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Multiband Evanescent Waveguide Antenna

Vedaprabhlu Basavarajappa and Vincent Fusco

A dual/tri-band evanescent waveguide antenna element is presented. The antenna operates in the 740-790 MHz, 1.9-2.2 GHz, and 2.5-2.7 GHz frequency bands. It measures 55mm x 27.5mm x 53mm and occupies a small volume making it attractive for miniaturized applications.

Introduction: Crowded frequency spectrum necessitate the deployment of multiband antennas in order to minimize co-band interference. An evanescent waveguide radiator with multiband operation is presented which can fulfill this function. In [1] multiband antenna operation was obtained using a Sierpinski fractal, while [2] proposed a planar monopole antenna with dual band notch characteristics using shaped slots included in the radiator. In [3] a multiband multiple ring monopole antenna design was proposed that used planar resonators to excite multiple resonances.

Classical waveguide antennas operating at L and S-band and below are generally too large for applications where space is a premium. A propagating rectangular waveguide which used multiband split ring resonator loaded slabs along the waveguide sidewalls and along its centre enabled tri-band operation, [4]. Due to its construction from propagating waveguide the resulting structure occupied a large volume. On the other hand evanescent waveguide antenna, EWGA, [5], which work on the principle of matching the reactive aperture admittance of a cut-off waveguide to free space occupy reduced volume as compared to propagating waveguide antenna equivalents. To the author’s knowledge no examples of multiband EWGA have been reported. The purpose of this paper is to redress this.

Antenna: The proposed antenna is based around an evanescent waveguide designed to operate in below cut-off mode, Figure 1. It operates with vertical linear polarization in the 1.9 -2.2 GHz and 2.5-2.7 GHz cellular bands and is excited at port 1, with port two exciting horizontally linear polarization at the 740-790MHz white space frequency bands, [6].

The EWGA was fabricated using an extruded aluminium casing, Fig. 1b, with cellular bands excited using a coaxial probe inserted into its base wall. On the open end of the antenna is added a 0.7mm foam layer onto which is positioned a stack of 5 layers of 3.18mm Taconic RF 60 substrate material which are bonded together using Tacbond film. U slot resonators are printed onto the front face of the outermost dielectric stack substrate.

Table 1. Slot dimensions in mm

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
<th>Value (in mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L_s$</td>
<td>Width of outer slot</td>
<td>14</td>
</tr>
<tr>
<td>$L_c$</td>
<td>Length of center slot</td>
<td>8</td>
</tr>
<tr>
<td>$w_0$</td>
<td>Thickness of the slot</td>
<td>2</td>
</tr>
</tbody>
</table>

Fig. 1 Multiband EWGA:  
- a schematic  
- b photograph  
- c Fractal backplane

Accommodation of the lower band 740-790 MHz requires an inherently electrically long antenna which should integrate into the already designed dual band antenna. To achieve this the solid metal short circuit back wall of the EWGA was replaced with a fractal dipole antenna which has dense enough metallization to approximate a solid conductor in the higher operating bands. A space-filling fractal resonator, [7], was designed to occupy this space, see Fig. 1c. The fractal antenna element was printed on one side of a grounded dielectric substrate with permittivity 3.55 and thickness 0.5mm. The fractal arm was meandered up to the 4th iteration of the Hilbert fractal curve and its aspect ratio modified to fit into the available rectangular space. The fractal arm was fed at its center by a coaxial probe position at right angles and at the center of the back face of the EWGA. The lengths of the fractal arms were set to resonate at 765 MHz.

Results: Figure 2 shows the measured and simulated return loss obtained without external additional port 1 matching applied, and simple LC matching at port 2.

The principle radiation patterns of the antenna are presented in Fig. 3. For the cellular band mid-band frequency points 2.1 and 2.6 GHz, sidetube levels were below -15 dB. EWGA gain measured using the comparison method were 5 dBi in the lower band at 2.1 GHz and 8dB at 2.6GHz GHz. At 765 MHz S11 was less than -10 dB with a bandwidth of 50 MHz and gain 2.1 dBi.
Conclusion: A dual/tri-band evanescent waveguide antenna has been presented. The antenna operates in the 740-790 MHz white space, 1.9-2.2 GHz and 2.5-2.7 GHz cellular frequency bands. The EWGA reported could be a possibility for insertion into next generation pico-cell equipment that require increased service facility in the lower frequency bands as well as form factor miniaturization.

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References


6. The European Table of Frequency Allocations and Applications, in the frequency range 8.3 KHz to 3000 GHz http://www.erodocdb.dk/docs/doc98/official/pdf/ERCRep025.pdf, last accessed May 2014.