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MICROSTRIP ANTENNA ARRAY WITH PARASITIC ELEMENTS

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INTRODUCTION

This paper discusses the design of a large microstrip antenna array in terms of subarrays consisting of one fed patch and several parasitic patches. The potential advantages of this design are discussed. Theoretical radiation patterns of a subarray in the configuration of a cross are presented.

DESCRIPTION OF THE IDEA

In order to obtain the high gain required in many applications, particularly in satellite communications, antenna arrays with large number of elements are required. This poses several problems if microstrip antenna elements are used. First, if each element is connected to a feed line, the resulting feeding network will introduce unwanted radiation as well as copper losses. Second, for a phase array, each individual element will require a phase shifter in order for the beam to be steered, with the result that a great number of phase shifters are needed in large arrays. For the next generation of satellite communication antennas in which MMIC (monolithic microwave integrated circuit) devices at 20 and 30 GHz are employed in array feeds, the cost of the phase shifters is likely to be prohibitive.

The above-mentioned problems will be reduced if the array is divided into subarrays. We propose that the subarray be consisting of one fed patch only, with several closely spaced parasitic patches around it. The parasitic patches derive their energies from near field coupling with the fed element. An example of the subarray configuration is shown in Fig. 1, consisting of 3x3=9 rectangular patches. A linear array of 4 such subarrays is shown in Fig. 3. Other subarray configurations are of course possible; that of the cross is shown in Fig. 2.

Note in Fig. 3 that, although there are 36 patches, only 4 are directly fed and only these 4 will be linked to a phase shifter in a phase array application. This arrangement offers the following potential advantages:

(1) Compared to the conventional arrangement in which every patch is fed, the number of phase shifters will be reduced by a factor which is equal to the number of patches in the subarray (9 in the example

shown in Fig. 1).

(2) There will be much less interconnecting lines and hence the heat loss as well as unwanted radiation will be reduced.

(3) The parasitic elements have the effect of widening the bandwidth, with the result that the array will have a larger bandwidth than the case when each patch is fed.

(4) These arrays are relatively simple to manufacture.

In the literature, the idea that parasitic elements can obtain their energies from a nearby fed patch and function as radiating elements in an array was demonstrated experimentally in [1]. More recent experimental work also showed that parasitic patches can enhance the gain [2]. However, the idea of designing a large array in terms of subarrays with parasitic microstrip patches appears to be new. Moreover, there is no theory in the literature on such subarrays. We have undertaken a theoretical analysis of the problem and some results for the cross-type configuration of Fig. 2 are presented below.

THEORETICAL PATTERN OF THE CROSS-TYPE SUBARRAY

In our theoretical model of the 5-element cross-type subarray, the patches are assumed to have the same dimensions and are treated as resonators of the same frequency. The fed patch is excited by the coax located at (x',y') at the resonant frequency corresponding to the TM_{10} mode. The side walls of the patch are assumed to be perfect magnetic walls, the magnetic currents on which are calculated by the cavity model [3]. The parasitic patches are excited by radiative coupling from the magnetic current on the adjacent edge of the fed patch. This near field coupling determines the amplitudes and phases of the magnetic currents on the side walls of the parasitic patches. The far-field of the antenna is obtained by summing the contributions from the fed and parasitic elements.

Fig. 4 shows the far-field patterns in the $\phi=0$ plane for a 5-element cross with a resonant frequency of 13.8 GHz for the TM_{10} mode. The aspect ratio a/b=1.5 and the substrate thickness $t=0.04\lambda_0$ where λ_0 is the free space wavelength. Results for two spacings are shown. For comparison purposes, the pattern of a single patch is also included. It is is seen that the parasitic elements increase the directional property of the antenna. Moreover, the field strength at broadside is found to be enhanced by the parasitic elements. It is 6db stronger when $d/\lambda_0=0.1$ and 10db stronger when $d/\lambda_0=0.05$. Similar results are obtained in the $\phi=90^o$ plane.

CONCLUSION

In conclusion, the idea of designing microstrip antenna arrays in terms of subarrays with parasitic patches has been discussed. A theoretical model of a subarray in the form of a cross shows that enhancement of the directivity is obtained by using close spacing between the fed and the parasitic elements. Theoretical and experimental work are continuing.

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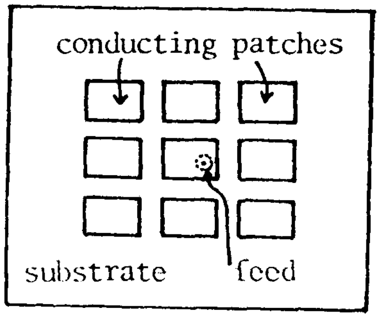

Fig. 1 A 3x3 Subarray of rectangular microstrip patches. Only the center patch is fed.

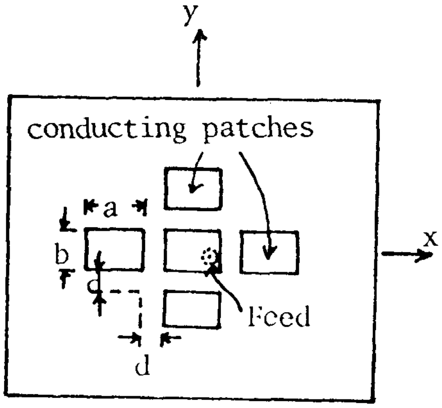

Fig. 2 A subarray in the form of a 5-element cross. Only the center patch is fed.

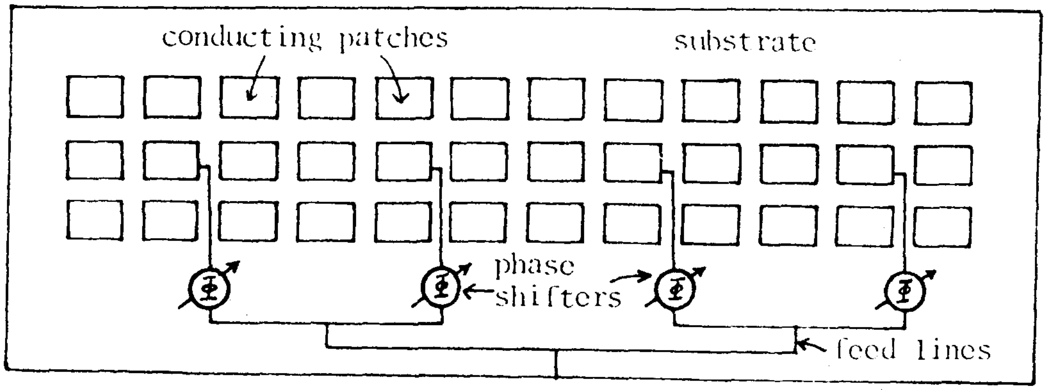

Fig. 3 A linear array consisting of 4 subarrays. Each subarray has one fed patch and eight parasitic patches.

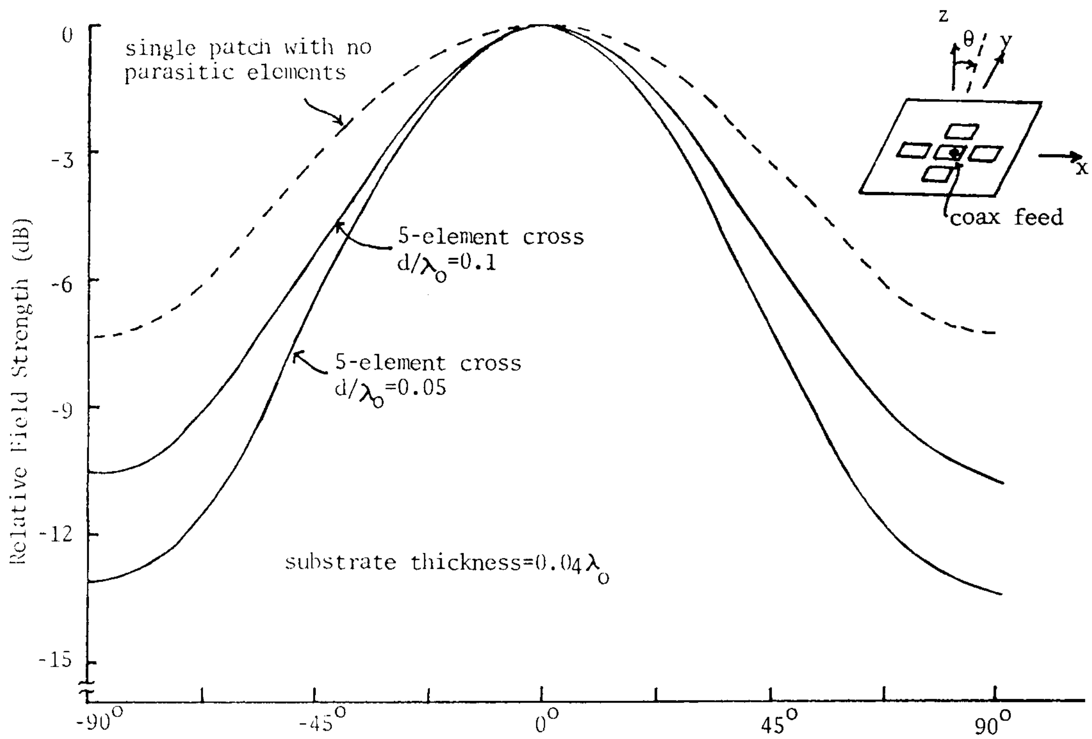

Fig. 4 Relative field strength in the $\phi=0^{\circ}$ plane of a 5-element cross-type subarray with a coax-fed center element.

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16. Abstract

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