01 Jun 1987

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Recommended Citation

J. L. Drewniak and P. E. Mayes, "Power Division by Element Design in a Circularly Polarized, Series-fed Array," *Proceedings of the Antennas and Propagation Society International Symposium (1987, Blacksburg, VA)*, pp. 798-801, Institute of Electrical and Electronics Engineers (IEEE), Jun 1987.
The definitive version is available at https://doi.org/10.1109/APS.1987.1149931

POWER DIVISION BY ELEMENT DESIGN IN A CIRCULARLY POLARIZED, SERIES-FED ARRAY

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INTRODUCTION

Microstrip patch elements are widely used in applications which require a low-profile array over a ground plane. For bandwidths of more than a few percent phase-shifters and feed lines may be required to obtain circular polarization (CP) from patch antennas. In addition to the components required to produce CP, a power division network is often used to yield a desired array excitation. Introduced here is a simple array of wideband, low-profile CP elements which requires no phase-shifters and only sufficient feed lines for the interconnection of the elements in a series-fed array. Furthermore, a complicated network is not required to obtain the excitation coefficients for a specified design. Rather, the excitation coefficients can be realized by utilizing the geometric parameters of the individual elements.

ARRAY DESIGN

The array element is a probe-fed, 50-ohm, CP, two-port, traveling-wave antenna. A top view of these antennas in a six-element array is shown in Figure 1. The magnitude of S_{21} for each two-port is determined by the arm width, the ratio of outer to inner diameter. This parameter then provides a simple means for the realization of a specified set of excitation coefficients. An experimental study to characterize these elements was conducted from which the geometric parameters of the six-element array were directly determined with no further experimentation.

The array was based upon Chebyshev design with a -20 dB sidelobe level to operate at 2.2 GHz. The theoretical excitation coefficients for these specifications are given at the bottom of Figure 1. The array was fed at the center from a matched power divider and the elements were series connected with the proper lengths of coaxial line to yield in-phase excitation at 2.2 GHz. The excitation coefficient for each element was determined by the magnitude of S_{21} for the preceding element. The geometry of each element was then selected to yield the desired $|S_{21}|$. The excitation coefficients as found from two-port measurements of the individual elements of the array are also shown in Figure 1. These numbers would represent the actual coefficients if there were no mutual coupling and no cable losses in the array. The elements were spaced rather far apart in order to reduce the mutual as much as feasible.

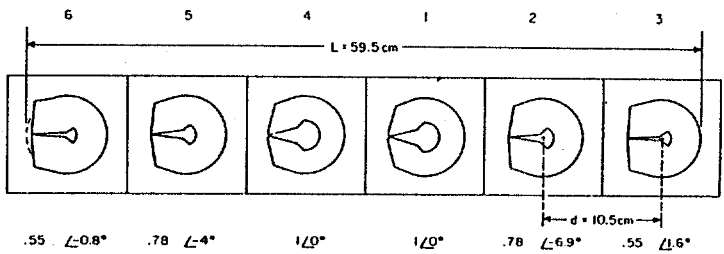
ARRAY PERFORMANCE

The input impedance of the array for the band from 2.0 to 3.0 GHz is shown in Figure 2. At the design frequency the return loss is -26 dB. The return loss of the matched power divider was less than -35 dB over this range. Since the impedance is typical of the performance of the individual elements, these results were indicative of the low coupling present among the elements of the array. Internal scattering in the feed lines is very small because each element is well-matched to the cable and the last element on each side of the array is terminated with a matched load. Thirty percent of the input power was left at the ends of the array. Further studies have produced individual elements capable of radiating 70% of the input power so that power gain achieved with this first prototype could be improved.

Shown in Figure 3 is a radiation pattern in the plane of the array as measured with a spinning dipole. The axial ratio is 1.5 dB on the main beam maximum with good CP over the entire main beam. The CP of the elements used was best at 2.05 GHz. As a result the array pattern had a lower axial ratio (1.0 dB) at 2.1 GHz. The measured sidelobe level of -18 dB is considered to be in very good agreement with the design value since no adjustments were made for mutual coupling or loss in the feed lines.

CONCLUSIONS

The feasibility of designing a wideband CP array of series-fed elements using the element geometry to control the array excitation has been demonstrated.

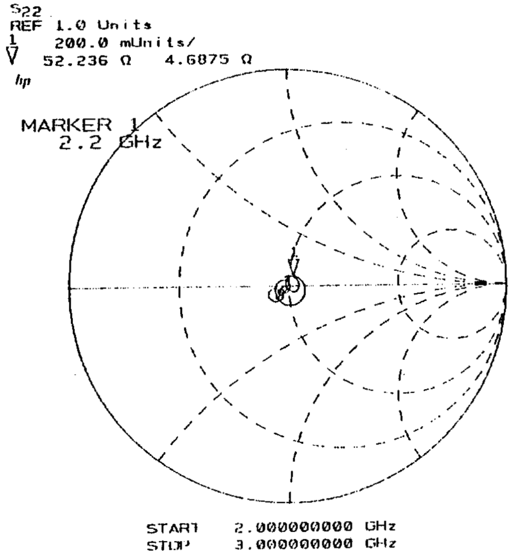


Measured coefficients.

.54 ∠0° .78∠0° 1∠0° 1∠0° .78 ∠0° .54 ∠0°

Theoretical coefficients.

Figure 1. The series-fed linear array of low-profile CP elements.



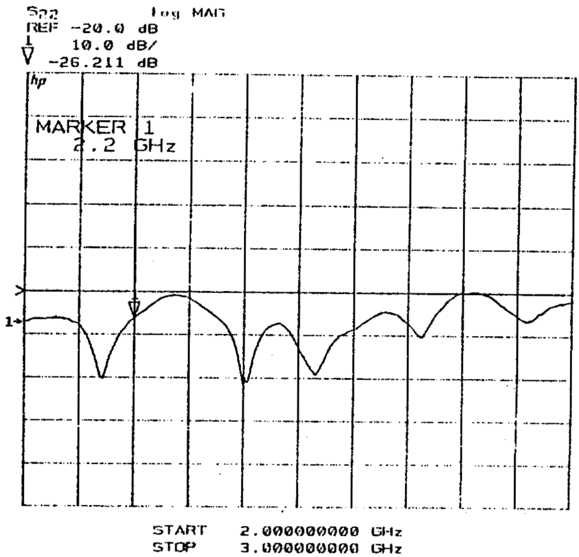


Figure 2. Input impedance (top) and return loss (bottom) of the array.

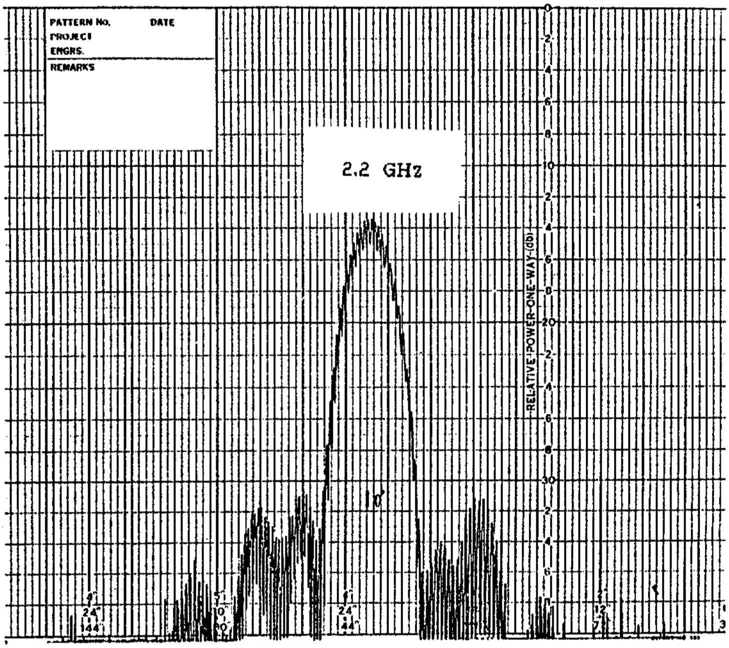


Figure 3. Radiation pattern in the plane of the array as measured by a spinning dipole.