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Formation and properties of signals based on recurrent codes

***Abstract**. The paper presents the strategy of forming the full value polyphase signals based on the recurrent codes. On the basis of these considerations the general structure of the multiphase recurrent code generator is proposed. The results of simulations are presented and discussed.*

***Streszczenie.** Artykuł przedstawia strategię tworzenia pełnych sygnałów wielofazowych na baize kodów rekurencyjnych. Zaproponowano ogólną strukturę dla wielofazowego generatora kodów ze sprzężeniem zwrotny. Wyniki symulacji zostały zaprezentowane i omówione. (**Generacja sygnałów na bazie kodów rekurencyjnych**)*

Keywords: correlation, polyphase signals, phasecoded signals, signals' generation
Słowa kluczowe: korelacja, sygnały wielofazowe, kodowanie fazowe, generowanie sygnałów.

Introduction

Effectiveness of the objects and scenes monitoring systems is greatly defined by the accuracy of the angle and distance and coordinates measurements. Such measurements can be realized in all weather conditions, at day or night only by using the radar systems. The characteristics mentioned above, hindrance immunity and reliability of the radar systems greatly depends on the type of the probe signal.

Well known and already applied signals can't meet the growing demands to monitoring systems. So the search for new algorithms of forming of the new classes of the complex signals is conducted. One of these signals' classes are the signals based on the recurrent codes.

Generation of recurrent codes

Recurrent codes are formed using linear shift registers (e.g. D-type flip-flops), modulus summation devices and feedbacks, so on the output of such device the code "number" will appear every cycle. The structure of the formation device depends on the chosen phase levels of the signal, forming sequence. The code that will appear is cyclic and repeats every 2^N-1 cycles (where N – number of phase levels).

The forming sequence is chosen from table of first formatives presented in [3]. According to the chosen forming sequence the structure will be changed.

The general structure of bi-phase recurrent code forming device is shown on Fig.1

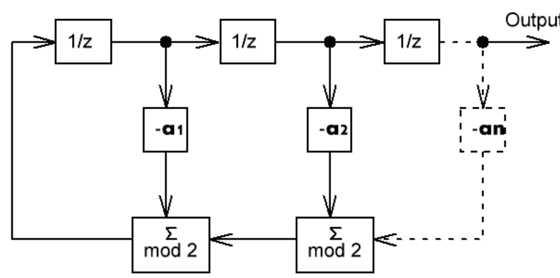

Fig. 1. General structural scheme of bi-phase recurrent code generator

Marked as *1/z* are the mentioned linear shift registers. Elements marked as *–an* are the multiplication elements with fixed multipliers. The multipliers in these elements are the elements of forming sequence.

For example, if the element of sequence is 1 and input of the multiplication block is 1, then the output will be -1 (Input * (-an)=Output, 1*(-1)=-1).

For better understandability the recurrent code formation device structure, for the forming sequence 10000011 is shown on Fig.2.

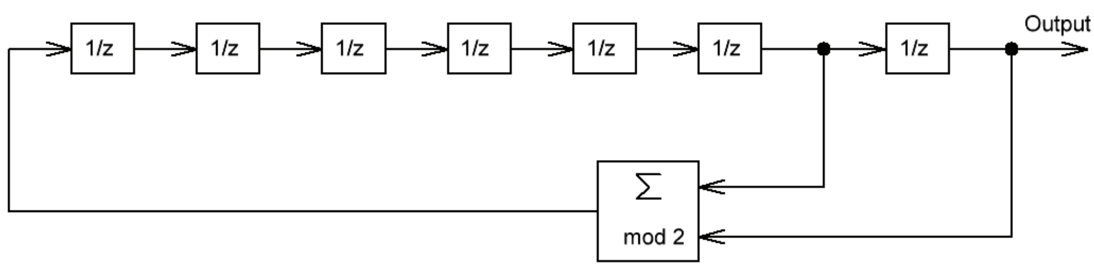

Fig. 2. Structural scheme of bi-phase recurrent code generator for forming sequence 10000011

The structure of the recurrent codes for more phase levels is very similar to the structure of bi-phase recurrent code generator. The main difference is that modulus summation device is different; it depends on the phase levels chosen.

The general structure of multiphase recurrent code generator is shown on Fig. 3.

The forming sequence for the multiphase recurrent code generator is chosen from the tables of *GF(N)* fields (tables of irreducible polynomials for prime modules [1]). According to the chosen forming sequence the structure will be changed

The general structure of the multiphase recurrent code forming device is shown on Fig. 4

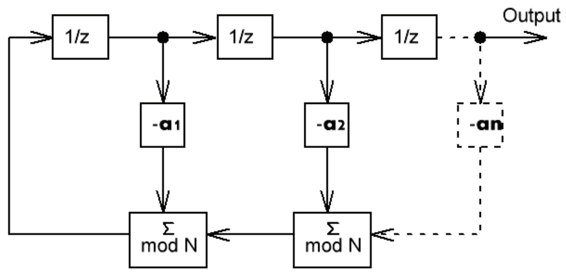

Fig. 3. General structural scheme of multiphase recurrent code generator

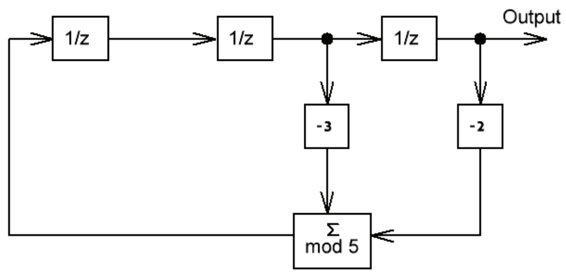

Fig. 4. Structural scheme of 5-phase recurrent code generator for forming sequence 1032

Formation of the signals based on recurrent codes

The output of the code forming device are only the constants, not the full value phase manipulated (PM) signals. These output sequences are used to manipulate the phase of the generated signals.

There are many ways of forming the full value polyphase signals based on the recurrent codes.

The first way is to create the circuit shown on the figs.1-4, using the output of the code generators switch the phase shifters.

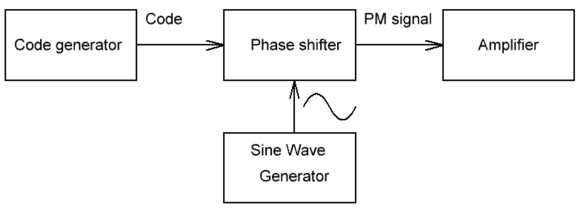

Fig. 5. Simplified structure of the PM signal generator

Another way is to use the memory blocks. Data for these blocks will be the recurrent code. In this case the necessity for big code generators on discrete elements will disappear.

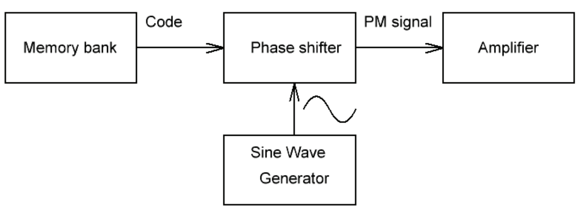

Fig. 6. Simplified structure of the PM signal generator

One more way, and maybe the most widespread in modern electronic systems is the Direct Digital Synthesis (DDS transformation).

All the mentioned methods have theirs advantages and disadvantages. But when the signal frequency gets close to tens of gigahertz, one of the ways to evade the phase distortions is to use the DDS transformations with further frequency multiplications.

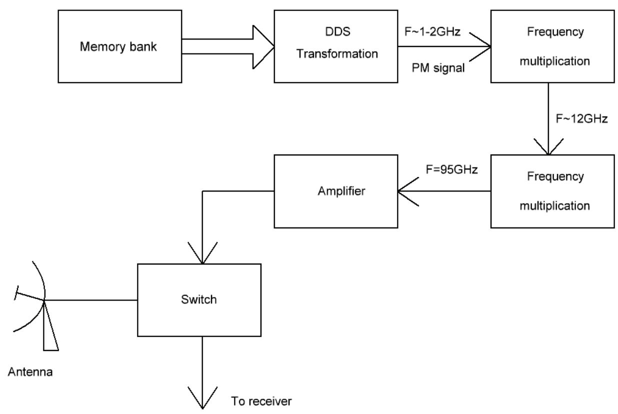

Fig. 7. Simplified structure of the radar transceiver

Properties of recurrent codes

In radar applications it is very important to know the spectral and correlation characteristics of the probe signal. These characteristics directly influence on the structure of the radar system, its receiver and signal processing methods.

The specter of the bi-phase signal based on recurrent code is shown on fig. 8.

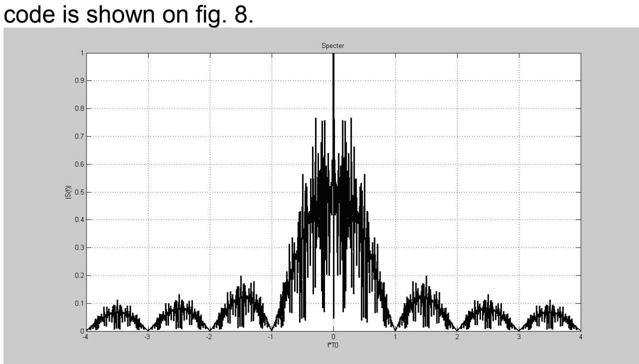

Fig. 8. Specter of bi-phase signal based on recurrent code

The autocorrelation function of such signal is shown on fig. 9.

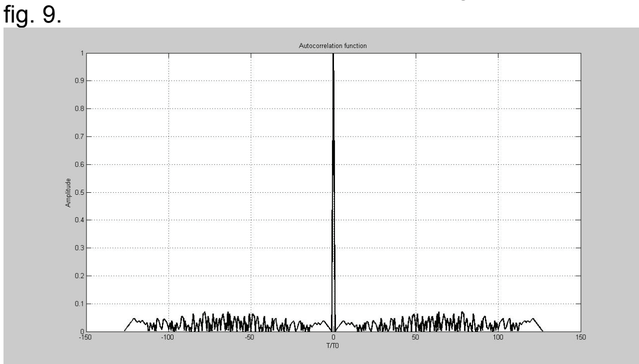

Fig. 9. Autocorrelation of bi-phase signal based on recurrent code

The ambiguity function is the most valuable characteristic of the signal in radar applications, as it describes the response of the signal on the time and Doppler frequency shifts.

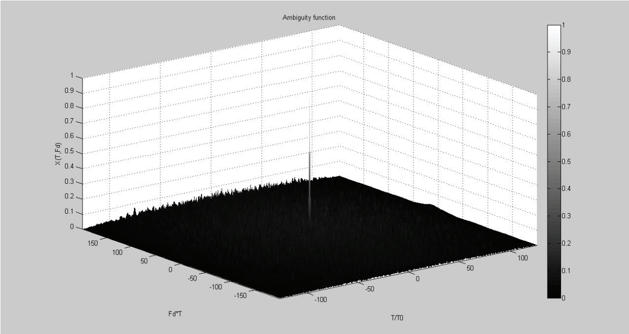

Fig. 10. Ambiguity function of bi-phase signal based on recurrent code

The same characteristics for the 5-phase signal based on recurrent code are shown on figs. 11-13.

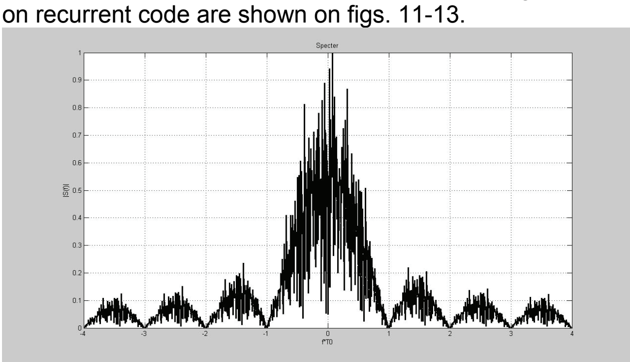

Fig. 11. Specter of 5-phase signal based on recurrent code

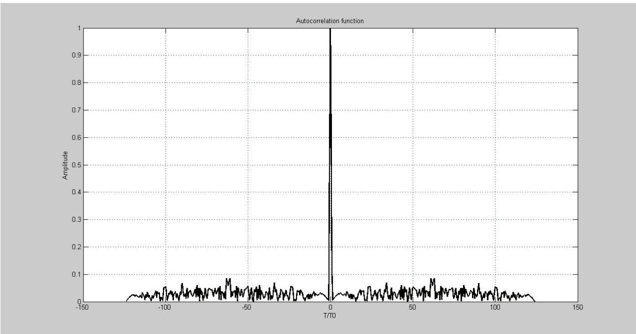

Fig. 12. Autocorrelation of 5-phase signal based on recurrent code

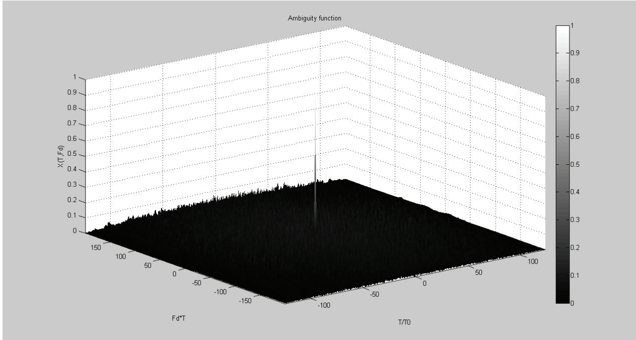

Fig. 13. Ambiguity function of bi-phase signal based on recurrent code

Conclusions

New types of signals give us the opportunity to form needle-shaped autocorrelation functions with low levels of the side lobes on the time-Doppler frequency field. Their use in the radar systems will lead to the growth of the system's resolution, hindrances immunity and reliability of the detection and recognition.

Choosing the most effective way of signal formation and generation will effect on the system's cost and technical parameters.

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