A Method for Constructing a Barker-like Sequences Based on Ideal Ring Bundles

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Abstract. To date, all major reserves for improving the quality of wireless communication are almost exhausted. It is becoming clear to all wireless network designers and manufacturers that instead of using the standard principles of network efficiency enhancement, they should focus their efforts on implementing other principles of radio exchange by creating new code sequences. The Barker-like sequence is taken as the main sequence, and then each element of the main sequence is replaced by a direct or inverse additional Barker-like sequence, depending on whether there is zero or one in the main Barker-like sequence. An algorithm for the synthesis of Barker-like sequences using ideal ring bundles of different types is proposed. The method of constructing Barker combined signals and their autocorrelation functions are considered. The simulation of the obtained Barker-like sequences in the LabVIEW software environment is performed.

Keywords: Barker code; Barker-like code; Barker sequence; Barker-like sequence; Combined signal; Cross-correlation function; Ideal ring bundle.

1 Introduction

In modern systems of information collection and processing, the number of different autonomous sensors that provide telemetric control objects is constantly increasing, respectively, increasing their accuracy and speed. The flow of information from sensors to higher-level control systems becomes more intense [1].

As a result of increasing the performance of microcontrollers and reducing their cost, closed local control systems for individual modules of technological systems appear. There are robotic devices that can operate autonomously or under the control of global commands from an external control system [2].

2019 DCSMart Workshop.

The development of these systems is only possible with the improvement of intelligent sensors that can be easily integrated into data collection systems. In short, modern sensors should have developed interfaces and standardized data formats [3].

Beyond that, with the penetration of microprocessor-based control systems into smaller-sized objects, the requirements for mass-scale characteristics and reliability of these devices are steadily increasing. For operation of control systems in highly noisy communication lines, including in power lines, resident noise-resistant channel coding of data using Barker-like sequences of any length is proposed [4].

In the data transmission and reception channels solve the problem of signal detection or the problem of signal discrimination, which can be considered as a special case of the problem of detection [5]. Receiving correlation is more efficient than more complex useful signal [6]. But not all complex signals are equally effective for solving the detection problem [7].

The best ones, for which the ratio of the N peak of the autocorrelation function (ACF) to the lateral particles is the highest. These signals in the form of binary sequences are known and commonly used, the so-called Barker signals (sequences) [8].

2 Review of the Literature

Modern systems of data transmission have many characteristics, but the main one is the protection of data transmission from interference. In addition, the current problem in our time is the ability to increase the protection of the impedance with fixed speed [9].

The purpose of the work is to develop such a method of noisy encoding, with the use of which it was possible to improve the system to protect the transmission of information from impedances.

The practical implementation of the work is to find the Barker sequences, in which the values of the main petal to the side petal is higher than the standard Barker codes. Without them, it will not be possible to solve the encoding problem of integrated resistance protection. [10].

Noise-like signals can be used in various communication systems. This is achieved by protecting high impedance from narrowband high-power interference. Signals redefine the possibilities of subscriber separation by codes, secrecy of data transmission and high resistance to high-frequency broadenings.

With the help of high-resolution noise-like signals for radar and navigational measurements, their location can always be determined. [11].

3 Problem Statement

It is very important to choose a pseudorandom code sequence in a radio engineering system, since its parameters depend on the enhancement of the processing of the system, its impedance and sensitivity. With the same code sequence length, the system parameters may be different in terms of interference protection, transmission speed, etc [12].

When using noisy signals, code combinations should be given certain mathematical characteristics, the most important of which is autocorrelation. Barker's sequences meet these requirements. It is clear that attempts to find Barker's sequences do not have the number of decision elements [13].

There are only 7 Barker signals, the longest of them being 13 characters and related to the ASF main peak height to the side $N = 13$. This property makes it possible to reliably detect such signal at signal / interference $S / I < 1$ [14].

In the least noise-resistant channels, such as control channels for unmanned aerial vehicles, classic Barker signals do not provide the necessary reliability for their detection. Development of algorithm for construction of analogical sequences of Barker is actual with the number of elements on the basis of ideal ring bundles (IRB) [15].

4 Algorithm of Synthesis of Barker-like Sequences

The method of construction on the basis of family of ideal ring bundle on the criterion of minimum value of autocorrelation function of discrete signal consists in the following:

- to choose the variant of ideal ring bundle of the set order N of necessary length L_N of multipleness R ;
- to build a L_N - position code μ_i , $i = 1,2,..., L_N$ with an one-level periodic autocorrelation function, based on the chosen variant of IRB $(k_1, k_2,..., k_l,..., k_N)$, where on N positions of sequence with serial numbers x_l, $l = 1,2,\ldots,N$, where determined with next formula:

$$x_l \equiv 1 + \sum_{i=1}^{l} k_i \pmod{L_N}, \quad (1)$$

where place numbers "1", and on the rest $L_N - N$ positions - numbers "-1".

For the construction of Barker-like sequences we choose those sequences from the different families of IRB, where correlation is $N / R \approx 2$.

Consider the example of constructing Barker-like sequences based on the IRB in accordance with a given algorithm, where $N = 12$, $L_N = 28$, $R = 5$.

For example, from the two existing variants of the IRB $N = 12$, constructed using the sampling displacement algorithm, we select the first type of IRB:

1, 1, 3, 1, 1, 7, 2, 2, 3, 3, 3, 1.

Let's synthesize a sequence with code $L_N = 28$. We place the characters "1" according to the formula (4) in twelve positions $(N = 12)$, while the rest of the position is filled with the symbols "-1":

1, 1, 1, -1, -1, 1, 1, 1, -1, -1, -1, -1, -1, -1, 1, -1, 1, -1, 1, -1, -1, 1, -1, -1, 1, -1, -1, 1.

A resulting Barker-like sequence with a "no longer match" property for which the value of autocorrelation function does not exceed 2 (except the main petal):

28, -1, 0, 1, -2, 1, 2, 1, -2, 1, -2, 1, -2, 1, 2, -1, 2, -1, -2, -1, -2, -1, 2, -1, -2, -1,0,1.

In this case, the ratio of the main lobe to another is 14, which is more than in the classical Barker sequences. Similarly, we can obtain variants of Barker-like sequences with the indicated properties by selecting other families of IRBs.

Therefore, the use of IRB for the synthesis of Barker-like sequences facilitates their construction, applying the results of constructing various families of IRBs [16].

It also makes it easier to search for complete families of these configurations, looking among them for Barker-like sequences with better characteristics.

Except for well-known families of Singer, a few families of IRB are known [16]. Will transfer them with a short description (Fig. 1).

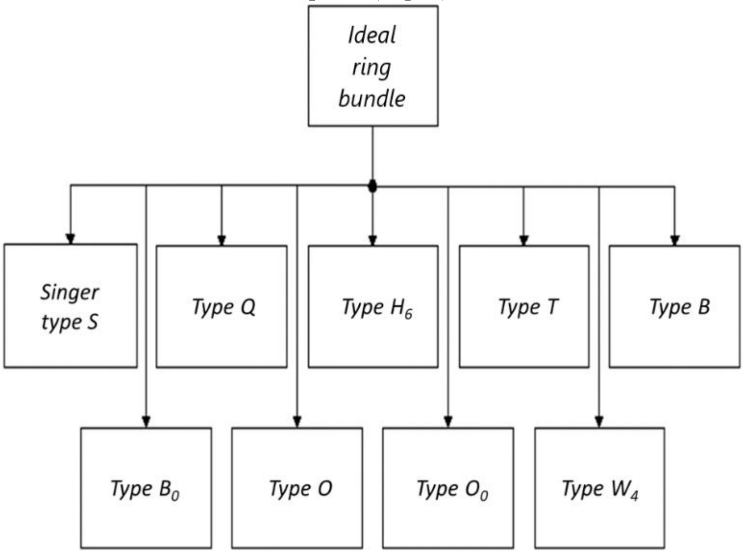

Fig. 1. Families of ideal ring bundles

All of these ideal ring bundle families can be used to synthesis Barker sequences and Barker-like sequences [17].

5 Synthesis of Combined Barker-like Sequences

Signals with a higher ratio than Barker signals are proposed. Methods for searching such sequences are described by the authors in [18]. One method is based on a combination of Barker signals.

The Barker sequence is taken as the main sequence, and then each element of the basic sequence is replaced by a direct or inverse additional Barker sequence, depending on whether there are zero or one in the Barker basic sequence [19].

Of all possible pair combinations of Barker basic and additional sequences, only 10 sequences satisfy our requirements: 3×4,1; 3×3; 3×7; 3×11; 7×3; 7×7; 7×11; 11×3;

11×7; 11×11, where the first number is the main Barker sequence and the second number is the additional Barker sequence [20].

For instance, for the 11×11 sequences, the basic sequence is 11100010010, and the additional sequence is 11100010010, then the new sequence looks like:

$$\underbrace{111000\ 10010}_{1}\ \underbrace{111000\ 10010}_{1}\ \underbrace{111000\ 10010}_{1}\ \underbrace{000\ 11101101}_{0}$$

$$\underbrace{000\ 11101101}_{0}\ \underbrace{000\ 11101101}_{0}\ \underbrace{111000\ 10010}_{1}\ \underbrace{000\ 11101101}_{0}$$

$$\underbrace{000\ 11101101}_{0}\ \underbrace{111000\ 10010}_{1}\ \underbrace{000\ 11101101}_{0}$$

In Fig. 2-10 are the ACF of new signals. We see that 9 of them are built from combinations 3, 7 and 11 only.

The ACF 3×4 signal is shown separately in Fig. 11 because it falls out of the general pattern [21].

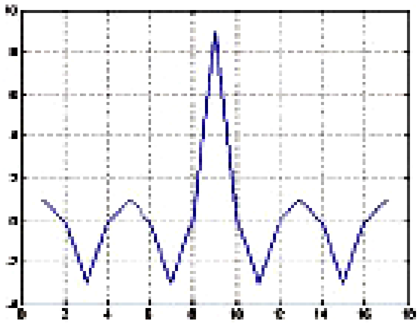

Fig. 2. ACF signals 3×3

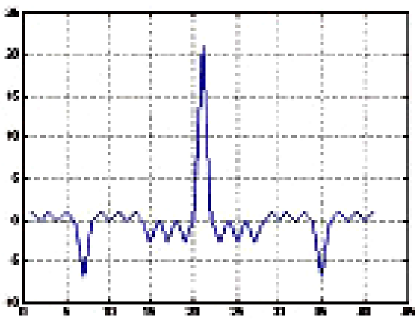

Fig. 3. ACF signals 3×7

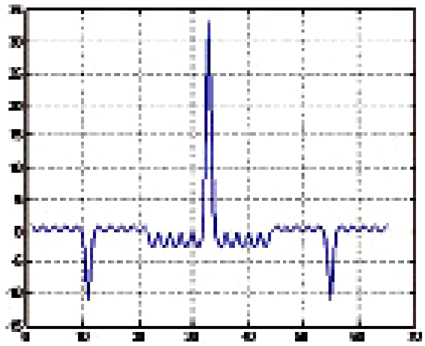

Fig. 4. ACF signals 3×11

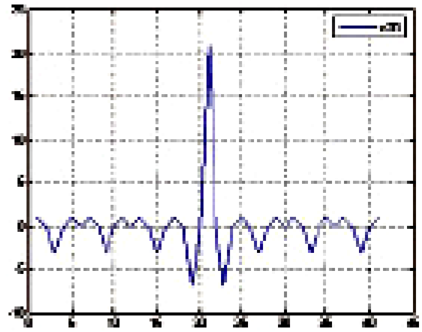

Fig. 5. ACF signals 7×3

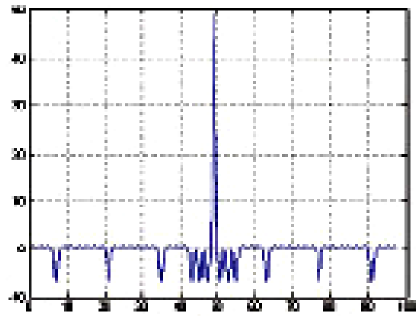

Fig. 6. ACF signals 7×7

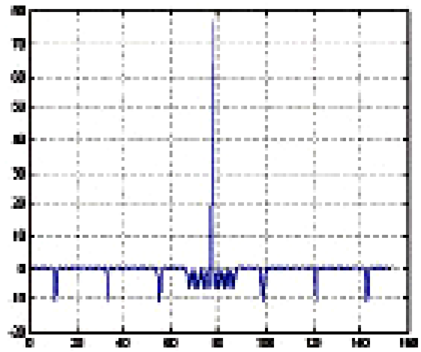

Fig. 7. ACF signals 7×11

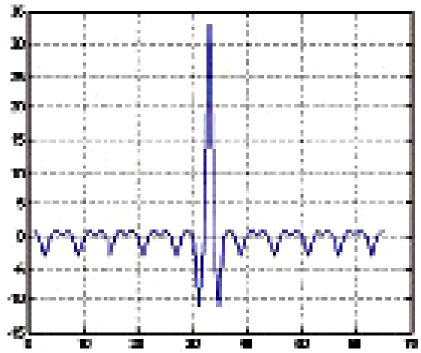

Fig. 8. ACF signals 11×3

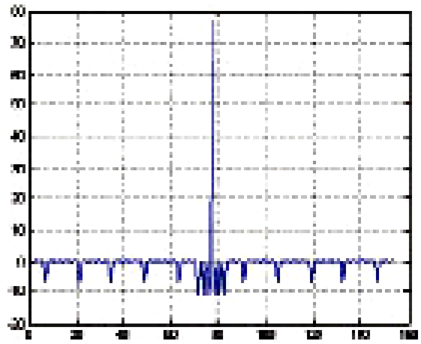

Fig. 9. ACF signals 11×7

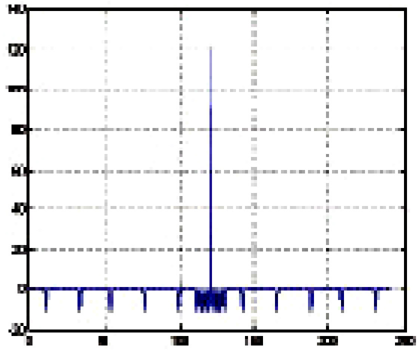

Fig. 10. ACF signals 11×11

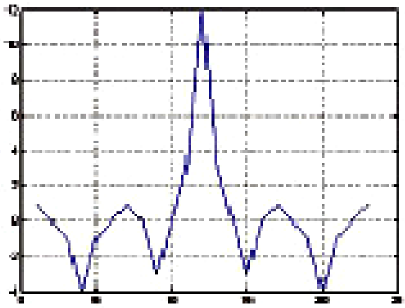

Fig. 11. ACF signal 3×4

The authors carried out studies on noise protection of new signals using modeling in the LabVIEW software environment shown in Fig. 12.

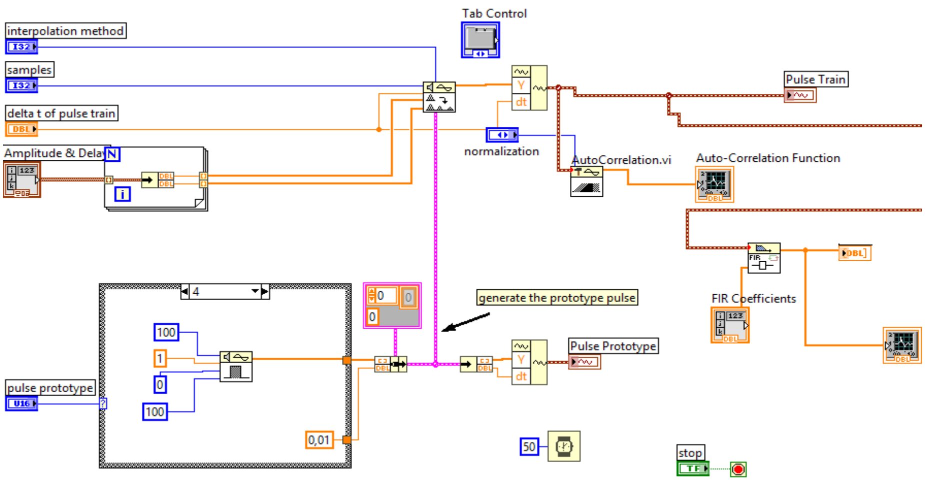

Fig. 12. Barker-like signals by modeling in the LabVIEW software environment

Detection of a new signal becomes difficult only when the Barker`s signal + interference ratio $S / I = 1/43$ [22].

The signals of automation, telemechanic and communication systems, formed in accordance with the found sequences, can be reliably distinguished from interference, many times more powerful than the signals themselves.

Such signals can be equally successfully used for transmitting commands and for reliable synchronization [23].

6 Conclusion

With the developed application the code with a number of discrete numbers over 13 is searched.

A unique sequence was found that resembles a barker-like sequence for phase-manipulated signals over 13 periods that have a minimum achievable level of lateral particle correlation function for this number of judgments.

Thus, the possibility of constructing a barker-like sequence s with the help of ideal ring bundles is shown, as well as creating efficient algorithms for their construction.

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