Application of •-Near-Zero Channel to Design of a High-Directivity Small Antenna

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ENZ (•-Near-Zero) channel can be constructed by reducing the height of a rectangular waveguide, as it is shown in Fig.1 [1]. Since the channel height *b* is considerably smaller in respect to its width *a*, propagation of TE_{10} mode is an equivalent to TEM mode in a parallel-plate waveguide. In that case, the relative effective channel permittivity $\bullet_{reff}$ can be written as:

$$\varepsilon_{reff} = \varepsilon_{rch} - c^2 / \left(4 f^2 a^2\right) \tag{1}$$

where $\bullet_{rch}$ is relative channel permittivity, *a* is waveguide width, and *c* is velocity of light in vacuum. It was shown that tunneling through the narrow channel happens at the frequency for which $\bullet_{reff}$ becomes equal to zero [2].

In this paper we investigate the design of a small antennas on ENZ channel using the bottom channel (with asymmetrical field distribution) and the middle channel shown in Fig. 2.

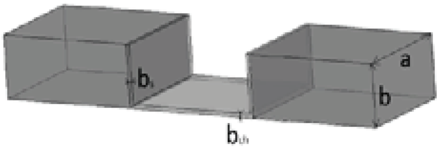

Figure 1. Bottom channel with relevant dimensions: a=50mm, b=25mm,b_{ch}=0.5mm, $\bullet_{rch}$=1

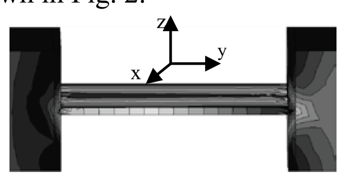

Figure 2. Middle channel with symmetric field distribution

Small antenna was designed at a wider side of a waveguide using two slots placed along x-axis in the middle of the channel. Dimensions of slots are 1x50 mm, and their mutual distance is 3 mm. Simulated radiation patterns for a bottom- and a middle-channel antenna are shown in Fig. 3 and 4, respectively. As we can see, the radiation patterns for a bottom-channel antenna are very asymmetrical, and the maximum of radiation is rotated by 30° in respect to the radiation maximum of a middle-channel antenna.

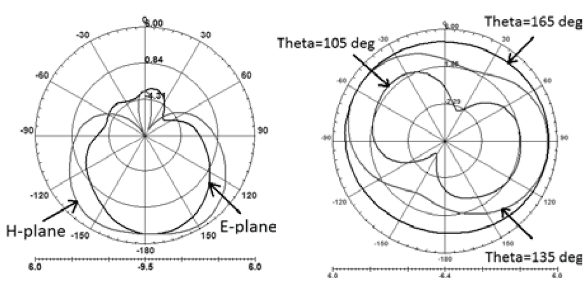

Figure 3. Radiation pattern of bottom-channel antenna in H- and E-plane (left), and for •=105°, •=135° and •=165° (right)

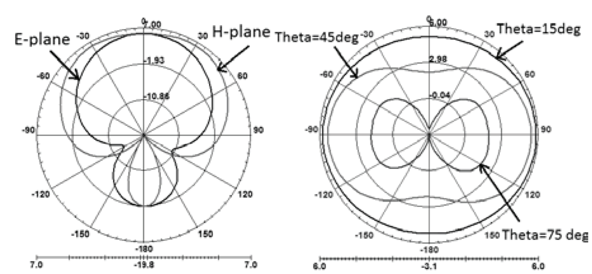

Figure 4. Radiation pattern of middle-channel antenna in H- and E-plane (left), and for •=15°, •=45° and •=75° (right)

3dB-beamwidths in H-plane and E-plane are θ_{H3dB}=139.7° and θ_{E3dB}=84.3°, respectively, which gives 5.44 dBi antenna directivity. The main drawback of this antenna is a very narrow frequency band of operation near 3 GHz.

References

[1] B. Edwards, A. Alù, M. E. Young, M. G. Silveirinha, and N. Engheta, *Physical Review Letters* **100**, 033903, (2008).
[2] B. Edwards, A. Alù, M. G. Silveirinha, and N. Engheta, *Journal of Applied Physics* **105**, 044905, (2009).