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Certificate of Calibration

SAR PROBE
IndexSAR
Model: IXP-030
Serial number: M0024

FOR:. CETECOM Inc.
411 Dixon Landing Road
Milpitas
California 95035
USA

Order number: PO000000000001200

DESCRIPTION: An IndexSAR isotropic electric field probe for determining specific absorption rates (SAR) in dielectric liquids. The probe has three orthogonal sensors, and the output voltage of the sensors is converted to an optical signal by a meter unit containing an analogue to digital (AD) converter. Probe readings are obtained using software via the RS232 port. The probe was calibrated with IndexSAR amplifier model IXA-010 S/N 036 belonging to NPL.

IDENTIFICATION: The probe is marked with the manufacturer's serial number M0024

MEASUREMENTS COMPLETED ON: 11 March 2008

PREVIOUS NPL CERTIFICATE: None

The reported uncertainty is based on a coverage factor $k = 2$, providing a level of confidence of approximately 95%

Reference : E08010103

Date of Issue : 12 March 2008 **Signed :** DG Gentle **(Authorised Signatory)**

Checked by : BLL **Name : Mr D G Gentle** **for Managing Director**

MEASUREMENT PROCEDURE

The calibration method is based on establishing a calculable specific absorption rate (SAR) using a matched waveguide cell [1]. The cell has a feed-section and a liquid-filled section separated by a matching window that is designed to minimise reflections at the interface. A TE_{01} mode is launched into the waveguide by means of a N-type-to-waveguide adapter. The power delivered to the liquid is calculated from the forward power and reflection coefficient measured at the input to the cell. At the centre of the cross-section of the waveguide cell, the volume specific absorption rate (SAR^V) in the liquid as a function of distance from the window is given by

$$SAR^V = \frac{4(P_w)}{ab\delta} e^{-2Z/\delta} \tag{1}$$

where

a = the larger cross-sectional dimension of the waveguide.
b = the smaller cross-sectional dimension of the waveguide.
δ = the skin depth for the liquid in the waveguide.
Z = the distance of the probe's sensors from the liquid to matching window boundary.
P_w = the power delivered to the liquid.

Liquids having the properties specified by British and IEEE Standards [2, 3] and FCC guidelines [4] were used for the calibration. The value of δ for the liquid was obtained by measuring the electric field (E) at a number of distances from the matching window. The calibration was for continuous wave (CW) signals, and the axis of the probe was parallel to the direction of propagation of the incident field i.e. end-on to the incident radiation. The probe was rotated about its axis in 15-degree steps, and the ratio of the calibration factors for the three probe sensors X, Y, & Z were optimized to give the best axial isotropy.

The probe was calibrated with the linearisation and air-correction factors enabled. Comparing the measured values of E^2 in the liquid to those calculated for the waveguide cell allows the ratio, $ConvF$, of sensitivity for (E^2_{LIQUID}) / (E^2_{AIR}) to be determined, as required by the probe software.

ENVIRONMENT

Measurements were made in a temperature-controlled laboratory at 22 ± 1°C. The temperature of the liquid used was measured at the beginning and end of each measurement.

UNCERTAINTIES

The estimated uncertainty in calibration for SAR (W kg^{-1}) is ± 10 %. The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95%.

This uncertainty is valid when the probe is used in a liquid with the same dielectric properties as those used for the calibration. No estimate is made for the long-term stability of the device calibrated or of the fluids used in the calibration.

When using the probe for SAR testing, additional uncertainties should be added to account for the spherical isotropy of the probe, proximity effects, linearity, and response to pulsed fields. There will be additional uncertainty if the probe is used in liquids having significantly different electrical properties to those used for the calibration. The electrical properties of the liquids will be related to temperature.

RESULTS

Table 1 gives the results for the calibration in liquid and the air factors.

These calibration factors are only correct when the values for sensitivity in free-space, diode compression and sensor offset from the tip of the probe, as set in the probe software, are the same as those given in the Table.

REFERENCES:

[1] Pokovic, KT, T.Schmid and N.Kuster, "Robust set-up for Precise Calibration of E-field probes in Tissue Simulating Liquids at Mobile Phone Frequencies", Proceedings ICECOM 1997, pp 120 – 124, Dubrovnik, Croatia Oct 12-17, 1997.

[2] British Standard BS EN 503361:2001. "Basic standard for the measurement of specific absorption rate related to human exposure to electromagnetic fields from mobile phones (300 MHz – 3 GHz)".

[3] IEEE Standard 1528-2003 "Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques".

[4] FCC-OET Bulletin 65 (97-01) "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", D. L. Means, K. W. Chan, June 2001.

Table 1
Sensitivity in Liquids.
SAR probe: IXP-030
S/N M0024

Probe settings for calibration		
Sensitivity in free-space[4]	**Diode Compression**[1]	**Sensor offset from tip of probe**[1]
Lin X = 411.50 $(V/m)^2/(V*200)$ Lin Y = 320.07 $(V/m)^2/(V*200)$ Lin Z = 275.84 $(V/m)^2/(V*200)$	DCP_X = 20 (V*200) DCP_Y = 20 (V*200) DCP_Z = 20 (V*200)	1.7 mm

Sensitivity in Liquid.							
Calibration frequency	Liquid [2]			Calibration Factors for E^2_{Liquid} / E^2_{Air}			Axial Isotropy
(MHz)	Identifier	ε' [3]	σ [3] (Sm^{-1})	$ConvF_X$	$ConvF_Y$	$ConvF_Z$	(dB)
850	TWS900B-1	56.8	0.97	**2.35**	**2.57**	**3.24**	±0.01
850	UOB900H-1	42.7	0.96	**2.32**	**2.55**	**3.17**	±0.04
900	TWS900B-1	56.6	1.00	**2.34**	**2.58**	**3.25**	±0.03
900	UOB900H-1	42.4	1.00	**2.35**	**2.57**	**3.21**	±0.13
1800	TWS1800B-2	53.7	1.58	**2.69**	**3.00**	**3.74**	±0.02
1800	TWS1800H-1	40.2	1.40	**2.60**	**2.86**	**3.68**	±0.03
1900	TWS1800B-2	53.3	1.68	**2.69**	**3.02**	**3.76**	±0.04
1900	NPL1950MHz	39.7	1.48	**2.58**	**2.89**	**3.62**	±0.06
2450	TWS2450B-1	53.5	2.02	**2.90**	**3.21**	**4.05**	±0.01
2450	TWS2450H-3	37.9	1.85	**2.63**	**3.03**	**3.78**	±0.03
5200	NPL5-6B-1	49.3	5.28	**3.46**	**3.82**	**4.87**	±0.14
5200	UOB5-6H-1	35.2	4.81	**2.92**	**3.27**	**3.99**	±0.11
5800	NPL5-6B-1	47.3	6.20	**3.21**	**3.56**	**4.43**	±0.12
5800	UOB5-6H-1	33.7	5.43	**2.95**	**3.29**	**4.17**	±0.08

Notes.
[1] The manufacturer supplied these figures.
[2] Head or Muscle Simulating Liquid supplied by NPL.
[3] Measured at NPL at 22 ± 1 °C.
[4] Measured at NPL in a Field Strength of 30 V/m at 900 MHz.

Date of Issue : 12 March 2008

Checked by : BCL.