

FINITE IMPULSE RESPONSE
UTILIZING THE PRINCIPLES OF SUPERPOSITION

by

SCOTT EDWARD CARTER
B.S.E.E., University of Central Florida, 1993

THESIS

Submitted in partial fulfillment of the requirements
for the degree of
Master of Science in Electrical Engineering
College of Engineering
University of Central Florida
Orlando, Florida

Spring Term
1995

ABSTRACT

Window functions have been greatly utilized in the synthesis of finite impulse response (FIR) filters implemented using surface acoustic wave (SAW) devices. The critical parameter in any FIR design is the impulse response length, which must be optimized for the given design specifications in order to reduce the size of each device. To this end, many design algorithms have been introduced such as Remez exchange, linear programming, and least mean squares. A new algorithm has been derived which is efficient and accurate for the design of arbitrary filter specifications requiring less computations than the current algorithms. The FIR design is applicable to general SAW filter design and allows two weighted transducers to be designed in a near optimal method without the need to perform zero splitting or de-convolution.

The thesis first provides the definition of the window functions used for the design process. Then the overview of the design process is discussed using a flowchart of the modeling program for designing an FIR without transducer separation and a sample simulation is presented. Next, the effects of monotonically increasing sidelobes on the transition bandwidth are discussed. This is followed by a discussion of the addition of arbitrary phase to the filter design requirements. Next, the separation of the response into a two transducer design utilizing the two window function series is explained. Finally, the results are discussed and compared with other design techniques.

ACKNOWLEDGMENTS

I would like to thank my advisor Dr. Donald Malocha for his guidance in my studies and my career. I would also like to thank all of my friends and colleagues in the Solid State Devices and Systems Laboratory for their support and advice. A special thanks goes to Rodolfo Chang for the matrix subroutine and Dr. Samuel Richie for the FFT subroutine.

Also, a special thanks goes to Sawtek Incorporated for their continued support and funding of this research.

Finally, I would like to send a special thanks to my family for their constant support and encouragement in all my endeavors.

TABLE OF CONTENTS

LIST OF TABLES	vi
LIST OF FIGURES	vii
CHAPTER 1 - INTRODUCTION	1
CHAPTER 2 - FUNCTION DEFINITION	4
Basis Set for Symmetric Filter Design	4
Basis Set for Non-symmetric Filter Design	5
CHAPTER 3 - FILTER DESIGN PROCESS	7
Filter Design Parameters	7
Filter Specifications	7
Filter Bandwidth Requirements	9
Impulse Response Length	10
Preliminary Operations	10
Solving for the Weighting Coefficients	11
Initialize Solver	12
Equiripple Solver	15
Matrix Solver	15
Interchange of Frequency Specifications	16
Bandwidth Solver	19
Bandwidth Specifications	20
Adjusting the Impulse Response Length	21
Calculate the Frequency Response	25
Calculate the Time Response	30
Improving the Impulse Response Length	33
CHAPTER 4 - MONOTONICALLY INCREASING SIDELOBES	36
Design Process	37
Results	39
CHAPTER 5 - PHASE DESIGN	44
Example	44
Results	47
Linear Phase Response	48
Chirp Phase Response	51

CHAPTER 6 - TRANSDUCER SEPARATION	55
Basis Sets	55
Transducer Design	56
Example	57
Results	57
CHAPTER 7 - CONCLUSIONS	62
APPENDICES	64
A. Optimizing Impulse Response Length	65
REFERENCES	68

LIST OF TABLES

1. Filter specifications	9
2. Bandwidth specifications	9
3. Initial conditions for the design example	15
4. New frequency specifications after each iteration	19
5. Adjusting the impulse response length until solution meets allowed error	22
6. Weighting coefficients for the design example for the pass-band cases presented	25
7. Approximate group delays of individual basis functions for chirp phase design	52

LIST OF FIGURES

1. Program flowchart	8
2. Solver frequency range of interest for $N = 11$	12
3. Initial pass-band conditions	13
4. Initial stop-band conditions	14
5a. Frequency response using initial specifications	17
5b. Frequency response after one iteration	17
5c. Frequency response after two iterations	18
5d. Frequency response after three iterations	18
6. Family of optimal, equiripple filter design curves each having the same transition bandwidth but differing pass-bandwidths	20
7a. Flat equiripple filter response	26
7b. Pass-band response of the flat equiripple filter design	26
8a. Dip filter response	27
8b. Pass-band response of the dip filter design	27
9a. Positively sloped linear filter response	28
9b. Pass-band response of the positively sloped linear filter design	28
10a. Negatively sloped linear filter response	29
10b. Pass-band response of the negatively sloped linear filter design	29
11. Time domain response of the flat pass-band filter design	31

