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Enhanced Antenna Performances Using Planar Circularly Symmetric EBG's

N. Llombart⁽¹⁾, A. Neto⁽¹⁾, G. Gerini⁽¹⁾, P. De Maagt⁽²⁾

(1) Radar Group, TNO, Den Haag, The Netherlands.

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 been recently 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 ϵ_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

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 ($S_{33} < -10$ 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 TM_{00} surface wave.

Fig 3 S-parameters pertinent to a) the simple antennas ($l_s=8.5\text{mm}$, $w_s=1\text{mm}$, $l_d=8.25\text{mm}$, $w_d=0.6\text{mm}$, $l_{\text{stub}}=4.3\text{mm}$, $w_m=0.37\text{mm}$) and b) the antenna surrounded by 2 rings of dipoles printed on a substrate with parameters $\epsilon_r=10$, $h=3.81\text{mm}$ and $h_m=0.381\text{mm}$

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_{55} 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.

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