Multi-layered Microstrip Line with an Electronically Controlled Phase-Shifter

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Abstract

A microstrip is one of the most commonly used transmission lines. The design procedure for parameters such as characteristic impedance, effective dielectric constant, and the propagation constant is well defined in terms of w/h and e_r. Since the propagation constant is proportional to the effective dielectric constant, a microstrip transmission line with an electronically controlled propagation constant can be achieved if w/h, the dielectric constant, or the area of the dielectric material where the signal is guided can be electronically proscribed.

A silicon modulator has been realized by introducing impurities into a strip of N-type silicon to produce a p^+ region in the middle and n^+ region on each side (C-S Shin and R. Nevels, "Electronically Controllable Transmission Line Design for Traveling Wave Array Antenna Feed Network," 2002 USNC/URSI National Radio Science Meeting, San Antonio, Texas June16-21, 2002). Figure 1 shows the cross sectional view of a proposed multi-layered microstrip line. In this configuration, adjusting the external dc bias between the doped regions controls the conductivity of the silicon. An increase in the bias voltage causes an effective upward and lateral growth in the conductive region, which is seen as an increase in the width (w) of the upper conducting plate by the wave propagating in the microstrip line, thus producing a change in the phase constant of the guided wave. Depending on the dielectric constant of the substrate (e_{r1}) compared to that of the silicon (e_{r2}), the effective dielectric constant increases or decreases, as the conductive region (w) becomes wider.

In this paper we will present results for the phase shift obtained with the silicon controlled microstrip line phase-shifter pictured in the figure below. It will be shown that the silicon controlled phase shifter accomplishes electronic scanning of an eight-element aperture coupled microstrip patch antenna array. Our results are compared to those obtained with an Ansoft HFSS 3D simulation with a width equal to the average effective width of the biased silicon strip.

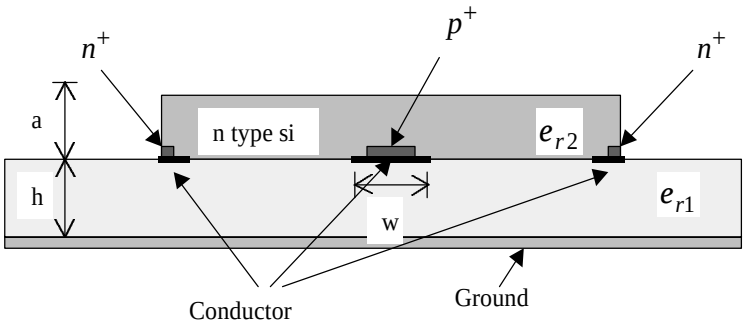

Figure 1. Cross sectional view of a multi-layered microstrip line with electronically controlled phase constant.