DESIGN OF A 26GHZ BASE STATION PHASED ARRAY ANTENNA ELEMENT

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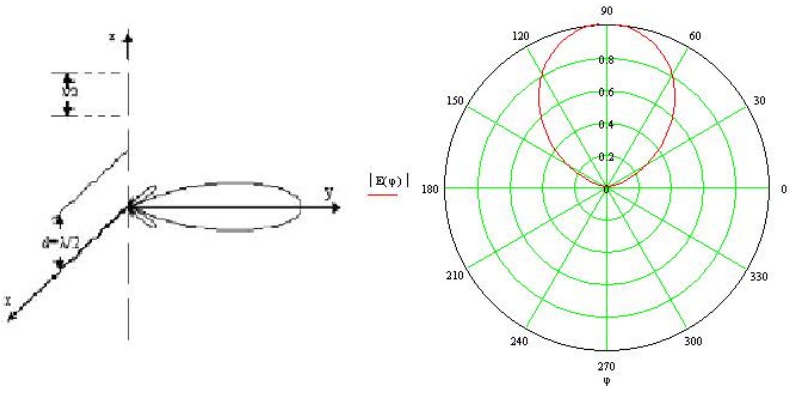
Abstract - A novel printed antenna array has been designed and simulated for the needs of a node antenna for point-to-multipoint, PMP, radio links, operating at 26GHz. The antenna array elements are derived from the concept of the Markoni-Franklin collinear array. Each array element is being fed by two parallel transmission lines via an under ground plane of approximately $3\lambda_{26GHz}/2$ x $3\lambda_{26GHz}/2$ mm^2. Following extensive simulations the radiation pattern of each array element was extracted concluding in an almost 8dB directivity with a 75% efficiency.

1. Introduction

In this paper, a novel printed antenna structure is proposed to operate at the frequency band between 25.5 – 26.5 GHz, as an element of a base station phased array antenna system [1]. Its advantage, comparing with a typical patch antenna is that it possesses the properties of an array antenna and still remains compact in size. The proposed antenna approximates a collinear Marconi-Franklin type array antenna [2], whose form and theoretical magnitude of the electric field, within the xOy plane, are shown in figure 1:



(a) (b)

Fig.1: Franklin array geometry (a), theoretical magnitude of the electric field (b)

All collinear dipoles are fed with excitation currents of equal amplitude and phase. The magnitude of the electric field within the xOy plane, at the far field of the Franklin array, is computed by eq.1, in which the influence of a metallic reflector at the back of the antenna is also included (examined case):

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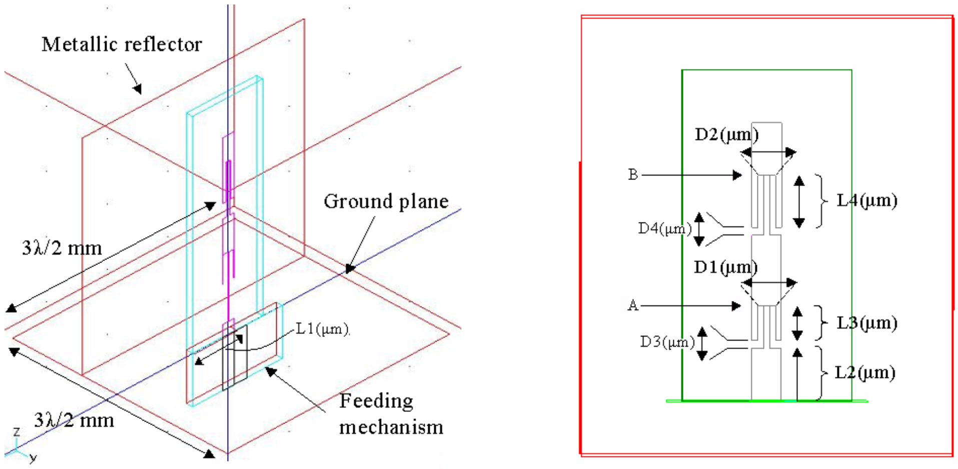
$$E(\varphi) = A \cdot \left[\frac{\cos\left(k \cdot \frac{L}{2} \cdot \cos(\varphi)\right) - \cos\left(k \cdot \frac{L}{2}\right)}{\sqrt{1 - (\cos(\phi))^2}} \right] \left[\sin\left(k \cdot h \cdot \sin(\phi)\right) \right] \quad \text{(Eq.1)}$$

where, k is the free space propagation constant (=2π/λ), L is each dipole length, h is the distance from the ground plane at the back of the antenna and A is a constant denoting the excitation's amplitude. In the examined case, L equals λ/2 and h equals λ/4. Input impedance and radiation characteristics are adjusted by using slots integrated within the antenna. Their, as well as other parts of the antenna influence on the antenna's radiation pattern and resonant frequency is extensively examined through simulations, performed using HFSS version 5.5 finite elements method software.

2. Printed Franklin antenna topology

The antenna geometry, together with its feeding mechanism is illustrated in fig.2:



(a) (b)

Fig.2: 3-D representation of the antenna geometry (a), 2-D equivalent (b)

It is a microstrip type of antenna, comprised of three patch antennas, one monopole and two dipoles of 1mm width and of λ/4 and λ/2 length, respectively [3,4]. Slots are integrated within each dipole and used as coplanar tuning stubs. The antenna is being fed by two in-plane parallel transmission lines: the "positive" line is connected with the monopole while the "negative" line is short-circuited with a ground plane, positioned at the bottom of the structure. The dimensions of this ground plane are approximately $3\lambda_{26GHz}/2$ x $3\lambda_{26GHz}/2$ mm^2. Each feeding line has a width of 1mm while the inter-lines gap is approximately 0.02mm, in order to minimize their radiation. The substrate of both the microstrip antenna and its feeding mechanism has relative dielectric constant of 3.38, although different types of substrates may be implemented in the future for optimizing purposes. At the back of this antenna and at a distance of a quarter of a wavelength lies a metallic reflector, in order to minimize the back lobes.

Analysing the topology of the proposed antenna, the parameters that affect its performance, in terms of radiation pattern and reflection coefficient, can be easily defined. These parameters (reference to fig.2) are:

I. The length L1 (mm) of the aperture, from where the antenna is being fed
II. The inter-coupled lines distance D1(μm) of the first dipole
III. The inter-coupled lines distance D2(μm) of the second dipole
IV. The distance D3(μm) between the monopole and the first dipole
V. The distance D4(μm) between the first and the second dipole
VI. The physical length L2(μm) of the monopole
VII. The distance L3(μm) between point A of the first dipole and its lower edges
VIII. The distance L4(μm) between point B of the second dipole and its lower edges

Each parameter was varied within a specific range of values, while all other parameters held their nominal values, in order to define each parameter influence on the antenna radiation pattern and reflection coefficient. The dimensions of the antenna were adjusted to create an antenna that matches the radiation characteristics of the theoretical collinear Marconi-Franklin type array antenna (fig.1). Simulations were performed using HFSS version 5.5 software; in each simulation eight iterations were realized.

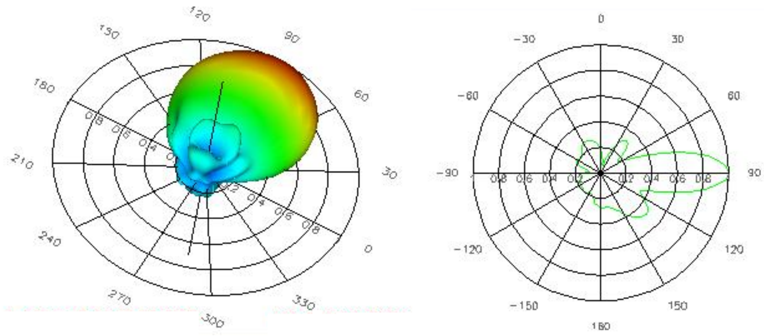
3. Simulation results

Simulations showed that the reflection coefficient of the antenna is basically determined by the shape and dimensions of the two dipoles (parameters D1, D2, L3 and L4) whereas, its radiation pattern is determined by the slots integrated within the antenna, the size of the monopole and the length of the feeding aperture. The parameters that yielded the optimum performance in terms of reflection coefficient and radiation pattern are summarized in the following table (table 1):

Parameter	**Value (μm)**
Length L1 of the aperture	3600
Inter-coupled lines distance D1 of the first dipole	800
Inter-coupled lines distance D2 of the second dipole	100
Distance D4 between the first and the second dipole	1200
Length L2 of the monopole	500, 1000, 2900
Distance L3	2000
Distance L4	3000

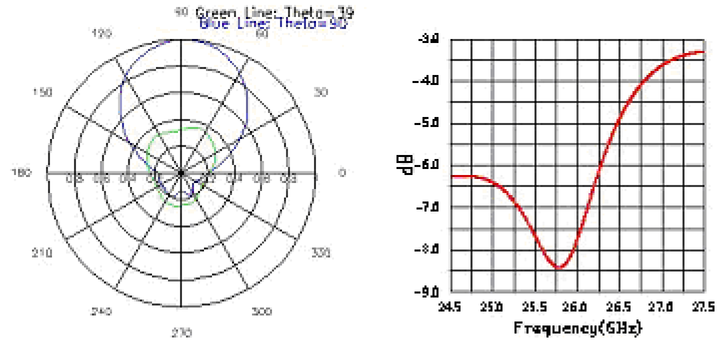
Table 1: Optimum parameter values

Several simulations have been made, for all different values of length L2. In fig.3 and 4, the simulated results, in the case where L2 equals 500μm are shown, for which there is a good agreement between the simulated and theoretical magnitude of the electric field, within the xOy plane.



(a) (b)

Fig.3: 3-D Radiation pattern (a), radiation diagram for phi=90^{o} (b)



Directivity: 8dB

(a) (b)

Fig.4: $\left|E(phi)\right|$ for theta=90^{o} (a), $\left|S(1,1)\right|$ in dB (b)

4. Conclusions

A novel printed antenna is being introduced whose efficiency is approximately 75% and directivity almost 8dB. From the simulations results it is seen that there is a good agreement between the theoretical properties of the Franklin array and the simulated ones of the proposed printed antenna. The slots integrated within the antenna add a great deal of design flexibility to the radiation pattern of the antenna while more simulations are made in order to improve the matching in the frequency of 26GHz.

5. References

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