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Multi Sector PCS-EBG Antenna for low cost high directivity applications

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Abstract

This work proposes a new topology of antenna based on the use of Planar Circular Symmetric EBG with different periodicities. These periodicities are used to impose different propagation velocities of the dominant surface waves on different zones of the same dielectric substrate. The control of the dispersion characteristics guides the design together with the definition of a centered feed suitable to excite the surface waves. One prototype has been designed, manufactured and tested to prove the concept.

Introduction

The use of the PCS-EBG to avoid surface waves has been investigated in the three recent works [1], [2], [3]. The common base of these works is the use of a radial symmetry on a completely planar structure to control the surface waves that are particularly significant for substrates that are thick in terms of the wavelength. The reason for using thick substrates in [1]-[3] was in the first place to achieve wide band behavior, but surface wave control was then mandatory. In the present work there is a shift in the philosophy. Here the use of EBGs is also driven by the will to convert the surface waves into leaky waves. This concept has been recently proposed in antenna designs which are referred to as holographic antennas [4]. These antennas present a modulated impedance surface as dictated by an interference pattern between the wave radiated by a feeder and a plane wave coming from a chosen direction of maximum radiation.

This work can be seen as a further enrichment of the so called holographic antenna field. From a design procedure point of view the enrichment resides in the fact that the present PCS-EBGs are designed using the full information of the dispersion diagrams [1] of the EBGs, which are characterized by complex attenuation constant whose imaginary part represents the power incremental leakage when the EBG is used as holographic antenna and a mode in cut off when the EBG is used as propagation filter. When the EBG is used in leaky regime also the real part of the propagation constant is significant as it defines the pointing angle.

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The dielectric substrates considered in this work have a thickness such that only the mode TM_0 is in propagation. A crucial point is the design of the feed in order to efficiently excite this surface wave. The feed chosen is a Yagi–Uda coplanar-waveguide (CPW)-fed slot launcher. The details of the design outlined previously are explained in the following.

Antenna Structure

The general configuration of the antenna is shown in fig. 1. The antenna is printed on a grounded substrate and fed by a Yagi–Uda coplanar-waveguide (CPW)-fed slot launcher. The feed and the substrate are designing following the steps outlined in [3]. In particular in order to lunch only the dominant TM_0 mode the thickness of the substrate, h, has to be $h < \frac{\lambda_0}{4\sqrt{e_r - 1}}$ where c is the speed of the light, ε_r is the relative permittivity of the substrate and λ_0 is the free space wavelength. The operative frequency of the antenna is 12.4 GHz. Choosing as dielectric constant 10.2 and h=1.9mm, commercially available substrate from Rogers verifies the mono-modal condition. The feed used is shown in fig 2. This feed ensures a completely planar structure which is desirable to diminish the costs of manufacturing solutions.

As anticipated the feeding slots are surrounded by two different PCS-EBGs, one operating in the leaky mode and the other operating in the cut off mode. The dispersion diagrams pertinent to the two periodicities (p_{leaky} and $p_{cut\ off}$) are shown in fig. 3. With reference to fig. 1 the leaky EBG is defined over the angular sector where most of the surface wave power is actually launched. The cut off EBG is covering the remaining angular sector to limit to the minimum the residual power that would be launched in surface waves and would result in effective losses. Fig. 4 shows the measured radiation patterns in the E and H plane at the frequency of 11.75 GHz. A shift of frequency is observed in the measurements with respect to the calculated results. The reason of this shift is under investigation. More details will be given during the oral presentation.

Conclusions

A novel design strategy based on the use of PCS EBG to realize directive antennas on printed circuit board technology has been proposed. This type of antennas can be used to implement with economical solutions all functions that are now obtained via standard slotted waveguide arrays.

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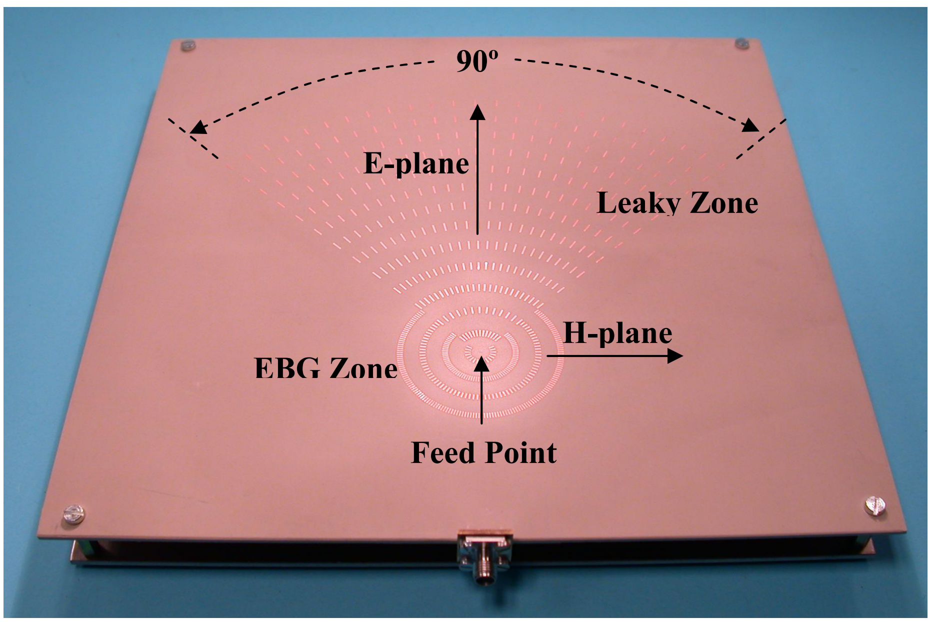

Figure 1: Antenna structure.

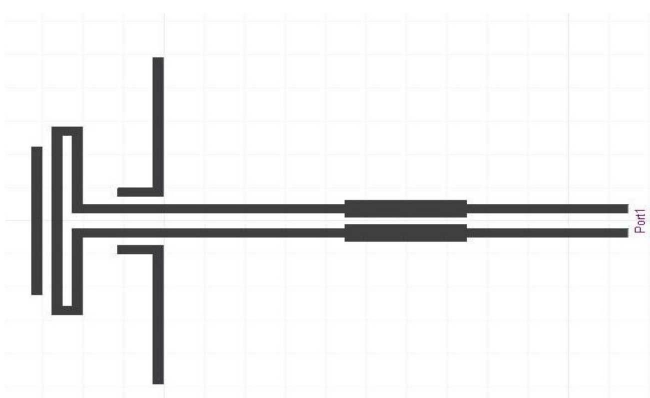

Figure 2: Yagi–Uda coplanar-waveguide (CPW)-fed slot launcher

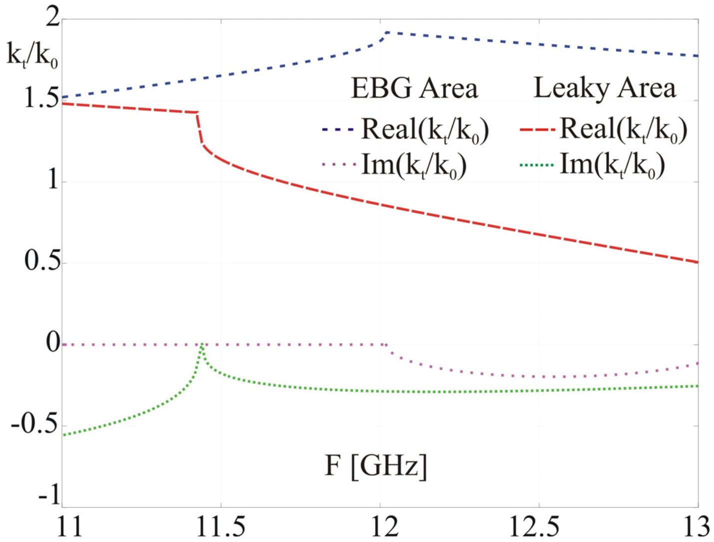

Figure3: Dispersion diagrams of the leaky and EBG zones.

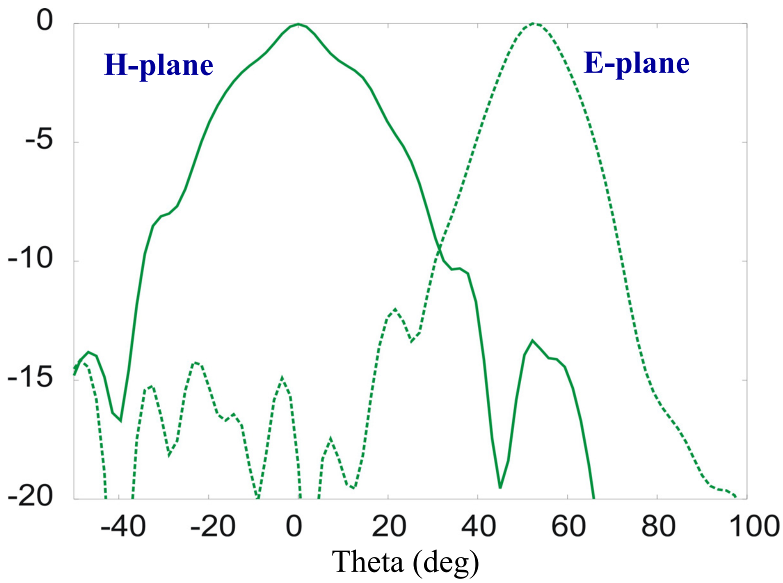

Figure 4: Radiation Patterns @ 11.75GHz on the E-plane and H-plane