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Abstract

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INVERSION OF "NONPLANAR" CIRCUITS

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From the theory of relay circuits it is known that any H-shaped circuit can be decomposed into the sum of several simple Π-shaped circuits. This decomposition is carried out by the method of determining the chains acting on the given element ([1]). Thus, it may be considered that there is no relay circuit that could not be represented without intersections in the plane of the drawing. In the analysis of relay circuits we trace the paths of current from one bus to another, i.e., graphically we trace the path of a point, which in any case can be represented as a straight line; analytically, however, it is obvious that equivalences of Boolean algebra cannot be equivalences of a higher degree than the first.

Fig. 1

In accordance with the method of determining the chains acting on the given element, one may assert that circuits constructed for the same conditions and differing from one another in that in one of them there is a larger number of single-valued elements differ from one another not in principle, but constructively. Therefore the circumstance that the branches g, b, and k (Fig. 1) have no point of intersection in the plane of the drawing, in principle has no influence whatever on the operation of the circuit and does not prevent the application to it of the usual methods of analysis of relay circuits.

Fig. 2

Consequently, a spatial circuit can be transformed into a plane H-shaped circuit, which under this transformation will contain a somewhat larger number of elements. However, from the essence of the transformation it is clear that this increase in the number of elements occurs at the expense of increasing the number of single-valued elements and is therefore fictitious.

Further, while inversion of parallel-series circuits is so simple that it can be successfully carried out analytically, inversion of H-shaped circuits is more conveniently performed graphically; in this case, in our opinion, the most acceptable method is that of transfiguration. The essence of this method, as applied to the inversion of H-shaped circuits, reduces to the following: instead of determining the nodes by which the contours of the original circuit must be replaced, the nodes of the original circuit are expanded into the contours of the inverse circuit. The transfiguration method for inverting H-shaped circuits is more convenient

Fig. 3

Figure 1: Fig. 3

because, in these circuits, the nodes are always distinguished, and the operation of successively expanding all nodes into contours is simple and quickly leads to the correct result.

Fig. 3

Since spatial or "nonplanar" circuits can be represented in the form of H-shaped circuits, and the inversion of the latter is accomplished by a simple graphical operation, it is natural, before inverting a spatial circuit, to decompose it into its constituent planar circuits.

Let us decompose the given circuit of Fig. 1 into two circuits by determining the chains on which the elements a and g act. Both circuits, whose sum is equivalent to the original one, are inverted separately (Fig. 2). The inverted summands of the original circuit are multiplied, i.e., connected in series. Then a graphical simplification is performed, the purpose of which is to obtain an inverse circuit with the same number of elements as in the original circuit (however, this is not always possible). The resulting circuit is inverse with respect to the original one. To verify this, let us perform on it the operation of repeated inversion, and, since $f = F$, the result of this operation (see Fig. 3) must be the original circuit. It is not difficult to verify that the resulting circuit is equivalent to the original one, since its closed contours *ebkcd* are completely identical and, in any case of their mutual connection, may be regarded as a single one; the connection points to which are also known.

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CITED LITERATURE

1. M. A. Gavrilov, *Theory of Relay-Contact Circuits*, Publishing House of the Academy of Sciences of the USSR, 1950.

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