The Application of Frequency Symbolic Method to Multivariate Analysis of Linear Parametric Circuits

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Abstract – **In this paper are considered the application of frequency symbolic method to multivariate analysis of linear parametric circuits on the basis of determining of their sensitivity.**
Keywords – **linear parametric circuits, statistical analysis frequency symbolic method, sensitivity of circuits.**

I. Introduction

An important issue of multivariate analysis of circuits is determining the sensitivity their's characteristics to the change parameters of elements. The presence of the functions of sensitivity, usually has a positive impact on the choice of methods of design (defining deviations of characteristics, statistical research, optimization, etc.), and makes it more purposeful and qualitative. In the proposed work this is demonstrated on a defining deviations of characteristics of the linear parametric circuit by the method of moments, which is based on the dependence:

$$\delta W \cong \sum_{i=1}^{n} S_{l_i}^{W} \cdot \delta l_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} S_{l_i l_j}^{W} \cdot \delta l_i \cdot \delta l_j, \qquad (1)$$

where $\delta W(\delta l_i, \delta l_j)$ - relative deviation of the parametric transfer function W (parameters of elements l_i, l_j) of circuit from the nominal value; n - quantity of parameters of elements of circuit;

$$S_{l_i}^{W} = (\partial W/\partial l_i)\cdot(l_i/W) \text{ i } S_{l_i l_j}^{W} = \left(\partial^2 W/\partial l_i \partial l_j\right)\cdot(l_i \cdot l_j/W) \quad (2)$$

- sensitivities of first and second order of function W to the change of parameters of elements of circuit, respectively.

II. Main Part

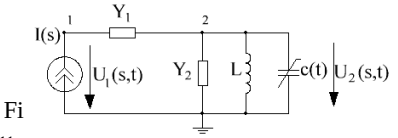
The main difficulty of multivariate analysis, in particular calculation of the deviation of characteristics of linear parametric circuits by method of moments, lies in determination of the chosen parametric transfer function W in which the parameters of elements of circuit are represented by symbols. We offer to determine such transfer functions by frequency symbolic method (FS-method) [1], and their presence makes trivial the following definition of sensitivity and relative deviations, in particular, by programme MATLAB.

EXAMPLE. To determine the relative deviation of parametric transfer function $Z_{IN} = U_1/I$ of the circuit that is presented at fig.1, with parameters L = 253.3 nH, Y_1 = 0.25 S, Y_2=0.4 mS, c_0=10 pF, m=0.05 by their relative change of 1%.

By FS-method, the approximation of function of input resistance Z_{IN} is obtained in the following symbolic form:

$$Z_{IN}(m, c_0, L, Y_1, Y_2, s, t) = Z_0(m, c_0, L, Y_1, Y_2, s) + \sum_{i=1}^{k}[Z_{-i}(m, c_0, L, Y_1, Y_2, s)\cdot \exp(-j i\Omega t) + Z_{+i}(m, c_0, L, Y_1, Y_2, s)\cdot \exp(j i\Omega t)], \quad (3)$$

where $Z_0(m, c_0, L, Y_1, Y_2, s)$, $Z_{-i}(m, c_0, L, Y_1, Y_2, s)$, $Z_{+i}(m, c_0, L, Y_1, Y_2, s)$ - approximation functions.



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c(t)=10^{-11}(1+0.05cos(4·10^{9}πt)); I(s)=10^{-3}exp(j·2·10^{8}πt-π/4).

Using formed expression (3) by programme Matlab the next values can be defined:

a) sensitivity of functions Z_{IN} of the first and second order by the formulas (2);

b) relative change δZ_{IN} in input resistance Z_{IN} at a given relative changes in parameters of elements of circuit m, c_0, L, Y_1, Y_2 by the formula (1).

At fig.2 the time-dependence of the module $\delta Z_{IN}(t)$ at a relative change of the of the parameters of elements of 1% is shown .

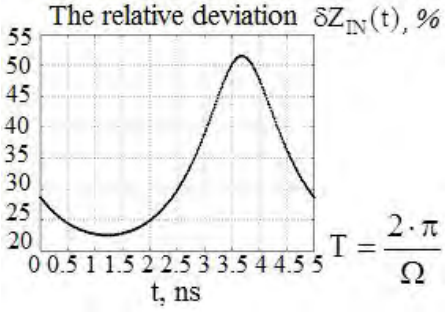

Рис.2. Dependence of the module $\delta Z_{IN}(t)$ of single-circuit parametric amplifier at time t.

III. Conclusion

1. As the parametric transfer function W depends on time, δW also depends on time. The maximum value at period T should be considered as a result (51,8 % at t=3.75 nc for the example).

2. If the expression (3) is bulky, then it is expedient to replace this expression by series of expressions, in which only the necessary parameters of the circle are symbols.

The presented material shows that FS-method allows us to effectively solve the problem of multivariate analysis of linear parametric circuits.

References

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