Experimental Study of Wall Effects on the Performance of a Dual Polarized, Broadband Array of Stacked E-Patch Elements in Through-Wall Imaging Applications

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Recent interests in radar applications such as through-the-wall microwave imaging (TWMI) and ground-penetrating radars have prompted research in the areas of portable, low-profile antenna array systems with relatively wide bandwidths. In general, these systems are designed for free-space performance since the materials for which the system is required to "see" beyond, or penetrate, may differ for various applications, or may not be known a priori. In addition, many materials may possess polarization dependencies, such as concrete blocks with metallic reinforcing bars or sheetrock walls with wooden studs. In this work we examine the effects of various types of walls on the performance of an 8x2-element antenna array with dual polarization capability. Each antenna within the array is a modified version of the E-patch antenna [Yang, F. et al, "Wide-band E-shaped patch antennas for wireless communications," IEEE Tran. on Ant & Prop., July 2001] and consists of two optimized stacked, E-patch elements with linear polarization, which provides an approximately 40% VSWR < 2 bandwidth [Komanduri, V. R., et al, "Low-profile array design considerations for through-the-wall microwave imaging applications," IEEE AP-S Int. Symp. , July 2005]. A collinear arrangement of 8 elements is utilized such that beam forming or other post-processing, including multiple angles of incidence, can be utilized. A second row of collinear elements is utilized with an orthogonal polarization, such that polarization dependencies can be studied as well as obtaining a collection of co-pol and cross-pol information, which is needed in the application of polarimetric-based techniques. The fabricated dual-stacked E-patch array is shown in Figure 1. For an individual antenna element, it has been previously shown that, when placed within close proximity of a wall, the antenna performance, including its impedance match, is affected and that these effects are highly dependant on the wall material as well as the wall-to-antenna distance (i.e., "stand-off distance") [Komanduri, et al.]. For illustration, the return loss of the 4th element (top row) is shown for the free-space case and when placed 3 cm (0.25 λ at the center frequency) in front of a cement wall. In this work, we will present more detailed results on the effect of various walls as they apply to antenna arrays taking into account polarization dependencies, cross and co-pol effects, and mutual coupling and polarization isolation between array elements.

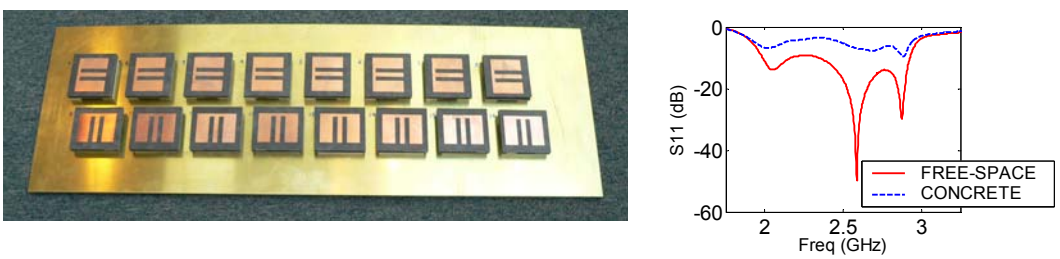

Fig. 1: 8x2 Dual Polarized Array of Stacked E-Patch Antennas for Experimental Investigation of Various Wall Effects in TWMI, Free-Space Return Loss (dB) and Return Loss near a Concrete Wall