METHODS FOR CALCULATING ACTIVE POWER LOSSES IN A CABLE DISTRIBUTION NETWORK UP TO 1000 KV.

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Annotation. In the given article, work was carried out to calculate additional active power losses that occur as a result of a violation of the quality indicators of electricity in a cable distribution network with a voltage of 0.4 kV. On the basis of the requirements of GOST 13109-97, which are placed on certain characteristics that allow the assessment of electrical energy quality indicators, the effects of high harmonics on electrical networks were studied.

Keywords. 0.4 KV cable line network, electrical energy quality indicators, current and voltage nosinusoidality, current and voltage symmetries, active power loss.

Introduction. When the lengths of transformer 0.4 kV transmission tobacco were analyzed it was determined that the brogan electric energy deviation reaching consumers under gost 13109-1997 or GOST 32145-2013 would be within the ±5% range on demand.

$$\Delta P_{\sum n}=3\sum_{n=2}^{40} I_n^2 R_1 k_{¿},(1)$$

where n is the harmonic number; In - is the current that makes up the harmonica; R_1-network length; $k_{¿}=0{,}47\sqrt{n}$ – the coefficient of change in the active resistance of current conducting parts in n-th harmonica.

(2) the computational method presented in the expression is given in [1].

$$\Delta P_{\sum n}=3r_0 l\sum_{n=2}^{40} I_n^2\left(k_{Пn}+k_{бn}\right),(2)$$

where $k_{Пn}=0{,}021\sqrt{f}$ – coefficient taking into account the effect of the external effect; $k_{бn}=\frac{1{,}18+k_{Пn}}{0{,}27+k_{Пn}}\left(\frac{d}{a}\right)^2$ – coefficient taking into account the interaction of the proximity of conductors in the transmission line; r_0 – comparative resistance, Om/m; l- length of the network part, m; f – n- frequency of harmonica, Gs; d – the diameter of the conductor, mm; a – distance between conductor centers, mm.

Results. Table 1 presents quantitative comparisons of increasing coefficients for each harmonica according to the first and second methods of calculating the cross section of cable 16 and 35 mm2:

Increasing the coefficients for different calculation methods

Table 1.

Harmonica number		3	5	7	9	11	13	15	17	19
Method 1		0,81	1,05	1,24	1,41	1,56	1,69	1,82	1,94	2,05
Method 2	35	1,26	1,25	1,26	1,28	1,3	1,32	1,34	1,36	1,38
	16	1,41	1,39	1,39	1,4	1,42	1,43	1,45	1,47	1,49
Harmonica number		21	23	25	27	29	31	33	35	37
Method 1		2,15	2,25	2,35	2,44	2,53	2,62	2,7	2,78	2,86
Method 2	35	1,4	1,42	1,44	1,46	1,48	1,5	1,52	1,54	1,55
	16	1,51	1,52	1,54	1,56	1,58	1,6	1,62	1,63	1,65

As we can see from Table 1, when calculating according to two different methods, the coefficients take different values, and it is necessary to choose or develop a new method that meets the requirements of accuracy (for example, according to the requirements of GOST 31819.21-2012 "equipment for measuring electricity of alternating current. Static active energy meters of precision classes 1 and 2, the energy measurement error should not exceed 2% and 3%, respectively, for accuracy classes 1 and 2 meters).

Taking as a basis the method of calculating additional power losses in a symmetric electrical network with a voltage of 0.4 kV by the expression (3)

$$\Delta P_i = k_{ui} I_{ei}^2 r_{ei} k_{Di}, (3)$$

where k_{ui} – coefficient that takes into account the number of phases that cause the circuit of contacts in a certain part of the network; $\dot{I}_{ei}$ - effective current in the network area (current value); r_{ei} – active resistance of the network part; k_{Di} – the coefficient of additional power losses resulting from uneven distribution of loads;

$$k_{Di} = N^2 \left(1 + 1.5 \frac{r_{NT}}{r_F} \right) - 1.5 \frac{r_{NT}}{r_F}, (4)$$

where $r_{NT}, r_F - zero\ working \wedge phase\ conductor\ resistors$;

$$N^2=3\frac{I_A^2+I_B^2+I_C^2}{(I_A+I_B+I_C)^2}(5)$$

unevenness coefficient of currents.

Method for performing the calculation taking into account the effect of symmetry and sinusoidality on the active power losses in the zero working conductor proposed in low-voltage three-phase networks:

1. Phase losses

Active power dissipation in phase a:

$$\Delta P_A=r_{0F}l_A\sum_{n=2}^{40}I_{nA}^2(k_{Pn}+k_{bnF}),(6)$$

where $k_{Pn}=0{,}021\sqrt{f}$ – – coefficient taking into account the effect of the external effect; coefficient; $k_{bn}=\frac{1{,}18+k_{Pn}}{0{,}27+k_{Pn}}\left(\frac{d}{a}\right)^2$ – coefficient taking into account the interaction of the proximity of conductors in the transmission line; r_{0F} – phase conductor specific resistance Om/m; l_A – length of the network part A, m; f – n- frequency of harmonica, Gs; d_f – the diameter of the conductor, mm; a – distance between conductor centers, mm; I_{nA} – A phase n-harmonic current.[3]

In this

$$a=\sqrt[6]{l_{AB}l_{BC}l_{CA}l_{A0}l_{B0}l_{C0}},(7)$$

where $l_{AB}l_{BC}l_{CA}l_{A0}l_{B0}l_{C0}$ – are the reciprocal distances between wires, respectively.

Phase A active power dissipation:

$$\Delta P_V=r_{0F}l_V\sum_{n=2}^{40}I_{nV}^2(k_{Pn}+k_{bnF}),(8)$$

L_V – Length of the branch part of Phase B, m; I_{nV} – N-harmonic current of Phase B.

Phase B active power dissipation:

$$\Delta P_S=r_{0F}l_S\sum_{n=2}^{40}I_{nS}^2(k_{Pn}+k_{bnF}),(9)$$

L_S – Length of the branch part of Phase C, m; I_{nS} - N-harmonic current of Phase C.

Active power loss in zero working conductor:

$$\Delta P_0=r_{0n}l_0\sum_{n=2}^{40}I_{n0}^2(k_{Pn}+k_{bn0}),(10)$$

The total loss of active power in a three-phase network with a nonlinear and symmetric consumer is determined by 11 expressions:

$$\Delta P_{\sum n} = \Delta P_A + \Delta P_B + \Delta P_C + \Delta P_0 . (11)$$

The assessment of losses from symmetry in a three-phase four-wire network is carried out on the condition that the consumer has a constant connection power, when the value of the power coefficient is 0.8, when the section surface of the 100 m long copper cable with a length of 35 mm2 is considered the part of the circuit.[4]

As a result of the fact that consumers with a non-linear change element are connected to the electrical network in a symmetrical way, the eleter network comes to a more symmetrical appearance.

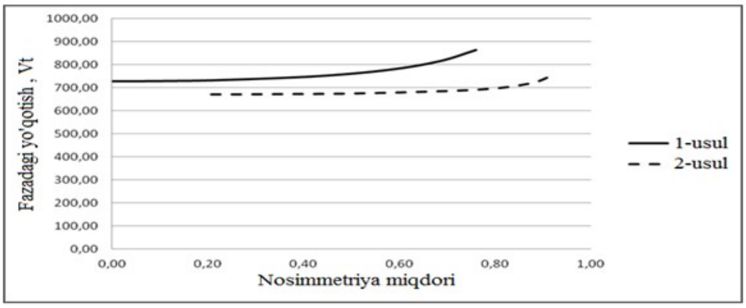

Figure 2 . Graph of dependence of Phase conductors on power losses of the symmetric indicator

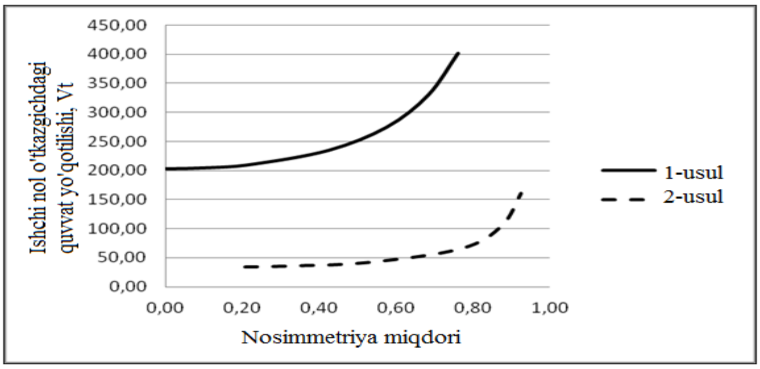

Figure 3. Graph of dependence of the working zero conductor symmetric indicator on power losses

The 1-count was done as part of the phase currents (28%) taking into account the large proportion of harmonic currents multiplied by 3.

In the 2nd count, 5-15% of the phase currents were carried out taking into account a large part of the harmonic currents multiplied by 3.

Conclusion. This article carried out a laboratory experiment confirming the effectiveness of the practical application of the developed method of calculating active power losses in a cable. The deviation of experimental additional coefficients from those calculated did not exceed ±3%, which is explained by the established error of measuring instruments. According to the results of the experiment, the maximum value of the measurement error was a maximum of 2.8%. However, given the measurement errors of the Fluke 43 voltage quality analyzer, the overall measurement error ranged from 3.04% to 15.26%.

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Comparing the developed loss estimation method with a method that only takes into account phase current symmetries, we can conclude that the nature of the increase in total losses in the network as well as the increase in the share of symmetries for both calculation methods is the same.

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