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Selection of linear filter elements parameters for measuring of voltage and currents components of direct and inverse order

***Abstract**. In the paper is presented the review of control functions of linear filters of symmetric components, in the systems for measuring of symmetric components of voltages and currents in electric networks, composed of impedances with passive R, L, C parameters.*
The characteristics of process and procedure for determination of parameters of filters elements based on mathematical model of three-phase filter equivalent circuit have been emphasized. The results on behaviour of measuring system with linear filter behaviour obtained in the analysis with application of MATLAB simulation have also been presented.

***Streszczenie.** W artykule przedstawiono przegląd filtrów liniowych składowych symetrycznych, w zastosowaniu do systemów pomiarowych tych składowych prądu i napięcia sieci elektroenergetycznej, zbudowanych z elementów RLC. Opisano wynik działania pomiarów, wykonanych przez podany system, modelu symulacyjnym w programie Matlab. (**Dobór parametrów filtru liniowego do pomiaru składowej zgodnej i przeciwnej napięcia i prądu w sieci elektroenergetycznej**).*

Keywords: measuring, parameter, filter, symmetric components.
Słowa kluczowe: pomiary, parametry, filtr, składowe symetryczne

Introduction

Economic parameters and reliability of power networks exploitation depend on quality parameters of electric energy, and one of the most important and most influent quality parameters which influences the efficiency of three-phase power network is symmetry of network voltage.

In secondary circuits of power networks (measuring, protection and control) filters with two, three of more branches have been used. In determination of values and adjustment of filter parameters, filters have been mainly treated as independent electric circuits, because the values of source impedances are considered lesser in regard to impedances of filter elements [1, 2, 3, 4].

With this assumption, the calculations in this paper have been also performed – it is considered that parameters of filter electric branches elements, connected to appropriate linear voltage values, are independent.

Possible asymmetries mainly are determined, measured or calculated by approximate methods [1, 3, 5, 6]. In the case of measuring, the current or voltage filters, which phase values of voltages/currents convert to symmetric values of components of voltages/currents, are used. All approximate measuring methods include high measuring uncertainties and the biggest disturbance appears in the case of filters failure, which is usually derived as three-phase circuit.

The most used three-phase filter of symmetric components of direct and inverse orders is composed of three electric branches and has been presented on Fig. 1 [1, 2].

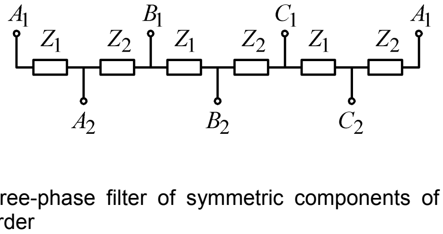

Fig.1. Three-phase filter of symmetric components of direct and inverse order

Disintegration of filter leads to impedance value discrepancy from nominal values. This can occur because errors during the manufacturing of filter elements as well as because of changes of impedances values due to changes of frequency, voltage or temperature.

Frequency change leads to changes of reactance value, since inductive reactance is directly and capacity reactance is inversely proportional to frequency.

Voltage discrepancies from nominal values cause changes of coils inductivity with ferromagnetic sheet metal in magnetic circuit. Temperature changes entail changes of active resistances and capacitances [7, 8, 9].

Determination of filter parameters values

Value changes of filter elements impedances are caused by discrepancy of parameters value R, f, L and C from nominal values. Inequality of impedances values and nominal values affects active as well as reactive part of filter impedance. Changed impedance value can be mathematically defined as a sum of nominal Z_n value and impedance change ΔZ, with expression:

(1) $$Z_h = Z_n + \Delta Z$$

where: nominal filter impedance Z_n is a sum of active and reactive part, and change of impedance value is included by introduction of coefficient h_*:

(2) $$Z_n = R_n + jX_n\,,\ \ \Delta Z = R_n \cdot h_{*R} + jx_n \cdot h_{*X}$$

Coefficients h_{*R} and h_{*X} of change of active and reactive impedance part are determined for each filter respectively, depending on its construction.

Frequency changes the most often, and with the assumption that it changes for value Δf in regard to nominal value (f_n), $f=fn+\Delta f$ the value of complex impedance of ohm-inductive (RL) character also changes:

(3) $$Z_h = R_n + j2\pi\left(f_n + \Delta f\right)L = Z_n + jX_n \cdot h_{*X}$$

In the case of frequency change, the value of coefficient h_* for R,L circuit is:

(4) $$h_{*X} = \Delta f / f_n$$

Value of impedance of ohm-capacitive RC character is:

(5) $$Z_h = R_n - j\frac{1}{2\pi\left(f_n + \Delta f\right)C} = Z_n + jX_n \cdot h_{*X}$$

In the case of frequency change in the circuit RC the value of coefficient h_* is:

(6) $$h_{*X} = \Delta f / \left(f_n + \Delta f\right)$$

In changes of values of inductivity for ΔL regarding the nominal value, the following expression has been used (3),