Project theme name: ИРН №AP09058186. «Methodology development and computer program for determining additional electrical energy losses during its transportation and distribution in the electrical grid.».

Relevance: The operating conditions of power supply systems are changing rapidly. This is due to changes both on the power supply side and on the load side. The stable operation of the power supply system is based on mathematical models and operating rules. Under changing conditions, there is a likelihood of an inadequate description of the situation and, accordingly, erroneous operation of electrical equipment and the power supply system as a whole. To prevent this situation, it is necessary to check the parameters of the regime and the applied calculation methods for adequacy.

The most important criterion for the operation of the power supply system is the level of electricity losses. Under changing conditions, the magnitude and components of electricity losses change. In the current situation, it is necessary to analyze these processes and make adjustments to the applied models.

For this study, it is envisaged to conduct: a review of documentation on the calculation of energy losses; instrumental studies of mode parameters; analysis of applied methods for calculating electricity losses; consideration of influencing factors on the magnitude and components of energy losses. Based on the results of the formation of the database by mathematical methods, their processing is envisaged to obtain dependencies on factors affecting the level of energy losses.

The end result will be the development of an improved model for calculating electricity losses and a computer program for calculating typical cases, it is also envisaged to introduce them into educational and production processes..

The object of research is 110 kV electrical networks.

The purpose of the work is to create an improved methodology for determining the added power losses caused by asymmetry and non-sinusoidal currents in the ES, as well as its implementation in a software environment.

Research methods. In the course of research were used: the theory of matrix calculus, methods and techniques of mathematical modelling, methods of physical and computational experiments, comparison of the results of instrumental surveys with the results of calculations. Synthesis of the results of theoretical and experimental studies will make it possible to assess the adequacy of the adopted solutions, reliability of the obtained results. Conducting instrumental measurements of mode parameters: voltage and current (RMS, AC + DC, peak, fundamental frequency); frequency (at 50 Hz); power (VA, VAreact); power factor; current and voltage harmonics.

As a result of the research, a software application was developed to estimate power losses due to asymmetry and non-sinusoidality of currents. The "Instruction on Loss Calculation for Electric Grid Companies on the Use of the Programme "Calculation of Losses on Power Transmission Lines" was developed. On the basis of the methodology for calculating basic and incremental losses, recommendations were developed, which set out the accounting of incremental losses in the regulation of commercial relations between the power supplying organisation and the consumer, recommendations for assessing incremental losses

of electricity and their accounting in the formation of tariffs, as well as recommendations for reducing the share of incremental losses of electricity. Educational and methodical manuals for implementation in the educational process have been developed.

Degree of implementation. The obtained results are used at network enterprises for processing the results of instrumental survey during energy audit.

Scope of application. Electricity grid companies to determine the structure of losses and assess their quantitative characteristics.

Члены исследовательской группы:

1**) Zhantlessova Assemgul Beisembayevna** (26.12.1982) - head, PhD "electric power engineering". Participates in the preparation of a utility model and development of a computer program for calculating the main and additional losses of electricity from non-symmetry and non-sinusoidality in power supply systems, in project risk assessment, preparation and publication of articles. Author ID: 57195505692. ORCID icon http://orcid.org/0000-0003-3730-0579. h-index=3. A total of 41, 7 copyright certificates, patents, 4 of which are published in Thomson Reuters.

2) Akimzhanov Temirbolat Baltabayevich-performer, PhD "electric power". In the project, he develops a utility model and a computer program for calculating losses of automatic reactive power compensation devices, prepares methodological guidelines for the developed program, prepares articles and reports, and participates in conferences. Certified energy auditor, is the head of the center for "energy Conservation and dissemination of knowledge". Author ID: 56485979700. the h-index:2.

3) Zhumazhanov Serik Karatayevich-candidate of technical Sciences "Eletrotechnical complexes and systems". In the project, he develops a utility model and a computer program for calculating the main and additional losses of electricity from asymmetry and non-sinusoidality in power supply systems, prepares methodological guidelines for the developed program, implements project developments, prepares articles and reports, and participates in conferences. Author ID: 54950223000. h-index: 2.

4) Yermek Zhaslanovich Sarsikeev (26.02.1987) - PhD "Electric power engineering". In the project, he is preparing a utility model and a computer program for calculating the main and additional losses of electricity from asymmetry and non-sinusoidality in power supply systems in engines, pumps and fans, and writing a methodological guide to the developed program, implementing developments on the project, preparing articles and reports, participating in conferences. Author ID: 56252099900. ORCID icon http://orcid.org/0000-0002-7209-5024. h-index: 5.

5) Zhanat Beisembayevich Issabekov- PhD "Electric power engineering". In the project, he develops a utility model and a computer program for calculating the main and additional losses of electricity from non-symmetry and non-sinusoidality in power supply systems in transformer substations, prepares methodological guidelines for the developed program, implements project

developments, prepares articles and reports, and participates in conferences. Author ID: 57194215799. h-index: 2.

6) Issabekova Bibigul Beisembayevna- PhD "Electric power". In the project, he prepares a utility model and a computer program for calculating the main and additional losses of electricity, grounding the neutral of electric networks and implementing developments on the project, preparing articles and reports, participating in conferences. Author ID: 56826203500.

7) Amir Yerlan Kamalievich- master's degree. In the project, he develops a utility model and a computer program for calculating the main and additional losses of electricity from asymmetry and non-sinusoidality in power supply systems, implements project developments, prepares articles and reports, and participates in conferences.

Information for potential users:

As a result of the work carried out, a method for calculating electricity losses will be developed, taking into account the influence of asymmetry and non-sinusoidality, implemented in the form of a computer program and a training manual for implementation in the educational process, as well as instructions for implementation in power grid and other organizations.

List of published works

In 2021:

1.Issabekova B., Tokombaev M., Zhantlessova A. Reed Switch Protection Devices with Symmetric Component Filter without Current Transformers //2021 International Ural Conference on Electrical Power Engineering (UralCon). – IEEE, 2021. – C. 141-146. (in English)

2. Zhantlesova A.B. Elektr zhabdyktaryn paidalanu, diagnostikalau zəne zhondeyu: oku kuraly / Zhantilesova A.B. - Nur-Sultan: S. Seifullin atyndagy Kazak Agrotechnical Universityinni baspasy,2021. – 220б. (in Kazakh)

In 2022:

3. Isabekov J.B., Isabekova B.B., Zhantlesova A.B., Zhalmagambetova U. K., Commercial losses of electric energy in distribution electric networks // Bulletin of Toraigyrov University. Energy Series. - 2022 - № 3. - C. 70-79. - URL: https://doi.org/10.48081/JTDY1576 (in Russian)

4. Isabekov J.B., Isabekova B.B., Zhantlesova A.B., Akayev A. M., Ordabaev M. E. Technical losses in distribution electrical networks // Vestnik Toraigyrov University. Energy Series. - 2022. - № 4. - C. 97-111. - URL: doi.org/10.48081/WBBT1581 (in Russian)

5. Akimzhanov T.B., Zhantlesova A.B., Isabekova B.B., Zhumazhanov S.K., Sarsikeev E.J., Isabekov J.B., Amir E.K. Instrumental energy audit: textbook. - Astana: S. Seifullin KazATU Publishing House, 2022 - 35 p. (in Russian)

6. Akimzhanov T.B., Zhantlesova A.B., Isabekova B.B., Zhumazhanov S.K., Sarsikeev E.J., Isabekov J.B., Amir E.K. Aspatyk energy audit: oku-adistemelik kuraly. - Astana, S. Seifullin atyndagy Kazak agrotechnical universityininң baspasy, 2022. - 33b (in Kazakh)

In 2023:

7. Zhantlessova, A., Zhumazhanov, S., Akimzhanov, T., Issabekova, B., Issabekov, Z., Mekhtiyev, A., & Neshina, Y.. Instrumental Research on the Voltage Harmonic Distortion Coefficient in the Modern 110 kV Urban Electric Network. International Journal on Energy Conversion (IRECON), - 2023 - № 11(2), C. 56. - URL: https://doi.org/10.15866/irecon.v11i2.22979, percentile - 52. (in English)

8. Zhantlessova, A.B., Zhumazhanov, S.K., Akimzhanov, T.B., Mekhtiyev, A.D., Alkina, A.D., Improving the method of controlling the stress-strain state of steel structures of electromechanical systems //Metalurgija. – 2023. – Т. 62. – №. 2. – С. 303-305, , процентиль - 35. (in English)

9. Akimzhanov T.B., Zhantlesova A.B., Zhumazhanov S.K., Sarsikeev E.J., Isabekova B.B., Isabekov J.B. Recommendations for accounting of added losses // recommendations. - Astana: S. Seifullin KazATIU Publishing House, 2023 - 14 p. (in Russian)

10. Zhantlesova A.B., Isabekova B.B., Isabekov J.B. Operation, diagnostics and repair of electrical equipment: textbook / Zhantlesova A.B., Isabekova B.B., Isabekov J.B.; Kazakh Agrotechnical Research University named after S.Seyfullin. - Astana: Izd-vo Kazakh Agrotechnical Research University named after S.Seyfullin, 2023. - 225 c. (in Russian)

11. Akimzhanov T.B., Zhumazhanov S.K., Sarsikeev E.J., Isabekov J.B., Amir E.K., Additive losses of electrical energy during its distribution in the electrical network. // Bulletin of Toraigyrov University. Energy Series. - 2023. - № 4. - C. 23-35. - https://vestnik-energy.tou.edu.kz/storage/journals/172.pdf (in Russian)

12. Akimzhanov, T., Sarsikeyev, Y., Zhantlessova, A., Zhumazhanov, S., Baydulla, Z., Issabekova, B., Issabekov, Z., Mekhtiyev, A., & Neshina, Y. (2023). Identifying the influence of the system and mode characteristics on the power loss mode based in 110 kV power grids. Eastern-European Journal of Enterprise Technologies, 6(8 (126), 6–14. https://doi.org/10.15587/1729-4061.2023.292253, percentile - 39. (in English)

Results

1. The developed software application that allows to estimate power losses from asymmetry and non-sinusoidality of currents (the certificate of inclusion of information in the state register of copyrighted objects No. 29086-1 dated 5 October 2022 was obtained). This software application allows to calculate power losses when taking into account asymmetry and non-sinusoidality of currents, can also be used in the processing of the results of instrumental energy surveys of overhead lines of power systems, in the study of voltage and current patterns, levels of added losses depending on the dimensions of supports, wires and cables. When assessing the level of additive losses in the network, a sufficient number of overhead lines surveyed for this purpose is established based on the results of a

complete energy survey of the power network by investigating the additive loss factor in overhead lines of the power system.

2. In 2021, the results of experimental studies of power quality indicators from LLP "Energy On Track" were received data of field experiments in the form of results of daily instrumental measurements of modes of overhead and cable lines of 110 kV electric network of JSC "Astana REC" in the amount of 22 lines, including single-circuit and double-circuit. In 2022, measurements were carried out in the power grids of South Kazakhstan region and West Kazakhstan region. Instrumental measurements of regime parameters were carried out to determine power quality indicators for formation of experimental database using Fluke 437 power quality analysers, as well as three-phase power quantity and quality analyser S.A. 8336 and MI 2892, purchased under the project.

The obtained experimental data were processed on the basis of GOST 13109-97 standard "Electrical Energy. Electromagnetic compatibility of technical means. Standards of quality of electric energy in general purpose power supply systems". On the basis of the obtained data the evaluation of electric power quality indicators was performed

3. Testing and debugging of the developed methodology and software applications on the basis of experimental data, taking into account typical and non-typical cases. An improved mathematical model and methodology for calculating power losses and its implementation in a software environment were developed and a certificate of inclusion of information in the state register of copyrighted objects No. 36231 dated 25 May 2023 was obtained.

4. Recommendations on the implementation of the proposed solutions in the educational and production environment have been developed (Appendix B, Appendix Z). There is an implementation in the educational process of ENU named after L.N. Gumilev, Toraigyrov University and KazTIU named after S. Seyfullin, as well as in LLP "ESG TREND", "LeaderCom", "Kazakhstan Centre for Energy Saving and Energy Efficiency", "Energy Op Track".

A textbook for universities and instructions on loss calculation for power grid companies were developed.

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ РЕСПУБЛИКА КАЗАХСТАН

АВТОРЛЫҚ ҚҰҚЫҚПЕН ҚОРҒАЛАТЫН ОБЪЕКТІЛЕРГЕ ҚҰҚЫҚТАРДЫҢ МЕМЛЕКЕТТІК ТІЗІЛІМГЕ МӘЛІМЕТТЕРДІ ЕНГІЗУ ТУРАЛЫ

КУӘЛІК

2022 жылғы «5» қазан № 29086-1

Автордың (лардың) жөні, аты, әкесінің аты (егер ол жеке басын куәландыратын құжатта көрсетілсе): АМИР ЕРЛАН КАМАЛИЕВИЧ, Акимжанов Темирболат Балтабаевич, Жантлесова Асемгуль Бейсембаевна, Сарсикеев Ермек Жасланович, Жумажанов Серик Каратаевич, Исабеков Жанат Бейсембаевич, Исабекова Бибигуль Бейсембаевна

Авторлық құқық объектісі: ЭЕМ-ге арналған бағдарлама

Объектінің атауы: Компьютерная программа по определению добавочных потерь при ее транспортировке и распределении в электрической сети

Объектіні жасаған күні: 20.06.2022

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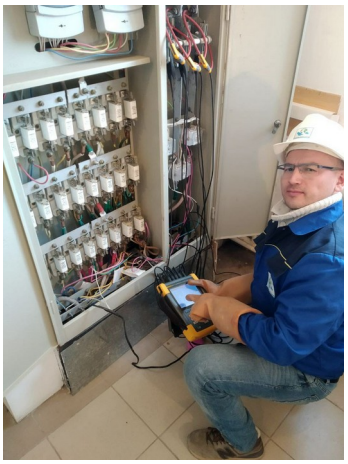
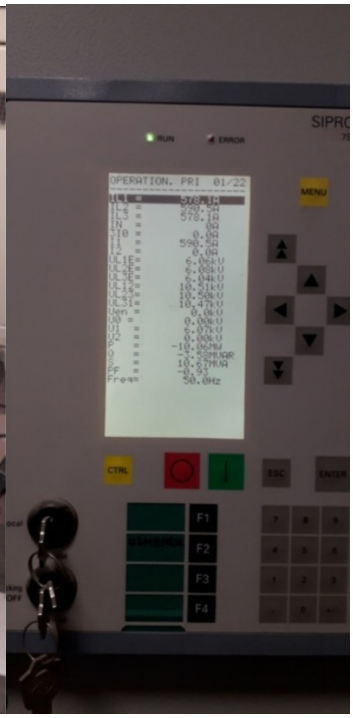
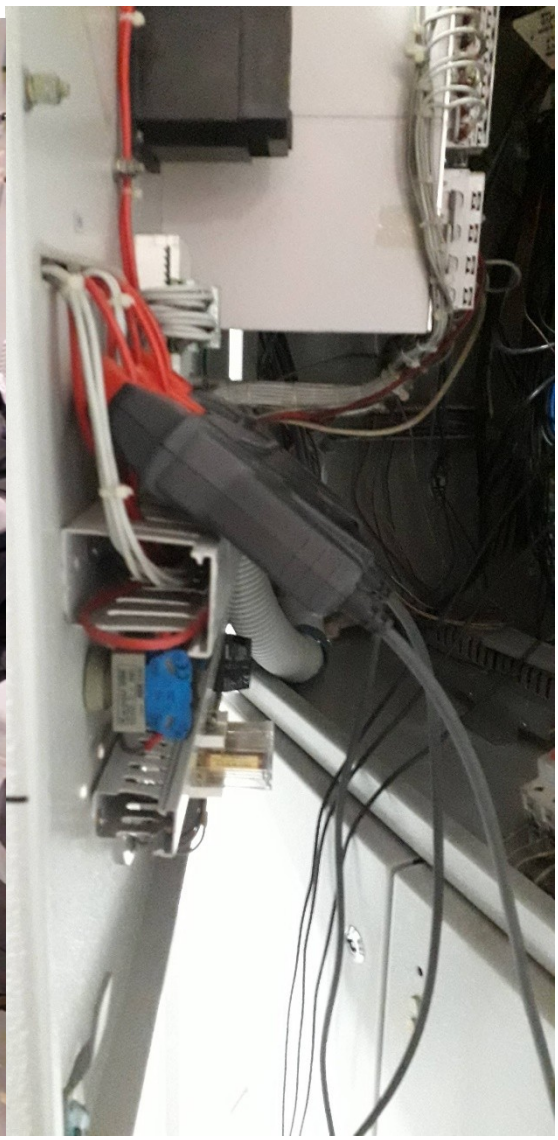
ЭЦҚ қол қойылды Е. Оспанов



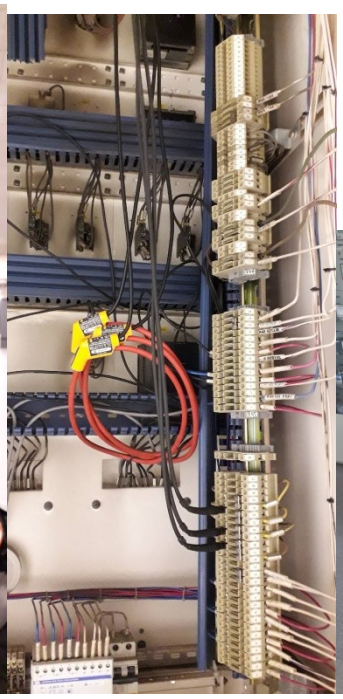

T1
T2


SIPROT
RUN
ERROR
MENU
CTRL
ESC
Сообщения
F1
Измерения
F2
Аварийные сообщения
F3
F4
Remote
Normal


RUN
ERROR
OPERATION. PRI 01/22
MENU
CTRL
ESC
ENTER
F1
F2
F3
F4




FLUKE 437 POWER QUALITY AND ENERGY ANALYZER
SCOPE
MENU
LOGGER
SETUP
MEMORY
SAVE SCREEN
ENTER



Power Log 5.8 - [AERLEV -- Карта SD.fpqo]

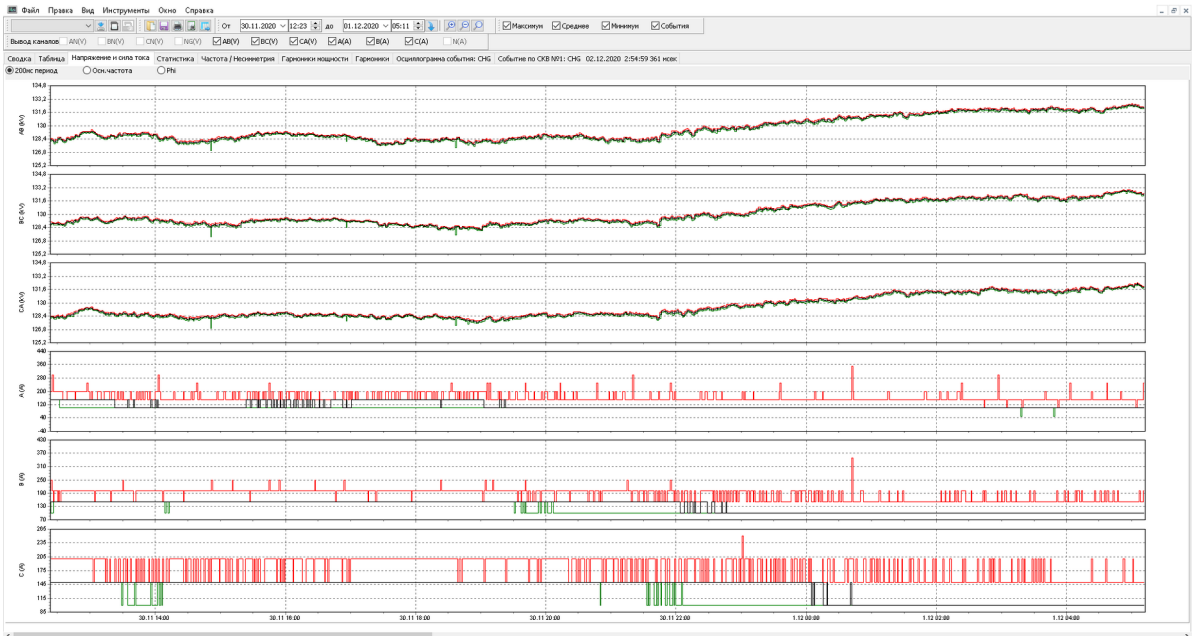
Файл Правка Вид Инструменты Окно Справка

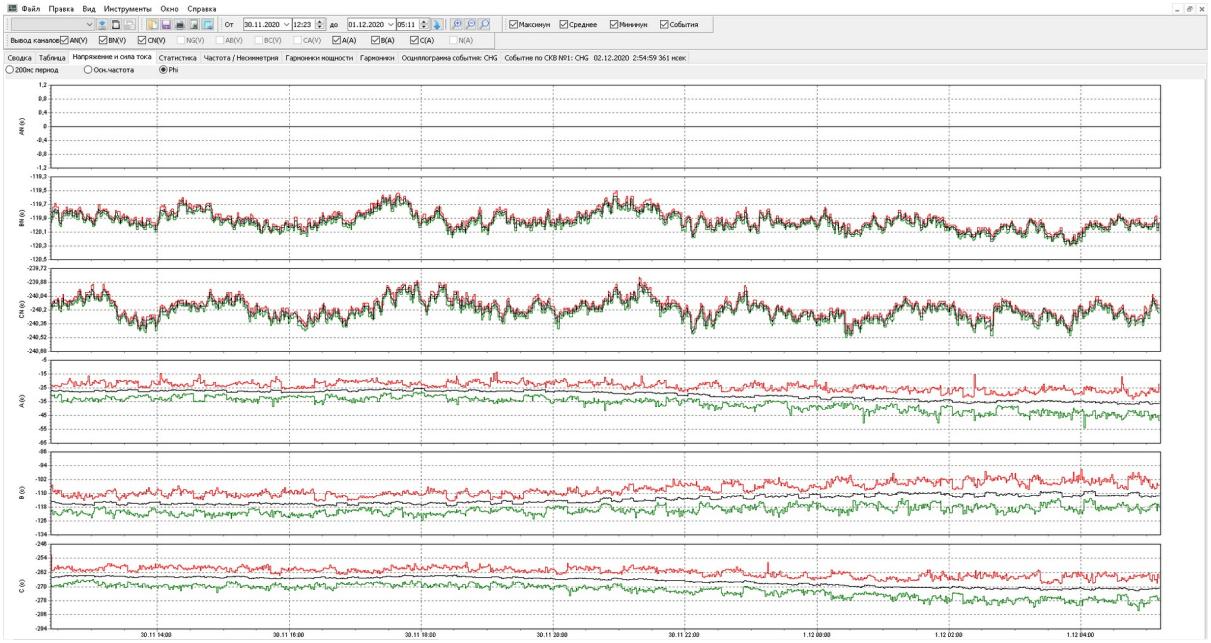
От 30.11.2020 12:23 до 01.12.2020 05:11

Сводка | Таблица | Напряжение и сила тока | Статистика | Частота / Несимметрия | Гармоники мощности | Гармоники | Осциллограмма события: CHG | Событие по СКВ №1: CHG 02.12.2020 2:54:59 361 мсек

Фильтр | Длительность | AN(V) / A(A) | BN(V) / B(A) | CN(V) / C(A) | NG(V) / N(A) | Итого | Min | Avg | Max

Дата	Функция	Длительность	AN(V) / A(A) Min	AN(V) / A(A) Avg	AN(V) / A(A) Max	BN(V) / B(A) Min	BN(V) / B(A) Avg	BN(V) / B(A) Max	CN(V) / C(A) Min	CN(V) / C(A) Avg	CN(V) / C(A) Max
30.11.2020 12:23:55 409мсек	Vrms ph-ph		128,139 kV (r)	128,238 kV (r)	128,37 kV (r)	128,524 kV (r)	128,755 kV (r)	129,063 kV (r)	128,106 kV (r)	128,227 kV (r)	128,403 kV (r)
30.11.2020 12:23:55 409мсек	Напряжение осн. частоты		73,92 kV (r)	73,92 kV (r)	74,03 kV (r)	74,14 kV (r)	74,25 kV (r)	74,36 kV (r)	74,14 kV (r)	74,25 kV (r)	74,36 kV (r)
30.11.2020 12:23:55 409мсек	Ток осн. частоты		100 A (r)	100 A (r)	200 A (r)	100 A (r)	100 A (r)	200 A (r)	100 A	100 A	200 A
30.11.2020 12:23:55 409мсек	Phi напряжения		0 ¢	0 ¢	0 ¢	-119,96 ¢	-119,86 ¢	-119,8 ¢	-240,18 ¢	-240,14 ¢	-240,12 ¢
30.11.2020 12:23:55 409мсек	Phi тока		-30,86 ¢	-27,12 ¢	-23,58 ¢	-120,72 ¢	-115,04 ¢	-106,7 ¢	-269,18 ¢	-264,96 ¢	-252,14 ¢
30.11.2020 12:23:55 409мсек	Arms		150 A (r)	150 A (r)	200 A (r)	150 A (r)	150 A (r)	200 A (r)	150 A (r)	150 A (r)	200 A (r)
30.11.2020 12:23:55 409мсек	THD напряжения		0,67 % (r)	0,69 % (r)	0,71 % (r)	0,75 % (r)	0,78 % (r)	0,81 % (r)	0,68 % (r)	0,72 % (r)	0,75 % (r)
30.11.2020 12:23:55 409мсек	THD тока		6,72 % (r)	9,86 % (r)	20,67 % (r)	2,96 % (r)	6,72 % (r)	15,87 % (r)	7,65 %	10,1 %	15,58 %
30.11.2020 12:23:55 409мсек	K-фактор A		1,54 (r)	1,82 (r)	2,99 (r)	1,58 (r)	1,89 (r)	2,62 (r)	1,42 (r)	1,62 (r)	2,25 (r)
30.11.2020 12:23:55 409мсек	THD мощности		0,01 % (r)	0,03 % (r)	0,08 % (r)	0 % (r)	0,01 % (r)	0,05 % (r)	0,02 % (r)	0,03 % (r)	0,06 % (r)
30.11.2020 12:23:55 409мсек	K-фактор W		0,99 (r)	1 (r)	1,02 (r)	0,98 (r)	1 (r)	1,02 (r)	0,99 (r)	1,01 (r)	1,02 (r)
30.11.2020 12:23:55 409мсек	Частота		49,984 Hz (r)	49,995 Hz (r)	50,026 Hz (r)						
30.11.2020 12:24:55 409мсек	Vrms ph-ph		128,172 kV (r)	128,359 kV (r)	128,458 kV (r)	128,788 kV (r)	128,876 kV (r)	129,041 kV (r)	128,161 kV (r)	128,304 kV (r)	128,414 kV (r)
30.11.2020 12:24:55 409мсек	Напряжение осн. частоты		73,92 kV (r)	74,03 kV (r)	74,03 kV (r)	74,25 kV (r)	74,36 kV (r)	74,36 kV (r)	74,25 kV (r)	74,25 kV (r)	74,36 kV (r)
30.11.2020 12:24:55 409мсек	Ток осн. частоты		100 A (r)	100 A (r)	100 A (r)	100 A (r)	100 A (r)	100 A (r)	100 A	100 A	200 A
30.11.2020 12:24:55 409мсек	Phi напряжения		0 ¢	0 ¢	0 ¢	-119,92 ¢	-119,88 ¢	-119,82 ¢	-240,18 ¢	-240,16 ¢	-240,14 ¢
30.11.2020 12:24:55 409мсек	Phi тока		-30,34 ¢	-27,04 ¢	-23,08 ¢	-119,96 ¢	-114,66 ¢	-105,2 ¢	-269,96 ¢	-264,96 ¢	-260,98 ¢
30.11.2020 12:24:55 409мсек	Arms		150 A (r)	150 A (r)	200 A (r)	100 A (r)	150 A (r)	250 A (r)	150 A (r)	150 A (r)	200 A (r)
30.11.2020 12:24:55 409мсек	THD напряжения		0,67 % (r)	0,7 % (r)	0,74 % (r)	0,75 % (r)	0,8 % (r)	0,86 % (r)	0,67 % (r)	0,7 % (r)	0,73 % (r)
30.11.2020 12:24:55 409мсек	THD тока		6,87 % (r)	9,95 % (r)	17,62 % (r)	3,48 % (r)	6,11 % (r)	25,02 % (r)	7,65 %	10,21 %	14,34 %
30.11.2020 12:24:55 409мсек	K-фактор A		1,55 (r)	1,86 (r)	2,42 (r)	1,51 (r)	1,75 (r)	3,01 (r)	1,46 (r)	1,66 (r)	2,07 (r)
30.11.2020 12:24:55 409мсек	THD мощности		0,01 % (r)	0,03 % (r)	0,09 % (r)	0 % (r)	0,01 % (r)	0,06 % (r)	0,01 % (r)	0,02 % (r)	0,05 % (r)
30.11.2020 12:24:55 409мсек	K-фактор W		0,98 (r)	1 (r)	1,02 (r)	0,99 (r)	1 (r)	1,01 (r)	1 (r)	1,01 (r)	1,01 (r)
30.11.2020 12:24:55 409мсек	Частота		50,013 Hz (r)	50,023 Hz (r)	50,033 Hz (r)						
30.11.2020 12:25:55 409мсек	Vrms ph-ph		128,161 kV (r)	128,26 kV (r)	128,37 kV (r)	128,81 kV (r)	128,92 kV (r)	129,019 kV (r)	128,216 kV (r)	128,337 kV (r)	128,436 kV (r)
30.11.2020 12:25:55 409мсек	Напряжение осн. частоты		73,92 kV (r)	73,92 kV (r)	74,03 kV (r)	74,25 kV (r)	74,25 kV (r)	74,36 kV (r)	74,25 kV (r)	74,36 kV (r)	74,36 kV (r)
30.11.2020 12:25:55 409мсек	Ток осн. частоты		100 A (r)	100 A (r)	200 A (r)	100 A (r)	100 A (r)	100 A (r)	100 A	100 A	200 A
30.11.2020 12:25:55 409мсек	Phi напряжения		0 ¢	0 ¢	0 ¢	-119,88 ¢	-119,8 ¢	-119,74 ¢	-240,16 ¢	-240,12 ¢	-240,1 ¢
30.11.2020 12:25:55 409мсек	Phi тока		-30,98 ¢	-27,26 ¢	-24,02 ¢	-122,34 ¢	-114,66 ¢	-108,84 ¢	-270,1 ¢	-264,92 ¢	-261,06 ¢
30.11.2020 12:25:55 409мсек	Arms		150 A (r)	150 A (r)	300 A (r)	100 A (r)	150 A (r)	200 A (r)	150 A (r)	150 A (r)	200 A (r)
30.11.2020 12:25:55 409мсек	THD напряжения		0,68 % (r)	0,73 % (r)	0,76 % (r)	0,78 % (r)	0,82 % (r)	0,85 % (r)	0,7 % (r)	0,74 % (r)	0,77 % (r)
30.11.2020 12:25:55 409мсек	THD тока		6,94 % (r)	9,93 % (r)	28,37 % (r)	3,5 % (r)	6,59 % (r)	14,88 % (r)	7,87 %	10,41 %	16,03 %
30.11.2020 12:25:55 409мсек	K-фактор A		1,45 (r)	1,86 (r)	3,73 (r)	1,56 (r)	1,88 (r)	2,3 (r)	1,48 (r)	1,72 (r)	2,16 (r)
30.11.2020 12:25:55 409мсек	THD мощности		0,02 % (r)	0,03 % (r)	0,14 % (r)	0 % (r)	0,02 % (r)	0,04 % (r)	0,01 % (r)	0,03 % (r)	0,08 % (r)
30.11.2020 12:25:55 409мсек	K-фактор W		0,99 (r)	1 (r)	1,02 (r)	0,99 (r)	1 (r)	1,01 (r)	1 (r)	1,01 (r)	1,02 (r)
30.11.2020 12:25:55 409мсек	Частота		50,019 Hz (r)	50,024 Hz (r)	50,031 Hz (r)						
30.11.2020 12:26:55 409мсек	Vrms ph-ph		127,996 kV (r)	128,117 kV (r)	128,249 kV (r)	128,678 kV (r)	128,843 kV (r)	128,964 kV (r)	128,139 kV (r)	128,271 kV (r)	128,381 kV (r)
30.11.2020 12:26:55 409мсек	Напряжение осн. частоты		73,81 kV (r)	73,92 kV (r)	73,92 kV (r)	74,14 kV (r)	74,25 kV (r)	74,25 kV (r)	74,25 kV (r)	74,36 kV (r)	74,36 kV (r)
30.11.2020 12:26:55 409мсек	Ток осн. частоты		100 A (r)	100 A (r)	200 A (r)	100 A (r)	100 A (r)	100 A (r)	100 A	200 A	200 A
30.11.2020 12:26:55 409мсек	Phi напряжения		0 ¢	0 ¢	0 ¢	-119,8 ¢	-119,78 ¢	-119,74 ¢	-240,14 ¢	-240,1 ¢	-240,08 ¢
30.11.2020 12:26:55 409мсек	Phi тока		-30,08 ¢	-27,26 ¢	-23,98 ¢	-120,66 ¢	-114,76 ¢	-109,3 ¢	-269,42 ¢	-264,74 ¢	-260,38 ¢
30.11.2020 12:26:55 409мсек	Arms		150 A (r)	150 A (r)	200 A (r)	150 A (r)	150 A (r)	150 A (r)	150 A (r)	150 A (r)	200 A (r)
30.11.2020 12:26:55 409мсек	THD напряжения		0,69 % (r)	0,75 % (r)	0,77 % (r)	0,79 % (r)	0,82 % (r)	0,86 % (r)	0,69 % (r)	0,72 % (r)	0,76 % (r)
30.11.2020 12:26:55 409мсек	THD тока		6,65 % (r)	9,88 % (r)	21,09 % (r)	3,15 % (r)	6,25 % (r)	13,39 % (r)	7,81 %	10,37 %	16,33 %
30.11.2020 12:26:55 409мсек	K-фактор A		1,58 (r)	1,93 (r)	2,46 (r)	1,51 (r)	1,8 (r)	2,45 (r)	1,47 (r)	1,71 (r)	2,13 (r)
30.11.2020 12:26:55 409мсек	THD мощности		0,02 % (r)	0,04 % (r)	0,1 % (r)	0 % (r)	0,01 % (r)	0,03 % (r)	0,02 % (r)	0,03 % (r)	0,07 % (r)
30.11.2020 12:26:55 409мсек	K-фактор W		0,99 (r)	1 (r)	1,02 (r)	0,99 (r)	1 (r)	1,01 (r)	1 (r)	1 (r)	1,02 (r)
30.11.2020 12:26:55 409мсек	Частота		50,007 Hz (r)	50,012 Hz (r)	50,024 Hz (r)						
30.11.2020 12:27:55 409мсек	Vrms ph-ph		127,776 kV (r)	128,018 kV (r)	128,216 kV (r)	128,678 kV (r)	128,81 kV (r)	128,92 kV (r)	128,062 kV (r)	128,172 kV (r)	128,271 kV (r)


Файл Правка Вид Инструменты Окно Справка
Сводка Таблица Напряжение и сила тока Статистика Частота / Несимметрия Гармоники мощности Гармоники Осциллограмма события: CHG Событие по СКВ №1: CHG 02.12.2020 2:54:59 361 нсек
200нс период Осн.частота Phi
AB (kV)
BC (kV)
CA (kV)
A (A)
B (A)
C (A)
30.11 14:00
30.11 16:00
30.11 18:00
30.11 20:00
30.11 22:00
1.12 00:00
1.12 02:00
1.12 04:00


Файл Правка Вид Инструменты Окно Справка
Сводка Таблица Напряжение и сила тока Статистика Частота / Несимметрия Гармоники мощности Гармоники Осциллограмма события: CHG Событие по СКВ №1: CHG 02.12.2020 2:54:59 361 нсек
200нс период Осн.частота Phi
AN (V)
BN (V)
CN (V)
A (V)
B (V)
C (V)
30.11 14:00
30.11 16:00
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