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Fig. 1

Figure 1: Fig. 1

Abstract

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IMPLEMENTATION OF CIRCUITS OF DISCRETE CORRECTORS

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1. Statement of the problem. At present much attention is being given to the study of signal systems with detection and correction of distortions. Of substantial importance here is the search for rational methods of implementing receiving devices that perform the functions of analyzing distortions and correcting them.

The methods known from the literature ([1–3]) provide for the sequential in time (multicycle) performance of the functions of the receiving device: fixing the signal, analyzing distortions, and correcting the distorted elements. This was the basis for introducing the term now in common use, "signal systems with detection and correction of distortions." M. A. Gavrilov proposed a method in which the single-cycle performance of the above functions is provided ([4,5]), which, under the same conditions, reduces by about a factor of three the time required to correct the signal and decreases the required number of relay elements. He also proposed the idea of the so-called "discrete corrector," a device to whose input a distorted signal is applied, and from whose output the corrected signal is taken (Fig. 1). Such a corrector can be inserted at any point of the signal-transmission path (in one place or in several) and can carry out correction of the distortions present.

Fig. 1

It is most rational to implement a discrete corrector, like receiving devices, in the class of single-cycle circuits. Circuits of discrete correctors belonging to the class of recounting circuits have certain special features. These features, as well as the implementation of one of the types of correctors using contact relays, crystal elements, and hysteresis elements, are considered below.

2. Corrector built on electromechanical relays. Let a system of k working signals be chosen, ensuring correction of d and detection of $d + \Delta$ errors**. Obviously, the i-th output (Fig. 1) must be energized every time the i'-th input is energized and the corresponding signal has undergone no more than d unit distortions (in the case of $d + \Delta$ distortions, the i-th output must not be energized, since in this case a "protective failure" ([6]) must be carried out). The problem of constructing the corrector reduces***

* The implementation of the structures of discrete correctors was developed: for structures on relay-contact elements by V. M. Ostianu (who also gives a general estimate of the number of valves in them), for the case of semiconductor elements by V. N. Rodin, and for the case of hysteresis elements by B. L. Timofeev.

** The notation adopted in ([4,5]) is used here.

*** The corrector circuit, which in general is an (n, n)-terminal network, can be divided into two subcircuits, one of which—an $(n, 1)$-terminal network—contains only the windings of the receiving elements and its construction presents no difficulties, while the second—an $(1, n)$-terminal network—contains the contacts of these elements.

to the construction of a $(1, n)$-multipole realizing the obtained functions of action on n actuating elements (n is the number of digits in the binary representation of the signal).

It is not hard to see that, for any d, these functions have the following properties:

1) They can be represented in the form

$$\begin{aligned} F_1 &= a_1^{(1)} + a_2^{(1)} + \dots + a_{k_1}^{(1)}, \\ F_2 &= a_1^{(2)} + a_2^{(2)} + \dots + a_{k_2}^{(2)}, \\ &\dots\dots\dots\dots\dots \\ F_n &= a_1^{(n)} + a_2^{(n)} + \dots + a_{k_n}^{(n)}, \end{aligned}$$

where $a_j^{(i)}$ are sums of certain unit constituents. Moreover, if one and the same unit constituent enters into $a_{j_1}^{(i_1)}$ and into $a_{j_2}^{(i_2)}$, then $a_{j_1}^{(i_1)} \equiv a_{j_2}^{(i_2)}$.

2) Let a system of operating signals be chosen

$$\begin{aligned} \alpha_1 &= \{\alpha_1^1, \alpha_1^2, \dots, \alpha_1^n\}, \\ \alpha_2 &= \{\alpha_2^1, \alpha_2^2, \dots, \alpha_2^n\}, \\ &\dots\dots\dots\dots \\ \alpha_k &= \{\alpha_k^1, \alpha_k^2, \dots, \alpha_k^n\}. \end{aligned}$$

If among the chosen signals there are at least two such signals α_{t_1} and α_{t_2} that, for at least one h $(0 < h \leq n)$, $\alpha_{t_1}^h = \alpha_{t_2}^h$, then there exists at least one pair of numbers i_0, i_0' $(i_0 \neq i_0',\ 0 < i_0 \leq n,\ 0 < i_0' \leq n)$ such that $M_{i_0} \cap M_{i_0'} \neq 0$,

Fig. 2

Figure 2: Fig. 2

where $M_i = \{a_j^{(i)}\}$, and m is the number of units in the representation of the signal. In relay realization of a $(1, n)$-multipole with prescribed conductivities possessing properties 1) and 2), it is convenient to use the following method: a) the set $M_0 = \{a_j^{(0)}\} = \bigcup_i M_i$ is formed; let its cardinality be p; b) a $(1, p)$-multipole is constructed which realizes all elements of the set M_0; c) by means of a valve network, from the constructed $(1, p)$-multipole one obtains a $(1, n)$-multipole realizing the prescribed conductivities*. In this case the number of valve elements N is bounded above by the number

$$Q = 2[2^p - (p + 1)].$$

$N = Q$ in the case when, for some fixed i_s, $M_{i_s} = M_0$, while all the remaining M_i are all possible combinations of elements from M_{i_s} taken $1, 2, \dots, k_{i_s} - 1$ at a time (obviously, in this case $n = 2^{k_{i_s}}$). Fig. 2 gives the circuit of a corrector correcting one and detecting two unit errors for $n = 5$, constructed by this method (the signals 11010 and 10101 are chosen as operating signals).

Fig. 2

3. **Corrector on electronic or crystalline elements.** The problem of constructing a corrector reduces to the

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* This can be done by virtue of property 2).

the construction of the gate network (7), which is connected to the flip-flops recording the input signal.

The construction procedure is as follows:

1) For the i-th operating signal, the set A_i is written out of such unit constituents, each of which corresponds to the i-th undistorted signal and to all possible distorted ones obtained as a result of distorting this signal by no more than d unit distortions.

2) In the set A_i, from each two constituents differing by one unit distortion, one is excluded, and in the other the element on which this unit distortion fell is omitted. As a result, a set B_i is obtained, whose cardinality b_i is equal to

$$b_i = \sum_{r=1}^{d} (-1)^{r-1} C_n^{d-(r-1)}, \qquad \text{where } i = 1, 2, \dots, k.$$

Fig. 3

Figure 3: Fig. 3

Fig. 4

Figure 4: Fig. 4

3) For every i, each element of B_i is decomposed in accordance with the method (8).

4) A gate network is constructed that realizes each element of the set

Fig. 3

B_i, taking into account identical parts of the constituents both in the elements of the given set and in other sets.

5) The outputs of the corrector for each element of the given set B_i are combined by means of gates into one, which realizes the units of the basic signal from the set A_i. Figure 3 gives the circuit of the corrector for the same system of operating signals as in item 2.

4. Corrector constructed on hysteresis elements (h.e.) with a rectangular loop. In the circuit of such a corrector, the number of h.e. for each signal is equal to n. H.e. that respond identically to the action of a signal can be combined similarly to contacts in relay-contact circuits. Each h.e. has three windings, independently of m and n. All h.e. are assembled into groups, each of which is intended to receive one of the operating signals. The outputs of the h.e. in each group are connected in series. The number of groups is k.

The voltages at the outputs of the h.e. of one group are summed algebraically. For an undistorted signal, the voltage at the output of the corresponding

of the relay-element group is equal to mU, where U is the unit voltage. For any single distortion the voltage at the output of the corresponding group will become equal to $(m-1)U$; for $d+\Delta$ distortions, it will be $(m-d-\Delta)U$.

To ensure proper operation of the circuit it is necessary to satisfy the following condition:

1) $(m-d-\Delta)U < E < (m-d)U$, where E is the firing potential of the output element. In the circuit shown in Fig. 4, a thyratron MTKh-90 is used as the output element B (the beginnings of the windings are marked by dots).

Fig. 4

The proposed circuit was developed for the case where m is small. If m is large, the corrector circuit can be constructed in the following way. With an undistorted signal, a constant voltage U_0 from a source connected in series with each relay-element group is applied to the output element. The connection of the relay elements is carried out in such a way that, when the signal is distorted, a voltage directed opposite to the voltage of the source U_0 arises at each relay-element group that has received a false binary digit. The condition necessary for operation of the circuit has the form

$$U_0 - (d + \Delta) < E < U_0 - dU.$$

In this case U depends only on d. The output element in this case must respond to polarity.

Figure 4 gives a corrector circuit using relay elements for the same system of operating signals as in §§ 2 and 3, constructed according to the first of the indicated methods. In the circuit shown, the elements $T_{1,1}$ and $T_{2,1}$ have been combined:

$$T_{1,1} \cdot T_{1,2} \cdot T_{1,3} \cdot T_{1,4} \cdot T_{1,5} + T_{2,1} \cdot T_{2,2} \cdot T_{2,3} \cdot T_{2,4} \cdot T_{2,5} =$$

$$= T_1 \left(T_{1,2} \cdot T_{1,3} \cdot T_{1,4} \cdot T_{1,5} + T_{2,2} \cdot T_{2,3} \cdot T_{2,4} \cdot T_{2,5} \right).$$

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REFERENCES

1. R. W. Hamming, Bell Syst. Techn. J., **26**, No. 2 (1950).
2. D. Slepian, Bell Syst. Techn. J., **35**, No. 1 (1956).
3. R. R. Varshamov, DAN, **117**, No. 5 (1957).
4. M. A. Gavrilov, *Automation and Telemechanics*, **17**, No. 12 (1956).
5. M. A. Gavrilov, G. A. Shastova, Session of the Academy of Sciences of the USSR on Scientific Problems of Automation of Production (15–20 X 1956), **4**, Publishing House of the Academy of Sciences of the USSR, 1957.
6. M. A. Gavrilov, *Telemechanization in the National Economy*, Publishing House of the Academy of Sciences of the USSR, 1956.
7. M. A. Gavrilov, *Automation and Telemechanics*, **16**, No. 4 (1955).

8. D. R. Brown, N. Rochester, Proc. IRE, **37**, No. 2 (1949).

Note: Figure translations are in progress. See original paper for figures.