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STRIPLINE FEED NETWORKS FOR RECONFIGURABLE PATCH ANTENNAS

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Reconfigurable patch antennas have drawn a lot of attention recently as a paradigm for generating several different antenna array operating modes with a single reconfigurable antenna aperture. Such "operating modes" may consist of various operating frequency bands (e.g. L-band and X-band), polarizations, beampatterns or nulls. Different technologies have been proposed as methods of switching the array elements to the various configurations including MEMS switches, photonic switches, and solid-state switches, including FET switches and PIN diodes. What is often neglected in the reconfigurable antenna design, however, is a practical method of feeding the antenna elements. In this paper, we discuss stripline feed networks that may be used to feed reconfigurable patch antennas, independent of the switching technology used to reconfigure the elements. Simulation and measurement results are presented for Wilkinson power dividers used to distribute the RF energy in a corporate feed network. Blind via transitions are used to transition energy from the feed network to the radiating elements, and results are presented for various cases considered.

1. Introduction

Reconfigurable antennas have gained a lot of attention recently [1-3] as a method of obtaining several operating modes out of a single antenna aperture. Such operating modes may consist of different frequency bands, polarizations, beampatterns, nulls, etc. for which the antenna may be configured using switching elements. Different technologies have been proposed as methods of switching the array elements to the various configurations including MEMS switches, photonic switches, and solid-state switches, including FET switches and PIN diodes. What is often neglected in the reconfigurable antenna design, however, is a practical method of feeding the antenna elements. In this paper, we discuss stripline feed networks that may be used to feed reconfigurable patch antennas, independent of the switching technology used to reconfigure the elements.

Last year [1], we presented simulations and prototype measurement results for a 3x3 array of microstrip patch elements that may be configured to resonate at either L-band or X-band. We also presented a general adaptive reconfigurable feed (GARF) methodology whereby each array configuration would be fed independently using a separate stripline corporate feed. In the current paper, we present simulation and measurement results for stripline Wilkinson power dividers and blind via transitions that may be used both as a basis for the corporate feed network and to transition between the multiple PCB layers.

2. Wilkinson Power Divider Results

An X-band Wilkinson power divider was designed using HFSS, fabricated and tested. Figure 1 shows the CAD model used for HFSS. A termination resistor is shunted across the output arms to reduce mismatch reflections. The device was fabricated using layers of 0.030 inch Rogers 5880. Figures 2 and 3 show the simulation and measured data at X-band. The performance is excellent. A 1-to-4 power divider has also been successfully built and tested at X-band, and will be presented in the oral presentation.

3. Blind Via Vertical Transition Results

Blind via vertical transitions at X-band were also designed, built and tested. Figure 4 shows the HFSS model, and Figure 5 defines the various components of the design. The design started using the coaxial equation relating the center via pin and relief opening to the impedance

$$Zo= [\ 138 / \mathrm{sqrt}(\ ?_r)\ ]\ \log_{10} (R_r / R_v) \qquad (1)$$

where $?_r$ is the relative permittivity of the substrate, R_r is the relief hole radius, and R_v is the via hole radius. This allows us to obtain a course estimates of the relief hole for a particular via size. Next, the design was fine-tuned using HFSS.

The following optimized parameters were obtained from the HFSS simulations:

Thru via diameter= 0.020 in
Relief diameter= 0.070 in
Mode suppression pin diameter= 0.120 in

Figure 6 shows the HFSS results on a Smith chart. Figure 7 shows the corresponding measured data on the Smith Chart. Figure 8 shows the return loss (S11) and insertion loss (S22). The measured data has an insertion loss of about 0.6 dB and an input match of –18.2 dB. Overall, the performance is very good.

4. Conclusions

Wilkinson power dividers and blind via transitions were designed, fabricated and tested for application to reconfigurable patch antennas using stripline technology. The examples presented here were for X-band. Using the GARF feed methodology, a separate feed mechanism uncoupled through switches would be used for the L-band configuration. A similar design procedure could be used to design the L-band transitions and power splitters.

Acknowledgement

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References

[1] W. H. Weedon, W. J. Payne, G. M. Rebeiz and J. S. Herd and M. Champion, "MEMS-Switched reconfigurable multi-band antenna: design and modeling," 1999 Antenna Application Symposium, Monticello, IL, Sept. 15-17, 1999.

[2] DARPA RECAP workshop, McLean, VA Dec. 7-9, 1999 (Various papers).

[3] J. K. Smith, Organizer, Session on "Reconfigurable Aperture Antennas", IEEE AP-S International Symposium, Salt Lake City, UT, July 16-21, 2000 (Various papers).

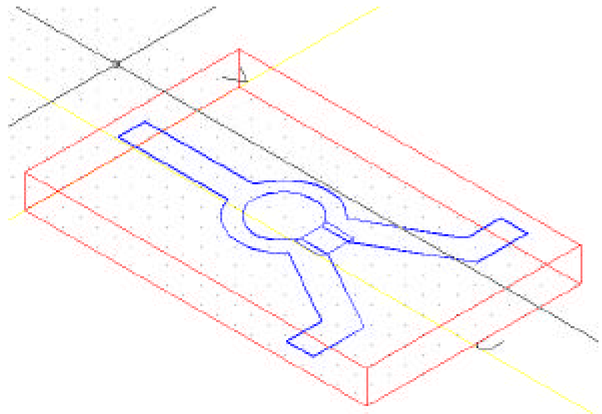

Figure 1: HFSS model for Wilkinson power divider.

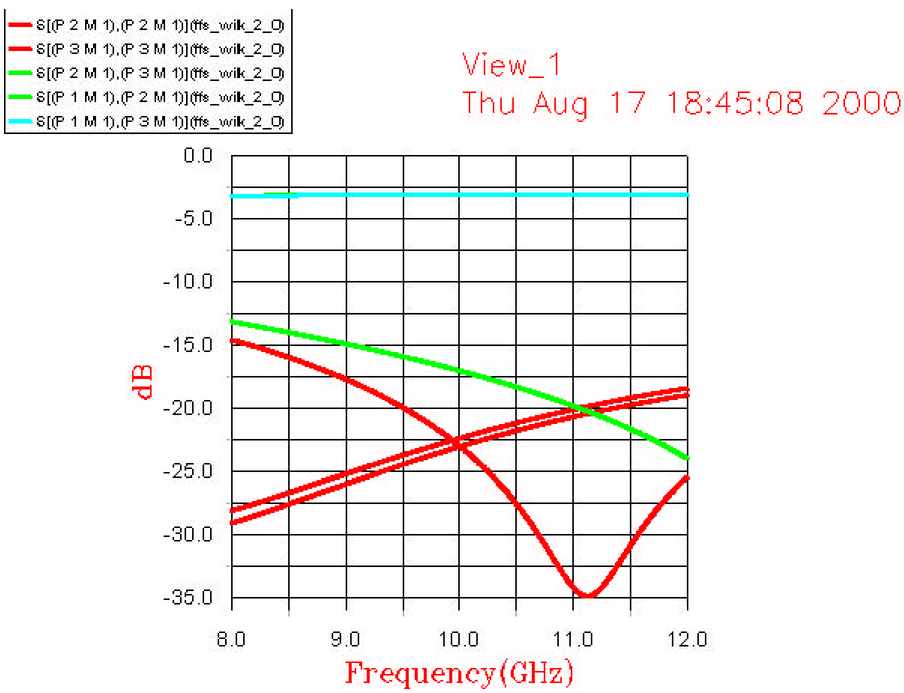

Figure 2: Simulation results for Wilkinson power divider.

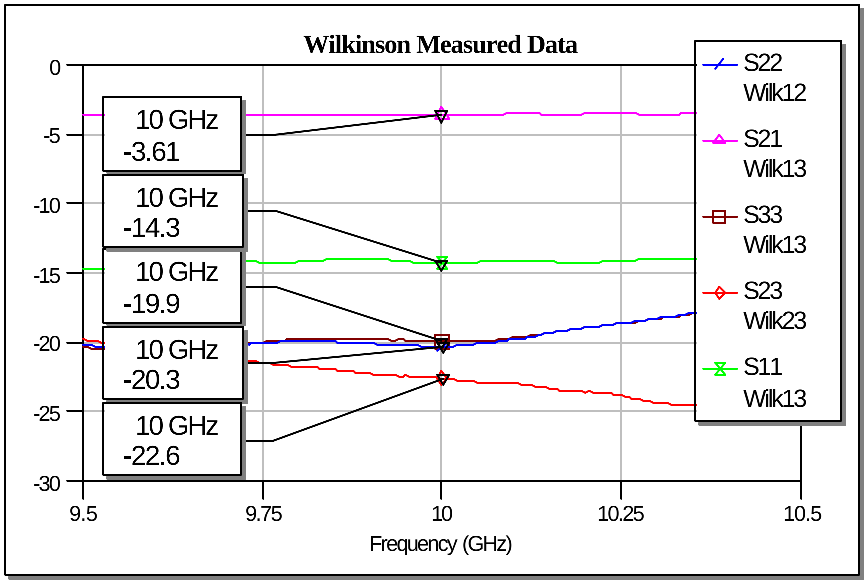

Figure 3: Measured data for Wilkinson power divider.

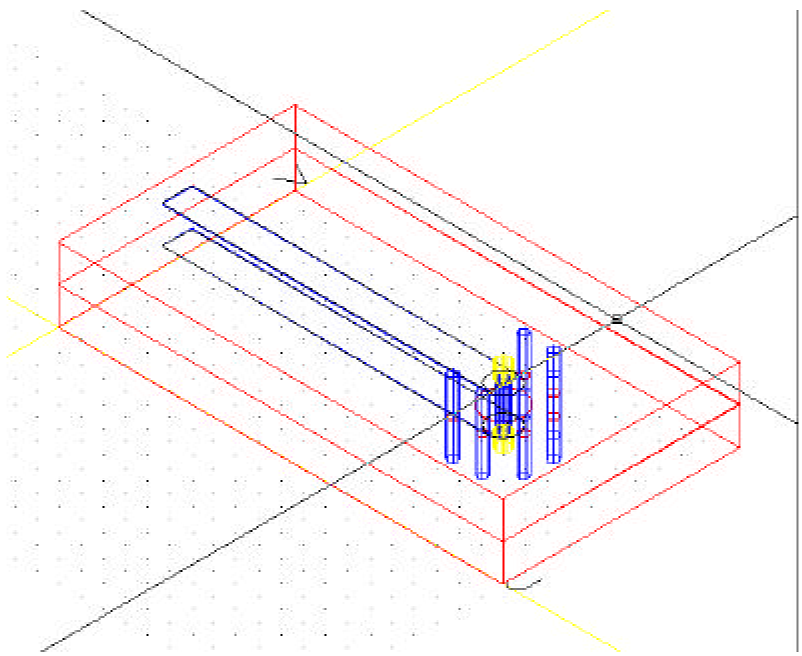

Figure 4: HFSS model of vertical transition

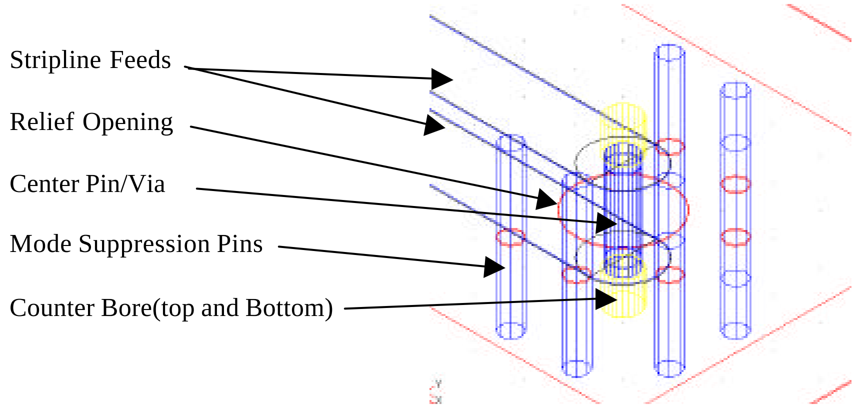

Figure 5: Definition of components in blind via vertical transition.

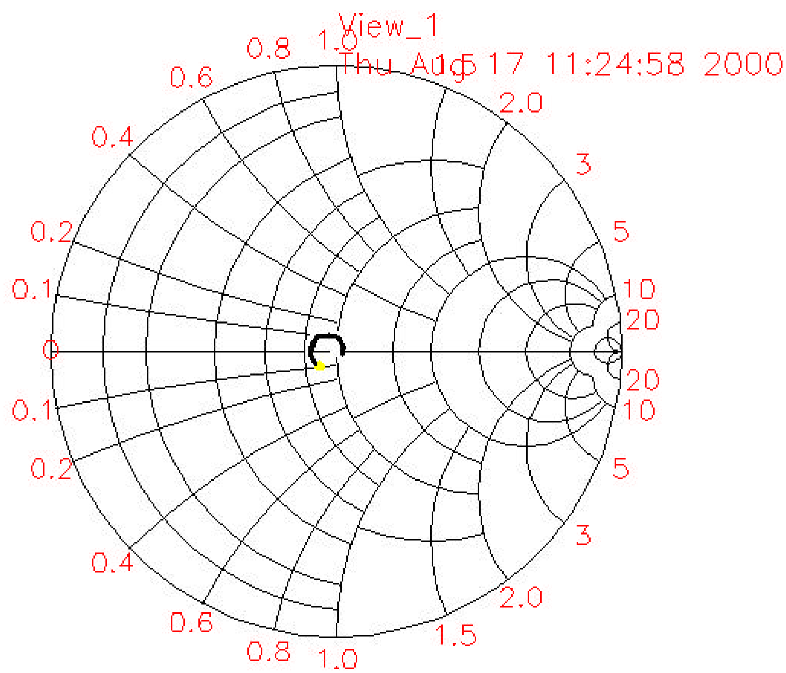

Figure 6: HFFS simulation results for blind via vertical transition.

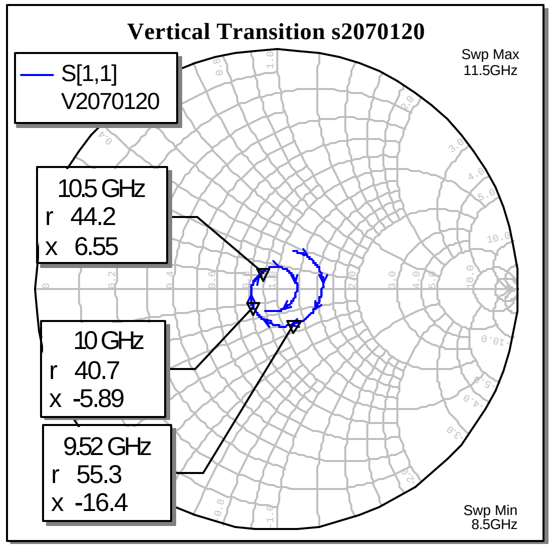

Figure 7: Measured Smith Chart results for blind via vertical transition.

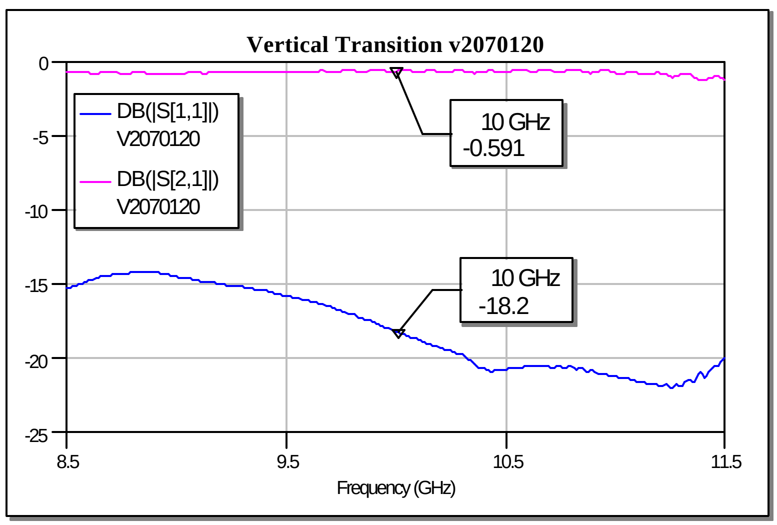

Figure 8: Measured return loss (S11) and insertion loss (S21) results for blind via vertical transition.