VIZUALISATION OF PORTABLE PHONE-USER INTERACTIONS VIA NEAR FIELD MAPPING ON MANNEQUINS AND VOLUNTEERS

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ABSTRACT

The characterization of the interaction between portable telephone and user is one of the key of a better power budget predictions in cellular links. Lot of works considers the problem under numerical modelling and only a few have a complete experimental approach. This paper describes a near field (NF) technique wich allows, from measurements, to vizualise the field distribution almost anywhere outside a cylinder enclosing the system made up by a full scale user (volonteers or mannequin phantoms) and a portable telephone. Tests are conducted in the 800-1050 MHz operating frequency range, wich corresponds to actual GSM equipments. A mapping of the field provides a unique assistance in identifying the effective part of the user contribuing to the radiation and can help in developping an equivalent antenna model for validating computer codes base only on head-hand modelling.

INTRODUCTION

Lot of investigations on the interactions between user and portable handset are conducted using numerical methods [e.g.1-4] often based only on hand-head modelling. Most of time, for comparisons purposes, radiation measurements are carried only in the main planes. Few of the studies available on the topic are able to show true measurements on a full scale user [5] [6] equiped with the handset and a radiation pattern almost in all directions.

This paper describes an experimental approach based on near field techniques. The user equipped with a commercial GSM telephone is considered as an equivalent antenna.The far field radiated by such equivalent antenna is calculated almost anywhere and back projected on seacted choosen transversal planes (Figurel). The effective part of the user contribying to the radiation is shown, and the shadow effect of the head is assessed.

NEAR FIELD TECHNIQUES

Near field techniques are shown to be a very interesting tool for characterizing complex antenna when the far field radiated over all directions are of interest. The principle of the near field technique is simple. First the tangential components of the electrical or magnetic field on a surface enclosing entirely the antenna under test is measured.

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Second the far field radiated anywhere outside the surface of measurement can be calculated via near to far field transformations. The surface of measurement depends on the type of antenna to be measured.

The near field facilities available at Supelec [7], [8] allows measurements on cylindrical surface (Figurel). The near field radiated is recorded in amplitude and phase for the two polarisations θ and ϕ; then via NF to FF transformations based on the modal development using elementaries cylindrical wave fonctions. The far field radiated outside the minimum cylinder containing the antenna can be calculated almost anywhere, because, despite the cylinder is open, its lateral surface covers the major part of the radiated field.

EXPERIMENTAL NEAR FIELD MEASUREMENT SETUP

The measurements are conducted until now on volonteers or mannequins phantoms. Advanced mannequins phantoms (AMP) have been developped to replace volonteers for repeatabilities purposes. The AMP are made of an empty polyurethane envelop filled with a liquid simulating the electrical properties of muscle tissues at the operating frequency of 1 GHz. These AMP reproduce same geometrical and electrical properties observed with human leaves [9] . The AMP basics characteristics are summary in Table 1a and Table1 b.

Installed on a turntable, the radiating object consisting of an mannequins phantoms (sitting on a chair) equipped with the telephone (turn 60° from upright) can rotate around a vertical axis while an electrical probe, at a distance d from the turntable axis, can translated vertically over 4 meters. Both displacement allows to record the near field on a cylindrical surface. At the operating frequency of 900 MHz the sampling intervals δz along the probe axis, and $\delta\phi$ along the rotation axis are shown in Table2. The probe is a half wavelength dipole and the wireless transveicer consists of an commercial GSM telephone modified to enable direct connection of the antenna by coaxial cable. The length of the antenna is about 1 lcm. The feeding coaxial cable has been loaded with ferrite cores to prevent current circulating on the outer of the conductor and making it pertubations acceptable.

The duration of the probing process when measuring the two polarisations of the field radiated is about one hour.

Composition: Propanedioll-2 (33%) and salted water (57%)
Temperature: [20 - 30°C]
Frequency: [850 - 1050 GHz]
$\varepsilon_r' = 58$, $\varepsilon_r'' = 22.4$

Table1 a: Characteristics of muscle equivalent liquid used to filled mannequin phantoms

Composition: polyurethane
thickness : **2** à **3** mm
ε_r' #3, ε_r'' : negligible around 900 MHz

Table1 b: mannequin envelop characteristics

BACK PROPAGATION

The far field pattern radiated in spherical coordinate is calculated via near to far field transformation. With far field approximation koz>>1, the electric field is given by the next formula:

$$\mathbf{E}(r',\theta',\phi') = j\,k_{z'}\,(e^{-jkr'}/r')\,\mathbf{A}(k_{x'}, k_{y'})$$

where $A(k_{x'},k_{y'})$ is the plane wave spectrum, and $k_{x'} = ko\ \sin\theta'\cos\phi'$

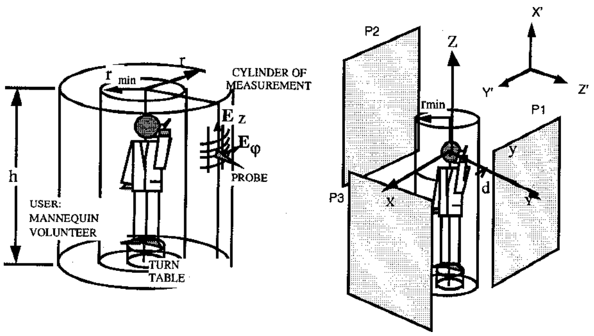
$k_{y'}= k_0 \sin\theta'\sin\phi'$

$kz'= k_0 \cos\theta', k_0 = 2\pi / \lambda_0$.

λ_0 is the wavelength in free space. The electrical field can be determined in a choosen plane by the relation :

$\mathbf{E}(x',y',z')= FT\ (A(k_{x'}, k_{y'})e^{-jz'k_{z'}})$,

FT meaning Fourier Transform.



Figurel: Configuration of the cylindrical NF measurements setup (a), and geometry associated to the field reconstruction (b). P1, P2, P3 are the reconstruction planes.

RESULTS

The total E-field is calculated on 3m x3m vertical transverse planes. The center of the planes are 34 cm below the user's nose tip.

Three planes are selected (Figure 2a, 2b, 2c). The plane P3 is in front of the user, the plane P1 is located at the handset side and contains the handset plane; the third plane, plane P2 is just opposite to the plane P1 so located at the side of the head where the aren't the telephone.

The mapped field on the three planes shows high field level within the handheld location area. The E-field level decreases very fastly when going away from the head zone where the telephone is located. This shows that the effective part of the user contribuing to the radiation can be limit to the head. The field mapping on the Plane P2 shows at the left ear level high field values although below those at the telephone side. The maximum of the field in the plane P2 is 3dB below maximum in the plane P1. This proves that the mask effect of the head is partial and the field pass round the head. The field shown on planes PI, P2, P3 are normalized to the maximum value.

δz= 12cm
$\delta \phi$= 5,6°
Frequency:900 GHz
r_{min}=30cm
cylinder height h=4m
Cylinder radius: R=0.8m
Near field grid of measurement: 32 by 64 points

Table2: Characteristics of near-field measurements

CONCLUSION

Near field techniques are a convenient way for characterizing the radiation of the user and the hand combination. Coupled with NF techniques, back propagation tools can be used to get quickly more details on planes near the radiation area. The results above presented validate investigations wich only take into account the hand and the head of the user when working on the interactions between the telephone and the user. Our results also confirm that the field pass round quite well the head.

Back propagation can also be used for a quick assessement of the effect of the coaxial cable when it feed the handset antenna or for cellular antenna depolarisation studies.

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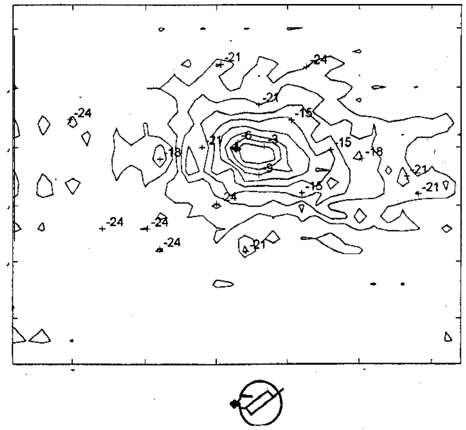

Figure 2a: The mapped field on the plane P1

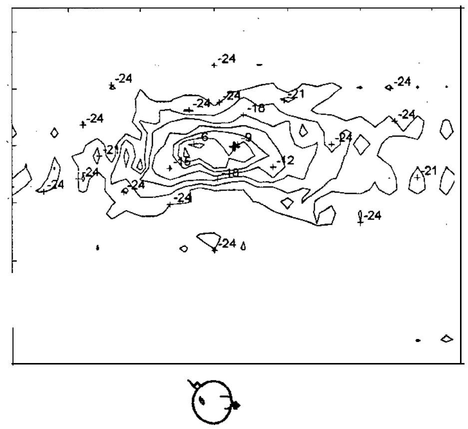

Figure 2b: The mapped field on the plane P2

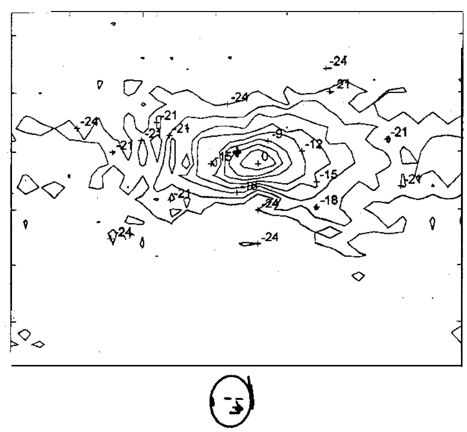

Figure 2c: The mapped field on the plane P3