NUMERICAL RECONSTRUCTION AND APPLICATIONS OF ACOUSTIC AND ELECTROMAGNETIC ULTRA-WIDEBAND LOCALIZED PULSES GENERATED BY DYNAMIC APERTURE ANTENNAS

by

Mohamed A. Abdel-Rahman

Dissertation submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy
in
Electrical Engineering

APPROVED:

____

Dr. Ioannis M. Besieris, Chairman

______________________	______________________
Dr. A. Elshibini Riad	Dr. W. E. Kohler
______________________	______________________
Dr. W. A. Scales	Dr. Amr M. Shaarawi

December, 1997

Blacksburg, Virginia

Key words: Acoustic and Electromagnetic Localized Pulses, Dynamic Aperture Antennas, Huygens and Rayleigh-Sommerfeld Reconstruction, Plasma, Bistatic Scattering, Remote Sensing

NUMERICAL RECONSTRUCTION AND APPLICATIONS OF ACOUSTIC AND ELECTROMAGNETIC ULTRA-WIDEBAND LOCALIZED PULSES GENERATED BY DYNAMIC APERTURE ANTENNAS

by

Mohamed A. Abdel-Rahman
Committee Chairman: Professor Ioannis M. Besieris

(ABSTRACT)

A study is undertaken of the numerical reconstruction of acoustic and electromagnetic (EM) localized waves (LWs). The latter are carrier-free ultra-wideband pulses characterized by large focusing depths and extended ranges of localization. Special emphasis is placed on finite energy LWs that can be generated by dynamic aperture antennas with independently addressable elements. The reconstruction techniques are based on Huygens and Rayleigh-Sommerfeld integral I and II representations, both in the time and frequency domains. In contradistinction to the Weyl representation, they lend themselves to the physical realization of space-time aperture sources capable of generating localized wave solutions propagating away from the aperture plane. A detailed comparison of the three reconstruction techniques has been carried out in connection with LW solutions to the scalar wave equation, especially with respect to their handling of acausal components incorporated in the aperture excitation fields. In addition, a study is presented of the characteristic properties of LWs propagating through dispersive media modeled by the Klein-Gordon equation. It is demonstrated that contrary to expectation, the depletion of the spectral components of the LW Klein-Gordon field may be slower than that associated with the free space scalar field. Previous work by Power *et al*. [73] is extended by studying the acoustic bistatic scattering of a modified power spectrum (MPS) pulse from rigid and compressible spheres. The analysis allows the extraction of the radius of a sphere from the backscattered data. Finally, a special class of electromagnetic (EM) LWs, referred to as azimuthally polarized X waves (APXWs), is derived and their reconstruction is addressed, both in the time and frequency domains.

Dedicated

to the memory of my father who encouraged

me and provided me the valuable guidance

to pursue my life and career

ACKNOWLEDGMENTS

Special thanks are due to my committee chairman and major advisor, Professor Ioannis M. Besieris. His devotion, guidance and untiring help throughout the course of this work were invaluable. It was through his patience, understanding and stimulating discussions that this dissertation was accomplished.

I am deeply indebted to Dr. Amr M. Shaarawi, University of Cairo, for his sincere advice, helpful contributions and many useful suggestions. His original research with my advisor paved the way and motivated me to join their research group.

I am extremely grateful to Professors Sedki Riad and Aicha Elshibini-Riad for their generous support and kind benevolence during the pursuit of my degree program since I came from Egypt in 1994. Also, a great deal of thanks are due to Professor W. E. Kohler and Dr. W. A Scales for serving on my doctoral committee and for their encouragement and continued inquiry into the progress of this study.

Financial support of this research by my government, Arab Republic of Egypt, is also gratefully acknowledged.

I owe a heartfelt thank you to my family, especially my mother for her prayers, which provided me wisdom and strength from God, and my wife for her constant forbearance, sacrifice and enthusiasm during the course of my degree research.

TABLE OF CONTENTS

LIST OF FIGURES