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POWER QUALITY IN THE LOW-VOLTAGE AIR NETWORK

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ABSTRACT:
Objective. One of the important criteria for evaluating electrical energy is the indicators that characterize the symmetry of this three-phase voltage system. In the analysis of these indicators, the peculiarities of the three-phase network, including the uneven operating modes, the diversity of consumers, the occurrence of power imbalances as a result of non-uniform distribution of phases, the resulting nonlinear distribution of voltage across phases, the possibility of equal distribution of single-phase consumers limited, as well as the diversity of power consumption, factors that negatively affect the neutral operating mode, the nonlinear nature of the power consumption, and other factors lead to factors that cause voltage symmetry of the three-phase network.
Methods. There are several specific measures to bring the voltage symmetry of the three-phase network to the required level, which is based on the analysis of the calculated parameters, based on the current operating mode of the existing network, the condition of the elements in the connection scheme. This takes into account not only the normal operation of the three-phase network, but also the requirements of the normative operation of single-phase consumers. Due to this requirement, it is difficult to calculate and analyze the voltage symmetry of three-phase networks. This article refers to one of the measures aimed at eliminating voltage asymmetry, which is relevant in terms of complexity. One of the main reasons for the fact that the power quality indicators exceed the normative indicators is the significant additional active losses of electricity in the symmetrical parts of the reverse and zero-sequence currents passing through the elements of the power grid.
Results. The purpose of the study was to analyze the quality and additional losses of electricity in 0.4 kV transmission lines (TP-503,504 and 518) in the Andijan region.
Conclusion. Thus, the analysis showed that the operating mode of the tested power grid is symmetrical, in particular, requires the installation of asymmetrical devices to reduce additional losses and improve the quality of electricity.

Keyword: 0.4 kV, electricity, transformation, line, ASKUE, calculation, voltage, symmetry.

Introduction

One of the important criteria for assessing the quality of electricity is the indicators that characterize the asymmetry of the three-phase voltage system. There are short-term (emergency) and long-term (operational) symmetrical cases in power supply systems. Short-term unbalanced situations are usually associated with various emergency processes, such as unbalanced short circuits, phase ground faults, breakage of one or two wires, and so on. Long unbalanced conditions are usually caused by connecting elements of the power grid to nonphase rods (single, two-phase branches) or symmetrical (single, two, or three-phase) loads to the power supply system [21-22]. The symmetry of the currents that occur for various reasons flows through the elements of the electrical network, causing an asymmetrical voltage drop across them, which in turn leads to the symmetry of the voltage system.

Theoretical Part

Criteria for the assessment of voltage symmetry are determined by two qualitative indicators: that is, the coefficients of voltage symmetry in the inverse and zero sequences, the values of which are regulated by GOST [1]. Also, the symmetrical parts of the reverse and zero-sequence currents passing through the elements of the electrical network result in significant additional active losses of electrical energy.

Many scientists around the world have studied the symmetry of currents and voltages, evaluated their effects, and developed methods and special techniques to minimize these effects. No such studies have been conducted in Uzbekistan. Symmetrical cases in 0.4 kV power grids were carried out using several studies and in several transformer substations supplying different loads.

To achieve this goal, the following tasks were set:

1) use of ASKUE data to determine the average value of current and voltage in power transmission lines at different times of the year (hot, cold, foggy, and humid);

2) calculation of electricity quality indicators, as well as additional losses of active power, using the developed model;

3) to compile and analyze the schedule of the studied quantities, to determine the nature of their measurements;

4) economic assessment of power losses of low-voltage assets;

5) suggest ways or techniques normalize quality and reduce energy losses.

Discussion and Results

We would like to show the results of the research conducted in TP-503, 504, and 518 of the Bobur ETC of the Andijan region, the specifics of the substation, and the connected consumers are shown below.

The substation is equipped with a TM-250 10 / 0.4 kV voltage transformers.

There are 4 power transmission lines (power transmission lines) made of SIP-2 cable. The total length of the power transmission line is 5990 m, which corresponds to the 1st power transmission line produced by SIP-2, size 50 mm^2, - 1036 m; Made of 2-SIP-2 wire, 35 mm^2 power transmission line -1536 m; Power transmission line made of SIP-2 wire 3, 25 mm^2, - 2081 m and power transmission line 4, made of SIP-2 wire, cross-sections 16 mm^2, - 1337 m., Number of consumers distributed: phase "A" - 95 pcs .; Phase "V" - 95 pieces; phase "S" - 93 pcs. Homes with an electrical receiver load are household consumers [23-24].

For example electric heaters (in winter), electric ovens, refrigerators, washing machines, irons, lighting fixtures, televisions, hand-held electrical appliances, etc.

The total installed capacity of consumers is 5 kW (for each family). The results of the measurements obtained using the symmetry program were tabulated. Based on the data in the table, time tables of current changes are compiled, as well as power quality indicators and additional losses. Figure 2 shows a timing diagram of the phase currents in the power transmission lines being tested. The most loaded phase is "C", through which the average current for the time flow period studied is 35.4 A, while in phases "A" and "B" such current is 12.8 and 9.3 A, respectively. Such 'phase asymmetry' led to the emergence of current asymmetry coefficients along with the inverse (K_2U) and zero (K_0U) sequences (Fig. 2, b). Their mean readings over the study period were 0.47 and 0.45, respectively, which led to an increase in power losses characterized by an additional loss coefficient of KP, averaging 2.4 (Figure 1).

№	name	Power	Ua	Ub	Uc	Ia	Ib	Ic
1	TP-518	630 kWA	217	219	254	55,17	49,21	41,07

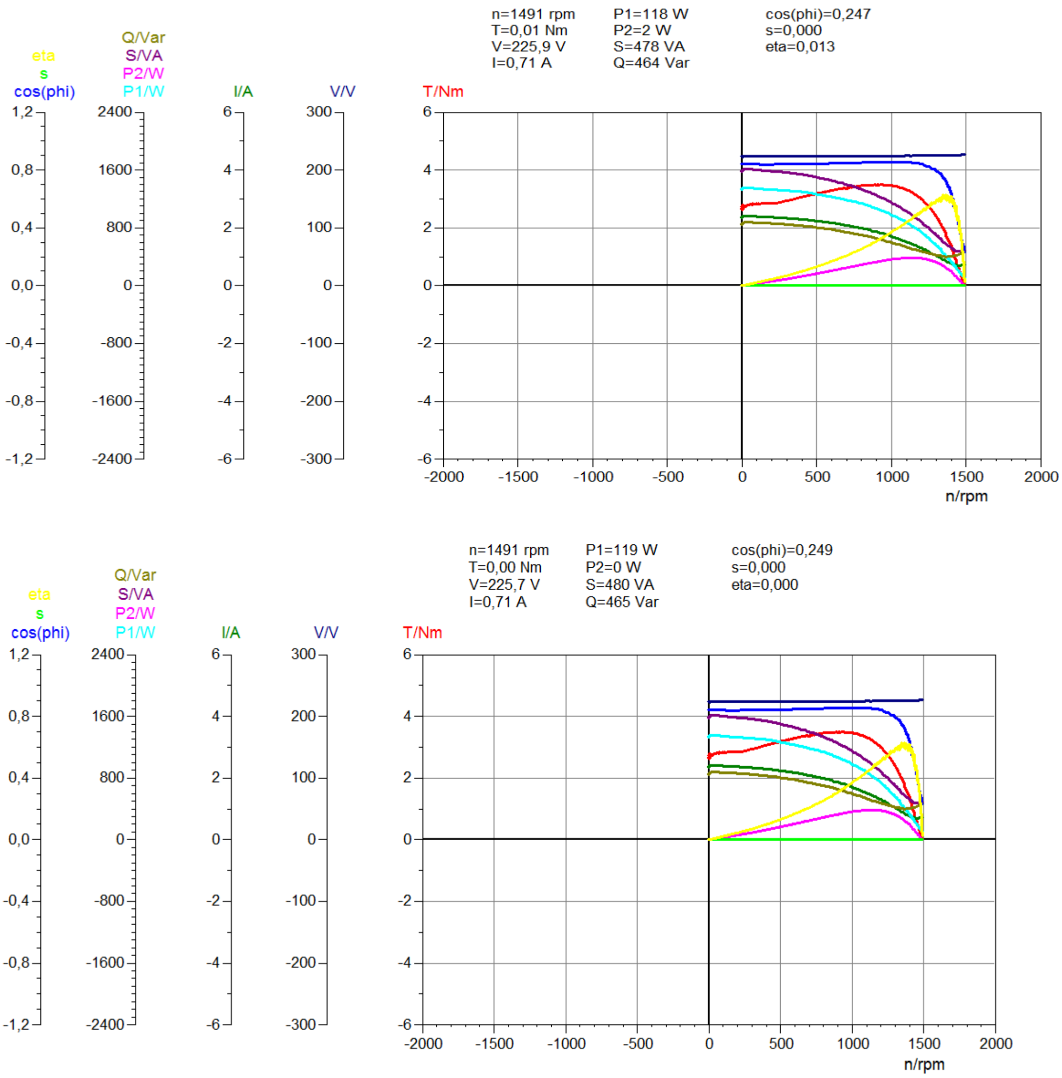

Figure 1. Tables of currents over time (a) and their symmetric values - coefficients for inverse and zero sequences (b)

Thus, in a real asymmetric state, the loss of electrical energy is 2.4 times higher than the loss due to direct consecutive currents alone. Let us consider how additional power losses in a symmetrical case affect the increase in electricity prices. We estimate that electricity will be transmitted continuously throughout this year through this transmission line. Thus, the lost time can be conditionally taken to be 2190 hours (91 days) (for each season of the year).

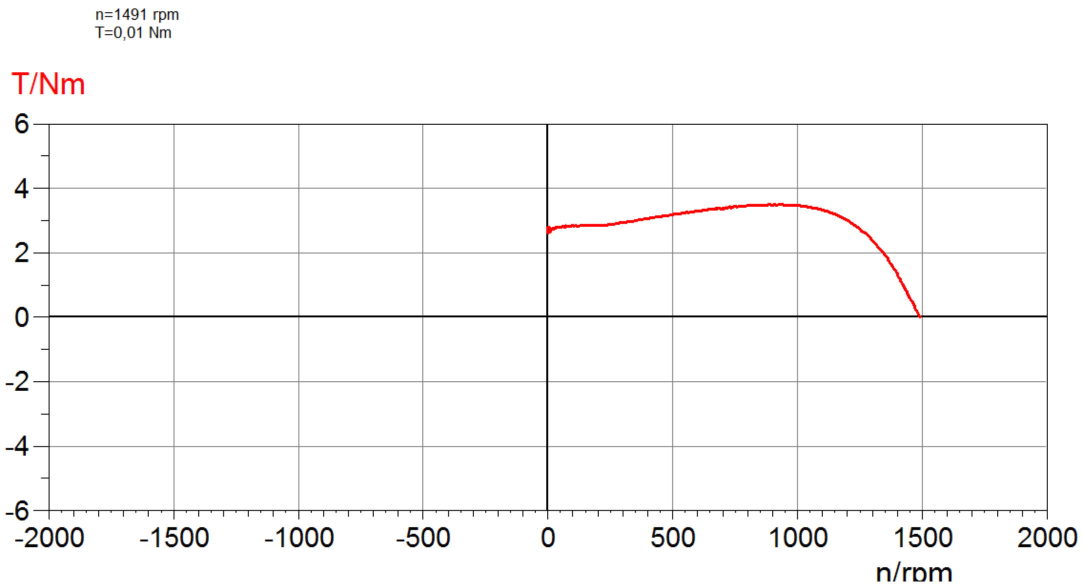

Figure 2. Time diagram of change of additional power loss coefficient in the studied electric network 0.4 kV

Complete loss of electricity in the power transmission lines being tested, taking into account the symmetry

Currents in each phase:

$\Delta w = \ell * p0 * \tau * (IA_2+IB_2+IC_2)$ (1)

where ℓ is the length of the power transmission lines being tested (1,036 km);

r0 is the active resistance of 1 km of wire, equal to 0.641 Ohm/km;

IA, IB, IC are the mean values of the phase currents in the power transmission lines for the period under study, respectively (average phase currents in the measurement period are 12.76; 9.3 and 35.4 A, respectively).

Thus: $\Delta W = 1.036*0.641*2190*(12.762+9.32+35.42) = 2185.67$ kVt * s

In the conditionally symmetrical state, the power loss (in this case) is the power loss coefficient 1), the average value of the loss coefficient is 2.43:

Δ Wsiм=ΔwKp=2185,672,43=899,45 kW * s

Loss of electrical energy due to symmetry of phase currents:

Δ Wnos = Δ W = Δ Wsim = 2185.67 = 899.45 = 1286.22 kW * s

The cost of electricity for consumers is 390 soums / kWh. As of August 20, 2020, in dollar terms, it is \$ 0.038 / kWh (\$ 1 = 10,320 sums).

Thus, the value of additional power losses due to the asymmetry of currents in the power transmission line under test for a year is as follows: It should be noted that these power losses and their value are calculated directly for the power transmission line under study. The currents of the zero and reverse series along the low voltage circuit of the power transformer lead to an increase in losses, which is determined by the sum of the currents of the reverse and zero series of each [20].

Thus, at 100% of the measurement time, the coefficients K_2U and K_0U are pre-calculated values are 2.34 and 2.7 times, respectively, and at 95%, respectively, in the study period, these values exceed the normal (2%) values, respectively, of course, 4.65 and 5.4 once.

The decrease in the symmetry of the operating state of this power grid may be due to the systematic (random) and probable asymmetry of the phase currents [6].

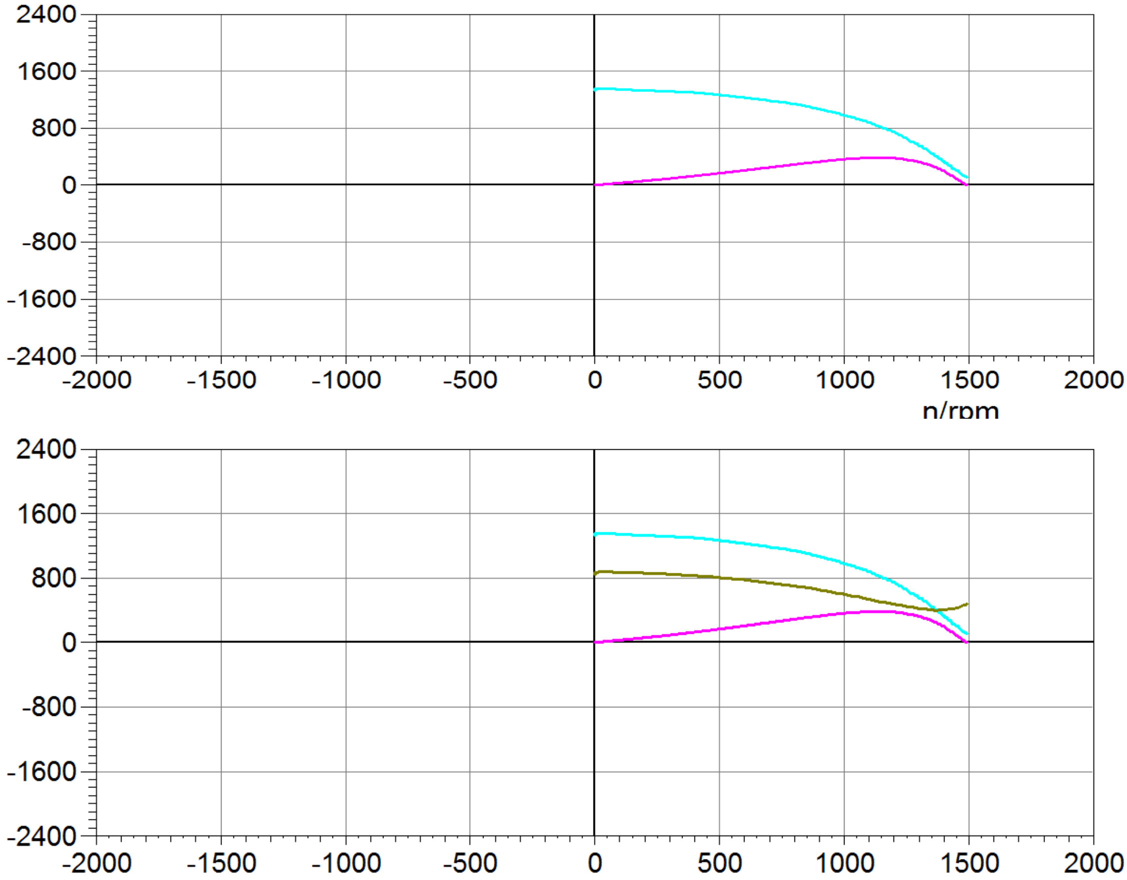

Figure.3. Phase A and phase B voltage changes in the air transmission lines over time

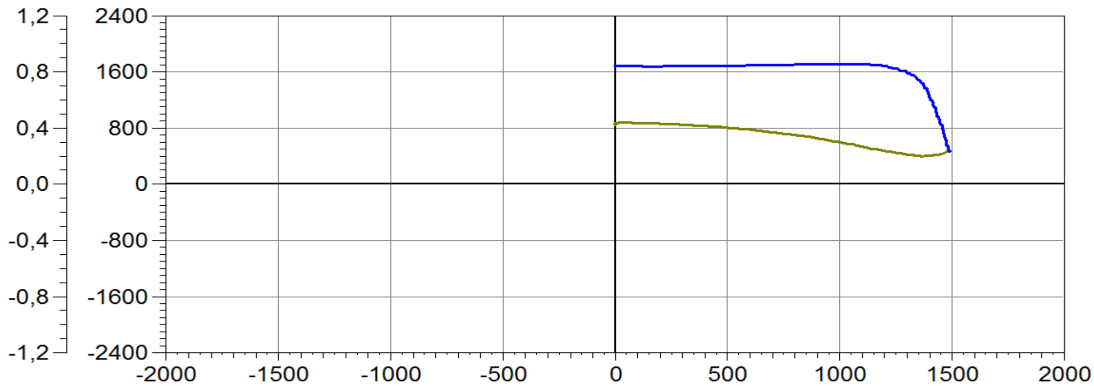

Figure 4. Diagram of time variability of inverse and zero sequences of asymmetry coefficients

Due to the unevenness of the composition, the statistical symmetry of the currents is reduced by the redistribution of single-phase loads, which can be single-phase load distribution in the phases of a three-phase power grid, ie: remove the load overloaded "C" phase - 16.5 A and "A" - 6, 2 to phase A and phase "B" -9.6 A

However, the probability component of the symmetry of the currents cannot be reduced by anything other than a balancing device. As a result, the most effective means of normalizing the operating condition of this power transmission line is to connect a shunt balancing device, the parameters of which can be calculated according to the method shown in [7] :(2).

where is the complex conductivity of the forward, reverse, and zero sequences of the equilibrium device, respectively;

- the corresponding conductivity of the equivalent chains, direct, inverse, and zero sequences;
- complex conductivity of the power grid, direct, reverse and zero sequences, respectively;
- forward and reverse conduction of a three-phase symmetrical load, respectively.

Only because the utility is connected to this power grid loading, so this permeability can be neglected. Using this technique, it was possible to determine the parameters of the balancing device of the power transmission line under study: (3)

It should be noted that the study of symmetrical operating conditions is only for one power transmission line for the specified TP-503 and only for one winter condition. Also, additional losses in the power transformer were not taken into account. The pictures of the TP-503 and the four output power lines located on the transformer itself are as follows. The total value of additional power losses due to phase asymmetry

Currents in four output lines and TP-503 power transformer: in winter:

1403921 sums. = $ 758.12; in the spring: 914030 sums. = $ 494 $; in summer: 851051.25 sums. ($ 443);

in the fall: 842669 sums, i. e. The total annual losses in this sector amounted to 3972522.2 sums. ($ 2,066).

Conclusion

Thus, the analysis showed that the operating mode of the tested power grid is symmetrical, in particular, requires the installation of asymmetrical devices to reduce additional losses and improve the quality of electricity.

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