC HT80 antA+B 5775MHz 10mm/Area Scan (91x131x1):** Interpolated grid:  $dx=1.500$  mm,  $dy=1.500$  mm

Reference Value = 0.351 V/m; Power Drift = 0.08 dB

Fast SAR: SAR(1 g) = 0.046 W/kg; SAR(10 g) = 0.017 W/kg

Maximum value of SAR (interpolated) = 0.113 W/kg

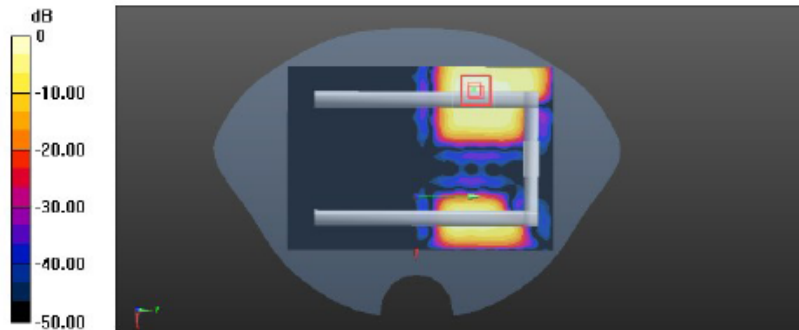
**802.11AC HT80 10mm/WF2190 802.11AC HT80 antA+B 5775MHz 10mm/Zoom Scan (7x7x7)/Cube 0:** Measurement grid:  $dx=5$ mm,  $dy=5$ mm,  $dz=5$ mm

Reference Value = 0.351 V/m; Power Drift = 0.08 dB

Peak SAR (extrapolated) = 0.235 W/kg

SAR(1 g) = 0.037 W/kg; SAR(10 g) = 0.013 W/kg

Maximum value of SAR (measured) = 0.114 W/kg



0 dB = 0.114 W/kg = -9.43 dBW/kg



**4. Probe Calibration Certificate**

**EX3DV4**

**Calibration Laboratory of  
Schmid & Partner  
Engineering AG**  
Zeughausstrasse 43, 8004 Zurich, Switzerland



**S** Schweizerischer Kalibrierdienst  
**S** Service suisse d'étalonnage  
**S** Servizio svizzero di taratura  
**S** Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)  
The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **Neutron Engineering (Auden)**

Certificate No: **EX3-3932\_Sep13**

**CALIBRATION CERTIFICATE**

Object: **EX3DV4 - SN:3932**

Calibration procedure(s): **QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6  
Calibration procedure for dosimetric E-field probes**

Calibration date: **September 16, 2013**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	04-Apr-13 (No. 217-01733)	Apr-14
Power sensor E4412A	MY41498087	04-Apr-13 (No. 217-01733)	Apr-14
Reference 3 dB Attenuator	SN: S5054 (3c)	04-Apr-13 (No. 217-01737)	Apr-14
Reference 20 dB Attenuator	SN: S5277 (20x)	04-Apr-13 (No. 217-01735)	Apr-14
Reference 30 dB Attenuator	SN: S5129 (30b)	04-Apr-13 (No. 217-01738)	Apr-14
Reference Probe ES3DV2	SN: 3013	28-Dec-12 (No. ES3-3013_Dec12)	Dec-13
DAE4	SN: 660	4-Sep-13 (No. DAE4-660_Sep13)	Apr-14
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642UD1700	4-Aug-99 (in house check Apr-13)	In house check: Apr-15
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-12)	In house check: Oct-13

	Name	Function	Signature
Calibrated by:	<b>Leif Klyner</b>	<b>Laboratory Technician</b>	
Approved by:	<b>Katja Pokovic</b>	<b>Technical Manager</b>	

Issued: September 17, 2013

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.



Calibration Laboratory of Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland



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Accreditation No.: SCS 108

Glossary:

- TSL tissue simulating liquid
NORMx,y,z sensitivity in free space
ConvF sensitivity in TSL / NORMx,y,z
DCP diode compression point
CF crest factor (1/duty\_cycle) of the RF signal
A, B, C, D modulation dependent linearization parameters
Polarization phi phi rotation around probe axis
Polarization theta theta rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., theta = 0 is normal to probe axis

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

Methods Applied and Interpretation of Parameters:

- NORMx,y,z: Assessed for E-field polarization theta = 0 (f <= 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below ConvF).
NORM(f)x,y,z = NORMx,y,z \* frequency\_response (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
DCPx,y,z: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
PAR: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z; A, B, C, D are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
ConvF and Boundary Effect Parameters: Assessed in flat phantom using E-field (or Temperature Transfer Standard for f <= 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORMx,y,z \* ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from +/- 50 MHz to +/- 100 MHz.
Spherical isotropy (3D deviation from isotropy): in a field of low gradients realized using a flat phantom exposed by a patch antenna.
Sensor Offset: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.



EX3DV4 – SN:3932

September 16, 2013

# Probe EX3DV4

## SN:3932

Manufactured: July 24, 2013  
Calibrated: September 16, 2013

Calibrated for DASY/EASY Systems  
(Note: non-compatible with DASY2 system!)



EX3DV4- SN:3932

September 16, 2013

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3932

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup>	0.52	0.55	0.46	$\pm 10.1 \%$
DCP (mV) <sup>B</sup>	102.3	102.8	101.8	

### Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc <sup>E</sup> (k=2)
0	CW	X	0.0	0.0	1.0	0.00	167.8	$\pm 3.0 \%$
		Y	0.0	0.0	1.0		179.9	
		Z	0.0	0.0	1.0		157.1	

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor  $k=2$ , which for a normal distribution corresponds to a coverage probability of approximately 95%.

<sup>A</sup> The uncertainties of NormX,Y,Z do not affect the E<sup>2</sup>-field uncertainty inside TSL (see Pages 5 and 6).

<sup>B</sup> Numerical linearization parameter: uncertainty not required.

<sup>E</sup> Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.



**DASY/EASY - Parameters of Probe: EX3DV4 - SN:3932**

**Calibration Parameter Determined in Head Tissue Simulating Media**

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (mm)	Unct. (k=2)
750	41.9	0.89	10.36	10.36	10.36	0.20	1.35	± 12.0 %
835	41.5	0.90	9.89	9.89	9.89	0.29	1.02	± 12.0 %
900	41.5	0.97	9.67	9.67	9.67	0.21	1.33	± 12.0 %
1750	40.1	1.37	8.47	8.47	8.47	0.33	0.89	± 12.0 %
1900	40.0	1.40	8.21	8.21	8.21	0.12	1.47	± 12.0 %
2100	39.8	1.49	8.31	8.31	8.31	0.80	0.50	± 12.0 %
2300	39.5	1.67	7.75	7.75	7.75	0.43	0.70	± 12.0 %
2450	39.2	1.80	7.40	7.40	7.40	0.36	0.81	± 12.0 %
2600	39.0	1.96	7.16	7.16	7.16	0.44	0.78	± 12.0 %

<sup>C</sup> Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

<sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.



**DASY/EASY - Parameters of Probe: EX3DV4 - SN:3932**

**Calibration Parameter Determined in Body Tissue Simulating Media**

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (mm)	Unct. (k=2)
750	55.5	0.96	9.92	9.92	9.92	0.21	1.47	± 12.0 %
835	55.2	0.97	9.92	9.92	9.92	0.30	1.12	± 12.0 %
900	55.0	1.05	9.67	9.67	9.67	0.51	0.79	± 12.0 %
1750	53.4	1.49	8.14	8.14	8.14	0.56	0.73	± 12.0 %
1900	53.3	1.52	7.80	7.80	7.80	0.42	0.80	± 12.0 %
2100	53.2	1.62	8.12	8.12	8.12	0.29	1.01	± 12.0 %
2300	52.9	1.81	7.57	7.57	7.57	0.59	0.68	± 12.0 %
2450	52.7	1.95	7.34	7.34	7.34	0.80	0.50	± 12.0 %
2600	52.5	2.16	7.08	7.08	7.08	0.80	0.50	± 12.0 %
5200	49.0	5.30	4.69	4.69	4.69	0.45	1.90	± 13.1 %
5300	48.9	5.42	4.48	4.48	4.48	0.45	1.90	± 13.1 %
5500	48.6	5.65	4.15	4.15	4.15	0.50	1.90	± 13.1 %
5600	48.5	5.77	4.07	4.07	4.07	0.45	1.90	± 13.1 %
5800	48.2	6.00	4.19	4.19	4.19	0.55	1.90	± 13.1 %

<sup>C</sup> Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

<sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

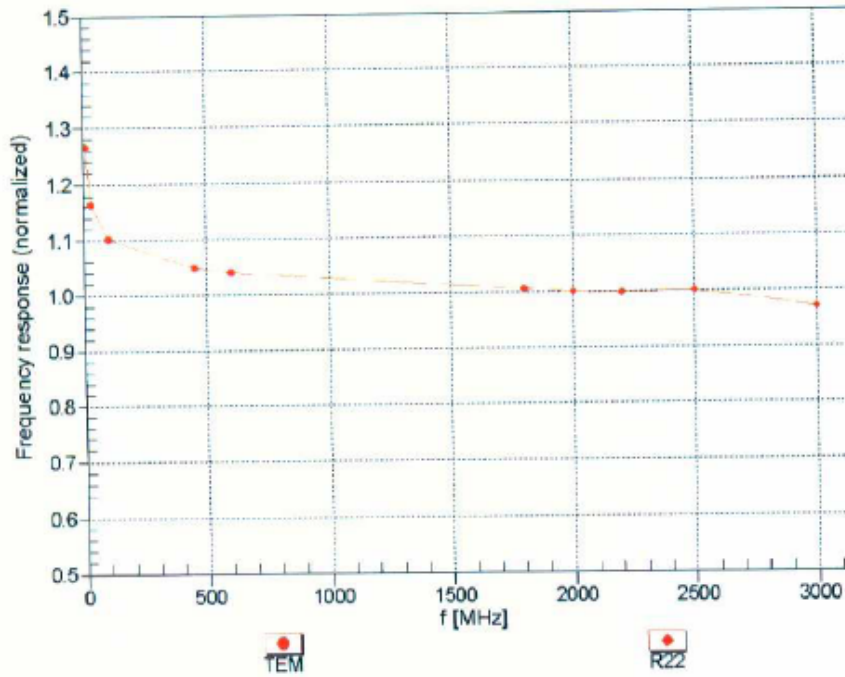




EX3DV4-SN:3932

September 16, 2013

### Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)



Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)

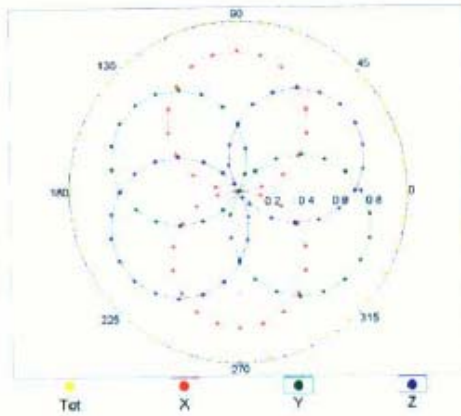


EX3DV4-SN:3932

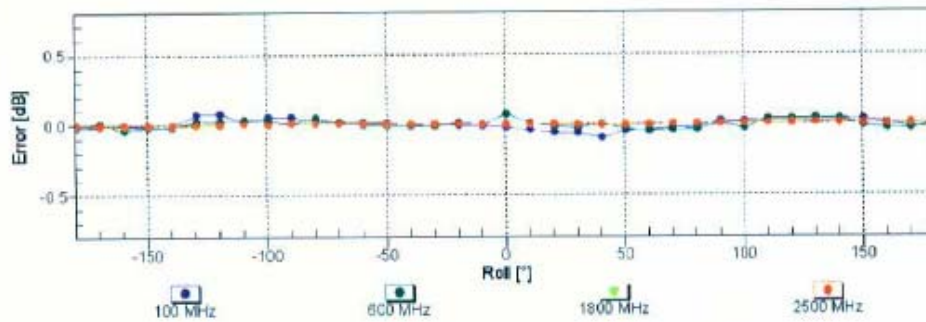
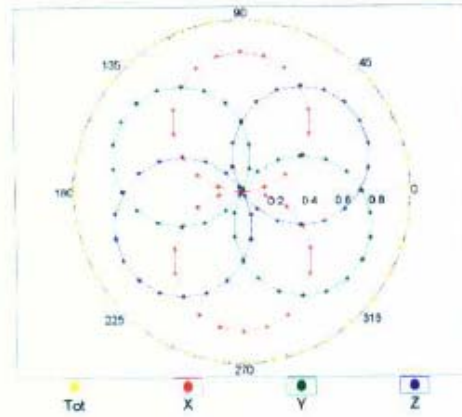
September 16, 2013

### Receiving Pattern ( $\phi$ ), $\theta = 0^\circ$

f=600 MHz,TEM



f=1800 MHz,R22



Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  (k=2)