ABSTRACT

This dissertation presents the design of an octic-style optical true-time delay cell and a proof-of-concept experimental demonstration of a subset of it. The octic cell is a "polynomial" cell, which is one of two classes of true time delay cells being designed by our group. The octic cell is designed to produce a maximum of 6399 sequential delays (or more than 12 bits of delay) in 17 bounces for a given light beam through the apparatus with a unit delay of 3ps. The largest delay in the octic cell is 19.197 ns. We use both glass blocks for small delays and lens trains for the longer delays. The octic cell is designed to use a micro-electrical mechanical systems or MEMS device, which consists of tip/tilt micromirror array to direct the light beams in various directions on each bounce. White cells of different lengths are set up in each of these different directions. By forcing the light to travel the different lengths, we are able to obtain different delays.

For our proof-of-concept experiment, we set up only six of the ten arms of the octic cell (arms C, D, J and K and the null arms A and B) as a planar quartic cell.

With the use of a Calient® MEMS device, we were able to demonstrate switching of light between the different arms by just tipping the right micro mirrors. The experimental results also proved that it is possible to use glass blocks as delays elements for short delays with lens trains for longer delays. We were able to measure delays with an accuracy of 0.5ps with a E8320B Network Analyzer.

In this dissertation, the architecture of the cell is described along with a discussion of how to select the mirror progressions, how the optics were chosen including a detailed description of the design technique used to determine the focal lengths, positions and diameters of the optics of the cell. A detailed step-by-step description of the alignment procedure used in the setting up of the quartic cell has also been described in the dissertation. Finally, a simulation of the quartic cell in OSLO showed that the quartic cell using a single field lens tends to suffer from spherical aberrations. Further simulations showed that by using separate field lenses we are able to rid the cell of spherical aberrations.