Folded Dipole Antenna Above EBG Surface

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Product identification requires modern techniques where RFID (radio frequency identification) has become a promising method recently (P.R. Foster and R.A. Burberry, IEE Colloquium on, 1999 pp. 3/1 -3/5). Therefore, new antennas need to be designed for that purpose. In this paper, the effects of an EBG (electromagnetic band-gap) surface (Fan Yang and Y. Rahmat-Samii, AP-S int. symposium, 2002. IEEE vol.3, pp. 744-747) and the same sized metal plate (or PEC) on a folded dipole antenna are studied. The antenna is placed horizontally very near the surface. Radiation efficiency, antenna impedance, impedance matching and radiated power are simulated as function of antenna height.

When an antenna is close to a metal plate, its surface will reflect all the radiation from the antenna, therefore, it acts like a reflector or mirror. The consequence of this is that the antenna becomes more directive. And this is the case of EBG-surface also, because most of its area is metal. But when the antenna is very near to the metal, its surface will affect to other antenna parameters as well. At least antenna impedance, impedance matching and radiation efficiency will change, even dramatically, and so radiated power will change. The purpose of this study is to find out how the antenna works, when it is placed very near to the EBG surface or the metal surface (PEC). Distance or antenna height is varied from 0.2mm to 10mm. Because the simulation problem is complex, especially for EBG case, analytical solutions for these situations are probably impossible. So simulation is only alternative to find out the effects of the surfaces, if measuring is out of count. This study is carried out with (Ansoft HFSS) Finite Element Method (FEM).

The folded dipole antenna is made of copper and is very thin like tape and the tape is 1mm wide. Its resonance frequency is 2350MHz (wave-length is 128mm) in free space and also all the results of this paper will concern that frequency. In addition, the antenna impedance is approximately 265+j3Ω in free space, so there is very good matching without any extra matching circuit, if 300Ω feeding cable is in use (S11 is then –24dB). The EBG surface and the metal plate are not groundplanes for the antenna, because folded dipole does not need one, but they work as reflectors. The EBG surface consist of 4x6 little square patches, which are joined to ground through the substrate via tiny ducts. The dimensions of the patches are designed for frequency 2350MHz and they depend on dielectric constant of the substrate, substrate height and gap between the patches. The metal plate is copper (conductivity 58MS/m), which works as reflector nearly as good as PEC would work.

When the antenna distance from the metal plate approaches zero (from 10mm to 0.2mm), its impedance changes dramatically. Resistive part becomes very small and it approaches to zero, also reactive part becomes much higher (55->95Ω). So if the impedance of the feed line is 300Ω, the matching is very poor (-2.6->-0.06dB). Actually 50Ω feed provides much better matching (app. –6dB), but it is still very poor (<-1.7dB), when the antenna is close to (0.2-4mm) the metal. Radiation efficiency is reasonably good (>92%), when distance is 4mm or more. If the distance is less than 4 mm, the efficiency is very low and approaches to zero. With 1W feed power, the radiated power is 0.45-0.0002W and 0.76W-0.001W in 300Ω and 50Ω case, respectively. In the EBG case, when antenna distance from the metal plate approaches zero, the resistive part of the antenna impedance becomes little lower (app. 150Ω) and reactive part becomes very high (200->800Ω). Matching to 300Ω is much better than in the metal case (-6,7->-1.3dB), but it still needs extra matching. Matching to 50Ω is as good as in the metal case when antenna is very near (0.2-4mm). Actually the metal case performs much better when distance is longer (app. –1.7dB). The radiation efficiency remains suitable (88%) even when antenna is almost in touch (0.2mm) with the EBG surface, which is wilfully better than in the metal case (1%). And thus, radiated powers are 0.78-0.23W in 300Ω case and 0.35-0.05W in 50Ω case.

As for conclusion one can say that EBG surface provide much better efficiency and matching, compared to the metal plate surface (PEC), when the folded dipole antenna is very near the surface. And consequence of this is more radiated power and/or lower profile antenna designs.