Simulation study of photonic true time-delay techniques using waveguide Bragg grating prism

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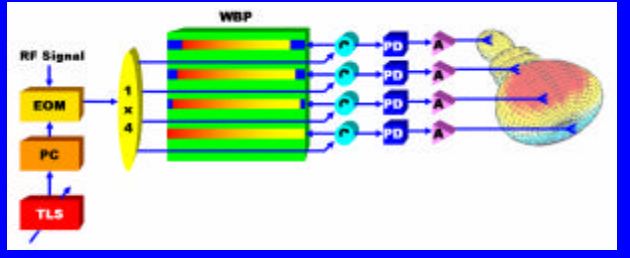
1. Introduction

True-time delay (TTD) for phased array antennas has been intensively investigated in the past . Optical techniques for TTD offer several advantages such as the absence of the beam squint problem, low loss, small size, lightweight and immunity to electromagnetic interference (EMI). Several techniques for a photonic true-time-delay system have evolved in the recent years and the use of a Bragg grating prism as a delay line application is found to be a promising approach.

2. System overview



TLS : Tunable Laser Source

PC : Polarization Controller

EOM : Electrooptic Modulator

1x4 : 1 by 4 power splitter

WBP : Waveguide Bragg Prism

PD : Photodetector

A : RF Amplifier

3. Theory

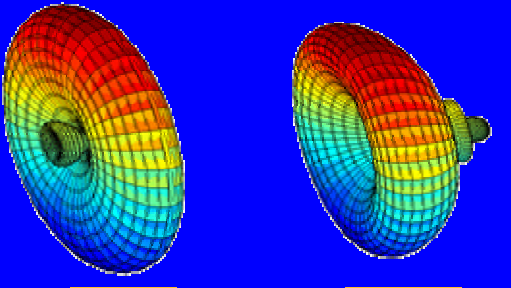
Phased Array Antennas

The normalized array factor of an *N*-element phased array with a uniform spacing of d_{elem} between its elements is given by

$$af(y) = \left| \frac{\sin\left(Ny/2\right)}{N\sin\left(y/2\right)} \right| \quad \text{and}$$

$$y(q) = kd_{elem}\sin q + b$$

Array factor



$\Delta t = 0\,ps$ $\Delta t = 10\,ps$

Waveguide Bragg Gratings

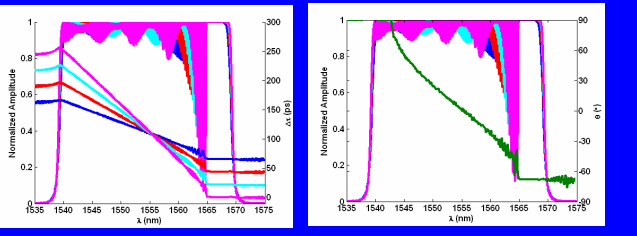
For the simulation of Bragg gratings, the Transfer Matrix Method (TMM) has been used.

$$\begin{bmatrix} A_L^+ \\ B_L^+ \end{bmatrix} = TM \ldots T3 \;\; T2 \;\; T1 \begin{bmatrix} A_0^+ \\ B_0^+ \end{bmatrix}$$

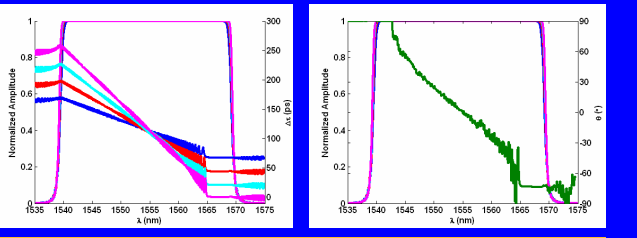
Theoretical presentation

4. Results

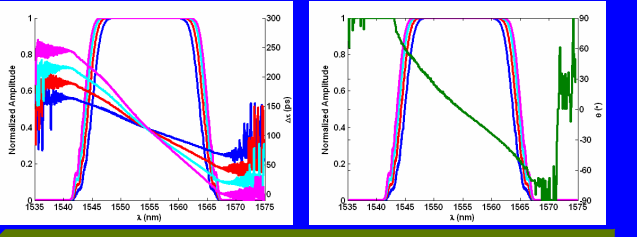
Unapodized gratings - DSB Modulation



Unapodized gratings - SSB Modulation



Gaussian Apodization - SSB Modulation



5. Conclusion

- Simulation results of a photonic TTD beamforming module have been presented
- Different modulation techniques have been considered
- SSB modulation was shown to be well suited for broadband operation
- The effects of apodization on the system performances have been studied