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Analysis of Measured Active Power Values in Assessing the State of the Power System

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ABSTRACT. In this work, further improvement of the assessment of the state of nodes is achieved by analyzing the reliability of measurement data at the nodes of the power system. As an object of study, the measurement data of the 220 kV network in the South-Western part of the energy system of Uzbekistan are presented. The study used the three most commonly used data processing methods. Based on the combination of these methods, an algorithm was created and a model was formed on its basis. The adequacy of the model was determined by comparing the results of experiments conducted by world scientists. Experience in practice tested as an experiment at the National Dispatch Center under the Ministry of Energy of the Republic of Uzbekistan. Confidence sorting identifies and sorts random values to improve the calculation of electrical modes. In addition, this algorithm is considered efficient in network digitization and is very efficient in dividing nodes into observable, partially observable or completely unobservable parts.

When digitalizing a network, the reliability of all data is very important, and it is quite effective for sorting and evaluating errors in measurement data. Also in the process of designing power plants and substations, increasing the level of accuracy with the help of average values gives a high economic effect. The DIgSILENT PowerFactory software is used to calculate the electrical modes, and the developed model facilitates the assessment of the mode by comparing the calculated and actual values. The scope of the model is mainly effective in assessing the current state of the power system, in the implementation of projects for connecting stations and substations to the network.

KEY WORDS: Uzbek power system, measurements, monitored cross-sections, emission, graphical spread, sampling, controllability, observability.

I. INTRODUCTION

The transition of the economy to market economy methods of management imposes stringent requirements on the reliability and efficiency of electricity metering. These requirements can only be met by creating automated electricity control and metering systems (ASCMS) equipped with modern electricity metering devices.

The main criterion in managing the power system and assessing its condition is the degree of accuracy of the metered values. Theoretically, there are many methods for sorting and processing raw data on reliability, and in this paper the calculations are done using boxplot, three sigma and standard deviation methods [2,3,5].

Boxplots are a convenient way of visually representing groups of numerical data through quartiles.

Straight lines emanating from the box are called "whiskers" and are used to indicate the degree of dispersion (variance) outside the upper and lower quartiles. Outliers are sometimes plotted as single points in line with the whiskers. Scatter plots can be arranged either horizontally or vertically [23-26].

Scatter plots are generally used in descriptive statistics and allow one or more data sets to be quickly examined graphically. Although it may seem primitive compared to a histogram or density plot, it has the advantage of saving space, which is particularly useful when comparing distributions between a large number of groups or data sets.

Types of observations that can be made based on the whisker box:

Definition of key values, e.g.: mean, median 25th percentile; definition of outliers; data symmetry; data clustering density; data bias and its direction.

Two of the most common variants of the whisker box are the variable-width and the labeled spread diagram.

A span diagram is very useful in analyzing data. It is easy to construct and interpret. Like point and bar charts, it is used to show common properties or differences in groups of data. The basic element of the diagram is a rectangle whose height covers the area where 50% of the observed value lies, with a line indicating the median and whiskers indicating the maximum and minimum values in the sample [1-6].

Determine random values using the boxplot tool in the following sequence.

Determine the index i, using the following formulas;

$$i=(p/100)*n; \qquad (1)$$

p is the percentile of interest; n is the number of observations.

If i turns out to be a non-integer, round it up. This will give you the position of the value corresponding to the p-percentile. The value itself will be p-percentile.

If i is an integer, the p% percentile is the average of the i n i+1 positions. Q1 is the first quartile or 25 per centile; Q2 is the second quartile or 50 per centile (median); Q3 is the third quartile or 75 per centile. Find the interquartile range: IQR=Q3-Q1, calculate the overall range IQR*1.5, then determine the quartile range; Q1-1.5*IQR and Q1+1.5*IQR [18-24,25,26].

For the calculations, one-way measurements of the active power of the 220 kV overhead transmission network are presented. The performed work estimates the state of each network by sorting the random values and using the mean value before determining the mean value. Measurements are taken every 30 seconds and the values are processed according to the capabilities of the measurement tools in the nodes we analyse. Today, with advances in technology, the speed of measurement has reached several times per second. If the time between measurements is shortened, the accuracy of using the average value will increase.

Table 3.1. Measurement of active power on 220 kV lines.

n	1	2	3	4	5	6	7	8	9	10
P (MBт)	140	140	143	76	76	85	84	91	91	90
n	11	12	13	14	15	16	17	18	19	20
P (MBт)	91	94	78	78	78	78	78	79	78	78

Based on the measurement data in Table 1 above, random values were determined using the boxplot tool. In Table 2 below, the validity range of the data was determined using the boxplot tool and outlier values were determined.

Table 3.2. Main final calculation results presented

quantity	20
average	91,3
standard deviation	22,2145
minimum	58,5
quartile 1	78
median	81,5
quartile 1	91
maximum	110,5
low	78
2Q box	3,5
3Q box	9,5
whiskers -	19,5
whiskers +	19,5

II. RESULTS

Even in the presence of zero values in the raw data, the method described above is very effective in sorting the data. To ensure the validity of the calculations, the data are sorted using several methods.

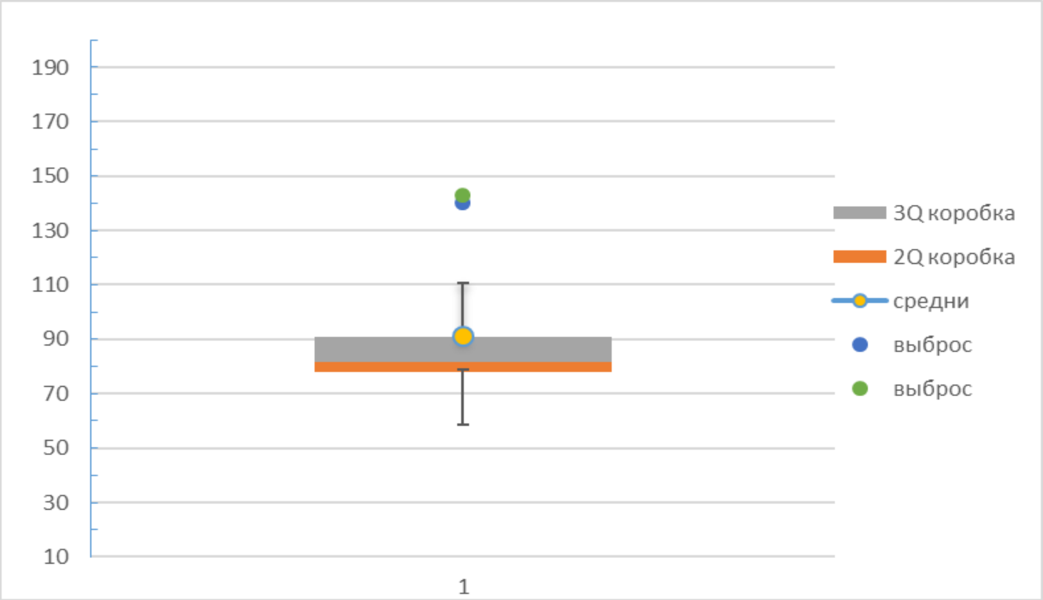

Figure 3.3. The whisker box constructed from the calculated values.

Thus, it can be seen from the above calculations and graph that the error values of the two values have been determined. Once these calculations are completed, the identified random values are excluded and do not participate in the determination of the mean values.

Three Sigma method: In statistical estimation, the Three Sigma rule is widely used: the deviation of a normally distributed random variable X from its mathematical expectation M(x) does not exceed triple the standard deviation σ with a probability of about 0.9973. In other words, with probability 0.9973 the value of a normally distributed random variable X is in the interval [16,17,22,23].

$$[M(x) - 3\sigma \dots M(x) + 3\sigma], \tag{2}$$

where σ is the standard deviation of the random variable.

Based on this rule, three sigma criterion is often used to exclude gross errors (outliers, outliers, anomalous values) from measurement results: values of a normally distributed random variable deviating from the mathematical expectation M(x) by more than three sigmas are unlikely, and therefore are gross errors. That is, a value of xi is a gross error if

$$|M(x) - x_i| / \sigma > k = 3 \tag{3}$$

Three sigma criteria are usually used for a quick approximation of gross errors in a sample. More valid outlier criteria are known for normal distribution. The advantages of the three sigma test are that it is simple, straightforward and easy to remember, and there is no need for tables.

Three sigma test can be formalized from the point of view of statistical hypothesis testing as follows

- the null hypothesis H0: all sample values belong to the same normal distribution
- competing (alternative) hypothesis H1: sample values moving away from the mathematical expectation by more than three sigmas belong to a different distribution.

However, in case of repeated measurements the probability of deviation of at least one sample value from the mathematical expectation is not equal to 0.0027 and depends on the sample volume n. Thus, given the known parameters of a normal distribution, the probability that at least one sample value satisfies the condition in the absence of gross errors. In practice, distribution parameters are most often not known with sufficient accuracy, and their sample estimates are used – the mean value Xcp and the sample RMS (standard deviation) s. In this case the levels of significance are markedly different from those when the distribution parameters are known.

$$S = \sqrt{\frac{\sum_{i=1}^{n}(x_i - x_{cp})^2}{n-1}} \tag{4}$$

Here xi are the elements of the sample.

Then expression (4), i.e., the condition for determining the coarse errors, becomes

$$|x_{cp} - x_i| / s > k \tag{5}$$

All sample values satisfying condition (5) are considered to be gross errors.

There may also be situations where the mathematical expectation is estimated from xcr and the RMS is known with high accuracy, for example, when estimating the variance (and hence the RMS) from a series of measurements. Then expression (2), i.e. the condition for determining the coarse errors, becomes (6):

$$|x_{cp} - x_i| / \sigma > k \qquad (6)$$

All sample values satisfying condition (6) are considered to be gross errors.

The calculation of xcf and S in (5) and (6) can be done in two ways:

1) Including all sample values.

2) Excluding questionable values.

The second method is more complicated, which greatly reduces the advantages of the three sigmas over the other methods. This paper considers the first option when all sample values are taken into account in estimating distribution parameters [4-9, 12, 14, 15].

In this case three sigma remains statistically poorly justified due to the instability of the significance level.

Table 3.3. Measurement of active power on 220 kV lines.

№	P (МВт)	(P1-Pcp)	(P1-Pcp)^2
1	140	48,7	2371,69
2	140	48,7	2371,69
3	143	51,7	2672,89
4	76	-15,3	234,09
5	76	-15,3	234,09
6	85	-6,3	39,69
7	84	-7,3	53,29
8	91	-0,3	0,09
9	91	-0,3	0,09
10	90	-1,3	1,69
11	91	-0,3	0,09
12	94	2,7	7,29
13	78	-13,3	176,89
14	78	-13,3	176,89
15	78	-13,3	176,89
16	78	-13,3	176,89
17	78	-13,3	176,89
18	79	-12,3	151,29
19	78	-13,3	176,89
20	78	-13,3	176,89
Итог	1826		9376,2

Based on the raw data in the table above, the mean value was determined and the maximum and minimum deviations of the values were found.

Table 3.4 The results are calculated on the basis of raw data

quantity	20
average	91,3
Root-mean-square deviations	22,2145

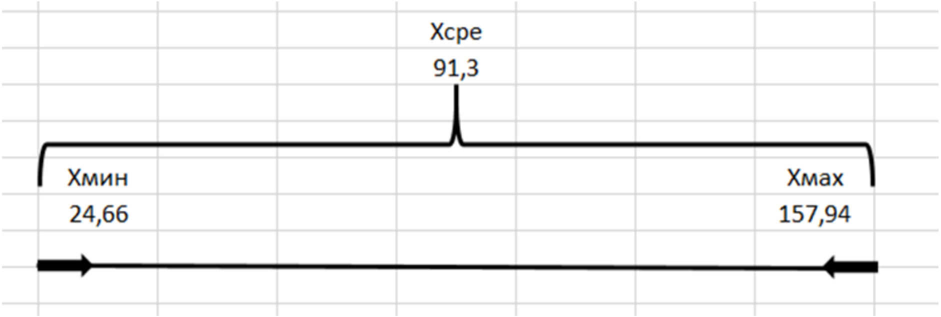

Figure 3.4: Boundary values defined in data processing.

Figure 3.4. shows that the input data must be within this limit value. If the limit value is higher or lower than this, the value is considered an error and is excluded from the final calculation. The results of the third method calculation need not be reported because the standard deviation is three times less than the coverage of the three sigma value.

III. CONCLUSION

The methods considered have their advantages, but the calculation results show that the three sigma method covers a wider range of values than the other methods. This in turn makes it difficult to determine the randomness between values. The boxplot tool covers somewhat less randomness in the data, allowing errors to be easily identified. The standard deviation has less coverage of random variables than the above methods, and is more effective at detecting errors. But the standard deviation and Three Sigma methods have disadvantages in extracting the zero value. It is therefore desirable to separate errors using three or more extrema when determining randomness in the data. In view of the disadvantages of all the above methods a model based on an algorithm combining the three methods was developed.

REFERENCES

[1]. Mirzaev A.T., Khalilov A.S. Analysis of measurement reliability for use in assessing the state of the electric power system. Problems of energy and resource saving No. 3-4, Tashkent, 2020. - pp. 87-91.
[2]. Allaev K.R. Energy of the world and Uzbekistan. –T.: Molia, 2007, -388 pp.
[3]. A. Khalilov and A. Mirzaev. Validity of use in assessment of the state of the electric power system. 2020 IOP Conf. Ser.: Earth Environ. Sci. 614 012012.
[4]. Gamm A.Z. Statistical methods for assessing the state of electric power systems. M: Nauka, 1976 pp. 27-35.
[5]. Allaev K.R., Basidov I.S., Sadullaev E.F. Electric power industry of Uzbekistan during the years of independence and prospects for its development. –T.: Ishonch, 2016, -pp. 137-174.
[6]. Khalilov A. Analysis of nodal voltages of an incompletely observed part of the electric power system in the presence of renewable energy sources. //Uzbekhydroenergy 2020. No. 4 ISSN-C-15351.-pp. 55-56.
[7]. Brian Wang, “European EcoSwing Builds Full Scale Superconductor Wind Turbine,” Nextbigfuture, November 21, 2018. https://www.nextbigfuture.com/2018/11/european-ecoswing-builds-first-full-scale-superconductor-wind-turbine.html.
[8]. Authors: S. A. Eroshenko, A. O. Egorov, V. O. Samoilenko, A. I. Khalyasmaa Calculations of allowable power flows in power systems. Yekaterinburg: Publishing House Ural. un-ta, 2017. - 86 pp.
[9]. Idelchik V.I. Calculations and optimization of modes of electrical networks and systems. – M.: Energoatomizdat, 1988. – 288 pp.
[10]. Allaev K.R. Modern scenarios for the development of the world's energy. // Problems of energy and resource saving No. 3-4, Tashkent, 2020. - pp. 14-24.
[11]. Allaev K.R. Directions of transformation of modern energy systems. // Problems of energy and resource saving 2020. No. 3-4, Tashkent, - pp. 48-57.
[12]. Fazylov Kh.F., Nasyrov T.Kh. Steady regimes of electric power systems and their optimization. - Tashkent: Molia, 1999.
[13]. Ayres M. Bad data groups in power system state estimation / M. Ayres, P. H. Haley // IEEE Transactions on Power Systems. 1986. Vol. 1. - №3. pp. 1-7.
[14]. Clements K. A. Power system state estimation residual analysis: an algorithm using network topology / K. A. Clements, G. R. Krumpholz, P. W. Davis // IEEE Transactions on Power Systems. - 1981. - Vol. PAS-100. - №4. pp. 1779-1787.
[15]. Khalilov AS, Musinova G. Evaluation of the influence of renewable energy sources on static stability in controlled sections of the power system. International Scientific and Technical Conference "Trends in the Development of Alternative and Renewable Energy: Problems and Solutions". Tashkent-2021. May 17-18 - P. 85-89.
[16]. Gamm A. Z. Observability of electric power systems / A. Z. Gamm, I. I. Golub, D. Ya. Keselman // Electricity. - 1975. - No. 9. - pp. 1-7.
[17]. Gamm A. Z. Detection of insufficiently reliable data when evaluating the state of the EPS using topological analysis / A. Z. Gamm // Electricity. - 1978. - No. 4. - pp. 1-8.

[18]. Gamm AZ Methods for solving the problem of estimating the state of the electric power system. / A. Z. Gamm, Yu. A. Grishin, I. N. Kolosok. Issues of evaluation and identification in energy systems. Irkutsk: - 1974. - pp. 149-163.
[19]. Gamm A. Z. Estimation of the state in the electric power industry A. Z. Gamm, L. N. Gerasimov, I. I. Golub and others - M .: Nauka, 1983. - 302 pp.
[20]. Nazarov N. G. Metrology. Basic concepts and mathematical models / N. G. Nazarov, Moscow: Higher school, 2002. -348 pp.
[21]. Garcia A. Fast decoupled state estimation and bad data processing / A. Garcia, A. Monticelli, P. Abreu // IEEE Transactions on Power Apparatus and Systems. 1979. Vol. PAS-98. №5. pp. 1645-1652.
[22]. Gmurman V.E. Probability Theory and Mathematical Statistics: Textbook for High Schools. - M.: Higher School, 2002. - 479 pp.
[23]. Gmurman V.E. A Guide to Problem Solving in Probability Theory and Mathematical Statistics: Textbook for High Schools. - M.: Higher School, 2002. - 452 pp.
[24]. Gmurman V.E. Probability theory and mathematical statistics: T., "Ukituvchi", 1977. - 368 pp.
[25]. Theory of Probability and Mathematical Statistics. (https://studme.org/290263/matematika_himiya_fizik/pravilo_treh_sigm)
[26]. Graphical methods for data analysis. (http://statsoft.ru/home/textbook/modules/stgraph.html)