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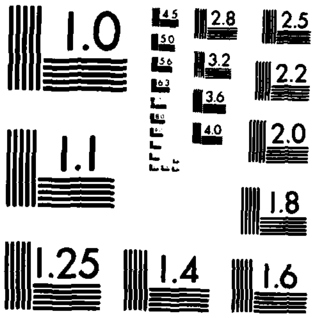

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HOLOSWITCH - PHASE I
SBIR INTERIM TECHNICAL REPORT

CONTRACT #N00014-84-C-0727

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Prepared By:

H. J. Caulfield
Aerodyne Research, Inc.
45 Manning Road
Billerica, MA. 01821
(617)663-9500

Final Report ~~Due 21 April, 1985~~

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I. INTRODUCTION

The purpose of this Phase I SBIR contract is to develop ways of using "switchable holograms" to change from one optical interconnect pattern to another with great rapidity. That is we sought to combine the high flexibility in design and high diffraction efficiency of classical holography with the reprogrammability of the far-less-efficient real time holographic methods of four wave mixing, three wave mixing, etc.

II. DESIGNING A FIXED INTERCONNECT HOLOGRAM

Before we start switching from one interconnect hologram to another, we should have in mind a design for a single fixed hologram.

We imagine a nondescript array of M solid state sources (LEDs, LDs, etc.) each being modulated with its own signal. Likewise we imagine an array of N fast detectors. We would like, in general, to specify for each source (s_i, $i = 1,2,\ldots,M$) a particular detector (d_j, $j = 1,2,\ldots,N$). For now our objective is to implement a particular M to N pattern holographically. For simplicity we will ignore the very real problems of beam shape and beam direction and simply postulate beams of the shape and direction we need.

We have distinguished two major approaches. In Approach 1 all beams strike the entire hologram and are then sorted out by the hologram's angular selectivity. In Approach 2 each beam strikes its own unique region of the hologram.

For a variety of reasons, we believe Approach 2 is better. In Approach 1 we must have "sufficient" angular selectivity. "Sufficient" is clearly a situation-dependent term, but even 1% cross talk on a given detector from many "wrong" sources could be a major problem. Only very thick holograms can do this. Most highly selective thick holograms allow ±5° or more variation. This is a solid angle of about 0.01Π steradians. An f/1 cone is about 0.5Π steradians and could, therefore, have an M no larger than 50. Even that would be difficult. Unfortunately, the problems do not end there. How do we record the hologram? If we superimpose M exposures sequentially, the efficiency of any one interconnect is only $1/M^2$ that of a single hologram. If we expose all simultaneously, the factor is still $1/M$ and massive cross talk problems can arise from "nonlinearities," i.e., $|\gamma| \neq 2$. When spatially separate holograms are used cross talk is impossible and the degradation factor (M^2 or M in Approach 1) is 1. In view of such considerations we are opting for Approach 2.

III. SWITCHING MECHANISMS

We are considering three distinct ways to switch holograms. In one approach, the hologram itself is "multistable." That is, its action depends on an applied electric field. In the second approach, the hologram is fixed but whether or not it operates is electrically controlled. The third approach is a startling simple variation of the second.

Multistable holograms can include a very useful state of no diffraction. Therefore they can be arrayed in such a way that, if they are "inactive," the light passes through them to the next hologram. Arrays of these can do almost anything in the way of switching. We have found in the literature both bistable and multistable holograms.

The second approach is to use fixed holograms which are "active" for one polarization state and "inactive" for the other. Electro-optic switches control which one operates. Thus we need holograms which diffract one polarization state but not the orthogonal state. Three ways to do this were discovered. First, we can work the vector coupled wave analysis to design holograms. This is tricky mathematically and practically. Second, we can use metallic reflective gratings. If the grating spacing lines can be diffracted quite efficiently while the orthogonal state is specularly reflected. Third, we can use a 90° hologram through which only light polarized in the plane of the hologram can diffract. This is because the E field vector of light polarized normal to the plane of the hologram would point along the direction of propagation if it did diffract. This is impossible, so the assumption is that it will not diffract at all.

The fourth approach is to use birefringent prisms to switch light out of the incident direction and onto a hologram or array of holograms afixed directly onto one face of the prism. These prisms are easily stackable, commercially available, and of excellent contrast (often 10^4:1 or better).

IV. CONCLUSION

The work we have been conducting on this Phase I contract is in considering all options involved in the problem of using holograms for interconnects. We are on the track of two significant design contributions. Some description of them has been given here. A thorough description will follow in the Phase I Final Report.