EBG Superstrate Antenna for WAAS Bands

Osés, A., Iriarte, J.C. , Ederra, I. , and Gonzalo, R.

Electrical and Electronic Engineering Department, Universidad Pública de Navarra,
Campus Arrosadia, E-31006, Pamplona, Navarra, Spain
Email: jcarlos.iriarte@unavarra.es

Abstract

Multiband antennas can simplify considerably the complexity of receivers and transmitters, reducing the size and the mass of the conventional configurations. On the other hand, applications with high directivity requirements need array designs to comply with the directivity specifications using conventional technology. EBG superstrate designs have been satisfactory applied to single band applications using a single EBG superstrate layer. The number of number of radiating elements of conventional technology designs are considerably reduced when using EBG technology. Dual band configurations have also been designed in a single layer, but when working frequencies are too close a second EBG layer is needed.

A dual layer EBG superstrate which can easily be adjusted to the desired operational frequencies is presented. The design has been realized to comply with the navigation antenna requirements of Wide Area Augmentation system (WAAS) application in L1 and L2 bands.

1. Introduction

Nowadays many applications require high directivity values in dual frequency bands. EBG technology offers new alternatives to comply with these applications requirements using a single radiating element or a small 2x2 array of elements instead of the large array typically used in conventional technology [1-3]. Gain enhancement in a single band can be obtained using a single layer EBG superstrate, but configurations for dual operational frequencies are considerably more difficult. Moreover, the complexity increases if the desired working bands are too close. A second superstrate layer is needed to obtain the gain enhancement at both close frequencies.

In this paper a dual band EBG antenna is presented. The antenna has been adjusted to work at the L1 and L2 bands, typically used for navigation antennas. The design has to comply with the directivity and Axial Ratio (AR) requirements of the WAAS application took as reference [1]. The proposed configuration can be easily adjusted to work at different bands just by changing the superstrate heights.

2. Bi-band Superstrate design

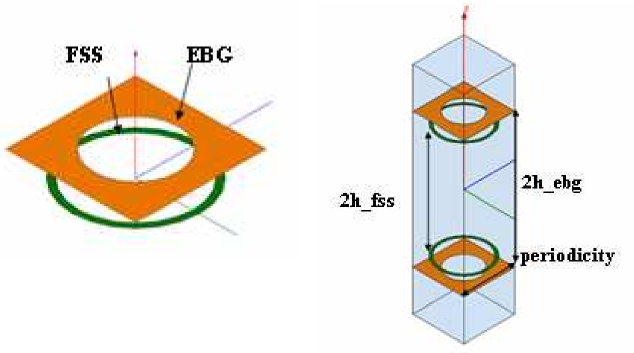
A dual layer EBG superstrate has been designed to obtain the desired gain enhancement phenomenon at L1 and L2 frequencies. The superstrate is placed over a ground plane creating a cavity. The resonance frequency of the cavity can be obtained using (1), where h is the distance between the superstrate and the ground plane and φ_r is the phase introduced by the EBG superstrate.

$$f_o = \frac{v}{2h}\left(\frac{1}{2} + \frac{\varphi_r}{2\pi}\right) \quad (1)$$

In the proposed design the height has been fixed to 91 mm. As the design has to satisfy (1) at two different frequencies, the relation between the phase introduced by the superstrate at both working frequencies is given by (2).

$$\varphi_{L1}{}^{o} = 50.36^{o} + 1.280\varphi_{L2}{}^{o} \quad (2)$$

The dual band behaviour can be obtained using one frequency, but as the desired frequencies are too close equation (2) can be more easily satisfied using a two layers solution. The dual layer EBG superstrate configuration is shown in Fig. 1.

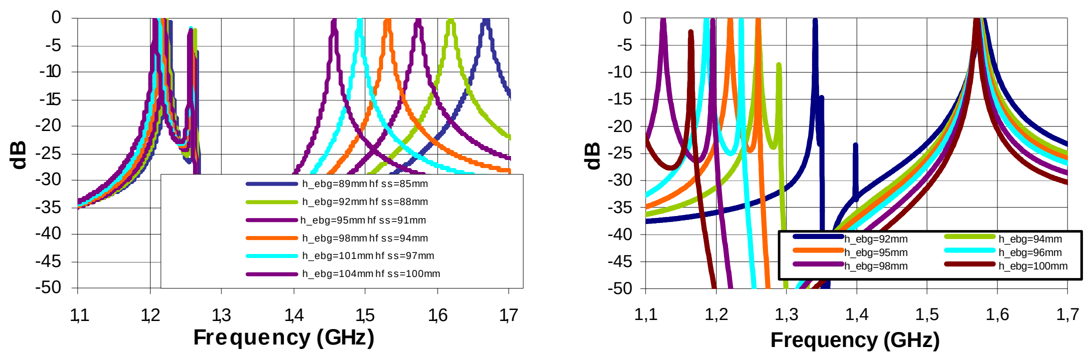


a) b)

Fig.1.a) Basic configuration and b) elementary cell for the cavity

A square grid of circular holes with band pass response (EBG layer) and an array of circular metallic rings (FSS layer [4]) with a reject band behaviour are used to design the superstrate. The resonance frequencies of the cavity can be easily adjusted (see Fig. 2.a and Fig. 2.b). The higher frequency can be adjusted by changing the distance between the ground plane and the superstrate (keeping constant the distance between both layers) and the lower frequency can be adjusted by changing the distance between the EBG layer and the ground plane (keeping constant the distance between the FSS and the ground plane).

The phase introduced by the superstrate in both frequency adjustment cases are shown in Fig. 2.c and Fig. 2.d.



a) b)

Fig. 2. Resonance frequencies for the elemental cell cavity in function a) EBG+FSS superstrate height, b) EBG superstrate height and Phase when changing c) EBG+FSS superstrate height and d) EBG superstrate height

3. Dual band Antenna

The Complete design of the dual band configuration antenna is shown in Fig.3. A circularly polarized patch at L1 and L2 bands has been used to excite the cavity.

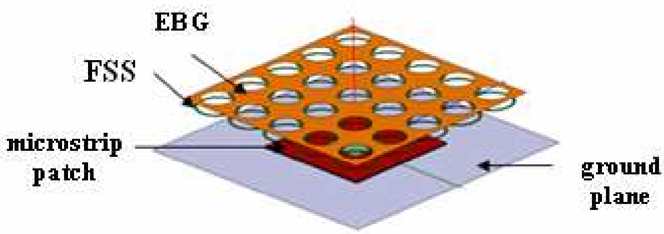
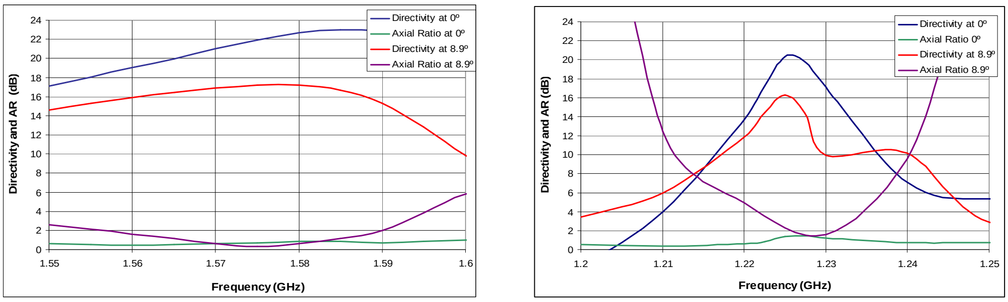


Fig. 3. Dual Band EBG Navigation antenna prototype.

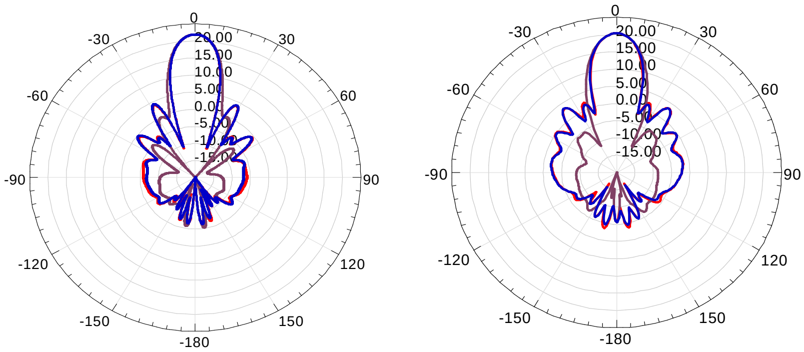
The directivity and AR values versus frequency obtained in both operational bands are shown in Fig. 4.a and Fig. 4.b. The directivity at 8.9º is over 16 dBi and the AR at this theta angle is lower than 1.5 dB at the resonant frequency, complying with the WAAS antenna application requirements. 24 MHz of bandwidth is needed. L1 band complies with the bandwidth requirements while the abrupt phase slope of the reflected field in L2 band makes the bandwidth smaller.



a) b)

Fig. 4. Directivity and AR for both working frequencies a) L1 and b) L2 band

Radiation patterns at L1 and L2 center frequencies are shown in Fig. 5.a and Fig. 5.b.



a) b)

Fig. 5. Directivity at φ=0º (red), 45º (brown), 90º (blue) for a) L1 band and b) L2 band.

4. Conclusions

Dual EBG superstrate antennas can be design to work at two close frequency bands by using a dual EBG superstrate layer.

Working frequencies can be easily adjusted by changing the EBG+FSS superstrate height or the EBG height, changing independently the higher or the lower frequency respectively.

The proposed design complies with WAAS antenna directivity and AR requirements in L1 and L2 bands.

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