The Spectrometric Algorithm of Parameters Determination of the Microwave Circuits

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Abstract — **the algorithm for determination of module and argument of complex reflection coefficient (CRC) of microwave circuits, which is based on digital processing of the measurement signal in the spectral domain, is proposed.**

Keywords — **reflection coefficient, module, argument, discrete Fourier transform**

I. Introduction

The radical increasing of the stability of the built-in measurer of parameters of microwave circuits is achieved by the implementation of the switching principle [1]. At the same time it allows us to use the digital methods of measurement information processing. In this paper the spectrometric algorithm of measurement signal processing is considered.

II. The Structure of the Algorithm

The analog measurement signal of primary sensor is subjected to the sampling with the number of steps equal to $N_1 = 16$ over a period T (fig. 1).

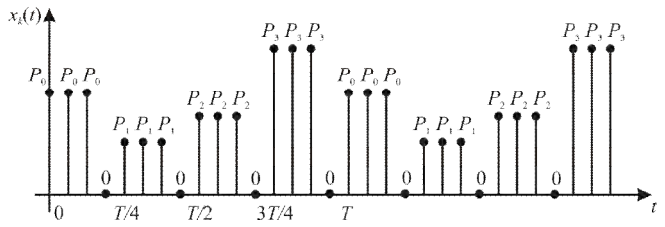

Fig. 1

Taking into account [1] we define the complex amplitude of the first and the fourth harmonic of the signal, using the direct discrete Fourier transform (DDFT):

$$A_1 = \frac{1}{N_1}\sum_{k=0}^{N_1-1} x_k \exp\left(-\mathrm{j}\frac{2\pi k}{N_1}\right) = \frac{k_1 P_{\text{п}}|\Gamma|}{\Delta}\exp\left[\mathrm{j}(\varphi-\varphi_1)\right]; \quad (1)$$

$$A_4 = \frac{1}{N_1}\sum_{k=0}^{N_1-1} x_k \exp\left(-\mathrm{j}\frac{8\pi k}{N_1}\right) = \mathrm{j}\frac{k_2 P_{\text{п}}}{\Delta}\left(1+|\Gamma|^2\right), \quad (2)$$

where $|\Gamma|$ and φ are the module and the argument of the complex reflection coefficient; $P_{\text{п}}$ is the power of the incident wave; Δ is the determinant of the graph; k_1, k_2, φ_1 are constants, which are determined by the calibration procedure.

We define the amplitudes and initial phases of these harmonics, using (1) and (2). As a result, we obtain the following system of equations:

$$\begin{cases} |A_1| = k_1 P_{\text{п}}|\Gamma|/\Delta; \\ |A_4| = k_2 P_{\text{п}}(1+|\Gamma|^2)/\Delta; \\ \arg(A_1) = \varphi - \varphi_1. \end{cases} \quad (3)$$

The resolving of the system of equations (3) regarding the module and the argument of CRC, taking into consideration that $|\Gamma| \le 1$, results in:

$$|\Gamma| = \frac{1}{2}\frac{|A_4|k_1}{|A_1|k_2} - \sqrt{\frac{1}{4}\left(\frac{|A_4|k_1}{|A_1|k_2}\right)^2 - 1}; \quad (4)$$

$$\varphi = \arg(A_1) + \varphi_1. \quad (5)$$

The structure of the proposed algorithm for determination of the module and the argument of CRC is shown in fig. 2.

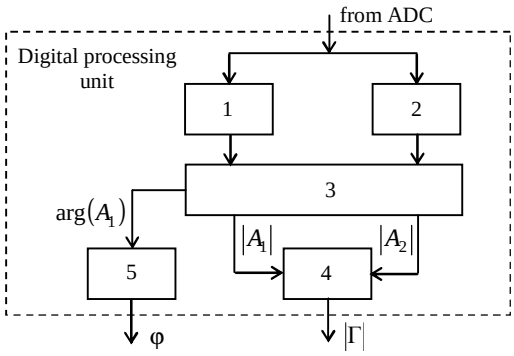

Fig. 2

The signal from analog-to-digital converter (ADC) enters the digital processing unit. In order to improve the accuracy and the noise immunity of algorithm we apply the digital filters 1 and 2, which form the samples of the first and the fourth harmonics respectively. In block 3 the procedure of DDFT is implemented, which results in definition of modules and arguments of the first and the fourth coefficients. In block 4 the module of the reflection coefficient is determined by the formula (4), and in block 5 the argument is determined by the formula (5).

III. Conclusion

In this paper the possibility of measurement of the complex parameters of microwave circuits is demonstrated. These measurements are based on digital processing of the measurement signal in the spectral domain.

References

[1] Gimpilewich Yu. B. Measurement and control of microwave chains parameters. Sevastopol, SNTU, Ukraine, 2009.— 293 p.

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