FORMATION REACTION OF LINEAR CIRCUITS BY THE IMPLICIT METHOD OF SUPERPOSITION

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The analysis of linear circuits by the symbolic method consists in forming a response in a symbolic form, which is solved using the principle of superposition. According to the principle, the response (voltage or current of the jth branch) is determined

$$y_j = \sum_{i=1}^{n} F_{ji} x_i,$$

where x_i is the voltage or current of the i-th source of exposure (total n sources); F_{ji} - circuit (transfer from branch i to branch j) function. Variables y_j, F_{ji}, x_i are presented in complex or operator form for circuit analysis in steady-state harmonic or transient modes, respectively.

For a Cramer Rule Response

$$y_j = \frac{\Delta_j}{\Delta},$$

and any other methods of decomposing the determinant of the numerator matrix Δ_j obtained by replacing the jth column in the parameter matrix with the column matrix of the right side of the system of equations, are not widely used. Thus, the superposition principle has become the basis of the symbolic theory of linear chains due to the simplicity of solving systems of linear equations. Using the principle of superposition revealed the possibility of applying the theory of determinants and theory of matrices.

However, for all its merits, the principle of superposition requires finding any response to get n numerators (with one common denominator), which prevents the construction of a symbolic expression of a circuit function according to the criterion of minimum computational complexity. This is a significant drawback of the principle of superposition, since it is computational complexity that serves as a criterion for evaluating modern methods and programs of symbolic analysis. In addition, the overlap principle is not economical in terms of the number of formative operations, since it requires finding the same repeated factors several times in different circuit functions. The principle of superposition requires, of course, a multiple of the number of sources to increase the time spent on combinatorial operations to search for cross sections for diakoptic analysis.

Even in his topological method, Kirchhoff used the grouping of the terms of the numerator Δj with respect to the products of the circuit resistances corresponding to its trees. Moreover, the parameters of independent sources appeared repeatedly in the generated expression, that is, implicitly. In the matrix interpretation, this corresponds to the decomposition of the determinant of the numerator matrix into elements selected arbitrarily. To obtain the optimal expression of the desired response, the choice of the element should not be arbitrary, but according to the criterion of maximum participation of the corresponding parameter in the generated character expression.

Therefore, it is necessary to apply the method of constructing the responses of linear circuits with several independent sources in implicit form

$$y_j = \frac{\Delta_j}{\Delta} = \frac{W(x_1, x_2, \ldots, x_n)}{D}.$$

This method is called the implicit superposition method. It should provide arbitrary (according to a given criterion) selection of parameters of independent sources, along with the parameters of other elements of the circuit. Previous attempts to implement the method on the basis of replacing independent sources with quasi-passive two-terminal devices did not give the desired result due to the difficulty of finding their parameters.

Most often, this method is used to analyze short circuit modes. In a single-phase earth fault, the combined equivalent circuit is obtained by connecting the equivalent circuits of all three sequences in series and triple the resistance at the short circuit location. In this case, the currents of all three sequences are equal to each other.

With a bipolar short circuit to ground, all three circuits sequences are connected in parallel, while the triple short-circuit resistance is connected in series to the branch with a zero sequence diagram.

In a mutual bipolar short circuit, the combined circuit consists of two branches connected in parallel. The first branch is a series connection of a direct sequence circuit and a half resistance at the point of short circuit. The second branch is also a serial connection, but already reverse sequence and half resistance circuits short circuit.

Each of the noted combined equivalent schemes contains many sources, therefore, for their analysis in symbolic form, it is desirable to use the implicit principle of overlap. Thus, when analyzing one and the same scheme, it is supposed to use both the explicit superposition principle in the form of the method of symmetric components, and the implicit superposition principle for constructing the response using one circuit function. The proposed technique for the simultaneous use of both the overlay principle and the implicit overlay method can be called the combined explicitly-implicit superposition method. This method allows you to get a more compact expression for the desired response.

Along with the above limitations of the method of symmetrical components, its disadvantage is the need to calculate three additionally generated schemes. Meanwhile very attractive is an approach in which one general device equivalent circuit is used and the calculation is carried out relative to the actual currents, as in conventional circuits. The implementation of this approach in symbolic form is also facilitated by using the implicit method of superposition.

A numerical analysis of circuits without using the explicit principle of superposition is obvious and is solved by forming a single vector of sources of influence for the system of equations. For two or more numerical action vectors, the principle of superposition is applied.

In symbolic analysis, this approach is not effective, since here the task is to construct compact expressions for the desired responses. This can be achieved when there is freedom to highlight any parameter, including sources. Such a selection of parameters is not possible within the framework of the overlay principle. Therefore, it is advisable to use the implicit method of superposition, which allows generating responses in a general (non-canonical) form.

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Анотація

Показано, що для формування компактних шуканих реакції лінійних кіл доцільно використовувати неявний метод суперпозиції при символьному аналізі.

Ключові слова: неявний метод суперпозиції, реакція кола.

Аннотация

Показано, что для формирования компактных искомых реакции линейных цепей целесообразно использовать неявный метод суперпозиции при символьном анализе.

Ключевые слова: неявный метод суперпозиции, реакция цепи.

Abstract

It is shown that for the formation of the compact desired reaction of linear circuits it is advisable to use the implicit method of superposition in symbolic analysis.

Keywords: radio implicit superposition method, circuit reaction.