Low-Cost, Multi-beam Antenna System for Direction Finding

Matthew J. Berry*[1], Roy Williams[2], Daniel Ramierz[2], and Russell P. Jedlicka[1]
[1] Klipsch School of Electrical and Computer Engineering, New Mexico State University, Las Cruces NM 88003 {matberry, rjedlick} @nmsu.edu
[2] TMC Design Corporation, Las Cruces, NM 88012, http://www.TMCDesign.com

Narrow beams scanned or switched over a wide coverage region can be used in many applications; one example is direction finding. The cost of a phased array approach to scan the beam was prohibitive, thus more affordable techniques were investigated. Rotman lens configurations have been shown to be low cost alternatives to phased arrays and provide satisfactory performance when the angular discrimination requirement is not too tight. Here we present a Rotman lens/microstrip patch configuration wherein the use of low-cost materials is compensated through the use of integrated amplifiers in this receive-only application. The complete design produces 100 beams simultaneously; direction finding is accomplished through a simple switching scheme. Specifically, this paper outlines the design, fabrication and test of one-quarter of the entire system; that is, a prototype unit of 24 broad- band microstrip patches interconnected with a Rotman lens to form 25 simultaneous beams spaced 3.75° across the +/- 45° region. The design was required to work over a 110 MHz band centered upon 2.25 GHz. The core feature of the design is that it is implemented using low cost, readily available materials. Specifically, FR-4 is used in the design of a four wavelength focal distance Rotman lens and that same material is used in conjunction with off-the-shelf polypropylene to produce the microstrip elements.

The relatively broadband microstrip elements consisted of three layers; 0.125 inch thick polypropylene sandwiched between two 0.060 inch thick FR-4 boards. A driven patch was etched on the lower FR-4 board, a second parasitic patch was included on the inside surface of the upper FR-4 board, which provided an integrated radome to protect the unit. This configuration yielded a VSWR < 2 bandwidth of 280 MHz centered around 2.25 GHz. This was more than twice the required bandwidth of 110 MHz thus providing margin to accommodate tolerances in the material properties as well as errors during the fabrication process. The radiation efficiency of the individual elements was satisfactory producing a nominal gain of 7 dBi across the band of interest.

The 24-element linear array with 0.55λ spacing in conjunction the Rotman lens provided a nominal 3 dB beamwidth of 5.25° for the 25 beams; the crossovers were less than 1.5 dB providing greater than 20.5 dBi coverage across the +/- 45° scan region. The directivity of the configuration was 20 dBi so the integrated amplifiers more than compensated for the inherent loss of the cables, lens and switches (calculated to be about 20 dB) of the low-cost materials used in the prototype. Complete results will be presented.