

# REPORT DOCUMENTATION PAGE

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**PROGRESS AND PLANS FOR NAVCIITI PROGRAM ELEMENT 1.2.2,  
INCLUDING DELIVERABLES 8 AND 9:  
Wideband Antenna Research**

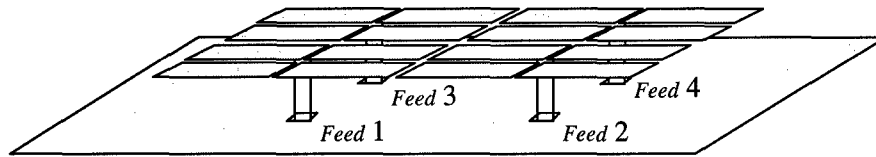
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[www.ee.vt.edu/antenna](http://www.ee.vt.edu/antenna)

**1. Research Progress For the Three Quarters**

Several activities were initiated and completed during the first 270 days. First, the Antenna Group completed detailed simulation runs of the Foursquare radiating element using an in-house computer code based on finite-difference time-domain (FDTD) techniques. The Foursquare element was selected because of its low profile and wide bandwidth. It is ideal for use in phased arrays on ships and aircraft. The FDTD code was used to calculate input impedance of a single Foursquare element. The calculated values compare very well with measured results. The FDTD code was also used to calculate the E- and H-plane far-field patterns of the Foursquare antenna. The calculated results compare well with the measured patterns. The Foursquare has similar far-field patterns in both the E- and H-planes. The gain loss is 5 dB or less for 45° of scan in any direction off broadside, making the element ideal for phased array applications. In addition, the far-field patterns are nearly constant in shape over the operating bandwidth of the Foursquare. These results were reported earlier.

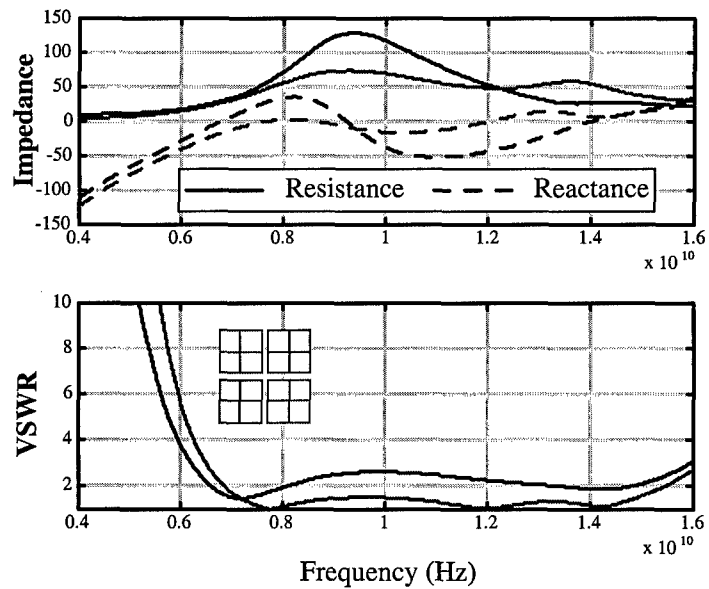
Recent work has focused on optimizing the performance of the Foursquare for two purposes: widening the element bandwidth and investigating array performance. Figure 1 shows a four-element array of Foursquare antennas in a two-by-two configuration. This is a basic array and allows examination of the effects of element performance when embedded in an array. We examined the input impedance of Foursquare antennas in this array environment. Simulations showed that bandwidth is actually increased over single isolated element performance. The results are shown in Figure 2 for input impedance. The upper (lower) of the two curves in the VSWR plot correspond to the upper left and lower right (upper right and lower left) elements. The bandwidth increased from 45 % to 73 %. This makes the Foursquare antenna very valuable as an element in a phased array. An additional feature of the Foursquare is its small electrical size (0.27 wavelength at the low end of the frequency band), permitting tight inter-element spaced in phased arrays.

We also investigated the use of calculated mutual impedance values for evaluation of impedance performance during phase scanning. The technique was shown to be accurate. This approach greatly simplifies array analysis.



BW=73%	frequency (GHz)	Element Spacing
$f_L$	7.0	$0.27\lambda$
$f_H$	15.0	$0.57\lambda$

**Figure 1** Geometry of a four-element array of Foursquare antennas in a two-by-two configuration.



**Figure 2** Calculated input impedance and VSWR for the array of Fig. 1.

## **2. Equipment Acquisitions**

Task 1.2.2 includes money for a near field scanner and associated equipment to measure wideband antennas. In addition, funds were provided for software to simulate wideband antennas. During the first three quarters, software and hardware was ordered. Orders were placed for two large commercial packages (IE3D and Fidelity), which have been received and are being used to analyze antennas. Purchase orders have been placed with Antcom for the near field scanner and with Hewlett Packard for the vector network analyzer.

## **3. Publications**

C. G. Buxton, W. L. Stutzman, and J. R. Nealy, "Analysis of a New Wideband Printed Antenna Element (the Foursquare) Using FDTD Techniques." URSI National Radio Science Meeting (Atlanta), June 1998.

C. Buxton, W. Stutzman, J. Nealy, "Implementation of the Foursquare antenna in broadband arrays," URSI National Radio Science Meeting (Orlando, FL), July 1999.