High-gain and Low-profile Metalens-horn Antenna based on the Fishnet Metamaterial

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Lenses are commonly used to reduce the profile and enhance radiation properties of horn antennas. To this purpose, metallic as well as metamaterial lenses have been successfully employed in the past showing a clear gain enhancement and shortening of the horn antenna (D. Ramaccia, *et al.*, IEEE Trans. Antennas Propag., 61, 2929-2937, 2013). The aim of this work is to implement a high-frequency metamaterial lens-antenna based on a fishnet structure which promises improved impedance matching compared to dielectric lenses.

Here, we show a metamaterial fishnet lens-antenna that enhances the antenna gain when it is coupled to the aperture of a modified H-plane sectorial horn showing also good matching in a narrow bandwidth. The fishnet consists in a pair of perforated metallic $0.089\lambda_0$-thick plates separated by a gap of $0.133\lambda_0$. The unit cell of each perforated plate is $0.535\lambda_0 \times 0.892\lambda_0$ and is perforated with a circular aperture of diameter $0.446\lambda_0$. The fishnet matches the aperture of the H-plane sectorial horn dimensions which are $5.89\lambda_0$ wide and $0.892\lambda_0$ high. Hence, it consists of a row of 11 unit cells, see Figure. The antenna is designed to work at 53.5 GHz. For given aperture dimensions a wide flare angle such as the one employed here means a low profile horn antenna (i.e. a shorter horn length). The semi-angle flare of the horn is 75º and this implies a horn length of $1.31\lambda_0$. The system was simulated using the commercial software CST MWS™. Results show good matching at 53.5 GHz, and a realized gain enhancement within a 1 GHz bandwidth, with a gain peak of 15.8 dB at 53.5 GHz (see Figure). A standard H-plane sectorial horn with a $5.16\lambda_0$ long and 30º semi-angle flare provides the same gain, which means that our design is about 74% shorter although it works in a narrower bandwidth. Gain is enhanced at the expense of bandwidth. Nevertheless, results show another range between 58 GHz and 60 GHz where gain is also enhanced. Experimental verification of the findings is now in progress.