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

A Thesis

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

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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).

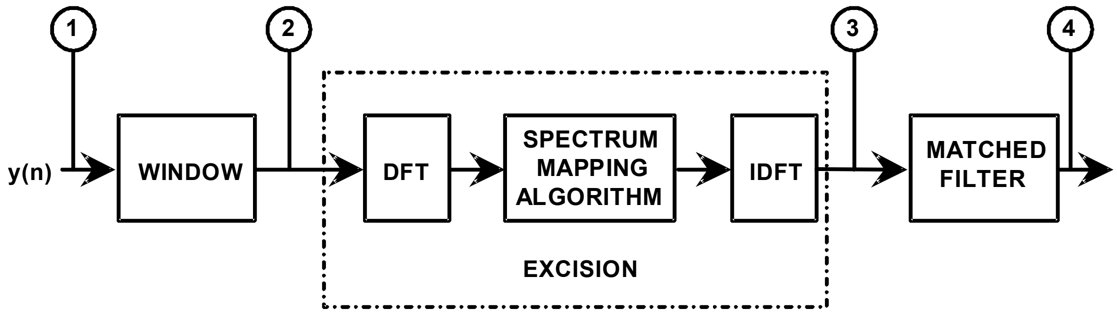

Fig. 4.1: Windowed RT-DFT architecture.

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

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

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

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

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

Table 4.1
The caption should come before the table.

	A	B	C
1.1	2.2	3.3	4.5
X	Z	Z	[illegible]

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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VITA

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