

METROLOGICAL POLAR - COORDINATES IMPEDANCE SIMULATORS

Vitalie Nastas

Technical University of Moldova,
2001-MD, Chisinau, Stefan cel Mare Bd., 168,
E-mail: v_nastas@yahoo.com

Abstract. The paper contains analysis of two types of metrological polar - coordinate impedance simulators: with current control and with voltage control. Synthesis of the impedance simulators circuits is considered. The offered devices have high exactitude and simplicity of practical realization and are suitable for application both in simple and cheap automatic high exactitude impedance meters.

Keywords: Impedance measurement, polar – coordinates impedance simulator.

1. INTRODUCTION

The modern practical implementation of resonance method is based on application of the impedance simulator as the impedance standard, that allows to ensure the possibility of impedance with different character of components measurement : active, reactive or complex [1]. It executes the function of the reference impedance (measure) and there are imposed to it a requirements bound with metrological support of measurements. Among them:

- Low error and high stability of reproduced impedances;
- Possibility of any character impedance reproduction and the separate regulation of the impedance components;
- The known and warranted systematic error;
- Digital control.

Realization of polar coordinates impedance simulators (P-MSI) presents the large practical interest, because in this case the considerable simplification of measurement algorithm is possible.

To the polar - coordinate MSI (P-MSI), apart from defined above requirements, the following supplementary requirements can be formulated:

- Separate regulation of the module and phase of the reproduced impedance;
- Necessary resolution and exactitudes of the impedance module and phase regulation ;
- Assurance of control bands for module in limits $Z_{min} \div Z_{max}$ and for phase in limits $0 \div 360^{\circ}$;
- Absolute stability of the circuits at the variation of module and phase of the reproduced impedance in necessary limits.

Realization of impedance simulators answering to the aforementioned requirements is possible on the basis of operational amplifiers (OA) with negative and positive feedbacks. Due to properties of modern OA, the parameters of reproduced impedances are determined with high exactitude only by feedbacks and do not depend on OA characteristics. The nonideality of OA properties results in an error of reproduced impedances which magnitude can be determinate.

2. IMPEDANCE SIMULATORS

As it is known, on the basis of OA with positive and negative feedbacks the realization of impedance converter with classical structure [2] ensuring reproduction of impedance with aspect (1) and suitable for use in the elementary measuring circuits with simulated resonance as the impedance simulator is possible. Also is known the impedance simulator with ladder structure [3] for usage as reference element in Cartesian coordinates resonant impedance meters.

However, the specified MSI cannot be used for reproduction of impedances represented in polar coordinates and looking like:

$$\mathbf{Z} = Z \exp(j\varphi) \tag{1}$$

where: Z – the module of reproduced impedance, φ - its phase.

As it is known from the theory of impedance converters [4], on the basis of active elements the realization of two types of MSI is possible:

- Current controlled impedance simulator stable down to a no-load condition (I-MSI),
- Voltage controlled simulator stable down to a condition of short-circuit (U-MSI).

The method of formal structural synthesis was applied for synthesis of structures of P-MSI obeying to all requirements imposed to them, as initial conditions the necessary transformation algorithms of the information is used .

For synthesis of I-MSI structure, the information conversion algorithm represented in the fig. 1.a was used. The practical realization of algorithm is executed in MSI, which block diagram is presented in a fig. 1b.

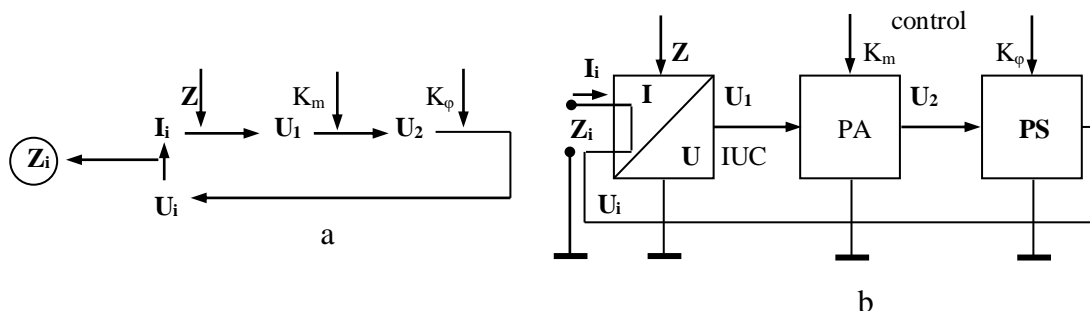


Fig. 1. Conversion algorithm (a) and the structure (b) of I-MSI

The variant of the simulator circuit with presented in a fig. 1.b. structure is presented in fig. 2. The

expression for entering impedance Z_i :

$$Z_i = R K_m \exp(j\varphi) = Z_i \exp(j\varphi_i) \quad (2)$$

where: K_m – gain factor of programmable amplifier PA, φ - defazage introduced by defazor PS.

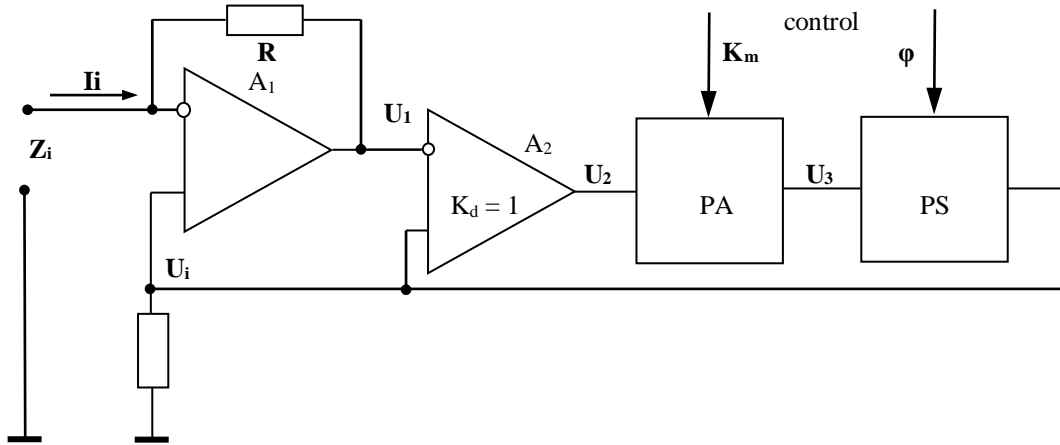


Fig. 2. The circuit of I – MSI.

The information conversion algorithm and the block diagram accepted as an initial condition for synthesized U - MSI is submitted in fig. 3. Are used an voltage repeater A_1 , an programmable amplifier PA, an defazor PS and an differential amplifier A_2 connected in cascade. The entry impedance is controlled by means of regulation of gain factor of programmable amplifier K_m and of defazage introduced by defazor φ .

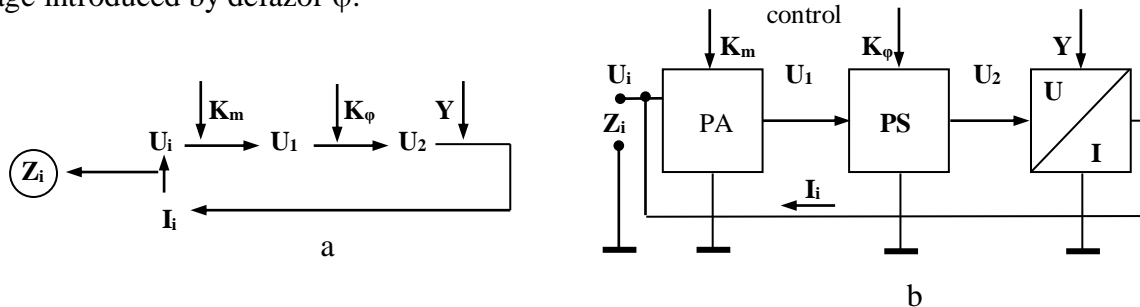


Fig. 3. Conversion algorithm (a) and the structure (b) of U - MSI

The practical circuit realized on the basis of the considered block diagram is submitted in fig. 4. The entry impedance of MSI :

$$Z_i = U_i / I_i = (K_m)^{-1} G^{-1} \exp(-j\varphi) \quad (3)$$

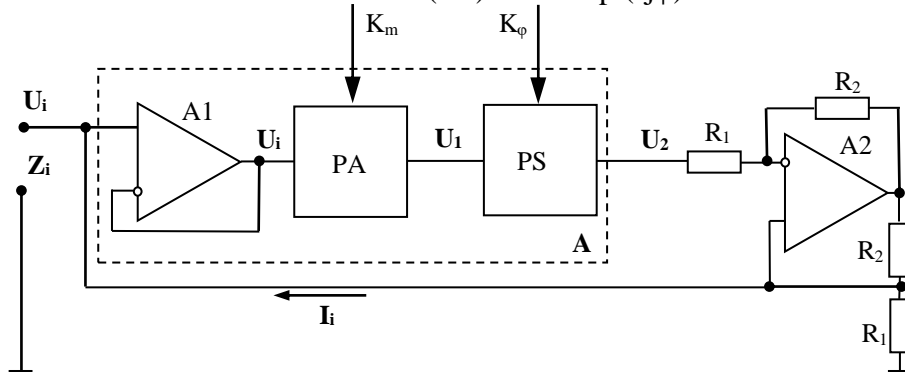


Fig. 4. Impedance simulator realized on the block diagram from fig. 5, b.

As follows from (2) and (3), the proposed structures of I-MSI and U-MSI ensure reproduction of virtual impedances represented in polar coordinates with independent control of its module and phase.

REFERENCES

1. V. Nastas, M. Scînteianu, "The impedance measurement by method of simulated resonance" *Proceedings of the 8th International Conference OPTIM 2002*, pp. 683-688, Braşov, 2002
2. J. Dostal "Operational amplifiers", ELSEVIER SPC, New York, 1981.
3. V. Nastas, "Synthesis of impedance simulators for resonant measuring circuits". *Meridian ingineresc*, nr. 4, 2002, pp. 83-88, "TEHNICA-INFO", Chişinău.
4. F. Bening, „Negative widerstände in elektronischen schaltungen”, VEB VERLAG TECHNIC, Berlin, 1971