MICROWAVE SIGNAL PROCESSING

WITH

PHOTOREFRACTIVE DYNAMIC HOLOGRAPHY

By

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The final copy of this thesis has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards for scholarly work in the above mentioned discipline.

Fotheringham, Edeline (Ph.D. Electrical Engineering)

Microwave signal processing with dynamic holography

Thesis directed by Prof. Dr. Dana Z. Anderson

Abstract

Have you ever found yourself listening to the music playing from the closest stereo rather than to the bromidic (uninspiring) person speaking to you? Your ears receive information from two sources but your brain listens to only one. What if your cell phone could distinguish among signals sharing the same bandwidth too? There would be no "full" channels to stop you from placing or receiving a call.

This thesis presents a nonlinear optical circuit capable of distinguishing uncorrelated signals that have overlapping temporal bandwidths. This so called autotuning filter is the size of a U.S. quarter dollar and requires less than 3 mW of optical power to operate. It is basically an oscillator in which the losses are compensated with dynamic holographic gain. The combination of two photorefractive crystals in the resonator governs the filter's winner-take-all dynamics through signal-competition for gain. This physical circuit extracts what is mathematically referred to as the largest principal component of its spatio-temporal input space.

The circuit's practicality is demonstrated by its incorporation in an RF-photonic system. An unknown mixture of unknown microwave signals, received by an antenna array, constitutes the input to the system. The output electronically returns one of the original microwave signals. The front-end of the system down converts the 10 GHz microwave signals and amplifies them before the signals phase modulate optical beams. The optical carrier is suppressed from these beams so that it may not be considered as a signal itself to the autotuning filter. The suppression is achieved with two-beam coupling in a single

photorefractive crystal. The filter extracts the more intense of the signals present on the carrier-suppressed input beams. The detection of the extracted signal restores the microwave signal to an electronic form. The system, without the receiving antenna array, is packaged in a 13x18x6” briefcase. Its power consumption equals that of a regular 50 W household light bulb. The system was shipped to different parts of the country for real-time demonstrations of signal separation thus also validating its claim to robustness.

DEDICATION

To my mother,

who lovingly offered me the keys to a blossoming life.

To my friends Gaelle and Christophe,

who opened my eyes to the world and to myself.

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TABLE OF CONTENTS

LIST OF FIGURES