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RESEARCH PAPER

Very Low Correlation Sequence Design with Power Control

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Abstract

Barker sequences and generalized Barker sequences with complex symbols on the unit circle have very limited lengths to achieve maximum aperiodic autocorrelation of 1. In the performed innovation, we consider symbols beyond the unit circle in the complex plain to obtain more degrees of freedom to achieve the desired minimum autocorrelation level with much longer sequences. The sequence symbols are obtained by direct solution of a minimax problem (i.e., minimization of the maximum autocorrelation), with limitation on their maximum power to preserve the sequence randomness. The sequence length is arbitrary and is an input parameter to the algorithm. The developed algorithm leads to excellent results. For instance, sequences with the length of 1000 can simply be obtained with maximum autocorrelation of not only below 1, but even much smaller.

Keywords Barker sequences · Aperiodic correlation · Spread spectrum · Minimax problem

1 Introduction

Sequences with minimum aperiodic autocorrelation have been extensively applied for spread spectrum signaling and radar (Schulze and Luders 2005; Barton and Leonov 1998). In this domain, Barker sequences with binary ± 1 symbols are defined as the codes with maximum aperiodic autocorrelation of 1 (Barker 1953; Borwein and Mossinghoff 2008). There are very few samples of Barker sequences, and it is proven that their lengths do not exceed from 13 (Bomer and Antweiler 1989). To achieve a good processing gain, longer sequences with minimum autocorrelation level have been interested and desired. Generalization of Barker sequences with the complex symbols on the unit circle leads to longer codes with maximum aperiodic autocorrelation of 1. Extensive researches have been performed for designing the generalized Barker sequences (Bomer and Antweiler 1989; Golomb and Scholtz 1965; Mutkov et al. 2009; Zhang and Golomb 1989; Chang and Golomb 1994, 1996; Friese and Zottmann 1994; Friese 1996; Brenner 1998; Ho and Mow 2004; Mow 1996; Borwein and Ferguson 2005). For instance, Zhang and Golomb (1989) declare these sequences for the lengths of $L = 1,\ldots,19$. Chang and Golomb (1994) declare these sequences for the lengths of $L = 17$, 18, 19. Chang and Golomb (1996) declare these sequences for the lengths of $L = 19,\ldots,31$. Friese and Zottmann (1994) declare these sequences for the lengths of $L = 20, 26,\ldots, 31$. Friese (1996) declares these sequences for the lengths of $L = 32,\ldots,36$. Brenner (1998) declares these sequences for the lengths of $L = 37,\ldots,45$. Finally, Borwein and Ferguson (2005) declare these sequences for the lengths of $L = 46, \ldots,$ 63. Hence, there is still limitation in the sequence length (i.e., up to 63).

In the performed innovation, we generalize the symbols domain from the unit circle to the complex plain to obtain more degrees of freedom to achieve the desired minimum autocorrelation level with much longer sequences. Absolute generalization of the symbols domain to the complex plain leads to an impulse-like sequence with the ideal autocorrelation property (exactly zero); but the signal power (corresponding to the sequence) has been concentrated on one symbol, and the sequence is no longer random like. It is desired that a spread spectrum sequence be spread both in the time and in the frequency domain. Therefore, it is desired that the sequence symbols power be limited, so that the sequence is random like, not similar to an impulse waveform.

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