

# COMOSAR E-Field probe Calibration Report



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Issue: A

Date: 2009/05/11

## COMOSAR E-FIELD PROBE CALIBRATION REPORT

Prepared By: BUTET Romain, SATIMO  
Project Description: COMOSAR E-FIELD PROBE  
Prepared For (End User): CCS

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# COMOSAR E-Field probe Calibration Report



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## COMOSAR SEPT ISOTROPIC E-FIELD PROBE CALIBRATION REPORT

**DATE:** 6/8/2009

**OFFER REFERENCE:** PF.127.1.09.SATB.A

**OBJECT:** COMOSAR SEPT ISOTROPIC E-FIELD PROBE

**MANUFACTURER:** SATIMO

**SERIAL NUMBER:** SN 11/09 EP100

**CUSTOMER:** CCS

**CONTRACT:** B01351

**DATE OF CALIBRATION:** 16/04/2009

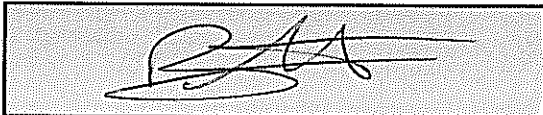
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Date

11/05/2009

SAR TEAM MANAGER

A rectangular box containing a handwritten signature in black ink. The signature is stylized and appears to be "BAA" followed by a horizontal line.

# COMOSAR E-Field probe Calibration Report



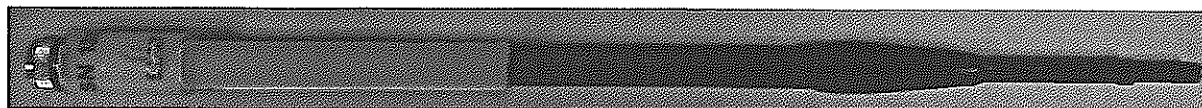
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## PRODUCT DESCRIPTION



|                                                   |                                                                            |
|---------------------------------------------------|----------------------------------------------------------------------------|
| Frequency Range                                   | 100 MHz - 30 GHz                                                           |
| Probe length                                      | 330 mm                                                                     |
| Length of one dipole                              | 4.5 mm                                                                     |
| Maximum external diameter                         | 8 mm                                                                       |
| Probe extremity diameter                          | 6.5 mm                                                                     |
| Distance between dipoles/probe extremity          | < 2.7 mm                                                                   |
| Resistance of the three dipole (at the connector) | Dipole 1: R1=2.5307 MΩ<br>Dipole 2: R2=2.6353 MΩ<br>Dipole 3: R3=2.5471 MΩ |
| Connector (HIROSE series SR30)                    | 6 wire male (Hirose SR30series)                                            |

The probe could be checked by measuring the resistance of the three dipoles.

## CALIBRATION TEST EQUIPMENT

| TYPE              | IDENTIFICATION                     | DATE OF CALIBRATION             |
|-------------------|------------------------------------|---------------------------------|
| Calibration bench | CALISAR CALIBRATION<br>SYSTEM V2.0 |                                 |
| Multimeter        | Keithley (2000, SN: 1000572)       | Date of calibration: 01-07-2008 |

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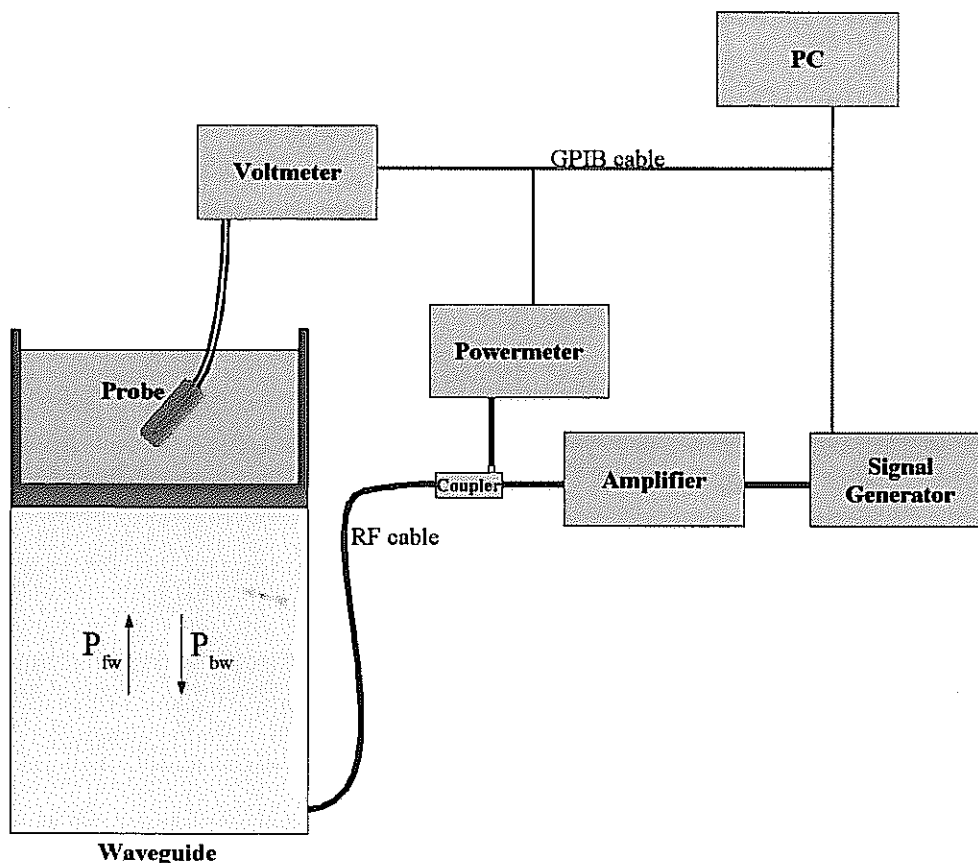
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## MEASUREMENT PROCEDURE

Probe calibration is realized, in compliance with CENELEC EN 50361 and IEEE 1528 std, with CALISAR, SATIMO proprietary calibration system. The calibration is performed with the EN 50361 annexe technique using reference guide at the five frequencies.



$$SAR = \frac{4(P_{fw} - P_{bw})}{ab\delta} \cos^2\left(\pi \frac{y}{a}\right) e^{-(2z/\delta)}$$

Where :

- $P_{fw}$  = Forward Power
- $P_{bw}$  = Backward Power
- $a$  and  $b$  = Waveguide dimensions
- $d$  = Skin depth

Keithley configuration:

Rate = Medium; Filter =ON; RDGS=10; FILTER TYPE =MOVING AVERAGE; RANGE AUTO

After each calibration, a SAR measurement is performed on a validation dipole and compared with a NPL calibrated probe, to verify it.

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## PROBE UNCERTAINTIES

### Calibration report of dosimetric SATIMO probe

#### Uncertainty on calibration system

| ERROR SOURCES                                            | Uncertainty value (%) | Probability Distribution | Divisor    | ci | Standard Uncertainty (%) |
|----------------------------------------------------------|-----------------------|--------------------------|------------|----|--------------------------|
| Incident or forward power                                | 3,00%                 | Rectangular              | $\sqrt{3}$ | 1  | 1,732%                   |
| Reflected power                                          | 3,00%                 | Rectangular              | $\sqrt{3}$ | 1  | 1,732%                   |
| Liquid conductivity                                      | 5,00%                 | Rectangular              | $\sqrt{3}$ | 1  | 2,887%                   |
| Liquid permittivity                                      | 4,00%                 | Rectangular              | $\sqrt{3}$ | 1  | 2,309%                   |
| Field homogeneity                                        | 3,00%                 | Rectangular              | $\sqrt{3}$ | 1  | 1,732%                   |
| Field probe positioning                                  | 5,00%                 | Rectangular              | $\sqrt{3}$ | 1  | 2,887%                   |
| Field probe linearity                                    | 3,00%                 | Rectangular              | $\sqrt{3}$ | 1  | 1,732%                   |
| <b>Combined standard uncertainty</b>                     |                       |                          |            |    | 4,761%                   |
| <b>Expanded uncertainty</b> (confidence interval of 95%) |                       |                          |            |    | 9,331%                   |

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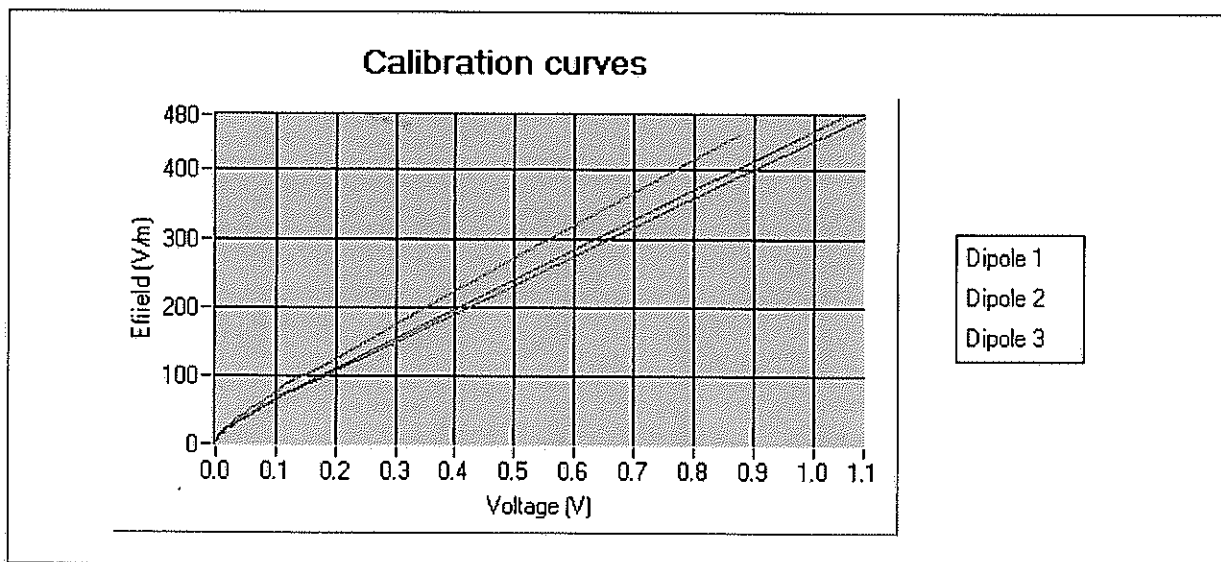
## 1. Calibration at 835.00 MHz

### A. Calibration parameters.

|                     |                         |
|---------------------|-------------------------|
| Label               | 850                     |
| Epsilon             | 41.82                   |
| Sigma               | 0.89 S/m                |
| Temperature         | 21°C                    |
| Cable loss          | 0.11 dB                 |
| Coupler loss        | 20.50 dB                |
| Waveguide S11       | -11.20 dB               |
| Low limit detection | 0.824 V/m (0.604 mW/kg) |

Calibration curves  $e_i=f(V)$  ( $i=1,2,3$ ) allow to obtain E-field value using the formula:

$$E = \sqrt{E_1^2 + E_2^2 + E_3^2}$$



The following tables represent the calibration curves linearization by curve segment in CW signal.

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Calibration coefficients for the three dipoles in CW:

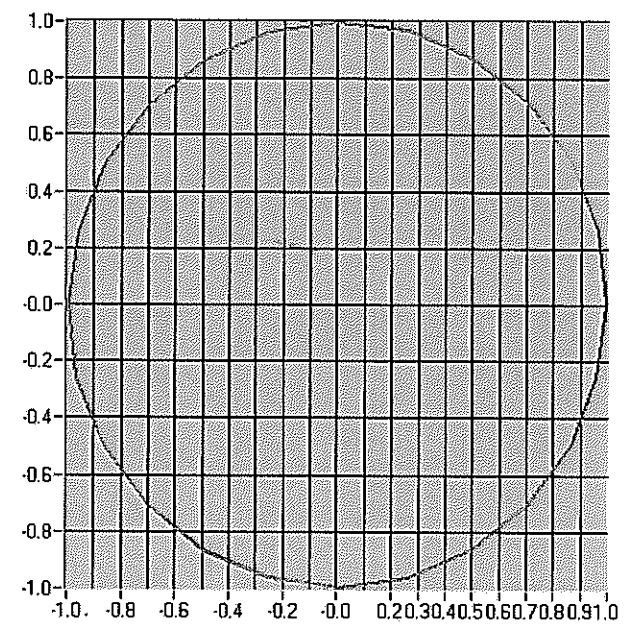
Sensitivity in liquid:

| Liquid | Epsilon | Sigma (S/m) | CF dipole 1<br>(W.kg-1 (mV)-1) | CF dipole 2<br>(W.kg-1 (mV)-1) | CF dipole 3<br>(W.kg-1 (mV)-1) |
|--------|---------|-------------|--------------------------------|--------------------------------|--------------------------------|
| Head   | 41.82   | 0.89        | 20.63                          | 20.50                          | 28.35                          |
| Body   | 55.09   | 0.94        | 20.01                          | 19.89                          | 27.76                          |

## B. Isotropy.

- Axial isotropy: 0.029 dB
- Hemispherical isotropy: 0.030 dB

Isotropy curves



Hemispheric -30°  
Hemispheric -15°  
Hemispheric 0°  
Hemispheric 15°  
Hemispheric 30°

## C. Linearity.

- Linearity:

0.04 dB

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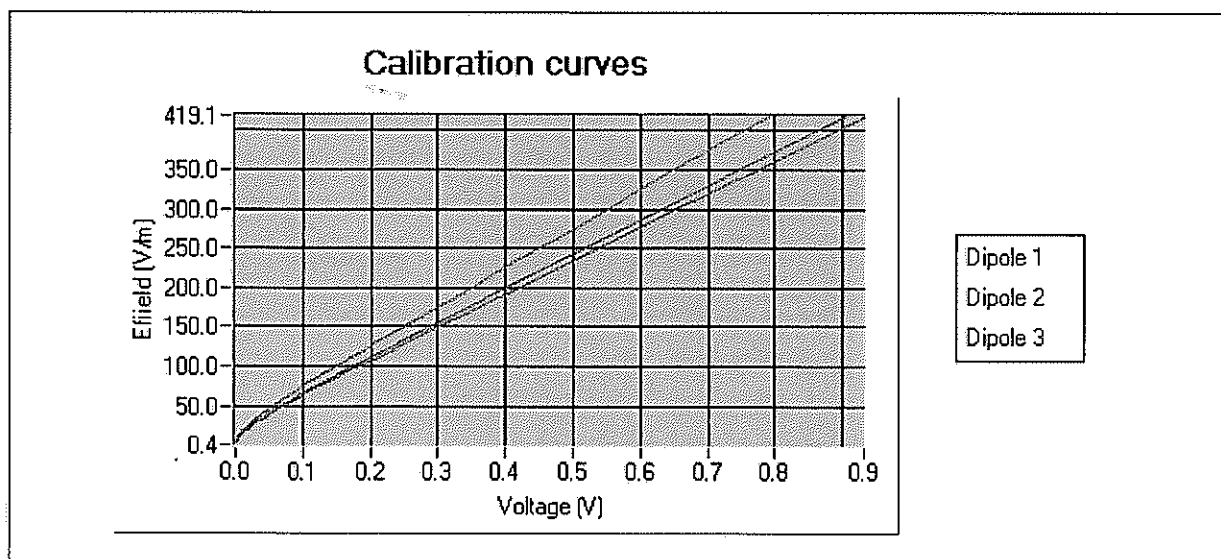
## 2. Calibration at 897.00 MHz

### A. Calibration parameters.

|                     |                        |
|---------------------|------------------------|
| Label               | 900                    |
| Epsilon             | 41.24                  |
| Sigma               | 0.94 S/m               |
| Temperature         | 21°C                   |
| Cable loss          | 0.10 dB                |
| Coupler loss        | 20.27 dB               |
| Waveguide S11       | -16.70 dB              |
| Low limit detection | 0.795 V/m (0.59 mW/kg) |

Calibration curves  $e_i=f(V)$  ( $i=1,2,3$ ) allow to obtain E-field value using the formula:

$$E = \sqrt{E_1^2 + E_2^2 + E_3^2}$$



The following tables represent the calibration curves linearization by curve segment in CW signal.

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Calibration coefficients for the three dipoles in CW:

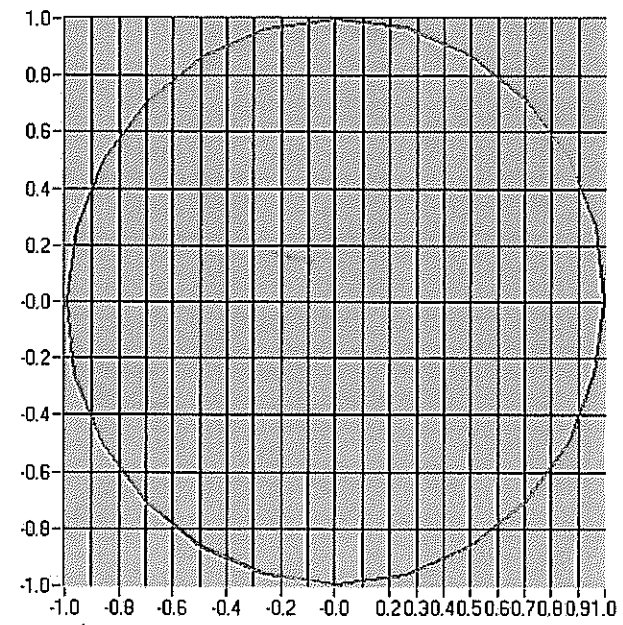
Sensitivity in liquid:

| Liquid | Epsilon | Sigma (S/m) | CF dipole 1<br>(W.kg-1 (mV)-1) | CF dipole 2<br>(W.kg-1 (mV)-1) | CF dipole 3<br>(W.kg-1 (mV)-1) |
|--------|---------|-------------|--------------------------------|--------------------------------|--------------------------------|
| Head   | 41.24   | 0.94        | 22.07                          | 22.01                          | 30.17                          |
| Body   | 55.99   | 1.02        | 21.56                          | 21.33                          | 29.11                          |

## B. Isotropy.

- Axial isotropy: 0.029 dB
- Hemispherical isotropy: 0.030 dB

Isotropy curves



Hemispheric -30°  
Hemispheric -15°  
Hemispheric 0°  
Hemispheric 15°  
Hemispheric 30°

## C. Linearity.

- Linearity:

0.04 dB

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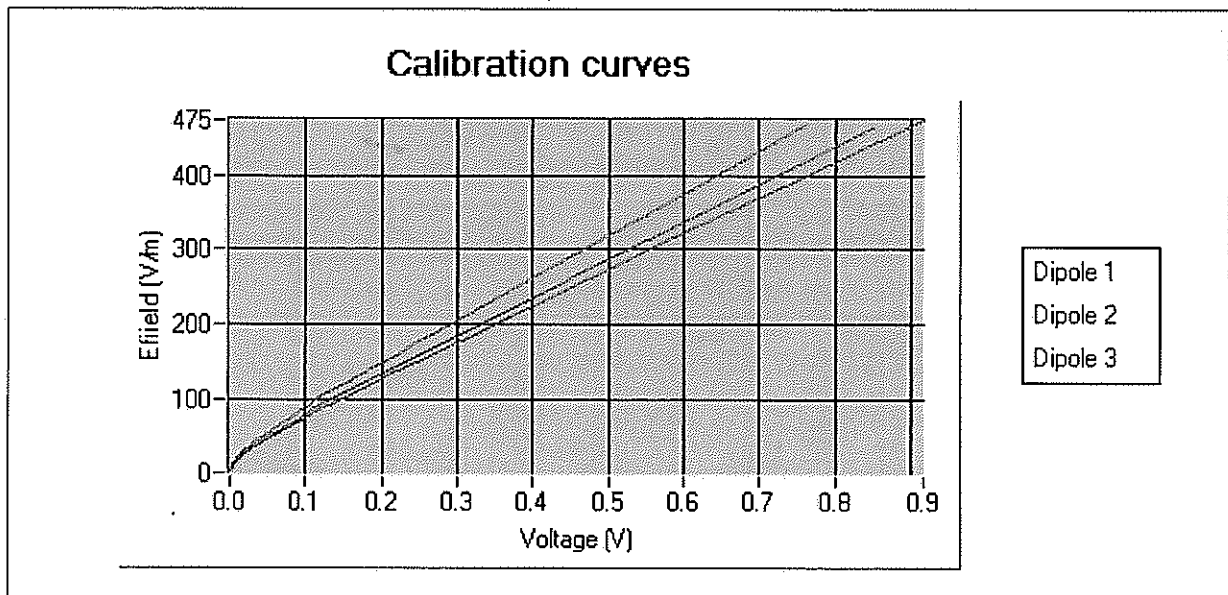
## 3. Calibration at 1747.00 MHz

### A. Calibration parameters.

|                     |                        |
|---------------------|------------------------|
| Label               | 1800                   |
| Epsilon             | 38.57                  |
| Sigma               | 1.34 S/m               |
| Temperature         | 21°C                   |
| Cable loss          | 0.18 dB                |
| Coupler loss        | 20.20 dB               |
| Waveguide S11       | -13.15 dB              |
| Low limit detection | 0.832 V/m (0.93 mW/kg) |

Calibration curves  $e_i=f(V)$  ( $i=1,2,3$ ) allow to obtain E-field value using the formula:

$$E = \sqrt{E_1^2 + E_2^2 + E_3^2}$$



The following tables represent the calibration curves linearization by curve segment in CW signal.

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Calibration coefficients for the three dipoles in CW:

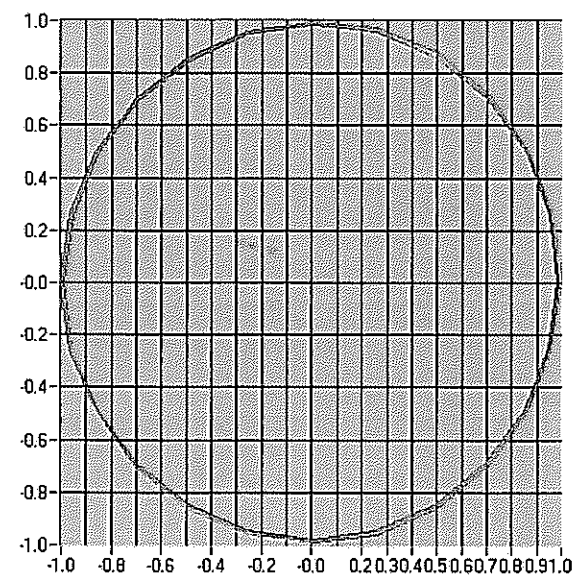
Sensitivity in liquid:

| Liquid | Epsilon | Sigma (S/m) | CF dipole 1<br>(W.kg-1 (mV)-1) | CF dipole 2<br>(W.kg-1 (mV)-1) | CF dipole 3<br>(W.kg-1 (mV)-1) |
|--------|---------|-------------|--------------------------------|--------------------------------|--------------------------------|
| Head   | 38.57   | 1.34        | 37.12                          | 38.57                          | 50.40                          |
| Body   | 51.99   | 1.49        | 36.65                          | 37.99                          | 49.65                          |

## B. Isotropy.

- Axial isotropy: 0.050 dB
- Hemispherical isotropy: 0.076 dB

Isotropy curves



Hemispheric -30°  
Hemispheric -15°  
Hemispheric 0°  
Hemispheric 15°  
Hemispheric 30°

## C. Linearity.

- Linearity:

0.03 dB

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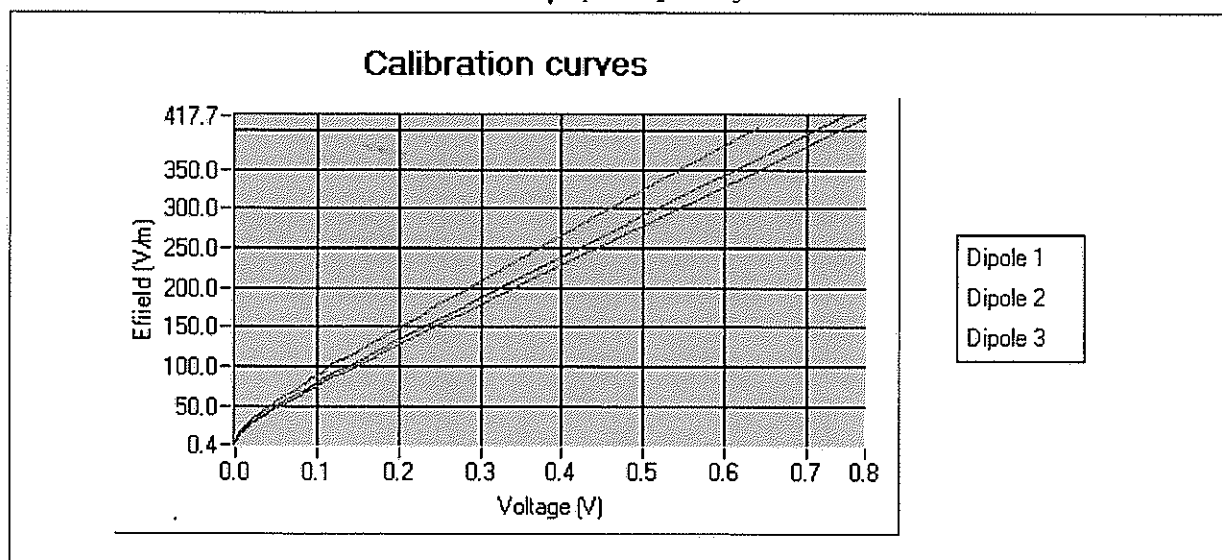
## 4. Calibration at 1880.00 MHz

### A. Calibration parameters.

|                     |                        |
|---------------------|------------------------|
| Label               | 1900                   |
| Epsilon             | 38.34                  |
| Sigma               | 1.45 S/m               |
| Temperature         | 21°C                   |
| Cable loss          | 0.18 dB                |
| Coupler loss        | 21.15 dB               |
| Waveguide S11       | -26.90 dB              |
| Low limit detection | 0.796 V/m (0.92 mW/kg) |

Calibration curves  $e_i=f(V)$  ( $i=1,2,3$ ) allow to obtain E-field value using the formula:

$$E = \sqrt{E_1^2 + E_2^2 + E_3^2}$$



The following tables represent the calibration curves linearization by curve segment in CW signal.

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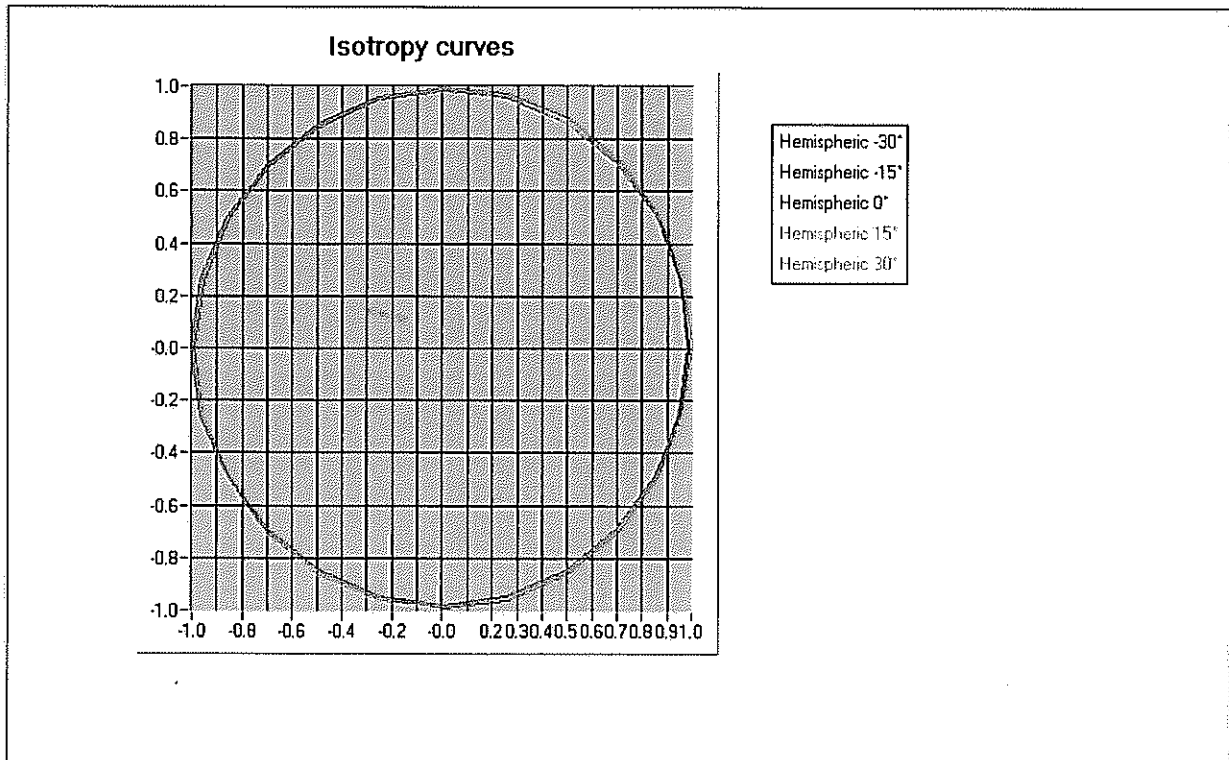
Calibration coefficients for the three dipoles in CW:

Sensitivity in liquid:

| Liquid | Epsilon | Sigma (S/m) | CF dipole 1<br>(W.kg-1 (mV)-1) | CF dipole 2<br>(W.kg-1 (mV)-1) | CF dipole 3<br>(W.kg-1 (mV)-1) |
|--------|---------|-------------|--------------------------------|--------------------------------|--------------------------------|
| Head   | 38.34   | 1.45        | 41.07                          | 42.36                          | 55.46                          |
| Body   | 52.13   | 1.50        | 40.41                          | 41.11                          | 54.77                          |

## B. Isotropy.

- Axial isotropy: 0.050 dB
- Hemispherical isotropy: 0.076 dB



## C. Linearity.

- Linearity: 0.03 dB

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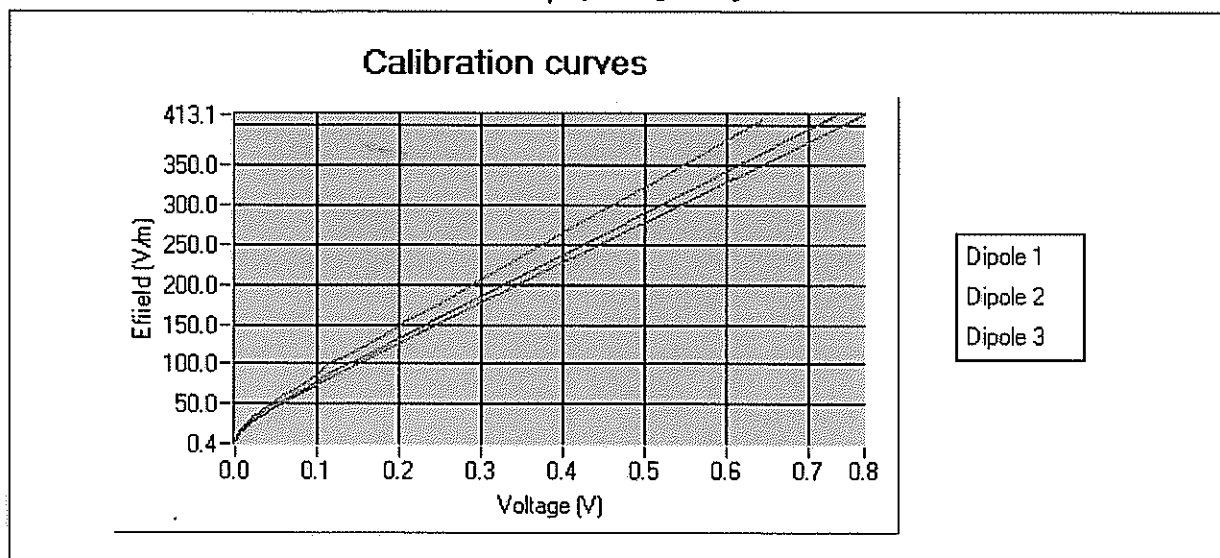
## 5. Calibration at 1950.00 MHz

### A. Calibration parameters.

|                     |                        |
|---------------------|------------------------|
| Label               | 2000                   |
| Epsilon             | 38.19                  |
| Sigma               | 1.47 S/m               |
| Temperature         | 21°C                   |
| Cable loss          | 0.19 dB                |
| Coupler loss        | 20.10 dB               |
| Waveguide S11       | -30.10 dB              |
| Low limit detection | 0.787 V/m (0.94 mW/kg) |

Calibration curves  $e_i=f(V)$  ( $i=1,2,3$ ) allow to obtain E-field value using the formula:

$$E = \sqrt{E_1^2 + E_2^2 + E_3^2}$$



The following tables represent the calibration curves linearization by curve segment in CW signal.

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Calibration coefficients for the three dipoles in CW:

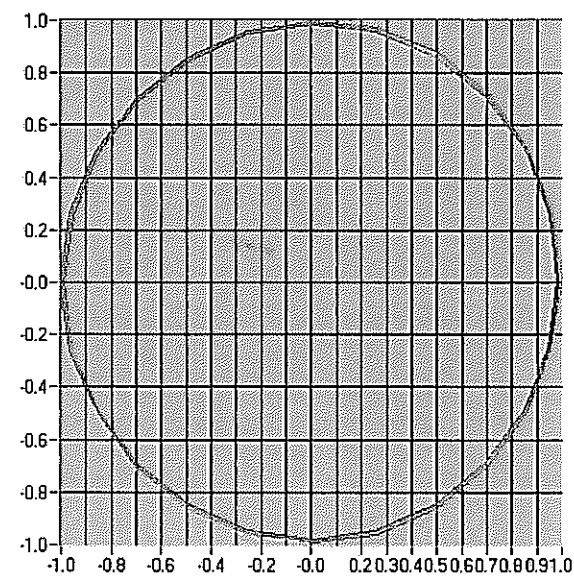
Sensitivity in liquid:

| Liquid | Epsilon | Sigma (S/m) | CF dipole 1<br>(W.kg-1 (mV)-1) | CF dipole 2<br>(W.kg-1 (mV)-1) | CF dipole 3<br>(W.kg-1 (mV)-1) |
|--------|---------|-------------|--------------------------------|--------------------------------|--------------------------------|
| Head   | 38.19   | 1.46        | 41.92                          | 43.16                          | 56.44                          |
| Body   | 54.05   | 1.52        | 41.01                          | 42.41                          | 55.66                          |

## B. Isotropy.

- Axial isotropy: 0.050 dB
- Hemispherical isotropy: 0.076 dB

Isotropy curves



Hemispheric -30°  
Hemispheric -15°  
Hemispheric 0°  
Hemispheric 15°  
Hemispheric 30°

## C. Linearity.

- Linearity:

0.03 dB

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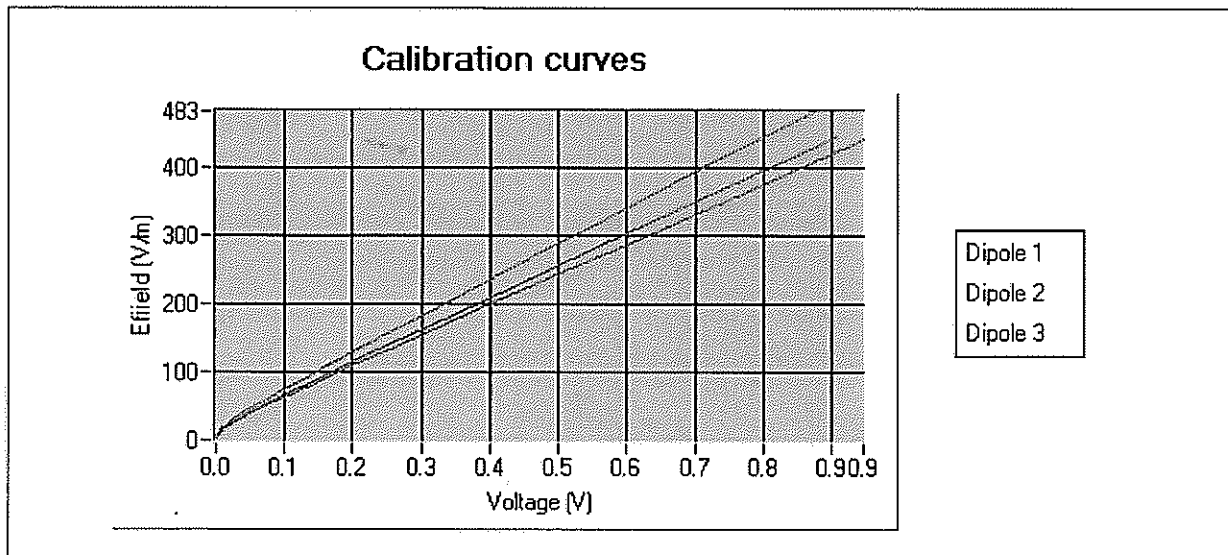
## 6. Calibration at 2450.00 MHz

### A. Calibration parameters.

|                     |                        |
|---------------------|------------------------|
| Label               | 2450                   |
| Epsilon             | 37.44                  |
| Sigma               | 1.75 S/m               |
| Temperature         | 21°C                   |
| Cable loss          | 0.20 dB                |
| Coupler loss        | 21.50 dB               |
| Waveguide S11       | -13.65 dB              |
| Low limit detection | 0.793 V/m (1.09 mW/kg) |

Calibration curves  $e_i=f(V)$  ( $i=1,2,3$ ) allow to obtain E-field value using the formula:

$$E = \sqrt{E_1^2 + E_2^2 + E_3^2}$$



The following tables represent the calibration curves linearization by curve segment in CW signal.

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Calibration coefficients for the three dipoles in CW:

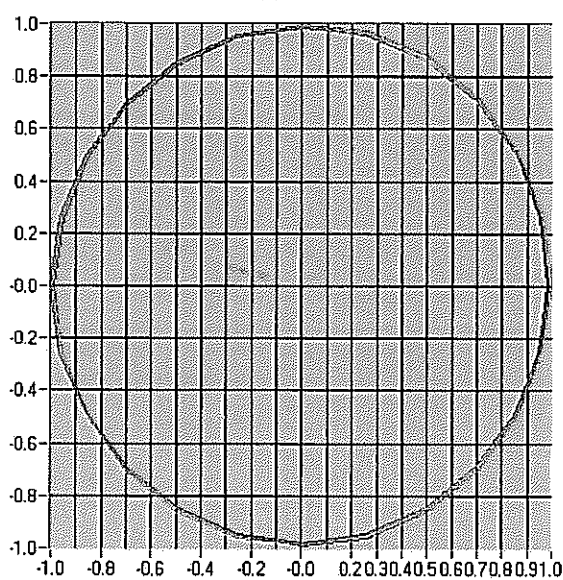
Sensitivity in liquid:

| Liquid | Epsilon | Sigma (S/m) | CF dipole 1<br>(W.kg-1 (mV)-1) | CF dipole 2<br>(W.kg-1 (mV)-1) | CF dipole 3<br>(W.kg-1 (mV)-1) |
|--------|---------|-------------|--------------------------------|--------------------------------|--------------------------------|
| Head   | 37.44   | 1.75        | 51.19                          | 53.87                          | 70.49                          |
| Body   | 53.70   | 1.96        | 50.36                          | 52.99                          | 69.77                          |

## B. Isotropy.

- Axial isotropy: 0.050 dB
- Hemispherical isotropy: 0.076 dB

Isotropy curves



Hemispheric -30°  
Hemispheric -15°  
Hemispheric 0°  
Hemispheric 15°  
Hemispheric 30°

## C. Linearity.

- Linearity: 0.03 dB