A SCANNING SWITCH MATRIX FOR A CYLINDRICAL ARRAY*

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ABSTRACT

A full-commutating scanning switch matrix has been implemented for a 96-element C-band cylindrical array. The impact of cost/performance tradeoffs on the resulting configuration is discussed.

Introduction

A cylindrical array has been developed by Lincoln Laboratory to support a C-band tactical battlefield radar. One of the elements of the array is the beam-forming and scanning matrix whose implementation, as described in this paper, was driven by an attempt at reconciling opposing requirements of high performance, low cost and compact packaging.

Matrix Architecture

One of the conventional ways of scanning a cylindrical array is to selectively excite only that arc of the circle, typically between 90° and 120°, which is centered on the desired direction of the beam. Since this implies a simple rotation of the excitation, control is achieved purely by switching, thus it is pure amplitude scanning and as many beam positions are generated as there are numbers of elements around the circle. This type of scanning has the unique attribute that, in principle, all beams are identical since the same amplitude and phase distribution is impressed for each excited arc.

The realization of such a scheme requires a beam-forming power divider, which sets the amplitude taper for side-lobe control and the phase taper for collimation, and a scanning switch matrix whose function is to route the power divider outputs to the appropriate subset of elements, i.e., the desired arc, corresponding to a particular beam direction. This architecture is depicted in Fig. 1 in the case of a 96-element array in which 32 elements (120° arc) are excited for any given beam. Fig. 2 presents the R.F. interconnections of the power divider and matrix.

Components Description

Such a matrix requires a total of 80 transfer and 32 single-pole triple-throw switches. In order to simplify the intercabling and provide as high a level of modularity as possible, these switches were integrated into two types of modules: one contains four transfer switches (type "A") and the other one transfer and two SP3T (type "B"). Sixteen modules of each type are required. Any one path through the matrix goes through two type "A" and one type "B" module. There is, therefore, the potential for excessive loss and excitation distortion due to phase and amplitude errors. The hardware realization adopted is an attempt at reconciling the basic performance requirements of low loss, phase identity, and high isolation with the need for low cost and light weight. The design and fabrication of the modules was accomplished by Microwave Associates, Inc. The switch control elements are inexpensive PIN diodes encapsulated in miniature glass packages. These are mounted on a printed circuit which includes all RF and bias circuitry. Four diodes in series are required in each arm to obtain adequate isolation. The use of non-heat-sinked diodes is possible because of the modest power handling requirement. Drivers with TTL logic inputs are integral to each module. Photographs of these units are shown on Figures 3 and 4. A summary of the achieved performance is presented on Table 1.

Table 1. Switch Module Characteristics (5.3 GHz)

	Type A	Type B
Insertion loss	1.5 dB	1.3 dB
Isolation	>35 dB	>35 dB
Phase identity*	6° rms	6° rms
Power handling	5W (CW)	5W (CW)

* All paths and from unit to unit, with no post-assembly trimming.

The input power divider was implemented as a manifold of reactive type unequal spliters in honeycomb triplate line. The tapered phase variation required primarily for beam collimation is taken into account by the cables connecting the power divider outputs to the matrix inputs.

Cabling between the modules is accomplished by use of four sets of semirigid cables. Within a given set (typically 32), these cables must be matched in phase. Iterative trimming to 1° rms was facilitated through the use of crimped-type connectors, in which final crimping is deferred until the last iteration.

Beam control is accomplished by a relatively simple read-only memory with 7-bit TTL logic input for beam selection. The control logic is totally frequency-independent.

Overall Performance

A photograph of the complete matrix is shown on Figure 5. Its total weight is 70 lbs. The matrix is packaged to provide easy access to individual modules for replacement. Furthermore, it fits entirely inside the cylindrical array structure yielding a totally integrated antenna system.

The rms insertion phase variation for all paths is of the order of 10°; when integrated in the full cylindrical array, this has been experimentally determined to raise peak side lobes by 5 dB, from 30 dB to 25 dB. Overall insertion loss of the matrix is about 9 dB. While the matrix is capable of handling the power required to overcome this loss, it

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is nevertheless desirable, from an overall radar product viewpoint, to reduce this loss. Modifications have been identified by which a 3 dB reduction is achievable.

The antenna has been supporting radar operations at what is believed to represent the highest frequency implemented to date for a cylindrical array.

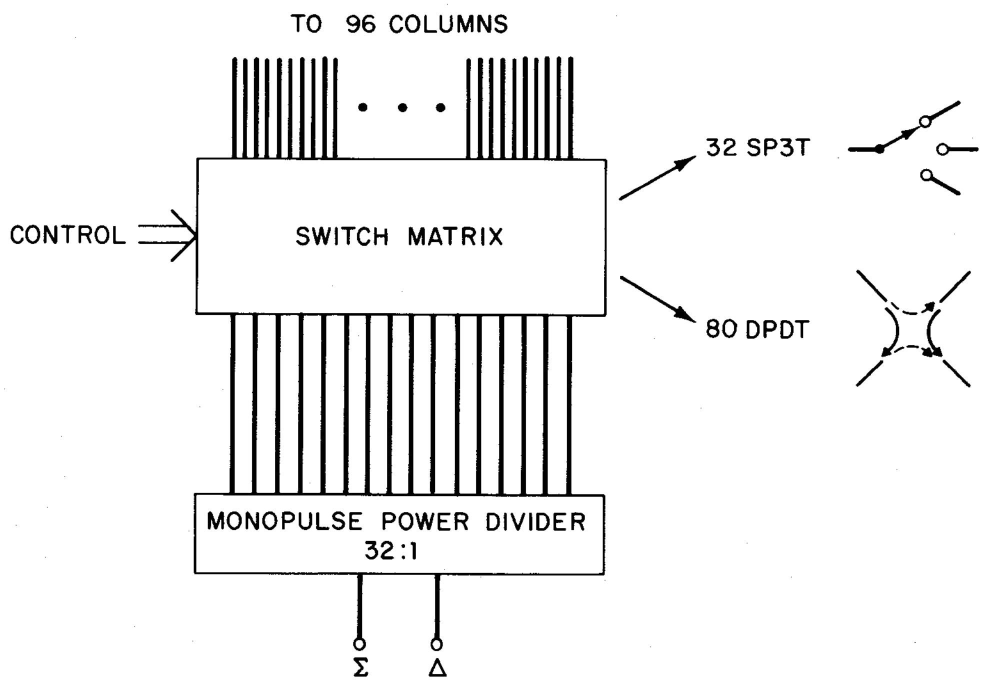

Figure 1. Beam-forming and scanning matrix architecture.

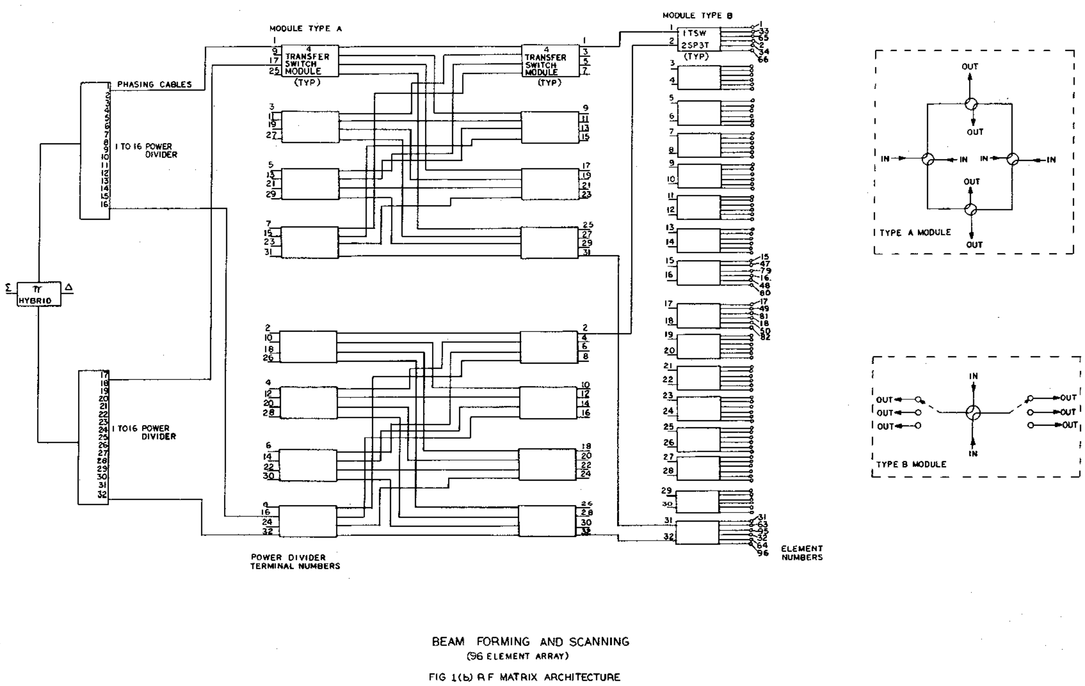

Figure 2. Beam-forming and scanning matrix detailed interconnection.

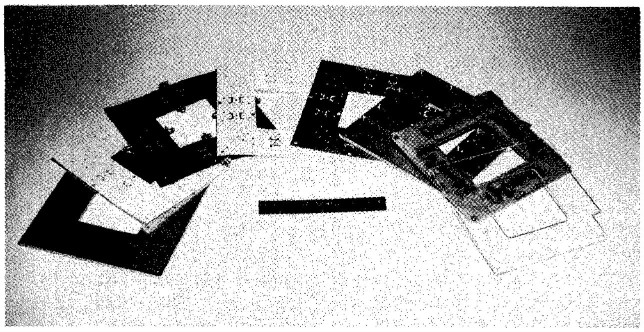

Figure 3. Type "A" switch module.

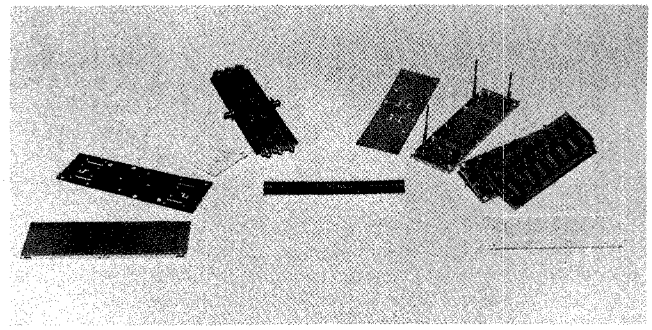

Figure 4. Type "B" switch module.

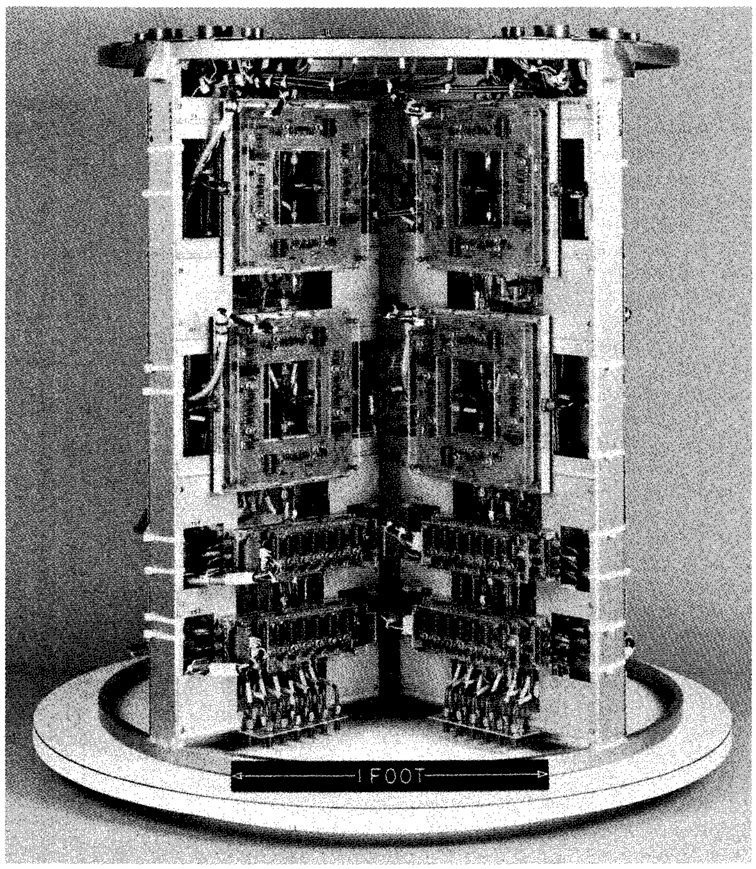

Figure 5. Assembled matrix package.