Three Dimensional Imaging Of Leakages From Cylinderic Microwave Applicator

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Abstract

Investigation is done to make three dimensional imaging for electromagnetic leakages from cylindrical applicator . Suitable function for continuation and smoothing the samples is chosen as well as filter transfer function . The results of a computer simulation aimed at demonstrating the imaging technique are reported . The high resolution capability of this new mode of imaging is illustrated for frequency of 2.45 GHz.

Key Words : Cylindrical Microwave applicator ,Leakage imaging , signal processing, Microwave hologram , Antenna Array , Filtering.

Introduction

The harmful effects of microwave radiations enforced specialists to study leakages from different forms of microwave applicators in order to save workers as well as users and professionals . Use of image processing for microwave power has been studied before (see literature) . Exact and precise determination of leakages or microwave radiations require intensive and high resolution capability signal processing . The object radiant energies are transferred by a linear system into image radiant energies . The signals received from the object are filtered , amplified , detected and then converted by analog to digital converter (A/D) . Consequently , signal processing begins as given in the next section.

The main purpose of this paper is to present three dimensional imaging for the radiated electromagnetic waves from the open circular end of cylindrical applicator . Such applicator is used for processing of gelatin which represents dielectric characteristics of the living tissues .

Mathematical Approach

In an ordinary photography only amplitude information is recorded . In a hologram both amplitude and phase information are recorded. Thus , when the hologram is illuminated with coherent microwave source, it generates waves (in both amplitude and phase) which produce a three dimensional picture, in accordance with Hygen's principle . So , using the radiation integrals , the E-plane field pattern radiated from the circular aperture of the underlying applicator is given as follows:

$$E_{\theta 1} = (j / r)[k\ a^2\ E_O \exp(-jkr)][(J1(ka \sin\theta_1))/ (ka \sin\theta_1)] \qquad (1)$$

Where $k=2\Pi/\lambda$, λ is the free space wavelength , θ_1 is the cone angle , a is the radius of an aperture radiates a distance
$r = R$.

Microwave hologram is formed by scanning a plane (x_1 y_1). The rectangular and cylindrical coordinates are related by the following relations:

In the aperture plane	In the scanning plane
$X = \rho \sin\theta$	$X_1 = \rho_1 \sin\theta_1$
$Y = \rho\cos\theta$	$Y_1 = \rho_1 \cos\theta_1$
$Z = 0$	$Z_1 = Zo$

Where ρ is the radial distance from the origin O to the point n and ρ_1 is the radial distance between the origin 1 to the point n_1 , θ and θ_1 are angles shown by the geometry of figure 1 .

Signal Processing

Discrete –time signals are often formed by sampling continuous time signals (A/D conversion) as the first step in a digital signal processor. A more rapidly varying signal will require more samples for its representations. The benefits of the discrete – time signals are latent in their using in the development of processors to detect the presence of signals of interest or to estimate signal parameters. In addition to providing efficient signal approximations, the frequency representation gives insight into the choice of adequate spacing of samples in A/D conversion of continuous time signals, a step which is necessary for presenting signals to digital processors.

After closely spaced samples have been transformed, the sampling theorem assures that future digital processing of such samples for signal detection (or radar tracing) can use the interval T_S such that $T_S < (1/2B)$ (Nyquist rate) without destroying any information. B is the bandwidth in hertz. The sampling theorem uses all past and future sample values to compute a signal x(t) as infinite sum of weighted sample values. This sum is easier to interpret using the basic and well known interpolation function which is given by the following relation:

$$X(t) = (\sin(\Pi\, t / T_S))/ (\Pi\, t / T_S) \qquad (2)$$

Where t is the time.

Frequency transformation can be used to describe the behavior of signal processors or filters. The frequency characterization of a filter is called its transfer function. It can be employed in the analysis of both the filters used to manipulate numerical signals and the physical systems which connect physical signals. The type of the used filter is a linear one .

Results and Conclusions

A numerical example is given to indicate that a high imaging efficiency can be realized by the presented technique. The open end circular aperture has radius a=30 cm and frequency of operation is 2.45 GHz . The aperture radiates a horizontal distance Zo to a plane (x_1 =200 cm, Y_1 = 200 cm).

16 antenna and crystal detectors are equidistance spaced and vertically placed to form linear array . The array moves in a direction perpendicular to its length (horizontally) to scan the aperture one time. Treatment of the detected signals is according to the protocol addressed in figure 1 . Real time results are reported in the three dimensional surfaces representing the radiated electric field pattern as a function of the aperture dimensions as shown in figures 2 and 3 .

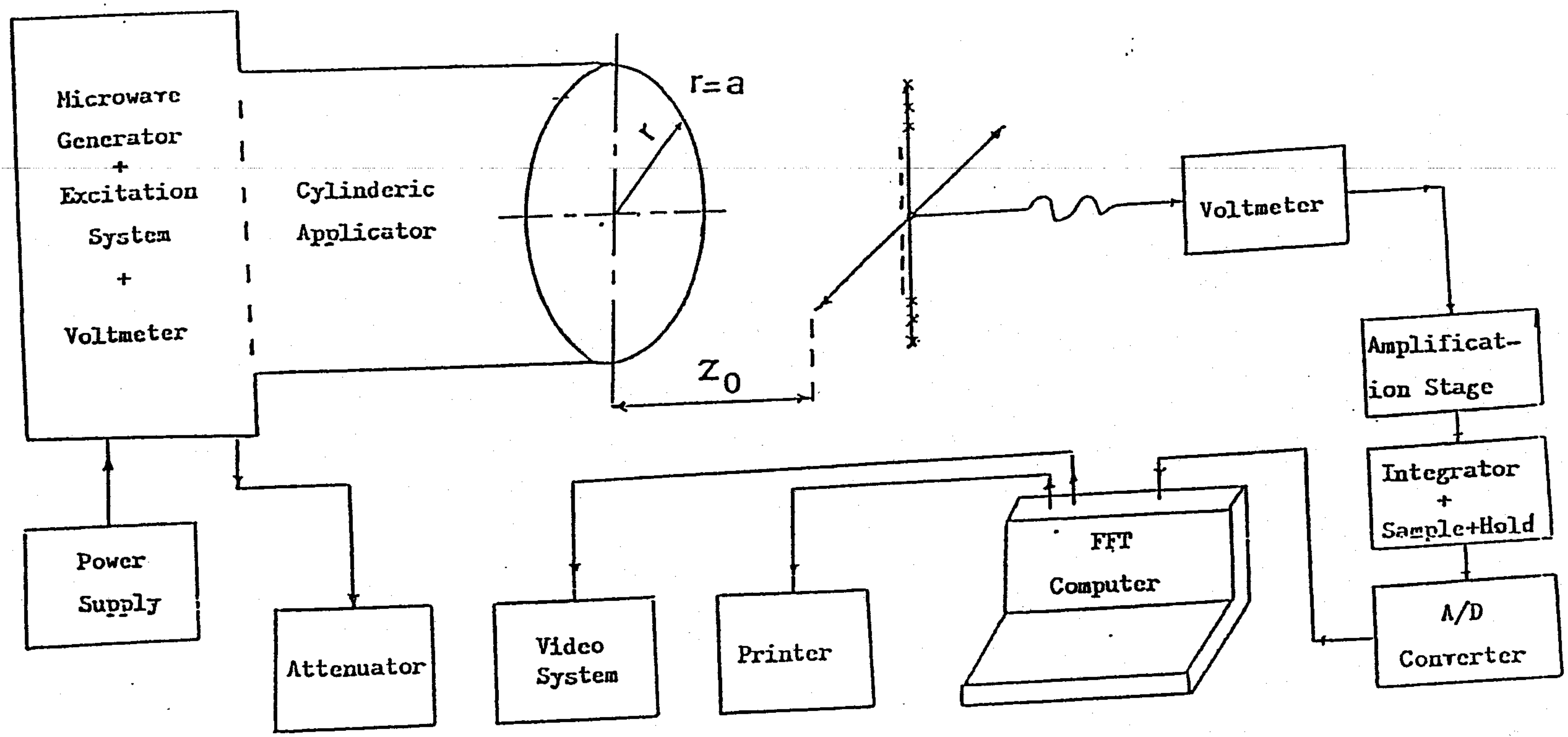

Fig. 1 Organization of the simulation protocol showing how the results are obtained by both the printer and video system.

It is to conclude that a computer –aided image reconstruction method allows high resolution three dimensional imaging. The proposed techniques for filtering and processing achieved high resolution and good quality imaging results.

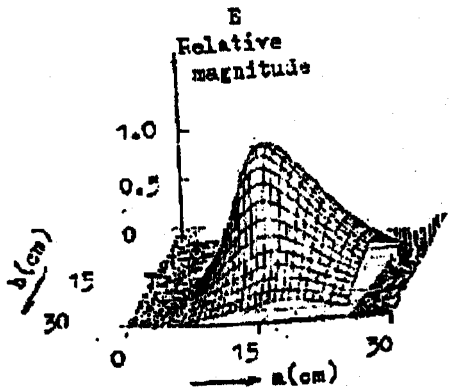

Fig. 2 Relative magnitude of the radiated electric field E as a function of the geometric dimensions of the square plane contains the original radiating circular aperture (a = b = 2 r = 30 cm) for Z_0 = 20 cm.

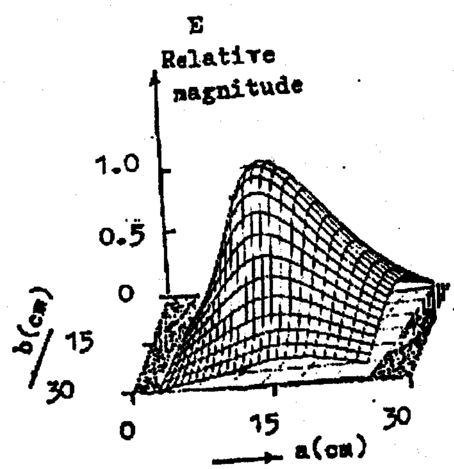

Fig. 3 Relative magnitude of the radiated electric field E as a function of the geometric dimensions of the square plane contains the original radiating circular aperture (a = b = 2 r = 30 cm) for Z_0 = 25 cm.

References: List of references is available by writing to the author.