Schiffman Phase Shifter Results Summary

Ideal

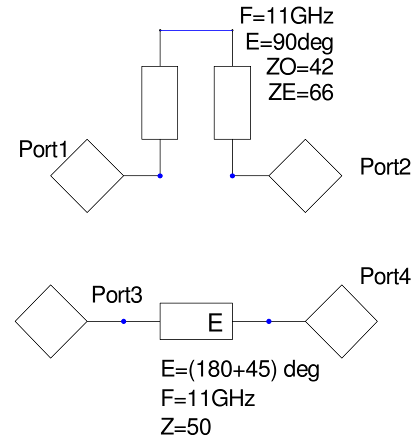

Figure 1: Schematic View of Ideal Schiffman Phase Shifter

- The ideal model was developed using Schiffman's original paper published in the IEEE Microwave Techniques Journal.
  B.M. Schiffman, "A New Class of Broadband Microwave 90-Degree Phase Shifters," IRE Trans. Microwave Theory Tech., vol. MTT-6, no. 4, pp.232-237.
- To obtain the even and odd mode impedances that will yield the desired phase outcome were obtained by starting with a base model using ideal components, where $Z_{oe}=Z_{oo}=50\Omega$ with an electrical length of 90° for each coupled section. Adjusting the even and odd mode impedances until a flat phase difference between 10 and 12GHz is obtained, keeping in mind that $Z_{oe}>Z_{oo}$, results in $Z_{oe}=66\Omega$ and $Z_{oo}=42\Omega$.
- The Schiffman phase shifter is a differential phase shifter, in that the resulting phase is compared to a reference line. For a 45° phase shift, the reference line is 180° (total electrical length of the phase shifter) plus a 45° extra reference length.
- The results are: Over 10 – 12GHz, the phase difference between the reference line and the Schiffman phase shifter is 45° flat, with a return loss of -34.88dB at worst over the bandwidth.

Physical

- The even and odd mode impedance values obtained from the ideal model are applied to a model with includes the 121.5 mil substrate.
- The phase difference between the Schiffman phase shifter and the reference line are compared between 10GHz and 12GHz. There is a slight change in the return loss, with -31.07dB at worst, and no significant change in the phase difference (flat at 45°).
- The Designer model yields widths and lengths for the copper traces that will be applied to the HFSS model

HFSS

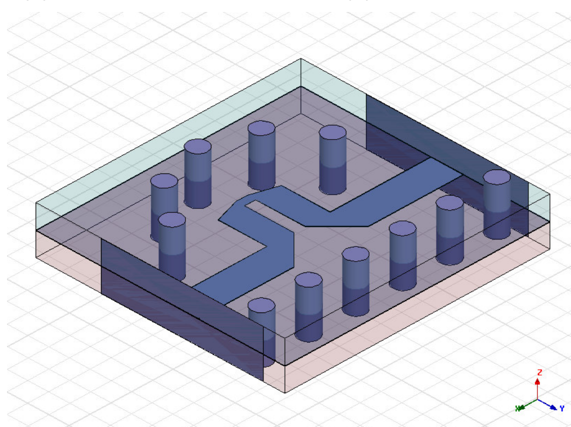

Figure 2: Schiffman phase shifter model in HFSS, with vias.

- The Schiffman phase shifter is designed primarily in HFSS. To speed up the analysis process, the reference line is not included in simulation since straight transmission line characteristics are well known and standard.
- The Designer model gives the length and width of the coupled lines. Port lines and the strip connecting the coupled lines is manually added and designed in HFSS. Chamfering was utilized to reduce reflection.
- The result was a phase shift centered at 45° ±2° and with a return loss of -15.69dB at worst over the bandwidth. The phase difference changed from the Designer model slightly, and the greatest change was seen in the reflection due to the additional copper.

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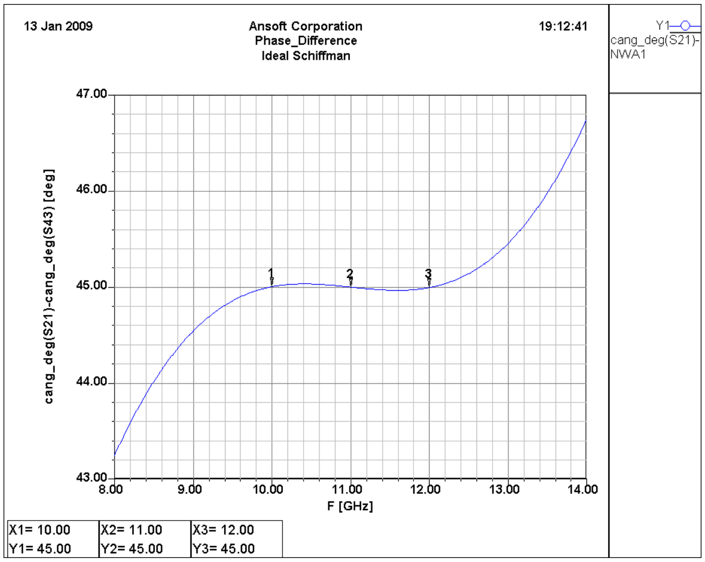


Figure 3: Ideal model phase difference, markers showing 45° at 10GHz, 11GHz, and 12GHz.

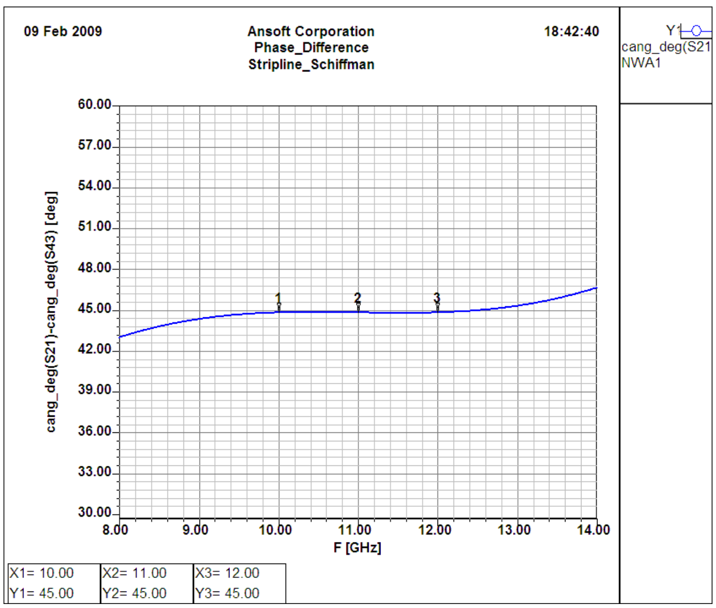
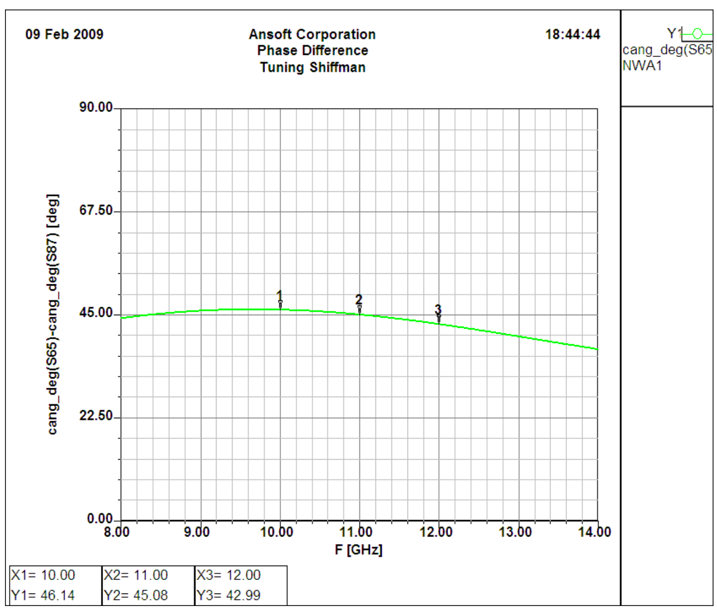


Figure 4: Physical Designer model phase difference, markers showing 45° at 10GHz, 11GHz, and 12GHz.

Figure 5: HFSS model phase difference, with markers showing 46.14° at 10GHz, 45.08° at 11GHz, and 42.99° at 12GHz.



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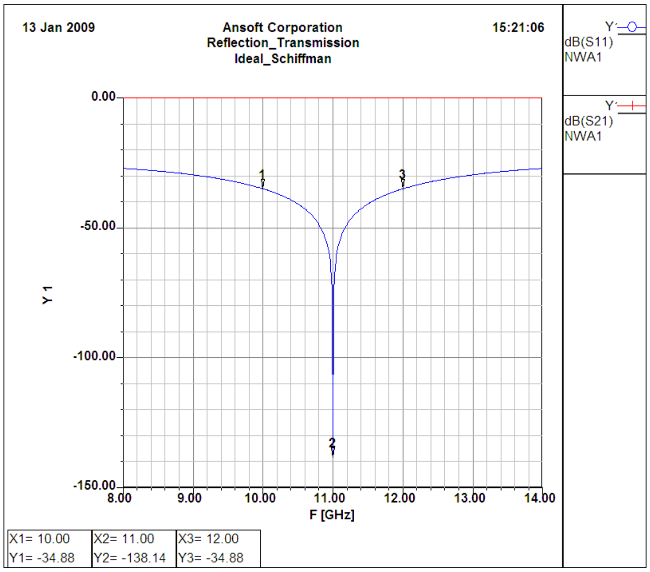

Figure 6: Ideal model reflection. Markers at 11GHz (-34.88dB), 12GHz (-138.14dB), and 12GHz (-34.88dB).

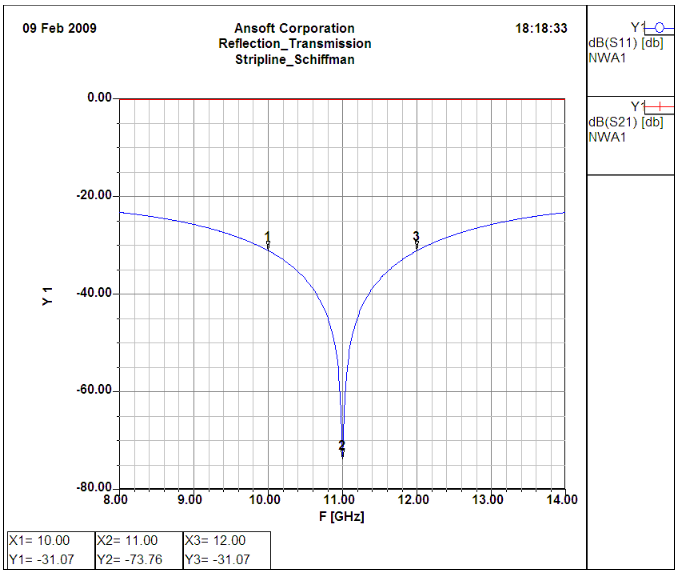

Figure 7: Physical Designer model reflection. Markers at 11GHz (-31.07dB), 12GHz (-73.76dB), and 12GHz (-31.07dB).

Figure 8: HFSS model reflection. Markers at 11GHz (-15.69dB), 12GHz (-16.96dB), and 12GHz (-18.25dB).