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An Investigation of the Channel Crosstalk in Optical Heterodyne Controlled Phased Array Radars.

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13. ABSTRACT *(Maximum 200 words)*

The principal objective of this project is to investigate problems associated with achieving the drive/read-out system complexity necessary to control a phased array antenna with optical heterodyne techniques. In particular, this work concentrates on multi-channel microwave optical conversion. The approach has been to study the problems associated with device arrays of single sideband modulators that would be necessary to control the amplitudes and phases of all signals delivered to a phased array front end. Our approach remains focused on increasing the complexity of control by modulating only a small number of optical channels which can then be locked to a previously locked active antenna array. This approached is also enabling a better understanding of the accuracy and validity of our con puter aided analysis and is also allowing a greater range of device complexity to be analyzed.

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TECHNICAL PROGRESS REPORT

for Office of Naval Research
for the period June 1,1993 through May 31, 1994

1. Contract Title:

An Investigation of the Channel Crosstalk in Optical Heterodyne Controlled Phased Array Radars

Principal Investigator:

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Program Manager:

Dr. Arthur Jordan

2. Technical Objectives:

The principal objective of this project is to investigate problems associated with achieving the drive/read-out system complexity necessary to control a phased array antenna with optical heterodyne techniques. In particular, this work concentrates on multi-channel microwave optical conversion.

3. Approach:

The approach has been to study the problems associated with device arrays of single sideband modulators that would be necessary to control the amplitudes and phases of all signals delivered to a phased array front end. Our approach remains focused on increasing the complexity of control by modulating only a small number of optical channels which can then be locked to a previously locked active antenna array. This approached is enabling a better understanding of the accuracy and validity of our computer aided analysis and is also allowing a greater range of device complexity to be analyzed.

4. Accomplishments:

The development of "ZOOM," an computer aided electromagnetic analysis technique has been extended to allow analysis of more complicated electrode geometries. A greens function for electrodes on multiple dielectric layers has been derived and incorporated into the program. This allows accurate modeling of realistic optical devices.

Potential distributions of an active antenna array (composed of a 5X5 array of oscillating field effect transistors) given by optical sampling measurements agree with theoretical calculations. These results show that the stability of the active device is determined by the near field radiation and electrode geometry within a period of an elementary cell. Additionally, it was found that the bias lines of the active array provide both the dc bias to the active device and provides a coplanar structure that supports a radiation mode.

The optical to microwave modulation transfer function has been derived for an optically injected FET (field effect transistor). The transfer function can then give the characteristics of the optically injected microwave MESFET oscillator circuit. The model can vary the injected power level and the amount of phase detuning between the injected signal and the free running oscillation making it possible to accurately model microwave control by optical means.

5. Significance:

The geometry of an active antenna plays an important role in its feasibility as an effective control for complicated drive/read- out phased array system. This will enable an efficient antenna array to be constructed. Electromagnetic analyses of a realistic stacked multilayer dielectric and its associated electrode structure makes it possible to design and model the required complexity needed for multi-channel microwave optical conversion. MESFET oscillators and the associated control lasers can be modeled by simply changing a constant in the model to give their characteristics with and with out optical injection.

6. Future Efforts:

Future work involves trying to physically understand locked array results while simultaneously trying to modify existent software to accurately analyze optically addressed antenna elements.

7. Publications and Presentations Partially Supported Under This Grant June 1, 1993 through May 31, 1994.

(a) M.R. Surette, D.R. Hjelme and A.R. Mickelson, "An Optically Driven Phased Array Antenna Utilizing Heterodyne Techniques," *IEEE JLT*, 11, 1500-1509 (Sept. 1993)

(b) M.R. Surette, D.R. Hjelme, R. Ellingson and A.R. Mickelson, "Effects of Noise on Transients in Injection-Locked Semiconductor Lasers, IEEE Journ. Quant. Elect., QE-29, 1046-1063 (April, 1993).

(c) K.Y. Chen, S. Buchheit, and A.R. Mickelson, "Evanescent Current Modes in Active Antenna," International Union of Radio Science, Boulder (CO), (Jan. 5-8, 1994).

(d) K.Y. Chen and A.R. Mickelson, Transistors "Oscillators as Van Der Pol Oscillators," International Union of Radio Science, Boulder (CO), (Jan. 5-8, 1994).

(e) S.J. Buchheit and A.R. Mickelson, "Electromagnetic Modeling of Active Circuits," International Union of Radio Science, Boulder (CO), (Jan. 5-8, 1994).

(f) S.M. Genco and A.R. Mickelson, "Optically Induced Effects in Microwave Mesfets: Experiments and Analysis," International Union of Radio Science, Boulder (CO), (Jan. 5-8, 1994).

(g) M. Popovic, S.L. Kwiatkowski, and A.R. Mickelson, Characterization of X-Cut LiNbO3 Planar Waveguides," International Union of Radio Science, Boulder (CO), (Jan. 5-8, 1994).

(h) S.L. Kwiatkowski and A.R. Mickelson, "Effects of the Prism Waveguide Coupling Strength on Effective Index Measurement Accuracy," International Union of Radio Science, Boulder (CO), (Jan. 5-8, 1994).

(i) P. Biernacki and A.R. Mickelson, "Optical Sampling for Determination of Material Characteristics," International Union of Radio Science, Boulder (CO), (Jan. 5-8, 1994).

(j) W. Feng, S. Lin, H.B. Hooker, and A.R. Mickelson, "Propagation Loss of Polymeric Thin Film Optical Waveguides," International Union oif Radio Science, Boulder (CO), (Jan. 5-8, 1994).

(k) W. Feng, S. Lin, H.B. Hooker, and A.R. Mickelson, "Characterization of Polymeric Optical Channel Waveguides and Their Applications in High Speed Electro-Optic Devices," International Union of Radio Science, Boulder (CO), (Jan. 5-8, 1994).

(l) J. Ma, S. Lin, W. Geng, and A.R. Mickelson, "Modeling Photobleached Optical Polymer Waveguides," International Union of Radio Science, Boulder (CO), (Jan. 5-8, 1994).

(m) S. Lin, J. Ma, W. Feng, H.B. Hooker, and A.R. Mickelson, "UV Bleaching of NLO Polymers for Formation of Channel Waveguide," International Union of Radio Science, Boulder (CO), (Jan. 5-8, 1994).

(n) L. E. Rohlev and A.R. Mickelson, "Microwave Characterization of Nonlinear Optical Polymers," International Union of Radio Science, Boulder (CO), (Jan. 5-8, 1994).

(o) R. Narayan and A.R. Mickelson, "Analysis of Travelling Wave Electrodes in Integrated Optical Devices," International Union of Radio Science, Boulder (CO), (Jan. 5-8, 1994).

p) S.L. Kwiatkowski, D.R. Hjelme, K.H. Wagner and A.R. Mickelson, "Polarization Coupling in Y-Cut Titanium In-Diffused Lithium Niobate Planar Waveguides," IEEE Lasers and Electro-Optics Society, San Jose, (CA), Nov. 15-18, 1993).

(q) S.L. Kwiatkowski and A.R. Mickelson "Characterization of Lithium Out-Diffused Slab Waveguides In LiNbO3 As a Function of Fabrication Conditions,"IEEE Lasers and Electro-Optics Society, San Jose, (CA), (Nov. 15-18, 1993).

(r) P. Biernacki, K.Y. Cheng, D.R. Hjelme and A.R. Mickelson, "Determination of Electrode Currents from Electro-optical Sampling Measurements," Fifth International Conference on Defect Recognition and Image Processing in Semiconductors and Devices, Santander, Spain, (Sept. 6-10, 1993).

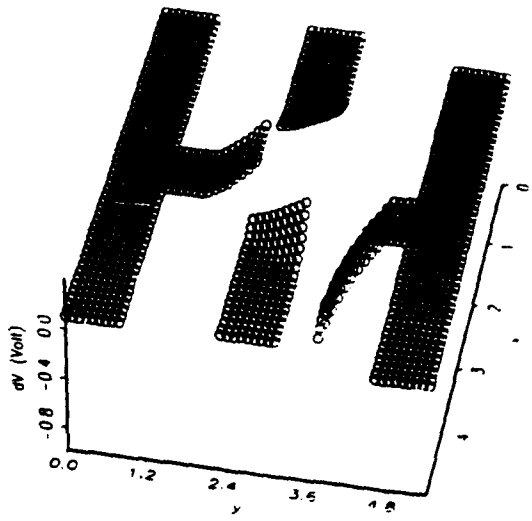
(s) P. Biernacki, D.R. Hjelme, M. Yadlowsky, A.R. Mickelson, "Electro-Optical Sampling for High Frequency Electric Circuits," Fifth International Conference on Defect Recognition and Image Processing in Semiconductors and Devices, Santander, Spain, (Sept. 6-10, 1993).

(t) V. Radisic, D. R. Hjelme, Z. B. Popovic and A. R. Mickelson, "Analysis and Measurement of Coplanar Waveguide Discontinuities," IEEE MTT-S International Microwave Symposium, Atlanta (GA), (June 15-17, 1993).

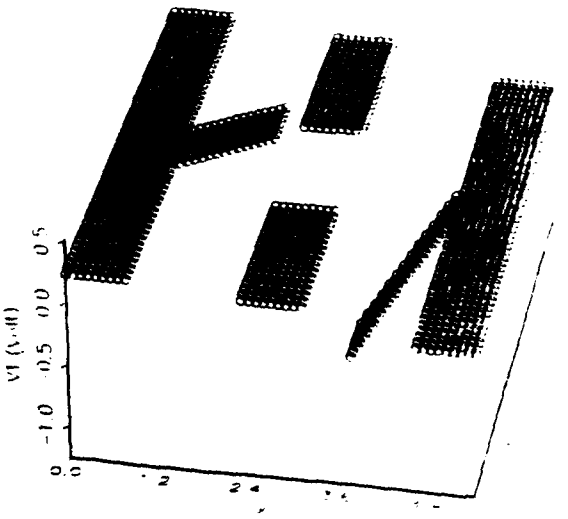
(u) K. Y. Chen, P. Biernacki, A. R. Mickelson and Z. B. Popovic, "Optical Measurements of Microwave Grid Oscillator Power Combiners," IEEE MTT-S International Symposium, Atlanta (GA), (June 15-17, 1993).

8. Participants:

Professor Alan R. Mickelson
Kuang Yi Chen
Raghu Narayan



Prediction of Measured Potential dV on a Single Active Antenna



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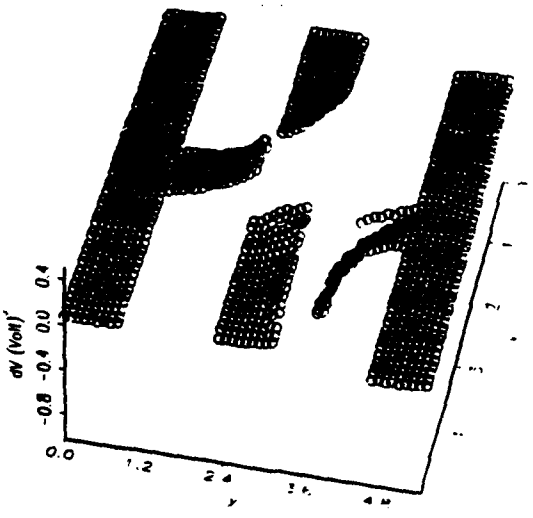
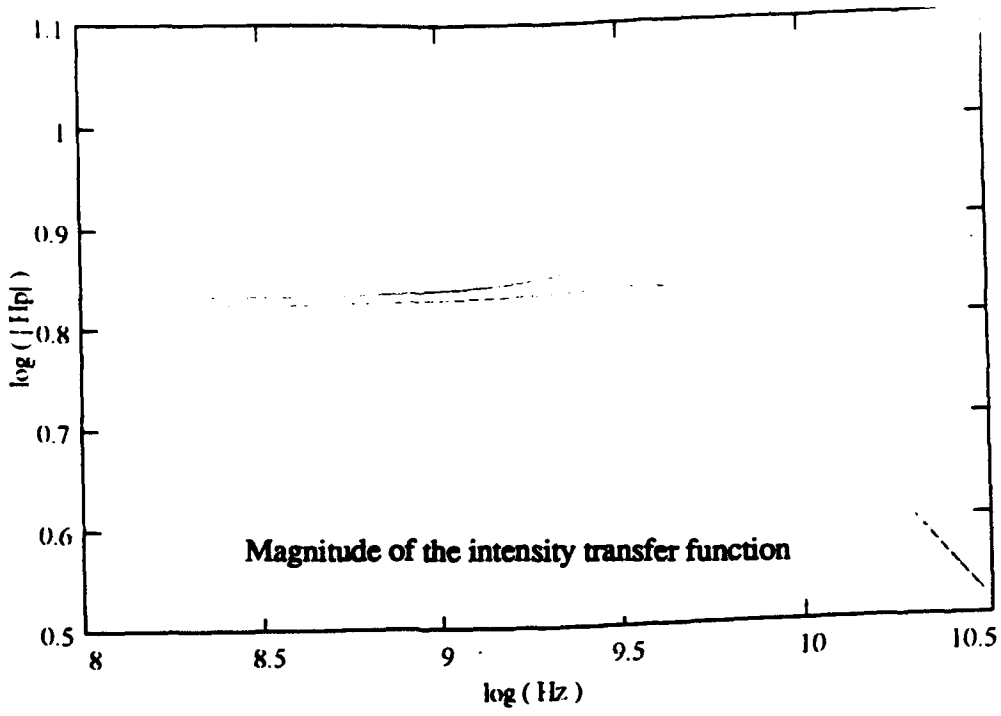
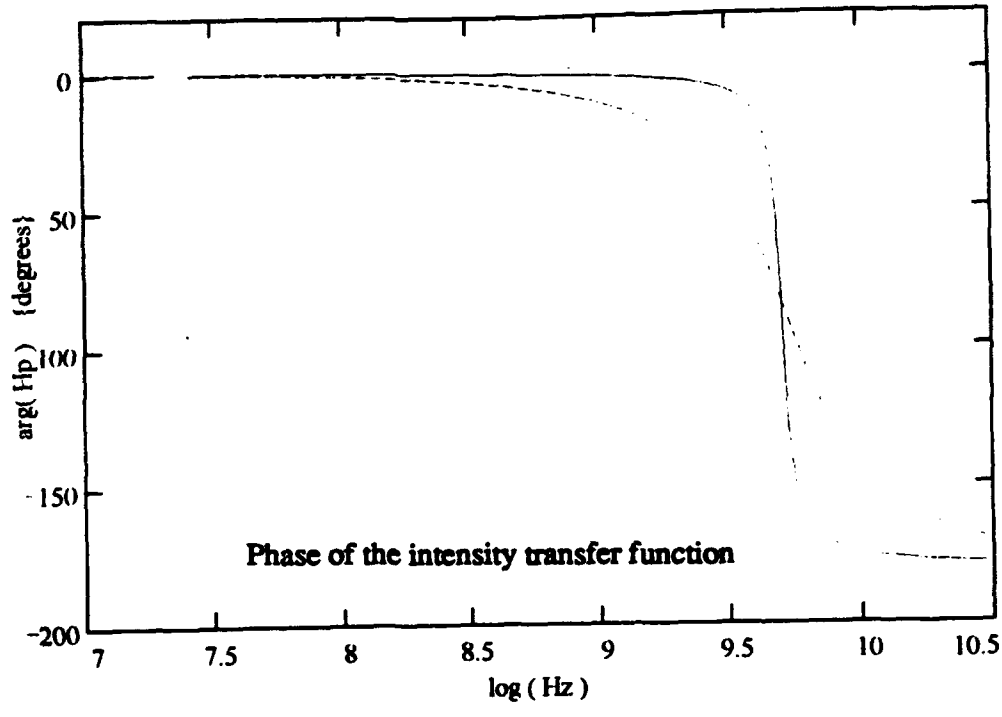


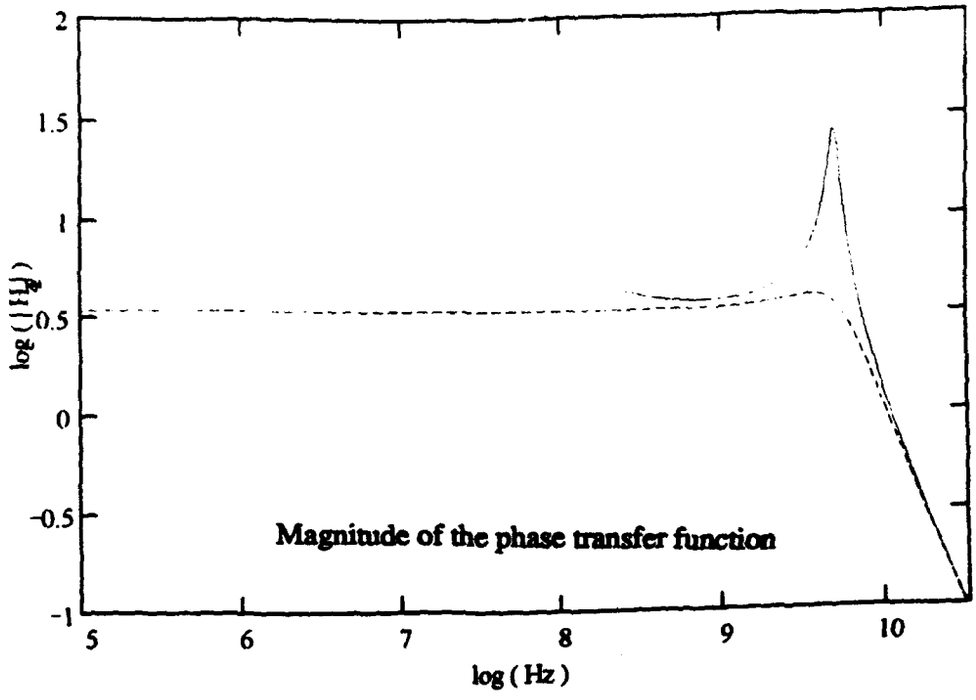
Actaul Measured Potential dV

OPTICAL TO MICROWAVE MODULATION TRANSFER FUNCTION





OPTICAL TO MICROWAVE MODULATION TRANSFER FUNCTION



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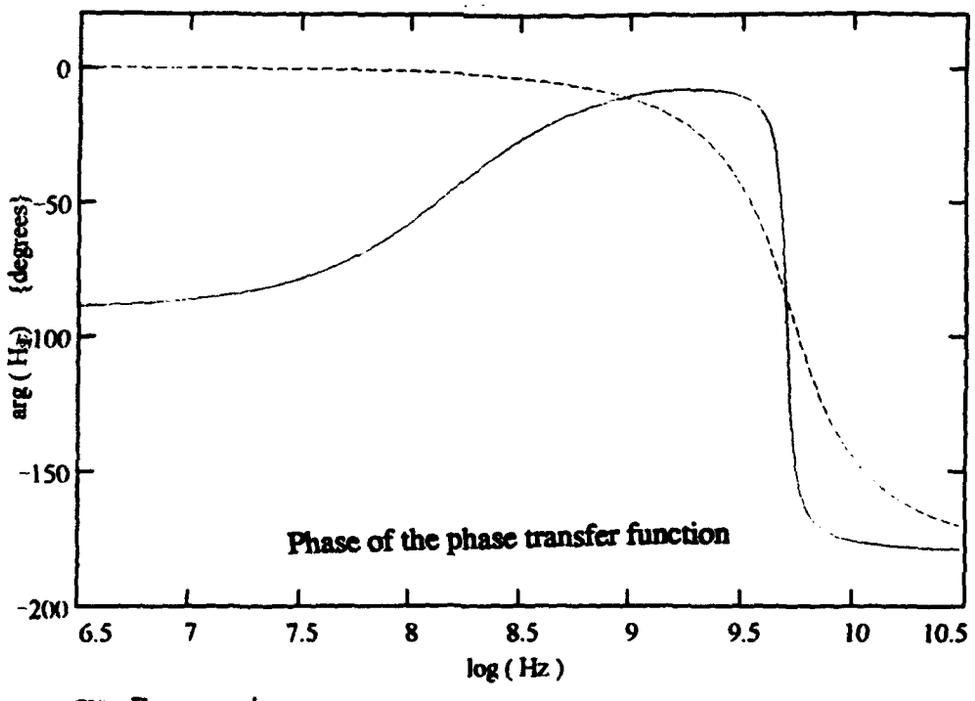

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