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SYNTHESIS OF THE BINARY ENCODER WITH PULSE-FREQUENCY DATA REPRESENTATION

A possibility of synthesis of radio-frequency encoder is considered using known methods developed for the case of pulse-potential representation of information and pulse-frequency method for synthesis of radio-frequency logic elements. It is shown that application of physical schemes for synthesis of the encoder with radio-frequency pulsing data representation enables significant simplification of the flowchart compared with traditional methods using radio-frequency logic elements as the basis.

Key words: *radio-frequency logic elements, pulse-frequency data representation, encoder, decoder, total intermediate result, radio-frequency pulse, filling frequency.*

Introduction

If radio-frequency (RF) or pulse-frequency signals are the informative parameters characterizing the object state (e.g. in non-linear radar systems where multiple-frequency signals are the probing ones and this allows to receive gain in the range of target detection without increasing the radar power), it is expedient to process information signals directly at carrier frequency. First, this will allow to avoid additional transformations and accuracy loss connected with them, and second, to increase interference immunity of data transmission and processing systems, to use the same and significantly lower voltage levels corresponding to logic "0" and "1" as compared with discrete data representation with pulse-potential signals. Besides, this makes it possible to avoid one of the main disadvantages of discrete data representation with pulse-potential signals – the necessity of transmission of signals with low-frequency spectrum components.

Basic logic and operational elements with frequency data representation have been developed lately [3, 4] as well as methods of their synthesis. Corresponding research was conducted. The aim of this paper is synthesis of one of the common elements of data processing systems – the encoder designed for transformation of input m-digit unitary code into n-digit positional code.

Synthesis of radio-frequency pulse binary encoder

Let's consider synthesis of binary encoder for frequency data representation when radio-frequency pulse with filling frequency ω_0 corresponds to logic zero and RF pulse with filling frequency ω_1 - to logic unit.

It is known that the relation between the number of encoder inputs and outputs is defined by the expression $m = 2^n$. For the case of encoder being used for the operation of the unitary code transformation into output binary position code, the logic of its work is presented in Table 1.

For synthesis of the flowchart of RF pulse encoder traditional method [5] will be used first. According to it, flowchart of the encoder in "OR" basis has the form shown in fig. 1.

Table 1

i	x_3	x_2	x_1	x_0	y_1	y_2	I
	0	0	0	0	-	-	0
	0	0	0	1	0	0	1
	0	0	1	0	0	1	1
	0	1	0	0	1	0	1
	1	0	0	0	1	1	1

Using the flowchart of RF pulse element "OR" [3], it is easy to build flowchart of encoder with RF pulse data representation (fig. 2). As fig. 2 shows, in order to build this encoder, it is necessary to use 6 converters of frequency *F*, 6 high-pass filters Φ_B, 5 output splitters *T*, 4 power combiners, 2 band-pass filters $\Phi_c^{\,0}$ for the frequency of logic «0» and 2 – for the frequency of logic "1", 2 generators of auxiliary signals at frequencies ω_0 и ω_1. So the diagram is rather complicated and its practical application is inexpedient.

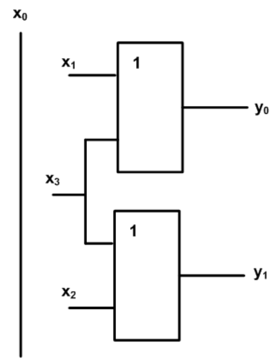

Fig. 1. Flowchart of the encoder with pulse-potential data representation

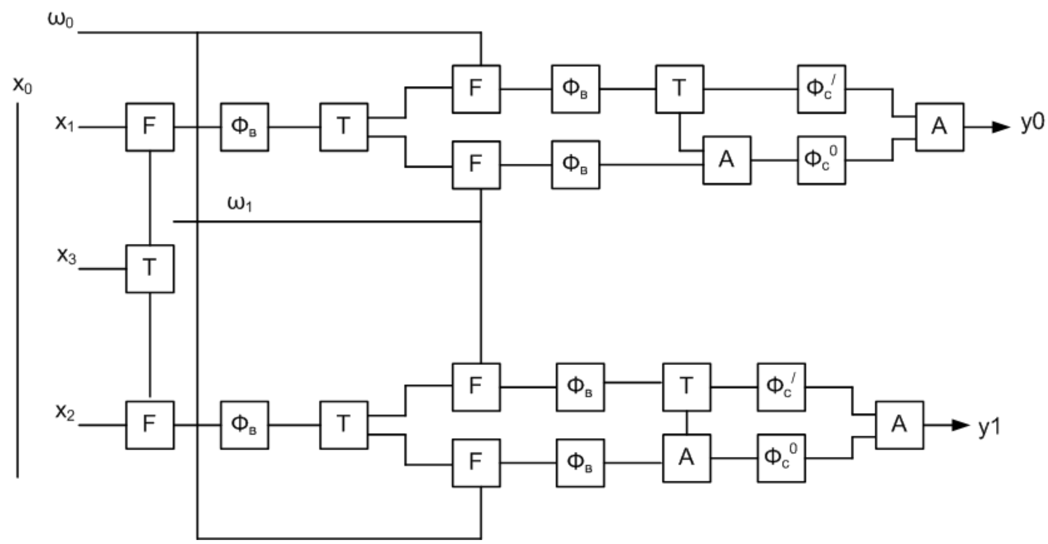

Fig. 2.Flowchart of the pulse-frequency encoder

Using the method of synthesis of RF pulse logic elements, suggested in [4], and taking into account equations describing the encoder operation [5]

$$y_0 = x_1 + x_3$$
$$y_1 = x_2 + x_3, \qquad (1)$$

we shall perform synthesis of such encoder.

Taking into account that RF pulse with filling frequency ω_0 corresponds to logic zero and RF pulse with filling frequency ω_1 corresponds to logic "1", the truth table for RF pulse encoder has the form (Table 2):

Table 2

x_3	x_2	x_1	x_0	y_1	y_2	I
ω_0	ω_0	ω_0	ω_0	-	-	ω_0
ω_0	ω_0	ω_0	ω_1	ω_0	ω_0	ω_1
ω_0	ω_0	ω_1	ω_0	ω_0	ω_1	ω_1
ω_0	ω_1	ω_0	ω_0	ω_1	ω_0	ω_1
ω_1	ω_0	ω_0	ω_0	ω_1	ω_1	ω_1

Each of y functions can be written as operator equation of the form

$$Y=PX. \tag{2}$$

This equation establishes the relation between two information sets Y and X and one operator sequence P. Proceeding from (2), the problem of the encoder synthesis consists in the following. For given X and Y it is the necessary to find operator sequence P, satisfying equation (2), i. e. it is necessary to synthesize the encoder described by operator sequence P that performs the transformation of input signals set X into output signals set Y.

As operator sequence for each Y function will have common parts, it seems possible to build common operator sequence. Taking into account characteristic features of encoder equations (i. e. the fact that not all information sets X are included into both equations (1)), we shall first consider synthesis of operator sequences for each of the equations (1).

The analysis of the truth table separately for functions Y_0 and Y_1 shows that there exists a unique dependence between them as different values of the functions correspond to different values of total intermediate results (TIR) and equal values of the functions correspond to equal values of TIR. In this case TIR are calculated by the expression:

$$Z=\sum_{i=1}^{m}\omega_i .$$

Let's determine operator sequences for each of the functions..

As separate set of input signals $x_1, x, \ldots x_n$, on the one hand, corresponds to definite TIR values Z_i, and, on the other hand, – to the values of functions Y_i, deviation of the values of Z_i from Y_i can be found:

$$\Delta_i = Z_i - Y_i .$$

From the set of values of deviation function Δ_i we select all of its different values. The number of different Δ_i values determines the number of additional signals, and the values of these functions are the signal values..

When Y_i functions are being realized, it is not known a priori what frequency set arrives at the given moment. So it is necessary to check if values of Z_i correspond to the values of $Y_{\rm i}$ by considering all possible values of Δ_i of the function Δ_j , i. e.

$$\delta_{ij} = z_i\Delta_j ,\ \ (j=1,2,...,g). \tag{3}$$

And only when $\Delta_i = \Delta_j$, the values of δ_{ij} will be equal to Y_i. Function C_j corresponds to each j value. At each frequency set function C_j takes the value 1 or 0 and

$$C_{ij} = \begin{cases} 1, \text{если } \Delta_{\rm i} = \Delta_j \\ 0, \text{если } \Delta_{\rm i} \neq \Delta_j \end{cases} .$$

Taking this into account, the values of Y_i are found by the expression:

$$Y_i = \delta_{i1}C_{i1} + \delta_{i2}C_{i2} + \ldots + \delta_{ig}C_{ig} .$$

Here the values of C_{ij} provide filtration, i. e. they show if the values of function Y_i belong or do not belong to the values of δ_{ij} . Each operation (3) is realized by a separate element described by operator F. To ensure the arrival of signal Z_i at all F elements, it is necessary to provide its branching using the elements realized by operator T. To provide the output signal of RF pulse encoder, it is necessary to derive K information signals from each difference of signals formed by elements F. This is provided by filters Φ_C^0 and Φ_C^1. In general case filters can extract signals coming from one element F. Considering this, elements of branching T and union A can be located between element F and the filters. Output signals from r. F. Pulse encoder are formed directly by the combination of signals from the outputs of all filters. This function is realized by element A. Proceeding from this, all the above-mentioned calculations for function Y_0 are presented in Table 3, that we call a summary table.

The analysis of deviation function shows that it can take only one value ω_0, and so for the realization of function Y_0 one auxiliary signal is necessary. Membership functions are given in Table 4.

Table 3

x_1	x_3	y_0	z_i	$z_i - y_0$	C
ω_0	ω_0	ω_0	$2\omega_0$	ω_0	1
ω_1	ω_0	ω_1	$\omega_0+\omega_1$	ω_0	1
ω_0	ω_0	ω_0	$2\omega_0$	ω_0	1
ω_0	ω_1	ω_1	$\omega_0+\omega_1$	ω_0	1

Ttable 4

C	$f(\omega_0)$	$f(\omega_1)$
1	1	0
1	0	1
1	1	0
1	0	1

Using these tables, operator description of function Y_0 is built:

$$x_1 \overset{1}{\uparrow} x_3 \overset{2}{\uparrow} \omega_0 \overset{3}{\uparrow} : \overset{1}{\downarrow}\overset{2}{\downarrow} F\Phi_B \overset{4}{\uparrow}\overset{3}{\downarrow}\overset{4}{\downarrow} F\Phi_B T \overset{5}{\uparrow}\overset{6}{\uparrow}\left(\overset{5}{\downarrow}\Phi_c^0 \overset{7}{\uparrow}\overset{6}{\downarrow}\Phi_c^1 \overset{8}{\uparrow}\right)\overset{7}{\downarrow}\overset{8}{\downarrow} A : Y_0 .$$

Let's compile summary table for function Y_1 (Table 5).

From the analysis of this table it follows that for realization of function Y_1 only one auxiliary RF signal with filling frequency ω_0 is required. Membership functions are given in Table 6.

Table 5

x_2	x_3	y_1	z_i	$z_i - y_1$	C
ω_0	ω_0	ω_0	$2\omega_0$	ω_0	1
ω_0	ω_0	ω_0	$2\omega_0$	ω_0	1
ω_1	ω_0	ω_1	$\omega_1+\omega_0$	ω_0	1
ω_0	ω_1	ω_1	$\omega_1+\omega_0$	ω_0	1

Table 6

C	$f(\omega_0)$	$f(\omega_1)$
1	1	0
1	1	0
1	0	1
1	0	1

Using tables 5, 6, we build operator description for function Y_1.

$$x_2 \overset{1}{\uparrow} x_3 \overset{2}{\uparrow} \omega_0 \overset{3}{\uparrow} : \overset{1}{\downarrow}\overset{2}{\downarrow} F\Phi_B \overset{4}{\uparrow}\overset{3}{\downarrow}\overset{4}{\downarrow} F\Phi_B T \overset{5}{\uparrow}\overset{6}{\uparrow}\left(\overset{5}{\downarrow}\Phi_c^0 \overset{7}{\uparrow}\overset{6}{\downarrow}\Phi_c^1 \overset{8}{\uparrow}\right)\overset{7}{\downarrow}\overset{8}{\downarrow} A : Y_1 .$$

From the analysis of operator descriptions for functions Y_0, Y_1 it follows that for the encoder realization only one RF signal with filling frequency ω_0 is required.

Taking this into consideration as well as operator descriptions for each function, we build general operator description for the encoder.

$$x_1 \overset{1}{\uparrow} x_2 \overset{2}{\uparrow} x_3 \overset{3}{\uparrow} \omega_0 \overset{4}{\uparrow} : \overset{3}{\downarrow} T \overset{5}{\uparrow}\overset{6}{\uparrow}\Big(\overset{1}{\downarrow}\overset{5}{\downarrow} F\Phi_B \overset{7}{\uparrow}\overset{2}{\downarrow}\overset{6}{\downarrow} F\Phi_B \overset{8}{\uparrow}\overset{4}{\downarrow}\overset{7}{\downarrow}$$

$$F\Phi_B \overset{9}{\uparrow}\overset{4}{\downarrow}\overset{8}{\downarrow} F\Phi_B \overset{10}{\uparrow}\overset{9}{\downarrow} T \overset{11}{\uparrow}\overset{12}{\uparrow}\overset{10}{\downarrow} T \overset{13}{\uparrow}\overset{14}{\uparrow}\overset{11}{\downarrow}\Phi_C^0 \overset{15}{\uparrow}\overset{12}{\downarrow}\Phi_C^1 \overset{16}{\uparrow}\overset{13}{\downarrow}\Phi_C^0 \overset{17}{\uparrow}\overset{14}{\downarrow}$$

$$\Phi_c^1 \overset{18}{\uparrow}\overset{15}{\downarrow}\overset{16}{\downarrow} A \overset{19}{\uparrow}\overset{17}{\downarrow}\overset{18}{\downarrow} A \overset{20}{\uparrow} : \overset{19}{\downarrow} Y_0 \overset{20}{\downarrow} Y_1 .$$

Flowchart, presented in fig. 3, corresponds to this operator description.

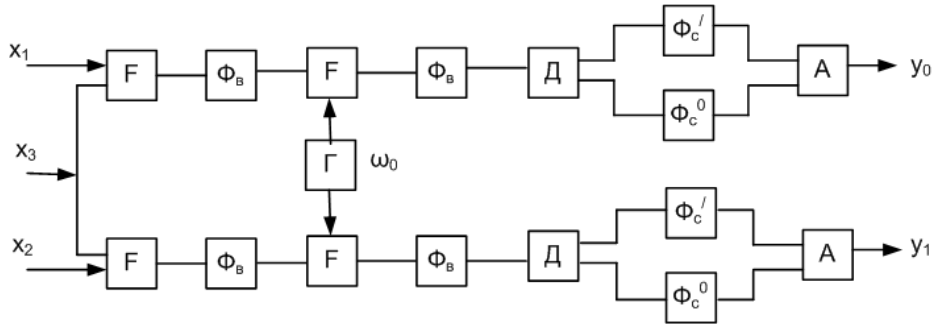

Fig. 3 Flowchart of RF pulse encoder

Comparison of encoder flowcharts, presented in fig. 2 and fig. 3, shows that application of the suggested method makes it possible to simplify the flowchart: the number of *F* elements is decreased by 2, Φ_B элементов – by 2, *T* and *A* elements – by 2 and there will be one additional RF signal source less.

Conclusions

Synthesis of radio-frequency pulse encoder of binary code has been performed using physical charts, which enables flowchart simplification as compared with the same encoder synthesized according to the traditional method with the application of radio-frequency logic elements as the basis.

REFERENCES

1. Попов Д. Н. Обработка многочастотных сигналов // Радиоэлектроника. – 2001. – Т. 44. – № 3. – С. 26 – 30.
2. Вернигоров И. С., Борисов А. Р., Харин Б. В. К вопросу о применении многочастотных сигналов и нелинейной радиолокации // Радиотехника и электроника. – 1998. – Т. 43. – № 1. – С. 63 – 66.
3. Кичак В. М. Синтез частотно-імпульсних елементів цифрової техніки. Монографія. – Вінниця: УНІВЕРСУМ-Вінниця, 2005. – 266 с.
4. Кичак В. М., Семенова О.О. Радіочастотні та широтно-імпульсні елементи цифрової техніки. Монографія. – Вінниця: УНІВЕРСУМ-Вінниця, 2008. – 163 с.
5. Бабич Н. П., Жуков И. А. Компьютерная схемотехника. Методы построения и проектирования. – К.: «МК- Пресс», 2004. – 576 с.

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