

SYSTEMATIC PERFORMANCE COMPARISON
OF NARROW-BAND INTERFERENCE REJECTION ALGORITHMS FOR
DIRECT SEQUENCE SPREAD SPECTRUM RECEPTION

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This thesis is dedicated to my Father John William Young who gave me the courage, etc.

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TABLE OF CONTENTS

	Page
LIST OF TABLES.....	vi
LIST OF FIGURES.....	vii
ABSTRACT.....	x
1 INTRODUCTION.....	1
1.1 Spectrum Re-use Direct Sequence Spread Spectrum Communications.....	2
1.2 Recent Research in DSSS Narrow-Band Frequency Excision.....	4
1.3 Research Objective.....	7
2 REAL-TIME DFT RECEIVE EXCISION ALGORITHM ANALYSIS IN AWGN. 9	
2.1 Effect of Sampling Rate on Spectrum Characteristics.....	9
2.2 Instability of the Optimum Perfect Estimation Solution.....	14
2.3 Consistency of the Proposed Analysis Technique with Bayes Error Analysis.	17
3 APPLICATION OF THE ANALYSIS TO THE COMPARISON OF MAPPING ALGORITHMS IN AWGN.....	21
3.1 Fraction Zeroize Performance.....	21
3.2 Threshold Zeroize Performance.....	22
3.3 Fraction Clip Performance.....	26
3.3.1 Optimum selection of clip magnitude.....	29
3.3.2 Noise power selection of clip magnitude.....	29
3.3.3 Threshold selection of clip magnitude.....	30
3.4 Comparison of Spectrum Mapping Methods.....	30
3.5 Verification by Simulation.....	30
4 ANALYSIS OF EXCISION WITH WINDOWING AND OVERLAPPING IN AWGN AND TONES.....	35

	Page
4.1 Over-Excision Loss in Windowed AWGN.....	35
4.2 Application to Multiple Tone Interference.....	39
4.3 The Use of Overlap and Add to Recover Sensitivity.....	47
4.4 Performance Metrics of Windows for Single Tones.....	58
4.5 Performance Metrics of Windows for Multiple Tones.....	61
4.6 Trade Study: Evaluation of Windows and RT-DFT Algorithms.....	71
5 PRACTICAL IMPLICATIONS ON SYSTEM PLANNING.....	81
5.1 Standoff Range Derivation.....	81
5.2 Single Use Standoff Range Performance.....	85
5.2.1 Narrow-band transmission standoff range for narrow-band reception	85
5.2.2 DSSS wideband transmission standoff range for wideband reception	86
5.3 Narrow-Band Transmission Standoff Range for Wideband DSSS Reception.	87
REFERENCES.....	89
APPENDICES	
APPENDIX A: Moments of Rank Order Statistics.....	92
APPENDIX B: Small Signal Clip Inner Product.....	103
APPENDIX C: 4-Term Cosine Series Window Data.....	104
VITA	129

LIST OF TABLES

Table	Page
1.1: Description of alternative algorithms for real-time modification of the DFT record for narrow-band frequency excision.....	33
4.1: Non-overlapped window data.....	39
4.2: Side-lobe leakage models for different windows evaluated with multi-tone RT-DFT excision.....	73
C-1: 4-term Cosine Series (4CS) window coefficient data.....	105

LIST OF FIGURES

Figure	Page
2.1: Illustration of non-zero variance expectation terms.....	11
2.2: Illustration of non-zero cross-correlation expectation terms.....	14
3.1: Average fraction excised for a fixed threshold using the TZ algorithm..... 24	
3.2: Standard deviation of the fraction excised for the TZ algorithm.....	24
3.3: Loss for Threshold Zeroize (TZ) algorithm by three calculation methods..... 25	
3.4: Clip magnitude for each fraction excised by the Optimum Clip (OC) algorithm 31	
3.5: Clip magnitude at each fraction excised, Fraction Clip to Threshold algorithm. 31	
3.6: Comparison of spectrum mapping algorithms in AWGN only.....	32
3.7: Simulation verification for all mapping algorithms in AWGN..... 34	
4.1: Windowed RT-DFT architecture.....	36
4.2: Over-excision sensitivity loss in 16 equal tones.....	46
4.3: Simulated loss due to unexcised sidelobes of 16 tones with no overlap.....	46
4.4: Overlap-and-add output time series formation.....	47
4.5: Linearized equivalent circuit for overlap-and-add excision.....	48
4.6: Sensitivity loss for overlap-and-add windowed records.....	52

Figure	Page
4.7: Effect of overlapping in AWGN, moderate r	53
4.8: Effect of overlapping in AWGN, small r	54
4.9: Effect of overlapping in AWGN, large r	54
4.10: Simulation accuracy in AWGN, moderate r	55
4.11: Simulation accuracy in AWGN, small r	55
4.12: Simulation accuracy in AWGN, large r	56
4.13: Effect of overlapping in 16 tones, moderate r	56
4.14: Effect of overlapping in 16 tones, small r	57
4.15: Effect of overlapping in 16 tones, large r	57
4.16: Mean main-lobe width as a function of threshold for 4CS windows, $N=256$... 60	60
4.17: Mean sidelobe power as a function of threshold for 4CS windows, $N=256$	60
4.18: Standard Deviation of 4CS window main-lobe width, $N=256$	61
4.19: Mean fraction $m_f(B/N)$ containing main-lobe energy for K_T tones in an $N=256$ point FFT for a first order multiple tone model of various single tone widths.....	65
4.20: Standard Deviation of the fraction containing main-lobe energy $\sqrt{v_f(B/N)}$ for K_T tones in an $N=256$ point FFT using a first order multiple tone model.....	65
4.21: Mean number of bins containing interference for some popular 4CS windows as a function of I/S , $N=256$, $N/S=14$ dB, $m=6$ dB, $K_T=5$	67
4.22: Mean number of bins containing interference for some popular 4CS windows as a function of I/S , $N=256$, $N/S=14$ dB, $m=6$ dB, $K_T=25$	67

ABSTRACT

Young, Jeffrey A. Ph.D.. Purdue University, May 1995. Systematic Performance Comparison of Narrow-Band Interference Rejection Algorithms for Direct Sequence Spread Spectrum Reception. Major Professor: James S. Lehnert.

The capacity of Direct Sequence Spread-Spectrum (DSSS) modulation to reject narrow-band interference can be significantly improved by eliminating narrow-band energy at the receiver (frequency excision) using algorithms that operate on the Real Time Discrete Fourier Transform of the received signal (RT-DFT-Based). These algorithms have the potential to adapt very quickly to a changing interference spectrum and eliminate multiple tones, but to do this the decision of which frequency bins to excise must be made based on a very short observation time. Under these circumstances, the number of bins excised can be much larger than the number of bins containing narrow-band interference. The receive signal strength loss due to "over-excision" can be very significant and limits receive sensitivity. This work shows theoretical over-excision losses of several heuristic algorithms using a new analysis technique that accurately describes the performance of alternative non-linear time varying algorithms over a broad class of possible conditions. The sensitivity loss due to time weighting (or windowing) is presented for variable overlap and several different windows. These theoretical results are confirmed with simulation results and can be used to project sensitivity of PN spread spectrum systems that are located in a band that is also used by narrow-band systems. These results are instrumental in predicting the performance of systems which operate in the presence of multiple narrow-band interference, comparing the relative merits of alternative algorithms for arbitrary interference spectrum, and determining hardware requirements necessary to support a given level of system performance.

4. ANALYSIS OF EXCISION WITH WINDOWING AND OVERLAPPING IN AWGN AND TONES.

The analytical technique proposed in chapters 2 and 3 allows the performance of spectrum mapping algorithms to be compared when applied in conjunction with widely known properties of windows [33]. This chapter expands the scope of the analytical technique to derive performance for a general class of windows, and proposes a linearized model of excision that allows the loss for the overlap-and-add architecture to be derived. Section 4.1 shows how the suggested technique can be applied to predict performance in windowed Additive White Gaussian Noise (AWGN). A general form that gives the performance of at least ten different commonly used alternative windows is provided. Section 4.2 shows how the suggested technique can be applied to predict performance in windowed AWGN and multiple tone interference. Section 4.3 presents a linear equivalent circuit model of the RT-DFT excision algorithm that allows the sensitivity performance of the overlap-and-add architecture to be computed in general. Closed form results are given for the class of windows indicated in section 4.1. Simulation results confirm the utility of the linearized model over a large class of spectrum mapping algorithms.

4.1 Over-Excision Loss In Windowed AWGN

For the analysis of this section, the input signal to the architecture defined in Figure 4.1 contains only spread spectrum signal and AWGN. Numerical subscripts on the signal variables usually indicate the node of Figure 4.1.

Section 3.3 explicitly states E_b/N_o at node 4 in Figure 4.1 for a general class of spectrum mapping algorithms when no window is applied (node 1 is the same as node 2).

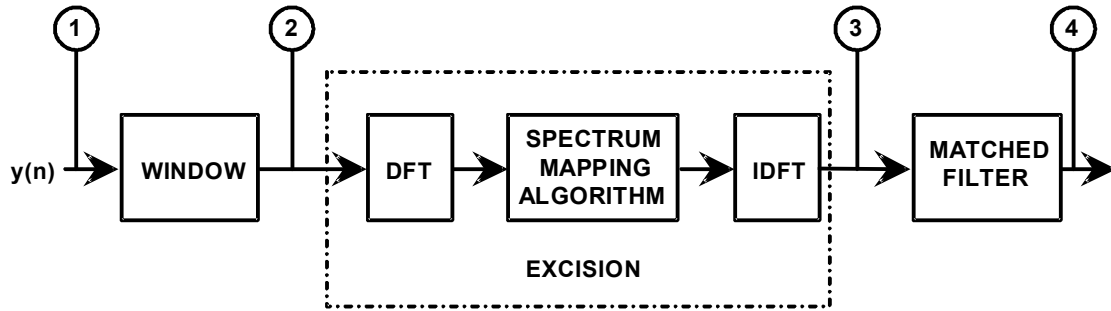


Fig. 4.1: Windowed RT-DFT architecture.

This result can be restated in terms of a loss from the signal strength expected when no excision is performed. The symbol L_E denotes the loss due to excision and can be written

$$L_E = \frac{r^2 M + N \sum_{k=M}^{N-1} C_{1,k}^N}{\frac{\sum_{n=0}^{N-1} w^2(n)}{2N} \left[\frac{r}{\sum_{k=0}^{M-1} C_{1,k}^N C_{1/2,k}^N} + \sqrt{N} \sum_{k=M}^{N-1} C_{1,k}^N \right]^2} \quad (4.1)$$

Widely known window analysis techniques [33] define performance for a window $w(n)$ in terms of the noise power gain and peak power gain which can be defined as

$$G_{NP} = \frac{1}{N} \sum_{n=0}^{N-1} w^2(n), \text{ and} \quad (4.2)$$

$$G_{PP} = \frac{1}{\sum_{n=0}^{N-1} w(n)} \sum_{n=0}^{N-1} w(n)^2, \text{ respectively.} \quad (4.3)$$

Table 4.1

The caption should come before the table.

	A	B	C
1.1	2.2	3.3	4.5
X	Z	Z	

This result is good for all spectrum mapping algorithms that operate on the rank ordered magnitude of the frequency spectrum and map the $L+M$ largest magnitude samples in the frequency domain into the same magnitude, denoted by r , while leaving the remaining $N-M$ magnitudes unchanged.

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