Enhanced antenna performances using planar circularly symmetric EBG’s
Llombart, N.; Neto, A.; Gerini, G.; de Maagt, P.J.I.

Published in:

DOI:
10.1109/APS.2005.1551436

Published: 01/01/2005

Document Version
Publisher’s PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:
- A submitted manuscript is the author’s version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher’s website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

Citation for published version (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal?

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Download date: 07. Dec. 2018
Enhanced Antenna Performances Using Planar Circularly Symmetric EBG’s

N. Llombart(1), A. Neto(1), G. Gerini(1), P. De Maagt(2)
E-mail: nuria.llombartjuan, andrea.neto, giampiero.gerini@tno.nl
(2) European Space Research and Technology Center (ESTEC), Noordwijk, The Netherlands. E-mail: peter.de.maagt@esa.int

Introduction

Planar Circularly Symmetric (PCS) Electromagnetic Band-Gap (EBG) substrates have recently been proposed to suppress the surface waves [1]-[3]. The major advantage of the PCS-EBG’s with respect to structures based on vertical pins [4][5] is the fabrication simplicity since the dielectric slabs do not need to be perforated. With respect to other planar type of EBG, an advantage is that the surface waves launched by a central source are reduced equally in all radial directions. In [1] the general properties of the Green’s Function (GF) of a non periodic source operating in the presence of a periodic loading were discussed in a two dimensional TM case. In [2] the GF has been extended to a 3D case, to treat the field scattered by a PCS-EBG excited by a TM symmetric source, while in [3] the design rules that optimize the performances of such EBG’s have been presented.

In this contribution the application of PCS-EBG to reduce the surface waves excited by an antenna printed on a dielectric slab is discussed. The study starts from a reference micro-strip excited, slot coupled dipole that presents about a relatively large bandwidth (12%) and relatively low efficiency (about 40%-60%) due to surface wave losses. Some design considerations on how to enhance the performances of this antenna by surrounding it with a PCS-EBG are then presented. Finally the measured results are presented. These latter explicitly show the advantages in terms of bandwidth and radiation pattern of the proposed EBG substrate. A bandwidth of 20% is achieved without significant surface wave losses.

Antenna Design and Measurement

The antenna considered is shown in Fig. 1. It consists of two dielectric slabs with the same dielectric constant $\varepsilon_r$ and different heights $h$ and $h_m$ divided by a ground plane. There is a slot etched in the ground plane of dimensions $l_s$ and $w_s$. The slot is coupled to an orthogonal dipole ($l_d$ and $w_d$) located on the top of the higher dielectric slab $h$. Finally, the structure is excited via a micro-strip of dimensions $l_{stub}$ and $w_m$ printed on the other side of the lower dielectric slab $h_m$. Printed antennas present one disadvantage: relative small bandwidth over which high
efficiency is obtained. In practice the height of the substrate on which the dipole is printed \( h \) dominates the bandwidth and efficiency. Beyond a certain substrate height, the antenna starts to generate a dominant surface wave field. The bandwidth achieved from this type of antenna configurations with a limited substrate thickness and dielectric constant of \( \varepsilon_r = 10 \), and without any dedicated optimization is about 12\%. Nevertheless, also in this configuration with relatively thin substrate, 60-70\% of the power delivered by the source [6] can be launched in the TM\(_{00}\) mode.

**Fig. 1** Side and top view of the printed antenna: Slot (\( l_s \) and \( w_s \)) coupled to a dipole (\( l_d \) and \( w_d \)) and excited via micro-strip (\( l_{stub} \) and \( w_m \)).

Note that in this contribution the thickness of the dielectric in the antenna side of the ground plane is maintained such that only this first mode can propagate. The design rules that were shown in [3] have been used in [2] to improve the efficiency of such antennas. In those contributions a symmetric TM source was assumed, that generated only a pure TM field with the electric field entirely polarized along \( \rho \). Continuous rings were used to stop the surface wave propagation. When the source is not symmetric, it generates electric field components in both, \( \rho \) and \( \phi \), directions. If one was simply to use the continuous rings that were introduced in [2] they would support azimuthal electric currents that can lead to strong resonances. Such strong resonances will then be responsible for a significant alteration of the input impedance and thus a bandwidth reduction. However the electric field associated to the TM surface waves can be demonstrated to present, for large values of \( \rho \), an electric field with only the \( \rho \) component. Thus, a simple modification of the PCS-EBG configurations that resorts to dipoles oriented in the radial direction around the source can be applied. The radial dipoles will only act on the \( \rho \) component of the electric currents (or of the electric fields), so will not introduce additional resonances.

In order to quantify the improvement of the EBG super-structure on the performances of the antenna in fig. 1, a panel composed of six printed antennas has been built (fig. 2). Two of these antennas are surrounded by a PCS-EBG consisting of two or three rings. The other four antennas are simple printed antennas.
Fig. 2 Panel with six antennas located in a square grid of 80mm

Fig. 3a shows the S-parameters pertinent to these latter type antennas. The measurements are compared with the simulations done using Ansoft Designer. One can first note that the single element impedance bandwidth ($S_{33} < -10 \text{ dB}$) is in the order of 12%. The $S_{34}$, case in which the antennas are situated at a distance of 80mm ($1.45 \lambda_0$, at the central frequency) in the maximum coupling direction, is around -17dB. The second parameter $S_{36}$ is around -23dB and corresponds to case where the antennas are placed at 45° one to the other. For both these configurations the coupling is essentially due to the $\text{TM}_{00}$ surface wave.

The PCS-EBG implemented in the prototype is designed using the 2D design rules shown in [3] starting from the grounded slab and aimed at achieving the band-gap in the frequency band from 4.75GHz to 6.4GHz (29.6%). The
parameters that define the appropriate 2D-EBG are the length of the dipoles and their period. Fig. 3b shows the S-Parameters related to the antenna with the two rings EBG surrounding it. The $S_{33}$ parameter of the antenna surrounded by the EBG is improved so that the impedance bandwidth is about 20%. The parameters of the antenna, length and width of the dipole and of the slot are slightly tuned to obtain a good matching in the presence of the rings loading. This demonstrates how a careful design can lead to an increase of the impedance matching with respect to the single antenna configuration. Most important, there is also a significant reduction of the coupling between the two antennas. The $S_{56}$ parameter is in the order of -30 dB's. These results show that as far as impedance bandwidth is concerned PCS-EBG may be tuned to achieve 20% bandwidth without surface wave excitation. Due to the limited space available the S parameters associated to antennas surrounded by 3 rings EBG will be shown during the oral presentation as well as the measured radiation patterns.

Conclusion

The measured results explicitly show radical improvements in the isolation between antennas printed on the same substrate by using PCS EBG. Also the purity of the radiation patterns is greatly improved thanks to the fact that the contributions arising from the diffraction of surface waves at the edges of the slab are not present.

References: