CYLINDRICAL MICROWAVE IMAGING SYSTEM

M. Ferrando*, L. Jofre, A. Broquetas
E. Reyes, A. Cardama, A. Elías
E.T.S.I. Telecomunicación
Apdo. 30002, 08080-Barcelona ,Spain

I. INTRODUCTION.

The potential use of linear and planar imaging systems for non invasive permittivity measurements has been proved in the past ,|1|

A cylindrical system for microwave tomography working at 2.45 GHz has been presented |2|; in this set-up, the body, immersed in water, is illuminated whith a cylindrical wave and the measured scattered fields are processed by an algorithm for cylindrical geometries |3|,|4|. Temperature and permitivity measurementes were made using this system |5|.

In this paper we present the numerical simulations for different parameters and the last experimental images of biological bodies obtained with the system.

II. THEORY

The imaging algorithm is based in the Born assumption, the field distribution in the object is supossed to be similar to the incident field. The object is illuminated by a set of cylindrical waves and the scattered fields are measured with a set of antennas located in a circle.

The relationship between the total field , $\Psi(\vec{r})$, and the scattering object $\varepsilon(\vec{r})$ is given by the inhomogeneous Helmholtz equation.

$$(\nabla^2+k^2)\ \psi(\vec{r}) = k^2(1-\frac{\varepsilon(\vec{r})}{\varepsilon})\ \psi(\vec{r}) \qquad [1]$$

Under the assumption of weak scattering, the right-hand of [1] can be replaced by the incident field.

The reconstruction expression is:

$$f(m,m_o)=j\omega\mu_o\ R^2(\frac{2\pi}{N})\sum_{n=o}^{N}\sum_{n=o}^{N}\psi^s(n,n_o)I(m-n)I(m_o-n_o) \qquad [2]$$

CH2563-5/88/0000-0782$1.00 © 1988 IEEE

Where $f(m;m_o)$ is the Discrete Fourier Transform of the object, evaluated over circles as shown in fig.1; $\psi^s(n;n_o)$ is the scattered field, when transmiting with antenna n and receiving with n . $I(m-n)$ and $I(m_o-n_o)$ are the weigths for the synthesis of the plane waves in transmission and reception.

The impulsional response, uniformity of the reconstruction and resolution for a circular array of 64 antennas in a lossy medium is shown in fig. 2. For a region of $r = 5\lambda$,the dynamic range is 35 dB, and the resolution is 0.5λ .

III EXPERIMENTAL RESULTS

The block diagram of the system is shown in the fig. 3. The object under test is immersed in a cylindrical water tank surrounded by the circular array antenna. This array consist of a 20 cm diameter circular horn, fed by 64 guides, where each one can work in emission and reception controlled by two sets of RF multiplexers. A low frecuency modulation is used to mark the emitter and receiver guides and to improve the sensitivity with a final coherent detection.

A C.W. signal is provided by an oscillator, followed by an 1 watt amplifier. The incident power density on the object is smaller than 0.1 mw/cm2. In the receiver chain, a low-noise amplifier followed by a RF coherent detector are used.

Data acquisition, image reconstruction and representation are done with a HP 9000 model 320 computer whith high-resolution colour display. The total time is shorter than one minute.

Fig. 4 shows the tomographics reconstructions for a human arm and a cut of the five fingers.

V REFERENCES

|1|.- C. Pichot, L. Jofre, G. Peronnet, J.C. Bolomey, "Active microwave imaging of inhomogeneous bodies", IEEE Trans. AP-S, April 1985,pp 416-425

|2|.- L.Jofre et al. "A cylindrical system for quasi-real time microwave tomography", 16th EuMc, Dublin, pp 599-604, Sept 1986.

|3|.- A.J. Devaney, G. Beylkin, "Difraction tomography using arbitrary transmitter and receiver surfaces", Ultrason. Imaging, 1984,6,pp 181-193

|4|.- J. M. Rius ,M. Ferrando et al ,"Microwave tomography, an algorithm for cylindrical geometries". Electronic Letters, vol 23, No 11, pp 564-565, May 1987

|5|.- A. Broquetas et al. "Temperature and permitivity measurements using a cylindrical microwave imaging system", 17th EuMc, Rome, pp 892-895, Sept 1987

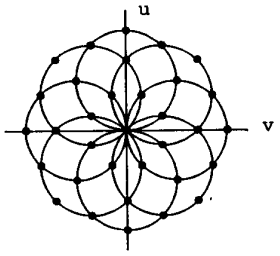

Fig.1 Samples of $F(1-\frac{\varepsilon(\vec{r})}{\varepsilon})$

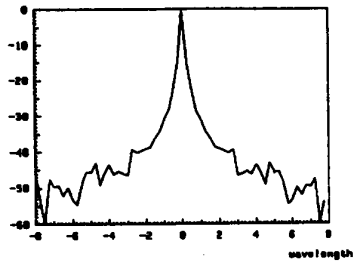

Fig.2a Impulse response

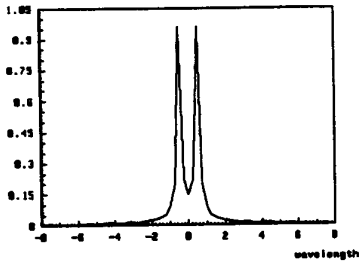

Fig. 2b Resolution: 2 dielectric cylinders spaced 1λ

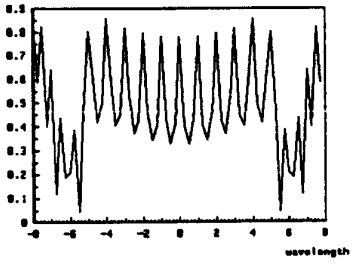

Fig. 3b Uniformity of the reconstruction (11 cylinders placed 1λ apart.)

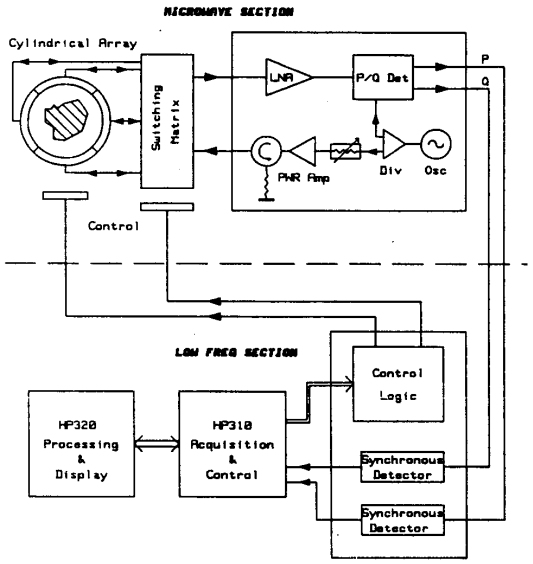

Fig. 3 Block diagram of the cylindrical microwave imaging system.

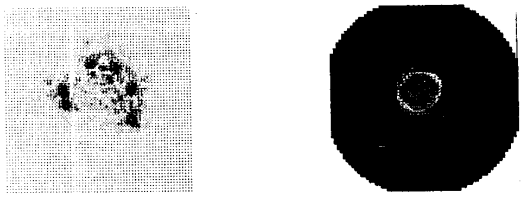

Fig. 4 Tomographic Images: five fingers and human harm.