

Branko D. Popović

Univ. of Belgrade, Yugoslavia

Branislav M. Notaros

University of Colorado

Zoya Popović

University of Colorado

Dept. of Electrical and Computer Engineering, Boulder, Colorado 80309-0425, USA

Tel: (303) 492 7077, Fax: (303) 492 5323, E-mail: notaros@colorado.edu

A supergain antenna array is an array confined to an electrically small domain in one plane, but having nevertheless a directive pattern in that plane. For example, a collection of parallel wire antennas centered in one plane and close to each other, if appropriately driven, can produce a directive pattern in that plane. Supergain arrays are usually loosely described as "arrays characterized by large reactive energy". They are also known to be very narrowband. No physical insight into their operation and guidelines for their design seem to exist.

This paper is aimed at presenting and justifying a novel definition of supergain arrays, based on the Poynting vector. Briefly, when several parallel antennas have currents with controlled relative amplitudes and phases, it is possible to produce a spatial Pointing vector distribution such that the Pointing vector in the *near zone* in some directions is small, and in some large. Using this new understanding, it is next demonstrated that a "canonical" supergain mini array can be synthesized in the form of three identical close parallel wire dipoles, driven with three generators. The distance between the dipoles is only few times greater than the dipole wire diameter, and the lengths of the dipoles are about half a wavelength at the lowest frequency. The "forward" gain of such a canonical supergain array made of copper (i.e., with real losses) is between 5 and 9 dBi, and the "backward" gain between -4 and -7 dBi, in a frequency range 1.7-3.5 GHz. It is also explained how such an array, operating in a narrow frequency band, can be approximately realized with a single feed and appropriate reactive loads for achieving the necessary current phasing. An array of such canonical supergain mini arrays can be combined to obtain a much more directive supergain array. As is the case for classical supergain arrays, the proposed arrays are narrowband in the dipole impedances. The analysis in this case was performed by two independent MOM codes, developed by the authors, *WireZeus* and *GEM* (General ElectroMagnetic code).

The next canonical case considered is a bow-tie mini supergain array, consisting of three flat, parallel, very closely spaced (less than  $0.01 \lambda$ ) bow-tie dipoles, about one half wavelength long at the lowest frequency. If the dipoles are driven separately, the array can be synthesized with a "forward" gain between 6 and 11 dBi, and a "backward" between -2 and -7 dBi, in a frequency range 1.0-2.3 GHz. The array is again very narrowband in the dipole impedances. A specific feed system, consisting of a single generator feeding the three bow-tie dipoles and appropriate phasing reactive loadings at the driving point of dipoles, can be designed to make this canonical mini supergain array operate in approximately the same way with a single feed (instead of three separate feeds), although in only a narrow frequency band. The analysis in this case is performed by *GEM*.

Many other canonical mini supergain arrays are possible, the combination of which results in large array gains in a given plane in spite of very small electrical size of the array in that plane.