Antenna Array for a Radar Using MEMs PZT Phase Shifters

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The clash between stealth and enemy detection is an on going battle that has motivated much of the technological advancements in radar systems. Historically, most of this effort has been geared toward engineering large, expensive, industrial sized radars that are immobile. However, for the soldier in the battlefield, these types of radars become ineffective when equipment must be easily transported on a frequent basis. Resolving this problem has spawned a new generation of mobile radar systems that are compact, light-weight and low-cost. This paper discusses a novel antenna array for a radar that achieves a scan angle of 90 degrees with a beam width of 9 degrees in the azimuth plane and 18 degrees in the elevation plane. The radiating aperture is comprised of a 4 x 8 microstrip rectangular patch array. The array is excited through a complex feed network operating at a center frequency of 9.1375 GHz with a bandwidth of 75 MHz. Electric scanning is accomplished by PZT MEMs phase shifters developed by ARL. The integration of the antenna array, feed network and active components (MEMs phase shifters) poses various problems when trying to develop an optimal electrically scanning array.

ARL's MEMs phase shifters are fabricated on a Silicon wafer (dielectric constant = 11.8) that is approximately 20 mils in thickness. Additionally, the topology of the device uses co-planar waveguide as the optimal technique for the RF input and output ports. As such, the feed network for the array should be resident on a dielectric material of the same thickness and permittivity. This will ensure that the dimensions of the transmission lines are the same order of magnitude throughout the feed structure. However, being compelled to use a thin feed layer with high permittivity to accommodate the MEMs phase shifters results in a degradation of radiation efficiency for a patch antenna fed on this layer. For best efficiency, the patch antenna will reside on a thicker material (h = 0.02 – 0.04 lambda) with lower permittivity. The feed mechanism will exploit a coupling aperture excited through a microstrip line. This necessitates the need for a microstrip to co-planar waveguide transition on the feed layer.

Innovative microstrip to co-planar waveguide transitions have been reported in various literatures. Following the methodology of (G. Zheng, J. Papapolymerou, and M. Tentzeris, *IEEE Microwave and Wireless Components Letters*, pp. 544-546, December 2003.), a microstrip to co-planar waveguide to microstrip transition has been simulated and measured with good results. A key aspect to attaining low-loss transitions are the placement of via structures coupling the co-planar finite grounds to the reference ground plane. The results will be presented and are found to be in excellent agreement between simulation and measurement. The completed feed structure will be presented and discussed. We are confident that this architecture and feed methodology will produce a sufficient, low-cost antenna array for use in compact radar.