# Behavior of Pattern and/or Frequency Reconfigurable Antennas in Small Arrays

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Novel antenna designs capable of reconfiguring their radiation characteristics and/or frequency responses will play an increasingly important role in both civil and military sectors in response to the demanding tasks presented by high speed data communication. Individually reconfigurable antenna elements can be integrated onto devices or into arrays to meet these challenges. The switching of simple tuning elements within these individual antennas provides variable directionality and multi-band operation that can greatly enhance the overall effectiveness of the system. In both single element and array settings, the ability to alter directionality as well as frequency selectivity can generate extra degrees of freedom to better enable data intensive applications as well as operation in harsh or noisy electromagnetic environments. These new degrees of freedom can also lead to a decrease in the peripheral electronics needed to achieve array beam steering, as well as provide reductions in spatial dimensions from the use of a single antenna for multi-band operation.

This study reports on the theory and measurement of small arrays consisting of novel pattern and/or frequency reconfigurable antennas. The antenna being considered (G.H. Huff, J. Feng, S. Zhang, and J.T. Bernhard, *IEEE Microwave and Wireless Components Letters*, **2**, 2003) is a single-turn Archimedean square microstrip spiral capable of both broadside and endfire radiation within two well-spaced frequency bands. To characterize the functionality of an array comprised of this new breed of antenna, parameters such as the array spacing are examined to determine the benefits and limitations arising from the pattern reconfigurability and relative spacing of the operating frequency bands. Along with factors surrounding array spacing and beamforming constraints, operation of the individual antenna elements will be studied to determine the effects of spacing and orientation on radiation and impedance bandwidths, as well as the inter-element coupling. Electromagnetic visibility studies on the packaging and integration of reconfigurable antennas have shown a strong dependence on the performance of the device based on its integration position. Therefore, in addition to parameters directly related to the antenna, the possible effects from packaging will also be considered. Measurements of the radiation characteristics, impedance, 2:1 VSWR bandwidth, inter-element coupling, and array gain will be provided and compared with theoretical results.