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Loop Antennas At Microwave Frequencies Using Nano-metamaterials

William Whittow, Yiannis Vardaxoglou*

Department of Electronic and Electrical Engineering, Loughborough University,
Loughborough, Leics., LE11 3TU, U.K

w.g.whittow@lboro.ac.uk, j.c.vardaxoglou@lboro.ac.uk

The hypothesis of this work, introduced by the authors in [1], is that many nanoparticles can be grouped together to form larger predefined shaped antennas with total lengths in the mm or cm range and which therefore resonate at their respective frequencies. The advantages of using such nanostructures for microwave antennas includes being able to build the antenna, the substrate and RF circuitry in one process. This will allow us to use the flexibility of nanomaterials to create novel and specific substrate properties, such as permittivity, permeability and low losses. Using nanomaterials will also allow the antennas to have metamaterial-like behavior. In [1] we showed that a dipole antenna could be built from many small metallic *dots* with coupling gaps in-between. If the total metal was approximately 14.9mm along a 15mm dipole, the composite object behaved similarly but not identically to a continuous dipole. The metal *dots* are capacitively coupled and this means that thinner objects require a higher ratio of metal to non-metal. In this work, we apply the same assertions to loop antennas. EMPIRE, a commercial FDTD code (www.empire.de), has been used in simulations. Note, finely meshing the space in two dimensions is extremely computationally expensive. An Ez (vertically) polarized plane wave travelling in the Y-direction was used as a source and the antennas considered are all passive devices. The loops were square (10.1mm × 10.1mm) and were 0.1mm thick. The continuous loop resonated at 8GHz. the maximum electric fields were along the horizontal sections and the maximum currents were along the vertical sections.

The side section of the loop was replaced with metallic *dots* and increasing numbers of 0.01mm air gaps. The results are shown in Fig. 1. Removing the side section meant the antenna behaved like a C-shaped dipole, resonating at 5GHz. With two 0.01mm gaps (total metal = 10.08mm), the antenna behaved similarly to a continuous loop antenna. With 10 to 100 (or more) air gaps, the side section became increasingly transparent at microwave frequencies and the antenna behaved like a C-shaped dipole. With five gaps, the antenna did not behave like a loop nor a C-shaped dipole. These results suggest that the same section of metal *dots* and gaps will behave differently at different frequencies. The effect of replacing the top section of the loop, where the current was a minimum, with metallic *dots* and increasing number of gaps, changed the behavior from a loop to a U-shaped dipole. These results show the potential for developing microwave antennas using groupings of metallic / dielectric nano-metamaterials.

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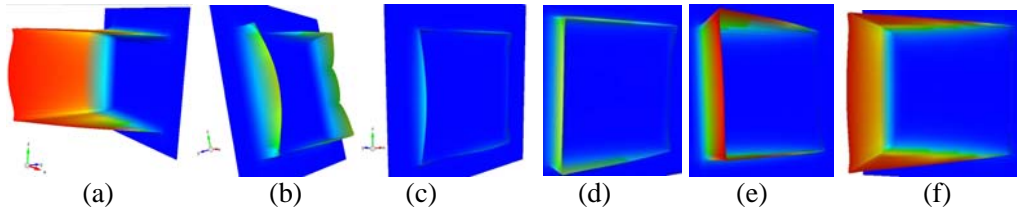


Fig 1. The current at 8GHz including physical extrapolation to aid visualization. (a) No side section, (b) $2 \times 0.01\text{mm}$ gaps, (c) 5 gaps, (d) 10 gaps, (e) 50 gaps, (f) 100 gaps.

- [1] W. G. Whittow and J. C. Vardaxoglou, "Nano-metamaterial Antennas At Microwave Frequencies", Nanometa 2009, Seefeld, Austria, 5-8 January, 2009.