About the Accuracy of Analysis of Linear Parametric Circuits Performed by Frequency-Symbolic Method

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Abstract - **It deals with comparison of the results of the calculations performed by frequency-symbolic method with the calculations done by MicroCAP programme and analytical solution**

Keywords – **symbolic analysis of parametric circuits, linear parametric circuits, symbolic analysis.**

The transfer function of a linear parametric circuit $W(s,t)$ (s -complex variable, t -time) performed by the frequency-symbolic method is defined by calculating the approximation $\hat{W}(s,t)$ of the function $W(s,t)$ by the Furie series:

$$\hat{W}(s,t) = W_0(s) + \sum_{i=1}^{n} [W_{-i}(s) \cdot \exp(-j \cdot i \cdot \Omega \cdot t) + \\ + W_{+i}(s) \cdot \exp(j \cdot i \cdot \Omega \cdot t)],$$

where $W_0(s)$, $W_{-i}(s)$, $W_{+i}(s)$ - independent on time t fractionally rational functions of complex variable s, n - the number of harmonics in series.

At the same time the basis of calculations is linear differential equation which connects incoming and outgoing signals in the given circuit. According to this equation, Zade' linear differential equation with time variable complex coefficients relative to transfer function $W(s,t)$ is formed and solved by frequency-symbolic method.

Such calculation $W(s,t)$ always contains methodic inaccuracy which is connected with the limited number of members of series in approximation $\hat{W}(s,t)$. It is obvious because of the fact that there is not accurate expression for $W(s,t)$ in a general case.

The given work deals with the accuracy of results received by frequency-symbolic method. The comparison is made with the results of the calculations done by *MicroCAP* programme and analytical solution. The test example is linear parametric circuit that consists of two pieces of conductance connected in series (constant $y1$ and variable $y(t)$) and described by the system of equations done by the main voltage method.

$$\begin{cases} y1 \cdot u_1 - y1 \cdot u_2 = i \\ -y1 \cdot u_1 + (y1 + y(t)) \cdot u_2 = 0 \end{cases} \quad (1)$$

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with the following algebraic connection between the voltage i given to the circuit and voltage of response u_1:

$$[y1 \cdot y(t)] \cdot u_1 = [y1 + y(t)] \cdot i \quad (2)$$

The researched systems of differential equations are formed from the system (1) by differentiating its first equation (system A), the second one (system B) or both equations simultaneously (system C). According to this each of the systems A, B or C defines its transfer differential equation (of the first, second or third order respectively) for the outgoing variable u_1 relative to incoming voltage i. These transfer equations are researched for the purpose of accuracy of the received solutions made by frequency-symbolic method in comparison with the results of calculations carried out by MicroCAP programme and common analytical solution (2).

The received experimental data help to make the following conclusion.

1. As it was expected, momentary values of outgoing voltage u_1 received according to analytical solution (2) with the help of MicroCAP programme and frequency-symbolic method coincide. The coincidence of analytical solution and calculations done by MicroCAP programme within three symbols after the point (the results in MicroCAP are presented in this form) is complete. To get the accurate result the symbolic method demands including different number of harmonics (in the conducted experiments most number of harmonics should be included in transfer equation of higher order).

2. It is desirable to choose the number of harmonics in the approximation of transfer function in the following way:

a) according to the suggestion of researcher of parametric circuit that can predict which harmonics to include;

b) before using symbolic method momentary values of a chosen variable are defined, for example, by MicroCAP -the programme of number calculations. Then we obtain the same values of this variable received by symbolic method in the way of selecting the number of harmonics in approximation of transfer function. The approximation of transfer function received in such way is considered to be quite accurate and can be used for the following research of parametric circuit.

3. Differentiating of equations of the given system can lead to the necessity of increasing the number of harmonics included in transfer function. It is important to remember when there is inductance in the circuit. It can also demand differentiating of some circuit equations that include integrals.

4. Insufficient number of harmonics included in transfer function can lead to obtaining inaccurate or incorrect result.