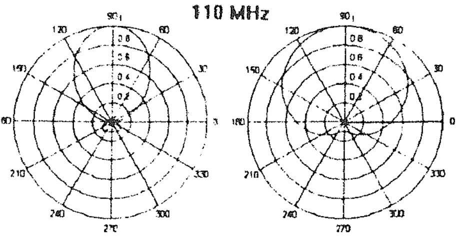
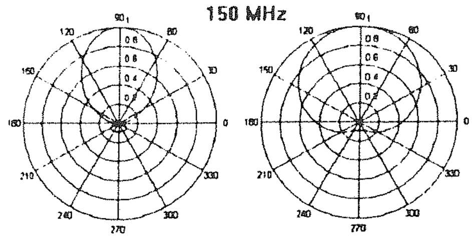


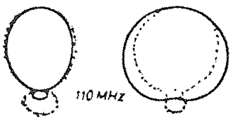
E-Plane H-Plane

Computed radiation patterns by method of moment

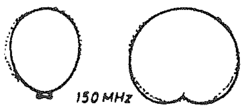


E-Plane H-Plane

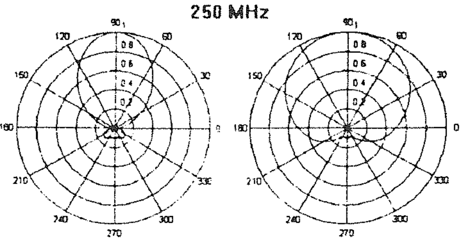
Computed radiation patterns by method of moment



Measured (...) and computed (-) radiation patterns by solution of Maxwell's equations

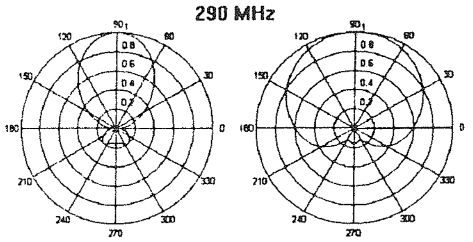


Measured (...) and computed (-) radiation patterns by solution of Maxwell's equations



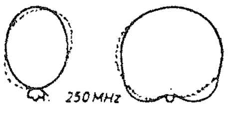
E-Plane H-Plane

Computed radiation patterns by method of moment

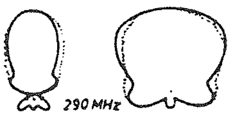


E-Plane H-Plane

Computed radiation patterns by method of moment



Measured (...) and computed (-) radiation patterns by solution of Maxwell's equations



Measured (...) and computed (-) radiation patterns by solution of Maxwell's equations

Fig.8 Radiation patterns of the LPDA

Conclusion

A LPDA in HF band is analysed using a novel time domain method of moment. The antenna characteristics have been successfully determined and the effects of various types of feeding on input impedance are investigated. The comparison between the theoretical and the experimental results demonstrates acceptable consistency.

The computed efficiency of the method compared to other methods is strongly noticable.

the frequency domain methods require Considerable computing time for The same band of frequency.

The Current Distribution

Figure 7 shows the normalized fourier transform of the input current amplitude of the antenna elements at three different frequencies. Meanwhile, the currents evaluated by the solution of the Maxwell's equations for the considered LPDA, is also indicated[7]. In these figures, only the indicated points are meaningful. The comparison of the two methods demonstrates acceptable consistency. At 100 MHz, the lowest frequency limit, (Fig.7a) the element 1 is the $\lambda/2$ resonant dipole and has the maximum input current. This region is called the active region where the maximum radiation occurs. As the frequency increases, the active region moves towards the apex. At 150 MHz (Fig.7b) the maximum element input current is at the element 6, the one ahead of the resonant element. The input current drops off rapidly to both sides of the active region. Its distance from the apex in terms of wavelength remains constant for all operating frequencies. When the active region begins to include the front or back element, the upper or the lower frequency limit is reached. The termination load does not affect the place of active region and for three models the active region does not differ. Also the computed currents correspond very well with currents computed by the solution of Maxwell's equations.

Radiation Patterns

The characteristic radiation pattern is an endfire beam directed towards the apex of the antenna. Some computed radiation patterns using our method are given in (Fig.8). The radiation patterns are obtained using the solution of Maxwell's equations [7]. The measured radiation patterns at four different frequencies are also shown in figure 8.

The computed radiation patterns obtained by our method, compares very well with the two theoretical and experimental results. It is noted that the three models of LPDA have identical radiation patterns.

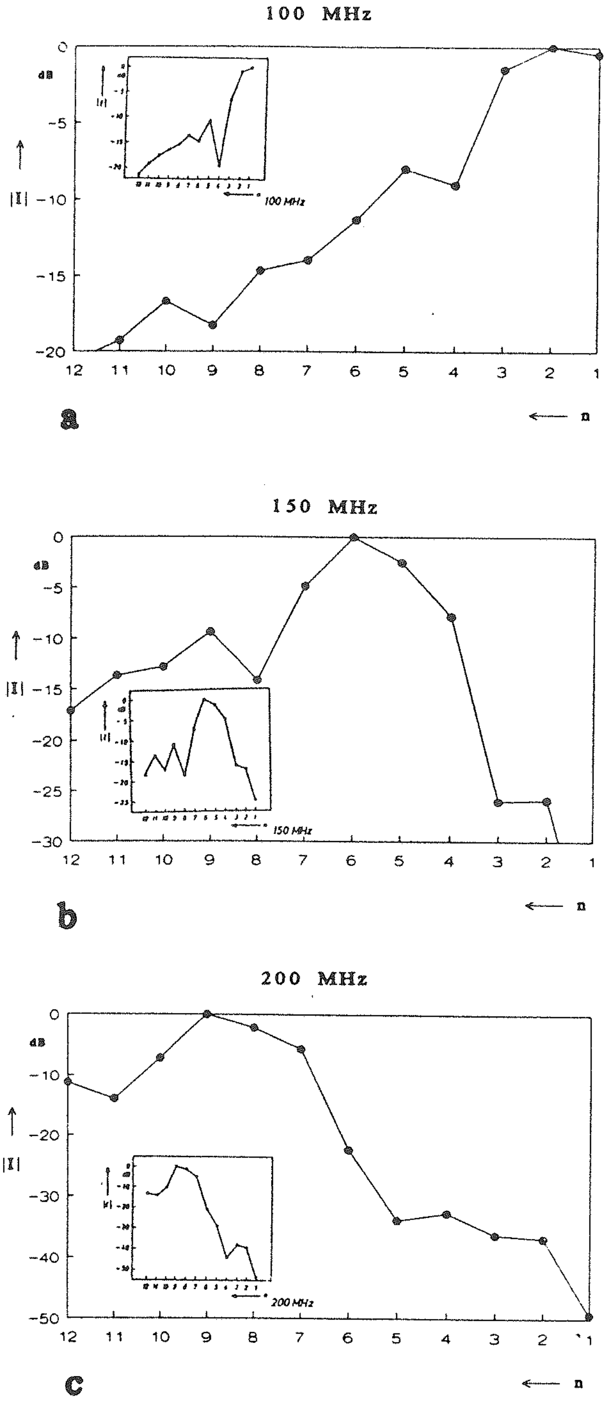


Fig.7 Computed element currents

This is a transient wave with $\Delta t \cong 1.1/a_n$ and $\Delta f \cong 0.4\ a_n$ [8]. Decreasing the gaussian pulse width in time domain, increases the gaussian pulse width in frequency domain.

Input Impedance

Using the fourier transform, the generator voltage [V(t)] and the computed current at the feed point [I(t)] are transformed to frequency domain [V(f), I(f)]. Then the input impedance of the antenna is found using $Z(f) = \frac{V(f)}{I(f)}$. The input impedance for a wide band of frequency is shown in (Fig.6) for three considered models of LPDA. The behavior of the input impedance in the operating frequency band (100- 320 MHz) for all three kinds of termination is identical, and does not depend on the terminator load. The input impedance is periodic with period τ. The deviation from the mean resistance R_0 is very small, such that it can be assumed constant in this band. The imaginary part of the input impedance is near zero and it can be put equal to zero at this band.

In (Fig.6), it is shown that for the three models, the input impedances are different outside the operating frequency band. For the antenna terminated to a resistive load (Fig 6c), the input impedance differs slightly from the mean value. This is due to the matched load which causes no standing wave along the feeder line. For the two other models (Figs.6a and 6b) it is shown that the input impedance has abrupt changes out of the operating frequency band. The impedance in this band, behaves similar to the input impedance of a dipole. At this band, the elements of LPDA are very short and act as a capacitive load. The resonance points (series and parallel) of the input impedance is proportional to the length of the feeder line. Due to the reactive termination, a standing wave along the feeder line is produced at frequencies below the operating frequency band. Thus, at these resonance points the feeder line acts like a dipole and radiates strongly, and at receiving mode receives effectively. There for, if the output (input) filter at the transmitter (receiver) does not have suitable characteristics, serious problems may occur.

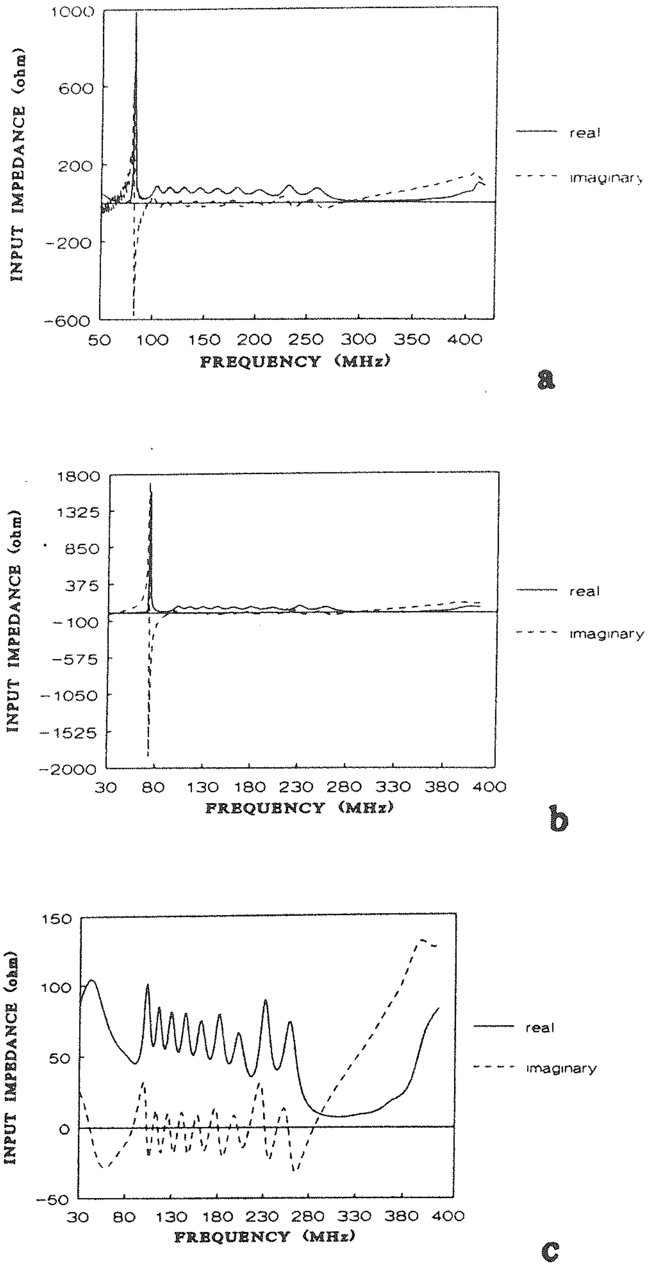


Fig.6 Input impedance for three considered LPDA

Using the method of moment in time domain enables us to investigate the radiation characteristics of LPDA in a wide band of frequency, whereas

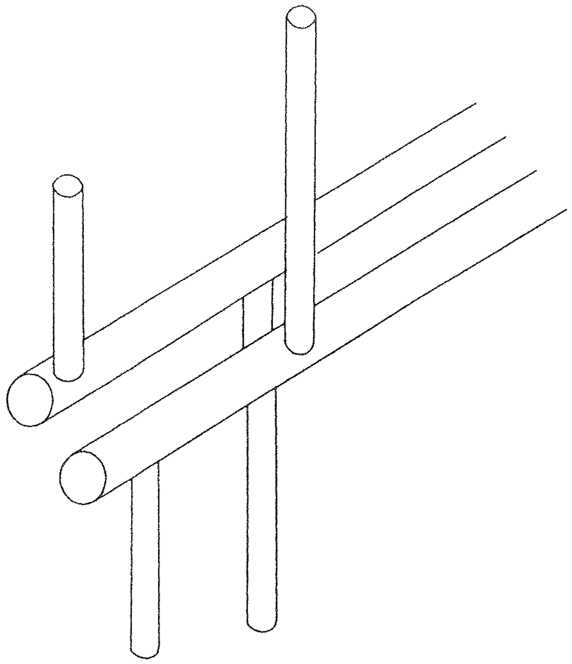


Fig.3 Connection of elements to balanced feeder line

with following parameters:

$N = 12$, $\tau=0.9$, $h_1 = 750$ mm, $h_{12} = 235$ mm,

$\alpha = 28.6°$ $Z_c = 75\ \Omega$, radius of dipoles = 4mm

Considering the values of h_1 and h_{12}, it is evident that the antenna is designed for the frequency band $[f_l, f_h]$ where $f_l = 100$ MHz and $f_h = 320$ MHz. The method of obtaining the 180° phase reversal between elements is depicted in (Fig.3). The antenna is modeled exactly like the one shown in the figure.

The antenna is considered in three different states of termination (Fig.4). First, it is terminated to a reactive load equal to Z_c by short circuiting the balanced feeder at a distance $l_1/8$ beyond the longest element. In the second state, the feeder line is open circuited. Finally at the third state, the antenna's termination is a resistive load equal to characteristic impedance of the feeder line.

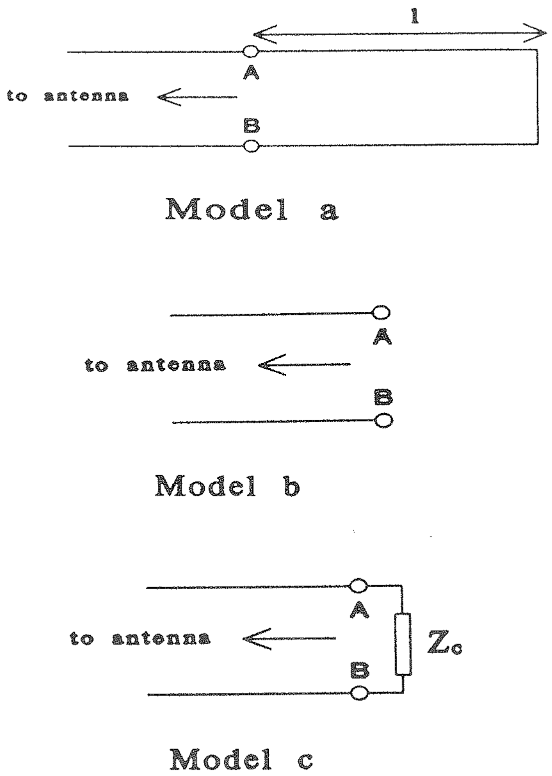


Fig.4 Three termination's configuration of the feeder line

The generator is a gaussian narrow pulse (Fig.5), which is modulated to frequency f_c.

$$V(t)=V_o e^{-a_n^2(t - t_{max})^2}.\mathrm{Sin}2\pi f_c(t - t_{max})$$

$$t_{max}=\frac{2.1456}{a_n}$$

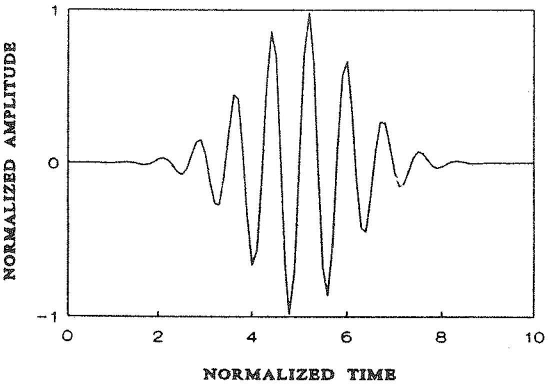


Fig.5 Time variation of input generator

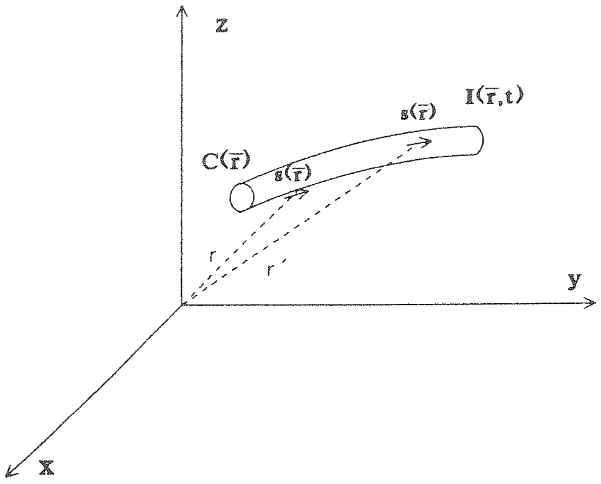


Fig.1 Geometry for thin wire electric field integral equation

$$\vec{E}^{d}(s,t) = -\frac{\mu_0}{4\pi}\int_{\text{wire}} \left[\frac{\hat{s}.\hat{s}'}{R}.\frac{\partial}{\partial t'}I(s',t') + c\frac{\hat{s}.\vec{R}}{R^2}.\frac{\partial}{\partial s'}I(s',t') - c^2\frac{\hat{s}.\vec{R}}{R^3}\int_0^{t'}\frac{\partial}{\partial s'}I(s',t')dt\right]ds'$$

where:

$\hat{s}$: unit tangential vector at s

$\hat{s}'$: unit tangential vector at s'

$R = |\vec{R}| = |\bar{r}-\bar{r}'|$

$t' = t - \frac{R}{c}$

c : speed of light

It must be noted that the current I induced by the incident wave $[\vec{E}^{i}, \vec{H}^{i}]$ is not known. Since it is assumed that the wires are perfect conductors, the tangential electric fields on the wire is continuous and results to:

$$\hat{s}.[\vec{E}^{i} + \vec{H}^{d}] = 0$$

where $\vec{E}^{i}$ is the incident wave and its amplitude and polarization is known. Thus, by using the method of moment in time domain, the induced transient electric current on the antenna is computed [9].

LPDA

LPDA consists of N parallel dipoles of cylindrical tubes (Fig.2). The dipole with the number n has the length $2h_n$, and the distance l_n from the feeding point of the antenna. The structure is defined in terms of the geometric ratio τ, the angle α, and the characteristic impedance of the feeder. The dimensions of each element and the distance of the dipoles from the apex is obtained using the following relations:

$$\frac{h_{n+1}}{h_n} = \frac{l_n}{l_{n+1}} = \tau \qquad 1 \leq n \leq N$$

The antenna is connected to a transmission line of characteristic impedance Z_c. In order to obtain the optimum efficiency in the desired frequncy band $[f_l = \frac{c}{4h_l}$ to $f_h = \frac{c}{4h_{l2}}]$, adjacent dipoles are fed with a 180° phase difference. The spacing between the two rods of the feeder line is determined using the transmission line theory to give a characteristic impedance (Z_c) equal to desired mean input impedance of the LPDA.

The feeder line can be terminated either in a reactive or an active load at the lowest frequency end.

Results

Model Description

The antenna is designed in the VHF band

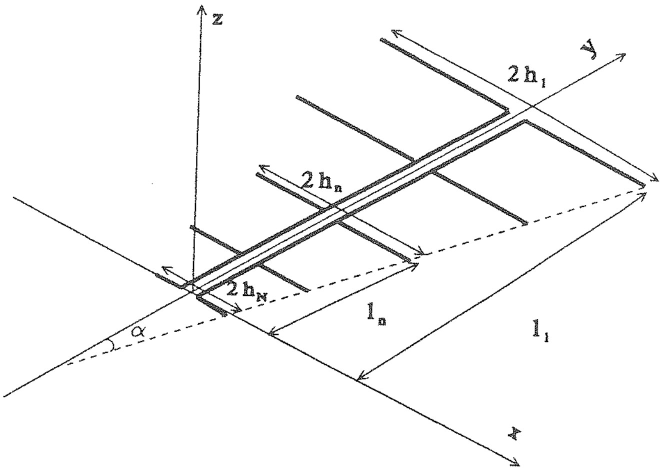


Fig.2 The LPDA with definition of parameteres

Time Domain Analysis of Logarithmic Periodic Dipole Array

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Abstract

A numerical method based on the Method of Moment for computing the current distribution of the elements of Logarithmic Periodic Dipole Array (LPDA) is developed.
According to the solution of electric field integral equations (EFIE) on wire structures, the input impedance, pattern, and other characteristics of such antennas are calculated. Since LPDA is wideband, EFIE is solved in time domain. The fourier transform of the computed currents is then used to calculate the frequency characteristics of LPDA. Interestingly, the method enables us to find the frequency characteristics of the antenna for a wide band frequency range using only a single narrow transient pulse.

Introduction

Broadband antennas have been considered since a few decades ago by many researchers, and eversince, they have introduced many kinds of such antennas. One of the most important and widely used broadband antenna is LPDA. DuHamel and Isbell [1] described the first log-periodic antennas. In 1959, Isbell made a successful LPDA by introducing the switched feeder [2]. Several analysis on LPDA, based on the theory of transmission lines, have led to a better understanding of peculiarities of these antennas. Carrel [3] analysed the LPDA in terms of a circuit model. Jones and Mittra [4],[5] analysed it in terms of a nonuniform but continuously scaled transmission line. Cheong and King [6] presented an analysis of LPDA, which permits the calculation of current distributions in both amplitude and phase along the elements. Wolter [7] derived the theory of LPDA from Maxwell's Equations by solving the wave equations in cylindrical coordinates and satisfying boundary conditions.

In this paper, the solution of electric field integral equation is first used to compute the current at the feed point of the antenna. This current is used to find the radiation characteristics of the antenna. By using the fourier transform, the characteristics of LPDA in frequency domain are obtained.

Theory

To analyse the structures made of perfect conducting wires, such as LPDA, the antenna is modeled by many infinitesimally thin wires [8]. A transient wave $[\vec{E}^i, \vec{H}^i]$ illuminates the feed point of the antenna. The incident wave acts like a generator and induces the current I(s,t) on the antenna which is the source of the scattered fields $[\vec{E}^d, \vec{H}^d]$. The expression for the scattered fields of a thin wire shown in (Fig.1) is given by Miller as [9][10]: