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Evaluation of Power Losses under Asymmetrical and Nonsinusoidal Modes

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ABSTRACT: This article discusses the issues of assessing power and electricity losses in relation to distribution networks of power supply systems.

I. INTRODUCTION

A feature of distribution networks is a fairly simple structure, usually consisting of medium voltage network of 6-10 kV, a transformer substation with step-down transformers, and a low voltage network of 0.4 kV. As a rule, these are fairly long networks made in the form of overhead lines (less often cable lines), through which end consumers are supplied, mostly in the form of single-phase loads. This leads to the fact that often it is not possible to fairly evenly distribute their load across all three phases, which in turn leads to an increase in network losses [1].

II. THEORETICAL PART

To assess the power losses associated with the asymmetry and nonsinusoidality of the phase loads, the existing calculation methods were considered, taking into account the influence of the asymmetry and the nonsinusoidality of the load.

In the method presented in [2], it is proposed to estimate the power loss by the expression:

$$\Delta P_{\sum n} = 3\sum_{n=2}^{40} I_n^2 R_1 k_{in} \ , \tag{1}$$

where n - the harmonic number; I_n- current of the n – th harmonic component; R_1 - the length of the network section; $k_{in} = 0{,}47\sqrt{n}$ - the coefficient of change of the active resistance of live parts at the n-th harmonic.

As can be seen from expression (1), this method is applicable only to symmetric networks with non-linear load for cables of all possible cross sections, and the losses in this case are not taken into account in the zero working conductor.

Consider another method [3], which is based on expression (2):

$$\Delta P_{\sum n} = 3r_0 l\sum_{n=2}^{40} I_n^2 (k_{Sn} + k_{pn}) \ , \tag{2}$$

where $k_{Sn} = 0{,}021\sqrt{f}$ – surface effect factor; $k_{pn} = \frac{1{,}18+k_{Sn}}{0{,}27+k_{Sn}}(\frac{d}{a})^2$ –coefficient taking into account the effect of proximity of conductors in the power line; r_0 – specific resistance of a conductor to a direct current (taking into account temperature), Om/m; l- chain length, m; f – v-harmonic frequency, Hz; d – conductor core diameter, mm; a – the distance between the centers of the cores, mm.

Formula (2) as well as (1) are used to calculate symmetric nonlinear circuits. In addition, in these formulas, along with harmonics, the conductor cross section and the location of the current-carrying conductors relative to each other are also taken into account.

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In the method of calculating additional power losses in asymmetrical networks of 0.4 kV with a zero working conductor, given in [4], the basis is (3):

$$\Delta P_i = k_{ui} I_{ei}^2 r_{ei} k_{ai} \ , \tag{3}$$

where k_{ui} – coefficient taking into account the number of phases of a circuit in a network section; I_{ei}^2 - effective current on the network (current value of the current); r_{ei} – line resistance; k_{ai} – coefficient taking into account additional losses from uneven phase load;

$$k_{ai} = N^2\left(1 + 1.5\frac{r_{z\text{T}}}{r_{ph}}\right) - 1.5\frac{r_{z\text{T}}}{r_{ph}}, \tag{4}$$

where $r_{z\text{T}}, r_{ph}$ – resistance of the zero working and phase conductor; $N^2 = 3\frac{I_A^2+I_B^2+I_C^2}{(I_A+I_B+I_C)^2}$ – coefficient of unevenness.

Expression (3) allows you to calculate additional losses in the zero working conductor. However, they are determined only by the effective value of the current of the zero working conductor and do not take into account the possible change in the resistance of the zero working conductor from the frequency of harmonic currents.

In the calculation method [5], which takes into account the influence of both asymmetry and nonsinusoidality on active power losses in low-voltage three-phase networks with a zero working conductor, namely:

1.Phase losses

Active power losses in phase A:

$$\Delta P_{\text{A}} = r_{0ph} l_{\text{A}} \sum_{n=2}^{40} I_{n\text{A}}^2 (k_{Sn} + k_{pnPh}) \ , \tag{5}$$

where $\mathrm{k_{Sn}} = 0{,}021\sqrt{\mathrm{f}}$ – surface effect factor; $\mathrm{k_{pn}} = \frac{1{,}18+\mathrm{k_{Sn}}}{0{,}27+\mathrm{k_{Sn}}}(\frac{\mathrm{d}}{\mathrm{a}})^2$ – coefficient taking into account the effect of proximity of phase conductors in a power line; $r_{0\text{Ph}}$ - specific resistance of a phase conductor to direct current (taking into account temperature), Om/m; l_A– phase chain length A, m; f – n -th harmonic frequency, Hz; d_{Ph}– phase conductor core diameter, mm; a – average distance between centers of veins, mm; I_{nA} - current of the n-th harmonic in phase A.

To determine the average distance between the centers of the wires in the four-wire cable in Fig. 1 shows the possible distances between the centers of the cores [6].

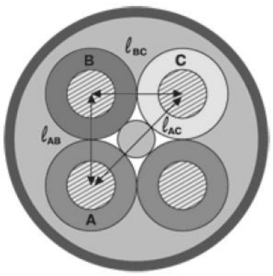

Fig. 1. Scheme of four-wire cable

Then

$$a = \sqrt[6]{l_{AB} l_{BC} l_{CA} l_{A0} l_{B0} l_{C0}} \ , \tag{6}$$

where $l_{AB} l_{BC} l_{CA} l_{A0} l_{B0} l_{C0}$ - the distance of the corresponding cable cores.

Active power losses in phase B:

$$\Delta P_{\text{B}} = r_{0Ph} l_{\text{B}} \sum_{n=2}^{40} I_{n\text{B}}^2 (k_{Sn} + k_{pnPh}) \ , \tag{7}$$

L_B - the length of the chain in phase B, m; I_{nB} - the current of the n-th harmonic of phase B. Loss of active power in phase C:

$$\Delta P_{\text{C}} = r_{0Ph} l_{\text{C}} \sum_{n=2}^{40} I_{n\text{C}}^2 (k_{Sn} + k_{pnPh}) \ , \tag{8}$$

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L_C– the length of the chain in phase C, m; I_{nC} - the current of the n-th harmonic of phase C.

Losses of active power in the zero working conductor:

$$\Delta P_0 = r_{0n} l_0 \sum_{n=2}^{40} I_{n0}^2 \left(k_{Sn} + k_{pn0}\right) \ , \qquad (9)$$

$\mathrm{k_{pn0}} = \frac{1,18+\mathrm{k_{Sn}}}{0,27+\mathrm{k_{Sn}}}(\frac{\mathrm{d}}{\mathrm{a}})^2$ – coefficient taking into account the effect of proximity of phase conductors in a power line; r_{0n} - resistivity of the zero working conductor to direct current (taking into account temperature), Ом/м; l_0– length of the circuit section of the zero working conductor, м; d_0– core diameter of the zero working conductor, мм; I_{n0} - current of the n-th harmonic of the zero working conductor.

Then the total loss of active power in a three-phase network with non-linear and asymmetric load can be determined by the expression [5]:

$$\Delta P_{\sum n} = \Delta P_A + \Delta P_B + \Delta P_C + \Delta P_0 \, . \qquad (10)$$

III. INVESTIGATION

A laboratory experiment of the calculation method [5] was conducted to confirm the assumption that additional losses in cables increase with increasing degree of asymmetry and non-sinusoidal load.

The experiment was aimed at determining additional coefficients when changing the frequency of currents flowing in the cable, as well as at determining losses in the zero working conductor not only from the main harmonic currents, but also from non-linear components flowing in it due to asymmetric and non-sinusoidal loads.

The experimental setup included a four-wire cable, a three-phase programmable Malika instrument, and a single-phase Fluke 43 power quality analyzer.

The Malika device is designed to measure power quality indicators in accordance with a programmable digital signal model [7]. The device parameters are given in [8].

Appearance of the Malika device is shown in fig. 2.

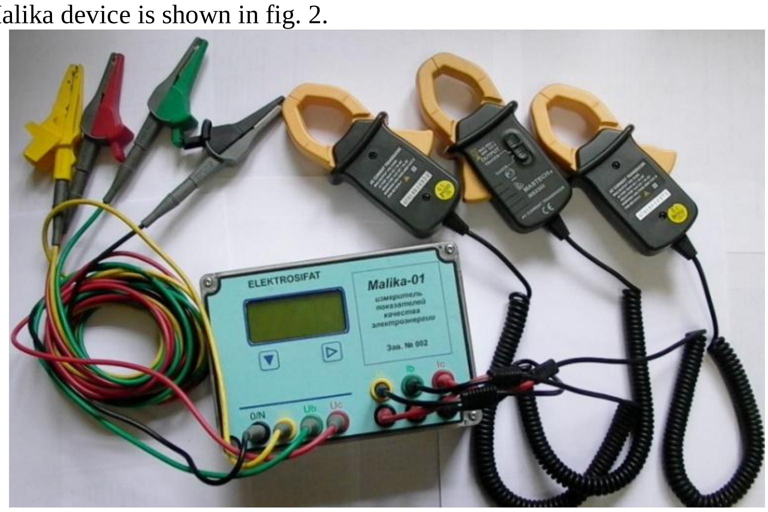

Fig. 2 General view of the "Malika"

Theoretical calculations were performed according to [5]. The shape of the current curve in the zero working conductor is shown in Fig. 3.

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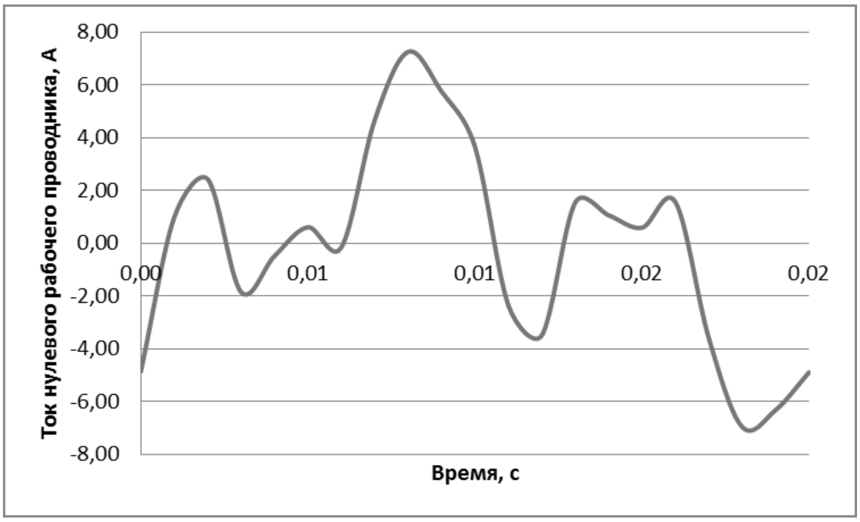

Fig. 3. Theoretically calculated current shape in the neutral conductor

The effective current in phase A was 4.94 A, in the neutral conductor - 3.81 A. The deviation from the experimental data was 2.92% and 4.4%, respectively.

The calculated shape of the current curve of the zero working conductor coincides with the shape of the current curve shown in Figure 2, obtained in an experimental study.

IV. RESULTS

The power loss in the zero working conductor in the calculation was 1.75 W, experimental data - 1.4 W, in phase A - 3.12 W and 2.75 W, respectively. This discrepancy is due to the high measurement error of the active power with the Fluke 34 Power Quality Analyzer.

Comparison of power losses for the above case, calculated by various methods, is shown in table 1.

Table 1

Estimated power loss for various techniques

Method 1, W	Method 2, W	Method 3, W
7,917	8,117	9,172

The deviation of the values of active power losses calculated by the considered methods amounted to:

$$\Delta P_1 = \frac{9.172 - 7.917}{9.172} \cdot 100\% = 13{,}68\%;$$

$$\Delta P_2 = \frac{9.172 - 8.117}{9.172} \cdot 100\% = 11{,}5\%.$$

V. CONCLUSION

Comparison of active power losses in the calculation by various theoretical methods revealed a deviation that is much larger than the permissible error, which raises the question of the reliability of these methods and the possibility of their further application [9, 10].Such a high value of the deviation is due primarily to the fact that the considered methods [2, 3] did not take into account the loss of active power in the zero working conductor, while this method was eliminated in the method [5].

REFERENCES

[1]. Ponomarenko O.I., KholiddinovI.Kh..Vliyanienesimmetrichnixrejimovnapoterimoshnosti v elektricheskixsetyaxraspredelyonnix system elektrosnabjeniya – Energetik, 2015, №12.-C. 6-8.

[2]. Shidlovsciy,A. C.,Cuznetsov,V.G. Povisheniecachestvaenergiivelektrichescixsetyax/ A.C.Shidlovsciy,V.G. Cuznetsov. – Ciev: Naucovadumka, 1985. 268 s.

[3]. Lyutarevich, A.G., Virva, A.A., Dolinger, S.Yu.,Osipov, D.S., Chetveric, I.N. Otsenkadopolnitelnixpotermoshnostiotvisshixgarmonic v elementaxsistemielectrosnabjeniya// Omskiynauchniyvestnic.-№1(77).-2009.-s.109-113.

[4]. Ded, A.V. Opredeleniyepotermoshnosti v raspredelitelnixsetyax s uchetomvliyaniyanesimmetrichnoynagruzki / A.V. Ded // Omsciynauchniyvestnic. - №2(80).-2009.- s.167-170.

[5]. Belitsky A.A., ShklyarskyYa.E. Estimation of additional power losses in electric networks with non-linear and asymmetric load - Bulletin of the TSU. Technical science. 2018. Issue. 7

[6]. Kamensky, M.K., Cold, S.D. 1-10 kV power cables with plastic insulation. Calculation of active and inductive resistances // RusCable [Electronic resource] URL: https://www.ruscable.ru/article/silovye_kabeli_1-10_kv_s_plastmassovoy_i (accessed July 17, 2018)

[7]. Patent UZ FAP No. 01166. A device for recording additional losses of electricity with asymmetry of loads in low-voltage electric networks. / Allaev K.R., Shaismatov S.E., KholddinovI.Kh. // Rasmiumakhborotnoma. –2016, - No. 12. - P. 36. 05.22.2015.

[8]. Allaev K.R., HolydinovI.Kh. Analysis of indicators of the quality of electric energy in distribution networks of 6-10 / 0.4 kV. // Problems of energy and computer science, 2015. – №6. - S. 61-65.

[9]. Kholiddinov I. Kh. Electric power quality analysis 6-10/0.4 kV distribution networks. Journal Energy and Power Engineering (EPE)2016 y. USA.

[10]. HolydinovI.Kh. Development and further use of a class S electric power quality meter // VestnikTashGTU, 2015. (special issue) - S. 51-56.

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Yolchiev Mash'albek Erkinovich was born in 1985 year. From 2012 he worked as an assistant at the Fergana Polytechnic Institute at the Faculty of power engineering at the Department of electrical energy. Since January 2019 doctoral student of the energy Faculty of Tashkent State Technical University